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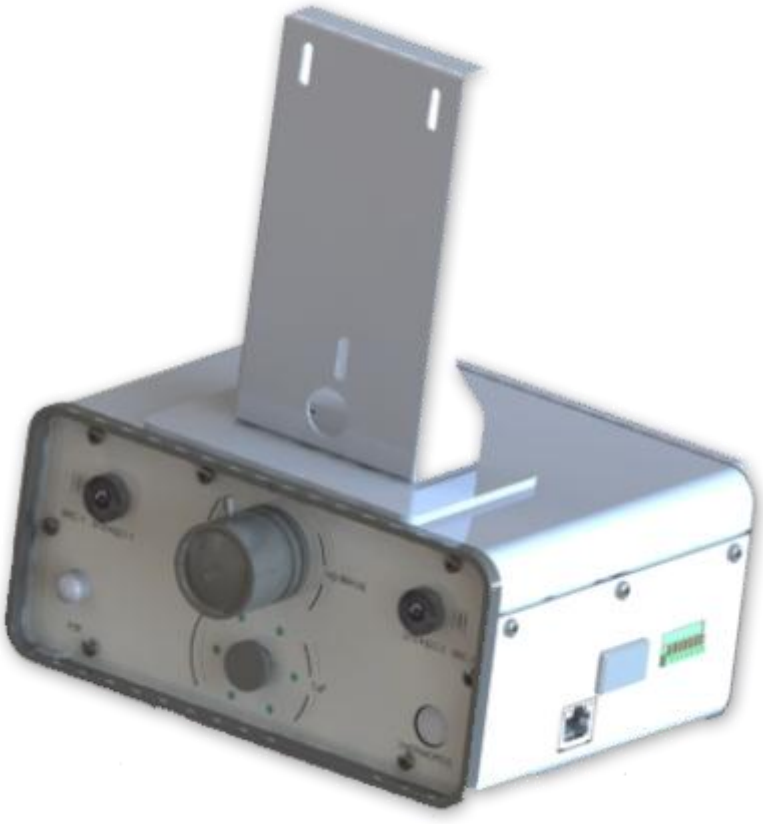
TI TDA2 Based
Multi Sensor Fusion Reference Platform
Configuration and User Guide



Revision 1.0

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Figures

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1. ABOUT THIS DOCUMENT

Purpose

This document provides details of the Multi Sensor Fusion Reference Platform including its features, functionality, installation and configuration of the Multi Sensor Fusion Reference Platform.

Intended Audience

This document is intended for the following target groups:

- Development Engineers
- Installation Engineers
- Network Administrators

ⓘ**Note**: It is a pre-requisite to have a practical working knowledge of Wi-Fi and networking.

Document Conventions

The different conventions used in this document are explained in the following table:

Table 1: Document Conventions

Convention	Description
ⓘ	**Note**: Provides information about important features or instructions.
⃠	**Caution**: Alerts you to potential damage to a program, device, or system.
⚠	**Warning**: Alerts you to potential injury or fatality and to potential electrical hazards.
`file/directory names`	All Courier New
Bold font	Any option that needs to be selected or typed in the user interface is represented using bold font.

Terms and Abbreviations

The different terms and abbreviations used in this document are explained in Table 2 below.

Table 2 Terms and Abbreviations

Terms / Abbreviation	Description / Expansion
ADAS	Advanced Driving Assistance System
VS	Video Security
DSS	Display Subsystem
GUI	Graphical User Interface
LSP	Linux Support Package
MB/s	Mega Byte per second
Mbps	Mega bit per second
OSD	On Screen Display
PIR	Passive Infra- Red
POE	Power Over Ethernet
PTZ	Pan Tilt Zoom
TOF	Time of Flight
RTSP	Real Time Streaming Protocol
SDK	Software Development Kit
UI	User Interface

2. MULTI SENSOR FUSION REFERENCE PLATFORM

Reference Design Description

The Multi Fusion Sensor Platform coupled with multiple advanced sensor systems, is intended for evaluation and use in Advanced Driver Assistance Systems (ADAS).

This platform enables customers to operate directly from a Low Power (POE) Power over Ethernet Source in 1080 Video. This reference design allows the flexibility to run from two different sources including 12VDC or IEEE-803.3at Power Over Ethernet (POE+). The design features the Texas Instruments TDA2x Video Processor, running on 1GB of DDR3L memory which can be upgraded to 2GB.

The Multi Sensor Fusion Reference Platform contains a comprehensive blend of advanced sensors which enable OEMs and ODMS to evaluate, develop and rapidly deploy advanced ADAS systems resulting in faster time to market with minimal engineering effort. Customers can use and further upgrade the hardware files with the downloadable files provided as open source from TI.

The comprehensive sensor suite supported by the Multi Sensor Fusion Platform includes:

- TDA2x ADAS Media Processor Board (Main Board)
- DM388 Media Processor Board
- Power Supply Board
- Sensor Boards

The reference design has different sensor board options as given below:

- Image Sensor, Single FHD Color– primary image sensor
- Image Sensors, Stereo FHD– 3D and stereo video and imaging
- ToF Sensor (Time of Flight) – depth of field and points cloud
- PIR Sensor – Passive infrared motion detection
- Thermopile Sensor – temperature difference or gradient measurement
- Microphones – stereo audio reception and detection

The completely optioned Multi Sensor Fusion Reference Boards assembly, shown in Figure 1 below, contains all the boards which are stacked together.

Figure 1 TI TDA2 Based Multi Sensor Fusion Reference Platform

Hardware Overview

Each of the different boards available for the Multi Sensor Fusion Reference Platform is shown below and may be used for reference. Note the images are for representation only and may be slightly different depending upon build and revision.

Figure 2 Main Board

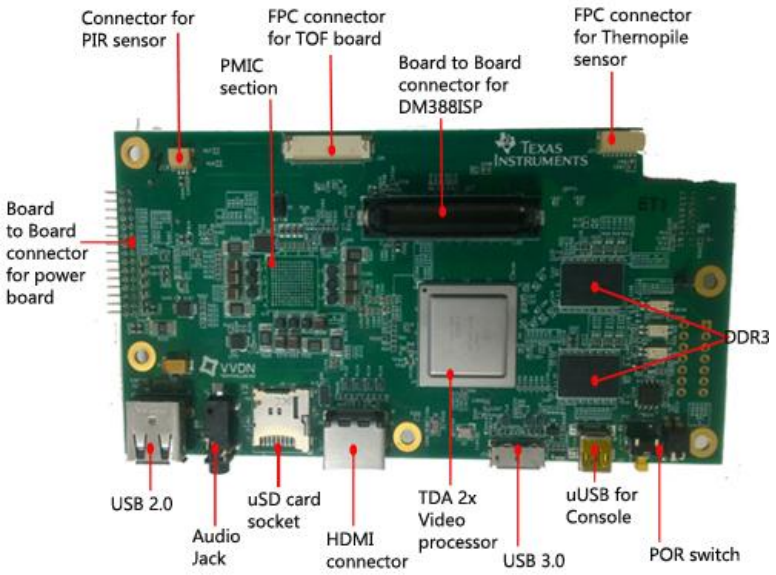


Figure 3 DM388 ISP Board

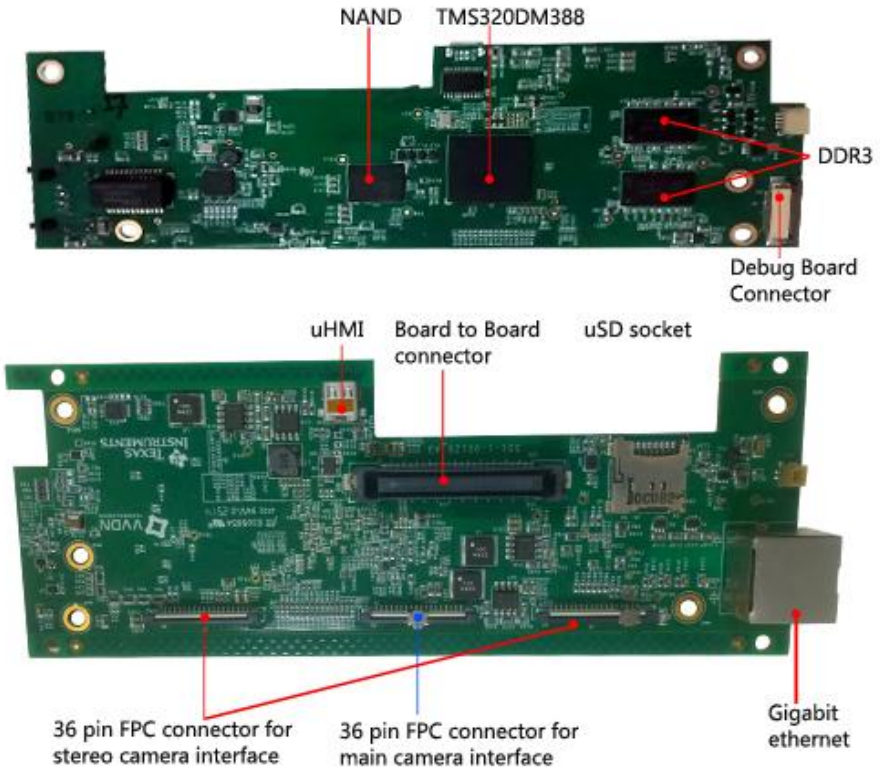


Figure 4 Main Image Sensor Board

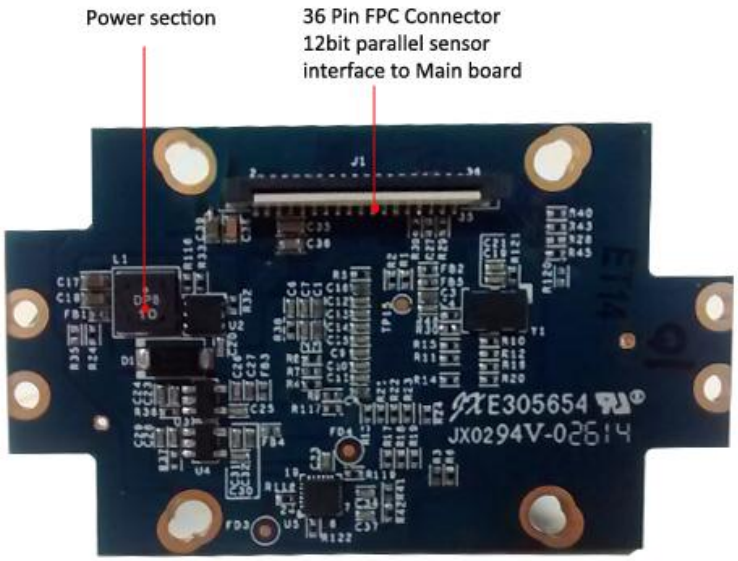
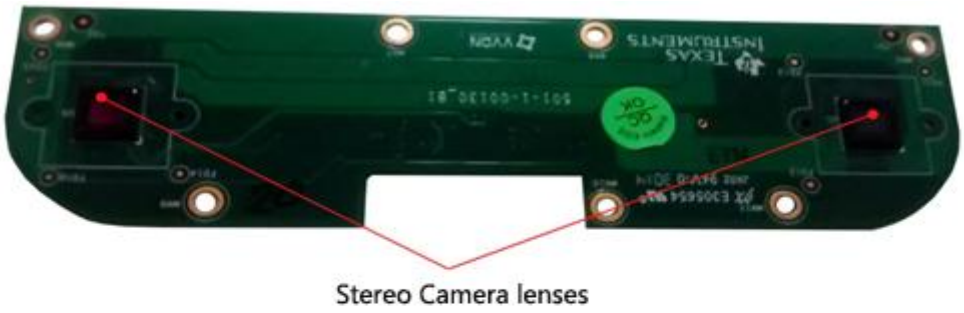


Figure 5 Stereo Board



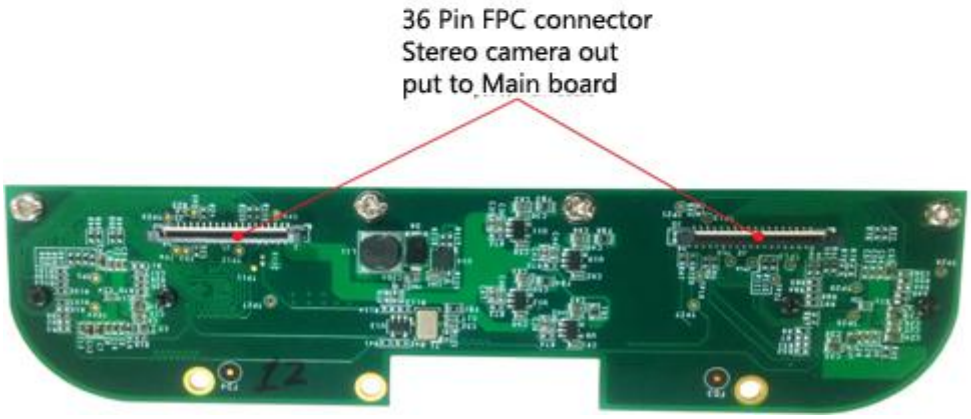


Figure 6 FPD Link Board

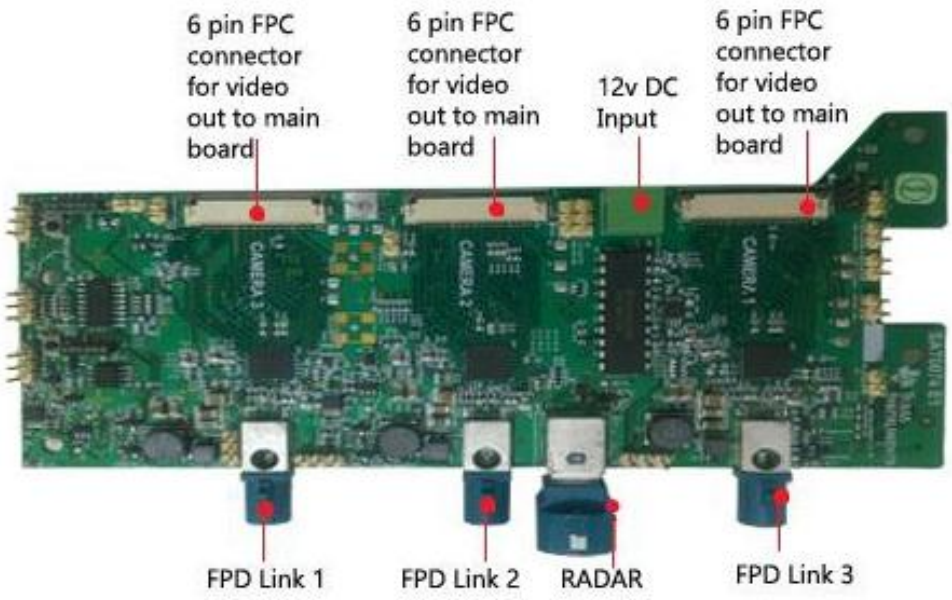


Figure 7 Power Board

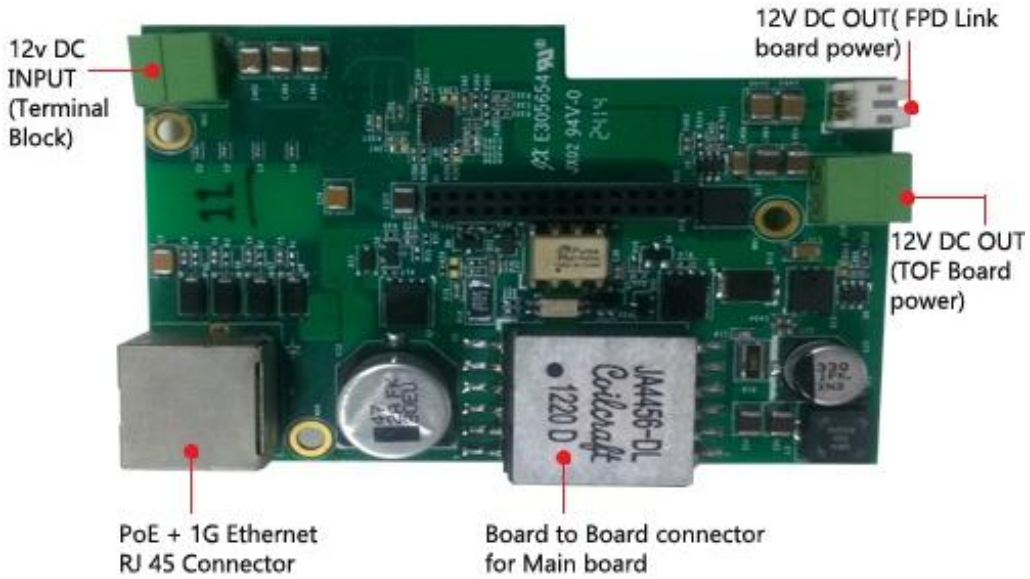


Table 4 below describes the various interfaces to the Multi Sensor Fusion Platform.

Table 3: Multi Sensor Fusion Interface Description

Interface	Description
Camera Connector	One pair of Stereo Sensor, one Image Sensor and one FPD Camera Sensor are present on the front panel.
Ethernet Connector PoE	Standard RJ-45 Ethernet connector for IP network connection. If PoE card is attached it allows transmission of power and data via a single Ethernet cable upto 30W.
Power Input	Power adapter connection. This is a +12V DC inlet, which connects to an external power supply. To be used if no PoE is available.
SD Card Holder	For inserting the SD card to store data directly onto the card and to support the booting of the Vayu board.
USB	USB interface can be used to connect the Wi-Fi USB Stick or USB 3G dongle
Alarm In Alarm out	Two alarm ports – input and output available on the back panel of the camera.
Debug Console	Debug console is used for service and debugging purposes.
HDMI	A standard HDMI interface on back panel for streaming video to HDTVs.
3.5mm Audio Jack	An audio jack for listening and recording the voice
JTAG Connector	JTAG connector for debugging and development
Individual Sensor	One PIR sensor, one thermopile Sensor on front panel for different activities like motion detection, temparature measurement.

Variants

Radium's Multi Sensor Fusion Reference Platform suite is a modular design based on the industry leading TI TDA2 platform SoC. This modular design allows multiple product configurations as described in the table below.

Table 4 Multi Sensor Fusion Module Configurations

Description	Base Model	ToF Model	FPD Model
TDA2x Main Board	✓	✓	✓
DM388 ISP Board	✓	✓	✓
Stereo Image Sensor Board	✓	✓	✓
Power Board	✓	✓	✓
Mono Image Sensor Board	✓	✓	✓
TOF Board	×	✓	×
TOF LED Board	×	✓	×
FPD Link Board	×	×	✓
Accessories			
PIR Motion Sensor	O	O	O
FPD Link Camera + Cable			✓
Thermopile Sensor	O	O	O

ⓘNote: O – Optional accessory for purchase

Features

The TDA2x Multi Sensor Fusion Reference Platform captures image data from an image sensor, encodes the image stream, and performs analytics functions on the video and streams data over Ethernet as well as stores data on local storage. It provides live NTSC/PAL composite video (when the DM388 board is used) as well as live high definition video via HDMI. It also captures audio from dual microphones.

In addition, it also has event-triggered inputs and alarm outputs. Peripheral connection and system control via RS-485, USB and SD memory card is enabled by the appropriate hardware connections to the TDA2x Board.

The comprehensive sensor suite supported by the Multi Sensor Fusion Platform includes the following:

- TDA2 ADAS SoC with 1GB DDR3L DRAM
- DM388 Video SoC with 512MB DDR3L DRAM
- USB 3.0 Interface and USB 2.0 Interface
- 10/100/1000Mbs Ethernet (RJ-45)
- SD-Card slot
- “Standard” Image Sensor Board Interface
- Iris Control
- FPD-Link
- Mono / Stereo Image Sensors
- PIR Sensor
- ToF Sensor
- Microphones
- Thermopile Sensor
- RTC
- HDMI Output
- Debug / JTAG Ports
- RS-485 / Alarm Connectors
- Ruggedized Housing
- Power Supply (Global)
- LED Indicators
- C / CS Lens Mount
- Stereo Line Output
- FPD-Link support

Below are the detailed features of the various boards used in Multi Sensor Fusion Reference Platform.

Video Processor Board - TDA2x

- Vision and analytics processing SoC from Texas Instruments
- ADAS Superset 28 high performance automotive vision processor
- Dual A15, DSPs, EVEs and HW video accelerator for H.264, MPEG4 and JPEG encode and decode
- 256K-Bytes On-Chip Memory Controller(OCMC) RAM
- Imaging Subsystem (ISS)
- Face Detect Engine (FD)
- Programmable High-Definition Video Image Coprocessing (HDVICP v2) Engine
- HD Video Processing Subsystem (HDVPSS)
- 32-bit DDR2/DDR3 SDRAM Interface
- Ethernet Switch With Dual 10/100/1000 Mb/s
- Dual USB 2.0 Ports With Integrated PHYs

Main Image Sensor- using Aptina AR1032T Sensor

- 1/3-inch CMOS digital image sensor with an active-pixel array of 1280H x 960V.
- Support HD Video (720p60)
- Captures images in either linear or high dynamic range modes, with a rolling-shutter readout
- Fixed focal length CS mount lenses are considered to avoid blocking FOV from other sensors on the front panel
- Sensor interface options for both parallel and CSI2 (MIPI) similar to DM385 IPNC design
- Support 5M-pixel capture as a minimum, up to 14Mp capture at reduced frame rate

Stereo 3D vision using Aptina AR1032T Sensor

- Dual sensor configuration with initial target to use Aptina AR0132T RCCC format sensors.
- Fixed focal length , S-Mount (M12x0.5) Lenses for stereo sensors
- Time-synchronized reading of the images from both CMOS devices , hardware sync GPIO for trigger

TOF Image Sensor using OPT8241 Sensor

- OPT8241 based TOF sensor implementation
- High Performance QVGA 3D sensor device which senses depth information based on TOF technique.
- 5m range, 75-degree FOV, 10mm resolution for HMI and 10cm for human detection.

Thermopile Sensor (Accessory) Using Omron MEMS Sensor

- Omron MEMS 16x16 thermopile sensor module

PIR Sensor Using Panasonic AMN31111 Sensor

- High sensitive human detection sensor
- Simplified circuitry with fully integrated circuit design
- 1μA low current consumption with the proprietary design
- Excellent resistance to electromagnetic noise
- High Signal/Noise ratio to minimize false operation

FPD Link Board

- FPD link serializer /deserializer board with three FPD link
- A solution for a small form factor camera module with minimum footprint power supply requirements

- A single coax cable for uncompressed megapixel camera data, control signals and power supply.
- Reduced camera module size, lower connector count: with fewer connectors and reduced power loss.
- Complete compact camera solution for automotive.

Stereo Mics

- 2 microphones on the board for Stereo 3D sensor
- Microphones placed at 100 mm distance

Technical Specifications

The following table provides the technical specification of the TDA2x Multi Sensor Fusion Reference Platform:

Table 5 Technical Specifications

Items	Description	
Video Processor	TI TDA2x Video Processor	
ISP	TI DM388	
Sensors	• Main Image Sensor • Stereo Sensor and Stereo Microphone • PIR Sensor • TOF Image Sensor • Thermopile Sensor • Radar Sensor • FPD Camera Link Sensors	
Boot/Configuration	• TDA2x - 256Mb QSPI Flash • DM388- 256 MB ,SLC NAND Flash	
Memory	• TDA2x -1GB, 64-bit (four x16 devices)DDR3L • DM388 - 512MB, 32-bit wide DDR3L memory (two x16 devices)	
Networking	10/100/1000 Base-TX with RJ-45 connectors	
Video/Display	Standard HDMI Out	
Audio	• Dual-microphone input on front face of camera for audio analytics • Line out (3.5mm) for external amplifier and speaker connection	
Connectors	**Back Panel**	**Side Panel**
	• USB 3.0 micro B • USB2.0 TYPE A • Micro SD push –push with CD • HDMI • Power IN terminal block • Gigabit PoE+ Port (RJ 45)	• 7 Port terminal block for Alarm /control • Auto IRIS • Debug Port connector
Miscellaneous	• RTC • IR Cut Filter on Main Image Sensor	
Control and I/O	• USB 3.0 Device Interface • USB 2.0 Host Interface • SD Card	
Debug Interfaces	• JTAG • Console	
Power	• PoE+ (IEEE-803.3at standard PoE input) • 12V , DC adapter input	
Status LED	Tri color LED for power /status indication	

System Requirements

The TI TDA2x Multi Sensor Fusion Reference Platform may be configured from any PC that is on the same network. The minimum requirements include:

- Operating system: Microsoft Windows 2000, XP, Vista or Windows 7
- Minimum of 6GB free disk space

Kit Contents

1) Board with mechanical casings
2) 12 V DC Power Adapter
3) 1 SD Card
4) 1 Console Cable

3. QUICK START UP GUIDE

This guide describes how to set up a Multi Fusion Sensor network demo.

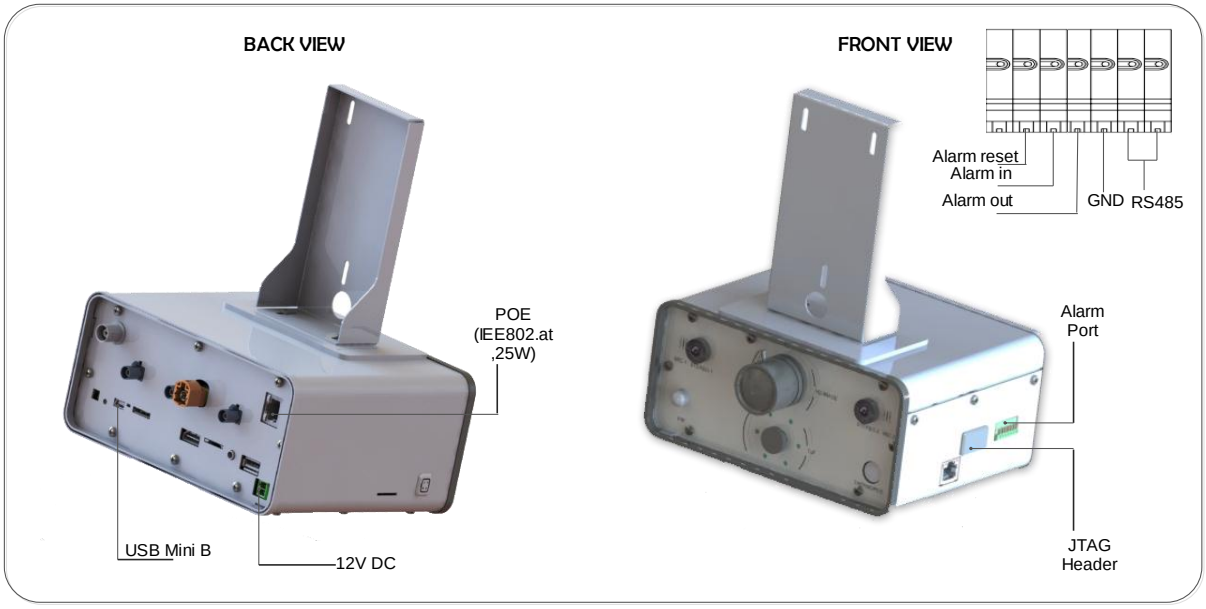


Figure 8: TDA2x Multi Sensor Fusion Reference Platform Ports

Connecting the TDA2x Multi Sensor Fusion Reference Platform

You may perform the following steps to connect power and network to the Reference Platform.

- Powering up the camera

Connect 12V DC adapter to the terminal block header for Powering up the Camera

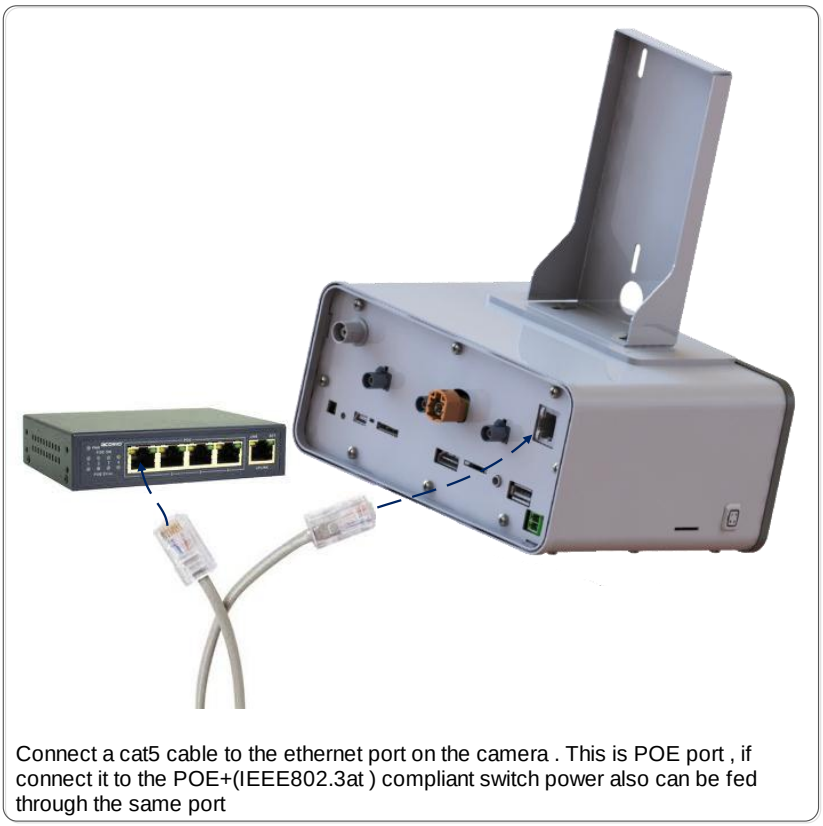
Figure 9 Powering up the camera

- Connecting the camera console

Connect a USB min B cable to the console Port and connect to the PC.

Figure 10: Camera Console connection with USB mini B Cable

- Connecting to the Network



Connect a cat5 cable to the ethernet port on the camera . This is POE port , if connect it to the POE+(IEEE802.3at) compliant switch power also can be fed through the same port

Figure 11: Camera Connection with the Network

Installation Overview

This section provides a brief description on the system requirements (hardware and software) and instructions for installing the Vision SDK.

PC Requirements

Installation of this release needs a windows machine with about 6GB of free disk space. Building of the SDK is supported on windows environment.

Software Requirements

You need **Vision Software Development Kit (Vision SDK)** - a multi processor software development package for TI's family of ADAS SoCs. The software framework allows users to create different ADAS application data flows involving video capture, video pre-processing, video analytics algorithms, and video display. The framework has sample ADAS data flows which exercises different CPUs and HW accelerators in the ADAS SoC and shows customer how to effectively use different sub-systems in the SoC. Frame work is generic enough to plug in application specific algorithms in the system.

4. HARDWARE DESCRIPTION

This chapter explains TI TDA2x Multi Sensor Fusion Reference Platform development board which includes a TI TDA2x Board as microcontroller and all the different subsystems and Interfaces between these subsystems as well as a range of useful peripheral features (see the block diagram in Figure 12). This chapter describes how these peripherals operate and interface to the microcontroller.

Block Diagram

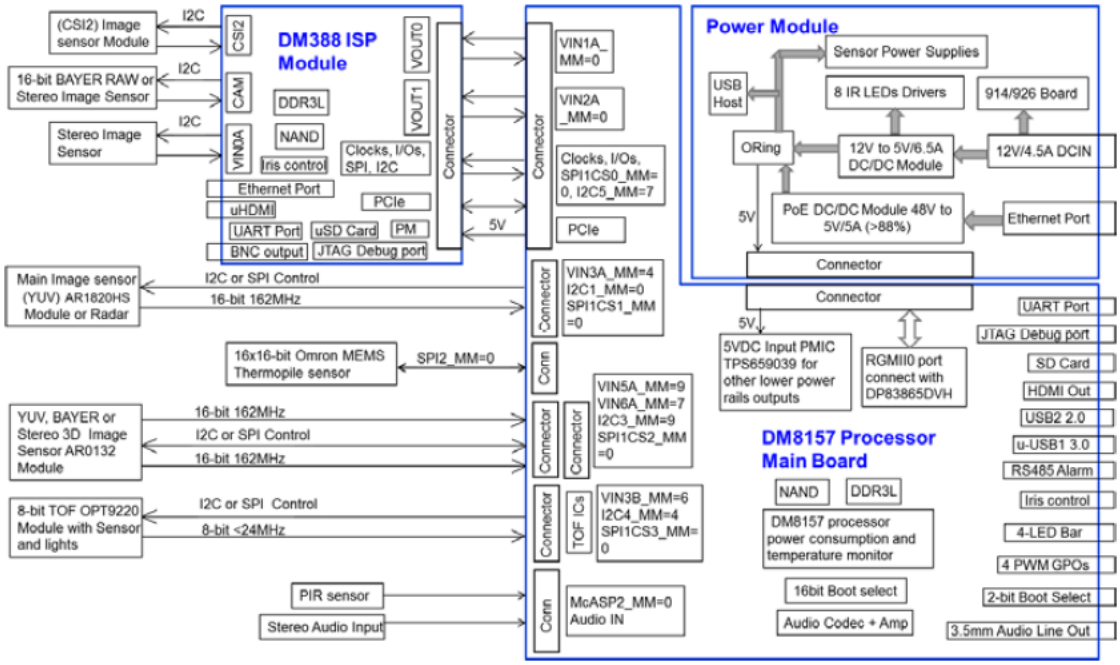


Figure 12: Hardware Block Diagram

The platform is divided into the following four different subsystems.

- TDA2x Board (Main board)
- DM388 Board
- Power supply Board
- Sensor Boards
    - HD image sensor board (main image sensor)
    - Stereo Image sensor Board
    - ToF sensor Board
    - PIR sensor Module –Panel mount and there will be three pin header on the DM8157 Board
    - Thermopile sensor – bought out part Omron MEMS 16x16 thermopile sensor module.

TDA2x Processor Board

TDA2x board is the main board of the multi sensor fusion reference platform. Following major interfaces / features of the processor utilized in this design:

- Bulk storage /Packet memory - DDR3L over DDR EMIF
- Boot/Configuration storage – NAND Flash over GPMC
- Giga bit Ethernet – Over RGMII0 Interface
- Audio Interface
- SD Interface
- HDMI Interface
- Serial Communication interfaces
- Video Input Port
- Video output Port
- Inter Board interface (Board to Board DM388 to DM8157)
- Boot mode selection switches
- Sensor Interfaces
- Alarm Ports
- Debug Interfaces

Bulk storage / Packet memory

TDA2x Processor has two EMIF (External Memory Interface) controllers; each supports upto 2GB SDRAMs over single chip select. So maximum of 4GB can be supported .EMIF Controllers supports DDR2 or DDR3 memories upto a bus width of 32 bit. The board has 1GB of DDR-3L memory – (Two nos of x16 bus width 256MB DDR3L devices on each EMIF controller). It can be upgraded to 2GB – (Two nos of x16 bus width 512MB DDR3L) if required in future based on the application.

Below diagram shows the DDR3 interface diagram to DM8157 one of the EMIF port, similar interface is there on the second port also.

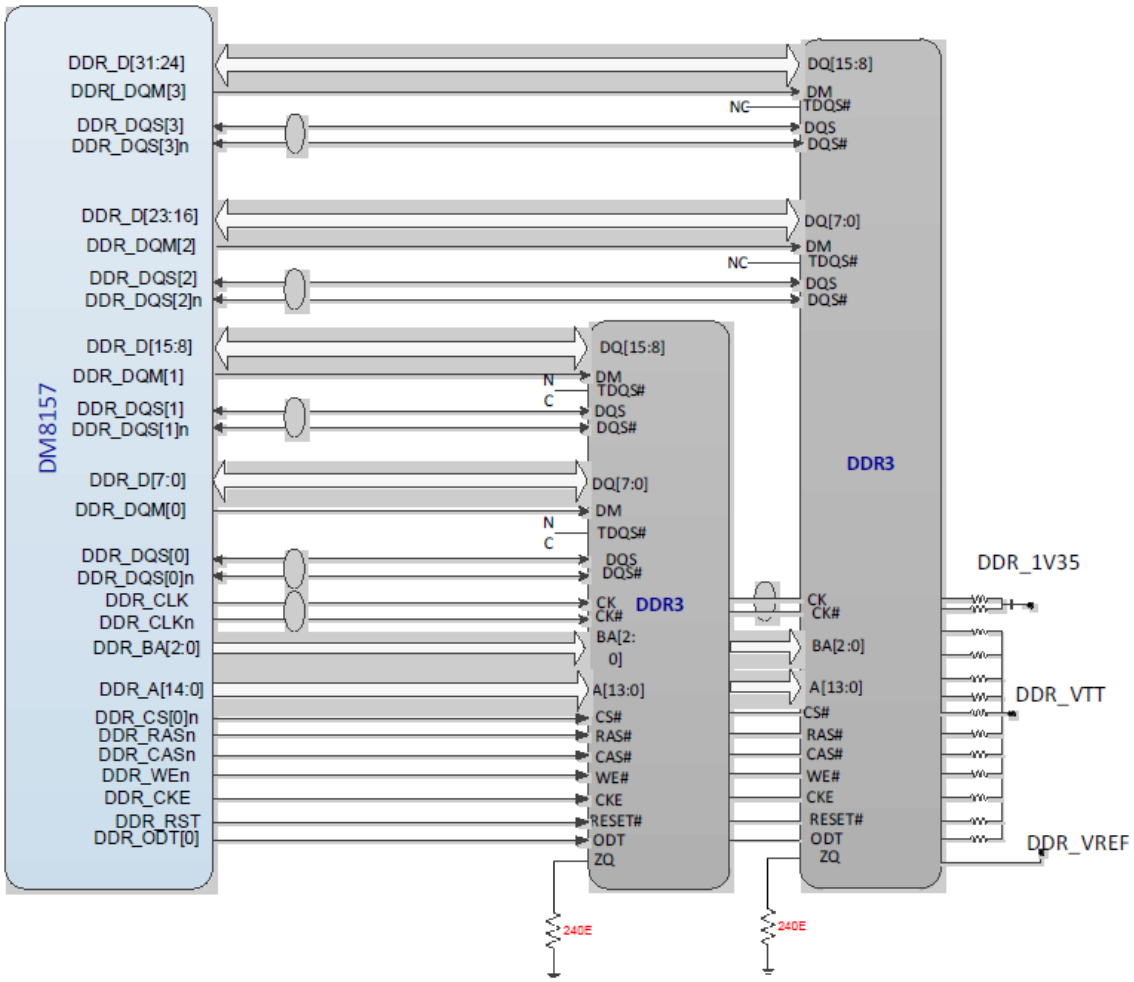


Figure 13: DDR3 Interface

Boot/Configuration Memory

DM8157 has a GPMC (General Purpose Memory Controller) dedicated for connected the external memories like, Asynchronous SRAM , NOR Flash , NAND Flash and pseudo SRAM devices. The reference platform design has serial Flash interfaced to QSPI interface. NAND Flash interface to the DM8157 GPMC is as shown below diagram

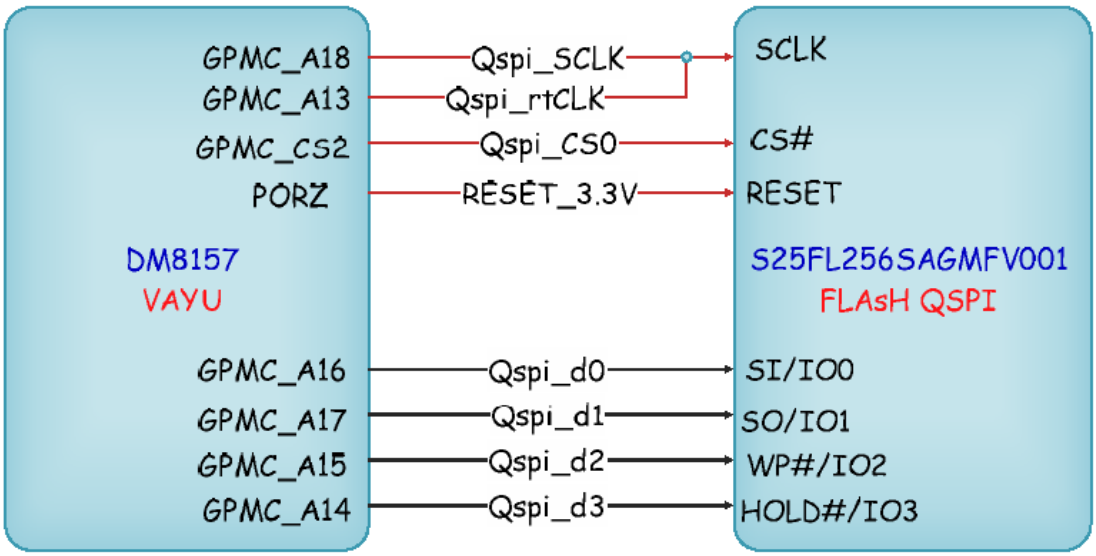


Figure 14: QSPI Flash Interface

Gigabit Ethernet Interface

TDA2x Multi Sensor Fusion Reference Platform has three ports Gigabit Ethernet switch subsystem, (GMAC_SW), it supports, GMII, RGMII, RMII mode operation. In the design uses port0 in RGMII mode with Aheros AR8301 Gigabit PHY to provide the Ethernet connectivity. The Pulse HX6097NL is the 1000BASE-T, PoE + compatible magnetic module with a 1:1 turn's ratio and is used as Ethernet Transformer It provides galvanic isolation between the cable and the system. It has isolation strength of 1.5KVrms
Two TPD4S009 devices are used on the secondary side of the magnetics for ESD protection.

MDIO / MDC – the IEE802.3U compliance management interface for PHY. MDIO is and open drain signal and requires 1.5K pull up for proper operation.

In TDA2x all IO power rails are connected to 3.3V, so the AR8301 is set to 2.5V I/O operation. AR8031 can work at 2.5 V RGMII I/O voltages and 3.3 V MAC RGMII interface. Since the input can bear 3.3V logic signal, and the output logic VoH and VoL can satisfy the 3.3V LVCMOS/LVTTL requirement.

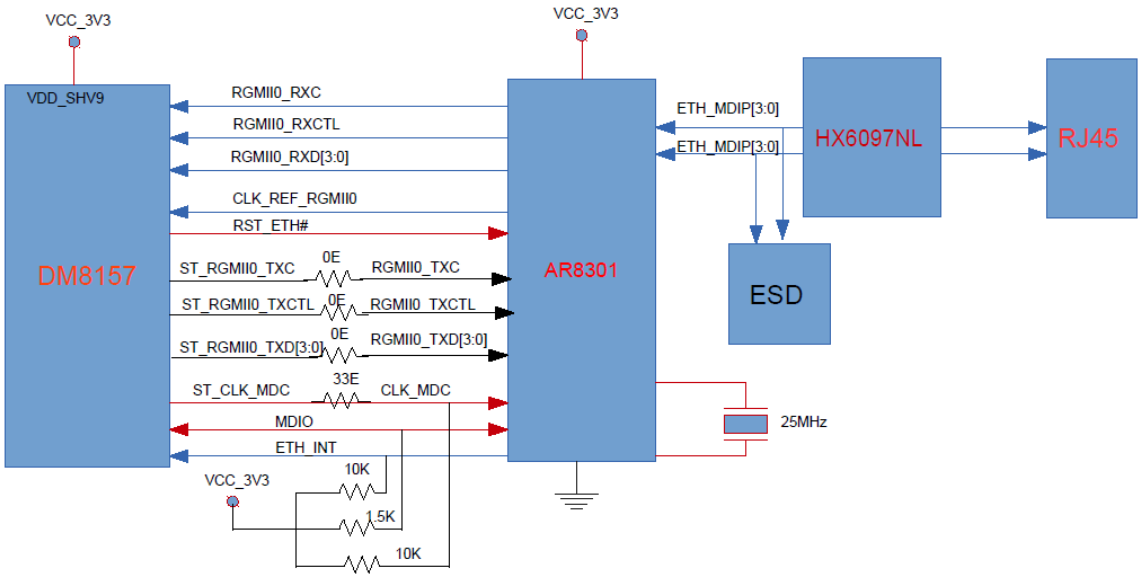


Figure 15: Ethernet Interface

Default strapping for PHY Address is: 000001 (0x01)

Audio Interface

TDA2x has support up to 8 Multi-channel Audio serial peripheral interfaces (McASP) Modules, McASP1 and 2 can support up to 16 channels each and independent clock /sync demines. McASP1 to MCASP8 supports up to 4 channels each and unified clock/sync domain. Multi Sensor Fusion design use the McASP3 port with external low power Audio codec and audio amplifier from TI.
Stereo audio input, stereo output (line-out), mono output (speaker) are supported in the IPNC. Audio input uses two condenser Omni directional microphones and audio output a 3.5mm plug.

SD Interface

TDA2x has the eMMC /SD/SDIO host controller is connected to the L3_MAIN interconnect and have the DMA support. Up to four eMMC/SD/SDIO Controllers can be configured in DM8157. Controller 1 and 4 supports 4-bit wide data bus and controller's 3abd 4 supports 8 bit wide data bus. Multi Sensor Fusion design uses a micro SD socket with card detect switch on the controller 3 of TDA2x. MMC write protect function is not used in the design.

I2C Interface

Up to five I2C interfaces are available in DM8157, below diagram shows the initial design for I2C distribution.

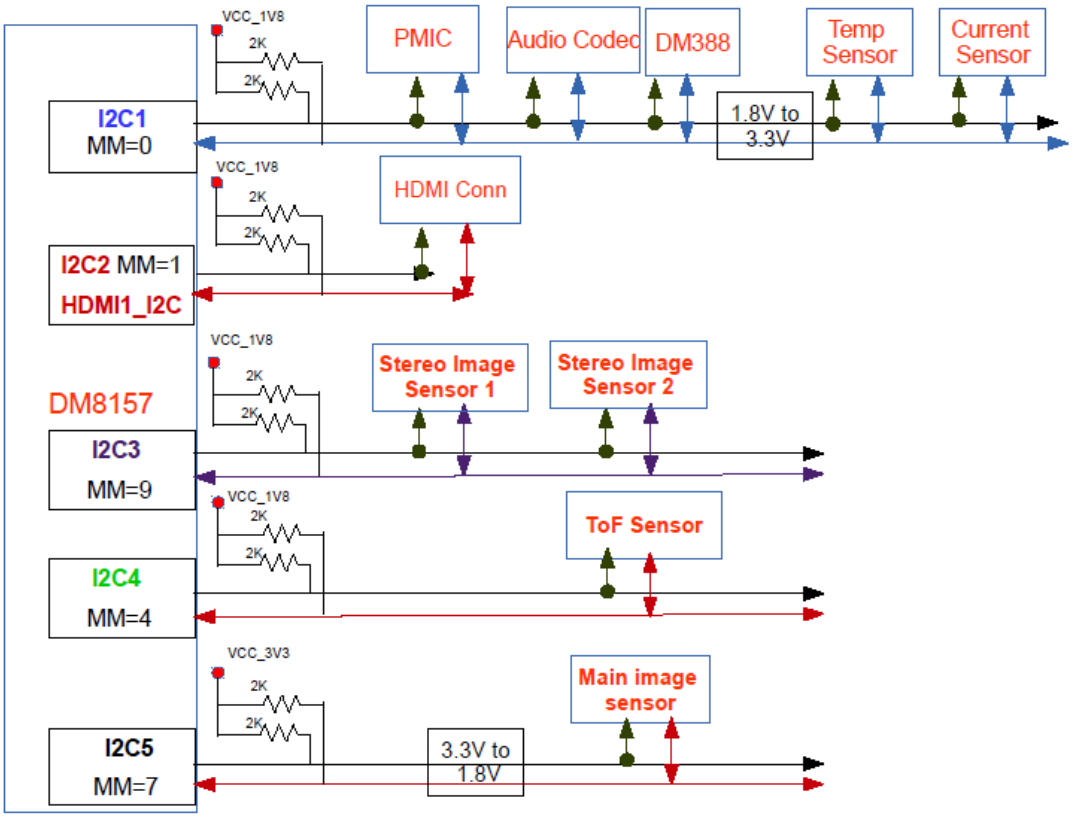


Figure 16:I2C Interface

SPI Interface

SPI Interface is used as the configuration interface for the video input ports (sensors). SPI 1 with multiple chip select I used to connect the different sensors, Mostly it is single time configuration of sensors at the boot up.
SPI-2 is used dedicated to thermopile sensor; this is the data path interface to TDA2x .

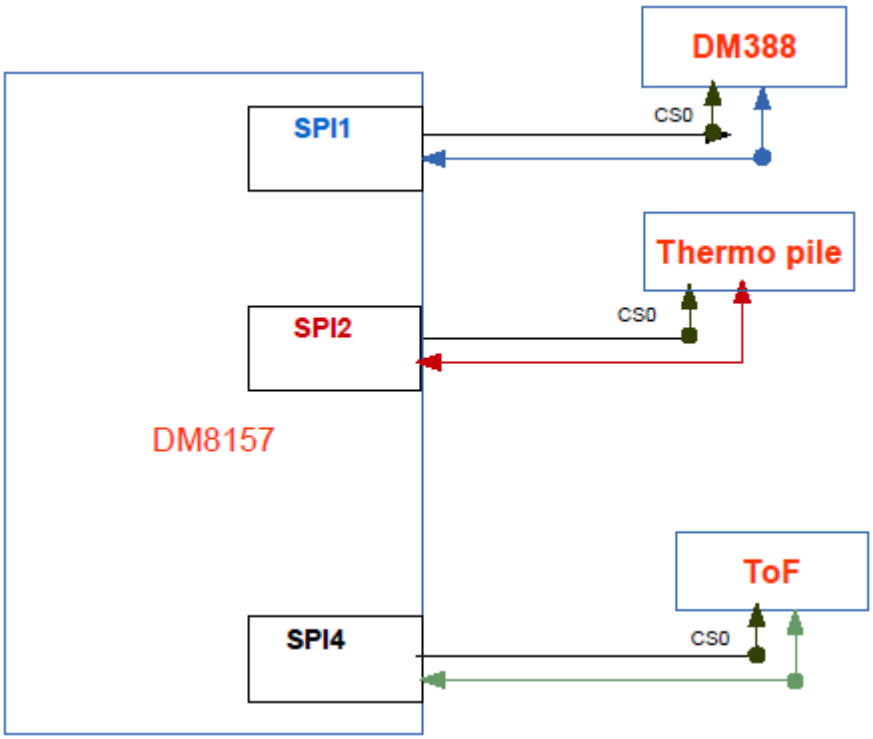


Figure 17: SPI Interface

UART Interface

Two UART from TDA2x is used in the multi sensor fusion design , UART 1 is configured as debug UART and it is terminated to the Debug board header , UART transceiver is on debug board . UART2 is used as the RS485 peripheral control port, and it is terminated to the terminal block connector, this port is exposed to the user on mechanical.

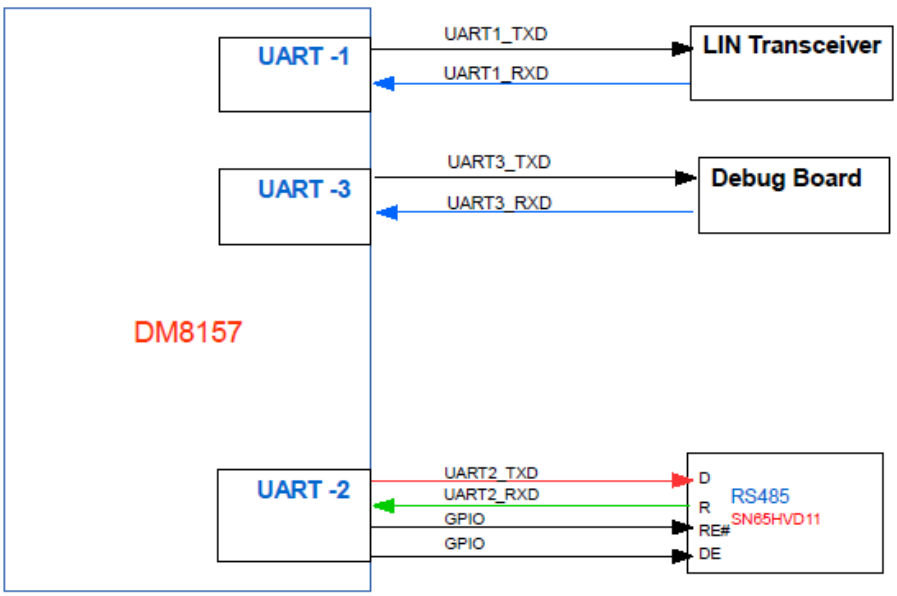


Figure 18: UART Interface

Serial Communication Interface

TDA2x has I2C, SPI, USB ,UART, etc. as control path serial interfaces .In Multi Sensor Fusion design following serial interfaces are configured .Each subsection describes the configuration /connectivity

Video Output Ports

HDMI Interface

TDA2x Multi Sensor Fusion Reference Platform HDMI PHY supports, HDMI 1.4, HDCP1.4 and DVI 1.0 compliance – with support of the 3D stereoscopic frame-packing formats of the HDMI V1.4 standard. HDMI Port is terminated to the standard HDMI Connector.

Inter Board interface (Board to Board DM388 to TDA2x Board)

TDA2x main board is connected to the DM388 ISP board through a rigid fine pitch board to board connector.
Board to Board connector 2x60 part FX20-120P-0.5SV15 is used in the design.