User's Guide

DS320PR412-421EVM User's Guide

ABSTRACT

The DS320PR412-421EVM evaluation module provides a complete high-bandwidth platform for evaluating the signal conditioning features of the DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 Quad-Channel PCI Express 5.0 Linear Redrivers with integrated Mux/Demux. This evaluation board can be used for standard compliance testing, performance evaluation, and initial system prototyping.

Note: In this document, all instances of DS320PR412 can be interchangeable with SN75LVPE5412 and all instances of DS320PR421 are interchangeable with SN75LVPE5421.

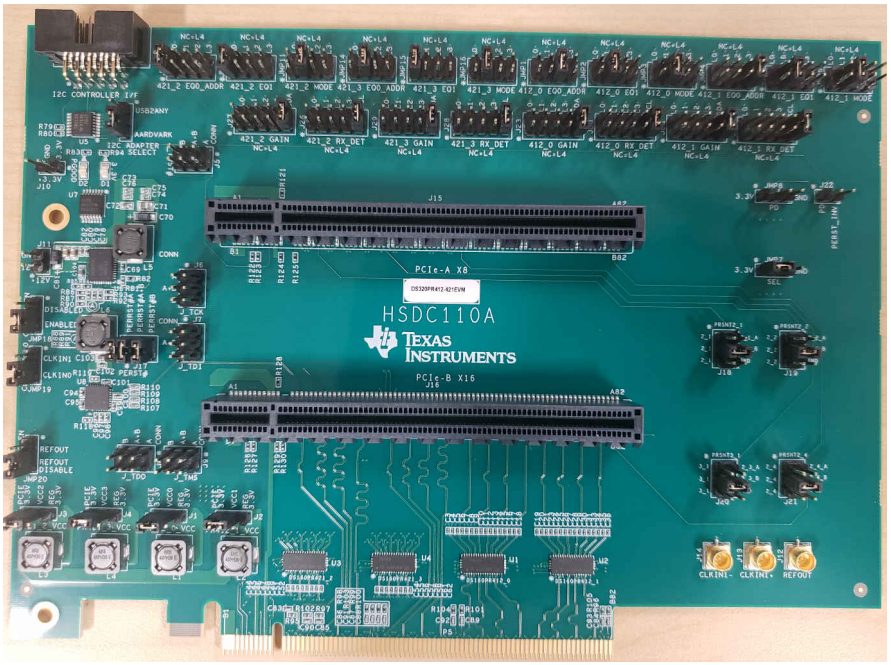

Figure 1-1. DS320PR412-421EVM

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The DS320PR412-421EVM features two DS320PR412 and two DS320PR421 linear redrivers that can extend the transmission distance of a PCIe Gen-5 x8 bus. The EVM can be directly plugged into a PCIe slot on a server or PC motherboard using the PCIe Edge connector on the board and paired with a PCIe add-in card using one of the two PCIe connectors on the EVM.

1.1 Features

DS320PR412-421EVM includes the following features:

- PCIe x16 and PCIe x8 Riser Card with two DS320PR412 and two DS320PR421 4-channel unidirectional linear redrivers operating at rates up to 32Gbps.
- DS320PR412: linear redriver with 1:2 MUX
- DS320PR421: linear redriver with 2:1 DEMUX
- Linear equalization for seamless support of link training and PCIe channel extension
- CTLE boosts up to 24dB at 16GHz
- Device configuration and MUX selection by pin control, SMBus, or I2C.
- Flow-thru layout with no heat sink required

1.2 Applications

- PCI Express Gen 1, 2, 3, 4, and 5
- High-speed interfaces up to 32Gbps
- Enterprise server motherboard, workstation
- Enterprise storage
- Enterprise add-in card, end-point

2 Description

2.1 Redriver-Mux 5-Level I/O Control Inputs

Each DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 features 5-level input pins (MODE, GAIN/SDA, EQ0/ADDR, EQ1, and RX_DET/SCL) that are used to control the configuration of the device. These 5-level inputs use a resistor divider to help set the five valid levels to provide a wider range of control settings.

Table 2-1. Five-Level Control Pin Settings

PIN LEVEL	PIN SETTING
L0	1 kΩ to GND
L1	8.25K Ω to GND
L2	24.9 Ω to GND
L3	75 Ω to GND
L4	Float

2.2 Redriver-Mux Modes of Operation

Each DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 can be configured to operate in either Pin Mode, SMBus Mode, or I2C Slave Mode. The mode of operation of the redriver is determined by the pin strap setting on the MODE pin as shown in Table 2-2.

Table 2-2. Modes of Operation

MODE PIN LEVEL	MODE OF OPERATION
L0	Pin Mode
L1	SMBus Mode or I2C Slave Mode
L2	SMBus Mode or I2C Slave Mode
L3	RESERVED
L4	RESERVED

2.3 Redriver-Mux SMBus or I2C Register Control Interface

The DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 internal registers can be accessed through standard SMBus protocol. The DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 features two banks of channels, Bank 0 (Channels 0-1) and Bank 1 (Channels 2-3), each featuring a separate register set and requiring a unique SMBus slave address. The SMBus slave address pairs (one for each channel bank) are determined at power up based on the configuration of the MODE and EQ0/ADDR pins. The pin state is read on power up, after the internal power-on reset signal is deasserted.

There are 8 unique SMBus slave address pairs (one address for each channel bank) that can be assigned to the device by placing external resistor straps on the MODE and EQ0/ADDR pins as shown in Table 2-3. When multiple DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 devices are on the same SMBus interface bus, each channel bank of each device must be configured with a unique SMBus slave address pair.

Table 2-3. Redriver-Mux SMBus Address Map

MODE	EQ0/ADDR Pin Level	Channels 0-1: 7-Bit Address [HEX]	Channels 2-3: 7-Bit Address [HEX]
L1	L0	0x18	0x19
L1	L1	0x1A	0x1B
L1	L2	0x1C	0x1D
L1	L3	0x1E	0x1F
L2	L0	0x20	0x21
L2	L1	0x22	0x23
L2	L2	0x24	0x25
L2	L3	0x26	0x27

2.4 Redriver-Mux Equalization Control

Each channel of the DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 features a continuous-time linear equalizer (CTLE) that applies high-frequency boost and low-frequency attenuation to help equalize the frequency-dependent insertion loss effects of the passive channel. Table 2-4 shows available equalization boost index through EQ control pins (EQ1 and EQ0) for all channels when in Pin Control mode (MODE = L0). Please refer to data sheet for actual EQ Gain values.

Table 2-4. Equalization Control Settings

EQ INDEX	EQ1 PIN LEVEL	EQ0 PIN LEVEL
0	L0	L0
1	L0	L1
2	L0	L2
3	L0	L3
4	L0	L4
5	L1	L0
6	L1	L1
7	L1	L2
8	L1	L3
9	L1	L4
10	L2	L0
11	L2	L1
12	L2	L2
13	L2	L3
14	L2	L4
15	L3	L0
16	L3	L1
17	L3	L2
18	L3	L3
19	L3	L4

The equalization gain of each channel of each device can also be set by writing to SMBus / I2C registers in I2C Mode.

2.5 Redriver-Mux RX Detect State Machine

Each DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 deploys an RX Detect state machine that governs the RX detection cycle as defined in the PCI Express specification. At power up or after a manually triggered event, the redriver determines whether or not a valid PCI Express termination is present at the far end of the link. The RX_DET/SCL pin of DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 provides additional flexibility to system designers to appropriately set the device in their desired mode, according to Table 2-5.

Table 2-5. Rx Detect Control Pin Settings

PD PIN LEVEL	RX_DET PIN LEVEL	DESCRIPTION
L	L0	PCI Express RX detection state machine is disabled. Recommended for non-PCI Express use cases. Inputs are always 50 Ω.
L	L1	Outputs poll until three consecutive valid detections.
L	L2	Outputs poll until two consecutive valid detections.
L	L3	Reserved.
L	L4	TX polls every ~150us until valid termination is detected. Recommended Default setting for PCIe.
H	X	Manual reset, inputs are Hi-Z

2.6 Redriver-Mux DC Gain Control

When operating in Pin Mode, the GAIN/SDA pin can be used to set the overall datapath DC (low frequency) gain of the DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 as shown in Table 2-6. Please refer to data sheet for actual Gain values.

Table 2-6. GAIN Control

GAIN/SDA PIN LEVEL	GAIN SETTING
L0	Refer to data sheet
L1	Refer to data sheet
L2	Refer to data sheet
L3	Refer to data sheet
L4	0 dB (Recommended for most use cases)

The DC gain of each channel of each device can also be set by writing to SMBus / I2C registers in Slave or Master Modes.

2.7 DS320PR412-421EVM Global Controls

Table 2-7 shows the DS320PR412, DS320PR421, SN75LVPE5412 and SN75LVPE5421 EVM global controls that affect all devices on the board.

Table 2-7. EVM Global Controls

COMPONENT	NAME	FUNCTION OR DESCRIPTION
J1	DS320PR412-0 VCC	Pins 1-2 : PCIe Connector VCC Pins 2-3: Regulator 3.3V
J2	DS320PR412-1 VCC	Pins 1-2 : PCIe Connector VCC Pins 2-3: Regulator 3.3V
J3	DS320PR421-2 VCC	Pins 1-2 : PCIe Connector VCC Pins 2-3: Regulator 3.3V
J4	DS320PR421-3 VCC	Pins 1-2 : PCIe Connector VCC Pins 2-3: Regulator 3.3V
J5	PCIe JTAG TRST	1-2: Edge Finger to PCIe-B 3-4 Edge Finger to PCIe A + B 5-6 Edge Finger to PCIe-A
J6	PCIe JTAG TCK	1-2: Edge Finger to PCIe-B 3-4 Edge Finger to PCIe A + B 5-6 Edge Finger to PCIe-A
J7	PCIe TDI	1-2: Edge Finger to PCIe-B 3-4 Edge Finger to PCIe A + B 5-6 Edge Finger to PCIe-A
J8	PCIe TDO	1-2: Edge Finger to PCIe-B 3-4 Edge Finger to PCIe A + B 5-6 Edge Finger to PCIe-A
J9	PCIe TMS	1-2: Edge Finger to PCIe-B 3-4 Edge Finger to PCIe A + B 5-6 Edge Finger to PCIe-A
J10	Board Regulator 3.3-V Output	Pin 1 : Board 3.3V Pin 2: GND
J11	Board 12-V Supply	Pin 1 : Board 12V Pin 2: GND
JMP7	MUX SEL	1-2 : PCIe Edge Finger to PCIe-B 2-3: PCIe Edge Finger to PCIe-A
JMP8	Redriver PD	1-2 : Power Down 2-3: Normal Operation
JMP17	I2C Interface Sel	1-2 : USB2ANY 2-3: Aardvark
JMP18	CLK Buffer Enable	1-2 : Disabled 2-3: Enabled
JMP19	CLK Buffer Input Sel	1-2 : CLKIN1 2-3: CLKIN0
JMP20	CLK Buffer Ref. Out	1-2 : Enabled 2-3: Disabled

2.8 DS320PR412-421EVM Downstream Devices Control

Table 2-8 shows DS320PR412-421EVM downstream devices controls that affect DS1 and DS2 devices on the board.

Table 2-8. EVM Downstream Devices Controls

COMPONENT	NAME	FUNCTION OR DESCRIPTION
JMP1	DS320PR412_0 EQ0_ADDR_0	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4
JMP2	DS320PR412_0 EQ1	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4
JMP3	DS320PR412_0 MODE	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4
J30	DS320PR412_0 RX_DET_SCL_0	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4 9-10: SCL
J23	DS320PR412_0 GAIN_SDA	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4 9-10: SDA
JMP4	DS320PR412_1 EQ0_ADDR_0	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP5	DS320PR412_1 EQ1	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP6	DS320PR412_1 MODE	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4
J24	DS320PR412_1 RX_DET_SCL_0	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4 9-10: SCL
J25	DS320PR412_1 GAIN_SDA	1-2: L0 3-4: L1 5-6: L2 7-8: L3 N/C: L4 9-10: SDA

2.9 DS320PR412-421EVM Upstream Devices Control

Table 2-9 shows DS320PR412-421EVM upstream devices controls that affect US1-US2 devices on the board.

Table 2-9. EVM Upstream Devices Controls

COMPONENT	NAME	FUNCTION OR DESCRIPTION
JMP9	DS320PR421_0 EQ0_ADDR_0	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP10	DS320PR421_0 EQ1	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP11	DS320PR421_0 MODE	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
J26	DS320PR421_0 RX_DET_SCL_0	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4 9-10: SCL
J27	DS320PR421_0 GAIN_SDA	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4 9-10: SDA
JMP14	DS320PR421_1 EQ0_ADDR_0	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP15	DS320PR421_1 EQ1	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
JMP16	DS320PR421_1 MODE	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4
J28	DS320PR421_1 RX_DET_SCL_0	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4 9-10: SCL
J29	DS320PR421_1 GAIN_SDA	1-2: L0 3-4: L1 5-6: L27-8: L3 N/C: L4 9-10: SDA

2.10 Quick-Start Guide (Pin Mode)

Check that the shunts are at the following positions as shown in Table 2-10.

Table 2-10. Pin Mode Shunt Configuration

SHNT#	HEADER	SHUNT ACROSS PINS
1	J1 - J4	1-2
2	JMP7	1-2
3	JMP8	2-3
4	JMP17	2-3
5	JMP18	2-3
6	JMP19	2-3
7	J17	1-2, 3-4
8	J18	1-2, 3-4
9	J19	1-2, 3-4
10	J20	1-2, 3-4
11	J21	1-2, 3-4
12	JMP1	1-2
13	JMP2	3-4
14	JMP3	1-2
15	J30	N/C
16	J23	N/C
17	JMP4	1-2
18	JMP5	3-4
19	JMP6	1-2
20	J24	N/C
21	J25	N/C
22	JMP9	1-2
23	JMP10	3-4
24	JMP11	1-2
25	J26	N/C
26	J27	N/C
27	JMP14	1-2
28	JMP15	3-4
29	JMP16	1-2
30	J28	N/A
31	J29	N/A

The redrivers are configured to operate in Pin Mode (MODE pins tied to L0).

1. RX_Detect state machine of all redrivers is enabled by leaving RX_DET pin open.
2. The redrivers are enabled (PWDN pins tied to GND).
3. The board is configured for any PCIe bus width.
4. DC Gain of all redrivers is set to 0 dB by leaving the GAIN config pin open for the redrivers.
5. EQ level is set to CTLE index 5.
6. If necessary, adjust EQ levels of the downstream and upstream redrivers.
7. Plug the EVM into a PCIe x16 server motherboard slot. Ensure the motherboard is powered down before installing the EVM or configured for hot-plug operation.
8. Install a compatible PCIe endpoint card into one of the PCIe connectors on the EVM based on configuration of the SEL pin. Note: PCIe-A requires enabling bifurcation on the motherboard.
9. Power-up the motherboard.

2.11 Quick-Start Guide (SMBus Slave Mode)

Configure all devices to operate in the SMBus Slave Mode by setting their MODE pins to the L1 level, each redriver is assigned a unique SMBus secondary address. This is accomplished by placing shunts as shown in Table 2-11.

Table 2-11. SMBus/I2C Mode Shunt Configuration

SHNT#	HEADER	SHUNT ACROSS PINS
1	J1 - J4	1-2
2	JMP7	1-2
3	JMP8	2-3
4	JMP17	2-3
5	JMP18	2-3
6	JMP19	2-3
7	J17	1-2, 3-4
8	J18	1-2, 3-4
9	J19	1-2, 3-4
10	J20	1-2, 3-4
11	J21	1-2, 3-4
12	JMP1	5-6
13	JMP2	3-4
14	JMP3	3-4
15	J30	9-10
16	J23	9-10
17	JMP4	7-8
18	JMP5	3-4
19	JMP6	3-4
20	J24	9-10
21	J25	9-10
22	JMP9	1-2
23	JMP10	1-2
24	JMP11	3-4
25	J26	9-10
26	J27	9-10
27	JMP14	3-4
28	JMP15	1-2
29	JMP16	3-4
30	J28	9-10
31	J29	9-10

1. Connect USB2ANY or Aardvark Adapter to P4 (Note that the Adapter is not supplied with the DS320PR412-421EVM). Install shunt on JMP17 across pins 1-2 for USB2ANY, 3-4 for Aardvark.
2. Install SigCon Architect Version 3.0.0.16 application and the DS320PR412-421 profile.
3. Plug the EVM into a PCIe x16 server motherboard slot. Ensure the motherboard is powered down before installing the EVM or configured for hot-plug operation.
4. Install a compatible PCIe endpoint card into the straddle connector of the EVM.
5. Power-up the motherboard.
6. Start the SigCon Architect application.
7. Select the DS320PR412-421 Configuration Page and select the *Apply* box to enable the device profile. If necessary, edit device addresses in the Edit Device Addresses box.
8. In the DS320PR412-421 High Level Page, select Block Diagram as shown in Figure 2-1.

9. Select desired EQ Settings and Driver VOD.
10. Select the devices to which you want to apply the selected settings and click the *Apply to All Channels* button.

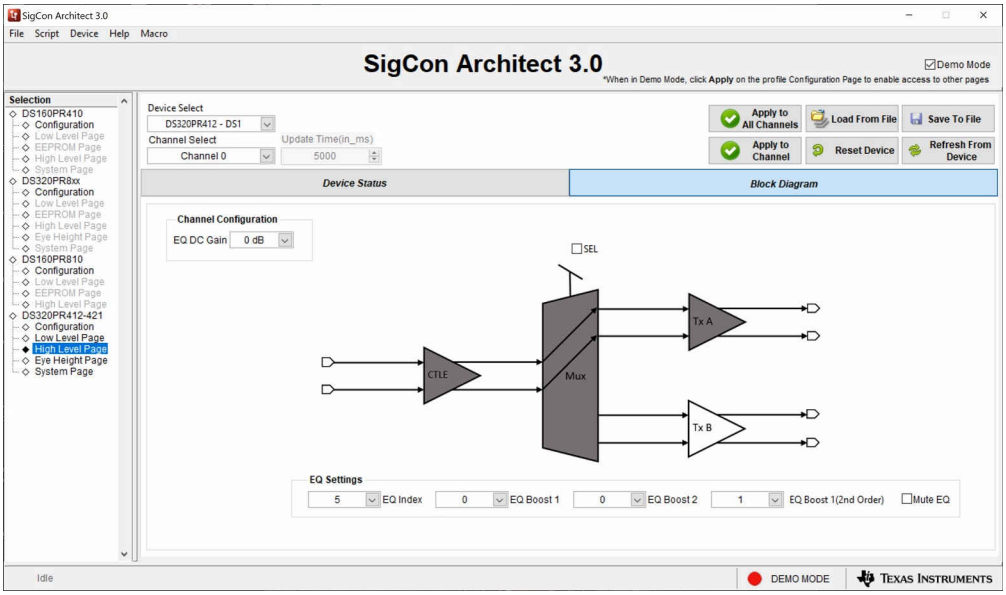

Figure 2-1. SigCon Architect DS320PR412-421 High Level Page

3 Schematics

Figure 3-1 through Figure 3-9 show the EVM schematics.

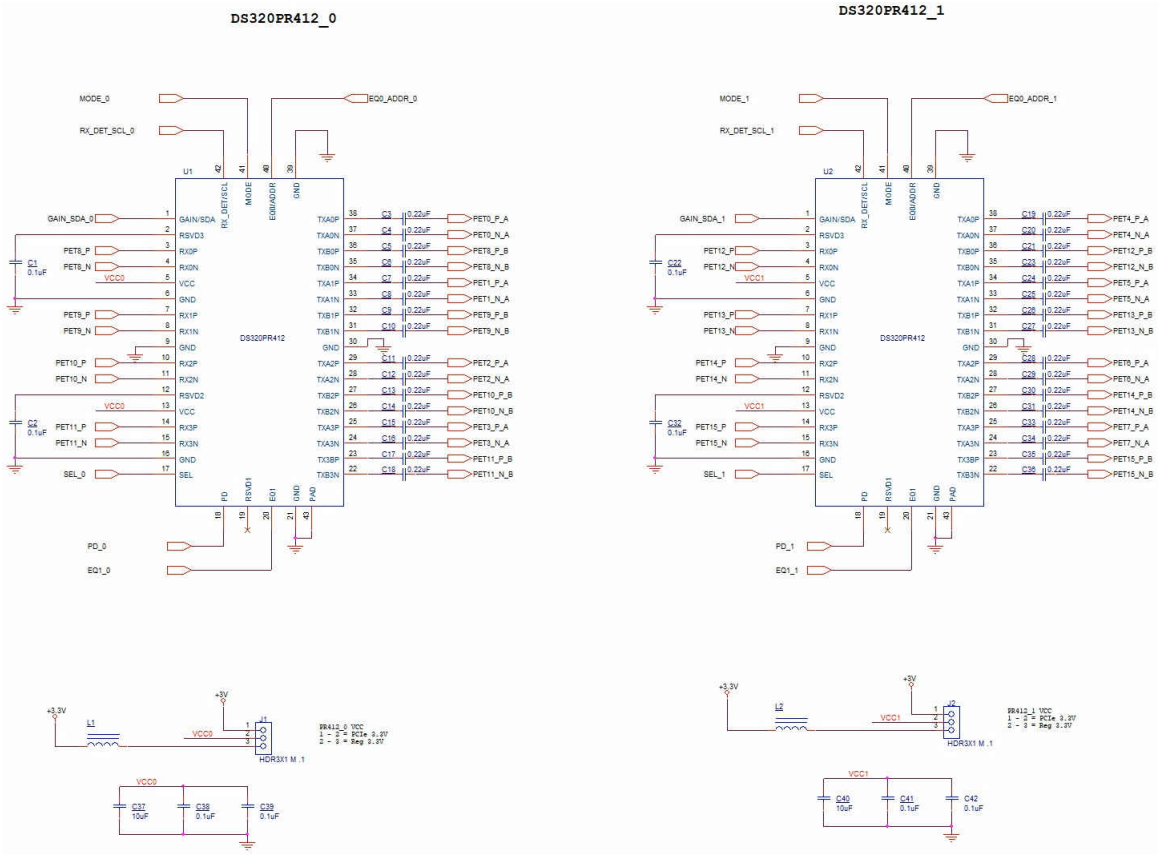

Figure 3-1. DS320PR412

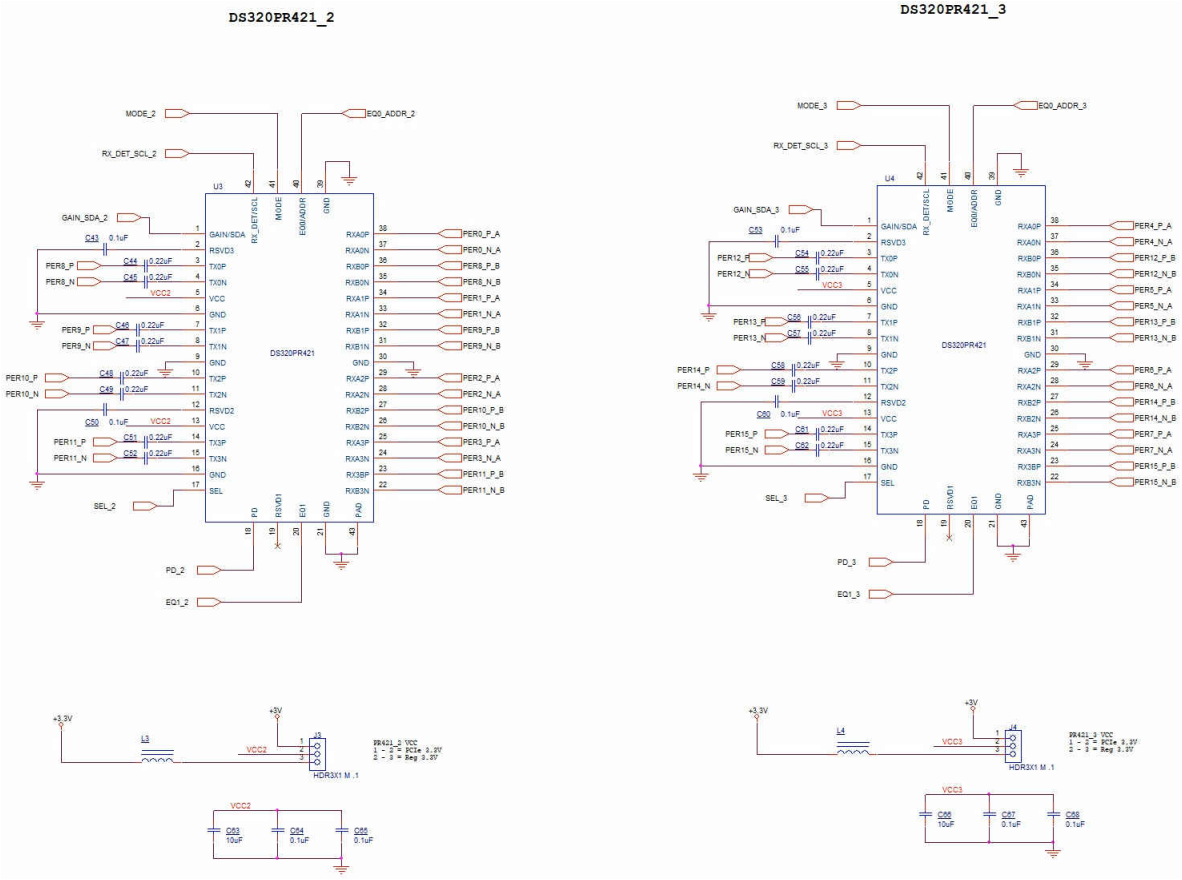

Figure 3-2. DS320PR421

Figure 3-3. Configuration Headers

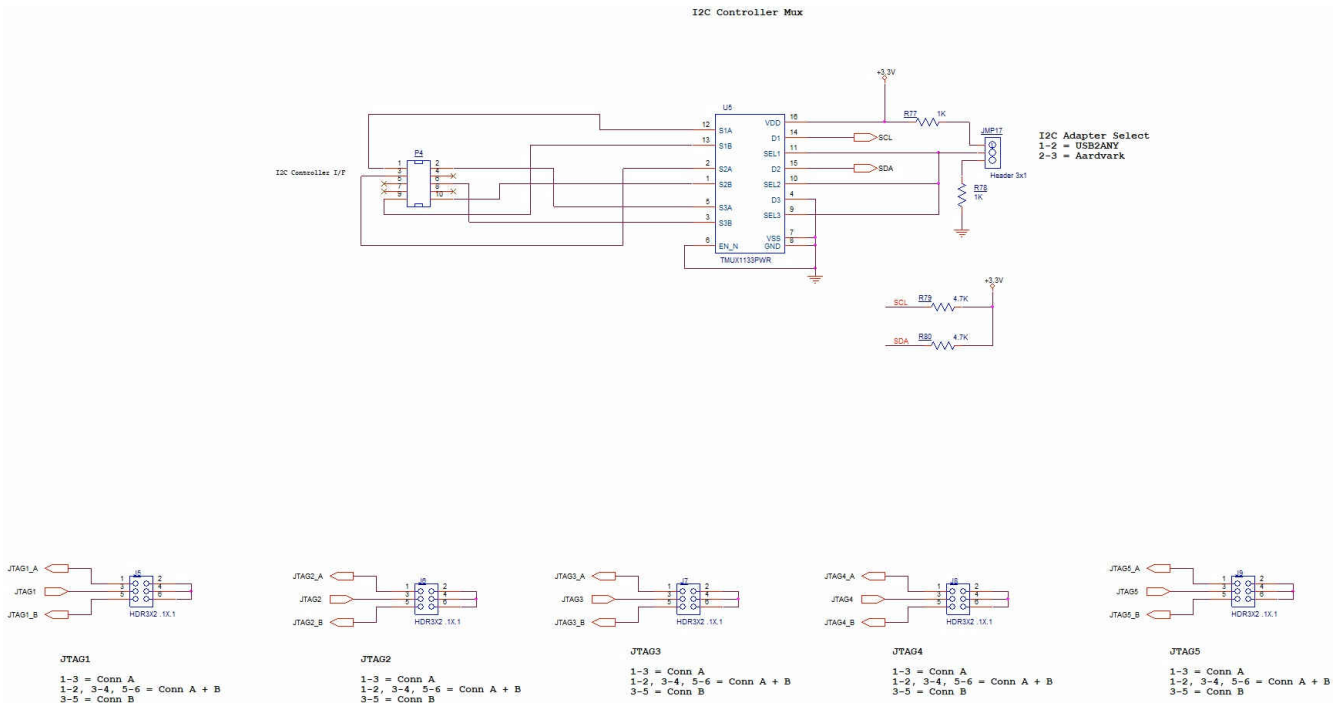

Figure 3-4. I2C Adapter Selection

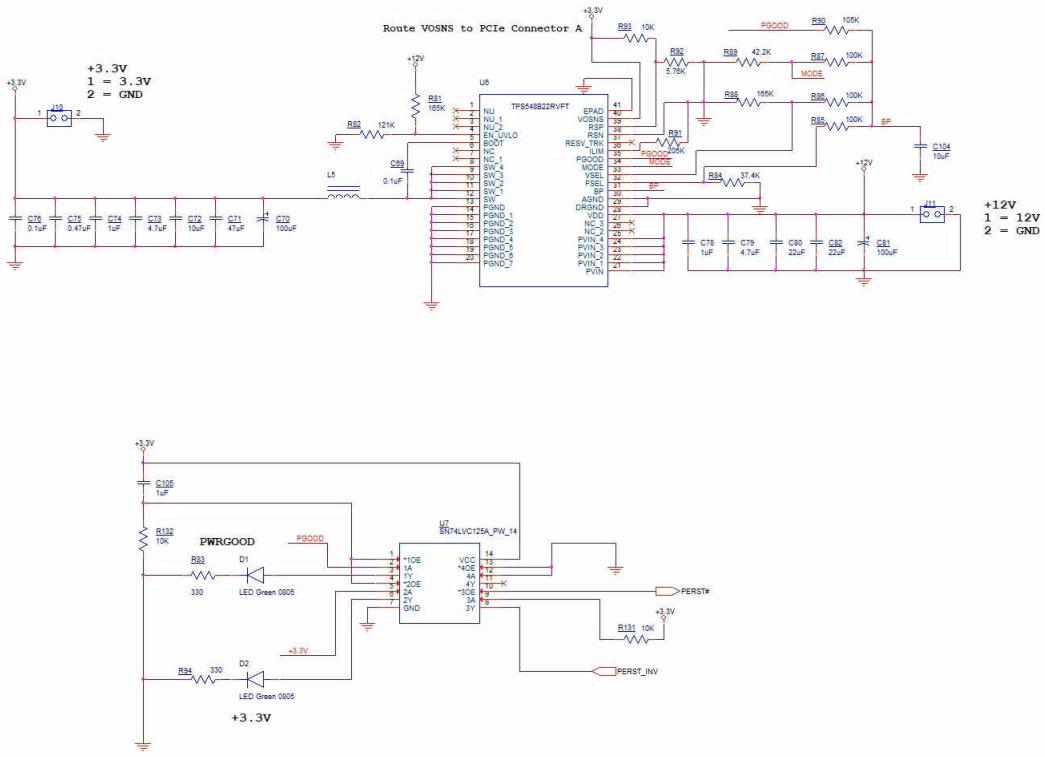

Figure 3-5. Power

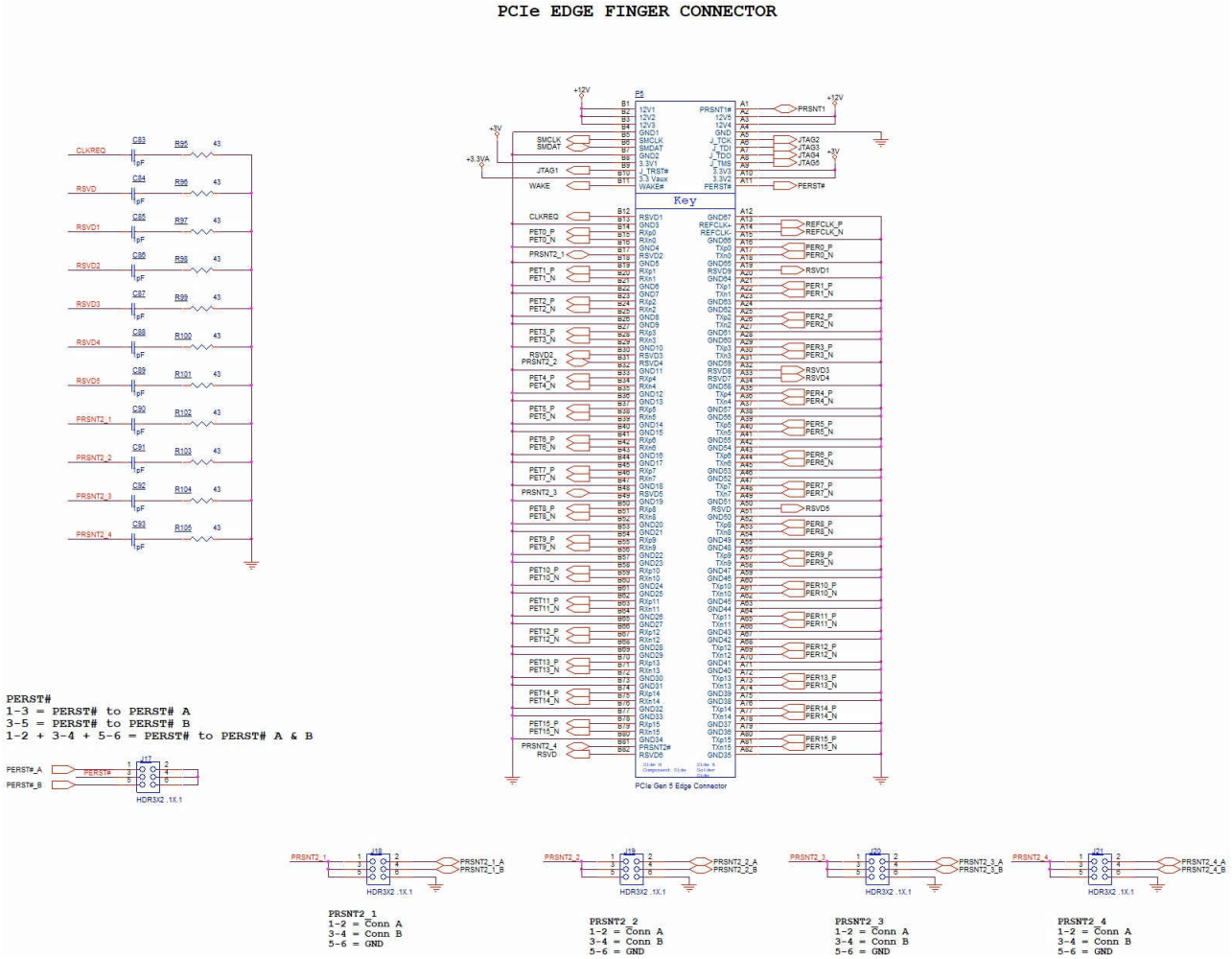

Figure 3-6. EDGE Finger

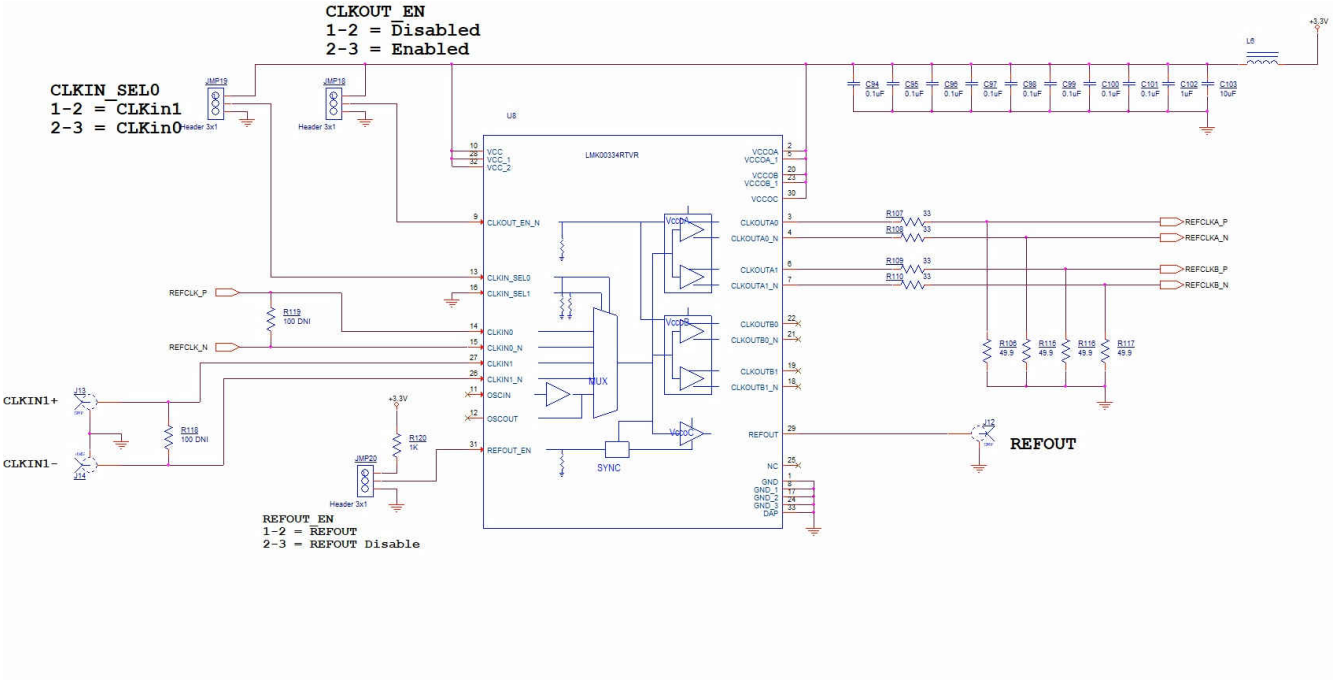

Figure 3-7. PCIe Clock

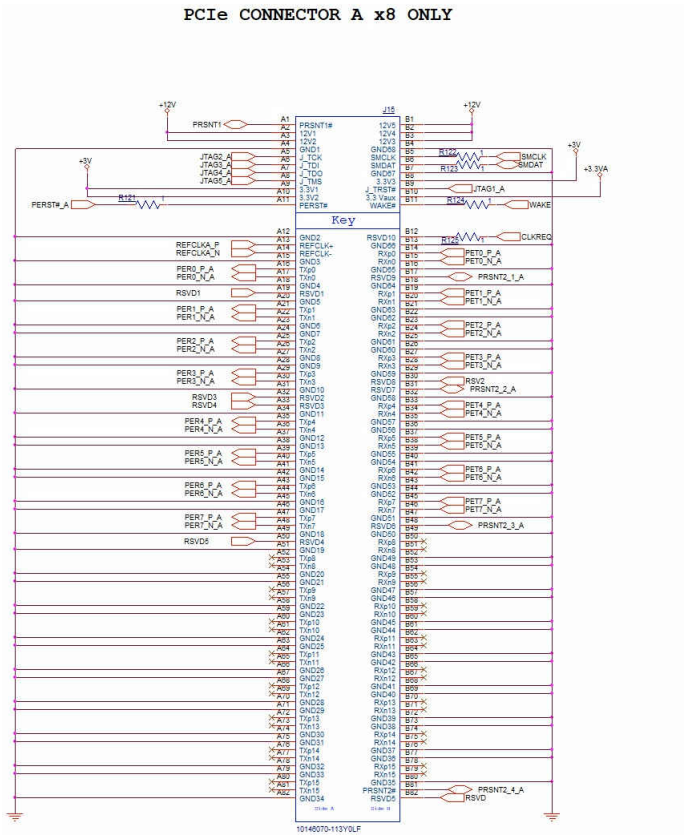

Figure 3-8. PCIe x8 Connector A

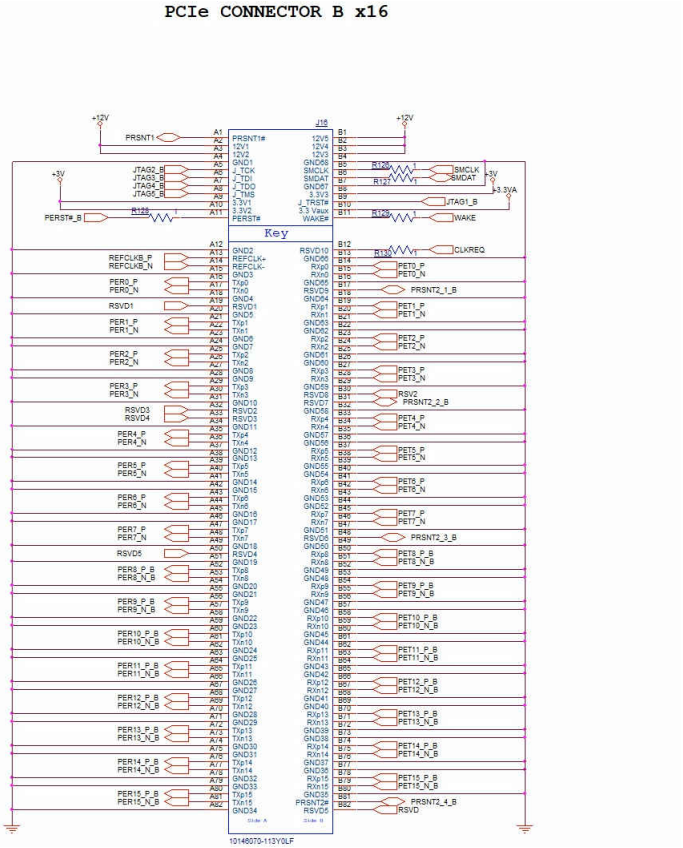

Figure 3-9. PCIe x16 Connector B

4 PCB Layouts

Figure 4-1 through Figure 4-6 illustrate the EVM PCB layout images.

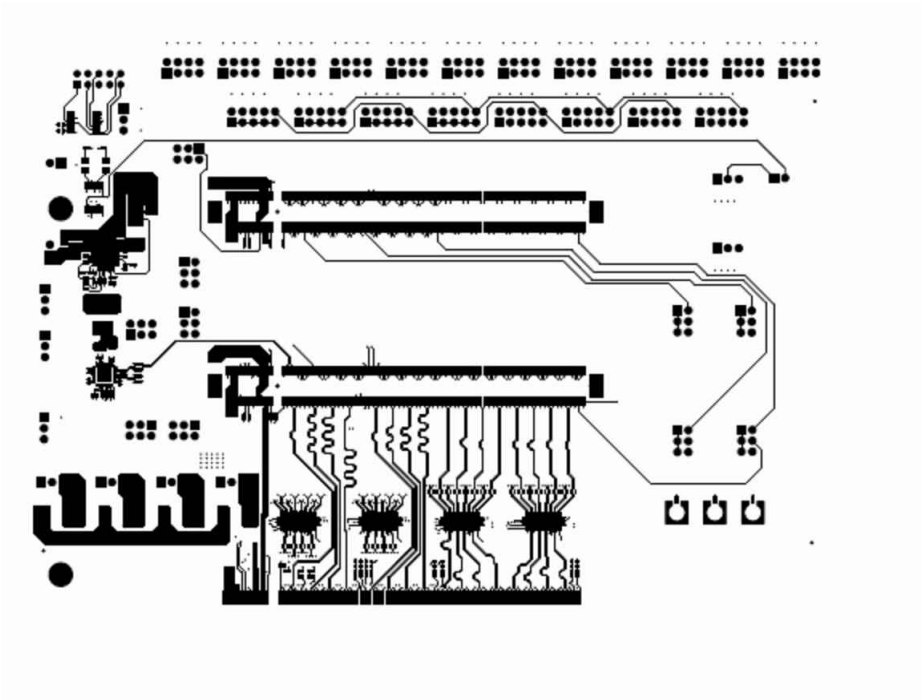

Figure 4-1. Top Layer

Figure 4-2. Layer 2

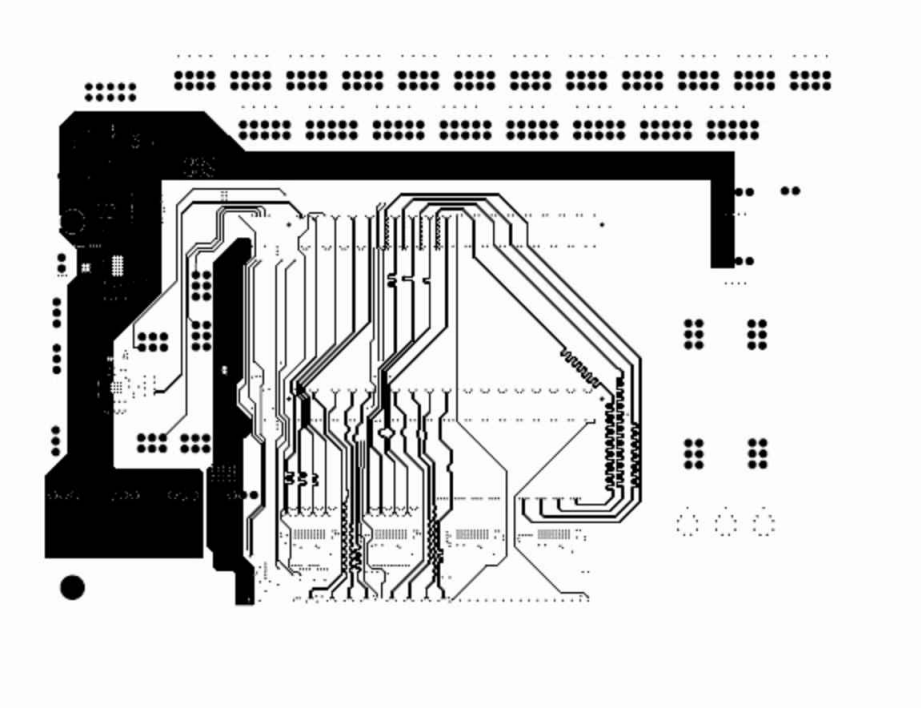

Figure 4-3. Layer 3

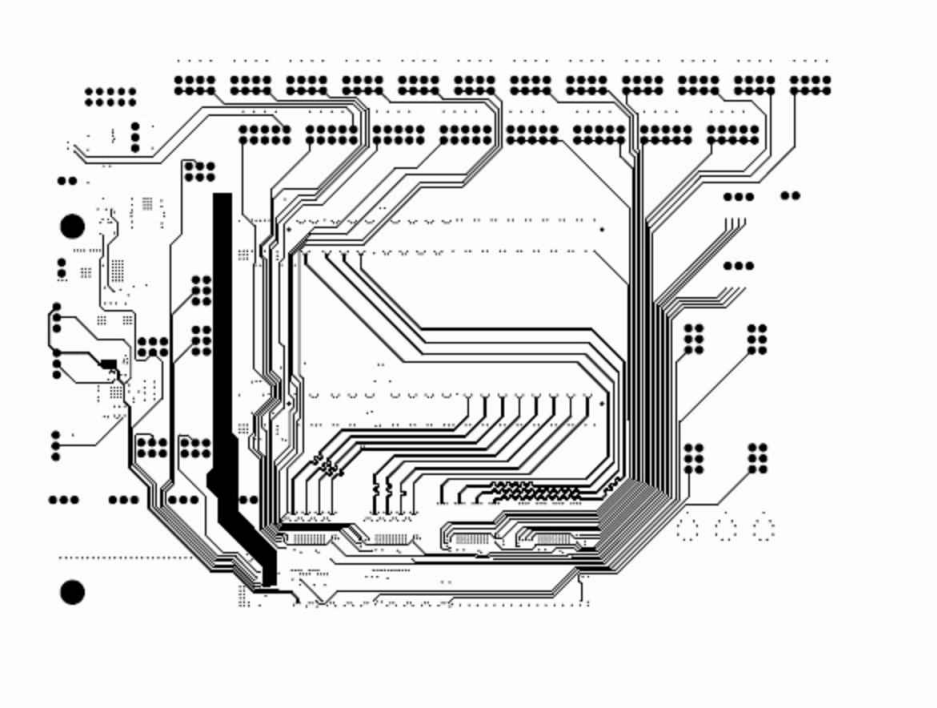

Figure 4-4. Layer 4

Figure 4-5. Layer 5

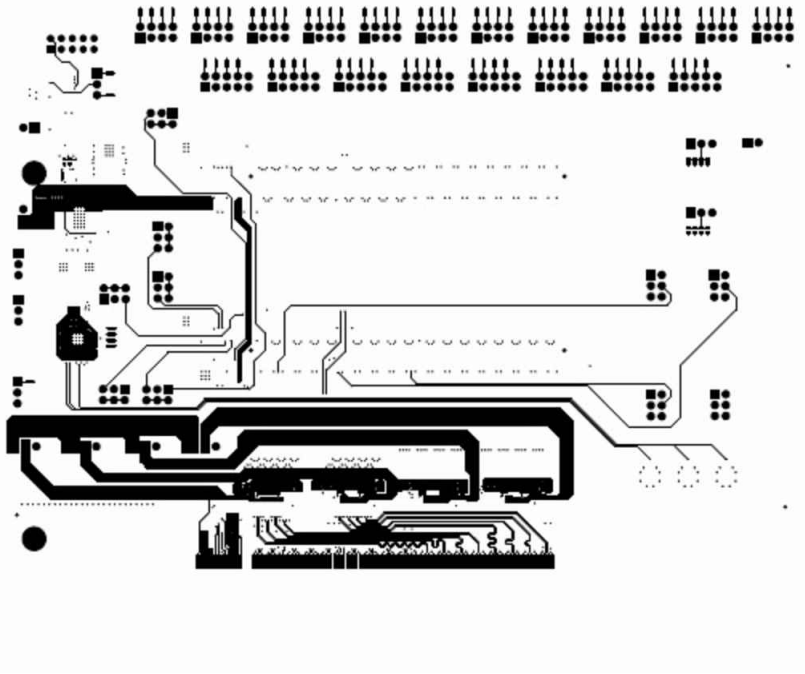

Figure 4-6. Bottom Layer

5 Bill of Materials

Table 5-1 displays the EVM bill of materials.

Table 5-1. DS320PR412-421 Bill of Materials

ITEM	QTY	Reference	Part	Manufacturer	Part Number
1	26	C1,C2,C22,C32,C38,C39,C41,C42,C43,C50,C53,C60,C64,C65,C67,C68,C69,C76,C94,C95,C96,C97,C98,C99,C100,C101	0.1uF	Murata Electronics	GRM155R71A104KA01J
2	48	C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,C21,C23,C24,C25,C26,C27,C28,C29,C30,C31,C33,C34,C35,C36,C44,C45,C46,C47,C48,C49,C51,C52,C54,C55,C56,C57,C58,C59,C61,C62	0.22uF	TDK Corporation	C0603X5R0J224K030BB
3	5	C37,C40,C63,C66,C103	10uF	Murata Electronics	GRM188R60J106ME47D
4	2	C70,C81	100uF	KEMET	T520A107M006ATE070
5	1	C71	47uF	Taiyo Yuden	JMK212BJ476MG-T
6	2	C72,C104	10uF	Murata Electronics	GRM188R61A106KE69D
7	2	C73,C79	4.7uF	Murata Electronics	GRM155R60J475ME47D
8	4	C74,C78,C102,C105	1uF	Yageo	CC0402KRX5R6BB105
9	1	C75	0.47uF	Murata Electronics	GRM155R60J474KE19D
10	2	C80,C82	22uF	Murata	GRM188C80G226MEA0D
11	11	C83,C84,C85,C86,C87,C88,C89,C90,C91,C92,C93	1pF	Murata Electronics	GRM1555C1H1R0CA01D
12	2	D1,D2	LED Green 0805		
13	12	JMP1,JMP2,JMP3,JMP4,JMP5,JMP6,JMP9,JMP10,JMP11,JMP14,JMP15,JMP16	Header 4x2	AMP	
14	6	JMP7,JMP8,JMP17,JMP18,JMP19,JMP20	Header 3x1	AMP	
15	4	J1,J2,J3,J4	HDR3X1 M .1		
16	10	J5,J6,J7,J8,J9,J17,J18,J19,J20,J21	HDR3X2 .1X.1		
17	3	J10,J11,J22	HDR2X1 M .1		
18	3	J12,J13,J14	SMP	Rosenberger	
19	2	J15,J16	10146070-113Y0LF		
20	8	J23,J24,J25,J26,J27,J28,J29,J30	HDR5X2 .1X.1		
21	6	L1,L2,L3,L4,L5,L6	6.8uH	Eaton	
22	1	P4	Header 5x2 0.1" Shroud RA thru-hole	3M	
23	31	R1,R5,R9,R13,R17,R21,R25,R29,R31,R32,R33,R34,R35,R36,R37,R38,R41,R45,R49,R53,R65,R69,R73,R77,R78,R120,R133,R137,R141,R145,R149	1K	Panasonic Electronic Components	ERJ-2GEJ102X
24	20	R2,R6,R10,R14,R18,R22,R26,R30,R42,R46,R50,R62,R66,R70,R74,R134,R138,R142,R146,R150	8.25K	Panasonic Electronic Components	ERJ-2RKF8251X

Table 5-1. DS320PR412-421 Bill of Materials (continued)

ITEM	QTY	Reference	Part	Manufacturer	Part Number
25	20	R3,R7,R11,R15,R19,R23,R27,R39,R43,R47,R51,R63,R67,R71,R75,R135,R139,R143,R147,R151	24.9K	Panasonic Electronic Components	ERA-2AEB2492X
26	20	R4,R8,R12,R16,R20,R24,R28,R40,R44,R48,R52,R64,R68,R72,R76,R136,R140,R144,R148,R152	75K	Panasonic Electronic Components	ERA-2AED753X
27	2	R79,R80	4.7K	Panasonic Electronic Components	ERJ-2GEJ472X
28	2	R81,R88	165K	Panasonic Electronic Components	ERJ-2RKF1653X
29	1	R82	121K	Yageo	RC0402FR-07121KL
30	2	R83,R94	330	Panasonic Electronic Components	ERA-2AEB331X
31	1	R84	37.4K	Panasonic Electronic Components	ERJ-2RKF3742X
32	3	R85,R86,R87	100K	Panasonic Electronic Components	ERJ-2GEJ104X
33	1	R89	42.2K	Panasonic Electronic Components	ERJ-2RKF4222X
34	1	R90	105K	Panasonic Electronic Components	ERJ-2RKF1053X
35	1	R91	205K	Panasonic Electronic Components	ERJ-2RKF2053X
36	1	R92	5.76K	Panasonic Electronic Components	ERJ-2RKF5761X
37	3	R93,R131,R132	10K	Panasonic Electronic Components	ERA-2AED103X
38	11	R95,R96,R97,R98,R99,R100,R101,R102,R103,R104,R105	43	Panasonic	
39	4	R106,R115,R116,R117	49.9	Panasonic Electronic Components	ERJ-2RKF49R9X
40	4	R107,R108,R109,R110	33	Panasonic Electronic Components	ERA-2AKD330X
41	2	R118,R119	100 DNI	Panasonic Electronic Components	ERA-2AED101X
42	10	R121,R122,R123,R124,R125,R126,R127,R128,R129,R130	1	Yageo	RC0402FR-071RL
43	26	SHNT1,SHNT2,SHNT3,SHNT4,SHNT5,SHNT6,SHNT7,SHNT8,SHNT9,SHNT10,SHNT11,SHNT12,SHNT13,SHNT14,SHNT15,SHNT16,SHNT17,SHNT18,SHNT19,SHNT20,SHNT21,SHNT22,SHNT23,SHNT24,SHNT25,SHNT26	QPC02SXGN-RC	Sullins Connector Solutions	
44	2	U1,U2	DS320PR412 or SN75LVPE5412	Texas Instruments	

Table 5-1. DS320PR412-421 Bill of Materials (continued)

ITEM	QTY	Reference	Part	Manufacturer	Part Number
45	2	U3,U4	DS320PR421 or SN75LVPE5421	Texas Instruments	
46	1	U5	TMUX1133PWR	Texas Instruments	
47	1	U6	TPS548B22RVFT	Texas Instruments	TPS548B22RVFT
48	1	U7	SN74LVC125A_PW_14	Texas Instruments	SN74LVC125AQPWRQ1
49	1	U8	LMK00334RTVR	Texas Instruments	

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