THOR96

Hardware Manual

Powered by:

Contents

1 INTRODUCTION

Acronyms and abbreviation definitions

Acronym / Abbreviation	Definition
A2B	Automotive Audio Bus
BOM	Bill of Materials
BT	Bluetooth
BLE	Bluetooth Low Energy
CLK	CLK Clock
CPU	Central Processing Unit
CS	Chip Select
CSI	Camera Serial Interface
DSI	Display Serial Interface
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EN	Enable
ESD	Electro-Static Discharge
GND	Ground
GPIO	General Purpose I/O
GPS	Global Positioning System
HDMI	High Definition Multimedia Interface
HMI	Human Machine Interface
I2C	Inter-Integrated Circuit
I2S	Inter-IC Sound
INT	Interrupt
LDO	Low Drop-Out
LPDDR	Low Power Double Data Rate
LTE	Long-Term Evolution
MIC IN	Microphone Input
MIPI	Mobile Industry Processor Interface
PCB	Printed Circuit Board
PCIE	Peripheral Component Interconnect Express
PMIC	Power Management IC
PWM	Pulse-Width Modulation
RAM	Random Access Memory
RGMII	Reduced Gigabit Media Independent Interface
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RTC	Real Time Clock
RX	Receive
SCL	Serial Clock
SD	Secure Digital
SDA	Serial Data
SDI	Secure Digital Interface
SOM	System On Module
SPI	Serial Peripheral Interface
TX	Transmit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WLAN	Wireless Local Area Network

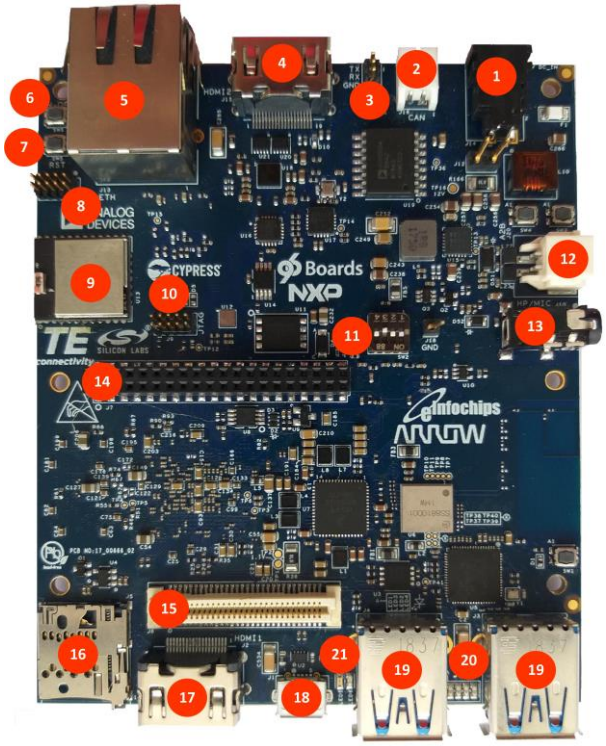
2 KEY FEATURES

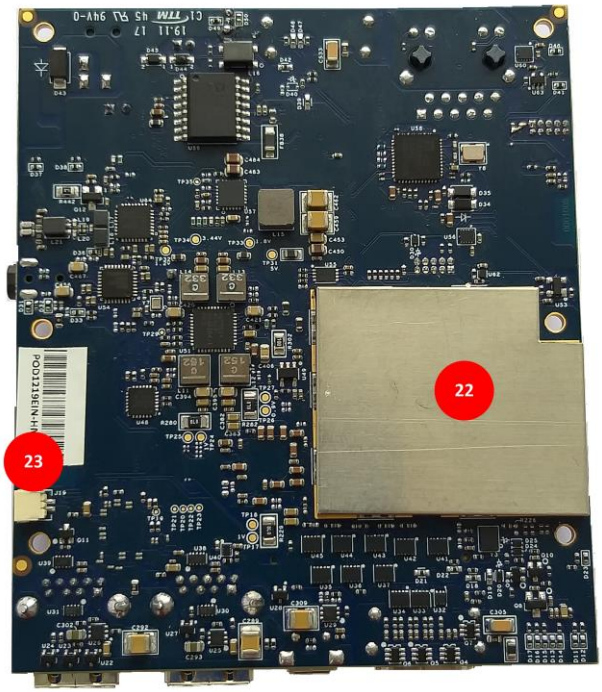
The THOR96 board is a 96Boards compliant community board based on NXP iMX8M QUAD Core Processor.

The following table lists its key features:

Device	Specification
Microprocessor	iMX8M QUAD NXP Internal core operation: Four ARM Cortex-A53 (1.3 GHz) One ARM Cortex-M4 (266 MHz)
Memory / Storage	2GB LPDDR4 1600 MHz SD 3.0 (UHS-I) 256 Mb NOR FLASH 128 Kb EEPROM
Video	4K UltraHD@30fps video playback and capture with H.265 (HEVC) on HDMI 3.0 1080p HD video play on HDMI 3.0 (DSI to HDMI using MIPI Switch)
Camera Support	4 lane MIPI port 2 lane MIPI port
Audio	Audio Codec (MIC IN + Headphone Out) Automotive Audio Bus (A2B) in Master Mode
Connectivity	WiFi 5 GHz & 2.4GHz IEEE 802.11a/b/g/n/ac (Trace Antenna) Bluetooth® v4.2 (BLE) ZigBee & Thread IEEE 802.15.4 RGMII 10/100/1000 Mbit/s IEEE 802.3 CAN 5kV isolation in transceiver mode One USB 2.0 micro AB otg Two USB 3.0 type A
Debug	UART (3 pin) JTAG (10 pin)
I/O Interfaces	One 40-pin Low Speed (LS) expansion connector • UARTx2, SPI, I2S, I2C x2, GPIO x12, DC power One 60-pin High Speed (HS) expansion connector • 4L-MIPI DSI, 2L+4L-MIPI CSI, SPI, USB, I2C x2 THOR96 board can be made compatible with Camera, Display, Sensors, LTE Module and Audio interface as an add-on mezzanine.
User Interface	Switches • Power ON/OFF • Processor RESET • Boot Mode (x4) selection 6 LED Indicators • 4 - user controllable • 2 - for radios (BT and WLAN activity)
OS-support	Linux
Power, Mechanical and Environmental	Input voltage: +8V to +18V Dimensions: 85 x 100 mm meeting 96Boards™ Consumer Edition 'extended' B Form Factor Number of Layers: 12 Layers Operating Temp: 0°C to +55°C RoHS and Reach compliant

Board overview

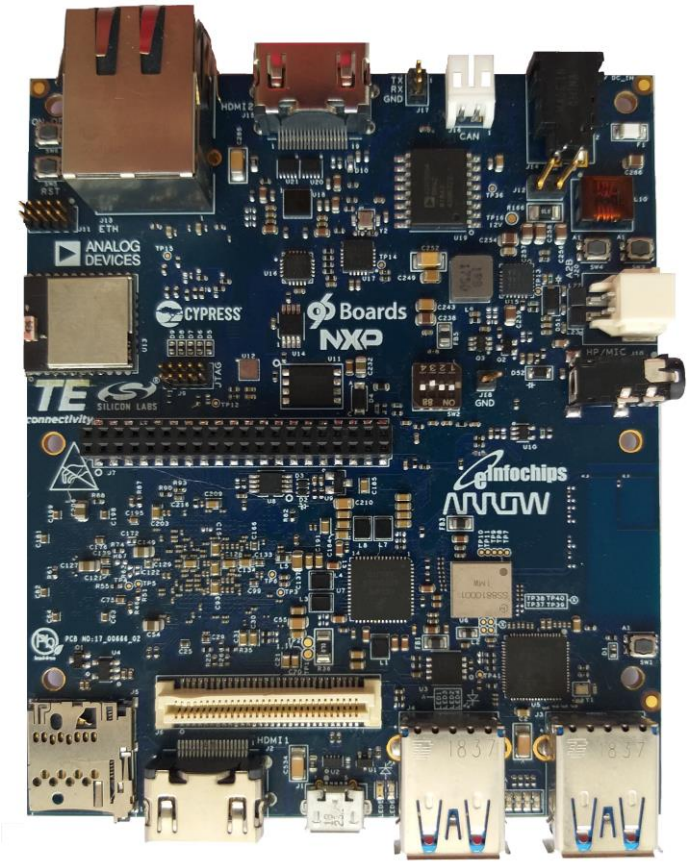




1	Power Jack
2	CAN connector
3	Debug UART connector
4	HDMI2 connector (DSI to HDMI)
5	Ethernet connector
6	ONOFF Switch
7	RESET Switch
8	ZigBee connector
9	ZigBee Module
10	Debug JTAG connector
11	Boot Mode Selection Switch
12	A2B connector
13	MIC IN + Headphone out jack
14	LS Expansion connector
15	HS Expansion connector
16	microSD connector
17	HDMI1 connector
18	Micro AB USB OTG connector
19	USB Type A connector
20	User LEDs 1-4
21	WiFi-BT LEDs
22	Shield Compartment containing iMX8M QUAD Processor/LPDDR4
23	FAN connector

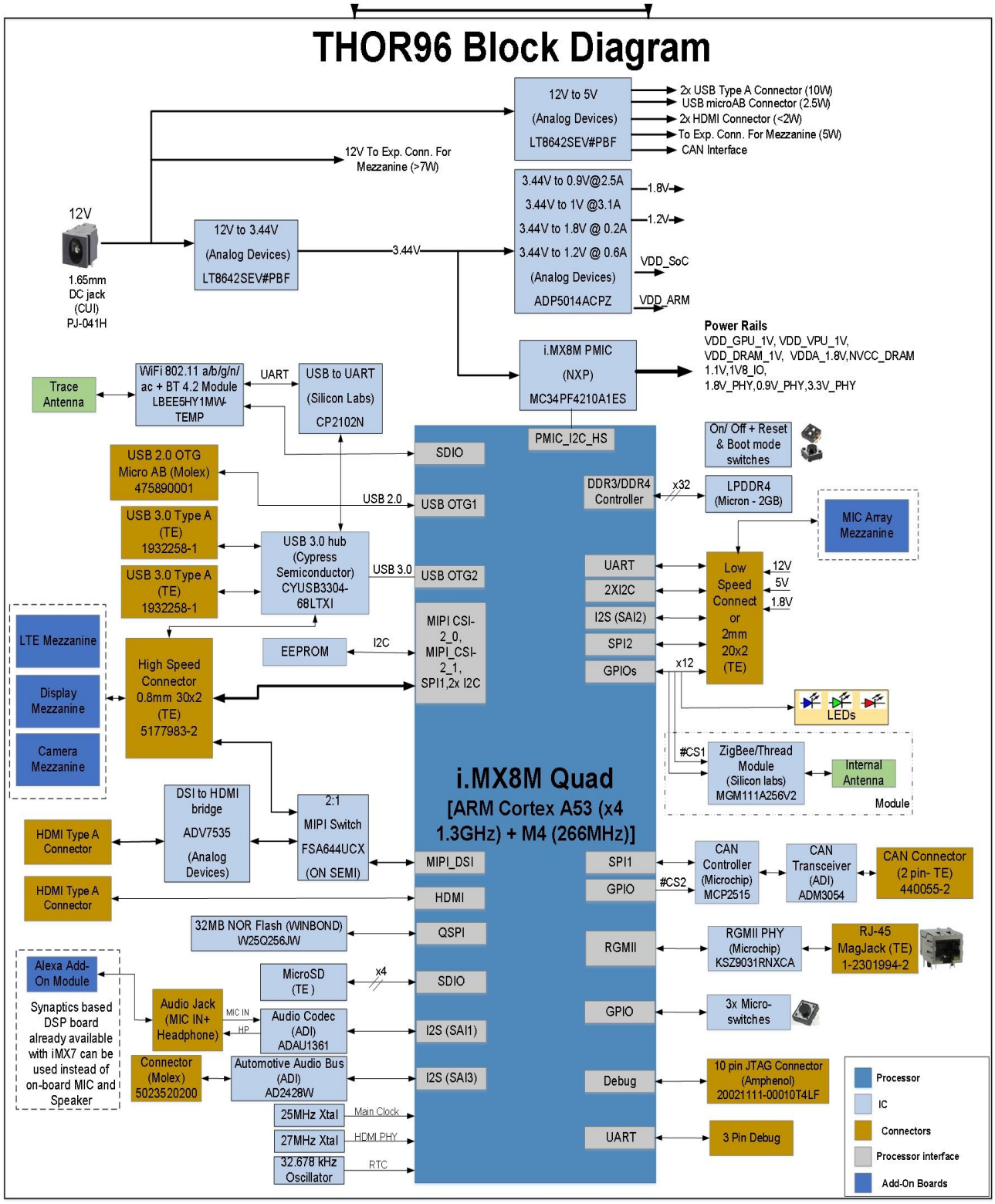
3 WHAT'S IN THE BOX

The box contains one THOR96 development board assembled with Base Plate, FAN, Heatsink and EMI Shield.



4 THOR96 BOARD OVERVIEW

4.1 System Block Diagram



4.2 Processor

IMX8M QUAD processor is a 64-bit ARM Cortex-A53 compliant 1.3 GHz Quad-core application processor from NXP, supports 64-bit Armv8-A architecture, supports Arm Cortex-M4 core platform, Video Processing Unit (VPU), Graphics Processing Unit (GPU), HDMI Display, MIPI DSI Display, Audio, Camera inputs.

4.3 Memory

- The LPDDR4 2GB (512Mbit x 32) is a 16bit width bus implementation interfacing directly to the iMX8M Processor build-in LPDDR controller. The maximum DDR clock is 533MHz (1066Mbps).
- The 96Boards specification calls for microSD port to be on the board. The microSD card is used to flash the board interfacing with iMX8M QUAD Core Processor SD2 interface supporting SDIO 3.0 specifications. The size supports up to 64 GB. The maximum SDIO clock is 200 MHz.
- The NOR flash is given as option to flash the board in absence of microSD card. NOR flash is interfacing directly to iMX8M QUAD Core Processor QSPI interface. The size supports 256Mb. The maximum QSPI clock is 25 MHz.
- The EEPROM is interfacing directly to iMX8M QUAD Core Processor I2C interface. The size supports 128Kb.

4.4 Video

- HDMI: The 96Boards specification calls for an HDMI port to be on the board. The THOR96 provides native support for an HDMI interface. It supports a resolution up to 4K Ultra HD resolution at 60Hz.

  - In THOR96, DSI0 port is connected to HS connector and using MIPI switch(FSA644UCX) it is converted into DSI to HDMI converter
    1. DSI0 port connected to High speed connector
    2. DSI_HDMI converted to HDMI for display (through ADV7535)
- **DSI0:** It supports a resolution from 480i to 1080p at 30Hz.
- **DSI to HDMI:** It supports a resolution 1080P via DSI to HDMI Bridge Chip.

4.5 Camera Support

- THOR96 supports one 4-lane CSI1 port and one 2-lane CSI2 port which used to connect high speed expansion connector as per 96boards standard.

4.6 Audio

- THOR96 supports the requirement of audio codec with MIC IN + Headphone Out 3.5 mm jack connector.
- THOR96 supports Automotive Audio Bus interfaces in Master mode with 2 pin connector.

4.7 Connectivity

4.7.1 WiFi

- The 96Boards specification calls for WiFi module to be on the board.
- THOR96 supports Wi-Fi (802.11 a/b/g/n/ac, 2.4GHz and 5GHz) over LBEE5HY1MW-230 module.
- Wi-Fi will be mainly used for cloud connectivity.
- The WiFi module is interfacing with iMX8M Processor SD1 interface supporting SDIO 3.0 specifications.
- The maximum SDIO clock is 200 MHz.
- Module is certified with PCB trace antenna.

4.7.2 Bluetooth

- The 96Boards specification calls for bluetooth to be on the board.
- THOR96 supports Bluetooth 4.2 over LBEE5HY1MW-230 module.
- Bluetooth is used for Audio streaming and BLE sensor communication.
- UART communication is used to transfer data between processor and connected Bluetooth device.
- UART interface is used for Audio streaming over Bluetooth.
- BLE is also supported in the Module.

4.7.3 ZigBee & Thread

- THOR96 supports ZigBee and Thread protocol using MGM111 module for connecting to sensors.
- Flash memory: 256 kB, RAM: 32 kB
- Module supports integrated antenna for wireless communication.
- Application is to control and communicate with the external ZigBee sensors over SPI interface.
- Module supports data rate of up to 250kbps.

4.7.4 RGMII

- THOR96 supports 1Gbps Ethernet connection.
- Single chip 10/100/1000 Mbps Ethernet Transceiver Suitable for IEEE 802.3 Applications.
- Programmable LED Outputs for Link, Activity and Speed.
- Power-Down and Power-Saving Modes.

4.7.5 CAN

- THOR96 supports CAN interface for industrial application using CAN controller and CAN transceiver with 5kV isolation.
- SPI protocol is used for communication which supports High-Speed SPI Interface.
- The maximum SPI clock is 10 MHz.

4.7.6 USB 2.0

- THOR96 supports USB2.0 OTG port with micro-AB connector.
- USB OTG supports either USB as Host or USB as Device.

4.7.7 USB 3.0

- THOR96 have one USB 3.0 HUB (CYUSB3304-68LTXI - Cypress) connected to USB 3.0 port of iMX8M Processor.
- Two downstream port used as USB 3.0 Host port with a USB 3.0 Type-A connector.
- Separate load switches on the board will limit USB current on USB 3.0 ports as per USB specifications.
- USB bandwidth will be shared between devices if more than one devices are attached to USB HUB.

4.8 Debug

4.8.1 Debug UART

- THOR96 console is supported through debug UART using 3 pin connector.

4.8.2 Debug JTAG

- THOR96 can be programmed through JTAG emulator.
- JTAG 10 pin connector is provided for JTAG debug and programming.

4.9 I/O Interfaces

4.9.1 40-pin Low Speed (LS) expansion connector

The following tables show the Low Speed Expansion Connector pin out:

Pin No.	96Boards Signals	THOR96 Signals	Remarks
1	GND	GND	
2	GND	GND	
3	UART0_CTS	UART2_CTS	
4	PWR_BTN_N	ONOFF_LS	
5	UART0_TxD	UART2_TXD	
6	RST_BTN_N	RST_LS	
7	UART0_RxD	UART2_RXD	
8	SPI0_SCLK	E CSPI2_SCLK	
9	UART0_RTS	UART2_RTS	
10	SPI0_DIN	ECSPI2_MISO	
11	UART1_TxD	UART3_TXD	

12	SPI0_CS	ECSPI2_SS0	
13	UART1_RxD	UART3_RXD	
14	SPI0_DOUT	E CSPI2_MOSI	
15	I2C0_SCL	I2C1_SCL	
16	PCM_FS	SAI2_TXFS	
17	I2C0_SDA	I2C1_SDA	
18	PCM_CLK	S AI2_TXC	
19	I2C1_SCL	I2C2_SCL	
20	PCM_DO	SAI2_TXD	
21	I2C1_SDA	I2C2_SDA	
22	PCM_DI	SAI2_RXD	
23	GPIO-A	LS_GPIO2_A	
24	GPIO-B	LS_GPIO3_B	
25	GPIO-C	LS_GPIO3_C	
26	GPIO-D	LS_GPIO3_D	
27	GPIO-E	LS_GPIO2_E	
28	GPIO-F	LS_GPIO3_F	
29	GPIO-G	LS_GPIO2_G	
30	GPIO-H	LS_GPIO3_H	
31	GPIO-I	LS_GPIO2_I	
32	GPIO-J	LS_GPIO3_J	
33	GPIO-K	LS_GPIO3_K	
34	GPIO-L	LS_GPIO3_L	
35	+1V8	VCC_1V8_EXT	1.8V
36	SYS_DCIN	VCC_12V0	12V
37	+5V	VCC_5V	5V
38	SYS_DCIN	VCC_12V0	12V
39	GND	GND	
40	GND	GND	

UART {0/1}

- The 96Boards specifications calls for a 4-wire UART implementation (UART2) and an optional second 2-wire UART (UART3) on the Low Speed Expansion Connector.
- The THOR96 implements UART2 as a 4-wire UART that connects directly to the IMX8M Processor. These signals are driven at 1.8V.
- The THOR96 implements UART3 as a 2-wire UART that connects directly to the IMX8M Processor. These signals are driven at 1.8V.

I2C {0/1}

- The 96Boards specification calls for two I2C interfaces to be implemented on the Low Speed Expansion Connector.
- The THOR96 implements both interfaces, I2C1 and I2C2 that connects directly to the IMX8M Processor.
- A 2.2K resistor is provided as pull-up for each of the I2C lines per the I2C specifications, these pull-ups are connected to the 1.8V voltage rail.

GPIO {A-L}

- The 96Boards specifications calls for 12 GPIO lines to be implemented on the Low Speed Expansion Connector.
- These signals are driven at 1.8V.

SPI 0

- The 96Boards specification calls for one SPI bus master to be provided on the Low Speed Expansion Connector.
- The THOR96 implements a full SPI master with 4 wires, CLK, CS, MOSI and MISO all connect directly to the IMX8M Processor. These signals are driven at 1.8V.

PCM/I2S

- The 96Boards specification calls for one PCM/I2S bus to be provided on the Low Speed Expansion Connector.
- The CLK, FS and DO signals are required while the DI is optional.
- The THOR96 implements a PCM/I2S with 4 wires, TXFC, TXC, TXD and RXD. The I2S signals are connected directly to the IMX8M Processor. These signals are driven at 1.8V.

4.9.2 60-pin High Speed (HS) expansion connector

The following table shows the High Speed Expansion Connector pin out:

Pin No.	96Boards Signals	THOR96 Signals	Remarks
1	SD_DAT0/SPI1_DOUT	ECSPI1_MOSI	
2	CSI0_C+	CSI_MCP_CONN	
3	SD_DAT1	NC	
4	CSI0_C-	CSI_MCN_CONN	
5	SD_DAT2	NC	
6	GND	GND	
7	SD_DAT3/SPI1_CS	ECSPI1_SS0	
8	CSI0_D0+	CSI_MDP0_CONN	
9	SD_SCLK/SPI1_SCLK	ECSPI1_SCLK	
10	CSI0_D0-	CSI_MDN0_CONN	
11	SD_CMD/SPI1_DIN	ECSPI1_MISO	
12	GND	GND	
13	GND	GND	
14	CSI0_D1+	CSI_MDP1_CONN	
15	CLK0/CSI0_MCLK	CSI0_CLK	
16	CSI0_D1-	CSI_MDN1_CONN	
17	CLK1/CSI1_MCLK	CSI1_CLK	
18	GND	GND	
19	GND	GND	
20	CSI0_D2+	CSI_MDP2_CONN	
21	DSI_CLK+	DSI_MCP_CONN	
22	CSI0_D2-	CSI_MDN2_CONN	
23	DSI_CLK-	DSI_MCN_CONN	
24	GND	GND	
25	GND	GND	
26	CSI0_D3+	CSI_MDP3_CONN	
27	DSI_D0+	DSI_MDP0_CONN	
28	CSI0_D3-	CSI_MDN3_CONN	
29	DSI_D0-	DSI_MDN0_CONN	
30	GND	GND	
31	GND	GND	
32	I2C2_SCL	I2C3_SCL	
33	DSI_D1+	DSI_MDP1_CONN	
34	I2C2_SDA	I2C3_SDA	
35	DSI_D1-	DSI_MDN1_CONN	
36	I2C3_SCL	I2C4_SCL	
37	GND	GND	
38	I2C3_SDA	I2C4_SDA	
39	DSI_D2+	DSI_MDP2_CONN	
40	GND	GND	
41	DSI_D2-	DSI_MDN2_CONN	
42	CSI1_D0+	CSI_MD2P0_CONN	
43	GND	GND	
44	CSI1_D0-	CSI_MD2N0_CONN	
45	DSI_D3+	DSI_MDP3_CONN	
46	GND	GND	
47	DSI_D3-	DSI_MDN3_CONN	
48	CSI1_D1+	CSI_MD2P1_CONN	
49	GND	GND	
50	CSI1_D1-	CSI_MD2N1_CONN	
51	USB_D+	USBDN_DP1	

52	GND	GND	
53	USB_D-	USBDN_DM1	
54	CSI1_C+	CSI_MC2P_CONN	
55	GND	GND	
56	CSI1_C-	CSI_MC2N_CONN	
57	HSIC_STR	NC	
58	GND	GND	
59	HSIC_DATA	NC	
60	RESERVED	VCC_1V8_EXT	

MIPI DSI 0

- The 96Boards specification calls for a MIPI-DSI to be present on the High Speed Expansion Connector.
- A minimum of one lane is required and up to four lanes can be accommodated on the connector.
- The THOR96 implementation supports a full four lane MIPI-DSI interface that is routed to the High Speed Expansion Connector.

MIPI CSI {0/1}

- The 96Boards specification calls for two MIPI-CSI interfaces to be present on the High Speed Expansion Connector.
- Both interfaces are optional. CSI0 interface can be up to four lanes while CSI1 is up to two lanes.
- The THOR96 implementation supports a full four lane MIPI-CSI interface on CSI0 and two lanes of MIPI-CSI on CSI1. All MIPI-CSI signals are routed directly to/from the Processor.

I2C {2/3}

- The 96Boards specification calls for two I2C interfaces to be present on the High Speed Expansion Connector.
- Both interfaces are optional unless a MIPI-CSI interface has been implemented. Then an I2C interface shall be implemented.
- The current THOR96 implementation supports two MIPI-CSI interfaces and therefore must support two I2C interfaces.
- For MIPI-CSI1 the companion I2C2 is routed directly from the Processor. For MIPI-CSI2, the companion I2C is I2C3.

HSIC

- The 96Boards specification calls for an optional MIPI-HSIC interface to be present on the High Speed Expansion Connector. The THOR96 implementation doesn't support this optional requirement.

Reserved

- The 96Boards specification calls for a 100K pull-up to 1.8V to be connected to pin 60 of the High Speed Expansion Connector.
- The THOR96 utilizes a 100K pull-up (R220) on pin 60.

SD/SPI

- The 96Boards specification calls for an SD interface or a SPI port to be part of the High Speed Expansion Connector.
- The THOR96 implements a full SPI master with 4 wires (96Boards SPI Configuration), CLK, CS, MOSI and MISO all connect directly to the Processor. These signals are driven at 1.8V.

Clocks

- The 96Boards specification calls for one or two programmable clock interfaces to be provided on the High Speed Expansion Connector.
- These clocks may have a secondary function of being CSI0_MCLK and CSI1_MCLK. These signals are driven at 1.8V.

USB

- The 96Boards specification calls for a USB Data line interface to be present on the High Speed Expansion Connector.
- The THOR96 implements this requirement by routing USB channel 3 from the USB HUB to the High Speed Expansion Connector.

4.10 Power management

THOR96 supports 12VDC (+8V to 18V @60W) for the input supply to power up processor and all its peripherals.

The processor and peripherals requires different voltage supplies and current for their normal functionality. The power supply section is designed to generate all required voltage rails with respective current requirements.

4.10.1 Input Power Supply

For protection of input power supply, below components are used

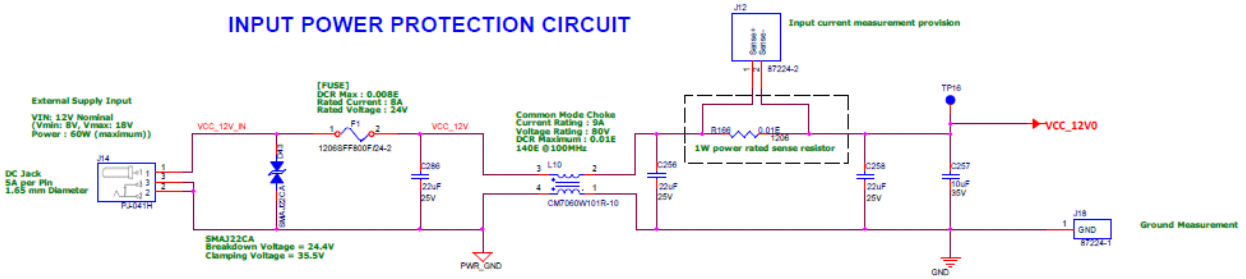
1. Fuse
2. TVS Diodes

For EMI EMC protection, below components are used

1. Common mode choke

For Input current sensing, below components are used

1. 0.01E Sense Resistor in series of input supply path
2. Two pins header across sense resistor



4.10.2 12V to 5V@4A Regulator LT8642SEV#PBF

- Regulator LT8642SEV#PBF is selected to convert 5V from 8-18V input power supply.
- This Regulator is in always in ON condition.

4.10.3 12V to 3.44V@6A Regulator LT8642SEV#PBF

- Regulator LT8642SEV#PBF is selected to convert 3.44V from 8-18V input power supply.
- This Regulator is in always in ON condition.

4.10.4 Regulator ADP5014ACPZ-R7

- Regulator ADP5014ACPZ-R77 is selected to generate four Low Noise Current through Buck Regulator for processor.
- Enable of two power supply is provided by PMIC and enable of two power supply is provided by 1.8V supply.

4.10.5 PMIC (MC34PF4210A1ES)

- PF4210 is used to provide sequencing to the processor and it is controlled through I2C.
- PMIC provides a highly programmable/configurable architecture with fully integrated power devices and minimal external components.
- PMIC provides up to six buck converters, six linear regulators, RTC supply, and a coin cell charger.
- PMIC designed as per datasheet.

Below are the features of PF4210:

- Four to six buck converters, depending on configuration
  - Single/dual phase/parallel options

- DDR termination tracking mode option
- Boost regulator to 5.0 V output
- Six general purpose linear regulators
- Programmable output voltage, sequence, and timing
- OTP (one-time programmable) memory for device configuration

4.10.6 Linear Regulator ADP1710AUJZ-R7

- Two ADP1710 is used in design for low noise output voltage.
- One LDO is used for processor supply VDD_SNVS_0.9V and other for SD card voltage selection option
- Maximum output current is 150mA.
- Input voltage range is 2.5V to 5.5V

4.10.7 CAN Supply isolator ADUM5020-5BRWZ

- ADUM5020 is used for isolation of voltage supply for CAN interface.
- 5V for CAN interface is isolated with DC-DC converter

4.11 Switches and status LED's

4.11.1 Switches

- **ON-OFF Switch**

  Option 1: Long press/hold
  - While the device is awake, pressing and holding the ONOFF Switch for longer than 7 seconds will result in the device powering off.

  Option 2: Short press/hold
  - Once powered off, pressing and holding the ONOFF Switch for longer than 3 seconds will result in the device powering on.

- **RESET Switch**
- While the device is awake, pressing the RESET Switch will force a hard reset of THOR96 Board.

- **User Switch**
- Three Micro switches are used to give user inputs.

4.11.2 Status LED's

- **User LED 1-4**
- The four user LEDs are surface mount Green LEDs, 0603 size, located next to the two USB type A connector and labeled 'USER LEDS 3 2 1 0'.

- **Bluetooth status**
- The BT LED on the THOR96 is located next to the USBOTG connector, this LED reflects the status of the Bluetooth device.

- **WiFi status**
- The WiFi LED on the THOR96 is located beside the BT LED, this LED reflects the status of the Wi-Fi device.

4.12 Other Parts

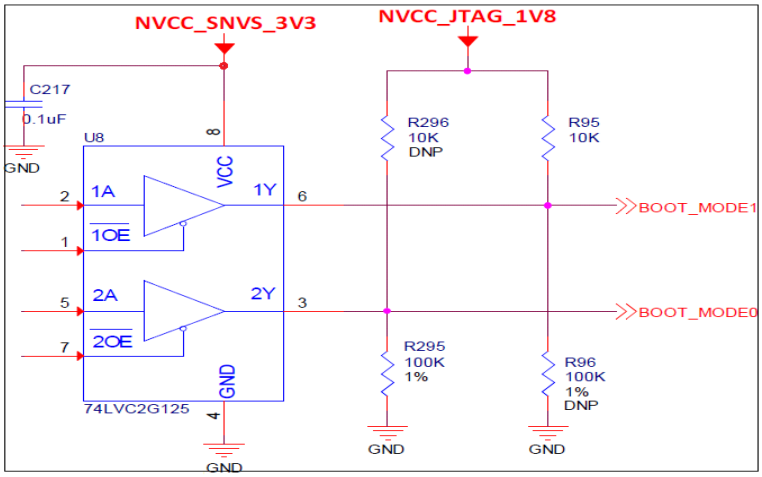
- FAN and Heatsink are used to overcome thermal issue
- RF Shield is used to overcome the EMI/EMC issues

4.13 Boot Configuration

4.13.1 CPU Boot Mode settings

- Below are the CPU boot mode settings option.
- Board is designed for boot configuration for Internal Boot.

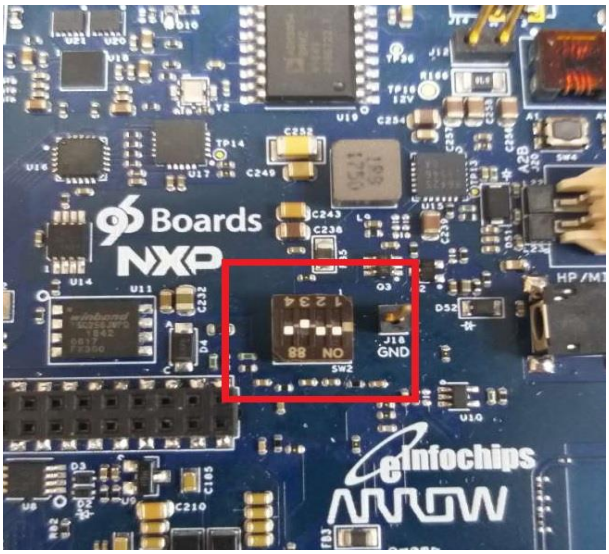
BOOT_MODE1	BOOT_MODE 0	Boot Source
0	0	Boot from fuses
0	1	Serial downloader
1	0	Internal boot
1	1	Reserved



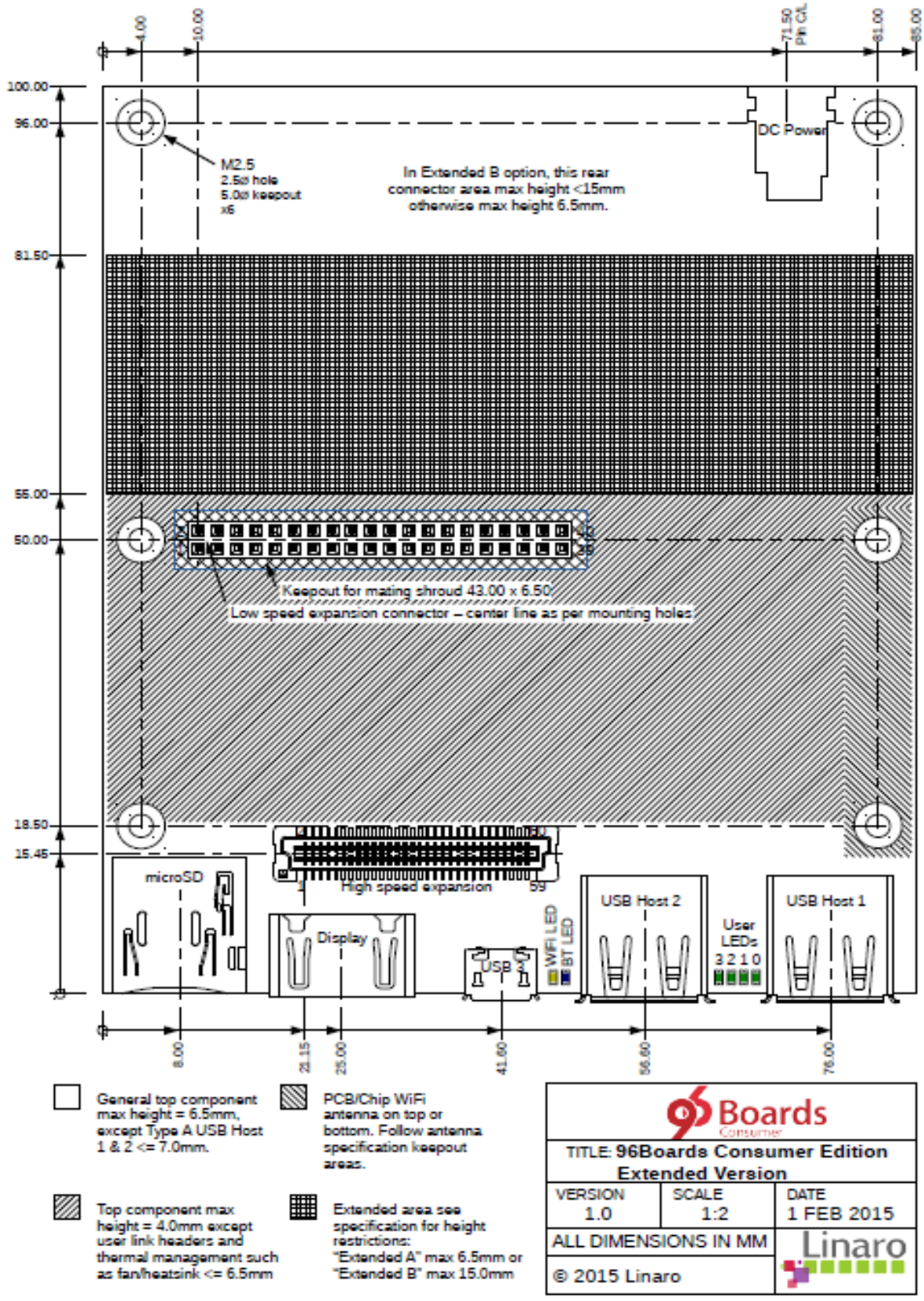
4.13.2 Boot Mode Selection Switch

- Below are the Boot mode switch selection settings to boot the board.
- Board is designed for boot configuration with microSD card.

BMODE [3:0]	Boot Configuration
x011	Boot from SD2
x100	Boot from QSPI



5 MECHANICAL SPECIFICATION



Additional interfaces

THOR96 includes interfaces which are in addition to the base 96boards CE Extended B specification. These include below mentioned interfaces.

- Audio Codec (MIC IN + Headphone Out)
- Automotive Audio Bus (A2B)
- CAN Interface
- Debug UART
- JTAG Debug
- HDMI2 (DSI to HDMI)
- RGMII Ethernet
- ZigBee

Locations of these connectors are noted on the following drawing.