TI TDA2x Based
Multi Sensor Fusion Platform
Configuration and User Guide

Revision 1.0
Copyright Notice
This document is copyrighted material of RadiumBoards, All Rights Reserved. No part of this document, in whole or in part, may be used, reproduced, stored in a retrieval system or transmitted, in any form, or by any means, electronic or otherwise, including photocopying, reprinting, or recording, for any purpose, without the express written permission of RadiumBoards.

Legal Disclaimer
The information contained in this document is subject to change without notice. The information in this document is provided for informational purposes only. RadiumBoards specifically disclaims all warranties, express or limited, including, but not limited, to the implied warranties of merchantability and fitness for a particular purpose, except as provided for in a separate software license agreement.

RadiumBoards
RadiumBoards is a unique website providing complete board and software solutions addressing a broad range of markets including Security and Surveillance, Networking, Wireless, Video, Audio, Automotive, Mobile Device and IOT (Internet of Things).

OEMs and Systems Integrators can shop for complete assemblies, with firmware, BSP and applications ready to integrate into your own enclosures.

ODMs can shop for reference designs complete with full BSP (Board Support Package) and application support. Radium Boards can also provide any level of customization to the hardware or software required by the ODM to help differentiate in their markets.

Electronics hardware and software hobbyists, experimenters and educators now have access to complete high performance platforms for application in an infinite range of projects.

Correspondence
Corporate Office
B-22, Infocity Sector-34,
Gurgaon-122001, Haryana, India
Tel No: +91 124 4284250
US Office
2025 Gateway Place, Suite 465
San Jose, California 95110
E-MAIL
info@radiumboards.com
WEBSITE
www.radiumboards.com

VVDN Technologies
VVDN Technologies Pvt. Ltd. is a sibling company of RadiumBoards and is responsible for the design and development of all products sold through the RadiumBoards brand. Founded in 2007, VVDN is a technology innovation and development company providing a broad spectrum of services and technology expertise to our core domains. VVDN provides “Concept to Customer” services at any point in the development cycle, as well as full turnkey solutions.

WEBSITE
www.vvdntech.com
1. ABOUT THIS DOCUMENT ........................................................................................................... 6
1.1 INTRODUCTION .................................................................................................................. 6
1.2 DOCUMENT CONVENTIONS .............................................................................................. 6
1.3 TERMS AND ABBREVIATIONS ........................................................................................ 7
2. MULTI SENSOR FUSION PLATFORM ...................................................................................... 8
2.1 REFERENCE DESIGN DESCRIPTION ................................................................................. 8
2.2 FEATURES .......................................................................................................................... 9
2.3 TECHNICAL SPECIFICATIONS ........................................................................................ 12
2.4 HARDWARE OVERVIEW ................................................................................................... 13
2.5 VARIANTS .......................................................................................................................... 19
2.6 SYSTEM REQUIREMENTS ............................................................................................... 19
2.7 KIT CONTENTS .................................................................................................................... 19
3. ADAS DOMAIN USE CASES ............................................................................................... 20
3.1 STEREO DISPARITY PROCESSING FLOW ........................................................................... 20
3.2 RADAR PROCESSING FLOW ........................................................................................... 21
3.3 IMAGE SENSOR PROCESSING FLOW ............................................................................... 22
4. MECHANICAL INFORMATION ............................................................................................. 23
4.1 DIMENSION OF ENCLOSURE .......................................................................................... 23
4.2 ENCLOSURE DESIGN ........................................................................................................ 24
5. QUICK STARTUP GUIDE ....................................................................................................... 25
5.1 CONNECTING THE TDA2X MULTI SENSOR FUSION REFERENCE PLATFORM ... 25
5.2 INSTALLATION OVERVIEW ............................................................................................ 27

Figures

FIGURE 1: TITDA2X BASED MULTI SENSOR FUSION PLATFORM ........................................... 9
FIGURE 2: TDA2X MAIN BOARD ............................................................................................. 13
FIGURE 3: DM388 ISP BOARD ............................................................................................... 14
FIGURE 4: MAIN IMAGE SENSOR BOARD ........................................................................... 15
FIGURE 5: STEREO BOARD ................................................................................................... 15
FIGURE 6: FPD LINK BOARD .................................................................................................. 16
FIGURE 7: POWER BOARD ..................................................................................................... 16
FIGURE 8: INTERFACE OF STEREO WITH TDA2X MAIN BOARD ..................................... 17
FIGURE 9: INTERFACE OF IMAGE SENSOR WITH DM388ISP BOARD .............................. 17
FIGURE 10: SIMPLIFIED STEREO PROCESSING FLOW HARDWARE / SOFTWARE DATAFLOW DIAGRAM ...................................................................................................................... 21
FIGURE 11: SIMPLIFIED RADAR PROCESSING FLOW HARDWARE/SOFTWARE DATAFLOW DIAGRAM ................................................................................................................................. 22
FIGURE 12: SIMPLIFIED IMAGE SENSOR PROCESSING FLOW HARDWARE/SOFTWARE DATAFLOW DIAGRAM
FIGURE 13: CAMERA FRONT PLATE MEASUREMENTS
FIGURE 14: FUSION CAMERA INTERNAL ASSEMBLY VIEW
FIGURE 15: TDA2X MULTI SENSOR FUSION PLATFORM PORTS
FIGURE 16: POWERING UP THE CAMERA
FIGURE 17: CAMERA CONSOLE CONNECTION WITH USB MINI B CABLE
FIGURE 18: CAMERA CONNECTION WITH THE NETWORK

TABLES
TABLE 1: DOCUMENT CONVENTIONS
TABLE 2: TERMS AND ABBREVIATIONS
TABLE 3: TECHNICAL SPECIFICATIONS
TABLE 4: MULTI SENSOR FUSION INTERFACE DESCRIPTION
TABLE 5: MULTI SENSOR FUSION MODULE CONFIGURATIONS
TABLE 6: CONFIGURATION WITH/WITHOUT VISION ADAPTER BOARD.
1. About This Document

1.1 Introduction
This document provides details of the multi sensor fusion platform including its features, functionality, installation and configuration of the multi sensor fusion reference platform.

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

<table>
<thead>
<tr>
<th>Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>📌 Note:</td>
<td>Provides information about important features or instructions.</td>
</tr>
<tr>
<td>☢️ Caution:</td>
<td>Alerts you to potential damage to a program, device, or system.</td>
</tr>
<tr>
<td>⚠️ Warning:</td>
<td>Alerts you to potential injury or fatality and to potential electrical hazards.</td>
</tr>
<tr>
<td><strong>Bold font</strong></td>
<td>Any option that needs to be selected or typed in the user interface is represented using bold font.</td>
</tr>
</tbody>
</table>

Table 1: Document Conventions
1.3 Terms and Abbreviations

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

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

Table 2: Terms and Abbreviations
2. Multi Sensor Fusion Platform

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 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:

- TDA2xADAS Media Processor Board (Main Board)
- DM388 Media Processor Board
- Power Supply Board
- Sensor Boards

2.1 Reference Design Description

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
- Microphones – stereo audio reception and detection

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

The TDA2x Multi Sensor Fusion 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:

- TDA2x 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
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

**Stereo Mics**

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

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

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

Table 3: Technical Specifications
2.4 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: TDA2x 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
Figure 8: Interface of Stereo with TDA2x Main Board

Figure 9: Interface of Image Sensor with DM388ISP Board
Table 4 below describes the various interfaces to the Multi Sensor Fusion Platform.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Connector</td>
<td>One pair of Stereo Sensor, one Image Sensor are present on the front panel.</td>
</tr>
<tr>
<td>Ethernet Connector PoE</td>
<td>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 up to 30W.</td>
</tr>
<tr>
<td>Power Input</td>
<td>Power adapter connection. This is a +12V DC inlet, which connects to an external power supply.</td>
</tr>
<tr>
<td>SD Card Holder</td>
<td>For inserting the SD card to store data directly onto the card and to support the booting of the Vayu board.</td>
</tr>
<tr>
<td>USB</td>
<td>USB interface can be used to connect the Wi-Fi USB Stick or USB 3G dongle</td>
</tr>
<tr>
<td>Alarm In Alarm out</td>
<td>Two alarm ports – input and output available on the back panel of the camera.</td>
</tr>
<tr>
<td>Debug Console</td>
<td>Debug console is used for service and debugging purposes.</td>
</tr>
<tr>
<td>HDMI</td>
<td>A standard HDMI interface on back panel for streaming video to HDTVs.</td>
</tr>
<tr>
<td>3.5mm Audio Jack</td>
<td>An audio jack for listening and recording the voice</td>
</tr>
<tr>
<td>JTAG Connector</td>
<td>JTAG connector for debugging and development</td>
</tr>
</tbody>
</table>

Table 4: Multi Sensor Fusion Interface Description
2.5 Variants

RadiumBoard’s Multi Sensor Fusion Platform suite is a modular design based on the industry leading TI TDA2x platform SoC. This modular design allows multiple product configurations as described in the table below.

<table>
<thead>
<tr>
<th>Description</th>
<th>* Base Model</th>
<th>ToF Model</th>
<th>FPD Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDA2x Main Board</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>DM388 ISP Board</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Stereo Image Sensor Board</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Power Board</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Mono Image Sensor Board</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>TOF Board</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>TOF LED Board</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>FPD Link Board</td>
<td>✗</td>
<td>✗</td>
<td>✔</td>
</tr>
</tbody>
</table>

*Base models are available currently. TOF and FPD Model will be available in future.

Table 5: Multi Sensor Fusion Module Configurations

2.6 System Requirements

The TI TDA2x Multi Sensor Fusion 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

2.7 Kit Contents

1) Board with mechanical casings
2) 12 V DC Power Adapter
3) 1 SD Card
4) 1 Console Cable
3. ADAS Domain Use Cases

Multi-sensor fusion platform includes a full featured software development platform called Vision SDK development kit. Vision Software Development Kit (Vision SDK) is 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. The Vision SDK on Multi-sensor fusion camera platform supports the following use-cases as examples:

- Stereo disparity processing flow
- Radar processing flow
- Image sensor processing flow

3.1 Stereo Disparity Processing Flow

The Fusion Camera's stereo board is enabled by two Aptina AR0132 RCCC sensors, which deliver sharp, high definition images with great low-light and high dynamic range performance as well as rapid capture up to 60 fps. With a baseline separation of 115mm and the flexibility to attach a variety of optics that can provide field-of-views (FOVs) from 40 degrees (narrow) to 120 degree (fisheye).

The stereo module on Fusion Camera can be configured to support many different applications that leverage depth information, including automatic emergency braking, collision avoidance, obstacle detection, adaptive cruise control, and advanced park assist.
Some salient features for Stereo processing flow are:

- Dual AR0132 RCCC sensor support
- Hardware sensor synchronization
- RCCC (CFA) ISP support
- High performance Disparity processing algorithm implementation on DSP

3.2 Radar Processing Flow

Multi-sensor fusion platform allows connecting RADAR module via FPD LINK III to one of the on-board capture interface. The simplified connectivity diagram is shown below:
Vision SDK will support framework for RADAR processing and output interpolation for vision purpose.

3.3 Image Sensor Processing Flow

Multi Sensor Fusion Platform has facility for High quality color imaging. This functionality is provided by main image sensor. Main image sensor is a 12 bit aptina sensor having 720p resolution. It captures the RGB data and then passes it to DM388. The main role of DM388 here is to provide ISP(Image signal Process). After image processing the data is routed to video encoder. VENC setting is selected for VOUT1 port. The moment someone selects the usecase from TDA2x console, TDA2x captures the data from VOUT port of DM388 through its VIN port and displays it on HDMI.
4. Mechanical Information

4.1 Dimension Of Enclosure

The tentative camera front plate measurements are shown below:

![Camera front plate measurements diagram](image-url)

Figure 13: Camera front plate measurements
4.2 Enclosure Design

Enclosure has been designed not only for easy assembly/disassembly, but also easy for internal connectivity.

The figure below shows the internal board to board connections. It shows how those sensors and sensor boards are connected to their respective board.

![Fusion Camera Internal Assembly View](image)

Figure 14: Fusion Camera Internal Assembly View

### Table 6 Configuration with/without vision adapter board.

<table>
<thead>
<tr>
<th>TDA2x Main Board Capture Interface</th>
<th>Vision Board Use Case</th>
<th>On-camera sensors use case</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN 2A</td>
<td>Dedicated to DM388 ISP module (main image camera)</td>
<td></td>
</tr>
<tr>
<td>VIN 1A</td>
<td>FPD Link (Radar)*</td>
<td>None</td>
</tr>
<tr>
<td>VIN 3A</td>
<td>FPD Link (camera)*</td>
<td>Leopard Imaging Sensor Module</td>
</tr>
<tr>
<td>VIN 3B</td>
<td>TOF Sensor (optional)*</td>
<td>TOF Sensor (optional)*</td>
</tr>
<tr>
<td>VIN 5A</td>
<td>FPD Link (camera)*</td>
<td>Stereo Sensor 1 (AR0132)</td>
</tr>
<tr>
<td>VIN 6A</td>
<td>FPD Link (camera)*</td>
<td>Stereo Sensor 2 (AR0132)</td>
</tr>
</tbody>
</table>

*Will be available in Phase 2.
5. Quick Startup Guide

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

Figure 15: TDA2x Multi Sensor Fusion Platform Ports

5.1 Connecting the TDA2x Multi Sensor Fusion Platform

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

- Powering up the camera

Figure 16: Powering up the camera
• Connecting the camera console

![Camera Console connection with USB mini B Cable](image)

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

Figure 17: Camera Console connection with USB mini B Cable

• Connecting to the Network
5.2 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.