AM17x ARM Microprocessor Enhanced Direct Memory Access (EDMA3) Controller

User's Guide

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About This Manual

This document describes the operation of the enhanced direct memory access (EDMA3) controller. The EDMA3 controller is a high-performance, multichannel, multithreaded DMA controller that allows you to program a wide variety of transfer geometries and transfer sequences.

Notational Conventions

This document uses the following conventions.

- Hexadecimal numbers are shown with the suffix h. For example, the following number is 40 hexadecimal (decimal 64): 40h.
- Registers in this document are shown in figures and described in tables.
  - Each register figure shows a rectangle divided into fields that represent the fields of the register. Each field is labeled with its bit name, its beginning and ending bit numbers above, and its read/write properties below. A legend explains the notation used for the properties.
  - Reserved bits in a register figure designate a bit that is used for future device expansion.

Related Documentation From Texas Instruments

Copies of these documents are available on the Internet at www.ti.com. *Tip:* Enter the literature number in the search box provided at www.ti.com.

The current documentation that describes the DSP, related peripherals, and other technical collateral, is available in the C6000 DSP product folder at: www.ti.com/c6000.

SPRUGU3 — ***AM1705 ARM Microprocessor System Reference Guide.*** Describes the ARM subsystem, system memory, memory protection unit (MPU), device clocking, phase-locked loop controller (PLLC), power and sleep controller (PSC), power management, ARM interrupt controller (AINTC), and system configuration module.

SPRUGR6 — ***AM1707 ARM Microprocessor System Reference Guide.*** Describes the ARM subsystem, system memory, memory protection unit (MPU), device clocking, phase-locked loop controller (PLLC), power and sleep controller (PSC), power management, ARM interrupt controller (AINTC), and system configuration module.

SPRUFU0 — ***AM17x/AM18x ARM Microprocessor Peripherals Overview Reference Guide.*** Provides an overview and briefly describes the peripherals available on the AM17x/AM18x ARM Microprocessors.

Enhanced Direct Memory Access (EDMA3) Controller

This document describes the features and operations of the enhanced direct memory access (EDMA3) controller. The EDMA3 controller is a high-performance, multichannel, multithreaded DMA controller that allows you to program a wide variety of transfer geometries and transfer sequences.

Section 1 provides a brief overview, features, and terminology. Section 2 provides the architecture details and common operations of the EDMA3 channel controller (EDMA3CC) and the EDMA3 transfer controller (EDMA3TC). Section 3 contains examples and common usage scenarios. Section 4 describes the memory-mapped registers associated with the EDMA3 controller.

1 Introduction

1.1 Overview

The enhanced direct memory access (EDMA3) controller's primary purpose is to service user-programmed data transfers between two memory-mapped slave endpoints on the device. Typical usage includes, but is not limited to:

- Servicing software driven paging transfers (for example, from external memory to internal device memory
- Servicing event driven peripherals, such as a serial port
- Performing sorting or subframe extraction of various data structures
- Offloading data transfers from the main device CPU(s) (See your device-specific data manual for specific peripherals that are accessible via EDMA3. See the section on SCR connectivity in your device-specific data manual for EDMA3 connectivity.)

The EDMA3 controller consists of two principal blocks:

- EDMA3 channel controller: EDMA3CC
- EDMA3 transfer controller(s): EDMA3TC*n*

The EDMA3 channel controller serves as the user interface for the EDMA3 controller. The EDMA3CC includes parameter RAM (PaRAM), channel control registers, and interrupt control registers. The EDMA3CC serves to prioritize incoming software requests or events from peripherals, and submits transfer requests (TR) to the EDMA3 transfer controller.

The EDMA3 transfer controllers are responsible for data movement. The transfer request packets (TRP) submitted by the EDMA3CC contains the transfer context, based on which the transfer controller issues read/write commands to the source and destination addresses programmed for a given transfer.

1.2 Features

The EDMA3 channel controller (EDMA3CC) has the following features:

- Fully orthogonal transfer description
  - 3 transfer dimensions
  - A-synchronized transfers: 1 dimension serviced per event
  - AB-synchronized transfers: 2 dimensions serviced per event
  - Independent indexes on source and destination
  - Chaining feature allows 3-D transfer based on single event
- Flexible transfer definition
  - Increment or constant addressing modes
  - Linking mechanism allows automatic PaRAM set update. Useful for ping-pong type transfers, auto-reload transfers.
  - Chaining allows multiple transfers to execute with a single event
- Interrupt generation for:
  - Transfer completion
  - Error conditions (illegal addresses, illegal modes, exceeding queue threshold)
- Debug visibility
  - Queue watermarking
  - Error and status recording to facilitate debug
  - Missed event detection
- 128 parameter RAM (PaRAM) entries
- 4 shadow regions
- 32 DMA channels
  - Event triggered transfers (transfers initiated by system/peripheral events)
  - Manual transfers (CPU(s) initiated DMA transfers)
  - Chained transfers (completion of transfer on one channel triggers a transfer on a “chained” channel)
- 8 QDMA channels
  - QDMA channels are triggered automatically upon writing to a parameter RAM (PaRAM) set entry
  - Supports linking and chaining features (similar to DMA channels)
  - Support for programmable QDMA channel to PaRAM mapping (any PaRAM entry can be used as a QDMA channel)
- 2 event queues
- 16 event entries per event queue

The EDMA3 transfer controller (EDMA3TC) has the following features:

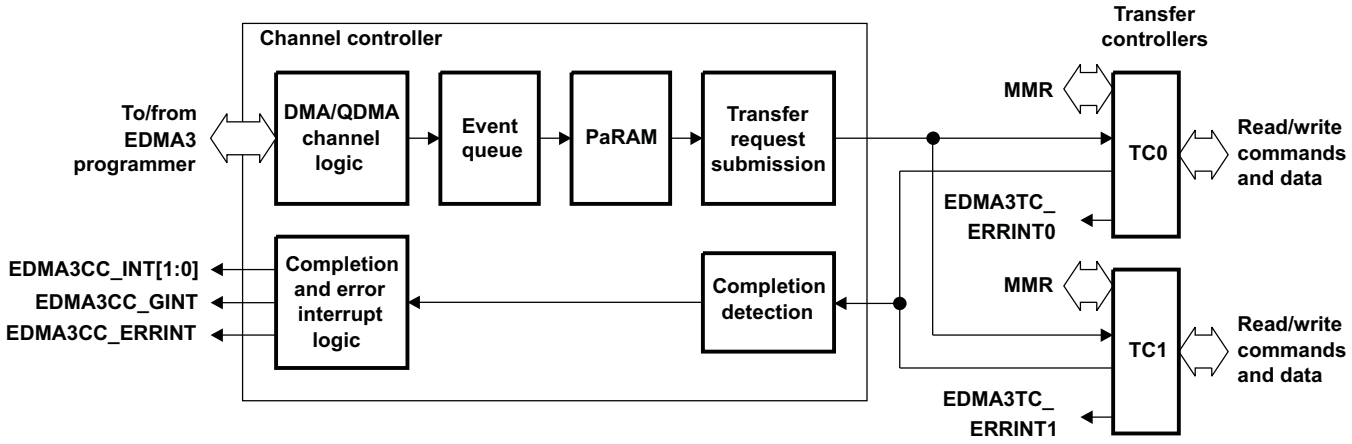
- Supports 2-dimensional transfers with independent indexes on source and destination (EDMA3CC manages the 3rd dimension)
- More then one transfer controller allows concurrent transfers
- Programmable priority level for each transfer controller relative to each other and other masters in the system.
- Support for increment or constant addressing mode transfers
- Error conditions with interrupt support
- Supports more then one in-flight transfer requests
- Debug/status visibility
- 64-bit wide read and write ports
- Little-endian mode

- Transfer controller(s):
  - FIFIOSIZE = 128 bytes
  - BUSWIDTH (Read/Write Controllers) = 8 byte
  - DSTREGDEPTH = 4
  - DBS (default) = 16 bytes. The default burst size (DBS) is programmable, and can be configured for 16-, 32-, or 64-bytes burst size. See your device-specific *System Reference Guide* for details to change the default burst size value.

1.3 Functional Block Diagram

Figure 1 shows a block diagram of the EDMA3 controller.

Figure 1. EDMA3 Controller Block Diagram



1.4 Terminology Used in This Document

The following is a brief explanation of some terms used in this document.

Term	Meaning
A-synchronized transfer	A transfer type where 1 dimension is serviced per synchronization event.
AB-synchronized transfer	A transfer type where 2 dimensions are serviced per synchronization event.
Chaining	A trigger mechanism in which a transfer can be initiated at the completion of another transfer or subtransfer.
CPU(s)	The main processing engine or engines on a device.
DMA channel	A channel that can be triggered by external, manual, and chained events. All DMA channels exist in the EDMA3CC.
Dummy set or Dummy PaRAM set	A PaRAM set for which at least one of the count fields is equal to 0 and at least one of the count fields is nonzero. A null PaRAM set has all the count set fields cleared.
Dummy transfer	A dummy set results in the EDMA3CC performing a dummy transfer. This is not an error condition. A null set results in an error condition.
EDMA3 channel controller (EDMA3CC)	The user-programmable portion of the EDMA3. The EDMA3CC contains the parameter RAM (PaRAM) , event processing logic, DMA/QDMA channels, event queues, etc. The EDMA3CC services events (external, manual, chained, QDMA) and is responsible for submitting transfer requests to the transfer controllers (EDMA3TC), which perform the actual transfer.

Term	Meaning
EDMA3 programmer	Any entity on the chip that has read/write access to the EDMA3 registers and can program an EDMA3 transfer.
EDMA3 transfer controller(s) (EDMA3TC)	Transfer controllers are the transfer engine for the EDMA3. Performs the read/writes as dictated by the transfer requests submitted by the EDMA3CC.
Enhanced direct memory access (EDMA3) controller	Consists of the EDMA3 channel controller (EDMA3CC) and EDMA3 transfer controller(s) (EDMA3TC). Is referred to as EDMA3 in this document.
Link parameter set	A PaRAM set that is used for linking.
Linking	The mechanism of reloading a PaRAM set with new transfer characteristics on completion of the current transfer.
Memory-mapped slave	All on-chip memories, off-chip memories, and slave peripherals. These typically rely on the EDMA3 (or other master peripheral) to perform transfers to and from them.
Master peripherals	All peripherals that are capable of initiating read and write transfers to the peripherals system and may not solely rely on the EDMA3 for their data transfers.
Null set or Null PaRAM set	A PaRAM set that has all count fields cleared (except for the link field). A dummy PaRAM set has at least one of the count fields nonzero.
Null transfer	A trigger event for a null PaRAM set results in the EDMA3CC performing a null transfer. This is an error condition. A dummy transfer is not an error condition.
QDMA channel	One of the 8 channels that can be triggered when writing to the trigger word (TRWORD) of a PaRAM set. All QDMA channels exist in the EDMA3CC.
Parameter RAM (PaRAM)	Programmable RAM that stores PaRAM sets used by DMA channels, QDMA channels, and linking.
Parameter RAM (PaRAM) set	A 32-byte EDMA3 channel transfer definition. Each parameter set consists of 8 words (4-bytes each), which store the context for a DMA/QDMA/link transfer. A PaRAM set includes source address, destination address, counts, indexes, options, etc.
Parameter RAM (PaRAM) set entry	One of the 4-byte components of the parameter set.
Slave end points	All on-chip memories, off-chip memories, and slave peripherals. These rely on the EDMA3 to perform transfers to and from them.
Transfer request (TR)	A command for data movement that is issued from the EDMA3CC to the EDMA3TC. A TR includes source and destination addresses, counts, indexes, options, etc.
Trigger event	Action that causes the EDMA3CC to service the PaRAM set and submit a transfer request to the EDMA3TC. Trigger events for DMA channels include manual triggered (CPU triggered), external event triggered, and chain triggered. Trigger events for QDMA channels include autotriggered and link triggered.
Trigger word	For QDMA channels, the trigger word specifies the PaRAM set entry that when written results in a QDMA trigger event. The trigger word is programmed via the QDMA channel *n* mapping register (QCHMAP*n*) and can point to any PaRAM set entry.
TR synchronization (sync) event	See Trigger event.

2 Architecture

This section discusses the architecture of the EDMA3 controller.

2.1 Functional Overview

This section provides an overview of the EDMA3 channel controller (EDMA3CC) and EDMA3 transfer controller (EDMA3TC).

2.1.1 EDMA3 Channel Controller (EDMA3CC)

Figure 2 shows a functional block diagram of the EDMA3 channel controller (EDMA3CC).

The main blocks of the EDMA3CC are:

- DMA/QDMA Channel Logic: This block consists of logic that captures external system or peripheral events that can be used to initiate event triggered transfers, it also includes registers that allow configuring the DMA/QDMA channels (queue mapping, PaRAM entry mapping). It includes all the registers for different trigger type (manual, external events, chained and auto triggered) for enabling/disabling events, and monitor event status.
- Parameter RAM (PaRAM): Maintains parameter set entries for channel and reload parameter sets. The PaRAM needs to be written with the transfer context for the desired channels and link parameter sets.
- Event queues: These form the interface between the event detection logic and the transfer request submission logic.
- Transfer Request Submission Logic: This logic processes PaRAM sets based on a trigger event submitted to the event queue and submits a transfer request (TR) to the transfer controller associated with the event queue.
- Completion detection: The completion detect block detects completion of transfers by the EDMA3 transfer controller (EDMA3TC) and/or slave peripherals. Completion of transfers can optionally be used to chain trigger new transfers or to assert interrupts. The logic includes the interrupt processing registers for enabling/disabling interrupt (to be sent to the CPU), interrupt status/clearing registers.

Additionally there are:

- Region registers: Region registers allow DMA resources (DMA channels and interrupts) to be assigned to unique regions, which can be owned by unique EDMA programmers (a use model for hetero/multi core devices) or by unique tasks/threads (a use model for single core devices).
- Debug registers: Debug registers allow debug visibility by providing registers to read the queue status, channel controller status (what logic within the CC is active), and missed event status.

The EDMA3CC includes two channel types: DMA channels and QDMA channels.

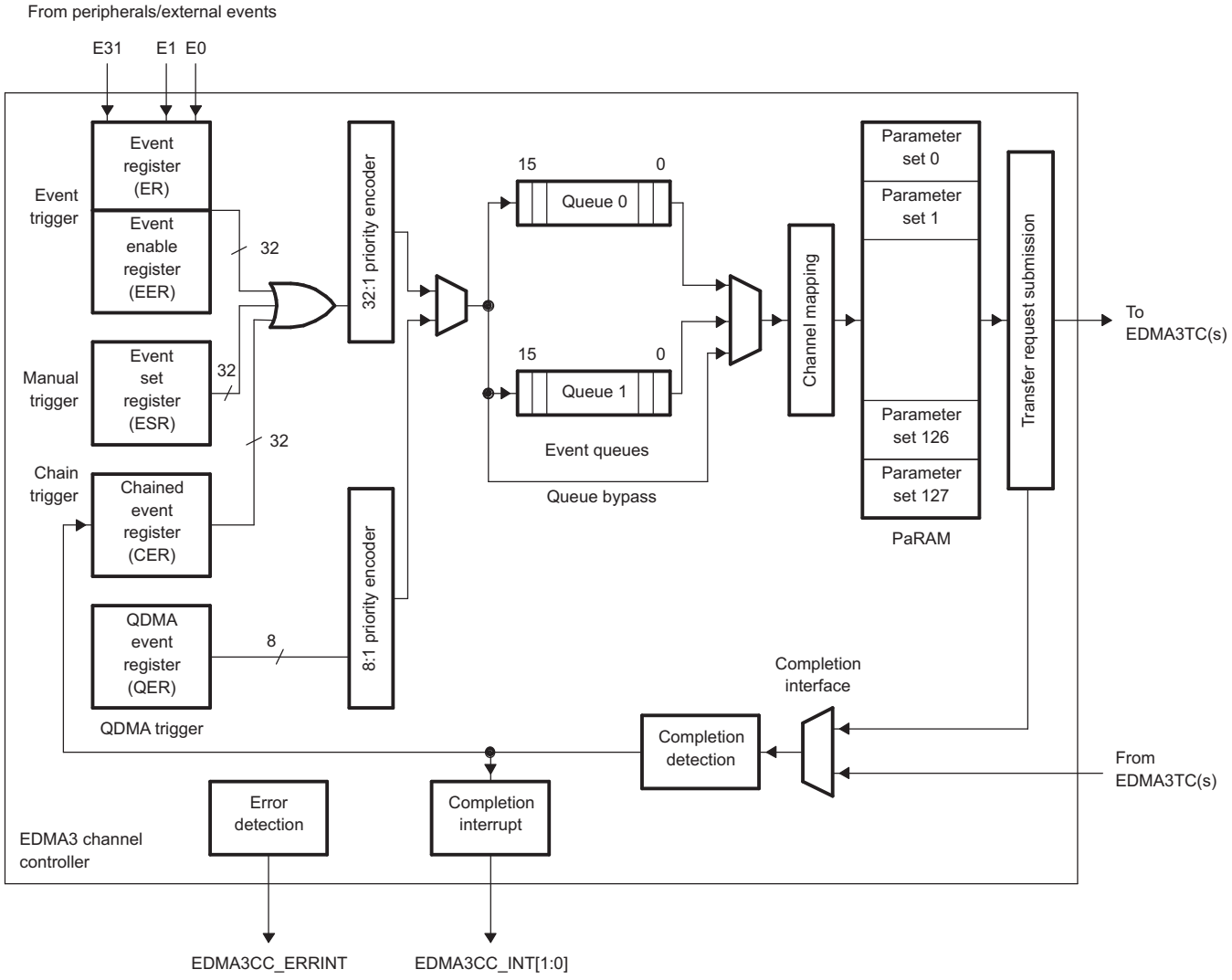
Each channel is associated with a given event queue/transfer controller and with a given PaRAM set. The main difference between a DMA channel and QDMA channel is how the transfers are triggered by the system. See Section 2.4.

A trigger event is needed to initiate a transfer. For DMA channels, a trigger event may be due to an external event, manual write to the event set register, or chained event. QDMA channels are autotriggered when a write is performed to the user-programmed trigger word. All such trigger events are logged into appropriate registers upon recognition. See DMA channel registers (Section 4.2.5) and QDMA channel registers (Section 4.2.7).

Once a trigger event is recognized, the event type/channel is queued in the appropriate EDMA3CC event queue. The assignment of each DMA/QDMA channel to event queue is programmable. Each queue is 16 deep, so up to 16 events may be queued (on a single queue) in the EDMA3CC at an instant in time. Additional pending events mapped to a full queue are queued when event queue space becomes available. See Section 2.10.

If events on different channels are detected simultaneously, the events are queued based on fixed priority arbitration scheme with the DMA channels being higher priority than the QDMA channels. Among the two groups of channels, the lowest-numbered channel is the highest priority.

Figure 2. EDMA3 Channel Controller (EDMA3CC) Block Diagram



Each event in the event queue is processed in the order it was queued. On reaching the head of the queue, the PaRAM associated with that channel is read to determine the transfer details. The TR submission logic evaluates the validity of the TR and is responsible for submitting a valid transfer request (TR) to the appropriate EDMA3TC (based on the event queue to EDMA3TC association, Q0 goes to TC0, and Q1 goes to TC1, etc.). For more details, see Section 2.3.

The EDMA3TC receives the request and is responsible for data movement as specified in the transfer request packet (TRP) and other necessary tasks like buffering, ensuring transfers are carried out in an optimal fashion wherever possible. For more details on EDMA3TC, see Section 2.1.2.

You may have chosen to receive an interrupt or chain to another channel on completion of the current transfer in which case the EDMA3TC signals completion to the EDMA3CC completion detection logic when the transfer is done. You can alternately choose to trigger completion when a TR leaves the EDMA3CC boundary rather than wait for all the data transfers to complete. Based on the setting of the EDMA3CC interrupt registers, the completion interrupt generation logic is responsible for generating EDMA3CC completion interrupts to the CPU. For more details, see Section 2.5.

Additionally, the EDMA3CC also has an error detection logic, which causes error interrupt generation on various error conditions (like missed events, exceeding event queue thresholds, etc.). For more details on error interrupts, see Section 2.9.4.

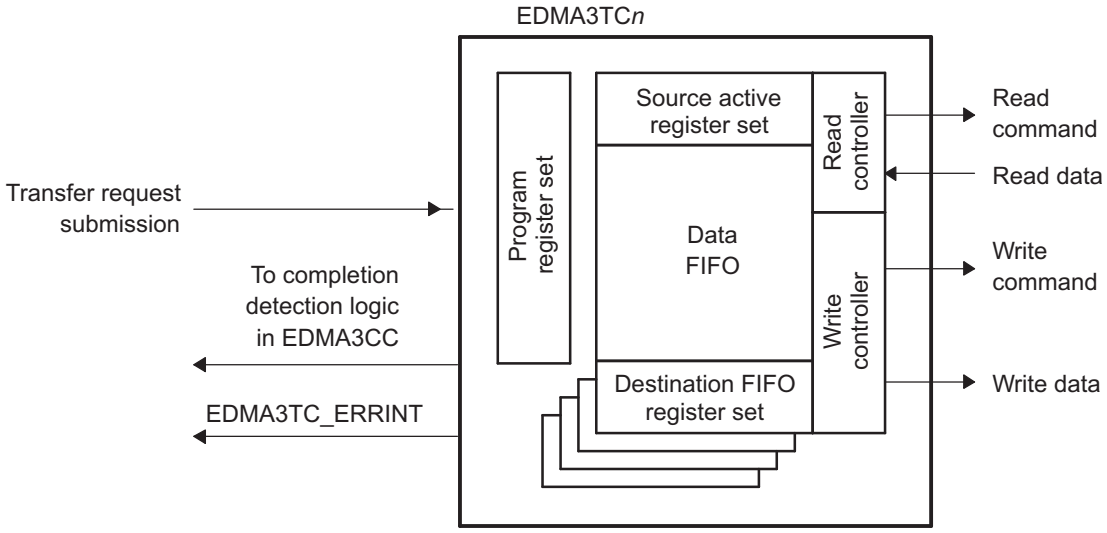
2.1.2 EDMA3 Transfer Controller (EDMA3TC)

Figure 3 shows a functional block diagram of the EDMA3 transfer controller (EDMA3TC).

The main blocks of the EDMA3TC are:

- DMA program register set: The DMA program register set stores the transfer requests received from the EDMA3 channel controller (EDMA3CC).
- DMA source active register set: The DMA source active register set stores the context for the DMA transfer request currently in progress in the read controller.
- Read controller: The read controller issues read commands to the source address.
- Destination FIFO register set: The destination (Dst) FIFO register set stores the context for the DMA transfer request(s) currently in progress or pending in the write controller.
- Write controller: The write controller issues write commands/write data to the destination address.
- Data FIFO: The data FIFO holds temporary in-flight data. The source peripheral's read data is stored in the data FIFO and subsequently written to the destination peripheral/end point by the write controller.
- Completion interface: The completion interface sends completion codes to the EDMA3CC when a transfer completes, and is used for generating interrupts and chained events (see Section 2.5 for details on transfer completion reporting).

Figure 3. EDMA3 Transfer Controller (EDMA3TC) Block Diagram



When the EDMA3TC is idle and receives its first TR, the TR is received in the DMA program register set, where it transitions to the DMA source active set and the destination FIFO register set immediately. The source active register set tracks the commands for the source side of the transfers, and the destination FIFO register set tracks commands for the destination side of the transfer. The second TR (if pending from EDMA3CC) is loaded into the DMA program set, ensuring it can start as soon as possible when the active transfer (the transfer in the source active set) is completed. As soon as the current active set is exhausted, the TR is loaded from the DMA program register set into the DMA source active register set as well as to the appropriate entry in the destination FIFO register set.

The read controller issues read commands governed by the rules of command fragmentation and optimization. These are issued only when the data FIFO has space available for the read data. The number of read commands issued depends on the TR transfer size. The TC write controller starts issuing write commands as soon as sufficient data is read in the data FIFO for the write controller to issue optimally sized write commands following the rules for command fragmentation and optimization. For details on command fragmentation and optimization, see Section 2.11.1.2.

The DSTREGDEPTH parameter (fixed for a given transfer controller) determines the number of entries in the Dst FIFO register set. The number of entries determines the amount of TR pipelining possible for a given TC. The write controller can manage the write context for the number of entries in the Dst FIFO register set. This allows the read controller to go ahead and issue read commands for the subsequent TRs while the Dst FIFO register set manages the write commands and data for the previous TR. In summary, if the DSTREGDEPTH is *n*, the read controller is able to process up to *n*TRs ahead of the write controller. However, the overall TR pipelining is also subject to the amount of free space in the data FIFO.

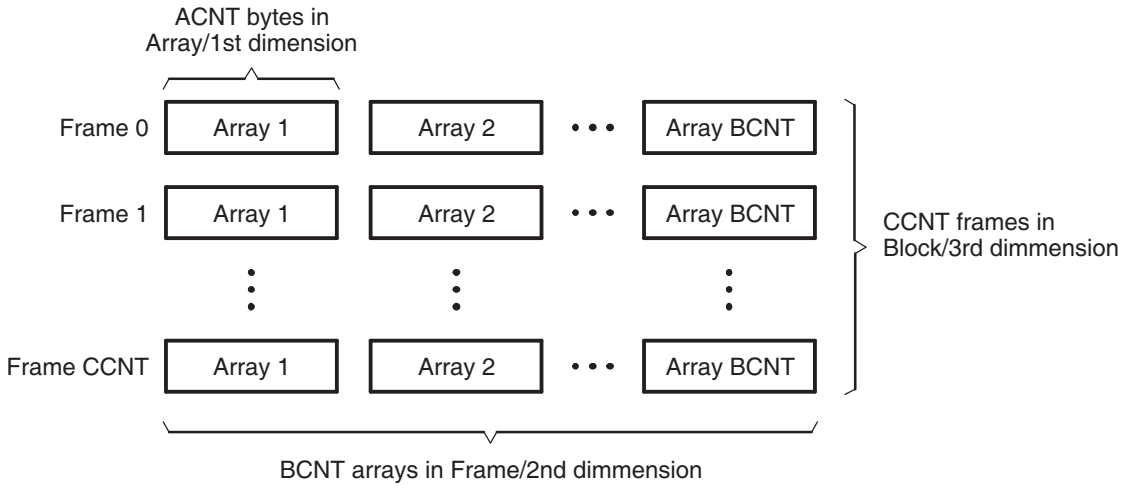
2.2 Types of EDMA3 Transfers

An EDMA3 transfer is always defined in terms of three dimensions. Figure 4 shows the three dimensions used by EDMA3 transfers. These three dimensions are defined as:

- 1st Dimension or Array (A): The 1st dimension in a transfer consists of ACNT contiguous bytes.
- 2nd Dimension or Frame (B): The 2nd dimension in a transfer consists of BCNT arrays of ACNT bytes. Each array transfer in the 2nd dimension is separated from each other by an index programmed using SRCBIDX or DSTBIDX.
- 3rd Dimension or Block (C): The 3rd dimension in a transfer consists of CCNT frames of BCNT arrays of ACNT bytes. Each transfer in the 3rd dimension is separated from the previous by an index programmed using SRCCIDX or DSTCIDX.

Note that the reference point for the index depends on the synchronization type. The amount of data transferred upon receipt of a trigger/synchronization event is controlled by the synchronization types (SYNCDIM bit in OPT). Of the three dimensions, only two synchronization types are supported: A-synchronized transfers and AB-synchronized transfers.

Figure 4. Definition of ACNT, BCNT, and CCNT



2.2.1 A-Synchronized Transfers

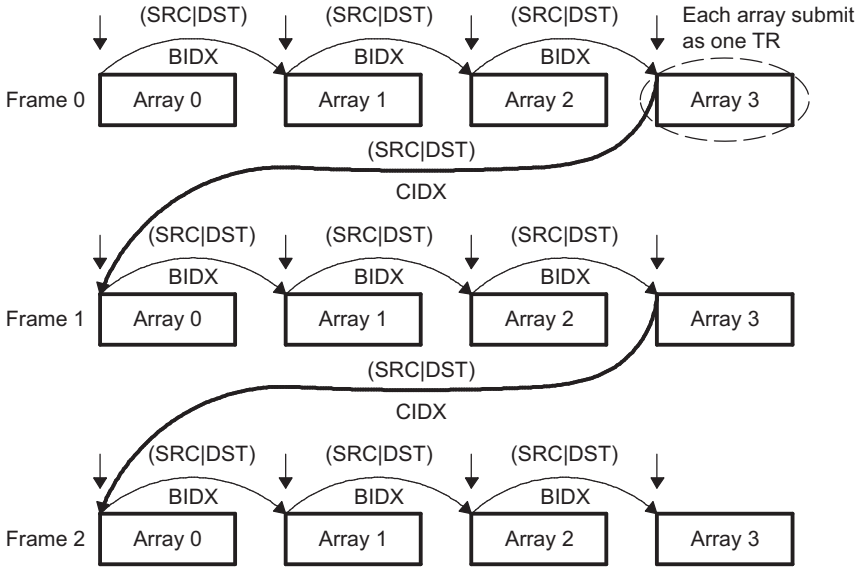
In an A-synchronized transfer, each EDMA3 sync event initiates the transfer of the 1st dimension of ACNT bytes, or one array of ACNT bytes. In other words, each event/TR packet conveys the transfer information for one array only. Thus, BCNT × CCNT events are needed to completely service a PaRAM set.

Arrays are always separated by SRCBIDX and DSTBIDX, as shown in Figure 5, where the start address of Array N is equal to the start address of Array N – 1 plus source (SRCBIDX) or destination (DSTBIDX).

Frames are always separated by SRCCIDX and DSTCIDX. For A-synchronized transfers, after the frame is exhausted, the address is updated by adding SRCCIDX/DSTCIDX to the beginning address of the last array in the frame. As in Figure 5, SRCCIDX/DSTCIDX is the difference between the start of Frame 0 Array 3 to the start of Frame 1 Array 0.

Figure 5 shows an A-synchronized transfer of 3 (CCNT) frames of 4 (BCNT) arrays of n (ACNT) bytes. In this example, a total of 12 sync events (BCNT × CCNT) exhaust a PaRAM set. See Section 2.3.6 for details on parameter set updates.

Figure 5. A-Synchronized Transfers (ACNT = n, BCNT = 4, CCNT = 3)



2.2.2 AB-Synchronized Transfers

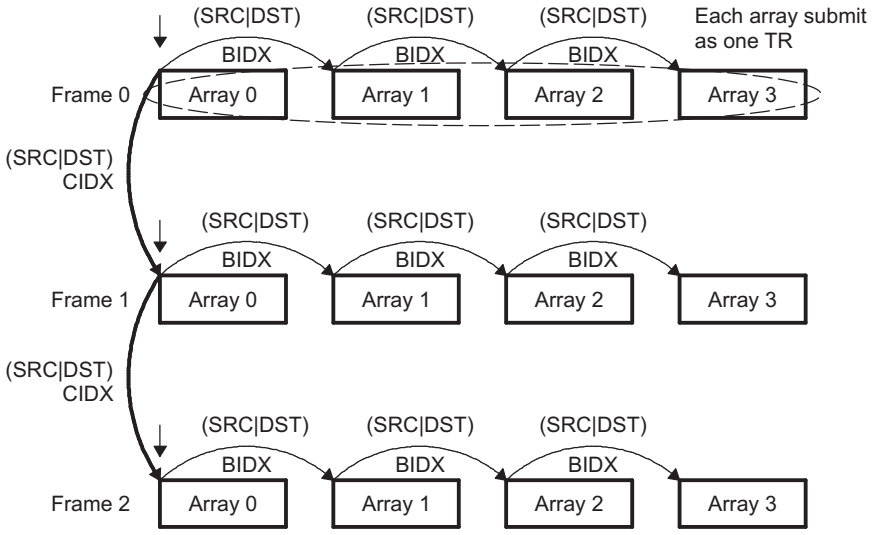
In a AB-synchronized transfer, each EDMA3 sync event initiates the transfer of 2 dimensions or one frame. In other words, each event/TR packet conveys information for one entire frame of BCNT arrays of ACNT bytes. Thus, CCNT events are needed to completely service a PaRAM set.

Arrays are always separated by SRCBIDX and DSTBIDX as shown in Figure 6. Frames are always separated by SRCCIDX and DSTCIDX.

Note that for AB-synchronized transfers, after a TR for the frame is submitted, the address update is to add SRCCIDX/DSTCIDX to the beginning address of the beginning array in the frame. This is different from A-synchronized transfers where the address is updated by adding SRCCIDX/DSTCIDX to the start address of the last array in the frame. See Section 2.3.6 for details on parameter set updates.

Figure 6 shows an AB-synchronized transfer of 3 (CCNT) frames of 4 (BCNT) arrays of *n* (ACNT) bytes. In this example, a total of 3 sync events (CCNT) exhaust a PaRAM set; that is, a total of 3 transfers of 4 arrays each completes the transfer.

Figure 6. AB-Synchronized Transfers (ACNT = n, BCNT = 4, CCNT = 3)



NOTE: ABC-synchronized transfers are not directly supported. But can be logically achieved by chaining between multiple AB-synchronized transfers.

2.3 Parameter RAM (PaRAM)

The EDMA3 controller is a RAM-based architecture. The transfer context (source/destination addresses, count, indexes, etc.) for DMA or QDMA channels is programmed in a parameter RAM table within the EDMA3CC, referred to as PaRAM. The PaRAM table is segmented into multiple PaRAM sets. Each PaRAM set includes eight 4-byte PaRAM set entries (32-bytes total per PaRAM set), which includes typical DMA transfer parameters such as source address, destination address, transfer counts, indexes, options, etc. See your device-specific data manual for the addresses of the PaRAM set entries.

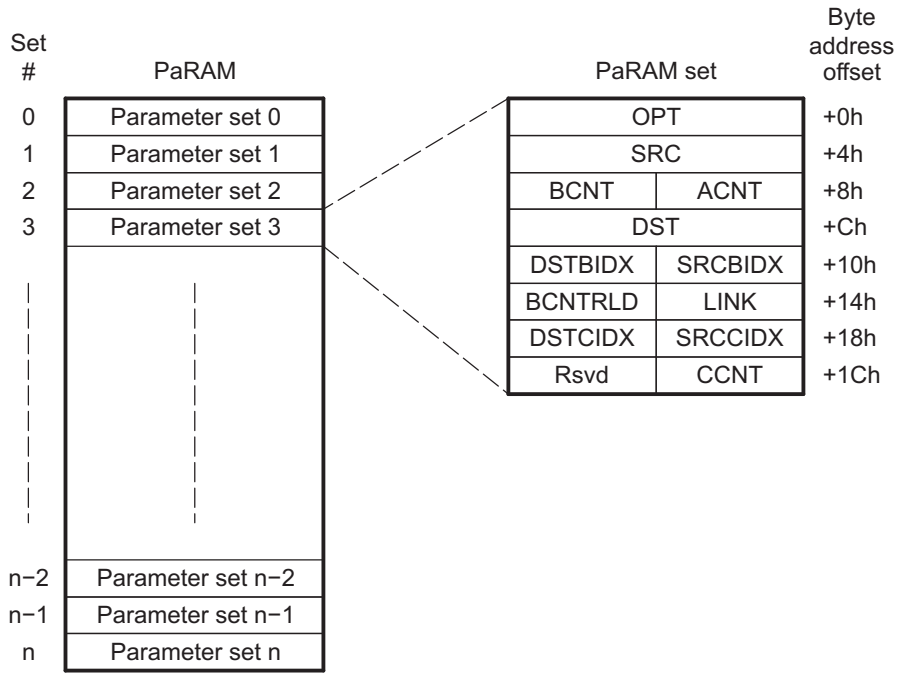
The PaRAM structure supports flexible ping-pong, circular buffering, channel chaining, and autoreloading (linking). The first *n* PaRAM sets are directly mapped to the DMA channels (where *n* is the number of DMA channels supported in the EDMA3CC for a specific device). The remaining PaRAM sets can be used for link entries or associated with QDMA channels. Additionally if the DMA channels are not used, the PaRAM sets associated with the unused DMA channels can also be used for link entries or QDMA channels.

NOTE: By default, QDMA channels are mapped to PaRAM set 0. These should be remapped before use, see Section 2.6.2.

2.3.1 PaRAM Set

Each parameter set of PaRAM is organized into eight 32-bit words or 32 bytes, as shown in Figure 7 and described in Table 1. Each PaRAM set consists of 16-bit and 32-bit parameters.

Figure 7. PaRAM Set



Note: *n* is the number of PaRAM sets supported in the EDMA3CC for a specific device.

Table 1. EDMA3 Channel Parameter Description

Offset Address (bytes)	Acronym	Parameter	Description
0h	OPT	Channel Options	Transfer Configuration Options
4h	SRC	Channel Source Address	The byte address from which data is transferred.
8h[(1)]	ACNT	Count for 1st Dimension	Unsigned value specifying the number of contiguous bytes within an array (first dimension of the transfer). Valid values range from 1 to 65 535.
	BCNT	Count for 2nd Dimension	Unsigned value specifying the number of arrays in a frame, where an array is ACNT bytes. Valid values range from 1 to 65 535.
Ch	DST	Channel Destination Address	The byte address to which data is transferred.
10h[(1)]	SRCBIDX	Source BCNT Index	Signed value specifying the byte address offset between source arrays within a frame (2nd dimension). Valid values range from –32 768 and 32 767.
	DSTBIDX	Destination BCNT Index	Signed value specifying the byte address offset between destination arrays within a frame (2nd dimension). Valid values range from –32 768 and 32 767.
14h[(1)]	LINK	Link Address	The PaRAM address containing the PaRAM set to be linked (copied from) when the current PaRAM set is exhausted. A value of FFFFh specifies a null link.
	BCNTRLD	BCNT Reload	The count value used to reload BCNT when BCNT decrements to 0 (TR submitted for the last array in 2nd dimension). Only relevant in A-synchronized transfers.
18h[(1)]	SRCCIDX	Source CCNT Index	Signed value specifying the byte address offset between frames within a block (3rd dimension). Valid values range from –32 768 and 32 767. A-synchronized transfers: The byte address offset from the beginning of the last source array in a frame to the beginning of the first source array in the next frame. AB-synchronized transfers: The byte address offset from the beginning of the first source array in a frame to the beginning of the first source array in the next frame.
	DSTCIDX	Destination CCNT index	Signed value specifying the byte address offset between frames within a block (3rd dimension). Valid values range from –32 768 and 32 767. A-synchronized transfers: The byte address offset from the beginning of the last destination array in a frame to the beginning of the first destination array in the next frame. AB-synchronized transfers: The byte address offset from the beginning of the first destination array in a frame to the beginning of the first destination array in the next frame.
1Ch	CCNT	Count for 3rd Dimension	Unsigned value specifying the number of frames in a block, where a frame is BCNT arrays of ACNT bytes. Valid values range from 1 to 65 535.
	RSVD	Reserved	Reserved

(1) It is recommended to access the parameter set entries as 32-bit words whenever possible.

2.3.2 EDMA3 Channel Parameter Set Fields

2.3.2.1 Channel Options Parameter (OPT)

The 32-bit channel options parameter (OPT) specifies the transfer configuration options. The channel options parameter (OPT) is described in Section 4.1.1.

2.3.2.2 Channel Source Address (SRC)

The 32-bit source address parameter specifies the starting byte address of the source. For SAM in increment mode, there are no alignment restrictions imposed by EDMA3. For SAM in constant addressing mode, you must program the source address to be aligned to a 256-bit aligned address (5 LSBs of address must be 0). The EDMA3TC will signal an error, if this rule is violated. See Section 2.11.2 for additional details.

2.3.2.3 Channel Destination Address (DST)

The 32-bit destination address parameter specifies the starting byte address of the destination. For DAM in increment mode, there are no alignment restrictions imposed by EDMA3. For DAM in constant addressing mode, you must program the destination address to be aligned to a 256-bit aligned address (5 LSBs of address must be 0). The EDMA3TC will signal an error, if this rule is violated. See Section 2.11.2 for additional details.

2.3.2.4 Count for 1st Dimension (ACNT)

ACNT represents the number of bytes within the 1st dimension of a transfer. ACNT is a 16-bit unsigned value with valid values between 0 and 65 535. Therefore, the maximum number of bytes in an array is 65 535 bytes (64K – 1 bytes). ACNT must be greater than or equal to 1 for a TR to be submitted to EDMA3TC. A transfer with ACNT equal to 0 is considered either a null or dummy transfer.

See Section 2.3.5 and Section 2.5.3 for details on dummy/null completion conditions.

2.3.2.5 Count for 2nd Dimension (BCNT)

BCNT is a 16-bit unsigned value that specifies the number of arrays of length ACNT. For normal operation, valid values for BCNT are between 1 and 65 535. Therefore, the maximum number of arrays in a frame is 65 535 (64K – 1 arrays). A transfer with BCNT equal to 0 is considered either a null or dummy transfer.

See Section 2.3.5 and Section 2.5.3 for details on dummy/null completion conditions.

2.3.2.6 Count for 3rd Dimension (CCNT)

CCNT is a 16-bit unsigned value that specifies the number of frames in a block. Valid values for CCNT are between 1 and 65 535. Therefore, the maximum number of frames in a block is 65 535 (64K – 1 frames). A transfer with CCNT equal to 0 is considered either a null or dummy transfer.

See Section 2.3.5 and Section 2.5.3 for details on dummy/null completion conditions.

2.3.2.7 BCNT Reload (BCNTRLD)

BCNTRLD is a 16-bit unsigned value used to reload the BCNT field once the last array in the 2nd dimension is transferred. This field is only used for A-synchronized transfers. In this case, the EDMA3CC decrements the BCNT value by 1 on each TR submission. When BCNT reaches 0, the EDMA3CC decrements CCNT and uses the BCNTRLD value to reinitialize the BCNT value.

For AB-synchronized transfers, the EDMA3CC submits the BCNT in the TR and the EDMA3TC decrements BCNT appropriately. For AB-synchronized transfers, BCNTRLD is not used.

2.3.2.8 Source B Index (SRCBIDX)

SRCBIDX is a 16-bit signed value (2s complement) used for source address modification between each array in the 2nd dimension. Valid values for SRCBIDX are between –32 768 and 32 767. It provides a byte address offset from the beginning of the source array to the beginning of the next source array. It applies to both A-synchronized and AB-synchronized transfers. Some examples:

- SRCBIDX = 0000h (0): no address offset from the beginning of an array to the beginning of the next array. All arrays are fixed to the same beginning address.
- SRCBIDX = 0003h (+3): the address offset from the beginning of an array to the beginning of the next array in a frame is 3 bytes. For example, if the current array begins at address 1000h, the next array begins at 1003h.
- SRCBIDX = FFFFh (–1): the address offset from the beginning of an array to the beginning of the next array in a frame is –1 byte. For example, if the current array begins at address 5054h, the next array begins at 5053h.

2.3.2.9 Destination B Index (DSTBIDX)

DSTBIDX is a 16-bit signed value (2s complement) used for destination address modification between each array in the 2nd dimension. Valid values for DSTBIDX are between –32 768 and 32 767. It provides a byte address offset from the beginning of the destination array to the beginning of the next destination array within the current frame. It applies to both A-synchronized and AB-synchronized transfers. See SRCBIDX (Section 2.3.2.8) for examples.

2.3.2.10 Source C Index (SRCCIDX)

SRCCIDX is a 16-bit signed value (2s complement) used for source address modification in the 3rd dimension. Valid values for SRCCIDX are between –32 768 and 32 767. It provides a byte address offset from the beginning of the current array (pointed to by SRC address) to the beginning of the first source array in the next frame. It applies to both A-synchronized and AB-synchronized transfers. Note that when SRCCIDX is applied, the current array in an A-synchronized transfer is the last array in the frame (Figure 5), while the current array in an AB-synchronized transfer is the first array in the frame (Figure 6).

2.3.2.11 Destination C Index (DSTCIDX)

DSTCIDX is a 16-bit signed value (2s complement) used for destination address modification in the 3rd dimension. Valid values are between –32 768 and 32 767. It provides a byte address offset from the beginning of the current array (pointed to by DST address) to the beginning of the first destination array TR in the next frame. It applies to both A-synchronized and AB-synchronized transfers. Note that when DSTCIDX is applied, the current array in an A-synchronized transfer is the last array in the frame (Figure 5), while the current array in a AB-synchronized transfer is the first array in the frame (Figure 6).

2.3.2.12 Link Address (LINK)

The EDMA3CC provides a mechanism, called linking, to reload the current PaRAM set upon its natural termination (that is, after the count fields are decremented to 0) with a new PaRAM set. The 16-bit parameter LINK specifies the byte address offset in the PaRAM from which the EDMA3CC loads/reloads the next PaRAM set during linking.

You must program the link address to point to a valid aligned 32-byte PaRAM set. The 5 LSBs of the LINK field should be cleared to 0.

The EDMA3CC ignores the upper 2 bits of the LINK entry, allowing the programmer the flexibility of programming the link address as either an absolute/literal byte address or use the PaRAM-base-relative offset address. Therefore, if you make use of the literal address with a range from 4000h to 7FFFh, it will be treated as a PaRAM-base-relative value of 0000h to 3FFFh.

You should make sure to program the LINK field correctly, so that link update is requested from a PaRAM address that falls in the range of the available PaRAM addresses on the device.

A LINK value of FFFFh is referred to as a NULL link that should cause the EDMA3CC to perform an internal write of 0 to all entries of the current PaRAM set, except for the LINK field that is set to FFFFh. Also, see Section 2.5 for details on terminating a transfer.

2.3.3 Null PaRAM Set

A null PaRAM set is defined as a PaRAM set where all count fields (ACNT, BCNT, and CCNT) are cleared to 0. If a PaRAM set associated with a channel is a NULL set, then when serviced by the EDMA3CC, the bit corresponding to the channel is set in the associated event missed register (EMR or QEMR). This bit remains set in the associated secondary event register (SER or QSER). *This implies that any future events on the same channel are ignored by the EDMA3CC and you are required to clear the bit in SER or QSER for the channel.* This is considered an error condition, since events are not expected on a channel that is configured as a null transfer. See Section 4.2.5.8 and Section 4.2.2.1 for more information on the SER and EMR registers, respectively.

2.3.4 Dummy PaRAM Set

A dummy PaRAM set is defined as a PaRAM set where at least one of the count fields (ACNT, BCNT, or CCNT) is cleared to 0 and at least one of the count fields is nonzero.

If a PaRAM set associated with a channel is a dummy set, then when serviced by the EDMA3CC, it will not set the bit corresponding to the channel (DMA/QDMA) in the event missed register (EMR or QEMR) and the secondary event register (SER or QSER) bit gets cleared similar to a normal transfer. Future events on that channel are serviced. A dummy transfer is a legal transfer of 0 bytes. See Section 4.2.5.8 and Section 4.2.2.1 for more information on the SER and EMR registers, respectively.

2.3.5 Dummy Versus Null Transfer Comparison

There are some differences in the way the EDMA3CC logic treats a dummy versus a null transfer request. A null transfer request is an error condition, but a dummy transfer is a legal transfer of 0 bytes. A null transfer causes an error bit (E*n*) in EMR to get set and the E*n* bit in SER remains set, essentially preventing any further transfers on that channel without clearing the associated error registers.

Table 2 summarizes the conditions and effects of null and dummy transfer requests.

Table 2. Dummy and Null Transfer Request

Feature	Null TR	Dummy TR
EMR/QEMR is set	Yes	No
SER/QSER remains set	Yes	No
Link update (STATIC = 0 in OPT)	Yes	Yes
QER is set	Yes	Yes
IPR and CER is set using early completion	Yes	Yes

2.3.6 Parameter Set Updates

When a TR is submitted for a given DMA/QDMA channel and its corresponding PaRAM set, the EDMA3CC is responsible for updating the PaRAM set in anticipation of the next trigger event. For nonfinal events, this includes address and count updates; for final events, this includes the link update.

The specific PaRAM set entries that are updated depend on the channel's synchronization type (A-synchronized or B-synchronized) and the current state of the PaRAM set. A B-update refers to the decrementing of BCNT in the case of A-synchronized transfers after the submission of successive TRs. A C-update refers to the decrementing of CCNT in the case of A-synchronized transfers after BCNT TRs for ACNT byte transfers have submitted. For AB-synchronized transfers, a C-update refers to the decrementing of CCNT after submission of every transfer request.

See Table 3 for details and conditions on the parameter updates. A link update occurs when the PaRAM set is exhausted, as described in Section 2.3.7.

After the TR is read from the PaRAM (and is in process of being submitted to EDMA3TC), the following fields are updated if needed:

- A-synchronized: BCNT, CCNT, SRC, DST
- AB-synchronized: CCNT, SRC, DST

The following fields are not updated (except for during linking, where all fields are overwritten by the link PaRAM set):

- A-synchronized: ACNT, BCNTRLD, SRCBIDX, DSTBIDX, SRCCIDX, DSTCIDX, OPT, LINK
- AB-synchronized: ACNT, BCNT, BCNTRLD, SRCBIDX, DSTBIDX, SRCCIDX, DSTCIDX, OPT, LINK

Note that PaRAM updates only pertain to the information that is needed to properly submit the next transfer request to the EDMA3TC. Updates that occur while data is moved within a transfer request are tracked within the transfer controller, and is detailed in Section 2.11. For A-synchronized transfers, the EDMA3CC always submits a TRP for ACNT bytes (BCNT = 1 and CCNT = 1). For AB-synchronized transfers, the EDMA3CC always submits a TRP for ACNT bytes of BCNT arrays (CCNT = 1). The EDMA3TC is responsible for updating source and destination addresses within the array based on ACNT and FWID (in OPT). For AB-synchronized transfers, the EDMA3TC is also responsible to update source and destination addresses between arrays based on SRCBIDX and DSTBIDX.

Table 3 shows the details of parameter updates that occur within EDMA3CC for A-synchronized and AB-synchronized transfers.

Table 3. Parameter Updates in EDMA3CC (for Non-Null, Non-Dummy PaRAM Set)

	A-Synchronized Transfer			AB-Synchronized Transfer		
	B-Update	**C-Update**	**Link Update**	**B-Update**	**C-Update**	**Link Update**
Condition:	**BCNT > 1**	**BCNT == 1 && CCNT > 1**	**BCNT == 1 && CCNT == 1**	**N/A**	**CCNT > 1**	**CCNT == 1**
SRC	+= SRCBIDX	+= SRCCIDX	= Link.SRC	in EDMA3TC	+= SRCCIDX	= Link.SRC
DST	+= DSTBIDX	+= DSTCIDX	= Link.DST	in EDMA3TC	+= DSTCIDX	= Link.DST
ACNT	None	None	= Link.ACNT	None	None	= Link.ACNT
BCNT	–= 1	= BCNTRLD	= Link.BCNT	in EDMA3TC	N/A	= Link.BCNT
CCNT	None	–= 1	= Link.CCNT	in EDMA3TC	–=1	= Link.CCNT
SRCBIDX	None	None	= Link.SRCBIDX	in EDMA3TC	None	= Link.SRCBIDX
DSTBIDX	None	None	= Link.DSTBIDX	None	None	= Link.DSTBIDX
SRCCIDX	None	None	= Link.SRCBIDX	in EDMA3TC	None	= Link.SRCBIDX
DSTCIDX	None	None	= Link.DSTBIDX	None	None	= Link.DSTBIDX
LINK	None	None	= Link.LINK	None	None	= Link.LINK
BCNTRLD	None	None	= Link.BCNTRLD	None	None	= Link.BCNTRLD
OPT[1]	None	None	= LINK.OPT	None	None	= LINK.OPT

(1) In all cases, no updates occur if OPT.STATIC == 1 for the current PaRAM set.

NOTE: The EDMA3CC includes no special hardware to detect when an indexed address update calculation overflows/underflows. The address update will wrap across boundaries as programmed by the user. You should ensure that no transfer is allowed to cross internal port boundaries between peripherals. A single TR must target a single source/destination slave endpoint.

2.3.7 Linking Transfers

The EDMA3CC provides a mechanism known as linking, which allows the entire PaRAM set to be reloaded from a location within the PaRAM memory map (for both DMA and QDMA channels). Linking is especially useful for maintaining ping-pong buffers, circular buffering, and repetitive/continuous transfers all with no CPU intervention. Upon completion of a transfer, the current transfer parameters are reloaded with the parameter set pointed to by the 16-bit link address field (of the current parameter set). Linking only occurs when the STATIC bit in OPT is cleared to 0.

NOTE: A transfer (DMA or QDMA) should always be linked to another useful transfer. If it is required to terminate a transfer, the transfer should be linked to a NULL set.

The link update occurs after the current PaRAM set event parameters have been exhausted. An event's parameters are exhausted when the EDMA3 channel controller has submitted all the transfers associated with the PaRAM set.

A link update occurs for null and dummy transfers depending on the state of the STATIC bit in OPT and the LINK field. In both cases (null or dummy), if the value of LINK is FFFFh then a null PaRAM set (with all 0s and LINK set to FFFFh) is written to the current PaRAM set. Similarly, if LINK is set to a value other than FFFFh then the appropriate PaRAM location pointed to by LINK is copied to the current PaRAM set.

Once the channel completion conditions are met for an event, the transfer parameters located at the link address are loaded into the current DMA or QDMA channel's associated parameter set. The EDMA3CC reads the entire PaRAM set (8 words) from the PaRAM set specified by LINK and writes all 8 words to the PaRAM set associated with the current channel. Figure 8 shows an example of a linked transfer.

Any PaRAM set in the PaRAM can be used as a link/reload parameter set; however, it is recommended that the PaRAM sets associated with peripheral synchronization events (see Section 2.6) should only be used for linking if the synchronization event isolated with the channel mapped to that PaRAM set is disabled.

If a PaRAM set location is mapped to a QDMA channel (by QCHMAP*n*), then copying the link PaRAM set onto the current QDMA channel PaRAM set is recognized as a trigger event and is latched in QER since a write to the trigger word was performed. This feature can be used to create a linked list of transfers using a single QDMA channel and multiple PaRAM sets.

Link-to-self transfers replicate the behavior of autoinitialization, which facilitates the use of circular buffering and repetitive transfers. After an EDMA3 channel exhausts its current PaRAM set, it reloads all the parameter set entries from another PaRAM set, which is initialized with values identical to the original PaRAM set. Figure 9 shows an example of a linked-to-self transfer. In Figure 9, parameter set 127 has the LINK field address pointing to the address of parameter set 127, that is, linked-to-self.

NOTE: If the STATIC bit in OPT is set for a PaRAM set, then link updates are not performed. The link updates performed internally by the EDMA3CC are atomic. This implies that when the EDMA3CC is updating a PaRAM set, accesses to PaRAM by other EDMA3 programmer's (for example, CPU configuration accesses) are not allowed. Also for QDMA, for example, if the first word of the PaRAM entry is defined as a trigger word, EDMA3CC logic assures that all 8 PaRAM words are updated before the new QDMA event can trigger the transfer for that PaRAM entry.

2.3.7.1 Constant Addressing Mode Transfers/Alignment Issues

If either SAM or DAM is set to 1 (constant addressing mode), then the source or destination address must be aligned to a 256-bit aligned address, respectively, and the corresponding BIDX should be an even multiple of 32 bytes (256 bit). The EDMA3CC does not recognize errors here but the EDMA3TC asserts an error, if this is not true. See Section 2.11.2.

NOTE: The constant addressing (CONST) mode has limited applicability. The EDMA3 should be configured for the constant addressing mode (SAM/DAM = 1) only if the transfer source or destination (on-chip memory, off-chip memory controllers, slave peripherals) support the constant addressing mode. See your device-specific data manual to verify if constant addressing mode is supported. If the constant addressing mode is not supported, the similar logical transfer can be achieved using the increment (INCR) mode (SAM/DAM = 0) by appropriately programming the count and indices values.

2.3.7.2 Element Size

The EDMA3 controller does not use the concept of element-size and element-indexing. Instead, all transfers are defined in terms of all three dimensions: ACNT, BCNT, and CCNT. An element-indexed transfer is logically achieved by programming ACNT to the size of the element and BCNT to the number of elements that need to be transferred. For example, if you have 16-bit audio data and 256 audio samples that needed to be transferred to a serial port, this can be done by programming the ACNT = 2 (2 bytes) and BCNT = 256.

Figure 8. Linked Transfer Example

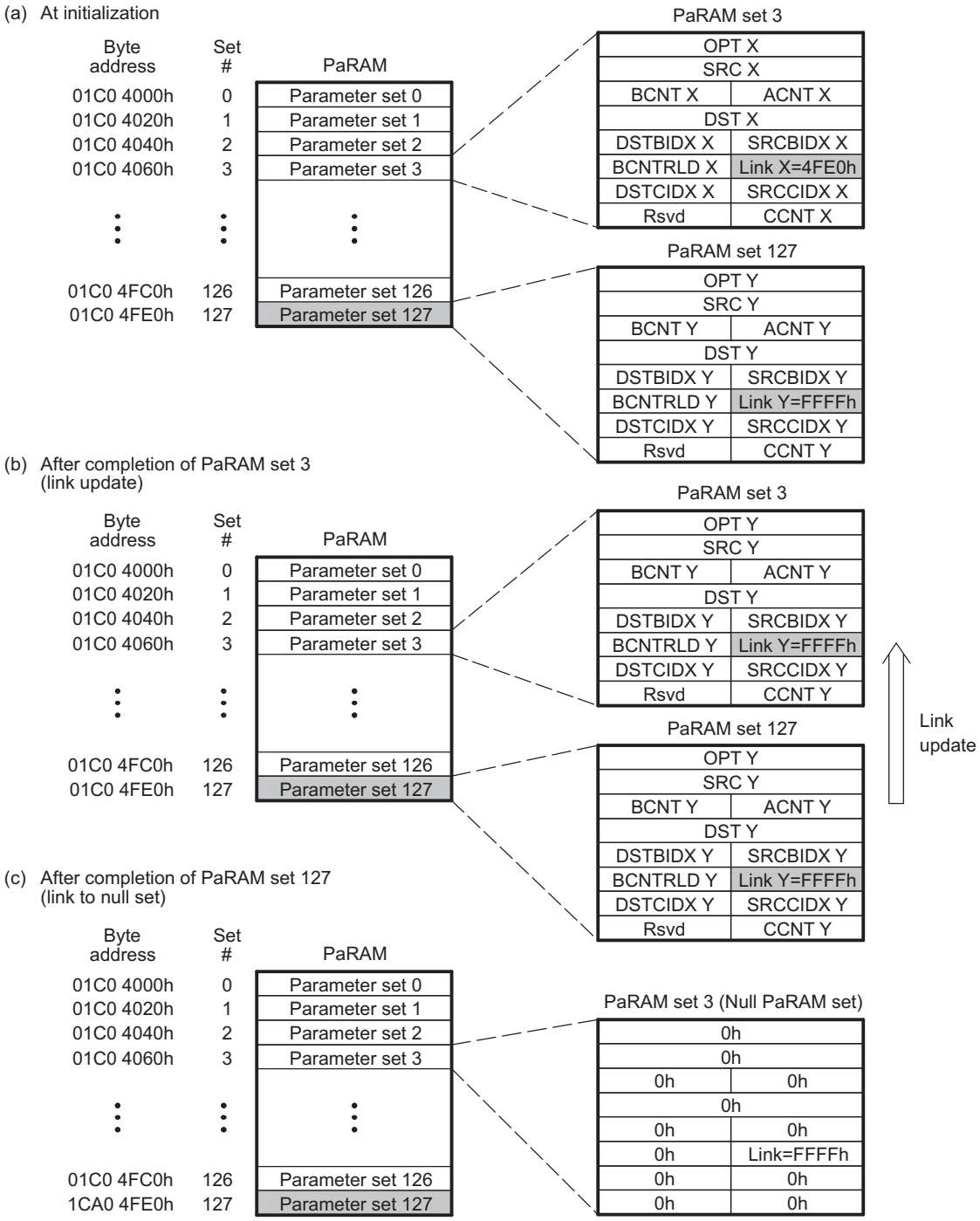
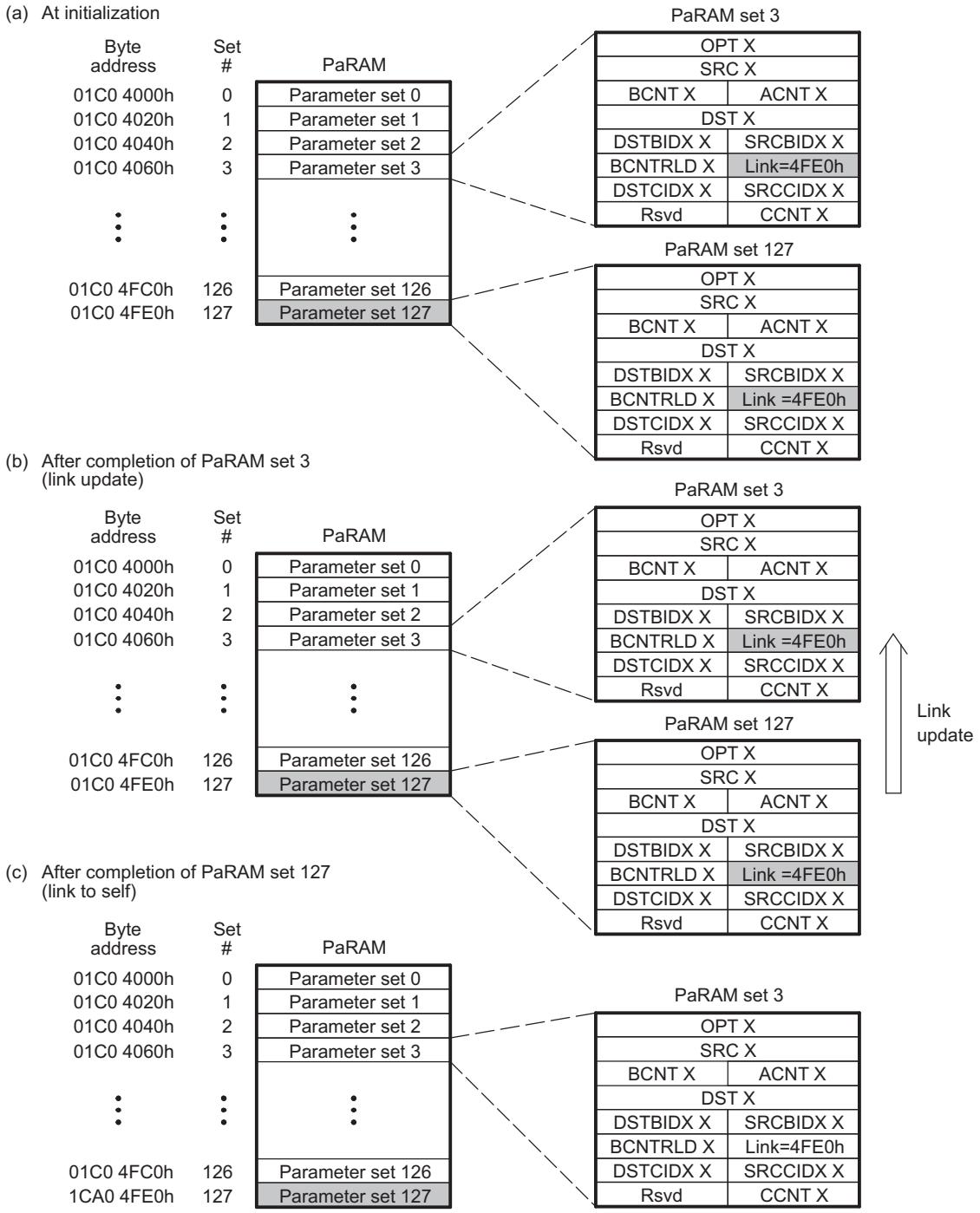


Figure 9. Link-to-Self Transfer Example



2.4 Initiating a DMA Transfer

There are multiple ways to initiate a programmed data transfer using the EDMA3 channel controller. Transfers on DMA channels are initiated by three sources:

- **Event-triggered transfer request** (this is the more typical usage of EDMA3): Allows for a peripheral, system, or externally-generated event to trigger a transfer request.
- **Manually-triggered transfer request:** The CPU manually triggers a transfer by writing a 1 to the corresponding bit in the event set register (ESR).
- **Chain-triggered transfer request:** A transfer is triggered on the completion of another transfer or subtransfer.

Transfers on QDMA channels are initiated by two sources:

- **Autotriggered transfer request:** A transfer is triggered when the PaRAM set entry programmed trigger word is written to.
- **Link-triggered transfer requests:** When linking occurs, the transfer is triggered when the PaRAM set entry programmed trigger word is written to.

2.4.1 DMA Channel

2.4.1.1 Event-Triggered Transfer Request

When an event is asserted from a peripheral or device pins, it gets latched in the corresponding bit of the event register (ER.E*n* = 1). If the corresponding event in the event enable register (EER) is enabled (EER.E*n* = 1), then the EDMA3CC prioritizes and queues the event in the appropriate event queue. When the event reaches the head of the queue, it is evaluated for submission as a transfer request to the transfer controller.

If the PaRAM set is valid (not a NULL set), then a transfer request packet (TRP) is submitted to the EDMA3TC and the E*n* bit in ER is cleared. At this point, a new event can be safely received by the EDMA3CC.

If the PaRAM set associated with the channel is a NULL set (see Section 2.3.3), then no transfer request (TR) is submitted and the corresponding E*n* bit in ER is cleared and simultaneously the corresponding channel bit is set in the event miss register (EMR.E*n* = 1) to indicate that the event was discarded due to a null TR being serviced. Good programming practices should include cleaning the event missed error before retriggering the DMA channel.

When an event is received, the corresponding event bit in the event register is set (ER.E*n* = 1), regardless of the state of EER.E*n*. If the event is disabled when an external event is received (ER.E*n* = 1 and EER.E*n* = 0), the ER.E*n* bit remains set. If the event is subsequently enabled (EER.E*n* = 1), then the pending event is processed by the EDMA3CC and the TR is processed/submitted, after which the ER.E*n* bit is cleared.

If an event is being processed (prioritized or is in the event queue) and another sync event is received for the same channel prior to the original being cleared (ER.E*n* != 0), then the second event is registered as a missed event in the corresponding bit of the event missed register (EMR.E*n* = 1).

For the synchronization events associated with each of the programmable DMA channels, see your device-specific data manual to determine the event to channel mapping.

2.4.1.2 Manually-Triggered Transfer Request

A DMA transfer is initiated by a write to the event set register (ESR) by the CPU (or any EDMA programmer). Writing a 1 to an event bit in the ESR results in the event being prioritized/queued in the appropriate event queue, regardless of the state of the EER.E*n* bit. When the event reaches the head of the queue, it is evaluated for submission as a transfer request to the transfer controller.

As in the event-triggered transfers, if the PaRAM set associated with the channel is valid (it is not a null set) then the TR is submitted to the associated EDMA3TC and the channel can be triggered again.

If the PaRAM set associated with the channel is a NULL set (see Section 2.3.3), then no transfer request (TR) is submitted and the corresponding E*n* bit in ER is cleared and simultaneously the corresponding channel bit is set in the event miss register (EMR.E*n* = 1) to indicate that the event was discarded due to a null TR being serviced. Good programming practices should include clearing the event missed error before retriggering the DMA channel.

If an event is being processed (prioritized or is in the event queue) and the same channel is manually set by a write to the corresponding channel bit of the event set register (ESR.E*n* = 1) prior to the original being cleared (ESR.E*n* = 0), then the second event is registered as a missed event in the corresponding bit of the event missed register (EMR.E*n* = 1).

2.4.1.3 Chain-Triggered Transfer Request

Chaining is a mechanism by which the completion of one transfer automatically sets the event for another channel. When a chained completion code is detected, the value of which is dictated by the transfer completion code (TCC[5:0] in OPT of the PaRAM set associated with the channel), it results in the corresponding bit in the chained event register (CER) to be set (CER.E[TCC] = 1).

Once a bit is set in CER, the EDMA3CC prioritizes and queues the event in the appropriate event queue. When the event reaches the head of the queue, it is evaluated for submission as a transfer request to the transfer controller.

As in the event-triggered transfers, if the PaRAM set associated with the channel is valid (it is not a null set) then the TR is submitted to the associated EDMA3TC and the channel can be triggered again.

If the PaRAM set associated with the channel is a NULL set (see Section 2.3.3), then no transfer request (TR) is submitted and the corresponding E*n* bit in CER is cleared and simultaneously the corresponding channel bit is set in the event miss register (EMR.E*n* = 1) to indicate that the event was discarded due to a null TR being serviced. In this case, the error condition must be cleared by you before the DMA channel can be retriggered. Good programming practices might include clearing the event missed error before retriggering the DMA channel.

If a chaining event is being processed (prioritized or queued) and another chained event is received for the same channel prior to the original being cleared (CER.E*n* != 0), then the second chained event is registered as a missed event in the corresponding channel bit of the event missed register (EMR.E*n* = 1).

NOTE: Chained event registers, event registers, and event set registers operate independently. An event (E*n*) can be triggered by any of the trigger sources (event-triggered, manually-triggered, or chain-triggered).

2.4.2 QDMA Channels

2.4.2.1 Autotriggered and Link-Triggered Transfer Request

QDMA-based transfer requests are issued when a QDMA event gets latched in the QDMA event register (QER.E*n* = 1). A bit corresponding to a QDMA channel is set in the QDMA event register (QER) when the following occurs:

- A CPU (or any EDMA3 programmer) write occurs to a PaRAM address that is defined as a QDMA channel trigger word (programmed in the QDMA channel *n* mapping register (QCHMAP*n*)) for the particular QDMA channel and the QDMA channel is enabled via the QDMA event enable register (QEER.E*n* = 1).
- EDMA3CC performs a link update on a PaRAM set address that is configured as a QDMA channel (matches QCHMAP*n* settings) and the corresponding channel is enabled via the QDMA event enable register (QEER.E*n* = 1).

Once a bit is set in QER, the EDMA3CC prioritizes and queues the event in the appropriate event queue. When the event reaches the head of the queue, it is evaluated for submission as a transfer request to the transfer controller.

As in the event-triggered transfers, if the PaRAM set associated with the channel is valid (it is not a null set) then the TR is submitted to the associated EDMA3TC and the channel can be triggered again.

If a bit is already set in QER (QER.E*n* = 1) and a second QDMA event for the same QDMA channel occurs prior to the original being cleared, the second QDMA event gets captured in the QDMA event miss register (QEMR.E*n* = 1).

2.4.3 Comparison Between DMA and QDMA Channels

The primary difference between DMA and QDMA channels is the event/channel synchronization. QDMA events are either autotriggered or link triggered. Autotriggering allows QDMA channels to be triggered by CPU(s) with a minimum number of linear writes to PaRAM. Link triggering allows a linked list of transfers to be executed, using a single QDMA PaRAM set and multiple link PaRAM sets.

A QDMA transfer is triggered when a CPU (or other EDMA3 programmer) writes to the trigger word of the QDMA channel parameter set (autotriggered) or when the EDMA3CC performs a link update on a PaRAM set that has been mapped to a QDMA channel (link triggered). Note that for CPU triggered (manually triggered) DMA channels, in addition to writing to the PaRAM set, it is required to write to the event set register (ESR) to kick-off the transfer.

QDMA channels are typically for cases where a single event will accomplish a complete transfer since the CPU (or EDMA3 programmer) must reprogram some portion of the QDMA PaRAM set in order to retrigger the channel. In other words, QDMA transfers are programmed with BCNT = CCNT = 1 for A-synchronized transfers, and CCNT = 1 for AB-synchronized transfers.

Additionally, since linking is also supported (if STATIC = 0 in OPT) for QDMA transfers, it allows you to initiate a linked list of QDMAs, so when EDMA3CC copies over a link PaRAM set (including the write to the trigger word), the current PaRAM set mapped to the QDMA channel will automatically be recognized as a valid QDMA event and initiate another set of transfers as specified by the linked set.

2.5 Completion of a DMA Transfer

A parameter set for a given channel is complete when the required number of transfer requests is submitted (based on receiving the number of synchronization events). The expected number of TRs for a non-null/non-dummy transfer is shown in Table 4 for both synchronization types along with state of the PaRAM set prior to the final TR being submitted. When the counts (BCNT and/or CCNT) are this value, the next TR results in a:

- Final chaining or interrupt codes to be sent by the transfer controllers (instead of intermediate).
- Link updates (linking to either null or another valid link set).

Table 4. Expected Number of Transfers for Non-Null Transfer

Sync Mode	Counts at time 0	Total # Transfers	Counts prior to final TR
A-synchronized	ACNT BCNT CCNT	(BCNT × CCNT) TRs of ACNT bytes each	BCNT == 1 && CCNT == 1
AB-synchronized	ACNT BCNT CCNT	CCNT TRs for ACNT × BCNT bytes each	CCNT == 1

You must program the PaRAM OPT field with a specific transfer completion code (TCC) along with the other OPT fields (TCCHEN, TCINTEN, ITCCHEN, and ITCINTEN bits) to indicate whether the completion code is to be used for generating a chained event or/and for generating an interrupt upon completion of a transfer.

The specific TCC value (6-bit binary value) programmed dictates which of the 64-bits in the chain event register (CER[TCC]) and/or interrupt pending register (IPR[TCC]) is set.

See Section 2.9 for details on interrupts and Section 2.8 for details on chaining.

You can also selectively program whether the transfer controller sends back completion codes on completion of the final transfer request (TR) of a parameter set (TCCHEN or TCINTEN), for all but the final transfer request (TR) of a parameter set (ITCCHEN or ITCINTEN), or for all TRs of a parameter set (both). See Section 2.8 for details on chaining (intermediate/final chaining) and Section 2.9 for details on intermediate/final interrupt completion.

A completion detection interface exists between the EDMA3 channel controller and transfer controller(s). This interface sends back information from the transfer controller to the channel controller to indicate that a specific transfer is completed.

All DMA/QDMA PaRAM sets must also specify a link address value. For repetitive transfers such as ping-pong buffers, the link address value should point to another predefined PaRAM set. Alternatively, a nonrepetitive transfer should set the link address value to the null link value. The null link value is defined as FFFFh. See Section 2.3.7 for more details.

NOTE: Any incoming events that are mapped to a null PaRAM set results in an error condition. The error condition should be cleared before the corresponding channel is used again. See Section 2.3.5.

There are three ways the EDMA3CC gets updated/informed about a transfer completion: normal completion, early completion, and dummy/null completion. This applies to both chained events and completion interrupt generation.

2.5.1 Normal Completion

In normal completion mode (TCCMODE = 0 in OPT), the transfer or sub-transfer is considered to be complete when the EDMA3 channel controller receives the completion codes from the EDMA3 transfer controller. In this mode, the completion code to the channel controller is posted by the transfer controller after it receives a signal from the destination peripheral. Normal completion is typically used to generate an interrupt to inform the CPU that a set of data is ready for processing.

2.5.2 Early Completion

In early completion mode (TCCMODE = 1 in OPT), the transfer is considered to be complete when the EDMA3 channel controller submits the transfer request (TR) to the EDMA3 transfer controller. In this mode, the channel controller generates the completion code internally. Early completion is typically useful for chaining, as it allows subsequent transfers to be chained-triggered while the previous transfer is still in progress within the transfer controller, maximizing the overall throughput of the set of the transfers.

2.5.3 Dummy or Null Completion

This is a variation of early completion. Dummy or null completion is associated with a dummy set (Section 2.3.4) or null set (Section 2.3.3). In both cases, the EDMA3 channel controller does not submit the associated transfer request to the EDMA3 transfer controller(s). However, if the set (dummy/null) has the OPT field programmed to return completion code (intermediate/final interrupt/chaining completion), then it will set the appropriate bits in the interrupt pending register (IPR) or chained event register (CER). The internal early completion path is used by the channel controller to return the completion codes internally (that is, EDMA3CC generates the completion code).

2.6 Event, Channel, and PaRAM Mapping

Most of the DMA channels are tied to a specific hardware peripheral event, thus allowing transfers to be triggered by events from device peripherals or external hardware. A DMA channel typically requests a data transfer when it receives its event (apart from manually-triggered, chain-triggered, and other transfers). The amount of data transferred per synchronization event depends on the channel's configuration (ACNT, BCNT, CCNT, etc.) and the synchronization type (A-synchronized or AB-synchronized).

The association of an event to a channel is fixed. Each of the DMA channels has one specific event associated with it. For the synchronization events associated with each of the programmable DMA channels, see your device-specific data manual to determine the event to channel mapping.

If in an application, a channel does not make use of the associated synchronization event or does not have an associated synchronization event (unused), that channel can be used for manually-triggered or chained-triggered transfers, for linking/reloading, or as a QDMA channel.

2.6.1 DMA Channel to PaRAM Mapping

The mapping between the DMA channel numbers and the PaRAM sets is a fixed, one-to-one mapping (see Table 5). In other words, channel (event) 0 is mapped to PaRAM set 0, channel (event 1) is mapped to PaRAM set 1, etc. So, for example, in order to program a transfer for event number 3, DMA channel 3 is associated with PaRAM set number 3 and you need to program this PaRAM set for configuring transfers associated with event number 3. See your device-specific data manual for the addresses of the PaRAM set entries.

Table 5. EDMA3 DMA Channel to PaRAM Mapping

PaRAM Set Number	Mapping
PaRAM Set 0	DMA Channel 0/Reload/QDMA
PaRAM Set 1	DMA Channel 1/Reload/QDMA
PaRAM Set 2	DMA Channel 2/Reload/QDMA
PaRAM Set 3	DMA Channel 3/Reload/QDMA
PaRAM Set 4	DMA Channel 4/Reload/QDMA
PaRAM Set 5	DMA Channel 5/Reload/QDMA
PaRAM Set 6	DMA Channel 6/Reload/QDMA
PaRAM Set 7	DMA Channel 7/Reload/QDMA
PaRAM Set 8	DMA Channel 8/Reload/QDMA
PaRAM Set 9	DMA Channel 9/Reload/QDMA
PaRAM Set 10	DMA Channel 10/Reload/QDMA
PaRAM Set 11	DMA Channel 11/Reload/QDMA
PaRAM Set 12	DMA Channel 12/Reload/QDMA
PaRAM Set 13	DMA Channel 13/Reload/QDMA
PaRAM Set 14	DMA Channel 14/Reload/QDMA
PaRAM Set 15	DMA Channel 15/Reload/QDMA
PaRAM Set 16	DMA Channel 16/Reload/QDMA
...	...
PaRAM Set 30	DMA Channel 30/Reload/QDMA
PaRAM Set 31	DMA Channel 31/Reload/QDMA
PaRAM Set 32	Reload/QDMA
PaRAM Set 33	Reload/QDMA
...	...
PaRAM Set *n* - 2	Reload/QDMA
PaRAM Set *n* - 1	Reload/QDMA
PaRAM Set *n*	Reload/QDMA

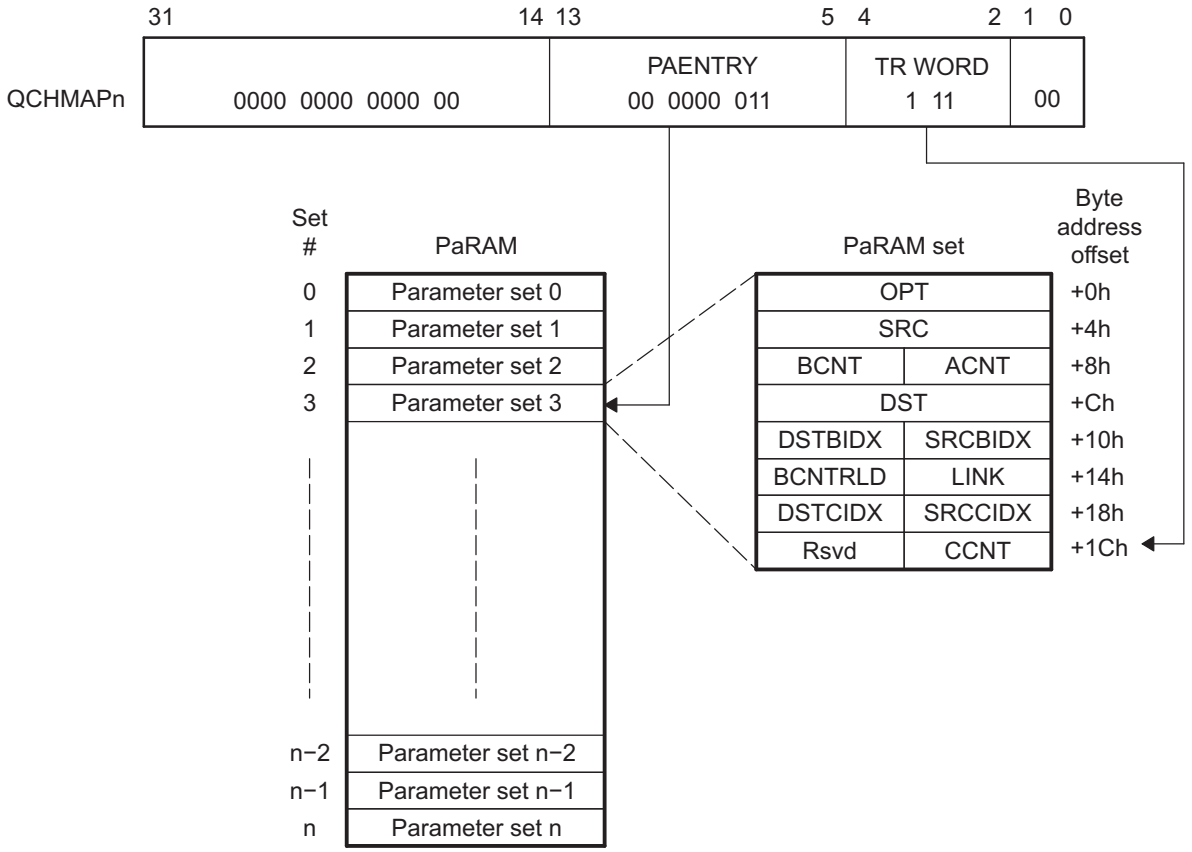
2.6.2 QDMA Channel to PaRAM Mapping

The mapping between the QDMA channels and the PaRAM sets is programmable .The QDMA channel *n* mapping register (QCHMAP*n*) in the EDMA3CC provides programmability for the QDMA channels to be mapped to any of the PaRAM sets in the PaRAM memory map. Figure 10 illustrates the use of QCHMAP.

Additionally, QCHMAP allows you to program the trigger word in the PaRAM set for the QDMA channel. A trigger word is one of the 8 words in the PaRAM set. For a QDMA transfer to occur, a valid TR synchronization event for EDMA3CC is a write to the trigger word in the PaRAM set pointed to by QCHMAP for a particular QDMA channel.

NOTE: By default, QDMA channels are mapped to PaRAM set 0. Care must be taken to appropriately remap PaRAM set 0 before it is used.

Figure 10. QDMA Channel to PaRAM Mapping



Note: *n* is the number of PaRAM sets supported in the EDMA3CC for a specific device.

2.7 EDMA3 Channel Controller Regions

The EDMA3 channel controller (EDMA3CC) divides its address space into multiple regions. Individual channel resources can be exclusively assigned to a specific region, where each region is typically assigned to a specific EDMA programmer. This allows partitioning of EDMA channel (DMA/QDMA) resources in hetero- or multi-core devices, and devices where certain additional masters (for example, coprocessors) can also program/initiate EDMA3 transfers. The application software running on these cores/coprocessors can operate in these exclusive shadow region memory-maps, minimizing possibilities of resource conflicts.

2.7.1 Region Overview

The EDMA3CC memory-mapped registers are divided in three main categories:

1. Global registers
2. Global region channel registers
3. Shadow region channel registers

The global registers are located at a single/fixed location in the EDMA3CC memory map. These registers control EDMA3 resource mapping and provide debug visibility and error tracking information. See your device-specific data manual for the EDMA3CC memory map.

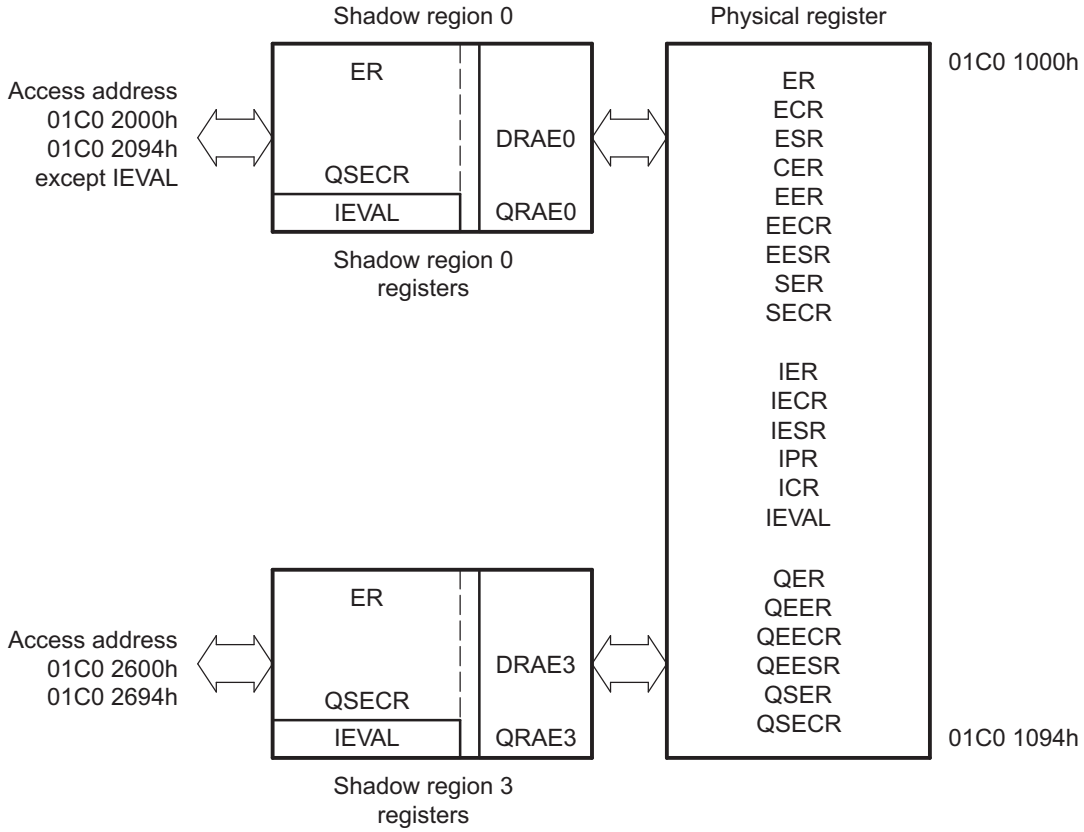
The channel registers (including DMA, QDMA, and interrupt registers) are accessible via the global channel region address range, or in the shadow *n* channel region address range(s). For example, the event enable register (EER) is visible in the global region register space at offset 1020h, or region addresses at offset 2020h for region 0 and at offset 2220h for region 1.

The underlying control register bits that are accessible via the shadow region address space (except for IEVAL*n*) are controlled by the DMA region access enable registers (DRAE*m*) and QDMA region access enable registers (QRAE*m*). Table 6 lists the registers in the shadow region memory-map. (See EDMA3CC memory-map figure for the complete global and shadow region memory-maps.) Figure 11 illustrates the conceptual view of the regions (where *n* is the number of shadow regions supported in the EDMA3CC for a specific device).

Table 6. Shadow Region Registers

DRAE*m*	**QRAE***m*
ER	QER
ECR	QEER
ESR	QEECR
CER	QEESR
EER	
EECR	
EESR	
SER	
SECR	
IER	
IECR	
IESR	
IPR	
ICR	
Register not affected by DRAE	
IEVAL	

Figure 11. Shadow Region Registers



2.7.2 Channel Controller Shadow Regions

For each EDMA3 shadow region (and associated memory-maps) there is a set of registers associated with the shadow region that allows association of the DMA/QDMA channels and interrupt completion codes to the region. These registers are user-programmed per region to assign ownership of the DMA/QDMA channels and TCC values to a region.

- DRAE*m*: One register exists for each of the shadow regions. The number of bits in each register matches the number of DMA channels. These registers need to be programmed to assign ownership of DMA channels to the respective region. Accesses to DMA event registers and interrupt registers via the shadow region address map are filtered through DRAE. A value of 1 in the corresponding DRAE bit implies that the corresponding DMA/interrupt channel is accessible; a value of 0 in the corresponding DRAE bit forces writes to be discarded and returns a value of 0 for reads.
- QRAE*m*: One register exists for every region. The number of bits in each register matches the number of QDMA channels. These registers must be programmed to assign ownership of QDMA channels to the respective region. To enable a channel in a shadow region using shadow region 0 QEER, the respective bit in QRAE must be set or writing into QEESR will not have the desired effect.

It is typical for an application to have a unique assignment of QDMA/DMA channels (and, therefore, a given bit position) to a given region.

The use of shadow regions allows for restricted access to EDMA3 resources (DMA channels, QDMA channels, TCC, interrupts) by tasks/cores/EDMA3 programmers in a system by setting or clearing bits in the DRAE/QRAE registers. If exclusive access to any given channel/TCC code is required for a region, then only that region's DRAE/QRAE should have the associated bit set.

Additionally, with each shadow region, there is an associated shadow region completion interrupt (EDMA3CC_INT*n* where *n* denotes the shadow region number). For multi-core/hetero-core devices, the various shadow region interrupts might be tied to the interrupt controllers for different cores. For single core devices, all shadow region interrupts would be routed to the device interrupt controller. See your device-specific data manual for the shadow region interrupt hookup to the device interrupt controller(s). The DRAE associated with each shadow region acts as a secondary interrupt enable (along with the interrupt enable register) for the respective shadow region interrupts. See Section 2.9 for more information on interrupts.

Example 1. Resource Pool Division Across Two Regions

This example illustrates a resource pool division across two regions, assuming region 0 must be allocated 16 DMA channels (0-15) and 1 QDMA channel (0), and 16 TCC codes (0-15). Region 1 needs to be allocated 16 DMA channels (16-31) and 7 QDMA channels (1-7), and 16 TCC codes (16-31). DRAE should be equal to the OR of the bits that are required for the DMA channels and the TCC codes:

```
Region 0: DRAE = 0x0000FFFF QRAE = 0x00000001 Region 1: DRAE = 0xFFFF0000 QRAE = 0x000000FE
```

2.8 Chaining EDMA3 Channels

The channel chaining capability for the EDMA3 allows the completion of an EDMA3 channel transfer to trigger another EDMA3 channel transfer. The purpose is to allow you the ability to chain several events through one event occurrence.

Chaining is different from linking (Section 2.3.7). The EDMA3 link feature reloads the current channel parameter set with the linked parameter set. The EDMA3 chaining feature does not modify or update any channel parameter set; it provides a synchronization event to the chained channel (see Section 2.4.1.3 for chain-triggered transfer requests).

Chaining is achieved at either final transfer completion or intermediate transfer completion, or both, of the current channel. Consider a channel *m* (DMA/QDMA) required to chain to channel *n*. Channel number *n* (0-31) needs to be programmed into the TCC field of channel *m* channel options parameter (OPT) set.

- If final transfer completion chaining (TCCHEN = 1 and ITCCHEN = 0 in channel *m* OPT) is enabled, the chain-triggered event occurs after the *last* transfer request of channel *m* is submitted (early completion) or completed (normal completion).
- If intermediate transfer completion chaining (TCCHEN = 0 and ITCCHEN = 0 in channel *m* OPT) is enabled, the chain-triggered event occurs after every *intermediate* transfer request of channel *m* is submitted (early completion) or completed (normal completion).
- If both final and intermediate transfer completion chaining (TCCHEN = 1 and ITCCHEN = 1 in channel *m* OPT) are enabled, the chain-trigger event occurs after *every* transfer request of channel *m* is submitted (early completion) or completed (normal completion).

Table 7 shows the number of chain event triggers occurring in different synchronized scenarios. Consider channel 31 programmed with ACNT = 3, BCNT = 4, CCNT = 5, and TCC = 30.

Table 7. Chain Event Triggers

	(Number of chained event triggers on channel 30)	
Options	**A-Synchronized**	**AB-Synchronized**
TCCHEN = 1, ITCCHEN = 0	1 (Last TR)	1 (Last TR)
TCCHEN = 0, ITCCHEN = 1	19 (All but the last TR)	4 (All but the last TR)
TCCHEN = 1, ITCCHEN = 1	20 (All TRs)	5 (All TRs)

2.9 EDMA3 Interrupts

The EDMA3 interrupts are divided into 2 categories:

- Transfer completion interrupts
- Error interrupts

For information on the transfer completion interrupts and the error interrupts, see your device-specific data manual.

2.9.1 Transfer Completion Interrupts

The EDMA3CC is responsible for generating transfer completion interrupts to the CPU. The EDMA3 generates a single completion interrupt per shadow region on behalf of all DMA/QDMA channels. Various control registers and bit fields facilitate EDMA3 interrupt generation.

The transfer completion code (TCC) value is directly mapped to the bits of the interrupt pending register (IPR), as shown in Table 8. For example, if TCC = 00 0000b, IPR[0] is set after transfer completion, and results in an interrupt generation to the CPU if in the EDMA3CC and device interrupt controller are configured to allow a CPU interrupt. See Section 2.9.1.1 for details on enabling EDMA3 transfer completion interrupts.

When a completion code is returned (as a result of early or normal completion), the corresponding bit in IPR is set. For the completion code to be returned, the PaRAM set associated with the transfer must enable the transfer completion interrupt (final/intermediate) in the channel options parameter (OPT).

The transfer completion code (TCC) can be programmed to any value for a DMA/QDMA channel. There does not need to be a direct relation between the channel number and the transfer completion code value. This allows multiple channels having the same transfer completion code value to cause a CPU to execute the same interrupt service routine (ISR) for different channels.

NOTE: The TCC field in the channel options parameter (OPT) is a 6-bit field and can be programmed for any value between 0-64. For devices with 32 DMA channels, the TCC should have a value between 0 to 31 so that it sets the appropriate bits (0 to 31) in IPR (and can interrupt the CPU(s) on enabling the IER register bits (0-31)).

Table 8. Transfer Complete Code (TCC) to EDMA3CC Interrupt Mapping

TCC Bits in OPT (TCINTEN/ITCINTEN = 1)	IPR Bit Set
00 0000b	IPR0
00 0001b	IPR1
00 0010b	IPR2
00 0011b	IPR3
00 0100b	IPR4
…	…
…	…
01 1110b	IPR30
01 1111b	IPR31

You can enable interrupt generation at either final transfer completion or intermediate transfer completion, or both. Consider channel *m* as an example.

- If the final transfer interrupt (TCINTEN = 1 and ITCINTEN = 0 in OPT) is enabled, the interrupt occurs after the *last* transfer request of channel *m* is either submitted or completed (depending on early or normal completion).
- If the intermediate transfer interrupt (TCINTEN = 0 and ITCINTEN = 1 in OPT) is enabled, the interrupt occurs after every *intermediate* transfer request of channel *m* is either submitted or completed (depending on early or normal completion).
- If both final and intermediate transfer completion interrupts (TCINTEN = 1 and ITCINTEN = 1 in OPT) are enabled, the interrupt occurs after *every* transfer request of channel *m* is submitted or completed (depending on early or normal completion).

Table 9 shows the number of interrupts occurring in different synchronized scenarios. Consider channel 31 programmed with ACNT = 3, BCNT = 4, CCNT = 5, and TCC = 30.

Table 9. Number of Interrupts

Options	A-Synchronized	AB-Synchronized
TCINTEN = 1, ITCINTEN = 0	1 (Last TR)	1 (Last TR)
TCINTEN = 0, ITCINTEN = 1	19 (All but the last TR)	4 (All but the last TR)
TCINTEN = 1, ITCINTEN = 1	20 (All TRs)	5 (All TRs)

2.9.1.1 Enabling Transfer Completion Interrupts

For the EDMA3 channel controller to assert a transfer completion to the external world, the interrupts have to be enabled in the EDMA3CC. This is in addition to setting up the TCINTEN and ITCINTEN bits in OPT of the associated PaRAM set.

The EDMA3 channel controller has interrupt enable registers (IER) and each bit location in IER serves as a primary enable for the corresponding interrupt pending register (IPR).

All the interrupt registers (IER, IESR, IECR, and IPR) are either manipulated from the global DMA channel region or by way of the DMA channel shadow regions. The shadow regions provide a view to the same set of physical registers that are in the global region.

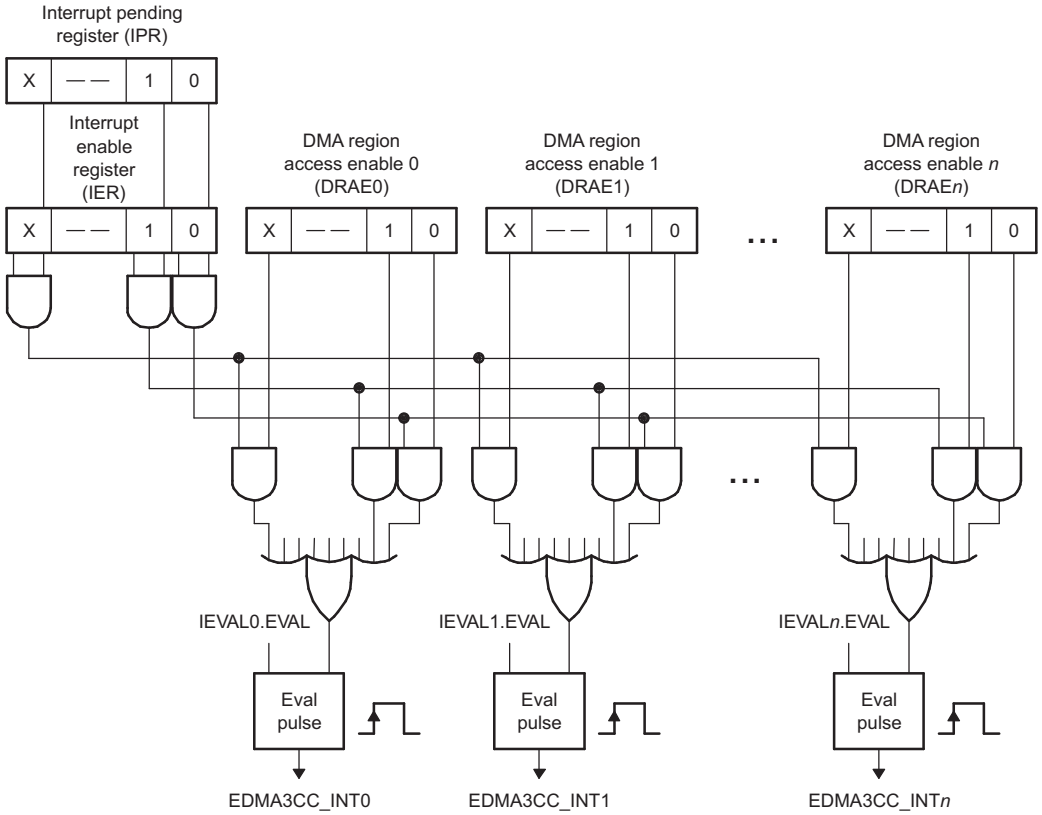
The EDMA3 channel controller has a hierarchical completion interrupt scheme that makes use of a single set of interrupt pending register (IPR) and single set of interrupt enable registers (IER). A second level of interrupt masking is provided by the programmable DMA region access enable registers (DRAE). See Figure 12.

For the EDMA3CC to generate the transfer completion interrupts that are associated with each shadow region, the following conditions must be true:

- EDMA3CC_INT0: (IPR.E0 & IER.E0 & DRAE0.E0) | (IPR.E1 & IER.E1 & DRAE0.E1) | …| (IPR.E*n* & IER.E*n* & DRAE0.E*n*)
- EDMA3CC_INT1: (IPR.E0 & IER.E0 & DRAE1.E0) | (IPR.E1 & IER.E1 & DRAE1.E1) | …| (IPR.E*n* & IER.E*n* & DRAE1.E*n*)

  where *n* is the number of shadow regions supported in the EDMA3CC for a specific device.

Figure 12. Interrupt Diagram



Note: *n* is the number of shadow regions supported in the EDMA3CC for a specific device.

NOTE: The DRAE for all regions is expected to be set up at system initialization and to remain static for an extended period of time. The interrupt enable registers should be used for dynamic enable/disable of individual interrupts.

Because there is no relation between the TCC value and the DMA/QDMA channel, it is possible, for example, for DMA channel 0 to have the OPT.TCC = 31 in its associated PaRAM set. This would mean that if a transfer completion interrupt is enabled (OPT.TCINTEN or OPT.ITCINTEN is set), then based on the TCC value, IPR.E31 is set up on completion. For proper channel operations and interrupt generation using the shadow region map, you must program the DRAE that is associated with the shadow region to have read/write access to both bit 0 (corresponding to channel 0) and bit 31 (corresponding to IPR.E31 bit that is set upon completion).

2.9.1.2 Clearing Transfer Completion Interrupts

Transfer completion interrupts that are latched to the interrupt pending register (IPR) is cleared by writing a 1 to the corresponding bit in the interrupt pending clear register (ICR). For example, a write of 1 to ICR.E0 clears a pending interrupt in IPR.E0.

If an incoming transfer completion code (TCC) gets latched to a bit in IPR, then additional bits that get set due to a subsequent transfer completion will not result in asserting the EDMA3CC completion interrupt. In order for the completion interrupt to be pulsed, the required transition is from a state where no enabled interrupts are set to a state where at least one enabled interrupt is set.

2.9.2 EDMA3 Interrupt Servicing

On completion of a transfer (early or normal completion), the EDMA3 channel controller sets the appropriate bit in the interrupt pending register (IPR) as specified by the transfer completion codes. If the completion interrupts are appropriately enabled, then the CPU enters the interrupt service routine (ISR) when the completion interrupt is asserted. Since there is a single completion interrupt for all DMA/QDMA channels.

After servicing the interrupt, the ISR should clear the corresponding bit in IPR; therefore, enabling recognition of future interrupts. Only when all IPR bits are cleared, the EDMA3CC will assert additional completion interrupts.

It is possible that when one interrupt is serviced; many other transfer completions result in additional bits being set in IPR, thereby resulting in additional interrupts. It is likely that each of these bits in IPR would need different types of service; therefore, the ISR must check all pending interrupts and continue until all the posted interrupts are appropriately serviced.

Following are examples (pseudo code) for a CPU interrupt service routine for an EDMA3CC completion interrupt.

The ISR routine in Example 2 is more exhaustive and incurs a higher latency.

Example 2. Interrupt Servicing

The pseudo code:

1. Read the interrupt pending register (IPR).
2. Perform the operations needed.
3. Write to the interrupt pending clear register (ICR) to clear the corresponding IPR bit.
4. Read IPR again:

   (a) If IPR is not equal to 0, repeat from step 2 (implies occurrence of new event between step 2 to step 4).
   (b) If IPR is equal to 0, this should assure you that all enabled interrupts are inactive.

NOTE: It is possible that during step 4, an event occurs while the IPR bits are read to be 0 and the application is still in the interrupt service routine. If this happens, a new interrupt is recorded in the device interrupt controller and a new interrupt is generated as soon as the application exits the interrupt service routine.

Example 3 is less rigorous, with less burden on the software in polling for set interrupt bits, but can occasionally cause a race condition, as mentioned above.

Example 3. Interrupt Servicing

If it is desired to leave any enabled and pending (possibly lower priority) interrupts, it is required to force the interrupt logic to reassert the interrupt pulse by setting the EVAL bit in the interrupt evaluation register (IEVAL).

The pseudo code:

1. Enter ISR.
2. Read IPR.
3. For the condition set in IPR that you desire to service:
   (a) Service interrupt as required by application.
   (b) Clear bit for serviced conditions (others may still be set, and other transfers may have resulted in returning the TCC to EDMA3CC after step 2).
4. Read IPR prior to exiting ISR:
   (a) If IPR is equal to 0, then exit ISR.
   (b) If IPR is not equal to 0, then set IEVAL so that upon exit of ISR, a new interrupt is triggered if any enabled interrupts are still pending.

The EVAL bit must not be set when IPR is read to be 0, to avoid generation of extra interrupt pulses.

NOTE: Since the DMA region access registers (DRAE) are required to enable the transfer completion region interrupts, it is assumed that there will be a unique and nonoverlapping (in most cases) assignment of the channels and interrupts among the different shadow regions. This allows the interrupt registers (IER, IESR, IECR, IPR, and ICR) in the different shadow regions to functionally operate in an independent manner and nonoverlapping. The above examples for the interrupt service routine is based on this assumption.

2.9.3 Interrupt Evaluation Operations

The EDMA3CC has interrupt evaluate registers (IEVAL) in each shadow region. These registers are the only registers in the DMA channel shadow region memory map that are not affected by the settings for the DMA region access enable registers (DRAE). A write of 1 to the EVAL bit in these registers associated with a particular shadow region results in pulsing the associated region interrupt, if any enabled interrupt (via IER) is still pending (IPR). This register can be used in order to assure that the interrupts are not missed by the CPU (or the EDMA3 master associated with the shadow region) if the software architecture chooses not to use all interrupts. See Example 3 for the use of IEVAL in the EDMA3 interrupt service routine (ISR).

Similarly an error evaluate register (EEVAL) exists in the global region. A write of 1 to the EVAL bit in EEVAL causes the pulsing of the error interrupt if any pending errors are in EMR, QEMR, or CCERR. See Section 2.9.4 for additional details on error interrupts.

NOTE: While using IEVAL for shadow region completion interrupts, you should make sure that the IEVAL operated upon is from that particular shadow region memory map.

2.9.4 Error Interrupts

The EDMA3CC error registers provide the capability to differentiate error conditions (event missed, threshold exceed, etc.). Additionally, if the error bits are set in these registers, it results in asserting the EDMA3CC error interrupt. If EDMA3CC error interrupt is enabled in the device interrupt controller, then it allows the CPU to handle the error conditions.

The EDMA3CC has a single error interrupt (EDMA3_CC0_ERRINT) that gets asserted for all EDMA3CC error conditions. There are four conditions that cause the error interrupt to be pulsed:

- DMA missed events: for all 32 DMA channels. These get latched in the event missed registers (EMR).
- QDMA missed events: for all QDMA channels. These get latched in the QDMA event missed register (QEMR).
- Threshold exceed: for all event queues. These get latched in EDMA3CC error register (CCERR).
- TCC error: for outstanding transfer requests expected to return completion code (TCCHEN or TCINTEN bit in OPT is set to 1) exceeding the maximum limit of 31. This also gets latched in the EDMA3CC error register (CCERR).

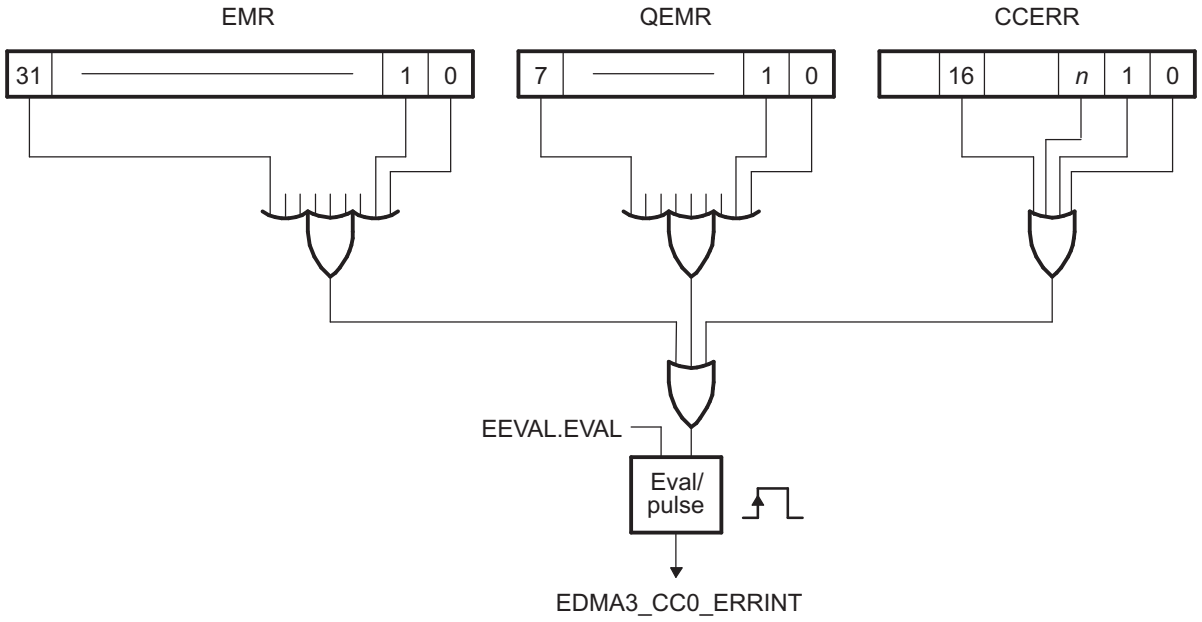
Figure 13 illustrates the EDMA3CC error interrupt generation operation.

If any of the bits are set in the error registers due to any error condition, the (EDMA3_CC0_ERRINT) always is asserted, as there are no enables for masking these error events. Similar to the transfer completion interrupts, the error interrupt also is pulsed only when the error interrupt condition transitions from a state where no errors are set to a state where at least one error bit is set. If additional error events are latched prior to the original error bits being cleared, the EDMA3CC does not generate additional interrupt pulses.

To reduce the burden on the software, similar to the interrupt evaluate register (IEVAL), there is an error evaluate register (EEVAL) that allows reevaluation of pending set error events/bits. This can be used so that the CPU(s) does not miss any error events.

NOTE: It is a good practice to have the error interrupt enabled in the device interrupt controller and associate an interrupt service routine with it to address the various error conditions appropriately. This puts less burden on software (polling for error status) and additionally provides a good debug mechanism for unexpected error conditions.

Figure 13. Error Interrupt Operation



Note: *n* is the number of queues supported in the EDMA3CC for a specific device.

2.10 Event Queue(s)

Event queues are a part of the EDMA3 channel controller. Event queues form the interface between the event detection logic in the EDMA3CC and the transfer request (TR) submission logic of the EDMA3CC. Each queue is 16 entries deep, that is, a maximum of 16 queued events per event queue. If there are more than 16 events, then the events that cannot find a place in the event queue remain set in the associated event register.

The number of event queues in the EDMA3CC determines the number of transfer controllers connected to the EDMA3CC. By default, there is a one-to-one mapping between the queues and transfer controllers. Therefore, the transfer requests (TRs) associated with events in Q0 get submitted to TC0. Similarly, transfer requests associated with events in Q1 get submitted to TC1, and so on.

An event that wins prioritization against other DMA and/or QDMA pending events is placed at the end of the appropriate event queue. Each event queue is serviced in a FIFO (first in–first out) order. Once the event reaches the head of its queue and the corresponding transfer controller is ready to receive another TR, the event is dequeued and the PaRAM set corresponding to the dequeued event is processed and submitted as a transfer request packet (TRP) to the associated EDMA3 transfer controller.

A lower numbered queue has a higher dequeuing priority then a higher numbered queue. For example, Q0 has higher priority than Q1, if Q0 and Q1 both have at least one event entry and if both TC0 and TC1 can accept transfer requests, then the event in Q0 is dequeued first and its associated PaRAM set is processed and submitted as a transfer request (TR) to TC0.

All the event entries in all the event queues are software readable (not writeable) by accessing the event queue entry registers (Q*x*E*y*). Each event entry register characterizes the queued event in terms of the type of event (manual, event, chained or autotriggered) and the event number. See Section 4.2.4.1 for a description of the bit fields in the queue event entry registers.

2.10.1 DMA/QDMA Channel to Event Queue Mapping

Each DMA channel and QDMA channel is independently programmed to map to a specific queue using the DMA queue number register *n* (DMAQNUM*n*) and the QDMA channel queue number register (QDMANUM). The mapping of DMA/QDMA channels is critical to achieving the desired performance level for the EDMA and most importantly in meeting real-time deadlines.

NOTE: If an event is ready to be queued and both the event queue and the EDMA3 transfer controller associated to the event queue are empty, then the event bypasses the event queue, and goes to the PaRAM processing logic and eventually to the transfer request submission logic for submission to the EDMA3TC. In this case, the event is not logged in the event queue status registers.

2.10.2 Queue RAM Debug Visibility

Each event queue has 16 entries. These 16 entries are managed in a circular FIFO manner. All event queue entries for all event queues are software readable by the event queue entry register (Q*x*E*x*). Additionally, for each queue there is a queue status register (QSTAT*n*).

These registers provide user visibility and may be helpful while debugging real-time issues (typically post-mortem), involving multiple events and event sources. The event queue entry register (Q*x*E*x*) uniquely identifies the specific event type (event-triggered, manually-triggered, chain-triggered, and QDMA events) along with the event number (for DMA/QDMA channels) that are in the queue or have been de-queued (passed through the queue). QSTAT*n* includes fields for the start pointer (STRTPTR) that provides the offset to the head entry of an event. It also includes a NUMVAL field that provides the total number of valid entries residing in the event queue at a given instance of time. The STRTPTR field may be used to index appropriately into the 16 event entries. The NUMVAL number of entries starting from STRTPTR are indicative of events still queued in the respective queue. The remaining entries may be read to determine which events have already been de-queued and submitted to the associated transfer controller.

2.10.3 Queue Resource Tracking

The EDMA3CC event queue includes watermarking/threshold logic that allows you to keep track of maximum usage of all event queues. This is useful for debugging real-time deadline violations that may result from head-of-line blocking on a given EDMA3 event queue.

You can program the maximum number of events that can queue up in an event queue by programming the threshold value (between 0 to 15) in the queue watermark threshold A register (QWMTHRA). The maximum queue usage is recorded actively in the watermark (WM) field of the queue status register (QSTAT*n*) that keeps getting updated based on a comparison of number of valid entries, which is also visible in the NUMVAL bit in QSTAT*n* and the maximum number of entries (WM bit in QSTAT*n*).

If the queue usage is exceeded, this status is visible in the EDMA3CC registers: the QTHRXCD*n* bit in the channel controller error register (CCERR) and the THRXCD bit in QSTAT*n*, where *n* stands for the event queue number. Any bits that are set in CCERR also generate an EDMA3CC error interrupt.

2.11 EDMA3 Transfer Controller (EDMA3TC)

The EDMA3 channel controller is the user-interface of the EDMA3 and the EDMA3 transfer controller (EDMA3TC) is the data movement engine of the EDMA3. The EDMA3CC submits transfer requests (TR) to the EDMA3TC and the EDMA3TC performs the data transfers dictated by the TR.

2.11.1 Architecture Details

2.11.1.1 EDMA3TC Configuration

Each transfer controller on a device is designed differently based on considerations like performance requirements, system topology (main SCR bus width, external memory bus width), gate count, etc. The parameters that determine the TC configurations are:

- FIFOSIZE: Determines the size in bytes for the Data FIFO that is the temporary buffer for the in-flight data. The data FIFO is where the read return data read by the TC read controller from the source endpoint is stored and subsequently written out to the destination endpoint by the TC write controller.
- Default Burst Size (DBS): The DBS is the maximum number of bytes per read/write command issued by a transfer controller.
- BUSWIDTH: The width of the read and write data buses in bytes, for the TC read and write controller, respectively. This is typically equal to the bus width of the main SCR interface.
- DSTREGDEPTH: This determines the number of Destination FIFO register set. The number of Destination FIFO register set for a transfer controller, determines the maximum number of outstanding transfer requests (TR pipelining).

Of the four parameters, the FIFOSIZE, BUSWIDTH, and DSTREGDEPTH values are fixed in design for a given device. The default burst size (DBS) for each transfer controller is configurable by the chip configuration 0 register (CFGCHIP0) in the System Configuration Module. See your device-specific *System Reference Guide* for more details on this register.

The burst size for each transfer controlled can be programmed to be 16-, 32-, or 64-bytes. The default values for DBS are typically chosen for optimal performance in most intended-use conditions; therefore, if you decide to use a value other then the default, you should evaluate the impact on performance. Depending on the FIFOSIZE and source/destination locations the performance for the transfer can vary significantly for different burst size values.

NOTE: It is expected that the DBS value for a transfer controller is static and should be based on the application requirement. It is not recommended that the DBS value be changed on-the-fly.

2.11.1.2 Command Fragmentation

The TC read and write controllers in conjunction with the source and destination register sets are responsible for issuing optimally-sized reads and writes to the slave endpoints. The transfer controller read/write transaction as specified by the transfer request packet is internally broken down into smaller bursts; this determines the default burst size (DBS) for the transfer controller. See Section 2.11.1.1 for the DBS value of each EDMA3TC.

The EDMA3TC attempts to issue the largest possible command size as limited by the DBS value or the ACNT/BCNT value of the TR. EDMA3TC obeys the following rules:

- The read/write controllers always issue commands less than or equal to the DBS value.
- The first command of a 1D transfer is always issued so that subsequent commands align to the DBS value.

Example 4 shows the command fragmentation for a DBS of 32 bytes. In summary, if the ACNT value is larger than the DBS value, then the EDMA3TC breaks the ACNT array into DBS-sized commands to the source/destination addresses. Each BCNT number of arrays are then serviced in succession.

Example 4. Command Fragmentation (DBS = 32)

The pseudo code:

1. ACNT = 8, BCNT = 8, SRCBIDX = 8, DSTBIDX = 10, SRCADDR = 64, DSTADDR = 191

   Read Controller: This is optimized from a 2D-transfer to a 1D-transfer such that the read side is equivalent to ACNT = 64, BCNT = 1.

   Cmd0 = 32 byte, Cmd0 = 32 byte

   Write Controller: Since DSTBIDX != ACNT, it is not optimized.

   Cmd0 = 8 byte, Cmd1 = 8 byte, Cmd2 = 8 byte, Cmd3 = 8 byte, Cmd4 = 8 byte, Cmd5 = 8 byte, Cmd6 = 8 byte, Cmd7 = 8 byte.

2. ACNT = 64, BCNT = 1, SRCADDR = 31, DSTADDR = 513

   Read Controller: Read address is not aligned.

   Cmd0 = 1 byte, (now the SRCADDR is aligned to 32 for the next command)

   Cmd1 = 32 bytes

   Cmd2 = 31 bytes

   Write Controller: The write address is also not aligned.

   Cmd0 = 31 bytes, (now the DSTADDR is aligned to 32 for the next command)

   Cmd1 = 32 bytes

   Cmd2 = 1 byte

2.11.1.3 TR Pipelining and Data Ordering

The transfer controller(s) can issue back-to-back transfer requests (TR). The number of outstanding TRs for a TC is limited by the number of destination FIFO register entries that is controlled by the DSTREGDEPTH parameter (fixed in design for a given transfer controller). TR pipelining refers to the ability of the TC read controller to issue read commands for a subsequent TR, while the TC write controller is still performing writes for the previous TR. Consider the case of 2 TRs (TR0 followed by TR1), because of TR pipelining, the TC read controller can start issuing the read commands for TR1 as soon as the last read command for TR0 has been issued, meanwhile the write commands and write data for TR0 are tracked by the destination FIFO registers. In summary, the TC read controller is able to process *n* TRs ahead of the write controller, where *n* is the number of destination FIFO register entries (typically 4).

TR pipelining is useful for maintaining throughput on back-to-back small TRs. It eliminates the read overhead because reads start in the background of a previous TR writes.

It should be noted that back-to-back TRs are targeted to different end points even though the read return data for the two TRs might get returned out of order (that is, read data for TR1 might come in before read data for TR0), the transfer controller issues that the write commands are issued in order (that is, write commands for TR0 will be issued before write commands for TR1).

2.11.2 Error Generation

Similar to the channel controller, the transfer controllers are capable of detecting and reporting several error conditions. The TC errors are generated, under three main conditions:

- BUSERR: The TC read or write controllers detect an error signaled by the source or destination address. The additional details on the type of error is also recorded in the ERRDET register, which indicates whether it is a read error (source address errors) or write error (destination address error).
- MMRAERR: CPU accesses illegal/reserved addresses in the EDMA3CC/TC memory-map.
- TRERR: A transfer request packet is detected to be violating the constant addressing mode transfer rules (the source/destination addresses and source/destination indexes must be aligned to 32 bytes).

You can poll for the errors, as the status of the errors can be read from the ERRSTAT registers, additionally if the error bits are enabled in the ERREN register, a bit set in the ERRSTAT will cause the error condition to interrupt the CPU(s). You can decide to enable/disable either or all error types.

2.11.3 Debug Features

The DMA program register set, DMA source active register set, and the destination FIFO register set are used to derive a brief history of TRs serviced through the transfer controller.

Additionally, the EDMA3TC status register (TCSTAT) has dedicated bit fields to indicate the ongoing activity within different parts of the transfer controller:

- The SRCACTV bit indicates whether the source active set is active.
- The DSTACTV bit indicates the number of TRs resident in the destination register active set at a given instance.
- The PROGBUSY bit indicates whether a valid TR is present in the DMA program set.

If the TRs are in progression, caution must be used and you must realize that there is a chance that the values read from the EDMA3TC status registers will be inconsistent since the EDMA3TC may change the values of these registers due to ongoing activities.

It is recommended that you ensure no additional submission of TRs to the EDMA3TC in order to facilitate ease of debug.

2.11.3.1 Destination FIFO Register Pointer

The destination FIFO register pointer is implemented as a circular buffer with the start pointer being DFSTRTPTR and a buffer depth of usually 2 or 4. The EDMA3TC maintains two important status details in TCSTAT that may be used during advanced debugging, if necessary. The DFSTRTPTR is a start pointer, that is, the index to the head of the destination FIFO register. The DSTACTV is a counter for the number of valid (occupied) entries. These registers may be used to get a brief history of transfers.

Examples of some register field values and their interpretation:

- DFSTRTPTR = 0 and DSTACTV = 0 implies that no TRs are stored in the destination FIFO register.
- DFSTRTPTR = 1 and DSTACTV = 2h implies that two TRs are present. The first pending TR is read from the destination FIFO register entry 1 and the second pending TR is read from the destination FIFO register entry 2.
- DFSTRTPTR = 3h and DSTACTV = 2h implies that two TRs are present. The first pending TR is read from the destination FIFO register entry 3 and the second pending TR is read from the destination FIFO register entry 0.

2.12 Event Dataflow

This section summarizes the data flow of a single event, from the time the event is latched to the channel controller to the time the transfer completion code is returned. The following steps list the sequence of EDMA3CC activity:

1. Event is asserted from an external source (peripheral or external interrupt). This also is similar for a manually-triggered, chained-triggered, or QDMA-triggered event. The event is latched into the ER.E*n* (or CER.E*n*, ESR.E*n*, QER.E*n*) bit.
2. Once an event is prioritized and queued into the appropriate event queue, the SER.E*n* (or QSER.E*n*) bit is set to inform the event prioritization/processing logic to disregard this event since it is already in the queue. Alternatively, if the transfer controller and the event queue are empty, then the event bypasses the queue.
3. The EDMA3CC processing and the submission logic evaluates the appropriate PaRAM set and determines whether it is a non-null and non-dummy transfer request (TR).
4. The EDMA3CC clears the ER.E*n* (or CER.E*n*, ESR.E*n*, QER.E*n*) bit and the SER.E*n* bit as soon as it determines the TR is non-null. In the case of a null set, the SER.E*n* bit remains set. It submits the non-null/non-dummy TR to the associated transfer controller. If the TR was programmed for early completion, the EDMA3CC immediately sets the interrupt pending register (IPR.I[TCC]).
5. If the TR was programmed for normal completion, the EDMA3CC sets the interrupt pending register (IPR.I[TCC]) when the EDMA3TC informs the EDMA3CC about completion of the transfer (returns transfer completion codes).
6. The EDMA3CC programs the associated EDMA3TC*n* Program Register Set with the TR.
7. The TR is then passed to the Source Active set and the Dst FIFO Register Set, if both the register sets are available.
8. The Read Controller processes the TR by issuing read commands to the source slave endpoint. The Read Data lands in the Data FIFO of the EDMA3TC*n*.
9. As soon as sufficient data is available, the Write Controller begins processing the TR by issuing write commands to the destination slave endpoint.
10. This continues until the TR completes and the EDMA3TC*n* then signals completion status to the EDMA3CC.

2.13 EDMA3 Prioritization

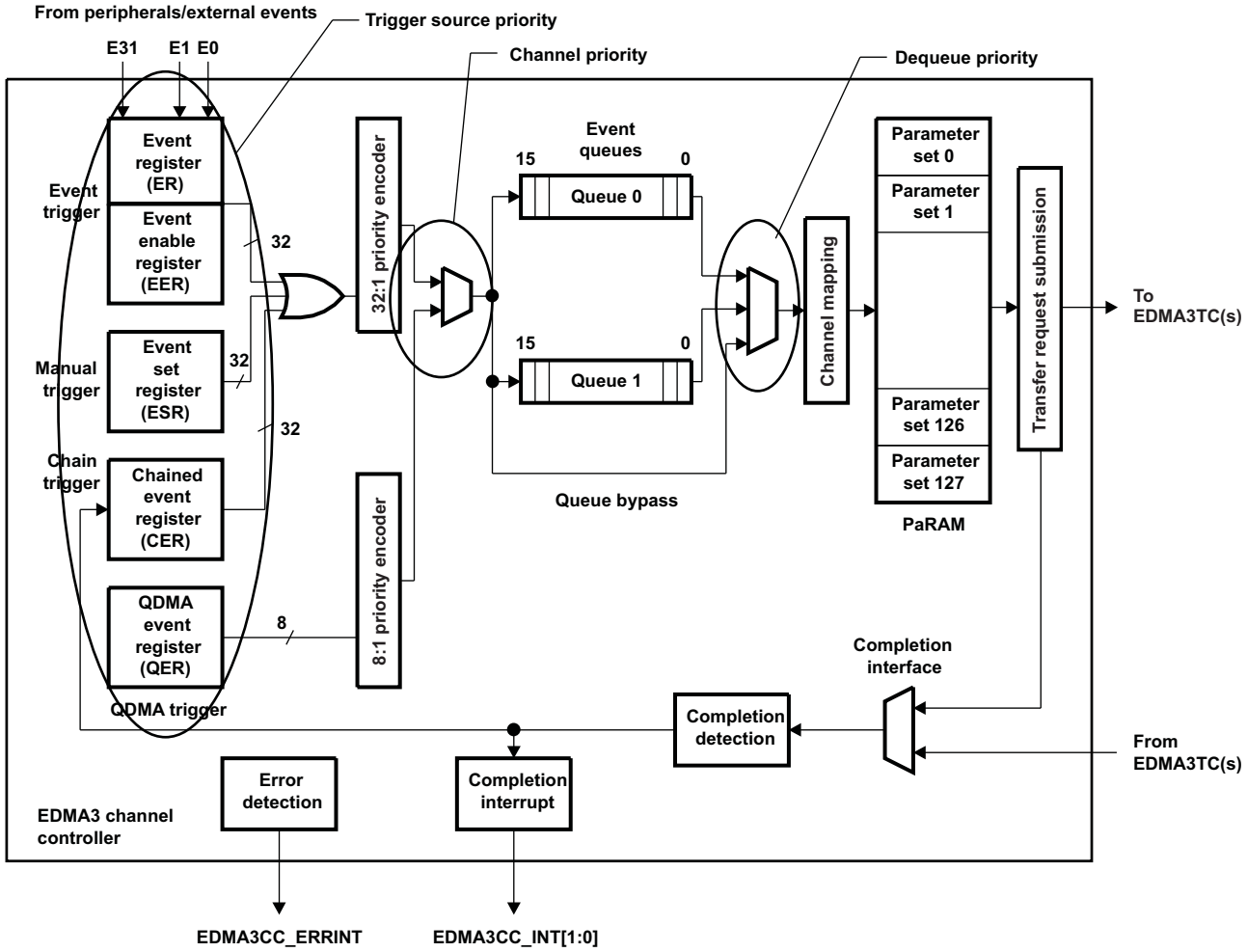
The EDMA3 controller has many implementation rules to deal with concurrent events/channels, transfers, etc. The following subsections detail various arbitration details whenever there might be occurrence of concurrent activity. Figure 14 shows the different places EDMA3 priorities come into play.

2.13.1 Channel Priority

The DMA event register (ER) captures all external/peripheral events connected to the EDMA3CC; likewise, the QDMA event register (QER) captures QDMA events for all QDMA channels; therefore, it is possible for events to occur simultaneously on the DMA/QDMA event inputs. For events arriving simultaneously, the event associated with the lowest channel number is prioritized for submission to the event queues (for DMA events, channel 0 has the highest priority and channel 31 has the lowest priority; similarly, for QDMA events, channel 0 has the highest priority and channel 7 has the lowest priority). This mechanism only sorts simultaneous events for submission to the event queues.

If a DMA and QDMA event occurs simultaneously, the DMA event always has prioritization against the QDMA event for submission to the event queues.

Figure 14. EDMA3 Prioritization



2.13.2 Trigger Source Priority

If a DMA channel is associated with more than one trigger source (event trigger, manual trigger, and chain trigger), and if multiple events are set simultaneously for the same channel (ER.E*n* = 1, ESR.E*n* = 1, CER.E*n* = 1), then the EDMA3CC always services these events in the following priority order: event trigger (via ER) is higher priority than chain trigger (via CER) and chain trigger is higher priority than manual trigger (via ESR).

This implies that if for channel 0, both ER.E0 = 1 and CER.E0 = 1 at the same time, then the ER.E0 event is always queued before the CER.E0 event.

2.13.3 Dequeue Priority

The priority of the associated transfer request (TR) is further mitigated by which event queue is being used for event submission (dictated by DMAQNUM*n* and QDMAQNUM). For submission of a TR to the transfer controller, events need to be dequeued from the event queues. A lower numbered queue has a higher dequeuing priority then a higher numbered queue. For example, if there are events in Q0 and Q1 and the respective transfer controllers (TC0 and TC1) are ready to receive the next TR from the EDMA3CC, then the transfer requests associated with events in Q0 will get submitted to TC0 prior to any transfer requests associated with events in Q1 getting submitted to TC1.

NOTE: At any given time, if there are outstanding events in multiple queues, when the transfer controller associated with the lower numbered (higher priority) queue is busy processing earlier transfer requests and the transfer controller associated with the higher numbered (lower priority) queue is idle, then the event in the higher numbered (lower priority) queue will dequeue first.

2.13.4 Master (Transfer Controller) Priority

All master peripherals on the device have a programmable priority level. When multiple masters are trying to access common shared resources (slave memory or peripherals), this priority value allows the system interconnect to arbitrate requests from different masters based on their priority. This priority assignment is determined in chip-level registers in the System Configuration Module (see your device-specific *System Reference Guide*), where each master has an allocated priority value (power on reset default value), which can be re programmed based on the applications prioritization requirements. The priority value can be configured between 0 to 7, with 0 being the highest priority and 7 being the lowest priority.

Each transfer controller on the device is also a master peripheral. The priority of the transfer requests (read/write commands) issued by the individual EDMA3TC read/write ports in the system can be programmed via these registers.

The dequeue priority has a relatively secondary effect as compared to this Master priority; therefore, it is important to program the priority of each transfer controller with respect to each other and also with respect to other masters in the system.

NOTE: On previous architectures, the EDMA3TC priority was controlled by the QUEPRI register in the EDMA3CC memory-map. However for this device, the priority control for the transfer controllers is controlled by the chip-level registers in the System Configuration Module.

2.14 EDMA3CC and EDMA3TC Performance and System Considerations

2.14.1 System Priority Considerations

The main switched central resource (SCR) (see your device-specific data manual) arbitrates bus requests from all the masters (CPU, master peripherals, and the EDMA3 transfer controllers) to the shared slave resources (peripherals and memories). The priorities of transfer requests (read and write commands) from the EDMA3 transfer controllers with respect to each other and the other masters within the system is configured as explained in Section 2.13.4.

It is recommended that this priority be altered based on system level considerations. For example, peripherals servicing audio/video/display threads that typically have real-time deadlines should be programmed as highest priority requestors in the systems, where as, peripherals responsible for doing bulk/block/paging transfers with no real-time deadlines, should be programmed as a lower system priority.

The default priority for all transfer controllers is the same, 0 or highest priority relative to other masters; therefore, it is recommended that a TC servicing audio data requests from serial ports should be configured at a higher priority as compared to TC service memory to memory (paging/bulk) transfer requests.

2.14.2 TC Transfer Optimization Considerations

The transfer controller can internally optimize the way it issues read commands and write commands for a given transfer under certain conditions. For 2D transfers (that is, BCNT arrays of ACNT bytes), if the ACNT value is less than or equal to the DBS value, then the transfer controller will try to optimize the TR into a 1D transfer in order to maximize efficiency. The optimization only takes place if the EDMA3TC recognizes that the 2D transfer is organized as a single dimension (SAM/DAM = 0, increment mode), SRC/DST BIDX = ACNT, the ACNT value is a power of 2, and the BCNT value is less than or equal to 1023. If these conditions are met, then instead of issuing ACNT bytes worth read and/or write commands, the TC will try to optimize the bus usage by issuing commands as if ACNT' = ACNT × BCNT and BCNT = 1.

Table 10 summarizes the conditions in which the optimizations are performed.

Table 10. Read/Write Command Optimization Rules

ACNT ≤ DBS	ACNT is power of 2	BIDX = ACNT	BCNT ≤ 1023	SAM/DAM = 0 (Increment)	Description
Yes	Yes	Yes	Yes	Yes	Optimized
Yes	No	x	x	Yes	Not Optimized
Yes	x	No	x	Yes	Not Optimized
No	x	x	x	Yes	Not Optimized
x	x	x	x	No	Not Optimized

Consider a case in which it is needed to transfer 4096 bytes where the data is arranged linearly in both the source and destination locations (SAM/DAM = 0, SRC/DST BIDX = ACNT): Scenario A programs the ACNT = 4, BCNT = 1024 , AB-synchronized transfer; and Scenario B programs the ACNT = 64, BCNT = 64. Scenario B will yield a much optimized transfer and higher throughput, as the transfer meets all the optimization rules, which would result in TC internally treating it as a transfer with an ACNT' = 4096 (ACNT × BCNT). The TC will optimally size, default burst size worth read and write commands. In the case of Scenario B, since one of the optimization rules is not met (BCNT value is greater then 1023), the TC will end up issuing several ACNT byte (4 byte) size commands to complete the transfers, which will result in inefficient usage of the read/write buses.

2.14.3 Throttling the Read Command Rate in a Transfer Controller

By default, the transfer controller issues reads as fast as possible. In some cases, the reads issued by the EDMA3TCC could fill the available command buffering for a slave, delaying other (potentially higher priority) masters from successfully submitting commands to that slave. The rate at which read commands are issued by the EDMA3TC is controlled by the read command rate register (RDRATE), and this can be used to throttle the rate at which the commands are issued from the TC read interface. RDRATE defines the number of cycles that the EDMA3TC read controller waits before issuing subsequent commands for a given TR, thus minimizing the chance of the EDMA3TC consuming all available slave resources. The RDRATE value should be set to a relatively small value (or kept at default, which implies issuing read requests as fast as possible) if the transfer controller is targeted for high-priority transfers and set to a high value if the transfer controller is targeted for low-priority transfers. In contrast, the write Interface does not have any performance turning knobs because writes always have an interval between commands as write commands are submitted along with the associated write data.

2.15 EDMA3 Operating Frequency (Clock Control)

The EDMA3 channel controller and transfer controller are clocked from PLL controller 0 (PLLC0). For details, see your device-specific *System Reference Guide*.

2.16 Reset Considerations

A hardware reset resets the EDMA3 (EDMA3CC and EDMA3TC) and the EDMA3 configuration registers. The PaRAM memory contents are undefined after device reset and you should not rely on parameters to be reset to a known state. The PaRAM set must be initialized to a desired value before it is used.

2.17 Power Management

The EDMA3 (EDMA3CC and EDMA3TC) can be placed in reduced-power modes to conserve power during periods of low activity. The power management of the peripheral is controlled by the device Power and Sleep Controller (PSC). The PSC acts as a master controller for power management for all peripherals on the device. For detailed information on power management procedures using the PSC, see your device-specific *System Reference Guide*.

The EDMA3 controller can be idled on receiving a clock stop request from the PSC. The requests to EDMA3CC and EDMA3TC are separate. In general, you should verify that there are no pending activities in the EDMA3 controller before issuing a clock stop request via PSC.

The EDMA3CC checks for the following conditions:

- No pending DMA/QDMA events
- No outstanding events in the event queues
- Transfer request processing logic is not active
- No completion requests outstanding (early or normal completion)
- No configuration bus requests in progress

The first four conditions are software readable by the channel controller status register (CCSTAT) in the EDMA3CC.

Similarly, from the EDMA3TC perspective, you should check that there are no outstanding TRs that are getting processed and essentially the read/write controller is not busy processing a TR. The activity of EDMA3TC logic is read in TCSTAT for each EDMA3TC.

It is generally recommended to first disable the EDMA3CC and then the EDMA3TC(s) to put the EDMA3 controller in reduced-power modes.

Additionally, when EDMA3 is involved in servicing a peripheral and it is required to power-down both the peripheral and the EDMA, the recommended sequence is to first disable the peripheral, then disable the DMA channel associated with the peripheral (clearing the EER bit for the channel), then disable the EDMA3CC, and finally disable the EDMA3TC(s).

2.18 Emulation Considerations

During debug when using the emulator, the CPU(s) may be halted on an execute packet boundary for single-stepping, benchmarking, profiling, or other debug purposes. During an emulation halt, the EDMA3 channel controller and transfer controller operations continue. Events continue to be latched and processed and transfer requests continue to be submitted and serviced.

Since EDMA3 is involved in servicing multiple master and slave peripherals, it is not feasible to have an independent behavior of the EDMA3 for emulation halts. EDMA3 functionality would be coupled with the peripherals it is servicing, which might have different behavior during emulation halts. For example, if a multichannel buffered serial port (McBSP) is halted during an emulation access (FREE = 0 and SOFT = 0 or 1 in the McBSP registers), the McBSP stops generating the McBSP receive or transmit events (REVT or XEVT) to the EDMA. From the point of view of the McBSP, the EDMA3 is suspended, but other peripherals (for example, a timer) still assert events and will be serviced by the EDMA.

3 Transfer Examples

The EDMA3 channel controller performs a variety of transfers depending on the parameter configuration. The following sections provides a description and PaRAM configuration for some typical use case scenarios.

3.1 Block Move Example

The most basic transfer performed by the EDMA3 is a block move. During device operation it is often necessary to transfer a block of data from one location to another, usually between on-chip and off-chip memory.

In this example, a section of data is to be copied from external memory to internal L2 SRAM. A data block of 256 bytes residing at address 4000 0000h (external memory) needs to be transferred to internal address 1180 0000h (L2), as shown in Figure 15. Figure 16 shows the parameters for this transfer.

The source address for the transfer is set to the start of the data block in external memory, and the destination address is set to the start of the data block in L2. If the data block is less than 64K bytes, the PaRAM configuration in Figure 16 holds true with the synchronization type set to A-synchronized and indexes cleared to 0. If the amount of data is greater than 64K bytes, BCNT and the B-indexes need to be set appropriately with the synchronization type set to AB-synchronized. The STATIC bit in OPT is set to prevent linking.

This transfer example may also be set up using QDMA. For successive transfer submissions, of a similar nature, the number of cycles used to submit the transfer are fewer depending on the number of changing transfer parameters. You may program the QDMA trigger word to be the highest numbered offset in the PaRAM set that undergoes change.

Figure 15. Block Move Example

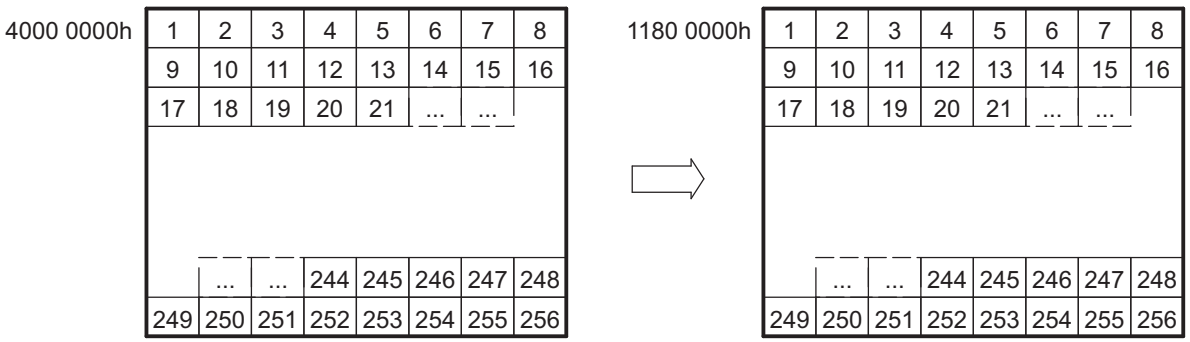


Figure 16. Block Move Example PaRAM Configuration

(a) EDMA Parameters

Parameter Contents	Parameter
0010 0008h	Channel Options Parameter (OPT)
4000 0000h	Channel Source Address (SRC)
0001h | 0100h	Count for 2nd Dimension (BCNT) | Count for 1st Dimension (ACNT)
1180 0000h	Channel Destination Address (DST)
0000h | 0000h	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) 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	00	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	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.2 Subframe Extraction Example

The EDMA3 can efficiently extract a small frame of data from a larger frame of data. By performing a 2D-to-1D transfer, the EDMA3 retrieves a portion of data for the CPU to process. In this example, a 640 × 480-pixel frame of video data is stored in external memory, SDRAM. Each pixel is represented by a 16-bit halfword. The CPU extracts a 16 × 12-pixel subframe of the image for processing. To facilitate more efficient processing time by the CPU, the EDMA3 places the subframe in internal L2 SRAM. Figure 17 shows the transfer of a subframe from external memory to L2. Figure 18 shows the parameters for this transfer.

The same PaRAM set options are used for QDMA channels, as well as DMA channels. The STATIC bit in OPT is set to 1 to prevent linking. For successive transfers, only changed parameters need to be programmed before triggering the channel.

Figure 17. Subframe Extraction Example

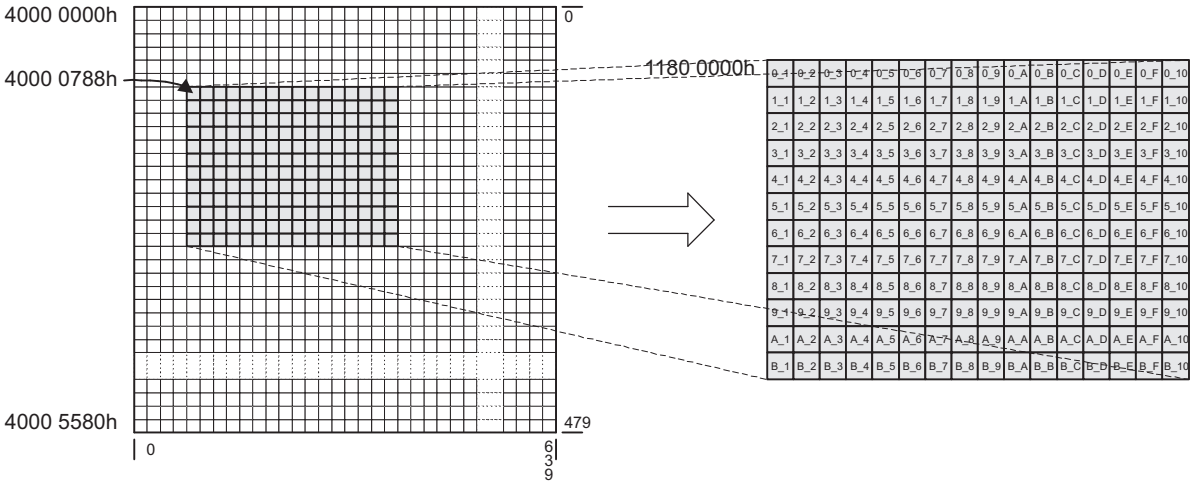


Figure 18. Subframe Extraction Example PaRAM Configuration

(a) EDMA Parameters

Parameter Contents	
0010 000Ch	
4000 0788h	
000Ch	0020h
1180 0000h	
0020h	0500h
0000h	FFFFh
0000h	0000h
0000h	0001h

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

(b) 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	00	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	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.3 Data Sorting Example

Many applications require the use of multiple data arrays; it is often desirable to have the arrays arranged such that the first elements of each array are adjacent, the second elements are adjacent, and so on. Often this is not how the data is presented to the device. Either data is transferred via a peripheral with the data arrays arriving one after the other or the arrays are located in memory with each array occupying a portion of contiguous memory spaces. For these instances, the EDMA3 can reorganize the data into the desired format. Figure 19 shows the data sorting.

In order to determine the parameter entry values, the following need to be considered:

- ACNT – Program this to be the size in bytes of an element.
- BCNT – Program this to be the number of elements in a frame.
- CCNT – Program this to be the number of frames.
- SRCBIDX – Program this to be the size of the element or ACNT.
- DSTBIDX = CCNT × ACNT
- SRCCDX = ACNT × BCNT
- DSTCIDX = ACNT

The synchronization type needs to be AB-synchronized and the STATIC bit is 0 to allow updates to the parameter set. It is advised to use normal DMA channels for sorting.

It is not possible to sort this with a single trigger event. Instead, the channel can be programmed to be chained to itself. After BCNT elements get sorted, intermediate chaining could be used to trigger the channel again causing the transfer of the next BCNT elements and so on. Figure 20 shows the parameter set programming for this transfer, assuming channel 0 and an element size of 4 bytes.

Figure 19. Data Sorting Example

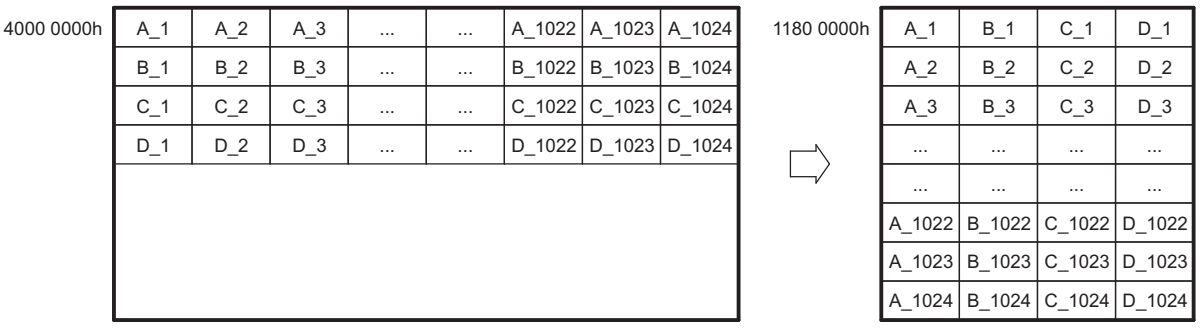


Figure 20. Data Sorting Example PaRAM Configuration

(a) EDMA Parameters

Parameter Contents		Parameter	
0090 0004h		Channel Options Parameter (OPT)	
4000 0000h		Channel Source Address (SRC)	
0400h	0004h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
1180 0000h		Channel Destination Address (DST)	
0010h	0001h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0000h	FFFFh	BCNT Reload (BCNTRLD)	Link Address (LINK)
0001h	1000h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0004h	Reserved	Count for 3rd Dimension (CCNT)

(b) Channel Options Parameter (OPT) Content

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	1	0	0	1	00	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	0	1	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.4 Peripheral Servicing Example

NOTE: Examples in this section are sample examples. The peripherals, channels, and addresses used in these examples may not apply to your specific device. See your device-specific data manual for supported peripherals.

The EDMA3 channel controller also services peripherals in the background of CPU operation, without requiring any CPU intervention. Through proper initialization of the DMA channels, they can be configured to continuously service on-chip and off-chip peripherals throughout the device operation. Each event available to the EDMA3 has its own dedicated channel, and all channels operate simultaneously. The only requirements are to use the proper channel for a particular transfer and to enable the channel event in the event enable register (EER). When programming a DMA channel to service a peripheral, it is necessary to know how data is to be presented to the CPU. Data is always provided with some kind of synchronization event as either one element per event (nonbursting) or multiple elements per event (bursting).

3.4.1 Nonbursting Peripherals

Nonbursting peripherals include the on-chip multichannel buffered serial port (McBSP) and many external devices, such as codecs. Regardless of the peripheral, the DMA channel configuration is the same.

The McBSP transmit and receive data streams are treated independently by the EDMA3. The transmit and receive data streams can have completely different counts, data sizes, and formats. Figure 21 shows servicing incoming McBSP data.

To transfer the incoming data stream to its proper location in L2 memory, the DMA channel must be set up for a 1D-to-1D transfer with A-synchronization. Since an event (REVT) is generated for every word as it arrives, it is necessary to have the EDMA3 issue the transfer request for each element individually. Figure 22 shows the parameters for this transfer. The source address of the DMA channel is set to the data receive register (DRR) address for the McBSP, and the destination address is set to the start of the data block in L2. Since the address of DRR is fixed, the source B index is cleared to 0 (no modification) and the destination B index is set to 01b (increment).

Based on the premise that serial data is typically a high priority, the DMA channel should be programmed to be on queue 0.

Figure 21. Servicing Incoming McBSP Data Example

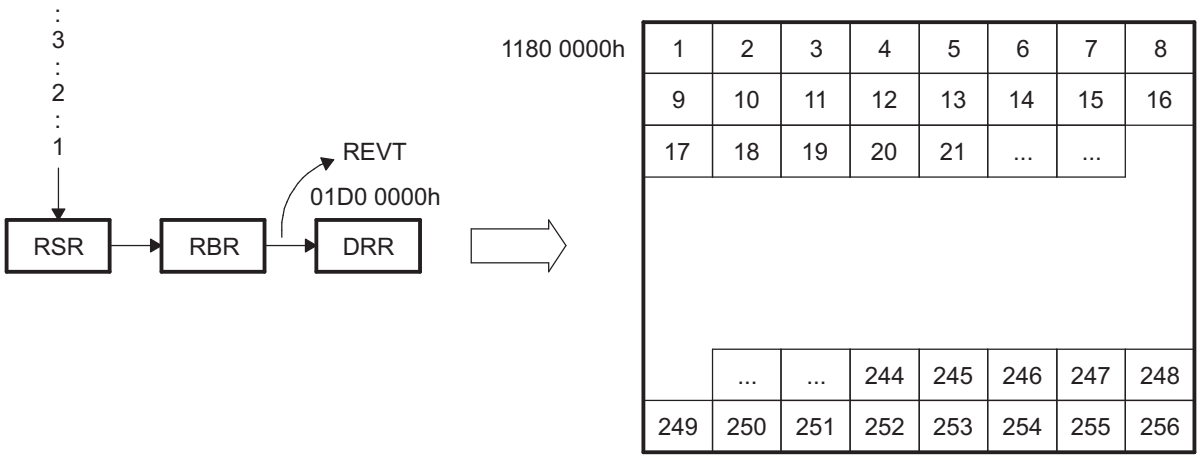


Figure 22. Servicing Incoming McBSP Data Example PaRAM

(a) EDMA Parameters

Parameter Contents	Parameter
0010 0000h	Channel Options Parameter (OPT)
01D0 0000h	Channel Source Address (SRC)
0100h / 0001h	Count for 2nd Dimension (BCNT) / Count for 1st Dimension (ACNT)
1180 0000h	Channel Destination Address (DST)
0001h / 0000h	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 / 0004h	Reserved / Count for 3rd Dimension (CCNT)

(b) 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	00	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	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.4.2 Bursting Peripherals

Higher bandwidth applications require that multiple data elements be presented to the CPU for every synchronization event. This frame of data can either be from multiple sources that are working simultaneously or from a single high-throughput peripheral that streams data to/from the CPU. In this example, a port is receiving a video frame from a camera and presenting it to the CPU one array at a time. The video image is 640 × 480 pixels, with each pixel represented by a 16-bit element. The image is to be stored in external memory. Figure 23 shows this example.

To transfer data from an external peripheral to an external buffer one array at a time based on EVT*n* , channel *n* must be configured. Due to the nature of the data (a video frame made up of arrays of pixels) the destination is essentially a 2D entity. Figure 24 shows the parameters to service the incoming data with a 1D-to-2D transfer using AB-synchronization. The source address is set to the location of the video framer peripheral, and the destination address is set to the start of the data buffer. Since the input address is static, the SRCBIDX is 0 (no modification to the source address). The destination is made up of arrays of contiguous, linear elements; therefore, the DSTBIDX is set to pixel size, 2 bytes. ANCT is equal to the pixel size, 2 bytes. BCNT is set to the number of pixels in an array, 640. CCNT is equal to the total number of arrays in the block, 480. SRCCIDX is 0 since the source address undergoes no increment. The DSTCIDX is equal to the difference between the starting addresses of each array. Since a pixel is 16 bits (2 bytes), DSTCIDX is equal to 640 × 2.

Figure 23. Servicing Peripheral Burst Example

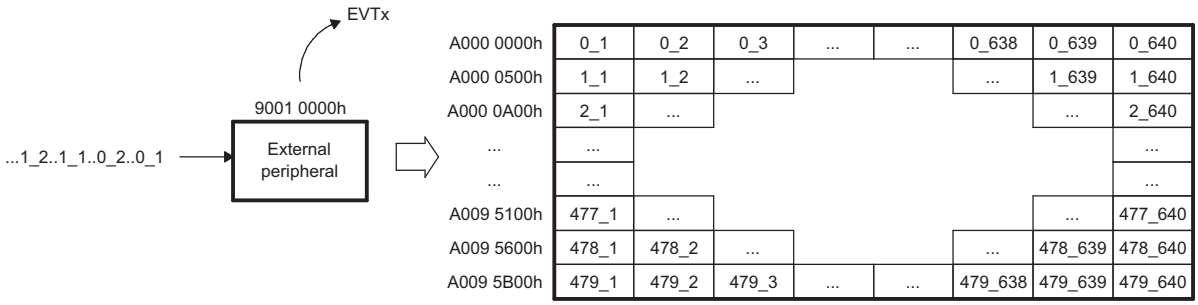


Figure 24. Servicing Peripheral Burst Example PaRAM

(a) EDMA Parameters

Parameter Contents	
0010 0004h	
Channel Source Address	
0280h	0002h
4000 0000h	
0002h	0000h
0000h	FFFFh
0500h	0000h
0000h	01E0h

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

(b) 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	00	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	0	1	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.4.3 Continuous Operation

Configuring a DMA channel to receive a single frame of data is useful, and is applicable to some systems. A majority of the time, however, data is going to be continuously transmitted and received throughout the entire operation of the CPU. In this case, it is necessary to implement some form of linking such that the DMA channels continuously reload the necessary parameter sets. In this example, the multichannel buffered serial port (McBSP) is configured to transmit and receive data on a array. To simplify the example, only two channels are active for both transmit and receive data streams. Each channel receives packets of 128 elements. The packets are transferred from the serial port to L2 memory and from L2 memory to the serial port, as shown in Figure 25.

The McBSP generates REVT for every element received and generates XEVT for every element transmitted. To service the data streams, the DMA channels associated with the McBSP must be set up for 1D-to-1D transfers with A-synchronization.

Figure 26 shows the parameters for the parameter entries for the channel for these transfers. In order to service the McBSP continuously throughout CPU operation, the channels must be linked to a duplicate PaRAM set in the PaRAM. After all frames have been transferred, the DMA channels reload and continue. Figure 27 shows the reload parameters for the channel.

3.4.3.1 Receive Channel

DMA channel 3 services the incoming data stream of the McBSP. The source address is set to that of the data receiver register (DRR), and the destination address is set to the first element of the data block. Since there are two data channels being serviced, A and B, they are to be located separately within the L2 SRAM.

In order to facilitate continuous operation, a copy of the PaRAM set for the channel is placed in PaRAM set 64. The LINK option is set and the link address is provided in the PaRAM set. Upon exhausting the channel 3 parameter set, the parameters located at the link address are loaded into the channel 3 parameter set and operation continues. This function continues throughout device operation until halted by the CPU.

3.4.3.2 Transmit Channel

DMA channel 2 services the outgoing data stream of the McBSP. In this case the destination address needs no update, hence, the parameter set changes accordingly. Linking is also used to allow continuous operation by the DMA channel, with duplicate PaRAM set entries at PaRAM set 65.

Figure 25. Servicing Continuous McBSP Data Example

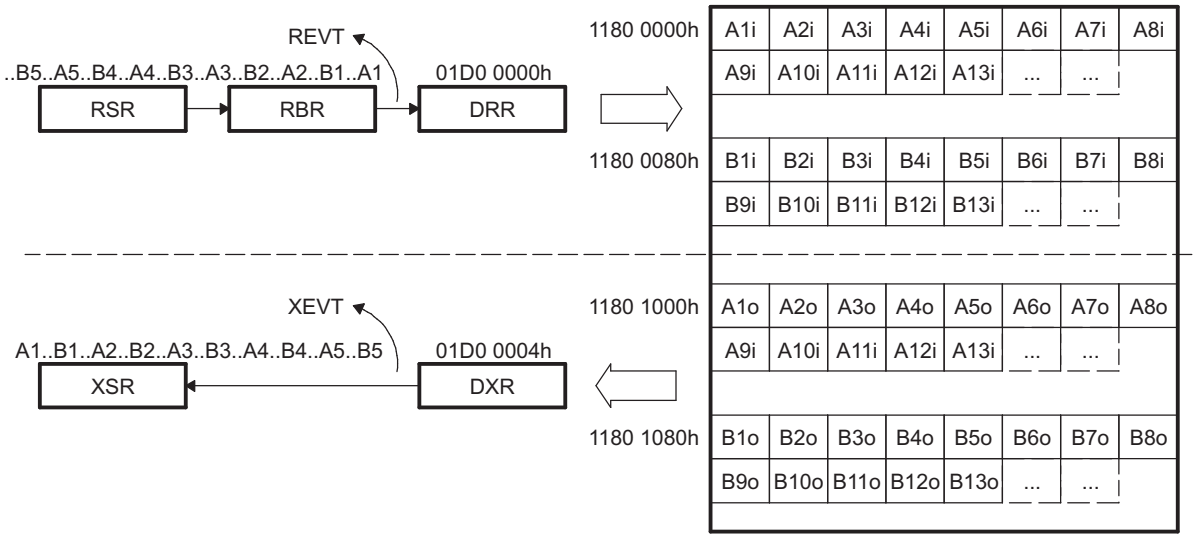


Figure 26. Servicing Continuous McBSP Data Example PaRAM

(a) EDMA Parameters for Receive Channel (PaRAM Set 3) being Linked to PaRAM Set 64

Parameter Contents	Parameter
0010 0000h	Channel Options Parameter (OPT)
01D0 0000h	Channel Source Address (SRC)
0080h / 0001h	Count for 2nd Dimension (BCNT) / Count for 1st Dimension (ACNT)
1180 0000h	Channel Destination Address (DST)
0001h / 0000h	Destination BCNT Index (DSTBIDX) / Source BCNT Index (SRCBIDX)
0080h / 4800h	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) Channel Options Parameter (OPT) Content for Receive Channel (PaRAM Set 3)

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	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	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

(c) EDMA Parameters for Transmit Channel (PaRAM Set 2) being Linked to PaRAM Set 65

Parameter Contents	Parameter
0010 1000h	Channel Options Parameter (OPT)
1180 1000h	Channel Source Address (SRC)
0080h / 0001h	Count for 2nd Dimension (BCNT) / Count for 1st Dimension (ACNT)
01D0 0004h	Channel Destination Address (DST)
0000h / 0001h	Destination BCNT Index (DSTBIDX) / Source BCNT Index (SRCBIDX)
0080h / 4820h	BCNT Reload (BCNTRLD) / Link Address (LINK)
0000h / 0000h	Destination CCNT Index (DSTCIDX) / Source CCNT Index (SRCCIDX)
0000h / 0001h	Reserved / Count for 3rd Dimension (CCNT)

(d) Channel Options Parameter (OPT) Content for Transmit Channel (PaRAM Set 2)

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	00
PRIV	Reserved	PRIVID	ITCCHEN	TCCHEN	ITCINTEN	TCINTEN	Reserved	TCC

15 12	11	10 8	7 4	3	2	1	0
0001	0	000	0000	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

Figure 27. Servicing Continuous McBSP Data Example Reload PaRAM

(a) EDMA Reload Parameters (PaRAM Set 64) for Receive Channel

Parameter Contents		Parameter	
0010 0000h		Channel Options Parameter (OPT)	
01D0 0000h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
1180 0000h		Channel Destination Address (DST)	
0001h	0000h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4800h	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) Channel Options Parameter (OPT) Content for Receive Channel (PaRAM Set 64)

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	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	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

(c) EDMA Reload Parameters (PaRAM Set 65) for Transmit Channel

Parameter Contents		Parameter	
0010 1000h		Channel Options Parameter (OPT)	
1180 1000h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
01D0 0004h		Channel Destination Address (DST)	
0000h	0001h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4820h	BCNT Reload (BCNTRLD)	Link Address (LINK)
0000h	0000h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0001h	Reserved	Count for 3rd Dimension (CCNT)

(d) Channel Options Parameter (OPT) Content for Transmit Channel (PaRAM Set 65)

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	00
PRIV	Reserved	PRIVID	ITCCHEN	TCCHEN	ITCINTEN	TCINTEN	Reserved	TCC

15 12	11	10 8	7 4	3	2	1	0
0001	0	000	0000	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

3.4.4 Ping-Pong Buffering

Although the previous configuration allows the EDMA3 to service a peripheral continuously, it presents a number of restrictions to the CPU. Since the input and output buffers are continuously being filled/emptied, the CPU must match the pace of the EDMA3 very closely in order to process the data. The EDMA3 receive data must always be placed in memory before the CPU accesses it, and the CPU must provide the output data before the EDMA3 transfers it. Though not impossible, this is an unnecessary challenge. It is particularly difficult in a 2-level cache scheme.

Ping-pong buffering is a simple technique that allows the CPU activity to be distanced from the EDMA3 activity. This means that there are multiple (usually two) sets of data buffers for all incoming and outgoing data streams. While the EDMA3 transfers the data into and out of the ping buffers, the CPU manipulates the data in the pong buffers. When both CPU and EDMA3 activity completes, they switch. The EDMA3 then writes over the old input data and transfers the new output data. Figure 28 shows the ping-pong scheme for this example.

To change the continuous operation example, such that a ping-pong buffering scheme is used, the DMA channels need only a moderate change. Instead of one parameter set, there are two; one for transferring data to/from the ping buffers and one for transferring data to/from the pong buffers. As soon as one transfer completes, the channel loads the PaRAM set for the other and the data transfers continue. Figure 29 shows the DMA channel configuration required.

Each channel has two parameter sets, ping and pong. The DMA channel is initially loaded with the ping parameters (Figure 29). The link address for the ping set is set to the PaRAM offset of the pong parameter set (Figure 30). The link address for the pong set is set to the PaRAM offset of the ping parameter set (Figure 31). The channel options, count values, and index values are all identical between the ping and pong parameters for each channel. The only differences are the link address provided and the address of the data buffer.

3.4.4.1 Synchronization with the CPU

In order to utilize the ping-pong buffering technique, the system must signal the CPU when to begin to access the new data set. After the CPU finishes processing an input buffer (ping), it waits for the EDMA3 to complete before switching to the alternate (pong) buffer. In this example, both channels provide their channel numbers as their report word and set the TCINTEN bit to 1 to generate an interrupt after completion. When channel 3 fills an input buffer, the E3 bit in the interrupt pending register (IPR) is set to 1; when channel 2 empties an output buffer, the E2 bit in IPR is set to 1. The CPU must manually clear these bits. With the channel parameters set, the CPU polls IPR to determine when to switch. The EDMA3 and CPU could alternatively be configured such that the channel completion interrupts the CPU. By doing this, the CPU could service a background task while waiting for the EDMA3 to complete.

Figure 28. Ping-Pong Buffering for McBSP Data Example

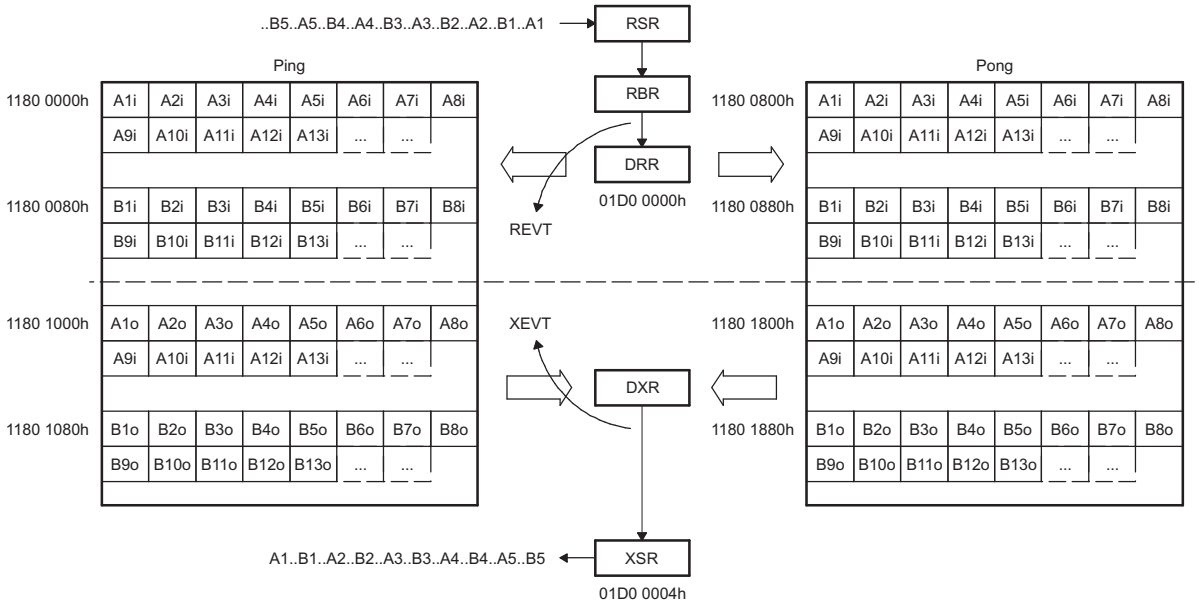


Figure 29. Ping-Pong Buffering for McBSP Example PaRAM

(a) EDMA Parameters for Channel 3 (Using PaRAM Set 3 Linked to Pong Set 64)

Parameter Contents	Parameter
0010 3000h	Channel Options Parameter (OPT)
01D0 0000h	Channel Source Address (SRC)
0080h | 0001h	Count for 2nd Dimension (BCNT) | Count for 1st Dimension (ACNT)
1180 0000h	Channel Destination Address (DST)
0001h | 0000h	Destination BCNT Index (DSTBIDX) | Source BCNT Index (SRCBIDX)
0080h | 4800h	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) Channel Options Parameter (OPT) Content for Channel 3

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	00
PRIV	Reserved	PRIVID	ITCCHEN	TCCHEN	ITCINTEN	TCINTEN	Reserved	TCC

15 12	11	10 8	7 4	3	2	1	0
0011	0	000	0000	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

(c) EDMA Parameters for Channel 2 (Using PaRAM Set 2 Linked to Pong Set 65)

Parameter Contents	Parameter
0010 2000h	Channel Options Parameter (OPT)
1180 1000h	Channel Source Address (SRC)
0080h | 0001h	Count for 2nd Dimension (BCNT) | Count for 1st Dimension (ACNT)
01D0 0004h	Channel Destination Address (DST)
0000h | 0001h	Destination BCNT Index (DSTBIDX) | Source BCNT Index (SRCBIDX)
0080h | 4840h	BCNT Reload (BCNTRLD) | Link Address (LINK)
0000h | 0000h	Destination CCNT Index (DSTCIDX) | Source CCNT Index (SRCCIDX)
0000h | 0001h	Reserved | Count for 3rd Dimension (CCNT)

(d) Channel Options Parameter (OPT) Content for Channel 2

31	30 28	27 24	23	22	21	20	19 18	17 16
0	000	0000	0	0	0	1	00	00
PRIV	Reserved	PRIVID	ITCCHEN	TCCHEN	ITCINTEN	TCINTEN	Reserved	TCC

15 12	11	10 8	7 4	3	2	1	0
0010	0	000	0000	0	0	0	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM

Figure 30. Ping-Pong Buffering for McBSP Example Pong PaRAM

(a) EDMA Pong Parameters for Channel 3 at Set 64 Linked to Set 65

Parameter Contents		Parameter	
0010 D000h		Channel Options Parameter (OPT)	
01D0 0000h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
1180 0800h		Channel Destination Address (DST)	
0001h	0000h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4820h	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 Pong Parameters for Channel 2 at Set 66 Linked to Set 67

Parameter Contents		Parameter	
0010 C000h		Channel Options Parameter (OPT)	
1180 1800h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
01D0 0004h		Channel Destination Address (DST)	
0000h	0001h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4860h	BCNT Reload (BCNTRLD)	Link Address (LINK)
0000h	0000h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0001h	Reserved	Count for 3rd Dimension (CCNT)

Figure 31. Ping-Pong Buffering for McBSP Example Ping PaRAM

(a) EDMA Ping Parameters for Channel 3 at Set 65 Linked to Set 64

Parameter Contents		Parameter	
0010 D000h		Channel Options Parameter (OPT)	
01D0 0000h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
1180 0000h		Channel Destination Address (DST)	
0001h	0000h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4800h	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 Ping Parameters for Channel 2 at Set 67 Linked to Set 66

Parameter Contents		Parameter	
0010 C000h		Channel Options Parameter (OPT)	
1180 1000h		Channel Source Address (SRC)	
0080h	0001h	Count for 2nd Dimension (BCNT)	Count for 1st Dimension (ACNT)
01D0 0004h		Channel Destination Address (DST)	
0000h	0001h	Destination BCNT Index (DSTBIDX)	Source BCNT Index (SRCBIDX)
0080h	4840h	BCNT Reload (BCNTRLD)	Link Address (LINK)
0000h	0000h	Destination CCNT Index (DSTCIDX)	Source CCNT Index (SRCCIDX)
0000h	0001h	Reserved	Count for 3rd Dimension (CCNT)

3.4.5 Transfer Chaining Examples

The following examples explain the intermediate transfer complete chaining function.

3.4.5.1 Servicing Input/Output FIFOs with a Single Event

Many systems require the use of a pair of external FIFOs that must be serviced at the same rate. One FIFO buffers data input, and the other buffers data output. The EDMA3 channels that service these FIFOs can be set up for AB-synchronized transfers. While each FIFO is serviced with a different set of parameters, both can be signaled from a single event. For example, an external interrupt pin can be tied to the status flags of one of the FIFOs. When this event arrives, the EDMA3 needs to perform servicing for both the input and output streams. Without the intermediate transfer complete chaining feature this would require two events, and thus two external interrupt pins. The intermediate transfer complete chaining feature allows the use of a single external event (for example, a GPIO event). Figure 32 shows the EDMA3 setup and illustration for this example.

A GPIO event (in this case, GPINT0) triggers an array transfer. Upon completion of each intermediate array transfer of channel 16, intermediate transfer complete chaining sets the E31 bit (specified by TCC of 31) in the chained event register (CER) and provides a synchronization event to channel 31. Upon completion of the last array transfer of channel 16, transfer complete chaining—not intermediate transfer complete chaining—sets the E31 bit in CER (specified by TCCMODE:TCC) and provides a synchronization event to channel 31. The completion of channel 31 sets the I31 bit (specified by TCCMODE:TCC) in the interrupt pending register (IPR), which can generate an interrupt to the CPU, if the I31 bit in the interrupt enable register (IER) is set to 1.

3.4.5.2 Breaking Up Large Transfers with Intermediate Chaining

Another feature of intermediate transfer chaining (ITCCHEN) is for breaking up large transfers. A large transfer may lock out other transfers of the same priority level for the duration of the transfer. For example, a large transfer on queue 0 from the internal memory to the external memory using the EMIF may starve other EDMA3 transfers on the same queue. In addition, this large high-priority transfer may prevent the EMIF for a long duration to service other lower priority transfers. When a large transfer is considered to be high priority, it should be split into multiple smaller transfers. Figure 33 shows the EDMA3 setup and illustration of an example single large block transfer.

The intermediate transfer chaining enable (ITCCHEN) provides a method to break up a large transfer into smaller transfers. For example, to move a single large block of memory (16K bytes), the EDMA3 performs an A-synchronized transfer. The element count is set to a reasonable value, where reasonable derives from the amount of time it would take to move this smaller amount of data. Assume 1K byte is a reasonable small transfer in this example. The EDMA3 is set up to transfer 16 arrays of 1K byte elements, for a total of 16K byte elements. The TCC field in the channel options parameter (OPT) is set to the same value as the channel number and ITCCHEN are set. In this example, DMA channel 25 is used and TCC is also set to 25. The TCINTEN may also be set to trigger interrupt 25 when the last 1K byte array is transferred. The CPU starts the EDMA3 transfer by writing to the appropriate bit of the event set register (ESR.E25). The EDMA3 transfers the first 1K byte array. Upon completion of the first array, intermediate transfer complete code chaining generates a synchronization event to channel 25, a value specified by the TCC field. This intermediate transfer completion chaining event causes DMA channel 25 to transfer the next 1K byte array. This process continues until the transfer parameters are exhausted, at which point the EDMA3 has completed the 16K byte transfer. This method breaks up a large transfer into smaller packets, thus providing natural time slices in the transfer such that other events may be processed. Figure 34 shows the EDMA3 setup and illustration of the broken up smaller packet transfers.

Figure 32. Intermediate Transfer Completion Chaining Example

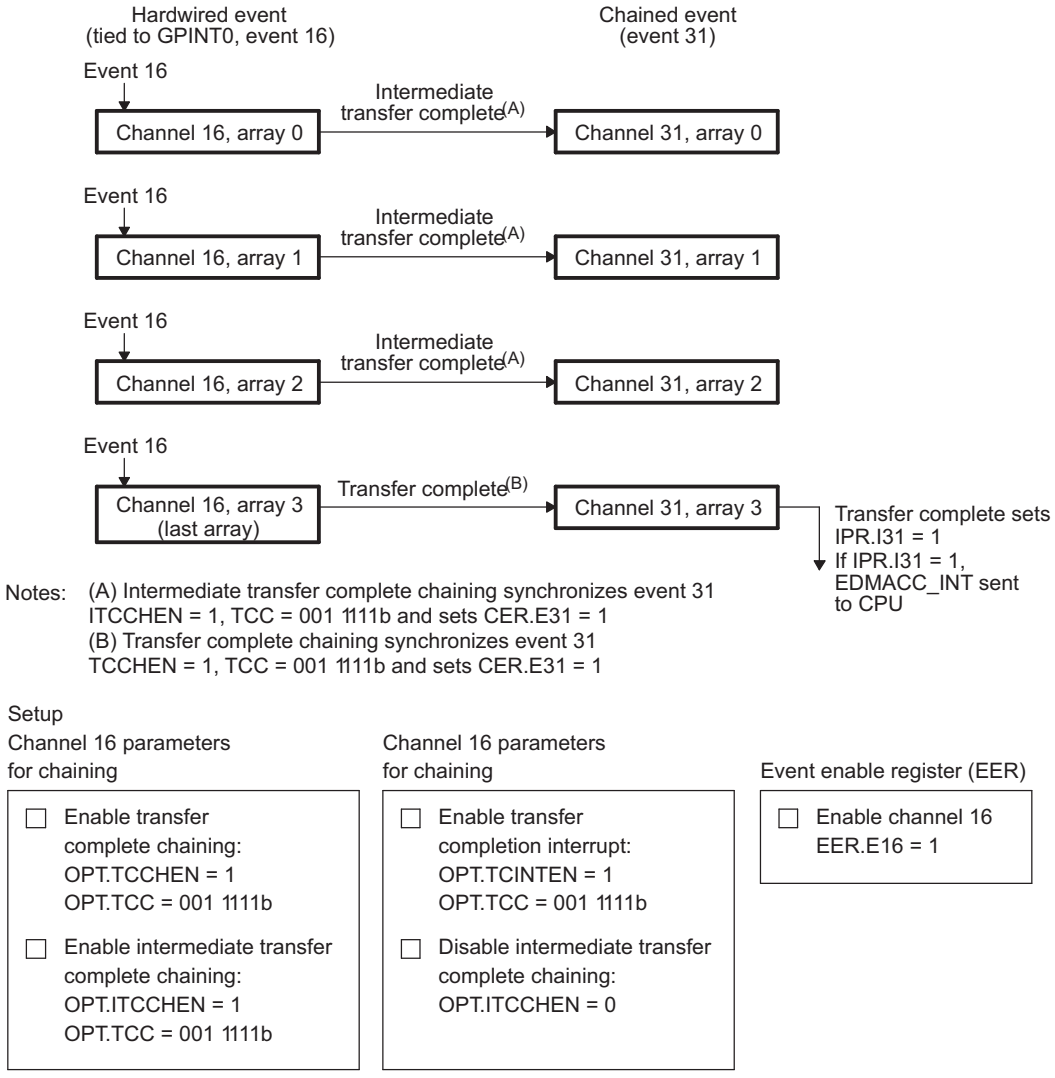


Figure 33. Single Large Block Transfer Example

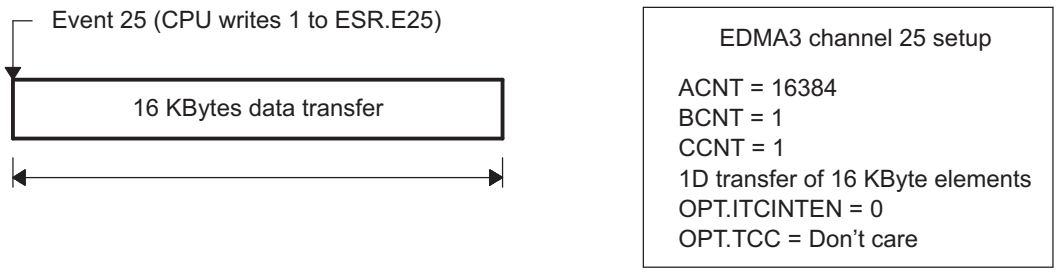
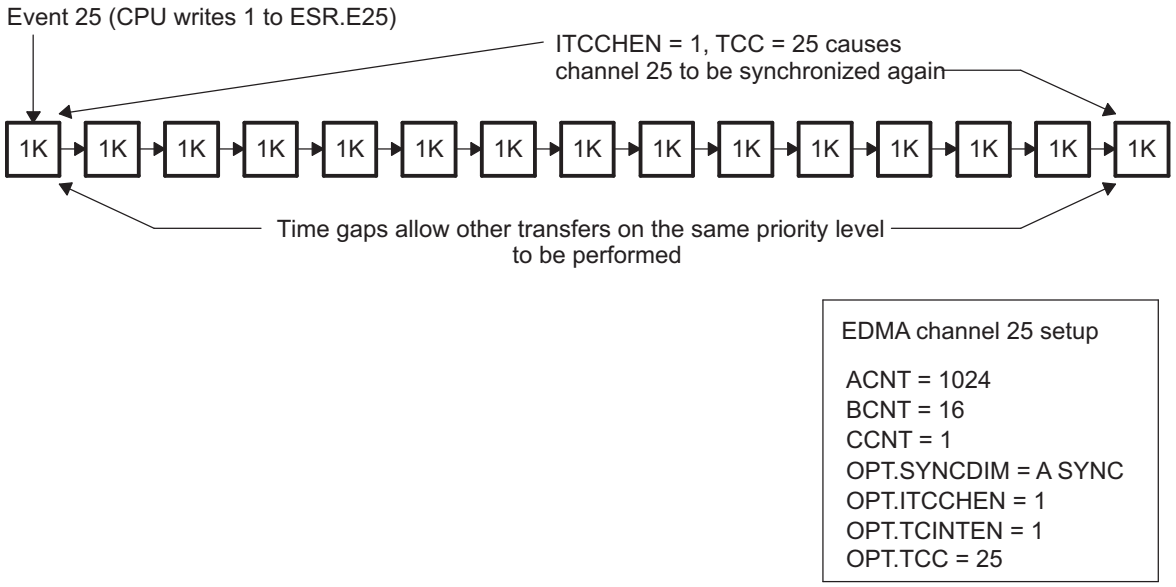


Figure 34. Smaller Packet Data Transfers Example



4 Registers

This section discusses the registers of the EDMA3 controller.

4.1 Parameter RAM (PaRAM) Entries

Table 11 lists the parameter RAM (PaRAM) entries for the EDMA3 channel controller (EDMA3CC). See your device-specific data manual for the memory address of these registers.

Table 11. EDMA3 Channel Controller (EDMA3CC) Parameter RAM (PaRAM) Entries

Offset	Acronym	Parameter	Section
0h	OPT	Channel Options	Section 4.1.1
4h	SRC	Channel Source Address	Section 4.1.2
8h	A_B_CNT	A Count/B Count	Section 4.1.3
Ch	DST	Channel Destination Address	Section 4.1.4
10h	SRC_DST_BIDX	Source B Index/Destination B Index	Section 4.1.5
14h	LINK_BCNTRLD	Link Address/B Count Reload	Section 4.1.6
18h	SRC_DST_CIDX	Source C Index/Destination C Index	Section 4.1.7
1Ch	CCNT	C Count	Section 4.1.8

4.1.1 Channel Options Parameter (OPT)

The channel options parameter (OPT) is shown in Figure 35 and described in Table 12.

NOTE: The TCC field in OPT is a 6-bit field and can be programmed for any value between 0-64. For devices with 32 DMA channels, the TCC field should have a value between 0 to 31 so that it sets the appropriate bits (0 to 31) in the interrupt pending register (IPR) (and can interrupt the CPU(s) on enabling the interrupt enable register (IER) bits (0-31)).

Figure 35. Channel Options Parameter (OPT)

31–28	27–24	23	22	21	20	19–18	17–16
Reserved	PRIVID	ITCCHEN	TCCHEN	ITCINTEN	TCINTEN	Reserved	TCC
R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0 R-0	R/W-0

15–12	11–10	9–8	7–4	3	2	1	0
TCC	TCCMOD	FWID	Reserved	STATIC	SYNCDIM	DAM	SAM
R/W-0	R/W-0	R/W-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 12. Channel Options Parameters (OPT) Field Descriptions

Bit	Field	Value	Description
31-28	Reserved	0	Reserved
27-24	PRIVID	0-Fh	Privilege identification for the external host/CPU/DMA that programmed this PaRAM set. This value is set with the EDMA3 master's privilege identification value when any part of the PaRAM set is written.
23	ITCCHEN		Intermediate transfer completion chaining enable.
		0	Intermediate transfer complete chaining is disabled.
		1	Intermediate transfer complete chaining is enabled.
			When enabled, the chained event register (CER) bit is set on every intermediate chained transfer completion (upon completion of every intermediate TR in the PaRAM set, except the final TR in the PaRAM set). The bit (position) set in CER is the TCC value specified.
22	TCCHEN		Transfer complete chaining enable.
		0	Transfer complete chaining is disabled.
		1	Transfer complete chaining is enabled.
			When enabled, the chained event register (CER) bit is set on final chained transfer completion (upon completion of the final TR in the PaRAM set). The bit (position) set in CER is the TCC value specified.
21	ITCINTEN		Intermediate transfer completion interrupt enable.
		0	Intermediate transfer complete interrupt is disabled.
		1	Intermediate transfer complete interrupt is enabled.
			When enabled, the interrupt pending register (IPR) bit is set on every intermediate transfer completion (upon completion of every intermediate TR in the PaRAM set, except the final TR in the PaRAM set). The bit (position) set in IPR is the TCC value specified. In order to generate a completion interrupt to the CPU, the corresponding IER[TCC] bit must be set to 1.
20	TCINTEN		Transfer complete interrupt enable.
		0	Transfer complete interrupt is disabled.
		1	Transfer complete interrupt is enabled.
			When enabled, the interrupt pending register (IPR) bit is set on transfer completion (upon completion of the final TR in the PaRAM set). The bit (position) set in IPR is the TCC value specified. In order to generate a completion interrupt to the CPU, the corresponding IER[TCC] bit must be set to 1.
19	Reserved	0	Reserved. Always write 0 to this bit.
18	Reserved	0	Reserved

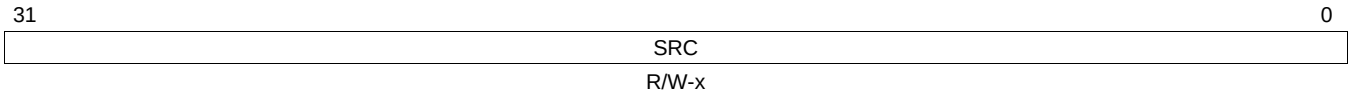
Table 12. Channel Options Parameters (OPT) Field Descriptions (continued)

Bit	Field	Value	Description
17-12	TCC	0-3Fh	Transfer complete code. This 6-bit code is used to set the relevant bit in chaining enable register (CER[TCC]) for chaining or in interrupt pending register (IPR[TCC]) for interrupts.
		0-1Fh	Valid values
		20h-3Fh	Reserved
11	TCCMODE		Transfer complete code mode. Indicates the point at which a transfer is considered completed for chaining and interrupt generation.
		0	Normal completion: A transfer is considered completed after the data has been transferred.
		1	Early completion: A transfer is considered completed after the EDMA3CC submits a TR to the EDMA3TC. TC may still be transferring data when interrupt/chain is triggered.
10-8	FWID	0-7h	FIFO Width. Applies if either SAM or DAM is set to constant addressing mode.
		0	FIFO width is 8-bit.
		1h	FIFO width is 16-bit.
		2h	FIFO width is 32-bit.
		3h	FIFO width is 64-bit.
		4h	FIFO width is 128-bit.
		5h	FIFO width is 256-bit.
		6h-7h	Reserved
7-4	Reserved	0	Reserved
3	STATIC		Static PaRAM set.
		0	PaRAM set is not static. PaRAM set is updated or linked after TR is submitted. A value of 0 should be used for DMA channels and for nonfinal transfers in a linked list of QDMA transfers.
		1	PaRAM set is static. PaRAM set is not updated or linked after TR is submitted. A value of 1 should be used for isolated QDMA transfers or for the final transfer in a linked list of QDMA transfers.
2	SYNCDIM		Transfer synchronization dimension.
		0	A-synchronized. Each event triggers the transfer of a single array of ACNT bytes.
		1	AB-synchronized. Each event triggers the transfer of BCNT arrays of ACNT bytes.
1	DAM		Destination address mode.
		0	Increment (INCR) mode. Destination addressing within an array increments. Destination is not a FIFO.
		1	Constant addressing (CONST) mode. Destination addressing within an array wraps around upon reaching FIFO width. Note: The constant addressing (CONST) mode has limited applicability. The EDMA3 should be configured for the constant addressing mode (SAM/DAM = 1) only if the transfer source or destination (on-chip memory, off-chip memory controllers, slave peripherals) support the constant addressing mode. See your device-specific data manual to verify if constant addressing mode is supported. If the constant addressing mode is not supported, the similar logical transfer can be achieved using the increment (INCR) mode (SAM/DAM = 0) by appropriately programming the count and indices values.
0	SAM		Source address mode.
		0	Increment (INCR) mode. Source addressing within an array increments. Source is not a FIFO.
		1	Constant addressing (CONST) mode. Source addressing within an array wraps around upon reaching FIFO width. Note: The constant addressing (CONST) mode has limited applicability. The EDMA3 should be configured for the constant addressing mode (SAM/DAM = 1) only if the transfer source or destination (on-chip memory, off-chip memory controllers, slave peripherals) support the constant addressing mode. See your device-specific data manual to verify if constant addressing mode is supported. If the constant addressing mode is not supported, the similar logical transfer can be achieved using the increment (INCR) mode (SAM/DAM = 0) by appropriately programming the count and indices values.

4.1.2 Channel Source Address Parameter (SRC)

The channel source address parameter (SRC) specifies the starting byte address of the source. The SRC is shown in Figure 36 and described in Table 13.

Figure 36. Channel Source Address Parameter (SRC)



LEGEND: R = Read only; -*n* = value after reset

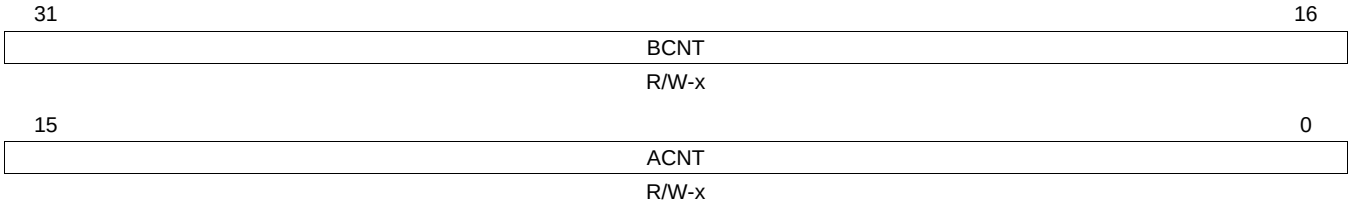
Table 13. Channel Source Address Parameter (SRC) Field Descriptions

Bit	Field	Value	Description
31-0	SRC	0-FFFF FFFFh	Source address. Specifies the starting byte address of the source.

4.1.3 A Count/B Count Parameter (A_B_CNT)

The A count/B count parameter (A_B_CNT) specifies the number of bytes within the 1st dimension of a transfer and the number of arrays of length ACNT. The A_B_CNT is shown in Figure 37 and described in Table 14.

Figure 37. A Count/B Count Parameter (A_B_CNT)



LEGEND: R/W = Read/Write; -*n* = value after reset; -x = value is indeterminate after reset

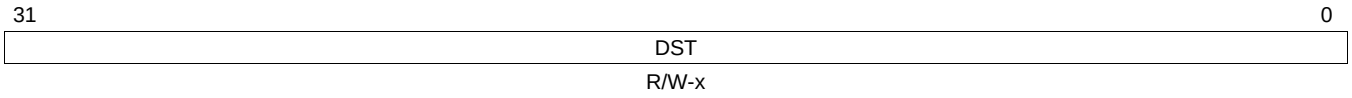
Table 14. A Count/B Count Parameter (A_B_CNT) Field Descriptions

Bit	Field	Value	Description
31-16	BCNT	0-FFFFh	B count. Unsigned value specifying the number of arrays in a frame, where an array is ACNT bytes. Valid values range from 1 to 65 535.
15-0	ACNT	0-FFFFh	A count for 1st Dimension. Unsigned value specifying the number of contiguous bytes within an array (first dimension of the transfer). Valid values range from 1 to 65 535.

4.1.4 Channel Destination Address Parameter (DST)

The channel destination address parameter (DST) specifies the starting byte address of the source. The DST is shown in Figure 38 and described in Table 15.

Figure 38. Channel Destination Address Parameter (DST)



LEGEND: R = Read only; -*n* = value after reset

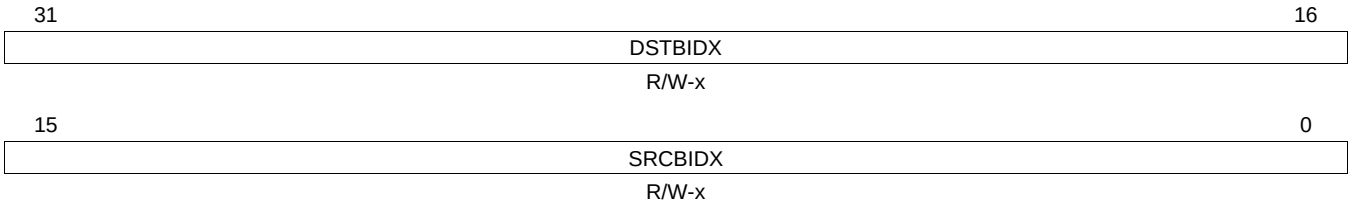
Table 15. Channel Destination Address Parameter (DST) Field Descriptions

Bit	Field	Value	Description
31-0	DST	0-FFFF FFFFh	Destination address. Specifies the starting byte address of the destination where data is transferred.

4.1.5 Source B Index/Destination B Index Parameter (SRC_DST_BIDX)

The source B index/destination B index parameter (SRC_DST_BIDX) specifies the value (2s complement) used for source address modification between each array in the 2nd dimension and the value (2s complement) used for destination address modification between each array in the 2nd dimension. The SRC_DST_BIDX is shown in Figure 39 and described in Table 16.

Figure 39. Source B Index/Destination B Index Parameter (SRC_DST_BIDX)



LEGEND: R/W = Read/Write; -*n* = value after reset; -x = value is indeterminate after reset

Table 16. Source B Index/Destination B Index Parameter (SRC_DST_BIDX) Field Descriptions

Bit	Field	Value	Description
31-16	DSTBIDX	0-FFFFh	Destination B index. Signed value specifying the byte address offset between destination arrays within a frame (2nd dimension). Valid values range from –32 768 and 32 767.
15-0	SRCBIDX	0-FFFFh	Source B index. Signed value specifying the byte address offset between source arrays within a frame (2nd dimension). Valid values range from –32 768 and 32 767.

4.1.6 Link Address/B Count Reload Parameter (LINK_BCNTRLD)

The link address/B count reload parameter (LINK_BCNTRLD) specifies the byte address offset in the PaRAM from which the EDMA3CC loads/reloads the next PaRAM set during linking and the value used to reload the BCNT field in the A count/B count parameter (A_B_CNT) once the last array in the 2nd dimension is transferred. The LINK_BCNTRLD is shown in Figure 40 and described in Table 17.

Figure 40. Link Address/B Count Reload Parameter (LINK_BCNTRLD)

31	16
BCNTRLD	
R/W-x	

15	0
LINK	
R/W-x	

LEGEND: R/W = Read/Write; -*n* = value after reset; -x = value is indeterminate after reset

Table 17. Link Address/B Count Reload Parameter (LINK_BCNTRLD) Field Descriptions

Bit	Field	Value	Description
31-16	BCNTRLD	0-FFFFh	B count reload. The count value used to reload BCNT in the A count/B count parameter (A_B_CNT) when BCNT decrements to 0 (TR submitted for the last array in 2nd dimension). Only relevant in A-synchronized transfers.
15-0	LINK	0-FFFFh	Link address. The PaRAM address containing the PaRAM set to be linked (copied from) when the current PaRAM set is exhausted. You must program the link address to point to a valid aligned 32-byte PaRAM set. The 5 LSBs of the LINK field should be cleared to 0. A value of FFFFh specifies a null link.

4.1.7 Source C Index/Destination C Index Parameter (SRC_DST_CIDX)

The source C index/destination C index parameter (SRC_DST_CIDX) specifies the value (2s complement) used for source address modification between each array in the 3rd dimension and the value (2s complement) used for destination address modification between each array in the 3rd dimension. The SRC_DST_CIDX is shown in Figure 41 and described in Table 18.

Figure 41. Source C Index/Destination C Index Parameter (SRC_DST_CIDX)

31	16
DSTCIDX	
R/W-x	

15	0
SRCCIDX	
R/W-x	

LEGEND: R/W = Read/Write; *-n* = value after reset; -x = value is indeterminate after reset

Table 18. Source C Index/Destination C Index Parameter (SRC_DST_CIDX) Field Descriptions

Bit	Field	Value	Description
31-16	DSTCIDX	0-FFFFh	Destination C index. Signed value specifying the byte address offset between frames within a block (3rd dimension). Valid values range from –32 768 and 32 767.
15-0	SRCCIDX	0-FFFFh	Source C index. Signed value specifying the byte address offset between frames within a block (3rd dimension). Valid values range from –32 768 and 32 767.

4.1.8 C Count Parameter (CCNT)

The C count parameter (CCNT) specifies the number of frames in a block. The CCNT is shown in Figure 42 and described in Table 19.

Figure 42. C Count Parameter (CCNT)

31	16
Reserved	
R/W-x	

15	0
CCNT	
R/W-x	

LEGEND: R/W = Read/Write; *-n* = value after reset; -x = value is indeterminate after reset

Table 19. C Count Parameter (CCNT) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	Reserved
15-0	CCNT	0-FFFFh	C counter. Unsigned value specifying the number of frames in a block, where a frame is BCNT arrays of ACNT bytes. Valid values range from 1 to 65 535.

4.2 EDMA3 Channel Controller (EDMA3CC) Registers

Table 20 lists the memory-mapped registers for the EDMA3 channel controller (EDMA3CC). See your device-specific data manual for the memory address of these registers and for the shadow region addresses. All other register offset addresses not listed in Table 20 should be considered as reserved locations and the register contents should not be modified.

Table 20. EDMA3 Channel Controller (EDMA3CC) Registers

Offset	Acronym	Register Description	Section
0h	REVID	Revision Identification Register	Section 4.2.1.1
4h	CCCFG	EDMA3CC Configuration Register	Section 4.2.1.2
		Global Registers	
200h	QCHMAP0	QDMA Channel 0 Mapping Register	Section 4.2.1.3
204h	QCHMAP1	QDMA Channel 1 Mapping Register	Section 4.2.1.3
208h	QCHMAP2	QDMA Channel 2 Mapping Register	Section 4.2.1.3
20Ch	QCHMAP3	QDMA Channel 3 Mapping Register	Section 4.2.1.3
210h	QCHMAP4	QDMA Channel 4 Mapping Register	Section 4.2.1.3
214h	QCHMAP5	QDMA Channel 5 Mapping Register	Section 4.2.1.3
218h	QCHMAP6	QDMA Channel 6 Mapping Register	Section 4.2.1.3
21Ch	QCHMAP7	QDMA Channel 7 Mapping Register	Section 4.2.1.3
240h	DMAQNUM0	DMA Channel Queue Number Register 0	Section 4.2.1.4
244h	DMAQNUM1	DMA Channel Queue Number Register 1	Section 4.2.1.4
248h	DMAQNUM2	DMA Channel Queue Number Register 2	Section 4.2.1.4
24Ch	DMAQNUM3	DMA Channel Queue Number Register 3	Section 4.2.1.4
260h	QDMAQNUM	QDMA Channel Queue Number Register	Section 4.2.1.5
284h	QUEPRI	Queue Priority Register(1)	Section 4.2.1.6
300h	EMR	Event Missed Register	Section 4.2.2.1
308h	EMCR	Event Missed Clear Register	Section 4.2.2.2
310h	QEMR	QDMA Event Missed Register	Section 4.2.2.3
314h	QEMCR	QDMA Event Missed Clear Register	Section 4.2.2.4
318h	CCERR	EDMA3CC Error Register	Section 4.2.2.5
31Ch	CCERRCLR	EDMA3CC Error Clear Register	Section 4.2.2.6
320h	EEVAL	Error Evaluate Register	Section 4.2.2.7
340h	DRAE0	DMA Region Access Enable Register for Region 0	Section 4.2.3.1
348h	DRAE1	DMA Region Access Enable Register for Region 1	Section 4.2.3.1
350h	DRAE2	DMA Region Access Enable Register for Region 2	Section 4.2.3.1
358h	DRAE3	DMA Region Access Enable Register for Region 3	Section 4.2.3.1
380h	QRAE0	QDMA Region Access Enable Register for Region 0	Section 4.2.3.2
384h	QRAE1	QDMA Region Access Enable Register for Region 1	Section 4.2.3.2
388h	QRAE2	QDMA Region Access Enable Register for Region 2	Section 4.2.3.2
38Ch	QRAE3	QDMA Region Access Enable Register for Region 3	Section 4.2.3.2
400h-43Ch	Q0E0-Q0E15	Event Queue Entry Registers Q0E0-Q0E15	Section 4.2.4.1
440h-47Ch	Q1E0-Q1E15	Event Queue Entry Registers Q1E0-Q1E15	Section 4.2.4.1
600h	QSTAT0	Queue 0 Status Register	Section 4.2.4.2
604h	QSTAT1	Queue 1 Status Register	Section 4.2.4.2
620h	QWMTHRA	Queue Watermark Threshold A Register	Section 4.2.4.3
640h	CCSTAT	EDMA3CC Status Register	Section 4.2.4.4

(1) On previous architectures, the EDMA3TC priority was controlled by the queue priority register (QUEPRI) in the EDMA3CC memory-map. However for this device, the priority control for the transfer controllers is controlled by the chip-level registers in the System Configuration Module. You should use the chip-level registers and not QUEPRI to configure the TC priority.

Table 20. EDMA3 Channel Controller (EDMA3CC) Registers (continued)

Offset	Acronym	Register Description	Section
		Global Channel Registers	
1000h	ER	Event Register	Section 4.2.5.1
1008h	ECR	Event Clear Register	Section 4.2.5.2
1010h	ESR	Event Set Register	Section 4.2.5.3
1018h	CER	Chained Event Register	Section 4.2.5.4
1020h	EER	Event Enable Register	Section 4.2.5.5
1028h	EECR	Event Enable Clear Register	Section 4.2.5.6
1030h	EESR	Event Enable Set Register	Section 4.2.5.7
1038h	SER	Secondary Event Register	Section 4.2.5.8
1040h	SECR	Secondary Event Clear Register	Section 4.2.5.9
1050h	IER	Interrupt Enable Register	Section 4.2.6.1
1058h	IECR	Interrupt Enable Clear Register	Section 4.2.6.2
1060h	IESR	Interrupt Enable Set Register	Section 4.2.6.3
1068h	IPR	Interrupt Pending Register	Section 4.2.6.4
1070h	ICR	Interrupt Clear Register	Section 4.2.6.5
1078h	IEVAL	Interrupt Evaluate Register	Section 4.2.6.6
1080h	QER	QDMA Event Register	Section 4.2.7.1
1084h	QEER	QDMA Event Enable Register	Section 4.2.7.2
1088h	QEECR	QDMA Event Enable Clear Register	Section 4.2.7.3
108Ch	QEESR	QDMA Event Enable Set Register	Section 4.2.7.4
1090h	QSER	QDMA Secondary Event Register	Section 4.2.7.5
1094h	QSECR	QDMA Secondary Event Clear Register	Section 4.2.7.6
		Shadow Region 0 Channel Registers	
2000h	ER	Event Register	
2008h	ECR	Event Clear Register	
2010h	ESR	Event Set Register	
2018h	CER	Chained Event Register	
2020h	EER	Event Enable Register	
2028h	EECR	Event Enable Clear Register	
2030h	EESR	Event Enable Set Register	
2038h	SER	Secondary Event Register	
2040h	SECR	Secondary Event Clear Register	
2050h	IER	Interrupt Enable Register	
2058h	IECR	Interrupt Enable Clear Register	
2060h	IESR	Interrupt Enable Set Register	
2068h	IPR	Interrupt Pending Register	
2070h	ICR	Interrupt Clear Register	
2078h	IEVAL	Interrupt Evaluate Register	
2080h	QER	QDMA Event Register	
2084h	QEER	QDMA Event Enable Register	
2088h	QEECR	QDMA Event Enable Clear Register	
208Ch	QEESR	QDMA Event Enable Set Register	
2090h	QSER	QDMA Secondary Event Register	
2094h	QSECR	QDMA Secondary Event Clear Register	

Table 20. EDMA3 Channel Controller (EDMA3CC) Registers (continued)

Offset	Acronym	Register Description	Section
		Shadow Region 1 Channel Registers	
2200h	ER	Event Register	
2208h	ECR	Event Clear Register	
2210h	ESR	Event Set Register	
2218h	CER	Chained Event Register	
2220h	EER	Event Enable Register	
2228h	EECR	Event Enable Clear Register	
2230h	EESR	Event Enable Set Register	
2238h	SER	Secondary Event Register	
2240h	SECR	Secondary Event Clear Register	
2250h	IER	Interrupt Enable Register	
2258h	IECR	Interrupt Enable Clear Register	
2260h	IESR	Interrupt Enable Set Register	
2268h	IPR	Interrupt Pending Register	
2270h	ICR	Interrupt Clear Register	
2278h	IEVAL	Interrupt Evaluate Register	
2280h	QER	QDMA Event Register	
2284h	QEER	QDMA Event Enable Register	
2288h	QEECR	QDMA Event Enable Clear Register	
228Ch	QEESR	QDMA Event Enable Set Register	
2290h	QSER	QDMA Secondary Event Register	
2294h	QSECR	QDMA Secondary Event Clear Register	
4000h-4FFFh	—	Parameter RAM (PaRAM)	

4.2.1 Global Registers

4.2.1.1 Revision Identification Register (REVID)

The revision identification register (REVID) uniquely identifies the EDMA3CC and the specific revision of the EDMA3CC. The REVID is shown in Figure 43 and described in Table 21.

Figure 43. Revision ID Register (REVID)

31	0
REV	
R-4001 5300h	

LEGEND: R = Read only; -*n* = value after reset

Table 21. Revision ID Register (REVID) Field Descriptions

Bit	Field	Value	Description
31-0	REV	4001 5300h	Peripheral identifier. Uniquely identifies the EDMA3CC and the specific revision of the EDMA3CC.

4.2.1.2 EDMA3CC Configuration Register (CCCFG)

The EDMA3CC configuration register (CCCFG) provides the features/resources for the EDMA3CC in a particular device. The CCCFG is shown in Figure 44 and described in Table 22.

Figure 44. EDMA3CC Configuration Register (CCCFG)

31	26	25	24
Reserved		MP_EXIST	CHMAP_EXIST
R-x		R-0	R-0

23	22	21	20	19	18	16
Reserved		NUM_REGN		Reserved	NUM_EVQUE	
R-0		R-2h		R-x	R-2h	

15	14	12	11	10	8
Reserved	NUM_PAENTRY		Reserved	NUM_INTCH	
R-x	R-3h		R-x	R-4h	

7	6	4	3	2	0
Reserved	NUM_QDMACH		Reserved	NUM_DMACH	
R-x	R-4h		R-x	R-5h	

LEGEND: R = Read only; -*n* = value after reset; -x = value is indeterminate after reset

Table 22. EDMA3CC Configuration Register (CCCFG) Field Descriptions

Bit	Field	Value	Description
31-26	Reserved	0-3Fh	Reserved
25	MP_EXIST		Memory protection existence.
		0	No memory protection.
		1	Reserved
24	CHMAP_EXIST		Channel mapping existence
		0	No channel mapping. This implies that there is fixed association for a channel number to a parameter entry number or, in other words, PaRAM entry *n* corresponds to channel *n*.
		1	Reserved
23-22	Reserved	0	Reserved
21-20	NUM_REGN	0-3h	Number of shadow regions.
		0-1	Reserved
		2h	4 regions
		3h	Reserved
19	Reserved	0	Reserved
18-16	NUM_EVQUE	0-7h	Number of queues/number of TCs.
		0-1h	Reserved
		2h	2 EDMA3TC/Event Queues
		3h-7h	Reserved
15	Reserved	0	Reserved
14-12	NUM_PAENTRY	0-7h	Number of PaRAM sets.
		0-2h	Reserved
		3h	128 sets
		4h-7h	Reserved
11	Reserved	0	Reserved
10-8	NUM_INTCH	0-7h	Number of interrupt channels.
		0-3h	Reserved
		4h	32 interrupt channels
		5h-7h	Reserved
7	Reserved	0	Reserved
6-4	NUM_QDMACH	0-7h	Number of QDMA channels.
		0-3h	Reserved
		4h	8 QDMA channels
		5h-7h	Reserved
3	Reserved	0	Reserved
2-0	NUM_DMACH	0-7h	Number of DMA channels.
		0-4h	Reserved
		5h	32 DMA channels
		6h-7h	Reserved

4.2.1.3 QDMA Channel *n* Mapping Register (QCHMAP*n*)

Each QDMA channel in EDMA3CC can be associated with any PaRAM set available on the device. Furthermore, the specific trigger word (0-7) of the PaRAM set can be programmed. The PaRAM set association and trigger word for every QDMA channel register is configurable using the QDMA channel *n* mapping register (QCHMAP*n*). The QCHMAP*n* is shown in Figure 45 and described in Table 23.

NOTE: At reset the QDMA channel mapping registers for all QDMA channels point to the PaRAM set 0. Prior to using any QDMA channel, QCHMAP*n* should be programmed appropriately to point to a different PaRAM set.

Figure 45. QDMA Channel *n* Mapping Register (QCHMAP*n*)

31	16
Reserved	
R-0	

15	14	13	5	4	2	1	0
Reserved		PAENTRY		TRWORD		Reserved	
R-0		R/W-0		R/W-0		R-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 23. QDMA Channel *n* Mapping Register (QCHMAP*n*) Field Descriptions

Bit	Field	Value	Description
31-14	Reserved	0	Reserved
13-5	PAENTRY	0-1FFh	PAENTRY points to the PaRAM set number for QDMA channel *n*.
		0-7Fh	PaRAM set number 0 through 127
		80h-1FFh	Reserved
4-2	TRWORD	0-7h	Points to the specific PaRAM entry or the trigger word in the PaRAM set pointed to by PAENTRY. A write to the trigger word results in a QDMA event being recognized.
1-0	Reserved	0	Reserved

4.2.1.4 DMA Channel Queue Number Register *n* (DMAQNUM*n*)

The DMA channel queue number register *n* (DMAQNUM*n*) allows programmability of each of the 32 DMA channels in the EDMA3CC to submit its associated synchronization event to any event queue in the EDMA3CC. At reset, all channels point to event queue 0. The DMAQNUM*n* is shown in Figure 46 and described in Table 24. Table 25 shows the channels and their corresponding bits in DMAQNUM*n*.

NOTE: Since the event queues in EDMA3CC have a fixed association to the transfer controllers, that is, Q0 TRs are submitted to TC0 and Q1 TRs are submitted to TC1, by programming DMAQNUM*n* for a particular DMA channel also dictates which transfer controller is utilized for the data movement (or which EDMA3TC receives the TR request).

Figure 46. DMA Channel Queue Number Register *n* (DMAQNUM*n*)

31	30 28	27	26 24	23	22 20	19	18 16
Rsvd	E*n*	Rsvd	E*n*	Rsvd	E*n*	Rsvd	E*n*
R-0	R/W-0	R-0	R/W-0	R-0	R/W-0	R-0	R/W-0

15	14 12	11	10 8	7	6 4	3	2 0
Rsvd	E*n*	Rsvd	E*n*	Rsvd	E*n*	Rsvd	E*n*
R-0	R/W-0	R-0	R/W-0	R-0	R/W-0	R-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 24. DMA Channel Queue Number Register *n* (DMAQNUM*n*) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*	0-7h	DMA queue number. Contains the event queue number to be used for the corresponding DMA channel. Programming DMAQNUM*n* for an event queue number to a value more then the number of queues available in the EDMA3CC results in undefined behavior.
		0	Event *n* is queued on Q0.
		1h	Event *n* is queued on Q1.
		2h-7h	Reserved

Table 25. Bits in DMAQNUM*n*

	DMAQNUM*n*			
E*n* bit	**0**	**1**	**2**	**3**
0-2	E0	E8	E16	E24
4-6	E1	E9	E17	E25
8-10	E2	E10	E18	E26
12-14	E3	E11	E19	E27
16-18	E4	E12	E20	E28
20-22	E5	E13	E21	E29
24-26	E6	E14	E22	E30
28-30	E7	E15	E23	E31

4.2.1.5 QDMA Channel Queue Number Register (QDMAQNUM)

The QDMA channel queue number register (QDMAQNUM) is used to program all the QDMA channels in the EDMA3CC to submit the associated QDMA event to any of the event queues in the EDMA3CC. The QDMAQNUM is shown in Figure 47 and described in Table 26.

Figure 47. QDMA Channel Queue Number Register (QDMAQNUM)

31	30 28	27	26 24	23	22 20	19	18 16
Rsvd	E7	Rsvd	E6	Rsvd	E5	Rsvd	E4
R-0	R/W-0	R-0	R/W-0	R-0	R/W-0	R-0	R/W-0

15	14 12	11	10 8	7	6 4	3	2 0
Rsvd	E3	Rsvd	E2	Rsvd	E1	Rsvd	E0
R-0	R/W-0	R-0	R/W-0	R-0	R/W-0	R-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 26. QDMA Channel Queue Number Register (QDMAQNUM) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*	0-7h	QDMA queue number. Contains the event queue number to be used for the corresponding QDMA channel.
		0	Event *n* is queued on Q0.
		1h	Event *n* is queued on Q1.
		2h-7h	Reserved

4.2.1.6 Queue Priority Register (QUEPRI)

On previous architectures, the EDMA3TC priority was controlled by the queue priority register (QUEPRI) in the EDMA3CC memory-map. However for this device, the priority control for the transfer controllers is controlled by the chip-level registers in the System Configuration Module. You should use the chip-level registers and not QUEPRI to configure the TC priority.

4.2.2 Error Registers

The EDMA3CC contains a set of registers that provide information on missed DMA and/or QDMA events, and instances when event queue thresholds are exceeded. If any of the bits in these registers is set, it results in the EDMA3CC generating an error interrupt.

4.2.2.1 Event Missed Registers (EMR)

For a particular DMA channel, if a second event is received prior to the first event getting cleared/serviced, the bit corresponding to that channel is set/asserted in the event missed register (EMR). All trigger types are treated individually, that is, manual triggered (ESR), chain triggered (CER), and event triggered (ER) are all treated separately. The EMR bit for a channel is also set if an event on that channel encounters a NULL entry (or a NULL TR is serviced). If any EMR bit is set (and all errors, including bits in other error registers (QEMR, CCERR) were previously cleared), the EDMA3CC generates an error interrupt. See Section 2.9.4 for details on EDMA3CC error interrupt generation.

The EMR is shown in Figure 48 and described in Table 27.

Figure 48. Event Missed Register (EMR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 27. Event Missed Register (EMR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Channel 0-31 event missed. E*n* is cleared by writing a 1 to the corresponding bit in the event missed clear register (EMCR).
		0	No missed event.
		1	Missed event occurred.

4.2.2.2 Event Missed Clear Registers (EMCR)

Once a missed event is posted in the event missed register (EMR), the bit remains set and you need to clear the set bit(s). This is done by way of CPU writes to the event missed clear register (EMCR). Writing a 1 to any of the bits clears the corresponding missed event (bit) in EMR; writing a 0 has no effect.

The EMCR is shown in Figure 49 and described in Table 28.

Figure 49. Event Missed Clear Register (EMCR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 28. Event Missed Clear Register (EMCR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event missed 0-31 clear. All error bits must be cleared before additional error interrupts will be asserted by the EDMA3CC.
		0	No effect.
		1	Corresponding missed event bit in the event missed register (EMR) is cleared (E*n* = 0).

4.2.2.3 QDMA Event Missed Register (QEMR)

For a particular QDMA channel, if two QDMA events are detected without the first event getting cleared/serviced, the bit corresponding to that channel is set/asserted in the QDMA event missed register (QEMR). The QEMR bits for a channel are also set if a QDMA event on the channel encounters a NULL entry (or a NULL TR is serviced). If any QEMR bit is set (and all errors, including bits in other error registers (EMR or CCERR) were previously cleared), the EDMA3CC generates an error interrupt. See Section 2.9.4 for details on EDMA3CC error interrupt generation.

The QEMR is shown in Figure 50 and described in Table 29.

Figure 50. QDMA Event Missed Register (QEMR)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 29. QDMA Event Missed Register (QEMR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		Channel 0-7 QDMA event missed. E*n* is cleared by writing a 1 to the corresponding bit in the QDMA event missed clear register (QEMCR).
		0	No missed event.
		1	Missed event occurred.

4.2.2.4 QDMA Event Missed Clear Register (QEMCR)

Once a missed event is posted in the QDMA event missed registers (QEMR), the bit remains set and you need to clear the set bit(s). This is done by way of CPU writes to the QDMA event missed clear registers (QEMCR). Writing a 1 to any of the bits clears the corresponding missed event (bit) in QEMR; writing a 0 has no effect.

The QEMCR is shown in Figure 51 and described in Table 30.

Figure 51. QDMA Event Missed Clear Register (QEMCR)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 30. QDMA Event Missed Clear Register (QEMCR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA event missed clear. All error bits must be cleared before additional error interrupts will be asserted by the EDMA3CC.
		0	No effect.
		1	Corresponding missed event bit in the QDMA event missed register (QEMR) is cleared (E*n* = 0).

4.2.2.5 EDMA3CC Error Register (CCERR)

The EDMA3CC error register (CCERR) indicates whether or not at any instant of time the number of events queued up in any of the event queues exceeds or equals the threshold/watermark value that is set in the queue watermark threshold register (QWMTHRA). Additionally, CCERR also indicates if when the number of outstanding TRs that have been programmed to return transfer completion code (TRs that have the TCINTEN or TCCHEN bit in OPT set to 1) to the EDMA3CC has exceeded the maximum allowed value of 31. If any bit in CCERR is set (and all errors, including bits in other error registers (EMR or QEMR) were previously cleared), the EDMA3CC generates an error interrupt. See Section 2.9.4 for details on EDMA3CC error interrupt generation. Once the error bits are set in CCERR, they can only be cleared by writing to the corresponding bits in the EDMA3CC error clear register (CCERRCLR).

The CCERR is shown in Figure 52 and described in Table 31.

Figure 52. EDMA3CC Error Register (CCERR)

31	17	16
Reserved		TCCERR
R-0		R-0

15	2	1	0
Reserved		QTHRXCD1	QTHRXCD0
R-0		R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 31. EDMA3CC Error Register (CCERR) Field Descriptions

Bit	Field	Value	Description
31-17	Reserved	0	Reserved
16	TCCERR		Transfer completion code error. TCCERR is cleared by writing a 1 to the corresponding bit in the EDMA3CC error clear register (CCERRCLR).
		0	Total number of allowed TCCs outstanding has not been reached.
		1	Total number of allowed TCCs has been reached.
15-2	Reserved	0	Reserved
1	QTHRXCD1		Queue threshold error for queue 1. QTHRXCD1 is cleared by writing a 1 to the corresponding bit in the EDMA3CC error clear register (CCERRCLR).
		0	Watermark/threshold has not been exceeded.
		1	Watermark/threshold has been exceeded.
0	QTHRXCD0		Queue threshold error for queue 0. QTHRXCD0 is cleared by writing a 1 to the corresponding bit in the EDMA3CC error clear register (CCERRCLR).
		0	Watermark/threshold has not been exceeded.
		1	Watermark/threshold has been exceeded.

4.2.2.6 EDMA3CC Error Clear Register (CCERRCLR)

The EDMA3CC error clear register (CCERRCLR) is used to clear any error bits that are set in the EDMA3CC error register (CCERR). In addition, CCERRCLR also clears the values of some bit fields in the queue status registers (QSTAT*n*) associated with a particular event queue. Writing a 1 to any of the bits clears the corresponding bit in CCERR; writing a 0 has no effect.

The CCERRCLR is shown in Figure 53 and described in Table 32.

Figure 53. EDMA3CC Error Clear Register (CCERRCLR)

31	17	16
Reserved		TCCERR
W-0		W-0

15	2	1	0
Reserved		QTHRXCD1	QTHRXCD0
W-0		W-0	W-0

LEGEND: W= Write only; -*n* = value after reset

Table 32. EDMA3CC Error Clear Register (CCERRCLR) Field Descriptions

Bit	Field	Value	Description
31-17	Reserved	0	Reserved
16	TCCERR		Transfer completion code error clear.
		0	No effect.
		1	Clears the TCCERR bit in the EDMA3CC error register (CCERR).
15-2	Reserved	0	Reserved
1	QTHRXCD1		Queue threshold error clear for queue 1.
		0	No effect.
		1	Clears the QTHRXCD1 bit in the EDMA3CC error register (CCERR) and the WM and THRXCD bits in the queue status register 1 (QSTAT1).
0	QTHRXCD0		Queue threshold error clear for queue 0.
		0	No effect.
		1	Clears the QTHRXCD0 bit in the EDMA3CC error register (CCERR) and the WM and THRXCD bits in the queue status register 0 (QSTAT0).

4.2.2.7 Error Evaluate Register (EEVAL)

The EDMA3CC error interrupt is asserted whenever an error bit is set in any of the error registers (EMR, QEMR, and CCERR). For subsequent error bits that get set, the EDMA3CC error interrupt is reasserted only when transitioning from an “all the error bits cleared” to “at least one error bit is set”. Alternatively, a CPU write of 1 to the EVAL bit in the error evaluate register (EEVAL) results in reasserting the EDMA3CC error interrupt, if there are any outstanding error bits set due to subsequent error conditions. Writes of 0 have no effect.

The EEVAL is shown in Figure 54 and described in Table 33.

Figure 54. Error Evaluate Register (EEVAL)

31	16
Reserved	
R-0	

15	2	1	0
Reserved		Rsvd	EVAL
R-0		R/W-0	W-0

LEGEND: R/W = Read/Write; R = Read only; W = Write only; -*n* = value after reset

Table 33. Error Evaluate Register (EEVAL) Field Descriptions

Bit	Field	Value	Description
31-2	Reserved	0	Reserved
1	Reserved	0	Reserved. Always write 0 to this bit; writes of 1 to this bit are not supported and attempts to do so may result in undefined behavior.
0	EVAL		Error interrupt evaluate.
		0	No effect.
		1	EDMA3CC error interrupt will be pulsed if any errors have not been cleared in any of the error registers (EMR, QEMR, or CCERR).

4.2.3 Region Access Enable Registers

The region access enable register group consists of the DMA access enable registers (DRAE*m*) and the QDMA access enable registers (QRAE*m*). Where *m* is the number of shadow regions in the EDMA3CC memory-map for a device. You can configure these registers to assign ownership of DMA/QDMA channels to a particular shadow region.

4.2.3.1 DMA Region Access Enable for Region m (DRAEm)

The DMA region access enable registers for shadow region *m* (DRAE*m*) is programmed to allow or disallow read/write accesses on a bit-by-bit bases for all DMA registers in the shadow region *m* view of the DMA channel registers. See the EDMA3CC register memory-map for a list of all the DMA channel and interrupt registers mapped in the shadow region view. Additionally, the DRAE*m* configuration determines completion of which DMA channels will result in assertion of the shadow region *m* DMA completion interrupt (see Section 2.9).

The DRAE*m* is shown in Figure 55 and described in Table 34.

Figure 55. DMA Region Access Enable Register for Region *m* (DRAE*m*)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; -*n* = value after reset

Table 34. DMA Region Access Enable Register for Region *m* (DRAE*m*) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		DMA region access enable for bit *n*/channel *n* in region *m*.
		0	Accesses via region *m* address space to bit *n* in any DMA channel register are not allowed. Reads return 0 on bit *n* and writes do not modify the state of bit *n*. Enabled interrupt bits for bit *n* do not contribute to the generation of a transfer completion interrupt for shadow region *m*.
		1	Accesses via region *m* address space to bit *n* in any DMA channel register are allowed. Reads return the value from bit *n* and writes modify the state of bit *n*. Enabled interrupt bits for bit *n* contribute to the generation of a transfer completion interrupt for shadow region *m*.

4.2.3.2 QDMA Region Access Enable Registers (QRAE*m*)

The QDMA region access enable registers for shadow region *m* (QRAE*m*) is programmed to allow or disallow read/write accesses on a bit-by-bit bases for all QDMA registers in the shadow region *m* view of the QDMA registers. This includes all 8-bit QDMA registers.

The QRAE*m* is shown in Figure 56 and described in Table 35.

Figure 56. QDMA Region Access Enable for Region *m* (QRAE*m*)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 35. QDMA Region Access Enable for Region *m* (QRAE*m*) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA region access enable for bit *n*/QDMA channel *n* in region *m*.
		0	Accesses via region *m* address space to bit *n* in any QDMA channel register are not allowed. Reads return 0 on bit *n* and writes do not modify the state of bit *n*.
		1	Accesses via region *m* address space to bit *n* in any QDMA channel register are allowed. Reads return the value from bit *n* and writes modify the state of bit *n*.

4.2.4 Status/Debug Visibility Registers

The following set of registers provide visibility into the event queues and a TR lifecycle. These are useful for system debug as they provide in-depth visibility for the events queued up in the event queue and also provide information on what parts of the EDMA3CC logic are active once the event has been received by the EDMA3CC.

4.2.4.1 Event Queue Entry Registers (QxEy)

The event queue entry registers (Q*x*E*y*) exist for all 16 queue entries (the maximum allowed queue entries) for all event queues (Q0 and Q1) in the EDMA3CC: Q0E0 to Q0E15 and Q1E0 to Q1E15. Each register details the event number (ENUM) and the event type (ETYPE). For example, if the value in Q1E4 is read as 0000 004Fh, this means the 4th entry in queue 1 is a manually-triggered event on DMA channel 15.

The Q*x*E*y* is shown in Figure 57 and described in Table 36.

Figure 57. Event Queue Entry Registers (Q*x*E*y*)

31	16
Reserved	
R-0	

15	8	7	6	5	4	0
Reserved		ETYPE		Rsvd	ENUM	
R-0		R-x		R-0	R-x	

LEGEND: R = Read only; -*n* = value after reset; -x = value is indeterminate after reset

Table 36. Event Queue Entry Registers (Q*x*E*y*) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-6	ETYPE	0-3h	Event entry *y* in queue *x*. Specifies the specific event type for the given entry in the event queue.
		0	Event triggered via ER
		1h	Manual triggered via ESR
		2h	Chain triggered via CER
		3h	Autotriggered via QER
5	Reserved	0	Reserved
4-0	ENUM	0-1Fh	Event entry *y* in queue *x*. Event number:
		0-7h	QDMA channel number (0 to 7)
		0-1Fh	DMA channel/event number (0 to 31)

4.2.4.2 *Queue n* Status Registers (QSTAT*n*)

The queue *n* status register (QSTAT*n*) is shown in Figure 58 and described in Table 37.

Figure 58. Queue *n* Status Register (QSTAT*n*)

31	25	24	23	21	20	16
Reserved		THRXCD	Reserved		WM	
R-0		R-0	R-0		R-0	

15	13	12	8	7	4	3	0
Reserved		NUMVAL		Reserved		STRTPTR	
R-0		R-0		R-0		R-0	

LEGEND: R = Read only; -*n* = value after reset

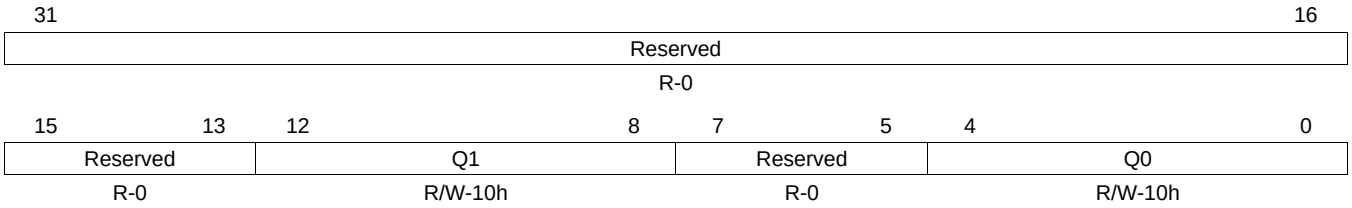
Table 37. Queue *n* Status Register (QSTAT*n*) Field Descriptions

Bit	Field	Value	Description
31-25	Reserved	0	Reserved
24	THRXCD		Threshold exceeded. THRXCD is cleared by writing a 1 to the corresponding QTHRXCD*n* bit in the EDMA3CC error clear register (CCERRCLR).
		0	Threshold specified by the Q*n* bit in the queue watermark threshold A register (QWMTHRA) has not been exceeded.
		1	Threshold specified by the Q*n* bit in the queue watermark threshold A register (QWMTHRA) has been exceeded.
23-21	Reserved	0	Reserved
20-16	WM	0-1Fh	Watermark for maximum queue usage. Watermark tracks the most entries that have been in queue *n* since reset or since the last time that the watermark (WM) bit was cleared. WM is cleared by writing a 1 to the corresponding QTHRXCD*n* bit in the EDMA3CC error clear register (CCERRCLR).
		0-10h	Legal values are 0 (empty) to 10h (full).
		11h-1Fh	Reserved
15-13	Reserved	0	Reserved
12-8	NUMVAL	0-1Fh	Number of valid entries in queue *n*. The total number of entries residing in the queue manager FIFO at a given instant. Always enabled.
		0-10h	Legal values are 0 (empty) to 10h (full).
		11h-1Fh	Reserved
7-4	Reserved	0	Reserved
3-0	STRTPTR	0-Fh	Start pointer. The offset to the head entry of queue *n*, in units of entries. Always enabled. Legal values are 0 (0th entry) to Fh (15th entry).

4.2.4.3 Queue Watermark Threshold A Register (QWMTHRA)

The queue watermark threshold A register (QWMTHRA) is shown in Figure 59 and described in Table 38.

Figure 59. Queue Watermark Threshold A Register (QWMTHRA)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

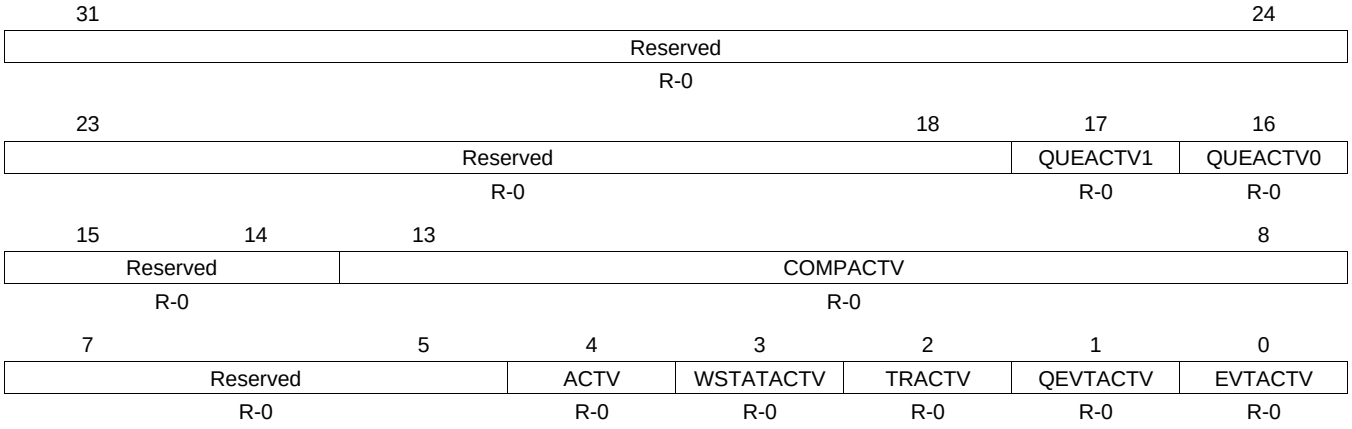
Table 38. Queue Watermark Threshold A Register (QWMTHRA) Field Descriptions

Bit	Field	Value	Description
31-13	Reserved	0	Reserved
12-8	Q1	0-1Fh	Queue threshold for queue 1 value. The QTHRXCD1 bit in the EDMA3CC error register (CCERR) and the THRXCD bit in the queue status register 1 (QSTAT1) are set when the number of events in queue 1 at an instant in time (visible via the NUMVAL bit in QSTAT1) equals or exceeds the value specified by Q1.
		0-10h	The default is 16 (maximum allowed).
		11h	Disables the threshold errors.
		12h-1Fh	Reserved
7-5	Reserved	0	Reserved
4-0	Q0	0-1Fh	Queue threshold for queue 0 value. The QTHRXCD0 bit in the EDMA3CC error register (CCERR) and the THRXCD bit in the queue status register 0 (QSTAT0) are set when the number of events in queue 0 at an instant in time (visible via the NUMVAL bit in QSTAT0) equals or exceeds the value specified by Q0.
		0-10h	The default is 16 (maximum allowed).
		11h	Disables the threshold errors.
		12h-1Fh	Reserved

4.2.4.4 EDMA3CC Status Register (CCSTAT)

The EDMA3CC status register (CCSTAT) has a number of status bits that reflect which parts of the EDMA3CC logic is active at any given instant of time. The CCSTAT is shown in Figure 60 and described in Table 39.

Figure 60. EDMA3CC Status Register (CCSTAT)



LEGEND: R = Read only; -*n* = value after reset

Table 39. EDMA3CC Status Register (CCSTAT) Field Descriptions

Bit	Field	Value	Description
31-18	Reserved	0	Reserved
17	QUEACTV1		Queue 1 active.
		0	No events are queued in queue 1.
		1	At least one TR is queued in queue 1.
16	QUEACTV0		Queue 0 active.
		0	No events are queued in queue 0.
		1	At least one TR is queued in queue 0.
15-14	Reserved	0	Reserved
13-8	COMPACTV	0-3Fh	Completion request active. The COMPACTV field reflects the count for the number of completion requests submitted to the transfer controllers. This count increments every time a TR is submitted and is programmed to report completion (the TCINTEN or TCCCHEN bits in OPT in the parameter entry associated with the TR are set to 1). The counter decrements for every valid TCC received back from the transfer controllers. If at any time the count reaches a value of 63, the EDMA3CC will not service any new TRs until the count is less then 63 (or return a transfer completion code from a transfer controller, which would decrement the count).
		0	No completion requests outstanding.
		1h-3Fh	Total of 1 completion request to 63 completion requests are outstanding.
7-5	Reserved	0	Reserved
4	ACTV		Channel controller active. Channel controller active is a logical-OR of each of the *ACTV bits. The ACTV bit remains high through the life of a TR.
		0	Channel is idle.
		1	Channel is busy.
3	WSTATACTV		Write status interface active.
		0	Write status req is idle and write status fifo is idle.
		1	Either the write status request is active or additional write status responses are pending in the write status fifo.
2	TRACTV		Transfer request active.
		0	Transfer request processing/submission logic is inactive.
		1	Transfer request processing/submission logic is active.

Table 39. EDMA3CC Status Register (CCSTAT) Field Descriptions (continued)

Bit	Field	Value	Description
1	QEVTACTV		QDMA event active.
		0	No enabled QDMA events are active within the EDMA3CC.
		1	At least one enabled QDMA event (QER) is active within the EDMA3CC.
0	EVTACTV		DMA event active.
		0	No enabled DMA events are active within the EDMA3CC.
		1	At least one enabled DMA event (ER and EER, ESR, CER) is active within the EDMA3CC.

4.2.5 DMA Channel Registers

The following registers pertain to the 32 DMA channels. The 32 DMA channels consist of registers (with the exception of DMAQNUM*n*) that each have 32 bits and the bit position of each register matches the DMA channel number.

The DMA channel registers are accessible via read/writes to the global address range. They are also accessible via read/writes to the shadow address range. The read/write ability to the registers in the shadow region is controlled by the DMA region access registers (DRAE*m*). These registers are described in Section 4.2.3.1 and the details for shadow region/global region usage is explained in Section 2.7.

4.2.5.1 Event Register (ER)

All external events are captured in the event register (ER). The events are latched even when the events are not enabled. If the event bit corresponding to the latched event is enabled (EER.E*n* = 1), then the event is evaluated by the EDMA3CC logic for an associated transfer request submission to the transfer controllers. The event register bits are automatically cleared (ER.E*n* = 0) once the corresponding events are prioritized and serviced. If ER.E*n* are already set and another event is received on the same channel/event, then the corresponding event is latched in the event miss register (EMR.E*n*), provided that the event was enabled (EER.E*n* = 1).

Event *n* can be cleared by the CPU writing a 1 to corresponding event bit in the event clear register (ECR). The setting of an event is a higher priority relative to clear operations (via hardware or software). If set and clear conditions occur concurrently, the set condition wins. If the event was previously set, then EMR would be set since an event is lost. If the event was previously clear, then the event remains set and is prioritized for submission to the event queues.

The ER is shown in Figure 61 and described in Table 40.

Figure 61. Event Register (ER)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	19	E18	E17	E16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 40. Event Register (ER) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event 0-31. Events 0-31 are captured by the EDMA3CC and are latched into ER. The events are set (E*n* = 1) even when events are disabled (E*n* = 0 in the event enable register, EER).
		0	EDMA3CC event is not asserted.
		1	EDMA3CC event is asserted. Corresponding DMA event is prioritized versus other pending DMA/QDMA events for submission to the EDMA3TC.

4.2.5.2 Event Clear Register (ECR)

Once an event has been posted in the event register (ER), the event is cleared in two ways. If the event is enabled in the event enable register (EER) and the EDMA3CC submits a transfer request for the event to the EDMA3TC, it clears the corresponding event bit in the event register. If the event is disabled in the event enable register (EER), the CPU can clear the event by way of the event clear register (ECR).

Writing a 1 to any of the bits clears the corresponding event; writing a 0 has no effect. Once an event bit is set in the event register, it remains set until EDMA3CC submits a transfer request for that event or the CPU clears the event by setting the corresponding bit in ECR.

The ECR is shown in Figure 62 and described in Table 41.

Figure 62. Event Clear Register (ECR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 41. Event Clear Register (ECR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event clear for event 0-31. Any of the event bits in ECR is set to 1 to clear the event (E*n*) in the event register (ER). A write of 0 has no effect.
		0	No effect.
		1	EDMA3CC event is cleared in the event register (ER).

4.2.5.3 Event Set Register (ESR)

The event set register (ESR) allows the CPU (or EDMA programmers) to manually set events to initiate DMA transfer requests. CPU writes of 1 to any event set register (E*n*) bits set the corresponding bits in the registers. The set event is evaluated by the EDMA3CC logic for an associated transfer request submission to the transfer controllers. Writing a 0 has no effect.

The event set register operates independent of the event register (ER), and a write of 1 is always considered a valid event regardless of whether the event is enabled (the corresponding event bits are set or cleared in EER.E*n*).

Once the event is set in the event set register, it cannot be cleared by CPU writes, in other words, the event clear register (ECR) has no effect on the state of ESR. The bits will only be cleared once the transfer request corresponding to the event has been submitted to the transfer controller. The setting of an event is a higher priority relative to clear operations (via hardware). If set and clear conditions occur concurrently, the set condition wins. If the event was previously set, then EMR would be set since an event is lost. If the event was previously clear, then the event remains set and is prioritized for submission to the event queues.

Manually-triggered transfers via writes to ESR allow the CPU to submit DMA requests in the system, these are relevant for memory-to-memory transfer scenarios. If the ESR.E*n* bit is already set and another CPU write of 1 is attempted to the same bit, then the corresponding event is latched in the event missed registers (EMR.E*n* = 1).

The ESR is shown in Figure 63 and described in Table 42.

Figure 63. Event Set Register (ESR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; -*n* = value after reset

Table 42. Event Set Register (ESR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event set for event 0-31.
		0	No effect.
		1	Corresponding DMA event is prioritized versus other pending DMA/QDMA events for submission to the EDMA3TC.

4.2.5.4 Chained Event Register (CER)

When the OPTIONS parameter for a PaRAM entry is programmed to returned a chained completion code (ITCCHEN = 1 and/or TCCHEN = 1), then the value dictated by the TCC[5:0] (also programmed in OPT) forces the corresponding event bit to be set in the chained event register (CER). The set chained event is evaluated by the EDMA3CC logic for an associated transfer request submission to the transfer controllers. This results in a chained-triggered transfer.

The chained event registers do not have any enables. The generation of a chained event is essentially enabled by the PaRAM entry that has been configured for intermediate and/or final chaining on transfer completion. The E*n* bit is set (regardless of the state of EER.E*n*) when a chained completion code is returned from one of the transfer controllers or is generated by the EDMA3CC via the early completion path. The bits in the chained event register are cleared when the corresponding events are prioritized and serviced.

If the E*n* bit is already set and another chaining completion code is return for the same event, then the corresponding event is latched in the event missed register (EMR.E*n* = 1). The setting of an event is a higher priority relative to clear operations (via hardware). If set and clear conditions occur concurrently, the set condition wins. If the event was previously set, then EMR would be set since an event is lost. If the event was previously clear, then the event remains set and is prioritized for submission to the event queues.

The CER is shown in Figure 64 and described in Table 43.

Figure 64. Chained Event Register (CER)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 43. Chained Event Register (CER) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Chained event for event 0-31.
		0	No effect.
		1	Corresponding DMA event is prioritized versus other pending DMA/QDMA events for submission to the EDMA3TC.

4.2.5.5 Event Enable Register (EER)

The EDMA3CC provides the option of selectively enabling/disabling each event in the event register (ER) by using the event enable register (EER). If an event bit in EER is set to 1 (using the event enable set register, EESR), it will enable that corresponding event. Alternatively, if an event bit in EER is cleared (using the event enable clear register, EECR), it will disable the corresponding event.

The event register latches all events that are captured by EDMA3CC, even if the events are disabled (although EDMA3CC does not process it). Enabling an event with a pending event already set in the event register enables the EDMA3CC to process the already set event like any other new event. The EER settings do not have any effect on chained events (CER.E*n* = 1) and manually set events (ESR.E*n* = 1).

The EER is shown in Figure 65 and described in Table 44.

Figure 65. Event Enable Register (EER)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 44. Event Enable Register (EER) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event enable for events 0-31.
		0	Event is not enabled. An external event latched in the event register (ER) is not evaluated by the EDMA3CC.
		1	Event is enabled. An external event latched in the event register (ER) is evaluated by the EDMA3CC.

4.2.5.6 Event Enable Clear Register (EECR)

The event enable register (EER) cannot be modified by directly writing to it. The intent is to ease the software burden for the case where multiple tasks are attempting to simultaneously modify these registers. The event enable clear register (EECR) is used to disable events. Writes of 1 to the bits in EECR clear the corresponding event bits in EER; writes of 0 have no effect.

The EECR is shown in Figure 66 and described in Table 45.

Figure 66. Event Enable Clear Register (EECR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 45. Event Enable Clear Register (EECR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event enable clear for events 0-31.
		0	No effect.
		1	Event is disabled. Corresponding bit in the event enable register (EER) is cleared (E*n* = 0).

4.2.5.7 Event Enable Set Register (EESR)

The event enable register (EER) cannot be modified by directly writing to it. The intent is to ease the software burden for the case where multiple tasks are attempting to simultaneously modify these registers. The event enable set register (EESR) is used to enable events. Writes of 1 to the bits in EESR set the corresponding event bits in EER; writes of 0 have no effect.

The EESR is shown in Figure 67 and described in Table 46.

Figure 67. Event Enable Set Register (EESR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 46. Event Enable Set Register (EESR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Event enable set for events 0-31.
		0	No effect.
		1	Event is enabled. Corresponding bit in the event enable register (EER) is set (E*n* = 1).

4.2.5.8 Secondary Event Register (SER)

The secondary event register (SER) provides information on the state of a DMA channel or event (0 through 31). If the EDMA3CC receives a TR synchronization due to a manual-trigger, event-trigger, or chained-trigger source (ESR.E*n* = 1, ER.E*n* = 1, or CER.E*n* = 1), which results in the setting of a corresponding event bit in SER (SER.E*n* = 1), it implies that the corresponding DMA event is in the queue.

Once a bit corresponding to an event is set in SER, the EDMA3CC does not prioritize additional events on the same DMA channel. Depending on the condition that leads to the setting of the SER bits, either the EDMA3CC hardware or the software (using SECR) needs to clear the SER bits for the EDMA3CC to evaluate subsequent events and perform subsequent transfers on the same channel. Based on whether the associated TR is valid, or it is a null or dummy TR, the implications on the state of SER and the required user action in order to submit another DMA transfer might be different.

The SER is shown in Figure 68 and described in Table 47.

Figure 68. Secondary Event Register (SER)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 47. Secondary Event Register (SER) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Secondary event register. The secondary event register is used to provide information on the state of an event.
		0	Event is not currently stored in the event queue.
		1	Event is currently stored in the event queue. Event arbiter will not prioritize additional events.

4.2.5.9 Secondary Event Clear Register (SECR)

The secondary event clear register (SECR) clears the status of the secondary event registers (SER). CPU writes of 1 clear the corresponding set bits in SER. Writes of 0 have no effect.

The SECR is shown in Figure 69 and described in Table 48.

Figure 69. Secondary Event Clear Register (SECR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
E15	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 48. Secondary Event Clear Register (SECR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Secondary event clear register
		0	No effect.
		1	Corresponding bit in the secondary event register (SER) is cleared (E*n* = 0).

4.2.6 Interrupt Registers

All DMA/QDMA channels can be set to assert an EDMA3CC completion interrupt to the CPU on transfer completion, by appropriately configuring the PaRAM entry associated with the channels. The following registers are used for the transfer completion interrupt reporting/generating by the EDMA3CC. See Section 2.9 for more details on EDMA3CC completion interrupt generation.

4.2.6.1 Interrupt Enable Registers (IER)

Interrupt enable register (IER) is used to enable/disable the transfer completion interrupt generation by the EDMA3CC for all DMA/QDMA channels. The IER cannot be written to directly. To set any interrupt bit in IER, a 1 must be written to the corresponding interrupt bit in the interrupt enable set registers (IESR). Similarly, to clear any interrupt bit in IER, a 1 must be written to the corresponding interrupt bit in the interrupt enable clear register (IECR).

The IER is shown in Figure 70 and described in Table 49.

Figure 70. Interrupt Enable Register (IER)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
I31	I30	I29	I28	I27I	I26	I25	I24	I23	I22	I21	I20	I19	I18	I17	I16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 49. Interrupt Enable Register (IER) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Interrupt enable for channels 0-31.
		0	Interrupt is not enabled.
		1	Interrupt is enabled.

4.2.6.2 Interrupt Enable Clear Register (IECR)

The interrupt enable clear register (IECR) is used to clear interrupts. Writes of 1 to the bits in IECR clear the corresponding interrupt bits in the interrupt enable registers (IER); writes of 0 have no effect.

The IECR is shown in Figure 71 and described in Table 50.

Figure 71. Interrupt Enable Clear Register (IECR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
I31	I30	I29	I28	I27	I26	I25	I24	I23	I22	I21	I20	I19	I18	I17	16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 50. Interrupt Enable Clear Register (IECR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Interrupt enable clear for channels 0-31.
		0	No effect
		1	Corresponding bit in the interrupt enable register (IER) is cleared (I*n* = 0).

4.2.6.3 Interrupt Enable Set Register (IESR)

The interrupt enable set register (IESR) is used to enable interrupts. Writes of 1 to the bits in IESR set the corresponding interrupt bits in the interrupt enable registers (IER); writes of 0 have no effect.

The IESR is shown in Figure 72 and described in Table 51.

Figure 72. Interrupt Enable Set Register (IESR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
I31	I30	I29	I28	I27	I26	I25	I24	I23	I22	I21	I20	I19	II8	I17	I16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 51. Interrupt Enable Set Register (IESR) Field Descriptions

Bit	Field	Value	Description
31-0	E*n*		Interrupt enable set for channels 0-31.
		0	No effect.
		1	Corresponding bit in the interrupt enable register (IER) is set (I*n* = 1).

4.2.6.4 Interrupt Pending Register (IPR)

If the TCINTEN and/or ITCINTEN bit in the channel option parameter (OPT) is set to 1 in the PaRAM entry associated with the channel (DMA or QDMA), then the EDMA3TC (for normal completion) or the EDMA3CC (for early completion) returns a completion code on transfer or intermediate transfer completion. The value of the returned completion code is equal to the TCC bit in OPT for the PaRAM entry associated with the channel.

When an interrupt transfer completion code with TCC = *n* is detected by the EDMA3CC, then the corresponding bit is set in the interrupt pending register (IPR.I*n*, if *n* = 0 to 31). Note that once a bit is set in the interrupt pending registers, it remains set; it is your responsibility to clear these bits. The bits set in IPR are cleared by writing a 1 to the corresponding bits in the interrupt clear registers (ICR).

The IPR is shown in Figure 73 and described in Table 52.

Figure 73. Interrupt Pending Register (IPR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
I31	I30	I29	I28	I27	I26	I25	I24	I23	I22	I21	I20	I19	I18	I17	I16
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 52. Interrupt Pending Register (IPR) Field Descriptions

Bit	Field	Value	Description
31-0	I*n*		Interrupt pending for TCC = 0-31.
		0	Interrupt transfer completion code is not detected or was cleared.
		1	Interrupt transfer completion code is detected (I*n* = 1, *n* = EDMA3TC[5:0]).

4.2.6.5 Interrupt Clear Register (ICR)

The bits in the interrupt pending register (IPR) are cleared by writing a 1 to the corresponding bits in the interrupt clear register (ICR); writes of 0 have no effect. All set bits in IPR must be cleared to allow EDMA3CC to assert additional transfer completion interrupts.

The ICR is shown in Figure 74 and described in Table 53.

Figure 74. Interrupt Clear Register (ICR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
I31	I30	I29	I28	I27	I26	I25	I24	I23	I22	I21	I20	I19	I18	I17	I16
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I15	I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: W = Write only; -*n* = value after reset

Table 53. Interrupt Clear Register (ICR) Field Descriptions

Bit	Field	Value	Description
31-0	I*n*		Interrupt clear register for TCC = 0-31.
		0	No effect.
		1	Corresponding bit in the interrupt pending register (IPR) is cleared (I*n* = 0).

4.2.6.6 Interrupt Evaluate Register (IEVAL)

The interrupt evaluate register (IEVAL) is the only register that physically exists in both the global region and the shadow regions. In other words, the read/write accessibility for the shadow region IEVAL is not affected by the DMA/QDMA region access registers (DRAE*m* and QRAE*m*). IEVAL is needed for robust ISR operations to ensure that interrupts are not missed by the CPU.

The IEVAL is shown in Figure 75 and described in Table 54.

Figure 75. Interrupt Evaluate Register (IEVAL)

31	16
Reserved	
R-0	

15	2	1	0
Reserved		Rsvd	EVAL
R-0		W-0	W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 54. Interrupt Evaluate Register (IEVAL) Field Descriptions

Bit	Field	Value	Description
31-2	Reserved	0	Reserved
1	Reserved	0	Reserved. Always write 0 to this bit; writes of 1 to this bit are not supported and attempts to do so may result in undefined behavior.
0	EVAL		Interrupt evaluate.
		0	No effect.
		1	Causes EDMA3CC completion interrupt to be pulsed, if any enabled (IER*n* = 1) interrupts are still pending (IPR*n* = 1). The EDMA3CC completion region interrupt that is pulsed depends on which IEVAL is being exercised. For example, writing to the EVAL bit in IEVAL0 pulses the region 0 completion interrupt, but writing to the EVAL bit in IEVAL1 pulses the region 1 completion interrupt.

4.2.7 QDMA Channel Registers

The following registers pertain to the 8 QDMA channels. The 8 QDMA channels consist of registers (with the exception of QDMAQNUM) that each have 8 bits and the bit position of each register matches the QDMA channel number.

The QDMA channel registers are accessible via read/writes to the global address range. They are also accessible via read/writes to the shadow address range. The read/write ability to the registers in the shadow region is controlled by the QDMA region access registers (QRAE*m*). These registers are described in Section 4.2.3.2 and the details for shadow region/global region usage is explained in Section 2.7.

4.2.7.1 QDMA Event Register (QER)

The QDMA event register (QER) channel *n* bit is set (E*n* = 1) when the CPU or any EDMA programmer (including EDMA3) performs a write to the trigger word (using the QDMA channel *n* mapping register (QCHMAP*n*)) in the PaRAM entry associated with QDMA channel *n* (which is also programmed using QCHMAP*n*). The E*n* bit is also set when the EDMA3CC performs a link update on a PaRAM address that matches the QCHMAP*n* settings. The QDMA event is latched only if the QDMA event enable register (QEER) channel *n* bit is also enabled (QEER.E*n* = 1). Once a bit is set in QER, then the corresponding QDMA event (auto-trigger) is evaluated by the EDMA3CC logic for an associated transfer request submission to the transfer controllers.

The setting of an event is a higher priority relative to clear operations (via hardware). If set and clear conditions occur concurrently, the set condition wins. If the event was previously set, then the QDMA event missed register (QEMR) would be set because an event is lost. If the event was previously clear, then the event remains set and is prioritized for submission to the event queues.

The set bits in QER are only cleared when the transfer request associated with the corresponding channels has been processed by the EDMA3CC and submitted to the transfer controller. If the E*n* bit is already set and a QDMA event for the same QDMA channel occurs prior to the original being cleared, then the second missed event is latched in QEMR (E*n* =1).

The QER is shown in Figure 76 and described in Table 55.

Figure 76. QDMA Event Register (QER)

31								16
Reserved								
R-0								
15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 55. QDMA Event Register (QER) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA event for channels 0-7.
		0	No effect.
		1	Corresponding QDMA event is prioritized versus other pending DMA/QDMA events for submission to the EDMA3TC.

4.2.7.2 QDMA Event Enable Register (QEER)

The EDMA3CC provides the option of selectively enabling/disabling each channel in the QDMA event register (QER) by using the QDMA event enable register (QEER). If any of the event bits in QEER is set to 1 (using the QDMA event enable set register, QEESR), it will enable that corresponding event. Alternatively, if any event bit in QEER is cleared (using the QDMA event enable clear register, QEECR), it will disable the corresponding QDMA channel. The QDMA event register will not latch any event for a QDMA channel, if it is not enabled via QEER.

The QEER is shown in Figure 77 and described in Table 56.

Figure 77. QDMA Event Enable Register (QEER)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 56. QDMA Event Enable Register (QEER) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA event enable for channels 0-7.
		0	QDMA channel *n* is not enabled. QDMA event will not be recognized and will not latch in the QDMA event register (QER).
		1	QDMA channel *n* is enabled. QDMA events will be recognized and will get latched in the QDMA event register (QER).

4.2.7.3 QDMA Event Enable Clear Register (QEECR)

The QDMA event enable register (QEER) cannot be modified by directly writing to the register, in order to ease the software burden when multiple tasks are attempting to simultaneously modify these registers. The QDMA event enable clear register (QEECR) is used to disable events. Writes of 1 to the bits in QEECR clear the corresponding QDMA channel bits in QEER; writes of 0 have no effect.

The QEECR is shown in Figure 78 and described in Table 57.

Figure 78. QDMA Event Enable Clear Register (QEECR)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 57. QDMA Event Enable Clear Register (QEECR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA event enable clear for channels 0-7.
		0	No effect.
		1	QDMA event is disabled. Corresponding bit in the QDMA event enable register (QEER) is cleared (E*n* = 0).

4.2.7.4 QDMA Event Enable Set Register (QEESR)

The QDMA event enable register (QEER) cannot be modified by directly writing to the register, in order to ease the software burden when multiple tasks are attempting to simultaneously modify these registers. The QDMA event enable set register (QEESR) is used to enable events. Writes of 1 to the bits in QEESR set the corresponding QDMA channel bits in QEER; writes of 0 have no effect.

The QEESR is shown in Figure 79 and described in Table 58.

Figure 79. QDMA Event Enable Set Register (QEESR)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 58. QDMA Event Enable Set Register (QEESR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA event enable set for channels 0-7.
		0	No effect.
		1	QDMA event is enabled. Corresponding bit in the QDMA event enable register (QEER) is set (E*n* = 1).

4.2.7.5 QDMA Secondary Event Register (QSER)

The QDMA secondary event register (QSER) provides information on the state of a QDMA event. If at any time a bit corresponding to a QDMA channel is set in QSER, that implies that the corresponding QDMA event is in the queue. Once a bit corresponding to a QDMA channel is set in QSER, the EDMA3CC does not prioritize additional events on the same QDMA channel. Depending on the condition that lead to the setting of the QSER bits, either the EDMA3CC hardware or the software (using QSECR) needs to clear the QSER bits for the EDMA3CC to evaluate subsequent QDMA events on the channel. Based on whether the associated TR is valid, or it is a null or dummy TR, the implications on the state of QSER and the required user action in order to submit another QDMA transfer might be different.

The QSER is shown in Figure 80 and described in Table 59.

Figure 80. QDMA Secondary Event Register (QSER)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 59. QDMA Secondary Event Register (QSER) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA secondary event register for channels 0-7.
		0	QDMA event is not currently stored in the event queue.
		1	QDMA event is currently stored in event queue. EDMA3CC will not prioritize additional events.

4.2.7.6 QDMA Secondary Event Clear Register (QSECR)

The QDMA secondary event clear register (QSECR) clears the status of the QDMA secondary event register (QSER) and the QDMA event register (QER). CPU writes of 1 clear the corresponding set bits in QSER and QER. Writes of 0 have no effect. Note that this differs from the secondary event clear register (SECR) operation, which only clears the secondary event register (SER) bits and does not affect the event registers.

The QSECR is shown in Figure 81 and described in Table 60.

Figure 81. QDMA Secondary Event Clear Register (QSECR)

31	16
Reserved	
R-0	

15	8	7	6	5	4	3	2	1	0
Reserved		E7	E6	E5	E4	E3	E2	E1	E0
R-0		W-0	W-0	W-0	W-0	W-0	W-0	W-0	W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 60. QDMA Secondary Event Clear Register (QSECR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
7-0	E*n*		QDMA secondary event clear register for channels 0-7.
		0	No effect.
		1	Corresponding bit in the QDMA secondary event register (QSER) and the QDMA event register (QER) is cleared (E*n* = 0).

4.3 EDMA3 Transfer Controller (EDMA3TC) Registers

Table 61 lists the memory-mapped registers for the EDMA3 transfer controller (EDMA3TC). See your device-specific data manual for the memory address of these registers. All other register offset addresses not listed in Table 61 should be considered as reserved locations and the register contents should not be modified.

Table 61. EDMA3 Transfer Controller (EDMA3TC) Registers

Offset	Acronym	Register Description	Section
0h	REVID	Revision Identification Register	Section 4.3.1
4h	TCCFG	EDMA3TC Configuration Register	Section 4.3.2
100h	TCSTAT	EDMA3TC Channel Status Register	Section 4.3.3
120h	ERRSTAT	Error Status Register	Section 4.3.4.1
124h	ERREN	Error Enable Register	Section 4.3.4.2
128h	ERRCLR	Error Clear Register	Section 4.3.4.3
12Ch	ERRDET	Error Details Register	Section 4.3.4.4
130h	ERRCMD	Error Interrupt Command Register	Section 4.3.4.5
140h	RDRATE	Read Command Rate Register	Section 4.3.5
240h	SAOPT	Source Active Options Register	Section 4.3.6.1
244h	SASRC	Source Active Source Address Register	Section 4.3.6.2
248h	SACNT	Source Active Count Register	Section 4.3.6.3
24Ch	SADST	Source Active Destination Address Register	Section 4.3.6.4
250h	SABIDX	Source Active B-Index Register	Section 4.3.6.5
254h	SAMPPRXY	Source Active Memory Protection Proxy Register	Section 4.3.6.6
258h	SACNTRLD	Source Active Count Reload Register	Section 4.3.6.7
25Ch	SASRCBREF	Source Active Source Address B-Reference Register	Section 4.3.6.8
260h	SADSTBREF	Source Active Destination Address B-Reference Register	Section 4.3.6.9
280h	DFCNTRLD	Destination FIFO Set Count Reload Register	Section 4.3.6.10
284h	DFSRCBREF	Destination FIFO Set Source Address B-Reference Register	Section 4.3.6.11
288h	DFDSTBREF	Destination FIFO Set Destination Address B-Reference Register	Section 4.3.6.12
300h	DFOPT0	Destination FIFO Options Register 0	Section 4.3.6.13
304h	DFSRC0	Destination FIFO Source Address Register 0	Section 4.3.6.14
308h	DFCNT0	Destination FIFO Count Register 0	Section 4.3.6.15
30Ch	DFDST0	Destination FIFO Destination Address Register 0	Section 4.3.6.16
310h	DFBIDX0	Destination FIFO B-Index Register 0	Section 4.3.6.17
314h	DFMPPRXY0	Destination FIFO Memory Protection Proxy Register 0	Section 4.3.6.18
340h	DFOPT1	Destination FIFO Options Register 1	Section 4.3.6.13
344h	DFSRC1	Destination FIFO Source Address Register 1	Section 4.3.6.14
348h	DFCNT1	Destination FIFO Count Register 1	Section 4.3.6.15
34Ch	DFDST1	Destination FIFO Destination Address Register 1	Section 4.3.6.16
350h	DFBIDX1	Destination FIFO B-Index Register 1	Section 4.3.6.17
354h	DFMPPRXY1	Destination FIFO Memory Protection Proxy Register 1	Section 4.3.6.18
380h	DFOPT2	Destination FIFO Options Register 2	Section 4.3.6.13
384h	DFSRC2	Destination FIFO Source Address Register 2	Section 4.3.6.14
388h	DFCNT2	Destination FIFO Count Register 2	Section 4.3.6.15
38Ch	DFDST2	Destination FIFO Destination Address Register 2	Section 4.3.6.16
390h	DFBIDX2	Destination FIFO B-Index Register 2	Section 4.3.6.17
394h	DFMPPRXY2	Destination FIFO Memory Protection Proxy Register 2	Section 4.3.6.18
3C0h	DFOPT3	Destination FIFO Options Register 3	Section 4.3.6.13
3C4h	DFSRC3	Destination FIFO Source Address Register 3	Section 4.3.6.14
3C8h	DFCNT3	Destination FIFO Count Register 3	Section 4.3.6.15

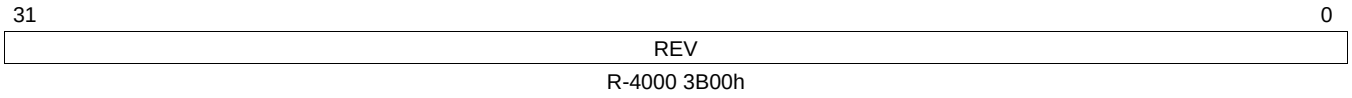
Table 61. EDMA3 Transfer Controller (EDMA3TC) Registers (continued)

Offset	Acronym	Register Description	Section
3CCh	DFDST3	Destination FIFO Destination Address Register 3	Section 4.3.6.16
3D0h	DFBIDX3	Destination FIFO B-Index Register 3	Section 4.3.6.17
3D4h	DFMPPRXY3	Destination FIFO Memory Protection Proxy Register 3	Section 4.3.6.18

4.3.1 Revision Identification Register (REVID)

The revision identification register (REVID) is a constant register that uniquely identifies the EDMA3TC and specific revision of the EDMA3TC. The REVID is shown in Figure 82 and described in Table 62.

Figure 82. Revision ID Register (REVID)



LEGEND: R = Read only; -*n* = value after reset

Table 62. Revision ID Register (REVID) Field Descriptions

Bit	Field	Value	Description
31-0	REV		Peripheral identifier.
		4000 3B00h	Uniquely identifies the EDMA3TC and the specific revision of the EDMA3TC.

4.3.2 EDMA3TC Configuration Register (TCCFG)

The EDMA3TC configuration register (TCCFG) is shown in Figure 83 and described in Table 63.

Figure 83. EDMA3TC Configuration Register (TCCFG)

31	16
Reserved	
R-0	

15	10	9	8	7	6	5	4	3	2	0
Reserved		DREGDEPTH		Reserved		BUSWIDTH		Rsvd	FIFOSIZE	
R-0		R-x		R-0		R-x		R-0	R-x	

LEGEND: R = Read only; -*n* = value after reset; -x = value is indeterminate after reset

Table 63. EDMA3TC Configuration Register (TCCFG) Field Descriptions

Bit	Field	Value	Description
31-10	Reserved	0	Reserved
9-8	DREGDEPTH	0-3h	Destination register FIFO depth parameterization.
		0	1 entry
		1h	2 entry
		2h	4 entry (for EDMA3TC0 and EDMA3TC1)
		3h	Reserved
7-6	Reserved	0	Reserved
5-4	BUSWIDTH	0-3h	Bus width parameterization.
		0	32-bit
		1h	64-bit (for EDMA3TC0 and EDMA3TC1)
		2h-3h	Reserved
3	Reserved	0	Reserved
2-0	FIFOSIZE	0-7h	FIFO size.
		0	32-byte FIFO
		1h	64-byte FIFO
		2h	128-byte FIFO (for EDMA3TC0 and EDMA3TC1)
		3h	256-byte FIFO
		4h-7h	Reserved

4.3.3 EDMA3TC Channel Status Register (TCSTAT)

The EDMA3TC channel status register (TCSTAT) is shown in Figure 84 and described in Table 64.

Figure 84. EDMA3TC Channel Status Register (TCSTAT)

31	16
Reserved	
R-0	

15	13	12	11	10	8
Reserved		DFSTRTPTR		Reserved	
R-0		R-0		R-0	

7	6	4	3	2	1	0
Reserved	DSTACTV		Reserved	WSACTV	SRCACTV	PROGBUSY
R-0	R-0		R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 64. EDMA3TC Channel Status Register (TCSTAT) Field Descriptions

Bit	Field	Value	Description
31-13	Reserved	0	Reserved
12-11	DFSTRTPTR	0-3h	Destination FIFO start pointer. The offset to the head entry of the destination register FIFO, in units of *entries*.
10-7	Reserved	0	Reserved
6-4	DSTACTV	0-7h	Destination active state. Specifies the number of transfer requests (TRs) that are resident in the destination register FIFO at a given instant. This bit field can be primarily used for advanced debugging.
		0	Destination FIFO is empty.
		1h	Destination FIFO contains 1 TR.
		2h	Destination FIFO contains 2 TR.
		3h	Destination FIFO contains 3 TR.
		4h	Destination FIFO contains 4 TR. (Full if DSTREGDEPTH == 4)
			If the destination register FIFO is empty, then any TR written to Prog Set immediately transitions to the destination register FIFO. If the destination register FIFO is not empty and not full, then any TR written to Prog Set immediately transitions to the destination register FIFO set if the source active state (SRCACTV) bit is set to idle.
			If the destination register FIFO is full, then TRs cannot transition to the destination register FIFO. The destination register FIFO becomes not full when the TR at the head of the destination register FIFO is completed.
		5h-7h	Reserved
3	Reserved	0	Reserved
2	WSACTV		Write status active.
		0	Write status is not pending. Write status has been received for all previously issued write commands.
		1	Write status is pending. Write status has not been received for all previously issued write commands.
1	SRCACTV		Source active state.
		0	Source active set is idle and is available for programming by the EDMA3CC. Source active register set contains a previously processed transfer request.
		1	Source active set is busy servicing a transfer request.
0	PROGBUSY		Program register set busy.
		0	Program set idle and is available for programming by the EDMA3CC.
		1	Program set busy.

4.3.4 Error Registers

4.3.4.1 Error Status Register (ERRSTAT)

The error status register (ERRSTAT) is shown in Figure 85 and described in Table 65.

Figure 85. Error Status Register (ERRSTAT)

31	16
Reserved	
R-0	

15	4	3	2	1	0
Reserved		MMRAERR	TRERR	Reserved	BUSERR
R-0		R-0	R-0	R-0	R-0

LEGEND: R = Read only; -*n* = value after reset

Table 65. Error Status Register (ERRSTAT) Field Descriptions

Bit	Field	Value	Description
31-4	Reserved	0	Reserved
3	MMRAERR		MMR address error.
		0	MMR address error is not detected.
		1	User attempted to read or write to an invalid address in configuration memory map.
2	TRERR		Transfer request (TR) error event.
		0	Transfer request (TR) error is not detected.
		1	Transfer request (TR) detected that violates constant addressing mode transfer (SAM or DAM is set to 1) alignment rules or has ACNT or BCNT == 0.
1	Reserved	0	Reserved
0	BUSERR		Bus error event.
		0	Bus error is not detected.
		1	EDMA3TC has detected an error at source or destination address. Error information can be read from the error details register (ERRDET).

4.3.4.2 Error Enable Register (ERREN)

The error enable register (ERREN) is shown in Figure 86 and described in Table 66. When any of the enable bits in ERREN is set, a bit set in the corresponding error status register (ERRSTAT) causes an assertion of the EDMA3TC interrupt.

Figure 86. Error Enable Register (ERREN)

31	16
Reserved	
R-0	

15	4	3	2	1	0
Reserved		MMRAERR	TRERR	Reserved	BUSERR
R-0		R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 66. Error Enable Register (ERREN) Field Descriptions

Bit	Field	Value	Description
31-4	Reserved	0	Reserved
3	MMRAERR		Interrupt enable for MMR address error (MMRAERR).
		0	MMRAERR is disabled.
		1	MMRAERR is enabled and contributes to the state of EDMA3TC error interrupt generation
2	TRERR		Interrupt enable for transfer request error (TRERR).
		0	TRERR is disabled.
		1	TRERR is enabled and contributes to the state of EDMA3TC error interrupt generation.
1	Reserved	0	Reserved. Always write 0 to this bit; writes of 1 to this bit are not supported and attempts to do so may result in undefined behavior.
0	BUSERR		Interrupt enable for bus error (BUSERR).
		0	BUSERR is disabled.
		1	BUSERR is enabled and contributes to the state of EDMA3TC error interrupt generation.

4.3.4.3 Error Clear Register (ERRCLR)

The error clear register (ERRCLR) is shown in Figure 87 and described in Table 67.

Figure 87. Error Clear Register (ERRCLR)

31	16
Reserved	
R-0	

15	4	3	2	1	0
Reserved		MMRAERR	TRERR	Reserved	BUSERR
R-0		W-0	W-0	R-0	W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 67. Error Clear Register (ERRCLR) Field Descriptions

Bit	Field	Value	Description
31-4	Reserved	0	Reserved
3	MMRAERR		Interrupt enable clear for the MMR address error (MMRAERR) bit in the error status register (ERRSTAT).
		0	No effect.
		1	Clears the MMRAERR bit in the error status register (ERRSTAT) but does not clear the error details register (ERRDET).
2	TRERR		Interrupt enable clear for the transfer request error (TRERR) bit in the error status register (ERRSTAT).
		0	No effect.
		1	Clears the TRERR bit in the error status register (ERRSTAT) but does not clear the error details register (ERRDET).
1	Reserved	0	Reserved
0	BUSERR		Interrupt clear for the bus error (BUSERR) bit in the error status register (ERRSTAT).
		0	No effect.
		1	Clears the BUSERR bit in the error status register (ERRSTAT) and clears the error details register (ERRDET).

4.3.4.4 Error Details Register (ERRDET)

The error details register (ERRDET) is shown in Figure 88 and described in Table 68.

Figure 88. Error Details Register (ERRDET)

31	18	17	16
Reserved		TCCHEN	TCINTEN
R-0		R-0	R-0

15	14	13	8	7	4	3	0
Reserved		TCC		Reserved		STAT	
R-0		R-0		R-0		R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 68. Error Details Register (ERRDET) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	Reserved
17	TCCHEN	0-1	Transfer completion chaining enable. Contains the TCCHEN value in the channel options parameter (OPT) programmed by the channel controller for the read or write transaction that resulted in an error.
16	TCINTEN	0-1	Transfer completion interrupt enable. Contains the TCINTEN value in the channel options parameter (OPT) programmed by the channel controller for the read or write transaction that resulted in an error.
15-14	Reserved	0	Reserved
13 - 8	TCC	0-3Fh	Transfer complete code. Contains the TCC value in the channel options parameter (OPT) programmed by the channel controller for the read or write transaction that resulted in an error.
7-4	Reserved	0	Reserved
3-0	STAT	0-Fh	Transaction status. Stores the nonzero status/error code that was detected on the read status or write status bus. If read status and write status are returned on the same cycle, then the EDMA3TC chooses nonzero version. If both are nonzero, then the write status is treated as higher priority.
		0	No error
		1h	Read addressing error
		2h	Read privilege error
		3h	Read timeout error
		4h	Read data error
		5h-6h	Reserved
		7h	Read exclusive operation error
		8h	Reserved
		9h	Write addressing error
		Ah	Write privilege error
		Bh	Write timeout error
		Ch	Write data error
		Dh-Eh	Reserved
		Fh	Write exclusive operation error

4.3.4.5 Error Interrupt Command Register (ERRCMD)

The error interrupt command register (ERRCMD) is shown in Figure 89 and described in Table 69.

Figure 89. Error Interrupt Command Register (ERRCMD)

31	16
Reserved	
R-0	

15	1	0
Reserved		EVAL
R-0		W-0

LEGEND: R = Read only; W = Write only; -*n* = value after reset

Table 69. Error Interrupt Command Register (ERRCMD) Field Descriptions

Bit	Field	Value	Description
31-1	Reserved	0	Reserved
0	EVAL		Error evaluate.
		0	No effect.
		1	EDMA3TC error line is pulsed if any of the error status register (ERRSTAT) bits are set to 1.

4.3.5 Read Command Rate Register (RDRATE)

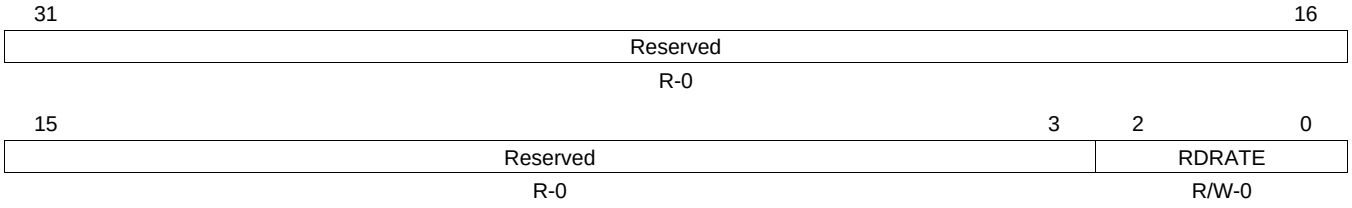
The EDMA3 transfer controller issues Read commands at a rate controlled by the Read command rate register (RDRATE). The RDRATE defines the number of idle cycles that the Read controller must wait before issuing subsequent commands. This applies both to commands within a transfer request packet (TRP) and for commands that are issued for different transfer requests (TRs). For instance, if RDRATE is set to 4 cycles between reads, there are 32 inactive cycles between reads.

RDRATE allows flexibility in transfer controller access requests to an endpoint. For an application, RDRATE can be manipulated to slow down the access rate, so that the endpoint may service requests from other masters during the inactive EDMA3TC cycles.

The RDRATE is shown in Figure 90 and described in Table 70.

NOTE: It is expected that the RDRATE value for a transfer controller is static, as it is decided based on the application requirement. It is not recommended to change this setting on the go.

Figure 90. Read Command Rate Register (RDRATE)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 70. Read Command Rate Register (RDRATE) Field Descriptions

Bit	Field	Value	Description
31-3	Reserved	0	Reserved
2-0	RDRATE	0-7h	Read rate. Controls the number of cycles between Read commands. This is a global setting that applies to all TRs for this EDMA3TC.
		0	Reads issued as fast as possible.
		1h	4 EDMA3TC cycles between reads.
		2h	8 EDMA3TC cycles between reads.
		3h	16 EDMA3TC cycles between reads.
		4h	32 EDMA3TC cycles between reads.
		5h-7h	Reserved

4.3.6 EDMA3TC Channel Registers

The EDMA3TC channel registers are split into three parts: the programming registers, the source active registers, and the destination FIFO registers. This section describes the registers and their functions. The program register set is programmed by the channel controller and is for internal use. The source active registers and the destination FIFO registers are read-only and are provided to facilitate advanced debug capabilities. The number of destination FIFO register sets depends on the destination FIFO depth. Both TC0 and TC1 have a destination FIFO depth of 4, and there are four sets of destination FIFO registers.

4.3.6.1 Source Active Options Register (SAOPT)

The source active options register (SAOPT) is shown in Figure 91 and described in Table 71.

Figure 91. Source Active Options Register (SAOPT)

31	23	22	21	20	19	18	17	16
Reserved		TCCHEN	Rsvd	TCINTEN	Reserved		TCC	
R-0		R/W-0	R-0	R/W-0	R-0		R/W-0	

15	12	11	10	8	7	6	4	3	2	1	0
TCC		Rsvd	FWID		Rsvd	PRI[1]		Reserved		DAM	SAM
R/W-0		R-0	R/W-0		R-0	R/W-0		R-0		R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

(1) On previous architectures, the EDMA3TC priority was controlled by the queue priority register (QUEPRI) in the EDMA3CC memory-map. However for this device, the priority control for the transfer controllers is controlled by the chip-level registers in the System Configuration Module. You should use the chip-level registers and not QUEPRI to configure the TC priority.

Table 71. Source Active Options Register (SAOPT) Field Descriptions

Bit	Field	Value	Description
31-23	Reserved	0	Reserved
22	TCCHEN		Transfer complete chaining enable.
		0	Transfer complete chaining is disabled.
		1	Transfer complete chaining is enabled.
21	Reserved	0	Reserved
20	TCINTEN		Transfer complete interrupt enable.
		0	Transfer complete interrupt is disabled.
		1	Transfer complete interrupt is enabled.
19-18	Reserved	0	Reserved
17-12	TCC	0-3Fh	Transfer complete code. This 6-bit code is used to set the relevant bit in CER or IPR of the EDMA3CC.
11	Reserved	0	Reserved
10-8	FWID	0-7h	FIFO width. Applies if either SAM or DAM is set to constant addressing mode.
		0	FIFO width is 8 bits.
		1h	FIFO width is 16 bits.
		2h	FIFO width is 32 bits.
		3h	FIFO width is 64 bits.
		4h	FIFO width is 128 bits.
		5h-7h	Reserved
7	Reserved	0	Reserved
6-4	PRI	0-7h	Transfer priority. Reflects the values programmed in the queue priority register (QUEPRI) in the EDMA3CC.
		0	Priority 0 - Highest priority
		1h-6h	Priority 1 to priority 6
		7h	Priority 7 - Lowest priority
3-2	Reserved	0	Reserved

Table 71. Source Active Options Register (SAOPT) Field Descriptions (continued)

Bit	Field	Value	Description
1	DAM		Destination address mode within an array.
		0	Increment (INCR) mode. Destination addressing within an array increments.
		1	Constant addressing (CONST) mode. Destination addressing within an array wraps around upon reaching FIFO width.
0	SAM		Source address mode within an array.
		0	Increment (INCR) mode. Source addressing within an array increments.
		1	Constant addressing (CONST) mode. Source addressing within an array wraps around upon reaching FIFO width.

4.3.6.2 Source Active Source Address Register (SASRC)

The source active source address register (SASRC) is shown in Figure 92 and described in Table 72.

Figure 92. Source Active Source Address Register (SASRC)

31	0
SADDR	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 72. Source Active Source Address Register (SASRC) Field Descriptions

Bit	Field	Value	Description
31-0	SADDR	0-FFFF FFFFh	Source address for program register set. EDMA3TC updates value according to source addressing mode (SAM bit in the source active options register, SAOPT) .

4.3.6.3 Source Active Count Register (SACNT)

The source active count register (SACNT) is shown in Figure 93 and described in Table 73.

Figure 93. Source Active Count Register (SACNT)

31	16
BCNT	
R-0	
15	0
ACNT	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 73. Source Active Count Register (SACNT) Field Descriptions

Bit	Field	Value	Description
31-16	BCNT	0-FFFFh	B dimension count. Number of arrays to be transferred, where each array is ACNT in length. It is decremented after each Read command appropriately. Represents the amount of data remaining to be Read. It should be 0 when transfer request (TR) is complete.
15-0	ACNT	0-FFFFh	A dimension count. Number of bytes to be transferred in first dimension. It is decremented after each Read command appropriately. Represents the amount of data remaining to be Read. It should be 0 when transfer request (TR) is complete.

4.3.6.4 Source Active Destination Address Register (SADST)

The source active destination address register (SADST) is shown in Figure 94 and described in Table 74.

Figure 94. Source Active Destination Address Register (SADST)

31	0
DADDR	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 74. Source Active Destination Address Register (SADST) Field Descriptions

Bit	Field	Value	Description
31-0	DADDR	0	Always reads as 0

4.3.6.5 Source Active B-Index Register (SABIDX)

The source active B-index register (SABIDX) is shown in Figure 95 and described in Table 75.

Figure 95. Source Active B-Index Register (SABIDX)

31	16
DSTBIDX	
R-0	

15	0
SRCBIDX	
R-0	

LEGEND: R = Read only; -*n* = value after reset

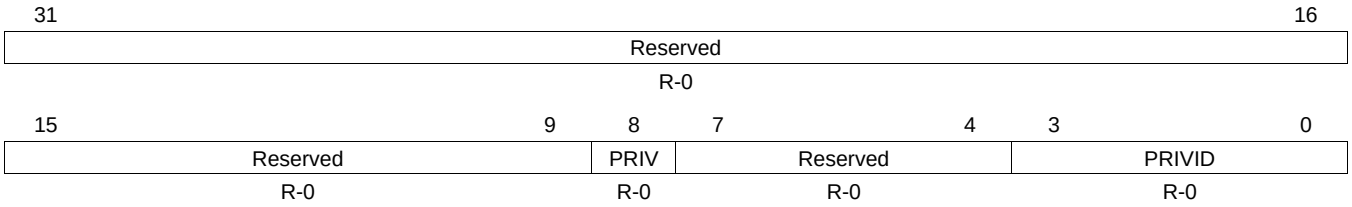
Table 75. Source Active B-Index Register (SABIDX) Field Descriptions

Bit	Field	Value	Description
31-16	DSTBIDX	0	B-Index offset between destination arrays. Represents the offset in bytes between the starting address of each destination. Always reads as 0.
15-0	SRCBIDX	0-FFFFh	B-Index offset between source arrays. Represents the offset in bytes between the starting address of each source array.

4.3.6.6 Source Active Memory Protection Proxy Register (SAMPPRXY)

The source active memory protection proxy register (SAMPPRXY) is shown in Figure 96 and described in Table 76.

Figure 96. Source Active Memory Protection Proxy Register (SAMPPRXY)



LEGEND: R = Read only; -*n* = value after reset

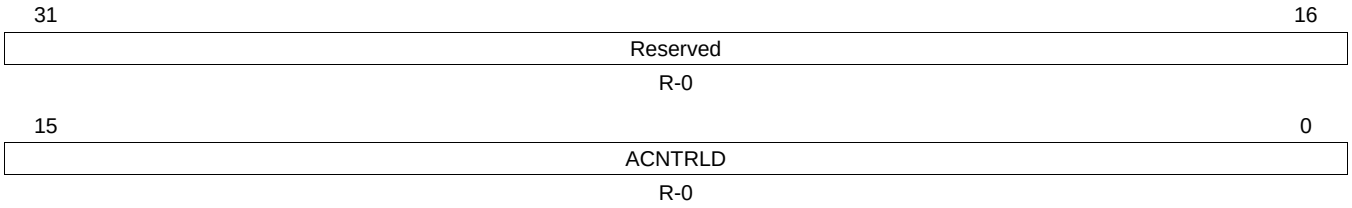
Table 76. Source Active Memory Protection Proxy Register (SAMPPRXY) Field Descriptions

Bit	Field	Value	Description
31-9	Reserved	0	Reserved
8	PRIV		Privilege level. The privilege level used by the host to set up the parameter entry in the channel controller. This field is set up when the associated TR is submitted to the EDMA3TC. The privilege ID is used while issuing Read and write command to the target endpoints so that the target endpoints can perform memory protection checks based on the PRIV of the host that set up the DMA transaction.
		0	User-level privilege
		1	Supervisor-level privilege
7-4	Reserved	0	Reserved
3-0	PRIVID	0-Fh	Privilege ID. This contains the privilege ID of the host that set up the parameter entry in the channel controller. This field is set up when the associated TR is submitted to the EDMA3TC. This PRIVID value is used while issuing Read and write commands to the target endpoints so that the target endpoints can perform memory protection checks based on the PRIVID of the host that set up the DMA transaction.
		0	For any other master that sets up the PaRAM entry.
		1	If CPU sets up the PaRAM entry.

4.3.6.7 Source Active Count Reload Register (SACNTRLD)

The source active count reload register (SACNTRLD) is shown in Figure 97 and described in Table 77.

Figure 97. Source Active Count Reload Register (SACNTRLD)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

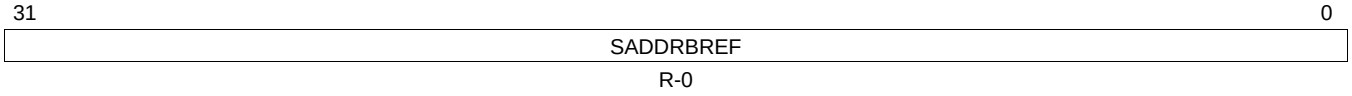
Table 77. Source Active Count Reload Register (SACNTRLD) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	Reserved
15-0	ACNTRLD	0-FFFFh	A-count reload value. Represents the originally programmed value of ACNT. The reload value is used to reinitialize ACNT after each array is serviced.

4.3.6.8 Source Active Source Address B-Reference Register (SASRCBREF)

The source active source address B-reference register (SASRCBREF) is shown in Figure 98 and described in Table 78.

Figure 98. Source Active Source Address B-Reference Register (SASRCBREF)



LEGEND: R = Read only; -*n* = value after reset

Table 78. Source Active Source Address B-Reference Register (SASRCBREF) Field Descriptions

Bit	Field	Value	Description
31-0	SADDRBREF	0-FFFF FFFFh	Source address B-reference. Represents the starting address for the array currently being Read.

4.3.6.9 Source Active Destination Address B-Reference Register (SADSTBREF)

The source active destination address B-reference register (SADSTBREF) is shown in Figure 99 and described in Table 79.

Figure 99. Source Active Destination Address B-Reference Register (SADSTBREF)

31	0
DADDRBREF	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 79. Source Active Destination Address B-Reference Register (SADSTBREF) Field Descriptions

Bit	Field	Value	Description
31-0	DADDRBREF	0	Always reads as 0

4.3.6.10 Destination FIFO Set Count Reload Register (DFCNTRLD)

The destination FIFO set count reload register (DFCNTRLD) is shown in Figure 100 and described in Table 80.

Figure 100. Destination FIFO Set Count Reload Register (DFCNTRLD)

31	16
Reserved	
R-0	
15	0
ACNTRLD	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 80. Destination FIFO Set Count Reload Register (DFCNTRLD) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	Reserved
15-0	ACNTRLD	0-FFFFh	A-count reload value. Represents the originally programmed value of ACNT. The reload value is used to reinitialize ACNT after each array is serviced.

4.3.6.11 Destination FIFO Set Source Address B-Reference Register (DFSRCBREF)

The destination FIFO set source address B-reference register (DFSRCBREF) is shown in Figure 101 and described in Table 81.

Figure 101. Destination FIFO Set Source Address B-Reference Register (DFSRCBREF)

31	0
SADDRBREF	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 81. Destination FIFO Set Source Address B-Reference Register (DFSRCBREF) Field Descriptions

Bit	Field	Value	Description
31-0	SADDRBREF	0	Not applicable. Always Read as 0.

4.3.6.12 Destination FIFO Set Destination Address B-Reference (DFDSTBREF)

The destination FIFO set destination address B-reference register (DFDSTBREF) is shown in Figure 102 and described in Table 82.

Figure 102. Destination FIFO Set Destination Address B-Reference Register (DFDSTBREF)

31	0
DADDRBREF	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 82. Destination FIFO Set Destination Address B-Reference Register (DFDSTBREF) Field Descriptions

Bit	Field	Value	Description
31-0	DADDRBREF	0-FFFF FFFFh	Destination address reference for the destination FIFO register set. Represents the starting address for the array currently being written.

4.3.6.13 Destination FIFO Options Register *n* (DFOPT*n*)

The destination FIFO options register *n* (DFOPT*n*) is shown in Figure 103 and described in Table 83.

Figure 103. Destination FIFO Options Register *n* (DFOPT*n*)

31	23	22	21	20	19 18	17 16
Reserved		TCCHEN	Rsvd	TCINTEN	Reserved	TCC
R-0		R/W-0	R-0	R/W-0	R-0	R/W-0

15 12	11	10 8	7	6 4	3 2	1	0
TCC	Rsvd	FWID	Rsvd	PRI	Reserved	DAM	SAM
R/W-0	R-0	R/W-0	R-0	R/W-0	R-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 83. Destination FIFO Options Register *n* (DFOPT*n*) Field Descriptions

Bit	Field	Value	Description
31-23	Reserved	0	Reserved
22	TCCHEN		Transfer complete chaining enable.
		0	Transfer complete chaining is disabled.
		1	Transfer complete chaining is enabled.
21	Reserved	0	Reserved
20	TCINTEN		Transfer complete interrupt enable.
		0	Transfer complete interrupt is disabled.
		1	Transfer complete interrupt is enabled.
19-18	Reserved	0	Reserved
17-12	TCC	0-3Fh	Transfer complete code. This 6-bit code is used to set the relevant bit in CER or IPR of the EDMA3CC.
11	Reserved	0	Reserved
10-8	FWID	0-7h	FIFO width. Applies if either SAM or DAM is set to constant addressing mode.
		0	FIFO width is 8 bits.
		1h	FIFO width is 16 bits.
		2h	FIFO width is 32 bits.
		3h	FIFO width is 64 bits.
		4h	FIFO width is 128 bits.
		5h-7h	Reserved
7	Reserved	0	Reserved
6-4	PRI	0-7h	Transfer priority.
		0	Priority 0 - Highest priority
		1h-6h	Priority 1 to priority 6
		7h	Priority 7 - Lowest priority
3-2	Reserved	0	Reserved
1	DAM		Destination address mode within an array.
		0	Increment (INCR) mode. Destination addressing within an array increments.
		1	Constant addressing (CONST) mode. Destination addressing within an array wraps around upon reaching FIFO width.
0	SAM		Source address mode within an array.
		0	Increment (INCR) mode. Source addressing within an array increments.
		1	Constant addressing (CONST) mode. Source addressing within an array wraps around upon reaching FIFO width.

4.3.6.14 Destination FIFO Source Address Register *n* (DFSRC*n*)

The destination FIFO source address register *n* (DFSRC*n*) is shown in Figure 104 and described in Table 84.

Figure 104. Destination FIFO Source Address Register *n* (DFSRC*n*)

31	0
SADDR	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 84. Destination FIFO Source Address Register *n* (DFSRC*n*) Field Descriptions

Bit	Field	Value	Description
31-0	SADDR	0	Always Read as 0.

4.3.6.15 Destination FIFO Count Register *n* (DFCNT*n*)

The destination FIFO count register *n* (DFCNT*n*) is shown in Figure 105 and described in Table 85.

Figure 105. Destination FIFO Count Register *n* (DFCNT*n*)

31	16
BCNT	
R-0	
15	0
ACNT	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 85. Destination FIFO Count Register *n* (DFCNT*n*) Field Descriptions

Bit	Field	Value	Description
31-16	BCNT	0-FFFFh	B-dimension count. Number of arrays to be transferred, where each array is ACNT in length. Count/count remaining for destination register set. Represents the amount of data remaining to be written.
15-0	ACNT	0-FFFFh	A-dimension count. Number of bytes to be transferred in first dimension count/count remaining for destination register set. Represents the amount of data remaining to be written.

4.3.6.16 Destination FIFO Destination Address Register *n* (DFDST*n*)

The destination FIFO destination address register *n* (DFDST*n*) is shown in Figure 106 and described in Table 86.

Figure 106. Destination FIFO Destination Address Register *n* (DFDST*n*)

31	0
DADDR	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 86. Destination FIFO Destination Address Register *n* (DFDST*n*) Field Descriptions

Bit	Field	Value	Description
31-0	DADDR	0	Destination address for the destination FIFO register set. When a transfer request (TR) is complete, the final value should be the address of the last write command issued.

4.3.6.17 Destination FIFO B-Index Register *n* (DFBIDX*n*)

The destination FIFO B-index register *n* (DFBIDX*n*) is shown in Figure 107 and described in Table 87.

Figure 107. Destination FIFO B-Index Register *n* (DFBIDX*n*)

31	16
DSTBIDX	
R-0	
15	0
SRCBIDX	
R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 87. Destination FIFO B-Index Register *n* (DFBIDX*n*) Field Descriptions

Bit	Field	Value	Description
31-16	DSTBIDX	0-FFFFh	B-Index offset between destination arrays. Represents the offset in bytes between the starting address of each destination.
15-0	SRCBIDX	0	B-Index offset between source arrays. Represents the offset in bytes between the starting address of each source array. Always Read as 0.

4.3.6.18 Destination FIFO Memory Protection Proxy Register *n* (DFMPPRXY*n*)

The destination FIFO memory protection proxy register *n* (DFMPPRXY*n*) is shown in Figure 108 and described in Table 88.

Figure 108. Destination FIFO Memory Protection Proxy Register *n* (DFMPPRXY*n*)

31	16
Reserved	
R-0	

15	9	8	7	4	3	0
Reserved		PRIV	Reserved		PRIVID	
R-0		R-0	R-0		R-0	

LEGEND: R = Read only; -*n* = value after reset

Table 88. Destination FIFO Memory Protection Proxy Register *n* (DFMPPRXY*n*) Field Descriptions

Bit	Field	Value	Description
31-9	Reserved	0	Reserved
8	PRIV		Privilege level. This contains the privilege level used by the EDMA programmer to set up the parameter entry in the channel controller. This field is set up when the associated TR is submitted to the EDMA3TC. The privilege ID is used while issuing Read and write command to the target endpoints so that the target endpoints can perform memory protection checks based on the PRIV of the host that set up the DMA transaction.
		0	User-level privilege
		1	Supervisor-level privilege
7-4	Reserved	0	Reserved
3-0	PRIVID	0-Fh	Privilege ID. This contains the Privilege ID of the EDMA programmer that set up the parameter entry in the channel controller. This field is set up when the associated TR is submitted to the EDMA3TC. This PRIVID value is used while issuing Read and write commands to the target endpoints so that the target endpoints can perform memory protection checks based on the PRIVID of the host that set up the DMA transaction.
		0	For any other master that sets up the PaRAM entry
		1	If CPU sets up the PaRAM entry

Appendix A Tips

A.1 Debug Checklist

This section lists some tips to keep in mind while debugging applications using the EDMA3. Table 89 provides some common issues and their probable causes and resolutions.

Table 89. Debug List

Issue	Description/Solution
The transfer associated with the channel does not happen. The channel does not get serviced.	The EDMA3 channel controller (EDMA3CC) may not service a transfer request, even though the associated PaRAM set is programmed appropriately. Check for the following: 1) Verify that events are enabled, that is, if an external/peripheral event is latched in the event register (ER), make sure that the event is enabled in the event enable register (EER). Similarly for QDMA channels, make sure that QDMA events are appropriately enabled in the QDMA event enable register (QEER). 2) Verify that the DMA or QDMA secondary event register (SER) bits corresponding to the particular event or channel are not set.
The secondary event register bits are set, not allowing additional transfers to occur on a channel.	It is possible that a trigger event was received when the parameter set associated with the channel/event was a NULL set for a previous transfer on the channel. This is typical in two cases: 1) QDMA channels: Typically if the parameter set is nonstatic and expected to be terminated by a NULL set (OPT.STATIC = 0, LINK = FFFFh), the parameter set is updated with a NULL set after submission of the last TR. Because QDMA channels are autotriggered, this update caused the generation of an event. An event generated for a NULL set causes an error condition and results in setting the bits corresponding to the QDMA channel in QEMR and QSER. This will disable further prioritization of the channel. 2) DMA channels used in a continuous mode: The peripheral may be set up to continuously generate infinite events (for instance, in case of the McBSP, every time the data shifts out from DXR, it generates an XEVT). The parameter set may be programmed to expect only a finite number of events and to be terminated by a NULL link. After the expected number of events, the parameter set is reloaded with a NULL parameter set. Because the peripheral will generate additional events, an error condition is set in SER.E*n* and EMR.E*n*, preventing further event prioritization. You must ensure that the number of events received is limited to the expected number of events for which the parameter set is programmed, or you must ensure that bits corresponding to a particular channel or event are not set in the secondary event registers (SER/QSER) and the event missed registers (EMR/QEMR) before trying to perform subsequent transfers for the event/channel.
Completion interrupts are not asserted, or no further interrupts are received after the first completion interrupt.	You must ensure the following: 1) The interrupt generation is enabled in the OPT of the associated PaRAM set (TCINTEN = 1 and/or ITCINTEN = 1). 2) The interrupts are enabled in the EDMA3 channel controller (EDMA3CC), via the interrupt enable register (IER). 3) The corresponding interrupts are enabled in the device interrupt controller. 4) The set interrupts are cleared in the interrupt pending register (IPR) before exiting the transfer completion interrupt service routine (ISR). See Section 2.9.1.2 for details on writing EDMA3 ISRs. 5) If working with shadow region interrupts, make sure that the DMA region access enable registers (DRAE) are set up properly, because DRAE act as secondary enables for shadow region completion interrupts, along with IER. If working with shadow region interrupts, make sure that the bits corresponding to the transfer completion code (TCC) value are also enabled in DRAE. For instance, if the PaRAM set associated with channel 0 returns a completion code of 31 (OPT.TCC = 31), make sure that DRAE.E31 is also set for a shadow region completion interrupt because the interrupt pending register bit set will be IPR.I31.

A.2 Miscellaneous Programming/Debug Tips

1. For several registers, the setting and clearing of bits needs to be done via separate dedicated registers. For example, the event register (ER) bits can only be cleared by writing a 1 to the corresponding bits in the event clear register (ECR). Similarly, the event enable register (EER) bits can only be set with writes of 1 to the corresponding bits in the event enable set registers (EESR) and can only be cleared with writes of 1 to the corresponding bits in the event enable clear register (EECR).
2. Writes to the shadow region memory maps are governed by region access enable registers (DRAE/QRAE). If the appropriate channels are not enabled in these registers, read/write access to the shadow region memory map is not enabled.
3. When working with shadow region completion interrupts, ensure that the DMA region access enable registers (DRAE) for every region are set in a mutually exclusive way (unless it is a requirement for an application). If there is an overlap in the allocated channels and transfer completion codes (setting of interrupt pending register bits) in the region resource allocation, it results in multiple shadow region completion interrupts. For example, if DRAE0.E0 and DRAE1.E0 are both set, then on completion of a transfer that returns a TCC = 0, they will generate both shadow region 0 and 1 completion interrupts.
4. While programming a non-dummy parameter set, ensure the CCNT is not left to zero.
5. Enable the EDMA3CC error interrupt in the device controller and attach an interrupt service routine (ISR) to ensure that error conditions are not missed in an application and are appropriately addressed with the ISR.
6. Depending on the application, you may want to break large transfers into smaller transfers and use self-chaining to prevent starvation of other events in an event queue.
7. In applications where a large transfer is broken into sets of small transfers using chaining or other methods, you might choose to use the early chaining option to reduce the time between the sets of transfers and increase the throughput. However, keep in mind that with early completion, all data might have not been received at the end point when completion is reported because the EDMA3CC internally signals completion when the TR is submitted to the EDMA3TC, potentially before any data has been transferred.
8. The event queue entries can be observed to determine the last few events if there is a system failure (provided the entries were not bypassed).
9. In order to put the EDMA3CC and EDMA3TC in power-down modes, you should ensure that there is no activity with the EDMA3CC and EDMA3TC. The EDMA3CC status register (CCSTAT) and the EDMA3TC channel status register (TCSTAT) should be used.

Appendix B Setting Up a Transfer

The following list provides a quick guide for the typical steps involved in setting up a transfer.

1. Initiating a DMA/QDMA channel:
   (a) Determine the type of channel (QDMA or DMA) to be used.
   (b) If using a QDMA channel, program the QDMA channel *n* mapping register (QCHMAP*n*) with the parameter set number to which the channel maps and the trigger word.
   (c) If the channel is being used in the context of a shadow region, ensure the DMA region access enable register (DRAE) for the region is properly set up to allow read/write accesses to bits in the event register and interrupt register in the shadow region memory-map. The subsequent steps in this process should be done using the respective shadow region registers. (Shadow region descriptions and usage are provided in Section 2.7.1.)
   (d) Determine the type of triggering used.
      (i) If external events are used for triggering (DMA channels), enable the respective event in EER by writing into EESR.
      (ii) If a QDMA channel is used, enable the channel in QEER by writing into QEESR.
   (e) Queue setup.
      (i) If a QDMA channel is used, set up QDMAQNUM to map the channel to the respective event queue.
      (ii) If a DMA channel is used, set up DMAQNUM to map the event to the respective event queue.
2. Parameter set setup: Program the PaRAM set number associated with the channel. Note that if it is a QDMA channel, the PaRAM entry that is configured as trigger word is written last. Alternatively, enable the QDMA channel just before the write to the trigger word.

   See Section 3 for parameter set field setups for different types of transfers. See the sections on chaining (Section 2.8) and interrupt completion (Section 2.9) on how to set up final/intermediate completion chaining and/or interrupts.
3. Interrupt setup:
   (a) If working in the context of a shadow region, ensure the relevant bits in DRAE are set.
   (b) Enable the interrupt in IER by writing into IESR.
   (c) Ensure that the EDMA3CC completion interrupt is enabled properly in the device interrupt controller.
   (d) Set up the interrupt controller properly to receive the expected EDMA3 interrupt.
4. Initiate transfer (this step is highly dependent on the event trigger source):
   (a) If the source is an external event coming from a peripheral, the peripheral will be enabled to start generating relevant EDMA3 events that can be latched to the ER transfer.
   (b) For QDMA events, writes to the trigger word will initiate the transfer.
   (c) Manually-triggered transfers will be initiated by writes to the event set register (ESR).
   (d) Chained-trigger events initiate when a previous transfer returns a transfer completion code equal to the chained channel number.
5. Wait for completion:
   (a) If the interrupts are enabled as mentioned in step 3, then the EDMA3CC generates a completion interrupt to the CPU whenever transfer completion results in setting the corresponding bits in the interrupt pending register (IPR). The set bits must be cleared in IPR by writing to the corresponding bit in ICR.
   (b) If polling for completion (interrupts not enabled in the device controller), then the application code can wait on the expected bits to be set in IPR. Again, the set bits in IPR must be manually cleared by writing to ICR before the next set of transfers is performed for the same transfer completion code values.

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