

***Texas Instruments***  
***XIO2001***  
***EVM Guide***

## Table of Contents

<b>1</b>	<b>Overview.....</b>	<b>3</b>
<b>2</b>	<b>EVM Features.....</b>	<b>4</b>
2.1	<i>PCI Express Connector.....</i>	4
2.2	<i>PCI Add-In Slots .....</i>	4
2.3	<i>EEPROM Interface .....</i>	5
2.4	<i>Test Header.....</i>	5
2.5	$\overline{\text{CLKRUN}}$ .....	6
2.6	<i>JTAG HEADER.....</i>	7
2.7	<i>LEDs .....</i>	7
<b>3</b>	<b>FAQ/Troubleshooting.....</b>	<b>8</b>
3.1	<i>BIOS Fails to Assign Memory Window to Bridge.....</i>	8
3.2	<i>x16 slots Only Support <math>\overline{\text{INTA}}</math> .....</i>	8
3.3	<i>System Turns On When PCI Card Is Inserted Into EVM Or When EVM Is Plugged Into Slot.....</i>	9
3.4	<i>What To Do If EVM Is Not Working .....</i>	9
3.4.1	Check EVM Power.....	9
3.4.2	Check If Bridge Is Link Training .....	10
3.4.3	Check If Bridge Has Been Configured.....	10
3.4.4	Check Devices Downstream From Bridge.....	12
<b>4</b>	<b>EVM Schematics.....</b>	<b>13</b>
<b>5</b>	<b>EVM Bill of Materials .....</b>	<b>17</b>

# 1 Overview

The XIO2001 Evaluation Board (EVM) implements a Peripheral Component Interconnect (PCI) Express to PCI bridge circuit using the Texas Instruments XIO2001 PCI Express to PCI Bus Translation Bridge. Designed as an x1 add-in card, it is routed on FR4 as a 8-layer (4 signals, 2 power, and 2 ground) board with a 100- $\Omega$  differential impedance (50- $\Omega$  single-ended) using standard routing guidelines and requirements.<sup>1</sup>

Power for the XIO2001 EVM and any PCI add-in card connected to the EVM is provided or derived from the standard voltages provided on the PCI Express connector. Power for the 3.3-V and 12-V rails is provided directly from the add-in connector, while regulators are present to derive 1.5-V (for the XIO2001) and 5-V and -12-V (for the PCI slots).

Upon request, gerber files for the EVM can be provided that illustrate techniques that achieve fan-out of the  $\mu$ \*BGA, use of split power planes, placement of filters and other critical components, and methods used to match lengths on PCI and PCI Express signals on a standard 8-layer board.

Schematics and a Bill of Materials are provided to illustrate the design of this EVM.

**Note:** Observe proper ESD procedures when handling the EVM. Failure to observe proper procedures may result in damage either to the EVM or the XIO2001 silicon which may cause the board to malfunction.

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<sup>1</sup> As specified in the *PCI Express Electromechanical Specification*, revision 1.0a and the *PCI Local Bus Specification*, revision 2.3

## 2 EVM Features

### 2.1 PCI Express Connector

The EVM is designed as a half-width PCI Express add-in card. The card fits into any standard x1, x2, x4, x8, or x16 add-in connector that is compliant with the *PCI Express Electromechanical Specification* revision 2.0 or lower. In addition to the standard transmit-and-receive pairs, the connector must supply 3.3V, 12V,  $\overline{\text{PERST}}$ , a 100-MHz differential clock, and  $V_{\text{AUX}}$ . The  $\overline{\text{WAKE}}$  signal is also supported by the EVM although, as an optional pin, the system is not required to support this signal.

The height of the board is nonstandard due to the presence of PCI slots. Inserting PCI add-in cards into the EVM will, in most cases, prohibit the EVM from being placed in a case. If possible, provide some mechanical support to the EVM. Otherwise, the weight of PCI add-in cards can strain the board in the PCI Express add-in slot and may result in the board making poor contact with the connector. Poor connector contact can lead to signal integrity issues.

### 2.2 PCI Add-In Slots

The XIO2001 EVM provides three standard PCI add-in slots. While reversible, these slots, as shipped, are keyed as 5-V slots and provide a 5-V VIO clamping voltage that provides accessibility to any 5-V or universally keyed PCI add-in cards. All standard voltages (3.3 V, 5 V, 12 V, and -12 V) are provided through the PCI connectors, enabling standard PCI add-in cards to function without requiring external power.

Cards placed into the PCI add-in slots must be inserted into the slots in accordance with labeling on the EVM. Referencing the component side of the EVM as front and the PCI express edge connector as down, boards must be inserted with the component side of the board down and the mounting bracket to the left of the EVM.

**WARNING:** Inserting either a 3.3-V card or a universally keyed card into the EVM backwards will damage the EVM and possibly the add-in card as well.

The PCI bus operates at 66 MHz only when 66-MHz-capable PCI add-in cards are placed in the socket. If a 33-MHz card is inserted into the socket, then the XIO2001 detects the presence of the lower speed device and automatically sets the bus speed to 33 MHz. If 66-MHz operation is desired, place no more than two add-in cards into board slots. (This limitation is due to bus loading issues inherent to the PCI specification.) If a third 66-MHz device is added to the bus, signal

integrity may still permit proper functioning of the interface, but such functionality cannot be assured and is beyond the scope of this document.

Two of the reserved pins on the PCI add-in connectors are used to route  $\overline{\text{PME}}$  and  $V_{\text{AUX}}$  to any add-in cards. These assignments, while not part of the *PCI Local Bus Specification*, are used by many in the industry as de facto standards and must not interfere with any add-in cards. If cards are used that use these terminals for other purposes, the following modifications may be made to the EVM to isolate the signals from the PCI add-in connectors:

- $\overline{\text{PME}}$  (routed to reserved terminal A19 on each connector). Remove resistors R55, R53, and R54 (for slots 0, 1, and 2, respectively).
- $V_{\text{AUX}}$  (routed to reserved terminal A14 on each connector). Remove resistors R50, R51, and R52 (for slots 0, 1, and 2, respectively).

## 2.3 EEPROM Interface

Each XIO2001 EVM provides an on-board EEPROM. As shipped, each EEPROM is programmed with values that will allow the EVM to function in most systems. The EEPROM interface is left as programmable (not write-protected) so that EEPROM contents may be modified for testing other optional settings. TI recommends that you do not change the EEPROM values. To change EEPROM contents, use the EEPROM access registers as detailed in the XIO2001 data manual or request the WinROM access tool.

## 2.4 Test Header

Each XIO2001 EVM provides accessibility to the GPIO pins on the XIO2001. From header J1, all five GPIOs have external visibility and can be used in any manner consistent with their functionality as detailed in the XIO2001 data manual. All GPIO signals are labeled on the header and are terminated with an on-board pullup resistor.

By default, GPIO3 and GPIO4 are configured as the EEPROM interface which was detailed in the previous section. The EEPROM interface can be removed from the XIO2001 by removing resistors R28 and R29. This allows these GPIO pins to be used for another purpose, although any configuration done by the EEPROM will then have to be done in some other fashion. While removing R28 and R29 will physically disconnect the EEPROM from GPIO3/GPIO4, in order to release the pins from this functionality, GPIO4 (SCL) must be held low at the deassertion of  $\overline{\text{PERST}}$ . As no pulldown is available for this purpose, the pin must be externally shorted at boot time (deassertion of reset) by shorting J1 pin 5 to J1 pin 11. Once the system has booted, this short may be removed and GPIO3 and GPIO4 will be available for other uses.

Pin 9 on the J1 header is a global reset ( $\overline{\text{GRST}}$ ) for the XIO2001. Driving this pin low will cause all registers and state machines within the XIO2001 to return to a default power-up state. This pin generally must remain disconnected.

Pin 10 is an access point for the  $\overline{\text{PME}}$  signal and may be used to externally wire this signal to any PCI add-in card that has the signal available but does not route the signal to pin A19 on the PCI expansion connector.

Pin 8 on header J1 is CLKREQ# for the XIO2001. Driving this pin low will allow the REFCLK to stop when the XIO2001 is in PCI PM L1. The CLKREQ# protocol as described in the PCI Express Base Specification and Express Card standard is supported.

Pin 7 on header J1 is PERST# for the XIO2001. When asserted, this signal generates an internal PCI Express reset, clears all non-sticky bit registers and is deasserted when system power is stable.

Pin 12 on header J1 is PCLK66\_SEL for the XIO2001 controlling the PCI clock frequency. When this signal is pulled high, the PCI clock will operate at 33 or 66Mz depending on the state of M66EN. When this signal is low, the PCI clock will operate at 25MHz or 50MHz depending on the state of M66EN. Most applications will pull this pin high.

Pin 2 on the connector is a 3.3-V test point and pin 11 is a ground test point. These signals may be used to externally toggle GPIOs for any required testing.

## 2.5 $\overline{\text{CLKRUN}}$

The  $\overline{\text{CLKRUN}}$  (Clock run) signal is a power-saving mechanism (defined in the *PCI Mobile Design Guide*) which functions to stop the PCI bus clock when the bus is idle. Because devices which do not support this protocol are unable to restart the system clock, this feature is disabled by default on the XIO2001 EVM. This feature may be enabled to function with PCI add-in cards that also support this feature.

Enabling  $\overline{\text{CLKRUN}}$  requires that resistor R24 be populated with a 0805 form factor 10-k $\Omega$  resistor. When this option is populated at the de-assertion of the reset pin, GPIO0 will internally map to  $\overline{\text{CLKRUN}}$ . When this happens, GPIO0 will be unavailable for other purposes. An external wire must then be connected from GPIO0/ $\overline{\text{CLKRUN}}$  (available on J1 pin 1) to all add-in cards being tested with this functionality.

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## 2.6 JTAG HEADER

Each XIO2001 EVM provides access to JTAG interface pins for boundary scan testing on test header JP1. The JTAG interface for the XIO2001 complies with IEEE standard 1149 using the standard 5 pin interface (TCK, TDI, TDO, TMS and TRST#). If boundary scan testing is not needed, TCK (JP1 pin 10) and TRST# (JP1 pin 2) should be jumpered to GND (JP1 pins 1, 3, 5, 7 or 9). The remainder of the JTAG signals can be left unconnected.

If boundary scan testing is needed, TI can provide the appropriate BSDL file upon request.

## 2.7 LEDs

The XIO2001 EVM has LEDs onboard to indicate availability of power and status of certain control signals. The onboard LEDs are as follows:

- LED1 – 5-V power indicator
- LED2 – 3.3-V power indicator
- LED3 – 1.5-V (**Note:** this LED will generally not light due to absence of LED with  $V_f \leq 1.5$  V)
- LED4 – 12-V power indicator
- LED5 – PCI Express  $\overline{\text{PERST}}$  indicator (power on, reset asserted)
- LED6 – PCI Express  $\overline{\text{WAKE}}$  indicator (power on,  $\overline{\text{WAKE}}$  asserted)
- LED7 – PCI  $\overline{\text{PME}}$  indicator (any PCI add-in card that has  $\overline{\text{PME}}$  line asserted)

## 3 FAQ/Troubleshooting

To use the EVM:

1. Plug the PCI add-in cards into the EVM, oriented as indicated on the board
2. Place the EVM into a PCI express add-in slot
3. Turn the system on

From the operating system perspective, the XIO2001 appears to be a standard PCI-to-PCI bridge (PCI header type 1) and the OS will configure the bridge and any devices behind the bridge accordingly using legacy PCI configuration transactions. Following sections of this chapter describe issues that may impair use of the bridge in a system.

### 3.1 BIOS Fails to Assign Memory Window to Bridge.

Microsoft operating systems generally attempt to respect the resource allocations made by system BIOS. The XIO2001 requires a memory window in order to access some registers used by the device. If the Microsoft OS determines that the BIOS failed to assign a memory window to the XIO2001, it will assume that one cannot be assigned and that the device is nonfunctional. The OS will then assume the bridge is not functional and will not enumerate devices behind the bus. Consequently, these devices will never be configured or assigned resources.

This failure can be determined by examining device manager in the OS. If failure has occurred, the bridge will appear “banged out” and if the bridge properties are examined the OS will reveal this device cannot find enough free resources that it can use. (Code 12) If you want to use this device, you will need to disable one of the other devices on this system.

### 3.2 x16 slots Only Support $\overline{\text{INTA}}$

As the x16 PCI express add-in slots are designed as a graphics expansion port, many only support a single interrupt ( $\overline{\text{INTA}}$ ), as this is the only interrupt that will be required by a graphics card. The XIO2001 EVM supports all interrupts and balances interrupt loading by rotating the interrupts to each add-in slot as required by the *PCI Local Bus Specification*. Accordingly, any PCI add-in card behind the bridge that asserts an interrupt other than  $\overline{\text{INTA}}$  will not be serviced as the interrupt is not supported by the chipset. Consequently, the add-in card will fail. Any devices that do not require interrupts or that only assert  $\overline{\text{INTA}}$  (as routed to the specific slot they are placed in) will still function normally.

### 3.3 System Turns On When PCI Card Is Inserted Into EVM Or When EVM Is Plugged Into Slot

As mentioned previously,  $\overline{\text{PME}}$  is routed on the EVM to the various PCI slots through a reserved pin that many PCI add-in cards use for this purpose. On occasion, when a PCI card is inserted into the EVM (while the EVM is plugged into a board), the add-in card may be inserted in such a way as to pull the  $\overline{\text{PME}}$  line low on the EVM. When this happens, the XIO2001 sees a PCI device trying to wake the system and will appropriately assert  $\overline{\text{WAKE}}$ , which may cause the system to turn on.

Similarly, when the EVM is inserted into the slot,  $V_{\text{AUX}}$  from the connector may not have had enough time to pull the  $\overline{\text{PME}}$  line high (as the on-board pullup resistors dictate), yet  $V_{\text{AUX}}$  may have powered the XIO2001 which now samples  $\overline{\text{PME}}$  as low and again wakes the system. This is a limitation of the inability to appropriately power the pullup resistors before the XIO2001 is powered. If this occurs, turn power to the system off and reboot to ensure the EVM receives a clean reset from the system.

### 3.4 What To Do If EVM Is Not Working

#### 3.4.1 Check EVM Power

Diodes LED1, LED2, and LED4 show the status of the 5-V, 3.3-V, and 12-V rails, respectively. 1.5 V may be probed on the top pad of C44 (directly next to U3), and -12 V may be probed from C100. A ground reference is available at J1 pin 11 and JP1 pins 2, 4, 6, 8 and 10. If any of these voltages fail, a problem is likely to occur with EVM functionality. The XIO2001 requires 3.3 V and 1.5 V, other voltages are supplied for use by PCI add-in cards, and PCI VIO is by default 5 V (which will cause the entire PCI bus to be clamped to 0.7 V if this voltage is not present). If any of these voltages fail, it is likely that the EVM won't function because:

- The XIO2001 will not be powered
- The add-in card will not be powered
- Neither the XIO2001 or the add-in card will be powered

All voltages have resettable fuses to prevent overcurrent conditions, so if a particular power rail fails:

1. Detach all devices from the EVM
2. Remove the EVM from the system
3. Wait for 30 minutes before trying again

### 3.4.2 Check If Bridge Is Link Training

If the system does not boot, remove all PCI add-in cards from EVM and try again. If the system hangs before the OS loads, then probably the system and the EVM are having difficulty completing link training ( probably an issue with signal integrity on the differential pairs). If a PCI Express analyzer is unavailable, then try a different express slot or a different system if possible. Re-check the 1.5-V rail and examine the differential clock on an oscilloscope to ensure it is clean.

If link training successfully completes, the system will boot and the XIO2001 will appear in the device manager. If the bridge does not appear in the device manager, then the system may not have detected the presence of the bridge, perform the previous checks again.

Also, if the PCI add-in cards have enough weight and there is no mechanical support, the EVM may flex and some components may crack or become disconnected. Check the coupling capacitors on the EVM transmit lines (C102 and C103). These 0.1- $\mu$ F 0402 components have a tendency to crack if enough weight is put on the board; they will need to be replaced if they are damaged.

### 3.4.3 Check If Bridge Has Been Configured

Once the bridge is communicating with the system, the BIOS and/or the OS are expected to configure the bridge for proper operation. As the bridge appears to software to be a standard PCI-to-PCI bridge, most existing BIOS and OS software must be capable of configuring the bridge with no special considerations for PCI Express. In addition to the memory window the bridge requests for internal resources, the following items are required for bridge operation:

- Command register – PCI offset 0x4 : The bus master enable (bit 2), memory enable (bit 1), and I/O enable (bit 0) must be set to enable the bridge to send upstream transactions.
- Cache line size register – PCI offset 0xC : Must be set to the cache line size for the system. Failure to set this bit will not cause the bridge to fail but will cause the bridge to limit all upstream transactions to 1 DWord.
- Primary, secondary, and subordinate bus numbers – PCI offsets 0x18, 0x19, and 0x1A : The bridge must have the bus numbers configured so that it can determine which transactions are targeting the bridge, which transactions are targeting devices directly attached to the bridge, and which transactions are farther downstream from the bridge.
- I/O base and limit registers and I/O base upper 16 bits and I/O limit upper 16 bits registers – PCI offsets 0x1C, 0x1D, 0x30 and 0x32: If any devices downstream from the bridge require I/O resources, the bridge must be programmed with a window that contains the I/O resources of all devices

downstream. Failure to program these windows will cause the bridge to respond to I/O transactions with a response of Unsupported Request. Any transactions initiated on the secondary side of the bus that fall within this range will not be claimed by the bridge. The I/O window for the XIO2001 has a minimum size of 4 KBytes and is naturally 4K-aligned. Typically, most systems use only 16-bit addressing for I/O transactions, so the upper base and limit registers remain 0.

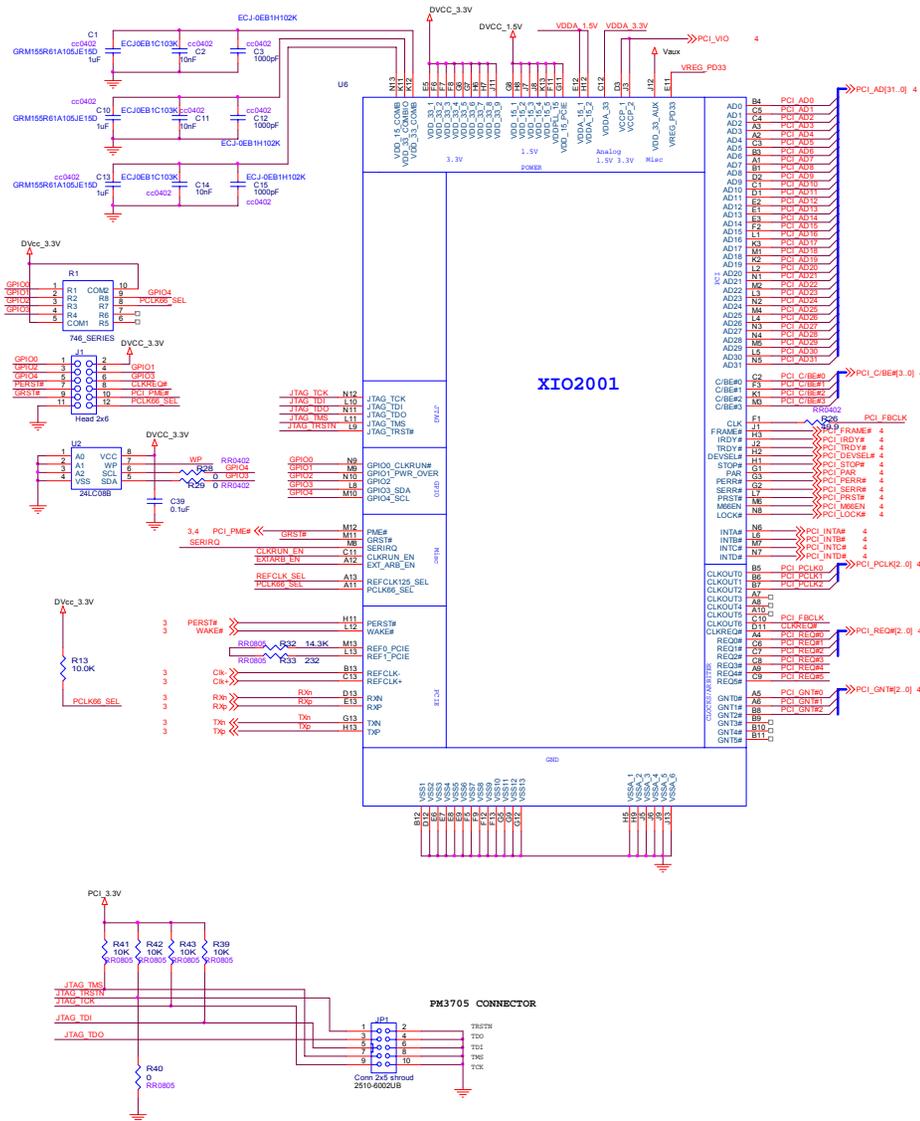
- Memory base and memory limit registers – PCI offsets 0x20 and 0x22 : Similar to the I/O base and limit registers, the bridge must be programmed with a memory address window containing the nonprefetchable memory resources of all downstream PCI devices requiring nonprefetchable memory. Memory windows have a minimum size of 1 MByte and are naturally 1M-aligned. The bridge does not claim either a memory transaction initiated from upstream that does not fall within its memory window nor memory transactions initiated downstream that do fall within its memory window.
- Prefetchable memory base, prefetchable memory limit, prefetchable base upper 32-bit, and prefetchable limit upper 32-bit registers – PCI offsets 0x24, 0x26, 0x28, and 0x2C: Identical to the memory base and limit registers but for prefetchable memory resources. The prefetchable base upper 32-bit, and prefetchable limit upper 32-bit registers are only used if 64-bit addressing is in use and in most systems both of these registers will remain all zeroes. If 64-bit addressing is desired and the memory window for devices behind the XIO2001 resides all or in part in 64-bit memory space then the prefetchable base upper 32-bit register will combine with the prefetchable base register and the prefetchable limit upper 32-bit register will combine with the prefetchable limit register to create 64-bit base and limit registers. All memory addresses between the two addresses will be considered to be located behind the bridge.
- For all base and limit registers any case in which the limit register contains a lower address than the base register will be considered invalid. In this situation the bridge will react as if all resources of that type resided upstream of the bridge. The bridge will respond to all downstream transactions of that type with Unsupported Request and will claim and forward upstream any transactions of that type that initiate on the PCI bus.

Depending on desired functionality, other PCI registers on the XIO2001 may have to be configured. Consult the XIO2001 data manual for a description of the previous registers, or for any other XIO2001 registers.

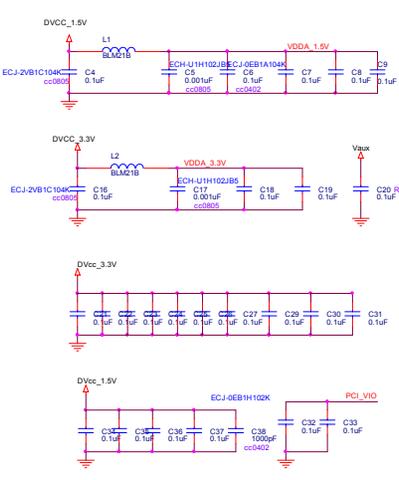
#### **3.4.4 Check Devices Downstream From Bridge**

Once the bridge is communicating and is properly configured, check if devices downstream from the bridge have been configured as required. Check the Windows Device Manager to determine if the device drivers have been loaded or if other problems exist with the device. Once you have performed these checks, you can perform PCI transactions on the bus and examine them with any standard PCI analyzer.

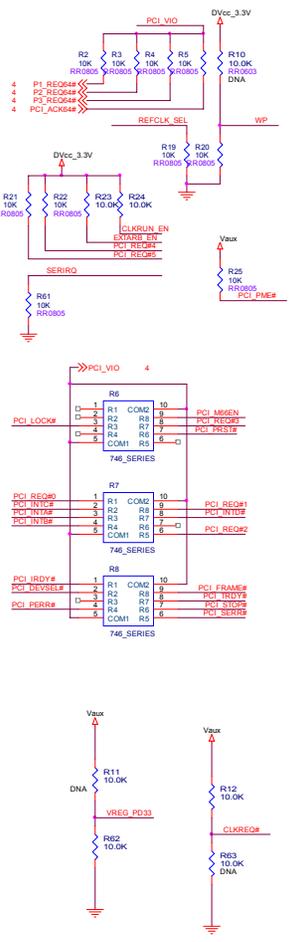
## 4 EVM Schematics

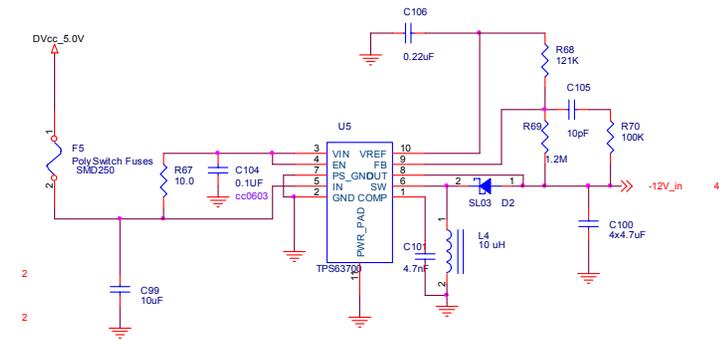
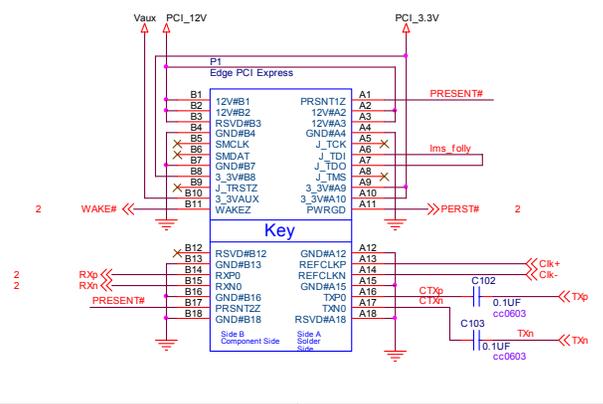


### Bridge Power Filtering/Decoupling

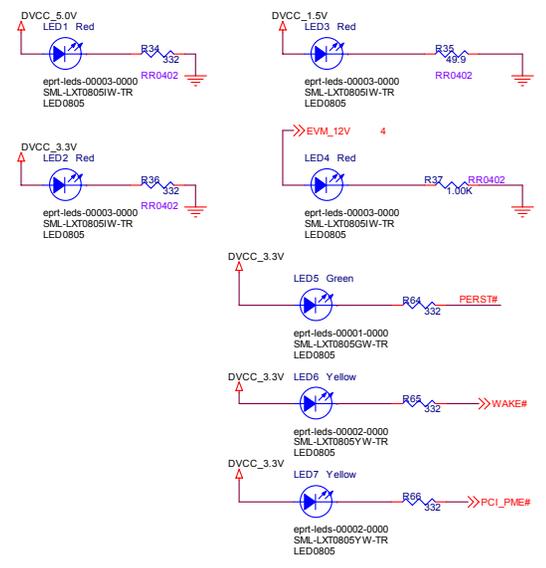


### Pull Ups/Pull Downs

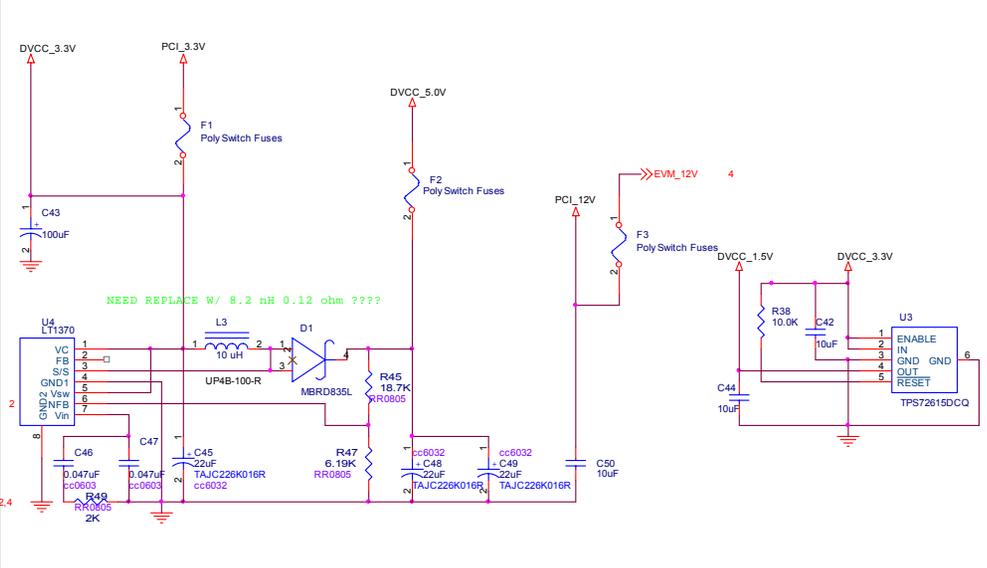




**LEDs 670-0203 (SML\_LX0805SRC) ???**



**Power**





# 5 EVM Bill of Materials

Evaluation board bill of materials as assembled. Unused options (e.g., 3.3-V VIO) are not populated and not listed.

Item	Qty	Reference	Value	Manufacturer	Part #	Package
1	3	C1 C10 C13	1uF	Murata	GRM155R61A105JE15D	cc0402
2	3	C2 C11 C14	10nF	Panasonic	ECJ0EB1C103K	cc0402
3	4	C3 C12 C15 C38	1000pF	Panasonic	ECJ-0EB1H102K	cc0402
4	2	C4 C16	0.1uF	Panasonic	ECJ-2VB1C104K	cc0805
5	2	C5 C17	0.001uF	Panasonic	ECH-U1H102JB5	cc0805
6	72	C6 C7 C8 C9 C18 C19 C20 C21 C22 C23 C24 C25 C26 C27 C29 C30 C31 C32 C33 C34 C35 C36 C37 C39 C51 C52 C53 C54 C55 C56 C57 C58 C59 C60 C61 C62 C63 C64 C65 C66 C67 C68 C69 C70 C71 C72 C73 C74 C75 C76 C77 C78 C79 C80 C81 C82 C83 C84 C85 C86 C87 C88 C89 C90 C91 C92 C93 C94 C95 C96 C97 C98	0.1uF	Panasonic	ECJ-0EB1A104K	cc0402
7	6	C42 C44 C50 C99 C100 C101	10uF	Panasonic	ECJ-2FB1A106K	cc0805
8	1	C43	100uF	Panasonic	ECA1EHG101	THCap_2P5MM
9	3	C45 C48 C49	22uF	AVX	TAJC226K016R	cc6032
10	2	C46 C47	0.047uF	Panasonic	ECJ1VB1C473K	cc0603
11	3	C102 C103 C104	0.1UF	Kemet	C0603C104M4RACTU	cc0603
12	1	C105	10pF	TDK	C1608C0G1H100DB	cc0603
13	1	C106	0.22uF	Panasonic	ECJ1VB1A224K	cc0603
14	1	D1	MBRD835L	Diodes, Inc.	MBRD835L	DPAK_4
15	1	D2	SL03	Vishay	SL03D0-219AB-GS08	sl03_schottky_diode
16	4	F1 F2 F3 F5	PolySwitch Fuses	Tyco Electronics	SMD250	SMD250
17	1	J1	Head 2x6	Berg	54102-T32-05	HDR_6X2
18	1	JP1	Conn 2x5 shroud	3M	2510-6002UB	eppt-conn-00002-0001
19	2	L1 L2	BLM21B	MuRata	BLM21BB221SN1	cc0805
20	1	L3	10 uH	Coiltronics	UP4B-100-R	IND_UP4B_100_R
21	1	L4	10 uH	Sumida	CDRH5D18NP-100NC	CDRH5D18

Item	Qty	Reference	Value	Manufacturer	Part #	Package
22	4	LED1 LED2 LED3 LED4	Red	Lumex	SML-LXT0805IW-TR	LED0805
23	1	LED5	Green	Lumex	SML-LXT0805GW-TR	LED0805
24	2	LED6 LED7	Yellow	Lumex	SML-LXT0805YW-TR	LED0805
25	1	P1	Edge PCI Express		DNA	eprt-conn-00023-0000
26	3	P2 P3 P4	PCI 5V Conn	Tyco Electronics	145154-8	Conn_PCI_60_Dual
27	4	R1 R6 R7 R8	746_SERIES	CTS	746X101103JCT-ND?	10Pin_8Res
28	14	R2 R3 R4 R5 R19 R20 R21 R22 R25 R39 R41 R42 R43 R61	10K	Panasonic	ERJ6ENF1002V	RR0805
29	9	R10 R11 R12 R13 R23 R24 R38 R62 R63	10.0K	Panasonic	ERJ3EKF1002V	RR0603
30	2	R26 R35	49.9	Panasonic	ERJ2RKF49R9X	RR0402
31	2	R28 R29	0	Panasonic	ERJ2GE0R00X	RR0402
32	1	R32	14.3K	Panasonic	ERJ6ENF1432V	RR0805
33	1	R33	232	Panasonic	ERJ6ENF2320V	RR0805
34	2	R34 R36	332	Panasonic	ERJ2GEJ3320X	RR0402
35	1	R37	conn 2x5 shroud	Panasonic	ERJ2RKF1001V	RR0402
36	7	R40 R50 R51 R52 R53 R54 R55	0	Panasonic	ERJ6ENF0000V	RR0805
37	1	R45	18.7K	Panasonic	ERJ6ENF1872V	RR0805
38	1	R47	6.19K	Panasonic	ERJ6ENF6191V	RR0805
39	1	R49	2K	Panasonic	ERJ6ENF2001V	RR0805
40	2	R56 R57	0	Panasonic	ERJ3GEY0R00V	RR0603
41	3	R58 R59 R60	100	Panasonic	ERJ6ENF1000V	RR0805
42	3	R64 R65 R66	332	Panasonic	ERAV39J3320V	RR0603
43	1	R67	10.0	Panasonic	ERJ2RKF10R0V	RR0402
44	1	R68	121K	Panasonic	ERJ2RKF1213X	RR0402
45	1	R69	1.2M	Vishay	CRCW0603	RR0603
46	1	R70	100K	Panasonic	ERJ2RKF1003V	RR0402
47	1	U2	24LC08B	Microchip	24LC08BIST	TSSOP_8_122X177_26
48	1	U3	TPS72615DCQ	Texas Instruments	TPS72615DCQ	TO_263_6_DCQ
49	1	U4	LT1370	Linear Technology	LT1370CR	DDPAK_R_7
50	1	U5	TPS63700	Texas Instruments	TPS63700DRCT	DRC_S_PVSON_N10
51	1	U6	XIO2001_ZAJ	Texas Instruments	XIO2001ZAJ	bga144ZAJ_0p5mm_socket

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