

Preliminary Specification

DAB Series

[PNP All-in-One SOC]

PAIOS²-AD

[Dual/MRC with SL]

DATA SHEET

PnpNetwork Technologies, Inc.

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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 PAIOS ² -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
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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 I ² S TX Functions.....	17
4.10 I ² S 7.1 Channel Functions.....	17
4.11 SPDIF Functions.....	17
4.12 I ² S RX Functions	17
4.13 I ² C Functions	18
4.14 UART Functions.....	18
4.15 SPI Functions.....	18
4.16 SPI Bridge Functions	18
5. Peripheral Descriptions	19

5.1	I ² C 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	I ² S TX Interface.....	23
5.5	I ² S 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		PAIOS ² -AD
Stacked SDRAM Size		16MByte
Package Information	Ball Pitch	0.65mm
	Body Size	10mm × 10mm × 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
PAIOS ² -AD	[MRC Diversity Antenna] DAB 2-ch Receiver Baseband All In One SOC for Audio & Data ^(*) mode with Seamless linking + BGS/Data ^(*) 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 Order type overview

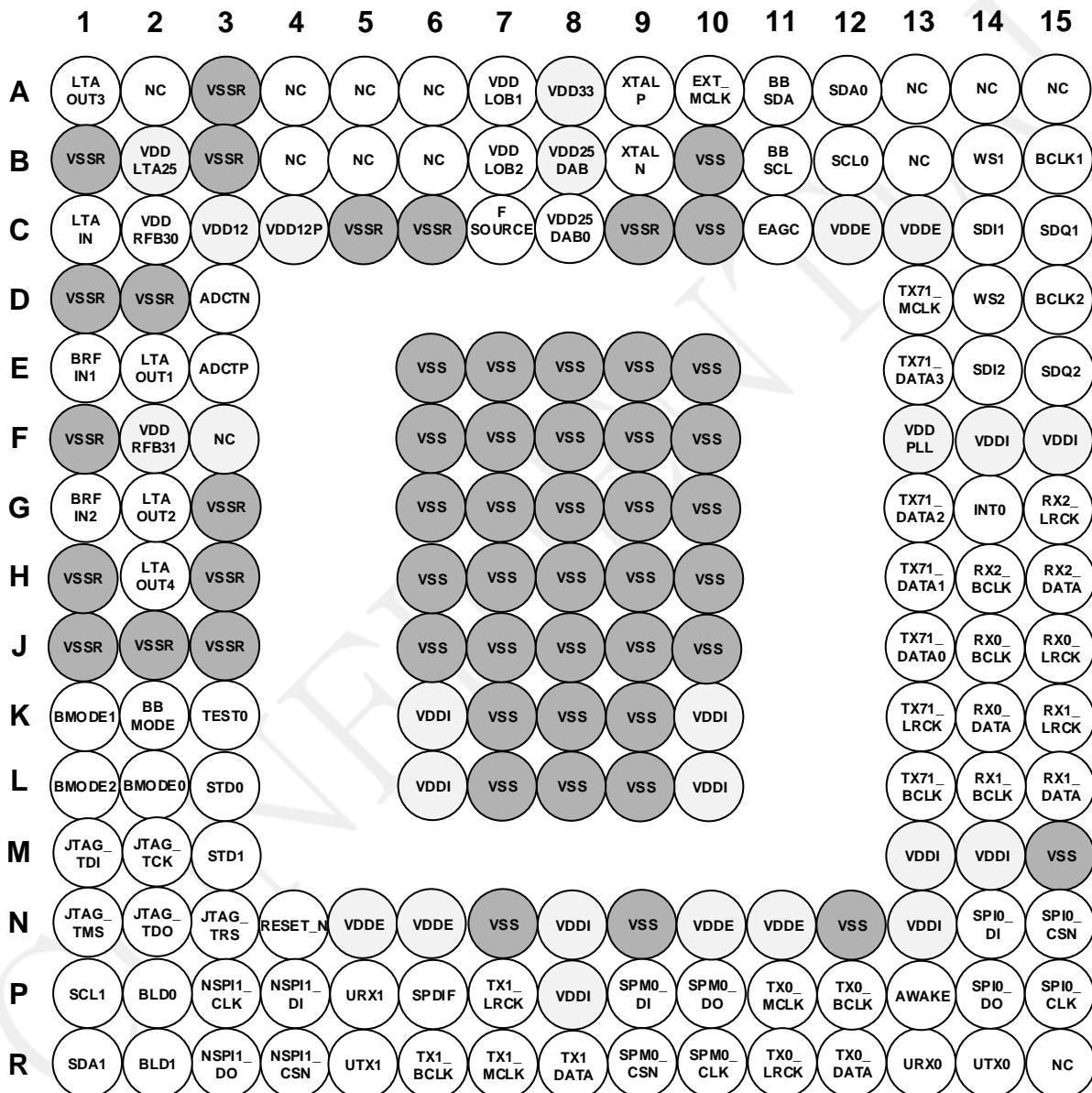
* Note 1: “Audio & Data” means audio and data service are received simultaneous on the same frequency station.

* 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	I ² C DATA (Master Mode only)
B12	I2C_SCL0	O	I2C	I ² C CLK (Master Mode only)
R1	I2C_SDA1	IO	I2C	I ² C DATA (Master/Slave Mode)
P1	I2C_SCL1	IO	I2C	I ² C CLK (Master/Slave Mode)
A11	BB_SDA	IO	I2C	I ² C DATA (Master Mode only)
B11	BB_SCL	O	I2C	I ² C 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	I ² S TX0 Main Clock
R11	TX0_LRCK	IO	I2S	I ² S TX0 Left / Right CLK
P12	TX0_BCLK	IO	I2S	I ² S TX0 Bit Clock

R12	TX0_DATA	O	I2S	I ² S TX0 Data
R7	TX1_MCLK	O	I2S	I ² S TX1 Main Clock
P7	TX1_LRCK	IO	I2S	I ² S TX1 Left / Right CLK
R6	TX1_BCLK	IO	I2S	I ² S TX1 Bit Clock
R8	TX1_DATA	O	I2S	I ² S TX1 Data
D13	TX71_MCLK	O	I2S	I ² S TX71 Main Clock
E13	TX71_DATA3	O	I2S	I ² S TX71 Data3
G13	TX71_DATA2	O	I2S	I ² S TX71 Data2
H13	TX71_DATA1	O	I2S	I ² S TX71 Data1
J13	TX71_DATA0	O	I2S	I ² S TX71 Data0
K13	TX71_LRCK	IO	I2S	I ² S TX71 Left / Right CLK
L13	TX71_BCLK	IO	I2S	I ² S TX71 Bit Clock
J14	RX0_BCLK	I	I2S	I ² S RX0 Bit Clock
J15	RX0_LRCK	I	I2S	I ² S RX0 Left-Right Clock
K14	RX0_DATA	I	I2S	I ² S RX0 Data
L14	RX1_BCLK	I	I2S	I ² S RX1 Bit Clock
K15	RX1_LRCK	I	I2S	I ² S RX1 Left-Right Clock
L15	RX1_DATA	I	I2S	I ² S RX1 Data
H14	RX2_BCLK	I	I2S	I ² S RX2 Bit Clock
G15	RX2_LRCK	I	I2S	I ² S RX2 Left-Right Clock
H15	RX2_DATA	I	I2S	I ² S 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 (TBD)

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 (TBD)

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.

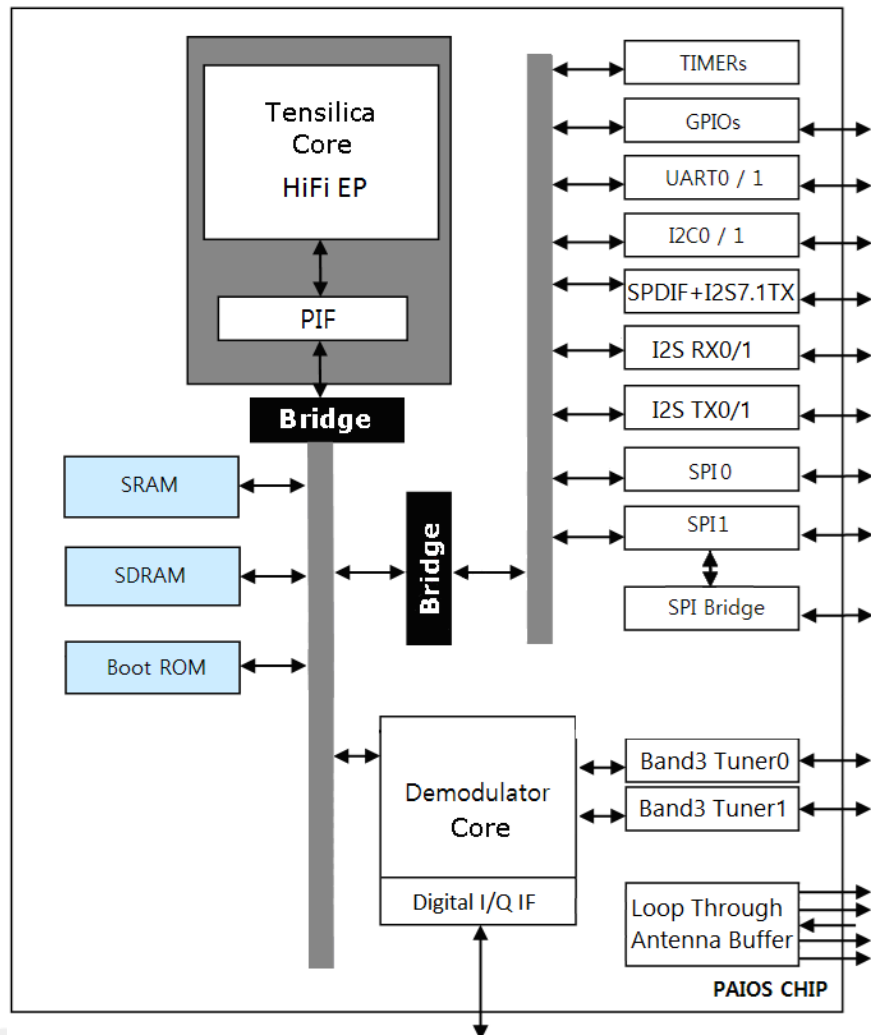


Figure 4-1 Functional Block Diagram

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
- ☐ Relaxed crystal tolerance ($\pm 500\text{ppm}$ @ All modes, Not included RF part clock)

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 automatic 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 through 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)

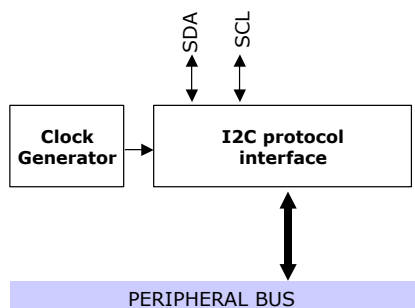


Figure 5-1 I²C Block Diagram

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

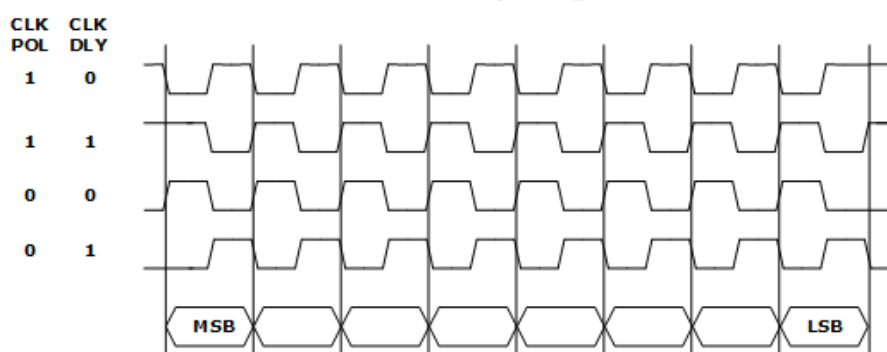


Figure 5-5 SPI Clock Polarity

5.2.2 SPI Timing Diagram

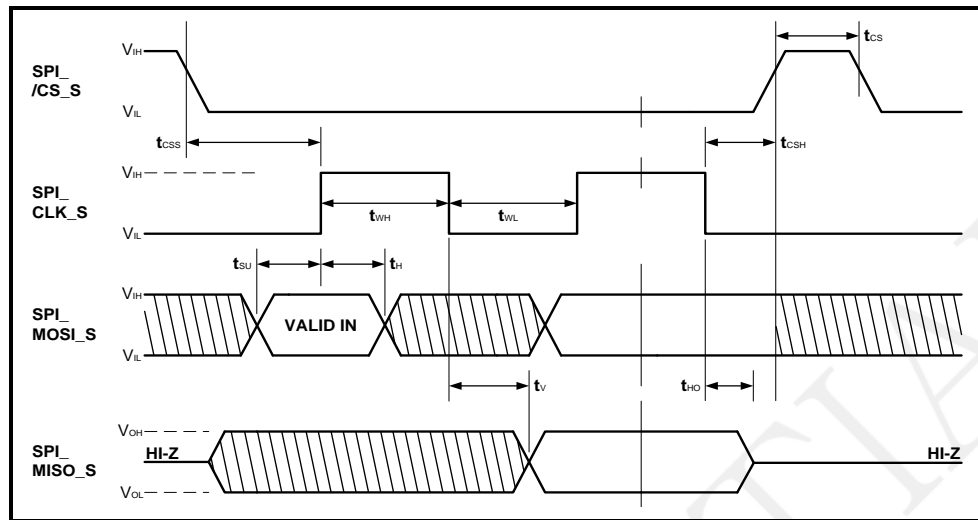


Figure 5-6 SPI Timing Diagram

5.2.3 SPI Timing Characteristics

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
f_{CLKF}	CLK Clock Frequency	Normal Mode	0	-	Fbus/2	MHz
f_{CLKN}		Standby Mode	0	-	Fbus/2	MHz
f_{CLKS}						
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 \approx 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.

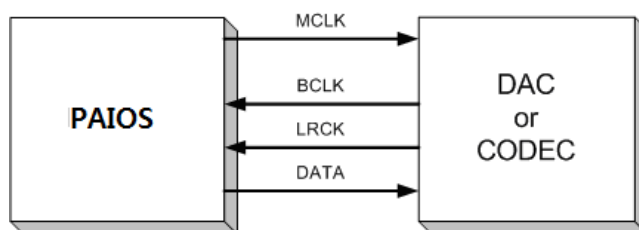


Figure 5-8 I²S Slave Mode = DAC Master Mode

- In master mode, divided DSP core clock signals are delivered to outside device as MCLK, BCLK and LRCK.

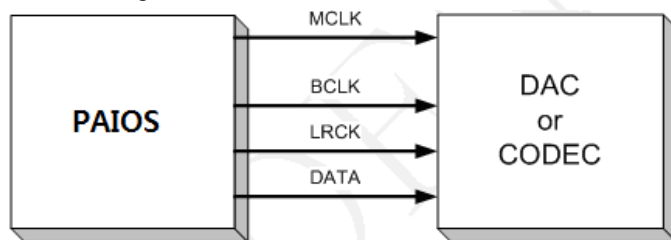


Figure 5-9 I²S Master Mode = DAC Slave Mode

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.

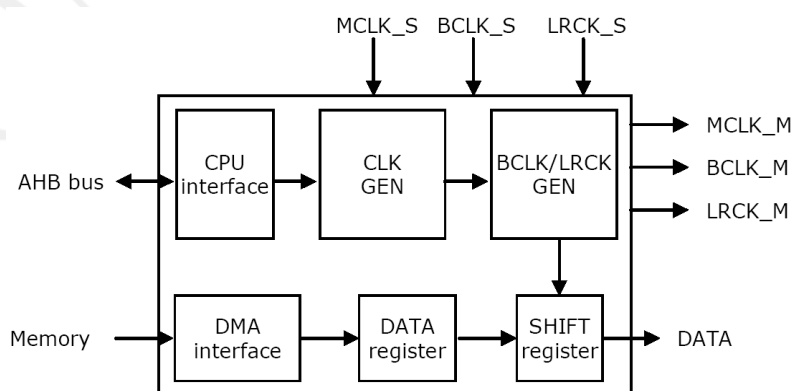


Figure 5-10 I²S Interface Block Diagram

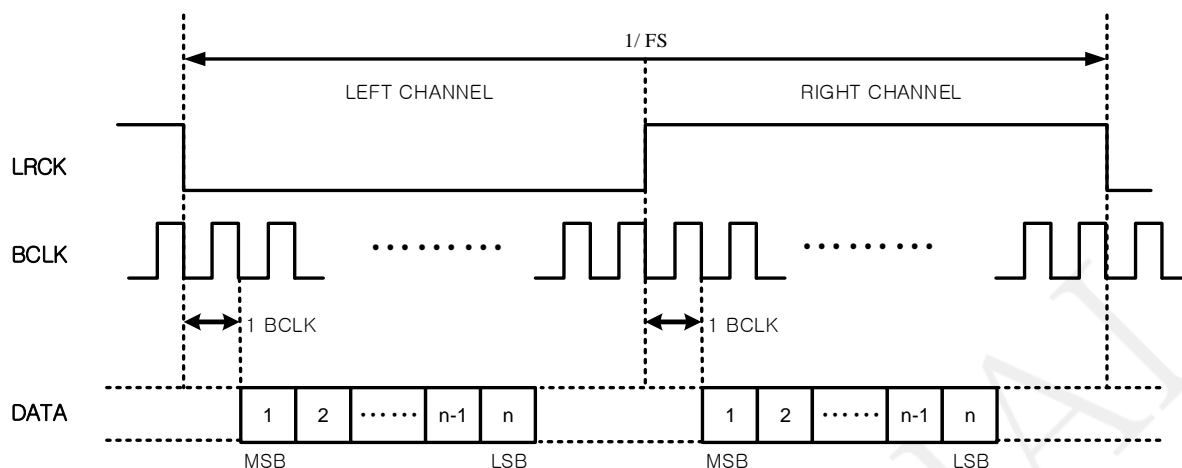


Figure 5-11 I2S Timing Diagram

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

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 5-2 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.

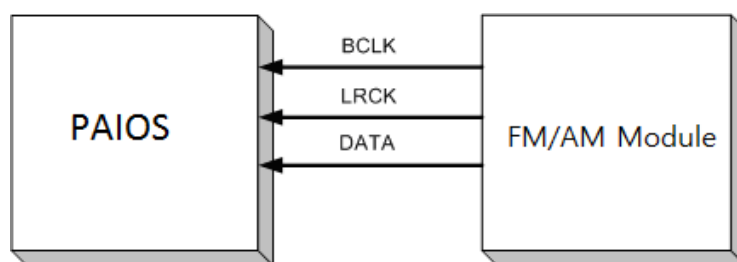


Figure 5-12 I²S RX Mode

Please refer to below block diagram.

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

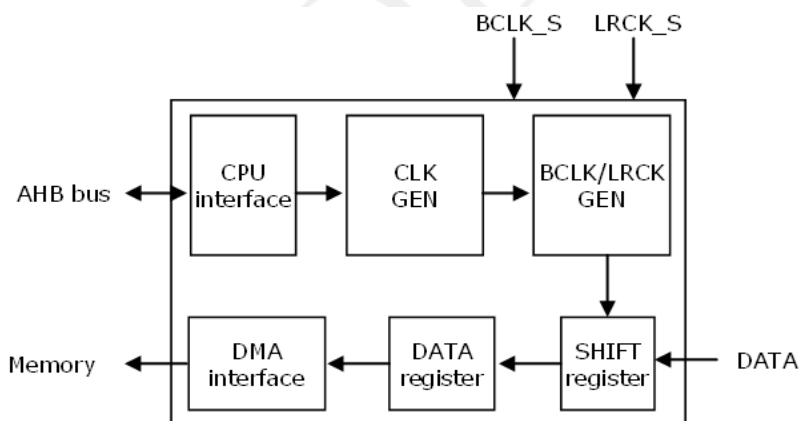


Figure 5-13 I²S RX Interface Block Diagram

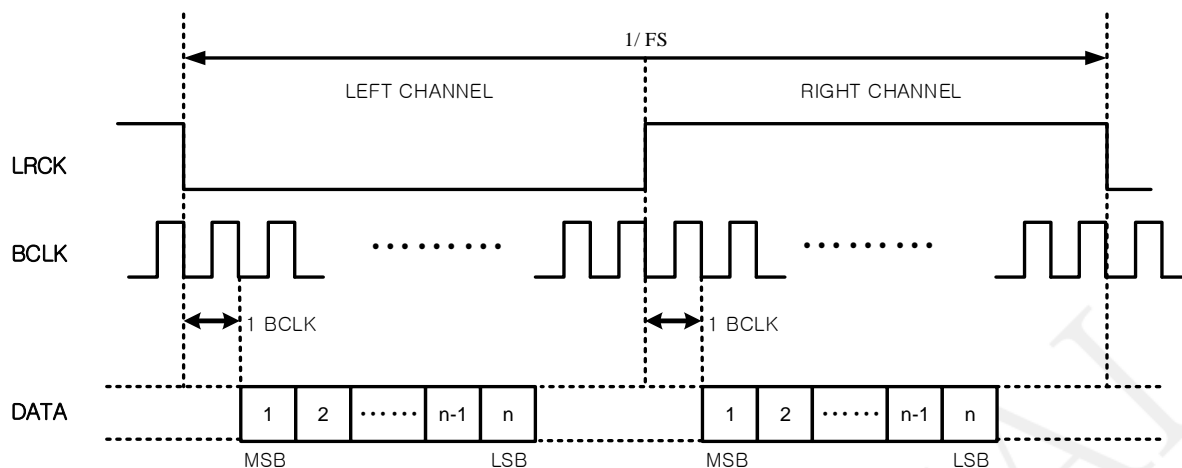


Figure 5-14 I²S RX Timing Diagram

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

Sample Rate Frequency	LRCK	BCLK	Valid Data Bit Number (n) ^{*2)}	MODE
24KHz	24KHz	1.536MHz	16-bits	I ² S RX mode ¹⁾
32KHz	32KHz	2.048MHz	16-bits	
44.1KHz	44.1KHz	2.8224MHz	16-bits	
48KHz	48KHz	3.072MHz	16-bits	

Table 5-3 Sample Rate Frequency Table

Note

1) PAIOS²-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.

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

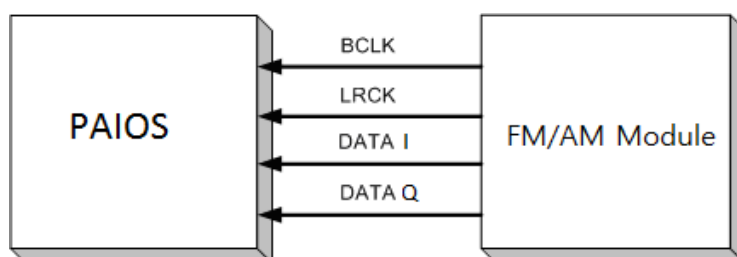


Figure 5-12 Digital I/Q Mode

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

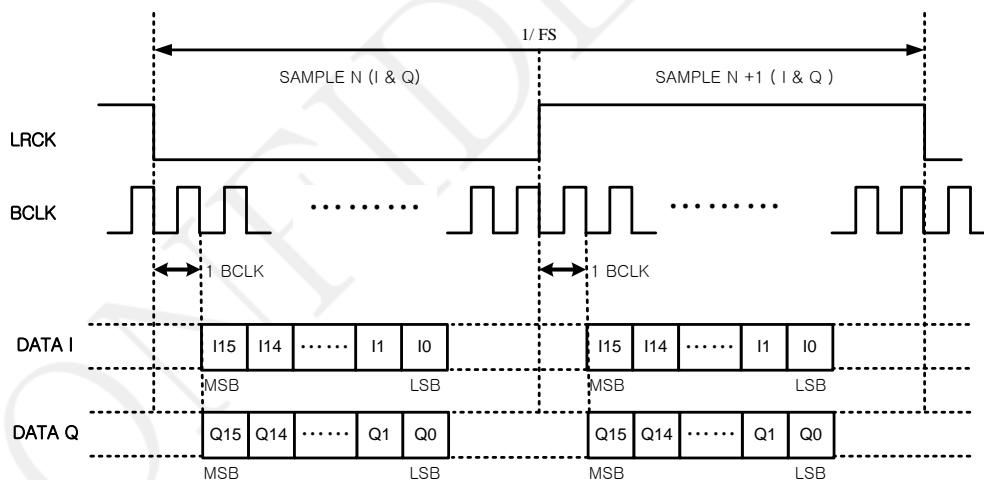


Figure 5-14 Digital I/Q Split mode Timing Diagram

The diagram illustrates a dual-band receiver architecture with two parallel processing paths, DAB1 and DAB2. At the top, a common control and power management section includes blocks for PDR, LDO2B, LDO2, XTAL, and BIAS. A LDO block is connected to the input of the receiver chains. The input signal is split into two paths, each passing through a variable gain amplifier (LNA) and a power detector (Power Detector LNA). The signals then enter the DAB1 and DAB2 blocks. Each DAB block contains an LNA, a mixer (represented by a circle with an 'X'), a LOPLL (Local Oscillator Phase-Locked Loop), a TIA (Transimpedance Amplifier), a LPF (Low Pass Filter), an ADC (Analog-to-Digital Converter), and a DFE (Digital Baseband Processor) block. The DFE block is further divided into CSF (Channel Selection Filter), Channel RSSI (Channel Received Signal Strength Indicator), and PGA (Programmable Gain Amplifier). The receiver is designed to operate at 2.4 GHz.

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 ± 50 ppm.

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

– **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 _{VDDI}	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 9-1 Absolute Maximum Ratings (TBD)

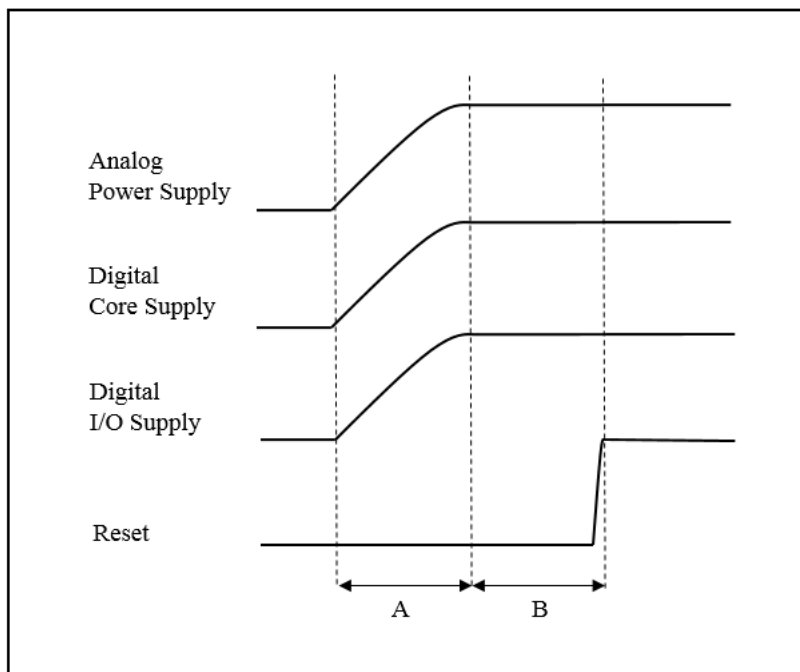
7.2 Recommended operating conditions

Symbol	Description	Min	Max	Units
T _{op}	Operation Temperature	-40	+85	°C
T _{STG}	Storage Temperature	-50	+150	°C
V _{VDDI}	Digital Core Supply Voltage	1.14	1.26	V
V _{VDDE}	Digital I/O Supply Voltage	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 _{VDDI2_RA}	RF & Analog Supply Voltage	1.14	1.26	V
V _{VDD_RA}	RF & Analog Supply Voltage	3.0	3.6	V

Table 9-2 Recommended Ratings (TBD)

7.3 Power-on and Reset Timing

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



Characteristic	Symbol	Min	Max	Unit
Power Supply Sequence	A	Don't Care	-	μs
Setup time for IC Reset	B	500	-	μs

Table 9-3 Power-on and Reset Timing

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 9-4 Power Consumption (TBD)

8. Package Dimension

- The Package dimension of PAIOS²-AD

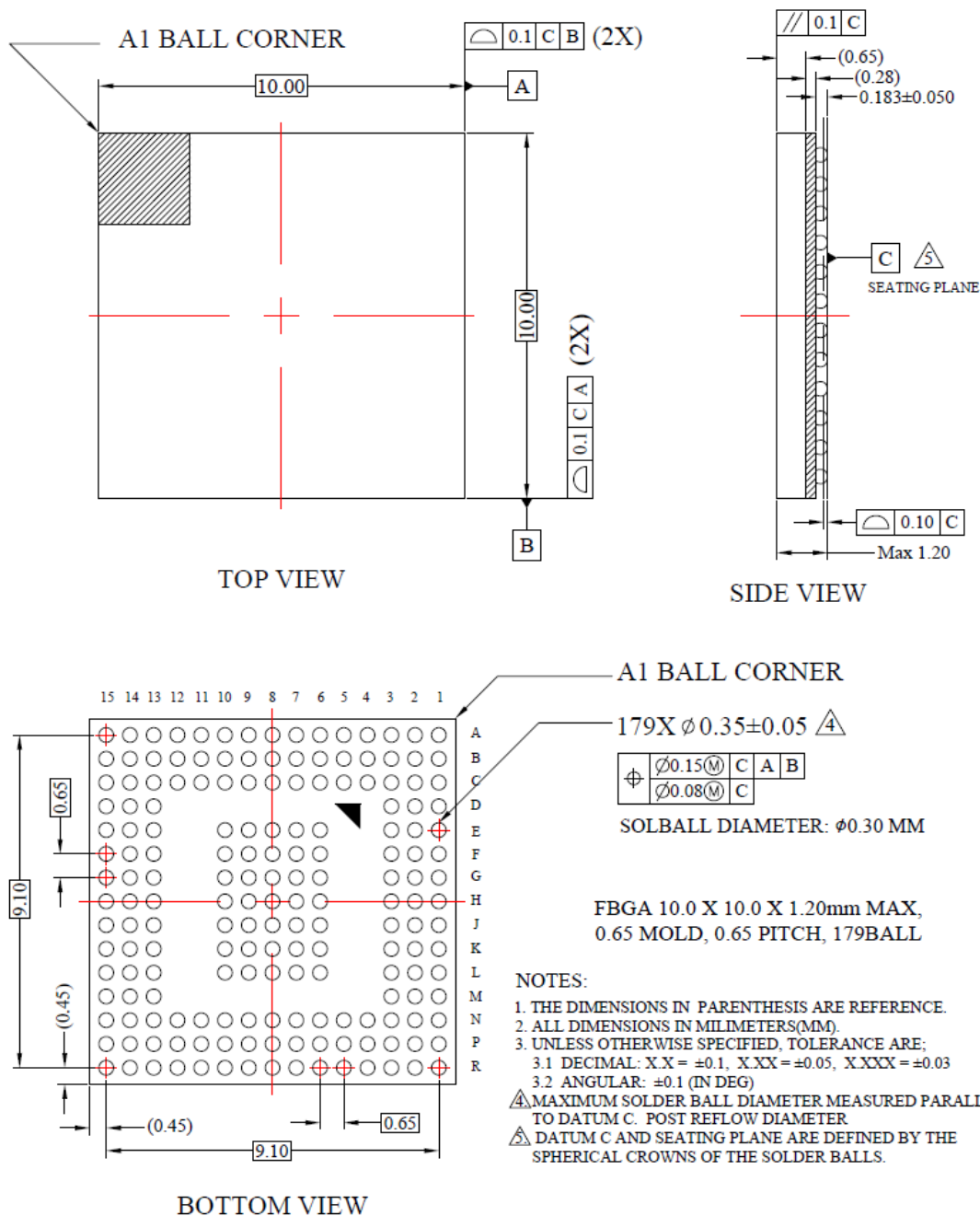


Figure 11.1 PAIOS²-AD Package Dimension

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 12 -1 Board Pad Design

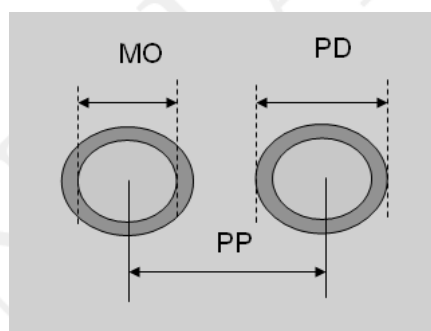


Figure 12-1 Pad design

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 12 -2 Moisture classification level and floor life

9.3 DRYING

Component drying options for various moisture sensitivity levels and ambient humidity exposures of $\leq 60\%$ 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: **Level 3, 9 hours, Bake @ 125°C**

Package Body Thickness	Level	Bake @ 125°C		Bake @ 90°C ≤ 5% RH		Bake @ 40° C ≤ 5% RH	
≤ 1.4mm		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						
	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 12 -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

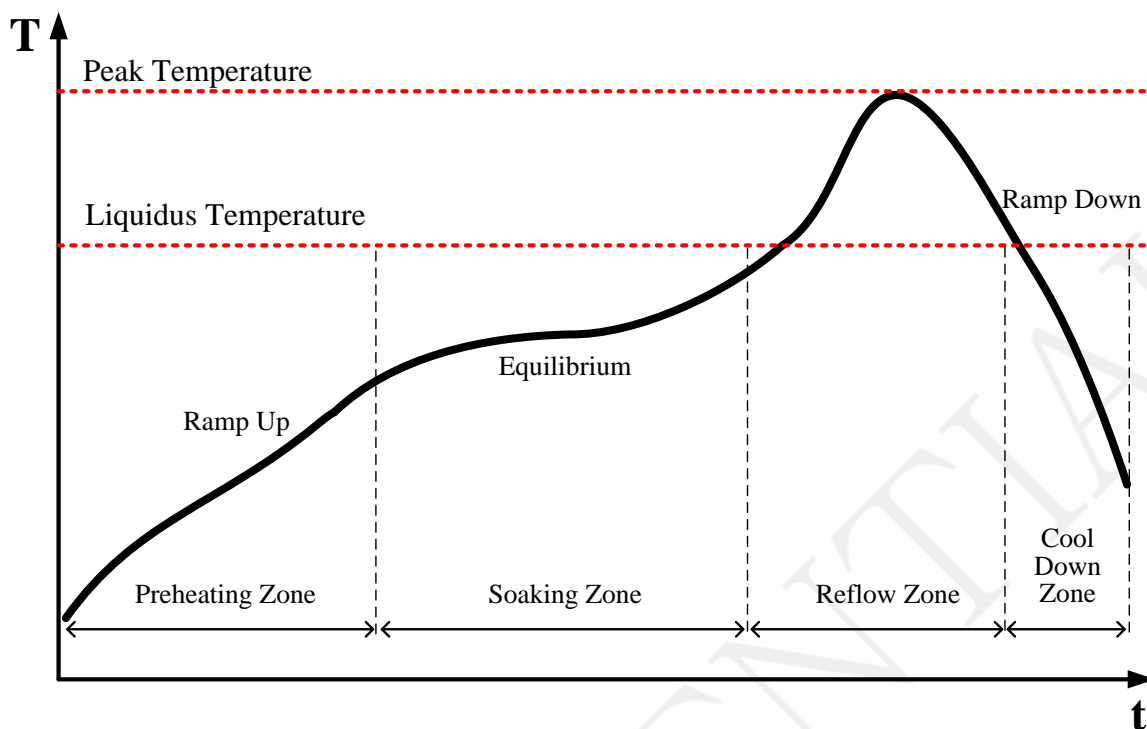


Figure 12-3 The temperature profile of a reflow process

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

Table 12-4 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	
<div><div><div>*1 Device name : PAIOS²-AD</div><div>*2 Application name : WWR SoC</div><div>*3 Manufacturing date : KYYWW</div><div><div>- K : Site</div><div>- YYWW : Date code</div></div></div><div><div>*4 Assembly lot number : CYWWPPTTT</div><div><div>- C : Customer code</div><div>- Y : Years</div><div>- WW : Week</div><div>- PP : Package code</div><div>- TTT : Serial No.</div></div></div></div>		

Table 14-1 Marking Information: PAIOS²-AD

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