PCIe-7360

100 MHz 32-CH High-Speed Digital I/O Card

User's Manual

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Revision History

Revision	Release Date	Description of Change(s)
2.00	Aug. 2, 2013	Initial release

Preface

Disclaimer

The information in this document is subject to change without prior notice in order to improve reliability, design, and function and does not represent a commitment on the part of the manufacturer.

In no event will the manufacturer be liable for direct, indirect, special, incidental, or consequential damages arising out of the use or inability to use the product or documentation, even if advised of the possibility of such damages.

Environmental Responsibility

ADLINK is committed to fulfill its social responsibility to global environmental preservation through compliance with the European Union's Restriction of Hazardous Substances (RoHS) directive and Waste Electrical and Electronic Equipment (WEEE) directive. Environmental protection is a top priority for ADLINK. We have enforced measures to ensure that our products, manufacturing processes, components, and raw materials have as little impact on the environment as possible. When products are at their end of life, our customers are encouraged to dispose of them in accordance with the product disposal and/or recovery programs prescribed by their nation or company.

Trademarks

Product names mentioned herein are used for identification purposes only and may be trademarks and/or registered trademarks of their respective companies.

Conventions

Take note of the following conventions used throughout this manual to make sure that users perform certain tasks and instructions properly.


NOTE:

Additional information, aids, and tips that help users perform tasks.


CAUTION:

Information to prevent ***minor*** physical injury, component damage, data loss, and/or program corruption when trying to complete a task.


WARNING:

Information to prevent ***serious*** physical injury, component damage, data loss, and/or program corruption when trying to complete a specific task.

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1 Introduction

ADLINK's PCIe-7360 is a high-speed digital I/O board with 32-channel bi-directional parallel I/O lines. Data rate up to 400 MB/s is available through the x4 PCI Express® interfaces, with clock rate up to 100 MHz internal clock or 200 MHz external clock, ideally suited for high-speed and large scale digital data acquisition or exchange applications, such as digital image capture, video playback, and IC testing.

1.1 Features

- x4 lane PCI Express® interface
- 8/16/24/32-CH @ up to 100MHz for DI or DO and 8/16-CH @ up to 200MHz for DI in external clock mode
- 400 MB/s maximum throughput
- Software selectable 1.8 V, 2.5 V, or 3.3 V (5 V compatible) voltage levels
- 80-step phase shift in external clock mode
- Per group (8-bit) input/output direction selectable
- Supports I2C and SPI programmable serial interfaces for external device communication
- Scatter-gather DMA support
- Flexible handshake and external digital trigger modes
- 8-channel auxiliary programmable I/O support

1.2 Applications

- High-speed digital data exchange
- Digital pattern generation and acquisition
- IC testing
- Interface to external high-speed A/D and D/A converter
- ATE

1.3 Specifications

1.3.1 General

Interface	x4 PCI Express interface		
Connectors	SMB Jack Connector x2 (CLK IN & OUT) 68-pin SCSI-VHDCI x1 (32-bit Data Lines & 8-CH AFI)		
Operating Temperature	0°C - 55°C		
Storage Temperature	-20°C - 70°C		
Humidity	5 - 95%, non-condensing		
Dimensions	168 mm (L) x 112 mm (H), not including connectors		
Power Consumption		Typical	Maximum
	+3.3 VDC	860 mA	950 mA
	+12V VDC	270 mA	550 mA
	Total Power	6.1 W	9.8 W

1.3.2 Digital I/O

Channels		32		
Direction (programmable)		Input or output, per group (8 channel) basis		
Logic level (programmable)		1.8 V	2.5 V	3.3 V (5 V compatible)
Input voltage	Min. V_{IH}	1.2 V	1.6 V	2 V
	Max. V_{IL}	0.63 V	0.7 V	0.8 V
Output voltage	Min. V_{OH}	1.6 V	2.3 V	3.1 V
	Max. V_{OL}	0.2 V	0.2 V	0.2 V
Driving capacity (min.)		±8 mA	±16 mA	±32 mA
Max. throughput		Digital input: 400M Byte/s Digital output: 400M Byte/s		

Buffer size	Digital input: 8k samples Digital output: 20k samples
Data transfer	Software polling Bus-mastering DMA with scatter-gather
Clock modes	Internal clock: up to 100 MHz External clock: 200 MHz for DI, 100MHz for DO (see Note) Handshake Burst handshake
Trigger source	Software External digital signal Pattern match
Trigger modes	Post trigger with re-trigger Gate trigger
Input impedance	10 kΩ
Input protection range	-1 to 6 V
Input protection range	-1 to 6 V
Output impedance	50 Ω
Power-up initial state	Tri-state/All digital inputs
Output protection range	-0.5 V to 3.8 V

NOTE: External clock rate, which can be up to 200 MHz, only supports 8 or 16-bit data width

1.3.3 Application Function I/O (AFI)

Channels		8		
Direction (programmable)		Input or output, per channel basis		
Logic levels (programmable)		1.8 V	2.5 V	3.3 V (5 V compatible)
Input voltage	Min. V_{IH}	1.2 V	1.6 V	2 V
	Max. V_{IL}	0.63 V	0.7 V	0.8 V
Output voltage	Min. V_{OH}	1.6 V	2.3 V	3.1 V
	Max. V_{OL}	0.2 V	0.2 V	0.2 V
Driving capacity (max.)		±8 mA	±16 mA	±32 mA
Input impedance		10 kΩ		
Input protection range		-1 to 6 V		
Output impedance		50 Ω		
Power-up initial state		Tri-state/All digital inputs		
Output protection range		-0.5V to 3.8V		
Supported Modes (programmable)		I^2C master SPI master Handshake External trigger in/out DI/DO sample clock in/out		

1.3.4 Timing Specifications

Sample Clock	
Clock sources	Internal clock: onboard 100MHz with 16-bit divider External clock: AFI6 (for DO) AFI7 (for DI) SMB CLK in

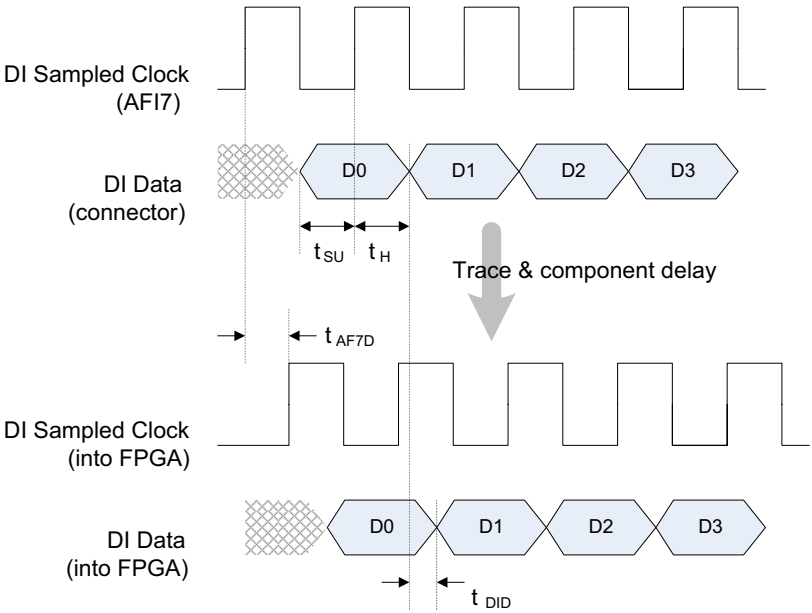
Internal clock rate (programmable)	1526 Hz – 100 MHz (100 MHz/ N; 1≤N≤65,535)
Ext. frequency range	Phase shift disabled: 0-200 MHz Phase shift enabled: 20MHz - 100MHz (see Note)
Phase shift	Internal clock: N/A External clock: 80 steps; 1 step = 4.5°
Sample Clock Exporting	
Destination	AFI6 (for DO) AFI7 (for DI) SMB CLK out
Frequency range	Phase shift disabled: 0-100 MHz Phase shift enabled: 20MHz - 100MHz (see Note)
Clock jitter	Period jitter: 300 ps
Clock duty cycle	50%
Phase shift resolution	1/80 of external sampled clock period (80 steps; 1 step = 4.5°)

NOTE:

When phase shift is enabled, the clock must be continuous and free-running

1.3.5 Timing Accuracy

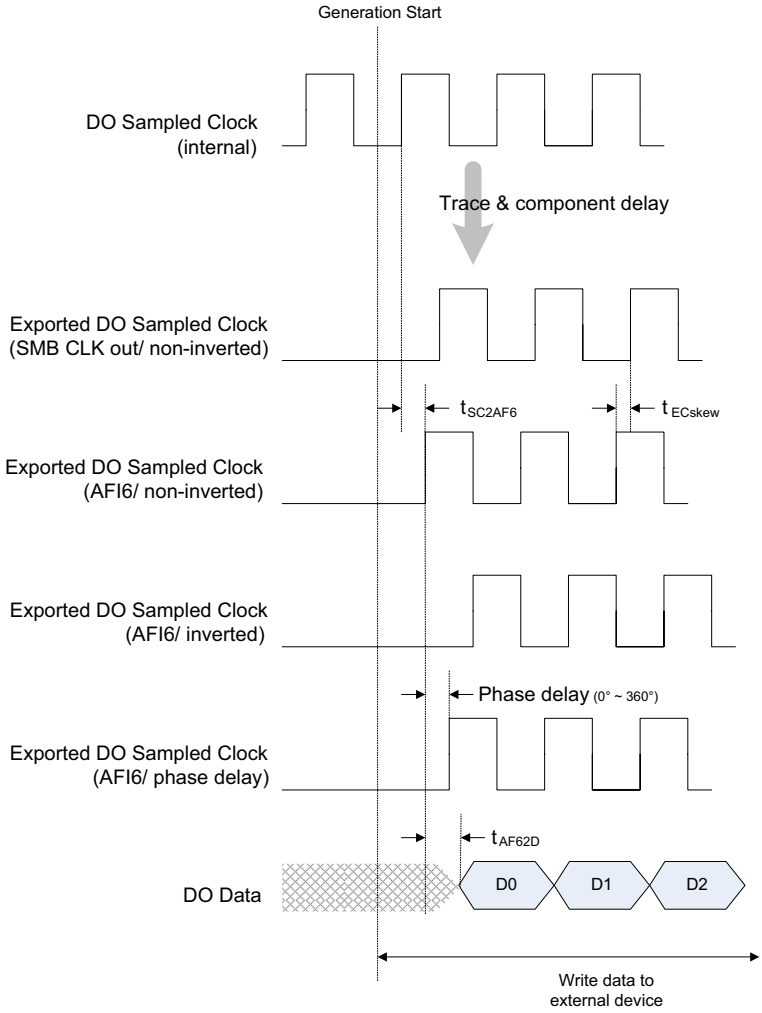
Acquisition Timing	
Channel-to-Cannel skew	±1.08 ns
Setup time to sampled clock (t_{SU})	2 ns
Hold time to sampled clock (t_H)	2 ns
Time delay of external sampled clock from AFI7 to internal (t_{AF7D})	6.3 ns
Time delay of external sampled clock from SMB CLK in to internal (t_{SMBID})	9.1 ns
Time delay of DI data from VHDCI connector to internal (t_{DID})	3.26 ns - 4.34 ns
Generation Timing	
Exported clock skew AFI6 -to- SMB CLK out (t_{ECskew})	2 ns
Exported clock (AFI6) -to- DO data delay (t_{AF62D})	600 ps - 5 ns



t_{AF7D} = Time delay of external sampled clock from AFI7 to internal

t_{DID} = Time delay of DI data from VHDCI connector to internal

Figure 1-1: Acquisition Timing Diagram



t_{SC2AF6} = Time delay from sampled clock (internal) to exported sampled clock (AFI6)

t_{ECskew} = Time delay from exported clock (AFI6) to exported clock (SMB CLK out)

t_{AF62D} = Time delay from exported sampled clock (AFI6) to do data

Figure 1-2: Generation Timing Diagram

1.3.6 External Clock I/O Specification

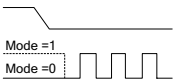
CLK IN (SMB Jack Connector)		
Destination	DI or DO sample clock	
Input coupling	AC	
Input Impedance	50 Ω	
Minimum detectable pulse width	8 ns	
External sampled clock range	Square Wave	
	Voltage	0.2 Vpp to 5 Vpp
	Frequency	Phase shift disabled: 0-200 MHz Phase shift enabled: 20MHz - 100MHz
	Duty cycle	40% - 60%
	Sine Wave	
	Voltage	0.2 Vpp to 5 Vpp
	Frequency	Phase shift disabled: 0-200 MHz Phase shift enabled: 20MHz - 100MHz
CLK OUT (SMB Jack Connector)		
Sources	DI or DO internal sample clock	
Source impedance	50 Ω	
Logic Levels (programmable)	The same logic level of AFI I/O (1.8 V, 2.5 V, or 3.3 V)	
Driving Capacity (Max.)	±8 mA at 1.8 V ±16 mA at 2.5 V ±32 mA at 3.3 V	

1.3.7 I^2C Master Specification

Signal		Direction	Pin
	SCL	O	AFI0
	SDA	I/O	AFI1
Supported clock rate (programmable)	1.9 kHz -244.14 kHz; 488.28125 kHz / (n + 1); 1 ≤ n ≤ 255		

Transfer size of Data		0 - 4 Bytes		
Transfer size of Cmd/ Addr		0 - 4 Bytes		
Logic families (programmable)		1.8 V	2.5 V	3.3 V
Input Voltage	Min. V_{IH}	1.2 V	1.6 V	2.0 V
	Max. V_{IL}	0.63 V	0.7 V	0.8 V
Output Voltage	Min. V_{OH}	1.6 V	2.3 V	3.1 V
	Max. V_{OL}	0.2 V	0.2 V	0.2 V

1.3.8 SPI Master Specification

Signal			**Direction**	**Pin**
		SCK	O	AFI0
		SDO	O	AFI1
		SDI	I	AFI2
		CS_0	O	AFI3
Supported clock rate (programmable)		244.14 kHz -62.5 MHz, 62.5 MHz / (n + 1); 0 ≤ n ≤ 255		
Clock mode				
The first bit be transferred		MSB/ LSB (Default: MSB)		
Transfer size of Data		0 - 32 bits		
Transfer size of Cmd/ Addr		0 - 32 bits		
Dummy size		0 - 15 bits		
SPI Slave selection		CS_0		
Logic families (programmable)		1.8 V	2.5 V	3.3 V
Input Voltage	Min. V_{IH}	1.2 V	1.6 V	2 V
	Max. V_{IL}	0.63 V	0.7 V	0.8 V
Output Voltage	Min. V_{OH}	1.6 V	2.3 V	3.1 V
	Max. V_{OL}	0.2 V	0.2 V	0.2 V

1.4 Software Support

ADLINK provides versatile software drivers and packages for users' different approach to building up a system. ADLINK not only provides programming libraries such as DLL for most Windows based systems, but also provide drivers for other software packages such as LabVIEW®.

All software options are included in the ADLINK CD. Non-free software drivers are protected with licensing codes. Without the software code, you can install and run the demo version for two hours for trial/demonstration purposes. Please contact ADLINK dealers to purchase the formal license.

DAQPilot

DAQPilot is ADLINK's proprietary task-oriented software development kit (SDK), supporting ActiveX Controls/.NET Assembly, Express VI and Polymorphic VI for LabVIEW and DAQ Toolbox for MATLAB.

You can download and install DAQPilot at:

http://www.adlinktech.com/TM/DAQPilot.html

Please note that only DAQPilot versions 2.6.1.0705 and later support the PCIe-7360.

PCIS-DASK

PCIS-DASK comprises advanced 32/64-bit kernel drivers for customized DAQ application development, enabling detailed operations and superior performance and reliability from the data acquisition system. DASK kernel drivers now support Windows 8/7/XP OS.

Please note that only PCIS-DASK versions 5.10 and later support the PCIe-7360 module.

1.5 Schematics, I/O and Indicators

NOTE:

All dimensions shown are in mm

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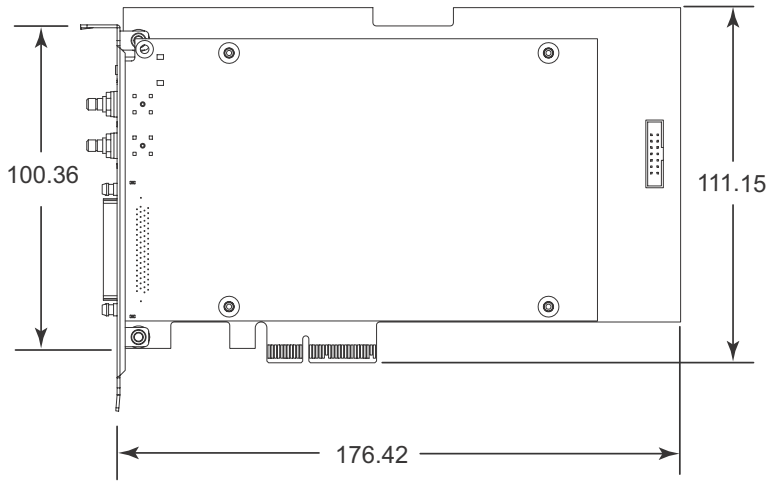

Figure 1-3: PCIe-7360 Schematic Diagram

1.6 Connectors

The PCIe-7360 card is equipped with one 68-pin SCSI-VHDCI connector for high-speed digital I/O and programmable function

I/O, and two SMB connectors for sample clock input and output, as labeled on the faceplate.

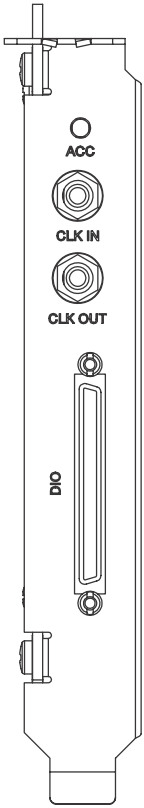

Figure 1-4: PCIe-7360 Connectors

ID	Pin	Pin	ID
GND	68	34	GND
(DI CLK) AFI7	67	33	AFI6 (DO CLK)
GND	66	32	GND
D0	65	31	D1
AFI5	64	30	AFI4
D2	63	29	D3
GND	62	28	GND
D4	61	27	D5
AFI3	60	26	AFI2
D6	59	25	D7
GND	58	24	GND
D8	57	23	D9
GND	56	22	GND
D10	55	21	D11
GND	54	20	GND
D12	53	19	D13
AFI1	52	18	GND
D14	51	17	D15
GND	50	16	GND
D16	49	15	D17
GND	48	14	GND
D18	47	13	D19
GND	46	12	GND
D20	45	11	D21
GND	44	10	GND
D22	43	9	D23
GND	42	8	AFI0
D24	41	7	D25
GND	40	6	GND
D26	39	5	D27
GND	38	4	GND

ID	Pin	Pin	ID
D28	37	3	D29
GND	36	2	GND
D30	35	1	D31

Table 1-1: PCIe-7360 SCSI-VHDCI 68-pin Assignment

Pin	Signal	Signal Type	Direction	Description
25, 27, 29, 31, 59, 61, 63, 65	D0 – D7	Data	I/O	Port_A bi-directional digital data lines
17, 19, 21, 23, 51, 53, 55, 57	D8 – D15	Data	I/O	Port_B bi-directional digital data lines
9, 11, 13, 15, 43, 45, 47, 49	D16 – D23	Data	I/O	Port_C bi-directional digital data lines
1, 3, 5, 7, 35, 37, 39, 41	D24 – D31	Data	I/O	Port_D bi-directional digital data lines
8, 26, 30, 52, 60, 64	AFI0 – AFI5	Control /Data	I/O	Application Function I/O, can be configured as: ▶ I^2C/ SPI ▶ Handshake signal ▶ External trigger in/out ▶ Event out

Pin	Signal	Signal Type	Direction	Description
33	AFI6	Control /Data	I/O	Application Function I/O, can be configured as: ▶ Handshake signal ▶ External trigger in/out ▶ Event out ▶ DO sampled clock in/out
67	AFI7	Control /Data	I/O	Application Function I/O, can be configured as: ▶ Handshake signal ▶ External trigger in/out ▶ Event out ▶ DI sampled clock in/out
2, 4,6, 10, 12, 14, 16, 18,20, 22, 24, 28, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 54, 56, 58, 62, 66, 68	GND	Ground	N/A	Ground reference for Data I/O and AFI I/O

Table 1-2: Signal Descriptions for SCSI-VHDCI and SMB Connectors

Signal	Signal Type	Direction	Description
CLK IN	Clock	I	External clock input for DI/DO sampled clock from external device to the PCIe-7360
CLK OUT	Clock	O	DI/DO sampled clock exporting from the PCIe-7360 to an external device

Table 1-3: SMB Jack Connector Signal Description

1.7 LED indicator

The LED on the faceplate indicates I2C & SPI communication and digital I/O status of the PCIe-7360.

LED	Color	Mode
ACC (Access)	Red	DI DMA operation
	Green	DO DMA operation
	Amber	DI & DO DMA operation

Table 1-4: LED indicator

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2 Getting Started

2.1 Unpacking Checklist

Before unpacking, check the shipping carton for any damage. If the shipping carton and/or contents are damaged, inform your dealer immediately. Retain the shipping carton and packing materials for inspection. Obtain authorization from your dealer before returning any product to ADLINK. Check if the following items are included in the package.

- PCIe-7360 high-speed DIO card
- ADLINK All-in-One CD
- Quick Start Guide

If any of the items is damaged or missing, contact your dealer immediately.

The card must be protected from static discharge and physical shock. Never remove any of the socketed parts except at a static-free workstation. Use the anti-static bag shipped with the product to handle the card. Wear a grounded wrist strap when servicing.

2.2 Installing the Card

Install the card driver before you install the card into your computer system. See “Software Support” on page 11. for driver support information.

To install the card:

1. Turn off the system/chassis and disconnect the power plug from the power source.
2. Remove the system/chassis cover.
3. Select the PCI Express slot that you intend to use, then remove the bracket opposite the slot, if any.
4. Align the card connectors (golden fingers) with the slot, then press the card firmly until the card is completely seated on the slot.

5. Secure the card to the chassis with a screw.
6. Replace the system/chassis cover.
7. Connect the power plug to a power source, then turn on the system.

Configuration

All PCI/PCI Express cards on your system are configured individually. Because configuration is controlled by the system and the software, no jumper setting is required for base address, DMA, and interrupt IRQ. Configuration is subject to change with every boot of the system as new PCI/PCI Express® cards are added or removed.

Troubleshooting

If your system fails to boot or if you experience erratic operation with your PCI/PCI Express card in place, an interrupt conflict may have been generated (such as when the BIOS Setup is incorrectly configured). Refer to the system's BIOS documentation for details.

2.3 Selecting Cables and Termination Board

Since the PCIe-7360 is a high-speed digital I/O card, impedance matching is important in eliminating signal reflection generated by cabling or PCB trace. The following recommended cables and termination board can improve signal quality during high-speed signal transfer.

DIN-68H – Termination board with one 68-pin SCSI-VHDCI connector and user selectable impedance. See "ADLINK DIN-68H" on page 77. for more information.

ACL-10279 – 68-pin SCSI-VHDCI cable with 50Ω impedance

SMB-SMB-1M – SMB to SMB cable, 1 M, for sample clock in/out

SMB-BNC-1M – SMB to BNC cable, 1 M, for sample clock in/out

3 Operations

The PCIe-7360 provides functions including high-speed digital pattern acquisition, digital pattern generation, application function I/O, and others.

3.1 Block Diagram

The PCIe-7360 provides 32-channel bi-directional high-speed digital I/O lines, 8-channel AFI (Application Function I/O) lines, and two sample clock input/output channels. All 32-channel high-speed digital I/O lines are connected to the level shifter and can be programmed as 1.8 V, 2.5 V, or 3.3 V (5 V compatible) logic levels. These channels can also be programmed as input channels for digital pattern acquisition or output channels for digital pattern generation.

8-channel application function I/O lines are also connected to the level shifter. These application function I/Os can be programmed as I2C or SPI serial interface, handshake interface, external digital trigger input, event output and external clock input/output with 1.8 V or 2.5 V or 3.3 V (5 compatible) logic levels by direction and logic level control of level shifter and by AFI controller implemented in FPGA.

The digital pattern acquisition/generation and corresponding flexible sample timing are controlled by ADLINK's Smart Control Engine implemented by FPGA, as shown

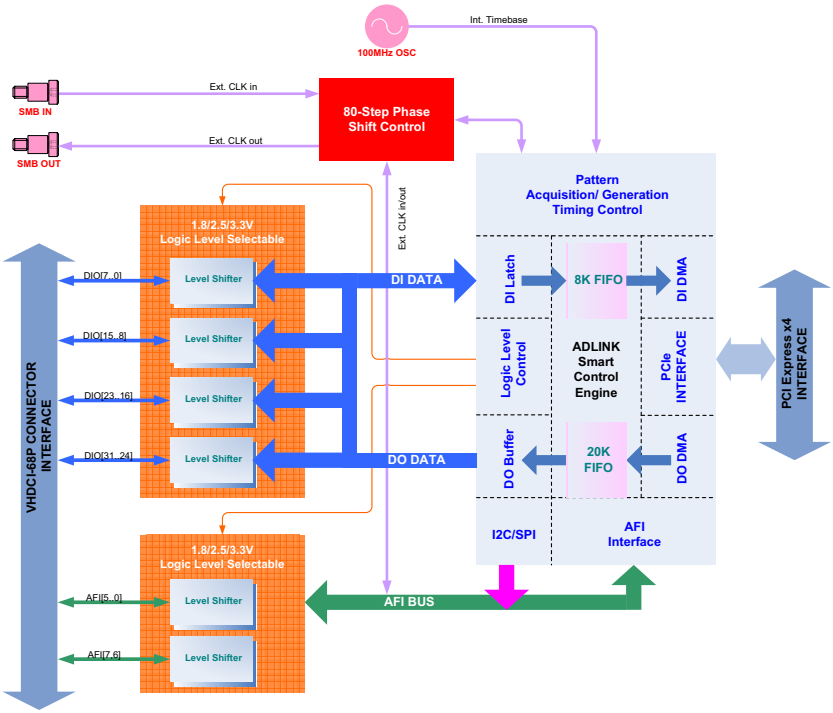


Figure 3-1: PCIe-7360 Block Diagram

3.2 Programmable Logic Level

To interface different logic level applications, the PCIe-7360 supports three software selectable logic levels of 1.8 V, 2.5 V, or 3.3 V (5 V compatible) for all digital I/O lines, sample clocks, I^2C, SPI, triggers, and events. All I/O lines conform to the selected logic

level. When connecting PCIe-7360 to a device under test (DUT), interface voltage levels must be compatible, as follows.

- V_{IH}: The digital input voltage at logic high; senses a binary one (1)
- V_{IL}: The digital input voltage at logic low; senses a binary zero (0)
- V_{OH}: The digital output voltage at logic high; generates a binary one (1)
- V_{OL}: The digital output voltage at logic low; generates a binary zero (0)

Logic Levels		1.8 V	2.5 V	3.3 V (5 V compatible)
Digital Input	Min. VIH	1.2 V	1.6 V	2 V
	Max. VIL	0.63 V	0.7 V	0.8 V
Digital Output	Min. VOH	1.6 V	2.3 V	3.1 V
	Max. VOL	0.2 V	0.2 V	0.2 V

Table 3-1: Logic Levels

3.3 Digital I/O Configuration

32-channel high-speed digital I/O lines are bi-directional and divided into four groups. Each group contains 8 channels and can be configured as input port or output port individually. At power-up, all I/O lines are preset to input ports. When configuring to digital output mode, the initial status of digital outputs are in tri-state. Possible configuration modes are as follows:

Port	Channel	Power-up status	Direction
Port A	D0 to D7	Input	Input or output
Port B	D8 to D15	Input	Input or output
Port C	D16 to D23	Input	Input or output
Port D	D24 to D31	Input	Input or output

DI Raw Data Mapping

For digital pattern acquisition, the data width can be configured to 8-bit, 16-bit, 24-bit, or 32-bit and the data transfer is based on 32-bit data width. Below is the mapping table for different DI port combination.

Data Width	Input Ports				raw data Mapping
8 bits	D	C	B	**A**	See Figure 3-2
	D	C	**B**	A	
	D	**C**	B	A	
	D	C	B	A	
16 bits	D	C	**B**	**A**	See Figure 3-3
	D	**C**	B	**A**	
	D	C	B	**A**	
	D	**C**	**B**	A	
	D	C	**B**	A	
	D	**C**	B	A	
24 bits	D	**C**	**B**	**A**	See Figure 3-4
	D	C	**B**	**A**	
	D	**C**	B	**A**	
	D	**C**	**B**	A	
32 bits	**D**	**C**	**B**	**A**	See Figure 3-5

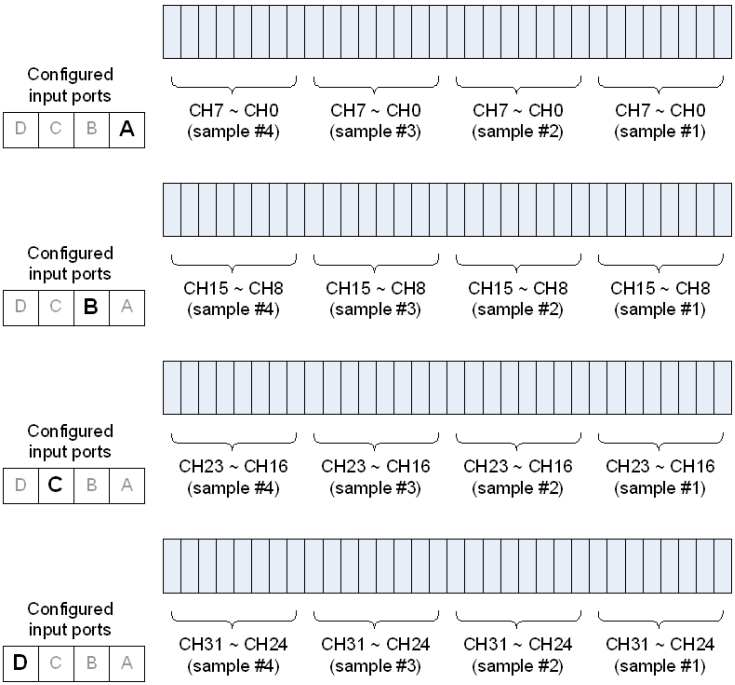


Figure 3-2: DI Raw Data Mapping for 8-Bit Data Width

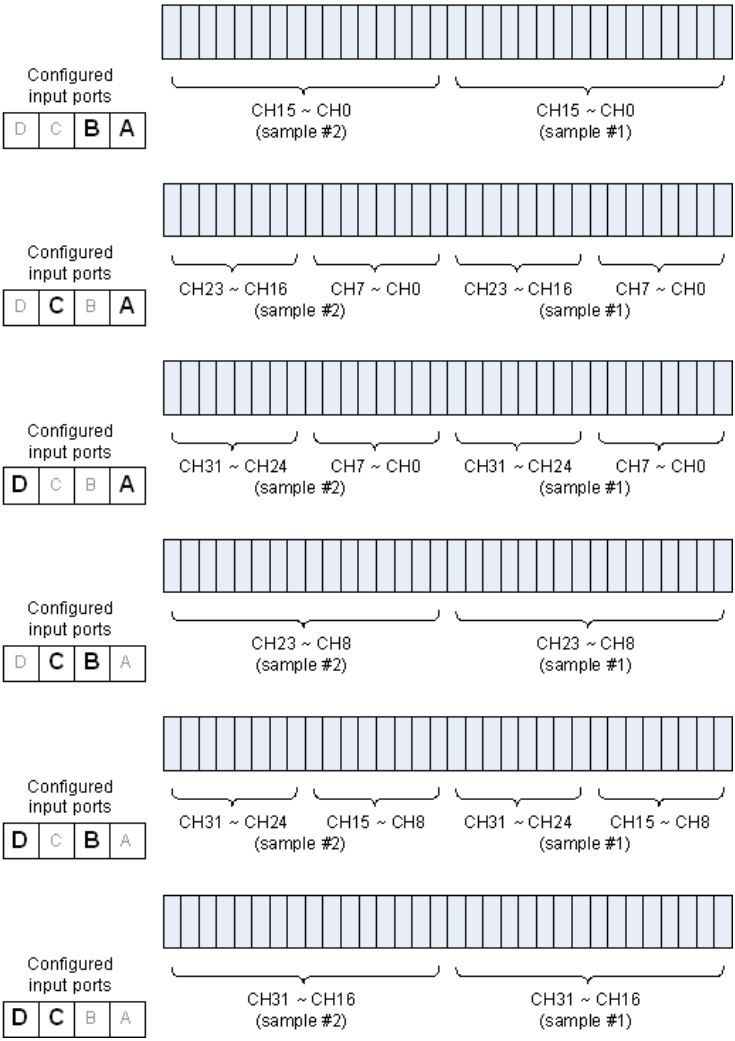


Figure 3-3: DI raw data Mapping for 16-Bit Data Width

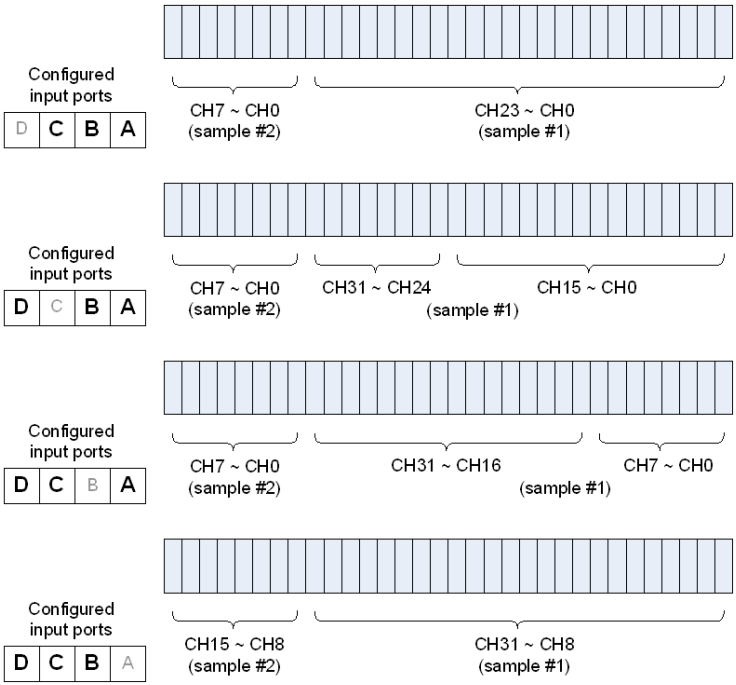


Figure 3-4: DI raw data Mapping for 24-Bit Data Width

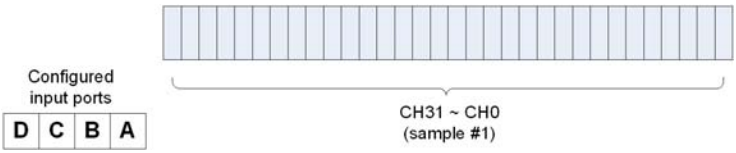


Figure 3-5: DI raw data Mapping for 32-Bit Data Width

3.4 Sample Clock Phase Shift

PCIe-7360 features phase shift of sample clock (on SMB connector or AFI6 & AFI7 of SCSI-VHDCI connector). The sample clock can be from external DUT or can be the exporting clock generated from internal time base. The resolution of phase shift is 80 step, implemented by Phase-Locked Loop (PLL) function of FPGA. In

other words, the phase shift of sample clock is 4.5° x N, where N is any integer from 1 to 80. Furthermore, in phase shifting mode, the supported clock frequency is from 20 to 100 MHz. This function can optimize the timing of digital pattern acquisition or generation to avoid sampling/exporting the data from/to DUT at transition state. Therefore, for digital input, the data can be sampled in clean and valid timing instead of transition timing. For digital output, it can fine tune the exporting clock to avoid the sampling of DUT at setup time or hold time instead of aligning the data.

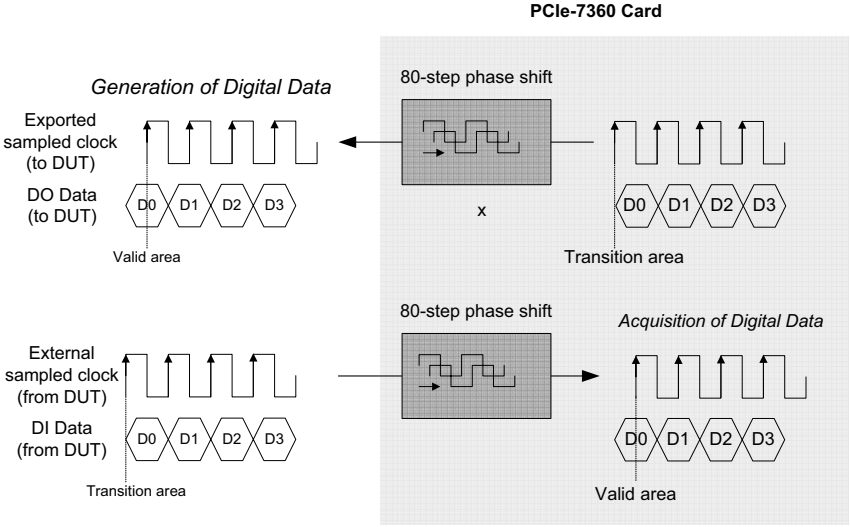


Figure 3-6: Phase Shift of Sample Clock

	Value
Revolution	80 steps (1 step = 4.5°)
Supported Frequency Range	20 MHz to 100MHz
Supported CLK	User can shift the clock phase ofthe following clock: External DI sample clock (from SMB CLK IN or AFI7) External DO sample clock (from SMB CLK IN or AFI6) Exported DI sample clock (from SMB CLK IN or AFI7) Exported DO sample clock (from SMB CLK IN or AFI6)

3.5 Bus-mastering DMA Data Transfer

Digital I/O data transfer between PCIe-7360 and PC's system memory is through bus mastering DMA, which is controlled by PCIe IP Core.

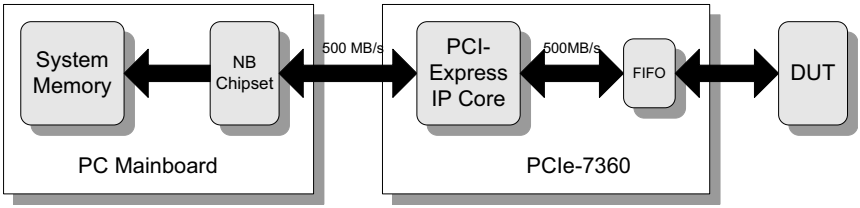


Figure 3-7: Maximum Data Throughput

The bus-mastering controller controls the PCI/PCIe bus when it becomes the master of the bus. Bus mastering reduces the size of the on-board memory and reduces the CPU loading because data is directly transferred to the computer's memory without host CPU intervention.

Bus-mastering DMA provides the fastest data transfer rate on the PCI/PCIe bus. Once the analog/digital input operation starts, control is returned to the program. The hardware temporarily stores the acquired data in the onboard Data FIFO and then transfers the data to a user-defined DMA buffer memory in the computer. Please note that even when the acquired data length is less than the Data FIFO, the data will not be kept in the Data FIFO but directly transferred into host memory by the bus-mastering DMA.

due to the complexity of programming DMA transfer mode, It is recommended that a high-level program library provided by our driver be used to configure this card, a number needs only to be assigned to the sampling period and the number of conversion into the specified counters. After the trigger condition is matched, the data is transferred to the system memory by the bus-mastering DMA.

The PCI/PCIe controller also supports scatter/gather bus mastering DMA, enabling transfer of large amounts of data by linking all the memory blocks into a continuous linked list.

In a multi-user or multi-tasking OS, like Microsoft Windows, or Linux, it is difficult to allocate a large continuous memory block to DMA transfer. Therefore, the PCI/PCIe controller enables scatter-gather or chaining mode DMA to link the non-continuous memory blocks into a linked list avoiding fragments of small size memory limiting transfer. Users can configure the linked list for the input DMA channel or the output DMA channel.

As shown in a linked list constructed by three DMA descriptors, each descriptor contains a PCI/PCIe address, PCI/PCIe dual address, a transfer size, and the pointer to the next descriptor. PCI/PCIe address and PCI/PCIe dual address support 64-bit addresses which can be mapped into more than 4GB of the address space. Many small size memory blocks can be allocated and their associative DMA descriptors chained together by their application programs. The software driver provides simple settings of the scatter-gather function, and some sample programs are also provided within the ADLINK all-in-one CD.

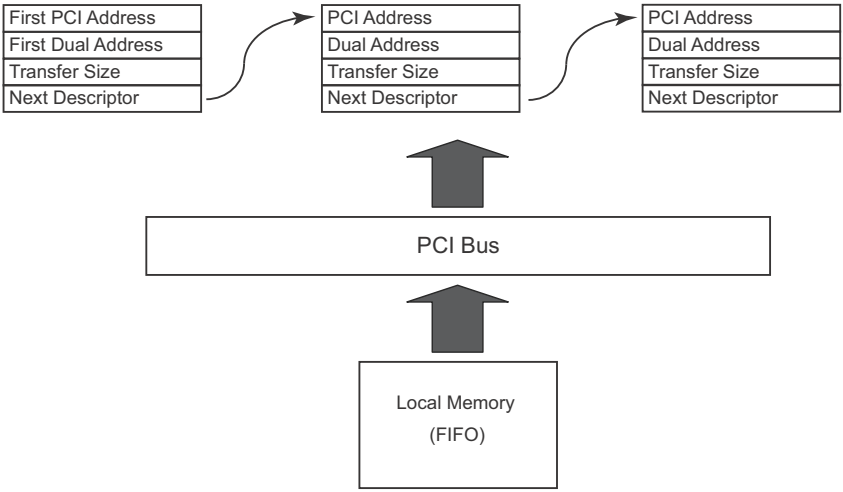


Figure 3-8: Scatter-Gather DMA for Data Transfer

Choose Finite or Continuous Operation

Data can be transferred continuously to or from computer memory (continuous operation), or you can specify the number of samples you want to transfer (one-shot operation). In either case, the PCIe-7360 transfers the data using direct memory access (DMA) without occupying CPU resources.

3.6 Sample Clock

The sample clock controls the data rate of digital pattern acquisition and generation. For PCIe-7360, the sample clock can be configured from internal timer pacer or external clock through the SMB connectors or SCSI-VHDCI connector.

Digital Input (DI) Sample Clock

For the operation of digital pattern acquisition in continuous mode or burst handshake mode, the PCIe-7360 card can acquire digital data from external devices at a specific sampling rate (DI sample

clock). DI sample clock can be selected as the following two clock sources:

- Internal DI sample clock – the PCIe-7360 can internally generate the sample clock signal for digital data acquisition. With an internal base clock source of 100 MHz, the PCIe-7360 can generate any clock frequency of 100 MHz/n, where n is any integer from 1 to 65535.
- External DI sample clock – the PCIe-7360 can receive external clock signal from AFI7 or SMB CLK as the DI sample clock for synchronization applications. The external DI sample clock supports up to 100MHz @ 8/16/24/32-CH (8/16/24/32-bit data width) or up to 200MHz @ 8/16-CH (8/16-bit data width).

In addition, the PCIe-7360 can also export internal DI sample clock to external devices through AFI7 pin or SMB CLK connector.

Digital Output (DO) Sample Clock

For the operation of digital pattern generation in continuous mode or burst handshake mode, PCIe-7360 card can generate digital data to external devices at a specific update rate (DO sample clock). DO sample clock can be selected as the following two clock sources:

- Internal DO sample clock – the PCIe-7360 can internally generate the sample clock signal for digital data generation. With an internal clock source of 100MHz, the PCIe-7360 can generate any clock frequency of 100 MHz/n, where n is any integer from 1 to 65535.
- External DO sample clock – the PCIe-7360 can receive an external sample clock signal from AFI6 or SMB CLK connector as the DO sample clock for synchronization applications.

In addition, the PCIe-7360 can also export internal DO sample clock to external devices through AFI6 pin or SMB CLK connector. DI/DO sample clock architecture of PCIe-7360 is as follows.

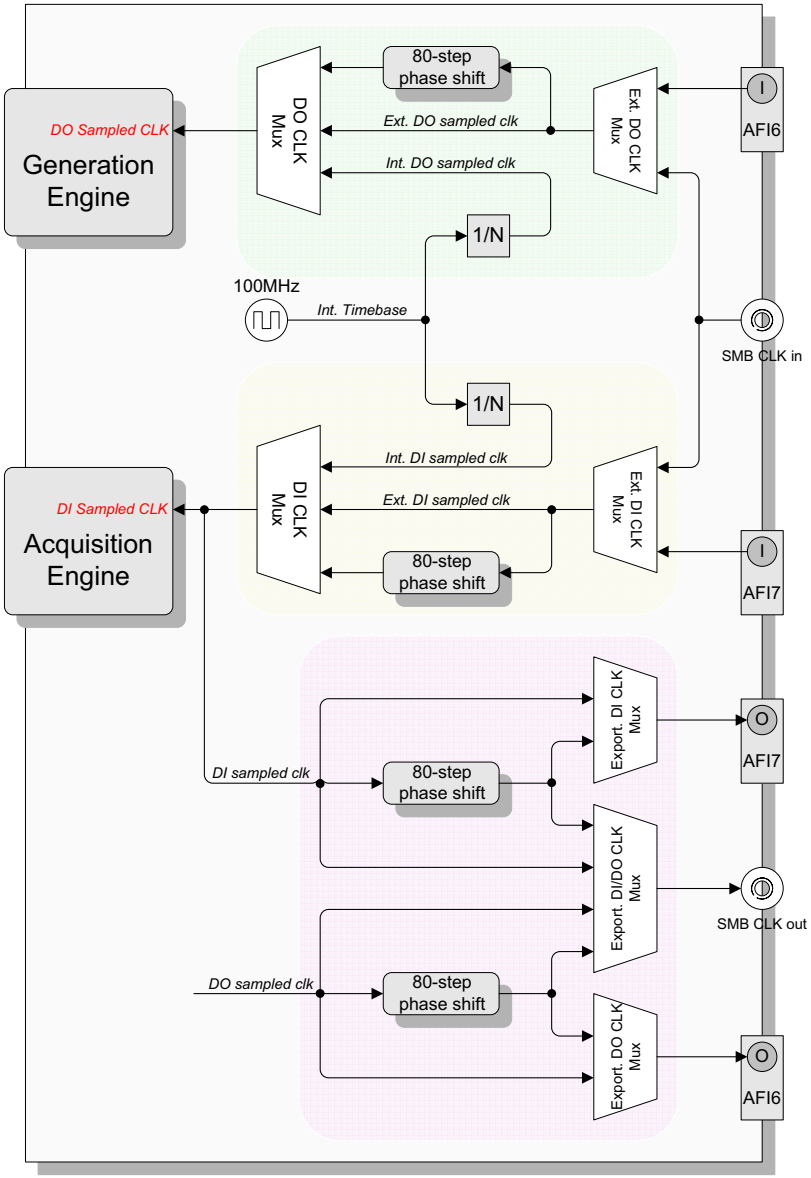


Figure 3-9: DI/DO Sample Clock Architecture

		DI Sample CLK	DO Sample CLK
Internal clock	Source	Onboard 100 MHz oscillator	Onboard 100 MHz oscillator
	Freq.	100 MHz/n (n = 1 to 65535)	100 MHz/n (n = 1 to 65535)
External clock	Source	AFI7 SMB CLK in	AFI6 SMB CLK in
	Freq.	0-100MHz @ 8/16/24/32-CH 0-200MHz @ 8/16-CH	0-100MHz @ 8/16/24/32-CH
	Freq. (phase shift)	20 to 100 MHz	20 to 100 MHz
Sample clock exporting	Destination	AFI7 SMB CLK out	AFI6 SMB CLK out
	Freq.	0 – 100 MHz	0 – 100 MHz
	Freq. (phase shift)	20 to 100 MHz	20 to 100 MHz

Table 3-2: DI/DO Sample Clock Configuration

3.7 Operating Modes

The PCIe-7360 supports four different modes for acquisition and generation operation, including software polling, continuous, handshake, and burst handshake mode..

Polling Mode (Single Read/Write)

The PCIe-7360 supports a software polling mode to read or write a single chunk of data via a software command. That is, the 32-bit high-speed I/O lines can be used as a static I/O. The data width can be 8-bit, 16-bit, 24bit, or 32-bit.

DI DMA in Continuous Mode

For the DI pattern acquisition operation in continuous mode, PCIe-7360 card can acquire input data from external devices at a specific sampling clock rate (DI sampled clock). DI sample clock

can be selected from internal or external clock source. The operation sequences are listed as follows:

Steps:

- Define DI port configuration (32/24/16/8-bits data width)
- Define DI logic level configuration (3.3/2.5/1.8 V)
- Define DI sample clock configuration (internal/external)
  - If choose internal sampled clock, you can define sampling clock rate to be 100MHz/n (n = 1 to 65535)
  - If choose external sampled clock, the phase shift function is available when external clock is a free-running clock (not a strobe signal) and external clock rate is from 20 to 100 MHz.
- Define DI starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DI-Start) from AFI0 to AFI7.
- Define DI data count
- Execute DI DMA Read Command (continuous mode)

Operating architecture of DI DMA in continuous mode is as shown.

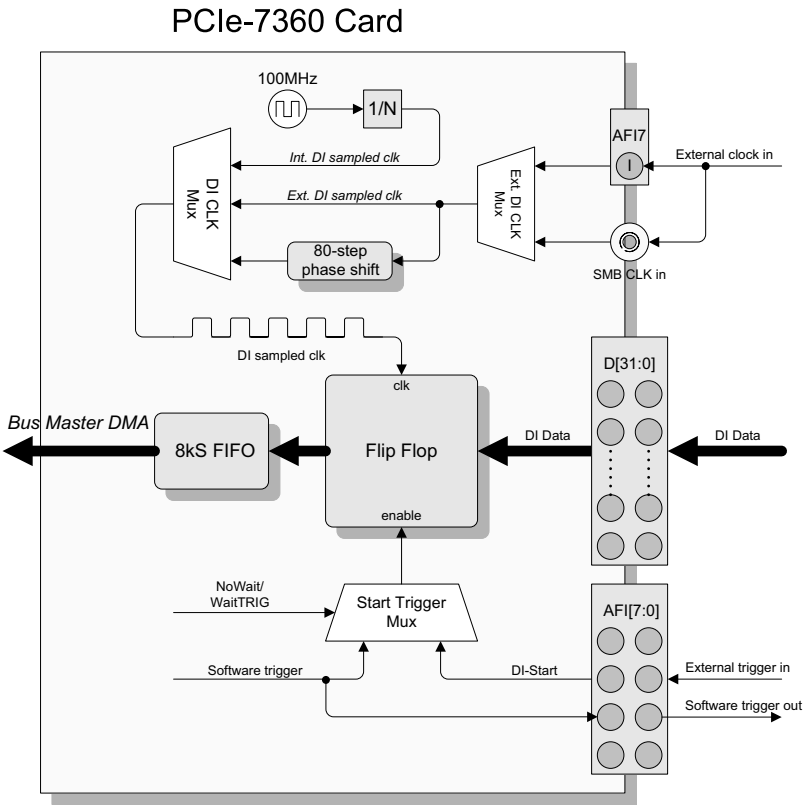
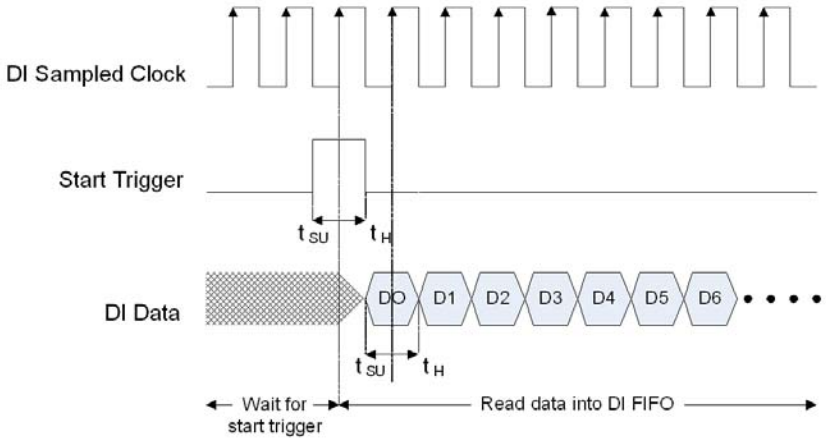


Figure 3-10: DI Continuous Mode Architecture

Timing of DI DMA in continuous mode is as shown.



t_{SU} = Maximum required setup time

t_H = Maximum required hold time

Figure 3-11: DI Timing Diagram

DO DMA in Continuous Mode

For the DO pattern generation operation in continuous mode, PCIe-7360 card can generate digital data to external devices at a specific update clock rate (DO sample clock). DO sample clock can be selected from internal or external clock source. The operation sequences are listed as follows:

Steps:

- Define DO port configuration (32/24/16/8-bits data width)
- Define DO logic level configuration (3.3/2.5/1.8 V)
- Define DO sample clock configuration (internal/external)
  - If choose internal sample clock, you can define sampling clock rate to be 100MHz/n (n = 1 to 65535)
  - If choose external sample clock, the phase shift function is available when external clock rate is 20 to 100 MHz.
- Define DO exporting sample clock configuration (AFI6/SMB CLK out)

- PCIe-7360 can also export DO sample clock to external devices. The destination of DO sample clock exporting can be AFI6 or SMB CLK out connector.
- The phase shift function is available when exported clock is a free-running clock and the clock rate is 20 to 100 MHz.

- Define DO starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DO-Start) from AFI0 to AFI7.
- Define DO data count.
- Execute DO DMA Write Command (continuous mode)

Operational architecture of DO DMA in continuous mode is as shown.

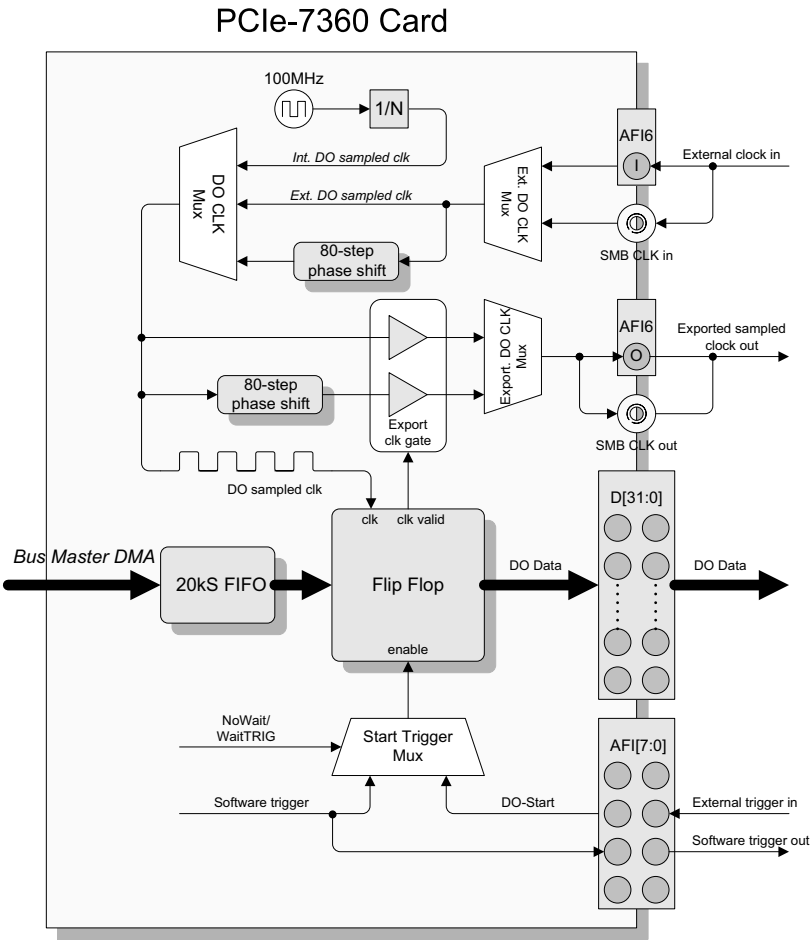
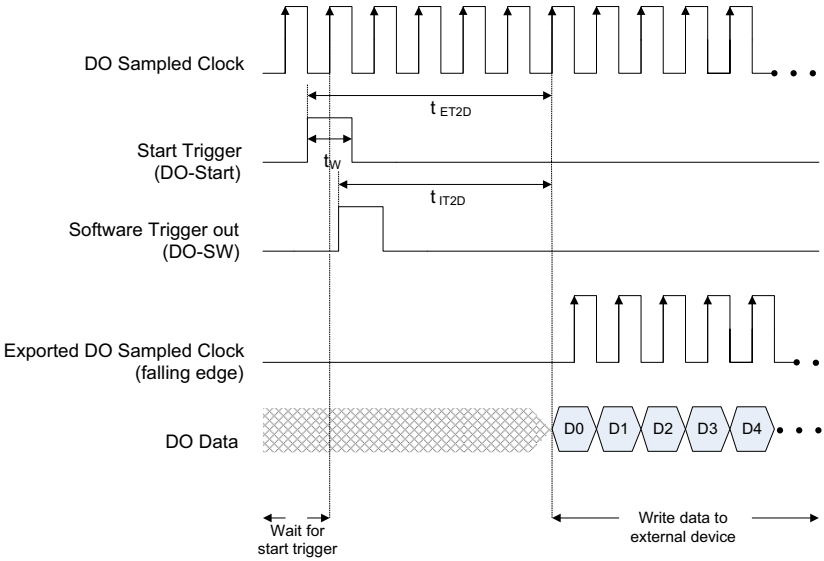


Figure 3-12: DO Continuous Mode Architecture

Timing of DO DMA in continuous mode is as shown.



t_W = Minimum detectable trigger width

t_{ET2D} = Delay from external trigger to do data out (about 5 cycle)

t_{IT2D} = Delay from software trigger out to do data out (about 4 cycle)

Figure 3-13: DO Timing Diagram

DI DMA in Handshake Mode

For the DI pattern acquisition operation in handshake mode, PCIe-7360 card can acquire input data from external devices by handshake data transfer through DI-REQ input signal and DI-ACK output signal of AFI interface. The operation sequences are listed as follows:

Step1: Configuration

- Define DI port configuration (32/24/16/8-bits data width)
- Define DI logic level configuration (3.3/2.5/1.8V)
- Define DI-REQ and DI-ACK signal (AFI0 to AFI7)
  - For example: if configure AFI3 as DI-REQ and AFI4 as DI-ACK, and then you must connect the handshake sig-

nal (DI-REQ and DI-ACK) of external device to the AFI3 and AFI4.

- Define DI starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DI-Start or DI-TRIG) from AFI0 to AFI7.
- Define DI data count

Step2: Execute DI DMA Read Command (handshake mode)

- After DI data is ready on device side, the peripheral device strobe data into the PCIe-7360 by asserting a DI-REQ signal. (action_1)
- The DI-REQ signal caused the PCIe-7360 to latch DI data and store it into DI FIFO. (action_2)
- The PCIe-7360 asserts a DI-ACK signal when it is ready for another input. (action_3)
  - The action_1 to action_3 is repeated in handshake mode.
- The DI data in the DI FIFO is transferred into system memory directly and automatically by bus mastering DMA.

The operating architecture of DI DMA in handshake mode is as shown.

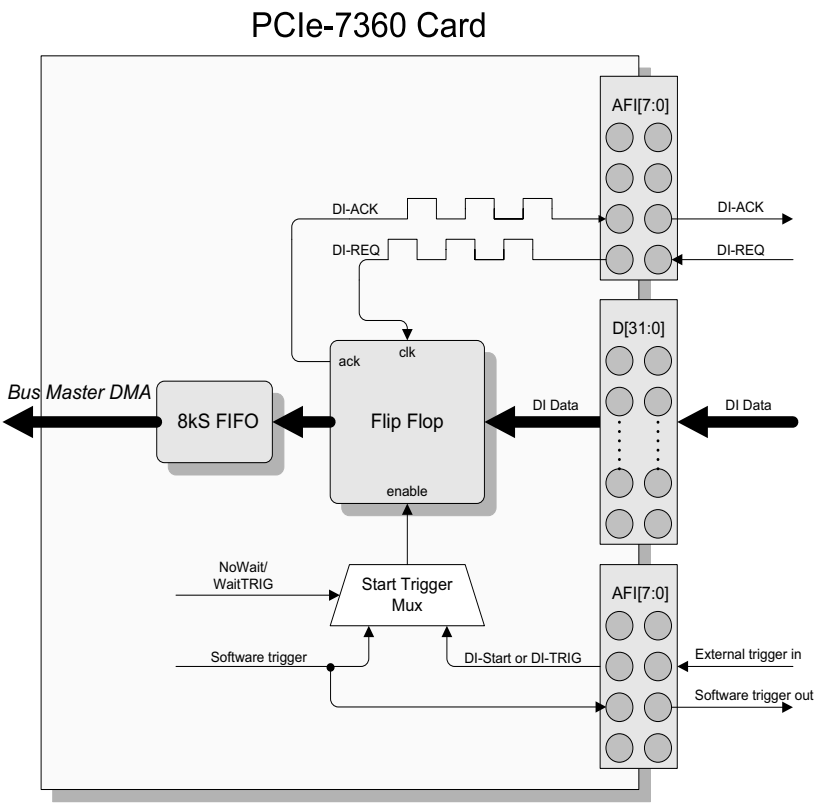
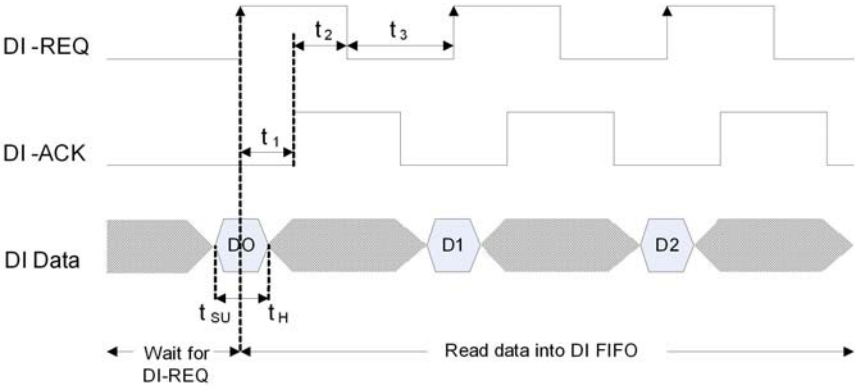


Figure 3-14: DI Handshake Mode Architecture

Timing of DI DMA in handshake mode is as shown.



t_{SU} = Maximum required setup time

t_H = Maximum required hold time

$t_1 \geq 20$ ns

$t_2 \geq 10$ ns

$t_3 \geq 50$ ns

Figure 3-15: DI Handshake Timing Diagram

DO DMA in Handshake Mode

For the DO pattern generation operation in handshake mode, PCIe-7360 card can generate output data to external devices by handshake data transfer through DO-REQ output signal and DO-ACK input signal of AFI interface. The operation sequences are listed as follows:

Step1: Configuration

- Define DO port configuration (32/24/16/8-bits data width)
- Define DO logic level configuration (3.3/2.5/1.8V)
- Define DO-REQ and DO-ACK signal (AFI0 to AFI7)
  - For example: if configure AFI3 as DO-REQ and AFI4 as DO-ACK, and then you must connect the handshake sig-

nal (DO-REQ and DO-ACK) of external device to the AFI3 and AFI4.

- Define DO starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DO-Start or DO-TRIG) from AFI0 to AFI7.
- Define DO write count

Step2: Execute DO DMA Write Command (handshake mode)

- The DO data saved in the system memory is transferred to DO FIFO directly and automatically by bus mastering DMA.
- After DO data are ready, DO-REQ signal is generated and DO data are sent to the external device. (action_1)
- After DO-ACK signal from external device is gotten (action_2)
  - The action_1 to action_2 is repeated in handshake mode.

The operating architecture of DO DMA in handshake mode is as shown.

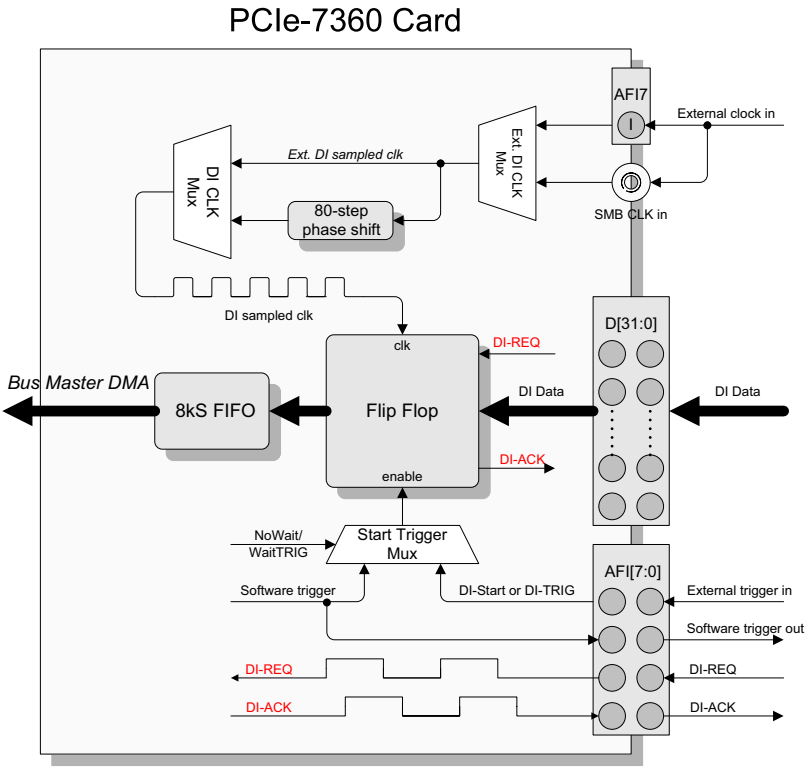
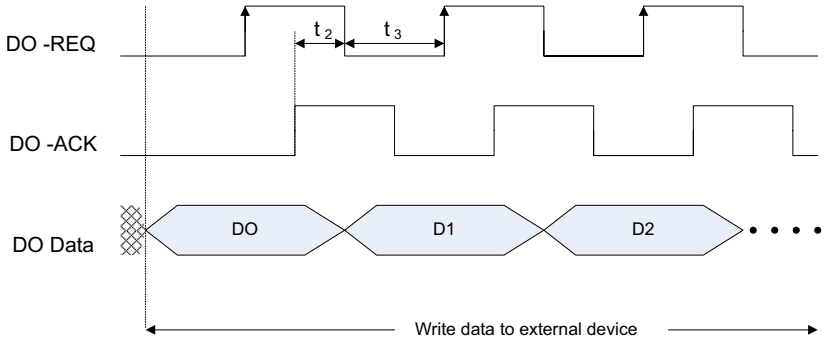


Figure 3-16: DO Handshake Mode Architecture

Timing of DO DMA in handshake mode is as shown.



$t_2 \geq 40$ ns

$t_3 \geq 50$ ns

Figure 3-17: DO Handshake Timing Diagram

DI DMA in Burst Handshake Mode

The burst handshake mode is a fast and reliable data transfer protocol. It has both advantage of handshake mode and continuous mode.

In DI burst handshake mode, DI-REQ signal is active by external device when it is ready to send DI data and sample clock. And then DI-ACK signal is generated by PCIe-7360 when it is ready to receive DI data from external device.

External device should start to send DI data after it detect DI-ACK signal is active. DI data transfer between PCIe-7360 and external device should be continued when both DI-REQ and DI-ACK are active. When DI FIFO of PCIe-7360 becomes almost full, DI-ACK signal is inactive. External device should stop to send DI data and sample clock after it detects DI-ACK signal inactive. The operation sequences are listed as follows:

Step1: Configuration

- Define DI port configuration (32/24/16/8-bits data width)
- Define DI logic level configuration (3.3/2.5/1.8 V)
- Define DI sample clock configuration (only external)
  - The phase shift function is available when external clock is a free-running clock (not a strobe signal) and external clock rate is from 20 to 100 MHz.
- Define DI-REQ and DI-ACK signal (AFI0 to AFI7)
  - For example: if configure AFI3 as DI-REQ and AFI4 as DI-ACK, and then you must connect the handshake signal (DI-REQ and DI-ACK) of external device to the AFI3 and AFI4.
- Define DI starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DI-Start or DI-TRIG) from AFI0 to AFI7.
- Define DI data count

Step2: Execute DI DMA Read Command (burst handshake mode)

- PCIe-7360 will generate DI-ACK signal when it is ready to receive DI data after DI-REQ signal is active.
- External device starts to send DI data and DI sample clock after DI-ACK signal is active.
- PCIe-7360 starts to receive DI data and DI sample clock from external device when DI-REQ and DI-ACK are all active.
- The DI data in the DI FIFO is transferred into system memory directly and automatically by bus mastering DMA.

The operating architecture of DI DMA in burst handshake mode is as shown.

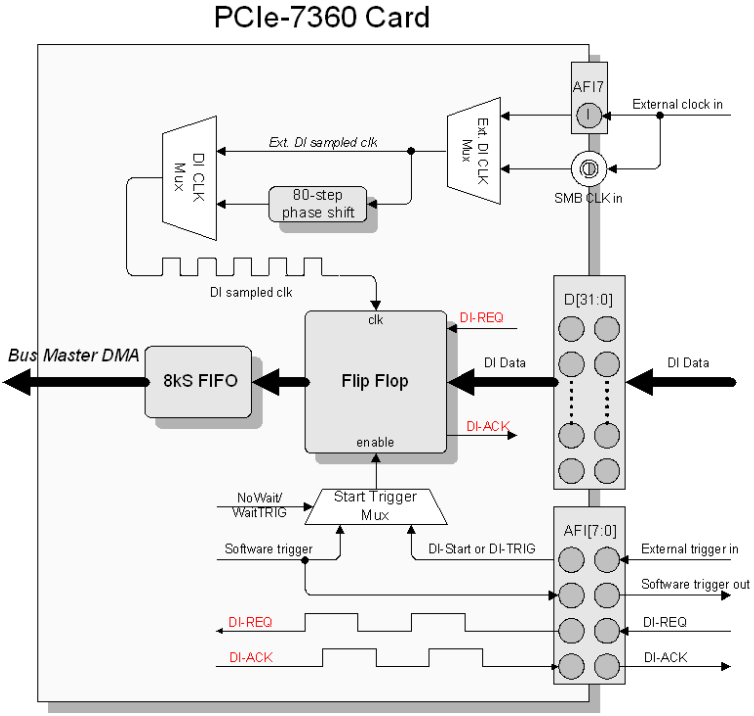


Figure 3-18: DI Burst Handshake Mode Architecture

Timing of DI DMA in burst handshake mode is as shown.

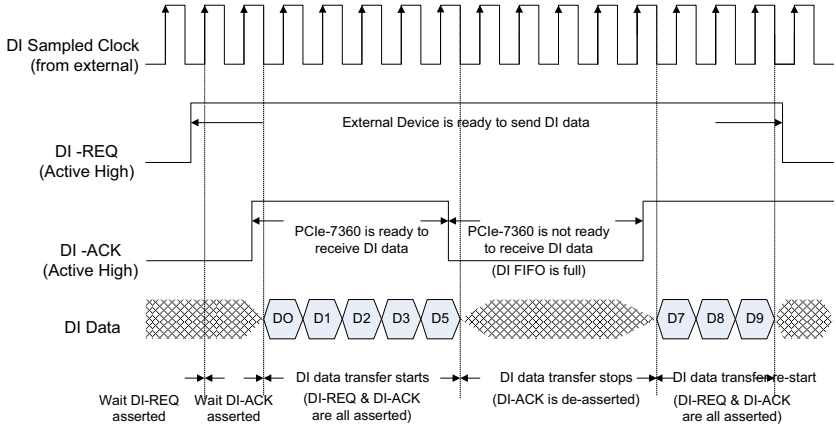


Figure 3-19: DI Burst Handshake Timing Diagram

DO DMA in Burst Handshake Mode

In DO burst handshake mode, DO-REQ signal is active by PCIe-7360 when it is ready to send out DO data. And then DO-ACK signal should be generated by external device when it is ready to receive DO data. Once DO-ACK is active, external device has to keep DO-ACK active until its input buffer is almost full. The operation sequences are listed as follows:

Step1: Configuration

- Define DO port configuration (32/24/16/8-bits data width)
- Define DO logic level configuration (3.3/2.5/1.8 V)
- Define DO sample clock configuration (internal/external)
  - If choose internal sampled clock, you can define sampling clock rate to be 100 MHz/n (n = 1 to 65535)
  - If choose external sampled clock, the phase shift function is available when external clock rate is from 20 to 100 MHz.
- Define DO exporting sample clock configuration (AFI6/SMB CLK out)

- The PCIe-7360 can also export DO sampled clock to external devices. The destination of the exported DO sampled clock can be AFI6 or SMB CLK out connector.
- The phase shift function is available when exported clock rate is from 20 to 100 MHz.

- Define DO-REQ and DO-ACK signal (AFI0 - AFI7)
  - For example: if configure AFI3 as DO-REQ and AFI4 as DO-ACK, and then you must connect the handshake signal (DO-REQ and DO-ACK) of external device to the AFI3 and AFI4.
- Define DO starting mode configuration (NoWait or WaitTRIG)
  - If choose WaitTRIG, you can define start trigger source to be software trigger or external trigger (DO-Start or DO-TRIG) from AFI0 - AFI7.
- Define DO data count

Step2: Execute DO DMA Write Command (burst handshake mode)

- The DO data saved in the system memory is transferred to DO FIFO directly and automatically by bus mastering DMA.
- After DO data are ready, DO-REQ signal is asserted.
- PCIe-7360 start to send DO data and DO sampled clock to external device after DO-ACK signal is asserted.
- If input buffer of external device has no much space for new DO data, DO-ACK signal is inactive and PCIe-7360 is only allowed to send 4 more data to the receiver.
- If DO data are not ready (DO FIFO is empty), DO-REQ signal is inactive and PCIe-7360 stops to send DO data and DO sample clock until DO data are ready again.

The operating architecture of DO DMA in burst handshake mode is as shown.

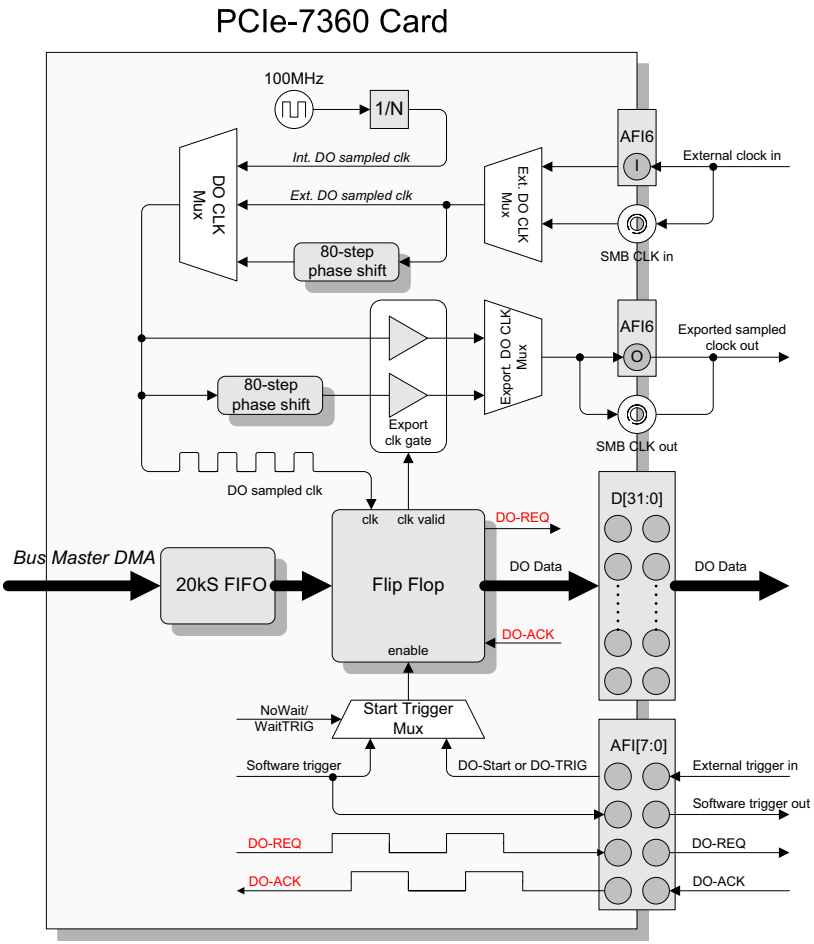


Figure 3-20: DO Burst Handshake Mode Architecture

Timing of DO DMA in burst handshake mode is as shown.

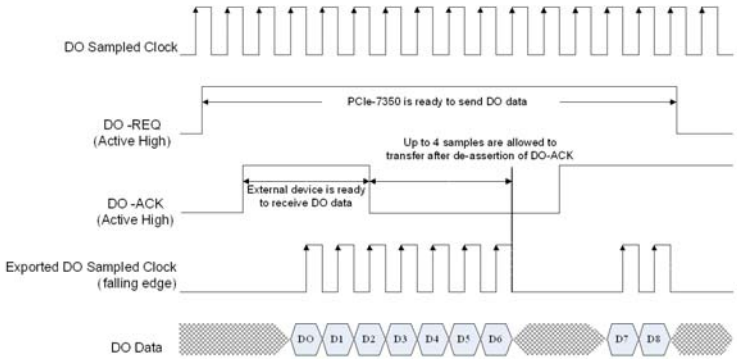


Figure 3-21: DO Burst Handshake Timing Diagram

DO DMA in Burst Handshake Mode 2

DO burst handshake mode 2 improves tolerance in burst handshaking applications with large wire delay. In this mode, the PCIe-7360 confirms availability of the receiver indicated by the DO-ACK signal before it starts to send data. Once the DO-ACK is asserted, the external device (receiver) maintains assertion of the DO-ACK signal before its input buffer becomes too small. When the DO-ACK is de-asserted, indicating the receiver's buffer is low on space for new data, the PCIe-7360 is still allowed to send 4 data to the receiver, and the receiver has to receive the data. Timing of burst handshake mode 2 is as shown.

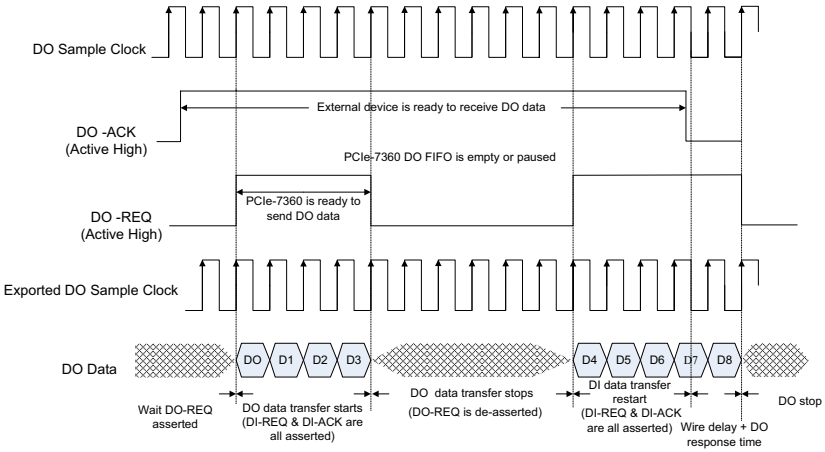


Figure 3-22: DO Burst Handshake 2 Timing Diagram

3.8 Trigger Source and Trigger Mode

The PCIe-7360 supports 2 trigger sources, software command trigger and external digital trigger, to start or pause the DI or DO operation. In addition, the PCIe-7360 supports 3 trigger modes, including post trigger, gated trigger, and post trigger with re-trigger. In post trigger mode and post trigger with re-trigger mode, the polarity of digital trigger signal can be configured to rising edge or falling edge. In gated trigger mode, the level of trigger signal will start or pause the operation of digital pattern acquisition or generation. Below are the examples of these trigger conditions.

[Example 1] External digital trigger with post trigger mode

DI data Count: 8 samples

Trigger Event: DI-Start (rising edge)

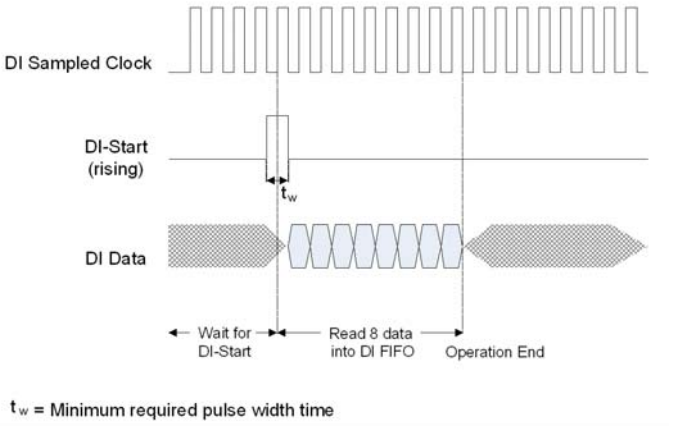


Figure 3-23: DI Post Trigger

[Example 2] External digital trigger with post trigger

DO data Count: 8 samples

Trigger Event: DO-Start (rising edge)

Re-Trigger Count: 3

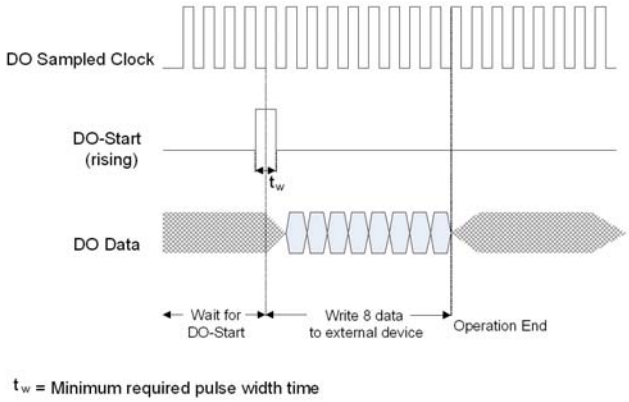


Figure 3-24: DO Post Trigger

[Example 3] External digital trigger with post trigger and re-trigger

DI data Count: 4 samples per trigger

Trigger Event: DI-Start (rising edge)

Re-Trigger Count: 3

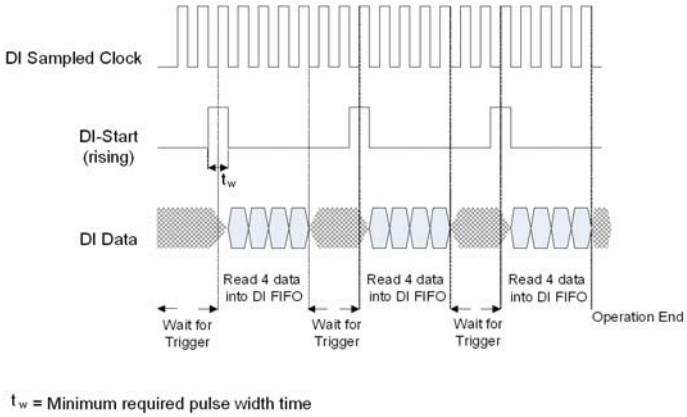


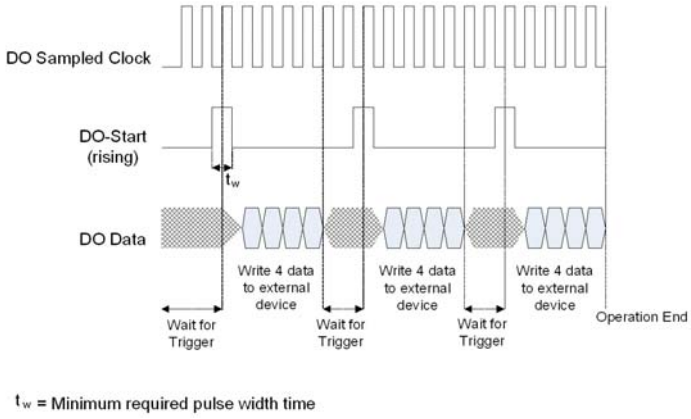
Figure 3-25: DI Post Trigger with Re-trigger

[Example 4] External digital trigger with post trigger and re-trigger

DO data Count: 4 samples per trigger

Trigger Event: DO-Start (rising edge)

Re-Trigger Count: 3



t_w = Minimum required pulse width time

Figure 3-26: DO Post Trigger with Re-Trigger

[Example 5] External digital trigger with gated trigger

DI data Count: 12 samples

Trigger Event: DI-Pause (logic high)

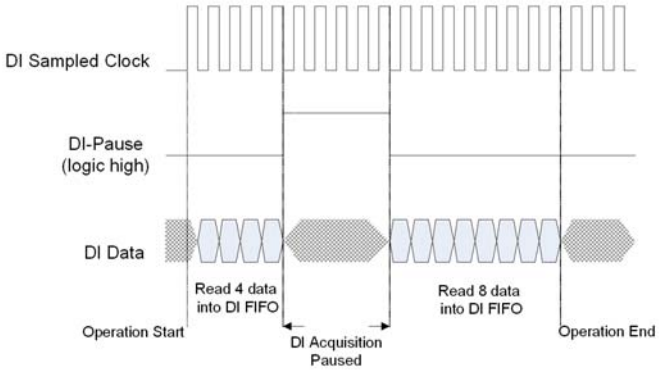


Figure 3-27: DI Gated Trigger

[Example 6] External digital trigger with gated trigger

DO data Count: 12 samples

Trigger Event: DO-Pause (logic high)

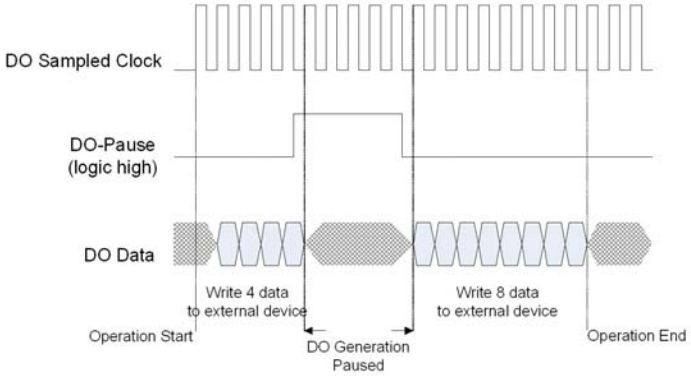


Figure 3-28: DO Gated Trigger

3.9 Application Function I/O

The PCIe-7360 features eight AFI (Application Function I/O) lines. These bi-directional digital I/O lines allow you to route I2C, SPI, trigger, event, handshake, and clock signals to/from the SCSI-VHDCI I/O connector. The following table lists the supporting functions of AFI lines and the corresponding pin out.

Function	Signal	I/O	AFI0	AFI1	AFI2	AFI3	AFI4	AFI5	AFI6	AFI7
I^2C Master	SCL	O	•							
	SDA	I/O		•						
SPI Master	SCLK	O	•							
	SDO	O		•						
	SDI	I			•					
	CS_0	O				•				
External Trigger in	DI-Start	I	•	•	•	•	•	•	•	•
	DO-Start	I	•	•	•	•	•	•	•	•
	DI-Pause	I	•	•	•	•	•	•	•	•
	DO-Pause	I	•	•	•	•	•	•	•	•

Function	Signal	I/O	AFI0	AFI1	AFI2	AFI3	AFI4	AFI5	AFI6	AFI7
Trigger out	DI_SW	O	●	●	●	●	●	●	●	●
	DO_SW	O	●	●	●	●	●	●	●	●
Event	PM	O	●	●	●	●	●	●	●	●
	COS	O	●	●	●	●	●	●	●	●
Handshake	DI-REQ	I	●	●	●	●	●	●	●	●
	DI-ACK	O	●	●	●	●	●	●	●	●
	DI-TRIG	I	●	●	●	●	●	●	●	●
	DO-REQ	O	●	●	●	●	●	●	●	●
	DO-ACK	I	●	●	●	●	●	●	●	●
	DO-TRIG	I	●	●	●	●	●	●	●	●
Clock	DO-SCLK	I/O							●	
	DI-SCLK	I/O								●

Function	Signal	I/O	Description
I^2C Master	SCL	O	**I^2C Clock**– I^2C clock signal to slave device capable of clock rate up to 1953.125KHz.
	SDA	I/O	**I^2C Serial Data**– Data signal for I^2C read/ write communication.
SPI Master	SCK	O	**SPI Clock**– SPI clock signal to slave device capable of clock rate up to 62.5MHz.
	SDI	I	**Master Input Slave Output**– Data signal for SPI read communication.
	SDO	O	**Master Output Slave Input**– Data signal for SPI write communication.
	CS_0	O	**Chip Select of Slave Device 0**– Output signal to select the desired SPI slave device 0.

Function	Signal	I/O	Description
External Trigger in	DI-Start	I	**DI Start Trigger in**– External digital trigger signal to begin an acquisition operation.
	DO-Start	I	**DO Start Trigger in**– External digital trigger signal to begin a generation operation.
	DI-Pause	I	**DI Gate Trigger in**– External digital signal to start/pause an acquisition operation.
	DO-Pause	I	**DO Gate Trigger in**– External digital signal to start/pause a generation operation.
Trigger out	DI_SW	O	**DI Trigger out**– A pulse signal output generated by PCIe-7360 when receiving a software start command of DI.
	DO_SW	O	**DO Trigger out**– A pulse signal output generated by PCIe-7360 when receiving a software start command of DO.
Event	PM	O	**Pattern Match Event**– A pulse signal output to indicate the event of pattern match of user-defined data lines.
	COS	O	**Change Detection Event**– A pulse signal output to indicate the change detection of any user-defined data lines.

Function	Signal	I/O	Description
Handshake	DI-REQ	I	**Digital Input Reques**– In handshake mode for DI pattern acquisition, DI-REQ carries handshake control information from DUT to PCIe-7360.
	DI-ACK	O	**Digital Input Acknowledge**– In handshake mode for DI pattern acquisition, DI-ACK carries handshake status information from PCIe-7360 to DUT.
	DI-TRIG	I	**Digital Input Trigger**– In handshake mode for DI pattern acquisition, DI-TRIG can be used to start the operation.
	DO-REQ	O	**Digital Output Request**– In handshake mode for DO pattern generation, DO-REQ carries handshake control information from PCIe-7360 to DUT.
	DO-ACK	I	**Digital Output Acknowledge**– In handshake mode for DO pattern generation, DO-ACK carries handshake status information from DUT to PCIe-7360.
	DO-TRIG	I	**Digital Output Trigger**– In handshake mode for DO pattern generation, DO-TRIG can be used to start the operation.

Function	Signal	I/O	Description
Clock	DI-SCLK	I/O	**External DI Sampled Clock in**– In free-running mode or burst handshake mode, PCIe-7360 can receive external sampled clock from DUT for acquisition by DI-SCLK. **Export DI Sampled Clock out**– In free-running mode or burst handshake mode, PCIe-7360 can export sampled clock of acquisition to DUT by DI-SCLK.
	DO-SCLK	I/O	**External DO Sample Clock in**– In continuous mode or burst handshake mode, PCIe-7360 can receive external sampled clock from DUT for generation by DO-SCLK. **Export DO Sample Clock out**– In continuous mode or burst handshake mode, PCIe-7360 can export sample clock of generation to DUT by DO-SCLK.

I²C Master

PCIe-7360's application function I/O (AFI) can be configured as I2C node for communicating with peripheral devices through PCIe-7360's built-in I²C master protocol and provided Windows API directly. Along with I²C master of PCIe-7360, users can easily communicate with ADC/ Microcontroller/ EEPROM/ image sensor for initializing and programming.

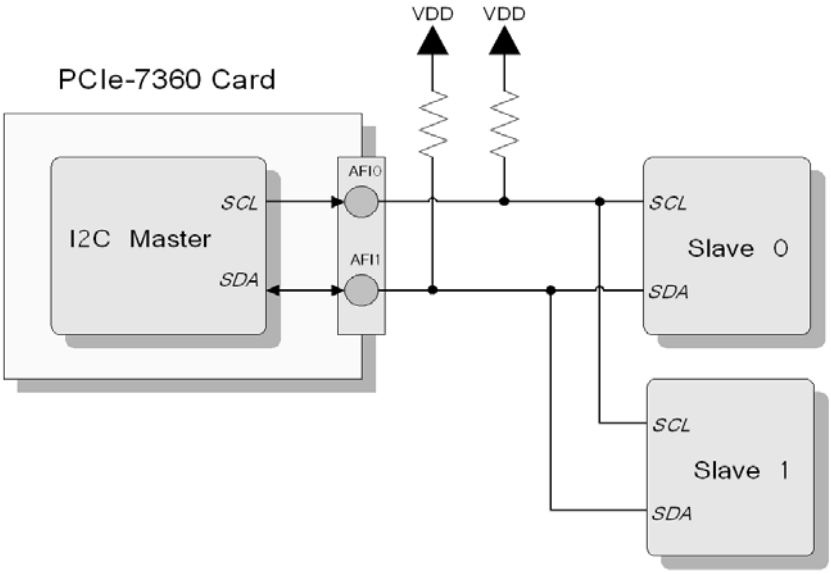


Figure 3-29: I2C Master of PCIe-7360

The I²C master of the PCIe-7360 provides at most 8 bytes data width -- 4 bytes address/ command and 4 bytes data. A basic I²C command is consisted of at least two parts: slave address (with Read/Write bit) and one or more types of data bytes (Command,

Address or Data). Figure 3-29 shows the data transfer on the I^2C bus.

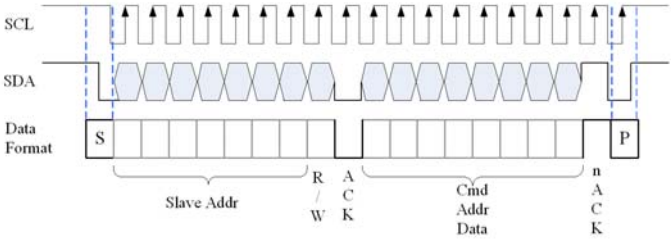
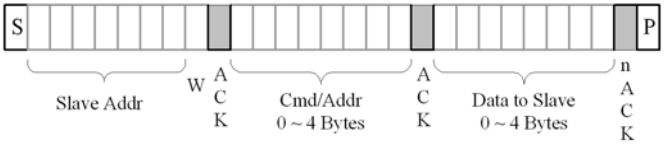


Figure 3-30: Data Transfer on the I^2C Bus

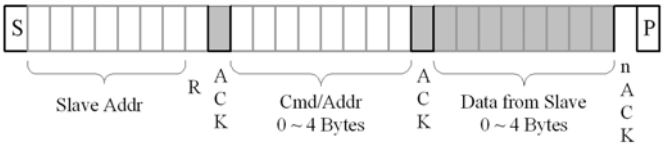
I^2C master of PCIe-7360 supports the clock range from 1.9 kHz to 244.14 kHz. After issuing command to I^2C slave device, the clock rate might be changed according the request from I^2C slave. The below formula is to calculate the I^2C clock rate.

F_{scl} = 488.28 / (Clk Pre-scale + 1) (kHz),
where Clk Pre-scale = 1 to 255

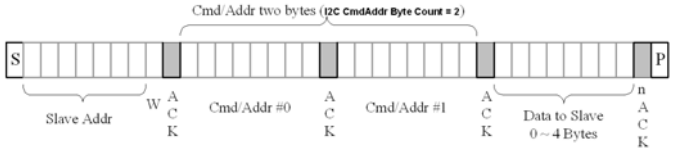
I^2C Write Command: the content of Cmd/Addr and Data are stored in registers $I^2C\_A\_CA$ and $I^2C\_A\_DAT$ and their byte counts are indicated by I^2C CmdAddr Byte Count and Access Byte Count, respectively.



I^2C Read Command: the format of Read command is similar with a write command except that the data part is derived by slave device.



I²C Cmd/Addr Count is less than 4 byte:



I²C Data Count is less than 4 byte:

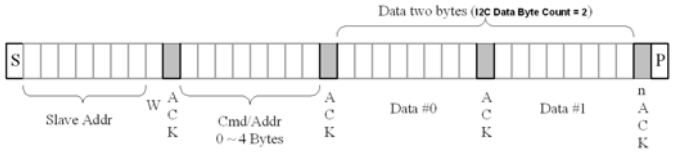


Figure 3-31: I²C Data Format

SPI Master

PCIe-7360's application function I/O (AFI) can be configured as SPI node for user to communicate with peripheral devices through PCIe-7360's built-in SPI master protocol and provided API directly. Along with SPI master of PCIe-7360, user can easily communicate with ADC/ Microcontroller/ EEPROM/ image sensor for initializing and programming.

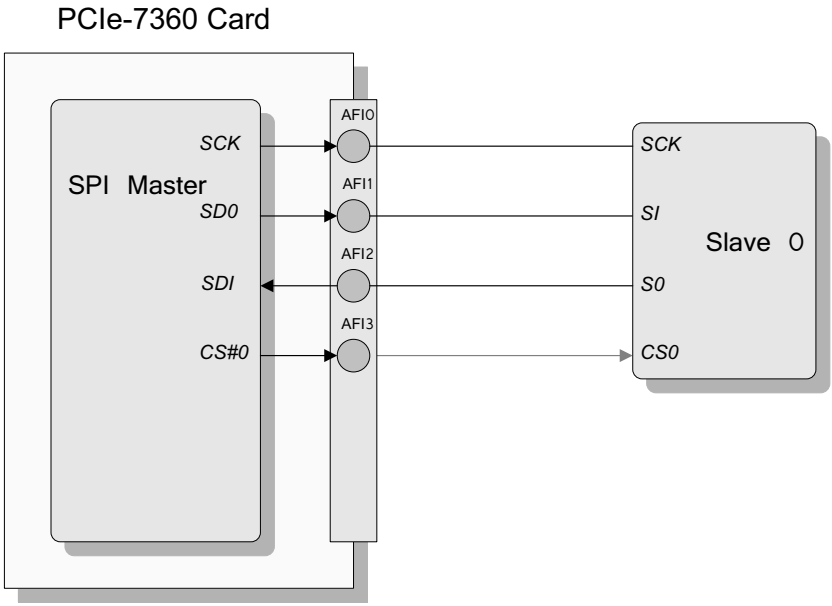


Figure 3-32: SPI Master of PCIe-7360

SPI master of PCIe-7360 provide at most 64 bits -- 32 bits address/ command and 32 bits data. SPI master of PCIe-7360 supports only one slave device. Figure 3-32 shows the data transfer on SPI bus.

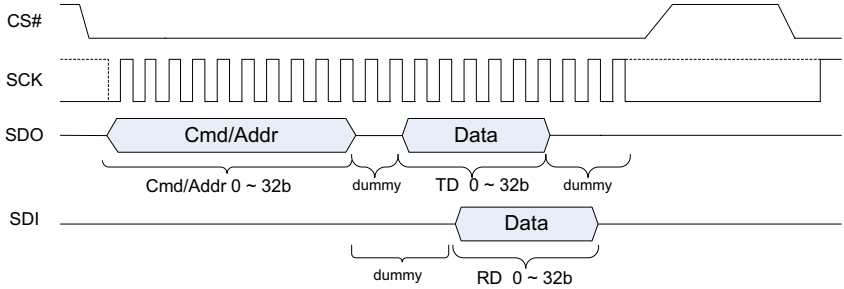


Figure 3-33: Data Transfer on SPI Bus

SPI master of PCIe-7360 supports clock frequency range from 244.14 kHz to 62.5 MHz. After issuing command to SPI slave device, the clock rate might be changed according the request from SPI slave. The below formula is to calculate the SPI clock rate.

Fscl = 62.5 / (Clk Pre-scale + 1) (MHz),
where Clk Pre-scale=0 to 255

SPI master of PCIe-7360 supports two different modes of SCK. Clock modes 0 and 1 of SCK are as shown.

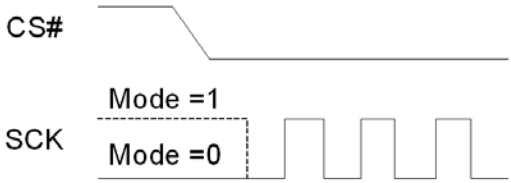


Figure 3-34: Clock Mode of SCK

External Digital Trigger

PCIe-7360 supports external digital trigger mode to start or pause an acquisition or generation operation. PCIe-7360 supports two trigger sources, internal software trigger and external digital trigger. The digital pattern acquisition or generation will start upon a software command or an external digital trigger signal to start or pause the process. The PCIe-7360's Application Function I/O (AFI) can be configured as the external digital trigger source.

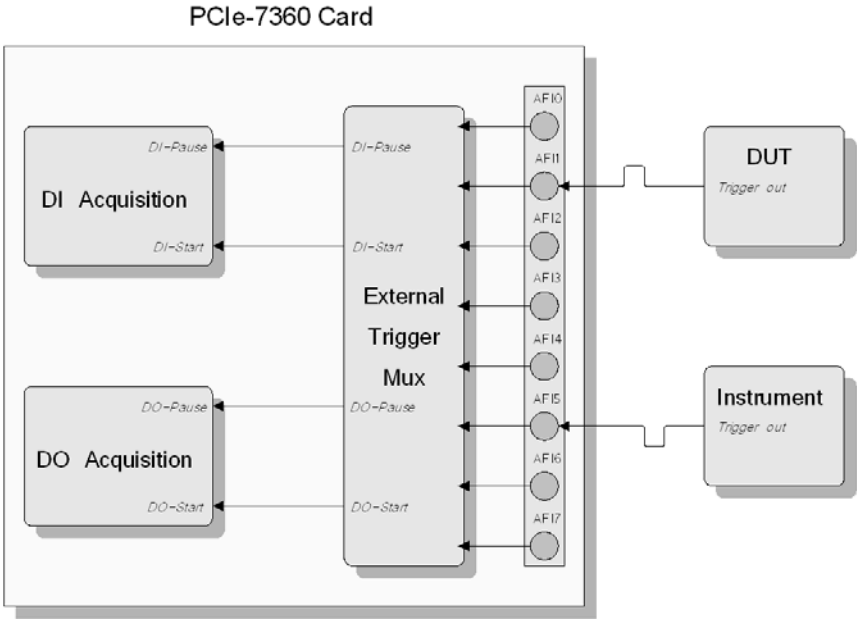


Figure 3-35: External Digital Trigger Input Configuration

Trigger Out

PCIe-7360's Application Function I/O (AFI) can be configured as trigger output when receiving a software start command of digital pattern acquisition or generation. The trigger out signal can synchronize the operation between PCIe-7360 and DUT.

The pulse width of trigger out signal can be configured from 16ns to 524.288 µs. (8 ns x (N+1), where N is from 1 to 65535)

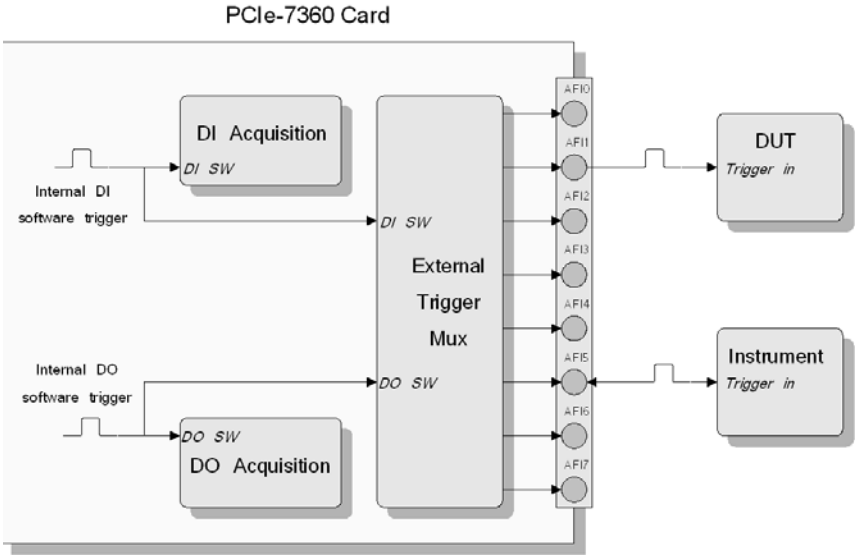


Figure 3-36: Configured AFI as Internal Software Trigger Output

Event Out

PCIe-7360's Application Function I/O (AFI) can be configured as event output of pattern match or COS (Change of State).

Pattern Match event is a pulse signal generated while the PCIe-7360's digital data input lines matching the pre-defined pattern. COS (Change of State) event is a pulse signal generated while the PCIe-7360 detects a change on the pre-defined data input line. The pulse width of Event Out signal can be configured from 16ns to 524.288 µs. (8 ns x (N+1), where N is from 1 to 65535).

You can export this event out signal to trigger external devices for synchronization or to inform external devices.

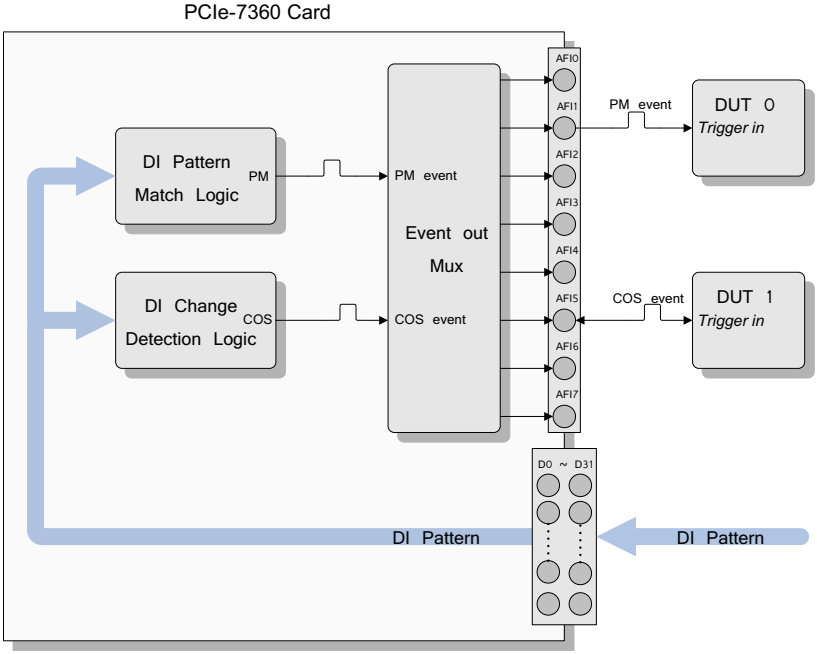


Figure 3-37: Pattern Match and COS Event Configuration

Handshake

PCIe-7360's Application Function I/O (AFI) can be configured as handshake mode (DI-REQ/DI-ACK/DI-TRIG/DO-REQ/DO-ACK/DO-TRIG) to communicate with an external device using an acknowledge signals to request and acknowledge each data transfer. The handshake mode can ensure the data transfer without loss.

For the digital pattern acquisition using handshake, through DI-REQ input signal from external device and DI-ACK output signal to the external device, the digital input can have simple handshake data transfer. (See Section 3.7 Operating Modes)

For the digital pattern generation using handshake, through DO-REQ output signal to the external device and DO-ACK input signal from external device, the digital output can have simple handshake data transfer.

For the PCIe-7360 to communicate with peripheral devices using handshake, verify that the DUT and the PCIe-7360 have compatible timing.

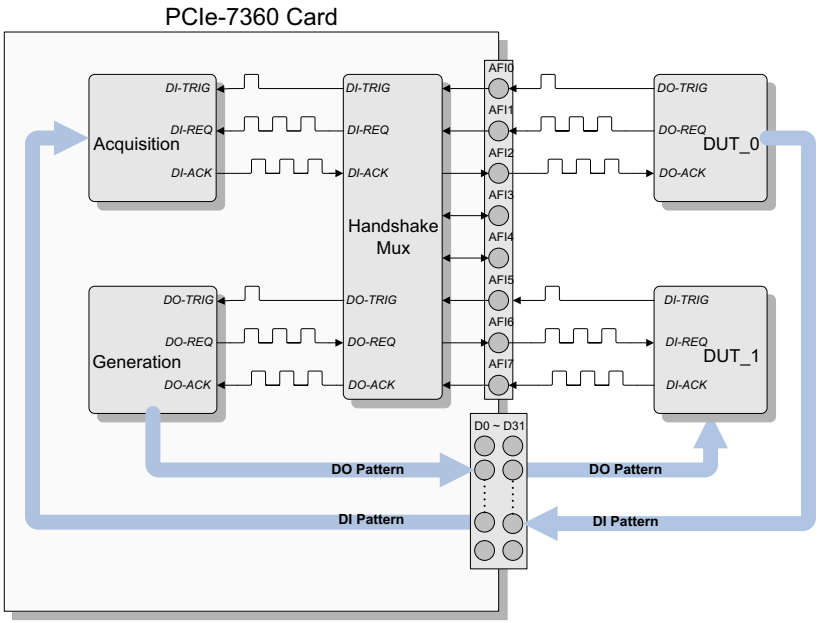


Figure 3-38: Configured AFI as Handshake Interface

Sample Clock In/Out

The AFI of PCIe-7360 can be configured to sample clock in/out pin. For more details, please see Section 3.6 Sample Clock

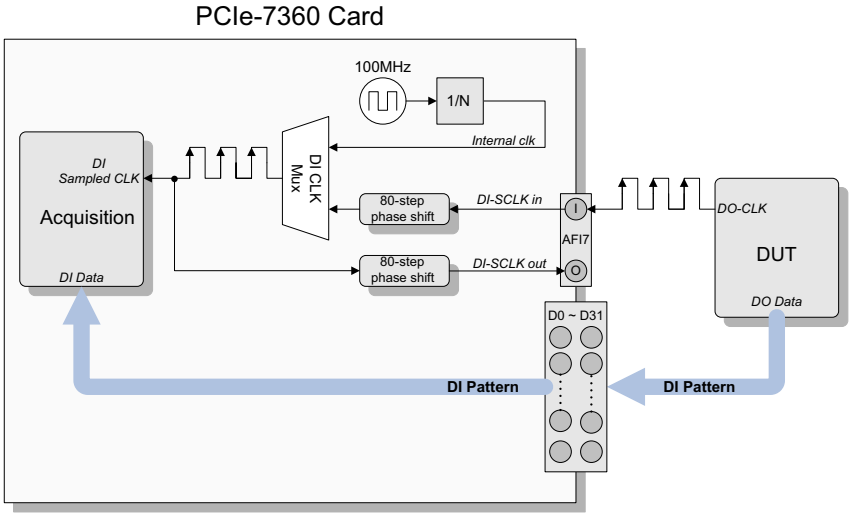


Figure 3-39: Configured AFI7 as DI Sampled Clock In/Out

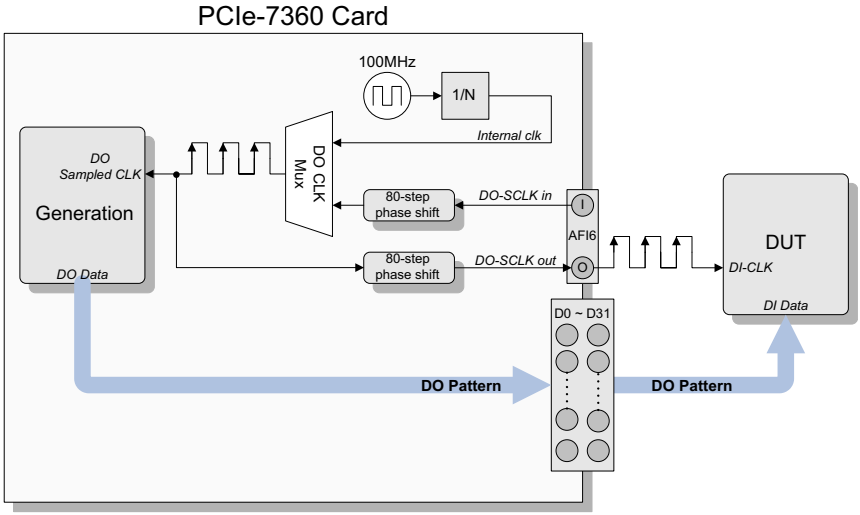


Figure 3-40: Configured AFI6 as DO Sampled Clock In/Out

3.10 Pattern Match

PCIe-7360 supports pattern match function to monitor the data input lines that conform to the user-defined pattern (for example, 10101110). When the data lines conform to the user-defined pattern, PCIe-7360 will generate a pulse signal of pattern match event to the AFI pin and generate the pattern match interrupt to host PC as well.

Below are the conditions of pattern match. The pattern match can be a single change of specific data line or a combination of different data lines.

Logic State	Description
0	Match on a logic low level at the input channel
1	Match on a logic high level at the input channel
R	Match on rising edge at the input channel
F	Match on falling edge at the input channel
X	Ignore the input channel

An example of 9 channel (CH0 – CH8) pattern match operation is shown. All of the enabled DI channel's signal logic states is compared with the user-defined pattern "1100RRFFX". The pattern match event and interrupt is generated while the following conditions are all matched:

- CH0 and CH1 are logic high
- CH2 and CH3 are logic low
- CH4 and CH5 are rising edge
- CH6 and CH7 are falling edge
- CH8 is ignored


NOTE:

In the PCIe-7360, edge detection (rising or falling) compares currently sampled data with the previously sampled data.

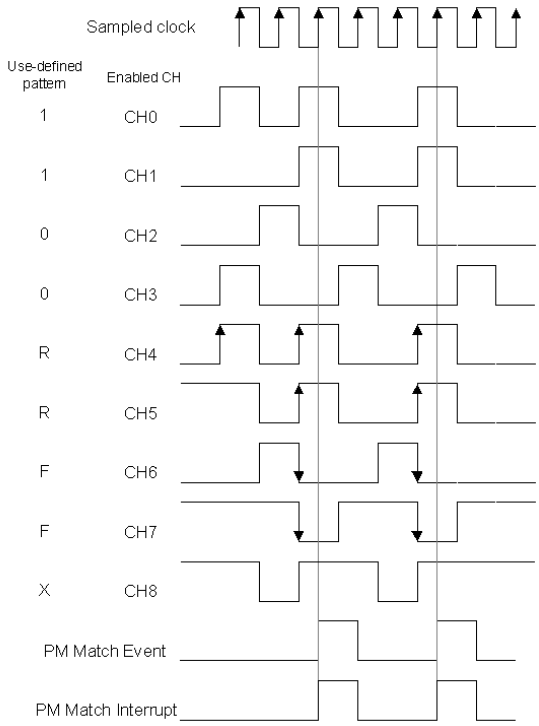


Figure 3-41: Example of Pattern Matching

3.11 COS (Change of State) Event

PCIe-7360 supports COS (Change of State) Event to monitor if there is any change on the user-defined or any data lines.

When PCIe-7360 detects the change (either the input state changes from low to high or from high to low) of data input lines, PCIe-7360 will have the following response:

- Generate a pulse signal of change detection event to AFI
- Generate the change detection interrupt to host PC
- Latch the corresponding DI data into change detection latch register

In COS mode, the DI data are sampled by 125 MHz clock rate. Therefore, the pulse width of the DI data should be longer than 8ns. Otherwise, the change detection latch register won't latch the correct input data.

An example of 8 channel change detection operation is shown. Any level change of the enabled DI data lines is detected and then generate the event and interrupt. The corresponding DI data is latched into change detection register.

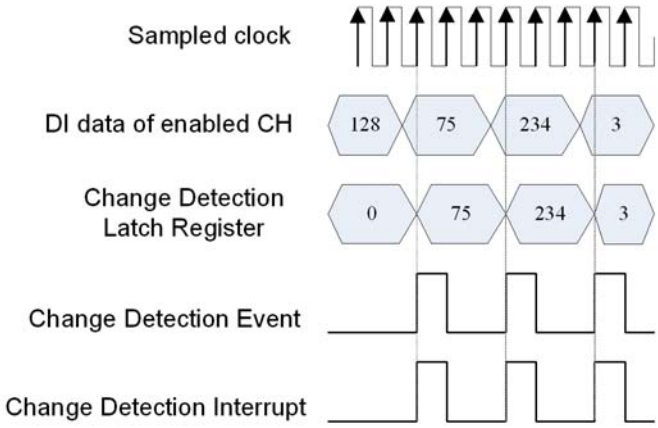


Figure 3-42: Example of Pattern Match

3.12 Termination

Proper termination is very important for applications using high-speed digital data transfer to eliminate the signal reflection caused by cables, wiring, connectors, or PCB traces and improve signal quality.

The output impedance (source impedance) of the PCIe-7360 is 50 Ω and the characteristic impedance of the SCSI-VHDCI cable is also 50 Ω. When you connect to a DUT with 50 Ω input impedance, the best impedance matching is achieved, but the voltage level sensed by the DUT is half of the PCI-7360's output voltage due to voltage-divider principles. You can also connect to a DUT with a high impedance (at least 1 - 100 kΩ) if precision timing and excellent signal integrity is not so critical. The voltage level sensed

by the DUT is almost the same as the output voltage of the PCIe-7360.

The input impedance of the PCIe-7360 is 10 kΩ, which is a high impedance. So with a high impedance 10 kΩ load termination, the external source impedance of DUT should match the characteristic impedance (50 Ω) of the SCSI-VHDCI cable to achieve better signal integrity and avoid signal reflection.

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Appendix A ADLINK DIN-68H

The DIN-68H is a terminal board designed for PCIe-7360 to provide the easier wiring for test circuit or measure signal. Below is the layout and pin-to-pin reference table of DIN-68H:

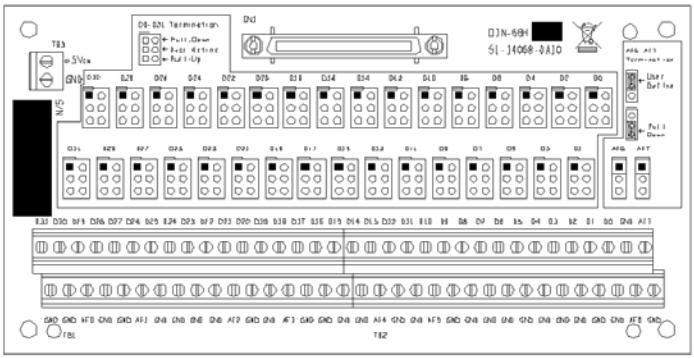

Figure A-1: DIN-68H Layout

PCIe-7360	DI/O0	DI/O1	DI/O2	DI/O3	DI/O4	DI/O5	DI/O6	DI/O7
DIN-68H	D0	D1	D2	D3	D4	D5	D6	D7

PCIe-7360	DI/O8	DI/O9	DI/O10	DI/O11	DI/O12	DI/O13	DI/O14	DI/O15
DIN-68H	D8	D9	D10	D11	D12	D13	D14	D15

PCIe-7360	DI/O16	DI/O17	DI/O18	DI/O19	DI/O20	DI/O21	DI/O22	DI/O23
DIN-68H	D16	D17	D18	D19	D20	D21	D22	D23

PCIe-7360	DI/O24	DI/O25	DI/O26	DI/O27	DI/O28	DI/O29	DI/O30	DI/O31
DIN-68H	D24	D25	D26	D27	D28	D29	D30	D31

PCIe-7360	AFI6	AFI7
DIN-68H	AF6	AF7

Table A-1: DIN-68H Pin Assignment

All jumpers on DIN-68H are used for the setting of pull-up or pull-down resistor termination. The proper termination setting can reduce signal refection during high-speed data transfer. The below diagram is the schematic of AF6, AF7, and D0 to D31. The default jumper setting of DIN-68H is set to 50Ω pull-down termination. When you change the jumper setting to 5V pull-up termination, you have to apply +5V power to $+5V_{IN}$ connector. If you don't want to set termination on specific channels, just remove the corresponding jumpers on the DIN-68H..

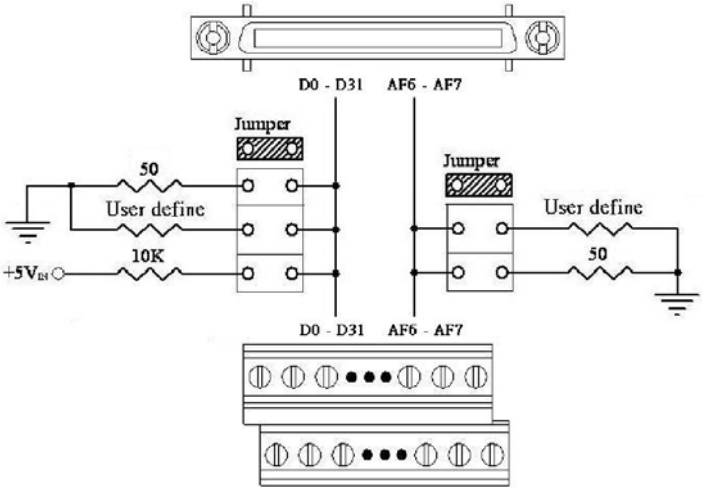

Figure A-2: Resistor Termination Schematic

The DIN-68H also provides the option of user define pull-up resistor termination. Please note that the pad position of the resistor is on the back side of PCB and the resistor footprint is 1206 packaging. Below is the layout of the back side PCB and reference table of user-defined resistor termination.

Channel	D0	D1	D2	D3	D4	D5	D6	D7
Resistor	R71	R72	R79	R80	R87	R88	R97	R98

PCIe-7360	D8	D9	D10	D11	D12	D13	D14	D15
DIN-68H	R73	R74	R81	R82	R89	R90	R99	R100

PCIe-7360	D16	D17	D18	D19	D20	D21	D22	D23
DIN-68H	R75	R76	R83	R84	R91	R92	R101	R102

PCIe-7360	D24	D25	D26	D27	D28	D29	D30	D31
DIN-68H	R77	R78	R85	R86	R93	R94	R103	R104

PCIe-7360	AF6	AF7
DIN-68H	R95	R96

Table A-2: Pad Position of User-Defined Resistor Termination

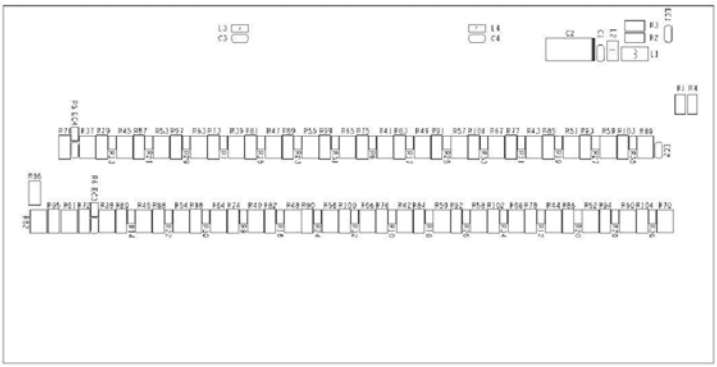

Figure A-3: DIN-68H Layout (Back Side)

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Important Safety Instructions

For user safety, please read and follow all **instructions**, **WARNINGS**, **CAUTIONS,** and **NOTES** marked in this manual and on the associated equipment before handling/operating the equipment.

- Read these safety instructions carefully.
- Keep this user's manual for future reference.
- Read the specifications section of this manual for detailed information on the operating environment of this equipment.
- When installing/mounting or uninstalling/removing equipment:
  - Turn off power and unplug any power cords/cables.
- To avoid electrical shock and/or damage to equipment:
  - Keep equipment away from water or liquid sources;
  - Keep equipment away from high heat or high humidity;
  - Keep equipment properly ventilated (do not block or cover ventilation openings);
  - Make sure to use recommended voltage and power source settings;
  - Always install and operate equipment near an easily accessible electrical socket-outlet;
  - Secure the power cord (do not place any object on/over the power cord);
  - Only install/attach and operate equipment on stable surfaces and/or recommended mountings; and,
  - If the equipment will not be used for long periods of time, turn off and unplug the equipment from its power source.

- Never attempt to fix the equipment. Equipment should only be serviced by qualified personnel.

A Lithium-type battery may be provided for uninterrupted, backup or emergency power.

Risk of explosion if battery is replaced with one of an incorrect type. Dispose of used batteries appropriately.

- Equipment must be serviced by authorized technicians when:
  - The power cord or plug is damaged;
  - Liquid has penetrated the equipment;
  - It has been exposed to high humidity/moisture;
  - It is not functioning or does not function according to the user's manual;
  - It has been dropped and/or damaged; and/or,
  - It has an obvious sign of breakage.

Getting Service

Contact us should you require any service or assistance.

ADLINK Technology, Inc.
Address: 9F, No.166 Jian Yi Road, Zhonghe District
New Taipei City 235, Taiwan
新北市中和區建一路 166 號 9 樓
Tel: +886-2-8226-5877
Fax: +886-2-8226-5717
Email: service@adlinktech.com

Ampro ADLINK Technology, Inc.
Address: 5215 Hellyer Avenue, #110, San Jose, CA 95138, USA
Tel: +1-408-360-0200
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