## Revision History

The following table shows the revision history for this document.

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/27/2018</td>
<td>1.4</td>
<td>Added the Electrostatic Discharge Caution section. Renamed heading QSFP28 Module Connectors and updated the section (28 Gb/s QSFP+ became QSFP28 throughout). Updated banks in Figure 3-1. Renamed Figure 3-12. Updated DDR4 DIMM Memory.</td>
</tr>
<tr>
<td>08/07/2018</td>
<td>1.3</td>
<td>Revised Step 4: Program the Base Platform.</td>
</tr>
<tr>
<td>07/09/2018</td>
<td>1.2</td>
<td>Revised Board Features, Board Specifications, Table 2-1, Installing the VCU1525 Board in a Server Chassis, and Figure 3-11. Removed Xilinx constraints file information. Added Appendix A, Board Installation.</td>
</tr>
<tr>
<td>04/02/2018</td>
<td>1.1</td>
<td>Revised Board Specifications and Installing the VCU1525 Board in a Server Chassis. Updated Table 2-1, Table 2-2, and Table 3-9. Revised paragraph after Table 3-2. Added Figure 3-13. Updated Figure 3-14, Figure 3-15, and Figure 3-16. Revised Appendix B, Regulatory and Compliance Information.</td>
</tr>
<tr>
<td>11/13/2017</td>
<td>1.0</td>
<td>Initial Xilinx release.</td>
</tr>
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</table>
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## Introduction

### Installing a Board

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Chapter 1

Introduction

Overview

The VCU1525 Reconfigurable Acceleration Platform is a peripheral component interconnect express (PCIe®) Gen3 x16 compliant board featuring the Xilinx® Virtex® UltraScale+™ XCUV9P-L2FSGD2104E FPGA. This Xilinx FPGA-based PCIe accelerator board is designed to accelerate compute-intensive applications like machine learning, data analytics, and video processing.

The VCU1525 board is available in both active and passive cooling configurations and designed to be used in cloud data center servers.

Figure 1-1 shows the VCU1525 active cooling configuration (PC applications).
Figure 1-2 shows the VCU1525 passive cooling configuration (data center server applications).

CAUTION! The VCU1525 board with passive cooling is designed to be installed into a data center server, where controlled air flow provides direct cooling. The VCU1525 board with active cooling is designed to be installed into a PC environment where the air flow is uncontrolled, hence this configuration has the heat sink and fan enclosure cover installed to provide appropriate cooling. In either cooling configuration, due to the board enclosure, switches are not accessible, nor are LEDs visible (except the triple-LED module DS3 which protrudes through the left front end PCIe bracket). Board details revealed in this user guide are provided to aid understanding of board features. If the cooling enclosure is removed from either configuration of the board and it is powered-up, external fan cooling airflow MUST be applied to prevent over-temperature shut-down and possible damage to the board electronics.

See Appendix C, Additional Resources and Legal Notices for references to documents, files, and resources relevant to the VCU1525 board.
Block Diagram

A block diagram of the VCU1525 board is shown in Figure 1-3.

Figure 1-3: VCU1525 Board Block Diagram
Chapter 1: Introduction

Board Features

The VCU1525 board features are listed in this section. Detailed information for each feature is provided in Component Descriptions in Chapter 3.

- Virtex UltraScale+ XCVU9P-L2FSGD2104E FPGA
- Memory (four independent dual-rank DDR4 interfaces)
  - 48 gigabyte (GB) DDR4 memory
  - 4x DDR4 16 GB, 2400 mega-transfers per second (MT/s), 64-bit with error correcting code (ECC) DIMM
  - x4/x8 unregistered dual inline memory module (RDIMM) support
- Configuration options
  - 1 gigabit (Gb) Quad Serial Peripheral Interface (SPI) flash memory
  - Micro-AB universal serial bus (USB) J13 JTAG configuration port (FT4232HQ U65 bridge)
- 76 GTY transceivers (19 Quads)
  - 16-lane PCI Express (16 GTY)
  - Two QSFP28 100G interfaces (8 GTY)
  - 52 GTY not used
- Clock sources
  - Two Si5335A Quad clock generators
  - Si570 I2C programmable LVDS clock generator
- USB-to-UART FT4232HQ bridge with Micro-AB USB connector
- PCIe integrated Endpoint block connectivity
  - Gen1, 2 or 3 x1/x2/x4/x8/x16
  - Gen4 x8
- I2C bus
- Status LEDs
- User I/O (4-pole user dual-inline package (DIP) SW3, CPU_RESET PB SW1)
- Power management with system management bus (SMBus) voltage, current, and temperature monitoring
- Dynamic power sourcing based on external power supplied
- 75W PCIe slot functional with 35 A max $V_{CCINT}$ current PCIe slot power only
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- 150 W PCIe slot functional with 110 A max $V_{CCINT}$ current PCIe slot power and 6-pin PCIe Aux power cable connected
- 225 W PCIe slot functional with 160 A max $V_{CCINT}$ current PCIe slot power and 8-pin PCIe Aux power cable connected
- Two QSFP28 100G interfaces
- Onboard reprogrammable flash configuration memory
- Front panel JTAG and universal asynchronous receiver-transmitter (UART) access through the USB port
- FPGA configurable over USB/JTAG and Quad SPI configuration flash memory
- Thermal management with variable rate fan for minimal fan noise

Board Specifications

Dimensions

- Height: 4.2 inch (10.67 cm)
- PCB thickness (±5%): 0.062 inch (0.157 cm)
- Board length, passive heat sink: 9.2 inch (23.4 cm)
- Board length, active heat sink: 11.4 inch (29 cm)
- Board thickness with heat sink enclosure installed:
  - Active: 1.52 inch (3.86 cm)
  - Passive: 1.44 inch (3.66 cm)
- Dual slot PCIe full-length, full height form-factor compliant

Note: A 3D model of this board is not available.

Environmental

Temperature

- Operating: 0°C to +45°C
- Storage: −25°C to +60°C

Humidity

- 10% to 90% non-condensing
Chapter 1: Introduction

Operating Voltage

- PCIe slot $+12 \, V_{DC}$, $+3.3 \, V_{DC}$, $+3.3 \, V_{AUXDC}$, External $+12 \, V_{DC}$
Board Setup and Configuration

**Electrostatic Discharge Caution**

**CAUTION!** ESD can damage electronic components when they are improperly handled, and can result in total or intermittent failures. Always follow ESD-prevention procedures when removing and replacing components.

To prevent ESD damage:

- Use an ESD wrist or ankle strap and ensure that it makes skin contact. Connect the equipment end of the strap to an unpainted metal surface on the chassis.
- Avoid touching the adapter against your clothing. The wrist strap protects components from ESD on the body only.
- Handle the adapter by its bracket or edges only. Avoid touching the printed circuit board or the connectors.
- Put the adapter down only on an antistatic surface such as the bag supplied in your kit.
- If you are returning the adapter to Xilinx Product Support, place it back in its antistatic bag immediately.

**Board Component Location**

Figure 2-1 shows the location of components on the VCU1525 board. Each component shown is keyed to Table 2-1. Table 2-1 identifies the components, references the respective schematic page numbers, and links to a detailed functional description of the component and board features in Chapter 3, Board Component Descriptions.
Chapter 2: Board Setup and Configuration

**IMPORTANT:** Figure 2-1 is for visual reference only and might not reflect the current revision of the board.

### VCU1525 Board Components

*Figure 2-1: VCU1525 Board Components*

**Table 2-1: VCU1525 Board Component Descriptions**

<table>
<thead>
<tr>
<th>Number</th>
<th>Ref. Des.</th>
<th>Feature (Link)</th>
<th>Notes</th>
<th>Schematic Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U13</td>
<td><strong>Virtex UltraScale+ XCVU9P-L2FSGD2104E FPGA</strong></td>
<td>XCVU9P-L2FSGD2104E</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>J14</td>
<td>C0 DDR4 72-bit DIMM memory (16 GB) (DDR4 DIMM Memory)</td>
<td>Micron MTA18ASF2G72PZ-2G3B1IG</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>J12</td>
<td>C1 DDR4 72-bit DIMM memory (16 GB) (DDR4 DIMM Memory)</td>
<td>Micron MTA18ASF2G72PZ-2G3B1IG</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>J5</td>
<td>C2 DDR4 72-bit DIMM memory (16 GB) (DDR4 DIMM Memory)</td>
<td>Micron MTA18ASF2G72PZ-2G3B1IG</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>J2</td>
<td>C3 DDR4 72-bit DIMM memory (16 GB) (DDR4 DIMM Memory)</td>
<td>Micron MTA18ASF2G72PZ-2G3B1IG</td>
<td>36</td>
</tr>
<tr>
<td>6</td>
<td>U17, U58</td>
<td><strong>Quad SPI Flash Memory (1Gb total)</strong></td>
<td>Micron MT25QU01GBBA8E12-0SIT</td>
<td>12</td>
</tr>
</tbody>
</table>

Send Feedback
Chapter 2: Board Setup and Configuration

Default Switch Settings

Default switch settings are listed in Table 2-2. Switch locations are shown in Figure 2-1.

Table 2-2: Default Switch Settings

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default</th>
<th>Comments</th>
<th>Figure 2-1 Callout</th>
<th>Schematic Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW3</td>
<td>4-pole GPIO DIP</td>
<td>ON, ON, ON, ON</td>
<td>4-pole user DIP</td>
<td>18</td>
<td>11</td>
</tr>
</tbody>
</table>
Table 2-3 shows other visible switch locations.

### Table 2-3: Other Visible Switches

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
<th>Comments</th>
<th>Figure 2-1 Callout</th>
<th>Schematic Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>Pushbutton switch</td>
<td>CPU_RESET_B</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>SW2</td>
<td>Pushbutton switch</td>
<td>PROGRAM_B</td>
<td>20</td>
<td>11</td>
</tr>
</tbody>
</table>

### Installing the VCU1525 Board in a Server Chassis

Because each server or PC vendor’s hardware is different, for physical card installation guidance, see the manufacturer’s PCIe card installation instructions.

For programming and start-up details, see Appendix A, Board Installation.

---

### FPGA Configuration

The VCU1525 board supports two UltraScale+ FPGA configuration modes:

- Quad SPI flash memory
- JTAG using USB JTAG configuration port (USB J13/FT4232H U27)

The FPGA bank 0 mode pins are hardwired to M[2:0] = 001 Master SPI mode with pull-up/down resistors.

At power up, the FPGA is configured by the Quad SPI NOR Flash U17 device (Micron MT25QU01GBBA8E12-0SIT) with the FPGA_CCLK operating at clock rate of 105 MHz (EMCCLK) using the Master Serial Configuration mode.

The Quad SPI flash memory NOR device has a capacity of 1 Gb.

While the FPGA default mode selects Quad SPI configuration, JTAG mode overrides it if invoked. JTAG mode is always available independent of the Mode pin settings.

M0 is pulled up, however it is also connected to the I2C I/O port U2 PCA9536 device (port P1, pin 2). This connection allows M0 to be driven low by the MSP432 U19 BMC over I2C (via the I2C PCS9536 U2 port expander), disabling the Master SPI mode.

For complete details on configuring the FPGA, see UltraScale Architecture Configuration User Guide (UG570) [Ref 1].
Table 2-4: Configuration Modes

<table>
<thead>
<tr>
<th>Configuration Mode</th>
<th>M[2:0]</th>
<th>Bus Width</th>
<th>CCLKL Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master SPI</td>
<td>001</td>
<td>x1, x2, x4</td>
<td>FPGA output</td>
</tr>
<tr>
<td>JTAG</td>
<td>Not applicable - JTAG overrides</td>
<td>x1</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

The configuration circuit is shown in Figure 2-2.

Figure 2-2: VCU1525 Configuration Circuit
Overview

This chapter provides a detailed functional description of board components and features. Table 2-1 identifies the components, references the respective schematic page numbers, and links to the corresponding detailed functional description in this chapter. Component locations are shown in Table 2-1.

Component Descriptions

Virtex UltraScale+ XCVU9P-L2FSGD2104E FPGA

[Figure 2-1, callout 1]

The VCU1525 board is populated with the Virtex® UltraScale+™ XCVU9P-L2FSGD2104E FPGA.

For more information on Virtex UltraScale+ FPGAs, see Virtex UltraScale+ FPGA Data Sheet: DC and AC Switching Characteristics (DS923) [Ref 2].

I/O Voltage Rails

There are 13 I/O banks available on the XCVU9P-L2FSGD2104E FPGA and the VCU1525 board.
Figure 3-1 shows the XCVU9P-L2FSGD2104E bank arrangement.

The voltages applied to the XCVU9P-L2FSGD2104E U13 FPGA I/O banks are listed in Table 3-1.

Table 3-1: I/O Bank Voltage Rails

<table>
<thead>
<tr>
<th>XCVU9P-L2FSGD2104E</th>
<th>Power Net Name</th>
<th>Voltage</th>
<th>Connected To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank 61</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>DDR4 C0 DQ[0:15], DQ[40:55]</td>
</tr>
<tr>
<td>Bank 62</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>DDR4 C0 DQ[16:39], DQ[56:63]</td>
</tr>
<tr>
<td>Bank 63</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>DDR4 C0 DQ[64:71], ADDR/CTRL</td>
</tr>
<tr>
<td>Bank 64</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>USB, QSFP0, QSFP1, I2C, GPIO_MSP, SW_DP</td>
</tr>
<tr>
<td>Bank 65</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>DDR4 C1 DQ[64:71], ADDR/CTRL</td>
</tr>
<tr>
<td>Bank 66</td>
<td>VCC1V2_BTM</td>
<td>1.2V</td>
<td>DDR4 C1 DQ[32:63]</td>
</tr>
<tr>
<td>Bank 67</td>
<td>VCC1V8_BTM</td>
<td>1.2V</td>
<td>DDR4 C1 DQ[0:31]</td>
</tr>
<tr>
<td>Bank 69</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4_C2 DQ[32:71]</td>
</tr>
<tr>
<td>Bank 70</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4 C2 DQ[40:47], ADDR/CTRL</td>
</tr>
</tbody>
</table>
Chapter 3: Board Component Descriptions

Table 3-1: I/O Bank Voltage Rails (Cont’d)

<table>
<thead>
<tr>
<th>XCVU9P-L2FSGD2104E</th>
<th>Power Net Name</th>
<th>Voltage</th>
<th>Connected To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank 71</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4_C2 DQ[0:31]</td>
</tr>
<tr>
<td>Bank 72</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4 C3 DQ[64:71], ADDR/CTRL</td>
</tr>
<tr>
<td>Bank 73</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4_C3 DQ[16:31], DQ[40:55]</td>
</tr>
<tr>
<td>Bank 74</td>
<td>VCC1V2_TOP</td>
<td>1.2V</td>
<td>DDR4_C3 DQ[0:15], DQ[32:39], DQ[56:63]</td>
</tr>
</tbody>
</table>

**DDR4 DIMM Memory**

[Figure 2-1, callout 2, 3, 4, 5]

Four independent dual-rank DDR4 DIMM interfaces are available on the VCU1525 board. The VCU1525 board is populated with four socketed single-rank DDR4 RDIMM modules.

- Manufacturer: Micron
- Part Number: MTA18ASF2G72PZ-2G3B1
- Description:
  - 16GB DDR4 RDIMM, 288-pin
  - Configuration: 2Gb x 72
  - Single rank
  - Supports ECC error detection and correction
  - Supports 2400 MT/s

The VCU1525 XCVU9P MPSoC DDR4 interface performance is documented in the *Virtex UltraScale+ FPGA Data Sheet: DC and AC Switching Characteristics* (DS923) [Ref 2].

Memory interface-to-FPGA bank assignment is shown in Table 3-1. The DDR4 0.6V VTT termination voltages are sourced from four independent TI TPS51200DR regulator circuits.

The VCU1525 DDR4 memory interfaces adhere to the constraints guidelines documented in the "DDR3/DDR4 Design Guidelines" section of the *UltraScale Architecture-Based FPGAs Memory IP LogiCORE IP Product Guide* (PG150) [Ref 3]. The VCU1525 board DDR4 memory interfaces are 40 Ω impedance implementations.

For more details about the Micron DDR4 DIMM, see the Micron MTA18ASF2G72PZ-2G3B1IG data sheet at the Micron website [Ref 7].

For more details about the Samsung DDR4 DIMM, see the Samsung M393A2K40BB1-CRC data sheet at the Samsung website [Ref 8].
Quad SPI Flash Memory

[Figure 2-1, callout 6]

Two Quad Serial Peripheral Interface (SPI) flash memory devices of the same type and wired in parallel are provided on the VCU1525 board (U17 and U58). A field effect transistor (FET) switch structure (U57 and U61) implements a chip-select enable mechanism, controlled by the MSP432 board management controller (BMC). Only one Quad SPI device can be enabled at a time.

The default selected (bank 0 configuration) Quad SPI flash memory is U17. Each Quad SPI device provides 1 Gb of nonvolatile storage.

- Part number: MT25QU01GBB8E12-0SIT (Micron)
- Supply voltage: 1.8V
- Datapath width: 4 bits
- Data rate: variable

Figure 3-2 shows the linear Quad SPI flash memory circuitry on the VCU1525 board. For more flash memory details, see the Micron MT25QU01GBB8E12-0SIT data sheet at the Micron website [Ref 7].
For details on bank 0 pins, see *UltraScale Architecture Configuration User Guide* (UG570) [Ref 1].

**USB JTAG Interface**

[Figure 2-1, callout 7]

The VCU1525 board XCVU9P-L2FSGD2104E FPGA U13 is the only component in the Joint Test Action Group (JTAG) chain. JTAG configuration is available through the USB-to-JTAG FTDI FT4232HQ U27 bridge device connected to Micro-AB USB connector J13. The FTDI JTAG signals are level-shifted through TXBN0304 device U35. The PCIe 16-lane edge connector CN1 JTAG port is connected in parallel through level-shifter U34. GPIO port 3 of the U19 MSP432 BMC is also connected through level-shifter U33. Each level-shifter enable pin is controlled by the BMC to allow only one JTAG connection at a time.

JTAG configuration is allowed at any time regardless of the FPGA mode pin settings.

The JTAG chain block diagram is shown in Figure 3-3.

![Figure 3-3: VCU1525 JTAG Chain Block Diagram](image-url)
For more details about the FT4232HQ device, see the FTDI website [Ref 9].

**FT4232HQ USB-UART Interface**

[Figure 2-1, callout 7]

The FT4232HQ U27 Quad USB-UART on the VCU1525 board provides two UART connections through the single Micro-AB USB connector J13.

- Channel AD is configured to support the JTAG chain.
- Channel AC implements a 2-wire TX/RX UART connection to the MSP432 BMC U19.
- Channel BD implements a 2-wire level-shifted TX/RX UART connection to the XVU9P U13.
- Channel BC is not used.

The USB UART interface circuit is shown in Figure 3-4.
The channel BD UART connection from XCVU9P-L2FSGD2104E U13 bank 64 to the FT4232HQ U27 device is level-shifted via Q36 (TX) and Q37 (RX).

**Table 3-2** shows the two UART channel connections between FT4232HQ U27 and XCVU9P-L2FSGD2104E U13 and MSP432 U19.

**Table 3-2: VCU1525 USB Switch Circuit Connections**

<table>
<thead>
<tr>
<th>Target Pin</th>
<th>Net Name</th>
<th>FT4232HQ U27</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pin Name</td>
</tr>
<tr>
<td>U13.BB20</td>
<td>USB_UART_RX</td>
<td>BDBUS1</td>
</tr>
<tr>
<td>U13.BF18</td>
<td>USB_UART_TX</td>
<td>BDBUS0</td>
</tr>
<tr>
<td>U19.7</td>
<td>FT2232H_UART_RX</td>
<td>ACBUS1</td>
</tr>
<tr>
<td>U19.6</td>
<td>FT2232H_UART_TX</td>
<td>ACBUS0</td>
</tr>
</tbody>
</table>
The VCU1525 board hosts a second USB connector. J17 is a keyed 1.2 mm right-angle receptacle (Amphenol 10125839-04RAEHLF). J17 is selectable via TI TS3USB221RSER 1-to-2 USB switch U59, which is controlled by the MSP432 U19 BMC. USB switch U59 selects between the Micro-AB USB connector J13 (port 1) and the J17 4-pin receptacle (port 2). J13 is selected by default at VCU1525 power on. The USB switch circuit is shown in Figure 3-5.

Table 3-3 lists the USB switch circuit connections.

Table 3-3: VCU1525 USB Switch Circuit Connections

<table>
<thead>
<tr>
<th>TS3USB221RSER U59 Pin</th>
<th>Schematic Net Name</th>
<th>Connected To Pin</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1D+</td>
<td>J13.3</td>
<td>D_P</td>
<td>USB J13 DP</td>
</tr>
<tr>
<td>2</td>
<td>1D-</td>
<td>J13.2</td>
<td>D_N</td>
<td>USB J13 DN</td>
</tr>
<tr>
<td>3</td>
<td>2D+</td>
<td>J17.2</td>
<td>2</td>
<td>USB J17 DP</td>
</tr>
<tr>
<td>4</td>
<td>2D-</td>
<td>J17.3</td>
<td>3</td>
<td>USB J17 DN</td>
</tr>
<tr>
<td>6</td>
<td>OE_B</td>
<td>U19.52</td>
<td>P9_0</td>
<td>U59 USB Switch ENABLE_B</td>
</tr>
<tr>
<td>7</td>
<td>D-</td>
<td>U27.7</td>
<td>DM</td>
<td>FT4232HQ U27 DN</td>
</tr>
<tr>
<td>8</td>
<td>D+</td>
<td>U27.8</td>
<td>DP</td>
<td>FT4232HQ U27 DP</td>
</tr>
<tr>
<td>9</td>
<td>S</td>
<td>U19.53</td>
<td>P9_1</td>
<td>U59 USB Switch Port Select</td>
</tr>
<tr>
<td>J17_USB_VBUS2 present</td>
<td>USB_PRES</td>
<td>U19.24</td>
<td>P10_4</td>
<td>USB J17 pin 1 voltage detection</td>
</tr>
</tbody>
</table>

The FTDI FT4232HQ data sheet is available on the FTDI website [Ref 9].
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The TS3USB221RSER data sheet is available on the TI website [Ref 10].

Clock Generation

[Figure 2-1, callout 10, 11, 12]

The VCU1525 board provides eight clock sources to the XCVU9P-L2FSGD2104E device, listed in Table 3-4.

Table 3-4: VCU1525 Board Clock Sources

<table>
<thead>
<tr>
<th>Clock Name</th>
<th>Clock Ref. Des.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSCLK_300 clock buffer U44</td>
<td>U44 (Q0)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. SYSCLK0_300_P/N DDR4 C0 I/F bank 63.</td>
</tr>
<tr>
<td>DDR4 C0 I/F 300MHz</td>
<td>U44 (Q0)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. SYSCLK0_300_P/N DDR4 C0 I/F bank 63.</td>
</tr>
<tr>
<td>DDR4 C1 I/F 300MHz</td>
<td>U44 (Q1)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. SYSCLK1_300_P/N GPIO I/F bank 64.</td>
</tr>
<tr>
<td>DDR4 C2 I/F 300MHz</td>
<td>U44 (Q2)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. SYSCLK2_300_P/N DDR4 C2 I/F bank 70.</td>
</tr>
<tr>
<td>DDR4 C3 I/F 300MHz</td>
<td>U44 (Q3)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. SYSCLK3_300_P/N DDR4 C3 I/F bank 72.</td>
</tr>
<tr>
<td>QSFP0 CLOCK 156.250MHz</td>
<td>U9 (CLK1)</td>
<td>Silicon Labs Si5335A 1.8 LVDS QSFP0_CLOCK_P/N QSFP0 GTY231 REFCLK1</td>
</tr>
<tr>
<td>QSFP1 CLOCK 156.250MHz</td>
<td>U12 (CLK1)</td>
<td>Silicon Labs Si5335A 1.8 LVDS QSFP1_CLOCK_P/N QSFP1 GTY230 REFCLK1</td>
</tr>
<tr>
<td>USER/MGT_SI570_CLOCK</td>
<td>U43 (Q0)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. USER_SI570_CLOCK_P/N GPIO I/F bank 64.</td>
</tr>
<tr>
<td>USER_SI570_CLOCK</td>
<td>U43 (Q0)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. USER_SI570_CLOCK_P/N GPIO I/F bank 64.</td>
</tr>
<tr>
<td>MGT SI570 CLOCK0 (QSFP0)</td>
<td>U43 (Q2)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. USER_SI570_CLOCK0_P/N QSFP0 GTY231 REFCLK0.</td>
</tr>
<tr>
<td>MGT SI570 CLOCK1 (QSFP1)</td>
<td>U43 (Q3)</td>
<td>Silicon Labs Si53340 3.3V LVDS clock buffer. USER_SI570_CLOCK1_P/N QSFP1 GTY230 REFCLK0.</td>
</tr>
<tr>
<td>PEX_REFCLK (PCIe input)</td>
<td>CN1</td>
<td>PCIe edge conn. CN1 input clock 100MHz PEX_REFCLK_P/N GTY226 REFCLK0.</td>
</tr>
</tbody>
</table>
The VCU1525 clocking diagram is shown in Figure 3-6.

Figure 3-6: VCU1525 Clocking Diagram
System Clock and QSFP0 Clock

[Figure 2-1, callout 10]

The system clock source is a Silicon Labs SI5335A quad clock generator/buffer (U9).

- Clock generator: Silicon Labs SI5335A-B06201-GM
  - Frequency Plan: FS1, FS0=01
  - Input Type: crystal, input frequency 25MHz
  - Device Operating Mode: Clock Generator Loop bandwidth 1.6MHz
  - CLK0A/0B: 300MHz 1.8V low-voltage differential signaling (LVDS)
  - CLK1A/1B: 156.25MHz 1.8V LVDS
  - CLK2A/2B: 90MHz 1.8V CMOS (output on A only)
  - CLK3A/3B: 33.333MHz 1.8V CMOS (output on A only)
- Low phase jitter of 0.7 ps RMS

Two outputs of the SI5335A U9 are used:

- CLK0A/B: The system clock (SYSCLK) is a LVDS 300MHz clock wired to SI53340 (U44) 1-to-4 clock buffer, which drives four AC-coupled versions of the 300-MHz clock into the clock capable (global clock (GC)) inputs of three DDR4 interface banks (C0: bank 63; C1, C2: bank 70; C3: bank 72). The DDR4 C1 interface gets its clock from bank 64 (which is in the same column as the C1 bank 65 Addr/Ctrl interface).
- CLK1A/B: The QSFP0_CLOCK_P/N clock is an AC-coupled LVDS 156.25-MHz clock wired to QSFP0 interface GTY bank 231 MGTREFCLK1 P/N input pins K11 and K10.
  - CLK2A is not used
  - CLK3A is not used.
The system and QSFP0 clock source Si5335A U9 is shown in Figure 3-7.

![Figure 3-7: 300MHz and QSFP0 156.25MHz Clock Source](image)

The 300 MHz clock buffer Si53340 U44 is shown in Figure 3-8.

![Figure 3-8: 300 MHz Clock Buffer](image)
**QSFP1 Clock**

[Figure 2-1, callout 11]

The QSFP1 clock source is a Silicon Labs SI5335A quad clock generator/buffer (U12).

- **Clock generator: Silicon Labs SI5335A-B06201-GM**
  - Frequency Plan: FS1, FS0 = 01
  - Input Type: crystal, input frequency 25MHz
  - Device Operating Mode: Clock Generator Loop bandwidth 1.6MHz
  - CLK0A/0B: 300MHz 1.8V LVDS
  - CLK1A/1B: 156.25MHz 1.8V LVDS
    - CLK2A/2B: 90MHz 1.8V CMOS (output on A only)
    - CLK3A/3B: 33.333MHz 1.8V CMOS (output on A only)
  - Low phase jitter of 0.7 ps RMS

One output of the SI5335A U12 is used:

- CLK0A/B: are not used.
- CLK1A/B: The QSFP1_CLOCK_P/N clock is an AC-coupled LVDS 156.25 MHz clock wired to QSFP1 interface GTY bank 230 MGTFCLK1P/N input pins P11 and P10.
- CLK2A: is not used.
- CLK3A is not used.
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The QSFP1 Si5335A U12 clock circuit is shown in Figure 3-9.

Figure 3-9: QSFP1 156.25MHz Clock Circuit

Programmable MGT and User Clock

[Figure 2-1, callout 12]

The VCU1525 board has an Si570 programmable low-jitter 3.3V LVDS differential oscillator (U14) connected to a Si53340 (U43) 1-to-4 LVDS clock buffer.

On power-up, the Si570 user clock defaults to an output frequency of 156.250MHz. User applications can change the output frequency within the range of 10MHz to 810 MHz through an inter IC (I2C) interface. Power cycling the VCU1525 board resets this clock to the default frequency of 156.250MHz.

- Programmable oscillator: Silicon Labs Si570BAB0000544DG (10MHz–810MHz)
- Frequency jitter: 50 ppm
- 3.3V LVDS differential output
- Default frequency 156.250MHz
- I2C address 0x5D
Three of the SI53340 (U14) 1-to-4 LVDS clock buffer outputs are used:

- Q0_P/N: USER_SI570_CLOCK_P/N are wired to GPIO and QSFP0/1 control I/O bank 64 GC input pins AU19 and AV19. The I2C_MAIN_SDA/SCL bus is also wired to bank 64.
- Q1_P/N: Not used.
- Q2_P/N: MGT_SI570_CLOCK0_P/N are AC-coupled to QSFP0 I/F GTY bank 231 REFCLK0 pins M11 and M10.
- Q3_P/N: MGT_SI570_CLOCK1_P/N are AC-coupled to QSFP1 I/F GTY bank 230 REFCLK0 pins T11 and T10.

The USER_SI570 and QSFP0/1 MGT_SI570 clock circuit is shown in Figure 3-10.

**GTY Transceivers**

**Figure 3-10: USER and MGT SI570 Clock Circuit**

The VCU1525 board provides access to 24 of the 76 GTY transceivers:

- Four GTY transceivers (bank 231) are wired to QSFP28 connector QSFP0 J7.
- Four GTY transceivers (bank 230) are wired to QSFP28 connector QSFP1 J9.

Sixteen GTY transceivers are wired to the PCIe edge connector PEX signals:

- Four GTY transceivers (bank 224) are wired to PCIe edge connector CN1 lanes 15:12.
- Four GTY transceivers (bank 225) are wired to PCIe edge connector CN1 lanes 11:8.
- Four GTY transceivers (bank 226) are wired to PCIe edge connector CN1 lanes 7:4.
- Four GTY transceivers (bank 227) are wired to PCIe edge connector CN1 lanes 3:0.
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The GTY transceivers in the XCVU9P-L2FSGD2104E are grouped into four channels or quads. The reference clock for a quad can be sourced from the quad above or the quad below the GTY quad of interest. The six GTY quads used on the VCU1525 board have the following connectivity (also see Figure 3-10):

Quad 231:
- MGTREFCLK0 - MGT_SI570_CLOCK0_C_P/N
- MGTREFCLK1 - QSFP0_CLOCK_P/N
- Contains four GTY transceivers allocated to QSFP0 TX/RX lanes 1:4

Quad 230:
- MGTREFCLK0 - MGT_SI570_CLOCK1_C_P/N
- MGTREFCLK1 - QSFP1_CLOCK_P/N
- Contains four GTY transceivers allocated to QSFP1 TX/RX lanes 1:4

Quad 224:
- MGTREFCLK0 - not connected
- MGTREFCLK1 - not connected
- Contains four GTY transceivers allocated to PCIe lanes 15:12

Quad 225:
- MGTREFCLK0 - not connected
- MGTREFCLK1 - not connected
- Contains four GTY transceivers allocated to PCIe lanes 11:8

Quad 226:
- MGTREFCLK0 - PEX_REFCLK_C_P/N unbuffered PCIe edge connector clock
- MGTREFCLK1 - not connected
- Contains four GTY transceivers allocated to PCIe lanes 7:4

Quad 227:
- MGTREFCLK0 - not connected
- MGTREFCLK1 - not connected
- Contains four GTY transceivers allocated to PCIe lanes 3:0
Figure 3-11 shows the GTY assignments.

PCI Express Endpoint Connectivity

[Figure 2-1, PCIe edge connector]

The 16-lane PCI Express edge connector CN1 performs data transfers at the rate of 2.5 giga-transfers per second (GT/s) for Gen1, 5.0 GT/s for Gen2, 8.0 GT/s for Gen3, and 16.0 GT/s for Gen4 applications. The PCIe transmit and receive signal datapaths have a characteristic impedance of 85 Ω ±10%. The PCIe clock is routed as a 100 Ω differential pair.

The XCVU9P-L2FSGD2104E FPGA (-2 speed grade) included with the VCU1525 board supports up to Gen3 x16 and Gen4 x8.

The PCIe PEX_REFCLK_P/N pair is input from the CN1 edge connector and AC-coupled directly to FPGA U1 Quad 226 MGTREFCLK0 pins AM11 (P) and AM10 (N) (also see Figure 3-11).
QSFP28 Module Connectors

[Figure 2-1, callout 13, 14]

The VCU1525 board hosts two 4-lane QSFP28 small form-factor pluggable (QSFP) connectors (QSFP0 J7, QSFP1 J9) which accept an array of optical modules. Each connector is housed within a single QSFP cage assembly. QSFP0 J7 RX/TX lanes are wired to GTY bank/quad 231, and QSFP1 J9 RX/TX lanes are wired to GTY bank/quad 230.

Figure 3-12 shows QSFP28 module connector circuitry typical to each connector.

Figure 3-12: QSFP28 Module Connector

The QSFP28 connectors J7 and J9 I2C SCL/SDA are accessible through the TCA9548 I2C switch U28 IIC_MAIN_SCL/SDA bus. See I2C Bus.

The QSFP28 connectors J7 and J9 I2C control signals are level-shifted by U38/Q5 (QSFP0) and U48/Q11 (QSFP1) and are connected to FPGA U1 bank 64.
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For additional information about the quad small form-factor pluggable (28 Gb/s QSFP+) module, see the SFF-8663 and SFF-8679 specifications at the SNIA Technology Affiliates website [Ref 11].

**I2C Bus**

The VCU1525 board implements two I2C bus networks, I2C_FPGA_SDA/SCL (4-channel PCA9546 U28 at address 0b1110100/0x74) connected to the XCVU9P-L2FSGD2104E U13 only, and I2C_MAIN_SDA/SCL (4-channel PCA9546 U56 at address 0b1110101/0x75), which is connected to the MSP432 U19 BMC only. The TI PCA9546 bus switch can operate at speeds up to 400 kHz. The VCU1525 board I2C_FPGA_SDA/SCL bus circuit is shown in Figure 3-13.

**IMPORTANT:** PCA9546 U28 RESET_B pin 3 is connected to U13 FPGA bank 64 pin BF19 via level-shifter Q33. PCA9546 U56 RESET_B pin 3 is connected to U19 MPS432 port 6_4 pin 79. The reset nets I2C_MAIN_RESET_B_LS on U13 FPGA pin BF19 and I2C_MAIN_RESET_B on MSP432 U19 pin 79 net must both be driven High to enable I2C bus transactions with the devices connected to U28 and U56.

---

**Figure 3-13: I2C Bus Circuit**
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The I2C_FPGA_SDA/SCL topology is shown in Figure 3-14.

FPGA user applications that communicate with devices on one of the downstream I2C buses must first set up a path to the desired target bus through the U28 bus switch at I2C address 0x74 (0b1110100).

The VCU1525 U28 PCA9546 bus switch hosts both a Si570 programmable clock and an 8-Kbit M24C08 EEPROM on the USER_SI570_CLOCK_SDA/SCL channel 2 I2C bus.
Table 3-5 lists the I2C address of the PCA9546 U28 bus switch target devices.

Table 3-5:  I2C_FPGA_SDA/SCL I2C Bus Addresses (FPGA U13 only)

<table>
<thead>
<tr>
<th>I2C Bus</th>
<th>I2C Switch Position</th>
<th>I2C Address</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA9546 4-channel bus switch</td>
<td>Not applicable</td>
<td>0b1110100</td>
<td>0x74</td>
</tr>
<tr>
<td>QSFP0_I2C_SDA/SCL</td>
<td>0</td>
<td>0b1010000</td>
<td>0x50</td>
</tr>
<tr>
<td>QSFP1_I2C_SDA/SCL</td>
<td>1</td>
<td>0b1010000</td>
<td>0x50</td>
</tr>
<tr>
<td>USER_SI570_CLOCK_SDA/SCL</td>
<td>2</td>
<td>0b1011101</td>
<td>0x5D</td>
</tr>
<tr>
<td>USER_SI570_CLOCK_SDA/SCL</td>
<td>2</td>
<td>0b1010100</td>
<td>0x54</td>
</tr>
<tr>
<td>SYSMON_SDA/SCL</td>
<td>3</td>
<td>0b0110010</td>
<td>0x32</td>
</tr>
</tbody>
</table>

Notes:
1. SYSMON_SDA/SCL I2C bus is level-shifted to 1.2V by Q31/Q30.

MSP432 user applications that communicate with devices on one of the downstream I2C buses must first set up a path to the desired target bus through the U56 bus switch at I2C address 0x75 (0b1110101).

VCU1525 U56 PCA9546 bus switch hosts three NXP SE98ATP thermal sensors plus a TI PCA9536 4-bit port expander and an 8-Kbit M24C08 EEPROM on the IIC_SDA/SCL_EEPROM channel 1 I2C bus. Also, channel 2 supports four DDR4 DIMM sockets on the DDR4_SDA/SCL bus.
The VCU1525 board I2C_MAIN_SDA/SCL bus topology is shown in Figure 3-15.

**Figure 3-15:** I2C_FPGA_SDA/SCL Bus Topology
Table 3-6 lists the I2C address of the PCA9546 U56 bus switch target devices.

**Table 3-6: I2C_MAIN_SDA/SCL I2C Bus Addresses (MSP432 U19 only)**

<table>
<thead>
<tr>
<th>I2C Bus</th>
<th>I2C Switch Position</th>
<th>I2C Address</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA9546 4-channel bus switch</td>
<td>Not applicable</td>
<td>0b1110101</td>
<td>0x75 U56 PCA9546</td>
</tr>
<tr>
<td>FAN_I2C_SDA/SCL</td>
<td>0</td>
<td>0b1001100</td>
<td>0x4C U53 LM96063</td>
</tr>
<tr>
<td>EEPROM_IIC_SDA/SCL</td>
<td>1</td>
<td>0b0011000</td>
<td>0x18 U31 SE98ATP</td>
</tr>
<tr>
<td>EEPROM_IIC_SDA/SCL</td>
<td>1</td>
<td>0b0011001</td>
<td>0x19 U37 SE98ATP</td>
</tr>
<tr>
<td>EEPROM_IIC_SDA/SCL</td>
<td>1</td>
<td>0b0011101</td>
<td>0x1A U50 SE98ATP</td>
</tr>
<tr>
<td>EEPROM_IIC_SDA/SCL</td>
<td>1</td>
<td>0b1000001</td>
<td>0x41 U2 PCA9536</td>
</tr>
<tr>
<td>EEPROM_IIC_SDA/SCL</td>
<td>1</td>
<td>0b1010100</td>
<td>0x54 U52 M24C08</td>
</tr>
<tr>
<td>DDR4_SDA/SCL</td>
<td>2</td>
<td>0b1010xxx</td>
<td>0x50–0x53 J14, J12, J5, J2 Socket</td>
</tr>
<tr>
<td>I2C_FPGA_SDA/SCL(1)</td>
<td>3</td>
<td>Various</td>
<td>Various U28 PCA9546</td>
</tr>
</tbody>
</table>

**Notes:**
1. This connection allows the MSP432 U19 to access the U28 switch target devices and FPGA U13.

**Status LEDs**

The VCU1525 board is designed to operate with the heat sink and fan enclosure cover installed. Status light emitting diode (LED) DS3 is a triple-stack LED which is visible through a cut-out in the PCIe end bracket.

Table 3-7 defines VCU1525 board status LEDs.

**Table 3-7: VCU1525 Board Status LEDs**

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS1</td>
<td>RED: POWER_GOOD</td>
</tr>
<tr>
<td>DS2</td>
<td>BLUE: DONE_0</td>
</tr>
<tr>
<td>DS3</td>
<td>RED: STATUS_LED0</td>
</tr>
<tr>
<td>DS3</td>
<td>YELLOW: STATUS_LED1</td>
</tr>
<tr>
<td>DS3</td>
<td>GREEN: STATUS_LED2</td>
</tr>
</tbody>
</table>
User I/O

[Figure 2-1, callout 18]

The VCU1525 board provides these user and general purpose I/O capabilities:

• 4-position active-Low user DIP switch (callout 18) USER_SW_DP[0:3]: SW3
• DIP switch SW3 (not populated)

Board Management Controller

[Figure 2-1, callout 15]

The VCU1525 hosts an MSP432P401RIPZ board management controller (BMC) U19 comprising a MSP432 ARM® Cortex® microcontroller with integrated ADCs and GPIO for control, monitoring, and sideband communication with the host system and FPGA.

For MSP432 functional block diagram details, see Figure 1-1. MSP432P401M Functional Block Diagram in the MSP432P401M data sheet at the Texas Instruments website [Ref 10].

Table 3-8 shows the MSP432 key features.

Table 3-8: Key Features of the MSP432P401RIPZ Device

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash (KB)</td>
<td>256</td>
</tr>
<tr>
<td>SRAM (KB)</td>
<td>64</td>
</tr>
<tr>
<td>ADC14 (Channels)</td>
<td>24 external, 2 internal</td>
</tr>
<tr>
<td>COMP_E0 (Channels)</td>
<td>8</td>
</tr>
<tr>
<td>COMP_E1 (Channels)</td>
<td>8</td>
</tr>
<tr>
<td>Timer_A (1)</td>
<td>5, 5, 5, 5</td>
</tr>
<tr>
<td>eUSCI CHANNEL A: UART, IrDA, SPI</td>
<td>4</td>
</tr>
<tr>
<td>CHANNEL B: SPI, I2C</td>
<td>4</td>
</tr>
<tr>
<td>20 mA drive I/O</td>
<td>4</td>
</tr>
<tr>
<td>Total I/Os</td>
<td>84</td>
</tr>
<tr>
<td>Package</td>
<td>100 PZ</td>
</tr>
</tbody>
</table>

Notes:
1. Each number in the sequence represents an instantiation of Timer_A with its associated number of capture/compare registers and PWM output generators available. For example, a number sequence of 3, 5 would represent two instantiations of Timer_A, the first instantiation having 3 and the second instantiation having 5 capture/compare registers and PWM output generators, respectively.
Figure 3-16 shows the U19 MSP432 I2C connectivity.

**Figure 3-16: U19 MSP432 I2C Connectivity**
Figure 3-17 shows the U19 MSP432 circuit.

Figure 3-17: MSP432 Circuit
Figure 3-18 shows the voltage and sense points monitored by the U19 MSP432.

**Figure 3-18: MSP432 Voltage and Sense Points**
Chapter 3: Board Component Descriptions

Board Management Controller Voltage Measurements

The VCU1525 MSP432 U19 board management controller ADC interface allows additional power system voltage measuring capability. The VCU1525 voltage rail-to-ADC channel assignments are listed in Table 3-9.

Table 3-9: MSP432 U19 ADC Channel Assignments

<table>
<thead>
<tr>
<th>Rail</th>
<th>Net Name</th>
<th>MSP432 U19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pin#</td>
<td>Name</td>
</tr>
<tr>
<td>12V_PEX</td>
<td>ADC0</td>
<td>P5_5/A0</td>
</tr>
<tr>
<td>3V3_PEX</td>
<td>ADC1</td>
<td>P5_4/A1</td>
</tr>
<tr>
<td>3V3AUX</td>
<td>ADC2</td>
<td>P5_3/A2</td>
</tr>
<tr>
<td>12V_AUX</td>
<td>ADC3</td>
<td>P5_2/A3</td>
</tr>
<tr>
<td>DDR4_VPP_BTM</td>
<td>ADC4</td>
<td>P5_1/A4</td>
</tr>
<tr>
<td>SYS_5V5</td>
<td>ADC5</td>
<td>P5_0/A5</td>
</tr>
<tr>
<td>VCC1V2_TOP</td>
<td>ADC6</td>
<td>P4_7/A6</td>
</tr>
<tr>
<td>VCC1V8</td>
<td>ADC7</td>
<td>P4_6/A7</td>
</tr>
<tr>
<td>VCC0V85</td>
<td>ADC8</td>
<td>P4_5/A8</td>
</tr>
<tr>
<td>DDR4_VPP_TOP</td>
<td>ADC9</td>
<td>P4_4/A9</td>
</tr>
<tr>
<td>MGT0V9AVCC</td>
<td>ADC10</td>
<td>P4_3/A10</td>
</tr>
<tr>
<td>12V_SW</td>
<td>ADC11</td>
<td>P4_2/A11</td>
</tr>
<tr>
<td>MGTAVTT</td>
<td>ADC12</td>
<td>P4_1/A12</td>
</tr>
<tr>
<td>3V3PEX_I_IN</td>
<td>ADC13</td>
<td>P4_0/A13</td>
</tr>
<tr>
<td>12VPEX_I_IN</td>
<td>ADC14</td>
<td>P6_1/A14</td>
</tr>
<tr>
<td>12V_AUX_I_IN</td>
<td>ADC15</td>
<td>P6_0/A15</td>
</tr>
</tbody>
</table>

Each voltage listed in Table 3-9 is scaled through a resistor attenuator network and the resulting scaled voltage is connected to the specified MSP432 board management controller ADC channel.
VCU1525 Board Power System

The VCU1525 board hosts a Linear Technology based power system. Essential input power rails are sourced from the 16-lane PCIe connector CN1 through pins A2, A3, B1, and B2 12V_IN (12V), A9, A10, and B8 3V3_PEX_IN (3.3V) and B10 3V3AUX (3.3V).

The VCCINT voltage regulator has a PMBus interface. Figure 3-19 shows the VCU1525 power system block diagram.

![Figure 3-19: VCU1525 Power System Block Diagram](figure-url)
The VCU1525 board uses power regulators from Linear Technology to supply the core and auxiliary voltages. The \( V_{CCINT} \) 2-phase (of 6) regulator U41 is PMBus-compliant. The power system regulators are listed in Table 3-10.

### Table 3-10: Onboard Power System Devices

<table>
<thead>
<tr>
<th>Rail Name</th>
<th>Ref. Des.</th>
<th>Device Type</th>
<th>Vout (V)</th>
<th>Max. I (A)</th>
<th>Schematic Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCCINT (Addr. 0x44)</td>
<td>U41</td>
<td>LTC3884EUK</td>
<td>0.85</td>
<td>40</td>
<td>14</td>
</tr>
<tr>
<td>VCCINT (phases 3 &amp; 4)</td>
<td>U40</td>
<td>LTC3874EUF</td>
<td>0.85</td>
<td>38.5</td>
<td>15</td>
</tr>
<tr>
<td>VCCINT (phases 5 &amp; 6)</td>
<td>U39</td>
<td>LTC3874EUF</td>
<td>0.85</td>
<td>38.5</td>
<td>16</td>
</tr>
<tr>
<td>SYS_5V5</td>
<td>U18</td>
<td>LT8607</td>
<td>5.5</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>VCC0V85</td>
<td>U11</td>
<td>LTC3636</td>
<td>0.85</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>VCC1V8</td>
<td>U24</td>
<td>LTC3636EUF</td>
<td>1.8</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>MGTVCACCAUX</td>
<td>U24</td>
<td>Filtered branch of VCC1V8 power supply</td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>VCC1V2_TOP (Mem.)</td>
<td>U6</td>
<td>LTC7150EY</td>
<td>1.2</td>
<td>17.5</td>
<td>18</td>
</tr>
<tr>
<td>VCC1V2_BTM (Mem.)</td>
<td>U20</td>
<td>LTC7150EY</td>
<td>1.2</td>
<td>17.5</td>
<td>19</td>
</tr>
<tr>
<td>MGTAVTT</td>
<td>U25</td>
<td>LTC3636EUF</td>
<td>1.2</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>VPP_TOP</td>
<td>U7</td>
<td>LT8608</td>
<td>2.5</td>
<td>1.5</td>
<td>21</td>
</tr>
<tr>
<td>VPP_BTM</td>
<td>U23</td>
<td>LT8608</td>
<td>2.5</td>
<td>1.5</td>
<td>21</td>
</tr>
<tr>
<td>DDR4_C0_VTT</td>
<td>U53</td>
<td>TPS51200</td>
<td>0.6</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>DDR4_C1_VTT</td>
<td>U49</td>
<td>TPS51200</td>
<td>0.6</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>DDR4_C2_VTT</td>
<td>U32</td>
<td>TPS51200</td>
<td>0.6</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>DDR4_C3_VTT</td>
<td>U30</td>
<td>TPS51200</td>
<td>0.6</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>

Documentation describing PMBus programming for the Linear Technology power controller is available at the Linear Technology website [Ref 12]. The PCB layout and power system design meet the recommended criteria described in the Linear Technology website.
Monitoring Voltage and Current

Voltage and current monitoring and control are available for the Linear Technology \( V_{CCINT} \) power controller U41 via the Linear Technology LTpowerPlay software graphical user interface and the DC1613A USB-to-PMbus dongle. The onboard Linear Technology U41 LTC3884 power controller listed in Table 3-10 is accessed through the 2x5 PMBus connector J1 provided for use with the Linear Technology DC1613A USB-to-PMbus dongle. This cable can be ordered from the Linear Technology website [Ref 12]. The associated Linear Technology LTpowerPlay GUI can be downloaded from the Linear Technology website. See Vccint Regulator Circuit for more details.

\( V_{CCINT} \) (0.85V nom.), \( V_{CCAUX} \) (1.8V nom.), and \( V_{CCBRAM} \) (0.85V nom.) rail voltages can be displayed via the SYSMON internal voltage measurement capability.

Vccint Regulator Circuit

The VCU1525 PCIe CN1 edge connector provides limited 12V power (5.5 amperes max.). The \( V_{CCINT} \) power circuit is comprised of six phases to allow a two-step additional power increase when the auxiliary 12V power is applied through the 2x4 power connector JP1. JP1 is split into two sections, each with its own PRSNT detection circuit.

\( V_{CCINT} \) power is incrementally increased as follows:

- PCIe edge connector 12V power only results in \( V_{CCINT} \) phase 1 voltage at 35 amperes max.
- Plugging a 4-pin 2x2 12V connector into JP1 pins 1-2-5-6 enables 12V AUX0 recognition, and \( V_{CCINT} \) phase 2, 3, and 4 come on (phase 1–4 max. current is 110 amperes).
- Plugging an additional 4-pin 2x2 12V connector into JP1 pins 3-4-7-8 enables 12V AUX1 recognition, and \( V_{CCINT} \) phase 5 and 6 come on (phase 1–6 max. current is 160 amperes).
- The Linear Technology LTpowerPlay GUI (with PMBus access to the primary LTC3884 U41 voltage controller phases 1/2 regulator only) assumes equal current sharing by the LTC3874 slave controllers (phases 3/4 U40, and phases 5/6 U39), so the total \( V_{CCINT} \) rail current reported is the measured phases 1/2 current x 3.
Cooling Fan Connector

[Figure 2-1, callout 17]

The VCU1525 board cooling fan connector J4 location is shown in Figure 2-1. The VCU1525 cooling assembly enclosing the entire board is shown installed in Figure 1-1 VCU1525 Reconfigurable Acceleration Platform (Active Cooling).

Note: Figure 1-1 shows the active version of the board showing the whole-board fan enclosure installed.

The VCU1525 board uses a TI LM96063 (U1) fan controller, which autonomously controls the fan speed by controlling the pulse width modulation (PWM) signal to the fan based on the die temperature via the FPGA’s DXP and DXN pins. The fan rotates slowly (acoustically quiet) when the FPGA is cool and rotates faster as the FPGA heats up (acoustically noisy).

The fan speed (PWM) versus the FPGA die temperature algorithm along with the over temperature set point and fan failure alarm mechanisms are defined by user values programmed into the LM96063 device register set. The LM96063 has I2C address 0x4B and is accessed through channel 0 of the U56 PCA9546 I2C mux (address 0x75) as shown in the I2C Bus section of this document. The LM96063 over-temperature TCRIT# output is wired to a MAX16052 (U3) supervisory device which turns off the VCU1525 power system voltage regulators if an over-temperature event is detected.

See the LM96063 [Ref 10] data sheet for more information on the device circuit implementation on this board.
Board Installation

Introduction
This appendix provides the information required to install, program, debug, and deploy a Xilinx® accelerator board to execute applications created with the SDx® environment. The SDx environment executes in hardware using one of the FPGA boards listed in the application.

Installing a Board
The VCU1525 card is a high-performance reconfigurable computing card for data center applications and includes these features:

- XCVU9P-L2FSGD2104E FPGA
- Four 16 GB of DDR4 banks (64 GB total)

The following sections describe how to install a board.

Step 1: Set Up the Card and Computer
1. Make sure the host computer is completely turned off.
2. Install the FPGA board in an open PCIe® slot on the host computer.
3. Turn on the host computer.

*Note:* Follow the host computer manufacturer recommendations to ensure proper mounting and adequate cooling.
Step 2: Prepare Board Installation Files

The SDx environment provides the `xbinst` utility, which generates firmware and driver files for the target board plugged into the deployment computer.

1. Run the following commands to prepare files for the target board installation.

   See the SDx Command and Utility Reference Guide (UG1279) [Ref 6] for more details on the `xbinst` utility. Depending on the target location, some commands must be run with `root` or `sudo` privilege. Otherwise, access permissions must be changed to enable read access for all users on that system.

2. Use the following commands to create the deployment area inside `/opt/dsa/`:

   ```
   $ mkdir /opt/dsa
   $ mkdir /opt/dsa/xilinx_vcu1525_dynamic_5_1
   $ cd /opt/dsa/xilinx_vcu1525_dynamic_5_1
   ```

3. Execute `xbinst` to install the files needed for the deployment machine. Output similar to the following is displayed:

   ```
   $ xbinst --platform xilinx_vcu1525_dynamic_5_1 -d .
   ****** xbinst v2018.2 (64-bit)
   **** SW Build 2254440 on Sun Jun 10 18:05:35 MDT 2018
   ** Copyright 1986-2018 Xilinx, Inc. All Rights Reserved.
   Attempting to get a license: ap_opencl
   Feature available: ap_opencl
   INFO: [XBINST 60-895] Target platform:
   /opt/Xilinx/SDx/2018.2/platforms/xilinx_vcu1525_dynamic_5_1/xilinx_vcu1525_dynamic_5_1.xpfm
   INFO: [XBINST 60-267] Packaging for PCIe...
   INFO: [XBINST 60-1032] Extracting DSA to
   ./Xilinx/vcu1525_dynamic_5_1.xpfm
   INFO: [XBINST 60-267] Packaging for PCIe...
   INFO: [XBINST 60-1032] Extracting DSA to
   ./Xilinx/vcu1525Dynamic_5_1.xpfm
   INFO: Adding section [FIRMWARE (3)] using: 'mgmt' (23192 Bytes)
   INFO: Adding section [SCHED_FIRMWARE (5)] using: 'sched' (9748 Bytes)
   Successfully completed 'xclbincat'
   INFO: [XBINST 60-268] Packaging for PCIe...COMPLETE
   INFO: [XBINST 60-667] xbinst has successfully created a board installation directory at /opt/dsa/xilinx_vcu1525_dynamic_5_1.
   ```

   The files are installed in this location:

   `/opt/dsa/xilinx_vcu1525_dynamic_5_1/xbinst`

   Make a note of the deployment location area because it is required at a later stage.

   This section refers to this location as the `<xbinst-area>` or as the deployment directory.

4. Install the drivers as described in Step 3: Install Board Drivers.
Step 3: Install Board Drivers

The drivers for the card must be installed before it can be used to run SDx applications.

1. Go to the board deployment directory generated previously and run the installation script:

   ```
   $ cd <xbinst-area>/xbinst
   $ sudo ./install.sh -f yes
   ```

   The script performs the following:

   - Compiles and installs the Linux kernel device drivers. The force option (`-f yes`) ensures that the previous drivers are removed first.
   - Installs the firmware to the Linux firmware area.
   - Installs the Xilinx installable client driver (ICD) to `/etc/OpenCL/vendors`. The OpenCL® ICD allows multiple implementations of OpenCL to co-exist on the same system. It allows applications to choose a platform from the list of installed platforms and dispatches OpenCL API calls to the underlying implementation.
   - Generates a `setup.sh` (Bash shell) or `setup.csh` (for csh/tcsh shells) to set up the run-time environment. To run applications, the setup script must be sourced before running any application on the target FPGA card, as follows:

     ```
     $ source <xbinst-area>/setup.sh
     ```

     **Note:** To generate only the setup scripts, use `./install.sh -k no`. The install script does not try to install the drivers so this can be run without `sudo` privileges.

   This command must be run if the `xbinst` installation area is moved to another directory location because the setup scripts generated export environment variables that use absolute paths. Re-running the command ensures the scripts are updated accordingly.

Step 4: Program the Base Platform

This section describes how to program the board using the `xbsak flash` command directly from the deployment computer and its Linux OS. The command line prompt is used to program the configuration memory (flash memory device) on the FPGA board with specified configuration files from which the FPGA can boot.

1. Before programming the board, check which device support archive (DSA) is currently programmed onto the configuration memory of the board as follows:

   ```
   $ sudo <xbinst-area>/runtime/bin/xbsak flash scan
   ```

   or equivalently:

   ```
   $ sudo ‘which xbsak flash scan’;
   ```
Typical output is:

```
$ sudo `which xbsak` flash scan
XBFLASH -- Xilinx Board Flash Utility
SCAN found the following devices:
[0]
  DBDF:  0000:03:00.1
  DSA:   xilinx_vcu1525_dynamic_5_1
  Flash: SPI
```

In this example, the board does not need to be re-flashed because it is already up-to-date.

All of the Xilinx boards are already programmed and are visible with the following command, which confirms that the board is programmable using the `xbsak flash` because it is visible as a PCI device:

```
$ lspci -d 10ee:
  03:00.0 Serial controller: Xilinx Corporation Device 6a90
  03:00.1 Serial controller: Xilinx Corporation Device 6a8f
```

2. **Source the `setup.{sh,csh}` from the `xbinst` area to use `xbsak flash`:**

```
$ source <xbinst-area>/setup.{sh|csh}
```

3. **Find the necessary MCS files:**

```
$ find <xbinst-area> -name '/*.mcs'
```

   * For a Kintex UltraScale KCU1500 board, this command returns two MCS files—the primary and the secondary MCS files that are needed for the `xbsak flash` command:

```
$ find -name '/*.mcs'
./firmware/xilinx_kcu1500_dynamic_5_0_primary.mcs
./firmware/xilinx_kcu1500_dynamic_5_0_secondary.mcs
$ xbsak flash -m <primary mcs file> -n <secondary mcs file>
```

   * For a Virtex UltraScale+-based VCU1525 board, this command returns one MCS file needed for the `xbsak flash` command:

```
$ find -name '/*.mcs'
./firmware/xilinx_vcu1525_dynamic_5_1.mcs
$ xbsak flash -m <mcs file>
```

**Step 5: Verify Successful Board Installation**

During execution of `xbinst`, a simple, prebuilt executable and the associated `xclbin` is included in the `<xbinst-area>/test` directory. This executable checks that the drivers and the DSA are correctly installed and that the setup is operating as expected. These steps are required to perform the installation validation:
1. Source the setup.sh (Bash) or setup.csh (csh/tcsh):

   $ source <xbinst-area>/setup.[sh|csh]

2. Change to the test directory and run the validation executable.

   If the test directory is not write-enabled, it might be necessary to run the executable from a different directory with an absolute path to the verify.exe.

3. Execute the following:

   $ cd /tmp/
   $ <xbinst-area>/test/verify.exe <xbinst-area>/test/verify.xclbin

   The system is correctly functioning if the output looks similar to the following:

   CL_PLATFORM_VENDOR Xilinx
   CL_PLATFORM_NAME Xilinx
   Get 1 devices
   Using 1th device
   loading <..path to..>/verify.xclbin

   RESULT:
   Hello World

---

**Debugging the Installation**

This section covers debugging and troubleshooting. For software support and related software debug techniques, see the *SDx Command and Utility Reference Guide* (UG1279) [Ref 6]. For more information, see Answer Record 43745.

This section lists the commands used to query and investigate different scenarios such as:

- A sanity check needs to be performed on a new board.
- The host application is abruptly interrupted and the board or the driver is in a stale or unknown mode.
- The deployment machine needs to be rebooted to set everything back to a working state.

The commands in this section are used for debugging. The first two commands are SDAccel board utility tools that are further detailed in the *SDx Command and Utility Reference Guide* (UG1279) [Ref 6]. The other commands are Linux command line tools: `lspci` and `dmesg`.

The utilities for the board installation tool are:

- xbsak
- xbinst
Appendix A: Board Installation

Two common scenarios that require debugging are:

- A new board is not showing as an SDAccel device using the `lspci` command, which indicates that the board is probably not programmed. The board’s firmware needs to be installed as listed in the installation directory. After the firmware is installed, a sanity check can be performed before using the application.

- A working board is not behaving properly after an accelerator function design was running on the board. In this case, an OS or driver issue needs to be resolved.

SDx Debug Command Options

The `xbsak scan` scans for devices and associated drivers for the host machine. A normal output is as follows:

```
$ xbsak scan
Linux:4.4.0-116-generic:#140-#Ubuntu SMP Mon Feb 12 21:23:04 UTC 2018:x86_64
Distribution: #Ubuntu 16.04.3 LTS
GLIBC: 2.23
---
XILINX_OPENCL="/opt/dsa/<board_name>/xbinst"
LD_LIBRARY_PATH="/opt/dsa/<board_name>/xbinst/runtime/lib/x86_64:"
---
[0]mgmt:0x6a8f:0x4351:[xclmgmt:2017.4.4:0]
[0]user:0x6a90:0x4351:[xocl:2017.4.5:129]
```

Determining if Output is Showing an Error

When the `xbsak scan` command is used, results are as follows:

```
[0]mgmt:0x6a8f:0x4351:[???:???:???:]
[0]user:0x6a90:0x4351:[xocl:2017.4.5:129]
```

Such output indicates that the management driver, `xclmgmt` is not loaded; it could either have been unloaded using the Linux command, `$ sudo rmmod xclmgmt`, or there was an error at the OS level.

To fix an unloaded management driver, use this command:

```
$ sudo modprobe xclmgmt
```

Otherwise, if the `xbsak scan` command is used, the results are as follows:

```
[0]mgmt:0x6a8f:0x4351:[xclmgmt:2017.4.4:0]
[0]user:0x6a90:0x4351:[???:???:???:]
```

This indicates that the user function driver `xocl` is not loaded; it could have either have been unloaded with the `xbsak list` command or there was an error at the OS level.

To fix this issue, use this command:

```
$ sudo modprobe xocl
```
**dmatest Command**

Use the `xbsak dmatest` command to confirm that there are no issues accessing the DDR device memory from the host, or to ensure that the path from the host to PCIe to device DDR and corresponding reverse path DDR to device to PCIe to host are still working and functioning as expected.

The `xbsak dmatest` command also provides a bandwidth test/benchmark and confirmation that the board and host computer are operating at the optimum speed. The maximum performance is achieved with Gen3 by 16 lanes and write speeds of around 7 GB/s and read speeds of around 11 GB/s.

**Example Output using VCU1525**

A typical output for VCU1525 is:

```bash
$ xbsak dmatest
Linux:3.10.0-327.el7.x86_64:#1 SMP Thu Nov 19 22:10:57 UTC 2015:x86_64
Distribution: CentOS Linux release 7.2.1511 (Core)
GLIBC: 2.17
---
XILINX_OPENCL="/opt/dsa/<board_name>/xbinst"
LD_LIBRARY_PATH="/opt/dsa/<board_name>/xbinst/runtime/lib/x86_64:"
---
INFO: Found 1 device(s)
Total DDR size: 65536 MB
Reporting from mem_topology:
Data Validity & DMA Test on DDR[0]
INFO: Host -> PCIe -> MIG write bandwidth = 7284.55 MB/s
INFO: Host <-> PCIe <-> MIG read bandwidth = 11192 MB/s
Data Validity & DMA Test on DDR[1]
INFO: Host -> PCIe -> MIG write bandwidth = 7514.58 MB/s
INFO: Host <-> PCIe <-> MIG read bandwidth = 11523.6 MB/s
Data Validity & DMA Test on DDR[2]
INFO: Host -> PCIe -> MIG write bandwidth = 7539.88 MB/s
INFO: Host <-> PCIe <-> MIG read bandwidth = 11238.2 MB/s
Data Validity & DMA Test on DDR[3]
INFO: Host -> PCIe -> MIG write bandwidth = 7840.42 MB/s
INFO: Host <-> PCIe <-> MIG read bandwidth = 11264.1 MB/s
INFO: xbsak dmatest successful.
```

In the previous output, the memory topology of the programmed design is used by the four memory banks on the card. Other designs, such as the verify design only, use one DDR memory bank so the output would show only one channel.

Use the `xbsak query` command to check the general status of the board. A typical output is:

```bash
---
INFO: Found 1 device(s)
DSA name: xilinx_vcu1525_dynamic_5_1
Vendor: 10ee
Device: 6a8f
SDevice: 4350
```
Appendix A: Board Installation

SVendor: 10ee
DDR size: 0x40000000 KB
DDR count: 4
OnChip Temp: 35 C
Power(Beta): **Unable to estimate power**
OCL Frequency:
  0: 300 MHz
  1: 500 MHz
PCIe: GEN3 x 16
DMA bi-directional threads: 2
MIG Calibrated: true

Device DDR Usage:
  Bank[0].mem: 0x0 KB
  Bank[0].bo: 0
  Bank[1].mem: 0x0 KB
  Bank[1].bo: 0
  Bank[2].mem: 0x0 KB
  Bank[2].bo: 0
  Bank[3].mem: 0x0 KB
  Bank[3].bo: 0

Total DMA Transfer Metrics:
  Chan[0].h2c: 0x2d1ea5a KB
  Chan[0].c2h: 0x2c3383b KB
  Chan[1].h2c: 0x24a7a51 KB
  Chan[1].c2h: 0x232b000 KB

Firewall Last Error Status:
  0: 0x0 (GOOD)
  1: 0x0 (GOOD)
  2: 0x0 (GOOD)

Xclbin ID: 0x5ade7395

Mem Topology:

<table>
<thead>
<tr>
<th>Bank</th>
<th>Type</th>
<th>Base Address</th>
<th>Size (KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[0]</td>
<td>bank0</td>
<td>MEM_DDR4</td>
<td>0x0</td>
</tr>
<tr>
<td>[1]</td>
<td>bank2</td>
<td>MEM_DDR4</td>
<td>0x800000000</td>
</tr>
<tr>
<td>[2]</td>
<td>bank3</td>
<td>MEM_DDR4</td>
<td>0xc00000000</td>
</tr>
<tr>
<td>[3]</td>
<td>bank1</td>
<td>MEM_DDR4</td>
<td>0x400000000</td>
</tr>
</tbody>
</table>

Compute Unit Status:
  CU[0]: sdx_kernel_wizard_0@0x1800000 (IDLE)
  INFO: xbsak query successful.

Failure to Create a Compute Program

To check potential issues, use the clCreateProgramWithBinary() function. This function can identify issues that occur when programming the FPGA with the provided xclbin file. One scenario is that the program is not compatible with the currently programmed bitstream, which derived from the programmed firmware DSA on the configuration flash memory of the card.
Appendix A: Board Installation

There are several ways to determine if the DSA matches, but they all need to check the timestamp programmed into the bitstream of the programmed DSA against the `xclbin`, by checking the output of `dmesg`:

```
xclbin: TimeStamp:5a27f562 VBNV:
ROM: TimeStamp:5aace1cf VBNV:<board_name>
TimeStamp of ROM did not match Xclbin
```

If the `xbinst` installation area used to program the device configuration memory is accessible, the `dsa.bin` in the `firmware` directory can be checked using the following command, which shows the timestamp programmed into the device configuration memory:

```
/opt/dsa/<board_name>/xbinst/firmware/10ee-6a90-4350-00000000M<########>.dsabin
```

If the `xclbin` file is accessible, use the `xclbinsplit` option to split the `xclbin` into several files as follows:

- On the deployment machine (after sourcing `setup.sh|csh`), type the following:

  `$ $XILINX_OPENCL/runtime/bin/xclbinsplit verify.xclbin`

- Alternatively, use the following command:

  `$ xclbinsplit verify.xclbin`

When the SDx tool is setup on the development machine, type the following:

```
$ $XILINX_SDX/runtime/bin/xclbinsplit verify.xclbin
```

This produces a set of files for which the `split-xclbin.xml` lists the timestamp of the DSA that was used to create it:

```
<platform vendor="xilinx" boardid="vcu1525" name="dynamic"
featureRomTime="#####"/>
```

The output is in decimal representation. To convert to a hexadecimal representation:

```
$ printf "%x\n" 1512568162
5a27f562
```

Also, to look directly into the DSA archive file for the same information:

```
$ unzip $XILINX_SDX/platforms/<board_name>/hw/<board_name>.dsa dsa.xml -d unzip_dsa
[...] inflating: unzip_dsa/dsa.xml
$ grep -i time unzip_dsa/dsa.xml
< ... FeatureRomTimestamp="#####">
```

Useful Debug Operating System Commands

This section includes some typical outputs for a VCU1525 board when running debug commands. Only the relevant output relating to accelerator boards is included. Some numbers can change depending on the deployment machine.
• *lspci*: command on Unix-like operating systems that prints ("lists") detailed information about all buses and devices in the system. It is based on a common portable library, *libpci*, that provides access to the configuration space on a variety of operating systems. Use this command to check if the accelerator board is booted up correctly, is recognized as a device, and is enumerated. The *lspci* command lists the controller addresses as follows:

```
$ lspci
...
03:00.0 Serial controller: Xilinx Corporation Device 6a90
03:00.1 Serial controller: Xilinx Corporation Device 6a8f
...
```

Output lines for this command have been omitted for brevity here.

If using a board (as opposed to a board in a cloud environment), use the following command to query using only the *vendor_ID* (10ee for Xilinx):

```
$ lspci -d 10ee:
03:00.0 Serial controller: Xilinx Corporation Device 6a90
03:00.1 Serial controller: Xilinx Corporation Device 6a8f
```

Where:

• `-d` is the device.
• `10ee` is the ID.

A more verbose output can be generated as follows:

```
$ lspci -vv -d 10ee:
03:00.0 Serial controller: Xilinx Corporation Device 6a90 (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Control: I/O+ Mem+ BusMaster+ SpecCycle- MemWINV- VGASnoop- ParErr- Stepping- SERR-FastB2B- DisINTx-
  Status: Cap+ 66MHz- UDF- FastB2B- ParErr- DEVSEL=fast >TAbort- <TAbort- <MAbort- >SERR- <PERR- INTx-
  Latency: 0, Cache Line Size: 64 bytes
  Interrupt: pin A routed to IRQ 46
  Region 0: Memory at f6000000 (32-bit, non-prefetchable) [size=32M]
  Region 1: Memory at f8040000 (32-bit, non-prefetchable) [size=64K]
  Capabilities: <access denied>
  Kernel driver in use: xocl
  Kernel modules: xocl

03:00.1 Serial controller: Xilinx Corporation Device 6a8f (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Control: I/O+ Mem+ BusMaster- SpecCycle- MemWINV- VGASnoop- ParErr- Stepping- SERR-FastB2B- DisINTx-
  Status: Cap+ 66MHz- UDF- FastB2B- ParErr- DEVSEL=fast >TAbort- <TAbort- <MAbort- >SERR- <PERR- INTx-
  Latency: 0, Cache Line Size: 64 bytes
  Interrupt: pin A routed to IRQ 46
  Region 0: Memory at f4000000 (32-bit, non-prefetchable) [size=32M]
  Region 2: Memory at f8020000 (32-bit, non-prefetchable) [size=128K]
  Region 4: Memory at f8000000 (32-bit, non-prefetchable) [size=128K]
  Capabilities: <access denied>
  Kernel driver in use: xclmgmt
  Kernel modules: xclmgmt
```
Appendix A: Board Installation

//Using the verbose option shows:
$ lspci -v
03:00.0 Serial controller: Xilinx Corporation Device 6a90 (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Flags: bus master, fast devsel, latency 0, IRQ 46
  Memory at f6000000 (32-bit, non-prefetchable) [size=32M]
  Memory at f8040000 (32-bit, non-prefetchable) [size=64K]
  Capabilities: <access denied>
  Kernel driver in use: xocl
  Kernel modules: xocl

03:00.1 Serial controller: Xilinx Corporation Device 6a8f (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Flags: fast devsel
  Memory at f4000000 (32-bit, non-prefetchable) [size=32M]
  Memory at f8020000 (32-bit, non-prefetchable) [size=128K]
  Memory at f8000000 (32-bit, non-prefetchable) [size=128K]
  Capabilities: <access denied>
  Kernel driver in use: xclmgmt
  Kernel modules: xclmgmt

When required, run the `lspci` command in super-user (`sudo`) mode to show the information hidden under the access-denied entries. The output is as follows:

$ sudo lspci -v
...
03:00.0 Serial controller: Xilinx Corporation Device 6a90 (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Flags: bus master, fast devsel, latency 0, IRQ 46
  Memory at f6000000 (32-bit, non-prefetchable) [size=32M]
  Memory at f8040000 (32-bit, non-prefetchable) [size=64K]
  Capabilities: [40] Power Management version 3
  Capabilities: [60] MSI-X: Enable+ Count=33 Masked-
  Capabilities: [70] Express Endpoint, MSI 00
  Capabilities: [100] Advanced Error Reporting
  Capabilities: [1c0] #19
  Capabilities: [350] Vendor Specific Information: ID=0001 Rev=1 Len=02c <?>
  Capabilities: [400] Access Control Services
  Kernel driver in use: xocl
  Kernel modules: xocl

03:00.1 Serial controller: Xilinx Corporation Device 6a8f (prog-if 01 [16450])
  Subsystem: Xilinx Corporation Device 4351
  Flags: fast devsel
  Memory at f4000000 (32-bit, non-prefetchable) [size=32M]
  Memory at f8020000 (32-bit, non-prefetchable) [size=128K]
  Memory at f8000000 (32-bit, non-prefetchable) [size=128K]
  Capabilities: [40] Power Management version 3
  Capabilities: [70] Express Endpoint, MSI 00
  Capabilities: [100] Advanced Error Reporting
  Capabilities: [400] Access Control Services
  Kernel driver in use: xclmgmt
  Kernel modules: xclmgmt

• `dmesg`: use to view the messages from the drivers:

  $ dmesg
Another `dmesg` option is `dmesg -T`. This option provides a timestamp that is human-readable instead of using the time in seconds since the machine has booted.

If the `dmesg` command returns too much information, use the following variation, which clears the buffer before the next use:

```
$ sudo dmesg -C
lsmod: Lets you check if driver modules are loaded in the OS, as follows:
lsmod | grep -E "^xocl|^xclmgmt"
The output would be similar to the following:
xocl  94208  0
xclmgmt  69632  0
```

The first column shows the `xocl` and `xclmgmt` that are driver modules. The second column is the size in memory of the drivers. The third column with the 0 indicates the drivers are currently not in use, also indicating that no application is running on the host and using or accessing the accelerator board.

**Other OS Commands**

To insert or remove drivers, use the `modprobe` and `rmmod` functions.
Regulatory and Compliance Information

Overview

This product is designed and tested to conform to the European Union directives and standards described in this section.

VCU1525 Board — Master Answer Record 69844

For Technical Support, open a Support Service Request.

CE Directives

2006/95/EC, Low Voltage Directive (LVD)


CE Standards

EN standards are maintained by the European Committee for Electrotechnical Standardization (CENELEC). IEC standards are maintained by the International Electrotechnical Commission (IEC).

Electromagnetic Compatibility


EN 55024:2010, Information Technology Equipment Immunity Characteristics – Limits and Methods of Measurement

This is a Class A product. In a domestic environment, this product can cause radio interference, in which case the user might be required to take adequate measures.
Appendix B: Regulatory and Compliance Information

Safety

IEC 60950-1:2005, Information technology equipment – Safety, Part 1: General requirements
EN 60950-1:2006, Information technology equipment – Safety, Part 1: General requirements

Markings

This product complies with Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). The affixed product label indicates that the user must not discard this electrical or electronic product in domestic household waste.

This product complies with Directive 2002/95/EC on the restriction of hazardous substances (RoHS) in electrical and electronic equipment.

Appendix C

Additional Resources and Legal Notices

Xilinx Resources
For support resources such as Answers, Documentation, Downloads, and Forums, see Xilinx Support.

Documentation Navigator and Design Hubs
Xilinx® Documentation Navigator provides access to Xilinx documents, videos, and support resources, which you can filter and search to find information. To open the Xilinx Documentation Navigator (DocNav):

• From the Vivado® IDE, select Help > Documentation and Tutorials.
• On Windows, select Start > All Programs > Xilinx Design Tools > DocNav.
• At the Linux command prompt, enter docnav.

Xilinx Design Hubs provide links to documentation organized by design tasks and other topics, which you can use to learn key concepts and address frequently asked questions. To access the Design Hubs:

• In the Xilinx Documentation Navigator, click the Design Hubs View tab.
• On the Xilinx website, see the Design Hubs page.

Note: For more information on Documentation Navigator, see the Documentation Navigator page on the Xilinx website.
Appendix C: Additional Resources and Legal Notices

References

The most up to date information related to the VCU1525 board and its documentation is available on the following websites.

VCU1525 Acceleration Development Kit (Active)

VCU1525 Acceleration Development Kit (Passive)

Master Answer Record 69844

These Xilinx documents provide supplemental material useful with this guide:

1. UltraScale Architecture Configuration User Guide (UG570)
2. Virtex UltraScale+ FPGA Data Sheet: DC and AC Switching Characteristics (DS923)
3. UltraScale Architecture-Based FPGAs Memory IP LogiCORE IP Product Guide (PG150)
6. SDx Command and Utility Reference Guide (UG1279)

For additional documents associated with Xilinx devices, design tools, intellectual property, boards, and kits see the Xilinx documentation website.

The following websites provide supplemental material useful with this guide:

7. Micron Technology: www.micron.com
   (MTA18ASF2G72PZ-2G3B1IG, MT25QU01GBB8E12-0SIT)
8. Samsung Electronics: www.samsung.com
   (M393A2K40BB1-CRC)
   (FT4232HQ)
10. Texas Instruments: www.ti.com
    (PCA9546, TS3USB221RSER, LM96063, TXBN0304, MSP432P401RIPZ)
11. SFF-8663, SFF-8679 specification: SNIA Technology Affiliates
12. Linear Technology: www.linear.com
13. Xilinx, Inc: www.xilinx.com
    (XCVU9P-L2FSGD2104E)
    (Si5335A, Si570, Si53340)
15. PCI Express® standard: www.pcisig.com/specifications
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