



# Allwinner R11 Datasheet

*Cost-efficient Smart Hardware Processor*

**Revision 1.0**

**Dec.22,2017**

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## Revision History

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|----------|-------------|-------------------------|
| 1.0      | Dec.22,2017 | Initial release version |
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# Chapter 1 About This Document

## 1.1. Purpose

The document describes features of each module, pin/signal characteristics, electrical characteristic and package information of the R11 processor. And the register descriptions of each module are included.

## 1.2. Symbol Conventions

The symbols that may be found in this document are defined as follows.

| Symbol   | Description   |
|--|---|
|  <b>WARNING</b>  | A warning means that injury or death is possible if the instructions are not obeyed.          |
|  <b>CAUTION</b> | A caution means that damage to equipment is possible.   |
|  <b>NOTE</b>    | Provides additional information to emphasize or supplement important points of the main text. |

## 1.3. Acronyms and Abbreviations

The table below contains acronyms and abbreviations used in this document.

| A   |                              |  |
|-----|------------------------------|--|
| AES | Advanced Encryption Standard | A specification for the encryption of electronic data established by the U.S. National Institute of Standards and Technology (NIST) in 2001  |
| AGC | Automatic Gain Control       | An adaptive system found in electronic devices that automatically controls the gain of a signal: the average output signal level is fed back to adjust the gain to an appropriate level for a range of input signal levels |
| AHB | AMBA High-speed Bus          | A bus protocol introduced in Advanced Microcontroller Bus Architecture version 2 published by ARM Ltd company  |

|      |                                       |   |
|------|---------------------------------------|---|
| APB  | Advanced Peripheral Bus               | APB is designed for low bandwidth control accesses, which has an address and data phase similar to AHB, but a much reduced, low complexity signal list (for example no bursts)  |
| AVS  | Audio Video Standard                  | A compression standard for digital audio and video  |
| C    |                                       |   |
| CRC  | Cyclic Redundancy Check               | A type of hash function used to produce a checksum in order to detect errors in data storage or transmission  |
| CSI  | CMOS Sensor Interface                 | The hardware block that interfaces with different image sensor interfaces and provides a standard output that can be used for subsequent image processing.  |
| CE   | Crypto Engine                         | The Crypto Engine is one encrypt/ decrypt function accelerator of Allwinner. It can support encryption/ decryption and calculate the hash value.  |
| D    |                                       |   |
| DES  | Data Encryption Standard              | A previously predominant algorithm for the encryption of electronic data  |
| DLL  | Delay-Locked Loop                     | A digital circuit similar to a phase-locked loop (PLL), with the main difference being the absence of an internal voltage-controlled oscillator, replaced by a delay line   |
| DRC  | Dynamic Range Compression             | It reduces the volume of loud sounds or amplifies quiet sounds by narrowing or "compressing" an audio signal's dynamic range.   |
| DVFS | Dynamic Voltage and Frequency Scaling | Dynamic voltage scaling is a power management technique where the voltage used in a component is increased or decreased, depending on circumstances. Dynamic frequency scaling is a technique whereby the frequency of a microprocessor can be automatically adjusted on the fly so that the power consumption or heat generated by the chip can be reduced. These two are often used together to save power in mobile devices. |
| E    |                                       |   |

|          |                                    |   |
|----------|------------------------------------|---|
| EHCI     | Enhanced Host Controller Interface | The register-level interface for a Host Controller for the USB Revision 2.0.  |
| eMMC     | Embedded Multi-Media Card          | An architecture consisting of an embedded storage solution with MMC interface, flash memory and controller, all in a small BGA package.   |
| <b>F</b> |                                    |   |
| FBGA     | Fine Ball Grid Array               | FBGA is based on BGA technology, but comes with thinner contacts and is mainly used in SoC design   |
| <b>G</b> |                                    |   |
| GIC      | Generic Interrupt Controller       | A centralized resource for supporting and managing interrupts in a system that includes at least one processor  |
| <b>I</b> |                                    |   |
| I2S      | Inter IC Sound                     | An electrical serial bus interface standard used for connecting digital audio devices together  |
| <b>L</b> |                                    |   |
| LSB      | Least Significant Bit              | The bit position in a binary integer giving the units value, that is, determining whether the number is even or odd. It is sometimes referred to as the right-most bit, due to the convention in positional notation of writing less significant digits further to the right. |
| LRADC    | Analog to Digital Converter        | Used for KEY Application  |
| <b>M</b> |                                    |   |
| MAC      | Media Access Control               | A sublayer of the data link layer, which provides addressing and channel access control mechanisms that make it possible for several terminals or network nodes to communicate within a multiple access network that incorporates a shared medium, e.g. Ethernet.             |
| MII      | Media Independent Interface        | An interface originally designed to connect a fast Ethernet MAC-block to a PHY chip, which now has been extended to support reduced signals and increased speeds.   |

|          |                                      |  |
|----------|--------------------------------------|--|
| MIPI     | Mobile Industry Processor Interface  | MIPI alliance is an open membership organization that includes leading companies in the mobile industry that share the objective of defining and promoting open specifications for interfaces inside mobile terminals. |
| MSB      | Most Significant Bit                 | The bit position in a binary number having the greatest value, which is sometimes referred to as the left-most bit due to the convention in positional notation of writing more significant digits further to the left |
| <b>N</b> |                                      |  |
| NTSC     | National Television System Committee | An analog television system that is used in most of North America, and many other countries  |
| <b>O</b> |                                      |  |
| OHCI     | Open Host Controller Interface       | A register-level interface that enables a host controller for USB to communicate with a host controller driver in software   |
| <b>P</b> |                                      |  |
| PAL      | Phase Alternating Line               | An analogue television color encoding system used in broadcast television systems in many countries  |
| PCM      | Pulse Code Modulation                | A method used to digitally represent sampled analog signals  |
| <b>S</b> |                                      |  |
| SPI      | Synchronous Peripheral Interface     | A synchronous serial data link standard that operates in full duplex mode. Devices communicate in master/slave mode where the master device initiates the data frame.  |
| <b>T</b> |                                      |  |
| TWI      | Two Wire Interface                   | A two-wire, bidirectional serial bus that provides simple, efficient method of data exchange, minimizing the interconnection between devices.  |
| <b>U</b> |                                      |  |
| USB OTG  | Universal Serial Bus On The Go       | A Dual Role Device controller, which supports both USB Host and USB Device functions.  |

|      |   |   |
|------|---|---|
| UART | Universal Asynchronous Receiver/<br>Transmitter | A serial communication interface, which translates data between parallel and serial forms. UARTs are commonly used in conjunction with communication standards. |
|------|---|---|

Confidential

## Chapter 2 Overview

The R11 represents Allwinner's latest achievement in smart hardware processors, which integrates a single ARM Cortex™-A7 CPU that operates at speed up to 1.2GHz with supporting numerous peripherals.

Dedicated video engine is included to provide an advanced multimedia applications and services. Video Engine supports multi-formats such as H.264 decoder by 1080p@30fps, JPEG/MJPEG decoder by 1080p@30fps and H.264 encoder by 720p@60fps. To enrich camera feature, the R11 equips an 8M HawkView™ ISP with advanced features like spatial de-noise, chrominance de-noise, zone-based AE/AF/AWB statistics, black level correction, lens shading correction, color correction and anti-flick detection statistics. In addition, The R11 has one built-in DDR2 ,and has optimized external memory interfaces to SPI NAND /Nor flash, SD/MMC.

To reduce total system cost and enhance overall functionality ,the R11 integrates the power-on reset,real-time clock ,and audio codec, and supports various popular hardware peripherals such as CSI,I2S/PCM, UART, SPI, USB OTG , EMAC, TWI ,etc.

## 2.1. Processor Features

### 2.1.1. CPU Architecture

- ARM Cortex™-A7 MP1 Processor
- Thumb-2 Technology
- Supports NEON Advanced SIMD(Single Instruction Multiple Data) instruction for acceleration of media and signal processing functions
- Supports Large Physical Address Extensions(LPAE)
- VFPv4 Floating Point Unit
- 32KB L1 Instruction cache and 32KB L1 Data cache
- 128KB L2 cache

### 2.1.2. Memory Subsystem

#### 2.1.2.1. Boot ROM

- Internal on-chip memory
- Supports system boot from the following devices:
  - SPI Nor flash
  - SPI Nand flash
  - SD/TF card
  - eMMC
- Supports system code download through USB OTG

#### 2.1.2.2. SDRAM

- Internal on-chip memory
- Built-in DDR2 in the R11
- Clock frequency up to 400MHz
- Supports Memory Dynamic Frequency Scale(MDFS)

#### 2.1.2.3. SD/MMC

- External off-chip memory and storage device
- Two SD/MMC controllers
- 1/4-bit data bus
- Complies with eMMC standard specification V4.41, SD physical layer specification V2.0, SDIO card specification V2.0

- Supports hardware CRC generation and error detection
- Block size from 1 to 65535 bytes

### 2.1.3. System Peripheral

#### 2.1.3.1. Timer

- Three on-chip timers with interrupt-based operation
- One watchdog to generate reset signal or interrupt
- 33 bits Audio/Video Sync(AVS) Counter
- 24MHz or internal OSC clock input

#### 2.1.3.2. High Speed Timer

- Up to two high speed timers
- Counters up to 56 bits
- Clock source is synchronized with AHB1 clock, much more accurate than other timers

#### 2.1.3.3. GIC

- Supports 16 Software Generated Interrupts(SGIs), 16 Private Peripheral Interrupts(PPIs) and 125 Shared Peripheral Interrupts(SPIs)

#### 2.1.3.4. DMA

- Up to 8-channel DMA
- Flexible data width of 8/16/32 bits
- Supports linear and IO address modes
- Supports data transfer types with memory-to-memory, memory-to-peripheral, peripheral-to-memory

#### 2.1.3.5. CCU

- 9 PLLs
- One on-chip RC oscillator
- One 24MHz external oscillator
- One 32.768kHz external oscillator
- Clock management: clock gating ,clock enabling to the device modules, clock reset, clock generation, clock division

### 2.1.3.6. PWM

- Two PWM channels
- Supports outputting two kinds of waveform: continuous waveform and pulse waveform
- 0% to 100% adjustable duty cycle
- Up to 24MHz output frequency

### 2.1.3.7. RTC

- Time,calendar
- Counters second,minutes,hours,day,week,month and year with leap year generator
- Alarm:general alarm and weekly alarm

### 2.1.3.8. LRADC

- 6-bit resolution
- Supports hold key and continuous key
- Supports single key, normal key and continuous key

### 2.1.3.9. Crypto Engine

- Supports AES 128/192/256-bit with ECB,CBC,CTS,CTR mode
- Supports DES/TDES with ECB,CBC,CTR mode
- Supports SHA1 and MD5
- 160-bit hardware PRNG with 175-bit seed

## 2.1.4. Display Subsystem

### 2.1.4.1. DE2.0

- Output size up to 1024x1024
- Supports three alpha blending channel for main display
- Supports four overlay layers in each channel, and has a independent scale
- Supports potter-duff compatible blending operation
- Supports input format YUV422/YUV420/YUV411/ARGB8888/XRGB8888/RGB888/ARGB4444/ARGB1555/RGB565

#### 2.1.4.2. Display Output

- Supports LVDS interface with single link, up to 1024x768@60fps
- Supports RGB interface with DE/SYNC mode, up to 1024x768@60fps
- Supports serial RGB/dummy RGB/CCIR656 interface, up to 800x480@60fps
- Supports i80 interface with 18/16/9/8 bit, support TE, up to 800x480@60fps
- Supports pixel format: RGB888, RGB666 and RGB565
- Dither function from RGB666/RGB565 to RGB888
- Gamma correction with R/G/B channel independence

### 2.1.5. Video Engine

#### 2.1.5.1. Video Decoding

- Supports video decoder for H.264 and JPEG/MJPEG
- Supports H.264 BP/MP/HP up to 1080p@30fps
- Supports H.264 output formats :NV21,NV12,YU12,YV12
- Supports JPEG/MJPEG up to 1080p@30fps

#### 2.1.5.2. Video Encoding

- Supports H.264 video encoding up to 720p@60fps
- JPEG baseline: picture size up to 8192x8192
- Supports input picture size up to 4800x4800
- Supports input format: YU12/YV12/NV12/NV21/YUYV/YYVU/UYVY/VYUY
- Supports Alpha blending
- Supports thumb generation
- Supports 4x2 scaling ratio: from 1/16 to 64 arbitrary non-integer ratio
- Supports rotated input

### 2.1.6. Image Subsystem

#### 2.1.6.1. Image Input

- Supports 8/10-bit CMOS sensor parallel interface
- Supports 8-bit CCIR656 protocol for NTSC and PAL
- Supports ITU-R BT 1120 protocol for HD-CIF system
- Supports 16-bit interface with separate syncs
- MIPI-CSI2 interface compliant with MIPI-DPHY v1.0 and MIPI-CSI2 v1.0
- Supports MIPI-CSI2 1/2 data lanes configuration
- Supports Format:

- YUV422-8/10 bits
- YUV420-8/10 bits(for MIPI-CSI2 only)
- RAW-8/10 bits
- RGB888/RGB565(for MIPI-CSI2 only)
- Performance:
  - Still capture resolution up to 5M with parallel interface
  - Video capture resolution up to 1080p@30fps with parallel interface
  - Still capture resolution up to 5M with MIPI-CSI2 interface
  - Video capture resolution up to 1080p@30fps with MIPI-CSI2 interface
  - MIPI-DPHY maximum data rate up to 1Gbps per lane

### 2.1.6.2. ISP

- Supports input formats:8/10-bit RAW RGB,8-bit YCbCr
- Supports output formats: YCbCr420 semi-planar,YCrCb420 semi-planar, YCbCr422 semi-planar,YCrCb422 semi-planar,YUV420 planar,YUV422 planar
- Supports image mirror flip and rotation
- Supports two output channels
- Speed up to 8MPixels@24fps
- Defect pixel correction
- Super lens shading correction
- Anisotropic non-linear Bayer interpolation with false color suppression
- Programmable color correction
- Advanced contrast enhance and sharpening
- Advanced saturation adjust
- Advanced spatial(2D) de-noise filter
- Advanced chrominance noise reduction
- Zone-based AE/AF/AWB statistics
- Anti-flick detection statistics
- Histogram statistics

### 2.1.7. Audio Subsystem

#### 2.1.7.1. Audio Codec

- Two audio digital-to-analog(DAC) channels
- Supports analog/digital volume control
- One low-noise analog microphone bias output
- Analog low-power loop from microphone to headphone outputs
- Supports Dynamic Range Controller adjusting the DAC playback output
- One Microphone input
- One Stereo Lineout output
- Two audio analog-to-digital(ADC) channels

- 92dB SNR@A-weight
- Supports ADC Sample Rates from 8kHz to 48kHz
- Supports Automatic Gain Control(AGC) and Dynamic Range Control(DRC) adjusting the ADC recording input

## 2.1.8. External Peripherals

### 2.1.8.1. USB

- One USB 2.0 OTG controller with integrated PHY
- Complies with USB2.0 Specification
- Supports High-Speed(HS,480 Mbit/s),Full-Speed(FS,12 Mbit/s),and Low-Speed(LS,1.5 Mbit/s) in host mode
- Complies with Enhanced Host Controller Interface (EHCI) Specification, Version 1.0, and the Open Host Controller Interface(OHCI) Specification,Version 1.0a for host mode
- Up to 8 User-Configurable Endpoints in device mode
- Supports point-to-point and point-to-multipoint transfer in both host and peripheral mode

### 2.1.8.2. I2S/PCM

- Compliant with standard Inter-IC sound(I2S) bus specification
- Compliant with left-justified, right-justified, PCM mode, and TDM(Time Division Multiplexing) format
- Full-duplex synchronous work mode
- Master and slave mode configured
- Adjustable audio sample resolution from 8-bit to 32-bit
- Sample rate from 8 kHz to 192 kHz
- Supports 8-bit u-law and 8-bit A-law companded sample

### 2.1.8.3. EMAC

- Supports 10/100/1000 Mbit/s data transfer rate
- Supports RGMII/MII/RMII interface
- Full-duplex and half-duplex operation
- Linked-list descriptor list structure
- Programmable frame length to support Standard or Jumbo Ethernet frames with sizes up to 16 KB
- Supports a variety of flexible address filtering modes

### 2.1.8.4. UART

- Up to three UART controllers
- 64-Bytes Transmit and receive data FIFOs for all UART
- Compliant with industry-standard 16550 UARts

- Supports Infrared Data Association(IrDA) 1.0 SIR

#### 2.1.8.5. SPI

- Full-duplex synchronous serial interface
- Master/Slave configurable
- Mode0~3 are supported for both transmit and receive operations
- Supports single and dual read mode
- Two 64-Byte FIFO for SPI-TX and SPI-RX operation
- DMA-based or interrupt-based operation

#### 2.1.8.6. TWI

- Up to two Two Wire Interface(TWI)controllers
- Supports Standard mode(up to 100 kbit/s) and Fast mode(up to 400 kbit/s)
- Master/Slave configurable
- Allows 10-bit addressing transactions

#### 2.1.9. Package

- eLQFP 128(including one built-in DDR2)

## 2.2. System Block Diagram

Figure 2-1 shows the block diagram of the R11.

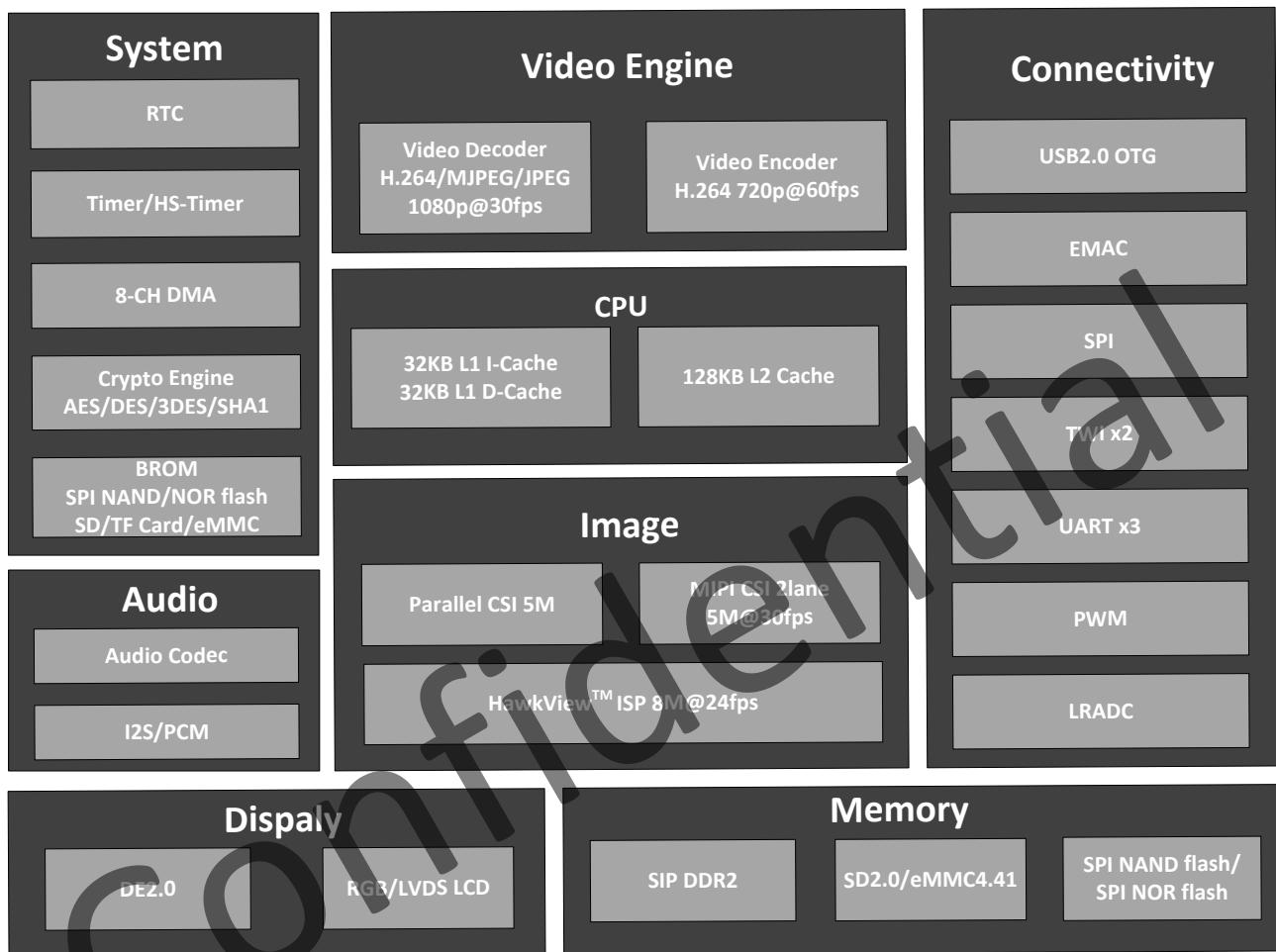


Figure 2-1. R11 Block Diagram

# Chapter 3 Pin Description

## 3.1. Pin Characteristics

Table 3-1 lists the characteristics of R11 pins from eight aspects: BALL#, Pin Name, Default Function, Type, Reset State, Default Pull Up/Down, Buffer Strength and Pin Power Domain.

- 1) **Default Function** defines the default function of each pin, especially for pins with multiplexing functions;
- 2) **Type** defines the signal direction: I (Input), O (Output), I/O(Input/Output), OD(Open-Drain),A (Analog), AI(Analog Input),AO(Analog Output),A I/O(Analog Input /Output),P (Power), G (Ground);
- 3) **Reset State** defines the state of the terminal at reset: Z for high-impedance ;
- 4) **Default Pull Up/Down** defines the presence of an internal pull up or pull down resister. Unless otherwise specified, the pin is default to be floating, and can be configured as pull up or pull down;
- 5) **Buffer Strength** defines drive strength of the associated output buffer.

Table 3-1. Pin Characteristics

| Ball#         | Pin Name   | Default Function | Type | Reset State | Default Pull Up/Down | Buffer Strength (mA) | Pin Power Domain  |
|---------------|------------|------------------|------|-------------|----------------------|----------------------|---|
| <b>DRAM</b>   |            |                  |      |             |                      |                      |   |
| 70            | VCC-DRAM0  | DRAM             | P    | -           | -                    | -                    | VCC-DRAM0,<br>VCC-DRAM1,<br>VCC-DRAM2,<br>VCC-DRAM3,<br>VCC-DRAM4,<br>VCC-DRAM6,<br>VCC-DRAM7,<br>VCC-DRAM8,<br>VCC-DRAM9,<br>VCC-DRAM10,<br>VCC-DRAM11 |
| 71            | VCC-DRAM1  | DRAM             | P    | -           | -                    | -                    |   |
| 72            | VCC-DRAM2  | DRAM             | P    | -           | -                    | -                    |   |
| 74            | VCC-DRAM3  | DRAM             | P    | -           | -                    | -                    |   |
| 73            | VCC-DRAM4  | DRAM             | P    | -           | -                    | -                    |   |
| 76            | VCC-DRAM6  | DRAM             | P    | -           | -                    | -                    |   |
| 78            | VCC-DRAM7  | DRAM             | P    | -           | -                    | -                    |   |
| 64            | VCC-DRAM8  | DRAM             | P    | -           | -                    | -                    |   |
| 65            | VCC-DRAM9  | DRAM             | P    | -           | -                    | -                    |   |
| 66            | VCC-DRAM10 | DRAM             | P    | -           | -                    | -                    |   |
| 67            | VCC-DRAM11 | DRAM             | P    | -           | -                    | -                    |   |
| 75            | SVREF0     | DRAM             | P    | -           | -                    | -                    |   |
| 68            | SVREF1     | DRAM             | P    | -           | -                    | -                    |   |
| 77            | SZQ        | DRAM             | A    | -           | -                    | -                    |   |
| <b>GPIO B</b> |            |                  |      |             |                      |                      |   |
| 45            | PB0        | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-IO  |
| 46            | PB1        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |
| 47            | PB2        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |
| 48            | PB3        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |
| 49            | PB4        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |
| 50            | PB5        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |
| 51            | PB6        | GPIO             | I/O  | Z           | NO PULL              | 20                   |   |

| Ball#         | Pin Name | Default Function | Type | Reset State | Default Pull Up/Down | Buffer Strength (mA) | Pin Power Domain    |
|---------------|----------|------------------|------|-------------|----------------------|----------------------|---------------------|
| 52            | PB7      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 54            | PB8      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 55            | PB9      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 57            | PB10     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| <b>GPIO C</b> |          |                  |      |             |                      |                      |                     |
| 58            | PC0      | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-IO              |
| 59            | PC1      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 60            | PC2      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 61            | PC3      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| <b>GPIO D</b> |          |                  |      |             |                      |                      |                     |
| 4             | PD0      | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-PD              |
| 5             | PD1      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 6             | PD2      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 7             | PD3      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 8             | PD4      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 9             | PD5      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 10            | PD6      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 11            | PD7      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 12            | PD8      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 14            | PD9      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 16            | PD10     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 17            | PD11     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 18            | PD12     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 19            | PD13     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 20            | PD14     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 21            | PD15     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 22            | PD16     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 23            | PD17     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 24            | PD18     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 25            | PD19     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 26            | PD20     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 27            | PD21     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 15            | VCC-PD   | POWER            | P    | -           | -                    | -                    |                     |
| <b>GPIO E</b> |          |                  |      |             |                      |                      |                     |
| 43            | PE0      | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-PE0,<br>VCC-PE1 |
| 42            | PE1      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 41            | PE2      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 40            | PE3      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 39            | PE6      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 38            | PE7      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |
| 36            | PE8      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                     |

| Ball#                 | Pin Name | Default Function | Type | Reset State | Default Pull Up/Down | Buffer Strength (mA) | Pin Power Domain |
|-----------------------|----------|------------------|------|-------------|----------------------|----------------------|------------------|
| 35                    | PE9      | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-IO           |
| 32                    | PE10     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 31                    | PE11     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 30                    | PE12     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 3                     | PE13     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 2                     | PE14     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 1                     | PE15     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 128                   | PE20     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 127                   | PE21     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 126                   | PE22     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 124                   | PE24     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 125                   | VCC-PE0  | POWER            | P    | -           | -                    | -                    |                  |
| 37                    | VCC-PE1  | POWER            | P    | -           | -                    | -                    |                  |
| <b>GPIO F</b>         |          |                  |      |             |                      |                      |                  |
| 101                   | PF0      | Function3        | I/O  | Z           | NO PULL              | 20                   | VCC-IO           |
| 100                   | PF1      | Function3        | I/O  | Z           | NO PULL              | 20                   |                  |
| 99                    | PF2      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 97                    | PF3      | Function3        | I/O  | Z           | NO PULL              | 20                   |                  |
| 96                    | PF4      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 95                    | PF5      | Function3        | I/O  | Z           | NO PULL              | 20                   |                  |
| <b>GPIO G</b>         |          |                  |      |             |                      |                      |                  |
| 123                   | PG6      | GPIO             | I/O  | Z           | NO PULL              | 20                   | VCC-IO           |
| 122                   | PG7      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 121                   | PG8      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 120                   | PG9      | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 118                   | PG10     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 117                   | PG11     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 116                   | PG12     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| 115                   | PG13     | GPIO             | I/O  | Z           | NO PULL              | 20                   |                  |
| <b>RTC</b>            |          |                  |      |             |                      |                      |                  |
| 92                    | RTC-VIO  | -                | A    | -           | -                    | -                    | VCC-RTC          |
| 91                    | X32KIN   | -                | A    | -           | -                    | -                    |                  |
| 90                    | X32KOUT  | -                | A    | -           | -                    | -                    |                  |
| 93                    | VCC-RTC  | -                | P    | -           | -                    | -                    |                  |
| <b>System Control</b> |          |                  |      |             |                      |                      |                  |
| 94                    | RESET    | -                | I    | -           | NO PULL              | -                    | VCC-PLL          |
| 80                    | X24MIN   | -                | A    | -           | -                    | -                    |                  |
| 79                    | X24MOUT  | -                | A    | -           | -                    | -                    |                  |
| 81                    | VCC-PLL  | -                | P    | -           | -                    | -                    |                  |
| <b>USB</b>            |          |                  |      |             |                      |                      |                  |
| 103                   | VCC-USB  | -                | P    | -           | -                    | -                    | VCC-USB          |

| Ball#              | Pin Name | Default Function | Type | Reset State | Default Pull Up/Down | Buffer Strength (mA) | Pin Power Domain |
|--------------------|----------|------------------|------|-------------|----------------------|----------------------|------------------|
| 104                | USB-DM   | -                | A    | -           | -                    | -                    |                  |
| 105                | USB-DP   | -                | A    | -           | -                    | -                    |                  |
| <b>AUDIO CODEC</b> |          |                  |      |             |                      |                      |                  |
| 110                | MICIN1P  | -                | A    | -           | -                    | -                    | AVCC             |
| 109                | LINEOUTL | -                | A    |             |                      |                      |                  |
| 108                | LINEOUTR | -                | A    |             |                      |                      |                  |
| 111                | AVCC     | -                | P    | -           | -                    | -                    |                  |
| 112                | VRA1     | -                | A    | -           | -                    | -                    |                  |
| 113                | VRA2     | -                | A    | -           | -                    | -                    |                  |
| <b>LRADC</b>       |          |                  |      |             |                      |                      |                  |
| 106                | LRADC0   | -                | A    | -           | -                    | -                    | AVCC             |
| 107                | LRADC1   | -                | A    | -           | -                    | -                    |                  |
| <b>MIPI CSI</b>    |          |                  |      |             |                      |                      |                  |
| 83                 | MCSI-D0P | -                | A    | -           | -                    | -                    | VCC-MCSI         |
| 84                 | MCSI-D0N | -                | A    | -           | -                    | -                    |                  |
| 85                 | MCSI-D1P | -                | A    | -           | -                    | -                    |                  |
| 86                 | MCSI-D1N | -                | A    | -           | -                    | -                    |                  |
| 87                 | VCC-MCSI | -                | P    | -           | -                    | -                    |                  |
| 88                 | MCSI-CKP | -                | A    | -           | -                    | -                    |                  |
| 89                 | MCSI-CKN | -                | A    | -           | -                    | -                    |                  |
| <b>Power</b>       |          |                  |      |             |                      |                      |                  |
| 82                 | VDD-SYS0 | -                | P    | -           | -                    | -                    | -                |
| 102                | VDD-SYS1 | -                | P    | -           | -                    | -                    | -                |
| 114                | VDD-SYS2 | -                | P    | -           | -                    | -                    | -                |
| 13                 | VDD-SYS3 | -                | P    | -           | -                    | -                    | -                |
| 63                 | VDD-SYS4 | -                | P    | -           | -                    | -                    | -                |
| 69                 | VDD-SYS5 | -                | P    | -           | -                    | -                    | -                |
| 34                 | VDD-CPU0 | -                | P    | -           | -                    | -                    | -                |
| 33                 | VDD-CPU1 | -                | P    | -           | -                    | -                    | -                |
| 29                 | VDD-CPU2 | -                | P    | -           | -                    | -                    | -                |
| 28                 | VDD-CPU3 | -                | P    | -           | -                    | -                    | -                |
| 44                 | VDD-CPU4 | -                | P    | -           | -                    | -                    | -                |
| 53                 | VDD-CPU5 | -                | P    | -           | -                    | -                    | -                |
| 62                 | VDD-CPU7 | -                | P    | -           | -                    | -                    | -                |
| 98                 | VCC-IO0  | -                | P    | -           | -                    | -                    | -                |
| 119                | VCC-IO1  | -                | P    | -           | -                    | -                    | -                |
| 56                 | VCC-IO3  | -                | P    | -           | -                    | -                    | -                |

### 3.2. GPIO Multiplex Functions

The following table provides a description of the R11 GPIO multiplexing functions.

Table 3-2. Multiplexing Functions

| Pin Name | Default Function | IO Type | Default IO State | Default Pull-up/down | Function 0 | Function 1 | Function 2 | Function3     | Function 4                       | Function 5 | Function 6 |
|----------|------------------|---------|------------------|----------------------|------------|------------|------------|---------------|----------------------------------|------------|------------|
| PB0      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | UART2_TX   | -             | -                                | -          | PB_EINT0   |
| PB1      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART2_RX   | -             | -                                | -          | PB_EINT1   |
| PB2      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART2_RTS  | -             | -                                | -          | PB_EINT2   |
| PB3      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART2_CTS  | -             | -                                | -          | PB_EINT3   |
| PB4      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PWM0       | -             | -                                | -          | PB_EINT4   |
| PB5      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PWM1       | -             | -                                | -          | PB_EINT5   |
| PB6      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | TWI0_SCK   | -             | -                                | -          | PB_EINT6   |
| PB7      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | TWI0_SDA   | -             | -                                | -          | PB_EINT7   |
| PB8      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | TWI1_SCK   | UART0_TX      | -                                | -          | PB_EINT8   |
| PB9      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | TWI1_SDA   | UART0_RX      | -                                | -          | PB_EINT9   |
| PB10     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | -          | -             | -                                | -          | PB_EINT10  |
| PC0      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | SDC2_CLK   | SPI0_MISO     | -                                | -          | -          |
| PC1      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | SDC2_CMD   | SPI0_CLK      | -                                | -          | -          |
| PC2      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | SDC2_RST   | SPI0_CS       | -                                | -          | -          |
| PC3      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | SDC2_D0    | SPI0_MOSI     | -                                | -          | -          |
| PD0      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D2     | -             | RGMII_RXD3/MII_RXD3/RMII_NULL    | -          | -          |
| PD1      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D3     | -             | RGMII_RXD2/MII_RXD2/RMII_NULL    | -          | -          |
| PD2      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D4     | -             | RGMII_RXD1/MII_RXD1/RMII_RXD1    | -          | -          |
| PD3      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D5     | -             | RGMII_RXD0/MII_RXD0/RMII_RXD0    | -          | -          |
| PD4      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D6     | -             | RGMII_RXCK/MII_RXCK/RMII_NULL    | -          | -          |
| PD5      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D7     | -             | RGMII_RXCTL/MII_RXDV/RMII_CRS_DV | -          | -          |
| PD6      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D10    | -             | RGMII_NULL/MII_RXERR/RMII_RXER   | -          | -          |
| PD7      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D11    | -             | RGMII_TXD3/MII_TXD3/RMII_NULL    | -          | -          |
| PD8      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D12    | -             | RGMII_TXD2/MII_TXD2/RMII_NULL    | -          | -          |
| PD9      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D13    | -             | RGMII_TXD1/MII_TXD1/RMII_TXD1    | -          | -          |
| PD10     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D14    | -             | RGMII_TXD0/MII_TXD0/RMII_TXD0    | -          | -          |
| PD11     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D15    | -             | RGMII_NULL/MII_CRS/RMII_NULL     | -          | -          |
| PD12     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D18    | LVDS_VP0      | RGMII_TXCK/MII_TXCK/RMII_TXCK    | -          | -          |
| PD13     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D19    | LVDS_VN0      | RGMII_TXCTL/MII_TXEN/RMII_TXEN   | -          | -          |
| PD14     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D20    | LVDS_VP1      | RGMII_NULL/MII_TXERR/RMII_NULL   | -          | -          |
| PD15     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D21    | LVDS_VN1      | RGMII_CLKIN/MII_COL/RMII_NULL    | -          | -          |
| PD16     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D22    | LVDS_VP2      | MDC                              | -          | -          |
| PD17     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_D23    | LVDS_VN2      | MDIO                             | -          | -          |
| PD18     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_CLK    | LVDS_VPC      | -                                | -          | -          |
| PD19     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_DE     | LVDS_VNC      | -                                | -          | -          |
| PD20     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_HSYNC  | LVDS_VP3      | -                                | -          | -          |
| PD21     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | LCD_VSYNC  | LVDS_VN3      | -                                | -          | -          |
| PE0      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_PCLK   | -             | -                                | -          | -          |
| PE1      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_MCLK   | -             | -                                | -          | -          |
| PE2      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_HSYNC  | -             | -                                | -          | -          |
| PE3      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_VSYNC  | -             | -                                | -          | -          |
| PE6      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D2     | -             | -                                | -          | -          |
| PE7      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D3     | -             | -                                | -          | -          |
| PE8      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D4     | -             | -                                | -          | -          |
| PE9      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D5     | -             | -                                | -          | -          |
| PE10     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D6     | -             | -                                | -          | -          |
| PE11     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D7     | -             | -                                | -          | -          |
| PE12     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D8     | -             | -                                | -          | -          |
| PE13     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D9     | -             | -                                | -          | -          |
| PE14     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D10    | -             | -                                | -          | -          |
| PE15     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_D11    | -             | -                                | -          | -          |
| PE20     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_FIELD  | CSI_MIPI_MCLK | -                                | -          | -          |
| PE21     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_SCK    | TWI1_SCK      | UART1_TX                         | -          | -          |
| PE22     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | CSI_SDA    | TWI1_SDA      | UART1_RX                         | -          | -          |
| PE24     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | -          | -             | -                                | -          | -          |
| PF0      | GPIO             | I/O     | Function3        | NO PULL              | Input      | Output     | SDCO_D1    | JTAG_MS       | -                                | -          | -          |
| PF1      |                  | I/O     | Function3        | NO PULL              | Input      | Output     | SDCO_D0    | JTAG_DI       | -                                | -          | -          |

| Pin Name | Default Function | IO Type | Default IO State | Default Pull-up/down | Function 0 | Function 1 | Function 2 | Function3 | Function 4 | Function 5 | Function 6 |
|----------|------------------|---------|------------------|----------------------|------------|------------|------------|-----------|------------|------------|------------|
| PF2      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | SDC0_CLK   | UART0_TX  | -          | -          | -          |
| PF3      |                  | I/O     | Function3        | NO PULL              | Input      | Output     | SDC0_CMD   | JTAG_DO   | -          | -          | -          |
| PF4      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | SDC0_D3    | UART0_RX  | -          | -          | -          |
| PF5      |                  | I/O     | Function3        | NO PULL              | Input      | Output     | SDC0_D2    | JTAG_CK   | -          | -          | -          |
| PG6      | GPIO             | I/O     | DIS              | NO PULL              | Input      | Output     | UART1_TX   | -         | -          | -          | PG_EINT6   |
| PG7      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART1_RX   | -         | -          | -          | PG_EINT7   |
| PG8      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART1_RTS  | -         | -          | -          | PG_EINT8   |
| PG9      |                  | I/O     | DIS              | NO PULL              | Input      | Output     | UART1_CTS  | -         | -          | -          | PG_EINT9   |
| PG10     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PCM_SYNC   | -         | -          | -          | PG_EINT10  |
| PG11     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PCM_BCLK   | -         | -          | -          | PG_EINT11  |
| PG12     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PCM_DOUT   | -         | -          | -          | PG_EINT12  |
| PG13     |                  | I/O     | DIS              | NO PULL              | Input      | Output     | PCM_DIN    | -         | -          | -          | PG_EINT13  |

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### 3.3. Detailed Pin/Signal Description

The following table shows the detailed function description of every pin/signal based on the different interface.

Table 3-3. Detailed Pin Description

| Pin/Signal Name                  | Description  | Type  |
|----------------------------------|--|-------|
| <b>System Control</b>            |  |       |
| RESET                            | RESET Signal   | I     |
| X24MIN                           | Clock Input of 24MHz Crystal   | AI    |
| X24MOUT                          | Clock Output of 24MHz Crystal  | AO    |
| RTC-VIO                          | Internal LDO Output Bypass   | AO    |
| X32KIN                           | Clock input of 32768Hz Crystal   | AI    |
| X32KOUT                          | Clock output of 32768Hz Crystal  | AO    |
| VCC-RTC                          | RTC Power Supply   | P     |
| <b>USB</b>                       |  |       |
| USB-DM                           | USB DM Signal  | A I/O |
| USB-DP                           | USB DP Signal  | A I/O |
| VCC-USB                          | USB Power Supply   | P     |
| <b>LRADC</b>                     |  |       |
| LRADC0                           | ADC Input for Key0   | AI    |
| LRADC1                           | ADC Input for Key1   | AI    |
| <b>AUDIO CODEC</b>               |  |       |
| MICIN1P                          | MIC Positive Input 1   | AI    |
| LINEOUTL                         | Lineout Left Channel Output  | AO    |
| LINEOUTR                         | Lineout Right Channel Output   | AO    |
| VRA1                             | Reference Voltage  | AO    |
| VRA2                             | Reference Voltage  | AO    |
| AVCC                             | Power Supply for Analog Part   | P     |
| <b>I2S/PCM</b>                   |  |       |
| PCM_SYNC                         | I2S/PCM Sample Rate Clock/Sync   | I/O   |
| PCM_BCLK                         | I2S/PCM Sample Rate Clock  | I/O   |
| PCM_DOUT                         | I2S/PCM Serial Data Output   | O     |
| PCM_DIN                          | I2S/PCM Serial Data Input  | I     |
| <b>EMAC</b>                      |  |       |
| RGMII_RXD3/MII_RXD3/RMII_NULL    | RGMII/MII Receive Data   | I     |
| RGMII_RXD2/MII_RXD2/RMII_NULL    | RGMII/MII Receive Data   | I     |
| RGMII_RXD1/MII_RXD1/RMII_RXD1    | RGMII/MII/RMII Receive Data  | I     |
| RGMII_RXD0/MII_RXD0/RMII_RXD0    | RGMII/MII/RMII Receive Data  | I     |
| RGMII_RXCK/MII_RXCK/RMII_NULL    | RGMII/MII Receive Clock  | I     |
| RGMII_RXCTL/MII_RXDV/RMII_CRS_DV | RGMII Receive Control/MII Receive Enable/RMII Carrier Sense Receive Data Valid | I     |

| Pin/Signal Name                | Description   | Type |
|--------------------------------|---|------|
| RGMII_NULL/MII_RXERR/RMII_RXER | MII/RMII Receive Error  | I    |
| RGMII_TXD3/MII_TXD3/RMII_NULL  | RGMII/MII Transmit Data   | O    |
| RGMII_TXD2/MII_TXD2/RMII_NULL  | RGMII/MII Transmit Data   | O    |
| RGMII_TXD1/MII_TXD1/RMII_TXD1  | RGMII/MII/RMII Transmit Data  | O    |
| RGMII_TXD0/MII_TXD0/RMII_TXDO  | RGMII/MII/RMII Transmit Data  | O    |
| RGMII_NULL/MII_CRS/RMII_NULL   | MII Carrier Sense   | I    |
| RGMII_TXCK/MII_TXCK/RMII_TXCK  | RGMII/MII/RMII Transmit Clock: Output Pin for RGMII, Input Pin for MII/RMII                                   | I/O  |
| RGMII_TXCTL/MII_TXEN/RMII_TXEN | RGMII Transmit Control/MII Transmit Enable/RMII Transmit Enable: Output Pin for RGMII/RMII, Input Pin for MII | I/O  |
| RGMII_NULL/MII_TXERR/RMII_NULL | MII Transmit Error  | O    |
| RGMII_CLKIN/MII_COL/RMII_NULL  | RGMII Transmit Clock from External/MII Collision Detect   | I    |
| MDC                            | RGMII/MII/RMII Management Data Clock  | O    |
| MDIO                           | RGMII/MII/RMII Management Data Input/Output   | I/O  |
| <b>SD/MMC</b>                  |   |      |
| SDC0_CMD                       | Command Signal for SD Card  | I/O  |
| SDC0_CLK                       | Clock for SD Card   | O    |
| SDC0_D[3:0]                    | Data Input and Output for SD Card   | I/O  |
| SDC2_CMD                       | Command Signal for eMMC   | I/O  |
| SDC2_CLK                       | Clock for eMMC  | O    |
| SDC2_D0                        | Data Input and Output for eMMC  | I/O  |
| SDC2_RST                       | Reset Signal for eMMC   | O    |
| <b>Interrupt</b>               |   |      |
| PB_EINT9:0]                    | GPIO B Interrupt  | I    |
| PG_EINT[13:6]                  | GPIO G Interrupt  | I    |
| <b>PWM</b>                     |   |      |
| PWM0                           | Pulse Width Modulation Output Channel0  | O    |
| PWM1                           | Pulse Width Modulation Output Channel1  | O    |
| <b>LCD</b>                     |   |      |
| LCD_D[23:0]                    | LCD Data Output   | O    |
| LCD_CLK                        | LCD Clock Signal  | O    |
| LCD_DE                         | LCD Data Enable   | O    |
| LCD_HSYNC                      | LCD Horizontal SYNC   | O    |
| LCD_VSYNC                      | LCD Vertical SYNC   | O    |
| <b>LVDS</b>                    |   |      |
| LVDS_VP[3:0]                   | LVDS Data Positive Signal Output  | O    |
| LVDS_VN[3:0]                   | LVDS Data Negative Signal Output  | O    |
| LVDS_VPC                       | LVDS Clock Positive Signal Output   | O    |
| LVDS_VNC                       | LVDS Clock Negative Signal Output   | O    |
| <b>CSI</b>                     |   |      |

| Pin/Signal Name | Description                        | Type |
|-----------------|------------------------------------|------|
| CSI_PCLK        | CSI Pixel Clock                    | I    |
| CSI_MCLK        | CSI Master Clock                   | O    |
| CSI_HSYNC       | CSI Horizontal SYNC                | I    |
| CSI_VSYNC       | CSI Vertical SYNC                  | I    |
| CSI_D[11:2]     | CSI Data Bit                       | I    |
| CSI_SCK         | CSI Command Serial Clock Signal    | I/O  |
| CSI_SDA         | CSI Command Serial Data Signal     | I/O  |
| CSI_FIELD       | CSI Field Signal                   | I/O  |
| <b>MIPI_CSI</b> |                                    |      |
| MCSI-CKN        | MIPI CSI Clock Negative            | AI   |
| MCSI-CKP        | MIPI CSI Clock Positive            | AI   |
| MCSI-D0N        | MIPI CSI Data0 Negative            | AI   |
| MCSI-D0P        | MIPI CSI Data0 Positive            | AI   |
| MCSI-D1N        | MIPI CSI Data1 Negative            | AI   |
| MCSI-D1P        | MIPI CSI Data1 Positive            | AI   |
| VCC-MCSI        | MIPI CSI Power Supply              | P    |
| <b>SPI</b>      |                                    |      |
| SPI0_CS         | SPI Chip Select Signal             | I/O  |
| SPI0_CLK        | SPI Clock Signal                   | I/O  |
| SPI0_MOSI       | SPI Master Data Out, Slave Data In | I/O  |
| SPI0_MISO       | SPI Master Data In, Slave Data Out | I/O  |
| <b>UART</b>     |                                    |      |
| UART0_TX        | UART0 Data Transmit                | O    |
| UART0_RX        | UART0 Data Receive                 | I    |
| UART1_TX        | UART1 Data Transmit                | O    |
| UART1_RX        | UART1 Data Receive                 | I    |
| UART1_CTS       | UART1 Data Clear to Send           | I    |
| UART1_RTS       | UART1 Data Request to Send         | O    |
| UART2_TX        | UART2 Data Transmit                | O    |
| UART2_RX        | UART2 Data Receive                 | I    |
| UART2_CTS       | UART2 Data Clear to Send           | I    |
| UART2_RTS       | UART2 Data Request to Send         | O    |
| <b>TWI</b>      |                                    |      |
| TWI0_SCK        | TWI0 Serial Clock Signal           | I/O  |
| TWI0_SDA        | TWI0 Serial Data Signal            | I/O  |
| TWI1_SCK        | TWI1 Serial Clock Signal           | I/O  |
| TWI1_SDA        | TWI1 Serial Data Signal            | I/O  |
| <b>JTAG</b>     |                                    |      |
| JTAG_MS         | JTAG Mode Select Input             | I    |
| JTAG_CK         | JTAG Clock Input                   | I    |
| JTAG_DO         | JTAG Data Output                   | O    |
| JTAG_DI         | JTAG Data Input                    | I    |

# Chapter 4 System

The chapter describes the R11 system from following sections:

- Memory mapping
- Boot system
- CCU
- System control
- Timer
- High-speed Timer
- PWM
- DMA
- GIC
- Crypto Engine
- LRADC
- RTC
- Audio Codec
- Port Controller

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## 4.1. Memory Mapping

| Module              | Address  | Size (byte) |
|---------------------|--|-------------|
| SRAM A1             | 0x0000 0000---0x0000 3FFF  | 16K         |
| SRAM C              | 0x0000 4000---0x0000 EFFF  | 44K         |
| DE                  | 0x0100 0000---0x011F FFFF  | 2M          |
| System Control      | 0x01C0 0000---0x01C0 0FFF  | 4K          |
| DMA                 | 0x01C0 2000---0x01C0 2FFF  | 4K          |
| TCON                | 0x01C0 C000---0x01C0 CFFF  | 4K          |
| VE                  | 0x01C0 E000---0x01C0 EFFF  | 4K          |
| SD/MMC 0            | 0x01C0 F000---0x01C0 FFFF  | 4K          |
| SD/MMC 2            | 0x01C1 1000---0x01C1 1FFF  | 4K          |
| Crypto Engine       | 0x01C1 5000---0x01C1 5FFF  | 4K          |
| USB OTG_Device      | 0x01C1 9000---0x01C1 9FFF  | 4K          |
| USB OTG_EHCI0/OHCI0 | 0x01C1 A000---0x01C1 AFFF  | 4K          |
| CCU                 | 0x01C2 0000---0x01C2 03FF  | 1K          |
| PIO                 | 0x01C2 0800---0x01C2 0BFF  | 1K          |
| TIMER               | 0x01C2 0C00---0x01C2 0FFF  | 1K          |
| PWM                 | 0x01C2 1400---0x01C2 17FF  | 1K          |
| I2S/PCM             | 0x01C2 2000---0x01C2 23FF  | 1K          |
| LRADC               | 0x01C2 2800---0x01C2 2BFF  | 1K          |
| Audio Codec         | 0x01C2 2C00---0x01C2 33FF  | 2K          |
| UART 0              | 0x01C2 8000---0x01C2 83FF  | 1K          |
| UART 1              | 0x01C2 8400---0x01C2 87FF  | 1K          |
| UART 2              | 0x01C2 8800---0x01C2 8BFF  | 1K          |
| TWI 0               | 0x01C2 AC00---0x01C2 AFFF  | 1K          |
| TWI 1               | 0x01C2 B000---0x01C2 B3FF  | 1K          |
| EMAC                | 0x01C3 0000---0x01C3 FFFF  | 64K         |
| HSTMR               | 0x01C6 0000---0x01C6 0FFF  | 4K          |
| DRAMCOM             | 0x01C6 2000---0x01C6 2FFF  | 4K          |
| DRAMCTL0            | 0x01C6 3000---0x01C6 3FFF  | 4K          |
| DRAMPHY0            | 0x01C6 5000---0x01C6 5FFF  | 4K          |
| SPI0                | 0x01C6 8000---0x01C6 8FFF  | 4K          |
| SCU Space           | 0x01C80000<br>GIC_DIST: 0x01C80000 + 0x1000<br>GIC_CUIF: 0x01C80000 + 0x2000 |             |
| CSI                 | 0x01CB 0000---0x01CF FFFF  | 320K        |
| RTC                 | 0x01C2 0400---0x01C2 07FF  | 1K          |
| CoreSight Debug     | 0x3F50 0000---0x3F51 FFFF  | 128K        |
| TSGEN RO            | 0x3F50 6000---0x3F50 6FFF  | 4K          |
| TSGEN CTRL          | 0x3F50 7000---0x3F50 7FFF  | 4K          |
| DDR2                | 0x4000 0000---0xBFFF FFFF  | 2G          |

|      |                         |     |
|------|-------------------------|-----|
| BROM | 0xFFFF 0000—0xFFFF 7FFF | 32K |
|------|-------------------------|-----|

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## 4.2. Boot System

The boot system can boot from SPI NOR Flash,SPI NAND Flash,SD Card and USB for different application. There is one 32KB ROM in the system .The SPI0,SDC0 controller are used for booting system.

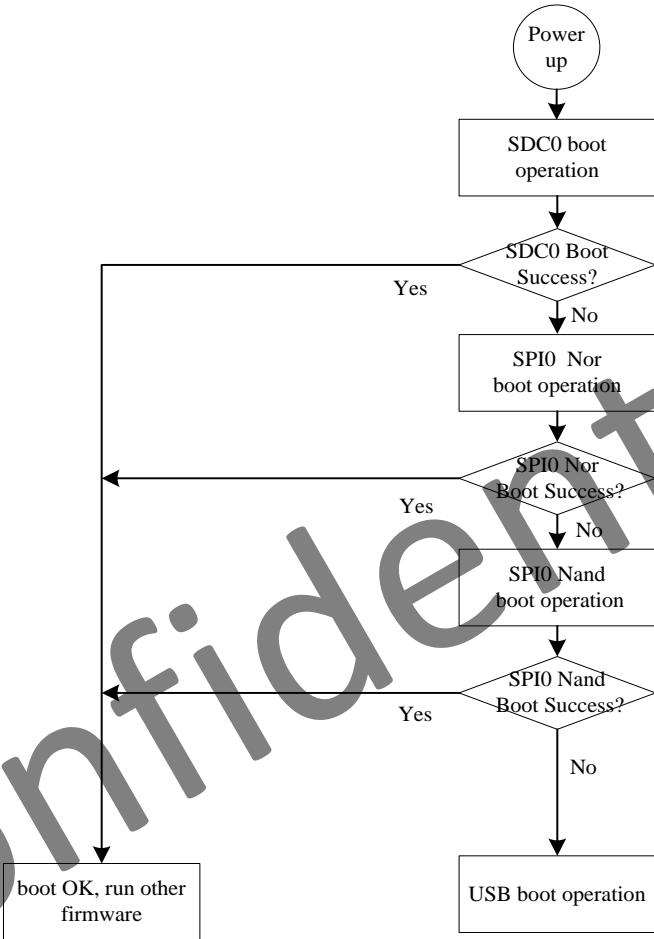


Figure 4-1. Boot System Sequence Diagram

## 4.3. CCU

### 4.3.1. Overview

The CCU controls the PLLs configuration and most of the clock generation, division, distribution, synchronization and gating. CCU input signals include the external clock for the reference frequency (24MHz). The outputs from CCU are mostly clocks to other blocks in the system.

The CCU includes the following features:

- 9 PLLs, independent PLL for CPU
- Bus Source and Divisions
- Clock Output Control
- PLLs Bias Control
- PLLs Tuning Control
- PLLs Pattern Control
- Configuring Modules Clock
- Bus Clock Gating
- Bus Software Reset

## 4.3.2. Functionalities Description

### 4.3.2.1. System Bus

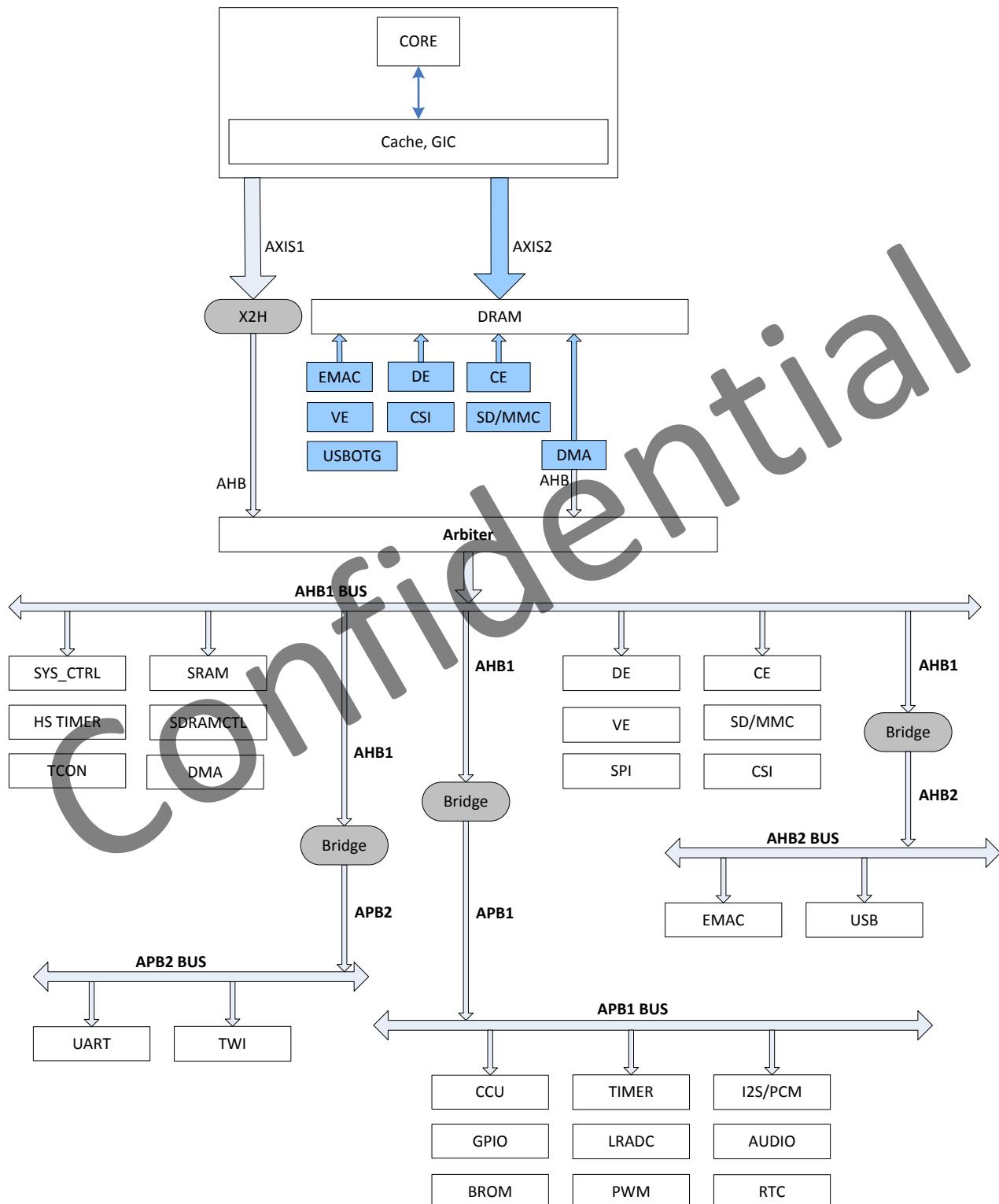


Figure 4-2. System Bus Tree

#### 4.3.2.2. Bus Clock Tree

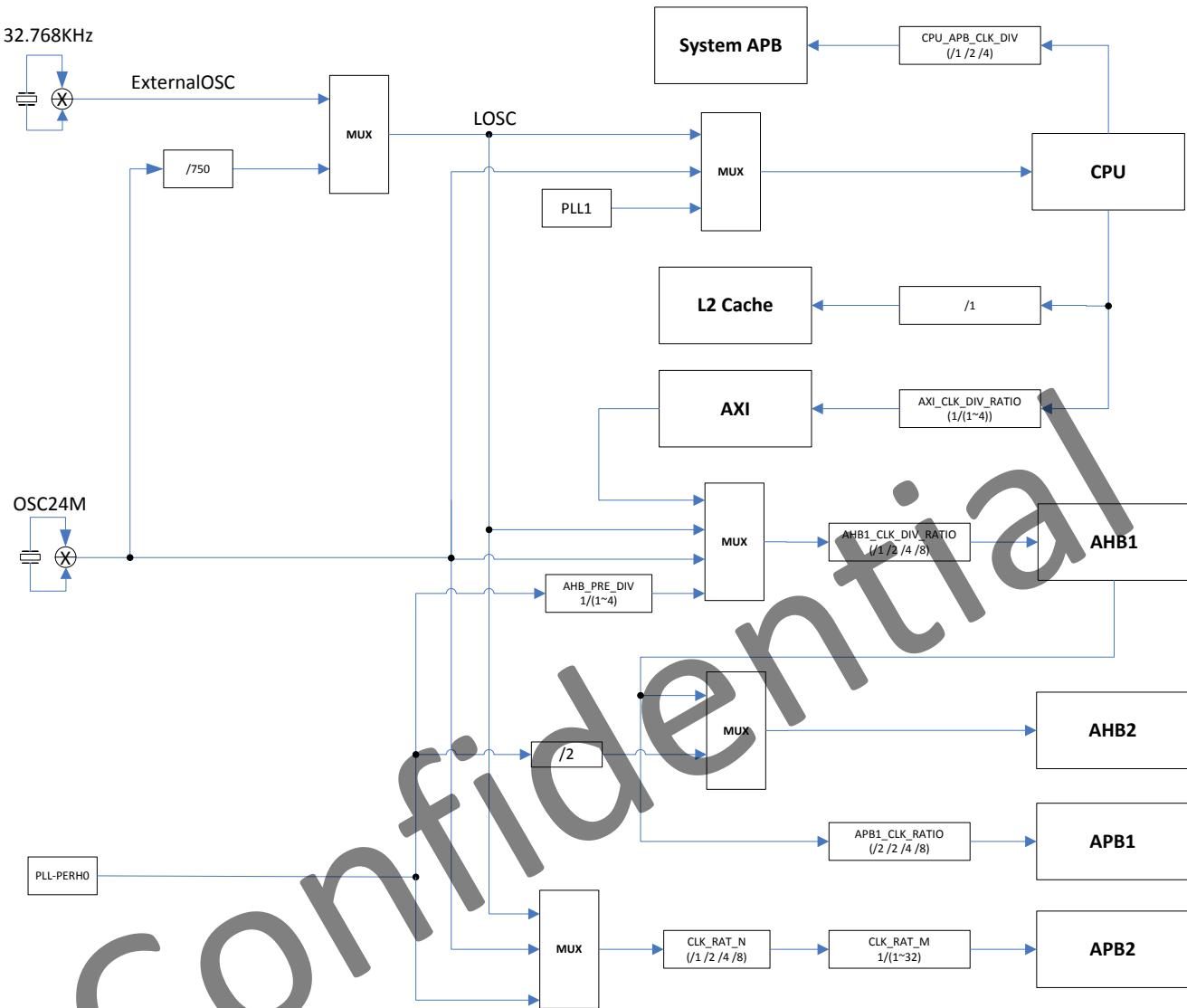


Figure 4-3. Bus Clock Tree

#### 4.3.3. Typical Applications

Clock output of PLL\_CPU is used only for CPU, and the frequency factor can be dynamically modified for DVFS;  
 Clock output of PLL\_AUDIO can be used for I2S/PCM, AC DIGITAL etc, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_PERIPH0 can be used for MBUS/AHB1/APB1/APB2 and MMC0/MMC2/CE/SPI0/DE etc, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_PERIPH1 can be used for MMC0/MMC2/SPI0 etc, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_VIDEO can be used for DE/TCON/CSI, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_VE can be used for CSI/VE, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_DDR0 can be used for MBUS and DRAM, and dynamic frequency scaling is not supported;  
 Clock output of PLL\_DDR1 can be used for DRAM, and dynamic frequency scaling is supported;

#### 4.3.4. Register List

| Module Name | Base Address |
|-------------|--------------|
| CCU         | 0x01C20000   |

| Register Name        | Offset | Description                        |
|----------------------|--------|------------------------------------|
| PLL_CPU_CTRL_REG     | 0x0000 | PLL_CPU Control Register           |
| PLL_AUDIO_CTRL_REG   | 0x0008 | PLL_AUDIO Control Register         |
| PLL_VIDEO_CTRL_REG   | 0x0010 | PLL_VIDEO Control Register         |
| PLL_VE_CTRL_REG      | 0x0018 | PLL_VE Control Register            |
| PLL_DDR0_CTRL_REG    | 0x0020 | PLL_DDR0 Control Register          |
| PLL_PERIPH0_CTRL_REG | 0x0028 | PLL_PERIPH0 Control Register       |
| PLL_ISP_CTRL_REG     | 0x002C | PLL_ISP Control Register           |
| PLL_PERIPH1_CTRL_REG | 0x0044 | PLL_PERIPH1 Control Register       |
| PLL_DDR1_CTRL_REG    | 0x004C | PLL_DDR1 Control Register          |
| CPU_AXI_CFG_REG      | 0x0050 | CPU/AXI Configuration Register     |
| AHB_APB0_CFG_REG     | 0x0054 | AHB/APB0 Configuration Register    |
| APB1_CFG_REG         | 0x0058 | APB1 Configuration Register        |
| AHB2_CFG_REG         | 0x005C | AHB2 Configuration Register        |
| BUS_CLK_GATING_REG0  | 0x0060 | Bus Clock Gating Register 0        |
| BUS_CLK_GATING_REG1  | 0x0064 | Bus Clock Gating Register 1        |
| BUS_CLK_GATING_REG2  | 0x0068 | Bus Clock Gating Register 2        |
| BUS_CLK_GATING_REG3  | 0x006C | Bus Clock Gating Register 3        |
| BUS_CLK_GATING_REG4  | 0x0070 | Bus Clock Gating Register4         |
| SDMMC0_CLK_REG       | 0x0088 | SDMMC0 Clock Register              |
| SDMMC2_CLK_REG       | 0x0090 | SDMMC2 Clock Register              |
| CE_CLK_REG           | 0x009C | CE Clock Register                  |
| SPI0_CLK_REG         | 0x00A0 | SPI0 Clock Register                |
| I2S/PCM_CLK_REG      | 0x00B0 | I2S/PCM Clock Register             |
| USBPHY_CFG_REG       | 0x00CC | USBPHY Configuration Register      |
| DRAM_CFG_REG         | 0x00F4 | DRAM Configuration Register        |
| PLL_DDR1_CFG_REG     | 0x00F8 | PLL_DDR Configuration Register     |
| MBUS_RST_REG         | 0x00FC | MBUS Reset Register                |
| DRAM_CLK_GATING_REG  | 0x0100 | DRAM Clock Gating Register         |
| DE_CLK_REG           | 0x0104 | DE Clock Register                  |
| TCON_CLK_REG         | 0x0118 | TCON Clock Register                |
| CSI_MISC_CLK_REG     | 0x0130 | CSI_MISC Clock Register            |
| CSI_CLK_REG          | 0x0134 | CSI Clock Register                 |
| VE_CLK_REG           | 0x013C | VE Clock Register                  |
| AC_DIG_CLK_REG       | 0x0140 | Audio Codec Digital Clock Register |
| AVS_CLK_REG          | 0x0144 | AVS Clock Register                 |
| MBUS_CLK_REG         | 0x015C | MBUS Clock Register                |
| MIPI_CSI_REG         | 0x016C | MIPI_CSI Register                  |

|                          |        |                                      |
|--------------------------|--------|--------------------------------------|
| PLL_STABLE_TIME_REG0     | 0x0200 | PLL Stable Time Register0            |
| PLL_STABLE_TIME_REG1     | 0x0204 | PLL Stable Time Register1            |
| PLL_CPU_BIAS_REG         | 0x0220 | PLL_CPU Bias Register                |
| PLL_AUDIO_BIAS_REG       | 0x0224 | PLL_AUDIO Bias Register              |
| PLL_VIDEO_BIAS_REG       | 0x0228 | PLL_VIDEO Bias Register              |
| PLL_VE_BIAS_REG          | 0x022C | PLL_VE Bias Register                 |
| PLL_DDR0_BIAS_REG        | 0x0230 | PLL_DDR0 Bias Register               |
| PLL_PERIPH0_BIAS_REG     | 0x0234 | PLL_PERIPH0 Bias Register            |
| PLL_ISP_BIAS_REG         | 0x0238 | PLL_ISP Bias Register                |
| PLL_PERIPH1_BIAS_REG     | 0x0244 | PLL_PERIPH1 Bias Register            |
| PLL_DDR1_BIAS_REG        | 0x024C | PLL_DDR1 Bias Register               |
| PLL_CPU_TUN_REG          | 0x0250 | PLL_CPU Tuning Register              |
| PLL_DDR0_TUN_REG         | 0x0260 | PLL_DDR0 Tuning Register             |
| PLL_CPU_PAT_CTRL_REG     | 0x0280 | PLL_CPU Pattern Control Register     |
| PLL_AUDIO_PAT_CTRL_REG   | 0x0284 | PLL_AUDIO Pattern Control Register   |
| PLL_VIDEO_PAT_CTRL_REG   | 0x0288 | PLL_VIDEO Pattern Control Register   |
| PLL_VE_PAT_CTRL_REG      | 0x028C | PLL_VE Pattern Control Register      |
| PLL_DDR0_PAT_CTRL_REG    | 0x0290 | PLL_DDR0 Pattern Control Register    |
| PLL_ISP_PAT_CTRL_REG     | 0x0298 | PLL_ISP Pattern Control Register     |
| PLL_PERIPH1_PAT_CTRL_REG | 0x02A4 | PLL_PERIPH1 Pattern Control Register |
| PLL_DDR1_PAT_CTRL_REG0   | 0x02AC | PLL_DDR1 Pattern Control Register0   |
| PLL_DDR1_PAT_CTRL_REG1   | 0x02B0 | PLL_DDR1 Pattern Control Register1   |
| BUS_SOFT_RST_REG0        | 0x02C0 | Bus Software Reset Register 0        |
| BUS_SOFT_RST_REG1        | 0x02C4 | Bus Software Reset Register 1        |
| BUS_SOFT_RST_REG2        | 0x02C8 | Bus Software Reset Register 2        |
| BUS_SOFT_RST_REG3        | 0x02D0 | Bus Software Reset Register 3        |
| BUS_SOFT_RST_REG4        | 0x02D8 | Bus Software Reset Register 4        |
| PS_CTRL_REG              | 0x0300 | PS Control Register                  |
| PS_CNT_REG               | 0x0304 | PS Counter Register                  |

#### 4.3.5. Register Description

##### 4.3.5.1. PLL\_CPU Control Register (Default Value: 0x000001000)

| Offset: 0x0000 |     |             | Register Name: PLL_CPU_CTRL_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | PLL_ENABLE.<br>0: Disable<br>1: Enable<br>The PLL Output= (24MHz*N*K)/(M*P).<br>The PLL output is for the CPUX Clock.<br>The PLL output clock must be in the range of 200MHz~2.6GHz. |

|       |     |      |   |
|-------|-----|------|---|
|       |     |      | Its default is 408MHz.  |
| 30:29 | /   | /    | /   |
| 28    | R   | 0x0  | LOCK<br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)   |
| 27:25 | /   | /    | /   |
| 24    | R/W | 0x0  | CPU_X_SDM_EN.<br>0: Disable<br>1: Enable  |
| 23:18 | /   | /    | /   |
| 17:16 | R/W | 0x0  | PLL_OUT_EXT_DIVP<br>PLL Output external divider P<br>00: /1<br>01: /2<br>10: /4<br>11: /<br>The P factor only use in the condition that PLL output less than 288 MHz. |
| 15:13 | /   | /    | /   |
| 12:8  | R/W | 0x10 | PLL_FACTOR_N<br>PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=31, N=32  |
| 7:6   | /   | /    | /   |
| 5:4   | R/W | 0x0  | PLL_FACTOR_K.<br>PLL Factor K.(K=Factor + 1 )<br>The range is from 1 to 4.  |
| 3:2   | /   | /    | /   |
| 1:0   | R/W | 0x0  | PLL_FACTOR_M.<br>PLL Factor M. (M=Factor + 1)<br>The range is from 1 to 4.  |

#### 4.3.5.2. PLL\_Audio Control Register (Default Value: 0x00035514)

| Offset: 0x0008 |     |             | Register Name: <b>PLL_AUDIO_CTRL_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | PLL_ENABLE.<br>0: Disable<br>1: Enable.<br>The PLL is for Audio.<br>$\text{PLL\_AUDIO} = (24\text{MHz} * \text{N}) / (\text{M} * \text{P})$<br>$\text{PLL\_AUDIO(8X)} = (24\text{MHz} * \text{N} * 2) / \text{M}$ |

|       |     |      |   |
|-------|-----|------|---|
|       |     |      | PLL_AUDIO(4X)=PLL_AUDIO(8X)/2<br>PLL_AUDIO(2X)=PLL_AUDIO(4X)/2<br>The PLL output clock must be in the range of 20MHz~200MHz.<br>Its default is 24.571MHz. |
| 30:29 | /   | /    | /   |
| 28    | R   | 0x0  | LOCK.<br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)  |
| 27:25 | /   | /    | /   |
| 24    | R/W | 0x0  | PLL_SDM_EN.<br>0: Disable<br>1: Enable<br>In this case, the PLL_FACTOR_N only low 4 bits are valid (N: The range is from 1 to 16).                        |
| 23:20 | /   | /    | /   |
| 19:16 | R/W | 0x3  | PLL_POSTDIV_P.<br>Post-div factor (P= Factor+1)<br>The range is from 1 to 16.   |
| 15    | /   | /    | /   |
| 14:8  | R/W | 0x55 | PLL_FACTOR_N.<br>PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>.....<br>Factor=127, N=128  |
| 7:5   | /   | /    | /   |
| 4:0   | R/W | 0x14 | PLL_PREDIV_M.<br>PLL Pre-div Factor(M = Factor+1).<br>The range is from 1 to 32.  |

#### 4.3.5.3. PLL\_VIDEO Control Register (Default Value: 0x03006207)

| Offset: 0x0010 |     |             | Register Name: <b>PLL_VIDEO_CTRL_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | PLL_ENABLE.<br>0: Disable<br>1: Enable<br>In the integer mode, the PLL Output = (24MHz*N)/M.<br>In the fractional mode, the PLL Output is select by bit 25.<br>In the Clock Control Module, PLL(1X) Output=PLL while PLL(2X) Output=PLL * 2.<br>The PLL output clock must be in the range of 30MHz~600MHz.<br>Its default is 297MHz. |
| 30             | R/W | 0x0         | PLL_MODE.  |

|       |     |      |  |
|-------|-----|------|--|
|       |     |      | 0: Manual Mode<br>1: Auto Mode (Controlled by DE)  |
| 29    | /   | /    | /  |
| 28    | R   | 0x0  | LOCK.<br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)   |
| 27:26 | /   | /    | /  |
| 25    | R/W | 0x1  | FRAC_CLK_OUT.<br>PLL clock output when PLL_MODE_SEL=0(PLL_PREDIV_M factor must be set to 0); No meaning when PLL_MODE_SEL =1.<br>0: PLL Output=270MHz<br>1: PLL Output =297MHz |
| 24    | R/W | 0x1  | PLL_MODE_SEL.<br>0: Fractional Mode<br>1: Integer Mode<br>When in Fractional mode, the Per Divider M should be set to 0.   |
| 23:21 | /   | /    | /  |
| 20    | R/W | 0x0  | PLL_SDM_EN.<br>0: Disable<br>1: Enable   |
| 19:15 | /   | /    | /  |
| 14:8  | R/W | 0x62 | PLL_FACTOR_N.<br>PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=127, N=128  |
| 7:4   | /   | /    | /  |
| 3:0   | R/W | 0x7  | PLL_PREDIV_M.<br>PLL Pre-div Factor(M = Factor+1).<br>The range is from 1 to 16.   |

#### 4.3.5.4. PLL\_VE Control Register (Default Value: 0x03006207)

| Offset: 0x0018 |     |             | Register Name: <b>PLL_VE_CTRL_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | PLL_ENABLE.<br>0: Disable<br>1: Enable<br>In the integer mode, The PLL Output = (24MHz*N)/M.<br>In the fractional mode, the PLL Output is select by bit 25.<br>The PLL output clock must be in the range of 30MHz~600MHz.<br>Its default is 297MHz. |

|       |     |      |   |
|-------|-----|------|---|
| 30:29 | /   | /    | /   |
| 28    | R   | 0x0  | <b>LOCK</b><br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)  |
| 27:26 | /   | /    | /   |
| 25    | R/W | 0x1  | <b>FRAC_CLK_OUT.</b><br>PLL clock output when PLL_MODE_SEL=0(PLL_PREDIV_M factor must be set to 0); No meaning when PLL_MODE_SEL =1.<br>0: PLL Output=270MHz<br>1: PLL Output =297MHz |
| 24    | R/W | 0x1  | <b>PLL_MODE_SEL.</b><br>0: Fractional Mode<br>1: Integer Mode<br>When in Fractional mode, the Per Divider M should be set to 0.   |
| 23:21 | /   | /    | /   |
| 20    | R/W | 0x0  | <b>PLL_SDM_EN.</b><br>0: Disable<br>1: Enable   |
| 19:15 | /   | /    | /   |
| 14:8  | R/W | 0x62 | <b>PLL_FACTOR_N.</b><br>PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=31, N=32<br>...<br>Factor=127, N=128                                      |
| 7:4   | /   | /    | /   |
| 3:0   | R/W | 0x7  | <b>PLL_PREDIV_M.</b><br>PLL Pre Divider (M = Factor+1).<br>The range is from 1 to 16.   |

#### 4.3.5.5. PLL\_DDR0 Control Register (Default Value: 0x00001000)

| Offset: 0x0020 |     |             | Register Name: <b>PLL_DDR0_CTRL_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | <b>PLL_ENABLE.</b><br>0: Disable<br>1: Enable<br>Set bit20 to validate the PLL after this bit is set to 1.<br>The PLL Output = (24MHz*N*K)/M.<br>The PLL output clock must be in the range of 200MHz~2.6GHz.<br>Its default is 408MHz. |

|       |     |      |  |
|-------|-----|------|--|
| 30:29 | /   | /    | /  |
| 28    | R   | 0x0  | <b>LOCK</b><br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)   |
| 27:25 | /   | /    | /  |
| 24    | R/W | 0x0  | <b>PLL_SDM_EN.</b><br>0: Disable<br>1: Enable  |
| 23:21 | /   | /    | /  |
| 20    | R/W | 0x0  | <b>PLL_DDR_CFG_UPDATE.</b><br><b>PLL_DDR Configuration Update.</b><br>When PLL_DDR has been changed, this bit should be set to 1 to validate the PLL, otherwise the change would be invalid. And this bit would be cleared automatically after the PLL change is valid.<br>0: No effect<br>1: Validating the PLL_DDR |
| 19:13 | /   | /    | /  |
| 12:8  | R/W | 0x10 | <b>PLL_FACTOR_N.</b><br><b>PLL Factor N.</b><br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=31, N=32  |
| 7:6   | /   | /    | /  |
| 5:4   | R/W | 0x0  | <b>PLL_FACTOR_K.</b><br><b>PLL Factor K.(K=Factor + 1 )</b><br>The range is from 1 to 4.   |
| 3:2   | /   | /    | /  |
| 1:0   | R/W | 0x0  | <b>PLL_FACTOR_M.</b><br><b>PLL Factor M.(M = Factor + 1 )</b><br>The range is from 1 to 4.   |

#### 4.3.5.6. PLL\_PERIPH0 Control Register (Default Value: 0x00041811)

| Offset: 0x0028 |     |             | Register Name: <b>PLL_PERIPH0_CTRL_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | <b>PLL_ENABLE.</b><br>0: Disable<br>1: Enable<br>The PLL Output = $24\text{MHz} \times N \times K / 2$ .<br>The PLL Output should be fixed to 600MHz, it is not recommended to vary this value arbitrarily.<br>In the Clock Control Module, PLL(2X) output= PLL * 2 = $24\text{MHz} \times N \times K$ . |

|       |     |      |  |
|-------|-----|------|--|
|       |     |      | The PLL output clock must be in the range of 200MHz~1.8GHz.<br>Its default is 600MHz.  |
| 30:29 | /   | /    | /  |
| 28    | R   | 0x0  | LOCK.<br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)   |
| 27:26 | /   | /    | /  |
| 25    | R/W | 0x0  | PLL_BYPASS_EN.<br>PLL Output Bypass Enable.<br>0: Disable<br>1: Enable<br>If the bypass is enabled, the PLL output is 24MHz.                                       |
| 24    | R/W | 0x0  | PLL_CLK_OUT_EN.<br>PLL Clock Output Enable.<br>0: Disable<br>1: Enable   |
| 23:19 | /   | /    | /  |
| 18    | R/W | 0x1  | PLL_24M_OUT_EN.<br>PLL 24MHz Output Enable.<br>0: Disable<br>1: Enable<br>When 25MHz crystal used, this PLL can output 24MHz.                                      |
| 17:16 | R/W | 0x0  | PLL_24M_POST_DIV.<br>PLL 24M Output Clock Post Divider (When 25MHz crystal used)1/2/3/4.   |
| 15:13 | /   | /    | /  |
| 12:8  | R/W | 0x18 | PLL_FACTOR_N.<br>PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=31, N=32  |
| 7:6   | /   | /    | /  |
| 5:4   | R/W | 0x1  | PLL_FACTOR_K.<br>PLL Factor K.(K=Factor + 1 )<br>The range is from 1 to 4.   |
| 3:2   | /   | /    | /  |
| 1:0   | R/W | 0x1  | PLL_FACTOR_M.<br>PLL Factor M (M = Factor + 1) is only valid in plitest debug.<br>The PLL_PERIPH back door clock output =24MHz*N*K/M.<br>The range is from 1 to 4. |

**4.3.5.7. PLL\_ISP Control Register (Default Value: 0x03006207)**

| Offset: 0x002C |     |             | Register Name: <b>PLL_ISP_CTRL_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | <p>PLL_ENABLE.</p> <p>0: Disable</p> <p>1: Enable</p> <p>In the integer mode, the PLL Output = (24MHz*N)/M.</p> <p>In the fractional mode, the PLL Output is select by bit 25.</p> <p>In the Clock Control Module, PLL(1X) Output=PLL while PLL(2X) Output=PLL * 2.</p> <p>The PLL output clock must be in the range of 30MHz~600MHz.</p> <p>Its default is 297MHz.</p> |
| 30             | R/W | 0x0         | <p>PLL_MODE.</p> <p>0: Manual Mode</p> <p>1: Auto Mode (Controlled by DE)</p>   |
| 29             | /   | /           | /   |
| 28             | R   | 0x0         | <p>LOCK.</p> <p>0: Unlocked</p> <p>1: Locked (It indicates that the PLL has been stable.)</p>   |
| 27:26          | /   | /           | /   |
| 25             | R/W | 0x1         | <p>FRAC_CLK_OUT.</p> <p>PLL clock output when PLL_MODE_SEL=0(PLL_PREDIV_M factor must be set to 0); No meaning when PLL_MODE_SEL =1.</p> <p>0: PLL Output=270MHz</p> <p>1: PLL Output =297MHz</p>   |
| 24             | R/W | 0x1         | <p>PLL_MODE_SEL.</p> <p>0: Fractional Mode</p> <p>1: Integer Mode</p> <p>When in Fractional mode, the Per Divider M should be set to 0.</p>   |
| 23:21          | /   | /           | /   |
| 20             | R/W | 0x0         | <p>PLL_SDM_EN.</p> <p>0: Disable</p> <p>1: Enable</p>   |
| 19:15          | /   | /           | /   |
| 14:8           | R/W | 0x62        | <p>PLL_FACTOR_N.</p> <p>PLL Factor N.</p> <p>Factor=0, N=1</p> <p>Factor=1, N=2</p> <p>Factor=2, N=3</p> <p>.....</p> <p>Factor=127,N=128</p>   |
| 7:4            | /   | /           | /   |
| 3:0            | R/W | 0x7         | <p>PLL_PREDIV_M.</p> <p>PLL Pre-div Factor(M = Factor+1).</p>   |

|  |  |  |                            |
|--|--|--|----------------------------|
|  |  |  | The range is from 1 to 16. |
|--|--|--|----------------------------|

#### 4.3.5.8. PLL\_PERIPH1 Control Register (Default Value: 0x00041811)

| Offset: 0x0044 |     |             | Register Name: PLL_PERIPH1_CTRL_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | <b>PLL_ENABLE.</b><br>0: Disable<br>1: Enable<br>The PLL Output = $24\text{MHz} \times N \times K / 2$ .<br>The PLL Output should be fixed to 600MHz, it is not recommended to vary this value arbitrarily.<br>In the Clock Control Module, PLL(2X) output = $\text{PLL} \times 2 = 24\text{MHz} \times N \times K$ .<br>The PLL output clock must be in the range of 200MHz~1.8GHz.<br>Its default is 600MHz. |
| 30:29          | /   | /           | /  |
| 28             | R   | 0x0         | <b>LOCK.</b><br>0: Unlocked<br>1: Locked (It indicates that the PLL has been stable.)  |
| 27:26          | /   | /           | /  |
| 25             | R/W | 0x0         | <b>PLL_BYPASS_EN.</b><br>PLL Output Bypass Enable.<br>0: Disable<br>1: Enable<br>If the bypass is enabled, the PLL output is 24MHz.  |
| 24             | R/W | 0x0         | <b>PLL_CLK_OUT_EN.</b><br>PLL clock output enable(Just for the SATA Phy)<br>0: Disable<br>1: Enable  |
| 23:21          | /   | /           | /  |
| 20             | R/W | 0x0         | <b>PLL_SDM_EN.</b><br>0: Disable<br>1: Enable  |
| 19             | /   | /           | /  |
| 18             | R/W | 0x1         | <b>PLL_24M_OUT_EN.</b><br>PLL 24MHz Output Enable.<br>0: Disable<br>1: Enable<br>When 25MHz crystal used, this PLL can output 24MHz.   |
| 17:16          | R/W | 0x0         | <b>PLL_24M_POST_DIV.</b><br>PLL 24M Output Clock Post Divider (When 25MHz crystal used).<br>1/2/3/4.   |
| 15:13          | /   | /           | /  |
| 12:8           | R/W | 0x18        | <b>PLL_FACTOR_N.</b>   |

|     |     |     |  |
|-----|-----|-----|--|
|     |     |     | PLL Factor N.<br>Factor=0, N=1<br>Factor=1, N=2<br>Factor=2, N=3<br>.....<br>Factor=31, N=32   |
| 7:6 | /   | /   | /  |
| 5:4 | R/W | 0x1 | PLL_FACTOR_K.<br>PLL Factor K.(K=Factor + 1 )<br>The range is from 1 to 4.   |
| 3:2 | /   | /   | /  |
| 1:0 | R/W | 0x1 | PLL_FACTOR_M.<br>PLL Factor M (M = Factor + 1) is only valid in plitest debug.<br>The PLL_PERIPH back door clock output =24MHz*N*K/M.<br>The range is from 1 to 4. |

#### 4.3.5.9. PLL\_DDR1 Control Register (Default Value: 0x00001800)

| Offset: 0x004C |     |             | Register Name: PLL_DDR1_CTRL_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | PLL_ENABLE.<br>0: Disable<br>1: Enable.<br>The PLL Output = 24MHz*N/M.<br>Its default is 600 MHz.   |
| 30             | R/W | 0x0         | SDRPLL_UPD.<br>SDRPLL Configuration Update.<br>When PLL_DDR1 has changed, this bit should be set to 1 to validate the PLL, otherwise the change is invalid. It will be auto cleared after the PLL is valid.<br>0: No effect<br>1: To validate the PLL_DDR1. |
| 29             | /   | /           | /   |
| 28             | R   | 0x0         | LOCK<br>0:Unlocked<br>1: Locked (It indicates that the PLL has been stable.)  |
| 27:25          | /   | /           | /   |
| 24             | R/W | 0x0         | PLL_SDM_EN.<br>0: Disable<br>1: Enable.   |
| 23:16          | /   | /           | /   |
| 15:8           | R/W | 0x18        | PLL_FACTOR_N.<br>PLL Factor N. (N = Factor + 1 )<br>The range is from 0 to 127.<br>Bit 15 can not be accessed.  |

|     |     |     |  |
|-----|-----|-----|--|
| 7:2 | /   | /   | /  |
| 1:0 | R/W | 0x0 | PLL_FACTOR_M.<br>PLL Factor M.(M = Factor + 1 )<br>The range is from 1 to 4. |

#### 4.3.5.10. CPU/AXI Configuration Register (Default Value: 0x00010000)

| Offset: 0x0050 |     |             | Register Name: <b>CPU_AXI_CFG_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:18          | /   | /           | /  |
| 17:16          | R/W | 0x1         | CPU_CLK_SRC_SEL.<br>CPU Clock Source Select.<br>CPU Clock = Clock Source<br>00: LOSC<br>01: OSC24M<br>1X: PLL_CPU<br>If the clock source is changed, at most to wait for 8 present running clock cycles. |
| 15:10          | /   | /           | /  |
| 9:8            | R/W | 0x0         | CPU_APB_CLK_DIV.<br>00: /1<br>01: /2<br>1x: /4<br>System APB clock source is CPU clock source.   |
| 7:2            | /   | /           | /  |
| 1:0            | R/W | 0x0         | AXI_CLK_DIV_RATIO.<br>AXI Clock Divide Ratio.<br>AXI Clock source is CPU clock source.<br>00: /1<br>01: /2<br>10: /3<br>11: /4   |

#### 4.3.5.11. AHB1/APB1 Configuration Register (Default Value: 0x00001010)

| Offset: 0x0054 |     |             | Register Name: <b>AHB1_APB1_CFG_REG</b>                |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:14          | /   | /           | /  |
| 13:12          | R/W | 0x1         | AHB1_CLK_SRC_SEL.<br>00: LOSC<br>01: OSC24M<br>10: AXI |

|       |     |     |  |
|-------|-----|-----|--|
|       |     |     | 11: PLL_PERIPH0/AHB1_PRE_DIV   |
| 11:10 | /   | /   | /  |
| 9:8   | R/W | 0x0 | APB1_CLK_RATIO.<br>APB1 Clock Divide Ratio. APB1 clock source is AHB1 clock.<br>00: /2<br>01: /2<br>10: /4<br>11: /8 |
| 7:6   | R/W | 0x0 | AHB1_PRE_DIV<br>AHB1 Clock Pre Divide Ratio<br>00: /1<br>01: /2<br>10: /3<br>11: /4                                  |
| 5:4   | R/W | 0x1 | AHB1_CLK_DIV_RATIO.<br>AHB1 Clock Divide Ratio.<br>00: /1<br>01: /2<br>10: /4<br>11: /8                              |
| 3:0   | /   | /   | /  |

#### 4.3.5.12. APB2 Configuration Register (Default Value: 0x01000000)

| Offset: 0x0058 |     |             | Register Name: APB2_CFG_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:26          | /   | /           | /   |
| 25:24          | R/W | 0x1         | APB2_CLK_SRC_SEL.<br>APB2 Clock Source Select<br>00: LOSC<br>01: OSC24M<br>1X: PLL_PERIPH0<br>This clock is used for some special module apbclk(UART、TWI). Because these modules need special clock rate even if the apb1clk changed. |
| 23:18          | /   | /           | /   |
| 17:16          | R/W | 0x0         | CLK_RAT_N<br>Clock Pre Divide Ratio (n)<br>The select clock source is pre-divided by $2^n$ . The divider is 1/2/4/8.  |
| 15:5           | /   | /           | /   |
| 4:0            | R/W | 0x0         | CLK_RAT_M.<br>Clock Divide Ratio (m)<br>The Pre Divide clock is divided by (m+1). The divider M is from 1 to 32.  |

**4.3.5.13. AHB2 Configuration Register (Default Value: 0x00000000)**

| Offset: 0x005C |     |             | Register Name: AHB2_CFG_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:2           | /   | /           | /   |
| 1:0            | R/W | 0x0         | AHB2_CLK_CFG.<br>00: AHB1 Clock<br>01: PLL_PERIPH0 / 2<br>1X: /<br>EMAC,USB OTG_EHCI0/OHCI0 and USB OTG_Device0 default clock source is AHB2 Clock. |

**4.3.5.14. Bus Clock Gating Register0 (Default Value: 0x00000000)**

| Offset: 0x0060 |     |             | Register Name: BUS_CLK_GATING_REG0  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:30          | /   | /           | /   |
| 29             | R/W | 0x0         | USB OTG_OHCI_GATING.<br>Gating Clock for USB OTG_OHCI<br>0: Mask<br>1: Pass     |
| 28:27          | /   | /           | /   |
| 26             | R/W | 0x0         | USB OTG_EHCI_GATING.<br>Gating Clock For USB OTG_EHCI<br>0: Mask<br>1: Pass     |
| 25             | /   | /           | /   |
| 24             | R/W | 0x0         | USB OTG_Device_GATING.<br>Gating Clock For USB OTG_Device<br>0: Mask<br>1: Pass |
| 23:21          | /   | /           | /   |
| 20             | R/W | 0x0         | SPI0_GATING.<br>Gating Clock For SPI0<br>0: Mask<br>1: Pass                     |
| 19             | R/W | 0x0         | HSTMR_GATING.<br>Gating Clock For High Speed Timer<br>0: Mask<br>1: Pass        |
| 18             | /   | /           | /   |
| 17             | R/W | 0x0         | EMAC_GATING.<br>Gating Clock For EMAC   |

|       |     |     |   |
|-------|-----|-----|---|
|       |     |     | 0: Mask<br>1: Pass  |
| 16:15 | /   | /   | /   |
| 14    | R/W | 0x0 | DRAM_GATING.<br>Gating Clock For DRAM<br>0: Mask<br>1: Pass |
| 13:11 | /   | /   | /   |
| 10    | R/W | 0x0 | MMC2_GATING.<br>Gating Clock For MMC2<br>0: Mask<br>1: Pass |
| 9     | /   | /   | /   |
| 8     | R/W | 0x0 | MMCO_GATING.<br>Gating Clock For MMCO<br>0: Mask<br>1: Pass |
| 7     | /   | /   | /   |
| 6     | R/W | 0x0 | DMA_GATING.<br>Gating Clock For DMA<br>0: Mask<br>1: Pass   |
| 5     | R/W | 0x0 | CE_GATING.<br>Gating Clock For CE.<br>0: Mask<br>1: Pass    |
| 4:0   | /   | /   | /   |

#### 4.3.5.15. Bus Clock Gating Register1 (Default Value: 0x00000000)

| Offset: 0x0064 |     |             | Register Name: <b>BUS_CLK_GATING_REG1</b>                 |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:13          | /   | /           | /   |
| 12             | R/W | 0x0         | DE_GATING.<br>0: Mask<br>1: Pass.                         |
| 11:9           | /   | /           | /   |
| 8              | R/W | 0x0         | CSI_GATING.<br>Gating Clock For CSI<br>0: Mask<br>1: Pass |
| 7:5            | /   | /           | /   |
| 4              | R/W | 0x0         | TCON_GATING.  |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | Gating Clock For TCON<br>0: Mask<br>1: Pass             |
| 3:1 | /   | /   | /   |
| 0   | R/W | 0x0 | VE_GATING.<br>Gating Clock For VE<br>0: Mask<br>1: Pass |

#### 4.3.5.16. Bus Clock Gating Register2 (Default Value: 0x00000000)

| Offset: 0x0068 |     |             | Register Name: <b>BUS_CLK_GATING_REG2</b>                                    |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:13          | /   | /           | /  |
| 12             | R/W | 0x0         | I2S/PCM_GATING.<br>Gating Clock For I2S/PCM<br>0: Mask<br>1: Pass            |
| 11:6           | /   | /           | /  |
| 5              | R/W | 0x0         | PIO_GATING.<br>Gating Clock For PIO<br>0: Mask<br>1: Pass                    |
| 4:1            | /   | /           | /  |
| 0              | R/W | 0x0         | AC_DIG_GATING.<br>Gating Clock For Audio Codec Digital<br>0: Mask<br>1: Pass |

#### 4.3.5.17. Bus Clock Gating Register3 (Default Value: 0x00000000)

| Offset: 0x006C |     |             | Register Name: <b>BUS_CLK_GATING_REG3</b>                     |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:19          | /   | /           | /   |
| 18             | R/W | 0x0         | UART2_GATING.<br>Gating Clock For UART2<br>0: Mask<br>1: Pass |
| 17             | R/W | 0x0         | UART1_GATING.<br>Gating Clock For UART1<br>0: Mask<br>1: Pass |

|      |     |     |   |
|------|-----|-----|---|
| 16   | R/W | 0x0 | UART0_GATING.<br>Gating Clock For UART0<br>0: Mask<br>1: Pass |
| 15:2 | /   | /   | /   |
| 1    | R/W | 0x0 | TWI1_GATING.<br>Gating Clock For TWI1<br>0: Mask<br>1: Pass   |
| 0    | R/W | 0x0 | TWI0_GATING.<br>Gating Clock For TWI0<br>0: Mask<br>1: Pass   |

#### 4.3.5.18. Bus Clock Gating Register4 (Default Value: 0x00000000)

| Offset: 0x0070 |     |             | Register Name: <b>BUS_CLK_GATING_REG4</b>                       |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7              | R/W | 0x0         | DBGSYS_GATING.<br>Gating Clock For DBGSYS<br>0: Mask<br>1: Pass |
| 6:0            | /   | /           | /   |

#### 4.3.5.19. SDMMC0 Clock Register (Default Value: 0x00000000)

| Offset: 0x0088 |     |             | Register Name: <b>SDMMC0_CLK_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock(Max Clock = 200MHz)<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK = Clock Source/Divider N/Divider M. |
| 30:26          | /   | /           | /  |
| 25:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>00: OSC24M<br>01: PLL_PERIPH0<br>10: PLL_PERIPH1<br>11: /   |
| 23             | /   | /           | /  |

|       |     |     |  |
|-------|-----|-----|--|
| 22:20 | R/W | 0x0 | SAMPLE_CLK_PHASE_CTR.<br>Sample Clock Phase Control.<br>The sample clock phase delay is based on the number of source clock that is from 0 to 7. |
| 19:18 | /   | /   | /  |
| 17:16 | R/W | 0x0 | CLK_DIV_RATIO_N.<br>Clock Pre Divide Ratio (n)<br>00: /1<br>01: /2<br>10: /4<br>11: /8.  |
| 15:11 | /   | /   | /  |
| 10:8  | R/W | 0x0 | OUTPUT_CLK_PHASE_CTR.<br>Output Clock Phase Control.<br>The output clock phase delay is based on the number of source clock that is from 0 to 7. |
| 7:4   | /   | /   | /  |
| 3:0   | R/W | 0x0 | CLK_DIV_RATIO_M.<br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.                          |

#### 4.3.5.20. SDMMC2 Clock Register (Default Value: 0x00000000)

| Offset: 0x0090 |     |             | Register Name: SDMMC2_CLK_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock(Max Clock = 200MHz)<br>0: Clock is OFF<br>1: Clock is ON.<br>If SDMMC2 is in old mode, SCLK = Clock Source/Divider N/Divider M.<br>If SDMMC2 is in new mode, SCLK= Clock Source/Divider N/Divider M/2. |
| 30             | R/W | 0x0         | MMC2_MODE_SELECT.<br>0: Old Mode<br>1: New Mode.  |
| 29:26          | /   | /           | /   |
| 25:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>00: OSC24M<br>01: PLL_PERIPH0<br>10: PLL_PERIPH1<br>11: /  |
| 23             | /   | /           | /   |
| 22:20          | R/W | 0x0         | CLK_PHASE_CTR.<br>Sample Clock Phase Control.   |

|       |     |     |  |
|-------|-----|-----|--|
|       |     |     | The sample clock phase delay is based on the number of source clock that is from 0 to 7.   |
| 19:18 | /   | /   | /  |
| 17:16 | R/W | 0x0 | CLK_DIV_RATIO_N.<br>Clock Pre Divide Ratio (n)<br>00: /1<br>01: /2<br>10: /4<br>11: /8.  |
| 15:11 | /   | /   | /  |
| 10:8  | R/W | 0x0 | OUTPUT_CLK_PHASE_CTR.<br>Output Clock Phase Control.<br>The output clock phase delay is based on the number of source clock that is from 0 to 7. |
| 7:4   | /   | /   | /  |
| 3:0   | R/W | 0x0 | CLK_DIV_RATIO_M.<br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.                          |

#### 4.3.5.21. CE Clock Register (Default Value: 0x00000000)

| Offset: 0x009C |     |             | Register Name: CE_CLK_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock(Max Clock = 200MHz)<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK = Clock Source/Divider N/Divider M. |
| 30:26          | /   | /           | /  |
| 25:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>00: OSC24M<br>01: PLL_PERIPH0<br>10: /<br>11: /   |
| 23:18          | /   | /           | /  |
| 17:16          | R/W | 0x0         | CLK_DIV_RATIO_N.<br>Clock Pre Divide Ratio (n)<br>00: /1<br>01: /2<br>10: /4<br>11: /8.  |
| 15:4           | /   | /           | /  |
| 3:0            | R/W | 0x0         | CLK_DIV_RATIO_M.   |

|  |  |  |   |
|--|--|--|---|
|  |  |  | Clock divide ratio (m)<br>The pre-divided clock is divided by (m+1). The divider M is from 1 to 16. |
|--|--|--|---|

#### 4.3.5.22. SPI0 Clock Register (Default Value: 0x00000000)

| Offset: 0x00A0 |     |             | Register Name: SPI0_CLK_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock(Max Clock = 200MHz)<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK = Clock Source/Divider N/Divider M. |
| 30:26          | /   | /           | /  |
| 25:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>00: OSC24M<br>01: PLL_PERIPH0<br>10: PLL_PERIPH1<br>11: /   |
| 23:18          | /   | /           | /  |
| 17:16          | R/W | 0x0         | CLK_DIV_RATIO_N.<br>Clock Pre Divide Ratio (n)<br>00: /1<br>01: /2<br>10: /4<br>11: /8.  |
| 15:4           | /   | /           | /  |
| 3:0            | R/W | 0x0         | CLK_DIV_RATIO_M.<br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.                    |

#### 4.3.5.23. I2S/PCM Clock Register (Default Value: 0x00000000)

| Offset: 0x00B0 |     |             | Register Name: I2S/PCM_CLK_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock(Max Clock = 200MHz)<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK= Clock Source PLL_AUDIO/Divider M. |
| 30:18          | /   | /           | /   |
| 17:16          | R/W | 0x0         | CLK_SRC_SEL.  |

|      |   |   |   |
|------|---|---|---|
|      |   |   | 00: PLL_AUDIO (8X)<br>01: PLL_AUDIO(8X)/2<br>10: PLL_AUDIO(8X)/4<br>11: PLL_AUDIO |
| 15:0 | / | / | /   |

#### 4.3.5.24. USBPHY Configuration Register (Default Value: 0x00000000)

| Offset: 0x00CC |     |             | Register Name: <b>USBPHY_CFG_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:17          | /   | /           | /   |
| 16             | R/W | 0x0         | SCLK_GATING_OTG_OHCI0.<br>Gating Special Clock For USB OTG_OHCI0<br>0: Clock is OFF<br>1: Clock is ON |
| 15:9           | /   | /           | /   |
| 8              | R/W | 0x0         | SCLK_GATING_USBPHY0.<br>Gating Special Clock For USB PHY0<br>0: Clock is OFF<br>1: Clock is ON        |
| 7:1            | /   | /           | /   |
| 0              | R/W | 0x0         | USBPHY0_RST.<br>USB PHY0 Reset Control<br>0: Assert<br>1: De-assert                                   |

#### 4.3.5.25. DRAM Configuration Register (Default Value: 0x00000001)

| Offset: 0x00F4 |     |             | Register Name: <b>DRAM_CFG_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | DRAM_CTR_RST.<br>DRAM Controller Reset For AHB Clock Domain.<br>0: Assert<br>1: De-assert. |
| 30:22          | /   | /           | /  |
| 21:20          | R/W | 0x0         | CLK_SRC_SEL.<br>00: PLL_DDR0<br>01: PLL_DDR1<br>10: PLL_PERIPH0 (2X)<br>11: /              |
| 19:17          | /   | /           | /  |
| 16             | R/W | 0x0         | SDRCLK_UPD.  |

|      |     |     |  |
|------|-----|-----|--|
|      |     |     | SDRCLK Configuration Update.<br>0:Invalid<br>1:Valid.<br>Setting this bit will validate Configuration 0 . It will be auto cleared after the Configuration 0 is valid.<br>The DRAMCLK Source is from PLL_DDR. |
| 15:4 | /   | /   | /  |
| 3:0  | R/W | 0x1 | DRAM_DIV_M.<br>DRAMCLK Divider of Configuration.<br>The clock is divided by (m+1). The divider M should be from 2 to 16.   |

#### 4.3.5.26. PLL\_DDR1 Configuration Register (Default Value: 0x00000030)

| Offset: 0x00F8 |     |             | Register Name: <b>PLL_DDR_CFG_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:13          | /   | /           | /  |
| 12             | R/W | 0x0         | PLL_DDR1_MODE.<br>0: Normal Mode<br>1: Continuously Frequency Scale  |
| 11:7           | /   | /           | /  |
| 6:4            | R/W | 0x3         | PLL_DDR1_PHASE_COMPENSATE.<br>The value of bit[6:4] is based on 24M clock, then the default PLL_DDR phase compensate is (3/24000000) s.  |
| 3:0            | R/W | 0x0         | PLL_DDR1_STEP.<br>0000: 0.004MHz/us (576/2^17)<br>0001: 0.008MHz/us (576/2^16)<br>0010: 0.016MHz/us (576/2^15)<br>0011: 0.032MHz/us (576/2^14)<br>0100: 0.064MHz/us (576/2^13)<br>0101: 0.128MHz/us (576/2^12)<br>0110: 0.256MHz/us (576/2^11)<br>0111: 0.512MHz/us (576/2^10)<br>1000: 1.024MHz/us (576/2^9)<br>1001: 2.048MHz/us (576/2^8)<br>Others: 0.004MHz/us (576/2^17) |

#### 4.3.5.27. MBUS Reset Register (Default Value: 0x80000000)

| Offset: 0x00FC |     |             | Register Name: <b>MBUS_RST_REG</b>  |
|----------------|-----|-------------|-------------------------------------|
| Bit            | R/W | Default/Hex | Description                         |
| 31             | R/W | 0x1         | MBUS_RESET.<br>0: Reset Mbus Domain |

|      |   |   |                        |
|------|---|---|------------------------|
|      |   |   | 1: Assert Mbus Domain. |
| 30:0 | / | / | /                      |

#### 4.3.5.28. DRAM Clock Gating Register (Default Value: 0x00000000)

| Offset: 0x0100 |     |             | Register Name: DRAM_CLK_GATING_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:19          | /   | /           | /   |
| 18             | R/W | 0x0         | USB OTG_OHCI_DCLK_GATING.<br>Gating DRAM Clock For USB OTG_OHCI<br>0: Mask<br>1: Pass |
| 17             | R/W | 0x0         | USB OTG_EHCI_DCLK_GATING.<br>Gating DRAM Clock For USB OTG_EHCI<br>0: Mask<br>1: Pass |
| 16:2           | /   | /           | /   |
| 1              | R/W | 0x0         | CSI_DCLK_GATING.<br>Gating DRAM Clock For CSI<br>0: Mask<br>1: Pass                   |
| 0              | R/W | 0x0         | VE_DCLK_GATING.<br>Gating DRAM Clock For VE<br>0: Mask<br>1: Pass                     |

#### 4.3.5.29. DE Clock Gating Register (Default Value: 0x00000000)

| Offset: 0x0104 |     |             | Register Name: DE_CLK_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON<br>This special clock = Clock Source/Divider M. |
| 30:27          | /   | /           | /   |
| 26:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>000: PLL_VIDEO<br>010: PLL_PERIPH0<br>Others: /                                    |
| 23:4           | /   | /           | /   |

|     |     |     |  |
|-----|-----|-----|--|
| 3:0 | R/W | 0x0 | <b>CLK_DIV_RATIO_M.</b><br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 16. |
|-----|-----|-----|--|

#### 4.3.5.30. TCON Clock Register (Default Value: 0x00000000)

| Offset: 0x0118 |     |             | Register Name: <b>TCON_CLK_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | <b>SCLK_GATING.</b><br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON<br>This special clock = Clock Source/Divider M. |
| 30:27          | /   | /           | /  |
| 26:24          | R/W | 0x0         | <b>CLK_SRC_SEL.</b><br>Clock Source Select<br>000: PLL_VIDEO<br>001: PLL_PERIPH0<br>Others: /                                    |
| 23:4           | /   | /           | /  |
| 3:0            | R/W | 0x0         | <b>CLK_DIV_RATIO_M.</b><br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 16.     |

#### 4.3.5.31. CSIO Clock Register (Default Value: 0x00000000)

| Offset: 0x0130 |     |             | Register Name: <b>CSIO_CLK_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | <b>CSI_MISC_SCLK_GATING.</b><br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK = OSC24M.                               |
| 30:16          | /   | /           | /   |
| 15             | R/W | 0x0         | <b>CSIO_MCLK_GATING.</b><br>Gating Master Clock<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK = CSIO Master Clock Source/ CSIO_MCLK_DIV_M. |
| 14:11          | /   | /           | /   |
| 10:8           | R/W | 0x0         | <b>CSIO_MCLK_SRC_SEL.</b><br>CSIO Master Clock Source Select  |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | 000: OSC24M<br>001: PLL_VIDEO<br>010: PLL_PERIPH1<br>011: PLL_PERIPHO<br>Others: /  |
| 7:5 | /   | /   | /   |
| 4:0 | R/W | 0x0 | CSI0_MCLK_DIV_M.<br>CSI0 Master Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 32. |

#### 4.3.5.32. CSI1 Clock Register (Default Value: 0x00000000)

| Offset: 0x0134 |     |             | Register Name: <b>CSI1_CLK_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | CSI_TOP_SCLK_GATING.<br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK = Special Clock Source/CSI_SCLK_DIV_M.            |
| 30:27          | /   | /           | /   |
| 26:24          | R/W | 0x0         | SCLK_SRC_SEL.<br>Special Clock Source Select<br>000: PLL_VIDEO<br>001: PLL_ISP<br>Others: /   |
| 23:20          | /   | /           | /   |
| 19:16          | R/W | 0x0         | CSI_SCLK_DIV_M.<br>CSI Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 16.                    |
| 15             | R/W | 0x0         | CSI1_MCLK_GATING.<br>Gating Master Clock<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK =CSI1 Master Clock Source/ CSI1_MCLK_DIV_M.           |
| 14:11          | /   | /           | /   |
| 10:8           | R/W | 0x0         | CSI1_MCLK_SRC_SEL.<br>CSI1 Master Clock Source Select<br>000: OSC24M<br>001: PLL_VIDEO<br>010: PLL_PERIPH1<br>011: PLL_PERIPHO<br>Others: / |
| 7:5            | /   | /           | /   |
| 4:0            | R/W | 0x0         | CSI1_MCLK_DIV_M.  |

|  |  |  |   |
|--|--|--|---|
|  |  |  | CSI1 Master Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 32. |
|--|--|--|---|

#### 4.3.5.33. VE Clock Register (Default Value: 0x00000000)

| Offset: 0x013C |     |             | Register Name: VE_CLK_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | VE_SCLK_GATING.<br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK = PLL_VE /Divider N.                     |
| 30:19          | /   | /           | /.   |
| 18:16          | R/W | 0x0         | CLK_DIV_RATIO_N.<br>Clock Pre Divide Ratio (N)<br>The select clock source is pre-divided by n+1. The divider N is from 1 to 8. |
| 15:0           | /   | /           | /  |

#### 4.3.5.34. Audio Codec Digital Clock Register (Default Value: 0x00000000)

| Offset: 0x0140 |     |             | Register Name: AC_DIG_CLK_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SCLK_1X_GATING.<br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK = PLL_AUDIO Output. |
| 30:0           | /   | /           | /  |

#### 4.3.5.35. AVS Clock Register (Default Value: 0x00000000)

| Offset: 0x0144 |     |             | Register Name: AVS_CLK_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | SCLK_GATING.<br>Gating Special Clock<br>0: Clock is OFF<br>1: Clock is ON.<br>SCLK= OSC24M. |
| 30:0           | /   | /           | /   |

**4.3.5.36. MBUS Clock Register (Default Value: 0x00000000)**

| Offset: 0x015C |     |             | Register Name: <b>MBUS_CLK_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | MBUS_SCLK_GATING.<br>Gating Clock for MBUS<br>0: Clock is OFF<br>1: Clock is ON.<br>MBUS_CLOCK = Clock Source/Divider M  |
| 30:26          | /   | /           | /  |
| 25:24          | R/W | 0x0         | MBUS_SCLK_SRC<br>Clock Source Select<br>00: OSC24M<br>01: PLL_PERIPH0(2X)<br>10: PLL_DDR0<br>11: /.  |
| 23:3           | /   | /           | /  |
| 2:0            | R/W | 0x0         | MBUS_SCLK_RATIO_M<br>Clock Divide Ratio (m)<br>The pre-divided clock is divided by (m+1). The divider M is from 1 to 8.<br>The divide ratio must be changed smoothly.<br>If the clock has been changed ,it must wait for at least 16 cycles. |

**4.3.5.37. MIPI\_CSI Register (Default Value: 0x00000000)**

| Offset: 0x016C |     |             | Register Name: <b>MIPI_CSI_REG</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0x0         | MIPICSI2_DPHY_CLK_GATING.<br>Gating Clock For CSI_DPHY<br>0: Clock is OFF<br>1: Clock is ON<br>SCLK= Clock Source/Divider M |
| 30:26          | /   | /           | /   |
| 25:24          | R/W | 0x0         | CLK_SRC_SEL.<br>Clock Source Select<br>00: PLL_VIDEO<br>01: PLL_PERIPH0<br>10: PLL_ISP<br>11: /                             |
| 23:3           | /   | /           | /   |
| 3:0            | R/W | 0x0         | CLK_DIV_RATIO_M.<br>Clock divide ratio (m)<br>The pre-divided clock is divided by (m+1). The divider is from 1 to 16.       |

#### 4.3.5.38. PLL Stable Time Register0 (Default Value: 0x000000FF)

| Offset: 0x0200 |     |             | Register Name: <b>PLL_STABLE_TIME_REG0</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:16          | /   | /           | /  |
| 15:0           | R/W | 0x0OFF      | PLL_LOCK_TIME<br>PLL Lock Time (Unit: us).<br>When any PLL (except PLL_CPU) is enabled or changed, the corresponding PLL lock bit will be set after the PLL STABLE Time. |

#### 4.3.5.39. PLL Stable Time Register1 (Default Value: 0x000000FF)

| Offset: 0x0204 |     |             | Register Name: <b>PLL_STABLE_TIME_REG1</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:16          | /   | /           | /   |
| 15:0           | R/W | 0x0OFF      | PLL_CPU_LOCK_TIME<br>PLL_CPU Lock Time (Unit: us).<br>When PLL_CPU is enabled or changed, the PLL_CPU lock bit will be set after the PLL_CPU STABLE Time. |

#### 4.3.5.40. PLL\_CPUX Bias Register (Default Value: 0x08100200)

| Offset: 0x0220 |     |             | Register Name: <b>PLL_CPUX_BIAS_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | VCO_RST.<br>VCO reset in.  |
| 30:29          | /   | /           | /  |
| 28             | R/W | 0x0         | EXG_MODE.<br>Exchange Mode.<br>CPU PLL source will select PLL_PERIPH0 instead of PLL_CPU |
| 27:24          | R/W | 0x8         | PLL_VCO_BIAS_CTRL.<br>PLL VCO Bias Control[3:0].   |
| 23:21          | /   | /           | /  |
| 20:16          | R/W | 0x10        | PLL_BIAS_CUR_CTRL.<br>PLL Bias Current Control[4:0].                                     |
| 15:11          | /   | /           | /  |
| 10:8           | R/W | 0x2         | PLL_LOCK_CTRL.<br>PLL Lock Time Control[2:0].  |
| 7:4            | /   | /           | /  |
| 3:0            | R/W | 0x0         | PLL_DAMP_FACT_CTRL.  |

|  |  |  |                                  |
|--|--|--|----------------------------------|
|  |  |  | PLL Damping Factor Control[3:0]. |
|--|--|--|----------------------------------|

#### 4.3.5.41. PLL\_AUDIO Bias Register (Default Value: 0x10100000)

| Offset: 0x0224 |     |             | Register Name: <b>PLL_AUDIO_BIAS_REG</b>    |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                 |
| 31:29          | /   | /           | /   |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS.<br>PLL VCO Bias Current[4:0]. |
| 23:21          | /   | /           | /   |
| 20:16          | R/W | 0x10        | PLL_BIAS_CUR.<br>PLL Bias Current[4:0].     |
| 15:0           | /   | /           | /   |

#### 4.3.5.42. PLL\_VIDEO Bias Register (Default Value: 0x10100000)

| Offset: 0x0228 |     |             | Register Name: <b>PLL_VIDEO_BIAS_REG</b>                  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:29          | /   | /           | /   |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS_CTRL.<br>PLL VCO Bias Control[4:0].          |
| 23:21          | /   | /           | /   |
| 20:16          | R/W | 0x10        | PLL_BIAS_CTRL.<br>PLL Bias Control[4:0].                  |
| 15:3           | /   | /           | /   |
| 2:0            | R/W | 0x0         | PLL_DAMP_FACTOR_CTRL.<br>PLL Damping Factor Control[2:0]. |

#### 4.3.5.43. PLL\_VE Bias Register (Default Value: 0x10100000)

| Offset: 0x022C |     |             | Register Name: <b>PLL_VE_BIAS_REG</b>            |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description                                      |
| 31:29          | /   | /           | /  |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS_CTRL.<br>PLL VCO Bias Control[4:0]. |
| 23:21          | /   | /           | /  |
| 20:16          | R/W | 0x10        | PLL_BIAS_CTRL.<br>PLL Bias Control[4:0].         |
| 15:3           | /   | /           | /  |
| 2:0            | R/W | 0x0         | PLL_DAMP_FACTOR_CTRL.                            |

|  |  |  |                                  |
|--|--|--|----------------------------------|
|  |  |  | PLL Damping Factor Control[2:0]. |
|--|--|--|----------------------------------|

#### 4.3.5.44. PLL\_DDR0 Bias Register (Default Value: 0x81104000)

| Offset: 0x0230 |     |             | Register Name: <b>PLL_DDR0_BIAS_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:28          | R/W | 0x8         | PLL_VCO_BIAS.<br>PLL VCO Bias[3:0].   |
| 27:26          | /   | /           | /.  |
| 25             | R/W | 0x0         | PLL_VCO_GAIN_CTRL_EN.<br>PLL VCO Gain Control Enable.<br>0: Disable<br>1: Enable. |
| 24             | R/W | 0x1         | PLL_BANDW_CTRL.<br>PLL Band Width Control.<br>0: Narrow<br>1: Wide.               |
| 23:21          | /   | /           | /   |
| 20:16          | R/W | 0x10        | PLL_BIAS_CUR_CTRL.<br>PLL Bias Current Control.                                   |
| 15             | /   | /           | /   |
| 14:12          | R/W | 0x4         | PLL_VCO_GAIN_CTRL.<br>PLL VCO Gain Control Bit[2:0].                              |
| 11:4           | /   | /           | /   |
| 3:0            | R/W | 0x0         | PLL_DAMP_FACTOR_CTRL.<br>PLL Damping Factor Control[3:0].                         |

#### 4.3.5.45. PLL\_PERIPH0 Bias Register (Default Value: 0x10100010)

| Offset: 0x0234 |     |             | Register Name: <b>PLL_PERIPH0_BIAS_REG</b>                         |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:29          | /   | /           | /  |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS.<br>PLL VCO Bias[4:0].                                |
| 23:21          | /   | /           | /  |
| 20:16          | R/W | 0x10        | PLL_BIAS_CUR_CTRL.<br>PLL Bias Current Control.                    |
| 15:5           | /   | /           | /  |
| 4              | R/W | 0x1         | PLL_BANDW_CTRL.<br>PLL Band Width Control.<br>0: Narrow<br>1: Wide |

|     |     |     |   |
|-----|-----|-----|---|
| 3:2 | /   | /   | /   |
| 1:0 | R/W | 0x0 | PLL_DAMP_FACTOR_CTRL.<br>PLL Damping Factor Control[1:0]. |

#### 4.3.5.46. PLL\_ISP Bias Register (Default Value: 0x10100000)

| Offset: 0x0238 |     |             | Register Name: <b>PLL_ISP_BIAS_REG</b>                    |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:29          | /   | /           | /   |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS_CTRL.<br>PLL VCO Bias Control[4:0].          |
| 23:21          | /   | /           | /   |
| 20:16          | R/W | 0x10        | PLL_BIAS_CTRL.<br>PLL Bias Control[4:0].                  |
| 15:3           | /   | /           | /   |
| 2:0            | R/W | 0x0         | PLL_DAMP_FACTOR_CTRL.<br>PLL Damping Factor Control[2:0]. |

#### 4.3.5.47. PLL\_PERIPH1 Bias Register (Default Value: 0x10100010)

| Offset: 0x0244 |     |             | Register Name: <b>PLL_PERIPH1_BIAS_REG</b>                         |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:29          | /   | /           | /  |
| 28:24          | R/W | 0x10        | PLL_VCO_BIAS.<br>PLL VCO Bias[4:0].                                |
| 23:21          | /   | /           | /  |
| 20:16          | R/W | 0x10        | PLL_BIAS_CUR_CTRL.<br>PLL Bias Current Control.                    |
| 15:5           | /   | /           | /  |
| 4              | R/W | 0x1         | PLL_BANDW_CTRL.<br>PLL Band Width Control.<br>0: Narrow<br>1: Wide |
| 3:2            | /   | /           | /  |
| 1:0            | R/W | 0x0         | PLL_DAMP_FACTOR_CTRL.<br>PLL Damping Factor Control[1:0].          |

#### 4.3.5.48. PLL\_DDR1 Bias Register (Default Value: 0x10010000)

| Offset: 0x024C |     |             | Register Name: <b>PLL_DDR1_BIAS_REG</b> |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                             |

|       |     |      |  |
|-------|-----|------|--|
| 31:29 | /   | /    | /  |
| 28:24 | R/W | 0x10 | PLL_VCO_BIAS_CTRL.<br>PLL VCO Bias Control[4:0].     |
| 23:21 | /   | /    | /  |
| 20:16 | R/W | 0x01 | PLL_BIAS_CUR_CTRL.<br>PLL Bias Current Control[4:0]. |
| 15:0  | /   | /    | /  |

#### 4.3.5.49. PLL\_CPU Tuning Register (Default Value: 0x0A101000)

| Offset: 0x0250 |     |             | Register Name: <b>PLL_CPU_TUN_REG</b>                                    |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:28          | /   | /           | /  |
| 27             | R/W | 0x1         | PLL_BAND_WID_CTRL.<br>PLL Band Width Control.<br>0: Narrow<br>1: Wide    |
| 26             | R/W | 0x0         | VCO_GAIN_CTRL_EN.<br>VCO Gain Control Enable.<br>0: Disable<br>1: Enable |
| 25:23          | R/W | 0x4         | VCO_GAIN_CTRL.<br>VCO Gain Control Bits[2:0].                            |
| 22:16          | R/W | 0x10        | PLL_INIT_FREQ_CTRL.<br>PLL Initial Frequency Control[6:0].               |
| 15             | R/W | 0x0         | C_OD.<br>C-Reg-Od For Verify.  |
| 14:8           | R/W | 0x10        | C_B_IN.<br>C-B-In[6:0] For Verify.                                       |
| 7              | R/W | 0x0         | C_OD1.<br>C-Reg-Od1 For Verify.  |
| 6:0            | R   | 0x0         | C_B_OUT.<br>C-B-Out[6:0] For Verify.                                     |

#### 4.3.5.50. PLL\_DDR0 Tuning Register (Default Value: 0x14880000)

| Offset: 0x0260 |     |             | Register Name: <b>PLL_DDR0_TUN_REG</b>           |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description                                      |
| 31:29          | /   | /           | /  |
| 28             | R/W | 0x1         | VREG1_OUT_EN.<br>Vreg1 Out Enable.<br>0: Disable |

|       |     |      |  |
|-------|-----|------|--|
|       |     |      | 1: Enable  |
| 27    | /   | /    | /  |
| 26:24 | R/W | 0x4  | PLL_LTME_CTRL.<br>PLL Lock Time Control[2:0].              |
| 23    | R/W | 0x1  | VCO_RST.<br>VCO Reset In.                                  |
| 22:16 | R/W | 0x08 | PLL_INIT_FREQ_CTRL.<br>PLL Initial Frequency Control[6:0]. |
| 15    | R/W | 0x0  | OD1.<br>Reg-Od1 For Verify.                                |
| 14:8  | R/W | 0x0  | B_IN.<br>B-In[6:0] For Verify.                             |
| 7     | R/W | 0x0  | OD.<br>Reg-Od For Verify.                                  |
| 6:0   | R   | 0x0  | B_OUT.<br>B-Out[6:0] For Verify.                           |

#### 4.3.5.51. PLL\_CPU Pattern Control Register (Default Value: 0x00000000)

| Offset: 0x0280 |     |             | Register Name: PLL_CPU_PAT_CTRL_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave Step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32Khz<br>10: 32.5KHz<br>11: 33Khz        |
| 16:0           | R/W | 0x0         | WAVE_BOT.<br>Wave Bottom.  |

**4.3.5.52. PLL\_AUDIO Pattern Control Register(Default Value: 0x00000000)**

| Offset: 0x0284 |     |             | Register Name: <b>PLL_AUDIO_PAT_CTRL_REG</b>                                       |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave Step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz        |
| 16:0           | R/W | 0x0         | WAVE_BOT.<br>Wave Bottom.  |

**4.3.5.53. PLL\_VIDEO Pattern Control Register (Default Value: 0x00000000)**

| Offset: 0x0288 |     |             | Register Name: <b>PLL_VIDEO_PAT_CTRL_REG</b>                                       |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave Step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz        |

|      |     |     |                           |
|------|-----|-----|---------------------------|
| 16:0 | R/W | 0x0 | WAVE_BOT.<br>Wave Bottom. |
|------|-----|-----|---------------------------|

#### 4.3.5.54. PLL\_VE Pattern Control Register (Default Value: 0x00000000)

| Offset: 0x028C |     |             | Register Name: <b>PLL_VE_PAT_CTRL_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave Step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32Khz<br>10: 32.5KHz<br>11: 33Khz        |
| 16:0           | R/W | 0x0         | WAVE_BOT.<br>Wave Bottom.  |

#### 4.3.5.55. PLL\_DDR0 Pattern Control Register (Default Value: 0x00000000)

| Offset: 0x0290 |     |             | Register Name: <b>PLL_DDR0_PAT_CTRL_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.  |

|      |     |     |  |
|------|-----|-----|--|
|      |     |     | 00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz |
| 16:0 | R/W | 0x0 | WAVE_BOT.<br>Wave Bottom.                            |

#### 4.3.5.56. PLL\_ISP Pattern Control Register (Default Value: 0x00000000)

| Offset: 0x0298 |     |             | Register Name: <b>PLL_ISP_PAT_CTRL_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz        |
| 16:0           | R/W | 0x0         | WAVE_BOT.<br>Wave Bottom.  |

#### 4.3.5.57. PLL\_PERIPH1 Pattern Control Register (Default Value: 0x00000000)

| Offset: 0x02A4 |     |             | Register Name: <b>PLL_PERIPH1_PAT_CTRL_REG</b>                                     |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-Delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.   |

|       |     |     |   |
|-------|-----|-----|---|
|       |     |     | Wave Step.  |
| 19    | /   | /   | /   |
| 18:17 | R/W | 0x0 | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz |
| 16:0  | R/W | 0x0 | WAVE_BOT.<br>Wave Bottom.   |

#### 4.3.5.58. PLL\_DDR1 Pattern Control Register0 (Default Value: 0x00000000)

| Offset: 0x02AC |     |             | Register Name: <b>PLL_DDR1_PAT_CTRL_REG0</b>                                       |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | SIG_DELT_PAT_EN.<br>Sigma-Delta Pattern Enable.                                    |
| 30:29          | R/W | 0x0         | SPR_FREQ_MODE.<br>Spread Frequency Mode.<br>00: DC=0<br>01: DC=1<br>1X: Triangular |
| 28:20          | R/W | 0x0         | WAVE_STEP.<br>Wave Step.   |
| 19             | /   | /           | /  |
| 18:17          | R/W | 0x0         | FREQ.<br>Frequency.<br>00: 31.5KHz<br>01: 32KHz<br>10: 32.5KHz<br>11: 33KHz        |
| 16:0           | R/W | 0x0         | WAVE_BOT.<br>Wave Bottom.  |

#### 4.3.5.59. PLL\_DDR1 Pattern Control Register1 (Default Value: 0x00000000)

| Offset: 0x02B0 |     |             | Register Name: <b>PLL_DDR1_PAT_CTRL_REG1</b> |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description                                  |
| 30:25          | /   | /           | /  |
| 24             | R/W | 0x0         | DITHER_EN.                                   |
| 23:21          | /   | /           | /  |
| 20             | R/W | 0x0         | FRAC_EN.                                     |

|       |     |     |          |
|-------|-----|-----|----------|
| 19:17 | /   | /   | /        |
| 16:0  | R/W | 0x0 | FRAC_IN. |

#### 4.3.5.60. Bus Software Reset Register 0 (Default Value: 0x00000000)

| Offset: 0x02C0 |     |             | Register Name: <b>BUS_SOFT_RST_REG0</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:30          | /   | /           | /  |
| 29             | R/W | 0x0         | USB OTG_OHCI_RST.<br>USB OTG_OHCI Reset Control<br>0: Assert<br>1: De-assert     |
| 27:28          | /   | /           | /  |
| 26             | R/W | 0x0         | USB OTG_EHCI_RST.<br>USB OTG_EHCI Reset Control<br>0: Assert<br>1: De-assert     |
| 25             | /   | /           | /  |
| 24             | R/W | 0x0         | USB OTG_Device_RST.<br>USB OTG_Device Reset Control<br>0: Assert<br>1: De-assert |
| 23:21          | /   | /           | /  |
| 20             | R/W | 0x0         | SPI0_RST.<br>SPI0 Reset.<br>0: Assert<br>1: De-assert                            |
| 19             | R/W | 0x0         | HSTMR_RST.<br>HSTMR Reset.<br>0: Assert<br>1: De-assert                          |
| 18             | /   | /           | /  |
| 17             | R/W | 0x0         | EMAC_RST.<br>EMAC Reset.<br>0: Assert<br>1: De-assert                            |
| 16:15          | /   | /           | /  |
| 14             | R/W | 0x0         | SDRAM_RST.<br>SDRAM AHB Reset.<br>0: Assert<br>1: De-assert                      |
| 13:11          | /   | /           | /  |
| 10             | R/W | 0x0         | SD2_RST.   |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | SD/MMC2 Reset.<br>0: Assert<br>1: De-assert             |
| 9   | /   | /   | /   |
| 8   | R/W | 0x0 | SD0_RST.<br>SD/MMC0 Reset.<br>0: Assert<br>1: De-assert |
| 7   | /   | /   | /   |
| 6   | R/W | 0x0 | DMA_RST.<br>DMA Reset.<br>0: Assert<br>1: De-assert     |
| 5   | R/W | 0x0 | CE_RST.<br>CE Reset.<br>0: Assert<br>1: De-assert       |
| 4:0 | /   | /   | /   |

#### 4.3.5.61. Bus Software Reset Register 1 (Default Value: 0x00000000)

| Offset: 0x02C4 |     |             | Register Name: BUS_SOFT_RST_REG1                         |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0x0         | DBGSYS_RST.<br>DBGSYS Reset<br>0: Assert<br>1: De-assert |
| 30:13          | /   | /           | /  |
| 12             | R/W | 0x0         | DE_RST.<br>DE Reset.<br>0: Assert<br>1: De-assert        |
| 11:9           | /   | /           | /  |
| 8              | R/W | 0x0         | CSI_RST.<br>CSI Reset.<br>0: Assert<br>1: De-assert      |
| 7:5            | /   | /           |  |
| 4              | R/W | 0x0         | TCON_RST.<br>TCON Reset.<br>0: Assert<br>1: De-assert    |
| 3:1            | /   | /           | /  |

|   |     |     |   |
|---|-----|-----|---|
| 0 | R/W | 0x0 | VE_RST.<br>VE Reset.<br>0: Assert<br>1: De-assert |
|---|-----|-----|---|

#### 4.3.5.62. Bus Software Reset Register 2 (Default Value: 0x00000000)

| Offset: 0x02C8 |     |             | Register Name: <b>BUS_SOFT_RST_REG2</b>              |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:1           | /   | /           | /  |
| 0              | R/W | 0x0         | LVDS_RST<br>LVDS Reset.<br>0: Assert<br>1: De-assert |

#### 4.3.5.63. Bus Software Reset Register 3 (Default Value: 0x00000000)

| Offset: 0x02D0 |     |             | Register Name: <b>BUS_SOFT_RST_REG3</b>                                |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:13          | /   | /           | /  |
| 12             | R/W | 0x0         | I2S/PCM_RST.<br>I2S/PCM Reset.<br>0: Assert<br>1: De-assert            |
| 11:1           | /   | /           | /  |
| 0              | R/W | 0x0         | AC_DIG_RST.<br>Audio Codec Digital Reset.<br>0: Assert<br>1: De-assert |

#### 4.3.5.64. Bus Software Reset Register 4 (Default Value: 0x00000000)

| Offset: 0x02D8 |     |             | Register Name: <b>BUS_SOFT_RST_REG4</b>                 |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:19          | /   | /           | /   |
| 18             | R/W | 0x0         | UART2_RST.<br>UART2 Reset.<br>0: Assert<br>1: De-assert |
| 17             | R/W | 0x0         | UART1_RST.<br>UART1 Reset.<br>0: Assert                 |

|      |     |     |   |
|------|-----|-----|---|
|      |     |     | 1: De-assert  |
| 16   | R/W | 0x0 | UART0_RST.<br>UART0 Reset.<br>0: Assert<br>1: De-assert |
| 15:2 | /   | /   | /   |
| 1    | R/W | 0x0 | TWI1_RST.<br>TWI1 Reset.<br>0: Assert<br>1: De-assert   |
| 0    | R/W | 0x0 | TWIO_RST.<br>TWIO Reset.<br>0: Assert<br>1: De-assert   |

#### 4.3.5.65. PS Control Register (Default Value: 0x00000000)

| Offset: 0x0300 |     |             | Register Name: PS_CTRL_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7              | R/W | 0x0         | DET_FIN.<br>Detect Finish.<br>0: Unfinished<br>1: Finished<br>Setting 1 to this bit will clear it.                      |
| 6              | R/W | 0x0         | DLY_SEL.<br>Delay Select<br>0: 1 Cycle<br>1: 2 Cycles   |
| 5:4            | R/W | 0x0         | OSC_SEL<br>OSC Select.<br>00: IDLE<br>01: SVT<br>10: LVT<br>11: ULVT  |
| 3:1            | R/W | 0x0         | TIME_DET.<br>Time detect.<br>000: 0.5/4 us<br>001: 0.5/2 us<br>010: 0.5/1 us<br>011: 0.5*2us<br>.....<br>111: 0.5*2^5us |
| 0              | R/W | 0x0         | MOD_EN.   |

|  |  |  |   |
|--|--|--|---|
|  |  |  | Module enable.<br>0: Disable<br>1: Enable |
|--|--|--|---|

#### 4.3.5.66. PS Counter Register (Default Value: 0x00000000)

| Offset: 0x0304 |     |             | Register Name: PS_CNT_REG |
|----------------|-----|-------------|---------------------------|
| Bit            | R/W | Default/Hex | Description               |
| 31:16          | /   | /           | /                         |
| 15:0           | R/W | 0x0         | PS_CNT.<br>PS Counter.    |

### 4.3.6. Programming Guidelines

#### 4.3.6.1. PLL

- 1) In practical application, other PLLs doesn't support dynamic frequency scaling except for PLL\_CPU and PLL\_DDR1;
- 2) After the PLL\_DDR0 frequency changes, the 20-bit of PLL\_DDR0 Control Register should be written 1 to make it valid;
- 3) After the PLL\_DDR1 frequency changes, the 30-bit of PLL\_DDR1 Control Register should be written 1 to make it valid.

#### 4.3.6.2. BUS

- 1) When setting the BUS clock , you should set the division factor first, and after the division factor becomes valid, switch the clock source. The clock source will be switched after at least three clock cycles;
- 2) The BUS clock should not be dynamically changed in most applications.

#### 4.3.6.3. Clock Switch

Make sure that the clock source output is valid before the clock source switch, and then set a proper divide ratio; after the division factor becomes valid, switch the clock source.

#### 4.3.6.4. Gating and reset

Make sure that the reset signal has been released before the release of module clock gating;

## 4.4. System Control

### 4.4.1. Overview

| Area         | Size(Bytes) |
|--------------|-------------|
| SRAM A1      | 16K         |
| SRAM C       | 44K         |
| CPU I-Cache  | 32K         |
| CPU D-Cache  | 32K         |
| CPU L2 Cache | 128K        |
| Total        | 252K        |

### 4.4.2. System Control Register List

| Module Name    | Base Address |
|----------------|--------------|
| System Control | 0x01C00000   |

| Register Name | Offset | Description              |
|---------------|--------|--------------------------|
| VER_REG       | 0x24   | Version Register         |
| EMAC_CLK_REG  | 0x30   | EMAC-EPHY Clock Register |

### 4.4.3. System Control Register Description

#### 4.4.3.1. Version Register (Default Value: 0x00000000)

| Offset:0x24 |     |             | Register Name: VER_REG   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:9        | /   | /           | /  |
| 8           | R   | x           | UBOOT_SEL_PAD_STA.<br>U_boot Select Pin Status.<br>0: U_Boot<br>1: Normal Boot               |
| 7:0         | R   | 0x0         | VER_BITS.<br>This read-only bit field always reads back the mask revision level of the chip. |

**4.4.3.2. EMAC-EPHY Clock Register (Default Value: 0x00058000)**

| Offset:0x30 |     |             | Register Name: EMAC_EPHY_CLK_REG   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:28       | R/W | 0x0         | BPS_EFFUSE   |
| 27          | R/W | 0x0         | XMII_SEL<br>0: Internal SMI and MII<br>1: External SMI and MII   |
| 26:25       | R/W | 0x0         | EPHY_MODE<br>Operation Mode Selection<br>00 : Normal Mode<br>01 : Sim Mode<br>10 : AFE Test Mode<br>11 : /   |
| 24:20       | R/W | 0x0         | PHY_ADDR<br>PHY Address  |
| 19          | R/W | 0x0         | BIST_CLK_EN<br>0 : BIST clk disable<br>1 : BIST clk enable   |
| 18          | R/W | 0x1         | CLK_SEL<br>0 : 25MHz<br>1 : 24MHz  |
| 17          | R/W | 0x0         | LED_POL<br>0 : High active<br>1 : Low active   |
| 16          | R/W | 0x1         | SHUTDOWN<br>0 : Power up<br>1 : Shutdown   |
| 15          | R/W | 0x1         | PHY_SELECT.<br>0 : External PHY<br>1 : Internal PHY  |
| 14          | /   | /           | /  |
| 13          | R/W | 0x0         | RMII_EN<br>0 : Disable RMII Module<br>1 : Enable RMII Module<br>When this bit assert, MII or RGMII interface is disabled( This means bit13 is prior to bit2) |
| 12:10       | R/W | 0x0         | ETXDC.<br>Configure EMAC Transmit Clock Delay Chain.   |
| 9:5         | R/W | 0x0         | ERXDC.<br>Configure EMAC Receive Clock Delay Chain.  |
| 4           | R/W | 0x0         | ERXIE<br>Enable EMAC Receive Clock Invertor.<br>0: Disable   |

|     |     |     |  |
|-----|-----|-----|--|
|     |     |     | 1: Enable  |
| 3   | R/W | 0x0 | ETXIE<br>Enable EMAC Transmit Clock Invertor.<br>0: Disable<br>1: Enable   |
| 2   | R/W | 0x0 | EPIT<br>EMAC PHY Interface Type<br>0: MII<br>1: RGMII  |
| 1:0 | R/W | 0x0 | ETCS.<br>EMAC Transmit Clock Source<br>00: Transmit clock source for MII<br>01: External transmit clock source for GMII and RGMII<br>10: Internal transmit clock source for GMII and RGMII<br>11: Reserved |

## 4.5. Timer

### 4.5.1. Overview

Timer 0/1/2 can take their inputs from Internal OSC or OSC24M. They provide the operating system's scheduler interrupt. It is designed to offer maximum accuracy and efficient management, even for systems with long or short response time. They provide 24-bit programmable overflow counter and work in auto-reload mode or no-reload mode. When the current value in *Current Value Register* is counting down to zero, the timer will generate interrupt if set interrupt enable bit.

The watchdog is used to resume the controller operation when it had been disturbed by malfunctions such as noise and system errors. It features a down counter that allows a watchdog period of up to 16 seconds (512000 cycles). It can generate a general reset or interrupt request.

AVS counter is used to synchronize video and audio in the player.

### 4.5.2. Block Diagram

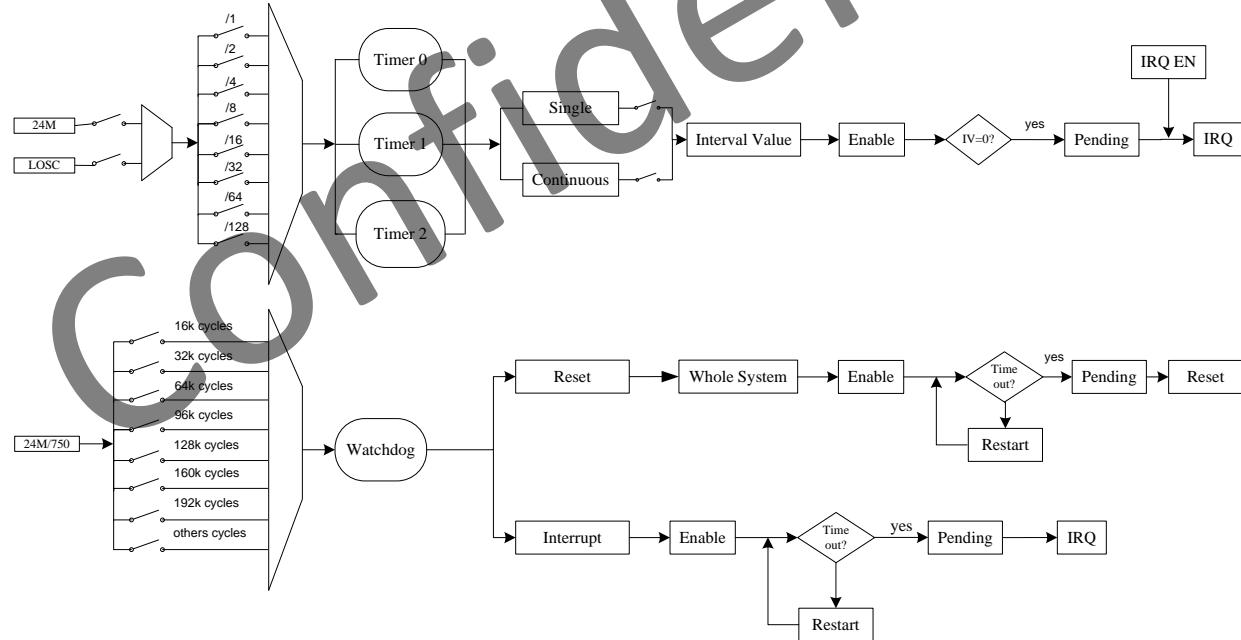


Figure 4-4. Timer Block Diagram

### 4.5.3. Timer Register List

| Module Name | Base Address |
|-------------|--------------|
| TIMER       | 0x01C20C00   |

| Register Name       | Offset | Description                       |
|---------------------|--------|-----------------------------------|
| TMR_IRQ_EN_REG      | 0x0    | Timer IRQ Enable Register         |
| TMR_IRQ_STA_REG     | 0x4    | Timer Status Register             |
| TMRO_CTRL_REG       | 0x10   | Timer 0 Control Register          |
| TMRO_INTV_VALUE_REG | 0x14   | Timer 0 Interval Value Register   |
| TMRO_CUR_VALUE_REG  | 0x18   | Timer 0 Current Value Register    |
| TMR1_CTRL_REG       | 0x20   | Timer 1 Control Register          |
| TMR1_INTV_VALUE_REG | 0x24   | Timer 1 Interval Value Register   |
| TMR1_CUR_VALUE_REG  | 0x28   | Timer 1 Current Value Register    |
| TMR2_CTRL_REG       | 0x30   | Timer 2 Control Register          |
| TMR2_INTV_VALUE_REG | 0x34   | Timer 2 Interval Value Register   |
| TMR2_CUR_VALUE_REG  | 0x38   | Timer 2 Current Value Register    |
| AVS_CNT_CTL_REG     | 0x80   | AVS Control Register              |
| AVS_CNT0_REG        | 0x84   | AVS Counter 0 Register            |
| AVS_CNT1_REG        | 0x88   | AVS Counter 1 Register            |
| AVS_CNT_DIV_REG     | 0x8C   | AVS Divisor Register              |
| WDOG_IRQ_EN_REG     | 0xA0   | Watchdog IRQ Enable Register      |
| WDOG_IRQ_STA_REG    | 0xA4   | Watchdog Status Register          |
| WDOG_CTRL_REG       | 0xB0   | Watchdog Control Register         |
| WDOG_CFG_REG        | 0xB4   | Watchdog Configuration Register   |
| WDOG_MODE_REG       | 0xB8   | Watchdog Mode Register            |
| CNT64_TEST_REG      | 0xD0   | 64-bit Counter Test Mode Register |
| CNT64_CTRL_REG      | 0xD4   | 64-bit Counter Control Register   |
| CNT64_LOW_REG       | 0xD8   | 64-bit Counter Low Register       |
| CNT64_HIGH_REG      | 0xDC   | 64-bit Counter High Register      |

#### 4.5.4. Timer Register Description

##### 4.5.4.1. Timer IRQ Enable Register (Default Value: 0x00000000)

| Offset:0x0 |     |             | Register Name: TMR_IRQ_EN_REG   |
|------------|-----|-------------|---|
| Bit        | R/W | Default/Hex | Description   |
| 31:3       | /   | /           | /   |
| 2          | R/W | 0x0         | TMR2_IRQ_EN.<br>Timer 2 Interrupt Enable.<br>0: No effect;<br>1: Timer 2 Interval Value reached interrupt enable. |
| 1          | R/W | 0x0         | TMR1_IRQ_EN.<br>Timer 1 Interrupt Enable.<br>0: No effect;<br>1: Timer 1 Interval Value reached interrupt enable. |
| 0          | R/W | 0x0         | TMRO_IRQ_EN.  |

|  |  |  |   |
|--|--|--|---|
|  |  |  | Timer 0 Interrupt Enable.<br>0: No effect;<br>1: Timer 0 Interval Value reached interrupt enable. |
|--|--|--|---|

#### 4.5.4.2. Timer IRQ Status Register (Default Value: 0x00000000)

| Offset:0x04 |     |             | Register Name: TMR_IRQ_STA_REG  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:3        | /   | /           | /   |
| 2           | R/W | 0x0         | TMR2_IRQ_PEND.<br>Timer 2 IRQ Pending. Set 1 to the bit will clear it.<br>0: No effect;<br>1: Pending, timer 2 interval value is reached. |
| 1           | R/W | 0x0         | TMR1_IRQ_PEND.<br>Timer 1 IRQ Pending. Set 1 to the bit will clear it.<br>0: No effect;<br>1: Pending, timer 1 interval value is reached. |
| 0           | R/W | 0x0         | TMR0_IRQ_PEND.<br>Timer 0 IRQ Pending. Set 1 to the bit will clear it.<br>0: No effect;<br>1: Pending, timer 0 interval value is reached. |

#### 4.5.4.3. Timer 0 Control Register (Default Value: 0x00000004)

| Offset:0x10 |     |             | Register Name: TMRO_CTRL_REG  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:8        | /   | /           | /   |
| 7           | R/W | 0x0         | TMRO_MODE.<br>Timer 0 mode.<br>0: Continuous mode. When interval value reached, the timer will not disable automatically.<br>1: Single mode. When interval value reached, the timer will disable automatically. |
| 6:4         | R/W | 0x0         | TMRO_CLK_PRES.<br>Select the pre-scale of timer 0 clock source.<br>000: /1<br>001: /2<br>010: /4<br>011: /8<br>100: /16<br>101: /32<br>110: /64   |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | 111: /128   |
| 3:2 | R/W | 0x1 | <p>TMRO_CLK_SRC.</p> <p>Timer 0 Clock Source.</p> <p>00: Internal OSC / 512</p> <p>01: OSC24M.</p> <p>10: /</p> <p>11: /</p> <p>Internal OSC / N is about 32KHz.</p>  |
| 1   | R/W | 0x0 | <p>TMRO_RELOAD.</p> <p>Timer 0 Reload.</p> <p>0: No effect</p> <p>1: Reload timer 0 Interval value.</p> <p>After the bit is set, it can not be written again before it's cleared automatically.</p>   |
| 0   | R/W | 0x0 | <p>TMRO_EN.</p> <p>Timer 0 Enable.</p> <p>0: Stop/Pause</p> <p>1: Start.</p> <p>When the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In timer pause state; the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.</p> |

#### 4.5.4.4. Timer 0 Interval Value Register

| Offset:0x14 |     |             | Register Name: <b>TMRO_INTV_VALUE_REG</b>  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:0        | R/W | 0x0         | <p>TMRO_INTV_VALUE.</p> <p>Timer 0 Interval Value.</p> <p>The value setting should consider the system clock and the timer clock source.</p> |

#### 4.5.4.5. Timer 0 Current Value Register

| Offset:0x18 |     |             | Register Name: <b>TMRO_CUR_VALUE_REG</b>             |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:0        | R/W | 0x0         | <p>TMRO_CUR_VALUE.</p> <p>Timer 0 Current Value.</p> |

|  |  |  |   |
|--|--|--|---|
|  |  |  | It is a 32-bit down-counter (from interval value to 0). |
|--|--|--|---|

#### 4.5.4.6. Timer 1 Control Register (Default Value: 0x00000004)

| Offset:0x20 |     |             | Register Name: TMR1_CTRL_REG   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:8        | /   | /           | /  |
| 7           | R/W | 0x0         | <p>TMR1_MODE.</p> <p>Timer 1 mode.</p> <p>0: Continuous mode. When interval value reached, the timer will not disable automatically.</p> <p>1: Single mode. When interval value reached, the timer will disable automatically.</p>   |
| 6:4         | R/W | 0x0         | <p>TMR1_CLK_PRES.</p> <p>Select the pre-scale of timer 1 clock source.</p> <p>000: /1<br/>001: /2<br/>010: /4<br/>011: /8<br/>100: /16<br/>101: /32<br/>110: /64<br/>111: /128</p>   |
| 3:2         | R/W | 0x1         | <p>TMR1_CLK_SRC.</p> <p>00: Internal OSC / 512<br/>01: OSC24M.<br/>10: /<br/>11: /.</p> <p>Internal OSC / N is about 32KHz.</p>  |
| 1           | R/W | 0x0         | <p>TMR1_RELOAD.</p> <p>Timer 1 Reload.</p> <p>0: No effect<br/>1: Reload timer 1 Interval value.</p> <p>After the bit is set, it can not be written again before it's cleared automatically.</p>   |
| 0           | R/W | 0x0         | <p>TMR1_EN.</p> <p>Timer 1 Enable.</p> <p>0: Stop/Pause<br/>1: Start.</p> <p>If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0.</p> <p>If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1.</p> |

|  |  |  |  |
|--|--|--|--|
|  |  |  | In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time. |
|--|--|--|--|

#### 4.5.4.7. Timer 1 Interval Value Register

| Offset:0x24 |     |             | Register Name: <b>TMR1_INTV_VALUE_REG</b>   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | 0x0         | TMR1_INTV_VALUE.<br>Timer 1 Interval Value.<br>The value setting should consider the system clock and the timer clock source. |

#### 4.5.4.8. Timer 1 Current Value Register

| Offset:0x28 |     |             | Register Name: <b>TMR1_CUR_VALUE_REG</b>   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:0        | R/W | 0x0         | TMR1_CUR_VALUE.<br>Timer 1 Current Value.<br>It is a 32-bit down-counter (from interval value to 0). |

#### 4.5.4.9. Timer 2 Control Register

| Offset:0x30 |     |             | Register Name: <b>TMR2_CTRL_REG</b>   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:8        | /   | /           | /   |
| 7           | R/W | 0x0         | TMR2_MODE.<br>Timer 2 mode.<br>0: Continuous mode. When interval value reached, the timer will not disable automatically.<br>1: Single mode. When interval value reached, the timer will disable automatically. |
| 6:4         | R/W | 0x0         | TMR2_CLK_PRES.<br>Select the pre-scale of timer 2 clock source.<br>000: /1<br>001: /2<br>010: /4<br>011: /8<br>100: /16<br>101: /32   |

|     |     |     |  |
|-----|-----|-----|--|
|     |     |     | 110: /64<br>111: /128  |
| 3:2 | R/W | 0x1 | TMR2_CLK_SRC.<br>00: Internal OSC / 512<br>01: OSC24M.<br>10: /<br>11: /.  |
| 1   | R/W | 0x0 | TMR2_RELOAD.<br>Timer 2 Reload.<br>0: No effect, 1: Reload timer 2 Interval value.<br>After the bit is set, it can not be written again before it's cleared automatically.   |
| 0   | R/W | 0x0 | TMR2_EN.<br>Timer 2 Enable.<br>0: Stop/Pause, 1: Start.<br>If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0.<br>If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1.<br>In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time. |

#### 4.5.4.10. Timer 2 Interval Value Register

| Offset:0x34 |     |             | Register Name: TMR2_INTV_VALUE_REG  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | 0x0         | TMR2_INTV_VALUE.<br>Timer 2 Interval Value.<br>The value setting should consider the system clock and the timer clock source. |

#### 4.5.4.11. Timer 2 Current Value Register

| Offset:0x38 |     |             | Register Name: TMR2_CUR_VALUE_REG   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | 0x0         | TMR2_CUR_VALUE.<br>Timer 2 Current Value.<br>Timer 2 current value is a 32-bit down-counter (from interval value to 0). |

#### 4.5.4.12. AVS Counter Control Register (Default Value: 0x00000000)

| Offset:0x80 |     |             | Register Name: AVS_CNT_CTL_REG  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:10       | /   | /           | /   |
| 9           | R/W | 0x0         | AVS_CNT1_PS.<br>Audio/Video Sync Counter 1 Pause Control<br>0: Not pause<br>1: Pause Counter 1.                       |
| 8           | R/W | 0x0         | AVS_CNT0_PS.<br>Audio/Video Sync Counter 0 Pause Control<br>0: Not pause<br>1: Pause Counter 0.                       |
| 7:2         | /   | /           | /   |
| 1           | R/W | 0x0         | AVS_CNT1_EN.<br>Audio/Video Sync Counter 1 Enable/ Disable. The counter source is OSC24M.<br>0: Disable<br>1: Enable. |
| 0           | R/W | 0x0         | AVS_CNT0_EN.<br>Audio/Video Sync Counter 0 Enable/ Disable. The counter source is OSC24M.<br>0: Disable<br>1: Enable. |

#### 4.5.4.13. AVS Counter 0 Register (Default Value: 0x00000000)

| Offset:0x84 |     |             | Register Name: AVS_CNT0_REG   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | 0x0         | AVS_CNT0.<br>Counter 0 for Audio/ Video Sync Application<br>The high 32 bits of the internal 33-bits counter register. The initial value of the internal 33-bits counter register can be set by software. The LSB bit of the 33-bits counter register should be zero when the initial value is updated. It will count from the initial value. The initial value can be updated at any time. It can also be paused by setting AVS_CNT0_PS to '1'. When it is paused, the counter won't increase. |

#### 4.5.4.14. AVS Counter 1 Register (Default Value: 0x00000000)

| Offset:0x88 |     |             | Register Name: AVS_CNT1_REG   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | 0x0         | AVS_CNT1.<br>Counter 1 for Audio/ Video Sync Application<br>The high 32 bits of the internal 33-bits counter register. The initial value of |

|  |  |  |   |
|--|--|--|---|
|  |  |  | the internal 33-bits counter register can be set by software. The LSB bit of the 33-bits counter register should be zero when the initial value is updated. It will count from the initial value. The initial value can be updated at any time. It can also be paused by setting AVS_CNT1_PS to '1'. When it is paused, the counter won't increase. |
|--|--|--|---|

#### 4.5.4.15. AVS Counter Divisor Register (Default Value: 0x05DB05DB)

| Offset:0x8C |     |             | Register Name: <b>AVS_CNT_DIV_REG</b>   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:28       | /   | /           | /   |
| 27:16       | R/W | 0x5DB       | <p>AVS_CNT1_D.<br/>Divisor N for AVS Counter 1<br/>AVS CN1 CLK=24MHz/Divisor_N1.<br/>Divisor N1 = Bit [27:16] + 1.<br/>The number N is from 1 to 0x7ff. The zero value is reserved.<br/>The internal 33-bits counter engine will maintain another 12-bit counter. The 12-bit counter is used for counting the cycle number of one 24MHz clock. When the 12-bit counter reaches (&gt;= N) the divisor value, the internal 33-bit counter register will increase 1 and the 12-bit counter will reset to zero and restart again.<br/>It can be configured by software at any time.</p> |
| 15:12       | /   | /           | /   |
| 11:0        | R/W | 0x5DB       | <p>AVS_CNT0_D.<br/>Divisor N for AVS Counter 0<br/>AVS CNO CLK=24MHz/Divisor_N0.<br/>Divisor N0 = Bit [11:0] + 1<br/>The number N is from 1 to 0x7ff. The zero value is reserved.<br/>The internal 33-bit counter engine will maintain another 12-bit counter. The 12-bit counter is used for counting the cycle number of one 24MHz clock. When the 12-bit counter reaches (&gt;= N) the divisor value, the internal 33-bit counter register will increase 1 and the 12-bits counter will reset to zero and restart again.<br/>It can be configured by software at any time.</p>   |

#### 4.5.4.16. Watchdog IRQ Enable Register (Default Value: 0x00000000)

| Offset:0xA0 |     |             | Register Name: <b>WDOG_IRQ_EN_REG</b>      |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description                                |
| 31:1        | /   | /           | /  |
| 0           | R/W | 0x0         | WDOG_IRQ_EN.<br>Watchdog Interrupt Enable. |

|  |  |  |  |
|--|--|--|--|
|  |  |  | 0: No effect<br>1: Watchdog0 interrupt enable. |
|--|--|--|--|

#### 4.5.4.17. Watchdog Status Register (Default Value: 0x00000000)

| Offset:0xA4 |     |             | Register Name: WDOG_IRQ_STA_REG  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:1        | /   | /           | /  |
| 0           | R/W | 0x0         | WDOG_IRQ_PEND.<br>Watchdog IRQ Pending. Set 1 to the bit will clear it.<br>0: No effect,<br>1: Pending, watchdog0 interval value is reached. |

#### 4.5.4.18. Watchdog Control Register (Default Value: 0x00000000)

| Offset:0xB0 |     |             | Register Name: WDOG_CTRL_REG  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:13       | /   | /           | /   |
| 12:1        | R/W | 0x0         | WDOG_KEY_FIELD.<br>Watchdog Key Field.<br>Should be written at value 0xA57. Writing any other value in this field aborts the write operation. |
| 0           | R/W | 0x0         | WDOG_RSTSTART.<br>Watchdog Restart.<br>0: No effect,<br>1: Restart watchdog.  |

#### 4.5.4.19. Watchdog Configuration Register (Default Value: 0x00000001)

| Offset:0xB4 |     |             | Register Name: WDOG_CFG_REG  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:2        | /   | /           | /  |
| 1:0         | R/W | 0x1         | WDOG_CONFIG.<br>Watchdog generates a reset signal<br>00: /<br>01: To whole system<br>10: Only interrupt<br>11: / |

**4.5.4.20. Watchdog Mode Register (Default Value: 0x00000000)**

| Offset:0xB8 |     |             | Register Name: <b>WDOG_MODE_REG</b>  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:8        | /   | /           | /  |
| 7:4         | R/W | 0x0         | <p><b>WDOG_INTV_VALUE.</b><br/>                     Watchdog Interval Value<br/>                     Watchdog clock source is <i>OSC24M / 750</i>. If the clock source is turned off, Watchdog will not work.</p> <p>0000: 16000 cycles (0.5s)<br/>                     0001: 32000 cycles (1s)<br/>                     0010: 64000 cycles (2s)<br/>                     0011: 96000 cycles (3s)<br/>                     0100: 128000 cycles (4s)<br/>                     0101: 160000 cycles (5s)<br/>                     0110: 192000 cycles (6s)<br/>                     0111: 256000 cycles (8s)<br/>                     1000: 320000 cycles (10s)<br/>                     1001: 384000 cycles (12s)<br/>                     1010: 448000 cycles (14s)<br/>                     1011: 512000 cycles (16s)<br/>                     others; /</p> |
| 3:1         | /   | /           | /  |
| 0           | R/W | 0x0         | <p><b>WDOG_EN.</b><br/>                     Watchdog Enable.<br/>                     0: No effect;<br/>                     1: Enable watchdog.</p>   |

**4.5.4.21. 64-bit Counter Control Register (Default Value: 0x00000000)**

| Offset:0xD0 |     |             | Register Name: <b>CNT64_CTRL_REG</b>   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31          | R/W | 0x0         | <p><b>CNT64_TEST_EN.</b><br/>                     64-bit Counter Test Mode Enable.<br/>                     0: Normal Mode,<br/>                     1: Test Mode.<br/>                     In the Test Mode, this Counter Low/Hi registers will count simultaneously.</p> |
| 30:3        | /   | /           | /.   |
| 2           | R/W | 0x0         | <p><b>CNT64_CLK_SRC_SEL.</b><br/>                     64-bit Counter Clock Source Select.<br/>                     0: OSC24M<br/>                     1: /</p>   |
| 1           | R/W | 0x0         | <b>CNT64_RL_EN.</b>  |

|   |     |     |  |
|---|-----|-----|--|
|   |     |     | 64-bit Counter Read Latch Enable.<br>0: no effect, 1: to latch the 64-bit Counter to the Low/Hi registers and it will change to zero after the registers are latched.  |
| 0 | R/W | 0x0 | CNT64_CLR_EN.<br>64-bit Counter Clear Enable.<br>0: no effect, 1: to clear the 64-bit Counter Low/Hi registers and it will change to zero after the registers are cleared.<br>It is not recommended to clear this counter arbitrarily. |

#### 4.5.4.22. 64-bit Counter Low Register (Default Value: 0x00000000)

| Offset:0xD4 |     |             | Register Name: CNT64_LOW_REG        |
|-------------|-----|-------------|-------------------------------------|
| Bit         | R/W | Default/Hex | Description                         |
| 31:0        | R/W | 0x0         | CNT64_LO.<br>64-bit Counter [31:0]. |

#### 4.5.4.23. 64-bit Counter High Register (Default Value: 0x00000000)

| Offset:0xD8 |     |             | Register Name: CNT64_HIGH_REG        |
|-------------|-----|-------------|--------------------------------------|
| Bit         | R/W | Default/Hex | Description                          |
| 31:0        | R/W | 0x0         | CNT64_HI.<br>64-bit Counter [63:32]. |

## 4.6. High-speed Timer

### 4.6.1. Overview

High Speed Timer Clock Source is fixed to AHBCLK, which is much higher than OSC24M. Compared with other timers, High Speed Timer clock source is synchronized with AHB clock, and when the relevant bit in the Control Register is set 1, timer goes into the test mode, which is used to System Simulation. When the current value in both LO and HI Current Value Register are counting down to zero, the timer will generate interrupt if set interrupt enable bit.

The High Speed Timer includes the following features:

- 56-bit counter
- Clock source is synchronized with AHB clock, which means calculating much more accurate than other timers

### 4.6.2. Operation Principle

#### 4.6.2.1. HSTimer Clock Gating and Software Reset

By default the HSTimer clock gating is mask. When it is necessary to use HSTimer, its clock gating should be open in **BUS Clock Gating Register0** and then de-assert the software reset in **BUS Software Reset Register0** on CCU module. If it is no need to use HSTimer, both the gating bit and software reset bit should be set 0.

#### 4.6.2.2. HSTimer Reload Bit

Differing from the reload of Timer, when interval value is reloaded into current value register, the reload bit would not turn to 0 automatically until you clear it. If software hopes the current value register to down-count from the new interval value in pause status, the reload bit and the enable bit should be written 1 at the same time.

### 4.6.3. HSTimer Register List

| Module Name      | Base Address |
|------------------|--------------|
| High Speed Timer | 0x01C60000   |

| Register Name       | Offset | Description                            |
|---------------------|--------|--|
| HS_TMR_IRQ_EN_REG   | 0x00   | HS Timer IRQ Enable Register           |
| HS_TMR_IRQ_STAS_REG | 0x04   | HS Timer Status Register               |
| HS_TMR0_CTRL_REG    | 0x10   | HS Timer0 Control Register             |
| HS_TMR0_INTV_LO_REG | 0x14   | HS Timer0 Interval Value Low Register  |
| HS_TMR0_INTV_HI_REG | 0x18   | HS Timer0 Interval Value High Register |

|                      |      |  |
|----------------------|------|--|
| HS_TMR0_CURNT_LO_REG | 0x1C | HS Timer0 Current Value Low Register   |
| HS_TMR0_CURNT_HI_REG | 0x20 | HS Timer0 Current Value High Register  |
| HS_TMR1_CTRL_REG     | 0x30 | HS Timer1 Control Register             |
| HS_TMR1_INTV_LO_REG  | 0x34 | HS Timer1 Interval Value Low Register  |
| HS_TMR1_INTV_HI_REG  | 0x38 | HS Timer1 Interval Value High Register |
| HS_TMR1_CURNT_LO_REG | 0x3C | HS Timer1 Current Value Low Register   |
| HS_TMR1_CURNT_HI_REG | 0x40 | HS Timer1 Current Value High Register  |

#### 4.6.4. HSTimer Register Description

##### 4.6.4.1. HS Timer IRQ Enable Register (Default Value: 0x00000000)

| Offset:0x0 |     |             | Register Name: HS_TMR_IRQ_EN_REG   |
|------------|-----|-------------|--|
| Bit        | R/W | Default/Hex | Description  |
| 31:2       | /   | /           | /  |
| 1          | R/W | 0x0         | HS_TMR1_INT_EN.<br>High Speed Timer1 Interrupt Enable.<br>0: No effect<br>1: High Speed Timer1 Interval Value reached interrupt enable |
| 0          | R/W | 0x0         | HS_TMR0_INT_EN.<br>High Speed Timer0 Interrupt Enable.<br>0: No effect<br>1: High Speed Timer0 Interval Value reached interrupt enable |

##### 4.6.4.2. HS Timer IRQ Status Register (Default Value: 0x00000000)

| Offset:0x4 |     |             | Register Name: HS_TMR_IRQ_STAS_REG   |
|------------|-----|-------------|--|
| Bit        | R/W | Default/Hex | Description  |
| 31:2       | /   | /           | /  |
| 1          | R/W | 0x0         | HS_TMR1_IRQ_PEND.<br>High Speed Timer1 IRQ Pending. Setting 1 to the bit will clear it.<br>0: No effect<br>1: Pending, High speed timer interval value is reached. |
| 0          | R/W | 0x0         | HS_TMR0_IRQ_PEND.<br>High Speed Timer0 IRQ Pending. Setting 1 to the bit will clear it.<br>0: No effect<br>1: Pending, High speed timer interval value is reached. |

##### 4.6.4.3. HS Timer0 Control Register (Default Value: 0x00000000)

|             |                                 |
|-------------|---------------------------------|
| Offset:0x10 | Register Name: HS_TMR0_CTRL_REG |
|-------------|---------------------------------|

| Bit  | R/W | Default/Hex | Description   |
|------|-----|-------------|---|
| 31   | R/W | 0x0         | <p>HS_TMR0_TEST.</p> <p>High Speed Timer0 Test Mode.</p> <p>In test mode, the low register should be set to 0x1, the high register will down counter. The counter needs to be reloaded.</p> <p>0: Normal mode<br/>1: Test mode</p>  |
| 30:8 | /   | /           | /   |
| 7    | R/W | 0x0         | <p>HS_TMR0_MODE.</p> <p>High Speed Timer0 Mode.</p> <p>0: Continuous mode. When interval value reached, the timer will not disable automatically.<br/>1: Single mode. When interval value reached, the timer will disable automatically.</p>  |
| 6:4  | R/W | 0x0         | <p>HS_TMR0_CLK</p> <p>Select the pre-scale of the high speed timer0 clock sources.</p> <p>000: /1<br/>001: /2<br/>010: /4<br/>011: /8<br/>100: /16<br/>101: /<br/>110: /<br/>111: /</p>   |
| 3:2  | /   | /           | /   |
| 1    | R/W | 0x0         | <p>HS_TMR0_RELOAD.</p> <p>High Speed Timer0 Reload.</p> <p>0: No effect<br/>1: Reload High Speed Timer0 Interval Value.</p>   |
| 0    | R/W | 0x0         | <p>HS_TMR0_EN.</p> <p>High Speed Timer0 Enable.</p> <p>0: Stop/Pause<br/>1: Start.</p> <p>If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0.</p> <p>If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1.</p> <p>In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.</p> |

#### 4.6.4.4. HS Timer0 Interval Value Lo Register

| Offset:0x14 |     |             | Register Name: <b>HS_TMR0_INTV_LO_REG</b>                         |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | x           | HS_TMR0_INTV_VALUE_LO.<br>High Speed Timer Interval Value [31:0]. |

#### 4.6.4.5. HS Timer0 Interval Value Hi Register

| Offset:0x18 |     |             | Register Name: <b>HS_TMR0_INTV_HI_REG</b>                           |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:24       | /   | /           | /   |
| 23:0        | R/W | x           | HS_TMR0_INTV_VALUE_HI.<br>High Speed Timer0 Interval Value [55:32]. |

The interval value register is a 56-bit register. When read or write the interval value, the Lo register should be read or written first. And the Hi register should be written after the Lo register.

#### 4.6.4.6. HS Timer0 Current Value Lo Register

| Offset:0x1C |     |             | Register Name: <b>HS_TMR0_CURNT_LO_REG</b>                       |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:0        | R/W | x           | HS_TMR0_CUR_VALUE_LO.<br>High Speed Timer0 Current Value [31:0]. |

#### 4.6.4.7. HS Timer0 Current Value Hi Register

| Offset:0x20 |     |             | Register Name: <b>HS_TMR0_CURNT_HI_REG</b>                        |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:24       | /   | /           | /   |
| 23:0        | R/W | x           | HS_TMR0_CUR_VALUE_HI.<br>High Speed Timer0 Current Value [55:32]. |

HSTimer0 current value is a 56-bit down-counter (from interval value to 0).

The current value register is a 56-bit register. When read or write the current value, the Lo register should be read or written first.

#### 4.6.4.8. HS Timer1 Control Register (Default Value: 0x00000000)

| Offset:0x30 |     |             | Register Name: <b>HS_TMR1_CTRL_REG</b> |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description                            |

|      |     |     |   |
|------|-----|-----|---|
| 31   | R/W | 0x0 | HS_TMR1_TEST.<br>High Speed Timer1 Test Mode.<br>In test mode, the low register should be set to 0x1, the high register will down counter. The counter needs to be reloaded.<br>0: normal mode;<br>1: test mode.  |
| 30:8 | /   | /   | /   |
| 7    | R/W | 0x0 | HS_TMR1_MODE.<br>High Speed Timer1 Mode.<br>0: Continuous mode. When interval value reached, the timer will not disable automatically.<br>1: Single mode. When interval value reached, the timer will disable automatically.  |
| 6:4  | R/W | 0x0 | HS_TMR1_CLK<br>Select the pre-scale of the high speed timer1 clock sources.<br>000: /1<br>001: /2<br>010: /4<br>011: /8<br>100: /16<br>101: /<br>110: /<br>111: /   |
| 3:2  | /   | /   | /   |
| 1    | R/W | 0x0 | HS_TMR1_RELOAD.<br>High Speed Timer1 Reload.<br>0: No effect<br>1: Reload High Speed Timer1 Interval Value.   |
| 0    | R/W | 0x0 | HS_TMR1_EN.<br>High Speed Timer1 Enable.<br>0: Stop/Pause<br>1: Start.<br>If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0.<br>If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1.<br>In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time. |

#### 4.6.4.9. HS Timer1 Interval Value Lo Register

| Offset:0x34 |     |             | Register Name: <b>HS_TMR1_INTV_LO_REG</b>                         |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:0        | R/W | x           | HS_TMR0_INTV_VALUE_LO.<br>High Speed Timer Interval Value [31:0]. |

#### 4.6.4.10. HS Timer1 Interval Value Hi Register

| Offset:0x38 |     |             | Register Name: <b>HS_TMR1_INTV_HI_REG</b>                           |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:24       | /   | /           | /   |
| 23:0        | R/W | x           | HS_TMR1_INTV_VALUE_HI.<br>High Speed Timer1 Interval Value [55:32]. |

The interval value register is a 56-bit register. When read or write the interval value, the Lo register should be read or written first. And the Hi register should be written after the Lo register.

#### 4.6.4.11. HS Timer1 Current Value Lo Register

| Offset:0x3C |     |             | Register Name: <b>HS_TMR1_CURNT_LO_REG</b>                       |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31:0        | R/W | x           | HS_TMR1_CUR_VALUE_LO.<br>High Speed Timer1 Current Value [31:0]. |

#### 4.6.4.12. HS Timer1 Current Value Hi Register

| Offset:0x40 |     |             | Register Name: <b>HS_TMR1_CURNT_HI_REG</b>                        |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:24       | /   | /           | /   |
| 23:0        | R/W | x           | HS_TMR1_CUR_VALUE_HI.<br>High Speed Timer1 Current Value [55:32]. |

HS timer1 current value is a 56-bit down-counter (from interval value to 0).

The current value register is a 56-bit register. When read or write the current value, the Lo register should be read or written first.

### 4.6.5. Programming Guidelines

Take making a 1us delay using HSTimer for an instance as follow, AHB1CLK will be configurated as 100MHz and n\_mode, Single mode and 2 pre-scale will be selected in this instance.

```
writel(0x0, HS_TMR_INTV_HI);           //Set interval value Hi 0x0
writel(0x32, HS_TMR_INTV_LO);          //Set interval value Lo 0x32
writel(0x90, HS_TMR_CTRL);             //Select n_mode,2 pre-scale,single mode
writel(readl(HS_TMR_CTRL)|(1<<1), HS_TMR_CTRL); //Set Reload bit
writel(readl(HS_TMR_CTRL)|(1<<0), HS_TMR_CTRL); //Enable HSTimer
While(!(readl(HS_TMR_IRQ_STAT)&1));    //Wait for HSTimer to generate pending
Writel(1,HS_TMR_IRQ_STAT);             //Clear HSTimer pending
```

Confidential

## 4.7. PWM

### 4.7.1. Overview

The output of the PWM is a toggling signal whose frequency and duty cycle can be modulated by its programmable registers. Each channel has a dedicated internal 16-bit up counter. If the counter reaches the value stored in the channel period register, it resets. At the beginning of a count period cycle, the PWMOUT is set to active state and count from 0x0000. The PWM divider divides the clock(24MHz) by 1~4096 according to the pre-scalar bits in the PWM control register.

In PWM cycle mode, the output will be a square waveform, the frequency is set to the period register. In PWM pulse mode, the output will be a positive pulse or a negative pulse.

### 4.7.2. Functionalities Description

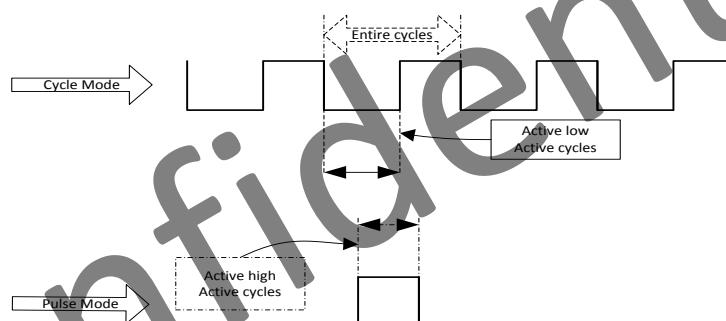


Figure 4-5. PWM Block Diagram

When PWM is enabling, the PWM can output two signals, which are reversed on two pins. And when PWM is disabling, the PWM can control the status of two pins. The PWM divider divides the clock (24MHz) by 1-64 according to the pre-scalar bits in the PWM control register. The PWM output Frequency can be divided by 65536 at most. In PWM cycle mode, the output will be a square waveform; the frequency is set to the period register. In PWM pulse mode, the output will be a positive pulse or a negative pulse.

### 4.7.3. PWM Register List

| Module Name | Base Address |
|-------------|--------------|
| PWM         | 0x01C21400   |

| Register Name  | Offset | Description                   |
|----------------|--------|-------------------------------|
| PWM_CH_CTRL    | 0x00   | PWM Control Register          |
| PWM_CH0_PERIOD | 0x04   | PWM Channel 0 Period Register |

|                |      |                               |
|----------------|------|-------------------------------|
| PWM_CH1_PERIOD | 0x08 | PWM Channel 1 Period Register |
|----------------|------|-------------------------------|

#### 4.7.4. PWM Register Description

##### 4.7.4.1. PWM Control Register(Default Value: 0x00000000)

| Offset:0x0 |     |             | Register Name: PWM_CTRL_REG  |
|------------|-----|-------------|--|
| Bit        | R/W | Default/Hex | Description  |
| 31:30      | /   | /           | /.   |
| 29         | RO  | 0x0         | PWM1_RDY.<br>PWM1 Period Register Ready.<br>0: PWM1 period register is ready to write,<br>1: PWM1 period register is busy.   |
| 28         | RO  | 0x0         | PWM0_RDY.<br>PWM0 Period Register Ready.<br>0: PWM0 period register is ready to write<br>1: PWM0 period register is busy   |
| 27:25      | /   | /           | /  |
| 24         | R/W | 0x0         | PWM1_BYPASS.<br>PWM CH1 Bypass Enable.<br>If the bit is set to 1, PWM1's output is OSC24MHz.<br>0: Disable<br>1: Enable  |
| 23         | R/W | 0x0         | PWM_CH1_PULSE_OUT_START.<br>PWM Channel 1 Pulse Output Start.<br>0: No effect<br>1: Output 1 pulse<br>The pulse width should be according to the period 1 register[15:0],and the pulse state should be according to the active state.<br>After the pulse is finished, the bit will be cleared automatically. |
| 22         | R/W | 0x0         | PWM_CH1_MODE.<br>PWM Channel 1 Mode.<br>0: Cycle mode<br>1: Pulse mode   |
| 21         | R/W | 0x0         | PWM_CH1_CLK_GATING<br>Gating the Special Clock for PWM1(0: mask, 1: pass).   |
| 20         | R/W | 0x0         | PWM_CH1_ACT_STATE.<br>PWM Channel 1 Active State.<br>0: Low Level<br>1: High Level   |
| 19         | R/W | 0x0         | PWM_CH1_EN.<br>PWM Channel 1 Enable.<br>0: Disable<br>1: Enable  |

|       |     |     |   |
|-------|-----|-----|---|
| 18:15 | R/W | 0x0 | PWM_CH1_PRESCAL.<br>PWM Channel 1 Prescalar.<br>These bits should be setting before the PWM Channel 1 clock gate on.<br>0000: /120<br>0001: /180<br>0010: /240<br>0011: /360<br>0100: /480<br>0101: /<br>0110: /<br>0111: /<br>1000: /12k<br>1001: /24k<br>1010: /36k<br>1011: /48k<br>1100: /72k<br>1101: /<br>1110: /<br>1111: /1 |
| 14:10 | /   | /   | /   |
| 9     | R/W | 0x0 | PWM0_BYPASS.<br>PWM CH0 Bypass Enable.<br>If the bit is set to 1, PWM0's output is OSC24MHz.<br>0: Disable<br>1: Enable   |
| 8     | R/W | 0x0 | PWM_CH0_PUL_START.<br>PWM Channel 0 Pulse Output Start.<br>0: No effect<br>1: Output 1 pulse<br>The pulse width should be according to the period 0 register[15:0],and the pulse state should be according to the active state.<br>After the pulse is finished,the bit will be cleared automatically.                               |
| 7     | R/W | 0x0 | PWM_CHANNEL0_MODE.<br>0: Cycle mode<br>1: Pulse mode  |
| 6     | R/W | 0x0 | SCLK_CH0_GATING.<br>Gating the Special Clock for PWM0(0: mask, 1: pass).  |
| 5     | R/W | 0x0 | PWM_CH0_ACT_STA.<br>PWM Channel 0 Active State.<br>0: Low Level<br>1: High Level  |
| 4     | R/W | 0x0 | PWM_CH0_EN.<br>PWM Channel 0 Enable.<br>0: Disable<br>1: Enable   |

|     |     |     |   |
|-----|-----|-----|---|
| 3:0 | R/W | 0x0 | PWM_CH0_PRESCAL.<br>PWM Channel 0 Prescalar.<br>These bits should be setting before the PWM Channel 0 clock gate on.<br>0000: /120<br>0001: /180<br>0010: /240<br>0011: /360<br>0100: /480<br>0101: /<br>0110: /<br>0111: /<br>1000: /12k<br>1001: /24k<br>1010: /36k<br>1011: /48k<br>1100: /72k<br>1101: /<br>1110: /<br>1111: /1 |
|-----|-----|-----|---|

#### 4.7.4.2. PWM Channel 0 Period Register

| Offset:0x4 |     |             | Register Name: PWM_CH0_PERIOD   |
|------------|-----|-------------|---|
| Bit        | R/W | Default/Hex | Description   |
| 31:16      | R/W | x           | PWM_CH0_ENTIRE_CYS<br>Number of the entire cycles in the PWM clock.<br>0 = 1 cycle<br>1 = 2 cycles<br>.....<br>N = N+1 cycles<br>If the register need to be modified dynamically, the PCLK should be faster than the PWM CLK (PWM CLK = 24MHz/pre-scale). |
| 15:0       | R/W | x           | PWM_CH0_ENTIRE_ACT_CYS<br>Number of the active cycles in the PWM clock.<br>0 = 0 cycle<br>1 = 1 cycles<br>.....<br>N = N cycles   |

The active cycles should be no larger than the period cycles.

#### 4.7.4.3. PWM Channel 1 Period Register

| Offset:0x8 |     |             | Register Name: PWM_CH1_PERIOD   |
|------------|-----|-------------|---|
| Bit        | R/W | Default/Hex | Description   |
| 31:16      | R/W | x           | PWM_CH1_ENTIRE_CYS<br>Number of the entire cycles in the PWM clock.<br>0 = 1 cycle<br>1 = 2 cycles<br>.....<br>N = N+1 cycles<br>If the register need to be modified dynamically, the PCLK should be faster than the PWM CLK (PWM CLK = 24MHz/pre-scale). |
| 15:0       | R/W | x           | PWM_CH1_ENTIRE_ACT_CYS<br>Number of the active cycles in the PWM clock.<br>0 = 0 cycle<br>1 = 1 cycles<br>.....<br>N = N cycles   |

The active cycles should be no larger than the period cycles.

## 4.8. DMA

### 4.8.1. Overview

There are 8 DMA channels in the chip. Each DMA channel can generate interrupts. According to different pending status, the referenced DMA channel generates corresponding interrupt. And, the configuration information of every DMA channel are storing in the DDR or SRAM. When start a DMA transferring, the **DMA Channel Descriptor Address Register** contains the address information in the DDR or SRAM, where has the relevance configuration information of the DMA transferring.

### 4.8.2. Functionalities Description

#### 4.8.2.1. Block Diagram

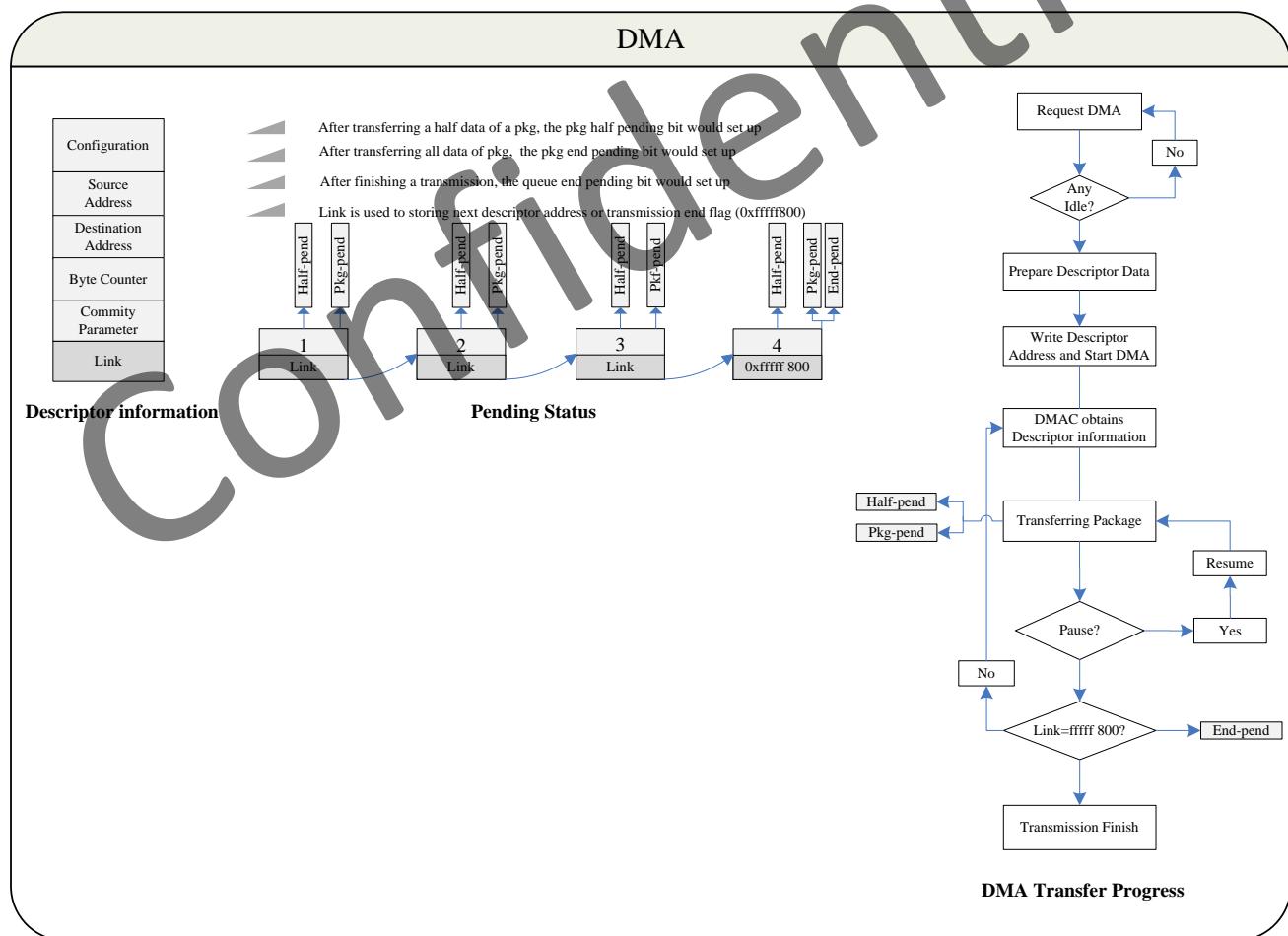


Figure 4-6. DMA Block Diagram

#### 4.8.2.2. DRQ Type and Corresponding Relation

Table 4-1. DMA DRQ Table

| Source DRQ Type |                    | Destination DRQ Type |                    |
|-----------------|--------------------|----------------------|--------------------|
| Port NO.        | Module Name        | Port NO.             | Module Name        |
| Port 0          | SRAM               | Port 0               | SRAM               |
| Port 1          | SDRAM              | Port 1               | SDRAM              |
| Port 2          |                    | Port 2               |                    |
| Port 3          | I2S/PCM_RX         | Port 3               | I2S/PCM_TX         |
| Port 4          |                    | Port 4               |                    |
| Port 5          |                    | Port 5               |                    |
| Port 6          | UART0_RX           | Port 6               | UART0_TX           |
| Port 7          | UART1_RX           | Port 7               | UART1_TX           |
| Port 8          | UART2_RX           | Port 8               | UART2_TX           |
| Port 9          | /                  | Port 9               | /                  |
| Port 10         | /                  | Port 10              | /                  |
| Port 11         | /                  | Port 11              | /                  |
| Port 12         | /                  | Port 12              | /                  |
| Port 13         | /                  | Port 13              | /                  |
| Port 14         | /                  | Port 14              | /                  |
| Port 15         | Audio Codec        | Port 15              | Audio Codec        |
| Port 16         | CE_RX              | Port 16              | CE_TX              |
| Port 17         | USB OTG_Device_EP1 | Port 17              | USB OTG_Device_EP1 |
| Port 18         | USB OTG_Device_EP2 | Port 18              | USB OTG_Device_EP2 |
| Port 19         | USB OTG_Device_EP3 | Port 19              | USB OTG_Device_EP3 |
| Port 20         | USB OTG_Device_EP4 | Port 20              | USB OTG_Device_EP4 |
| Port 21         | /                  | Port 21              | /                  |
| Port 22         | /                  | Port 22              | /                  |
| Port 23         | SPI0_RX            | Port 23              | SPI0_TX            |
| Port 24         |                    | Port 24              |                    |
| Port 25         |                    | Port 25              |                    |
| Port 26         |                    | Port 26              |                    |
| Port 27         |                    | Port 27              |                    |
| Port 28         |                    | Port 28              |                    |
| Port 29         |                    | Port 29              |                    |
| Port 30         |                    | Port 30              |                    |

#### 4.8.2.3. DMA Descriptor

In this section, the DMA descriptor registers will be introduced in detail.

When starting a DMA transmission, the module data are transferred as packages, which have the link data information.

And, by reading the DMA Status Register, the status of a DMA channel could be known. Reading back the descriptor address register, the value is the link data in the transferring package. If only the value is equal to 0xfffff800, then it can be regarded as NULL, which means the package is the last package in this DMA transmission. Otherwise, the value means the start address of the next package. And, the Descriptor Address Register can be changed during a package transferring.

When transferring the half of a package, the relevant pending bit will be set up automatically, and if the corresponding interrupt is enabled, DMA generates an interrupt to the system. The similar thing would occur when transferring a package completely. Meanwhile, if DMA have transferred the last package in the data, the relevant pending bit would be set up, and generates an interrupt if the corresponding interrupt is enabled. The flow-process diagram is showed in Block Diagram section.

During a DMA transmission, the configuration could be obtained via the Configuration Register. And, behind the address of the config register in DDR or SRAM, there are some registers including other information of a DMA transmission. The structure chart is showed in Block Diagram section. Also, other information of a transferring data can be obtained by reading the Current Source Address Register, Current Destination Address Register and Byte Counter Left Register. The configuration must be word-aligning.

The transferring data would be paused when setting up the relevant Pause Register, if coming up emergency. And the pausing data could be presunable when set 0 to the same bit in Pause Register.

#### 4.8.3. DMA Register List

| Module Name | Base Address |
|-------------|--------------|
| DMA         | 0x01C02000   |

| Register Name     | Offset            | Description                                     |
|-------------------|-------------------|---|
| DMA IRQ_EN_REG    | 0x00              | DMA IRQ Enable Register                         |
| DMA IRQ_PEND_REG  | 0x10              | DMA IRQ Pending Register                        |
| DMA_AUTO_GATE_REG | 0x20              | DMA Auto Gating Register                        |
| DMA_STA_REG       | 0x30              | DMA Status Register                             |
| DMA_EN_REG        | 0x100+N*0x40      | DMA Channel Enable Register (N=0~7)             |
| DMA_PAU_REG       | 0x100+N*0x40+0x4  | DMA Channel Pause Register(N=0~7)               |
| DMA_DESC_ADDR_REG | 0x100+N*0x40+0x8  | DMA Channel Start Address Register(N=0~7)       |
| DMA_CFG_REG       | 0x100+N*0x40+0xC  | DMA Channel Configuration Register(N=0~7)       |
| DMA_CUR_SRC_REG   | 0x100+N*0x40+0x10 | DMA Channel Current Source Register(N=0~7)      |
| DMA_CUR_DEST_REG  | 0x100+N*0x40+0x14 | DMA Channel Current Destination Register(N=0~7) |
| DMA_BCNT_LEFT_REG | 0x100+N*0x40+0x18 | DMA Channel Byte Counter Left Register(N=0~7)   |
| DMA_PARA_REG      | 0x100+N*0x40+0x1C | DMA Channel Parameter Register(N=0~7)           |

#### 4.8.4. DMA Register Description

##### 4.8.4.1. DMA IRQ Enable Register0 (Default Value: 0x00000000)

| Offset: 0x0000 |     |             | Register Name: DMA_IRQ_EN_REG0  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | /   | /           | /   |
| 30             | R/W | 0x0         | DMA7_QUEUE_IRQ_EN<br>DMA 7 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 29             | R/W | 0x0         | DMA7_PKG_IRQ_EN<br>DMA 7 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 28             | R/W | 0x0         | DMA7_HLAF_IRQ_EN<br>DMA 7 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 27             | /   | /           | /   |
| 26             | R/W | 0x0         | DMA6_QUEUE_IRQ_EN<br>DMA 6 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 25             | R/W | 0x0         | DMA6_PKG_IRQ_EN<br>DMA 6 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 24             | R/W | 0x0         | DMA6_HLAF_IRQ_EN<br>DMA 6 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 23             | /   | /           | /   |
| 22             | R/W | 0x0         | DMA5_QUEUE_IRQ_EN<br>DMA 5 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 21             | R/W | 0x0         | DMA5_PKG_IRQ_EN<br>DMA 5 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 20             | R/W | 0x0         | DMA5_HLAF_IRQ_EN<br>DMA 5 Half package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 19             | /   | /           | /   |
| 18             | R/W | 0x0         | DMA4_QUEUE_IRQ_EN<br>DMA 4 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 17             | R/W | 0x0         | DMA4_PKG_IRQ_EN<br>DMA 4 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 16             | R/W | 0x0         | DMA4_HLAF_IRQ_EN  |

|    |     |     |   |
|----|-----|-----|---|
|    |     |     | DMA 4 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable.                     |
| 15 | /   | /   | /   |
| 14 | R/W | 0x0 | DMA3_QUEUE_IRQ_EN<br>DMA 3 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 13 | R/W | 0x0 | DMA3_PKG_IRQ_EN<br>DMA 3 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 12 | R/W | 0x0 | DMA3_HLAF_IRQ_EN<br>DMA 3 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 11 | /   | /   | /   |
| 10 | R/W | 0x0 | DMA2_QUEUE_IRQ_EN<br>DMA 2 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 9  | R/W | 0x0 | DMA2_PKG_IRQ_EN<br>DMA 2 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 8  | R/W | 0x0 | DMA2_HLAF_IRQ_EN<br>DMA 2 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 7  | /   | /   | /   |
| 6  | R/W | 0x0 | DMA1_QUEUE_IRQ_EN<br>DMA 1 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 5  | R/W | 0x0 | DMA1_PKG_IRQ_EN<br>DMA 1 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 4  | R/W | 0x0 | DMA1_HLAF_IRQ_EN<br>DMA 1 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable. |
| 3  | /   | /   | /   |
| 2  | R/W | 0x0 | DMA0_QUEUE_IRQ_EN<br>DMA 0 Queue End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 1  | R/W | 0x0 | DMA0_PKG_IRQ_EN<br>DMA 0 Package End Transfer Interrupt Enable.<br>0: Disable, 1: Enable.   |
| 0  | R/W | 0x0 | DMA0_HLAF_IRQ_EN<br>DMA 0 Half Package Transfer Interrupt Enable.<br>0: Disable, 1: Enable  |

#### 4.8.4.2. DMA IRQ Pending Status Register (Default Value: 0x00000000)

| Offset:0x10 |     |             | Register Name: DMA_IRQ_PEND_REG  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 31          | /   | /           | /  |
| 30          | R/W | 0x0         | DMA7_QUEUE_IRQ_PEND.<br>DMA 7 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 29          | R/W | 0x0         | DMA7_PKG_IRQ_PEND<br>DMA 7 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 28          | R/W | 0x0         | DMA7_HLAF_IRQ_PEND.<br>DMA 7 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 27          | /   | /           | /  |
| 26          | R/W | 0x0         | DMA6_QUEUE_IRQ_PEND.<br>DMA 6 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 25          | R/W | 0x0         | DMA6_PKG_IRQ_PEND<br>DMA 6 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 24          | R/W | 0x0         | DMA6_HLAF_IRQ_PEND.<br>DMA 6 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 23          | /   | /           | /  |
| 22          | R/W | 0x0         | DMA5_QUEUE_IRQ_PEND.<br>DMA 5 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 21          | R/W | 0x0         | DMA5_PKG_IRQ_PEND<br>DMA 5 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 20          | R/W | 0x0         | DMA5_HLAF_IRQ_PEND.<br>DMA 5 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 19          | /   | /           | /  |
| 18          | R/W | 0x0         | DMA4_QUEUE_IRQ_PEND.<br>DMA 4 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 17          | R/W | 0x0         | DMA4_PKG_IRQ_PEND<br>DMA 4 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 16          | R/W | 0x0         | DMA4_HLAF_IRQ_PEND.<br>DMA 4 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |

|    |     |     |  |
|----|-----|-----|--|
| 15 | /   | /   | /  |
| 14 | R/W | 0x0 | DMA3_QUEUE_IRQ_PEND.<br>DMA 3 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 13 | R/W | 0x0 | DMA3_PKG_IRQ_PEND<br>DMA 3 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 12 | R/W | 0x0 | DMA3_HLAF_IRQ_PEND.<br>DMA 3 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 11 | /   | /   | /  |
| 10 | R/W | 0x0 | DMA2_QUEUE_IRQ_PEND.<br>DMA 2 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 9  | R/W | 0x0 | DMA2_PKG_IRQ_PEND<br>DMA 2 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 8  | R/W | 0x0 | DMA2_HLAF_IRQ_PEND.<br>DMA 2 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 7  | /   | /   | /  |
| 6  | R/W | 0x0 | DMA1_QUEUE_IRQ_PEND.<br>DMA 1 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 5  | R/W | 0x0 | DMA1_PKG_IRQ_PEND<br>DMA 1 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 4  | R/W | 0x0 | DMA1_HLAF_IRQ_PEND.<br>DMA 1 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |
| 3  | /   | /   | /  |
| 2  | R/W | 0x0 | DMA0_QUEUE_IRQ_PEND.<br>DMA 0 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.   |
| 1  | R/W | 0x0 | DMA0_PKG_IRQ_PEND<br>DMA 0 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending.    |
| 0  | R/W | 0x0 | DMA0_HLAF_IRQ_PEND.<br>DMA 0 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it.<br>0: No effect, 1: Pending. |

#### 4.8.4.3. DMA Auto Gating Register (Default Value: 0x00000000)

|             |                                  |
|-------------|----------------------------------|
| Offset:0x20 | Register Name: DMA_AUTO_GATE_REG |
|-------------|----------------------------------|

| Bit  | R/W | Default/Hex | Description  |
|------|-----|-------------|--|
| 31:3 | /   | /           | /  |
| 2    | R/W | 0x0         | DMA_MCLK_CIRCUIT.<br>DMA MCLK interface circuit auto gating bit.<br>0: Auto gating enable<br>1: Auto gating disable. |
| 1    | R/W | 0x0         | DMA_COMMON_CIRCUIT.<br>DMA common circuit auto gating bit.<br>0: Auto gating enable<br>1: Auto gating disable.       |
| 0    | R/W | 0x0         | DMA_CHAN_CIRCUIT.<br>DMA channel circuit auto gating bit.<br>0: Auto gating enable<br>1: Auto gating disable.        |

When initializing DMA Controller,bit-2 should be set up.

#### 4.8.4.4. DMA Status Register (Default Value: 0x00000000)

| Offset:0x30 |     |             | Register Name: DMA_STA_REG                                  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 31:8        | /   | /           | /   |
| 7           | RO  | 0x0         | DMA7_STATUS<br>DMA Channel 7 Status.<br>0: Idle<br>1: Busy  |
| 6           | RO  | 0x0         | DMA6_STATUS<br>DMA Channel 6 Status.<br>0: Idle<br>1: Busy  |
| 5           | RO  | 0x0         | DMA5_STATUS<br>DMA Channel 5 Status.<br>0: Idle<br>1: Busy  |
| 4           | RO  | 0x0         | DMA4_STATUS<br>DMA Channel 4 Status.<br>0: Idle<br>1: Busy. |
| 3           | RO  | 0x0         | DMA3_STATUS<br>DMA Channel 3 Status.<br>0: Idle<br>1: Busy. |
| 2           | RO  | 0x0         | DMA2_STATUS<br>DMA Channel 2 Status.<br>0: Idle,            |

|   |    |     |  |
|---|----|-----|--|
|   |    |     | 1: Busy.   |
| 1 | RO | 0x0 | DMA1_STATUS<br>DMA Channel 1 Status.<br>0: Idle,<br>1: Busy. |
| 0 | RO | 0x0 | DMA0_STATUS<br>DMA Channel 0 Status.<br>0: Idle,<br>1: Busy. |

#### 4.8.4.5. DMA Channel Enable Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x0(N=0~7) |     |             | Register Name: DMA_EN_REG                                 |
|---------------------------------|-----|-------------|---|
| Bit                             | R/W | Default/Hex | Description   |
| 31:1                            | /   | /           | /   |
| 0                               | R/W | 0x0         | DMA_EN.<br>DMA Channel Enable<br>0: Disable<br>1: Enable. |

It's not recommended to disable dma while dma is transmitting. If it is necessary to do that, dma has to be paused first and then disabled.

#### 4.8.4.6. DMA Channel Pause Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x4(N=0~7) |     |             | Register Name: DMA_PAU_REG  |
|---------------------------------|-----|-------------|---|
| Bit                             | R/W | Default/Hex | Description   |
| 31:1                            | /   | /           | /   |
| 0                               | R/W | 0x0         | DMA_PAUSE.<br>Pausing DMA Channel Transfer Data.<br>0: Resume Transferring,<br>1: Pause Transferring. |

#### 4.8.4.7. DMA Channel Descriptor Address Register(Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x8(N=0~7) |     |             | Register Name: DMA_DESC_ADDR_REG                 |
|---------------------------------|-----|-------------|--|
| Bit                             | R/W | Default/Hex | Description                                      |
| 31:0                            | R/W | 0x0         | DMA_DESC_ADDR<br>DMA Channel Descriptor Address. |

**4.8.4.8. DMA Channel Configuration Register (Default Value: 0x00000000)**

| Offset: 0x100+N*0x40+0xC(N=0~7) |     |             | Register Name: DMA_CFG_REG   |
|---------------------------------|-----|-------------|--|
| Bit                             | R/W | Default/Hex | Description  |
| 31:27                           | /   | /           | /  |
| 26:25                           | RO  | 0x0         | DMA_DEST_DATA_WIDTH.<br>DMA Destination Data Width.<br>00: 8-bit<br>01: 16-bit<br>10: 32-bit<br>11: /      |
| 24:23                           | RO  | 0x0         | DMA_DEST_BST_LEN.<br>DMA Destination Burst Length.<br>00: 1<br>01: /<br>10: 8<br>11: /                     |
| 22:21                           | RO  | 0x0         | DMA_ADDR_MODE.<br>DMA Destination Address Mode<br>00: Linear Mode<br>01: IO Mode<br>10: /<br>11: /         |
| 20:16                           | RO  | 0x0         | DMA_DEST_DRQ_TYPE.<br>DMA Destination DRQ Type<br>The details in DRQ Type and Port Corresponding Relation. |
| 15:11                           | /   | /           | /  |
| 10:9                            | RO  | 0x0         | DMA_SRC_DATA_WIDTH.<br>DMA Source Data Width.<br>00: 8-bit<br>01: 16-bit<br>10: 32-bit<br>11: /            |
| 8:7                             | RO  | 0x0         | DMA_SRC_BST_LEN.<br>DMA Source Burst Length.<br>00: 1<br>01: /<br>10: 8<br>11: /                           |
| 6:5                             | RO  | 0x0         | DMA_SRC_ADDR_MODE.<br>DMA Source Address Mode<br>00: Linear Mode<br>01: IO Mode<br>10: /<br>11: /          |

|     |    |     |  |
|-----|----|-----|--|
| 4:0 | RO | 0x0 | DMA_SRC_DRQ_TYPE.<br>DMA Source DRQ Type<br>The details in DRQ Type and Port Corresponding Relation. |
|-----|----|-----|--|


**NOTE**

If the DRQ type is dram, then, the corresponding burst length will be fixed, and the options will be invalid.

The address of the DMA Channel Configuration Register must be word-aligned.

If the DRQ type is SRAM, then, the source address or destination address must be word-aligned.

#### 4.8.4.9. DMA Channel Current Source Address Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x10(N=0~7) |     |             | Register Name: DMA_CUR_SRC_REG  |
|----------------------------------|-----|-------------|---|
| Bit                              | R/W | Default/Hex | Description   |
| 31:0                             | RO  | 0x0         | DMA_CUR_SRC.<br>DMA Channel Current Source Address, read only.<br>The address of the <b>DMA Channel Current Source Address Register</b> must be word-aligned. |

#### 4.8.4.10. DMA Channel Current Destination Address Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x14(N=0~7) |     |             | Register Name: DMA_CUR_DEST_REG  |
|----------------------------------|-----|-------------|--|
| Bit                              | R/W | Default/Hex | Description  |
| 31:0                             | RO  | 0           | DMA_CUR_DEST.<br>DMA Channel Current Destination Address, read only.<br>The address of the <b>DMA Channel Current Destination Address Register</b> must be word-aligned. |

#### 4.8.4.11. DMA Channel Byte Counter Left Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x18(N=0~11) |     |             | Register Name: DMA_BCNT_LEFT_REG  |
|-----------------------------------|-----|-------------|---|
| Bit                               | R/W | Default/Hex | Description   |
| 31:25                             | /   | /           | /   |
| 24:0                              | RO  | 0x0         | DMA_BCNT_LEFT.<br>DMA Channel Byte Counter Left, read only.<br>The address of the <b>DMA Channel Byte Counter Left Register</b> must be word-aligned. |

#### 4.8.4.12. DMA Channel Parameter Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x40+0x1C(N=0~7) |     |             | Register Name: DMA PARA_REG          |
|----------------------------------|-----|-------------|--------------------------------------|
| Bit                              | R/W | Default/Hex | Description                          |
| 31:16                            | /   | /           | /                                    |
| 15:8                             | RO  | 0x0         | DATA_BLK_SIZE.<br>Data Block Size N. |
| 7:0                              | RO  | 0x0         | WAIT_CYC.<br>Wait Clock Cycles n.    |

**NOTE**

The number of data block size usually depends on the capacity of the device's FIFO in the practical application.

The data block size must be multiple of *burst\*width* (byte). For example: if burst is 4 and the width is 32-bit, so the data block size must be  $m * 16$ (byte), i.e.  $N = m * 16$ .

When DMA controller has completed transferring  $N$  bytes data, and waiting  $n$  clock cycles to check the DRQ signal.

This register is only effective to devices, and the Data Block Size  $N$  should be 0 if it is less than 32.

## 4.9. GIC

For details about GIC, please refer to the ***GIC PL400 technical reference manual*** and ***ARM GIC Architecture Specification V2.0***.

### 4.9.1. Interrupt Source

| Interrupt number | Vector | Interrupt Source | Description      |
|------------------|--------|------------------|------------------|
| 0                | 0x0000 | SGI 0            | SGI 0 interrupt  |
| 1                | 0x0004 | SGI 1            | SGI 1 interrupt  |
| 2                | 0x0008 | SGI 2            | SGI 2 interrupt  |
| 3                | 0x000C | SGI 3            | SGI 3 interrupt  |
| 4                | 0x0010 | SGI 4            | SGI 4 interrupt  |
| 5                | 0x0014 | SGI 5            | SGI 5 interrupt  |
| 6                | 0x0018 | SGI 6            | SGI 6 interrupt  |
| 7                | 0x001C | SGI 7            | SGI 7 interrupt  |
| 8                | 0x0020 | SGI 8            | SGI 8 interrupt  |
| 9                | 0x0024 | SGI 9            | SGI 9 interrupt  |
| 10               | 0x0028 | SGI 10           | SGI 10 interrupt |
| 11               | 0x002C | SGI 11           | SGI 11 interrupt |
| 12               | 0x0030 | SGI 12           | SGI 12 interrupt |
| 13               | 0x0034 | SGI 13           | SGI 13 interrupt |
| 14               | 0x0038 | SGI 14           | SGI 14 interrupt |
| 15               | 0x003C | SGI 15           | SGI 15 interrupt |
| 16               | 0x0040 | PPI 0            | PPI 0 interrupt  |
| 17               | 0x0044 | PPI 1            | PPI 1 interrupt  |
| 18               | 0x0048 | PPI 2            | PPI 2 interrupt  |
| 19               | 0x004C | PPI 3            | PPI 3 interrupt  |
| 20               | 0x0050 | PPI 4            | PPI 4 interrupt  |
| 21               | 0x0054 | PPI 5            | PPI 5 interrupt  |
| 22               | 0x0058 | PPI 6            | PPI 6 interrupt  |
| 23               | 0x005C | PPI 7            | PPI 7 interrupt  |
| 24               | 0x0060 | PPI 8            | PPI 8 interrupt  |
| 25               | 0x0064 | PPI 9            | PPI 9 interrupt  |
| 26               | 0x0068 | PPI 10           | PPI 10 interrupt |
| 27               | 0x006C | PPI 11           | PPI 11 interrupt |
| 28               | 0x0070 | PPI 12           | PPI 12 interrupt |
| 29               | 0x0074 | PPI 13           | PPI 13 interrupt |
| 30               | 0x0078 | PPI 14           | PPI 14 interrupt |
| 31               | 0x007C | PPI 15           | PPI 15 interrupt |
| 32               | 0x0080 | UART 0           | UART 0 interrupt |
| 33               | 0x0084 | UART 1           | UART 1 interrupt |

|    |        |              |                             |
|----|--------|--------------|-----------------------------|
| 34 | 0x0088 | UART 2       | UART 2 interrupt            |
| 35 | 0x008C |              |                             |
| 36 | 0x0090 |              |                             |
| 37 | 0x0094 |              |                             |
| 38 | 0x0098 | TWI 0        | TWI 0 interrupt             |
| 39 | 0x009C | TWI 1        | TWI 1 interrupt             |
| 40 | 0x00A0 |              |                             |
| 41 | 0x00A4 |              |                             |
| 42 | 0x00A8 |              |                             |
| 43 | 0x00AC |              |                             |
| 44 | 0x00B0 |              |                             |
| 45 | 0x00B4 | I2S/PCM      | I2S/PCM interrupt           |
| 46 | 0x00B8 |              |                             |
| 47 | 0x00BC | PB_EINT      | PB_EINT interrupt           |
| 48 | 0x00C0 |              |                             |
| 49 | 0x00C4 | PG_EINT      | PG_EINT interrupt           |
| 50 | 0x00C8 | Timer 0      | Timer 0 interrupt           |
| 51 | 0x00CC | Timer 1      | Timer 1 interrupt           |
| 52 | 0x00D0 | Timer 2      | Timer 2 interrupt           |
| 53 | 0x00D4 |              |                             |
| 54 | 0x00D8 |              |                             |
| 55 | 0x00DC |              |                             |
| 56 | 0x00E0 |              |                             |
| 57 | 0x00E4 | Watchdog     | Watchdog interrupt          |
| 58 | 0x00E8 |              |                             |
| 59 | 0x00EC |              |                             |
| 60 | 0x00F0 |              |                             |
| 61 | 0x00F4 | Audio Codec  | Audio Codec interrupt       |
| 62 | 0x00F8 | LRADC        | LRADC interrupt             |
| 63 | 0x00FC |              |                             |
| 64 | 0x100  | External NMI | External Non-Mask Interrupt |
| 65 | 0x104  |              |                             |
| 66 | 0x108  |              |                             |
| 67 | 0x010C |              |                             |
| 68 | 0x0110 |              |                             |
| 69 | 0x0114 |              |                             |
| 70 | 0x0118 |              |                             |
| 71 | 0x011C |              |                             |
| 72 | 0x0120 | Alarm 0      | Alarm 0 interrupt           |
| 73 | 0x0124 | Alarm 1      | Alarm 1 interrupt           |
| 74 | 0x0128 |              |                             |
| 75 | 0x012C |              |                             |
| 76 | 0x0130 |              |                             |
| 77 | 0x0134 |              |                             |

|     |        |                |                                    |
|-----|--------|----------------|------------------------------------|
| 78  | 0x0138 |                |                                    |
| 79  | 0x013C |                |                                    |
| 80  | 0x0140 |                |                                    |
| 81  | 0x0144 |                |                                    |
| 82  | 0x0148 | DMA            | DMA channel interrupt              |
| 83  | 0x014C | HS Timer0      | HS Timer0 interrupt                |
| 84  | 0x0150 | HS Timer1      | HS Timer1 interrupt                |
| 85  | 0x0154 |                |                                    |
| 86  | 0x0158 |                |                                    |
| 87  | 0x015C |                |                                    |
| 88  | 0x0160 |                |                                    |
| 89  | 0x0164 |                |                                    |
| 90  | 0x0168 | VE             | VE interrupt                       |
| 91  | 0x016C |                |                                    |
| 92  | 0x0170 | SD/MMC 0       | SD/MMC Host Controller 0 interrupt |
| 93  | 0x0174 |                |                                    |
| 94  | 0x0178 | SD/MMC 2       | SD/MMC Host Controller 2 interrupt |
| 95  | 0x017C |                |                                    |
| 96  | 0x0180 |                |                                    |
| 97  | 0x0184 | SPI0           | SPI0 interrupt                     |
| 98  | 0x0188 |                |                                    |
| 99  | 0x018C |                |                                    |
| 100 | 0x0190 |                |                                    |
| 101 | 0x0194 |                |                                    |
| 102 | 0x0198 |                |                                    |
| 103 | 0x019C | USB OTG_Device | USB OTG_Device interrupt           |
| 104 | 0x01A0 | USB OTG_EHCI   | USB OTG_EHCI interrupt             |
| 105 | 0x01A4 | USB OTG_OHCI   | USB OTG_OHCI interrupt             |
| 106 | 0x01A8 |                |                                    |
| 107 | 0x01AC |                |                                    |
| 108 | 0x01B0 |                |                                    |
| 109 | 0x01B4 |                |                                    |
| 110 | 0x01B8 |                |                                    |
| 111 | 0x01BC |                |                                    |
| 112 | 0x01C0 | CE             | CE interrupt                       |
| 113 | 0x01C4 |                |                                    |
| 114 | 0x01C8 | EMAC           | EMAC interrupt                     |
| 115 | 0x01CC | CSI0           | CSI0 interrupt                     |
| 116 | 0x01D0 | CSI1           | CSI1 interrupt                     |
| 117 | 0x01D4 | CSI_CCI        | CSI_CCI interrupt                  |
| 118 | 0x01D8 | TCON           | TCON Controller interrupt          |
| 119 | 0x01DC |                |                                    |
| 120 | 0x01E0 |                |                                    |
| 121 | 0x01E4 |                |                                    |

|     |        |           |                     |
|-----|--------|-----------|---------------------|
| 122 | 0x01E8 | MIPI CSI  | MIPI CSI interrupt  |
| 123 | 0x01EC |           |                     |
| 124 | 0x01F0 |           |                     |
| 125 | 0x01F4 |           |                     |
| 126 | 0x01F8 |           |                     |
| 127 | 0x01FC | DE        | DE interrupt        |
| 128 | 0x0200 |           |                     |
| 129 | 0x0204 |           |                     |
| 130 | 0x0208 |           |                     |
| 131 | 0x020C |           |                     |
| 132 | 0x0210 |           |                     |
| 133 | 0x0214 |           |                     |
| 134 | 0x0218 |           |                     |
| 135 | 0x021C |           |                     |
| 136 | 0x0220 |           |                     |
| 137 | 0x0224 |           |                     |
| 138 | 0x0228 |           |                     |
| 139 | 0x022C |           |                     |
| 140 | 0x0230 | CTI0      | CTI0 interrupt      |
| 141 | 0x0234 | CTI1      | CTI1 interrupt      |
| 142 | 0x0238 | CTI2      | CTI2 interrupt      |
| 143 | 0x023C | CTI3      | CTI3 interrupt      |
| 144 | 0x0240 | COMMTX0   | COMMTX0 interrupt   |
| 145 | 0x0244 | COMMTX1   | COMMTX1 interrupt   |
| 146 | 0x0248 | COMMTX2   | COMMTX2 interrupt   |
| 147 | 0x024C | COMMTX3   | COMMTX3 interrupt   |
| 148 | 0x0250 | COMMRX0   | COMM RX0 interrupt  |
| 149 | 0x0254 | COMM RX1  | COMM RX1 interrupt  |
| 150 | 0x0258 | COMM RX2  | COMM RX2 interrupt  |
| 151 | 0x025C | COMM RX3  | COMM RX3 interrupt  |
| 152 | 0x0260 | PMU0      | PMU0 interrupt      |
| 153 | 0x0264 | PMU1      | PMU1 interrupt      |
| 154 | 0x0268 | PMU2      | PMU2 interrupt      |
| 155 | 0x026C | PMU3      | PMU3 interrupt      |
| 156 | 0x0270 | AXI_ERROR | AXI_ERROR interrupt |
|     |        |           |                     |

## 4.10. Crypto Engine

### 4.10.1. Overview

The Crypto Engine (CE) is one encrypt/ decrypt function accelerator. It is suitable for a variety of applications. It can support encryption/decryption and calculate the hash value. Besides, both CPU mode and DMA method are supported for different applications.

The CE includes the following features:

- Supports AES, DES, 3DES, SHA-1, MD5
- 160-bit hardware PRNG with 175-bit seed
- Supports ECB, CBC ,CTR,CTS modes for AES/DES/3DES
- 128-bit, 192-bit and 256-bit key size for AES
- Supports 32 words RX FIFO and 32 words TX FIFO for high speed application
- Supports CPU mode and DMA mode

### 4.10.2. Block Diagram

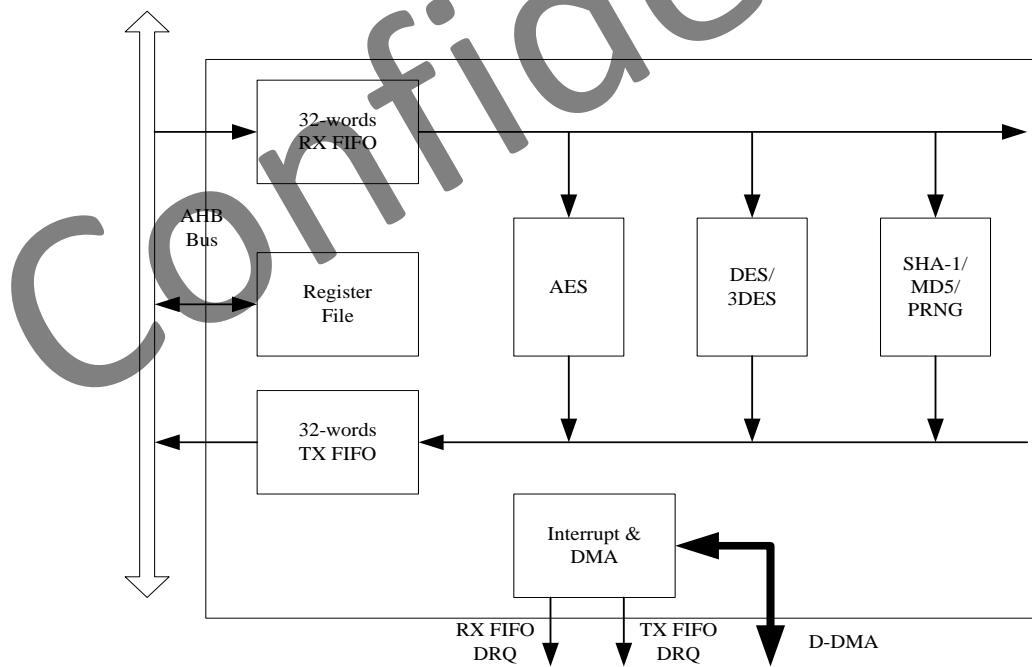


Figure 4-7. CE Block Diagram

### 4.10.3. Crypto Engine Register List

| Module Name | Base Address |
|-------------|--------------|
| CE          | 0x01C15000   |

| Register Name | Offset | Description                          |
|---------------|--------|--------------------------------------|
| CE_CTL        | 0x00   | Control Register                     |
| CE_KEY0       | 0x04   | Input Key 0/ PRNG Seed 0             |
| CE_KEY1       | 0x08   | Input Key 1/ PRNG Seed 1             |
| ...           | ...    | ...                                  |
| CE_KEY7       | 0x20   | Input Key 7                          |
| CE_IV0        | 0x24   | Initialization Vector 0              |
| CE_IV1        | 0x28   | Initialization Vector 1              |
| CE_IV2        | 0x2C   | Initialization Vector 2              |
| CE_IV3        | 0x30   | Initialization Vector 3              |
| CE_CNT0       | 0x34   | Preload Counter 0                    |
| CE_CNT1       | 0x38   | Preload Counter 1                    |
| CE_CNT2       | 0x3C   | Preload Counter 2                    |
| CE_CNT3       | 0x40   | Preload Counter 3                    |
| CE_FCSR       | 0x44   | FIFO Control/ Status Register        |
| CE_ICSR       | 0x48   | Interrupt Control/ Status Register   |
| CE_MDO        | 0x4C   | SHA1/MD5 Message Digest 0/PRNG Data0 |
| CE_MD1        | 0x50   | SHA1/MD5 Message Digest 1/PRNG Data1 |
| CE_MD2        | 0x54   | SHA1/MD5 Message Digest 2/PRNG Data2 |
| CE_MD3        | 0x58   | SHA1/MD5 Message Digest 3/PRNG Data3 |
| CE_MD4        | 0x5C   | SHA1/MD5 Message Digest 4/PRNG Data4 |
| CE_CTS_LEN    | 0x60   | AES-CTS ciphertext length            |
| CE_RXFIFO     | 0x200  | RX FIFO input port                   |
| CE_TXFIFO     | 0x204  | TX FIFO output port                  |

### 4.10.4. Crypto Engine Register Description

#### 4.10.4.1. Control Register(Default Value: 0x00000000)

| Offset: 0x00 |     |             | Register Name: CE_CTL  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:28        | /   | /           | /  |
| 27:24        | R/W | 0           | SKEY_SELECT<br>AES/DES/3DES key select<br>0000: Select input CE_KEYx (Normal Mode)<br>0001: /<br>0010: /<br>0011-1010: Select internal Key n (n from 0 to 7) |

|       |     |   |   |
|-------|-----|---|---|
|       |     |   | Others: Reserved  |
| 18:16 | R   | x | DIE_ID<br>Die Bonding ID  |
| 15    | R/W | 0 | PRNG_MODE<br>PRNG generator mode<br>0: One-shot mode<br>1: Continue mode  |
| 14    | R/W | 0 | IV_MODE<br>IV Steady of SHA-1/MD5 constants<br>0: Constants<br>1: Arbitrary IV<br>It is only used for SHA-1/MD5 engine. If the number of IV word is beyond of 4, Counter 0 register is used for IV4.  |
| 13:12 | R/W | 0 | CE_OP_MODE<br>CE Operation Mode<br>00: Electronic Code Book (ECB) mode<br>01: Cipher Block Chaining (CBC) mode<br>10:/<br>11: AES Ciphertext Stealing (CTS) mode  |
| 11:10 | /   | / | /   |
| 9:8   | R/W | 0 | AES_KEY_SIZE<br>Key Size for AES<br>00: 128-bit<br>01: 192-bit<br>10: 256-bit<br>11: Reserved   |
| 7     | R/W | 0 | CE_OP_DIR<br>CE Operation Direction<br>0: Encryption<br>1: Decryption   |
| 6:4   | R/W | 0 | CE_METHOD<br>CE Method<br>000: AES<br>001: DES<br>010: Triple DES (3DES)<br>011: SHA-1<br>100: MD5<br>101: PRNG<br>Others: Reserved   |
| 3     | /   | / | /   |
| 2     | R/W | 0 | SHA1_MD5_END_BIT<br>SHA-1/MD5 Data End bit<br>Write '1' to tell SHA-1/MD5 engine that the text data is end. If there is some data in FIFO, the engine would fetch these data and process them. After finishing message digest, this bit is clear to '0' by hardware and message |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | digest can be read out from digest registers.<br>It is only used for SHA-1/MD5 engine.  |
| 1 | R/W | 0 | PRNG_START<br><br>PRNG start bit<br><br>In PRNG one-shot mode, write '1' to start PRNG. After generating one group random data (5 words), this bit is clear to '0' by hardware. |
| 0 | R/W | 0 | CE_ENABLE<br><br>CE Enable<br><br>A disable on this bit overrides any other block and flushes all FIFOs.<br>0: Disable<br>1: Enable   |

#### 4.10.4.2. Key [n] Register (Default Value: 0x00000000)

| Offset: 0x04+4*n |     |             | Register Name: CE_KEY[n]   |
|------------------|-----|-------------|--|
| Bit              | R/W | Default/Hex | Description  |
| 31:0             | R/W | 0           | CE_KEY<br><br>Key[n] Input Value (n= 0~7)/ PRNG Seed[n] (n= 0~5) |

#### 4.10.4.3. IV[n] Register (Default Value: 0x00000000)

| Offset: 0x24+4*n |     |             | Register Name: CE_IV[n]   |
|------------------|-----|-------------|---|
| Bit              | R/W | Default/Hex | Description   |
| 31:0             | R/W | 0           | CE_IV_VALUE<br><br>Initialization Vector (IV[n]) Input Value (n= 0~3) |

#### 4.10.4.4. Count [n] Register (Default Value: 0x00000000)

| Offset: 0x34+4*n |     |             | Register Name: CE_CNT[n]                         |
|------------------|-----|-------------|--|
| Bit              | R/W | Default/Hex | Description                                      |
| 31:0             | R/W | 0           | CE_CNT_VALUE<br><br>Counter Input Value (n= 0~3) |

#### 4.10.4.5. FIFO Control/ Status Register (Default Value: 0x60000F0F)

| Offset: 0x44 |     |             | Register Name: CE_FCSR |
|--------------|-----|-------------|------------------------|
| Bit          | R/W | Default/Hex | Description            |
| 31           | /   | /           | /                      |
| 30           | R   | 0x1         | RXFIFO_STATUS          |

|       |     |      |  |
|-------|-----|------|--|
|       |     |      | RX FIFO Empty<br>0: No room for new word in RX FIFO<br>1: More than one room for new word in RX FIFO (>= 1 word)   |
| 29:24 | R   | 0x20 | RXFIFO_EMP_CNT<br>RX FIFO Empty Space Word Counter   |
| 23    | /   | /    | /  |
| 22    | R   | 0    | TXFIFO_STATUS<br>TX FIFO Data Available Flag<br>0: No available data in TX FIFO<br>1: More than one data in TX FIFO (>= 1 word)  |
| 21:16 | R   | 0    | TXFIFO_AVA_CNT<br>TX FIFO Available Word Counter   |
| 15:13 | /   | /    | /  |
| 12:8  | R/W | 0xF  | RXFIFO_INT_TRIG_LEVEL<br>RX FIFO Empty Trigger Level<br>Interrupt and DMA request trigger level for RXFIFO normal condition<br>Trigger Level = RXTL + 1<br>RX FIFO is used for input the data.   |
| 7:5   | /   | /    | /  |
| 4:0   | R/W | 0xF  | TXFIFO_INT_TRIG_LEVEL<br>TX FIFO Trigger Level<br>Interrupt and DMA request trigger level for TXFIFO normal condition<br>Trigger Level = TXTL + 1<br>TX FIFO is used for output the result data. |

#### 4.10.4.6. Interrupt Control/ Status Register (Default Value: 0x00000000)

| Offset: 0x48 |     |             | Register Name: CE_ICSR   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:11        | /   | /           | /  |
| 10           | R/W | 0           | RXFIFO_EMP_PENDING_BIT<br>RX FIFO Empty Pending bit<br>0: No pending<br>1: RX FIFO Empty pending<br>Write '1' to clear or automatic clear if interrupt condition fails.            |
| 9            | /   | /           | /  |
| 8            | R/W | 0           | TXFIFO_AVA_PENDING_BIT<br>TX FIFO Data Available Pending bit<br>0: No TX FIFO pending<br>1: TX FIFO pending<br>Write '1' to clear or automatic clear if interrupt condition fails. |
| 7:5          | /   | /           | /  |
| 4            | R/W | 0           | DRA_ENABLE   |

|   |     |   |  |
|---|-----|---|--|
|   |     |   | DRQ Enable<br>0: Disable DRQ (CPU polling mode)<br>1: Enable DRQ (DMA mode)  |
| 3 | /   | / | /  |
| 2 | R/W | 0 | RXFIFO_EMP_INT_ENABLE<br>RX FIFO Empty Interrupt Enable<br>0: Disable<br>1: Enable<br>If it is set to '1', when the number of empty room is great or equal ( $\geq$ ) the preset threshold, the interrupt is trigger and the correspond flag is set.       |
| 1 | /   | / | /  |
| 0 | R/W | 0 | TXFIFO_AVA_INT_ENABLE<br>TX FIFO Data Available Interrupt Enable<br>0: Disable<br>1: Enable<br>If it is set to '1', when available data number is great or equal ( $\geq$ ) the preset threshold, the interrupt is trigger and the correspond flag is set. |

#### 4.10.4.7. Message Digest[n] Register (Default Value: 0x00000000)

| Offset: 0x4C+4*n |     |             | Register Name: CE_MD[n]   |
|------------------|-----|-------------|---|
| Bit              | R/W | Default/Hex | Description   |
| 31:0             | R   | 0           | CE_MID_DATA<br>SHA1/ MD5 Message digest MD[n] for SHA1/MD5 (n= 0~4) |

#### 4.10.4.8. CTS Length Register (Default Value: 0x00000000)

| Offset: 0x60 |     |             | Register Name: CE_CTS_LEN   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0           | AES-CTS ciphertext length in byte unit<br>The value of '0' means no data. |

#### 4.10.4.9. RXFIFO Register (Default Value: 0x00000000)

| Offset: 0x200 |     |             | Register Name: CE_RX                    |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description                             |
| 31:0          | W   | 0           | CE_RX_FIFO<br>32-bits RX FIFO for Input |

#### 4.10.4.10. TXFIFO Register (Default Value: 0x00000000)

| Offset: 0x204 |     |             | Register Name: CE_TX                     |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description                              |
| 31:0          | W   | 0           | CE_RX_FIFO<br>32-bits TX FIFO for Output |

#### 4.10.5. Crypto Engine Clock Requirement

| Clock Name | Description                | Requirement |
|------------|----------------------------|-------------|
| ahb_clk    | AHB bus clock              | >=24MHz     |
| CE_clk     | Crypto Engine serial clock | <= 150MHz   |

## 4.11. LRADC

### 4.11.1. Overview

LRADC is 6-bit resolution ADC for key application. The LRADC can work up to 250Hz conversion rate.

The LRADC includes the following features:

- Supports APB 32-bit bus width
- Supports interrupt
- Supports Hold Key and General Key
- Supports Single Key and Continue Key mode
- 6-bit resolution
- Voltage input range between 0V to 2.0V
- Sample rate up to 250Hz

### 4.11.2. Clock Source

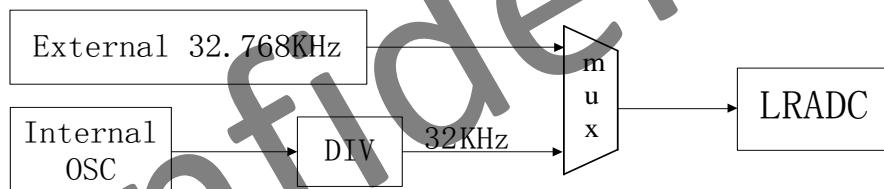


Figure 4-8. LRADC Clock Source

### 4.11.3. Operation Principle

The LRADC converted data can accessed by interrupt and polling method. If software can't access the last converted data instantly, the new converted data would update the old one at new sampling data.

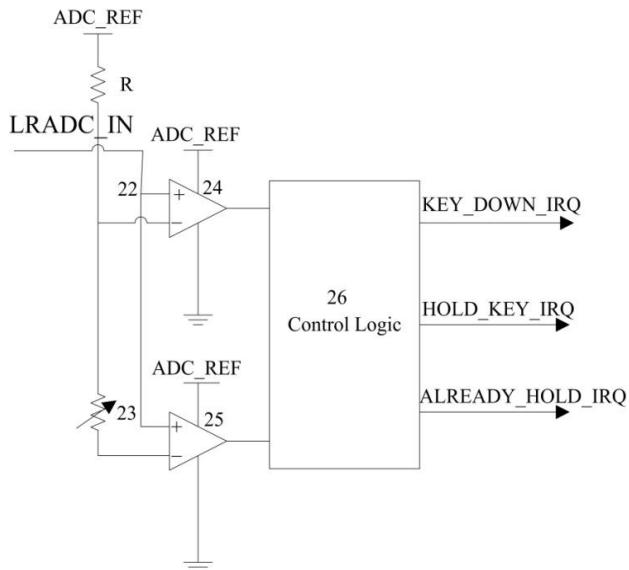


Figure 4-9. LRADC Data Converted Diagram

When ADC\_IN Signal changes from 3.0V to less than 2.0V (Level A), the comparator24 send first interrupt to control logic; When ADC\_IN Signal changes from 2.0V to less than certain level (Program can set), the comparator25 gives second interrupt. If the control Logic get the first interrupt, in a certain time range (program can set), doesn't get second interrupt, it will send hold key interrupt to the host; if the control Logic get the first interrupt, in a certain time range (program can set), get second interrupt, it will send key down interrupt to the host; if the control logic only get the second interrupt, doesn't get the first interrupt, it will send already hold interrupt to the host.

The LRADC has three modes, including Normal Mode, Single Mode and Continue Mode. Normal mode is that the LRADC will report the result data of each convert all the time when the key is down. Single Mode is that the LRADC will only report the first convert result data when the key is down. Continue Mode is that the LRADC will report one of  $8*(N+1)$  ( $N$  is program can set) sample convert result data when key is down.

The LRADC supports four sample rate such as 250Hz、125Hz、62.5Hz and 32.25Hz, you can configure the value of LRADC\_SAMPLE\_RATE to select the fit sample rate.

#### 4.11.4. LRADC Register List

| Module Name | Base Address |
|-------------|--------------|
| LRADC       | 0x01C22800   |

| Register Name | Offset | Description                      |
|---------------|--------|----------------------------------|
| LRADC_CTRL    | 0x00   | LRADC Control Register           |
| LRADC_INTC    | 0x04   | LRADC Interrupt Control Register |
| LRADC_INTS    | 0x08   | LRADC Interrupt Status Register  |
| LRADC_DATA0   | 0x0C   | LRADC Data0 Register             |
| LRADC_DATA1   | 0x10   | LRADC Data1 Register             |

#### 4.11.5. LRADC Register Description

##### 4.11.5.1. LRADC Control Register (Default Value: 0x01000168)

| Offset: 0x00 |     |             | Register Name: LRADC_CTRL_REG  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31: 24       | R/W | 0x1         | FIRST_CONVERT_DLY.<br>ADC First Convert Delay setting, ADC conversion is delayed by n samples  |
| 23:22        | R/W | 0x0         | ADC_CHAN_SELECT<br>ADC channel select<br>00: ADC0 channel<br>01: ADC1 channel<br>1x: ADC0&ADC1 channel   |
| 21:20        | /   | /           | /  |
| 19:16        | R/W | 0x0         | CONTINUE_TIME_SELECT.<br>Continue Mode time select, one of $8^*(N+1)$ sample as a valuable sample data   |
| 15:14        | /   | /           | /  |
| 13:12        | R/W | 0x0         | KEY_MODE_SELECT.<br>Key Mode Select<br>00: Normal Mode<br>01: Single Mode<br>10: Continue Mode   |
| 11:8         | R/W | 0x1         | LEVELA_B_CNT.<br>Level A to Level B time threshold select, judge ADC convert value in level A to level B in n+1 samples  |
| 7            | R/W | 0x0         | LRADC_HOLD_KEY_EN.<br>LRADC Hold Key Enable<br>0: Disable<br>1: Enable   |
| 6            | R/W | 0x1         | LRADC_HOLD_EN.<br>LRADC Sample hold Enable<br>0: Disable<br>1: Enable  |
| 5: 4         | R/W | 0x2         | LEVELB_VOL.<br>Level B Corresponding Data Value setting (the real voltage value)<br>00: 0x3C (~1.9V)<br>01: 0x39 (~1.8V)<br>10: 0x36 (~1.7V)<br>11: 0x33 (~1.6V) |
| 3: 2         | R/W | 0x2         | LRADC_SAMPLE_RATE.<br>LRADC Sample Rate<br>00: 250 Hz<br>01: 125 Hz  |

|   |     |     |   |
|---|-----|-----|---|
|   |     |     | 10: 62.5 Hz<br>11: 32.25 Hz                         |
| 1 | /   | /   | /   |
| 0 | R/W | 0x0 | LRADC_EN<br>LRADC enable<br>0: Disable<br>1: Enable |

#### 4.11.5.2. LRADC Interrupt Control Register (Default Value: 0x00000000)

| Offset: 0x04 |     |             | Register Name: LRADC_INTC_REG  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:13        | /   | /           | /  |
| 12           | R/W | 0x0         | ADC1_KEYUP_IRQ_EN<br>ADC 1 Key Up IRQ Enable<br>0: Disable<br>1: Enable                |
| 11           | R/W | 0x0         | ADC1_ALRDY_HOLD_IRQ_EN<br>ADC 1 Already Hold Key IRQ Enable<br>0: Disable<br>1: Enable |
| 10           | R/W | 0x0         | ADC 1 Hold Key IRQ Enable<br>0: Disable<br>1: Enable                                   |
| 9            | R/W | 0x0         | ADC1_KEYIRQ_EN<br>ADC 1 Key IRQ Enable<br>0: Disable<br>1: Enable                      |
| 8            | R/W | 0x0         | ADC1_DATA_IRQ_EN<br>ADC 1 DATA IRQ Enable<br>0: Disable<br>1: Enable                   |
| 7:5          | /   | /           | /  |
| 4            | R/W | 0x0         | ADC0_KEYUP_IRQ_EN<br>ADC0 Key Up IRQ Enable<br>0: Disable<br>1: Enable                 |
| 3            | R/W | 0x0         | ADC0_ALRDY_HOLD_IRQ_EN<br>ADC0 Already Hold IRQ Enable<br>0: Disable<br>1: Enable      |
| 2            | R/W | 0x0         | ADC0_HOLD_IRQ_EN<br>ADC0 Hold Key IRQ Enable<br>0: Disable                             |

|   |     |     |   |
|---|-----|-----|---|
|   |     |     | 1: Enable   |
| 1 | R/W | 0x0 | ADC0_KEYDOWN_EN<br>ADC0 Key Down Enable<br>0: Disable<br>1: Enable  |
| 0 | R/W | 0x0 | ADC0_DATA_IRQ_EN<br>ADC0 Data IRQ Enable<br>0: Disable<br>1: Enable |

#### 4.11.5.3. LRADC Interrupt Status Register (Default Value: 0x00000000)

| Offset: 0x08 |     |             | Register Name:LRADC_INTS_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:13        | /   | /           | /  |
| 12           | R/W | 0x0         | ADC1_KEYUP_PENDING<br>ADC 1 Key up Pending Bit<br>When general key pull up, if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable   |
| 11           | R/W | 0x0         | ADC1_ALRDY_HOLD_PENDING<br>ADC 1 Already Hold Pending Bit<br>When hold key pull down and pull the general key down, if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable                 |
| 10           | R/W | 0x0         | ADC1_HOLDKEY_PENDING<br>ADC 1 Hold Key Pending Bit<br>When Hold key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled.<br>0: NO IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable. |
| 9            | R/W | 0x0         | ADC1_KEYDOWN_IRQ_PENDING<br>ADC 1 Key Down IRQ Pending Bit<br>When General key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending  |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.  |
| 8   | R/W | 0x0 | <b>ADC1_DATA_IRQ_PENDING</b><br>ADC 1 Data IRQ Pending Bit<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.   |
| 7:5 | /   | /   | /   |
| 4   | R/W | 0x0 | <b>ADC0_KEYUP_PENDING</b><br>ADC0 Key up Pending Bit<br>When general key pull up, if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable  |
| 3   | R/W | 0x0 | <b>ADC0_ALRDY_HOLD_PENDING</b><br>ADC0 Already Hold Pending Bit<br>When hold key pull down and pull the general key down, if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable                        |
| 2   | R/W | 0x0 | <b>ADC0_HOLDKEY_PENDING</b><br>ADC0 Hold Key Pending Bit<br>When Hold key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled.<br>0: NO IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.        |
| 1   | R/W | 0x0 | <b>ADC0_KEYDOWN_PENDING</b><br>ADC0 Key Down IRQ Pending Bit<br>When General key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled.<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable. |
| 0   | R/W | 0x0 | <b>ADC0_DATA_PENDING</b><br>ADC0 Data IRQ Pending Bit<br>0: No IRQ<br>1: IRQ Pending<br>Writing 1 to the bit will clear it and its corresponding interrupt if the   |

|  |  |  |                      |
|--|--|--|----------------------|
|  |  |  | interrupt is enable. |
|--|--|--|----------------------|

#### 4.11.5.4. LRADC Data0 Register (Default Value: 0x00000000)

| Offset: 0x0C |     |             | Register Name: LRADC_DATA0_REG |
|--------------|-----|-------------|--------------------------------|
| Bit          | R/W | Default/Hex | Description                    |
| 31:6         | /   | /           | /                              |
| 5:0          | R   | 0x0         | LRADC_DATA0<br>LRADC Data0     |

#### 4.11.5.5. LRADC Data1 Register (Default Value: 0x00000000)

| Offset: 0x10 |     |             | Register Name: LRADC_DATA1_REG |
|--------------|-----|-------------|--------------------------------|
| Bit          | R/W | Default/Hex | Description                    |
| 31:6         | /   | /           | /                              |
| 5:0          | R   | 0x0         | LRADC_DATA1<br>LRADC Data1     |

## 4.12. RTC

### 4.12.1. Overview

The real time clock (RTC) is for calendar usage. It is built around a 30-bit counter and used to count elapsed time in YY-MM-DD and HH-MM-SS. The unit can be operated by the backup battery while the system power is off. It has a built-in leap year generator and a independent power pin (RTC\_VIO).

The alarm generates an alarm signal at a specified time in the power-off mode or normal operation mode. In normal operation mode, both the alarm interrupt and the power management wakeup are activated. In power-off mode, the power management wakeup signal is activated. In this section, there are two kinds of alarm. Alarm 0 is a general alarm, its counter is based on second. Alarm 1 is a weekly alarm, its counter is based on the real time.

The 32768Hz oscillator is used only to provide a low power, accurate reference for the RTC.

General Purpose Register can be flag register, and it will save the value all the time when the VDD\_RTC is not power off.

### 4.12.2. RTC Register List

| Module Name | Base Address |
|-------------|--------------|
| RTC         | 0x01C20400   |

| Register Name         | Offset        | Description                            |
|-----------------------|---------------|--|
| LOSC_CTRL_REG         | 0x0           | Low Oscillator Control Register I      |
| LOSC_AUTO_SWT_STA_REG | 0x4           | LOSC Auto Switch Status Register       |
| RTC_YY_MM_DD_REG      | 0x10          | RTC Year-Month-Day Register            |
| RTC_HH_MM_SS_REG      | 0x14          | RTC Hour-Minute-Second Register        |
| ALARM0_COUNTER_REG    | 0x20          | Alarm 0 Counter Register               |
| ALARM0_CUR_VLU_REG    | 0x24          | Alarm 0 Counter Current Value Register |
| ALARM0_ENABLE_REG     | 0x28          | Alarm 0 Enable Register                |
| ALARM0_IRQ_EN         | 0x2C          | Alarm 0 IRQ Enable Register            |
| ALARM0_IRQ_STA_REG    | 0x30          | Alarm 0 IRQ Status Register            |
| ALARM1_WK_HH_MM_SS    | 0x40          | Alarm 1 Week HMS Register              |
| ALARM1_ENABLE_REG     | 0x44          | Alarm 1 Enable Register                |
| ALARM1_IRQ_EN         | 0x48          | Alarm 1 IRQ Enable Register            |
| ALARM1_IRQ_STA_REG    | 0x4C          | Alarm 1 IRQ Status Register            |
| ALARM_CONFIG_REG      | 0x50          | Alarm Config Register                  |
| LOSC_OUT_GATING_REG   | 0x60          | LOSC output gating register            |
| GP_DATA_REG           | 0x100 + N*0x4 | General Purpose Register (N=0~7)       |
| VDD_RTC_REG           | 0x190         | VDD RTC Regulate Register              |
| IC_CHAR_REG           | 0x1F0         | IC Characteristic Register             |

### 4.12.3. RTC Register Description

#### 4.12.3.1. LOSC Control Register (Default Value: 0x00004000)

| Offset: 0x00 |     |             | Register Name: LOSC_CTRL_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:16        | W   | 0x0         | KEY_FIELD.<br>Key Field. This field should be filled with 0x16AA, and then the bit 0 can be written with the new value.   |
| 15           | /   | /           | /   |
| 14           | R/W | 0x1         | LOSC_AUTO_SWT_EN.<br>LOSC auto switch enable.<br>0: Disable<br>1: Enable.   |
| 13:10        | /   | /           | /   |
| 9            | R/W | 0x0         | ALM_DDHHMMSS_ACCE.<br>ALARM DD-HH-MM-SS access.<br>After writing the ALARM DD-HH-MM-SS register, this bit is set and it will be cleared until the real writing operation is finished.   |
| 8            | R/W | 0x0         | RTC_HHMMSS_ACCE.<br>RTC HH-MM-SS access.<br>After writing the RTC HH-MM-SS register, this bit is set and it will be cleared until the real writing operation is finished.<br>After writing the RTC YY-MM-DD register, the YY-MM-DD register will be refreshed for at most one second. |
| 7            | R/W | 0x0         | RTC_YYMMDD_ACCE.<br>RTC YY-MM-DD access.<br>After writing the RTC YY-MM-DD register, this bit is set and it will be cleared until the real writing operation is finished.<br>After writing the RTC YY-MM-DD register, the YY-MM-DD register will be refreshed for at most one second. |
| 6:4          | /   | /           | /   |
| 3:2          | R/W | 0x0         | EXT_LOSC_GSM.<br>External 32768Hz Crystal GSM.<br>00: low<br>01:/<br>10:/<br>11: high   |
| 1            | /   | /           | /   |
| 0            | R/W | 0x0         | LOSC_SRC_SEL.<br>LOSC Clock source Select. 'N' is the value of Internal OSC Clock Prescalar register.<br>0: Internal 32KHz  |

|  |  |  |  |
|--|--|--|--|
|  |  |  | 1: External 32.768KHz OSC.<br>Internal 32KHz is divided from OSC24MHz. |
|--|--|--|--|


**NOTE**

Any bit of [9:7] is set, the RTC HH-MM-SS, YY-MM-DD and ALARM DD-HH-MM-SS register can't be written .

#### 4.12.3.2. LOSC Auto Swith Status Register (Default Value: 0x00000000)

| Offset: 0x04 |     |             | Register Name: <b>LOSC_AUTO_SWT_STA_REG</b>  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:2         | /   | /           | /  |
| 1            | R/W | 0x0         | LOSC_AUTO_SWT_PEND.<br>LOSC auto switch pending.<br>0: No effect<br>1: Auto switches pending<br>Setting 1 to this bit will clear it.                                 |
| 0            | RO  | 0x0         | LOSC_SRC_SEL_STA.<br>Checking LOSC Clock Source Status. 'N' is the value of Internal OSC Clock Prescalar register.<br>0: Internal 32KHz<br>1: External 32.768KHz OSC |

#### 4.12.3.3. RTC YY-MM-DD Register (Default Value: 0x00000000)

| Offset: 0x10 |     |             | Register Name: <b>RTC YY_MM_DD_REG</b>   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:23        | /   | /           | /  |
| 22           | R/W | 0x0         | LEAP.<br>Leap Year.<br>0: not, 1: Leap year.<br>This bit can not set by hardware. It should be set or cleared by software. |
| 21:16        | R/W | x           | YEAR.<br>Year.<br>Range from 0~63.   |
| 15:12        | /   | /           | /  |
| 11:8         | R/W | x           | MONTH.<br>Month.<br>Range from 1~12.   |
| 7:5          | /   | /           | /  |
| 4:0          | R/W | x           | DAY.<br>Day.<br>Range from 1~31.   |


**NOTE**

If the written value is not from 1 to 31 in Day Area, it turns into 31 automatically. Month Area and Year Area are similar to Day Area.

The number of days in different month may be different.

#### 4.12.3.4. RTC HH-MM-SS Register (Default Value: 0x00000000)

| Offset: 0x14 |     |             | Register Name: RTC_HH_MM_SS_REG   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:29        | R/W | 0x0         | WK_NO.<br>Week number.<br>000: Monday<br>001: Tuesday<br>010: Wednesday<br>011: Thursday<br>100: Friday<br>101: Saturday<br>110: Sunday<br>111: / |
| 28:21        | /   | /           | /   |
| 20:16        | R/W | x           | HOUR.<br>Range from 0~23  |
| 15:14        | /   | /           | /   |
| 13:8         | R/W | x           | MINUTE.<br>Range from 0~59  |
| 7:6          | /   | /           | /   |
| 5:0          | R/W | x           | SECOND.<br>Range from 0~59  |


**NOTE**

If the written value is not from 0 to 59 in Second Area, it turns into 59 automatically. Minute Area and Hour Area are similar to Second Area.

#### 4.12.3.5. Alarm 0 Counter Register (Default Value: 0x00000000)

| Offset: 0x20 |     |             | Register Name: ALARM0_COUNTER_REG   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0x0         | ALARM0_COUNTER.<br>Alarm 0 Counter is Based on Second.<br>If the second is set to 0, it will be 1 second in fact. |

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#### 4.12.3.6. Alarm 0 Current Value Register (Default Value: 0x00000000)

| Offset: 0x24 |     |             | Register Name: ALARM0_CUR_VLU_REG   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | RO  | x           | ALARM0_CUR_VLU.<br>Check Alarm 0 Counter Current Values.<br>If the second is set to 0, it will be 1 second in fact. |

#### 4.12.3.7. Alarm 0 Enable Register (Default Value: 0x00000000)

| Offset: 0x28 |     |             | Register Name: ALARM0_ENABLE_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:1         | /   | /           | /   |
| 0            | R/W | 0x0         | ALM_0_EN<br>Alarm 0 Enable.<br>If this bit is set to "1", the Alarm 0 Counter register's valid bits will down count to zero, and the alarm pending bit will be set to "1".<br>0: Disable<br>1: Enable |

#### 4.12.3.8. Alarm 0 IRQ Enable Register (Default Value: 0x00000000)

| Offset: 0x2C |     |             | Register Name: ALARM0_IRQ_EN_REG                                 |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:1         | /   | /           | /  |
| 0            | R/W | 0x0         | ALARM0_IRQ_EN.<br>Alarm 0 IRQ Enable.<br>0: Disable<br>1: Enable |

#### 4.12.3.9. Alarm 0 IRQ Status Register (Default Value: 0x00000000)

| Offset: 0x30 |     |             | Register Name: ALARM0_IRQ_STA_REG            |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description                                  |
| 31:1         | /   | /           | /  |
| 0            | R/W | 0x0         | ALARM0_IRQ_PEND.<br>Alarm 0 IRQ Pending bit. |

|  |  |  |  |
|--|--|--|--|
|  |  |  | 0: No effect<br>1: Pending, alarm 0 counter value is reached<br>If alarm 0 irq enable is set to 1, the pending bit will be sent to the interrupt controller. |
|--|--|--|--|

#### 4.12.3.10. Alarm 1 Week HH-MM-SS Register (Default Value: 0x00000000)

| Offset: 0x40 |     |             | Register Name: ALARM0_WK_HH_MM-SS |
|--------------|-----|-------------|-----------------------------------|
| Bit          | R/W | Default/Hex | Description                       |
| 31:21        | /   | /           | /                                 |
| 20:16        | R/W | x           | HOUR.<br>Range from 0~23.         |
| 15:14        | /   | /           | /                                 |
| 13:8         | R/W | x           | MINUTE.<br>Range from 0~59.       |
| 7:6          | /   | /           | /                                 |
| 5:0          | R/W | x           | SECOND.<br>Range from 0~59.       |


**NOTE**

If the written value is not from 0 to 59 in Second Area, it turns into 59 automatically. Minute Area and Hour Area are similar to Second Area.

#### 4.12.3.11. Alarm 1 Enable Register (Default Value: 0x00000000)

| Offset: 0x44 |     |             | Register Name: ALARM1_EN_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:7         | /   | /           | /   |
| 6            | R/W | 0x0         | WK6_ALM1_EN.<br>Week 6 (Sunday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to "1", only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 6, the week 6 alarm irq pending bit will be set to "1".   |
| 5            | R/W | 0x0         | WK5_ALM1_EN.<br>Week 5 (Saturday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to "1", only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 5, the week 5 alarm irq pending bit will be set to "1". |

|   |     |     |  |
|---|-----|-----|--|
| 4 | R/W | 0x0 | WK4_ALM1_EN.<br>Week 4 (Friday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to “1”, only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 4, the week 4 alarm irq pending bit will be set to “1”.    |
| 3 | R/W | 0x0 | WK3_ALM1_EN.<br>Week 3 (Thursday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to “1”, only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 3, the week 3 alarm irq pending bit will be set to “1”.  |
| 2 | R/W | 0x0 | WK2_ALM1_EN.<br>Week 2 (Wednesday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to “1”, only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 2, the week 2 alarm irq pending bit will be set to “1”. |
| 1 | R/W | 0x0 | WK1_ALM1_EN.<br>Week 1 (Tuesday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to “1”, only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 1, the week 1 alarm irq pending bit will be set to “1”.   |
| 0 | R/W | 0x0 | WKO_ALM1_EN.<br>Week 0 (Monday) Alarm 1 Enable.<br>0: Disable<br>1: Enable<br>If this bit is set to “1”, only when the Alarm 1 Week HH-MM-SS register valid bits is equal to RTC HH-MM-SS register and the register RTC HH-MM-SS bit [31:29] is 0, the week 0 alarm irq pending bit will be set to “1”.    |

#### 4.12.3.12. Alarm 1 IRQ Enable Register (Default Value: 0x00000000)

| Offset: 0x48 |     |             | Register Name: ALARM1_IRQ_EN_REG                    |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:1         | /   | /           | /   |
| 0            | R/W | 0x0         | ALARM1_IRQ_EN.<br>Alarm 1 IRQ Enable.<br>0: Disable |

|  |  |  |           |
|--|--|--|-----------|
|  |  |  | 1: Enable |
|--|--|--|-----------|

#### 4.12.3.13. Alarm 1 IRQ Status Register (Default Value: 0x00000000)

| Offset: 0x4C |     |             | Register Name: ALARM1_IRQ_STA_REG  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:1         | /   | /           | /  |
| 0            | R/W | 0x0         | ALARM1_WEEK_IRQ_PEND.<br>Alarm 1 Week (0/1/2/3/4/5/6) IRQ Pending.<br>0: No effect<br>1: Pending, week counter value is reached<br>If alarm 1 week irq enable is set to 1, the pending bit will be sent to the interrupt controller. |

#### 4.12.3.14. Alarm Config Register (Default Value: 0x00000000)

| Offset: 0x50 |     |             | Register Name: ALARM_CONFIG_REG  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:1         | /   | /           | /  |
| 0            | R/W | 0x0         | ALARM_WAKEUP.<br>Configuration of alarm wake up output.<br>0: Disable alarm wake up output<br>1: Enable alarm wake up output |

#### 4.12.3.15. LOSC Output Gating Register (Default Value: 0x00000000)

| Offset: 0x60 |     |             | Register Name: LOSC_OUT_GATING_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:1         | /   | /           | /   |
| 0            | R/W | 0x0         | LOSC_OUT_GATING.<br>Configuration of LOSC output, and no LOSC output by default.<br>0: Enable LOSC output gating<br>1: Disable LOSC output gating |

#### 4.12.3.16. LOSC Output Gating Register (Default Value: 0x00000000)

| Offset: 0x100+N*0x4(N=0~7) |     |             | Register Name: GP_DATA_REGn |
|----------------------------|-----|-------------|-----------------------------|
| Bit                        | R/W | Default/Hex | Description                 |
| 31:0                       | R/W | 0x0         | GP_DATA.                    |

|  |  |  |              |
|--|--|--|--------------|
|  |  |  | Data [31:0]. |
|--|--|--|--------------|


**NOTE**

General purpose register 0~7 value can be stored if the VDD\_RTC is larger than 1.0V.

#### 4.12.3.17. VDD RTC Regulation Register (Default Value: 0x00000004)

| Offset: 0x190 |     |             | Register Name: VDD_RTC_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:3          | /   | /           | /  |
| 2:0           | R/W | 0x100       | <p>VDD_RTC_REGU.</p> <p>These bits are useful for regulating the RTC_VIO from 0.7v to 1.4v, and the regulation step is 0.1V.</p> <p>000: 0.7V<br/>         001: 0.8V<br/>         010: 0.9V<br/>         011: 1.0V<br/>         100: 1.1V<br/>         101: 1.2V<br/>         110: 1.3V<br/>         111: 1.4V</p> |

#### 4.12.3.18. IC Characteristic Register (Default Value: 0x00000000)

| Offset: 0x1F0 |     |             | Register Name: IC_CHARA_REG  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:16         | R/W | 0x0         | <p>IC_CHARA.</p> <p>Key Field.</p> <p>Should be written at value 0x16AA. Writing any other value in this field aborts the write operation.</p> |
| 15:0          | R/W | 0x0         | <p>ID_DATA.</p> <p>Return 0x16aa only if the KEY_FIELD is set as 0x16aa when read those bits, otherwise return 0x0.</p>                        |

## 4.13. Audio Codec

### 4.13.1. Overview

The embedded Audio Codec is a high-quality stereo audio codec designed for embed device. It provides a stereo DAC for playback, and a stereo ADC for recording.

The Audio Codec has the following features:

- Two audio digital-to-analog(DAC) channels
- Supports analog/digital volume control
- One low-noise analog microphone bias output
- Analog low-power loop from microphone to headphone outputs
- Supports Dynamic Range Controller adjusting the DAC playback output
- One Microphone input
- One Stereo Lineout output
- Two audio analog-to-digital(ADC) channels
  - 92dB SNR@A-weight
  - Supports ADC sample rate from 8 KHz to 48 KHz
- Supports Automatic Gain Control(AGC) and Dynamic Range Control(DRC) adjusting the ADC recording input
- Interrupt and DMA support

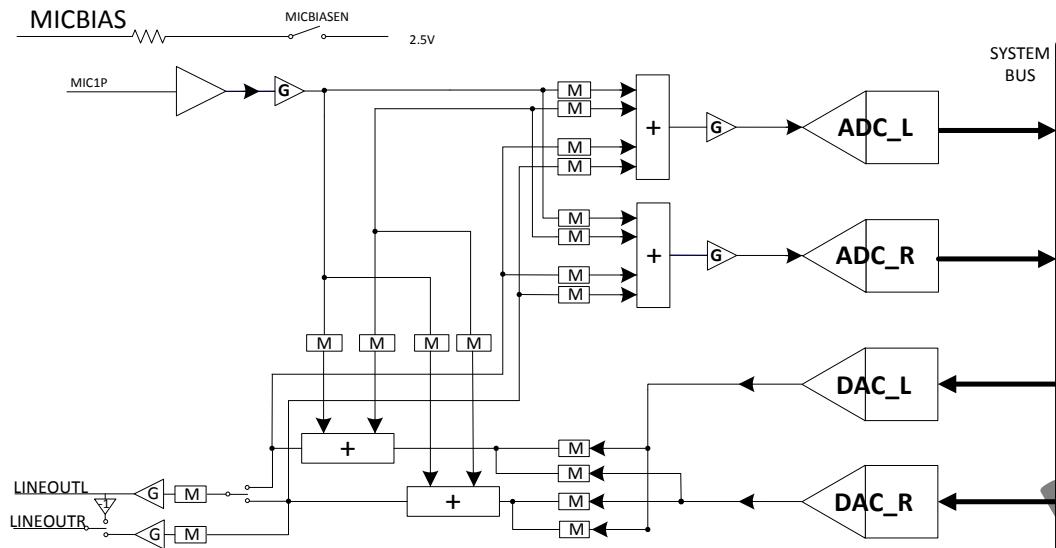
### 4.13.2. Power and Signal Description

#### 4.13.2.1. Analog I/O Pins

| Signal Name | Type | Description                     |
|-------------|------|---------------------------------|
| MICIN1P     | AI   | First microphone positive input |
| LINEOUTL    | AO   | Lineout left channel output     |
| LINEOUTR    | AO   | Lineout right channel output    |

#### 4.13.2.2. Filter/Reference

|      |    |                            |
|------|----|----------------------------|
| VRA1 | AO | internal reference voltage |
| VRA2 | AO | internal reference voltage |



#### 4.13.2.3. Power/Ground

|      |   |              |
|------|---|--------------|
| AVCC | P | Analog power |
|------|---|--------------|

#### 4.13.3. Audio Codec Register List

| Module Name | Base Address |
|-------------|--------------|
| Audio Codec | 0x01C22C00   |

| Register Name   | Offset | Description                       |
|-----------------|--------|-----------------------------------|
| AC_DAC_DPC      | 0x000  | DAC Digital Part Control Register |
| AC_DAC_FIFOC    | 0x004  | DAC FIFO Control Register         |
| AC_DAC_FIFOS    | 0x008  | DAC FIFO Status Register          |
| AC_ADC_FIFOC    | 0x010  | ADC FIFO Control Register         |
| AC_ADC_FIFOS    | 0x014  | ADC FIFO Status Register          |
| AC_ADC_RXDATA   | 0x018  | ADC RX Data Register              |
| AC_DAC_TXDATA   | 0x020  | DAC TX Data Register              |
| AC_DAC_CNT      | 0x040  | DAC TX FIFO Counter Register      |
| AC_ADC_CNT      | 0x044  | ADC RX FIFO Counter Register      |
| AC_DAC_DG       | 0x048  | DAC Debug Register                |
| AC_ADC_DG       | 0x04C  | ADC Debug Register                |
| AC_DAC_DAP_CTR  | 0x060  | DAC DAP Control Register          |
| AC_ADC_DAP_CTR  | 0x070  | ADC DAP Control Register          |
| AC_ADC_DAP_LCTR | 0x074  | ADC DAP Left Control Register     |
| AC_ADC_DAP_RCTR | 0x078  | ADC DAP Right Control Register    |

|                    |       |   |
|--------------------|-------|---|
| AC_ADC_DAP_PARA    | 0x07C | ADC DAP Parameter Register                                      |
| AC_ADC_DAP_LAC     | 0x080 | ADC DAP Left Average Coef Register                              |
| AC_ADC_DAP_LDAT    | 0x084 | ADC DAP Left Decay and Attack Time Register                     |
| AC_ADC_DAP_RAC     | 0x088 | ADC DAP Right Average Coef Register                             |
| AC_ADC_DAP_RDAT    | 0x08C | ADC DAP Right Decay and Attack Time Register                    |
| ADC_DAP_HPFC       | 0x090 | ADC DAP HPF Coef Register                                       |
| ADC_DAP_LINAC      | 0x094 | ADC DAP Left Input Signal Low Average Coef Register             |
| ADC_DAP_RINAC      | 0x098 | ADC DAP Right Input Signal Low Average Coef Register            |
| ADC_DAP_ORT        | 0x09C | ADC DAP Optimum Register  |
| AC_DAC_DRC_HHPFC   | 0x100 | DAC DRC High HPF Coef Register                                  |
| AC_DAC_DRC_LHPFC   | 0x104 | DAC DRC Low HPF Coef Register                                   |
| AC_DAC_DRC_CTRL    | 0x108 | DAC DRC Control Register  |
| AC_DAC_DRC_LPFHAT  | 0x10C | DAC DRC Left Peak Filter High Attack Time Coef Register         |
| AC_DAC_DRC_LPFLAT  | 0x110 | DAC DRC Left Peak Filter Low Attack Time Coef Register          |
| AC_DAC_DRC_RPFHAT  | 0x114 | DAC DRC Right Peak Filter High Attack Time Coef Register        |
| AC_DAC_DRC_RPFLAT  | 0x118 | DAC DRC Peak Filter Low Attack Time Coef Register               |
| AC_DAC_DRC_LPFHRT  | 0x11C | DAC DRC Left Peak Filter High Release Time Coef Register        |
| AC_DAC_DRC_LPFLRT  | 0x120 | DAC DRC Left Peak Filter Low Release Time Coef Register         |
| AC_DAC_DRC_RPFHRT  | 0x124 | DAC DRC Right Peak filter High Release Time Coef Register       |
| AC_DAC_DRC_RPFLRT  | 0x128 | DAC DRC Right Peak filter Low Release Time Coef Register        |
| AC_DAC_DRC_LRMSHAT | 0x12C | DAC DRC Left RMS Filter High Coef Register                      |
| AC_DAC_DRC_LRMSLAT | 0x130 | DAC DRC Left RMS Filter Low Coef Register                       |
| AC_DAC_DRC_RRMSHAT | 0x134 | DAC DRC Right RMS Filter High Coef Register                     |
| AC_DAC_DRC_RRMSLAT | 0x138 | DAC DRC Right RMS Filter Low Coef Register                      |
| AC_DAC_DRC_HCT     | 0x13C | DAC DRC Compressor Threshold High Setting Register              |
| AC_DAC_DRC_LCT     | 0x140 | DAC DRC Compressor Slope High Setting Register                  |
| AC_DAC_DRC_HKC     | 0x144 | DAC DRC Compressor Slope High Setting Register                  |
| AC_DAC_DRC_LKC     | 0x148 | DAC DRC Compressor Slope Low Setting Register                   |
| AC_DAC_DRC_HOPC    | 0x14C | DAC DRC Compressor High Output at Compressor Threshold Register |
| AC_DAC_DRC_LOPC    | 0x150 | DAC DRC Compressor Low Output at Compressor Threshold Register  |
| AC_DAC_DRC_HLT     | 0x154 | DAC DRC Limiter Threshold High Setting Register                 |
| AC_DAC_DRC_LL      | 0x158 | DAC DRC Limiter Threshold Low Setting Register                  |
| AC_DAC_DRC_HKI     | 0x15C | DAC DRC Limiter Slope High Setting Register                     |
| AC_DAC_DRC_LKI     | 0x160 | DAC DRC Limiter Slope Low Setting Register                      |
| AC_DAC_DRC_HOPL    | 0x164 | DAC DRC Limiter High Output at Limiter Threshold                |
| AC_DAC_DRC_LOPL    | 0x168 | DAC DRC Limiter Low Output at Limiter Threshold                 |
| AC_DAC_DRC_HET     | 0x16C | DAC DRC Expander Threshold High Setting Register                |
| AC_DAC_DRC LET     | 0x170 | DAC DRC Expander Threshold Low Setting Register                 |
| AC_DAC_DRC_HKE     | 0x174 | DAC DRC Expander Slope High Setting Register                    |
| AC_DAC_DRC_LKE     | 0x178 | DAC DRC Expander Slope Low Setting Register                     |
| AC_DAC_DRC_HOPE    | 0x17C | DAC DRC Expander High Output at Expander Threshold              |
| AC_DAC_DRC_LOPE    | 0x180 | DAC DRC Expander Low Output at Expander Threshold               |

|                     |       |   |
|---------------------|-------|---|
| AC_DAC_DRC_HKN      | 0x184 | DAC DRC Linear Slope High Setting Register                      |
| AC_DAC_DRC_LKN      | 0x188 | DAC DRC Linear Slope Low Setting Register                       |
| AC_DAC_DRC_SFHAT    | 0x18C | DAC DRC Smooth filter Gain High Attack Time Coef Register       |
| AC_DAC_DRC_SFLAT    | 0x190 | DAC DRC Smooth filter Gain Low Attack Time Coef Register        |
| AC_DAC_DRC_SFVRT    | 0x194 | DAC DRC Smooth filter Gain High Release Time Coef Register      |
| AC_DAC_DRC_SFLRT    | 0x198 | DAC DRC Smooth filter Gain Low Release Time Coef Register       |
| AC_DAC_DRC_MXGHS    | 0x19C | DAC DRC MAX Gain High Setting Register                          |
| AC_DAC_DRC_MXGLS    | 0x1A0 | DAC DRC MAX Gain Low Setting Register                           |
| AC_DAC_DRC_MNGHS    | 0x1A4 | DAC DRC MIN Gain High Setting Register                          |
| AC_DAC_DRC_MNGLS    | 0x1A8 | DAC DRC MIN Gain Low Setting Register                           |
| AC_DAC_DRC_EPSHC    | 0x1AC | DAC DRC Expander Smooth Time High Coef Register                 |
| AC_DAC_DRC_EPSLC    | 0x1B0 | DAC DRC Expander Smooth Time Low Coef Register                  |
| AC_DAC_DRC_HPFHGAIN | 0x1B8 | DAC DRC HPF Gain High   |
| AC_DAC_DRC_HPFLGAIN | 0x1BC | DAC DRC HPF Gain Low  |
| AC_ADC_DRC_HHPFC    | 0x200 | ADC DRC High HPF Coef Register                                  |
| AC_ADC_DRC_LHPFC    | 0x204 | ADC DRC Low HPF Coef Register                                   |
| AC_ADC_DRC_CTRL     | 0x208 | ADC DRC Control Register  |
| AC_ADC_DRC_LPFHAT   | 0x20C | ADC DRC Left Peak Filter High Attack Time Coef Register         |
| AC_ADC_DRC_LPFLAT   | 0x210 | ADC DRC Left Peak Filter Low Attack Time Coef Register          |
| AC_ADC_DRC_RPFHAT   | 0x214 | ADC DRC Right Peak Filter High Attack Time Coef Register        |
| AC_ADC_DRC_RPFLAT   | 0x218 | ADC DRC Peak Filter Low Attack Time Coef Register               |
| AC_ADC_DRC_LPFHRT   | 0x21C | ADC DRC Left Peak Filter High Release Time Coef Register        |
| AC_ADC_DRC_LPFLRT   | 0x220 | ADC DRC Left Peak Filter Low Release Time Coef Register         |
| AC_ADC_DRC_RPFHRT   | 0x224 | ADC DRC Right Peak filter High Release Time Coef Register       |
| AC_ADC_DRC_RPFLRT   | 0x228 | ADC DRC Right Peak filter Low Release Time Coef Register        |
| AC_ADC_DRC_LRMSHAT  | 0x22C | ADC DRC Left RMS Filter High Coef Register                      |
| AC_ADC_DRC_LRMSLAT  | 0x230 | ADC DRC Left RMS Filter Low Coef Register                       |
| AC_ADC_DRC_RRMSHAT  | 0x234 | ADC DRC Right RMS Filter High Coef Register                     |
| AC_ADC_DRC_RRMSLAT  | 0x238 | ADC DRC Right RMS Filter Low Coef Register                      |
| AC_ADC_DRC_HCT      | 0x23C | ADC DRC Compressor Threshold High Setting Register              |
| AC_ADC_DRC_LCT      | 0x240 | ADC DRC Compressor Slope High Setting Register                  |
| AC_ADC_DRC_HKC      | 0x244 | ADC DRC Compressor Slope High Setting Register                  |
| AC_ADC_DRC_LKC      | 0x248 | ADC DRC Compressor Slope Low Setting Register                   |
| AC_ADC_DRC_HOPC     | 0x24C | ADC DRC Compressor High Output at Compressor Threshold Register |
| AC_ADC_DRC_LOPC     | 0x250 | ADC DRC Compressor Low Output at Compressor Threshold Register  |
| AC_ADC_DRC_HLT      | 0x254 | ADC DRC Limiter Threshold High Setting Register                 |
| AC_ADC_DRC_LLT      | 0x258 | ADC DRC Limiter Threshold Low Setting Register                  |
| AC_ADC_DRC_HKI      | 0x25C | ADC DRC Limiter Slope High Setting Register                     |
| AC_ADC_DRC_LKI      | 0x260 | ADC DRC Limiter Slope Low Setting Register                      |
| AC_ADC_DRC_HOPL     | 0x264 | ADC DRC Limiter High Output at Limiter Threshold                |
| AC_ADC_DRC_LOPL     | 0x268 | ADC DRC Limiter Low Output at Limiter Threshold                 |
| AC_ADC_DRC_HET      | 0x26C | ADC DRC Expander Threshold High Setting Register                |

|                        |       |  |
|------------------------|-------|--|
| AC_ADC_DRC_LET         | 0x270 | ADC DRC Expander Threshold Low Setting Register            |
| AC_ADC_DRC_HKE         | 0x274 | ADC DRC Expander Slope High Setting Register               |
| AC_ADC_DRC_LKE         | 0x278 | ADC DRC Expander Slope Low Setting Register                |
| AC_ADC_DRC_HOPE        | 0x27C | ADC DRC Expander High Output at Expander Threshold         |
| AC_ADC_DRC_LOPE        | 0x280 | ADC DRC Expander Low Output at Expander Threshold          |
| AC_ADC_DRC_HKN         | 0x284 | ADC DRC Linear Slope High Setting Register                 |
| AC_ADC_DRC_LKN         | 0x288 | ADC DRC Linear Slope Low Setting Register                  |
| AC_ADC_DRC_SFHAT       | 0x28C | ADC DRC Smooth filter Gain High Attack Time Coef Register  |
| AC_ADC_DRC_SFLAT       | 0x290 | ADC DRC Smooth filter Gain Low Attack Time Coef Register   |
| AC_ADC_DRC_SFVRT       | 0x294 | ADC DRC Smooth filter Gain High Release Time Coef Register |
| AC_ADC_DRC_SFLRT       | 0x298 | ADC DRC Smooth filter Gain Low Release Time Coef Register  |
| AC_ADC_DRC_MXGHS       | 0x29C | ADC DRC MAX Gain High Setting Register                     |
| AC_ADC_DRC_MXGLS       | 0x2A0 | ADC DRC MAX Gain Low Setting Register                      |
| AC_ADC_DRC_MNGLS       | 0x2A4 | ADC DRC MIN Gain High Setting Register                     |
| AC_ADC_DRC_MXGLS       | 0x2A8 | ADC DRC MIN Gain Low Setting Register                      |
| AC_ADC_DRC_EPSHC       | 0x2AC | ADC DRC Expander Smooth Time High Coef Register            |
| AC_ADC_DRC_EPSLC       | 0x2B0 | ADC DRC Expander Smooth Time Low Coef Register             |
| AC_ADC_DRC_HPFHGAIN    | 0x2B8 | ADC DRC HPF Gain High                                      |
| AC_ADC_DRC_HPFLGAIN    | 0x2BC | ADC DRC HPF Gain Low                                       |
| AC_PR_CFG              | 0x400 | AC Parameter Configuration Register                        |
| Analog Domain Register |       |  |
| AC_LOMIXSC             | 0x01  | Left Output Mixer Source Select Control Register           |
| AC_ROMIXSC             | 0x02  | Right Output Mixer Source Select Control Register          |
| DAC_PA_SRC             | 0x03  | DAC Analog Enable and PA Source Control Register           |
| MIC_GCTR               | 0x06  | MIC1 Gain Control Register                                 |
| LINEOUT_VOLC           | 0x09  | Lineout Volume Control Register                            |
| LINEOUT_CTRL           | 0x0A  | Lineout Enable Control Register                            |
| BIAS_MIC_CTRL          | 0x0B  | BIAS and MIC1 boost  |
| LADC_MIX_MUTE          | 0x0C  | Left ADC Mixer Mute Control                                |
| RADC_MIX_MUTE          | 0x0D  | Right ADC Mixer Mute Control                               |
| AC_ADC_CTRL            | 0x0F  | ADC Analog Control Register                                |
| OPADC_CTRL             | 0x10  | OPDRV/OPCOM 、 OPADC Control                                |
| OPMIC_CTRL             | 0x11  | OPMIC、 OPVR and OPADC Control                              |
| ZERO_CROSS_CTRL        | 0x12  | ZERO CROSS Control   |
| ADC_FUN_CTRL           | 0x13  | ADC Function Control                                       |
| CALIBRATION_CTRL       | 0x14  | Bias & DA16 Calibration Control Register                   |
| DA16CALI_DATA          | 0x15  | DA16 Calibration Data                                      |
| BIAS16CALI_DATA        | 0x17  | Bias Calibration Data                                      |
| BIAS16CALI_SET         | 0x18  | Bias Register Setting Data                                 |

#### 4.13.4. Audio Codec Register Description

##### 4.13.4.1. 0x000 DAC Digital Part Control Register(Default Value: 0x00000000)

| Offset: 0x000 |     |             | Register Name: AC_DAC_DPC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31            | R/W | 0x0         | EN_DAC<br>DAC Digital Part Enable<br>0 : Disable<br>1 : Enable  |
| 30:29         | /   | /           | /   |
| 28:25         | R/W | 0x0         | MODQU<br>Internal DAC Quantization Levels<br>Levels=[7*(21+MODQU[3:0])]/128<br>Default levels=7*21/128=1.15 |
| 24:19         | /   | /           | /   |
| 18            | R/W | 0x0         | HPF_EN<br>High Pass Filter Enable<br>0: Disable<br>1: Enable  |
| 17:12         | R/W | 0x0         | DVOL<br>Digital volume control: DVC, ATT=DVC[5:0]*(-1.16Db)<br>64 steps, -1.16Db/step                       |
| 11:0          | /   | /           | /   |

##### 4.13.4.2. 0x004 DAC FIFO Control Register(Default Value: 0x00000F00)

| Offset: 0x004 |     |             | Register Name: AC_DAC_FIFOC  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:29         | R/W | 0X0         | DAC_FS<br>Sample Rate Of DAC<br>000: 48KHz<br>010: 24KHz<br>100: 12KHz<br>110: 192KHz<br>001: 32KHz<br>011: 16KHz<br>101: 8KHz<br>111: 96KHz<br>44.1KHz/22.05KHz/11.025KHz can be supported by Audio PLL Configure Bit |
| 28            | R/W | 0x0         | FIR_VER<br>FIR Version   |

|       |     |     |  |
|-------|-----|-----|--|
|       |     |     | 0: 64-Tap FIR; 1: 32-Tap FIR   |
| 27    | /   | /   | /  |
| 26    | R/W | 0x0 | <b>SEND_LASAT</b><br>Audio sample select when TX FIFO under run<br>0: Sending zero<br>1: Sending last audio sample   |
| 25:24 | R/W | 0x0 | <b>FIFO_MODE</b><br>For 24-bits transmitted audio sample:<br>00/10: FIFO_I[23:0] = {TXDATA[31:8]}<br>01/11: Reserved<br>For 16-bits transmitted audio sample:<br>00/10: FIFO_I[23:0] = {TXDATA[31:16], 8'b0}<br>01/11: FIFO_I[23:0] = {TXDATA[15:0], 8'b0}   |
| 23    | /   | /   | /  |
| 22:21 | R/W | 0x0 | <b>DAC_DRQ_CLR_CNT</b><br>When TX FIFO Available Room Less Than Or Equal N, DRQ Request Will Be De-Asserted. N Is Defined Here:<br>00: IRQ/DRQ De-Asserted When WLEVEL > TXTL<br>01: 4<br>10: 8<br>11: 16  |
| 20:15 | /   | /   | /  |
| 14:8  | R/W | 0XF | <b>TX_TRIG_LEVEL</b><br>TX FIFO Empty Trigger Level (TXTL[12:0])<br>Interrupt and DMA request trigger level for TX FIFO normal condition.<br>IRQ/DRQ Generated when WLEVEL ≤ TXTL<br> <b>NOTE</b><br><b>WLEVEL</b> represents the number of valid samples in the TX FIFO.<br><b>Only TXTL[6:0] valid when TXMODE = 0.</b> |
| 7     | R/W | 0x0 | <b>ADDA_LOOP_EN</b><br>ADDA Loop Enable<br>0: Disable<br>1: Enable   |
| 6     | R/W | 0x0 | <b>DAC_MONO_EN</b><br>DAC Mono Enable<br>0: Stereo, 64 Levels FIFO<br>1: Mono, 128 Levels FIFO<br>When Enabled, L & R Channel Send Same Data   |
| 5     | R/W | 0x0 | <b>TX_SAMPLE_BITS</b><br>Transmitting Audio Sample Resolution<br>0: 16 bits<br>1: 24 bits  |
| 4     | R/W | 0x0 | <b>DAC_DRQ_EN</b><br>DAC FIFO Empty DRQ Enable   |

|   |     |     |  |
|---|-----|-----|--|
|   |     |     | 0: Disable<br>1: Enable  |
| 3 | R/W | 0X0 | DAC_IRQ_EN<br>DAC FIFO Empty IRQ Enable<br>0: Disable<br>1: Enable               |
| 2 | R/W | 0X0 | FIFO_UNDERRUN_IRQ_EN<br>DAC FIFO Under Run IRQ Enable<br>0: Disable<br>1: Enable |
| 1 | R/W | 0X0 | FIFO_OVERRUN_IRQ_EN<br>DAC FIFO Over Run IRQ Enable<br>0: Disable<br>1: Enable   |
| 0 | R/W | 0X0 | FIFO_FLUSH<br>DAC FIFO Flush<br>Write '1' To Flush TX FIFO, Self Clear to '0'    |

#### 4.13.4.3. 0x008 DAC FIFO Status Register(Default Value: 0x00800088)

| Offset: 0x008 |     |             | Register Name: AC_DAC_FIFOS   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:24         | /   | /           | /   |
| 23            | R   | 0x1         | TX_EMPTY<br>TX FIFO Empty<br>0: No room for new sample in TX FIFO<br>1: More than one room for new sample in TX FIFO (>= 1 word)  |
| 22:8          | R   | 0x80        | TXE_CNT<br>TX FIFO Empty Space Word Counter   |
| 7:4           | /   | /           | /   |
| 3             | R/W | 0x1         | TXE_INT<br>TX FIFO Empty Pending Interrupt<br>0: No Pending IRQ<br>1: FIFO Empty Pending Interrupt<br>Write '1' to clear this interrupt or automatic clear if interrupt condition fails |
| 2             | R/W | 0x0         | TXU_INT<br>TX FIFO Under run Pending Interrupt<br>0: No Pending Interrupt<br>1: FIFO Under run Pending Interrupt<br>Write '1' to clear this interrupt                                   |
| 1             | R/W | 0x0         | TXO_INT<br>TX FIFO Overrun Pending Interrupt<br>0: No Pending Interrupt<br>1: FIFO Overrun Pending Interrupt  |

|   |   |   |                                   |
|---|---|---|-----------------------------------|
|   |   |   | Write '1' to clear this interrupt |
| 0 | / | / | /                                 |

#### 4.13.4.4. 0x010 ADC FIFO Control Register(Default Value: 0x00000F00)

| Offset: 0x010 |     |             | Register Name: AC_ADC_FIFOC  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:29         | R/W | 0X0         | <p>ADFS<br/>Sample Rate of ADC<br/>000: 48KHz<br/>010: 24KHz<br/>100: 12KHz<br/>110: Reserved<br/>001: 32KHz<br/>011: 16KHz<br/>101: 8KHz<br/>111: Reserved<br/>44.1KHz/22.05KHz/11.025KHz can be supported by Audio PLL Configure Bit</p>   |
| 28            | R/W | 0X0         | <p>EN_AD<br/>ADC Digital Part Enable<br/>0: Disable<br/>1: Enable</p>  |
| 27:25         | /   | /           | /  |
| 24            | R/W | 0X0         | <p>RX_FIFO_MODE<br/>RX FIFO Output Mode (Mode 0, 1)<br/>0: Expanding '0' at LSB of TX FIFO register<br/>1: Expanding received sample sign bit at MSB of TX FIFO register<br/>For 24-bits received audio sample:<br/>Mode 0: RXDATA[31:0] = {FIFO_O[23:0], 8'h0}<br/>Mode 1: Reserved<br/>For 16-bits received audio sample:<br/>Mode 0: RXDATA[31:0] = {FIFO_O[23:8], 16'h0}<br/>Mode 1: RXDATA[31:0] = {16{FIFO_O[23]}, FIFO_O[23:8]}</p> |
| 23:19         | /   | /           | /  |
| 18:17         | R/W | 0X0         | <p>ADCFDT<br/>ADC FIFO Delay Time For writing Data after EN_AD<br/>00:5ms<br/>01:10ms<br/>10:20ms<br/>11:30ms</p>  |
| 16            | R/W | 0X0         | <p>ADCDFEN<br/>ADC FIFO Delay Function For writing Data after EN_AD<br/>0: Disable<br/>1: Enable</p>   |

|       |     |     |   |
|-------|-----|-----|---|
| 15:13 | /   | /   | /   |
| 12:8  | R/W | 0XF | <p>RX_FIFO_TRG_LEVEL<br/>RX FIFO Trigger Level (RXTL[4:0])<br/>Interrupt and DMA request trigger level for RX FIFO normal condition<br/>IRQ/DRQ Generated when WLEVEL &gt; RXTL[4:0]</p> <p> <b>NOTE</b></p> <p><b>WLEVEL represents the number of valid samples in the RX FIFO.</b></p> |
| 7     | R/W | 0X0 | <p>ADC_MONO_EN<br/>ADC Mono Enable<br/>0: Stereo, 16 levels FIFO<br/>1: mono, 32 levels FIFO<br/>When set to '1', Only left channel samples are recorded</p>  |
| 6     | R/W | 0x0 | <p>RX_SAMPLE_BITS<br/>Receiving Audio Sample Resolution<br/>0: 16 bits<br/>1: 24 bits</p>   |
| 5     | /   | /   | /   |
| 4     | R/W | 0X0 | <p>ADC_DRQ_EN<br/>ADC FIFO Data Available DRQ Enable<br/>0: Disable<br/>1: Enable</p>   |
| 3     | R/W | 0X0 | <p>ADC_IRQ_EN<br/>ADC FIFO Data Available IRQ Enable<br/>0: Disable<br/>1: Enable</p>   |
| 2     | /   | /   |   |
| 1     | R/W | 0X0 | <p>ADC_OVERRUN_IRQ_EN<br/>ADC FIFO Over Run IRQ Enable<br/>0: Disable<br/>1: Enable</p>   |
| 0     | R/W | 0X0 | <p>ADC_FIFO_FLUSH<br/>ADC FIFO Flush<br/>Write '1' to flush TX FIFO, self clear to '0'</p>  |

#### 4.13.4.5. 0x014 ADC FIFO Status Register(Default Value: 0x00000000)

| Offset: 0x014 |     |             | Register Name: AC_ADC_FIFOS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:24         | /   | /           | /  |
| 23            | R   | 0X0         | <p>RXA<br/>RX FIFO Available<br/>0: No available data in RX FIFO<br/>1: More than one sample in RX FIFO (&gt;= 1 word)</p> |

|       |     |     |  |
|-------|-----|-----|--|
| 22:14 | /   | /   | /  |
| 13:8  | R   | 0X0 | RXA_CNT<br>RX FIFO Available Sample Word Counter   |
| 7:4   | /   | /   | /  |
| 3     | R/W | 0X0 | RXA_INT<br>RX FIFO Data Available Pending Interrupt<br>0: No Pending IRQ<br>1: Data Available Pending IRQ<br>Write '1' to clear this interrupt or automatic clear if interrupt condition fails |
| 2     | /   | /   | /  |
| 1     | R/W | 0X0 | RXO_INT<br>RX FIFO Overrun Pending Interrupt<br>0: No Pending IRQ<br>1: FIFO Overrun Pending IRQ<br>Write '1' to clear this interrupt  |
| 0     | /   | /   | /  |

#### 4.13.4.6. 0x018 ADC RX DATA Register(Default Value: 0x00000000)

| Offset: 0x018 |     |             | Register Name: AC_ADC_RXDATA   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:0          | R   | 0X0         | RX_DATA<br>RX Sample<br>Host can get one sample by reading this register. The left channel sample data is first and then the right channel sample. |

#### 4.13.4.7. 0x020 DAC TX DATA Register(Default Value: 0x00000000)

| Offset: 0x020 |     |             | Register Name: AC_DAC_TXDATA  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:0          | W   | 0X0         | TX_DATA<br>Transmitting left, right channel sample data should be written this register one by one. The left channel sample data is first and then the right channel sample |

#### 4.13.4.8. 0x040 DAC TX Counter Register(Default Value: 0x00000000)

| Offset: 0x040 |     |             | Register Name: AC_DAC_CNT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:0          | R/W | 0X0         | TX_CNT<br>TX Sample Counter<br>The audio sample number of sending into TXFIFO. When one sample is put |

|  |  |  |  |
|--|--|--|--|
|  |  |  | <p>into TXFIFO by DMA or by host IO, the TX sample counter register increases by one. The TX sample counter register can be set to any initial value at any time. After been updated by the initial value, the counter register should count on base of this initial value</p> <p> <b>NOTE</b></p> <p><b>It is used for Audio/ Video Synchronization.</b></p> |
|--|--|--|--|

#### 4.13.4.9. 0x044 ADC RX Counter Register(Default Value: 0x00000000)

| Offset: 0x044 |     |             | Register Name: AC_ADC_CNT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:0          | R/W | 0X0         | <p><b>RX_CNT</b><br/>RX Sample Counter<br/>The audio sample number of writing into RXFIFO. When one sample is written by Digital Audio Engine, the RX sample counter register increases by one. The RX sample counter register can be set to any initial value at any time. After been updated by the initial value, the counter register should count on base of this initial value.</p> <p> <b>NOTE</b></p> <p><b>It is used for Audio/ Video Synchronization.</b></p> |

#### 4.13.4.10. 0x048 DAC Debug Register(Default Value: 0x00000000)

| Offset: 0x048 |     |             | Register Name: AC_DAC_DG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:12         | /   | /           | /  |
| 11            | R/W | 0X0         | <p><b>DAC_MODU_SELECT</b><br/>DAC Modulator Debug<br/>0: DAC Modulator Normal Mode<br/>1: DAC Modulator Debug Mode</p>   |
| 10:9          | R/W | 0X0         | <p><b>DAC_PATTERN_SELECT.</b><br/>DAC Pattern Select<br/>00: Normal (Audio Sample from TX FIFO)<br/>01: -6 dB Sin wave<br/>10: -60 dB Sin wave<br/>11: silent wave</p> |
| 8             | R/W | 0X0         | <p><b>CODEC_CLK_SELECT</b><br/>CODEC Clock Source Select<br/>0: CODEC Clock from PLL<br/>1: CODEC Clock from OSC (For Debug)</p>                                       |

|     |     |     |   |
|-----|-----|-----|---|
| 7   | /   | /   | /   |
| 6   | R/W | 0X0 | DA_SWP<br>DAC output channel swap enable<br>0:Disable<br>1:Enable |
| 5:0 | /   | /   | /   |

#### 4.13.4.11. 0x04C ADC Debug Register(Default Value: 0x00000000)

| Offset: 0x4C |     |             | Register Name: AC_ADC_DG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:25        | /   | /           | /  |
| 24           | R/W | 0X0         | AD_SWP<br>ADC Output Channel Swap Enable (for digital filter)<br>0: Disable<br>1: Enable |
| 23:0         | /   | /           | /  |

#### 4.13.4.12. 0x050 HMIC Control Register(Default Value: 0x00000000)

| Offset: 0x50 |     |             | Register Name: HMIC_CTRL   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:28        | R/W | 0x0         | HMIC_M<br>Debounce when key down or key up   |
| 27:24        | R/W | 0x0         | HMIC_N<br>Debounce when earphone plug in or pull out   |
| 23           | R/W | 0x0         | HMIC_DATA_IRQ_MODE<br>Hmic Data Irq Mode Select<br>0: Hmic data irq once after key down<br>1: Hmic data irq from key down, until key up  |
| 22:21        | R/W | 0x0         | HMIC_TH1_HYSTESIS<br>Hmic Hysteresis Threshold1<br>00: no Hysteresis<br>01: Pull Out when Data <= (Hmic_th2-1)<br>10: Pull Out when Data <= (Hmic_th2-2)<br>11: Pull Out when Data <= (Hmic_th2-3) |
| 20           | R/W | 0x0         | HMIC_PULLOUT_IRQ<br>Hmic Earphone Pull out Irq Enable<br>00: disable, 11: enable   |
| 19           | R/W | 0x0         | HMIC_PLUGIN_IRQ<br>Hmic Earphone Plug in Irq Enable<br>00: disable 11: enable  |

|       |     |     |   |
|-------|-----|-----|---|
| 18    | R/W | 0x0 | HMIC_KEYUP_IRQ<br>Hmic Key Up Irq Enable<br>00: disable 11: enable  |
| 17    | R/W | 0x0 | HMIC_KEYDOWN_IRQ<br>Hmic Key Down Irq Enable<br>00: disable 11: enable  |
| 16    | R/W | 0x0 | HMIC_DATA_IRQ_EN<br>Hmic Data Irq Enable<br>00: disable 11: enable  |
| 15:14 | R/W | 0x0 | HMIC_SAMPLE_SELECT<br>Down Sample Setting Select<br>00: Down by 1, 128Hz<br>01: Down by 2, 64Hz<br>10: Down by 4, 32Hz<br>11: Down by 8, 16Hz |
| 13    | R/W | 0x0 | HMIC_TH2_HYSTESIS<br>Hmic Hysteresis Threshold2<br>0: no Hysteresis<br>1: Key Up when Data <= (Hmic_th2-1)                                    |
| 12:8  | R/W | 0x0 | HMIC_TH2<br>Hmic_th2 for detecting Key down or Key up.  |
| 7:6   | R/W | 0x0 | HMIC_SF<br>Hmic Smooth Filter setting<br>00: by pass<br>01: (x1+x2)/2<br>10: (x1+x2+x3+x4)/4<br>11: (x1+x2+x3+x4+ x5+x6+x7+x8)/8              |
| 5     | R/W | 0x0 | KEYUP_CLEAR<br>Key Up Irq Pending bit auto clear when Key Down Irq<br>0: don't clear 1: auto clear  |
| 4:0   | R/W | 0x0 | HMIC_TH1<br>Hmic_th1[4:0], detecting eraphone plug in or pull out.  |

#### 4.13.4.13. 0x054 HMIC Data Register(Default Value: 0x00000000)

| Offset: 0x54 |            |         | Register Name: <b>HMIC_DATA</b>  |
|--------------|------------|---------|--|
| Bit          | Read/Write | Default | Description  |
| 31:21        | /          | /       | /  |
| 20           | R/W        | 0x0     | HMIC_PULLOUT_PENDING<br>Hmic Earphone Pull out Irq pending bit, write 1 to clear<br>0: No Pending Interrupt<br>1: Pull out Irq Pending Interrupt |
| 19           | R/W        | 0x0     | HMIC_PLUGIN_PENDING<br>Hmic Earphone Plug in Irq pending bit, write 1 to clear   |

|      |     |     |   |
|------|-----|-----|---|
|      |     |     | 0: No Pending Interrupt<br>1: Plug in Irq Pending Interrupt   |
| 18   | R/W | 0x0 | HMIC_KEYUP_PENDING<br>Hmic Key Up Irq pending bit, write 1 to clear<br>0: No Pending Interrupt<br>1: Key up Irq Pending Interrupt       |
| 17   | R/W | 0x0 | HMIC_KEYDOWN_PENDING<br>Hmic Key Down Irq pending bit, write 1 to clear<br>0: No Pending Interrupt<br>1: Key down Irq Pending Interrupt |
| 16   | R/W | 0x0 | HMIC_DATA_PENDING<br>Hmic Data Irq pending bit, write 1 to clear<br>0: No Pending Interrupt<br>1: Data Irq Pending Interrupt            |
| 15:5 | /   | /   | /   |
| 4:0  | R   | 0x0 | HMIC_DATA<br>HMIC ADC Data  |

#### 4.13.4.14. 0x060 DAC DAP Control Register(Default Value: 0x00000000)

| Offset: 0x060 |     |             | Register Name: AC_DAC_DAP_CTR                              |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | R/W | 0X0         | DDAP_EN<br>DAP for dac Enable<br>0 : bypass<br>1 : enable  |
| 30:16         | /   | /           | /  |
| 15            | R/W | 0X0         | DDAP_DRC_EN<br>DRC enable control<br>0:disable<br>1:enable |
| 14            | R/W | 0X0         | DDAP_HPF_EN<br>HPF enable control<br>0:disable<br>1:enable |
| 13:0          | /   | /           | /  |

#### 4.13.4.15. 0x070 ADC DAP Control Register(Default Value: 0x00000000)

| Offset: 0x070 |     |             | Register Name: AC_ADC_DAP_CTR |
|---------------|-----|-------------|-------------------------------|
| Bit           | R/W | Default/Hex | Description                   |
| 31            | R/W | 0X0         | ADAP_EN                       |

|       |     |     |   |
|-------|-----|-----|---|
|       |     |     | DAP for ADC enable<br>0 : bypass<br>1: enable   |
| 30    | R/W | 0x0 | ADAP_START.<br>DAP for ADC start up<br>0 : disable<br>1: start up   |
| 29:27 | /   | /   | /   |
| 26    | R/W | 0x0 | ENADC_DRC<br>DRC for ADC enable<br>0 : bypass<br>1 : enable   |
| 25    | R/W | 0x0 | ADC_DRC_EN<br>ADC DRC function enable<br>0 : disable<br>1 : enable  |
| 24    | R/W | 0x0 | ADC_DRC_HPF_EN<br>ADC DRC HPF function enable<br>0 : disable<br>1 : enable  |
| 23:22 | /   | /   | /   |
| 21    | R   | 0x0 | ADAP_LSATU_FLAG.<br>Left channel AGC saturation flag<br>0 : no saturation<br>1: saturation  |
| 20    | R   | 0x0 | ADAP_LNOI_FLAG.<br>Left channel AGC noise-threshold flag  |
| 19:12 | R   | 0x0 | ADAP_LCHAN_GAIN<br>Left channel Gain applied by AGC<br>(7.1format 2s component(-20dB – 40dB), 0.5dB/ step)<br>0x50 : 40dB<br>0x4F : 39.5dB<br>-----<br>0x00 : 00dB<br>0xFF : -0.5dB |
| 11:10 | /   | /   | /   |
| 9     | R   | 0x0 | ADAP_RSATU_FLAG.<br>Right AGC saturation flag<br>0 : no saturation<br>1: saturation   |
| 8     | R   | 0x0 | ADAP_RNOI_FLAG.<br>Right channel AGC noise-threshold flag   |
| 7:0   | R   | 0x0 | ADAP_LCHAN_GAIN.<br>Right Channel Gain applied by AGC (7.1format 2s component)(0.5dB step)<br>0x50 : 40dB   |

|  |  |  |  |
|--|--|--|--|
|  |  |  | 0x4F : 39.5dB<br>-----<br>0x00 : 00dB<br>0xFF : -0.5dB |
|--|--|--|--|

#### 4.13.4.16. 0x074 ADC DAP Left Control Register(Default Value: 0x001F1800)

| Offset: 0x074 |     |                 | Register Name: AC_ADC_DAP_LCTR  |
|---------------|-----|-----------------|---|
| Bit           | R/W | Default/Hex     | Description   |
| 31:24         | /   | /               | /   |
| 23:16         | R/W | 0x1F<br>(-86dB) | ADAP_LNOI_SET.<br>Left channel noise threshold setting<br>0x00 : -24dB<br>0x01 : -26dB<br>0x02 : -28dB<br>-----<br>0x1D : -82dB<br>0x1E : -84dB<br>0x1F : -86dB |
| 15            | /   | /               | /   |
| 14            | R/W | 0x1             | AAGC_LCHAN_EN.<br>Left AGC function enable<br>0:disable<br>1:enable   |
| 13            | R/W | 0x1             | ADAP_LHPF_EN.<br>Left HPF enable<br>0: disable<br>1: enable   |
| 12            | R/W | 0x1             | ADAP_LNOI_DET.<br>Left Noise detect enable<br>0: disable<br>1: enable   |
| 11:10         | /   | /               | /   |
| 9:8           | R/W | 0x0             | ADAP_LCHAN_HYS.<br>Left Hysteresis setting<br>00 : 1dB<br>01 : 2dB<br>10 : 4dB<br>11 : disable  |
| 7:4           | R/W | 0x0             | ADAP_LNOI_DEB.<br>Left Noise debounce time<br>0000:0/fs<br>0001:4/fs<br>0010:8/fs   |

|     |     |     |  |
|-----|-----|-----|--|
|     |     |     | -----<br>1111 :16*4096/fs<br>T=2(N+1)/fs ,except N=0   |
| 3:0 | R/W | 0x0 | ADAP_LSIG_DEB.<br>Left Signal debounce time<br>0000:0/fs<br>0001:4/fs<br>0010:8/fs<br>-----<br>1111 :16*4096/fs<br>T=2(N+1)/fs ,except N=0 |

#### 4.13.4.17. 0x078 ADC DAP Right Control Register(Default Value: 0x001F7000)

| Offset: 0x078 |     |                 | Register Name: AC_ADC_DAP_RCTR  |
|---------------|-----|-----------------|---|
| Bit           | R/W | Default/Hex     | Description   |
| 31:21         | /   | /               | /   |
| 20:16         | R/W | 0x1F<br>(-86dB) | ADAP_RNOI_SET.<br>Right channel noise threshold setting<br>0x00 : -24dB<br>0x01 : -26dB<br>0x02 : -28dB<br>-----<br>0x1D: -82dB<br>0x1E: -84dB<br>0x1F: -86dB |
| 15            | /   | /               | /   |
| 14            | R/W | 0x1             | AAGC_RCHAN_EN.<br>Right AGC enable<br>0:disable<br>1:enable   |
| 13            | R/W | 0x1             | ADAP_RHPF_EN.<br>Right HPF enable<br>0: disable<br>1: enable  |
| 12            | R/W | 0x1             | ADAP_RNOI_DET.<br>Right Noise detect enable<br>0: disable<br>1:enable   |
| 11:10         | /   | /               | /   |
| 9:8           | R/W | 0x0             | ADAP_RCHAN_HYS.<br>Right Hysteresis setting<br>00 : 1dB<br>01 : 2dB   |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | 10 : 4dB<br>11 : disable;   |
| 7:4 | R/W | 0x0 | ADAP_RNOI_DEB.<br>Right Noise debounce time<br>0000:0/fs<br>0001:4/fs<br>0010:8/fs<br>-----<br>1111: 16*4096/fs<br>T=2(N+1)/fs ,except N=0  |
| 3:0 | R/W | 0x0 | ADAP_RSIG_DEB.<br>Right Signal debounce time<br>0000:0/fs<br>0001:4/fs<br>0010:8/fs<br>-----<br>1111: 16*4096/fs<br>T=2(N+1)/fs ,except N=0 |

#### 4.13.4.18. 0x07CADC DAP Parameter Register(Default Value: 0x2C2C2828)

| Offset: 0x07C |     |             | Register Name: AC_ADC_DAP_PARA  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:30         | /   | /           | /   |
| 29:24         | R/W | 0x2C        | ADAP_LTARG_SET.<br>Left channel target level setting (-1dB -- -30dB). (6.0format 2s component)  |
| 23:22         | /   | /           | /   |
| 21:16         | R/W | 0x2C        | ADAP_RTARG_SET.<br>Right channel target level setting (-1dB -- -30dB). (6.0format 2s component) |
| 15:8          | R/W | 0x28        | ADAP_LGAIN_MAX.<br>Left channel max gain setting (0-40dB). (7.1format 2s component)             |
| 7:0           | R/W | 0x28        | ADAP_RGAIN_MAX.<br>Right channel max gain setting (0-40dB). (7.1format 2s component)            |

#### 4.13.4.19. 0x080 ADC DAP Left Average Coef Register(Default Value: 0x00051EB8)

| Offset: 0x080 |     |             | Register Name: AC_ADC_DAP_LAC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:27         | /   | /           | /   |
| 26:0          | R/W | 0x00051EB8  | ADAP_LAC.<br>Average level coefficient setting(3.24format 2s component) |

**4.13.4.20. 0x084 ADC DAP Left Decay & Attack Time Register(Default Value: 0x0000001F)**

| Offset: 0x084 |     |                     | Register Name: AC_ADC_DAP_LDAT   |
|---------------|-----|---------------------|--|
| Bit           | R/W | Default/Hex         | Description  |
| 31            | /   | /                   | /  |
| 30:16         | R/W | 0x0000              | <p>ADAP_LATT_SET<br/>Left attack time coefficient setting</p> <p>0000 : 1x32/fs<br/>0001 : 2x32/fs</p> <hr/> <p>7FFF : 215 x32/fs<br/><math>T=(n+1)*32*fs</math></p> <p>When the gain decreases, the actual gain will decrease 0.5dB at every attack time.</p> |
| 15            | /   | /                   | /  |
| 14:0          | R/W | 0x001F<br>(32x32fs) | <p>ADAP_LDEC_SET<br/>Left decay time coefficient setting</p> <p>0000 : 1x32/fs<br/>0001 : 2x32/fs</p> <hr/> <p>7FFF : 215 x32/fs<br/><math>T=(n+1)*32*fs</math></p> <p>When the gain increases, the actual gain will increase 0.5dB at every decay time.</p>   |

**4.13.4.21. 0x088 ADC DAP Right Average Coef Register(Default Value: 0x00051EB8)**

| Offset: 0x088 |     |             | Register Name: AC_ADC_DAP_RAC                             |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:27         | /   | /           | /   |
| 26:0          | R/W | 0x0051EB8   | ADAP_RAC.<br>Average level coefficient setting(3.24fomat) |

**4.13.4.22. 0x08C ADC DAP Right Decay & Attack Time Register(Default Value: 0x0000001F)**

| Offset: 0x08C |     |             | Register Name: AC_ADC_DAP_RDAT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | /   | /           | /  |
| 30:16         | R/W | 0x0000      | <p>ADAP_RATT_SET.<br/>Right attack time coefficient setting</p> <p>0000 : 1x32/fs<br/>0001 : 2x32/fs</p> |

|      |     |        |  |
|------|-----|--------|--|
|      |     |        | <p>-----</p> <p>7FFF : 215 x32/fs<br/> <math>T=(n+1)*32/fs</math><br/>         When the gain decreases, the actual gain will decrease 0.5dB at every attack time.</p>  |
| 15   | /   | /      | /  |
| 14:0 | R/W | 0x001F | <p>ADAP_RDEC_SET<br/>         Right decay time coefficient setting<br/>         0000 : 1x32/fs<br/>         0001 : 2x32/fs</p> <p>-----</p> <p>7FFF : 215x32/fs<br/> <math>T=(n+1)*32/fs</math><br/>         When the gain increases, the actual gain will increase 0.5dB at every decay time.</p> |

#### 4.13.4.23. 0x090 ADC DAP HPF Coef Register(Default Value: 0x00FFAC1)

| Offset: 0x090 |     |             | Register Name: AC_ADC_DAP_HPFC                    |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description                                       |
| 31:27         | /   | /           | /   |
| 26:0          | R/W | 0x0FFAC1    | ADAP_HPFC.<br>HPF coefficient setting (3.24fomat) |

#### 4.13.4.24. 0x094 ADC DAP Left Input Signal Low Average Coef Register(Default Value: 0x00051EB8)

| Offset: 0x094 |     |             | Register Name: AC_ADC_DAP_LINAC  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:27         | /   | /           | /  |
| 26:0          | R/W | 0x00051EB8  | ADAP_LINAC<br>Left input signal average filter coefficient to check noise or not (the coefficient is 3.24 format 2s complement) always the same as the left output signal average filter's |

#### 4.13.4.25. 0x098 ADC DAP Right Input Signal Low Average Coef Register(Default Value: 0x00051EB8)

| Offset: 0x098 |     |             | Register Name: AC_ADC_DAP_RNAC   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:27         | /   | /           | /  |
| 26:0          | R/W | 0x00051EB8  | ADAP_RINAC<br>Right input signal average filter coefficient to check noise or not (the |

|  |  |  |  |
|--|--|--|--|
|  |  |  | coefficient is 3.24 format 2s complement) always the same as the left output signal average filter's |
|--|--|--|--|

#### 4.13.4.26. 0x09C ADC DAP Optimum Register(Default Value: 0x00000000)

| Offset: 0x09C |     |             | Register Name: AC_ADC_DAP_OPT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:11         | /   | /           | /  |
| 10            | R/W | 0x0         | Left energy default value setting(include the input and output)<br>0 : min<br>1 : max  |
| 9:8           | R/W | 0x0         | Left channel gain hysteresis setting.<br>The different between target level and the signal level must larger than the hysteresis when the gain change.<br>00 : 0.4375db<br>01 : 0.9375db<br>10 : 1.9375db<br>11 : 3db  |
| 7:3           | /   | /           | /  |
| 5             | R/W | 0x0         | The input signal average filter coefficient setting<br>0 : is the reg94/reg98<br>1 : is the reg80/reg88;   |
| 4             | R/W | 0x0         | AGC output when the channel in noise state<br>0 : output is zero<br>1 : output is the input data   |
| 3             | /   | /           | /  |
| 2             | R/W | 0x0         | Right energy default value setting(include the input and output)<br>0 : min<br>1 : max   |
| 1:0           | R/W | 0x0         | Right channel gain hysteresis setting.<br>The different between target level and the signal level must larger than the hysteresis when the gain change.<br>00 : 0.4375db<br>01 : 0.9375db<br>10 : 1.9375db<br>11 : 3db |

#### 4.13.4.27. 0x100 DAC DRC High HPF Coef Register(Default Value: 0x000000FF)

| Offset: 0x100 |     |             | Register Name: AC_DAC_DRC_HHPFC |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 15:11         | /   | /           | /                               |

|      |     |      |  |
|------|-----|------|--|
| 10:0 | R/W | 0xFF | HPF coefficient setting and the data is 3.24 format. |
|------|-----|------|--|

**4.13.4.28. 0x104 DAC DRC Low HPF Coef Register(Default Value: 0x0000FAC1)**

| Offset: 0x104 |     |             | Register Name: AC_DAC_DRC_LHPFC                      |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFAC1      | HPF coefficient setting and the data is 3.24 format. |

**4.13.4.29. 0x108 DAC DRC Control Register(Default Value: 0x00000080)**

| Offset: 0x108 |     |             | Register Name: AC_DAC_DRC_CTRL   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15            | R   | 0           | DRC delay buffer data output state when drc delay function is enable and the drc funciton disable. After disable drc function and this bit go to 0, the user should write the drc delay function bit to 0;<br>0 : not complete<br>1 : is complete                            |
| 14:10         | /   | /           | /  |
| 13:8          | R/W | 0           | Signal delay time setting<br>6'h00 : (8x1)fs<br>6'h01 : (8x2)fs<br>6'h02 : (8x3)fs<br>-----<br>6'h2e : (8*47)fs<br>6'h2f : (8*48)fs<br>6'h30 -- 6'h3f : (8*48)fs<br>Delay time = 8*(n+1)fs, n<6'h30;<br>When the delay function is disable, the signal delay time is unused. |
| 7             | R/W | 0x1         | The delay buffer use or not when the drc disable and the drc buffer data output completely<br>0 : don't use the buffer<br>1 : use the buffer   |
| 6             | R/W | 0x0         | DRC gain max limit enable<br>0 : disable<br>1 : enable   |
| 5             | R/W | 0x0         | DRC gain min limit enable. when this fuction enable, it will overwrite the noise detect funciton.<br>0 : disable<br>1 : enable   |
| 4             | R/W | 0x0         | Control the drc to detect noise when ET enable<br>0 : disable<br>1 : enable  |

|   |     |     |   |
|---|-----|-----|---|
| 3 | R/W | 0x0 | <p>Signal function Select<br/>0 : RMS filter<br/>1 : Peak filter<br/>When Signal function Select Peak filter, the RMS parameter is unused.<br/>(AC_DRC_LRMSSHAT / AC_DRC_LRMSLAT / AC_DRC_LRMSSHAT /<br/>AC_DRC_LRMSLAT)</p> <p>When Signal function Select RMS filter, the Peak filter parameter is unused.(AC_DRC_LPFHAT / AC_DRC_LPFLAT / AC_DRC_RPFHAT /<br/>AC_DRC_RPFLAT / AC_DRC_LPFHRT / AC_DRC_LPFLRT / AC_DRC_RPFHRT /<br/>AC_DRC_RPFLRT)</p> |
| 2 | R/W | 0x0 | <p>Delay function enable<br/>0 : disable<br/>1 : enable<br/>When the Delay function enable is disable, the Signal delay time is unused.</p>   |
| 1 | R/W | 0x0 | <p>DRC LT enable<br/>0 : disable<br/>1 : enable<br/>When the DRC LT is disable the LT, KI and QPL parameter is unused.</p>  |
| 0 | R/W | 0x0 | <p>DRC ET enable<br/>0 : disable<br/>1 : enable<br/>When the DRC ET is disable the ET, Ke and OPE parameter is unused.</p>  |

#### 4.13.4.30. 0x10C DAC DRC Left Peak Filter High Attack Time Coef Register(Default Value: 0x0000000B)

| Offset: 0x10C |     |             | Register Name: <b>AC_DAC_DRC_LPFHAT</b>   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x000B      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

#### 4.13.4.31. 0x110 DAC DRC Left Peak Filter Low Attack Time Coef Register(Default Value: 0x000077BF)

| Offset: 0x110 |     |             | Register Name: <b>AC_DAC_DRC_LPFLAT</b>   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x77BF      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

#### 4.13.4.32. 0x114 DAC DRC Right Peak Filter High Attack Time Coef Register(Default Value: 0x0000000B)

|               |   |
|---------------|---|
| Offset: 0x114 | Register Name: <b>AC_DAC_DRC_RPFHAT</b> |
|---------------|---|

| Bit   | R/W | Default/Hex | Description   |
|-------|-----|-------------|---|
| 15:11 | /   | /           | /   |
| 10:0  | R/W | 0x000B      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

#### 4.13.4.33. 0x118 DAC DRC Peak Filter Low Attack Time Coef Register(Default Value: 0x000077BF)

| Offset: 0x118 |     |             | Register Name: AC_DAC_DRC_RPFAT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x77BF      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

#### 4.13.4.34. 0x11C DAC DRC Left Peak Filter High Release Time Coef Register(Default Value: 0x000000FF)

| Offset: 0x11C |     |             | Register Name: AC_DAC_DRC_LPFHRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x00FF      | The left peak filter release time parameter setting, which determine by the equation that RT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.35. 0x120 DAC DRC Left Peak Filter Low Release Time Coef Register(Default Value: 0x0000E1F8)

| Offset: 0x120 |     |             | Register Name: AC_DAC_DRC_LPFLRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xE1F8      | The left peak filter release time parameter setting, which determine by the equation that RT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.36. 0x124 DAC DRC Right Peak filter High Release Time Coef Register(Default Value: 0x000000FF)

| Offset: 0x124 |     |             | Register Name: AC_DAC_DRC_RPFHRT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x00FF      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

#### 4.13.4.37. 0x128 DAC DRC Right Peak filter Low Release Time Coef Register(Default Value: 0x0000E1F8)

| Offset: 0x128 |  |  | Register Name: AC_DAC_DRC_RPFLRT |
|---------------|--|--|----------------------------------|
|---------------|--|--|----------------------------------|

| Bit  | R/W | Default/Hex | Description  |
|------|-----|-------------|--|
| 15:0 | R/W | 0xE1F8      | The left peak filter release time parameter setting, which determine by the equation that AT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.38. 0x12C DAC DRC Left RMS Filter High Coef Register(Default Value: 0x00000001)

| Offset: 0x12C |     |             | Register Name: AC_DAC_DRC_LRMSHAT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x0001      | The left RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.39. 0x130 DAC DRC Left RMS Filter Low Coef Register(Default Value: 0x00002BAF)

| Offset: 0x130 |     |             | Register Name: AC_DAC_DRC_LRMSLAT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x2BAF      | The left RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.40. 0x134 DAC DRC Right RMS Filter High Coef Register(Default Value: 0x00000001)

| Offset: 0x134 |     |             | Register Name: AC_DAC_DRC_RRMSHAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0001      | The right RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.41. 0x138 DAC DRC Right RMS Filter Low Coef Register(Default Value: 0x00002BAF)

| Offset: 0x138 |     |             | Register Name: AC_DAC_DRC_RRMSLAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x2BAF      | The right RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.42. 0x13C DAC DRC Compressor Theshold High Setting Register(Default Value: 0x000006A4)

| Offset: 0x13C |     |             | Register Name: AC_DAC_DRC_HCT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x06A4      | The compressor threshold setting, which set by the equation that CTin = |

|  |  |  |  |
|--|--|--|--|
|  |  |  | -CT/6.0206. The format is 8.24 (-40dB) |
|--|--|--|--|

#### 4.13.4.43. 0x140 DAC DRC Compressor Slope High Setting Register(Default Value: 0x0000D3C0)

| Offset: 0x140 |     |             | Register Name: AC_DAC_DRC_LCT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xD3C0      | The compressor threshold setting, which set by the equation that CTin = -CT/6.0206. The format is 8.24 (-40dB) |

#### 4.13.4.44. 0x144 DAC DRC Compressor Slope High Setting Register(Default Value: 0x00000080)

| Offset: 0x144 |     |             | Register Name: AC_DAC_DRC_HKC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:13         | /   | /           | /   |
| 13:0          | R/W | 0x0080      | The slope of the compressor which determine by the equation that $K_c = 1/R$ , there, R is the ratio of the compressor, which always is interger. The format is 8.24. (2 : 1) |

#### 4.13.4.45. 0x148 DAC DRC Compressor Slope Low Setting Register(Default Value: 0x00000000)

| Offset: 0x148 |     |             | Register Name: AC_DAC_DRC_LKC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x0000      | The slope of the compressor which determine by the equation that $K_c = 1/R$ , there, R is the ratio of the compressor, which always is interger. The format is 8.24. (2 : 1) |

#### 4.13.4.46. 0x14C DAC DRC Compressor High Output at Compressor Threshold Register(Default Value: 0x0000F95B)

| Offset: 0x14C |     |             | Register Name: AC_DAC_DRC_HOPC   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xF95B      | The output of the compressor which determine by the equation $-OPC/6.0206$<br>The format is 8.24 (-40dB) |

#### 4.13.4.47. 0x150 DAC DRC Compressor Low Output at Compressor Threshold Register(Default Value: 0x00002C3F)

| Offset: 0x150 |     |             | Register Name: AC_DAC_DRC_LOPC  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x2C3F      | The output of the compressor which determine by the equation $OPC/6.0206$<br>The format is 8.24 (-40dB) |

**4.13.4.48. 0x154 DAC DRC Limiter Threshold High Setting Register(Default Value: 0x000001A9)**

| Offset: 0x154 |     |             | Register Name: <b>AC_DAC_DRC_HLT</b>   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x01A9      | The limiter threshold setting, which set by the equation that LTin = -LT/6.0206, The format is 8.24. (-10dB) |

**4.13.4.49. 0x158 DAC DRC Limiter Threshold Low Setting Register(Default Value: 0x000034F0)**

| Offset: 0x158 |     |             | Register Name: <b>AC_DAC_DRC_LLT</b>   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x34F0      | The limiter threshold setting, which set by the equation that LTin = -LT/6.0206, The format is 8.24. (-10dB) |

**4.13.4.50. 0x15C DAC DRC Limiter Slope High Setting Register(Default Value: 0x00000005)**

| Offset: 0x15C |     |             | Register Name: <b>AC_DAC_DRC_HKI</b>  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 13:0          | R/W | 0x0005      | The slope of the limiter which determine by the equation that KI = 1/R, there, R is the ratio of the limiter, which always is interger. The format is 8.24. (50 :1) |

**4.13.4.51. 0x160 DAC DRC Limiter Slope Low Setting Register(Default Value: 0x1EB8)**

| Offset: 0x160 |     |             | Register Name: <b>AC_DAC_DRC_LKI</b>  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x1EB8      | The slope of the limiter which determine by the equation that KI = 1/R, there, R is the ratio of the limiter, which always is interger. The format is 8.24. (50 :1) |

**4.13.4.52. 0x164 DAC DRC Limiter High Output at Limiter Threshold(Default Value: 0x0000FBD8)**

| Offset: 0x164 |     |             | Register Name: <b>AC_DAC_DRC_HOPL</b>  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFBD8      | The output of the limiter which determine by equation OPT/6.0206. The format is 8.24 (-25dB) |

**4.13.4.53. 0x168 DAC DRC Limiter Low Output at Limiter Threshold(Default Value: 0x0000FBA7)**

| Offset: 0x168 |     |             | Register Name: AC_DAC_DRC_LOPL   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFBA7      | The output of the limiter which determine by equation OPT/6.0206. The format is 8.24 (-25dB) |

**4.13.4.54. 0x16C DAC DRC Expander Threshold High Setting Register(Default Value: 0x00000BA0)**

| Offset: 0x16C |     |             | Register Name: AC_DAC_DRC_HET   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x0BA0      | The expander threshold setting, which set by the equation that ETin = -ET/6.0206, The format is 8.24. (-70dB) |

**4.13.4.55. 0x170 DAC DRC Expander Threshold Low Setting Register(Default Value: 0x00007291)**

| Offset: 0x170 |     |             | Register Name: AC_DAC_DRC_LET   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x7291      | The expander threshold setting, which set by the equation that ETin = -ET/6.0206, The format is 8.24. (-70dB) |

**4.13.4.56. 0x174 DAC DRC Expander Slope High Setting Register(Default Value: 0x00000500)**

| Offset: 0x174 |     |             | Register Name: AC_DAC_DRC_HKE  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:14         | /   | /           | /  |
| 13:0          | R/W | 0x0500      | The slope of the expander which determine by the equation that Ke = 1/R, there, R is the ratio of the expander, which always is interger and the ke must larger than 50. The format is 8.24. (1:5) |

**4.13.4.57. 0x178 DAC DRC Expander Slope Low Setting Register(Default Value: 0x00000000)**

| Offset: 0x178 |     |             | Register Name: AC_DAC_DRC_LKE  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x0000      | The slope of the expander which determine by the equation that Ke = 1/R, there, R is the ratio of the expander, which always is interger and the ke must larger than 50. The format is 8.24. (1:5) |

**4.13.4.58. 0x17C DAC DRC Expander High Output at Expander Threshold(Default Value: 0xF45F)**

| Offset: 0x17C |     |             | Register Name: AC_DAC_DRC_HOPE  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0xF45F      | The output of the expander which determine by equation OPE/6.0206. The format is 8.24 (-70dB) |

**4.13.4.59. 0x180 DAC DRC Expander Low Output at Expander Threshold(Default Value: 0x00008D6E)**

| Offset: 0x180 |     |             | Register Name: AC_DAC_DRC_LOPE  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x8D6E      | The output of the expander which determine by equation OPE/6.0206. The format is 8.24 (-70dB) |

**4.13.4.60. 0x184 DAC DRC Linear Slope High Setting Register(Default Value: 0x00000100)**

| Offset: 0x184 |     |             | Register Name: AC_DAC_DRC_HKN  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:14         | /   | /           | /  |
| 13:0          | R/W | 0x0100      | The slope of the linear which determine by the equation that $K_n = 1/R$ , there, R is the ratio of the linear, which always is interger . The format is 8.24. (1:1) |

**4.13.4.61. 0x188 DAC DRC Linear Slope Low Setting Register(Default Value: 0x00000000)**

| Offset: 0x188 |     |             | Register Name: AC_DAC_DRC_LKN  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x0000      | The slope of the linear which determine by the equation that $K_n = 1/R$ , there, R is the ratio of the linear, which always is interger . The format is 8.24. (1:1) |

**4.13.4.62. 0x18C DAC DRC Smooth filter Gain High Attack Time Coef Register(Default Value: 0x00000002)**

| Offset: 0x18C |     |             | Register Name: AC_DAC_DRC_SFHAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0002      | The smooth filter attack time parameter setting, which determine by the equation that $AT = 1 - \exp(-2.2Ts/tr)$ . The format is 3.24. (5ms) |

**4.13.4.63. 0x190 DAC DRC Smooth filter Gain Low Attack Time Coef Register(Default Value: 0x00005600)**

| Offset: 0x190 |     |             | Register Name: AC_DAC_DRC_SFAT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x5600      | The smooth filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tr). The format is 3.24. (5ms) |

**4.13.4.64. 0x194 DAC DRC Smooth filter Gain High Release Time Coef Register(Default Value: 0x00000000)**

| Offset: 0x194 |     |             | Register Name: AC_DAC_DRC_SFRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0000      | The gain smooth filter release time parameter setting, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (200ms) |

**4.13.4.65. 0x198 DAC DRC Smooth filter Gain Low Release Time Coef Register(Default Value: 0x00000F04)**

| Offset: 0x198 |     |             | Register Name: AC_DAC_DRC_SFLRT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x0F04      | The gain smooth filter release time parameter setting, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (200ms) |

**4.13.4.66. 0x19C DAC DRC MAX Gain High Setting Register(Default Value: 0x0000FE56)**

| Offset: 0x19C |     |             | Register Name: AC_DAC_DRC_MXGHS   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0xFE56      | The max gain setting which determine by equation MXG/6.0206. The format is 8.24 and must -20dB < MXG < 30dB (-10dB) |

**4.13.4.67. 0x1A0 DAC DRC MAX Gain Low Setting Register(Default Value: 0x0000CB0F)**

| Offset: 0x1A0 |     |             | Register Name: AC_DAC_DRC_MXGLS   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0xCB0F      | The max gain setting which determine by equation MXG/6.0206. The format is 8.24 and must -20dB < MXG < 30dB (-10dB) |

**4.13.4.68. 0x1A4 DAC DRC MIN Gain High Setting Register(Default Value: 0x0000\_F95B)**

| Offset: 0x1A4 |     |             | Register Name: AC_DAC_DRC_MNGHS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xF95B      | The min gain setting which determine by equation MXG/6.0206. The format is 8.24 and must -60dB ≤ MNG ≤ -30dB (-40dB) |

**4.13.4.69. 0x1A8 DAC DRC MIN Gain Low Setting Register(Default Value: 0x00002C3F)**

| Offset: 0x1A8 |     |             | Register Name: AC_DAC_DRC_MNGLS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x2C3F      | The min gain setting which determine by equation MNG/6.0206. The format is 8.24 and must -60dB ≤ MNG ≤ -30dB (-40dB) |

**4.13.4.70. 0x1AC DAC DRC Expander Smooth Time High Coef Register(Default Value: 0x00000000)**

| Offset: 0x1AC |     |             | Register Name: AC_DAC_DRC_EPSHC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 11:0          | R/W | 0x0000      | The gain smooth filter release and attack time parameter setting in expander region, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (30ms) |

**4.13.4.71. 0x1B0 DAC DRC Expander Smooth Time Low Coef Register(Default Value: 0x0000640C)**

| Offset: 0x1B0 |     |             | Register Name: AC_DAC_DRC_EPSLC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x640C      | The gain smooth filter release and attack time parameter setting in expander region, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (30ms) |

**4.13.4.72. 0x1B8 DAC DRC HPF Gain High Coef Register(Default Value: 0x00000100)**

| Offset: 0x1B8 |     |             | Register Name: AC_DAC_DRC_HPFHGAIN                                      |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0X100       | The gain of the hpf coefficient setting which format is 3.24.(gain = 1) |

**4.13.4.73. 0x1BC DAC DRC HPF Gain Low Coef Register(Default Value: 0x00000000)**

| Offset: 0x1BC |     |             | Register Name: <b>AC_DAC_DRC_HPFLGAIN</b>                               |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0X0000      | The gain of the hpf coefficient setting which format is 3.24.(gain = 1) |

**4.13.4.74. 0x200 ADC DRC High HPF Coef Register(Default Value: 0x000000FF)**

| Offset: 0x200 |     |             | Register Name: <b>AC_ADC_DRC_HHPFC</b>               |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0xFF        | HPF coefficient setting and the data is 3.24 format. |

**4.13.4.75. 0x204 ADC DRC Low HPF Coef Register(Default Value: 0x0000FAC1)**

| Offset: 0x204 |     |             | Register Name: <b>AC_ADC_DRC_LHPFC</b>               |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFAC1      | HPF coefficient setting and the data is 3.24 format. |

**4.13.4.76. 0x208 ADC DRC Control Register(Default Value: 0x00000080)**

| Offset: 0x208 |     |             | Register Name: <b>AC_ADC_DRC_CTRL</b>  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15            | R   | 0           | DRC delay buffer data output state when drc delay function is enable and the drc funciton disable. After disable drc function and this bit go to 0, the user should write the drc delay function bit to 0;<br>0 : not complete<br>1 : is complete                            |
| 14:10         | /   | /           | /  |
| 13:8          | R/W | 0           | Signal delay time setting<br>6'h00 : (8x1)fs<br>6'h01 : (8x2)fs<br>6'h02 : (8x3)fs<br>-----<br>6'h2e : (8*47)fs<br>6'h2f : (8*48)fs<br>6'h30 -- 6'h3f : (8*48)fs<br>Delay time = 8*(n+1)fs, n<6'h30;<br>When the delay function is disable, the signal delay time is unused. |
| 7             | R/W | 0x1         | The delay buffer use or not when the drc disable and the drc buffer data   |

|   |     |     |  |
|---|-----|-----|--|
|   |     |     | output completely<br>0 : don't use the buffer<br>1 : use the buffer  |
| 6 | R/W | 0x0 | DRC gain max limit enable<br>0 : disable<br>1 : enable   |
| 5 | R/W | 0x0 | DRC gain min limit enable. when this fuction enable, it will overwrite the noise detect funciton.<br>0 : disable<br>1 : enable   |
| 4 | R/W | 0x0 | Control the drc to detect noise when ET enable<br>0 : disable<br>1 : enable  |
| 3 | R/W | 0x0 | Signal function Select<br>0 : RMS filter<br>1 : Peak filter<br>When Signal function Select Peak filter, the RMS parameter is unused.<br>(AC_DRC_LRMSSHAT / AC_DRC_LRMSLAT / AC_DRC_LRMSSHAT / AC_DRC_LRMSLAT)<br><br>When Signal function Select RMS filter, the Peak filter parameter is unused.<br>(AC_DRC_LPFHAT / AC_DRC_LPFLAT / AC_DRC_RPFHAT / AC_DRC_RPFLAT / AC_DRC_LPFHRT / AC_DRC_LPFLRT / AC_DRC_RPFHRT / AC_DRC_RPFLRT) |
| 2 | R/W | 0x0 | Delay function enable<br>0 : disable<br>1 : enable<br>When the Delay function enable is disable, the Signal delay time is unused.  |
| 1 | R/W | 0x0 | DRC LT enable<br>0 : disable<br>1 : enable<br>When the DRC LT is disable the LT, KI and OPL parameter is unused.   |
| 0 | R/W | 0x0 | DRC ET enable<br>0 : disable<br>1 : enable<br>When the DRC ET is disable the ET, Ke and OPE parameter is unused.   |

#### 4.13.4.77. 0x20C ADC DRC Left Peak Filter High Attack Time Coef Register(Default Value: 0x0000000B)

| Offset: 0x20C |     |             | Register Name: AC_ADC_DRC_LPFHAT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x000B      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

**4.13.4.78. 0x210 ADC DRC Left Peak Filter Low Attack Time Coef Register(Default Value: 0x000077BF)**

| Offset: 0x210 |     |             | Register Name: AC_ADC_DRC_LPFLAT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x77BF      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

**4.13.4.79. 0x214 ADC DRC Right Peak Filter High Attack Time Coef Register(Default Value: 0x0000000B)**

| Offset: 0x214 |     |             | Register Name: AC_ADC_DRC_RPFHAT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x000B      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

**4.13.4.80. 0x218 ADC DRC Peak Filter Low Attack Time Coef Register(Default Value: 0x000077BF)**

| Offset: 0x218 |     |             | Register Name: AC_ADC_DRC_RPFLAT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x77BF      | The left peak filter attack time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/ta). The format is 3.24. (1ms) |

**4.13.4.81. 0x21C ADC DRC Left Peak Filter High Release Time Coef Register(Default Value: 0x000000FF)**

| Offset: 0x21C |     |             | Register Name: AC_ADC_DRC_LPFHRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x00FF      | The left peak filter release time parameter setting, which determine by the equation that RT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

**4.13.4.82. 0x220 ADC DRC Left Peak Filter Low Release Time Coef Register(Default Value: 0x0000E1F8)**

| Offset: 0x220 |     |             | Register Name: AC_ADC_DRC_LPFLRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xE1F8      | The left peak filter release time parameter setting, which determine by the equation that RT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.83. 0x224 ADC DRC Right Peak filter High Release Time Coef Register(Default Value: 0x000000FF)

| Offset: 0x224 |     |             | Register Name: AC_ADC_DRC_RPFHRT  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x00FF      | The left peak filter attack time parameter setting, which determine by the equation that RT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.84. 0x228 ADC DRC Right Peak filter Low Release Time Coef Register(Default Value: 0x0000E1F8)

| Offset: 0x228 |     |             | Register Name: AC_ADC_DRC_RPFLRT   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xE1F8      | The left peak filter release time parameter setting, which determine by the equation that AT = exp(-2.2Ts/tr). The format is 3.24. (100ms) |

#### 4.13.4.85. 0x22C ADC DRC Left RMS Filter High Coef Register(Default Value: 0x00000001)

| Offset: 0x22C |     |             | Register Name: AC_ADC_DRC_LRMSHAT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x0001      | The left RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.86. 0x230 ADC DRC Left RMS Filter Low Coef Register(Default Value: 0x00002BAF)

| Offset: 0x230 |     |             | Register Name: AC_ADC_DRC_LRMSLAT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x2BAF      | The left RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

#### 4.13.4.87. 0x234 ADC DRC Right RMS Filter High Coef Register(Default Value: 0x00000001)

| Offset: 0x234 |     |             | Register Name: AC_ADC_DRC_RRMSHAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0001      | The right RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

**4.13.4.88. 0x238 ADC DRC Right RMS Filter Low Coef Register(Default Value: 0x00002BAF)**

| Offset: 0x238 |     |             | Register Name: AC_ADC_DRC_RRMSLAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x2BAF      | The right RMS filter average time parameter setting, which determine by the equation that AT = 1-exp(-2.2Ts/tav). The format is 3.24. (10ms) |

**4.13.4.89. 0x23C ADC DRC Compressor Threshold High Setting Register(Default Value: 0x000006A4)**

| Offset: 0x23C |     |             | Register Name: AC_ADC_DRC_HCT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x06A4      | The compressor threshold setting, which set by the equation that CTin = -CT/6.0206. The format is 8.24 (-40dB) |

**4.13.4.90. 0x240 ADC DRC Compressor Slope High Setting Register(Default Value: 0x0000D3C0)**

| Offset: 0x240 |     |             | Register Name: AC_ADC_DRC_LCT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xD3C0      | The compressor threshold setting, which set by the equation that CTin = -CT/6.0206. The format is 8.24 (-40dB) |

**4.13.4.91. 0x244 ADC DRC Compressor Slope High Setting Register(Default Value: 0x00000080)**

| Offset: 0x244 |     |             | Register Name: AC_ADC_DRC_HKC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:13         | /   | /           | /   |
| 13:0          | R/W | 0x0080      | The slope of the compressor which determine by the equation that Kc = 1/R, there, R is the ratio of the compressor, which always is interger. The format is 8.24. (2 : 1) |

**4.13.4.92. 0x248 ADC DRC Compressor Slope Low Setting Register(Default Value: 0x00000000)**

| Offset: 0x248 |     |             | Register Name: AC_ADC_DRC_LKC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x0000      | The slope of the compressor which determine by the equation that Kc = 1/R, there, R is the ratio of the compressor, which always is interger. The format is 8.24. (2 : 1) |

**4.13.4.93. 0x24C ADC DRC Compressor High Output at Compressor Threshold Register(Default Value: 0x0000F95B)**

| Offset: 0x24C |     |             | Register Name: AC_ADC_DRC_HOPC   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xF95B      | The output of the compressor which determine by the equation -OPC/6.0206<br>The format is 8.24 (-40dB) |

**4.13.4.94. 0x250 ADC DRC Compressor Low Output at Compressor Threshold Register(Default Value: 0x00002C3F)**

| Offset: 0x250 |     |             | Register Name: AC_ADC_DRC_LOPC  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x2C3F      | The output of the compressor which determine by the equation OPC/6.0206<br>The format is 8.24 (-40dB) |

**4.13.4.95. 0x254 ADC DRC Limiter Threshold High Setting Register(Default Value: 0x000001A9)**

| Offset: 0x254 |     |             | Register Name: AC_ADC_DRC_HLT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x01A9      | The limiter threshold setting, which set by the equation that LTin = -LT/6.0206,<br>The format is 8.24. (-10dB) |

**4.13.4.96. 0x258 ADC DRC Limiter Threshold Low Setting Register(Default Value: 0x000034F0)**

| Offset: 0x258 |     |             | Register Name: AC_ADC_DRC_LLT   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x34F0      | The limiter threshold setting, which set by the equation that LTin = -LT/6.0206,<br>The format is 8.24. (-10dB) |

**4.13.4.97. 0x25C ADC DRC Limiter Slope High Setting Register(Default Value: 0x00000005)**

| Offset: 0x25C |     |             | Register Name: AC_ADC_DRC_HKI  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 13:0          | R/W | 0x0005      | The slope of the limiter which determine by the equation that KI = 1/R, there,<br>R is the ratio of the limiter, which always is interger. The format is 8.24. (50 :1) |

**4.13.4.98. 0x260 ADC DRC Limiter Slope Low Setting Register(Default Value: 0x1EB8)**

| Offset: 0x260 |     |             | Register Name: AC_ADC_DRC_LKI  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x1EB8      | The slope of the limiter which determine by the equation that $KI = 1/R$ , there, R is the ratio of the limiter, which always is interger. The format is 8.24. (50 :1) |

**4.13.4.99. 0x264 ADC DRC Limiter High Output at Limiter Threshold(Default Value: 0x0000FBD8)**

| Offset: 0x264 |     |             | Register Name: AC_ADC_DRC_HOPL   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFBD8      | The output of the limiter which determine by equation OPT/6.0206. The format is 8.24 (-25dB) |

**4.13.4.100. 0x268 ADC DRC Limiter Low Output at Limiter Threshold(Default Value: 0x0000FBA7)**

| Offset: 0x268 |     |             | Register Name: AC_ADC_DRC_LOPL   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFBA7      | The output of the limiter which determine by equation OPT/6.0206. The format is 8.24 (-25dB) |

**4.13.4.101. 0x26C ADC DRC Expander Theshold High Setting Register(Default Value: 0x00000BA0)**

| Offset: 0x26C |     |             | Register Name: AC_ADC_DRC_HET  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x0BA0      | The expander threshold setting, which set by the equation that $ETin = -ET/6.0206$ , The format is 8.24. (-70dB) |

**4.13.4.102. 0x270 ADC DRC Expander Theshold Low Setting Register(Default Value: 0x00007291)**

| Offset: 0x270 |     |             | Register Name: AC_ADC_DRC_LET  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x7291      | The expander threshold setting, which set by the equation that $ETin = -ET/6.0206$ , The format is 8.24. (-70dB) |

**4.13.4.103. 0x274 ADC DRC Expander Slope High Setting Register(Default Value: 0x00000500)**

|               |                               |
|---------------|-------------------------------|
| Offset: 0x274 | Register Name: AC_ADC_DRC_HKE |
|---------------|-------------------------------|

| Bit   | R/W | Default/Hex | Description   |
|-------|-----|-------------|---|
| 15:14 | /   | /           | /   |
| 13:0  | R/W | 0x0500      | The slope of the expander which determine by the equation that $Ke = 1/R$ , there, R is the ratio of the expander, which always is interger and the ke must larger than 50. The format is 8.24. (1:5) |

#### 4.13.4.104. 0x278 ADC DRC Expander Slope Low Setting Register(Default Value: 0x00000000)

| Offset: 0x278 |     |             | Register Name: AC_ADC_DRC_LKE   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x0000      | The slope of the expander which determine by the equation that $Ke = 1/R$ , there, R is the ratio of the expander, which always is interger and the ke must larger than 50. The format is 8.24. (1:5) |

#### 4.13.4.105. 0x27C ADC DRC Expander High Output at Expander Threshold(Default Value: 0xF45F)

| Offset: 0x27C |     |             | Register Name: AC_ADC_DRC_HOPE  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0xF45F      | The output of the expander which determine by equation OPE/6.0206. The format is 8.24 (-70dB) |

#### 4.13.4.106. 0x280 ADC DRC Expander Low Output at Expander Threshold(Default Value: 0x00008D6E)

| Offset: 0x280 |     |             | Register Name: AC_ADC_DRC_LOPE  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x8D6E      | The output of the expander which determine by equation OPE/6.0206. The format is 8.24 (-70dB) |

#### 4.13.4.107. 0x284 ADC DRC Linear Slope High Setting Register(Default Value: 0x00000100)

| Offset: 0x284 |     |             | Register Name: AC_ADC_DRC_HKN   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:14         | /   | /           | /   |
| 13:0          | R/W | 0x0100      | The slope of the linear which determine by the equation that $Kn = 1/R$ , there, R is the ratio of the linear, which always is interger . The format is 8.24. (1:1) |

#### 4.13.4.108. 0x288 ADC DRC Linear Slope Low Setting Register(Default Value: 0x00000000)

|               |                               |
|---------------|-------------------------------|
| Offset: 0x288 | Register Name: AC_ADC_DRC_LKN |
|---------------|-------------------------------|

| Bit  | R/W | Default/Hex | Description  |
|------|-----|-------------|--|
| 15:0 | R/W | 0x0000      | The slope of the linear which determine by the equation that $K_n = 1/R$ , there, R is the ratio of the linear, which always is interger . The format is 8.24. (1:1) |

#### 4.13.4.109. 0x28C ADC DRC Smooth filter Gain High Attack Time Coef Register(Default Value: 0x00000002)

| Offset: 0x28C |     |             | Register Name: AC_ADC_DRC_SFHAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0002      | The smooth filter attack time parameter setting, which determine by the equation that $AT = 1 - \exp(-2.2Ts/tr)$ . The format is 3.24. (5ms) |

#### 4.13.4.110. 0x290 ADC DRC Smooth filter Gain Low Attack Time Coef Register(Default Value: 0x000005600)

| Offset: 0x290 |     |             | Register Name: AC_ADC_DRC_SFLAT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x5600      | The smooth filter attack time parameter setting, which determine by the equation that $AT = 1 - \exp(-2.2Ts/tr)$ . The format is 3.24. (5ms) |

#### 4.13.4.111. 0x294 ADC DRC Smooth filter Gain High Release Time Coef Register(Default Value: 0x00000000)

| Offset: 0x294 |     |             | Register Name: AC_ADC_DRC_SFHRT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:11         | /   | /           | /  |
| 10:0          | R/W | 0x0000      | The gain smooth filter release time parameter setting, which determine by the equation that $RT = 1 - \exp(-2.2Ts/tr)$ . The format is 3.24. (200ms) |

#### 4.13.4.112. 0x298 ADC DRC Smooth filter Gain Low Release Time Coef Register(Default Value: 0x00000F04)

| Offset: 0x298 |     |             | Register Name: AC_ADC_DRC_SFLRT  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x0F04      | The gain smooth filter release time parameter setting, which determine by the equation that $RT = 1 - \exp(-2.2Ts/tr)$ . The format is 3.24. (200ms) |

#### 4.13.4.113. 0x29C ADC DRC MAX Gain High Setting Register(Default Value: 0x0000FE56)

| Offset: 0x29C |     |             | Register Name: AC_ADC_DRC_MXGHS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xFE56      | The max gain setting which determine by equation $MXG/6.0206$ . The format |

|  |  |  |   |
|--|--|--|---|
|  |  |  | is 8.24 and must -20dB < MXG < 30dB (-10dB) |
|--|--|--|---|

#### 4.13.4.114. 0x2A0 ADC DRC MAX Gain Low Setting Register(Default Value: 0x0000CB0F)

| Offset: 0x2A0 |     |             | Register Name: AC_ADC_DRC_MXGLS   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0xCB0F      | The max gain setting which determine by equation MXG/6.0206. The format is 8.24 and must -20dB < MXG < 30dB (-10dB) |

#### 4.13.4.115. 0x2A4 ADC DRC MIN Gain High Setting Register(Default Value: 0x0000F95B)

| Offset: 0x2A4 |     |             | Register Name: AC_ADC_DRC_MNGHS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0xF95B      | The min gain setting which determine by equation MXG/6.0206. The format is 8.24 and must -60dB ≤ MNG ≤ -30dB (-40dB) |

#### 4.13.4.116. 0x2A8 ADC DRC MIN Gain Low Setting Register(Default Value: 0x00002C3F)

| Offset: 0x2A8 |     |             | Register Name: AC_ADC_DRC_MNGLS  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 15:0          | R/W | 0x2C3F      | The min gain setting which determine by equation MNG/6.0206. The format is 8.24 and must -60dB ≤ MNG ≤ -30dB (-40dB) |

#### 4.13.4.117. 0x2AC ADC DAP Expander Smooth Time High Coef Register(Default Value: 0x00000000)

| Offset: 0x2AC |     |             | Register Name: AC_ADC_DRC_EPSHC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 11:0          | R/W | 0x0000      | The gain smooth filter release and attack time parameter setting in expander region, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (30ms) |

#### 4.13.4.118. 0x2B0 ADC DRC Expander Smooth Time Low Coef Register (Default Value: 0x0000640C)

| Offset: 0x2B0 |     |             | Register Name: AC_ADC_DRC_EPSLC   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x640C      | The gain smooth filter release and attack time parameter setting in expander region, which determine by the equation that RT = 1-exp(-2.2Ts/tr). The format is 3.24. (30ms) |

**4.13.4.119. 0x2B8 ADC DRC HPF Gain High(Default Value: 0x00000100)**

| Offset: 0x2B8 |     |             | Register Name: AC_ADC_DRC_HPFHGAIN                                      |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:11         | /   | /           | /   |
| 10:0          | R/W | 0x100       | The gain of the hpf coefficient setting which format is 3.24.(gain = 1) |

**4.13.4.120. 0x2BC ADC DRC HPF Gain Low(Default Value: 0x00000000)**

| Offset: 0x2BC |     |             | Register Name: AC_ADC_DRC_HPFLGAIN                                      |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 15:0          | R/W | 0x0000      | The gain of the hpf coefficient setting which format is 3.24.(gain = 1) |

**4.13.4.121. AC Parameter Configuration Register(Default Value: 0x10000000)**

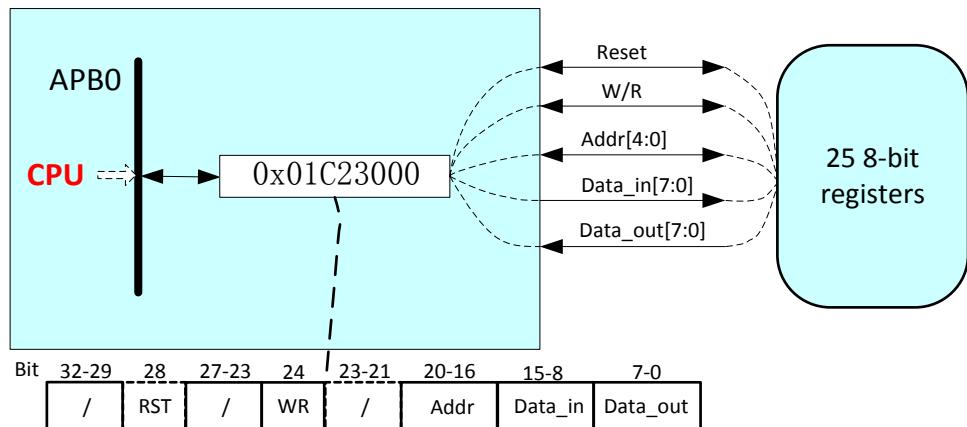
| Address: 0x400 |     |             | Register Name: AC_PR_CFG                               |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:29          | /   | /           | /  |
| 28             | R/W | 0x1         | AC_PR_RST<br>AC_PR Reset<br>0: Assert<br>1: De-assert  |
| 27:25          | /   | /           | /  |
| 24             | R/W | 0x0         | AC_PR_RW<br>AC_PR Read Or Write<br>0: read<br>1: write |
| 23:21          | /   | /           | /  |
| 20:16          | R/W | 0x0         | AC_PR_ADDR<br>AC_PR Address [4:0]                      |
| 15:8           | R/W | 0x0         | ADDA_PR_WDAT<br>ADDA_PR Write Data [7:0]               |
| 7:0            | R/W | 0x0         | ADDA_PR_RDAT<br>ADDA_PR Read Data [7:0]                |


**NOTE**

The address of this Register is 0x01c23000, using this register to configure the AC\_PR register.

Reset: Reset signal; ADDR[4:0] : AC\_PR Address; W/R: Write/Read Enable;

WDAT[7:0]: Write Data; RDAT[7:0]: Read Data.



#### 4.13.4.122. 0x01 Left Output Mixer Source Select Control Register(Default Value: 0x00)

| Offset:0x01 |     |             | Register Name: AC_LOMIXSC   |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | /   | /           | /   |
| 6:0         | R/W | 0x0         | <p>LMIXMUTE<br/>Left Output Mixer Mute Control<br/>0-Mute<br/>1-Not Mute<br/>Bit 6: MIC1 Boost Stage<br/>Bit 5: /<br/>Bit 4: /<br/>Bit 3: /<br/>Bit 2: /<br/>Bit 1: Left Channel DAC<br/>Bit 0: Right Channel DAC</p> |

#### 4.13.4.123. 0x02 Right Output Mixer Source Select Control Register(Default Value: 0x00)

| Offset:0x02 |     |             | Register Name: AC_ROMIXSC  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 7           | /   | /           | /  |
| 6:0         | R/W | 0x0         | <p>RMIXMUTE<br/>Right Output Mixer Mute Control<br/>0-Mute<br/>1-Not Mute<br/>Bit 6: MIC1 Boost Stage<br/>Bit 5: /<br/>Bit 4: /<br/>Bit 3: /</p> |

|  |  |  |   |
|--|--|--|---|
|  |  |  | Bit 2: /<br>Bit 1: Right Channel DAC<br>Bit 0: Left Channel DAC |
|--|--|--|---|

#### 4.13.4.124. 0x03 DAC Analog Enable and PA Source Control Register(Default Value: 0x00)

| Offset:0x03 |     |             | Register Name: <b>DAC_PA_SRC</b>   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 7           | R/W | 0x0         | DACAREN<br>Internal Analog Right channel DAC Enable<br>0:Disable<br>1:Enable |
| 6           | R/W | 0x0         | DACALEN<br>Internal Analog Left channel DAC Enable<br>0:Disable<br>1:Enable  |
| 5           | R/W | 0x0         | RMIXEN<br>Right Analog Output Mixer Enable<br>0:Disable<br>1:Enable          |
| 4           | R/W | 0x0         | LMIXEN<br>Left Analog Output Mixer Enable<br>0:Disable<br>1:Enable           |
| 3:0         | /   | /           | /  |

#### 4.13.4.125. 0x06 MIC1 Gain Control Register(Default Value: 0x33)

| Offset:0x06 |     |             | Register Name: <b>MIC_GCTR</b>  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | /   | /           | /   |
| 6:4         | R/W | 0x3         | MIC1_GAIN<br>MIC1 BOOST stage to L or R output mixer Gain Control<br>From -4.5dB to 6dB, 1.5dB/step, default is 0dB |
| 3           | /   | /           | /   |
| 2:0         | R/W | 0x3         | Reserved  |

#### 4.13.4.126. 0x09 Lineout Volume Control Register(Default Value: 0x40)

| Offset:0x09 |     |             | Register Name: <b>LINEOUT_VOLC</b> |
|-------------|-----|-------------|------------------------------------|
| Bit         | R/W | Default/Hex | Description                        |

|     |     |     |   |
|-----|-----|-----|---|
| 7:3 | R/W | 0x0 | LINEOUTVOL<br>Line-out Volume Control, Total 31 level, from 0dB to -48dB, 1.5dB/step, mute when 00000 & 00001 |
| 2:0 | R/W | 0x4 | Reserved  |

#### 4.13.4.127. 0x0A Lineout Enable Control Register(Default Value: 0x40)

| Offset:0x0A |     |             | Register Name: LINEOUT_CTRL  |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 7           | R/W | 0x0         | /  |
| 6:4         | R/W | 0x4         | /  |
| 3           | R/W | 0x0         | Line-out Left Enable<br>0:disable<br>1:enable  |
| 2           | R/W | 0x0         | Line-out Right Enable<br>0:disable<br>1:enable   |
| 1           | R/W | 0x0         | Left line-out source select<br>0:left output mixer<br>1:left output mixer + right output mixer   |
| 0           | R/W | 0x0         | Right line-out source select<br>0:right output mixer<br>1:left line-out, for differential output |

#### 4.13.4.128. 0x0B BIAS and MIC1 Boost Register (Default Value: 0x14)

| Offset:0x0B |     |             | Register Name: BIAS_MIC_CTRL  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | /   | /           | /   |
| 6           | R/W | 0x0         | MMICBIASEN<br>Master Microphone Bias Enable<br>0: disable<br>1: enable  |
| 5:4         | R/W | 0x1         | Reserved  |
| 3           | R/W | 0x0         | MIC1AMPEN<br>MIC1 Boost AMP Enable<br>0: disable<br>1: enable   |
| 2:0         | R/W | 0x4         | MIC1BOOST<br>MIC1 Boost AMP Gain Control<br>0dB when 000, 24dB to 42dB when 001 to 111, 3dB/step, default is 33dB |

**4.13.4.129. 0x0C Left ADC Mixer Mute Control Register (Default Value: 0x00)**

| Offset:0x0C |     |             | Register Name: LADC_MIX_MUTE   |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 7           | /   | /           | /  |
| 6:0         | R/W | 0x0         | <p>LADC MIXMUTE<br/>Left ADC Mixer Mute Control<br/>0: Mute<br/>1: On<br/>Bit 6: MIC1 Boost stage<br/>Bit 5: /<br/>Bit 4: /<br/>Bit 3: /<br/>Bit 2: /<br/>Bit 1: Left output mixer<br/>Bit 0: Right output mixer</p> |

**4.13.4.130. 0x0D Right ADC Mixer Mute Control Register (Default Value: 0x00)**

| Offset:0x0D |     |             | Register Name: RADC_MIX_MUTE  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | /   | /           | /   |
| 6:0         | R/W | 0x0         | <p>RADC MIXMUTE<br/>Right ADC Mixer Mute Control<br/>0: Mute<br/>1: On<br/>Bit 6: MIC1 Boost stage<br/>Bit 5: /<br/>Bit 4: /<br/>Bit 3: /<br/>Bit 2: /<br/>Bit 1: Right output mixer<br/>Bit 0: Left output mixer</p> |

**4.13.4.131. 0x0F ADC Analog Control Register Register (Default Value: 0x03)**

| Offset:0x0F |     |             | Register Name: AC_ADC_CTRL  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | R/W | 0x0         | <p>ADCREN<br/>ADC Right Channel Enable<br/>0: Disable<br/>1: Enable</p> |

|     |     |     |   |
|-----|-----|-----|---|
| 6   | R/W | 0x0 | ADCLEN<br>ADC Left Channel Enable<br>0:Disable<br>1:Enable                      |
| 5:3 | R/W | 0x0 | /   |
| 2:0 | R/W | 0x3 | ADCG<br>ADC Input Gain Control<br>From -4.5dB to 6dB, 1.5dB/step default is 0dB |

#### 4.13.4.132. 0x10 OPDRV/OPCOM/OPADC Control Register (Default Value: 0x55)

| Offset:0x10 |     |             | Register Name: <b>OPADC_CTRL</b>                             |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description  |
| 7:6         | R/W | 0x1         | OPDRV_OPCom_CUR.<br>OPDRV/OPCOM output stage current setting |
| 5:4         | R/W | 0x1         | OPADC1_BIAS_CUR.<br>OPADC1 Bias Current Select               |
| 3:2         | R/W | 0x1         | OPADC2_BIAS_CUR.<br>OPADC2 Bias Current Select               |
| 1:0         | R/W | 0x1         | OPAAF_BIAS_CUR.<br>OPAAF in ADC Bias Current Select          |

#### 4.13.4.133. 0x11 OPMIC、OPVR and OPADC Control Register (Default Value: 0x55)

| Offset:0x11 |     |             | Register Name: <b>OPMIC_CTRL</b>  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7:6         | R/W | 0x1         | OPMIC_BIAS_CUR<br>OPMIC Bias Current Control  |
| 5:4         | R/W | 0x1         | OPVR_BIAS_CUR.<br>OPVR Bias Current Control<br>Especially, bit 5 can also control HPCOMFB:<br>=0, HPCOMFB pin can be used to PA when R07_[6:5] is not 11;<br>=1, HPCOMFB pin always can not be used to PA |
| 3:2         | R/W | 0x1         | OPDAC_BIAS_CUR.<br>OPDAC Bias Current Control   |
| 1:0         | R/W | 0x1         | OPMIX_BIAS_CUR.<br>OPMIX/OPLPF/OPDRV/OPCOM Bias Current Control   |

#### 4.13.4.134. 0x12 ZERO CROSS Control Register (Default Value: 0x42)

|             |                                       |
|-------------|---------------------------------------|
| Offset:0x12 | Register Name: <b>ZERO_CROSS_CTRL</b> |
|-------------|---------------------------------------|

| Bit | R/W | Default/Hex | Description   |
|-----|-----|-------------|---|
| 7   | R/W | 0x0         | Function enable for master volume change at zero cross over<br>0: disable<br>1: enable  |
| 6   | R/W | 0x1         | Timeout control for master volume change at zero cross over<br>0: 32ms<br>1: 64ms   |
| 5:4 | R/W | 0x0         | PTDBS<br>HPCOM protect de-bounce time setting<br>00: 2-3ms<br>01: 4-6ms<br>10: 8-12ms<br>11: 16-24ms<br>At the same time, bit 17 is used to control the AVCCPORFLAG, write 1 to this bit, flag will be cleared, and the calibration is done again |
| 3   | R/W | 0x0         | PA_SLOPE_SELECT<br>PA slope select cosine or ramp<br>0: select cosine<br>1: select ramp   |
| 2:0 | R/W | 0x2         | USB_BIAS_CUR.<br>USB bias current tuning<br>From 23uA to 30uA, Default is 25uA  |

#### 4.13.4.135. 0x13 ADC Function Control Register (Default Value: 0xD6)

| Offset:0x13 |     |             | Register Name: <b>ADC_FUN_CTRL</b>  |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description   |
| 7           | R/W | 0x1         | MMIC BIAS chopper enable<br>0: disable<br>1:enable  |
| 6:5         | R/W | 0x2         | MMIC BIAS chopper clock select<br>00: 250KHz<br>01: 500KHz<br>10: 1MHz<br>11: 2MHz  |
| 4           | R/W | 0x1         | DITHER<br>ADC dither on/off control<br>0: dither off<br>1: dither on  |
| 3:2         | R/W | 0x1         | DITHER_CLK_SELECT<br>ADC dither clock select<br>00: ADC FS * (8/9), about 43KHz when FS=48KHz<br>01: ADC FS * (16/15), about 51KHz when FS=48KHz<br>10: ADC FS * (4/3), about 64KHz when FS=48KHz |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | 11: ADC FS * (16/9), about 85KHz when FS=48KHz  |
| 1:0 | R/W | 0x2 | BIHE_CTRL, BIHE control<br>00: no BIHE<br>01: BIHE=7.5 HOSC<br>10: BIHE=11.5 HOSC<br>11: BIHE=15.5 HOSC |

#### 4.13.4.136. 0x14 Bias & DA16 Calibration Control Register(Default Value: 0x00)

| Offset:0x14 |     |             | Register Name: CALIBRATION_CTRL   |
|-------------|-----|-------------|---|
| bit         | R/W | Default/Hex | Description   |
| 7           | R/W | 0x0         | <b>PA_SPEED_SELECT</b><br>PA setup speed control (for testing)<br>0: slow<br>1: fast  |
| 6           | R/W | 0x0         | <b>CURRENT_TEST_SELECT</b><br>Internal current sink test enable (from LINEIN pin)<br>0:Normal<br>1: For Debug   |
| 5           | R/W | 0x0         | /   |
| 4           | R/W | 0x0         | <b>BIAS and DA16 calibration clock select</b><br>0: 1KHz<br>1: 500Hz  |
| 3           | R/W | 0x0         | <b>BIAS calibration mode select</b><br>0: average<br>1: single  |
| 2           | R/W | 0x0         | <b>BIAS and DA16 calibration control</b><br>Write 1 to this bit, the calibration will be doing again. Then this bit will be reset to zero automatically |
| 1           | R/W | 0x0         | <b>BIASCALIVERIFY</b><br>Bias Calibration Verify<br>0: Calibration<br>1: Register setting   |
| 0           | R/W | 0x0         | <b>DA16CALIVERIFY</b><br>DA16 Calibration Verify<br>0: Calibration<br>1: Register setting   |

#### 4.13.4.137. 0x15 DA16 Calibration Data Register (Default Value: 0x80)

| Offset:0x15 |     |             | Register Name: DA16CALI_DATA |
|-------------|-----|-------------|------------------------------|
| Bit         | R/W | Default/Hex | Description                  |

|     |   |      |                                   |
|-----|---|------|-----------------------------------|
| 7:0 | R | 0x80 | DA16CALI<br>DA16 Calibration Data |
|-----|---|------|-----------------------------------|

#### 4.13.4.138. 0x17 Bias Calibration Data Register (Default Value: 0x20)

| Offset:0x17 |     |             | Register Name: DA16CALI_DATA            |
|-------------|-----|-------------|---|
| Bit         | R/W | Default/Hex | Description                             |
| 7:6         | /   | /           | /                                       |
| 5:0         | R   | 0x20        | BIASCALI<br>Bias Calibration Data, 6bit |

#### 4.13.4.139. 0x18 Bias Register Setting Data Register (Default Value: 0x20)

| Offset:0x18 |     |             | Register Name: DA16CALI_SET                    |
|-------------|-----|-------------|--|
| Bit         | R/W | Default/Hex | Description                                    |
| 7:6         | /   | /           | /  |
| 5:0         | R/W | 0x20        | BIASVERIFY<br>Bias Register Setting Data, 6bit |

## 4.14. Port Controller

### 4.14.1. Overview

The chip has 6 ports for multi-functional input/output pins. They are shown below:

- Port B(PB): 11 input/output port
- Port C(PC): 4 input/output port
- Port D(PD): 22 input/output port
- Port E(PE) : 18 input/output port
- Port F(PF) : 6 input/output port
- Port G(PG) : 8 input/output port

For various system configurations, these ports can be easily configured by software. All these ports can be configured as GPIO if multiplexed functions are not used. The total 2 group external PIO interrupt sources are supported and interrupt mode can be configured by software.

### 4.14.2. Port Controller Register List

| Module Name | Base Address |
|-------------|--------------|
| PIO         | 0x01C20800   |

| Register Name | Offset            | Description                                     |
|---------------|-------------------|---|
| Pn_CFG0       | n*0x24+0x00       | Port n Configure Register 0 (n=1,2,3,4,5,6)     |
| Pn_CFG1       | n*0x24+0x04       | Port n Configure Register 1 (n=1,2,3,4,5,6)     |
| Pn_CFG2       | n*0x24+0x08       | Port n Configure Register 2 (n=1,2,3,4,5,6)     |
| Pn_CFG3       | n*0x24+0x0C       | Port n Configure Register 3 (n=1,2,3,4,5,6)     |
| Pn_DAT        | n*0x24+0x10       | Port n Data Register (n=1,2,3,4,5,6)            |
| Pn_DRV0       | n*0x24+0x14       | Port n Multi-Driving Register 0 (n=1,2,3,4,5,6) |
| Pn_DRV1       | n*0x24+0x18       | Port n Multi-Driving Register 1 (n=1,2,3,4,5,6) |
| Pn_PUL0       | n*0x24+0x1C       | Port n Pull Register 0 (n=1,2,3,4,5,6)          |
| Pn_PUL1       | n*0x24+0x20       | Port n Pull Register 1 (n=1,2,3,4,5,6)          |
| Pn_INT_CFG0   | 0x200+n*0x20+0x00 | PIO Interrupt Configure Register 0(n=1,2)       |
| Pn_INT_CFG1   | 0x200+n*0x20+0x04 | PIO Interrupt Configure Register 1(n=1,2)       |
| Pn_INT_CFG2   | 0x200+n*0x20+0x08 | PIO Interrupt Configure Register 2(n=1,2)       |
| Pn_INT_CFG3   | 0x200+n*0x20+0x0C | PIO Interrupt Configure Register 3(n=1,2)       |
| Pn_INT_CTL    | 0x200+n*0x20+0x10 | PIO Interrupt Control Register(n=1,2)           |
| Pn_INT_STA    | 0x200+n*0x20+0x14 | PIO Interrupt Status Register(n=1,2)            |
| Pn_INT_DEB    | 0x200+n*0x20+0x18 | PIO Interrupt Debounce Register(n=1,2)          |

#### 4.14.3. Port Controller Register Description

##### 4.14.3.1. PB Configure Register 0 (Default Value: 0x77777777)

| Offset: 0x24 |     |             | Register Name: PB_CFG0_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | /   | /           | /  |
| 30:28        | R/W | 0x7         | PB7_SELECT<br>000: Input<br>010: TWI0_SDA<br>100: Reserved<br>110: PB_EINT7<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 27           | /   | /           | /  |
| 26:24        | R/W | 0x7         | PB6_SELECT<br>000: Input<br>010: TWI0_SCK<br>100: Reserved<br>110: PB_EINT6<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 23           | /   | /           | /  |
| 22:20        | R/W | 0x7         | PB5_SELECT<br>000: Input<br>010: PWM1<br>100: Reserved<br>110: PB_EINT5<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable      |
| 19           | /   | /           | /  |
| 18:16        | R/W | 0x7         | PB4_SELECT<br>000: Input<br>010: PWM0<br>100: Reserved<br>110: PB_EINT4<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable      |
| 15           | /   | /           | /  |
| 14:12        | R/W | 0x7         | PB3_SELECT<br>000: Input<br>010: UART2_CTS<br>100: Reserved<br>110: PB_EINT3<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 11           | /   | /           | /  |
| 10:8         | R/W | 0x7         | PB2_SELECT<br>000: Input<br>010: UART2_RTS<br>100: Reserved<br>110: PB_EINT2<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 7            | /   | /           | /  |
| 6:4          | R/W | 0x7         | PB1_SELECT   |

|     |     |     |   |  |
|-----|-----|-----|---|--|
|     |     |     | 000: Input<br>010: UART2_RX<br>100: Reserved<br>110: PB_EINT1               | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 3   | /   | /   | /   |  |
| 2:0 | R/W | 0x7 | PB0_SELECT<br>000: Input<br>010: UART2_TX<br>100: Reserved<br>110: PB_EINT0 | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.2. PB Configure Register 1 (Default Value: 0x00777777)

| Offset: 0x28 |     |             | Register Name: PB_CFG1_REG  |  |
|--------------|-----|-------------|---|--|
| Bit          | R/W | Default/Hex | Description   |  |
| 31:23        | /   | /           |   | /  |
| 22:20        | R/W | 0x7         |   | /  |
| 19           | /   | /           |   | /  |
| 18:16        | R/W | 0x7         |   | /  |
| 15           | /   | /           |   |  |
| 14:12        | R/W | 0x7         |   | /  |
| 11           | /   | /           |   | /  |
| 10:8         | R/W | 0x7         | PB10_SELECT<br>000: Input<br>010: Reserved<br>100: Reserved<br>110: PB_EINT10 | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 7            | /   | /           |   | /  |
| 6:4          | R/W | 0x7         | PB9_SELECT<br>000: Input<br>010: TWI1_SDA<br>100: Reserved<br>110: PB_EINT9   | 001: Output<br>011: UART0_RX<br>101: Reserved<br>111: IO Disable |
| 3            | /   | /           |   | /  |
| 2:0          | R/W | 0x7         | PB8_SELECT<br>000: Input<br>010: TWI1_SCK<br>100: Reserved<br>110: PB_EINT8   | 001: Output<br>011: UART0_TX<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.3. PB Configure Register 2 (Default Value: 0x00000000)

| Offset: 0x2C |     |             | Register Name: PB_CFG2_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           |                            |

#### 4.14.3.4. PB Configure Register 3 (Default Value: 0x00000000)

| Offset: 0x30 |     |             | Register Name: PB_CFG3_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.5. PB Data Register (Default Value: 0x00000000)

| Offset: 0x34 |     |             | Register Name: PB_DATA_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:14        | /   | /           | /  |
| 13:0         | R/W | 0x0         | PB_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |

#### 4.14.3.6. PB Multi-Driving Register 0 (Default Value: 0x05555555)

| Offset: 0x38          |     |             | Register Name: PB_DRV0_REG  |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:28                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~13) | R/W | 0x1         | PB_DRV<br>PB[n] Multi-Driving Select (n = 0~13)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

#### 4.14.3.7. PB Multi-Driving Register 1 (Default Value: 0x00000000)

| Offset: 0x3C |     |             | Register Name: PB_DRV1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

**4.14.3.8. PB PULL Register 0 (Default Value: 0x00000000)**

| Offset: 0x40          |     |             | Register Name: PB_PULL0_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:28                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~13) | R/W | 0x0         | PB_PULL<br>PB[n] Pull-up/down Select (n = 0~13)<br>00: Pull-up/down disable      01: Pull-up<br>10: Pull-down      11: Reserved |

**4.14.3.9. PB PULL Register 1 (Default Value: 0x00000000)**

| Offset: 0x44 |     |             | Register Name: PB_PULL1_REG |
|--------------|-----|-------------|-----------------------------|
| Bit          | R/W | Default/Hex | Description                 |
| 31:0         | /   | /           | /                           |

**4.14.3.10. PC Configure Register 0 (Default Value: 0x77777777)**

| Offset: 0x48 |     |             | Register Name: PC_CFG0_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | /   | /           | /   |
| 30:28        | R/W | 0x7         | /   |
| 27           | /   | /           | /   |
| 26:24        | R/W | 0x7         | /   |
| 23           | /   | /           | /   |
| 22:20        | R/W | 0x7         | /   |
| 19           | /   | /           | /   |
| 18:16        | R/W | 0x7         | /   |
| 15           | /   | /           | /   |
| 14:12        | R/W | 0x7         | PC3_SELECT<br>000: Input                          001: Output<br>010: SDC2_D0                          011: SPI0_MOSI<br>100: Reserved                        101: Reserved<br>110: Reserved                        111: IO Disable |
| 11           | /   | /           | /   |
| 10:8         | R/W | 0x7         | PC2_SELECT<br>000: Input                            001: Output<br>010: SDC2_RST                        011: SPI0_CS<br>100: Reserved                        101: Reserved<br>110: Reserved                        111: IO Disable  |
| 7            | /   | /           | /   |

|     |     |     |   |   |
|-----|-----|-----|---|---|
| 6:4 | R/W | 0x7 | PC1_SELECT<br>000: Input<br>010: SDC2_CMD<br>100: Reserved<br>110: Reserved | 001: Output<br>011: SPI0_CLK<br>101: Reserved<br>111: IO Disable  |
| 3   | /   | /   | /   |   |
| 2:0 | R/W | 0x7 | PC0_SELECT<br>000: Input<br>010: SDC2_CLK<br>100: Reserved<br>110: Reserved | 001: Output<br>011: SPI0_MISO<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.11. PC Configure Register 1 (Default Value: 0x00000777)

| Offset: 0x4C |     |             | Register Name: PC_CFG1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:11        | /   | /           | /                          |
| 10:8         | R/W | 0x7         | /                          |
| 7            | /   | /           | /                          |
| 6:4          | R/W | 0x7         | /                          |
| 3            | /   | /           | /                          |
| 2:0          | R/W | 0x7         | /                          |

#### 4.14.3.12. PC Configure Register 2 (Default Value: 0x00000000)

| Offset: 0x50 |     |             | Register Name: PC_CFG2_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.13. PC Configure Register 3 (Default Value: 0x00000000)

| Offset: 0x54 |     |             | Register Name: PC_CFG3_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.14. PC Data Register (Default Value: 0x00000000)

| Offset: 0x58 |     |             | Register Name: PC_DATA_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:11        | /   | /           | /                          |

|      |     |     |  |
|------|-----|-----|--|
| 10:0 | R/W | 0x0 | PC_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |
|------|-----|-----|--|

#### 4.14.3.15. PC Multi-Driving Register 0 (Default Value: 0x00155555)

| Offset: 0x5C          |     |             | Register Name: PC_DRV0_REG  |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:22                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~10) | R/W | 0x1         | PC_DRV<br>PC[n] Multi-Driving SELECT (n = 0~10)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

#### 4.14.3.16. PC Multi-Driving Register 1 (Default Value: 0x00000000)

| Offset: 0x60 |     |             | Register Name: PC_DRV1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.17. PC PULL Register 0 (Default Value: 0x00000000)

| Offset: 0x64          |     |             | Register Name: PC_PULL0_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:22                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~10) | R/W | 0x0         | PC_PULL<br>PC[n] Pull-up/down Select (n = 0~10)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

#### 4.14.3.18. PC PULL Register 1 (Default Value: 0x00000000)

| Offset: 0x68 |     |             | Register Name: PC_PULL1_REG |
|--------------|-----|-------------|-----------------------------|
| Bit          | R/W | Default/Hex | Description                 |
| 31:0         | /   | /           | /                           |

**4.14.3.19. PD Configure Register 0 (Default Value: 0x77777777)**

| Offset: 0x6C |     |             | Register Name: PD_CFG0_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | /   | /           | /  |
| 30:28        | R/W | 0x7         | PD7_SELECT<br>000:Input 001:Output<br>010: LCD_D11 011:Reserved<br>100: RGMII_TXD3/MII_TXD3/RMII_NULL 101:Reserved<br>110:Reserved 111:IO Disable  |
| 27           | /   | /           | Reserved   |
| 26:24        | R/W | 0x7         | PD6_SELECT<br>000:Input 001:Output<br>010: LCD_D10 011:Reserved<br>100: RGMII_NULL/MII_RXERR/RMII_RXER 101:Reserved<br>110:Reserved 111:IO Disable |
| 23           | /   | /           | /  |
| 22:20        | R/W | 0x7         | PD5_SELECT<br>000:Input 001:Output<br>010: LCD_D7 011:Reserved<br>100: RGMII_RXCTL/MII_RXDV/RMII_NULL 101:Reserved<br>110:Reserved 111:IO Disable  |
| 19           | /   | /           | /  |
| 18:16        | R/W | 0x7         | PD4_SELECT<br>000:Input 001:Output<br>010: LCD_D6 011:Reserved<br>100: RGMII_RXCK/MII_RXCK/RMII_NULL 101:Reserved<br>110:Reserved 111:IO Disable   |
| 15           | /   | /           | /  |
| 14:12        | R/W | 0x7         | PD3_SELECT<br>000:Input 001:Output<br>010: LCD_D5 011:Reserved<br>100: RGMII_RXD0/MII_RXD0/RMII_RXD0 101:Reserved<br>110:Reserved 111:IO Disable   |
| 11           | /   | /           | /  |
| 10:8         | R/W | 0x7         | PD2_SELECT<br>000:Input 001:Output<br>010: LCD_D4 011:Reserved<br>100: RGMII_RXD1/MII_RXD1/RMII_RXD1 101:Reserved<br>110:Reserved 111:IO Disable   |
| 7            | /   | /           | /  |
| 6:4          | R/W | 0x7         | PD1_SELECT<br>000:Input 001:Output<br>010: LCD_D3 011:Reserved   |

|     |     |     |   |  |
|-----|-----|-----|---|--|
|     |     |     | 100: RGMII_RXD2/MII_RXD2/RMII_NULL<br>110:Reserved  | 101:Reserved<br>111:IO Disable                               |
| 3   | /   | /   | /   |  |
| 2:0 | R/W | 0x7 | PDO_SELECT<br>000:Input<br>010: LCD_D2<br>100: RGMII_RXD3/MII_RXD3/ RMII_NULL<br>110:Reserved | 001:Output<br>011:Reserved<br>101:Reserved<br>111:IO Disable |

#### 4.14.3.20. PD Configure Register 1 (Default Value: 0x77777777)

| Offset: 0x70 |     |             | Register Name: PD_CFG1_REG   |   |
|--------------|-----|-------------|--|---|
| Bit          | R/W | Default/Hex | Description  |   |
| 31           | /   | /           | /  |   |
| 30:28        | R/W | 0x7         | PD15_SELECT<br>000:Input<br>010: LCD_D21<br>100: RGMII_CLKIN/MII_COL/RMII_NULL<br>110:Reserved     | 001:Output<br>011: LVDS_VN1<br>101:Reserved<br>111:IO Disable |
| 27           | /   | /           | /  |   |
| 26:24        | R/W | 0x7         | PD14_SELECT<br>000:Input<br>010: LCD_D20<br>100: RGMII_NULL/MII_TXERR/RMII_NULL<br>110:Reserved    | 001:Output<br>011: LVDS_VP1<br>101:Reserved<br>111:IO Disable |
| 23           | /   | /           | /  |   |
| 22:20        | R/W | 0x7         | PD13_SELECT<br>000:Input<br>010: LCD_D19<br>100: RGMII_TXCTL/MII_TXEN/RMII_TXEN<br>110:Reserved    | 001:Output<br>011: LVDS_VN0<br>101:Reserved<br>111:IO Disable |
| 19           | /   | /           | /  |   |
| 18:16        | R/W | 0x7         | PD12_SELECT<br>000:Input<br>010: LCD_D18<br>100: RGMII_TXCK/MII_TXCK/RMII_TXCK<br>110:Reserved     | 001:Output<br>011: LVDS_VPO<br>101:Reserved<br>111:IO Disable |
| 15           | /   | /           | /  |   |
| 14:12        | R/W | 0x7         | PD11_SELECT<br>000:Input<br>010: LCD_D15<br>100: RGMII_NULL/MII_CRS_DV/RMII_CRS_DV<br>110:Reserved | 001:Output<br>011:Reserved<br>101:Reserved<br>111:IO Disable  |
| 11           | /   | /           | /  |   |

|      |     |     |  |  |
|------|-----|-----|--|--|
| 10:8 | R/W | 0x7 | PD10_SELECT<br>000:Input<br>010: LCD_D14<br>100: RGMII_TXD0/MII_TXD0/RMII_TXD0<br>110:Reserved | 001:Output<br>011:Reserved<br>101:Reserved<br>111:IO Disable |
| 7    | /   | /   | /  |  |
| 6:4  | R/W | 0x7 | PD9_SELECT<br>000:Input<br>010: LCD_D13<br>100: RGMII_TXD1/MII_TXD1/RMII_TXD1<br>110:Reserved  | 001:Output<br>011:Reserved<br>101:Reserved<br>111:IO Disable |
| 3    | /   | /   | /  |  |
| 2:0  | R/W | 0x7 | PD8_SELECT<br>000:Input<br>010: LCD_D12<br>100: RGMII_TXD2/MII_TXD2/RMII_NULL<br>110:Reserved  | 001:Output<br>011:Reserved<br>101:Reserved<br>111:IO Disable |

#### 4.14.3.21. PD Configure Register 2 (Default Value: 0x00777777)

| Offset: 0x74 |     |             | Register Name: PD_CFG2_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:23        | /   | /           | /   |
| 22:20        | R/W | 0x7         | PD21_SELECT<br>000: Input<br>010: LCD_VSYNC<br>100: Reserved<br>110: Reserved |
| 19           | /   | /           | Reserved  |
| 18:16        | R/W | 0x7         | PD20_SELECT<br>000: Input<br>010: LCD_HSYNC<br>100: Reserved<br>110: Reserved |
| 15           | /   | /           | /   |
| 14:12        | R/W | 0x7         | PD19_SELECT<br>000: Input<br>010: LCD_DE<br>100: Reserved<br>110: Reserved    |
| 11           | /   | /           | /   |
| 10:8         | R/W | 0x7         | PD18_SELECT<br>000: Input<br>010: LCD_CLK                                     |

|     |     |     |   |  |
|-----|-----|-----|---|--|
|     |     |     | 100: Reserved<br>110: Reserved  | 101: Reserved<br>111: IO Disable                                 |
| 7   | /   | /   | /   |  |
| 6:4 | R/W | 0x7 | PD17_SELECT<br>000: Input<br>010: LCD_D23<br>100: MDIO<br>110: Reserved | 001: Output<br>011: LVDS_VN2<br>101: Reserved<br>111: IO Disable |
| 3   | /   | /   | /   |  |
| 2:0 | R/W | 0x7 | PD16_SELECT<br>000: Input<br>010: LCD_D22<br>100: MDC<br>110: Reserved  | 001: Output<br>011: LVDS_VP2<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.22. PD Configure Register 3 (Default Value: 0x00000000)

| Offset: 0x78 |     |             | Register Name: PD_CFG3_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.23. PD Data Register (Default Value: 0x00000000)

| Offset: 0x7C |     |             | Register Name: PD_DATA_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:22        | /   | /           | /  |
| 21:0         | R/W | 0x0         | PD_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |

#### 4.14.3.24. PD Multi-Driving Register 0 (Default Value: 0x55555555)

| Offset: 0x80          |     |             | Register Name: PD_DRV0_REG  |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| [2i+1:2i]<br>(i=0~15) | R/W | 0x1         | PD_DRV<br>PD[n] Multi-Driving SELECT (n = 0~15)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

**4.14.3.25. PD Multi-Driving Register 1 (Default Value: 0x00000555)**

| Offset: 0x84         |     |             | Register Name: PD_DRV1_REG   |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:12                | /   | /           | /  |
| [2i+1:2i]<br>(i=0~5) | R/W | 0x1         | PD_DRV<br>PD[n] Multi-Driving Select (n = 16~21)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

**4.14.3.26. PD PULL Register 0 (Default Value: 0x00000000)**

| Offset: 0x88          |     |             | Register Name: PD_PULL0_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| [2i+1:2i]<br>(i=0~15) | R/W | 0x0         | PD_PULL<br>PD[n] Pull-up/down Select (n = 0~15)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

**4.14.3.27. PD PULL Register 1 (Default Value: 0x00000000)**

| Offset: 0x8C         |     |             | Register Name: PD_PULL1_REG  |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:12                | /   | /           | Reserved   |
| [2i+1:2i]<br>(i=0~5) | R/W | 0x0         | PD_PULL<br>PD[n] Pull-up/down Select (n = 16~21)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

**4.14.3.28. PE Configure Register 0 (Default Value: 0x77777777)**

| Offset: 0x90 |     |             | Register Name: PE_CFG0_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | /   | /           | /   |
| 30:28        | R/W | 0x7         | PE7_SELECT<br>000: Input                    001: Output<br>010: CSI_D3                011: Reserved<br>100: Reserved                101: Reserved<br>110: Reserved                111: IO Disable |
| 27           | /   | /           | /   |

|       |     |     |  |  |
|-------|-----|-----|--|--|
|       |     |     | PE6_SELECT<br>000: Input<br>010: CSI_D2<br>100: Reserved<br>110: Reserved    | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 26:24 | R/W | 0x7 |  |  |
| 23    | /   | /   | /  |  |
| 22:20 | R/W | 0x7 | Reserved   |  |
| 19    | /   | /   | /  |  |
| 18:16 | R/W | 0x7 | Reserved   |  |
| 15    | /   | /   | /  |  |
|       |     |     | PE3_SELECT<br>000: Input<br>010: CSI_VSYNC<br>100: Reserved<br>110: Reserved | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 14:12 | R/W | 0x7 |  |  |
| 11    | /   | /   | /  |  |
|       |     |     | PE2_SELECT<br>000: Input<br>010: CSI_HSYNC<br>100: Reserved<br>110: Reserved | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 10:8  | R/W | 0x7 |  |  |
| 7     | /   | /   | /  |  |
|       |     |     | PE1_SELECT<br>000: Input<br>010: CSI_MCLK<br>100: Reserved<br>110: Reserved  | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 6:4   | R/W | 0x7 |  |  |
| 3     | /   | /   | /  |  |
|       |     |     | PE0_SELECT<br>000: Input<br>010: CSI_PCLK<br>100: Reserved<br>110: Reserved  | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 2:0   | R/W | 0x7 |  |  |

#### 4.14.3.29. PE Configure Register 1 (Default Value: 0x77777777)

| Offset: 0x94 |     |             | Register Name: PE_CFG1_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | /   | /           | /   |
|              |     |             | PE15_SELECT<br>000: Input<br>010: CSI_D11<br>100: Reserved<br>110: Reserved |
| 30:28        | R/W | 0x7         | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable            |

|       |     |     |  |
|-------|-----|-----|--|
| 27    | /   | /   | /  |
| 26:24 | R/W | 0x7 | <b>PE14_SELECT</b><br>000: Input<br>010: CSI_D10<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 23    | /   | /   | /  |
| 22:20 | R/W | 0x7 | <b>PE13_SELECT</b><br>000: Input<br>010: CSI_D9<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 19    | /   | /   | /  |
| 18:16 | R/W | 0x7 | <b>PE12_SELECT</b><br>000: Input<br>010: CSI_D8<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 15    | /   | /   | /  |
| 14:12 | R/W | 0x7 | <b>PE11_SELECT</b><br>000: Input<br>010: CSI_D7<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 11    | /   | /   | /  |
| 10:8  | R/W | 0x7 | <b>PE10_SELECT</b><br>000: Input<br>010: CSI_D6<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable  |
| 7     | /   | /   | /  |
| 6:4   | R/W | 0x7 | <b>PE9_SELECT</b><br>000: Input<br>010: CSI_D5<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable   |
| 3     | /   | /   | /  |
| 2:0   | R/W | 0x7 | <b>PE8_SELECT</b><br>000: Input<br>010: CSI_D4<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable   |

**4.14.3.30. PE Configure Register 2 (Default Value: 0x77777777)**

| Offset: 0x98 |     |             | Register Name: PE_CFG2_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | /   | /           | /  |
| 30:28        | R/W | 0x7         | Reserved   |
| 27           | /   | /           | /  |
| 26:24        | R/W | 0x7         | PE22_SELECT<br>000: Input<br>010: CSI_SDA<br>100: UART1_RX<br>110: Reserved<br>001: Output<br>011: TWI1_SDA<br>101: Reserved<br>111: IO Disable        |
| 23           | /   | /           | /  |
| 22:20        | R/W | 0x7         | PE21_SELECT<br>000: Input<br>010: CSI_SCK<br>100: UART1_TX<br>110: Reserved<br>001: Output<br>011: TWI1_SCK<br>101: Reserved<br>111: IO Disable        |
| 19           | /   | /           | /  |
| 18:16        | R/W | 0x7         | PE20_SELECT<br>000: Input<br>010: CSI_FIELD<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: CSI_MIPI_MCLK<br>101: Reserved<br>111: IO Disable |
| 15           | /   | /           | /  |
| 14:12        | R/W | 0x7         | Reserved   |
| 11           | /   | /           | /  |
| 10:8         | R/W | 0x7         | Reserved   |
| 7            | /   | /           | /  |
| 6:4          | R/W | 0x7         | Reserved   |
| 3            | /   | /           | /  |
| 2:0          | R/W | 0x7         | Reserved   |

**4.14.3.31. PE Configure Register 3 (Default Value: 0x00000007)**

| Offset: 0x9C |     |             | Register Name: PE_CFG3_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:3         | /   | /           | /  |
| 2:0          | R/W | 0x7         | PE24_SELECT<br>000: Input<br>010: Reserved<br>100: Reserved<br>110: Reserved<br>001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.32. PE Data Register (Default Value: 0x00000000)

| Offset: 0xA0 |     |             | Register Name: PE_DATA_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:25        | /   | /           | /  |
| 24:0         | R/W | 0x0         | PE_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |

#### 4.14.3.33. PE Multi-Driving Register 0 (Default Value: 0x55555555)

| Offset: 0xA4          |     |             | Register Name: PE_DRV0_REG  |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| [2i+1:2i]<br>(i=0~15) | R/W | 0x1         | PE_DRV<br>PE[n] Multi-Driving SELECT (n = 0~15)<br>00: Level 0                            01: Level 1<br>10: Level 2                            11: Level 3 |

#### 4.14.3.34. PE Multi-Driving Register 1 (Default Value: 0x00015555)

| Offset: 0xA8         |     |             | Register Name: PE_DRV1_REG   |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:18                | /   | /           | /  |
| [2i+1:2i]<br>(i=0~8) | R/W | 0x1         | PE_DRV<br>PE[n] Multi-Driving Select (n = 16~24)<br>00: Level 0                            01: Level 1<br>10: Level 2                            11: Level 3 |

#### 4.14.3.35. PE PULL Register 0 (Default Value: 0x00000000)

| Offset: 0xAC          |     |             | Register Name: PE_PULL0_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| [2i+1:2i]<br>(i=0~15) | R/W | 0x0         | PE_PULL<br>PE[n] Pull-up/down Select (n = 0~15)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                    11: Reserved |

#### 4.14.3.36. PE PULL Register 1 (Default Value: 0x00000000)

| Offset: 0xB0         |     |             | Register Name: PE_PULL1_REG  |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:18                | /   | /           | /  |
| [2i+1:2i]<br>(i=0~8) | R/W | 0x0         | PE_PULL<br>PE[n] Pull-up/down Select (n = 16~24)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

#### **4.14.3.37. PF Configure Register 0 (Default Value: 0x07373733)**

| Offset: 0xB4 |     |             | Register Name: PF_CFG0_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:27        | /   | /           | /   |
| 26:24        | R/W | 0x7         | Reserved  |
| 23           | /   | /           | /   |
| 22:20        | R/W | 0x3         | PF5_SELECT<br>000: Input<br>010: SDC0_D2<br>100: Reserved<br>110: Reserved  |
| 19           | /   | /           | /   |
| 18:16        | R/W | 0x7         | PF4_SELECT<br>000: Input<br>010: SDC0_D3<br>100: Reserved<br>110: Reserved  |
| 15           | /   | /           | /   |
| 14:12        | R/W | 0x3         | PF3_SELECT<br>000: Input<br>010: SDC0_CMD<br>100: Reserved<br>110: Reserved |
| 11           | /   | /           | /   |
| 10:8         | R/W | 0x7         | PF2_SELECT<br>000: Input<br>010: SDC0_CLK<br>100: Reserved<br>110: Reserved |
| 7            | /   | /           | /   |
| 6:4          | R/W | 0x3         | PF1_SELECT<br>000: Input<br>001: Output                                     |

|     |     |     |  |   |
|-----|-----|-----|--|---|
|     |     |     | 010: SDC0_D0<br>100: Reserved<br>110: Reserved                             | 011: JTAG_DI<br>101: Reserved<br>111: IO Disable                |
| 3   | /   | /   | /  |   |
| 2:0 | R/W | 0x3 | PFO_SELECT<br>000: Input<br>010: SDC0_D1<br>100: Reserved<br>110: Reserved | 001: Output<br>011: JTAG_MS<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.38. PF Configure Register 1 (Default Value: 0x00000000)

| Offset: 0xB8 |     |             | Register Name: PF_CFG1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.39. PF Configure Register 2 (Default Value: 0x00000000)

| Offset: 0xBC |     |             | Register Name: PF_CFG2_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.40. PF Configure Register 3 (Default Value: 0x00000000)

| Offset: 0xC0 |     |             | Register Name: PF_CFG3_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.41. PF Data Register (Default Value: 0x00000000)

| Offset: 0xC4 |     |             | Register Name: PF_DATA_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:7         | /   | /           | /  |
| 6:0          | R/W | 0x0         | PF_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |

**4.14.3.42. PF Multi-Driving Register 0 (Default Value: 0x00001555)**

| Offset: 0xC8         |     |             | Register Name: PF_DRV0_REG   |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:14                | /   | /           | /  |
| [2i+1:2i]<br>(i=0~6) | R/W | 0x1         | PF_DRV<br>PF[n] Multi-Driving SELECT (n = 0~6)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

**4.14.3.43. PF Multi-Driving Register 1 (Default Value: 0x00000000)**

| Offset: 0xCC |     |             | Register Name: PF_DRV1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

**4.14.3.44. PF PULL Register 0 (Default Value: 0x00000000)**

| Offset: 0xD0         |     |             | Register Name: PF_PULL0_REG  |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| 31:14                | /   | /           | /  |
| [2i+1:2i]<br>(i=0~6) | R/W | 0x0         | PF_PULL<br>PF[n] Pull-up/down Select (n = 0~6)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

**4.14.3.45. PF PULL Register 1 (Default Value: 0x00000000)**

| Offset: 0xD4 |     |             | Register Name: PF_PULL1_REG |
|--------------|-----|-------------|-----------------------------|
| Bit          | R/W | Default/Hex | Description                 |
| 31:0         | /   | /           | /                           |

**4.14.3.46. PG Configure Register 0 (Default Value: 0x77777777)**

| Offset: 0xD8 |     |             | Register Name: PG_CFG0_REG                              |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | /   | /           | /   |
| 30:28        | R/W | 0x7         | PG7_SELECT<br>000: Input                    001: Output |

|       |     |     |   |  |
|-------|-----|-----|---|--|
|       |     |     | 010: UART1_RX<br>100: Reserved<br>110: PG_EINT7                             | 011: Reserved<br>101: Reserved<br>111: IO Disable                |
| 27    | /   | /   | /   |  |
| 26:24 | R/W | 0x7 | PG6_SELECT<br>000: Input<br>010: UART1_TX<br>100: Reserved<br>110: PG_EINT6 | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 23    | /   | /   | /   |  |
| 22:20 | R/W | 0x7 | Reserved  |  |
| 19    | /   | /   | /   |  |
| 18:16 | R/W | 0x7 | Reserved  |  |
| 15    | /   | /   | /   |  |
| 14:12 | R/W | 0x7 | Reserved  |  |
| 11    | /   | /   | /   |  |
| 10:8  | R/W | 0x7 | Reserved  |  |
| 7     | /   | /   | /   |  |
| 6:4   | R/W | 0x7 | Reserved  |  |
| 3     | /   | /   | /   |  |
| 2:0   | R/W | 0x7 | Reserved  |  |

#### 4.14.3.47. PG Configure Register 1 (Default Value: 0x00777777)

| Offset: 0xDC |     |             | Register Name: PG_CFG1_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:23        | /   | /           | /   |
| 22:20        | R/W | 0x7         | PG13_SELECT<br>000: Input<br>010: PCM_DIN<br>100: Reserved<br>110: PG_EINT13  |
| 19           | /   | /           | /   |
| 18:16        | R/W | 0x7         | PG12_SELECT<br>000: Input<br>010: PCM_DOUT<br>100: Reserved<br>110: PG_EINT12 |
| 15           | /   | /           | /   |
| 14:12        | R/W | 0x7         | PG11_SELECT<br>000: Input<br>010: PCM_BCLK<br>100: Reserved                   |
|              |     |             | 001: Output<br>011: Reserved<br>101: Reserved                                 |

|      |     |     |   |  |
|------|-----|-----|---|--|
|      |     |     | 110: PG_EINT11  | 111: IO Disable  |
| 11   | /   | /   | /   |  |
| 10:8 | R/W | 0x7 | PG10_SELECT<br>000: Input<br>010: PCM_SYNC<br>100: Reserved<br>110: PG_EINT10 | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 7    | /   | /   | /   |  |
| 6:4  | R/W | 0x7 | PG9_SELECT<br>000: Input<br>010: UART1_CTS<br>100: Reserved<br>110: PG_EINT9  | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |
| 3    | /   | /   | /   |  |
| 2:0  | R/W | 0x7 | PG8_SELECT<br>000: Input<br>010: UART1_RTS<br>100: Reserved<br>110: PG_EINT8  | 001: Output<br>011: Reserved<br>101: Reserved<br>111: IO Disable |

#### 4.14.3.48. PG Configure Register 2 (Default Value: 0x00000000)

| Offset: 0xE0 |     |             | Register Name: PG_CFG2_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.49. PG Configure Register 3 (Default Value: 0x00000000)

| Offset: 0xE4 |     |             | Register Name: PG_CFG3_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.50. PG Data Register (Default Value: 0x00000000)

| Offset: 0xE8 |     |             | Register Name: PG_DATA_REG   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:14        | /   | /           | /  |
| 13:0         | R/W | 0x0         | PG_DAT<br>If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read. |

#### 4.14.3.51. PG Multi-Driving Register 0 (Default Value: 0x05555555)

| Offset: 0xEC          |     |             | Register Name: PG_DRV0_REG  |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:28                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~13) | R/W | 0x1         | PF_DRV<br>PF[n] Multi-Driving SELECT (n = 0~13)<br>00: Level 0                    01: Level 1<br>10: Level 2                    11: Level 3 |

#### 4.14.3.52. PG Multi-Driving Register 1 (Default Value: 0x00000000)

| Offset: 0xF0 |     |             | Register Name: PG_DRV1_REG |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:0         | /   | /           | /                          |

#### 4.14.3.53. PG PULL Register 0 (Default Value: 0x00000000)

| Offset: 0xF4          |     |             | Register Name: PG_PULL0_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:28                 | /   | /           | /   |
| [2i+1:2i]<br>(i=0~13) | R/W | 0x0         | PF_PULL<br>PF[n] Pull-up/down Select (n = 0~13)<br>00: Pull-up/down disable    01: Pull-up<br>10: Pull-down                11: Reserved |

#### 4.14.3.54. PG PULL Register 1 (Default Value: 0x00000000)

| Offset: 0xF8 |     |             | Register Name: PG_PULL1_REG |
|--------------|-----|-------------|-----------------------------|
| Bit          | R/W | Default/Hex | Description                 |
| 31:0         | /   | /           | /                           |

#### 4.14.3.55. PB External Interrupt Configure Register 0 (Default Value: 0x00000000)

| Offset: 0x220 |     |             | Register Name: PB_EINT_CFG0_REG |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| [4i+3:4i]     | R/W | 0x0         | EINT_CFG                        |

|         |  |  |  |
|---------|--|--|--|
| (i=0~7) |  |  | External INTn Mode (n = 0~7)<br>0x0: Positive Edge<br>0x1: Negative Edge<br>0x2: High Level<br>0x3: Low Level<br>0x4: Double Edge (Positive/ Negative)<br>Others: Reserved |
|---------|--|--|--|

#### 4.14.3.56. PB External Interrupt Configure Register 1 (Default Value: 0x00000000)

| Offset: 0x224        |     |             | Register Name: <b>PB_EINT_CFG1_REG</b>  |
|----------------------|-----|-------------|---|
| Bit                  | R/W | Default/Hex | Description   |
| 31:12                | /   | /           | /   |
| [4i+3:4i]<br>(i=0~2) | R/W | 0x0         | EINT_CFG<br>External INTn Mode (n = 8~10)<br>0x0: Positive Edge<br>0x1: Negative Edge<br>0x2: High Level<br>0x3: Low Level<br>0x4: Double Edge (Positive/ Negative)<br>Others: Reserved |

#### 4.14.3.57. PB External Interrupt Configure Register 2 (Default Value: 0x00000000)

| Offset: 0x228 |     |             | Register Name: <b>PB_EINT_CFG2_REG</b> |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description                            |
| 31:0          | /   | /           | /                                      |

#### 4.14.3.58. PB External Interrupt Configure Register 3 (Default Value: 0x00000000)

| Offset: 0x22C |     |             | Register Name: <b>PB_EINT_CFG3_REG</b> |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description                            |
| 31:0          | /   | /           | /                                      |

#### 4.14.3.59. PB External Interrupt Control Register (Default Value: 0x00000000)

| Offset: 0x230 |     |             | Register Name: <b>PB_EINT_CTL_REG</b> |
|---------------|-----|-------------|---------------------------------------|
| Bit           | R/W | Default/Hex | Description                           |
| 31:11         | /   | /           | /                                     |

|                 |     |     |  |
|-----------------|-----|-----|--|
| [n]<br>(n=0~10) | R/W | 0x0 | EINT_CTL<br>External INTn Enable (n = 0~10)<br>0: Disable<br>1: Enable |
|-----------------|-----|-----|--|

#### 4.14.3.60. PB External Interrupt Status Register (Default Value: 0x00000000)

| Offset: 0x234   |     |             | Register Name: PB_EINT_STATUS_REG  |
|-----------------|-----|-------------|--|
| Bit             | R/W | Default/Hex | Description  |
| 31:11           | /   | /           | /  |
| [n]<br>(n=0~10) | R/W | 0x0         | EINT_STATUS<br>External INTn Pending Bit (n = 0~10)<br>0: No IRQ pending<br>1: IRQ pending<br>Write '1' to clear it. |

#### 4.14.3.61. PB External Interrupt Debounce Register (Default Value: 0x00000000)

| Offset: 0x238 |     |             | Register Name: PB_EINT_DEB_REG  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:7          | /   | /           | /   |
| 6:4           | R/W | 0x0         | DEB_CLK_PRE_SCALE<br>Debounce Clock Pre-scale n<br>The selected clock source is prescaled by 2^n. |
| 3:1           | /   | /           | /   |
| 0             | R/W | 0x0         | PIO_INT_CLK_SELECT<br>PIO Interrupt Clock Select<br>0: LOSC 32KHz<br>1: HOSC 24MHz                |

#### 4.14.3.62. PG External Interrupt Configure Register 0 (Default Value: 0x00000000)

| Offset: 0x240        |     |             | Register Name: PG_EINT_CFG0_REG  |
|----------------------|-----|-------------|--|
| Bit                  | R/W | Default/Hex | Description  |
| [4i+3:4i]<br>(i=6~7) | R/W | 0x0         | EINT_CFG<br>External INTn Mode (n = 6~7)<br>0x0: Positive Edge<br>0x1: Negative Edge<br>0x2: High Level<br>0x3: Low Level<br>0x4: Double Edge (Positive/ Negative) |

|      |   |   |                  |
|------|---|---|------------------|
|      |   |   | Others: Reserved |
| 23:0 | / | / | /                |

#### 4.14.3.63. PG External Interrupt Configure Register 1 (Default Value: 0x00000000)

| Offset: 0x244        |     |             | Register Name: PG_EINT_CFG1_REG   |
|----------------------|-----|-------------|---|
| Bit                  | R/W | Default/Hex | Description   |
| 31:24                | /   | /           | /   |
| [4i+3:4i]<br>(i=0~5) | R/W | 0x0         | EINT_CFG<br>External INTn Mode (n = 8~13)<br>0x0: Positive Edge<br>0x1: Negative Edge<br>0x2: High Level<br>0x3: Low Level<br>0x4: Double Edge (Positive/ Negative)<br>Others: Reserved |

#### 4.14.3.64. PG External Interrupt Configure Register 2 (Default Value: 0x00000000)

| Offset: 0x248 |     |             | Register Name: PG_EINT_CFG2_REG |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 31:0          | /   | /           | /                               |

#### 4.14.3.65. PG External Interrupt Configure Register 3 (Default Value: 0x00000000)

| Offset: 0x24C |     |             | Register Name: PG_EINT_CFG3_REG |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 31:0          | /   | /           | /                               |

#### 4.14.3.66. PG External Interrupt Control Register (Default Value: 0x00000000)

| Offset: 0x250   |     |             | Register Name: PG_EINT_CTL_REG   |
|-----------------|-----|-------------|--|
| Bit             | R/W | Default/Hex | Description  |
| 31:14           | /   | /           | /  |
| [n]<br>(n=6~13) | R/W | 0x0         | EINT_CTL<br>External INTn Enable (n = 6~13)<br>0: Disable<br>1: Enable |
| 5:0             | /   | /           | /  |

**4.14.3.67. PG External Interrupt Status Register (Default Value: 0x00000000)**

| Offset: 0x254   |     |             | Register Name: PG_EINT_STATUS_REG  |
|-----------------|-----|-------------|--|
| Bit             | R/W | Default/Hex | Description  |
| 31:14           | /   | /           | /  |
| [n]<br>(n=6~13) | R/W | 0x0         | EINT_STATUS<br>External INTn Pending Bit (n = 6~13)<br>0: No IRQ pending<br>1: IRQ pending<br>Write '1' to clear it. |
| 5:0             | /   | /           | /  |

**4.14.3.68. PG External Interrupt Debounce Register (Default Value: 0x00000000)**

| Offset: 0x258 |     |             | Register Name: PG_EINT_DEB_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:7          | /   | /           | /  |
| 6:4           | R/W | 0x0         | DEB_CLK_PRE_SCALE<br>Debounce Clock Pre-scale n<br>The selected clock source is prescaled by $2^n$ . |
| 3:1           | /   | /           |  |
| 0             | R/W | 0x0         | PIO_INT_CLK_SELECT<br>PIO Interrupt Clock Select<br>0: LOSC 32KHz<br>1: HOSC 24MHz                   |

# Chapter 5 Memory

This section describes the R11 memory:

- SD/MMC

## 5.1. SD/MMC

### 5.1.1. Overview

The SD/MMC controller can be configured either as a Secure Digital Multimedia Card controller, which simultaneously supports Secure Digital memory (SD Memory), Secure Digital I/O (SDIO), Multimedia Cards (MMC), eMMC Card.

The SD/MMC controller includes the following features:

- Supports Secure Digital memory protocol commands (up to SD2.0)
- Supports Secure Digital I/O protocol commands
- Supports Multimedia Card protocol commands (up to eMMC4.41)
- Supports eMMC boot operation and alternative boot operation
- Supports Command Completion signal and interrupt to host processor and Command Completion Signal disable feature
- Supports one SD (Version1.0 to 2.0) or MMC (Version3.3 to eMMC4.41)
- Supports hardware CRC generation and error detection
- Supports host pull-up control
- Supports SDIO interrupts in 1-bit and 4-bit modes
- Supports SDIO suspend and resume operation
- Supports SDIO read wait
- Supports block size of 1 to 65535 bytes
- Supports descriptor-based internal DMA controller
- Internal 128 bytes FIFO for data transfer

### 5.1.2. Block Diagram

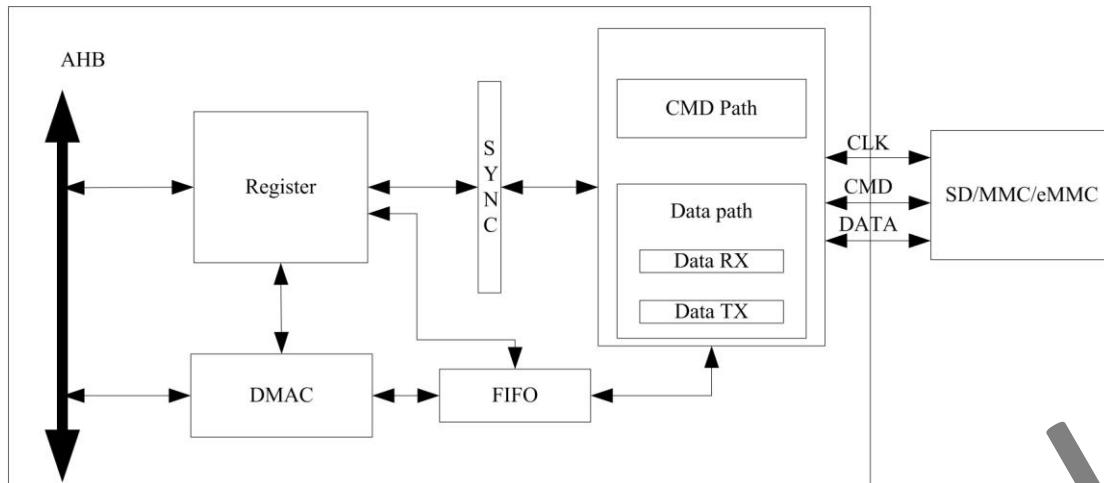


Figure 5-1. SD/MMC Controller Block Diagram

### 5.1.3. SD/MMC Controller Timing Diagram

Please refer to relative specifications:

- Physical Layer Specification Ver2.00
- SDIO Specification Ver2.00
- Multimedia Cards (MMC – version 4.2)
- JEDEC Standard – JESD84-44, Embedded Multimedia Card (e•MMC) Product Standard

### 5.1.4. SD/MMC Controller Special Requirement

#### 5.1.4.1. SD/MMC Pin List

| Port Name | Width | Direction | Description  |
|-----------|-------|-----------|--------------|
| SDC_CLK   | 1     | OUT       | Clock output |
| SDC_CMD   | 1     | IN/OUT    | Command line |
| SDC_DATA  | 1/4   | IN/OUT    | Data line    |

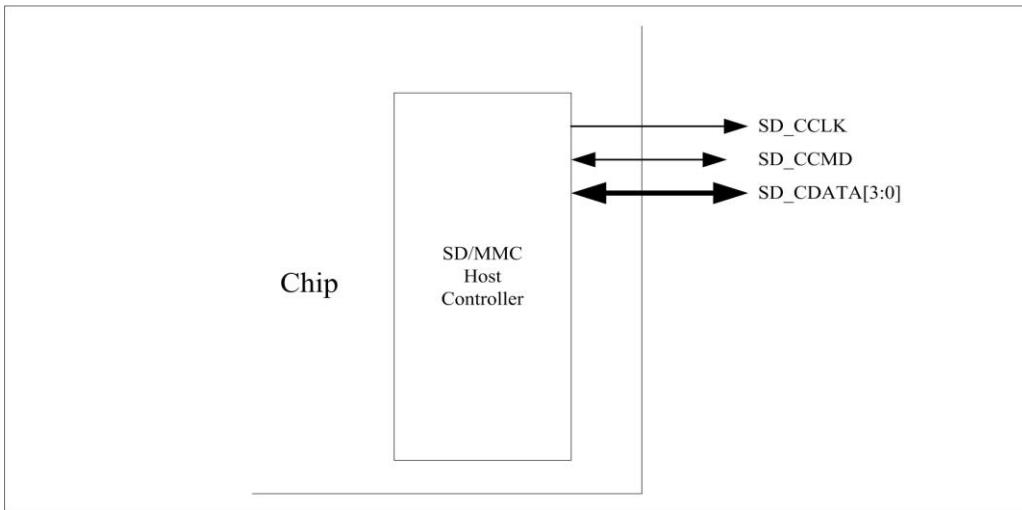


Figure 5-2. SD/MMC Pin Diagram

### 5.1.5. Internal DMA Controller Description

SD/MMC controller has an internal DMA controller (IDMAC) to transfer data between host memory and SDMMC port. With a descriptor, IDMAC can efficiently move data from source to destination by automatically loading next DMA transfer arguments, which need less CPU intervention. Before transfer data in IDMAC, host driver should construct a descriptor list, configure arguments of every DMA transfer, then launch the descriptor and start the DMA. IDMAC has an interrupt controller, when enabled, it can interrupt the HOST CPU in situations such as data transmission completed or some errors happened.

#### 5.1.5.1. IDMAC Descriptor Structure

The IDMAC uses a descriptor with a chain structure, and each descriptor points to a unique buffer and the next descriptor.

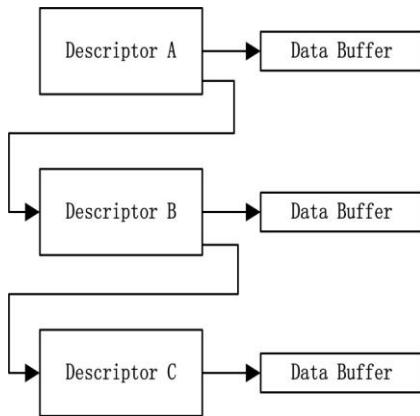


Figure 5-3. SD/MMC IDMAC Descriptor and Buffer

This figure illustrates the internal formats of a descriptor. The descriptor addresses must be aligned to the bus width

used for 32-bit buses. Each descriptor contains 16 bytes of control and status information.



Figure 5-4. Internal Formats of A Descriptor

DES0 is a notation used to denote the [31:0] bits, DES1 to denote [63:32] bits, DES2 to denote [95:64] bits, and DES3 to denote [127:96] bits in a descriptor.

#### 5.1.5.2. DES0 Definition

| Bits | Name                            | Descriptor   |
|------|---------------------------------|--|
| 31   | HOLD                            | DES_OWN_FLAG<br>When set, this bit indicates that the descriptor is owned by the IDMAC.<br>When this bit is reset, it indicates that the descriptor is owned by the host. This bit is cleared when transfer is over. |
| 30   | ERROR                           | ERR_FLAG<br>When some error happened in transfer, this bit will be set.  |
| 29:5 | /                               | /  |
| 4    | Chain Flag                      | CHAIM_MOD<br>When set, this bit indicates that the second address in descriptor is the next descriptor address. Must be set 1.   |
| 3    | First DES Flag                  | FIRST_FLAG<br>When set, this bit indicates that this descriptor contains the first buffer of data. Must be set to 1 in first DES.  |
| 2    | Last DES Flag                   | LAST_FLAG<br>When set, this bit indicates that the buffers pointed to by this descriptor are the last data buffer  |
| 1    | Disable Interrupt on completion | CUR_TXRX_OVER_INT_DIS<br>When set, this bit will prevent the setting of the TX/RX interrupt bit of the IDMAC status register for data that ends in the buffer pointed to by this descriptor                          |
| 0    | /                               | /  |

### 5.1.5.3. DES1 Definition

| Bits  | Name        | Descriptor  |
|-------|-------------|---|
| 31:13 | /           | /   |
| 15:0  | Buffer size | BUFF_SIZE<br>These bits indicate the data buffer byte size, which must be a multiple of 4 bytes. If this field is 0, the DMA ignores this buffer and proceeds to the next descriptor. |

### 5.1.5.4. DES2 Definition

| Bits | Name                   | Descriptor   |
|------|------------------------|--|
| 31:0 | Buffer address pointer | BUFF_ADDR<br>These bits indicate the physical address of data buffer. The IDMAC ignores DES2[1:0], corresponding to the bus width of 32. |

### 5.1.5.5. DES3 Definition

| Bits | Name                    | Descriptor   |
|------|-------------------------|--|
| 31:0 | Next descriptor address | NEXT_DESP_ADDR<br>These bits indicate the pointer to the physical memory where the next descriptor is present. |

### 5.1.6. SD/MMC Register List

| Module Name | Base Address |
|-------------|--------------|
| SD/MMC0     | 0x01C0F000   |
| SD/MMC2     | 0x01C11000   |

| Register Name | Offset | Description               |
|---------------|--------|---------------------------|
| SD_GCTL       | 0x00   | Control register          |
| SD_CKCR       | 0x04   | Clock control register    |
| SD_TMOR       | 0x08   | Time out register         |
| SD_BWDR       | 0x0C   | Bus width register        |
| SD_BKSR       | 0x10   | Block size register       |
| SD_BYCR       | 0x14   | Byte count register       |
| SD_CMDR       | 0x18   | Command register          |
| SD_CAGR       | 0x1C   | Command argument register |
| SD_RESP0      | 0x20   | Response 0 register       |
| SD_RESP1      | 0x24   | Response 1 register       |

|              |       |  |
|--------------|-------|--|
| SD_RESP2     | 0x28  | Response 2 register                          |
| SD_RESP3     | 0x2C  | Response 3 register                          |
| SD_IMKR      | 0x30  | Interrupt mask register                      |
| SD_MISR      | 0x34  | Masked interrupt status register             |
| SD_RISR      | 0x38  | Raw interrupt status register                |
| SD_STAR      | 0x3C  | Status register                              |
| SD_FWLR      | 0x40  | FIFO water level register                    |
| SD_FUNS      | 0x44  | FIFO function select register                |
| SD_A12A      | 0x58  | Auto command 12 argument                     |
| SD_NTSR      | 0x5C  | SD new timing set register                   |
| SD_SDBG      | 0x60  | SD new timing set debug register             |
| SD_HWRST     | 0x78  | Hardware reset register                      |
| SD_DMAC      | 0x80  | BUS mode control                             |
| SD_DLBA      | 0x84  | Descriptor list base address                 |
| SD_IDST      | 0x88  | DMAc status                                  |
| SD_IDIE      | 0x8C  | DMAc interrupt enable                        |
| SD_THLDC     | 0x100 | Card threshold control register              |
| SD_DSBD      | 0x10C | eMMC4.41 DDR start bit detection control     |
| SD_RES_CRC   | 0x110 | CRC status from card/eMMC in write operation |
| SD_DATA7_CRC | 0x114 | CRC Data7 from card/eMMC                     |
| SD_DATA6_CRC | 0x118 | CRC Data7 from card/eMMC                     |
| SD_DATA5_CRC | 0x11C | CRC Data7 from card/eMMC                     |
| SD_DATA4_CRC | 0x120 | CRC Data7 from card/eMMC                     |
| SD_DATA3_CRC | 0x124 | CRC Data7 from card/eMMC                     |
| SD_DATA2_CRC | 0x128 | CRC Data7 from card/eMMC                     |
| SD_DATA1_CRC | 0x12C | CRC Data7 from card/eMMC                     |
| SD_DATA0_CRC | 0x130 | CRC Data7 from card/eMMC                     |
| SD_CRC_STA   | 0x134 | Response CRC from card/eMMC                  |
| SD_FIFO      | 0X200 | Read/Write FIFO                              |

### 5.1.7. SD/MMC Register Description

#### 5.1.7.1. SD Global Control Register(Default Value: 0x000000100)

| Offset: 0x0000 |     |             | Register Name: SD_CTRL                                    |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0           | FIFO_AC_MOD<br>FIFO Access Mode<br>1:AHB bus<br>0:DMA bus |
| 30:11          | /   | /           | /   |
| 10             | R/W | 0           | DDR_MOD_SEL   |

|     |     |   |  |
|-----|-----|---|--|
|     |     |   | DDR Mode Select<br>0:SDR mode<br>1:DDR mode  |
| 9   | /   | / | reserved   |
| 8   | R/W | 1 | CD_DBC_ENB<br>Card Detect (Data[3] status) De-bounce Enable<br>0: Disable de-bounce<br>1: Enable de-bounce                                       |
| 7:6 | /   | / | /  |
| 5   | R/W | 0 | DMA_ENB<br>DMA Global Enable<br>0:Disable DMA to transfer data, using AHB bus<br>1:Enable DMA to transfer data                                   |
| 4   | R/W | 0 | INT_ENB<br>Global Interrupt Enable<br>0:Disable interrupts<br>1:Enable interrupts  |
| 3   | /   | / | /  |
| 2   | R/W | 0 | DMA_RST<br>DMA Reset   |
| 1   | R/W | 0 | FIFO_RST<br>FIFO Reset<br>0:No change<br>1:Reset FIFO<br><i>This bit is auto-cleared after completion of reset operation.</i>                    |
| 0   | R/W | 0 | SOFT_RST<br>Software Reset<br>0: No change<br>1: Reset SD/MMC controller<br><i>This bit is auto-cleared after completion of reset operation.</i> |

### 5.1.7.2. SD Clock Control Register(Default Value: 0x00000000)

| Offset: 0x0004 |     |             | Register Name: SD_CLKDIV   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0           | MASK_DATA0<br>0: Do not mask data0 when updata clock<br>1: Mask data0 when updata clock                            |
| 30:18          | /   | /           | /  |
| 17             | R/W | 0           | CCLK_CTRL<br>Card Clock Output Control<br>0: Card clock always on<br>1: Turn off card clock when FSM in IDLE state |
| 16             | R/W | 0           | CCLK_ENB   |

|      |     |   |   |
|------|-----|---|---|
|      |     |   | Card Clock Enable<br>0: Card Clock off<br>1: Card Clock on                    |
| 15:8 | /   | / | /   |
| 7:0  | R/W | 0 | CCLK_DIV<br>Card clock divider<br>n: Source clock is divided by 2*n.(n=0~255) |

#### 5.1.7.3. SD Timeout Register (Default Value: 0xFFFFFFF40)

| Offset: 0x0008 |     |             | Register Name: <b>SD_TMOUT</b>    |
|----------------|-----|-------------|-----------------------------------|
| Bit            | R/W | Default/Hex | Description                       |
| 31:8           | R/W | 0xffffffff  | DTO_LMT<br>Data Timeout Limit     |
| 7:0            | R/W | 0x40        | RTO_LMT<br>Response Timeout Limit |

#### 5.1.7.4. SD Bus Width Register (Default Value: 0x00000000)

| Offset: 0x000c |     |             | Register Name: <b>SD_CTYPE</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:2           | /   | /           | /   |
| 1:0            | R/W | 0           | CARD_WID<br>Card width<br>00: 1-bit width<br>01: 4-bit width<br>1x: 8-bit width |

#### 5.1.7.5. SD Block Size Register (Default Value: 0x00000200)

| Offset: 0x0010 |     |             | Register Name: <b>SD_BLKSIZ</b> |
|----------------|-----|-------------|---------------------------------|
| Bit            | R/W | Default/Hex | Description                     |
| 31:16          | /   | /           | /                               |
| 15:0           | R/W | 0x200       | BLK_SZ<br>Block size            |

#### 5.1.7.6. SD Block Count Register (Default Value: 0x00000200)

|                |                                 |
|----------------|---------------------------------|
| Offset: 0x0014 | Register Name: <b>SD_BYTCNT</b> |
|----------------|---------------------------------|

| Bit  | R/W | Default/Hex | Description  |
|------|-----|-------------|--|
| 31:0 | R/W | 0x200       | BYTE_CNT<br>Byte counter<br>Number of bytes to be transferred; should be integer multiple of Block Size for block transfers. |

#### 5.1.7.7. SD Command Register (Default Value: 0x00000000)

| Offset: 0x0018 |     |             | Register Name: SD_CMD  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0           | CMD_LOAD<br>Start Command.<br>This bit is auto cleared when current command is sent. If there is no any response error happened, a command complete interrupt bit (CMD_OVER) will be set in interrupt register. You should not write any other command before this bit is cleared, or a command busy interrupt bit (CMD_BUSY) will be set in interrupt register. |
| 30             | /   | /           | /  |
| 29             | R/W | 0           | Use Hold Register<br>0: CMD and DATA sent to card bypassing HOLD Register<br>1: CMD and DATA sent to card through the HOLD Register  |
| 28             | R/W | 0           | VOL_SW<br>Voltage Switch<br>0: Normal command<br>1: Voltage switch command, set for CMD11 only   |
| 27             | R/W | 0           | BOOT_ABST<br>Boot Abort<br>Setting this bit will terminate the boot operation.   |
| 26             | R/W | 0           | EXP_BOOT_ACK<br>Expect Boot Acknowledge.<br>When Software sets this bit along in mandatory boot operation, controller expects a boot acknowledge start pattern of 0-1-0 from the selected card.  |
| 25:24          | R/W | 0           | BOOT_MOD<br>Boot Mode<br>00: Normal command<br>01: Mandatory Boot operation<br>10: Alternate Boot operation<br>11: Reserved  |
| 23             | /   | /           | /  |
| 22             | /   | /           | /  |
| 21             | R/W | 0           | PRG_CLK<br>Change Clock<br>0: Normal command<br>1: Change Card Clock; when this bit is set, controller will change clock   |

|       |     |   |   |
|-------|-----|---|---|
|       |     |   | domain and clock output. No command will be sent.   |
| 20:16 | /   | / | /   |
| 15    | R/W | 0 | <b>SEND_INIT_SEQ</b><br>Send Initialization<br>0: Normal command sending<br>1: Send initialization sequence before sending this command.  |
| 14    | R/W | 0 | <b>STOP_ABТ_CMD</b><br>Stop Abort Command<br>0: Normal command sending<br>1: Send Stop or abort command to stop current data transfer in progress.(CMD12, CMD52 for writing "I/O Abort" in SDIO CCCR) |
| 13    | R/W | 0 | <b>WAIT_PRE_OVER</b><br>Wait Data Transfer Over<br>0: Send command at once, do not care of data transferring<br>1: Wait for data transfer completion before sending current command                   |
| 12    | R/W | 0 | <b>STOP_CMD_FLAG</b><br>Send Stop CMD Automatically (CMD12)<br>0: Do not send stop command at end of data transfer<br>1: Send stop command automatically at end of data transfer                      |
| 11    | R/W | 0 | <b>TRANS_MODE</b><br>Transfer Mode<br>0: Block data transfer command<br>1: Stream data transfer command   |
| 10    | R/W | 0 | <b>TRANS_DIR</b><br>Transfer Direction<br>0: Read operation<br>1: Write operation   |
| 9     | R/W | 0 | <b>DATA_TRANS</b><br>Data Transfer<br>0: Without data transfer<br>1: With data transfer   |
| 8     | R/W | 0 | <b>CHK_RESP_CRC</b><br>Check Response CRC<br>0: Do not check response CRC<br>1: Check response CRC  |
| 7     | R/W | 0 | <b>LONG_RESP</b><br>Response Type<br>0:Short Response (48 bits)<br>1:Long Response (136 bits)   |
| 6     | R/W | 0 | <b>RESP_RCV</b><br>Response Receive<br>0: Command without Response<br>1: Command with Response  |
| 5:0   | R/W | 0 | <b>CMD_IDX</b><br>CMD Index   |

|  |  |  |                     |
|--|--|--|---------------------|
|  |  |  | Command index value |
|--|--|--|---------------------|

#### 5.1.7.8. SD Command Argument Register (Default Value: 0x00000000)

| Offset: 0x001c |     |             | Register Name: SD_CMDARG    |
|----------------|-----|-------------|-----------------------------|
| Bit            | R/W | Default/Hex | Description                 |
| 31:0           | R/W | 0           | CMD_ARG<br>Command argument |

#### 5.1.7.9. SD Response 0 Register (Default Value: 0x00000000)

| Offset: 0x0020 |     |             | Register Name: SD_RESP0                          |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description                                      |
| 31:0           | R   | 0           | CMD_RESP0<br>response 0<br>Bit[31:0] of response |

#### 5.1.7.10. SD Response 1 Register (Default Value: 0x00000000)

| Offset: 0x0024 |     |             | Register Name: SD_RESP1                           |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                       |
| 31:0           | R   | 0           | CMD_RESP1<br>response 1<br>Bit[63:31] of response |

#### 5.1.7.11. SD Response 2 Register (Default Value: 0x00000000)

| Offset: 0x0028 |     |             | Register Name: SD_RESP2                           |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                       |
| 31:0           | R   | 0           | CMD_RESP2<br>response 2<br>Bit[95:64] of response |

#### 5.1.7.12. SD Response 3 Register (Default Value: 0x00000000)

| Offset: 0x002C |     |             | Register Name: SD_RESP3 |
|----------------|-----|-------------|-------------------------|
| Bit            | R/W | Default/Hex | Description             |

|      |   |   |  |
|------|---|---|--|
| 31:0 | R | 0 | CMD_RESP3<br>response 3<br>Bit[127:96] of response |
|------|---|---|--|

#### 5.1.7.13. SD Interrupt Mask Register (Default Value: 0x00000000)

| Offset: 0x0030 |     |             | Register Name: <b>SD_INTMASK</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R/W | 0           | <p>INT_MASK<br/>0: Interrupt masked<br/>1: Interrupt enabled</p> <p>Bit field defined as following:</p> <ul style="list-style-type: none"> <li>bit 31 – card removed</li> <li>bit 30 – card inserted</li> <li>bit 17~29 - reserved</li> <li>bit 16 – SDIO interrupt</li> <li>bit 15 – Data End-bit error</li> <li>bit 14 – Auto Stop Command done</li> <li>bit 13 – Data Start Error</li> <li>bit 12 – Command Busy and illegal write</li> <li>bit 11 – FIFO under run/overflow</li> <li>bit 10 – Data starvation timeout /V1.8 Switch Done</li> <li>bit 9 – Data timeout/Boot data start</li> <li>bit 8 – Response timeout/Boot ACK received</li> <li>bit 7 – Data CRC error</li> <li>bit 6 – Response CRC error</li> <li>bit 5 – Data Receive Request</li> <li>bit 4 – Data Transmit Request</li> <li>bit 3 – Data Transfer Complete</li> <li>bit 2 – Command Complete</li> <li>bit 1 – Response Error (no response or response CRC error)</li> <li>bit 0 – Reserved</li> </ul> |

#### 5.1.7.14. SD Masked Interrupt Status Register (Default Value: 0x00000000)

| Offset: 0x0034 |     |             | Register Name: <b>SD_MINTSTS</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   | 0           | <p>MSKDISTA<br/>Interrupt status. Enabled only if corresponding bit in mask register is set.</p> <p>Bit field defined as following:</p> |

|  |  |  |
|--|--|--|
|  |  | bit 31 – card removed<br>bit 30 – card inserted<br>bit 17~29 - reserved<br>bit 16 – SDIO interrupt<br>bit 15 – Data End-bit error<br>bit 14 – Auto command done<br>bit 13 – Data Start Error<br>bit 12 – Command Busy and illegal write<br>bit 11 – FIFO under run/overflow<br>bit 10 – Data starvation timeout (HTO)/V1.8 Switch Done<br>bit 9 – Data timeout/Boot data start<br>bit 8 – Response timeout/Boot ACK received<br>bit 7 – Data CRC error<br>bit 6 – Response CRC error<br>bit 5 – Data Receive Request<br>bit 4 –Data Transmit Request<br>bit 3 – Data Transfer Complete<br>bit 2 – Command Complete<br>bit 1 – Response Error (no response or response CRC error)<br>bit 0 – Reserved |
|--|--|--|

#### 5.1.7.15. SD Raw Interrupt Status Register (Default Value: 0x00000000)

| Offset: 0x0038 |     |             | Register Name: SD_RINTSTS   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R/W | 0           | <p>RAWISTA<br/>                     Raw Interrupt Status.<br/> <i>This is write-1-to-clear bits.</i></p> <p>Bit field defined as following:</p> <p>bit 31 – card removed<br/>                 bit 30 – card inserted<br/>                 bit 17~29 - reserved<br/>                 bit 16 – SDIO interrupt<br/>                 bit 15 – Data End-bit error<br/>                 bit 14 – Auto command done<br/>                 bit 13 – Data Start Error<br/>                 bit 12 – Command Busy and illegal write<br/>                 bit 11 – FIFO under run/overflow<br/>                 bit 10 – Data starvation timeout (HTO)/V1.8 Switch Done<br/>                 bit 9 – Data timeout/Boot data start<br/>                 bit 8 – Response timeout/Boot ACK received<br/>                 bit 7 – Data CRC error<br/>                 bit 6 – Response CRC error</p> |

|  |  |  |   |
|--|--|--|---|
|  |  |  | bit 5 – Data Receive Request<br>bit 4 – Data Transmit Request<br>bit 3 – Data Transfer Complete<br>bit 2 – Command Complete<br>bit 1 – Response Error (no response or response CRC error)<br>bit 0 – Reserved |
|--|--|--|---|

#### 5.1.7.16. SD Status Register (Default Value: 0x00000006)

| Offset: 0x003C |     |             | Register Name: SD_STATUS   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R   | 0           | DMA_REQ<br>dma_req<br>DMA request signal state   |
| 30:22          | /   | /           | /  |
| 21:17          | R   | 0           | FIFO_LEVEL<br>FIFO Level<br>Number of filled locations in FIFO   |
| 16:11          | R   | 0           | RESP_IDX<br>Response Index<br>Index of previous response, including any auto-stop sent by controller   |
| 10             | R   | 0           | FSM_BUSY<br>Data FSM Busy<br>Data transmit or receive state-machine is busy  |
| 9              | R   | 0           | CARD_BUSY<br>Card data busy<br>Inverted version of DATA[0]<br>0: card data not busy<br>1: card data busy   |
| 8              | R   | 0           | CARD_PRESENT<br>Data[3] status<br>level of DATA[3]; checks whether card is present<br>0: card not present<br>1: card present   |
| 7:4            | R   | 0           | FSM_STA<br>Command FSM states<br>0000: Idle<br>0001: Send init sequence<br>0010: Tx cmd start bit<br>0011: Tx cmd tx bit<br>0100: Tx cmd index + arg<br>0101: Tx cmd crc7<br>0110: Tx cmd end bit<br>0111: Rx resp start bit |

|   |   |   |   |
|---|---|---|---|
|   |   |   | 1000: Rx resp IRQ response<br>1001: Rx resp tx bit<br>1010: Rx resp cmd idx<br>1011: Rx resp data<br>1100: Rx resp crc7<br>1101: Rx resp end bit<br>1110: Cmd path wait NCC<br>1111: Wait; CMD-to-response turnaround |
| 3 | R | 0 | FIFO_FULL<br>FIFO full<br>1: FIFO full<br>0: FIFO not full  |
| 2 | R | 1 | FIFO_EMPTY<br>FIFO Empty<br>1: FIFO Empty<br>0: FIFO not Empty  |
| 1 | R | 1 | FIFO_TX_LEVEL<br>FIFO TX Water Level flag<br>0: FIFO didn't reach transmit trigger level<br>1: FIFO reached transmit trigger level  |
| 0 | R | 0 | FIFO_RX_LEVEL<br>FIFO TX Water Level flag<br>0: FIFO didn't reach receive trigger level<br>1: FIFO reached receive trigger level  |

#### 5.1.7.17. SD FIFO Water Level Register (Default Value: 0x000F0000)

| Offset: 0x0040 |     |             | Register Name: <b>SD_FIFOTH</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | /   | /           | /   |
| 30:28          | R/W | 0           | BSIZE_OF_TRANS<br>Burst size of multiple transaction<br>000: 1 transfers<br>001: 4<br>010: 8<br>011: 16<br>100: 32<br>101: 64<br>110: 128<br>111: 256<br>Should be programmed same as DMA controller multiple transaction size.<br>The units for transfers are the DWORD. A single transfer would be signaled based on this value. Value should be sub-multiple of (RX_TL + 1) and (FIFO_DEPTH - TX_TL) |

|       |     |     |   |
|-------|-----|-----|---|
|       |     |     | Recommended:<br>MSize = 8, TX_TL = 16, RX_TL = 15   |
| 27:21 | R   | 0   | /   |
| 20:16 | R/W | 0xF | <p>RX_TL<br/>         Rx Trigger Level<br/>         0x0~0x1e: RX Trigger Level is 0~30<br/>         0x1f: reserved</p> <p>FIFO threshold when FIFO request host to receive data from FIFO. When FIFO data level is greater than this value, DMA is request is raised if DMA enabled, or RX interrupt bit is set if interrupt enabled. At the end of packet, if the last transfer is less than this level, the value is ignored and relative request will be raised as usual.</p> <p>Recommended: 15 (means greater than 15)</p>                           |
| 15:5  | R   | 0   | /   |
| 4:0   | R/W | 0   | <p>TX_TL<br/>         TX Trigger Level<br/>         0x1~0xf: TX Trigger Level is 1~31<br/>         0x0: no trigger</p> <p>FIFO threshold when FIFO requests host to transmit data to FIFO. When FIFO data level is less than or equal to this value, DMA TX request is raised if DMA enabled, or TX request interrupt bit is set if interrupt enabled. At the end of packet, if the last transfer is less than this level, the value is ignored and relative request will be raised as usual.</p> <p>Recommended: 16 (means less than or equal to 16)</p> |

#### 5.1.7.18. SD Function Select Register (Default Value: 0x00000000)

| Offset: 0x0044 |     |             | Register Name: <b>SD_CTRL</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:16          | R/W | 0           | <p>CEATA_EN<br/>         CEATA Support ON/OFF</p> <p>0xceaa: CEATA support on. All hidden CEATA relative bits are accessible normally and these 16 bits return value of 0x1 when be read.</p> <p>Other value – CEATA support off. All hidden CEATA relative bits cannot be access and these 16 bits return value of 0 when be read.</p>   |
| 15:3           | /   | /           | /   |
| 2              | R/W | 0           | <p>ABT_RDATA<br/>         Abort Read Data<br/>         0: Ignored<br/>         1: After suspend command is issued during read-transfer, software polls card to find when suspend happened. Once suspend occurs, software sets bit to reset data state-machine, which is waiting for next block of data.<br/>         Used in SDIO card suspends sequence.<br/> <i>This bit is auto-cleared once controller reset to idle state.</i></p> |

|   |     |   |  |
|---|-----|---|--|
| 1 | R/W | 0 | <p>READ_WAIT<br/>Read Wait<br/>0: Clear SDIO read wait<br/>1: Assert SDIO read wait</p>  |
| 0 | R/W | 0 | <p>HOST_SEND_MMC_IRQRESQ<br/>Host Send MMC IRQ Response<br/>0: Ignored<br/>1: Send auto IRQ response<br/>When host is waiting MMC card interrupt response, setting this bit will make controller cancel wait state and return to idle state, at which time, controller will receive IRQ response sent by itself.<br/><i>This bit is auto-cleared after response is sent.</i></p> |

#### 5.1.7.19. SD Auto Command 12 Register (Default Value: 0x0000ffff)

| Offset: 0x0058 |     |             | Register Name: <b>SD_A12A</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:16          | /   | /           | /   |
| 0:15           | R/W | 0xffff      | SD_A12A.<br>SD_A12A set the argument of command 12 automatically send by controller |

#### 5.1.7.20. SD NewTiming Set Register (Default Value: 0x00000001,only used in SDC2)

| Offset: 0x005C |     |             | Register Name: <b>SD_NTSR_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0           | MODE_SELEC<br>0: Old mode of Sample/Output Timing ;<br>1: New mode of Sample/Output Timing;   |
| 30:6           | R/W | 0x00        | SAMPLE_TIMING_PHASE(RX)<br>00:Sample timing phase offset 90°<br>01:Sample timing phase offset 180°<br>10:Sample timing phase offset 270°<br>11:Ignore         |
| 3:2            | /   | /           | /   |
| 1:0            | R/W | 0x01        | OUTPUT_TIMING_PHASE(TX)<br>00 : Output timing phase offset 90°<br>01 : Output timing phase offset 180°<br>10 : Output timing phase offset 270°<br>11 : Ignore |

**5.1.7.21. SD Hardware Reset Register (Default Value: 0x00000001)**

| Offset: 0x0078 |     |             | Register Name: SD_HWRST   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:1           | /   | /           | /   |
| 0              | R/W | 1           | <p>HW_RESET.<br/>1 : Active mode<br/>0 : Reset</p> <p>These bits cause the cards to enter pre-idle state, which requires them to be re-initialized.</p> |

**5.1.7.22. SD DMAC Control Register (Default Value: 0x00000000)**

| Offset: 0x0080 |     |             | Register Name: SD_BUS_MODE   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | W   | 0           | <p>DES_LOAD_CTRL</p> <p>When DMAC fetches a descriptor, if the valid bit of a descriptor is not set, DMAC FSM will go to the suspend state. Setting this bit will make DMAC re-fetch descriptor again and do the transfer normally.</p>  |
| 30:11          | /   | /           | /  |
| 10:8           | R   | 0           | <p>PRG_BURST_LEN</p> <p>Programmable Burst Length.</p> <p>These bits indicate the maximum number of beats to be performed in one IDMAC transaction. The IDMAC will always attempt to burst as specified in PBL each time it starts a Burst transfer on the host bus. The permissible values are 1, 4, 8, 16, 32, 64, 128 and 256. This value is the mirror of MSIZE of FIFOH register. In order to change this value, write the required value to FIFOH register. This is an encode value as follows.</p> <p>000 : 1 transfers<br/>001 : 4 transfers<br/>010 : 8 transfers<br/>011 : 16 transfers<br/>100 : 32 transfers<br/>101 : 64 transfers<br/>110 : 128 transfers<br/>111 : 256 transfers</p> <p>Transfer unit is either 16, 32, or 64 bits, based on HDATA_WIDTH. PBL is a read-only value.</p> |
| 7              | R/W | 0           | <p>IDMAC_ENB</p> <p>IDMAC Enable.</p> <p>When set, the IDMAC is enabled. DE is read/write.</p>   |
| 6:2            | R/W | 0           | <p>DES_SKIP_LEN</p> <p>Descriptor Skip Length.</p>   |

|   |     |   |  |
|---|-----|---|--|
|   |     |   | Specifies the number of Word to skip between two unchained descriptors.<br>This is applicable only for dual buffer structure.<br>Default value is set to 4 DWORD.  |
| 1 | R/W | 0 | FIX_BUST_CTRL<br><br>Fixed Burst.<br><br>Controls whether the AHB Master interface performs fixed burst transfers or not. When set, the AHB will use only SINGLE, INCR4, INCR8 during start of normal burst transfers. When reset, the AHB will use SINGLE and INCR burst transfer operations. |
| 0 | R/W | 0 | IDMAC_RST<br><br>DMA Reset.<br><br>When set, the DMA Controller resets all its internal registers. SWR is read/write. It is automatically cleared after 1 clock cycle.   |

#### 5.1.7.23. SD Descriptor List Base Address Register (Default Value: 0x00000000)

| Offset: 0x0084 |     |             | Register Name: SD_DLBA   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:0           | R/W | 0           | DES_BASE_ADDR<br><br>Start of Descriptor List.<br><br>Contains the base address of the First Descriptor. The LSB bits [1:0] are ignored and taken as all-zero by the IDMAC internally. Hence these LSB bits are read-only. |

#### 5.1.7.24. SD DMAC Status Register (Default Value: 0x0000\_0000)

| Offset: 0x0088 |     |             | Register Name: SD_DSR   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:17          | /   | /           | /   |
| 16:13          | R   | 0           | DMAC_FSM_STA<br><br>DMAC FSM present state.<br>0000: DMA_IDLE<br>0001: DMA_SUSPEND<br>0010: DESC_RD<br>0011: DESC_CHK<br>0100: DMA_RD_REQ_WAIT<br>0101: DMA_WR_REQ_WAIT<br>0110: DMA_RD<br>0111: DMA_WR<br>1000: DESC_CLOSE<br><br>This bit is read-only. |
| 12:10          | R   | 0           | DMAC_ERR_STA  |

|     |     |   |  |
|-----|-----|---|--|
|     |     |   | Error Bits.<br>Indicates the type of error that caused a Bus Error. Valid only with Fatal Bus Error bit (IDSTS[2]) set. This field does not generate an interrupt.<br>001: Host Abort received during transmission<br>010: Host Abort received during reception<br>Others: Reserved EB is read-only.   |
| 9   | R/W | 0 | ABN_INT_SUM<br>Abnormal Interrupt Summary.<br>Logical OR of the following:<br>IDSTS[2] – Fatal Bus Interrupt<br>IDSTS[4] – DU bit Interrupt<br>IDSTS[5] – Card Error Summary Interrupt<br>Only unmasked bits affect this bit.<br>This is a sticky bit and must be cleared each time a corresponding bit that causes AIS to be set is cleared. Writing a 1 clears this bit.   |
| 8   | R/W | 0 | NOR_INT_SUM<br>Normal Interrupt Summary.<br>Logical OR of the following:<br>IDSTS[0] – Transmit Interrupt<br>IDSTS[1] – Receive Interrupt<br>Only unmasked bits affect this bit.<br>This is a sticky bit and must be cleared each time a corresponding bit that causes NIS to be set is cleared. Writing a 1 clears this bit.  |
| 7:6 | /   | / | /  |
| 5   | R/W | 0 | ERR_FLAG_SUM<br>Card Error Summary.<br>Indicates the status of the transaction to/from the card; also present in RINTSTS. Indicates the logical OR of the following bits:<br>EBE – End Bit Error<br>RTO – Response Timeout/Boot Ack Timeout<br>RCRC – Response CRC<br>SBE – Start Bit Error<br>DRTO – Data Read Timeout/BDS timeout<br>DCRC – Data CRC for Receive<br>RE – Response Error<br><i>Writing 1 clears this bit.</i> |
| 4   | R/W | 0 | DES_UNAVL_INT<br>Descriptor Unavailable Interrupt.<br>This bit is set when the descriptor is unavailable due to OWN bit = 0 (DESO[31] =0). Writing a 1 clears this bit.  |
| 3   | /   | / | /  |
| 2   | R/W | 0 | FATAL_BERR_INT<br>Fatal Bus Error Interrupt.<br>Indicates that a Bus Error occurred (IDSTS[12:10]). When this bit is set, the DMA disables all its bus accesses. Writing a 1 clears this bit.  |

|   |     |   |   |
|---|-----|---|---|
| 1 | R/W | 0 | <b>RX_INT</b><br>Receive Interrupt.<br>Indicates the completion of data reception for a descriptor. Writing a 1 clears this bit.      |
| 0 | R/W | 0 | <b>TX_INT</b><br>Transmit Interrupt.<br>Indicates that data transmission is finished for a descriptor. Writing a '1' clears this bit. |

#### 5.1.7.25. SD DMAC Interrupt Enable Register (Default Value: 0x00000000)

| Offset: 0x008C |     |             | Register Name: <b>SD_IDIE_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:10          | /   | /           | /  |
| 9              | R/W | 0           | <b>ABN_INT_ENB</b><br>Abnormal Interrupt Summary Enable.<br>When set, an abnormal interrupt is enabled. This bit enables the following bits:<br>IDINTEN[2] – Fatal Bus Error Interrupt<br>IDINTEN[4] – DU Interrupt<br>IDINTEN[5] – Card Error Summary Interrupt |
| 8              | R/W | 0           | <b>NOR_INT_ENB</b><br>Normal Interrupt Summary Enable.<br>When set, a normal interrupt is enabled. When reset, a normal interrupt is disabled. This bit enables the following bits:<br>IDINTEN[0] – Transmit Interrupt<br>IDINTEN[1] – Receive Interrupt         |
| 7:6            | /   | /           | /  |
| 5              | R/W | 0           | <b>ERR_SUM_INT_ENB</b><br>Card Error summary Interrupt Enable.<br>When set, it enables the Card Interrupt summary.   |
| 4              | R/W | 0           | <b>DES_UNAVL_INT_ENB</b><br>Descriptor Unavailable Interrupt.<br>When set along with Abnormal Interrupt Summary Enable, the DU interrupt is enabled.   |
| 3              | /   | /           | /  |
| 2              | R/W | 0           | <b>FERR_INT_ENB</b><br>Fatal Bus Error Enable.<br>When set with Abnormal Interrupt Summary Enable, the Fatal Bus Error Interrupt is enabled. When reset, Fatal Bus Error Enable Interrupt is disabled.   |
| 1              | R/W | 0           | <b>RX_INT_ENB</b><br>Receive Interrupt Enable.<br>When set with Normal Interrupt Summary Enable, Receive Interrupt is  |

|   |     |   |  |
|---|-----|---|--|
|   |     |   | enabled. When reset, Receive Interrupt is disabled.  |
| 0 | R/W | 0 | <b>TX_INT_ENB</b><br>Transmit Interrupt Enable.<br>When set with Normal Interrupt Summary Enable, Transmit Interrupt is enabled. When reset, Transmit Interrupt is disabled. |

#### 5.1.7.26. Card Threshold Control Register (Default Value: 0x00000000)

| Offset: 0x0100 |     |             | Register Name: <b>SD_THLD_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:28          | /   | /           | /   |
| 27:16          | R/W | 0           | <b>CARD_RD_THLD</b><br>Card Read Threshold Size   |
| 15:1           | /   | /           | /   |
| 0              | R/W | 0           | <b>CARD_RD_THLD_ENB</b><br>Card Read Threshold Enable<br>0 : Card Read Threshold Disable<br>1 : Card Read Threshold Enable<br>Host controller initiates Read Transfer only if CARD_RD_THLD amount of space is available in receive FIFO |

#### 5.1.7.27. eMMC4.41 DDR Start Bit Detection Control Register (Default Value: 0x00000000)

| Offset: 0x010C |     |             | Register Name: <b>EMMC_DDR_SBIT_DET_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:1           | /   | /           | /   |
| 0              | R/W | 0           | <b>HALF_START_BIT</b><br>Control for start bit detection mechanism inside mstorage based on duration of start bit.<br>For eMMC 4.41, start bit can be:<br>0 : Full cycle<br>1 : Less than one full cycle<br>Set HALF_START_BIT=1 for eMMC 4.41 and above; set to 0 for SD applications. |

#### 5.1.7.28. SD Response CRC Register (Default Value: 0x00000000)

| Offset: 0x0110 |     |             | Register Name: <b>RESP_CRC_REG</b> |
|----------------|-----|-------------|------------------------------------|
| Bit            | R/W | Default/Hex | Description                        |
| 31:7           | /   | /           | /                                  |
| 6:0            | R   | 0           | <b>RESP_CRC</b>                    |

|  |  |  |  |
|--|--|--|--|
|  |  |  | Response CRC<br>Response CRC from card/eMMC. |
|--|--|--|--|

#### 5.1.7.29. SD Data7 CRC Register (Default Value: 0x00000000)

| Offset: 0x0114 |     |             | Register Name: DATA7_CRC_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   | 0           | DATA7_CRC<br>Data[7] CRC<br>CRC in data[7] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data, and the lower 16 bits indicate the CRC of odd data.In SDR mode, the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.30. SD Data6 CRC Register (Default Value: 0x00000000)

| Offset: 0x0118 |     |             | Register Name: DATA6_CRC_REG   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:0           | R   | 0           | DATA6_CRC<br>Data[6] CRC<br>CRC in data[6] from card/eMMC.In DDR mode, the higher 16 bits indicate the CRC of even data, and the lower 16 bits indicate the CRC of odd data.In SDR mode, the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.31. SD Data5 CRC Register (Default Value: 0x00000000)

| Offset: 0x011c |     |             | Register Name: DATA5_CRC_REG   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:0           | R   | 0           | DATA5_CRC<br>Data[5] CRC<br>CRC in data[5] from card/eMMC.In DDR mode, the higher 16 bits indicate the CRC of even data, and the lower 16 bits indicate the CRC of odd data.In SDR mode, the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.32. SD Data4 CRC Register (Default Value: 0x00000000)

| Offset: 0x0120 |     |             | Register Name: DATA4_CRC_REG |
|----------------|-----|-------------|------------------------------|
| Bit            | R/W | Default/Hex | Description                  |
| 31:0           | R   | 0           | DATA4_CRC<br>Data[4] CRC     |

|  |  |  |   |
|--|--|--|---|
|  |  |  | CRC in data[4] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data,and the lower 16 bits indicate the CRC of odd data.In SDR mode,the higher of 16 bits indicate the CRC of all data. |
|--|--|--|---|

#### 5.1.7.33. SD Data3 CRC Register (Default Value: 0x00000000)

| Offset: 0x0124 |     |             | Register Name: DATA3_CRC_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   | 0           | DATA3_CRC<br>Data[3] CRC<br>CRC in data[3] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data,and the lower 16 bits indicate the CRC of odd data.In SDR mode,the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.34. SD Data2 CRC Register (Default Value: 0x00000000)

| Offset: 0x0128 |     |             | Register Name: DATA2_CRC_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   | 0           | DATA2_CRC<br>Data[2] CRC<br>CRC in data[2] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data,and the lower 16 bits indicate the CRC of odd data.In SDR mode,the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.35. SD Data1 CRC Register (Default Value: 0x00000000)

| Offset: 0x012c |     |             | Register Name: DATA1_CRC_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   | 0           | DATA1_CRC<br>Data[1] CRC<br>CRC in data[1] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data,and the lower 16 bits indicate the CRC of odd data.In SDR mode,the higher of 16 bits indicate the CRC of all data. |

#### 5.1.7.36. SD Data0 CRC Register (Default Value: 0x00000000)

| Offset: 0x0130 |     |             | Register Name: DATA0_CRC_REG |
|----------------|-----|-------------|------------------------------|
| Bit            | R/W | Default/Hex | Description                  |
| 31:0           | R   | 0           | DATA0_CRC<br>Data[0] CRC     |

|  |  |  |   |
|--|--|--|---|
|  |  |  | CRC in data[0] from card/eMMC.In DDR mode,the higher 16 bits indicate the CRC of even data, and the lower 16 bits indicate the CRC of odd data.In SDR mode, the higher of 16 bits indicate the CRC of all data. |
|--|--|--|---|

#### 5.1.7.37. SD CRC Status Register (Default Value: 0x00000000)

| Offset: 0x0134 |     |             | Register Name: <b>CRC_STA_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:3           | /   | /           | /   |
| 2:0            | R   | 0           | CRC_STA<br>CRC Status<br>CRC status from card/eMMC in write operation<br>Positive CRC status token:3'b010<br>Negative CRC status token:3'b101 |

#### 5.1.7.38. SD FIFO Register (Default Value: 0x00000000)

| Offset: 0x0200 |     |             | Register Name: <b>SD_FIFO_REG</b> |
|----------------|-----|-------------|-----------------------------------|
| Bit            | R/W | Default/Hex | Description                       |
| 31:0           | R/W | 0           | TX/RX FIFO<br>Data FIFO           |

# Chapter 6 Image

This section describes the image of R11:

- CSI
- MIPI CSI2

## 6.1. CSI

### 6.1.1. Overview

The CSI includes the following feature:

#### CSI

- Supports 8/10-bit yuv422 CMOS sensor interface
- Supports 8bit BT656 interface ,support CCIR656 protocol for NTSC and PAL
- Supports ITU-R BT1120 protocol for HD-CIF system
- Supports 16bit interface with separate syncs
- Supports parallel interface still capture resolution up to 5M,video capture resolution up to 1080p@30fps
- Supports MIPI interface still capture resolution up to 5M,video capture resolution up to 1080p@30fps
- Supports PIP(picture in picture)

#### CCI

- Compatible with i2c transmission in 7 bit slave ID + 1 bit R/W
- Automatic transmission
- 0/8/16/32 bit register address supported
- 8/16/32 bit data supported
- 64bytes-FIFO input CCI data supported
- Synchronized with CSI signal and delay trigger supported
- Repeated transmission with sync signal supported

## 6.1.2. Functionalities Description

### 6.1.2.1. Block Diagram

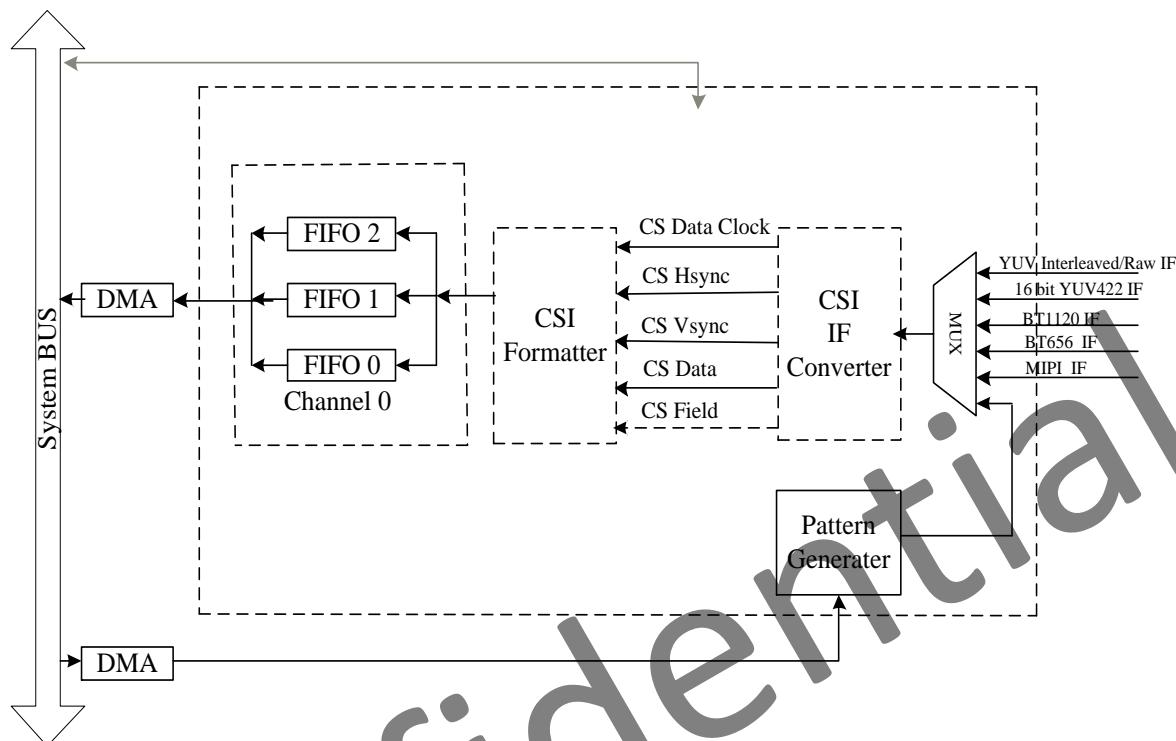


Figure 6-1. CSI Block Diagram

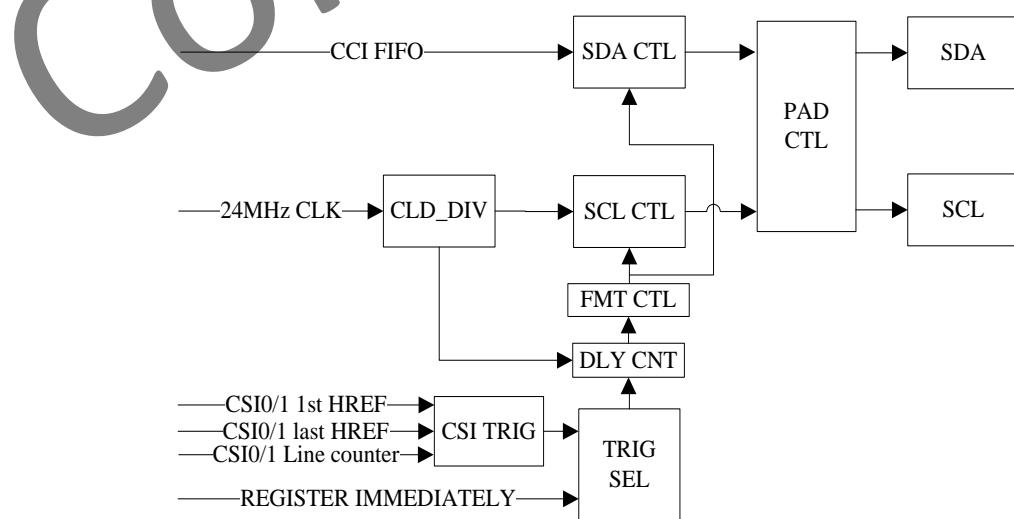


Figure 6-2. CCI Block Diagram

### 6.1.2.2. CSI FIFO Distribution

| Interface     | YUYV422 Interleaved/Raw |                          | BT656 /BT1120 Interface |        | MIPI Interface |               |                 |
|---------------|-------------------------|--------------------------|-------------------------|--------|----------------|---------------|-----------------|
| Input format  | YUV422                  |                          | Raw                     | YUV422 |                | YUV422/YUV420 | Raw             |
| Output format | Planar                  | UV combined/MB           | Raw/RGB /PRGB           | Planar | UV combined/MB | Planar        | UV combined/MB  |
| CH0_FIFO0     | Y pixel data            | Y pixel data             | All pixels data         | Y      | Y              | Y             | All pixels data |
| CH0_FIFO1     | Cb (U) pixel data       | Cb (U) Cr (V) pixel data | -                       | Cb (U) | CbCr (UV)      | Cb (U)        | CbCr (UV)       |
| CH0_FIFO2     | Cr (V) pixel data       | -                        | -                       | Cr (V) | -              | Cr (V)        | -               |

### 6.1.2.3. Pin Mapping

| Pin | 8-bit | 10-bit |
|-----|-------|--------|
| P2  | -     | D0     |
| P3  | -     | D1     |
| P4  | D0    | D2     |
| P5  | D1    | D3     |
| P6  | D2    | D4     |
| P7  | D3    | D5     |
| P8  | D4    | D6     |
| P9  | D5    | D7     |
| P10 | D6    | D8     |
| P11 | D7    | D9     |

#### 6.1.2.4. Timing

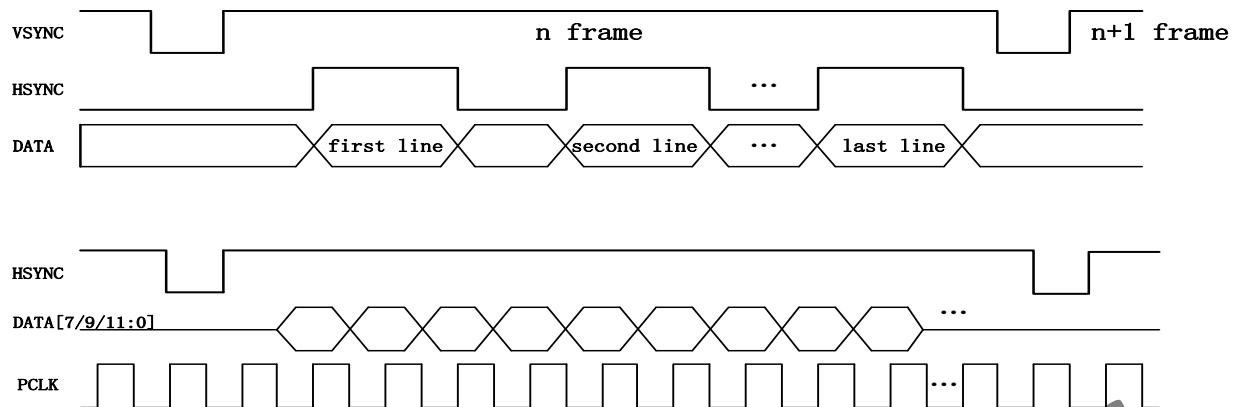


Figure 6-3. 8/10-bit CMOS Sensor Interface Timing  
(clock rising edge sample.vsync valid = positive,hsync valid = positive)

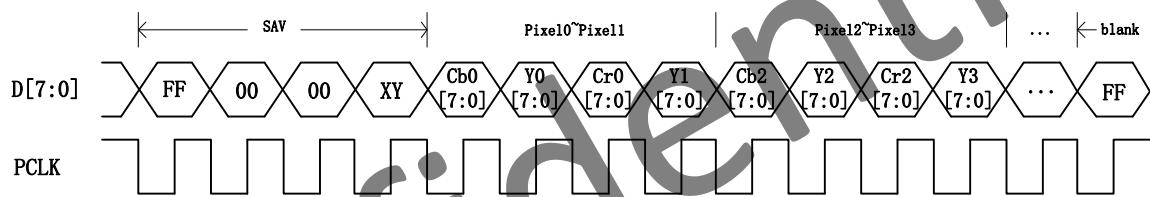


Figure 6-4. 8-bit YCbCr4:2:2 with embedded syncs(BT656) Timing

#### 6.1.2.5. Bit Definition

##### CCIR656 Header Data Bit Definition:

| Data Bit      | First Word(0xFF) | Second Word(0x00) | Third Word(0x00) | Fourth Word |
|---------------|------------------|-------------------|------------------|-------------|
| CS D[9] (MSB) | 1                | 0                 | 0                | 1           |
| CS D[8]       | 1                | 0                 | 0                | F           |
| CS D[7]       | 1                | 0                 | 0                | V           |
| CS D[6]       | 1                | 0                 | 0                | H           |
| CS D[5]       | 1                | 0                 | 0                | P3          |
| CS D[4]       | 1                | 0                 | 0                | P2          |
| CS D[3]       | 1                | 0                 | 0                | P1          |
| CS D[2]       | 1                | 0                 | 0                | P0          |
| CS D[1]       | x                | x                 | x                | x           |
| CS D[0]       | x                | x                 | x                | x           |

For compatibility with 8-bit interface, CS D[1] and CS D[0] are not defined.

| Decode                              | F | V | H | P3 | P2 | P1 | P0 |
|-------------------------------------|---|---|---|----|----|----|----|
| Field 1 start of active video (SAV) | 0 | 0 | 0 | 0  | 0  | 0  | 0  |
| Field 1 end of active video (EAV)   | 0 | 0 | 1 | 1  | 1  | 0  | 1  |
| Field 1 SAV (digital blanking)      | 0 | 1 | 0 | 1  | 0  | 1  | 1  |
| Field 1 EAV (digital blanking)      | 0 | 1 | 1 | 0  | 1  | 1  | 0  |
| Field 2 SAV                         | 1 | 0 | 0 | 0  | 1  | 1  | 1  |
| Field 2 EAV                         | 1 | 0 | 1 | 1  | 0  | 1  | 0  |
| Field 2 SAV (digital blanking)      | 1 | 1 | 0 | 1  | 1  | 0  | 0  |
| Field 2 EAV (digital blanking)      | 1 | 1 | 1 | 0  | 0  | 0  | 1  |

**Multi-Channel:**

| Condition |        |        | 656FVH Value |   |   | SAV-EAV Code |        |       |        |      |      |      |  |
|-----------|--------|--------|--------------|---|---|--------------|--------|-------|--------|------|------|------|--|
| Field     | V-time | H-time | F            | V | H | First        | Second | Third | Fourth |      |      |      |  |
|           |        |        |              |   |   |              |        |       | Ch1    | Ch2  | Ch3  | Ch4  |  |
| EVEN      | BLANK  | EAV    | 1            | 1 | 1 | 0xFF         | 0x00   | 0x00  | 0xF0   | 0xF1 | 0xF2 | 0xF3 |  |
| EVEN      | BLANK  | SAV    | 1            | 1 | 0 | 0xFF         | 0x00   | 0x00  | 0xE0   | 0xE1 | 0xE2 | 0xE3 |  |
| EVEN      | BLANK  | EAV    | 1            | 0 | 1 | 0xFF         | 0x00   | 0x00  | 0xD0   | 0xD1 | 0xD2 | 0xD3 |  |
| EVEN      | BLANK  | SAV    | 1            | 0 | 0 | 0xFF         | 0x00   | 0x00  | 0xC0   | 0xC1 | 0xC2 | 0xC3 |  |
| ODD       | BLANK  | EAV    | 0            | 1 | 1 | 0xFF         | 0x00   | 0x00  | 0xB0   | 0xB1 | 0xB2 | 0xB3 |  |
| ODD       | BLANK  | SAV    | 0            | 1 | 0 | 0xFF         | 0x00   | 0x00  | 0xA0   | 0xA1 | 0xA2 | 0xA3 |  |
| ODD       | ACTIVE | EAV    | 0            | 0 | 1 | 0xFF         | 0x00   | 0x00  | 0x90   | 0x91 | 0x92 | 0x93 |  |
| ODD       | ACTIVE | SAV    | 0            | 0 | 0 | 0xFF         | 0x00   | 0x00  | 0x80   | 0x81 | 0x82 | 0x83 |  |

**6.1.3. CSI Register list**

| Module Name | Base Address |
|-------------|--------------|
| CSI         | 0x01CB0000   |

| Register Name          | Offset | Register name   |
|------------------------|--------|---|
| CSI_EN_REG             | 0x0000 | CSI Enable Register                                   |
| CSI_IF_CFG_REG         | 0x0004 | CSI Interface Configuration Register                  |
| CSI_CAP_REG            | 0x0008 | CSI Capture Register                                  |
| CSI_SYNC_CNT_REG       | 0x000C | CSI Synchronization Counter Register                  |
| CSI_FIFO_THRS_REG      | 0x0010 | CSI FIFO Threshold Register                           |
| CSI_BT656_HEAD_CFG_REG | 0x0014 | CSI BT656 Header Configuration Register               |
| CSI_PTN_LEN_REG        | 0x0030 | CSI Pattern Generation Length register                |
| CSI_PTN_ADDR_REG       | 0x0034 | CSI Pattern Generation Address register               |
| CSI_CO_CFG_REG         | 0x0044 | CSI Channel_0 Configuration Register                  |
| CSI_CO_SCALE_REG       | 0x004C | CSI Channel_0 Scale Register                          |
| CSI_CO_F0_BUFA_REG     | 0x0050 | CSI Channel_0 FIFO 0 Output Buffer-A Address Register |
| CSI_CO_F1_BUFA_REG     | 0x0058 | CSI Channel_0 FIFO 1 Output Buffer-A Address Register |

|                             |        |   |
|-----------------------------|--------|---|
| CSI_CO_F2_BUFA_REG          | 0x0060 | CSI Channel_0 FIFO 2 Output Buffer-A Address Register         |
| CSI_CO_CAP_STA_REG          | 0x006C | CSI Channel_0 Status Register                                 |
| CSI_CO_INT_EN_REG           | 0x0070 | CSI Channel_0 Interrupt Enable Register                       |
| CSI_CO_INT_STA_REG          | 0x0074 | CSI Channel_0 Interrupt Status Register                       |
| CSI_CO_FLD1_VSIZE_REG       | 0x0078 | CSI Channel_0 Filed1 Vertical Size Register                   |
| CSI_CO_HSIZE_REG            | 0x0080 | CSI Channel_0 Horizontal Size Register                        |
| CSI_CO_VSIZE_REG            | 0x0084 | CSI Channel_0 Vertical Size Register                          |
| CSI_CO_BUF_LEN_REG          | 0x0088 | CSI Channel_0 Line Buffer Length Register                     |
| CSI_CO_FLIP_SIZE_REG        | 0x008C | CSI Channel_0 Flip Size Register                              |
| CSI_CO_FRM_CLK_CNT_REG      | 0x0090 | CSI Channel_0 Frame Clock Counter Register                    |
| CSI_CO_ACC_ITNL_CLK_CNT_REG | 0x0094 | CSI Channel_0 Accumulated and Internal Clock Counter Register |
| CSI_CO_FIFO_STAT_REG        | 0x0098 | CSI Channel_0 FIFO Statistic Register                         |
| CSI_CO_PCLK_STAT_REG        | 0x009C | CSI Channel_0 PCLK Statistic Register                         |
| CCI_CTRL                    | 0x3000 | CCI Control Register  |
| CCI_CFG                     | 0x3004 | CCI Transmission Config Register                              |
| CCI_FMT                     | 0x3008 | CCI Packet Format Register                                    |
| CCI_BUS_CTRL                | 0x300C | CCI Bus Control Register                                      |
| CCI_INT_CTRL                | 0x3014 | CCI Interrupt Control Register                                |
| CCI_LC_TRIG                 | 0x3018 | CCI Line Counter Trigger Register                             |
| CCI_FIFO_ACC                | 0x3100 | CCI FIFO Access Register                                      |

#### 6.1.4. CSI Register Description

##### 6.1.4.1. CSI Enable Register (Default Value: 0x00000000)

| Offset: 0x0000 |     | Register Name: <b>CSI0_EN_REG</b> |   |
|----------------|-----|-----------------------------------|---|
| Bit            | R/W | Default/Hex                       | Description   |
| 31             | /   | /                                 | /   |
| 30             | R/W | 0x0                               | Reserved  |
| 29:24          | /   | /                                 | /   |
| 23:16          | R/W | 0x00                              | PTN_CYCLE<br>Pattern generating cycle counter.<br>The pattern in dram will be generated in cycles of PTN_CYCLE+1. |
| 15:9           | /   | /                                 | /   |
| 8              | R/W | 0x0                               | SRAM_PWDN<br>0: SRAM in normal<br>1: SRAM in power down   |
| 7:5            | /   | /                                 | /   |
| 4              | R/W | 0x0                               | PTN_START<br>CSI Pattern Generating Start<br>0: Finish  |

|   |     |   |  |
|---|-----|---|--|
|   |     |   | other: Start<br>Software writes this bit to "1" to start pattern generating from DRAM. When finished, the hardware will clear this bit to "0" automatically. Generating cycles depends on PTN_CYCLE. |
| 3 | R/W | 0 | CLK_CNT_SPL<br>Sampling time for clk counter per frame<br>0: Sampling clock counter every frame done<br>1: Sampling clock counter every vsync  |
| 2 | R/W | 0 | CLK_CNT_EN<br>clk count per frame enable   |
| 1 | R/W | 0 | PTN_GEN_EN<br>Pattern Generation Enable  |
| 0 | R/W | 0 | CSI_EN<br>Enable<br>0: Reset and disable the CSI module<br>1: Enable the CSI module  |

#### 6.1.4.2. CSI Interface Configuration Register (Default Value: 0x00000000)

| Offset: 0x0004 |     |             | Register Name: CSIO_IF_CFG_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:28          | /   | /           | /   |
| 27:24          | R/W | 1           | FIELD_DT_PCLK_SHIFT<br>Only for vsync detected field mode, the odd field permitted pclk shift = 4*FIELD_DT_PCLK_SHIFT   |
| 23:22          | /   | /           | /   |
| 21             | R/W | 0           | SRC_TYPE<br>Source type<br>0: Progressed<br>1: Interlaced   |
| 20             | R/W | 0           | FPS_DS<br>Fps down sample<br>0: no down sample<br>1: 1/2 fps, only receives the first frame every 2 frames  |
| 19             | R/W | 0           | FIELD<br>For YUV HV timing, Field polarity<br>0: negative(field=0 indicate odd, field=1 indicate even)<br>1: positive(field=1 indicate odd, field=0 indicate even)<br>For BT656 timing, Field sequence<br>0: Normal sequence (field 0 first)<br>1: Inverse sequence (field 1 first) |
| 18             | R/W | 1           | VREF_POL<br>Vref polarity<br>0: negative  |

|       |     |   |  |
|-------|-----|---|--|
|       |     |   | 1: positive<br>This register is not applied to CCIR656 interface.  |
| 17    | R/W | 0 | HERF_POL<br>Href polarity<br>0: negative<br>1: positive<br>This register is not applied to CCIR656 interface.  |
| 16    | R/W | 1 | CLK_POL<br>Data clock type<br>0: active in rising edge<br>1: active in falling edge  |
| 15:14 | R/W | 0 | Field_DT_MODE (only valid when CSI_IF is YUV and source type is interlaced)<br>00:by both field and vsync<br>01:by field<br>10:by vsync<br>11:reserved   |
| 13    | /   | / | /  |
| 12:11 | R/W | 0 | SEQ_8PLUS2<br>When select IF_DATA_WIDTH to be 8+2bit, odd/even pixel byte at CSI-D[11:4] will be rearranged to D[11:2]+2'b0 at the actual csi data bus according to these sequences:<br>00: 6'bx+D[9:8], D[7:0]<br>01: D[9:2], 6'bx+D[1:0]<br>10: D[7:0], D[9:8]+6'bx<br>11: D[7:0], 6'bx+D[9:8] |
| 10:8  | R/W | 0 | IF_DATA_WIDTH<br>000: 8 bit data bus<br>001: 10 bit data bus<br>010: 12 bit data bus<br>011: 8+2bit data bus<br>100: 2x8bit data bus<br>Other:reserved   |
| 7     | R/W | 0 | MIPI_IF<br>MIPI Interface Enable:<br>0: CSI<br>1: MIPI   |
| 6:5   | /   | / | /  |
| 4:0   | R/W | 0 | CSI_IF<br>YUV:<br>00000: YUYV422 Interleaved or RAW (All data in one data bus)<br>00001: YUV422 UV Combined (16 bit interface with separate syncs)<br><br>CCIR656:<br>00100: YUYV422 Interleaved or RAW (All data in one data bus)   |

|  |  |  |   |
|--|--|--|---|
|  |  |  | 00101:YUV422 UV Combined (16 bit interface with embedded syncs,BT1120 )<br>Others: Reserved |
|--|--|--|---|

#### 6.1.4.3. CSI Capture Register (Default Value: 0x00000000)

| Offset: 0x0008 |     |             | Register Name: <b>CSI0_CAP_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:6           | /   | /           | /  |
| 5:2            | R/W | 0x0         | CHO_CAP_MASK<br>Vsync number masked before capture.  |
| 1              | R/W | 0x0         | CHO_VCAP_ON<br>Video capture control: Capture the video image data stream on channel 0.<br>0: Disable video capture<br>If video capture is in progress, the CSI stops capturing image data at the end of the current frame, and all of the current frame data is wrote to output FIFO.<br>1: Enable video capture<br>The CSI starts capturing image data at the start of the next frame. |
| 0              | R/W | 0x0         | CHO_SCAP_ON<br>Still capture control: Capture a single still image frame on channel 0.<br>0: Disable still capture.<br>1: Enable still capture<br>The CSI module starts capturing image data at the start of the next frame.<br>The CSI module captures only one frame of image data. This bit is self clearing and always reads as a 0.   |

#### 6.1.4.4. CSI Synchronization Counter Register (Default Value: 0x00000000)

| Offset: 0x000C |     |             | Register Name: <b>CSI0_SYNC_CNT_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:24          | /   | /           | /  |
| 23:0           | R   | 0           | SYNC_CNT<br>The counter value between vsync of CSI0 channel 0 and vsync of CSI1 channel 0 , using 24MHz. |

#### 6.1.4.5. CSI FIFO Threshold Register (Default Value: 0x040f0400)

| Offset: 0x0010 |     |             | Register Name: <b>CSI0_FIFO_THRS_REG</b> |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description                              |
| 31:29          | /   | /           | /  |

|       |     |       |  |
|-------|-----|-------|--|
| 28:26 | R/W | 0x1   | FIFO_NEARLY_FULL_TH<br>The threshold of FIFO being nearly full. Indicates that the ISP should stop writing. Only valid when ISP is enabled.<br>0~7:<br>The smaller the value, the flag of FIFO being nearly full is easier to reach. |
| 25:24 | R/W | 0x0   | PTN_GEN_CLK_DIV<br>Packet generator clock divider  |
| 23:16 | R/W | 0x0f  | PTN_GEN_DLY<br>Clocks delayed before pattern generating start.   |
| 15:12 | /   | /     | /  |
| 11:00 | R/W | 0x400 | FIFO_THRS<br>When CSIO FIFO occupied memory exceed the threshold, dram frequency can not change.   |

#### 6.1.4.6. CSI BT656 Header Configuration Register (Default Value: 0x03020100)

| Offset: 0x0014 |     |             | Register Name: <b>CSIO_BT656_HEAD_CFG_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:28          | /   | /           | /  |
| 27:24          | R/W | 0x3         | CH3_ID<br>The low 4bit of BT656 header for channel 3<br>Only valid in BT656 multi-channel mode |
| 23:20          | /   | /           | /  |
| 19:16          | R/W | 0x2         | CH2_ID<br>The low 4bit of BT656 header for channel 2<br>Only valid in BT656 multi-channel mode |
| 15:12          | /   | /           | /  |
| 11:08          | R/W | 0x1         | CH1_ID<br>The low 4bit of BT656 header for channel 1<br>Only valid in BT656 multi-channel mode |
| 07:04          | /   | /           | /  |
| 03:00          | R/W | 0x0         | CHO_ID<br>The low 4bit of BT656 header for channel 0<br>Only valid in BT656 multi-channel mode |

#### 6.1.4.7. CSI Pattern Generation Length Register (Default Value: 0x00000000)

| Offset: 0x0030 |     |             | Register Name: <b>CSIO_PTN_LEN_REG</b>                         |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:0           | R/W | 0x0         | PTN_LEN<br>The pattern length in byte when generating pattern. |

#### 6.1.4.8. CSI Pattern Generation Address Register (Default Value: 0x00000000)

| Offset: 0x0034 |     |             | Register Name: <b>CSI0_PTN_ADDR_REG</b>                       |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R/W | 0x0         | PTN_ADDR<br>The pattern DRAM address when generating pattern. |

#### 6.1.4.9. CSI Channel\_0 Configuration Register (Default Value: 0x00300200)

| Offset: 0x0044 |     |             | Register Name: <b>CSI0_CO_CFG_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:24          | R/W | 0           | PAD_VAL<br>Padding value when OUTPUT_FMT is prgb888<br>0x00~0xff   |
| 23:20          | R/W | 3           | INPUT_FMT<br>Input data format<br>0000: RAW stream<br>0001: reserved<br>0010: reserved<br>0011: YUV422<br>0100: YUV420<br>Others: reserved   |
| 19:16          | R/W | 0           | OUTPUT_FMT<br>Output data format<br>When the input format is set RAW stream<br>0000: field-raw-8<br>0001: field-raw-10<br>0010: field-raw-12<br>0011: reserved<br>0100: field-rgb565<br>0101: field-rgb888<br>0110: field-prgb888<br>1000: frame-raw-8<br>1001: frame-raw-10<br>1010: frame-raw-12<br>1011: reserved<br>1100: frame-rgb565<br>1101: frame-rgb888<br>1110: frame-prgb888<br><br>When the input format is set YUV422<br>0000: field planar YCbCr 422<br>0001: field planar YCbCr 420 |

|       |     |   |  |
|-------|-----|---|--|
|       |     |   | <p>0010: frame planar YCbCr 420<br/>     0011: frame planar YCbCr 422<br/>     0100: field planar YCbCr 422 UV combined<br/>     0101: field planar YCbCr 420 UV combined<br/>     0110: frame planar YCbCr 420 UV combined<br/>     0111: frame planar YCbCr 422 UV combined<br/>     1000: field MB YCbCr 422<br/>     1001: field MB YCbCr 420<br/>     1010: frame MB YCbCr 420<br/>     1011: frame MB YCbCr 422<br/>     1100: field planar YCbCr 422 10bit UV combined<br/>     1101: field planar YCbCr 420 10bit UV combined<br/>     1110: Reserved<br/>     1111: Reserved</p> <p>When the input format is set YUV420</p> <p>0000: Reserved<br/>     0001: field planar YCbCr 420<br/>     0010: frame planar YCbCr 420<br/>     0011: Reserved<br/>     0100: Reserved<br/>     0101: field planar YCbCr 420 UV combined<br/>     0110: frame planar YCbCr 420 UV combined<br/>     0111: Reserved<br/>     1000: Reserved<br/>     1001: field MB YCbCr 420<br/>     1010: frame MB YCbCr 420<br/>     1011: Reserved<br/>     1100: Reserved<br/>     1101: field planar YCbCr 420 10bit UV combined<br/>     1110: Reserved<br/>     1111: Reserved</p> <p>Others: reserved</p> |
| 15:14 | /   | / | /  |
| 13    | R/W | 0 | <p>VFLIP_EN<br/>     Vertical flip enable<br/>     When enabled, the received data will be arranged in vertical flip.<br/>     0:Disable<br/>     1:Enable</p>   |
| 12    | R/W | 0 | <p>HFLIP_EN<br/>     Horizontal flip enable<br/>     When enabled, the received data will be arranged in horizontal flip.<br/>     0:Disable<br/>     1:Enable</p>   |

|       |     |   |  |
|-------|-----|---|--|
| 11:10 | R/W | 0 | FIELD_SEL<br>Field selection.<br>00: capturing with field 1.<br>01: capturing with field 2.<br>10: capturing with either field.<br>11: reserved  |
| 09:08 | R/W | 2 | INPUT_SEQ<br>Input data sequence, only valid for YUV422 and YUV420 input format.<br>All data interleaved in one channel:<br>00: YUYV<br>01: YVYU<br>10: UYVY<br>11: VYUY<br>Y and UV in separated channel:<br>x0: UV<br>x1: VU |
| 07:02 | /   | / | /  |
| 01:00 | R/W | 0 | MIN_SDR_WR_SIZE<br>Minimum size of SDRAM block write<br>0: 256 bytes (if hflip is enable, always select 256 bytes)<br>1: 512 bytes<br>2: 1k bytes<br>3: 2k bytes   |

#### 6.1.4.10. CSI Channel\_0 Scale Register (Default Value: 0x00000000)

| Offset: 0x004C |     |             | Register Name: CSIO_C0_SCALE_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:01          | /   | /           | /   |
| 00             | R/W | 0           | QUART_EN<br>When this bit is set to 1, input image will be decimated to quarter size. All input format are supported. |

#### 6.1.4.11. CSI Channel\_0 FIFO 0 Output Buffer-A Address Register (Default Value: 0x00000000)

| Offset: 0x0050 |     |             | Register Name: CSIO_C0_F0_BUFA_REG          |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                 |
| 31:00          | R/W | 0           | COFO_BUFA<br>FIFO 0 output buffer-A address |

#### 6.1.4.12. CSI Channel\_0 FIFO 1 Output Buffer-A Address Register (Default Value: 0x00000000)

| Offset: 0x0058 |     |             | Register Name: <b>CSI0_CO_F1_BUFA_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                 |
| 31:00          | R/W | 0           | C0F1_BUFA<br>FIFO 1 output buffer-A address |

#### 6.1.4.13. CSI Channel\_0 FIFO 2 Output Buffer-A Address Register (Default Value: 0x00000000)

| Offset: 0x0060 |     |             | Register Name: <b>CSI0_CO_F2_BUFA_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                 |
| 31:00          | R/W | 0           | C0F2_BUFA<br>FIFO 2 output buffer-A address |

#### 6.1.4.14. CSI Channel\_0 Status Register (Default Value: 0x00000000)

| Offset: 0x006C |     |             | Register Name: <b>CSI0_CO_CAP_STA_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:03          | /   | /           | /   |
| 02             | R   | 0           | FIELD_STA<br>The status of the received field<br>0: Field 0<br>1: Field 1   |
| 01             | R   | 0           | VCAP_STA<br>Video capture in progress<br>Indicates the CSI is capturing video image data (multiple frames). The bit is set at the start of the first frame after enabling video capture. When software disables video capture, it clears itself after the last pixel of the current frame is captured.  |
| 00             | R   | 0           | SCAP_STA<br>Still capture in progress<br>Indicates the CSI is capturing still image data (single frame). The bit is set at the start of the first frame after enabling still frame capture. It clears itself after the last pixel of the first frame is captured.<br>For CCIR656 interface, if the output format is frame planar YCbCr 420 mode, the frame end means the field2 end, the other frame end means filed end. |

#### 6.1.4.15. CSI Channel\_0 Interrupt Enable Register (Default Value: 0x00000000)

|                |  |
|----------------|--|
| Offset: 0x0070 | Register Name: <b>CSI0_CO_INT_EN_REG</b> |
|----------------|--|

| Bit   | R/W | Default/Hex | Description  |
|-------|-----|-------------|--|
| 31:08 | /   | /           | /  |
| 07    | R/W | 0           | <p>VS_INT_EN<br/>vsync flag</p> <p>The bit is set when vsync come. And at this time load the buffer address for the coming frame. So after this irq come, change the buffer address could only effect next frame</p>   |
| 06    | R/W | 0           | <p>HB_OF_INT_EN<br/>Hblank FIFO overflow</p> <p>The bit is set when 3 FIFOs still overflow after the hblank.</p>   |
| 05    | R/W | 0           | <p>MUL_ERR_INT_EN<br/>Multi-channel writing error</p> <p>Indicates error has been detected for writing data to a wrong channel.</p>  |
| 04    | R/W | 0           | <p>FIFO2_OF_INT_EN<br/>FIFO 2 overflow</p> <p>The bit is set when the FIFO 2 become overflow.</p>  |
| 03    | R/W | 0           | <p>FIFO1_OF_INT_EN<br/>FIFO 1 overflow</p> <p>The bit is set when the FIFO 1 become overflow.</p>  |
| 02    | R/W | 0           | <p>FIFO0_OF_INT_EN<br/>FIFO 0 overflow</p> <p>The bit is set when the FIFO 0 become overflow.</p>  |
| 01    | R/W | 0           | <p>FD_INT_EN<br/>Frame done</p> <p>Indicates the CSI has finished capturing an image frame. Applies to video capture mode. The bit is set after each completed frame capturing data is writed to buffer as long as video capture remains enabled.</p>  |
| 00    | R/W | 0           | <p>CD_INT_EN<br/>Capture done</p> <p>Indicates the CSI has completed capturing the image data.</p> <p>For still capture, the bit is set when one frame data has been wrote to buffer.</p> <p>For video capture, the bit is set when the last frame has been wrote to buffer after video capture has been disabled.</p> <p>For CCIR656 interface, if the output format is frame planar YCbCr 420 mode, the frame end means the field2 end, the other frame end means field end.</p> |

#### 6.1.4.16. CSI Channel\_0 Interrupt Status Register (Default Value: 0x00000000)

| Offset: 0x0074 |     |             | Register Name: CSIO_C0_INT_STA_REG |
|----------------|-----|-------------|------------------------------------|
| Bit            | R/W | Default/Hex | Description                        |
| 31:08          | /   | /           | /                                  |
| 07             | R/W | 0           | VS_PD<br>vsync flag                |

|    |     |   |   |
|----|-----|---|---|
| 06 | R/W | 0 | HB_OF_PD<br>Hblank FIFO overflow          |
| 05 | R/W | 0 | MUL_ERR_PD<br>Multi-channel writing error |
| 04 | R/W | 0 | FIFO2_OF_PD<br>FIFO 2 overflow            |
| 03 | R/W | 0 | FIFO1_OF_PD<br>FIFO 1 overflow            |
| 02 | R/W | 0 | FIFO0_OF_PD<br>FIFO 0 overflow            |
| 01 | R/W | 0 | FD_PD<br>Frame done                       |
| 00 | R/W | 0 | CD_PD<br>Capture done                     |

#### 6.1.4.17. CSI Channel\_0 Filed1 Vertical Size Register (Default Value: 0x01E00000)

| Offset: 0x0078 |     |             | Register Name: CSIO_CO_FLD1_VSIZE_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:29          | /   | /           | /   |
| 28:16          | R/W | 1E0         | VER_LEN<br>Valid line number of filed1,only valid when CSI_IF is YUV and source type is interlaced.                                   |
| 15:13          | /   | /           | /   |
| 12:00          | R/W | 0           | VER_START<br>Vertical line start of filed1. data is valid from this line,only valid when CSI_IF is YUV and source type is interlaced. |

#### 6.1.4.18. CSI Channel\_0 Horizontal Size Register (Default Value: 0x05000000)

| Offset: 0x0080 |     |             | Register Name: CSIO_CO_INT_STA_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:29          | /   | /           | /   |
| 28:16          | R/W | 500         | HOR_LEN<br>Horizontal pixel unit length. Valid pixel of a line.           |
| 15:13          | /   | /           | /   |
| 12:00          | R/W | 0           | HOR_START<br>Horizontal pixel unit start. Pixel is valid from this pixel. |

#### 6.1.4.19. CSI Channel\_0 Vertical Size Register (Default Value: 0x01E00000)

| Offset: 0x0084 |     |             | Register Name: <b>CSI0_CO_VSIZE_REG</b>  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:29          | /   | /           | /  |
| 28:16          | R/W | 1E0         | VER_LEN<br>Vertical line length. Valid line number of a frame. Stand for line number of field0 when CSI_IF is YUV and source type is interlaced. |
| 15:13          | /   | /           | /  |
| 12:00          | R/W | 0           | VER_START<br>Vertical line start. data is valid from this line. Stand for start line of field0 when CSI_IF is YUV and source type is interlaced. |

#### 6.1.4.20. CSI Channel\_0 Buffer Length Register (Default Value: 0x01400280)

| Offset: 0x0088 |     |             | Register Name: <b>CSI0_CO_BUFLEN_REG</b>                         |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:30          | /   | /           | /  |
| 29:16          | R/W | 140         | BUF_LEN_C<br>Buffer length of chroma C in a line. Unit is byte.  |
| 15:14          | /   | /           | /  |
| 13:00          | R/W | 280         | BUF_LEN<br>Buffer length of luminance Y in a line. Unit is byte. |

#### 6.1.4.21. CSI Channel\_0 Flip Size Register (Default Value: 0x01E00280)

| Offset: 0x008C |     |             | Register Name: <b>CSI0_CO_FLIP_SIZE_REG</b>                |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:29          | /   | /           | /  |
| 28:16          | R/W | 1E0         | VER_LEN<br>Vertical line number when in vflip mode.        |
| 15:13          | /   | /           | /  |
| 12:00          | R/W | 280         | VALID_LEN<br>Valid components of a line when in flip mode. |

#### 6.1.4.22. CSI Channel\_0 Frame Clock Counter Register (Default Value: 0x00000000)

| Offset: 0x0090 |     |             | Register Name: <b>CSI0_CO_FRM_CLK_CNT_REG</b> |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description                                   |
| 31:24          | /   | /           | /   |

|       |   |   |  |
|-------|---|---|--|
| 23:00 | R | 0 | <b>FRM_CLK_CNT</b><br>Counter value between every frame. For instant hardware frame rate statics.<br>The internal counter is added by one every 24MHz clock cycle. When frame done or vsync comes, the internal counter value is sampled to <b>FRM_CLK_CNT</b> , and cleared to 0. |
|-------|---|---|--|

#### 6.1.4.23. CSI Channel\_0 Accumulated and Internal Clock Counter Register (Default Value: 0x00000000)

| Offset: 0x0094 |     |             | Register Name: <b>CSI0_CO_ACC_ITNL_CLK_CNT_REG</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:24          | R   | 0           | <b>ACC_CLK_CNT</b><br>The accumulated value of <b>FRM_CLK_CNT</b> for software frame rate statics.<br>Every interrupt of frame done, the software check this accumulated value and clear it to 0. If the <b>ACC_CLK_CNT</b> is larger than 1, the software has lost frame.<br>When frame done or vsync comes, <b>ACC_CLK_CNT</b> = <b>ACC_CLK_CNT</b> + 1, and cleared to 0 when writing 0 to this register. |
| 23:00          | R   | 0           | <b>ITNL_CLK_CNT</b><br>The instant value of internal frame clock counter.<br>When frame done interrupt comes, the software can query this counter for judging whether it is the time for updating the double buffer address registers.   |

#### 6.1.4.24. CSI Channel\_0 FIFO Statistic Register (Default Value: 0x00000000)

| Offset: 0x0098 |     |             | Register Name: <b>CSI0_CO_FIFO_STAT_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:12          | /   | /           | /   |
| 11:00          | R   | 0           | <b>FIFO_FRM_MAX</b><br>Indicates the maximum depth of FIFO being occupied for whole frame.<br>Update at every vsync or framedone. |

#### 6.1.4.25. CSI Channel\_0 PCLK Statistic Register (Default Value: 0x00007FFF)

| Offset: 0x009C |     |             | Register Name: <b>CSI0_CO_PCLK_STAT_REG</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | /   | /           | /   |
| 30:16          | R   | 0           | <b>PCLK_CNT_LINE_MAX</b><br>Indicates maximum pixel clock counter value for each line.<br>Update at every vsync or framedone. |

|       |   |        |  |
|-------|---|--------|--|
| 15    | / | /      | /  |
| 14:00 | R | 0x7fff | PCLK_CNT_LINE_MIN<br>Indicates minimum pixel clock counter value for each line.<br>Update at every vsync or framedone. |

#### 6.1.4.26. CCI Control Register (Default Value: 0x00000000)

| Offset: 0x3000 |     |             | Register Name: CCI_CTRL_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0           | SINGLE_TRAN<br>0: Transmission idle<br>1: Start single transmission<br>Automatically cleared to '0' when finished. Abort current transmission immediately if changing from '1' to '0'. If slave not respond for the expected status over the time defined by TIMEOUT, current transmission will stop. PACKET_CNT will return the sequence number when transmission fail. All format setting and data will be loaded from registers and FIFO when transmission start. |
| 30             | R/W | 0           | REPEAT_TRAN<br>0: transmission idle<br>1: repeated transmission<br>When this bit is set to 1, transmission repeats when trigger signal (such as VSYNC/ VCAP done) repeats.<br>If changing this bit from '1' to '0' during transmission, the current transmission will be guaranteed then stop.   |
| 29             | R/W | 0           | RESTART_MODE<br>0: RESTART<br>1: STOP+START<br>Define the CCI action after sending register address.   |
| 28             | R/W | 0           | READ_TRAN_MODE<br>0: send slave_id+W<br>1: do not send slave_id+W<br><b>Setting this bit to 1 if reading from a slave which register width is equal to 0.</b>  |
| 27:24          | R   | 0           | TRAN_RESULT<br>000: OK<br>001: FAIL<br>Other: Reserved   |
| 23:16          | R   | /           | CCI_STA<br>0x00: bus error<br>0x08: START condition transmitted<br>0x10: Repeated START condition transmitted<br>0x18: Address + Write bit transmitted, ACK received<br>0x20: Address + Write bit transmitted, ACK not received  |

|      |     |   |   |
|------|-----|---|---|
|      |     |   | 0x28: Data byte transmitted in master mode, ACK received<br>0x30: Data byte transmitted in master mode, ACK not received<br>0x38: Arbitration lost in address or data byte<br>0x40: Address + Read bit transmitted, ACK received<br>0x48: Address + Read bit transmitted, ACK not received<br>0x50: Data byte received in master mode, ACK received<br>0x58: Data byte received in master mode, ACK not received<br>0x01: Timeout when sending 9th SCL clk<br>Other: Reserved |
| 15:2 | /   | / | /   |
| 1    | R/W | 0 | SOFT_RESET<br>0: normal<br>1: reset   |
| 0    | R/W | 0 | CCI_EN<br>0: Module disable<br>1: Module enable   |

#### 6.1.4.27. CCI Transmission Configuration Register (Default Value: 0x10000000)

| Offset: 0x3004 |     |             | Register Name: CCI_CFG_REG   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:24          | R/W | 0x10        | TIMEOUT_N<br>When sending the 9th clock, assert fail signal when slave device did not response after N*FSCL cycles. And software must do a reset to CCI module and send a stop condition to slave.   |
| 23:16          | R/W | 0x00        | INTERVAL<br>Define the interval between each packet in 40*FSCL cycles. 0~255   |
| 15             | R/W | 0           | PACKET_MODE<br>Select where to load slave id / data width<br>0: Compact mode<br>1: Complete mode<br>In compact mode, slave id/register width / data width will be loaded from CCI_FMT register, only address and data read from memory.<br>In complete mode, they will be loaded from packet memory. |
| 14:7           | /   | /           | /  |
| 6:4            | R/W | 0           | TRIG_MODE<br>Transmit mode:<br>000: Immediately, no trigger<br>001: Reserved<br>010: CSI0 int trigger<br>011: CSI1 int trigger   |
| 3:0            | R/W | 0           | CSI_TRIG<br>CSI Int trig signal select:<br>0000: First HREF start  |

|  |  |  |   |
|--|--|--|---|
|  |  |  | 0001: Last HREF done<br>0010: Line counter trigger<br>other: Reserved |
|--|--|--|---|

#### 6.1.4.28. CCI Packet Format Register (Default Value: 0x00110001)

| Offset: 0x3008 |     |             | Register Name: CCI_FMT_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:25          | R/W | 0           | SLV_ID<br>7bit address  |
| 24             | R/W | 0           | CMD<br>0: write<br>1: read  |
| 23:20          | R/W | 1           | ADDR_BYTE<br>How many bytes be sent as address<br>0~15  |
| 19:16          | R/W | 1           | DATA_BYTE<br>How many bytes be sent/received as data<br>1~15<br>Normally use ADDR_DATA with 0_2, 1_1, 1_2, 2_1, 2_2 access mode. If DATA bytes is 0, transmission will not start. In complete mode, the ADDR_BYTE and DATA_BYTE is defined in a byte's high/low 4bit. |
| 15:0           | R/W | 1           | PACKET_CNT<br>FIFO data be transmitted as PACKET_CNT packets in current format.<br>Total bytes not exceed 32bytes.  |

#### 6.1.4.29. CCI Bus Control Register (Default Value: 0x00002500)

| Offset: 0x300C |     |             | Register Name: CCI_BUS_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:16          | R/W | 0           | DLY_CYC<br>0~65535 FSCL cycles between each transmission                                      |
| 15             | R/W | 0           | DLY_TRIG<br>0: disable<br>1: execute transmission after internal counter delay when triggered |
| 14:12          | R/W | 0x2         | CLK_N<br>CCI bus sampling clock F0=24MHz/2^CLK_N  |
| 11:8           | R/W | 0x5         | CLK_M<br>CCI output SCL frequency is FSCL=F1/10=(F0/(CLK_M+1))/10                             |
| 7              | R   | /           | SCL_STA<br>SCL current status   |
| 6              | R   | /           | SDA_STA   |

|   |     |   |                                    |
|---|-----|---|------------------------------------|
|   |     |   | SDA current status                 |
| 5 | R/W | 0 | SCL_PEN<br>SCL PAD enable          |
| 4 | R/W | 0 | SDA_PEN<br>SDA PAD enable          |
| 3 | R/W | 0 | SCL_MOV<br>SCL manual output value |
| 2 | R/W | 0 | SDA_MOV<br>SDA manual output value |
| 1 | R/W | 0 | SCL_MOE<br>SCL manual output en    |
| 0 | R/W | 0 | SDA_MOE<br>SDA manual output en    |

#### 6.1.4.30. CCI Interrupt Control Register (Default Value: 0x00000000)

| Offset: 0x3014 |     |             | Register Name: CCI_INT_CTRL_REG |
|----------------|-----|-------------|---------------------------------|
| Bit            | R/W | Default/Hex | Description                     |
| 31:18          | /   | /           | /                               |
| 17             | R/W | 0           | S_TRAN_ERR_INT_EN               |
| 16             | R/W | 0           | S_TRAN_COM_INT_EN               |
| 15:2           | /   | /           | /                               |
| 1              | R/W | 0           | S_TRAN_ERR_PD                   |
| 0              | R/W | 0           | S_TRAN_COM_PD                   |

#### 6.1.4.31. CCI Line Counter Trigger Control Register (Default Value: 0x00000000)

| Offset: 0x3018 |     |             | Register Name: CCI_LC_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:13          | /   | /           | /   |
| 12:0           | R/W | 0           | LN_CNT<br>0~8191: line counter send trigger when 1st~8192th line is received. |

#### 6.1.4.32. CCI FIFO Acess Register (Default Value: 0x00000000)

| Offset: 0x3100~0x313f |     |             | Register Name: CCI_FIFO_ACC_REG   |
|-----------------------|-----|-------------|---|
| Bit                   | R/W | Default/Hex | Description   |
| 31:0                  | R/W | 0           | DATA_FIFO<br>From 0x100 to 0x13f, CCI data fifo is 64bytes, used in fifo input mode. CCI transmission read/write data from/to fifo in byte. |

## 6.2. MIPI CSI2

### 6.2.1. Overview

The MIPI CSI2 includes the following feature:

- MIPI CSI-2 Receiver as a slave without CCI (Camera Control Interface)
- Unidirectional Clock and Data Lane
- Standard CSI-2 protocol with ECC and CRC
- Supports format: YUV422-8bit/10bit,YUV420-8bit/10bit,RAW-8,RAW-10,RAW-12,RGB888,RGB565
- D-PHY with HS-RX, LP-TX, LP-RX
- 1,2 data lanes configuration and up to 1Gbps per Lane in HS transmission
- Maximum to 720p@30fps or 1080p@15fps with one data lane in one channel
- Maximum to 1080p@30fps or 5M@15fps with two data lanes in one channel
- Maximum to 2 data type interleaving in one channel

# Chapter 7 Display

This chapter describes the R11 display system from two aspects:

- DE2.0
- TCON

The following figure shows the block diagram of display system:

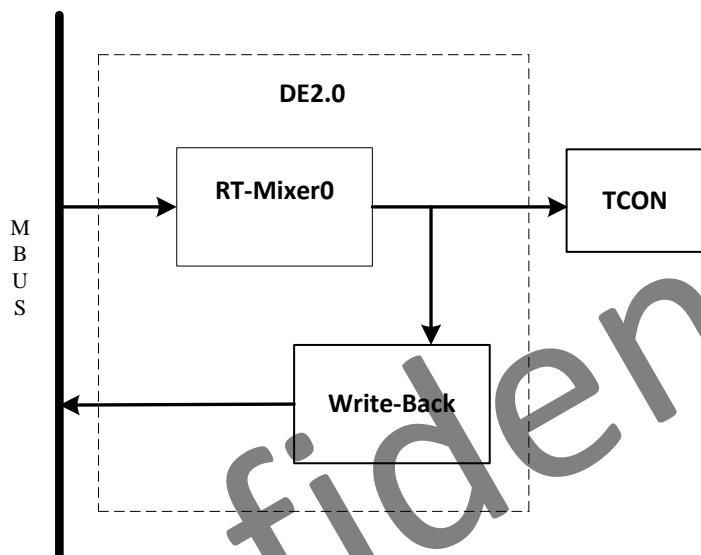


Figure 7-1. Display System Block Diagram

## 7.1. DE 2.0

### 7.1.1. Overview

- Output size up to 1024x1024
- Supports three alpha blending channel for main display
- Supports four overlay layers in each channel, and has a independent scale
- Supports potter-duff compatible blending operation
- Supports input format YUV422/YUV420/YUV411/ARGB8888/XRGB8888/RGB888/ARGB4444/ARGB1555/RGB565

Confidential

## 7.2. TCON

### 7.2.1. Overview

- Supports LVDS interface with single link, up to 1024x768@60fps
- Supports RGB interface with DE/SYNC mode, up to 1024x768@60fps
- Supports serial RGB/dummy RGB/CCIR656 interface, up to 800x480@60fps
- Supports i80 interface with 18/16/9/8 bit, support TE, up to 800x480@60fps
- Supports pixel format: RGB888, RGB666 and RGB565
- Dither function from RGB666/RGB565 to RGB888
- Gamma correction with R/G/B channel independence
- 4 interrupts for programmer LCD output

### 7.2.2. Block Diagram

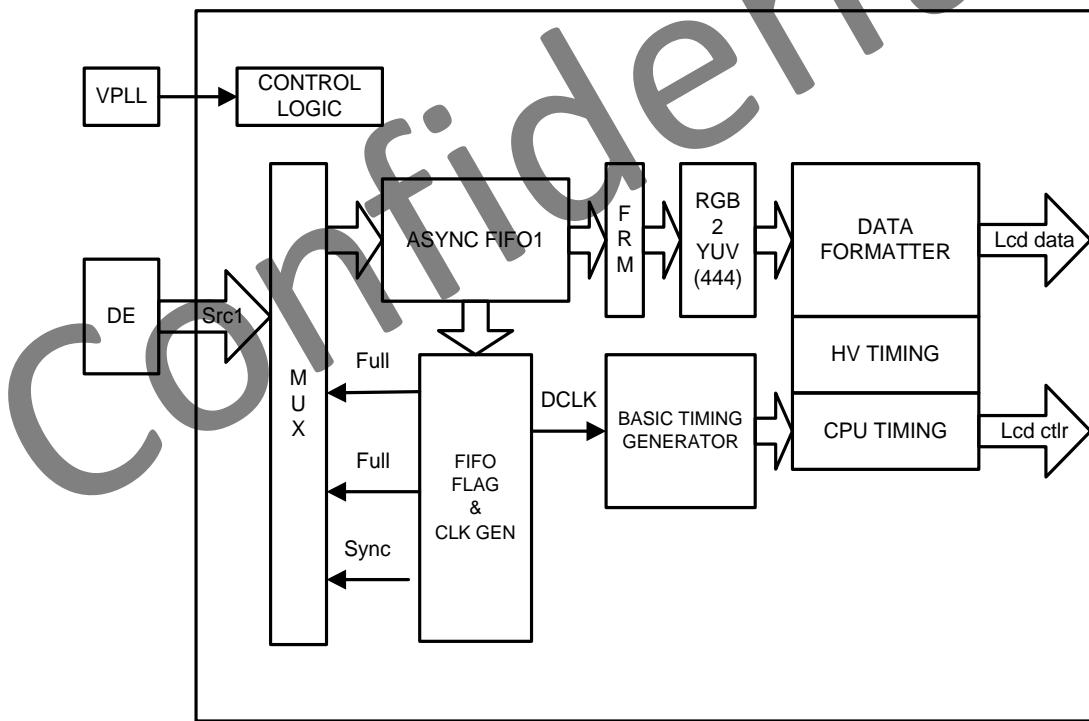


Figure 7-2. TCON Block Diagram

## 7.2.3. Functionalities Description

### 7.2.3.1. Panel Interface

#### HV\_I/F(Sync+DE mode)

HV I/F is also known as Sync + DE mode, which is widely used in TFT LCD module for PMP/MP4 applications. Its signals are define as:

| Main Signal | I/O type | Definition And Description                     |
|-------------|----------|--|
| Vsync       | O        | Vertical sync, indicates one new frame         |
| Hsync       | O        | Horizontal sync, indicate one new scan line    |
| DCLK        | O        | Dot clock, pixel data are sync by this clock   |
| LDE         | O        | LCD data enable                                |
| LD[23..0]   | O        | 18Bit RGB/YUV output from input FIFO for panel |

HV control signals are active low.

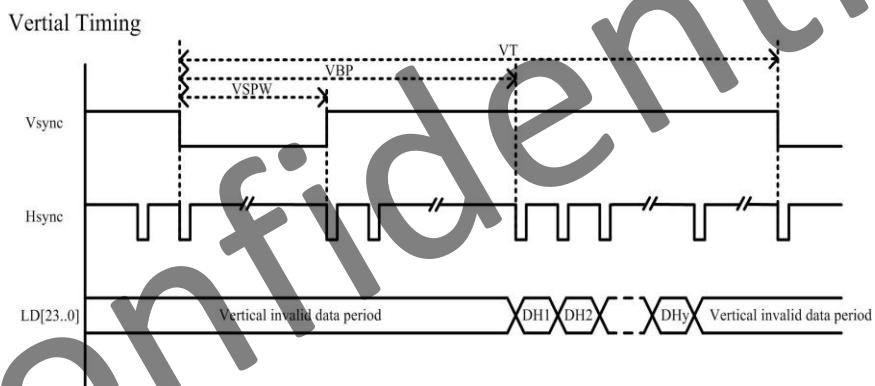


Figure 7-3. Panel Interface Odd/Even Field Vertical Timing

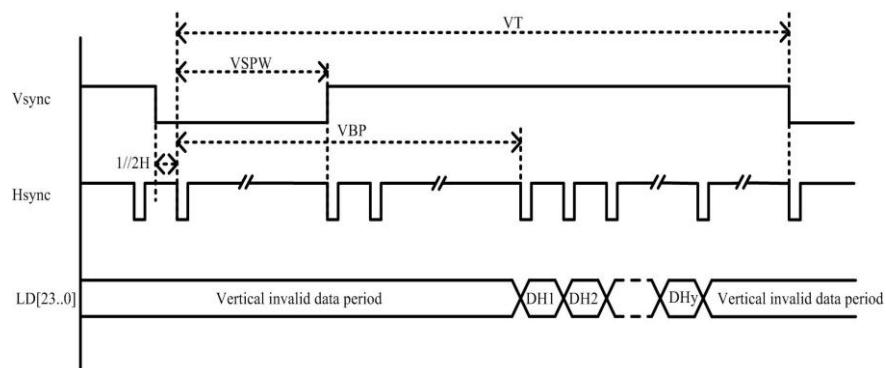


Figure 7-4. Panel Interface Even Field Vertical Timing

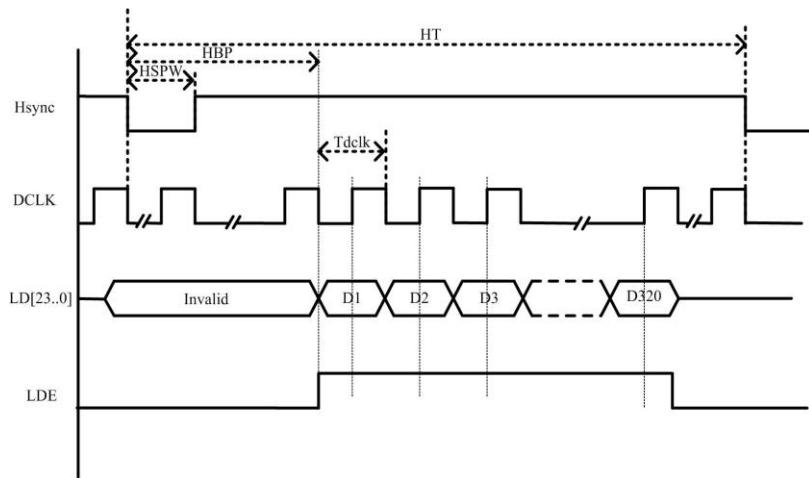


Figure 7-5. Parallel Mode Horizontal Timing

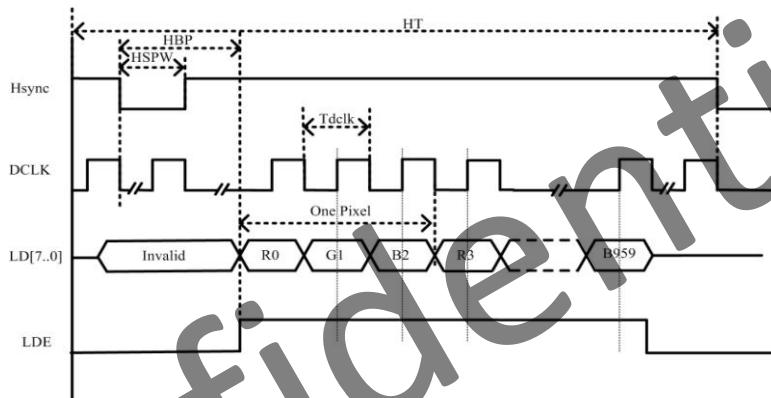


Figure 7-6. Serial Mode Horizontal Timing

### CCIR output SAV/EAV sync signal

When in HV serial YUV output mode, it's timing is CCIR656/601 compatible. SAV add right before active area every line; EAV add right after active area every line.

It logic are:

$$F = "0" \text{ for Field 1 } F = "1" \text{ for Field 2}$$

$$V = "1" \text{ during vertical blanking}$$

$$H = "0" \text{ at SAV } H = "1" \text{ at EAV}$$

P3-P0 = protection bits

$$P3 = V \oplus H$$

$$P2 = F \oplus H$$

$$P1 = F \oplus V$$

$$P0 = F \oplus V \oplus H$$

Where  $\oplus$  represents the exclusive-OR function

The 4 byte SAV/EAV sequences are:

|  |            |             |
|--|------------|-------------|
|  | 8-bit Data | 10-bit Data |
|--|------------|-------------|

|             | D9<br>(MSB) | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-------------|-------------|----|----|----|----|----|----|----|----|----|
| preamble    | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
|             | 0           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
|             | 0           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| Status word | 1           | F  | V  | H  | P3 | P2 | P1 | P0 | 0  | 0  |

### CPU\_I/F

CPU I/F LCD panel is most common interface for small size, low resolution LCD panels.

CPU control signals are active low.

| Main Signal | I/O type | Definition And Description                       |
|-------------|----------|--|
| CS          | O        | Chip select, active low                          |
| WR          | O        | Write strobe, active low                         |
| RD          | O        | Read strobe, active low                          |
| A1          | O        | Address bit, controlled by "LCD_CPUI/F" BIT26/25 |
| D[23..0]    | I/O      | Digital RGB output signal                        |

The following figure relationship between basic timing and CPU timing. WR is 180 degree delay of DCLK; CS is active when pixel data are valid; RD is always set to 1; A1 are set by "Lcd\_CPUI/F".

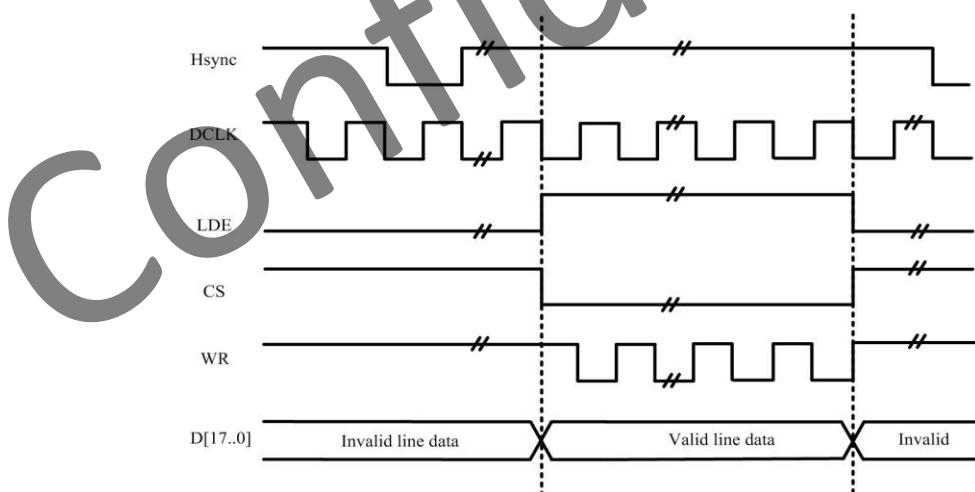


Figure 7-7. Lcd\_CPUI/F Timing

When CPU I/F is in IDLE state, it can generate WR/RD timing by setting "Lcd\_CPUI/F". CS strobe is one DCLK width, WR/RD strobe is half DCLK width.

#### 7.2.3.2. RGB Gamma Correction

Function: This module correct the RGB input data of DE0 .

A 256\*8\*3 Byte register file is used to store the gamma table. The following is the layout:

| Offset              | Value                               |
|---------------------|-------------------------------------|
| 0x400, 0x401, 0x402 | { B0[7:0], G0[7:0], R0[7:0] }       |
| 0x404,              | { B1[7:0], G1[7:0], R1[7:0] }       |
| .....               | .....                               |
| 0x4FC               | { B255[7:0], G255[7:0], R255[7:0] } |

### 7.2.3.3. CEU Module

Function: This module enhance color data from DE0 .

$$R' = Rr * R + Rg * G + Rb * B + Rc$$

$$G' = Gr * R + Gg * G + Gb * B + Gc$$

$$B' = Br * R + Bg * G + Bb * B + Bc$$



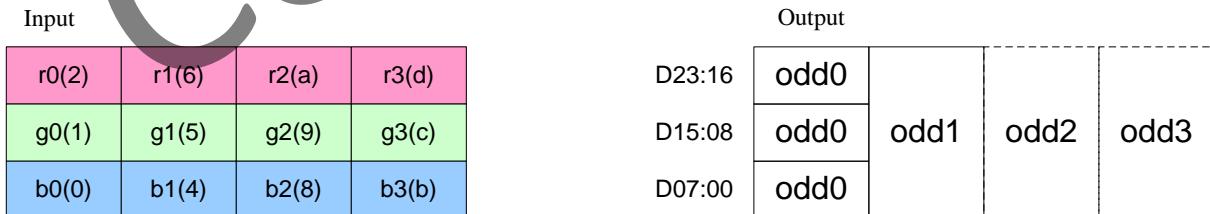
#### NOTE

**Rr, Rg, Rb, ,Gr, Gg, Gb, Br, Bg, Bb**    s13    (-16,16)  
**Rc, Gc, Bc**    s19 (-16384, 16384)  
**R, G, B**    u8 [0-255]  
**R'** have the range of [Rmin ,Rmax]  
**G'** have the range of [Rmin ,Rmax]  
**B'** have the range of [Rmin ,Rmax]

### 7.2.3.4. CMAP Module

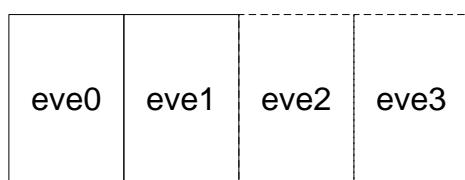
Function: This module map color data from DE0

Every 4 input pixels as a unit. a unit is divided into 12 bytes. Output byte can select one of those 12 bytes. Note that even line and odd line can be different, and output can be 12 bytes(4 pixels) or reduce to 6 bytes(2 pixels).



In mode: 4 pixels

Out mode: 4 pixels/2 pixels



### 7.2.4. TCON Module Register List

| Module Name | Base Address |
|-------------|--------------|
|-------------|--------------|

|                        |              |  |
|------------------------|--------------|--|
| TCON                   | 0x01C0C000   |  |
| Register Name          | Offset       | Description  |
| TCON_GCTL_REG          | 0x000        | TCON global control register                             |
| TCON_GINT0_REG         | 0x004        | TCON global interrupt register0                          |
| TCON_GINT1_REG         | 0x008        | TCON global interrupt register1                          |
| TCONO_FRM_CTL_REG      | 0x010        | TCON FRM control register                                |
| TCONO_FRM_SEED_REG     | 0x014+N*0x04 | TCON FRM seed register<br>(N=0,1,2,3,4,5)                |
| TCONO_FRM_TAB_REG      | 0x02C+N*0x04 | TCON FRM table register<br>(N=0,1,2,3)                   |
| TCONO_CTL_REG          | 0x040        | TCONO control register                                   |
| TCONO_DCLK_REG         | 0x044        | TCONO data clock register                                |
| TCONO_BASIC0_REG       | 0x048        | TCONO basic timing register0                             |
| TCONO_BASIC1_REG       | 0x04C        | TCONO basic timing register1                             |
| TCONO_BASIC2_REG       | 0x050        | TCONO basic timing register2                             |
| TCONO_BASIC3_REG       | 0x054        | TCONO basic timing register3                             |
| TCONO_HV_IF_REG        | 0x058        | TCONO hv panel interface register                        |
| TCONO_CPU_IF_REG       | 0x060        | TCONO cpu panel interface register                       |
| TCONO_CPU_WR_REG       | 0x064        | TCONO cpu panel write data register                      |
| TCONO_CPU_RDO_REG      | 0x068        | TCONO cpu panel read data register0                      |
| TCONO_CPU_RD1_REG      | 0x06C        | TCONO cpu panel read data register1                      |
| TCONO_LVDS_IF_REG      | 0x084        | TCONO lvds panel interface register                      |
| TCONO_IO_POL_REG       | 0x088        | TCONO IO polarity register                               |
| TCONO_IO_TRI_REG       | 0x08C        | TCONO IO control register                                |
| TCON_ECC_FIFO_REG      | 0x0F8        | TCON ECC FIFO register                                   |
| TCON_DEBUG_REG         | 0x0FC        | TCON debug register                                      |
| TCON_CEU_CTL_REG       | 0x100        | TCON CEU control register                                |
| TCON_CEU_COEF_MUL_REG  | 0x110+N*0x04 | TCON CEU coefficient register0<br>(N=0,1,2,4,5,6,8,9,10) |
| TCON_CEU_COEF_ADD_REG  | 0x11C+N*0x10 | TCON CEU coefficient register1<br>(N=0,1,2)              |
| TCON_CEU_COEF_RANG_REG | 0x140+N*0x04 | TCON CEU coefficient register2<br>(N=0,1,2)              |
| TCONO_CPU_TRI0_REG     | 0x160        | TCONO cpu panel trigger register0                        |
| TCONO_CPU_TRI1_REG     | 0x164        | TCONO cpu panel trigger register1                        |
| TCONO_CPU_TRI2_REG     | 0x168        | TCONO cpu panel trigger register2                        |
| TCONO_CPU_TRI3_REG     | 0x16C        | TCONO cpu panel trigger register3                        |
| TCON_CMAP_CTL_REG      | 0x180        | TCON color map control register                          |
| TCON_CMAP_ODD0_REG     | 0x190        | TCON color map odd line register0                        |
| TCON_CMAP_ODD1_REG     | 0x194        | TCON color map odd line register1                        |
| TCON_CMAP_EVEN0_REG    | 0x198        | TCON color map even line register0                       |
| TCON_CMAP_EVEN1_REG    | 0x19C        | TCON color map even line register1                       |
| TCONO_LVDS_ANAO_REG    | 0x220        | TCON LVDS analog register0                               |

|                        |             |  |
|------------------------|-------------|--|
| TCON0_GAMMA_TABLE_REG  | 0x400-0x7FF |  |
| TCON_TRI_FIFO_BIST_REG | 0xFF8       |  |
| TCON_ECC_FIFO_BIST_REG | 0xFFC       |  |

## 7.2.5. TCON Module Register Description

### 7.2.5.1. TCON\_GCTL\_REG (Default Value: 0x00000000)

| Offset: 0x0000 |     |             | Register Name: TCON_GCTL_REG  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31             | R/W | 0           | TCON_En<br>0: disable<br>1: enable<br>When it's disabled, the module will be reset to idle state. |
| 30             | R/W | 0           | TCON_Gamma_En<br>0: disable<br>1: enable  |
| 29:0           | /   | /           | /   |

### 7.2.5.2. TCON\_GINT0\_REG (Default Value: 0x00000000)

| Offset: 0x0004 |     |             | Register Name: TCON_GINT0_REG  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31             | R/W | 0           | TCON0_Vb_Int_En<br>0: disable<br>1: enable   |
| 30             | /   | /           | /  |
| 29             | R/W | 0           | TCON0_Line_Int_En<br>0: disable<br>1: enable   |
| 28             | /   | /           | /1: enable   |
| 27             | R/W | 0           | TCON0_Tri_Finish_Int_En<br>0: disable<br>1: enable   |
| 26:            | R/W | 0           | TCON0_Tri_Counter_Int_En<br>0: disable<br>1: enable  |
| 25:16          | /   | /           | /  |
| 15             | R/W | 0           | TCON0_Vb_Int_Flag<br>Asserted during vertical no-display period every frame.<br>Write 0 to clear it. |

|     |     |   |  |
|-----|-----|---|--|
| 14  | /   | / | /  |
| 13  | R/W | 0 | TCON0_Line_Int_Flag<br>trigger when SY0 match the current TCON0 scan line<br>Write 0 to clear it.                    |
| 12  | /   | / | /  |
| 11  | R/W | 0 | TCON0_Tri_Finish_Int_Flag<br>trigger when cpu trigger mode finish<br>Write 0 to clear it.                            |
| 10  | R/W | 0 | TCON0_Tri_Counter_Int_Flag<br>trigger when tri counter reache this value<br>Write 0 to clear it.                     |
| 9   | R/W | 0 | TCON0_Tri_Underflow_Flag<br>only used in dsi video mode, tri when sync by dsi but not finish<br>Write 0 to clear it. |
| 8:0 | /   | / | /  |

#### 7.2.5.3. TCON\_GINT1\_REG (Default Value: 0x00000000)

| Offset: 0x0008 |     |             | Register Name: TCON_GINT1_REG   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:28          | /   | /           | /   |
| 27:16          | R/W | 0           | TCON0_Line_Int_Num<br>Scan line for TCON0 line trigger(including inactive lines)<br>Setting it for the specified line for trigger0.<br>SY0 is writable only when LINE_TRG0 disable. |
| 15:0           | /   | /           | /   |

#### 7.2.5.4. TCON0\_FRM\_CTL\_REG (Default Value: 0x00000000)

| Offset: 0x010 |     |             | Register Name: TCON0_FRM_CTL_REG                             |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | R/W | 0           | TCON0_Frm_En<br>0:disable<br>1:enable                        |
| 30:7          | /   | /           | /  |
| 6             | R/W | 0           | TCON0_Frm_Mode_R<br>0: 6bit frm output<br>1: 5bit frm output |
| 5             | R/W | 0           | TCON0_Frm_Mode_G<br>0: 6bit frm output<br>1: 5bit frm output |
| 4             | R/W | 0           | TCON0_Frm_Mode_B   |

|     |     |   |   |
|-----|-----|---|---|
|     |     |   | 0: 6bit frm output<br>1: 5bit frm output  |
| 3:2 | /   | / | /   |
| 1:0 | R/W | 0 | TCON0_Frm_Test<br>00: FRM<br>01: half 5/6bit, half FRM<br>10: half 8bit, half FRM<br>11: half 8bit, half 5/6bit |

#### 7.2.5.5. TCON0\_FRM\_SEED\_REG (Default Value: 0x00000000)

| Offset: 0x014+N*0x04<br>(N=0,1,2,3,4,5) |     |             | Register Name: TCON0_FRM_SEED_REG   |
|---|-----|-------------|---|
| Bit                                     | R/W | Default/Hex | Description   |
| 31:25                                   | /   | /           | /   |
| 24:0                                    | R/W | 0           | Seed_Value<br>N=0: Pixel_Seed_R<br>N=1: Pixel_Seed_G<br>N=2: Pixel_Seed_B<br>N=3: Line_Seed_R<br>N=4: Line_Seed_G<br>N=5: Line_Seed_B<br>Avoid setting it to 0. |

#### 7.2.5.6. TCON0\_FRM\_TAB\_REG (Default Value: 0x00000000)

| Offset: 0x02C+N*0x04<br>(N=0,1,2,3) |     |             | Register Name: TCON0_FRM_TAB_REG |
|-------------------------------------|-----|-------------|----------------------------------|
| Bit                                 | R/W | Default/Hex | Description                      |
| 31:0                                | R/W | 0           | Frm_Table_Value                  |

#### 7.2.5.7. TCON0\_CTL\_REG (Default Value: 0x00000000)

| Offset: 0x040 |     |             | Register Name: TCON0_CTL_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | R/W | 0           | TCON0_En<br>0: disable<br>1: enable<br>It executes at the beginning of the first blank line of TCON0 timing. |
| 30:29         | /   | /           | /  |
| 28            | R/W | 0           | TCON0_Work_Mode  |

|       |     |   |  |
|-------|-----|---|--|
|       |     |   | 0: normal<br>1: dynamic freq   |
| 27:26 | /   | / | /  |
| 25:24 | R/W | 0 | TCON0_IF<br>00: HV(Sync+DE)<br>01: 8080 I/F<br>1x:reserved   |
| 23    | R/W | 0 | TCON0_RB_Swap<br>0: default<br>1: swap RED and BLUE data at FIFO1  |
| 22    | /   | / | /  |
| 21    | R/W | 0 | TCON0_FIFO1_Rst<br>Write 1 and then 0 at this bit will reset FIFO 1<br>1 holding time must more than 1 DCLK                                    |
| 20    | /   | / | /  |
| 19:9  | /   | / | /  |
| 8:4   | R/W | 0 | TCON0_Start_Delay<br>STA delay<br>Valid only when TCON0_EN == 1  |
| 3     | /   | / | /  |
| 2:0   | R/W | 0 | TCON0_SRC_SEL:<br>000: DE0<br>001: reserved<br>010: reserved<br>011: reserved<br>100: Test Data all 0<br>101: Test Data all 1<br>11x: reserved |

#### 7.2.5.8. TCON0\_DCLK\_REG (Default Value: 0x00000000)

| Offset: 0x044 |     |             | Register Name: TCON0_DCLK_REG  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:28         | R/W | 0           | TCON0_Dclk_En<br>LCLK_EN[3:0] :TCON0 clock enable<br>4'h0, 'h4, 'h6, 'ha7:dclk_en=0;dclk1_en=0;dclk2_en=0;dclkm2_en=0;<br>4'h1: dclk_en = 1; dclk1_en = 0; dclk2_en = 0; dclkm2_en = 0;<br>4'h2: dclk_en = 1; dclk1_en = 0; dclk2_en = 0; dclkm2_en = 1;<br>4'h3: dclk_en = 1; dclk1_en = 1; dclk2_en = 0; dclkm2_en = 0;<br>4'h5: dclk_en = 1; dclk1_en = 0; dclk2_en = 1; dclkm2_en = 0;<br>4'h8, 'h9, 'ha, 'hb, 'hc, 'hd, 'he, 'hf:<br>dclk_en = 1;<br>dclk1_en = 1;<br>dclk2_en = 1; |

|      |     |   |  |
|------|-----|---|--|
|      |     |   | dclkm2_en = 1;   |
| 27:7 | /   | / | /  |
| 6:0  | R/W | 0 | TCON0_Dclk_Div<br>Tdclk = Tsclk * DCLKDIV<br>If dclk1&dclk2 used, DCLKDIV >=6.<br>If dclk only, DCLKDIV >=1. |

#### 7.2.5.9. TCON0\_BASIC0\_REG (Default Value: 0x00000000)

| Offset: 0x048 |     |             | Register Name: TCON0_BASIC0_REG |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 31:28         | /   | /           | /                               |
| 27:16         | R/W | 0           | TCON0_X<br>Panel width is X+1   |
| 15:12         | /   | /           | /                               |
| 11:0          | R/W | 0           | TCON0_Y<br>Panel height is Y+1  |

#### 7.2.5.10. TCON0\_BASIC1\_REG (Default Value: 0x00000000)

| Offset: 0x04C |     |             | Register Name: TCON0_BASIC1_REG   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:29         | /   | /           | /   |
| 28:16         | R/W | 0           | HT<br>Thcycle = (HT+1) * Tdclk<br>Computation<br>1) parallel: HT = X + BLANK<br>Limitation:<br>1) parallel :HT >= (HBP +1) + (X+1) +2<br>2) serial 1: HT >= (HBP +1) + (X+1) *3+2<br>3) serial 2: HT >= (HBP +1) + (X+1) *3/2+2 |
| 15:12         | /   | /           | /   |
| 11:0          | R/W | 0           | HBP<br>horizontal back porch (in dclk)<br>Thbp = (HBP +1) * Tdclk   |

#### 7.2.5.11. TCON0\_BASIC2\_REG (Default Value: 0x00000000)

| Offset: 0x050 |     |             | Register Name: TCON0_BASIC2_REG |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 31:29         | /   | /           | /                               |
| 28:16         | R/W | 0           | VT                              |

|       |     |   |   |
|-------|-----|---|---|
|       |     |   | $T_{VT} = (V_T)/2 * Thsync$<br>$V_T/2 \geq (VBP+1) + (Y+1) + 2$ |
| 15:12 | /   | / | /   |
| 11:0  | R/W | 0 | VBP<br>$T_{VBP} = (VBP + 1) * Thsync$                           |

#### 7.2.5.12. TCON0\_BASIC3\_REG (Default Value: 0x00000000)

| Offset: 0x054 |     |             | Register Name: TCON0_BASIC3_REG                          |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:26         | /   | /           | /  |
| 25:16         | R/W | 0           | HSPW<br>$Thspw = (HSPW+1) * Tdclk$<br>$HT > (HSPW+1)$    |
| 15:10         | /   | /           | /  |
| 9:0           | R/W | 0           | VSPW<br>$Tvspw = (VSPW+1) * Thsync$<br>$VT/2 > (VSPW+1)$ |

#### 7.2.5.13. TCON0\_HV\_IF\_REG (Default Value: 0x00000000)

| Offset: 0x058 |     |             | Register Name: TCON0_HV_IF_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:28         | R/W | 0           | HV_Mode<br>0000: 24bit/1cycle parallel mode<br>1000: 8bit/3cycle RGB serial mode(RGB888)<br>1010: 8bit/4cycle Dummy RGB(DRGB)<br>1011: 8bit/4cycle RGB Dummy(RGBD)<br>1100: 8bit/2cycle YUV serial mode(CCIR656) |
| 27:26         | R/W | 0           | RGB888_SM0<br>serial RGB888 mode output sequence at odd lines of the panel (line 1, 3, 5, 7...)<br>00: R→G→B<br>01: B→R→G<br>10: G→B→R<br>11: R→G→B  |
| 25:24         | R/W | 0           | RGB888_SM1<br>serial RGB888 mode output sequence at even lines of the panel (line 2, 4, 6, 8...)<br>00: R→G→B<br>01: B→R→G<br>10: G→B→R  |

|       |     |   |  |
|-------|-----|---|--|
|       |     |   | 11: R→G→B  |
| 23:22 | R/W | 0 | <p>YUV_SM<br/>                     serial YUV mode output sequence 2-pixel-pair of every scan line<br/>                     00: YUYV<br/>                     01: YVYU<br/>                     10: UYVY<br/>                     11: VYUY</p> |
| 21:20 | R/W | 0 | <p>YUV EAV/SAV F line delay<br/>                     00:F toggle right after active video line<br/>                     01:delay 2 line(CCIR PAL)<br/>                     10:delay 3 line(CCIR NTSC)<br/>                     11:reserved</p> |
| 19:0  | /   | / | /  |

#### 7.2.5.14. TCON0\_CPU\_IF\_REG (Default Value: 0x00000000)

| Offset: 0x060 |     |             | Register Name: TCON0_CPU_IF_REG   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:28         | R/W | 0           | <p>CPU_Mode<br/>                     0000: 18bit/256K mode<br/>                     0010: 16bit mode0<br/>                     0100: 16bit mode1<br/>                     0110: 16bit mode2<br/>                     1000: 16bit mode3<br/>                     1010: 9bit mode<br/>                     1100: 8bit 256K mode<br/>                     1110: 8bit 65K mode<br/>                     xxx1: 24bit for DSI</p> |
| 27            | /   | /           | /   |
| 26            | R/W | 0           | DA<br>pin A1 value in 8080 mode auto/flash states   |
| 25            | R/W | 0           | CA<br>pin A1 value in 8080 mode WR/RD execute   |
| 24            | /   | /           | /   |
| 23            | R   | 0           | Wr_Flag<br>0:write operation is finishing<br>1:write operation is pending   |
| 22            | R   | 0           | Rd_Flag<br>0:read operation is finishing<br>1:read operation is pending   |
| 21:18         | /   | /           | /   |
| 17            | R/W | 0           | AUTO<br>auto Transfer Mode:<br>If it's 1, all the valid data during this frame are write to panel.  |

|      |     |   |   |
|------|-----|---|---|
|      |     |   | This bit is sampled by Vsync  |
| 16   | R/W | 0 | FLUSH<br>direct transfer mode:<br>If it's enabled, FIFO1 is regardless of the HV timing, pixels data keep being transferred unless the input FIFO was empty.<br>Data output rate control by DCLK. |
| 15:6 | /   | / | /   |
| 5:4  | R/W | 0 | /   |
| 3    | R/W | 0 | Trigger_FIFO_Bist_En<br>0: disable<br>1: enable<br>Entry addr is 0xFF8  |
| 2    | R/W | 0 | Trigger_FIFO_En<br>0:enable<br>1:disable  |
| 1    | R/W | 0 | Trigger_Start<br>write '1' to start a frame flush, write'0' has no effect.<br>this flag indicated frame flush is running<br>software must make sure write '1' only when this flag is '0'.         |
| 0    | R/W | 0 | Trigger_En<br>0: trigger mode disable<br>1: trigger mode enable   |

#### 7.2.5.15. TCON0\_CPU\_WR\_REG (Default Value: 0x00000000)

| Offset: 0x064 |     |             | Register Name: TCON0_CPU_WR_REG   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:24         | /   | /           | /   |
| 23:0          | W   | 0           | Data_Wr<br>data write on 8080 bus, launch a write operation on 8080 bus |

#### 7.2.5.16. TCON0\_CPU\_RD0\_REG (Default Value: 0x00000000)

| Offset: 0x068 |     |             | Register Name: TCON0_CPU_RD0_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:24         | /   | /           | /  |
| 23:0          | R   | /           | Data_Rd0<br>data read on 8080 bus, launch a new read operation on 8080 bus |

**7.2.5.17. TCON0\_CPU\_RD1\_REG (Default Value: 0x00000000)**

| Offset: 0x6C |     |             | Register Name: TCON0_CPU_RD1_REG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:24        | /   | /           | /   |
| 23:0         | R   | /           | Data_Rd1<br>data read on 8080 bus, without a new read operation on 8080 bus |

**7.2.5.18. TCON0\_LVDS\_IF\_REG (Default Value: 0x00000000)**

| Offset: 0x084 |     |             | Register Name: TCON0_LVDS_IF_REG  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31            | R/W | 0           | TCON0_LVDS_En<br>0: disable<br>1: enable  |
| 30            | /   | /           | /   |
| 29            | R/W | 0           | TCON0_LVDS_Even_Odd_Dir<br>0: normal<br>1: reverse  |
| 28            | R/W | 0           | TCON0_LVDS_Dir<br>1: normal<br>2: reverse<br>LVDS direction                                     |
| 27            | R/W | 0           | TCON0_LVDS_Mode<br>0: NS mode<br>1: JEIDA mode  |
| 26            | R/W | 0           | TCON0_LVDS_BitWidth<br>0: 24bit<br>1: 18bit   |
| 25            | R/W | 0           | TCON0_LVDS_DeBug_En<br>0: disable<br>1: enable  |
| 24            | R/W | 0           | TCON0_LVDS_DeBug_Mode<br>0: mode0 RANDOM DATA<br>1: mode1 output CLK period=7/2 LVDS CLK period |
| 23            | R/W | 0           | TCON0_LVDS_Correct_Mode<br>0: mode0<br>1: mode1   |
| 22:21         | /   | /           | /   |
| 20            | R/W | 0           | TCON0_LVDS_Clk_Sel<br>0: MIPI PLL<br>1: TCON0 CLK   |
| 19:5          | /   | /           | /   |

|     |     |   |   |
|-----|-----|---|---|
| 4   | R/W | 0 | TCON0_LVDS_CLK_Polarity<br>0: reverse<br>1: normal  |
| 3:0 | R/W | 0 | TCON0_LVDS_Data_Polarity<br>0: reverse<br>1: normal |

#### 7.2.5.19. TCON0\_IO\_POL\_REG (Default Value: 0x00000000)

| Offset: 0x88 |     |             | Register Name: TCON0_IO_POL_REG   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | IO_Output_Sel<br>0: normal output<br>1: register output<br>when set as '1', d[23:0], io0, io1, io3 sync to dclk   |
| 30:28        | R/W | 0           | DCLK_Sel<br>000: used DCLK0(normal phase offset)<br>001: used DCLK1(1/3 phase offset)<br>010: used DCLK2(2/3 phase offset)<br>101: DCLK0/2 phase 0<br>100: DCLK0/2 phase 90<br>reserved |
| 27           | R/W | 0           | IO3_Inv<br>0: not invert<br>1: invert   |
| 26           | R/W | 0           | IO2_Inv<br>0: not invert<br>1: invert   |
| 25           | R/W | 0           | IO1_Inv<br>0: not invert<br>1: invert   |
| 24           | R/W | 0           | IO0_Inv<br>0: not invert<br>1: invert   |
| 23:0         | R/W | 0           | Data_Inv<br>TCON0 output port D[23:0] polarity control, with independent bit control:<br>0s: normal polarity<br>1s: invert the specify output   |

#### 7.2.5.20. TCON0\_IO\_TRI\_REG (Default Value: 0xFFFFFFFF)

|               |                                 |
|---------------|---------------------------------|
| Offset: 0x08C | Register Name: TCON0_IO_TRI_REG |
|---------------|---------------------------------|

| Bit   | R/W | Default/Hex | Description   |
|-------|-----|-------------|---|
| 31:29 | /   | /           | /   |
| 28    | /   | /           | RGB_Endian<br>0: normal<br>1: bits_invert   |
| 27    | R/W | 1           | IO3_Output_Tri_En<br>1: disable<br>0: enable  |
| 26    | R/W | 1           | IO2_Output_Tri_En<br>1: disable<br>0: enable  |
| 25    | R/W | 1           | IO1_Output_Tri_En<br>1: disable<br>0: enable  |
| 24    | R/W | 1           | IO0_Output_Tri_En<br>1: disable<br>0: enable  |
| 23:0  | R/W | 0xFFFFF     | Data_Output_Tri_En<br>TCON0 output port D[23:0] output enable, with independent bit control:<br>1s: disable<br>0s: enable |

#### 7.2.5.21. TCON\_ECC\_FIFO\_REG (Default Value: 0x00000000)

| Offset: 0x0F8 |     |             | Register Name: TCON_ECC_FIFO_REG   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | R/W | /           | ECC_FIFO_BIST_EN<br>0: disable<br>1: enable  |
| 30            | R/W | /           | ECC_FIFO_ERR_FLAG  |
| 29:24         | /   | /           | /  |
| 23:16         | R/W | /           | ECC_FIFO_ERR_BITS  |
| 15:9          | /   | /           | /  |
| 8             | R/W | 0           | ECC_FIFO_BLANK_EN<br>0: disable ecc function in blanking<br>1: enable ecc function in blanking<br>ECC function is tent to triggered in blanking area at hv mode, set '0' when in hv mode |
| 7:0           | R/W | /           | ECC_FIFO_SETTING<br>bit3 0 enable, 1 disable   |

**7.2.5.22. TCON\_DEBUG\_REG (Default Value: 0x00000000)**

| Offset: 0x0FC |     |             | Register Name: TCON_DEBUG_REG                             |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31            | R/W | /           | TCON0_FIFO_Under_Flow                                     |
| 30            | /   | /           | /   |
| 29            | R   | /           | TCON0_Field_Polarity<br>0: second field<br>1: first field |
| 28            | /   | /           | /   |
| 27:16         | R   | /           | TCON0_Current_Line  |
| 15:14         | /   | /           | /   |
| 13            | R/W | 0           | ECC_FIFO_Bypass<br>0: used<br>1: bypass                   |
| 12:0          | /   | /           | /   |

**7.2.5.23. TCON\_CEU\_CTL\_REG (Default Value: 0x00000000)**

| Offset: 0x100 |     |             | Register Name: TCON_CEU_CTL_REG  |
|---------------|-----|-------------|----------------------------------|
| Bit           | R/W | Default/Hex | Description                      |
| 31            | R/W | 0           | CEU_en<br>0: bypass<br>1: enable |
| 30:0          | /   | /           | /                                |

**7.2.5.24. TCON\_CEU\_COEF\_MUL\_REG (Default Value: 0x00000000)**

| Offset: 0x110+N*0x04<br>(N=0,1,2,4,5,6,8,9,10) |     |             | Register Name: TCON_CEU_COEF_MUL_REG  |
|--|-----|-------------|---|
| Bit  | R/W | Default/Hex | Description   |
| 31:13  | /   | /           | /   |
| 12:0   | R/W | 0           | CEU_Coef_Mul_Value<br>signed 13bit value, range of (-16,16)<br>N=0: Rr<br>N=1: Rg<br>N=2: Rb<br>N=4: Gr<br>N=5: Gg<br>N=6: Gb<br>N=8: Br<br>N=9: Bg |

|  |  |  |          |
|--|--|--|----------|
|  |  |  | N=10: Bb |
|--|--|--|----------|

**7.2.5.25. TCON\_CEU\_COEF\_ADD\_REG (Default Value: 0x00000000)**

| Offset: 0x11C+N*0x10<br>(N=0,1,2) |     |             | Register Name: <b>TCON_CEU_COEF_ADD_REG</b>   |
|-----------------------------------|-----|-------------|---|
| Bit                               | R/W | Default/Hex | Description   |
| 31:19                             | /   | /           | /   |
| 18:0                              | R/W | 0           | CEU_Coef_Add_Value<br>signed 19bit value, range of (-16384, 16384)<br>N=0: Rc<br>N=1: Gc<br>N=2: Bc |

**7.2.5.26. TCON\_CEU\_COEF\_RANG\_REG (Default Value: 0x00000000)**

| Offset: 0x140+N*0x04<br>(N=0,1,2) |     |             | Register Name: <b>TCON_CEU_COEF_RANG_REG</b>                |
|-----------------------------------|-----|-------------|---|
| Bit                               | R/W | Default/Hex | Description   |
| 31:24                             | /   | /           | /   |
| 23:16                             | R/W | 0           | CEU_Coef_Range_Min<br>unsigned 8bit value, range of [0,255] |
| 15:8                              | /   | /           | /   |
| 7:0                               | R/W | 0           | CEU_Coef_Range_Max<br>unsigned 8bit value, range of [0,255] |

**7.2.5.27. TCON0\_CPU\_TRI0\_REG (Default Value: 0x00000000)**

| Offset: 0x160 |     |             | Register Name: <b>TCON0_CPU_TRI0_REG</b>     |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description                                  |
| 31:28         | /   | /           | /  |
| 27:16         | R/W | 0           | Block_Space<br>should be set >20*pixel_cycle |
| 15:12         | /   | /           | /  |
| 11:0          | R/W | 0           | Block_Size                                   |

**7.2.5.28. TCON0\_CPU\_TRI1\_REG (Default Value: 0x00000000)**

|               |  |
|---------------|--|
| Offset: 0x164 | Register Name: <b>TCON0_CPU_TRI1_REG</b> |
|---------------|--|

| Bit   | R/W | Default/Hex | Description       |
|-------|-----|-------------|-------------------|
| 31:16 | R   | 0           | Block_Current_Num |
| 15:0  | R/W | 0           | Block_Num         |

#### 7.2.5.29. TCON0\_CPU\_TRI2\_REG (Default Value: 0x00200000)

| Offset: 0x168 |     |             | Register Name: TCON0_CPU_TRI2_REG                       |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:16         | R/W | 0x20        | Start_Delay<br>Tdly = (Start_Delay +1) * be_clk*8       |
| 15            | R/W | 0           | Trans_Start_Mode<br>0: ecc_fifo+tri_fifo<br>1: tri_fifo |
| 14:13         | R/W | 0           | Sync_Mode<br>0x: auto<br>10: 0<br>11: 1                 |
| 12:0          | R/W | 0           | Trans_Start_Set   |

#### 7.2.5.30. TCON0\_CPU\_TRI3\_REG (Default Value: 0x00000000)

| Offset: 0x16C |     |             | Register Name: TCON0_CPU_TRI3_REG   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:30         | /   | /           | /   |
| 29:28         | R/W | 0           | Tri_Int_Mode<br>00: disable<br>01: counter mode<br>10: te rising mode<br>11: te falling mode<br>when set as 01, Tri_Counter_Int occur in cycle of<br>(Count_N+1)×(Count_M+1)×4 dclk.<br>when set as 10 or 11, io0 is map as TE input. |
| 27:24         | /   | /           | /   |
| 23:8          | R/W | 0           | Counter_N   |
| 7:0           | R/W | 0           | Counter_M   |

#### 7.2.5.31. TCON\_CMAP\_CTL\_REG (Default Value: 0x00000000)

| Offset: 0x180 |     |             | Register Name: TCON_CMAP_CTL_REG |
|---------------|-----|-------------|----------------------------------|
| Bit           | R/W | Default/Hex | Description                      |
| 31            | R/W | 0           | Color_Map_En                     |

|      |     |   |  |
|------|-----|---|--|
|      |     |   | 0: bypass<br>1: enable<br>This module only work when X is divided by 4                                     |
| 30:1 | /   | / | /  |
| 0    | R/W | 0 | Out_Format<br>0: 4 pixel output mode: Out0 -> Out1 -> Out2 -> Out3<br>1: 2 pixel output mode: Out0 -> Out1 |

#### 7.2.5.32. TCON\_CMAP\_ODD0\_REG (Default Value: 0x00000000)

| Offset: 0x190 |     |             | Register Name: TCON_CMAP_ODD0_REG   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:16         | R/W | 0           | Out_Odd1  |
| 15:0          | R/W | 0           | Out_Odd0<br>bit15-12: Reservd<br>bit11-08: Out_Odd0[23:16]<br>bit07-04: Out_Odd0[15:8]<br>bit03-00: Out_Odd0[7:0]<br>0x0: in_b0<br>0x1: in_g0<br>0x2: in_r0<br>0x3: reservd<br>0x4: in_b1<br>0x5: in_g1<br>0x6: in_r1<br>0x7: reservd<br>0x8: in_b2<br>0x9: in_g2<br>0xa: in_r2<br>0xb: reservd<br>0xc: in_b3<br>0xd: in_g3<br>0xe: in_r3<br>0xf: reservd |

#### 7.2.5.33. TCON\_CMAP\_ODD1\_REG (Default Value: 0x00000000)

| Offset: 0x194 |     |             | Register Name: TCON_CMAP_ODD1_REG |
|---------------|-----|-------------|-----------------------------------|
| Bit           | R/W | Default/Hex | Description                       |
| 31:16         | R/W | 0           | Out_Odd3                          |
| 15:0          | R/W | 0           | Out_Odd2                          |

**7.2.5.34. TCON\_CMAP\_EVEN0\_REG (Default Value: 0x00000000)**

| Offset: 0x198 |     |             | Register Name: TCON_CMAP_EVEN0_REG |
|---------------|-----|-------------|------------------------------------|
| Bit           | R/W | Default/Hex | Description                        |
| 31:16         | R/W | 0           | Out_Even1                          |
| 15:0          | R/W | 0           | Out_Even0                          |

**7.2.5.35. TCON\_CMAP\_EVEN1\_REG (Default Value: 0x00000000)**

| Offset: 0x19C |     |             | Register Name: TCON_CMAP_EVEN1_REG |
|---------------|-----|-------------|------------------------------------|
| Bit           | R/W | Default/Hex | Description                        |
| 31:16         | R/W | 0           | Out_Even3                          |
| 15:0          | R/W | 0           | Out_Even2                          |

**7.2.5.36. TCON0\_LVDS\_ANA0\_REG (Default Value: 0x00000000)**

| Offset: 0x220 |     |             | Register Name: TCON_LVDS_ANA0_REG  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31            | R/W | 0           | lvds0_en_mb<br>enable the bias circuit of the LVDS_Ana module  |
| 30            | R/W | 0           | lvds0_en_ldo   |
| 29:25         | /   | /           | /  |
| 24            | R/W | 0           | lvds0_en_drvc<br>enable all circuits working when transmitting the data in channel clock of LVDS_tx0   |
| 23:20         | R/W | 0           | lvds0_en_drv<br>enable all circuits working when transmitting the data in channel<3:0> of LVDS_tx0   |
| 19            | /   | /           | /  |
| 18:17         | R/W | 0           | lvds0_reg_c<br>adjust current flowing through Rload of Rx to change the differential signals amplitude<br>0:250mV 1:300mV<br>2:350mV 3:400mV |
| 16            | R/W | 0           | lvds0_reg_denc<br>choose data output or PLL test clock output in LVDS_tx   |
| 15:12         | R/W | 0           | lvds0_reg_den<br>choose data output or PLL test clock output in LVDS_tx  |
| 11:10         | /   | /           | /  |
| 9:8           | R/W | 0           | lvds0_reg_v<br>adjust common mode voltage of the differential signals in five channels<br>single signal high level:                          |

|     |     |   |  |
|-----|-----|---|--|
|     |     |   | 0:1.1V      1:1.19V<br>2:1.3V      3:1.43V   |
| 7:6 | /   | / | /  |
| 5:4 | R/W | 0 | lvds0_reg_pd<br>fine adjust the slew rate of output data                           |
| 3:2 | /   | / | /  |
| 1   | R/W | 0 | lvds0_reg_pwslv<br>adjust voltage amplitude of low power in LVDS_Ana               |
| 0   | R/W | 0 | lvds0_reg_pwsmb<br>adjust voltage amplitude of mbias voltage reference in LVDS_Ana |

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# Chapter 8 Interfaces

This chapter describes the R11 interfaces, including:

- TWI
- SPI
- UART
- USB
- EMAC
- I2S/PCM

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## 8.1. TWI

### 8.1.1. Overview

This TWI Controller is designed to be used as an interface between CPU host and the serial TWI bus. It can support all the standard TWI transfer, including Slave and Master. The communication to the TWI bus is carried out on a byte-wise basis using interrupt or polled handshaking. This TWI Controller can be operated in standard mode (100 kbit/s) or fast-mode, supporting data rate up to 400 kbit/s. The 10-bit addressing mode is supported for this specified application. General Call Addressing is also supported in Slave mode.

The TWI Controller includes the following features:

- Software-programmable for Slave or Master
- Supports repeated START signal
- Allow 10-bit addressing with TWI bus
- Performs arbitration and clock synchronization
- Own address and general call address detection
- Interrupt on address detection
- Supports speeds up to 400 Kbit/s ('fast mode')
- Allow operation from a wide range of input clock frequency

### 8.1.2. Timing Diagram

Data transferred are always in a unit of 8-bit (byte), followed by an acknowledge bit. The number of bytes that can be transmitted per transfer is unrestricted. Data is transferred in serial with the MSB first. Between each byte of data transfer, a receiver device will hold the clock line SCL low to force the transmitter into a wait state while waiting the response from microprocessor.

Data transfer with acknowledge is obligatory. The clock line is driven by the master all the time, including the acknowledge-related clock cycle, except for the SCL holding between each byte. After sending each byte, the transmitter releases the SDA line to allow the receiver to pull down the SDA line and send an acknowledge signal (or leave it high to send a "not acknowledge") to the transmitter.

When a slave receiver doesn't acknowledge the slave address (unable to receive because of no resource available), the data line must be left high by the slave so that the master can then generate a STOP condition to abort the transfer. Slave receiver can also indicate not to want to send more data during a transfer by leave the acknowledge signal high. And the master should generate the STOP condition to abort the transfer.

Below diagram provides an illustration the relation of SDA signal line and SCL signal line on the TWI serial bus.

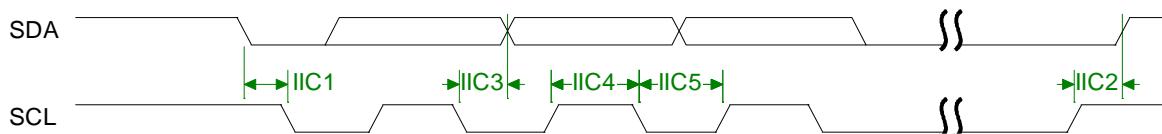


Figure 8-1 . TWI Timing Diagram

### 8.1.3. TWI Controller Special Requirement

#### 8.1.3.1. TWI Pin List

| Port Name | Width | Direction | Description          |
|-----------|-------|-----------|----------------------|
| TWI_SCL   | 1     | IN/OUT    | TWI Clock line       |
| TWI_SDA   | 1     | IN/OUT    | TWI Serial Data line |

#### 8.1.3.2. TWI Controller Operation

There are four operation modes on the TWI bus which dictates the communications method. They are Master Transmit, Master Receive, Slave Transmit and Slave Receive. In general, CPU host controls TWI by writing commands and data to its registers. The TWI interrupts the CPU host for the attention each time a byte transfer is done or a START/STOP conditions is detected. The CPU host can also poll the status register for current status if the interrupt mechanism is not disabled by the CPU host.

When the CPU host wants to start a bus transfer, it initiates a bus START to enter the master mode by setting IM\_STA bit in the 2WIRE\_CNTR register to high (before it must be low). The TWI will assert INT line and INT\_FLAG to indicate a completion for the START condition and each consequent byte transfer. At each interrupt, the micro-processor needs to check the 2WIRE\_STAT register for current status. A transfer has to be concluded with STOP condition by setting M\_STP bit high.

In Slave Mode, the TWI also constantly samples the bus and look for its own slave address during addressing cycles. Once a match is found, it is addressed and interrupt the CPU host with the corresponding status. Upon request, the CPU host should read the status, read/write 2WIRE\_DATA data register, and set the 2WIRE\_CNTR control register. After each byte transfer, a slave device always halt the operation of remote master by holding the next low pulse on SCL line until the microprocessor responds to the status of previous byte transfer or START condition.

### 8.1.4. TWI Controller Register List

| Module Name | Base Address |
|-------------|--------------|
| TWI0        | 0x01C2AC00   |

|      |            |
|------|------------|
| TWI1 | 0x01C2B000 |
|------|------------|

| Register Name | Offset | Description                  |
|---------------|--------|------------------------------|
| TWI_ADDR      | 0x0000 | TWI Slave address            |
| TWI_XADDR     | 0x0004 | TWI Extended slave address   |
| TWI_DATA      | 0x0008 | TWI Data byte                |
| TWI_CNTR      | 0x000C | TWI Control register         |
| TWI_STAT      | 0x0010 | TWI Status register          |
| TWI_CCR       | 0x0014 | TWI Clock control register   |
| TWI_SRST      | 0x0018 | TWI Software reset           |
| TWI_EFR       | 0x001C | TWI Enhance Feature register |
| TWI_LCR       | 0x0020 | TWI Line Control register    |

### 8.1.5. TWI Controller Register Description

#### 8.1.5.1. TWI Slave Address Register(Default Value: 0x00000000)

| Offset: 0x00 |     |             | Register Name: TWI_ADDR   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:8         | /   | /           | /   |
| 7:1          | R/W | 0           | SLA<br>Slave address<br><ul style="list-style-type: none"> <li>7-bit addressing<br/>SLA6, SLA5, SLA4, SLA3, SLA2, SLA1, SLA0</li> <li>10-bit addressing<br/>1, 1, 1, 1, 0, SLAX[9:8]</li> </ul> |
| 0            | R/W | 0           | GCE<br>General call address enable<br>0: Disable<br>1: Enable   |

For 7-bit addressing:

SLA6 – SLA0 is the 7-bit address of the TWI when in slave mode. When the TWI receives this address after a START condition, it will generate an interrupt and enter slave mode. (SLA6 corresponds to the first bit received from the TWI bus.) If GCE is set to ‘1’, the TWI will also recognize the general call address (00h).

For 10-bit addressing:

When the address received starts with 11110b, the TWI recognizes this as the first part of a 10-bit address and if the next two bits match ADDR[2:1] (i.e. SLAX9 and SLAX8 of the device’s extended address), it sends an ACK. (The device does not generate an interrupt at this point.) If the next byte of the address matches the XADDR register (SLAX7 – SLAX0), the TWI generates an interrupt and goes into slave mode.

#### 8.1.5.2. TWI Extend Address Register(Default Value: 0x00000000)

| Offset: 0x04 |     |             | Register Name: <b>TWI_XADDR</b>           |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description                               |
| 31:8         | /   | /           | /   |
| 7:0          | R/W | 0           | SLAX<br>Extend Slave Address<br>SLAX[7:0] |

#### 8.1.5.3. TWI Data Register(Default Value: 0x00000000)

| Offset: 0x08 |     |             | Register Name: <b>TWI_DATA</b>                     |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:8         | /   | /           | /  |
| 7:0          | R/W | 0           | TWI_DATA<br>Data byte for transmitting or received |

#### 8.1.5.4. TWI Control Register(Default Value: 0x00000000)

| Offset: 0x0C |     |             | Register Name: <b>TWI_CNTR</b>   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:8         | /   | /           | /  |
| 7            | R/W | 0           | INT_EN<br>Interrupt Enable<br>1'b0: The interrupt line always low<br>1'b1: The interrupt line will go high when INT_FLAG is set.   |
| 6            | R/W | 0           | BUS_EN<br>TWI Bus Enable<br>1'b0: The TWI bus inputs ISDA/ISCL are ignored and the TWI Controller will not respond to any address on the bus<br>1'b1: The TWI will respond to calls to its slave address – and to the general call address if the GCE bit in the ADDR register is set.<br><br> <b>NOTE</b><br><b>In master operation mode, this bit should be set to '1'.</b> |
| 5            | R/W | 0           | M_STA<br>Master Mode Start<br>When M_STA is set to '1', TWI Controller enters master mode and will transmit a START condition on the bus when the bus is free. If the M_STA bit is set to '1' when the TWI Controller is already in master mode and one or more bytes have been transmitted, then a repeated START condition will be sent. If the M_STA bit is set to '1' when the TWI is being accessed in slave  |

|     |     |   |   |
|-----|-----|---|---|
|     |     |   | mode, the TWI will complete the data transfer in slave mode then enter master mode when the bus has been released.<br>The M_STA bit is cleared automatically after a START condition has been sent: writing a '0' to this bit has no effect.  |
| 4   | R/W | 0 | M_STP<br><br>Master Mode Stop<br><br>If M_STP is set to '1' in master mode, a STOP condition is transmitted on the TWI bus. If the M_STP bit is set to '1' in slave mode, the TWI will behave as if a STOP condition has been received, but no STOP condition will be transmitted on the TWI bus. If both M_STA and M_STP bits are set, the TWI will first transmit the STOP condition (if in master mode) then transmit the START condition.<br><br>The M_STP bit is cleared automatically: writing a '0' to this bit has no effect.   |
| 3   | R/W | 0 | INT_FLAG<br><br>Interrupt Flag<br><br>INT_FLAG is automatically set to '1' when any of 28 (out of the possible 29) states is entered (see 'STAT Register' below). The only state that does not set INT_FLAG is state F8h. If the INT_EN bit is set, the interrupt line goes high when IFLG is set to '1'. If the TWI is operating in slave mode, data transfer is suspended when INT_FLAG is set and the low period of the TWI bus clock line (SCL) is stretched until '1' is written to INT_FLAG. The TWI clock line is then released and the interrupt line goes low.   |
| 2   | R/W | 0 | A_ACK<br><br>Assert Acknowledge<br><br>When A_ACK is set to '1', an Acknowledge (low level on SDA) will be sent during the acknowledge clock pulse on the TWI bus if:<br><ol style="list-style-type: none"> <li>1. Either the whole of a matching 7-bit slave address or the first or the second byte of a matching 10-bit slave address has been received.</li> <li>2. The general call address has been received and the GCE bit in the ADDR register is set to '1'.</li> <li>3. A data byte has been received in master or slave mode.</li> </ol><br>When A_ACK is '0', a Not Acknowledge (high level on SDA) will be sent when a data byte is received in master or slave mode.<br><br>If A_ACK is cleared to '0' in slave transmitter mode, the byte in the DATA register is assumed to be the 'last byte'. After this byte has been transmitted, the TWI will enter state C8h then return to the idle state (status code F8h) when INT_FLAG is cleared.<br><br>The TWI will not respond as a slave unless A_ACK is set. |
| 1:0 | R/W | 0 | /   |

#### 8.1.5.5. TWI Status Register(Default Value: 0x000000F8)

| Offset: 0x10 |     | Register Name: <b>TWI_STAT</b> |             |
|--------------|-----|--------------------------------|-------------|
| Bit          | R/W | Default/Hex                    | Description |
|              |     |                                |             |

|      |   |      |   |
|------|---|------|---|
| 31:8 | / | /    | /   |
| 7:0  | R | 0xF8 | <p>STA</p> <p>Status Information Byte</p> <p>Code Status</p> <p>0x00: Bus error</p> <p>0x08: START condition transmitted</p> <p>0x10: Repeated START condition transmitted</p> <p>0x18: Address + Write bit transmitted, ACK received</p> <p>0x20: Address + Write bit transmitted, ACK not received</p> <p>0x28: Data byte transmitted in master mode, ACK received</p> <p>0x30: Data byte transmitted in master mode, ACK not received</p> <p>0x38: Arbitration lost in address or data byte</p> <p>0x40: Address + Read bit transmitted, ACK received</p> <p>0x48: Address + Read bit transmitted, ACK not received</p> <p>0x50: Data byte received in master mode, ACK transmitted</p> <p>0x58: Data byte received in master mode, not ACK transmitted</p> <p>0x60: Slave address + Write bit received, ACK transmitted</p> <p>0x68: Arbitration lost in address as master, slave address + Write bit received, ACK transmitted</p> <p>0x70: General Call address received, ACK transmitted</p> <p>0x78: Arbitration lost in address as master, General Call address received, ACK transmitted</p> <p>0x80: Data byte received after slave address received, ACK transmitted</p> <p>0x88: Data byte received after slave address received, not ACK transmitted</p> <p>0x90: Data byte received after General Call received, ACK transmitted</p> <p>0x98: Data byte received after General Call received, not ACK transmitted</p> <p>0xA0: STOP or repeated START condition received in slave mode</p> <p>0xA8: Slave address + Read bit received, ACK transmitted</p> <p>0xB0: Arbitration lost in address as master, slave address + Read bit received, ACK transmitted</p> <p>0xB8: Data byte transmitted in slave mode, ACK received</p> <p>0xC0: Data byte transmitted in slave mode, ACK not received</p> <p>0xC8: Last byte transmitted in slave mode, ACK received</p> <p>0xD0: Second Address byte + Write bit transmitted, ACK received</p> <p>0xD8: Second Address byte + Write bit transmitted, ACK not received</p> <p>0xF8: No relevant status information, INT_FLAG=0</p> <p>Others: Reserved</p> |

#### 8.1.5.6. TWI Clock Register(Default Value: 0x00000000)

| Offset: 0x14 |     |             | Register Name: TWI_CCR |
|--------------|-----|-------------|------------------------|
| Bit          | R/W | Default/Hex | Description            |
| 31:7         | /   | /           | /                      |
| 6:3          | R/W | 0           | CLK_M                  |

|     |     |   |  |
|-----|-----|---|--|
| 2:0 | R/W | 0 | <b>CLK_N</b><br>The TWI bus is sampled by the TWI at the frequency defined by F0:<br>$F_{amp} = F_0 = Fin / 2^{CLK\_N}$<br>The TWI OSCL output frequency, in master mode, is $F1 / 10$ :<br>$F1 = F0 / (CLK\_M + 1)$<br>$F_{oscl} = F1 / 10 = Fin / (2^{CLK\_N} * (CLK\_M + 1) * 10)$<br>For Example:<br>$Fin = 48\text{Mhz}$ (APB clock input)<br>For 400kHz full speed 2Wire, $CLK\_N = 2$ , $CLK\_M=2$<br>$F0 = 48\text{M}/2^2=12\text{Mhz}$ , $F1= F0/(10*(2+1)) = 0.4\text{Mhz}$<br>For 100Khz standard speed 2Wire, $CLK\_N=2$ , $CLK\_M=11$<br>$F0=48\text{M}/2^2=12\text{Mhz}$ , $F1=F0/(10*(11+1)) = 0.1\text{Mhz}$ |
|-----|-----|---|--|

#### 8.1.5.7. TWI Soft Reset Register(Default Value: 0x00000000)

| Offset: 0x18 |     |             | Register Name: <b>TWI_SRST</b>   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:1         | /   | /           | /  |
| 0            | R/W | 0           | <b>SOFT_RST</b><br>Soft Reset<br>Write '1' to this bit to reset the TWI and clear to '0' when completing Soft Reset operation. |

#### 8.1.5.8. TWI Enhance Feature Register(Default Value: 0x00000000)

| Offset: 0x1C |     |             | Register Name: <b>TWI_EFR</b>  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:2         | /   | /           | /  |
| 0:1          | R/W | 0           | <b>DBN</b><br>Data Byte number follow Read Command Control<br>0— No Data Byte to be written after read command<br>1— Only 1 byte data to be written after read command<br>2— 2 bytes data can be written after read command<br>3— 3 bytes data can be written after read command |

#### 8.1.5.9. TWI Line Control Register(Default Value: 0x0000003A)

| Offset: 0x20 |     |             | Register Name: <b>TWI_LCR</b> |
|--------------|-----|-------------|-------------------------------|
| Bit          | R/W | Default/Hex | Description                   |

|      |     |   |  |
|------|-----|---|--|
| 31:6 | /   | / | /  |
| 5    | R   | 1 | <b>SCL_STATE</b><br>Current state of TWI_SCL<br>0 - low<br>1 - high  |
| 4    | R   | 1 | <b>SDA_STATE</b><br>Current state of TWI_SDA<br>0 - low<br>1 - high  |
| 3    | R/W | 1 | <b>SCL_CTL</b><br>TWI_SCL line state control bit<br>When line control mode is enabled (bit[2] set), value of this bit decide the output level of TWI_SCL<br>0 – output low level<br>1 – output high level            |
| 2    | R/W | 0 | <b>SCL_CTL_EN</b><br>TWI_SCL line state control enable<br>When this bit is set, the state of TWI_SCL is control by the value of bit[3].<br>0-disable TWI_SCL line control mode<br>1-enable TWI_SCL line control mode |
| 1    | R/W | 1 | <b>SDA_CTL</b><br>TWI_SDA line state control bit<br>When line control mode is enabled (bit[0] set), value of this bit decide the output level of TWI_SDA<br>0 – output low level<br>1 – output high level            |
| 0    | R/W | 0 | <b>SDA_CTL_EN</b><br>TWI_SDA line state control enable<br>When this bit is set, the state of TWI_SDA is control by the value of bit[1].<br>0-disable TWI_SDA line control mode<br>1-enable TWI_SDA line control mode |

## 8.2. SPI

### 8.2.1. Overview

The SPI is the Serial Peripheral Interface which allows rapid data communication with fewer software interrupts. It can interface with up to four slave external devices or one single external master. The SPI module contains one 64x8 receiver buffer (RXFIFO) and one 64x8 transmit buffer (TXFIFO). It can work at two modes: Master mode and Slave mode.

The SPI includes the following features:

- Full-duplex synchronous serial interface
- Master/slave configurable
- Programmable clock granularity
- 8-bit wide by 64-entry FIFO for both transmit and receive date
- Polarity and phase of the Chip Select (SPI\_SS) are configurable

### 8.2.2. SPI Timing Diagram

The serial peripheral interface master uses the SPI\_SCLK signal to transfer data in and out of the shift register. Data is clocked using any one of four programmable clock phase and polarity combinations.

During Phase 0, Polarity 0 and Phase 1, Polarity 1 operations, output data changes on the falling clock edge and input data is shifted in on the rising edge.

During Phase 1, Polarity 0 and Phase 0, Polarity 1 operations, output data changes on the rising edges of the clock and is shifted in on falling edges.

The POL defines the signal polarity when SPI\_SCLK is in idle state. The SPI\_SCLK is high level when POL is '1' and it is low level when POL is '0'. The PHA decides whether the leading edge of SPI\_SCLK is used for setup or sample data. The leading edge is used for setup data when PHA is '1' and for sample data when PHA is '0'. The four kind of modes are listed below:

Table 8-1. Four Mode of SPI

| SPI Mode | POL | PHA | Leading Edge    | Trailing Edge   |
|----------|-----|-----|-----------------|-----------------|
| 0        | 0   | 0   | Rising, Sample  | Falling, Setup  |
| 1        | 0   | 1   | Rising, Setup   | Falling, Sample |
| 2        | 1   | 0   | Falling, Sample | Rising, Setup   |
| 3        | 1   | 1   | Falling, Setup  | Rising, Sample  |

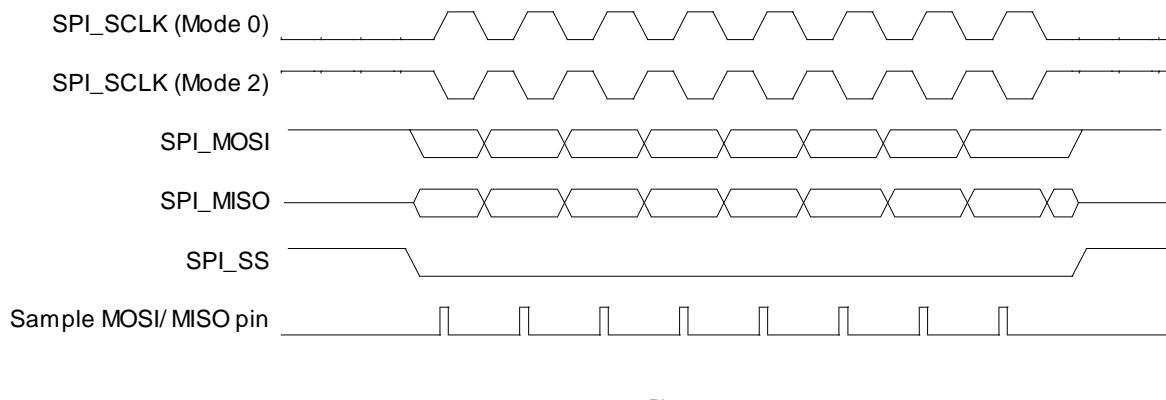


Figure 8-2 . SPI Phase 0 Timing Diagram

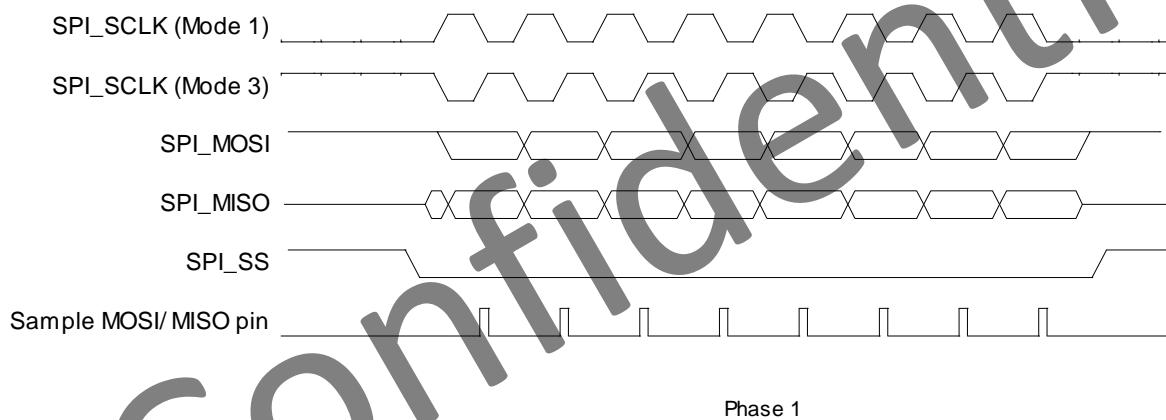


Figure 8-3. SPI Phase 1 Timing Diagram

### 8.2.3. SPI Special Requirement

#### 8.2.3.1. SPI Pin List

The direction of SPI pin is different in two work modes: Master Mode and Slave Mode.

Table 8-2. SPI Pin Description

| Port Name | Width | Direction(M) | Direction(S) | Description                               |
|-----------|-------|--------------|--------------|---|
| SPI_SCLK  | 1     | OUT          | IN           | SPI Clock                                 |
| SPI_MOSI  | 1     | OUT          | IN           | SPI Master Output Slave Input Data Signal |
| SPI_MISO  | 1     | IN           | OUT          | SPI Master Input Slave Output Data Signal |

|        |   |     |    |                        |
|--------|---|-----|----|------------------------|
| SPI_CS | 1 | OUT | IN | SPI Chip Select Signal |
|--------|---|-----|----|------------------------|

### 8.2.3.2. SPI Module Clock Source and Frequency

The SPI Controller get three different clocks, users can select one of them to make SPI Clock Source. The SPI\_SCLK can in the range from 3 kHz to 100 MHz. The following table describes the clock sources for SPI Controller. Users can see **Clock Controller Unit(CCU)** in chapter4 for clock setting, configuration and gating information.

Table 8-3. SPI Clock Sources

| Clock Name  | Description                               |
|-------------|---|
| OSC24M      | 24MHz Crystal                             |
| PLL_PERIPH0 | Peripheral Clock, default value is 600MHz |
| PLL_PERIPH1 | Peripheral Clock, default value is 600MHz |

### 8.2.4. SPI Register List

| Module Name | Base Address |
|-------------|--------------|
| SPI0        | 0x01C68000   |

| Register Name | Offset | Description                     |
|---------------|--------|---------------------------------|
| SPI_GCR       | 0x04   | SPI Global Control Register     |
| SPI_TCR       | 0x08   | SPI Transfer Control Register   |
| /             | 0x0C   | reserved                        |
| SPI_IER       | 0x10   | SPI Interrupt Control Register  |
| SPI_ISR       | 0x14   | SPI Interrupt Status Register   |
| SPI_FCR       | 0x18   | SPI FIFO Control Register       |
| SPI_FSR       | 0x1C   | SPI FIFO Status Register        |
| SPI_WCR       | 0x20   | SPI Wait Clock Counter Register |
| SPI_CCR       | 0x24   | SPI Clock Rate Control Register |
| /             | 0x28   | reserved                        |
| /             | 0x2C   | reserved                        |
| SPI_MBC       | 0x30   | SPI Burst Counter Register      |
| SPI_MTC       | 0x34   | SPI Transmit Counter Register   |
| SPI_BCC       | 0x38   | SPI Burst Control Register      |
| SPI_TXD       | 0x200  | SPI TX Data Register            |
| SPI_RXD       | 0x300  | SPI RX Data Register            |

## 8.2.5. SPI Register Description

### 8.2.5.1. SPI Global Control Register(Default Value: 0x00000080)

| Offset: 0x04 |     |             | Register Name: SPI_CTL   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | R/W | 0           | <b>SRST</b><br>Soft reset<br>Write '1' to this bit will clear the SPI controller, and auto clear to '0' when reset operation completes<br>Write '0' has no effect.   |
| 30:8         | /   | /           | /  |
| 7            | R/W | 1           | <b>TP_EN</b><br>Transmit Pause Enable<br>In master mode, it is used to control transmit state machine to stop smart burst sending when RX FIFO is full.<br>1 – stop transmit data when RXFIFO full<br>0 – normal operation, ignore RXFIFO status<br>Can't be written when XCH=1. |
| 6:2          | /   | /           | /  |
| 1            | R/W | 0           | <b>MODE</b><br>SPI Function Mode Select<br>0: Slave Mode<br>1: Master Mode<br>Can't be written when XCH=1  |
| 0            | R/W | 0           | <b>EN</b><br>SPI Module Enable Control<br>0: Disable<br>1: Enable  |

### 8.2.5.2. SPI Transfer Control Register(Default Value: 0x00000087)

| Offset: 0x08 |     |             | Register Name: SPI_INTCTL   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0x0         | <b>XCH</b><br>Exchange Burst<br>In master mode it is used to start SPI burst<br>0: Idle<br>1: Initiates exchange.<br>Write "1" to this bit will start the SPI burst, and will auto clear after finishing the bursts transfer specified by BC. Write "1" to SRST will also clear this bit.<br>Write '0' to this bit has no effect. |

|       |     |     |   |
|-------|-----|-----|---|
|       |     |     | Can't be written when XCH=1.  |
| 30:14 | /   | /   | /   |
| 13    | R/W | 0x0 | <p>SDM<br/>Master Sample Data Mode<br/>0 - Delay Sample Mode<br/>1 - Normal Sample Mode<br/>In Normal Sample Mode, SPI master samples the data at the correct edge for each SPI mode;<br/>In Delay Sample Mode, SPI master samples data at the edge that is half cycle delayed by the correct edge defined in respective SPI mode.</p>  |
| 12    | R/W | 0x0 | <p>FBS<br/>First Transmit Bit Select<br/>0: MSB first<br/>1: LSB first<br/>Can't be written when XCH=1.</p>   |
| 11    | R/W | 0x0 | <p>SDC<br/>Master Sample Data Control<br/>Set this bit to '1' to make the internal read sample point with a delay of half cycle of SPI_CLK. It is used in high speed read operation to reduce the error caused by the time delay of SPI_CLK propagating between master and slave.<br/>0 – normal operation, do not delay internal read sample point<br/>1 – delay internal read sample point<br/>Can't be written when XCH=1.</p> |
| 10    | R/W | 0x0 | <p>RPSM<br/>Rapids mode select<br/>Select Rapids mode for high speed write.<br/>0: normal write mode<br/>1: rapids write mode<br/>Can't be written when XCH=1.</p>  |
| 9     | R/W | 0x0 | <p>DDB<br/>Dummy Burst Type<br/>0: The bit value of dummy SPI burst is zero<br/>1: The bit value of dummy SPI burst is one<br/>Can't be written when XCH=1.</p>   |
| 8     | R/W | 0x0 | <p>DHB<br/>Discard Hash Burst<br/>In master mode it controls whether discarding unused SPI bursts<br/>0: Receiving all SPI bursts in BC period<br/>1: Discard unused SPI bursts, only fetching the SPI bursts during dummy burst period. The bursts number is specified by TC.<br/>Can't be written when XCH=1.</p>   |
| 7     | R/W | 0x1 | <p>SS_LEVEL<br/>When control SS signal manually (SPI_CTRL_REG.SS_CTRL==1), set this bit to '1' or '0' to control the level of SS signal.<br/>0: set SS to low</p>   |

|     |     |     |   |
|-----|-----|-----|---|
|     |     |     | 1: set SS to high<br>Can't be written when XCH=1.   |
| 6   | R/W | 0x0 | SS_OWNER<br>SS Output Owner Select<br>Usually, controller sends SS signal automatically with data together. When this bit is set to 1, software must manually write SPI_CTL_REG.SS_LEVEL to 1 or 0 to control the level of SS signal.<br>0: SPI controller<br>1: Software<br>Can't be written when XCH=1. |
| 5:4 | R/W | 0x0 | SS_SEL<br>SPI Chip Select<br>Select one of four external SPI Master/Slave Devices<br>00: SPI_SS0 will be asserted<br>01: SPI_SS1 will be asserted<br>10: SPI_SS2 will be asserted<br>11: SPI_SS3 will be asserted<br>Can't be written when XCH=1.   |
| 3   | R/W | 0x0 | SSCTL<br>In master mode, this bit selects the output wave form for the SPI_SSx signal.<br>Only valid when SS_OWNER = 0.<br>0: SPI_SSx remains asserted between SPI bursts<br>1: Negate SPI_SSx between SPI bursts<br>Can't be written when XCH=1.   |
| 2   | R/W | 0x1 | SPOL<br>SPI Chip Select Signal Polarity Control<br>0: Active high polarity (0 = Idle)<br>1: Active low polarity (1 = Idle)<br>Can't be written when XCH=1.  |
| 1   | R/W | 0x1 | CPOL<br>SPI Clock Polarity Control<br>0: Active high polarity (0 = Idle)<br>1: Active low polarity (1 = Idle)<br>Can't be written when XCH=1.   |
| 0   | R/W | 0x1 | CPHA<br>SPI Clock/Data Phase Control<br>0: Phase 0 (Leading edge for sample data)<br>1: Phase 1 (Leading edge for setup data)<br>Can't be written when XCH=1.   |

#### 8.2.5.3. SPI Interrupt Control Register(Default Value: 0x00000000)

| Offset: 0x10 |     |             | Register Name: SPI_IER |
|--------------|-----|-------------|------------------------|
| Bit          | R/W | Default/Hex | Description            |
|              |     |             |                        |

|       |     |     |   |
|-------|-----|-----|---|
| 31:14 | R   | 0x0 | Reserved.   |
| 13    | R/W | 0x0 | <b>SS_INT_EN</b><br>SSI Interrupt Enable<br>Chip Select Signal (SSx) from valid state to invalid state<br>0: Disable<br>1: Enable |
| 12    | R/W | 0x0 | <b>TC_INT_EN</b><br>Transfer Completed Interrupt Enable<br>0: Disable<br>1: Enable  |
| 11    | R/W | 0x0 | <b>TF_UDR_INT_EN</b><br>TXFIFO under run Interrupt Enable<br>0: Disable<br>1: Enable  |
| 10    | R/W | 0x0 | <b>TF_OVF_INT_EN</b><br>TX FIFO Overflow Interrupt Enable<br>0: Disable<br>1: Enable  |
| 9     | R/W | 0x0 | <b>RF_UDR_INT_EN</b><br>RXFIFO under run Interrupt Enable<br>0: Disable<br>1: Enable  |
| 8     | R/W | 0x0 | <b>RF_OVF_INT_EN</b><br>RX FIFO Overflow Interrupt Enable<br>0: Disable<br>1: Enable  |
| 7     | R   | 0x0 | Reserved.   |
| 6     | R/W | 0x0 | <b>TF_FUL_INT_EN</b><br>TX FIFO Full Interrupt Enable<br>0: Disable<br>1: Enable  |
| 5     | R/W | 0x0 | <b>TX_EMP_INT_EN</b><br>TX FIFO Empty Interrupt Enable<br>0: Disable<br>1: Enable   |
| 4     | R/W | 0x0 | <b>TX_ERQ_INT_EN</b><br>TX FIFO Empty Request Interrupt Enable<br>0: Disable<br>1: Enable   |
| 3     | R   | 0x0 | Reserved  |
| 2     | R/W | 0x0 | <b>RF_FUL_INT_EN</b><br>RX FIFO Full Interrupt Enable<br>0: Disable<br>1: Enable  |
| 1     | R/W | 0x0 | <b>RX_EMP_INT_EN</b>  |

|   |     |     |  |
|---|-----|-----|--|
|   |     |     | RX FIFO Empty Interrupt Enable<br>0: Disable<br>1: Enable                          |
| 0 | R/W | 0x0 | RF_RDY_INT_EN<br>RX FIFO Ready Request Interrupt Enable<br>0: Disable<br>1: Enable |

#### 8.2.5.4. SPI Interrupt Status Register(Default Value: 0x00000022)

| Offset: 0x14 |     |             | Register Name: SPI_INT_STA   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:14        | /   | 0x0         | /  |
| 13           | R/W | 0           | SSI<br>SS Invalid Interrupt<br>When SSI is 1, it indicates that SS has changed from valid state to invalid state. Writing 1 to this bit clears it.   |
| 12           | R/W | 0           | TC<br>Transfer Completed<br>In master mode, it indicates that all bursts specified by BC has been exchanged. In other condition, When set, this bit indicates that all the data in TXFIFO has been loaded in the Shift register, and the Shift register has shifted out all the bits. Writing 1 to this bit clears it.<br>0: Busy<br>1: Transfer Completed |
| 11           | R/W | 0           | TF_UDF<br>TXFIFO Underrun<br>This bit is set when if the TXFIFO is underrun. Writing 1 to this bit clears it.<br>0: TXFIFO is not underrun<br>1: TXFIFO is underrun  |
| 10           | R/W | 0           | TF_OVF<br>TXFIFO Overflow<br>This bit is set when if the TXFIFO is overflow. Writing 1 to this bit clears it.<br>0: TXFIFO is not overflow<br>1: TXFIFO is overflowed  |
| 9            | R/W | 0           | RX_UDF<br>RXFIFO Underrun<br>When set, this bit indicates that RXFIFO has underrun. Writing 1 to this bit clears it.   |
| 8            | R/W | 0           | RX_OVF<br>RXFIFO Overflow<br>When set, this bit indicates that RXFIFO has overflowed. Writing 1 to this bit clears it.<br>0: RXFIFO is available.  |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | 1: RXFIFO has overflowed.   |
| 7 | /   | / | /   |
| 6 | R/W | 0 | <b>TX_FULL</b><br>TXFIFO Full<br>This bit is set when if the TXFIFO is full . Writing 1 to this bit clears it.<br>0: TXFIFO is not Full<br>1: TXFIFO is Full  |
| 5 | R/W | 1 | <b>TX_EMP</b><br>TXFIFO Empty<br>This bit is set if the TXFIFO is empty. Writing 1 to this bit clears it.<br>0: TXFIFO contains one or more words.<br>1: TXFIFO is empty  |
| 4 | R/W | 0 | <b>TX_READY</b><br>TXFIFO Ready<br>0: TX_WL > TX_TRIG_LEVEL<br>1: TX_WL <= TX_TRIG_LEVEL<br>This bit is set any time if TX_WL <= TX_TRIG_LEVEL. Writing "1" to this bit clears it. Where TX_WL is the water level of RXFIFO |
| 3 | /   | / | reserved  |
| 2 | R/W | 0 | <b>RX_FULL</b><br>RXFIFO Full<br>This bit is set when the RXFIFO is full . Writing 1 to this bit clears it.<br>0: Not Full<br>1: Full   |
| 1 | R/W | 1 | <b>RX_EMP</b><br>RXFIFO Empty<br>This bit is set when the RXFIFO is empty . Writing 1 to this bit clears it.<br>0: Not empty<br>1: empty  |
| 0 | R/W | 0 | <b>RX_RDY</b><br>RXFIFO Ready<br>0: RX_WL < RX_TRIG_LEVEL<br>1: RX_WL >= RX_TRIG_LEVEL<br>This bit is set any time if RX_WL >= RX_TRIG_LEVEL. Writing "1" to this bit clears it. Where RX_WL is the water level of RXFIFO.  |

#### 8.2.5.5. SPI FIFO Control Register(Default Value: 0x00400001)

| Offset: 0x18 |     |             | Register Name: SPI_FCR  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | <b>TX_FIFO_RST</b><br>TX FIFO Reset<br>Write '1' to this bit will reset the control portion of the TX FIFO and auto clear to '0' when completing reset operation, write to '0' has no effect. |

|       |     |      |  |
|-------|-----|------|--|
|       |     |      | <b>TF_TEST_ENB</b><br>TX Test Mode Enable<br>0: disable<br>1: enable<br><br> <b>NOTE</b><br><b>In normal mode, TX FIFO can only be read by SPI controller, write '1' to this bit will switch TX FIFO read and write function to AHB bus. This bit is used to test the TX FIFO, don't set in normal operation and don't set RF_TEST and TF_TEST at the same time.</b>  |
| 30    | R/W | 0    |  |
| 29:26 | /   | /    | /  |
| 25    | /   | /    | /  |
| 24    | R/W | 0x0  | <b>TF_DRQ_EN</b><br>TX FIFO DMA Request Enable<br>0: Disable<br>1: Enable  |
| 23:16 | R/W | 0x40 | <b>TX_TRIG_LEVEL</b><br>TX FIFO Empty Request Trigger Level  |
| 15    | R/W | 0x0  | <b>RF_RST</b><br>RX FIFO Reset<br>Write '1' to this bit will reset the control portion of the receiver FIFO, and auto clear to '0' when completing reset operation, write '0' to this bit has no effect.   |
| 14    | R/W | 0x0  | <b>RF_TEST</b><br>RX Test Mode Enable<br>0: Disable<br>1: Enable<br><br> <b>NOTE</b><br><b>In normal mode, RX FIFO can only be written by SPI controller, write '1' to this bit will switch RX FIFO read and write function to AHB bus. This bit is used to test the RX FIFO, don't set in normal operation and don't set RF_TEST and TF_TEST at the same time.</b> |
| 13:10 | R   | 0x0  | Reserved   |
| 9     | R/W | 0x0  | <b>RX_DMA_MODE</b><br>SPI RX DMA Mode Control<br>0: Normal DMA mode<br>1: Dedicate DMA mode  |
| 8     | R/W | 0x0  | <b>RF_DRQ_EN</b><br>RX FIFO DMA Request Enable<br>0: Disable<br>1: Enable  |
| 7:0   | R/W | 0x1  | <b>RX_TRIG_LEVEL</b><br>RX FIFO Ready Request Trigger Level  |

#### 8.2.5.6. SPI FIFO Status Register(Default Value: 0x00000000)

| Offset: 0x1C |     |             | Register Name: SPI_FSR  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R   | 0x0         | TB_WR<br>TX FIFO Write Buffer Write Enable  |
| 30:28        | R   | 0x0         | TB_CNT<br>TX FIFO Write Buffer Counter<br>These bits indicate the number of words in TX FIFO Write Buffer   |
| 27:24        | R   | 0x0         | Reserved  |
| 23:16        | R   | 0x0         | TF_CNT<br>TX FIFO Counter<br>These bits indicate the number of words in TX FIFO<br>0: 0 byte in TX FIFO<br>1: 1 byte in TX FIFO<br>...<br>64: 64 bytes in TX FIFO |
| 15           | R   | 0x0         | RB_WR<br>RX FIFO Read Buffer Write Enable   |
| 14:12        | R   | 0x0         | RB_CNT<br>RX FIFO Read Buffer Counter<br>These bits indicate the number of words in RX FIFO Read Buffer   |
| 11:8         | R   | 0x0         | Reserved  |
| 7:0          | R   | 0x0         | RF_CNT<br>RX FIFO Counter<br>These bits indicate the number of words in RX FIFO<br>0: 0 byte in RX FIFO<br>1: 1 byte in RX FIFO<br>...<br>64: 64 bytes in RX FIFO |

#### 8.2.5.7. SPI Wait Clock Register(Default Value: 0x0000\_0000)

| Offset: 0x20 |     |             | Register Name: SPI_WAIT   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:20        | /   | /           | /   |
| 19:16        | R/W | 0x0         | SWC<br>Dual mode direction switch wait clock counter (for master mode only).<br>0: No wait states inserted<br>n: n SPI_SCLK wait states inserted<br>Can't be written when XCH=1.<br><br><span style="font-size: 2em; vertical-align: middle;">NOTE</span> |

|      |     |   |   |
|------|-----|---|---|
|      |     |   | <b>These bits control the number of wait states to be inserted before start dual data transfer in dual SPI mode. The SPI module counts SPI_SCLK by SWC for delaying next word data transfer.</b>  |
| 15:0 | R/W | 0 | <p>WCC<br/>Wait Clock Counter (In Master mode)</p> <p>These bits control the number of wait states to be inserted in data transfers. The SPI module counts SPI_SCLK by WCC for delaying next word data transfer.</p> <p>0: No wait states inserted<br/>N: N SPI_SCLK wait states inserted</p> |

#### 8.2.5.8. SPI Clock Control Register(Default Value: 0x00000002)

| Offset: 0x24 |     |             | Register Name: SPI_CCTL   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:13        | /   | /           | /   |
| 12           | R/W | 0           | <p>DRS<br/>Divide Rate Select (Master Mode Only)</p> <p>0: Select Clock Divide Rate 1<br/>1: Select Clock Divide Rate 2</p>                                       |
| 11:8         | R/W | 0           | <p>CDR1<br/>Clock Divide Rate 1 (Master Mode Only)</p> <p>The SPI_SCLK is determined according to the following equation: SPI_CLK = Source_CLK / 2^n.</p>         |
| 7:0          | R/W | 0x2         | <p>CDR2<br/>Clock Divide Rate 2 (Master Mode Only)</p> <p>The SPI_SCLK is determined according to the following equation: SPI_CLK = Source_CLK / (2*(n + 1)).</p> |

#### 8.2.5.9. SPI Master Burst Counter Register(Default Value: 0x00000000)

| Offset: 0x30 |     |             | Register Name: SPI_BC  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:24        | /   | /           | /  |
| 23:0         | R/W | 0           | <p>MBC<br/>Master Burst Counter</p> <p>In master mode, this field specifies the total burst number when SMC is 1.</p> <p>0: 0 burst<br/>1: 1 burst<br/>...<br/>N: N bursts</p> |

**8.2.5.10. SPI Master Transmit Counter Register(Default Value: 0x00000000)**

| Offset: 0x34 |     |             | Register Name: SPI_TC   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:24        | /   | /           | /   |
| 23:0         | R/W | 0           | <p><b>MWTC</b><br/>                     Master Write Transmit Counter<br/>                     In master mode, this field specifies the burst number that should be sent to TXFIFO before automatically sending dummy burst when SMC is 1. For saving bus bandwidth, the dummy burst (all zero bits or all one bits) is sent by SPI Controller automatically.</p> <p>0: 0 burst<br/>                     1: 1 burst<br/>                     ...<br/>                     N: N bursts</p> |

**8.2.5.11. SPI Master Burst Control Counter Register(Default Value: 0x00000000)**

| Offset: 0x38 |     |             | Register Name: SPI_BCC  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:29        | R   | 0x0         | Reserved  |
| 28           | R/W | 0x0         | <p><b>DRM</b><br/>                     Master Dual Mode RX Enable<br/>                     0: RX use single-bit mode<br/>                     1: RX use dual mode<br/>                     Can't be written when XCH=1.</p>   |
| 27:24        | R/W | 0x0         | <p><b>DBC</b><br/>                     Master Dummy Burst Counter<br/>                     In master mode, this field specifies the burst number that should be sent before receive in dual SPI mode. The data is don't care by the device.<br/>                     0: 0 burst<br/>                     1: 1 burst<br/>                     ...<br/>                     N: N bursts<br/>                     Can't be written when XCH=1.</p> |
| 23:0         | R/W | 0x0         | <p><b>STC</b><br/>                     Master Single Mode Transmit Counter<br/>                     In master mode, this field specifies the burst number that should be sent in single mode before automatically sending dummy burst. This is the first transmit counter in all bursts.<br/>                     0: 0 burst<br/>                     1: 1 burst<br/>                     ...</p>   |

|  |  |  |   |
|--|--|--|---|
|  |  |  | N: N bursts<br>Can't be written when XCH=1. |
|--|--|--|---|

#### 8.2.5.12. SPI TX Data Register(Default Value: 0x00000000)

| Offset: 0x200 |     |             | Register Name: SPI_TXD   |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:0          | W/R | 0x0         | <p>TDATA<br/>Transmit Data</p> <p>This register can be accessed in byte, half-word or word unit by AHB. In byte accessing method, if there are rooms in RXFIFO, one burst data is written to RXFIFO and the depth is increased by 1. In half-word accessing method, two SPI burst data are written and the TXFIFO depth is increase by 2. In word accessing method, four SPI burst data are written and the TXFIFO depth is increased by 4.</p> <p> NOTE</p> <p><b>This address is writing-only if TF_TEST is '0', and if TF_TEST is set to '1', this address is readable and writable to test the TX FIFO through the AHB bus.</b></p> |

#### 8.2.5.13. SPI RX Data Register(Default Value: 0x00000000)

| Offset: 0x300 |     |             | Register Name: SPI_RXD  |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:0          | R   | 0           | <p>RDATA<br/>Receive Data</p> <p>This register can be accessed in byte, half-word or word unit by AHB. In byte accessing method, if there are data in RXFIFO, the top word is returned and the RXFIFO depth is decreased by 1. In half-word accessing method, two SPI bursts are returned and the RXFIFO depth is decrease by 2. In word accessing method, the four SPI bursts are returned and the RXFIFO depth is decreased by 4.</p> <p> NOTE</p> <p><b>This address is read-only if RF_TEST is '0', and if RF_TEST is set to '1', this address is readable and writable to test the RX FIFO through the AHB bus.</b></p> |

## 8.3. UART

### 8.3.1. Overview

The UART is used for serial communication with a peripheral, modem (data carrier equipment, DCE) or data set. Data is written from a master (CPU) over the APB bus to the UART and it is converted to serial form and transmitted to the destination device. Serial data is also received by the UART and stored for the master (CPU) to read back.

The UART contains registers to control the character length, baud rate, parity generation/checking, and interrupt generation. Although there is only one interrupt output signal from the UART, there are several prioritized interrupt types that can be responsible for its assertion. Each of the interrupt types can be separately enabled/disabled with the control registers.

The UART has 16450 and 16550 modes of operation, which are compatible with a range of standard software drivers. In 16550 mode, transmit and receive operations are both buffered by FIFOs. In 16450 mode, these FIFOs are disabled.

The UART supports data lengths from five to eight bits, an optional parity bit and 1, 1 ½ or 2 stop bits, and is fully programmable by an AMBA APB CPU interface. A 16-bit programmable baud rate generator and an 8-bit scratch register are included, together with separate transmit and receive FIFOs. Eight modem control lines and a diagnostic loop-back mode are provided.

Interrupts can be generated for a range of TX Buffer/FIFO, RX Buffer/FIFO, Modem Status and Line Status conditions.

The UART includes the following features:

- Compatible with industry-standard 16550 UARTs
- 64-Bytes Transmit and receive data FIFOs
- DMA controller interface
- Software/ Hardware Flow Control
- Programmable Transmit Holding Register Empty interrupt
- Interrupt support for FIFOs, Status Change
- Supports IrDA 1.0 SIR

### 8.3.2. UART Timing Diagram



Figure 8-4. UART Serial Data Format

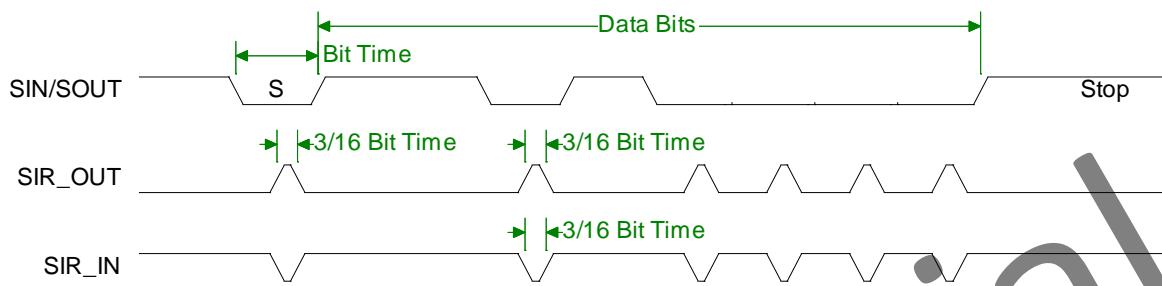


Figure 8-5. Serial IrDA Data Format

### 8.3.3. UART Pin List

| Port Name | Width | Direction | Description   |
|-----------|-------|-----------|---|
| UART0_TX  | 1     | OUT       | UART Serial Bit output  |
| UART0_RX  | 1     | IN        | UART Serial Bit input   |
| UART1_TX  | 1     | OUT       | UART Serial Bit output  |
| UART1_RX  | 1     | IN        | UART Serial Bit input   |
| UART1_RTS | 1     | OUT       | UART Request To Send<br>This active low output signal informs Modem that the UART is ready to send data |
| UART1_CTS | 1     | IN        | UART Clear To End<br>This active low signal is an input showing when Modem is ready to accept data      |
| UART2_TX  | 1     | OUT       | UART Serial Bit output  |
| UART2_RX  | 1     | IN        | UART Serial Bit input   |
| UART2_RTS | 1     | OUT       | UART Request To Send<br>This active low output signal informs Modem that the UART is ready to send data |
| UART2_CTS | 1     | IN        | UART Clear To End<br>This active low signal is an input showing when Modem is ready to accept data      |

### 8.3.4. UART Register List

There are 3 UART controllers. All UART controllers can be configured as Serial IrDA.

| Module Name | Base Address |
|-------------|--------------|
| UART0       | 0x01C28000   |
| UART1       | 0x01C28400   |
| UART2       | 0x01C28800   |

| Register Name | Offset | Description                      |
|---------------|--------|----------------------------------|
| UART_RBR      | 0x00   | UART Receive Buffer Register     |
| UART_THR      | 0x00   | UART Transmit Holding Register   |
| UART_DLL      | 0x00   | UART Divisor Latch Low Register  |
| UART_DLH      | 0x04   | UART Divisor Latch High Register |
| UART_IER      | 0x04   | UART Interrupt Enable Register   |
| UART_IIR      | 0x08   | UART Interrupt Identity Register |
| UART_FCR      | 0x08   | UART FIFO Control Register       |
| UART_LCR      | 0x0C   | UART Line Control Register       |
| UART_MCR      | 0x10   | UART Modem Control Register      |
| UART_LSR      | 0x14   | UART Line Status Register        |
| UART_MSR      | 0x18   | UART Modem Status Register       |
| UART_SCH      | 0x1C   | UART Scratch Register            |
| UART_USR      | 0x7C   | UART Status Register             |
| UART_TFL      | 0x80   | UART Transmit FIFO Level         |
| UART_RFL      | 0x84   | UART_RFL                         |
| UART_HALT     | 0xA4   | UART Halt TX Register            |

### 8.3.5. UART Register Description

#### 8.3.5.1. UART Receiver Buffer Register(Default Value: 0x00000000)

| Offset: 0x0000 |     |             | Register Name: <b>UART_RBR</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7:0            | R   | 0           | RBR<br>Receiver Buffer Register<br>Data byte received on the serial input port . The data in this register is valid only if the Data Ready (DR) bit in the Line Status Register (LCR) is set.<br>If in FIFO mode and FIFOs are enabled (FCR[0] set to one), this register accesses the head of the receive FIFO. If the receive FIFO is full and this register is not read before the next data character arrives, then the data already in the FIFO is preserved, but any incoming data are lost and an |

|  |  |  |                       |
|--|--|--|-----------------------|
|  |  |  | overrun error occurs. |
|--|--|--|-----------------------|

### 8.3.5.2. UART Transmit Holding Register(Default Value: 0x00000000)

| Offset: 0x0000 |     |             | Register Name: <b>UART_THR</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7:0            | W   | 0           | <p><b>THR</b><br/> <b>Transmit Holding Register</b><br/>                     Data to be transmitted on the serial output port . Data should only be written to the THR when the THR Empty (THRE) bit (LSR[5]) is set.<br/>                     If in FIFO mode and FIFOs are enabled (FCR[0] = 1) and THRE is set, 16 number of characters of data may be written to the THR before the FIFO is full. Any attempt to write data when the FIFO is full results in the write data being lost.</p> |

### 8.3.5.3. UART Divisor Latch Low Register(Default Value: 0x00000000)

| Offset: 0x0000 |     |             | Register Name: <b>UART_DLL</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7:0            | R/W | 0           | <p><b>DLL</b><br/> <b>Divisor Latch Low</b><br/>                     Lower 8 bits of a 16-bit, read/write, Divisor Latch register that contains the baud rate divisor for the UART. This register may only be accessed when the DLAB bit (LCR[7]) is set and the UART is not busy (USR[0] is zero).<br/>                     The output baud rate is equal to the serial clock (sclk) frequency divided by sixteen times the value of the baud rate divisor, as follows: baud rate = (serial clock freq) / (16 * divisor).<br/>                     Note that with the Divisor Latch Registers (DLL and DLH) set to zero, the baud clock is disabled and no serial communications occur. Also, once the DLL is set, at least 8 clock cycles of the slowest UART clock should be allowed to pass before transmitting or receiving data.</p> |

### 8.3.5.4. UART Divisor Latch High Register(Default Value: 0x00000000)

| Offset: 0x0004 |     |             | Register Name: <b>UART_DLH</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7:0            | R/W | 0           | <p><b>DLH</b><br/> <b>Divisor Latch High</b><br/>                     Upper 8 bits of a 16-bit, read/write, Divisor Latch register that contains the</p> |

|  |  |  |  |
|--|--|--|--|
|  |  |  | <p>baud rate divisor for the UART. This register may only be accessed when the DLAB bit (LCR[7]) is set and the UART is not busy (USR[0] is zero). The output baud rate is equal to the serial clock (sclk) frequency divided by sixteen times the value of the baud rate divisor, as follows: baud rate = (serial clock freq) / (16 * divisor).</p> <p>Note that with the Divisor Latch Registers (DLL and DLH) set to zero, the baud clock is disabled and no serial communications occur. Also, once the DLH is set, at least 8 clock cycles of the slowest UART clock should be allowed to pass before transmitting or receiving data.</p> |
|--|--|--|--|

### 8.3.5.5. UART Interrupt Enable Register(Default Value: 0x00000000)

| Offset: 0x0004 |     |             | Register Name: <b>UART_IER</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7              | R/W | 0           | <b>PTIME</b><br>Programmable THRE Interrupt Mode Enable<br>This is used to enable/disable the generation of THRE Interrupt.<br>0: Disable<br>1: Enable  |
| 6:4            | /   | /           | /   |
| 3              | R/W | 0           | <b>EDSSI</b><br>Enable Modem Status Interrupt<br>This is used to enable/disable the generation of Modem Status Interrupt.<br>This is the fourth highest priority interrupt.<br>0: Disable<br>1: Enable  |
| 2              | R/W | 0           | <b>ELSI</b><br>Enable Receiver Line Status Interrupt<br>This is used to enable/disable the generation of Receiver Line Status Interrupt. This is the highest priority interrupt.<br>0: Disable<br>1: Enable   |
| 1              | R/W | 0           | <b>ETBEI</b><br>Enable Transmit Holding Register Empty Interrupt<br>This is used to enable/disable the generation of Transmitter Holding Register Empty Interrupt. This is the third highest priority interrupt.<br>0: Disable<br>1: Enable                               |
| 0              | R/W | 0           | <b>ERBFI</b><br>Enable Received Data Available Interrupt<br>This is used to enable/disable the generation of Received Data Available Interrupt and the Character Timeout Interrupt (if in FIFO mode and FIFOs enabled). These are the second highest priority interrupts. |

|  |  |  |                         |
|--|--|--|-------------------------|
|  |  |  | 0: Disable<br>1: Enable |
|--|--|--|-------------------------|

### 8.3.5.6. UART Interrupt Identity Register(Default Value: 0x00000000)

| Offset: 0x0008 |     |             | Register Name: <b>UART_IIR</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7:6            | R   | 0           | <b>FEFLAG</b><br>FIFOs Enable Flag<br>This is used to indicate whether the FIFOs are enabled or disabled.<br>00: Disable<br>11: Enable  |
| 5:4            | /   | /           | /   |
| 3:0            | R   | 0x1         | <b>IID</b><br>Interrupt ID<br>This indicates the highest priority pending interrupt which can be one of the following types:<br>0000: modem status<br>0001: no interrupt pending<br>0010: THR empty<br>0100: received data available<br>0110: receiver line status<br>0111: busy detect<br>1100: character timeout<br>Bit 3 indicates an interrupt can only occur when the FIFOs are enabled and used to distinguish a Character Timeout condition interrupt. |

| Interrupt ID | Priority Level | Interrupt Type               | Interrupt Source   | Interrupt Reset  |
|--------------|----------------|------------------------------|--|--|
| 0001         | -              | None                         | None   | -  |
| 0110         | Highest        | Receiver line status         | Overrun/parity/ framing errors or break interrupt  | Reading the line status register   |
| 0100         | Second         | Received data available      | Receiver data available (non-FIFO mode or FIFOs disabled) or RCVR FIFO trigger level reached (FIFO mode and FIFOs enabled)         | Reading the receiver buffer register (non-FIFO mode or FIFOs disabled) or the FIFO drops below the trigger level (FIFO mode and FIFOs enabled) |
| 1100         | Second         | Character timeout indication | No characters in or out of the RCVR FIFO during the last 4 character times and there is at least 1character in it during This time | Reading the receiver buffer register   |

|      |        |                                 |  |  |
|------|--------|---------------------------------|--|--|
| 0010 | Third  | Transmit holding register empty | Transmitter holding register empty (Program THRE Mode disabled) or XMIT FIFO at or below threshold (Program THRE Mode enabled)   | Reading the IIR register (if source of interrupt); or, writing into THR (FIFOs or THRE Mode not selected or disabled) or XMIT FIFO above threshold (FIFOs and THRE Mode selected and enabled). |
| 0000 | Fourth | Modem status                    | Clear to send or data set ready or ring indicator or data carrier detect. Note that if auto flow control mode is enabled, a change in CTS (that is, DCTS set) does not cause an interrupt. | Reading the Modem status Register  |
| 0111 | Fifth  | Busy detect indication          | UART_16550_COMPATIBLE = NO and master has tried to write to the Line Control Register while the UART is busy (USR[0] is set to one).   | Reading the UART status register   |

### 8.3.5.7. UART FIFO Control Register(Default Value: 0x00000000)

| Offset: 0x0008 |     |             | Register Name: UART_FCR  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7:6            | W   | 0           | <p>RT<br/>RCVR Trigger</p> <p>This is used to select the trigger level in the receiver FIFO at which the Received Data Available Interrupt is generated. In auto flow control mode it is used to determine when the rts_n signal is de-asserted. It also determines when the dma_rx_req_n signal is asserted in certain modes of operation.</p> <p>00: 1 character in the FIFO<br/>01: FIFO <math>\frac{1}{4}</math> full<br/>10: FIFO <math>\frac{1}{2}</math> full<br/>11: FIFO-2 less than full</p> |
| 5:4            | W   | 0           | <p>TFT<br/>TX Empty Trigger</p> <p>Writes have no effect when THRE_MODE_USER = Disabled. This is used to select the empty threshold level at which the THRE Interrupts are generated when the mode is active. It also determines when the dma_tx_req_n signal is asserted when in certain modes of operation.</p> <p>00: FIFO empty<br/>01: 2 characters in the FIFO<br/>10: FIFO <math>\frac{1}{4}</math> full<br/>11: FIFO <math>\frac{1}{2}</math> full</p>   |
| 3              | W   | 0           | DMAM   |

|   |   |   |   |
|---|---|---|---|
|   |   |   | DMA Mode<br>0: Mode 0<br>1: Mode 1  |
| 2 | W | 0 | XFIFOR<br>XMIT FIFO Reset<br><br>This resets the control portion of the transmit FIFO and treats the FIFO as empty. This also de-asserts the DMA TX request.<br><br>It is 'self-clearing'. It is not necessary to clear this bit. |
| 1 | W | 0 | RFIFOR<br>RCVR FIFO Reset<br><br>This resets the control portion of the receive FIFO and treats the FIFO as empty. This also de-asserts the DMA RX request.<br><br>It is 'self-clearing'. It is not necessary to clear this bit.  |
| 0 | W | 0 | FIFOE<br>Enable FIFOs<br><br>This enables/disables the transmit (XMIT) and receive (RCVR) FIFOs. Whenever the value of this bit is changed both the XMIT and RCVR controller portion of FIFOs is reset.                           |

### 8.3.5.8. UART Line Control Register(Default Value: 0x00000000)

| Offset: 0x000C |     |             | Register Name: <b>UART_LCR</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7              | R/W | 0           | DLAB<br><br>Divisor Latch Access Bit<br><br>It is writeable only when UART is not busy (USR[0] is zero) and always readable. This bit is used to enable reading and writing of the Divisor Latch register (DLL and DLH) to set the baud rate of the UART. This bit must be cleared after initial baud rate setup in order to access other registers.<br><br>0: Select RX Buffer Register (RBR) / TX Holding Register(THR) and Interrupt Enable Register (IER)<br>1: Select Divisor Latch LS Register (DLL) and Divisor Latch MS Register (DLM) |
| 6              | R/W | 0           | BC<br><br>Break Control Bit<br><br>This is used to cause a break condition to be transmitted to the receiving device. If set to one the serial output is forced to the spacing (logic 0) state. When not in Loopback Mode, as determined by MCR[4], the sout line is forced low until the Break bit is cleared. If SIR_MODE = Enabled and active (MCR[6] set to one) the sir_out_n line is continuously pulsed. When in Loopback Mode, the break condition is internally looped back to the receiver and the sir_out_n line is forced low.     |
| 5:4            | R/W | 0           | EPS<br>Even Parity Select  |

|     |     |   |   |
|-----|-----|---|---|
|     |     |   | <p>It is writeable only when UART is not busy (USR[0] is zero) and always writable readable. This is used to select between even and odd parity, when parity is enabled (PEN set to one). Setting the LCR[5] is to reverse the LCR[4].</p> <p>00: Odd Parity<br/>01: Even Parity<br/>1X: Reverse LCR[4]</p>   |
| 3   | R/W | 0 | <p>PEN<br/>Parity Enable</p> <p>It is writeable only when UART is not busy (USR[0] is zero) and always readable. This bit is used to enable and disable parity generation and detection in transmitted and received serial character respectively.</p> <p>0: parity disabled<br/>1: parity enabled</p>  |
| 2   | R/W | 0 | <p>STOP<br/>Number of stop bits</p> <p>It is writeable only when UART is not busy (USR[0] is zero) and always readable. This is used to select the number of stop bits per character that the peripheral transmits and receives. If set to zero, one stop bit is transmitted in the serial data. If set to one and the data bits are set to 5 (LCR[1:0] set to zero) one and a half stop bits is transmitted. Otherwise, two stop bits are transmitted. Note that regardless of the number of stop bits selected, the receiver checks only the first stop bit.</p> <p>0: 1 stop bit<br/>1: 1.5 stop bits when DLS (LCR[1:0]) is zero, else 2 stop bit</p> |
| 1:0 | R/W | 0 | <p>DLS<br/>Data Length Select</p> <p>It is writeable only when UART is not busy (USR[0] is zero) and always readable. This is used to select the number of data bits per character that the peripheral transmits and receives. The number of bit that may be selected areas follows:</p> <p>00: 5 bits<br/>01: 6 bits<br/>10: 7 bits<br/>11: 8 bits</p>   |

### 8.3.5.9. UART Modem Control Register(Default Value: 0x00000000)

| Offset: 0x0010 |     |             | Register Name: <b>UART_MCR</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:7           | /   | /           | /   |
| 6              | R/W | 0           | <p>SIRE<br/>SIR Mode Enable</p> <p>0:IrDA SIR Mode disabled<br/>1:IrDA SIR Mode enabled</p> |

|     |     |   |   |
|-----|-----|---|---|
| 5   | R/W | 0 | <b>AFCE</b><br>Auto Flow Control Enable<br>When FIFOs are enabled and the Auto Flow Control Enable (AFCE) bit is set, Auto Flow Control features are enabled.<br>0: Auto Flow Control Mode disabled<br>1: Auto Flow Control Mode enabled  |
| 4   | R/W | 0 | <b>LOOP</b><br>Loop Back Mode<br>0: Normal Mode<br>1: Loop Back Mode<br>This is used to put the UART into a diagnostic mode for test purposes. If operating in UART mode (SIR_MODE != Enabled or not active, MCR[6] set to zero), data on the sout line is held high, while serial data output is looped back to the sin line, internally. In this mode all the interrupts are fully functional. Also, in loopback mode, the modem control inputs (dsr_n, cts_n, ri_n, dcd_n) are disconnected and the modem control outputs (dtr_n, rts_n, out1_n, out2_n) are looped back to the inputs, internally. If operating in infrared mode (SIR_MODE == Enabled AND active, MCR[6] set to one), data on the sir_out_n line is held low, while serial data output is inverted and looped back to the sir_in line.  |
| 3:2 | /   | / | /   |
| 1   | R/W | 0 | <b>RTS</b><br>Request to Send<br>This is used to directly control the Request to Send (rts_n) output. The Request To Send (rts_n) output is used to inform the modem or data set that the UART is ready to exchange data. When Auto RTS Flow Control is not enabled (MCR[5] set to zero), the rts_n signal is set low by programming MCR[1] (RTS) to a high. In Auto Flow Control, AFCE_MODE == Enabled and active (MCR[5] set to one) and FIFOs enable (FCR[0] set to one), the rts_n output is controlled in the same way, but is also gated with the receiver FIFO threshold trigger (rts_n is inactive high when above the threshold). The rts_n signal is de-asserted when MCR[1] is set low.<br>0: rts_n de-asserted (logic 1)<br>1: rts_n asserted (logic 0)<br>Note that in Loopback mode (MCR[4] set to one), the rts_n output is held inactive high while the value of this location is internally looped back to an input. |
| 0   | R/W | 0 | <b>DTR</b><br>Data Terminal Ready<br>This is used to directly control the Data Terminal Ready (dtr_n) output. The value written to this location is inverted and driven out on dtr_n.<br>0: dtr_n de-asserted (logic 1)<br>1: dtr_n asserted (logic 0)<br>The Data Terminal Ready output is used to inform the modem or data set that the UART is ready to establish communications.  |

|  |  |  |  |
|--|--|--|--|
|  |  |  | Note that in Loopback mode (MCR[4] set to one), the dtr_n output is held inactive high while the value of this location is internally looped back to an input. |
|--|--|--|--|

### 8.3.5.10. UART Line Status Register(Default Value: 0x00000060)

| Offset: 0x0014 |     |             | Register Name: <b>UART_LSR</b>  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:8           | /   | /           | /   |
| 7              | R   | 0           | <b>FIFOERR</b><br>RX Data Error in FIFO<br>When FIFOs are disabled, this bit is always 0. When FIFOs are enabled, this bit is set to 1 when there is at least one PE, FE, or BI in the RX FIFO. It is cleared by a read from the LSR register provided there are no subsequent errors in the FIFO.  |
| 6              | R   | 1           | <b>TEMT</b><br>Transmitter Empty<br>If the FIFOs are disabled, this bit is set to "1" whenever the TX Holding Register and the TX Shift Register are empty. If the FIFOs are enabled, this bit is set whenever the TX FIFO and the TX Shift Register are empty. In both cases, this bit is cleared when a byte is written to the TX data channel.   |
| 5              | R   | 1           | <b>THRE</b><br>TX Holding Register Empty<br>If the FIFOs are disabled, this bit is set to "1" whenever the TX Holding Register is empty and ready to accept new data and it is cleared when the CPU writes to the TX Holding Register.<br>If the FIFOs are enabled, this bit is set to "1" whenever the TX FIFO is empty and it is cleared when at least one byte is written to the TX FIFO.  |
| 4              | R   | 0           | <b>BI</b><br>Break Interrupt<br>This is used to indicate the detection of a break sequence on the serial input data.<br>It is set whenever the serial input, sin, is held in a logic '0' state for longer than the sum of start time + data bits + parity + stop bits.<br>In the FIFO mode, the character associated with the break condition is carried through the FIFO and is revealed when the character is at the top of the FIFO. Reading the LSR clears the BI bit. In the non-FIFO mode, the BI indication occurs immediately and persists until the LSR is read. |
| 3              | R   | 0           | <b>FE</b><br>Framing Error<br>This is used to indicate the occurrence of a framing error in the receiver. A framing error occurs when the receiver does not detect a valid STOP bit in the received data.   |

|   |   |   |   |
|---|---|---|---|
|   |   |   | <p>In the FIFO mode, since the framing error is associated with a character received, it is revealed when the character with the framing error is at the top of the FIFO. When a framing error occurs, the UART tries to resynchronize. It does this by assuming that the error was due to the start bit of the next character and then continues receiving the other bit i.e. data, and/or parity and stop. It should be noted that the Framing Error (FE) bit (LSR[3]) is set if a break interrupt has occurred, as indicated by Break Interrupt (BI) bit (LSR[4]).</p> <p>0: no framing error<br/>1:framing error<br/>Reading the LSR clears the FE bit.</p> |
| 2 | R | 0 | <p>PE<br/>Parity Error</p> <p>This is used to indicate the occurrence of a parity error in the receiver if the Parity Enable (PEN) bit (LCR[3]) is set. In the FIFO mode, since the parity error is associated with a character received, it is revealed when the character with the parity error arrives at the top of the FIFO. It should be noted that the Parity Error (PE) bit (LSR[2]) is set if a break interrupt has occurred, as indicated by Break Interrupt (BI) bit (LSR[4]).</p> <p>0: no parity error<br/>1: parity error<br/>Reading the LSR clears the PE bit.</p>  |
| 1 | R | 0 | <p>OE<br/>Overrun Error</p> <p>This occurs if a new data character was received before the previous data was read. In the non-FIFO mode, the OE bit is set when a new character arrives in the receiver before the previous character was read from the RBR. When this happens, the data in the RBR is overwritten. In the FIFO mode, an overrun error occurs when the FIFO is full and a new character arrives at the receiver. The data in the FIFO is retained and the data in the receive shift register is lost.</p> <p>0: no overrun error<br/>1: overrun error<br/>Reading the LSR clears the OE bit.</p>  |
| 0 | R | 0 | <p>DR<br/>Data Ready</p> <p>This is used to indicate that the receiver contains at least one character in the RBR or the receiver FIFO.</p> <p>0: no data ready<br/>1: data ready</p> <p>This bit is cleared when the RBR is read in non-FIFO mode, or when the receiver FIFO is empty, in FIFO mode.</p>   |

**8.3.5.11. UART Modem Status Register(Default Value: 0x00000000)**

| Offset: 0x0018 |     |             | Register Name: <b>UART_MSR</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7              | R   | 0           | <p><b>DCD</b><br/>         Line State of Data Carrier Detect<br/>         This is used to indicate the current state of the modem control line <code>dcd_n</code>. This bit is the complement of <code>dcd_n</code>. When the Data Carrier Detect input (<code>dcd_n</code>) is asserted it is an indication that the carrier has been detected by the modem or data set.<br/>         0: <code>dcd_n</code> input is de-asserted (logic 1)<br/>         1: <code>dcd_n</code> input is asserted (logic 0)</p>   |
| 6              | R   | 0           | <p><b>RI</b><br/>         Line State of Ring Indicator<br/>         This is used to indicate the current state of the modem control line <code>ri_n</code>. This bit is the complement of <code>ri_n</code>. When the Ring Indicator input (<code>ri_n</code>) is asserted it is an indication that a telephone ringing signal has been received by the modem or data set.<br/>         0: <code>ri_n</code> input is de-asserted (logic 1)<br/>         1: <code>ri_n</code> input is asserted (logic 0)</p>  |
| 5              | R   | 0           | <p><b>DSR</b><br/>         Line State of Data Set Ready<br/>         This is used to indicate the current state of the modem control line <code>dsr_n</code>. This bit is the complement of <code>dsr_n</code>. When the Data Set Ready input (<code>dsr_n</code>) is asserted it is an indication that the modem or data set is ready to establish communications with UART.<br/>         0: <code>dsr_n</code> input is de-asserted (logic 1)<br/>         1: <code>dsr_n</code> input is asserted (logic 0)<br/>         In Loopback Mode (MCR[4] set to one), DSR is the same as MCR[0] (DTR).</p> |
| 4              | R   | 0           | <p><b>CTS</b><br/>         Line State of Clear To Send<br/>         This is used to indicate the current state of the modem control line <code>cts_n</code>. This bit is the complement of <code>cts_n</code>. When the Clear to Send input (<code>cts_n</code>) is asserted it is an indication that the modem or data set is ready to exchange data with UART.<br/>         0: <code>cts_n</code> input is de-asserted (logic 1)<br/>         1: <code>cts_n</code> input is asserted (logic 0)<br/>         In Loopback Mode (MCR[4] = 1), CTS is the same as MCR[1] (RTS).</p>                     |
| 3              | R   | 0           | <p><b>DDCD</b><br/>         Delta Data Carrier Detect<br/>         This is used to indicate that the modem control line <code>dcd_n</code> has changed since the last time the MSR was read.<br/>         0: no change on <code>dcd_n</code> since last read of MSR<br/>         1: change on <code>dcd_n</code> since last read of MSR</p>  |

|   |   |   |   |
|---|---|---|---|
|   |   |   | Reading the MSR clears the DDCD bit.<br>If the DDCD bit is not set and the dcd_n signal is asserted (low) and a reset occurs (software or otherwise), then the DDCD bit is set when the reset is removed if the dcd_n signal remains asserted.  |
| 2 | R | 0 | <b>TERI</b><br>Trailing Edge Ring Indicator<br>This is used to indicate that a change on the input ri_n (from an active-low to an inactive-high state) has occurred since the last time the MSR was read.<br>0: no change on ri_n since last read of MSR<br>1: change on ri_n since last read of MSR<br>Reading the MSR clears the TERI bit.  |
| 1 | R | 0 | <b>DDSR</b><br>Delta Data Set Ready<br>This is used to indicate that the modem control line dsr_n has changed since the last time the MSR was read.<br>0: no change on dsr_n since last read of MSR<br>1: change on dsr_n since last read of MSR<br>Reading the MSR clears the DDSR bit. In Loopback Mode (MCR[4] = 1), DDSR reflects changes on MCR[0] (DTR).<br>If the DDSR bit is not set and the dsr_n signal is asserted (low) and a reset occurs (software or otherwise), then the DDSR bit is set when the reset is removed if the dsr_n signal remains asserted.      |
| 0 | R | 0 | <b>DCTS</b><br>Delta Clear to Send<br>This is used to indicate that the modem control line cts_n has changed since the last time the MSR was read.<br>0: no change on ctsdsr_n since last read of MSR<br>1: change on ctsdsr_n since last read of MSR<br>Reading the MSR clears the DCTS bit. In Loopback Mode (MCR[4] = 1), DCTS reflects changes on MCR[1] (RTS).<br>If the DCTS bit is not set and the cts_n signal is asserted (low) and a reset occurs (software or otherwise), then the DCTS bit is set when the reset is removed if the cts_n signal remains asserted. |

### 8.3.5.12. UART Scratch Register(Default Value: 0x00000000)

| Offset: 0x001C |     |             | Register Name: <b>UART_SCH</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:8           | /   | /           | /  |
| 7:0            | R/W | 0           | <b>SCRATCH_REG</b><br>Scratch Register<br>This register is for programmers to use as a temporary storage space. It has no defined purpose in the UART. |

### 8.3.5.13. UART Status Register(Default Value: 0x00000006)

| Offset: 0x007C |     |             | Register Name: <b>UART_USR</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:5           | /   | /           | /  |
| 4              | R   | 0           | <p>RFF<br/>Receive FIFO Full<br/>This is used to indicate that the receive FIFO is completely full.<br/>0: Receive FIFO not full<br/>1: Receive FIFO Full<br/>This bit is cleared when the RX FIFO is no longer full.</p>                |
| 3              | R   | 0           | <p>RFNE<br/>Receive FIFO Not Empty<br/>This is used to indicate that the receive FIFO contains one or more entries.<br/>0: Receive FIFO is empty<br/>1: Receive FIFO is not empty<br/>This bit is cleared when the RX FIFO is empty.</p> |
| 2              | R   | 1           | <p>TFE<br/>Transmit FIFO Empty<br/>This is used to indicate that the transmit FIFO is completely empty.<br/>0: Transmit FIFO is not empty<br/>1: Transmit FIFO is empty<br/>This bit is cleared when the TX FIFO is no longer empty.</p> |
| 1              | R   | 1           | <p>TFNF<br/>Transmit FIFO Not Full<br/>This is used to indicate that the transmit FIFO is not full.<br/>0: Transmit FIFO is full<br/>1: Transmit FIFO is not full<br/>This bit is cleared when the TX FIFO is full.</p>                  |
| 0              | R   | 0           | <p>BUSY<br/>UART Busy Bit<br/>0: Idle or inactive<br/>1: Busy</p>  |

### 8.3.5.14. UART Transmit FIFO Level Register(Default Value: 0x00000000)

| Offset: 0x0080 |     |             | Register Name: <b>UART_TFL</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:7           | /   | /           | /  |
| 6:0            | R   | 0           | <p>TFL<br/>Transmit FIFO Level<br/>This indicates the number of data entries in the transmit FIFO.</p> |

### 8.3.5.15. UART Receive FIFO Level Register(Default Value: 0x00000000)

| Offset: 0x0084 |     |             | Register Name: <b>UART_RFL</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:7           | /   | /           | /  |
| 6:0            | R   | 0           | RFL<br>Receive FIFO Level<br>This is indicates the number of data entries in the receive FIFO. |

### 8.3.5.16. UART Halt TX Register(Default Value: 0x00000000)

| Offset: 0x00A4 |     |             | Register Name: <b>UART_HALT</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:6           | /   | /           | /   |
| 5              | R/W | 0           | SIR_RX_INVERT<br>SIR Receiver Pulse Polarity Invert<br>0:Not invert receiver signal<br>1:Invert receiver signal   |
| 4              | R/W | 0           | SIR_TX_INVERT<br>SIR Transmit Pulse Polarity Invert<br>0:Not invert transmit pulse<br>1:Invert transmit pulse   |
| 3              | /   | /           | /   |
| 2              | R/W | 0           | CHANGE_UPDATE<br>After the user using HALT[1] to change the baudrate or LCR configuration, write 1 to update the configuration and waiting this bit self clear to 0 to finish update process. Write 0 to this bit has no effect.<br>1: Update trigger, Self clear to 0 when finish update.  |
| 1              | R/W | 0           | CHCFG_AT_BUSY<br>This is an enable bit for the user to change LCR register configuration (except for the DLAB bit) and baudrate register (DLH and DLL) when the UART is busy (USB[0] is 1).<br>1: Enable change when busy   |
| 0              | R/W | 0           | HALT_TX<br>Halt TX<br>This register is use to halt transmissions for testing, so that the transmit FIFO can be filled by the master when FIFOs are implemented and enabled.<br>0 : Halt TX disabled<br>1 : Halt TX enabled<br> <b>NOTE</b><br><b>If FIFOs are not enabled, the setting of the halt TX register has no effect on operation.</b> |

## 8.4. USB

### 8.4.1. USB OTG Controller

The USB OTG controller is a Dual-Role Device which supports both device and host functions which can also be configured as a Host-only or Device-only controller, fully compliant with the USB 2.0 Specification. It can support high-speed (HS, 480-Mbps), full-speed (FS, 12-Mbps), and low-speed (LS, 1.5-Mbps) transfers in Host mode. It can support high-speed (HS, 480-Mbps), and full-speed (FS, 12-Mbps) in Device mode. Standard USB transceiver can be used through its UTMI+PHY Level3 interface. The UTMI+PHY interface is bidirectional with 8-bit data bus. For saving CPU bandwidth, USB-OTG DMA interface can support external DMA controller to take care of the data transfer between the memory and USB-OTG FIFO. The USB-OTG core also supports USB power saving functions.

The USB2.0 OTG controller has following features:

- Supports Device or Host operation at a time
- Supports High-Speed (HS, 480-Mbps), Full-Speed (FS, 12-Mbps), and Low-Speed (LS, 1.5-Mbps) in host mode
- Complies with Enhanced Host Controller Interface (EHCI) Specification, Version 1.0, and the Open Host Controller Interface (OHCI) Specification, Version 1.0a in host mode
- Supports High-Speed (HS, 480-Mbps), Full-Speed (FS, 12-Mbps) in device mode
- Supports up to 8 User-Configurable Endpoints for Bulk , Isochronousl and Interrupt bi-directional transfers (Endpoint1, Endpoint2, Endpoint3, Endpoint4, Endpoint5) in device mode
- Supports up to 4032BytesFIFO for EPs (Excluding EP0) in device mode
- Supports bi-directional endpoint0 for Control transfer in device mode
- Supports the UTMI+ Level 3 interface . The 8-bit bidirectional data buses are used
- Supports High-Bandwidth Isochronous & Interrupt transfers in device mode
- Automated splitting/combining of packets for Bulk transfers in device mode
- Supports point-to-point and point-to-multipoint transfer in both Host and Peripheral mode
- Performs all transaction scheduling in hardware
- Power Optimization and Power Management capabilities
- Supports only 1 USB Root Port shared between EHCI and OHCI

#### 8.4.1.1. Block Diagram

Figure 8-6 shows the block diagram of USB OTG Controller:

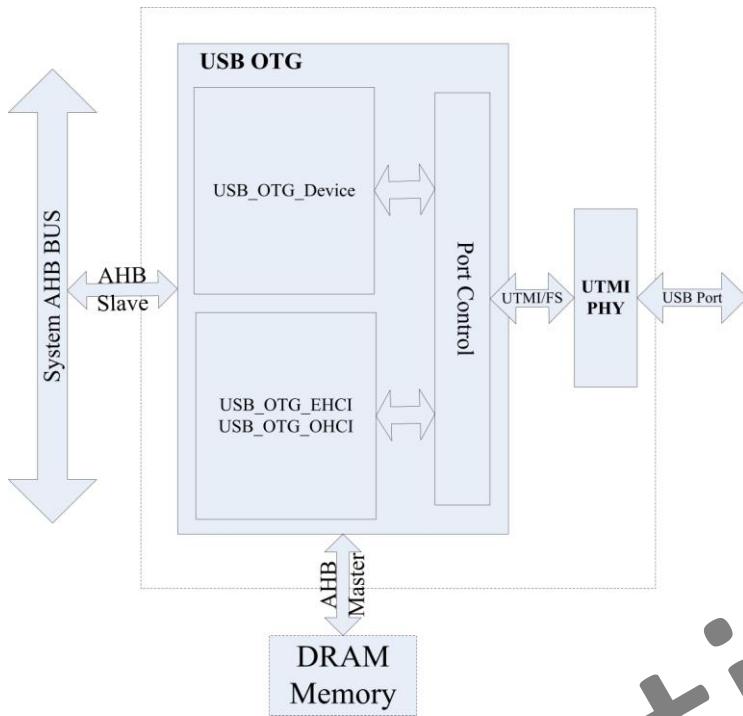


Figure 8-6. USB OTG Controller Block Diagram

#### 8.4.1.2. USB OTG Register List

| Module Name         | Base Address |
|---------------------|--------------|
| USB OTG_EHCI0/OHCI0 | 0x01C1A000   |

| Register Name                                     | Offset | Description                                     |
|---|--------|---|
| <b>EHCI Capability Register</b>                   |        |   |
| E_CAPLENGTH                                       | 0x000  | EHCI Capability register Length Register        |
| E_HCIVERSION                                      | 0x002  | EHCI Host Interface Version Number Register     |
| E_HCSPARAMS                                       | 0x004  | EHCI Host Control Structural Parameter Register |
| E_HCCPARAMS                                       | 0x008  | EHCI Host Control Capability Parameter Register |
| E_HCSPPORTROUTE                                   | 0x00c  | EHCI Companion Port Route Description           |
| <b>EHCI Operational Register</b>                  |        |   |
| E_USBCMD  | 0x010  | EHCI USB Command Register                       |
| E_USBSTS  | 0x014  | EHCI USB Status Register                        |
| E_USBINTR   | 0x018  | EHCI USB Interrupt Enable Register              |
| E_FRINDEX   | 0x01c  | EHCI USB Frame Index Register                   |
| E_CTRLDSSEGMENT                                   | 0x020  | EHCI 4G Segment Selector Register               |
| E_PERIODICLISTBASE                                | 0x024  | EHCI Frame List Base Address Register           |
| E_ASYNCLISTADDR                                   | 0x028  | EHCI Next Asynchronous List Address Register    |
| E_CONFIGFLAG                                      | 0x050  | EHCI Configured Flag Register                   |
| E_PORTSC  | 0x054  | EHCI Port Status/Control Register               |
| <b>OHCI Control and Status Partition Register</b> |        |   |

|   |       |                                     |
|---|-------|-------------------------------------|
| O_HcRevision                                  | 0x400 | OHCI Revision Register              |
| O_HcControl                                   | 0x404 | OHCI Control Register               |
| O_HcCommandStatus                             | 0x408 | OHCI Command Status Register        |
| O_HcInterruptStatus                           | 0x40c | OHCI Interrupt Status Register      |
| O_HcInterruptEnable                           | 0x410 | OHCI Interrupt Enable Register      |
| O_HcInterruptDisable                          | 0x414 | OHCI Interrupt Disable Register     |
| <b>OHCI Memory Pointer Partition Register</b> |       |                                     |
| O_HcHCCA                                      | 0x418 | OHCI HCCA Base                      |
| O_HcPeriodCurrentED                           | 0x41c | OHCI Period Current ED Base         |
| O_HcControlHeadED                             | 0x420 | OHCI Control Head ED Base           |
| O_HcControlCurrentED                          | 0x424 | OHCI Control Current ED Base        |
| O_HcBulkHeadED                                | 0x428 | OHCI Bulk Head ED Base              |
| O_HcBulkCurrentED                             | 0x42c | OHCI Bulk Current ED Base           |
| O_HcDoneHead                                  | 0x430 | OHCI Done Head Base                 |
| <b>OHCI Frame Counter Partition Register</b>  |       |                                     |
| O_HcFmInterval                                | 0x434 | OHCI Frame Interval Register        |
| O_HcFmRemaining                               | 0x438 | OHCI Frame Remaining Register       |
| O_HcFmNumber                                  | 0x43c | OHCI Frame Number Register          |
| O_HcPeriodicStart                             | 0x440 | OHCI Periodic Start Register        |
| O_HcLSThreshold                               | 0x444 | OHCI LS Threshold Register          |
| <b>OHCI Root Hub Partition Register</b>       |       |                                     |
| O_HcRhDescriptorA                             | 0x448 | OHCI Root Hub Descriptor Register A |
| O_HcRhDescriptorB                             | 0x44c | OHCI Root Hub Descriptor Register B |
| O_HcRhStatus                                  | 0x450 | OHCI Root Hub Status Register       |
| O_HcRhPortStatus                              | 0x454 | OHCI Root Hub Port Status Register  |

#### 8.4.1.3. EHCI Register Description

##### 8.4.1.3.1. EHCI Identification Register(Default Value: Implementation Dependent)

| Offset: 0x0000 |     |             | Register Name: <b>CAPLENGTH</b>   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 7:0            | R   | 0x10        | CAPLENGTH<br>The value in these bits indicates an offset to add to register base to find the beginning of the Operational Register Space. |

##### 8.4.1.3.2. EHCI Host Interface Version Number Register(Default Value: 0x0100)

| Offset: 0x0002 |     |             | Register Name: <b>HCIVERSION</b> |
|----------------|-----|-------------|----------------------------------|
| Bit            | R/W | Default/Hex | Description                      |
| 15:0           | R   | 0x0100      | HCIVERSION                       |

|  |  |  |  |
|--|--|--|--|
|  |  |  | This is a 16-bits register containing a BCD encoding of the EHCI revision number supported by this host controller. The most significant byte of this register represents a major revision and the least significant byte is the minor revision. |
|--|--|--|--|

#### 8.4.1.3.3. EHCI Host Control Structural Parameter Register(Default Value: Implementation Dependent)

| Offset: 0x0004 |   |             | Register Name: HCSPARAMS   |       |         |   |   |   |  |
|----------------|---|-------------|--|-------|---------|---|---|---|--|
| Bit            | R/W   | Default/Hex | Description  |       |         |   |   |   |  |
| 31:24          | /   | 0           | Reserved.<br>These bits are reserved and should be set to zero.  |       |         |   |   |   |  |
| 23:20          | R   | 0           | Debug Port Number<br>This register identifies which of the host controller ports is the debug port.<br>The value is the port number (one based) of the debug port.<br>This field will always be '0'.   |       |         |   |   |   |  |
| 19:16          | /   | 0           | Reserved.<br>These bits are reserved and should be set to zero.  |       |         |   |   |   |  |
| 15:12          | R   | 0           | Number of Companion Controller (N_CC)<br>This field indicates the number of companion controllers associated with this USB2.0 host controller. A zero in this field indicates there are no companion host controllers. And a value larger than zero in this field indicates there are companion USB1.1 host controller(s).<br>This field will always be '0'.   |       |         |   |   |   |  |
| 11:8           | R   | 0           | Number of Port per Companion Controller(N_PCC)<br>This field indicates the number of ports supported per companion host controller host controller. It is used to indicate the port routing configuration to system software.<br>This field will always fix with '0'.  |       |         |   |   |   |  |
| 7              | R   | 0           | Port Routing Rules<br>This field indicates the method used by this implementation for how all ports are mapped to companion controllers. The value of this field has the following interpretation: <table border="1" style="margin-left: 20px;"> <tr> <th>Value</th> <th>Meaning</th> </tr> <tr> <td>0</td> <td>The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on.</td> </tr> <tr> <td>1</td> <td>The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array.</td> </tr> </table> This field will always be '0'. | Value | Meaning | 0 | The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on. | 1 | The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array. |
| Value          | Meaning   |             |  |       |         |   |   |   |  |
| 0              | The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on. |             |  |       |         |   |   |   |  |
| 1              | The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array.  |             |  |       |         |   |   |   |  |
| 6:4            | /   | 0           | Reserved.<br>These bits are reserved and should be set to zero.  |       |         |   |   |   |  |
|                |   |             | N_PORTS<br>This field specifies the number of physical downstream ports implemented  |       |         |   |   |   |  |

|     |   |   |   |
|-----|---|---|---|
| 3:0 | R | 1 | on this host controller. The value of this field determines how many port registers are addressable in the Operational Register Space. Valid values are in the range of 0x1 to 0x0f.<br>This field is always 1. |
|-----|---|---|---|

#### 8.4.1.3.4. EHCI Host Control Capability Parameter Register(Default Value: Implementation Dependent)

| Offset: 0x0008 |     |             | Register Name: HCCPARAMS  |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:16          | /   | 0           | Reserved<br>These bits are reserved and should be set to zero.  |
| 15:18          | R   | 0           | EHCI Extended Capabilities Pointer (EECP)<br>This optional field indicates the existence of a capabilities list. A value of 00b indicates no extended capabilities are implemented. A non-zero value in this register indicates the offset in PCI configuration space of the first EHCI extended capability. The pointer value must be 40h or greater if implemented to maintain consistency of the PCI header defined for this class of device.<br>The value of this field is always '00b'.  |
| 7:4            | R   |             | Isochronous Scheduling Threshold<br>This field indicates, relative to the current position of the executing host controller, where software can reliably update the isochronous schedule.<br>When bit[7] is zero, the value of the least significant 3 bits indicates the number of micro-frames a host controller can hold a set of isochronous data structures(one or more) before flushing the state. When bit[7] is a one, then host software assumes the host controller may cache an isochronous data structure for an entire frame.              |
| 3              | R   | 0           | Reserved<br>These bits are reserved and should be set to zero.  |
| 2              | R   |             | Asynchronous Schedule Park Capability<br>If this bit is set to a one, then the host controller supports the park feature for high-speed queue heads in the Asynchronous Schedule. The feature can be disabled or enabled and set to a specific level by using the Asynchronous Schedule Park Mode Enable and Asynchronous Schedule Park Mode Count fields in the USBCMD register.   |
| 1              | R   |             | Programmable Frame List Flag<br>If this bit is set to a zero, then system software must use a frame list length of 1024 elements with this host controller.The USBCMD register Frame List Size field is a read-only register and should be set to zero.<br>If set to 1,then system software can specify and use the frame list in the USBCMD register Frame List Size field to configure the host controller.<br>The frame list must always aligned on a 4K page boundary.This requirement ensures that the frame list is always physically contiguous. |
| 0              | R   | 0           | Reserved  |

|  |  |  |   |
|--|--|--|---|
|  |  |  | These bits are reserved for future use and should return a value of zero when read. |
|--|--|--|---|

#### 8.4.1.3.5. EHCI Companion Port Route Description (Default Value: UNDEFINED)

| Offset: 0x000C |     |             | Register Name: HCSP-PORTROUTE   |
|----------------|-----|-------------|---|
| Bit            | R/W | Default/Hex | Description   |
| 31:0           | R   |             | <p><b>HCSP-PORTROUTE</b></p> <p>This optional field is valid only if Port Routing Rules field in HCSPARAMS register is set to a one.</p> <p>This field is used to allow a host controller implementation to explicitly describe to which companion host controller each implemented port is mapped. This field is a 15-element nibble array (each 4 bit is one array element). Each array location corresponds one-to-one with a physical port provided by the host controller (e.g. PORTROUTE [0] corresponds to the first PORTSC port, PORTROUTE [1] to the second PORTSC port, etc.). The value of each element indicates to which of the companion host controllers this port is routed. Only the first N_PORTS elements have valid information. A value of zero indicates that the port is routed to the lowest numbered function companion host controller. A value of one indicates that the port is routed to the next lowest numbered function companion host controller, and so on.</p> |

#### 8.4.1.3.6. EHCI USB Command Register (Default Value: 0x00080000(0x00080B00 if Asynchronous Schedule Park Capability is a one))

| Offset: 0x0010 |   |             | Register Name: USBCMD   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
|----------------|---|-------------|---|-------|----------------------------|------|----------|------|---------------|------|---------------|------|---------------|------|---|------|---------------------|------|---------------------|------|---------------------|
| Bit            | R/W                                     | Default/Hex | Description   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 31:24          | /                                       | 0           | <p>Reserved</p> <p>These bits are reserved and should be set to zero.</p>   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 23:16          | R/W                                     | 0x08        | <p>Interrupt Threshold Control</p> <p>The value in this field is used by system software to select the maximum rate at which the host controller will issue interrupts. The only valid values are defined below:</p> <table border="1"> <tr> <td>Value</td> <td>Minimum Interrupt Interval</td> </tr> <tr> <td>0x00</td> <td>Reserved</td> </tr> <tr> <td>0x01</td> <td>1 micro-frame</td> </tr> <tr> <td>0x02</td> <td>2 micro-frame</td> </tr> <tr> <td>0x04</td> <td>4 micro-frame</td> </tr> <tr> <td>0x08</td> <td>8 micro-frame(default, equates to 1 ms)</td> </tr> <tr> <td>0x10</td> <td>16 micro-frame(2ms)</td> </tr> <tr> <td>0x20</td> <td>32 micro-frame(4ms)</td> </tr> <tr> <td>0x40</td> <td>64 micro-frame(8ms)</td> </tr> </table> | Value | Minimum Interrupt Interval | 0x00 | Reserved | 0x01 | 1 micro-frame | 0x02 | 2 micro-frame | 0x04 | 4 micro-frame | 0x08 | 8 micro-frame(default, equates to 1 ms) | 0x10 | 16 micro-frame(2ms) | 0x20 | 32 micro-frame(4ms) | 0x40 | 64 micro-frame(8ms) |
| Value          | Minimum Interrupt Interval              |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x00           | Reserved                                |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x01           | 1 micro-frame                           |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x02           | 2 micro-frame                           |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x04           | 4 micro-frame                           |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x08           | 8 micro-frame(default, equates to 1 ms) |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x10           | 16 micro-frame(2ms)                     |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x20           | 32 micro-frame(4ms)                     |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |
| 0x40           | 64 micro-frame(8ms)                     |             |   |       |                            |      |          |      |               |      |               |      |               |      |   |      |                     |      |                     |      |                     |

|       |          |   |  |
|-------|----------|---|--|
|       |          |   | Any other value in this register yields undefined results.<br>The default value in this field is 0x08 .<br>Software modifications to this bit while HC Halted bit is equal to zero results in undefined behavior.  |
| 15:12 | /        | 0 | Reserved<br>These bits are reserved and should be set to zero.   |
| 11    | R/W or R | 0 | Asynchronous Schedule Park Mode Enable(OPTIONAL)<br>If the Asynchronous Park Capability bit in the HCCPARAMS register is a one, then this bit defaults to a 1 and is R/W. Otherwise the bit must be a zero and is Read Only. Software uses this bit to enable or disable Park mode. When this bit is one, Park mode is enabled. When this bit is zero, Park mode is disabled.  |
| 10    | /        | 0 | Reserved<br>These bits are reserved and should be set to zero.   |
| 9:8   | R/W or R | 0 | Asynchronous Schedule Park Mode Count(OPTIONAL)<br>Asynchronous Park Capability bit in the HCCPARAMS register is a one, Then this field defaults to 0x3 and is W/R. Otherwise it defaults to zero and is R. It contains a count of the number of successive transactions the host controller is allowed to execute from a high-speed queue head on the Asynchronous schedule before continuing traversal of the Asynchronous schedule.<br>Valid value are 0x1 to 0x3. Software must not write a zero to this bit when Park Mode Enable is a one as it will result in undefined behavior.   |
| 7     | R/W      | 0 | Light Host Controller Reset(OPTIONAL)<br>This control bit is not required.<br>If implemented, it allows the driver to reset the EHCI controller without affecting the state of the ports or relationship to the companion host controllers. For example, the PORSTC registers should not be reset to their default values and the CF bit setting should not go to zero (retaining port ownership relationships).<br>A host software read of this bit as zero indicates the Light Host Controller Reset has completed and it is safe for software to re-initialize the host controller. A host software read of this bit as a one indicates the Light Host  |
| 6     | R/W      | 0 | Interrupt on Async Advance Doorbell<br>This bit is used as a doorbell by software to tell the host controller to issue an interrupt the next time it advances asynchronous schedule. Software must write a 1 to this bit to ring the doorbell.<br>When the host controller has evicted all appropriate cached schedule state, it sets the Interrupt on Async Advance status bit in the USBSTS. If the Interrupt on Async Advance Enable bit in the USBINTR register is a one then the host controller will assert an interrupt at the next interrupt threshold.<br>The host controller sets this bit to a zero after it has set the Interrupt on Async Advance status bit in the USBSTS register to a one.<br>Software should not write a one to this bit when the asynchronous schedule is disabled. Doing so will yield undefined results. |

|           |  |   | Asynchronous Schedule Enable<br>This bit controls whether the host controller skips processing the Asynchronous Schedule. Values mean:<br><table border="1"><thead><tr><th>Bit Value</th><th>Meaning</th></tr></thead><tbody><tr><td>0</td><td>Do not process the Asynchronous Schedule.</td></tr><tr><td>1</td><td>Use the ASYNLISTADDR register to access the Asynchronous Schedule.</td></tr></tbody></table>  | Bit Value | Meaning | 0   | Do not process the Asynchronous Schedule. | 1   | Use the ASYNLISTADDR register to access the Asynchronous Schedule. |     |   |     |          |
|-----------|--|---|---|-----------|---------|-----|---|-----|--|-----|---|-----|----------|
| Bit Value | Meaning  |   |   |           |         |     |   |     |  |     |   |     |          |
| 0         | Do not process the Asynchronous Schedule.                          |   |   |           |         |     |   |     |  |     |   |     |          |
| 1         | Use the ASYNLISTADDR register to access the Asynchronous Schedule. |   |   |           |         |     |   |     |  |     |   |     |          |
| 5         | R/W  | 0 | The default value of this field is '0b'.  |           |         |     |   |     |  |     |   |     |          |
| 4         | R/W  | 0 | Periodic Schedule Enable<br>This bit controls whether the host controller skips processing the Periodic Schedule. Values mean:<br><table border="1"><thead><tr><th>Bit Value</th><th>Meaning</th></tr></thead><tbody><tr><td>0</td><td>Do not process the Periodic Schedule.</td></tr><tr><td>1</td><td>Use the PERIODICLISTBASE register to access the Periodic Schedule.</td></tr></tbody></table><br>The default value of this field is '0b'.  | Bit Value | Meaning | 0   | Do not process the Periodic Schedule.     | 1   | Use the PERIODICLISTBASE register to access the Periodic Schedule. |     |   |     |          |
| Bit Value | Meaning  |   |   |           |         |     |   |     |  |     |   |     |          |
| 0         | Do not process the Periodic Schedule.                              |   |   |           |         |     |   |     |  |     |   |     |          |
| 1         | Use the PERIODICLISTBASE register to access the Periodic Schedule. |   |   |           |         |     |   |     |  |     |   |     |          |
| 3:2       | R/W or R   | 0 | Frame List Size<br>This field is R/W only if Programmable Frame List Flag in the HCCPARAMS registers is set to a one. This field specifies the size of the Frame list. The size the frame list controls which bits in the Frame Index Register should be used for the Frame List Current index. Values mean:<br><table border="1"><thead><tr><th>Bits</th><th>Meaning</th></tr></thead><tbody><tr><td>00b</td><td>1024 elements(4096bytes)Default value</td></tr><tr><td>01b</td><td>512 elements(2048bytes)</td></tr><tr><td>10b</td><td>256 elements(1024bytes)For resource-constrained condition</td></tr><tr><td>11b</td><td>reserved</td></tr></tbody></table><br>The default value is '00b'.  | Bits      | Meaning | 00b | 1024 elements(4096bytes)Default value     | 01b | 512 elements(2048bytes)  | 10b | 256 elements(1024bytes)For resource-constrained condition | 11b | reserved |
| Bits      | Meaning  |   |   |           |         |     |   |     |  |     |   |     |          |
| 00b       | 1024 elements(4096bytes)Default value                              |   |   |           |         |     |   |     |  |     |   |     |          |
| 01b       | 512 elements(2048bytes)  |   |   |           |         |     |   |     |  |     |   |     |          |
| 10b       | 256 elements(1024bytes)For resource-constrained condition          |   |   |           |         |     |   |     |  |     |   |     |          |
| 11b       | reserved   |   |   |           |         |     |   |     |  |     |   |     |          |
| 1         | R/W  | 0 | Host Controller Reset<br>This control bit is used by software to reset the host controller. The effects of this on Root Hub registers are similar to a Chip Hardware Reset.<br>When software writes a one to this bit, the Host Controller resets its internal pipelines, timers, counters, state machines, etc. to their initial value. Any transaction currently in progress on USB is immediately terminated. A USB reset is not driven on downstream ports.<br>All operational registers, including port registers and port state machines are set to their initial values. Port ownership reverts to the companion host controller(s). Software must reinitialize the host controller as described in Section 4.1 of the CHEI Specification in order to return the host controller to an operational state.<br>This bit is set to zero by the Host Controller when the reset process is complete. Software cannot terminate the reset process early by writing a zero to this register.<br>Software should not set this bit to a one when the HC Halted bit in the USBSTS register is a zero. Attempting to reset an actively running host |           |         |     |   |     |  |     |   |     |          |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | controller will result in undefined behavior.   |
| 0 | R/W | 0 | <p>Run/Stop</p> <p>When set to a 1, the Host Controller proceeds with execution of the schedule. When set to 0, the Host Controller completes the current and any actively pipelined transactions on the USB and then halts. The Host Controller must halt within 16 micro-frames after software clears this bit.</p> <p>The HC Halted bit indicates when the Host Controller has finished its pending pipelined transactions and has entered the stopped state.</p> <p>Software must not write a one to this field unless the Host Controller is in the Halt State.</p> <p>The default value is 0x0.</p> |

#### 8.4.1.3.7. EHCI USB Status Register (Default Value: 0x00001000)

| Offset: 0x0014 |     |             | Register Name: <b>USBSTS</b>   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:16          | /   | 0           | <p>Reserved</p> <p>These bits are reserved and should be set to zero.</p>  |
| 15             | R   | 0           | <p>Asynchronous Schedule Status</p> <p>The bit reports the current real status of Asynchronous Schedule. If this bit is a zero then the status of the Asynchronous Schedule is disabled. If this bit is a one then the status of the Asynchronous Schedule is enabled. The Host Controller is not required to immediately disable or enable the Asynchronous Schedule when software transitions the Asynchronous Schedule Enable bit in the USBCMD register. When this bit and the Asynchronous Schedule Enable bit are the same value, the Asynchronous Schedule is either enabled (1) or disabled (0).</p> |
| 14             | R   | 0           | <p>Periodic Schedule Status</p> <p>The bit reports the current real status of the Periodic Schedule. If this bit is a zero then the status of the Periodic Schedule is disabled. If this bit is a one then the status of the Periodic Schedule is enabled. The Host Controller is not required to immediately disable or enable the Periodic Schedule when software transitions the Periodic Schedule Enable bit in the USBCMD register. When this bit and the Periodic Schedule Enable bit are the same value, the Periodic Schedule is either enabled (1) or disabled (0).</p>                             |
| 13             | R   | 0           | <p>Reclamation</p> <p>This is a read-only status bit, which is used to detect an empty asynchronous schedule.</p>  |
| 12             | R   | 1           | <p>HC Halted</p> <p>This bit is a zero whenever the Run/Stop bit is a one. The Host Controller Sets this bit to one after it has stopped executing as a result of the Run/Stop bit being set to 0, either by software or by the Host Controller Hardware (e.g. internal error).</p> <p>The default value is '1'.</p>   |

|      |      |   |   |
|------|------|---|---|
| 11:6 | /    | 0 | Reserved<br>These bits are reserved and should be set to zero.  |
| 5    | R/WC | 0 | Interrupt on Async Advance<br>System software can force the host controller to issue an interrupt the next time the host controller advances the asynchronous schedule by writing a one to the Interrupt on Async Advance Doorbell bit in the USBCMD register. This status bit indicates the assertion of that interrupt source.  |
| 4    | R/WC | 0 | Host System Error<br>The Host Controller set this bit to 1 when a serious error occurs during a host system access involving the Host Controller module. When this error occurs, the Host Controller clears the Run/Stop bit in the Command register to prevent further execution of the scheduled TDs.   |
| 3    | R/WC | 0 | Frame List Rollover<br>The Host Controller sets this bit to a one when the Frame List Index rolls over from its maximum value to zero. The exact value at which the rollover occurs depends on the frame list size. For example, if the frame list size is 1024, the Frame Index Register rolls over every time FRINDEX [13] toggles. Similarly, if the size is 512, the Host Controller sets this bit to a one every time FRINDEX [12] toggles.  |
| 2    | R/WC | 0 | Port Change Detect<br>The Host Controller sets this bit to a one when any port for which the Port Owner bit is set to zero has a change bit transition from a zero to a one or a Force Port Resume bit transition from a zero to a one as a result of a J-K transition detected on a suspended port. This bit will also be set as a result of the Connect Status Chang being set to a one after system software has relinquished ownership of a connected port by writing a one to a port's Port Owner bit. |
| 1    | R/WC | 0 | USB Error Interrupt(USBERRINT)<br>The Host Controller sets this bit to 1 when completion of USB transaction results in an error condition(e.g. error counter underflow).If the TD on which the error interrupt occurred also had its IOC bit set, both. This bit and USBINT bit are set.  |
| 0    | R/WC | 0 | USB Interrupt(USBINT)<br>The Host Controller sets this bit to a one on the completion of a USB transaction, which results in the retirement of a Transfer Descriptor that had its IOC bit set.<br>The Host Controller also sets this bit to 1 when a short packet is detected (actual number of bytes received was less than the expected number of bytes)  |

#### 8.4.1.3.8. EHCI USB Interrupt Enable Register (Default Value: 0x00000000)

| Offset: 0x0018 |     |             | Register Name: <b>USBINTR</b> |
|----------------|-----|-------------|-------------------------------|
| Bit            | R/W | Default/Hex | Description                   |

|      |     |   |  |
|------|-----|---|--|
| 31:6 | /   | 0 | Reserved<br>These bits are reserved and should be zero.  |
| 5    | R/W | 0 | Interrupt on Async Advance Enable<br>When this bit is 1, and the Interrupt on Async Advance bit in the USBSTS register is 1, the host controller will issue an interrupt at the next interrupt threshold. The interrupt is acknowledged by software clearing the Interrupt on Async Advance bit. |
| 4    | R/W | 0 | Host System Error Enable<br>When this bit is 1, and the Host System Error Status bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Host System Error bit.   |
| 3    | R/W | 0 | Frame List Rollover Enable<br>When this bit is 1, and the Frame List Rollover bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Frame List Rollover bit.  |
| 2    | R/W | 0 | Port Change Interrupt Enable<br>When this bit is 1, and the Port Chang Detect bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Port Chang Detect bit.  |
| 1    | R/W | 0 | USB Error Interrupt Enable<br>When this bit is 1, and the USBERRINT bit in the USBSTS register is 1, the host controller will issue an interrupt at the next interrupt threshold.<br>The interrupt is acknowledged by software clearing the USBERRINT bit.                                       |
| 0    | R/W | 0 | USB Interrupt Enable<br>When this bit is 1, and the USBINT bit in the USBSTS register is 1, the host controller will issue an interrupt at the next interrupt threshold.<br>The interrupt is acknowledged by software clearing the USBINT bit  |

#### 8.4.1.3.9. EHCI Frame Index Register (Default Value: 0x00000000)

| Offset: 0x001C          |                 |             | Register Name: FRINDEX   |                         |                 |   |     |      |    |
|-------------------------|-----------------|-------------|--|-------------------------|-----------------|---|-----|------|----|
| Bit                     | R/W             | Default/Hex | Description  |                         |                 |   |     |      |    |
| 31:14                   | /               | 0           | Reserved<br>These bits are reserved and should be zero.  |                         |                 |   |     |      |    |
| 13:0                    | R/W             | 0           | Frame Index<br>The value in this register increment at the end of each time frame (e.g. micro-frame). Bits[N:3] are used for the Frame List current index. It means that each location of the frame list is accessed 8 times(frames or Micro-frames) before moving to the next index. The following illustrates values of N based on the value of the Frame List Size field in the USBCMD register. <table border="1" data-bbox="595 1965 1405 2055"> <tr> <td>USBCMD[Frame List Size]</td> <td>Number Elements</td> <td>N</td> </tr> <tr> <td>00b</td> <td>1024</td> <td>12</td> </tr> </table> | USBCMD[Frame List Size] | Number Elements | N | 00b | 1024 | 12 |
| USBCMD[Frame List Size] | Number Elements | N           |  |                         |                 |   |     |      |    |
| 00b                     | 1024            | 12          |  |                         |                 |   |     |      |    |

|  |  |  |     |          |    |  |
|--|--|--|-----|----------|----|--|
|  |  |  | 01b | 512      | 11 |  |
|  |  |  | 10b | 256      | 10 |  |
|  |  |  | 11b | Reserved |    |  |

This register must be written as a DWord. Byte writes produce undefined results.

#### 8.4.1.3.10. EHCI Periodic Frame List Base Address Register (Default Value: Undefined)

| Offset: 0x0024 |     |             | Register Name: PERIODICLISTBASE  |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:12          | R/W |             | Base Address<br>These bits correspond to memory address signals [31:12], respectively.<br>This register contains the beginning address of the Periodic Frame List in the system memory.<br>System software loads this register prior to starting the schedule execution by the Host Controller. The memory structure referenced by this physical memory pointer is assumed to be 4-K byte aligned. The contents of this register are combined with the Frame Index Register (FRINDEX) to enable the Host Controller to step through the Periodic Frame List in sequence. |
| 11:0           | /   |             | Reserved<br>Must be written as 0x0 during runtime, the values of these bits are undefined.   |

Writes must be Dword Writes.

#### 8.4.1.3.11. EHCI Current Asynchronous List Address Register (Default Value: Undefined)

| Offset: 0x0028 |     |             | Register Name: ASYNCLISTADDR   |
|----------------|-----|-------------|--|
| Bit            | R/W | Default/Hex | Description  |
| 31:5           | R/W |             | Link Pointer (LP)<br>This field contains the address of the next asynchronous queue head to be executed.<br>These bits correspond to memory address signals [31:5], respectively.    |
| 4:0            | /   | /           | Reserved<br>These bits are reserved and their value has no effect on operation.<br>Bits in this field cannot be modified by system software and will always return a zero when read. |

Write must be DWord Writes.

#### 8.4.1.3.12. EHCI Configure Flag Register (Default Value: 0x00000000)

| Offset: 0x0050 |     |             | Register Name: CONFIGFLAG |
|----------------|-----|-------------|---------------------------|
| Bit            | R/W | Default/Hex | Description               |

| 31:1  | /  | 0 | Reserved<br>These bits are reserved and should be set to zero.   |       |         |   |  |   |   |
|-------|--|---|--|-------|---------|---|--|---|---|
| 0     | R/W  | 0 | Configure Flag(CF)<br>Host software sets this bit as the last action in its process of configuring the Host Controller. This bit controls the default port-routing control logic as follow:<br><table border="1"> <thead> <tr> <th>Value</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Port routing control logic default-routs each port to an implementation dependent classic host controller.</td> </tr> <tr> <td>1</td> <td>Port routing control logic default-routs all ports to this host controller.</td> </tr> </tbody> </table> The default value of this field is '0'. | Value | Meaning | 0 | Port routing control logic default-routs each port to an implementation dependent classic host controller. | 1 | Port routing control logic default-routs all ports to this host controller. |
| Value | Meaning  |   |  |       |         |   |  |   |   |
| 0     | Port routing control logic default-routs each port to an implementation dependent classic host controller. |   |  |       |         |   |  |   |   |
| 1     | Port routing control logic default-routs all ports to this host controller.                                |   |  |       |         |   |  |   |   |


**NOTE**

This register is not used in the normal implementation.

#### 8.4.1.3.13. EHCI Port Status and Control Register (Default Value: 0x00002000(w/PPC set to one);0x00003000

(w/PPC set to a zero))

| Offset: 0x0054 |   |             | Register Name: PORTSC   |      |           |       |   |       |              |       |              |       |              |
|----------------|---|-------------|---|------|-----------|-------|---|-------|--------------|-------|--------------|-------|--------------|
| Bit            | R/W                                       | Default/Hex | Description   |      |           |       |   |       |              |       |              |       |              |
| 31:22          | /   | 0           | Reserved<br>These bits are reserved for future use and should return a value of zero when read.   |      |           |       |   |       |              |       |              |       |              |
| 21             | R/W                                       | 0           | Wake on Disconnect Enable(WKDSNNT_E)<br>Writing this bit to a one enables the port to be sensitive to device disconnects as wake-up events.<br>This field is zero if Port Power is zero.<br>The default value in this field is '0'.   |      |           |       |   |       |              |       |              |       |              |
| 20             | R/W                                       | 0           | Wake on Connect Enable(WKCNNT_E)<br>Writing this bit to a one enable the port to be sensitive to device connects as wake-up events.<br>This field is zero if Port Power is zero.<br>The default value in this field is '0'.   |      |           |       |   |       |              |       |              |       |              |
| 19:16          | R/W                                       | 0           | Port Test Control<br>The value in this field specifies the test mode of the port. The encoding of the test mode bits are as follow:<br><table border="1"> <thead> <tr> <th>Bits</th> <th>Test Mode</th> </tr> </thead> <tbody> <tr> <td>0000b</td> <td>The port is NOT operating in a test mode.</td> </tr> <tr> <td>0001b</td> <td>Test J_STATE</td> </tr> <tr> <td>0010b</td> <td>Test K_STATE</td> </tr> <tr> <td>0011b</td> <td>Test SEO_NAK</td> </tr> </tbody> </table> | Bits | Test Mode | 0000b | The port is NOT operating in a test mode. | 0001b | Test J_STATE | 0010b | Test K_STATE | 0011b | Test SEO_NAK |
| Bits           | Test Mode                                 |             |   |      |           |       |   |       |              |       |              |       |              |
| 0000b          | The port is NOT operating in a test mode. |             |   |      |           |       |   |       |              |       |              |       |              |
| 0001b          | Test J_STATE                              |             |   |      |           |       |   |       |              |       |              |       |              |
| 0010b          | Test K_STATE                              |             |   |      |           |       |   |       |              |       |              |       |              |
| 0011b          | Test SEO_NAK                              |             |   |      |           |       |   |       |              |       |              |       |              |

|   |                   |  | <table border="1"> <tr><td>0100b</td><td>Test Packet</td></tr> <tr><td>0101b</td><td>Test FORCE_ENABLE</td></tr> <tr><td>0110b<br/>-<br/>1111b</td><td>Reserved</td></tr> </table>  | 0100b      | Test Packet | 0101b          | Test FORCE_ENABLE | 0110b<br>-<br>1111b | Reserved                                  |     |         |   |     |         |  |     |           |   |  |
|---|-------------------|--|---|------------|-------------|----------------|-------------------|---------------------|---|-----|---------|---|-----|---------|--|-----|-----------|---|--|
| 0100b                                       | Test Packet       |  |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 0101b                                       | Test FORCE_ENABLE |  |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 0110b<br>-<br>1111b                         | Reserved          |  |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| The default value in this field is '0000b'. |                   |  |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 15:14                                       | R/W               | 0  | <p>Reserved</p> <p>These bits are reserved for future use and should return a value of zero when read.</p>  |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 13  | R/W               | 1  | <p>Port Owner</p> <p>This bit unconditionally goes to a 0b when the Configured bit in the CONFIGFLAG register makes a 0b to 1b transition. This bit unconditionally goes to 1b whenever the Configured bit is zero.</p> <p>System software uses this field to release ownership of the port to selected host controller (in the event that the attached device is not a high-speed device). Software writes a one to this bit when the attached device is not a high-speed device. A one in this bit means that a companion host controller owns and controls the port.</p> <p>Default Value = 1b.</p>  |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 12  | /                 | 0  | <p>Reserved</p> <p>These bits are reserved for future use and should return a value of zero when read.</p>  |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 11:10                                       | R                 | 0  | <p>Line Status</p> <p>These bits reflect the current logical levels of the D+ (bit11) and D- (bit10) signal lines. These bits are used for detection of low-speed USB devices prior to port reset and enable sequence. This read only field is valid only when the port enable bit is zero and the current connect status bit is set to a one.</p> <p>The encoding of the bits are:</p> <table border="1"> <thead> <tr> <th>Bit[11:10]</th><th>USB State</th><th>Interpretation</th></tr> </thead> <tbody> <tr><td>00b</td><td>SEO</td><td>Not Low-speed device, perform EHCI reset.</td></tr> <tr><td>10b</td><td>J-state</td><td>Not Low-speed device, perform EHCI reset.</td></tr> <tr><td>01b</td><td>K-state</td><td>Low-speed device, release ownership of port.</td></tr> <tr><td>11b</td><td>Undefined</td><td>Not Low-speed device, perform EHCI reset.</td></tr> </tbody> </table> <p>This value of this field is undefined if Port Power is zero.</p> | Bit[11:10] | USB State   | Interpretation | 00b               | SEO                 | Not Low-speed device, perform EHCI reset. | 10b | J-state | Not Low-speed device, perform EHCI reset. | 01b | K-state | Low-speed device, release ownership of port. | 11b | Undefined | Not Low-speed device, perform EHCI reset. |  |
| Bit[11:10]                                  | USB State         | Interpretation                               |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 00b   | SEO               | Not Low-speed device, perform EHCI reset.    |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 10b   | J-state           | Not Low-speed device, perform EHCI reset.    |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 01b   | K-state           | Low-speed device, release ownership of port. |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 11b   | Undefined         | Not Low-speed device, perform EHCI reset.    |   |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 9   | /                 | 0  | <p>Reserved</p> <p>This bit is reserved for future use, and should return a value of zero when read.</p>  |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |
| 8   | R/W               | 0  | <p>Port Reset</p> <p>1=Port is in Reset. 0=Port is not in Reset. Default value = 0.</p> <p>When software writes a one to this bit (from a zero), the bus reset sequence as defined in the USB Specification Revision 2.0 is started. Software writes a</p>  |            |             |                |                   |                     |   |     |         |   |     |         |  |     |           |   |  |

|                             |            |   | <p>zero to this bit to terminate the bus reset sequence. Software must keep this bit at a one long enough to ensure the reset sequence, as specified in the USB Specification Revision 2.0, completes.</p> <p> <b>NOTE</b></p> <p><b>When software writes this bit to a one , it must also write a zero to the Port Enable bit.</b></p> <p>Note that when software writes a zero to this bit there may be a delay before the bit status changes to a zero. The bit status will not read as a zero until after the reset has completed. If the port is in high-speed mode after reset is complete, the host controller will automatically enable this port (e.g. set the Port Enable bit to a one). A host controller must terminate the reset and stabilize the state of the port within 2 milliseconds of software transitioning this bit from a one to a zero. For example: if the port detects that the attached device is high-speed during reset, then the host controller must have the port in the enabled state with 2ms of software writing this bit to a zero.</p> <p>The HC Halted bit in the USBSTS register should be a zero before software attempts to use this bit. The host controller may hold Port Reset asserted to a one when the HC Halted bit is a one.</p> <p>This field is zero if Port Power is zero.</p>               |                             |            |    |         |    |        |    |         |
|-----------------------------|------------|---|--|-----------------------------|------------|----|---------|----|--------|----|---------|
|                             |            |   | <p>Suspend</p> <p>Port Enabled Bit and Suspend bit of this register define the port states as follows:</p> <table border="1"> <thead> <tr> <th>Bits[Port Enables, Suspend]</th><th>Port State</th></tr> </thead> <tbody> <tr> <td>0x</td><td>Disable</td></tr> <tr> <td>10</td><td>Enable</td></tr> <tr> <td>11</td><td>Suspend</td></tr> </tbody> </table> <p>When in suspend state, downstream propagation of data is blocked on this port, except for port reset. The blocking occurs at the end of the current transaction, if a transaction was in progress when this bit was written to 1. In the suspend state, the port is sensitive to resume detection. Note that the bit status does not change until the port is suspend and that there may be a delay in suspending a port if there is a transaction currently in progress on the USB.</p> <p>A write of zero to this bit is ignored by the host controller. The host controller will unconditionally set this bit to a zero when:</p> <ul style="list-style-type: none"> <li>① Software sets the Force Port Resume bit to a zero(from a one).</li> <li>② Software sets the Port Reset bit to a one(from a zero).</li> </ul> <p>If host software sets this bit to a one when the port is not enabled(i.e. Port enabled bit is a zero), the results are undefined.</p> <p>This field is zero if Port Power is zero.</p> <p>The default value in this field is '0'.</p> | Bits[Port Enables, Suspend] | Port State | 0x | Disable | 10 | Enable | 11 | Suspend |
| Bits[Port Enables, Suspend] | Port State |   |  |                             |            |    |         |    |        |    |         |
| 0x                          | Disable    |   |  |                             |            |    |         |    |        |    |         |
| 10                          | Enable     |   |  |                             |            |    |         |    |        |    |         |
| 11                          | Suspend    |   |  |                             |            |    |         |    |        |    |         |
| 7                           | R/W        | 0 |  |                             |            |    |         |    |        |    |         |
| 6                           | R/W        | 0 | Force Port Resume  |                             |            |    |         |    |        |    |         |

|   |      |   |   |
|---|------|---|---|
|   |      |   | <p>1 = Resume detected/driven on port. 0 = No resume (K-state) detected/driven on port. Default value = 0.</p> <p>This functionality defined for manipulating this bit depends on the value of the Suspend bit. For example, if the port is not suspend and software transitions this bit to a one, then the effects on the bus are undefined. Software sets this bit to a 1 drive resume signaling. The Host Controller sets this bit to a 1 if a J-to-K transition is detected while the port is in the Suspend state. When this bit transitions to a one because a J-to-K transition is detected, the Port Change Detect bit in the USBSTS register is also set to a one. If software sets this bit to a one, the host controller must not set the Port Change Detect bit.</p> <p>Note that when the EHCI controller owns the port, the resume sequence follows the defined sequence documented in the USB Specification Revision 2.0. The resume signaling (Full-speed 'K') is driven on the port as long as this remains a one. Software must appropriately time the Resume and set this bit to a zero when the appropriate amount of time has elapsed. Writing a zero (from one) causes the port to return high-speed mode (forcing the bus below the port into a high-speed idle). This bit will remain a one until the port has switched to high-speed idle. The host controller must complete this transition within 2 milliseconds of software setting this bit to a zero.</p> <p>This field is zero if Port Power is zero.</p> |
| 5 | R/WC | 0 | <p>Over-current Change</p> <p>Default = 0. This bit gets set to a one when there is a change to Over-current Active. Software clears this bit by writing a one to this bit position.</p>  |
| 4 | R    | 0 | <p>Over-current Active</p> <p>0 = This port does not have an over-current condition. 1 = This port currently has an over-current condition. This bit will automatically transition from a one to a zero when the over current condition is removed.</p> <p>The default value of this bit is '0'.</p>  |
| 3 | R/WC | 0 | <p>Port Enable/Disable Change</p> <p>Default = 0. 1 = Port enabled/disabled status has changed. 0 = No change.</p> <p>For the root hub, this bit gets set to a one only when a port is disabled due to the appropriate conditions existing at the EOF2 point (See Chapter 11 of the USB Specification for the definition of a Port Error). Software clears this bit by writing a 1 to it.</p> <p>This field is zero if Port Power is zero.</p>  |
| 2 | R/W  | 0 | <p>Port Enabled/Disabled</p> <p>1=Enable, 0=Disable. Ports can only be enabled by the host controller as a part of the reset and enable. Software cannot enable a port by writing a one to this field. The host controller will only set this bit to a one when the reset sequence determines that the attached device is a high-speed device.</p> <p>Ports can be disabled by either a fault condition(disconnect event or other fault condition) or by host software. Note that the bit status does not change until the port state actually changes. There may be a delay in disabling or enabling a port due to other host controller and bus events.</p>   |

|   |      |   |   |
|---|------|---|---|
|   |      |   | When the port is disabled, downstream propagation of data is blocked on this port except for reset.<br>The default value of this field is '0'.<br>This field is zero if Port Power is zero.   |
| 1 | R/WC | 0 | Connect Status Change<br>1=Change in Current Connect Status, 0=No change, Default=0.<br>Indicates a change has occurred in the port's Current Connect Status. The host controller sets this bit for all changes to the port device connect status, even if system software has not cleared an existing connect status change. For example, the insertion status changes twice before system software has cleared the changed condition, hub hardware will be "setting" an already-set bit. Software sets this bit to 0 by writing a 1 to it.<br>This field is zero if Port Power is zero. |
| 0 | R    | 0 | Current Connect Status<br>Device is present on port when the value of this field is a one, and no device is present on port when the value of this field is a zero. This value reflects the current state of the port, and may not correspond directly to the event that caused the Connect Status Change(Bit 1) to be set.<br>This field is zero if Port Power zero.   |


**NOTE**

This register is only reset by hardware or in response to a host controller reset.

#### 8.4.1.4. OHCI Register Description

##### 8.4.1.4.1. HcRevision Register(Default Value: 0x00000010)

| Offset: 0x400 |            |    | Register Name: HcRevision |   |
|---------------|------------|----|---------------------------|---|
| Bit           | Read/Write |    | Default/Hex               | Description   |
|               | HCD        | HC |                           |   |
| 31:8          | /          | /  | 0x00                      | Reserved  |
| 7:0           | R          | R  | 0x10                      | Revision<br>This read-only field contains the BCD representation of the version of the HCI specification that is implemented by this HC. For example, a value of 0x11 corresponds to version 1.1. All of the HC implementations that are compliant with this specification will have a value of 0x10. |

##### 8.4.1.4.2. HcControl Register(Default Value: 0x00000000)

| Offset: 0x404 |            |             | Register Name: HcRevision |  |
|---------------|------------|-------------|---------------------------|--|
| Bit           | Read/Write | Default/Hex |                           |  |
|               |            |             |                           |  |

|       | HCD            | HC  |      | Description  |     |          |     |           |     |                |     |            |
|-------|----------------|-----|------|--|-----|----------|-----|-----------|-----|----------------|-----|------------|
| 31:11 | /              | /   | 0x00 | Reserved   |     |          |     |           |     |                |     |            |
| 10    | R/W            | R   | 0x0  | <p><b>RemoteWakeUpEnable</b><br/>                     This bit is used by HCD to enable or disable the remote wakeup feature upon the detection of upstream resume signaling. When this bit is set and the ResumeDetected bit in HcInterruptStatus is set, a remote wakeup is signaled to the host system. Setting this bit has no impact on the generation of hardware interrupt.</p>   |     |          |     |           |     |                |     |            |
| 9     | R/W            | R/W | 0x0  | <p><b>RemoteWakeUpConnected</b><br/>                     This bit indicates whether HC supports remote wakeup signaling. If remote wakeup is supported and used by the system, it is the responsibility of system firmware to set this bit during POST. HC clear the bit upon a hardware reset but does not alter it upon a software reset. Remote wakeup signaling of the host system is host-bus-specific and is not described in this specification.</p>  |     |          |     |           |     |                |     |            |
| 8     | R/W            | R   | 0x0  | <p><b>InterruptRouting</b><br/>                     This bit determines the routing of interrupts generated by events registered in HcInterruptStatus. If clear, all interrupt are routed to the normal host bus interrupt mechanism. If set, interrupts are routed to the System Management Interrupt. HCD clears this bit upon a hardware reset, but it does not alter this bit upon a software reset. HCD uses this bit as a tag to indicate the ownership of HC.</p>   |     |          |     |           |     |                |     |            |
| 7:6   | R/W            | R/W | 0x0  | <p><b>HostControllerFunctionalState for USB</b></p> <table border="1" data-bbox="603 1156 1421 1336"> <tr> <td>00b</td><td>USBReset</td></tr> <tr> <td>01b</td><td>USBResume</td></tr> <tr> <td>10b</td><td>USBOperational</td></tr> <tr> <td>11b</td><td>USBSuspend</td></tr> </table> <p>A transition to USBOperational from another state causes SOF generation to begin 1 ms later. HCD may determine whether HC has begun sending SOFs by reading the StartFrame field of HcInterruptStatus.</p> <p>This field may be changed by HC only when in the USBSUSPEND state. HC may move from the USBSUSPEND state to the USBRESUME state after detecting the resume signaling from a downstream port.</p> <p>HC enters USBSUSPEND after a software reset, whereas it enters USBRESET after a hardware reset. The latter also resets the Root Hub and asserts subsequent reset signaling to downstream ports.</p> | 00b | USBReset | 01b | USBResume | 10b | USBOperational | 11b | USBSuspend |
| 00b   | USBReset       |     |      |  |     |          |     |           |     |                |     |            |
| 01b   | USBResume      |     |      |  |     |          |     |           |     |                |     |            |
| 10b   | USBOperational |     |      |  |     |          |     |           |     |                |     |            |
| 11b   | USBSuspend     |     |      |  |     |          |     |           |     |                |     |            |
| 5     | R/W            | R   | 0x0  | <p><b>BulkListEnable</b><br/>                     This bit is set to enable the processing of the Bulk list in the next Frame. If cleared by HCD, processing of the Bulk list does not occur after the next SOF. HC checks this bit whenever it determines to process the list. When disabled, HCD may modify the list. If HcBulkCurrentED is pointing to an ED to be removed, HCD must advance the pointer by updating HcBulkCurrentED before re-enabling processing of the list.</p>   |     |          |     |           |     |                |     |            |
| 4     | R/W            | R   | 0x0  | <b>ControlListEnable</b>   |     |          |     |           |     |                |     |            |

|      |   |   |     | This bit is set to enable the processing of the Control list in the next Frame. If cleared by HCD, processing of the Control list does not occur after the next SOF. HC must check this bit whenever it determines to process the list. When disabled, HCD may modify the list. If HcControlCurrentED is pointing to an ED to be removed, HCD must advance the pointer by updating HcControlCurrentED before re-enabling processing of the list.   |      |   |   |     |   |     |   |     |   |     |
|------|---|---|-----|--|------|---|---|-----|---|-----|---|-----|---|-----|
| 3    | R/W                                     | R | 0x0 | <p>IsochronousEnable</p> <p>This bit is used by HCD to enable/disable processing of isochronous EDs. While processing the periodic list in a Frame, HC checks the status of this bit when it finds an Isochronous ED (F=1). If set (enabled), HC continues processing the EDs. If cleared (disabled), HC halts processing of the periodic list (which now contains only isochronous EDs) and begins processing the Bulk/Control lists.</p> <p>Setting this bit is guaranteed to take effect in the next Frame (not the current Frame).</p>   |      |   |   |     |   |     |   |     |   |     |
| 2    | R/W                                     | R | 0x0 | <p>PeriodicListEnable</p> <p>This bit is set to enable the processing of periodic list in the next Frame. If cleared by HCD, processing of the periodic list does not occur after the next SOF. HC must check this bit before it starts processing the list.</p>   |      |   |   |     |   |     |   |     |   |     |
| 1:0  | R/W                                     | R | 0x0 | <p>ControlBulkServiceRatio</p> <p>This specifies the service ratio between Control and Bulk EDs. Before processing any of the nonperiodic lists, HC must compare the ratio specified with its internal count on how many nonempty Control EDs have been processed, in determining whether to continue serving another Control ED or switching to Bulk EDs. The internal count will be retained when crossing the frame boundary. In case of reset, HCD is responsible for restoring this value.</p> <table border="1"> <thead> <tr> <th>CBSR</th> <th>No. of Control EDs Over Bulk EDs Served</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1:1</td> </tr> <tr> <td>1</td> <td>2:1</td> </tr> <tr> <td>2</td> <td>3:1</td> </tr> <tr> <td>3</td> <td>4:1</td> </tr> </tbody> </table> <p>The default value is 0x0.</p> | CBSR | No. of Control EDs Over Bulk EDs Served | 0 | 1:1 | 1 | 2:1 | 2 | 3:1 | 3 | 4:1 |
| CBSR | No. of Control EDs Over Bulk EDs Served |   |     |  |      |   |   |     |   |     |   |     |   |     |
| 0    | 1:1                                     |   |     |  |      |   |   |     |   |     |   |     |   |     |
| 1    | 2:1                                     |   |     |  |      |   |   |     |   |     |   |     |   |     |
| 2    | 3:1                                     |   |     |  |      |   |   |     |   |     |   |     |   |     |
| 3    | 4:1                                     |   |     |  |      |   |   |     |   |     |   |     |   |     |

#### 8.4.1.4.3. HcCommandStatus Register(Default Value: 0x00000000)

| Offset: 0x408 |            |     | Register Name: HcCommandStatus |   |
|---------------|------------|-----|--------------------------------|---|
| Bit           | Read/Write |     | Default/Hex                    | Description   |
|               | HCD        | HC  |                                |   |
| 31:18         | /          | /   | 0x0                            | Reserved  |
| 17:16         | R          | R/W | 0x0                            | <p>SchedulingOverrunCount</p> <p>These bits are incremented on each scheduling overrun error. It is initialized to 00b and wraps around at 11b. This will be incremented when a</p> |

|      |     |     |     |   |
|------|-----|-----|-----|---|
|      |     |     |     | scheduling overrun is detected even if SchedulingOverrun in HcInterruptStatus has already been set. This is used by HCD to monitor any persistent scheduling problem.   |
| 15:4 | /   | /   | 0x0 | Reserved  |
| 3    | R/W | R/W | 0x0 | <p><b>OwnershipChangeRequest</b></p> <p>This bit is set by an OS HCD to request a change of control of the HC. When set HC will set the OwnershipChange field in HcInterruptStatus. After the changeover, this bit is cleared and remains so until the next request from OS HCD.</p>  |
| 2    | R/W | R/W | 0x0 | <p><b>BulkListFilled</b></p> <p>This bit is used to indicate whether there are any TDs on the Bulk list. It is set by HCD whenever it adds a TD to an ED in the Bulk list.</p> <p>When HC begins to process the head of the Bulk list, it checks BLF. As long as BulkListFilled is 0, HC will not start processing the Bulk list. If BulkListFilled is 1, HC will start processing the Bulk list and will set BF to 0. If HC finds a TD on the list, then HC will set BulkListFilled to 1 causing the Bulk list processing to continue. If no TD is found on the Bulk list, and if HCD does not set BulkListFilled, then BulkListFilled will still be 0 when HC completes processing the Bulk list and Bulk list processing will stop.</p>  |
| 1    | R/W | R/W | 0x0 | <p><b>ControlListFilled</b></p> <p>This bit is used to indicate whether there are any TDs on the Control list. It is set by HCD whenever it adds a TD to an ED in the Control list.</p> <p>When HC begins to process the head of the Control list, it checks CLF. As long as ControlListFilled is 0, HC will not start processing the Control list. If CF is 1, HC will start processing the Control list and will set ControlListFilled to 0. If HC finds a TD on the list, then HC will set ControlListFilled to 1 causing the Control list processing to continue. If no TD is found on the Control list, and if the HCD does not set ControlListFilled, then ControlListFilled will still be 0 when HC completes processing the Control list and Control list processing will stop.</p> |
| 0    | R/W | R/E | 0x0 | <p><b>HostControllerReset</b></p> <p>This bit is by HCD to initiate a software reset of HC. Regardless of the functional state of HC, it moves to the USBSuspend state in which most of the operational registers are reset except those stated otherwise; e.g., the InterruptRouting field of HcControl, and no Host bus accesses are allowed. This bit is cleared by HC upon the completion of the reset operation. The reset operation must be completed within 10 ms. This bit, when set, should not cause a reset to the Root Hub and no subsequent reset signaling should be asserted to its downstream ports.</p>  |

#### 8.4.1.4.4. HcInterruptStatus Register(Default Value: 0x00000000)

| Offset: 0x40c |            |             | Register Name: HcInterruptStatus |
|---------------|------------|-------------|----------------------------------|
| Bit           | Read/Write | Default/Hex | Description                      |

|      |     |     |     |  |
|------|-----|-----|-----|--|
|      | HCD | HC  |     |  |
| 31:7 | /   | /   | 0x0 | Reserved   |
| 6    | R/W | R/W | 0x0 | <p><b>RootHubStatusChange</b><br/>                     This bit is set when the content of HcRhStatus or the content of any of HcRhPortStatus[NumberofDownstreamPort] has changed.</p>   |
| 5    | R/W | R/W | 0x0 | <p><b>FrameNumberOverflow</b><br/>                     This bit is set when the MSb of HcFmNumber (bit 15) changes value, from 0 to 1 or from 1 to 0, and after HccaFrameNumber has been updated.</p>  |
| 4    | R/W | R/W | 0x0 | <p><b>UnrecoverableError</b><br/>                     This bit is set when HC detects a system error not related to USB. HC should not proceed with any processing nor signaling before the system error has been corrected. HCD clears this bit after HC has been reset.</p>                            |
| 3    | R/W | R/W | 0x0 | <p><b>ResumeDetected</b><br/>                     This bit is set when HC detects that a device on the USB is asserting resume signaling. It is the transition from no resume signaling to resume signaling causing this bit to be set. This bit is not set when HCD sets the USBRseume state.</p>       |
| 2    | R/W | R/W | 0x0 | <p><b>StartofFrame</b><br/>                     This bit is set by HC at each start of frame and after the update of HccaFrameNumber. HC also generates a SOF token at the same time.</p>  |
| 1    | R/W | R/W | 0x0 | <p><b>WritebackDoneHead</b><br/>                     This bit is set immediately after HC has written HcDoneHead to HccaDoneHead. Further updates of the HccaDoneHead will not occur until this bit has been cleared. HCD should only clear this bit after it has saved the content of HccaDoneHead.</p> |
| 0    | R/W | R/W | 0x0 | <p><b>SchedulingOverrun</b><br/>                     This bit is set when the USB schedule for the current Frame overruns and after the update of HccaFrameNumber. A scheduling overrun will also cause the SchedulingOverrunCount of HcCommandStatus to be Incremented.</p>                             |

#### 8.4.1.4.5. HcInterruptEnable Register(Default Value: 0x00000000)

| Offset: 0x410 |            |    | Register Name: HcInterruptEnable Register |   |   |         |
|---------------|------------|----|---|---|---|---------|
| Bit           | Read/Write |    | Default/Hex                               | Description   |   |         |
|               | HCD        | HC |   |   |   |         |
| 31            | R/W        | R  | 0x0                                       | <p><b>MasterInterruptEnable</b><br/>                     A '0' written to this field is ignored by HC. A '1' written to this field enables interrupt generation due to events specified in the other bits of this register. This is used by HCD as Master Interrupt Enable.</p> |   |         |
| 30:7          | /          | /  | 0x0                                       | Reserved  |   |         |
| 6             | R/W        | R  | 0x0                                       | <p><b>RootHubStatusChange Interrupt Enable</b></p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>0</td> <td>Ignore;</td> </tr> </table>  | 0 | Ignore; |
| 0             | Ignore;    |    |   |   |   |         |

|   |     |   |     |   |   |  |
|---|-----|---|-----|---|---|--|
|   |     |   |     | 1 | Enable interrupt generation due to Root Hub Status Change;  |  |
| 5 | R/W | R | 0x0 |   | FrameNumberOverflow Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Frame Number Over Flow; |  |
| 4 | R/W | R | 0x0 |   | UnrecoverableError Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Unrecoverable Error;     |  |
| 3 | R/W | R | 0x0 |   | ResumeDetected Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Resume Detected;             |  |
| 2 | R/W | R | 0x0 |   | StartofFrame Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Start of Flame;                |  |
| 1 | R/W | R | 0x0 |   | WritebackDoneHead Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Write back Done Head;     |  |
| 0 | R/W | R | 0x0 |   | SchedulingOverrun Interrupt Enable<br>0 Ignore;<br>1 Enable interrupt generation due to Scheduling Overrun;       |  |

#### 8.4.1.4.6. HcInterruptDisable Register(Default Value: 0x00000000)

| Offset: 0x414 |            |    |             | Register Name: HcInterruptDisable Register   |  |  |
|---------------|------------|----|-------------|--|--|--|
| Bit           | Read/Write |    | Default/Hex | Description  |  |  |
|               | HCD        | HC |             |  |  |  |
| 31            | R/W        | R  | 0x0         | MasterInterruptEnable<br>A written '0' to this field is ignored by HC. A '1' written to this field disables interrupt generation due events specified in the other bits of this register.<br>This field is set after a hardware or software reset. |  |  |
| 30:7          | /          | /  | 0x00        | Reserved   |  |  |
| 6             | R/W        | R  | 0x0         | RootHubStatusChange Interrupt Disable<br>0 Ignore;<br>1 Disable interrupt generation due to Root Hub Status Change;  |  |  |
| 5             | R/W        | R  | 0x0         | FrameNumberOverflow Interrupt Disable<br>0 Ignore;<br>1 Disable interrupt generation due to Frame Number Over Flow;  |  |  |
| 4             | R/W        | R  | 0x0         | UnrecoverableError Interrupt Disable<br>0 Ignore;<br>1 Disable interrupt generation due to Unrecoverable Error;  |  |  |
| 3             | R/W        | R  | 0x0         | ResumeDetected Interrupt Disable<br>0 Ignore;  |  |  |

|   |     |   |     |                                     |   |  |
|---|-----|---|-----|-------------------------------------|---|--|
|   |     |   |     | 1                                   | Disable interrupt generation due to Resume Detected;    |  |
| 2 | R/W | R | 0x0 | StartofFrame Interrupt Disable      |   |  |
|   |     |   |     | 0                                   | Ignore;   |  |
| 1 | R/W | R | 0x0 | WritebackDoneHead Interrupt Disable |   |  |
|   |     |   |     | 0                                   | Ignore;   |  |
| 0 | R/w | R | 0x0 | SchedulingOverrun Interrupt Disable |   |  |
|   |     |   |     | 0                                   | Ignore;   |  |
|   |     |   |     | 1                                   | Disable interrupt generation due to Scheduling Overrun; |  |

#### 8.4.1.4.7. HcHCCA Register(Default Value: 0x00000000)

| Offset: 0x418 |            |    |             | Register Name: HcHCCA  |
|---------------|------------|----|-------------|--|
| Bit           | Read/Write |    | Default/Hex | Description  |
|               | HCD        | HC |             |  |
| 31:8          | R/W        | R  | 0x0         | HCCA[31:8]<br>This is the base address of the Host Controller Communication Area. This area is used to hold the control structures and the Interrupt table that are accessed by both the Host Controller and the Host Controller Driver. |
| 7:0           | R          | R  | 0x0         | HCCA[7:0]<br>The alignment restriction in HcHCCA register is evaluated by examining the number of zeros in the lower order bits. The minimum alignment is 256 bytes, therefore, bits 0 through 7 must always return 0 when read.         |

#### 8.4.1.4.8. HcPeriodCurrentED Register(Default Value: 0x00000000)

| Offset: 0x41c |            |     |             | Register Name: HcPeriodCurrentED(PCED)  |
|---------------|------------|-----|-------------|---|
| Bit           | Read/Write |     | Default/Hex | Description   |
|               | HCD        | HC  |             |   |
| 31:4          | R          | R/W | 0x0         | PCED[31:4]<br>This is used by HC to point to the head of one of the Periodic list which will be processed in the current Frame. The content of this register is updated by HC after a periodic ED has been processed. HCD may read the content in determining which ED is currently being processed at the time of reading. |
| 3:0           | R          | R   | 0x0         | PCED[3:0]<br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.  |

#### 8.4.1.4.9. HcControlHeadED Register(Default Value: 0x00000000)

| Offset: 0x420 |            |    |             | Register Name: HcControlHeadED[CHED]   |
|---------------|------------|----|-------------|--|
| Bit           | Read/Write |    | Default/Hex | Description  |
|               | HCD        | HC |             |  |
| 31:4          | R/W        | R  | 0x0         | <b>EHCD[31:4]</b><br>The HcControlHeadED register contains the physical address of the first Endpoint Descriptor of the Control list. HC traverse the Control list starting with the HcControlHeadED pointer. The content is loaded from HCCA during the initialization of HC. |
| 3:0           | R          | R  | 0x0         | <b>EHCD[3:0]</b><br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.  |

#### 8.4.1.4.10. HcControlCurrentED Register(Default Value: 0x00000000)

| Offset: 0x424 |            |     |             | Register Name: HcControlCurrentED[CCED]   |
|---------------|------------|-----|-------------|---|
| Bit           | Read/Write |     | Default/Hex | Description   |
|               | HCD        | HC  |             |   |
| 31:4          | R/W        | R/W | 0x0         | <b>CCED[31:4]</b><br>The pointer is advanced to the next ED after serving the present one. HC will continue processing the list from where it left off in the last Frame. When it reaches the end of the Control list, HC checks the ControlListFilled of in HcCommandStatus. If set, it copies the content of HcControlHeadED to HcControlCurrentED and clears the bit. If not set, it does nothing.<br>HCD is allowed to modify this register only when the ControlListEnable of HcControl is cleared. When set, HCD only reads the instantaneous value of this register. Initially, this is set to zero to indicate the end of the Control list. |
| 3:0           | R          | R   | 0x0         | <b>CCED[3:0]</b><br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.   |

#### 8.4.1.4.11. HcBulkHeadED Register(Default Value: 0x00000000)

| Offset: 0x428 |            |    |             | Register Name: HcBulkHeadED[BHED] |
|---------------|------------|----|-------------|-----------------------------------|
| Bit           | Read/Write |    | Default/Hex | Description                       |
|               | HCD        | HC |             |                                   |
| 31:4          | R/W        | R  | 0x0         | <b>BHED[31:4]</b>                 |

|     |   |   |     |  |
|-----|---|---|-----|--|
|     |   |   |     | The HcBulkHeadED register contains the physical address of the first Endpoint Descriptor of the Bulk list. HC traverses the Bulk list starting with the HcBulkHeadED pointer. The content is loaded from HCCA during the initialization of HC. |
| 3:0 | R | R | 0x0 | BHED[3:0]<br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.                               |

#### 8.4.1.4.12. HcBulkCurrentED Register(Default Value: 0x00000000)

| Offset: 0x42c |            |     | Register Name: HcBulkCurrentED [BCED] |  |
|---------------|------------|-----|---------------------------------------|--|
| Bit           | Read/Write |     | Default/Hex                           | Description  |
|               | HCD        | HC  |                                       |  |
| 31:4          | R/W        | R/W | 0x0                                   | BulkCurrentED[31:4]<br>This is advanced to the next ED after the HC has served the present one. HC continues processing the list from where it left off in the last Frame. When it reaches the end of the Bulk list, HC checks the ControlListFilled of HcControl. If set, it copies the content of HcBulkHeadED to HcBulkCurrentED and clears the bit. If it is not set, it does nothing. HCD is only allowed to modify this register when the BulkListEnable of HcControl is cleared. When set, the HCD only reads the instantaneous value of this register. This is initially set to zero to indicate the end of the Bulk list. |
| 3:0           | R          | R   | 0x0                                   | BulkCurrentED [3:0]<br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.   |

#### 8.4.1.4.13. HcDoneHead Register(Default Value: 0x00000000)

| Offset: 0x430 |            |     | Register Name: HcDoneHead |  |
|---------------|------------|-----|---------------------------|--|
| Bit           | Read/Write |     | Default/Hex               | Description  |
|               | HCD        | HC  |                           |  |
| 31:4          | R          | R/W | 0x0                       | HcDoneHead[31:4]<br>When a TD is completed, HC writes the content of HcDoneHead to the NextTD field of the TD. HC then overwrites the content of HcDoneHead with the address of this TD. This is set to zero whenever HC writes the content of this register to HCCA. It also sets the WritebackDoneHead of HcInterruptStatus. |
| 3:0           | R          | R   | 0x0                       | HcDoneHead[3:0]<br>Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.   |

**8.4.1.4.14. HcFmInterval Register(Default Value: 0x00002EDF)**

| Offset: 0x434 |            |    |             | Register Name: HcFmInterval Register   |
|---------------|------------|----|-------------|--|
| Bit           | Read/Write |    | Default/Hex | Description  |
|               | HCD        | HC |             |  |
| 31            | R/W        | R  | 0x0         | FrameIntervalToggler<br>HCD toggles this bit whenever it loads a new value to FrameInterval.   |
| 30:16         | R/W        | R  | 0x0         | FSLargestDataPacket<br>This field specifies a value which is loaded into the Largest Data Packet Counter at the beginning of each frame. The counter value represents the largest amount of data in bits which can be sent or received by the HC in a single transaction at any given time without causing scheduling overrun.<br>The field value is calculated by the HCD.  |
| 15:14         | /          | /  | 0x0         | Reserved   |
| 13:0          | R/W        | R  | 0x2edf      | FrameInterval<br>This specifies the interval between two consecutive SOFs in bit times. The nominal value is set to be 11,999. HCD should store the current value of this field before resetting HC. By setting the HostControllerReset field of HcCommandStatus as this will cause the HC to reset this field to its nominal value. HCD may choose to restore the stored value upon the completion of the Reset sequence. |

**8.4.1.4.15. HcFmRemaining Register(Default Value: 0x00000000)**

| Offset: 0x438 |            |     |             | Register Name: HcFmRemaining  |
|---------------|------------|-----|-------------|---|
| Bit           | Read/Write |     | Default/Hex | Description   |
|               | HCD        | HC  |             |   |
| 31            | R          | R/W | 0x0         | FrameRemaining Toggle<br>This bit is loaded from the FrameIntervalToggle field of HcFmInterval whenever FrameRemaining reaches 0. This bit is used by HCD for the synchronization between FrameInterval and FrameRemaining.   |
| 30:14         | /          | /   | 0x0         | Reserved  |
| 13:0          | R          | RW  | 0x0         | FramRemaining<br>This counter is decremented at each bit time. When it reaches zero, it is reset by loading the FrameInterval value specified in HcFmInterval at the next bit time boundary. When entering the USBOPERATIONAL state, HC re-loads the content with the FrameInterval of HcFmInterval and uses the updated value from the next SOF. |

**8.4.1.4.16. HcFmNumber Register(Default Value: 0x00000000)**

| Offset: 0x43c |            |     |             | Register Name: <b>HcFmNumber</b>   |
|---------------|------------|-----|-------------|--|
| Bit           | Read/Write |     | Default/Hex | Description  |
|               | HCD        | HC  |             |  |
| 31:16         |            |     |             | Reserved   |
| 15:0          | R          | R/W | 0x0         | <p><b>FrameNumber</b></p> <p>This is incremented when HcFmRemaining is re-loaded. It will be rolled over to 0x0 after 0xffff. When entering the USBOPERATIONAL state, this will be incremented automatically. The content will be written to HCCA after HC has incremented the FrameNumber at each frame boundary and sent a SOF but before HC reads the first ED in that Frame. After writing to HCCA, HC will set the StartofFrame in HcInterruptStatus.</p> |

**8.4.1.4.17. HcPeriodicStart Register(Default Value: 0x00000000)**

| Offset: 0x440 |            |    |             | Register Name: <b>HcPeriodicStatus</b>   |
|---------------|------------|----|-------------|--|
| Bit           | Read/Write |    | Default/Hex | Description  |
|               | HCD        | HC |             |  |
| 31:14         | /          | /  | /           | Reserved   |
| 13:0          | R/W        | R  | 0x0         | <p><b>PeriodicStart</b></p> <p>After a hardware reset, this field is cleared. This is then set by HCD during the HC initialization. The value is calculated roughly as 10% off from HcFmInterval. A typical value will be 0x2A3F (0x3e67??). When HcFmRemaining reaches the value specified, processing of the periodic lists will have priority over Control/Bulk processing. HC will therefore start processing the Interrupt list after completing the current Control or Bulk transaction that is in progress.</p> |

**8.4.1.4.18. HcLSThreshold Register(Default Value: 0x00000628)**

| Offset: 0x444 |            |    |             | Register Name: <b>HcLSThreshold</b>  |
|---------------|------------|----|-------------|--|
| Bit           | Read/Write |    | Default/Hex | Description  |
|               | HCD        | HC |             |  |
| 31:12         | /          | /  | /           | Reserved   |
| 11:0          | R/W        | R  | 0x0628      | <p><b>LSThreshold</b></p> <p>This field contains a value which is compared to the FrameRemaining field prior to initiating a Low Speed transaction. The transaction is started only if FrameRemaining <sup>3</sup> this field. The value is calculated by HCD with the consideration of transmission and setup overhead.</p> |

**8.4.1.4.19. HcRhDescriptorA Register(Default Value: 0x02001201)**

| Offset: 0x448 |   |    |             | Register Name: HcRhDescriptorA  |   |  |   |   |
|---------------|---|----|-------------|---|---|--|---|---|
| Bit           | Read/Write  |    | Default/Hex | Description   |   |  |   |   |
|               | HCD   | HC |             |   |   |  |   |   |
| 31:24         | R/W   | R  | 0x2         | <p>PowerOnToPowerGoodTime[POTPGT]</p> <p>This byte specifies the duration HCD has to wait before accessing a powered-on port of the Root Hub. It is implementation-specific. The unit of time is 2 ms. The duration is calculated as POTPGT * 2ms.</p>  |   |  |   |   |
| 23:13         | /   | /  | /           | Reserved  |   |  |   |   |
| 12            | R/W   | R  | 1           | <p>NoOverCurrentProtection</p> <p>This bit describes how the overcurrent status for the Root Hub ports are reported. When this bit is cleared, the OverCurrentProtectionMode field specifies global or per-port reporting.</p> <table border="1"> <tr> <td>0</td><td>Over-current status is reported collectively for all downstream ports.</td></tr> <tr> <td>1</td><td>No overcurrent protection supported.</td></tr> </table>  | 0 | Over-current status is reported collectively for all downstream ports. | 1 | No overcurrent protection supported.  |
| 0             | Over-current status is reported collectively for all downstream ports.  |    |             |   |   |  |   |   |
| 1             | No overcurrent protection supported.  |    |             |   |   |  |   |   |
| 11            | R/W   | R  | 0           | <p>OverCurrentProtectionMode</p> <p>This bit describes how the overcurrent status for the Root Hub ports are reported. At reset, these fields should reflect the same mode as PowerSwitchingMode. This field is valid only if the NoOverCurrentProtection field is cleared.</p> <table border="1"> <tr> <td>0</td><td>Over-current status is reported collectively for all downstream ports.</td></tr> <tr> <td>1</td><td>Over-current status is reported on per-port basis.</td></tr> </table>   | 0 | Over-current status is reported collectively for all downstream ports. | 1 | Over-current status is reported on per-port basis.  |
| 0             | Over-current status is reported collectively for all downstream ports.  |    |             |   |   |  |   |   |
| 1             | Over-current status is reported on per-port basis.  |    |             |   |   |  |   |   |
| 10            | R   | R  | 0x0         | <p>Device Type</p> <p>This bit specifies that the Root Hub is not a compound device. The Root Hub is not permitted to be a compound device. This field should always read/write 0.</p>  |   |  |   |   |
| 9             | R/W   | R  | 1           | <p>PowerSwitchingMode</p> <p>This bit is used to specify how the power switching of the Root Hub ports is controlled. It is implementation-specific. This field is only valid if the NoPowerSwitching field is cleared.</p> <table border="1"> <tr> <td>0</td><td>All ports are powered at the same time.</td></tr> <tr> <td>1</td><td>Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower).</td></tr> </table> | 0 | All ports are powered at the same time.                                | 1 | Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower). |
| 0             | All ports are powered at the same time.   |    |             |   |   |  |   |   |
| 1             | Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower). |    |             |   |   |  |   |   |

|     |  |   |      |  |   |                           |   |  |
|-----|--|---|------|--|---|---------------------------|---|--|
|     |  |   |      | NoPowerSwitching<br>These bits are used to specify whether power switching is supported or ports are always powered. It is implementation-specific. When this bit is cleared, the PowerSwitchingMode specifies global or per-port switching. |   |                           |   |  |
| 8   | R/W  | R | 0    | <table border="1"> <tr> <td>0</td><td>Ports are power switched.</td></tr> <tr> <td>1</td><td>Ports are always powered on when the HC is powered on.</td></tr> </table>   | 0 | Ports are power switched. | 1 | Ports are always powered on when the HC is powered on. |
| 0   | Ports are power switched.                              |   |      |  |   |                           |   |  |
| 1   | Ports are always powered on when the HC is powered on. |   |      |  |   |                           |   |  |
| 7:0 | R  | R | 0x01 | NumberDownstreamPorts<br>These bits specify the number of downstream ports supported by the Root Hub. It is implementation-specific. The minimum number of ports is 1. The maximum number of ports supported.                                |   |                           |   |  |

#### 8.4.1.4.20. HcRhDescriptorB Register(Default Value: 0x00000000)

| Offset: 0x44c |                                |    | Register Name: HcRhDescriptorB Register |  |      |          |      |                               |      |                               |     |  |       |                                |
|---------------|--------------------------------|----|---|--|------|----------|------|-------------------------------|------|-------------------------------|-----|--|-------|--------------------------------|
| Bit           | Read/Write                     |    | Default/Hex                             | Description  |      |          |      |                               |      |                               |     |  |       |                                |
|               | HCD                            | HC |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| 31:16         | R/W                            | R  | 0x0                                     | <p>PortPowerControlMask<br/>Each bit indicates if a port is affected by a global power control command when PowerSwitchingMode is set. When set, the port's power state is only affected by per-port power control (Set/ClearPortPower). When cleared, the port is controlled by the global power switch (Set/ClearGlobalPower). If the device is configured to global switching mode (PowerSwitchingMode = 0 ), this field is not valid.</p> <table border="1"> <tr> <td>Bit0</td><td>Reserved</td></tr> <tr> <td>Bit1</td><td>Ganged-power mask on Port #1.</td></tr> <tr> <td>Bit2</td><td>Ganged-power mask on Port #2.</td></tr> <tr> <td>...</td><td></td></tr> <tr> <td>Bit15</td><td>Ganged-power mask on Port #15.</td></tr> </table> | Bit0 | Reserved | Bit1 | Ganged-power mask on Port #1. | Bit2 | Ganged-power mask on Port #2. | ... |  | Bit15 | Ganged-power mask on Port #15. |
| Bit0          | Reserved                       |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit1          | Ganged-power mask on Port #1.  |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit2          | Ganged-power mask on Port #2.  |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| ...           |                                |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit15         | Ganged-power mask on Port #15. |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| 15:0          | R/W                            | R  | 0x0                                     | <p>DeviceRemovable<br/>Each bit is dedicated to a port of the Root Hub. When cleared, the attached device is removable. When set, the attached device is not removable.</p> <table border="1"> <tr> <td>Bit0</td><td>Reserved</td></tr> <tr> <td>Bit1</td><td>Device attached to Port #1.</td></tr> <tr> <td>Bit2</td><td>Device attached to Port #2.</td></tr> <tr> <td>...</td><td></td></tr> <tr> <td>Bit15</td><td>Device attached to Port #15.</td></tr> </table>   | Bit0 | Reserved | Bit1 | Device attached to Port #1.   | Bit2 | Device attached to Port #2.   | ... |  | Bit15 | Device attached to Port #15.   |
| Bit0          | Reserved                       |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit1          | Device attached to Port #1.    |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit2          | Device attached to Port #2.    |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| ...           |                                |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |
| Bit15         | Device attached to Port #15.   |    |   |  |      |          |      |                               |      |                               |     |  |       |                                |

**8.4.1.4.21. HcRhStatus Register(Default Value: 0x00000000)**

| Offset: 0x450 |   |     |             | Register Name: HcRhStatus Register  |   |   |   |   |
|---------------|---|-----|-------------|---|---|---|---|---|
| Bit           | Read/Write  |     | Default/Hex | Description   |   |   |   |   |
|               | HCD   | HC  |             |   |   |   |   |   |
| 31            | W   | R   | 0           | (write)ClearRemoteWakeUpEnable<br>Write a '1' clears DeviceRemoteWakeUpEnable. Write a '0' has no effect.   |   |   |   |   |
| 30:18         | /   | /   | 0x0         | Reserved  |   |   |   |   |
| 17            | R/W   | R   | 0           | OverCurrentIndicatorChange<br>This bit is set by hardware when a change has occurred to the OverCurrentIndicator field of this register. The HCD clears this bit by writing a '1'. Writing a '0' has no effect.   |   |   |   |   |
| 16            | R/W   | R   | 0x0         | (read)LocalPowerStartusChange<br>The Root Hub does not support the local power status features, thus, this bit is always read as '0'.<br>(write)SetGlobalPower<br>In global power mode (PowerSwitchingMode=0), This bit is written to '1' to turn on power to all ports (clear PortPowerStatus). In per-port power mode, it sets PortPowerStatus only on ports whose PortPowerControlMask bit is not set. Writing a '0' has no effect.  |   |   |   |   |
| 15            | R/W   | R   | 0x0         | (read)DeviceRemoteWakeUpEnable<br>This bit enables a ConnectStatusChange bit as a resume event, causing a USBSUSPEND to USBRESUME state transition and setting the ResumeDetected interrupt.<br><table border="1" data-bbox="627 1235 1437 1325"> <tr> <td>0</td><td>ConnectStatusChange is not a remote wakeup event.</td></tr> <tr> <td>1</td><td>ConnectStatusChange is a remote wakeup event.</td></tr> </table><br>(write)SetRemoteWakeUpEnable<br>Writing a '1' sets DeviceRemoveWakeUpEnable. Writing a '0' has no effect. | 0 | ConnectStatusChange is not a remote wakeup event. | 1 | ConnectStatusChange is a remote wakeup event. |
| 0             | ConnectStatusChange is not a remote wakeup event. |     |             |   |   |   |   |   |
| 1             | ConnectStatusChange is a remote wakeup event.     |     |             |   |   |   |   |   |
| 14:2          | /   | /   | /           | Reserved  |   |   |   |   |
| 1             | R   | R/W | 0x0         | OverCurrentIndicator<br>This bit reports overcurrent conditions when the global reporting is implemented. When set, an overcurrent condition exists. When cleared, all power operations are normal.<br>If per-port overcurrent protection is implemented this bit is always '0'   |   |   |   |   |
| 0             | R/W   | R   | 0x0         | (Read)LocalPowerStatus<br>When read, this bit returns the LocalPowerStatus of the Root Hub. The Root Hub does not support the local power status feature; thus, this bit is always read as '0'.<br>(Write)ClearGlobalPower<br>When write, this bit is operated as the ClearGlobalPower. In global power mode (PowerSwitchingMode=0), This bit is written to '1' to turn off power to all ports (clear PortPowerStatus). In per-port power mode, it  |   |   |   |   |

|  |  |  |  |  |
|--|--|--|--|--|
|  |  |  |  | clears PortPowerStatus only on ports whose PortPowerControlMask bit is not set. Writing a '0' has no effect. |
|--|--|--|--|--|

#### 8.4.1.4.22. HcRhPortStatus Register(Default Value: 0x00000100)

| Offset: 0x454 |                                       |     |             | Register Name: HcRhPortStatus   |   |                                       |   |                                      |
|---------------|---------------------------------------|-----|-------------|---|---|---------------------------------------|---|--------------------------------------|
| Bit           | Read/Write                            |     | Default/Hex | Description   |   |                                       |   |                                      |
|               | HCD                                   | HC  |             |   |   |                                       |   |                                      |
| 31:21         | /                                     | /   | 0x0         | Reserved  |   |                                       |   |                                      |
| 20            | R/W                                   | R/W | 0x0         | <p>PortResetStatusChange<br/>This bit is set at the end of the 10-ms port reset signal. The HCD writes a '1' to clear this bit. Writing a '0' has no effect.</p> <table border="1"> <tr> <td>0</td><td>port reset is not complete</td></tr> <tr> <td>1</td><td>port reset is complete</td></tr> </table>  | 0 | port reset is not complete            | 1 | port reset is complete               |
| 0             | port reset is not complete            |     |             |   |   |                                       |   |                                      |
| 1             | port reset is complete                |     |             |   |   |                                       |   |                                      |
| 19            | R/W                                   | R/W | 0x0         | <p>PortOverCurrentIndicatorChange<br/>This bit is valid only if overcurrent conditions are reported on a per-port basis. This bit is set when Root Hub changes the PortOverCurrentIndicator bit. The HCD writes a '1' to clear this bit. Writing a '0' has no effect.</p> <table border="1"> <tr> <td>0</td><td>no change in PortOverCurrentIndicator</td></tr> <tr> <td>1</td><td>PortOverCurrentIndicator has changed</td></tr> </table>  | 0 | no change in PortOverCurrentIndicator | 1 | PortOverCurrentIndicator has changed |
| 0             | no change in PortOverCurrentIndicator |     |             |   |   |                                       |   |                                      |
| 1             | PortOverCurrentIndicator has changed  |     |             |   |   |                                       |   |                                      |
| 18            | R/W                                   | R/W | 0x0         | <p>PortSuspendStatusChange<br/>This bit is set when the full resume sequence has been completed. This sequence includes the 20-s resume pulse, LS EOP, and 3-ms resynchronization delay. The HCD writes a '1' to clear this bit. Writing a '0' has no effect. This bit is also cleared when ResetStatusChange is set.</p> <table border="1"> <tr> <td>0</td><td>resume is not completed</td></tr> <tr> <td>1</td><td>resume completed</td></tr> </table>  | 0 | resume is not completed               | 1 | resume completed                     |
| 0             | resume is not completed               |     |             |   |   |                                       |   |                                      |
| 1             | resume completed                      |     |             |   |   |                                       |   |                                      |
| 17            | R/W                                   | R/W | 0x0         | <p>PortEnableStatusChange<br/>This bit is set when hardware events cause the PortEnableStatus bit to be cleared. Changes from HCD writes do not set this bit. The HCD writes a '1' to clear this bit. Writing a '0' has no effect.</p> <table border="1"> <tr> <td>0</td><td>no change in PortEnableStatus</td></tr> <tr> <td>1</td><td>change in PortEnableStatus</td></tr> </table>   | 0 | no change in PortEnableStatus         | 1 | change in PortEnableStatus           |
| 0             | no change in PortEnableStatus         |     |             |   |   |                                       |   |                                      |
| 1             | change in PortEnableStatus            |     |             |   |   |                                       |   |                                      |
| 16            | R/W                                   | R/W | 0x0         | <p>ConnectStatusChange<br/>This bit is set whenever a connect or disconnect event occurs. The HCD writes a '1' to clear this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared when a SetPortReset,SetPortEnable, or SetPortSuspend write occurs, this bit is set to force the driver to re-evaluate the connection status since these writes should not occur if the port is disconnected.</p> <table border="1"> <tr> <td>0</td><td>no change in PortEnableStatus</td></tr> <tr> <td>1</td><td>change in PortEnableStatus</td></tr> </table> | 0 | no change in PortEnableStatus         | 1 | change in PortEnableStatus           |
| 0             | no change in PortEnableStatus         |     |             |   |   |                                       |   |                                      |
| 1             | change in PortEnableStatus            |     |             |   |   |                                       |   |                                      |

|       |                                 |     |     |   |   |                                 |   |                           |
|-------|---------------------------------|-----|-----|---|---|---------------------------------|---|---------------------------|
|       |                                 |     |     | If the DeviceRemovable[NDP] bit is set, this bit is set only after a Root Hub reset to inform the system that the device is attached.   |   |                                 |   |                           |
| 15:10 | /                               | /   | 0x0 | Reserved  |   |                                 |   |                           |
| 9     | R/W                             | R/W | -   | <p>(read)LowSpeedDeviceAttached<br/>This bit indicates the speed of the device attached to this port. When set, a Low Speed device is attached to this port. When clear, a Full Speed device is attached to this port. This field is valid only when the CurrentConnectStatus is set.</p> <table border="1"> <tr> <td>0</td><td>full speed device attached</td></tr> <tr> <td>1</td><td>low speed device attached</td></tr> </table> <p>(write)ClearPortPower<br/>The HCD clears the PortPowerStatus bit by writing a '1' to this bit. Writing a '0' has no effect.</p>   | 0 | full speed device attached      | 1 | low speed device attached |
| 0     | full speed device attached      |     |     |   |   |                                 |   |                           |
| 1     | low speed device attached       |     |     |   |   |                                 |   |                           |
| 8     | R/W                             | R/W | 0x1 | <p>(read)PortPowerStatus<br/>This bit reflects the port's power status, regardless of the type of power switching implemented. This bit is cleared if an overcurrent condition is detected. HCD sets this bit by writing SetPortPower or SetGlobalPower. HCD clears this bit by writing ClearPortPower or ClearGlobalPower. Which power control switches are enabled is determined by PowerSwitchingMode and PortPortControlMask[NumberDownstreamPort]. In global switching mode(PowerSwitchingMode=0), only Set/ClearGlobalPower controls this bit. In per-port power switching (PowerSwitchingMode=1), if the PortPowerControlMask[NDP] bit for the port is set, only Set/ClearPortPower commands are enabled. If the mask is not set, only Set/ClearGlobalPower commands are enabled. When port power is disabled, CurrentConnectStatus, PortEnableStatus, PortSuspendStatus, and PortResetStatus should be reset.</p> <table border="1"> <tr> <td>0</td><td>port power is off</td></tr> <tr> <td>1</td><td>port power is on</td></tr> </table> <p>(write)SetPortPower<br/>The HCD writes a '1' to set the PortPowerStatus bit. Writing a '0' has no effect.</p> <p>This bit is always reads '1b' if power switching is not supported.</p> | 0 | port power is off               | 1 | port power is on          |
| 0     | port power is off               |     |     |   |   |                                 |   |                           |
| 1     | port power is on                |     |     |   |   |                                 |   |                           |
| 7:5   | /                               | /   | 0x0 | Reserved  |   |                                 |   |                           |
| 4     | R/W                             | R/W | 0x0 | <p>(read)PortResetStatus<br/>When this bit is set by a write to SetPortReset, port reset signaling is asserted. When reset is completed, this bit is cleared when PortResetStatusChange is set. This bit cannot be set if CurrentConnectStatus is cleared.</p> <table border="1"> <tr> <td>0</td><td>port reset signal is not active</td></tr> </table>   | 0 | port reset signal is not active |   |                           |
| 0     | port reset signal is not active |     |     |   |   |                                 |   |                           |

|   |                                 |     |     |  |   |                             |   |                                 |
|---|---------------------------------|-----|-----|--|---|-----------------------------|---|---------------------------------|
|   |                                 |     |     | <table border="1"> <tr> <td>1</td><td>port reset signal is active</td></tr> </table> <p>(write)SetPortReset<br/>The HCD sets the port reset signaling by writing a '1' to this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared, this write does not set PortResetStatus, but instead sets ConnectStatusChange. This informs the driver that it attempted to reset a disconnected port.</p>  | 1 | port reset signal is active |   |                                 |
| 1 | port reset signal is active     |     |     |  |   |                             |   |                                 |
| 3 | R/W                             | R/W | 0x0 | <p>(read)PortOverCurrentIndicator<br/>This bit is only valid when the Root Hub is configured in such a way that overcurrent conditions are reported on a per-port basis. If per-port overcurrent reporting is not supported, this bit is set to 0. If cleared, all power operations are normal for this port. If set, an overcurrent condition exists on this port. This bit always reflects the overcurrent input signal.</p> <table border="1"> <tr> <td>0</td> <td>no overcurrent condition.</td> </tr> <tr> <td>1</td> <td>overcurrent condition detected.</td> </tr> </table> <p>(write)ClearSuspendStatus<br/>The HCD writes a '1' to initiate a resume. Writing a '0' has no effect. A resume is initiated only if PortSuspendStatus is set.</p>  | 0 | no overcurrent condition.   | 1 | overcurrent condition detected. |
| 0 | no overcurrent condition.       |     |     |  |   |                             |   |                                 |
| 1 | overcurrent condition detected. |     |     |  |   |                             |   |                                 |
| 2 | R/W                             | R/W | 0x0 | <p>(read)PortSuspendStatus<br/>This bit indicates the port is suspended or in the resume sequence. It is set by a SetSuspendState write and cleared when PortSuspendStatusChange is set at the end of the resume interval. This bit cannot be set if CurrentConnectStatus is cleared. This bit is also cleared when PortResetStatusChange is set at the end of the port reset or when the HC is placed in the USBRESUME state. If an upstream resume is in progress, it should propagate to the HC.</p> <table border="1"> <tr> <td>0</td> <td>port is not suspended</td> </tr> <tr> <td>1</td> <td>port is suspended</td> </tr> </table> <p>(write)SetPortSuspend<br/>The HCD sets the PortSuspendStatus bit by writing a '1' to this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared, this write does not set PortSuspendStatus; instead it sets ConnectStatusChange. This informs the driver that it attempted to suspend a disconnected port.</p> | 0 | port is not suspended       | 1 | port is suspended               |
| 0 | port is not suspended           |     |     |  |   |                             |   |                                 |
| 1 | port is suspended               |     |     |  |   |                             |   |                                 |
| 1 | R/W                             | R/W | 0x0 | <p>(read)PortEnableStatus<br/>This bit indicates whether the port is enabled or disabled. The Root Hub may clear this bit when an overcurrent condition, disconnect event, switched-off power, or operational bus error such as babble is detected. This change also causes PortEnabledStatusChange to be set. HCD sets this bit by writing SetPortEnable and clears it by writing ClearPortEnable. This bit cannot be set when CurrentConnectStatus is cleared. This bit is also set, if not already, at the completion of a port reset when ResetStatusChange is set or port suspend when SuspendStatusChange is set.</p>  |   |                             |   |                                 |

|   |                     |     |     |  |   |                     |   |                  |
|---|---------------------|-----|-----|--|---|---------------------|---|------------------|
|   |                     |     |     | <table border="1"> <tr> <td>0</td><td>port is disabled</td></tr> <tr> <td>1</td><td>port is enabled</td></tr> </table>   | 0 | port is disabled    | 1 | port is enabled  |
| 0 | port is disabled    |     |     |  |   |                     |   |                  |
| 1 | port is enabled     |     |     |  |   |                     |   |                  |
|   |                     |     |     | <p>(write)SetPortEnable<br/>                     The HCD sets PortEnableStatus by writing a '1'. Writing a '0' has no effect.<br/>                     If CurrentConnectStatus is cleared, this write does not set PortEnableStatus, but instead sets ConnectStatusChange. This informs the driver that it attempted to enable a disconnected Port.</p>  |   |                     |   |                  |
| 0 | R/W                 | R/W | 0x0 | <p>(read)CurrentConnectStatus<br/>                     This bit reflects the current state of the downstream port.</p> <table border="1"> <tr> <td>0</td><td>No device connected</td></tr> <tr> <td>1</td><td>Device connected</td></tr> </table> <p>(write)ClearPortEnable<br/>                     The HCD writes a '1' to clear the PortEnableStatus bit. Writing '0' has no effect. The CurrentConnectStatus is not affected by any write.<br/>                     This bit is always read '1' when the attached device is nonremovable(DeviceRemovable[NumberDownstreamPort]).</p> | 0 | No device connected | 1 | Device connected |
| 0 | No device connected |     |     |  |   |                     |   |                  |
| 1 | Device connected    |     |     |  |   |                     |   |                  |

#### 8.4.1.5. HCI Interface Control and PHY Interface Description

##### 8.4.1.5.1. HCI Interface Control Register (Default Value: 0x10000000)

| Offset: 0x800 |     |             | Register Name: <b>HCI_ICR</b>   |
|---------------|-----|-------------|---|
| Bit           | R/W | Default/Hex | Description   |
| 31:29         | /   | /           | Reserved.   |
| 28            | R   | 1           | DMA Transfer Status Enable<br>0: Disable<br>1: Enable   |
| 27:26         | /   | /           | Reserved.   |
| 25            | R/W | 0           | OHCI count select<br>1: Simulation mode, the counters will be much shorter than real time<br>0: Normal mode, the counters will count full time  |
| 24            | R/W | 0           | Simulation mode<br>1: Set PHY in a non-driving mode so the EHCI can detect device connection, this is used only for simulation<br>0: No effect  |
| 23:21         | /   | /           | /   |
| 20            | R/W | 0           | EHCI HS force<br>Set 1 to this field force the ehci enter the high speed mode during bus reset.<br>This field only valid when the bit 1 is set. |
| 19:18         | /   | /           | /   |
| 17            | R/W | 0           | HSIC Connect detect<br>1 in this field enable the hsic phy to detect device connect pulse on the bus.   |

|       |     |   |  |
|-------|-----|---|--|
| 16    | R/W | 0 | HSIC Connect Interrupt Enable<br>Enable the HSIC connect interrupt.  |
| 15:13 | /   | / | /  |
| 12    | R/W | 0 | PP2VBUS<br>1: ULPI wrapper interface will automatically set or clear DrvVbus register in ULPI PHY according to the port power status from the root hub<br>0: ULPI wrapper will ignore the difference between power status of root hub and ULPI PHY |
| 11    | R/W | 0 | AHB Master interface INCR16 enable<br>1: Use INCR16 when appropriate<br>0: do not use INCR16, use other enabled INCRX or unspecified length burst INCR   |
| 10    | R/W | 0 | AHB Master interface INCR8 enable<br>1: Use INCR8 when appropriate<br>0: do not use INCR8, use other enabled INCRX or unspecified length burst INCR  |
| 9     | R/W | 0 | AHB Master interface burst type INCR4 enable<br>1: Use INCR4 when appropriate<br>0: do not use INCR4, use other enabled INCRX or unspecified length burst INCR   |
| 8     | R/W | 0 | AHB Master interface INCRX align enable<br>1: Start INCRx burst only on burst x-align address<br>0: Start burst on any double word boundary<br>This bit must enable if any bit of 11:9 is enabled  |
| 7:2   | /   | / | Reserved   |
| 1     | R/W | 0 | HSIC Phy Select<br>0: Select the UTMI Phy for the EHCI<br>1: Select the HSIC Phy for the EHCI  |
| 0     | R/W | 0 | ULPI bypass enable.<br>1: Enable UTMI interface, disable ULPI interface<br>0: Enable ULPI interface, disable UTMI interface  |

#### 8.4.1.5.2. HSIC status Register(Default Value: 0x00000000)

| Offset: 0x804 |     |             | Register Name: <b>HSIC_STATUS</b>  |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:17         | /   | /           | /  |
| 16            | R/W | 0           | HSIC Connect Status<br>1 in this field indicates a device connect pulse being detected on the bus. This field only valid when the EHCI HS force bit and the HSIC Phy Select bit is set.<br>When the HSIC Connect Interrupt Enable is set, 1 in this bit will generate an interrupt to the system.<br>This register is valid on HCI1. |

|      |   |   |   |
|------|---|---|---|
| 15:0 | / | / | / |
|------|---|---|---|

#### 8.4.1.5.3. HSIC UTMI PHY TUNE Register(Default Value: 0x23438E4)

| Offset: 0x818 |     |             | Register Name: <b>UTMI_TUNE</b> |
|---------------|-----|-------------|---------------------------------|
| Bit           | R/W | Default/Hex | Description                     |
| 31:26         | /   | /           | /                               |
| 25:23         | R/W | 0x04        | COMPDISTUNE                     |
| 22:20         | R/W | 0x03        | SQRXTUNE                        |
| 19            | R/W | 0x0         | TXPREEMPPULSESETUNE             |
| 18:16         | R/W | 0x04        | OTGTUNE                         |
| 15:12         | R/W | 0x03        | TXFSLSTUNE                      |
| 11:8          | R/W | 0x08        | TXVREFTUNE                      |
| 7:6           | R/W | 0x03        | TXHSXVTUNE                      |
| 5:4           | R/W | 0x02        | TXRISETUNE                      |
| 3:2           | R/W | 0x01        | TXRESTUNE                       |
| 1:0           | R/W | 0x0         | TXPREEMPAMPTUNE                 |

#### 8.4.1.5.4. HSIC HSIC PHY Configuration(Default Value: 0x00000000)

| Offset: 0x820 |     |             | Register Name: <b>HSIC_CFG</b> |
|---------------|-----|-------------|--------------------------------|
| Bit           | R/W | Default/Hex | Description                    |
| 31:24         | /   | /           | /                              |
| 23            | R/W | 0x0         | SIDDQ                          |
| 22:16         | R/W | 0x0         | REF CLK                        |
| 15            | R/W | 0x0         | BIST EN                        |
| 14            | R/W | 0x0         | LOOP BACK                      |
| 13            | R/W | 0x0         | T OUT SEL                      |
| 12            | R/W | 0x0         | T CLK                          |
| 11:8          | R/W | 0x0         | T ADDR                         |
| 7:0           | R/W | 0x0         | T DATA                         |

#### 8.4.1.5.5. HSIC HSIC PHY Status(Default Value: 0x00000000)

| Offset: 0x824 |     |             | Register Name: <b>HSIC_STATUS</b>                    |
|---------------|-----|-------------|--|
| Bit           | R/W | Default/Hex | Description  |
| 31:6          | /   | /           | /  |
| 5             | R/W | 0x0         | BIST Error<br>0: HSIC BIST Pass<br>1: HSIC BIST Fail |

|     |     |     |  |
|-----|-----|-----|--|
| 4   | R/W | 0x0 | Bist Done<br>0: HSIC BIST is in progress<br>1: HSIC BIST is done |
| 3:0 | R/W | 0x0 | T DATA OUT<br>HSIC Test Data Out                                 |

Confidential

## 8.5. EMAC

### 8.5.1. Overview

The Ethernet MAC(EMAC) controller enables a host to transmit and receive data over Ethernet in compliance with the IEEE 802.3-2002 standard. It supports 10M/100M/1000M external PHY with MII/RGMII/RMII interface in both full and half duplex mode. The internal DMA is designed for packet-oriented data transfers based on a linked list of descriptors. 4K Byte TXFIFO and 16K Byte RXFIFO are provided to keep continuous transmission and reception. Flow Control, CRC Pad & Stripping, and address filtering are also supported in this module.

The Ethernet MAC Controller includes the following features:

- Supports 10/100/1000Mbps data transfer rates
- Supports MII/RGMII/RMII PHY interface
- Supports both full-duplex and half-duplex operation
- Programmable frame length to support Standard or Jumbo Ethernet frames with sizes up to 16 KB
- Supports a variety of flexible address filtering modes
- Separate 32-bit status returned for transmission and reception packets
- Optimization for packet-oriented DMA transfers with frame delimiters
- Linked-list (chained) descriptor chaining
- Descriptor architecture, allowing large blocks of data transfer with minimum CPU intervention; each descriptor can transfer up to 4 KB of data
- Comprehensive status reporting for normal operation and transfers with errors
- 4KB TXFIFO for transmission packets and 16KB RXFIFO for reception packets
- Programmable interrupt options for different operational conditions

### 8.5.2. Block Diagram

The EMAC Controller block diagram is shown below:

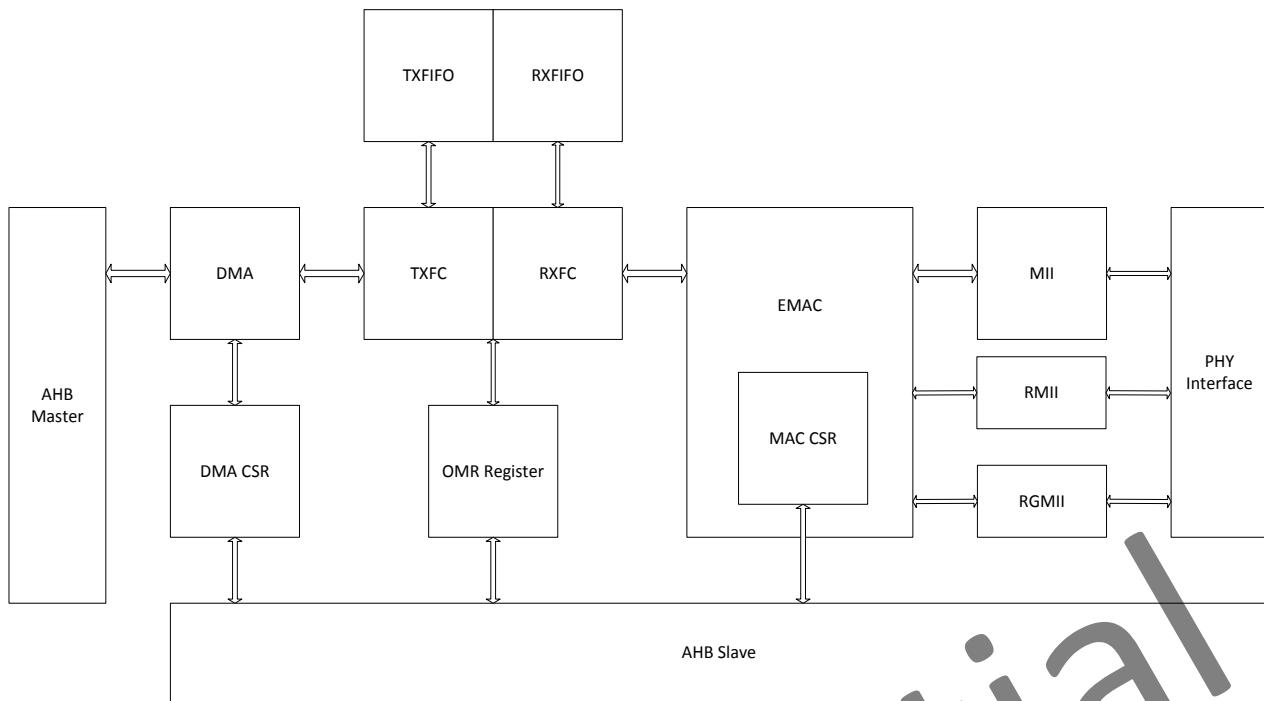


Figure 8-7. EMAC Block Diagram

### 8.5.3. EMAC Core Register List

| Module Name | Base Address |
|-------------|--------------|
| EMAC        | 0x01C30000   |

| Register Name    | Offset | Description                               |
|------------------|--------|---|
| BASIC_CTL_0      | 0x00   | Basic Control 0 Register                  |
| BASIC_CTL_1      | 0x04   | Basic Control 1 Register                  |
| INT_STA          | 0x08   | Interrupt Status Register                 |
| INT_EN           | 0x0C   | Interrupt Enable Register                 |
| TX_CTL_0         | 0x10   | Transmit Control 0 Register               |
| TX_CTL_1         | 0x14   | Transmit Control 1 Register               |
| TX_FLOW_CTL      | 0x1C   | Transmit Flow Control Register            |
| TX_DMA_DESC_LIST | 0x20   | Transmit Descriptor List Address Register |
| RX_CTL_0         | 0x24   | Receive Control 0 Register                |
| RX_CTL_1         | 0x28   | Receive Control 1 Register                |
| RX_DMA_DESC_LIST | 0x34   | Receive Descriptor List Address Register  |
| RX_FRMFLT        | 0x38   | Receive Frame Filter Register             |
| RX_HASH_0        | 0x40   | Hash Table 0 Register                     |
| RX_HASH_1        | 0x44   | Hash Table 1 Register                     |
| MII_CMD          | 0x48   | Management Interface Command Register     |
| MII_DATA         | 0x4C   | Management Interface Data Register        |
| ADDR_HIGH_0      | 0x50   | MAC Address High Register 0               |

|             |          |  |
|-------------|----------|--|
| ADDR_LOW_0  | 0x54     | MAC Address High Register 0              |
| ADDR_HIGH_x | 0x50+8*x | MAC Address High Register x(x:1~7)       |
| ADDR_LOW_x  | 0x54+8*x | MAC Address Low Register x(x:1~7)        |
| TX_DMA_STA  | 0xB0     | Transmit DMA Status Register             |
| TX_CUR_DESC | 0xB4     | Current Transmit Descriptor Register     |
| TX_CUR_BUF  | 0xB8     | Current Transmit Buffer Address Register |
| RX_DMA_STA  | 0xC0     | Receive DMA Status Register              |
| RX_CUR_DESC | 0xC4     | Current Receive Descriptor Register      |
| RX_CUR_BUF  | 0xC8     | Current Receive Buffer Address Register  |
| RGMII_STA   | 0xD0     | RGMII Status Register                    |

### 8.5.4. EMAC Core Register Description

#### 8.5.4.1. Basic Control 0 Register(Default Value: 0x00000000)

| Offset: 0x00 |     |             | Register Name: <b>BASIC_CTL_0</b>   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:4         | /   | /           | /   |
| 3:2          | R/W | 0           | <b>SPEED</b><br>00: 1000Mbps<br>11: 100Mbps<br>10: 10Mbps<br>01: Reserved |
| 1            | R/W | 0           | <b>LOOPBACK</b><br>0: Disable<br>1: Enable                                |
| 0            | R/W | 0           | <b>DUPLEX</b><br>0: Half-duplex<br>1: Full-duplex                         |

#### 8.5.4.2. Basic Control 1 Register(Default Value: 0x08000000)

| Offset: 0x04 |     |             | Register Name: <b>BASIC_CTL_1</b>   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:30        | /   | /           | /   |
| 29:24        | R/W | 8           | <b>BURST_LEN</b><br>The burst length of RX and TX DMA transfer.                                   |
| 23:2         | /   | /           | /   |
| 1            | R/W | 0           | <b>RX_TX_PRI</b><br>0: RX DMA and TX DMA have same priority<br>1: RX DMA has priority over TX DMA |

|   |     |   |  |
|---|-----|---|--|
| 0 | R/W | 0 | <b>SOFT_RST</b><br>When this bit is set, soft reset all registers and logic. All clock inputs must be valid before soft rest. This bit is cleared internally when the reset operation is completed fully. Before write any register, this bit should read a 0. |
|---|-----|---|--|

#### 8.5.4.3. Interrupt Status Register(Default Value: 0x00000000)

| Offset: 0x08 |     |             | Register Name: INT_STA   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:17        | /   | /           | /  |
| 16           | R   | 0           | <b>RGMII_LINK_STA_INT</b><br>When this bit is asserted, the link status of RGMII interface is changed.   |
| 15:14        | /   | /           | /  |
| 13           | R   | 0           | <b>RX_EARLY_INT</b><br>When this bit asserted, the RX DMA had filled the first data buffer of the receive frame.   |
| 12           | R   | 0           | <b>RX_OVERFLOW_INT</b><br>When this bit is asserted, the RX FIFO had an overflow error.  |
| 11           | R   | 0           | <b>RX_TIMEOUT_INT</b><br>When this bit asserted, the length of receive frame is greater than 2048 bytes(10240 when JUMBO_FRM_EN is set)  |
| 10           | R   | 0           | <b>RX_DMA_STOPPED_INT</b><br>When this bit asserted, the RX DMA FSM is stopped.  |
| 9            | R   | 0           | <b>RX_BUF_UA_INT</b><br>When this asserted, the RX DMA can't acquire next RX descriptor and RX DMA FSM is suspended. The ownership of next RX descriptor should be changed to RX DMA. The RX DMA FSM will resume when write to DMA_RX_START bit or next receive frame is coming. |
| 8            | R   | 0           | <b>RX_INT</b><br>When this bit is asserted, a frame reception is completed. The RX DMA FSM remains in the running state.   |
| 7:6          | /   | /           | /  |
| 5            | R   | 0           | <b>TX_EARLY_INT</b><br>When this bit asserted , the frame is transmitted to FIFO totally.  |
| 4            | R   | 0           | <b>TX_UNDERFLOW_INT</b><br>When this bit is asserted, the TX FIFO had an underflow error.  |
| 3            | R   | 0           | <b>TX_TIMEOUT_INT</b><br>When this bit is asserted, the transmitter had been excessively active.   |
| 2            | R   | 0           | <b>TX_BUF_UA_INT</b><br>When this asserted, the TX DMA can not acquire next TX descriptor and TX DMA FSM is suspended. The ownership of next TX descriptor should be changed to TX DMA. The TX DMA FSM will resume when write to DMA_TX_START bit.                               |

|   |   |   |   |
|---|---|---|---|
| 1 | R | 0 | TX_DMA_STOPPED_INT<br>When this bit is asserted, the TX DMA FSM is stopped. |
| 0 | R | 0 | TX_INT<br>When this bit is asserted, a frame transmission is completed.     |

#### 8.5.4.4. Interrupt Enable Register(Default Value: 0x00000000)

| Offset: 0x0C |     |             | Register Name: INT_EN  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:14        | /   | /           | /  |
| 13           | R/W | 0           | RX_EARLY_INT_EN<br>0: Disable early receive interrupt enable<br>1: Enable early receive interrupt enable               |
| 12           | R/W | 0           | RX_OVERFLOW_INT_EN<br>0: Disable overflow interrupt<br>1: Enable overflow interrupt                                    |
| 11           | R/W | 0           | RX_TIMEOUT_INT_EN<br>0: Disable receive timeout interrupt<br>1: Enable receive timeout interrupt                       |
| 10           | R/W | 0           | RX_DMA_STOPPED_INT_EN<br>0: Disable receive DMA FSM stopped interrupt<br>1: Enable receive DMA FSM stopped interrupt   |
| 9            | R/W | 0           | RX_BUF_UA_INT_EN<br>0: Disable receive buffer unavailable interrupt<br>1: Enable receive buffer unavailable interrupt  |
| 8            | R/W | 0           | RX_INT_EN<br>0: Disable receive interrupt<br>1: Enable receive interrupt   |
| 7:6          |     |             |  |
| 5            | R/W | 0           | TX_EARLY_INT_EN<br>0: Disable early transmit interrupt<br>1: Enable early transmit interrupt                           |
| 4            | R/W | 0           | TX_UNDERFLOW_INT_EN<br>0: Disable underflow interrupt<br>1: Enable underflow interrupt                                 |
| 3            | R/W | 0           | TX_TIMEOUT_INT_EN<br>0: Disable transmit timeout interrupt<br>1: Enable transmit timeout interrupt                     |
| 2            | R/W | 0           | TX_BUF_UA_INT_EN<br>0: Disable transmit buffer available interrupt<br>1: Enable transmit buffer available interrupt    |
| 1            | R/W | 0           | TX_DMA_STOPPED_INT_EN<br>0: Disable transmit DMA FSM stopped interrupt<br>1: Enable transmit DMA FSM stopped interrupt |

|   |     |   |  |
|---|-----|---|--|
| 0 | R/W | 0 | TX_INT_EN<br>0: Disable transmit interrupt<br>1: Enable transmit interrupt |
|---|-----|---|--|

#### 8.5.4.5. Transmit Control 0 Register(Default Value: 0x00000000)

| Offset: 0x10 |     |             | Register Name: TX_CTL_0  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | R/W | 0           | TX_EN<br>Enable transmitter.<br>0: Disable transmitter after current transmission<br>1: Enable   |
| 30           | R/W | 0           | TX_FRM_LEN_CTL<br>0: Allow to transmit frames no more than 2,048 bytes (10,240 if JUMBO_FRM_EN is set) and cut off any bytes after that<br>1: Allow to transmit frames of up to 16,384 bytes |
| 29:0         | /   | /           | /  |

#### 8.5.4.6. Transmit Control 1 Register(Default Value: 0x00000000)

| Offset: 0x14 |     |             | Register Name: TX_CTL_1   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | TX_DMA_START<br>When set this bit, the TX DMA FSM will go no to work. It is cleared internally and always read a 0.   |
| 30           | R/W | 0           | TX_DMA_EN<br>0: Stop TX DMA after the completion of current frame transmission.<br>1: Start and run TX DMA.   |
| 29:11        | /   | /           | /   |
| 10:8         | R/W | 0           | TX_TH<br>The threshold value of TX DMA FIFO. When TX_MD is 0, transmission starts when the size of frame in TX DMA FIFO is greater than the threshold. In addition, full frames with a length less than the threshold are transferred automatically.<br>000: 64<br>001: 128<br>010: 192<br>011: 256<br>Others: Reserved |
| 7:2          | /   | /           | /   |
| 1            | R/W | 0           | TX_MD<br>0: Transmission starts after the number of data in TX DAM FIFO is greater  |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | than TX_TH<br>1: Transmission starts after a full frame located in TX DMA FIFO                    |
| 0 | R/W | 0 | FLUSH_TX_FIFO<br>The functionality that flush the data in the TX FIFO.<br>0: Enable<br>1: Disable |

#### 8.5.4.7. Transmit Flow Control Register(Default Value: 0x00000000)

| Offset: 0x1C |     |             | Register Name: TX_FLOW_CTL  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | TX_FLOW_CTL_STA<br>This bit indicates a pause frame transmission is in progress. When the configuration of flow control is ready, set this bit to transmit a pause frame in full-duplex mode or activate the backpressure function. After completion of transmission, this bit will be cleared automatically. Before write register TX_FLOW_CTRL, this bit must be read as 0. |
| 30:22        | /   | /           | /   |
| 21:20        | R/W | 0           | TX_PAUSE_FRM_SLOT<br>The threshold of the pause timer at which the input flow control signal is checked for automatic retransmission of pause frame. The threshold values should be always less than the PAUSE_TIME   |
| 19:4         | R/W | 0           | PAUSE_TIME<br>The pause time field in the transmitted control frame.  |
| 3:2          | /   | /           | /   |
| 1            | R/W | 0           | ZQP_FRM_EN<br>When set, enable the functionality to generate Zero-Quanta Pause control frame.   |
| 0            | R/W | 0           | TX_FLOW_CTL_EN<br>When set, enable flow control operation to transmit pause frames in full-duplex mode, or enable the back-pressure operation in half-duplex mode.<br>0: Disable<br>1: Enable   |

#### 8.5.4.8. Transmit DMA Descriptor List Address Register(Default Value: 0x00000000)

| Offset: 0x20 |     |             | Register Name: TX_DMA_LIST   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:0         | R/W | 0           | TX_DESC_LIST<br>The base address of transmit descriptor list. It must be 32-bit aligned. |

**8.5.4.9. Receive Control 0 Register(Default Value: 0x00000000)**

| Offset: 0x24 |     |             | Register Name: RX_CTL_0  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | R/W | 0           | <b>RX_EN</b><br>Enable receiver<br>0: Disable receiver after current reception<br>1: Enable  |
| 30           | R/W | 0           | <b>RX_FRM_LEN_CTL</b><br>0: Allow to receive frames less than or equal to 2,048 bytes (10,240 if JUMBO_FRM_EN is set) and cuts off any bytes received after that<br>1: Allow to receive frames of up to 16,384 bytes   |
| 29           | R/W | 0           | <b>JUMBO_FRM_EN</b><br>When set, allows Jumbo frames of 9,018 bytes without reporting a giant frame error in the receive frame status.   |
| 28           | R/W | 0           | <b>STRIP_FCS</b><br>When set, strip the Pad/FCS field on received frames only when the length's field value is less than or equal to 1,500 bytes.  |
| 27           | R/W | 0           | <b>CHECK_CRC</b><br>When set, calculate CRC and check the IPv4 Header Checksum.  |
| 26:18        | /   | /           | /  |
| 17           | R/W | 0           | <b>RX_PAUSE_FRM_MD</b><br>0: Only detect multicast pause frame specified in the 802.3x standard.<br>1: In addition to detect multicast pause frame specified in the 802.3x standard, also detect unicast pause frame with address specified in MAC Address 0 High Register and MAC address 0 Low Register. |
| 16           | R/W | 0           | <b>RX_FLOW_CTL_EN</b><br>When set, enable the functionality that decode the received pause frame and disable its transmitter for a specified time by pause frame.  |
| 15:0         | /   | /           | /  |

**8.5.4.10. Receive Control 1 Register(Default Value: 0x00000000)**

| Offset: 0x28 |     |             | Register Name: RX_CTL_1   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | <b>RX_DMA_START</b><br>When set, the RX DMA will go no to work. It is cleared internally and always read a 0. |
| 30           | R/W | 0           | <b>RX_DMA_EN</b><br>0: Stop RX DMA after finish receiving current frame<br>1: Start and run RX DMA            |
| 29:25        | /   | /           | /   |
| 24           | R/W | 0           | <b>RX_FIFO_FLOW_CTL</b>   |

|       |     |   |   |
|-------|-----|---|---|
|       |     |   | 0: Disable RX flow control<br>1: Enable RX flow control based on RX_FLOW_CTL_TH_DEACT and RX_FLOW_CTL_TH_ACT  |
| 23:22 | R/W | 0 | RX_FLOW_CTL_TH_DEACT<br>The threshold for deactivating flow control in both half-duplex mode and full-duplex mode.<br>00: Full minus 1 KB<br>01: Full minus 2 KB<br>10: Full minus 3 KB<br>11: Full minus 4 KB  |
| 21:20 | R/W | 0 | RX_FLOW_CTL_TH_ACT<br>The threshold for activating flow control in both half-duplex mode and full-duplex mode.<br>00: Full minus 1 KB<br>01: Full minus 2 KB<br>10: Full minus 3 KB<br>11: Full minus 4 KB  |
| 19:6  | /   | / | /   |
| 5:4   | R/W | 0 | RX_TH<br>The threshold value of RX DMA FIFO. When RX_MD is 0, RX DMA starts to transfer data when the size of received frame in RX DMA FIFO is greater than the threshold. In addition, full frames with a length less than the threshold are transferred automatically.<br>00: 64<br>01: 32<br>10: 96<br>11: 128 |
| 3     | R/W | 0 | RX_ERR_FRM<br>0: RX DMA drops frames with error<br>1: RX DMA forwards frames with error   |
| 2     | R/W | 0 | RX_RUNT_FRM<br>When set, forward undersized frames with no error and length less than 64bytes   |
| 1     | R/W | 0 | RX_MD<br>0: RX DMA reads data from RX DMA FIFO to host memory after the number of data in RX DAM FIFO is greater than RX_TH<br>1: RX DMA reads data from RX DMA FIFO to host memory after a complete frame has been written to RX DMA FIFO  |
| 0     | R/W | 0 | FLUSH_RX_FRM<br>The functionality that flush the frames when receive descriptors/buffers is unavailable<br>0: Enable<br>1: Disable  |

**8.5.4.11. Receive DMA Descriptor List Address Register(Default Value: 0x00000000)**

| Offset: 0x34 |     |             | Register Name: RX_DMA_LIST  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0           | RX_DESC_LIST<br>The base address of receive descriptor list. It must be 32-bit aligned. |

**8.5.4.12. Receive Frame Filter Register(Default Value: 0x00000000)**

| Offset: 0x38 |     |             | Register Name: RX_FRM_FLT   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31           | R/W | 0           | DIS_ADDR_FILTER<br>0: Enable address filter<br>1: Disable address filter  |
| 30:18        | /   | /           | /   |
| 17           | R/W | 0           | DIS_BROADCAST<br>0: Receive all broadcast frames<br>1: Drop all broadcast frames  |
| 16           | R/W | 0           | RX_ALL_MULTICAST<br>0: Filter multicast frame according to HASH_MULTICAST<br>1: Receive all multicast frames  |
| 15:14        | /   | /           |   |
| 13:12        | R/W | 0           | CTL_FRM_FILTER<br>00, 01: Drop all control frames<br>10: Receive all control frames<br>11: Receive all control frames when pass the address filter  |
| 11:10        | /   | /           | /   |
| 9            | R/W | 0           | HASH_MULTICAST<br>0: Filter multicast frames by comparing the DA field with the values in DA MAC address registers<br>1: Filter multicast frames according to the hash table  |
| 8            | R/W | 0           | HASH_UNICAST<br>0: Filter unicast frames by comparing the DA field with the values in DA MAC address registers<br>1: Filter unicast frames according to the hash table  |
| 7            | /   | /           | /   |
| 6            | R/W | 0           | SA_FILTER_EN<br>0: Receive frames and update the result of SA filter<br>1: Update the result of SA filter. In addition, if the SA field of received frame does not match the values in SA MAC address registers, drop this frame. |
| 5            | R/W | 0           | SA_INV_FILTER<br>0: When the SA field of current frame matches the values in SA MAC address registers, it passes the SA filter  |

|     |     |   |  |
|-----|-----|---|--|
|     |     |   | 1: When the SA field of current frame does not match the values in SA MAC address registers,, it passes the SA filter  |
| 4   | R/W | 0 | DA_INV_FILTER<br>0: Normal filtering of frames is performed<br>1: Filter both unicast and multicast frames by comparing DA field in inverse filtering mode   |
| 3:2 | /   | / | /  |
| 1   | R/W | 0 | FLT_MD<br>0: If the HASH_MULTICAST or HASH_UNICAST is set, the frame is passed only when it matches the Hash filter<br>1: Receive the frame when it pass the address register filter or the hash filter(set by HASH_MULTICAST or HASH_UNICAST) |
| 0   | R/W | 0 | RX_ALL<br>0: Receive the frames that pass the SA/DA address filter<br>1: Receive all frames and update the result of address filter(pass or fail) in the receive status word   |

#### 8.5.4.13. Receive Hash Table 0 Register(Default Value: 0x00000000)

| Offset: 0x40 |     |             | Register Name: RX_HASH_0  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0           | HASH_TAB_0<br>The upper 32 bits of Hash table for receive frame filter. |

#### 8.5.4.14. Receive Hash Table 1 Register(Default Value: 0x00000000)

| Offset: 0x44 |     |             | Register Name: RX_HASH_1  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0           | HASH_TAB_1<br>The lower 32 bits of Hash table for receive frame filter. |

#### 8.5.4.15. MII Command Register(Default Value: 0x00000000)

| Offset: 0x48 |     |             | Register Name: MII_CMD  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:23        | /   | /           | /   |
| 22:20        | R/W | 0           | MDC_DIV_RATIO_M<br>MDC clock divide ration(m). The source of MDC clock is AHB clock.<br>000: 16<br>001: 32<br>010: 64 |

|       |     |   |  |
|-------|-----|---|--|
|       |     |   | 011: 128<br>Others: Reserved   |
| 19:17 | /   | / | /  |
| 16:12 | R/W | 0 | PHY_ADDR<br>Select a PHY device from 32 possible candidates.   |
| 11:9  | /   | / | /  |
| 8:4   | R/W | 0 | PHY_REG_ADDR<br>Select register in the selected PHY device   |
| 3:2   | /   | / | /  |
| 1     | R/W | 0 | MII_WR<br>0: Read register in selected PHY and return data in EMAC_GMII_DATA<br>1: Write register in selected PHY using data in EMAC_GMII_DATA   |
| 0     | R/W | 0 | MII_BUSY<br>This bit indicates that a read or write operation is in progress. When prepared the data and register address for a write operation or the register address for a read operation, set this bit and start to access register in PHY.<br>When this bit is cleared automatically, the read or write operation is over and the data in EMAC_GMII_DATA is valid for a read operation. |

#### 8.5.4.16. MII Data Register(Default Value: 0x00000000)

| Offset: 0x4C |     |             | Register Name: MII_DATA   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:16        | /   | /           | /   |
| 15:0         | R/W | 0           | MII_DATA<br>The 16-bit data to be written to or read from the register in the selected PHY. |

#### 8.5.4.17. MAC Address 0 High Register(Default Value: 0x0000FFFF)

| Offset: 0x50 |     |             | Register Name: ADDR0_HIGH   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:16        | /   | /           | /   |
| 15:0         | R/W | 0xFFFF      | MAC_ADDR_0_HIGH<br>The upper 16bits of the 1 <sup>st</sup> MAC address. |

#### 8.5.4.18. MAC Address 0 Low Register(Default Value: 0xFFFFFFFF)

| Offset: 0x54 |     |             | Register Name: ADDR0_LOW   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:0         | R/W | 0xFFFFFFFF  | MAC_ADDR_0_LOW<br>The lower 32bits of 1 <sup>st</sup> MAC address. |

#### 8.5.4.19. MAC Address x High Register(Default Value: 0x0000FFFF)

| Offset: 0x50+8*x (x=1~7) |     |             | Register Name: ADDR <sub>x</sub> _HIGH  |
|--------------------------|-----|-------------|---|
| Bit                      | R/W | Default/Hex | Description   |
| 31                       | R/W | 0           | <p>MAC_ADDR_CTL</p> <p>0: MAC address x(x: 1~7) is not valid, and it will be ignored by the address filter</p> <p>1: MAC address x(x: 1~7) is valid</p>   |
| 30                       | R/W | 0.          | <p>MAC_ADDR_TYPE</p> <p>1: MAC address x(x:1~7) used to compare with the source address of the received frame</p> <p>0: MAC address x(x:1~7) used to compare with the destination address of the received frame</p> |
| 29:24                    | R/W | 0           | <p>MAC_ADDR_BYTE_CTL</p> <p>MAC address byte control mask. The lower bit of mask controls the lower byte of in MAC address x(x:1~7). When the bit of mask is 1, do not compare the corresponding byte.</p>          |
| 23:16                    | /   | /           | /   |
| 15:0                     | R/W | 0xFFFF      | <p>MAC_ADDR_x_HIGH</p> <p>The upper 16bits of the MAC address x(x:1~7).</p>   |

#### 8.5.4.20. MAC Address x Low Register(Default Value: 0xFFFFFFFF)

| Offset: 0x54+8*x (x=1~7) |     |             | Register Name: ADDR <sub>x</sub> _LOW                                  |
|--------------------------|-----|-------------|--|
| Bit                      | R/W | Default/Hex | Description  |
| 31:0                     | R/W | 0xFFFFFFFF  | <p>MAC_ADDR_x_LOW</p> <p>The lower 32bits of MAC address x(x:1~7).</p> |

#### 8.5.4.21. Transmit DMA Status Register(Default Value: 0x00000000)

| Offset: 0xB0 |     |             | Register Name: TX_DMA_STA  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:3         | /   | /           | /  |
| 2:0          | R   | 0           | <p>TX_DMA_STA</p> <p>The state of Transmit DMA FSM.</p> <p>000: STOP: When reset or disable TX DMA;</p> <p>001: RUN_FETCH_DESC: Fetching TX DMA descriptor;</p> <p>010: RUN_WAIT_STA: Waiting for the status of TX frame;</p> <p>011: RUN_TRANS_DATA: Passing frame from host memory to TX DMA FIFO;</p> <p>111: RUN_CLOSE_DESC: Closing TX descriptor.</p> <p>110: SUSPEND: TX descriptor unavailable or TX DMA FIFO underflow;</p> |

|  |  |                     |
|--|--|---------------------|
|  |  | 100, 101: Reserved; |
|--|--|---------------------|

#### 8.5.4.22. Transmit DMA Current Descriptor Register(Default Value: 0x00000000)

| Offset: 0xB4 |     |             | Register Name: TX_DMA_CUR_DESC              |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description                                 |
| 31:0         | R   | 0           | The address of current transmit descriptor. |

#### 8.5.4.23. Transmit DMA Current Buffer Address Register(Default Value: 0x00000000)

| Offset: 0xB8 |     |             | Register Name: TX_DMA_CUR_BUF              |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description                                |
| 31:0         | R   | 0           | The address of current transmit DMA buffer |

#### 8.5.4.24. Receive DMA Status Register(Default Value: 0x00000000)

| Offset: 0xC0 |     |             | Register Name: RX_DMA_STA  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:3         | /   | /           | /  |
| 2:0          | R   | 0           | <p>RX_DMA_STA<br/>                     The state of RX DMA FSM.<br/>                     000: STOP: When reset or disable RX DMA;.<br/>                     001: RUN_FETCH_DESC: Fetching RX DMA descriptor;<br/>                     011: RUN_WAIT_FRM: Waiting for frame.<br/>                     100: SUSPEND: RX descriptor unavailable;<br/>                     101: RUN_CLOSE_DESC: Closing RX descriptor.<br/>                     111: RUN_TRANS_DATA: Passing frame from host memory to RX DMA FIFO;<br/>                     010, 110: Reserved.</p> |

#### 8.5.4.25. Receive DMA Current Descriptor Register(Default Value: 0x00000000)

| Offset: 0xC4 |     |             | Register Name: RX_DMA_CUR_DESC            |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description                               |
| 31:0         | R   | 0           | The address of current receive descriptor |

#### 8.5.4.26. Receive DMA Current Buffer Address Register(Default Value: 0x00000000)

| Offset: 0xC8 |  | Register Name: RX_DMA_CUR_BUF |
|--------------|--|-------------------------------|
|              |  |                               |

| Bit  | R/W | Default/Hex | Description                               |
|------|-----|-------------|---|
| 31:0 | R   | 0           | The address of current receive DMA buffer |

#### **8.5.4.27. RGMII Status Register(Default Value: 0x00000000)**

| Offset: 0xD0 |     |             | Register Name: RGMII_STA   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:4         | /   | /           | /  |
| 3            | R   | 0           | <p>RGMII_LINK<br/>The link status of RGMII interface<br/>0: down<br/>1: up</p>                             |
| 2:1          | R   | 0           | <p>RGMII_LINK_SPD<br/>The link speed of RGMII interface<br/>00: 2.5 MHz<br/>01: 25 MHz<br/>10: 125 MHz</p> |
| 0            | R   | 0           | <p>RGMII_LINK_MD<br/>The link Mode of RGMII interface<br/>0: Half-Duplex<br/>1: Full-Duplex</p>            |

### 8.5.5. EMAC RX/TX Descriptor

The EMAC' internal DMA transfers data between host memory and internal RX/TX FIFO with a linked list of descriptors. Each descriptor is consisted of four words, and contains some necessary information to transfer TX and RX frames. The descriptor list structure is shown in Figure 8-8. The address of each descriptor must be 32-bit aligned.

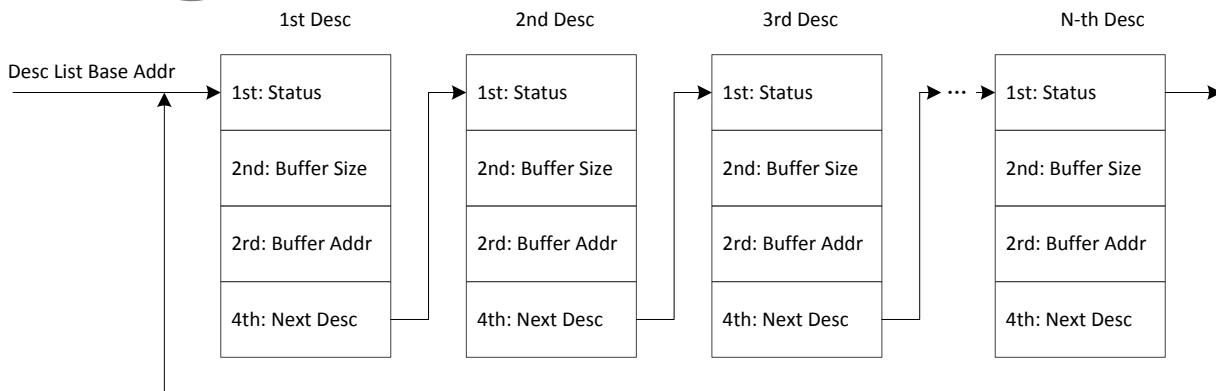


Figure 8-8. EMAC RX/TX Descriptor List

### 8.5.5.1. Transmit Descriptor

#### 1st Word of Transmit Descriptor

| Bits  | Description  |
|-------|--|
| 31    | TX_DESC_CTL<br>When set, current descriptor can be used by DMA. This bit is cleared by DMA when the whole frame is transmitted or all data in current descriptor's buffer are transmitted. |
| 30:17 | Reserved   |
| 16    | TX_HEADER_ERR<br>When set, the checksum of transmitted frame's header is wrong.  |
| 15    | Reserved   |
| 14    | TX_LENGTH_ERR<br>When set, the length of transmitted frame is wrong.   |
| 13    | Reserved   |
| 12    | TX_PAYLOAD_ERR<br>When set, the checksum of transmitted frame's payload is wrong.  |
| 11    | Reserved   |
| 10    | TX_CRS_ERR<br>When set, carrier is lost during transmission.   |
| 9     | TX_COL_ERR_0<br>When set, the frame is aborted because of collision after contention period.   |
| 8     | TX_COL_ERR_1<br>When set, the frame is aborted because of too many collisions.   |
| 7     | Reserved.  |
| 6:3   | TX_COL_CNT<br>The number of collisions before transmission.  |
| 2     | TX_DEFER_ERR<br>When set, the frame is aborted because of too much deferral.   |
| 1     | TX_UNDERFLOW_ERR<br>When set, the frame is aborted because of TX FIFO underflow error.   |
| 0     | TX_DEFER<br>When set in Half-Duplex mode, the EMAC defers the frame transmission.  |

#### 2nd Word of Transmit Descriptor

| Bits  | Description  |
|-------|--|
| 31    | TX_INT_CTL<br>When set and the current frame have been transmitted, the TX_INT in Interrupt Status Register will be set. |
| 30    | LAST_DESC<br>When set, current descriptor is the last one for current frame.   |
| 29    | FIR_DESC<br>When set, current descriptor is the first one for current frame.   |
| 28:27 | CHECKSUM_CTL   |

|       |   |
|-------|---|
|       | These bits control to insert checksums in transmit frame.       |
| 26    | CRC_CTL<br>When set, CRC field is not transmitted.              |
| 25:11 | Reserved  |
| 10:0  | BUF_SIZE<br>The size of buffer specified by current descriptor. |

### 3rd Word of Transmit Descriptor

| Bits | Description  |
|------|--|
| 31:0 | BUF_ADDR<br>The address of buffer specified by current descriptor. |

### 4th Word of Transmit Descriptor

| Bits | Description  |
|------|--|
| 31:0 | NEXT_DESC_ADDR<br>The address of next descriptor. It must be 32-bit aligned. |

### 8.5.5.2. Receive Descriptor

#### 1st Word of Receive Descriptor

| Bits  | Description  |
|-------|--|
| 31    | RX_DESC_CTL<br>When set, current descriptor can be used by DMA. This bit is cleared by DMA when complete frame is received or current descriptor's buffer is full.   |
| 30    | RX_DAF_FAIL<br>When set, current frame don't pass DA filter.   |
| 29:16 | RX_FRM_LEN<br>When LAST_DESC is not set and no error bit is set, this field is the length of received data for current frame.<br>When LAST_DESC is set, RX_OVERFLOW_ERR and RX_NO_ENOUGH_BUF_ERR are not set, this field is the length of receive frame. |
| 15    | Reserved   |
| 14    | RX_NO_ENOUGH_BUF_ERR<br>When set, current frame is clipped because of no enough buffer.  |
| 13    | RX_SAF_FAIL<br>When set, current fame don't pass SA filter.  |
| 12    | Reserved.  |
| 11    | RX_OVERFLOW_ERR<br>When set, a buffer overflow error occurred and current frame is wrong.  |
| 10    | Reserved   |

|   |   |
|---|---|
| 9 | FIR_DESC  |
|   | When set, current descriptor is the first descriptor for current frame.   |
| 8 | LAST_DESC   |
|   | When set, current descriptor is the last descriptor for current frame.    |
| 7 | RX_HEADER_ERR   |
|   | When set, the checksum of frame's header is wrong.                        |
| 6 | RX_COL_ERR  |
|   | When set, there is a late collision during reception in half-duplex mode. |
| 5 | Reserved.   |
| 4 | RX_LENGTH_ERR   |
|   | When set, the length of current frame is wrong.                           |
| 3 | RX_PHY_ERR  |
|   | When set, the receive error signal from PHY is asserted during reception. |
| 2 | Reserved.   |
| 1 | RX_CRC_ERR  |
|   | When set, the CRC field of received frame is wrong.                       |
| 0 | RX_PAYLOAD_ERR  |
|   | When set, the checksum or length of received frame's payload is wrong.    |

#### 2nd Word of Receive Descriptor

| Bits  | Description  |
|-------|--|
| 31    | RX_INT_CTL   |
|       | When set and a frame have been received, the RX_INT will not be set. |
| 30:11 | Reserved   |
| 10:0  | BUF_SIZE   |
|       | The size of buffer specified by current descriptor.                  |

#### 3rd Word of Receive Descriptor

| Bits | Description  |
|------|--|
| 31:0 | BUF_ADDR   |
|      | The address of buffer specified by current descriptor. |

#### 4th Word of Receive Descriptor

| Bits | Description  |
|------|--|
| 31:0 | NEXT_DESC_ADDR   |
|      | The address of next descriptor. This field must be 32-bit aligned. |

## 8.6. I2S/PCM

### 8.6.1. Overview

The I2S/PCM Controller has been designed to transfer streaming audio-data between the system memory and the codec chip. The controller supports standard I2S format, Left-justified Mode format, Right-justified Mode format and PCM Mode format and TDM Mode format.

The I2S/PCM controller includes the following features:

- Compliant with standard Philips Inter-IC sound (I2S) bus specification
- Compliant with Left-justified, Right-justified, PCM mode, and TDM (Time Division Multiplexing) format
- Different sample period width in each interface when using LRCK and LRCKR at the same time
- Full-duplex synchronous work mode
- Supports Master/Slave mode
- Adjustable interface voltage
- Clock up to 100MHz
- Supports up to 8 slots which has adjustable width from 8-bit to 32-bit
- Sample rate from 8 kHz to 192 kHz
- Supports 8-bit u-law and 8-bit A-law companded sample
- One 128 depth x 32-bit width FIFO for data transmit, one 64 depth x 32-bit width FIFO for data receive
- Supports programmable PCM frame width: 1 BCLK width (short frame) and 2 BCLKs width (long frame)
- Programmable FIFO thresholds
- Interrupt and DMA support
- Supports loopback mode for test

### 8.6.2. Signal Description

#### 8.6.2.1. I2S/PCM Pin List

| Signal Name | Type | Description                    |
|-------------|------|--------------------------------|
| PCM_DIN     | I    | I2S/PCM Serial Data Input      |
| PCM_DOUT    | O    | I2S/PCM Serial Data Output     |
| PCM_BCLK    | I/O  | I2S/PCM Sample Rate Clock      |
| PCM_SYNC    | I/O  | I2S/PCM Sample Rate Clock/Sync |

### 8.6.2.2. I2S/PCM Clock Source and Frequency

|           | Description   |
|-----------|---|
| Audio_PLL | 24.576MHz or 22.5792MHz generated by AUDIO-PLL to produce 48KHz or 44.1KHz serial frequency |

### 8.6.3. Functionalities Description

#### 8.6.3.1. Typical Applications

The TDM is the extended of I2S and PCM which provides a serial bus interface for stereo and multichannel audio data. This interface is most commonly used by consumer audio market, including compact disc, digital audio tape, digital sound processors, and digital TV-sound.

#### 8.6.3.2. Functional Block Diagram

The I2S/PCM Interface block diagram is shown below:

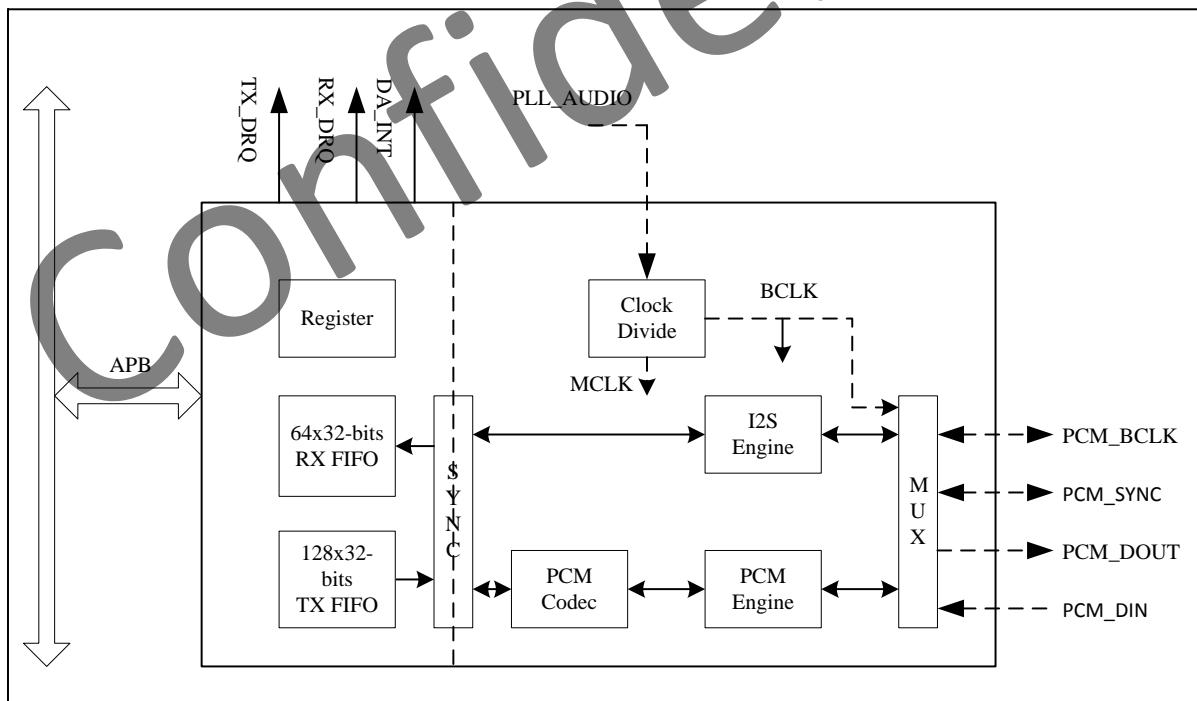


Figure 8-9. I2S/PCM Interface System Block Diagram

#### 8.6.4. Timing Diagram

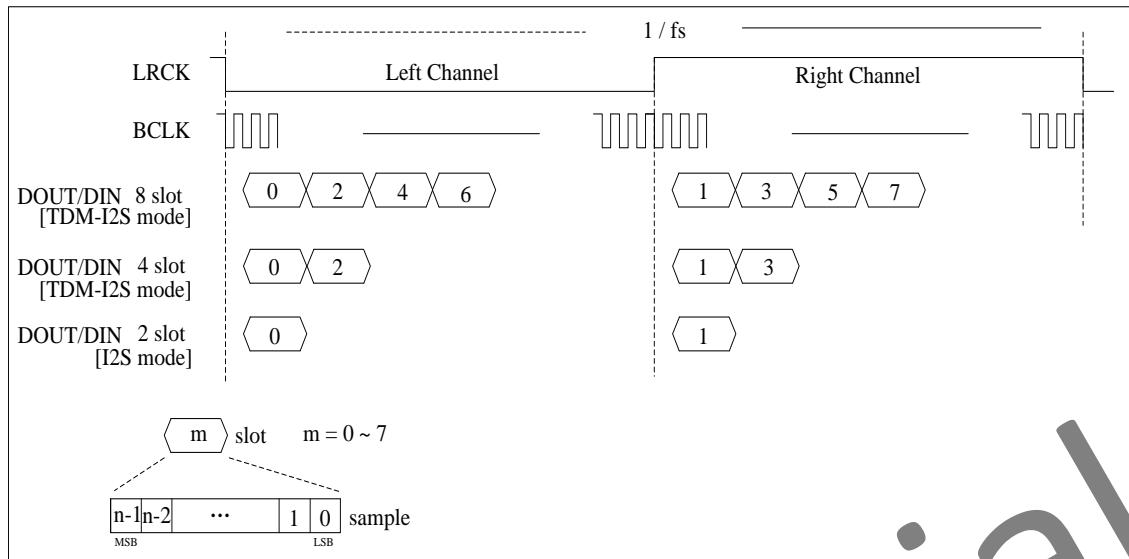


Figure 8-10. Timing Diagram for I2S/TDM-I2S Mode

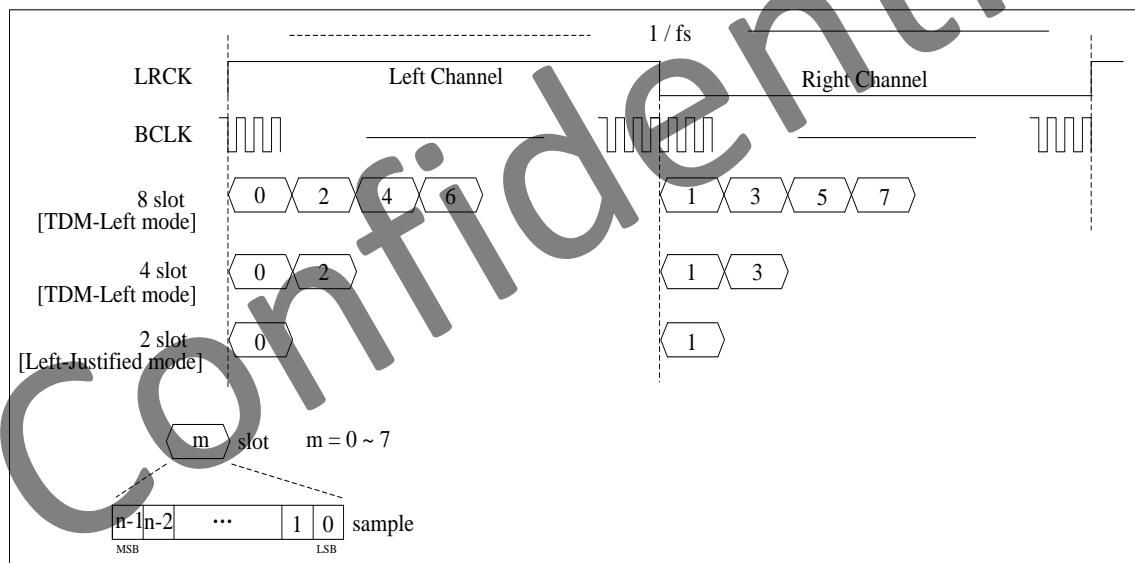


Figure 8-11. Timing Diagram for Left-justified/TDM-Left Mode

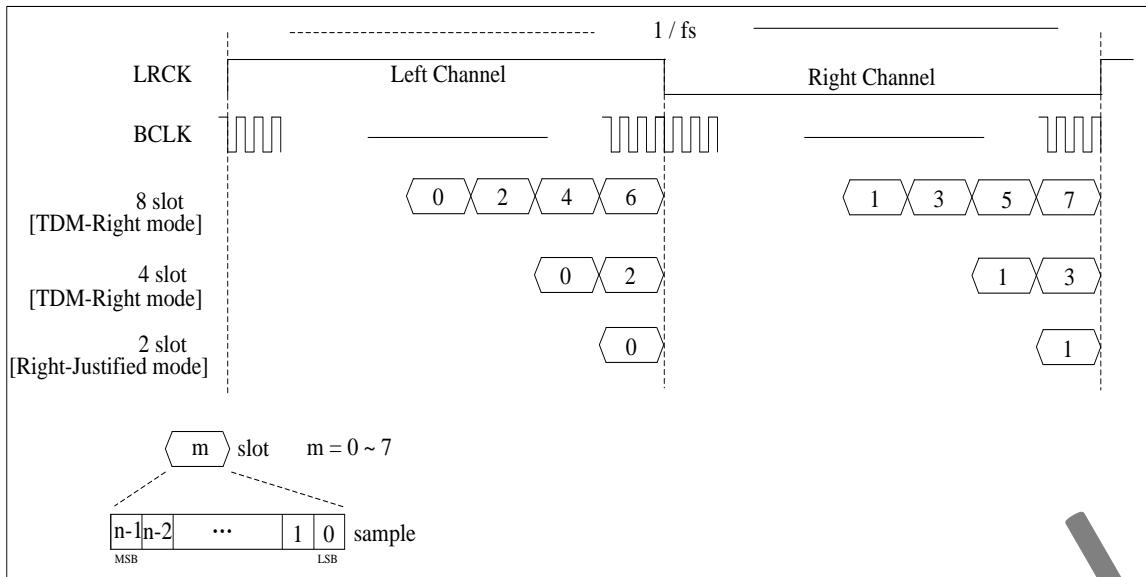


Figure 8-12. Timing Diagram for Right-justified/TDM-Right Mode

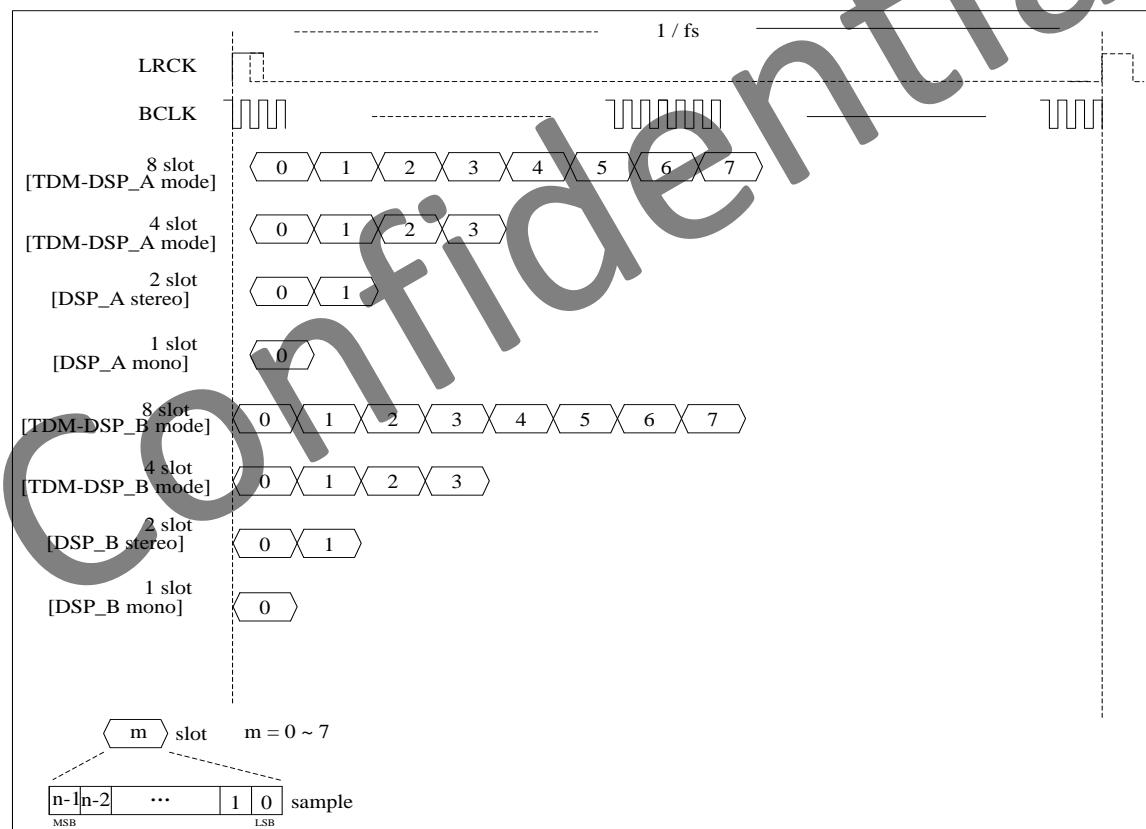


Figure 8-13.Timing Diagram for PCM/TDM-PCM Mode

### 8.6.5. Operation Modes

The software operation of the I2S/PCM is divided into five steps: system setup, I2S/PCM initialization, the channel setup, DMA setup and Enable/Disable module. These five steps are described in detail in the following sections.

#### 8.6.5.1. System Setup and I2S/PCM Initialization

The first step in the system setup is properly programming the GPIO. Because the I2S/PCM port is a multiplex pin. You can find the function in the pin multiplex specification. The clock source for the I2S/PCM should be followed. At first you must reset the audio PLL through the PLL\_ENABLE bit of PLL\_AUDIO\_CTRL\_REG in the CCU. The second step, you must setup the frequency of the audio pll in the PLL\_AUDIO\_CTRL\_REG. The configuration of audio pll can be found in CCU. After that, you must open the I2S/PCM gating through the I2S/PCM\_CLK\_REG when you checkout that the LOCK bit of PLL\_AUDIO\_CTRL\_REG becomes 1. At last, you must reset the I2S/PCM through the bit[12] of Bus Software Reset Register3 and open the I2S/PCM bus gating in the bit[12] of Bus Clock Gating Register2.

After the system setup, the register of I2S/PCM can be setup. At first, you should initialize the I2S/PCM. You should close the globe enable bit(DA\_CTL[0]) , TX enable bit(DA\_CTL[2]) and RX enable bit(DA\_CTL[1]) by writing 0 to it. After that, you must clear the TX/RX FIFO by writing 0 to register DA\_FCTL[25:24]. At last, you can clear the TX/RX FIFO counter by writing 0 to DA\_TXCNT/DA\_RXCNT.

#### 8.6.5.2. Channel Setup and DMA Setup

Before the usage and control of I2S/PCM, you must configure the I2C. The configuration of I2C will not describe in this chapter. But you can only configure I2S/PCM of master and slave though the I2C. In the following, you can setup the I2S/PCM of master and slave. The configuration can be referred to the the protocol of I2S/PCM. Then, you can set the translation mode, the sample precision, the wide of slot, the frame mode and the trigger level. The register set can be found in the spec.

The I2S/PCM supports three methods to transfer the data. The most common way is DMA, the set of DMA can be found in the DMA spec. In this module, you just enable the DRQ.

#### 8.6.5.3. Enable and Disable I2S/PCM

To enable the function, you can enable TX/RX by writing the DA\_CTL[2:1]. After that, you must enable I2S/PCM by writing the Globe Enable bit to 1 in the DA\_CTL. The disable process is to write the Globe Enable to 0.

### 8.6.6. I2S/PCM Interface Register List

| Module Name | Base Address |
|-------------|--------------|
| I2S/PCM     | 0x01C22000   |

| Register Name | Offset | Description                       |
|---------------|--------|-----------------------------------|
| I2S/PCM_CTL   | 0x00   | I2S/PCM Control Register          |
| I2S/PCM_FMT0  | 0x04   | I2S/PCM Format Register 0         |
| I2S/PCM_FMT1  | 0x08   | I2S/PCM Format Register 1         |
| I2S/PCMISTA   | 0x0C   | I2S/PCM Interrupt Status Register |
| I2S/PCMRXFIFO | 0x10   | I2S/PCM RX FIFO Register          |

|                  |      |  |
|------------------|------|--|
| I2S/PCM_FCTL     | 0x14 | I2S/PCM FIFO Control Register              |
| I2S/PCM_FSTA     | 0x18 | I2S/PCM FIFO Status Register               |
| I2S/PCM_INT      | 0x1C | I2S/PCM DMA & Interrupt Control Register   |
| I2S/PCM_TXFIFO   | 0x20 | I2S/PCM TX FIFO Register                   |
| I2S/PCM_CLKD     | 0x24 | I2S/PCM Clock Divide Register              |
| I2S/PCM_TXCNT    | 0x28 | I2S/PCM TX Sample Counter Register         |
| I2S/PCM_RXCNT    | 0x2C | I2S/PCM RX Sample Counter Register         |
| I2S/PCM_CHCFG    | 0x30 | I2S/PCM Channel Configuration register     |
| I2S/PCM_TX0CHCFG | 0x34 | I2S/PCM TX0 Channel Configuration register |
| I2S/PCM_TX1CHSEL | 0x38 | I2S/PCM TX1 Channel Select Register        |
| I2S/PCM_TX2CHSEL | 0x3C | I2S/PCM TX2 Channel Select Register        |
| I2S/PCM_TX3CHSEL | 0x40 | I2S/PCM TX3 Channel Select Register        |
| I2S/PCM_TX0CHMAP | 0x44 | I2S/PCM TX0 Channel Mapping Register       |
| I2S/PCM_TX1CHMAP | 0x48 | I2S/PCM TX1 Channel Mapping Register       |
| I2S/PCM_TX0CHMAP | 0x4C | I2S/PCM TX2 Channel Mapping Register       |
| I2S/PCM_RX0CHMAP | 0x50 | I2S/PCM TX3 Channel Mapping Register       |
| I2S/PCM_RXCHSEL  | 0x54 | I2S/PCM RX Channel Select register         |
| I2S/PCM_RXCHMAP  | 0x58 | I2S/PCM RX Channel Mapping Register        |

### 8.6.7. I2S/PCM Interface Register Description

#### 8.6.7.1. I2S/PCM Control Register(Default Value: 0x00060000)

| Offset: 0x00 |     |             | Register Name: I2S/PCM_CTL                                  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:19        | /   | /           | /   |
| 18           | R/W | 1           | BCLK_OUT<br>0: input<br>1: output                           |
| 17           | R/W | 1           | LRCK_OUT<br>0: input<br>1: output                           |
| 16:9         | /   | /           | /   |
| 8            | R/W | 0           | SDO0_EN<br>0: Disable, Hi-Z state<br>1: Enable              |
| 7            | /   | /           | /   |
| 6            | R/W | 0           | OUT Mute<br>0: normal transfer<br>1: force DOUT to output 0 |
| 5:4          | R/W | 0           | MODE_SEL<br>Mode Selection                                  |

|   |     |   |  |
|---|-----|---|--|
|   |     |   | 0: PCM mode (offset 0: DSP_B; offset 1: DSP_A)<br>1: Left mode (offset 0: LJ mode; offset 1: I2S mode)<br>2: Right-Justified mode<br>3: Reserved |
| 3 | R/W | 0 | LOOP<br>Loop back test<br>0: Normal mode<br>1: Loop back test<br>When set '1', connecting the SDO0 with the SDI                                  |
| 2 | R/W | 0 | TXEN<br>Transmitter Block Enable<br>0: Disable<br>1: Enable  |
| 1 | R/W | 0 | RXEN<br>Receiver Block Enable<br>0: Disable<br>1: Enable   |
| 0 | R/W | 0 | GEN<br>Globe Enable<br>A disable on this bit overrides any other block or channel enables.<br>0: Disable<br>1: Enable                            |

#### 8.6.7.2. I2S/PCM Format Register0 (Default Value: 0x00000033)

| Offset: 0x04 |     |             | Register Name: I2S/PCM_FMT0  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | R/W | 0           | SDI_SYNC_SEL<br>0: SDI use LRCK<br>1: SDI use LRCKR  |
| 30           | R/W | 0           | LRCK_WIDTH<br>(only apply in PCM mode ) LRCK width<br>0: LRCK = 1 BCLK width (short frame)<br>1: LRCK = 2 BCLK width (long frame)  |
| 29:20        | R/W | 0           | LRCKR_PERIOD<br>It is used to program the number of BCLKs per channel of sample frame. This value is interpreted as follow:<br>PCM mode: Number of BCLKs within (Left + Right) channel width<br>I2S / Left-Justified / Right-Justified mode: Number of BCLKs within each individual channel width (Left or Right)<br>N+1<br>For example:<br>n = 7: 8 BCLK width<br>... |

|      |     |     |  |
|------|-----|-----|--|
|      |     |     | n = 1023: 1024 BCLKs width   |
| 19   | R/W | 0   | <b>LRCK_POLARITY/LRCKR_POLARITY</b><br>When apply in I2S / Left-Justified / Right-Justified mode:<br>0: Left channel when LRCK is low<br>1: Left channel when LRCK is high<br>When apply in PCM mode:<br>0: PCM LRCK/LRCKR asserted at the negative edge<br>1: PCM LRCK/LRCKR asserted at the positive edge  |
| 18   | /   | /   | /  |
| 17:8 | R/W | 0   | <b>LRCK_PERIOD</b><br>It is used to program the number of BCLKs per channel of sample frame. This value is interpreted as follow:<br>PCM mode: Number of BCLKs within (Left + Right) channel width<br>I2S / Left-Justified / Right-Justified mode: Number of BCLKs within each individual channel width (Left or Right)<br>N+1<br>For example:<br>n = 7: 8 BCLK width<br>...<br>n = 1023: 1024 BCLKs width |
| 7    | R/W | 0   | <b>BCLK_POLARITY</b><br>0: normal mode, negative edge drive and positive edge sample<br>1: invert mode, positive edge drive and negative edge sample   |
| 6:4  | R/W | 3   | <b>SR</b><br>Sample Resolution<br>0: Reserved<br>1: 8-bit<br>2: 12-bit<br>3: 16-bit<br>4: 20-bit<br>5: 24-bit<br>6: 28-bit<br>7: 32-bit  |
| 3    | R/W | 0   | <b>EDGE_TRANSFER</b><br>0: SDO drive data and SDI sample data at the different BCLK edge<br>1: SDO drive data and SDI sample data at the same BCLK edge<br><b>BCLK_POLARITY = 0, use negative edge</b><br><b>BCLK_POLARITY = 1, use positive edge</b>  |
| 2:0  | R/W | 0x3 | <b>SW</b><br>Slot Width Select<br>0: Reserved<br>1: 8-bit<br>2: 12-bit<br>3: 16-bit<br>4: 20-bit   |

|  |  |  |                                     |
|--|--|--|-------------------------------------|
|  |  |  | 5: 24-bit<br>6: 28-bit<br>7: 32-bit |
|--|--|--|-------------------------------------|

#### 8.6.7.3. I2S/PCM Format Register1 (Default Value: 0x00000030)

| Offset: 0x08 |     |             | Register Name: I2S/PCM_FMT1  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:8         | /   | /           |  |
| 7            | R/W | 0           | RX MLS<br>MSB / LSB First Select<br>0: MSB First<br>1: LSB First   |
| 6            | R/W | 0           | TX MLS<br>MSB / LSB First Select<br>0: MSB First<br>1: LSB First   |
| 5:4          | R/W | 3           | SEXT<br>Sign Extend in slot [sample resolution < slot width]<br>0: Zeros or audio gain padding at LSB position<br>1: Sign extension at MSB position<br>2: Reserved<br>3: Transfer 0 after each sample in each slot |
| 3:2          | R/W | 0           | RX_PDM<br>PCM Data Mode<br>0: Linear PCM<br>1: reserved<br>2: 8-bits u-law<br>3: 8-bits A-law  |
| 1:0          | R/W | 0           | TX_PDM<br>PCM Data Mode<br>0: Linear PCM<br>1: reserved<br>2: 8-bits u-law<br>3: 8-bits A-law  |

#### 8.6.7.4. I2S/PCM Interrupt Status Register(Default Value: 0x00000010)

| Offset: 0x0C |     |             | Register Name: I2S/PCMISTA |
|--------------|-----|-------------|----------------------------|
| Bit          | R/W | Default/Hex | Description                |
| 31:7         | /   | /           | /                          |
| 6            | R/W | 0           | TXU_INT                    |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | TX FIFO Under run Pending Interrupt<br>0: No Pending Interrupt<br>1: FIFO Under run Pending Interrupt<br>Write 1 to clear this interrupt  |
| 5 | R/W | 0 | TXO_INT<br>TX FIFO Overrun Pending Interrupt<br>0: No Pending Interrupt<br>1: FIFO Overrun Pending Interrupt<br>Write '1' to clear this interrupt   |
| 4 | R/W | 1 | TXE_INT<br>TX FIFO Empty Pending Interrupt<br>0: No Pending IRQ<br>1: FIFO Empty Pending Interrupt when data in TX FIFO are less than TX trigger level<br>Write '1' to clear this interrupt or automatic clear if interrupt condition fails.        |
| 3 | /   | / | /   |
| 2 | R/W | 0 | RXU_INT<br>RX FIFO Under run Pending Interrupt<br>0: No Pending Interrupt<br>1:FIFO Under run Pending Interrupt<br>Write 1 to clear this interrupt  |
| 1 | R/W | 0 | RXO_INT<br>RX FIFO Overrun Pending Interrupt<br>0: No Pending IRQ<br>1: FIFO Overrun Pending IRQ<br>Write '1' to clear this interrupt   |
| 0 | R/W | 0 | RXA_INT<br>RX FIFO Data Available Pending Interrupt<br>0: No Pending IRQ<br>1: Data Available Pending IRQ when data in RX FIFO are more than RX trigger level<br>Write '1' to clear this interrupt or automatic clear if interrupt condition fails. |

#### 8.6.7.5. I2S/PCM RX FIFO Register(Default Value: 0x00000000)

| Offset: 0x10 |     |             | Register Name: I2S/PCM_RXFIFO  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:0         | R   | 0           | RX_DATA<br>RX Sample<br>Host can get one sample by reading this register. The left channel sample data is first and then the right channel sample. |

**8.6.7.6. I2S/PCM FIFO Control Register (Default Value: 0x000400F0)**

| Offset: 0x14 |     |             | Register Name: I2S/PCM_FCTL  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:26        | /   | /           | /  |
| 25           | R/W | 0           | FTX<br>Write '1' to flush TX FIFO, self clear to '0'.  |
| 24           | R/W | 0           | FRX<br>Write '1' to flush RX FIFO, self clear to '0'.  |
| 23:19        | /   | /           | /  |
| 18:12        | R/W | 0x40        | TXTL<br>TX FIFO Empty Trigger Level<br>Interrupt and DMA request trigger level for TXFIFO normal condition<br>Trigger Level = TXTL   |
| 11:10        | /   | /           | /  |
| 9:4          | R/W | 0xF         | RXTL<br>RX FIFO Trigger Level<br>Interrupt and DMA request trigger level for RXFIFO normal condition<br>Trigger Level = RXTL + 1   |
| 3            | /   | /           | /  |
| 2            | R/W | 0           | TXIM<br>TX FIFO Input Mode (Mode 0, 1)<br>0: Valid data at the MSB of TXFIFO register<br>1: Valid data at the LSB of TXFIFO register<br>Example for 20-bits transmitted audio sample:<br>Mode 0: FIFO_I[31:0] = {APB_WDATA[31:12], 12'h0}<br>Mode 1: FIFO_I[31:0] = {APB_WDATA[19:0], 12'h0}   |
| 1:0          | R/W | 0           | RXOM<br>RX FIFO Output Mode (Mode 0, 1, 2, 3)<br>00: Expanding '0' at LSB of DA_RXFIFO register.<br>01: Expanding received sample sign bit at MSB of DA_RXFIFO register.<br>10: Truncating received samples at high half-word of DA_RXFIFO register and low half-word of DA_RXFIFO register is filled by '0'.<br>11: Truncating received samples at low half-word of DA_RXFIFO register and high half-word of DA_RXFIFO register is expanded by its sign bit.<br>Example for 20-bits received audio sample:<br>Mode 0: APB_RDATA[31:0] = {FIFO_O[31:12], 12'h0}<br>Mode 1: APB_RDATA [31:0] = {12{FIFO_O[31]}, FIFO_O[31:12]}<br>Mode 2: APB_RDATA [31:0] = {FIFO_O[31:16], 16'h0}<br>Mode 3: APB_RDATA [31:0] = {16{FIFO_O[31]}, FIFO_O[31:16]} |

**8.6.7.7. I2S/PCM FIFO Status Register (Default Value: 0x10800000)**

| Offset: 0x18 |     |             | Register Name: I2S/PCM_FSTA   |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:29        | /   | /           | /   |
| 28           | R   | 1           | TXE<br>TX FIFO Empty<br>0: No room for new sample in TX FIFO<br>1: More than one room for new sample in TX FIFO (>= 1 word) |
| 27:24        | /   | /           | /   |
| 23:16        | R   | 0x80        | TXE_CNT<br>TX FIFO Empty Space Word Counter   |
| 15:9         | /   | /           | /   |
| 8            | R   | 0           | RXA<br>RX FIFO Available<br>0: No available data in RX FIFO<br>1: More than one sample in RX FIFO (>= 1 word)               |
| 7            | /   | /           | /   |
| 6:0          | R   | 0           | RXA_CNT<br>RX FIFO Available Sample Word Counter  |

**8.6.7.8. I2S/PCM DMA & Interrupt Control Register(Default Value: 0x00000000)**

| Offset: 0x1C |     |             | Register Name: I2S/PCM_INT  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:8         | /   | /           | /   |
| 7            | R/W | 0           | TX_DRQ<br>TX FIFO Empty DRQ Enable<br>0: Disable<br>1: Enable   |
| 6            | R/W | 0           | TXUI_EN<br>TX FIFO Under run Interrupt Enable<br>0: Disable<br>1: Enable  |
| 5            | R/W | 0           | TXOI_EN<br>TX FIFO Overrun Interrupt Enable<br>0: Disable<br>1: Enable<br>When set to '1', an interrupt happens when writing new audio data if TX FIFO is full. |
| 4            | R/W | 0           | TXEI_EN<br>TX FIFO Empty Interrupt Enable<br>0: Disable   |

|   |     |   |   |
|---|-----|---|---|
|   |     |   | 1: Enable   |
| 3 | R/W | 0 | RX_DRQ<br>RX FIFO Data Available DRQ Enable<br>0: Disable<br>1: Enable<br>When set to '1', RXFIFO DMA Request line is asserted if Data is available in RX FIFO. |
| 2 | R/W | 0 | RXUI_EN<br>RX FIFO Under run Interrupt Enable<br>0: Disable<br>1: Enable  |
| 1 | R/W | 0 | RXOI_EN<br>RX FIFO Overrun Interrupt Enable<br>0: Disable<br>1: Enable  |
| 0 | R/W | 0 | RXAI_EN<br>RX FIFO Data Available Interrupt Enable<br>0: Disable<br>1: Enable   |

#### 8.6.7.9. I2S/PCM TX FIFO Register(Default Value: 0x00000000)

| Offset: 0x20 |     |             | Register Name: I2S/PCM_TXFIFO  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:0         | W   | 0           | <b>TX_DATA</b><br>TX Sample<br>Transmitting left, right channel sample data should be written this register one by one. The left channel sample data is first and then the right channel sample. |

#### 8.6.7.10. I2S/PCM Clock Divide Register(Default Value: 0x00000000)

| Offset: 0x24 |     |             | Register Name: I2S/PCM_CLKD  |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:9         | /   | /           | /  |
| 8            | R/W | 0           | <b>MCLKO_EN</b><br>0: Disable MCLK Output<br>1: Enable MCLK Output<br>Whether in Slave or Master mode, when this bit is set to 1, MCLK should be output. |
| 7:4          | R/W | 0           | <b>BCLKDIV</b><br>BCLK Divide Ratio from PLL2  |

|     |     |   |  |
|-----|-----|---|--|
|     |     |   | <ul style="list-style-type: none"> <li>0: reserved</li> <li>1: Divide by 1</li> <li>2: Divide by 2</li> <li>3: Divide by 4</li> <li>4: Divide by 6</li> <li>5: Divide by 8</li> <li>6: Divide by 12</li> <li>7: Divide by 16</li> <li>8: Divide by 24</li> <li>9: Divide by 32</li> <li>10: Divide by 48</li> <li>11: Divide by 64</li> <li>12: Divide by 96</li> <li>13: Divide by 128</li> <li>14: Divide by 176</li> <li>15: Divide by 192</li> </ul>   |
| 3:0 | R/W | 0 | <p>MCLKDIV<br/>MCLK Divide Ratio from PLL2 Output</p> <ul style="list-style-type: none"> <li>0: reserved</li> <li>1: Divide by 1</li> <li>2: Divide by 2</li> <li>3: Divide by 4</li> <li>4: Divide by 6</li> <li>5: Divide by 8</li> <li>6: Divide by 12</li> <li>7: Divide by 16</li> <li>8: Divide by 24</li> <li>9: Divide by 32</li> <li>10: Divide by 48</li> <li>11: Divide by 64</li> <li>12: Divide by 96</li> <li>13: Divide by 128</li> <li>14: Divide by 176</li> <li>15: Divide by 192</li> </ul> |

#### 8.6.7.11. I2S/PCM TX Counter Register(Default Value: 0x00000000)

| Offset: 0x28 |     |             | Register Name: I2S/PCM_TXCNT   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:0         | R/W | 0           | <p>TX_CNT<br/>TX Sample Counter</p> <p>The audio sample number of sending into TXFIFO. When one sample is put into TXFIFO by DMA or by host IO, the TX sample counter register increases by one. The TX sample counter register can be set to any initial value at any time.</p> |

|  |  |  |   |
|--|--|--|---|
|  |  |  | After been updated by the initial value, the counter register should count on base of this initial value. |
|--|--|--|---|

#### 8.6.7.12. I2S/PCM RX Counter Register(Default Value: 0x00000000)

| Offset: 0x2C |     |             | Register Name: I2S/PCM_RXCNT  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:0         | R/W | 0           | <p>RX_CNT<br/>RX Sample Counter</p> <p>The audio sample number of writing into RXFIFO. When one sample is written by Digital Audio Engine, the RX sample counter register increases by one. The RX sample counter register can be set to any initial value at any time. After been updated by the initial value, the counter register should count on base of this initial value.</p> |

#### 8.6.7.13. I2S/PCM Channel Configuration Register(Default Value: 0x00000000)

| Offset: 0x30 |     |             | Register Name: I2S/PCM_CHCFG  |
|--------------|-----|-------------|---|
| Bit          | R/W | Default/Hex | Description   |
| 31:10        | /   | /           | /   |
| 9            | R/W | 0           | <p>TX_SLOT_HIZ</p> <p>0: normal mode for the last half cycle of BCLK in the slot</p> <p>1: turn to hi-z state for the last half cycle of BCLK in the slot</p> |
| 8            | R/W | 0           | <p>TXn_STATE</p> <p>0: transfer level 0 when not transferring slot</p> <p>1: turn to hi-z state when not transferring slot</p>                                |
| 7            | /   | /           | /   |
| 6:4          | R/W | 0           | <p>RX_SLOT_NUM</p> <p>RX Channel/Slot Number which between CPU/DMA and FIFO</p> <p>0: 1 channel or slot</p> <p>...</p> <p>7: 8 channels or slots</p>          |
| 3            | /   | /           | /   |
| 2:0          | R/W | 0           | <p>TX_SLOT_NUM</p> <p>TX Channel/Slot Number which between CPU/DMA and FIFO</p> <p>0: 1 channel or slot</p> <p>...</p> <p>7: 8 channels or slots</p>          |

**8.6.7.14. I2S/PCM TXn Channel Select Register(Default Value: 0x00000000)**

| Offset: 0x34 + n*4 (n = 0, 1, 2, 3) |     |             | Register Name: <b>I2S/PCM_TXnCHSEL</b>  |
|-------------------------------------|-----|-------------|---|
| Bit                                 | R/W | Default/Hex | Description   |
| 31:14                               | /   | /           | /   |
| 13:12                               | R/W | 0           | TXn_OFFSET<br>TXn offset tune, TXn data offset to LRCK<br>0: no offset<br>n: data is offset by n BCLKs to LRCK  |
| 11:4                                | R/W | 0           | TXn_CHEN<br>TXn Channel (slot) enable, bit[11:4] refer to slot [7:0]. When one or more slot(s) is(are) disabled, the affected slot(s) is(are) set to disable state<br>0: disable<br>1: enable |
| 3                                   | /   | /           | /   |
| 2:0                                 | R/W | 0           | TXn_CHSEL<br>TXn Channel (slot) number Select for each output<br>0: 1 channel / slot<br>...<br>7: 8 channels / slots  |

**8.6.7.15. I2S/PCM TXn Channel Mapping Register(Default Value: 0x00000000)**

| Offset: 0x44 + n*4 (n = 0, 1, 2, 3) |     |             | Register Name: <b>I2S/PCM_TXnCHMAP</b>                                       |
|-------------------------------------|-----|-------------|--|
| Bit                                 | R/W | Default/Hex | Description  |
| 31                                  | /   | /           | /  |
| 30:28                               | R/W | 0           | TXn_CH7_MAP<br>TXn Channel7 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 27                                  | /   | /           | /  |
| 26:24                               | R/W | 0           | TXn_CH6_MAP<br>TXn Channel6 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 23                                  | /   | /           | /  |
| 22:20                               | R/W | 0           | TXn_CH5_MAP<br>TXn Channel5 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |

|       |     |   |  |
|-------|-----|---|--|
| 19    | /   | / | /  |
| 18:16 | R/W | 0 | TXn_CH4_MAP<br>TXn Channel4 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 15    | /   | / | /  |
| 14:12 | R/W | 0 | TXn_CH3_MAP<br>TXn Channel3 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 11    | /   | / | /  |
| 10:8  | R/W | 0 | TXn_CH2_MAP<br>TXn Channel2 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 7     | /   | / | /  |
| 6:4   | R/W | 0 | TXn_CH1_MAP<br>TXn Channel1 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 3     | /   | / | /  |
| 2:0   | R/W | 0 | TXn_CH0_MAP<br>TXn Channel0 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |

#### 8.6.7.16. I2S/PCM RX Channel Select Register(Default Value: 0x00000000)

| Offset: 0x54 |     |             | Register Name: I2S/PCM_RXCHSEL   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31:14        | /   | /           | /  |
| 13:12        | R/W | 0           | <b>RX_OFFSET</b><br>RX offset tune, RX data offset to LRCK<br>0: no offset<br>n: data is offset by n BCLKs to LRCK |
| 11:3         | /   | /           |  |
| 2:0          | R/W | 0           | <b>RX_CHSEL</b><br>RX Channel (slot) number Select for input   |

|  |  |  |   |
|--|--|--|---|
|  |  |  | 0: 1 channel / slot<br>...<br>7: 8 channels / slots |
|--|--|--|---|

#### 8.6.7.17. I2S/PCM RX Channel Mapping Register (Default Value: 0x00000000)

| Offset: 0x58 |     |             | Register Name: I2S/PCM_RXCHMAP   |
|--------------|-----|-------------|--|
| Bit          | R/W | Default/Hex | Description  |
| 31           | /   | /           | /  |
| 30:28        | R/W | 0           | RX_CH7_MAP<br>RX Channel7 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 27           | /   | /           | /  |
| 26:24        | R/W | 0           | RX_CH6_MAP<br>RX Channel6 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 23           | /   | /           | /  |
| 22:20        | R/W | 0           | RX_CH5_MAP<br>RX Channel5 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 19           | /   | /           | /  |
| 18:16        | R/W | 0           | RX_CH4_MAP<br>RX Channel4 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 15           | /   | /           | /  |
| 14:12        | R/W | 0           | RX_CH3_MAP<br>RX Channel3 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 11           | /   | /           | /  |
| 10:8         | R/W | 0           | RX_CH2_MAP<br>RX Channel2 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |

|     |     |   |  |
|-----|-----|---|--|
| 7   | /   | / | /  |
| 6:4 | R/W | 0 | RX_CH1_MAP<br>TX Channel1 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |
| 3   | /   | / | /  |
| 2:0 | R/W | 0 | RX_CHO_MAP<br>RX Channel0 Mapping<br>0: 1st sample<br>...<br>7: 8th sample |

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# Chapter 9 Electrical Characteristics

## 9.1. Absolute Maximum Ratings

Table 9-1 gives the absolute maximum ratings.



### CAUTION

Stresses beyond those listed under Table 9-1 may affect reliability or cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under Section 9.2, *Recommended Operating Conditions*, is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

Table 9-1. Absolute Maximum Ratings

| Symbol     | Parameter                     | Min  | Max  | Unit |
|------------|-------------------------------|------|------|------|
| AVCC       | Power Supply for Analog Part  | -0.3 | 3.6  | V    |
| VCC-IO0    |                               |      |      |      |
| VCC-IO1    | Power Supply for Digital Part | -0.3 | 3.6  | V    |
| VCC-IO3    |                               |      |      |      |
| VCC-PD     | Power Supply for Port D       | -0.3 | 3.6  | V    |
| VCC-PE0    |                               |      |      |      |
| VCC-PE1    | Power Supply for Port E       | -0.3 | 3.6  | V    |
| VCC-PLL    | Power Supply for System PLL   | -0.3 | 3.6  | V    |
| VCC-MCSI   | Power Supply for MIPI CSI     | -0.3 | 3.6  | V    |
| VCC-RTC    | Power Supply for RTC          | -0.3 | 3.6  | V    |
| VCC-USB    | Power Supply for USB          | -0.3 | 3.6  | V    |
| VCC-DRA MO |                               |      |      |      |
| VCC-DRAM1  |                               |      |      |      |
| VCC-DRAM2  |                               |      |      |      |
| VCC-DRAM3  |                               |      |      |      |
| VCC-DRAM4  |                               |      |      |      |
| VCC-DRAM6  | Power Supply for DDR2         | -0.3 | 1.98 | V    |
| VCC-DRAM7  |                               |      |      |      |
| VCC-DRAM8  |                               |      |      |      |
| VCC-DRAM9  |                               |      |      |      |
| VCC-DRAM10 |                               |      |      |      |
| VCC-DRAM11 |                               |      |      |      |
| VDD-CPU0   | Power Supply for CPU          | -0.3 | 1.4  | V    |
| VDD-CPU1   |                               |      |      |      |

|                  |                         |      |     |    |
|------------------|-------------------------|------|-----|----|
| VDD-CPU2         |                         |      |     |    |
| VDD-CPU3         |                         |      |     |    |
| VDD-CPU4         |                         |      |     |    |
| VDD-CPU5         |                         |      |     |    |
| VDD-CPU7         |                         |      |     |    |
| VDD-SYS0         |                         |      |     |    |
| VDD-SYS1         |                         |      |     |    |
| VDD-SYS2         | Power Supply for System | -0.3 | 1.4 | V  |
| VDD-SYS3         |                         |      |     |    |
| VDD-SYS4         |                         |      |     |    |
| VDD-SYS5         |                         |      |     |    |
| T <sub>STG</sub> | Storage Temperature     | -40  | 125 | °C |

## 9.2. Recommended Operating Conditions

All R11 modules are used under the operating conditions contained in Table 9-2.



### NOTE

Logic functions and parameter values are not assured out of the range specified in the recommended operating conditions.

Table 9-2. Recommended Operating Conditions

| Symbol    | Parameter                     | Min                | Typ               | Max                 | Unit |
|-----------|-------------------------------|--------------------|-------------------|---------------------|------|
| Ta        | Ambient Operating Temperature | TBD                | -                 | TBD                 | °C   |
| AVCC      | Power Supply for Analog Part  | -                  | 3.0               | -                   | V    |
| VCC-IO0   |                               |                    |                   |                     |      |
| VCC-IO1   | Power Supply for Digital Part | 3.0                | 3.3               | 3.6                 | V    |
| VCC-IO3   |                               |                    |                   |                     |      |
| VCC-PD    | Power Supply for Port D       | 3.0<br>2.25        | 3.3<br>2.5        | 3.6<br>2.75         | V    |
| VCC-PE0   |                               |                    |                   |                     |      |
| VCC-PE1   | Power Supply for Port E       | 3.0<br>2.52<br>1.7 | 3.3<br>2.8<br>1.8 | 3.6<br>3.08<br>1.98 | V    |
| VCC-PLL   | Power Supply for System PLL   | 2.7                | 3.0               | 3.3                 | V    |
| VCC-MCSI  | Power Supply for MIPI CSI     | 3.0                | 3.3               | 3.6                 | V    |
| VCC-RTC   | Power Supply for RTC          | 3.0                | 3.3               | 3.6                 | V    |
| VCC-USB   | Power Supply for USB          | 3.0                | 3.3               | 3.6                 | V    |
| VCC-DRAM0 |                               |                    |                   |                     |      |
| VCC-DRAM1 |                               |                    |                   |                     |      |
| VCC-DRAM2 | Power Supply for DDR2         | 1.7                | 1.8               | 1.9                 | V    |
| VCC-DRAM3 |                               |                    |                   |                     |      |
| VCC-DRAM4 |                               |                    |                   |                     |      |

|            |                         |     |     |      |   |
|------------|-------------------------|-----|-----|------|---|
| VCC-DRAM6  |                         |     |     |      |   |
| VCC-DRAM7  |                         |     |     |      |   |
| VCC-DRAM8  |                         |     |     |      |   |
| VCC-DRAM9  |                         |     |     |      |   |
| VCC-DRAM10 |                         |     |     |      |   |
| VCC-DRAM11 |                         |     |     |      |   |
| VDD-CPU0   |                         |     |     |      |   |
| VDD-CPU1   |                         |     |     |      |   |
| VDD-CPU2   |                         |     |     |      |   |
| VDD-CPU3   | Power Supply for CPU    | 1.0 | -   | 1.32 | V |
| VDD-CPU4   |                         |     |     |      |   |
| VDD-CPU5   |                         |     |     |      |   |
| VDD-CPU7   |                         |     |     |      |   |
| VDD-SYS0   |                         |     |     |      |   |
| VDD-SYS1   |                         |     |     |      |   |
| VDD-SYS2   |                         |     |     |      |   |
| VDD-SYS3   | Power Supply for System | 1   | 1.1 | 1.2  | V |
| VDD-SYS4   |                         |     |     |      |   |
| VDD-SYS5   |                         |     |     |      |   |

### 9.3. DC Electrical Characteristics

Table 9-3 summarizes the DC electrical characteristics of R11.

Table 9-3. DC Electrical Characteristics

| Symbol    | Parameter                        | Min         | Typ | Max         | Unit |
|-----------|----------------------------------|-------------|-----|-------------|------|
| $V_{IH}$  | High-Level Input Voltage         | 0.7*VCC-IO0 | -   | VCC-IO0+0.3 | V    |
| $V_{IL}$  | Low-Level Input Voltage          | -0.3        | -   | 0.3*VCC-IO0 | V    |
| $R_{PU}$  | Input Pull-up Resistance         | 50          | 100 | 150         | kΩ   |
| $R_{PD}$  | Input Pull-down Resistance       | 50          | 100 | 150         | kΩ   |
| $I_{IH}$  | High-Level Input Current         | -           | -   | 10          | uA   |
| $I_{IL}$  | Low-Level Input Current          | -           | -   | 10          | uA   |
| $V_{OH}$  | High-Level Output Voltage        | VCC-IO0-0.2 | -   | VCC-IO0     | V    |
| $V_{OL}$  | Low-Level Output Voltage         | 0           | -   | 0.2         | V    |
| $I_{OZ}$  | Tri-State Output Leakage Current | -10         | -   | 10          | uA   |
| $C_{IN}$  | Input Capacitance                | -           | -   | 5           | pF   |
| $C_{OUT}$ | Output Capacitance               | -           | -   | 5           | pF   |

### 9.4. Oscillator Electrical Characteristics

R11 contains two external input clocks:X24MIN and X32KIN, two output clocks:X24MOUT and X32KOUT.

The 24MHz frequency is used to generate the main source clock for PLL and the main digital blocks, the clock is

provided through X24MIN.Table 9-4 lists the 24MHz crystal specifications.

Table 9-4. 24MHz Oscillator Characteristics

| Symbol           | Parameter                             | Min         | Typ    | Max | Unit |
|------------------|---------------------------------------|-------------|--------|-----|------|
| $1/(t_{CPMAIN})$ | Crystal Oscillator Frequency Range    | -           | 24.000 | -   | MHz  |
| $t_{ST}$         | Startup Time                          | -           | -      | -   | ms   |
|                  | Frequency Tolerance at 25 °C          | -50         | -      | +50 | ppm  |
|                  | Oscillation Mode                      | Fundamental |        |     | -    |
|                  | Maximum change over temperature range | -50         | -      | +50 | ppm  |
| $P_{ON}$         | Drive level                           | -           | -      | 300 | uW   |
| $C_L$            | Equivalent Load capacitance           | 12          | 18     | 22  | pF   |
| $R_S$            | Series Resistance(ESR)                | -           | 25     | -   | Ω    |
|                  | Duty Cycle                            | 30          | 50     | 70  | %    |
| $C_M$            | Motional capacitance                  | -           | -      | -   | pF   |
| $C_{SHUT}$       | Shunt capacitance                     | 5           | 6.5    | 7.5 | pF   |
| $R_{BIAS}$       | Internal bias resistor                | 0.4         | 0.5    | 0.6 | MΩ   |

The 32768Hz frequency is used for low frequency operation. It supplies the wake-up domain for operation in lowest power mode. The clock is provided through X32KIN.Table 9-5 lists the 32768Hz crystal specifications.

Table 9-5. 32768Hz Oscillator Characteristics

| Symbol           | Parameter                             | Min         | Typ   | Max | Unit |
|------------------|---------------------------------------|-------------|-------|-----|------|
| $1/(t_{CPMAIN})$ | Crystal Oscillator Frequency Range    | -           | 32768 | -   | Hz   |
| $t_{ST}$         | Startup Time                          | -           | -     |     | ms   |
|                  | Frequency Tolerance at 25 °C          | -20         | -     | +20 | ppm  |
|                  | Oscillation Mode                      | Fundamental |       |     | -    |
|                  | Maximum Change Over Temperature Range | -20         | -     | +20 | ppm  |
| $P_{ON}$         | Drive Level                           | -           | -     | 1.0 | uW   |
| $C_L$            | Equivalent Load Capacitance           | -           | 18    | -   | pF   |
| $R_S$            | Series Resistance(ESR)                | -           | 70    | -   | kΩ   |
|                  | Duty Cycle                            | 30          | 50    | 70  | %    |
| $C_M$            | Motional Capacitance                  | -           | 2     | -   | fF   |
| $C_{SHUT}$       | Shunt Capacitance                     | -           | 1.1   | -   | pF   |

## 9.5. Power On and Power Off Sequence

The external voltage regulator and other power-on devices must provide the processor with a specific sequence of power and resets to ensure proper operations. During the entire power-on sequence, the RESET pin must be held on low until all power domains are stable.In power-off sequence, other power supplies start to ramp down after RESET powers down .Following Figure 9-1 and 9-2 provides the timing requirements for the R11 power.

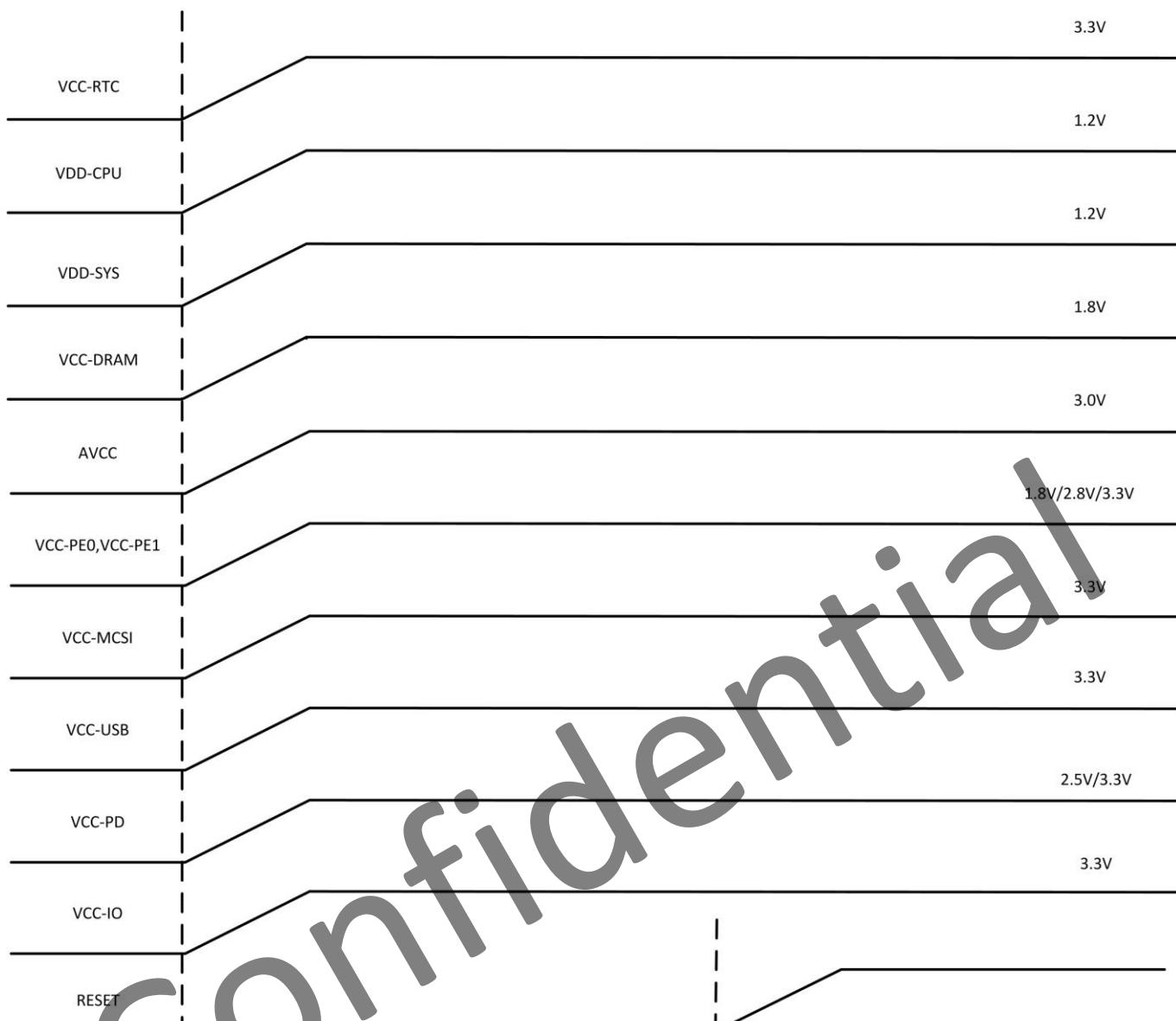


Figure 9-1. Power On Sequence

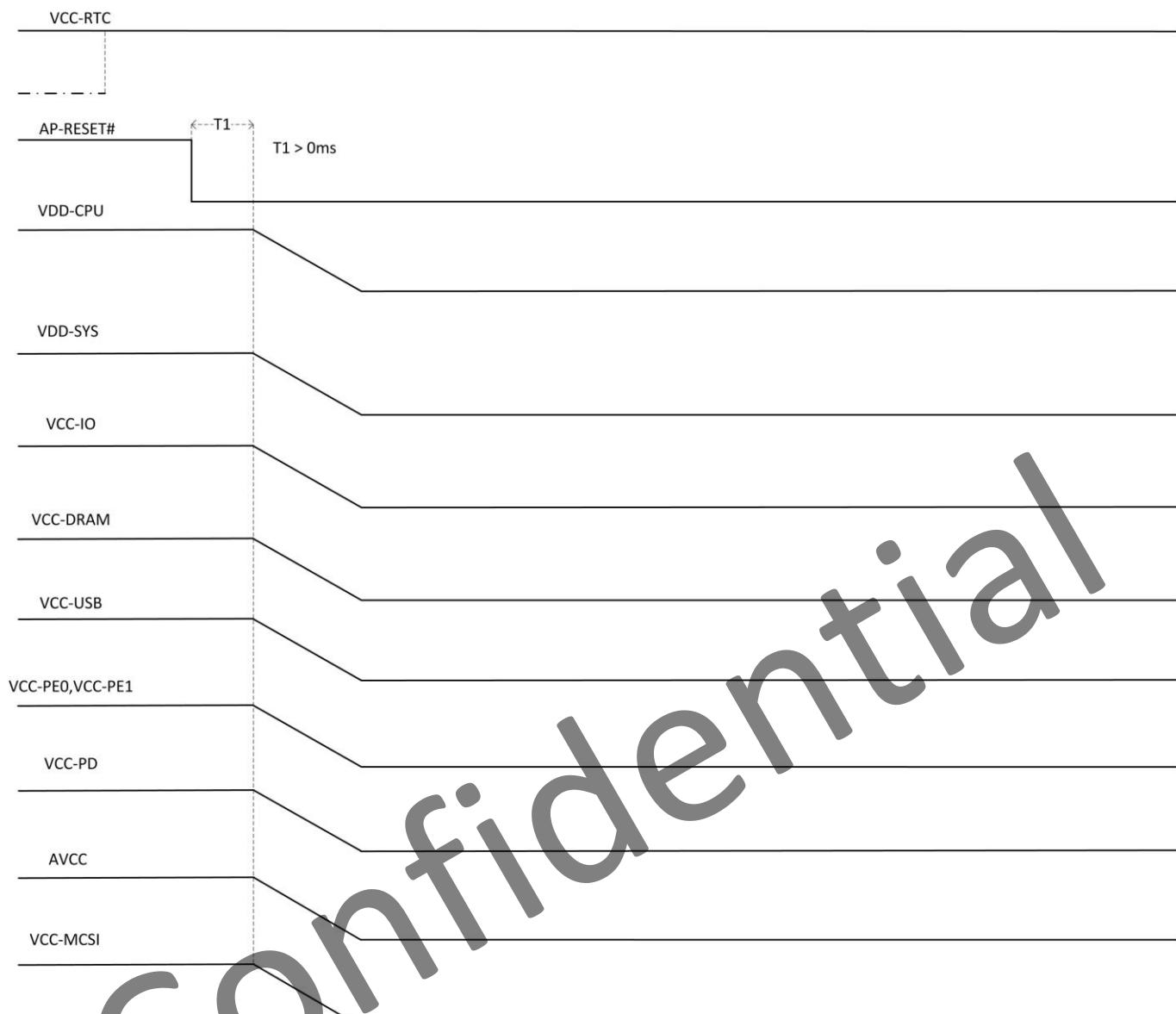
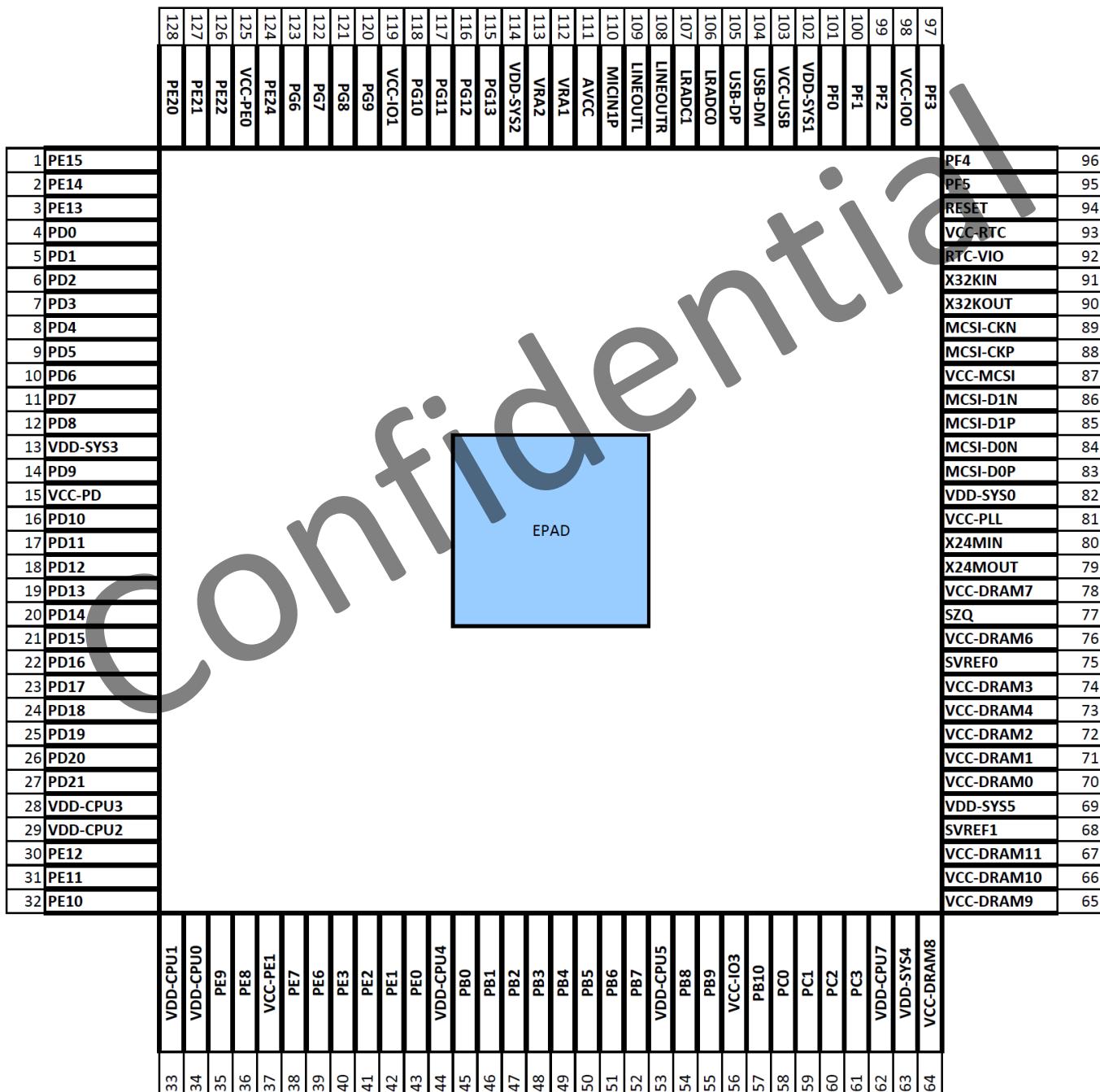


Figure 9-2. Power Off Sequence

# Appendix

## Pin Map

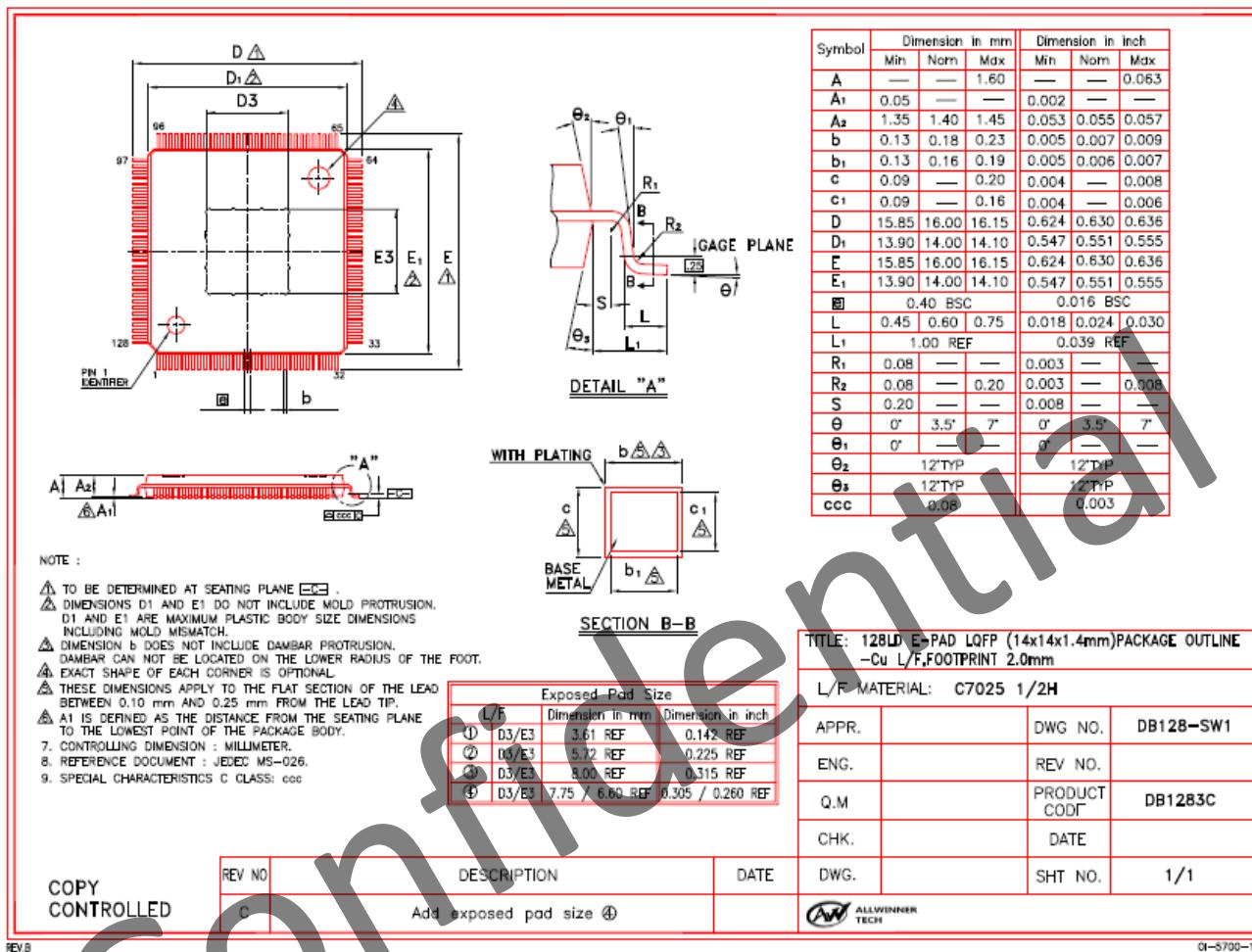
The following pin map shows the top views of the 128-pin eLQFP package of R11 processor.



|    |          |     |           |
|----|----------|-----|-----------|
| 1  | PE15     | 97  | PF3       |
| 2  | PE14     | 98  | VCC-J00   |
| 3  | PE13     | 99  | PF2       |
| 4  | PD0      | 100 | PF1       |
| 5  | PD1      | 101 | PF0       |
| 6  | PD2      | 102 | VDD-SYS1  |
| 7  | PD3      | 103 | VCC-USB   |
| 8  | PD4      | 104 | USB-DM    |
| 9  | PD5      | 105 | USB-DP    |
| 10 | PD6      | 106 | LRADC0    |
| 11 | PD7      | 107 | IRADC1    |
| 12 | PD8      | 108 | LINEOUTR  |
| 13 | VDD-SYS3 | 109 | LINEOUTL  |
| 14 | PD9      | 110 | MICIN1P   |
| 15 | VCC-PD   | 111 | AVCC      |
| 16 | PD10     | 112 | VRA1      |
| 17 | PD11     | 113 | VRA2      |
| 18 | PD12     | 114 | VDD-SYS2  |
| 19 | PD13     | 115 | PG13      |
| 20 | PD14     | 116 | PG12      |
| 21 | PD15     | 117 | PG11      |
| 22 | PD16     | 118 | PG10      |
| 23 | PD17     | 119 | VCC-I01   |
| 24 | PD18     | 120 | PG9       |
| 25 | PD19     | 121 | PG8       |
| 26 | PD20     | 122 | PG7       |
| 27 | PD21     | 123 | PG6       |
| 28 | VDD-CPU3 | 124 | PE24      |
| 29 | VDD-CPU2 | 125 | VCC-PE0   |
| 30 | PE12     | 126 | PE22      |
| 31 | PE11     | 127 | PE21      |
| 32 | PE10     | 128 | PE20      |
| 33 | VDD-CPU1 | 34  | VDD-CPU0  |
| 35 | PE9      | 36  | PE8       |
| 37 | VCC-PE1  | 38  | PE7       |
| 39 | PE6      | 40  | PE3       |
| 41 | PE2      | 42  | PE1       |
| 43 | PE0      | 44  | VDD-CPU4  |
| 45 | PB0      | 46  | PB1       |
| 47 | PB2      | 48  | PB3       |
| 49 | PB4      | 50  | PB5       |
| 51 | PB6      | 52  | PB7       |
| 53 | VDD-CPU5 | 54  | PB8       |
| 55 | PB9      | 56  | VCC-I03   |
| 57 | PB10     | 58  | PC0       |
| 59 | PC1      | 60  | PC2       |
| 61 | PC3      | 62  | VDD-CPU7  |
| 63 | VDD-SYS4 | 64  | VCC-DRAM8 |

## Package Dimension

The following diagram shows the package dimension of R11 processor.



**LCD Control Signal and Data Port Mapping**

|     | SYNC RGB        |                 |                 |     | CPU cmd  | CPU 18bit | CPU 16bit |                 |                 |                 |                 |                 |                 | CPU 8bit        |     |                 |                 | CPU 9bit        | LVDS            |                 |                 |                 |     |  |
|-----|-----------------|-----------------|-----------------|-----|----------|-----------|-----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----|--|
| I/O | Parallel RGB    | Serial RGB      |                 |     | CCIR 656 |           | 256K      | 256K            |                 |                 |                 |                 |                 |                 | 65K | 256K            |                 |                 | 65K             |                 | Single link     |                 |     |  |
|     | 1 <sup>st</sup> | 2 <sup>nd</sup> | 3 <sup>rd</sup> |     |          |           |           | 1 <sup>st</sup> | 2 <sup>nd</sup> | 3 <sup>rd</sup> | 1 <sup>st</sup> | 2 <sup>nd</sup> | 1 <sup>st</sup> | 2 <sup>nd</sup> |     | 1 <sup>st</sup> | 2 <sup>nd</sup> | 3 <sup>rd</sup> | 1 <sup>st</sup> | 2 <sup>nd</sup> | 1 <sup>st</sup> | 2 <sup>nd</sup> |     |  |
| IO0 | VSYNC           |                 |                 |     |          |           |           | CS              |                 |                 |                 |                 |                 |                 |     | D3N             |                 |                 |                 |                 |                 |                 |     |  |
| IO1 | HSYNC           |                 |                 |     |          |           |           | RD              |                 |                 |                 |                 |                 |                 |     | D3P             |                 |                 |                 |                 |                 |                 |     |  |
| IO2 | DCLK            |                 |                 |     |          |           |           | WR              |                 |                 |                 |                 |                 |                 |     | CKP             |                 |                 |                 |                 |                 |                 |     |  |
| IO3 | DE              |                 |                 |     |          |           |           | RS              |                 |                 |                 |                 |                 |                 |     | CKN             |                 |                 |                 |                 |                 |                 |     |  |
| D23 | R7              |                 |                 |     |          |           | D23       | R5              | R5              | B5              | G5              | R5              |                 | R5              | B5  | R4              |                 |                 |                 |                 |                 |                 | D2N |  |
| D22 | R6              |                 |                 |     |          |           | D22       | R4              | R4              | B4              | G4              | R4              |                 | R4              | B4  | R3              |                 |                 |                 |                 |                 |                 | D2P |  |
| D21 | R5              |                 |                 |     |          |           | D21       | R3              | R3              | B3              | G3              | R3              |                 | R3              | B3  | R2              |                 |                 |                 |                 |                 |                 | D1N |  |
| D20 | R4              |                 |                 |     |          |           | D20       | R2              | R2              | B2              | G2              | R2              |                 | R2              | B2  | R1              |                 |                 |                 |                 |                 |                 | D1P |  |
| D19 | R3              |                 |                 |     |          |           | D19       | R1              | R1              | B1              | G1              | R1              |                 | R1              | B1  | R0              |                 |                 |                 |                 |                 |                 | D0N |  |
| D18 | R2              |                 |                 |     |          |           | D18       | R0              | R0              | B0              | G0              | R0              |                 | R0              | B0  | G5              |                 |                 |                 |                 |                 |                 | D0P |  |
| D17 | R1              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D16 | R0              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D15 | G7              |                 |                 |     |          |           | D15       | G5              |                 |                 |                 |                 |                 |                 |     | G4              |                 |                 |                 |                 |                 |                 |     |  |
| D14 | G6              |                 |                 |     |          |           | D14       | G4              |                 |                 |                 |                 |                 |                 |     | G3              |                 |                 |                 |                 |                 |                 |     |  |
| D13 | G5              |                 |                 |     |          |           | D13       | G3              |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D12 | G4              | D17             | D27             | D37 | D7       | D12       | G2        | G5              | R5              | B5              | G5              | B5              | G5              |                 | G2  | R5              | G5              | B5              | R4              | G2              | R5              | G2              |     |  |
| D11 | G3              | D16             | D26             | D36 | D6       | D11       | G1        | G4              | R4              | B4              | G4              | B4              | G4              |                 | G1  | R4              | G4              | B4              | R3              | G1              | R4              | G1              |     |  |
| D10 | G2              | D15             | D25             | D35 | D5       | D10       | G0        | G3              | R3              | B3              | G3              | B3              | G3              |                 | G0  | R3              | G3              | B3              | R2              | G0              | R3              | G0              |     |  |
| D9  | G1              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D8  | G0              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D7  | B7              | D14             | D24             | D34 | D4       | D7        | B5        | G2              | R2              | B2              | G2              | B2              | G2              |                 | B4  | R2              | G2              | B2              | R1              | B4              | R2              | B5              |     |  |
| D6  | B6              | D13             | D23             | D33 | D3       | D6        | B4        | G1              | R1              | B1              | G1              | B1              | G1              |                 | B3  | R1              | G1              | B1              | R0              | B3              | R1              | B4              |     |  |
| D5  | B5              | D12             | D22             | D32 | D2       | D5        | B3        | G0              | R0              | B0              | G0              | B0              | G0              |                 | B2  | R0              | G0              | B0              | G5              | B2              | R0              | B3              |     |  |
| D4  | B4              | D11             | D21             | D31 | D1       | D4        | B2        |                 |                 |                 |                 |                 |                 |                 | B1  |                 |                 |                 |                 | G4              | B1              | G5              | B2  |  |
| D3  | B3              | D10             | D20             | D30 | D0       | D3        | B1        |                 |                 |                 |                 |                 |                 |                 | B0  |                 |                 |                 |                 | G3              | B0              | G4              | B1  |  |
| D2  | B2              |                 |                 |     |          |           | D2        | B0              |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 | G3              | B0              |     |  |
| D1  | B1              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |
| D0  | B0              |                 |                 |     |          |           |           |                 |                 |                 |                 |                 |                 |                 |     |                 |                 |                 |                 |                 |                 |                 |     |  |

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