COM Express
Carrier Design Guide

COM Express®
Carrier Design Guide

Guidelines for designing COM Express® Carrier Boards

December 6, 2013

Rev. 2.0

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1. Preface

1.1. About This Document

This document provides information for designing a custom system Carrier Board for COM Express Modules. It includes reference schematics for the external circuitry required to implement the various COM Express peripheral functions. It also explains how to extend the supported buses and how to add additional peripherals and expansion slots to a COM Express based system.

It's strongly recommended to use the latest COM Express specification and the Module vendors' product manuals as a reference.

This design guide is not a specification. It contains additional detail information but does not replace the PICMG COM Express (COM.0) specification.

For complete guidelines on the design of COM Express compliant Carrier Boards and systems, refer also to the full specification – do not use this design guide as the only reference for any design decisions.

1.2. Intended Audience

This design guide is intended for electronics engineers and PCB layout engineers designing Carrier Boards for PICMG COM Express Modules.

1.3. No special word usage

Unlike a PICMG specification, which assigns special meanings to certain words such as ”shall”, “should” and “may”, there is no such usage in this document. That is because this document is not a specification; it is a non-normative design guide.

1.4. No statements of compliance

As this document is not a specification but a set of guidelines, there should not be any statements of compliance made with reference to this document.

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The schematic examples given in this document are believed to be correct but no guarantee is given. In most cases, the examples come from designs that have been built and tested.

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1.8. Acronyms, Abbreviations and Definitions Used

Table 1: Acronyms, Abbreviations and Definitions Used

Term	Description
AC '97 / HDA	Audio CODEC '97/High Definition Audio
ACPI	Advanced Configuration Power Interface – standard to implement power saving modes in PCAT systems
ADD2	Advanced Digital Display, 2nd Generation
ADD2/MEC	Advanced Digital Display, 2nd Generation, Media Expansion Card
Basic Module	COM Express® 125mm x 95mm Module form factor.
BIOS	Basic Input Output System – firmware in PC-AT system that is used to initialize system components before handing control over to the operating system.
CAN	Controller-area network (CAN or CAN-bus) is a vehicle bus standard designed to allow microcontrollers to communicate with each other within a vehicle without a host computer.
Carrier Board	An application specific circuit board that accepts a COM Express® Module.
Compact Module	COM Express® 95mm x 95mm Module form factor
CRT	Cathode Ray Tube
DAC	Digital Analog Converter
DDC	Display Data Control – VESA (Video Electronics Standards Association) standard to allow identification of the capabilities of a VGA monitor
DDI	Digital Display Interface– containing DisplayPort, HDMI/DVI and SDVO
DNI	Do Not Install
DP	DisplayPort is a digital display interface standard put forth by the Video Electronics Standards Association (VESA). It defines a new license free, royalty free, digital audio/video interconnect, intended to be used primarily between a computer and its display monitor.
DVI	Digital Visual Interface - a Digital Display Working Group (DDWG) standard that defines a standard video interface supporting both digital and analog video signals. The digital signals use TMDS.
EAPI	Embedded Application Programming Interface Software interface for COM Express® specific industrial functions • System information • Watchdog timer • I2C Bus • Flat Panel brightness control • User storage area • GPIO
EDID	Extended Display Identification Data
EDP	Embedded DisplayPort (eDP) is a digital display interface standard produced by the Video Electronics Standards Association (VESA) for digital interconnect of Audio and Video.
EEPROM	Electrically Erasable Programmable Read-Only Memory
EFT	Electrical Fast Transient
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ExpressCard	A PCMCIA standard built on the latest USB 2.0 and PCI Express buses.
Extended Module	COM Express® 155mm x 110mm Module form factor.
FR4	A type of fiber-glass laminate commonly used for printed circuit boards.
Gb	Gigabit
GbE	Gigabit Ethernet
GPI	General Purpose Input
GPIO	General Purpose Input Output
GPO	General Purpose Output
HDA	Intel High Definition Audio (HD Audio) refers to the specification released by Intel in 2004 for delivering high definition audio that is capable of playing back more channels at higher quality than AC97.

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Term	Description
HDMI	High Definition Multimedia Interface
I2C	Inter Integrated Circuit – 2 wire (clock and data) signaling scheme allowing communication between integrated circuits, primarily used to read and load register values.
IDE	Integrated Device Electronics – parallel interface for hard disk drives – also known as PATA
Legacy Device	Relics from the PC-AT computer that are not in use in contemporary PC systems: primarily the ISA bus, UART-based serial ports, parallel printer ports, PS-2 keyboards, and mice. Definitions vary as to what constitutes a legacy device. Some definitions include IDE as a legacy device.
LAN	Local Area Network
LPC	Low Pin-Count Interface: a low speed interface used for peripheral circuits such as Super I/O controllers, which typically combine legacy-device support into a single IC.
LS	Least Significant
LVDS	Low-Voltage Differential Signaling – widely used as a physical interface for TFT flat panels. LVDS can be used for many high-speed signaling applications. In this document, it refers only to TFT flat-panel applications.
MEC	Media Expansion Card
Mini Module	COM Express® 84x55mm Module form factor
MS	Most Significant
NA	Not available
NC	Not connected
OBD-II	On-Board Diagnostics 2nd generation
OEM	Original Equipment Manufacturer
PATA	Parallel AT Attachment – parallel interface standard for hard-disk drives – also known as IDE, AT Attachment, and as ATA
PC-AT	“Personal Computer – Advanced Technology” – an IBM trademark term used to refer to Intel x86 based personal computers in the 1990s
PCB	Printed Circuit Board
PCI	Peripheral Component Interface
PCI Express (PCIe)	Peripheral Component Interface Express – next-generation high speed Serialized I/O bus
PCI Express Lane	One PCI Express Lane is a set of 4 signals that contains two differential lines for Transmitter and two differential lines for Receiver. Clocking information is embedded into the data stream.
PD	Pull Down
PEG	PCI Express Graphics
PHY	Ethernet controller physical layer device
Pin-out Type	A reference to one of seven COM Express® definitions for the signals that appear on the COM Express® Module connector pins.
PS2 PS2 Keyboard PS2 Mouse	“Personal System 2” - an IBM trademark term used to refer to Intel x86 based personal computers in the 1990s. The term survives as a reference to the style of mouse and keyboard interface that were introduced with the PS2 system.
PU	Pull Up
ROM	Read Only Memory – a legacy term – often the device referred to as a ROM can actually be written to, in a special mode. Such writable ROMs are sometimes called Flash ROMs. BIOS is stored in ROM or Flash ROM.
RTC	Real Time Clock – battery backed circuit in PC-AT systems that keeps system time and date as well as certain system setup parameters
S0, S1, S2, S3, S4, S5	Sleep States defined by the ACPI specificationS0 Full power, all devices powered S1Sleep State, all context maintained S2 Sleep State, CPU and Cache context lost S3 Suspend to RAM System context stored in RAM; RAM is in standby S4 Suspend to Disk System context stored on disk S5 Soft Off Main power rail off, only standby power rail present
SATA	Serial AT Attachment: serial-interface standard for hard disks
SDVO	Serial Digital Video Out is a proprietary technology introduced by Intel® to add additional video signaling interfaces to a system. Being phased out

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Term	Description
SMBus	System Management Bus
SO-DIMM	Small Outline Dual In-line Memory Module
SPI	Serial Peripheral Interface
TBD	To be determined
TMDS	Transition Minimized Differential Signaling - a digital signaling protocol between the graphics subsystem and display. TMDS is used for the DVI digital signals. DC coupled
TPM	Trusted Platform Module, chip to enhance the security features of a computer system.
UIM	User Identity Module
USB	Universal Serial Bus
VESA	Video Electronics Standards Association
WDT	Watch Dog Timer

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1.9. Signal Table Terminology

Table 2 below describes the terminology used in this section for the Signal Description tables. The "#" symbol at the end of the signal name indicates that the active or asserted state occurs when the signal is at a low voltage level. When "#" is not present, the signal is asserted when at a high voltage level.

The terms "Input" and "Output" and their abbreviations in Table 2 below refer to the Module's view, i.e. an input is an input for the Module and not for the Carrier-Board.

Table 2: Signal Table Terminology Descriptions

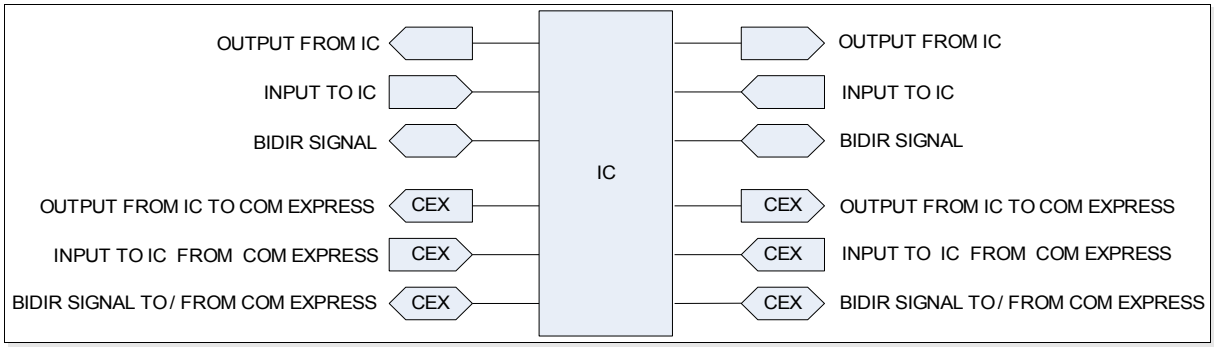
Term	Description
I/O 3.3V	Bi-directional signal 3.3V tolerant
I/O 5V	Bi-directional signal 5V tolerant
I 3.3V	Input 3.3V tolerant
I 5V	Input 5V tolerant
I/O 3V3_SBY	Bi-directional 3.3V tolerant active during Suspend and running state.
O 3.3V	Output 3.3V signal level
O 5V	Output 5V signal level
OD	Open drain output
P	Power input/output
*_S0	Signal active during running state.
PCIE	In compliance with PCI Express Base Specification
USB	In compliance with the Universal Serial Bus Specification
GbE	In compliance with IEEE 802.3ab 1000BASE-T Gigabit Ethernet
SATA	In compliance with Serial ATA specification
REF	Reference voltage output. May be sourced from a Module power plane.
PDS	Pull-down strap. A Module output pin that is either tied to GND or is not connected. Used to signal Module capabilities (pin-out type) to the Carrier Board.

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1.10. Schematic Conventions

Schematic examples are drawn with signal directions shown per the figure below. Signals that connect directly to the COM Express connector are flagged with the text “CEX” in the off-page connect symbol, as shown in Figure 1 below. Nets that connect to the COM Express Module are named per the PICMG COM Express specification.

Figure 1: Schematic Conventions



Power nets are labeled per the table below. The power rail behavior under the various system power states is shown in the table.

Table 3: Naming of Power Nets

Power Net	S0 On	S3 Suspend to RAM	S4 Suspend to Disk	S5 Soft Off	G3 Mechanical Off
VCC_12V	12V	off	off	off	off
VCC_5V0	5V	off	off	off	off
VCC_3V3	3.3V	off	off	off	off
VCC_1V5	1.5V	off	off	off	off
VCC_2V5	2.5V	off	off	off	off
VCC_5V_SBY	5V	5V	5V	5V	off
VCC_3V3_SBY	3.3V	3.3V	3.3V	3.3V	off
VCC_RTC	3.0V	3.0V	3.0V	3.0V	3.0V

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2. COM Express Interfaces

The following section summarizes the signals found on COM Express Type 10, Type 2 and Type 6 connectors. Most of the signals listed in the following sections also apply to other COM Express Module types. The pin-out for connector rows A and B remains mostly the same regardless of the Module type but the pin-out for connector rows D and C are dependent on the Module type. Refer to the COM Express Specification for information about the different pin-outs of the Module types other than Type 10, 2 and 6.

With some planning and forethought by the Carrier Board designer, it is possible to create dual use layouts that can accommodate Type 10 and Type 6 or Type 10 and Type 2, if desired.

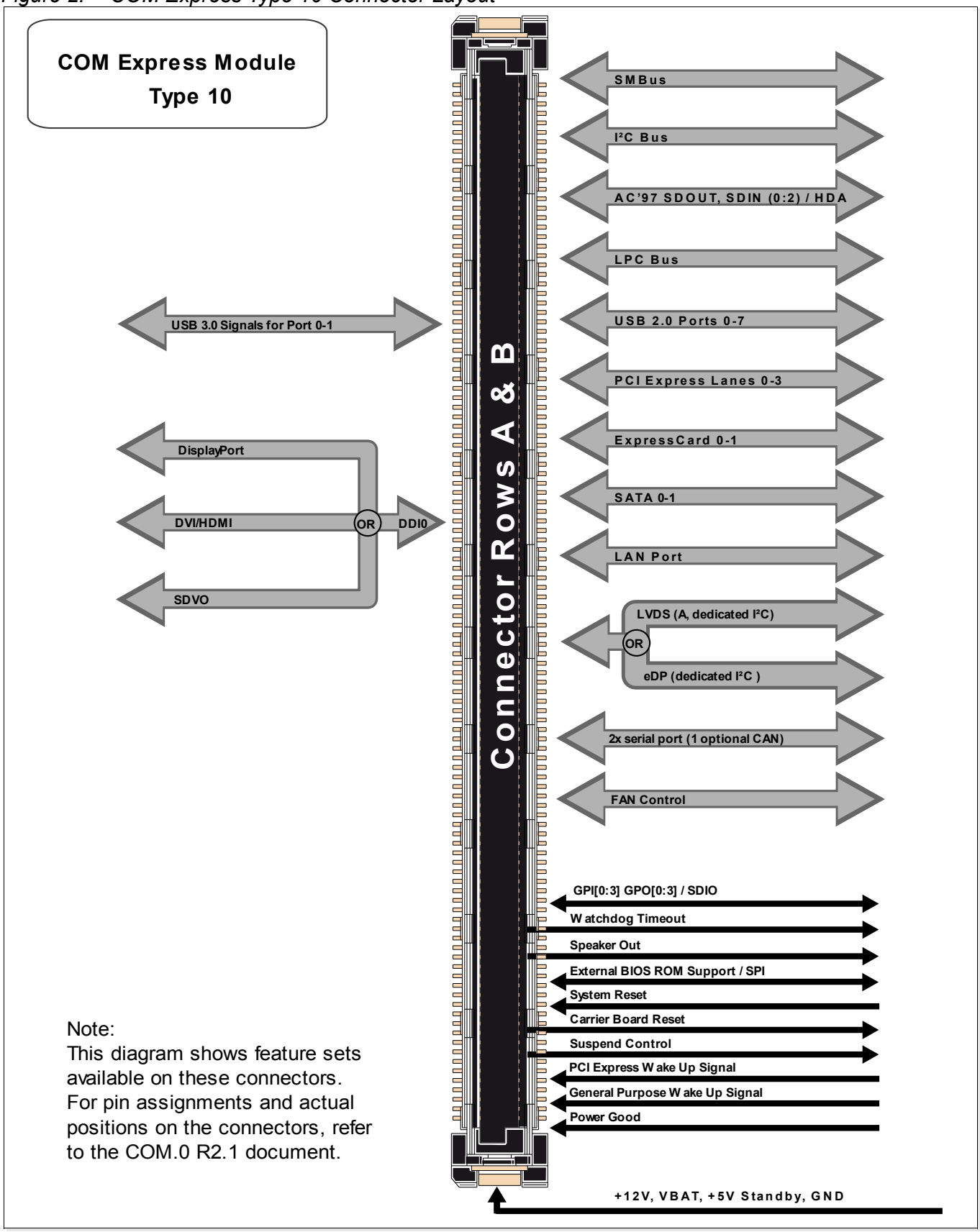
2.1. COM Express Signals

The source document for the definition of the COM Express signals is the ***PICMG COM.0 R2.1 COM Express Module Base Specification***.

Figure 2, Figure 3 and Figure 4 below summarizes the Type 10, Type 2 and Type 6 signals and show a graphical representation of the A-B and C-D COM Express connectors. Each of the signal groups in the figure is described and usage examples are given in the sub-sections of this section.

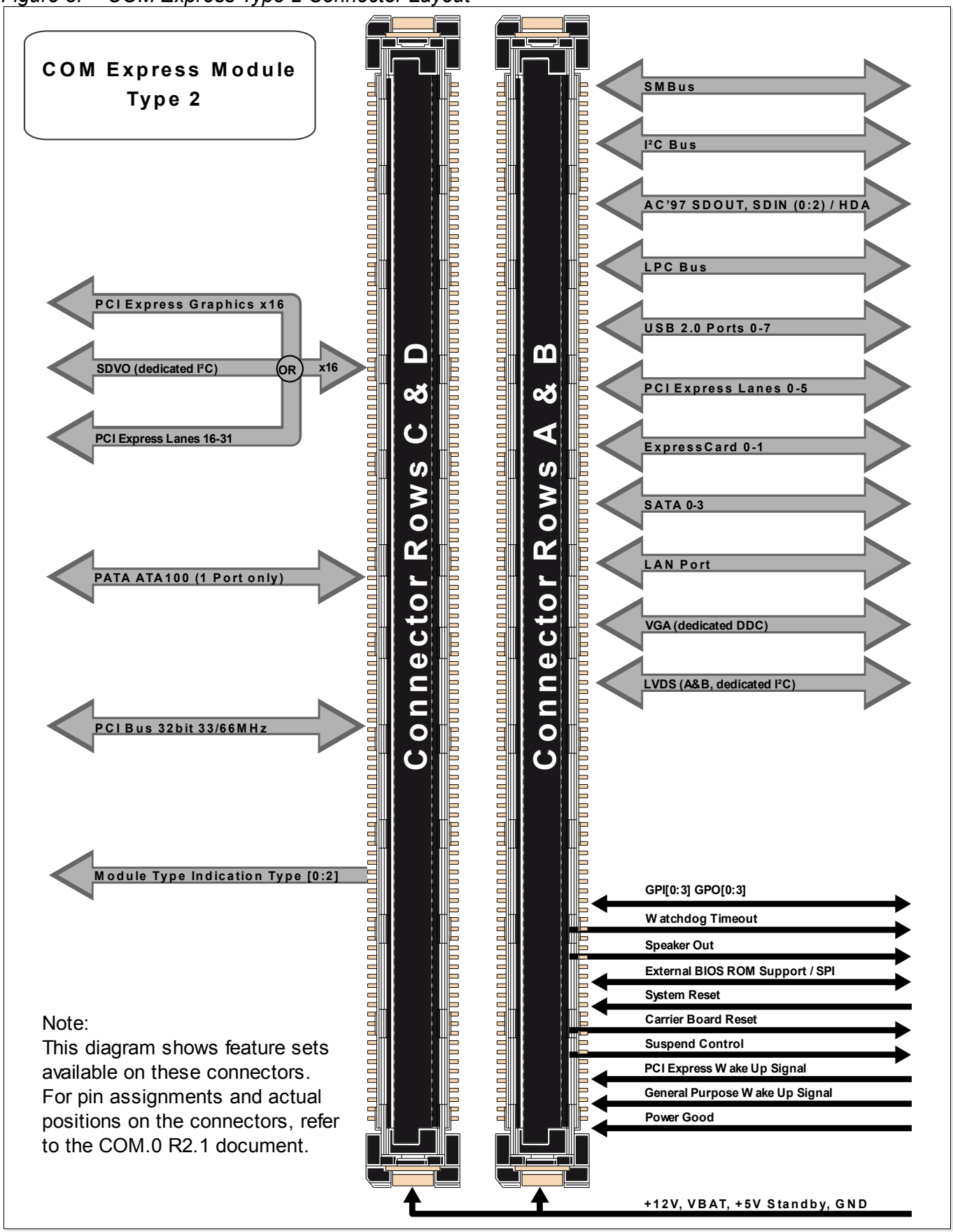
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Figure 2: COM Express Type 10 Connector Layout



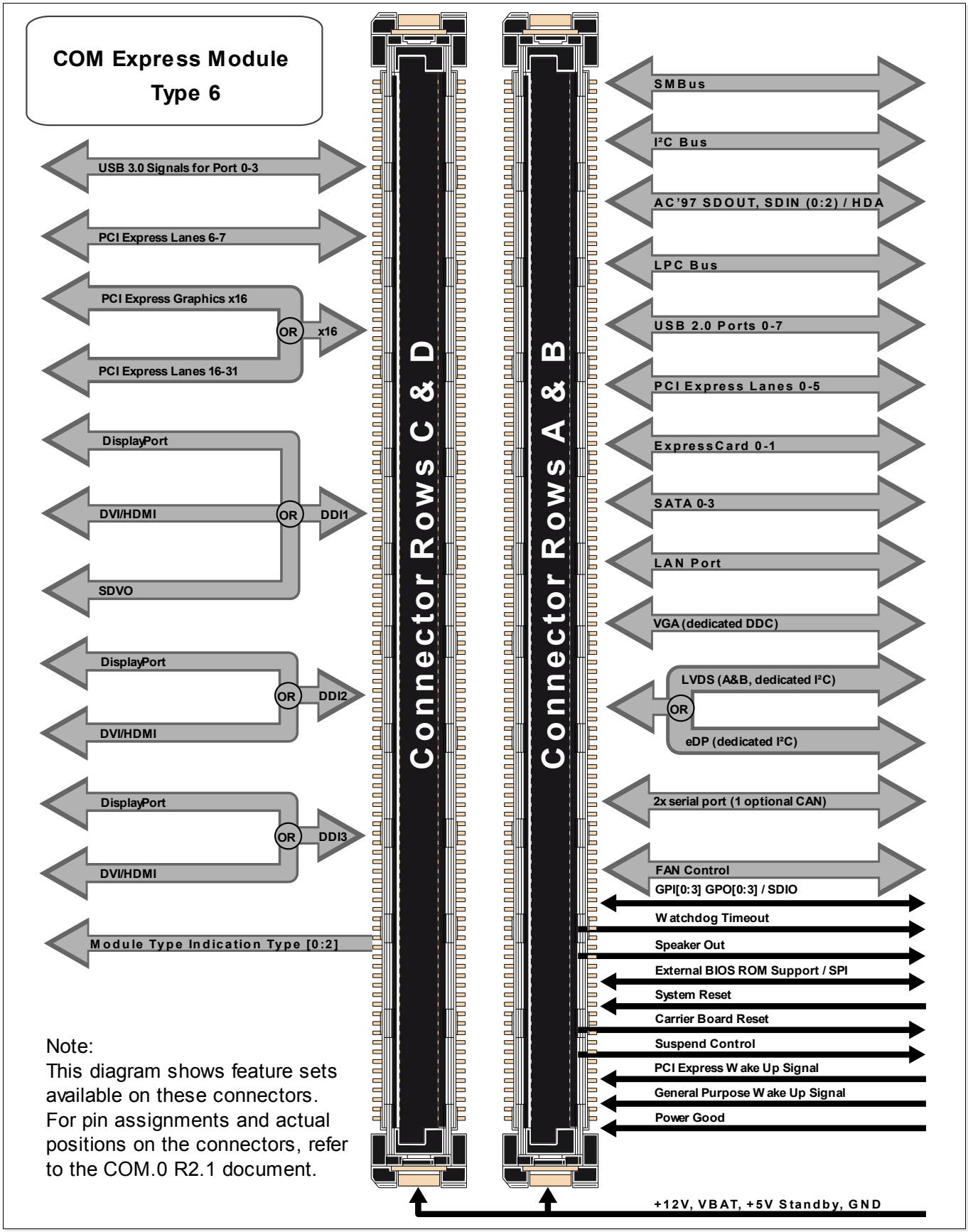
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Figure 3: COM Express Type 2 Connector Layout



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Figure 4: COM Express Type 6 Connector Layout



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2.1.1. Connector Pin-out Comparison

Table 4: Pin-out Comparison

Pin#	Type 10 Description	Type 2 Description	Type 6 Description
A1	GND(FIXED)	GND(FIXED)	GND(FIXED)
A2	GBE0_MDI3-	GBE0_MDI3-	GBE0_MDI3-
A3	GBE0_MDI3+	GBE0_MDI3+	GBE0_MDI3+
A4	GBE0_LINK100#	GBE0_LINK100#	GBE0_LINK100#
A5	GBE0_LINK1000#	GBE0_LINK1000#	GBE0_LINK1000#
A6	GBE0_MDI2-	GBE0_MDI2-	GBE0_MDI2-
A7	GBE0_MDI2+	GBE0_MDI2+	GBE0_MDI2+
A8	GBE0_LINK#	GBE0_LINK#	GBE0_LINK#
A9	GBE0_MDI1-	GBE0_MDI1-	GBE0_MDI1-
A10	GBE0_MDI1+	GBE0_MDI1+	GBE0_MDI1+
A11	GND(FIXED)	GND(FIXED)	GND(FIXED)
A12	GBE0_MDI0-	GBE0_MDI0-	GBE0_MDI0-
A13	GBE0_MDI0+	GBE0_MDI0+	GBE0_MDI0+
A14	GBE0_CTREF	GBE0_CTREF	GBE0_CTREF
A15	SUS_S3#	SUS_S3#	SUS_S3#
A16	SATA0_TX+	SATA0_TX+	SATA0_TX+
A17	SATA0_TX-	SATA0_TX-	SATA0_TX-
A18	SUS_S4#	SUS_S4#	SUS_S4#
A19	SATA0_RX+	SATA0_RX+	SATA0_RX+
A20	SATA0_RX-	SATA0_RX-	SATA0_RX-
A21	GND(FIXED)	GND(FIXED)	GND(FIXED)
A22	USB_SSRX0-	SATA2_TX+	SATA2_TX+
A23	USB_SSRX0+	SATA2_TX-	SATA2_TX-
A24	SUS_S5#	SUS_S5#	SUS_S5#
A25	USB_SSRX1-	SATA2_RX+	SATA2_RX+
A26	USB_SSRX1+	SATA2_RX-	SATA2_RX-
A27	BATLOW#	BATLOW#	BATLOW#
A28	(S)ATA_ACT#	(S)ATA_ACT#	(S)ATA_ACT#
A29	AC/HDA_SYNC	AC/HDA_SYNC	AC/HDA_SYNC
A30	AC/HDA_RST#	AC/HDA_RST#	AC/HDA_RST#
A31	GND(FIXED)	GND(FIXED)	GND(FIXED)
A32	AC/HDA_BITCLK	AC/HDA_BITCLK	AC/HDA_BITCLK
A33	AC/HDA_SDOUT	AC/HDA_SDOUT	AC/HDA_SDOUT
A34	BIOS_DIS0#	BIOS_DIS0#	BIOS_DIS0#
A35	THRMTRIP#	THRMTRIP#	THRMTRIP#
A36	USB6-	USB6-	USB6-
A37	USB6+	USB6+	USB6+
A38	USB_6_7_OC#	USB_6_7_OC#	USB_6_7_OC#
A39	USB4-	USB4-	USB4-
A40	USB4+	USB4+	USB4+
A41	GND(FIXED)	GND(FIXED)	GND(FIXED)
A42	USB2-	USB2-	USB2-
A43	USB2+	USB2+	USB2+

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
A44	USB_2_3_OC#	USB_2_3_OC#	USB_2_3_OC#
A45	USB0-	USB0-	USB0-
A46	USB0+	USB0+	USB0+
A47	VCC_RTC	VCC_RTC	VCC_RTC
A48	EXCD0_PERST#	EXCD0_PERST#	EXCD0_PERST#
A49	EXCD0_CPPE#	EXCD0_CPPE#	EXCD0_CPPE#
A50	LPC_SERIRQ	LPC_SERIRQ	LPC_SERIRQ
A51	GND(FIXED)	GND(FIXED)	GND(FIXED)
A52	RSVD	PCIE_TX5+	PCIE_TX5+
A53	RSVD	PCIE_TX5-	PCIE_TX5-
A54	GPI0	GPI0	GPI0
A55	RSVD	PCIE_TX4+	PCIE_TX4+
A56	RSVD	PCIE_TX4-	PCIE_TX4-
A57	GND	GND	GND
A58	PCIE_TX3+	PCIE_TX3+	PCIE_TX3+
A59	PCIE_TX3-	PCIE_TX3-	PCIE_TX3-
A60	GND(FIXED)	GND(FIXED)	GND(FIXED)
A61	PCIE_TX2+	PCIE_TX2+	PCIE_TX2+
A62	PCIE_TX2-	PCIE_TX2-	PCIE_TX2-
A63	GPI1	GPI1	GPI1
A64	PCIE_TX1+	PCIE_TX1+	PCIE_TX1+
A65	PCIE_TX1-	PCIE_TX1-	PCIE_TX1-
A66	GND	GND	GND
A67	GPI2	GPI2	GPI2
A68	PCIE_TX0+	PCIE_TX0+	PCIE_TX0+
A69	PCIE_TX0-	PCIE_TX0-	PCIE_TX0-
A70	GND(FIXED)	GND(FIXED)	GND(FIXED)
A71	LVDS_A0+	LVDS_A0+	LVDS_A0+
A72	LVDS_A0-	LVDS_A0-	LVDS_A0-
A73	LVDS_A1+	LVDS_A1+	LVDS_A1+
A74	LVDS_A1-	LVDS_A1-	LVDS_A1-
A75	LVDS_A2+	LVDS_A2+	LVDS_A2+
A76	LVDS_A2-	LVDS_A2-	LVDS_A2-
A77	LVDS_VDD_EN	LVDS_VDD_EN	LVDS_VDD_EN
A78	LVDS_A3+	LVDS_A3+	LVDS_A3+
A79	LVDS_A3-	LVDS_A3-	LVDS_A3-
A80	GND(FIXED)	GND(FIXED)	GND(FIXED)
A81	LVDS_A_CK+	LVDS_A_CK+	LVDS_A_CK+
A82	LVDS_A_CK-	LVDS_A_CK-	LVDS_A_CK-
A83	LVDS_I2C_CK	LVDS_I2C_CK	LVDS_I2C_CK
A84	LVDS_I2C_DAT	LVDS_I2C_DAT	LVDS_I2C_DAT
A85	GPI3	GPI3	GPI3
A86	RSVD	KBD_RST#	RSVD
A87	eDP_HPD	KBD_A20GATE	eDP_HPD
A88	PCIE_CLK_REF+	PCIE_CLK_REF+	PCIE_CLK_REF+
A89	PCIE_CLK_REF-	PCIE_CLK_REF-	PCIE_CLK_REF-

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
A90	GND(FIXED)	GND(FIXED)	GND(FIXED)
A91	SPI_POWER	SPI_POWER	SPI_POWER
A92	SPI_MISO	SPI_MISO	SPI_MISO
A93	GPO0	GPO0	GPO0
A94	SPI_CLK	SPI_CLK	SPI_CLK
A95	SPI_MOSI	SPI_MOSI	SPI_MOSI
A96	TPM_PP	GND	TPM_PP
A97	TYPE10#	TYPE10#	TYPE10#
A98	SER0_TX	RSVD	SER0_TX
A99	SER0_RX	RSVD	SER0_RX
A100	GND(FIXED)	GND(FIXED)	GND(FIXED)
A101	SER1_TX	RSVD	SER1_TX
A102	SER1_RX	RSVD	SER1_RX
A103	LID#	RSVD	LID#
A104	VCC_12V	VCC_12V	VCC_12V
A105	VCC_12V	VCC_12V	VCC_12V
A106	VCC_12V	VCC_12V	VCC_12V
A107	VCC_12V	VCC_12V	VCC_12V
A108	VCC_12V	VCC_12V	VCC_12V
A109	VCC_12V	VCC_12V	VCC_12V
A110	GND(FIXED)	GND(FIXED)	GND(FIXED)
B1	GND(FIXED)	GND(FIXED)	GND(FIXED)
B2	GBE0_ACT#	GBE0_ACT#	GBE0_ACT#
B3	LPC_FRAME#	LPC_FRAME#	LPC_FRAME#
B4	LPC_AD0	LPC_AD0	LPC_AD0
B5	LPC_AD1	LPC_AD1	LPC_AD1
B6	LPC_AD2	LPC_AD2	LPC_AD2
B7	LPC_AD3	LPC_AD3	LPC_AD3
B8	LPC_DRQ0#	LPC_DRQ0#	LPC_DRQ0#
B9	LPC_DRQ1#	LPC_DRQ1#	LPC_DRQ1#
B10	LPC_CLK	LPC_CLK	LPC_CLK
B11	GND(FIXED)	GND(FIXED)	GND(FIXED)
B12	PWRBTN#	PWRBTN#	PWRBTN#
B13	SMB_CK	SMB_CK	SMB_CK
B14	SMB_DAT	SMB_DAT	SMB_DAT
B15	SMB_ALERT#	SMB_ALERT#	SMB_ALERT#
B16	SATA1_TX+	SATA1_TX+	SATA1_TX+
B17	SATA1_TX-	SATA1_TX-	SATA1_TX-
B18	SUS_STAT#	SUS_STAT#	SUS_STAT#
B19	SATA1_RX+	SATA1_RX+	SATA1_RX+
B20	SATA1_RX-	SATA1_RX-	SATA1_RX-
B21	GND(FIXED)	GND(FIXED)	GND(FIXED)
B22	USB_SSTX0-	SATA3_TX+	SATA3_TX+
B23	USB_SSTX0+	SATA3_TX-	SATA3_TX-
B24	PWR_OK	PWR_OK	PWR_OK
B25	USB_SSTX1-	SATA3_RX+	SATA3_RX+

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
B26	USB_SSTX1+	SATA3_RX-	SATA3_RX-
B27	WDT	WDT	WDT
B28	AC/HDA_SDIN2	AC/HDA_SDIN2	AC/HDA_SDIN2
B29	AC/HDA_SDIN1	AC/HDA_SDIN1	AC/HDA_SDIN1
B30	AC/HDA_SDIN0	AC/HDA_SDIN0	AC/HDA_SDIN0
B31	GND(FIXED)	GND(FIXED)	GND(FIXED)
B32	SPKR	SPKR	SPKR
B33	I2C_CK	I2C_CK	I2C_CK
B34	I2C_DAT	I2C_DAT	I2C_DAT
B35	THRM#	THRM#	THRM#
B36	USB7-	USB7-	USB7-
B37	USB7+	USB7+	USB7+
B38	USB_4_5_OC#	USB_4_5_OC#	USB_4_5_OC#
B39	USB5-	USB5-	USB5-
B40	USB5+	USB5+	USB5+
B41	GND(FIXED)	GND(FIXED)	GND(FIXED)
B42	USB3-	USB3-	USB3-
B43	USB3+	USB3+	USB3+
B44	USB_0_1_OC#	USB_0_1_OC#	USB_0_1_OC#
B45	USB1-	USB1-	USB1-
B46	USB1+	USB1+	USB1+
B47	EXCD1_PERST#	EXCD1_PERST#	EXCD1_PERST#
B48	EXCD1_CPPE#	EXCD1_CPPE#	EXCD1_CPPE#
B49	SYS_RESET#	SYS_RESET#	SYS_RESET#
B50	CB_RESET#	CB_RESET#	CB_RESET#
B51	GND(FIXED)	GND(FIXED)	GND(FIXED)
B52	RSVD	PCIE_RX5+	PCIE_RX5+
B53	RSVD	PCIE_RX5-	PCIE_RX5-
B54	GPO1	GPO1	GPO1
B55	RSVD	PCIE_RX4+	PCIE_RX4+
B56	RSVD	PCIE_RX4-	PCIE_RX4-
B57	GPO2	GPO2	GPO2
B58	PCIE_RX3+	PCIE_RX3+	PCIE_RX3+
B59	PCIE_RX3-	PCIE_RX3-	PCIE_RX3-
B60	GND(FIXED)	GND(FIXED)	GND(FIXED)
B61	PCIE_RX2+	PCIE_RX2+	PCIE_RX2+
B62	PCIE_RX2-	PCIE_RX2-	PCIE_RX2-
B63	GPO3	GPO3	GPO3
B64	PCIE_RX1+	PCIE_RX1+	PCIE_RX1+
B65	PCIE_RX1-	PCIE_RX1-	PCIE_RX1-
B66	WAKE0#	WAKE0#	WAKE0#
B67	WAKE1#	WAKE1#	WAKE1#
B68	PCIE_RX0+	PCIE_RX0+	PCIE_RX0+
B69	PCIE_RX0-	PCIE_RX0-	PCIE_RX0-
B70	GND(FIXED)	GND(FIXED)	GND(FIXED)
B71	DDI0_PAIR0+	LVDS_B0+	LVDS_B0+

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
B72	DDI0_PAIR0-	LVDS_B0-	LVDS_B0-
B73	DDI0_PAIR1+	LVDS_B1+	LVDS_B1+
B74	DDI0_PAIR1-	LVDS_B1-	LVDS_B1-
B75	DDI0_PAIR2+	LVDS_B2+	LVDS_B2+
B76	DDI0_PAIR2-	LVDS_B2-	LVDS_B2-
B77	DDI0_PAIR4+	LVDS_B3+	LVDS_B3+
B78	DDI0_PAIR4-	LVDS_B3-	LVDS_B3-
B79	LVDS_BKLT_EN	LVDS_BKLT_EN	LVDS_BKLT_EN
B80	GND(FIXED)	GND(FIXED)	GND(FIXED)
B81	DDI0_PAIR3+	LVDS_B_CK+	LVDS_B_CK+
B82	DDI0_PAIR3-	LVDS_B_CK-	LVDS_B_CK-
B83	LVDS_BKLT_CTRL	LVDS_BKLT_CTRL	LVDS_BKLT_CTRL
B84	VCC_5V_SBY	VCC_5V_SBY	VCC_5V_SBY
B85	VCC_5V_SBY	VCC_5V_SBY	VCC_5V_SBY
B86	VCC_5V_SBY	VCC_5V_SBY	VCC_5V_SBY
B87	VCC_5V_SBY	VCC_5V_SBY	VCC_5V_SBY
B88	BIOS_DIS1#	BIOS_DIS1#	BIOS_DIS1#
B89	DDI0_HPD	VGA_RED	VGA_RED
B90	GND(FIXED)	GND(FIXED)	GND(FIXED)
B91	DDI0_PAIR5+	VGA_GRN	VGA_GRN
B92	DDI0_PAIR5-	VGA_BLU	VGA_BLU
B93	DDI0_PAIR6+	VGA_HSYNC	VGA_HSYNC
B94	DDI0_PAIR6-	VGA_VSYNC	VGA_VSYNC
B95	DDI0_DDC_AUX_SEL	VGA_I2C_CK	VGA_I2C_CK
B96	USB_HOST_PRSNT	VGA_I2C_DAT	VGA_I2C_DAT
B97	SPI_CS#	SPI_CS#	SPI_CS#
B98	DDI0_CTRLCLK_AUX+	RSVD	RSVD
B99	DDI0_CTRLDATA_AUX-	RSVD	RSVD
B100	GND(FIXED)	GND(FIXED)	GND(FIXED)
B101	FAN_PWMOUT	RSVD	FAN_PWMOUT
B102	FAN_TACHIN	RSVD	FAN_TACHIN
B103	SLEEP#	RSVD	SLEEP#
B104	VCC_12V	VCC_12V	VCC_12V
B105	VCC_12V	VCC_12V	VCC_12V
B106	VCC_12V	VCC_12V	VCC_12V
B107	VCC_12V	VCC_12V	VCC_12V
B108	VCC_12V	VCC_12V	VCC_12V
B109	VCC_12V	VCC_12V	VCC_12V
B110	GND(FIXED)	GND(FIXED)	GND(FIXED)
C1	-	GND(FIXED)	GND(FIXED)
C2	-	IDE_D7	GND
C3	-	IDE_D6	USB_SSRX0-
C4	-	IDE_D3	USB_SSRX0+
C5	-	IDE_D15	GND
C6	-	IDE_D8	USB_SSRX1-
C7	-	IDE_D9	USB_SSRX1+

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
C8	-	IDE_D2	GND
C9	-	IDE_D13	USB_SSRX2-
C10	-	IDE_D1	USB_SSRX2+
C11	-	GND(FIXED)	GND(FIXED)
C12	-	IDE_D14	USB_SSRX3-
C13	-	IDE_IORDY	USB_SSRX3+
C14	-	IDE_IOR#	GND
C15	-	PCI_PME#	DDI1_PAIR6+
C16	-	PCI_GNT2#	DDI1_PAIR6-
C17	-	PCI_REQ2#	RSVD
C18	-	PCI_GNT1#	RSVD
C19	-	PCI_REQ1#	PCIE_RX6+
C20	-	PCI_GNT0#	PCIE_RX6-
C21	-	GND(FIXED)	GND(FIXED)
C22	-	PCI_REQ0#	PCIE_RX7+
C23	-	PCI_RESET#	PCIE_RX7-
C24	-	PCI_AD0	DDI1_HPD
C25	-	PCI_AD2	DDI1_PAIR4 +
C26	-	PCI_AD4	DDI1_PAIR4-
C27	-	PCI_AD6	RSVD
C28	-	PCI_AD8	RSVD
C29	-	PCI_AD10	DDI1_PAIR5+
C30	-	PCI_AD12	DDI1_PAIR5-
C31	-	GND(FIXED)	GND(FIXED)
C32	-	PCI_AD14	DDI2_CTRLCLK_AUX+
C33	-	PCI_C/BE1#	DDI2_CTRLDATA_AUX-
C34	-	PCI_PERR#	DDI2_DDC_AUX_SEL
C35	-	PCI_LOCK#	RSVD
C36	-	PCI_DEVSEL#	DDI3_CTRLCLK_AUX+
C37	-	PCI_IRDY#	DDI3_CTRLDATA_AUX-
C38	-	PCI_C/BE2#	DDI3_DDC_AUX_SEL
C39	-	PCI_AD17	DDI3_PAIR0+
C40	-	PCI_AD19	DDI3_PAIR0-
C41	-	GND(FIXED)	GND(FIXED)
C42	-	PCI_AD21	DDI3_PAIR1+
C43	-	PCI_AD23	DDI3_PAIR1-
C44	-	PCI_C/BE3#	DDI3_HPD
C45	-	PCI_AD25	RSVD
C46	-	PCI_AD27	DDI3_PAIR2+
C47	-	PCI_AD29	DDI3_PAIR2-
C48	-	PCI_AD31	RSVD
C49	-	PCI_IRQA#	DDI3_PAIR3+
C50	-	PCI_IRQB#	DDI3_PAIR3-
C51	-	GND(FIXED)	GND(FIXED)
C52	-	PEG_RX0+	PEG_RX0+
C53	-	PEG_RX0-	PEG_RX0-

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
C54	-	TYPE0#	TYPE0#
C55	-	PEG_RX1+	PEG_RX1+
C56	-	PEG_RX1-	PEG_RX1-
C57	-	TYPE1#	TYPE1#
C58	-	PEG_RX2+	PEG_RX2+
C59	-	PEG_RX2-	PEG_RX2-
C60	-	GND(FIXED)	GND(FIXED)
C61	-	PEG_RX3+	PEG_RX3+
C62	-	PEG_RX3-	PEG_RX3-
C63	-	RSVD	RSVD
C64	-	RSVD	RSVD
C65	-	PEG_RX4+	PEG_RX4+
C66	-	PEG_RX4-	PEG_RX4-
C67	-	RSVD	RSVD
C68	-	PEG_RX5+	PEG_RX5+
C69	-	PEG_RX5-	PEG_RX5-
C70	-	GND(FIXED)	GND(FIXED)
C71	-	PEG_RX6+	PEG_RX6+
C72	-	PEG_RX6-	PEG_RX6-
C73	-	SDVO_DATA	GND
C74	-	PEG_RX7+	PEG_RX7+
C75	-	PEG_RX7-	PEG_RX7-
C76	-	GND	GND
C77	-	RSVD	RSVD
C78	-	PEG_RX8+	PEG_RX8+
C79	-	PEG_RX8-	PEG_RX8-
C80	-	GND(FIXED)	GND(FIXED)
C81	-	PEG_RX9+	PEG_RX9+
C82	-	PEG_RX9-	PEG_RX9-
C83	-	RSVD	RSVD
C84	-	GND	GND
C85	-	PEG_RX10+	PEG_RX10+
C86	-	PEG_RX10-	PEG_RX10-
C87	-	GND	GND
C88	-	PEG_RX11+	PEG_RX11+
C89	-	PEG_RX11-	PEG_RX11-
C90	-	GND(FIXED)	GND(FIXED)
C91	-	PEG_RX12+	PEG_RX12+
C92	-	PEG_RX12-	PEG_RX12-
C93	-	GND	GND
C94	-	PEG_RX13+	PEG_RX13+
C95	-	PEG_RX13-	PEG_RX13-
C96	-	GND	GND
C97	-	RSVD	RSVD
C98	-	PEG_RX14+	PEG_RX14+
C99	-	PEG_RX14-	PEG_RX14-

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
C100	-	GND(FIXED)	GND(FIXED)
C101	-	PEG_RX15+	PEG_RX15+
C102	-	PEG_RX15-	PEG_RX15-
C103	-	GND	GND
C104	-	VCC_12V	VCC_12V
C105	-	VCC_12V	VCC_12V
C106	-	VCC_12V	VCC_12V
C107	-	VCC_12V	VCC_12V
C108	-	VCC_12V	VCC_12V
C109	-	VCC_12V	VCC_12V
C110	-	GND(FIXED)	GND(FIXED)
D1	-	GND(FIXED)	GND(FIXED)
D2	-	IDE_D5	GND
D3	-	IDE_D10	USB_SSTX0-
D4	-	IDE_D11	USB_SSTX0+
D5	-	IDE_D12	GND
D6	-	IDE_D4	USB_SSTX1-
D7	-	IDE_D0	USB_SSTX1+
D8	-	IDE_REQ	GND
D9	-	IDE_IOW#	USB_SSTX2-
D10	-	IDE_ACK#	USB_SSTX2+
D11	-	GND(FIXED)	GND(FIXED)
D12	-	IDE_IRQ	USB_SSTX3-
D13	-	IDE_A0	USB_SSTX3+
D14	-	IDE_A1	GND
D15	-	IDE_A2	DDI1_CTRLCLK_AUX+
D16	-	IDE_CS1#	DDI1_CTRLDATA_AUX-
D17	-	IDE_CS3#	RSVD
D18	-	IDE_RESET#	RSVD
D19	-	PCI_GNT3#	PCIE_TX6+
D20	-	PCI_REQ3#	PCIE_TX6-
D21	-	GND(FIXED)	GND(FIXED)
D22	-	PCI_AD1	PCIE_TX7+
D23	-	PCI_AD3	PCIE_TX7-
D24	-	PCI_AD5	RSVD
D25	-	PCI_AD7	RSVD
D26	-	PCI_C/BE0#	DDI1_PAIR0+
D27	-	PCI_AD9	DDI1_PAIR0-
D28	-	PCI_AD11	RSVD
D29	-	PCI_AD13	DDI1_PAIR1+
D30	-	PCI_AD15	DDI1_PAIR1-
D31	-	GND(FIXED)	GND(FIXED)
D32	-	PCI_PAR	DDI1_PAIR2+
D33	-	PCI_SERR#	DDI1_PAIR2-
D34	-	PCI_STOP#	DDI1_DDC_AUX_SEL
D35	-	PCI_TRDY#	RSVD

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
D36	-	PCI_FRAME#	DDI1_PAIR3+
D37	-	PCI_AD16	DDI1_PAIR3-
D38	-	PCI_AD18	RSVD
D39	-	PCI_AD20	DDI2_PAIR0+
D40	-	PCI_AD22	DDI2_PAIR0-
D41	-	GND(FIXED)	GND(FIXED)
D42	-	PCI_AD24	DDI2_PAIR1+
D43	-	PCI_AD26	DDI2_PAIR1-
D44	-	PCI_AD28	DDI2_HPD
D45	-	PCI_AD30	RSVD
D46	-	PCI_IRQC#	DDI2_PAIR2+
D47	-	PCI_IRQD#	DDI2_PAIR2-
D48	-	PCI_CLKRUN#	RSVD
D49	-	PCI_M66EN	DDI2_PAIR3+
D50	-	PCI_CLK	DDI2_PAIR3-
D51	-	GND(FIXED)	GND(FIXED)
D52	-	PEG_TX0+	PEG_TX0+
D53	-	PEG_TX0-	PEG_TX0-
D54	-	PEG_LANE_RV#	PEG_LANE_RV#
D55	-	PEG_TX1+	PEG_TX1+
D56	-	PEG_TX1-	PEG_TX1-
D57	-	TYPE2#	TYPE2#
D58	-	PEG_TX2+	PEG_TX2+
D59	-	PEG_TX2-	PEG_TX2-
D60	-	GND(FIXED)	GND(FIXED)
D61	-	PEG_TX3+	PEG_TX3+
D62	-	PEG_TX3-	PEG_TX3-
D63	-	RSVD	RSVD
D64	-	RSVD	RSVD
D65	-	PEG_TX4+	PEG_TX4+
D66	-	PEG_TX4-	PEG_TX4-
D67	-	GND	GND
D68	-	PEG_TX5+	PEG_TX5+
D69	-	PEG_TX5-	PEG_TX5-
D70	-	GND(FIXED)	GND(FIXED)
D71	-	PEG_TX6+	PEG_TX6+
D72	-	PEG_TX6-	PEG_TX6-
D73	-	SDVO_CLK	GND
D74	-	PEG_TX7+	PEG_TX7+
D75	-	PEG_TX7-	PEG_TX7-
D76	-	GND	GND
D77	-	IDE_CBLID#	RSVD
D78	-	PEG_TX8+	PEG_TX8+
D79	-	PEG_TX8-	PEG_TX8-
D80	-	GND(FIXED)	GND(FIXED)
D81	-	PEG_TX9+	PEG_TX9+

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Pin#	Type 10 Description	Type 2 Description	Type 6 Description
D82	-	PEG_TX9-	PEG_TX9-
D83	-	RSVD	RSVD
D84	-	GND	GND
D85	-	PEG_TX10+	PEG_TX10+
D86	-	PEG_TX10-	PEG_TX10-
D87	-	GND	GND
D88	-	PEG_TX11+	PEG_TX11+
D89	-	PEG_TX11-	PEG_TX11-
D90	-	GND(FIXED)	GND(FIXED)
D91	-	PEG_TX12+	PEG_TX12+
D92	-	PEG_TX12-	PEG_TX12-
D93	-	GND	GND
D94	-	PEG_TX13+	PEG_TX13+
D95	-	PEG_TX13-	PEG_TX13-
D96	-	GND	GND
D97	-	PEG_ENABLE#	RSVD
D98	-	PEG_TX14+	PEG_TX14+
D99	-	PEG_TX14-	PEG_TX14-
D100	-	GND(FIXED)	GND(FIXED)
D101	-	PEG_TX15+	PEG_TX15+
D102	-	PEG_TX15-	PEG_TX15-
D103	-	GND	GND
D104	-	VCC_12V	VCC_12V
D105	-	VCC_12V	VCC_12V
D106	-	VCC_12V	VCC_12V
D107	-	VCC_12V	VCC_12V
D108	-	VCC_12V	VCC_12V
D109	-	VCC_12V	VCC_12V
D110	-	GND(FIXED)	GND(FIXED)

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2.2. PCIe General Introduction

PCI Express provides a scalable, high-speed, serial I/O point-to-point bus connection. A PCI Express lane consists of dual simplex channels, each implemented as a low-voltage differentially driven transmit pair and receive pair. They are used for simultaneous transmission in each direction. The bandwidth of a PCI Express link can be scaled by adding signal pairs to form multiple lanes between two devices. The PCI Express specification defines x1, x2, x4, x8, x16, and x32 link widths.

PCIe is easy to work with, but design rules must be followed. The most important design rule is that the PCIe lanes must be routed as differential pairs. PCIe design rules are covered in detail in Section 2.3.6 'PCI Express Routing Considerations' at page 47. Routing a PCIe link is often easier than routing a traditional 32 bit wide PCI bus, as there are fewer lines (2 data pairs and a clock pair for a PCIe x1 link as opposed to over 50 lines for parallel PCI). Routing a PCIe x16 graphics link is much easier than routing an AGP 8X link, as the constraints required for the PCIe implementation are much easier than those for AGP.

Three generations of PCI Express interfaces are available and offer different maximum transfer rates. Each generation has slightly different routing considerations, the higher the speed the tougher the constraints. During link training the PCI Express root complex checks which generation can be accomplished and configures the link to the highest possible speed.

Table 5: PCI Express Generations

Generation	PCIe 1.0/1.1	PCIe 2.0/2.1	PCIe 3.0
Symbol Rate	2.5 G Symbols/s	5.0 G Symbols/s	8.0 G Symbols/s
Line Encoding	8b10b	8b10b	128b130b
Embedded Clock	1.25 GHz	2.5 GHz	4.00 GHz
x1	250 MB/s	500 MB/s	985 MB/s
x2	500 MB/s	1000 MB/s	1969 MB/s
x4	1000 MB/s	2000 MB/s	3938 MB/s
x8	2000 MB/s	4000 MB/s	7877 MB/s
x16	4000 MB/s	8000 MB/s	15754 MB/s

The source specifications for PCI Express include the ***PCI Express Base Specification,*** the ***PCI Express Card Electromechanical Specification*** and the ***PCI Express Mini Card Electromechanical Specification.***

2.2.1. COM Express A-B Connector and C-D Connector PCIe Groups

COM Express Type 6 Modules have two groups of PCIe lanes. There is a group of up to eight lanes; six are located on COM Express A-B connector and two on C-D connector that are intended for general purpose use, such as interfacing the COM Express Module to Carrier Board PCIe peripherals. A second group of PCIe lanes is defined on the COM Express C-D connector. This group is intended primarily for the PCIe Graphics interfaces (also referred to as the PEG interface), and is typically 16 PCIe lanes wide. For some Modules, the PEG lanes may be used for general purpose PCIe lanes if the external graphics interface is not in use. This usage is Module and Module chipset dependent.

COM Express Type 2 Modules also have two groups of PCIe lanes. There is a group of up to six lanes on the COM Express A-B connector that are intended for general purpose use. A second group of PCIe lanes is defined on the COM Express C-D connector. This group is intended primarily for the PCIe Graphics interface and may be used for general purpose PCIe lanes if the external graphics interface is not in use. This usage is Module and Module chipset dependent.

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2.3. General Purpose PCIe Lanes

2.3.1. General Purpose PCIe Signal Definitions

The general purpose PCI Express interface of the COM Express Type 6 Module on the COM Express A-B connector consists of up to 6 lanes plus 2 lanes on connector C-D, each with a receive and transmit differential signal pair designated from PCIE_RX0 (+ and -) to PCIE_RX7 (+ and -) and correspondingly from PCIE_TX0 (+ and -) to PCIE_TX7 (+ and -). The 8 lanes may be grouped into various link widths as defined in the COM Express spec and summarized in Sections 2.3.3 and 2.3.2 below. The signals used are summarized in Table 6 below.

Table 6: General Purpose PCI Express Signal Descriptions

Signal	Pin#	Description	I/O	Comment
PCIE_RX0+ PCIE_RX0-	B68 B69	PCIe channel 0. Receive Input differential pair.	I PCIE	
PCIE_TX0+ PCIE_TX0-	A68 A69	PCIe channel 0. Transmit Output differential pair.	O PCIE	
PCIE_RX1+ PCIE_RX1-	B64 B65	PCIe channel 1. Receive Input differential pair.	I PCIE	
PCIE_TX1+ PCIE_TX1-	A64 A65	PCIe channel 1. Transmit Output differential pair.	O PCIE	
PCIE_RX2+ PCIE_RX2-	B61 B62	PCIe channel 2. Receive Input differential pair.	I PCIE	
PCIE_TX2+ PCIE_TX2-	A61 A62	PCIe channel 2. Transmit Output differential pair.	O PCIE	
PCIE_RX3+ PCIE_RX3-	B58 B59	PCIe channel 3. Receive Input differential pair.	I PCIE	
PCIE_TX3+ PCIE_TX3-	A58 A59	PCIe channel 3. Transmit Output differential pair.	O PCIE	
PCIE_RX4+ PCIE_RX4-	B55 B56	PCIe channel 4. Receive Input differential pair.	I PCIE	
PCIE_TX4+ PCIE_TX4-	A55 A56	PCIe channel 4. Transmit Output differential pair.	O PCIE	
PCIE_RX5+ PCIE_RX5-	B52 B53	PCIe channel 5. Receive Input differential pair.	I PCIE	
PCIE_TX5+ PCIE_TX5-	A52 A53	PCIe channel 5. Transmit Output differential pair.	O PCIE	
PCIE_RX6+ PCIE_RX6-	C19 C20	PCIe channel 6. Receive Input differential pair.	I PCIE	Type 6 only
PCIE_TX6+ PCIE_TX6-	D19 D20	PCIe channel 6. Transmit Output differential pair.	O PCIE	Type 6 only
PCIE_RX7+ PCIE_RX7-	C22 C23	PCIe channel 7. Receive Input differential pair.	I PCIE	Type 6 only
PCIE_TX7+ PCIE_TX7-	D22 D23	PCIe channel 7. Transmit Output differential pair.	O PCIE	Type 6 only
PCIE_CLK_REF+ PCIE_CLK_REF-	A88 A89	PCIe Reference Clock for all COM Express PCIe lanes, and for PEG lanes.	O PCIE	COM Express only allocates a single ref clock
EXCD0_CPPE#	A49	PCI ExpressCard0: PCI Express capable card request, active low, one per card	I CMOS	
EXCD0_PERST#	A48	PCI ExpressCard0: reset, active low, one per card	O CMOS	
EXCD1_CPPE#	B48	PCI ExpressCard1: PCI Express capable card request, active low, one per card	I CMOS	
EXCD1_PERST#	B47	PCI ExpressCard1: reset, active low, one per card	O CMOS	
CB_RESET#	B50	Reset output from Module to Carrier Board. Active low. Issued by Module chipset and may result from a low	O CMOS	

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Signal	Pin#	Description	I/O	Comment
		SYS_RESET# input, a low PWR_OK input, a VCC_12V power input that falls below the minimum specification, a watchdog timeout, or may be initiated by the Module software.		
WAKE0#	B66	PCI Express wake up signal	I CMOS	

2.3.2. PCI Express Lane Configurations – Per COM Express Spec

According to the COM Express specification, the general purpose PCIe lanes on the A-B connector can be configured as up to eight PCI Express x1 links or may be combined into various combinations of x8, x4, x2 and x1 links that add up to a total of 8 lanes. These configuration possibilities are based on the COM Express Module's chip-set capabilities.

The COM Express specification defines a "fill order" from mapping PCIe links that are wider than x1 onto the COM Express pins. For example, the spec requires that a x4 PCI Express link be mapped to COM Express PCI Express lanes 0,1,2 and 3. Refer to the COM Express specification for details.

Note: All PCI Express devices are required to work in x1 mode as well as at their full capability. A x4 PCIe card for example is required by the PCI Express specification to be usable in x4 and / or x1 mode. The "in-between" modes (x2 in this case) are optional.

2.3.3. PCI Express Lane Configurations – Module and Chipset Dependencies

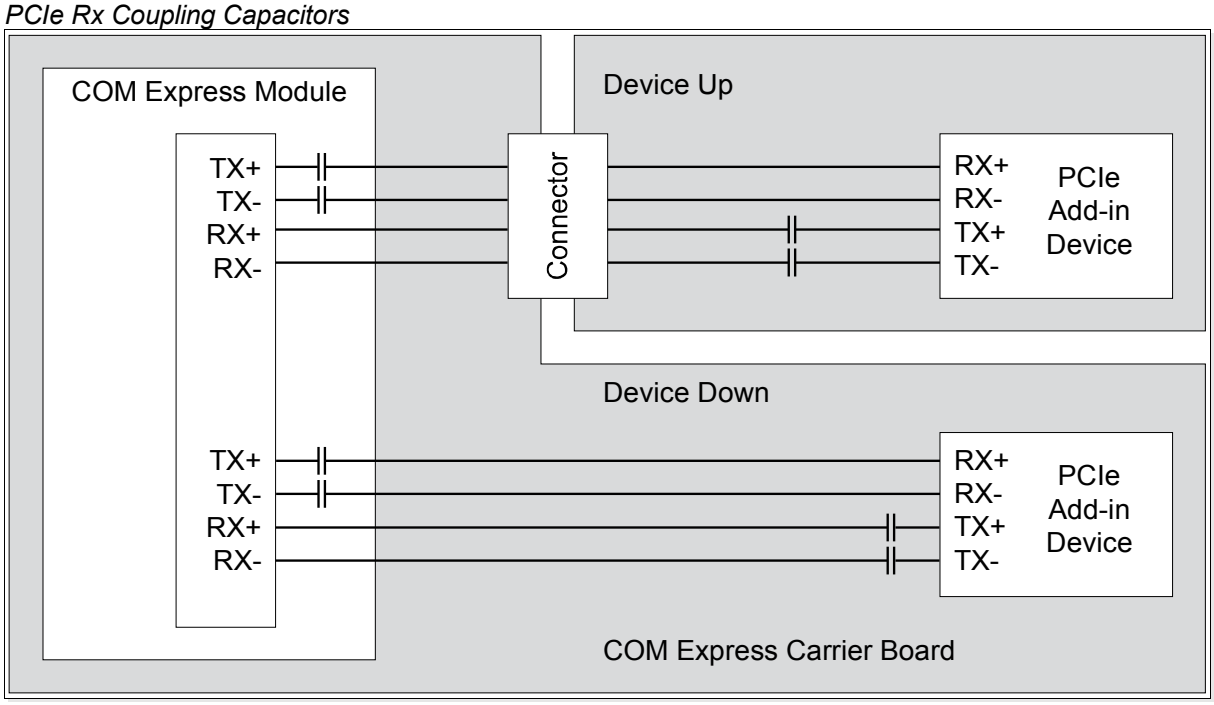
The lane configuration possibilities of the PCI Express interface of a COM Express Module are dependent on the Module's chip-set. Some Module and chip-set implementations may allow software or setup screen configuration of link width (x1, x2, x4, x8). Others may require a hardware strap or build option on the Module to configure the x4 or x8 option. The COM Express specification does not allocate any Module pins for strapping PCIe lane width options.

Refer to the vendor specific Module documentation for the Module that you are using for additional information about this subject.

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2.3.4. Device Up / Device Down and PCIe Rx / Tx Coupling Capacitors

Figure 5: PCIe Rx Coupling Capacitors



"Device Down" refers to a PCIe target device implemented down on the Carrier Board. "Device Up" refers to a PCIe target device implemented on a slot card (or mini-PCIe card, ExpressCard, AMC card). There are several distinctions between a PCIe "Device Down" and "Device Up" implementation:

Device Down:

- Coupling caps for the target device PCIe TX lines (COM Ex Module PCIe RX lines) are down on the Carrier Board, close to the target device TX pins;
- Trace length allowed for PCIe signals on the Carrier Board is longer for the Device Down case than for Device Up. See Section 6.5.1. 'PCI Express Trace Routing Guidelines' on page 182 for trace length details.

Device Up:

- Coupling caps for the target device PCIe TX lines (COM Ex Module PCIe RX lines) are up on the slot card.
- Trace length allowed for PCIe signals on the Carrier Board is shorter than for the Device Down case, to allow for slot card trace length. See Section 6.5.1 'PCI Express Trace Routing Guidelines' on page 182 for trace length details.

The coupling caps for the Module PCIe TX lines are defined by the COM Express specification to be on the Module.

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2.3.5. Schematic Examples

2.3.5.1. Reference Clock Buffer

The COM Express Specification calls for one copy of the PCIe reference clock pair to be brought out of the Module. This clock is a 100MHz differential pair and is sometimes known as a “hint” clock. The clock allows the PLL in the target PCIe device to lock faster onto the embedded clock in the PCIe bit stream.

If the Carrier Board implements only one PCIe device or slot, then the PCIe reference clock pair from the Module may be routed directly to that device or slot. However, if there are two or more PCIe devices or slots on the Carrier Board, then the Module PCIe reference clock should be buffered. A device which meets the jitter requirements for the intended PCI Express generation must be used.

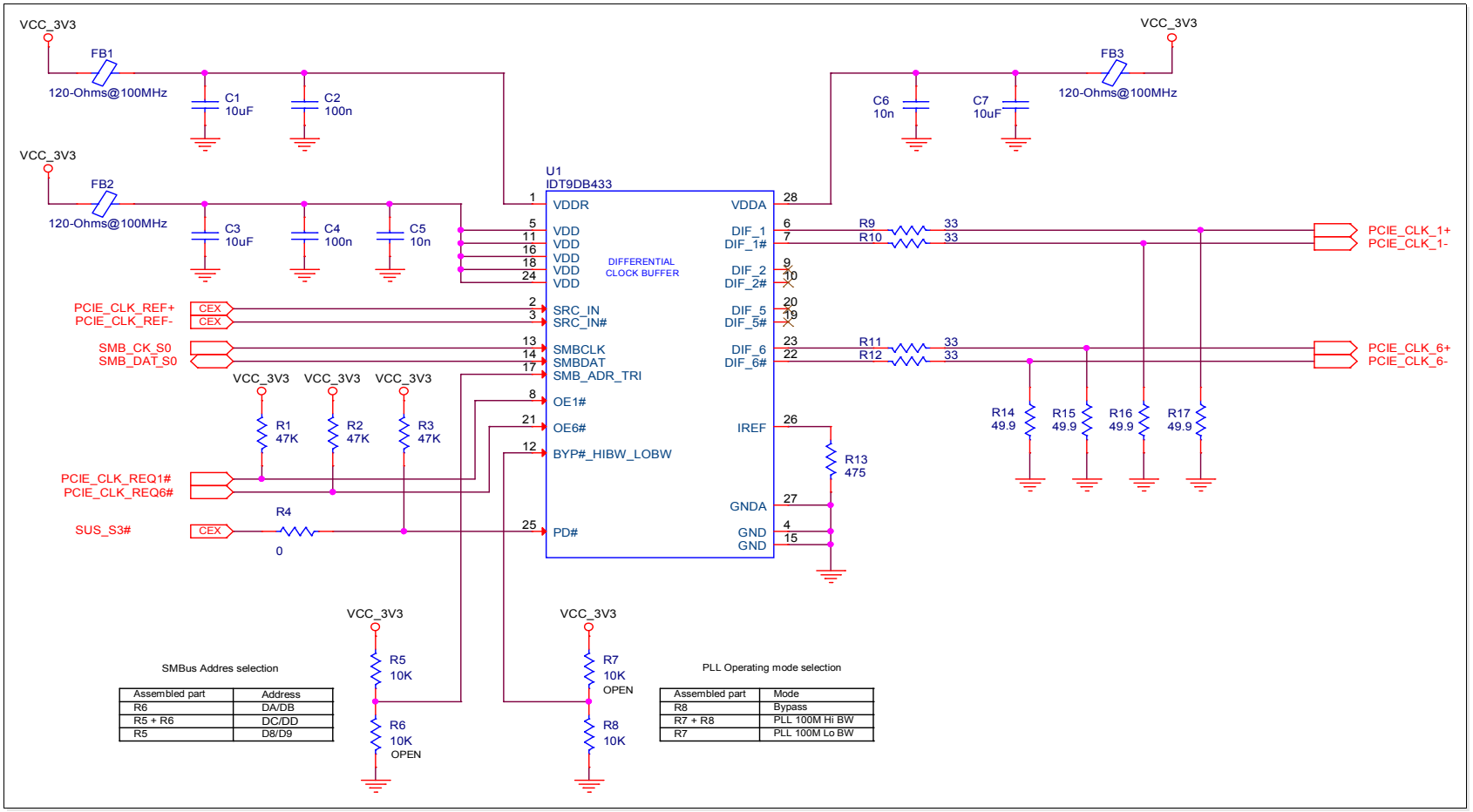
The IDT9DB233, IDT9DB433, IDT9DB844 have two, four and eight differential output replicas of the input clock, respectively. Each target device (PCIe “device down” chip, slot, Express Card slot, PEG slot) should get an individual copy of the reference clock. Similar parts may be available from other vendors.

The PCIe Clock buffers have both PLL and bypass modes. In some situations it is preferable to operate the clock buffer in bypass mode.

The reference clock pairs should be routed as directly as possible from source to destination.

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Figure 6: PCIe Reference Clock Buffer



The following notes apply to Figure 6 'PCIe Reference Clock Buffer'.

Nets that tie directly to the COM Express connector are indicated with the CEX flag in the off-page connection symbol.

Each clock pair is routed point to point to each connector or end device using differential signal routing rules.

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Each clock output pair in the example shown is terminated close to the IDT9DB433 buffer pins with a series resistor (shown as 33 Ω) and a termination to GND (shown as 49.9 Ω), per the vendor's recommendations. Other vendors may have different recommendations, particularly in regard to the source termination to GND.

SMBUS software can enable or disable clock-buffer outputs. Configuration resistors or alternativly the SMBUS also allow software to put the clock buffer into "Bypass Mode", which experience has shown is needed in some Carrier situations. Please refer to chapter 2.19 'System Management Bus (SMBus)' on page 123 below for more information on SMBUS. Disable unused outputs to reduce emissions.

The CLKREQ0# and CLKREQ1# should be pulled low to enable the corresponding clock buffer outputs. For applications in which power management is not a concern, these inputs may be tied low to permanently enable the outputs.

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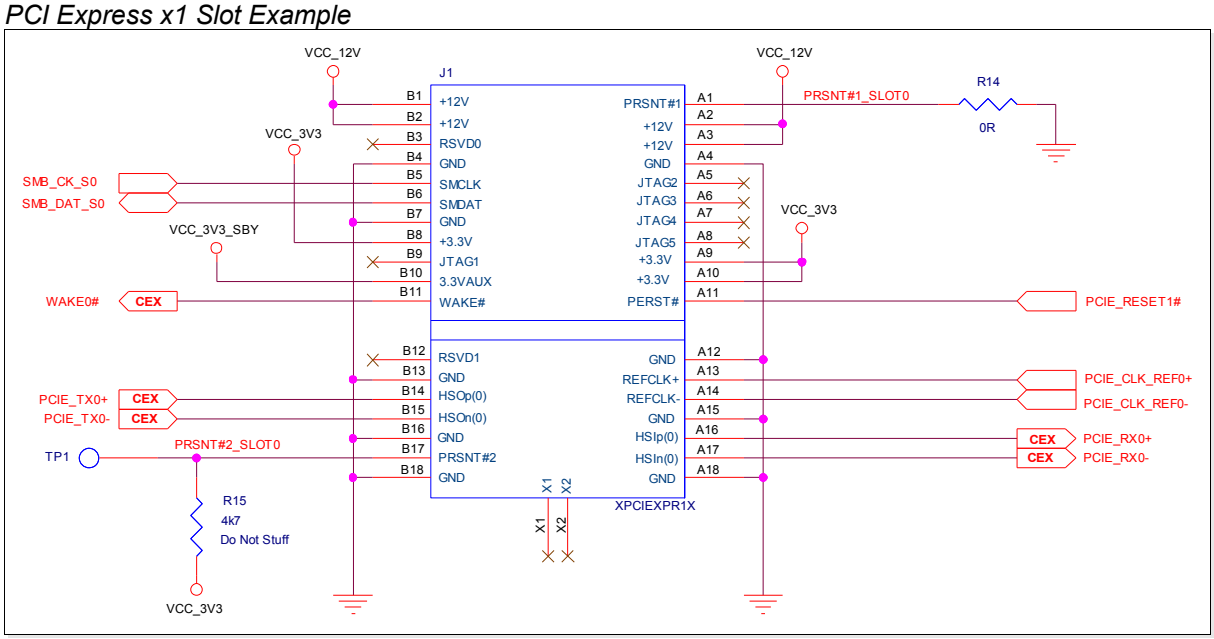
2.3.5.2. Reset

The PCI Interface of the COM Express Type 2 Module shares the reset signal 'PCI_RESET#' with the PCI Express interface. PCI_RESET# is not available on all COM Express Module Types. When design a carrier to support Module Types supporting PCI_RESET#, it is recommended to use PCI_RESET# to generate PCIE_RESETn#. If the carrier supports COM Express Module Types without PCI_RESET#, then it is recommended to use the COM Express signal CB_RESET# as this signal is available on all COM Express pin-out types. The signal PCIE_RESETn# in the schematics below is a buffered copy of either the PCI_RESET# or the CB_RESET# signal. It is not the same signal as PCI_RESET#.

2.3.5.3. x1 Slot Example

An example of a x1 PCIe slot is shown in Figure 7 below. The source specification for slot implementations is the PCI-SIG ***PCI Express Card Electromechanical Specification.***

Figure 7: PCI Express x1 Slot Example



The example above shows COM Express PCIe lane 0 connected to the slot. Other lanes may be used, depending on what is available on the particular Module being used.

No coupling caps are required on the PCIe data or clock lines. The PCIe TX series coupling caps on the data lines are on the COM Express Module. The PCIe RX coupling caps are up on the slot card.

Slot signals REFCLK+ and REFCLK- (pins A13 and A14) are driven by the Clock Buffer, which is shown in Figure 6 'PCIe Reference Clock Buffer' on page 35. If there is only one PCIe target on the Carrier Board, the Clock Buffer may be omitted and the slot REFCLK signals may be driven directly by the COM Express Module.

The slot PERST# signal (pin A11) is driven by a buffered copy of the COM Express PCI_RESET# signal. A buffered copy of CB_RESET# could also be used. If the Carrier Board only has one or two target devices, an unbuffered PCI_RESET# or CB_RESET# could be used.

The slot signals PRSNT1# and PRSNT2# are part of a mechanism defined in the ***PCI Express Card Electromechanical Specification*** to allow hot-plugged PCIe cards. However, most systems do not implement the support circuits needed to complete hot-plug capability. If used, the scheme works as follows: in Figure 7 above, PRSNT1# (pin A1) is pulled low on the Carrier Board through R14. On the slot card, PRSNT1# is routed to PRSNT2# (pin B17). The state of slot pin B17 may be read back by the BIOS or system software, if routed to an input port pin that can be read by software. If a slot card is present, this pin reads back low; if the slot is empty, the

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pin will be read high. Software then uses this information to apply power to the card. There is no standard input port pin defined by COM Express for this function. For systems that are not trying to implement hot-swap capability, it is not necessary to be able to read back the state of the PRSNT2# pin. Hence it is shown in the figure above as being brought to a test point.

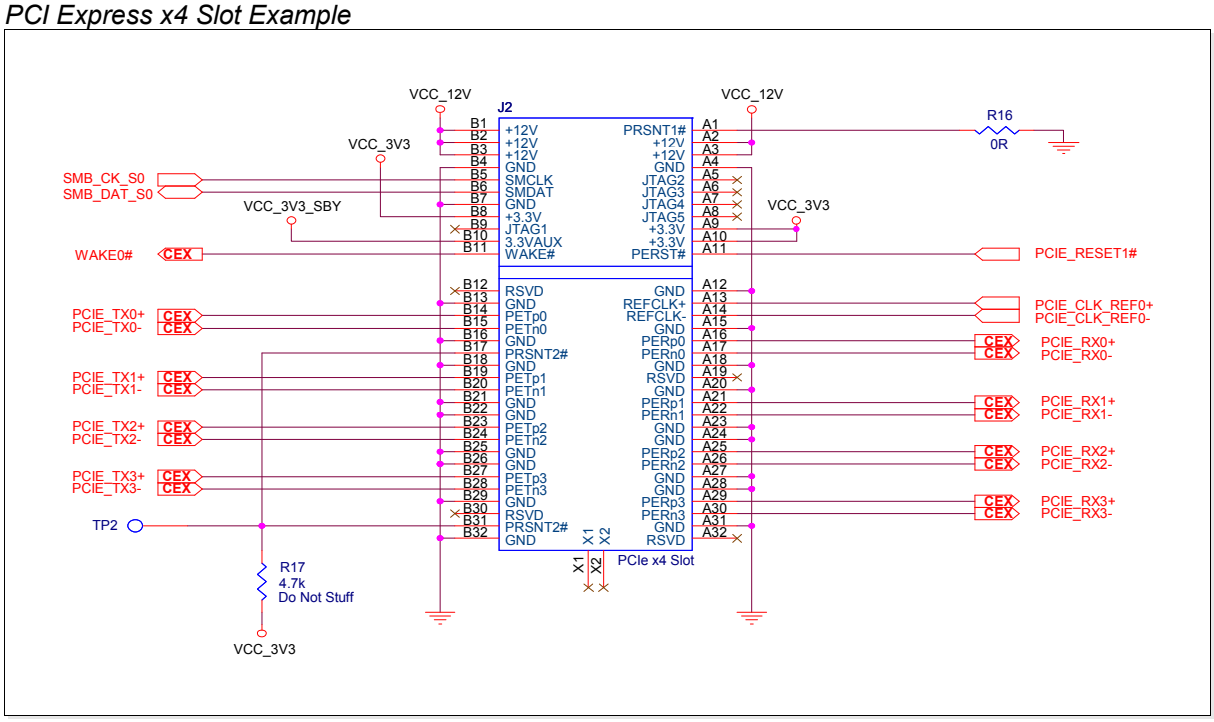
Nets SMB_CK_S0 and SMB_DAT_S0 are sourced from COM Express Module pins B13 and B14 respectively. _S0 version of SMBUS needs to be FET isolated from Module version which is on the _S5 power rail. The SMBUS supports card-management support functions. SMBUS software can save the state of the slot-card device before a Suspend event, report errors, accept control parameters, return status information and card information such as a serial number. Support for the SMBUS is optional on the slot card. Please refer to chapter 2.19 'System Management Bus (SMBus)' on page 123 below for more information on SMBUS.

WAKE0# is asserted by the slot card to cause COM Express Module wake-up at Module pin B66. This is an open-drain signal. It is an input to the Module and is pulled up on the Module. Other WAKE0# sources may pull this line low; it is a shared line.

Slot JTAG pins on A5-A8 are not used.

2.3.5.4. x4 Slot Example

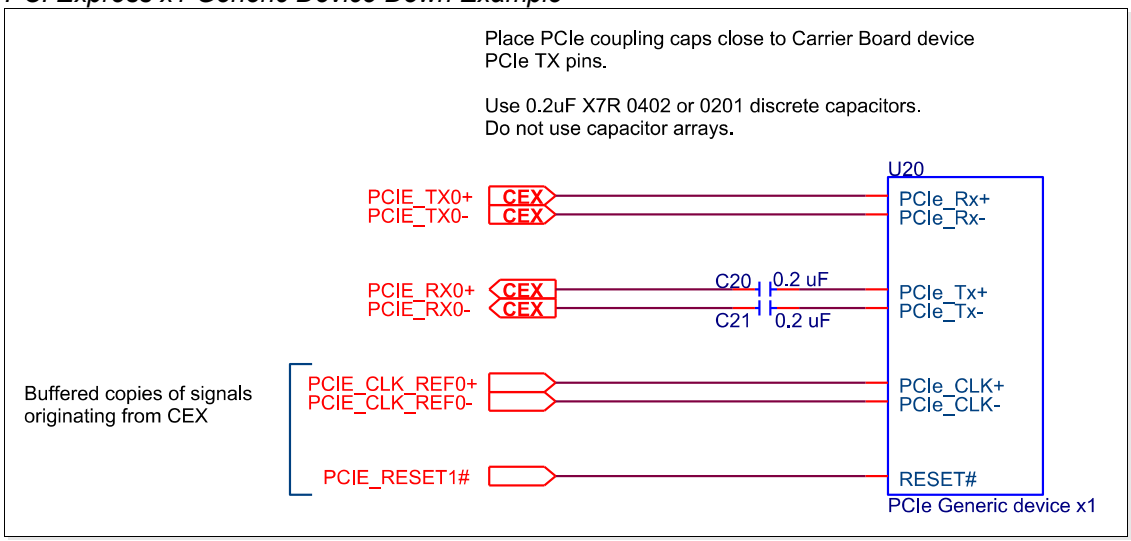
Figure 8: PCI Express x4 Slot Example



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2.3.5.5. PCIe x1 Generic Device Down Example

Figure 9: PCI Express x1 Generic Device Down Example



A generic example of a PCIe x1 device on a COM Express Carrier Board is shown in the figure above. Only the signals that interface to the COM Express Module in the full power-on state (S0) are shown here.

If the Carrier Board device is to support power management features, then some additional signals may come into play. To support wake-up from Suspend states, the Carrier Board device may assert the COM Express WAKE0# input by driving it low through an open drain device.

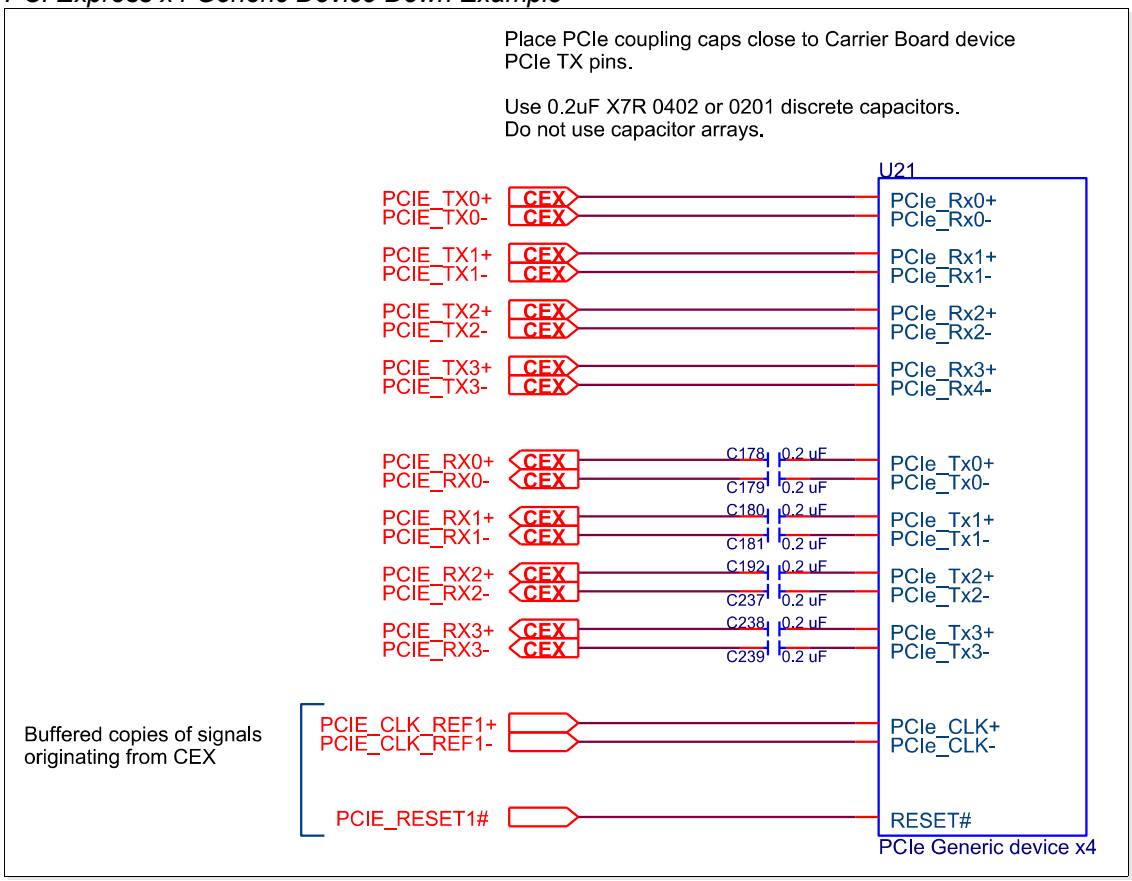
Some power managed Carrier Board PCIe devices may also have a CLKREQ# signal to disable the PCIe reference clock during periods of inactivity. There is no COM Express destination for this line. It may be used with certain clock buffers – see Figure 6 'PCIe Reference Clock Buffer' on page 35.

Carrier Board PCIe devices may also require SMBUS support. If the Carrier Board device has a Suspend power rail and if its SMBUS pins use that rail, then the device's SMBUS pins may be routed directly to the corresponding COM Express SMBUS pins (SMB_CK, SMB_DAT and SMB_ALERT#). If the Carrier Board SMBUS pins are not powered by the Suspend rail, they must be isolated from the COM Express SMBUS lines by isolation FETs or bus switches. Refer to Section 2.19 'System Management Bus (SMBus)' on page 123 for details.

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2.3.5.6. PCIe x4 Generic Device Down Example

Figure 10: PCI Express x4 Generic Device Down Example



A generic example of a PCIe x4 device on a COM Express Carrier Board is shown in the figure above. Only the signals that interface to the COM Express Module in the full power-on state (S0) are shown here.

If the Carrier Board device is to support power management features, then some additional signals may come into play. To support wake-up from Suspend states, the Carrier Board device may assert the COM Express WAKE0# input by driving it low through an open drain device.

Some power managed Carrier Board PCIe devices may also have a CLKREQ# signal to disable the PCIe reference clock during periods of inactivity. There is no COM Express destination for this line. It may be used with certain clock buffers – see Figure 6 'PCIe Reference Clock Buffer' on page 35 above.

Carrier Board PCIe devices may also require SMBUS support. If the Carrier Board device has a Suspend power rail and if its SMBUS pins use that rail, then the device's SMBUS pins may be routed directly to the corresponding COM Express SMBUS pins (SMB_CK, SMB_DAT and SMB_ALERT#). If the Carrier Board SMBUS pins are not powered by the Suspend rail, they must be isolated from the COM Express SMBUS lines by isolation FETs or bus switches. Refer to Section 2.19 'System Management Bus (SMBus)' on page 123 for details.

2.3.5.7. PCI Express Mini Card

The PCI Express Mini Card is a small form factor add-in card optimized for mobile computing and embedded platforms. It is not hot-swappable (for hot swap capability, use an ExpressCard interface, described in Section 2.3.5.8. 'ExpressCard' on page 44 below).

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PCI Express Mini Cards are popular for implementing features such as wireless LAN. A small footprint connector can be implemented on the Carrier Board providing the ability to insert different removable PCI Express Mini Cards. Using this approach gives the flexibility to mount an upgradeable, standardized PCI Express Mini Card device to the Carrier Board without additional expenditure of a redesign.

A PCI Express Mini Card interface includes a single x1 PCIe link and a single USB 2.0 channel. The mini PCI Express Card host should offer both interfaces. The PCI Express Mini Card installed into the socket may use either interface.

The source specification for mini-PCI Express Cards is the ***PCI Express Mini Card Electromechanical Specification.***

Two different card sizes of PCI Express Mini Card are allowed: a full sized card with 30.00 mm x 50.95 mm and a half sized card with 30.00 mm x 26.80 mm.

Figure 11: PCI Express Mini Full Sized Card Footprint

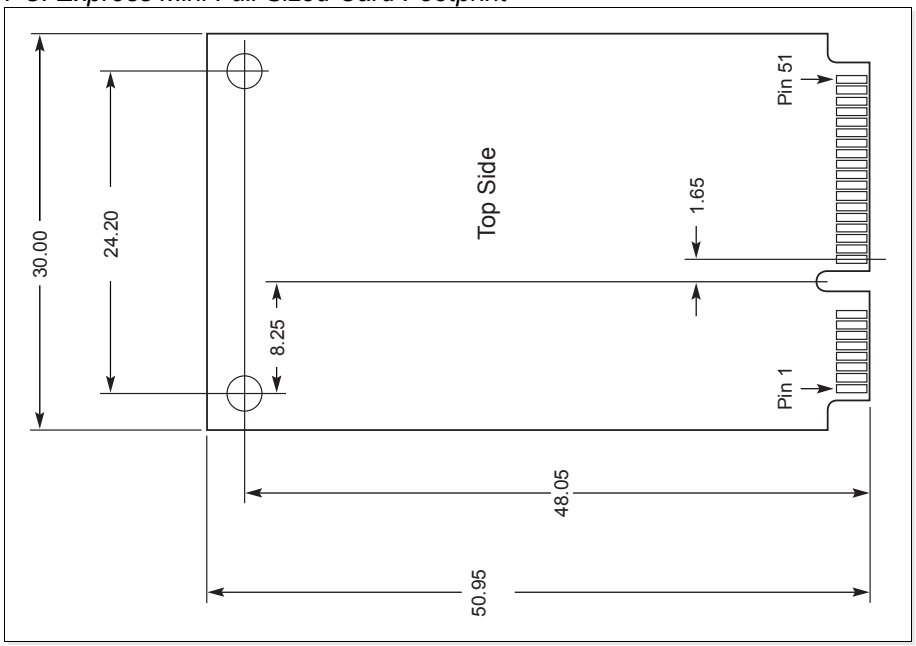
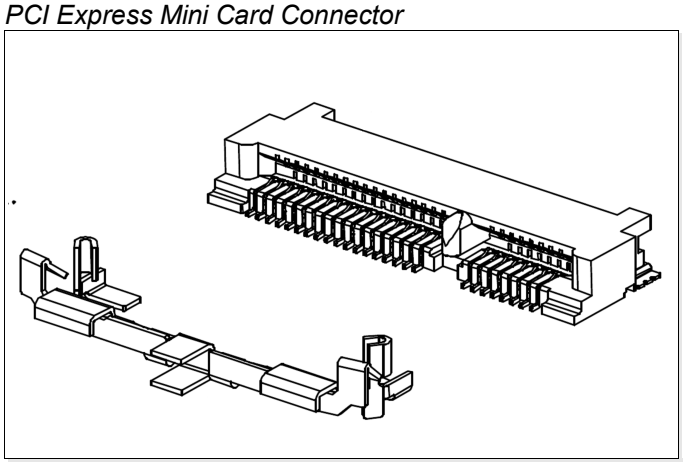


Figure 12: PCI Express Mini Card Connector

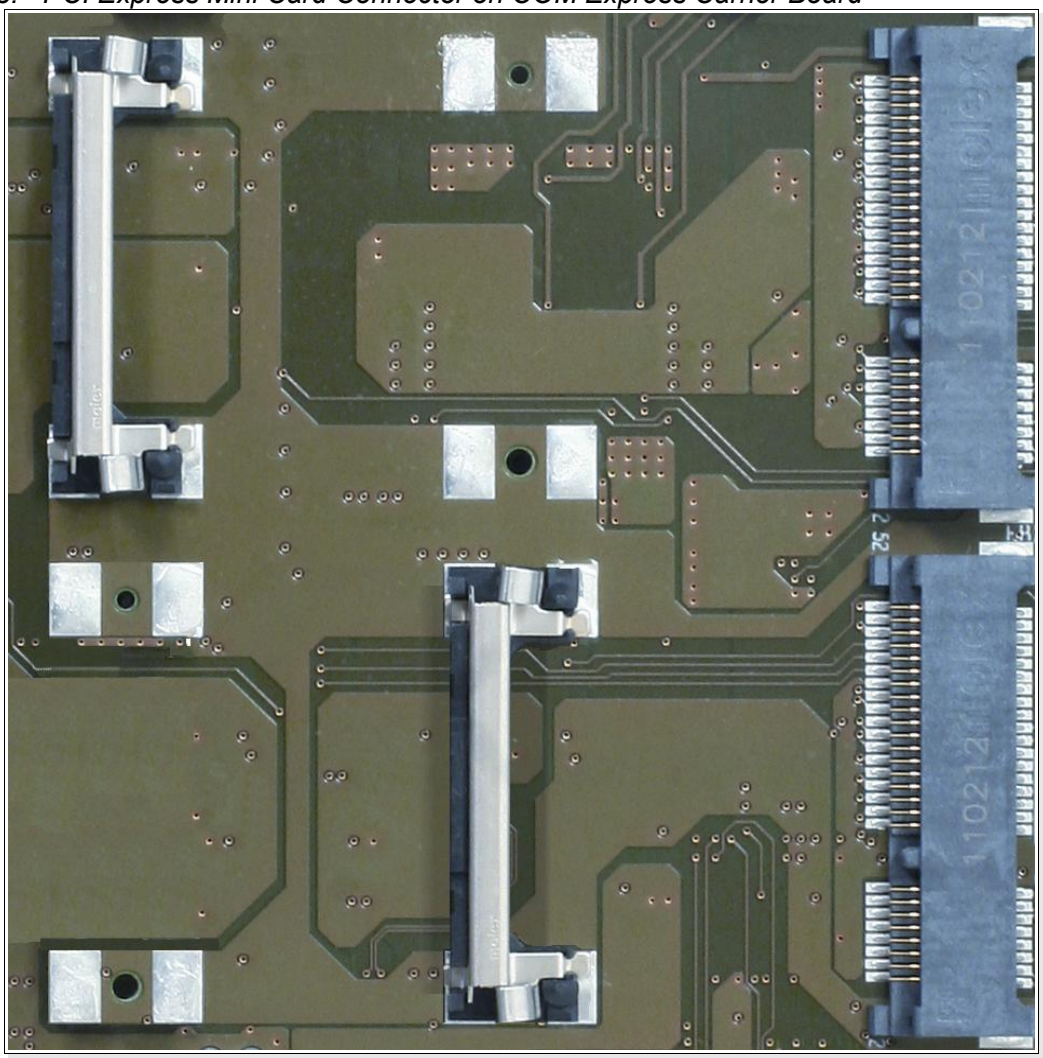


A typical PCI Express Mini-Card socket is shown in Figure 12 above.

The pins used on a PCI Express Mini-Card socket are listed in Table 7: PCIe Mini Card Connector Pin-out below.

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Figure 13: PCI Express Mini Card Connector on COM Express Carrier Board



The different card sized can be easily handled on the Carrier Board by having the latches optionally placed on the full size position or on the half size position as shown in Figure 13 above.

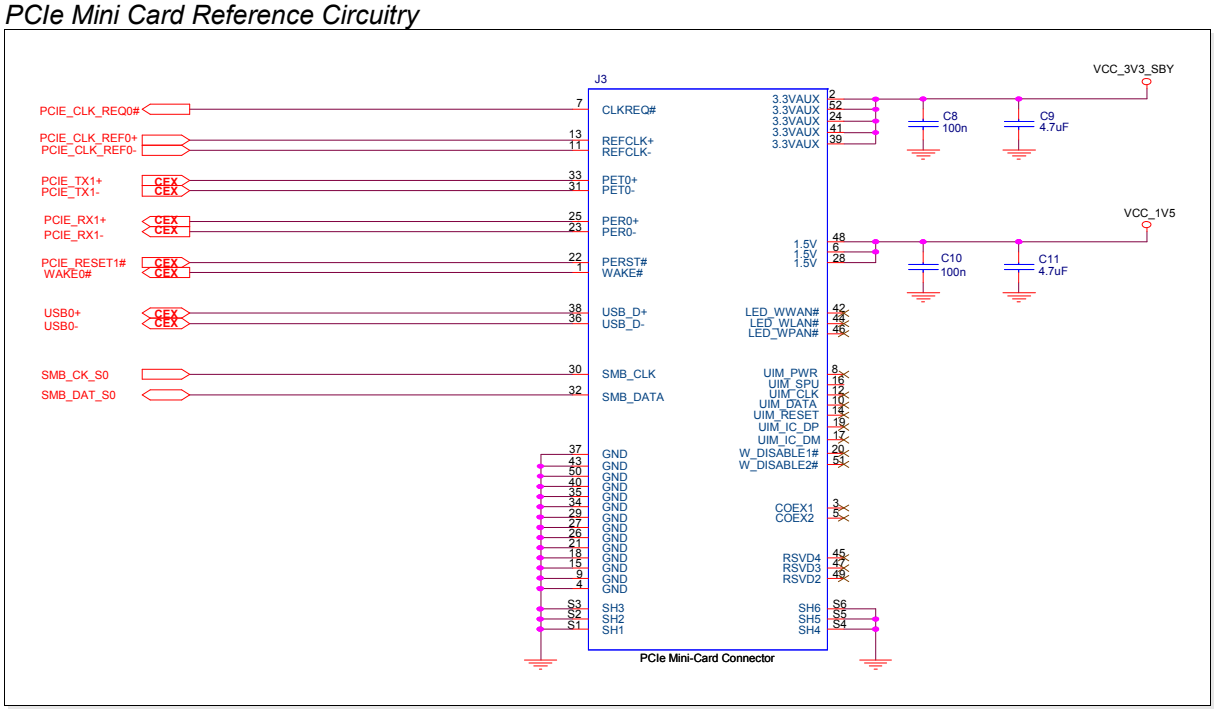
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Table 7: PCIe Mini Card Connector Pin-out

Pin	Signal	Description	Pin	Signal	Description
1	WAKE#	Requests the host interface to return to full operation and respond to PCIe.	2	+3.3VAux	Auxiliary voltage source, 3.3V.
3	COEX1	Coexistence Pin 1	4	GND	Ground
5	COEX2	Coexistence Pin 2	6	+1.5V	Secondary voltage source, 1.5V.
7	CLKREQ#	Reference clock request signal.	8	UIM_PWR	Power source for User Identity Modules (UIM).
9	GND	Ground	10	UIM_DATA	Data signal for UIM.
11	REFCLK-	Reference Clock differential pair negative signal.	12	UIM_CLK	Clock signal for UIM.
13	REFCLK+	Reference Clock differential pair positive signal.	14	UIM_RESET	Reset signal for UIM.
15	GND	Ground	16	UIM_SPU	Standard or Proprietary Use signal for UIM.
Mechanical Key					
17	UIM_IC_DM	Inter-Chip USB D- Data line	18	GND	Ground
19	UIM_IC_DP	Inter-Chip USB D+ Data line	20	W_DISABLE1#	Wireless Disable Signal 1
21	GND	Ground	22	PERST#	PCI Express Reset
23	PERn0	Receiver differential pair negative signal, Lane 0.	24	+3.3Vaux	Auxiliary voltage source, 3.3V.
25	PERp0	Receiver differential pair positive signal, Lane 0.	26	GND	Ground
27	GND	Ground	28	+1.5V	Secondary voltage source, 1.5V.
29	GND	Ground	30	SMB_CLK	System Management Bus Clock.
31	PETn0	Transmitter differential pair negative signal, Lane 0.	32	SMB_DATA	System Management Bus Data.
33	PETp0	Transmitter differential pair positive Signal, Lane 0.	34	GND	Ground
35	GND	Ground	36	USB_D-	USB Serial Data Interface differential pair, negative signal.
37	GND	Ground	38	USB_D+	USB Serial Data Interface differential pair, positive signal.
39	+3.3Vaux	Auxiliary voltage source, 3.3V.	40	GND	Ground
41	+3.3Vaux	Auxiliary voltage source, 3.3V.	42	LED_WWAN#	LED status indicator signals provided by the system.
43	GND	Ground	44	LED_WLAN#	LED status indicator signals provided by the system.
45	RSVD	Reserved	46	LED_WPAN#	LED status indicator signals provided by the system.
47	RSVD	Reserved	48	+1.5V	Secondary voltage source, 1.5V.
49	RSVD	Reserved	50	GND	Ground
51	W_DISABLE2#	Wireless Disable Signal 2	52	+3.3V	Primary voltage source, 3.3V.

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Figure 14: PCIe Mini Card Reference Circuitry



A PCI Express Mini Card schematic example is shown in Figure 14 above. The reference clock pair is sourced from the zero delay clock buffer shown earlier in Figure 6 'PCIe Reference Clock Buffer' on page 35 above. The clock pair is enabled when the PCI Express Mini-Card pulls its CLKREQ# pin low.

The example shows COM Express PCIe lane 1 and USB port 0 used, but other assignments may be made depending on Module capabilities and the system configuration.

If Suspend mode operation is not required, then the 3.3VAUX pin may be tied to VCC_3V3. The WAKE# pin should be left open in this case.

2.3.5.8. ExpressCard

ExpressCards are small form factor hot-swappable peripheral cards designed primarily for mobile computing. The card's electrical interface is through either a x1 PCIe link or a USB 2.0 link. Per the ExpressCard source specification, the host interface should support both the PCIe and USB links. The ExpressCard device may utilize one or the other or both interfaces.

There are several form factors defined, including: 34mm x 75mm; 54mm x 75mm; 34mm x 100mm, and 54mm x 100mm. All of the form factors use the same electrical and physical socket interface.

ExpressCards are the successor to Card Bus Cards (which are PCI-based). Card Bus cards, in turn, are the successors to PCMCIA cards. All three formats are defined by the PCMCIA Consortium.

The source specification document for ExpressCards is the ***ExpressCard Standard.***

COM Express includes four signals that are designated for the support of two ExpressCard slots:

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Table 8: Support Signals for ExpressCard

Signal	Pin	Description	I/O
EXCD0_CPPE#	A49	ExpressCard capable card request, slot 0.	I 3.3V CMOS
EXCD1_CPPE#	B48	ExpressCard capable card request, slot 1.	I 3.3V CMOS
EXCD0_PERST#	A48	ExpressCard reset, slot 0.	O 3.3V CMOS
EXCD1_PERST#	B47	ExpressCard reset, slot 1.	O 3.3V CMOS

Figure 15: ExpressCard Size

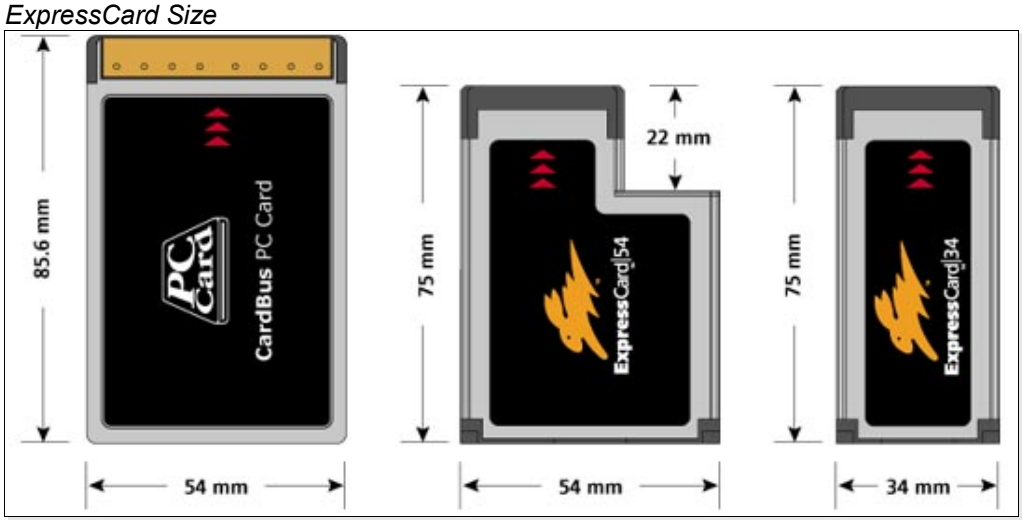
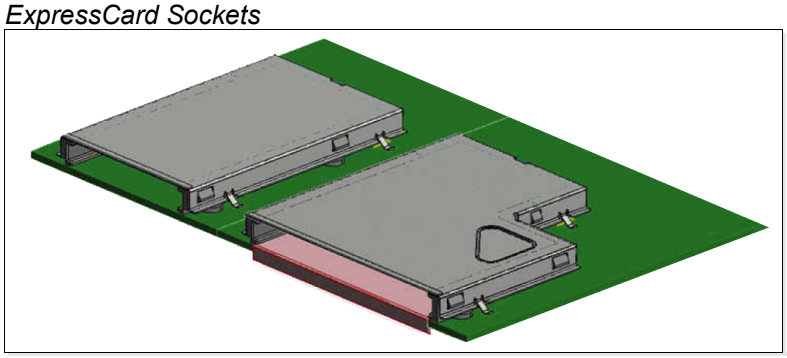


Figure 16: ExpressCard Sockets



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Figure 17: PCI Express: ExpressCard Example

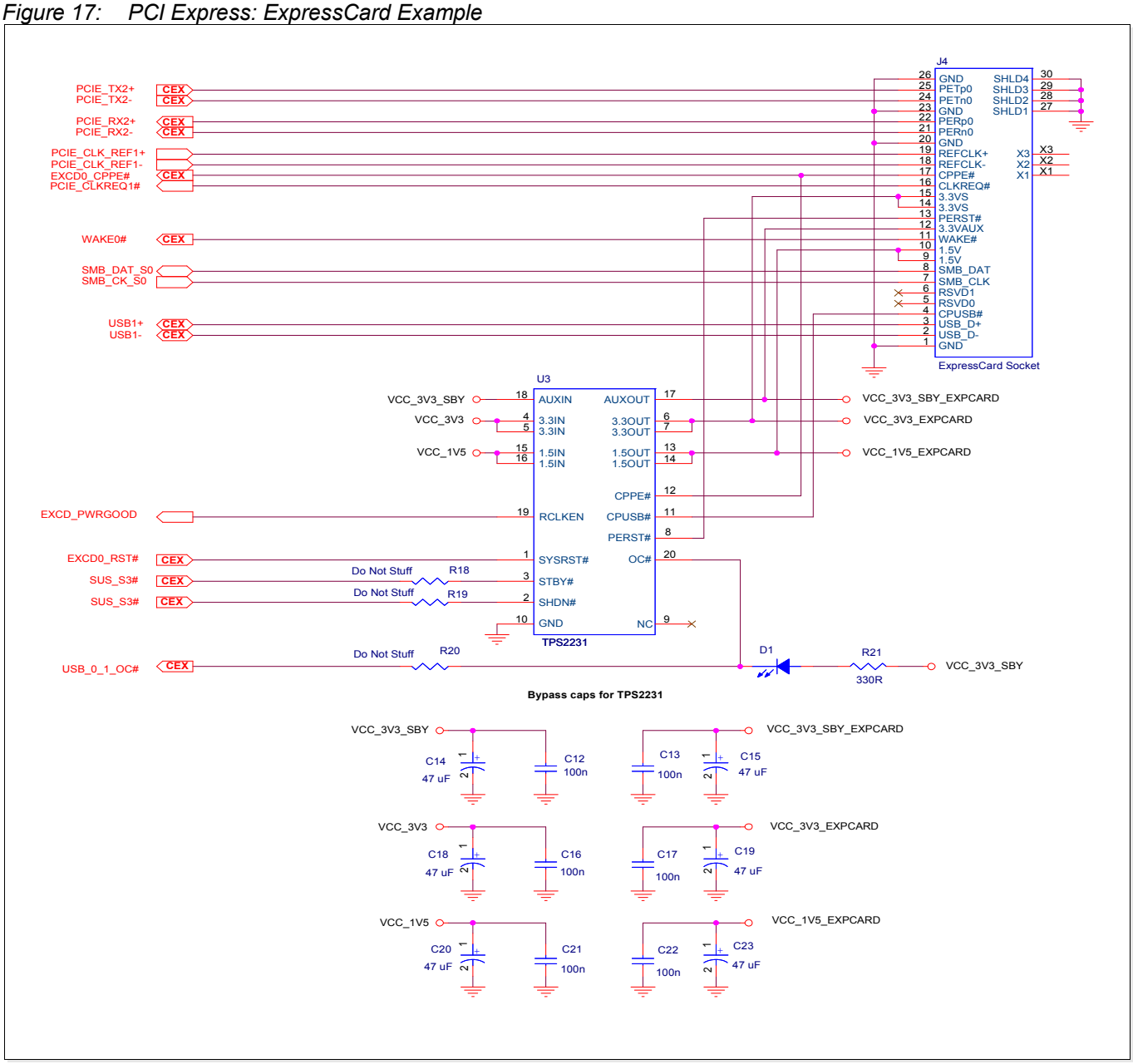


Figure 17 above shows an ExpressCard implementation. The example shows COM Express PCIe lane 2 and USB port 1 used, but other assignments may be made depending on Module capabilities and the system configuration.

Nets PCIE_TX2+ and PCIE_TX2- are sourced from the COM Express Module. These lines drive the PCIe receivers on the Express Card. No coupling capacitors are required on the Carrier Board. These lines are capacitively coupled on the COM Express Module.

Nets PCIE_RX2+ and PCIE_RX2- are driven by the Express Card. No coupling capacitors are required on the Carrier Board. These lines are capacitively coupled on the Express Card.

Nets PCIE_REF_CLK1+ and PCIE_REF_CLK1- are sourced from the PCIe Reference Clock Buffer (described earlier in Section 2.3.5.1. 'Reference Clock Buffer' on page 34 above).

CPPE# is pulled low on the Express Card to indicate that a card is present and has a PCIe interface. CPUSB# is pulled low on the Express Card to indicate the presences of an Express Card and a USB 2.0 interface. Either CPPE# or CPUSB# low causes the TPS2231 ExpressCard power control IC to provide power to the Express Card.

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The TPS2231 includes a number of integrated pull-up resistors. Other solutions may require external pull-ups not shown in this schematic example.

CLKREQ# is used for dynamic-clock management. When the signal is pulled low, the dynamic-clock management feature is not supported.

The ExpressCard PCIe reset signal, PERST#, is driven by the TPS2231. PERST# is asserted if the power rails are out of spec or if the COM Express ExpressCard reset, EXCD0_PERST#, is asserted.

WAKE# is asserted by the Express Card to cause the COM Express Module to wake-up at COM Express Module pin B66 WAKE0#. WAKE0# is pulled up on the Module to facilitate the “wire-ORed” interconnect from other WAKE0# sources.

SMB_CK and SMB_DAT are sourced from COM Express Module pins B13 and B14 respectively. The SMBUS supports client-alerting, wireless RF management, and sideband management. Support for the SMBUS is optional on the Carrier Board and the Express Card.

2.3.6. PCI Express Routing Considerations

New Carrier designs should route the PCIe lanes with 85Ω (+/- 15%) differential impedance. Previous designs that supported Gen1 and Gen2 signaling used 92Ω (+/- 10%) differential impedance. Gen1 only designs used 100Ω (+/- 20%) differential impedance. Newer designs should use 85Ω (+/- 15%) differential impedance to support Gen1, Gen2 and Gen3 signaling. Route the traces as differential pairs, preferably referenced to a continuous GND plane with a minimum of via transitions.

PCIe pairs need to be length-matched within a given pair (“intra-pair”), but the different pairs do not need to be closely matched (“inter-pair”).

PCB design rules for these signals are summarized in Section 6. 'Carrier Board PCB Layout Guidelines' on page 173.

2.3.6.1. Polarity Inversion

Per the ***PCI Express Card Electromechanical Specification***, all PCIe devices must support polarity inversion on each PCIe lane, independently of the other lanes. This means that, for example, you can route the Module PCIE_TX0+ signal to the corresponding ‘-’ pin on the slot or target device, and the PCIE_TX0- signal to the corresponding ‘+’ pin. If this makes the layout cleaner, with fewer layer transitions and better differential pairs, then take advantage of this PCIe feature.

2.3.6.2. Lane Reversal

PCIe lane reversal is not supported on the COM Express general purpose PCIe lanes. For x1 links, lane reversal is not relevant. It would potentially be useful for a x4 link, but is not supported in the COM Express specification. It is also not supported by the current crop of South Bridge chip-set components commonly used to create the general purpose PCIe lanes on COM Express Modules.

Lane reversal is supported for the COM Express x16 PEG interface. See Section 2.4. 'PEG (PCI Express Graphics)' on page 48 for details.

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2.4. PEG (PCI Express Graphics)

2.4.1. Signal Definitions

The PEG Port can utilize COM Express PCIe lanes 16-31 and is suitable to drive a link for an external high-performance PCI Express Graphics card, if implemented on the COM Express Module. Graphics Cards implemented as x16 use COM Express PCIe lanes 16-31; Graphics Cards implemented as x8 lanes should use COM Express PCIe lanes 16-23. Each lane of the PEG Port consists of a receive and transmit differential signal pair designated 'PEG_RX0' (+ and -) to 'PEG_RX15' (+ and -) and correspondingly from 'PEG_TX0' (+ and -) to 'PEG_TX15' (+ and -). The corresponding signals can be found on the Module connector rows C and D.

On Type 2 Modules the pins of the PEG Port might be shared with other functionality like SDVO or DVO, depending on the chipset used. SDVO and PEG are defined on COM Express specification for Type 2 Modules as “may be used”. Please be sure the functionality you require is supported by your Module vendor.

Table 9: PEG Signal Description

Signal	Pin#	Description	I/O	Comment	
PEG_RX0+ PEG_RX0-	C52 C53	PEG channel 0, Receive Input differential pair.	I PCIE	Type 2 Shared with:	 SDVO_TVCLKIN+ SDVO_TVCLKIN-
PEG_TX0+ PEG_TX0-	D52 D53	PEG channel 0, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOB_RED+ SDVOB_RED-
PEG_RX1+ PEG_RX1-	C55 C56	PEG channel 1, Receive Input differential pair.	I PCIE	Type 2 Shared with:	 SDVOB_INT+ SDVOB_INT-
PEG_TX1+ PEG_TX1-	D55 D56	PEG channel 1, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOB_GRN+ SDVOB_GRN-
PEG_RX2+ PEG_RX2-	C58 C59	PEG channel 2, Receive Input differential pair.	I PCIE	Type 2 Shared with:	 SDVO_FLDSTALL+ SDVO_FLDSTALL-
PEG_TX2+ PEG_TX2-	D58 D59	PEG channel 2, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOB_BLU+ SDVOB_BLU-
PEG_RX3+ PEG_RX3-	C61 C62	PEG channel 3, Receive Input differential pair.	I PCIE		
PEG_TX3+ PEG_TX3-	D61 D62	PEG channel 3, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOB_CK+ SDVOB_CK-
PEG_RX4+ PEG_RX4-	C65 C66	PEG channel 4, Receive Input differential pair.	I PCIE		
PEG_TX4+ PEG_TX4-	D65 D66	PEG channel 4, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOC_RED+ SDVOC_RED-
PEG_RX5+ PEG_RX5-	C68 C69	PEG channel 5, Receive Input differential pair.	I PCIE	Type 2 Shared with:	 SDVOC_INT+ SDVOC_INT-
PEG_TX5+ PEG_TX5-	D68 D69	PEG channel 5, Transmit Output differential pair.	O PCIE	Type 2 Shared with:	 SDVOC_GRN+ SDVOC_GRN-
PEG_RX6+ PEG_RX6-	C71 C72	PEG channel 6, Receive Input differential pair.	I PCIE		
PEG_TX6+ PEG_TX6-	D71 D72	PEG channel 6, Transmit Output differential pair.	O PCIE	Type 2 Shared with	 SDVOC_BLU+ SDVOC_BLU-
PEG_RX7+ PEG_RX7-	C74 C75	PEG channel 7, Receive Input differential pair.	I PCIE		
PEG_TX7+ PEG_TX7-	D74 D75	PEG channel 7, Transmit Output differential pair.	O PCIE	Type 2 : Shared with	 SDVOC_CK+ SDVOC_CK-
PEG_RX8+ PEG_RX8-	C78 C79	PEG channel 8, Receive Input differential pair.	I PCIE		
PEG_TX8+ PEG_TX8-	D78 D79	PEG channel 8, Transmit Output differential pair.	O PCIE		
PEG_RX9+ PEG_RX9-	C81 C82	PEG channel 9, Receive Input differential pair.	I PCIE		

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Signal	Pin#	Description	I/O	Comment
PEG_TX9+ PEG_TX9-	D81 D82	PEG channel 9, Transmit Output differential pair.	O PCIE	
PEG_RX10+ PEG_RX10-	C85 C86	PEG channel 10, Receive Input differential pair.	I PCIE	
PEG_TX10+ PEG_TX10-	D85 D86	PEG channel 10, Transmit Output differential pair.	O PCIE	
PEG_RX11+ PEG_RX11-	C88 C89	PEG channel 11, Receive Input differential pair.	I PCIE	
PEG_TX11+ PEG_TX11-	D88 D89	PEG channel 11, Transmit Output differential pair.	O PCIE	
PEG_RX12+ PEG_RX12-	C91 C92	PEG channel 12, Receive Input differential pair.	I PCIE	
PEG_TX12+ PEG_TX12-	D91 D92	PEG channel 12, Transmit Output differential pair.	O PCIE	
PEG_RX13+ PEG_RX13-	C94 C95	PEG channel 13, Receive Input differential pair.	I PCIE	
PEG_TX13+ PEG_TX13-	D94 D95	PEG channel 13 Transmit Output differential pair.	O PCIE	
PEG_RX14+ PEG_RX14-	C98 C99	PEG channel 14, Receive Input differential pair.	I PCIE	
PEG_TX14+ PEG_TX14-	D98 D99	PEG channel 14, Transmit Output differential pair.	O PCIE	
PEG_RX15+ PEG_RX15-	C101 C102	PEG channel 15, Receive Input differential pair.	I PCIE	
PEG_TX15+ PEG_TX15-	D101 D102	PEG channel 15, Transmit Output differential pair.	O PCIE	
SDVO_I2C_CLK	D73	I2C based control signal (clock) for SDVO device.	O 2.5V CMOS	SDVO enabled if this line is pulled up to 2.5V on Carrier or on ADD2 (Type 2 only)
SDVO_I2C_DATA	C73	I2C based control signal (data) for SDVO device	I/O 2.5V OD CMOS	SDVO enabled if this line is pulled up to 2.5V on Carrier or on ADD2 (Type 2 only)
PEG_LANE_RV#	D54	PCI Express Graphics lane reversal input strap. Pull low on the carrier board to reverse lane order.	I 3.3V CMOS	
PEG_ENABLE#	D97	PEG enable function. Strap to enable PCI Express x16 external graphics interface. Pull low to disable internal graphics and enable the x16 interface.	I 3.3V CMOS	Type 2 only
PCIE_CLK_REF+ PCIE_CLK_REF-	A88 A89	PCIe Reference Clock for all COM Express PCIe lanes, and for PEG lanes	O CMOS	COM Express only allocates a single reference clock

2.4.2. PEG Configuration

The COM Express PCIe Graphics (PEG) Port is comprised of COM Express PCIe lanes 16-31. The primary use of this set of signals is to interface to off-Module graphics controllers or cards. The COM Express spec also allows these pins to be shared with a set of Module generated SDVO lines.

If the PEG interface is not used for an external graphics card or SDVO, it may be possible to use these PCIe lanes for other Carrier Board PCIe devices. The details of this usage are Module and Module chip-set dependent. Operation in a x1 link is also supported. Wider links (x2, x4, x8, x16) are chip-set dependent. Refer to the Module product documentation for details.

The COM Express specification defines a fill order for this set of PCIe lanes. Larger link widths go to the lower lanes. Refer to the COM Express specification for details.

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2.4.2.1. Using PEG Pins for an External Graphics Card

To use the COM Express PEG lanes for an external graphics device or card, the Type 2 Module's PEG_ENABLE# line (pin D97 on the Module C-D connector) must be pulled low. Pulling this pin low disables the Module's internal graphics controller and makes the PEG x16 interface available to an external controller.

The usual effect of pulling PEG_ENABLE# low is to disable the on-Module graphics engine. For some Modules, it is possible to configure the Module such that the internal graphics engine remains active, even when the external PEG interface is being used for a Carrier Board graphics device. This is Module dependent. Check with your vendor.

If the external graphics controller is “down” on the Carrier Board, then the PEG_ENABLE# line should be pulled to GND on the Carrier Board.

There are four copies of PRSNT2# defined for slot cards, to allow detection of x1, x4, x8 and x16 cards. For PEG slot use, the PRSNT2# signals for the x1 and x4 links are used for SDVO detection per the following chart.

To enable carrier flexibility in slot configuration and to support x1, x4, x8 and x16 PCI Express cards as well as ADD2/MEC cards and MEC cards that utilize both SDVO and x1 PCI Express, a jumper is recommended on the carrier to configure the PEG_ENABLE# signal. For carrier implementations only requiring support of x8 and x16 PCI Express graphics cards and SDVO ADD2 cards, the PRSNT2# signals on slot pins B48 and B81 may be tied to COM Express Module PEG_ENABLE# pin D97 to automatically configure the Module based on the card inserted.

Table 10: PEG Configuration Pins

Slot Signal	Slot Pin	Carrier Board Connection	COM Ex Pin	Comment
PRSNT1#	A1	Tie to GND through low value resistor		Pins A1, B48 and B81 are tied together on a PEG slot card. Not tied together on ADD2.
PRSNT2#	B17	To COM Ex SDVO_I2C_CLK line	D73	SDVO use – pulled to 2.5V on ADD2
PRSNT2#	B31	To COM Ex SDVO_I2C_DAT line	C73	SDVO use – pulled to 2.5V on ADD2
PRSNT2#	B48	Not connected		
PRSNT2#	B81	To COM Ex PEG_ENABLE#		

2.4.2.2. Using PEG Pins for SDVO (Type 2 Modules only)

The COM Express Module graphics controller configures the PEG lines for SDVO operation if it detects that COM Express signals SDVO_I2C_CLK and SDVO_I2C_DATA are pulled high to 2.5V, and if the PEG_ENABLE# line is left floating. This combination leaves the Module's internal graphics engine enabled but converts the output format to SDVO. The SDVO_I2C_CLK and SDVO_I2C_DATA lines are pulled to 2.5V on an ADD2 card.

For a device “down” SDVO converter, the SDVO_I2C_CLK and SDVO_I2C_DATA lines have to be pulled up to 2.5V on the Carrier Board.

2.4.2.3. Using PEG Pins for General Purpose PCIe Lanes

The COM Express PEG lanes may be used for general-purpose use if the PEG port is not being used as an interface to an external graphics device. The characteristics of this usage are Module and chip-set dependent.

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Modules that employ desktop and mobile chip-sets with PEG capability can usually be set up to allow the COM Express PEG lanes to be configured as a single general purpose PCIe link, with link width possibilities of x1, x4, x8 or x16. The x1 configuration should always work; the wider links may be Module and chip-set dependent. Check with your vendor.

Modules based on server-class chip-sets may allow multiple links over the PEG lanes – for example, a x8 link on COM Express PCIe lanes 16 through 23 and a x4 link over lanes 24 through 27. This is Module and chip-set dependent.

PEG_ENABLE# should be left open when the PEG lanes are to be used for general purpose PCIe links.

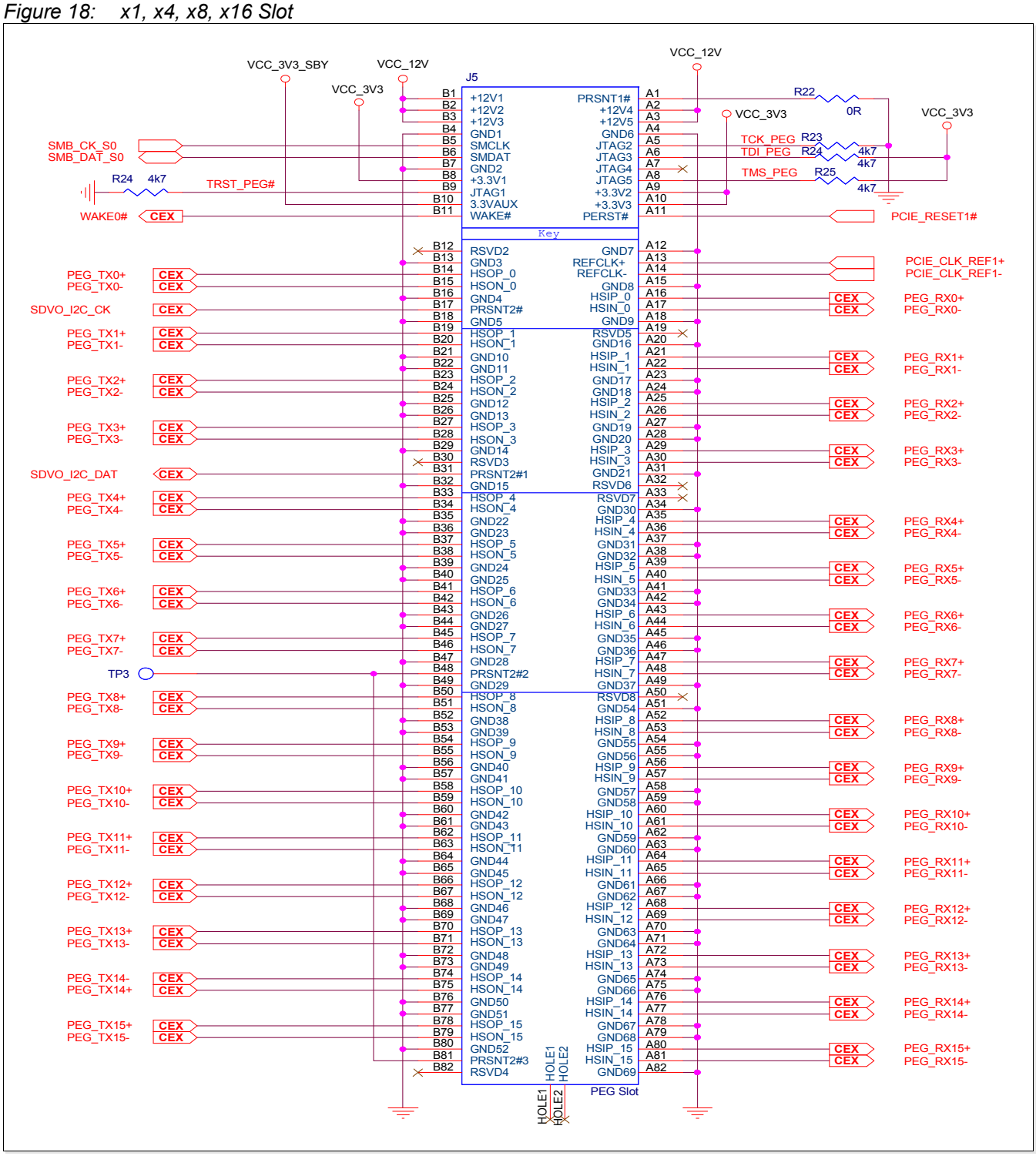
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2.4.3. Reference Schematics

2.4.3.1. x1, x4, x8, x16 Slot

Figure 18 below illustrates the pin-out definition for the standard x1, x4, x8 and x16 PCI Express connectors. The lines in the diagram depict where each different connector type ends.

Figure 18: x1, x4, x8, x16 Slot



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The x16 connector usually is used to drive the PCI Express Graphics Port (PEG) consisting of 16 PEG lanes, which are connected to the appropriate x16 connector pins. For more information about the signal definition of the PEG port, refer to Section 2.4. 'PEG (PCI Express Graphics)' on page 48 above.

Note: Auxiliary signals
The auxiliary signals are provided on the PCI Express connectors to assist with certain system level functionality or implementations. Some of these signals are required when implementing a PCI connector on the Carrier Board. For more information about this subject, refer to the PCI Express Card Electromechanical Specification, Rev. 1.1 Section 2.

2.4.4. Routing Considerations

Please refer to Section 2.3.6 'PCI Express Routing Considerations' on page 47 above.

2.4.4.1. Polarity Inversion

Per definition, PCI Express supports polarity inversion by each receiver on a link. The receiver accomplishes this by simply inverting the received data on the differential pair if it detects a polarity inversion during the initial training sequence of the link. In other words, a lane will still work correctly if a positive signal 'PEG_TX+' from a transmitter is connected to the negative signal 'PEG_RX-' of the receiver. Vice versa, the negative signal from the transmitter 'PEG_TX-' must be connected to the positive signal of the receiver 'PEG_RX+'. This feature can be very useful to make PCB layouts cleaner and easier to route.

Polarity inversion does not imply direction inversion, this means the 'PEG_TX' differential pairs of the Module must still be connected to the 'PEG_RX' differential signal pairs of the device.

2.4.4.2. Lane Reversal

During the PCB layout of a COM Express Carrier Board, it is quite possible that the signals between the Modules connectors and the PCI Express device on the Carrier Board have to be crossed. To help layout designers overcome this signal crossing scenario, PCI Express specifies Lane Reversal. Lane Reversal is the reverse mapping of lanes for x2 or greater links.

For example, on a link with a width of x16, which supports Lane Reversal, the TX0, TX1, ... TX14, TX15 of the transmitting device have to be connected to RX15, RX14, ... RX1, RX0 of the receiving device, and vice versa. See Figure 19 below.

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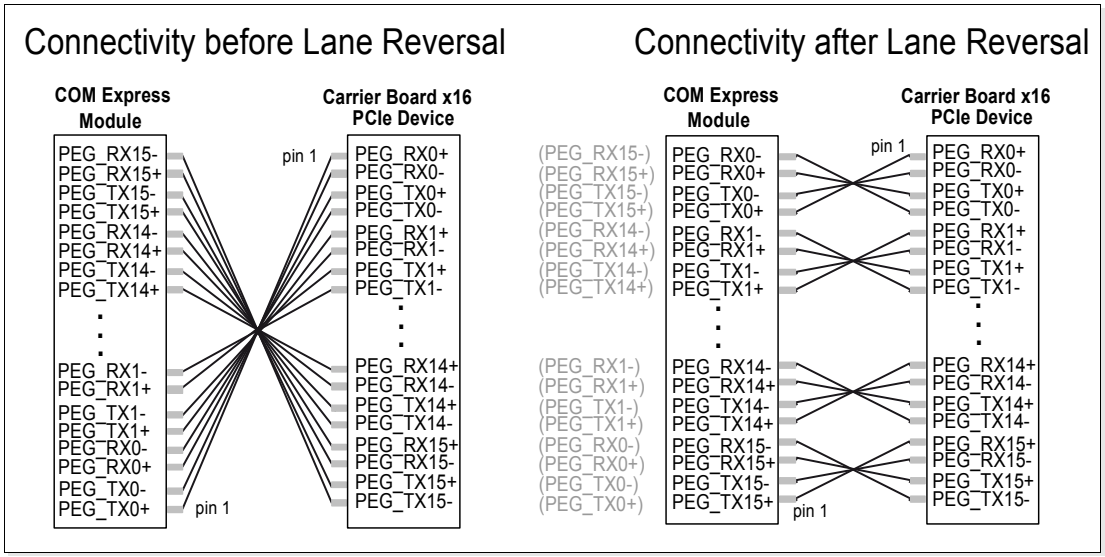


Figure 19: PEG Lane Reversal Mode

To activate the Lane Reversal mode for the PEG Port, the COM Express specification defines an active low signal 'PEG_LANE_RV#', which can be found on the Modules connector at row D pin D54. This pin is strapped low on the Carrier Board to invoke Lane Reversal mode.

Note ***Please be aware that the SDVO lines on Type 2 Modules (Section 2.5.2) that share the PEG Port (Section 2.4) may not support Lane Reversal mode. This is the reason that there are "normal" (ADD2-N) and "reverse" (ADD2-R) pin-out ADD2 cards on the market. ADD2-N cards are used in a PEG slot that does not employ lane reversal. An ADD2-R card is used in a PEG slot that does employ lane reversal.***

Check with your Module vendor to see if SDVO Lane Reversal is supported.

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2.5. Digital Display Interfaces

Module Types 6 and 10 use Digital Display Interfaces (DDI) to provide DisplayPort, HDMI/DVI, and SDVO interfaces. Type 10 Modules can contain a single DDI (DDI[0]) that can support DisplayPort, HDMI/DVI, and SDVO. Type 6 Modules can contain up to 3 DDIs (DDI[1:3]) of which DDI[1:3] can support DisplayPort, HDMI/DVI and DDI[1] can support DisplayPort, HDMI/DVI, and SDVO. The main difference is that SDVO is only supported on DDI[0] for Type 10 Modules and DDI[1] for Type 6 Modules.

Module Type 2 offers additionally the possibility to have SDVO shared with PEG.

2.5.1. DisplayPort / HDMI / DVI

DisplayPort was developed by the Video Electronics Standard Association (VESA) in order to create a new digital display port interface to connect a video source to a display device.

DisplayPort can be used to transfer audio and video at the same time, but each one is optional and can be transmitted without the other. A bi-directional, half-duplex auxiliary channel carries device management and device control data for the Main Link, such as VESA EDID.

DisplayPort is nowadays on almost all COM Express Modules available as Dual-mode DisplayPort, that can directly emit single-link HDMI and DVI signals using an adapter, which contains a level shifter to adjust for the lower voltages required by DisplayPort. These adapters can be directly implemented on the Carrier Board to have an easy, simple and future proof implementation of HDMI and/or DVI or an inexpensive cable adapter can be directly connected on the Carrier Board's DisplayPort connector.

2.5.1.1. Signal Definitions

Type 10 offers up to one DisplayPort interface and Type 6 Modules up to 3 DisplayPort interfaces. Both implementations are very similar, so only one reference schematic is necessary to show Carrier Board implementation.

Each DisplayPort interface consists of 4 differential lanes, 1 auxiliary lane and 1 hot-plug-detect signal. The DDC_AUX_SEL pin should be routed to pin 13 of the DisplayPort connector, to enable Dual-Mode. When HDMI/DVI is directly done on the Carrier Board, this pin shall be pulled to 3.3V with a 100k Ohm resistor to configure the AUX pairs as DDC channels.

Table 11: Display Port / HDMI / DVI Pin-out of Type 10 and Type 6

COM Express Pin Name	DDI0 Type 10	DDI1 Type 6	DDI2 Type 6	DDI3 Type 6	Function (DDIX) DisplayPort	Function (DDIX) HDMI / DVI
DDIX_PAIR0+	B71	D26	D39	C39	DPX_LANE0+	TMDSX_DATA2+
DDIX_PAIR0-	B72	D27	D40	C40	DPX_LANE0-	TMDSX_DATA2-
DDIX_PAIR1+	B73	D29	D42	C42	DPX_LANE1+	TMDSX_DATA1+
DDIX_PAIR1-	B74	D30	D43	C43	DPX_LANE1-	TMDSX_DATA1-
DDIX_PAIR2+	B75	D32	D46	C46	DPX_LANE2+	TMDSX_DATA0+
DDIX_PAIR2-	B76	D33	D47	C47	DPX_LANE2-	TMDSX_DATA0-
DDIX_PAIR3+	B81	D36	D49	C49	DPX_LANE3+	TMDSX_CLK+
DDIX_PAIR3-	B82	D37	D50	C50	DPX_LANE3-	TMDSX_CLK-
DDIX_HPD	B89	C24	D44	C44	DPX_HPD	HDMIX_HPD
DDIX_CTRLCLK_AUX+	B98	D15	C32	C36	DPX_AUX+	HDMIX_CTRLCLK
DDIX_CTRLDATA_AUX-	B99	D16	C33	C37	DPX_AUX-	HDMIX_CTRLDATA
DDIX_DDC_AUX_SEL	B95	D34	C34	C38		

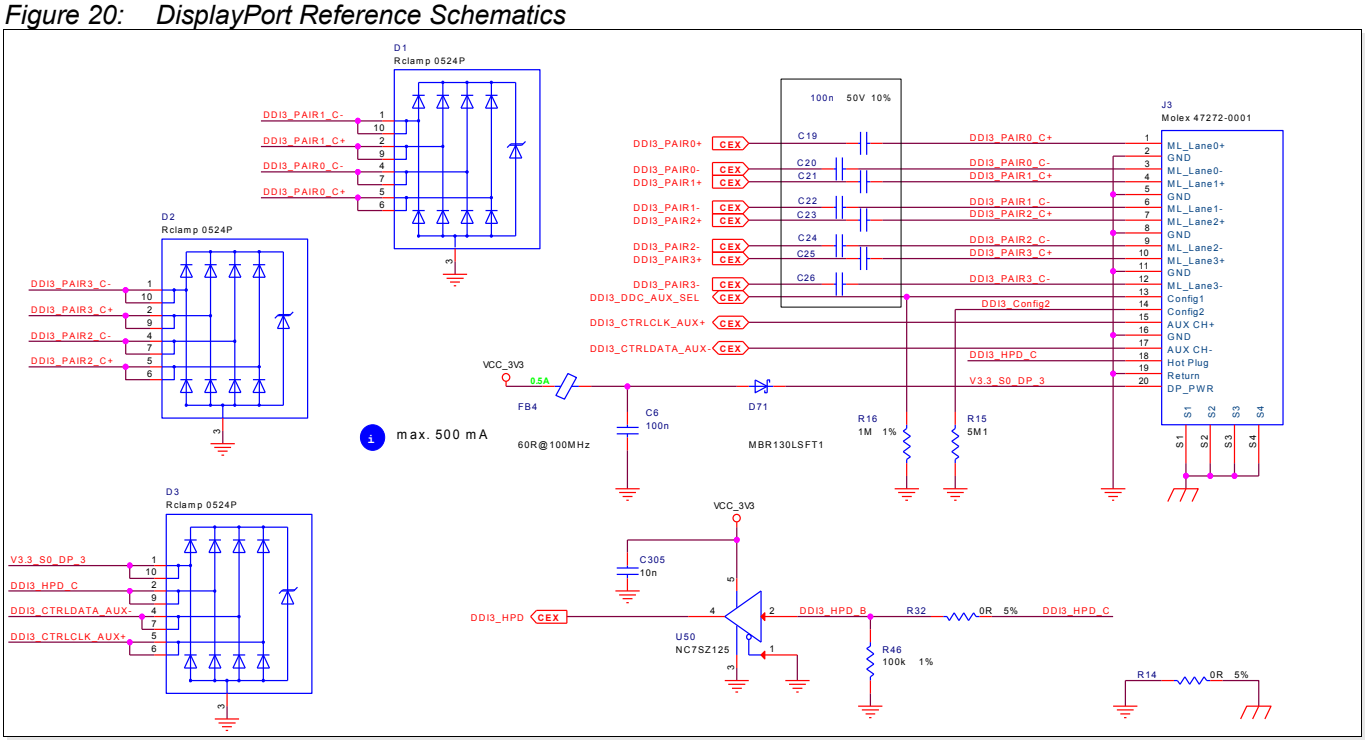
Note: Please verify in the Module's specification if DisplayPort or Dual-Mode DisplayPort is supported.

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2.5.1.2. Reference Schematic

DisplayPort Example

Figure 20: DisplayPort Reference Schematics



DisplayPort is directly supported by a dual-source DDI. ESD protection, DC blocking capacitors and hot plug detect are the only components required.

The DisplayPort differential data pairs (Lane [0..3]) are AC coupled off Module with capacitors C19-C26. Place the AC blocking capacitors close to the DisplayPort connector. The Aux differential pair is AC coupled on the Module. ESD clamping diodes D1, D2 and D3 protect the Module from external ESD events and should be placed near the DisplayPort connector. The pin-out of the ESD clamp diodes allows for a trace to run under the chip connector to two pins.

The Carrier provides up to 500 mA of 3.3V power to the DisplayPort connector. Diode D71 prevents back feeding of power in the event that the monitor is powered up when the Carrier is powered down.

Config lines 1 and 2 are pulled to ground per the VESA specification.

The DisplayPort Hot Plug Detect signal is buffered by U50 which prevents back feeding of power from the display to the Module as well as level translation to 3.3V levels.

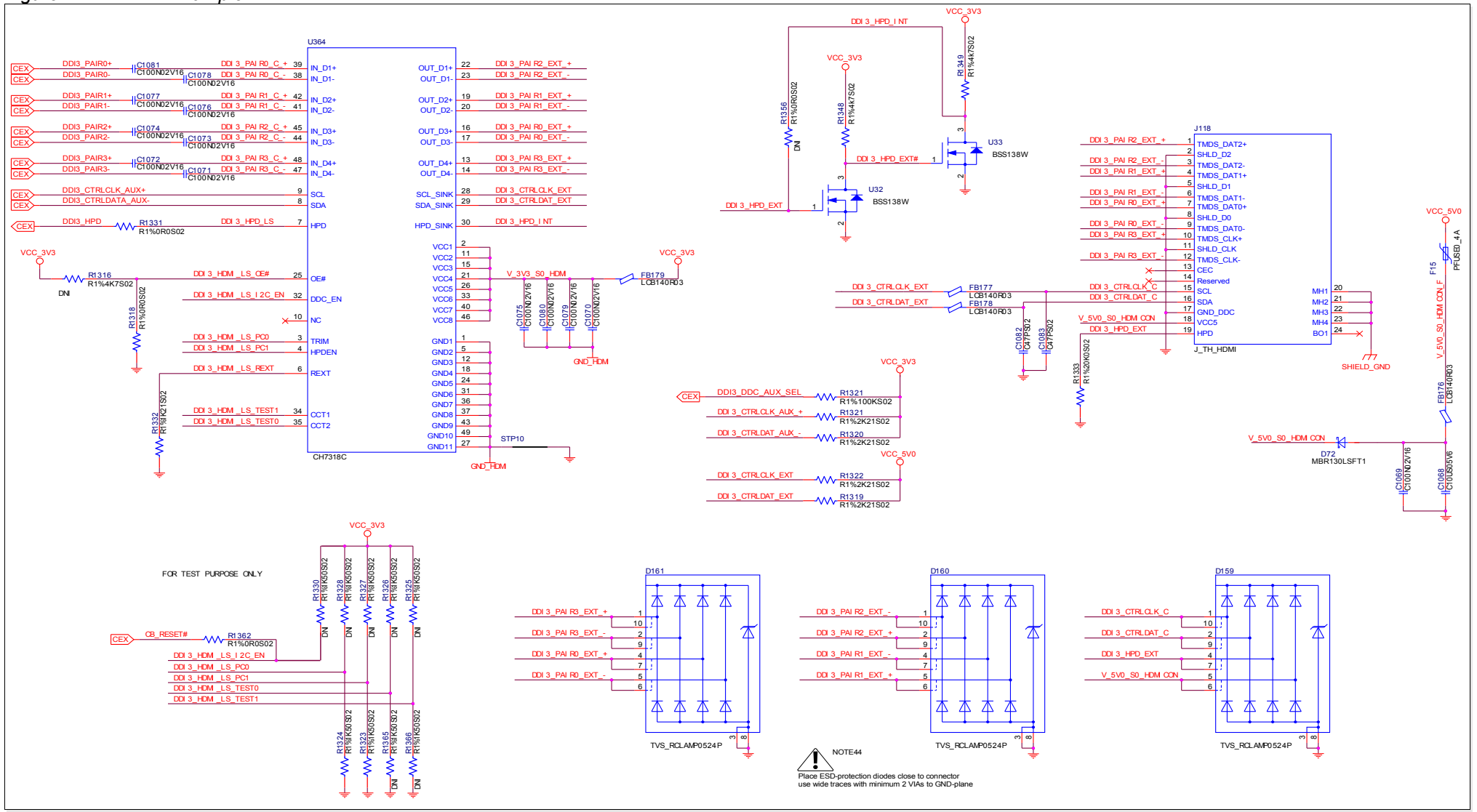
R14 connect logic and chassis ground together. Other techniques may be used depending on the overall grounding strategy.

Note: The reference schematics assume that the Module's DDI ports are dual-source capable – dual source indicates that the Module can output DisplayPort or HDMI/DVI based on the DDC_AUX_SEL signal.

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HDMI Example

Figure 21: HDMI Example



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A Dual-mode source Module requires level shifters on the Carrier to convert the low-swing AC coupled differential pairs from the video source to HDMI compliant current mode differential outputs. The example schematics use a Chrontel CH7318C translator which supports data rates up to 1.65GB/s per lane. FET based passive level translators can be used for lower data rates. The DisplayPort AUX channel is configured as a DDC interface for HDMI. Further information on pre-emphasis as well as output current trim capabilities of the CH7318C can be found in the Chrontel datasheet.

See http://www.chrontel.com/index.php/ch7318c-hdmi-hdcp-dvi-transmitters for more information.

ESD clamping diodes D159, D160 and D161 protect the Module from external ESD events and should be placed near the HDMI connector. The pin-out of the ESD clamp diodes allows for a trace to run under the chip connector to two pins.

HDMI uses I2C signaling for the DDC. Resistors 1319 and 1322 provide the necessary pull-up. The FETs U32 and U33 provide the Hot Plug Detect signal

The Carrier provides 5V power to the HDMI connector. A series diode (D72) should be used to prevent back feeding of power in the event that the monitor is powered up when the Carrier is powered down.

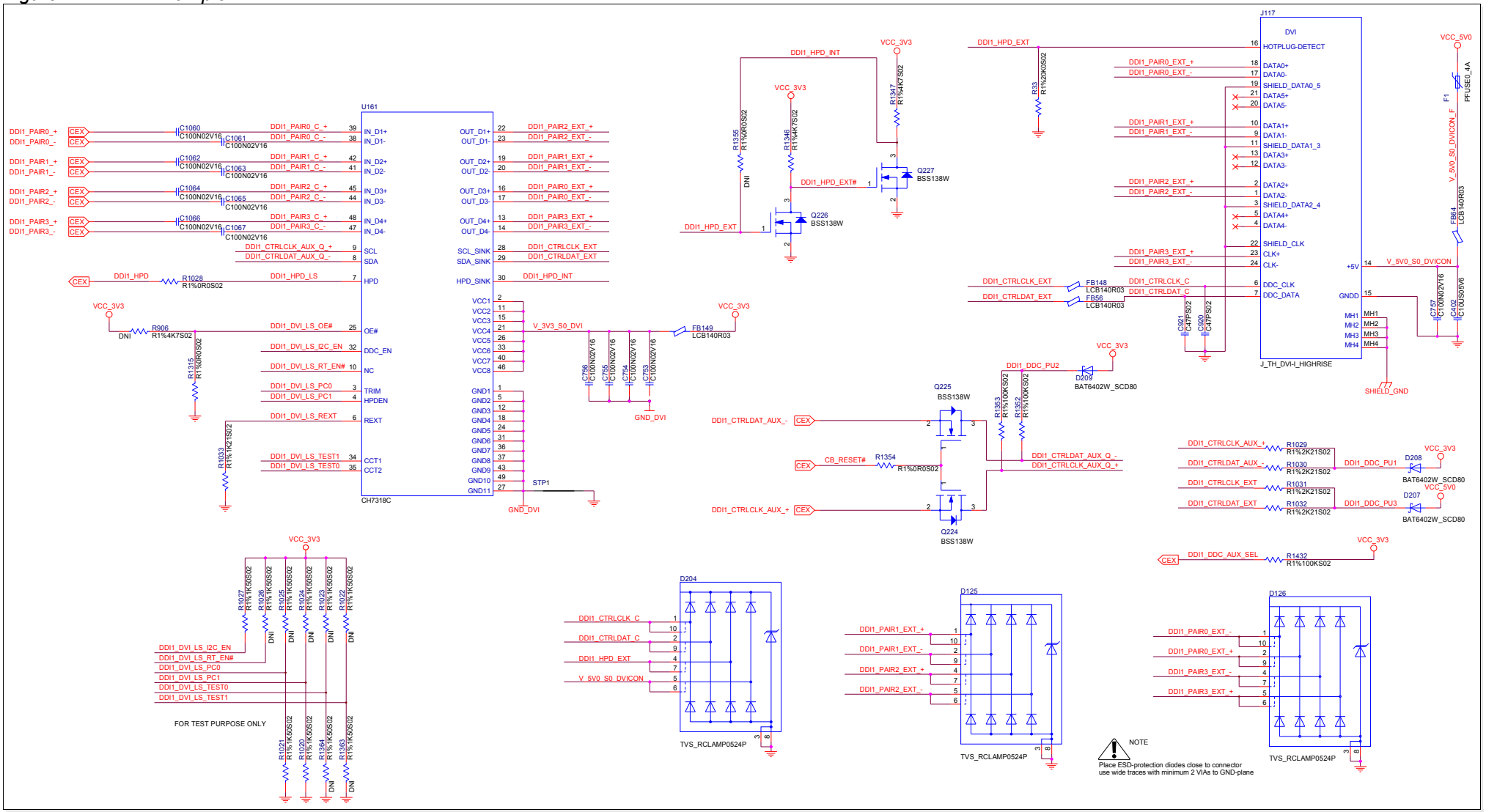
The HDMI Hot Plug Detect signal is buffered by two FETs U32 and U33 which prevent back feeding of power from the display to the Module as well as level translation to 3.3V levels.

Note: The reference schematics assume that the Module's DDI ports are dual-source capable – dual source indicates that the Module can output DisplayPort or HDMI/DVI based on the DDC_AUX_SEL signal.

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DVI Example

Figure 22: DVI Example



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A Dual-mode source Module requires level shifters on the Carrier to convert the low-swing AC coupled differential pairs from the video source to DVI compliant current mode differential outputs. The example schematics use a Chrontel CH7318C translator which supports data rates up to 1.65GB/s per lane. FET based passive level translators can be used for lower data rates. The DisplayPort AUX channel is configured as a DDC interface for HDMI. Further information on pre-emphasis as well as output current trim capabilities of the CH7318C can be found in the Chrontel datasheet.

See http://www.chrontel.com/index.php/ch7318c-hdmi-hdcp-dvi-transmitters for more information.

ESD clamping diodes D125, D126 and D204 protect the Module from external ESD events and should be placed near the DVI connector. The pin-out of the ESD clamp diodes allows for a trace to run under the chip connector to two pins.

DVI uses I2C signaling for the DDC. Resistors 1031 and 1032 provide the necessary pull-up. The FETs Q226 and Q227 provide the Hot Plug Detect signal

The Carrier provides 5V power to the DVI connector.

Series diodes (D207, D208, D209) should be used to prevent back feeding of power in the event that the monitor is powered up when the Carrier is powered down.

The DDI1 Hot Plug Detect signal is buffered by two FETs Q226 and Q227 which prevent back feeding of power from the display to the Module as well as level translation to 3.3V levels.

Note: The reference schematics assume that the Module's DDI ports are dual-source capable – dual source indicates that the Module can output DisplayPort or HDMI/DVI based on the DDC_AUX_SEL signal.

Other DisplayPort Output Options: LVDS, VGA, etc.

Other display interfaces can be created from DisplayPort, but this needs an active interface change. DisplayPort to LVDS can be created with interface chips from multiple vendors. One example is the Chrontel CH7511.

DisplayPort to VGA interface chips are available from multiple vendors including Chrontel or NXP.

Note: Please also follow the design guidelines from the chip vendor

2.5.1.3. Routing Considerations

For the DisplayPort interconnection between the COM Express Module and the DisplayPort connector or the level shifter, refer to Section 6.5.6 'DisplayPort Trace Routing Guidelines' on page 186 for details.

The Digital Video Interface (DVI) and the High Definition Multimedia Interface (HDMI) are based on the differential signaling method TMDS. To achieve the full performance and reliability of HDMI and DVI, the TDMS differential signals between the level shifter and the DVI connector have to be routed in pairs with a differential impedance of 100Ω. The length of the differential signals must be kept as close to the same as possible. The maximum length difference must not exceed 100mils for any of the pairs relative to each other. Pair to pair spacing should be more than 2x the trace width to reduce trace-to-trace couplings. For example, having wider gaps between differential pair DVI traces will minimize noise coupling. It is also strongly advised that ground not be placed adjacent to the DVI traces on the same layer. There should be a minimum distance of 30mils between the DVI trace and any ground on the same layer.

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2.5.2. SDVO

SDVO was developed by the Intel® Corporation to interface third party SDVO compliant display controller devices that may have a variety of output formats, including DVI, LVDS, HDMI and TV-Out. The electrical interface is based on the PCI Express interface, though the protocol and timings are completely unique. Whereas PCI Express runs at a fixed frequency, the frequency of the SDVO interface is dependent upon the active display resolution and timing.

Note: As SDVO is not supported in future chipsets and graphic controllers it is not recommended to use this interface in future designs.

2.5.2.1. Signal Definitions

The SDVO interface of the COM Express Module features its own dedicated I²C bus (SDVO_I2C_CLK and SDVO_I2C_DAT). It is used to control the external SDVO devices and to read out the display timing data from the connected display.

Type 6 Modules allow one SDVO port on DDI[1]. The DDI port needs to be configured to be used as SDVO usually via the Module's BIOS.

On Type 2 Modules the pins for SDVO ports B and C are shared with the PEG port.

If the Type 2 Module supports SDVO, the Module graphics controller configures the PEG lines for SDVO operation if it detects that COM Express signals SDVO_I2C_CLK and SDVO_I2C_DATA are pulled high to 2.5V, and if the PEG_ENABLE# line is left floating. This combination leaves the Module's internal graphics engine enabled but converts the output format to SDVO. The SDVO_I2C_CLK and SDVO_I2C_DATA lines are pulled to 2.5V on an ADD2 card.

For a device “down” SDVO converter, the SDVO_I2C_CLK and SDVO_I2C_DATA lines have to be pulled up to 2.5V on the Carrier Board and PEG_ENABLE# left open.

SDVO Port Configuration

The SDVO port and device configuration is fixed within the Intel® Graphics Video BIOS implementation of the COM Express Module. All COM Express Modules assume a I²C bus address 0111 000x for SDVO devices connected to port B and an I²C bus address of 0111 001x for SDVO devices connected to port C. Table 12 below lists the supported SDVO port configurations.

Table 12: SDVO Port Configuration

	SDVO Port B	SDVO Port C
Device Type	Selectable in BIOS Setup Program.	Selectable in BIOS Setup Program.
I²C Address	0111 000x	0111 001x
I²C Bus	SDVO I²C GPIO pins	SDVO I²C GPIO pins
DDC Bus	SDVO I²C GPIO pins	SDVO I²C GPIO pins

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Supported SDVO Devices

Due to the fact that SDVO is an Intel® defined interface, the number of supported SDVO devices is limited to devices that are supported by the Intel® Graphics Video BIOS and Graphics Driver software.

Table 13: Intel® SDVO Supported Device Descriptions

Device	Vendor	Type	Link
CH7021A	Chrontel	SDTV / HDTV	http://www.chrontel.com
CH7308A	Chrontel	LVDS	http://www.chrontel.com
CH7307C	Chrontel	DVI	http://www.chrontel.com
CH7312	Chrontel	DVI	http://www.chrontel.com
CX25905	Conexant	DVI-D / TV / CRT	http://www.conexant.com
SiL1362/1364	Silicon Image	DVI	http://www.siliconimage.com
SiL 1390	Silicon Image	HDMI	http://www.siliconimage.com

Note: The devices listed in Table 13 require BIOS support for proper operation. Check with the Modules vendor for a list of specific devices that are supported.

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2.5.2.2. Reference Schematics

SDVO to DVI Transmitter Example

Figure 23: SDVO to DVI Transmitter Example

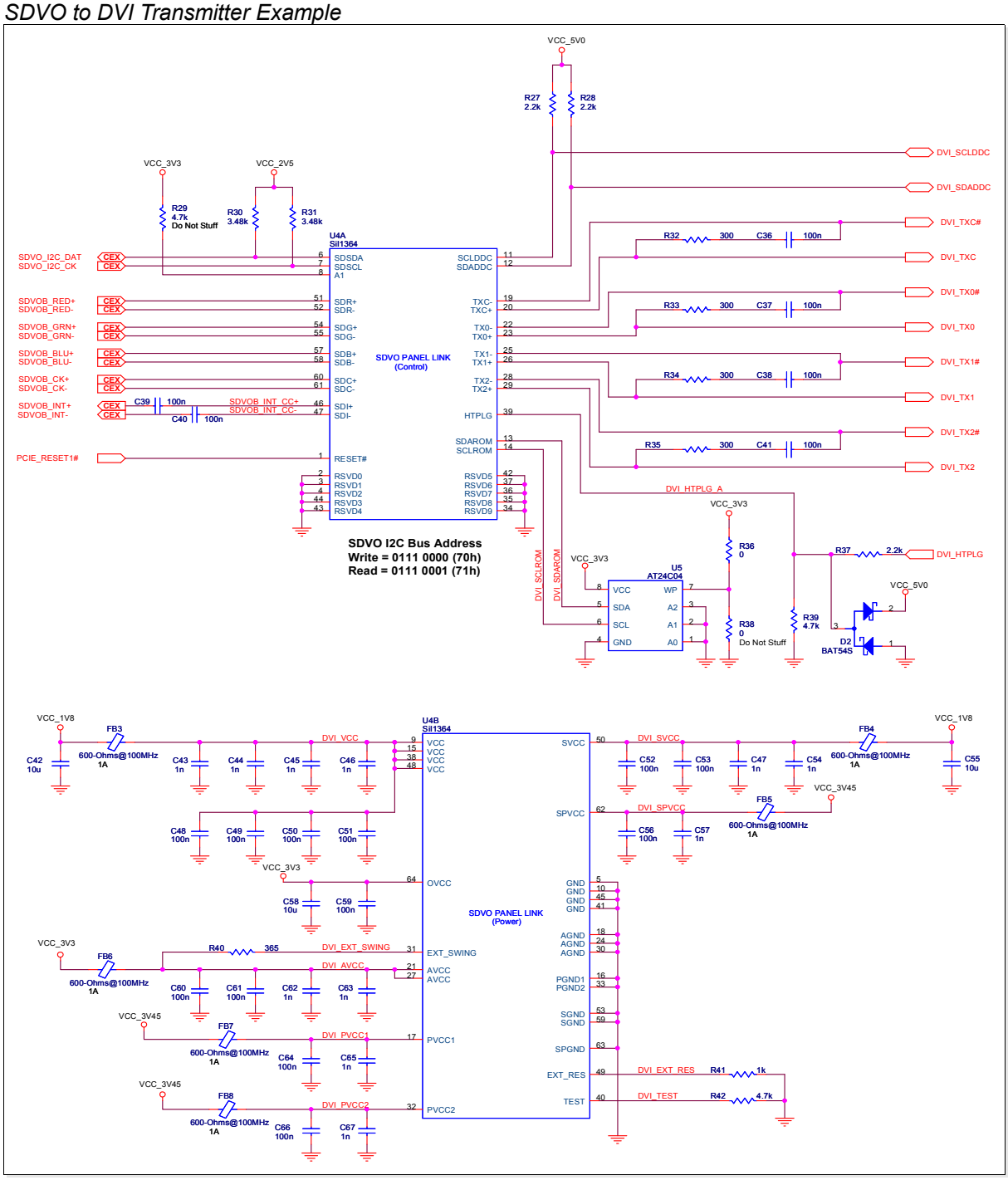


Figure 23 'SDVO to DVI Transmitter Example' above shows a single-channel, device-down application for SDVO to DVI implementation. A Silicon Image transmitter IC (SIL1364) converts SDVO signals from the Module to a DVI-D format. Pins are connected to the DVI-D Connector (Molex 74320-4004).

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PEG_RX1+ and PEG_RX1- are sourced from COM Express Module pins C55 and C56 and are defined as SDVOB_INT+ and SDVOB_INT- in the COM Express Specification respectively. They are driven by SDI+ and SDI- from the chip. The PEG Receive interface on the COM Express Module is driven by the TX source (Interrupt) on the SDVO chip. The TX source needs to be AC-coupled near the source (SDI pins).

EXT_RES is pulled low through a 1.0kΩ resistor to generate a reference-bias current.

PEG_TX0+/- through PEG_TX3- from COM Express Module pins are defined as SDVO_RED+/-, GRN+/-, BLU+/- and CK+/- in the COM Express Specification respectively. They drive SDR+/-, SDG+/-, SDB+/- and SDC+/- on the chip. The PEG Transmit interface on the COM Express Module drives the RX load on the graphics chip.

SDVO_I2C_CLK and SDVO_I2C_DAT are sourced from COM Express Module pins D73 and C73 respectively. A pull-up to 2.5V using a 3.5kΩ resistor is required for both lines on the Carrier Board for a device-down application. For an SDVO slot design, pull-ups are on the SDVO plug-in card.

The I2C Bus supports management functions and provides Manufacturer information, a model number, and a part number.

RESET# is driven by the PCI_RESET1# from COM Express Module pin C23, PCI_RESET#, after buffering. The signal resets the chip and causes initialization.

A1 establishes the I2C default address. Pulled Low = 0X70 (unconnected). Pulled High = 0X72 through a 4.7kΩ resistor.

HTPLUG – The Hot Plug input is driven by the Monitor Device, which causes the System OS to initiate a Plug and Play sequence that results in identifying the configuration of the Monitor. Protection diodes and a current-limiting resistor also are added.

TEST – The factory test pin needs to be tied low for normal operation.

EXT_SWING should be tied to AVCC pins through a 360Ω resistor. It sets the amplitude voltage swing. Smaller values set a larger voltage swing and vice versa.

SDAROM and SCLROM interface to a non-volatile memory U17, Serial Prom AT24C04.

TX0+/- through TX2+/- DVI output pins are TMDS low voltage differential signals.

TXC+/- DVI Clock pins are TMDS low voltage differential signals.

SCLDDC and SDADDC should be pulled up with a 2.2kΩ resistor. They serve as the signals for the I2C interface to the DVI connector. The interface supports the DDC (Display Data Channel) standard for EDID (Extended Display Identification Data) over I2C. The EDID includes the manufacturer's name, product type, phosphor or filter type, timings supported by the display, display size, luminance data and pixel mapping data (for digital displays only).

SDAROM and SCLROM external pull-ups are not required because they are internally pulled up. They serve as signals for the I2C interface to EEPROM AT24C04.

The schematics also show the requirements for decoupling and the filter caps for the SIL1364 graphics chip.

Other SDVO Output Options: LVDS, NTSC

SDVO to LVDS interface chips are available from multiple vendors. One example is the Chrontel CH7308.

SDVO to NTSC interface chips are available from multiple vendors including Chrontel.

Note: Please also follow the design guidelines from the SDVO chip vendor

2.5.2.3. Routing Considerations

For the SDVO interconnection between the COM Express Module and a third-party SDVO compliant device, refer to Section 6.5.5. 'SDVO Trace Routing Guidelines' on page 185 below and to the layout and routing considerations specified by the SDVO device manufacturer.

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The Digital Video Interface (DVI) is based on the differential signaling method TDMS. To achieve the full performance and reliability of DVI, the TDMS differential signals between the SDVO to DVI transmitter and the DVI connector have to be routed in pairs with a differential impedance of 100Ω. The length of the differential signals must be kept as close to the same as possible. The maximum length difference must not exceed 100mils for any of the pairs relative to each other. Spacing between the differential pair traces should be more than 2x the trace width to reduce trace-to-trace couplings. For example, having wider gaps between differential pair DVI traces will minimize noise coupling. It is also strongly advised that ground not be placed adjacent to the DVI traces on the same layer. There should be a minimum distance of 30mils between the DVI trace and any ground on the same layer. For more information, refer to the layout and routing considerations as specified by the manufacturer of the SDVO to DVI transmitter.

SDVO Option – PEG Lane Reversal

If Module pin D54 PEG_LANE_RV# is strapped low to untwist a bowtie on the PEGx16 lines to an x16 slot, then an ADD2 card used in this slot must be a reverse pin-out ADD2 card. Reverse pin-out ADD2 cards are designated ADD2-R.

If the SDVO device is “down” on the Carrier Board, then the PEG_LANE_REV# pin has no effect because SDVO lines are not reversed on the chipset – only PCIe x16 lines are.

Please see the Lane Reversal caution at Section 2.4.4.2. 'Lane Reversal' on page 53 above.

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2.6. Mobile PCI Express Module (MXM)

Mobile PCI Express Module is an interconnect standard for GPUs defined by the MXM-SIG, mainly used in laptops. The goal of this standard was to enable a user an easy way to upgrade the graphic card of a laptop without having to buy a hole new system or rely on proprietary vendor upgrades. This goal was achieved with a non-proprietary standard socket.

At this writing, the current generation of MXM is MXM3. Two Module sizes, designated as A and B, are allowed by MXM3 for different power envelopes and use cases.

Table 14: available MXM 3 Types

MXM Type	Width	Length	Module Compatility	Max. Power	GPU memory bus
MXM-A	82mm	70mm	A	55W	64-bit or 128-bit
MXM-B	82mm	105mm	A,B	100W	256-bit

The MXM3-COM Express interface is over the COM Express PEG lines. The MXM3 outputs are MXM3 Module dependent and can include DisplayPort, HDMI, DVI or TVout.

2.6.1. Signal Definitions

The primary interface between the COM Express Module and the MXM is a x16 PCI Express bus. The Carrier contains the AC coupling caps for the PEG_RX[0:15] signals, the COM Express Module contains the AC coupling caps for the PEG_TX[0:15] signals.

Three power rails are supplied to the MXM 3.3V@1A, 5V@2.5A and 12V@ up to 10A. The power rails are powered during S0. In the schematics below the main power rail to the MXM3 Module is shown as a fixed 12V (VCC_12V). An MXM3 Module can actually accept power over 7 to 20V range on this rail. Some COM Express Modules accept power over a similar range and if you are designing a battery powered system you may be able to take advantage of this wide range capability.

PEG_CLK_REQ# is used to enable the PCI Express clock PCIE_CLKPEG when a MXM is installed. The clock does not run when a MXM is not installed, reducing emissions.

The SMBus is connected between the COM Express Module and the MXM. Zero ohm resistors R115 and R116 are used to allow the SMBus to be disconnected from the MXM in the event there are address or other conflicts.

Table 15: special MXM signals

Signal	Signal Name	Signal Description
PEX_STD_SW#	PCI Express swing select	Pull-down resistor to ground determines the PCI Express voltage. PCI Express Gen1 and GEN2 select the correct resistor for short (resistor not installed), medium short (147K Ohm to ground), medium long (7.15K Ohm to ground), and long PCI Express channel length (0 Ohm to ground). Refer to the MXM specification for further information.
TH_OVERT#	Thermal shutdown request	The carrier must power down the MXM Module within 500 ms of assertion.
TH_PWM	Thermal PWM	May be used to control a fan on the MXM thermal solution.
PWR_OK	Power OK	Asserted by MXM card when all supplies are within tolerance. There is also a COM Express signal named “PWR_OK” which is not meant here.
PRSNT_R#/L#	MXM card presence detect	Tied to ground on the MXM card. Can be used by the carrier to detect that an MXM card is inserted

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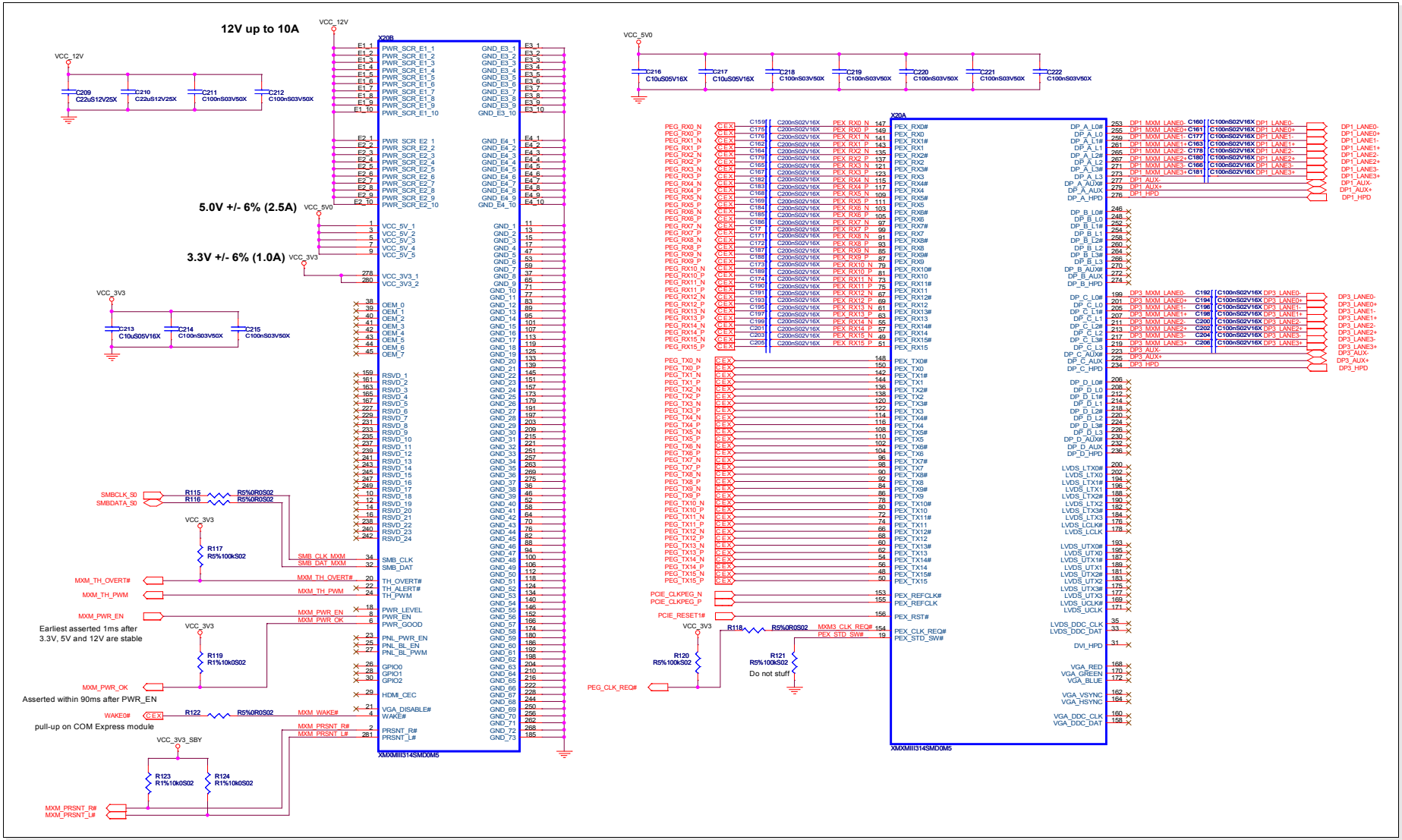
The MXM3 Module shown in this example supports two DisplayPort channels. They are designated DP1 and DP3 on the schematic. The DP1 reference schematic has Dual Mode support which switches the AUX channel from a differential pair for Display Port to an I2C compatible interface for DVI/HDMI. FETs are provided to switch in pull-up resistors required for the I2C interface as well as removal of the blocking capacitors. The DP1 schematic should be replicated for DP3 as required.

The reference design does not support the discrete panel and backlight control signals found on the MXM connector pins 23 (PNL_PWR_EN), 25 (PNL_BL_PWM), and 27 (PNL_BL_PWM). The design relies on panel support for these interfaces via the AUX channel.

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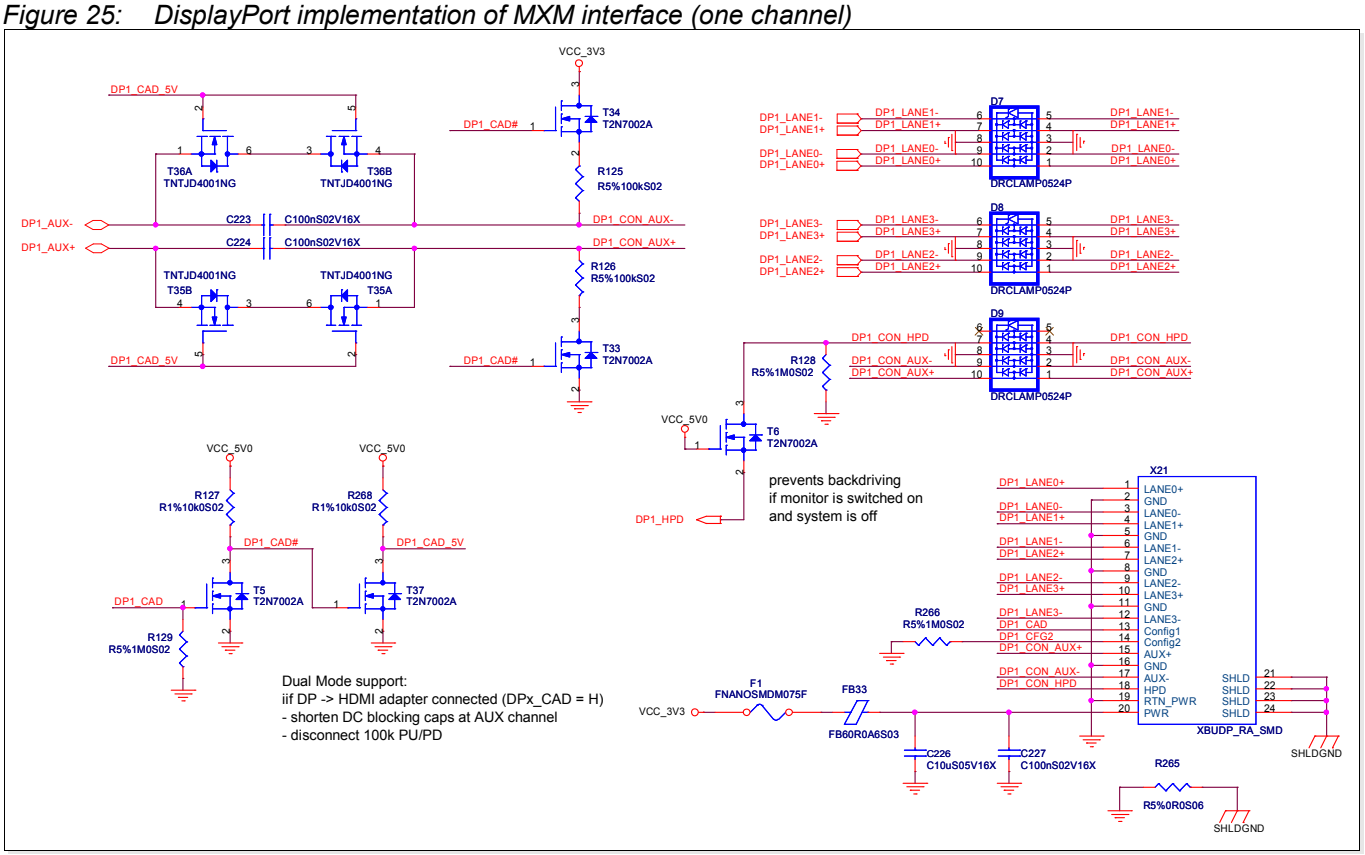
2.6.2. Reference Schematics

Figure 24: MXM Reference Schematics



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Figure 25: DisplayPort implementation of MXM interface (one channel)



Following notes apply to Figure 24: MXM Reference Schematics and Figure 25: DisplayPort implementation of MXM interface (one channel).

The reference designs supports a MXM card with two Display Port interfaces. The primary interface between the Module and MXM Card is x16 PCI Express. The RX DC blocking capacitors reside on the Carrier, the TX DC blocking capacitors reside on the COM Express Module. A MXM card can support PCI Express Gen1, Gen2, or Gen3. The resistor R121 is used to set the PCI Express voltage swing. The SMBus can be used for sideband communication with the MXM Module. The MXM card is powered from the non-standby rail so the “S0” SMBus signals are used. MXM_PWR_EN should be asserted no sooner than 1ms after the power to the MXM card is stable. PEG_CLK_REQ# can be used to disable the PCI Express clock when a MXM card is not installed to minimize emissions.

The reference schematic shows a dual mode Display Port implementation. Diodes D7, D8, and D9 clamp ESD. T6 prevents back driving of voltage if the monitor is on and the carrier power is off. FETs T5 and T37 level shift the cable adapter detect signal. The cable adapter detect is used to select between HDMI and Display Port. When HDMI is selected, the AUX channel is used as an I2C interface. The DC blocking capacitors are removed (shorted out) and pull-ups enabled. When Display Port is selected the AUX channel is a differential pair with the DC blocking capacitors.

2.6.3. Routing Considerations

MXM card power requirements can be large. Note that the MXM specification allows up to 10A of 12V, 2.5A of 5V and 1A of 3.3V. Use appropriate trace width and number of vias to deliver the required power. The PCI Express signals should follow the routing guidelines found in chapter 2.4.4. 'Routing Considerations' on page 53 above.

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2.7. LAN

All COM Express Modules provide at least one LAN port. The 8-wire 10/100/1000BASE-T Gigabit Ethernet interface compliant to the IEEE 802.3-2005 specification is the preferred interface for this port, with the COM Express Module PHY responsible for implementing auto-negotiation of 10/100BASE-TX vs 10/100/1000BASE-T operation. The carrier may also support a 4-wire 10/100BASE-TX interface from the COM Express Module on an exception basis. Check with your vendor for 10/100 only implementations.

2.7.1. Signal Definitions

The LAN interface of the COM Express Module consists of 4 pairs of low voltage differential pair signals designated from *'GBE0_MDI0'* (+ and -) to *'GBE0_MDI3'* (+ and -) plus additional control signals for link activity indicators. These signals can be used to connect to a 10/100/1000BASE-T RJ45 connector with integrated or external isolation magnetics on the Carrier Board. The corresponding LAN differential pair and control signals can be found on rows A and B of the Module's connector, as listed in Table 16 below.

Table 16: LAN Interface Signal Descriptions

Signal	Pin#	Description	I/O	Comment
GBE0_MDI0+ GBE0_MDI0-	A13 A12	Media Dependent Interface (MDI) differential pair 0. The MDI can operate in 1000, 100, and 10Mbit/sec modes.	I/O GBE	This signal pair is used for all modes.
GBE0_MDI1+ GBE0_MDI1-	A10 A9	Media Dependent Interface (MDI) differential pair 1. The MDI can operate in 1000, 100, and 10Mbit/sec modes.	I/O GBE	This signal pair is used for all modes.
GBE0_MDI2+ GBE0_MDI2-	A7 A6	Media Dependent Interface (MDI) differential pair 2. The MDI can operate in 1000, 100, and 10Mbit/sec modes.	I/O GBE	This signal pair is only used for 1000Mbit/sec Gigabit Ethernet mode.
GBE0_MDI3+ GBE0_MDI3-	A3 A2	Media Dependent Interface (MDI) differential pair 3. The MDI can operate in 1000, 100, and 10Mbit/sec modes.	I/O GBE	This signal pair is only used for 1000Mbit/sec Gigabit Ethernet mode.
GBE0_CTREF	A14	Reference voltage for Carrier Board Ethernet channel 0 magnetics center tap.	REF	
GBE0_LINK#	A8	Ethernet controller 0 link indicator, active low.	O 3.3V Suspend OD CMOS	
GBE0_LINK100#	A4	Ethernet controller 0 100Mbit/sec link indicator, active low.	O 3.3V Suspend OD CMOS	
GBE0_LINK1000#	A5	Ethernet controller 0 1000Mbit/sec link indicator, active low.	O 3.3V Suspend OD CMOS	
GBE0_ACT#	B2	Ethernet controller 0 activity indicator, active low.	O 3.3V Suspend OD CMOS	

2.7.1.1. Status LED Signal Definitions

The four link status signals (LINK#, LINK100#, LINK1000#, and ACT#) are combined on the carrier to drive two status LEDs (Link Activity and Link Speed). These two LEDs are typically integrated into the RJ45 receptacle housing for the Ethernet, but may be placed on the carrier Module assembly as discrete LEDs. The most common functional characteristics for each LED are listed in Table 17 below.

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Table 17: LAN Interface LED Function

LED-Function	LED Color#	LED State	Description
Link Speed	Green / Orange	Off	10 Mbps link speed
		Green	100 Mbps link speed
		Orange	1000 Mbps link speed
Link Status & Activity	Yellow	Off	No Link
		Steady On	Link established, no activity detected
		Blinking	Link established, activity detected

2.7.1.2. LAN 1 and 2 shared with IDE

The Type 2 COM Express Module only provides one LAN port to the carrier. Type 3 and 5 COM Express Modules provide two additional 10/100/1000BASE-T Gigabit Ethernet ports in place of the IDE port, and Type 5 Module definitions include an option to support 10 Gigabit Ethernet port operation.

This Design Guide does not explicitly define Carrier Board support for the Type 3 and 5 COM Express Modules. However, it is recommended that a carrier supporting one of those Modules should follow the guidelines for the LAN 0 port carrier circuit in this section when defining the LAN 1 and 2 port carrier circuits.

2.7.1.3. PHY / Magnetics Connections

The COM Express Module specification partitions the IEEE 802.3 PHY / MDI interface circuit resources between the Module and carrier, with the PHY located on the Module and the coupling magnetics located on the carrier, preferably physically integrated in the RJ-45 receptacle housing associated with the port. Section 5.4.5 of the COM Express Module specification shows this circuit topology and provides a high level signal attenuation budget for Ethernet signals traversing this circuit.

In order to meet the signal performance requirements for MDI signals as defined in the IEEE 802.3-2005 specification and to ensure maximum interoperability of COM Express Modules and carriers, the PHY / Magnetics circuit should be implemented using the following guidelines:

- The carrier should provide a full 8-wire (10/100/1000BASE-T) interface circuit to the COM Express Module
- Any secondary side resistive terminations required by the Module PHY will be present on the Module and are not on the Carrier
- The center tap reference signal should be routed from the COM Express Module connector to the secondary side center tap of each transformer as defined in the IEEE 802.3-2005 specification, without any series resistance or impedance circuits
- The Carrier Board design should utilize a coupling transformer capable of interoperating with the largest possible number of PHY devices
- The Carrier Board design should have the primary side and secondary side center tap termination components (75 Ω resistors and 100 nF capacitors, respectively) placed physically as close to the coupling transformer as possible
- The coupling transformer should be placed no further than 100mm (3.9”) from the COM Express Module connector on the Carrier Board.
- It is recommended that the carrier use a RJ-45 connector with an integrated transformer. However, if a discrete coupling transformer is used, the transformer must be placed no further than 25mm (1.0”) from the RJ-45 receptacle.

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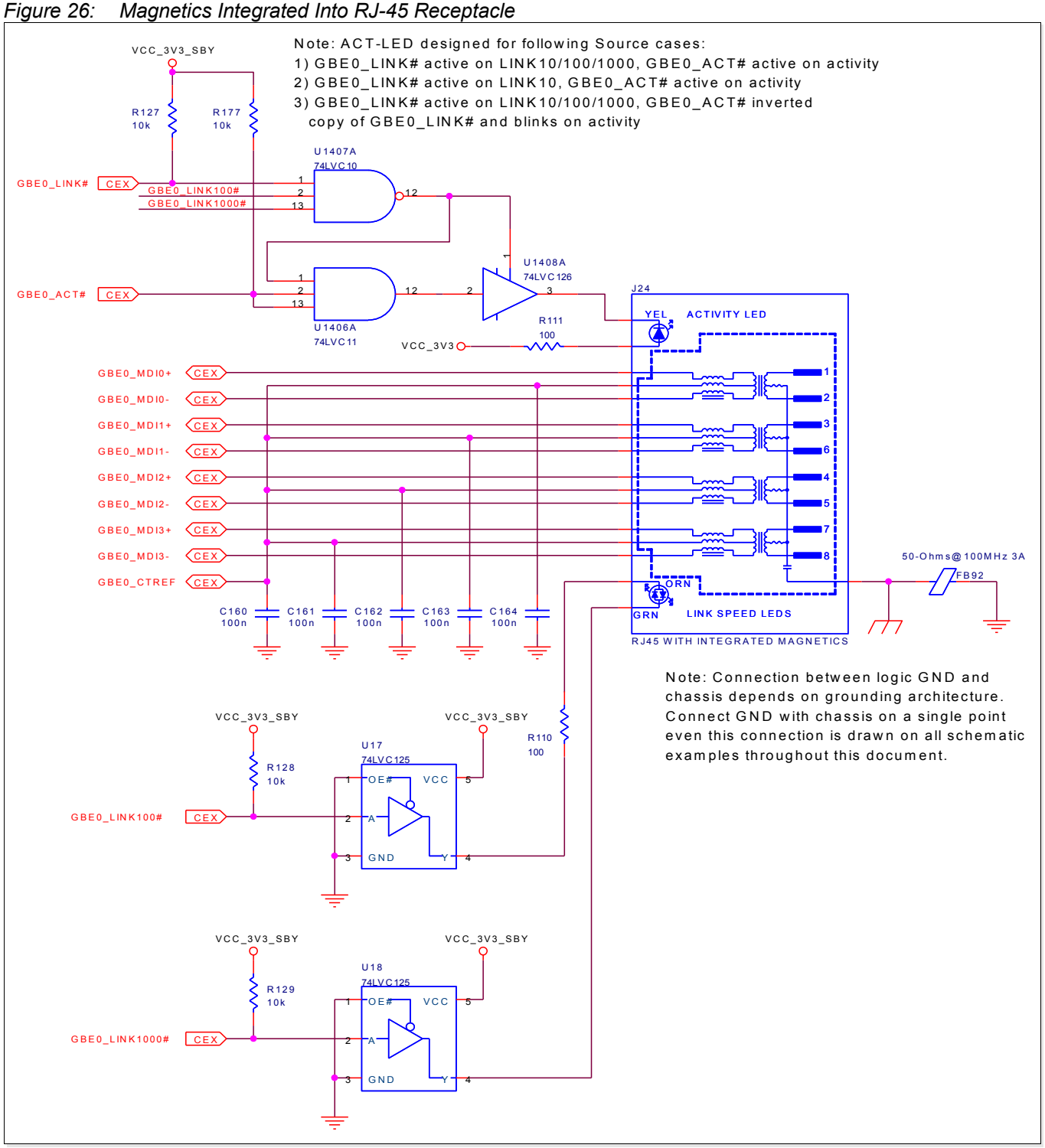
As there are a large number of Ethernet PHY components and coupling transformers on the market, it is strongly recommended that the Carrier Board vendor document the transformer used in this interface circuit, in order to facilitate interoperability analysis between Modules and carriers. It is also recommended that the COM Express Module vendor identify the specific PHY component used in the LAN 0 interface on the Module.

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2.7.2. Reference Schematics

2.7.2.1. Magnetics Integrated Into RJ-45 Receptacle

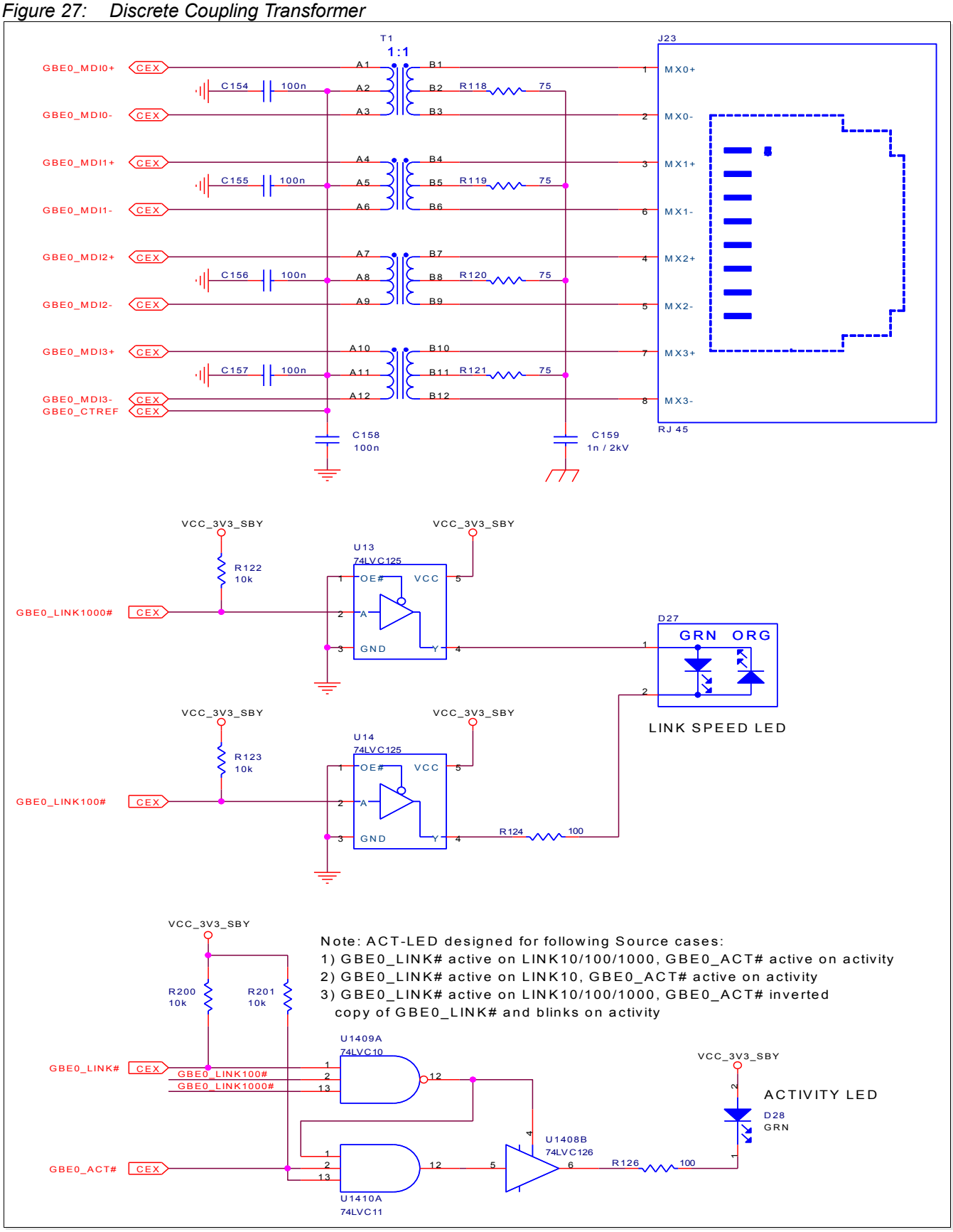
Figure 26: Magnetics Integrated Into RJ-45 Receptacle



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2.7.2.2. Discrete Coupling Transformer

Figure 27: Discrete Coupling Transformer



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2.7.3. Routing Considerations

The 8-wire PHY / MDI circuit is required to meet a specific waveform template and associated signal integrity requirements defined in the IEEE 802.3-2005 specification. In order to meet these requirements, the routing rules in Section 6.5.7. 'LAN Trace Routing Guidelines' on page 187 should be observed on the Carrier Board.

The four status signals driven by the COM Express Module to the Carrier Board are low frequency signals that do not have any signal integrity or trace routing requirements beyond generally accepted design practices for such signals.

2.7.3.1. Reference Ground Isolation and Coupling

The Carrier Board should maintain a well-designed analog ground plane around the components on the primary side of the transformer between the transformer and the RJ-45 receptacle. The analog ground plane is bonded to the shield of the external cable through the RJ-45 connector housing.

The analog ground plane should be coupled to the carrier's digital logic ground plane using a capacitive coupling circuit that meets the ground plane isolation requirements defined in the 802.3-2005 specification. It is recommended that the Carrier Board PCB design maintain a minimum 30 mil gap between the digital logic ground plane and the analog ground plane.

It's recommended to place an optional GND to SHIELDGND connection near the RJ-45 connector to improve EMI and ESD capabilities.

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2.8. USB Ports

A COM Express Module must support a minimum of 4 USB Ports and can support up to 8 USB Ports. All of the USB Ports must be USB2.0 compliant. There are 4 over-current signals shared by the 8 USB Ports. A Carrier must current limit the USB power source to minimize disruption of the Carrier in the event that a short or over-current condition exists on one of the USB Ports. A Module must fill the USB Ports starting at Port 0. The USB SuperSpeed ports 0, 1, 2 and 3, if used, are to be paired with USB 2.0 ports 0, 1, 2 and 3 in the same order. The USB SuperSpeed ports use the same over current signaling mechanism as the USB 2.0 ports, but USB 3.0 allows up to 1A current per port instead of 500mA allowed in USB 2.0. Although USB 2.0 signals use differential signaling, the USB specification also encodes single ended state information in the differential pair, making EMI filtering somewhat challenging. Ports that are internal to the Carrier do not need EMI filters. A USB Port can be powered from the Carrier Main Power or from the Carrier Suspend Power. Main Power is used for USB devices that are accessed when the system is powered on. Suspend Power (VCC_5V_SBY) is used for devices that need to be powered when the Module is in Sleep-State S5. This would typically be for USB devices that support Wake-on-USB. The amount of current available on VCC_5V_SBY is limited so it should be used sparingly.

2.8.1. Signal Definitions

All USB Ports appear on the COM Express A-B connector as shown in Table 18 below.

2.8.1.1. USB Over-Current Protection (USB_x_y_OC#)

The USB Specification describes power distribution over the USB port, which supplies power for USB devices that are directly connected to the Carrier Board. Therefore, the host must implement over-current protection on the ports for safety reasons. Should the aggregate current drawn by the downstream ports exceed a permitted value, the over-current protection circuit removes power from all affected downstream ports. The over-current limiting mechanism must be resettable without user mechanical intervention. For more detailed information about this subject, refer to the 'Universal Serial Bus Specifications Revision 2.0', which can be found on the website http://www.usb.org.

Over-current protection for USB ports can be implemented by using power distribution switches on the Carrier Board that monitor the USB port power lines. Power distribution switches usually have a soft-start circuitry that minimizes inrush current in applications where highly capacitive loads are employed. Transient faults are internally filtered.

Additionally, they offer a fault status output that is asserted during over-current and thermal shutdown conditions. These outputs should be connected to the corresponding COM Express Modules USB over-current sense signals. Fault status signaling is an option at the USB specification. If you don't need the popup message in your OS you may leave the signals USB_0_1_OC#, USB_2_3_OC#, USB_4_5_OC# and USB_6_7_OC# unconnected.

Simple resettable PolySwitch devices are capable of fulfilling the requirements of USB over-current protection and therefore can be used as a replacement for power distribution switches.

Fault status signals are connected by a pullup resistor to VCC_3V3_SBY on COM Express Module. Please check your tolerance on a USB port with VCC_5V supply.

2.8.1.2. Powering USB devices during S5

The power distribution switches and the ESD protection shown in the schematics can be powered from Main Power or Suspend Power (VCC_5V_SBY). Ports powered by Suspend Power are powered during the S3 and S5 system states. This provides the ability for the COM Express Module to generate system wake-up events over the USB interface.

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Table 18: USB Signal Description

Signal	Pin #	Description	I/O	Comment
USB0+	A46	USB Port 0, data + or D+	I/O USB	mandatory on Module
USB0-	A45	USB Port 0, data - or D-	I/O USB	mandatory on Module
USB1+	B46	USB Port 1, data + or D+	I/O USB	mandatory on Module
USB1-	B45	USB Port 1, data - or D-	I/O USB	mandatory on Module
USB2+	A43	USB Port 2, data + or D+	I/O USB	mandatory on Module
USB2-	A42	USB Port 2, data - or D-	I/O USB	mandatory on Module
USB3+	B43	USB Port 3, data + or D+	I/O USB	mandatory on Module
USB3-	B42	USB Port 3, data - or D-	I/O USB	mandatory on Module
USB4+	A40	USB Port 4, data + or D+	I/O USB	optional on Module
USB4-	A39	USB Port 4, data - or D-	I/O USB	optional on Module
USB5+	B40	USB Port 5, data + or D+	I/O USB	optional on Module
USB5-	B39	USB Port 5, data - or D-	I/O USB	optional on Module
USB6+	A37	USB Port 6, data + or D+	I/O USB	optional on Module
USB6-	A36	USB Port 6, data - or D-	I/O USB	optional on Module
USB7+	B37	USB Port 7, data + or D+	I/O USB	optional on Module
USB7-	B36	USB Port 7, data - or D-	I/O USB	optional on Module
USB_0_1_OC#	B44	USB over-current sense, USB ports 0 and 1.	I 3.3V CMOS	optional on Module
USB_2_3_OC#	A44	USB over-current sense, USB ports 2 and 3.	I 3.3VCMOS	optional on Module
USB_4_5_OC#	B38	USB over-current sense, USB ports 4 and 5.	I 3.3V CMOS	optional on Module
USB_6_7_OC#	A38	USB over-current sense, USB ports 6 and 7.	I 3.3V CMOS	optional on Module

2.8.1.3. USB connector

Figure 28: USB Connector

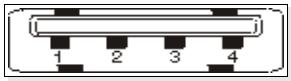


Table 19: USB Connector Signal Description

Signal	Pin	Description	I/O	Comment
VCC	1	+5V Power Supply	P 5V	Must be current-limited for external devices
-DATA	2	Universal Serial Bus Data, negative differential signal.	I/O USB	
+DATA	3	Universal Serial Bus Data, positive differential signal.	I/O USB	
GND	4	Ground	P	

2.8.2. Reference Schematics

The following notes apply to Figure 29 below.

J6 incorporate an USB Type A receptacle. J58 has two of them and in addition, includes an RJ-45 (Foxconn UB11123-J51, Pulse JW0A1P0R-E).

The reference design uses an over-current detection and protection device. Two examples are the Texas Instruments TPS2042AD and the Micrel MIC2026 dual channel power distribution switch. The second example includes a discrete implementation.

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The first schematic is powered from VCC_5V_SBY Suspend power and can provide Wake on LAN support. The second schematic is powered using 5V.

Power to the USB Port is filtered using a ferrite (90 Ω @100MHz, 3000mA) to minimize emissions. The ferrite should be placed adjacent to the USB Port connector pins.

USB_0_1_OC# and USB_2_3_OC# are over-current signals that are inputs to COM Express Module. Each signal is driven low upon detection of overload, short-circuit or thermal trip, which causes the affected USB Port power to turn off. Do not attach pull-ups to the OC signals on the COM Express Carrier Board; this is done on the COM Express Module.

The OC# signal is asserted until the over-current or over-temperature condition is resolved.

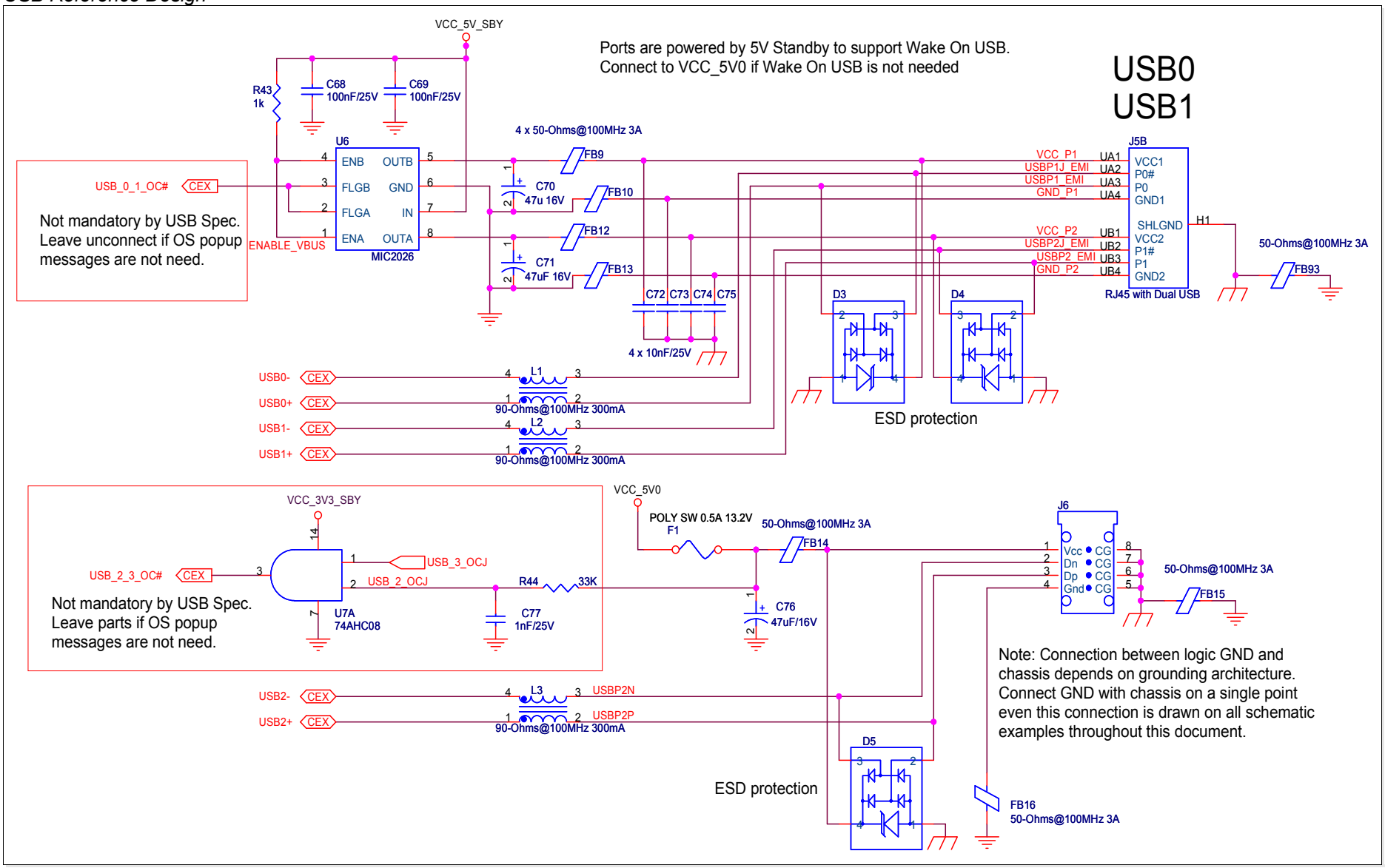
USB0+/- through USB2+/- from the COM Express Module are routed through a common mode choke to reduce radiated cable emissions. The part shown is a Coilcraft 0805USB-901MLC; this device has a common mode impedance of approximately 90 Ω at 100MHz. The common-mode choke should be placed close to the USB connector.

ESD protection diodes D1 and D2 provide overvoltage protection caused by ESD and electrical fast transients . Low capacitance diodes and transient voltage suppression diodes should be placed near the USB connector. The example design uses a SR05 RailClamp surge diode array DATVSSR05 from Semtech (http://semtech.com).

The example designs show a ferrite connecting Chassis Ground and Logic Ground at the USB connector. Many USB devices connect Chassis and Logic grounds together. To minimize the current in this path a ferrite or capacitor connecting Chassis Ground to Logic Ground should be placed close to the USB connector.

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Figure 29: USB Reference Design



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2.8.3. Avoiding Back-driving Problems

For more information please refer to chapter 2.9.3 'Avoiding Back-driving Problems' on page 86 below.

2.8.4. Routing Considerations

Route USB signals as differential pairs, with a 90-Ω differential impedance and a 45-Ω, single-ended impedance. Ideally, a USB pair is routed on a single layer adjacent to a ground plane.

USB pairs should not cross plane splits. Keep layer transitions to a minimum. Reference USB pairs to a power plane if necessary. The power plane should be well-bypassed. Section 6.5.2. 'USB Trace Routing Guidelines' on page 183 summarizes USB routing rules.

2.8.4.1. EMI / ESD Protection

To improve the EMI behavior of the USB interface, a design should include common mode chokes, which have to be placed as close as possible to the USB connector signal pins. Common mode chokes can provide required noise attenuation but they also distort the signal quality of full-speed and high-speed signaling. Therefore, common mode chokes should be chosen carefully to meet the requirements of the EMI noise filtering while retaining the integrity of the USB signals on the Carrier Board design.

To protect the USB host interface of the Module from over-voltage caused by electrostatic discharge (ESD) and electrical fast transients (EFT), low capacitance steering diodes and transient voltage suppression diodes have to be implemented on the Carrier Board design. In the USB reference schematics Figure 29 above, this is implemented by using 'SR05 RailClamp®' surge rated diode arrays from Semtech (http://semtech.com).

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2.9. USB 3.0

USB 3.0 is the third major revision of the Universal Serial Bus (USB) standard for computer connectivity. It adds a new transfer speed called SuperSpeed (SS) to the already existing LowSpeed (LS), FullSpeed (FS) and HighSpeed (HS).

USB 3.0 leverages the existing USB 2.0 infrastructure by adding two additional data pair lines to allow a transmission speed up to 5 Gbit/s, which is 10 times faster than USB 2.0 with 480 Mbit/s. The additional data lines are unidirectional instead of the bidirectional USB 2.0 data lines.

USB 3.0 is fully backward compatible to USB 2.0. USB 3.0 connectors are different from USB 2.0 connectors. The USB 3.0 connector is a super set of a USB 2.0 connector, with 4 additional pins that are invisible to USB 2.0 connectors. A USB 2.0 Type A plug may be used in a USB 3.0 Type A receptacle, but the USB 3.0 SuperSpeed functions will not be available.

2.9.1. Signal Definitions

Type 10 offers up to 2 USB 3.0 ports and Type 6 up to 4.

Table 20: USB 2.0 Differential Lines

Signal	Pins T6	Pins T10	Description	I/O
USB0+	A46	A46	USB Port 0, data + or D+	I/O USB
USB0-	A45	A45	USB Port 0, data - or D-	I/O USB
USB1+	B46	B46	USB Port 1, data + or D+	I/O USB
USB1-	B45	B45	USB Port 1, data - or D-	I/O USB
USB2+	A43		USB Port 2, data + or D+	I/O USB
USB2-	A42		USB Port 2, data - or D-	I/O USB
USB3+	B43		USB Port 3, data + or D+	I/O USB
USB3-	B42		USB Port 3, data - or D-	I/O USB

Table 21: USB Overcurrent Protection lines

Signal	Pins T6	Pins T10	Description	I/O
USB_0_1_OC#	B44	B44	USB over-current sense, USB channels 0 and 1.	I CMOS
USB_2-3_OC#	A44		USB over-current sense, USB channels 2 and 3.	I CMOS

Table 22: USB 3.0 Differential Lines

Signal	Pins T6	Pins T10	Description	I/O
USB_SSTX0+	D4	B23	USB Port 0, SuperSpeed TX +	O PCIE
USB_SSTX0-	D3	B22	USB Port 0, SuperSpeed TX -	O PCIE
USB_SSTX1+	D7	B26	USB Port 1, SuperSpeed TX +	O PCIE
USB_SSTX1-	D6	B25	USB Port 1, SuperSpeed TX -	O PCIE
USB_SSTX2+	D10		USB Port 2, SuperSpeed TX +	O PCIE
USB_SSTX2-	D9		USB Port 2, SuperSpeed TX -	O PCIE
USB_SSTX3+	D13		USB Port 3, SuperSpeed TX +	O PCIE
USB_SSTX3-	D12		USB Port 3, SuperSpeed TX -	O PCIE
USB_SSRX0+	C4	A23	USB Port 0, SuperSpeed RX +	I PCIE
USB_SSRX0-	C3	A22	USB Port 0, SuperSpeed RX -	I PCIE
USB_SSRX1+	C7	A26	USB Port 1, SuperSpeed RX +	I PCIE
USB_SSRX1-	C6	A25	USB Port 1, SuperSpeed RX -	I PCIE
USB_SSRX2+	C10		USB Port 2, SuperSpeed RX +	I PCIE
USB_SSRX2-	C9		USB Port 2, SuperSpeed RX -	I PCIE

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Signal	Pins T6	Pins T10	Description	I/O
USB_SSRX3+	C13		USB Port 3, SuperSpeed RX +	I PCIE
USB_SSRX3-	C12		USB Port 3, SuperSpeed RX -	I PCIE

2.9.1.1. USB Differential lines (USB[0:3/1]+/-)

These signals fully comply to the USB 2.0 implementation and are described in chapter 2.8.1 'Signal Definitions' on page 76 above.

2.9.1.2. USB Over-Current Protection (USB_x_y_OC#)

The USB Specification describes power distribution over the USB port, which supplies power for USB devices that are directly connected to the Carrier Board. Therefore, the host must implement over-current protection on the ports for safety reasons. Should the aggregate current drawn by the downstream ports exceed a permitted value, the over-current protection circuit removes power from all affected downstream ports. The over-current limiting mechanism must be resettable without user mechanical intervention. For more detailed information about this subject, refer to the 'Universal Serial Bus Specifications Revision 2.0', which can be found on the website http://www.usb.org.

Over-current protection for USB ports can be implemented by using power distribution switches on the Carrier Board that monitor the USB port power lines. Power distribution switches usually have a soft-start circuitry that minimizes inrush current in applications where highly capacitive loads are employed. Transient faults are internally filtered.

Additionally, they offer a fault status output that is asserted during over-current and thermal shutdown conditions. These outputs should be connected to the corresponding COM Express Modules USB over-current sense signals. Fault status signaling is an option at the USB specification. If you don't need the popup message in your OS you may leave the signals USB_0_1_OC#, USB_2_3_OC#, USB_4_5_OC# and USB_6_7_OC# unconnected.

Fault status signals are connected by a pullup resistor to VCC_3V3_SBY on COM Express Module. Please check your tolerance on a USB port with VCC_5V supply.

USB 2.0 port's VCC current limit should be set to 500mA. For USB 3.0 implementations, the VCC current limit is raised to 1A. A different, USB 3.0 compatible, power switch is used.

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2.9.1.3. USB 3.0 connector

Figure 30: USB 3.0 Connector

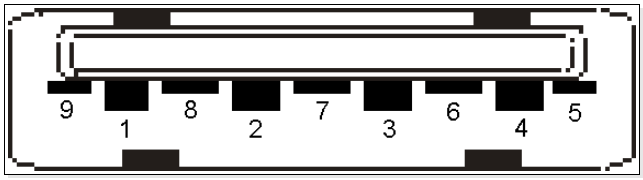


Table 23: USB 3.0 Connector Signal Description

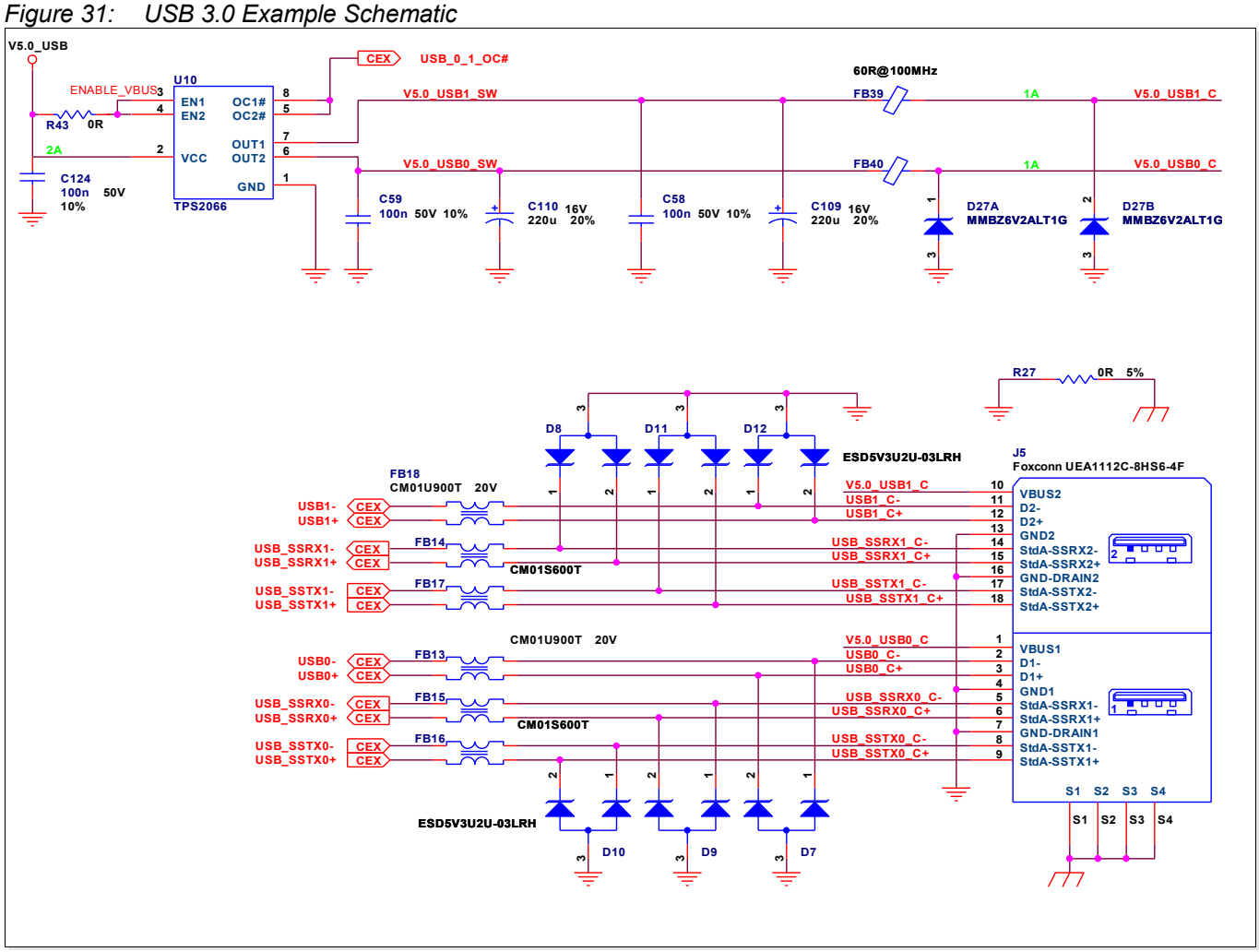
Signal	Pin	Description	I/O	Comment
VCC	1	+5V Power Supply	P 5V	Must be current-limited for external devices
-DATA	2	Universal Serial Bus Data, negative differential signal.	I/O USB	
+DATA	3	Universal Serial Bus Data, positive differential signal.	I/O USB	
GND	4	Ground	P	
SS_RX-	5	SuperSpeed Data Receive -	I PCIE	
SS_RX+	6	SuperSpeed Data Receive +	I PCIE	
GND	7	Ground	P	
SS_TX-	8	SuperSpeed Data Receive -	O PCIE	
SS_TX+	9	SuperSpeed Data Receive +	O PCIE	

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2.9.2. Reference Schematics

2.9.2.1. USB 3.0 Example

Figure 31: USB 3.0 Example Schematic



J5 incorporates a dual USB 3.0 Type A host receptacle. Note that the SuperSpeed pins are separate from the USB 2.0 pins.

This reference design uses an over-current detection and protection device (U10) dedicated for USB 3.0 with 1A current limit on each USB supply voltage line.

USB_0_1_OC# is an over-current signal that is input to COM Express Module. The signal is driven low upon detection of overload, short-circuit or thermal trip, which causes the affected USB Port power to turn off. Do not attach pull-ups to the OC signals on the COM Express Carrier Board; this is done on the COM Express Module.

The OC# signal is asserted until the over-current or over-temperature condition is resolved.

USB0+/- through USB1+/- from the COM Express Module are routed through a common mode choke to reduce radiated cable emissions. The part shown is a Taiyo Yuden CM01U900T; this device has a common mode impedance of approximately 90 Ω at 100MHz. The common-mode choke should be placed close to the USB connector. The SuperSpeed Signals USB_SSR/TX0+/- through USB_SSR/TX1+/- from the COM Express Module are also routed through a common mode choke to reduce radiated cable emissions. The part shown is a Taiyo Yuden CM01S600T; this device has a common mode impedance of approximately 60 Ω at 100MHz. The common-mode choke should be placed close to the USB connector.

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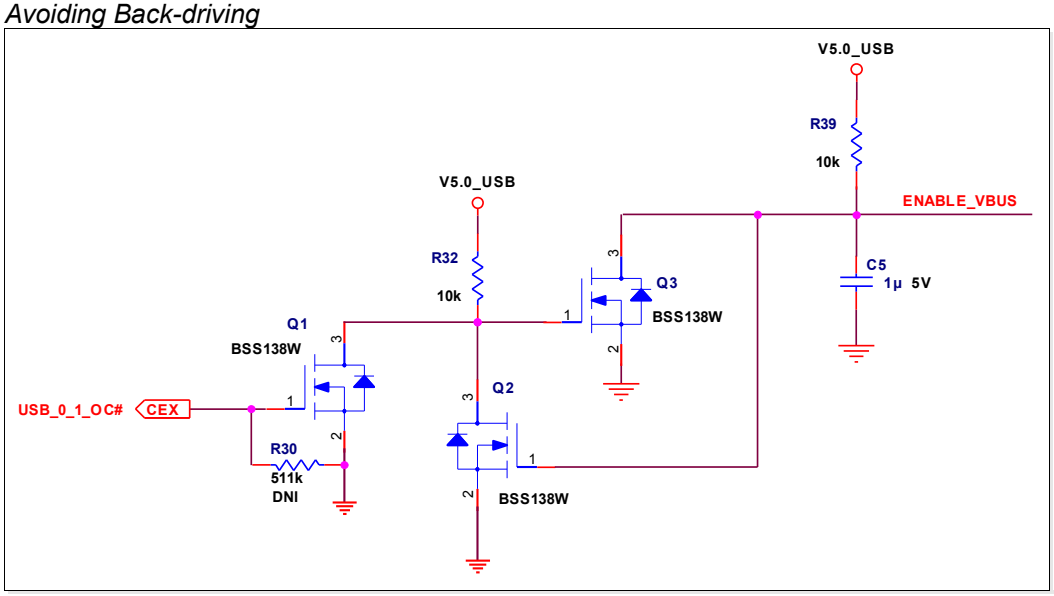
ESD protection diodes D7 through D12 provide overvoltage protection caused by ESD and electrical fast transients . Low capacitance diodes and transient voltage suppression diodes should be placed near the USB connector. The example design uses an Ultra-Low capacitance ESD diode array from Infineon. (http://www.infineon.com).

The example designs show a 0 Ohm resistor connecting Chassis Ground and Logic Ground at the USB connector. Many USB devices connect Chassis and Logic grounds together. To minimize the current in this path a ferrite, resistor or capacitor connecting Chassis Ground to Logic Ground should be placed close to the USB connector.

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2.9.3. Avoiding Back-driving Problems

Figure 32: Avoiding Back-driving



Back driving of power from a USB device to power rails on the Module can occur in some designs. It is recommended that USB power not be enabled until the Module's standby power rail (and therefore USB host power) is active. The COM Express standard does not provide a signal from the Module to the Carrier indicating the chipset standby rail is up. This reference schematic takes advantage of the USB_0_1_OC# pin as an indication of USB Host power. This pin which is typically pulled up on the Module to the correct standby rail, may be used as shown here to enable USB power. The FETs Q1, Q2 and Q3 form a latch and ensure that in case of an over-current event no toggling situation will occur. To use this circuit do not install R43 in Figure 31: USB 3.0 Example Schematic and put instead the schematic in Figure 32: Avoiding Back-driving. There may be other circuit implementations that perform the same functionality.

2.9.4. Routing Considerations

Route USB data signals as differential pairs, with a 90-Ω differential impedance and a 45-Ω, single-ended impedance. Route USB SuperSpeed signals as differential pairs, with an 85-Ω differential impedance and a 50-Ω, single-ended impedance. Ideally, a USB pair is routed on a single layer adjacent to a ground plane.

USB pairs should not cross plane splits. Keep layer transitions to a minimum. Reference USB pairs to a power plane if necessary. The power plane should be well-bypassed. Section 6.5.3 'USB 3.0 Trace Routing Guidelines' on page 184 summarizes routing rules for SuperSpeed signals. Section 6.5.2 'USB Trace Routing Guidelines' on page 183 below summarizes routing rules for USB data signals.

2.9.4.1. EMI / ESD Protection

To improve the EMI behavior of the USB interface, a design should include common mode chokes, which have to be placed as close as possible to the USB connector signal pins. Common mode chokes can provide required noise attenuation but they also distort the signal quality of FullSpeed, HighSpeed and SuperSpeed signaling. Therefore, common mode chokes should be chosen carefully to meet the requirements of the EMI noise filtering while retaining the integrity of the USB signals on the Carrier Board design.

To protect the USB host interface of the Module from over-voltage caused by electrostatic discharge (ESD) and electrical fast transients (EFT), low capacitance steering diodes and transient voltage suppression diodes have to be implemented on the Carrier Board design. In Figure 31: USB 3.0 Example Schematic on page 84 above, this is implemented by using Ultra-Low capacitance ESD diode arrays from Infineon. (http://www.infineon.com).

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2.10. SATA

Support for up to four SATA ports is defined on the COM Express A-B connector. Support for a minimum of two ports is required for all Module Types. The COM Express Specification allows for both SATA-150 and SATA-300 implementations. Constraints for SATA-300 implementations are more severe than those for SATA-150. The COM Express Specification addresses both in the section on insertion losses.

SATA devices can be internal to the system or external. The eSATA specification defines the connector used for external SATA devices. The eSATA interface must be designed to prevent damage from ESD, comply with EMI limits, and withstand more insertion/removals cycles than standard SATA. A specific eSATA connector was designed to meet these needs. The eSATA connector does not have the “L” shaped key, and because of this, SATA and eSATA cables cannot be interchanged.

2.10.1. Signal Definitions

Table 24: SATA Signal Description

Signal	Pin	Description	I/O	Comment
SATA0_RX+ SATA0_RX-	A19 A20	Serial ATA channel 0 Receive input differential pair.	I SATA	
SATA0_TX+ SATA0_TX-	A16 A17	Serial ATA channel 0 Transmit output differential pair.	O SATA	
SATA1_RX+ SATA1_RX-	B19 B20	Serial ATA channel 1 Receive input differential pair.	I SATA	
SATA1_TX+ SATA1_TX-	B16 B17	Serial ATA channel 1 Transmit output differential pair.	O SATA	
SATA2_RX+ SATA2_RX-	A25 A26	Serial ATA channel 2 Receive input differential pair.	I SATA	
SATA2_TX+ SATA2_TX-	A22 A23	Serial ATA channel 2 Transmit output differential pair.	O SATA	
SATA3_RX+ SATA3_RX-	B25 B26	Serial ATA channel 3 Receive input differential pair.	I SATA	
SATA3_TX+ SATA3_TX-	B22 B23	Serial ATA channel 3 Transmit output differential pair.	O SATA	
SATA_ACT#	A28	Serial ATA activity LED. Open collector output pin driven during SATA command activity.	O 3.3V CMOS OC	Able to drive 10 mA

Table 25: Serial ATA Connector Pin-out

Pin	Signal	Description
1	GND	Ground
2	TX+	Transmitter differential pair positive signal
3	TX-	Transmitter differential pair negative signal
4	GND	Ground
5	RX-	Receiver differential pair negative signal
6	RX+	Receiver differential pair positive signal
7	GND	Ground

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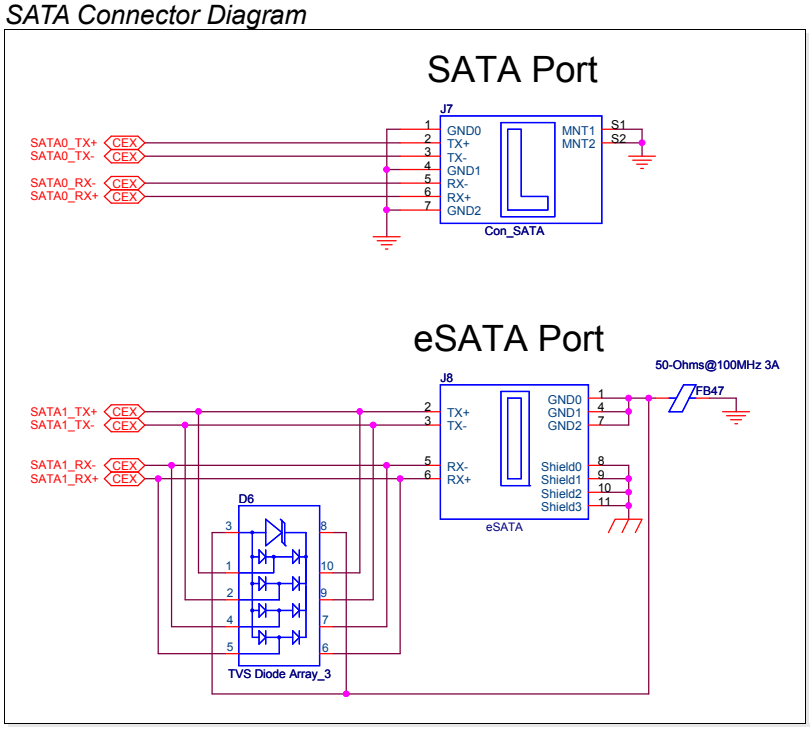
Table 26: Serial ATA Power Connector Pin-out

Pins	Signal	Description
1,2,3	+3.3V	3.3V power supply
4,5,6	GND	Ground
7,8,9	+5V	5V power supply
10,11,12	GND	Ground
13,14,15	+12V	12V power supply

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2.10.2. Reference Schematic

Figure 33: SATA Connector Diagram



The following notes apply to Figure 33 above.

The Module provides a single LED signal SATA_ACT# that can be used to indicate SATA drive activity.

The SATA connector shown is a Molex 67491 series, a 1.27mm-pitch 7-pin high-speed vertical plug.

The example design contains the SATA data and ground signals only. Power is provided through a separate connector from the system power supply. Alternate 22-pin connector types are available that deliver power and data to the SATA drive. This may be over a combined power/data cable or in a direct configuration in which the SATA drive mates directly to the 22-pin plug on the Carrier Board. Please refer to the SATA specification (Appendix G) for pin-out information.

ESD clamp diodes such as Semtech Rclamp0524 are shown in the eSATA schematic. This device contains low capacitance clamp diodes. The schematic shows two connections on each SATA signal to the clamp diodes. The second connection is actually a no-connect on the package and allows for straight-through routing for the SATA differential pairs.

Nets SATA0_TX+/- through SATA1_TX +/- are sourced from the COM Express Module SATA TX pins.

Nets SATA0_RX+/- through SATA1_RX +/- are sourced from SATA disks and are routed to the COM Express Module SATA RX pins.

Coupling capacitors are not needed on Carrier Board SATA lines. They are present on the COM Express Module.

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2.10.3. Routing Considerations

Route SATA signals as differential pairs, with a 85 Ω differential impedance and a 50 Ω, single-ended impedance. Ideally, a SATA pair is routed on a single layer adjacent to a ground plane. SATA pairs should not cross plane splits. Keep layer transitions to a minimum. SATA routing rules are also summarized in Section 6.5.8. 'Serial ATA Trace Routing Guidelines' on page 188.

As of the writing of this document, experience with SATA Gen3 implementations has shown that Carrier Board redrivers on the TX/RX pairs may be necessary. Check with your Module provider for further recommendations. Redrivers are available from vendors such as Texas Instruments, Pericom and others. The TI SN75LVCP600S is a redriver part in use by some Module vendors.

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2.11. LVDS

2.11.1. Signal Definitions

The COM Express Specification provides an optional LVDS interface on the COM Express A-B connector. Module pins for two LVDS channels are defined and designated as LVDS_A and LVDS_B.

Systems use a single-channel LVDS for most displays. Dual LVDS channels are used for very high-bandwidth displays. Single-channel LVDS means that one complete RGB pixel is transmitted per display input clock (also known as the shift clock – see Table 27 'LVDS Signal Descriptions' below for a summary of LVDS terms). Dual-channel LVDS means that two complete RGB pixels are transmitted per display input clock. The two pixels are adjacent along a display line. Dual-channel LVDS does not mean that two LVDS displays can be driven.

Each COM Express LVDS channel consists of four differential data pairs and a differential clock pair for a total of five differential pairs per channel. COM Express Modules and Module chipsets may not use all pairs. For example, with 18-bit TFT displays, only three of the four data pairs on the LVDS_A channel are used, along with the LVDS_A clock. The LVDS_B lines are not used. The manner in which RGB data is packed onto the LVDS pairs (including packing order and color depth) is not specified by the COM Express Specification. This may be Module-dependent. Further mapping details are given in Section 2.11.1.6. 'LVDS Display Color Mapping Tables' below.

There are five single-ended signals included to support the LVDS interface: two lines are used for an I2C interface that may be used to support EDID or other panel information and identification schemes. Additionally, there are an LVDS power enable (LVDS_VDD_EN) and backlight control and enable lines (LVDS_BKLT_CTRL and LVDS_BKLT_EN).

Table 27: LVDS Signal Descriptions

Signal	Pin	Description	I/O	Comment
LVDS_A0+ LVDS_A0-	A71 A72	LVDS channel A differential signal pair 0	O LVDS	
LVDS_A1+ LVDS_A1-	A73 A74	LVDS channel A differential signal pair 1	O LVDS	
LVDS_A2+ LVDS_A2-	A75 A76	LVDS channel A differential signal pair 2	O LVDS	
LVDS_A3+ LVDS_A3-	A78 A79	LVDS channel A differential signal pair 3	O LVDS	
LVDS_A_CK+ LVDS_A_CK-	A81 A82	LVDS channel A differential clock pair	O LVDS	
LVDS_B0+ LVDS_B0-	B71 B72	LVDS channel B differential signal pair 0	O LVDS	
LVDS_B1+ LVDS_B1-	B73 B74	LVDS channel B differential signal pair 1	O LVDS	
LVDS_B2+ LVDS_B2-	B75 B76	LVDS channel B differential signal pair 2	O LVDS	
LVDS_B3+ LVDS_B3-	B77 B78	LVDS channel B differential signal pair 3	O LVDS	
LVDS_B_CK+ LVDS_B_CK-	B81 B82	LVDS channel B differential clock pair	O LVDS	
LVDS_VDD_EN	A77	LVDS flat panel power enable.	O 3.3V, CMOS	
LVDS_BKLT_EN	B79	LVDS flat panel backlight enable high active signal	O 3.3V, CMOS	
LVDS_BKLT_CTRL	B83	LVDS flat panel backlight brightness control	O 3.3V, CMOS	
LVDS_I2C_CK	A83	DDC I2C clock signal used for flat panel detection and control.	O 3.3V, CMOS	
LVDS_I2C_DAT	A84	DDC I2C data signal used for flat panel detection and control.	I/O 3.3V, OD CMOS	

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2.11.1.1. Connector and Cable Considerations

When implementing LVDS signal pairs on a single-ended Carrier Board connector, the signals of a pair should be arranged so that the positive and negative signals are side by side. The trace lengths of the LVDS signal pairs between the COM Express Module and the connector on the Carrier Board should be the same as possible. Additionally, one or more ground traces/pins must be placed between the LVDS pairs.

Balanced cables (twisted pair) are usually better than unbalanced cables (ribbon cable) for noise reduction and signal quality. Balanced cables tend to generate less EMI due to field canceling effects and also tend to pick up electromagnetic radiation as common-mode noise, which is rejected by the receiver.

Twisted pair cables provide a low-cost solution with good balance and flexibility. They are capable of medium to long runs depending upon the application skew budget. A variety of shielding options are available.

Ribbon cables are a cost effective and easy solution. Even though they are not well suited for high-speed differential signaling they do work fine for very short runs. Most cables will work effectively for cable distances of <0.5m.

The cables and connectors that are to be utilized should have a differential impedance of 100Ω ±15%. They should not introduce major impedance discontinuities that cause signal reflections.

For more information about this subject, refer to the 'LVDS Owners Manual' available from Texas Instruments (http://www.ti.com).

2.11.1.2. Display Timing Configuration

The graphic controller needs to be configured to match the timing parameters of the attached flat panel display. To properly configure the controller, there needs to be some method to determine the display parameters. Different Module vendors provide differing ways to access display timing parameters. Some vendors store the data in non-volatile memory with the BIOS setup screen as the method for entering the data, other vendors might use a Module or Carrier based EEPROM. Some vendors might hard code the information into the BIOS, and other vendors might support panel located timing via the signals LVDS_I2C_CK and LVDS_I2C_DAT with an EEPROM strapped to 1010 000x. Regardless of the method used to store the panel timing parameters, the video BIOS will need to have the ability to access and decode the parameters. Given the number of variables it is recommended that Carrier designers contact Module suppliers to determine the recommend method to store and retrieve the display timing parameters.

The Video Electronics Standards Association (VESA) recently released DisplayID, a second generation display identification standard that can replace EDID and other proprietary methods for storing flat panel timing data. DisplayID defines a data structure which contains information such as display model, identification information, colorimetry, feature support, and supported timings and formats. The DisplayID data allows the video controller to be configured for optimal support for the attached display without user intervention. The basic data structure is a variable length block up to 256 bytes with additional 256 byte extensions as required. The DisplayID data is typically stored in a serial EPROM connected to the LVDS_I2C bus. The EPROM can reside on the display or Carrier. DisplayID is not backwards compatible with EDID. Contact VESA (www.vesa.org) for more information.

2.11.1.3. Backlight Control

Backlight inverters are either voltage, PWM or resistor controlled. The COM Express specification provides two methods for controlling the brightness. One method is to use the backlight control and enable signals from the CPU chipset. These signals are brought on COM Express LVDS_BKLT_EN and LVDS_BKLT_CTRL. LVDS_BKLT_CTRL is a Pulse Width Modulated (PWM) output that can be connected to display inverters that accept a PWM input. The second method it to use the LVDS I2C bus to control an I2C DAC. The output of the DAC can be used to support voltage controlled inverters. The DAC can be used driving the backlight voltage control input pin of the inverter. The reference design shown in Figure 34 on page 97 below supports this. A header is used to allow the user to configure the type of backlight inverter signal used. In the example a DAC from Maxim is used (MAX5362 http://www.maxim-ic.com).

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2.11.1.4. Color Mapping and Terms

FPD-Link and Open LDI Color Mapping

An LVDS stream consists of frames that pack seven data bits per LVDS frame. Details can be found in the tables below. The LVDS clock is one seventh of the source-data clock. The order in which panel data bits are packed into the LVDS stream is referred to as the LVDS color-mapping. There are two LVDS color-mappings in common use: FPD-Link and Open LDI. Open LDI is the newer standard.

The FPD-Link and Open LDI standards are the same for panels with color depths of 18 bits (6 Red, 6 Green, 6 Blue) or less. The 18 bits of color data and 3 bits of control data, or 21 bits total, are packed into 3 LVDS data streams. The LVDS clock is carried on a separate channel for a total of 4 LVDS pairs – 3 data pairs and a clock pair.

For 24-bit color depths, a 4th LVDS data pair is required (for a total of 5 LVDS pairs – 4 data and 1 clock). FPD-Link and Open LDI differ in this case. FPD-Link keeps the least significant color bits on the original 3 LVDS data pairs and adds the most significant color bits (the dominant or “most important” bits) to the 4th channel. Six bits are added: 2 Red, 2 Green, and 2 Blue (the seventh available bit slot in the 4th LVDS stream is not used).

A 24-bit, Open LDI implementation shifts the color bits on the original 3 LVDS data pairs up by two, such that the most significant color bits for both 18- and 24-bit panels occupy the same LVDS slots. For example, the most significant Red color bit is R5 for 18-bit panels and R7 for 24-bit panels. The 18-bit R5 and the 24-bit R7 occupy the same LVDS bit slot in Open LDI. The 4th LVDS data stream in Open LDI carries the least significant bits of a 24-bit panel – R0, R1, G0, G1, B0, and B1.

The advantage of Open LDI is that it provides an easier upgrade and downgrade path than FPD-Link does. An 18-bit panel can be used with an Open LDI 24-bit data stream by simply connecting the 1st three LVDS data pairs to the panel, and leaving the 4th LVDS data pair unused. This does not work with FPD-Link because the mapping for the 24-bit case is not compatible with the 18-bit case – the most significant data bits are on the 4th LVDS data stream.

If you design LVDS deserializers, work around the Module color-mapping by picking off the deserializer outputs in the order needed. If you use a flat panel with an integrated LVDS receiver, it is important that the displays color-mapping matches the Module’s color-mapping.

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Table 28: LVDS Display Terms and Definitions

Term	Definition
Color-Mapping	Color-mapping refers to the order in which display color bits and control bits are placed into the serial LVDS stream. Each LVDS data frame can accept seven bits. The way in which the bits are serialized into the stream is arbitrary, as long as they are de-serialized in a corresponding way. Two main color-mapping schemes are FPD-Link and Open LDI. They are the same for 18-bit panels but differ for 24-bit panels.
DE	Display Enable – a control signal that asserts during an active display line.
Dual Channel	In a dual-channel bit stream, two complete RGB pixels are transmitted with each shift clock. The shift clock is one half the pixel frequency in this case. Dual channel LVDS streams are either 8 differential pairs (6 data pairs, 2 clock pairs, for dual 18 bit streams) or 10 differential pairs (8 data pairs, 2 clock pairs, for dual 24-bit streams).
Even Pixel	A pixel from an even column number, counting from 1. For example, on an 800x600 display, the even pixels along a row are in columns 2,4 … 800. The odd pixels are in columns 1,3,5 … 799.
FPD-Link	Flat Panel Display Link – an LVDS color-mapping scheme popularized by National Semiconductor. FPD Link color-mapping is the same as open LDI color-mapping for 18-bit displays but is different for 24-bit displays. FPD color-mapping puts the most significant bits of a 24-bit display onto the 4th LVDS channel.
HSYNC	Horizontal Sync – a control signal that occurs once per horizontal display line.
LCLK	LVDS clock – the low voltage differential clock that accompanies the serialized LVDS data stream. For a single-channel LVDS stream, the LVDS clock is 1/7th the pixel clock, which means there is one LVDS clock period for every 7 pixel clock periods. For a dual-channel LVDS data stream, the LVDS clock is 1/14th the pixel clock, which means there is one LVDS clock period for every 14-pixel clock periods.
Odd Pixel	A pixel from an odd column number, counting from 1. For example, on an 800x600 display, the odd pixels along a row are in columns 1,3,5, … 799. The even pixels are in columns 2,4 …800.
Open LDI	Open LVDS Display Interface – a formalization by National Semiconductor of de facto LVDS standards. See Appendix G for a reference to the standard. Open LDI color-mapping is the same as FPD-Link color-mapping for 18-bit displays, but is different for 24-bit displays. Open LDI color-mapping puts the least significant bits of a 24-bit display onto the 4th LVDS channel. Doing so means that an 18-bit display can operate on a 24-bit Open LDI link by using the first 3 LVDS data channels.
PCLK	Pixel clock – the clock associated with a single display pixel. For example, on a 640x480 display, there are 640 pixel clocks during the active display line period (and additional pixel clocks during the blanking periods). For a single-channel TFT display, the pixel clock is the same as the shift clock. For a dual-channel TFT display, the pixel clock is twice the frequency of the shift clock.
SCLK	Shift clock – the clock that shifts either a single pixel or a group of pixels into the display, depending on the display type. For a single-channel TFT display, the shift clock is the same as the pixel clock. For a dual-channel TFT display, the shift clock period is twice the pixel clock. For some display types, such as passive STN displays, the shift clock may be four- or eight-pixel clocks.
Single Channel	In a single-channel bit stream, a single RGB pixel is transmitted with each shift clock. The shift clock and the pixel clock are the same in this case. Single-channel LVDS streams are either 4 differential pairs (3 data pairs, 1 clock pair, for a single 18 bit stream) or 5 differential pairs (4 data pairs, 1 clock pair, for a single 24-bit stream).
Transmit Bit Order	The order, in time, in which bits are placed into the seven bit slots per LVDS frame. Bit 1 is earlier in time than bit 2, etc.
Unbalanced	Unbalanced means that the LVDS serializing hardware does not insert or manipulate bits to achieve a DC balance – i.e. an equal number of 0 and 1 bits, when averaged over multiple frames.
VSYNC	Vertical Sync – a control signal that occurs once per display frame.
Xmit Bit Order	See Transmit Bit Order.

2.11.1.5. Note on Industry Terms

Some terms in this document that describe LVDS displays may vary from other documents (such as display data sheets from vendors, IC data sheets for graphics controllers and LVDS transmitters and receivers, the Open LDI specification, and COM Express Module documentation).

Examples of terms that may vary include:

For dual-channel displays, terms are needed to describe the adjacent pixels.

Various documents will reference for the same pair of pixels:

Odd and Even pixels (column count starts at 1)

Even and Odd pixels (column count starts at 0)

R10 and R20 for adjacent least significant Red bits

R00 and R10 for adjacent least significant Red bits

Terms used to describe the clocks vary:

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The Open LDI specification uses the term “pixel clock” differently from most other documents. In the Open LDI specification, the “pixel clock” period is seven pixel periods long. Most other documents refer to this concept as the “LVDS clock.”

Transmit Bit Order

In this document, the seven bits in an LVDS frame are numbered 1 – 7, with Bit 1 being placed into the stream before Bit 2.

Display terms used in this document are defined in Table 28 above.

2.11.1.6. LVDS Display Color Mapping Tables

LVDS display color-mappings for single- and dual-channel displays are shown in Table 29 and Table 30 below.

For single-channel displays, COM Express Module LVDS B pairs are not used and may be left open. For single-channel, 18-bit displays, the LVDS_A3± channel is not used and may be left open.

For 18-bit, single-channel and 36-bit, dual-channel displays, the FPD-Link and Open LDI color-mappings are the same. For 24-bit, single-channel and 48-bit, dual-channel displays, mappings differ and care must be taken that the Module and display LVDS color-mappings agree.

Table 29: LVDS Display: Single Channel, Unbalanced Color-Mapping

	Xmit Bit Order	LVDS Clock	Open LDI 18 bit Single Ch	Open LDI 24 bit Single Ch	FPD Link 18 bit Single Ch	FPD Link 24 bit Single Ch
LVDS_A0±	1	1	G0	G2	G0	G0
	2	1	R5	R7	R5	R5
	3	0	R4	R6	R4	R4
	4	0	R3	R5	R3	R3
	5	0	R2	R4	R2	R2
	6	1	R1	R3	R1	R1
	7	1	R0	R2	R0	R0
LVDS_A1±	1	1	B1	B3	B1	B1
	2	1	B0	B2	B0	B0
	3	0	G5	G7	G5	G5
	4	0	G4	G6	G4	G4
	5	0	G3	G5	G3	G3
	6	1	G2	G4	G2	G2
	7	1	G1	G3	G1	G1
LVDS_A2±	1	1	DE	DE	DE	DE
	2	1	VSYNC	VSYNC	VSYNC	VSYNC
	3	0	HSYNC	HSYNC	HSYNC	HSYNC
	4	0	B5	B7	B5	B5
	5	0	B4	B6	B4	B4
	6	1	B3	B5	B3	B3
	7	1	B2	B4	B2	B2
LVDS_A3±	1	1				
	2	1		B1		B7
	3	0		B0		B6
	4	0		G1		G7
	5	0		G0		G6
	6	1		R1		R7
	7	1		R0		R6
LVDS_A_CK±			LCLK = PCLK / 7 SCLK = PCLK	LCLK= PCLK / 7 SCLK = PCLK	LCLK = PCLK / 7 SCLK = PCLK	LCLK = PCLK / 7 SCLK = PCLK

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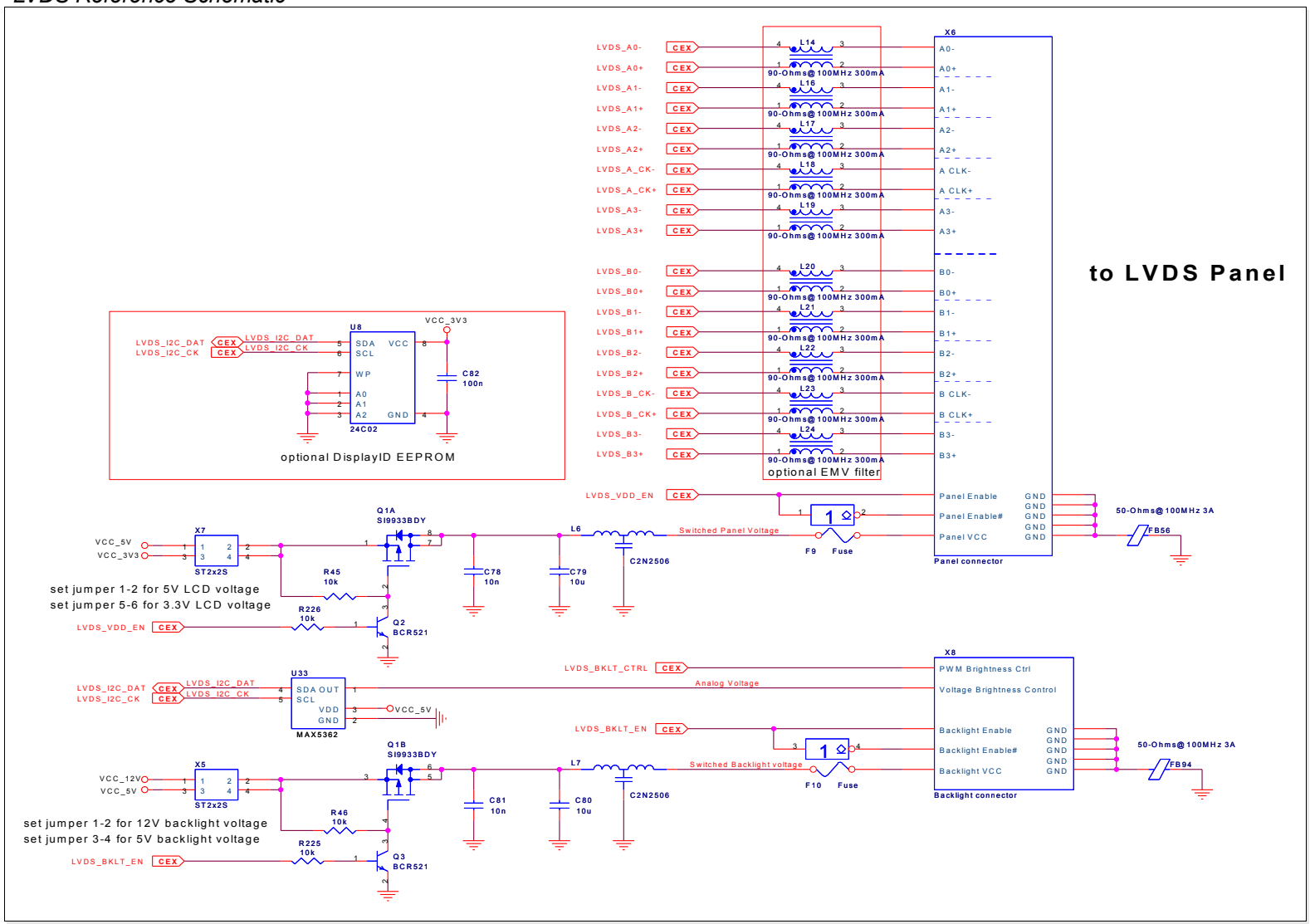
Table 30: LVDS Display: Dual Channel, Unbalanced Color-Mapping

	Xmit Bit Order	LVDS Clock	Open LDI 18 bit (36 bit) Dual Ch	Open LDI 24 bit (48 bit) Dual Ch	FPD Link 18 bit (36 bit) Dual Ch	FPD Link 24 bit (48 bit) Dual Ch
LVDS_A0±	1	1	Odd Pixel G0	Odd Pixel G2	Odd Pixel G0	Odd Pixel G0
	2	1	Odd Pixel R5	Odd Pixel R7	Odd Pixel R5	Odd Pixel R5
	3	0	Odd Pixel R4	Odd Pixel R6	Odd Pixel R4	Odd Pixel R4
	4	0	Odd Pixel R3	Odd Pixel R5	Odd Pixel R3	Odd Pixel R3
	5	0	Odd Pixel R2	Odd Pixel R4	Odd Pixel R2	Odd Pixel R2
	6	1	Odd Pixel R1	Odd Pixel R3	Odd Pixel R1	Odd Pixel R1
	7	1	Odd Pixel R0	Odd Pixel R2	Odd Pixel R0	Odd Pixel R0
LVDS_A1±	1	1	Odd Pixel B1	Odd Pixel B3	Odd Pixel B1	Odd Pixel B1
	2	1	Odd Pixel B0	Odd Pixel B2	Odd Pixel B0	Odd Pixel B0
	3	0	Odd Pixel G5	Odd Pixel G7	Odd Pixel G5	Odd Pixel G5
	4	0	Odd Pixel G4	Odd Pixel G6	Odd Pixel G4	Odd Pixel G4
	5	0	Odd Pixel G3	Odd Pixel G5	Odd Pixel G3	Odd Pixel G3
	6	1	Odd Pixel G2	Odd Pixel G4	Odd Pixel G2	Odd Pixel G2
	7	1	Odd Pixel G1	Odd Pixel G3	Odd Pixel G1	Odd Pixel G1
LVDS_A2±	1	1	DE	DE	DE	DE
	2	1	VSYNC	VSYNC	VSYNC	VSYNC
	3	0	HSYNC	HSYNC	HSYNC	HSYNC
	4	0	Odd Pixel B5	Odd Pixel B7	Odd Pixel B5	Odd Pixel B5
	5	0	Odd Pixel B4	Odd Pixel B6	Odd Pixel B4	Odd Pixel B4
	6	1	Odd Pixel B3	Odd Pixel B5	Odd Pixel B3	Odd Pixel B3
	7	1	Odd Pixel B2	Odd Pixel B4	Odd Pixel B2	Odd Pixel B2
LVDS_A3±	1	1				
	2	1		Odd Pixel B1		Odd Pixel B7
	3	0		Odd Pixel B0		Odd Pixel B6
	4	0		Odd Pixel G1		Odd Pixel G7
	5	0		Odd Pixel G0		Odd Pixel G6
	6	1		Odd Pixel R1		Odd Pixel R7
	7	1		Odd Pixel R0		Odd Pixel R6
LVDS_A_CK±			LCLK= PCLK / 14 SCLK = PCLK / 2	LCLK = PCLK / 14 SCLK = PCLK / 2	LCLK= PCLK / 14 SCLK = PCLK / 2	LCLK = PCLK / 14 SCLK = PCLK / 2
LVDS_B0±	1	1	Even Pixel G0	Even Pixel G2	Even Pixel G0	Even Pixel G0
	2	1	Even Pixel R5	Even Pixel R7	Even Pixel R5	Even Pixel R5
	3	0	Even Pixel R4	Even Pixel R6	Even Pixel R4	Even Pixel R4
	4	0	Even Pixel R3	Even Pixel R5	Even Pixel R3	Even Pixel R3
	5	0	Even Pixel R2	Even Pixel R4	Even Pixel R2	Even Pixel R2
	6	1	Even Pixel R1	Even Pixel R3	Even Pixel R1	Even Pixel R1
	7	1	Even Pixel R0	Even Pixel R2	Even Pixel R0	Even Pixel R0
LVDS_B1±	1	1	Even Pixel B1	Even Pixel B3	Even Pixel B1	Even Pixel B1
	2	1	Even Pixel B0	Even Pixel B2	Even Pixel B0	Even Pixel B0
	3	0	Even Pixel G5	Even Pixel G7	Even Pixel G5	Even Pixel G5
	4	0	Even Pixel G4	Even Pixel G6	Even Pixel G4	Even Pixel G4
	5	0	Even Pixel G3	Even Pixel G5	Even Pixel G3	Even Pixel G3
	6	1	Even Pixel G2	Even Pixel G4	Even Pixel G2	Even Pixel G2
	7	1	Even Pixel G1	Even Pixel G3	Even Pixel G1	Even Pixel G1
LVDS_B2±	1	1				
	2	1				
	3	0				
	4	0	Even Pixel B5	Even Pixel B7	Even Pixel B5	Even Pixel B5
	5	0	Even Pixel B4	Even Pixel B6	Even Pixel B4	Even Pixel B4
	6	1	Even Pixel B3	Even Pixel B5	Even Pixel B3	Even Pixel B3
	7	1	Even Pixel B2	Even Pixel B4	Even Pixel B2	Even Pixel B2
LVDS_B3±	1	1				
	2	1		Even Pixel B1		Even Pixel B7
	3	0		Even Pixel B0		Even Pixel B6
	4	0		Even Pixel G1		Even Pixel G7
	5	0		Even Pixel G0		Even Pixel G6
	6	1		Even Pixel R1		Even Pixel R7
	7	1		Even Pixel R0		Even Pixel R6
LVDS_B_CK±			LCLK= PCLK / 14 SCLK = PCLK / 2	LCLK = PCLK / 14 SCLK = PCLK / 2	LCLK= PCLK / 14 SCLK = PCLK / 2	LCLK = PCLK / 14 SCLK = PCLK / 2

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2.11.2. Reference Schematics

Figure 34: LVDS Reference Schematic



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2.11.3. Routing Considerations

Route LVDS signals as differential pairs (excluding the five single-ended support signals), with a 100-Ω differential impedance and a 55-Ω, single-ended impedance. Ideally, a LVDS pair is routed on a single layer adjacent to a ground plane. LVDS pairs should not cross plane splits. Keep layer transitions to a minimum. Reference LVDS pairs to a power plane if necessary. The power plane should be well-bypassed.

Length-matching between the two lines that make up an LVDS pair (“intra-pair”) and between different LVDS pairs (“inter-pair”) is required. Intra-pair matching is tighter than the inter-pair matching.

All LVDS pairs should have the same environment, including the same reference plane and the same number of vias.

LVDS routing rules are summarized in 6.5.9. 'LVDS Trace Routing Guidelines' on page 189 below.

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2.12. Embedded DisplayPort (eDP)

Embedded DisplayPort (eDP) is a digital display interface standard produced by the Video Electronics Standards Association (VESA) for digital interconnect of Audio and Video.

Embedded DisplayPort defines a standardized display panel interface for internal connections; e.g., graphics interfaces to notebook display panels. It supports advanced power-saving features including seamless refresh rate switching, display panel and backlight control protocol that works through the AUX channel, and Panel Self-Refresh (PSR) feature developed to save system power and further extend battery life in portable PC systems. PSR mode allows the GPU to enter power saving states in between frame updates by including framebuffer memory in the display panel controller.

Embedded DisplayPort is intended to replace LVDS as the interface to flat panel displays integrated into a product. Unlike DisplayPort, embedded DisplayPort does not define a specific connector or pin-out. The COM Express specification shares the LVDS pins with embedded DisplayPort.

2.12.1. Signal Definitions

eDP is available in Type 6 and type 10 pin-outs as an alternative to the LVDS A channel. The Module can provide LVDS only, eDP only or Dual-Mode for both interfaces. Please refer to relevant Module documentation for the supported interfaces.

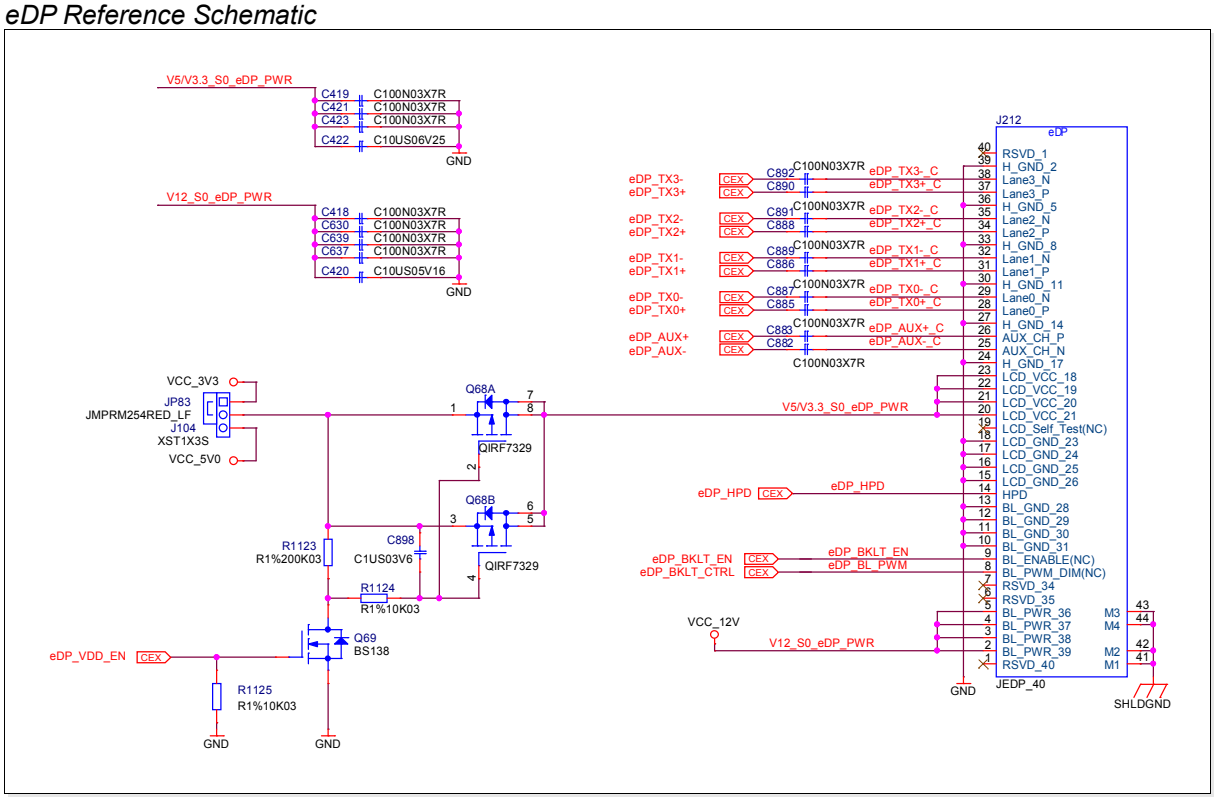
Table 31: eDP Signal Description

Signal	Pins T6/T10	Description	I/O
eDP_TX0+	A75	eDP lane 0, TX +	O PCIe
eDP_TX0-	A76	eDP lane 0, TX -	O PCIe
eDP_TX1+	A73	eDP lane 1, TX +	O PCIe
eDP_TX1-	A74	eDP lane 1, TX -	O PCIe
eDP_TX2+	A71	eDP lane 2, TX +	O PCIe
eDP_TX2-	A72	eDP lane 2, TX -	O PCIe
eDP_TX3+	A81	eDP lane 3, TX +	O PCIe
eDP_TX3-	A82	eDP lane 3, TX -	O PCIe
eDP_VDD_EN	A77	eDP power enable	O CMOS
eDP_BLKT_EN	B79	eDP backlight enable	O CMOS
eDP_BLKT_CTRL	B83	EDP backlight brightness control	O CMOS
eDP_AUX+	A83	eDP auxiliary lane +	I/O PCIe
eDP_AUX-	A84	eDP auxiliary lane -	I/O PCIe
eDP_HPD	A87	Detection of Hot Plug / Unplug and notification of the link layer	I CMOS

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2.12.2. Reference Schematics

Figure 35: eDP Reference Schematic



The reference schematic provides a generic eDP interface. The eDP connector used in the design is an example only. Other connectors can be used based on the design requirements. JP83 selects 3.3 or 5V for the panel power. R1125 ensures that panel power is disabled when the Module is powering up and before the signal is actively driven. The panel control signals eDP_BKLT_EN, eDP_BKLT_CTRL as well as eDP_HPD are 3.3V level signals, check your panel specifications for correct voltage levels and provide translation if necessary. The reference design supports individual backlight control signals. It should be noted that some panels handle these functions over the AUX channel.

2.12.3. Routing Considerations

The traces from JP83 and associated FETs to the eDP connector carry power to the panel. The traces should be routed with appropriate thickness to handle the current expected.

eDP_TX and eDP_AUX differential pairs should be routed as high speed differential pairs.

The panel control signals are low speed and do not require any additional care.

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2.13. VGA

2.13.1. Signal Definitions

The COM Express Specification defines an analog VGA RGB interface for all Module types, except type 10. The interface consists of three analog color signals (Red, Green, Blue); digital Horizontal and Vertical Sync signals as well as a dedicated I2C bus for Display Data Control (DDC) implementation for monitor capability identification. The corresponding signals can be found on the COM Express Module connector row B.

Table 32: VGA Signal Description

Signal	Pin	HDSUB15	Description	I/O	Comment
VGA_RED	B89	1	Red component of analog DAC monitor output, designed to drive a 37.5Ω equivalent load.	O Analog	Analog output
VGA_GRN	B91	2	Green component of analog DAC monitor output, designed to drive a 37.5Ω equivalent load.	O Analog	Analog output
VGA_BLU	B92	3	Blue component of analog DAC monitor output, designed to drive a 37.5Ω equivalent load.	O Analog	Analog output
VGA_HSYNC	B93	13	Horizontal sync output to VGA monitor.	O 3.3V CMOS	
VGA_VSYNC	B94	14	Vertical sync output to VGA monitor.	O 3.3V CMOS	
VGA_I2C_CK	B95	15	DDC clock line (I2C port dedicated to identify VGA monitor capabilities).	O 3.3V CMOS	Level shifter might be necessary
VGA_I2C_DAT	B96	12	DDC data line.	I/O 3.3V CMOS	Level shifter might be necessary
GND		5..8, 10	Analog and Digital GND		
DDC_POWER		9	5V DDC supply voltage for monitor EEPROM		Power
N.C.		4, 11	Not Connected		

2.13.2. VGA Connector

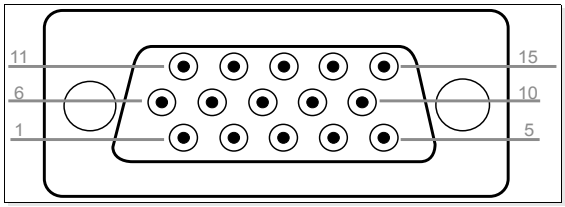


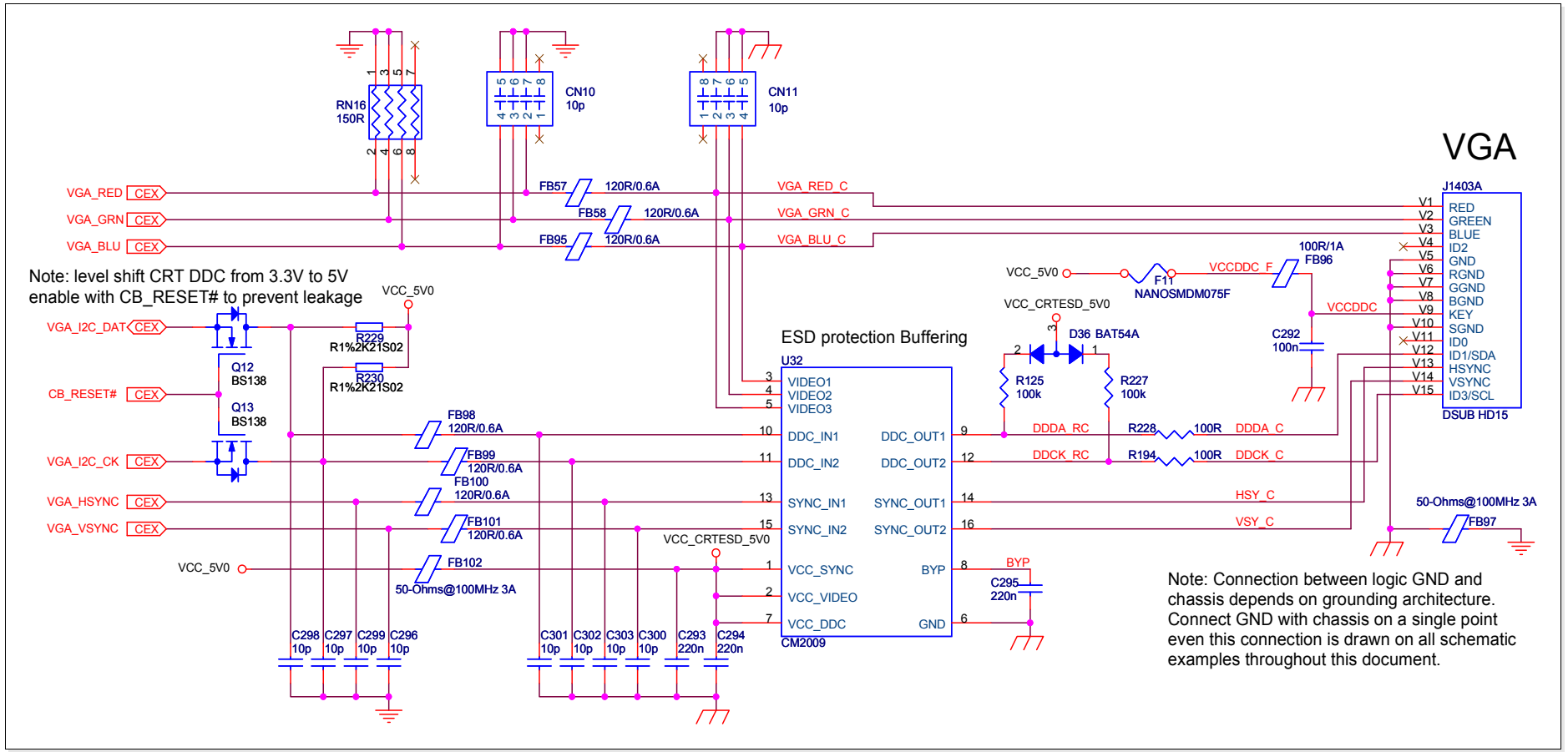
Figure 36: Female VGA Connector HDSUB15 for Carrier Board

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2.13.3. VGA Reference Schematics

This reference schematic shows a circuitry implementing a VGA port.

Figure 37: VGA Reference Schematics



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2.13.4. Routing Considerations

2.13.4.1. RGB Analog Signals

The RGB signal interface of the COM Express Module consists of three identical 8-bit digital-to-analog converter (DAC) channels. One each for the red, green, and blue components of the monitor signal. Each of these channels should have a 150Ω ±1% pull-down resistor connected from the DAC output to the Carrier Board ground. A second 150Ω ±1% termination resistor exists on the COM Express Module itself. An additional 75Ω termination resistor exists within the monitor for each analog DAC output signal.

Since the DAC runs at speeds up to 350MHz, special attention should be paid to signal integrity and EMI. There should be a PI-filter placed on each RGB signal that is used to reduce high-frequency noise and EMI. The PI-filter consists of two 10pF capacitors with a 120Ω @ 100MHz ferrite bead between them. It is recommended to place the PI-filters and the terminating resistors as close as possible to the standard VGA connector.

2.13.4.2. HSYNC and VSYNC Signals

The horizontal and vertical sync signals 'VGA_HSYNC' and 'VGA_VSYNC' provided by the COM Express Module are 3.3V tolerant outputs. Since VGA monitors may drive the monitor sync signals with 5V tolerance, it is necessary to implement high impedance unidirectional buffers. These buffers prevent potential electrical over-stress of the Module and avoid that VGA monitors may attempt to drive the monitor sync signals back to the Module.

For optimal ESD protection, additional low capacitance clamp diodes should be implemented on the monitor sync signals. They should be placed between the 5V power plane and ground and as close as possible to the VGA connector.

2.13.4.3. DDC Interface

COM Express provides a dedicated I2C bus for the VGA interface. It corresponds to the VESA™ defined DDC interface that is used to read out the CRT monitor specific Extended Display Identification Data (EDID™). The appropriate signals 'VGA_I2C_DAT' and 'VGA_I2C_CK' of the COM Express Module are supposed to be 3.3V tolerant. Since most VGA monitors drive the internal EDID™ EEPROM with a supply voltage of 5V, the DDC interface on the VGA connector must also be sourced with 5V. This can be accomplished by placing a 100kΩ pull-up resistors between the 5V power plane and each DDC interface line. Level shifters for the DDC interface signals are required between the COM Express Module signal side and the signals on the standard VGA connector on the Carrier Board.

Additional Schottky diodes must be placed between 5V and the pull-up resistors of the DDC signals to avoid backward current leakage during Suspend operation of the Module.

2.13.4.4. ESD Protection/EMI

All VGA signals need ESD protection and EMI filters. This can be provided by using a VGA port companion circuit or similar protective components. The Carrier Board sample VGA schematic shown above uses a “VGA companion” protection circuit, the CM2009 from California Micro Devices. The companion circuit implements ESD protection for the analog DAC output, DDC and SYNC signals through the use of low-capacitance current steering diodes. Additionally, it incorporates level shifting for the DDC signals and buffering for the SYNC signals. For more details, refer to the 'CM2009' data sheet.

Many other protection and level shifting solutions are possible. Semtech offers a wide variety of low capacitance ESD suppression parts suitable for high speed signals. One such Semtech part is the RCLAMP502B.

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2.14. TV-Out

TV-Out signals have been removed in COM.0 Rev. 2.0 and the former content of this chapter can still be found in the section Appendix A: Deprecated Features on page 203

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2.15. Digital Audio Interfaces

The COM Express Specification allocates seven pins on the A-B connector to support digital AC'97 and HD interfaces to audio Codecs on the Carrier Board. The pins are available on all Module types. High-definition (HD) audio uses the same digital-signal interface as AC '97 audio. Codecs for AC '97 and HD Audio are different and not compatible. Current Module chipsets support HD Audio only.

Signal Definitions

Table 33: Audio Codec Signal Descriptions

Signal	Pin	Description	I/O	Comment
AC/HDA_RST#	A30	CODEC Reset.	O 3.3V Suspend CMOS	
AC/HDA_SYNC	A29	Serial Sample Rate Synchronization.	O 3.3V CMOS	
AC/HDA_BITCLK	A32	24 MHz Serial Bit Clock for HDA CODEC.	O 3.3V CMOS	
AC/HDA_SDOUT	A33	Audio Serial Data Output Stream.	O 3.3V CMOS	
AC/HDA_SDIN0 AC/HDA_SDIN1 AC/HDA_SDIN2	B30 B29 B28	Audio Serial Data Input Stream from CODEC[0:2].	I 3.3V Suspend CMOS	

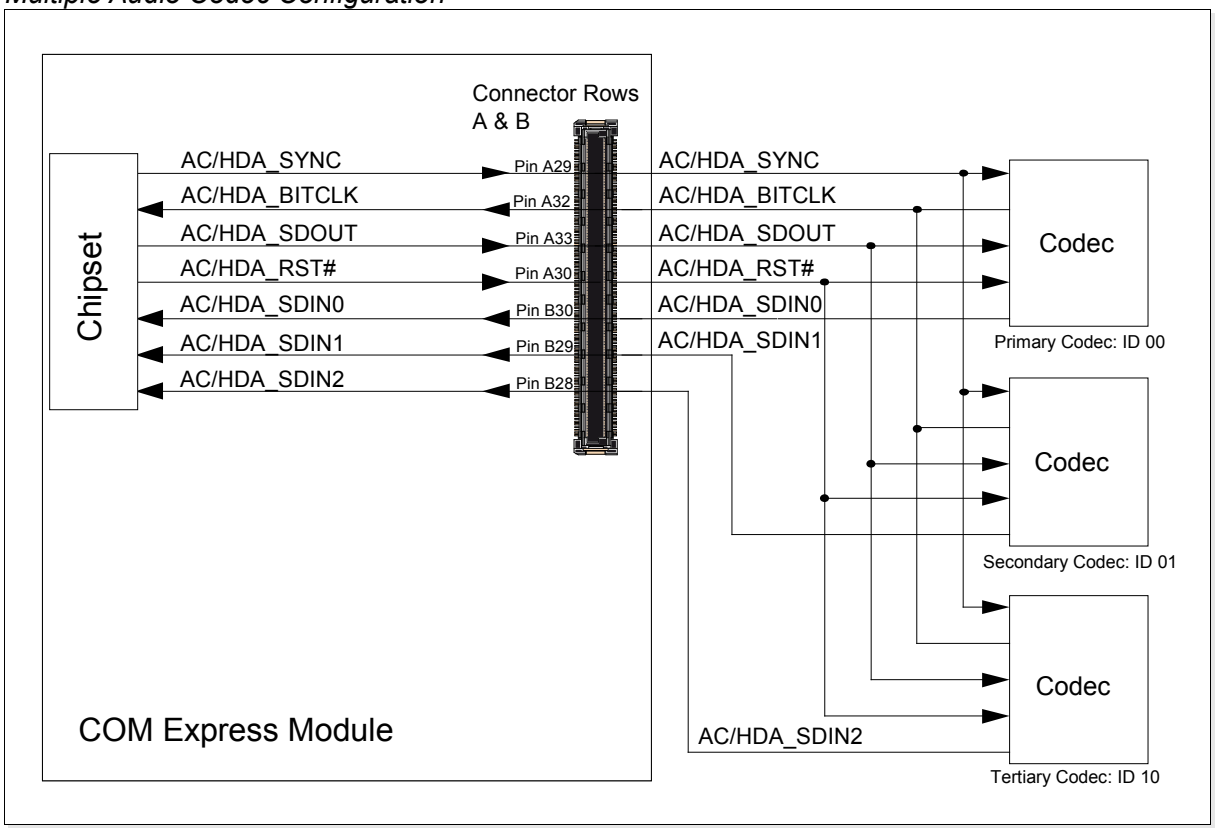
The codec on a COM Express Carrier Board is usually connected as the primary codec with the codec ID 00 using the data input line 'AC/HDA_SDIN0'. Up to two additional codecs with ID 01 and ID 10 can be connected to the COM Express Module by using the other designated signals 'AC/HDA_SDIN1' and 'AC/HDA_SDIN2'.

Connect the primary audio codec to the serial data input signal 'AC/HDA_SDIN0' and ensure that the corresponding bit clock input signal 'AC/HDA_BITCLK' is connected to the AC'97/HDA interface of the COM Express Module.

Clocking over the signal 'AC/HDA_BITCLK' is derived from a 24.576 MHz crystal or crystal oscillator provided by the primary codec in AC97 implementations. The crystal is not required in HDA implementations. This clock also drives the second and the third audio codec if more than one codec is used in the application. For crystal or crystal oscillator requirements, refer to the datasheet of the primary codec.

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Figure 38: Multiple Audio Codec Configuration

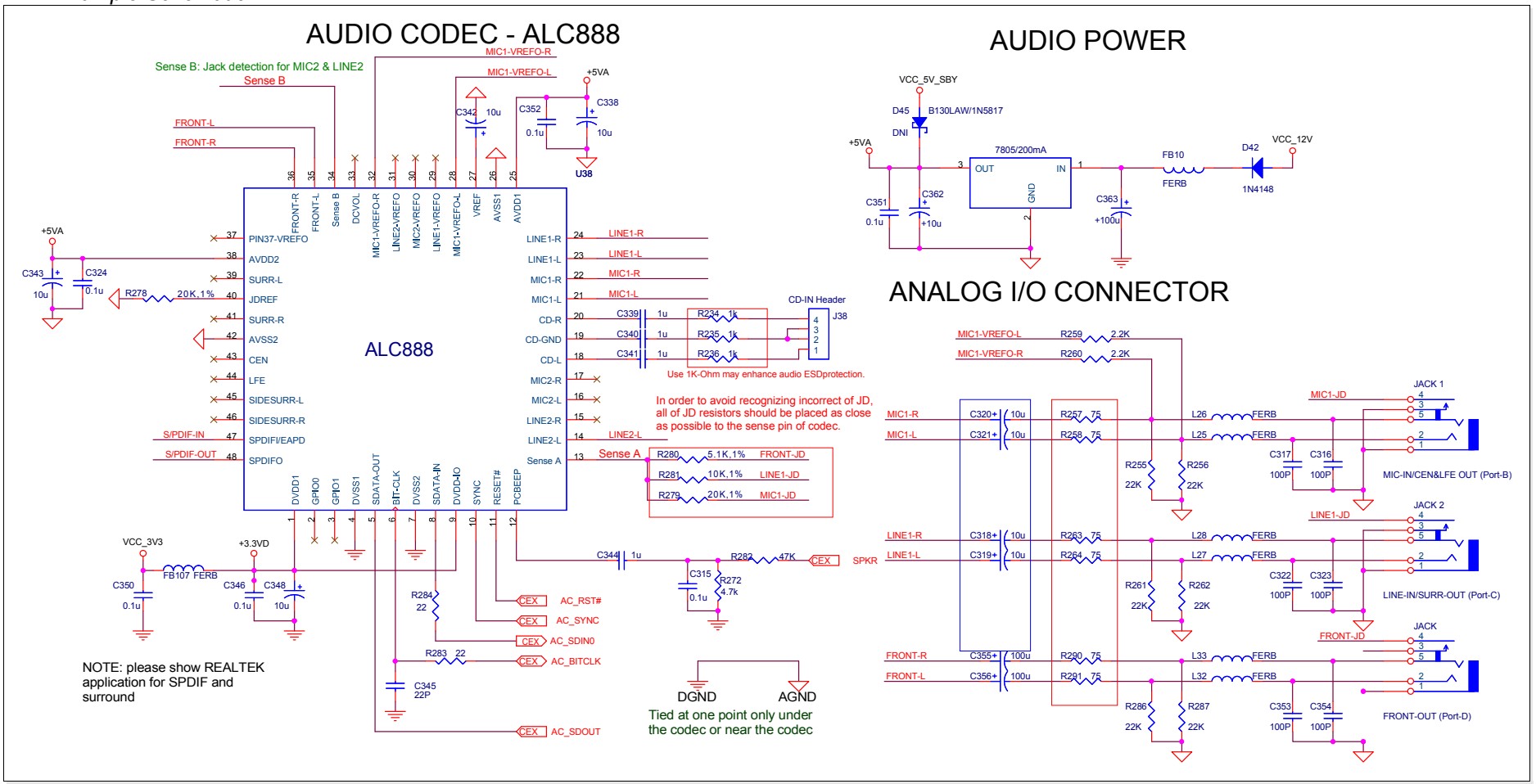


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2.15.1. Reference Schematics

2.15.1.1. High Definition Audio

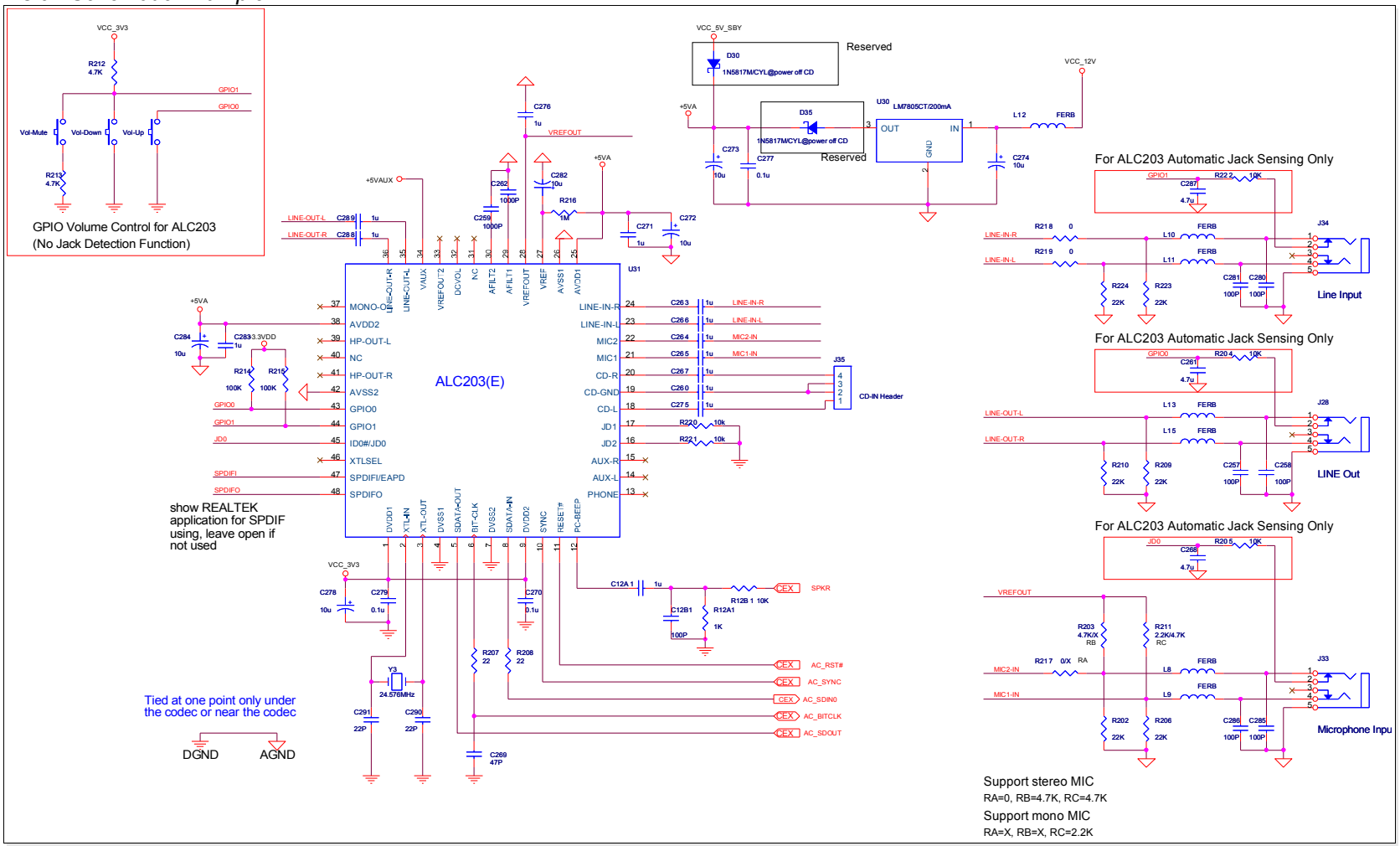
Figure 39: HDA Example Schematic



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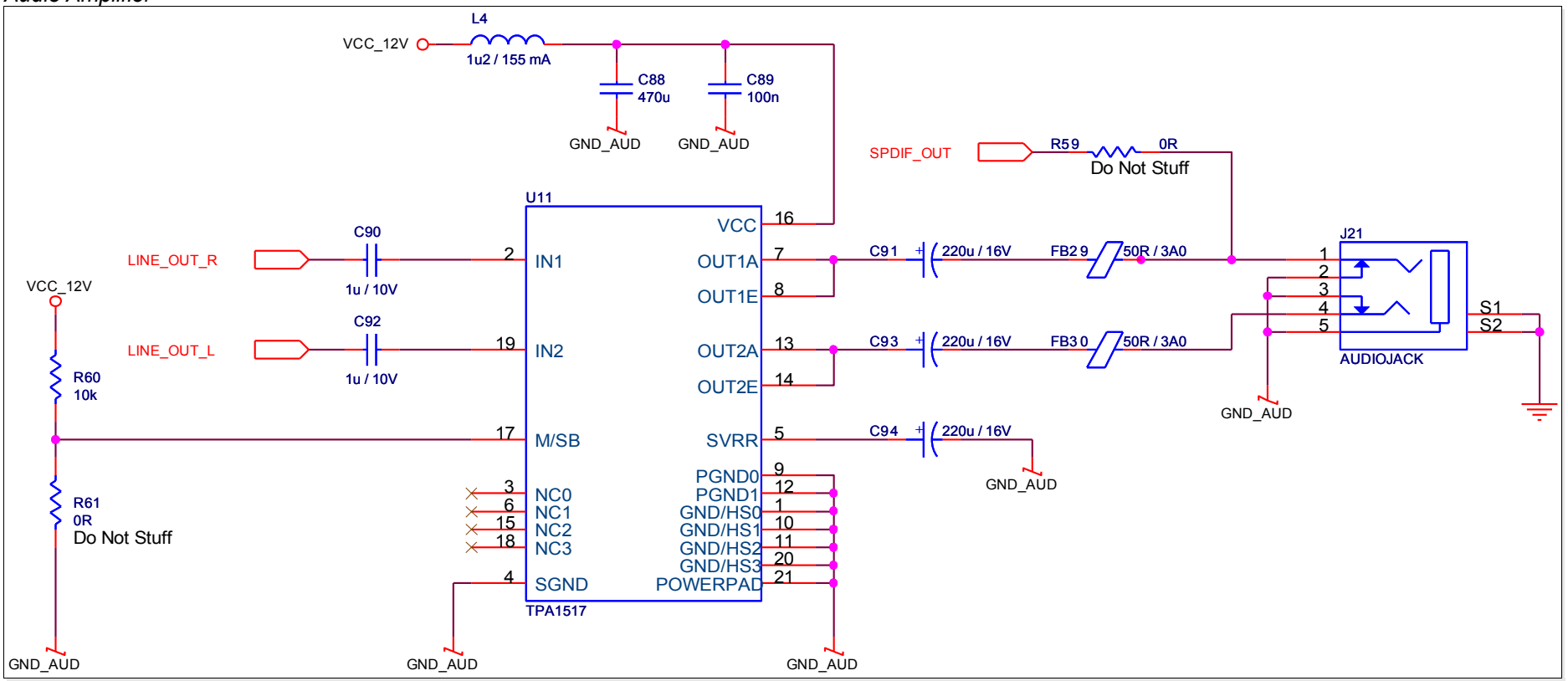
2.15.1.2. AC'97

Figure 40: AC'97 Schematic Example



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Figure 41: Audio Amplifier



The example above shows a traditional class AB amplifier. There are many physically smaller and more power efficient class D audio amplifier options from vendors such as Texas Instruments, NXP and others.

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2.15.1.3. Routing Considerations

The implementation of proper component placement and routing techniques will help to ensure that the maximum performance available from the codec is achieved. Routing techniques that should be observed include properly isolating the codec, associated audio circuitry, analog power supplies and analog ground planes from the rest of the Carrier Board. This includes split planes and the proper routing of signals not associated with the audio section.

The following is a list of basic recommendations:

Traces must be routed with a target impedance of 55Ω with an allowed tolerance of ±15%.

Ground return paths for the analog signals must be given special consideration.

Digital signals routed in the vicinity of the analog audio signals must not cross the power plane split lines. Locate the analog and digital signals as far as possible from each other.

Partition the Carrier Board with all analog components grouped together in one area and all digital components in another.

Keep digital signal traces, especially the clock, as far as possible from the analog input and voltage reference pins.

Provide separate analog and digital ground planes with the digital components over the digital ground plane, and the analog components, including the analog power regulators, over the analog ground plane. The split between the planes must be a minimum of 0.05 inch wide.

Route analog power and signal traces over the analog ground plane.

Route digital power and signal traces over the digital ground plane.

Position the bypassing and decoupling capacitors close to the IC pins with wide traces to reduce impedance.

Place the crystal or oscillator (depending on the codec used) as close as possible to the codec. (HDA implementations generally do not require a crystal at the codec)

Do not completely isolate the analog/audio ground plane from the rest of the Carrier Board ground plane. Provide a single point (0.25 inch to 0.5 inch wide) where the analog/isolated ground plane connects to the main ground plane. The split between the planes must be a minimum of 0.05 inch wide.

Any signals entering or leaving the analog area must cross the ground split in the area where the analog ground is attached to the main Carrier Board ground. That is, no signal should cross the split/gap between the ground planes, because this would cause a ground loop, which in turn would greatly increase EMI emissions and degrade the analog and digital signal quality.

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2.16. LPC Bus – Low Pin Count Interface

Since COM Express is designed to be a legacy free standard for embedded Modules, it does not support legacy functionality on the Module, such as PS/2 keyboard/mouse, serial ports, and parallel ports. Instead, it provides an LPC interface that can be used to add peripheral devices to the Carrier Board design. COM Express also provides interface pins necessary for (optional) Carrier Board resident PS keyboard controllers

The Low Pin Count Interface was defined by the Intel® Corporation to facilitate the industry's transition toward legacy free systems. It allows the integration of low-bandwidth legacy I/O components within the system, which are typically provided by a Super I/O controller. Furthermore, it can be used to interface Firmware Hubs, Trusted Platform Module (TPM) devices, general-purpose inputs and outputs, and Embedded Controller solutions. Data transfer on the LPC bus is implemented over a 4 bit serialized data interface, which uses a 33MHz LPC bus clock. It is straightforward to develop PLDs or FPGAs that interface to the LPC bus. A PLD circuit example is given in Figure 43 'LPC PLD Example – Port 80 Decoder Schematic' below.

For more information about LPC bus, refer to the 'Intel® Low Pin Count Interface Specification Revision 1.1'.

2.16.1. Signal Definition

Table 34: LPC Interface Signal Descriptions

Signal	Pin	Description	I/O	Comment
LPC_SERIRQ	A50	LPC serialized IRQ.	I/O 3.3V CMOS	
LPC_FRAME#	B3	LPC frame indicates start of a new cycle or termination of a broken cycle.	O 3.3V CMOS	
LPC_AD0 LPC_AD1 LPC_AD2 LPC_AD3	B4 B5 B6 B7	LPC multiplexed command, address and data.	I/O 3.3V CMOS	
LPC_DRQ0# LPC_DRQ1#	B8 B9	LPC encoded DMA/Bus master request.	I 3.3V CMOS	Not all Modules support LPC DMA. Contact your vendor for information.
LPC_CLK	B10	LPC clock output 33MHz.	O 3.3V CMOS	

Note ***Implementing external LPC devices on the COM Express Carrier Board always requires customization of the COM Express Module's BIOS in order to support basic initialization for those LPC devices. Otherwise the functionality of the LPC devices will not be supported by a Plug&Play or ACPI capable system. See Section 4 'BIOS Considerations' on page 170 below for further information. Contact your Module vendor for a list of specific SIO devices for which there may be BIOS support.***

2.16.2. LPC Bus Reference Schematics

2.16.2.1. LPC Bus Clock Signal

COM Express specifies a single LPC reference clock signal called 'LPC_CLK' on the Modules connector at row B pin B10. Newer chipsets do not provide a free running LPC_CLK. The clock is stopped and started on-the-fly. The clock is only active during LPC bus cycles. This kind of a clock can cause problems when used with PLL based zero delay buffers which require a number of clock cycles to lock onto the incoming clock before the output is active. The issue is that the LPC_CLK is not active for enough cycles before the data is read/written to the LPC bus. The result is that the target LPC device does not see an LPC_CLK and misses the LPC cycle.

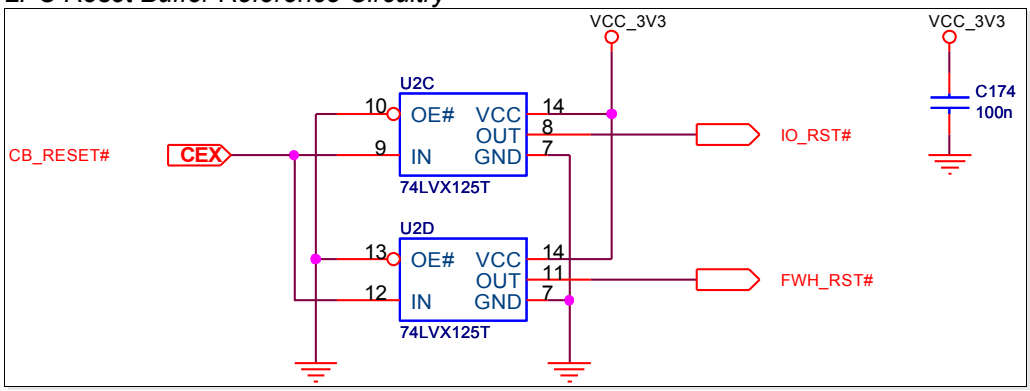
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Carrier designers should not buffer LPC_CLK for maximum Module interoperability. The COM Express specification intends for a single load on the clock but experience has shown that two devices can be driven if both devices are within 2" of each other.

2.16.2.2. LPC Reset Signal

The LPC interface should use the signal 'CB_RESET#' as its reset input. This signal is issued by the COM Express Module as a result of a low 'SYS_RESET#', a low 'PWR_OK' or a watchdog timeout event. If there are multiple LPC devices implemented on the Carrier Board, it is recommended to split the signal 'CB_RESET#' so that each LPC device will be provided with a separate reset signal. Therefore a buffer circuit like the one shown in Figure 42 below should be used.

Figure 42: LPC Reset Buffer Reference Circuitry

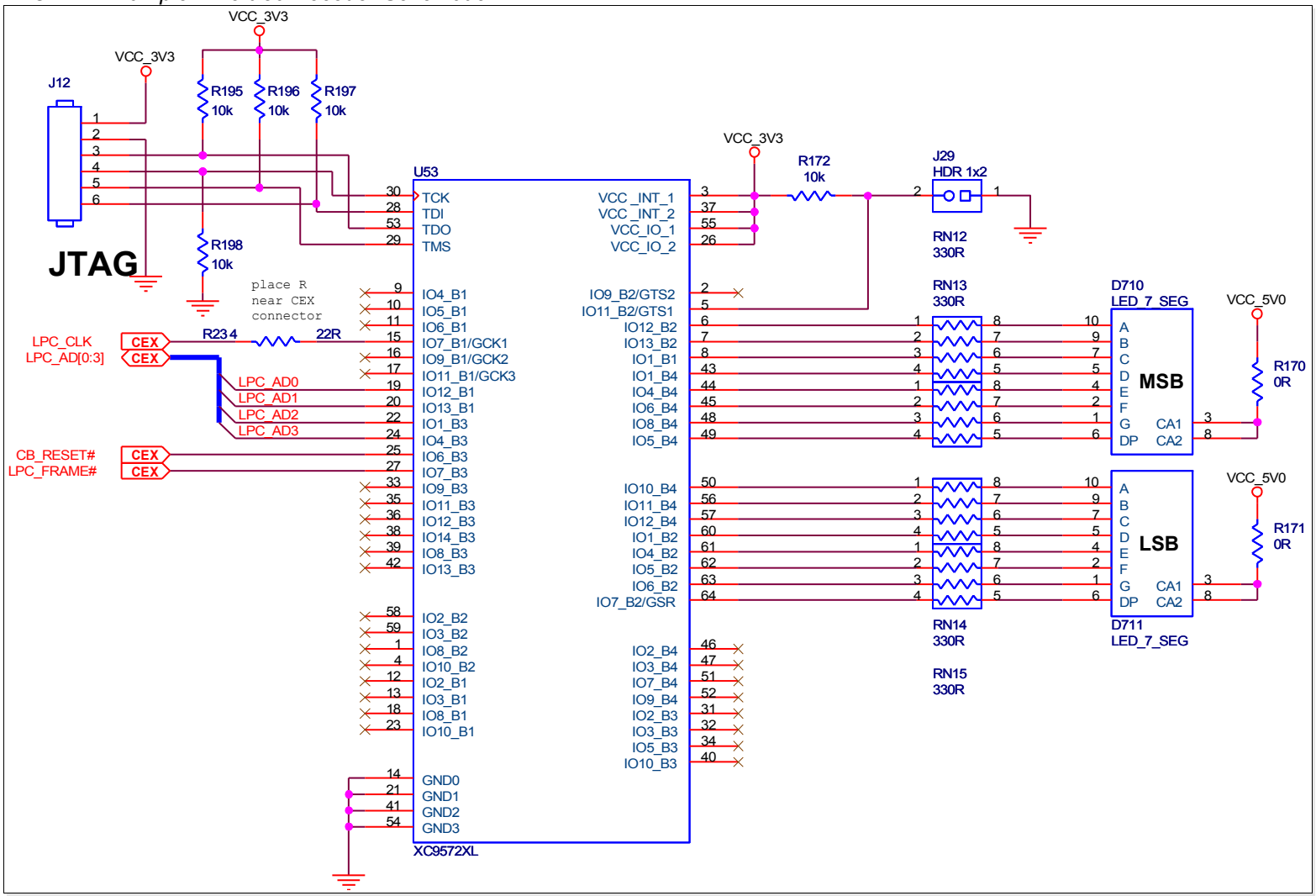


Note: The LPC Firmware Hub section has been moved to section 9 'Appendix A: Deprecated Features' on page 203 below in this version of the Carrier Design Guide. LPC Firmware hubs were typically used for Carrier based BIOS in previous generation designs. A Carrier based BIOS is now typically support on SPI. See section 2.17 'SPI – Serial Peripheral Interface Bus' on page 118 below for more information.

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2.16.2.3. LPC PLD Example – Port 80 Decoder

Figure 43: LPC PLD Example – Port 80 Decoder Schematic



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The following applies to Figure 43 above.

The JTAG header may be used to program the PLD in-circuit.

The LPC bus is the interface to the Module host system.

Two seven-segment LED displays show the Port 80 POST (Power On Self Test) codes.

PLD outputs drive the LEDs.

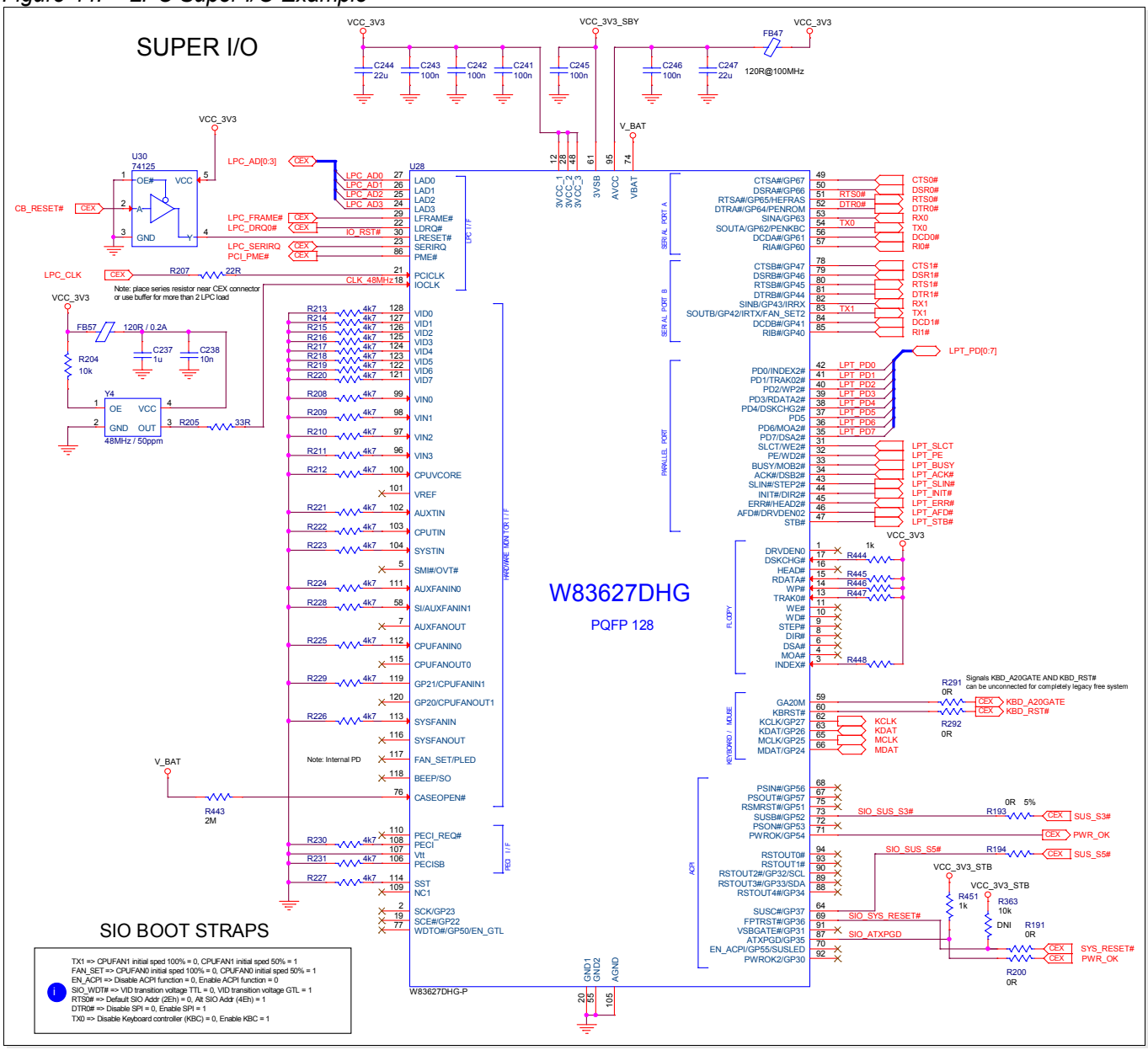
On some systems, a BIOS setting is needed to allow POST codes to be forwarded to the LPC bus.

Warning: Note that the pins on this particular CPLD are 5V tolerant and some of the pins are subjected to voltages near 5V through the 7 segment LED.

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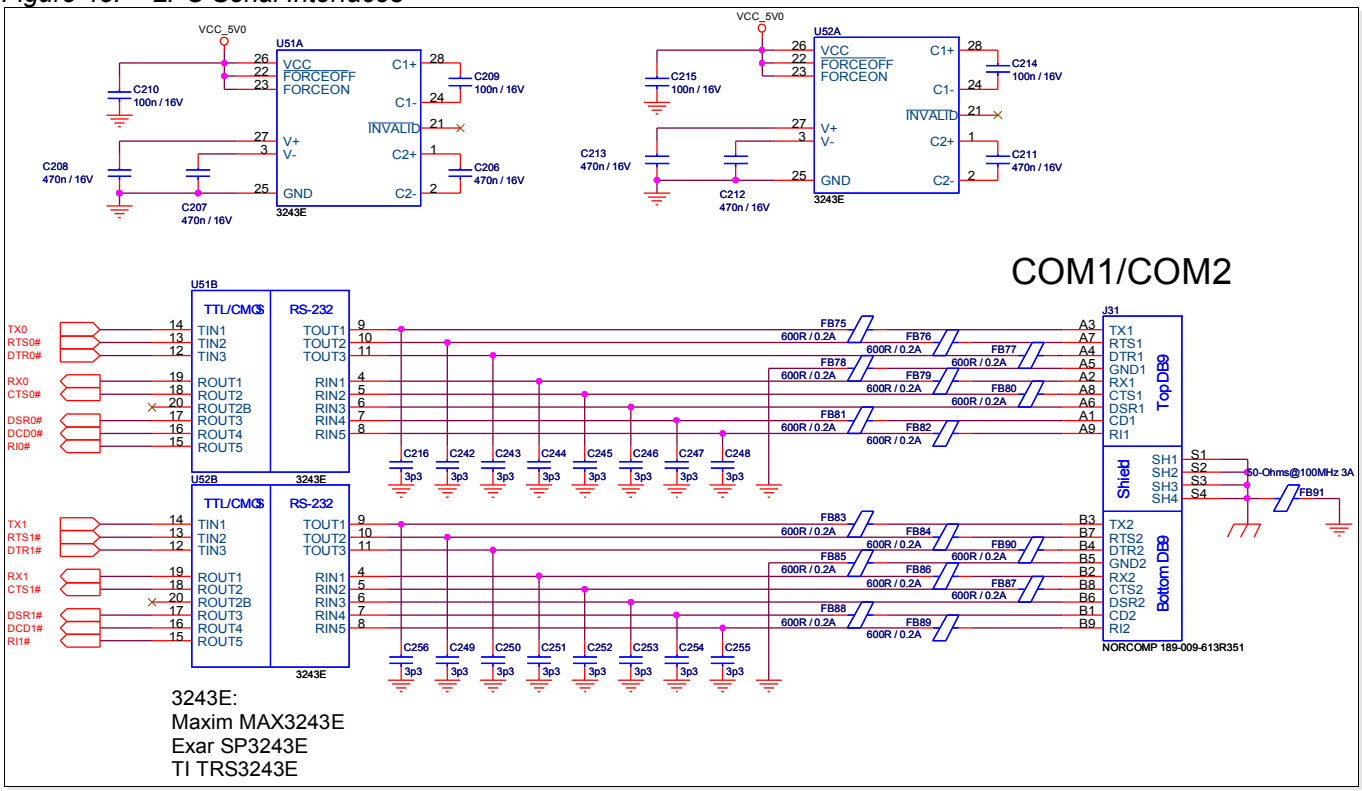
2.16.2.4. SuperIO

Figure 44: LPC Super I/O Example



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Figure 45: LPC Serial Interfaces



Note: ***Connection between logic GND and chassis depends on grounding architecture. Connect GND with chassis at a single point even though this connection is drawn on all schematic examples throughout this document.***

2.16.3. Routing Considerations

2.16.3.1. General Signals

LPC signals are similar to PCI signals and may be treated similarly. Route the LPC bus as 55 Ω, single-ended signals. The bus may be referenced to ground (preferred), or to a well-bypassed power plane or a combination of the two. Point-to-point (daisy-chain) routing is preferred, although stubs up to 1.5 inches may be acceptable. Length-matching among LPC_AD[3:0], LPC_FRAME# are needed

See Section 6.6.3 'LPC Trace Routing Guidelines' on page 193 below.

2.16.3.2. Bus Clock Routing

The LPC bus clock is similar to the PCI bus clock and should be treated similarly. The COM Express Specification allows 1.6 ns +/- 0.1ns for the propagation delay of the LPC clock from the Module pin to the LPC device destination pin. Using a typical propagation delay value of 180 ps / inch, this works out to 8.88 inches of Carrier Board trace for a device-down application. For device-up situations, 2.5 inches of clock trace are assumed to be on the LPC slot card (by analogy to the PCI specification). This is deducted from the 8.88 inches, yielding 6.38 inches.

On a Carrier Board with a small form factor, serpentine clock traces may be required to meet the clock-length requirement.

Route the LPC clock as a single-ended, 55 Ω trace with generous clearance to other traces and to itself. A continuous ground-plane reference is recommended. Routing the clock on a single ground referenced internal layer is preferred to reduce EMI.

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The LPC clock implementation should follow the routing guidelines for the PCI clock defined in the COM Express specification and the 'PCI Local Bus Specification Revision 2.3'. In addition to this refer to Section 6.6.1 'PCI Trace Routing Guidelines' on page 191 below.

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2.17. SPI – Serial Peripheral Interface Bus

The SPI interface is defined in this specification to service as an off-module option for BIOS storage. The SPI interface replaces the LPC Firmware Hub interface, which is now considered a legacy interface for firmware storage (LPC does continue to be used for SuperIO connectivity). Many current chipsets only specify SPI for BIOS/Firmware storage usage, so the COM.0 specification is limited to that connectivity use-case to enable maximum compatibility across Modules and silicon platforms. Additional features, such as SPI-based Trusted Platform Module support might be added to a given carrier design, but compatibility is not guaranteed across Modules.

2.17.1. Signal Definition

Table 35: SPI Signal Definition

Signal	Pin	Description	I/O
SPI_CS#	B97	Chip select for Carrier Board SPI – may be sourced from chipset SPI0 or SPI1	O CMOS – 3.3V Suspend
SPI_MISO	A92	Data in to Module from Carrier SPI	I CMOS – 3.3V Suspend
SPI_MOSI	A95	Data out from Module to Carrier SPI	O CMOS – 3.3V Suspend
SPI_CLK	A94	Clock from Module to Carrier SPI	O CMOS – 3.3V Suspend
SPI_POWER	A91	Power supply for Carrier Board SPI – sourced from Module – nominally 3.3V. The Module shall provide a minimum of 100mA on SPI_POWER. Carriers shall use less than 100mA of SPI_POWER. SPI_POWER shall only be used to power SPI devices on the Carrier.	O – 3.3V Suspend
BIOS_DIS0#	A34	Selection strap to determine the BIOS boot device. The Carrier should only float these or pull them low, please refer to for strapping options of BIOS disable signals.	I CMOS
BIOS_DIS1#	B88	Selection strap to determine the BIOS boot device. The Carrier should only float these or pull them low, please refer to Table 36: Effect of the BIOS disable signals on page 119 below for strapping options of BIOS disable signals.	I CMOS

The signals with the “SPI_” prefix names are used to connect directly to the regarding SPI device. SPI_CS# is the chip select signal and is usually sourced from the Module's chipset SPI0 or SPI1 signal. SPI_MISO and SPI_MOSI are the input and output signals and SPI_CLK offers the clock from the Module to the carrier's device. The SPI_POWER pin can be used to power the SPI devices and it should use less than 100mA in total. The signal is helpful to simplify the SPI schematic, because the Module's SPI power domain can be either in power state S0 or in S5.

BIOS_DIS[0:1]# signals are used to determine the boot device according to Table 36: Effect of the BIOS disable signals below. BIOS_DIS0# (formerly known as BIOS_DISABLE# in COM.0 R1.0) is used to disable the on-module BIOS device and enable the LPC firmware hub. For SPI BIOS flash device usage the signal BIOS_DIS1# should be activated to disable the on-module BIOS device and enable the BIOS flash chip on the carrier.

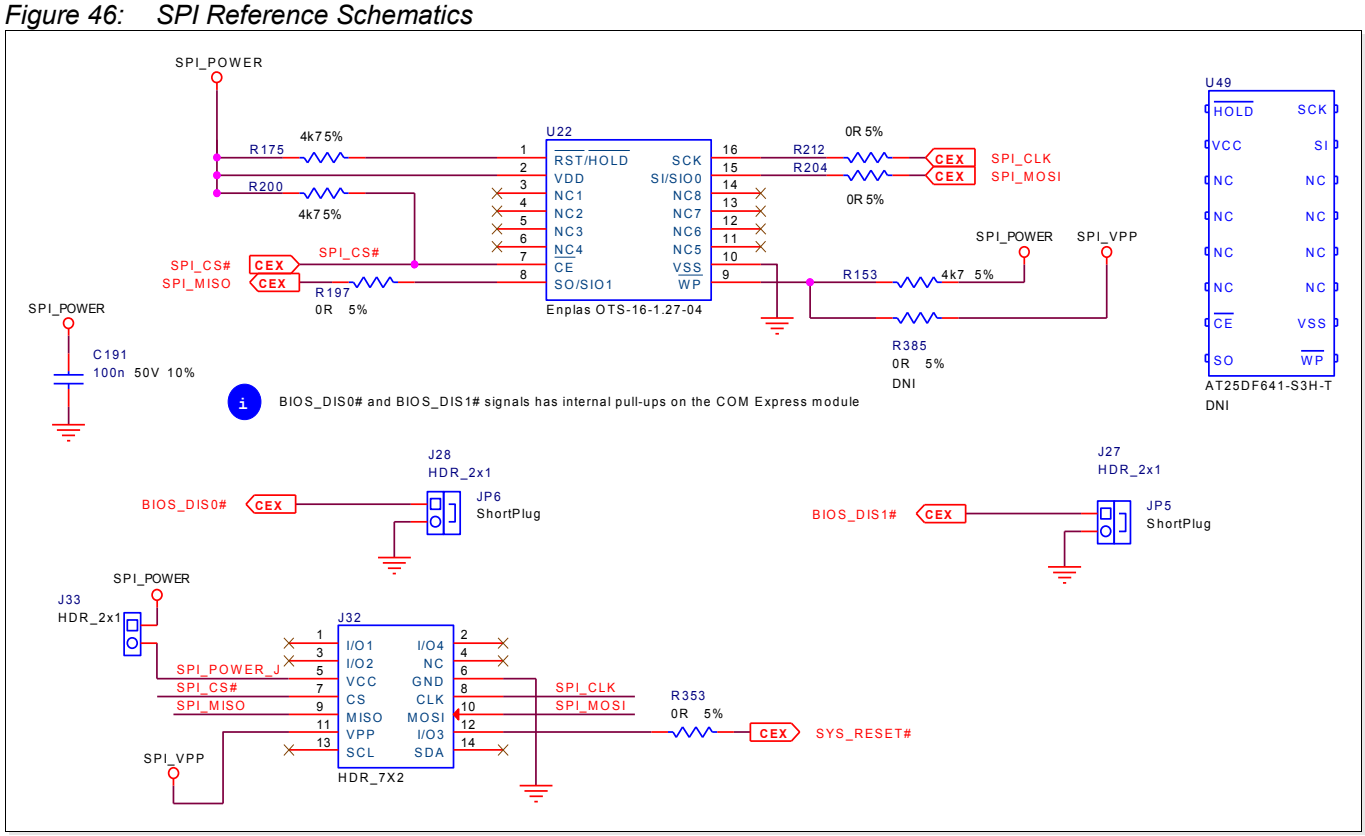
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Table 36: Effect of the BIOS disable signals

BIOS_DIS1#	BIOS_DIS0#	Chipset SPI CS1# Destination	Chipset SPI CS0# Destination	Carrier SPI_CS#	SPI Descriptor	BIOS Entry	Ref Line
1	1	Module	Module	High	Module	SPI0/SPI1	0
1	0	Module	Module	High	Module	Carrier FWH	1
0	1	Module	Carrier	SPI0	Carrier	SPI0/SPI1	2
0	0	Carrier	Module	SPI1	Module	SPI0/SP1	3

2.17.2. SPI Reference Schematics

Figure 46: SPI Reference Schematics



The BIOS device shown in Figure 46: SPI Reference Schematics is an Atmel AT25DF641-S3H flash memory device in a 16-SOIC package. The reference design above shows a socketed implementation, using a 16-pin SOIC socket, Enplas OTS-16-1.27-04. This surface-mount socket is footprint compatible with the SOIC-16 device, allowing for the PCB to be laid out such that the socket or the BIOS flash device itself is soldered to the Carrier Board. Of course a device with smaller package size (8-pin SOIC) can be used if a smaller footprint socket or device in use.

The flash device is connected via the SPI interface to the Module. SPI_POWER, coming from the Module is used as power source for the device.

Flash device pin 7 is the chip enable signal and is connected to the chip select pin SPI_CS# from the Module. Pin 8 is the data output signal of the flash chip and it is connected to the Module's SPI input SPI_MISO. PIN 15 is the data input signal of the flash chip and it is connected to the SPI output SPI_MOSI.

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The optional connector J32 offers the possibility to program the flash device with an external programmer.

The flash device can be used with the Module when the jumper JP5 is set. JP6 will enable the LPC firmware hub, which is already mentioned in chapter 9.2 'LPC Firmware Hub' on page 207 below.

2.17.3. Routing Considerations

The SPI signals SPI_MISO, SPI_MOSI, SPI_CS# and SPI_CLK should be routed with a maximum length of 4.5” and should match to each other within 0.1”.

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2.18. General Purpose I2C Bus Interface

The I2C (Inter-Integrated Circuit) bus is a two-wire serial bus originally defined by Philips. The bus is used for low-speed (up to 400kbps) communication between system ICs. The bus is often used to access small serial EEPROM memories and to set up IC registers. The COM Express Specification defines several I2C interfaces that are brought to the Module connector for use on the Carrier. Some of these interfaces are for very specific functions (VGA, LVDS, and DDIX), one interface is the SMBus used primarily for management and one other interface is a general purpose I2C interface. Since COM.0 Rev. 2.0 this interface should support multi-master operation. This capability will allow a Carrier to read an optional Module EEPROM before powering up the Module.

Revision 1.0 of the specification placed the I2C interface on the non-standby power domain. With this connection, the I2C interface can only be used when the Module is powered on. Since the I2C interface is used to connect to an optional Carrier EEPROM and since it is desirable to allow a Module based board controller access to the optional Carrier EEPROM before the Module is powered on, revision 2.0 of this specification changes the power domain of the I2C interface to standby-power allowing access during power down and suspend states. There is a possible leakage issue that can arise when using a R2.0 Module with a R1.0 Carrier that supports I2C devices. The R1.0 Carrier will power any I2C devices from the non-standby power rail. A R2.0 Module will pull-up the I2C clock and data lines to the standby-rail through a 2.2K resistor. The difference in the power domains on the Module and Carrier can provide a leakage path from the standby power rail to the non-standby power rail.

Vendor interoperability is given via EAPI – Embedded Application Programming Interface, which allows and easier interoperability of COM Express Modules.

2.18.1. Signal Definitions

The general purpose I2C Interface is powered from 3.3V suspend rail. The I2C_DAT is an open collector line with a pull-up resistor located on the Module. The I2C_CK has a pull-up resistor located on the Module. The Carrier should not contain pull-up resistors on the I2C_DAT and I2C_CK signals. Carrier based devices should be powered from 3.3V suspend voltage. The use of main power line for a Carrier I2C device will require a bus isolator to prevent leakage to other I2C devices on 3.3V power.

At this time, there is no allocation of I2C addresses between the Module and Carrier. Carrier designers will need to consult with Module providers for address ranges that can be used on the Carrier.

A reference to the I2C source specification can be found in Section 8 'Applicable Documents and Standards' on page 199.

The COM Express general purpose I2C pins are on the B row of the COM Express A-B connector as shown in Table 38 below.

Table 37: General Purpose I2C Interface Signal Descriptions

Signal	Pin	Description	I/O	Pwr Rail	Comment
I2C_CK	B33	General Purpose I2C Clock output	I/O OD CMOS	3.3V Suspend	
I2C_DAT	B34	General Purpose I2C data I/O line.	I/O OD CMOS	3.3V Suspend	

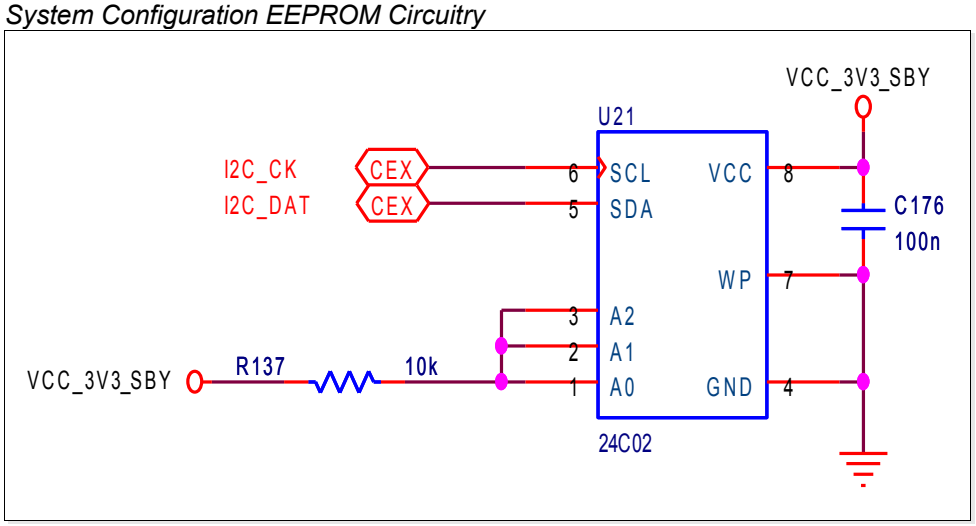
2.18.2. Reference Schematics

The COM Express specification recommends implementing a serial I2C EEPROM of at least 2kbit on the Carrier Board where all the necessary system configuration can be saved. For more information about the content of this system configuration EEPROM, refer to the COM Express

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Specification. The circuitry in Figure 47 below shows how to connect an Atmel 'AT24C04' 4kbit EEPROM to the General Purpose I2C bus on the COM Express Carrier Board (http://www.atmel.com). According to the COM Express specification, the I2C address lines A2, A1 and A0 of the system configuration EEPROM must be pulled high. Depending on the EEPROM size this leads to the I2C addresses 1010 111x (2kbit), 1010 110x (4kbit), or 1010 100x (8kbit).

Figure 47: System Configuration EEPROM Circuitry



The EEPROM stores configuration information for the system of the Carrier Board. The data structure used is defined in the PICMG EEEP Specification. The Specification recommends but does not require the use of this system configuration EEPROM. The Module BIOS may check the Carrier Board configuration EEPROM but is not required to do so by the Specification.

The Atmel AT24C02 with 2Kb organized as 256 x 8 is a suitable device in an 8-pin SOIC package. For applications that require additional ROM or memory capacity such as 8Kb (1K x 8) or 16Kb (2K x 8), an Atmel AT24C08A may be used.

The COM Express Specification requires a minimum capacity of 2Kb. The Atmel AT24C02 meets this minimum capacity.

Address inputs A0, A1, A2 are pulled high. This creates the I2C address 1010 111x, which is required by the COM Express Specification. EEPROM devices internally set I2C address lines A6, A5, A4, A3 to binary value 1010.

WP (write protect) is pulled low for normal read/write.

2.18.3. Connectivity Considerations

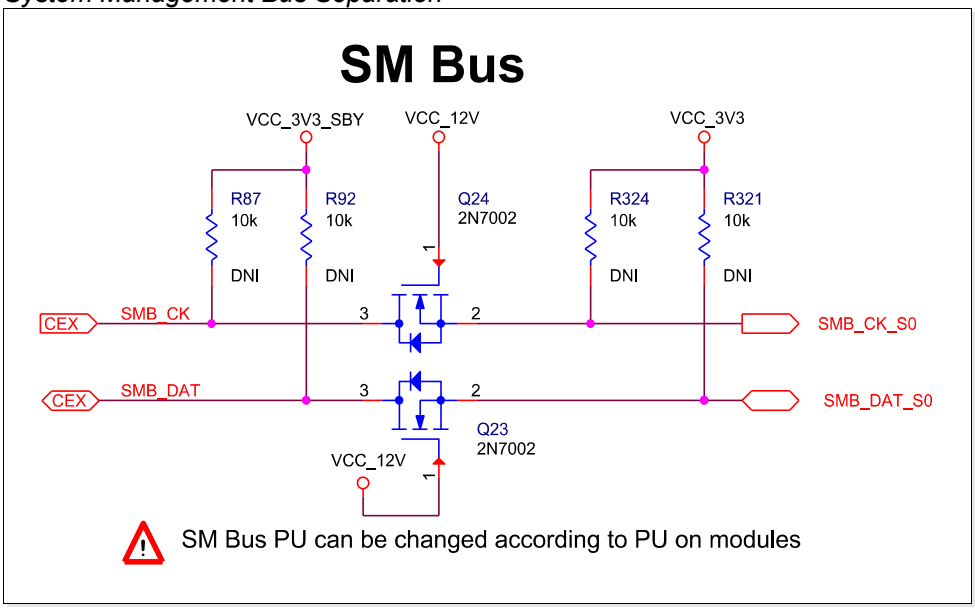
The maximum amount of capacitance allowed on the Carrier General Purpose I2C bus lines (I2C_DAT, I2C_CK) is specified by your Module vendor. The Carrier designer is responsible for ensuring that the maximum amount of capacitance is not exceeded and the rise/fall times of the signals meet the I2C bus specification. As a general guideline, an IC input has 8pF of capacitance, and a PCB trace has 3.8pF per inch of trace length.

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2.19. System Management Bus (SMBus)

The SMBus is primarily used as an interface to manage peripherals such as serial presence detect (SPD) on RAM, thermal sensors, PCI/PCIe devices, smart battery, etc. The devices that can connect to the SMBus can be located on the Module and Carrier. Designers need to take note of several implementation issues to ensure reliable SMBus interface operation. The SMBus is similar to I2C. I2C devices have the potential to lock up the data line while sending information and require a power cycle to clear the fault condition. SMBus devices contain a timeout to monitor for and correct this condition. Designers are urged to use SMBus devices when possible over standard I2C devices. COM Express Modules are required to power SMBus devices from Early Power in order to have control during system states S0-S5. The devices on the Carrier Board using the SMBus are normally powered by the 3.3V main power. To avoid current leakage between the main power of the Carrier Board and the Suspend power of the Module, the SMBus on the Carrier Board must be separated by a bus switch from the SMBus of the Module. Figure 48 below shows an appropriate bus switch circuit for separating the SMBus of the Carrier Board from the SMBus of the Module. However, if the Carrier Board also uses Suspend powered SMBus devices that are designed to operate during system states S3-S5, then these devices must be connected to the Suspend powered side of the SMBus, i. e. between the COM Express Module and the bus switch. Since the SMBus is used by the Module and Carrier, care must be taken to ensure that Carrier based devices do not overlap the address space of Module based devices. Typical Module located SMBus devices and their addresses include memory SPD (serial presence detect 1010 000x, 1010 001x), programmable clock synthesizes (1101 001x), clock buffers (1101 110x), thermal sensors (1001 000x), and management controllers (vendor defined address). Contact your Module vendor for information on the SMBus addresses used.

Figure 48: System Management Bus Separation



2.19.1. Signal Definitions

Table 38: System Management Bus Signals

Signal	Pin	Description	I/O	Pwr Rail	Comment
SMB_CK	B13	System Management Bus bidirectional clock line	I/O OD CMOS	3.3V Suspend rail	
SMB_DAT	B14	System Management bidirectional data line.	I/O OD CMOS	3.3V Suspend rail	
SMB_ALERT#	B15	System Management Bus Alert	I CMOS	3.3V Suspend Rail	

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2.19.2. Routing Considerations

The SMBus should be connected to all or none of the PCIe/PCI devices and slots. A general recommendation is to not connect these devices to the SMBus.

The maximum load of SMBus lines is limited to 3 external devices. Please contact your Module vendor if more devices are required.

Do not connect Non-Suspend powered devices to the SMBus unless a bus switch is used to prevent back feeding of voltage from the Suspend rail to other supplies.

Contact your Module vendor for a list of SMBus addresses used on the Module. Do not use the same address for Carrier located devices.

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2.20. General Purpose Serial Interface

Since Revision 2.0 of the COM Express specification two optional serial ports are available on Type 10 and Type 6 COM Express Modules uses pins on the A-B connector that have been reclaimed from the A-B VCC_12V pool. As such, it is possible that if a Type 6 or 10 Module is deployed in an R1.0 Carrier Board for Module Types 1,2,3,4,5 then the Module TTL level serial pins may be exposed to the 12V supply, and Module designers must plan for this. Similarly, an R1.0 Module deployed on an R2.0 Carrier may bridge 12V to the serial pins and Carrier designers must plan for this. These pins are designated SER0_TX, SER0_RX, SER1_TX and SER1_RX. Data out of the Module is on the _TX pins. Please refer to section 2.22.10 'Protecting COM.0 Pins Reclaimed From the VCC_12V Pool' on page 144 below. Hardware handshaking and hardware flow control are not supported.

2.20.1. Signal Definitions

Table 39: General Purpose Serial Interface Signal Definition

Signal	Pin	Description	I/O
SER0_TX	A98	Transmit Line for Serial Port 0	O CMOS (protected)
SER0_RX	A99	Receive Line for Serial Port 0	I CMOS (protected)
SER1_TX	A101	Transmit Line for Serial Port 1 (can be shared with CAN function)	O CMOS (protected)
SER1_RX	A102	Receive Line for Serial Port 1 (can be shared with CAN function)	I CMOS (protected)

In Revision 2.0 of COM Express Specification these signals have been reclaimed from the VCC_12V pool. Therefore protection on the Module and on the Carrier Board is necessary to avoid damage to those when accidentally exposed to 12V.

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2.20.2. Reference Schematics

2.20.2.1. General Purpose Serial Port Example

Figure 49: General Purpose Serial Port Example

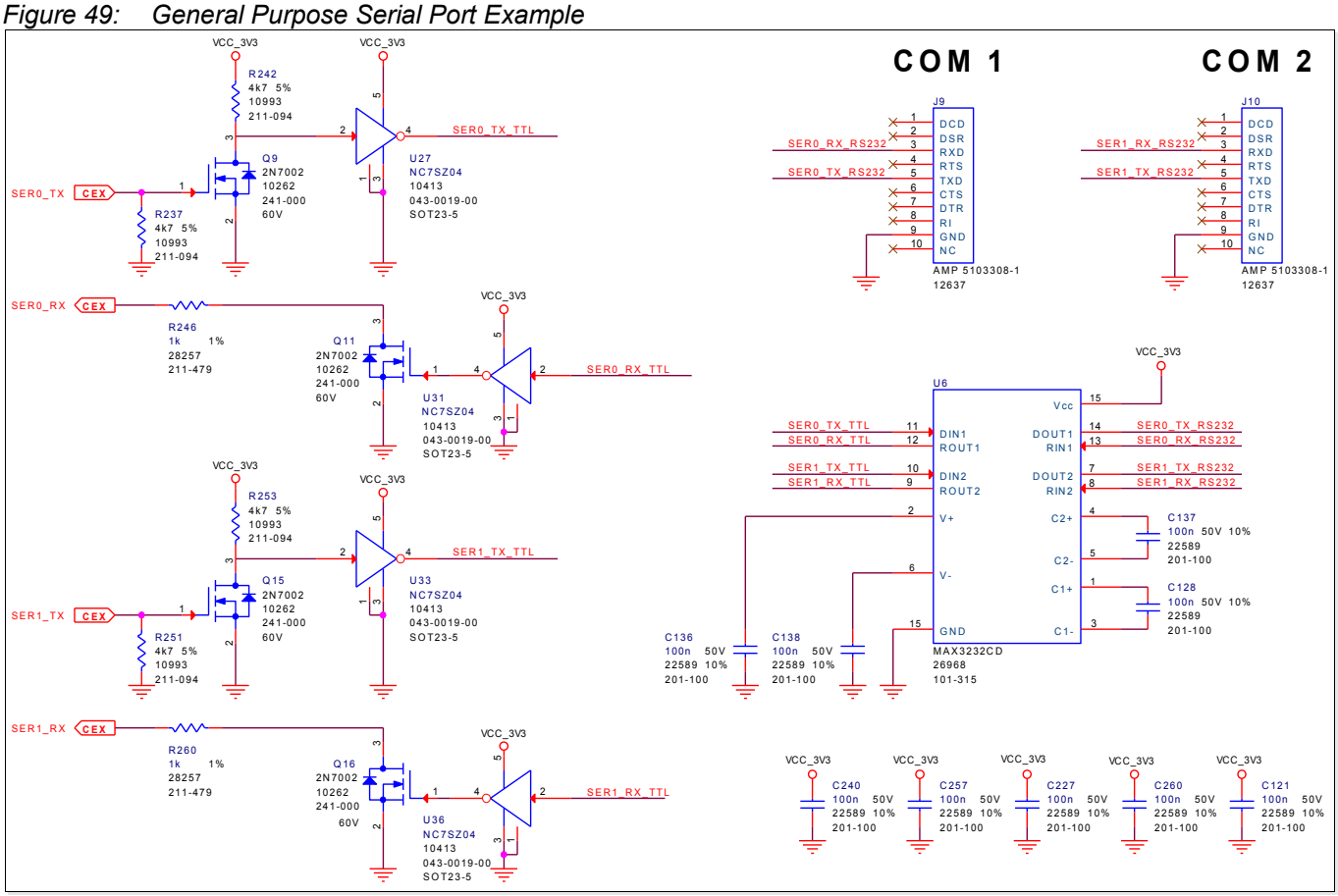


Figure 49: General Purpose Serial Port Example shows the schematic of two general purpose serial ports with RS232 level shifter (U6). The transistor / inverter combination at the serial TX and RX lines coming from the Module is necessary to handle the protection against VCC_12V connection according to chapter 5.10 of COM.0 Rev. 2.1. The MAX3232CD is a dual port RS232 transceiver and handles the level shifting of the TTL signals to the regarding voltage level.

Conformance to the protection scheme defined in COM.0 Rev 2 for pins recovered from the 12V pool results in a transfer rate limit of about 10 kbaud. If your situation requires higher speeds, contact your Module vendor for possible work-arounds. The work-arounds likely involve sacrificing the 12V protection as a tradeoff for higher speeds.

2.20.3. Routing Considerations

No further routing considerations need to be taken.

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2.21. CAN Interface

CAN bus is a vehicle bus standard designed to allow controllers and devices to communicate with each other without a host computer. CAN bus is a message-based protocol, designed specifically for automotive applications but now also used in other areas such as industrial automation and medical equipment.

Development of CAN bus started originally in 1983. The protocol was officially released in 1986 at the Society of Automotive Engineers (SAE) congress in Detroit, Michigan. The first CAN controller chips, produced by Intel and Philips, came on the market in 1987. In 1991 the CAN 2.0 specification was published.

Since 2008 CAN bus has been mandatory in any US vehicle in the OBD-II car diagnostic port. It is also used extensively in industrial automation.

2.21.1. Signal Definitions

Table 40: CAN Interface Signal Definition

Signal	Pin	Description	I/O
CAN_TX	A101	Transmit Line for CAN (can be shared with SER1 function)	O CMOS (protected)
CAN_RX	A102	Receive Line for CAN (can be shared with SER1 function)	I CMOS (protected)

This signals have been introduced in COM.0 Specification Revision 2.1 optionally for Type 10 and Type 6 Modules. They have been reclaimed from the VCC_12V pool. Therefore protection on the Module and on the Carrier Board is necessary that accidental exposure to 12V will not lead to either damaged Modules or Carrier Boards. Please refer to section 2.22.10 'Protecting COM.0 Pins Reclaimed From the VCC_12V Pool' on page 144 below.

The protection, especially the series diode on the Module reduce the maximum speed on the CAN interface to about 10 Kbaud.

The CAN port consists of an asynchronous CAN TX line and an RX line from and to the COM Express Module CAN protocol controller. A Carrier based CAN transceiver is required to realize a CAN implementation. CAN PHYs are available from Texas Instruments, On Semiconductor, NXP, Freescale, Microchip and numerous other vendors.

CAN bus on COM Express is an optional interface, which means that the system designer must verify, if the selected Module supports it.

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2.21.2. Reference Schematics

2.21.2.1. CAN Bus Example

Figure 50: CAN Bus Example

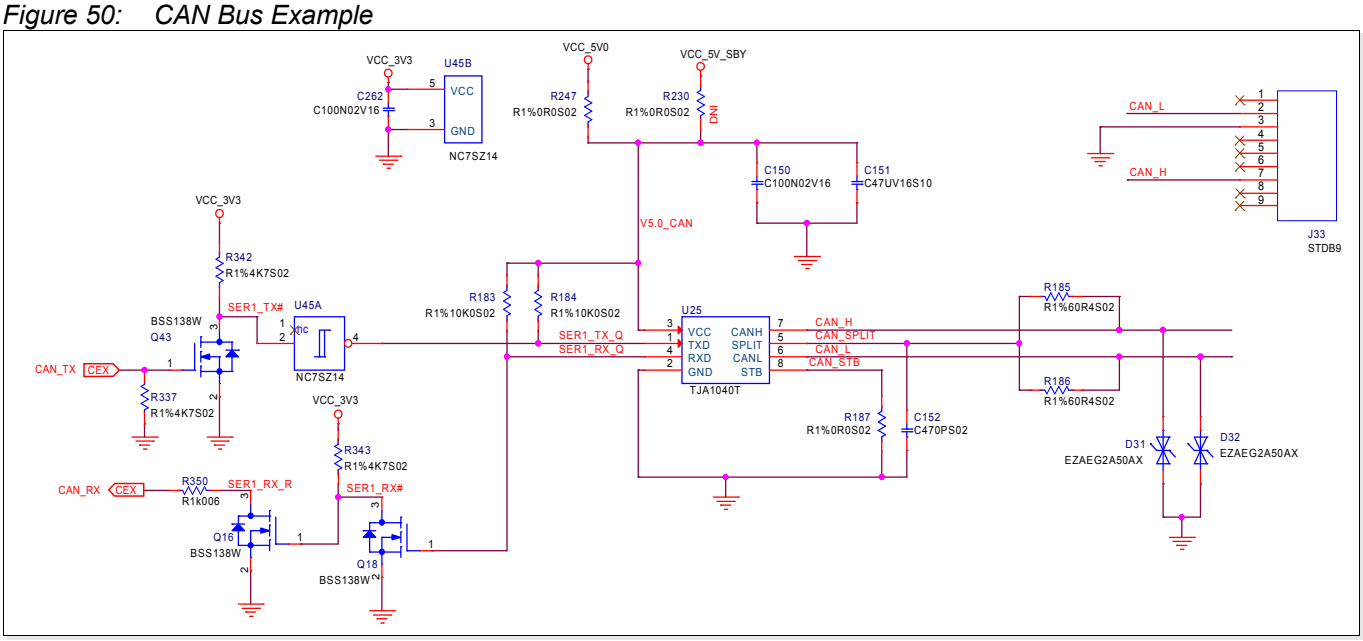


Figure 50: CAN Bus Example shows the schematics of a CAN Bus implementation with the CAN Transceiver TJA10407 (U25). The transistor / inverter combination at the CAN_TX and CAN_RX line coming from the Module is necessary to handle the protection against VCC_12V connection according to chapter 5.10 of COM.0 Rev. 2.1. The Diodes D31 and D32 accomplish ESD protection.

J33 is a DSUB-9 connector in standardized CAN pin-out. Please refer to Table 41: Pin-out Table DSUB-9 CAN Connector below.

If an ODB-II adapter is used pin 9 carries the car battery voltage. The automotive power rail is a difficult rail to work with. It is nominally a 12V rail but may dip to 6V when the engine is cranking and may be up to 16V when the engine is running and there may be transients in excess of +/- 100V.

Table 41: Pin-out Table DSUB-9 CAN Connector

J33 (9 positions)	Pin description
2	CAN_L
7	CAN_H
9	VCC
3	GND

The COM Express Specification conform 12V protection will decrease the maximum transfer rate to about 10kbaud. For higher speed please contact your Module vendor to find a solution.

2.21.3. Routing Considerations

It should be routed as a differential pair signal with 120 Ohm differential impedance. The end points of CAN bus should be terminated with 120 Ohms or with 60 Ohms from the CAN_H line and 60 Ohms from the CAN_L line to the CAN Bus reference voltage. Check your CAN transceiver application notes for further details on termination.

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2.22. Miscellaneous Signals

Table 42: Miscellaneous Signals

Signal	Pin	Description	I/O	Comment
TYPE0# TYPE1# TYPE2#	C54 C57 D57	The Type pins indicate the COM Express pin-out type of the Module. To indicate the Module's pin-out type, the pins are either not connected or strapped to ground on the Module. The Carrier Board has to implement additional logic, which prevents the system to switch power on, if a Module with an incompatible pin-out type is detected.	O 5V PDS	Only Available on T2-T6
TYPE10#	A97	Indicates to the Carrier Board that a Type 10 Module is installed. Indicates to the Carrier Board, that a Rev 1.0/2.0 Module is installed. TYPE10# NC Pin-out R2.0 PD Pin-out Type 10 pull down to ground with 47k 12V Pin-out R1.0		
SPKR	B32	Output used to control an external FET or a logic gate to drive an external PC speaker.	O 3.3V CMOS	
BIOS_DISABLE0#	A34	Selection straps to determine the BIOS boot device. The Carrier should only float these or pull them low,	I 3.3V CMOS	See Section 2.17 'SPI – Serial Peripheral Interface Bus' on page 118 above
BIOS_DISABLE1#	B88	Selection straps to determine the BIOS boot device. The Carrier should only float these or pull them low,	I 3.3V CMOS	See Section 2.17 'SPI – Serial Peripheral Interface Bus' on page 118 above
WDT	B27	Output indicating that a watchdog time-out event has occurred.	O 3.3V CMOS	
KBD_RST#	A86	Input signal of the Module used by an external keyboard controller to force a system reset.	I 3.3V CMOS	Only Available on T1-T5
KBD_A20GATE	A87	Input signal of the Module used by an external keyboard controller to control the CPU A20 gate line. The A20 gate restricts the memory access to the bottom megabyte of the system. Pulled high on the Module.	I 3.3V CMOS	Only Available on T1-T5
LID#	A103	LID switch. Low active signal used by the ACPI operating system for a LID switch.	I 3.3V CMOS OD	Only Available on T6 and T10
SLEEP#	B103	Sleep button. Low active signal used by the ACPI operating system to bring the system to sleep state or to wake it up again.	I 3.3V CMOS OD	Only Available on T6 and T10
FAN_PWMOUT[1]	B101	Fan speed control. Uses the Pulse Width Modulation (PWM) technique to control the fan's RPM.	O 3.3V CMOS OD	Only Available on T6 and T10
FAN_TACHIN[1]	B102	Fan tachometer input for a fan with a two pulse output.	I 3.3V CMOS OD	Only Available on T6 and T10
TPM_PP[1]	A96	Trusted Platform Module (TPM) Physical Presence pin. Active high. TPM chip has an internal pull down. This signal is used to indicate Physical Presence to the TPM.	I 3.3V CMOS	Only Available on T6 and T10
GPO0 GPO1 GPO2 GPO3	A93 B54 B57 B63	General Purpose Outputs for system specific usage.	O 3.3V CMOS	Refer to the Module's users guide for information about the functionality of these signals.
GPI0 GPI1 GPI2 GPI3	A54 A63 A67 A85	General Purpose Input for system specific usage. The signals are pulled up by the Module.	I 3.3V CMOS	Refer to the Module's users guide for information about the functionality of these signals.

1 *These signals use reclaimed VCC_12V pins and must be protected on Module and Carrier Board against 12V usage. Please refer to section 2.22.10 'Protecting COM.0 Pins Reclaimed From the VCC_12V Pool' on page 144 below.*

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2.22.1. Module Type Detection

The COM Express Specification includes three signals to determine the pin-out type of the Module connected to the Carrier Board. If an incompatible Module pin-out type is detected, external logic should prevent the Carrier Board from powering up the whole system by controlling the 12V supply voltage. The pins 'TYPE0#', 'TYPE1#' and 'TYPE2#' are either left open (NC) or strapped to ground (GND) by the Module to encode the pin-out type according to the following table. The Module Type 1 has no encoding. For more information about this subject, refer to the COM Express Specification.

Table 43: Module Type Detection

Module Type	Pin TYPE0#	Pin TYPE1#	Pin TYPE2#	Pin TYPE10#	
Module Type 1	X (don't care)	X (don't care)	X (don't care)	12V or NC	
Module Type 2	NC	NC	NC	12V or NC	
Module Type 3	NC	NC	GND	12V or NC	No IDE interface
Module Type 4	NC	GND	NC	12V or NC	No PCI interface
Module Type 5	NC	GND	GND	12V or NC	No IDE, no PCI interface
Module Type 6	GND	NC	NC	12V or NC	No IDE, no PCI interface
Module Type 10	X (don't care)	X (don't care)	X (don't care)	PD with 47k	

Pin TYPE10# is reclaimed from the VCC_12V pool. In R1.0 Modules this pin will connect to other VCC_12V pins. In R2.0 this pin is defined as a no connect for types 1-6. A Carrier can detect a R1.0 Module by the presence of 12V on this pin. R2.0 Module types 1-6 will no connect this pin. Type 10 Modules shall pull this pin to ground through a 47K resistor.

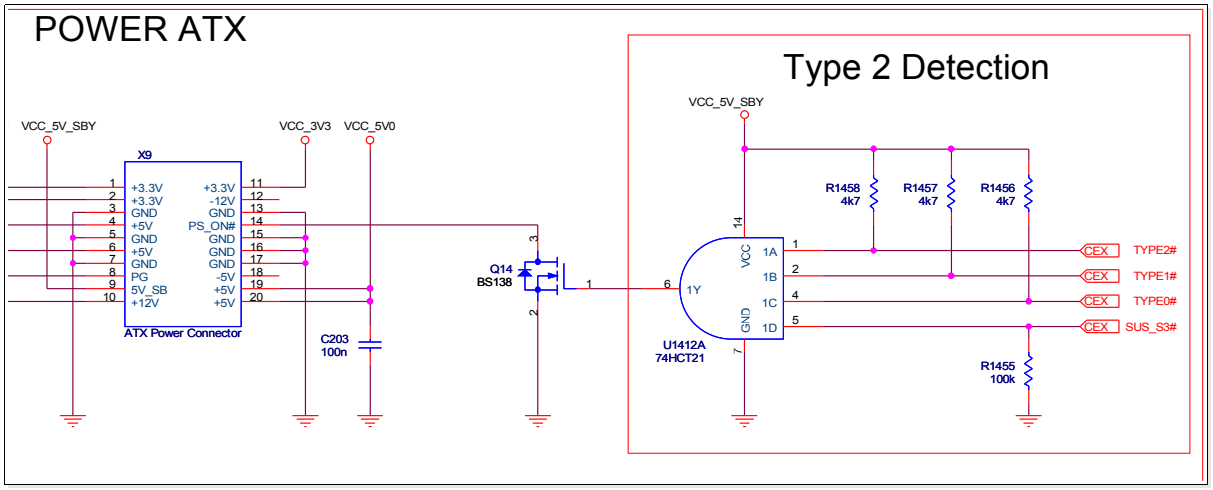
Figure 51 below illustrates a detection circuitry for Type 2 Modules. If any Module type other than Type 2 is connected, the 'PS_ON#' signal, which controls the ATX power supply, is not driven low by the Module, and hence the main power rails of the ATX supply do not come up. The Type Detection pins of the Module must be pulled up on the Carrier Board to the 5V Suspend voltage rail.

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Figure 51: Module Type 2 Detection Circuitry

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2.22.2. Speaker Output

The PC-AT architecture provides a speaker signal that creates beeps and chirps. The signal is a digital-logic signal that is created from system timers within the core chipset. The speaker provides feedback to the user that an error has occurred. The system BIOS usually drives the speaker line with a set of beep codes to indicate hardware problems such as a memory test failure, a missing video device, or a missing keyboard. Application software often uses the PC-AT speaker to flag an error such as an invalid key press.

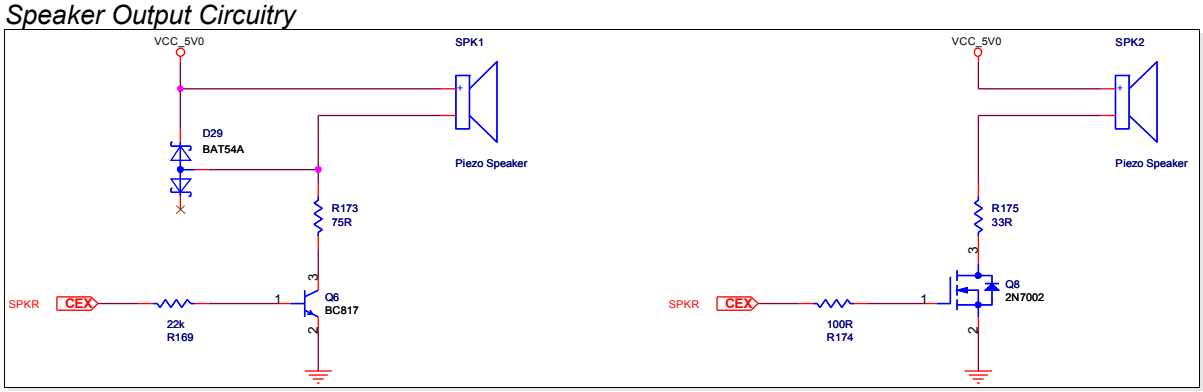
This speaker signal should not be confused with the analog-audio signals produced by the audio CODEC. In many systems, the PC-AT speaker signal is fed into one of the audio CODEC inputs, allowing it to be mixed with other audio signals and heard on the audio transducer (speakers and headphones) that the CODEC drives.

The COM Express Module provides a speaker output signal called 'SPKR', which is intended to drive an external FET or a logic gate to connect a PC speaker.

The 'SPKR' signal is often used as a configuration strap for the Modules chipset. It should not be connected to a pull-up or pull-down resistor, which could overwrite the internal chipset configuration and result in a malfunction of the Module.

The PC-AT audio transducer that is used for error messages is usually a small, low-cost loudspeaker or piezoelectric-electric buzzer. A buffering between the Module SPKR pin and the audio transducer is required. An example circuit is shown in Figure 52 below. The net SPKR is sourced from Module pin B32. If the transducer is a low impedance device, such as an 8 Ω speaker, then a larger resistor value and package size for R173/R175 is in order.

Figure 52: Speaker Output Circuitry



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2.22.3. RTC Battery Implementation

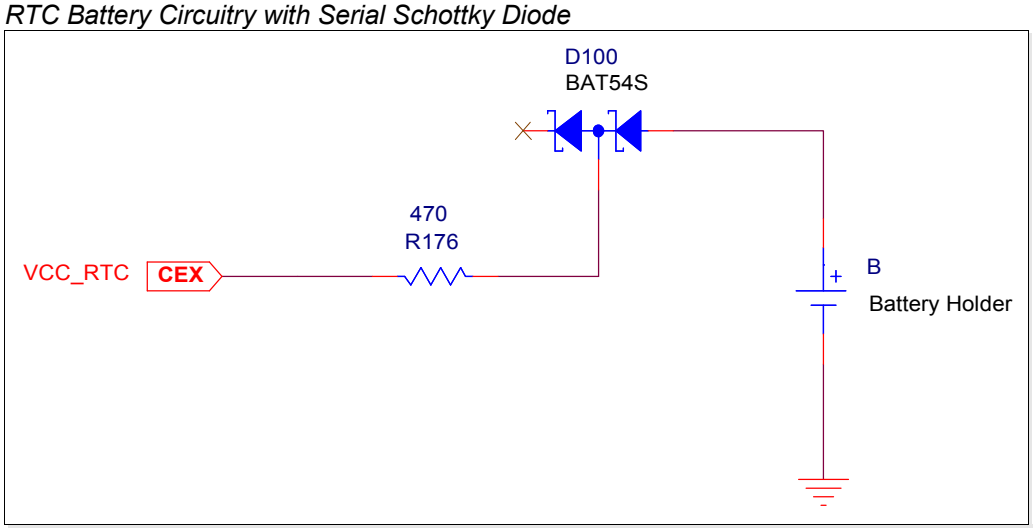
The Real Time Clock (RTC) is responsible for maintaining the time and date even when the COM Express Module is not connected to a main power supply. Usually a +3V lithium battery cell is used to supply the internal RTC of the Module. The COM Express Specification defines an extra power pin 'VCC_RTC', which connects the RTC of the Module to the external battery. The specified input voltage range of the battery is defined between +2.0V and +3.0V. The signal 'VCC_RTC' can be found on the Module's connector row A pin A47.

To implement the RTC Battery according to the Underwriters Laboratories Inc® (UL) guidelines (UL 1642), battery cells must be protected against a reverse current going to the cell. UL 1642 requires two blocking components (such as a pair of diodes) or a resistor and a diode. The resistor has to be large enough to prevent a current of more than one third of the battery's maximum allowed reverse charging current. An alternative to a pair of diodes are specialty ICs from companies such as Maxim or Dallas Semiconductor that have a UL1642 approval and perform the required blocking function.

The resistor and diode option is shown in Figure 53 below.

A possible drawback of this circuitry is that the battery voltage monitoring result displayed by the COM Express Module will be inaccurate due to current leakage on the Module side. When the system is running, this current leakage loads the capacitor of the battery circuitry. This leads to a higher voltage on the signal pin 'VCC_RTC' and therefore produces inaccurate monitoring results.

Figure 53: RTC Battery Circuitry with Serial Schottky Diode



2.22.3.1. RTC Battery Lifetime

The RTC battery lifetime determines the time interval between system battery replacement cycles. Current leakage from the RTC battery circuitry on the Carrier Board is a serious issue and must be considered during the system design phase. The current leakage will influence the RTC battery lifetime and must be factored in when a specific life expectancy of the system battery is being defined.

In order to accurately measure the value of the RTC current, it should be measured when the complete system is disconnected from primary power.

For information about the power consumption of the RTC circuit, refer to the Module's user's guide.

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2.22.4. Power Management Signals

COM Express specifies a set of signals to control the system power states such as the power-on and reset conditions. This enables the system designer to implement a fully ACPI compliant system supporting system states from S0 to S5. The minimum hardware requirements for an ACPI compliant system are an ATX conforming power supply and a power button.

The following table provides a short description of the ACPI defined system states S0 to S5 including the corresponding power rail state. For more information about ACPI and the several system power states, refer to the 'Advanced Configuration and Power Interface Specification Revision'.

Table 44: System States S0-S5 Definitions

System State	Description	Power Rail State
S0 Full On	All components are powered and the system is fully functional.	Full power on all power rails.
S1 Power-on Standby (POS)	In sleeping state, no system context is lost, hardware maintains all system context. During S1 operation some system components are set into low power state.	Full power on all power rails.
S2	Not supported.	
S3 Suspend to RAM (STR)	The current system state and context is stored in main memory and all unnecessary system logic is turned off.	Only main memory and logic required to wake-up the system remain powered by the Suspend voltages. All other power rails are switched off.
S4 Suspend to Disk (STD) Hibernate	The current system state and context is stored on disk and all unnecessary system logic is turned off. S4 is similar to S5 and just supported by OS.	Similar to S5; All other power rails are switched off.
S5 Soft Off	In S5 state the system is switched off. Restart is only possible with the power button or by a system wake-up event such as 'Wake On LAN' or RTC alarm.	Suspend power rails are powered. All other power rails are switched off.

Table 45: Power Management Signal Descriptions

Signal	Pin	Description	I/O	Comment
PWRBTN#	B12	Power button low active signal used to wake up the system from S5 state (soft off). This signal is triggered on the falling edge.	I 3.3V Suspend CMOS	Drive with >=10mA
SYS_RESET#	B49	Reset button input. Active low request for Module to reset and reboot. May be falling edge sensitive. For situations when SYS_RESET# is not able to reestablish control of the system, PWR_OK or a power cycle may be used.	I 3.3V Suspend CMOS	Drive with >=10mA
CB_RESET#	B50	Reset output signal from Module to Carrier Board. This signal may be driven low by the Module to reset external components located on the Carrier Board.	O 3.3V Suspend CMOS	
PWR_OK	B24	Power OK status signal generated by the ATX power supply to notify the Module that the DC operating voltages are within the ranges required for proper operation.	I 3.3V CMOS	
SUS_STAT#	B18	Suspend status signal to indicate that the system will be entering a low power state soon. It can be used by other peripherals on the Carrier Board as an indication that they should go into power-down mode.	O 3.3V Suspend CMOS	
SUS_S3#	A15	S3 Sleep control signal indicating that the system resides in S3 state (Suspend to RAM).	O 3.3V Suspend CMOS	This signal can be used to control the ATX power supply via the *'PS_ON#'* signal.
SUS_S4#	A18	S4 Sleep control signal indicating that the system resides in S4 state (Suspend to Disk).	O 3.3V Suspend CMOS	

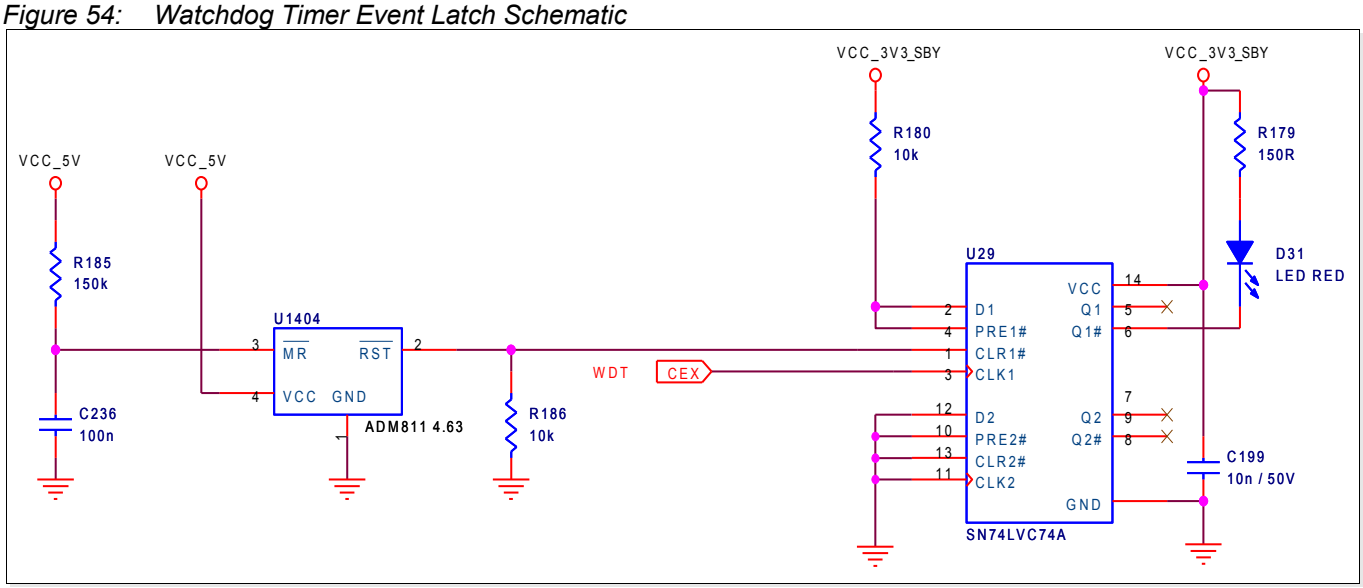
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Signal	Pin	Description	I/O	Comment
SUS_S5#	A24	S5 Sleep Control signal indicating that the system resides in S5 State (Soft Off).	O 3.3V Suspend CMOS	
WAKE0#	B66	PCI Express wake-up event signal.	I 3.3V Suspend CMOS	
WAKE1#	B67	General purpose wake-up signal.	I 3.3V Suspend CMOS	
BATLOW#	A27	Battery low input. This signal may be driven low by external circuitry to signal that the system battery is low. It also can be used to signal some other external power management event.	I 3.3V Suspend CMOS	

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2.22.5. Watchdog Timer

Figure 54: Watchdog Timer Event Latch Schematic



The Watchdog Timer (WDT) event signal is provided by the COM Express Module. The WDT output is active-high. It is sourced from Module pin B27.

The WDT event can cause the system to reset by making appropriate Carrier Board connections. It also may be possible to configure the Module to reset on a WDT event; check the manufacturer's Module Users Guide.

If the WDT output is used to cause a system reset, the WDT output will be cleared by the system reset event.

The WDT can be latched to drive a LED for a visual indication of an event, as shown in this example. The latch is only cleared by a complete power cycle.

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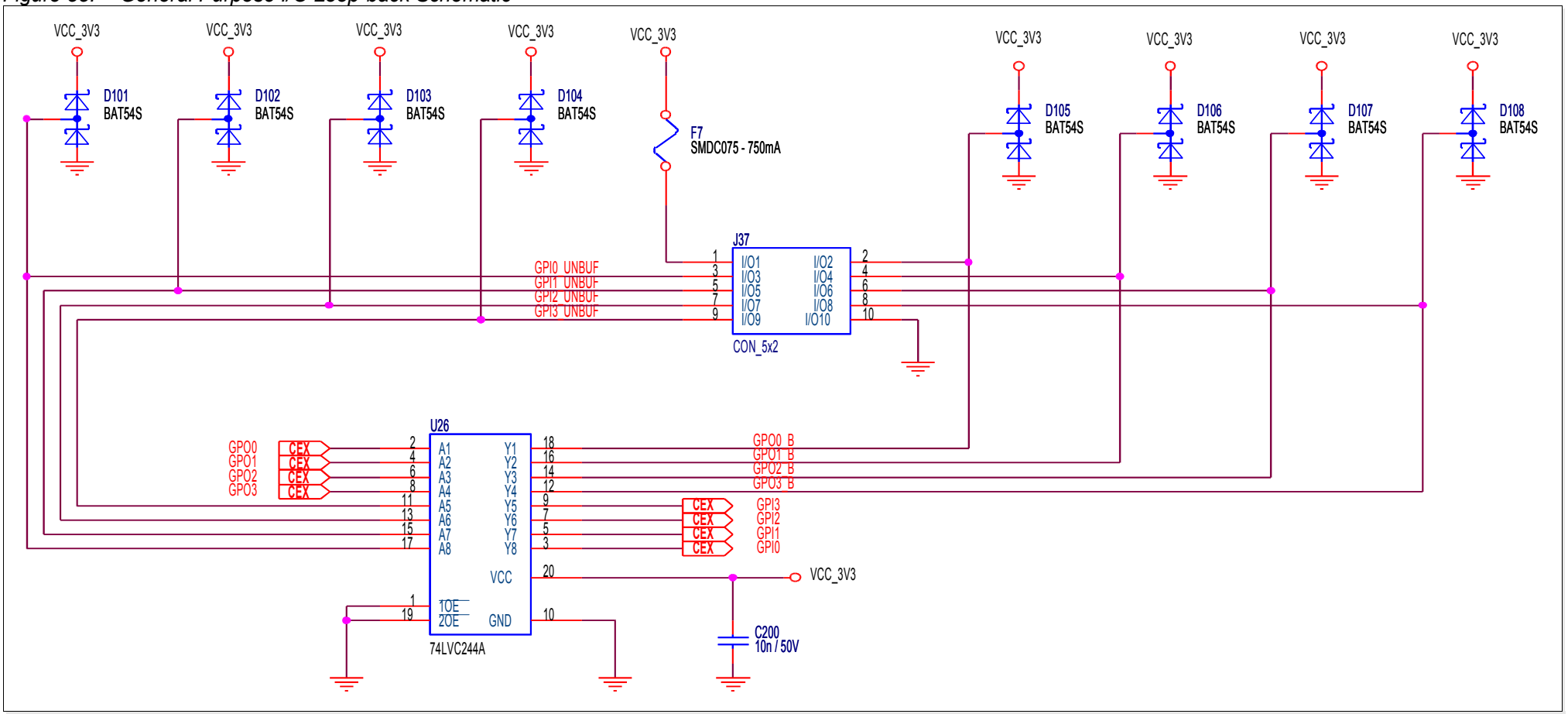
2.22.6. General Purpose Input/Output (GPIO)

Table 46: GPIO Signal Definition

Signal	Pin	Description	I/O	Comment
GPI0	A54	General purpose input pins. Pulled high internally on the Module.	I 3.3V CMOS	
GPI1	A63	General purpose input pins. Pulled high internally on the Module.	I 3.3V CMOS	
GPI2	A67	General purpose input pins. Pulled high internally on the Module.	I 3.3V CMOS	
GPI3	A85	General purpose input pins. Pulled high internally on the Module.	I 3.3V CMOS	
GPO0	A93	General purpose output pins. Upon a hardware reset, these outputs should be low.	O 3.3V CMOS	
GPO1	B54	General purpose output pins. Upon a hardware reset, these outputs should be low.	O 3.3V CMOS	
GPO2	B57	General purpose output pins. Upon a hardware reset, these outputs should be low.	O 3.3V CMOS	
GPO3	B63	General purpose output pins. Upon a hardware reset, these outputs should be low.	O 3.3V CMOS	

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Figure 55: General Purpose I/O Loop-back Schematic



There are 4 GPI (General Purpose Inputs) and 4 GPO (General Purpose Outputs) pins in Figure 55 above.

The signals drive switch inputs such as Lamps, Relays, and Sensors.

GPI signals from a header are shown with protection diodes. The signals are connected for input to the COM Express Module.

GPO signals from the COM Express Module are shown buffered. The signals are connected to the header with protection diodes.

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2.22.7. SDIO Interface Multiplexed with GPIOs

SD Card support was added in COM.0 Rev. 2.0 as an alternative use for the GPIO pins. The schematic below shows a multiplexer allowing the carrier to use the COM Express pins either as GPIO or as an SD Card interface. In a dedicated application the multiplexer is not necessary – if you just want an SD Card interface and no GPIO you can route the pins directly from the COM Express connectors to the SD Card. It is important that the SD Cards are ESD protected.

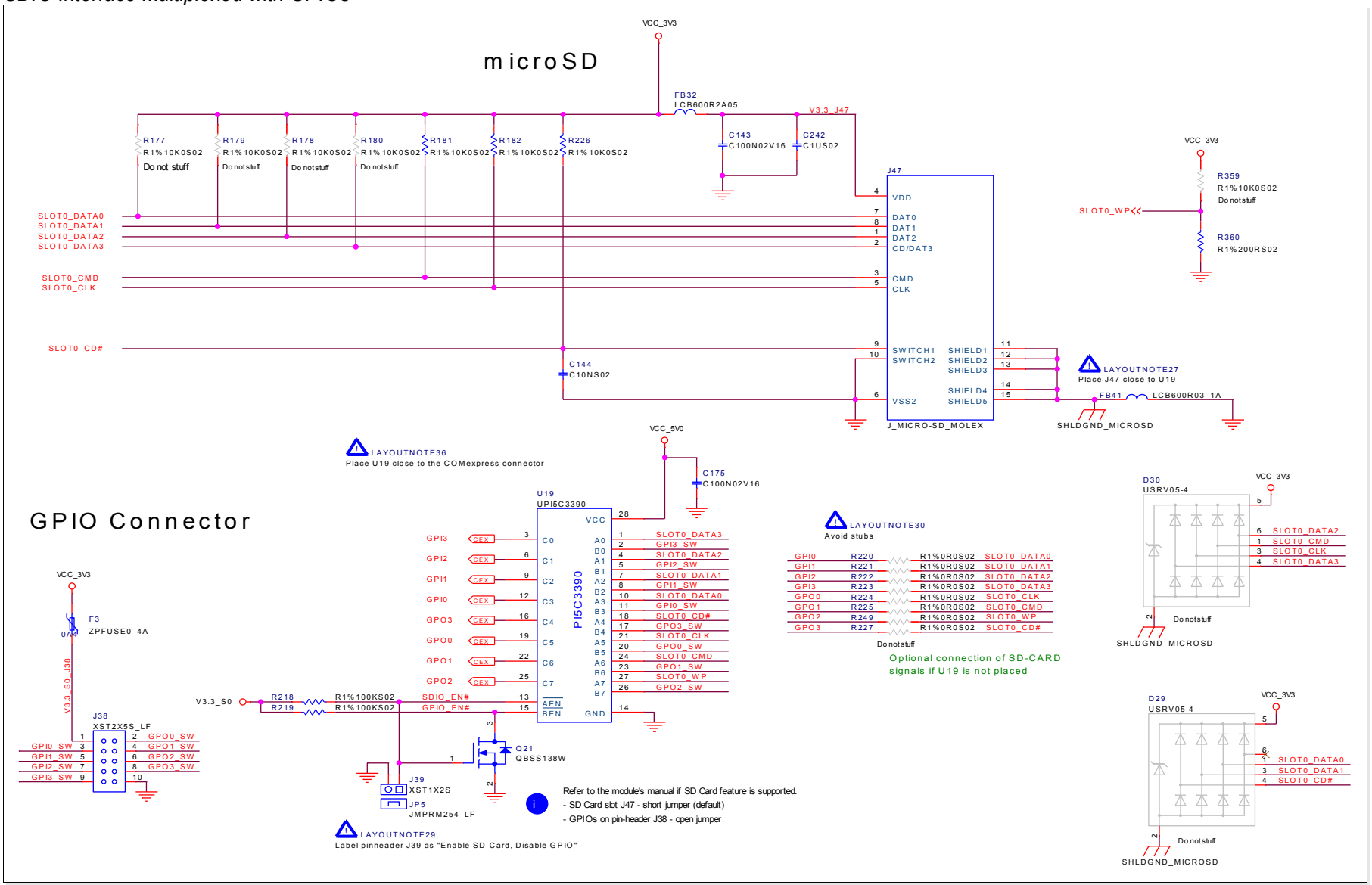
The following notes apply to Figure 56: SDIO Interface Multiplexed with GPIOs below.

U19 is the switch device to determine the usage of the GPI0 to GPI3 and GPO0 to GPO3 coming from the COM Express Module. When Jumper J39 is set to GND, SDIO is supported. When J39 is open, GPIO is supported. Please verify that the Module used supports the intended interface. To simplify the circuit, instead of installing U19, resistors R220 to R225, R227 and R249 can be installed when only SDIO is necessary without the usage of GPIOs.

Maximum length for SDIO should be restricted to 3 inches to the SDIO connector. Additional EMI or ESD measures might be applicable.

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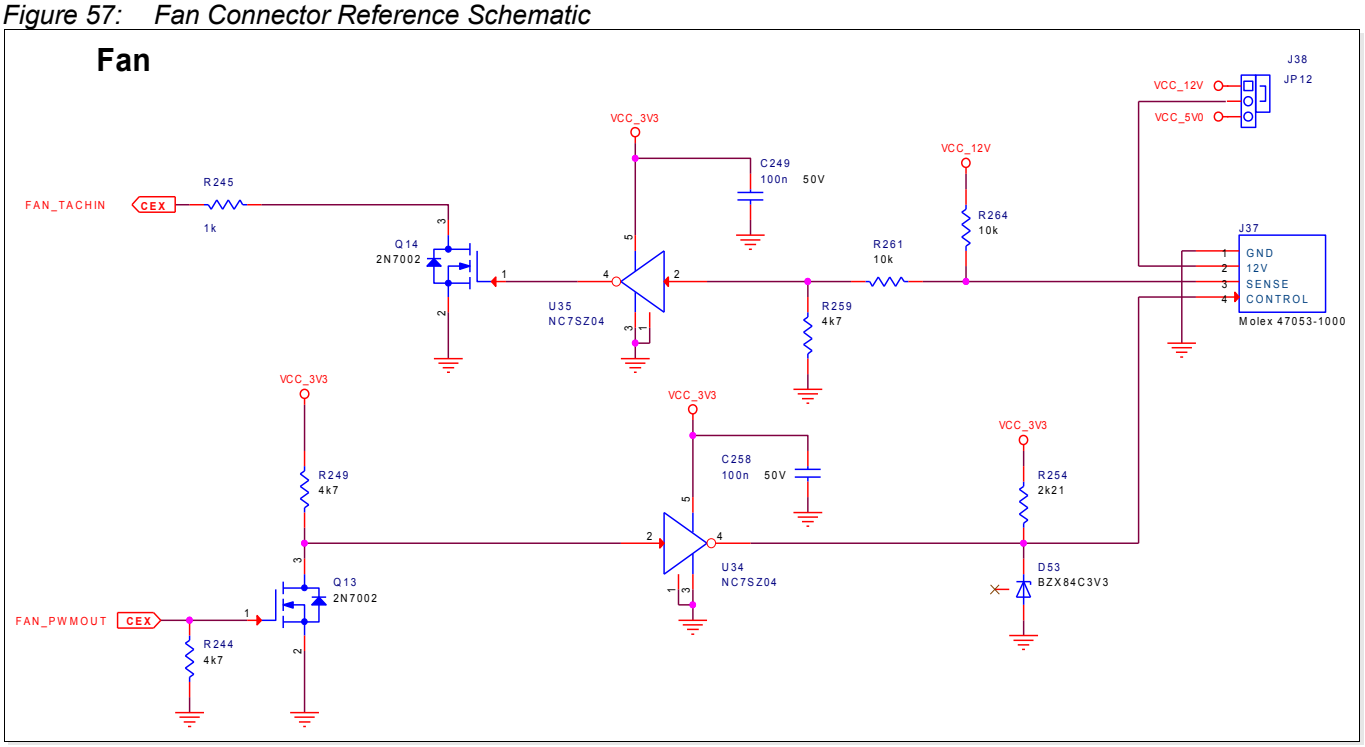
Figure 56: SDIO Interface Multiplexed with GPIOs



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2.22.8. Fan Connector

Figure 57: Fan Connector Reference Schematic



FAN_TACHIN and FAN_PWMOUT in Figure 57: Fan Connector Reference Schematic above are COM.0 pins reclaimed from the VCC_12V pool. Q13 / Q14 and U34 / U35 are the necessary circuitry on the Carrier Board to handle the 12V protection according to chapter 2.22.10 'Protecting COM.0 Pins Reclaimed From the VCC_12V Pool' on page 144 below. This reference schematic shows a 4-wire fan implementation, which should be preferred over a 3-wire fan. 4-wire fan implementations allow better sensing and control of the fan.

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2.22.9. Thermal Interface

COM Express provides the 'THRM#' and 'THRMTRIP#' signals, which are used for system thermal management. In most current system platforms, thermal management is closely associated with system power management. For more detailed information about the thermal management capabilities of the COM Express Module, refer to the manufacturer's Module's user's guide.

Table 47: Thermal Management Signal Descriptions

Signal	Pin	Description	I/O	Comment
THRM#	B35	Thermal Alarm active low signal generated by the external hardware to indicate an over temperature situation. This signal can be used to initiate thermal throttling.	I 3.3V CMOS	
THRMTRIP#	A35	Thermal Trip indicates an overheating condition of the processor. If *'THRMTRIP#'* goes active the system immediately transitions to the S5 State (Soft Off).	O 3.3V CMOS	

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2.22.10. Protecting COM.0 Pins Reclaimed From the VCC_12V Pool

The COM.0 Rev. 2 Type 6 and Type 10 pin-out types introduce eight signals that are mapped to pins that are re-claimed from pins that are VCC_12V supply pins on Type 1,2,3,4 and 5 Modules. These signals include

- SER0_TX, SER1_TX TTL level outputs from the Module
- SER0_RX, SER1_RX TTL level inputs to the Module
- LID#, SLEEP# 3.3V logic level inputs to the Module, in the suspend domain
- FAN_TACHIN 3.3V logic level input to the Module
- FAN_PWMOUT 3.3V logic level output from the Module

A new Type strap pin is also introduced in COM.0 Rev 2, for all Module Types. It also falls on a pin that was used exclusively for VCC_12V in COM.0 Rev. 1:

- TYPE10# VCC_12V on COM.0 Rev. 1 Module Types 1,2,3,4,5
  No connect on COM.0 Rev. 2 Module Types 1,2,3,4,5,6
  47K Module pull-down to GND on Module Type 10

All nine of the signals referenced above on COM.0 Rev. 2 compliant Module and Carrier designs shall be able to withstand continuous direct connections to low impedance 12V sources (i.e. a short to a 12V power supply).

One line of defense against such unintended connections is for Carrier designs to decode the Module TYPE pins (3 pins on the C-D connector, and the new TYPE10# pin on the A-B connector) and to not power the system up if an improper Module Type is detected. Examples of this may be found in the PICMG Carrier Design Guide. However, there are some situations in which this can not be relied upon. One such situation is if a user plugs a Type 10 Module into a Rev. 1 Type 1 Carrier. Since the TYPE10# strap was not anticipated in the Rev. 1 Carrier, the Carrier will apply power to the Type 10 Module. Thus it is very important that Type 10 and 6 Modules be able to withstand 12V exposure to the pins reclaimed from the VCC_12V pool.

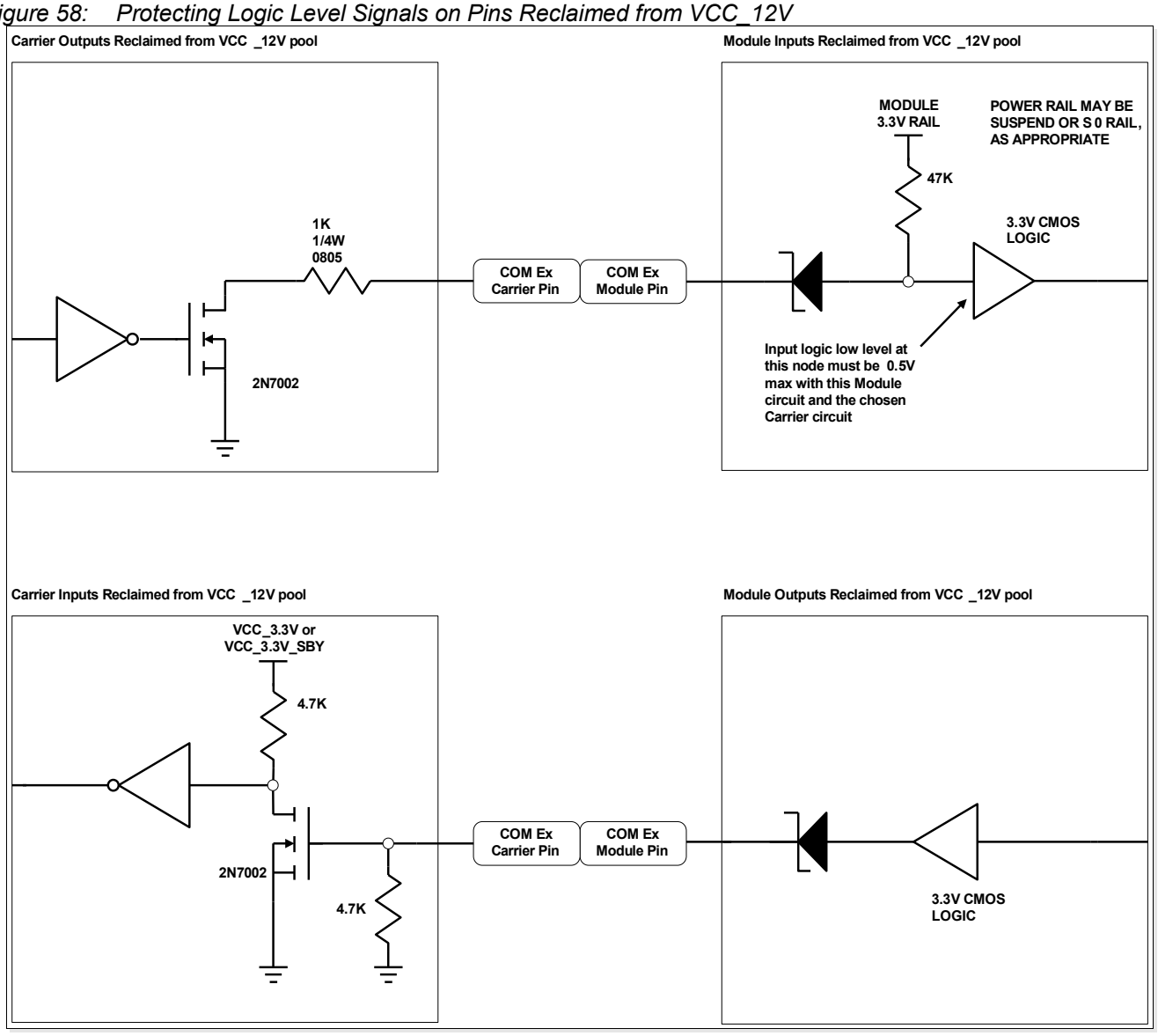
2.22.10.1. Logic Level Signals on Pins Reclaimed from VCC_12V

Module logic level inputs and outputs that are implemented on pins reclaimed from the VCC_12V pool shall implement the series Schottky diode protection shown in the right side of the figure below. The Schottky diode should be a BAT54 device. For inputs in this group, a 47K pull-up to the local 3.3V S0 or S5 rail (as appropriate) shall be used.

Carrier Board logic level inputs and outputs that are implemented on pins reclaimed from the VCC_12V pool shall be protected against protracted accidental exposure to 12V. The protection scheme shown in the left side of the Figure 5-13 below may be used. Any scheme that is used shall be able to pull the reclaimed Module input low enough such that Module CMOS input logic sees a maximum voltage of 0.5V for a logic low, as indicated in the figure.

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Figure 58: Protecting Logic Level Signals on Pins Reclaimed from VCC_12V



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2.22.10.2. TYPE10# Strap - Reclaimed from VCC_12V

No additional protection is needed for the TYPE10# strap on the Module side:

- On Type 10 Modules, this pin is tied through a 47K resistor to GND. Exposure of this Module pin to 12V is harmless.
- On Rev. 1 Type 1,2,3,4,5 Modules, this pin is tied to VCC_12V already.
- On Rev. 2 Type 1,2,3,4,5 Modules, this pin is a no connect.
- On Type 6 Modules, this pin is a no connect.

On the Carrier side, protection against accidental 12V exposure is required. Carrier Board designs shall be tolerant of protracted VCC_12V exposure on the TYPE10# pin. A Rev. 1 Type 1 Module, for example, would expose the TYPE10# pin on a Rev. 2 Type 1,2,3,4,5 Carrier to 12V (unless the Carrier design does not allow the system to power up for an incorrect Module type).

The TYPE10# Module pin is, in effect, a tri-level pin: it is tied, depending on Module Type and COM.0 Revision level, to either VCC_12V, to nothing, or to GND through 47K. Carrier Board circuits can be created that distinguish between the 3 levels. If implemented, this would allow the Carrier Board to determine whether a Type 1,2,3,4,5 Module is a built to COM.0 Rev. 1 or Rev. 2. This may be illustrated in a future edition of the PICMG Carrier Design Guide.

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2.23. PCI Bus

2.23.1. Signal Definitions

Type 2 and 3 COM Express Modules provide a 32-bit PCI bus that can operate up to 33 MHz. The corresponding signals can be found on the Module connector rows C and D.

Table 48: PCI Bus Signal Definition

Signal	Pin#	Description	I/O	Comment
PCI_AD0	C24	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD1	D22	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD2	C25	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD3	D23	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD4	C26	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD5	D24	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD6	C27	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD7	D25	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD8	C28	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD9	D27	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD10	C29	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD11	D28	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD12	C30	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD13	D29	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD14	C32	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD15	D30	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD16	D37	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD17	C39	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD18	D38	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD19	C40	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD20	D39	PCI bus multiplexed address and data lines	I/O 3.3V	IDSEL for slot 0
PCI_AD21	C42	PCI bus multiplexed address and data lines	I/O 3.3V	IDSEL for slot 1
PCI_AD22	D40	PCI bus multiplexed address and data lines	I/O 3.3V	IDSEL for slot 2
PCI_AD23	C43	PCI bus multiplexed address and data lines	I/O 3.3V	IDSEL for slot 3
PCI_AD24	D42	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD25	C45	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD26	D42	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD27	C46	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD28	D44	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD29	C47	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD30	D45	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_AD31	C48	PCI bus multiplexed address and data lines	I/O 3.3V	
PCI_C/BE0#	D26	PCI bus byte enable line 0, active low	I/O 3.3V	
PCI_C/BE1#	C33	PCI bus byte enable line 0, active low	I/O 3.3V	
PCI_C/BE2#	C38	PCI bus byte enable line 0, active low	I/O 3.3V	
PCI_C/BE3#	C44	PCI bus byte enable line 0, active low	I/O 3.3V	
PCI_DEVSEL#	C36	PCI bus Device Select, active low	I/O 3.3V	
PCI_Frame#	D36	PCI bus Frame control line, active low	I/O 3.3V	
PCI_IRDY#	C37	PCI bus Initiator Ready control line, active low	I/O 3.3V	
PCI_TRDY#	D35	PCI bus Target Ready control line, active low	I/O 3.3V	

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Signal	Pin#	Description	I/O	Comment
PCI_STOP#	D34	PCI bus STOP control line, active low	I/O 3.3V	
PCI_PAR	D32	PCI bus parity	I/O 3.3V	
PCI_PERR#	C34	Parity Error: An external PCI device drivers PERR# by driving it low, when it receives data that has a parity error.	I/O 3.3V	
PCI_REQ0#	C22	PCI bus master request input line, active low	I 3.3V	
PCI_REQ1#	C19	PCI bus master request input line, active low	I 3.3V	
PCI_REQ2#	C17	PCI bus master request input line, active low	I 3.3V	
PCI_REQ3#	D20	PCI bus master request input line, active low	I 3.3V	
PCI_GNT0#	C20	PCI bus master grant output line, active low	O 3.3V	
PCI_GNT1#	C18	PCI bus master grant output line, active low	O 3.3V	
PCI_GNT2#	C16	PCI bus master grant output line, active low	O 3.3V	
PCI_GNT3#	D19	PCI bus master grant output line, active low	O 3.3V	
PCI_RESET#	C23	PCI Reset output, active low	O 3.3V_SBY	Asserted during system reset
PCI_LOCK#	C35	PCI Lock control line, active low	I/O 3.3V	
PCI_SERR#	D33	System Error: SERR# may be pulsed active by any PCI device that detects a system error condition	I/O 3.3V	
PCI_PME#	C15	PCI Power Management Event: PCI peripherals drive PME# to low to wake up the system from low-power states S1-S5	I 3V3_SBY	
PCI_CLKRUN#	D48	Bidirectional pin used to support PCI clock run protocol for mobile systems.	I/O 3.3V	
PCI_IRQA#	C49	PCI interrupt request line A	I 3.3V	
PCI_IRQB#	C50	PCI interrupt request line B	I 3.3V	
PCI_IRQC#	D46	PCI interrupt request line C	I 3.3V	
PCI_IRQD#	D47	PCI interrupt request line D	I 3.3V	
PCI_CLK	D50	PCI 33MHz clock output	O 3.3V	
PCI_M66EN	D49	Module input signal that indicates whether a Carrier Board PCI device is capable of 66MHz operation. It is pulled to ground by Carrier Board device or by slot card, if one of the devices is NOT capable of 66MHz operation.	I 3.3V	

2.23.2. Reference Schematics

2.23.2.1. Resource Allocation

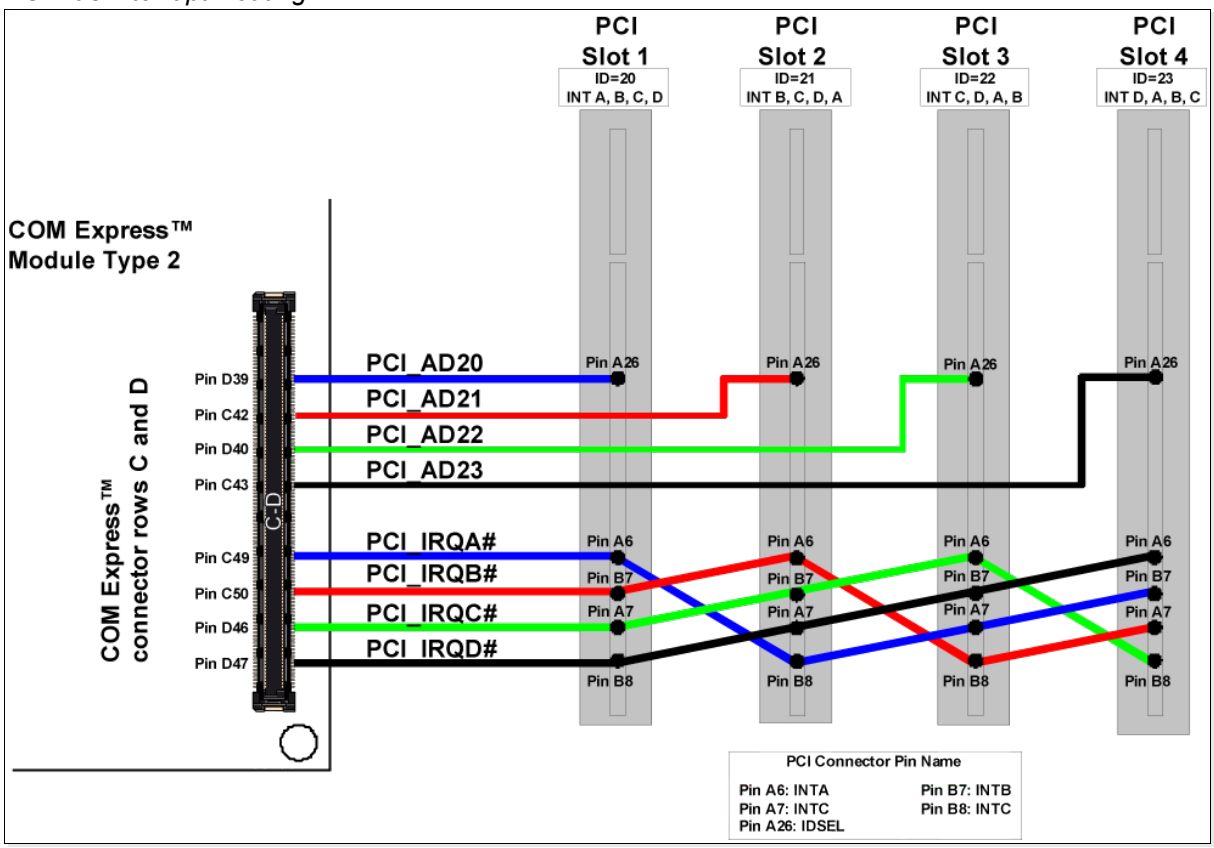
The COM Express PCI interface is compliant to the 'PCI Local Bus Specification Revision 2.3'. It supports up to four bus master capable PCI bus slots or external PCI devices designed on the COM Express Carrier Board. The PCI interface is specified to be +5V tolerant, with +3.3V signaling. All necessary PCI bus pull-up resistors must be included on the COM Express Module.

Allocate PCI resources (IDSEL pin assignments, interrupts, request lines and grant lines) per Figure 59: PCI Bus Interrupt Routing below. The PCI Specification requires that PCI devices be capable of sharing interrupts. Interrupt latency is reduced if devices do not share interrupts; hence the interrupt “rotation” scheme shown below is recommended. If there are more than four PCI devices in the system, then some interrupt-sharing is inevitable.

The signal 'IDSEL' of each external PCI device or PCI slot has to be connected through a 22Ω resistor to a separate PCI address line. For PCI bus slots 1-4, COM Express specifies the PCI address lines AD[20] to AD[23].

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Figure 59: PCI Bus Interrupt Routing



Most of these PCI devices only utilize the interrupt signal 'INTA#'. To distribute the interrupt source of the devices over the interrupt signals 'INTB#', 'INTC#' and 'INTD#', an interrupt cross routing scheme has to be implemented on the COM Express Carrier Board design. Figure 59 above and Table 49 below illustrate the PCI bus interrupt routing for the PCI bus slots 1-4.

Table 49: PCI Bus Interrupt Routing

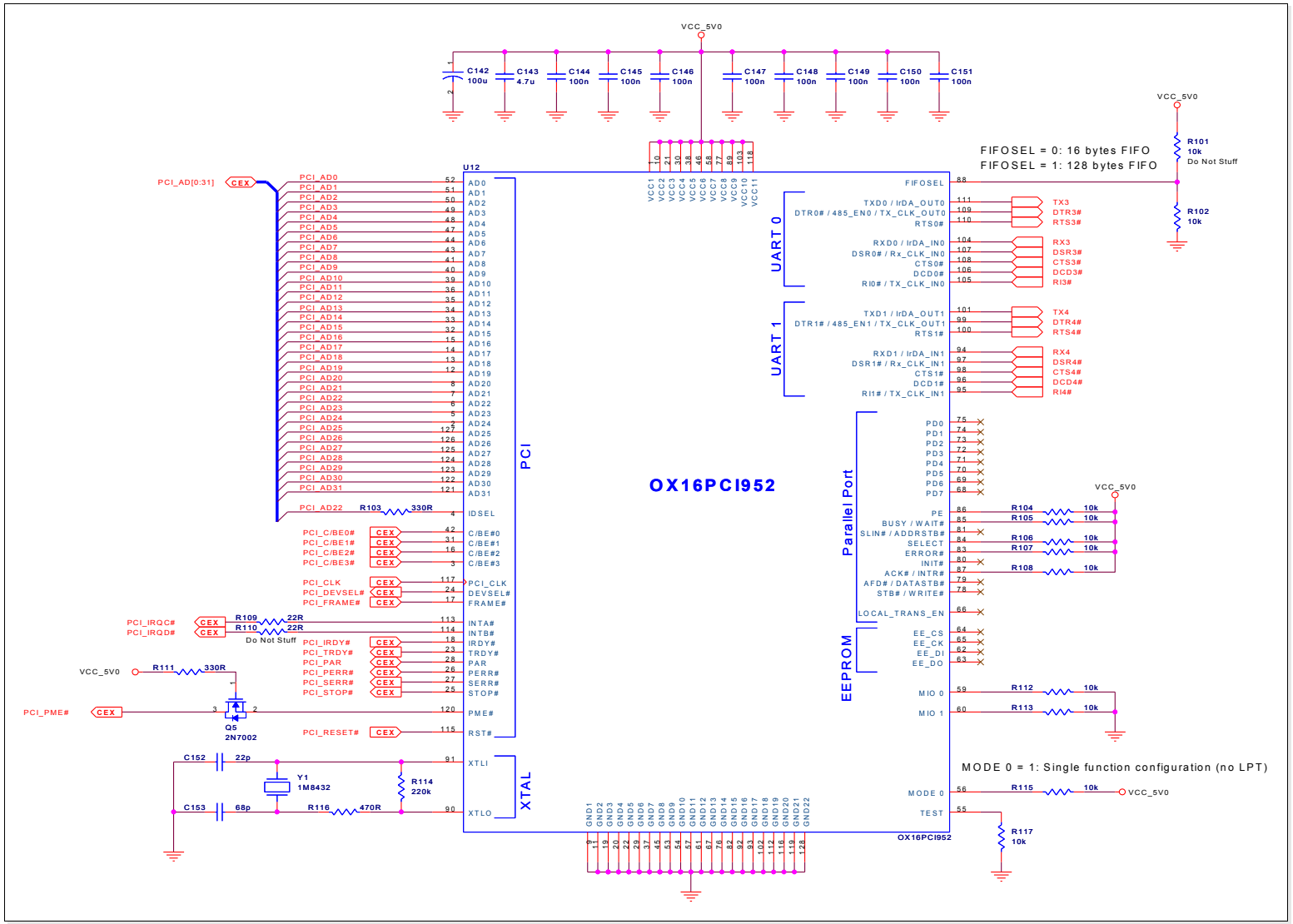
Device Signal	Slot / Device 1	Slot / Device 2	Slot / Device 3	Slot / Device 4
IDSEL	PCI_AD[20]	PCI_AD[21]	PCI_AD[22]	PCI_AD[23]
INTA#	PCI_IRQ[A]#	PCI_IRQ[B]#	PCI_IRQ[C]#	PCI_IRQ[D]#
INTB# (if used)	PCI_IRQ[B]#	PCI_IRQ[C]#	PCI_IRQ[D]#	PCI_IRQ[A]#
INTC# (if used)	PCI_IRQ[C]#	PCI_IRQ[D]#	PCI_IRQ[A]#	PCI_IRQ[B]#
INTC# (if used)	PCI_IRQ[D]#	PCI_IRQ[A]#	PCI_IRQ[B]#	PCI_IRQ[C]#

Requests and Grants cannot be shared. There should only be a single REQ / GNT pair per device.

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2.23.2.2. Device-Down Example

Figure 60: PCI Device Down Example; Dual UART



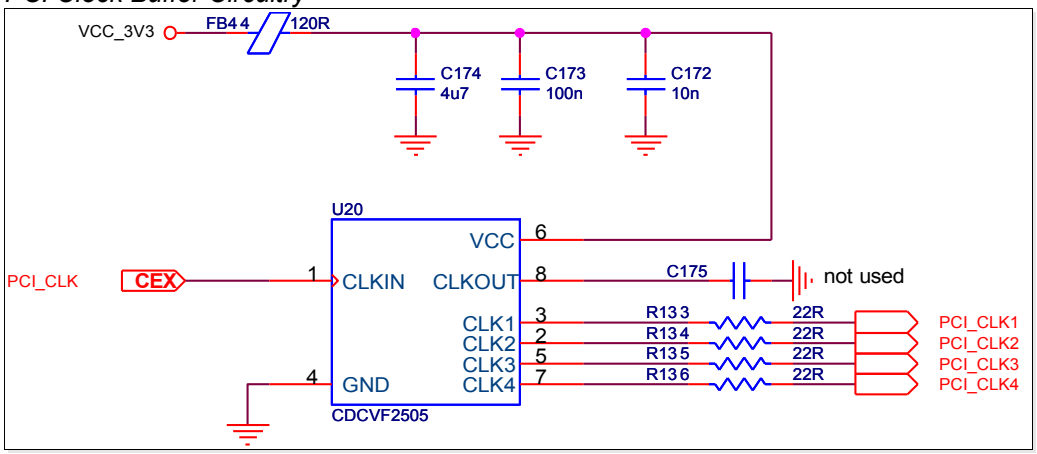
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2.23.2.3. Device-Down Considerations

2.23.2.4. Clock Buffer

The COM Express Specification only supports a single PCI clock signal called 'PCI_CLK' to be used on the Carrier Board. If there are multiple devices or slots implemented on the Carrier Board, a zero delay clock buffer is required to expand the number of PCI clocks so that each device or each bus slot will be provided with a separate clock signal. Figure 61 below shows an example using the Texas Instruments 'CDCVF2505' zero delay clock buffer providing four output clock signals with spread spectrum compatibility (http://www.ti.com).

Figure 61: PCI Clock Buffer Circuitry



Note: In accordance with the 'PCI Local Bus Specification Revision 2.3', the PCI clock signal requires a rise and fall time (slew rate) within 1V/ns and 4V/ns. The slew rate must be met across the minimum peak-to-peak portion of the clock wave form, which is between 0.66V and 1.98V for 3.3V clock signaling. These parameters are very critical for EMI and must be observed during Carrier Board layout when implementing the PCI Bus.

2.23.3. Routing Considerations

2.23.3.1. General PCI Signals

Route the PCI bus with 55-Ω, single-ended signals. The bus may be referenced to ground (preferred), or to a well-bypassed power plane, or a combination of the two. Point-to-point (daisy-chain) routing is preferred, although stubs up to 1.5 inches may be acceptable.

See Section 6.6.1. 'PCI Trace Routing Guidelines' on page 191 for a summary of trace routing parameters and guidelines.

2.23.3.2. PCI Clock Routing

Particular attention must be paid to the PCI clock routing. The PCI Local Bus specification requires a maximum propagation delay for the clock signals of 10ns within a propagation skew of 2ns @ 33MHz between the several clock signals.

The COM Express Specification allows 1.6ns ± 0.1ns @ 33MHz propagation delay for the PCI clock signal beginning from the Module pin to the destination pin of the PCI device. The propagation delay is dependent on the trace geometries, PCB stack-up and the PCB dielectric constant.

Calculating using a typical propagation delay value of 180ps/inch for an internal layer clock trace of the Carrier Board, a maximum trace length of 8.88 inches is allowed.

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The clock trace from the COM Express Module to a PCI bus slot should be 2.5 inches shorter because PCI cards are specified to have 2.5 inches of clock trace length on the card itself.

PCI clock signals should be routed as a single ended trace with a trace impedance of 55Ω. To reduce EMI, a single ground referenced internal layer is recommended. The clock traces should be separated as far as possible from other signal traces.

Refer to Section 6.6.1 'PCI Trace Routing Guidelines' on page 191 below and the 'PCI Local Bus Specification Revision 2.3' to get more information about this subject.

Note: ***An approximate value for the signal propagation delay per trace length inch can be calculated by using the following formula:***

$$t_{prop.} = \frac{\sqrt{\varepsilon_r'}}{11.8}\frac{ns}{inch}$$

ε_r' can be determined from the dielectric constant of the PCB that is used by the following approximation. A typical value for the dielectric constant of an FR4 PCB material is 4.2 < ε_r < 4.5.

For stripline routing: $\varepsilon_r' = \varepsilon_r$

For microstrip routing: $\varepsilon_r' = 0.475\varepsilon_r + 0.67 \quad for \quad 2.0 < \varepsilon_r < 6.0$

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2.24. IDE and CompactFlash (PATA)

2.24.1. Signal Definitions

Type 2 and 4 COM Express Modules provide a single channel IDE interface supporting two standard IDE hard drives or ATAPI devices with a maximum transfer rate of ATA100 (Ultra-DMA-100 with 100MB/s transfer rate). The corresponding signals can be found on the Module connector rows C and D.

Table 50: Parallel ATA Signal Descriptions

Signal	Pin	Description	I/O	IDE40	IDE44	CF
IDE_D0	D7	Bidirectional data to / from IDE device.	I/O 3.3V	17	17	21
IDE_D1	C10	Bidirectional data to / from IDE device.	I/O 3.3V	15	15	22
IDE_D2	C8	Bidirectional data to / from IDE device.	I/O 3.3V	13	13	23
IDE_D3	C4	Bidirectional data to / from IDE device.	I/O 3.3V	11	11	2
IDE_D4	D6	Bidirectional data to / from IDE device.	I/O 3.3V	9	9	3
IDE_D5	D2	Bidirectional data to / from IDE device.	I/O 3.3V	7	7	4
IDE_D6	C3	Bidirectional data to / from IDE device.	I/O 3.3V	5	5	5
IDE_D7	C2	Bidirectional data to / from IDE device.	I/O 3.3V	3	3	6
IDE_D8	C6	Bidirectional data to / from IDE device.	I/O 3.3V	4	4	47
IDE_D9	C7	Bidirectional data to / from IDE device.	I/O 3.3V	6	6	48
IDE_D10	D3	Bidirectional data to / from IDE device.	I/O 3.3V	8	8	49
IDE_D11	D4	Bidirectional data to / from IDE device.	I/O 3.3V	10	10	27
IDE_D12	D5	Bidirectional data to / from IDE device.	I/O 3.3V	12	12	28
IDE_D13	C9	Bidirectional data to / from IDE device.	I/O 3.3V	14	14	29
IDE_D14	C12	Bidirectional data to / from IDE device.	I/O 3.3V	16	16	30
IDE_D15	C5	Bidirectional data to / from IDE device.	I/O 3.3V	18	18	31
IDE_A[0:2]	D13-D15	Address lines to IDE device.	O 3.3V	35, 33, 36	35, 33, 36	20, 19, 18
IDE_IOW#	D9	I/O write line to IDE device.	O 3.3V	23	23	35
IDE_IOR#	C14	I/O read line to IDE device.	O 3.3V	25	25	34
IDE_REQ	D8	IDE device DMA request. It is asserted by the IDE device to request a data transfer.	I 3.3V	21	21	37
IDE_ACK#	D10	IDE device DMA acknowledge.	O 3.3V	29	29	44
IDE_CS1#	D16	IDE device chip select for 1F0h to 1FFh range.	O 3.3V	37	37	7
IDE_CS3#	D17	IDE device chip select for 3F0h to 3FFh range.	O 3.3V	38	38	32
IDE_IORDY	C13	IDE device I/O ready input. Pulled low by the IDE device to extend the cycle.	I 3.3V	27	27	42
IDE_RESET#	D18	Reset output to IDE device, active low.	O 3.3V	1	1	41
IDE_IRQ	D12	Interrupt request from IDE device.	I 3.3V	31	31	43
IDE_CBLID#	D77	Input from off-Module hardware indicating the type of IDE cable being used. High indicates a 40-pin cable used for legacy IDE modes. Low indicates that an 80-pin cable with interleaved grounds is used. Such a cable is required for Ultra-DMA 66, 100 modes.	I 3.3V	34	34	46
DASP				39	39	45
GND				2, 19, 22, 24, 26, 30, 40	2, 19, 22, 24, 26, 30, 40, 43	17, 16, 15, 14, 12, 11, 10, 8, 12, 6, 9, 33, 25, 26 39 (master)

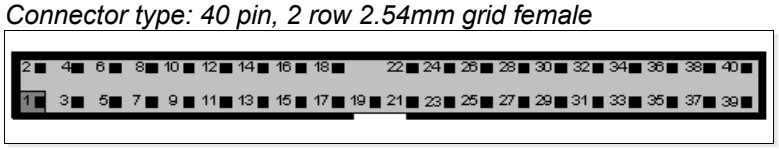
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Signal	Pin	Description	I/O	IDE40	IDE44	CF
CSEL				28	28	39
N.C.				20, 32	20, 32, 44	24, 40, 51, 52, 53, 54, 55, 56 39 (slave)
VCC_5V					41, 42,	13, 18, 36

2.24.2. IDE 40-Pin Header (3.5 Inch Drives)

To interface standard 3.5-inch parallel ATA drives, a standard 2.54mm, two row, 40-pin connector in combination with a ribbon conductor cable is used. For slower drive speeds up to ATA33, a normal 40-pin, 1.27mm-pitch conductor cable is sufficient. Higher transfer rates such as ATA66 and ATA100 require 80-pin conductor cables, where the extra 40 conductors are tied to ground to isolate the adjacent signals for better signal integrity. The 80-pin cable assembly also ties pin 34 (IDE_CBLID#) on the 40-pin header to GND. If IDE_CBLID# is sampled low by the Module's BIOS, it assumes that the proper high-speed cable is present and sets up the drive parameters accordingly. Jumper settings on the IDE devices determine Master/Slave configuration. The drive activity LED is driven by the Module's pin A28 (COM Express pin ATA_ACT#).

Figure 62: Connector type: 40 pin, 2 row 2.54mm grid female



2.24.3. IDE 44-Pin Header (2.5 Inch and Low Profile Optical Drives)

To interface standard 2.5-inch parallel ATA drives, as well as low profile optical drives, a standard 2.0mm, two row, 44-pin connector in combination with a 44-conductor ribbon cable is used. For slower drive speeds up to ATA33, a normal 44-conductor, 1.0mm-pitch cable is sufficient. Higher transfer rates such as ATA66 and ATA100 require special handling as ground isolated cables like those commonly used for 3.5” ATA devices do not exist for this interface. Simulation as well as testing should be used to determine if an application specific 44-pin cable interface can support ATA66 and ATA100 speeds. Items to be taken into consideration include cable length, placement in the system, folds and routing. Because 44-conductor cables have no method of indicating their transfer rate capability, IDE_CBLID# must be controlled on the Carrier Board or by using BIOS setup. For 44-pin ATA devices, the drive activity LED is driven by pin 39 of the header.

2.24.4. CompactFlash 50 Pin Header

CompactFlash (CF) cards with DMA capability require that the two signals 'IDE_REQ' and 'IDE_ACK#' are routed to the CF card socket on the COM Express Carrier Board. If this is not done then some DMA capable CF cards may not work because they are not designed for non DMA mode. For more information about this subject, refer to the data sheet of the CF card or contact your CF card manufacturer.

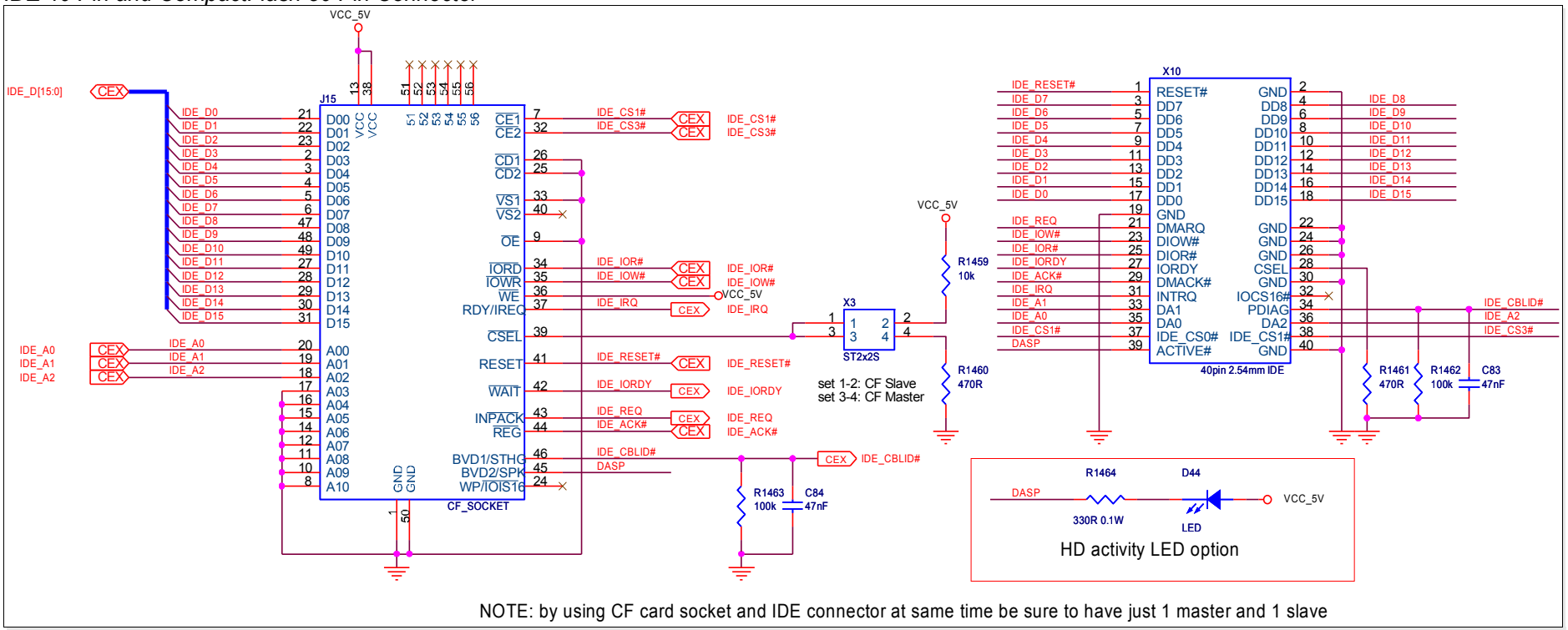
CF socket pin 39 (CSEL#) is connected to a jumper to select Master or Slave configuration. If jumpered low, the drive is configured for Master mode. This provides the ability to perform a CompactFlash boot.

2.24.5. IDE / CompactFlash Reference Schematics

This reference schematic shows a circuitry implementing an IDE connector and a CF card socket that is DMA capable.

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Figure 63: IDE 40 Pin and CompactFlash 50 Pin Connector



2.24.6. Routing Considerations

The IDE signals are single-ended signals with a nominal impedance of 55 Ω. See Section 6.6.2. 'IDE Trace Routing Guidelines' on page 192 for more information about routing considerations.

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3. Power and Reset

3.1. General Power requirements

COM Express calls for the Module to be powered by a single 12V power rail, with a +/-5% tolerance. The Mini format Modules are specified in COM.0 Rev. 2.1 to support a power input range of 4.75V to 20.0V. Some vendors offer a wide range input even on Compact and Basic Modules. COM Express Modules may consume significant amounts of power – 25 to 50W is common, and higher levels are allowed by the standard. Close attention must be paid by the Carrier Board designer to ensure adequate power delivery. Details are given in the sections below.

If Suspend functions such as Suspend-to-RAM, Suspend-to-disk, wake on power button press, wake on USB activity, etc. are to be supported, then a 5V Suspend power source must also be provided to the Module. If Suspend functions are not used, the Module VCC_5V_SBY pins should be left open. On some Modules, there may be a slight power efficiency advantage to connecting the Module VCC_5V_SBY rail to VCC_5V rather than leaving the Module pin open. Please contact your Module vendor for further details.

Carrier Boards typically require other power rails such as 5V, 3.3V, 3.3V Suspend, etc. These may be derived on the Carrier Board from the 12V and 5V Suspend rails.

3.1.1. VCC_12V Rise Time Caution and Inrush Currents

Direct connection of a COM Express Module to a low impedance supply such as a battery pack may result in excessive inrush currents. The supply to the COM Express Module should be slew limited to limit the input voltage ramp rate. A typical ATX supply ramps at about 2.5 volts per millisecond.

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3.2. ATX and AT Style Power Control

3.2.1. ATX vs AT Supplies

ATX power supplies are in common use in contemporary PCs. ATX supplies have two sets of power rails: a set for normal operation (12V, 5V, 3.3V and -12V) and a separate 5V Suspend rail. The 5V Suspend rail is present whenever the ATX supply has AC input power. The other rails are on only when a control signal from the PC hardware known as PS_ON# is held low by the motherboard, allowing software control of the power supply. The PC motherboard may implement several mechanisms for controlling the AC power, including a push button switch that switches a low voltage logic signal rather than the AC main power. Other options may be implemented, including the capability to turn on the main power on events such as a keyboard press, mouse activity, etc.

AT power supplies do not have a Suspend rail and do not allow software control of the power supply. An AT supply is on when the supply is connected to the AC main and the power switch that is in series with the AC main input is on. AT supplies are extinct in the commercial PC market, but the term lives on as a reference to a power supply that does not allow software control.

An ATX supply may be converted to AT style operation by simply holding the ATX PS_ON# input low all the time.

3.2.2. Power States

Power states are described by the following terms:

Table 51: Power States

State	Description	Comment
G3	Mechanical Off	AC power to system is removed by a mechanical switch. System power consumption is near zero – the only power consumption is that of the RTC circuits, which are powered by a backup battery.
S5	Soft Off	System is off except for a small subset that is powered by the 5V Suspend rail. There is no system context preserved. VCC_5V_SBY current consumption is system dependent, and it may be from tens of milliamps up to several hundred milliamps.
S4	Suspend to Disk	System is off except for a small subset that is powered by the 5V Suspend rail. System context is preserved on a non-volatile disk media (that is powered off). VCC_5V_SBY current consumption is system dependent, and it may be from tens of milliamps up to several hundred milliamps.
S3	Suspend to RAM	System is off except for system subset that includes the RAM. Suspend power is provided by the 5V Suspend rail. System context is preserved in the RAM. VCC_5V_SBY current consumption is system dependent, and it may be from several hundred milliamps up to a maximum of 2A.
S0	On	System is on.

COM Express signals SUS_S5#, SUS_S4# and SUS_S3# have the following behavior in the Power States:

Table 52: Power State Behavior

State	SUS_S5#	SUS_S4#	SUS_S3#
G3	NA	NA	NA
S5	Low	Low	Low
S4	High	Low	Low
S3	High	High	Low
S0	High	High	High

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3.2.3. ATX and AT Power Sequencing Diagrams

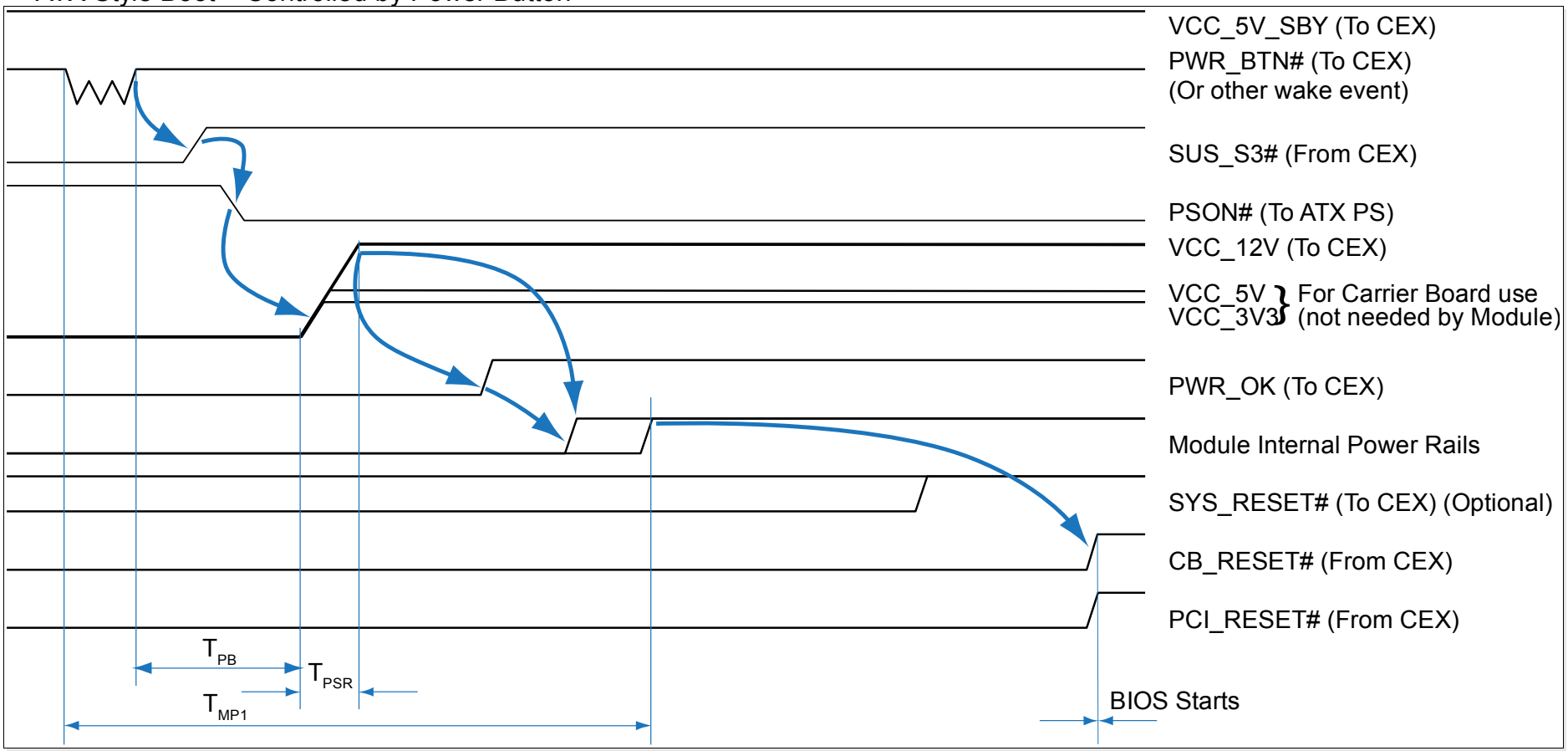
A sequence diagram for an ATX style boot from a soft-off state (S5), initiated by a power button press, is shown in Figure 64 below.

A sequence diagram for an AT style boot from the mechanical off state (G3) is shown in Figure 65 below below.

In both cases, the VCC_12V, VCC_5V and VCC_3V3 power lines should rise together in a monotonic ramp with a positive slope only, and their rise time should be limited. Please refer to the ATX specification for more details.

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Figure 64: ATX Style Boot – Controlled by Power Button



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Figure 65: AT Style Power Up Boot

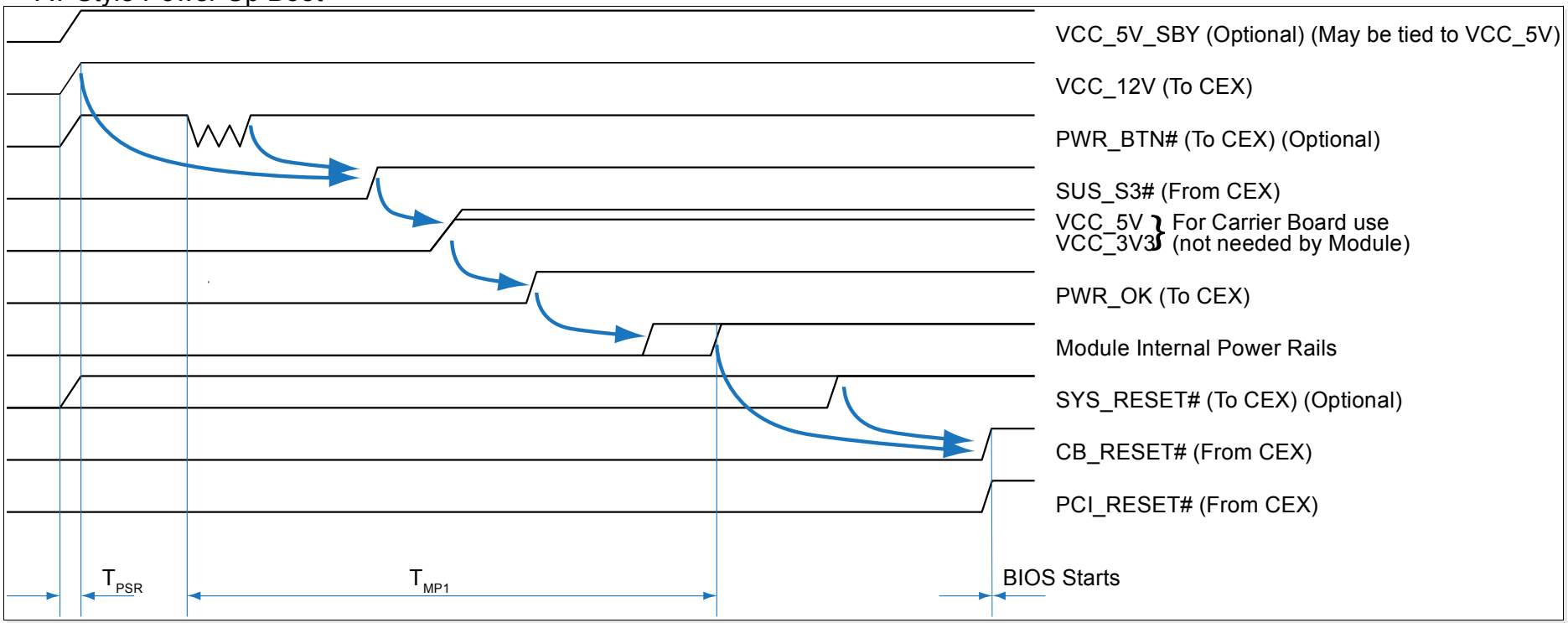


Table 53 below indicates roughly what time ranges can be expected during the boot process, per Figure 64 and 65 above. Check with your Module vendor if more specific information is required.

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Table 53: ATX and AT Power Up Timing Values

Parameter	Min Value	Max Value	Description	Comments
TPB	10ms	500ms	Push Button Power Switch – time to bring Module chipset out of Suspend mode	Applies only to ATX Style Power Up
TPSR	0.1ms	20ms	Power Supply Rise Time	

Notes

There is a period of time (TMP1 in Figure 64 and Figure 65 above) during which the Carrier Board circuits have power but the COM Express Module main internal power rails are not up. This is because almost all COM Express internal rails are derived from the external VCC_12V and there is a non-zero start-up time for the Module internal power supplies.

Carrier Board circuits should not drive any COM Express lines during the TMP1 interval except for those identified in the COM Express Specification as being powered from a Suspend power rail. Almost all such signals are active low. Such signals, if used, should be driven low by open drain Carrier Board circuits to assert them. Pull-ups, if present, should be high value (10K to 100K) and tied to VCC_5V_SBY.

The line PWR_OK may be used during the TMP1 interval to hold off a COM Express Module boot. Sometimes this is done, for example, to allow a Carrier Board device such as an FPGA to be configured before the Module boots.

The deployment of Carrier Board pull-ups on COM Express signals should be kept to a minimum in order to avoid back-driving the COM Express signal pins during this interval. Carrier Board pull-ups on COM Express signal pins are generally not necessary – most signals are pulled up if necessary on the Module.

3.2.4. Power Monitoring Circuit Discussion

Contemporary chipsets used in COM Express Modules incorporate a state machine or micro-controller that is powered from a Suspend power rail (i.e. a power rail that is derived from VCC_5V_SBY and is on whenever the ATX power supply has incoming AC line power). This state machine or micro-controller operates autonomously from the main CPU on the Module. The function of this state machine or micro-controller is to manage the system power states. It monitors various inputs (e.g. PWRBTN#, WAKE0#, WAKE1#, etc.) that can cause power state changes, and outputs status signals (e.g. SUS_S5#, SUS_S4#, SUS_S3#, SUSPEND#) that can be used by system hardware to control various power supplies and power planes in the system.

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3.2.5. Power Button

The COM Express PWRBTN# input may be used by Carrier Board hardware to implement ATX style power control. A schematic example of how to do this is given in 3.4.1 'ATX Power Supply' on page 164 below. The COM Express PWRBTN# input is typically de-bounced by the Module chipset.

The behavior of the system after a power failure depends on the Module chipset capabilities and on the Module vendor's hardware and BIOS implementation. With most Modules, the following behaviors may be set by RTC chipset register settings:

Table 54: Power Button States

State	Description
Always On	No Power Button press needed Chipset de-asserts SUS_S5#, SUS_S4# and SUS_S3# after Suspend rail to chipset is stable
Wait For Power Button Press	Chipset remains in Suspend state until power button press is received
Last State	If unit was “on” when power was removed, then unit returns to “on” state when power is restored

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3.3. Design Considerations for Carrier Boards containing FPGAs/CPLDs

Very often, the Carrier Board will contain custom FPGA or other programmable devices which require the loading of program code before they are usable. The Carrier Board designer needs to take the necessary precautions to ensure that his Carrier Board logic is up and running before the Module starts. Conflicts can occur if the Module is powered on and allowed to run before devices on the Carrier Board are fully programmed and initialized. A typical example is an FPGA which includes a PCIe device. Such devices must be initialized and ready before the chipset on the Module performs link training and before the BIOS code performs enumeration of PCI devices. The Module should therefore be prevented from starting before Carrier Board devices are ready.

One method to achieve this is to delay assertion of the PWR_OK# signal to the Module until the Carrier Board initialization process has completed. Note that during the phase when the Carrier Board is powered and the Module is not powered there is potential for back drive voltages from the carrier to the Module.

Another possibility is to use the SYS_RESET# signal to delay Module start-up. However, depending on the Module implementation and the chipset used, SYS_RESET# may only be a falling edge triggered signal and not a low active signal as was originally intended. In that case, asserting SYS_RESET# may not hold the Module in the reset state. Also, PCIe link training will occur regardless of the reset signal state for some chipsets.

Please refer to the COM.0 R2.1 specification (Power and System Management section) for more details and check the Module provider’s documentation for their implementations of these signals.

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3.4. Reference Schematics

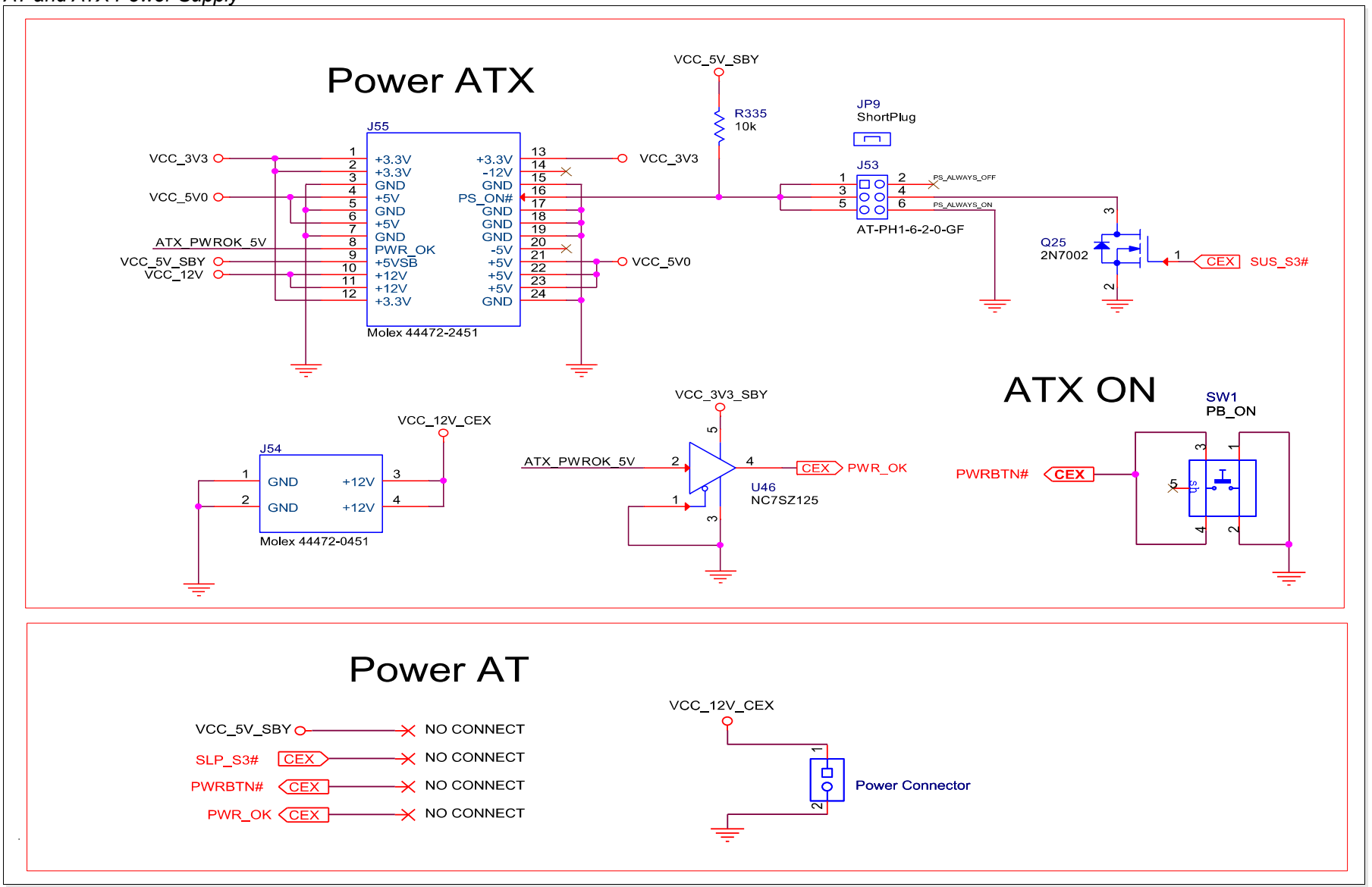
3.4.1. ATX Power Supply

ATX power supplies are used in millions of desktop PCs and are often used in OEM equipment as well. They are inexpensive and are readily available. An ATX power supply provides more power rails (two separate +12V rails, +5V, +3.3V, -12V and +5V Suspend) than are required by a COM Express Module, but often the Carrier Board and other system components make use of the additional rails.

The following figure shows the ATX power Carrier Board circuitry using a 24 pin ATX main power connector. For systems with power-hungry CPUs or Graphics Cards, two additional +12V power pins may be implemented using an auxiliary 4 pin (2x2) +12V/GND power connector.

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Figure 66: AT and ATX Power Supply



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The PWRBTN# signal is an input to the COM Express Module. Switch de-bouncing is done on the Module. The falling edge of the PWRBTN# signal can initiate a state transition from S5 (soft off) to S0 (full on). It may also cause the reverse transition, to S5, if the unit is in one of the 'on' states.

The ATX supply is controlled by the net PS_ON# in the figure above. The main ATX supply rails are on when PS_ON# is driven low. To turn the supply off, PS_ON# can be floated. This net is usually derived from an inverted copy of the COM Express SUS_S3# signal. Jumper J53 offers the possibility to override this signal with a fixed setup for debugging reasons.

Table 55: ATX Signal Names

ATX Signal Name	Description
PS_ON#	Active-low, TTL-level input to ATX supply that, when low, enables all power rails. If high or floating, all ATX power rails are disabled except for the +5V Suspend rail.
PWR_OK	Active-high, TTL-level output signal from the ATX supply that indicates that the +12V, +5V, +3.3V and -12V outputs are all present and OK to use.
+12V1DC	+12V power rail for use by all system components except for the CPU, controlled by PS_ON#
+12V2DC	+12V power rail for use by the CPU, controlled by PS_ON#. This power rail appears on a separate 2x2 connector for CPU use only.
+5VDC	+5V power rail, controlled by PS_ON#
+3.3VDC	+3.3V power rail, controlled by PS_ON#
-12VDC	-12V power rail, controlled by PS_ON#
+5VSB	+5V Suspend power rail, present whenever the ATX supply is connected to its AC power input source.
COM	Common return path – usually referred to as “ground” or GND.

ATX signals are summarized in Table 55 above. Note that there are two separate +12V outputs, +12V1DC and +12V2DC. These are independent +12V sources. Each source is limited to 240W maximum output to meet UL safety requirements. The +12V2DC output is intended for CPU use.

Contemporary ATX supplies have two power connectors on the motherboard:

- A 24-pin connector in a 2x12 array that includes all signals in Table 55 above except for +12V2DC.
- A 4-pin connector in a 2x2 array for CPU power that includes +12V2DC and COM only.

Earlier ATX supplies used a 2x10 connector instead of a 2x12. The two connector versions have compatible pin-outs. The 2x10 cable plug may be used with a 2x12 motherboard receptacle as long as pin 1 of the 2x10 cable plug mates with pin 1 of the 2x12 Carrier Board receptacle.

Very early ATX supplies had a single +12V rail, on a 2x10 connector. The 2x2 CPU connector was not present. ATX power supplies are designed for desktop systems, which often have power-hungry CPUs and peripherals. CPUs that require 80W are common. Most Modules use lower-power CPUs, and the ATX supply capacity may be overkill. In particular, two +12V supplies are not necessary for many COM Express Modules.

3.4.1.1. Minimum Loads

ATX supplies may not start up if the loading on the +12V, +5V and +3.3V rails is too light. The ATX12V Power Supply Design Guide shows suggested minimum loads in various configurations but does not specify what the minimum loads are. The minimum loads required may vary with different power supply vendors. Experience has shown that a dummy load on the order of at least 400 mA is required on the +5V line in COM Express Carrier Boards that use little or no +5V and are powered from ATX supplies.

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3.5. Routing Considerations

3.5.1. VCC_12V and GND

The primary consideration for the +12V power input (VCC_12V) to the Module is that the trace be wide enough to handle the maximum expected load, with plenty of margin. A power plane may be used for VCC_12V but is not recommended; VCC_12V should not be used as a reference for high-speed signals, such as PCIe, USB, or even PCI, because there may be switching noise present on VCC_12V.

A 40W CPU Module can draw over 3.5A on the VCC_12V pins. Sizing the VCC_12V delivery trace to handle at least twice the expected load is recommended for good design margin. It is best to keep the Carrier Board VCC_12 trace short, wide, and away from other parts of the Carrier Board. See the following section for advice on how to size the trace.

If there are layer transitions in the power delivery path, use redundant “power” vias – vias that are sized with larger holes and pads than default vias.

For the GND return, it is best to use a solid, continuous plane, or multiple planes, using the heaviest possible copper.

It is very important to connect all available power and ground pins available on the COM Express Module to the Carrier Board.

3.5.2. Copper Trace Sizing and Current Capacity

The current capacity of a PCB trace is proportional to the trace’s cross-sectional area – the product of the trace width and thickness. The trace thickness is proportional to the “weight” of copper used. The copper weight is expressed in ounces per square foot in the United States. Usually people will omit the “per square foot” and just use “ounce” to describe the copper. Copper weights of ½ ounce/ 17µm and sometimes 1 ounce/ 35µm are common for inner layer traces. A copper weight of 1 ounce/ 35µm is common for power planes. A copper weight of ½ ounce/ 17µm results in a thickness of approximately 0.7 mil, and 1 ounce/ 35µm copper yields approximately 1.4 mil. Outer layer traces are usually built with ½ ounce/ 17µm copper, but then are “plated up” with additional conductive material, often yielding an effective copper weight of about 1 ounce/ 35µm. The effective weight of outer layer traces may vary with different PCB processes. Check with your PCB vendor, or play it safe and make conservative assumptions.

Consult sources such as the IPC-2221 for charts that relate copper weight, trace width and trace-current capacity at a given temperature rise to the current capability. It is best to assume a conservative trace temperature rise, such as 10° C maximum, when making trace-width decisions. Per the IPC charts, external layer traces can carry significantly more current than internal layer traces, assuming the same base copper weight and the same temperature rise. Approximate current handling capabilities of selected trace widths read off of the IPC-2221 charts are shown in Table 56 below.

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Table 56: Approximate Copper Trace Current Capability per IPC-2221 Charts

Trace Type	Max Current with 10°C Temp Rise	Max Current with 20°C Temp Rise
100 mil wide internal trace ½ ounce/ 17µm base copper	1.3 A	1.8 A
200 mil wide internal trace ½ ounce/ 17µm base copper	2.0 A	3.0 A
400 mil wide internal trace ½ ounce/ 17µm base copper	3.5 A	5.0 A
100 mil wide internal trace 1 ounce/ 35µm base copper	2.1 A	3.0 A
200 mil wide internal trace 1 ounce/ 35µm base copper	3.5 A	5.2 A
400 mil wide internal trace 1 ounce/ 35µm base copper	6.0 A	8.0 A
100 mil wide external trace ½ ounce/ 17µm base copper	2.4 A	3.4 A
200 mil wide external trace ½ ounce/ 17µm base copper	4.0 A	5.5 A
400 mil wide external trace ½ ounce/ 17µm base copper	7.0 A	10.0 A

3.5.3. VCC5_SBY Routing

The +5V Suspend power rail, if used, should be sized to handle 2A. Most, but not all, Modules will use considerably less than 2A for this power rail. Modules with multiple Ethernet channels and wake-on-LAN capability will use more current. The COM Express Specification allows up to 2A on this rail.

3.5.4. Power State and Reset Signal Routing

Power state and reset signals are single-ended signals that do not have any particular routing constraints.

To utilize the full functionality of PCI Express devices on the COM Express Carrier Board, some additional supply voltages are necessary besides the standard supply voltages of the ATX power supply. Many PCI Express devices are capable of generating wake up events during Suspend operation; for example an external PCI Express Ethernet device that supports 'Wake On LAN' functionality. Therefore, it is necessary to generate an additional 3.3V Suspend voltage on the Carrier Board to supply such devices during Suspend operation. The voltage regulator must be designed to meet the power requirements of the connected devices.

The PCI Express specification defines maximum power requirements for the different PCI Express connectors and/or devices. The power supply for the Carrier Board must be designed to meet these maximum power requirements. Table 57 below shows the maximum current consumption defined for the different types of PCI Express connectors.

Table 57: PCIe Connector Power and Bulk Decoupling Requirements

Power Rail	PCIe x1, x4 or x8 Connector	PCIe x16 Connector	ExpressCard Connector	PCIe Mini Card Connector
VCC_12V	2.1A @ 1000uF bulk	5.5A @ 2000uF bulk		
VCC_3V3	3.0A @ 1000uF bulk	3.0A @ 1000uF bulk	1.35A	-
VCC_3V3_SB	375mA @ 150uF bulk	375mA @ 150uF bulk	275mA	2.75A
VCC_1V5			750mA	500mA

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3.5.5. Slot Card Supply Decoupling Recommendations

Implementing PCI Express connectors on the Carrier Board requires decoupling of the connector supply voltages to reduce possible voltage drops and to provide an AC return path in a manner consistent with high-speed signaling techniques. Decoupling capacitors should be placed as close as possible to the power pins of the connectors. Table 58 below shows the minimum requirements for power decoupling of the different power pin types of each PCI Express connector type.

Table 58: PCIe High Frequency Decoupling Requirements

Power Pin Type	PCIe x1, x4 Connector	PCIe x16 Connector	ExpressCard Connector	PCIe Mini Card Connector
VCC_12V	1x 22µF, 2x 100nF	4x 22uF, 2x 100nF	-	-
VCC_3V3	1x 22uF, 2x 100nF	1x 100uF, 2x 100nF	-	-
VCC_3V3_SB	1x 22uF, 2x 100nF	1x 22uF, 2x 100nF	-	-
VCC_1V5	-	-	-	-

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4. BIOS Considerations

4.1. Legacy versus Legacy-Free

For the purposes of this document, “legacy” refers to a set of peripherals provided in desktop PCs and associated chipsets that are no longer in production, including PS/2 keyboard and mouse, parallel port (LPT), and UART serial ports. The COM Express standard was created with newer chipsets in mind. As a result, COM Express is “legacy-free”, which means that legacy peripherals are not directly supported by the Module. Such peripherals have been replaced by space-efficient high-speed interfaces such as USB 2.0.

To facilitate the market’s transition toward newer peripherals, the Low Pin Count (LPC) interface was created as a space-efficient replacement for the Industry Standard Architecture (ISA) bus. In addition to firmware devices such as BIOS flash, low-speed super I/O controllers were developed for the LPC bus to fill the gap until the momentum could build for new high-speed-serial-based peripherals.

4.2. Super I/O

Within the COM Express modular architecture, super I/O controllers could be placed on Carrier Boards according to unique application requirements. However, LPC super I/O devices are closely coupled to the BIOS firmware that initializes them and performs setup-based interrupt assignments. The BIOS flash generally resides on the COM Express Modules in order for the Modules to be self-booting. This tight coupling of LPC super I/O to the BIOS presents a multitude of problems in a legacy-free modular environment.

Normally the BIOS vendor supplies to the BIOS developer the choice of different super I/O Modules that can be plugged-in at the source level during the BIOS build process. The BIOS super I/O code Modules often require considerable adaptation work by the BIOS developer to be able to be “plugged-in”. The supported super I/O device would be determined by the Module vendor, and other device support would involve a custom BIOS for each super I/O device.

Consequently, PICMG recommends using USB peripherals or PCI or PCI Express super I/O devices on Carrier Boards for customers wishing to use UART serial ports (COM1, COM2, etc.) or other legacy peripherals. Plug-and-play based interrupt assignments are automatic, and drivers initialize devices after the operating system is loaded. A USB keyboard can be used to enter BIOS setup prior to power-on self-test.

PICMG recommends against using LPC super I/O devices on the Carrier Board, as such usage creates BIOS customization requirements and can greatly restrict Module interoperability. PCI, PCI Express, and/or USB devices should be used instead.

PICMG suggests that alternate BIOS firmware support on the Carrier Board as well as port 0x80 implementations are appropriate uses of the LPC interface on the Carrier Board.

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5. COM Express Module Connectors

5.1. Connector Descriptions

A pair of 220-pin COM Express Carrier-Board connectors is available from the vendor in a bridged configuration in which the two 220-pin connectors are held together during assembly by a disposable bridge. The bridge keeps the two connectors aligned, relative to each other, during assembly.

Table 59: COM Express Module Connectors

Type	Height	Partnumber	Note
single connector	5 mm	Tyco 3-1827253-6 Foxconn QT002206-2131-3H ept 401-51101-51	220 pos., 0.5mm, Plug
connector pair	5 mm	Tyco 3-1827233-6 Foxconn QT002206-2141-3H ept 401-51501-51	440 pos., 0.5mm, Plug, with bridge
single connector	8 mm	Tyco 3-6318491-6 Foxconn QT002206-4131-3H ept 401-55101-51	220 pos., 0.5mm, Plug
connector pair	8 mm	Tyco 3-5353652-6 Foxconn QT002206-4141-3H ept 401-55501-51	440 pos., 0.5mm, Plug, with bridge

Please check with your Carrier Board manufacturer to determine if single connectors or connector pairs are preferred.

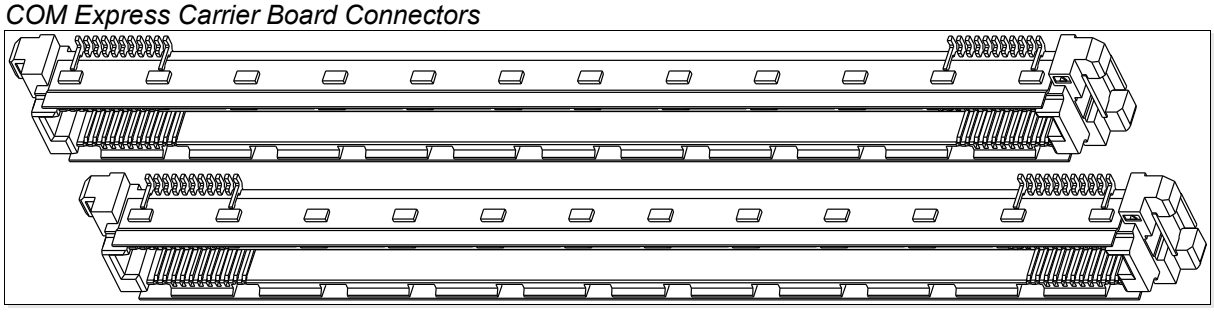
Vendorlinks:

TE: http://www.te.com/catalog/products/en?q=com+express

Foxconn: http://nw.foxconn.com/Search/Product_Details_Report.asp?P_Type=Board+to+Board+Connector&P_Family=Board+to+Board+Connector&P_Series=Board+to+Board+Connector+0%2E5mm+Pitch&P_PN=QT002206-2131-3H&searchTypeID=3

EPT: http://www.ept.de/index.php?colibri-COM-Express

Figure 67: COM Express Carrier Board Connectors



5.2. Connector Land Patterns and Alignment

It is extremely important that the designers of Carrier Boards ensure that the COM Express connectors have the proper land patterns and that the connectors are aligned correctly. The land pattern is diagrammed in the COM Express Specification. Connector alignment is ensured if the

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peg location holes in the PCB connector pattern are in the correct positions (as shown in the land pattern of the COM Express Specification) and if the holes are drilled to the proper size and tolerance by the PCB fabricator.

5.3. Connector and Module CAD Symbol Recommendations

The 440-pin COM Express connector should be shown in the Carrier Board CAD system as a single schematic symbol and a single PCB symbol, rather than as a pair of 220-pin symbols. This ensures that the relative position of the two 220-pin connectors remains correct as PCB placement for the Carrier Board is done.

It also is very advantageous to extend this concept to include the COM Express Module outline and the Module mounting holes in the same PCB land pattern. This allows PCB designers to easily move the entire Module around to try placement options without losing the relative positions and orientations of the Module connectors, mounting holes, and Module outline.

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6. Carrier Board PCB Layout Guidelines

6.1. General

6.2. PCB Stack-ups

Note ***Section 6 'Carrier Board PCB Layout Guidelines' assumes a thickness for the carrier PCB to be 0.0625 inches. Other PCB mechanics are possible but the described Stack-ups need to be adapted.***

6.2.1. Four-Layer Stack-up

Figure 68: Four-Layer Stack-up

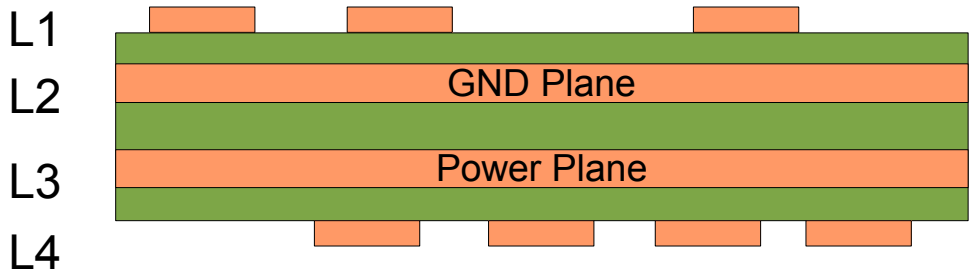


Figure 68 above is an example of a four layer stack-up. Layers L1 and L4 are used for signal routing.

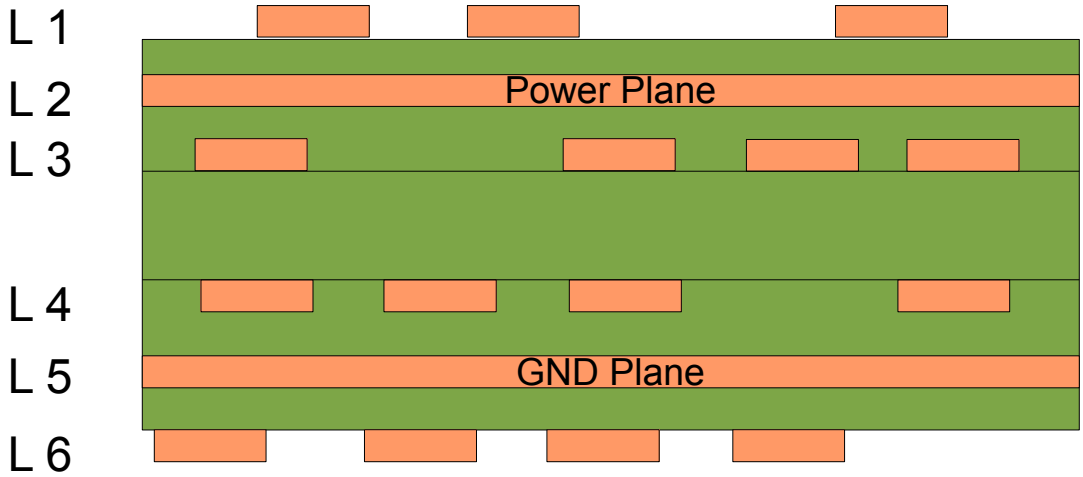
Layers L2 and L3 are used for solid ground and power planes respectively.

Microstrips on Layers 1 and 4 reference ground and power planes on Layers 2 and 3 respectively.

In some cases, it may be advantageous to swap the GND and PWR planes. This allows Layer 4 to be GND referenced. Layer 4 is clear of parts and may be the preferred primary routing layer.

6.2.2. Six-Layer Stack-up

Figure 69: Six-Layer Stack-up



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Figure 69 above is an example of a six layer stack-up. Layers L1, L3, L4 and L6 are used for signal-routing. Layers L2 and L5 are power and ground planes respectively.

Microstrips on Layers 1 and 6 reference solid ground and power planes on Layers 2 and 5 respectively.

Inner Layers 3 and 4 are asymmetric striplines that are referenced to planes on Layers 2 and 5.

6.2.3. Eight-Layer Stack-up

Figure 70: Eight-Layer Stack-up

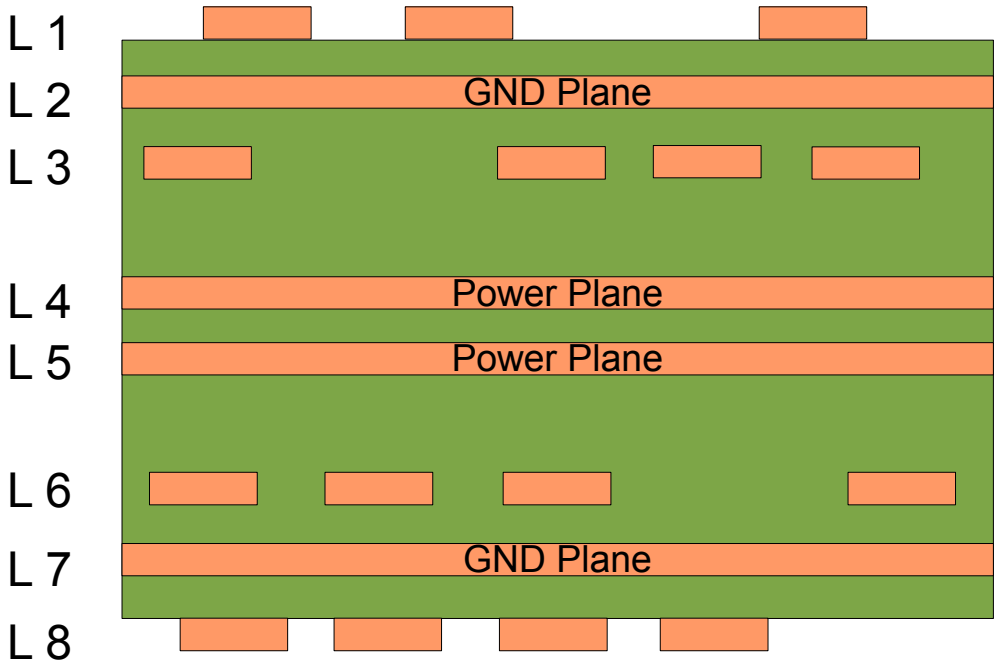


Figure 70 above is an example of an eight layer stack-up. Layers L1, L3, L6 and L8 are used for signal-routing. Layers L2 and L7 are solid ground planes, while L4 and L5 are used for power.

Microstrip Layers 1 and 8 reference solid ground planes on Layers 2 and 7 respectively.

Inner signal Layers 3 and 6 are asymmetric striplines that route differential signals. These signals are referenced to Layers 2 and 7 to meet the characteristic impedance target for these traces.

To reduce coupling to Layers 4 and 5, specify thicker prepreg to increase layer separation.

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6.3. Trace-Impedance Considerations

Most high-speed interfaces used in an COM Express design for a Carrier Board are differential pairs that need a well-defined and consistent differential and single-ended impedance. The differential pairs should be edge-coupled (i.e. the two lines in the pair are on the same PCB layer, at a consistent spacing to each other). Broadside coupling (in which the two lines in the pair track each other on different layers) is not recommended for mainstream commercial PCB fabrication.

There are two basic structures used for high-speed differential and single-ended signals. The first is known as a “microstrip”, in which a trace or trace pair is referenced to a single ground or power plane.

The outer layers of multi-layer PCBs are microstrips. A diagram of a microstrip cross section is shown in Figure 71: Microstrip Cross Section below.

The second structure is the “stripline”, in which a trace or pair of traces is sandwiched between two reference planes, as shown in Figure 72: Strip Line Cross Section below. If the traces are exactly halfway between the reference planes, then the stripline is said to be symmetric or balanced. Usually the traces are a lot closer to one of the planes than the other (often because there is another orthogonal trace layer, which is not shown in Figure 72: Strip Line Cross Section below). In this case, the striplines are said to be asymmetric or unbalanced. Inner layer traces on multi-layer PCBs are usually asymmetric striplines.

Before proceeding with a Carrier Board layout, designers should decide on a PCB stack-up and on trace parameters, primarily the trace-width and differential-pair spacing. It is quite a bit harder to change the differential impedance of a trace pair after layout work is done than it is to change the impedance of a single-ended signal. That is because (with reference to Figure 71: Microstrip Cross Section below, Figure 72: Strip Line Cross Section below, Table 60 'Trace Parameters' below) the geometric factors that have the biggest impact on the impedance of a single-ended trace are H1 and W1.

Both H1 and W1 can be manipulated slightly by the PCB vendor. The differential impedance of a trace pair depends primarily on H1, W1 and the pair pitch. A PCB vendor can easily manipulate H1 and W1 but changing the pair pitch cannot generally be done at fabrication time. It is more important for the PCB designer and the Project Engineer to determine the routing parameters for differential pairs ahead of time.

Work with a PCB vendor on a suitable board stack-up and do your own homework using a PCB-impedance calculator. An easy to use and comprehensive calculator is available from Polar Instruments (www.polarinstruments.com). Many PCB vendors use software from Polar Instruments for their calculations. Polar Instruments offers an impedance calculator on a low-cost, per-use basis. To find this, search the Web for a “Polar Instruments subscription”. Alternatively, impedance calculators are included in many PCB layout packages, although these are often incomplete when it comes to differential-pair impedances. There also are quite a few free impedance calculators available on the Web. Most are very basic, but they can be useful.

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Figure 71: Microstrip Cross Section

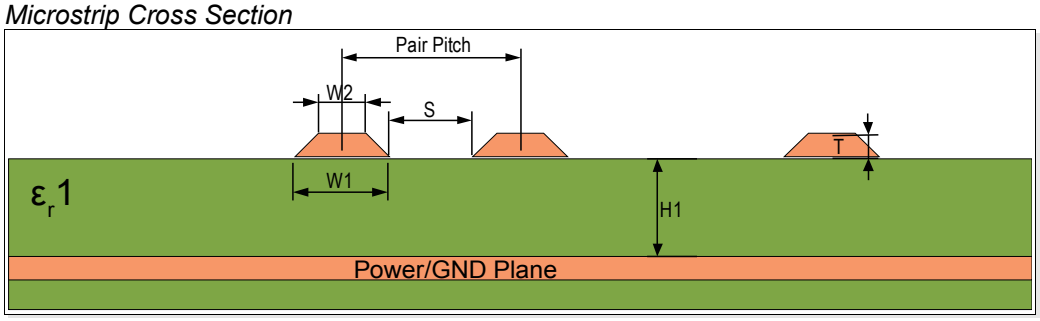


Figure 72: Strip Line Cross Section

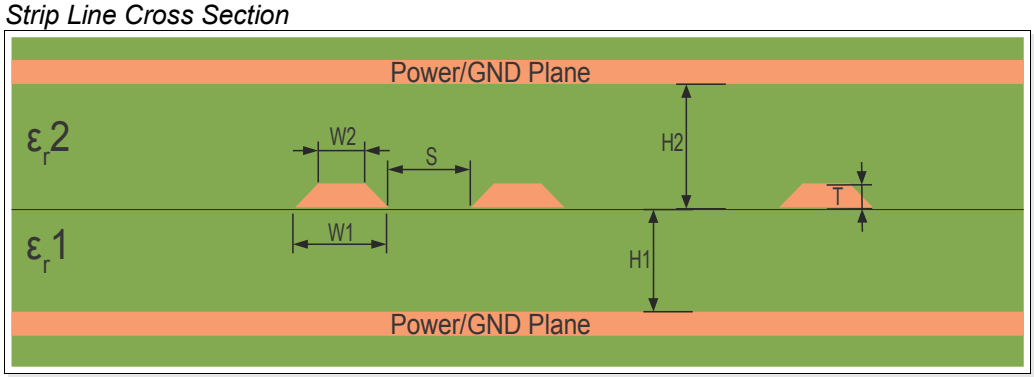


Table 60: Trace Parameters

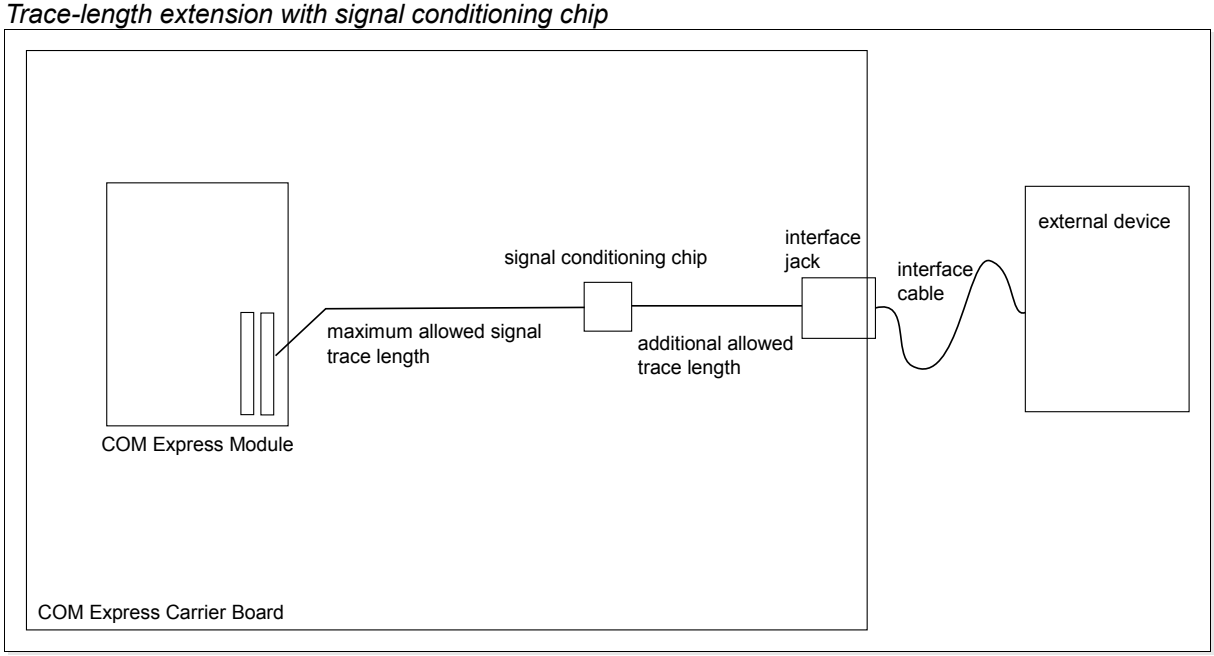
Symbol	Definition
ε_r1	Dielectric constant of material between the trace and the reference plane. Increasing ε_r1 results in a lower trace impedance.
ε_r2	Dielectric constant of the material between the 2nd reference plane (stripline case only). Usually ε_r1 and ε_r2 are the same. Increasing ε_r2 results in a lower trace impedance.
H1	Distance between the trace lower surface and the closer reference plane. Increasing H1 raises the trace impedance (assuming that H1 is less than H2).
H2	Distance between the trace lower surface and the more distant reference plane (stripline case only). Usually H2 is significantly greater than H1. When this is true, the lower plane shown in the figure is the primary reference plane. Increasing H2 raises the trace impedance.
Pair Pitch	The center-to-center spacing between two traces in a differential pair. Increasing the pair pitch raises the differential trace impedance.
S	The spacing or gap between two traces in a differential pair. The pair pitch is the sum of S and W1. Increasing S raises the differential trace impedance.
T	The thickness of the trace. The thickness of a ½ oz. inner layer trace is about 0.0007 inches. The thickness of a 1 oz. inner layer trace is about 0.0014 inches. Outer layer traces using a given copper weight are thicker, due to plating that is usually done on outer layers. Increasing the trace thickness lowers trace impedance.
W1, W2	W1 is the base thickness of the trace. W2 is the thickness at the top of the trace. The relation between W1 and W2 is called the “etch factor” in the PCB trade. For rough calculations, it can be assumed that W1 = W2. The etch factor is process dependent. W2 is often about 0.001 inches less than W1 for ½ oz inner layer traces; for example, a 5 mil (0.005 inch) nominal trace will be 5-mil wide at the bottom and 4-mil wide at the top. Increasing the trace-width lowers trace impedance.

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6.4. Trace-Length Extensions Considerations

High speed differential signals need controlled impedance and according to the maximum loss budget a controlled maximum trace length. In some systems the maximum trace length need to be exceeded on the Carrier Board according to mechanical or system engineering reasons. Trace-length extensions can be done with special signal conditioning chips from vendors like Texas Instruments or Pericom, which are available for USB 3.0, SATA and PCIe.

Figure 73: Trace-length extension with signal conditioning chip



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6.5. Routing Rules for High-Speed Differential Interfaces

The following is a list of suggestions for designing with high-speed differential signals. This should help implement these interfaces while providing maximum COM Express Carrier Board performance.

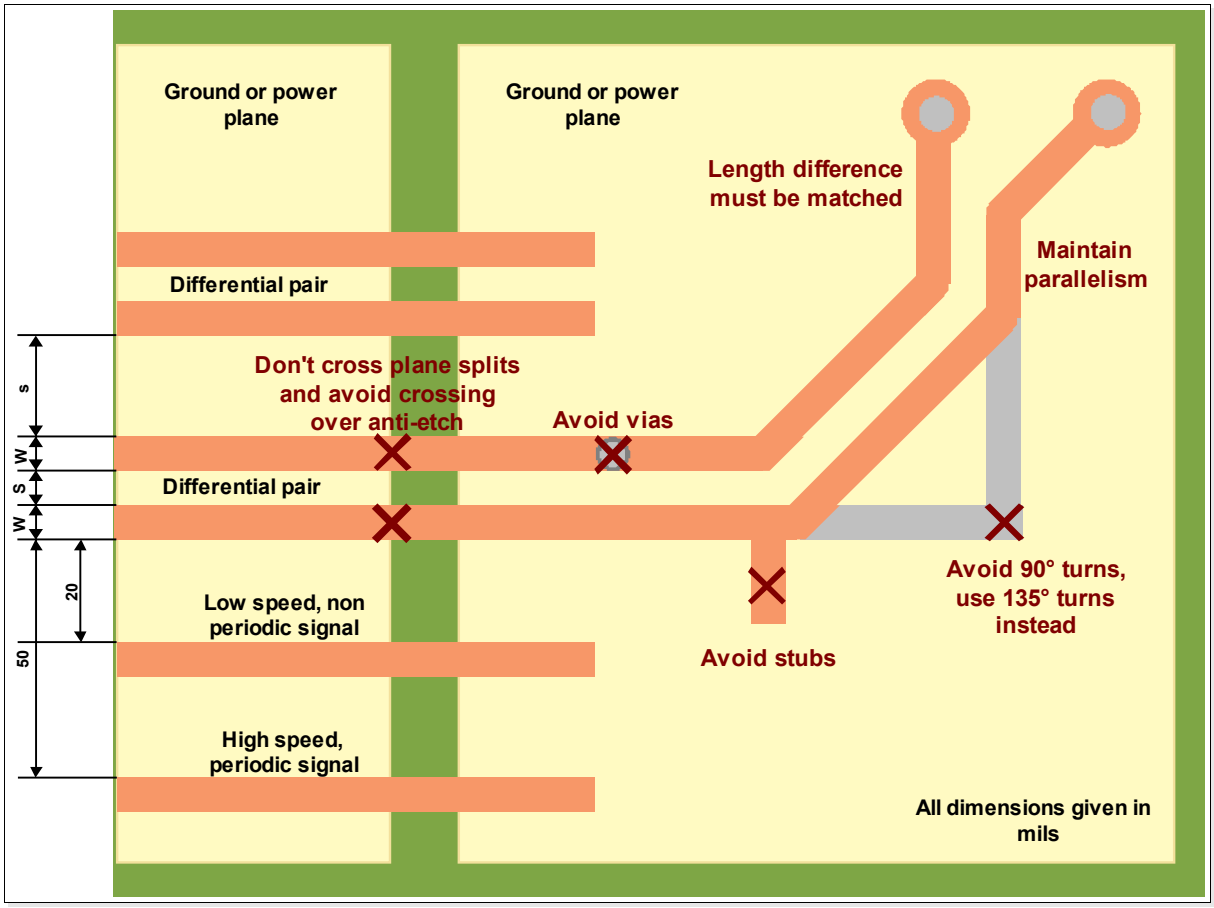
- Use controlled impedance PCB traces that match the specified differential impedance.
- Keep the trace lengths of the differential signal pairs as short as possible.
- The differential signal pair traces should be trace-length matched and the maximum trace-length mismatch should not exceed the specified values. Match each differential pair per segment.
- Maintain parallelism and symmetry between differential signals with the trace spacing needed to achieve the specified differential impedance.
- Maintain phase- and length-matching throughout the whole routing trace.
- Maintain maximum possible separation between the differential pairs and any high-speed clocks/periodic signals (CMOS/TTL) and any connector leaving the PCB (such as, I/O connectors, control and signal headers, or power connectors).
- Route differential signals on the signal layer nearest to the ground plane using a minimum of vias and corners. This will reduce signal reflections and impedance changes. Use GND stitching vias when changing layers.
- It is best to put CMOS/TTL and differential signals on a different layer(s), which should be isolated by the power and ground planes.
- Avoid tight bends. When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn.
- Do not route traces under crystals, crystal oscillators, clock synthesizers, magnetic devices or ICs that use, and/or generate, clocks.
- Stubs on differential signals should be avoided due to the fact that stubs will cause signal reflections and affect signal quality.
- Keep the length of high-speed clock and periodic signal traces that run parallel to high-speed signal lines at a minimum to avoid crosstalk. Based on EMI testing experience, the minimum suggested spacing to clock signals is 50mil.
- Use a minimum of 20mil spacing between the differential signal pairs and other signal traces for optimal signal quality. This helps to prevent crosstalk.
- Traces should be routed over a continuous GND plane. If this is not possible, a well bypassed VCC plane can be used. Route all traces over continuous planes (GND or VCC) with no interruptions. Avoid crossing over anti-etch if at all possible. Crossing over anti-etch (split planes) increases inductance and radiation levels by forcing a greater loop area.

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Figure 74: Layout Considerations

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In order to determine the necessary trace width, trace height and spacing needed to fulfill the requirements of the interface specification, it's necessary to use an impedance calculator.

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6.5.1. PCI Express Trace Routing Guidelines

Table 61: PCI Express Trace Routing Guidelines

Parameter	PCIe Gen1	PCIe Gen2	PCIe Gen3
Symbol Rate / PCIe Lane	2.5 G Symbols/s	5.0 G Symbols/s	8.0 G Symbols/s
Maximum signal line length (coupled traces) TX and RX	21.0 inches	21.0 inches	14.0 inches
Signal length allowance on the COM Express Carrier Board to PCIe device	15.85 inches	15.85 inches	10.0 inches
Signal length allowance on the COM Express Carrier Board to PCIe slot	9.00 inches	9.00 inches	4.0 inches
PCI-SIG: Differential impedance recommendation	100 Ω +/-20%	85 Ω +/-15%	85 Ω +/-15%
COMCDG Rev. 1.0: Differential impedance recommendation for a GEN1 and GEN2 design	92 Ω +/-10%		-
COMCDG Rev. 2.0: Differential impedance recommendation for new Carrier designs	**85 Ω +/-15%**		
Single-ended Impedance	55 Ω +/-15%	50 Ω +/-15%	50 Ω +/-15%
Trace width (W)	PCB stack-up dependent	PCB stack-up dependent	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent	PCB stack-up dependent	PCB stack-up dependent
Spacing between RX and TX pairs (inter-pair) (s)	Min. 20mils	Min. 20mils	Min. 20mils
Spacing between differential pairs and high-speed periodic signals	Min. 50mils	Min. 50mils	Min. 50mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils	Min. 20mils	Min. 20mils
Length matching between differential pairs (intra-pair)	Max. 5mils	Max. 5mils	Max. 5mils
Length matching between RX and TX pairs (inter-pair)	No strict electrical requirements. Keep difference within a 3.0 inch delta to minimize latency.	No strict electrical requirements. Keep difference within a 3.0 inch delta to minimize latency.	No strict electrical requirements. Keep difference within a 3.0 inch delta to minimize latency.
Length matching between reference clock differential pairs REFCLK+ and REFCLK- (intra-pair)	Max. 5mils	Max. 5mils	Max. 5mils
Length matching between reference clock pairs (inter-pair)	No electrical requirements.	No electrical requirements.	No electrical requirements.
Reference plane	GND referenced preferred	GND referenced preferred	GND referenced preferred
Spacing from edge of plane	Min. 40mils	Min. 40mils	Min. 40mils
Via Usage	Max. 2 vias per TX trace Max. 4 vias per RX trace	Max. 2 vias per TX trace Max. 4 vias per RX trace	Max. 2 vias / TX Max. 4 vias / RX (to device) Max. 2 vias / RX (to slot)
AC coupling capacitors	The AC coupling capacitors for the TX lines are incorporated on the COM Express Module. The AC coupling capacitors for RX signal lines have to be implemented on the customer COM Express Carrier Board. Capacitor type: X7R, 100nF +/-10%, 16V, shape 0402.	The AC coupling capacitors for the TX lines are incorporated on the COM Express Module. The AC coupling capacitors for RX signal lines have to be implemented on the customer COM Express Carrier Board. Capacitor type: X7R, 100nF +/-10%, 16V, shape 0402.	The AC coupling capacitors for the TX lines are incorporated on the COM Express Module. The AC coupling capacitors for RX signal lines have to be implemented on the customer COM Express Carrier Board. Capacitor type: X7R, 200nF +/-10%, 16V, shape 0402.

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6.5.2. USB Trace Routing Guidelines

Table 62: USB Trace Routing Guidelines

Parameter	Trace Routing
Transfer rate / Port	480 MBit/s
Maximum signal line length (coupled traces)	Max. 17.0 inches
Signal length used on COM Express Module (including the COM Express connector)	3.0 inches
Signal length allowance for the COM Express Carrier Board	14.0 inches
Differential Impedance	90 Ω +/-15%
Single-ended Impedance	45 Ω +/-10%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between pairs-to-pairs (inter-pair) (s)	Min. 20mils
Spacing between differential pairs and high-speed periodic signals	Min. 50mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils
Length matching between differential pairs (intra-pair)	150mils
Reference plane	GND referenced preferred
Spacing from edge of plane	Min. 40mils
Via Usage	Try to minimize number of vias

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6.5.3. USB 3.0 Trace Routing Guidelines

Table 63: USB 3.0 Trace Routing Guidelines

Parameter	Trace Routing
Transfer rate / Port	5.0 GBit/s
Maximum signal line length (coupled traces)	7.5 inches
Signal length used on COM Express Module (including the COM Express connector)	3.0 inches
Signal length allowance for the COM Express Carrier Board	4.5 inches
Differential Impedance	85 Ω +/-10%
Single-ended Impedance	50 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between pairs-to-pairs (inter-pair) (s)	Min. 15mils
Spacing between differential pairs and high-speed periodic signals	Min. 15mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils
Length matching between differential pairs (intra-pair)	Max. 5mils
Reference plane	Ground
Spacing from edge of plane	Min. 40mils
Via Usage	Max. 3 vias per differential signal trace

6.5.4. PEG Trace Routing Guidelines

Please refer to Section 6.5.1. 'PCI Express Trace Routing Guidelines' on page 182

Note ***The COM Express specification does not define different trace routing rules for PEG and PCI Express lanes. Newer chipsets feature low power modes for the PEG signals. In order to ensure compatibility it's recommended to keep the PEG signal lines as short as possible. A max of 5” to the carrier device down and 4” to a carrier slot is advisable.***

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6.5.5. SDVO Trace Routing Guidelines

Table 64: SDVO Trace Routing Guidelines

Parameter	Trace Routing
Transfer Rate / SDVO Lane	Up to 2.0 GBit/s
Maximum signal line length (coupled traces)	7 inches
Signal length used on COM Express Module (including the Carrier Board connector)	2 inches
Signal length allowance for the COM Express Carrier Board	5 inches to SDVO device
Differential Impedance	100 Ω +/-20%
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between pairs-to-pair	Min. 20mils
Spacing between differential pairs and high-speed periodic signals	Min. 50mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils
Length matching between differential pairs (intra-pair)	Max. 5mils
Length matching between differential pairs (inter-pair)	Keep difference within a 2.0 inch delta.
Length matching between differential signal pair and differential clock pair	Max. 5mils
Spacing from edge of plane	Min. 40mils
Via Usage	Max. 4 vias per differential signal trace
AC coupling capacitors	AC coupling capacitors on the signals 'SDVO_INT+' and 'SDVOINT-' have to be implemented on the customer COM Express Carrier Board, if the device is directly located on the Carrier Board. When using a slot at the Carrier Board the capacitors are located at the addon card. Capacitor type: X7R, 100nF +/-10%, 16V, shape 0402.

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6.5.6. DisplayPort Trace Routing Guidelines

Table 65: DisplayPort Trace Routing Guidelines

Parameter	Trace Routing
Transfer Rate	Max. 5.4 GBit/s
Maximum signal line length (coupled traces)	7.2 inches
Signal length used on COM Express Module (including the Carrier Board connector)	4.0 inches
Signal length allowance for the COM Express Carrier Board	3.2 inches
Differential Impedance	85 Ω +/-10%
Single-ended Impedance	50 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between pairs-to-pair	Min. 15mils
Spacing between differential pairs and high-speed periodic signals	Min. 15mils
Spacing between differential pairs and low-speed non periodic signals	Min. 15mils
Length matching between differential pairs (intra-pair)	Max. 5mils
Length matching between differential pairs (inter-pair)	Max 1 inch
Spacing from edge of plane	Min. 40mils
Via Usage	Max. 2
AC coupling capacitors	100nF

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6.5.7. LAN Trace Routing Guidelines

Table 66: LAN Trace Routing Guidelines

Parameter	Trace Routing
Signal length allowance for the COM Express Carrier Board	5.0 inches from the COM Express Module to the magnetics Module
Maximum signal length between isolation magnetics Module and RJ45 connector on the Carrier Board	1.0 inch
Differential Impedance	95 Ω +/-20%
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between RX and TX pairs (inter-pair) (s)	Min. 50mils
Spacing between differential pairs and high-speed periodic signals	Min. 300mils
Spacing between differential pairs and low-speed non periodic signals	Min. 100mils
Length matching between differential pairs (intra-pair)	Max. 5mils
Length matching between RX and TX pairs (inter-pair)	Max. 30mils
Spacing between digital ground and analog ground plane (between the magnetics Module and RJ45 connector)	Min. 60mils
Spacing from edge of plane	Min. 40mils
Via Usage	Max. of 2 vias on TX path Max. of 2 vias on RX path

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6.5.8. Serial ATA Trace Routing Guidelines

Table 67: Serial ATA Trace Routing Guidelines

Parameter	Trace Routing
Transfer Rate	Up to 6.0 GBit/s
Maximum signal line length (coupled traces)	5.0 inches on PCB (COM Express Module and Carrier Board. The length of the SATA cable is specified between 0 and 40 inches)
Signal length used on COM Express Module (including the COM Express Carrier Board connector)	2 inches
Signal length available for the COM Express Carrier Board	3 inches, a redriver may be necessary for GEN3 signaling rates
Differential Impedance	85 Ω +/-20%
Single-ended Impedance	50 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pairs (intra-pair) (S)	PCB stack-up dependent
Spacing between RX and TX pairs (inter-pair) (s)	Min. 20mils
Spacing between differential pairs and high-speed periodic signals	Min. 50mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils
Length matching between differential pairs (intra-pair)	Max. 5mils
Length matching between RX and TX pairs (inter-pair)	No strict length-matching requirements. Route the signals as directly as possible.
Spacing from edge of plane	Min. 40mils
Via Usage	A maximum of 2 vias is recommended.
AC Coupling capacitors	The AC coupling capacitors for the TX and RX lines are incorporated on the COM Express Module.

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6.5.9. LVDS Trace Routing Guidelines

Table 68: LVDS Trace Routing Guidelines

Parameter	Trace Routing
Maximum signal line length to the LVDS connector (coupled traces)	8.75 inches
Signal length used on COM Express Module (including the COM Express Carrier Board connector)	2.0 inches
Signal length to the LVDS connector available for the COM Express Carrier Board	6.75 inches
Differential Impedance	100 Ω +/-20%
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between differential pair signals (intra-pair) (S)	PCB stack-up dependent
Spacing between pair to pairs (inter-pair) (s)	Min. 20mils
Spacing between differential pairs and high-speed periodic signals	Min. 20mils
Spacing between differential pairs and low-speed non periodic signals	Min. 20mils
Length matching between differential pairs (intra-pair)	+/- 20mils
Length matching between clock and data pairs (inter-pair)	+/- 20mils
Length matching between data pairs (inter-pair)	+/- 40mils
Spacing from edge of plane	+/- 40mils
Reference plane	GND referenced preferred
Via Usage	Max. of 2 vias per line

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6.6. Routing Rules for Single Ended Interfaces

The following is a list of suggestions for designing with single ended signals. This should help implement these interfaces while providing maximum COM Express Carrier Board performance.

- Do not route traces under crystals, crystal oscillators, clock synthesizers, magnetic devices or ICs that use or generate clocks.
- Avoid tight bends. When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn.
- Stubs on signals should be avoided due to the fact that stubs will cause signal reflections and affect signal quality.
- Keep the length of high-speed clock and periodic signal traces that run parallel to high-speed signal lines at a minimum to avoid crosstalk. Based on EMI testing experience, the minimum suggested spacing to clock signals is 50mil.
- Route all traces over continuous planes with no interruptions (ground reference preferred). Avoid crossing over anti-etch if at all possible. Crossing over anti-etch (split planes) increases inductance and radiation levels by forcing a greater loop area.
- Route digital power and signal traces over the digital ground plane.
- Position the bypassing and decoupling capacitors close to the IC pins with wide traces to reduce impedance.

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6.6.1. PCI Trace Routing Guidelines

Table 69: PCI Trace Routing Guidelines

Parameter	Trace Routing
Transfer Rate @ 33MHz	132 MB/sec
Maximum data and control signal length allowance for the COM Express Carrier Board.	10 inches
Maximum clock signal length allowance for the COM Express Carrier Board.	8.88 inches
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between signals (inter-signal) (S)	PCB stack-up dependent
Length matching between single ended signals	Max. 200mils
Length matching between clock signals	Max. 200mils
Spacing from edge of plane	Min. 40mils
Reference plane	GND referenced preferred
Via Usage	Try to minimize number of vias
Decoupling capacitors for each PCI slot.	Min. 1x22µF, 2x 100nF @ VCC 5V Min. 2x22µF, 4x 100nF @ VCC 3.3V Min. 1x22µF, 2x 100nF @ +12V (if used) Min. 1x22µF, 2x 100nF @ -12V (if used) The decoupling capacitors for the power rails should be placed as close as possible to the slot power pins, connected with wide traces.

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6.6.2. IDE Trace Routing Guidelines

Table 70: IDE Trace Routing Guidelines

Parameter	Trace Routing
Maximum Transfer Rate @ ATA100	100 MB/sec
Maximum length allowance for signals on the COM Express Carrier Board @ ATA100.	7.0 inches
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between signals (inter-signal) (S)	PCB stack-up dependent
Length matching between strobe and data signals	Max. 450mils
Length matching between data signals	Max. 200mils
Length matching between strobe signals 'IDE_IOR' and 'IDE_IOW'.	Max. 100mils
Spacing from edge of plane	Min. 40mils
Reference plane	GND referenced preferred
Via Usage	Try to minimize number of vias

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6.6.3. LPC Trace Routing Guidelines

Table 71: LPC Trace Routing Guidelines

Parameter	Trace Routing
Transfer Rate @ 33MHz	16 MBit/s
Maximum data and control signal length allowance for the COM Express Carrier Board	15.0 inches
Maximum clock signal length allowance for the COM Express Carrier Board	8.88 inches
Single-ended Impedance	55 Ω +/-15%
Trace width (W)	PCB stack-up dependent
Spacing between signals (inter-signal) (S)	PCB stack-up dependent
Length matching between single ended signals	Max. 200mils
Length matching between clock signals	Max. 200mils
Spacing from edge of plane	Min. 40mils
Reference plane	GND referenced preferred
Via Usage	Try to minimize number of vias

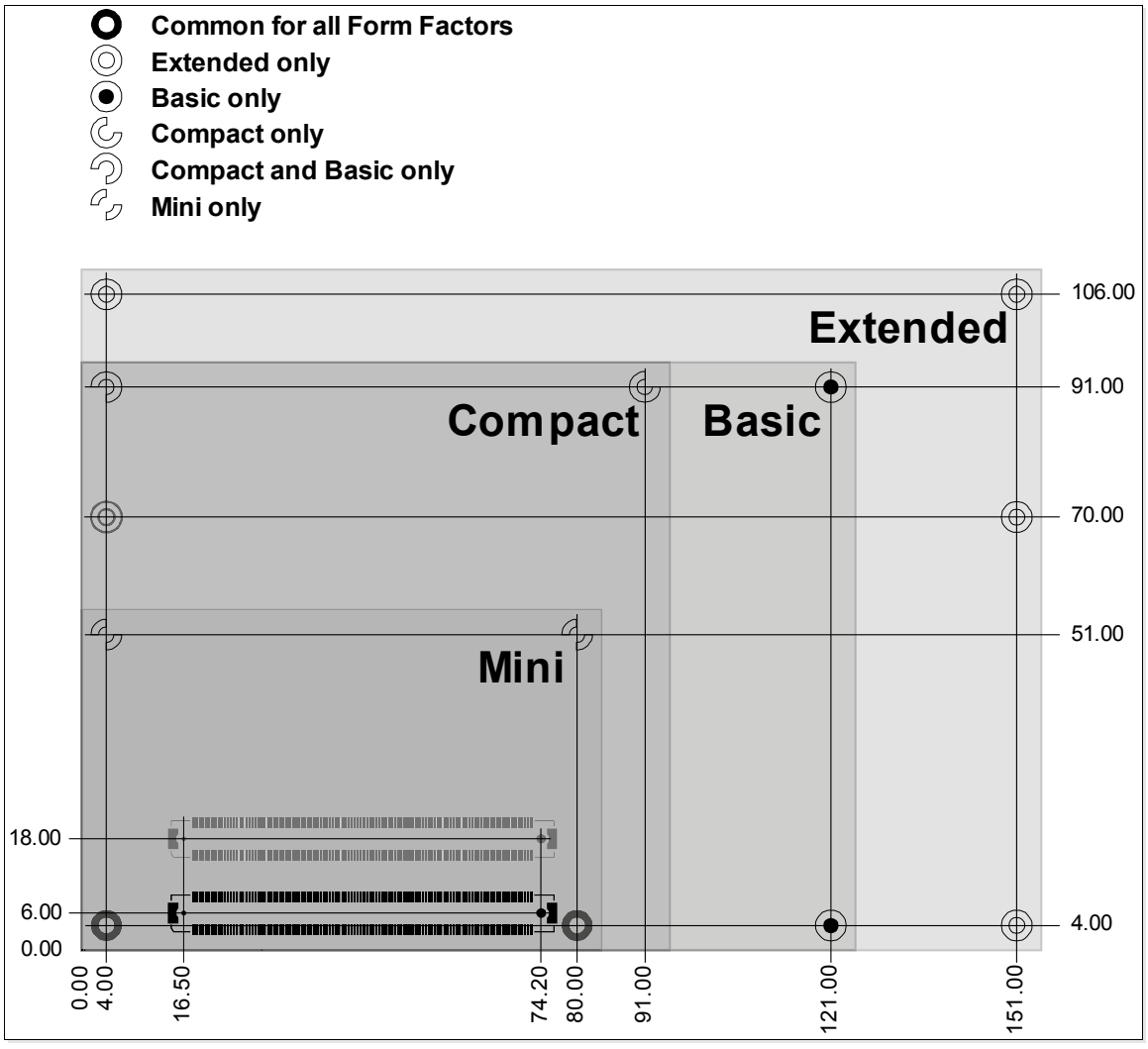
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7. Mechanical Considerations

7.1. Form Factors

The COM Express specification describes 4 different sized COM Express Modules. The Mini (55x84 mm), Compact (95x95 mm), Basic (95x125 mm) and the Extended (110x155 mm) Modules. A Carrier Board can be designed to handle more than one Module size by placing Carrier Board mounting holes at the appropriate locations for each Module size that will be supported. For example, a Carrier Board designed for Basic-sized Modules could provide additionally the one mounting hole, unique for Compact-sized Modules, to allow that size. The necessary standoffs can then be populated if applicable.

Figure 75: Mechanical comparison of available COM Express Form Factors



All dimensions are shown in millimeters.

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7.2. Heatspreader

An important factor for each system integration is the thermal design. The heatspreader acts as a thermal coupling device to the Module. Usually It is a 3mm thick aluminum plate.

The heatspreader is thermally coupled to the CPU via a thermal gap filler and on some Modules it may also be thermally coupled to other heat generating components with the use of additional thermal gap fillers.

Although the heatspreader is the thermal interface where most of the heat generated by the Module is dissipated, it is not to be considered as a heatsink. It has been designed to be used as a thermal interface between the Module and the application specific thermal solution. The application specific thermal solution may use heatsinks with fans, and/or heat pipes, which can be attached to the heatspreader. Some thermal solutions may also require that the heatspreader is attached directly to the systems chassis therefore using the whole chassis as a heat dissipater.

The main mechanical mounting solutions for systems based on COM Express Modules have proven to be the 'top-mounting' and 'bottom-mounting' solutions. The decision as to which solution will be used is determined by the mechanical construction and the cooling solution of the customer's system. There are two variants of the heatspreader, one for each mounting possibility. One version has threaded standoffs and the other has non-threaded standoffs (bore hole). The following sections describe these two common mounting possibilities and the additional components (standoffs, screws, etc...) that are necessary to implement the respective solution.

The examples shown in the following Sections 7.2.1 'Top mounting' and 7.2.2. 'Bottom mounting' are for heatspreader thermal solutions only. Other types of thermal solutions are possible that might require other mounting methods.

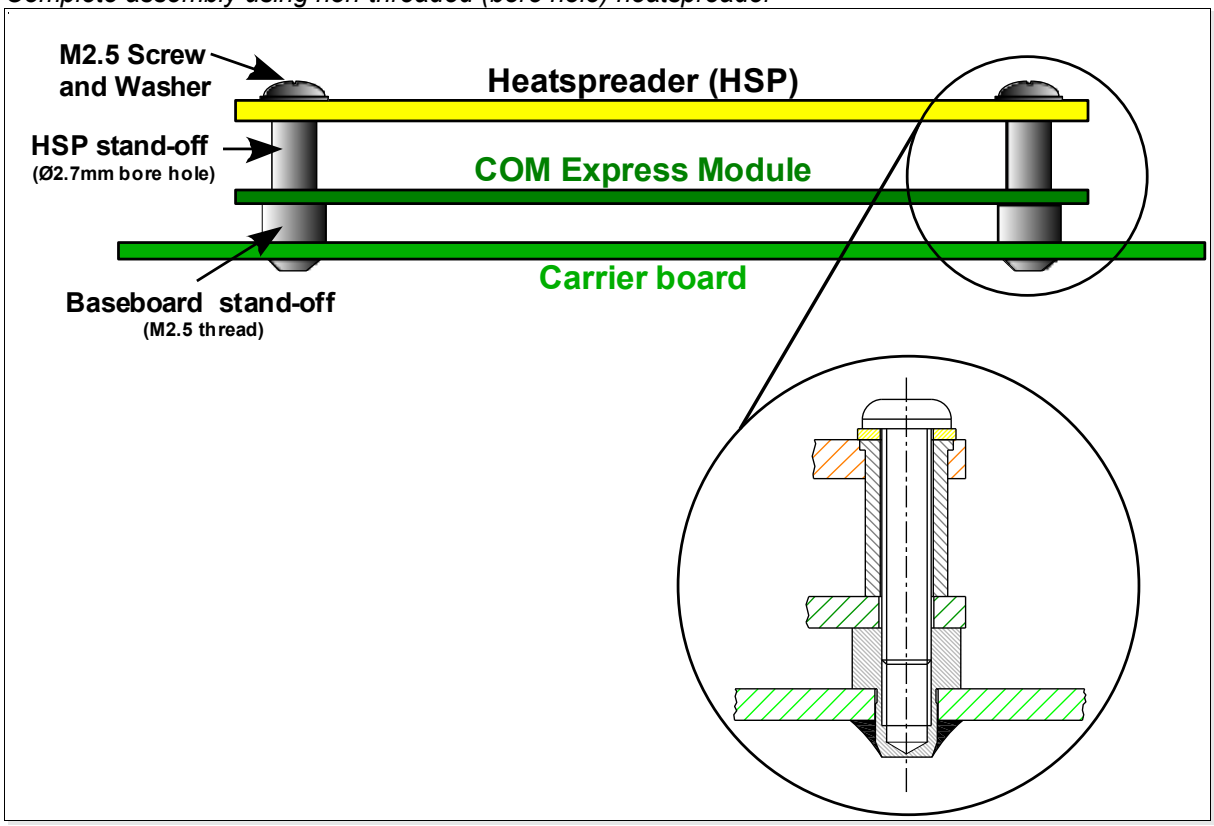
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7.2.1. Top mounting

For top mounting heatspreaders with non-threaded standoffs (bore hole) are used.

This variant of the heatspreader was designed to be used in a system where the heatspreader screws need to be inserted from the top side of the complete assembly. In this case the threads for securing the screws are in the Carrier Board's standoffs. This is the reason why the heatspreader must have non-threaded (bore hole) standoffs.

Figure 76: Complete assembly using non-threaded (bore hole) heatspreader



Note ***The torque specification for heatspreader screws is 0.5 Nm.***

Caution ***Do not use a threaded heatspreader together with threaded Carrier Board standoffs. The combination of the two threads may be staggered, which could lead to stripping or cross-threading of the threads in either the standoffs of the heatspreader or Carrier Board.***

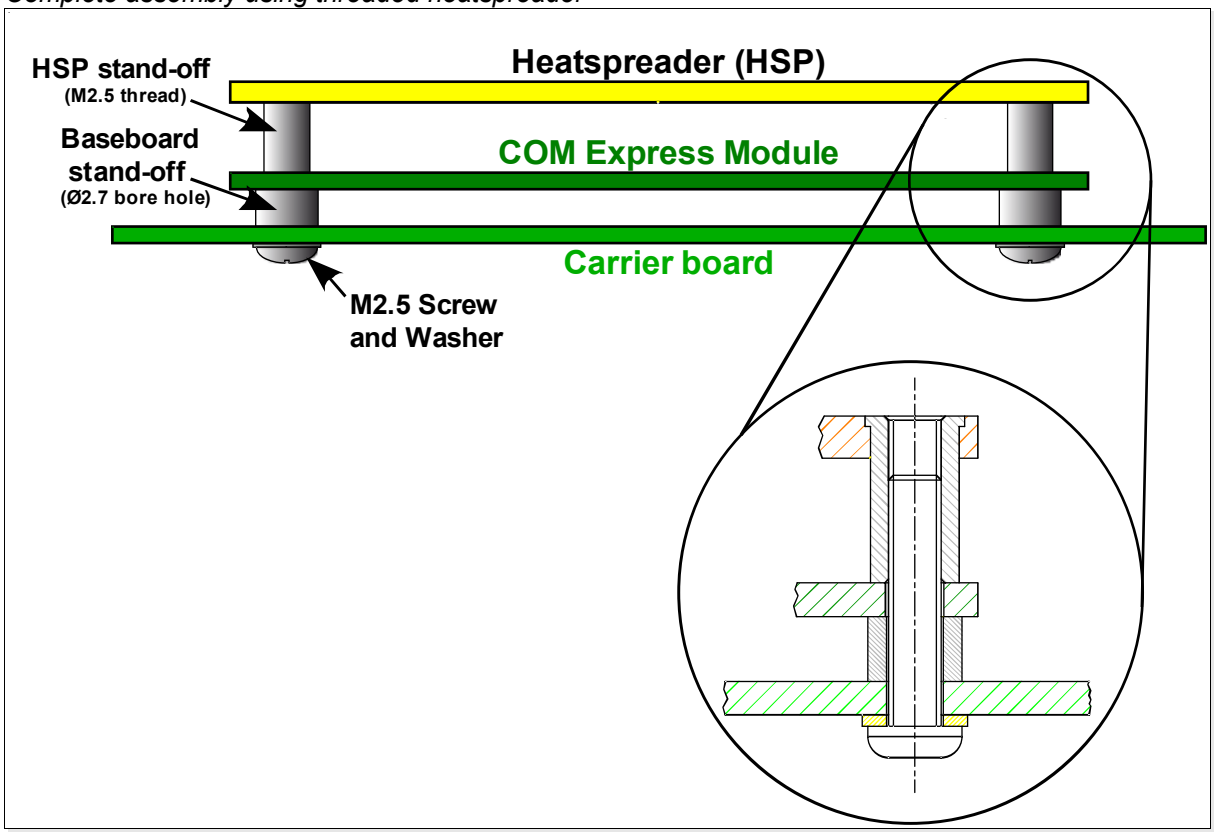
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7.2.2. Bottom mounting

Heatspreaders with threaded standoffs are used for bottom-mounting solutions.

This variant of the heatspreader has been designed to be used in systems where the heatspreader screws need to be inserted from the bottom side of the complete assembly. For this solution a heatspreader version with threaded standoffs must be used. In this case, the standoffs used on the Carrier Board are not threaded.

Figure 77: Complete assembly using threaded heatspreader



Note ***The torque specification for heatspreader screws is 0.5 Nm.***

Caution ***Do not use a threaded heatspreader together with threaded Carrier Board standoffs. The combination of the two threads may be staggered, which could lead to stripping of the threads in either the standoffs of the heatspreader or Carrier Board.***

7.2.3. Materials

Independently from the above mentioned mounting methods the material from the tables below is required to mount a COM Express Module to a Carrier Board.

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Table 72: Heatspreader mounting material needed (5mm connectors at the Carrier Board)

Component	Quantity	Comment
M2.5 x 16mm screw[1]	5	Recessed raised cheese head screw with point, galvanized with metric thread M2.5 and 16mm length DIN7985 / ISO7045
Washer 2.7mm	5	Plain washer galvanized for M2.5 DIN433 / ISO7092

Table 73: Heatspreader mounting material needed (8mm connectors at the Carrier Board)

Component	Quantity	Comment
M2.5 x 19mm screw	5	Recessed raised cheese head screw with point, galvanized with metric thread M2.5 and 19mm length DIN7985 / ISO7045
Washer 2.7mm	5	Plain washer galvanized for M2.5 DIN433 / ISO7092

Table 74: Carrier Board standoffs

Component	Mounting Type	Comment
5mm, press in, M2.5	Top	EFCO ECM00593-L, www.efcotec.com/product.asp?pid=102
5mm, press in, Ø2.7mm	Bottom	EFCO ECM00592-L, www.efcotec.com/product.asp?pid=102
5mm, solder, M2.5	Top	EFCO ECM00530-L, www.efcotec.com/product.asp?pid=102
8mm, press in, M2.5	Top	EFCO ECM00594L, www.efcotec.com/product.asp?pid=102
8mm, press in, Ø2.7mm	Bottom	EFCO ECM00588-L, www.efcotec.com/product.asp?pid=102
5mm, solder, M2.5	Top	EFCO ECM00579-L, www.efcotec.com/product.asp?pid=102
5mm spacer	Bottom	misc.
8mm spacer	Bottom	misc.
5mm spacer + nut	Top	misc.
8mm spacer + nut	Top	misc.

1 The ideal length of the mounting screws is 17mm. As this length is not easy available the 16mm version can be used as a replacement.

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8. Applicable Documents and Standards

8.1. Technology Specifications

Table 75: Reference specifications

Specification	Description	Link
1000BASE T	IEEE standard 802.3ab 1000BASE T Ethernet	www.ieee.org/portal/site
AC'97	Audio Codec '97 Component Specification, Version 2.3	download.intel.com/support/motherboards/desktop/sb/ac97_r23.pdf
ACPI	Advanced Configuration and Power Interface Specification	www.acpi.info
ATA	ANSI NCITS 397-2005: AT Attachment with Packet Interface - 7 (ATA/ATAPI-7)	www.ansi.org www.t13.org
ATX power	ATX power supply design guide	www.intel.com
CAN	Controller Area Network	www.iso.org
CF-Card	CF+ and CompactFlash Specification Copyright © Compact Flash Association.	www.compactflash.org
COM Express	PICMG® COM Express Module™ Base Specification	www.picmg.org
COM.0	PICMG COM.0 R2.1, "COM Express Module Base Specification", May 14, 2012	www.picmg.org
DDC	Enhanced Display Data Channel Specification (DDC)	www.vesa.org
DisplayID	DisplayID	www.vesa.org
DVI	Digital Visual Interface, Digital Display Working Group	www.ddwg.org
EAPI	Embedded Application Programming Interface	www.picmg.org
EDID	Extended Display Identification Data Standard (EDID™)	www.vesa.org
EEEP	Embedded EEPROM Specification	www.picmg.org
ExpressCard	ExpressCard Standard	www.expresscard.org
HDA	High Definition Audio Specification	www.intel.com/standards/hdaudio
I2C	The I2C Bus Specification	www.nxp.com
IEEE 802.3-2008	IEEE Standard for Information technology, Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications	www.ieee.org
LPC	Low Pin Count Interface Specification (LPC)	www.intel.com/design/chipsets/industry/lpc.htm
LVDS	Open LVDS Display Interface (Open LDI) Specification, Copyright © National Semiconductor	www.national.com
LVDS	LVDS Owner's Manual	www.national.com
LVDS	ANSI/TIA/EIA-644-A-2001: Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits, January 1, 2001.	www.ansi.org
OBD-II	On-Board Diagnostics 2nd generation	www.sae.org
PATA	Parallel ATA [IDE]	www.t13.org
PCI	PCI Local Bus Specification	www.pcisig.com/specifications
PCI Express	PCI Express Base Specification, PCI Special Interest Group. All rights reserved	www.pcisig.com
PCI Express	PCI Express Base Specification	www.pcisig.com/specifications

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Specification	Description	Link
PCI Express	Mobile Graphics Low-Power Addendum to the PCI Express Base Specification	www.pcisig.com
PCI Express Card	PCI Express Card Electromechanical Specification	www.pcisig.com/specifications
PCI Express Mini Card	PCI Express Mini Card Electromechanical Specification, PCI Special Interest Group	www.pcisig.com
SATA	Serial ATA: High Speed Serialized AT Attachment, Copyright © APT Technologies, Inc., Dell Computer Corporation, Intel Corporation, Maxtor Corporation, Seagate Technology LLC. All rights reserved	www.sata-io.org
SATA	Serial ATA Specification	www.serialata.org
SDVO	Intel NDA is required	
SMBUS	System Management Bus (SMBUS) Specification, Copyright © Duracell, Inc., Energizer Power Systems, Inc., Fujitsu, Ltd., Intel Corporation, Linear Technology Inc., Maxim Integrated Products, Mitsubishi Electric Semiconductor Company, PowerSmart, Inc., Toshiba Battery Co. Ltd., Unitrode Corporation, USAR Systems, Inc. All rights reserved	www.smbus.org
Smart Battery	Smart Battery Data Specification	www.sbs-forum.org
USB	Universal Serial Bus Specification, Copyright © Compaq Computer Corporation, Hewlett-Packard Company, Intel Corporation, Lucent Technologies Inc, Microsoft Corporation, NEC Corporation, Koninklijke Philips Electronics N.V. All rights reserved	www.usb.org
USB 3.0	Universal Serial Bus Revision 3.0 Specification	www.usb.org
USB	USB Power Delivery Specification	www.poweredusb.org

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8.2. Regulatory Specifications

FCC Rules Part 15 Class B devices

EN 61000-4-2 Personnel Electrostatic Discharge Immunity Testing

UL1642 Standard for Lithium Batteries

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8.3. Useful books

Table 76: Useful books

Title	Author	Note
PCI Express System Architecture	Ravi Budruk, Don Anderson, Tom Shanley	www.mindshare.com
PCI System Architecture (4th Edition)	Tom Shanley, Don Anderson	www.mindshare.com
Universal Serial Bus System Architecture	Don Anderson	www.mindshare.com
SATA Storage Technology	Don Anderson	www.mindshare.com
Protected Mode Software Architecture (The PC System Architecture Series)	Tom Shanley	www.mindshare.com
The Unabridged Pentium 4	Tom Shanley	www.mindshare.com
Building the Power-Efficient PC: A Developer's Guide to ACPI Power Management, First Edition	Jerzy Kolinski, Ram Chary, Andrew Henroid, and Barry Press	Intel Press, 2002, ISBN 0-9702846-8-3
Hardware Bible	Winn L. Rosch	SAMS, 1997, 0-672-30954-8
The Indispensable PC Hardware Book	Hans-Peter Messmer	Addison-Wesley, 1994, ISBN 0-201-62424-9
The PC Handbook: For Engineers, Programmers, and Other Serious PC Users, Sixth Edition	John P. Choisser and John O. Foster	Annabooks, 1997, ISBN 0-929392-36-1
PC Hardware in a Nutshell, 3rd Edition	Robert Bruce Thompson and Barbara Fritchman Thompson	O'Reilly, 2003, ISBN 0-596-00513-X
PCI & PCI-X Hardware and Software Architecture & Design, Fifth Edition	Edward Solari and George Willse	Annabooks, Intel Press, 2001, ISBN 0-929392-63-9
PCI System Architecture	Tom Shanley and Don Anderson	Addison-Wesley, 2000, ISBN 0-201-30974-2
PCI Express Electrical Interconnect Design: Practical Solutions for Board-level Integration and Validation, First Edition	Dave Coleman, Scott Gardiner, Mohamad Kolberhdari, and Stephen Peters	Intel Press, 2005, ISBN 0-9743649-9-1
Introduction to PCI Express: A Hardware and Software Developer's Guide, First Edition	Adam Wilen, Justin Schade, and Ron Thornburg	Intel Press, 2003, ISBN 0-9702846-9-1
Serial ATA Storage Architecture and Applications, First Edition	Knut Grimsrud and Hubbert Smith	Intel Press, 2003, ISBN 0-9717861-8-6
USB Design by Example, A Practical Guide to Building I/O Devices, Second Edition	John Hyde	Intel Press, ISBN 0-9702846-5-9
Universal Serial Bus System Architecture, Second Edition	Don Anderson and Dave Dzatko	Mindshare, Inc., ISBN 0-201-30975-0
Printed Circuits Handbook, Fourth Edition	Clyde F. Coombs Jr.	McGraw-Hill, 1996, ISBN 0—07-012754-9
High Speed Signal Propagation, First Edition	Howard Johnson and Martin Graham	Prentice Hall, 2003, ISBN 0-13-084408-X
High Speed Digital Design: A Handbook of Black Magic, First Edition	Howard Johnson	Prentice Hall, ISBN: 0133957241
C Programmer's Guide to Serial Communications, Second Edition	Joe Campbell	SAMS, 1987, ISBN 0-672-22584-0
The Programmer's PC Sourcebook, Second Edition	Thom Hogan	Microsoft Press, 1991, ISBN 1-55615-321-X
The Undocumented PC, A Programmer's Guide to I/O, CPUs, and Fixed Memory Areas	Frank van Gilluwe	Addison-Wesley, 1997, ISBN 0-201-47950-8
VHDL Modeling for Digital Design Synthesis	Yu-Chin Hsu, Kevin F. Tsai, Jessie T. Liu and Eric S. Lin	Kluwer Academic Publishers, 1995, ISBN: 0-7923-9597-2

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9. Appendix A: Deprecated Features

The following content was removed from the main part of this document because it is no longer part of the COM.0 Rev. 2.1 specification. It is kept here in the appendix for reference.

9.1. TV-Out

9.1.1. Signal Definitions

TV-Out signals are defined on COM Express connector row B. Up to 3 individual digital-to-analog converter (DAC) channels are available on the connector. The following video formats may be supported:

Composite Video: All color, brightness, blanking, and sync information are encoded onto a single signal.

S-Video: (Separated Video) video signal with two components, brightness (luma) and color (chroma). This is also known as Y-C video.

Component Video: A video signal that consists of three components. The components may be RGB or may be encoded using other component encoding schemes such as YUV, YCbCr, and YPbPr.

A COM Express Module may support all, some, or none of these formats. Within these formats, there are different encoding schemes that may be used. The most widely used encoding schemes are NTSC (used primarily in North America) and PAL (used primarily in Europe)

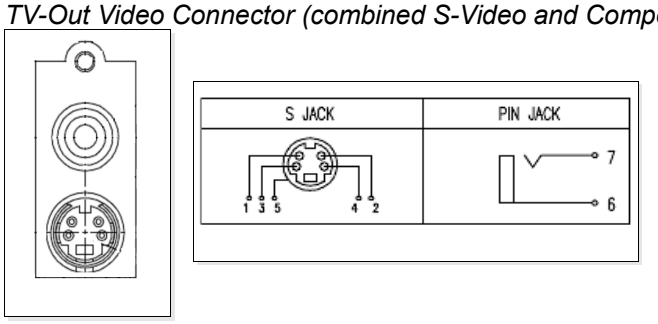
Which format and encoding options are available are Module and vendor dependent. Only one output mode can be used at any given time.

Table 77: TV-Out Signal Definitions

Signal	Pin	Description	I/O	Comment
TV_DAC_A	B97	TV-DAC channel A output supporting: **Composite video**: CVBS **Component video**: Chrominance (Pb) **S-Video**: not used	O Analog	Analog output
TV_DAC_B	B98	TV-DAC channel B output supporting: **Composite video**: not used **Component video**: Luminance (Y) **S-Video**: Luminance (Y)	O Analog	Analog output
TV_DAC_C	B99	TV-DAC channel C output supporting: **Composite video**: not used **Component**: Chrominance (Pr) **S-Video**: Chrominance (C)	O Analog	Analog output

9.1.2. TV-Out Connector

Figure 78: TV-Out Video Connector (combined S-Video and Composite)



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Table 78: TV-Out Connector Pin-out

Pin	Signal	Description	Pin	Signal	Description
1	Chrominance (C)	S-Video Chrominance Analog Signal (C)	2	Luminance (Y)	S-Video Luminance Analog Signal (Y)
3	GND (C)	Analog Ground for Chrominance (C)	4	GND (Y)	Analog Ground Luminance (Y)
5	GND	Analog Ground	6	GND	Analog Ground
7	Composite	Composite Video Output			

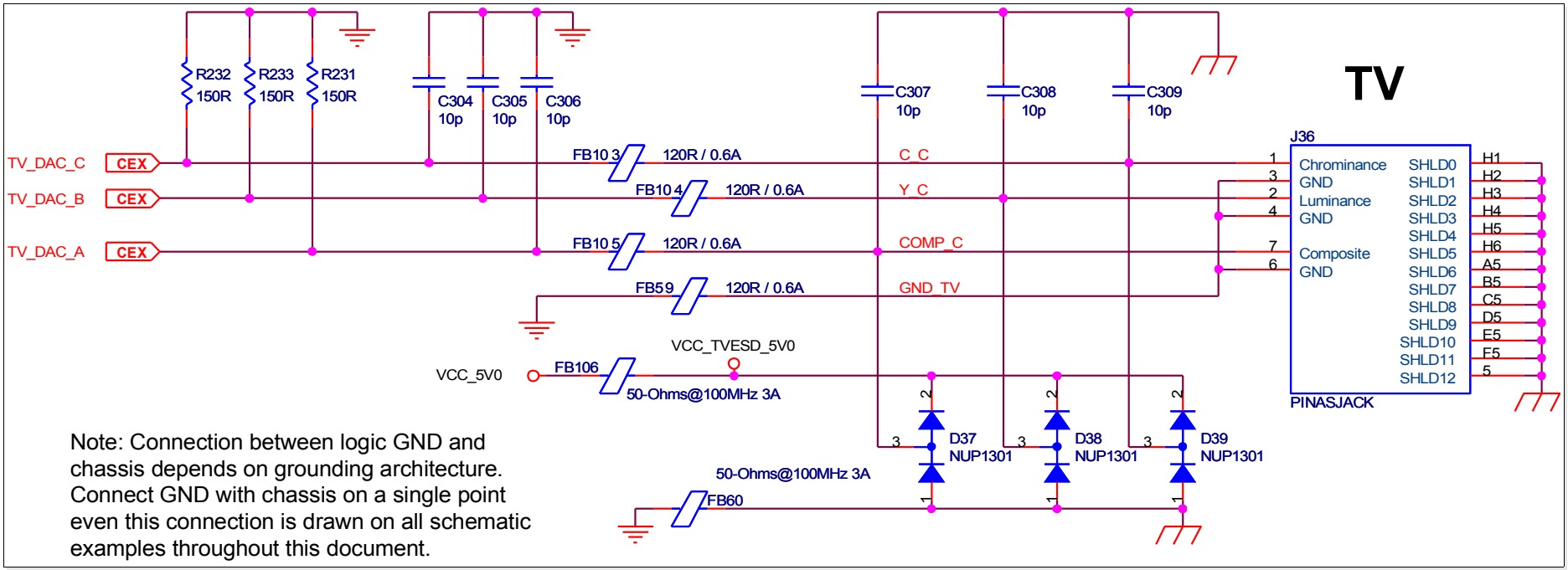
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9.1.3. TV-Out Reference Schematics

All signals along the left edge of the figure below are sourced directly from the COM Express Module. No additional pull-ups or terminations beyond what is shown in the figure are required.

The 150 Ω termination to ground is important both for signal integrity and to establish the correct DC level on the line. All components shown in this figure should be placed close to the Carrier Board connector shown in the figure.

Figure 79: TV-Out Reference Schematics



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9.1.4. Routing Considerations

At least 30mils of spacing should be used for the routing between each TV-DAC channel to prevent crosstalk between the TV-DAC signals. The maximum trace length distance of the TV-DAC signals between the COM Express connector and the 150Ω ±1% termination resistor should be within 12 inches. This distance should be routed with a 50Ω trace impedance.

9.1.5. Signal Termination

Each of the TV-DAC channels should have a 150Ω ±1% pull-down termination resistor connected from the TV-DAC output of the COM Express Module to the Carrier Board ground. This termination resistor should be placed as close as possible to the TV-Out connector on the Carrier Board. A second 150Ω ±1% termination resistor exists on the COM Express Module itself.

9.1.6. Video Filter

There should be a PI-filter placed on each TV-DAC channel output to reduce high-frequency noise and EMI. The PI-filter consists of two 10pF capacitors with a 120Ω @ 30Mhz ferrite bead between them. It is recommended to place the PI-filters and the termination resistors as close as possible to the TV-Out connector on the Carrier Board. The PI-filters should be separated from each other by at least 50mils or more in order to minimize crosstalk between the TV-DAC channels.

9.1.7. ESD Protection

ESD clamp diodes are required for each TV-DAC channel. These low capacitance clamp diodes should be placed as near as possible to the TV-Out connector on the COM Express Carrier Board between +5V supply voltage and ground.

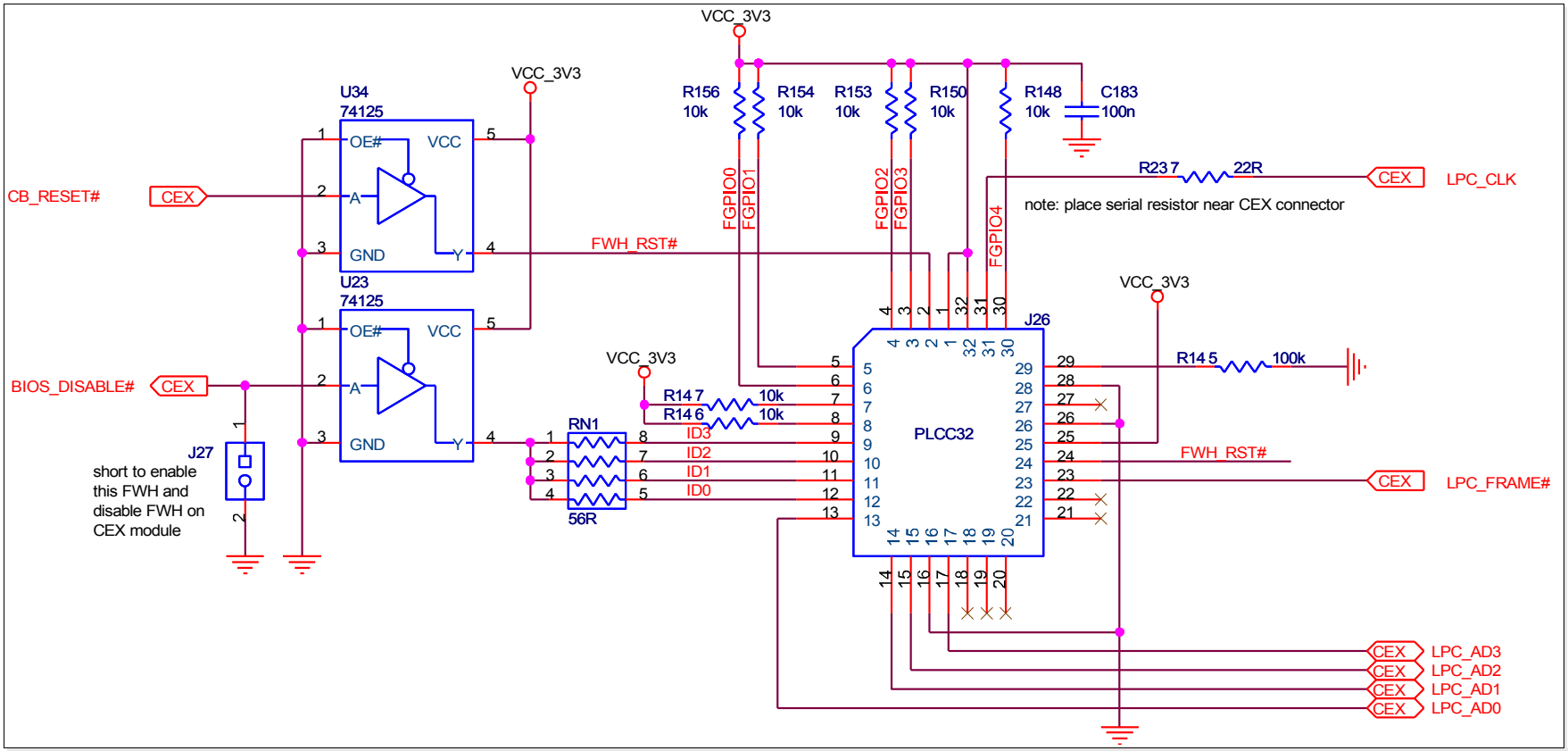
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9.2. LPC Firmware Hub

An example of a Carrier Board Firmware Hub (FWH) implementation is shown in Figure 80: LPC Firmware Hub below. Use the FWH to store and execute BIOS code.

A feature of the COM Express specification is the inclusion of the BIOS_DISABLE# pin. If this pin is pulled low on the Carrier Board, then the BIOS on the Module is disabled. The BIOS can instead reside on the Carrier Board LPC or PCI buses. This is useful in some regulatory situations in which it is required that regulatory technicians remove the BIOS, check its integrity, and replace it. There is usually room on a Carrier Board for a socketed BIOS, whereas the Module BIOS is often a surface-mount device. The use of this feature is illustrated in the example below.

Figure 80: LPC Firmware Hub



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The BIOS device shown in Figure 80: LPC Firmware Hub above is a SST SST49LF008A Firmware Hub in a 32-pin PLCC package. The socket used is a 32-pin PLCC socket, AMP/Tyco 822498-1. This is a surface-mount socket, and PCBs can be laid out such that the socket or the FWH itself is soldered to the Carrier Board.

The FWH is connected to the system via the LPC interface. Data and address information are carried on the LPC_AD[0:3] lines. LPC_FRAME# indicates the start of a new frame.

FWH pins 2 (RST#) and 24 (INIT#) reset the FWH. These pins are logically combined together internally on the FWH, and a low on either pin will reset the FWH.

FWH pins 6, 5, 4, 3, 30 – (FGPI [0:4]) are general-purpose inputs that may be read by system software. They should be tied to a valid logic level.

FWH pin 7 (WP#) enables write protection for main block sectors when it is pulled low. If pulled high, hardware write protection is disabled. FWH pin 8 (TBL#) enables write protection for the top block sector when pulled low.

FWH pins 12,11,10, 9 – (ID[0:3]) are ID pins that allow multiple FWH parts (up to 16) to be used. By convention, in Intel x86-based systems, the boot device is FWH number 0. To boot from the Carrier Board FWH, the Module BIOS_DISABLE# pin must be low (to disable the Module BIOS) and the Carrier Board FWH ID[0:3] pins (pins 12,11,10,9) must be low (to enable it as the boot device). If jumper J27 in Figure 80: LPC Firmware Hub above is installed, the Module BIOS is disabled, and the Carrier Board FWH may be used as a boot device.

FWH pin 29 configures the FWH into one of two modes: if high, the FWH is in the Programmer configuration. If low, it is in the firmware hub configuration. For normal operation on a Carrier Board, this pin should be tied low.

FWH pin 31 is the clock input. The clock source is the LPC_CLK signal from the COM Express Module.

FWH pin 2 – RST# supports Chip Reset. The LPC_RESET# signal from the COM Express Module drives the reset. The pin functions the same as INIT# above.

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10. Appendix B: Sourcecode for Port 80 Decoder

```
-- IO80 catcher for LPC bus.
-- File:  LPC_IOW80_1.1.VHD
-- Revision:  1.1
-- Author:   Eric Leonard (partially based on Nicolas Gonthier's T3001)
--          Subsequent modifications by:
--                Detlef Herbst and Travis Evans - 08/10/05
-- Decode only I/O writes to 80h
-- Features:
--    - I/O 80 access only (internally decoded)
--    - No support for read, only write.
--    - All signals synchronous to LPC clock
-- Notes:
--    - Unless otherwise noted, all signals are active high.
--    - Suffix "n" indicate active low logic.
--
--    - Successfully implemented on Brownsville baseboard with Seven Segment
--    - display P/N SA39-11 (common Anode - Low turns on segment) from Kingbright
-- Related documents:
--           - Low Pin Count (LPC) Interface Specification, Revision 1.0 (sept 1997)
--------------------------------------------------------------------------------
library IEEE;
use IEEE.std_logic_1164.all;

entity LPC_IOW80 is port (
  lclk:              in        std_logic;                    -- LPC: 33MHz clock (rising edge)
  lframe_n:          in        std_logic;                    -- LPC: frame, active low
  lreset_n:in        std_logic;                    -- LPC: reset, active low
  lad:               in        std_logic_vector(3 downto 0);-- LPC: multiplexed bus
  seven_seg_L:       out       std_logic_vector(7 downto 0);-- SSeg Data output
  seven_seg_H:       out       std_logic_vector(7 downto 0)  -- SSeg Data output
);
end LPC_IOW80;

architecture RTL of LPC_IOW80 is

        type LPC_State_Type is (
                IDLE,           -- Waiting for a start condition
                START,          -- Start condition detected
                WADDN3,                 -- I/O write address nibble 3 (A15..A12)
                WADDN2,                 -- I/O write address nibble 2 (A11..A8 )
                WADDN1,                 -- I/O write address nibble 1 (A7..A4)
                WADDN0,                 -- I/O write address nibble 0 (A3-A0)
                WDATN1,                 -- I/O write data nibble 0 (D7..D4)
                WDATN0,                 -- I/O write data nibble 1 (D3..D0)
                WHTAR0,                 -- I/O write host turn around phase 0
                WHTAR1,                 -- I/O write host turn around phase 1
                WSYNC,          -- I/O write sync
                WPTAR );        -- I/O write peripheral turn around

        signal LPC_State: LPC_State_Type;

        signal lframe_nreg: std_logic;                          -- LPC frame register
        signal lad_rin:             std_logic_vector(lad'range);   -- LPC input registers
        signal W_Data:              std_logic_vector(7 downto 0);           -- LPC input Post Code

begin

--------------------------------------------------------------------------------
-- LPC bidirectional pins definition.
--------------------------------------------------------------------------------

-- Input register to get some timing margin
P_input_register: process(lclk)
begin
        if (lclk'event and lclk='1') then
                lad_rin    <= lad;
                lframe_nreg <= lframe_n;
        end if;
end process;
```


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```
--------------------------------------------------------------------------------
-- LPC state machine
-- LPC_State value is actually one clock cycle late.
--------------------------------------------------------------------------------
P_LPC_StatMachine: process(lclk)

begin
  if (lclk'event and lclk='1') then

-- Synchronous reset
            if (lreset_n = '0') then
                        LPC_State <= IDLE;
                        W_Data(7 downto 0) <= "00000000";     -- init. both displays to all on
                        else
                                    case LPC_State is

                                     -- Looking for a START condition
                                     when IDLE =>

                                                if (lframe_nreg = '0') and (lad_rin = "0000") then
                                                            LPC_State <= START;          -- START condition detected
                                                            end if;

                                                -- Skip extra cycles on START frame
-- (can be many clock cycles)
                                                -- and then, check for I/O write transaction
                                      when START =>
                                                if (lframe_nreg = '0') then -- frame still asserted
                                                            if (lad_rin /= "0000") then
                                                            LPC_State <= IDLE; -- unsupported start code
                                                            end if;
                                                else
                                                if (lad_rin(3 downto 1) = "001") then
                                                            LPC_State <= WADDN3;       -- I/O write detected
                                                            else
                                                            LPC_State <= IDLE;            -- unsupported command
                                                            end if;
                                                end if;

                                                -- ---------------------------------
                                                -- I/O write transaction processing
                                                -- ---------------------------------
                                                when WADDN3 => -- Write Data Address Nibble 3

                                                            -- Find next state
                                                            if (lframe_nreg = '0') or (lad_rin /= "0000") then
LPC_State <= IDLE; -          -- abort cycle, bad frame
-- or address mismatch
                                                            else
                                                                        LPC_State <= WADDN2;
                                                            end if;

                                                when WADDN2 =>              -- Write Data Address Nibble 2

                                                            -- Find next state
                                                            if (lframe_nreg = '0') or (lad_rin /= "0000") then
LPC_State <= IDLE; -- abort cycle, bad frame
   -- or address mismatch
                                                            else
                                                                        LPC_State <= WADDN1;
                                                            end if;

                                                when WADDN1 =>              -- Write Data Address Nibble 1

                                                            -- Find next state
                                                            if (lframe_nreg = '0') or (lad_rin /= "1000") then
LPC_State <= IDLE; -- abort cycle, bad frame
   -- or address mismatch
                                                            else
                                                                        LPC_State <= WADDN0;
                                                            end if;

                                                when WADDN0 =>              -- Write Data Address Nibble 0

                                                            -- Find next state
                                                            if (lframe_nreg = '0') or (lad_rin /= "0000") then
```


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```
LPC_State <= IDLE; -- abort cycle, bad frame
    -- or address mismatch
                                        else
                                        -- Write address valid. Subsequent Data displays.
LPC_State <= WDATN0;        -- Next state will get
-- first data nibble
                                        end if;

when WDATN0 =>  -- Data LSN (Least Significant Nibble)is
-- sent first
                                        W_Data(3 downto 0) <= lad_rin; -- latch data (LSN)
                                        if (lframe_nreg = '1') then
 LPC_State <= WDATN1; ¬¬¬-- Next state gets
 -- 2nd data nibble
                                        else
                                                LPC_State <= IDLE;
                                        end if;

                                    when WDATN1 =>   -- Data MSN (Most Significant Nibble)
                                        W_Data(7 downto 4) <= lad_rin; -- latch data (MSN)
                                        if (lframe_nreg = '1') then
                                                LPC_State <= WHTAR0;
                                        else
                                                LPC_State <= IDLE;
                                        end if;

                                    when WHTAR0 =>   -- Write Data Turn Around Cycle 0

                                        if (lframe_nreg = '1') and (lad_rin = "1111") then
                                                LPC_State <= WHTAR1;
                                        else
                                                LPC_State <= IDLE;
                                        end if;

                                    when WHTAR1 =>    -- Write Data Turn Around Cycle 1

                                        if (lframe_nreg = '1') then
                                                LPC_State <= WSYNC;
                                        else
                                                LPC_State <= IDLE;
                                        end if;

                                    when WSYNC =>   -- Write Data Sync Cycle
-- Note: No device to respond with a synch at I\O addr
-- 080h. Therefore bus should time out and abort.
-- State ==> to IDLE
                                        if (lframe_nreg = '1') then
                                                LPC_State <= WPTAR;
                                        else
                                                LPC_State <= IDLE;
                                        end if;


when WPTAR =>    -- Write Data Final Turn Around Cycle
-- (not needed -- see WSYNC)
                                        LPC_State <= IDLE;          -- I/O write cycle end

                                    when others =>
                                        LPC_State <= IDLE;          -- all other cases
                                end case;
                        end if;
                end if;
end process;

P_sseg_decode: process(lclk)                                    -- decode section for 7 seg displays
begin
        if (lclk'event and lclk='1') then

                case W_Data(7 downto 4) is                      -- Most sig digit for display
                        when    "0000" => seven_seg_H <= "00000011";        -- Hex 03 displays a 0
                        when    "0001" => seven_seg_H <= "10011111";-- Hex 9f displays a 1
                        when    "0010" => seven_seg_H <= "00100101";        -- Hex 25 displays a 2
                        when    "0011" => seven_seg_H <= "00001101";        -- Hex 0d displays a 3
                        when    "0100" => seven_seg_H <= "10011001";        -- Hex 99 displays a 4
                        when    "0101" => seven_seg_H <= "01001001";        -- Hex 49 displays a 5
                        when    "0110" => seven_seg_H <= "01000001";        -- Hex 41 displays a 6
```


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```
                when    "0111" => seven_seg_H <= "00011111"; -- Hex 1f displays a 7
                when    "1000" => seven_seg_H <= "00000001";        -- Hex 01 displays a 8
                when    "1001" => seven_seg_H <= "00001001";        -- Hex 09 displays a 9
                when    "1010" => seven_seg_H <= "00010001";        -- Hex 11 displays a A
                when    "1011" => seven_seg_H <= "11000001";        -- Hex c1 displays a b
                when    "1100" => seven_seg_H <= "01100011";        -- Hex 63 displays a C
                when    "1101" => seven_seg_H <= "10000101";        -- Hex 85 displays a d
                when    "1110" => seven_seg_H <= "01100001";        -- Hex 61 displays a E
                when    "1111" => seven_seg_H <= "01110001";-- Hex 71 displays a F
                when    others => seven_seg_H <= "00000001";        -- Hex 01 displays a 8

        end case;


case W_Data(3 downto 0) is                      -- Least sig digit for display
                when    "0000" => seven_seg_L <= "00000011";        -- Hex 03 displays a 0
                when    "0001" => seven_seg_L <= "10011111"; -- Hex 9f displays a 1
                when    "0010" => seven_seg_L <= "00100101";        -- Hex 25 displays a 2
                when    "0011" => seven_seg_L <= "00001101";-- Hex 0d displays a 3
                when    "0100" => seven_seg_L <= "10011001";        -- Hex 99 displays a 4
                when    "0101" => seven_seg_L <= "01001001";        -- Hex 49 displays a 5
                when    "0110" => seven_seg_L <= "01000001";        -- Hex 41 displays a 6
                when    "0111" => seven_seg_L <= "00011111"; -- Hex 1f displays a 7
                when    "1000" => seven_seg_L <= "00000001";        -- Hex 01 displays a 8
                when    "1001" => seven_seg_L <= "00001001";        -- Hex 09 displays a 9
                when    "1010" => seven_seg_L <= "00010001";        -- Hex 11 displays a A
                when    "1011" => seven_seg_L <= "11000001";-- Hex c1 displays a b
                when    "1100" => seven_seg_L <= "01100011";-- Hex 63 displays a C
                when    "1101" => seven_seg_L <= "10000101";        -- Hex 85 displays a d
                when    "1110" => seven_seg_L <= "01100001";-- Hex 61 displays a E
                when    "1111" => seven_seg_L <= "01110001"; -- Hex 71 displays a F
                when    others => seven_seg_L <= "00000001";-- Hex 01 displays a 8

        end case;
    end if;
end process;

end RTL;
```


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13. Appendix E: Revision History

Table 79: Revision History

Revision	Date	Author	Changes
1.00 RC1.0	Jan 16, 2009	C. Eder	
1.10 beta0.1	Sept 14 2012	M. Unverdorben	Exchanged “Trademark” against “Registered” for COM Express Added Chapters: Interface description – DisplayPort – MXM – USB 3.0 – embedded DisplayPort – SPI Bus – General Purpose Serial Interface – CAN Power and Reset: – Design Considerations for Carrier Boards containing FPGAs or other programmable logic Routing Rules for High-Speed Differential Interfaces – USB 3.0 Trace Routing Guidelines – DisplayPort Trace Routing Guidelines
1.10 beta0.2	Sept 26, 2012	M. Unverdorben	Added Text for embedded DisplayPort Exchanged Chapter 7.1 Mechanical Considerations → Form Factors Added Text and drawing for 6.4 Trace-Lenght Extensions Considerations Added MXM Text Expanded Chapter 2 with additional pin-out types drawings and tables Updated Chapter 2 according to feedback Again updated Chapter 2 according to feedback updated General Purpose Serial Interface and CAN updated Abbreviations changed mechanical considerations according Bill's suggestion (2012-10-16) changed eDP according to Ben's suggestion (2012-10-12)
2.0 beta 0.1	Jan 07, 2013	M. Unverdorben	Changed to 2.0 revisions shifted TV-out to the Appendix reworked audio interfaces to have more focus on HDA added different generations at PCIe chapter (2.2) added type 6 to PCIe description (chapter 2.2.1) exchanged SM Bus buffer schematic remove I2C bus example (EEPROM) in SMB chapter
2.0 beta 0.2	Jan 18, 2013	M. Unverdorben	Reconfigured chapter order of SDVO / HDMI → Digital Display Interface updated abbreviation table updated PCIe chapter (2.3) updated and corrected PEG (2.4) corrected LAN and USB chapter corrected SATA reference schematics corrected and updated VGA switched on numbering in the appendices add note to LPC firmware hub, shifted chapter to deprecated chapters changed power domain on I2C reference schematic updated miscellaneous signals chapter added wide range for mini on chapter 3.0 shifted PCI chapter to the end of interfaces
2.0 beta 0.5	Feb 18, 2013	M. Unverdorben	Changed Power button behavior description Added connector vendors Foxconn and EPT Added “Protecting COM.0 Pins Reclaimed From the VCC_12V Pool' Added USB 3.0 Trace Routing Guidelines Added DP Trace Routing Guidelines Added SDIO Interface Multiplexed with GPIOs Added text for DDI Added missing References changed MXM schematic (SMB_S0) exchanged LPC SuperI/O example to W83267DHG-P Corrected SDIO/GPIO description according to Chris Lewis suggestions
2.0 beta 0.6	March, 20, 2013	M. Unverdorben	Corrected errors according to “Kontron List” Added MXM content Added USB power control via SPI_POWER

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			Added Note for later updated PCI Gen 3.0 Layout Rules
2.0 beta 0.7	April, 9, 2013	M. Unverdorben	Implementation of COM_CRs_Subcommittee_Review...
2.0 beta 0.8	April, 15, 2013	M. Unverdorben	Continue com Implementation of COM_CRs_Subcommittee_Review, added FAN Connector Schematics
2.0 beta 0.9	April, 16 2013	M. Unverdorben	Finished 2nd review round and implemented all inputs from COM_CRs Subcommittee_Review.
2.0 beta 0.10	April, 22 2013	M. Unverdorben	Content for USB backdriving issue only once in document.
2.0 beta 0.11	April, 29 2013	M. Unverdorben	Corrected Resistor designator in text to match drawing in 2.9.3 Corrected template of Figure 57 from “heading 3” to “figure” Reduced TOC from 4 to 3 header levels Updated boiler plate text and IPR
2.0 beta 0.12	May, 8 2013	M. Unverdorben	Corrected boiler plate text corrected several templates added ® in page footers corrected connector vendor link of TE made figure and table list click-able
2.0 beta 0.13	July, 30 2013	M. Unverdorben	Started to implement CR# from Member Review
2.0 beta 0.14	October, 24 2013	M. Unverdorben	Updated PCIe and SATA Routing Conserations to Gen3 Harmonized Routing Considerations tables corrected text color in 7.1
2.0 beta 0.15	November, 11 2013	M. Unverdorben	Updated according to correction list from Stefan Milnor
2.0		M. Unverdorben	Updated the document to follow COM.0 Rev. 2.1 Added Chapters: Interface description – Digital Display Interfaces – MXM – USB 3.0 – embedded DisplayPort – SPI Bus – General Purpose Serial Interface – CAN – Fan Connector Power and Reset: – Design Considerations for Carrier Boards containing – FPGAs or other programmable logic Routing Rules for High-Speed Differential Interfaces – Trace Length Extensions Considerations – USB 3.0 Trace Routing Guidelines – DisplayPort Trace Routing Guidelines

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