Specification

DAB Series
[PNP All-in-One SOC]

PAIOS²-AD
[Dual/MRC with SL]
DATA SHEET

PnpNetwork Technologies, Inc.

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(Version 0.97)

Note: This documentation is preliminary and subject to change. PnpNetwork Technologies, Inc. reserves the right to do any kind of modification in this datasheet regarding both hardware and software implementations without notice.

Revision History

Bars appearing in the left margin of the document as shown here indicate changes made to this document since the last revision issued.

Date	Revision	Description	Author
2018.04.19	Version 0.90	Revised by PAIOS²-VD	Jeremy
2018.05.10	Version 0.91	Errata's Correction 2 ball assignments are swapped - A10 (VSS -> EXT_MCLK) - B10 (EXT_MCLK -> VSS)	Jeremy
2019.04.02	Version 0.92	Pin assignment Pin Description Update Function Description Update	Jeremy
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Contents

1. Introduction 5
1.1 Overview 5
1.2 Features 5
1.3 Applications 5
1.4 Ordering Information 6
2. Pin Information 7
2.1 Pin Assignment 7
3. Pin Descriptions 8
4. Functional Description 13
4.1 General Functions 14
4.2 DSP Functions 14
4.3 DAB Functions 15
4.4 Tuner Interface Functions 15
4.5 Built-in RF tuners for DAB 16
4.6 Diversity Functions 16
4.7 Loop though Antenna 16
4.8 PLL Functions 17
4.9 I²S TX Functions 17
4.10 I²S 7.1 Channel Functions 17
4.11 SPDIF Functions 17
4.12 I²S RX Functions 17
4.13 I²C Functions 18
4.14 UART Functions 18
4.15 SPI Functions 18
4.16 SPI Bridge Functions 18
5. Peripheral Descriptions 19

5.1 I²C Interface 19
5.2 SPI Interface 20
5.2.1 Characteristics SPI Bus 20
5.2.2 SPI Timing Diagram 21
5.2.3 SPI Timing Characteristics 21
5.3 UART Interface & HSUART Interface 22
5.4 I²S TX Interface 23
5.5 I²S RX Interface 25
5.6 Digital I/Q Interface 27
5.7 Built-in RF tuners or DAB Band3 28
6. Application 29
6.1 Clock application 29
6.2 Operation Mode Selection 30
7. Electrical Characteristics 31
7.1 Absolute Maximum Rating 31
7.2 Recommended operating conditions 32
7.3 Power-on and Reset Timing 33
7.4 Power Consumption 34
8. Package Dimension 35
9. PCB Mounting Guidelines 36
9.1 Board Pad Design 36
9.2 Handling 36
9.3 DRYING 37
9.4 SMT Process 38
9.5 The temperature profile of a reflow process 39
10. Part marking 40

1. ,Introduction

1.1 Overview

The PAIOS²-AD is a superior system on chip for DAB applications. It fully supports both the Eureka-147 DAB consists of flexible hardware COFDM demodulator and Radio/Audio DSP. Several interfaces such as SPI, I²C and UART are implemented providing customers with more flexibility.

The PAIOS²-AD integrates the Tensilica HiFi EP DSP, offering the low-power, high-performance audio DSP core, support enhanced digital audio applications. The DSP EP core eliminates the need for the audio companion processors normally required for audio-based applications. In addition, dual DAB RF tuner are integrated with RF SOC technology. By removing the need for costly application coprocessors and memory subsystems and dual RF tuner, the PAIOS²-AD chipset solution reduces BOM costs. The PAIOS²-AD chipset solution integrates both DAB into a single chip.

1.2 Features

- Multi-standards support: DAB / DAB+ / DMB-A / T-DMB / HD-DMB
- Dual DAB tuners are integrated and dual Digital I/Q Tuner interface for external RF device
- Outstanding SFN, Mobility, Adjacent and Co-channel rejection
- Ideal C/N Performance and Superior Fading Performance
- Decoding Information: FIC and MSC
- MRC Diversity support for both DAB1.5 / DAB 2.0 system
- Low power consumption: MAX 990mW (TBD)
- 32-bits RISC architecture with integrated 24-bits audio processing instructions
- Modeless switching between 16-, 24-, and 64-bits dual-issue instructions
- Dual MACs can operate as 32 x 24-bits
- 16MByte Mobile SDRAM stacked for high technology audio codec process and data service
- 10 x 10 mm², 0.65 mm pitch, 179-pin Fine pitch BGA technology.

1.3 Applications

- Automotive Digital Radio System for receiving dual channel DAB signals
- Aftermarket car radio and audio system
- Boom Box and Audio component system
- Smart Speaker system for Digital Radio
- Kitchen Radio application

1.4 Ordering Information

Order Number		PAIOS²-AD
Stacked SDRAM Size		16MByte
Package Information	Ball Pitch	0.65mm
	Body Size	10mm x 10mm x 1.2mm
	Ball Count (Type)	179 balls (FBGA)
Supply Voltage	Core	1.2V
	I/O	3.0V / 3.3V
Operation Temperature		-40 ~ +85°C
Storage Temperature		-50 ~ +150°C

Table 1-1 Ordering Information

- Note: PAIOS²-AD is pin-to-pin compatible with PAIOS^X-H & PAIOS^X-VD series.

Type number	Target Application	Internal tuner	Digital I/Q tuner Interface
PAIOS²-AD	[MRC Diversity Antenna] DAB 2-ch Receiver Baseband All In One SOC for Audio & Data(*1) mode with Seamless linking + BGS/Data(*2) or MRC Audio & Data mode with Seamless linking	2 tuners: Band3+Band3	Up to 2
	[Single Antenna] DAB 2-ch Receiver Baseband All In One SOC for Audio & Data mode with Seamless linking + BGS/Data		

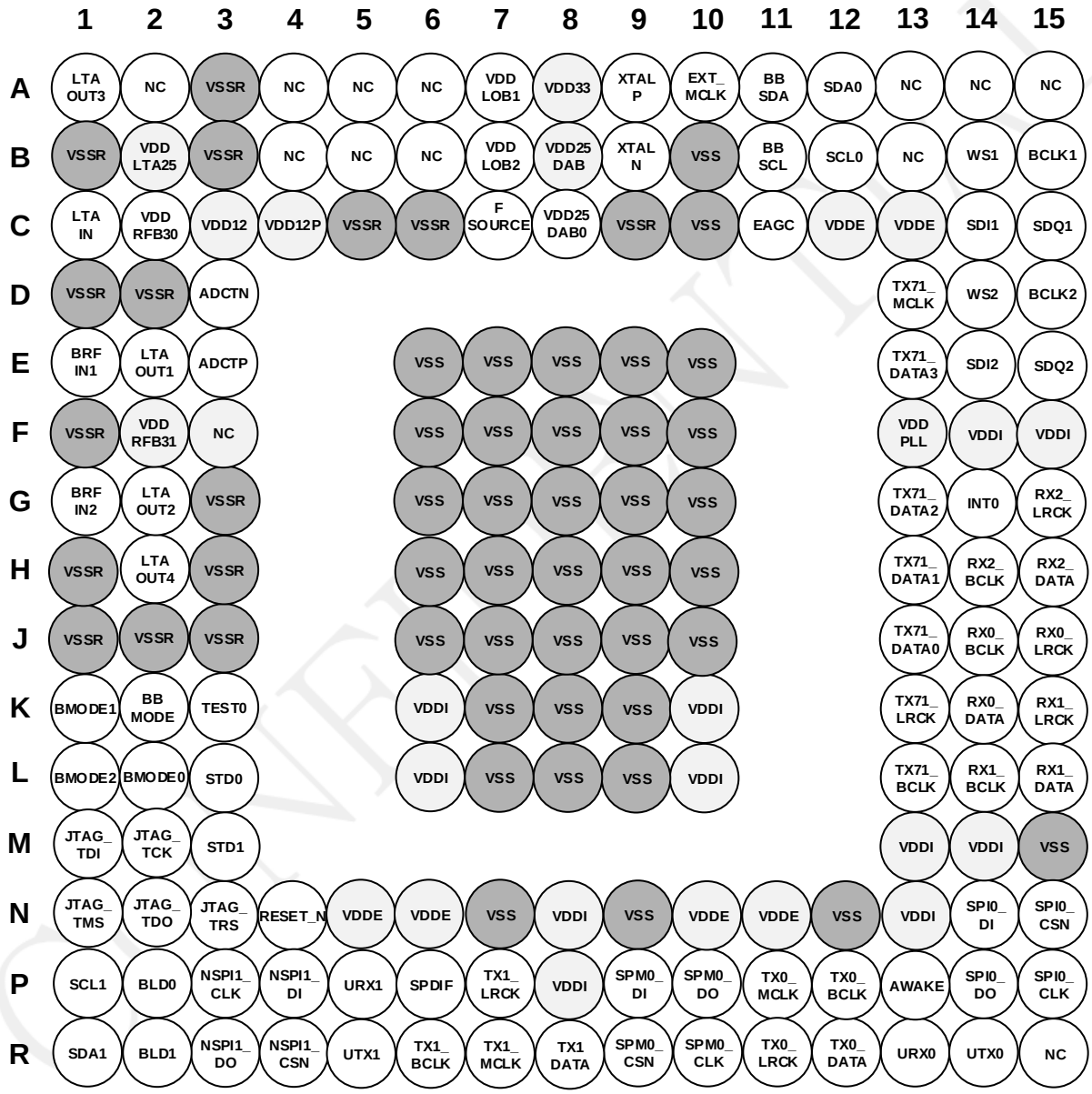
Table 1-2 Type and Target Application overview

* Note 1: “Audio & Data” means audio and data service are received simultaneous on the same frequency station.
* Note 2: “BGS/Data” means the separated tuner can be used for back ground scanning or data service on the other frequency stations time-dependently.

2. Pin Information

2.1 Pin Assignment

- Top View



PAIOS²-AD Pin assignment

3. Pin Descriptions

TYPE Description

I : Input, O : Output, IO : Bidirectional, AP : Analog Power, DP : Digital Power, DG : Digital Ground

- DSP & Baseband Pins

Pin	Symbol	Type	Function	Description
A12	I2C_SDA0	IO	I2C	I²C DATA (Master Mode only)
B12	I2C_SCL0	O	I2C	I²C CLK (Master Mode only)
R1	I2C_SDA1	IO	I2C	I²C DATA (Master/Slave Mode)
P1	I2C_SCL1	IO	I2C	I²C CLK (Master/Slave Mode)
A11	BB_SDA	IO	I2C	I²C DATA (Master Mode only)
B11	BB_SCL	O	I2C	I²C CLK (Master Mode only)
R14	UART_TX0	O	UART	UART0 Transfer data
R13	UART_RX0	I	UART	UART0 Receive data
P10	SPM0_DO	O	SPI	SPI0 master / Data out / MOSI
P9	SPM0_DI	I	SPI	SPI0 master / Data in / MISO
R9	SPM0_CSN	O	SPI	SPI0 master / Chip select / SS
R10	SPM0_CLK	O	SPI	SPI0 master Clock/ CLK
G14	INT0	IO	GPIO	External Interrupt Input[0]
R5	UART_TX1	IO	GPIO	UART1 TX
P5	UART_RX1	IO	GPIO	UART1 RX
P2	BLD0	IO	GPIO	GPIO0 / Blending Out0
R2	BLD1	IO	GPIO	GPIO1 / Blending Out1
R3	NSPI1_DO	IO	GPIO	SPI1 DO (Master or Slave)
P4	NSPI1_DI	IO	GPIO	SPI1 DI (Master or Slave)
P3	NSPI1_CLK	IO	GPIO	SPI1 CLK (Master or Slave)
R4	NSPI1_CSN	IO	GPIO	SPI1 nCS (Master or Slave)
P14	SPI0_DO	IO	GPIO	SPI0 Slave MISO
N15	SPI0_CSN	IO	GPIO	SPI0 Slave nCS
N14	SPI0_DI	IO	GPIO	SPI0 Slave MOSI
P15	SPI0_CLK	IO	GPIO	SPI0 Slave CLK
P6	SPDIF	IO	GPIO	SPDIF/ GPIO3[6]
P11	TX0_MCLK	O	I2S	I²S TX0 Main Clock
R11	TX0_LRCK	IO	I2S	I²S TX0 Left / Right CLK
P12	TX0_BCLK	IO	I2S	I²S TX0 Bit Clock

R12	TX0_DATA	O	I2S	I²S TX0 Data
R7	TX1_MCLK	O	I2S	I²S TX1 Main Clock
P7	TX1_LRCK	IO	I2S	I²S TX1 Left / Right CLK
R6	TX1_BCLK	IO	I2S	I²S TX1 Bit Clock
R8	TX1_DATA	O	I2S	I²S TX1 Data
D13	TX71_MCLK	O	I2S	I²S TX71 Main Clock
E13	TX71_DATA3	O	I2S	I²S TX71 Data3
G13	TX71_ DATA2	O	I2S	I²S TX71 Data2
H13	TX71_ DATA1	O	I2S	I²S TX71 Data1
J13	TX71_ DATA0	O	I2S	I²S TX71 Data0
K13	TX71_LRCK	IO	I2S	I²S TX71 Left / Right CLK
L13	TX71_BCLK	IO	I2S	I²S TX71 Bit Clock
J14	RX0_BCLK	I	I2S	I²S RX0 Bit Clock
J15	RX0_LRCK	I	I2S	I²S RX0 Left-Right Clock
K14	RX0_DATA	I	I2S	I²S RX0 Data
L14	RX1_BCLK	I	I2S	I²S RX1 Bit Clock
K15	RX1_LRCK	I	I2S	I²S RX1 Left-Right Clock
L15	RX1_DATA	I	I2S	I²S RX1 Data
H14	RX2_BCLK	I	I2S	I²S RX2 Bit Clock
G15	RX2_LRCK	I	I2S	I²S RX2 Left-Right Clock
H15	RX2_DATA	I	I2S	I²S RX2 Data
C11	EAGC	O	Tuner IF	External AGC
A13	NC	-	-	Reserved for Future extension
B13	NC	-	-	Reserved for Future extension
A14	NC	-	-	Reserved for Future extension
A15	NC	-	-	Reserved for Future extension
B15	BLK1	I	Tuner IF	Digital I/Q Input BCLK1
B14	WS1	I	Tuner IF	Digital I/Q Input WS1
C14	SDI1	I	Tuner IF	Digital I/Q Input Serial Data-I 1
C15	SDQ1	I	Tuner IF	Digital I/Q Input Serial Data-Q 1
D15	BLK2	I	Tuner IF	Digital I/Q Input BCLK2
D14	WS2	I	Tuner IF	Digital I/Q Input WS2
E14	SDI2	I	Tuner IF	Digital I/Q Input Serial Data-I 2
E15	SDQ2	I	Tuner IF	Digital I/Q Input Serial Data-Q 2

- MODE & SYSTEM Pins

Pin	Symbol	Type	Function	Description
L2	BMODE[0]	I	MODE	Configure Pin Boot MODE[0] 1)note
K1	BMODE[1]	I	MODE	Configure Pin Boot MODE[1] 2)note
L1	BMODE[2]	I	MODE	Configure Pin Boot MODE[2] 2)note
A10	EXT_MCLK	I	MODE	External Clock
K2	BBMODE	I	MODE	DSP or BASEBAND Mode Selection
K3	TEST0	I	MODE	Digital Part Test Mode Selection
N4	RESET_N	I	RESET	SYSTEM RESET IN
A9	XTAL P	I	CLOCK	Crystal Positive
B9	XTAL N	I	CLOCK	Crystal Negative
L3	STDO	I	MODE	Standard Mode0
M3	STD1	I	MODE	Standard Mode1
P13	AWAKE	I	MODE	AWAKE
R15	NC	-	-	Reserved for future use
N2	JTAG_TDO	IO	JTAG	DSP Debug Serial Instruction/Data Shift Output Port
N3	JTAG_TRS	IO	JTAG	DSP Debug Active Low Input Port
M1	JTAG_TDI	IO	JTAG	DSP Debug Serial Instruction/Data Shift Input Port
N1	JTAG_TMS	IO	JTAG	DSP Debug TAP Controller Port
M2	JTAG_TCK	IO	JTAG	DSP Debug Clock Port

Please refer to details for detail mode selection in section 6.2.

1) BMODE[0] = 1 → System clock Input = 24.576MHz

2) BMODE[2:1] = [1][0] → Booting From Serial Flash Memory BMODE[2:1] = [1][1] → Waiting for UART Download

BMODE[2:1] = [0][1] --> SPI Bridge Enabled between SPIM0 and SPIS2. So, Host can access Serial flash directly. (TBD)

- RF Pins

Pin	Symbol	Type	Function	Description
A1	LTAOUT3	I	RF	LTA Output Buffer3
C1	LTA IN	I	RF	LTA Input
C7	FSOURCE	IO	RF	Reserved
D3	ADCTN	IO	RF	ADC TEST Input Negative
E1	BRFIN1	I	RF	Band3 RF Input1
E2	LTA OUT1	O	RF	LTA Output Buffer1
E3	ADCTP	IO	RF	ADC TEST Input Positive
G1	BRFIN2	I	RF	Band3 RF Input2
G2	LTA OUT2	O	RF	LTA Output Buffer2
H2	LTAOUT4	O	RF	LTA Output Buffer4
A2, A4, A5, A6, B5, B6	NC	-	-	Reserved for future use

- Analog Power Pins

Pin	Symbol	Type	Function	Description
A7	VDDLOB1	AP	POWER	RF & Analog Part Power Supply
A8	VDD33	AP	POWER	RF & Analog Part Power Supply
B2	VDDLTA25	AP	POWER	RF & Analog Part Power Supply
B7	VDDLOB2	AP	POWER	RF & Analog Part Power Supply
B8	VDD25DAB	AP	POWER	RF & Analog Part Power Supply
C2	VDDRFB30	AP	POWER	RF & Analog Part Power Supply
C3	VDD12	AP	POWER	RF & Analog Part Power Supply
C4	VDD12P	AP	POWER	RF & Analog Part Power Supply
C8	VDD25DAB0	AP	POWER	RF & Analog Part Power Supply
F2	VDDRFB31	AP	POWER	RF & Analog Part Power Supply
A3, B1, B3, C5, C6, C9, D1, D2, F1, G3, H1, H3, J1, J2, J3	VSSR	AP	POWER	RF & Analog Part Ground
B4, F3	NC	-	-	Reserved for future use

- Digital Power Pins

Pin	Symbol	Type	Function	Description
F14, F15, K6, L6, K10, L10, N8, P8, M13, M14, N13	VDDI	DP	POWER	Digital Power supply voltage for Core
C12, C13, N5, N6, N10, N11	VDDE	DP	POWER	Digital Power supply voltage for I/O & SDRAM
F13	VDDPLL	DP	POWER	Digital Power supply voltage for PLL
B10, C10, E6, E7, E8, E9, E10, F6, F7, F8, F9, F10, G6, G7, G8, G9, G10, H6, H7, H8, H9, H10, J6, J7 J8, J9, J10, K7, K8, K9, L7, L8, L9, M15, N7, N9, N12	VSS	DG	POWER	Ground.

4. Functional Description

This chapter describes PAIOS²-AD internal structure, components and interfaces as shown in figure 4-1. The algorithms and architectures used in the PAIOS²-AD have been efficiently optimized in order to minimize hardware and chip area.

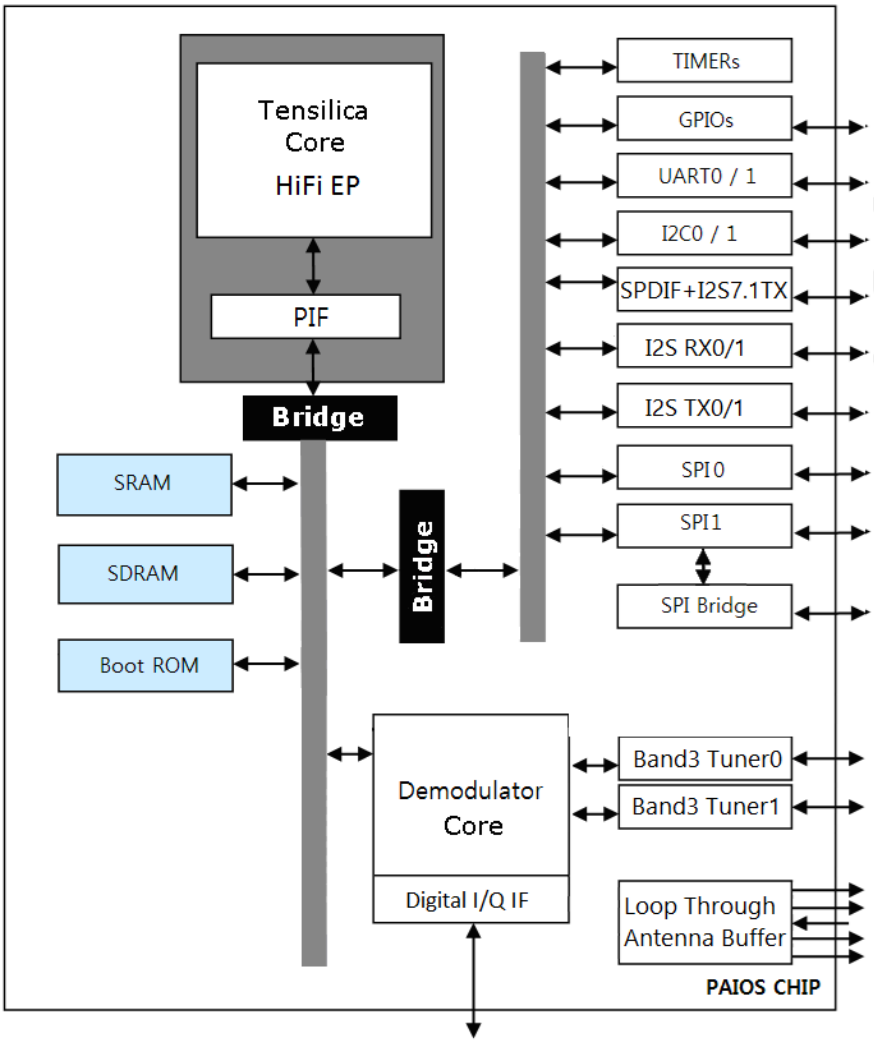


Figure 4-1 Functional Block Diagram

4.1 General Functions

The following is a total feature list and is spread over multiple commercial releases.
The initial releases will not include all of these simultaneously.

- ❑ Support for DAB ETSI 300 401 v1.4.1 standard
- ❑ High-performance Tensilica Diamond HiFi EP Core.
- ❑ 32Bit RISC with 24-bits Audio processing
- ❑ Advanced 10 x 10 mm2, 0.65 mm pitch, 179-pins Fine pitch BGA technology.

4.2 DSP Functions

- ❑ Based on standard 32-bits RISC architecture with integrated 24-bits audio processing instructions
- ❑ Industry-leading low-power consumption coupled with high-fidelity 24-bits audio
- ❑ Dual-issue, static super-scalar VLIW
- ❑ Dual MACs can operate as 32 x 24-bits
- ❑ Predictive pre-fetch cache memory subsystem for improvement of high-density memory latency
- ❑ Ultra-low power consumption increases battery life in portable applications
- ❑ Full 24-bits internal audio resolution throughout delivers extremely high-quality audio output

4.3 DAB Functions

- ❑ Multi-standards support in DAB Family: DAB/ DAB+/ DMB-A / T-DMB / HD-DMB
- ❑ Dual DAB demodulator support to receive the two ensembles in different frequency at once.
- ❑ Additional Back Scanning or Data service decoding by using dual demodulators
- ❑ All DAB transmission modes (I, II, III, and IV) support
- ❑ Low-IF (2.048 MHz) and Zero-IF support
- ❑ Fast automatic channel acquisition and re-acquisition
- ❑ EN 50248 performance environment compatible
- ❑ Dual AGC control for RF and IF amplifier, and WAGC/SLI to tuner
- ❑ Outstanding SFN, Mobility, Adjacent and Co-channel rejection
- ❑ Dynamic window positioning and channel tracking
- ❑ Internal digital AFC loop (no feedback to tuner)
- ❑ TII decoder can detect 5 signals
- ❑ Embedded on-chip de-interleaving memory for full 1.824Mbps data rate
- ❑ Required crystal tolerance (±50ppm)

4.4 Tuner Interface Functions

- ❑ 2 x Digital I/Q interface support for External Tuner connection
- ❑ Support Split mode, Multiplexed mode, Analog/Digital mode, MSB bit shift mode
- ❑ Software and hardware switching of sample rates supported

4.5 Built-in RF tuners for DAB

- ❑ PAIOS²-AD support dual Band-3 RF tuners
- ❑ Supports Bands: 174~245MHz (Band-3)
- ❑ Low Noise Amplifier (LNA) with 4-gain modes
- ❑ RF automatics Gain Control
- ❑ Typical AGC dynamic range: Over 60dB
- ❑ Bandwidth adjustable band-pass filter
- ❑ I/Q Down Conversion Mixer to Baseband
- ❑ Low noise figure: 3 dB
- ❑ Low noise and Wide frequency range On-chip Voltage Controlled Oscillator (VCO)

4.6 Diversity Functions

- ❑ MRC Diversity support in DAB family
- ❑ Better C/N performance and seamless switching between master and slave

4.7 Loop though Antenna

- ❑ VHF Band3 Band support
- ❑ Four RF output support with One Antenna input

4.8 PLL Functions

- Input Frequency: 24.576MHz
- Output Frequency: 37.5MHz~600MHz

4.9 I²S TX Functions

- 2 x Master or Slave I²S TX interface.
- Programmable clock generation (I²S master mode, MCLK, BCLK, LRCK).
- Programmable data width (up to 32-bits).
- Sample rate converter supporting for externally provided clock in slave mode

4.10 I²S 7.1 Channel Functions

- 1 x Master or Slave I²S 7.1ch interface.
- Programmable clock generation (I²S master mode, MCLK, BCLK, LRCK).
- Programmable data width (up to 32-bits).
- 4-pair I²S out mode and 1-pair I²S with TDM mode (DSP MODE)
- Sample rate converter supporting for externally provided clock in slave mode

4.11 SPDIF Functions

- 1 x SPDIF interface for Stereo channel audio PCM.
- Fixed sample rate output for 48KHz sample rate audio

4.12 I²S RX Functions

- 2 x Master or Slave I²S RX interface.
- Programmable clock generation (I²S master mode, BCLK, LRCK).
- Programmable data width (up to 32-bits).
- Sample rate converter supporting for externally provided clock in slave mode

4.13 I²C Functions

- Support 2 x channels I²C
- Detect/generate Start and Stop events
- Identify its slave (ID) address (in Slave mode)
- Identify the transfer direction (receive/transmit)
- Transfer data byte-wise according to the SCL clock line
- Generate an ACK signal following a byte receive
- Inspect an ACK signal following a byte transmit
- Generate vectored interrupt for receive and transmit events and receive/transmit/bus error exceptions
- Generate the clock signal (in Master mode)

4.14 UART Functions

- Support 2 x UART interfaces and one of them supports HSUART mode
- Programmable Baud Rate Generator
- 5- to 8-bits full-duplex asynchronous serial communication.
- Parity generation and error detection
- HSUART mode supports communication at up to 115,200 bps x2 and 115,200 bps x8 (TBD)
- UART mode supports communication at up to 115,200 bps

4.15 SPI Functions

- 2 x Master /Slave Serial Peripheral Bus Interface
- 8- or 16-bits Programmable Data Length Per Chip Select
- Programmable Phase and Polarity Per Chip Select (master mode)
- Communication at up to main (clock/2) bps (slave), main (clock/2) bps(master mode)

4.16 SPI Bridge Functions

- Host can program the serial flash directly via SPI interface by using SPI Bridge. (TBD)

5. Peripheral Descriptions

5.1 I²C Interface

The I²C is a standard 2 wire serial interface used to connect the acacia with I²C device or host. I²C bus application includes EEPROM, LCD, host controllers. The I²C interface is able to:

- Detect/generate Start and Stop events
- Identify its slave (ID) address (in Slave mode)
- Identify the transfer direction (receive/transmit)
- Transfer data byte-wise according to the SCL clock line
- Generate an ACK signal following a byte receive
- Inspect an ACK signal following a byte transmit
- Generate vectored interrupt for receive and transmit events and receive/transmit/bus error exceptions
- Generate the clock signal (in Master mode)

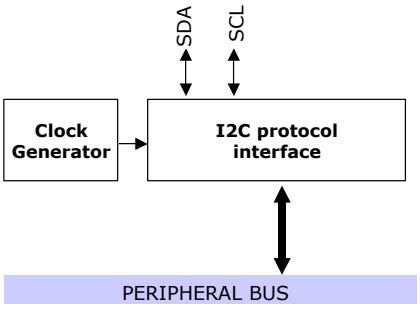


Figure 5-1 I²C Block Diagram

5.2 SPI Interface

The SPI makes a serial communication with external through SPM_CLK, SPM_CSN, SPM_DI, SPM_DO pin. The SPM_CLK is clock for the serial communication, SPM_CSN are chip enable signals, SPM_DI is serial data-in, and SPM_DO is serial data-out.

The SPM Master communicates in unit of 8-bits character. If CPU writes the contents to communicate to command register, SPI Master executes communication for command register and then clears the VALID bit in command register with 0 and stops operation. That is, always when CPU sends command through command register, SPI Master does its operations.

The SPI communicates in specified unit of character and the length of character, which is possible from 1-bits to 16-bits, is defined by setting of register.

The SPI operation modes are DMA mode and non-DMA mode. The DMA mode is used to transfer large data through SPI, it reduces interrupt's occurrence to CPU. In Non-DMA mode, each finish of 1-character transfer makes interrupt to CPU.

5.2.1 Characteristics SPI Bus

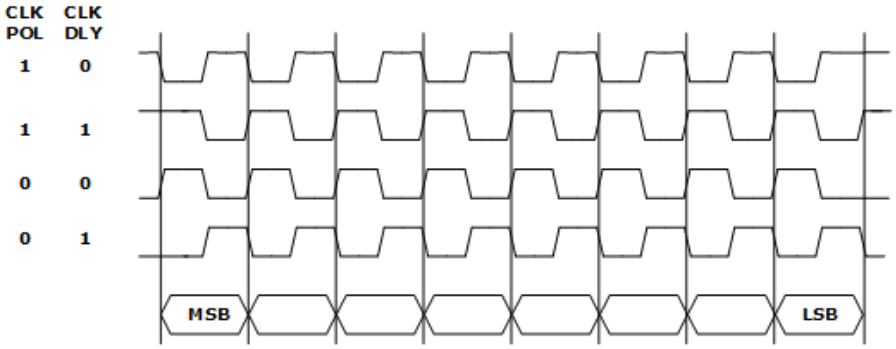


Figure 5-2 SPI Clock Polarity

5.2.2 SPI Timing Diagram

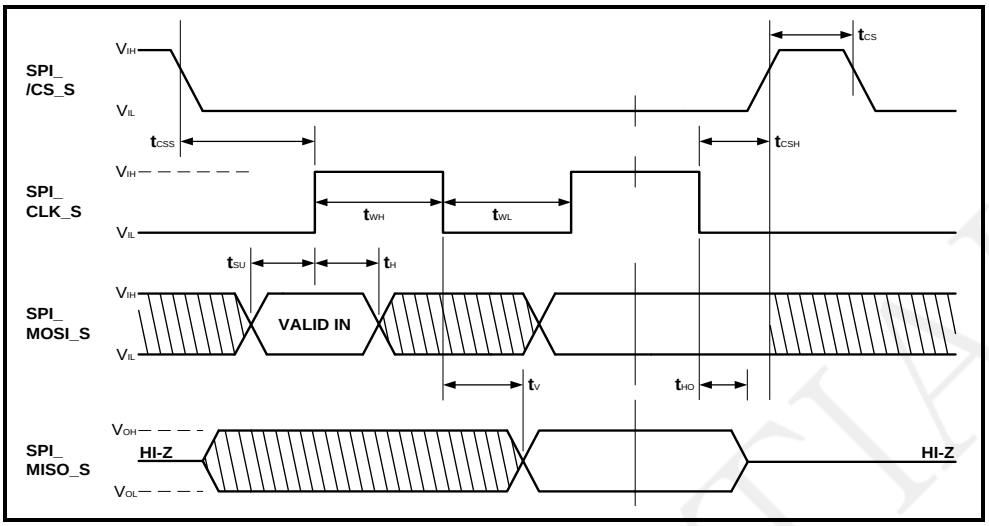


Figure 5-3 SPI Timing Diagram

5.2.3 SPI Timing Characteristics

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
f_{CLKF} f_{CLKN} f_{CLKS}	CLK Clock Frequency	Normal Mode Standby Mode	0 0	- -	Fbus/2 Fbus/2	MHz MHz
t_{CS}	Minimum CS High Time		CYC bus * 5	-	-	ns
t_{CSS}	CS Setup Time		CYC bus * 2	-	-	ns
t_{CSH}	CS Hold Time		CYC bus * 2	-	-	ns
t_{WH}	SCK High Time		CYC bus * 1	-	-	ns
t_{WL}	SCK Low Time		CYC bus * 1	-	-	ns
t_{SU}	Data In Setup Time		10	-	-	ns
t_{H}	Data In Hold Time		10	-	-	ns
t_{V}	Data Time		0		20	ns
t_{HD}	Hold Setup Time		0	0	0	ns

Table 5-1 SPI Timing

* Fbus = Bus Frequency, CYC bus = 1 clock cycle time of Bus Clock
* PAIOS²-AD's Bus Frequency ≒ 170 MHz (TBD) in Reference Firmware.

5.3 UART Interface & HSUART Interface

The UART (Universal Asynchronous Receiver/Transmitter) core and HSUART (High Speed Universal Asynchronous Receiver/Transmitter) core provides serial communication capabilities, which allow communication with modem or other external devices, like another computer using a serial cable and RS232 protocol. This core is designed to be maximally compatible with the industry standard National Semiconductors' 16550A device. The UART core implements the AMBA bus interface for communication with the system. It has an 8-bits data bus for compatibility reason. The core requires one interrupt. It requires 2 pads in the chip (serial in and serial out) and, optionally, another six modem control signals, which can otherwise be implemented using general purpose I/Os on the chip.

5.4 I²S TX Interface

I²S TX is peripheral which delivers audio data to DAC and it support DMA. DMA reduce interrupt frequency to DSP core as a result DMA increase whole chip operation efficiency.

- In slave mode, I²S TX receives the signal BCLK, LRCK from outside device possibly codec/DAC.
- In master mode, divided DSP core clock signals are delivered to outside device as MCLK, BCLK and LRCK.

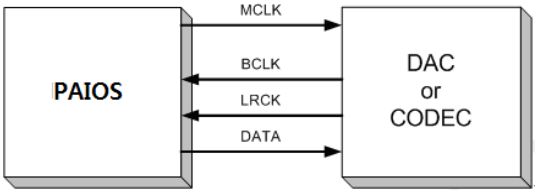


Figure 5-4 I²S Slave Mode = DAC Master Mode

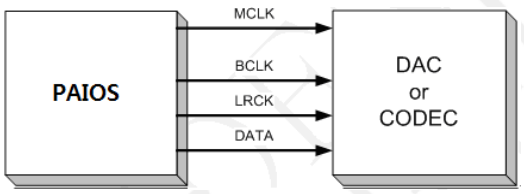


Figure 5-5 I²S Master Mode = DAC Slave Mode

In the block diagram below, signal name which is ended with "_S" are supplied by outside device in slave mode. Signal name which is ended with "_M" are drive outside device in master mode. MCLK does not exist in I²S specification but generally used by commercially available CODEC/DAC as main clock to support specific sampling frequency.

BCLK is serial clock and LRCK is word select signal.

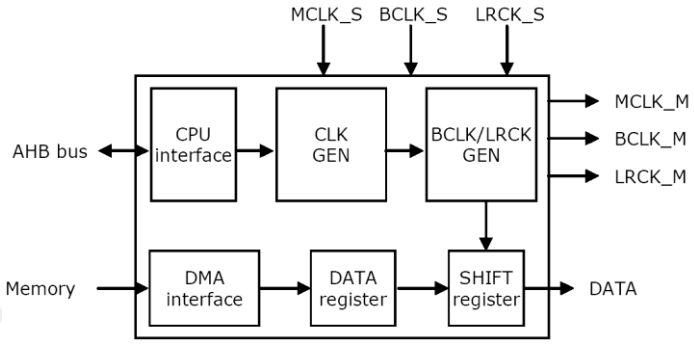


Figure 5-6 I²S Interface Block Diagram

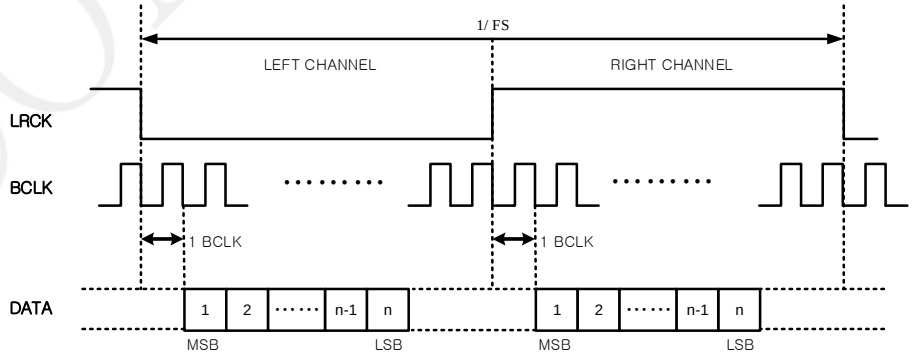


Figure 5-7 I2S Timing Diagram

- The MSB is available on the 2nd rising edge of BCLK following a DATA transition.

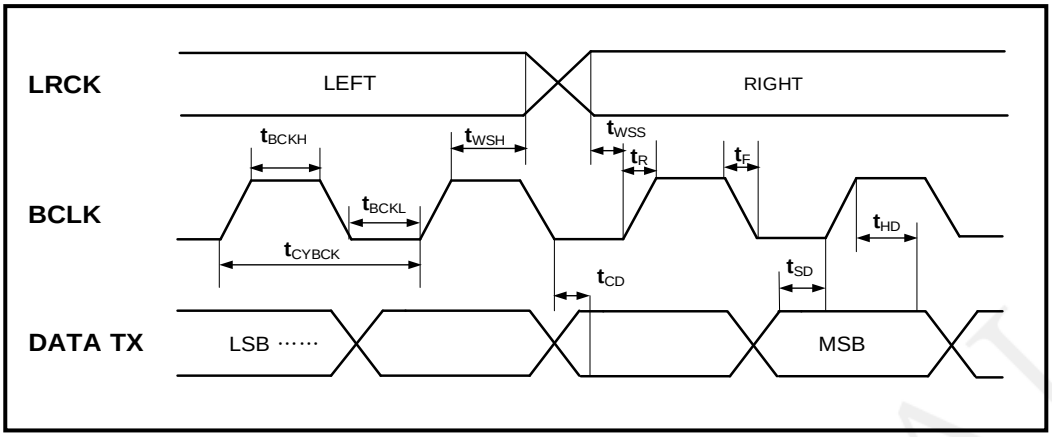


Figure 5-8 I2S TX Timing Diagram

Symbol	Parameter	Condition	Min	Typ	Max	Unit
-	Duty Cycle	-	-	50		%
t_{CYBCK}	BLCK Cycle Time	Output / 48Khz	320			ns
t_R	Rising Time				0.15 x t_{CYBCK}	ns
t_F	Falling Time				0.15 x t_{CYBCK}	ns
t_{BCKH}	BCLK High Time		0.35 x t_{CYBCK}			ns
t_{BCKL}	BCLK Low Time		0.35 x t_{CYBCK}			ns
t_{SD}	Data Set-up time		0.2 x t_{CYBCK}			ns
t_{HD}	Data hold time		0.2 x t_{CYBCK}			ns
t_{CD}	Clock to Data delay time				0.15 x t_{CYBCK}	ns
t_{WSS}	WS set-up time		0.2 x t_{CYBCK}			ns
t_{WSH}	WS hold time		0.2 x t_{CYBCK}			ns

Table 5-2 I2S TX Timing Table

Sample Rate Frequency	LRCK	BCLK	Valid Data Bit Number (n) *2)	MCLK	MODE
24 KHz*1)→48KHz	48KHz	3.072MHz	16-bits	12.288MHz	DAB
32 KHz*1)→48KHz	48KHz	3.072MHz	16-bits	12.288MHz	DAB+ DAB+(16KHz SBR)
44.1KHz*1)→48KHz	48KHz	3.072MHz	16-bits	12.288MHz	DMB-A
48KHz	48KHz	3.072MHz	16-bits	12.288MHz	DAB, DAB+, DMB-A DAB+(24KHz SBR)

Table 5-3 Sample Rate Frequency Table

Note

1) PAIOS²-AD has sample rate conversion function. So basically contents of 8, 12, 24, 32, 44.1KHz sample rate will be converted to 48KHz sample rate.

2) The number of all data in each channel is 32-bits

5.5 I²S RX Interface

I²S RX is peripheral which delivers audio data from outside of chip and it supports DMA mode. DMA reduce interrupt frequency to DSP core as a result DMA increase whole chip operation efficiency.

- Clock signals and data are delivered to outside device as BCLK, LRCK and DATA.

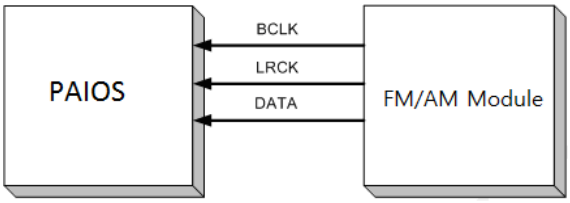


Figure 5-9 I²S RX Mode

Please refer to below block diagram.

In the block diagram below, signal name which is ended with "_S" are supplied by outside device

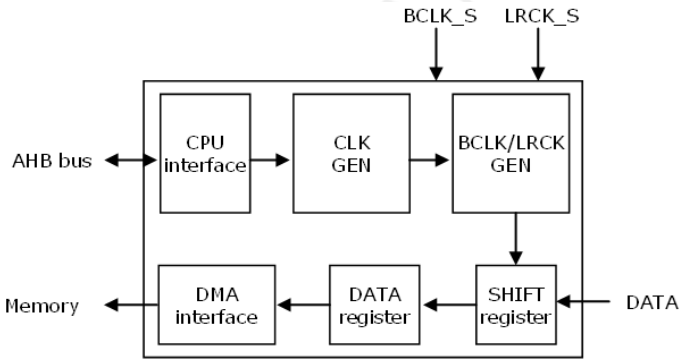


Figure 5-10 I²S RX Interface Block Diagram

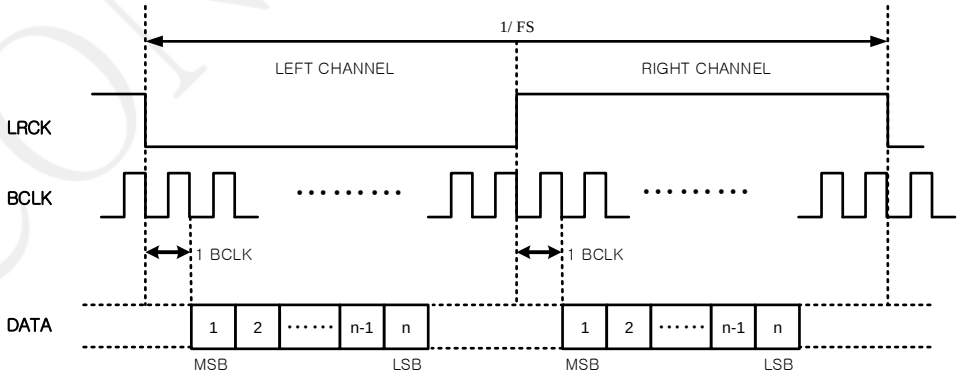


Figure 5-11 I²S RX Timing Diagram

- The MSB is available on the 2nd rising edge of BCLK following a DATA transition.

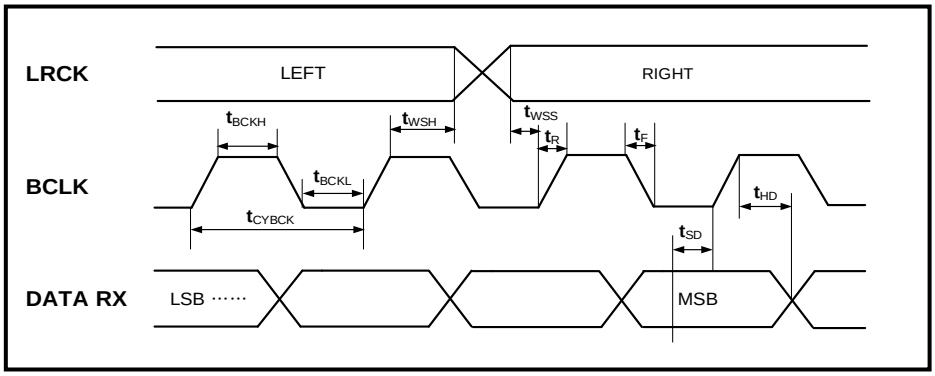


Figure 5-12 I²S RX Timing Diagram

Symbol	Parameter	Condition	Min	Typ	Max	Unit
-	Duty Cycle	-	-	50		%
t_{CYBCK}	BLCK Cycle Time	Input / 48Khz	320			ns
		Input / 44.1Khz	360			ns
t_R	Rising Time				0.15 x t_{CYBCK}	ns
t_F	Falling Time				0.15 x t_{CYBCK}	ns
t_{BCKH}	BCLK High Time		0.35 x t_{CYBCK}			ns
t_{BCKL}	BCLK Low Time		0.35 x t_{CYBCK}			ns
t_{SD}	Data Set-up time		0.2 x t_{CYBCK}			ns
t_{HD}	Data hold time		0.2 x t_{CYBCK}			ns
t_{WSS}	WS set-up time		0.2 x t_{CYBCK}			ns
t_{WSH}	WS hold time		0.2 x t_{CYBCK}			ns

Table 5-4 I2S RX Timing Table

Sample Rate Frequency	LRCK	BCLK	Valid Data Bit Number (n) *2)	MODE
24KHz*3)	24KHz	1.536MHz	16-bits	I²S RX mode1)
32KHz*3)	32KHz	2.048MHz	16-bits	
44.1KHz	44.1KHz	2.8224MHz	16-bits	
48KHz	48KHz	3.072MHz	16-bits	

Table 5-5 Sample Rate Frequency Table

Note*

1) PAIOS-AD has sample rate conversion function in I²S RX mode.

2) The number of all data is 32-bits and 16-bits will be valid in I²S RX's data.

3) 24Khz and 32Khz sample rate clock is reserved for customizing future option.

5.6 Digital I/Q Interface

- Digital I/Q Interface is peripheral which delivers RF tuner's I & Q data from outside of chip and it support DMA. DMA reduces interrupt frequency to DSP core as a result DMA increases whole chip operation efficiency.

- Clock signals and data are delivered to outside device as BCLK, LRCK and Serial Data-I / Serial Data Data-Q

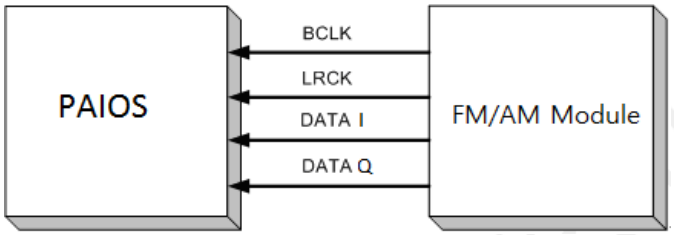


Figure 5-13 Digital I/Q Mode

- Support Split mode , Multiplexed mode , Analog/digital mode

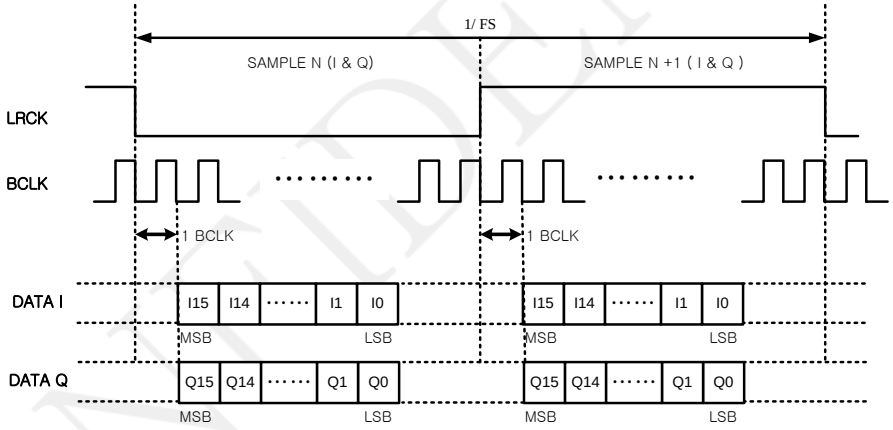


Figure 5-14 Digital I/Q Split mode Timing Diagram

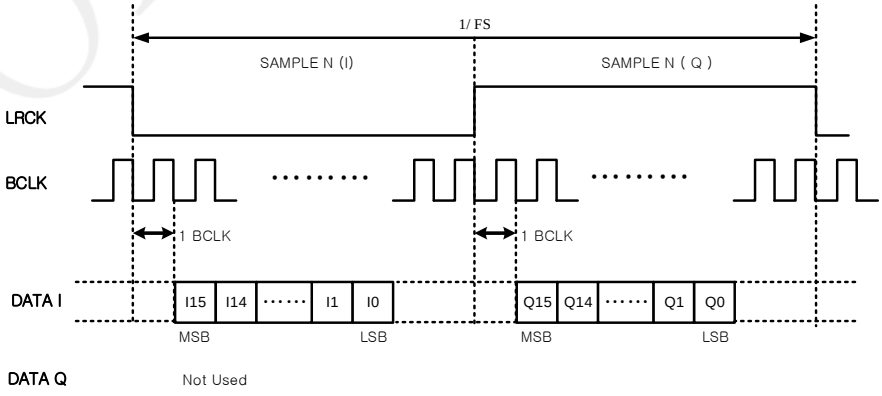


Figure 5-15 Digital I/Q Multiplexed mode Timing Diagra

5.7 Built-in RF tuners or DAB Band3

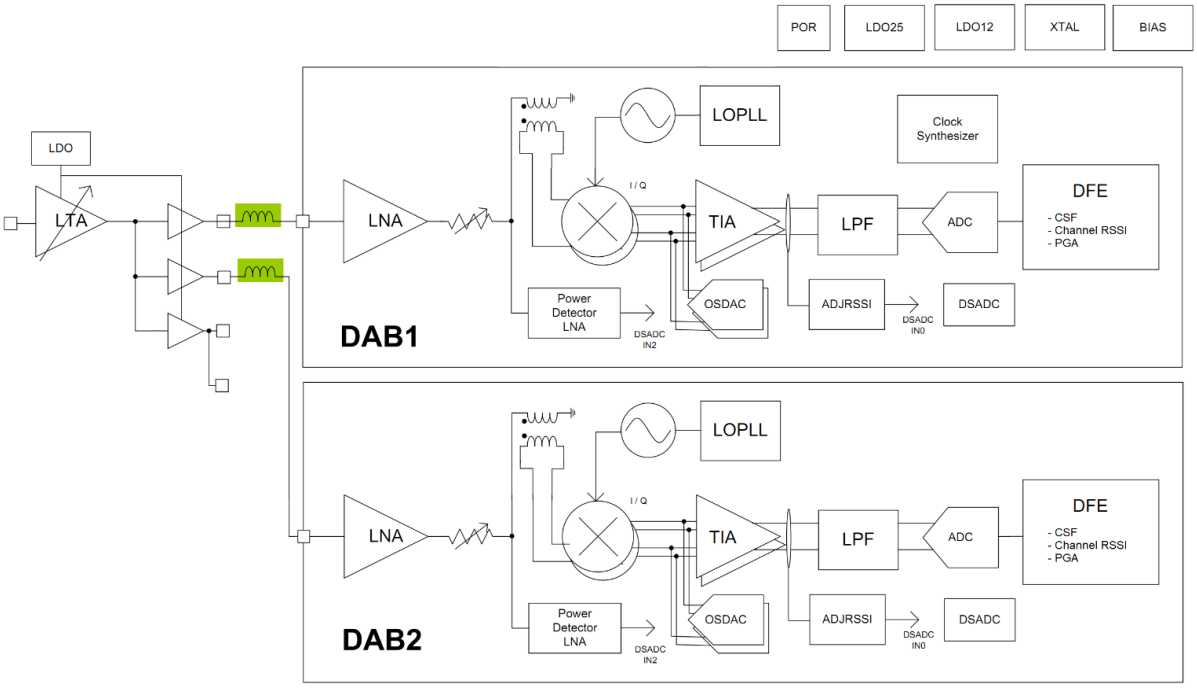


Figure 5-16 Built-in RF tuner Functional Block Diagram

The built-in RF tuners are highly integrated CMOS Receiver IP for DAB. The RF inputs can operate wideband range from 174MHz to 245MHz for DAB. The building blocks include LNA, RFPGA, I/Q down conversion mixer, bandwidth adjustable high-pass filter, baseband PGA, fractional-N frequency synthesizer with fully integrated VCO and LDO. The on-chip low phase noise VCO, along with the high-resolution fractional-N frequency synthesizer makes in-band phase noise low enough for reliable Radio applications.

6. Application

6.1 Clock application

− *Crystal Oscillator*

PAIOS²-AD has an oscillation circuit and PLL. It can generate the Master clock by connecting to a crystal oscillator, a capacitor and a fixed resistor as shown in the circuit diagram below.

It is recommended to use a crystal oscillator with a maximum frequency tolerance of ±50ppm.

Please contact the manufacturer of the crystal oscillator for the appropriate values of the load capacitors and resistors. PAIOS²-AD input clock is available only for 24.576MHz.

6.2 Operation Mode Selection

– *BMODE[0] (Pin L2)*

BMODE[0] = {1} : System clock input from Crystal Oscillator is 24.576Mhz (system requirement)

BMODE[0] = {0} : Reserved for future use

– *BMODE[1:2] (Pin K1 & Pin L1)*

BMODE [1][2] = {0 , 1} : Normal system booting mode with firmware in serial flash.

BMODE [1][2] = {1 , 1} : Firmware program mode into serial flash via UART downloading

BMODE [1][2] = {1 , 0 } : SPI bridge mode between SPM0 and NSPI0. Host can directly access to serial flash(TBD)

– *AWAKE (P13) –TBD-*

This pin should be controlled to Low during normal system operation

– *BBMODE & TEST0 (Pin K2 & K3)*

This pin should be connected to ground [Low state] for normal system booting mode with DSP.

– *STD[0:1] (Pin L3 & Pin M3)*

STD0, STD1 = {0 , 0} : User Define mode for post audio processing

STD0, STD1 = {1 , 0} : DAB Standard mode

STD0, STD1 = {0 , 1} : Reserved for future use

STD0, STD1 = {1 , 1} : DAB & DRM Standard mode

7. Electrical Characteristics

7.1 Absolute Maximum Rating

Operating the PAIOS²-AD under conditions that exceed those listed in Table 9-1 may result in damage to the device. Absolute maximum ratings are limiting values and are considered individually, while all other parameters are within their specified operating ranges. Functional operation of the PAIOS²-AD device under any of the conditions listed in Table 9-1 is not implied. Exposure to absolute maximum ratings for extended periods of time may affect the device's reliability.

Symbol	Description	Value	Units
T_J	Junction temperature	-40 to +125	°C
V_{VDDI}	Core Supply Voltage	-0.5 to + 1.4	V
V_{VDDE}	I/O Supply Voltage	-0.5 to + 3.6	V
V_{VDD33}	Analog I/O Supply Voltage	-0.5 to + 3.6	V
V_{VDD12} V_{VDD12P}	Analog Core Supply Voltage	-0.5 to + 1.4	V

Table 7-1 Absolute Maximum Ratings

7.2 Recommended operating conditions

Symbol	Description	Min	Max	Units
T_{op}	Operation Temperature	-40	+85	°C
T_{STG}	Storage Temperature	-50	+150	°C
V_{VDDI}	Core Supply Voltage	1.08	1.32	V
V_{VDDE}	I/O Supply Voltage (I/O=3.0V mode)	2.7	3.3	V
	I/O Supply Voltage (I/O=3.3V mode)	2.97	3.63	V
V_{IH}	High Level Input voltage at I/O	0.7 * V_{VDDE}	V_{VDDE} +0.3	V
V_{IL}	Low Level Input voltage at I/O	V_{VDDE} -0.3	0.3 * V_{VDDE}	V
V_{HYS}	Input Hysteresis Voltage	0.4	-	V
V_{VDD12} V_{VDD12P}	Analog Core Supply Voltage	1.14	1.26	V
V_{VDD33}	Analog Supply Voltage (3.0V mode)	2.85	3.15	V
	Analog Supply Voltage (3.3V mode)	2.97	3.63	V

Table 7-2 Recommended Ratings

7.3 Power-on and Reset Timing

Please refer to timing chart and table for proper power-on and IC reset.

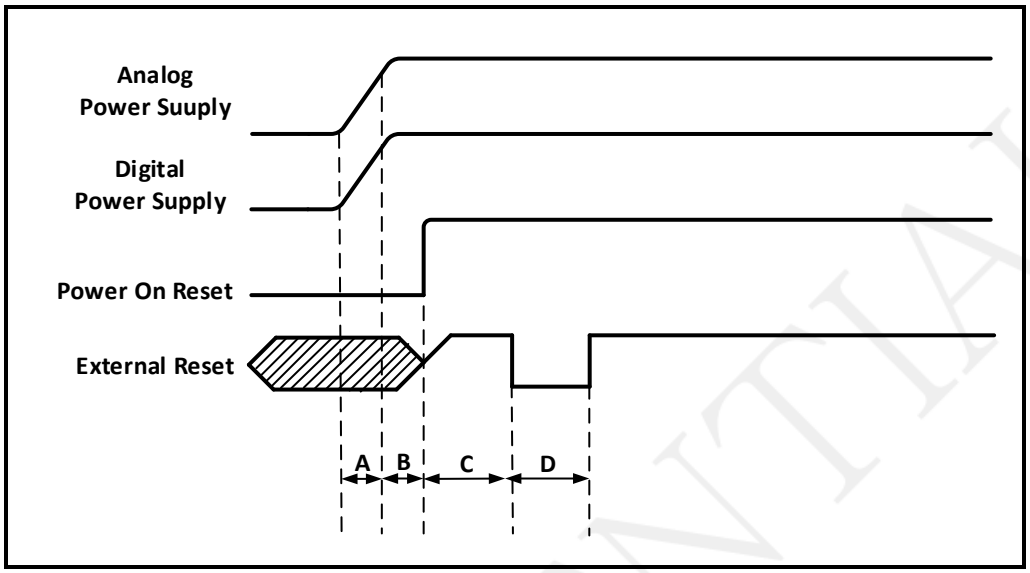


Figure 7-1 Power Sequence Timming Chart

Characteristic	Condition	Symbol	Min	Max	Unit
Power Supply Rising Time	Room Temperature	A	10	500	µs
	Over +85℃		10	150	µs
IC Internal Power on Reset *1)	Room Temperature	B	24	110	µs
	Over +85℃		12	50	µs
Idle State after System Reset	C	C	Don't Care	-	µs
External System Reset	D	D	500	-	µs

Table 7-3 Power-on and Reset Timing

In *Table 9-3*, if the *Power Supply Rising Time(A)* exceeds over 150 us, the *External Reset(D)* must to be toggled for guaranteed system reset.

Note *1) The required *IC Internal Power on Reset(B)* time is varied according to *Power Supply Rising Time(A)* and IC internal logic characteristic. So, the external interface should be operated after (A)+(B) time have passed from Power supply switch ON.

7.4 Power Consumption

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$I_{VDD12-ALL}$	Supply Current for Core	$V_{VDD12ALL}$ = 1.2V Dual DAB Mode	-	311.9	-	mA
I_{VDDE}	Supply Current for IO	V_{VDDE} = 3.0V Dual DAB Mode	-	19.6	-	mA
I_{VDD_RA}	Supply Current for RF & Analog	V_{VDD_RA} =3.0V Dual DAB Mode	-	188.1	-	mA
P_{TPOW}	Total Power Consumption	Dual DAB Mode	-	997.4	-	mW

Table 7-4 Power Consumption (TBD)

8. *Package Dimension*

- The Package dimension of PAIOS²-AD

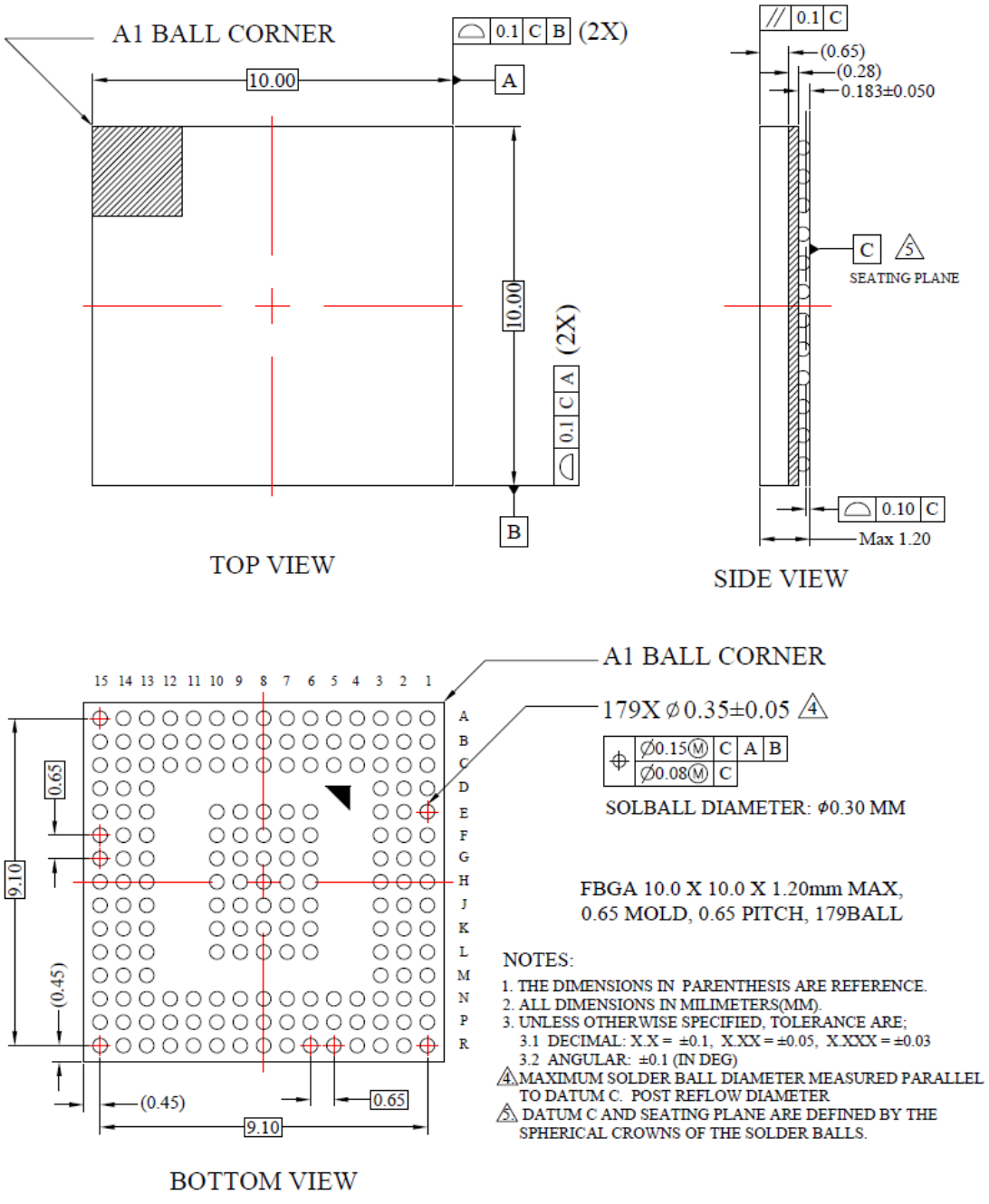


Figure 8-1 PAIOS²-AD Package Dimension

9. PCB Mounting Guidelines

Guidelines for mounting the PAIOS²-AD onto a printed circuit board (PCB) are presented in this part, including land pad and handling, SMT Process.

9.1 Board Pad Design

Item	Symbol	Recommendation
Pad pitch (mm)	PP	0.65
Pad diameter (mm)	PD	0.30
Solder mask open(mm)	MO	0.30

Table 9 -1 Board Pad Design

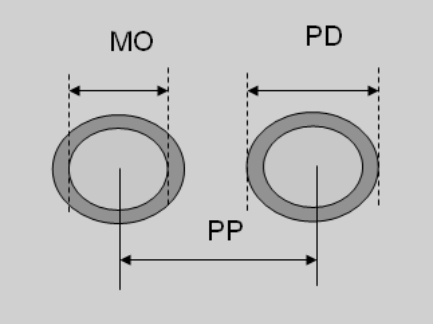


Figure 9-1 Pad design

9.2 Handling

Floor life time will be modified by environmental conditions other than 30'C/60%RH. If partial lots are used, the remaining SMD packages must be resealed or placed in safe storage within one hour of bag opening.

Refer to JEDEC spec (J-STD-033B) for details

Level	Floor life (out of bag) at factory Ambient 30'C/60%RH or as started
2	1 year
2a	4 weeks
3	168 hours
4	72 hours

Table 9 -2 Moisture classification level and floor life

9.3 DRYING

Component drying options for various moisture sensitivity levels and ambient humidity exposures of £≤ 60% RH are given in the following tables. Drying per an allowable option resets the floor life clock. If dried and sealed in an MBB with fresh desiccant, the shelf life is reset. Table 12-3 gives conditions for re-bake of SMD packages at a user site after the floor life has expired or other conditions have occurred to indicate excess moisture exposure.

PAIOS²-AD's condition: **Leve3, 9 hours, Bake @125℃**

Package Body Thickness	Level	Bake @ 125°C		Bake @ 90°C ≤ 5% RH		Bake @ 40° C ≤ 5% RH	
		Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤ 72 hours	Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤ 72 hours	Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤ 72 hours
	2						
≤ 1.4mm	2a	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	3	**9 hours**	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	23 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days

Table 9 -3 Reference Conditions for Drying Mounted or Un-mounted SMD Packages

9.4 SMT Process

- Screen print process

1. Type3 or type4 is recommended for solder paste.
2. No clean flux is recommended for lead-free condition.

- Component placement

Standard pick-and-place machines can be used for placing a package. The following methods can be used for recognition and positioning

1. Use ball inspection and compliant tip nozzle
2. It is recommended that the side-lighting option on pick and place machine
3. It is preferable to use IC placement/ fine pitch placement machines over chip-shooters for better accuracy.
4. Solder ball self-align when placed at an offset due to self-centering nature of it.
5. Little or no force needs to be exerted during placement to prevent damage to a part.
   It is recommended that balls be dipped into solder paste on PCB to greater than 20% of paste block height.

- Reflow and cleaning

1. Compatible with industry standard reflow process for both lead-free process.
2. Qualified for up to three reflow operation (260˚C peak) per J-STD-020.
3. Nitrogen gas is recommended (oxygen level<75ppm) to avoid oxidation or void formation.
4. Reflow profile depends on whole parts and board density.
5. Follow recommended recipe from paste manufacturer for reflow profile.

- Rework

The key features for rework are listed below.

1. Rework procedure used is identical to the one used for most BGA packages.
2. Rework reflow process should duplicate original reflow profile used for assembly.
3. Rework system should include localized convection heating element with profiling capacity, a bottom side pre-heater and a part pick and placer with image overlay.

9.5 The temperature profile of a reflow process

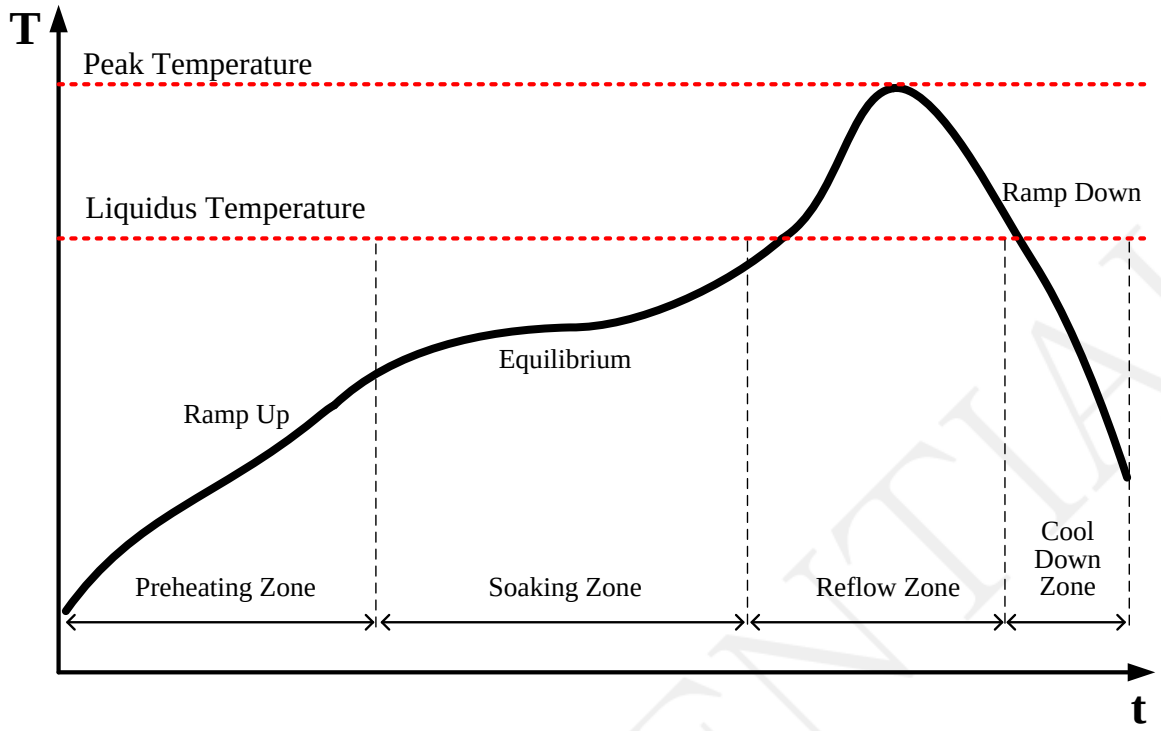


Figure 9-2 The temperature profile of a reflow process

Parameter	Tin-lead Alloy (SnPb or SnPbAg)	Lead-free Alloy (SnAgCu)	Main Requirements From
Preheating rate	2.5℃/sec	**2.5℃/sec**	Flux system(Solder paste)
Soaking temperature	140 ~ 170℃	**140 ~ 170℃**	Flux system(Solder paste)
Soaking time	80 second	**80 second**	Flux system(Solder paste)
Peak temperature	225℃	**245℃ ～ 260℃**	Alloy(Solder paste)
Reflow time over Liquidus	60 second	**60 or 90 second**	Alloy(Solder paste)
Liquidus temperature		**217℃or 219℃**	
Cool Down rate	2.5℃/sec	**2.5℃/sec**	

Table 9-4 The temperature profile of a reflow process

10. Part marking

- The marking information of PAIOS²-AD

Line	Description	Image
1st	Company logo	
2nd	Device name*1	
3rd	Application name*2	
4th	Chip revision	
5th	Manufacturing date (KYYWW)*3	
6th (vertical)	Assembly lot number(CYWWPPTTT)*4	

*1 Device name : PAIOS²-AD

*2 Application name : WWR SoC

*3 Manufacturing date : KYYWW

- K : Site
- YYWW : Date code

*4 Assembly lot number : CYWWPPTTT

- C : Customer code
- Y : Years
- WW : Week
- PP : Package code
- TTT : Serial No.

Table 10-1 Marking Information: PAIOS²-AD

PnpNetwork Technologies, Inc.
www.pnpnetwork.com
support@pnpnetwork.com
T : 82-2-2240-0800
3F, Fine Venture BLD, 41 , Seongnamdearo 925beangil, Bundang-gu, Seongnam-si, Gyeonggi-do, Korea 13496