

# **VISION SDK LINUX (v03.00.00)**

## **Data Sheet**

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| Amplifiers                  | <a href="http://amplifier.ti.com">amplifier.ti.com</a>             |
| Data Converters             | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>     |
| DLP® Products               | <a href="http://www.dlp.com">www.dlp.com</a>                       |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
| Power Mgmt                  | <a href="http://power.ti.com">power.ti.com</a>                     |
| Microcontrollers            | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> |
| RFID                        | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>               |
| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

### Applications

|                    |                                                                          |
|--------------------|--------------------------------------------------------------------------|
| Audio              | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                   |
| Automotive         | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>         |
| Broadband          | <a href="http://www.ti.com/broadband">www.ti.com/broadband</a>           |
| Digital Control    | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
| Medical            | <a href="http://www.ti.com/medical">www.ti.com/medical</a>               |
| Military           | <a href="http://www.ti.com/military">www.ti.com/military</a>             |
| Optical Networking | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
| Security           | <a href="http://www.ti.com/security">www.ti.com/security</a>             |
| Telephony          | <a href="http://www.ti.com/telephony">www.ti.com/telephony</a>           |
| Video & Imaging    | <a href="http://www.ti.com/video">www.ti.com/video</a>                   |
| Wireless           | <a href="http://www.ti.com/wireless">www.ti.com/wireless</a>             |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated

## Table of Contents

|          |                                                                                           |           |
|----------|-------------------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Supported Features.....</b>                                                            | <b>5</b>  |
| 1.1      | Use-cases .....                                                                           | 5         |
| 1.2      | Framework features.....                                                                   | 5         |
| 1.3      | Supported Links on A15 + Linux .....                                                      | 5         |
| <b>2</b> | <b>Common System Parameters .....</b>                                                     | <b>5</b>  |
| 2.1      | TDA2xx - Code/Data Memory Usage .....                                                     | 5         |
| 2.2      | TDA2Ex - Code/Data Memory Usage.....                                                      | 8         |
| <b>3</b> | <b>1CH VIP capture + SGX Copy + DISPLAY usecase on TDA2xx &amp; TDA2Ex .....</b>          | <b>9</b>  |
| 3.1      | Overview.....                                                                             | 9         |
| 3.2      | Dataflow .....                                                                            | 9         |
| 3.3      | System Parameters .....                                                                   | 10        |
| 3.4      | CPU loading and Task Info.....                                                            | 10        |
| 3.4.1    | <i>Total CPU load .....</i>                                                               | <i>10</i> |
| 3.4.2    | <i>Task Level Information and Task Level CPU load .....</i>                               | <i>10</i> |
| 3.4.3    | <i>Heap Memory Usage.....</i>                                                             | <i>10</i> |
| 3.5      | System Performance.....                                                                   | 11        |
| 3.6      | Processing Latency .....                                                                  | 11        |
| 3.7      | DDR BW usage .....                                                                        | 11        |
| <b>4</b> | <b>Multi-channel 1MP 3D Surround view using SGX on Linux on TDA2xx &amp; TDA2Ex .....</b> | <b>12</b> |
| 4.1      | Overview.....                                                                             | 12        |
| 4.2      | Data Flow.....                                                                            | 12        |
| 4.2.1    | <i>4CH LVDS capture, 3D Surround View demonstration .....</i>                             | <i>12</i> |
| 4.3      | System Parameters .....                                                                   | 14        |
| 4.4      | CPU loading and Task Info.....                                                            | 14        |
| 4.4.1    | <i>Total CPU load .....</i>                                                               | <i>14</i> |
| 4.4.2    | <i>Task Level Information and Task Level CPU load .....</i>                               | <i>14</i> |
| 4.4.3    | <i>Heap Memory Usage.....</i>                                                             | <i>14</i> |
| 4.5      | System Performance.....                                                                   | 15        |
| 4.6      | Processing Latency .....                                                                  | 15        |
| 4.7      | DDR BW usage .....                                                                        | 16        |
| <b>5</b> | <b>Multi-channel 2MP 3D Surround view using SGX on Linux on TDA2xx.....</b>               | <b>17</b> |
| 5.1      | Overview.....                                                                             | 17        |
| 5.2      | Data Flow.....                                                                            | 17        |
| 5.2.1    | <i>4CH LVDS capture, 3D Surround View demonstration .....</i>                             | <i>17</i> |
| 5.3      | System Parameters .....                                                                   | 19        |
| 5.4      | CPU loading and Task Info.....                                                            | 19        |
| 5.4.1    | <i>Total CPU load .....</i>                                                               | <i>19</i> |
| 5.4.2    | <i>Task Level Information and Task Level CPU load .....</i>                               | <i>19</i> |
| 5.4.3    | <i>Heap Memory Usage.....</i>                                                             | <i>20</i> |
| 5.5      | System Performance.....                                                                   | 20        |
| 5.6      | Processing Latency .....                                                                  | 20        |
| 5.7      | DDR BW usage .....                                                                        | 21        |

|           |                                                                                                                                          |           |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>6</b>  | <b>Multi-channel 3D Surround view using SGX on Linux + Car Black Box (2x2 mosaic record and playback on MMC/SD card) on TDA2Ex .....</b> | <b>22</b> |
| 6.1       | Overview.....                                                                                                                            | 22        |
| 6.2       | Data Flow.....                                                                                                                           | 22        |
| 6.2.1     | <i>4CH CSI2 CAL capture, 3D Surround View demonstration + Car Black Box .....</i>                                                        | <i>22</i> |
| 6.3       | System Parameters .....                                                                                                                  | 24        |
| 6.4       | CPU loading and Task Info.....                                                                                                           | 24        |
| 6.4.1     | <i>Total CPU load .....</i>                                                                                                              | <i>24</i> |
| 6.4.2     | <i>Task Level Information and Task Level CPU load .....</i>                                                                              | <i>24</i> |
| 6.4.3     | <i>Heap Memory Usage.....</i>                                                                                                            | <i>24</i> |
| 6.5       | System Performance.....                                                                                                                  | 25        |
| 6.6       | Processing Latency .....                                                                                                                 | 25        |
| 6.7       | DDR BW usage .....                                                                                                                       | 26        |
| <b>7</b>  | <b>Multi-channel AVB capture and display usecase on Linux for TDA2xx .....</b>                                                           | <b>27</b> |
| 7.1       | Overview.....                                                                                                                            | 27        |
| 7.2       | Data Flow.....                                                                                                                           | 27        |
| 7.2.1     | <i>4CH AVB capture.....</i>                                                                                                              | <i>27</i> |
| 7.3       | System Parameters .....                                                                                                                  | 28        |
| 7.4       | CPU loading and Task Info.....                                                                                                           | 28        |
| 7.4.1     | <i>Total CPU load .....</i>                                                                                                              | <i>28</i> |
| 7.4.2     | <i>Task Level Information and Task Level CPU load .....</i>                                                                              | <i>28</i> |
| 7.4.3     | <i>Heap Memory Usage.....</i>                                                                                                            | <i>28</i> |
| 7.5       | System Performance.....                                                                                                                  | 29        |
| 7.6       | Processing Latency .....                                                                                                                 | 29        |
| 7.7       | DDR BW usage .....                                                                                                                       | 29        |
| <b>8</b>  | <b>System Memory Usage for Tda2xx .....</b>                                                                                              | <b>30</b> |
| 8.1       | Code / Data Memory Usage .....                                                                                                           | 30        |
| <b>9</b>  | <b>System Memory Usage for TDA2Ex.....</b>                                                                                               | <b>30</b> |
| 9.1       | Code / Data Memory Usage .....                                                                                                           | 30        |
| <b>10</b> | <b>IPC latency measurements.....</b>                                                                                                     | <b>30</b> |
| 10.1      | A15->IPU1_0 IPC latencies .....                                                                                                          | 30        |
| 10.2      | IPU1_0->A15 IPC latencies .....                                                                                                          | 30        |
| <b>11</b> | <b>Revision History .....</b>                                                                                                            | <b>31</b> |

## 1 Supported Features

### 1.1 Use-cases

The Linux + Vision SDK supports the following use-cases categories

#### Single Camera Use-cases

#### Multi-Camera LVDS Use-cases

#### AVB RX Use-case

From the above category, three use-cases are picked for system-parameter measurements in this document. For others data can be interpreted from BIOS use-cases results – please refer Vision SDK BIOS datasheet at \$INSTALL\_DIR\vision\_sdk\docs\VisionSDK\_DataSheet.pdf.

### 1.2 Framework features

- Refer  
\$INSTALL\_DIR\vision\_sdk\docs\FeatureSpecificUserGuides\VisionSDK\_Feature\_List.xlsx

### 1.3 Supported Links on A15 + Linux

Links for the following modules with the features listed below

- Algorithm
- Dup, gate, merge, select, sync
- IPC\_IN, IPC\_OUT
- null, nullSrc
- sgxFrmcpy

## 2 Common System Parameters

Refer Section 2.1 in \$INSTALL\_DIR\vision\_sdk\docs\VisionSDK\_DataSheet.pdf

When Linux is in picture all the cores run at HIGH OPP with the following clock frequencies:

| CORE             | Frequency in MHz |
|------------------|------------------|
| MPU              | 1000             |
| DSPx             | 750              |
| EVE <sub>x</sub> | 650              |
| IPU <sub>x</sub> | 425              |
| GPU              | 532              |
| IVA              | 532              |

### 2.1 TDA2xx - Code/Data Memory Usage

NOTE: Code/data memory for data structures is same for all configurations and all use-cases since a single binary is used for all configurations and all use-cases. These configurations are with respect to 1GB Memory map.

| IPU1-0 | Initialized section (.text, .const)                         | 8MB  |  |
|--------|-------------------------------------------------------------|------|--|
|        | Uninitialized section (.bss, .heap, .stack)                 | 21MB |  |
| IPU2   | Initialized section (.text, .const)                         | 8MB  |  |
|        | Uninitialized section (.bss, .heap, .stack)                 | 20MB |  |
| DSP1   | Initialized section (.text, .const)                         | 2MB  |  |
|        | Uninitialized section (.bss, .heap, .stack, .far, .fardata) | 24MB |  |
| DSP2   | Initialized section (.text, .const)                         | 2MB  |  |

|       |                                                                                          |        |  |
|-------|------------------------------------------------------------------------------------------|--------|--|
|       | Uninitialized section<br>(.bss, .heap, .stack)                                           | 10MB   |  |
| EVE1  | Initialized section (.text,<br>.const)                                                   | 2MB    |  |
|       | Uninitialized section<br>(.bss, .heap, .stack)                                           | 13.5MB |  |
| EVE2  | Initialized section (.text,<br>.const)                                                   | 2MB    |  |
|       | Uninitialized section<br>(.bss, .heap, .stack)                                           | 13.5MB |  |
| EVE3  | Initialized section (.text,<br>.const)                                                   | 2MB    |  |
|       | Uninitialized section<br>(.bss, .heap, .stack)                                           | 13.5MB |  |
| EVE4  | Initialized section (.text,<br>.const)                                                   | 2MB    |  |
|       | Uninitialized section<br>(.bss, .heap, .stack)                                           | 13.5MB |  |
| A15-0 | Initialized section (.text,<br>.const)<br>Uninitialized section<br>(.bss, .heap, .stack) | 20MB   |  |

## 2.2 TDA2Ex - Code/Data Memory Usage

NOTE: Code/data memory for data structures is same for all configurations and all use-cases since a single binary is used for all configurations and all use-cases. These configurations are with respect to 1GB Memory map.

| CPU    | MEMORY SECTION                                                                     | MEMORY SIZE RESERVED | MEMORY SIZE USED |
|--------|------------------------------------------------------------------------------------|----------------------|------------------|
| IPU1-0 | Initialized section (.text, .const)                                                | 8MB                  | 5.16MB           |
|        | Uninitialized section (.bss, .heap, .stack)                                        | 20MB                 | 6.36MB           |
| IPU2   | Initialized section (.text, .const)                                                | 8MB                  |                  |
|        | Uninitialized section (.bss, .heap, .stack)                                        | 20MB                 |                  |
| DSP1   | Initialized section (.text, .const)                                                | 2MB                  | 669KB            |
|        | Uninitialized section (.bss, .heap, .stack, .far, .fardata)                        | 24MB                 | 8.17 MB          |
| A15-0  | Initialized section (.text, .const)<br>Uninitialized section (.bss, .heap, .stack) | 20MB                 | 11 MB            |

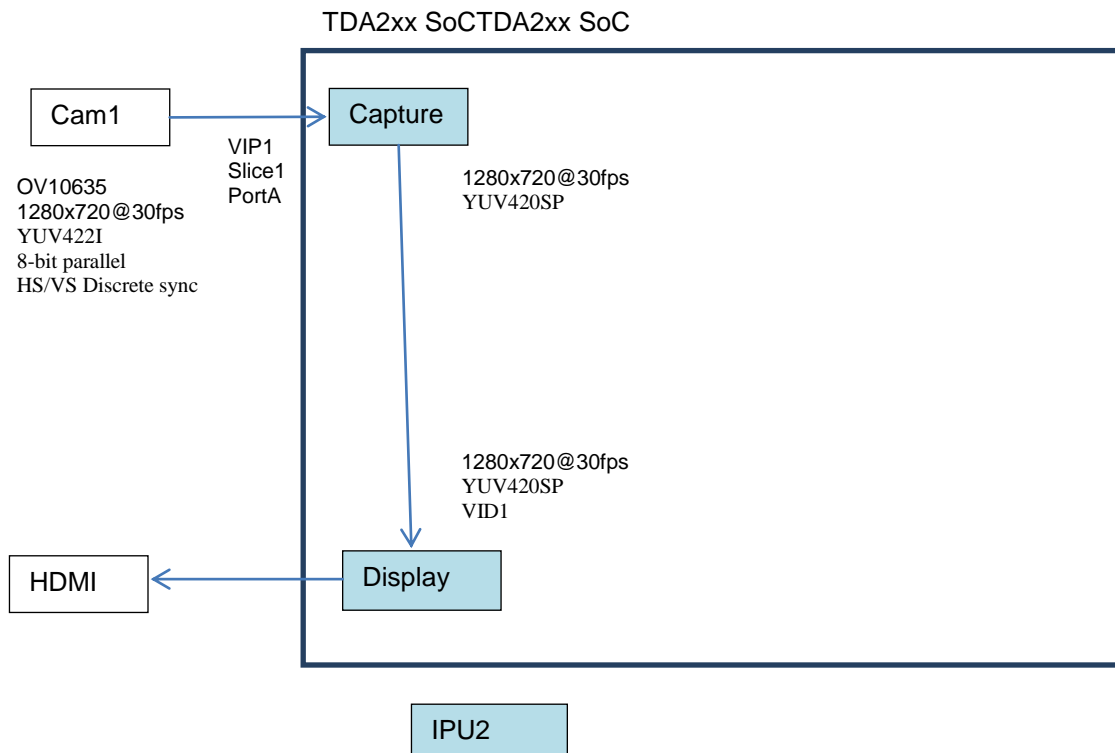


### 3 1CH VIP capture + SGX Copy + DISPLAY usecase on TDA2xx & TDA2Ex

#### 3.1 Overview

This usecase consists of continuous capture on IPU2 and display on IPU2 with SGX. Capture can be done at 720p@30fps (OV Sensor) via the VIP1 Slice1 Port A. Display can be on HDMI display via HDMI output port. This is supported on both TDA2x and TDA2Ex.

#### 3.2 Dataflow



### 3.3 System Parameters

Refer Section 2.1 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

The only difference when Linux is in picture is, A15 runs at 1000MHz instead of 750 MHz

### 3.4 CPU loading and Task Info

#### 3.4.1 Total CPU load

| CPU  | CPU LOAD (%)                                    |                                                |
|------|-------------------------------------------------|------------------------------------------------|
| SOC  | TDA2xx                                          | TDA2EX                                         |
| IPU2 | 22.7%                                           | 8.7%                                           |
| Sgx  | Fragment Shader – 18.1%<br>Vertex Shader -0.75% | Fragment Shader – 21%<br>Vertex Shader – 0.72% |

#### 3.4.2 Task Level Information and Task Level CPU load

| CPU  | TASK NAME | TASK DESCRIPTION                    | CPU LOAD (%) |        |
|------|-----------|-------------------------------------|--------------|--------|
| SOC  |           |                                     | TDA2xx       | TDA2EX |
| IPU2 | Capture   | Capture frames via VIP port         | 0.2%         | 0.2%   |
|      | Display   | Display via sgx link                | 0.6%         | 0.5%   |
|      | IPC OUT   | To send frame to another processor  | 0.7%         | 0.7%   |
|      | Stat Coll | Stat collector                      | 3.6%         | 2.6%   |
|      | GrpxSrc0  | Graphic source link                 | 14.0%        | 1.6%   |
|      | App Ctrl  | Sensor init and board level control | 0.1%         | 0.1%   |
|      | Misc      | Miscellaneous                       | 0.5%         | 0.4%   |

#### 3.4.3 Heap Memory Usage

| CPU  | MEMORY SECTION        | MEMORY SIZE RESERVED | MEMORY SIZE USED |        |
|------|-----------------------|----------------------|------------------|--------|
| SOC  |                       | TDA2xx               | TDA2XX           | TDA2EX |
| IPU2 | Local heap            | 256KB                | 14KB             | 8KB    |
|      | HDVPSS Descriptor Mem | 1MB                  | 1MB              | 1MB    |

|               |                     |       |       |        |
|---------------|---------------------|-------|-------|--------|
| Shared Memory | SR0 DDR             | 1MB   | 189KB | 9KB    |
|               | SR1 (Frame Buffers) | 330MB | 44MB  | 44 MB  |
|               | SR2 (OCMC)          | 512KB | 0KB   | 0 KB   |
|               | Remote Log Buffer   | 256KB | 145KB | 145 KB |

### 3.5 System Performance

| COMPONENT | PARAMETER | VALUE  |        |
|-----------|-----------|--------|--------|
| SOC       |           | TDA2xx | TDA2EX |
| Capture   | Out FPS   | 30     | 30     |
| SGX Copy  | Out FPS   | 30     | 30     |
| Display   | Input FPS | 30     | 30     |

NOTE: FPS numbers are rounded off to nearest integer

### 3.6 Processing Latency

|                            |     | LATENCY |        |
|----------------------------|-----|---------|--------|
| SOC                        |     | TDA2xx  | TDA2Ex |
| Capture to Display Latency | Avg | 7.4ms   | 8.4ms  |
|                            | Min | 7.3ms   | 8.2ms  |
|                            | Max | 8.1ms   | 14.7ms |

Note: Latency is from VIP output to the display. Additional capture latency needs to be added for end to end latency

### 3.7 DDR BW usage

| PARAMETER          | BANDWIDTH | TDA2XX    | TDA2EX    |
|--------------------|-----------|-----------|-----------|
| EMIF1 Read + Write | Avg       | 582 MB/s  | 1101 MB/s |
|                    | Peak      | 1294 MB/s | 2254 MB/s |
| EMIF2 Read + Write | Avg       | 556 MB/s  | NA        |
|                    | Peak      | 1255 MB/s | NA        |

## **4 Multi-channel 1MP 3D Surround view using SGX on Linux on TDA2xx & TDA2Ex**

### **4.1 Overview**

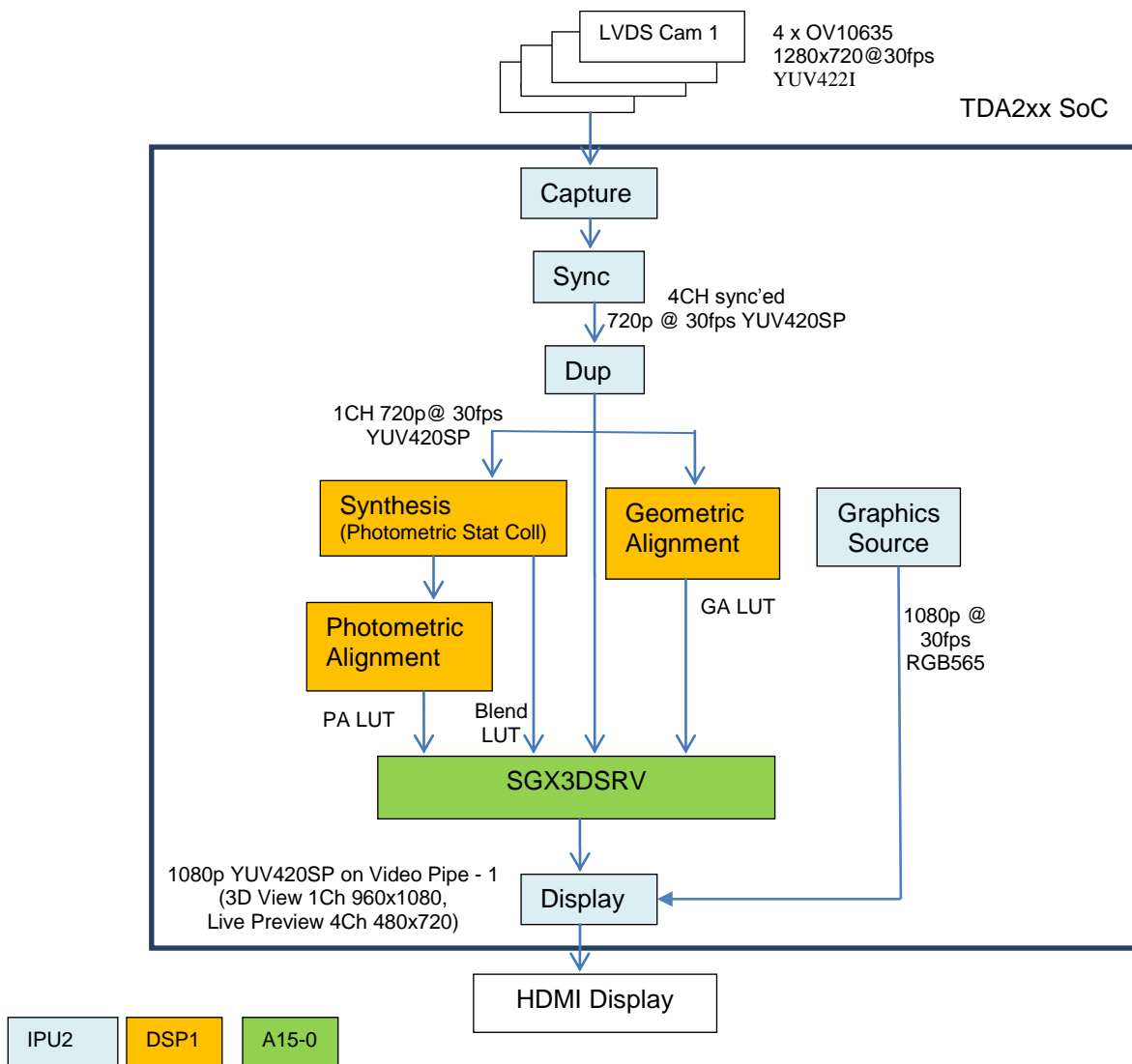
This use case demonstrates 1MP 3D surround view using SGX with Linux running on A15. This usecase is supported on both TDA2x and TDA2Ex.

### **4.2 Data Flow**

#### **4.2.1 4CH LVDS capture, 3D Surround View demonstration**

In this configuration we capture 4 Channel video from 4 OV1063x sensors @ 720p 30fps. Captured frames are then passed on to Sync link, where these captured frames are synced based on time stamps. This "group of sync'ed frames" is passed on to algorithm links of Geometric alignment and synthesis link. Geometric Analysis link running on DSP core is invoked once in K frames. This link generates the geometric alignment LUTs to be used during synthesis stage. Photometric Analysis link runs on DSP core. Certain image statistics needed for calculating photometric LUTs are provided by the synthesis stage. Photometric Analysis link generates LUTs for pixel value transformations during Synthesis. Synthesis link on DSP encapsulates the algorithm for generating the photometric statistics & Blend Lookup tables, based on geometric and photometric LUTs. SGX link encapsulates the algorithm for stitching, based on geometric, Blend and photometric LUTs. This Link runs on A15 (Linux) and SGX (3D GRPX Engine) is used to create the 360 degree of the car using Open GL API/Algos. Output of Synthesis link is the stitched frame which is passed onto display link, which shall display the surround view image using display drivers via HDMI output.

Please note in dataflow diagram below IPC IN/OUT blocks are left-out to improve readability. Please assume these whenever CPU changes in the flow.



\*\*IPC IN/OUT blocks are left-out to improve readability.

### 4.3 System Parameters

Refer Section 2.1 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

The only difference when Linux is in picture is, A15 runs at 1000MHz instead of 750 MHz

### 4.4 CPU loading and Task Info

#### 4.4.1 Total CPU load

| CPU  | TDA 2xx CPU LOAD (%)                         | TDA 2ex CPU LOAD (%)                         |
|------|----------------------------------------------|----------------------------------------------|
| IPU2 | 32.3%                                        | 27.4%                                        |
| DSP1 | 4.2%                                         | 4.1%                                         |
| Sgx  | Fragment Shader – 25%<br>Vertex Shader – 11% | Fragment Shader – 37%<br>Vertex Shader – 16% |

#### 4.4.2 Task Level Information and Task Level CPU load

| CPU  | TASK NAME     | TASK DESCRIPTION                                            | CPU LOAD (%) |        |
|------|---------------|-------------------------------------------------------------|--------------|--------|
| SOC  |               |                                                             | TDA2xx       | TDA2ex |
| IPU2 | Capture       | Capture frames via VIP port                                 | 1.2%         | 1.1%   |
|      | Display       | Display via sgx link                                        | 1.7%         | 1.5%   |
|      | VPE (2 Links) |                                                             | 4.8%         | 4.3%   |
|      | IPC OUT       | To send frame to another processor                          | 2.4%         | 2.2%   |
|      | IPC IN        |                                                             | 0.4%         | 0.4%   |
|      | DUP Link      |                                                             | 1.5%         | 1.4%   |
|      | SYNC Link     | Sync Link to synchronize the frames from different channels | 3.2%         | 2.9%   |
|      | Select Link   |                                                             | 0.7%         | 0.6%   |
|      | Stat Coll     | Stat collector                                              | 3.9%         | 3.3%   |
|      | GrpxSrc0      | Graphic source link                                         | 3.5%         | 0.4%   |
|      | App Ctrl      | Sensor init and board level control                         | 0.1%         | 0.1%   |
|      | Misc          | Miscellaneous                                               | 1.1%         | 1.2%   |

#### 4.4.3 Heap Memory Usage

| CPU | MEMORY SECTION | MEMORY SIZE RESERVED | TDA 2xx MEMORY SIZE USED | TDA 2ex MEMORY SIZE USED |
|-----|----------------|----------------------|--------------------------|--------------------------|
|-----|----------------|----------------------|--------------------------|--------------------------|

|               |                       |       |       |       |
|---------------|-----------------------|-------|-------|-------|
| IPU2          | Local heap            | 256KB | 20KB  | 14KB  |
|               | HDVPSS Descriptor Mem | 1MB   | 1MB   | 1MB   |
| DSP 1         | L2                    | 221KB | 128KB | 128KB |
|               | Local Heap            | 512KB | 9KB   | 4KB   |
| Shared Memory | SR0                   | 1MB   | 189KB | 9KB   |
|               | SR1 (Frame Buffers)   | 330MB | 239MB | 239MB |
|               | SR2 (OCMC)            | 512KB | 0KB   | 0KB   |
|               | Remote Log Buffer     | 256KB | 145KB | 145KB |

#### 4.5 System Performance

| COMPONENT               | PARAMETER  | VALUE |
|-------------------------|------------|-------|
| Capture                 | Out FPS    | 30fps |
| ALG Synthesis (DSP1)    | Output fps | 30fps |
| ALG – DMA_SWMS (IPU1_0) | Output fps | 30fps |
| SGX3DSRV (A15)          | Output fps | 30fps |
| ALG_PHOTOALIGN          | Output fps | 30fps |
| DISPLAY                 | Input FPS  | 30fps |

NOTE: FPS numbers are rounded off to nearest integer.

#### 4.6 Processing Latency

|                            |     | LATENCY |        |
|----------------------------|-----|---------|--------|
| SOC                        |     | TDA2xx  | TDA2Ex |
| Capture to Display Latency | Avg | 31.2ms  | 25.2ms |
|                            | Min | 21.5ms  | 23.2ms |
|                            | Max | 37.4ms  | 31.6ms |

NOTE:

- This latency is as measured inside the system by software.
- There will an additional  $1/(\text{capture rate})$  added on top of this from sensor/receiver itself.
- There will an additional  $1/(\text{display rate})$  added on top of this for the frame to actually get displayed on the screen.

- Thus e.g. in a scenario of display at 60fps and capture at 30fps - 16.67ms + 33.33ms needs to be added to latency figures in above table to get true capture to display latency

#### 4.7 DDR BW usage

| PARAMETER          | BANDWIDTH | TDA2XX    | TDA2EX    |
|--------------------|-----------|-----------|-----------|
| EMIF1 Read + Write | Avg       | 736 MB/s  | 1480 MB/s |
|                    | Peak      | 1540 MB/s | 2129 MB/s |
| EMIF2 Read + Write | Avg       | 704 MB/s  | NA        |
|                    | Peak      | 1477 MB/s | NA        |



## **5 Multi-channel 2MP 3D Surround view using SGX on Linux on TDA2xx**

### **5.1 Overview**

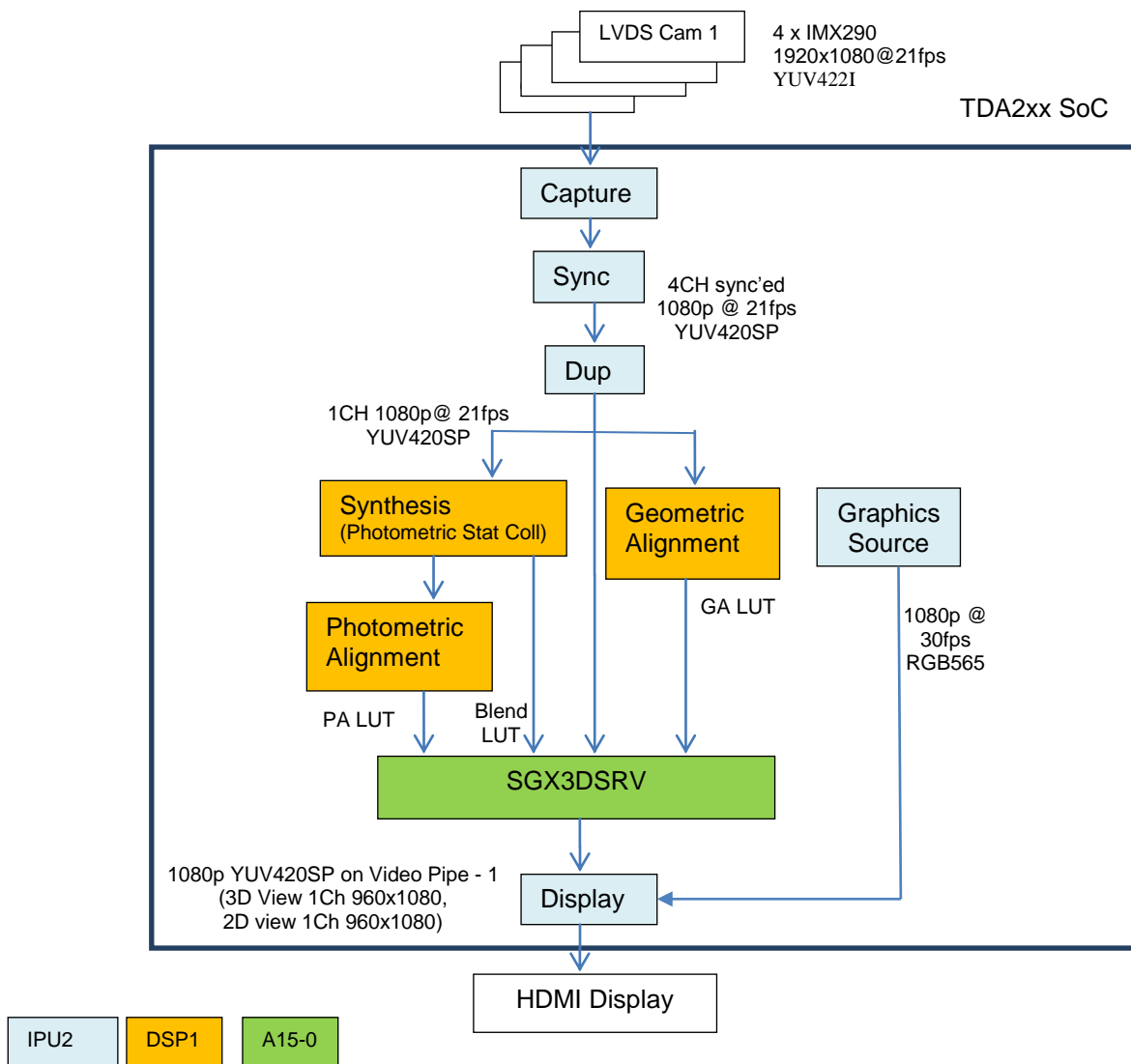
This use case demonstrates 2MP 3D surround view using SGX with Linux running on A15. This usecase is supported on both TDA2x

### **5.2 Data Flow**

#### **5.2.1 4CH LVDS capture, 3D Surround View demonstration**

In this configuration we capture 4 Channel video from 4 IMX290 sensors @ 1080p 21fps. Captured frames are then passed on to Sync link, where these captured frames are synced based on time stamps. This "group of sync'ed frames" is passed on to algorithm links of Geometric alignment and synthesis link. Geometric Analysis link running on DSP core is invoked once in K frames. This link generates the geometric alignment LUTs to be used during synthesis stage. Photometric Analysis link runs on DSP core. Certain image statistics needed for calculating photometric LUTs are provided by the synthesis stage. Photometric Analysis link generates LUTs for pixel value transformations during Synthesis. Synthesis link on DSP encapsulates the algorithm for generating the photometric statistics & Blend Lookup tables, based on geometric and photometric LUTs. SGX link encapsulates the algorithm for stitching, based on geometric, Blend and photometric LUTs. This Link runs on A15 (Linux) and SGX (3D GRPX Engine) is used to create the 360 degree of the car using Open GL API/Algos. Output of Synthesis link is the stitched frame which is passed onto display link, which shall display the surround view image using display drivers via HDMI output.

Please note in dataflow diagram below IPC IN/OUT blocks are left-out to improve readability. Please assume these whenever CPU changes in the flow.



\*\*IPC IN/OUT blocks are left-out to improve readability.

### 5.3 System Parameters

Refer Section 2.1 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

The only difference when Linux is in picture is, A15 runs at 1000MHz instead of 750 MHz

### 5.4 CPU loading and Task Info

#### 5.4.1 Total CPU load

| CPU  | TDA 2xx CPU LOAD (%)                            |
|------|-------------------------------------------------|
| IPU2 | 14.2%                                           |
| DSP1 | 4.7%                                            |
| Sgx  | Fragment Shader – 45.5%<br>Vertex Shader – 9.7% |

#### 5.4.2 Task Level Information and Task Level CPU load

| CPU        | TASK NAME | TASK DESCRIPTION                                            | CPU LOAD (%)  |
|------------|-----------|-------------------------------------------------------------|---------------|
| <b>SOC</b> |           |                                                             | <b>TDA2xx</b> |
| IPU2       | Capture   | Capture frames via VIP port                                 | 0.7%          |
|            | Display   | Display via sgx link                                        | 0.4%          |
|            | IPC OUT   | To send frame to another processor                          | 1.5%          |
|            | IPC IN    |                                                             | 0.3%          |
|            | DUP Link  |                                                             | 0.2%          |
|            | SYNC Link | Sync Link to synchronize the frames from different channels | 1.2%          |
|            | Stat Coll | Stat collector                                              | 3.7%          |
|            | GrpxSrc0  | Graphic source link                                         | 1.9%          |
|            | App Ctrl  | Sensor init and board level control                         | 0.1%          |
|            | Misc      | Miscellaneous                                               | 0.8%          |

### 5.4.3 Heap Memory Usage

| CPU           | MEMORY SECTION        | MEMORY SIZE RESERVED | TDA 2xx MEMORY SIZE USED |
|---------------|-----------------------|----------------------|--------------------------|
| IPU2          | Local heap            | 256KB                | 14KB                     |
|               | HDVPSS Descriptor Mem | 1MB                  | 1MB                      |
| DSP 1         | L2                    | 221KB                | 128KB                    |
|               | Local Heap            | 512KB                | 9KB                      |
| Shared Memory | SR0                   | 1MB                  | 189KB                    |
|               | SR1 (Frame Buffers)   | 330MB                | 244MB                    |
|               | SR2 (OCMC)            | 512KB                | 0KB                      |
|               | Remote Log Buffer     | 256KB                | 145KB                    |

## 5.5 System Performance

| COMPONENT            | PARAMETER  | VALUE |
|----------------------|------------|-------|
| Capture              | Out FPS    | 21fps |
| ALG Synthesis (DSP1) | Output fps | 21fps |
| SGX3DSRV (A15)       | Output fps | 21fps |
| ALG_PHOTOALIGN       | Output fps | 21fps |
| DISPLAY              | Input FPS  | 21fps |

NOTE: FPS numbers are rounded off to nearest integer.

## 5.6 Processing Latency

|                            |     | LATENCY |
|----------------------------|-----|---------|
| SOC                        |     | TDA2xx  |
| Capture to Display Latency | Avg | 36.7 ms |
|                            | Min | 33.1 ms |
|                            | Max | 45.9 ms |

NOTE:

- This latency is as measured inside the system by software.
- There will an additional  $1/(\text{capture rate})$  added on top of this from sensor/receiver itself.

- There will an additional  $1/(\text{display rate})$  added on top of this for the frame to actually get displayed on the screen.
- Thus e.g. in a scenario of display at 60fps and capture at 30fps - 16.67ms + 33.33ms needs to be added to latency figures in above table to get true capture to display latency

## 5.7 DDR BW usage

| PARAMETER          | BANDWIDTH | TDA2XX    |
|--------------------|-----------|-----------|
| EMIF1 Read + Write | Avg       | 869 MB/s  |
|                    | Peak      | 1385 MB/s |
| EMIF2 Read + Write | Avg       | 841 MB/s  |
|                    | Peak      | 1327 MB/s |

---

## **6 Multi-channel 3D Surround view using SGX on Linux + Car Black Box (2x2 mosaic record and playback on MMC/SD card) on TDA2Ex**

### **6.1 Overview**

This use case is supported with the CSI2 CAL capture interface using UB964 aggregator.

This use case demonstrates 3D surround view using SGX with Linux running on A15.

Along with the 3D surround view the Car Black Box (CBB) features are running in parallel.

The 2x2 mosaic created out of the 4 channels is encoded and stored onto MMC/SD card as raw bitstream. There is an optional playback feature to playback the recorded file content.

This usecase is supported onTDA2Ex.

### **6.2 Data Flow**

#### **6.2.1 4CH CSI2 CAL capture, 3D Surround View demonstration + Car Black Box**

In this configuration we capture 4 Channel video from 4 SAT0088-OV10635 sensors @ 720p 30fps using CSI2 CAL interface and UB964 aggregator. Captured frames are then passed on to Sync link, where these captured frames are synced based on time stamps. This "group of sync'ed frames" is passed on to algorithm links of Geometric alignment and synthesis link. Geometric Analysis link running on DSP core is invoked once in K frames. This link generates the geometric alignment LUTs to be used during synthesis stage. Photometric Analysis link runs on DSP core. Certain image statistics needed for calculating photometric LUTs are provided by the synthesis stage. Photometric Analysis link generates LUTs for pixel value transformations during Synthesis. Synthesis link on DSP encapsulates the algorithm for generating the photometric statistics & Blend Lookup tables, based on geometric and photometric LUTs. SGX link encapsulates the algorithm for stitching, based on geometric, Blend and photometric LUTs. This Link runs on A15 (Linux) and SGX (3D GRPX Engine) is used to create the 360 degree of the car using Open GL API/Algos. Output of Synthesis link is the stitched frame which is passed onto display link, which shall display the surround view image using display drivers via HDMI output.

Please note in dataflow diagram below IPC IN/OUT blocks are left-out to improve readability. Please assume these whenever CPU changes in the flow.

The captured frames are duped and routed onto the CBB record path where a 2x2 mosaic is created after downsizing to window size of 720p frame. This 720p frame is encoded and stored onto a file on MMC/SD card.

There is an standalone playback path involving null source, decode and display links which reads the bit stream from the file, decodes and displays the 720p frame.



### 6.3 System Parameters

Refer Section 2.1 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

The only difference when Linux is in picture is, A15 runs at 1000MHz instead of 750 MHz

### 6.4 CPU loading and Task Info

#### 6.4.1 Total CPU load

| CPU  | TDA 2ex CPU LOAD (%)                             |
|------|--------------------------------------------------|
| IPU2 | 40.9%                                            |
| DSP1 | 4.6%                                             |
| Sgx  | Fragment Shader – 34.5%<br>Vertex Shader – 16.3% |

#### 6.4.2 Task Level Information and Task Level CPU load

| CPU  | TASK NAME     | TASK DESCRIPTION                                            | CPU LOAD (%) |
|------|---------------|-------------------------------------------------------------|--------------|
| SOC  |               |                                                             | TDA2ex       |
| IPU2 | ISS Capture   | Capture frames via CSI2 CAL port                            | 1.3%         |
|      | Display       | Display via sgx link                                        | 1.4%         |
|      | VPE (2 Links) |                                                             | 7.3%         |
|      | IPC OUT       | To send frame to another processor                          | 3.1%         |
|      | IPC IN        |                                                             | 1.0%         |
|      | DUP Link      |                                                             | 1.0%         |
|      | SYNC Link     | Sync Link to synchronize the frames from different channels | 2.6%         |
|      | Stat Coll     | Stat collector                                              | 3.1%         |
|      | GrpxSrc0      | Graphic source link                                         | 2.3%         |
|      | App Ctrl      | Sensor init and board level control                         | 0.1%         |
|      | Misc          | Miscellaneous                                               | 1.3%         |
|      | Encoder       |                                                             | 1.0%         |
|      | Decoder       |                                                             | 1.0%         |

#### 6.4.3 Heap Memory Usage

| CPU | MEMORY | MEMORY SIZE | TDA 2ex MEMORY |
|-----|--------|-------------|----------------|
|-----|--------|-------------|----------------|



|                  | SECTION                  | RESERVED | SIZE USED |
|------------------|--------------------------|----------|-----------|
| IPU2             | Local heap               | 256KB    | 12KB      |
|                  | HDVPSS<br>Descriptor Mem | 1MB      | 1MB       |
| DSP 1            | L2                       | 221KB    | 128KB     |
|                  | Local Heap               | 512KB    | 4KB       |
| Shared<br>Memory | SR0                      | 1MB      | 9KB       |
|                  | SR1 (Frame<br>Buffers)   | 330MB    | 271MB     |
|                  | SR2 (OCMC)               | 512KB    | 0KB       |
|                  | Remote Log<br>Buffer     | 256KB    | 145KB     |

## 6.5 System Performance

| COMPONENT                  | PARAMETER  | VALUE |
|----------------------------|------------|-------|
| Capture                    | Out FPS    | 30fps |
| ALG Synthesis (DSP1)       | Output fps | 30fps |
| ALG – DMA_SWMS<br>(IPU1_0) | Output fps | 30fps |
| SGX3DSRV (A15)             | Output fps | 30fps |
| ALG_PHOTOALIGN             | Output fps | 30fps |
| DISPLAY                    | Input fps  | 30fps |
| Encoder                    | Output fps | 30fps |
| Decoder                    | Output fps | 30fps |

NOTE: FPS numbers are rounded off to nearest integer.

## 6.6 Processing Latency

|                               |     | LATENCY |
|-------------------------------|-----|---------|
| SOC                           |     | TDA2Ex  |
| Capture to<br>Display Latency | Avg | 43.0 ms |
|                               | Min | 32.9 ms |
|                               | Max | 96.1 ms |

NOTE:

- This latency is as measured inside the system by software.

- There will an additional  $1/(\text{capture rate})$  added on top of this from sensor/receiver itself.
- There will an additional  $1/(\text{display rate})$  added on top of this for the frame to actually get displayed on the screen.
- Thus e.g. in a scenario of display at 60fps and capture at 30fps -  $16.67\text{ms} + 33.33\text{ms}$  needs to be added to latency figures in above table to get true capture to display latency

## 6.7 DDR BW usage

| PARAMETER          | BANDWIDTH | TDA2EX    |
|--------------------|-----------|-----------|
| EMIF1 Read + Write | Avg       | 2447 MB/s |
|                    | Peak      | 3498 MB/s |
| EMIF2 Read + Write | Avg       | NA        |
|                    | Peak      | NA        |

## 7 Multi-channel AVB capture and display usecase on Linux for TDA2xx

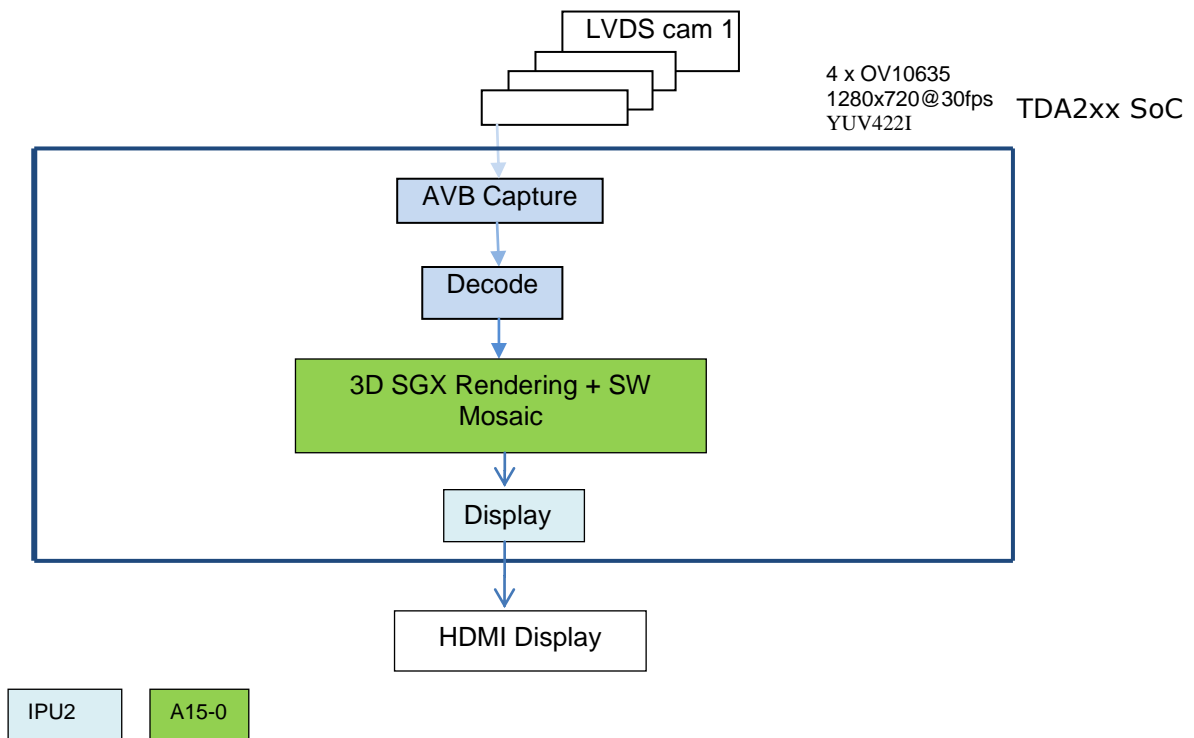
### 7.1 Overview

This use case demonstrates 4CH AVB using SGX with Linux running on A15. This is validated only on TDA2x.

### 7.2 Data Flow

#### 7.2.1 4CH AVB capture

Please note in dataflow diagram below IPC IN/OUT blocks are left-out to improve readability. Please assume these whenever CPU changes in the flow.



\*\*IPC IN/OUT blocks are left-out to improve readability.

### 7.3 System Parameters

Refer Section 2.1 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

The only difference when Linux is in picture is, A15 runs at 1000MHz instead of 750 MHz.

### 7.4 CPU loading and Task Info

#### 7.4.1 Total CPU load

| CPU  | TDA 2xx CPU LOAD (%)                             | TDA 2ex CPU LOAD (%)                             |
|------|--------------------------------------------------|--------------------------------------------------|
| IPU2 | 46.3                                             | 44.1%                                            |
| Sgx  | Fragment Shader – 27.4%<br>Vertex Shader – 0.85% | Fragment Shader – 37.1%<br>Vertex Shader – 0.78% |

#### 7.4.2 Task Level Information and Task Level CPU load

| CPU  | TASK NAME | TASK DESCRIPTION                          | TDA 2xx CPU LOAD (%) | TDA 2ex CPU LOAD (%) |
|------|-----------|-------------------------------------------|----------------------|----------------------|
| IPU2 | IPC_OUT   | To send frame to another processor        | 0.9%                 | 0.8%                 |
|      | IPC IN    | To receive frame from another processor   | 0.5%                 | 0.5%                 |
|      | Display   |                                           | 0.8%                 | 0.8%                 |
|      | Decoder   |                                           | 4.1%                 | 4.3%                 |
|      | SYNC      | Sync across frames from multiple channels | 2.2%                 | 2.2%                 |
|      | STAT COLL | DDR BW stats collector                    | 4.1%                 | 2.7%                 |
|      | MISC      | Miscellaneous                             | 12.4%                | 13.6%                |

#### 7.4.3 Heap Memory Usage

| CPU    | MEMORY SECTION        | MEMORY SIZE RESERVED | MEMORY SIZE USED on TDA2xx | MEMORY SIZE USED on TDA2ex |
|--------|-----------------------|----------------------|----------------------------|----------------------------|
| IPU2   | Local heap            | 256KB                | 42KB                       | 36KB                       |
|        | HDVPSS Descriptor Mem | 1MB                  | 1MB                        | 1MB                        |
| Shared | SR0                   | 1MB                  | 0MB                        | 0MB                        |

|        |                     |       |       |       |
|--------|---------------------|-------|-------|-------|
| Memory | SR1 (Frame Buffers) | 330MB | 81MB  | 81MB  |
|        | SR2 (OCMC)          | 512KB | 0KB   | 0KB   |
|        | Remote Log Buffer   | 256KB | 145KB | 145KB |

## 7.5 System Performance

| COMPONENT | PARAMETER | VALUE |
|-----------|-----------|-------|
| Capture   | Out FPS   | 31fps |
| DISPLAY   | Input FPS | 31fps |

NOTE: FPS numbers are rounded off to nearest integer

## 7.6 Processing Latency

| LATENCY                    |     | TDA2xx | TDA2ex |
|----------------------------|-----|--------|--------|
| Capture to Display Latency | Avg | 23.7ms | 26.5ms |
|                            | Min | 22.5ms | 25.3ms |
|                            | Max | 35.6ms | 35.4ms |

Note: Latency is from VIP output to the display. Additional capture latency needs to be added for end to end latency

## 7.7 DDR BW usage

| PARAMETER          | BANDWIDTH | TDA2XX    | TDA2EX    |
|--------------------|-----------|-----------|-----------|
| EMIF1 Read + Write | Avg       | 747 MB/s  | 1454 MB/s |
|                    | Peak      | 1350 MB/s | 2143 MB/s |
| EMIF2 Read + Write | Avg       | 717 MB/s  | NA        |
|                    | Peak      | 1281 MB/s | NA        |

## 8 System Memory Usage for Tda2xx

### 8.1 Code / Data Memory Usage

Overall Linux on A15 has full 1 GB on the EVM except following two holes in the memory

From 0x84203000 size 0x14A00000 bytes (vsdk\_sr1\_mem)

From 0xA0100000 size 0x100000 bytes (vsdk\_sr0\_mem)

From 0xA9000000 size 0x4000000 bytes (cmem)

From 0xA5000000 size 0x4000000 bytes (vsdk\_eve\_mem)

Refer Section 2.2 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf of code and data memory usage of IPU1\_0

## 9 System Memory Usage for TDA2Ex

### 9.1 Code / Data Memory Usage

Overall Linux on A15 has full 1 GB on the EVM except following one holes in the memory

From 0x84203000 size 0x14A00000 bytes (vsdk\_sr1\_mem)

From 0xA0100000 size 0x100000 bytes (vsdk\_sr0\_mem)

From 0xA9000000 size 0x4000000 bytes (cmem)

Refer Section 4.2 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf of code and data memory usage of IPU1\_0

## 10 IPC latency measurements

This section focuses on IPC latency measurements between Linux (A15) <-> Bios (IPU1\_0). A15 <-> DSP IPC latencies are not measured.

For Bios <-> Bios ipc measurements refer Section 16.2 in \$INSTALL\_DIR/vision\_sdk/docs/VisionSDK\_DataSheet.pdf

### 10.1 A15->IPU1\_0 IPC latencies

These are average case latencies.

This involves send from A15 + ISR on IPU1\_0 and receipt of notification / message on IPU1\_0

| SOC    | IPC One-way Notify<br>Interrupt Latency<br>(usecs) | IPC Buffer One-way<br>Passing Latency (usecs) |
|--------|----------------------------------------------------|-----------------------------------------------|
| TDA2xx | 80                                                 | 105                                           |
| TDA2EX | Not Tested                                         | Not Tested                                    |

### 10.2 IPU1\_0->A15 IPC latencies

These are average case latencies.

This involves time for command msg sent using System\_rpmsgSendNotify()/System\_rpmsgMsgQSendMsg() on IPU1\_0 till it is received on A15.

It means, it is send on IPU1\_0 + ISR on A15 + scheduling / context switching overheads on Linux.

| <b>SOC</b> | <b>IPC One-way Notify Interrupt Latency (usecs)</b> | <b>IPC Buffer One-way Passing Latency (usecs)</b> |
|------------|-----------------------------------------------------|---------------------------------------------------|
| TDA2xx     | 40                                                  | 40                                                |
| TDA2EX     | Not Tested                                          | Not Tested                                        |

## 11 Revision History

| <b>Version</b> | <b>Date</b>                | <b>Revision History</b>                                                                              |
|----------------|----------------------------|------------------------------------------------------------------------------------------------------|
| 1.0            | 25 <sup>th</sup> July 2014 | Created for Vision SDK release v2.03                                                                 |
| 2.0            | 17 <sup>th</sup> Nov 2014  | Updated for Vision SDK release v2.05                                                                 |
| 3.0            | 4 <sup>th</sup> Mar 2015   | Updated for Vision SDK release v2.06                                                                 |
| 4.0            | 7 <sup>th</sup> July 2015  | Updated for Vision SDK release v2.07                                                                 |
| 5.0            | 15 <sup>th</sup> Oct 2015  | Updated for Vision SDK release v2.08                                                                 |
| 6.0            | 29 <sup>th</sup> Mar 2016  | Updated for Vision SDK release v2.09                                                                 |
| 7.0            | 6 <sup>th</sup> July 2016  | Updated for Vision SDK release v2.10                                                                 |
| 8.0            | 31 <sup>st</sup> Oct 2016  | Updated for Vision SDK release v2.11                                                                 |
| 9.0            | 6 <sup>th</sup> Feb 2017   | Updated for Vision SDK release v2.12                                                                 |
| 10.0           | 14 <sup>th</sup> Apr 2017  | Updated for Vision SDK release v2.12.2 patch release<br>Added 2MP SRV & Car Black Box loads/BW usage |
| 11.0           | 04 <sup>th</sup> July 2017 | Updated for Vision SDK release v3.0                                                                  |