Ameba-Z

SINGLE-CHIP 802.11b/g/n 1T1R WLAN SoC

DATASHEET

(CONFIDENTIAL: Development Partners Only)

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USING THIS DOCUMENT

This document is intended for the software engineer's reference and provides detailed programming information.

Though every effort has been made to ensure that this document is current and accurate, more information may have become available subsequent to the production of this guide.

REVISION HISTORY

Revision	Release Date	Summary

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1. Product Overview

1.1. General Description

Ameba-Z is a highly integrated single-chip low power 802.11n Wireless LAN (WLAN) network controller. It combines an ARM-CM4 MCU, WLAN MAC, a 1T1R capable WLAN baseband, and RF in a single chip. It also provides a bunch of configurable GPIOs which are configured as digital peripherals for different applications and control usage.

Ameba-Z integrates internal memories for complete WIFI protocol functions. The embedded memory configuration also provides simple application developments.

1.2. Ordering Information

Part Number	*Package*	*Status*
RTL8710BN-VM1	QFN32	MP

1.3. Features

Table 1-1 Ameba-Z Features

Feature list		*RTL8710BN-VM1*
Package	trays and tape-in-reel	(5x5mm^2) QFN32
Integrated core	Core type	ARM CM4F
	Core clock maximum freq.	125MHz
	Internal SRAM	256KB
	External FLASH	128M Bytes 2IO
FPU	Float process unit	Yes
SWD/JTAG		SWD
Backup register	Backup register for power save	16B
Boot Reason	SystemReset/WDG/BOR	Yes
Security	❶ Security Boot ❷ Flash Encryption ❸ Trust-Zone Lite (4KB) ❹ SSL/TLS	❶ ❸ ❹
WIFI	802.11 B/G/N	Yes
HT40		Yes
BOR	BOR Detection	Yes
GPIO	IN/OUT/INT	10
Ext. 32K	External 32K	0
Dsleep Wakepin	Deep sleep wake pin	2

1.4. Peripherals

Table 1-2 Ameba-Z Peripherals

Feature list			*RTL8710BN-VM1*
peripherals	UART	Normal-UART	1
		Log-UART	1
	SPI Master	Max. 31.25Mbps	0
	SPI Slave	Max. 31.25Mbps	0
	I2C	Max. 400Kbps	2
	ADC	VBAT	NA
		Normal	NA
	GDMA	2*6 channels	2
	I2S		0
	RTC	D/H/M/S	1
		OUTPUT	1
	Timer	Basic (32K)	4
		Advanced (XTAL)	2
	PWM	OUTPUT	4
		INPUT Capture	1
	WDG	Watch Dog	1
	USB device		0
	SDIO 2.0 Device		0

1.5. Package Types and Pin Descriptions

1.5.1. RTL8710BN-VM1 (QFN32)

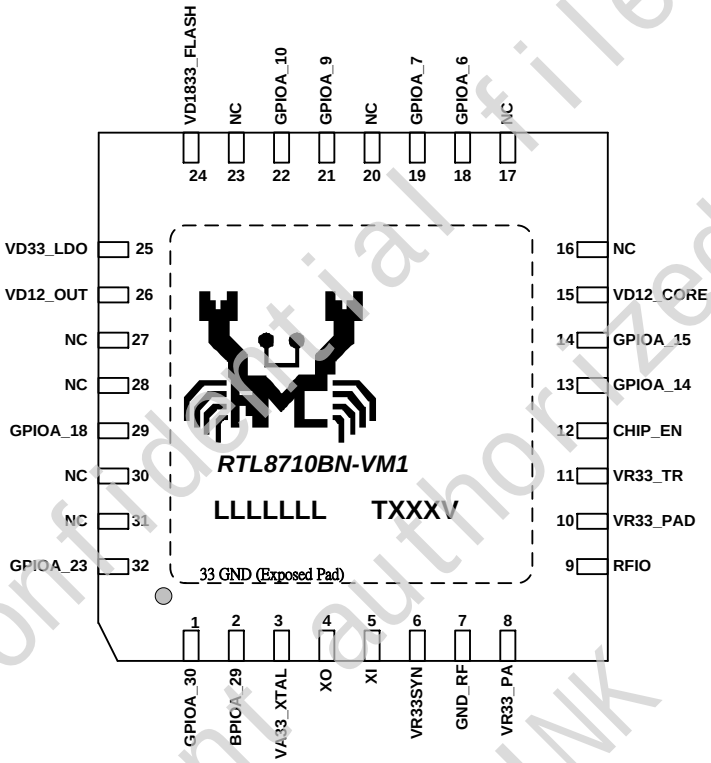

Figure 1 RTL8710BN-VM1 QFN32 Pin Assignments

1.6. Pin Descriptions

The following signal type codes are used in the tables:

Table 1-3 Pin Description

I:	*Input*	*O:*	*Output*
T/S:	Tri-State bi-directional input/output pin	S/T/S:	Sustained Tri-State
O/D:	Open Drain	P:	Power pin

1.6.1. Power On Trap Pin

Table 1-4 Power On Trap Pins

Symbol	*Type*	*RTL8710BN-VM1*	*Description*
TEST_MOSE_SEL	I	16	Internal use only
UART_DOWNLOAD	I	1	Shared with GPIOA_30 1: Boot from flash 0: Download image from UART

1.6.2. RF pin

Table 1-5 RF pin

Symbol	*Type*	*RTL8710BN-VM1*	*Description*
RF_IO	IO	9	WL RF signal

1.6.3. CHIP EN

Table 1-6 CHIP EN

Symbol	*Type*	*RTL8710BN-VM1*	*Description*
CHIP_EN	I	12	Enable chip. 1: enable chip; 0: shutdown chip

1.6.4. Power Pins

Table 1-7 Power Pins

Symbol	Type	RTL8710BN-VM1	Description
VA33_XTAL	P	3	3.3V for Crystal Oscillator
VR33_SYN	P	6	3.3V for RF Synthesizer
VR33_PA	P	8	3.3V for RF Power amplifier
VR33_PAD	P	10	3.3V for RF
VR33_TR	P	11	3.3V for RF
VD12_CORE	P	15	1.2V for digital core power
VD1833_FLASH	P	24	3.3V/1.8V for Flash IO power
VD33_LDO	P	25	Linear Regulator input from 3.3V to 1.2V
VD12_OUT	P	26	1.2V output from Linear Regulator

1.6.5. XTAL Pins

Table 1-8 XTAL Pins

Symbol	Type	RTL8710BN-VM1	Description
XI	I	5	40MHz OSC Input Input of 40MHz Crystal Clock Reference
XO	O	4	Output of 40MHz Crystal Clock Reference

1.6.6. GPIO Pins

Table 1-9 Ameba-Z GPIO

Symbol	*Type*	*RTL8710BN-VM1*	*Description*
GPIOA_14	I/O	13	PWM0
			SWD_CLK
GPIOA_15	I/O	14	PWM1
			SWD_DATA
			I2C1_SDA
GPIOA_6	I/O	18	SPIC_CS
			SD_D2
GPIOA_7	I/O	19	SPIC_DATA1
			SD_D3
GPIOA_9	I/O	21	SPIC_DATA0
			SD_CLK
GPIOA_10	I/O	22	SPIC_CLK
			SD_D0
GPIOA_18	I/O	29	UART0_RXD
			I2C1_SCL
			SD_D2
			TIMER4_TRIG
			TIMER5_TRIG
			PWM3
			I2S_CLK
GPIOA_23	I/O	32	UART0_TXD
			I2C1_SDA
			SD_D1
			PWM0
GPIOA_30	I/O	1	UART2_LOG_TXD
			I2C0_SDA
			PWM3

			RTC_OUT
GPIOA_29	I/O	2	UART2_Log_RXD
			I2C0_SCL
			PWM4

2. Block Diagram

2.1. Functional Block Diagram

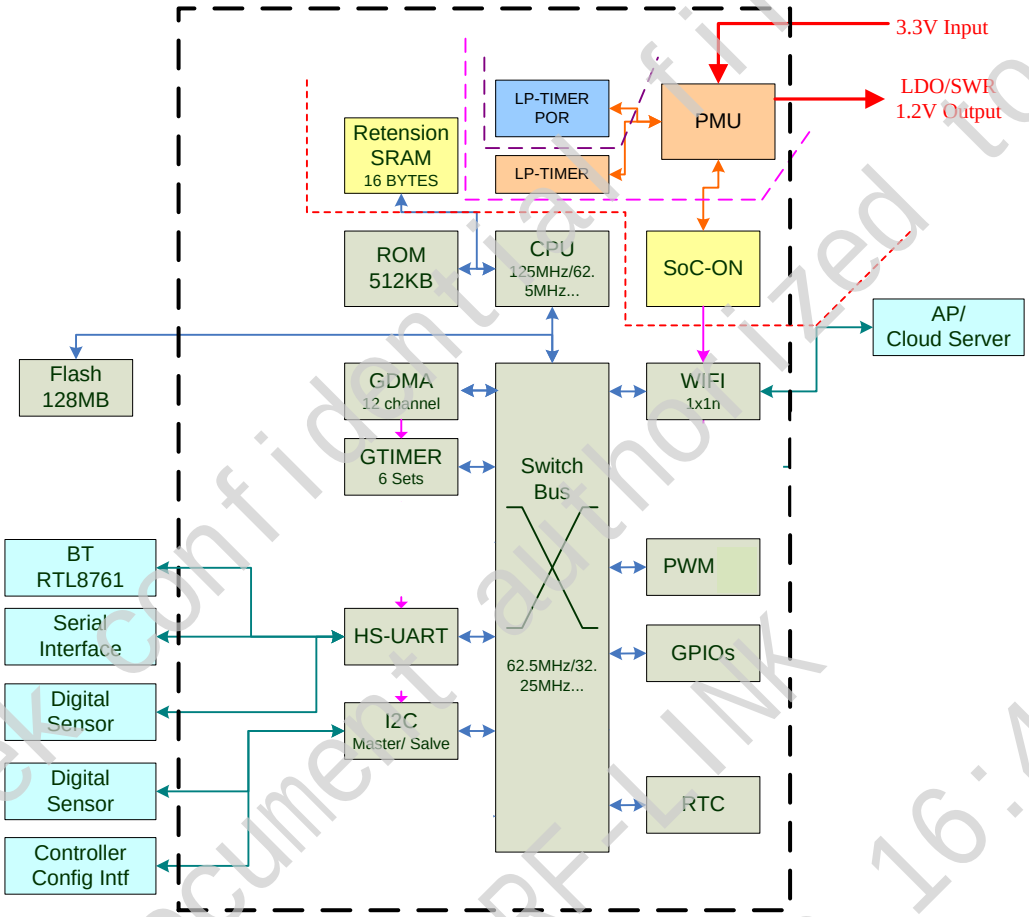

Figure 2 Block Diagram

2.2. WIFI Application Diagram

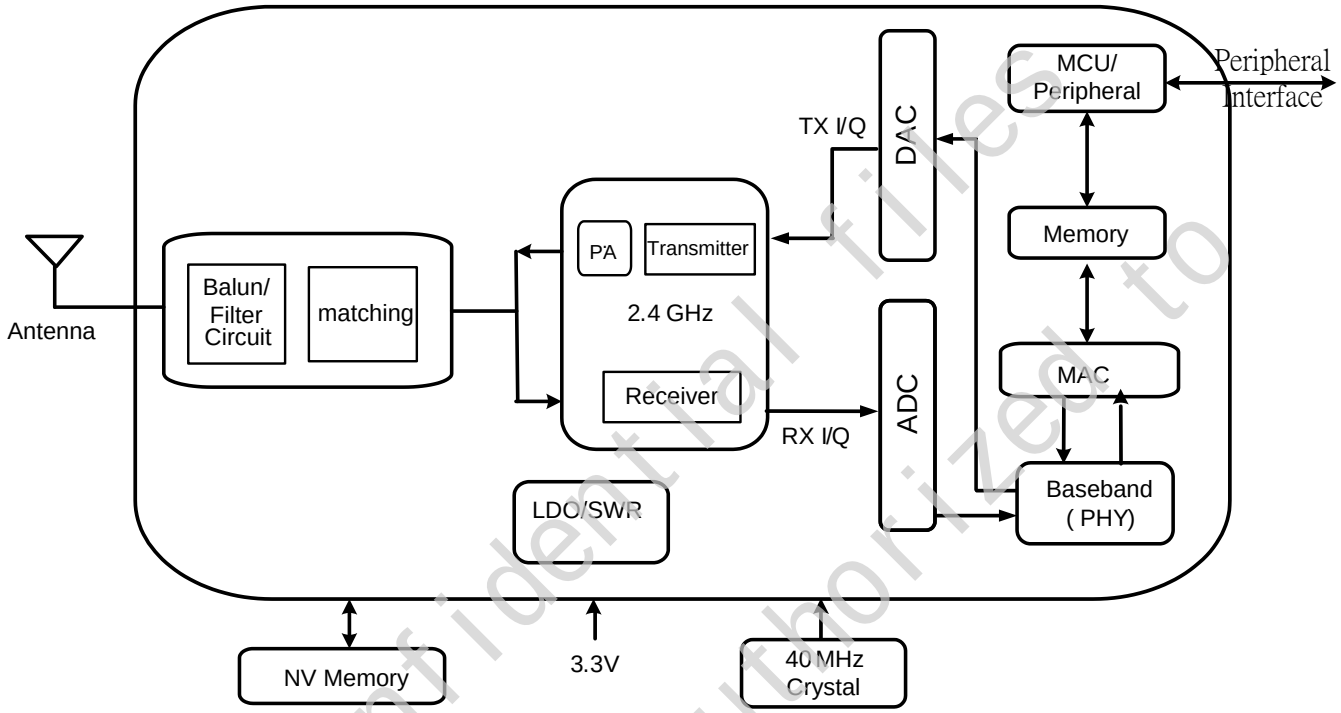

Figure 3 Single-Band 11n (1x1) Solution

2.3. Power Supply Application Diagram

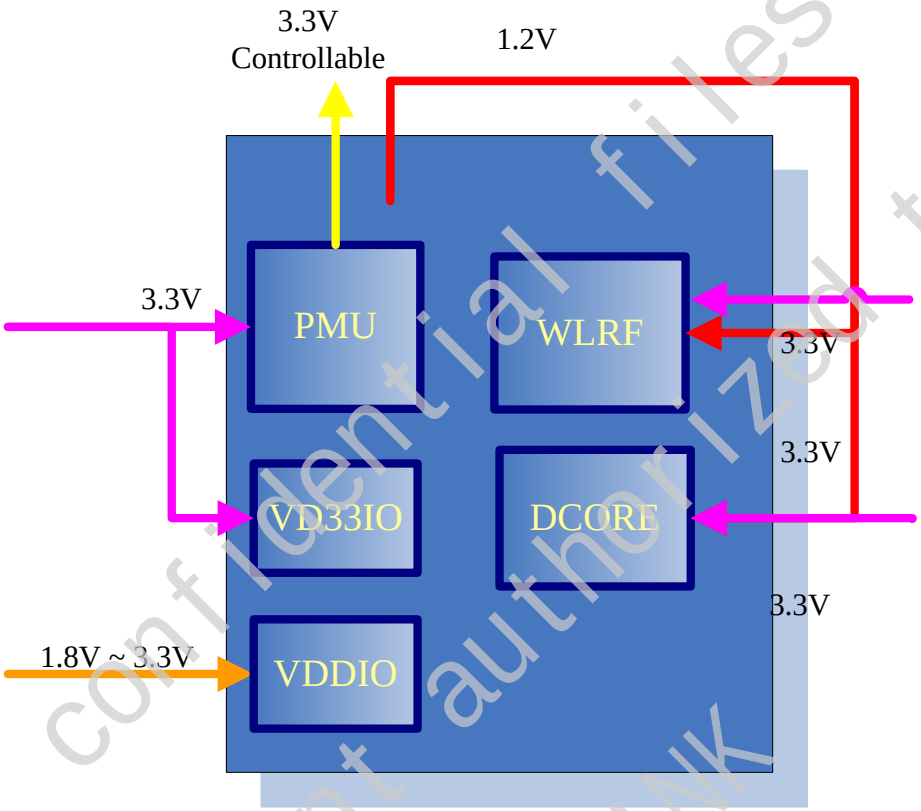

Figure 4 Power Supply Architecture

The integrated Power Management Unit (PMU) provides the following features:

- 1.2V LDO/SWR(Switching Regulator)
- 3.3V power source integrated power cut controlled by FW.

3. Memory organization

3.1. Introduction

Program memory, data memory, registers and I/O ports are organized within the same linear 4-Gbyte address space.

Ameba-Z integrates ROM, internal SRAM, NOR flash controller to provide applications with a variety of memory requirements.

The bytes are coded in memory in Little Endian format. The lowest numbered byte in a word is considered the word's least significant byte and the highest numbered byte the most significant.

All the memory areas that are not allocated to on-chip memories and peripherals are considered "Reserved". For the detailed mapping of available memory and register areas, please refer to the Memory map and register boundary addresses chapter and peripheral chapters.

3.2. Memory map and register boundary addresses

Table 3-1 Ameba-Z memory map

Name	*Physical address*	*size*	*IP function*
ROM	0x0000_0000~0x0007_FFFF	512KB	Internal ROM memory
SRAM	0x1000_0000~0x1001_FFFF	256KB	Internal SRAM memory
FLASH	0x0800_0000~0x0FFF_FFFF	128MB	External Flash memory
SYSON	0x4000_0000~0x4000_0FFF	4KB	SYS Control
GPIO	0x4000_1000~0x4000_17FF	2KB	GPIO Control
Timer	0x4000_2000~0x4000_2FFF	4KB	Timer Control
LOGUART	0x4000_3000~0x4000_33FF	1KB	UART for Log
RTC	0x4000_3400~0x4000_37FF	1KB	RTC control
Cache	0x4000_3C00~0x4000_4FFF	1KB	Flash cache control
Internal use only	0x4001_0000~0x4001_0FFF	4KB	NA
SPIC	0x4002_0000~0x4002_0FFF	4KB	SPI flash controller
UART0	0x4004_0000~0x4004_03FF	1KB	UART0 control
UART1	0x4004_0400~0x4004_07FF	1KB	UART1 control
Internal use only	0x4004_2000~0x4004_23FF	1KB	NA
Internal use only	0x4004_2400~0x4004_27FF	1KB	NA
I2C0	0x4004_4000~0x4004_43FF	1KB	I2C0 control
I2C1	0x4004_4400~0x4004_47FF	1KB	I2C0 control
Internal use only	0x4005_0000~0x4005_3FFF	16KB	NA

GDMA0	0x4006_0000~0x4006_07FF	2KB	GDMA0 control
GDMA1	0x4006_1000~0x4006_17FF	2KB	GDMA1 control
Internal use only	0x4006_2000~0x4006_23FF	1KB	NA
IPSEC	0x4007_0000~0x4007_3FFF	16KB	Security control
WIFI	0x4008_0000~0x400B_FFFF	256KB	WIFI register
Internal use only	0x400C_0000~0x400C_0FFF	4KB	NA
Internal use only	0x400C_2000~0x400C_2FFF	4KB	NA

3.3. Internal ROM

512KB ROM is integrated to provide high access speed, low leakage memory. The ROM memory clock speed is up to 125MHz. The ROM lib provides the following functions:

- Boot Code and MCU initialization
- Peripheral Drivers & API
- Non-flash booting functions and drivers
- Security function libs

3.4. Internal SRAM

Max. 256KB SRAM is integrated to provide instruction, data, and buffer usage. The maximum clock speed is up to 125MHz.

3.5. External SPI NOR Flash

3.5.1. Features

- SPI baud rate:
  - 100/83/71/62/50MHz ...
- Execute in place (XIP):
  - we supports a memory-mapped I/O interface for read operation
  - Support 32K I/D read cache, 2-way associative
  - Support decryption on the fly
- SPI mode:
  - SPI/Dual SPI/DIO SPI
- Flash size
  - Support up to 128M Bytes flash size

3.5.2. Supported NOR Flash List

Table 3-2 Flash supported

Vendor	Part Number	Density	Voltage	IO (max.)	Max. Clock
MXIC	MX25L1633E	2MB	3.3V	4I/O	85MHz
MXIC	MX25L3236F	4MB	3.3V	4I/O	104MHz(6 dummy cycle) 133MHz(10 dummy cycle)
MXIC	MX25L6433F	8MB	3.3V	4I/O	80MHz (6 dummy cycle) 133MHz (10 dummy cycle)
MXIC	MX25L12845G	16MB	3.3V	4I/O	70MHz
MXIC	MX25L1606E	2MB	3.3V	2O	80MHz
MXIC	MX25V8006E	1MB	3.3V	2O	70MHz
MXIC	MX25V1635F	2MB	3.3V	4I/O	80MHz
MXIC	MX25V8035F	1MB	3.3V	4I/O	104MHz
MXIC	KH25L8006EM2I-12G	1MB	3.3V	2O	80MHz
MXIC	KH25L1606EM2I-12G	2MB	3.3V	2O	80MHz
MXIC	MX25R1635FM1IH0	2MB	1.8/3.3V	4I/O	80MHz
Winbond	W25Q80DV	1MB	3.3V	4I/O	104MHz
Winbond	W25Q16DV	2MB	3.3V	4I/O	104MHz
Winbond	W25Q32FV	4MB	3.3V	4I/O	104MHz
Winbond	W25R64FV	8MB	3.3V	4I/O	104MHz
Winbond	W25R128FV	16MB	3.3V	4I/O	104MHz
Micron	N25Q032A13ESE40E	4MB	3.3V	4I/O	108MHz
Micron	N25Q064A13ESED0E	8MB	3.3V	4I/O	108MHz
Micron	N25Q128A	16MB	3.3V	4I/O	108MHz
Micron	N25Q00AA13GSF40F	128MB	3.3V	4I/O	108MHz
Gigadevice	GD25Q80C	1MB	3.3V	4I/O	120MHz
Gigadevice	GD25Q16C	2MB	3.3V	4I/O	120MHz
Gigadevice	GD25Q32C	4MB	3.3V	4I/O	120MHz
Gigadevice	GD25Q64C	8MB	3.3V	4I/O	120MHz
Gigadevice	GD25Q128C	16MB	3.3V	4I/O	80MHz

HuaHong	BH25D80A	2MB	3.3V	2O	108MHz
ESMT	EN25QH16A	2MB	3.3V	4I/O	104MHz
ESMT	EN25QH16B-104HIP2A	2MB	3.3V	4I/O	104MHz
ESMT	EN25Q80B	1MB	3.3V	4I/O	104MHz
FM	FM25Q08A	2MB	3.3V	4I/O	104MHz

3.5.3. Electrical Specifications

Table 3-3 Flash Bus DC Parameters

Symbol	*Parameter*	*Conditions*	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
V_{IH}	Input-High Voltage	LVTTL	2.0	-	-	V	1
V_{IL}	Input-Low Voltage	LVTTL	-	-	0.8	V	2
V_{OH}	Output-High Voltage	-	2.4	-	-	V	3
V_{OL}	Output-Low Voltage	-	-	-	0.4	V	3
I_{IL}	Input-Leakage Current	V_{IN}=3.3V or 0	-10	±1	10	µA	-
I_{OZ}	Tri-State Output-Leakage Current	-	-10	±1	10	µA	-
R_{PU}	Input Pull-Up Resistance	-	-	75	-	KΩ	4
R_{PD}	Input Pull-Down Resistance	-	-	75	-	KΩ	4

Note 1: V_{IH} overshoot: VIH (MAX)=VDDH + 2V for a pulse width ≤3ns.

Note 2: V_{IL} undershoot: $V_{IL\ (MIN)}$=-2V for a pulse width ≤3ns.

Note 3: The output current buffer is 8mA for the flash address and data bus; and is 8mA for Flash control signals.

Note 4: These values are typical values checked in the manufacturing process and are not tested.

4. Exception table

Table 4-1 Exception table

Exception Number	*Exception Type*	*Description*
	Reset	Reset
	NMI	Nonmaskable interrupt (external NMI input). The WDG is linked to the NMI vector
	Hard Fault	All fault conditions if the corresponding fault handler is not enabled
	MemManager Fault	Memory management fault; Memory Protection Unit (MPU) violation or access to illegal locations
	Bus Fault	Bus error; occurs when Advanced High-Performance Bus (AHB) interface receives an error response from a bus slave (also called prefetch abort if it is an instruction fetch or data abort if it is a data access)
	Usage Fault	Exceptions resulting from program error or trying to access coprocessor (the Cortex-M4 does not support a coprocessor)
	RSVD	-
	SVC	Supervisor Call
	Debug Monitor	Debug monitor (breakpoints, watchpoints, or external debug requests)
	RSVD	-
	PendSV	Pendable Service Call
	SYSTICK	System Tick Timer
[0]	System_ISR	
[1]	WDG	Watch dog global insterrupt
[2]	Timer0	Timer0 global interrupt
[3]	Timer1	Timer1 global interrupt
[4]	Timer2	Timer2 global interrupt
[5]	Timer3	Timer3 global interrupt
[6]	RSVD	--
[7]	GPIO	GPIO portA global interrupt
[8]	UART0	UART0 global interrupt
[9]	SPI_FLASH	SPI Flash global interrupt
[10]	UART1	UART1 global interrupt
[11]	Timer4	Timer4 global interrupt
[12]	RSVD	--
[13]	RSVD	--
[14]	Timer5	Timer5 global interrupt
[15]	WL_DMA	Wlan Host global interrupt
[16]	WL_PROTOCOL	Wlan Firmware Wlan global interrupt

[17]	CRYPTO	IPsec global interrupt
[18]	RSVD	--
[19]	Peripheral_ISR	See Below Table
[20]	GDMA0_Channel0	GDMA0 channel 0 global interrupt
[21]	GDMA0_Channel1	GDMA0 channel 1 global interrupt
[22]	GDMA0_Channel2	GDMA0 channel 2 global interrupt
[23]	GDMA0_Channel3	GDMA0 channel 3 global interrupt
[24]	GDMA0_Channel4	GDMA0 channel 4 global interrupt
[25]	GDMA0_Channel5	GDMA0 channel 5 global interrupt
[26]	I2C0	I2C0 global interrupt
[27]	I2C1	I2C1 global interrupt
[28]	uart log	log uart intr
[29]	RSVD	--
[30]	rdp_int	cpu rdp protection int
[31]	rtc_int	rtc timer int
[32]	GDMA1_CHANNEL0_IRQ	GDMA1 channel 0 global interrupt
[33]	GDMA1_CHANNEL1_IRQ	GDMA1 channel 1 global interrupt
[34]	GDMA1_CHANNEL2_IRQ	GDMA1 channel 2 global interrupt
[35]	GDMA1_CHANNEL3_IRQ	GDMA1 channel 3 global interrupt
[36]	GDMA1_CHANNEL4_IRQ	GDMA1 channel 4 global interrupt
[37]	GDMA1_CHANNEL5_IRQ	GDMA1 channel 5 global interrupt
[38]	RSVD	--
[39]	RXI300_IRQ	
[40]	RSVD	--

5. Pinmux Alternate Functions

Table 5-1 Pinmux Alternate Function mapping

RTL8710BN-VM1 GPIO	UART	SPI Master	SPI Slave	SPI Flash	I2C	SDIO	PWM/TIMER	EXT32K	I2S	Others
PA_14							PWM0	SWD_CLK		
PA_15							PWM1	SWD_DATA		
PA_6				SPIC_CS		SD_D2				
PA_7				SPIC_DATA1		SD_D3				
PA_9				SPIC_DATA0		SD_CLK				
PA_10				SPIC_CLK		SD_D0				
PA_18	UART0_RXD	SPI1_CLK	SPI0_SCK		I2C1_SCL	SD_D2	TIMER4_TRIG		I2S_MCK	WAKEUP_0
PA_23	UART0_TXD	SPI1_MOSI	SPI0_MOSI		I2C1_SDA	SD_D1	PWM0			WAKEUP_3
PA_30	UART2_log_TXD				I2C0_SDA		PWM3	RTC_OUT		
PA_29	UART2_log_RXD				I2C0_SCL		PWM4			

6. PMU

6.1. Features

6.2. Power Mode and Power Consumption

Table 6-1 Power Mode Brief Summary and Typical Power Consumption and Resume Time

Power Mode	*Power Consumption*		
	Typical	**Maximum**	**Units**
Deep Sleep Mode	7	7	uA
Deep Standby Mode	70	70	uA
Sleep Power Gate	120	120	uA
Sleep Clock Gate	350	350	uA

6.3. Shutdown Mode

- CHIP_EN deasserts to shutdown whole chip without external power cut components required.

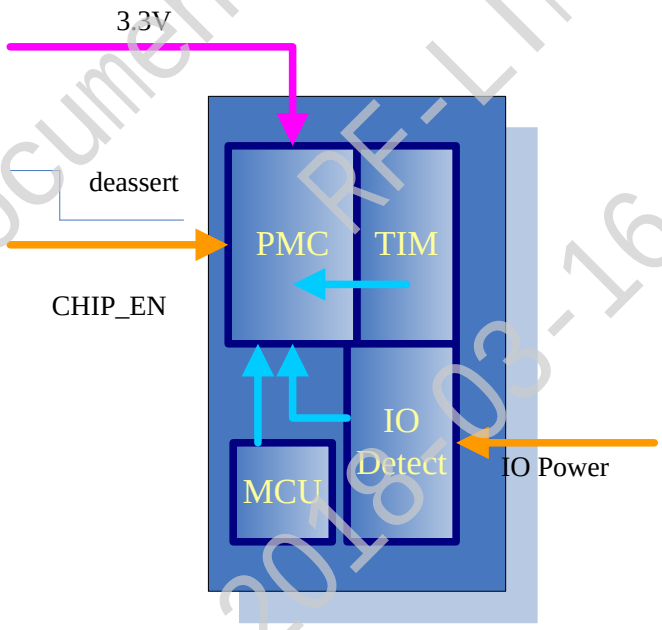

Figure 5 Shutdown Mode

6.4. Deep Sleep Mode

- CHIP_EN keeps high. Enter into Deep Sleep mode by API.

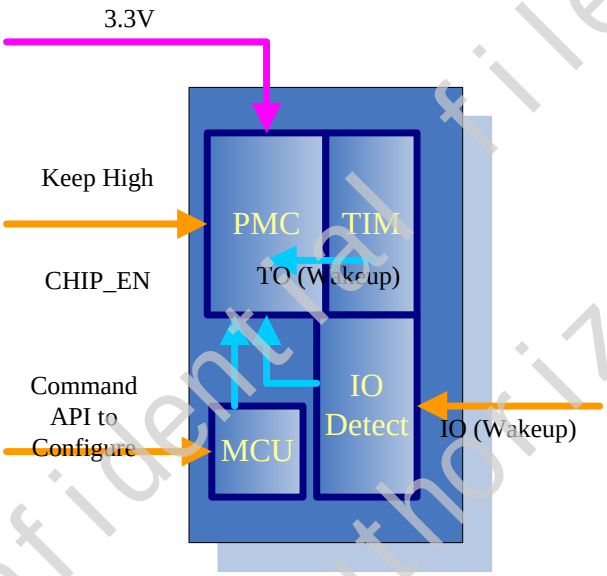

Figure 6 Deep Sleep Mode

6.4.1. Power Domain

Table 6-2 Deep Sleep Mode Power Domain

Functions	*Power State*	*Comment*
cortex-M4 core	OFF	
system clock	OFF	
SRAM	OFF	
Regulator	OFF	
Peripherals	OFF	
Backup register	OFF	
RTC	OFF	
low precision timer	ON	1
Dsleep wake pin	ON	4

6.4.2. Wakeup Source

Table 6-3 Deep Sleep Wakeup Source

Wakeup source	*Wakeup*	*Comment*
low precision timer	YES	
Dsleep Wake pin	YES	GPIOA_5 GPIOA_18 GPIOA_22 GPIOA_23

6.5. Deep Standby Mode

- CHIP_EN keeps high. Entering into Deep Sleep mode by API.

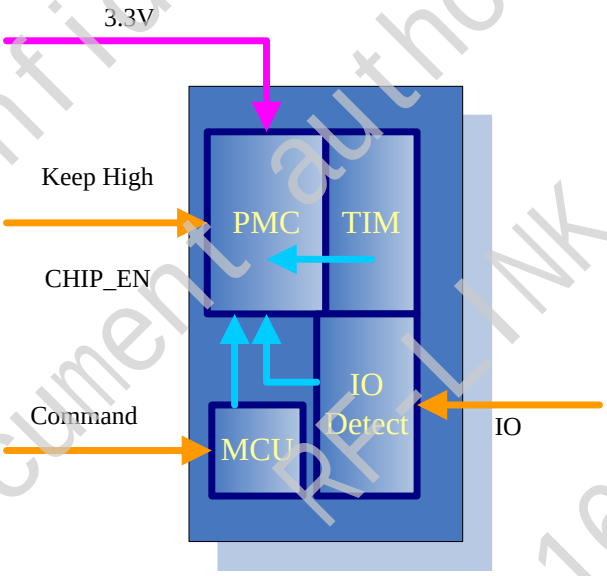

Figure 7 Deep Standby Mode

6.5.1. Power Domain

Table 6-4 Deep Standby Power Domain

functions	*Power State*	*comment*
cortex-M4 core	OFF	
system clock	OFF	

SRAM	OFF	
Regulator	OFF	
Peripherals	OFF	
Backup register	ON	16B
RTC	ON	
System timer	ON	1
low precision timer	ON	1
wake pin	ON	4

6.5.2. Wakeup Source

Table 6-5 Deep Standby Wakeup Source

Wakeup source	***Wakeup***	***Comment***
Wake pin	YES	GPIOA_18 GPIOA_23
RTC	YES	
System timer	YES	
low precision timer	YES	

6.6. Sleep Power Gate

6.6.1. Power Domain

Sleep mode turn off power domain including cortex-M4 core, and system clock. System is not required to restart after wakeup.

6.6.2. Wakeup source

Table 6-6 Sleep Power Gate Wakeup Source

Wakeup source	***Wakeup***	***comment***
GPIO interrupt	YES	High/Low active
general purpose timer	YES	
wlan	YES	
UART	YES	

I2C	YES	
Wake pin	YES	GPIOA_5 GPIOA_18 GPIOA_22 GPIOA_23
RTC	YES	
System timer	YES	
low precision timer	YES	

6.7. Sleep Clock Gate

6.7.1. Power Domain

Sleep mode turn off system clock. System is not required to restart after wakeup.

6.7.2. Wakeup source

Table 6-7 Sleep Clock Gate Wakeup Source

Wakeup source	***Wakeup***	***comment***
GPIO interrupt	YES	High/Low active
general purpose timer	YES	
wlan	YES	
UART	YES	
I2C	YES	
Wake pin	YES	GPIOA_5 GPIOA_18 GPIOA_22 GPIOA_23
RTC	YES	
System timer	YES	
low precision timer	YES	

7. Firmware Protection

7.1. Trust-Zone Lite

- Top 4k RAM cannot be read.
- RDP Interrupt will happen when invalid access happen.
- RDP image should be encrypted use RDP KEY,
- RDP image can only be decrypted and load to RDP RAM use IPSEC.
- KEY
  - 16B RDP key should be written to EFUSE RDP key area
  - Hidden EFUSE 0xB0~0xBF
  - Cannot read back again. (HW protect)
  - Auto-load to IPSEC when boot.
- Enable
  - Hidden EFUSE 0xC0[0].
  - Cannot be closed after open.

8. WIFI

8.1. General

- CMOS MAC, Baseband PHY, and RF in a single chip for 802.11b/g/n compatible WLAN
- Complete 802.11n solution for 2.4GHz band
- 72.2Mbps receive PHY rate and 72.2Mbps transmit PHY rate using 20MHz bandwidth
- 150Mbps receive PHY rate and 150Mbps transmit PHY rate using 40MHz bandwidth
- Compatible with 802.11n specification
- Backward compatible with 802.11b/g devices while operating in 802.11n mode

8.2. Standards Supported

- 802.11b/g/n compatible WLAN
- 802.11e QoS Enhancement (WMM)
- 802.11i (WPA, WPA2). Open, shared key, and pair-wise key authentication services
- WIFI WPS support
- WIFI Direct support
- Light Weight TCP/IP protocol

8.3. WLAN MAC Features

- Frame aggregation for increased MAC efficiency (A-MSDU, A-MPDU)
- Low latency immediate High-Throughput Block Acknowledgement (HT-BA)
- Long NAV for media reservation with CF-End for NAV release
- PHY-level spoofing to enhance legacy compatibility
- Power saving mechanism

8.4. WLAN PHY Features

- 802.11n OFDM
- One Transmit and one Receive path (1T1R)
- 20MHz and 40MHz bandwidth transmission
- Short Guard Interval (400ns)
- DSSS with DBPSK and DQPSK, CCK modulation with long and short preamble
- OFDM with BPSK, QPSK, 16QAM, and 640QAM modulation. Convolutional Coding Rate: 1/2, 2/3, 3/4, and 5/6
- Maximum data rate 54Mbps in 802.11g and 150Mbps in 802.11n
- Fast receiver Automatic Gain Control (AGC)

9. Basic timer

9.1. Introduction

The basic timers TIM0/TIM1/TIM2/TIM3 consist of a 32-bit auto-reload counter without prescaler.

They may be used as generic timers for time-base generation.

9.2. Features

Table 9-1 Basic timer features

Name	*TIM0/1/2/3*
channels	1
clock source	32k
resolution	32bit
prescaler	8bit
counter mode	Up
one pulse mode	-
PWM mode with polarity selection	-
statistic pulse width	-
statistic pulse number	-
interrupt generation	•
DMA generation	-
input pin	-
output pin	-

10. Capture timer

10.1. Introduction

The Capture timer (TIM4) consists of a 16-bit auto-reload counter driven by a 8-bit programmable prescaler.

It may be used for a variety of purposes, including measuring the pulse lengths or numbers of input signals.

10.2. Features

Table 10-1 Capture timer features

Name	*TIM4*
channels	1
clock source	XTAL
resolution	16bit
prescaler	8bit
counter mode	Up
one pulse mode	-
PWM mode with polarity selection	-
statistic pulse width	●
statistic pulse number	●
interrupt generation	●
DMA generation	●
input pin	1 input capture
output pin	-

11. PWM timer

11.1. Introduction

The PWM timer (TIM5) consists of a 16-bit auto-reload counter driven by a 8-bit programmable prescaler.

It may be used for a variety of purposes, including measuring the pulse lengths of input signals (input capture) or generating output waveforms (PWM).

Pulse lengths and waveform periods can be modulated from a few microseconds to several milliseconds using the timer prescaler.

11.2. Features

Table 11-1 PWM timer features

Name	*TIM5*
channels	6
clock source	XTAL
resolution	16bit
prescaler	8bit
counter mode	Up
one pulse mode	●
PWM mode with polarity selection	●
statistic pulse width	-
statistic pulse number	-
interrupt generation	●
DMA generation	●
input pin	1 input capture
output pin	6 PWM out

11.3. Function description

11.3.1. PWM mode

Pulse Width Modulation mode allows you to generate a signal with a frequency determined by the value of the TIMx_ARR register and a duty cycle determined by the value of the CCRx field of TIMx_CCRx register.

Period: $= (\mathrm{ARR} + 1) * T_{CNT}$

Duty cycle: $D_{PWM} = \frac{(\text{CCRx}+1)* T_{CNT}}{T_{PWM}}$

Where $T_{CNT} = T_{\text{XTAL}} * (\text{PSC} + 1)$

The PWM mode can be selected independently on each channel (one PWM per OCx output) by setting '0' in the OCxM bits in the TIMx_CCRx register. You must enable the corresponding preload register by setting the OCxPE bit in the TIMx_CCRx register, and eventually the auto-reload preload register by setting the ARPE bit in the TIMx_CR register.

As the preload registers are transferred to the shadow registers only when an update event occurs, before starting the counter, you have to initialize all the registers by setting the UG bit in the TIMx_EGR register.

OCx polarity is software programmable using the CCxP bit in the TIMx_CCRx register. It can be programmed as active high or active low.

In PWM mode, TIMx_CNT and CCRx (in TIMx_CCRx) are always compared to determine whether TIMx_CNT ⩽ CCRx (in TIMx_CCRx). The PWM signal OCx is active as long as TIMx_CNT ⩽CCRx (in TIMx_CCRx), otherwise it becomes inactive.

The timer is only able to generate PWM in edge-aligned mode.

12. RTC

12.1. Introduction

The real-time clock (RTC) is an independent BCD timer/counter.

One 32-bit registers contain the seconds, minutes, hours (12 or 24-hour format) expressed in binary coded decimal format (BCD).

One 32-bit registers contain the days expressed in binary format.

Daylight saving time compensation can also be performed.

Additional two 32-bit registers contain the programmable alarm seconds, minutes, hours and days.

A digital calibration feature is available to compensate for some deviation.

After backup domain reset, all RTC registers are protected against possible parasitic write accesses.

As long as the supply voltage remains in the operating range, the RTC never stops, regardless of the device status (Run mode, low power mode or under reset).

12.2. Features

- Time with seconds, minutes, hours, days (12 or 24-hour format).
- Daylight saving compensation programmable by software.
- One programmable alarm with interrupt function. The alarms can be triggered by any combination of the time fields.
- Maskable interrupts/events:
  - Alarm
- Digital calibration circuit
- Register write protection

12.3. Clock and Prescalers

A programmable prescaler stage generates a 1 Hz clock which is used to update the calendar. To minimize power consumption, the prescaler is split into 2 programmable prescalers.

A 9-bit asynchronous prescaler configured through the PREDIV_A bits of the RTC_PRER register.

A 9-bit synchronous prescaler configured through the PREDIV_S bits of the RTC_PRER register.

Note: It is recommended to configure the asynchronous prescaler to a high value to minimize consumption.

Default, the asynchronous prescaler division factor is set to 128, and the synchronous division factor to 256, to obtain an internal clock frequency of 1 Hz (ck_spre) with 32.768 kHz as RTCLCK

f_{clk_apre} is given by the following formula:

$$f_{clk\_apre} = \frac{f_{RTCCLK}}{\text{PREDIV\_A} + 1}$$

f_{clk_spre} is given by the following formula:

$$f_{clk\_spre} = \frac{f_{clk\_apre}}{\text{PREDIV\_S} + 1}$$

12.4. RTC Reset

	RTC Reset	*RTC Wakeup*
Power Off	Y	N/A
Hardware Reset	Y	N/A
Deep Sleep	Y	N/A
Deep Standby	N	Y
Sleep	N	Y
System Reset	N	N/A
Vector Reset	N	N/A

13. BACKUP Register

13.1. Introduction

The backup register are 32-bits registers used store 32 bytes of user application data, Backup registers are not reset by a system, or when the device wakes up from the Standby mode.

byte0~byte3 are reserved for system, and byte4-byte31 are reserved for user.

13.2. BACKUP Register API

Backup Register API	*Introduction*
< BKUP_Write >	■ backup register dwrod write
< BKUP_Read >	■ backup register dwrod read
< BKUP_Set >	■ set some bits of backup register
< BKUP_Clear >	■ clear some bits of backup register

13.3. BACKUP Register Reset

	RTC Reset
Power Off	Y
Hardware Reset	Y
Deep Sleep	Y
Deep Standby	N
Sleep	N
System Reset	N
Vector Reset	N

14. UART

14.1. Introduction

The Universal Asynchronous Receiver Transmitter (UART) module offers a flexible means of full duplex data exchange with external equipment requiring an industry standard NRZ asynchronous serial data format.

It offers a very wide range of baud rates using a fractional baud rate generator.

Low power Rx mode is implemented by monitoring Rx baud rate error and own frequency drift.

This chip integrates three UART modules:

- 2 normal UART with low power or high speed.
- 1 LOGUART with high speed.

14.2. Features

- Support UART format: 1 start bit, 7/8 data bits, 0/1 parity bit and 1/2 stop bit
- Support a very wide range of baud rate, 110~6Mbps.
- APB3 bus interface
- Support DMA mode
- Support auto flow control
- Support interrupt control
- Support IrDA
- Support loopback mode for test
- Differentiate clk for Tx path and Rx path
- Fractional baud rate generator for Tx path and Rx path
- Support low power Rx path without XTAL & PLL, Baud rate 110~500000.
- Monitor and eliminate Rx baud rate error and own frequency drift automatically for new Rx path
- Transmit and Receive Data FIFO
- Programmable Receive Data FIFO Trigger Level

14.3. Baud Rate

Table 14-1 UART Baud Rate

	High Rate	*Low Power*
clock select	40MHz XTAL	8MHz

supported baud rate(bps)	1200, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 128000, 153600, 230400, 406800, 500000, 921600, 1000000, 1382400, 1444400, 1500000, 1843200, 2000000, 2100000, 2764800, 3000000, 3250000, 3692300, 3750000, 4000000, 6000000	1200, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 128000, 153600, 230400, 406800, 500000

14.4. UART Interface Signal Levels

The UART signal level ranges from 1.8V to 3.3V. The host provides the power source with the targeted power level to the Ameba-Z UART interface via the IO power.

15. I2C

15.1. Introduction

The I2C bus is a two-wire serial interface, consisting of a serial data line (SDA) and a serial clock (SCL).

When the bus is idle, both the SCL and SDA signals are pulled high through internal pull-up resistors. When the master wants to start a transmission on the bus, the master issues a START condition. This is defined to be a high-to-low transition of the SDA signal while SCL is 1. When the master wants to terminate the transmission, the master issues a STOP condition. This is defined to be a low-to-high transition of the SDA line while SCL is 1. When data is being transmitted on the bus, the SDA line must be stable when SCL is 1.

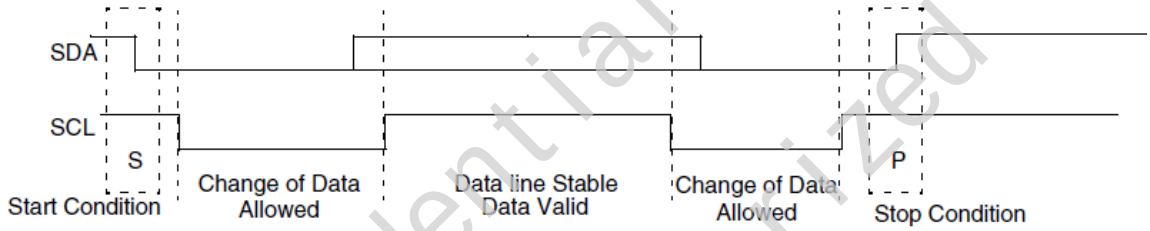

Figure 8 I2C start stop condition

I2C bus carry information between the devices connected to the bus. Each device is recognized by a unique address and can operate as either a "transmitter" or "receiver," depending on the function of the device.

Devices can also be considered as masters or slaves when performing data transfers. A master is a device that initiates a data transfer on the bus and generates the clock signals to permit that transfer. At that time, any device addressed is considered a slave.

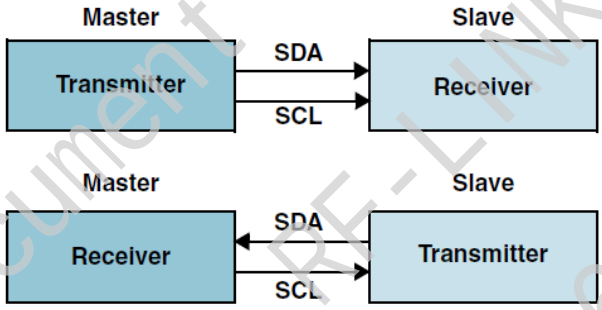

Figure 9 Master/Slave and Transmitter/Receiver Relationships

Ameba-Z can operate in standard mode (with data rates 0 to 100 Kb/s), fast mode (with data rates less than or equal to 400 Kb/s), high-speed mode (with data rates less than or equal to

3.4 Mb/s) are not supported.

Ameba-Z can communicate with devices only of these modes as long as they are attached to the bus. Additionally, fast mode devices are downward compatible. For instance, fast mode devices can communicate with standard mode devices in 0 to 100 Kb/s I2C bus system. However, standard mode devices are not upward compatible and should not be incorporated in a fast-mode I2C bus system as they cannot follow the higher transfer rate and unpredictable states would occur.

There are two address formats: the 7-bit address format and the 10-bit address format.

7-bit Address Format

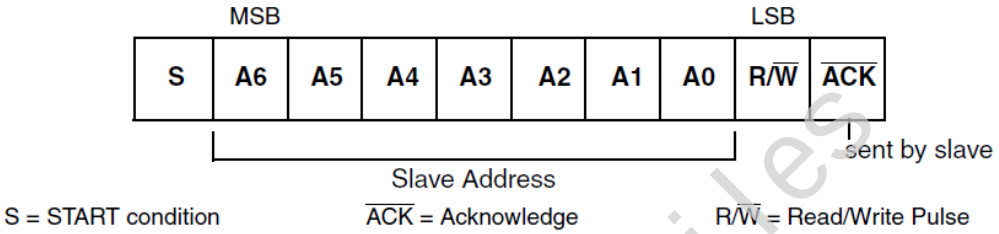

Figure 10 7-bit address format

10-bit Address Format

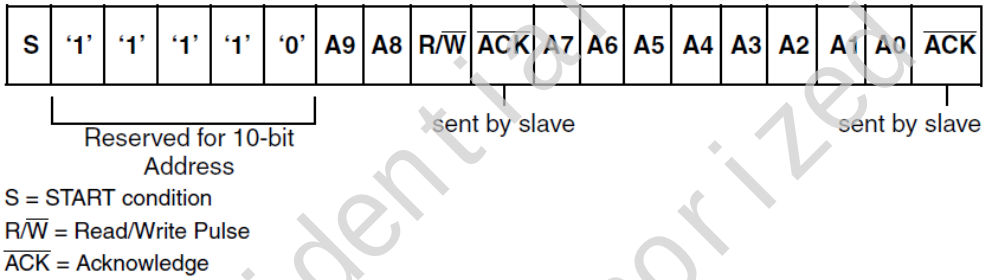

Figure 11 10-bit address format

15.2. Features

- Support maximum 2 I2C port
- Two speeds:
  - Standard mode (0 to 100 Kb/s)
  - Fast mode (<400 Kb/s)
  - Not support High-speed mode (<3.4 Mb/s)
- Master or Slave I2C operation
- 7- or 10-bit addressing
- Transmit and receive buffers
- TX and RX DMA support
- Slave mode address match wakeup for power save

16. GDMA

16.1. Introduction

General purpose direct memory access (GDMA) is used to transfer data between peripherals and memory as well as memory to memory without CPU actions.

Ameba-Z integrate two GDMA modules, One GDMA module has 6 channels to manage the data transfer between memory and peripherals.

16.2. Features of GDMA

- Dual port DMA with totally 12 channels
- Single FIFO per channel for source and destination
- Support memory-memory, memory-peripheral, peripheral-memory, and peripheral-peripheral DMA transfer
- Support multi block transfer
- Maximum block size is 4095
- Programmable source and destination addresses, address increment, decrement, no change or address auto-reload
- Configurable endian
- Support block level flow control
- DMA interrupt for complete or error

17. WGT (watchdog timer)

17.1. Introduction

The watchdog timer regains control in case of system failure (due to a software error) to increase application reliability. The WDT can generate a reset or an interrupt when the counter reaches a given timeout value.

17.2. Features

- Watch dog timer is count with 32.768KHz/(divfactor+1). Dividing factor is 1~0xFFFF.
- Timeout value: 1ms ~ 8190s
- Configurable reset or interrupt generation with the given timeout value
- Watch dog timer disable/enable/refresh

18. GPIO

18.1. Introduction

Ameba-Z GPIO IP controls the output data and direction of external I/O pads. It also can read back the data on external pads using memory-mapped registers.

Ameba-Z support two port: PORT_A(0~31) and PORT_B(0~6).

Port A can be programmed to accept external signals as interrupt sources on any of the bits of the signal. The type of interrupt is programmable with one of the following settings:

- Active-high and level
- Active-low and level
- Rising edge
- Falling edge

NOTICE: Both edge interrupt is not support.

The interrupts can be masked by programming the gpio_int_mask register. The interrupt status can be read before masking (called raw status) and after masking.

Whenever Port A is configured for interrupts, the data direction must be set to Input. If the data direction register is reprogrammed to Output, then any pending interrupts are not lost. However, no new interrupts are generated.

If the user has configured Port A to include the interrupt feature, the GPIO can be configured to either include or exclude a debounce capability using the GPIO_DEBOUNCE parameter.

The external signal can be debounced to remove any spurious glitches that are less than one period of the external debouncing clock.

18.2. Features of GPIO

- GPO and GPI function
- Support interrupt detection with configurable polarity per GPIO
- Internal weak pull up and pull low per GPIO
- Multiplexed with other specific digital functions
- GPIO_DEBOUNCE to remove any spurious glitches

19. Security Engine

19.1. Introduction

The Security engine provides fast and energy efficient hardware encryption and decryption service for Ameba-Z.

19.2. Features

- Provide low SW computing and high performance encryption
- Efficient CPU/DMA access support
- Block size up to 32KB.
- Supported authentication algorithms:
  - MD5
  - SHA-1
  - SHA-2 (SHA-224 / SHA-256)
  - HMAC-MD5
  - HMAC-SHA1
  - HMAC-SHA2
- Supported Encryption / Decryption mechanisms:
  - DES (CBC / ECB)
  - 3DES (CBC / ECB)
  - AES-128 (CBC / ECB / CTR)
  - AES-192 (CBC / ECB / CTR)
  - AES-256 (CBC / ECB / CTR)

20. Electrical Characteristics

20.1. Temperature Limit Ratings

Table 20-1 Temperature Limit Ratings

Parameter	*Minimum*	*Maximum*	*Units*
Storage Temperature	-55	+125	°C
Ambient Operating Temperature	-20	+85	°C
Junction Temperature	0	+125	°C

20.2. Power Supply DC Characteristics

Table 20-2 Power Supply DC Characteristics

Symbol	*Parameter*	*Minimum*	*Typical*	*Maximum*	*Units*
VA33, VD33IO, SW_HV3	3.3V Supply Voltage	3.0	3.3	3.6	V
VDD_IO	Digital IO Supply Voltage	1.62	1.8~3.3	3.6	V
VA12_AFE, VA12_SYN, VA12_RF	1.2V Core Supply Voltage	1.08	1.2	1.32	V
IDD33	3.3V Rating Current (with internal regulator and integrated CMOS PA)	-	-	450	mA
IDD_IO	IO Rating Current (including VDD_IO)			200	mA
IDD_IO_33	3.3V IO Rating Current			50	mA

20.3. Digital IO Pin DC Characteristics

20.3.1. Electrical Specifications

Table 20-3 Typical Digital IO DC Parameters (3.3V Case)

Symbol	*Parameter*	*Conditions*	*Min.*	*Typ.*	*Max.*	*Units*
V_{IH}	Input-High Voltage	LVTTL	2.0	-	-	V

V_{IL}	Input-Low Voltage	LVTTL	-	-	0.8	V
V_{OH}	Output-High Voltage	LVTTL	2.4	-	-	V
V_{OL}	Output-Low Voltage	LVTTL	-	-	0.4	V
I_{T+}	Schmitt-trigger High Level		1.78	1.87	1.97	V
I_{T-}	Schmitt-trigger Low Level		1.36	1.45	1.56	V
I_{IL}	Input-Leakage Current	V_{IN}=3.3V or 0	-10	±1	10	μA

Table 20-4 Typical Digital IO DC Parameters (1.8V Case)

Symbol	*Parameter*	*Conditions*	*Min.*	*Typ.*	*Max.*	*Units*
V_{IH}	Input-High Voltage	CMOS	0.65x Vcc	-	-	V
V_{IL}	Input-Low Voltage	CMOS	-	-	0.35x Vcc	V
V_{OH}	Output-High Voltage	CMOS	Vcc-0.45	-	-	V
V_{OL}	Output-Low Voltage	CMOS	-	-	0.45	V
I_{T+}	Schmitt-trigger High Level		1.02	1.09	1.14	V
I_{T-}	Schmitt-trigger Low Level		0.67	0.73	0.87	V
I_{IL}	Input-Leakage Current	V_{IN}=1.8V or 0	-10	±1	10	μA

21. Mechanical Dimensions

21.1. Package Specification

21.1.1. QFN32

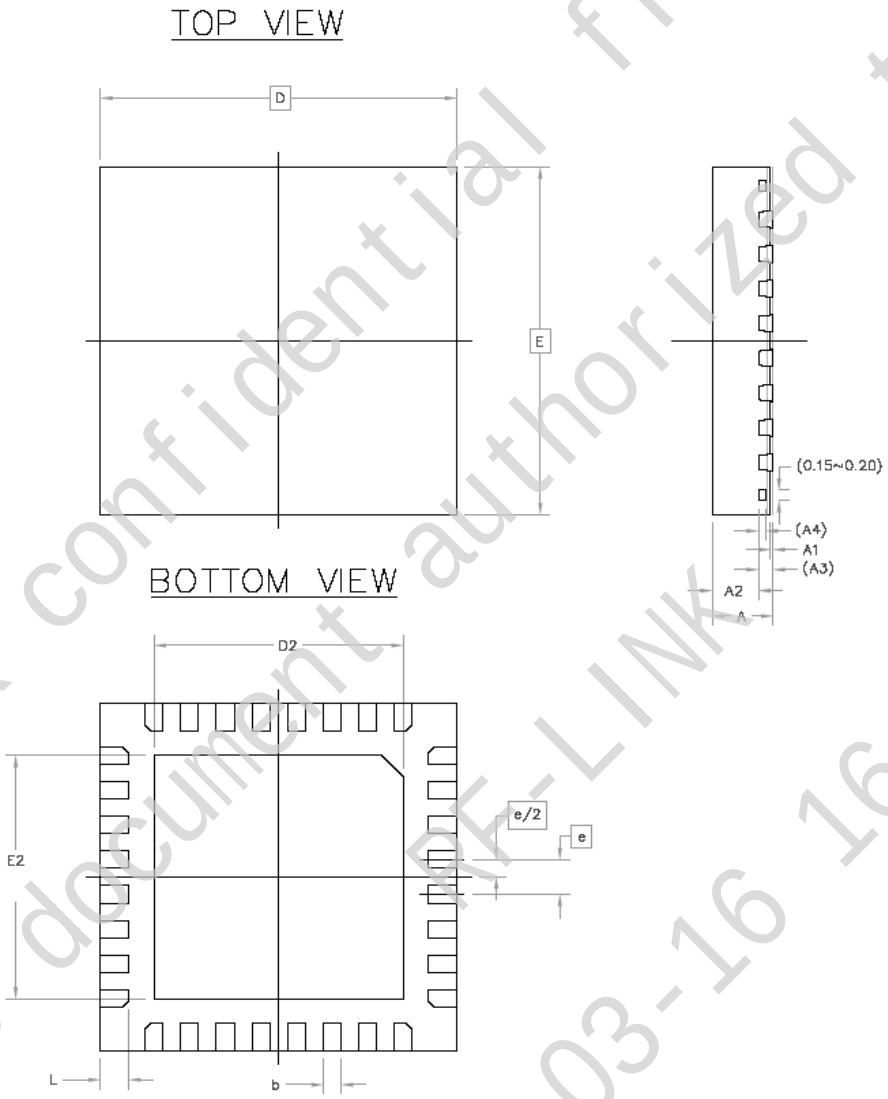

Figure 12 QFN32 Package Specification

Table 21-1 QFN32 Package Specification

Symbol	Dimension in mm			Dimension in inch		
	Min	Nom	Max	Min	Nom	Max
A	0.80	0.85	0.90	0.031	0.033	0.035

A1	0.00	0.02	0.05	0.000	0.001	0.002
A3	0.20 REF			0.008 REF		
A4	0.10 REF			0.004 REF		
b	0.18	0.25	0.30	0.007	0.010	0.012
D/E	5.00 BSC			0.020 BSC		
D2/E2	3.25	3.50	3.75	0.128	0.138	0.148
e	0.50 BSC			0.020 BSC		
L	0.30	0.40	0.50	0.012	0.016	0.020

Notes：

1. CONTROLLING DIMENSION：MILLIMETER(mm).
2. REFERENCE DOCUMENTL：JEDEC MO-220.