

Migrating from EDMA v2.0 to EDMA v3.0 TMS320C64X DSP

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DSP Software Applications

ABSTRACT

This application report summarizes the key differences between the enhanced direct memory access (EDMA3) used on C64x+™ DSP devices and the EDMA2 used on TMS320C64x™ DSP devices, and provides guidance for migrating from EDMA2 to EDMA3.

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1 Introduction

A newly designed EDMA3 is introduced on the C64x+ based devices. The EDMA3 has many new features that improve system performance and enhance debugging capabilities. For more details about EDMA3, see the device-specific EDMA3 Controller User's Guide. For example, the DM644x devices use the *TMS320DM644x DMSoC Enhanced Direct Memory Access (EDMA3) Controller User's Guide (SPRUE23)*. For details about EDMA2, see the *TMS3206000 DSP Enhanced Direct Memory Access (EDMA) Controller Reference Guide (SPRU234)*.

1.1 DM644x Example System Architecture Overview

This section discusses the basic EDMA3 architecture, using the DM644x series as an example; the same basic principles from this section apply to other C64x+ based devices. [Figure 1](#) shows the high-level system architecture of the DM644x device.

As shown in [Figure 1](#), the DM644x devices consist of masters, slaves, and a switched central resource (SCR). The masters and slaves are cross connected through the SCR. Masters initiate data transfer between masters and slaves. For example, the masters include the ARM processor, C64x+ CPU (DSP), video port subsystem (VPSS), EDMA transfer controllers, and a crossbar port through which six master peripherals including universal serial bus (USB), Ethernet media access controller (EMAC), AT attachment/Compact Flash (ATA/CF), and a VLYNQ™ communications interface port are connected to the SCR. The slaves include the ARM memory, C64x+ DSP memory, and DDR external memory interface (EMIF) which are connected to the SCR.

The SCR provides connectivity and arbitrations among masters and slaves. It allows concurrent data transfers between unique connections between masters and slaves. For example, the connection between the USB to the DDR2 EMIF is independent of the connection between the ASP and the DSP L2; the two data transfers are in parallel. The SCR handles the arbitration when multiple masters access the same slave. The priority levels among the masters are user programmable.

On C64x™ devices, both regular EDMA transfers and transfers between master peripherals and slaves all go through the EDMA2 transfer controller. Therefore, all the EDMA transfers and other master peripheral transfers compete for the bandwidth sources of the EDMA2 transfer controller.

There is a key difference between the C64x+ device-based system architecture and the C64x DSP-based system architecture. On C64x+ based devices, the EDMA3 transfer controller and other master peripherals are all masters, i.e., ATA/CF and USB on the DM644x device. EDMA3 only handles the data transfer between slaves. The transfers between other master peripherals and slaves do not go through EDMA.

In summary, the system architecture of the DM644x devices provides more concurrence and offers increased system performances.

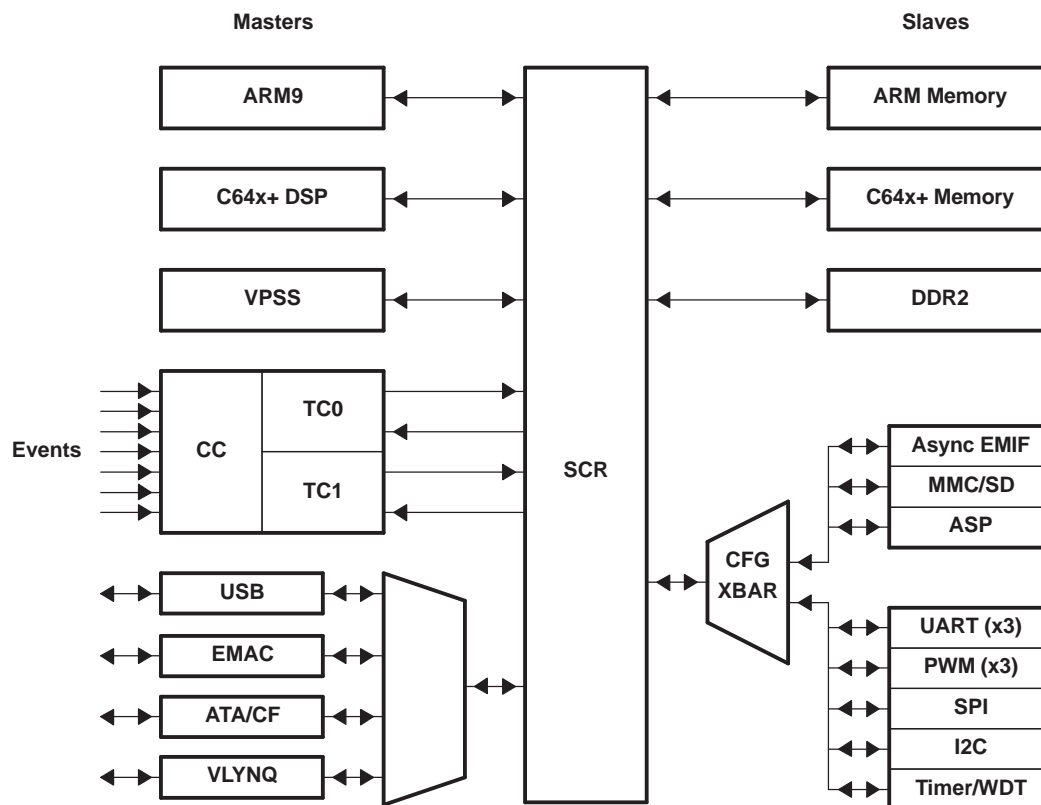


Figure 1. TMS320DM644x Device Block Diagram

1.2 EDMA3 Overview

The EDMA3 consists of a channel controller (CC) and transfer controllers (TC). The DM644x has two transfer controllers as shown in the [Figure 2](#), whereas, the DM643x has three and the C645x has four controllers. You can program the EDMA3 for data transfer between two slaves of a SCR. Programmed transfers are typically between a slave peripheral and a memory (ASP to/from L2 SRAM), or between two slave memories (L2 SRAM to/from EMIF). The EDMA3 supports 64 DMA channels and eight QDMA channels.

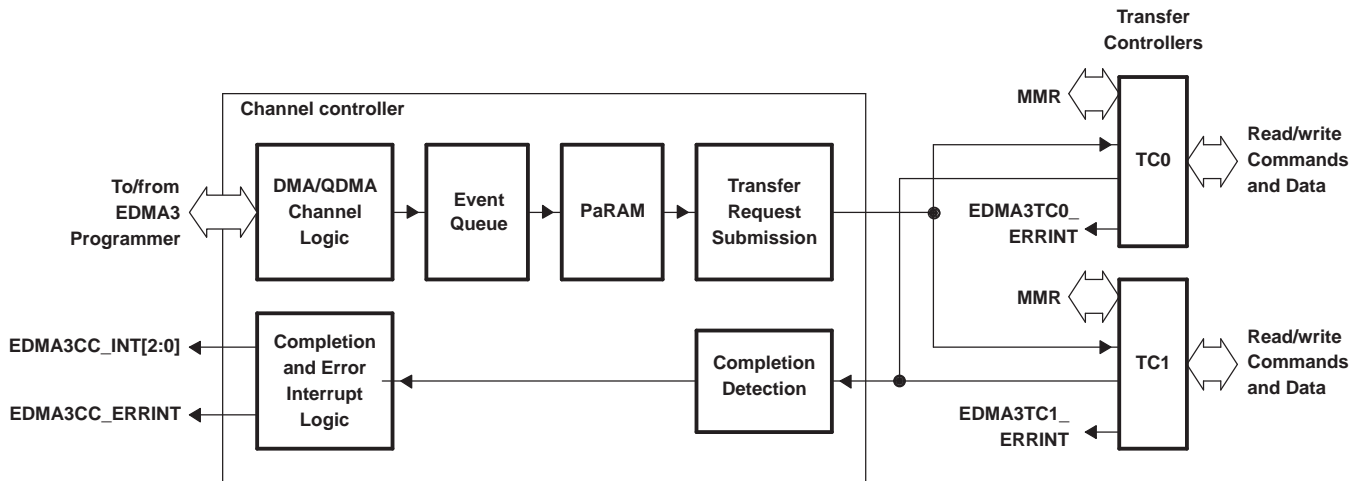


Figure 2. EDMA3 Block Diagram

1.2.1 EDMA3 Channel Controller Overview

[Figure 3](#) shows a high-level block diagram for the EDMA3 channel controller. The channel controller serves as the user interface for the EDMA3. It provides functionalities of detecting trigger events, prioritization of DMA events, queuing, and submitting transfer requests to the EDMA transfer controller for data movement between slave peripherals.

The EDMA3 supports two types of DMA channels: regular DMA channels and QDMA channels. DMA channels can be triggered by external events for example, ASP transmit event and receive event, by software writing a "1" to a given bit location of the event set register of a channel, or by way of chaining. QDMA channels can be triggered by writing to a designated QDMA trigger word.

The channel controller arbitrates among all pending DMA/QDMA events with a fixed 64:1 and 8:1 priority encoder for DMA and QDMA events, respectively; the lowest channel number is the highest priority. DMA events always have higher priority than QDMA events. The winning event is queued into the event queue. There are two event queues. Each event queue is serviced in first-in-first-out (FIFO) order with a maximum of 16 queued events per event queue. If more than one transfer controller is ready to be programmed with a transfer request, the event queues are serviced with fixed priority, Q0 is always higher than Q1.

The channel controller contains 128 parameter RAM (PaRAM) for DM644x and DM643x or 256 parameter RAM for C645x, and supports flexible ping-pong, circular buffering, channel chaining, auto reloading, memory protection, etc.

As soon as the transfer controller is available to be programmed for a new transfer request, events are extracted from the event queue. As an event is extracted from the event queue, the associated PaRAM entry is processed and submitted to the transfer controller. The channel controller updates the appropriate counts and addresses in the PaRAM entry in anticipation of the next trigger event for that PaRAM entry.

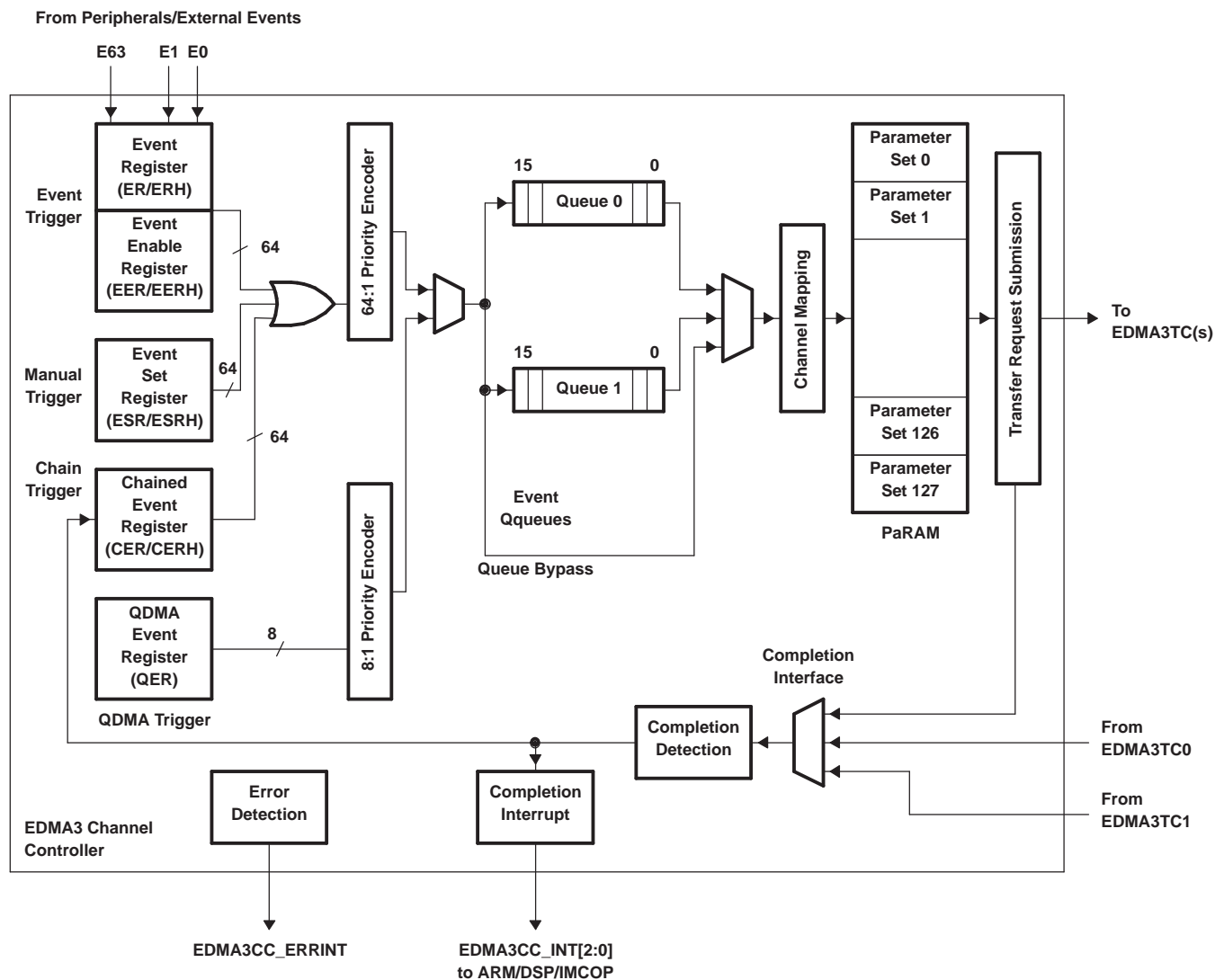


Figure 3. EDMA3 Channel Controller Block Diagram

1.2.2 EDMA3 Transfer Controller Overview

The transfer controller's primary responsibility is to perform read and write transfers to the slaves connected to the SCR as specified by the PaRAM entries. [Figure 4](#) shows a high-level block diagram of the EDMA3 transfer controller. For more details, see the device-specific EDMA3 Controller User's Guide. For example, for the DM644x the *TMS320DM644x DMSoC Enhanced Direct Memory Access (EDMA3) Controller User's Guide* ([SPRUE23](#)).

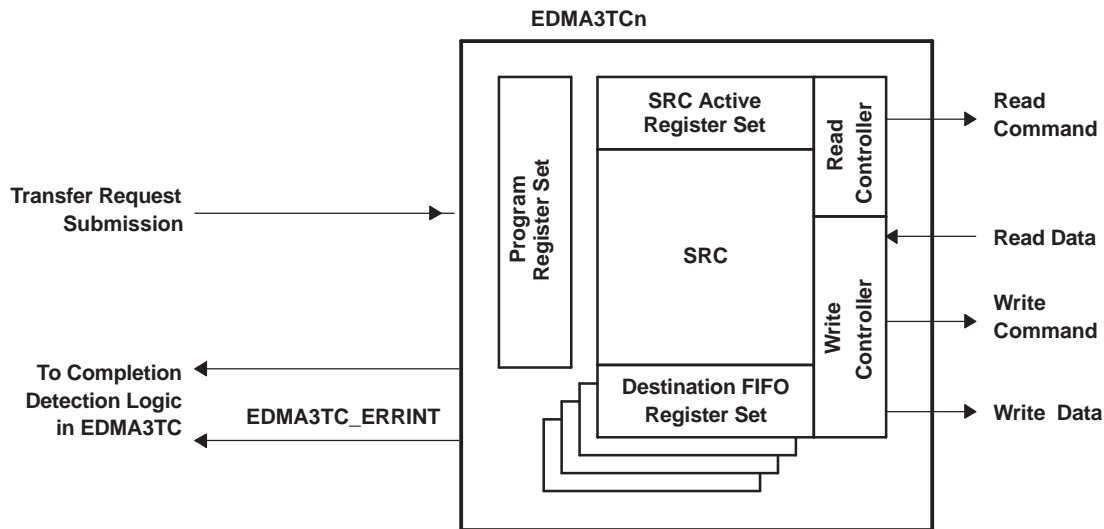


Figure 4. EDMA3 Transfer Controller Block Diagram

1.3 Architecture Comparison Between EDMA3 and EDMA2

On EDMA3-based devices, both the EDMA channel controllers and other Master peripherals are all Masters of a SCR. The EDMA channel controllers and transfer controllers only handle data transfers between two Slaves, such as ASP to DDR2 and/or DDR2 to DSP L2 memory. All other Master peripherals are directly connected to the SCR meaning that they are typically capable of initiating their own transfers; some of the peripherals even have their own DMAs. There are two levels of prioritization related with EDMA.

- One level is within the EDMA channel controller that handles prioritization and arbitration among all the DMA and QDMA schemes.
- The second level is the system level prioritization that configures the prioritization of the EDMA transfer controller versus other Masters. This system level priority resolution is performed by the SCR.

On EDMA2, all the DMA and master transfers go through the EDMA transfer controller. All the DMA transfers and other master transfers compete for the transfer controller bandwidth. The prioritization among all the transfers is done within the transfer controller.

In comparison with the EDMA2, the EDMA3-based devices provide more bandwidth and concurrence for both DMA/QDMA and other master related data transfers. It is capable of providing concurrent transfers for both DMA/QDMA and master transfers assuming all the masters go to different slaves.

1.4 Overview Feature Differences and New Features on EDMA3

Table 1 summarizes the major differences between EDMA3 and EDMA2.

Table 1. Summary of Major Differences Between EDMA3 and EDMA2

Feature	Description	EDMA2	EDMA3
PaRAM	PaRAM entry	6 32-bit words	8 32-bit words
	Number of PaRAM entries	Number depends on devices	128 to 512 depending on the device
	Event mapping to PaRAM	Fixed	Depends on device
	Indexing	Same for source and destination	Different for source and destination
Transfer Type	Dimension of transfer	Two	Three
	Synchronization types	Element synchronized 1-D	A-synchronized transfer
		Frame synchronized 1-D	AB-synchronized transfer
		Array synchronized 2-D	
		Block synchronized 2-D	
QDMA	QDMA location	Outside of EDMA	Part of EDMA
	QDMA channel mapping	NA	Flexible
	QDMA triggering	Write to QDMA pseudo register	Writing to trigger word
	QDMA linking	NA	Flexible
	STATIC bit in OPT for QDMA	NA	New feature on EDMA3
Interrupt	Interrupt types	No error interrupt	Transfer completion interrupt error interrupt
	Interrupt registers		Some new interrupt registers are introduced
	Region interrupt	NA	New feature on EDMA3
Event Queue	Number of event queues	4	2 to 4
	Queue length	16	16
	Queue utilization	Shared by DMA/QDMA and other master peripherals	Used only by EDMA/QDMA channels
	Event queue timing	Fire-and-Forget	Need to wait for TR submitted to TC to update PaRAM
Priority Processing	Mapping between events and event queues	Through PRI of OPT field	Through QUEPRI registers
	Queue priority versus other master transfers	Arbitrated at transfer controller (TC)	Arbitrated at switch center resource (SCR)
Linking	DMA linking feature availability	Available (optional)	Always
	QDMA linking feature availability	NA	Always
	Terminating linking	Link to a NULL entry	Configure FFFFh of LINK field of last linked PaRAM
Chaining	Chaining comparison	Use same bits for enabling chain and interrupt	Use different bits for enabling chain and interrupt
Set and Clear	Set and clear operation	NA	New feature on EDMA3
DMA Region Access	DMA region access	NA	New feature on EDMA3
Debug Visibility	Event queue visibility	NA	New feature on EDMA3
	Event queue watermarking	NA	New feature on EDMA3
	Event queue threshold	NA	New feature on EDMA3
Error Detection	Event missed registers	NA	New feature on EDMA3
	Channel controller error registers	NA	New feature on EDMA3
	Error from null parameter entry	NA	New feature on EDMA3
	Error interrupts	NA	New feature on EDMA3

Table 2. Summary of EDMA3 Differences Between C64x+ Devices

Feature	DM644x	DM643x	C645x	DM648	DM35x	C6474
Number of DMA Channels	64	64	64	64	64	64
Number of QDMA Channels	8	8	4	8	8	8
Number of Interrupt Channels	64	64	64	64	64	64
Number of PaRAM Entries	128	128	256	512	128	256
Number of Transfer Controllers	2	3	4	4	2	6
Number of Regions	2	2	8	8	4	8
DMA Channel Mapping	No	No	Yes	No	No	Yes
Memory Protection Support	No	No	Yes	Yes	No	Yes

2 Comparison Between EDMA3 and EDMA2

Although both EDMA3 and EDMA2 use RAM-based architecture, there are key differences related to PaRAM entries as summarized in this section.

2.1 PaRAM Set

Similar to EDMA2, the EDMA3 controller is also a RAM-based architecture and each EDMA channel transfer context (source/destination addresses, count, indexes, etc.) is programmed in a parameter table (see [Figure 5](#) and [Figure 6](#)). The table is a block of parameter RAM (PaRAM) located within the EDMA channel controller.

	31		0
Word 0	Channel Options Parameter (OPT)		
Word 1	Channel Source Address (SRC)		
Word 2	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)	
Word 3	Channel Destination Address (DST)		
Word 4	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)	
Word 5	BCNT Reload (BCNTRLD)	Link Address (LINK)	
Word 6	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)	
Word 7	Reserved	Count for 3rd Dimension (CCNT)	

Figure 5. PaRAM Entry for EDMA3

	31		0
Word 0	Channel Options Parameter (OPT)		
Word 1	Channel Source Address (SRC)		
Word 2	Array/Frame Count (FRMCNT)	Element Count (ELECNT)	
Word 3	Channel Destination Address (DST)		
Word 4	Array/Frame Index (FRMIDX)	Element Index (ELEIDX)	
Word 5	Element Count Reload (ELERLD)	Link Address (LINK)	

Figure 6. PaRAM Entry for EDMA2

2.1.1 PaRAM Entries

On EDMA3 ([Figure 5](#)), the PaRAM entry size is eight 32-bit words; on EDMA2 ([Figure 6](#)), the PaRAM entry size is six 32-bit words. [Table 3](#) summarizes the comparisons between the two PaRAM entries.

Table 3. Summary of PaRAM Comparison Between EDMA3 and EDMA2

PaRAM Entry	EDMA2	EDMA3
OPT field	See the <i>TMS320C6000 DSP Enhanced Direct Memory Access (EDMA) Controller Reference Guide (SPRU234)</i> .	Significant changes have been introduced. See the <i>TMS320DM644x DMSoC Enhanced Direct Memory Access (EDMA3) Controller User's Guide (SPRUE23)</i> .
Count	Only ELECNT and FRMCNT are available to specify 2-dimension transfers.	ACNT, BCNT, and CCNT are introduced to specify the sizes for 3-dimension transfers.
Index	Both source and destination use the same indexes ELEIDX and FRMIDX.	Source indexes (SRCBIDX and SRCCIDX) and destination indexes (DSTBIDX and DSTCIDX) are introduced and allow independent source and destination indexing.
DST and SRC fields	Both EDMA3 and EDMA2 have 32-bit source and destination fields specifying the source and destination addresses.	
Link field	Both EDMA3 and EDMA2 have 16-bit link field specifying the linking address.	
Reload field	The ELERLD field on EDMA2 is equivalent to the BCNTRLD field on EDMA3	

2.1.2 Number of PaRAM Entries

[Table 4](#) summarizes the number of PaRAM entries for some EDMA3-based devices and EDMA2-based devices. See your device-specific data manual for the number of PaRAM entries on your device.

Table 4. Number of PaRAM Entries for Different Devices

Device	EDMA Type	Number of PaRAM Entries
TMS320C6415 DSP	EDMA2	83
TMS320DM642 DSP	EDMA2	200
TMS320DM644x DMSoC	EDMA3	128
TMS320DM643x DMSoC	EDMA3	128
TMS320DM645x DSP	EDMA3	256
TMS320C6474 DSP	EDMA3	256

2.1.3 Event Mapping to PaRAM

Depending on the C64x+ based devices, the mapping between the DMA numbers and the PaRAM sets is either fixed, one-to-one mapping or programmable. For example, channel (event) 0 is mapped to PaRAM set 0, channel (event) 1 is mapped to PaRAM set 1, etc., in DM643x or DM644x devices; however, the C645x devices can configure this through the DCHMAP register. The mapping between the QDMA channels and the PaRAM sets is programmable. Map any of the eight QDMA channels to any of the 128 PaRAM entries through the QDMA channel mapping registers, QCHMAP0 to QCHMAP7, shown in Figure 7.

On EDMA2, the mapping between the 64 DMA channels and the PaRAM entries and the mapping between the DMA events and the PaRAM entries are fixed. For example, event 0 is permanently mapped to the first PaRAM entry and event 1 is permanently mapped to the second PaRAM. Five QDMA registers, not PaRAM, are used for configuration of QDMA transfers.

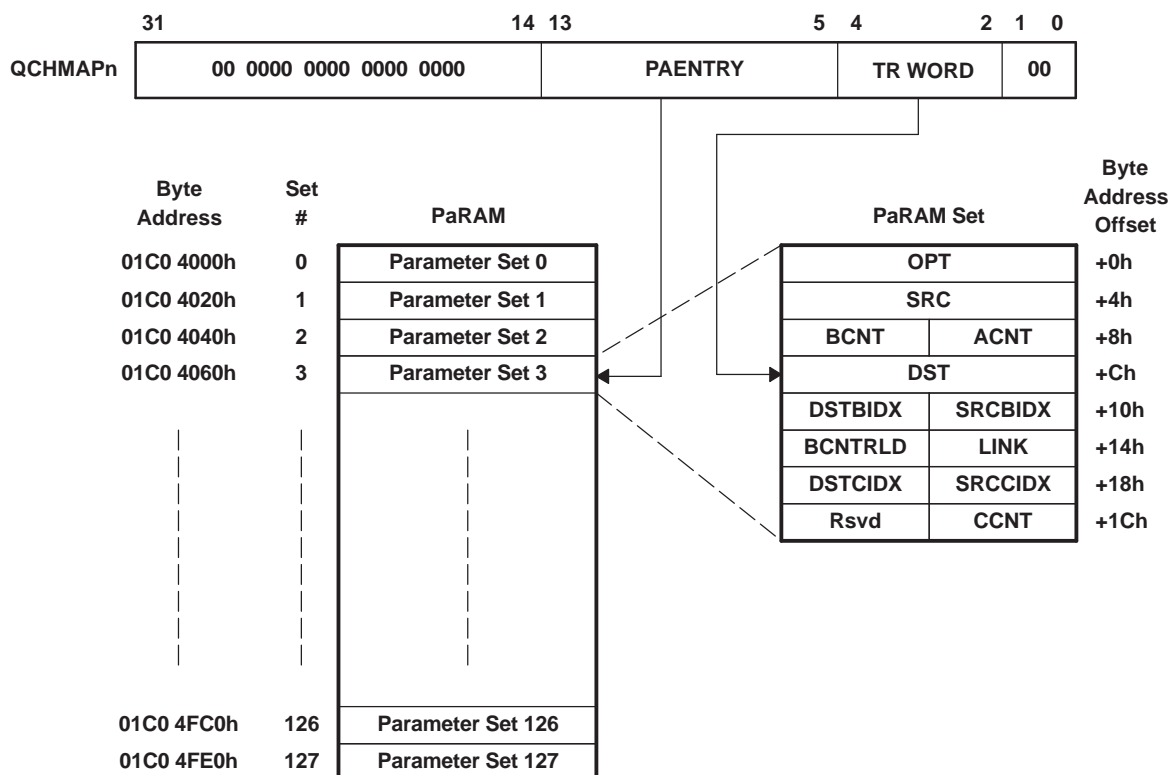


Figure 7. DMA and QDMA Channel Mapping to PaRAM

2.1.4 Dimension of Transfer

Unlike EDMA2, the EDMA3 uses more orthogonal structure for its DMA transfers. Each transfer is always defined by three dimensions. Of the three dimensions, only two synchronization types are supported: A-synchronized transfers and AB-synchronized transfers. ABC-synchronized transfers can be logically achieved using chaining. The three dimensions are shown in Figure 8 and summarized as follows:

- First dimension or array (A): The first dimension in a transfer consists of ACNT contiguous bytes. The total transfer size is ACNT bytes.
- Second dimension or frame (B): The second dimension in a transfer consists of BCNT arrays of ACNT bytes. Each array transfer in the second dimension is separated from each other by an index programmed using SRCBIDX or DSTBIDX. The total transfer size is ACNT × BCNT bytes.
- Third dimension or block (C): The third dimension in a transfer consists of CCNT frames of BCNT arrays programmed using SRCCIDX or DSTCIDX. The total transfer size is ACNT × BCNT × CCNT bytes.

On EDMA2, the transfer is defined as:

- First dimension or frame: The first dimension in a transfer consists of ELECNT elements and the consecutive elements are separated by ELEIDX. The element size is defined as ELECNT × ESIZE bytes, if ESIZE is configured as the number of bytes.
- Second dimension: The second dimension in a transfer consists of FRMCNT frames of ELECNT elements. Each frame transfer in the second dimension is separated from each other by the FRMIDX index. The total transfer size is FRMCNT × ELECNT × ESIZE bytes, if ESIZE is configured as the number of bytes.

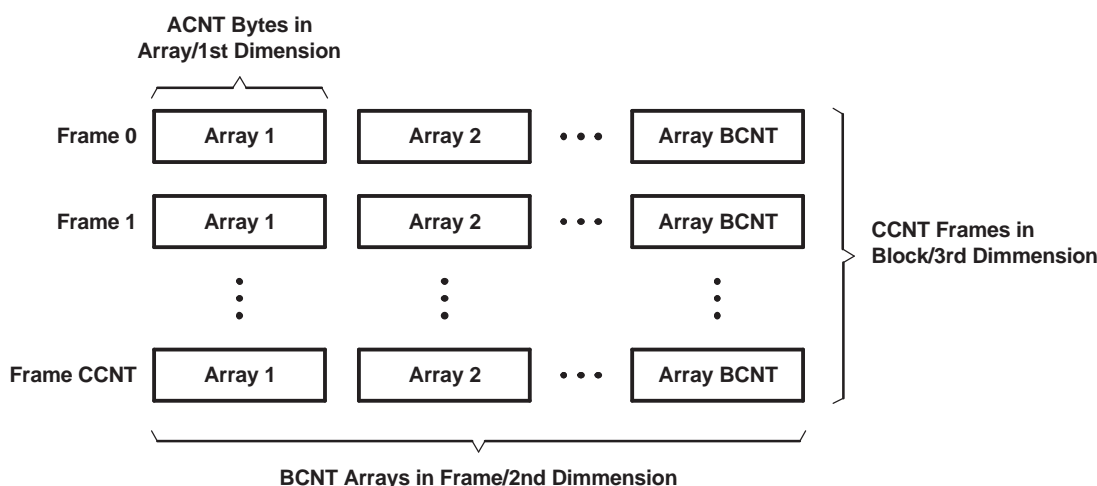


Figure 8. Dimension of Array, Frame, and Block

2.1.5 Indexing

EDMA2 uses the same two indexes, ELEIDX and FRMIDX, to specify the offset between the consecutive two elements or two frames for both source and destination.

EDMA3 uses different indexes for source and destinations. It uses SRCBIDX and DSTBIDX to specify the offsets between the two consecutive arrays and two consecutive frames for source indexing. It uses DSTBIDX and DSTCIDX to specify destination indexing. Figure 9 and Figure 10 show two examples demonstrating the potential indexing differences between EDMA2 and EDMA3.

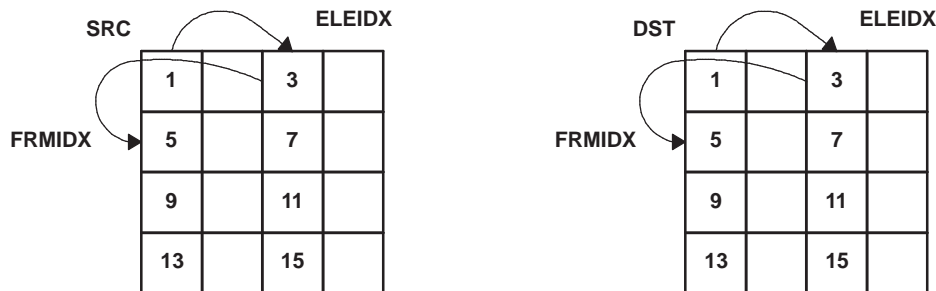


Figure 9. Indexing Example for EDMA2

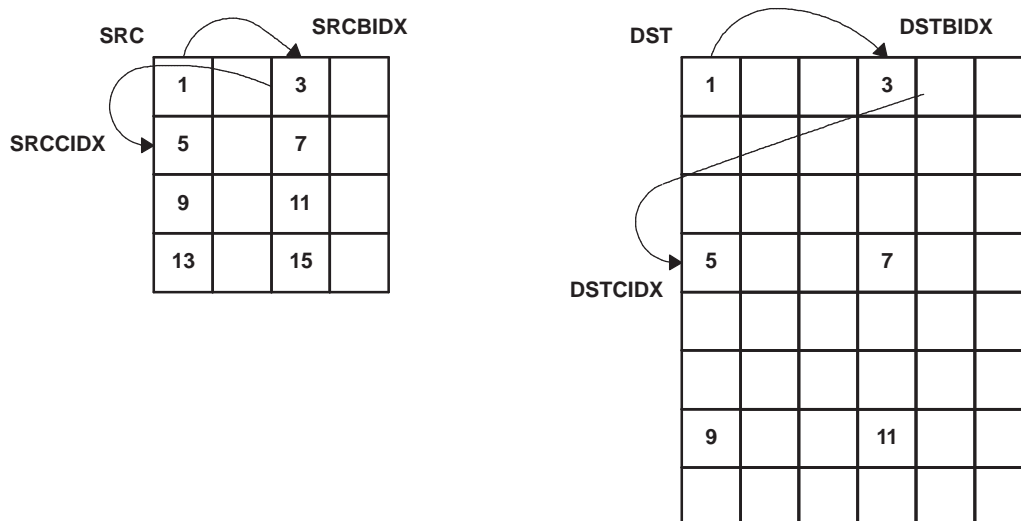


Figure 10. Indexing Example for EDMA3

2.2 EDMA3 Synchronization Type

There are two synchronization types on EDMA3: A and AB.

- **A-Synchronized Transfers:** In an A-synchronized transfer, each transfer request sync triggers the transfer of the first dimension of the ACNT bytes or one array of the ACNT bytes. Therefore, each TR packet consists of transfer information for one array only. Arrays can be separated by SRCBIDX and DSTBIDX as shown in Figure 11, where the start address of Array N is equal to the start address of Array N – 1 + (SRCBIDX or DSTBIDX).
- **AB-Synchronized Transfers:** In an AB-synchronized transfer, each transfer request sync triggers the transfer for two dimensions or for one entire frame of the BCNT of ACNT bytes. Arrays can be separated by SRCBIDX and DSTBIDX and frames can be separated by SRCIDX and DSTIDX. After a transfer request is submitted, the addresses are updated by adding SRCIDX and DSTIDX to the beginning addresses of the beginning array in the frame as shown in Figure 12.

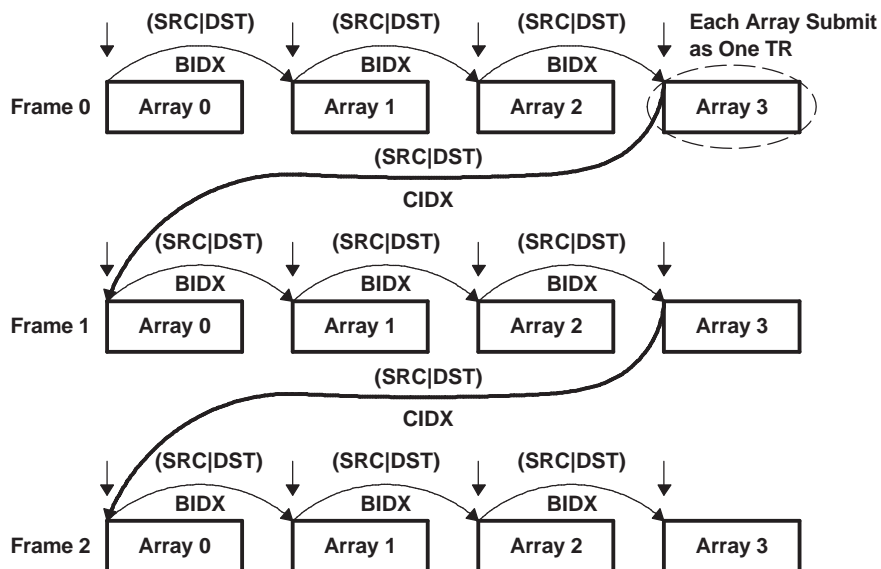


Figure 11. A-Synchronized Transfers (ACNT = n, BCNT = 4, CCNT = 3)

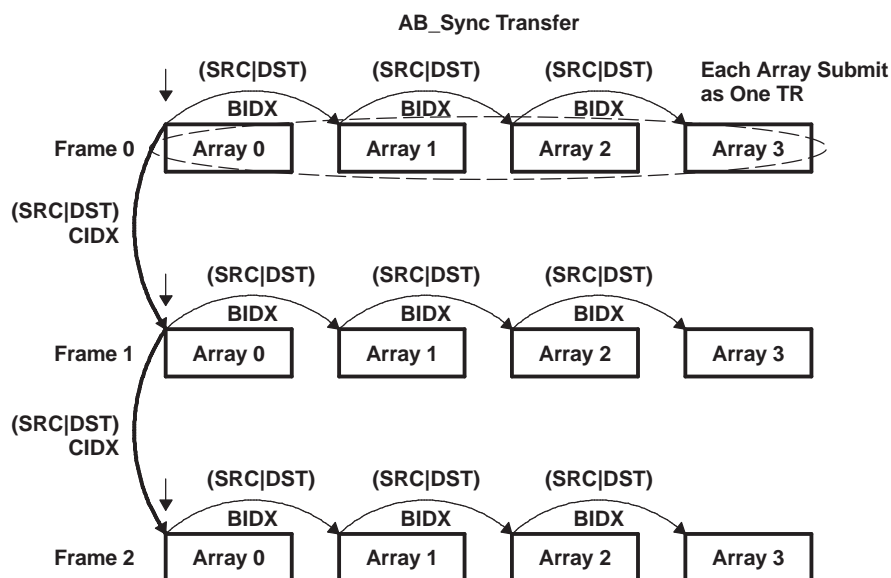


Figure 12. AB-Synchronized Transfers (ACNT = n, BCNT = 4, CCNT = 3)

EDMA2 has the following synchronization types for its DMA transfers:

- Element Synchronized 1-D Transfer (FS = 0)
- Frame Synchronized 1-D Transfer (FS = 1)
- Array Synchronized 2-D Transfer (FS = 0)
- Block Synchronized 2-D Transfer (FS = 1)

For more details on EDMA2 synchronization types, see the *TMS320C6000 DSP Enhanced Direct Memory Access (EDMA) Controller Reference Guide* ([SPRU234](#)).

2.3 Example of Element Synchronized 1-D-to-1-D Transfer on EDMA2

Figure 13 shows a block diagram of an element synchronized 1-D-to-1-D transfer and the configuration on EDMA2. The source address is from a fixed location. The data is copied to continue addresses in destination.

(a) Transfer Path



(b) EDMA Parameters

Parameter Contents		Parameter	
2020 0000h		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0002h	0004h	Array/Frame Count (FRMCNT)	Element Count (ELECNT)
Destination Address		Channel Destination Address (DST)	
Don't care	Don't care	Array/Frame Index (FRMIDX)	Element Index (ELEIDX)
0004h	Don't care	Element Count Reload (ELERLD)	Link Address (LINK)

©) EDMA Channel Options Parameter (OPT) Content

31	29	28	27	26	25	24	23	22	21	20	19	16
001	00	0	00	0	01	0	0000					
PRI	ESIZE	2DS	SUM	2DD	DUM	TCINT	TCC					
15	14	13	12							2	1	0
0	00						000 0000 0000			0	0	
Rsvd	TCCM						Reserved			LINK	FS	

Figure 13. Element Synchronized 1-D-to-1-D Transfer (SUM = 00, DUM = 01) on EDMA2

On EDMA3, the A-synchronization type is used for this EDMA2 element synchronized 1-D-to-1-D transfer. At every synchronization event, ACNT bytes are transferred from source to destination until all the counters are exhausted. Figure 14 shows the configuration for PaRAM entry and the channel options parameter content for this transfer example.

(a) EDMA Parameters

Parameter Contents		Parameter	
0010 000Bh		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0004h	0004h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
Destination Address		Channel Destination Address (DST)	
0004h	0004h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0004h	FFFFh	BCNT Reload (BCNTRLD)	Link Address (LINK)
0004h	0004h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0003h	Reserved	Count for 3rd Dimension (CCNT)

(b) EDMA Channel Options Parameter (OPT) Content

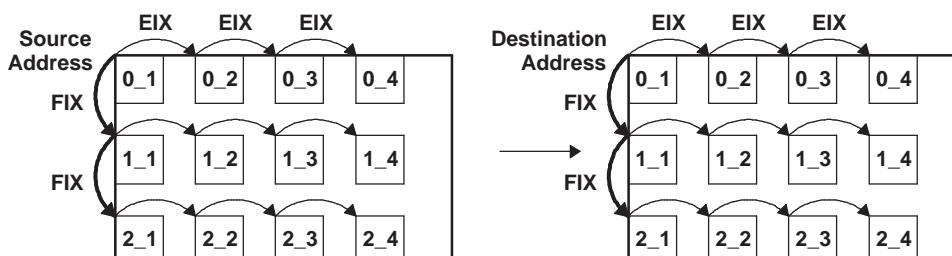
31	30	28	27	24	23	22	21	20	19	18	17	16
0	000	0000		0	0	0	1	xx		00		
PRIV	Reserved		PRIVID	ITCCHEN		TCCHEN	ITCINTEN	TCINTEN	Reserved		TCC	
15	12	11	10	8	7	4			3	2	1	0
0000		0	000	0000				1	0	1	1	
TCC		TCCMOD		FWID		Reserved			STATIC	SYNCDIM	DAM	SAM

Figure 14. Element Synchronized 1-D-to-1-D Transfer on EDMA3

2.4 Example of Frame Synchronized 1-D-to-1-D Transfer on EDMA2 and EDMA3

Figure 15 shows a block diagram of a frame synchronized 1-D-to-1-D transfer and the configuration on EDMA2. At every synchronization event, a frame of elements is transferred from source location to destination.

(a) Transfer Path



(b) EDMA Parameters

Parameter Contents		Parameter	
2360 0001h		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0002h	0004h	Array/Frame Count (FRMCNT)	Element Count (ELECNT)
Destination Address		Channel Destination Address (DST)	
FIX (frame index)	EIX (element index)	Array/Frame Index (FRMIDX)	Element Index (ELEIDX)
Don't care	Don't care	Element Count Reload (ELERLD)	Link Address (LINK)

©) EDMA Channel Options Parameter (OPT) Content

31	29	28	27	26	25	24	23	22	21	20	19	16
001	00	0	11	0	11	0	0000					
PRI	ESIZE	2DS	SUM	2DD	DUM	TCINT	TCC					
15	14	13	12							2	1	0
0	00						000 0000 0000			0	1	
Rsvd	TCCM						Reserved			LINK	FS	

Figure 15. Frame Synchronized 1-D-to-1-D Transfer (SUM = 11, DUM = 11) on EDMA2

On EDMA3, the AB-synchronization type is used for this EDMA2 frame synchronized 1-D-to-1-D transfer. At every synchronization event, the ACNT × BCNT bytes are transferred from source to destination until all the counters are exhausted. [Figure 16](#) shows the configuration for PaRAM entry and the channel options parameter content for this transfer example.

(a) EDMA Parameters

Parameter Contents		Parameter	
0010 000Fh		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0004h	0004h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
Destination Address		Channel Destination Address (DST)	
EIX (element index)	EIX (element index)	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0000h	FFFFh	BCNT Reload (BCNTRLD)	Link Address (LINK)
FIX (frame index)	FIX (frame index)	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0003h	Reserved	Count for 3rd Dimension (CCNT)

(b) EDMA Channel Options Parameter (OPT) Content

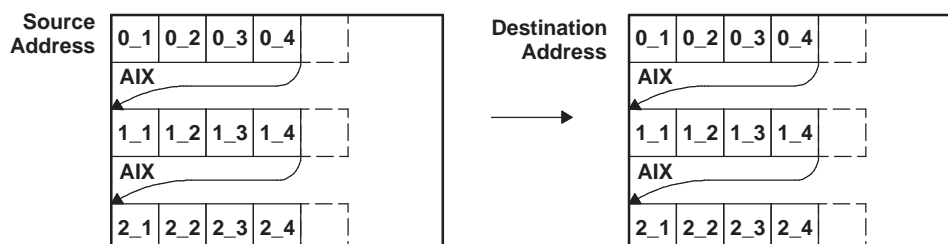
31	30	28	27	24	23	22	21	20	19	18	17	16
0	000	0000		0	0	0	1	xx		00		
PRIV	Reserved		PRIVID	ITCCHEN		TCCHEN	ITCINTEN	TCINTEN	Reserved		TCC	
15	12	11	10	8	7	4		3	2	1	0	
0000		0	000	0000				1	1	1	1	
TCC		TCCMOD	FWID	Reserved				STATIC	SYNCDIM	DAM	SAM	

Figure 16. Frame Synchronized 1-D-to-1-D Transfer on EDMA3

2.5 Example of Block Synchronized 2-D-to-2-D Transfer on EDMA2 and EDMA3

Figure 17 shows a block diagram of a block synchronized 2-D-to-2-D transfer and the configuration on EDMA2. At every synchronization event, a block of several frames of data is copied from source address to destination address.

(a) Transfer Path



(b) EDMA Parameters

Parameter Contents		Parameter	
65A0 0001h		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0002h	0004h	Array/Frame Count (FRMCNT)	Element Count (ELECNT)
Destination Address		Channel Destination Address (DST)	
AIX (array index)	Don't care	Array/Frame Index (FRMIDX)	Element Index (ELEIDX)
Don't care	Don't care	Element Count Reload (ELERLD)	Link Address (LINK)

©) EDMA Channel Options Parameter (OPT) Content

31	29	28	27	26	25	24	23	22	21	20	19	16			
011		00		1	01		1	01		0	0000				
PRI			ESIZE		2DS		SUM		2DD		DUM		TCINT	TCC	
15	14	13	12								2		1	0	
0	00		000 0000 0000									0	1		
Rsvd		TCCM		Reserved								LINK		FS	

Figure 17. Block Synchronized 2-D-to-2-D Transfer (SUM = 01, DUM = 01) on EDMA2

On EDMA3, the AB-synchronization type is used for this EDMA2 block synchronized 2-D-to-2-D transfer. At every synchronization event, a block of data specified by the ACNT × BCNT × CCNT bytes is transferred from source to destination. [Figure 18](#) shows the configuration for PaRAM entry and the channel options parameter content for this transfer example.

(a) EDMA Parameters

Parameter Contents		Parameter	
0010 000Fh		Channel Options Parameter (OPT)	
Source Address		Channel Source Address (SRC)	
0003h	0010h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
Destination Address		Channel Destination Address (DST)	
10h + AIX (array index)	10h + AIX (array index)	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0000h	FFFFh	BCNT Reload (BCNTRLD)	Link Address (LINK)
0000h	0000h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0001h	Reserved	Count for 3rd Dimension (CCNT)

(b) EDMA Channel Options Parameter (OPT) Content

31	30	28	27	24	23	22	21	20	19	18	17	16
0	000	0000		0	0	0	1	xx		00		
PRIV	Reserved		PRIVID	ITCCHEN		TCCHEN	ITCINTEN	TCINTEN	Reserved		TCC	
15	12	11	10	8	7	4			3	2	1	0
0000		0	000	0000				1	1	1	1	
TCC		TCCMOD	FWID	Reserved				STATIC	SYNCDIM	DAM	SAM	

Figure 18. Block Synchronized 2-D-to-2-D Transfer on EDMA3

2.6 QDMA Comparison Between EDMA3 and EDMA2

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2.6.1 QDMA Architecture Differences Between EDMA3 and EDMA2

Table 5 summarizes the QDMA architecture differences between EDMA3 and EDMA2.

Table 5. Summary of QDMA Architecture Differences Between EDMA3 and EDMA2

Feature	EDMA2	EDMA3
QDMA location	QDMA is part of the L2 cache controller that is a separate hardware module from EDMA channel and transfer controllers.	QDMA is an integral part of the EDMA channel controller as shown in Figure 3 .
PaRAM versus register for QDMA context saving	QDMA registers and pseudo registers for storing the contexts for its QDMA transfers.	Similar to DMA transfer, the PaRAM entry table is used for storing the QDMA transfer context including synchronization type, source, destination addresses, etc.
QDMA event queue comparison	Event queue stores the actual transfer context from either PaRAM for DMA or from QDMA registers for QDMA transfer, once the transfer request is admitted into event queue. The difference is on EDMA2, once the transfer request is admitted into the event queue, the QDMA registers are ready to be reconfigured by you for a new transfer. But on EDMA3, even after QDMA PaRAM set has been programmed, you still need to wait until the transfer request is submitted into the transfer controller to begin configuring the related PaRAM entry for a new transfer. Otherwise, the content of the PaRAM entry of the current QDMA transfer could be corrupted while the transfer request is waiting in the event queue. You need to be aware of this difference when configuring PaRAM for the QDMA transfer on EDMA3.	Two event queues are used for storing the indexes of DMA and QDMA events, rather than the actual context of PaRAM entries of the transfers. Only when the transfer request is submitted to the EDMA transfer controller, the actual transfer context is loaded into the transfer controller.
Number of QDMA channels	There is only one QDMA channel. Because the event queue on EDMA2 stores the actual transfer context and you can submit a new QDMA transfer once its current QDMA transfer request is admitted into the queue, EDMA2 can have multiple outstanding QDMA transfer requests waiting in the event queue. It's equivalent to having multiple QDMA channels. On EDMA2, you can allocate up to a maximum seven queue length of an event queue for QDMA. So equivalently, it has up to seven QDMA channels.	Four to eight QDMA channels depending on the device (C6455 is limited to four). So at any given time you can submit up to eight outstanding QDMA requests.

2.6.2 QDMA Channel Mapping to PaRAM on EDMA3

On the EDMA3, similar to DMA transfer, the PaRAM entry table is used to specify QDMA transfer. As previously mentioned, each PaRAM entry has eight 32-bit words. The PAENTRY field in the QDMA channel mapping register, QCHMAP n , is used for mapping QDMA channel n to any one of the PaRAM entries as shown in [Figure 7](#).

As mentioned in the previous section, QDMA on EDMA2 does not use the PaRAM for storing transfer context. Rather, two sets of the registers QDMA and QDMA pseudo registers are used for storing configuration information for QDMA transfer.

2.6.3 Triggering QDMA on EDMA3

On the EDMA3, you can specify a trigger word from any one of the eight 32-bit words of PaRAM for QDMA. Writing to the trigger word triggers the channel controller of QDMA to issue a transfer request. The trigger word, TRWORD, field in the QDMA Channel Mapping Register (QCHMAP n) defines the trigger word for a particular QDMA channel n as shown in [Figure 7](#).

This flexibility enables the CPU to selectively modify only the PaRAM entry that requires modification and, thereby, trigger the transfer. After a transfer, for example, if only the count must change, then QCHMAP n can be configured so that count is the trigger word and a write to it automatically triggers the transfer.

On the EDMA2, writing to the QDMA pseudo registers leads to submitting a QDMA transfer request.

2.6.4 Linking on QDMA

On the EDMA3, linking is always enabled for both DMA and QDMA transfers. On the EDMA2, linking is not available for QDMA and the LINK address field in the channel options parameter is reserved. For a more detailed comparison between EDMA2 and EDMA3 linking, see [Section 2.10](#) in this document.

Because linking is always enabled on EDMA3, when a QDMA transfer completes, its PaRAM is updated from its linked PaRAM entry. You are responsible to terminate the linked operation for any QDMA that is enabled. To terminate a QDMA linked list, you must set the LINK address field to FFFFh and the STATIC bit to "1" in OPT of the last PaRAM entry.

2.6.5 Using IDMA for Efficient Configuration of QDMA PaRAM Sets on EDMA3

The internal DMA (IDMA) is a newly introduced DMA on C64x+ based devices and is part of the TMS320C64x+™ DSP subsystem. IDMA performs fast-block transfers between two linear ranges of memory locations local to the device's DSP subsystem. IDMA has a mask register that allows you to enable/disable transfers to specific words within the linear range. The local memory includes level 1 program (L1P), level 1 data (L1D), level 2 (L2) memories, and peripheral configuration registers. For more details regarding IDMA, see the *TMS320C64x+ DSP Megamodule Reference Guide* ([SPRU871](#)).

IDMA is used to efficiently configure the PaRAM for QDMA operations. For example, if the last word of the PaRAM set is configured as the trigger word, then you can use IDMA to copy the entire content to the PaRAM set using IDMA. Upon the completion of IDMA transferring the QDMA, the QDMA event register (QER) is set and a transfer request is submitted.

IDMA is also used to efficiently configure multiple PaRAM entries for linking applications. For example, in an application that requires linking multiple PaRAM entries for a QDMA operation, you can allocate consecutive PaRAM entries for a particular QDMA. The last PaRAM entry (at the highest memory location) is used for the first QDMA transfer. You can use IDMA to write all the PaRAM entries allocated for the QDMA. Upon completion of transferring data to the last PaRAM entry, QDMA is triggered and linking to the rest of PaRAM happens automatically.

2.6.6 STATIC Bit in OPT and QDMA on EDMA3

In EDMA3, the STATIC bit in the channel options parameter is introduced.

When STATIC = 0, PaRAM entries are updated during the course of the transfer and the link is updated at the completion of a QDMA transfer. When STATIC = 1, none of the PaRAM entries are updated during a transfer and the linking is disabled when the transfer completes.

On EDMA3, linking is always enabled. You need to specify a valid address of a PaRAM entry table in the LINK field of each of its linked PaRAM entries to form a linked list. For all the linked PaRAM entries other than the last, you should configure the STATIC bit to "0" to allow PaRAM fields to be updated. To terminate a QDMA operation, it is required to set the STATIC bit and configure the LINK field to FFFFh in the last linked PaRAM entry of the QDMA transfers.

If a particular transfer only requires one QDMA transfer, then the LINK field should be configured to FFFFh and the STATIC bit set to "1" for the PaRAM entry.

2.6.7 Software Use Model on EDMA3

On EDMA3, when a transfer request from either DMA or QDMA is admitted to an event queue, only the event number is queued. Only after the transfer request is submitted to the EDMA transfer controller, the associated PaRAM entry is submitted to the channel controller and you can reconfigure the PaRAM entry for a new QDMA transfer.

When reprogramming the PaRAM entry of a QDMA, you must check and be sure that the last linked QDMA event has been submitted to the EDMA transfer controller. Otherwise, the contents of the PaPARAM entry of a QDMA transfer request could potentially be corrupted while the request is waiting in the event queue.

The issue is when you know that a linking operation of QDMA is complete and the associated PaPARAM entry is used for new QDMA operations. Figure 19 shows an example of a linking operation. This example demonstrates how the values of the QDMA event register and the QDMA secondary event register (QSER) change throughout the entire linking operation. For more details about the secondary event registers, see the later part of this document.

There are two methods for tracking the status of PaPARAM resources for any DMA and QDMA operation. These methods are summarized below.

- Wait for completion of interrupt. You can wait for the completion of a particular DMA and/or QDMA transfer to determine if the PaPARAM is available for use for new data transfers.
- Poll for a transfer request submission to the transfer controller. This method is particularly useful for QDMA linking operations. You can poll the status of the related bit in SER/ER for DMA or QSER/QER for QDMA and the STATIC bit in OPT to determine if the related transfer request is submitted to the transfer controller. If either SER/ER or QSER/QER bits are zeros and the STATIC bit equals "1", the last linked QDMA event has been submitted to the transfer controller, and the related PaPARAM is available to be configured for future use. Note that the polling of the STATIC bit only applies if you are polling for a linked list type transfer as discussed in Section 2.6.6, where the last transfer sets the STATIC bit.

As shown in Figure 19, once a QDMA linking operation is started, the QDMA channel is not available until after QSER:QER values become 0:0 and the value of the STATIC bit equals "1". This indicates that the last QDMA transfer is already submitted to the transfer controller.

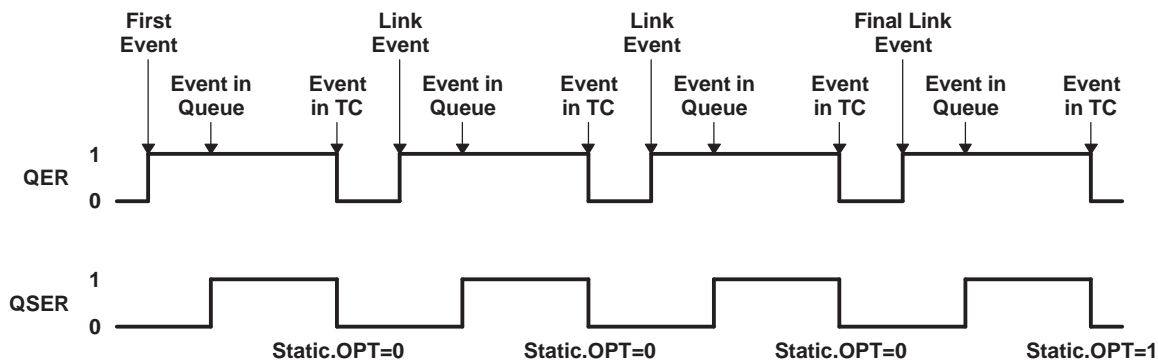


Figure 19. Linking Example With QER and QSER Values

2.7 Interrupt on EDMA3

On the high level, the interrupt operation on EDMA3 is similar to that on EDMA2. But there are some significant differences as summarized in this section.

2.7.1 Interrupt Types

The EDMA3 interrupts can be divided into two broad categories:

- Transfer completion interrupts
- Error interrupts

For more information on the interrupts in your device, see the device-specific reference guide. For example, on DM644x devices, the transfer completion interrupts are listed in [Table 6](#) and the error interrupts are listed in [Table 7](#). For more information on the DSP interrupt controller (DSPINTC), see the *TMS320DM644x DMSoC DSP Subsystem Reference Guide (SPRUE15)*. For more information on the ARM interrupt controller (AINTC), see the *TMS320DM644x DMSoC ARM Subsystem Reference Guide (SPRUE14)*. In [Table 6](#), shadow regions 0, 1, and 2 are mentioned, see [Section 2.7.3](#) for the concept of shadow region and shadow region interrupt.

Table 6. DM644x EDMA3 Transfer Completion Interrupts

Name	Description	ARM	DSP	Interrupt Number	
				AINTC	DSPINTC
EDMA3CC_INT0	EDMA3CC transfer completion interrupt shadow region 0	√	–	16	–
EDMA3CC_INT1	EDMA3CC transfer completion interrupt shadow region 1	–	√	–	36
EDMA3CC_INT2	EDMA3CC transfer completion interrupt shadow region 2	–	–	–	–

Table 7. DM644x EDMA3 Error Interrupts

Name	Description	ARM	DSP	Interrupt Number	
				AINTC	DSPINTC
EDMA3CC_ERRINT	EDMA3CC error interrupt	√	√	17	37
EDMA3TC0_ERRINT	TC0 error interrupt	√	√	18	38
EDMA3TC1_ERRINT	TC1 error interrupt	√	√	19	39

2.7.2 Comparison of Interrupt Registers Between EDMA2 and EDMA3

In both EDMA3 and EDMA2, there are equivalent parameters in the channel options parameter and registers for interrupt operation. In addition on EDMA3, some new interrupt registers are introduced for interrupt. [Table 8](#) summarizes the equivalent registers and parameters in OPT for interrupt operation on both EDMA3 and EDMA2. [Table 9](#) summarizes the new registers that are introduced for interrupt operation on EDMA3. [Table 10](#) summarizes the differences on interrupt parameters of the OPT field and newly introduced interrupt registers on EDMA3.

Table 8. Equivalent Interrupt Parameters of OPT Field and Registers on EDMA2 and EDMA3

Interrupt Parameter	EDMA2	EDMA3
Transfer complete enable field in OPT	TCINT	TCINTEN
Transfer complete code field in OPT	TCCM:TCC	TCC
Intermediate transfer completion interrupt enable register	ATCINT	ITCINTEN
Intermediate transfer complete code register	ATCC	TCC
Interrupt pending registers	CIPRL, CIPRH	IPR, IPRH
Interrupt enable registers	CIERL, CIERH	IER, IERH

Table 9. New Pseudo-Interrupt Registers Introduced on EDMA3

Description	Name
Interrupt clear registers	ICR, ICRH
Interrupt enable set registers	IESR, IESRH
Interrupt enable clear registers	IECR, IECRH
Interrupt evaluate register	IEVAL

Table 10. Summary of Interrupt Parameters of OPT Field Differences Between EDMA3 and EDMA2

Feature	EDMA2	EDMA3
Transfer complete code	Two fields, 2-bit TCCM and 4-bit TCC field, to form the final 6-bit interrupt complete code.	Single 6-bit field for interrupt complete code.
Intermediate transfer complete code	Uses TCC bit for interrupt complete code and ATCC bit for intermediate interrupt complete code.	Uses the same TCC bit for both final and intermediate interrupt complete code.
Pseudo registers for interrupt enable register on EDMA3	–	Pseudo registers are introduced for interrupt enable registers. Instead of directly modifying the interrupt enable registers, you must write to the interrupt enable set registers for enabling any interrupt and write to the interrupt enable clear registers for clearing any bits in interrupt enable registers.
Interrupt clear register (ICR and ICRH)	–	The interrupt clear registers are introduced for clearing any bits in the interrupt pending register.
Interrupt evaluate register (IEVAL)	–	The interrupt evaluate register is introduced. A write of "1" to the EVAL bit, in IEVAL, forces the EDMA channel controller to generate an interrupt if there are still interrupts pending in IPR/IPRH. Use this feature for writing robust DMA interrupt service routine.

2.7.3 Region Interrupt on EDMA3

On EDMA3, the concept of shadow region is introduced. Through each shadow region, you can only access a user-defined subset of DMA and QDMA resources. DMA and QDMA region control registers define or assign the ownership of DMA and/or QDMA channels for each shadow region. For example, on DM644x devices, there are three shadow regions as shown in [Table 11](#). For more details about shadow regions, see the device-specific EDMA3 Controller User's Guide. For the DM644x, for example, see the *TMS320DM644x DMSoC Enhanced Direct Memory Access (EDMA3) Controller User's Guide* ([SPRUE23](#)).

Table 11. DM644x EDMA Shadow Regions

EDMA Master	Region	Region Access Registers
ARM	Shadow region 0	DRAE0 , DRAEH0 and QRAE0
DSP (C64x)	Shadow region 1	DRAE1, DRAEH1 and QRAE1
Image coprocessor	Shadow region 2	DRAE2, DRAEH2 and QRAE2

On C64x+ based devices, each shadow region has its own interrupt signal. The transfer completion of any DMA or QDMA channels belonging to a shadow region can potentially trigger the region interrupt signal for each of the shadow regions. [Table 12](#) lists the interrupt signal for each region in a DM644x device as an example.

Table 12. DM644x EDMA Shadow Region Interrupt Signals

EDMA Master	Region	Region Interrupt Signal
ARM	Shadow region 0	EDMA3CC_INT0
DSP (C64x)	Shadow region 1	EDMA3CC_INT1
Image coprocessor	Shadow region 2	EDMA3CC_INT2

In addition to the global interrupt enable registers, the DMA and QDMA region access enable registers (DRAEn) serve as secondary interrupt enable registers. To enable the DMA transfer completion interrupt of a particular channel of a shadow region, both the corresponding bits in the global interrupt enable register and DMA region access enable register need to be set properly. For example in the DM644x:

- EDMA_CC_INT0 (to ARM):

```
(IPR.E0 & IER.E0 & DRAE0.E0) | (IPR.E1 & IER.E1 & DRAE0.E1) | ... | (IPRH.E63 & IERH.E63 & DRAHE0.E63)
```

- EDMA_CC_INT1 (to DSP):

```
(IPR.E0 & IER.E0 & DRAE1.E0) | (IPR.E1 & IER.E1 & DRAE1.E1) | ... | (IPRH.E63 & IERH.E63 & DRAHE1.E63)
```

- EDMA_CC_INT2 (to Image Coprocessor):

```
(IPR.E0 & IER.E0 & DRAE2.E0) | (IPR.E1 & IER.E1 & DRAE2.E1) | ... | (IPRH.E63 & IERH.E63 & DRAHE2.E63)
```

2.7.4 Interrupt Service Routine

On EDMA3, if the previous pending interrupts have not been cleared by you, the channel controller does not generate a new interrupt signal for any new interrupts that are pending. So, software needs to make sure all the pending interrupts are serviced by the interrupt service routines. In comparison, EDMA2 hardware is more forgiving. A write to clear a CIPR bit forces the EDMAINT signal to be repulsed if more interrupts are pending, thus minimizing the chance that interrupts are lost due to race conditions.

There are two options for constructing a robust interrupt service routine (ISR) for EDMA3:

- Poll all the bits during execution of the ISR and clear all enabled bits in the interrupt pending register (IPR) by writing to the interrupt pending clear register (ICR/ICRH) before exiting any ISR as shown in the following pseudo code:
 1. Enter ISR
 2. Read IPR
 3. For the condition set in IPR,
 - a. Perform operation as needed
 - b. Clear bit for serviced INT
 4. Read IPR
 - a. If IPR != 0, go to step 3
 - b. If IPR == 0, exit ISR
- Service the ISR and write to the EVAL bit in the interrupt evaluate register (IEVAL) before exiting ISR. This forces the EDMA channel controller to generate a new interrupt signal if there are still pending interrupts in the IPR/IPRH. The following lists the pseudo code for this ISR option:
 1. Enter ISR
 2. Read IPR
 3. For the condition set in IPR,
 - a. Perform operation as needed
 - b. Clear bit for serviced INT
 4. Read IPR
 - a. If IPR == 0, exit ISR
 - b. If IPR != 0, set EVAL bit in IEVAL to force to trigger a new interrupt

2.8 Event Queue

2.8.1 Number of Event Queues and Queue Length

On C64x+ based devices, EDMA3 can have up to four event queues and each queue is a length of 16. The DM644x has two event queues: the DM643x has three event queues and the C6455 has four event queues.

On C64x devices, EDMA2 has a total of four event queues and each queue length is 16.

2.8.2 Available Queue Length for EDMA and QDMA

On EDMA2, the entire queue length is allocated for DMA, QDMA, and master peripherals. A maximum seven queue length can be allocated to either DMA or QDMA.

On EDMA3, the entire queue length of 16, of all the available event queues, is allocated for DMA and QDMA channels. So you do not need to manually configure for allocation of queue length for EDMA or QDMA on EDMA3.

2.8.3 Event Queue Timing

On EDMA3, when a transfer request from either DMA or QDMA is admitted to an event queue, only its event number is queued. Only after a transfer request is accepted into the transfer controller is the corresponding PaRAM free to be configured for future DMA transfer.

On EDMA2, the event queue stores the entire PaRAM entry table. So as soon as an event is admitted into the event queue, the PaRAM is ready for future use.

It is important that you be aware of the differences of the event queues between two the DMAs. You must check and be sure the previous QDMA transfer request has been submitted to the EDMA transfer controller before configuring the related PaRAM for future use.

2.9 Priority Processing

2.9.1 Mapping Between DMA/QDMA Events and Event Queues

On EDMA3, the assignment or mapping of 64 DMA and up to eight QDMA channels to multiple event queues of the channel controller is achieved by configuring the DMA Queue Number Registers (DMAQNUM0-DMAQNUMn) and QDMA Queue Number Register (QDMAQNUM).

On EDMA2, the four event queues are categorized into urgent, high priority, medium priority and low priority queues. The mapping between DMA and QDMA channels and the four event queues is achieved by configuring the PRI parameter in the channel options parameter (OPT) of the corresponding PaRAM entry.

2.9.2 DMA/QDMA Queue Priorities versus Other Master Transfers

On EDMA3, only user-programmed DMA and QDMA transfers are handled by the EDMA transfer controller. The transfer requests eventually are submitted to the transfer controllers that are masters of a switched central resource (SCR). Other transfers between different masters such as EMAC, DSP, and ARM to different slaves such as DDR and asynchronous EMIF go directly through the SCR. The priority arbitration between DMA/QDMA transfers and other master-to-slave transfers are handled by the SCR. The priorities of each of the masters can be programmed by you through the following registers:

- Event Queue Priority Registers (QUEPRI0-QUEPRI_n). These two registers are programmed by you to set the priorities of the two event queues of EDMA that are connected to the SCR through the EDMA transfer controller.
- Master Priority Registers (MSTRPRI0-MSTRPRI_n). These two registers are programmed by you to set the priorities of masters including ARM, VLYNQ, ATA/CF, USB and EMAC.

In contrary, on EDMA2 both DMA/QDMA transfers and other master-to-slave transfers go through the same event queues and transfer controller. All the transfers compete for the same bandwidth of the transfer controller. The priorities are programmed by configuring the PRI field of PaRAM to assign masters to different priority queues.

2.10 Linking on EDMA3

2.10.1 Linking for DMA

On EDMA3, linking for DMA and QDMA transfer is always enabled. You need to provide a valid link address in the LINK field of the corresponding PaRAM entry. In addition for linking on QDMA, you must clear the STATIC bit in the channel options parameter (OPT) to "0" for all the linked PaRAM entries except the last one, and set to "1" for the last linked PaRAM entry.

On EDMA2, linking for DMA transfer is optional and can be enabled by setting LINK = 1 in OPT and provide a valid link address in the LINK field of the PaRAM entry. Linking is not available for QDMA on EDMA2. The link field of QDMA registers is reserved.

2.10.2 Terminating Linking

On both EDMA3 and EDMA2 linking is terminated by linking to a NULL parameter entry.

On EDMA3, you do not need to define a NULL entry explicitly and only need to set the LINK field of the last valid PaRAM entry to FFFFh. The channel controller automatically updates all the fields of the mapped PaRAM entry to zeros, except the LINK field that has the value of FFFFh. For QDMA, you must also set the STATIC bit in the OPT of the last valid PaRAM entry to "1".

On EDMA2, a NULL entry is defined as a PaRAM entry with all its fields being cleared to "0". A NULL entry must be defined and created by you. To terminate a linking, you need to link its last valid PaRAM entry to this NULL entry.

2.11 Chaining on EDMA3

Both EDMA3 and EDMA2 have similar chaining functionalities. If chaining is enabled for a DMA channel, the completion of the DMA transfer sets the chain event register of a DMA channel as specified by the TCC value in the OPT and, thus, triggers another transfer request. Although the chaining functionality is the same for both EDMA3 and EDMA2, there are some differences as summarized in [Table 13](#).

On EDMA3, the transfer and intermediate transfer complete chaining enabling (TCCHEN and ITCCHEN) bits are different from those for transfer and intermediate transfer complete interrupt enabling (TCINTEN and ITCINTEN) bits. The TCCHEN and ITCCHEN bits in OPT are used for enabling transfer and intermediate transfer complete chaining. The TCINTEN and ITCINTEN bits in OPT are used for enabling transfer and intermediate transfer complete interrupts.

On EDMA2, the transfer and intermediate transfer complete chaining enabling (TCINT and ATCINT) bits are the same as those for transfer and intermediate transfer complete interrupt enabling bits. In addition, there is a separate Channel Interrupt Enable Register (CIER) for enabling the interrupt and Chain Enable Register (CCER) for enabling chaining on EDMA2.

On EDMA3, having separate bits for enabling chaining and interrupt offers more flexibility for software development. The same TCC code can be used by two different DMA channels for different purposes. On one DMA channel, chaining can be enabled while the transfer completion interrupt is disabled. On the second DMA channel, transfer chaining can be disabled while its completion interrupt is enabled. This feature provides more flexibility and freedom for software development.

The same functionality of using the same TCC value for two different channels cannot be achieved on EDMA2 because the same bits are used for both enabling chaining and interrupt.

Table 13. Comparison of Parameters for Chaining for EDMA3 and EDMA2

Feature	Description	EDMA2	EDMA3
Chaining/Interrupt	Chain enabling bit in OPT	TCINT	TCCHEN
	Interrupt enabling bit in OPT	TCINT	TCINTEN
	Transfer complete code	TCCM:TCC	TCC
Intermediate Chaining/Interrupt	Intermediate chain enabling bit in OPT	ATCINT	ITCCHEN
	Intermediate interrupt enabling bit in OPT	ATCINT	ITCINTEN
	Intermediate transfer complete code	ATCC	TCC

2.12 Set and Clear Operation on EDMA3

On EDMA3, pseudo registers are introduced for reliable operation in multitasking and multiprocessor environments. Instead of directly modifying interrupt and event registers, these registers are actually set or cleared through their pseudo registers. This new feature eliminates race conditions when multiple processors try to access the same DMA register at the same time. The following summarizes the pseudo registers that are introduced on EDMA3.

- EESR/EESRH and EECR/EECRH for the Event Enable Register (EER/EERH). The Event Enable Register (EER n /EERH n) is set through the Event Enable Set Register (EESR/EESRH) and is cleared through the Event Enable Clear Register (EECR/EECRH).
- QEESR/QEESRH and QEECR/QEECRH for the QDMA Event Enable Register (QEER). The QDMA Event Enable Register (QEER) is set through the QDMA Set Register (QEESR/QEESRH) and is cleared through the QDMA Clear Register (QEECR/QEECRH).
- IESR/IESRH and IECR/IECRH for the Interrupt Enable Register (IER/IERH). The Interrupt Enable Register (IER/IERH) is enabled through the Interrupt Set Enable Register (IESR/IESRH) and is cleared through the Interrupt Enable Clear Register (IECR/IECRH).

3 New Features on EDMA3

3.1 DMA Channel Region Access

The concept of DMA channel region access is introduced on EDMA3. Three types of regions are defined for the channel controller on EDMA3:

1. Global regions
2. Global DMA channel region
3. DMA channel shadow regions

The global region and global DMA channel region consist of all of the memory-mapped registers for all the DMA channels, QDMA channels, and interrupt.

The DMA channel shadow regions provide restricted view or access to the DMA and/or QDMA registers in the global DMA channel region. There are eight shadow regions on EDMA3. Each region has a Region Access Enable Register (DRAEn/DRAEHn) and QDMA Region Access Enable Register (QRAEn). The region access enable registers define the ownership or the right of access of the shadow regions to the DMA and QDMA channel registers in the global DMA channel region.

A value of "1" in a bit position on the DMA/QDMA region access enable register implies that the ownership of that channel and that write, which are accessible to the corresponding bit position are allowed to take effect, and read accesses should return valid data. A value of "0" means that writes to that bit position are discarded without modifying the original register value and reads return a value of "0".

On DM644x devices, three shadow regions for ARM, DSP, and image coprocessor are defined. [Table 11](#) summarizes the region access enable registers for each of the shadow region.

3.2 Debugging Capabilities

3.2.1 Debug Visibility

3.2.1.1 Event Queue Visibility

On EDMA3, the history of 16 events in every event queue can be monitored. The EDMA channel controller records the events in each event queue in the Event Queue Entry Registers (QkEn), where $k = 0-1$, $n = 0-15$. k identifies the event queue and n indicates the order of the event entry.

The event queue entry registers capture the type of event, including the event triggered via ER, manual trigger via ESR, chain triggered via CER, auto-triggered via QER event, and the event number; or which of the DMA or QDMA channels.

3.2.1.2 Event Queue Watermarking

The event queue watermarking feature on EDMA3 monitors the maximum number of event entries in each of the event queues. The watermarking information is captured in the WM field of the Event Queue Status Register (QSTATn).

3.2.1.3 Event Queue Threshold

The EDMA3 channel controller keeps track of whether the number of event entries in an event queue exceeds the user-programmed threshold. The queue threshold for each event queue is programmed in the Queue Threshold x Registers (QWMTHRA and QWMTHRB) by you. A queue threshold error happens whenever the number of event entries in any of the event queues exceeds the user-programmed threshold and the error is captured in the THRXCD field of the Event Queue Status Register (QSTATn), and the QTHRXCDn field in the EDMA3CC Error Register (CCERR).

3.2.2 Error Detection

3.2.2.1 Event Missed Registers

On EDMA3, the Event Miss Register (EMR/EMRH) and the QDMA Event Miss Register (QEMR) are introduced.

For EMR/EMRH, if any DMA channel event happens before the channel's previous event has been cleared or submitted to the transfer controller, the event is considered a missed event and is captured in the corresponding bit of EMR or EMRH. You can clear the bits in EMR/EMRH by writing a "1" to the corresponding bit in the Event Miss Clear Register (EMCR/EMCRH).

For QEMR, if any QDMA channel event happens before the channel's previous event has been cleared or submitted to the transfer controller, the event is considered a missed event and is captured in the corresponding bit of QEMR. You can clear the bits in EMR/EMRH by writing a "1" to the corresponding bit in the QDMA Event Miss Clear Register (QEMCR).

3.2.2.2 Channel Controller Error Registers

The EDMA3CC Error Register (CCERR) captures the queue threshold error and transfer completion code error.

3.2.2.3 Error from Null Parameter Entry

On EDMA3, an error occurs if an event is triggered for a NULL PaRAM entry. When this error happens, the EDMA channel controller sets both the corresponding bits in the Secondary Event Register (SER) and Event Miss Register (EMR).

When a "1" is set in SER, the channel controller disables the corresponding DMA or EDMA channel for future use. To bring back the disabled DMA or QDMA channel, you need to clear both bits in SER and EMR.

3.2.2.4 Error Interrupts

Whenever there is a DMA missed event error, QDMA missed event error, and queue threshold error, the EDMA channel controller generates an interrupt signal via EDMA3CC_ERRINT.

Whenever there is a memory protection violation, the EDMA channel controller issues an interrupt signal via EDMA3CC_MPINT.

Whenever an outstanding transfer request returns a completion code that exceeds the maximum limit of 63, the EDMA controller generates an interrupt signal via EDMA3CC_ERRINT.

4 References

- *TMS320DM644x DMSoC Enhanced Direct Memory Access (EDMA3) Controller User's Guide* ([SPRUE23](#))
- *TMS3206000 DSP Enhanced Direct Memory Access (EDMA) Controller Reference Guide* ([SPRU234](#))
- *TMS320C64x+ DSP Megamodule Reference Guide* ([SPRU871](#))
- *TMS320DM644x DMSoC DSP Subsystem Reference Guide* ([SPRUE15](#))
- *TMS320DM644x DMSoC ARM Subsystem Reference Guide* ([SPRUE14](#))

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