

Introduction

The XPS Central DMA Controller provides simple Direct Memory Access (DMA) services to peripherals and memory devices on the PLB. The controller transfers a programmable quantity of data from a source address to a destination address without processor intervention.

Features

- Connects as a 32-bit master/slave on PLB V4.6 buses of 32, 64 or 128 bits
- Provides a single physical channel of Direct Memory Access between a source address and a destination address
- Provides programmable registers for source address, destination address and transfer length
- Parameterizable local FIFO depth and burst length
- Supports different clock domains for Master and Slave interfaces
- The source address and destination address can be arbitrarily aligned (down to the byte)
- Supports overlapped PLB read/write transfers which will give better performance
- Supports unaligned address transfers
- Supports setting up of source and destination addresses as incrementing or fixed (keyhole)
 - Supports PLB burst transfers

LogiCORE™ IP Facts Table	
Core Specifics	
Supported Device Family ⁽¹⁾	Spartan®-3, Spartan-3E, Spartan-3A, Spartan-6, Spartan-3A DSP, Automotive Spartan-3/3A/3A DSP/ 3E, Virtex®-4, Virtex-4Q, Virtex-4QV, Virtex-5/5FX, Virtex-6/6CX
Supported User Interfaces	PLBv46
Resources	
Block RAMS	For Virtex-5 FPGA, see Table 14 , for Virtex-5 FPGA, see Table 15 , for Spartan-3E, see Table 16 , for Virtex-6 FPGA, see Table 17 . and for Spartan-6 FPGA, see Table 18 .
LUTs	
Slices	
FFs	
Provided with Core	
Documentation	Product Specification
Design Files	VHDL
Example Design	Not Provided
Test Bench	Not Provided
Constraints File	Not Provided
Simulation Model	N/A
Tested Design Tools	
Design Entry Tools	Platform Studio
Simulation	Mentor Graphic ModelSim v6.5c and above
Synthesis Tools	XST
Support	
Provided by Xilinx, Inc.	

Notes:

1. For a complete listing of supported devices, see the release notes for this core.

Functional Description

The block diagram for the XPS Central DMA Controller is shown in Figure 1. The core is comprised of the following primary modules which are described in the subsequent sections:

- Slave Attachment Module
- Master Attachment Module
- FIFO
- DRE.

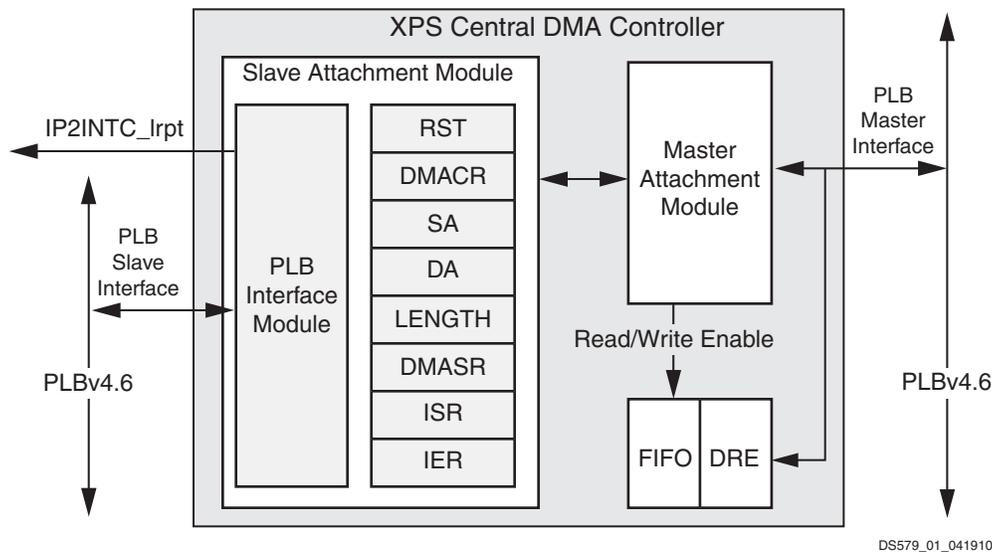


Figure 1: Block Diagram for the XPS Central DMA Controller

Slave Attachment

The Slave Attachment module performs the following operations:

- Interfaces with the PLB V4.6 using the PLB Interface Module.
- Responds to PLB transactions to read and write the DMA registers.
- Modifies the Source Address, Destination Address, Length, DMA Status and Interrupt Status Registers as a DMA operation proceeds.
- Generates interrupts based on DMA done and DMA error conditions, detected in the Master Attachment Module.

Master Attachment

The Master Attachment module performs the following operations:

- Performs read and write transactions as a PLB master to transfer the amount of data specified in the Length Register from source address to destination address, using bursts where appropriate.
- Detects errors.
- Updates the Source Address, Destination Address, Length and DMA Status Registers during the DMA transfer.

DRE

The DRE (Data Realignment Module) will align the unaligned data before writing in to the FIFO from the source address or to write in to the destination address from the FIFO.

FIFO

XPS Central DMA Controller contains a 32-bit FIFO:

- Stores the data to be transferred locally.
- The depth of the FIFO can be configured to 1, 16, 32 and 48.
- The FIFO enables the simultaneous read and write transactions based on its vacancy and occupancy.

Controller Operation

The XPS Central DMA Controller operates on the PLB using independent master and slave interfaces. It responds as a slave when its registers are being read and written. It initiates read and write transactions as a master when a DMA operation is in progress.

Although it is common to connect the master and slave interfaces to the same bus, it is possible, as shown in [Figure 1](#), to connect them to different PLB buses, possibly operating at different frequencies. Frequency ratios of 1:1, 2:1 and 1:2 between master and slave bus clocks are supported.

Note: The design accommodates arbitrary clock relationships, including uncorrelated clocks, but the core is specified and tested for the given ratios only.

The master and slave connections of the XPS Central DMA operate as 32-bit PLB agents. However, either the master or slave can connect to a PLB with wider data paths (64-bit or 128-bit) and conduct transactions with wider slaves or masters.

The operation of the XPS Central DMA is initiated by writing values into the following DMA registers. For more information, see the [Register Descriptions](#).

- Source Address register (SA): The source address for the transfer is written into this register.
- Destination Address register (DA): The destination address for the transfer is written into this register.
- DMA Control Register (DMACR): The parameters of the DMA transfer are controlled by setting the following values in this register.
 - Source Increment (SINC): SINC should be set to '0', if and only if the Source Address register is written with a *keyhole* address such that a single address is associated with a sequence of data.

Note: An example of a keyhole address is a memory mapped FIFO that maps as an element at a single address but can consume or produce an endless sequence of data. A variation on a keyhole address is a *wide keyhole* where a number of consecutive addresses map to the element. When SINC = '0', XPS Central DMA will perform all read transactions to the same address. It is the responsibility of the corresponding slave to impose a keyhole behavior. For bursts, this implies that the slave will not increment the keyhole address during the burst or will make the keyhole at least as wide as the burst size. It is not feasible to use SINC = '0' with a non-keyhole slave such as a memory. Even though the DMA Controller would deliver a non-incremented address during the address phase of PLB transactions, the memory would increment it during bursts. (See also DINC, which is subject to the same considerations when set to '0'.)
 - If the source address should increment for each data transferred, SINC should set to '1'.
 - Destination Increment (DINC): DINC should be set to '0' if and only if the Destination Address is written with a *keyhole* address such that a single address is associated with a sequence of data.

Note: See the note for SINC = '0' above. The case DINC = '0' has the same considerations except for the destination address.
 - If the destination address should increment for each data transferred, DINC should set to '1'.

- **LENGTH register (LENGTH):** The number of bytes to transfer is written into this register. Writing to this register is the event that starts the DMA operation, so it must be done last. (Refer to [Table 10](#) for more information on this register)

The data transfer starts by reading data from the source address into an internal FIFO followed by the transfer of data from the FIFO to the destination address. This repeats until all the data is moved. The DMA Status Registers get updated as the DMA operation progresses.

While it is moving data as the bus master, the XPS Central DMA Controller attempts to move data efficiently. It utilizes burst transactions where possible.

The status of the DMA operation is available in the DMA Status Register (DMASR). The DMABSY bit equal to '1' represents that a DMA operation is underway. When equal to '0', it represents the completion of a DMA transfer. Alternatively, the DMA Done (DD) interrupt can be used to detect when a DMA operation is complete.

If an error condition is detected during a bus transfer, the DMA operation will be aborted at its current point of progress. The error is reported through the DMA Error (DE) interrupt condition and the DMA Bus Error (DBE) status bit.

Interrupt and Error Condition Descriptions

DMA Interrupt Conditions

Interrupt conditions, which are established by the occurrence of interrupt events, are stored in the Interrupt Status Register of the channel (see [Table 12](#)). Interrupt conditions can be reported, cleared and enabled.

- **Reporting:** Port signal IP2INTC_Irpt is active if and only if either of the interrupt conditions occurs.
- **Clearing:** Active interrupt conditions are cleared by writing a value to the Interrupt Status Register with a 1 in the bit position to be cleared.
- **Enabling:** Interrupts are enabled by setting the corresponding bit in the Interrupt Enable Register. (see [Table 13](#))

Error Conditions

A DMA operation proceeds until it is complete or until it is aborted due to an error condition detected on the bus.

If completion is due to an error, the corresponding DMA BUS Error (DBE) bit of the DMA Status Register (DMASR) will be set. Additionally, the DMA Error (DE) interrupt condition will become active. The final values of LENGTH, SA and DA will reflect the partial completion status of the DMA operation, taking into account that unwritten data will be flushed out by resetting the internal FIFO.

I/O Signals

The XPS Central DMA Controller I/O signals are listed and described in [Table 1](#). All signals are active high.

Table 1: I/O Signal Description

Port	Signal Name	Interface	I/O	Initial State	Description
PLB Master Interface Signals					
P1	MPLB_Clk	PLB	I	-	PLB master clock
P2	MPLB_Rst	PLB	I	-	PLB master reset
P3	M_ABus[0:C_MPLB_AWIDTH - 1]	PLB	O	0	Master address bus
P4	M_BE[0:C_MPLB_DWIDTH/8 - 1]	PLB	O	0	Master byte enables
P5	M_wrDBus[0:C_MPLB_DWIDTH - 1]	PLB	O	0	Master write data bus
P6	M_request	PLB	O	0	Master bus request
P7	M_RNW	PLB	O	0	Master read not write
P8	M_priority[0:1]	PLB	O	0	Master bus request priority
P9	M_rdBurst	PLB	O	0	Master burst read transfer indicator
P10	M_type[0:2]	PLB	O	0	Master transfer type
P11	M_size[0:3]	PLB	O	0	Master transfer size
P12	M_wrBurst	PLB	O	0	Master burst write transfer indicator
P13	M_MSize[0:1]	PLB	O	0	Master data bus size
P14	MPLB_MRDBus[0:C_MPLB_DWIDTH - 1]	PLB	I	-	PLB master read data bus
P15	MPLB_MBusy	PLB	I	-	PLB master slave busy indicator
P16	MPLB_MRdErr	PLB	I	-	PLB master slave read error indicator
P17	MPLB_MWrErr	PLB	I	-	PLB master slave write error indicator
P18	MPLB_MWrBterm	PLB	I	-	PLB master terminate write burst indicator
P19	MPLB_MWrDAck	PLB	I	-	PLB master write data acknowledge
P20	MPLB_MAddrAck	PLB	I	-	PLB master address acknowledge
P21	MPLB_MRdBTerm	PLB	I	-	PLB master terminate read burst indicator
P22	MPLB_MRdDAck	PLB	I	-	PLB master read data acknowledge
P23	MPLB_MRearbitrate	PLB	I	-	PLB master bus rearbitrate indicator
P24	M_TAttribute[0:15]	PLB	O	0	Master Transfer Attribute bus
P25	M_UABus[0:31]	PLB	O	0	Master upper address bus
P26	M_lockErr	PLB	O	0	Master lock error indicator
P27	M_BusLock	PLB	O	0	Master bus lock
P28	M_abort	PLB	O	0	Master abort bus request indicator
P29	MPLB_MRdWdAddr[0:3]	PLB	I	-	PLB master read word address

Table 1: I/O Signal Description (Cont'd)

Port	Signal Name	Interface	I/O	Initial State	Description
P30	MPLB_MSSize[0:1]	PLB	I	-	PLB slave data bus size
P31	MPLB_MTimeout	PLB	I	-	PLB master bus time out
P32	MPLB_MIRQ	PLB	I	-	PLB master slave interrupt indicator
PLB Slave Interface Signals					
P33	SPLB_Clk	PLB	I	-	PLB clock
P34	SPLB_Rst	PLB	I	-	PLB reset
P35	SPLB_ABus[0:C_SPLB_AWIDTH - 1]	PLB	I	-	PLB address bus
P36	SPLB_type[0:2]	PLB	I	-	PLB transfer type
P37	SPLB_size[0:3]	PLB	I	-	PLB transfer size
P38	SPLB_abort	PLB	I	-	PLB abort bus request indicator
P39	SPLB_rdBurst	PLB	I	-	PLB burst read transfer indicator
P40	SPLB_wrBurst	PLB	I	-	PLB burst write transfer indicator
P41	SPLB_BE[0:C_SPLB_DWIDTH/8 - 1]	PLB	I	-	PLB byte enables
P42	SPLB_wrDBus[0:C_SPLB_DWIDTH - 1]	PLB	I	-	PLB write data bus
P43	SPLB_RNW	PLB	I	-	PLB read not write
P44	SPLB_PAVValid	PLB	I	-	PLB primary address valid indicator
P45	SPLB_SAVValid	PLB	I	-	PLB secondary address valid indicator
P46	SPLB_masterID[0:C_SPLB_MIDWIDTH - 1]	PLB	I	-	PLB current master identifier
P47	SPLB_rdPrim	PLB	I	-	PLB secondary to primary read request indicator
P48	SPLB_wrPrim	PLB	I	-	PLB secondary to primary write request indicator
P49	SPLB_busLock	PLB	I	-	PLB lock
P50	SPLB_MSize[0:1]	PLB	I	-	PLB master data bus size
P51	SPLB_UABus[0:31]	PLB	I	-	PLB upper address bus
P52	SPLB_reqpri[0:1]	PLB	I	-	PLB current request priority
P53	SPLB_TAttribute[0:15]	PLB	I	-	PLB Transfer Attribute bus
P54	SPLB_lockerr	PLB	I	-	PLB lock error indicator
P55	SPLB_rdpndPri[0:1]	PLB	I	-	PLB pending read request priority
P56	SPLB_wrpndPri[0:1]	PLB	I	-	PLB pending write request priority
P57	SPLB_rdpndReq	PLB	I	-	PLB pending bus read request indicator
P58	SPLB_wrpndReq	PLB	I	-	PLB pending bus write request indicator
P59	SI_rdDBus[0:C_SPLB_DWIDTH - 1]	PLB	O	0	Slave read data bus

Table 1: I/O Signal Description (Cont'd)

Port	Signal Name	Interface	I/O	Initial State	Description
P60	SI_addrAck	PLB	O	0	Slave address acknowledge
P61	SI_SSize[0:1]	PLB	O	0	Slave data bus size
P62	SI_MWrErr[0:C_SPLB_NUM_MASTERS - 1]	PLB	O	0	Slave write error indicator
P63	SI_MRdErr[0:C_SPLB_NUM_MASTERS - 1]	PLB	O	0	Slave read error indicator
P64	SI_wait	PLB	O	0	Slave wait indicator
P65	SI_rearbitrate	PLB	O	0	Slave rearbitrate bus indicator
P66	SI_wrDAck	PLB	O	0	Slave write data acknowledge
P67	SI_wrComp	PLB	O	0	Slave write transfer complete indicator
P68	SI_rdDAck	PLB	O	0	Slave read data acknowledge
P69	SI_rdComp	PLB	O	0	Slave read transfer complete indicator
P70	SI_MBusy[0:C_SPLB_NUM_MASTERS - 1]	PLB	O	0	Slave busy indicator
P71	SI_wrBTerm	PLB	O	0	Slave terminate write burst transfer
P72	SI_rdWdAddr[0:3]	PLB	O	0	Slave read word address
P73	SI_rdBTerm	PLB	O	0	Slave terminate read burst transfer
P74	SI_MIRQ[0:C_SPLB_NUM_MASTERS - 1]	PLB	O	0	Slave interrupt indicator
System Signals					
P75	IP2INTC_lrp	System	O	0	DMA Interrupt

Design Parameters

To allow the user to create a XPS Central DMA Controller that is uniquely tailored for the user's system, certain features are parameterizable in the XPS Central DMA Controller design. This allows the user to have a design that utilizes only the resources required by the system and runs at the best possible performance. The features that are parameterizable in the XPS Central DMA core are as shown in [Table 2](#).

Table 2: Design Parameters

Generic	Feature/Description	Parameter Name	Allowable Values	Default Value	VHDL Type
System Parameter					
G1	Target FPGA family	C_FAMILY	aspartan3, spartan3, spartan3a, spartan3e, aspartan3a, aspartan3e, aspartan3a, aspartan3adsp, spartan6, virtex4, qrvirtex4, qvirtex4, virtex5, virtex6	virtex5	string
PLB Parameters					
G2	XPS Central DMA Controller Base Address	C_BASEADDR	Valid Address ⁽¹⁾	None ⁽²⁾	std_logic_vector
G3	XPS Central DMA Controller High Address	C_HIGHADDR	Valid Address ⁽¹⁾	None ⁽²⁾	std_logic_vector
G4	PLB master data width	C_MPLB_DWIDTH	32,64,128	32	integer
G5	PLB master address width	C_MPLB_AWIDTH	32	32	integer
G6	PLB address width	C_SPLB_AWIDTH	32	32	integer
G7	PLB data width	C_SPLB_DWIDTH	32, 64, 128	32	integer
G8	Selects point-to-point or shared PLB topology 0 = Shared Bus Topology 1 = Point-to-Point Bus Topology	C_SPLB_P2P	0	0	integer
G9	PLB Master ID Bus Width	C_SPLB_MID_WIDTH	$\log_2(\text{C_SPLB_NUM_MASTERS})$ with a minimum value of 1	1	integer
G10	Number of PLB Masters	C_SPLB_NUM_MASTERS	1 - 16	1	integer
G11	Width of the Slave Data Bus	C_SPLB_NATIVE_DWIDTH	32	32	integer
G12	Burst support	C_SPLB_SUPPORT_BURSTS	0	0	integer
G13	Width of the Master Data Bus	C_MPLB_NATIVE_DWIDTH	32	32	integer
XPS Central DMA Controller Feature					
G14	FIFO Depth ⁽³⁾	C_FIFO_DEPTH	1, 8, 16, 32, 48	16	integer
G15	Read Burst Size ⁽⁴⁾	C_RD_BURST_SIZE	1, 8, 16	16	integer
G16	Write Burst Size ⁽⁴⁾	C_WR_BURST_SIZE	1, 8, 16	16	integer

Notes:

1. C_BASEADDR must be a multiple of the address-range size, where the size is C_HIGHADDR - C_BASEADDR + 1.
2. No default value will be specified to insure that the actual value is set.
3. FIFO Depth should be greater than or equal to the Read Burst Size and Write Burst Size
4. Read Burst Size should be greater than or equal to the Write burst Size

Allowable Parameter Combinations

The address-range size specified by C_BASEADDR and C_HIGHADDR must be a power of 2, and must be at least 0x40. For example, if C_BASEADDR = 0xE0000000, C_HIGHADDR must be at least = 0xE000003F.

C_PLB_MIDWIDTH depends on C_PLB_NUM_MASTERS. It must be set to the maximum of 1 or the smallest integer greater than or equal to $\log_2(C_PLB_NUM_MASTERS)$.

Below table shows the valid combinations among C_FIFO_DEPTH, C_RD_BURST_SIZE and C_WR_BURST_SIZE. If C_RD_BURST_SIZE = C_WR_BURST_SIZE and C_FIFO_DEPTH \geq 2X of C_RD_BURST_SIZE will give better performance in terms of latency. The user has the flexibility in choosing these parameters depending on the system requirements.

Table 3: Allowable FIFO Depth, Read and Write Burst Size Parameters

C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE
1	1	1
8	8	1
8	8	8
16	8	8
16	8	1
16	16	1
16	16	8
16	16	16
32	8	1
32	8	8
32	16	1
32	16	8
32	16	16
48	8	1
48	8	8
48	16	1
48	16	8
48	16	16

Parameter - Port Dependencies

The dependencies between the XPS Central DMA core design parameters and I/O signals are described in Table 4. In addition, when certain features are parameterized out of the design, the related logic will no longer be a part of the design. The unused input signals and related output signals are set to a specified value.

Table 4: Design Parameter - Port Dependencies

Generic or Port	Name	Affects	Depends	Relationship Description
Design Parameters				
G4	C_MPLB_DWIDTH	P4,P5,P14	-	Affects number of bits in master data bus.
G6	C_SPLB_AWIDTH	P35		Affects number of bits in address bus.
G7	C_SPLB_DWIDTH	P41,P42,P59	-	Affects number of bits in data bus.
G9	C_SPLB_MID_WIDTH	P46	G10	Affects the width of current master identifier signals and depends on $\log_2(\text{C_SPLB_NUM_MASTERS})$ with a minimum value of 1.
G10	C_SPLB_NUM_MASTERS	P62,P63,P70,P74	-	Affects the width of busy and error signals.
I/O Signals				
P3	M_ABUS[0:C_MPLB_AWIDTH]	-	G5	Width varies with the size of the PLB master address bus.
P4	M_BE[0:C_MPLB_DWIDTH/8 - 1]	-	G4	Width varies with the size of the PLB master data bus.
P5	M_wrDBus[0:C_MPLB_DWIDTH - 1]	-	G4	Width varies with the size of the PLB master data bus.
P14	MPLB_MRdDBus[0:C_MPLB_DWIDTH - 1]	-	G4	Width varies with the size of the PLB master data bus.
P35	SPLB_ABus[0:C_SPLB_AWIDTH - 1]	-	G6	Width varies with the size of the PLB address bus.
P41	SPLB_BE[0:C_SPLB_DWIDTH/8 - 1]	-	G7	Width varies with the size of the PLB data bus.
P42	SPLB_wrDBus[0:C_SPLB_DWIDTH - 1]	-	G7	Width varies with the size of the PLB data bus.
P46	SPLB_masterID[0:C_SPLB_MIDWIDTH - 1]	-	G9	Width varies with the size of the PLB number of masters.
P59	SI_rdDBus[0:C_SPLB_DWIDTH - 1]	-	G7	Width varies with the size of the PLB data bus.
P62	SI_MWrErr[0:C_SPLB_NUM_MASTERS - 1]	-	G10	Width varies with the size of the PLB number of masters.
P63	SI_MRdErr[0:C_SPLB_NUM_MASTERS - 1]	-	G10	Width varies with the size of the PLB number of masters.
P70	SI_MBusy[0:C_SPLB_NUM_MASTERS - 1]	-	G10	Width varies with the size of the PLB number of masters.
P74	SI_MIRQ[0:C_SPLB_NUM_MASTERS - 1]	-	G10	Width varies with the size of the PLB number of masters.

Register Descriptions

Table 5 shows the XPS Central DMA Controller registers and their addresses. The remaining unused addresses in the address-range size are reserved. Writing into the reserved registers has no effect. Reading of the reserved registers returns zero. Each register is addressable on a 32-bit boundary. All registers are defined for 32-bit access only. Any partial word access (byte, half-word) has undefined results and return a bus error. The detailed information about these registers is provided in the following section. The register addresses are offset to the base address, C_BASEADDR.

Table 5: Controller Registers

Register Name	Base Address + Offset (hex)	Default Value (hex)	Access
Software Reset Register (RST)	C_BASEADDR + 0	NA	Write ⁽¹⁾
DMA Control Register (DMACR) ⁽²⁾	C_BASEADDR + 4	80000000	R/W
Source Address (SA) ⁽²⁾	C_BASEADDR + 8	00000000	R/W
Destination Address (DA) ⁽²⁾	C_BASEADDR + C	00000000	R/W
Length (LENGTH) ⁽²⁾	C_BASEADDR + 10	00000000	R/W
DMA Status Register (DMASR)	C_BASEADDR + 14	00000000	Read ⁽³⁾
Interrupt Status Register (ISR) ⁽²⁾	C_BASEADDR + 2C	00000000	Read/TOW ⁽⁴⁾
Interrupt Enable Register (IER) ⁽²⁾	C_BASEADDR + 30	00000000	R/W

1. Reading of this register returns zero.
2. These registers are guaranteed to return a consistent value only if read when XPS Central DMA Controller is idle. Inconsistent values can be returned when these registers are sampled in SPLB clock domain while it is changing in the MPLB clock domain.
3. Writing into this register has no effect.
4. TOW =Toggle On Write. Writing a '1' to a bit position within the register causes the corresponding bit position in the register to toggle.

Software Reset Register (RST)

The Software Reset Register (RST) is shown in Figure 2. It is a write only register addressed at an offset 0x0 from base address C_BASEADDR. The bit definitions of this register are as shown in Table 6.

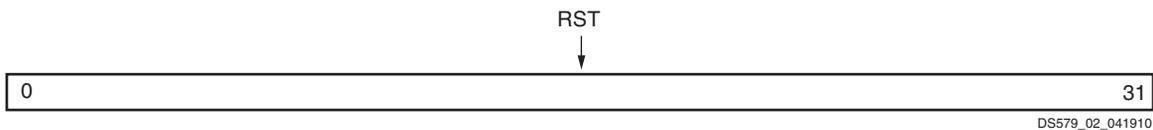


Figure 2: Software Reset Register (RST)

Table 6: RST Register Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 31	RST	Write	N/A	Software Reset A write of 0x0000000A causes reset of the XPS Central DMA Controller. A write of any other value has undefined effect and returns a bus error. A read of this register returns zero.

DMA Control Register (DMACR)

The DMA Control Register (DMACR) is shown in [Figure 3](#). It is a read/write register addressed at an offset 0x4 from base address C_BASEADDR. The bit definitions of this register are as shown in [Table 7](#).

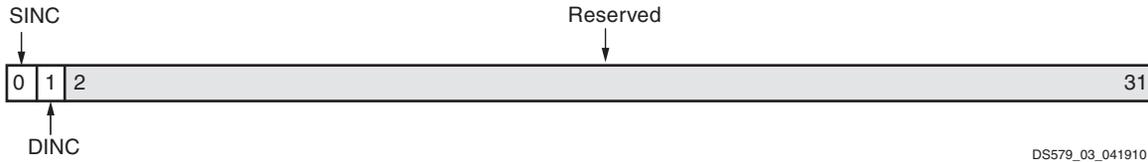


Figure 3: DMA Control Register (DMACR)

Table 7: DMACR Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0	SINC	R/W	'1'	Source Increment: Increment the source address by the number of source bytes read. '1' = Increment the source address. '0' = Do not increment the source address. SINC = '0' is allowed if and only if the Source Address register is written with a <i>keyhole</i> address. See also the An example of a keyhole address note on page 3 .
1	DINC	R/W	'0'	Destination Increment: Increment the destination address by the number of bytes written in to the destination. '1' = Increment the destination address '0' = Do not increment the destination address. DINC = '0' is allowed if and only if the Destination Address register is written with a <i>keyhole</i> address. See also The case DINC = '0' note on page 3 .
2 - 31	Reserved			

Source Address Register (SA)

The Source Address Register (SA) is shown in [Figure 4](#). It is a read/write register addressed at an offset 0x8 from base address C_BASEADDR. The bit definitions of this register are as shown in [Table 8](#).

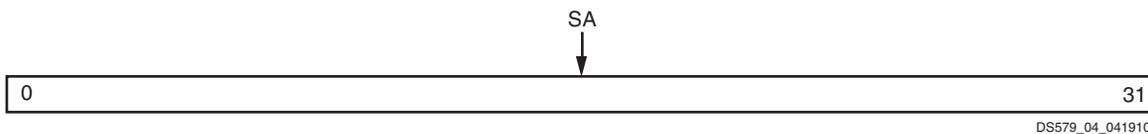


Figure 4: Source Address Register (SA)

Table 8: SA Register Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 31	SA	R/W	0	Source Address: Source address for the current DMA operation. When SINC = '1', as data is moved from the source address, this register updates to track the current source address. When SINC = '0', the source address remains constant at the programmed value. (See also the SINC field of the DMA Control Register).

Destination Address Register (DA)

The Destination Address Register (DA) is shown in Figure 5. It is a read/write register addressed at an offset 0xC from base address C_BASEADDR. The bit definitions of this register are as shown in Table 9.

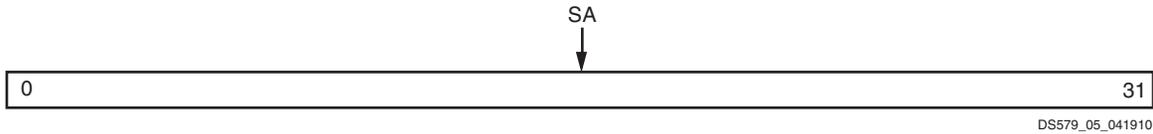


Figure 5: Destination Address Register (DA)

Table 9: DA Register Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 31	DA	R/W	0	Destination Address: Destination address for the current DMA operation. When DINC = '1', as data is moved to the destination address, this register updates to track the current destination address. When DINC = '0', the destination address remains constant at the programmed value. (See also the DINC field of the DMA Control Register.)

Length Register (LENGTH)

Length Register (LENGTH) is shown in Figure 6. It is a read/write register addressed at an offset 0x10 from base address C_BASEADDR. The bit definitions of this register are as shown in Table 10.

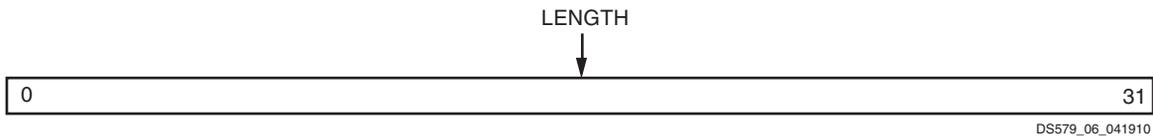


Figure 6: Length Register (LENGTH)

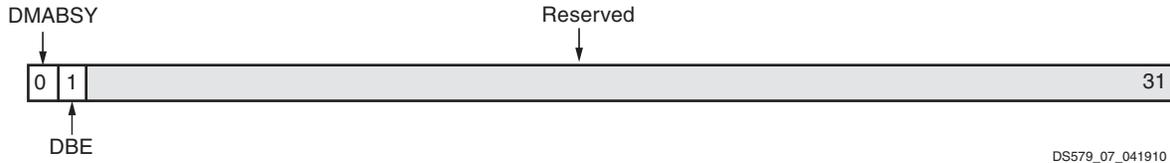
Table 10: LENGTH Register Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 31	LENGTH (1)	R/W	0	Length of the DMA Transfer: The DMA operation starts when the number of bytes to be transferred from source to destination is written to the Length Register. Therefore, this register is written only after the DMA Control register, the Source Address and the Destination Address registers have been written with their desired values and any other setup is complete. As bytes are successfully written to the destination, the Length Register decrements to reflect the number of bytes remaining to be transferred. The Length Register will be zero after a successful DMA operation.

1. If the written value is not a multiple of DSIZE, the transfer is a mix of byte as well as a word transfers. For example, if the Length Register is programmed to ten bytes, the XPS Central DMA Controller will transfer the two bytes using the byte enables as a single transfer. The remaining eight bytes will be transferred as two data word burst. The final value of the Length Register will be zero.

DMA Status Register (DMASR)

The DMA Status Register (DMASR) is shown in Figure 7. It is a read only register addressed at an offset 0x14 from base address C_BASEADDR. A write to this register has no effect. The bit definitions of this register are as shown in Table 11..



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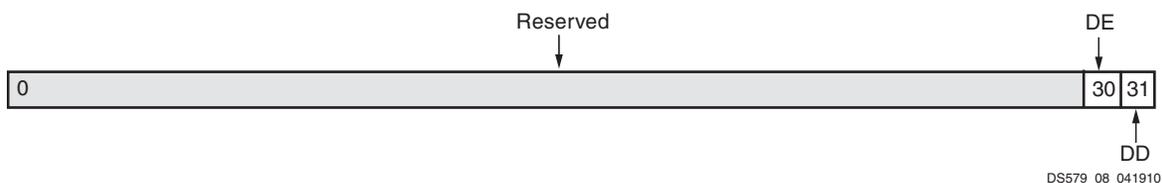
Figure 7: DMA Status Register (DMASR)

Table 11: DMASR Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0	DMABSY	Read	'0'	DMA Busy: '0' = DMA operation is not in progress. '1' = DMA operation is in progress.
1	DBE	Read	'0'	DMA Bus Error: '0' = No DMA bus error. '1' = DMA bus error.
2 - 31	Reserved			

Interrupt Status Register (ISR)

The Interrupt Status Register (ISR) is shown in Figure 8. It is a read/toggle-on-write register addressed at an offset 0x2C from base address C_BASEADDR. The bit definitions of this register are as shown in Table 12. The interrupt status bits are set whenever their corresponding condition holds. The corresponding interrupt enable bit set as false (see Table 13) does not inhibit ISR reporting but does inhibit assertion of the interrupt signal, IP2INTC_Irpt, in response to the interrupt status bit.



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Figure 8: Interrupt Status Register (ISR)

Table 12: ISR Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 29	Reserved			
30	DE	R/TOW	'0'	DMA Error: '0' = DMA error has not occurred. '1' = DMA error has occurred.
31	DD	R/TOW	'0'	DMA Done: '0' = DMA operation is not done. '1' = DMA operation is done.

Interrupt Enable Register (IER)

The Interrupt Enable Register (IER) is shown in Figure 9. It is a read/write register addressed at an offset 0x30 from base address C_BASEADDR. The bit definitions of this register are as shown in Table 13. These bits inhibit assertion of the IP2INTC_Irpt signal in response to the corresponding interrupt status bit (see Table 12).

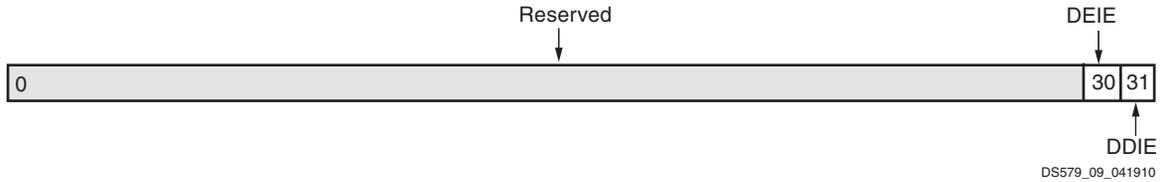


Figure 9: Interrupt Enable Register (IER)

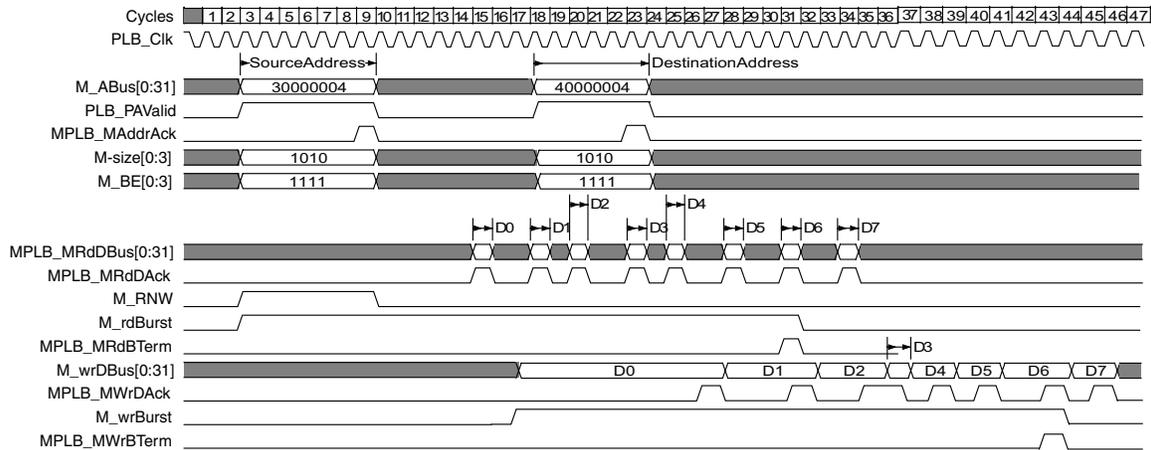
Table 13: IER Bit Definitions

Bits	Name	Core Access	Reset Value	Description
0 - 29	Reserved			
30	DEIE	R/W	'0'	DMA Error Interrupt Enable: Interrupt enable bit for DMA error. '0' = IP2INTC_Irpt will not assert in response to DMA Error interrupt status. '1' = IP2INTC_Irpt will assert in response to DMA Error interrupt status.
31	DDIE	R/W	'0'	DMA Done Interrupt Enable: Interrupt enable bit for DMA done. '0' = IP2INTC_Irpt will not assert in response to DMA Done interrupt status. '1' = IP2INTC_Irpt will assert in response to DMA Done interrupt status.

Timing Diagrams

The following timing diagrams illustrate the XPS Central DMA Controller operation for various read and write transactions of different lengths.

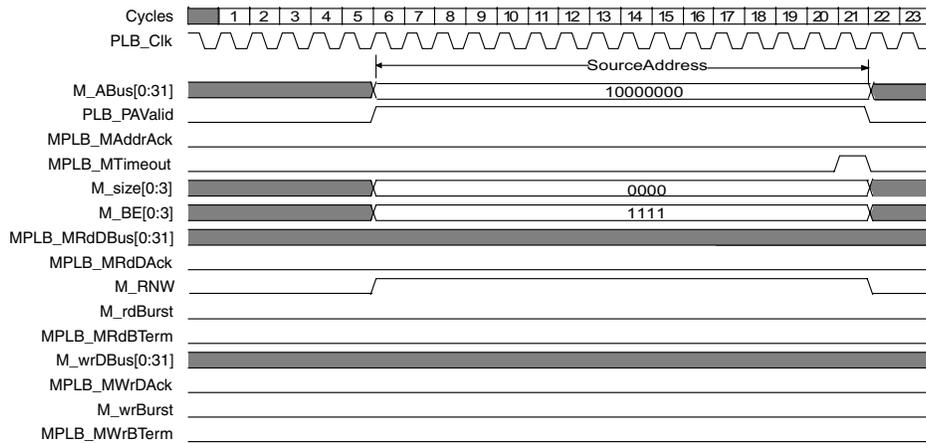
1. Read and write transactions of a 32-bit aligned DMA transfer of length 32 bytes are shown in Figure 10.
2. Read and write transactions of a time-out case in a 32-bit aligned DMA transfer of length 8 bytes are shown in Figure 11 and Figure 12.



- D0 : The first of the 4 bytes of data transferred from Source Address(SA) to Destination Address(DA)
- D1 : The second 4 bytes of data transferred from SA + 0x4 to DA + 0x4
- D2 : The third 4 bytes of data transferred from SA + 0x8 to DA + 0x8
- D3 : The fourth 4 bytes of data transferred from SA + 0xC to DA + 0xC
- D4 : The fifth 4 bytes of data transferred from SA + 0x10 to DA + 0x10
- D5 : The sixth 4 bytes of data transferred from SA + 0x14 to DA + 0x14
- D6 : The seventh 4 bytes of data transferred from SA + 0x18 to DA + 0x18
- D7 : The last 4 bytes of data transferred from SA + 0x1C to DA + 0x1C

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Figure 10: Transaction for 32-bit Aligned DMA Transfer of Length 32



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Figure 11: Read Time Out for 32-bit Aligned DMA Transfer of Length 8

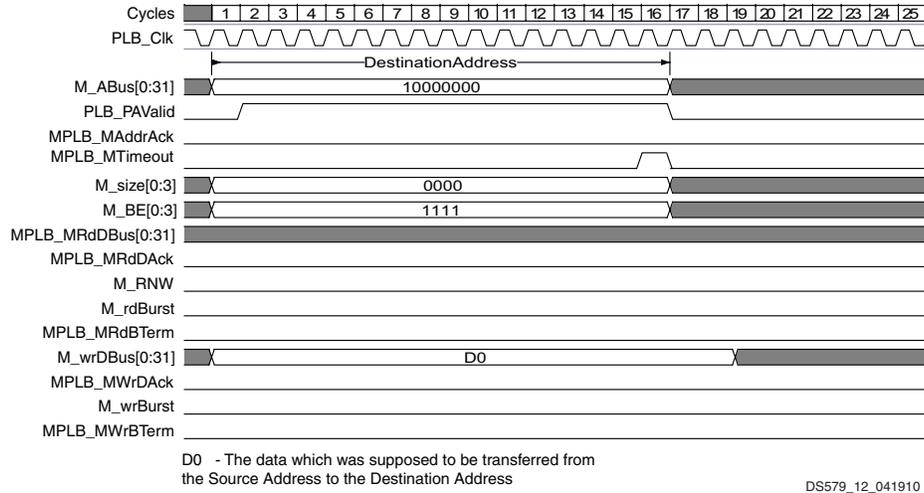


Figure 12: Write Time Out for 32-bit Aligned DMA Transfer of Length 8

Design Implementation

Target Technology

The intended target technology is an FPGA listed in the Supported Device Family field of the [LogiCORE™ IP Facts Table](#).

Device Utilization and Performance Benchmarks

Core Performance

Because the XPS Central DMA Controller core will be used with other design modules in the FPGA, the utilization and timing numbers reported in this section are estimates only. When this core is combined with other designs in the system, the utilization of FPGA resources and timing of the XPS Central DMA Controller design will vary from the results reported here.

Table 14 shows the XPS Central DMA Controller resource utilization for various parameter combinations measured with the Virtex-4 FPGA as the device under test (DUT).

Table 14: Performance and Resource Utilization Benchmarks on the Virtex-4 FPGA (xc4vlx12-10-ff1148)

Parameter Values			Device Resources			Performance
C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE	Slices	Slice Flip-Flops	LUTs	F _{Max} (MHz)
8	8	8	606	378	919	126
16	16	16	600	380	926	128
48	16	16	675	385	940	150
16	16	1	606	372	841	151
32	16	8	710	386	980	150
48	16	8	694	385	957	150

Table 15 shows the XPS Central DMA Controller resource utilization for various parameter combinations measured with Virtex-5 FPGA as the device under test (DUT).

Table 15: Performance and Resource Utilization Benchmarks on the Virtex-5 FPGA (xc5vlx30-1-ff676)

Parameter Values			Device Resources			Performance
C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE	Slices	Slice Flip-Flops	LUTs	F _{Max} (MHz)
8	8	8	297	488	743	179
16	16	16	307	490	748	165
48	16	16	291	504	761	158
16	16	1	280	481	687	171
32	16	8	300	541	801	170
48	16	8	295	516	777	181

Table 16 shows the XPS Central DMA Controller resource utilization for various parameter combinations measured with the Spartan[®]-3E FPGA as the device under test (DUT).

Table 16: Performance and Resource Utilization Benchmarks on the Spartan-3E FPGA (xc3s1600e-4-fg320) FPGA

Parameter Values			Device Resources			Performance
C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE	Slices	Slice Flip-Flops	LUTs	F _{Max} (MHz)
8	8	8	654	378	910	143
16	16	16	659	380	931	128
48	16	16	673	385	944	128
16	16	1	600	372	835	144
32	16	8	707	386	980	143
48	16	8	683	385	954	144

Table 17 shows the XPS Central DMA Controller resource utilization for various parameter combinations measured with the Virtex-6 FPGA as the device under test (DUT)..

Table 17: Performance and Resource Utilization Benchmarks on the Virtex-6 FPGA (xc6vlx195t-1-ff11156)

Parameter Values			Device Resources			Performance
C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE	Slices	Slice Flip-Flops	LUTs	F _{Max} (MHz)
8	8	8	297	383	719	170
16	16	16	298	385	720	174
48	16	16	295	425	727	182
16	16	1	275	379	668	174
32	16	8	315	438	776	160
48	16	8	307	429	748	161

Table 18 shows the XPS Central DMA Controller resource utilization for various parameter combinations measured with Spartan-6 FPGA as the device under test (DUT).

Table 18: Performance and Resource Utilization Benchmarks on the Spartan-6 FPGA (xc6slx45-2-fgg484)

Parameter Values			Device Resources			Performance
C_FIFO_DEPTH	C_RD_BURST_SIZE	C_WR_BURST_SIZE	Slices	Slice Flip-Flops	LUTs	F _{Max} (MHz)
8	8	8	289	564	727	101
16	16	16	299	566	730	100
48	16	16	305	577	720	110
16	16	1	290	553	660	111
32	16	8	315	616	766	112
48	16	8	310	590	737	115

System Performance

To measure the system performance (F_{MAX}) of this core, this core was added the Device Under Test (DUT) to a Virtex-4 FPGA system as shown in Figure 13, a Virtex-5 FPGA system as shown in Figure 14, a Spartan-3A FPGA system as shown in Figure 15, a Spartan-6 FPGA system as shown in Figure 16, and a Virtex-6 FPGA system as shown in Figure 17 as.

Because the XPS Central DMA core will be used with other design modules in the FPGA, the utilization and timing numbers reported in this section are estimates only. When the XPS Central DMA core is combined with other designs in the system, the utilization of FPGA resources and timing of the XPS Central DMA design will vary from the results reported here.

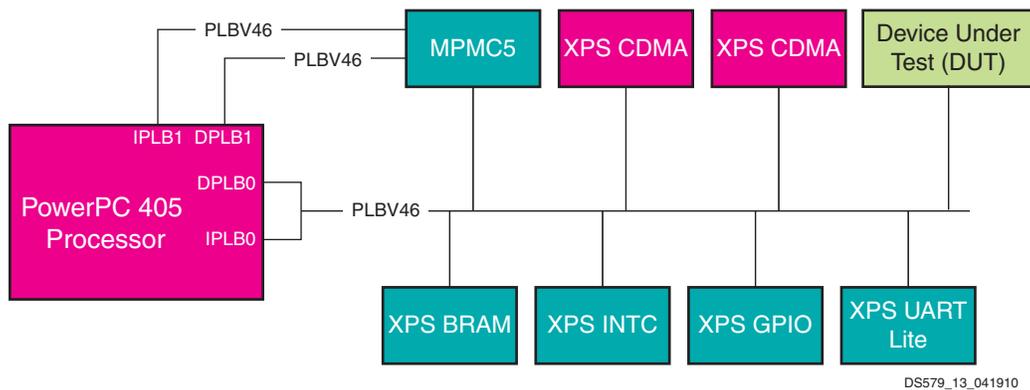


Figure 13: Virtex-4 FX FPGA System the XPS Central DMA core as the DUT

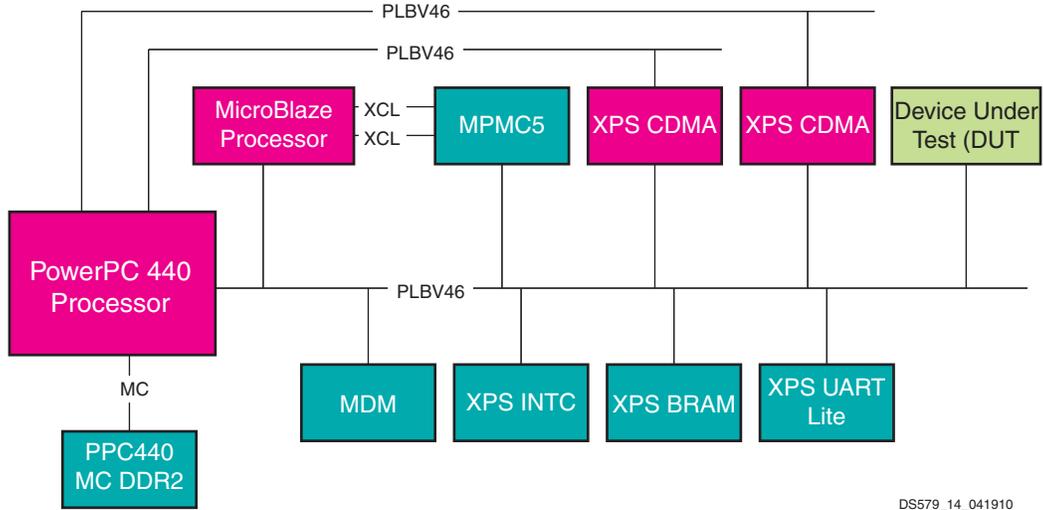


Figure 14: Virtex-5 FX FPGA System the XPS Central DMA core as the DUT

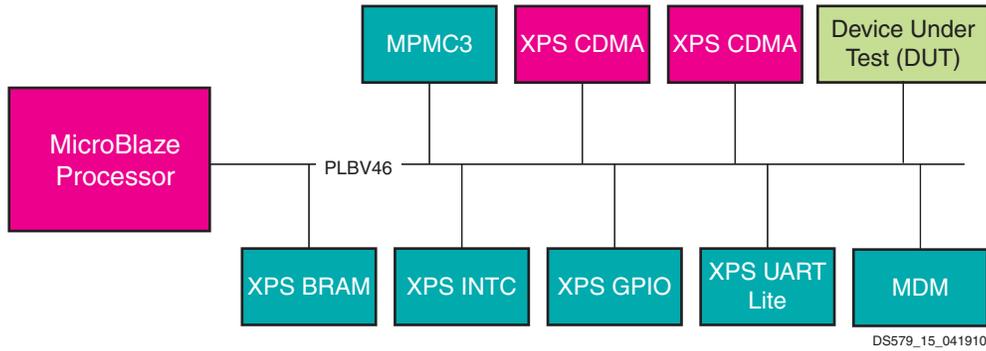


Figure 15: Spartan-3A FX FPGA System the XPS Central DMA core as the DUT

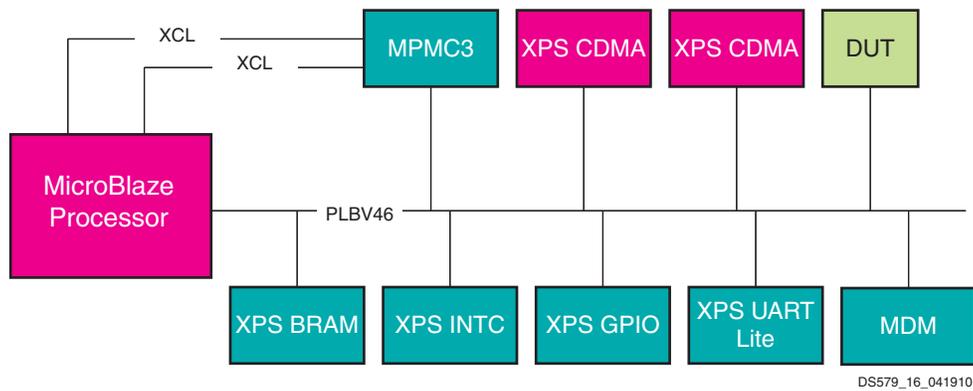


Figure 16: Virtex-6 FPGA System the XPS Central DMA core as the DUT

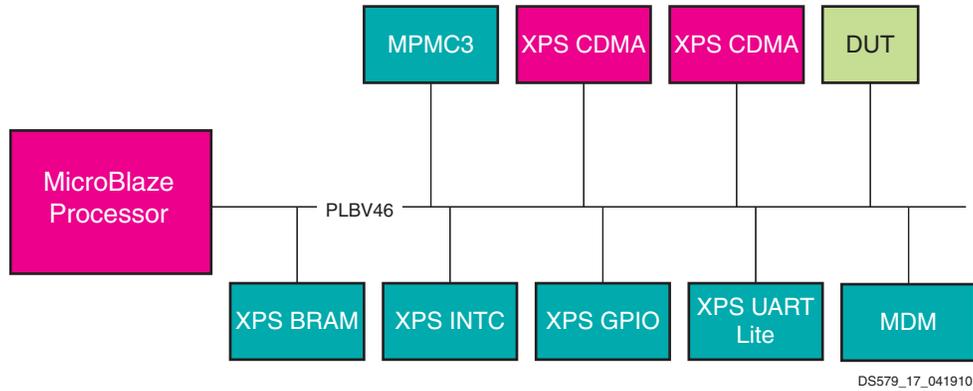


Figure 17: Spartan-6 FPGA System the XPS Central DMA core as the DUT

The target FPGA was then filled with logic to drive the LUT and BRAM utilization to approximately 70% and the I/O utilization to approximately 80%. Using the default tool options and the slowest speed grade for the target FPGA, the resulting target F_{MAX} numbers are shown in Table 19.

Table 19: System Performance

Target FPGA	Estimated F_{MAX} (MHz)
S3A700 -4	90
V4FX60 -10	100
V5LXT50 -1	120
V6LX130t - 1	150
S6LX45t - 2	100

The target F_{MAX} is influenced by the exact system and is provided for guidance. It is not a guaranteed value across all systems.

Specification Exceptions

N/A

Support

Xilinx provides technical support for this LogiCORE product when used as described in the product documentation. Xilinx cannot guarantee timing, functionality, or support of product if implemented in devices that are not defined in the documentation, if customized beyond that allowed in the product documentation, or if changes are made to any section of the design labeled *DO NOT MODIFY*.

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Reference Documents

N/A

Revision History

The following table shows the revision history for this document:

Date	Version	Description of Revisions
10/30/07	1.0	Initial Xilinx release.
7/22/08	2.0	Added QPro Virtex-4 Hi-Rel and QPro Virtex-4 Rad Tolerant FPGA support.
12/22/08	3.0	Removed Virtex-2 Pro support and added Spartan-6 support.
4/24/09	3.1	Replaced references to supported device families and tool name(s) with hyperlink to PDF file.
4/19/10	3.2	Updated to v2.01c for 12.1 release, converted to new DS template; updated Performance and Resource Utilization Benchmark tables for 12.1 release; added Spartan-6 and Virtex-6 details in XPS Central DMA System Performance Table.
7/23/10	3.3	Updated to v2.02.a for 12.2 release.
12/14/10	3.4	Updated to v2.03.a; incorporated CR567919.

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