

LogiCORE IP Block Memory Generator v7.3

Product Guide

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SECTION I: SUMMARY

IP Facts

Overview

Product Specification

Designing with the Core

Introduction

The Xilinx LogiCORE™ IP Block Memory Generator (BMG) core is an advanced memory constructor that generates area and performance-optimized memories using embedded block RAM resources in Xilinx FPGAs. Users can quickly create optimized memories to leverage the performance and features of block RAMs in Xilinx FPGAs.

The BMG core supports both Native and AXI4 interfaces.

The Native interface BMG core configurations support the same standard BMG functions delivered by previous versions of the Block Memory Generator (up to and including version 4.3). Port interface names are identical.

The AXI4 interface configuration of the BMG core is derived from the Native interface BMG configuration and adds an industry-standard bus protocol interface to the core. Two AXI4 interface styles are available: AXI4 and AXI4-Lite.

Features

For details on the features of each interface, see [Feature Summary in Chapter 1](#).

LogiCORE IP Facts Table	
Core Specifics	
Supported Device Family ⁽¹⁾	Zynq™-7000 ⁽²⁾ , Artix-7, Virtex®-7, Kintex®-7, Virtex-6, Virtex-5, Virtex-4, Spartan®-6, Spartan-3E/XA, Spartan-3/XA, Spartan-3A/3AN/3A DSP
Supported User Interfaces	AXI4, AXI4-Lite
Resources	See Table 2-2 .
Provided with Core	
Design Files	Vivado: Structural Netlist ISE: NGC Netlist
Example Design	VHDL
Test Bench	VHDL
Constraints File	Vivado: XDC ISE: UCF
Simulation Model	Verilog and VHDL Behavioral ⁽³⁾ and Structural
Supported S/W Driver	N/A
Tested Design Flows⁽⁴⁾	
Design Entry	Vivado™ Design Suite v2012.4 ⁽⁵⁾ ISE™ Design Suite v14.4
Simulation	Mentor Graphics ModelSim Cadence Incisive Enterprise Simulator Xilinx ISim
Synthesis	Vivado Synthesis XST
Support	
Provided by Xilinx @ www.xilinx.com/support	

Notes:

1. For a complete listing of supported devices, see the [release notes](#) for this core.
2. Supported in ISE Design Suite implementations only.
3. Behavioral models do not precisely model collision behavior. See [Simulation Models, page 9](#) for details.
4. For the supported versions of the tools, see the [Xilinx Design Tools: Release Notes Guide](#).
5. Supports only 7 series devices.

Overview

The Block Memory Generator core uses embedded Block Memory primitives in Xilinx FPGAs to extend the functionality and capability of a single primitive to memories of arbitrary widths and depths. Sophisticated algorithms within the Block Memory Generator core produce optimized solutions to provide convenient access to memories for a wide range of configurations.

The Block Memory Generator has two fully independent ports that access a shared memory space. Both A and B ports have a Write and a Read interface. In Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA architectures, each of the four interfaces can be uniquely configured with a different data width. When not using all four interfaces, the user can select a simplified memory configuration (for example, a Single-Port Memory or Simple Dual-Port Memory) to reduce FPGA resource utilization.

The Block Memory Generator is not completely backward-compatible with the discontinued legacy Single-Port Block Memory and Dual-Port Block Memory cores; for information about the differences, see [Appendix B, Migrating](#).

Feature Summary

Features Common to the Native Interface and AXI4 BMG Cores

- Optimized algorithms for minimum block RAM resource utilization or low power utilization
- Configurable memory initialization
- Individual Write enable per byte in Zynq™-7000, Kintex™-7, Virtex®-7, Virtex-6, Virtex-5, Virtex-4, Spartan®-6, and Spartan-3A/XA DSP with or without parity
- Optimized VHDL and Verilog behavioral models for fast simulation times; structural simulation models for precise simulation of memory behaviors
- Selectable operating mode per port: WRITE_FIRST, READ_FIRST, or NO_CHANGE
- Smaller fixed primitive configurations are now possible in Spartan-6 devices with the introduction of the new Spartan-6 device 9K primitives
- Lower data widths for Zynq-7000, 7 series, and Virtex-6 devices in SDP mode

- VHDL example design and demonstration test bench demonstrating the IP core design flow, including how to instantiate and simulate it

Native Block Memory Generator Specific Features

- Generates Single-port RAM, Simple Dual-port RAM, True Dual-port RAM, Single-port ROM, and Dual-port ROM
- Supports data widths from 1 to 4608 bits and memory depths from 2 to 9M words (limited only by memory resources on selected part)
- Configurable port aspect ratios for dual-port configurations and Read-to-Write aspect ratios in Virtex-6, Virtex-5, and Virtex-4 FPGAs
- Supports the built-in Hamming Error Correction Capability (ECC) available in Zynq-7000, 7 series, Virtex-6 and Virtex-5 devices for data widths greater than 64 bits. Error injection pins in Zynq-7000, 7 series, and Virtex-6 allow insertion of single and double-bit errors
- Supports soft Hamming Error Correction (Soft ECC) in Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices for data widths less than 64 bits.
- Option to pipeline DOUT bus for improved performance in specific configurations
- Choice of reset priority for output registers between priority of SR (Set Reset) or CE (Clock Enable) in Zynq-7000, 7 series, Virtex-6, and Spartan-6 families
- Asynchronous reset in Spartan-6 devices
- Performance up to 450 MHz

AXI4 Interface Block Memory Generator Specific Features

- Supports AXI4 and AXI4-Lite interface protocols
- AXI4 compliant Memory and Peripheral Slave types
- Independent Read and Write Channels
- Zero delay datapath
- Supports registered outputs for handshake signals
- INCR burst sizes up to 256 data transfers
- WRAP bursts of 2, 4, 8, and 16 data beats
- AXI narrow and unaligned burst transfers
- Simple Dual-port RAM primitive configurations
- Performance up to 300 MHz
- Supports data widths from up to 256 bits and memory depths from 2 to 9 M words (limited only by memory resources on selected part)

- Symmetric aspect ratios
- Asynchronous active low reset

Simulation Models

The Block Memory Generator core provides two types of functional simulation models:

- Behavioral Simulation Models (VHDL and Verilog)
- Structural/UniSim based Simulation Models (VHDL and Verilog)

The behavioral simulation models provide a simplified model of the core while the structural simulation models (UniSim) are an accurate modeling of the internal structure of the core. The behavioral simulation models are written purely in RTL and simulate faster than the structural simulation models and are ideal for functional debugging. Moreover, the memory is modeled in a two-dimensional array, making it easier to probe contents of the memory.

The structural simulation model uses primitive instantiations to model the behavior of the core more precisely. Use the structural simulation model to accurately model memory collision behavior and 'x' output generation. Note that simulation time is longer and debugging may be more difficult. The Simulation Files options in the CORE Generator Project Options determine the type of functional simulation models generated. [Table 1-1](#) defines the differences between the two functional simulation models.

Table 1-1: Differences between Simulation Models

	Behavioral Models	Structural Models (Unisim)
When core output is undefined	Never generates 'X'	Generates 'X' to match core
Out-of-range address access	Optionally flags a warning message	Generates 'X'
Collision behavior	Does not generate 'X' on output, and flags a warning message	Generates 'X' to match core
Byte-Write collision behavior	Flags all byte-Write collisions	Does not flag collisions if byte-writes do not overlap

Native Block Memory Generator Feature Summary

Supported Devices

[Table 1-2](#) shows the families and sub-families supported by the Block Memory Generator.

Table 1-2: Supported FPGA Families and Sub-Families

FPGA Family	Sub-Family
Spartan-3	
Spartan-3E	
Spartan-3A	
Spartan-3AN	
Spartan-3A DSP	
Spartan-6	LX/LXT
Virtex-4	LX/FX/SX
Virtex-5	LXT/FXT/SXT/TXT
Virtex-6	CXT/HXT/LXT/SXT
Virtex-7	XT
Kintex-7	
Artix™-7	
Zynq-7000	

Memory Types

The Block Memory Generator core uses embedded block RAM to generate five types of memories:

- Single-port RAM
- Simple Dual-port RAM
- True Dual-port RAM
- Single-port ROM
- Dual-port ROM

For dual-port memories, each port operates independently. Operating mode, clock frequency, optional output registers, and optional pins are selectable per port. For Simple Dual-port RAM, the operating modes are not selectable. See [Collision Behavior, page 59](#) for additional information.

Selectable Memory Algorithm

The core configures block RAM primitives and connects them together using one of the following algorithms:

- **Minimum Area Algorithm:** The memory is generated using the minimum number of block RAM primitives. Both data and parity bits are utilized.

- **Low Power Algorithm:** The memory is generated such that the minimum number of block RAM primitives are enabled during a Read or Write operation.
- **Fixed Primitive Algorithm:** The memory is generated using only one type of block RAM primitive. For a complete list of primitives available for each device family, see the data sheet for that family.

Configurable Width and Depth

The Block Memory Generator can generate memory structures from 1 to 4096 bits wide, and at least two locations deep. The maximum depth of the memory is limited only by the number of block RAM primitives in the target device.

Selectable Operating Mode per Port

The Block Memory Generator supports the following block RAM primitive operating modes: WRITE FIRST, READ FIRST, and NO CHANGE. Each port may be assigned its own operating mode.

Selectable Port Aspect Ratios

The core supports the same port aspect ratios as the block RAM primitives:

- In all supported device families, the A port width may differ from the B port width by a factor of 1, 2, 4, 8, 16, or 32.
- In Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA-based memories, the Read width may differ from the Write width by a factor of 1, 2, 4, 8, 16, or 32 for each port. The maximum ratio between any two of the data widths (DINA, DOUTA, DINB, and DOUTB) is 32:1.

Optional Byte-Write Enable

In Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP FPGA-based memories, the Block Memory Generator core provides byte-Write support for memory widths which are multiples of eight (no parity) or nine bits (with parity).

Optional Output Registers

The Block Memory Generator provides two optional stages of output registering to increase memory performance. The output registers can be chosen for port A and port B separately. The core supports the Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A DSP embedded block RAM registers as well as registers implemented in the FPGA fabric. See [Output Register Configurations, page 187](#) for more information about using these registers.

Optional Pipeline Stages

The core provides optional pipeline stages within the MUX, available only when the registers at the output of the memory core are enabled and only for specific configurations. For the available configurations, the number of pipeline stages can be 1, 2, or 3. For detailed information, see [Optional Pipeline Stages, page 64](#).

Optional Enable Pin

The core provides optional port enable pins (`ENA` and `ENB`) to control the operation of the memory. When deasserted, no Read, Write, or reset operations are performed on the respective port. If the enable pins are not used, it is assumed that the port is always enabled.

Optional Set/Reset Pin

The core provides optional set/reset pins (`RSTA` and `RSTB`) for each port that initialize the Read output to a programmable value.

Memory Initialization

The memory contents can be optionally initialized using a memory coefficient (`COE`) file or by using the default data option. A `COE` file can define the initial contents of each individual memory location, while the default data option defines the initial content of all locations.

Hamming Error Correction Capability

Simple Dual-port RAM memories support the built-in FPGA Hamming Error Correction Capability (ECC) available in the Zynq-7000, 7 series, Virtex-6 and Virtex-5 FPGA block RAM primitives for data widths greater than 64 bits. The `BuiltIn_ECC` (ECC) memory automatically detects single- and double-bit errors, and is able to auto-correct the single-bit errors.

For data widths of 64 bits or less, a soft Hamming Error Correction implementation is available for Zynq-7000, 7 series, Virtex-6, and Spartan-6 designs.

AXI4 Interface Block Memory Generator Feature Summary

Overview

AXI4 Interface Block Memories are built on the Native Interface Block Memories (see [Figure 1-1](#)). Two AXI4 interface styles are available - AXI4 and AXI4-Lite. The core can also be further classified as a Memory Slave or as a Peripheral Slave. In addition to applications

supported by the Native Interface Block Memories, AXI4 Block Memories can also be used in AXI4 System Bus applications and Point-to-Point applications.

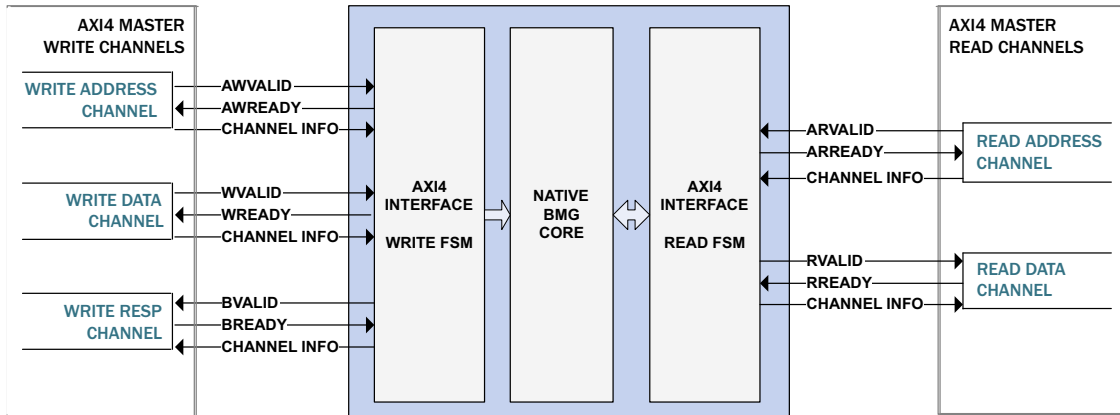


Figure 1-1: AXI4 Interface BMG Block Diagram

All communication in the AXI protocol is performed using five independent channels. Each of the five independent channels consists of a set of information signals and uses a two-way VALID and READY handshake mechanism. The information source uses the VALID signal to show when valid data or control information is available on the channel. The information destination uses the READY signal to show when it can accept the data.

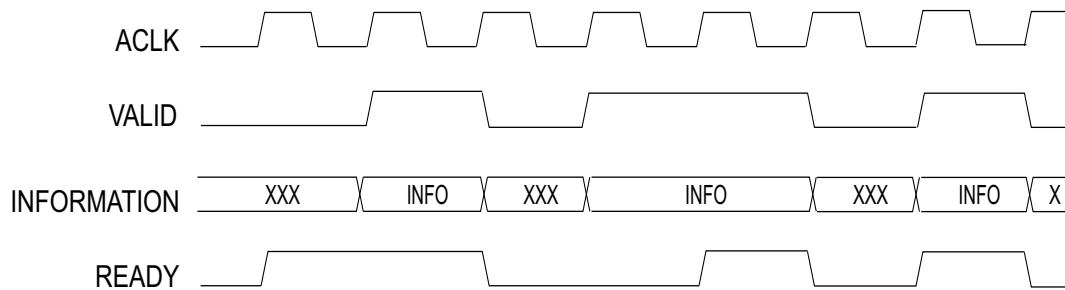


Figure 1-2: AXI4 Interface Handshake Timing Diagram

In Figure 1-2, the information source generates the VALID signal to indicate when data is available.

The destination generates the READY signal to indicate that it can accept the data, and transfer occurs only when both the VALID and READY signals are high.

The AXI4 Block Memory Generator is an AXI4 endpoint Slave IP and can communicate with multiple AXI4 Masters in an AXI4 System or with Standalone AXI4 Masters in point to point applications. The core supports Simple Dual Port RAM configurations. Because AXI4 Block Memories are built using Native interface Block Memories, they share many common features.

All Write operations are initiated on the Write Address Channel (AW) of the AXI bus. The AW channel specifies the type of Write transaction and the corresponding address information. The Write Data Channel (W) communicates all Write data for single or burst Write operations. The Write Response Channel (B) is used as the handshaking or response to the Write operation.

On Read operations, the Read Address Channel (AR) communicates all address and control information when the AXI master requests a Read transfer. When the Read data is available to send back to the AXI master, the Read Data Channel (R) transfers the data and status of the Read operation

Applications

AXI4 Block Memories - Memory Slave Mode

AXI4 Block Memories in Memory Slave mode are optimized for Memory Mapped System Bus implementations. The AXI4 Memory Slave Interface Type supports aligned, unaligned or narrow transfers for incremental or wrap bursts.

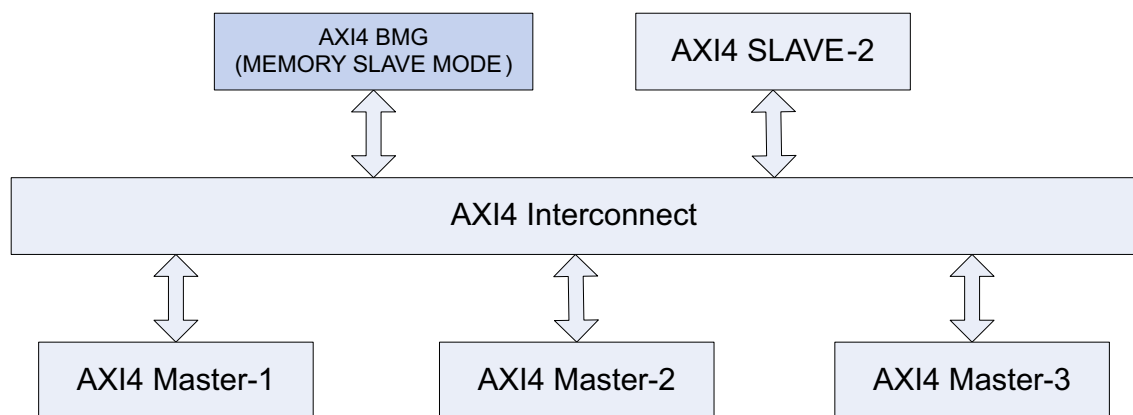


Figure 1-3: AXI4 Memory Slave Application Diagram

Figure 1-3 shows an example application for the AXI4 Memory Slave Interface Type with an AXI4 Interconnect for Multi Master AXI4 applications. Minimum memory requirement for this configuration is set to 4K bytes. Data widths supported by this configuration include 32, 64, 128 or 256 bits

AXI4-Lite Block Memories - Memory Slave Mode

AXI4-Lite Block Memories in Memory Slave mode are optimized for the AXI4-Lite interface. They can be used in implementations requiring simple Control/Status Accesses. AXI4-Lite Memory Slave Interface Type supports only single burst transactions.

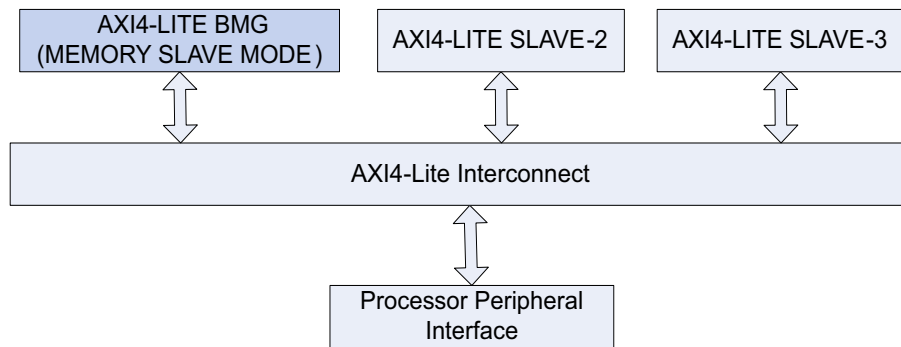


Figure 1-4: AXI4-Lite Memory Slave Application Diagram

Figure 1-4 shows an example application for AXI4-Lite Memory Slave Interface Type with an AXI4-Lite Interconnect to manage Control/Status Accesses. The minimum memory requirement for this configuration is set to 4K bytes. Data widths of 32 and 64 bits are supported by this configuration.

AXI4 Block Memories - Peripheral Slave Mode

AXI4 Block Memories in Peripheral Slave mode are optimized for a system or applications requiring data transfers that are grouped together in packets. The AXI4 Peripheral Slave supports aligned /unaligned addressing for incremental bursts.

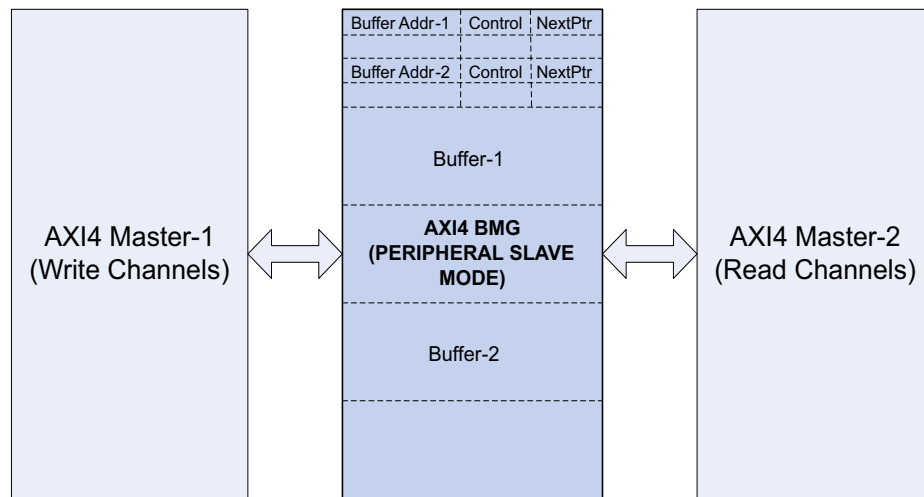


Figure 1-5: AXI4 Peripheral Slave Application Diagram

Figure 1-5 shows an example application for the AXI4 Peripheral Slave Interface Type in a Point-to-point buffered link list application. There is no minimum memory requirement set for this configuration. Data widths supported by this configuration include 8, 16, 32, 64, 128 and 256 bits.

AXI4-Lite Block Memories - Peripheral Slave Mode

AXI4-Lite Block Memories in Peripheral Slave mode are optimized for the AXI4-Lite interface. They can be used in implementations requiring single burst transactions.

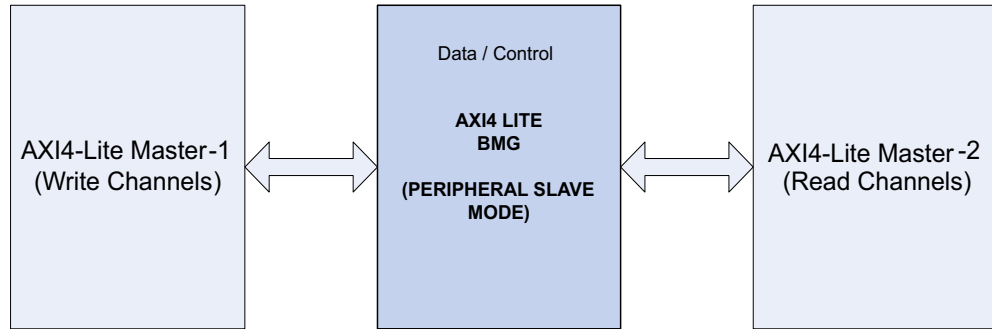


Figure 1-8: AXI4-Lite Peripheral Slave Application Diagram

Figure 1-8 shows an example application for the AXI4-Lite Memory Slave Interface Type in a Point-to-point application. There is no minimum memory requirement set for this configuration. Data widths supported by this configuration include 8, 16, 32 and 64 bits.

Supported Devices

Table 1-3: AXI4 BMG Supported FPGA Families and Sub-Families

FPGA Family	Sub-Family
Spartan-6	LX/LXT
Virtex-6	CXT/HXT/LXT/SXT
Virtex-7	XT
Kintex-7	
Artix-7	
Zynq-7000	

AXI4 BMG Core Channel Handshake Sequence

Figure 1-9 and Figure 1-10 illustrates an example handshake sequence for AXI4 BMG core. Figure 1-9 illustrates single burst Write operations to block RAM. By default the `AWREADY` signal is asserted on the bus so that the address can be captured immediately during the clock cycle when both `AWVALID` and `AWREADY` are asserted. (With the default set in this manner, there is no need to wait an extra clock cycle `AWREADY` to be asserted first.) By default, the `WREADY` signal will be de-asserted. Upon detecting `AWVALID` being asserted, the `WREADY` signal will be asserted (AXI4 BMG core has registered an AXI Address and is ready to accept Data), and when `WVALID` is also asserted, writes will be performed to the block RAM. If the write data channel (`WVALID`) is presented prior to the write address

channel valid (AWVALID) assertion, the write transactions will not be initiated until the write address channel has valid information.

The AXI4 Block Memory core will assert BVALID for each transaction only after the last data transfer is accepted. The core also will not wait for the master to assert BREADY before asserting BVALID.

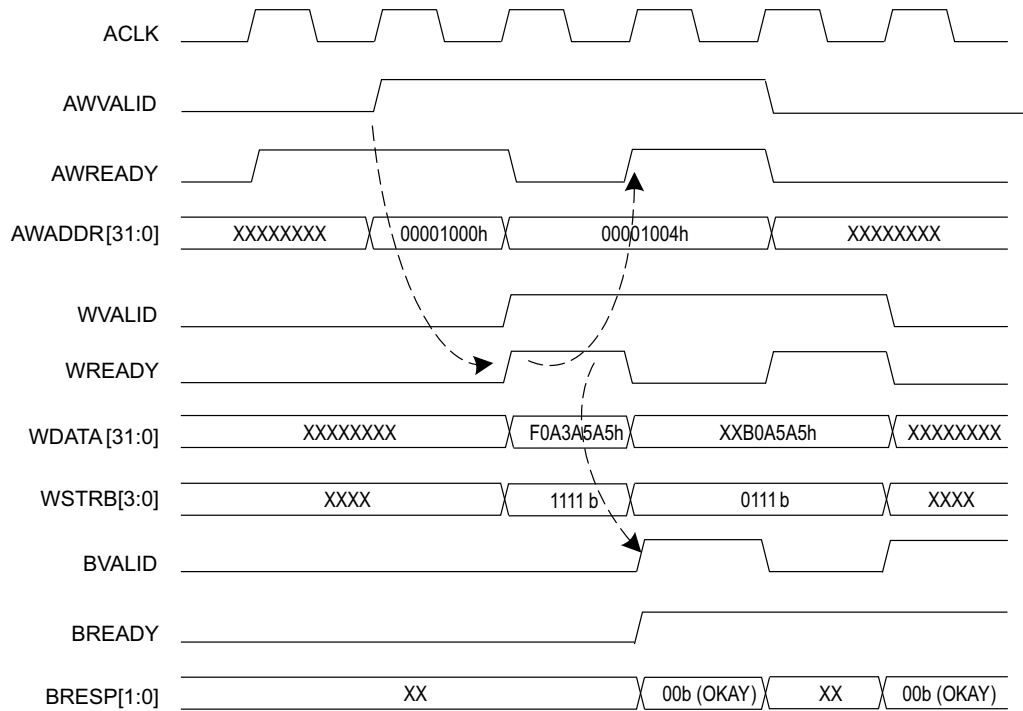


Figure 1-9: AXI4-Lite Single Burst Write Transactions

Figure 1-9 illustrates single burst Read operations to block RAM. The registered ARREADY signal output on the AXI Read Address Channel interface defaults to a high assertion. The AXI Read FSM can accept the read address in the clock cycle where the ARVALID signal is first valid.

The AXI Read FSM can accept a same clock cycle assertion of the RREADY by the master if the master can accept data immediately. When the RREADY signal is asserted on the AXI bus by the master, the Read FSM will either negate the RVALID signal or will place next valid data on the AXI Bus.

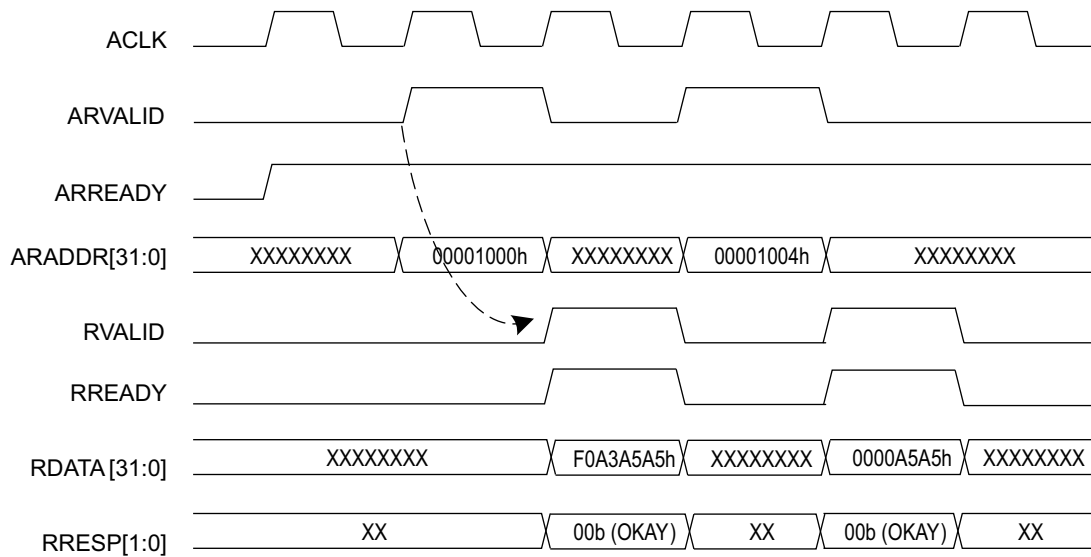


Figure 1-10: AXI4 Lite Single Burst Read Transactions

For more details on AXI4 Channel handshake sequences refer to the “Channel Handshake” section of the *AXI protocol specification* [Ref 1].

AXI4 Lite Single Burst Transactions

For AXI4 Lite interfaces, all transactions are burst length of one and all data accesses are the same size as the width of the data bus. Figure 1-9 and Figure 1-10 illustrates timing of AXI 32-bit write operations to the 32-bit wide BRAM. Figure 1-9 example illustrates single burst Write operations to block RAM addresses 0x1000h and 0x1004h. Figure 1-10 illustrates single burst Read operations to block RAM addresses 0x1000h and 0x1004h.

AXI4 Incremental Burst Support

Figure 1-11 illustrates an example of the timing for an AXI Write burst of four words to a 32-bit block RAM. The address Write channel handshaking stage communicates the burst type as INCR, the burst length of two data transfers ($AWLEN = 01h$). The Write burst utilizes all byte lanes of the AXI data bus going to the block RAM ($AWSIZE = 010b$).

In compliance with AXI Protocol, the burst termination boundary for a transaction is determined by the length specified in the $AWLEN$ signal. The allowable burst sizes for INCR bursts are from 1 (00h) to 256 (FFh) data transfers.

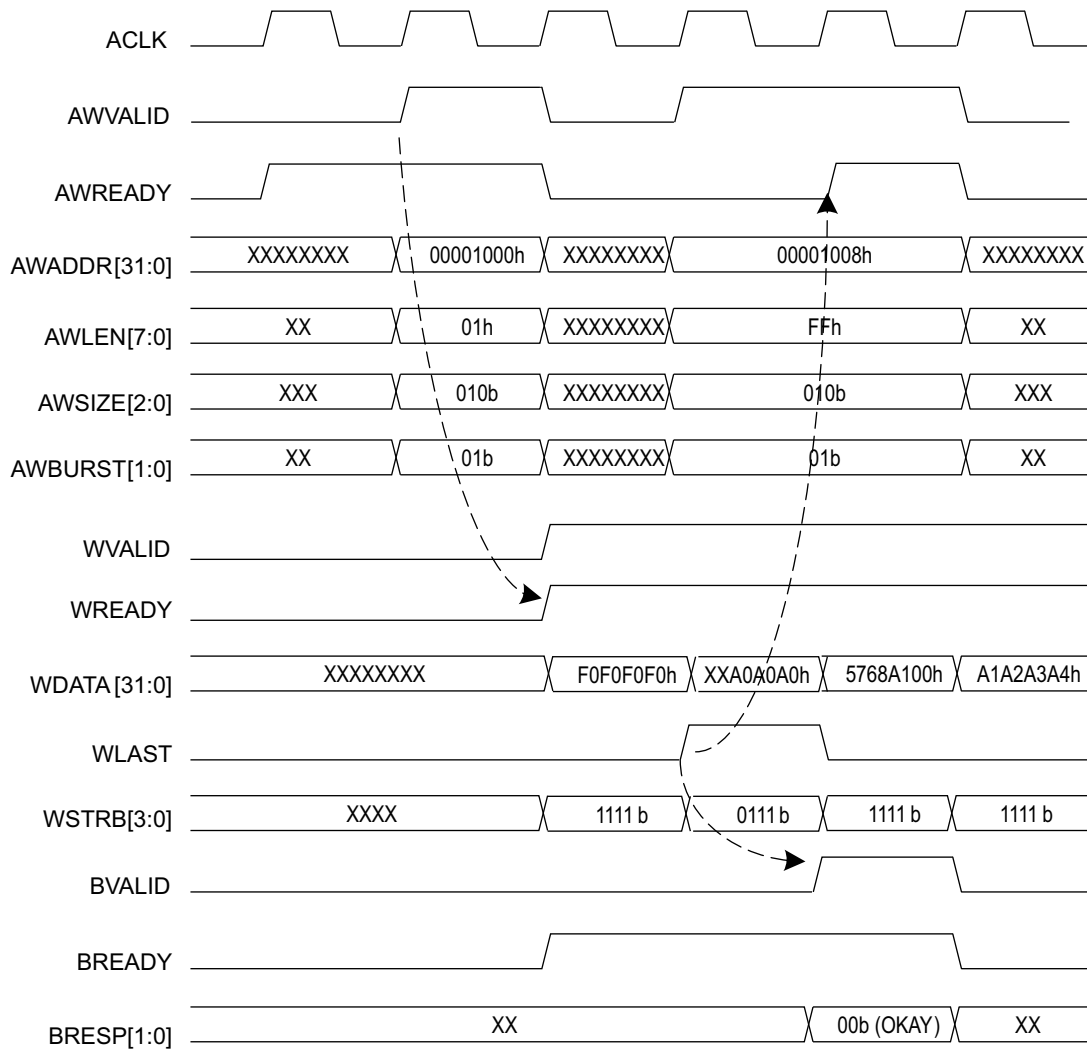


Figure 1-11: AXI4 Incremental Write Burst Transactions

Figure 1-12 illustrates the example timing for an AXI Read burst with block RAM managed by the Read FSM. The memory Read burst starts at address 0x1000h of the block RAM. On the AXI Read Data Channel, the Read FSM enables the AXI master/Interconnect to respond to the **RVALID** assertion when **RREADY** is asserted in the same clock cycle. If the requesting AXI master/Interconnect throttles on accepting the Read burst data (by negating **RREADY**), the Read FSM handles this by holding the data pipeline until **RREADY** is asserted.

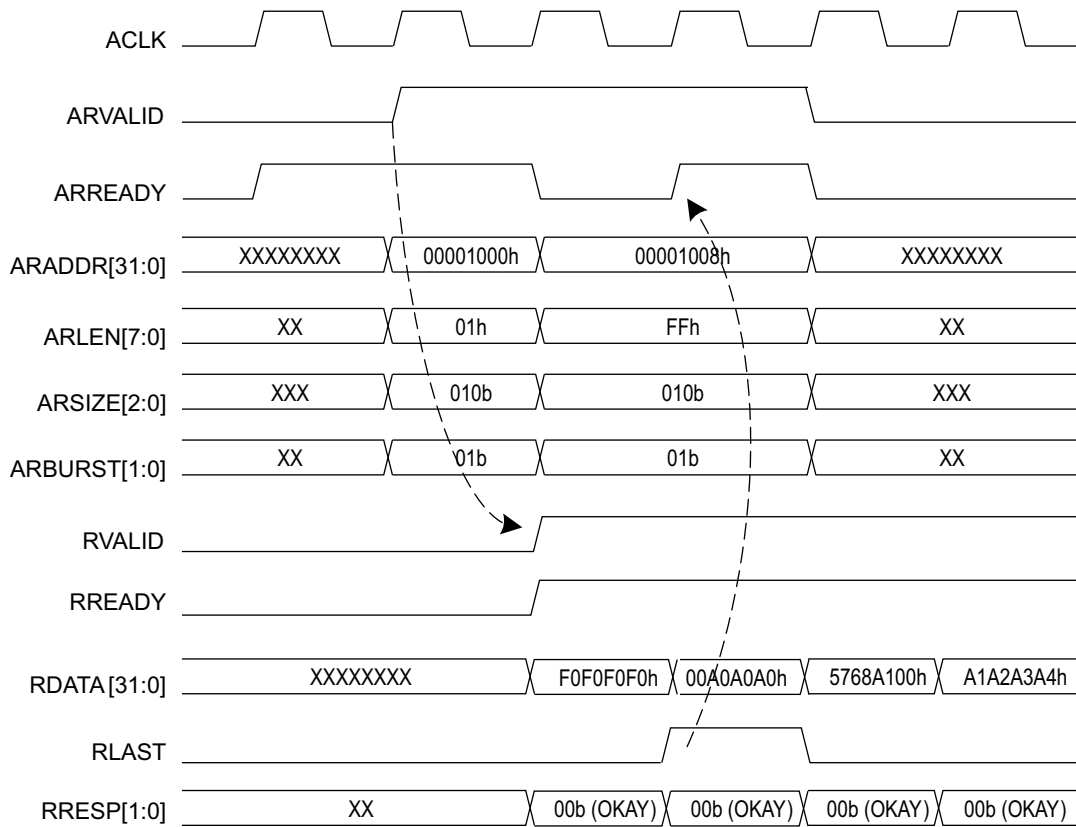


Figure 1-12: AXI4 Incremental Read Burst Transactions

AXI4 Wrap Burst Support

Cache line operations are implemented as WRAP burst types on AXI when presented to the block RAM. The allowable burst sizes for WRAP bursts are 2, 4, 8, and 16. The `AWBURST/ARBURST` must be set to "10" for the WRAP burst type.

WRAP bursts are handled by the address generator logic of the Write and Read FSM. The address seen by the block RAM must increment to the address space boundary, and then wrap back around to the beginning of the cache line address. For example, a processor issues a target word first cache line Read request to address 0x04h. On a 32-bit block RAM, the address space boundary is 0xFFh. So, the block RAM will see the following sequence of addresses for Read requests: 0x04h, 0x08h, 0x0Ch, 0x00h. Note the wrap of the cache line address from 0xCh back to 0x00h at the end.

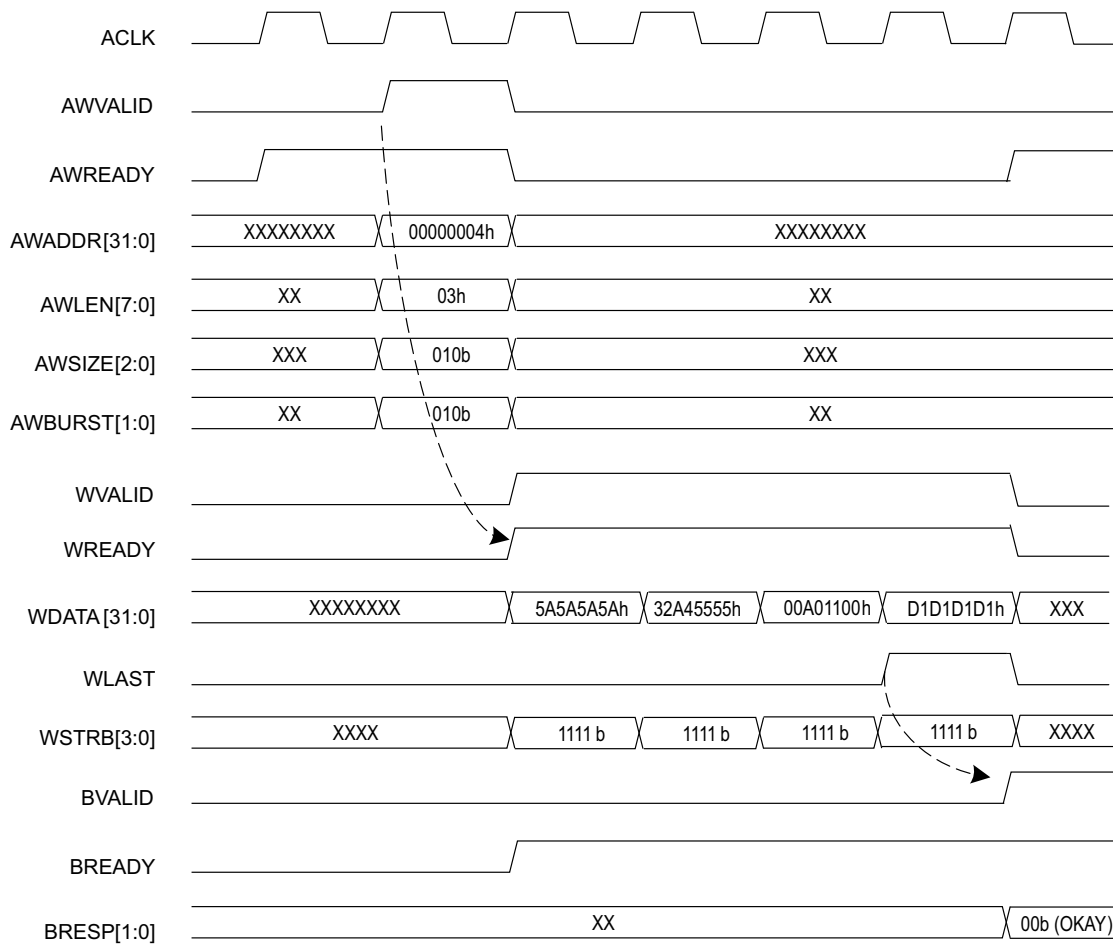


Figure 1-13: AXI4 Wrap Write Burst Transactions

Figure 1-13 illustrates the timing for AXI Wrap or cache line burst transactions. The address generated and presented to the block RAM starts at the target word and wraps around once the address space boundary is reached.

Figure 1-14 illustrates the timing on AXI WRAP or cache line burst Read transactions.

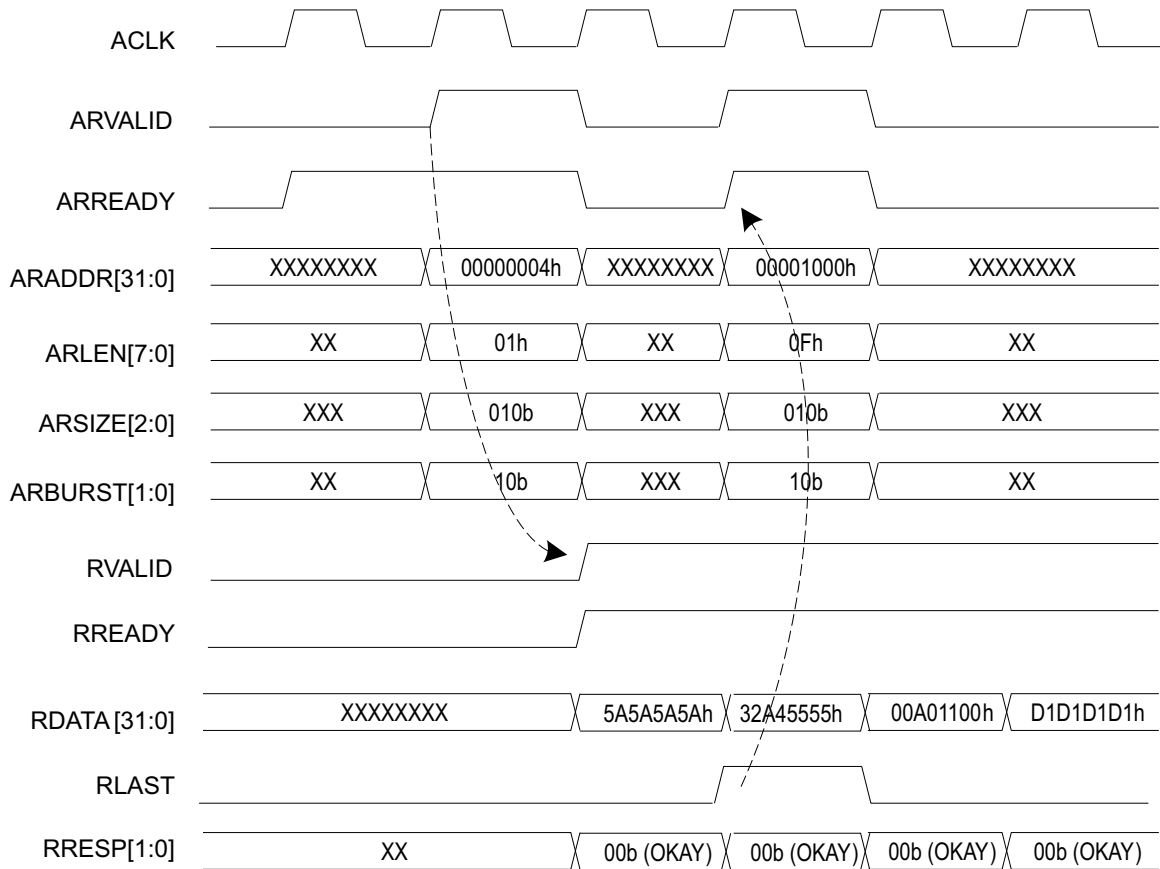


Figure 1-14: AXI4 Wrap Read Burst Transactions

Table 1-4 provides example address sequence to the block RAM for Wrap transactions.

Table 1-4: Example Address Sequence for AXI4 BMG Core Wrap Transactions

Memory Width	Transfer Size	Start Address	Burst Length	AXI4 BMG Core Address Sequence
32-bits	32-bits	0x100Ch	2	0x100Ch ⁽¹⁾ , 0x1008h
32-bits	32-bits	0x1008h	4	0x1008h, 0x100Ch ⁽¹⁾ , 0x1000h, 0x1004h
64-bits	64-bits	0x1008h	8	0x1008h, 0x1010h, 0x1018h, 0x1020h, 0x1028h, 0x1030h, 0x1038h ⁽¹⁾ , 0x1000h
64-bits	16-bits	0x1008h	16	0x1008h, 0x100Ah, 0x100Ch, 0x100Eh, 0x1010, 0x1012, 0x1014, 0x1016h, 0x1018h, 0x101Ah, 0x101Ch, 0x101Eh ⁽¹⁾ , 0x1000h, 0x1002h, 0x1004h, 0x1006h

1. Calculated Wrap Boundary address.

For more details on AXI4 Wrap Burst Transactions and Wrap boundary calculations, refer to the Burst Addressing section of the AXI protocol specification [Ref 1].

AXI4 Narrow Transactions

A narrow burst is defined as a master bursting a data size smaller than the block RAM data width. If the burst type (AWBURST) is set to INCR or WRAP, then the valid data on the block RAM interface to the AXI bus will rotate for each data beat. The Write and Read FSM handles each data beat on the AXI as a corresponding data beat to the block RAM, regardless of the smaller valid byte lanes. In this scenario, the AXI WSTRB is translated to the block RAM Write enable signals. The block RAM address only increments when the full address (data) width boundary is met with the narrow Write to block RAM.

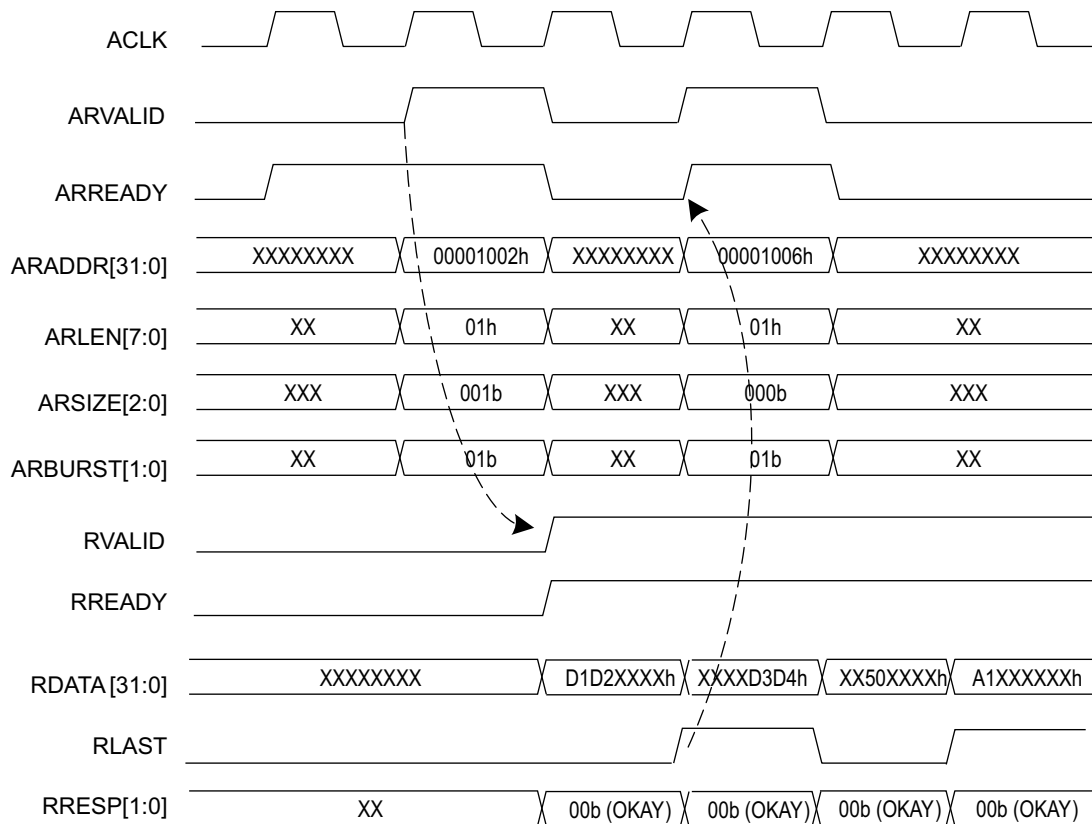


Figure 1-15: AXI4 Narrow Write Burst Transactions

Figure 1-15 illustrates an example of AXI narrow Write bursting with a 32-bit block RAM and the AXI master request is a half-word burst of four data beats. AWSIZE is set to 001b.

Figure 1-16 illustrates an example of AXI "narrow" Read bursting with a 32-bit block RAM and the AXI master request is a half-word burst of 4 data beats. ARSIZE is set to 001b.

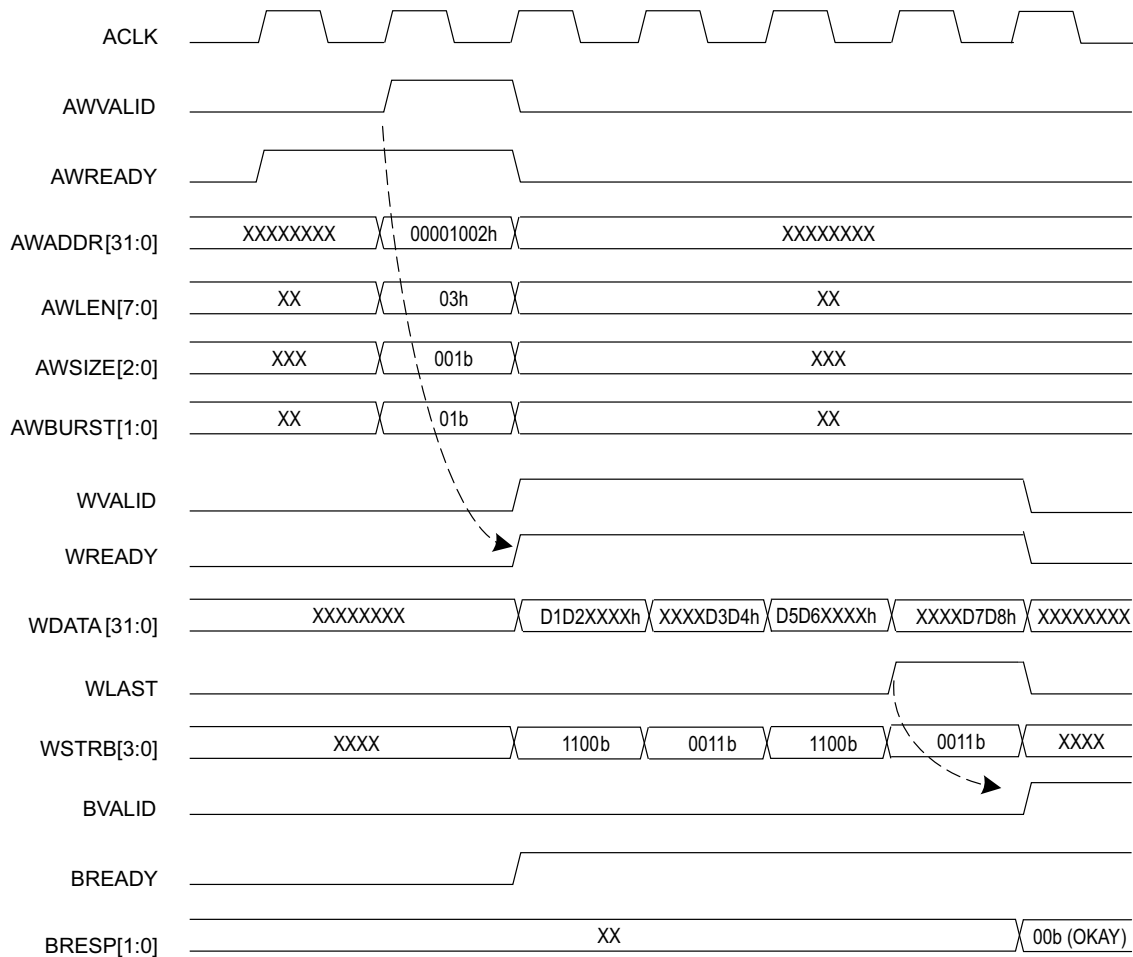


Figure 1-16: AXI4 Narrow Read Burst Transactions

For more details on AXI4 Narrow Transactions refer to the "Narrow transfers" section of the AXI protocol specification [Ref 1].

AXI4 Unaligned Transactions

Unaligned burst transfers for example, occur when a 32-bit word burst size does not start on an address boundary that matches a word memory location. The starting memory address is permitted to be something other than 0x0h, 0x4h, 0x8h, etc. The example shown in Figure 1-17 illustrates an unaligned word burst transaction of 4 data beats, which starts at address offset, 0x1002h.

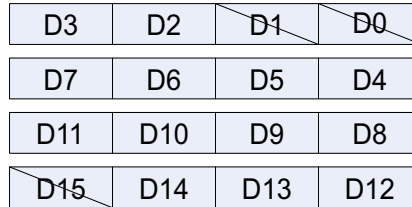


Figure 1-17: AXI4 Unaligned Transactions

For more details on AXI4 Narrow Transactions refer to the “about unaligned transfers” section of the *AXI protocol specification* [Ref 1].

Configurable Width and Depth

Table 1-5 provides supported Width and Depth for AXI4 Block Memory core.

Table 1-5: Supported Width and Depth

Operating Mode	Supported Memory Data Widths	Supported Minimum Memory Depth	
AXI4 Memory Slave	32,64,128, 256	Supports minimum 4kB address range:	
		<u>Data Width</u>	<u>Minimum Depth</u>
		32	1024
		64	512
AXI4 Lite Memory Slave	32,64	Supports minimum 4kB address range:	
		<u>Data Width</u>	<u>Minimum Depth</u>
		32	1024
AXI4 Peripheral Slave	8, 16, 32,64,128, 256	2	
		2	
AXI4 Lite Peripheral Slave	8, 16, 32,64,	2	

For Peripheral Slave configurations, there is no minimum requirement for the number of address bits used by Block Memory core. For Memory Slave configuration, AXI4 Block Memory slave has at least sufficient address bits to fully decode a 4kB address range.

For Peripheral Slave and AXI4 Lite Memory Slave configurations, AXI4 Block Memory core is not required to have low-order address bits to support decoding within the width of the system data bus and assumes that such low-order address bits have a default value of all zeros. For AXI4 Memory Slave configuration, AXI4 Block Memory core supports Narrow Transactions and performs low-order address bits decoding. For more details, see [AXI4 Interface Block Memory Addressing](#).

AXI4 Interface Block Memory Addressing

AXI4 Interface Block Memory cores support 32-bit byte addressing. There is no minimum requirement for the number of address bits supplied by a master. Typically a master is expected to supply 32-bits of addressing. [Table 1-6](#) illustrates some example settings to create a specific size of block RAM in the system.

Table 1-6: AXI4 Interface Block Memory Generator Example Address Ranges

Memory Width x Depth	Memory Size	Address Range Required	Example Base Address	Example Max Address	Block RAM Address
8 x 4096	4K	0x0000_0000 to 0x0000_0FFF	0xA000 0000	0xA000 0FFF	AXI_ADDR[11:0]
16 x 2048	4K	0x0000_0000 to 0x0000_0FFF	0xA000 0000	0xA000 0FFF	AXI_ADDR[11:1]
32 x 1024	4K	0x0000_0000 to 0x0000_0FFF	0xA000 0000	0xA000 0FFF	AXI_ADDR[11:2]
64 x 1024	8K	0x0000_0000 to 0x0000_1FFF	0x2400 0000	0x2400 1FFF	AXI_ADDR[12:3]
128 x 1024	16K	0x0000_0000 to 0x0000_3FFF	0x1F00 0000	0x1F00 3FFF	AXI_ADDR[13:4]
256 x 1024	32K	0x0000_0000 to 0x0000_7FFF	0x3000 0000	0x3000 7FFF	AXI_ADDR[14:5]

The Address Range of AXI Block Memory core must always start at zero. If the master has a different address bus width than that provided by the AXI4 Block Memory Core, follow these guidelines:

- If the Master address is wider than the configured Address Range for AXI Block Memory core, the additional high-order address bits can be connected as is. AXI Block Memory core will ignore these bits.
- If the Master address is narrower than 32-bits, the high-order address bits of the AXI Block Memory core can be left unconnected.

For more details on AXI4 Addressing refer to the “Master Addresses” and “Slave Addresses” section of the *AXI protocol specification* [\[Ref 1\]](#).

Throughput & Performance

To achieve 100 percent block RAM interface utilization of the Write port the following conditions must be satisfied.

- No single Write bursts.
- The AXI Master should not apply back pressure on the Write response channel

To achieve 100 percent block RAM interface utilization of the Read port the following conditions must be satisfied.

- The AXI Master should not apply back pressure on the Read data channel

Selectable Port Aspect Ratios

The core currently supports only symmetric aspect ratios (that is, a 1:1 aspect ratio only).

Optional Output Register

The Output Register option is currently not supported.

Optional Pipeline Stages

Pipeline stages are currently not supported.

Memory Initialization Capability

The memory contents can be optionally initialized using a memory coefficient (COE) file or by specifying a default data value. A COE file can define the initial contents of each individual memory location, while the default data value option defines the initial content for all locations.

Applications

The Block Memory Generator core is used to create customized memories to suit any application. Typical applications include:

- **Single-port RAM:** Processor scratch RAM, look-up tables
- **Simple Dual-port RAM:** Content addressable memories, FIFOs
- **True Dual-port RAM:** Multi-processor storage
- **Single-port ROM:** Program code storage, initialization ROM
- **Dual-port ROM:** Single ROM shared between two processors/systems

Licensing and Ordering Information

This Xilinx LogiCORE IP module is provided under the terms of the [Xilinx Core License Agreement](#). The module is shipped as part of the Vivado Design Suite and the ISE Design

Suite. For full access to all core functionalities in simulation and in hardware, you must purchase a license for the core. Contact your [local Xilinx sales representative](#) for information about pricing and availability.

For more information, visit the [Block Memory Generator product page](#).

Information about other Xilinx LogiCORE IP modules is available at the [Xilinx Intellectual Property](#) page. For information on pricing and availability of other Xilinx LogiCORE IP modules and tools, contact your [local Xilinx sales representative](#).

Product Specification

This chapter includes details on performance and latency.

Performance

Performance and resource utilization for a BMG varies depending on the configuration and features selected during core customization.

See [Resource Utilization](#) for the performance and resource utilization numbers.

Latency

The latency of output signals of BMG varies for different configurations. See [Optional Output Registers](#), [Optional Pipeline Stages](#), and [Memory Output Flow Control in Chapter 3](#) for more details.

Resource Utilization

The following tables show resource utilization data and maximum performance values for a variety of sample BMG configurations.

Native Block Memory Generator Resource Utilization and Performance Examples

Note: Benchmarking data for Virtex-7 and Kintex-7 devices will be available in future release.

The following tables provide examples of actual resource utilization and performance for Native Block Memory Generator implementations. Each section highlights the effects of a specific feature on resource utilization and performance. The actual results obtained will depend on core parameter selections, such as algorithm, optional output registers, and memory size, as well as surrounding logic and packing density.

Benchmarks were taken using a design targeting a Virtex-4 FPGA in the -10 speed grade (4VLX60-FF1148-10), Virtex-5 FPGA in the -1 speed grade (5VLX30-FF324-1), Virtex-6 FPGA

in the -1 speed grade (XC6VLX365T-FF1759-1) and a Spartan-6 FPGA in the -2 speed grade (XC6SLX150T-FGG484-2). All benchmarks were obtained using the ISE Design Suite. Better performance may be possible with higher speed grades.

In the benchmark designs described below, the core was encased in a wrapper with input and output registers to remove the effects of IO delays from the results; performance may vary depending on the user design. The minimum area algorithm was used unless otherwise noted. It is recommended that users register their inputs to the core for better performance. The following examples highlight the use of embedded registers in Virtex-4, Virtex-5, Virtex-6 and Spartan-6 devices, and the subsequent performance improvement that may result.

Single Primitive

The Block Memory Generator does not add additional logic if the memory can be implemented in a single Block RAM primitive. Table 2-1 through Table 2-5 define performance data for single-primitive memories.

Table 2-1: Single Primitive Examples - Virtex-7 FPGAs

Memory Type	Options	Width x Depth	Resource Utilization					Performance (MHz)
			Block RAMs		Shift Regs	FFs	LUTs	
			36K	18K				
True Dual-port RAM	No Output Registers	36x512	1	0	0	0	0	414
		9x2k	1	0	0	0	0	360
	Embedded Output Registers	36x512	1	0	0	0	0	538
		9x2k	1	0	0	0	0	454

Table 2-2: Single Primitive Examples - Virtex-6 FPGAs

Memory Type	Options	Width x Depth	Resource Utilization						Performance (MHz)
			Block RAMs			Shift Regs	FFs	LUTs ^a	
			36K	16K	8K				
True Dual-port RAM	No Output Registers	36x512	1	0	0	0	0	0	325
		9x2k	0	1	0	0	0	0	325
	Embedded Output Registers	36x512	1	0	0	0	0	0	450
		9x2k	0	1	0	0	0	0	450

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-3: Single Primitive Examples - Virtex-5 FPGAs

Memory Type	Options	Width x Depth	Resource Utilization						Performance (MHz)
			Block RAMs			Shift Regs	FFs	LUTs ^a	
			36K	16K	8K				
True Dual-port RAM	No Output Registers	36x512	1	0	0	0	0	0	300
		9x2k	0	1	0	0	0	0	325
	Embedded Output Registers	36x512	1	0	0	0	0	0	450
		9x2k	0	1	0	0	0	0	450

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-4: Single Primitive Examples - Virtex-4 FPGAs

Memory Type	Options	Width x Depth	Resource Utilization				Performance (MHz)
			Block RAMs 16K	Shift Regs	FFs	LUTs ^a	Virtex-4
True Dual-port RAM	No Output Registers	36x512	1	0	0	0	300
		9x2k	1	0	0	0	325
	Embedded Output Registers	36x512	1	0	0	0	400
		9x2k	1	0	0	0	400

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-5: Single Primitive Examples - Spartan-6 FPGAs

Memory Type	Options	Width x Depth	Resource Utilization						Performance (MHz)
			Block RAMs			Shift Regs	FFs	LUTs ^a	
			36K	16K	8K				
True Dual-port RAM	No Output Registers	36x512	0	1	0	0	0	0	200
		9x2k	0	1	0	0	0	0	225
	Embedded Output Registers	36x512	0	1	0	0	0	0	275
		9x2k	0	1	0	0	0	0	300

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Output Registers

The Block Memory Generator optional output registers increase the performance of memories by isolating the block RAM primitive clock-to-out delays and the data output multiplexer delays.

The output registers are only implemented for output ports. For this reason, when output registers are used, a Single-port RAM requires fewer resources than a True Dual-port RAM. Note that the effects of the core output registers are not fully illustrated due to the simple

register wrapper used. In a full-scale user design, core output registers may improve performance notably.

In Virtex-6, Virtex-5, Virtex-4, and Spartan-6 architectures, the embedded block RAM may be utilized, reducing the FPGA fabric resources required to create the registers.

Table 2-6: Virtex-6 Device Output Register Examples

Memory Type	Width x Depth	Output Register Options	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k		1	3	0	0	3	18	325
		Primitive	1	3	0	3	3	18	450
		Core	1	3	0	0	20	18	325
		Primitive, Core	1	3	0	3	20	18	450
True Dual-port RAM	17x5k		1	3	0	0	6	36	300
		Primitive	1	3	0	6	6	36	450
		Core	1	3	0	0	40	36	300
		Primitive, Core	1	3	0	6	40	36	450

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-7: Virtex-5 Device Output Register Examples

Memory Type	Width x Depth	Output Register Options	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k		1	3	0	0	3	18	300
		Primitive	1	3	0	3	3	18	450
		Core	1	3	0	0	20	18	300
		Primitive, Core	1	3	0	3	20	18	450
True Dual-port RAM	17x5k		1	3	0	0	6	36	300
		Primitive	1	3	0	6	6	36	450
		Core	1	3	0	0	40	36	300
		Primitive, Core	1	3	0	6	40	36	450

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-8: Virtex-4 Device Output Register Examples

Memory Type	Width x Depth	Output Register Option	Block RAMs 16K	Shift Regs	FFs	LUTs ^a	Performance (MHz)
Single-port RAM	17x5k	-	5	0	3	30	275
		Primitive	5	3	3	30	400
		Core	5	0	20	30	275
		Primitive, Core	5	2	22	32	400

Table 2-8: Virtex-4 Device Output Register Examples

Memory Type	Width x Depth	Output Register Option	Block RAMs 16K	Shift Regs	FFs	LUTs ^a	Performance (MHz)
True Dual-port RAM	17x5k	-	5	0	6	60	275
		Primitive	5	6	6	148	375
		Core	5	0	40	142	250
		Primitive, Core	5	6	40	148	375

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-9: Spartan-6 Device Output Register Examples

Memory Type	Width x Depth	Output Register Options	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k		0	5	0	0	3	19	175
		Primitive	0	5	0	3	3	19	250
		Core	0	5	0	0	20	19	175
		Primitive, Core	0	5	0	3	20	19	225
True Dual-port RAM	17x5k		0	5	0	0	6	38	175
		Primitive	0	5	0	4	6	38	250
		Core	0	5	0	0	40	38	175
		Primitive, Core	0	5	0	4	40	38	225

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Aspect Ratios

The Block Memory Generator selectable port and data width aspect ratios may increase block RAM usage and affect performance, because aspect ratios limit the primitive types available to the algorithm, which can reduce packing efficiency. Large aspect ratios, such as 1:32, have a greater impact than small aspect ratios. Note that width and depth are reported with respect to the port A Write interface.

Table 2-10: Virtex-6 Device Aspect Ratio

Memory Type	Width x Depth	Data Width Aspect Ratio	Block RAMs			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k	1:1	2	3	0	0	6	36	300
		1:8 ^b	8	1	0	0	0	0	275

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

b. Read port is 136x640; Write port is 17x5k.

Table 2-11: Virtex-5 Device Aspect Ratio

Memory Type	Width x Depth	Data Width Aspect Ratio	Block RAMs			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k	1:1	2	3	0	0	6	36	300
		1:8 ^b	8	1	0	0	0	0	275

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.
 b. Read port is 136x640; Write port is 17x5k.

Table 2-12: Virtex-4 Device Aspect Ratio

Memory Type	Width x Depth	Data Width Aspect Ratio	Block RAM 16K	Shift Regs	FFs	LUTs ^a	Performance (MHz)
Single Port	17x5k	1:1	5	0	6	60	275
		1:8 ^b	9	0	0	0	275

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.
 b. Read port is 136x640; Write port is 17x5k.

Algorithm

The differences between the minimum area, low power and fixed primitive algorithms are discussed in detail in [Selectable Memory Algorithm, page 10](#). Table 2-13 shows examples of the resource utilization and the performance difference between them for two selected configurations for Virtex-6 FPGA architectures.

Table 2-13: Memory Algorithm Examples Virtex-6 Devices

Memory Type	Width x Depth	Algorithm Type	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k	Minimum area	1	3	0	0	3	18	325
		Fixed Primitive using 18x1k block RAM	2	1	0	0	3	19	300
		Low power	0	5	0	0	3	37	275
	36x4k	Minimum area	4	0	0	0	0	0	325
		Fixed Primitive using 36x512 block RAM	4	0	0	0	2	38	275
		Low power	4	0	0	0	3	76	275

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-14 shows examples of the resource utilization and the performance difference between them for two selected configurations for Virtex-5 FPGA architecture.

Table 2-14: Memory Algorithm Examples Virtex-5 Devices

Memory Type	Width x Depth	Algorithm Type	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k	Minimum area	1	3	0	0	3	18	300
		Fixed Primitive using 18x1k block RAM	2	1	0	0	3	20	300
		Low power	0	5	0	0	3	39	275
	36x4k	Minimum area	4	0	0	0	0	0	300
		Fixed Primitive using 36x512 block RAM	4	0	0	0	2	40	275
		Low power	0	8	0	0	3	80	250

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-15 shows examples of the resource utilization and the performance difference between them for two selected configurations for Virtex-4 FPGA architecture.

Table 2-15: Memory Algorithm Examples Virtex-4 Devices

Memory Type	Width x Depth	Algorithm Type	Resource Utilization				Performance (MHz)
			Block RAM	Shift Regs	FFs	LUTs ^a	
Single-port RAM	17x5k	Minimum area	5	0	3	30	275
		Fixed Primitive using 18x1k block RAM	5	0	3	57	225
		Low power	5	0	3	57	225
	36x4k	Minimum area	8	0	1	36	275
		Fixed Primitive using 36x512 block RAM	8	0	3	152	225
		Low power	8	0	3	152	225

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

Table 2-16 shows examples of the resource utilization and the performance difference between them for two selected configurations for Spartan-6 FPGA architecture.

Table 2-16: Memory Algorithm Examples Spartan-6 Devices

Memory Type	Width x Depth	Algorithm Type	Block RAM			Shift Regs	FFs	LUTs ^a	Performance (MHz)
			36K	16K	8K				
Single-port RAM	17x5k	Minimum area	0	5	0	0	3	19	175
		Fixed Primitive using 18x1k block RAM	0	5	0	0	3	37	175
		Low power	0	0	10	0	4	57	150
	36x4k	Minimum area	0	8	0	0	1	18	175
		Fixed Primitive using 36x512 block RAM	0	8	0	0	3	76	150
		Low power	0	0	16	0	4	170	125

a. LUTs are reported as the number of 4-input LUTs, and do not reflect the number of LUTs used as a route-through.

AXI4 Block Memory Generator Resource Utilization and Performance Examples

Note: Benchmarking data for Virtex-7 and Kintex-7 devices will be available in future release.

Table 2-17 through Table 2-20 show the resource utilization and performance data for a BMG core using the AXI4 interface. Benchmarks were taken using a design targeting a Virtex-6 FPGA in the -2 speed grade (XC6VCX75T-FF484-2) and a Spartan-6 FPGA in the -2 speed grade (XC6SLX150T-FGG484-2). All benchmarks were obtained using the ISE Design Suite. Better performance may be possible with higher speed grades.

In the benchmark designs, the core was encased in a wrapper with input and output registers to remove the effects of I/O delays from the results. Performance may vary depending on the design.

Table 2-17: AXI4 Block Memory Generator Virtex-6 FPGA

Memory Type	Options	Width X Depth	Resource Utilization					Performance (MHz)	
			Block RAMs			FFs	LUTs		Occupied Slices
			36K	16K	8K				
Simple Dual Port RAM	Memory Slave	32x1024	1	0	0	92	207	74	306
		64x512	1	0	0	95	225	81	282
	Peripheral Slave	32x1024	1	0	0	52	151	53	320
		64x512	1	0	0	50	145	46	299

Table 2-18: AXI4 Interface Block Memory Generator Spartan-6 FPGA

Memory Type	Options	Width X Depth	Resource Utilization						Performance (MHz)
			Block RAMs			FFs	LUTs	Occupied Slices	
			36K	16K	8K				
Simple Dual Port RAM	Memory Slave	32x1024	-	2	0	95	207	79	163
		64x512	-	2	0	98	231	81	168
	Peripheral Slave	32x1024	-	2	0	56	159	57	175
		64x512	-	2	0	54	149	51	165

Table 2-19: AXI4-Lite Block Memory Generator Virtex-6 FPGA

Memory Type	Options	Width X Depth	Resource Utilization						Performance (MHz)
			Block RAMs			FFs	LUTs	Occupied Slices	
			36K	16K	8K				
Simple Dual Port RAM	Memory Slave	32x1024	1	0	0	15	33	15	325
		64x512	1	0	0	15	32	14	317
	Peripheral Slave	32x1024	1	0	0	15	33	15	335
		64x512	1	0	0	15	32	14	317

Table 2-20: AXI4-Lite Interface Block Memory Generator Spartan-6 FPGA

Memory Type	Options	Width X Depth	Resource Utilization						Performance (MHz)
			Block RAMs			FFs	LUTs	Occupied Slices	
			36K	16K	8K				
Simple Dual Port RAM	Memory Slave	32x1024	-	2	0	25	45	18	219
		64x512	-	2	0	24	43	20	217
	Peripheral Slave	32x1024	-	2	0	25	45	18	222
		64x512	-	2	0	24	43	20	215

Port Descriptions

Native Block Memory Generator Signal List

Table 2-21 provides a description of the Block Memory Generator core signals. The widths of the data ports (DINA, DOUTA, DINB, and DOUTB) are selected by the user in the CORE Generator GUI. The address port (ADDRA and ADDR B) widths are determined by the memory depth with respect to each port, as selected by the user in the GUI. The Write enable ports (WEA and WEB) are busses of width 1 when byte-writes are disabled. When byte-writes are enabled, WEA and WEB widths depend on the byte size and Write data widths selected in the GUI.

Table 2-21: Core Signal Pinout

Name	Direction	Description
CLKA	Input	Port A Clock: Port A operations are synchronous to this clock. For synchronous operation, this must be driven by the same signal as CLKB.
ADDRA	Input	Port A Address: Addresses the memory space for port A Read and Write operations. Available in all configurations.
DINA	Input	Port A Data Input: Data input to be written into the memory via port A. Available in all RAM configurations.
DOUTA	Output	Port A Data Output: Data output from Read operations via port A. Available in all configurations except Simple Dual-port RAM.
ENA	Input	Port A Clock Enable: Enables Read, Write, and reset operations via port A. Optional in all configurations.
WEA	Input	Port A Write Enable: Enables Write operations via port A. Available in all RAM configurations.
RSTA	Input	Port A Set/Reset: Resets the Port A memory output latch or output register. Optional in all configurations.
REGCEA	Input	Port A Register Enable: Enables the last output register of port A. Optional in all configurations with port A output registers.
CLKB	Input	Port B Clock: Port B operations are synchronous to this clock. Available in dual-port configurations. For synchronous operation, this must be driven by the same signal as CLKA.
ADDRB	Input	Port B address: Addresses the memory space for port B Read and Write operations. Available in dual-port configurations.
DINB	Input	Port B Data Input: Data input to be written into the memory via port B. Available in True Dual-port RAM configurations.
DOUTB	Output	Port B Data Output: Data output from Read operations via Port B. Available in dual-port configurations.
ENB	Input	Port B Clock Enable: Enables Read, Write, and reset operations via Port B. Optional in dual-port configurations.

Table 2-21: Core Signal Pinout (Cont'd)

Name	Direction	Description
WEB	Input	Port B Write Enable: Enables Write operations via Port B. Available in Dual-port RAM configurations.
RSTB	Input	Port B Set/Reset: Resets the Port B memory output latch or output register. Optional in all configurations.
REGCEB	Input	Port B Register Enable: Enables the last output register of port B. Optional in dual-port configurations with port B output registers.
SBITERR	Output	Single-Bit Error: Flags the presence of a single-bit error in memory which has been auto-corrected on the output bus.
DBITERR	Output	Double-Bit Error: Flags the presence of a double-bit error in memory. Double-bit errors cannot be auto-corrected by the built-in ECC decode module.
INJECTSBITERR	Input	Inject Single-Bit Error: Available only for Zynq-7000, 7 series, and Virtex-6 ECC configurations.
INJECTDBITERR	Input	Inject Double-Bit Error: Available only for Zynq-7000, 7 series, and Virtex-6 ECC configurations.
RDADDRECC	Output	Read Address for ECC Error output: Available only for Zynq-7000, 7 series, and Virtex-6 ECC configurations.

AXI4 Interface Block Memory Generator Signal List

AXI4 Interface - Global Signals

Table 2-22: AXI4 or AXI4-Lite- Global Interface Signals

Name	Direction	Description
AXI4 or AXI4-Lite Global Interface Signals		
S_ACLK	Input	Global Slave Interface Clock: All signals are sampled on the rising edge of this clock.
S_ARESETN	Input	Global Reset: This signal is active low.

AXI4-Interface Signals

Table 2-23: AXI4 Write Channel Interface Signals

Name	Direction	Description
AXI4 Write Address Channel Interface Signals		
S_AXI_AWID[m:0]	Input	Write Address ID: This signal is the identification tag for the Write address group of signals. Write address ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration.

Table 2-23: AXI4 Write Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_AWADDR[31:0]	Input	Write Address: The Write address bus gives the address of the first transfer in a Write burst transaction. The associated control signals are used to determine the addresses of the remaining transfers in the burst.
S_AXI_AWLEN[7:0]	Input	Burst Length: The burst length gives the exact number of transfers in a burst. This information determines the number of data transfers associated with the address.
S_AXI_AWSIZE[2:0]	Input	Burst Size: This signal indicates the size of each transfer in the burst. Byte lane strobes indicate exactly which byte lanes to update. Burst size should always be less than or equal to the width of the Write Data. Burst Size input is not supported for Peripheral Slave configuration.
S_AXI_AWBURST[1:0]	Input	Burst Type: The burst type, coupled with the size information, details how the address for each transfer within the burst is calculated. Burst type for Memory Slave configuration could be either incremental or wrap. Burst type input is not supported for Peripheral Slave configuration, Burst type for Peripheral Slave is always internally set to incremental.
S_AXI_AWVALID	Input	Write Address Valid: This signal indicates that valid Write address and control information are available: <ul style="list-style-type: none"> • 1 = address and control information available. • 0 = address and control information not available. The address and control information remain stable until the address acknowledge signal, AWREADY, goes HIGH.
S_AXI_AWREADY	Output	Write Address Ready: This signal indicates that the slave is ready to accept an address and associated control signals: <ul style="list-style-type: none"> • 1 = Slave ready • 0 = Slave not ready
AXI4 Write Data Channel Interface Signals		
S_AXI_WDATA[m-1:0]	Input	Write Data: For Memory Slave configurations, the Write data bus can be 32, 64, 128, or 256 bits wide. For Peripheral Slave configurations, the Write data bus can be 8, 16, 32, 64, 128, or 256 bits wide.
S_AXI_WSTRB[m/8-1:0]	Input	Write Strobes: This signal indicates which byte lanes to update in memory. There is one Write strobe for each eight bits of the Write data bus. Therefore, WSTRB[n] corresponds to WDATA[(8 × n) + 7:(8 × n)].
S_AXI_WLAST	Input	Write Last: This signal indicates the last transfer in a Write burst.
S_AXI_WVALID	Input	Write Valid: This signal indicates that valid Write data and strobes are available: <ul style="list-style-type: none"> • 1 = Write data and strobes available • 0 = Write data and strobes not available

Table 2-23: AXI4 Write Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_WREADY	Output	<p>Write Ready: This signal indicates that the slave can accept the Write data:</p> <ul style="list-style-type: none"> • 1 = slave ready • 0 = slave not ready
AXI4 Write Response Channel Interface Signals		
S_AXI_BID[m:0]	Output	<p>Response ID: The identification tag of the Write response. The BID value must match the AWID value of the Write transaction to which the slave is responding.</p> <p>Response ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration.</p> <p>Response ID can be 1 to 16 bits wide.</p>
S_AXI_BRESP[1:0]	Output	<p>Write Response: This signal indicates the status of the Write transaction. The allowable responses are OKAY, EXOKAY, SLVERR, and DECERR.</p> <p>Write response is always set to OKAY.</p> <p>Write response is generated only when AXI4 ID is enabled for Memory Slave. Write response is not supported for Peripheral Slave configuration.</p>
S_AXI_BVALID	Output	<p>Write Response Valid: This signal indicates that a valid Write response is available:</p> <ul style="list-style-type: none"> • 1 = Write response available • 0 = Write response not available
S_AXI_BREADY	Input	<p>Response Ready: This signal indicates that the master can accept the response information.</p> <ul style="list-style-type: none"> • 1 = Master ready • 0 = Master not ready

Table 2-24: AXI4 Read Channel Interface Signals

Name	Direction	Description
AXI4 Read Address Channel Interface Signals		
S_AXI_ARID[m:0]	Input	<p>Read Address ID: This signal is the identification tag for the Read address group of signals.</p> <p>Read address ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration.</p> <p>Read address ID can be 1 to 16 bits wide.</p>
S_AXI_ARADDR[31:0]	Input	<p>Read Address: The Read address bus gives the initial address of a Read burst transaction.</p> <p>Only the start address of the burst is provided and the control signals that are issued alongside the address detail how the address is calculated for the remaining transfers in the burst.</p>
S_AXI_ARLEN[7:0]	Input	<p>Burst Length: The burst length gives the exact number of transfers in a burst. This information determines the number of data transfers associated with the address.</p>

Table 2-24: AXI4 Read Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_ARSIZE[2:0]	Input	<p>Burst Size: This signal indicates the size of each transfer in the burst.</p> <p>Burst size should always be less than or equal to the width of the Read Data.</p> <p>Burst Size input is not supported for Peripheral Slave configuration.</p>
S_AXI_ARBURST[1:0]	Input	<p>Burst Type: The burst type, coupled with the size information, details how the address for each transfer within the burst is calculated.</p> <p>Burst type for Memory Slave configuration could be either incremental or wrap.</p> <p>Burst type input is not supported for Peripheral Slave configuration, Burst type for Peripheral Slave is always internally set to incremental.</p>
S_AXI_ARVALID	Input	<p>Read Address Valid: This signal indicates, when HIGH, that the Read address and control information is valid and will remain stable until the address acknowledge signal, ARREADY, is high.</p> <ul style="list-style-type: none"> • 1 = address and control information valid • 0 = address and control information not valid
S_AXI_ARREADY	Output	<p>Read Address Ready: This signal indicates that the slave is ready to accept an address and associated control signals:</p> <ul style="list-style-type: none"> • 1 = slave ready • 0 = slave not ready
AXI4 Read Data Channel Interface Signals		
S_AXI_RID[m:0]	Output	<p>Read ID Tag: This signal is the ID tag of the Read data group of signals. The RID value is generated by the slave and must match the ARID value of the Read transaction to which it is responding.</p> <p>Read ID tag is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration.</p> <p>Read ID can be 1 to 16 bits wide.</p>
S_AXI_RDATA[m-1:0]	Output	<p>Read Data: For Memory Slave configurations, the Read data bus can be 32, 64, 128, or 256 bits wide. For Peripheral Slave configurations, the Read data bus can be 8, 16, 32, 64, 128, or 256 bits wide.</p>
S_AXI_RRESP[1:0]	Output	<p>Read Response: This signal indicates the status of the Read transfer. The allowable responses are OKAY, EXOKAY, SLVERR, and DECERR.</p> <p>Read response is always set to OKAY.</p> <p>Read response is generated only when AXI4 ID is enabled for Memory Slave. Read response is not supported for Peripheral Slave configuration.</p>
S_AXI_RLAST	Output	<p>Read Last: This signal indicates the last transfer in a Read burst.</p>

Table 2-24: AXI4 Read Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_RVALID	Output	<p>Read Valid: This signal indicates that the required Read data is available and the Read transfer can complete:</p> <ul style="list-style-type: none"> • 1 = Read data available • 0 = Read data not available
S_AXI_RREADY	Input	<p>Read Ready: This signal indicates that the master can accept the Read data and response information:</p> <ul style="list-style-type: none"> • 1 = Master ready • 0 = Master not ready

AXI4-Lite Interface Signals

Table 2-25: AXI4-Lite Write Channel Interface Signals

Name	Direction	Description
AXI4-Lite Write Address Channel Interface Signals		
S_AXI_AWADDR[31:0]	Input	<p>Write Address: The Write address bus gives the address of the first transfer in a Write burst transaction. The associated control signals are used to determine the addresses of the remaining transfers in the burst.</p>
S_AXI_AWVALID	Input	<p>Write Address Valid: This signal indicates that valid Write address and control information are available:</p> <ul style="list-style-type: none"> • 1 = address and control information available • 0 = address and control information not available. <p>The address and control information remain stable until the address acknowledge signal, AWREADY, goes HIGH</p>
S_AXI_AWREADY	Output	<p>Write Address Ready: This signal indicates that the slave is ready to accept an address and associated control signals:</p> <ul style="list-style-type: none"> • 1 = slave ready • 0 = slave not ready
S_AXI_AWID[m:0]	Input	<p>Write Address ID: This signal is the identification tag for the Write address group of signals</p> <p>Write address ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration.</p> <p>Write address ID can be 1 to 16 bits wide.</p>
AXI4-Lite Write Data Channel Interface Signals		
S_AXI_WDATA[m-1:0]	Input	<p>Write Data: For Memory Slave configurations, the Write data bus can be 32 or 64 bits wide. For Peripheral Slave configurations, the Write data bus can be 8, 16, 32 or 64 bits wide.</p>
S_AXI_WSTRB[m/8-1:0]	Input	<p>Write Strobes: This signal indicates which byte lanes to update in memory. There is one Write strobe for each eight bits of the Write data bus. Therefore, WSTRB[n] corresponds to WDATA[(8 × n) + 7:(8 × n)].</p>

Table 2-25: AXI4-Lite Write Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_WVALID	Input	Write Valid: This signal indicates that valid Write data and strobes are available: 1 = Write data and strobes available 0 = Write data and strobes not available
S_AXI_WREADY	Output	Write Ready: This signal indicates that the slave can accept the Write data: • 1 = slave ready • 0 = slave not ready
AXI4-Lite Write Response Channel Interface Signals		
S_AXI_BVALID	Output	Write Response Valid: This signal indicates that a valid Write response is available: • 1 = Write response available • 0 = Write response not available
S_AXI_BREADY	Input	Response Ready: This signal indicates that the master can accept the response information. • 1 = Master ready • 0 = Master not ready
S_AXI_BID[m:0]	Output	Response ID: The identification tag of the Write response. The BID value must match the AWID value of the Write transaction to which the slave is responding. Response ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration. Response ID can be 1 to 16 bits wide.
S_AXI_BRESP[1:0]	Output	Write Response: This signal indicates the status of the Write transaction. The allowable responses are OKAY, EXOKAY, SLVERR, and DECERR. Write response is always set to OKAY. Write response is generated only when AXI4 ID is enabled for Memory Slave. Write response is not supported for Peripheral Slave configuration.

Table 2-26: AXI4-Lite Read Channel Interface Signals

Name	Direction	Description
AXI4-Lite Read Address Channel Interface Signals		
S_AXI_ARADDR[31:0]	Input	Read Address: The Read address bus gives the initial address of a Read burst transaction. Only the start address of the burst is provided and the control signals that are issued alongside the address detail how the address is calculated for the remaining transfers in the burst.
S_AXI_ARID[m:0]	Input	Read Address ID: This signal is the identification tag for the Read address group of signals. Read address ID is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration. Read address ID can be 1 to 16 bits wide.

Table 2-26: AXI4-Lite Read Channel Interface Signals (Cont'd)

Name	Direction	Description
S_AXI_ARVALID	Input	Read Address Valid: This signal indicates, when HIGH, that the Read address and control information is valid and will remain stable until the address acknowledge signal, ARREADY, is high. 1 = address and control information valid 0 = address and control information not valid
S_AXI_ARREADY	Output	Read Address Ready: This signal indicates that the slave is ready to accept an address and associated control signals: 1 = slave ready 0 = slave not ready
AXI4-Lite Read Data Channel Interface Signals		
S_AXI_RDATA[m-1:0]	Output	Read Data: For Memory Slave configurations, the Read data bus can be 32 or 64 bits wide. For Peripheral Slave configurations, the Read data bus can be 8, 16, 32 or 64 bits wide.
S_AXI_RRESP[1:0]	Output	Read Response: This signal indicates the status of the Read transfer. The allowable responses are OKAY, EXOKAY, SLVERR, and DECERR. Read response is always set to OKAY. Read response is generated only when AXI4 ID is enabled for Memory Slave. Read response is not supported for Peripheral Slave configuration.
S_AXI_RID[m:0]	Output	Read ID Tag: This signal is the ID tag of the Read data group of signals. The RID value is generated by the slave and must match the ARID value of the Read transaction to which it is responding. Read ID tag is optional for Memory Slave configuration and is not supported for Peripheral Slave configuration. Read ID tag can be 1 to 16 bits wide.
S_AXI_RVALID	Output	Read Valid: This signal indicates that the required Read data is available and the Read transfer can complete: 1 = Read data available 0 = Read data not available
S_AXI_RREADY	Input	Read Ready: This signal indicates that the master can accept the Read data and response information: 1 = Master ready 0 = Master not ready

Designing with the Core

This chapter describes the steps required to turn a Block memory Generator core into a fully functioning design integrated with the user application logic. It is important to note that depending on the configuration of the BMG core, only a subset of the implementation details provided are applicable. The guidelines in this chapter provide details about creating the most successful implementation of the core.

General Design Guidelines

The Block Memory Generator is used to build custom memory modules from block RAM primitives in Xilinx FPGAs. The core implements an optimal memory by arranging block RAM primitives based on user selections, automating the process of primitive instantiation and concatenation. Using the CORE Generator Graphical User Interface (GUI), users can configure the core and rapidly generate a highly optimized custom memory solution.

Memory Type

The Block Memory Generator creates five memory types: Single-port RAM, Simple Dual-port RAM, True Dual-port RAM, Single-port ROM, and Dual-port ROM. [Figure 3-1](#) through [Figure 3-5](#) illustrate the signals available for each type. Optional pins are displayed in italics.

For each configuration, optimizations are made within the core to minimize the total resources used. For example, a Simple Dual-port RAM with symmetric ports can utilize the special Simple Dual-port RAM primitive in Virtex-5 devices, which can save as much as fifty percent of the block RAM resources for memories 512 words deep or fewer. The Single-port ROM allows Read access to the memory space through a single port, as illustrated in [Figure 3-1](#).

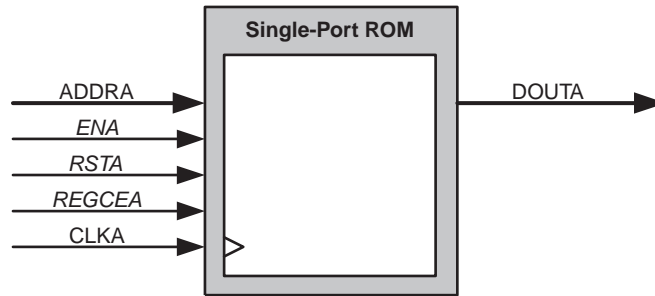


Figure 3-1: Single-port ROM

The Dual-port ROM allows Read access to the memory space through two ports, as shown in Figure 3-2.

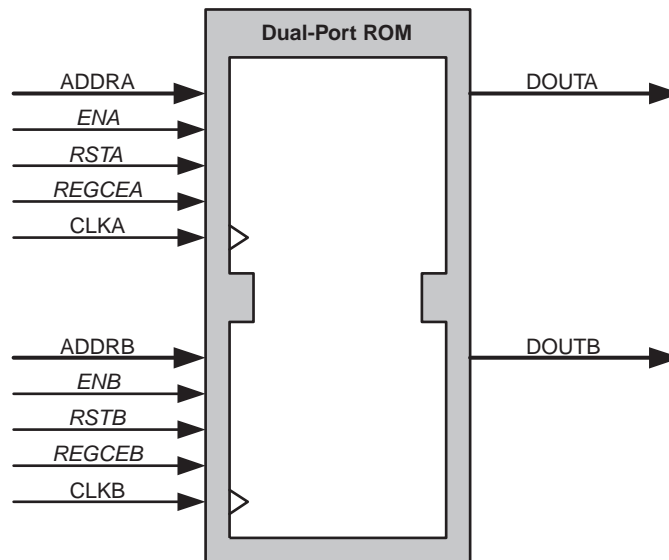


Figure 3-2: Dual-port ROM

The Single-port RAM allows Read and Write access to the memory through a single port, as shown in Figure 3-3.

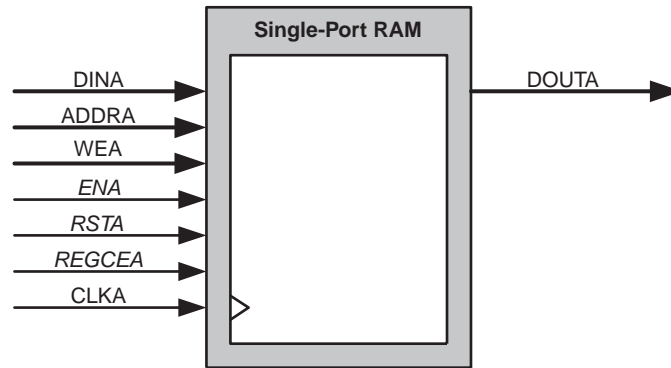


Figure 3-3: Single-port RAM

The Simple Dual-port RAM provides two ports, A and B, as illustrated in Figure 3-4. Write access to the memory is allowed via port A, and Read access is allowed via port B.

Note: For Virtex family architectures, Read access is via port A and Write access is via port B.

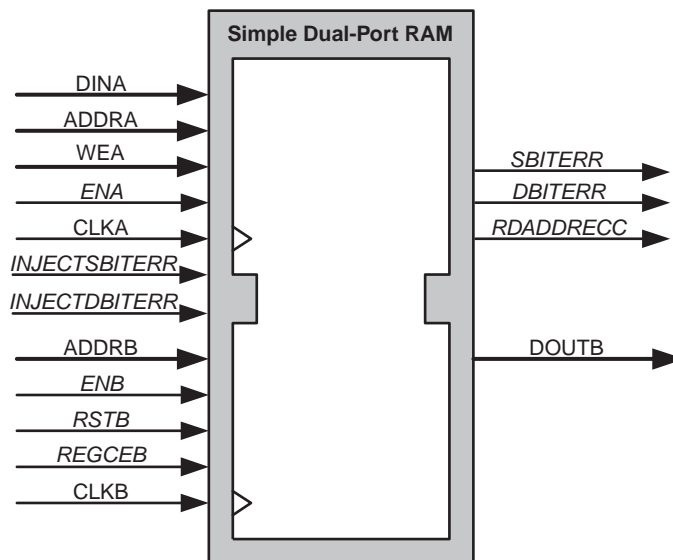


Figure 3-4: Simple Dual-port RAM

The True Dual-port RAM provides two ports, A and B, as illustrated in Figure 3-5. Read and Write accesses to the memory are allowed on either port.

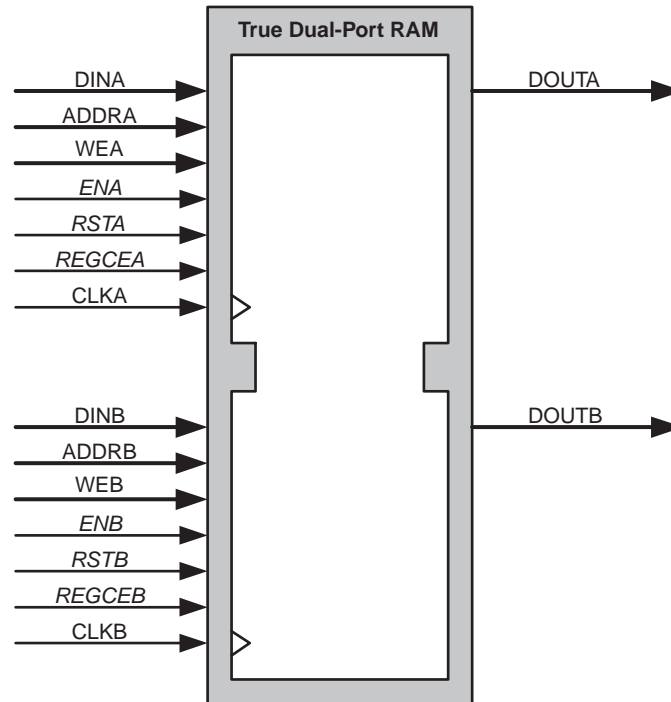


Figure 3-5: True Dual-port RAM

Selectable Memory Algorithm

The Block Memory Generator core arranges block RAM primitives according to one of three algorithms: the minimum area algorithm, the low power algorithm and the fixed primitive algorithm.

Minimum Area Algorithm

The minimum area algorithm provides a highly optimized solution, resulting in a minimum number of block RAM primitives used, while reducing output multiplexing. [Figure 3-6](#) shows two examples of memories built using the minimum area algorithm.

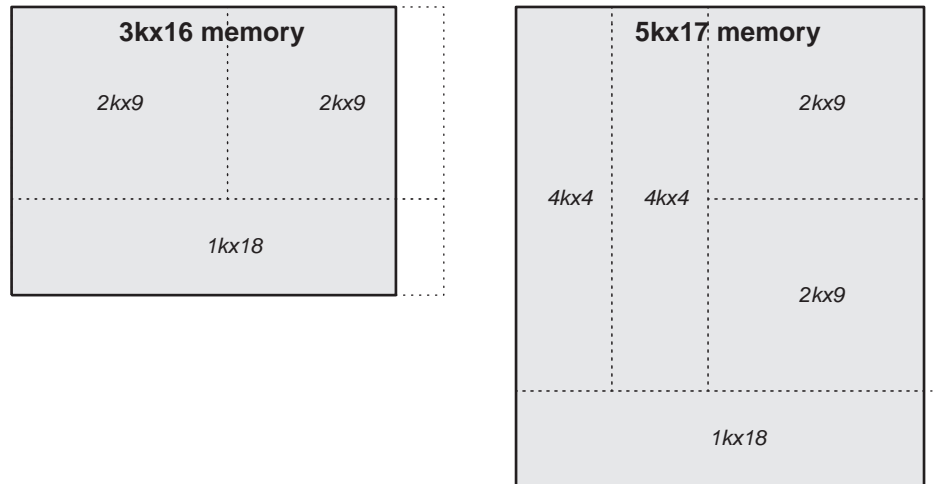


Figure 3-6: Examples of the Minimum Area Algorithm

Note: In Spartan-6 devices, two 9K block RAMs are used for one 1Kx18.

In the first example, a 3kx16 memory is implemented using three block RAMs. While it may have been possible to concatenate three 1kx18 block RAMs in depth, this would require more output multiplexing. The minimum area algorithm maximizes performance in this way while maintaining minimum block RAM usage.

In the second example, a 5kx17 memory, further demonstrates how the algorithm can pack block RAMs efficiently to use the fewest resources while maximizing performance by reducing output multiplexing.

Low Power Algorithm

The low power algorithm provides a solution that minimizes the number of primitives enabled during a Read or Write operation. This algorithm is not optimized for area and may use more block RAMs and multiplexers than the minimum area algorithm. Figure 3-7 shows two examples of memories built using the low power algorithm.

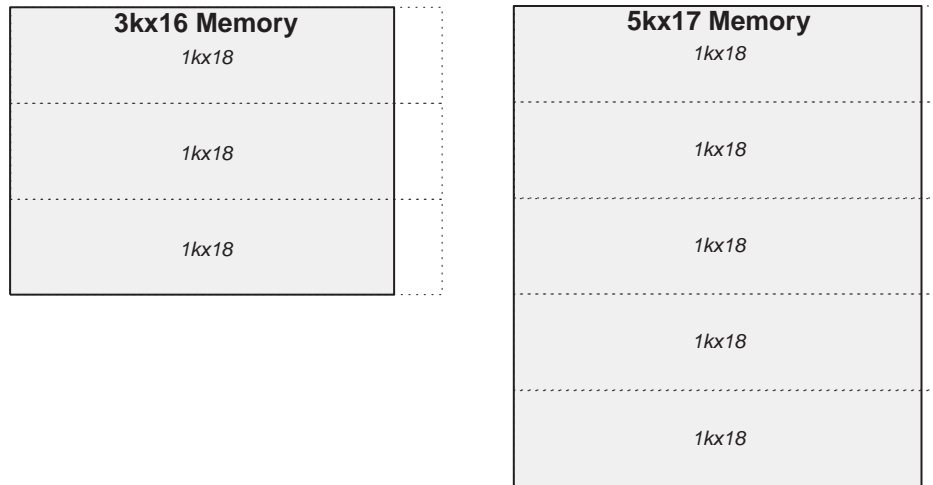


Figure 3-7: Examples of the Low Power Algorithm

Note: In Spartan-6 devices, two 9K block RAMs are used for one 1Kx18.

Fixed Primitive Algorithm

The fixed primitive algorithm allows the user to select a single block RAM primitive type. The core will build the memory by concatenating this single primitive type in width and depth. It is useful in systems that require a fixed primitive type. Figure 3-8 depicts two 3kx16 memories, one built using the 2kx9 primitive type, the other built using the 4kx4 primitive type.

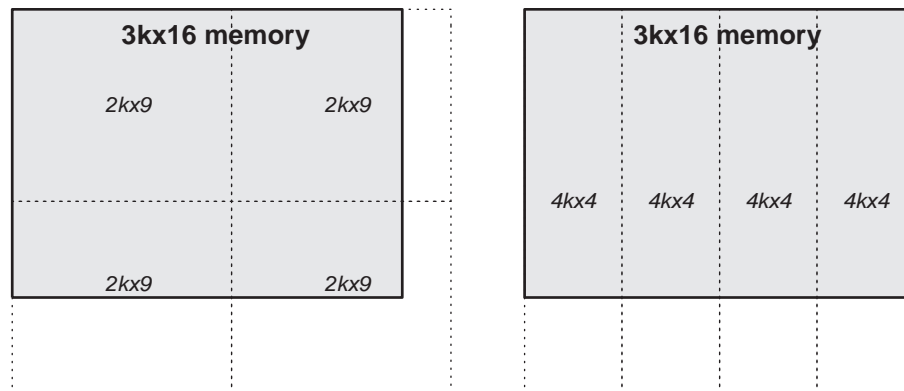


Figure 3-8: Examples of the Fixed Primitive Algorithm

Note that both implementations use four block RAMs, and that some of the resources utilized extend beyond the usable memory space. It is up to the user to decide which primitive type is best for their application.

The fixed primitive algorithm provides a choice of 16kx1, 8kx2, 4kx4, 2kx9, 1kx18, 512x36, 256x72 and 256x36 primitives. The primitive type selected is used to guide the construction of the total user memory space. Whenever possible, optimizations are made automatically

that use deeper embedded memory structures to enhance performance. Table 3-1 shows the primitives used to construct a memory given the specified architecture and primitive selection.

Table 3-1: Memory Primitives Used Based on Architecture (Supported in Native BMG)

Architecture	Primitive Selection	Primitives Used
Spartan-6 FPGA	16kx1	8kx1,16kx1
	8kx2	4kx2,8kx2
	4kx4	2kx4,4kx4
	2kx9	1kx9,2kx9
	1kx18	512x18,1kx18
	512x36	512x36
	256x72	256x72 (SP RAM/ROM configurations only)
	256x36	256x36 (SP RAM/ROM and SDP configurations only) ⁽²⁾
Spartan-3 ⁽¹⁾ FPGA	16kx1	16kx1
	8kx2	8kx2
	4kx4	4kx4
	2kx9	2kx9
	1kx18	1kx18
	512x36	512x36
	256x72	256x72 (Single Port configurations only)
	ZYNQ-7000 FPGA	16kx1
8kx2		16kx2, 8kx2
4kx4		4kx4, 8kx4
2kx9		2kx9, 4kx9
1kx18		1kx18, 2kx18
512x36		512x36 (SP RAM/ROM and SDP configurations only), 1kx36
Artix-7 FPGA		16kx1
	8kx2	16kx2, 8kx2
	4kx4	4kx4, 8kx4
	2kx9	2kx9, 4kx9
	1kx18	1kx18, 2kx18
	512x36	512x36 (SP RAM/ROM and SDP configurations only), 1kx36

Table 3-1: Memory Primitives Used Based on Architecture (Supported in Native BMG) (Cont'd)

Architecture	Primitive Selection	Primitives Used
Kintex-7 FPGA	16kx1	64x1, 32kx1, 16kx1
	8kx2	16kx2, 8kx2
	4kx4	4kx4, 8kx4
	2kx9	2kx9, 4kx9
	1kx18	1kx18, 2kx18
	512x36	512x36 (SP RAM/ROM and SDP configurations only), 1kx36
	256x72	512x72 (SP RAM/ROM and SDP configurations only)
Virtex-7 FPGA	16kx1	64x1, 32kx1, 16kx1
	8kx2	16kx2, 8kx2
	4kx4	4kx4, 8kx4
	2kx9	2kx9, 4kx9
	1kx18	1kx18, 2kx18
	512x36	512x36 (SP RAM/ROM and SDP configurations only), 1kx36
	256x72	512x72 (SP RAM/ROM and SDP configurations only)
Virtex-6 FPGA	16kx1	64x1, 32kx1, 16kx1
	8kx2	16kx2, 8kx2
	4kx4	4kx4, 8kx4
	2kx9	2kx9, 4kx9
	1kx18	1kx18, 2kx18
	512x36	512x36 (SP RAM/ROM and SDP configurations only), 1kx36 ⁽²⁾
	256x72	512x72 (SP RAM/ROM and SDP configurations only) ⁽²⁾
Virtex-5 FPGA	16kx1	64kx1, 32kx1, 16kx1
	8kx2	16kx2, 8kx2
	4kx4	8kx4, 4kx4
	2kx9	4kx9, 2kx9
	1kx18	2kx18, 1kx18
	512x36	1kx36
	256x72	512x72 (Single and Simple Dual-port RAMs and Single Port ROMs only)

Table 3-1: Memory Primitives Used Based on Architecture (Supported in Native BMG) (Cont'd)

Architecture	Primitive Selection	Primitives Used
Virtex-4 FPGA	16kx1	32kx1, 16kx1
	8kx2	8kx2
	4kx4	4kx4
	2kx9	2kx9
	1kx18	1kx18
	512x36	512x36
	256x72	256x72 (Single Port configurations only)

Notes:

1. Spartan-3 FPGAs and its derivatives, including Spartan-3E and Spartan-3A/3A DSP devices.
2. Refer to Additional memory collision restrictions in [Collision Behavior, page 59](#).

When using data-width aspect ratios, the primitive type dimensions are chosen with respect to the A port Write width. Note that primitive selection may limit port aspect ratios as described in [Aspect Ratio Limitations, page 58](#). When using the byte Write feature in Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP devices, only the 2kx9, 1kx18, and 512kx36 primitive choices are available.

Selectable Width and Depth

The Block Memory Generator generates memories with widths from 1 to 4096 bits, and with depths of two or more words. The memory is built by concatenating block RAM primitives, and total memory size is limited only by the number of block RAMs on the target device.

Write operations to out-of-range addresses are guaranteed not to corrupt data in the memory, while Read operations to out-of-range addresses will return invalid data. Note that the set/reset function should not be asserted while accessing an out-of-range address as this also results in invalid data on the output in the present or following clock cycles depending upon the output register stages of the core.

Operating Mode

The operating mode for each port determines the relationship between the Write and Read interfaces for that port. Port A and port B can be configured independently with any one of three Write modes: Write First Mode, Read First Mode, or No Change Mode. These operating modes are described in the sections that follow.

The operating modes have an effect on the relationship between the A and B ports when the A and B port addresses have a collision. For detailed information about collision behavior, see [Collision Behavior, page 59](#). For more information about operating modes, see the block RAM section of the user guide specific to the device family.

- Write First Mode:** In WRITE_FIRST mode, the input data is simultaneously written into memory and driven on the data output, as shown in [Figure 3-9](#). This transparent mode offers the flexibility of using the data output bus during a Write operation on the same port.

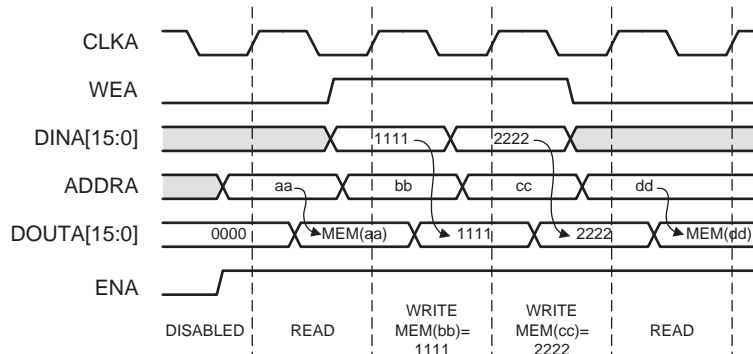


Figure 3-9: Write First Mode Example

Note: The WRITE_FIRST operation is affected by the optional byte-Write feature in Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6 and Spartan-3A/3A DSP devices. It is also affected by the optional Read-to-Write aspect ratio feature in Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 devices. For detailed information, see [Write First Mode Considerations, page 59](#).

- Read First Mode:** In READ_FIRST mode, data previously stored at the Write address appears on the data output, while the input data is being stored in memory. This Read-before-Write behavior is illustrated in [Figure 3-10](#).

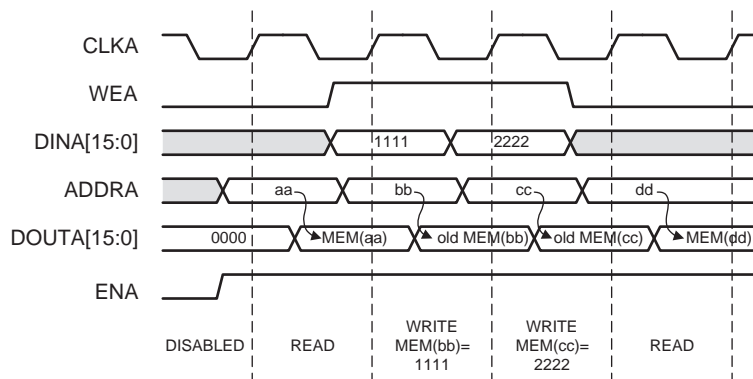


Figure 3-10: Read First Mode Example

- No Change Mode:** In NO_CHANGE mode, the output latches remain unchanged during a Write operation. As shown in [Figure 3-11](#), the data output is still the previous Read data and is unaffected by a Write operation on the same port.

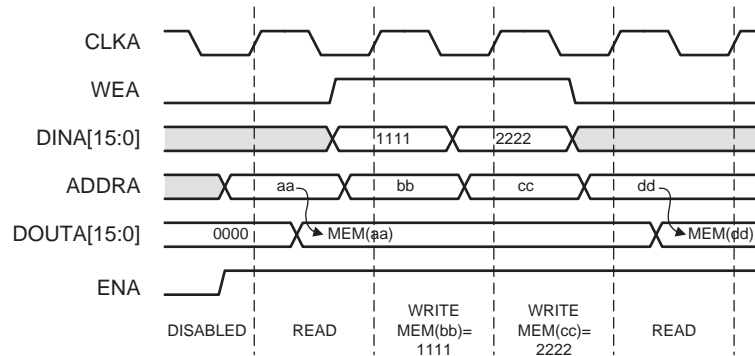


Figure 3-11: No Change Mode Example

Data Width Aspect Ratios

The Block Memory Generator supports data width aspect ratios. This allows the port A data width to be different than the port B data width, as described in Port Aspect Ratios in the following section. In Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA-based memories, all four data buses (DINA, DOUTA, DINB, and DOUTB) can have different widths, as described in [Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 Read-to-Write Aspect Ratios, page 57](#).

The limitations of the data width aspect ratio feature (some of which are imposed by other optional features) are described in [Aspect Ratio Limitations, page 58](#). The CORE Generator GUI ensures only valid aspect ratios are selected.

Port Aspect Ratios

The Block Memory Generator supports port aspect ratios of 1:32, 1:16, 1:8, 1:4, 1:2, 1:1, 2:1, 4:1, 8:1, 16:1, and 32:1. The port A data width can be up to 32 times larger than the port B data width, or vice versa. The smaller data words are arranged in little-endian format, as illustrated in [Figure 3-12](#).

Port Aspect Ratio Example

Consider a True Dual-port RAM of 32x2048, which is the A port width and depth. From the perspective of an 8-bit B port, the depth would be 8192. The ADDRA bus is 11 bits, while the ADDR_B bus is 13 bits. The data is stored little-endian, as shown in [Figure 3-12](#). Note that A_n is the data word at address n , with respect to the A port. B_n is the data word at address n with respect to the B port. A_0 is comprised of $B_3, B_2, B_1,$ and B_0 .

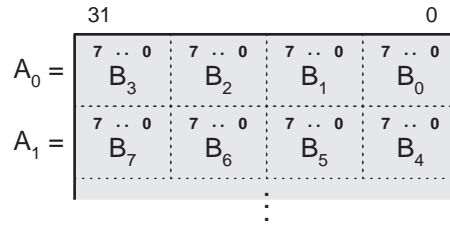


Figure 3-12: Port Aspect Ratio Example Memory Map

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 Read-to-Write Aspect Ratios

When implementing RAMs targeting Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGAs, the Block Memory Generator allows Read and Write aspect ratios on either port. On each port A and port B, the Read to Write data width ratio of that port can be 1:32, 1:16, 1:8, 1:4, 1:2, 1:1, 2:1, 4:1, 8:1, 16:1, or 32:1.

Because the Read and Write interfaces of each port can differ, it is possible for all four data buses (DINA, DOUTA, DINB, and DOUTB) of True Dual-port RAMs to have a different width. For Single-port RAMs, DINA and DOUTA widths can be independent. The maximum ratio between any two data buses is 32:1. The widest data bus can be no larger than 4096 bits.

If the Read and Write data widths on a port are different, the memory depth is different with respect to Read and Write accesses. For example, if the Read interface of port A is twice as wide as the Write interface, then it is also half as deep. The ratio of the widths is *always* the inverse of the ratio of the depths. Because a single address bus is used for both the Write and Read interface of a port, the address bus must be large enough to address the deeper of the two depths. For the shallower interface, the least significant bits of the address bus are ignored. The data words are arranged in little-endian format, as illustrated in [Figure 3-13](#).

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 Read-to-Write Aspect Ratio Example

Consider a True Dual-port RAM of 64x512, which is the port A Write width and depth. [Table 3-2](#) defines the four data-port widths and their respective depths for this example.

Table 3-2: Read-to-Write Aspect Ratio Example Ports

Interface	Data Width	Memory Depth
Port A Write	64	512
Port A Read	16	2048
Port B Write	256	128
Port B Read	32	1024

The ADDRA width is determined by the larger of the A port depths (2048). For this reason, ADDRA is 11 bits wide. On port A, Read operations utilize the entire ADDRA bus, while Write operations ignore the least significant 2 bits.

In the same way, the ADDR_B width is determined by the larger of the B port depths (1024). For this reason, ADDR_B is 10 bits wide. On port B, Read operations utilize the entire ADDR_B bus, while Write operations ignore the least significant 3 bits.

The memory map in Figure 3-13 shows how port B Write words are related to port A Write words, in a little-endian arrangement. Note that AW_{*n*} is the Write data word at address *n* with respect to port A, while BW_{*n*} is the Write data word at address *n* with respect to port B.

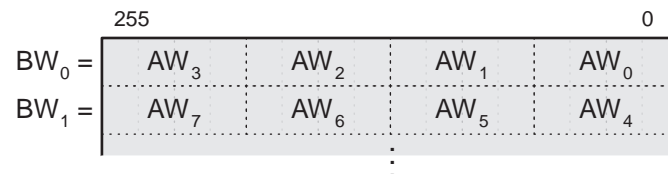


Figure 3-13: Read-to-Write Aspect Ratio Example Memory Map

BW₀ is made up of AW₃, AW₂, AW₁, and AW₀. In the same way, BR₀ is made up of AR₁ and AR₀, and AW₀ is made up of BR₁ and BR₀. In the example above, the largest data width ratio is port B Write words (256 bits) to port A Read words (16 bits); this ratio is 16:1.

Aspect Ratio Limitations

In general, no port data width can be wider than 4096 bits, and no two data widths can have a ratio greater than 32:1. However, the following optional features further limit data width aspect ratios:

- **Byte-writes:** When using byte-writes, no two data widths can have a ratio greater than 4:1.
- **Fixed primitive algorithm:** When using the fixed primitive algorithm with an N-bit wide primitive, aspect ratios are limited to 32:N and 1:N from the port A Write width. For example, using the 4x4 primitive type, the other ports may be no more than 8 times (32:4) larger than port A Write width and no less than 4 times (1:4) smaller.

Byte-Writes

The Block Memory Generator provides byte-Write support in Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP devices. Byte-writes are available using either 8-bit or 9-bit byte sizes. When using an 8-bit byte size, no parity bits are used and the memory width is restricted to multiples of 8 bits. When using a 9-bit byte size, each byte includes a parity bit, and the memory width is restricted to multiples of 9 bits.

When byte-writes are enabled, the WE[A|B] (WEA or WEB) bus is N bits wide, where N is the number of bytes in DIN[A|B]. The most significant bit in the Write enable bus corresponds to the most significant byte in the input word. Bytes will be stored in memory only if the corresponding bit in the Write enable bus is asserted during the Write operation.

When 8-bit bytes are selected, the DIN and DOUT data buses are constructed from 8-bit bytes, with no parity. When 9-bit bytes are selected, the DIN and DOUT data buses are constructed from 9-bit bytes, with the 9th bit of each byte in the data word serving as a parity bit for that byte.

The byte-Write feature may be used in conjunction with the data width aspect ratios, which may limit the choice of data widths as described in [Data Width Aspect Ratios, page 56](#). However, it may not be used with the NO_CHANGE operating mode. This is because if a memory configuration uses multiple primitives in width, and only one primitive is being written to (using partial byte writes), then the NO_CHANGE mode only applies to that single primitive. The NO_CHANGE mode does not apply to the other primitives that are not being written to, so these primitives can still be read. The byte-Write feature also affects the operation of WRITE_FIRST mode, as described in [Write First Mode Considerations, page 59](#).

Byte-Write Example

Consider a Single-port RAM with a data width of 24 bits, or 3 bytes with byte size of 8 bits. The Write enable bus, WEA, consists of 3 bits. [Figure 3-14](#) illustrates the use of byte-writes, and shows the contents of the RAM at address 0. Assume all memory locations are initialized to 0.

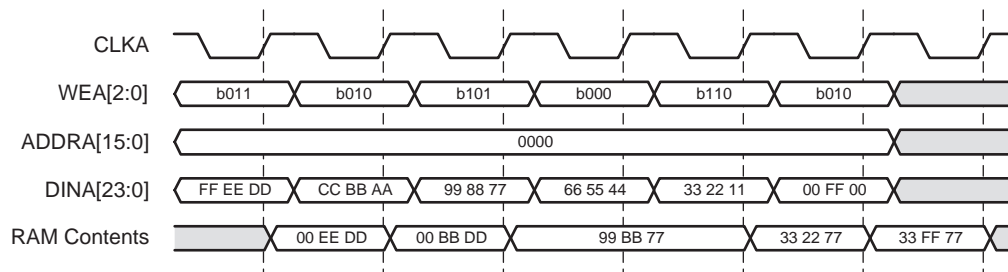


Figure 3-14: Byte-Write Example

Write First Mode Considerations

When performing a Write operation in WRITE_FIRST mode, the concurrent Read operation shows the newly written data on the output of the core. However, when using the byte-Write feature in Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP devices or the Read-to-Write aspect ratio feature in Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 devices, the output of the memory cannot be guaranteed.

Collision Behavior

The Block Memory Generator core supports Dual-port RAM implementations. Each port is equivalent and independent, yet they access the same memory space. In such an arrangement, is it possible to have data collisions. The ramifications of this behavior are described for both asynchronous and synchronous clocks below.

Collisions and Asynchronous Clocks: General Guidelines

Using asynchronous clocks, when one port writes data to a memory location, the other port must not Read or Write that location for a specified amount of time. This clock-to-clock setup time is defined in the device data sheet, along with other block RAM switching characteristics.

Collisions and Synchronous Clocks: General Guidelines

Synchronous clocks cause a number of special case collision scenarios, described below.

- Synchronous Write-Write Collisions:** A Write-Write collision occurs if both ports attempt to Write to the same location in memory. The resulting contents of the memory location are unknown. Note that Write-Write collisions affect memory content, as opposed to Write-Read collisions which only affect data output.
- Using Byte-Writes:** When using byte-writes, memory contents are not corrupted when separate bytes are written in the same data word. RAM contents are corrupted only when both ports attempt to Write the same byte. [Figure 3-15](#) illustrates this case. Assume $ADDR_A = ADDR_B = 0$.

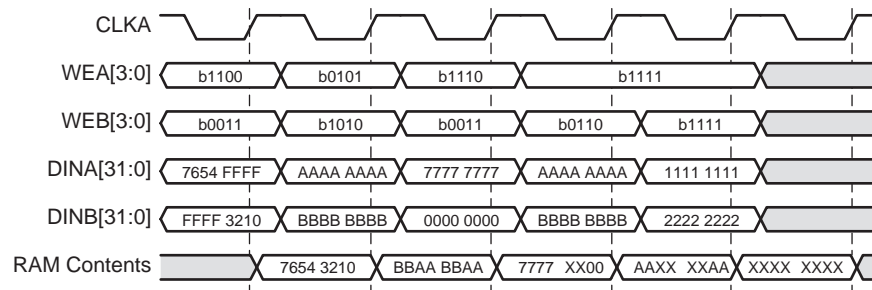


Figure 3-15: Write-Write Collision Example

- Synchronous Write-Read Collisions:** A synchronous Write-Read collision may occur if a port attempts to Write a memory location and the other port reads the same location. While memory contents are not corrupted in Write-Read collisions, the validity of the output data depends on the Write port operating mode.
 - If the Write port is in READ_FIRST mode, the other port can reliably read the old memory contents.
 - If the Write port is in WRITE_FIRST or NO_CHANGE mode, data on the output of the Read port is invalid.
 - In the case of byte-writes, only bytes which are updated will be invalid on the Read port output.

[Figure 3-16](#) illustrates Write-Read collisions and the effects of byte-writes. DOUTB is shown for when port A is in WRITE_FIRST mode and READ_FIRST mode. Assume $ADDR_A = ADDR_B =$

0, port B is always reading, and all memory locations are initialized to 0. The RAM contents are never corrupted in Write-Read collisions.

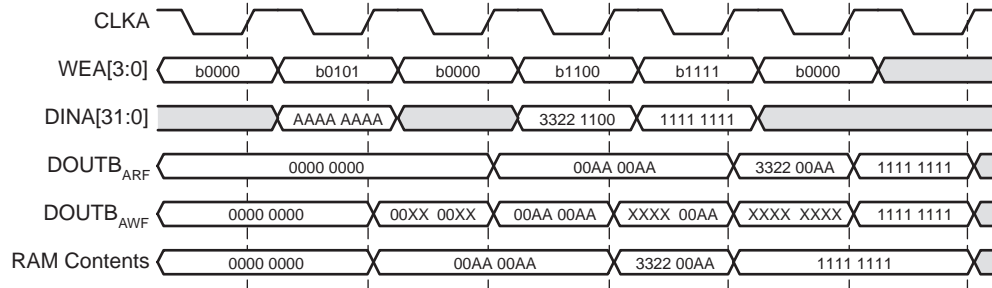


Figure 3-16: Write-Read Collision Example

Collisions and Simple Dual-port RAM

For Simple Dual-port RAM, the operating modes are not selectable, but are automatically set to either READ_FIRST or WRITE_FIRST depending on the target device family and clocking configuration (synchronous or asynchronous). The Simple Dual-port RAM is like a true dual-port RAM where only the Write interface of the A port and the Read interface of B port are connected. The operating modes define the Write-to-Read relationship of the A or B ports, and only impact the relationship between A and B ports during an address collision.

For Synchronous Clocking and during a collision, the Write mode of port A can be configured so that a Read operation on port B either produces data (acting like READ_FIRST), or produces undefined data (Xs). For this reason, the core is hard-coded to produce READ_FIRST-like behavior when configured as a Simple Dual-port RAM. For detailed information about this behavior, see [Collision Behavior, page 59](#).

Exceptions: For Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices, the operating mode (READ_FIRST or WRITE_FIRST respectively) is determined by whether the clocking mode selection is Synchronous (Common Clock) or Asynchronous. See [Clocking Options: Select the Common Clock option when the clock \(CLKA and CLKB\) inputs are driven by the same clock buffer. in Chapter 7](#) for more details.

Additional Memory Collision Restrictions: Address Space Overlap

Virtex-6 and Spartan-6 FPGA block RAM memories have additional collision restrictions in the following configurations:

- When configured as True Dual Port (TDP)
- When CLKA (port A) and CLKB (port B) are Asynchronous
- In applications that perform a simultaneous Read and Write

- When either port A, port B, or both ports are configured with Write Mode configured as READ_FIRST

When using TDP Memory with Write Mode = READ_FIRST (TDP-RF mode) in conjunction with asynchronous clocking, see the "Conflict Avoidance" section of the *7 Series FPGAs Memory Resources User Guide* (UG473), the *Virtex-6 FPGA Memory Resources User Guide* (UG363) or the *Spartan-6 FPGA Block RAM Resources User Guide* (UG383).

For Virtex-6 and Spartan-6 devices using the TDP-RF mode, the Address Space Overlap issue must be considered.

Optional Output Registers

The Block Memory Generator allows optional output registers, which may improve the performance of the core. The user may choose to include register stages at two places: at the output of the block RAM primitives and at the output of the core.

Registers at the output of the block RAM primitives reduce the impact of the clock-to-out delay of the primitives. Registers at the output of the core isolate the delay through the output multiplexers, improving the clock-to-out delay of the Block Memory Generator core. Each of the two optional register stages can be chosen for port A and port B separately. Note that each optional register stage used adds an additional clock cycle of latency to the Read operation.

Figure 3-17 shows a memory configuration with registers at the output of the memory primitives and at the output of the core for one of the ports.

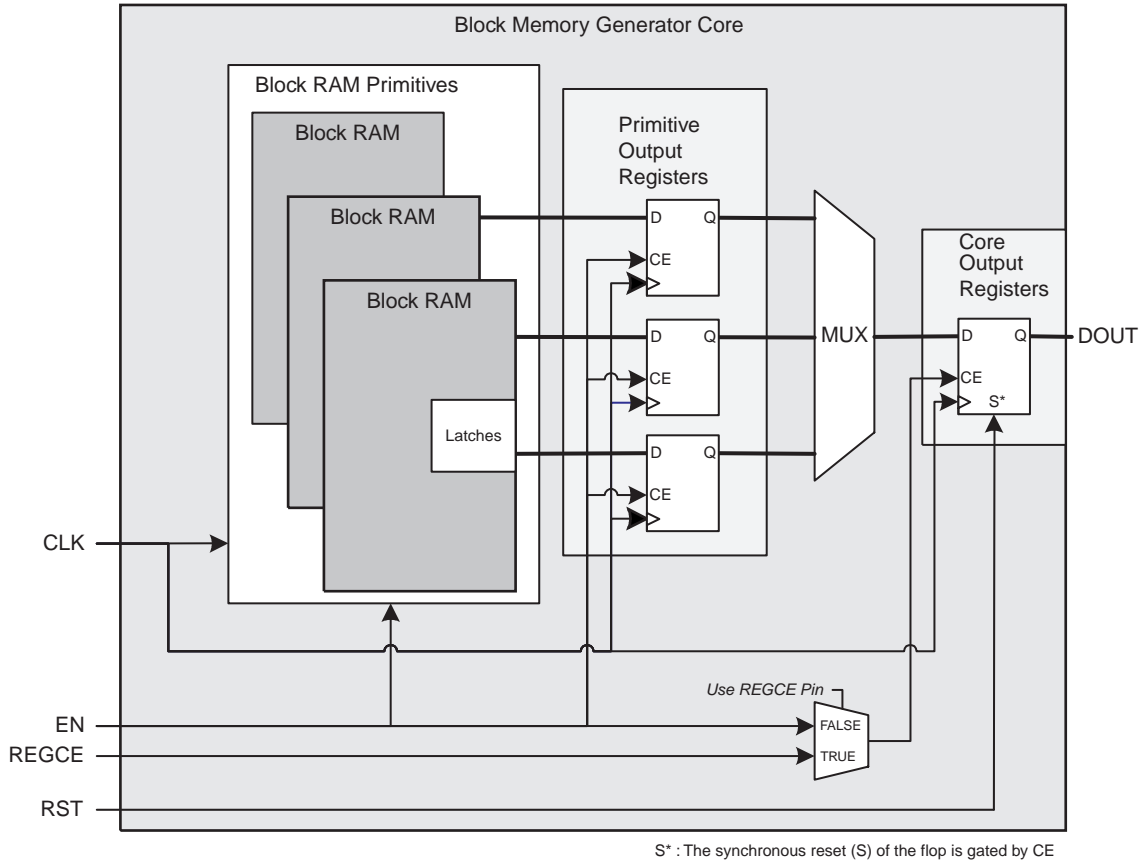


Figure 3-17: Spartan-3 Block Memory: Register Port [A|B] Outputs of Memory Primitives and Memory Core Options Enabled

For Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A DSP FPGAs, the Register Port [A|B] Output of Memory Primitives option may be implemented using the embedded block RAM registers, requiring no further FPGA resources. All other register stages are implemented in FPGA fabric. Figure 3-18 shows an example of a Zynq-7000, 7 series, Virtex-6, Virtex-5 or Virtex-4 FPGA-based memory that has been configured using both output register stages for one of the ports.

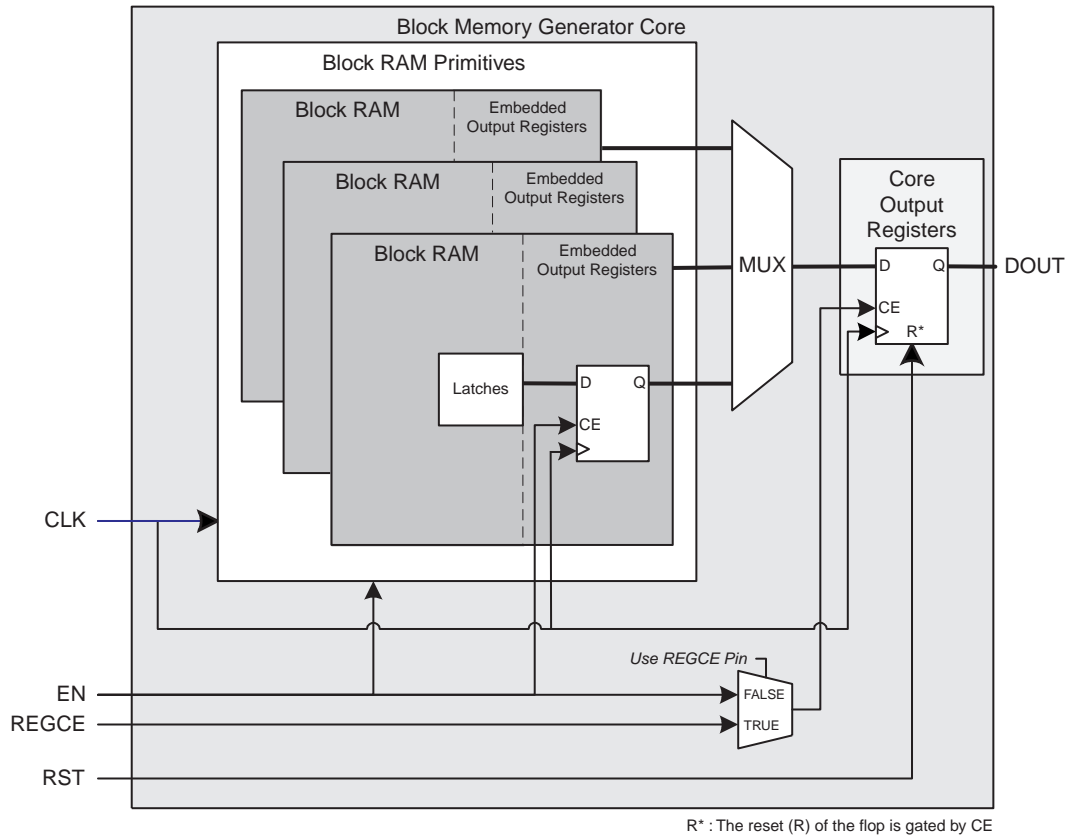


Figure 3-18: Zynq-7000, 7 Series, Virtex-6, Virtex-5, and Virtex-4 Block Memory with Register Port [A|B] Output of Memory Primitives and Register Port [A|B] Output of Memory Core Options Enabled

When using the Synchronous Reset Input (RST), the behavior of the embedded output registers in the Spartan-3A DSP FPGA differs slightly from the configuration shown in [Figure 3-18](#). By default, the Block Memory Generator builds the memory output register in the FPGA fabric to maintain functionality compatibility with Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA configurations. To force the core to use the embedded output registers in Spartan-6 and Spartan-3A DSP devices, the Reset Behavior options are provided. For a complete description of the supported output options, see [Output Register Configurations in Appendix D](#).

Optional Pipeline Stages

The Block Memory Generator core allows optional pipeline stages within the MUX, which may improve core performance. Users can add up to three pipeline stages within the MUX, excluding the registers at the output of the core. This optional pipeline stages option is available only when the registers at the output of the memory core are enabled and when the constructed memory has more than one primitive in depth, so that a MUX is needed on the output.

The pipeline stages are common for port A and port B and can be a value of 1, 2, or 3 if the Register Output of Memory Core option is selected in the GUI for both port A and port B. Note that each pipeline stage adds an additional clock cycle of latency to the Read operation.

If the configuration has BuiltIn_ECC (ECC), the SBITERR and DBITERR outputs are delayed to align with DOUT. Note that adding pipeline stages within the MUX improves performance only if the critical path in the design is the data through the MUX. The MUX size displayed in the GUI can be used to determine the number of pipeline stages to use within the MUX. See [Optional Output Registers in Chapter 7](#) for detailed information. [Figure 3-19](#) shows a memory configuration with an 8:1 MUX and two pipeline stages within the MUX. In the figure, the 8:1 MUX is pipelined internally with two register stages.

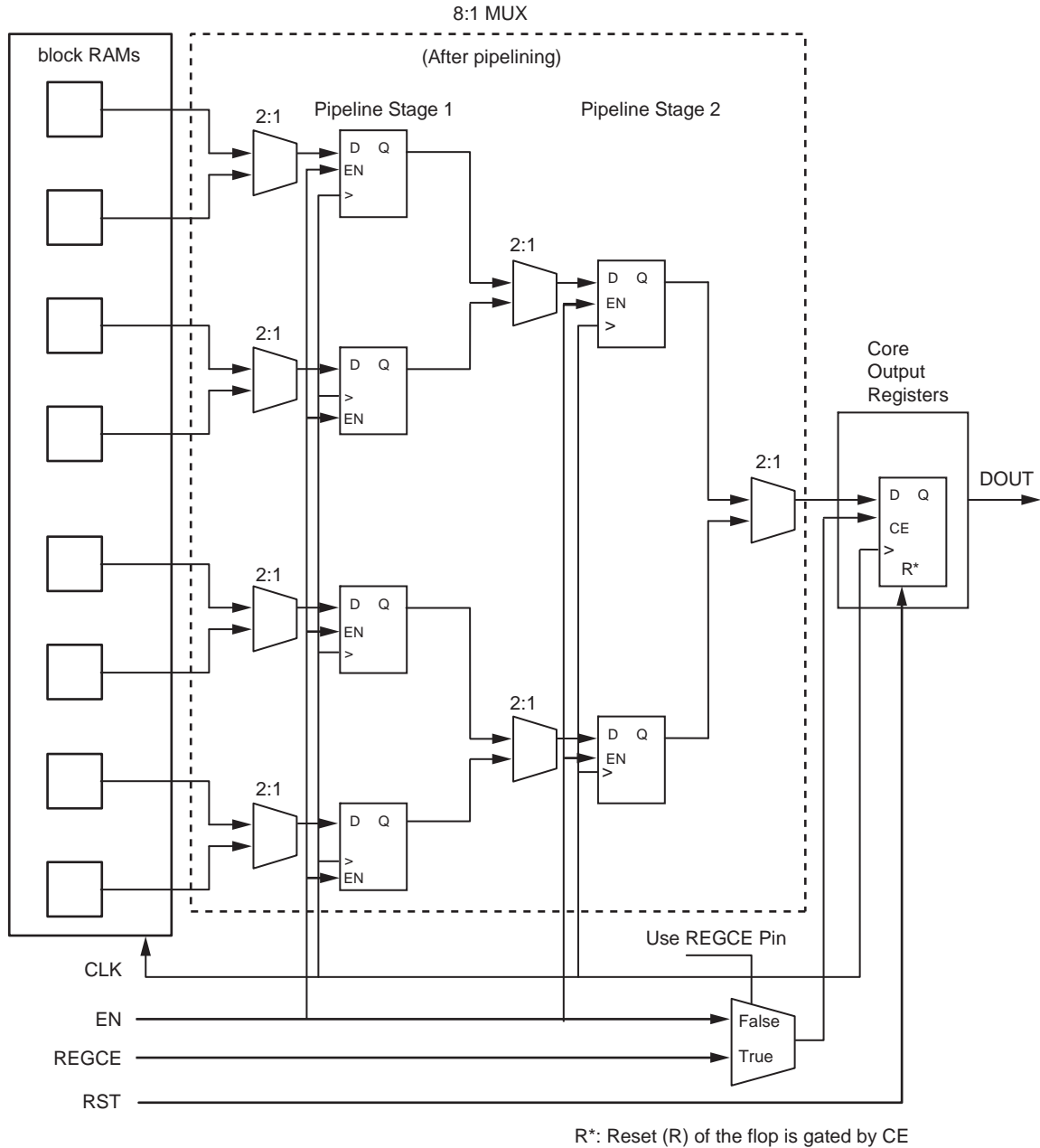


Figure 3-19: Memory Configuration with 8:1 MUX and Two Pipeline Stages within the MUX

Note: The Enable signal must be connected to each pipeline stage in the core and must be asserted for N clock cycles, where N is the number of pipeline stages.

Optional Register Clock Enable Pins

The optional output registers are enabled by the EN signal by default. However, when the Use REGCEA/REGCEB Pin option is selected, the output register stage of the corresponding port is controlled by the REGCEA/REGCEB pins; the data output from the core can be

controlled independent of the flow of data through the rest of the core. When using the REGCE pin, the last output register operates independent of the EN signal.

Optional Set/Reset Pins

The set/reset pins (RSTA and RSTB) control the reset operation of the last register in the output stage. For memories with no output registers, the reset pins control the memory output latches.

When RST and REGCE are asserted on a given port, the data on the output of that port is driven to the reset value defined in the CORE Generator GUI. (The reset occurs on RST and EN when the Use REGCE Pin option is not selected.)

- For Virtex-4 FPGAs, if the option to use the set/reset pin is selected in conjunction with memory primitive registers and without core output registers, the Virtex-4 embedded block RAM registers are not utilized for the corresponding port and are implemented in the FPGA logic instead.
- For Zynq-7000, 7 series, Virtex-6, Spartan-6, and Spartan-3A DSP FPGAs, the set/reset behavior differs when the reset behavior option is selected. However, this option saves resources by using the embedded output registers available in the Spartan-6 and Spartan-3A DSP primitives. See [Special Reset Behavior, page 69](#) for more information.

Memory Output Flow Control

The combination of the enable (EN), reset (RST), and register enable (REGCE) pins allow a wide range of data flows in the output stage. Figure 3-20 and Figure 3-21 are examples on how this can be accomplished. Keep in mind that the RST and REGCE pins apply only to the last register stage.

Figure 3-20 depicts how RST can be used to control the data output to allow only intended data through. Assume that both output registers are used for port A, the port A reset value is 0xFFFF, and that EN and REGCE are always asserted. The data on the block RAM memory latch is labeled LATCH, while the output of the block RAM embedded register is labeled REG1. The output of the last register is the output of the core, DOUT.

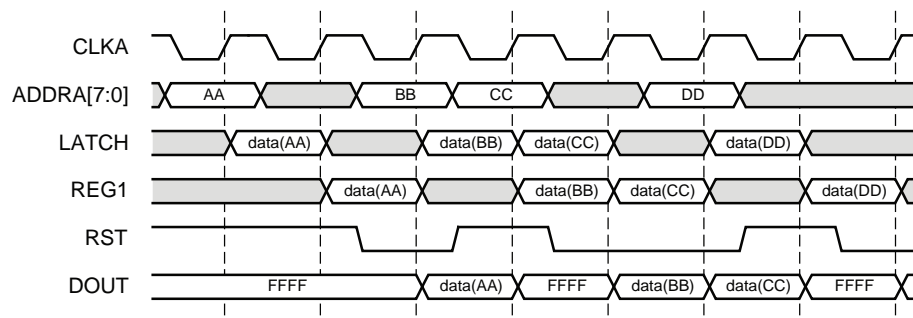


Figure 3-20: Flow Control Using RST

Figure 3-21 depicts how REGCE can be used to latch the data output to allow only intended data through. Assume that only the memory primitive registers are used for port A, and that EN is always asserted and RST is always deasserted. The data on the block RAM memory latch is labeled latch, while the output of the last register, the block RAM embedded register, is the core output, DOUT.

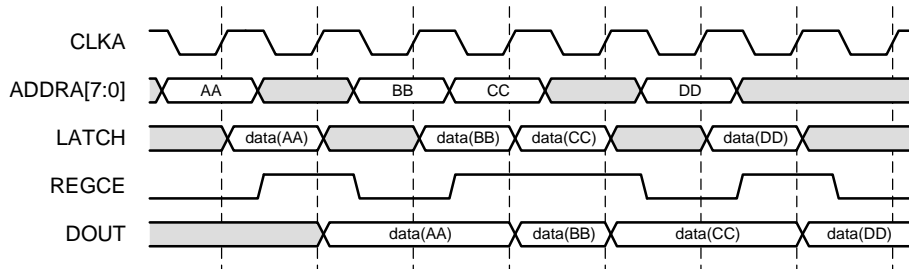


Figure 3-21: Flow Control Using REGCE

Reset Priority

For Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices, the Block Memory Generator core provides the option to choose the reset priority of the output stages of the Block Memory. In previous architectures such as Spartan-3A DSP and Virtex-5 devices, EN had a fixed priority over SSR (Synchronous Set Reset) for the memory latch, and REGCE (Register Clock Enable) had a fixed priority over SSR for embedded registers.

In Spartan-6 devices, when a user chooses the Reset Priority as CE, then the enable signal (ENA or ENB) has a priority over the reset signal (RSTA or RSTB) for the memory latch, and the CE signal (REGCEA or REGCEB) has a priority over the reset signal for the output registers. When Reset Priority is chosen as SR, then the reset signal has a priority over the enable signal and the CE signal, in the case of the latch and output registers respectively.

In Zynq-7000, 7 series, and Virtex-6 devices, reset priority can be set only for the output registers and not for the memory latch. When CE is the selected priority, then CE (REGCEA or REGCEB) has a priority over reset (RSTA or RSTB). When SR is the selected reset priority, then reset has a priority over CE.

Figure 3-22 illustrates the reset behavior when the Reset Priority option is set to CE. Here, the first reset operation occurs successfully because EN is high, but the second reset operation does not cause any change in output because EN is low.

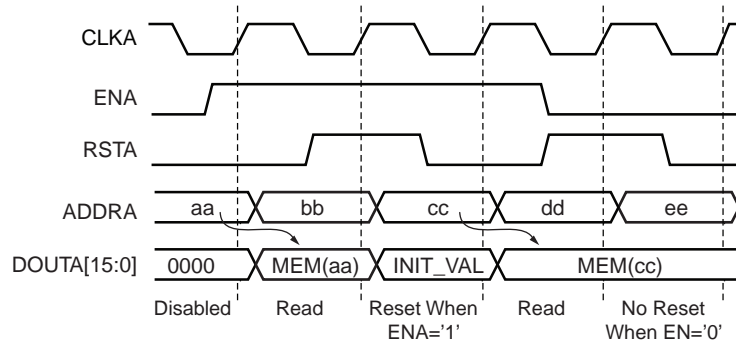


Figure 3-22: Reset Behavior When Reset Priority is Set to CE

Figure 3-23 illustrates the reset behavior when the Reset Priority option is set to SR. Here, reset is not dependent on enable and both reset operations occur successfully.

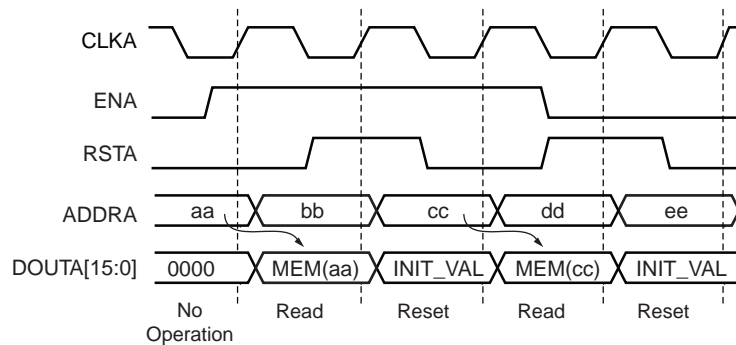


Figure 3-23: Reset Behavior When Reset Priority is Set to SR

Special Reset Behavior

For Zynq-7000, 7 series, Virtex-6, Spartan-6, and Spartan-3A DSP devices, the Block Memory Generator provides the option to reset both the memory latch and the embedded primitive output register. This Reset Behavior option is available to users when they choose to have a primitive output register, but no core output register. When a user chooses the option to Reset the Memory Latch besides the primitive output register, then the reset value is asserted at the output for two clock cycles. However, when the user does not choose the option to Reset the Memory Latch in the presence of a primitive output register, the reset value is asserted at the output for only one clock cycle, since only the primitive output register is reset.

Note that the duration of reset assertion specified here is the minimum duration when the latch and register are always enabled, and the RST input is held high for only one clock cycle. If the enable signals are de-asserted or the RST input is held high for more than one clock cycle, the reset value may be asserted at the output for a longer duration.

In Zynq-7000, 7 series, and Virtex-6 devices, the latch and the embedded output register can be reset independently using two separate inputs (RSTREG and RSTRAM) that are

connected to the primitive. So, if the user does not choose to reset the memory latch, only the embedded output register is reset.

In Spartan-6 and Spartan-3A DSP, the same reset signal (RST) is connected to both the latch and the embedded output register. So, if the user does not choose to reset the memory latch, the primitive output register needs to be constructed out of fabric to get the desired behavior. Thus in Spartan-6 and Spartan-3A DSP devices, by choosing the option to reset the memory latch, the reset behavior is modified slightly but resources are saved since the embedded register is used.

Figure 3-24 and Figure 3-25 illustrate the difference between the standard reset behavior similar to previous architectures obtained when the memory latch is not reset, and the special reset behavior in the new architectures, obtained when the memory latch is reset. Note that there is an extra clock cycle of latency in the data output because of the presence of the primitive output register.

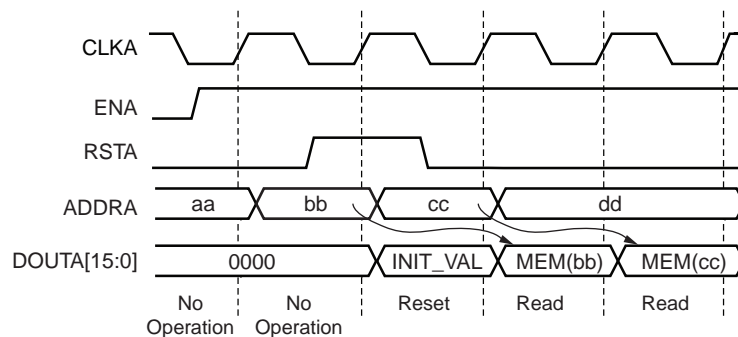


Figure 3-24: Standard Reset Behavior Similar to Previous Architectures

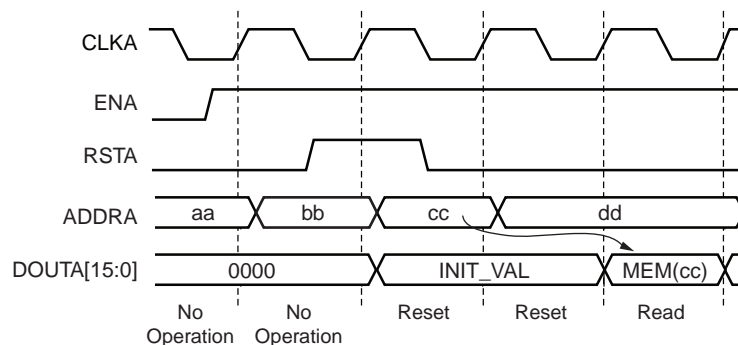


Figure 3-25: Special Reset Behavior using the Reset Memory Latch Option

The special reset behavior of Spartan-3A DSP devices also differs from standard reset behavior in that the reset of the latch and embedded output register is gated by the EN input to the core, independent of the state of $REGCE$. As shown in Figure 3-26, the enable input is low during the first reset, and therefore the reset value is not asserted at the output. However during the second reset, the ENA input is high, and the reset value is asserted at the output for two clock cycles.

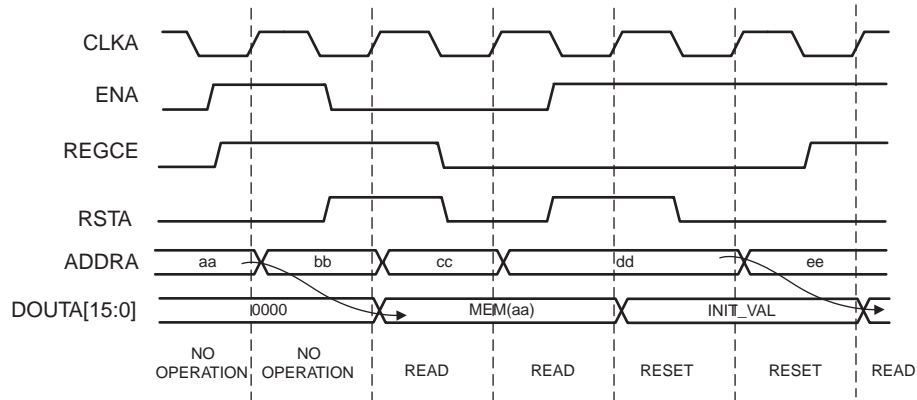


Figure 3-26: Reset Gated by EN in Spartan-3A DSP Devices with the Reset Memory Latch Option

In Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices, the reset of the memory latch is gated by EN, and the reset of the embedded register is gated by CE, similar to other architectures. As shown in Figure 3-27, both ENA and REGCEA are high at the time of the first reset, and the reset value is asserted at the output for two clock cycles. At the time of the second reset, ENA is high, but REGCEA is low; so the reset value does not appear at the output. At the time of the third reset, only REGCEA is high; so the reset value is asserted at the output for only one clock cycle.

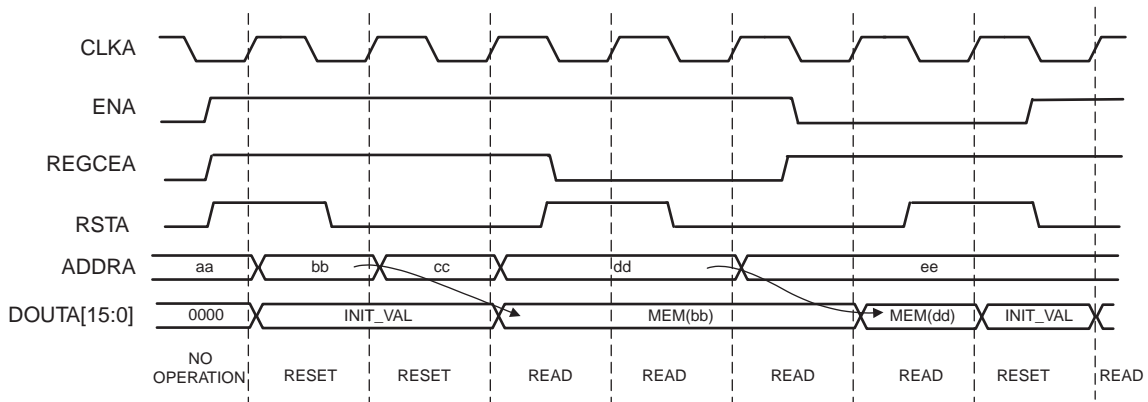


Figure 3-27: Reset Gated by CE in Zynq-7000, 7 Series, Virtex-6, and Spartan-6 Devices with Reset Memory Latch Option

Asynchronous Reset

The Spartan-6 device architecture provides the ability to asynchronously reset the memory latch and embedded output register. The Block Memory Generator core extends this capability to the core output registers and the primitive output registers constructed out of fabric. The GUI provides the option to choose between the two reset types: synchronous and asynchronous. When using an asynchronous reset, the reset value is asserted immediately when the reset input goes high, but is deasserted only at the following clock edge when reset is low and enable is high. Figure 3-28 illustrates an asynchronous reset operation in Spartan-6 devices.

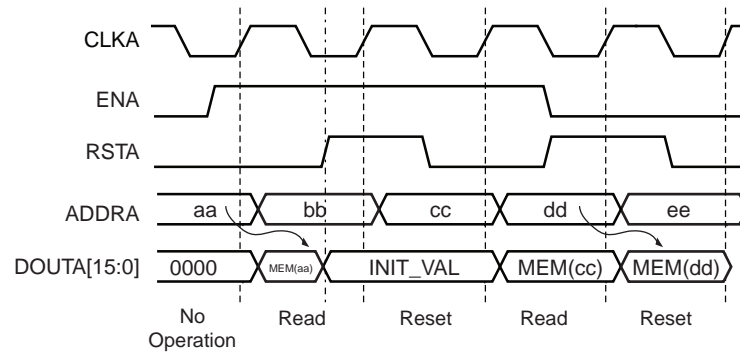


Figure 3-28: Asynchronous Reset

Controlling Reset Operations in Zynq-7000, 7 Series, Virtex-6, and Spartan-6 FPGAs

The reset operation in Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices is dependent on the following generics:

- **Use RST[A|B] Pin:** These options determine the presence or absence of RST pins at the output of the core.
- **Reset Memory Latch (for Port A and Port B):** This option determines if the memory latch will be reset in addition to the embedded primitive output register for the respective port.
- **Reset Priority (for Port A and Port B):** This option determines the priority of clock enable over reset or reset over clock enable for the respective port.
- **Reset Type:** This option determines if the reset is synchronous or asynchronous in Spartan-6 devices.

In addition to the above options, the options of output registers also affects reset functionality, since the option to reset the memory latch depends on these options. Table 3-3 lists the dependency of the reset behavior for Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices on these parameters. In these configurations, the core output register does not exist. The reset behavior detailed in Table 3-3 uses Port A as an example. The reset behavior for Port B is identical.

Table 3-3: Control of Reset Behavior in Zynq-7000, 7 Series, Virtex-6, and Spartan-6 for Single Port

Use RSTA Pin	Register Port A Output of Memory Primitives	Reset Memory Latch	Reset Priority for Port A	Reset Type (Spartan-6 Only)	S6 RESET BEHAVIOR	V6 RESET BEHAVIOR
0	X	X	X	X	No control over reset	No control over reset
1	0	(cannot be selected)	"CE", "SR"	"SYNC", "ASYNC"	Since no primitive output register exists, the reset applies only to the latch. Reset occurs synchronously or asynchronously depending on the Reset Type option, and is dependent or independent of the input enable signal based upon the Reset Priority. The reset value is asserted for only one clock cycle (only if input RST signal is high for only one clock and EN is high continuously).	Since no primitive output register exists, the reset applies only to the latch. For Zynq-7000, 7 series, and Virtex-6, the priority of SR cannot be set for the latch. Therefore, reset occurs synchronously when the enable input is '1'. The reset value is asserted for only one clock cycle (only if input RST signal is high for only one clock and EN is high continuously).
1	1	0	"CE"	"SYNC", "ASYNC"	Fabric register used. Reset occurs synchronously or asynchronously depending on the Reset Type option, and is dependent or independent of the input enable signal based on the Reset Priority. Reset value asserted for one clock cycle (only if input RST signal is high for only one clock and REGCE is high continuously).	For Zynq-7000, 7 series, and Virtex-6 devices, the priority cannot be set for the latch. Therefore reset priority of "SR" is not supported. Reset occurs synchronously, and is dependent or independent of the input enable signal. Reset value asserted for one clock cycle (only if input RST signal is high for only one clock and REGCE is high continuously).

Table 3-3: Control of Reset Behavior in Zynq-7000, 7 Series, Virtex-6, and Spartan-6 for Single Port (Cont'd)

Use RSTA Pin	Register Port A Output of Memory Primitives	Reset Memory Latch	Reset Priority for Port A	Reset Type (Spartan-6 Only)	S6 RESET BEHAVIOR	V6 RESET BEHAVIOR
1	1	1	"CE", "SR"	"SYNC", "ASYNC"	Both memory latch and embedded output register of primitive are reset. Reset occurs synchronously or asynchronously depending on the Reset Type option, and is dependent or independent of the input enable signal based upon the Reset Priority. Reset value is asserted for at least two clock cycles when enable inputs of both stages are '1', and may be more depending on the input RST and enable signals. If RST is asserted when the latch EN input is '1' and the register enable input is '0', the memory latch alone gets reset and this reset value gets output only when the register enable goes high.	For Zynq-7000, 7 series, and Virtex-6 devices, the priority cannot be set for the latch. Therefore reset priority of "SR" is not supported. Both memory latch and embedded output register of primitive are reset. Reset occurs synchronously at both these stages, and is dependent or independent of the input enable signal. Reset value is asserted for at least two clock cycles when enable inputs of both stages are '1', and may be more depending on the input RST and enable signals. If RST is asserted when the latch EN input is '1' and the register enable input is '0', the memory latch alone gets reset and this reset value gets output only when the register enable goes high.
1	1	0	"SR"	"SYNC", "ASYNC"	Fabric register used. Reset occurs synchronously or asynchronously when the RST input is '1', irrespective of the state of the enable input. However, the reset value will get deasserted synchronously only once the enable input is '1'.	Not applicable.

Table 3-3: Control of Reset Behavior in Zynq-7000, 7 Series, Virtex-6, and Spartan-6 for Single Port (Cont'd)

Use RSTA Pin	Register Port A Output of Memory Primitives	Reset Memory Latch	Reset Priority for Port A	Reset Type (Spartan-6 Only)	S6 RESET BEHAVIOR	V6 RESET BEHAVIOR
1	1	1	"SR"	"SYNC", "ASYNC"	Reset occurs synchronously or asynchronously when the RST input is '1', irrespective of the state of the enable input. However, the reset value will get deasserted synchronously when the latch and embedded register are enabled sequentially for at least one clock cycle each after the reset input is deasserted.	Not applicable.
1	X	X	"SR", "CE"	ASYNC	Reset occurs asynchronously when the RST input is '1'. Dependencies on the remaining options are as explained above.	Not applicable.

Built-in Error Correction Capability and Error Injection

For Zynq-7000, 7 series, Virtex-6, and Virtex-5 devices, the Block Memory Generator core supports built-in Hamming Error Correction Capability (ECC) for the block RAM primitives. For device support, see Table 3-4. Each Write operation generates eight protection bits for every 64 bits of data, which are stored with the data in memory. These bits are used during each Read operation to correct any single-bit error, or to detect (but not correct) any double-bit error.

Table 3-4: Hard ECC Data width Support

	Zynq-7000	7 Series	Virtex-6	Virtex-5	Spartan-6
Block RAM Mode	SDP Mode + Read First	SDP Mode + Read First	SDP Mode + Read First	SDP Mode + No Change	n/a
Supported Data Widths	≥ 64	≥ 64	≥ 64	≥ 64	n/a
Bit Error Insertion Support	Yes	Yes	Yes	No	n/a

This operation is transparent to the user. Two status outputs (SBITERR and DBITERR) indicate the three possible Read results: no error, single error corrected, and double error detected. For single-bit errors, the Read operation does not correct the error in the memory array; it only presents corrected data on DOUT. BuiltIn_ECC is only available when the following options are chosen:

- Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGAs
- Simple Dual-port RAM memory type

When using BuiltIn_ECC, the Block Memory Generator constructs the memory from special primitives available in Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGA architectures. The BuiltIn_ECC memory block is 512x64, and is composed of two 18k block RAMs combined with dedicated BuiltIn_ECC encoding and decoding hardware. The 512x64 primitives are used to build memory sufficient for the desired user memory space.

The Zynq-7000, 7 series, Virtex-6, and Virtex-5 BuiltIn_ECC primitives calculate BuiltIn_ECC for a 64-bit wide data input. If the data width chosen by a user is not an integral multiple of 64 (for example, there are spare bits in any BuiltIn_ECC primitive), then a double-bit error (DBITERR) may indicate that one or more errors have occurred in the spare bits. So, the accuracy of the DBITERR signal cannot be guaranteed in this case. For example, if the user's data width is 32, then 32 bits of the primitive are left spare. If two of the spare bits are corrupted, the DBITERR signal would be asserted even though the actual user data is not corrupt.

When using BuiltIn_ECC, the following limitations apply:

- Byte-Write enable is not available
- All port widths must be identical
- For Virtex-5 devices, No Change Operating mode is supported, and for Zynq-7000, 7 series, Virtex-6, and Virtex-5 devices, Read First Operating Mode is supported
- Use RST[A|B] Pin and the Output Reset Value options are not available
- Memory Initialization is not supported
- No Algorithm selection is available

Figure 3-29 illustrates a typical Write and Read operation for a Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGA Block Memory Generator core in Simple Dual-port RAM mode with BuiltIn_ECC enabled, and no additional output registers.

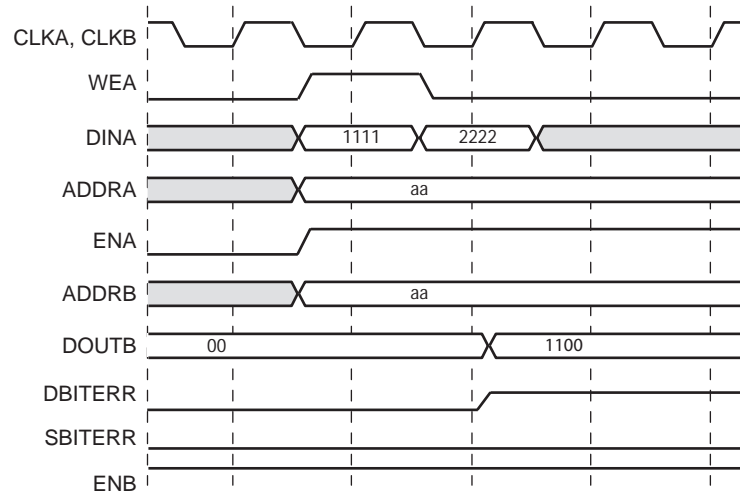


Figure 3-29: Read and Write Operation with BuiltIn_ECC in Zynq-7000, 7 Series, Virtex-6, and Virtex-5 FPGAs

Error Injection

For Virtex-5, the Block Memory Generator core does not support the insertion of errors for correction by BuiltIn_ECC in simulation. For this reason, the simulated functionality of ECC is identical to non-ECC behavior with the SBITERR and DBITERR outputs always disabled.

Zynq-7000, 7 series, and Virtex-6 devices, however, support error injection through two new optional pins: INJECTSBITERR and INJECTDBITERR. Users can use these optional error injection pins as debug pins to inject single or double-bit errors into specific locations during Write operations. The user can then check the assertion of the SBITERR and DBITERR signals at the output of those addresses. The user has the option to have no error injection pins, or to have only one or both of the error injection pins.

The RDADDRECC output port indicates the address at which a SBITERR or DBITERR has occurred. The RDADDRECC port, the two error injection ports, and the two error output ports are optional and become available only when the BuiltIn_ECC option is chosen. If the BuiltIn_ECC feature is not selected by the user, the primitive's INJECTSBITERR and INJECTDBITERR ports are internally driven to '0', and the primitive's outputs SBITERR, DBITERR, and RDADDRECC are not connected externally.

Figure 3-30 shows the assertion of the SBITERR and DBITERR output signals when errors are injected through the error injection pins during a Write operation.

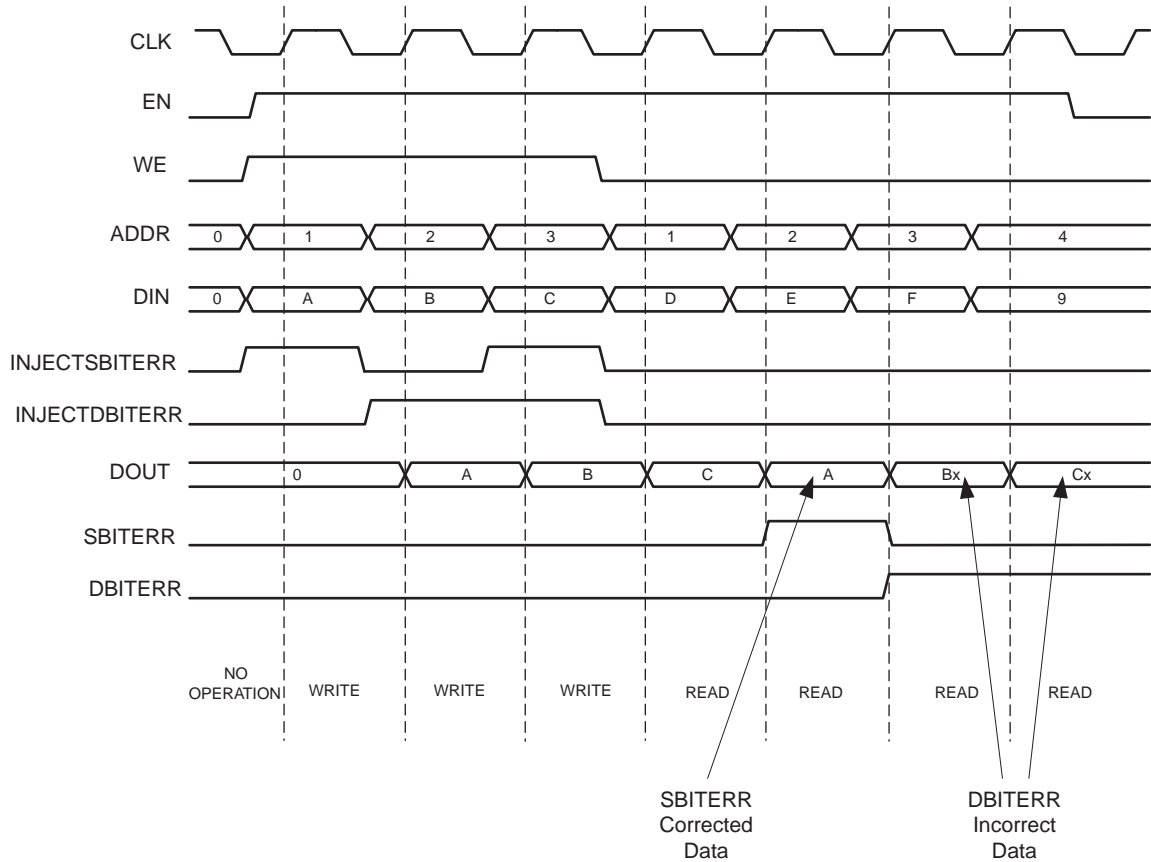


Figure 3-30: Assertion of SBITERR and DBITERR Signals by Using Error Injection Pins

When the INJECTSBITERR and INJECTDBITERR inputs are asserted together at the same time for the same address during a Write operation (as in the case of address 3 in Figure 3-30), the INJECTDBITERR input takes precedence, and only the DBITERR output is asserted for that address during a Read operation. The data output for this address is not corrected.

Soft Error Correction Capability and Error injection

This section describes the implementation and usage of the Soft Error Correction Control (Soft ECC) module that is supported in the Block Memory Generator.

Overview

The Soft ECC module detects and corrects all single-bit errors in a code word consisting of up to 64 bits of data and up to eight parity bits. In addition, it detects double-bit errors in the data. This design uses Hamming code, which is an efficient method for ECC operations.

Features

- Supports Soft ECC for data widths less than or equal to 64 bits in Zynq-7000, 7 series, Virtex-6 and Spartan-6 devices
- Uses Hamming error code correction
 - Single-bit errors are corrected
 - Double-bit errors are detected
- Supports Simple Dual-port RAM memory type
- Supports optional Input and/or Output Registering stages
- Supported Block Memory Generator features include:
 - Minimum Area, Fixed Primitive and Low Power Algorithms
 - Mux Pipelining Stages
 - Embedded Primitive Registers
 - Core Output Registers
 - Optional Enable Inputs
- Fully parameterized implementation enables optimization of resources

Details

Each Write operation generates between 4 and 8 protection bits for 1 to 64 bits of data, which are stored with the data in memory. These bits are used during each Read operation to correct any single-bit error, or to detect (but not correct) any double-bit error.

The two status outputs (SBITERR and DBITERR) indicate the three possible Read results: no error, single error corrected, and double error detected. For single-bit errors, the Read operation does not correct the error in the memory array; it only presents corrected data on DOUT.

When using Soft ECC, the Block Memory Generator can construct the memory from the available primitives in Zynq-7000, 7 series, Virtex-6, and Spartan-6 FPGA architectures. The Soft ECC feature is implemented as an overlay on top of the Block Memory Generator core. This allows users to select algorithm options and registering options in the core. When Soft ECC is selected, limited core options include:

- Byte-Write enable is not available
- All port widths must be identical
- Use RST[A|B] Pin and the Output Reset Value options are not available
- Memory Initialization is not supported

The Soft ECC implementation is optimized to generate the core for different data widths, as shown in Table 3-5. For the selected data width, the number of check bits appended is shown in Table 3-6. The operation of appending the additional check bits for the given data width is done within the Block Memory Generator core and is transparent to the user.

Table 3-5: Soft ECC Data width Support

	Spartan-6	Zynq-7000	Virtex-5	Virtex-6	7 Series
Block RAM mode	SDP Mode	SDP Mode	No	SDP Mode	SDP Mode
Supported Data Widths	≤ 64 bits	≤ 64 bits	n/a	≤ 64 bits	≤ 64 bits
Bit Error Insertion Support	Yes	Yes	n/a	Yes	Yes

Table 3-6: Memory Width Calculation for Selected User Data Width

User Input Data Width	Added Check Bits	Total Memory Width in Bits
1-4	4	5-8
5-11	5	10-16
12-26	6	18-32
27-57	7	34-64
58-64	8	66-72

Figure 3-31 illustrates the implementation of Soft ECC logic for the Block Memory Generator core. The implementation shown in Figure 3-31 is for 64 bits of data; the implementation is parameterized for other data widths.

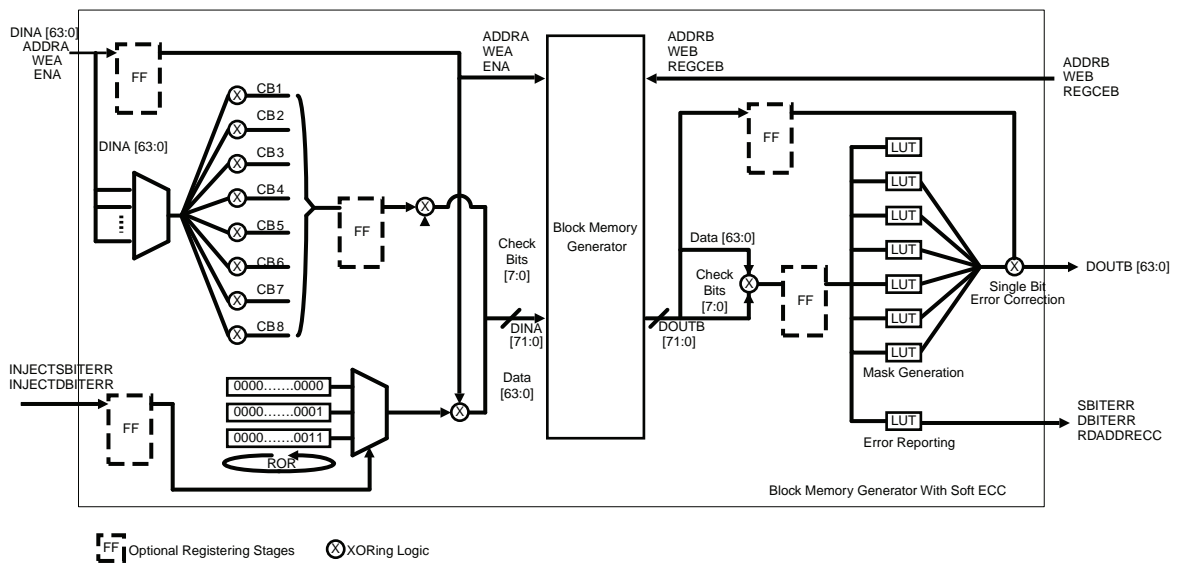


Figure 3-31: Block Memory Generator with Soft ECC

The optional input and output registering stages can be enabled by setting the values of parameters `register_porta_input_of_softecc` and `register_portb_output_of_softecc` appropriately. These registers improve the performance of the Soft ECC logic. By default, the input and output registering stages are disabled.

With Soft ECC, both Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices support error injection through two new optional pins: `INJECTSBITERR` and `INJECTDBITERR`. The error injection operation is performed on both data bits and added check bits. Users can use these optional error injection pins as debug pins to inject single or double-bit errors into specific locations during Write operations. Then, the user can check the assertion of the `SBITERR` and `DBITERR` signals at the output of those addresses. The user may select no error injection pins, one error injection pin or both.

The `RDADDRECC` output port indicates the address at which a single or double-bit error has occurred. The `RDADDRECC` port, the two error injection ports, and the two error output ports are optional and become available only when the Soft ECC option is chosen. If the Soft ECC feature is not selected, the outputs `SBITERR`, `DBITERR`, and `RDADDRECC` are not connected externally.

Parameters

- **softecc**: This parameter enables the Soft ECC logic for Zynq-7000, 7 series, Virtex-6, and Spartan-6 device families.
- **register_porta_input_of_softecc**: This parameter registers the input ports in the design.
- **register_portb_output_of_softecc**: This parameter registers the output ports in the design.
- **use_error_injection_pins**: This parameter enables single and/or double-bit error injection capability during Write operations
- **error_injection_type**: This parameter specifies the type of the error injection done in the Soft ECC logic. The error injection type can be either "Single_Bit_Error_Injection" or "Double_Bit_Error_Injection" or "Single_and_Double_Bit_Error_Injection."

Parameter - Port dependencies

- When the **softecc** parameter is enabled: `SBITERR`, `DBITERR` and `RDADDRECC` ports are made available on the IO interface.
- When the **use_error_injection_pins** parameter is enabled and "Single_Bit_Error_Injection" option is selected: `INJECTSBITERR` port is made available on the IO interface.
- When the **use_error_injection_pins** parameter is enabled and "Double_Bit_Error_Injection" option is selected: `INJECTDBITERR` port is made available on the IO interface

- When the **use_error_injection_pins** parameter is enabled and "Single_and_Double_Bit_Error_Injection" option is selected: INJECTSBITERR and INJECTDBITERR ports are made available on the IO interface

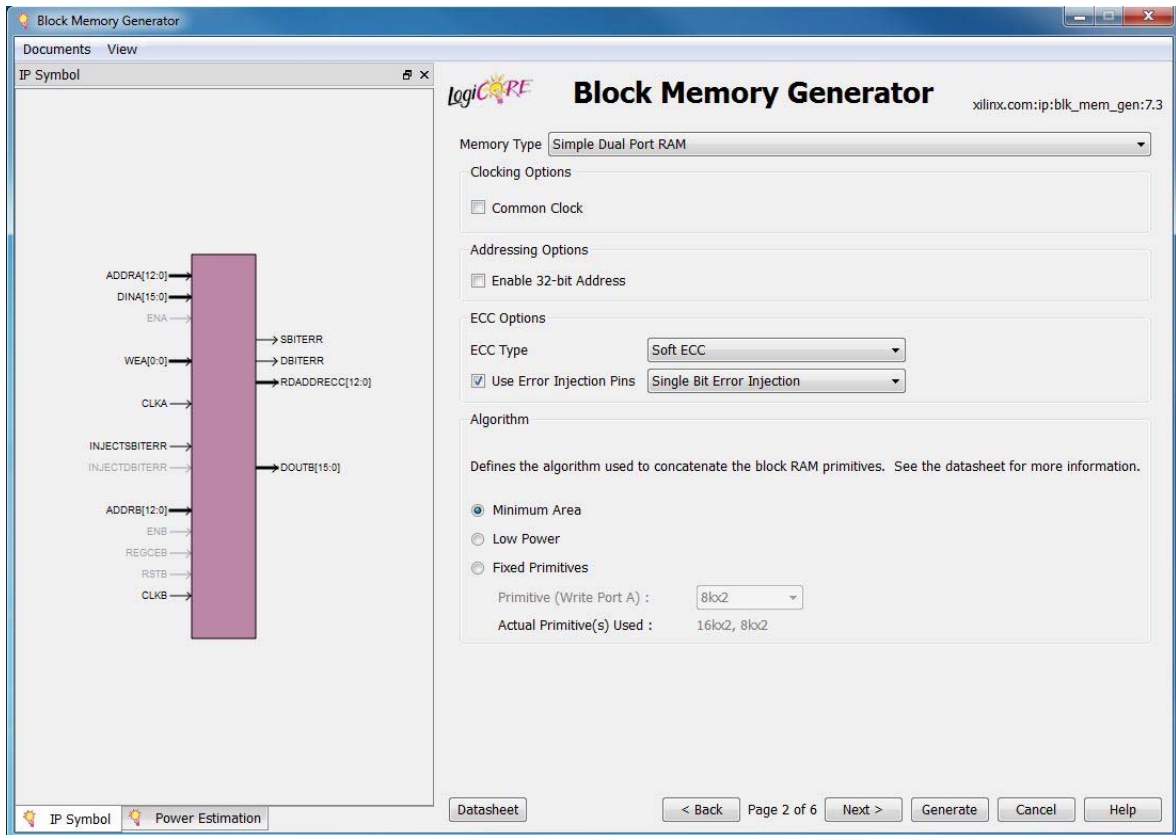


Figure 3-32: Enabling Soft ECC Option

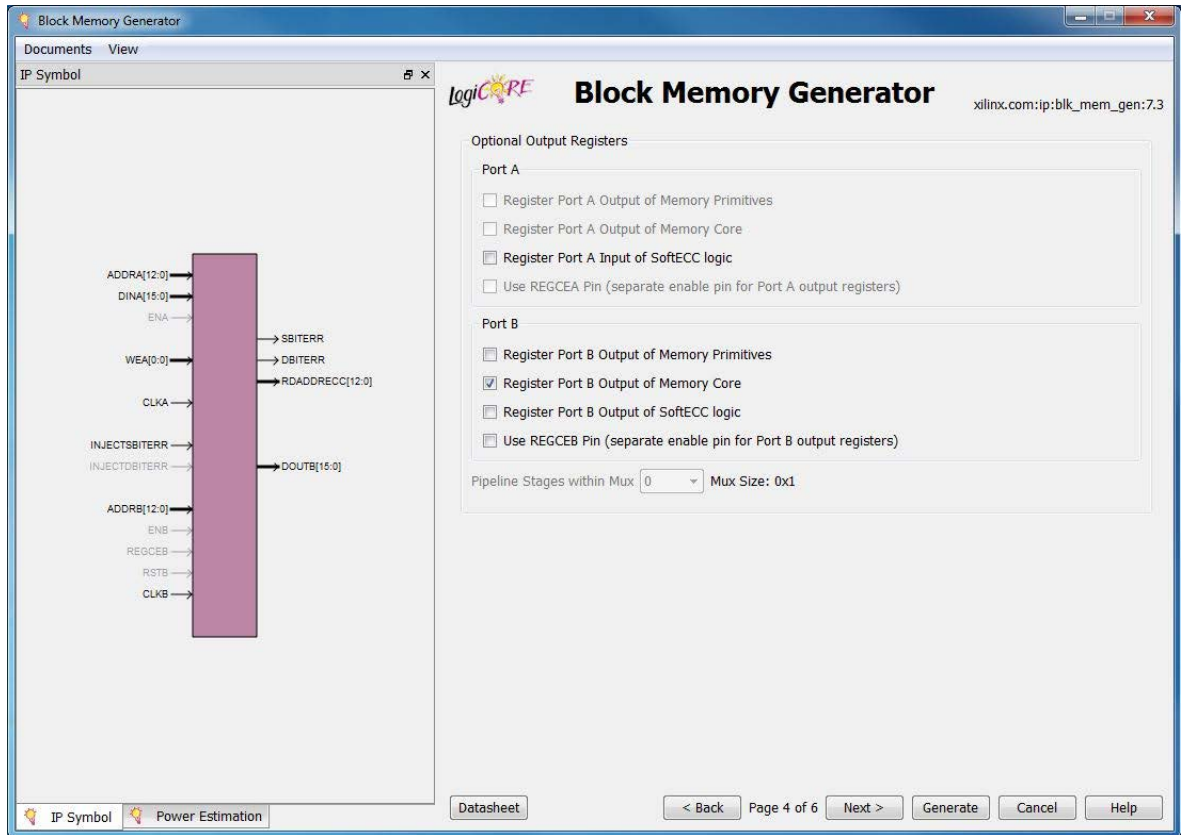


Figure 3-33: Enabling Input/Output Registering Stages

Timing Diagrams

Figure 3-34 illustrates a typical Write and Read operation for Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices for a core with a simple dual-port RAM configuration with Soft ECC enabled and no additional input or output registers.

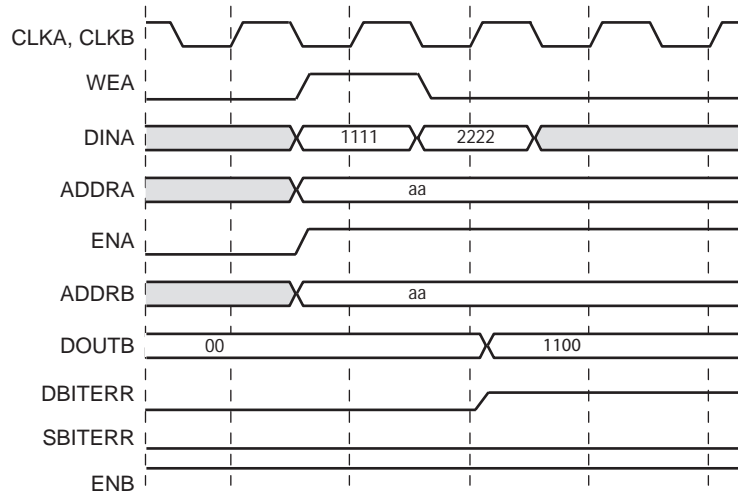


Figure 3-34: Read and Write Operations with Soft ECC

Figure 3-35 shows the assertion of the SBITERR and DBITERR output signals when errors are injected through the error injection pins during a Write operation.

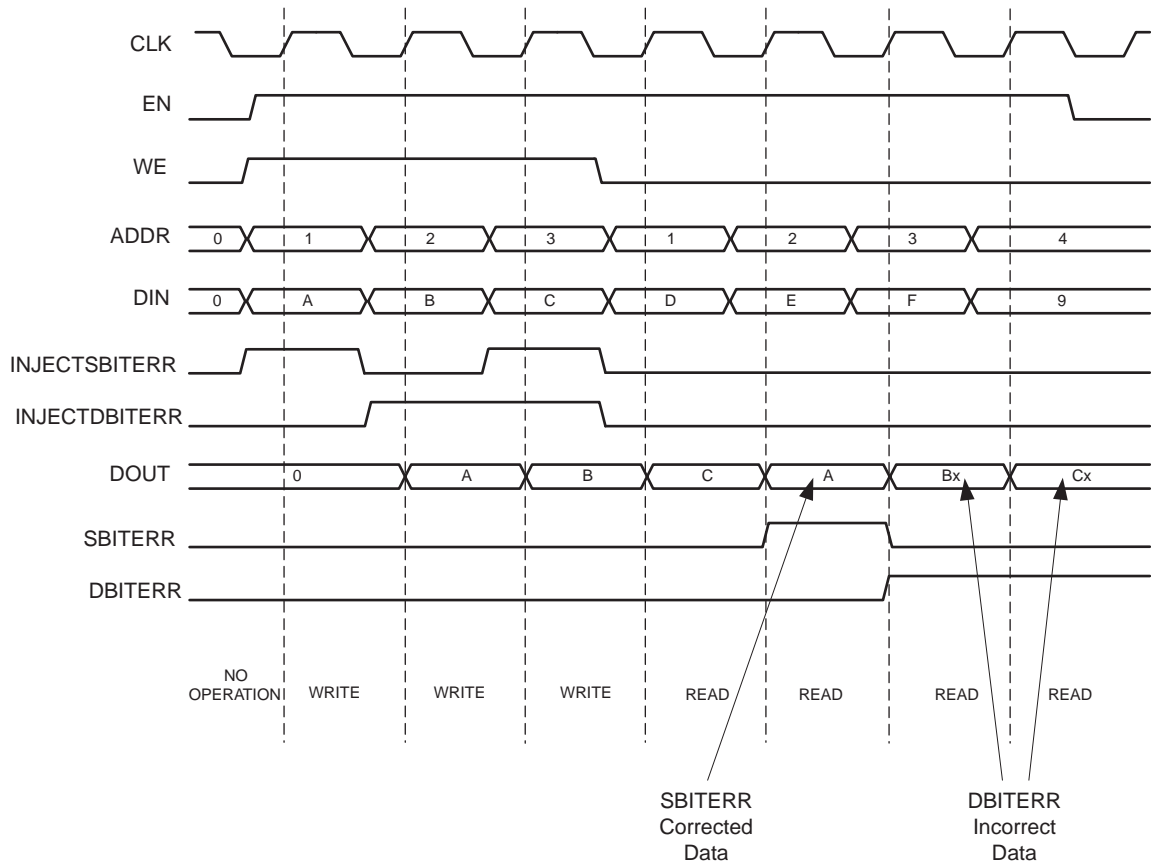


Figure 3-35: Assertion of SBITERR and DBITERR Signals

When the INJECTSBITERR and INJECTDBITERR inputs are asserted together at the same time for the same address during a Write operation (address 3 in [Figure 3-35](#)), then the INJECTDBITERR input takes precedence. Only the DBITERR output is asserted for that address during a Read operation. The data output for this address is not corrected.

Device Utilization and Performance Benchmarks

Table 3-7: Resource utilization for Spartan-6 Devices (XC6SLX25T-2CSG324)^{a b}

Depth x Width	Mode	Check Bits	Resource Utilization ^c			Performance ^d
			Block RAMs (52)	Slice LUTs (15032)	Slice Register (30064)	Max Freq (MHz)
1Kx8	W/o ECC		2	4	0	221
	With ECC	5	2	27	0	187
1Kx16	W/o ECC		2	8	0	219
	With ECC	6	2	61	0	201
1Kx32	W/o ECC		2	16	0	209
	With ECC	7	4	120	0	161
1Kx64	W/o ECC		4	32	0	200
	With ECC	8	4	231	0	121

- a. Uses Fixed Primitive Algorithm (Primitive Configuration is 512x36).
- b. Memory type is SDP.
- c. No register stage.
- d. Uses Memory Core Output Register.

Table 3-8: Resource utilization for Virtex-6 Devices (XC6VLX75T-2FF784)^{a b}

Depth x Width	Mode	Check Bits	Resource Utilization ^c			Performance ^d
			Block RAMs (52)	Slice LUTs (15032)	Slice Register (30064)	Max Freq (MHz)
1Kx8	W/o ECC		1	0	0	387
	With ECC	5	1	24	0	385
1Kx16	W/o ECC		1	0	0	391
	With ECC	6	1	57	0	379
1Kx32	W/o ECC		1	0	0	386
	With ECC	7	2	112	0	350
1Kx64	W/o ECC		2	0	0	370
	With ECC	8	2	218	0	291

- a. Uses Fixed Primitive Algorithm (Primitive Configuration is 1Kx36).
- b. Memory type is SDP.
- c. No register stage.
- d. Uses Memory Core Output Register.

Smaller Primitive Configurations in Spartan-6

The introduction of the new 9K primitive in Spartan-6 results in smaller memory configurations: 8kx1, 4kx2, 2kx4, 1kx9, 512x18 and 256x36 (this primitive is only supported in SP and SDP configurations). In previous Spartan families, extra-wide configurations were only supported in Single Port memory configurations. The 9K primitive, RAMB8BW, allows the primitive to be configured in either the TDP or the SDP mode. The presence of the SDP mode of operation allows the extra-wide 256x36 configuration, even for Simple Dual Port memory configurations.

Lower Data Widths in Zynq-7000, 7 Series, and Virtex-6 SDP Configurations

The Zynq-7000, 7 series, and Virtex-6 FPGA architectures with the new SDP primitives support lower data widths than the Virtex-5 FPGAs. In Virtex-5 devices, the RAMB18SDP primitive could only support a symmetric configuration with port widths of 36, and the RAMB36SDP primitive could only support a symmetric configuration with port widths of 72. For Zynq-7000, 7 series, and Virtex-6 devices, new width combinations are possible for Port A and Port B, as shown in [Table 3-9](#).

Table 3-9: Data Widths Supported by Zynq-7000, 7 series, and Virtex-6 SDP Primitives⁽¹⁾⁽²⁾⁽³⁾

Primitive	Read Port Width	Write Port Width	Read Port Width	Write Port Width
RAMB18 SDP Primitive	x1	x32	x32	x1
	x2	x32	x32	x2
	x4	x32	x32	x4
	x9	x36	x36	x9
	x18	x36	x36	x18
	x36	x36	-	-
RAMB36 SDP Primitive	x1	x64	x64	x1
	x2	x64	x64	x2
	x4	x64	x64	x4
	x9	x72	x72	x9
	x18	x72	x72	x18
	x36	x72	x72	x36
	x72	x72	-	-

Notes:

1. Refer to [Additional Memory Collision Restrictions: Address Space Overlap](#), page 61.
2. The selection of SDP primitives depends on the algorithm selected.
3. Asymmetric data widths cause the SDP to be not selected.

Clocking

The Block Memory Generator core has two clocks: `clk_a` and `clk_b`. Depending on the configuration, one or two clocks can be enabled.

Resets

The Block Memory Generator core has two resets. Depending on the configuration, the core can have different reset operations as explained in [Optional Set/Reset Pins](#), [Reset Priority](#), [Special Reset Behavior](#) and [Asynchronous Reset](#).

SECTION II: VIVADO DESIGN SUITE

Customizing and Generating the Core

Constraining the Core

Detailed Example Design

Customizing and Generating the Core

This chapter includes information on using Vivado tools to customize and generate the core.

For more details about getting started with the Vivado Design Suite, see the [Vivado tools user guides](#).

GUI

The Block Memory Generator is available in the Vivado IP catalog. To open the Block Memory core, go to **IP Catalog > Memories & Storage Elements > RAMs & ROMs**.

The following section defines the possible customization options in the Block Memory Generator GUI screens. The actual GUI screens depend on the user configuration.

The Native interface Block Memory Generator GUI includes six main screens:

- [Native Block Memory Generator First Screen](#)
- [Port Options Screen](#)
- [Other Options Screen](#)
- [Summary Screen](#)
- [Power Estimate Options Screen](#)
- [Interface Type Selection Screen](#)
- [AXI4 Interface Options Screen](#)

In addition, all the screens share common tabs and buttons to provide information about the core and to navigate the Block Memory Generator GUI.

Native Block Memory Generator First Screen

The main Block Memory Generator screen is used to define the component name and provides the Interface Options for the core.

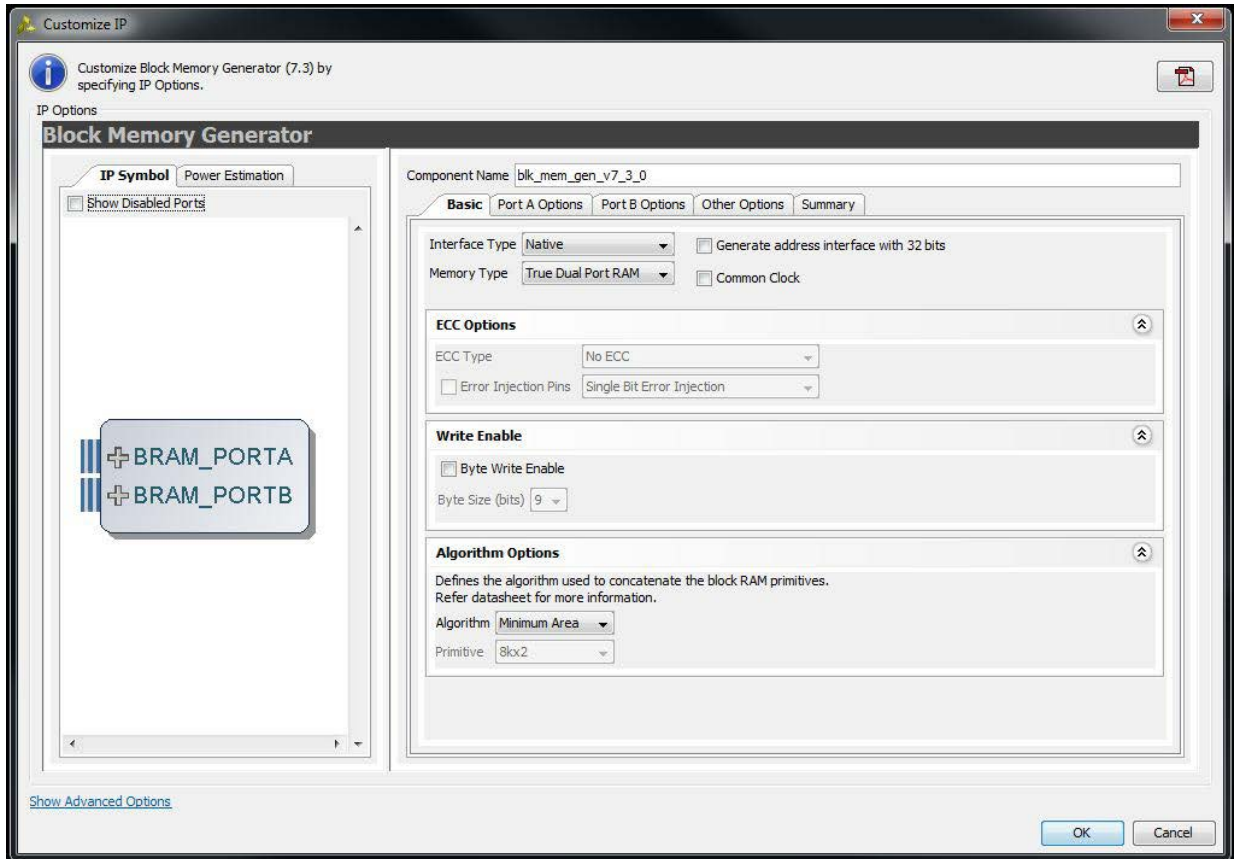


Figure 4-1: Block Memory Generator Main Screen

- **Interface Type**
 - Native: Implements a Native Block Memory Generator Core compatible with previously released versions of the Block Memory Generator.
- **Memory Type:** Select the type of memory to be generated.
 - Single-port RAM
 - Simple Dual-port RAM
 - True Dual-port RAM
 - Single-port ROM
 - Dual-port ROM
- **ECC Options:** When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5, and Spartan-6 devices, and when the Simple dual-port RAM memory type is selected, the ECC Type option becomes available. It provides the user the choice to select the type of ECC required.
 - Built-In ECC: When targeting Zynq-7000, 7 series, Virtex-6 and Virtex-5 devices, and when the selected ECC Type is BuiltIn_ECC, the built-in Hamming Error Correction is

enabled for the Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGA architecture.

For the Zynq-7000, 7 series, and Virtex-6 FPGA, the Use Error Injection Pins option is available for selection if the ECC option is selected. This option enables error injection pins. On choosing this option, additional options are available to have Single-Bit Error Injection (INJECTSBITERR), Double-Bit Error Injection (INJECTDBITERR), or both. See [Hamming Error Correction Capability in Chapter 1](#) for more information.

When using ECC, the following limitations apply:

- Byte-Write Enable is not available.
- All port widths must be identical.
- For Virtex-5 devices, No Change Operating mode is supported. For Zynq-7000, 7 series, and Virtex-6 devices, Read First Operating Mode is supported.
- The Use RST[A|B] Pin and the Output Reset Value options are not available.
- Memory Initialization is not supported.
- No algorithm selection is available.
- o Soft ECC: When targeting Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices, and when the selected ECC Type is Soft_ECC, soft error correction (using Hamming code) is enabled for the Zynq-7000, 7 series, Virtex-6, and Spartan-6 FPGAs.

The Use Error Injection Pins option is available for selection if the Soft ECC option is selected. This option enables error injection pins. On choosing this option, additional options are available to have Single-Bit Error Injection (INJECTSBITERR), Double-Bit Error Injection (INJECTDBITERR), or both. See [Soft Error Correction Capability and Error injection in Chapter 3](#) for more information about this option and the limitations that apply.

When using Soft ECC, the following conditions apply:

- Supports Soft ECC for data widths less than or equal to 64 bits
- Uses Hamming error code correction: Single-bit errors are corrected and double-bit errors are detected.
- Supports Simple Dual-port RAM memory type
- Supports optional Input and/or Output Registering stages
- Supported Block Memory Generator features include:
 - Minimum Area, Fixed Primitive and Low Power Algorithms
 - Mux Pipelining Stages

Embedded Primitive Registers

Core Output Registers

Optional Enable Inputs

- Fully parameterized implementation for optimized resource utilization
- **Common Clock:** Select the Common Clock option when the clock (CLKA and CLKB) inputs are driven by the same clock buffer.



IMPORTANT: For Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices with `COMMON_CLOCK` selected, `WRITE_MODE` is set as `READ_FIRST` for Simple Dual Port RAM Memory type, otherwise `WRITE_MODE` is set as `WRITE_FIRST`.

- **Write Enable:** When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP devices, select whether to use the byte-Write enable feature. Byte size is either 8-bits (no parity) or 9-bits (including parity). The data width of the memory will be multiples of the selected byte-size.
- **Algorithm:** Select the algorithm used to implement the memory:
 - **Minimum Area Algorithm:** Generates a core using the least number of primitives.
 - **Low Power Algorithm:** Generates a core such that the minimum number of block RAM primitives are enabled during a Read or Write operation.
 - **Fixed Primitive Algorithm:** Generates a core that concatenates a single primitive type to implement the memory. Choose which primitive type to use in the drop-down list.

Port Options Screen

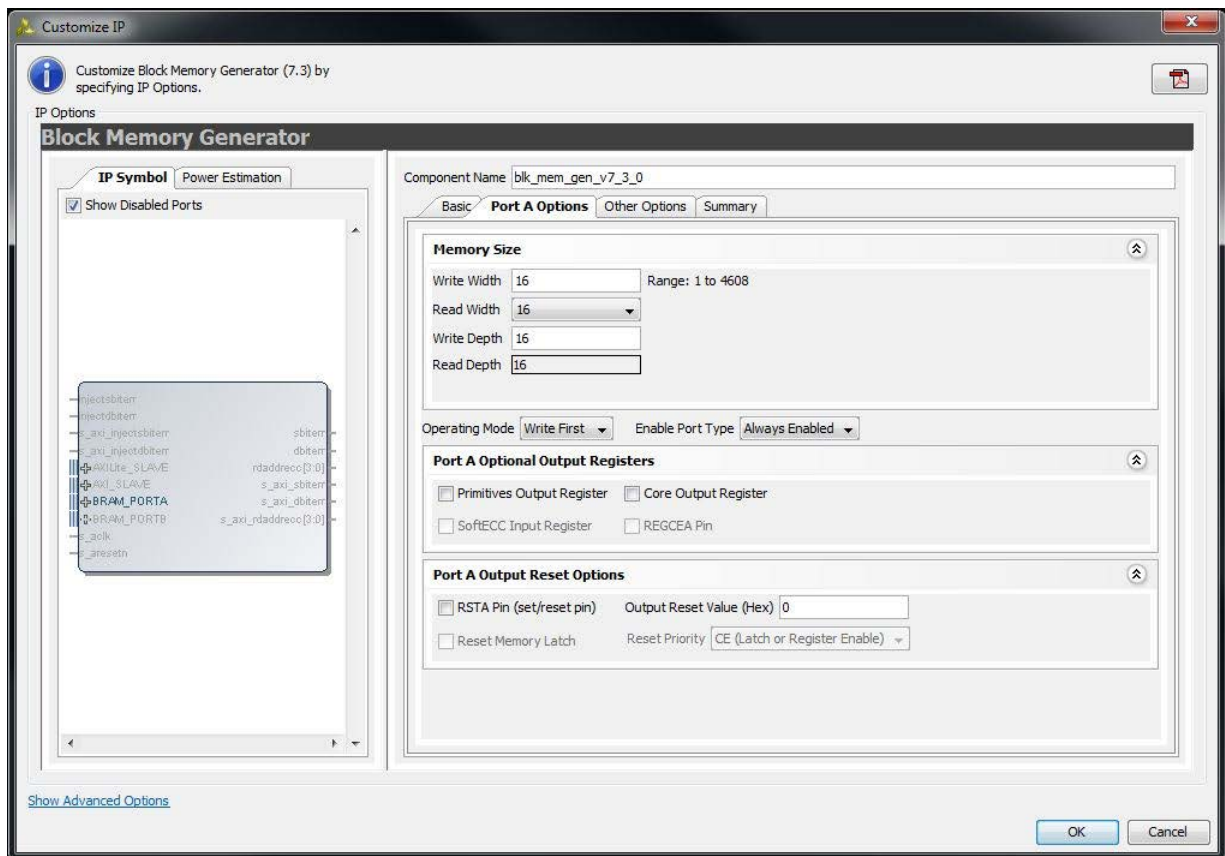


Figure 4-2: Port A Options

- **Memory Size:** Specify the port [A|B] Write width and depth. Select the port [A|B] Read width from the drop-down list of valid choices. The Read depth is calculated automatically.
- **Operating Mode:** Specify the port [A|B] operating mode.
 - READ_FIRST
 - WRITE_FIRST
 - NO_CHANGE
- **Enable Port Type:** Select the enable type:
 - Always enabled (no ENA | ENB pin available)
 - Use ENA | ENB pin
- **Port [A|B] Optional Output Registers:** Select the output register stages to include:
 - Primitives Output Register: Select to insert output register after the memory primitives for port A and port B separately. When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5 or Virtex-4 FPGAs, the embedded output registers in the block

RAM primitives are used if the user chooses to register the output of the memory primitives. For Spartan-6 and Spartan-3A DSP, either the primitive embedded registers or fabric registers from FPGA slices are used, depending upon the Reset Behavior option chosen by the user. For other architectures, the registers in the FPGA slices are used. Note that in Virtex-4 devices, the use of the RST input prevents the core from using the embedded output registers. See Output Register Configurations in Appendix D for more information.

- Core Output Register: Select for each port (A or B) to insert a register on the output of the memory core for that port. When selected, registers are implemented using FPGA slices to register the core's output.
- REGCE[A|B] Pin: Select to use a separate REGCEA or REGCEB input pin to control the enable of the last output register stage in the memory. When unselected, all register stages are enabled by ENA/ENB.
- **Port [A|B] Output Reset Options**
 - Use RST[A|B] Pin (Set/Reset Pin): Choose whether a set/reset pin (RST[A|B]) is needed.
 - Reset Priority: The Reset Priority option for each port is available only when the Use RST Pin option of the corresponding port is chosen. The user can set the reset priority to either CE or SR. For more information on the reset priority feature, see Reset Priority in Chapter 3.
 - Reset Behavior: The Reset Behavior (Reset Memory Latch) options for each port are available only when the Use RST Pin option and the Register Output of Memory Primitives option of the corresponding port are chosen, and the Register Memory Core option of the corresponding port is not chosen.
 - The Reset Memory Latch option modifies the behavior of the reset and changes the duration for which the reset value is asserted. The minimum duration of reset assertion is displayed as information in the GUI based upon the choice for this option. For more information on the Reset Memory Latch option, see Special Reset Behavior in Chapter 3.
 - Output Reset Value (Hex): Specify the reset value of the memory output latch and output registers. These values are with respect to the Read port widths.

Other Options Screen

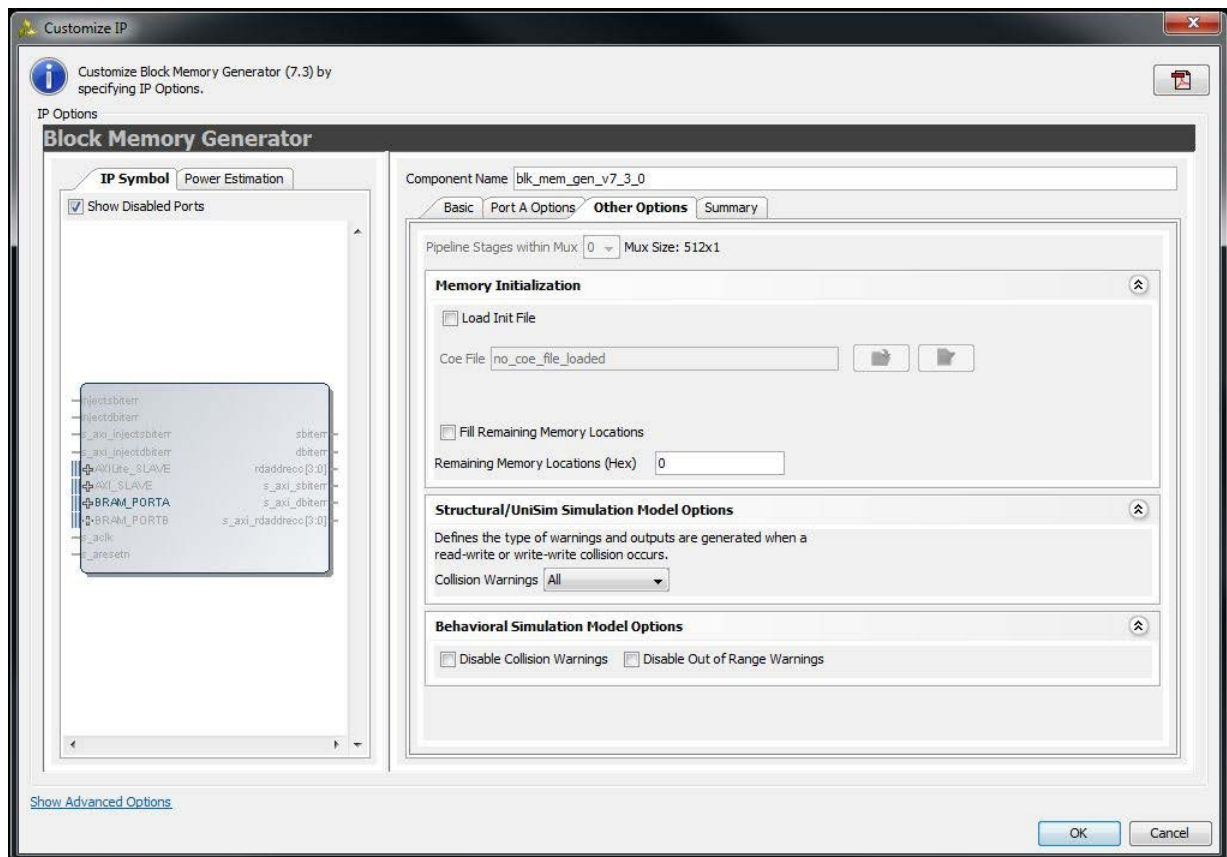


Figure 4-3: Other Options Screen

- **Pipeline Stages within Mux:** Available only when the Register Output of Memory Core option is selected for both port A and port B and when the constructed memory has more than one primitive in depth, so that a MUX is needed at the output. Select a value of 0, 1, 2, or 3 from the drop-down list.

The MUX size displayed in the GUI can be used to determine the number of pipeline stages to use within the MUX. Select the appropriate number of pipeline stages for your design based on the device architecture.

- **Memory Initialization:** Select whether to initialize the memory contents using a COE file, and whether to initialize the remaining memory contents with a default value. When using asymmetric port widths or data widths, the COE file and the default value are with respect to the port A Write width.
- **Structural/UNISIM Simulation Model Options:** Select the type of warning messages and outputs generated by the structural simulation model in the event of collisions. For the options of ALL, WARNING_ONLY and GENERATE_X_ONLY, the collision detection feature will be enabled in the UniSim models to handle collision under any condition.

Power Estimate Options Screen

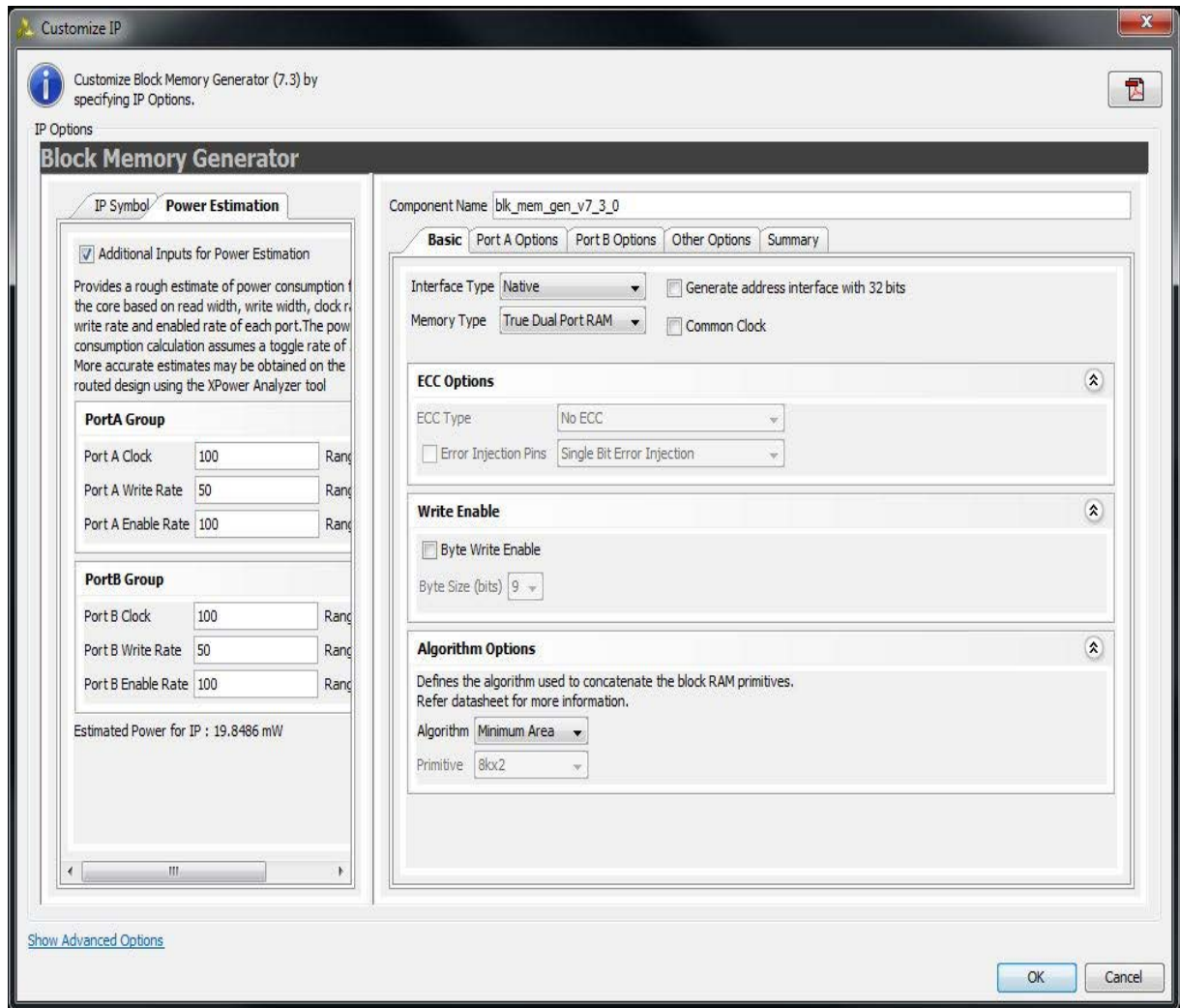


Figure 4-5: Power Estimate Options Screen

The Power Estimation tab on the left side of the GUI screen shown in [Figure 4-5](#) provides a rough estimate of power consumption for the core based on the configured Read width, Write width, clock rate, Write rate and enable rate of each port. The power consumption calculation assumes a toggle rate 50%. More accurate estimates can be obtained on the routed design using the XPower Analyzer tool. See www.xilinx.com/power for more information on the XPower Analyzer.

The screen has an option to provide "Additional Inputs for Power Estimation" apart from configuration parameters. The following parameters can be entered by the user for power calculation:

- **Clock Frequency [A|B]:** The operating clock frequency of the two ports A and B respectively.
- **Write Rate [A|B]:** Write rate of ports A and B respectively.

- **Enable Rate [A|B]:** Average access rate of port A and B respectively.

Information Section

This section displays an informational summary of the selected core options.

- **Memory Type:** Reports the selected memory type.
- **Block RAM Resources:** Reports the exact number of 9K, 18K and 36K block RAM primitives which will be used to construct the core.
- **Total Port A Read Latency:** The number of clock cycles for a Read operation for port A. This value is controlled by the optional output registers options for port A on the previous screen.
- **Total Port B Read Latency:** The number of clock cycles for a Read operation for port B. This value is controlled by the optional output registers options for port B on the previous screen.
- **Address Width:** The actual width of the address bus to each port.

Specifying Initial Memory Contents

The Block Memory Generator core supports memory initialization using a memory coefficient (COE) file or the default data option in the CORE Generator GUI, or a combination of both.

The COE file can specify the initial contents of each memory location, while default data specifies the contents of all memory locations. When used in tandem, the COE file can specify a portion of the memory space, while default data fills the rest of the remaining memory space. COE files and default data is formatted with respect to the port A Write width (or port A Read width for ROMs).

A COE is a text file which specifies two parameters:

- **memory_initialization_radix:** The radix of the values in the memory_initialization_vector. Valid choices are 2, 10, or 16.
- **memory_initialization_vector:** Defines the contents of each memory element. Each value is LSB-justified and assumed to be in the radix defined by memory_initialization_radix.

The following is an example COE file. Note that semi-colon is the end of line character.

```
; Sample initialization file for a
; 8-bit wide by 16 deep RAM
memory_initialization_radix = 16;
memory_initialization_vector =
12, 34, 56, 78, AB, CD, EF, 12, 34, 56, 78, 90, AA, A5, 5A, BA;
```

Coefficients can be separated by a space, a comma, or by placing one value in each line with a carriage return.

Block RAM Usage

The Information panel (screen 5 of the Block Memory Generator GUI) reports the actual number of 9K, 18K and 36K block RAM blocks to be used.

To estimate this value when using the fixed primitive algorithm, the number of block RAM primitives used is equal to the width ratio (rounded up) multiplied by the depth ratio (rounded up), where the width ratio is the width of the memory divided by the width of the selected primitive, and the depth ratio is the depth of the memory divided by the depth of the primitive selected.

To estimate block RAM usage when using the low power algorithm requires a few more calculations:

- If the memory width is an integral multiple of the width of the widest available primitive for the chosen architecture, then the number of primitives used is calculated in the same way as the fixed primitive algorithm. The width and depth ratios are calculated using the width and depth of the widest primitive. For example, for a memory configuration of 2kx72, the width ratio is 2 and the depth ratio is 4 using the widest primitive of 512x36. As a result, the total available primitives used is 8.
- If the memory width is greater than an integral multiple of the widest primitive, then in addition to the above calculated primitives, more primitives are needed to cover the remaining width. This additional number is obtained by dividing the memory depth by the depth of the additional primitive chosen to cover the remaining width. For example, a memory configuration of 17kx37 requires one 512x36 primitive to cover the width of 36, and an additional 16kx1 primitive to cover the remaining width of 1. To cover the depth of 17K, 34 512x36 primitives and 2 16kx1 primitives are needed. As a result, the total number of primitives used for this configuration is 36.
- If the memory width is less than the width of the widest primitive, then the smallest possible primitive that covers the memory width is chosen for the solution. The total number of primitives used is obtained by dividing the memory depth by the depth of the chosen primitive. For example, for a memory configuration of 2kx32, the chosen primitive is 512x36, and the total number of primitives used is 2k divided by 512, which is 4.

When using the minimum area algorithm, it is not as easy to determine the exact block RAM count. This is because the actual algorithms perform complex manipulations to produce optimal solutions. The optimistic estimate of the number of 18K block RAMs is total memory bits divided by 18k (the total number of bits per primitive) rounded up. Given that this algorithm packs block RAMs very efficiently, this estimate is often very accurate for most memories.

LUT Utilization and Performance

The LUT utilization and performance of the core are directly related to the arrangement of primitives and the selection of output registers. Particularly, the number of primitives cascaded in depth to implement a memory determines the size of the output multiplexer and the size of the input decoder, which are implemented in the FPGA fabric.

Note: Although the primary goal of the minimum area algorithm is to use the minimum number of block RAM primitives, it has a secondary goal of maximizing performance – as long as block RAM usage does not increase.

Generating the AXI4 Interface Block Memory Generator Core

The AXI4 Interface Block Memory Generator GUI includes two additional screens followed by Native BMG configuration screens:

- [Interface Type Selection Screen](#)
- [AXI4 Interface Options Screen](#)

Interface Type Selection Screen

The main Block Memory Generator screen is used to define the component name and provides the Interface Options for the core.

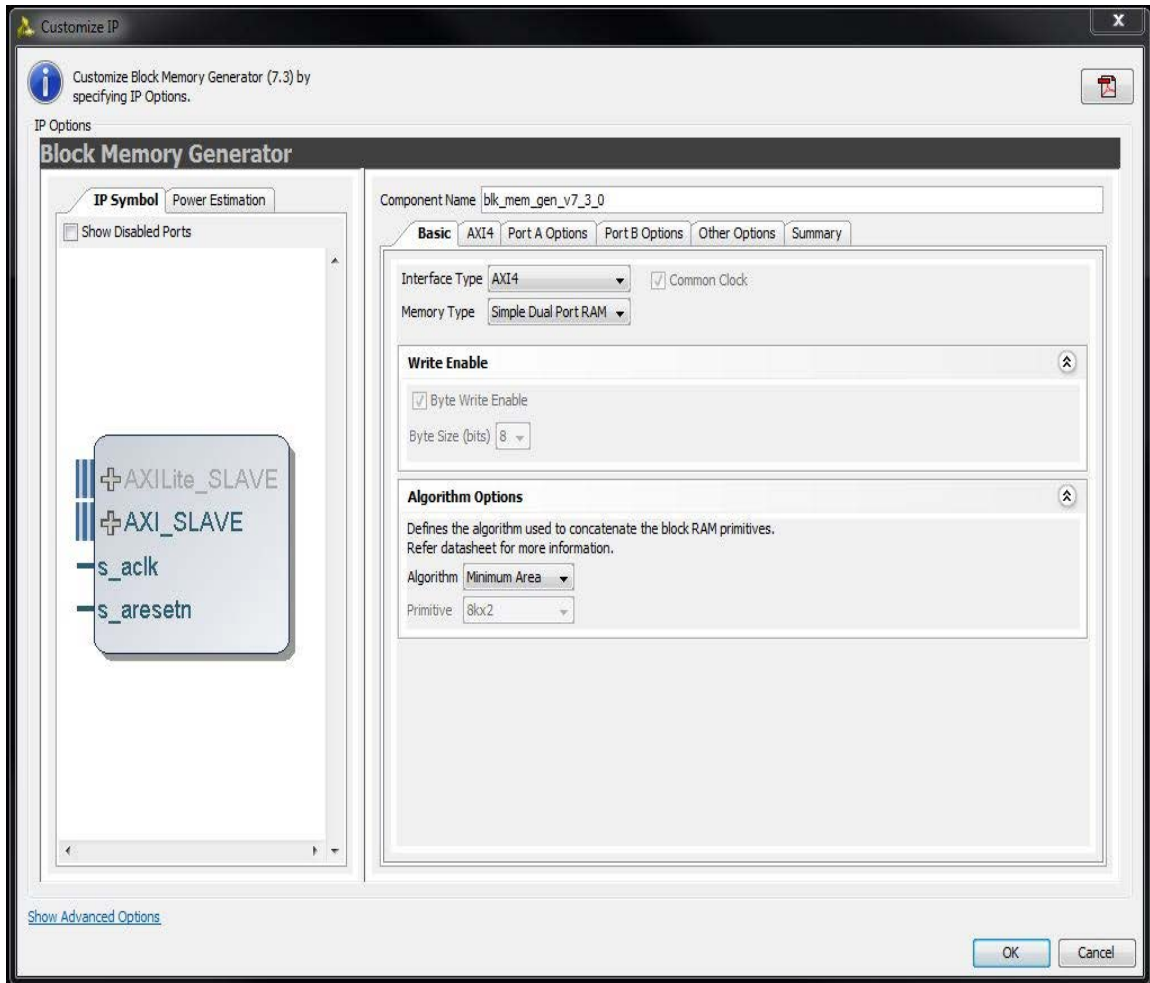


Figure 4-6: AXI4 Interface Selection Screen of Block Memory Generator

Component Name

Base name of the output files generated for this core. The name must begin with a letter and be composed of the following characters: a to z, 0 to 9, and "_".

- **Interface Type:**
 - AXI4: Implements an AXI4 Interface Block Memory Generator Core.

AXI4 Interface Options Screen

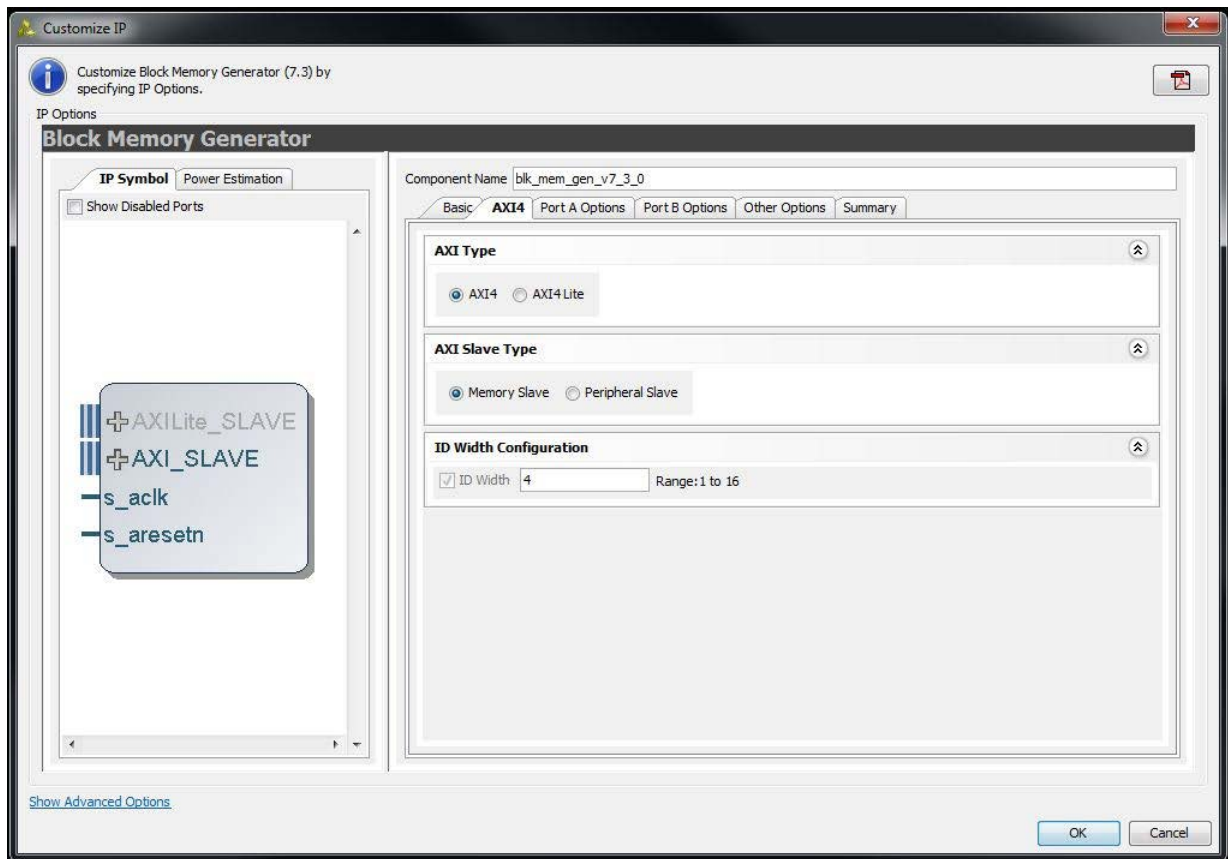










Figure 4-7: AXI4 Interface Options

- **AXI4 Interface Options:**
 - AXI4: Implements an AXI4 Block Memory Generator Core.
 - AXI4-Lite: Implements an AXI4-Lite Block Memory Generator Core.
- **AXI4 Slave Options:**
 - Memory Slave: Implements a AXI4 Interface Block Memory Generator Core in Memory Slave mode
 - Peripheral Slave: Implements a AXI4 Interface Block Memory Generator Core in Peripheral Slave mode
- **ID Width Configurations:**
 - ID Width: When enabled supports AWID/BID/ARID/RID generation, ID Width can be configured from 1 to 16 bits

Output Generation

The output files generated from the Xilinx Vivado Design Suite are placed in the `<project_directory>` top-level directory. Depending on the settings, the file output list may include some or all of the following files:

-  `<project_directory>/<project_name>.data`
Contains constraints and file set details.
-  `<project_directory>/<project_name>.src/sources_1/ip/<component_name>`
Contains the sources like XCI, XDC, TCL and document files.
-  `<component_name>/synth`
Contains the source file necessary to synthesize the Block Memory Generator
-  `<component_name>/sim`
Contains the source file necessary to synthesize the Block Memory Generator
-  `<component_name>/example_design`
Contains the source file necessary to synthesize the example design
-  `<component_name>/simulation`
Contains the source file necessary to simulate the example design
 -  `<component_name>/simulation/functional`
Contains the scripts necessary to run functional simulation on the core including example design
 -  `<component_name>/simulation/timing`
Contains the scripts necessary to run timing simulation on the core including example design

The Block Memory Generator core directories and their associated files are defined in the following sections.

`<project_directory>/<project_name>.src/sources_1/ip/<component_name>`

This directory contains templates for instantiation of the core, example design, synth, XML and the XCI files.

Table 4-1: Component Name Directory

Name	Description
<code><component_name>.xci</code>	Log file from VIVADO software describing which options were used to generate the Block Memory Generator core. An XCI file can also be used as an input to the Vivado Design Suite.
<code><component_name>.{veo vho}</code>	VHDL or Verilog instantiation template.

<component name>/synth

The synth directory contains the Block Memory Generator synthesis file.

Table 4-2: Synth Directory

Name	Description
<component_name>.vhd	VHDL file from the Vivado tools used to synthesize the Block Memory Generator core.

<component name>/sim

The sim directory contains the Block Memory Generator simulation wrapper file.

Table 4-3: Sim Directory

Name	Description
<component_name>.vhd	A VHDL file from the Vivado tools to simulate the Block Memory Generator.

<component name>/example_design

The example design directory contains the example design files provided with the core.

Table 4-4: Example Design Directory

Name	Description
<component_name>_exdes.vhd	The VHDL top-level file for the example design. It instantiates the Block Memory Generator core. This file contains entity with the IO's required for the core configuration.
<component_name>_exdes.xdc	Provides an example clock constraint for processing the Block Memory Generator core using the Vivado Design Suite implementation tools.

<component name>/simulation

The simulation directory contains the simulation files provided with the core.

Table 4-5: Simulation Directory

Name	Description
<component_name>_tb_pkg.vhd	This VHDL file has all the common functions used in stimulus generation.

Table 4-5: Simulation Directory (Cont'd)

Name	Description
<component_name>_tb_synth.vhd	This VHDL file instantiates the example design.
<component_name>_tb.vhd	This VHDL file is the top-level test bench File.

<component name>/simulation/functional

The functional directory contains the scripts to launch XSIM/MIT Simulation with simulation test bench set as top entity.

Table 4-6: Functional Directory

Name	Description
Simulate_xsim.sh	XSim macro file for Linux machines that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion.
Simulate_xsim.bat	XSim macro file for Windows that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion.
wave_xsim.tcl	XSim macro file that opens a Wave window with top-level signals.
simulate_mti.sh	Linux shell script that executes the ModelSim macro file.
simulate_mti.bat	Windows batch script that executes the ModelSim macro file.
simulate_mti.do	A ModelSim macro file that compiles the HDL sources and runs the simulation.

<component name>/simulation/timing

The timing directory contains the scripts to launch XSIM/MTI Simulation with simulation test bench set as top entity.

Table 4-7: Timing Directory

Name	Description
Simulate_xsim.sh	XSim macro file for Linux machines that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion.
Simulate_xsim.bat	XSim macro file for Windows that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion.
wave_xsim.tcl	XSim macro file that opens a Wave window with top-level signals.
simulate_mti.sh	Linux shell script that executes the ModelSim macro file.
simulate_mti.bat	Windows batch script that executes the ModelSim macro file.
simulate_mti.do	A ModelSim macro file that compiles the HDL sources and runs the simulation.

Constraining the Core

This chapter contains details about constraining the core.

Required Constraints

There are no required constraints.

Device, Package, and Speed Grade Selections

See [IP Facts](#) for details about support devices.

Clock Frequencies

This core can operate up-to 200 MHz with the maximum possible configuration on a Virtex-7 device.

Clock Management

The Block Memory Generator uses a CLKA,CLKB and ACLK and RSTA, RSTB and ARESETN based on the design configuration. The only constraints needed are clocking constraints.

Clock Placement

The Block Memory Generator core does not have any special requirement on the placement of the clock.

Banking

There are no banking constraints.

Transceiver Placement

There are no transceiver constraints.

I/O Standard and Placement

There are no I/O constraints.

Detailed Example Design

This chapter contains details about the Block Memory Generator example design using the Vivado Design Suite.

Directory and File Contents

See [Output Generation in Chapter 4](#) for a detailed list of files generated with the example design.

Example Design

The Block Memory Generator example design includes the following:

- HDL wrapper which instantiates the Block Memory Generator netlist
- Block Memory Generator constraint file

The Block Memory Generator example design has been tested with Vivado Design Suite v2012.4.

SECTION III: ISE DESIGN SUITE

Customizing and Generating the Core

Constraining the Core

Detailed Example Design

Customizing and Generating the Core

This chapter includes information on using Xilinx tools to customize and generate the core.

GUI

The Block Memory Generator is available from the CORE Generator software. To open the Block Memory core from the main CORE Generator window, do the following:

Click **View by Function > Memories & Storage Elements > RAMs & ROMs**

The following section defines the maximum possible customization options in the Block Memory Generator GUI screens. The actual GUI screens with enabled options will depend on the user configuration.

CORE Generator Parameter Screens

The Native interface Block Memory Generator GUI includes six main screens:

- [Interface Type Selection Screen](#)
- [Native Block Memory Generator First Screen](#)
- [Port Options Screen](#)
- [Output Registers and Memory Initialization Screen](#)
- [Reset Options Screen](#)
- [Simulation Model Options and Information Screen](#)

In addition, all the screens share common tabs and buttons to provide information about the core and to navigate the Block Memory Generator GUI.

Interface Type Selection Screen

The main Block Memory Generator screen is used to define the component name and provides the Interface Options for the core.

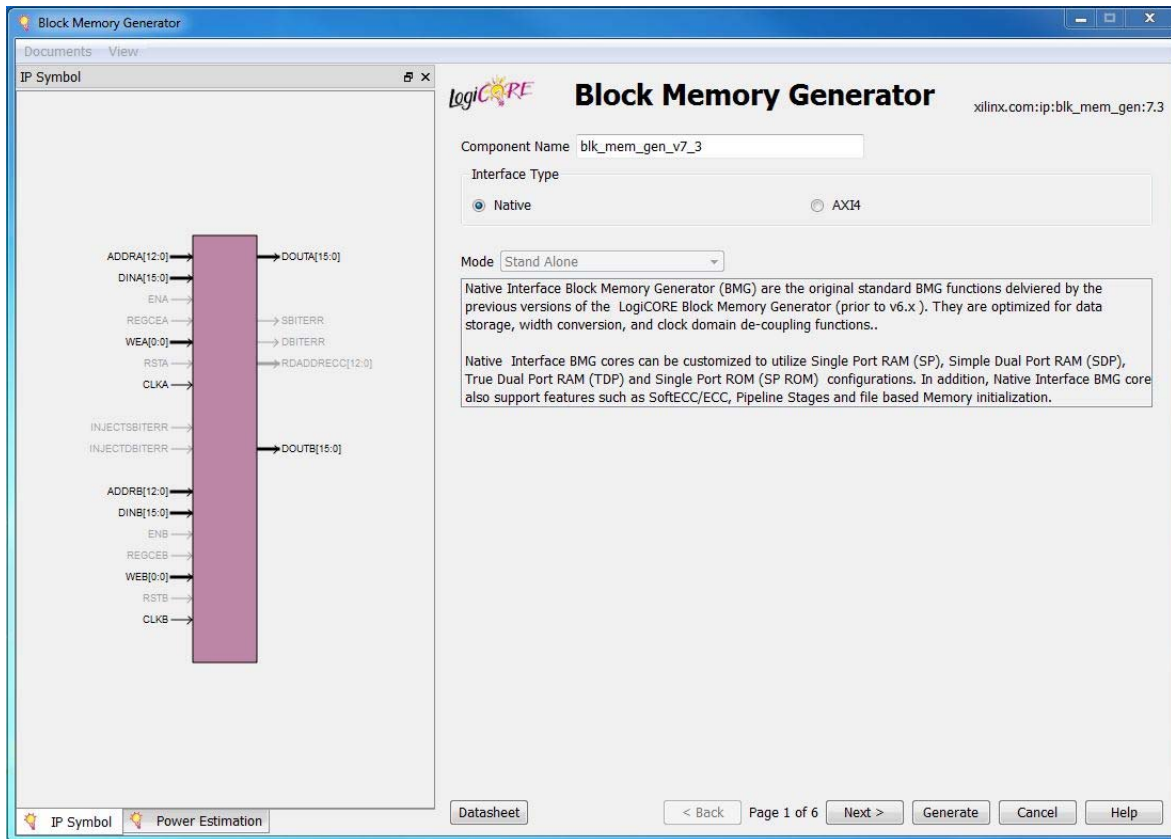


Figure 7-1: Interface Selection Screen

- **Component Name:** Base name of the output files generated for this core. The name must begin with a letter and be composed of the following characters: a to z, 0 to 9, and "_".
- **Interface Type**
 - Native: Implements a Native Block Memory Generator Core compatible with previously released versions of the Block Memory Generator.
 - AXI4: Implements an AXI4 Interface Block Memory Generator Core.

Native Block Memory Generator First Screen

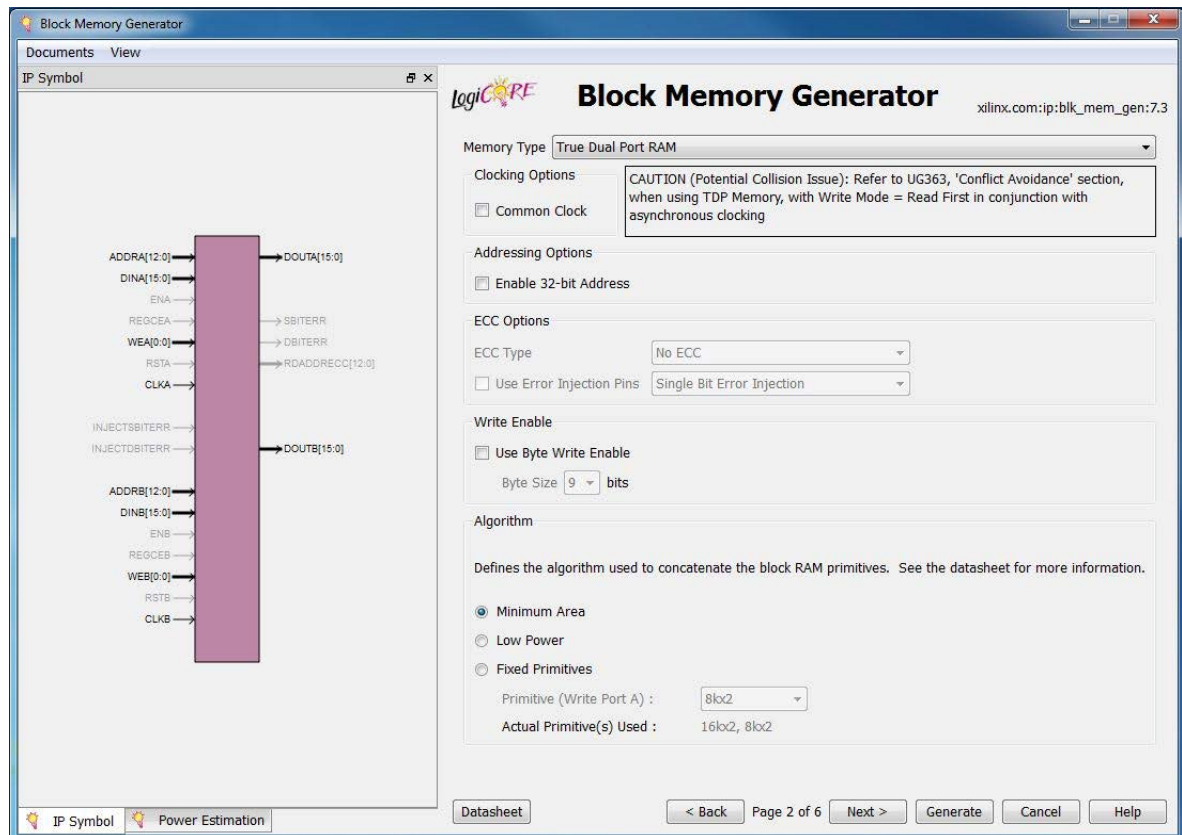


Figure 7-2: Block Memory Generator Main Screen

- **Component Name:** The base name of the output files generated for the core. Names must begin with a letter and be composed of any of the following characters: a to z, 0 to 9, and "_". Names can not be Verilog or VHDL reserved words.
- **Memory Type:** Select the type of memory to be generated.
 - Single-port RAM
 - Simple Dual-port RAM
 - True Dual-port RAM
 - Single-port ROM
 - Dual-port ROM
- **ECC Type:** When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5, and Spartan-6 devices, and when the Simple dual-port RAM memory type is selected, the ECC Type option becomes available. It provides the user the choice to select the type of ECC required.
 - **Built-In ECC:** When targeting Zynq-7000, 7 series, Virtex-6 and Virtex-5 devices, and when the selected ECC Type is BuiltIn_ECC, the built-in Hamming Error

Correction is enabled for the Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGA architecture.

For the Zynq-7000, 7 series, and Virtex-6 FPGA, the Use Error Injection Pins option is available for selection if the ECC option is selected. This option enables error injection pins. On choosing this option, additional options are available to have Single-Bit Error Injection (INJECTSBITERR), Double-Bit Error Injection (INJECTDBITERR), or both. See [Hamming Error Correction Capability in Chapter 1](#) for more information.

When using ECC, the following limitations apply:

- Byte-Write Enable is not available.
- All port widths must be identical.
- For Virtex-5 devices, No Change Operating mode is supported. For Zynq-7000, 7 series, and Virtex-6 devices, Read First Operating Mode is supported.
- The Use RST[A|B] Pin and the Output Reset Value options are not available.
- Memory Initialization is not supported.
- No algorithm selection is available.
- o **Soft ECC:** When targeting Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices, and when the selected ECC Type is Soft_ECC, soft error correction (using Hamming code) is enabled for the Zynq-7000, 7 series, Virtex-6, and Spartan-6 FPGAs.

The Use Error Injection Pins option is available for selection if the Soft ECC option is selected. This option enables error injection pins. On choosing this option, additional options are available to have Single-Bit Error Injection (INJECTSBITERR), Double-Bit Error Injection (INJECTDBITERR), or both. See [Soft Error Correction Capability and Error injection in Chapter 3](#) for more information about this option and the limitations that apply.

When using Soft ECC, the following conditions apply:

- Supports Soft ECC for data widths less than or equal to 64 bits
- Uses Hamming error code correction: Single-bit errors are corrected and double-bit errors are detected.
- Supports Simple Dual-port RAM memory type
- Supports optional Input and/or Output Registering stages
- Supported Block Memory Generator features include:
 - Minimum Area, Fixed Primitive and Low Power Algorithms
 - Mux Pipelining Stages

Embedded Primitive Registers

Core Output Registers

Optional Enable Inputs

- Fully parameterized implementation for optimized resource utilization

- **Clocking Options:** Select the Common Clock option when the clock (CLKA and CLKB) inputs are driven by the same clock buffer.



IMPORTANT: For Zynq-7000, 7 series, Virtex-6, and Spartan-6 devices with COMMON_CLOCK selected, WRITE_MODE is set as READ_FIRST for Simple Dual Port RAM Memory type, otherwise WRITE_MODE is set as WRITE_FIRST.

- **Write Enable:** When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5, Virtex-4, Spartan-6, and Spartan-3A/3A DSP devices, select whether to use the byte-Write enable feature. Byte size is either 8-bits (no parity) or 9-bits (including parity). The data width of the memory will be multiples of the selected byte-size.
- **Algorithm:** Select the algorithm used to implement the memory:
 - Minimum Area Algorithm: Generates a core using the least number of primitives.
 - Low Power Algorithm: Generates a core such that the minimum number of block RAM primitives are enabled during a Read or Write operation.
 - Fixed Primitive Algorithm: Generates a core that concatenates a single primitive type to implement the memory. Choose which primitive type to use in the drop-down list.

Port Options Screen

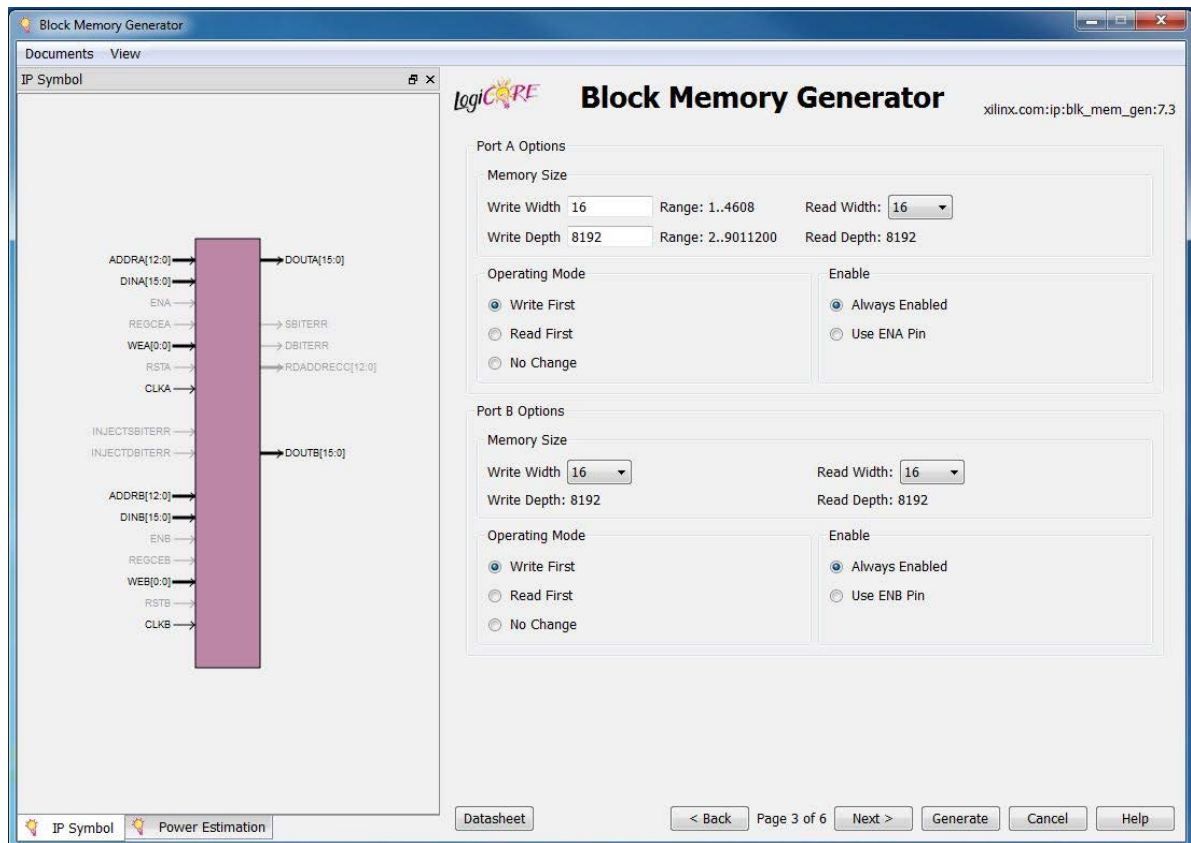


Figure 7-3: Port A Options

Port A Options

- Memory Size: Specify the port A Write width and depth. Select the port A Read width from the drop-down list of valid choices. The Read depth is calculated automatically.
 - Operating Mode: Specify the port A operating mode.
 - READ_FIRST
 - WRITE_FIRST
 - NO_CHANGE
 - Enable: Select the enable type:
 - Always enabled (no ENA pin available)
 - Use ENA pin

Port B Options

- Memory Size: Select the port B Write and Read widths from the drop-down list of valid choices. The Read depth is calculated automatically.

- Operating Mode: Specify the port B Write mode.
 - READ_FIRST
 - WRITE_FIRST
 - NO_CHANGE
- Enable: Select the enable type:
 - Always enabled (no ENB pin available)
 - Use ENB pin

Output Registers and Memory Initialization Screen

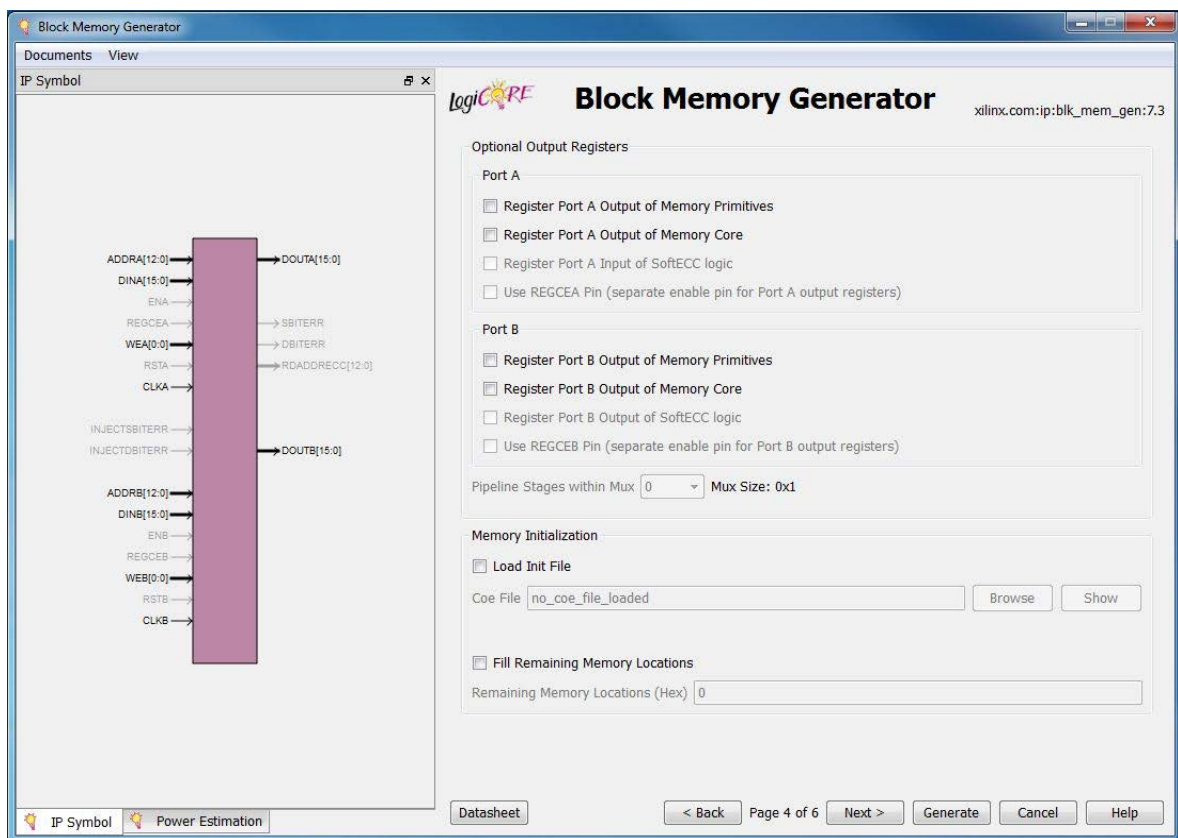


Figure 7-4: Output Registers and Memory Initialization Screen

Optional Output Registers

Select the output register stages to include:

- **Register Port [A|B] Output of Memory Primitives:** Select to insert output register after the memory primitives for port A and port B separately. When targeting Zynq-7000, 7 series, Virtex-6, Virtex-5 or Virtex-4 FPGAs, the embedded output registers in the block RAM primitives are used if the user chooses to register the output

of the memory primitives. For Spartan-6 and Spartan-3A DSP, either the primitive embedded registers or fabric registers from FPGA slices are used, depending upon the Reset Behavior option chosen by the user. For other architectures, the registers in the FPGA slices are used. Note that in Virtex-4 devices, the use of the RST input prevents the core from using the embedded output registers. See [Output Register Configurations in Appendix D](#) for more information.

- **Register Port [A|B] Output of Memory Core:** Select for each port (A or B) to insert a register on the output of the memory core for that port. When selected, registers are implemented using FPGA slices to register the core's output.
- **Use REGCE [A|B] Pin:** Select to use a separate REGCEA or REGCEB input pin to control the enable of the last output register stage in the memory. When unselected, all register stages are enabled by ENA/ENB.
- **Pipeline Stages within Mux:** Available only when the Register Output of Memory Core option is selected for both port A and port B and when the constructed memory has more than one primitive in depth, so that a MUX is needed at the output. Select a value of 0, 1, 2, or 3 from the drop-down list.

The MUX size displayed in the GUI can be used to determine the number of pipeline stages to use within the MUX. Select the appropriate number of pipeline stages for your design based on the device architecture.

Memory Initialization

Select whether to initialize the memory contents using a COE file, and whether to initialize the remaining memory contents with a default value. When using asymmetric port widths or data widths, the COE file and the default value are with respect to the port A Write width.

Reset Options Screen

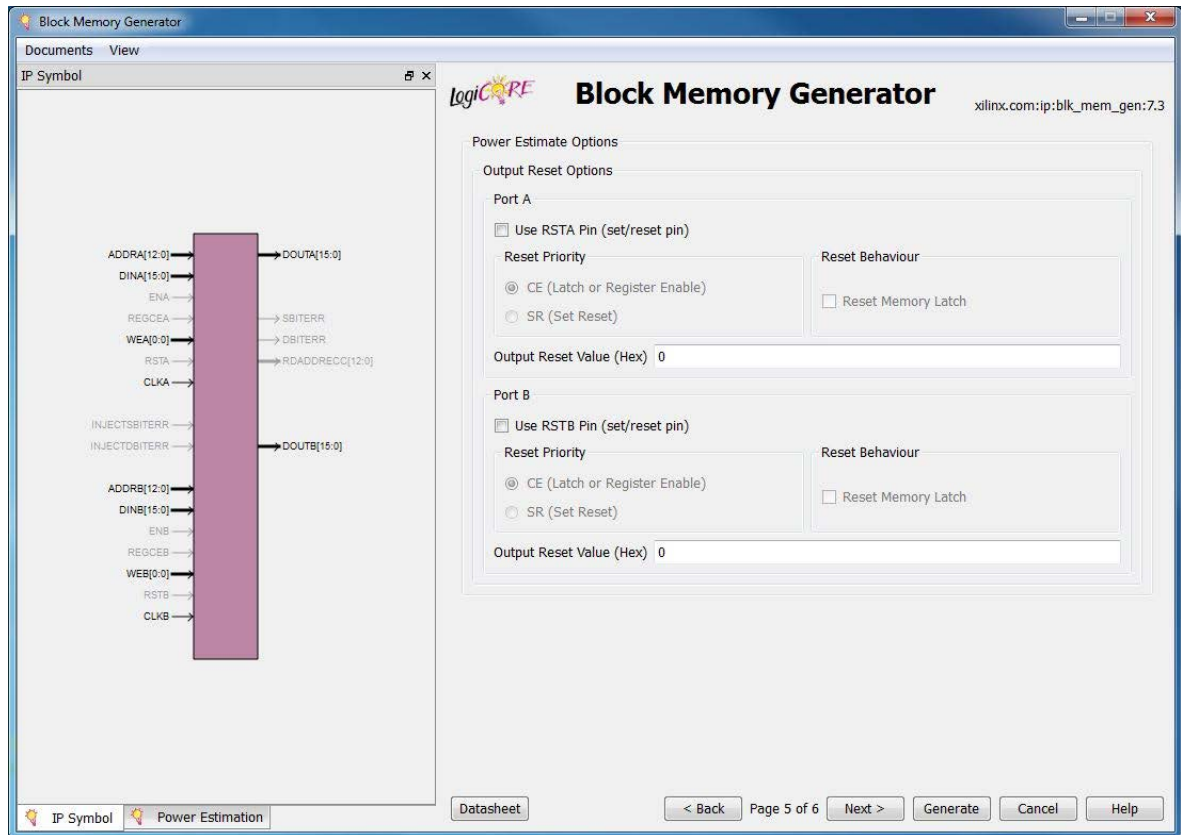


Figure 7-5: Reset Options Screen

Port [A|B] Output Reset Options

- **Use RST[A|B] Pin:** Choose whether a set/reset pin (RST[A|B]) is needed.
- **Reset Priority:** The Reset Priority option for each port is available only when the Use RST Pin option of the corresponding port is chosen. The user can set the reset priority to either CE or SR. For more information on the reset priority feature, see [Reset Priority in Chapter 3](#).
- **Reset Behavior:** The Reset Behavior (Reset Memory Latch) options for each port are available only when the Use RST Pin option and the Register Output of Memory Primitives option of the corresponding port are chosen, and the Register Memory Core option of the corresponding port is not chosen.

The Reset Memory Latch option modifies the behavior of the reset and changes the duration for which the reset value is asserted. The minimum duration of reset assertion is displayed as information in the GUI based upon the choice for this option. For more information on the Reset Memory Latch option, see [Special Reset Behavior in Chapter 3](#).

- **Output Reset Value (Hex):** Specify the reset value of the memory output latch and output registers. These values are with respect to the Read port widths.

Reset Type

The Reset Type option is available only for Spartan-6 devices and when either or both of Use RSTA Pin or Use RSTB Pin option are chosen. The user can set the reset type to either Synchronous or Asynchronous. For more information on this option, see [Asynchronous Reset in Chapter 3](#).

Simulation Model Options and Information Screen

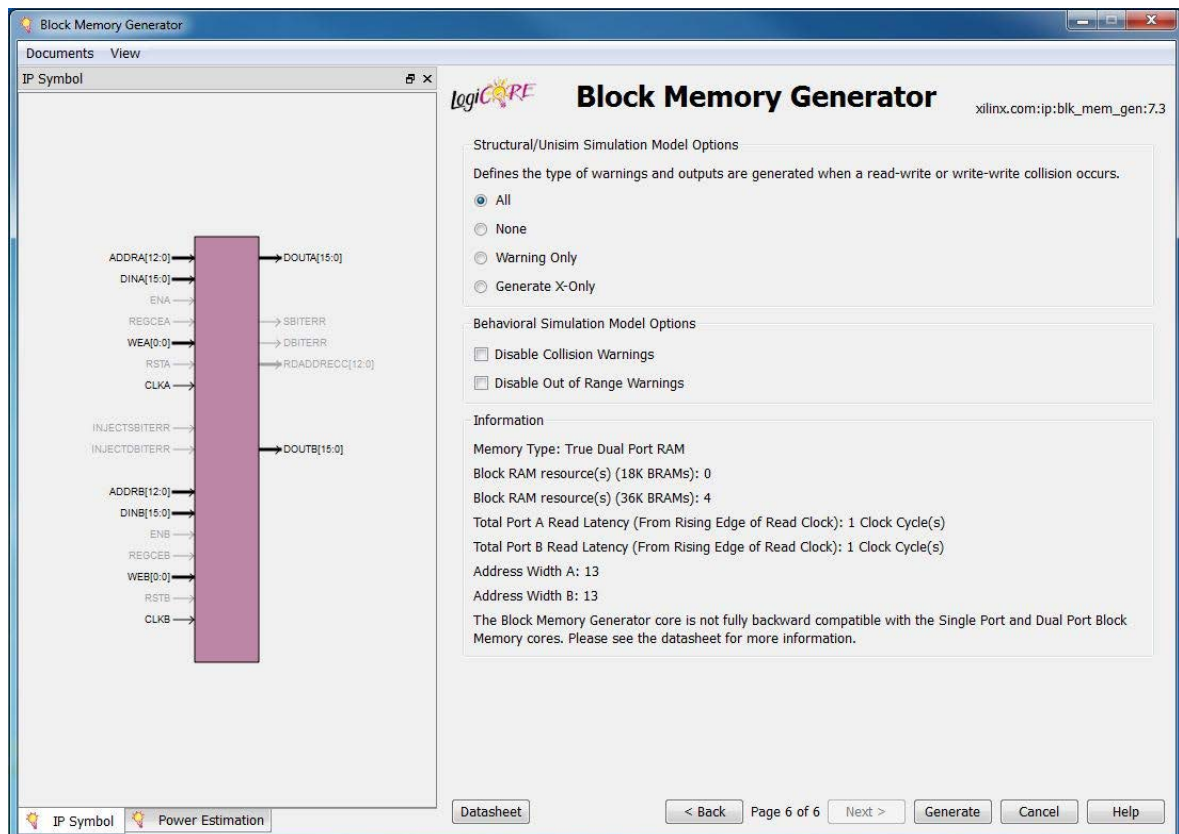


Figure 7-6: Simulation Model Options and Information Screen

Power Estimate Options Screen

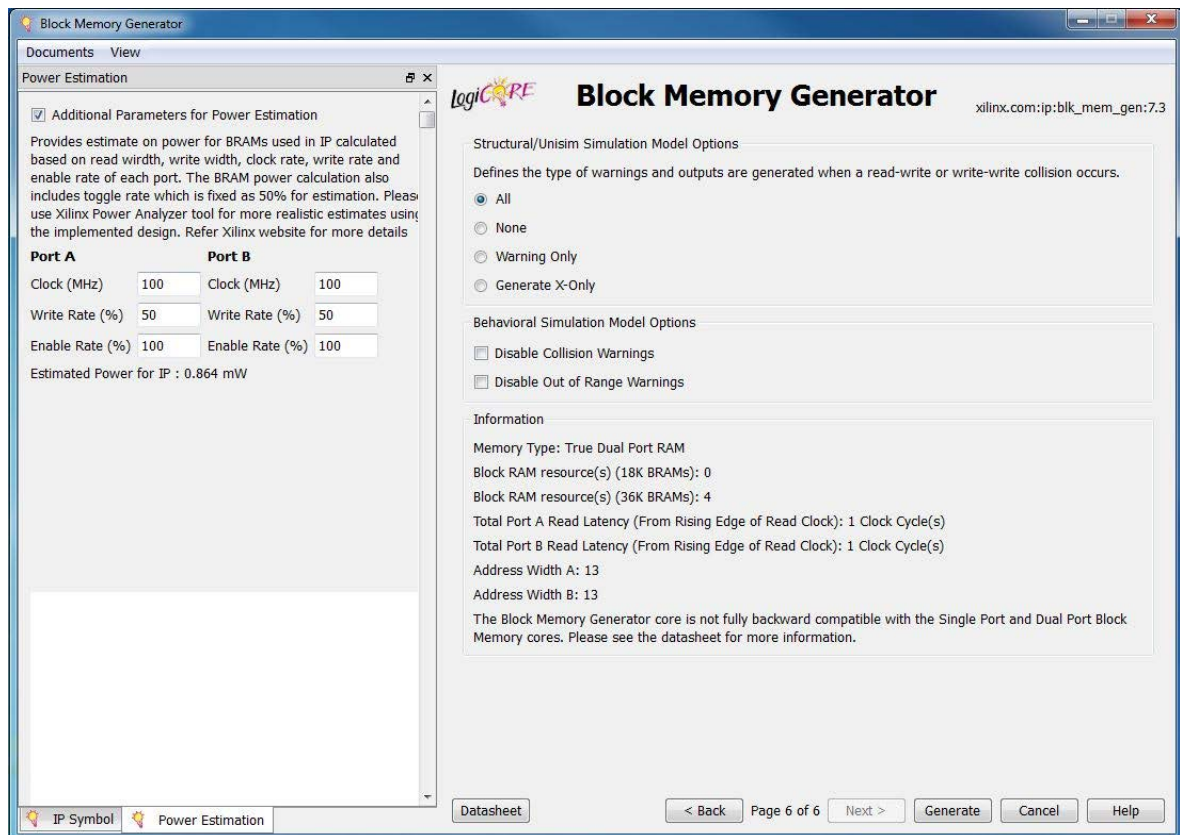


Figure 7-7: Power Estimate Options Screen

The Power Estimation tab on the left side of the GUI screen shown in [Figure 7-7](#) provides a rough estimate of power consumption for the core based on the configured Read width, Write width, clock rate, Write rate and enable rate of each port. The power consumption calculation assumes a toggle rate 50%. More accurate estimates can be obtained on the routed design using the XPower Analyzer tool. See www.xilinx.com/power for more information on the XPower Analyzer.

The screen has an option to provide "Additional Inputs for Power Estimation" apart from configuration parameters. The following parameters can be entered by the user for power calculation:

- **Clock Frequency [A|B]:** The operating clock frequency of the two ports A and B respectively.
- **Write Rate [A|B]:** Write rate of ports A and B respectively.
- **Enable Rate [A|B]:** Average access rate of port A and B respectively.

Structural/UNISIM Simulation Model Options

Select the type of warning messages and outputs generated by the structural simulation model in the event of collisions. For the options of ALL, WARNING_ONLY and GENERATE_X_ONLY, the collision detection feature will be enabled in the UniSim models to handle collision under any condition.

The NONE selection is intended for designs that have no collisions and clocks (Port A and Port B) that are never in phase or within 3000 ps in skew. If NONE is selected, the collision detection feature will be disabled in the models, and the behavior during collisions is left for the simulator to handle. So, the output will be unpredictable if the clocks are in phase or from the same clock source or within 3000 ps in skew, and the addresses are the same for both ports. The option NONE is intended for design with clocks never in phase.

Behavioral Simulation Model Options

Select the type of warning messages generated by the behavioral simulation model. Select whether the model should assume synchronous clocks (Common Clock) for collision warnings.

Information Section

This section displays an informational summary of the selected core options.

- **Memory Type:** Reports the selected memory type.
- **Block RAM Resources:** Reports the exact number of 9K, 18K and 36K block RAM primitives which will be used to construct the core.
- **Total Port A Read Latency:** The number of clock cycles for a Read operation for port A. This value is controlled by the optional output registers options for port A on the previous screen.
- **Total Port B Read Latency:** The number of clock cycles for a Read operation for port B. This value is controlled by the optional output registers options for port B on the previous screen.
- **Address Width:** The actual width of the address bus to each port.

Specifying Initial Memory Contents

The Block Memory Generator core supports memory initialization using a memory coefficient (COE) file or the default data option in the CORE Generator GUI, or a combination of both.

The COE file can specify the initial contents of each memory location, while default data specifies the contents of all memory locations. When used in tandem, the COE file can specify a portion of the memory space, while default data fills the rest of the remaining

memory space. COE files and default data is formatted with respect to the port A Write width (or port A Read width for ROMs).

A COE is a text file which specifies two parameters:

- **memory_initialization_radix:** The radix of the values in the memory_initialization_vector. Valid choices are 2, 10, or 16.
- **memory_initialization_vector:** Defines the contents of each memory element. Each value is LSB-justified, separated by a space, and assumed to be in the radix defined by memory_initialization_radix.

The following is an example COE file. Note that semi-colon is the end of line character.

```
; Sample initialization file for a
; 8-bit wide by 16 deep RAM
memory_initialization_radix = 16;
memory_initialization_vector =
12, 34, 56, 78, AB, CD, EF, 12, 34, 56, 78, 90, AA, A5, 5A, BA;
```

Block RAM Usage

The Information panel (screen 5 of the Block Memory Generator GUI) reports the actual number of 9K, 18K and 36K block RAM blocks to be used.

To estimate this value when using the fixed primitive algorithm, the number of block RAM primitives used is equal to the width ratio (rounded up) multiplied by the depth ratio (rounded up), where the width ratio is the width of the memory divided by the width of the selected primitive, and the depth ratio is the depth of the memory divided by the depth of the primitive selected.

To estimate block RAM usage when using the low power algorithm requires a few more calculations:

- If the memory width is an integral multiple of the width of the widest available primitive for the chosen architecture, then the number of primitives used is calculated in the same way as the fixed primitive algorithm. The width and depth ratios are calculated using the width and depth of the widest primitive. For example, for a memory configuration of 2kx72, the width ratio is 2 and the depth ratio is 4 using the widest primitive of 512x36. As a result, the total available primitives used is 8.
- If the memory width is greater than an integral multiple of the widest primitive, then in addition to the above calculated primitives, more primitives are needed to cover the remaining width. This additional number is obtained by dividing the memory depth by the depth of the additional primitive chosen to cover the remaining width. For example, a memory configuration of 17kx37 requires one 512x36 primitive to cover the width of 36, and an additional 16kx1 primitive to cover the remaining width of 1. To cover the depth of 17K, 34 512x36 primitives and 2 16kx1 primitives are needed. As a result, the total number of primitives used for this configuration is 36.

- If the memory width is less than the width of the widest primitive, then the smallest possible primitive that covers the memory width is chosen for the solution. The total number of primitives used is obtained by dividing the memory depth by the depth of the chosen primitive. For example, for a memory configuration of 2kx32, the chosen primitive is 512x36, and the total number of primitives used is 2k divided by 512, which is 4.

When using the minimum area algorithm, it is not as easy to determine the exact block RAM count. This is because the actual algorithms perform complex manipulations to produce optimal solutions. The optimistic estimate of the number of 18K block RAMs is total memory bits divided by 18k (the total number of bits per primitive) rounded up. Given that this algorithm packs block RAMs very efficiently, this estimate is often very accurate for most memories.

LUT Utilization and Performance

The LUT utilization and performance of the core are directly related to the arrangement of primitives and the selection of output registers. Particularly, the number of primitives cascaded in depth to implement a memory determines the size of the output multiplexer and the size of the input decoder, which are implemented in the FPGA fabric.

Note: Although the primary goal of the minimum area algorithm is to use the minimum number of block RAM primitives, it has a secondary goal of maximizing performance – as long as block RAM usage does not increase.

Generating the AXI4 Interface Block Memory Generator Core

The AXI4 Interface Block Memory Generator GUI includes two additional screens followed by Native BMG configuration screens:

- [Interface Type Selection Screen](#)
- [AXI4 Interface Options](#)

Interface Type Selection Screen

The main Block Memory Generator screen is used to define the component name and provides the Interface Options for the core.

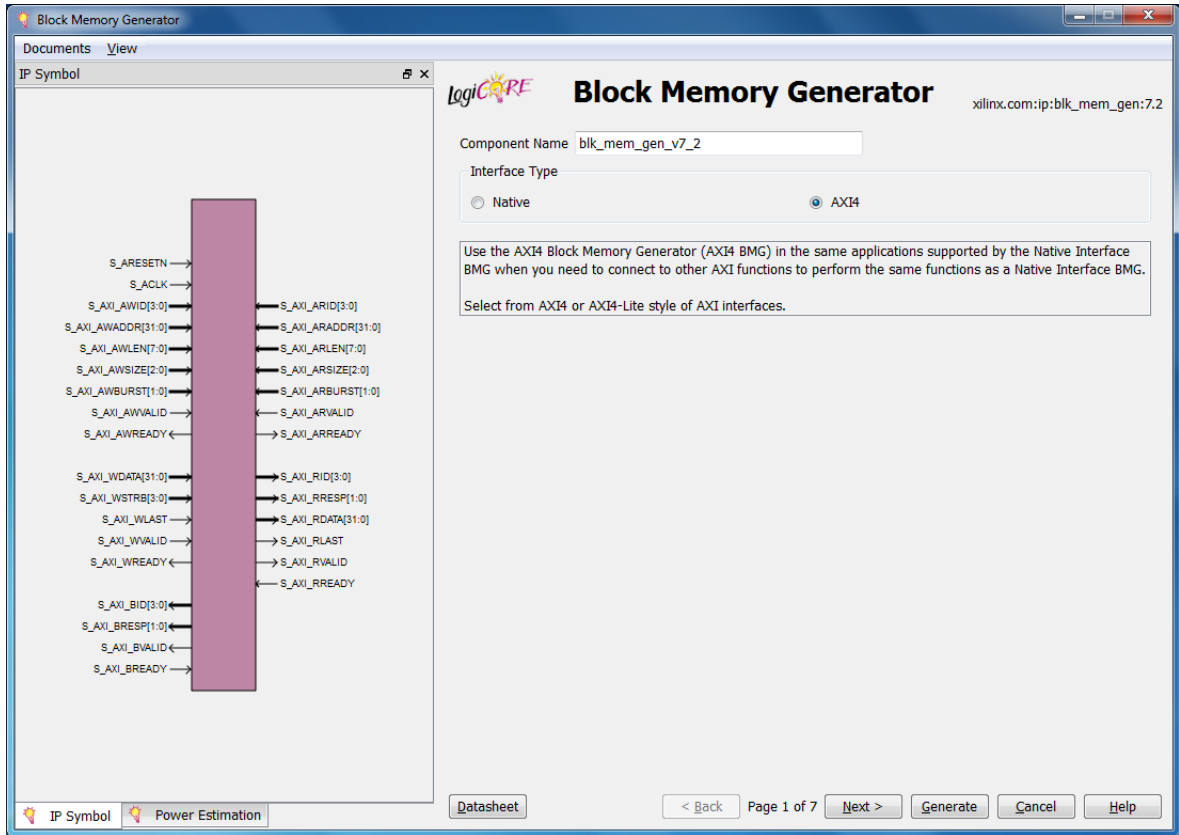


Figure 7-8: Interface Selection Screen of Block Memory Generator

Component Name

Base name of the output files generated for this core. The name must begin with a letter and be composed of the following characters: a to z, 0 to 9, and “_”.

Interface Type

- Native: Implements a Native Block Memory Generator Core.
- AXI4: Implements an AXI4 Interface Block Memory Generator Core.

AXI4 Interface Options

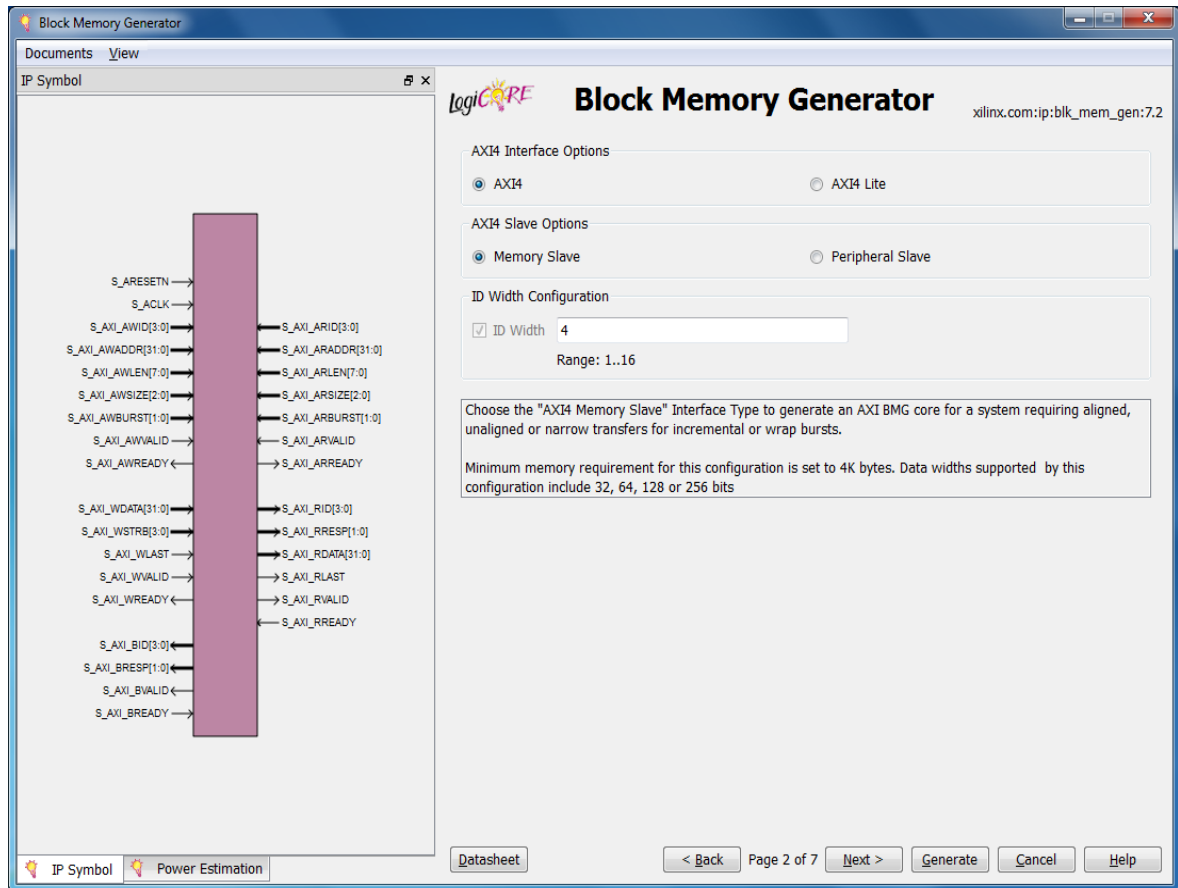


Figure 7-9: AXI4 Interface Options

AXI4 Interface Options

- AXI4: Implements an AXI4 Block Memory Generator Core.
- AXI4-Lite: Implements an AXI4-Lite Block Memory Generator Core.

AXI4 Slave Options

- Memory Slave: Implements a AXI4 Interface Block Memory Generator Core in Memory Slave mode
- Peripheral Slave: Implements a AXI4 Interface Block Memory Generator Core in Peripheral Slave mode

ID Width Configurations

- ID Width: When enabled supports AWID/BID/ARID/RID generation, ID Width can be configured from 1 to 16 bits

Parameter Values in the XCO File

Table 7-1 lists the XCO parameter values.

Table 7-1: Parameter Values

XCO Parameters	Values	Default Values
additional_inputs_for_power_estimation	TRUE, FALSE	FALSE
algorithm	Minimum_Area, Fixed_Primitives, Low_Power	Minimum_Area
assume_synchronous_clk	TRUE, FALSE	FALSE
axi_id_width	4, 1, 16	4
axi_slave_type	Memory_Slave, Peripheral_Slave	Memory_Slave
axi_type	AXI4_Full, AXI4_Lite	AXI4_Full
byte_size	8, 9	9
coe_file	no_coe_file_loaded, coe file name	no_coe_file_loaded
collision_warnings	ALL NONE, WARNING_ONLY, GENERATE_X_ONLY	ALL
component_name	blk_mem_gen_v7_3	blk_mem_gen_v7_3
disable_collision_warnings	TRUE, FALSE	FALSE
disable_out_of_range_warnings	TRUE, FALSE	FALSE
ecc	TRUE, FALSE	FALSE
ecctype	No_ECC, BuiltIn_ECC, Soft_ECC	No_ECC
enable_32bit_address	TRUE, FALSE	FALSE
enable_a	Always_Enabled, Use_ENA_Pin	Always_Enabled
enable_b	Always_Enabled, Use_ENB_Pin	Always_Enabled
error_injection_type	Single_Bit_Error_Injection, Double_Bit_Error_Injection, Single_and_Double_Bit_Error_Injection	Single_Bit_Error_Injection
fill_remaining_memory_locations	TRUE, FALSE	FALSE
interface_type	Native, AXI4	Native
load_init_file	TRUE, FALSE	FALSE
memory_type	Single_Port_RAM, Simple_Dual_Port_RAM, True_Dual_Port_RAM, Single_Port_ROM, Dual_Port_ROM	Single_Port_RAM
operating_mode_a	WRITE_FIRST, READ_FIRST, NO_CHANGE	WRITE_FIRST

Table 7-1: Parameter Values (Cont'd)

XCO Parameters	Values	Default Values
operating_mode_b	WRITE_FIRST, READ_FIRST, NO_CHANGE	WRITE_FIRST
output_reset_value_a	Any binay, decimal and hexadecimal values equal to the data width	0
output_reset_value_b	Any binay, decimal and hexadecimal values equal to the data width	0
pipeline_stages	0, 1, 2, 3	0
port_a_clock	0 - 800	100
port_a_enable_rate	0 - 100	100
port_a_write_rate	0 - 100	50
port_b_clock	0 - 800	100
port_b_enable_rate	0 - 100	100
port_b_write_rate	0 - 100	50
primitive	32kx1, 16kx1, 8kx2, 4kx4, 2kx9, 1kx18, 512x36, 256x72, 256x36	8kx2
read_width_a	1, 2, 4, 8, 16, 32	16
read_width_b	1, 2, 4, 8, 16, 32	16
register_porta_input_of_softecc	TRUE, FALSE	FALSE
register_porta_output_of_memory_core	TRUE, FALSE	FALSE
register_porta_output_of_memory_primitives	TRUE, FALSE	FALSE
register_portb_output_of_memory_core	TRUE, FALSE	FALSE
register_portb_output_of_memory_primitives	TRUE, FALSE	FALSE
register_portb_output_of_softecc	TRUE, FALSE	FALSE
remaining_memory_locations	Any binay, decimal and hexadecimal values equal to the data width	0
reset_memory_latch_a	TRUE, FALSE	FALSE
reset_memory_latch_b	TRUE, FALSE	FALSE
reset_priority_a	CE, SR	CE
reset_priority_b	CE, SR	CE
reset_type	SYNC, ASYNC	SYNC
softecc	TRUE, FALSE	FALSE
use_axi_id	TRUE, FALSE	FALSE
use_byte_write_enable	TRUE, FALSE	FALSE
use_error_injection_pins	TRUE, FALSE	FALSE

Table 7-1: Parameter Values (Cont'd)








XCO Parameters	Values	Default Values
use_regcea_pin	TRUE, FALSE	FALSE
use_regceb_pin	TRUE, FALSE	FALSE
use_rsta_pin	TRUE, FALSE	FALSE
use_rstb_pin	TRUE, FALSE	FALSE
write_depth_a	2 - 9011200	16
write_width_a	1 - 4096	16
write_width_b	1 - 4096	16

Output Generation

The top-level project directory, [<project_directory>](#), for the CORE Generator software contains the following directories:

 [<project_directory>/<component_name>](#)

Contains the Block Memory Generator release notes text file.

-  [<component_name>/example design](#)
Verilog and VHDL design files.
-  [<component_name>/implement](#)
Implementation script files.
-  [<component_name>/implement/results](#)
Created after implementation scripts are run and contains implement script results.
-  [<component_name>/simulation](#)
Contains the test bench and other supporting source files used to create the Block Memory Generator simulation model.
-  [<component_name>/simulation](#)
Contains the test bench and other supporting source files used to create the Block Memory Generator simulation model.
 -  [simulation/functional](#)
Functional simulation scripts.
 -  [simulation/timing](#)
Timing simulation scripts.

Directory and File Contents

This section contains details about the directories of the example design.

<project_directory>

The <project_directory> contains all the CORE Generator software project files.

Table 7-2: Project Directory

Name	Description
<project_directory>	
<component_name>.ngc	Top-level netlist.
<component_name>.v[hd]	Verilog or VHDL simulation model .
<component_name>.xco	CORE Generator software project-specific option file; can be used as an input to the CORE Generator software.
<component_name>_flist.txt	List of files delivered with the core.
<component_name>.{veo vho}	VHDL or Verilog instantiation template.

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<project_directory>/<component_name>

The <component_name> directory contains the release notes text file included with the core that contains last-minute changes and or updates.

Table 7-3: Component Name Directory

Name	Description
<project_directory>/<component_name>	
blk_mem_gen_v7_3_readme.txt	Core name release notes file.

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<component_name>/example design

The example design directory contains the example design files provided with the core.

Table 7-4: Example Design Directory

Name	Description
<project_directory>/<component_name>/example_design	
<component_name>_top.ucf	Provides example constraints necessary for processing the Block Memory Generator core using the Xilinx implementation tools.
<component_name>_exdes.vhd	The VHDL top-level file for the example design; it instantiates the Block Memory Generator core. This file contains entity with the IO's required for the core configuration.

Table 7-4: Example Design Directory (Cont'd)

Name	Description
<component_name>_top_wrapper.v[hd]	The VHDL wrapper file for the example design <component_name>_top.vhd file. This file contains entity with all ports of Block Memory Generator core.

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<component_name>/implement

The implement directory contains the core implementation script files.

Table 7-5: Implement Directory

Name	Description
<project_directory>/<component_name>/implement	
implement.{bat sh}	A Windows (.bat) or Linux script that processes the example design.
xst.prj	The XST project file for the example design that lists all of the source files to be synthesized. Only available when the CORE Generator software project option is set to ISE or Other.
xst.scr	The XST script file for the example design used to synthesize the core. Only available when the CORE Generator software Vendor project option is set to ISE or Other.

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<component_name>/implement/results

The results directory is created by the implement script, after which the implement script results are placed in the results directory.

Table 7-6: Results Directory

Name	Description
<project_directory>/<component_name>/results	
Implement script result files.	

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<component_name>/simulation

The simulation directory contains the demo test bench files provided with the core.

Table 7-7: Simulation Directory

Name	Description
<project_directory>/<component_name>/simulation	
bmg_tb_pkg.vhd	VHDL File provided with demonstration test bench. It contains common functions required by the test bench.
random.vhd	VHDL File provided with demonstration test bench. It contains logic for pseudo random number generation.
data_gen.vhd	VHDL File provided with demonstration test bench. It contains logic for random data generation.
addr_gen.vhd	VHDL File provided with demonstration test bench. It contains logic for generating address.
bmg_stim_gen.vhd	VHDL File provided with demonstration test bench. It contains logic to control the stimulus on the core.
checker.vhd	VHDL File provided with demonstration test bench. It contains logic for verifying correctness BMG core data output.
axi_checker.vhd	VHDL File provided with demonstration test bench. It contains logic for verifying accuracy of BMG core data output.
bmg_axi_protocol_chkr.vhd	VHDL File provided with demonstration test bench. It contains logic to check the basic protocol checks of AXI4.
<component_name>_synth.vhd	VHDL File provided with demonstration test bench. This file has the instances and connections for of core and test bench modules.
<component_name>_tb.vhd	VHDL File provided with demonstration test bench. This is the top file for the test bench which generates the clock and reset signals. It also checks the test bench status.

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simulation/functional

The functional directory contains functional simulation scripts provided with the core.

Table 7-8: Functional Directory

Name	Description
<project_directory>/<component_name>/simulation/functional	
simulate_mti.do	A macro file for ModelSim that compiles the HDL sources and runs the simulation.
wave_mti.do	A macro file for ModelSim that opens a wave window and adds key signals to the wave viewer. This file is called by the simulate_mti.do file and is displayed after the simulation is loaded.
simulate_isim.bat	ISim macro file that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion in the Microsoft Windows operating system.

Table 7-8: Functional Directory (Cont'd)

Name	Description
simulate_isim.sh	ISim macro file that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion in the Linux operating system.
simcmds.tcl	ISim macro file that opens a Wave window with top-level signals.
simulate_ncsim.sh	Linux shell script that compiles the example design sources and the structural simulation model then runs the functional simulation to completion using the Cadence IES simulator.
wave_ncsim.sv	The Cadence IES simulator macro file that opens a wave window and adds interesting signals to it. This macro is called by the simulate_ncsim.sh script.

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simulation/timing

The timing directory contains functional simulation scripts provided with the core.

Table 7-9: Timing Directory

Name	Description
<code><project_directory>/<component_name>/simulation/timing</code>	
simulate_mti.do	A macro file for ModelSim that compiles the HDL sources and runs the simulation.
wave_mti.do	A macro file for ModelSim that opens a wave window and adds key signals to the wave viewer. This file is called by the simulate_mti.do file and is displayed after the simulation is loaded.
simulate_isim.bat	ISim macro file that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion in the Microsoft Windows operating system.
simulate_isim.sh	ISim macro file that compiles the example design sources and the structural simulation model. The demonstration test bench then runs the functional simulation to completion in the Linux operating system.
simcmds.tcl	ISim macro file that opens a Wave window with top-level signals.

Table 7-9: Timing Directory (Cont'd)

Name	Description
simulate_ncsim.sh	Linux shell script that compiles the example design sources and the structural simulation model then runs the functional simulation to completion using the Cadence IES simulator.
wave_ncsim.sv	The Cadence IES simulator macro file that opens a wave window and adds interesting signals to it. This macro is called by the simulate_ncsim.sh script.

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Constraining the Core

Required Constraints

The Block Memory Generator core provides a sample clock constraint. This sample constraint can be added to the user's design constraint file.

Device, Package, and Speed Grade Selections

See [IP Facts](#) for details about support devices.

Clock Frequencies

There are no additional clock frequency constraints for this core.

Clock Management

There are no additional clock management constraints for this core.

Clock Placement

There are no additional clock placement constraints for this core.

Banking

There are no banking constraints for this core.

Transceiver Placement

There are no transceiver constraints for this core.

I/O Standard and Placement

There are no I/O constraints for this core.

Detailed Example Design

This chapter provides details on the example design included with the core.

Directory and File Contents

See [Output Generation in Chapter 7](#) for a detailed list of files generated with the example design.

Example Design

[Figure 9-1](#) shows the configuration of the example design.

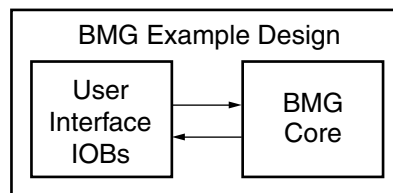


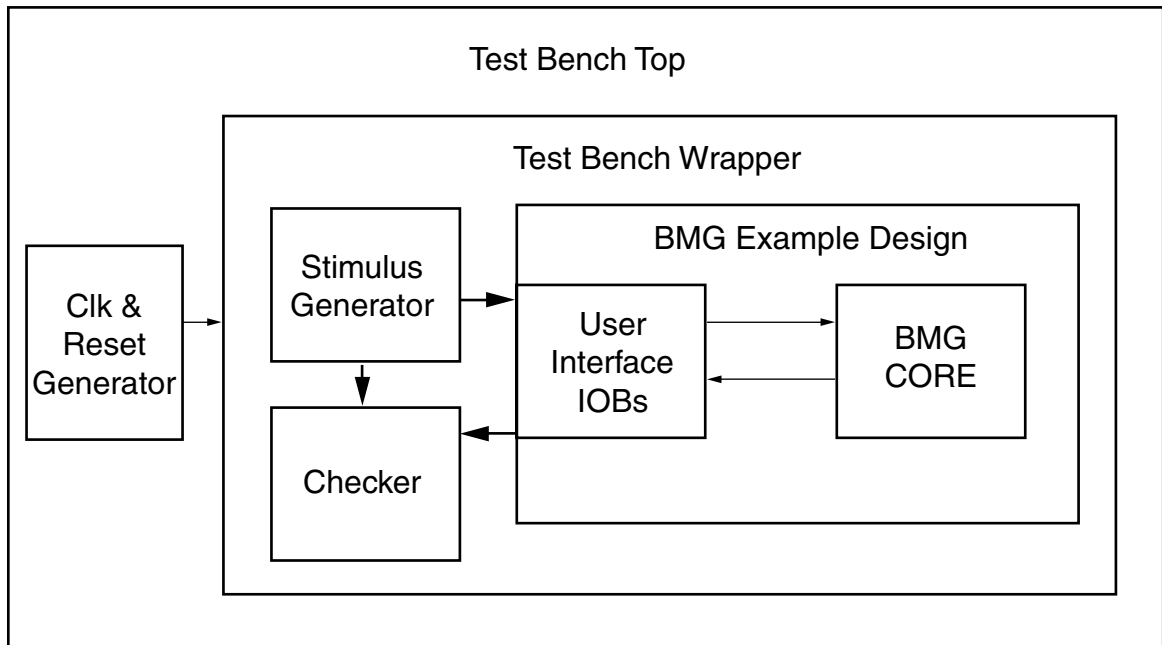
Figure 9-1: Example Design Configuration

The example design contains the following:

- An instance of the Block Memory Generator core. During simulation, the Block Memory Generator core is instantiated as a black box and replaced with the CORE Generator software netlist model during implementation for timing simulation or XST netlist/behavioral model for the functional simulation.
- Global clock buffers for top-level port clock signals.

Demonstration Test Bench

[Figure 9-2](#) shows a block diagram of the demonstration test bench.



X12417

Figure 9-2: Demonstration Test Bench

Test Bench Functionality

The demonstration test bench is a straightforward VHDL file to exercise the example design and the core itself. The test bench consists of the following:

- Clock Generators
- Address and data generator module
- Stimulus generator module
- Data checker
- Protocol checks for the AXI4 protocol

Core with Native Interface

The demonstration test bench in a core with a Native interface performs the following tasks:

- Input clock signals are generated.
- A reset is applied to the example design. Address is generated in a linear incremented format.
- Pseudo random data is generated and given as input to BMG data input port.
- During Reads, data out is compared with another pseudo-random generator with the same seed used for input data random generator.
- Core is exercised with 256 write and read transactions

Core with AXI4 Interface

The demonstration test bench in a core with an AXI4 interface performs the following tasks:

- Input clock signals are generated.
- A reset is applied to the example design.
- Stimulus is generated only when incremented burst and narrow transactions are not exercised.
- Address is generated in a linear incremented format.
- Pseudo-random data is generated for WDATA.
- Length (AWLEN/ARLEN) is determined randomly.
- During read, RDATA is compared with another pseudo-random generator with the same seed as WDATA random data generator.
- A basic AXI4 protocol checker checks the protocol violations.
- Core is exercised with 256 AXI4 write and read transactions.

Implementation

The implementation script is either a shell script (.sh) or batch file (.bat) that processes the example design through the Xilinx tool flow. It is located at:

Linux

```
<project_dir>/<component_name>/implement/implement.sh
```

Windows

```
<project_dir>/<component_name>/implement/implement.bat
```

The implement script performs these steps:

- Synthesizes the HDL example design files using XST
- Runs NGDBuild to consolidate the core netlist and the example design netlist into the NGD file containing the entire design
- Maps the design to the target technology
- Place-and-routes the design on the target device
- Performs static timing analysis on the routed design using Timing Analyzer (TRCE)
- Generates a bitstream

- Enables Netgen to run on the routed design to generate a VHDL or Verilog netlist (as appropriate for the Design Entry project setting) and timing information in the form of SDF files

The Xilinx tool flow generates several output and report files. These are saved in the following directory which is created by the implement script:

```
<project_dir>/<component_name>/implement/results
```

Simulation

This section contains details about the test scripts included in the example design.

Functional Simulation

The test scripts are ModelSim macros that automate the simulation of the test bench. They are available from the following location:

```
<project_dir>/<component_name>/simulation/functional/
```

The test script performs these tasks:

- Compiles the behavioral model/structural UNISIM simulation model
- Compiles HDL Example Design source code
- Compiles the demonstration test bench
- Starts a simulation of the test bench
- Opens a Wave window and adds signals of interest (*wave_mti.do*)
- Runs the simulation to completion

Timing Simulation

The test scripts are ModelSim macros that automate the simulation of the test bench. They are located in:

```
<project_dir>/<component_name>/simulation/timing/
```

The test script performs these tasks:

- Compiles the SIMPRIM based gate level netlist simulation model
- Compiles the demonstration test bench
- Starts a simulation of the test bench
- Opens a Wave window and adds signals of interest (*wave_mti.do*)

- Runs the simulation to completion
-

Messages and Warnings

When the functional or timing simulation has completed successfully, the test bench displays the following message, and it is safe to ignore this message.

```
Failure: Test Completed Successfully
```

SECTION IV: APPENDICES

Verification, Compliance, and Interoperability

Migrating

Debugging

Native Block Memory Generator Supplemental
Information

Additional Resources

Verification, Compliance, and Interoperability

The Block Memory Generator core and the simulation models delivered with it are rigorously verified using advanced verification techniques, including a constrained random configuration generator and a cycle-accurate bus functional model.

Simulation

The Block Memory Generator has been tested with Xilinx ISE® Design Suite v14.4, Xilinx Vivado Design Suite v2012.4, Xilinx ISIM/XSIM, Cadence Incisive Enterprise Simulator (IES), Synopsys VCS and VCS MX and Mentor Graphics ModelSim simulator.

Migrating

This appendix provides step-by-step instructions for migrating designs containing instances of either the legacy memory cores (Dual Port Block Memory and Single Port Block Memory cores) or older versions of the LogiCORE™ IP Block Memory Generator core to the latest version of the Block Memory Generator core.



TIP: For new designs, Xilinx recommends that you use the most recent version of the Block Memory Generator core for all block memory function requirements.

For information on migrating to the Vivado™ Design Suite, see [UG911](#), *Vivado Design Suite Migration Methodology Guide*.

Migration Overview

Two types of core migration are available: manual and automated. Manual migration includes converting the XCO file(s) of the legacy cores or the XCO file(s) of the older Block Memory Generator cores to XCO file(s) of the latest version of the Block Memory Generator core, generating a new core, and modifying the instantiations of the new cores. Automated migration, provided in the Block Memory Generator Migration Kit, uses a Perl script to automate the migration process.

A prerequisite for using the Migration Kit is that the device family of the user's old Block Memory design should be supported by the latest version of the Block Memory Generator core. Designs using unsupported families will have to be re-targeted to one of the supported device families. For information on the supported device families, see [IP Facts](#), page 6.

Before starting the migration process, do the following:

- [Evaluate the differences between the core features, page 145](#)
- Determine which migration process to use:
 - [Automated Migration, page 149](#)
 - [Manual Migration, page 155](#)

Differences Between Cores

The Block Memory Generator core leverages the capabilities of Xilinx FPGA embedded block RAM primitives to automatically build a wide range of single and dual port memories by concatenating Xilinx FPGA block RAM primitives in an optimal manner. Use of an enhanced algorithm optimizes block RAM primitive resource utilization and creates a higher level of performance than previous generations of block memory cores.

Core Compatibility

Core Compatibility with Legacy Block Memory Cores

The Block Memory Generator core is not backward compatible with the Single and Dual Port Block Memory cores in the following ways:

- Pin polarity, handshaking, and input register features supported by the previous generation memory cores are not supported in the Block Memory Generator.
- The behavior of synchronous set/reset pin (RST) in the Block Memory Generator differs from the previous generation v6.x cores when using optional output registers.
- The Single Port Block Memory v6.x core and the Block Memory Generator do not have the same port names for a single-port memory configuration.
- The Dual Port Block Memory core and the Block Memory Generator do not have the same reset port name.
- The XCO files for the previous generation memory cores are *not* compatible with the Block Memory Generator.
- Not all combinations of Read and Write, Write Only, and Read Only port configurations are natively supported by Dual Port memories generated in the new Block Memory Generator. In these cases, generate a True Dual Port RAM and manually tie-off the unused port (automated if using the Migration Kit).

Differences in port names and XCO parameters are provided in ["Convert the XCO File"](#) on page 156 and ["Modifying Instantiations of the Old Core"](#) on page 163.

Core Compatibility with Older versions of Block Memory Generator Core

Versions of the Block Memory Generator core newer than 2.x are not backward compatible with the 1.x and 2.x versions of the Block Memory Generator cores in the following ways:

- The names of the reset ports have been changed.
- The names of some of the reset related XCO parameters have changed.

Port Configuration/Memory Type

Not all combinations of Read and Write, Write Only, and Read Only port configurations are natively supported by Dual Port memories generated in the new Block Memory Generator. [Table B-1](#) defines the relationship between Dual Port Block Memory v6.x configurations and the equivalent implementation using the Block Memory Generator. The Migration Kit automatically maps Dual Port Block Memory v6.x instantiations to the equivalent Block Memory Generator usage, including tying-off the unused ports.

Table B-1: Block Memory Generator Port Configurations with Memory Types

Dual Port Block Memory Core		Block Memory Generator Core	
Port A Configuration	Port B Configuration	Memory Type	Notes
Read and Write	Read and Write	True Dual Port RAM	N/A
Write Only	Read Only	Simple Dual Port RAM	N/A
Read Only	Read Only	Dual Port RAM	N/A
Read Only	Read and Write	True Dual Port RAM	Tie-off Write Port A
Write Only	Read and Write	True Dual Port RAM	Tie-off Read Port A
Read and Write	Read Only	True Dual Port RAM	Tie-off Write Port B
Read and Write	Write Only	True Dual Port RAM	Tie-off Read Port B
Read Only	Write Only	Simple Dual Port RAM	Reverse A and B Ports

Modified Behaviors of Legacy Block Memory Cores

Enable Pin

The Block Memory Generator provides two enable pin options:

- `REGCE` pin only controls the enables of the registers in the last output stage.
- `EN` pin controls the enables of all other registers and memory, and in the absence of a `REGCE` pin, also controls the enables of the registers in the last output stage.

The v6.x memory cores only provide a core-wide enable (second option).

Synchronous Reset Pin

In the Block Memory v6.x cores, the synchronous reset (`SINIT` pin) initializes all memory latches and output registers. With the Block Memory Generator core, the synchronous set/reset (`RST` pin) only resets the registers in the last output stage. When there are no output register stages present, it initializes the memory latches.

Output Registers

The Block Memory v6.x cores allowed you to add an additional output pipeline register stage on the output of the block RAM. With the Block Memory Generator, you have better control on where and how these output registers are implemented. Output registers can be added to the following locations:

- Output of the block RAM primitives (before output multiplexing)
- Output of the core (after output multiplexing)
- Pipeline register stages within the MUX

When targeting the Virtex®-4 FPGA architecture, the primitive output register stage is implemented using the embedded register in Virtex-4 FPGA block RAM when the `RST` pin is not used. For all other Virtex-4 FPGA configurations and their derivatives, all output register stages are implemented in the FPGA fabric.

The Block Memory Generator core provides optional pipeline stages within the MUX, available only when the registers at the output of the memory core are enabled and only for specific configurations. For the available configurations, the number of pipeline stages can be 1, 2, or 3.

Changes in WEA/WEB Signal Type (VHDL)

In the Block Memory Generator core, the width of the write enable input signals (`WEA`, `WEB`) can vary depending on the configuration. The width of the write enable buses are larger than 1 bit only if the byte write enable feature is used. To accommodate this, the write enable signal is always a bus of type `std_logic_vector` instead of `std_logic` in VHDL, even when the width of the signal is 1 bit.

When migrating from the Single Port Block Memory or Dual Port Block Memory cores to the Block Memory Generator, be aware that the `WEA/WEB` inputs in the Block Memory Single Port and Dual Port cores are of type `std_logic`, whereas the `WEA/WEB` inputs of the Block Memory Generator are of type `std_logic_vector`. When the write enable is only 1-bit wide, this change requires the use of a different method to connect the `WEA/WEB` inputs to the rest of the design.

To connect the WEA port:

1. Declare an intermediate signal of type `std_logic_vector` for the write enable. This is the signal that connects to the Block Memory Generator `WEA` port in the instantiation.

Example:

```
signal we_int: std_logic_vector(0 downto 0);
```

2. Assign your write enable input (of type `std_logic`) to bit 0 of the 1-bit-wide intermediate signal.

Example:

```
signal <user_wea>: std_logic;
we_int(0) <= <user_wea>;
```

3. Connect the intermediate signal you created and assigned during your instantiation of the Block Memory Generator to the WEA port of the core.

Example:

```
user_bmg: bmg_inst PORT MAP (
    WEA => we_int;
    ...other port connections...
);
```

Note: This change in WEA/WEB type does not affect customers using Verilog.

A full example instantiation of the Block Memory Generator core is shown below:

```
signal we_int: std_logic_vector(0 downto 0);
signal <user_wea>: std_logic;
...
we_int(0) <= <user_wea>;
...
--Instantiate the new BMG core
uut: blk_mem_gen_v3_1
port map (
    dina    => <user_dina>,
    wea     => we_int,
    addra   => <user_addra>,
    rsta    => <user_rsta>,
    douta   => <user_douta>,
    clka    => <user_clka>,
    ena     => <user_ena>
);
```

Using the Migration Kit

The Migration Kit provides two Perl scripts to help automate the process of converting existing v6.x Legacy Block Memory cores or older versions of the Block Memory Generator core to the latest version of the Block Memory Generator core.

- The primary migration script automates all the manual steps, from converting the XCO file to modifying the instantiation of the old core. In addition, this script can be used to

select only specific steps to automate, making it useful as part of the manual migration process.

- The second script recreates XCO files from EDIF or NGC netlists, if necessary (see [Script Limitations](#) for more information).

Primary Migration Script

If you can provide all the original design files, the primary migration script (`bmg_migrate.pl`) completely and seamlessly automates the migration process by executing the following steps:

1. Converts old XCO files to new XCO files
2. Modifies instantiations of old cores to new cores including changing port names
3. Adds logic to implement obsolete features (input registers, signal polarity, enable, and reset behaviors)
4. Generates new netlists by calling the CORE Generator™ software Graphical User Interface (GUI) with the new XCO and related COE files
5. Restores original design files, if necessary

Recover XCO Script

If you do not have the v6.x XCO files and/or the related COE files, the recover XCO script (`recover_xco.pl`) can recreate the old v6.x XCO files from your netlist(s).

This script performs the following steps:

1. Scans the netlist(s) to determine the required values for the parameters in the XCO file.
2. Generates COE file(s) (initialization file) if initial values for the block RAMs have been specified in the netlist.

Supported Platforms

- Windows® 2000
- Windows XP Pro
- Red Hat® Enterprise WS

About the Migration Script

The migration script, `bmg_migrate.pl`, can operate on various inputs and create a variety of outputs based on user-specified command line options.

When using the script as part of the standard, fully-automated flow, you supply the script with one or more of these three file types:

- Single Port and/or Dual Port Block Memory XCO core configuration files or XCO configuration files of the older versions of the Block Memory Generator core (created by the GUI when these cores were generated)
- HDL source file(s) containing the core instantiations (VHDL or Verilog)
- COE files used to initialize the memory (if necessary)

The path to the COE file is defined in the XCO file. If you do not have the COE file available, use the `recover_xco.pl` script to recover it (see [Script Limitations, page 153](#)). The `recover_xco.pl` script can also be used to regenerate the original v6.x XCO file if it is not available.

From the script options, choose one or more of the following migration steps. All selected steps are automatically performed by the script.

- Convert XCO files of the Legacy Block Memory cores or the older versions of the Block Memory Generator core to Block Memory Generator XCO files of the latest version.
- Convert the instantiations of the old cores in your HDL source code to instances of the latest version of the Block Memory Generator core.
- Add logic to implement obsoleted features to make the new core backward compatible with the legacy instances.
- Generate the new netlists by running the CORE Generator software.

The script modifies and overwrites all input files so that the external project files and scripts do not need to be updated with new file names or locations. Although the script also automatically generates a backup of all files it modifies, it is strongly recommended that you create a backup of all project files before running the migration script.

Output Products

Depending on the chosen command line option, the script overwrites the input XCO files, modifies the input HDL files, and optionally generates Block Memory Generator netlists (in the same location as the XCO files).

The script creates a `./bmg_migrate_bak_<xcofilename>` backup directory for each XCO file in which a copy of all files modified by the migration process is placed. It also generates a restore script in this directory, `restore_files.pl`, to allow you to restore the original files if necessary.

Supported Features for Legacy Block Memory Cores

The migration script adds code to your HDL source files to supplement features that have become obsolete in the Block Memory Generator core, making your design almost drop-in

compatible with the original design containing the v6.x memory cores (see [Script Limitations, page 153](#) for details).

The script can add the following features to the Block Memory Generator core:

- Support for inverted clock and enable signals
- Support for input registers
- Support for handshaking signals

Using the Migration Script

To start the Migration Script, type the commands specific to your environment at the command prompt.

Note: The ISE 12.3 software requires a CGP file when CORE Generator is run in a command line. To help the user, the Migration Script comes with a sample CGP file (`coregen.cgp`). The user can modify the sample CGP file according to the user's requirement. The modified CGP file should be kept in the user directory where the XCO file and instantiation files are located. The CGP file name must be `coregen.cgp`.

Linux

```
<path to script>/bmg_migrate.pl [-x [-n]]  
[-m <HDL file(s)>] <xco file>
```

Windows

```
xilperl <path to script>\bmg_migrate.pl  
[-x [-n]]-m <HDL file(s)>] <xco file>
```

You must use at least one of the following options in the command string:

- **-x.** Creates an XCO output files needed by the CORE Generator software to generate the core. Requires an input of the old XCO file.
- **-n.** Calls the CORE Generator software to generate Block Memory Generator netlists necessary to synthesize the design. This option must be used in tandem with the **-x** option.
- **-m.** Modifies the HDL source files containing the core instantiations, converting the old instantiations and adding compatibility code where needed. Requires at least one old XCO file and one HDL design file containing old core instantiations.

`<HDL file(s)>` is a list of one or more HDL files containing instantiations of the cores described by the XCO files. These files can be referenced from directories other than the working directory. The HDL files listed with an XCO file must have instances with the same configuration as described by the XCO file.

`<xco file>` is a core configuration file of either the Legacy v6.x Block Memory cores or older versions of the Block Memory Generator core, which is to be converted to

configuration file of the latest version of the Block Memory Generator core. This file can be referenced from directories other than the working directory.

To reverse the changes made by the script, go to the backup directory of the XCO file at `./bmg_migrate_bak_<xcofilename>` and then run `xilperl script restore_files.pl`.

Usage Examples

```
bmg_migrate.pl -x -m -n my_design.v my_old_core.xco
```

1. Creates a Block Memory Generator version of `my_old_core.xco`.
2. Modifies the instantiations of `my_old_core` in `my_design.v`.
3. Runs CORE Generator software to generate the Block Memory Generator version of `my_old_core.ngc` netlist file.

```
bmg_migrate.pl -x my_mem_core.xco
```

1. Creates a Block Memory Generator version of `my_mem_core.xco`.

If an invalid Block Memory Generator version is given in the XCO, the script prompts the user to input a valid Block Memory Generator version.

Script Limitations

Block Memory Generator cores generated using the migration tool are backward compatible with the legacy v6.x Block Memory cores and the older versions of the Block Memory Generator.

The migration script can successfully read and parse most HDL files. Files written using standard coding styles and following standard Xilinx design methodologies (for example, using the CORE Generator software HDL instantiation templates typically generated with the cores) are handled appropriately. If the script cannot properly read and parse the user input HDL files, you must perform the conversion manually (see [Migrating a Design Manually](#)).

Recover XCO Script

The `recover_xco.pl` script scans netlists containing legacy v6.x Block Memory cores or older versions of the Block Memory Generator core and regenerates XCO and COE files of the respective core from them. It can be used to recover XCO or COE files from a design netlist if either of these types of files is missing. COE files are recovered *only* if there is memory initialization data within the netlist; this occurs by simulating the core using the Xilinx ISIM simulator. After recovering the XCO and/or COE files, run the migration script to create the new Block Memory Generator counterparts.

Using the Recover XCO Script

Note: To run this script, ISIM must be installed as part of ISE.

To start the Recover XCO script, type the commands specific to your environment at the command prompt. The Recover XCO script requires an input CORE Generator software project file (*.CGP).

Linux

```
<path to script>/recover_xco.pl -cgp=<coregen_project_file.cgp> <netlist(s)>
```

Windows

```
xilperl <path to script>\recover_xco.pl -cgp=<coregen_project_file.cgp> <netlist(s)>
```

For All Platforms

- `<netlist(s)>` is a list of netlist files of v6.x Block Memory core or old Block Memory Generator core versions in EDN or NGC format.
- `<coregen_project_file.cgp>` is a software project file (*.CGP) containing the project options to be applied to the output XCO file. If a CGP file is not available, you can create one by creating a new project in GUI. When creating the new project, you will be prompted to set project parameters such as target device, family, HDL language format (VHDL or Verilog), implementation output format, etc.

Note: You do not need to regenerate the v6.x core after recreating the CORE Generator software project file.

The script automatically detects if the block RAMs were initialized and runs ISIM simulation to extract initial values in the memory into a COE file.

Usage Examples

```
recover_xco.pl -cgp=coregen.cgp my_old_core.edn dp_mem.ngc
```

1. Scans the netlists and generates `my_old_core.xco` and `dp_mem.xco` files.
2. May create COE files if initialization data is embedded in the input netlist file.

```
recover_xco.pl -cgp=../proj/my_coregen.cgp ../netlists/my_rom.edn
```

Scans the netlists and generates `../netlists/my_rom.xco` and `../netlists/my_rom.coe`.

Using the Perl Scripts with a Windows OS

When running the Perl scripts in the Windows environment, the scripts must be invoked using a Perl program such as `xilperl`, which is distributed with Xilinx ISE software. The scripts are intended to be executed within a Windows command window (DOS shell).

Example Windows Usage

The location of HDL files and CORE Generator software netlists may differ from project to project. Assume that project HDL files are stored in `c:\xilinx\my_proj\hdl`, and Block Memory netlists and XCO files are in `c:\xilinx\my_proj\ip_cores`. Copy the migration scripts (`bmig_migrate.pl` and `recover_xco.pl`) into the `c:\xilinx\my_proj` directory.

Open a command window:

1. From the Windows Start menu, choose Run; then type `cmd` in the Run dialog box.
2. At the command prompt, type the following:

```
C:\> cd \xilinx\my_proj
C:\xilinx\my_proj> xilperl bmg_migrate.pl -v7.3 -x -n -m hdl\top.v
ip_cores\dp_ram.xco
```

The script performs the XCO conversion, modifies the HDL files containing the core instantiations, and generates new Block Memory Generator netlists. A new file, `bmig_migrate.log` is created, as well as a new subdirectory, `c:\xilinx\my_proj\bmig_migrate_bak` containing backups of all modified files.

Invoking the Restore_files Script

To invoke the `restore_files.pl` script, enter the following at the command prompt:

```
C:\> cd \xilinx\my_proj\bmig_migrate_bak
C:\xilinx\my_proj\bmig_migrate_bak> xilperl restore_files.pl
```

This effectively reverses the migration process by restoring any files modified by the `bmig_migrate.pl` script.

Migrating a Design Manually

This section provides instructions for manually migrating an existing design to a Block Memory Generator core. A summary of the required migration steps are provided below, followed by specific migration instructions. Note that some of the manual conversion tasks can be automated using the Migration Kit script; see individual sections for more information.

To migrate a design manually:

1. Convert the XCO File

The XCO file is the file the CORE Generator software uses to determine a core's configuration. The format for the Block Memory Generator XCO file differs from the Single Port and Dual Port Block Memory v6.x cores.

Note: If you plan to generate a new Block Memory Generator core using the GUI, skip this step.

2. Generate the Block Memory Generator core.
3. Modify the instantiations of the old core.

Convert the XCO File

The first step in the manual migration process is to convert an XCO file of either a legacy v6.x Block Memory core or an older version of Block Memory Generator core to the XCO file of the latest Block Memory Generator core. If you do not have the original XCO or COE files for the old cores, you can use the `recover_xco` script provided with the automated Migration Kit to recover XCO files from the implementation netlists (see ["Script Limitations" on page 153](#) for more information).

Core Parameter Differences

[Tables B-2, B-3](#) and [B-4](#) define the parameter differences between the older cores (Single and Dual Port Block Memory v6.x cores, or v1.1/v2.x versions of the Block Memory Generator cores) and the latest version of the Block Memory Generator core. In case of the legacy cores, parameters corresponding to features not supported in the Block Memory Generator core must be implemented in the user design by adding logic. For older versions of the Block Memory Generator core, almost all parameters are the same as the latest Block Memory Generator core. For parameter differences, see [Table B-4](#). See [Differences Between Cores, page 145](#) for information about unsupported features.

In addition to changes in the parameter section of the XCO file, you must change the core name specified in the XCO. Update the core name and version from the old core to the new core.

For example, for the old Dual Port Block Memory core, change the line from

```
SELECT Dual_Port_Block_Memory Spartan3 Xilinx,_Inc. 6.1
```

to:

```
SELECT Block_Memory_Generator family Xilinx,_Inc. 7.3
```

For the old Single Port Block Memory core, change the line from

```
SELECT Single_Port_Block_Memory Spartan3 Xilinx,_Inc. 6.1
```

to:

```
SELECT Block_Memory_Generator family Xilinx,_Inc. 7.3
```

For an old version of the Block Memory Generator core, change the line from

```
SELECT Block_Memory_Generator Spartan3 Xilinx,_Inc. 2.8
```

to:

```
SELECT Block_Memory_Generator family Xilinx,_Inc. 7.3
```

Once these changes have been made, use the CORE Generator GUI to import the modified XCO file using **Project > Import Existing Customized IP ...**. Ensure that all the parameters set in the GUI are appropriate for your design and then generate the core.

If you do not have an old XCO file to convert, the migration guide also provides a script (`recover_xco.pl`) that can recover XCO parameters by scanning the netlist of the old core (see ["Script Limitations" on page 153](#)).

Table B-2: XCO Parameter Mapping: Dual Port Block Memory Cores

Dual Port XCO Parameter	BMG XCO Parameter	Description of Conversion
component_name	component_name	No change required
width_[a b]	write_width_[a b] read_width_[a b]	read_width[a b]= write_width[a b] = width[a b]
depth_a	write_depth_a	Direct replacement
depth_b	-	Not needed
configuration_port_[a&b]	memory_type	<ul style="list-style-type: none"> A write, B read: Simple_Dual_Port A read, B write: Not supported, switch A and B ports A read, B read: Dual_Port_ROM Otherwise: True_Dual_Port_RAM
write_mode_port_[a b]	operating_mode_[a b]	<ul style="list-style-type: none"> Read_After_Write: WRITE_FIRST Read_Before_Write: READ_FIRST No_Read_On_Write: NO_CHANGE
global_init_value	remaining_memory_locations	Direct replacement
load_init_file	load_init_file	Direct replacement
coefficient_file	coe_file	Direct replacement
port_[a b]_enable_pin	enable_[a b]	<ul style="list-style-type: none"> False: Always_Enabled True: Use_EN[A B]_Pin
port_[a b]_handshaking_pins	-	Not supported

Table B-2: XCO Parameter Mapping: Dual Port Block Memory Cores (Cont'd)

Dual Port XCO Parameter	BMG XCO Parameter	Description of Conversion
port_[a b]_register_inputs	-	Not supported
port_[a b]_additional_output_pipe_stages	<ul style="list-style-type: none"> BMG v2.4 and earlier: register_output_of_memory_core BMG v2.5 and later: register_port[a b]_output_of_memory_core 	Direct replacement. 0: false 1: true
port_[a b]_init_pin	use_rst[a b]_pin	Parameter value is the same, behavior is different.
port_[a b]_init_value	output_reset_value_[a b]	Direct replacement
primitive_selection	algorithm	<ul style="list-style-type: none"> Optimize_For_Area: Minimum_Area Select_Primitive: Fixed_Primitives
select_primitive	primitive	Direct replacement
port_[a b]_write_enable_polarity	-	Not supported
port_[a b]_enable_pin_polarity	-	Not supported
port_[a b]_initialization_pin_polarity	-	Not supported
port_[a b]_active_clock_edge	-	Not supported
disable_warning_messages	disable_out_of_range_warnings	Direct Replacement
disable_warning_messages	disable_collision_warnings	Direct Replacement

Table B-3: XCO Parameter Mapping: Single Port Block Memory Cores

Single Port XCO Parameter	BMG XCO Parameter	Description of Conversion
component_name	component_name	No change required
width	write_width_[a&b] read_width_[a&b]	read_width[a b] = write_width[a b] = width
depth	write_depth_a	Direct replacement
port_configuration	memory_type	<ul style="list-style-type: none"> Read_And_Write: Single_Port_RAM Read_Only: Single_Port_ROM
write_mode	operating_mode_[a&b]	<ul style="list-style-type: none"> Read_After_Write: WRITE_FIRST Read_Before_Write: READ_FIRST No_Read_On_Write: NO_CHANGE
global_init_value	remaining_memory_locations	Direct replacement
load_init_file	load_init_file	Direct replacement
coefficient_file	coe_file	Direct replacement

Table B-3: XCO Parameter Mapping: Single Port Block Memory Cores (Cont'd)

Single Port XCO Parameter	BMG XCO Parameter	Description of Conversion
enable_pin	enable_[a&b]	False: Always_Enabled True: Use_EN[A B]_Pin
handshaking_pins	-	Not supported
register_inputs	-	Not supported
additional_output_pipe_stages	<ul style="list-style-type: none"> BMG v2.4 and earlier: register_output_of_memory_core BMG v2.5 and later: register_port[a&b]_output_of_memory_core 	Direct replacement 0: false 1: true
init_pin	use_rst[a&b]_pin	Parameter value is the same, behavior is different.
init_value	output_reset_value_[a&b]	Direct replacement
has_limit_data_pitch	-	Not supported
limit_data_pitch	-	Not supported
primitive_selection	Algorithm	<ul style="list-style-type: none"> Optimize_For_Area: Minimum_Area Select_Primitive: Fixed_Primitives
select_primitive	Primitive	Direct replacement
enable_pin_polarity	-	Not supported
initialization_pin_polarity	-	Not supported
write_enable_polarity	-	Not supported
active_clock_edge	-	Not supported
disable_warning_messages	disable_out_of_range_warnings	Direct Replacement
disable_warning_messages	disable_collision_warnings	Direct Replacement

Table B-4: XCO Parameter Differences Versions of Block Memory Generator Cores

BMG v2.x or v1.1 XCO Parameter	Block Memory Generator v7.3	Description of Conversion
use_ssr[a b]_pin	use_rst[a b]_pin	Direct Replacement
use_ramb16bwr_reset_behavior	reset_memory_latch_a reset_memory_latch_b	Direct Replacement
N/A	ecctype	New Parameter
N/A	softecc	New Parameter
N/A	register_porta_input_of_softecc	New Parameter
N/A	register_portb_output_of_softecc	New Parameter

Table B-4: XCO Parameter Differences Versions of Block Memory Generator Cores

BMG v2.x or v1.1 XCO Parameter	Block Memory Generator v7.3	Description of Conversion
N/A	use_bram_block	New Parameter
N/A	enable_32bit_address	New Parameter

Generate the Block Memory Core

To migrate from the Single Port or Dual Port Block Memory v6.x cores or older versions of the Block Memory Generator core to the new Block Memory Generator, a Block Memory Generator netlist must be generated to replace the old netlist.

Parameterizing the Block Memory Generator GUI

One method for generating an appropriate Block Memory Generator netlist is to parameterize the Block Memory Generator GUI without using an XCO file. Selecting parameterization options for the Block Memory Generator core are available from the GUI.

Table B-5 compares the GUI parameters between the v6.x Block Memory cores and the Block Memory Generator cores. Table B-6 compares GUI parameters between the old and new versions of the Block Memory Generator core. These tables help outline the appropriate options when creating a new core using the Block Memory Generator GUI.

Table B-5: GUI Parameter Comparison for Legacy Block Memory Cores

Single-Port/Dual-Port Block Memory	Block Memory Generator	Functionality of the GUI Parameter
Single Port: Read/Write, Read only Dual Port: Read/Write, Write Only, Read Only for each port	Single Port RAM Single Port ROM Simple Dual Port RAM Dual Port ROM True Dual Port RAM	Type of memory to be generated. See Table B-1 for equivalents.
-	Write Enable	When selected, the core has a write enable pin; when deselected, write enable is tied to '1' internally.
-	Byte Write Enable (for Virtex-6, Virtex-5, Virtex-4, Spartan®-6 and Spartan-3A/AN/DSP families only)	When targeting Virtex-6, Virtex-5, Virtex-4, Spartan-6, or Spartan-3A/AN/DSP, select whether to use the byte-write enable feature. Select whether to use a byte size of 8 or 9.

Table B-5: GUI Parameter Comparison for Legacy Block Memory Cores (Cont'd)

Single-Port/Dual-Port Block Memory	Block Memory Generator	Functionality of the GUI Parameter
Primitive Selection <ul style="list-style-type: none"> • Optimize For Area • Select Primitive 	Algorithm <ul style="list-style-type: none"> • Minimum Area • Fixed Primitives 	Algorithm used to implement the memory. <ul style="list-style-type: none"> • Minimum Area Algorithm: Generates a core using the least number of primitives. • Selectable Primitive Algorithm: Generates a core that concatenates a single primitive type to implement the memory. Choose which primitive type to use in the drop down box.
Width / Port [A&B] width	Port A write width, Port A read width / Port [A&B] write width, Port [A&B] read width	Specify the port's write width and depth. Select the port's read width from the drop-down menu of valid choices.
Depth / Port [A&B] depth	Port A write depth / Port [A&B] write depth	The minimum depth for both cores is 2. The read depth is calculated automatically.
Write mode / Port [A&B] write mode <ul style="list-style-type: none"> • Read After Write • Read Before Write • No Read On Write 	Port A Operating mode / Port [A&B] Operating mode <ul style="list-style-type: none"> • Write First • Read First • No Change 	The Block Memory Generator core provides the same operating modes found on the block memory primitives.
Design Options / Port [A&B] Design Options <ul style="list-style-type: none"> • Enable Pin 	Enable (Port A) / Enable (Port A and Port B) Select the enable type: <ul style="list-style-type: none"> • Use EN[A B] pin • Always enabled (no EN[A B] pin available) 	Defines whether an enable pin appears on the core.
Output Register Options <ul style="list-style-type: none"> • SINIT pin • INIT value 	Output Reset (Port A) / Output Reset (Port A and B) <ul style="list-style-type: none"> • Use RSTA/RST[A&B] pin • Output Reset value 	Specify the reset value of the memory output latch and output registers. These values are with respect to the read port widths. Choose whether a set/reset pin is needed.

Table B-5: GUI Parameter Comparison for Legacy Block Memory Cores (Cont'd)

Single-Port/Dual-Port Block Memory	Block Memory Generator	Functionality of the GUI Parameter
Output Register Options <ul style="list-style-type: none"> Additional output pipeline stages 	Optional Output Registers Register Port A Output of Memory Primitives/ Register Port [A B] of Memory Primitives Register Port A Output of Memory Core/ Register Port [A B] of Memory Core Output Register Enables Use REGCEA pin/Use REGCE[A B] pins Use REGCEB pin/Use REGCE[A B] pins	Output Registers may optionally be generated at the output of the memory primitives or on the output of the memory core, or at both locations. The output register stages can be chosen separately for port A and port B. When targeting Virtex-4 FPGAs, the embedded output registers in the block RAM primitives will be used if the user chooses to register the output of the memory primitives and if RST pin is not used. For other Virtex-4 FPGA architecture and its derivatives, the registers in the FPGA slices are used.
Initial content <ul style="list-style-type: none"> Load Init File Global Init value 	Memory Initialization <ul style="list-style-type: none"> Load Init File Fill remaining memory locations 	Select whether to initialize the memory contents using a COE file, and whether to initialize the remaining memory contents with a default value. When using asymmetric port widths or data widths, the COE file and the default value are with respect to the port A write width.
-	Structural/UNISIM Simulation Model Options	Select the type of warning messages and outputs generated by the structural simulation model for collisions. Select whether the behavioral model should assume synchronous clocks for collision warnings.
-	Pipeline stages within the MUX	Pipeline register stages may optionally be chosen within the MUX for certain configurations; this option is common for both ports.

Table B-6: GUI Parameter Comparison for Older Versions of Block Memory Generator

BMG XCO Parameter v3.x or v2.x or v1.1	Block Memory Generator v7.3	Functionality of the GUI Parameter
Use SSR[A B] Pin	Use RST[A B] Pin	Direct Replacement
Use Reset Behavior From RAMB16WER Primitive	Reset Memory Latch	Direct Replacement
N/A	ECC Type	New Parameter

Table B-6: GUI Parameter Comparison for Older Versions of Block Memory Generator

BMG XCO Parameter v3.x or v2.x or v1.1	Block Memory Generator v7.3	Functionality of the GUI Parameter
N/A	Soft ECC	New Parameter
N/A	Register Port A Input of SoftECC logic	New Parameter
N/A	Register Port B Output of SoftECC logic	New Parameter
N/A	Mode	Defines whether the BMG works in conjunction with the BRAM Controller or works in standalone IP mode.
N/A	Generates 32-bit address interface	Defines whether the BMG generates a 32-bit address interface.

Executing an Updated XCO File

After an XCO file for the new core is created (either using the migration kit script or manually), you can invoke CORE Generator software to generate a new netlist. First, create a new project and configure it with the appropriate options (including target family, output products, and so forth). After the project is created, generate a core by choosing **Project > Import Existing Customized IP**.

Modifying Instantiations of the Old Core

The final migration step involves updating all instantiations of the old cores in your HDL source code to reference the new core. Additionally, [Differences Between Cores, page 145](#) discusses whether you need to add additional logic to restore any features that have become obsolete.

To update each old memory core instantiation:

1. Change the name of the module (only necessary if component name of the core has changed).
2. Change the port names used.
See [Table B-7](#) and [Table B-8](#) for port name conversions.
3. Any code modifications or workarounds previously used in your code to compensate for specific behaviors in the Single Port or Dual Port v6.x Block Memory cores should be removed before migrating to the Block Memory Generator to prevent unpredictable behavior when using the new core.
4. Add any additional logic to make the core backward compatible.

Additional logic is necessary to implement input registers, handshaking signals, pin polarity, and to implement v6.x enable and reset behavior with optional output registers only (see [Differences Between Cores, page 145](#) for additional information).

Table B-7: Port Name Mapping: Dual Port Block Memory Cores

Old Dual-Port Block Memory Core		New Block Memory Generator Core		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
CLKA	Available	CLKA	All configurations	Same	Available
ADDRA	Available	ADDRA	All configurations	Same	Available
DINA	Optional	DINA	All RAM configurations	Same	Optional
DOUTA	Optional	DOUTA	All configurations except simple dual-port RAM	Same	Optional
ENA	Optional	ENA	Optional in all configurations	Behavior different with optional output registers	Optional
WEA	Optional	WEA	All configurations	Changed from std_logic to std_logic_vector	Optional
SINITA	Optional	RSTA	Optional in all configurations	Same	Optional
-	-	REGCEA	Optional in all configurations with output registers	-	-
NDA	Optional	-	-	Need additional logic	Optional
RFDA	Optional	-	-	Need additional logic	Optional
RDYA	Optional	-	-	Need additional logic	Optional
CLKB	Available	CLKB	Available in dual-port configurations	Same	Available
ADDRB	Available	ADDRB	Available in dual-port configurations	Same	Available
DINB	Optional	DINB	Available in true dual-port RAM configurations	Same	Optional
DOUTB	Optional	DOUTB	Available in dual-port configurations	Same	Optional

Table B-7: Port Name Mapping: Dual Port Block Memory Cores (Cont'd)

Old Dual-Port Block Memory Core		New Block Memory Generator Core		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
ENB	Optional	ENB	Optional in dual-port configurations	Behavior different with optional output registers	Optional
WEB	Optional	WEB	Available in dual-port RAM configurations	Changed from std_logic to std_logic_vector	Optional
SINITB	Optional	RSTB	Optional in dual-port configurations	Same	Optional
-	-	REGCEB	Optional in dual-port configurations with output registers	-	-
NDB	Optional		-	Need additional logic	Optional
RFDB	Optional		-	Need additional logic	Optional
RDYB	Optional	-	-	Need additional logic	Optional

Table B-8: Port Name Mapping: Single Port Block Memory Cores

Old Single-Port Block Memory Core		New Block Memory Generator Core		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
CLK	Available	CLKA	Available in all configurations	Same	Available
ADDR	Available	ADDRA	Available in all configurations	Same	Available
DIN	Optional	DINA	Available in all RAM configurations	Same	Optional
DOUT	Optional	DOUTA	Available in all configurations except simple dual-port RAM	Same	Optional
EN	Optional	ENA	Optional in all configurations	Behavior different with optional output registers	Optional

Table B-8: Port Name Mapping: Single Port Block Memory Cores (Cont'd)

Old Single-Port Block Memory Core		New Block Memory Generator Core		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
WE	Optional	WEA	Available in all configurations	Changed from std_logic to std_logic_vector	Optional
SINIT	Optional	RSTA	Optional in all configurations	Same	Optional
-	-	REGCEA	Optional in all configurations with output registers	-	-
ND	Optional	-	-	Need additional logic	Optional
RFD	Optional	-	-	Need additional logic	Optional
RDY	Optional	-	-	Need additional logic	Optional

Table B-9: Port Name Mapping: Older Versions of Block Memory Generator Core

Block Memory Generator Core v2.x		Block Memory Generator Core v7.3		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
CLKA	Available	CLKA	All Configurations	Same	Available
ADDRA	Available	ADDRA	All Configurations	Same	Available
DINA	Optional	DINA	All RAM Configurations	Same	Optional
DOUTA	Optional	DOUTA	All Configurations except simple dual port RAM	Same	Optional
ENA	Optional	ENA	Optional in all configurations	Same	Optional
WEA	Optional	WEA	All Configurations	Same	Optional
SSRA	Optional	RSTA	Optional in all configurations	Only name change	Optional
REGCEA	Optional	REGCEA	Optional in all configurations with output registers	Same	Optional
CLKB	Available	CLKB	Available in dual-port configurations	Same	Available
ADDRB	Available	ADDRB	Available in dual-port configurations	Same	Available
DINB	Optional	DINB	Available in true dual-port RAM configurations	Same	Optional

Table B-9: Port Name Mapping: Older Versions of Block Memory Generator Core (Cont'd)

Block Memory Generator Core v2.x		Block Memory Generator Core v7.3		Description of Conversion	Functionality
Port	Availability	Port	Availability	Port	Availability
DOUTB	Optional	DOUTB	Available in dual-port configurations	Same	Optional
ENB	Optional	ENB	Optional in dual-port configurations	Same	Optional
WEB	Optional	WEB	Available in dual-port RAM configurations	Same	Optional
SSRB	Optional	RSTB	Optional in dual-port configurations	Only name change	Optional
REGCEB	Optional	REGCEB	Optional in dual-port configurations with output registers	Same	Optional
SBITERR	Available	SBITERR	Available in ECC/Soft-ECC configurations	Same	Available
DBITERR	Available	DBITERR	Available in ECC/Soft-ECC configurations	Same	Available
-		RDADDRECC	Available in Virtex-6 ECC/Soft-ECC and Spartan-6 Soft-ECC configurations	-	Available
-		INJECTSBITERR	Available in Virtex-6 ECC/Soft-ECC and Spartan-6 Soft-ECC configurations	-	Optional
		INJECTDBITERR	Available in Virtex-6 ECC/Soft-ECC and Spartan-6 Soft-ECC configurations	-	Optional

Debugging

This appendix includes details about resources available on the Xilinx Support website and debugging tools. The following topics are included in this appendix:

- [Finding Help on Xilinx.com](#)
 - [Debug Tools](#)
 - [Simulation Debug](#)
 - [Hardware Debug](#)
 - [Interface Debug](#)
-

Finding Help on Xilinx.com

To help in the design and debug process when using the Block Memory Generator, the [Xilinx Support web page](http://www.xilinx.com/support) (www.xilinx.com/support) contains key resources such as product documentation, release notes, answer records, information about known issues, and links for opening a Technical Support WebCase.

Documentation

This product guide is the main document associated with the Block Memory Generator. This guide, along with documentation related to all products that aid in the design process, can be found on the Xilinx Support web page (www.xilinx.com/support) or by using the Xilinx Documentation Navigator.

Download the Xilinx Documentation Navigator from the Design Tools tab on the Downloads page (www.xilinx.com/download). For more information about this tool and the features available, open the online help after installation.

Release Notes

Known issues for all cores, including the Block Memory Generator are described in the [IP Release Notes Guide \(XTP025\)](#).

Known Issues

Answer Records include information about commonly encountered problems, helpful information on how to resolve these problems, and any known issues with a Xilinx product. Answer Records are created and maintained daily ensuring that users have access to the most accurate information available.

Answer Records for this core are listed below, and can also be located by using the Search Support box on the main [Xilinx support web page](#). To maximize your search results, use proper keywords such as

- Product name
- Tool message(s)
- Summary of the issue encountered

A filter search is available after results are returned to further target the results.

Contacting Technical Support

Xilinx provides premier technical support for customers encountering issues that require additional assistance.

To contact Xilinx Technical Support:

1. Navigate to www.xilinx.com/support.
2. Open a WebCase by selecting the [WebCase](#) link located under Support Quick Links.

When opening a WebCase, include:

- Target FPGA including package and speed grade.
- All applicable Xilinx Design Tools and simulator software versions.
- Additional files based on the specific issue might also be required. See the relevant sections in this debug guide for guidelines about which file(s) to include with the WebCase.

Debug Tools

Example Design

The Block Memory Generator is delivered with an example design that can be synthesized, complete with functional test benches. Information about the example design can be found

in [Chapter 6, Detailed Example Design](#) for Vivado Design Suite and [Chapter 9, Detailed Example Design](#) for ISE Design Suite.

ChipScope Pro Tool

The ChipScope™ Pro debugging tool inserts logic analyzer, bus analyzer, and virtual I/O cores directly into your design. The ChipScope Pro debugging tool allows you to set trigger conditions to capture application and integrated block port signals in hardware. Captured signals can then be analyzed through the ChipScope Pro logic analyzer tool. For detailed information for using the ChipScope Pro debugging tool, see www.xilinx.com/tools/cspro.htm.

Reference Boards

Various Xilinx development boards support Block Memory Generator. These boards can be used to prototype designs and establish that the core can communicate with the system.

- 7 series FPGA evaluation boards
 - KC705
 - KC724

License Checkers

If the IP requires a license key, the key must be verified. The ISE and Vivado design tools have several license check points for gating licensed IP through the flow. If the license check succeeds, the IP can continue generation. Otherwise, generation halts with error. License checkpoints are enforced by the following tools:

- ISE design tools: XST, NgdBuild, Bitgen
- Vivado design tools: Vivado Synthesis, Vivado Implementation, write_bitstream (Tcl command)



IMPORTANT: IP license level is ignored at checkpoints. The test confirms a valid license exists. It does not check IP license level.

Simulation Debug

This section provides debug steps for common issues seen in simulation. The following debug information can be used with any simulator

- If there any Memory Collision Errors, check the addresses on RD/WR ports or PORTA/B Ports.

- If there are any Data Mismatches on the Read Port, check the assertion of `REGEN` and `EN` signals from your stimulus.
 - If the Initialization Reads are incorrect, check the MIF file contents that are generated from COE file.
 - If you see 'x' on DOUT, check the `collision_warnings` parameter. It could be set to `Generate_x_only`.
 - If there are any data mismatches on a few bytes on DOUT, check the `WE` during write for that particular address.
 - If there is a data mismatch on deassertion of Reset, check for special Reset behavior sections.
-

Hardware Debug

Hardware issues can range from link bring-up to problems seen after hours of testing. This section provides debug steps for common issues. The ChipScope debugging tool is a valuable resource to use in hardware debug. The signal names mentioned in the following individual sections can be probed using the ChipScope debugging tool for debugging the specific problems.

General Checks

Ensure that all the timing constraints for the core were properly incorporated from the example design and that all constraints were met during implementation.

- Does it work in post-place and route timing simulation? If problems are seen in hardware but not in timing simulation, this could indicate a PCB issue. Ensure that all clock sources are active and clean.
 - If using MMCMs in the design, ensure that all MMCMs have obtained lock by monitoring the `LOCKED` port.
 - If your outputs go to 0, check your licensing.
-

Interface Debug

AXI4-Lite Interfaces

Read from a register that does not have all 0s as a default to verify that the interface is functional. See [Figure 1-10](#) for a read timing diagram. Output `s_axi_arready` asserts when the read address is valid, and output `s_axi_rvalid` asserts when the read data/

response is valid. If the interface is unresponsive, ensure that the following conditions are met:

- The S_AXI_ACLK and ACLK inputs are connected and toggling.
- The interface is not being held in reset, and S_AXI_ARESET is an active-Low reset.
- The main core clocks are toggling and that the enables are also asserted.
- If the simulation has been run, verify in simulation and/or a ChipScope debugging tool capture that the waveform is correct for accessing the AXI4-Lite interface.

Native Block Memory Generator Supplemental Information

The following sections provide additional information about working with the Block Memory Generator core.

- [Low Power Designs](#): Provides information on the Low Power algorithm and methods that can be followed by the user to optimize power consumption in block RAM designs.
- [Construction of Smaller Memories](#): Explains the process of creating shallower or wider memories using dual port block memory.
- [Native Block Memory Generator SIM Parameters](#): Defines the SIM parameters used to specify the core configuration.
- [Output Register Configurations](#): Provides information optional output registers used to improve core performance.

Low Power Designs

The Block Memory Generator core also supports a Low Power implementation algorithm. When this option is selected, the configuration of the core is optimized to minimize dynamic power consumption. This contrasts with the Minimum Area algorithm, which optimizes the core implementation with the sole purpose of minimizing resource utilization.

The Low Power algorithm reduces power through the following mechanisms:

- Minimizing the number of block RAMs enabled for a Write or Read operation for a given memory size.
- Unlike the Minimum Area algorithm, smaller block RAM blocks are not grouped to form larger blocks in the Low Power algorithm. For example, two 9K block RAMs are not combined to form an 18K block RAM in Spartan-6 devices, and two 18K block RAMs are not combined to form a 36K block RAM in Virtex-5 devices.
- The “Always Enabled” option is not available to the user for the Port A and Port B enable pins. This prevents the block RAMs from being enabled at all times.
- The NO_CHANGE mode is set as the default operating mode.

[Table D-1](#) and [Table D-2](#) compare power consumption and resource utilization for Low Power and Minimum Area block memory implementations targeted to Virtex-5 devices and

the Spartan-3 family of devices. Estimated power consumption values were obtained using the XPE Spreadsheets from the Power Solutions web page on Xilinx.com:

www.xilinx.com/products/design_resources/power_central/index.htm

XPE is a pre-implementation power estimation tool appropriate for estimating power requirements in the early stages of a design. For more accurate power consumption estimates and power analysis, the Xilinx Power Analyzer tool (XPA) available in ISE can be run on designs after place and route.

Power data shown in the following tables was collected assuming a 50% toggle rate and 50% Write rate. A frequency of 300 MHz was specified for Virtex-5 devices, and a frequency of 150 MHz was specified for the Spartan-3 family of devices.

Note: Data shown in [Table D-1](#) is preliminary and subject to change. Data shown is based on Virtex-5 FPGA XPE spreadsheet v11.1. Always use the latest version of each target architecture XPE spreadsheet to get the most accurate estimate.

Table D-1: Power-Resource benchmarking for Virtex-5 ⁽¹⁾

Memory Configuration	Memory Type	Operating Mode	Dynamic Power Consumption for Single Read/Write (mW)		Block RAM Resource Utilization (Number of 18K Block RAMs)	
			Minimum Area	Low Power	Minimum Area	Low Power
2kx36	TDP	Write First/ Read First	39	21	4	4
		No Change	34	19	4	4
8kx12	TDP	Write First/ Read First	51	11	6	8
		No Change	45	10	6	8
8kx72	TDP	Write First/ Read First	148	43	32	32
		No Change	129	38	32	32
8kx72	SP	Write First/ Read First	74	21	32	32 ⁽²⁾
		No Change	65	19	32	32 ⁽²⁾

Notes:

1. Assumptions: 50% toggle rate and 50% Write rate; 300 MHz frequency.
2. Use of 512x72 extra-wide primitive in a Single Port configuration.

Note: Data shown in [Table D-2](#) is preliminary and subject to change. Data shown is based on Spartan-3 FPGA XPE spreadsheet v11.1. Always use the latest version of each target architecture XPE spreadsheet to get the most accurate estimate

Table D-2: Power-Resource benchmarking for Spartan-3 Family^{a b}

Memory Configuration	Memory Type	Dynamic Power Consumption for Single Read/Write (mW)		Block RAM Resource Utilization (Number of 18K Block RAMs)	
		Minimum Area	Low Power	Minimum Area	Low Power
2kx36	TDP	32	13	4	4
8kx12	TDP	44	10	6	8
8kx72	TDP	69	30	32	32
8kx72	SP	38	15	32	32 ^c

a. All Spartan-3 and derivative families have similar power estimates.

b. Assumptions: 50% toggle rate and 50% Write rate; 150 MHz frequency.

c. Use of 256x72 extra-wide primitive in a Single Port configuration.

Besides using the Low Power algorithm, the following design considerations are recommended for power optimizations:

- The Low Power algorithm disables the “Always Enabled” option for the Port A and Port B enable pins, and the user is forced to have these pins at the output (the “Use EN[A|B] Pin” option). These pins must not be permanently tied to ‘1’ if it is desired that power be conserved. Each port’s enable pin must be asserted high only when that port of the block RAM needs to be accessed.
- Use of output registers improves performance, but also increases power consumption. Even if used in the design, the output registers should be disabled when the block RAMs are not being accessed.
- The user can choose the operating mode even in the Low Power algorithm based upon design requirements; however it is recommended that the default operating mode of the Low Power algorithm (NO_CHANGE mode) be used. This mode results in lower power consumption as compared to the WRITE_FIRST and READ_FIRST modes.

Auto Upgrade Feature

The Block Memory Generator core has an auto upgrade feature for updating older versions of the Block Memory Generator core to the latest version. The auto upgrade feature can be seen by right clicking the already generated older version of Block Memory Generator core in the **Project IP** tab of CORE Generator.

There are two types of auto upgrades:

- **Upgrade Version and Regenerate** (Under Current Project Settings): Upgrades an older Block Memory Generator core to any intermediate version. The supported intermediate versions include 2.4, 2.7, 2.8, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 6.1, 6.2, 6.3, 7.1 and 7.2 of the Block Memory Generator.

- Upgrade to Latest Version and Regenerate** (Under Current Project Settings):
 Upgrades an older Block Memory Generator Core to the latest version. Any earlier version of Block Memory Generator core can be upgraded to v7.3.

Construction of Smaller Memories

A single memory of a given depth can be used to construct two independent memories of half the depth. This can be achieved by tying the MSB of the address of one port to '0' and the MSB of the address of the second port to '1'. This feature can be used only for memories that are at most one primitive deep.

As an example, consider the construction of two independent 128x32 memories using a single 256x32 memory. Generate a 256x32 True Dual Port memory core in CORE Generator using the desired parameters. Once generated, the MSB of ADDRA is connected to '0' and the MSB of ADDR B is connected to '1'. This effectively turns a True Dual Port 256x32 memory (with both A and B ports sharing the same memory space) into two single-port 128x32 memories, where port A is a single-port memory addressing memory locations 0-127, and port B is a single-port memory addressing memory locations 128-255. In this configuration, the two 128x32 memories function completely independent of each other, in a single block RAM primitive. While initializing such a memory, the input COE file should contain 256 32-bit wide entries. The first 128 entries initialize memory A, while the second 128 entries initialize memory B, as shown in [Figure D-1](#).

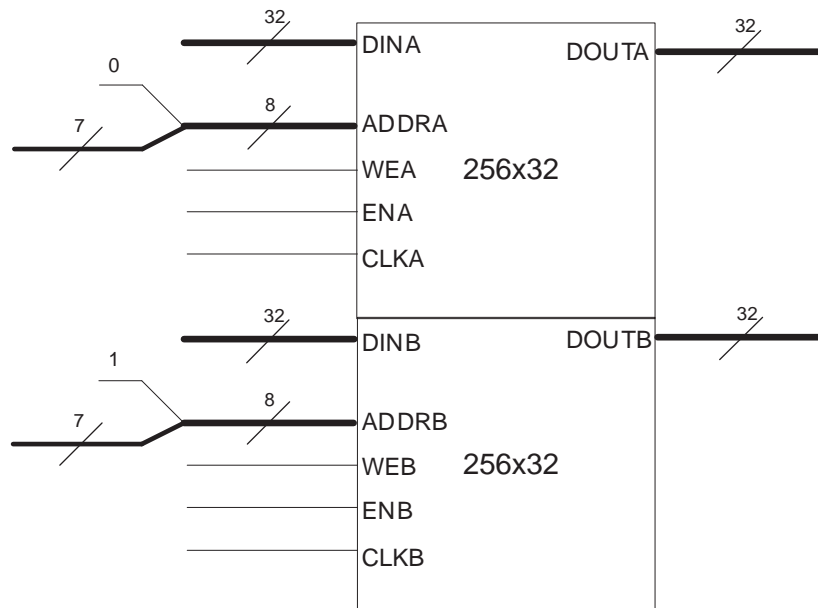


Figure D-1: Construction of Two Independent 128x32 Memories using a Single 256x32 Memory

For construction of memories narrower than 32-bits, for example 19 bits, the widths of both ports A and B can be set to 19 in the CORE Generator GUI. The cores are then connected the same way. The COE entries must then be just 19 bits wide. Alternately, a 32-bit wide memory may be generated, and only the least significant 19 bits may be used. COE entries

in this case will be trimmed or padded with 0s automatically to fill the appropriate number of bits.

For construction of memories shallower than 128 words, for example 23 words, simply use the first 23 entries in the memory, tying off the unused address bits to '0'. Alternately, use the same strategy as above to turn a True Dual Port 64-word deep memory into two 32-word deep memories.

Native Block Memory Generator SIM Parameters

Table D-3 defines the SIM parameters used to specify the configuration of the core. These parameters are only used to manually instantiate the core in HDL, calling the CORE Generator dynamically. This parameter list does not apply to users that generate the core using the CORE Generator GUI.

Table D-3: Native Interface SIM Parameters

	SIM Parameter	Type	Values	Description
1	C_FAMILY	String	"virtex7", "virtex6", "virtex5", "virtex4", "spartan3"	Target device family
2	C_XDEVICEFAMILY	String	"virtex7", "virtex6", "virtex5", "virtex4", "spartan3", "spartan3a", "spartan3adsp"	Finest resolution target family derived from the parent C_FAMILY
3	C_ELABORATION_DIR	String		Elaboration Directory
4	C_USE_BRAM_BLOCK	Integer	0: Standalone 1: BRAM Controller	Used in IPI Mode only. Defines whether the BMG works in conjunction with the BRAM Controller or if the core works in standalone IP mode.
5	C_ENABLE_32BIT_ADDRESS	Integer	0: Address interface defined by memory depth 1: Generates 32-bit address interface	Used in IPI Mode only. Defines whether the BMG core generates 32-bit address interface for BRAM Controller mode.
6	C_MEM_TYPE	Integer	0: Single Port RAM 1: Simple Dual Port RAM 2: True Dual Port RAM 3: Single Port ROM 4: Dual Port ROM	Type of memory
7	C_ALGORITHM	Integer	0 (selectable primitive), 1 (minimum area), 2 (low power)	Type of algorithm

Table D-3: Native Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
8	C_PRIM_TYPE	Integer	0 (1-bit wide) 1 (2-bit wide) 2 (4-bit wide) 3 (9-bit wide) 4 (18-bit wide) 5 (36-bit wide) 6 (72-bit wide, single-port only)	If fixed primitive algorithm is chosen, determines which type of primitive to use to build memory
9	C_BYTE_SIZE	Integer	9, 8	Defines size of a byte: 9 bits or 8 bits
10	C_SIM_COLLISION_CHECK	String	NONE, GENERATE_X_ONLY, ALL, WARNINGS_ONLY	Defines warning collision checks in structural/unisim simulation model
11	C_COMMON_CLOCK	Integer	0, 1	Determines whether to optimize behavioral models for Read/Write accesses and collision checks by assuming clocks are synchronous. It is recommended to set this option to 0 when both the clocks are not synchronous, in order to have the models function properly.
12	C_DISABLE_WARN_BHV_COLL	Integer	0, 1	Disables the behavioral model from generating warnings due to Read-Write collisions
13	C_DISABLE_WARN_BHV_RANGE	Integer	0, 1	Disables the behavioral model from generating warnings due to address out of range
14	C_LOAD_INIT_FILE	Integer	0, 1	Defined whether to load initialization file
15	C_INIT_FILE_NAME	String	""	Name of initialization file (MIF format)
16	C_USE_DEFAULT_DATA	Integer	0, 1	Determines whether to use default data for the memory
17	C_DEFAULT_DATA	String	"0"	Defines a default data for the memory
18	C_HAS_MEM_OUTPUT_REGS_A	Integer	0, 1	Determines whether port A has a register stage added at the output of the memory latch
19	C_HAS_MEM_OUTPUT_REGS_B	Integer	0,1	Determines whether port B has a register stage added at the output of the memory latch

Table D-3: Native Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
20	C_HAS_MUX_OUTPUT_REG_S_A	Integer	0,1	Determines whether port A has a register stage added at the output of the memory core
21	C_HAS_MUX_OUTPUT_REG_S_B	Integer	0,1	Determines whether port B has a register stage added at the output of the memory core
22	C_MUX_PIPELINE_STAGES	Integer	0,1,2,3	Determines the number of pipeline stages within the MUX for both port A and port B
23	C_WRITE_WIDTH_A	Integer	1 to 4608	Defines width of Write port A
24	C_READ_WIDTH_A	Integer	1 to 4608	Defines width of Read port A
25	C_WRITE_DEPTH_A	Integer	2 to 9011200	Defines depth of Write port A
26	C_READ_DEPTH_A	Integer	2 to 9011200	Defines depth of Read port A
27	C_ADDRA_WIDTH	Integer	1 to 24	Defines the width of address A
28	C_WRITE_MODE_A	String	Write_First, Read_first, No_change	Defines the Write mode for port A
29	C_HAS_ENA	Integer	0, 1	Determines whether port A has an enable pin
30	C_HAS_REGCEA	Integer	0, 1	Determines whether port A has an enable pin for its output register
31	C_HAS_RSTA	Integer	0, 1	Determines whether port A has reset pin
32	C_INITA_VAL	String	"0"	Defines initialization/power-on value for port A output
33	C_USE_BYTE_WEA	Integer	0, 1	Determines whether byte-Write feature is used on port A For True Dual Port configurations, this value is the same as C_USE_BYTE_WEB, since there is only a single byte Write enable option provided
34	C_WEA_WIDTH	Integer	1 to 512	Defines width of WEA pin for port A
35	C_WRITE_WIDTH_B	Integer	1 to 4608	Defines width of Write port B
36	C_READ_WIDTH_B	Integer	1 to 4608	Defines width of Read port B
37	C_WRITE_DEPTH_B	Integer	2 to 9011200	Defines depth of Write port B
38	C_READ_DEPTH_B	Integer	2 to 9011200	Defines depth of Read port B
39	C_ADDRB_WIDTH	Integer	1 to 24	Defines the width of address B
40	C_WRITE_MODE_B	String	Write_First, Read_first, No_change	Defines the Write mode for port B

Table D-3: Native Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
41	C_HAS_ENB	Integer	0, 1	Determines whether port B has an enable pin
42	C_HAS_REGCEB	Integer	0, 1	Determines whether port B has an enable pin for its output register
43	C_HAS_RSTB	Integer	0, 1	Determines whether port B has reset pin
44	C_INITB_VAL	String	"..."	Defines initialization/power-on value for port B output
45	C_USE_BYTE_WEB	Integer	0, 1	Determines whether byte-Write feature is used on port B This value is the same as C_USE_BYTE_WEA, since there is only a single byte Write enable provided
46	C_WEB_WIDTH	Integer	1 to 512	Defines width of WEB pin for port B
47	C_USE_ECC	Integer	0,1	For Zynq-7000, 7 series, Virtex-6, and Virtex-5 FPGAs only. Determines ECC options: • 0 = No ECC • 1 = ECC
48	C_RST_TYPE	String	(["SYNC", "ASYNC"] : "SYNC")	Type of Reset – synchronous or asynchronous. This parameter applies only for Spartan-6 devices.
49	C_RST_PRIORITY_A	String	(["CE", "SR"] : "CE")	In the absence of output registers, this selects the priority between the RAM ENA and the RSTA pin. When using output registers, this selects the priority between REGCEA and the RSTA pin.

Table D-3: Native Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
50	C_RSTRAM_A11	Integer	([0,1] : 1)	Applicable for Zynq-7000, 7 series, Virtex-6, Spartan-3A DSP, and Spartan-6 devices. If the value of this generic is 1, both the memory latch and the embedded primitive output register of Port A are reset. If this value is 0, then for Spartan-3A DSP and Spartan-6 devices, the primitive output register is built out of fabric, and only the output register is reset (the memory latch is not reset). If this value is 0 for Zynq-7000, 7 series, and Virtex-6 devices, then only the embedded output register of the primitive is reset (the memory latch is not reset). Setting this option to 1 results in the output reset value being asserted for two clock cycles.
51	C_RST_PRIORITY_B	String	(["CE", "SR"] : "CE")	In the absence of output registers, this selects the priority between the RAM ENB and the RSTB pin. When using output registers, this selects the priority between REGCEB and the RSTB pin.
52	C_RSTRAM_B	Integer	([0,1] : 1)	Applicable for Zynq-7000, 7 series, Virtex-6, Spartan-3A DSP, and Spartan-6 devices. If the value of this generic is 1, both the memory latch and the embedded primitive output register of Port B are reset. If this value is 0, then for Spartan-3A DSP and Spartan-6 devices, the primitive output register is built out of fabric, and only the output register is reset (the memory latch is not reset). If this value is 0 for Zynq-7000, 7 series, and Virtex-6 devices, then only the embedded output register of the primitive is reset (the memory latch is not reset). Setting this option to 1 results in the output reset value being asserted for two clock cycles.

Table D-3: Native Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
53	C_HAS_INJECTERR	Integer	([0,1,2,3] : 0)	For Zynq-7000, 7 series, and Virtex-6 FPGAs only. Determines the type of error injection: <ul style="list-style-type: none"> • 0 = No Error Injection • 1 = Single-Bit Error Injection Only • 2 = Double-Bit Error Injection Only • 3 = Both Single- and Double-Bit Error Injection
54	C_USE_SOFTECC	Integer	0,1	For Zynq-7000, 7 series, Virtex-6, and Spartan-6 FPGAs only. Determines Soft ECC options: <ul style="list-style-type: none"> • 0 = No Soft ECC • 1 = Soft ECC
55	C_HAS_SOFTECC_INPUT_REGS_A	Integer	0,1	Registers the input ports in the design when Soft ECC is enabled: <ul style="list-style-type: none"> • 0 = Registers not enabled • 1 = Registers enabled
56	C_HAS_SOFTECC_OUTPUT_REGS_B	Integer	0,1	Registers the input ports in the design when Soft ECC is enabled: <ul style="list-style-type: none"> • 0 = Registers not enabled • 1 = Registers enabled

AXI4 Interface Block Memory Generator SIM Parameters

Table D-4: AXI4 Interface SIM Parameters

	SIM Parameter	Type	Values	Description
1	C_FAMILY	String	"virtex6" "7 series" "spartan6"	Target device family.
2	C_XDEVICEFAMILY	String	"virtex6" "7 series" "spartan6"	Finest resolution target family.
3	C_ELABORATION_DIR	String		Elaboration Directory.
4	C_INTERFACE_TYPE	Integer	1: AXI4	Determines the type of interface selected.
5	C_AXI_TYPE	Integer	0: AXI4_Lite 1: AXI4_Full	Determines the type of the AXI4 interface.
6	C_AXI_SLAVE_TYPE	Integer	0: Memory Slave 1: Peripheral Slave	Determines the type of the AXI4 Slave interface.
7	C_HAS_AXI_ID	Integer	0: Core does not use AXI4 ID 1: Core uses AXI4 ID	Determines whether the AXI4 interface supports AXI4 ID.

Table D-4: AXI4 Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
8	C_AXI_ID_WIDTH	Integer	1 to 16	Defines the AXI4 ID value.
9	C_MEM_TYPE	Integer	1: Simple Dual Port RAM	Type of memory.
10	C_ALGORITHM	Integer	0 (selectable primitive), 1 (minimum area), 2 (low power)	Type of algorithm.
11	C_PRIM_TYPE	Integer	3 (9-bit wide) 4 (18-bit wide) 5 (36-bit wide) 6 (72-bit wide)	If fixed primitive algorithm is chosen, determines which type of primitive to use to build memory.
12	C_BYTE_SIZE	Integer	8	Defines size of a byte: 8 bits.
13	C_COMMON_CLOCK	Integer	1	Determines whether to optimize behavioral models for Read/Write accesses and collision checks by assuming clocks are synchronous.
14	C_DISABLE_WARN_BHV_COLL	Integer	0, 1	Disables the behavioral model from generating warnings due to Read Write collisions.
15	C_DISABLE_WARN_BHV_RANGE	Integer	0, 1	Disables the behavioral model from generating warnings due to address out of range.
16	C_LOAD_INIT_FILE	Integer	0, 1	Defined whether to load initialization File.
17	C_INIT_FILE_NAME	String	""	Name of initialization file (MIF format).
18	C_USE_DEFAULT_DATA	Integer	0, 1	Determines whether to use default data for the memory.
19	C_DEFAULT_DATA	String	0	Defines a default data for the Memory.
20	C_HAS_MEM_OUTPUT_REGS_A	Integer	0	Determines whether port A has a register stage added at the output of the memory latch.
21	C_HAS_MEM_OUTPUT_REGS_B	Integer	0	Determines whether port B has a register stage added at the output of the memory latch.
22	C_HAS_MUX_OUTPUT_REGS_A	Integer	0	Determines whether port A has a register stage added at the output of the memory core.
23	C_HAS_MUX_OUTPUT_REGS_B	Integer	0	Determines whether port B has a register stage added at the output of the memory core.

Table D-4: AXI4 Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
24	C_MUX_PIPELINE_STAGES	Integer	0	Determines the number of pipeline stages within the MUX for both port A and port B.
25	C_WRITE_WIDTH_A	Integer	32 to 256	Defines width of Write port A.
26	C_READ_WIDTH_A	Integer	32 to 256	Defines width of Read port A.
27	C_WRITE_DEPTH_A	Integer	1024 to 9011200	Defines depth of Write port A.
28	C_READ_DEPTH_A	Integer	1024 to 9011200	Defines depth of Read port A.
29	C_ADDRA_WIDTH	Integer	1 to 32	Defines the width of address A.
30	C_WRITE_MODE_A	String	Read_first	Defines the Write mode for port A.
31	C_HAS_ENA	Integer	1	Determines whether port A has an enable pin.
32	C_HAS_REGCEA	Integer	0	Determines whether port A has an enable pin for its output register.
33	C_HAS_RSTA	Integer	0	Determines whether port A has reset pin.
34	C_INITA_VAL	String	"0"	Defines initialization/power-on value for port A output.
35	C_USE_BYTE_WEA	Integer	1	Determines whether byte-Write feature is used on port A.
36	C_WEA_WIDTH	Integer	1 to 128	Defines width of WEA pin for port A.
37	C_WRITE_WIDTH_B	Integer	32 to 256	Defines width of Write port B.
38	C_READ_WIDTH_B	Integer	32 to 256	Defines width of Read port B.
39	C_WRITE_DEPTH_B	Integer	1024 to 9011200	Defines depth of Write port B.
40	C_READ_DEPTH_B	Integer	1024 to 9011200	Defines depth of Read port B.
41	C_ADDRB_WIDTH	Integer	1 to 32	Defines the width of address B.
42	C_WRITE_MODE_B	String	Read_first,	Defines the Write mode for port B.
43	C_HAS_ENB	Integer	1	Determines whether port B has an enable pin.
44	C_HAS_REGCEB	Integer	0	Determines whether port B has an enable pin for its output register.
45	C_HAS_RSTB	Integer	1	Determines whether port B has reset pin.
46	C_INITB_VAL	String	"0"	Defines initialization/power-on value for port B output.

Table D-4: AXI4 Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
47	C_USE_BYTE_WEB	Integer	1	Determines whether byte-Write feature is used on port B. This value is the same as C_USE_BYTE_WEA, since there is only a single byte Write enable provided.
48	C_WEB_WIDTH	Integer	1 to 128	Defines width of WEB pin for port B.
49	C_USE_ECC	Integer	0	Determines ECC options: <ul style="list-style-type: none"> • 0 = No ECC • 1 = ECC
50	C_RST_TYPE	String	"ASYNC"	Type of Reset: synchronous or asynchronous. This parameter applies only for Spartan-6 devices.
51	C_RST_PRIORITY_A	String	"CE"	In the absence of output registers, this selects the priority between the RAM ENA and the RSTA pin. When using output registers, this selects the priority between REGCEA and the RSTA pin.
52	C_RSTRAM_A	Integer	0	Applicable for Zynq-7000, 7 series, Virtex-6 and Spartan-6 devices. If the value of this generic is 1, both the memory latch and the embedded primitive output register of Port A are reset. If this value is 0, then for Spartan-3A DSP and Spartan-6 devices, the primitive output register is built out of fabric, and only the output register is reset (the memory latch is not reset). If this value is 0 for Zynq-7000, 7 series, and Virtex-6 devices, then only the embedded output register of the primitive is reset (the memory latch is not reset). Setting this option to 1 results in the output reset value being asserted for two clock cycles.

Table D-4: AXI4 Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
53	C_RST_PRIORITY_B	String	"CE"	In the absence of output registers, this selects the priority between the RAM ENB and the RSTB pin. When using output registers, this selects the priority between REGCEB and the RSTB pin.
54	C_RSTRAM_B	Integer	0	Applicable for Zynq-7000, 7 series, Virtex-6, Spartan-3A DSP, and Spartan-6 devices. If the value of this generic is 1, both the memory latch and the embedded primitive output register of Port B are reset. If this value is 0, then for Spartan-3A DSP and Spartan-6 devices, the primitive output register is built out of fabric, and only the output register is reset (the memory latch is not reset). If this value is 0 for Zynq-7000, 7 series, and Virtex-6 devices, then only the embedded output register of the primitive is reset (the memory latch is not reset). Setting this option to 1 results in the output reset value being asserted for two clock cycles.
55	C_HAS_INJECTERR	Integer	0	Determines the type of error injection: <ul style="list-style-type: none"> • 0 = No Error Injection • 1 = Single-Bit Error Injection Only • 2 = Double-Bit Error Injection Only • 3 = Both Single- and Double-Bit Error Injection
56	C_USE_SOFTECC	Integer	0	For Zynq-7000, 7 series, Virtex-6, and Spartan-6 FPGAs only. Determines Soft ECC options: <ul style="list-style-type: none"> • 0 = No Soft ECC • 1 = Soft ECC

Table D-4: AXI4 Interface SIM Parameters (Cont'd)

	SIM Parameter	Type	Values	Description
57	C_HAS_SOFTECC_INPUT_REGS_A	Integer	0	Registers the input ports in the design when Soft ECC is enabled: <ul style="list-style-type: none"> • 0 = Registers not enabled • 1 = Registers enable
58	C_HAS_SOFTECC_OUTPUT_REGS_B	Integer	0	Registers the input ports in the design when Soft ECC is enabled: <ul style="list-style-type: none"> • 0 = Registers not enabled • 1 = Registers enabled
59	C_SIM_COLLISION_CHECK	String	NONE, GENERATE_X_ONLY, ALL, WARNINGS_ONLY	Defines warning collision checks in structural/UniSim simulation model.

Output Register Configurations

The Block Memory Generator core provides optional output registers that can be selected for port A and port B separately, and that may improve the performance of the core. The configurations described in the sections that follow are separated into these sections:

- Zynq-7000, 7 series, Virtex-6, Virtex-5, and Virtex-4 Devices
- Spartan-6 and Spartan-3A DSP Devices
- Spartan-3 Devices and Implementations

Figure D-2 shows the Optional Output Registers section of the Block Memory Generator GUI.

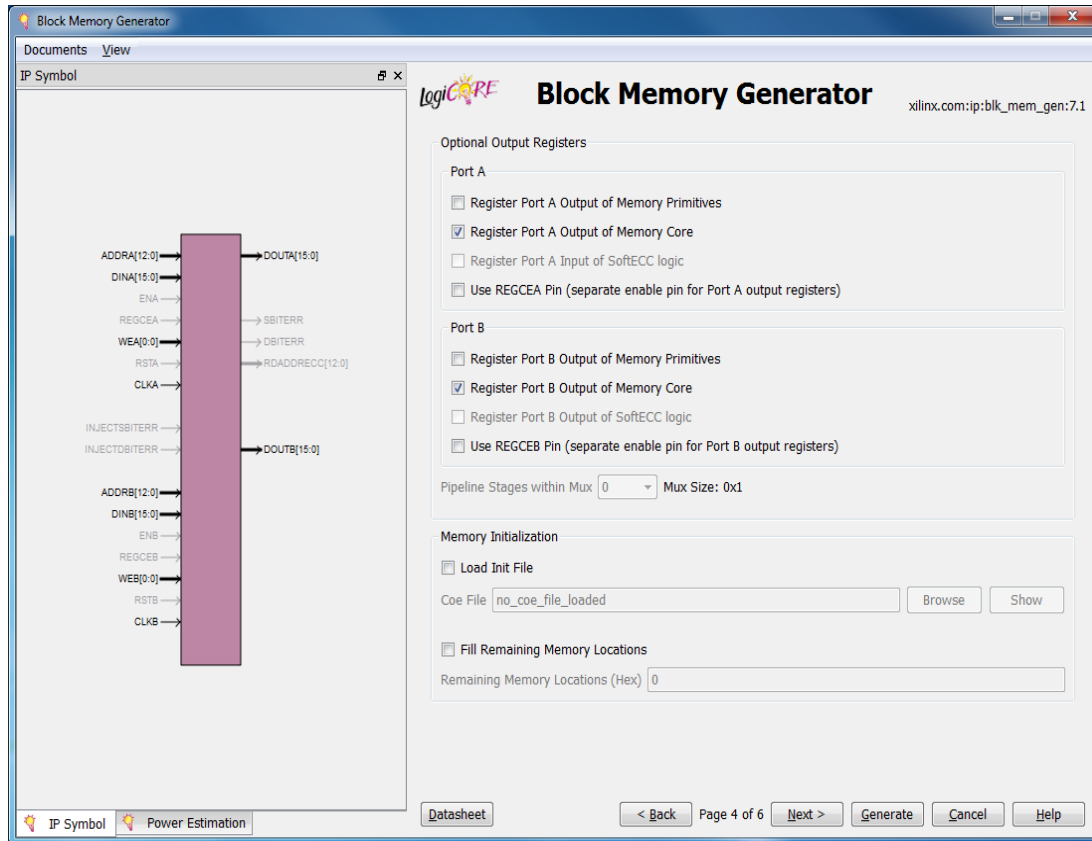


Figure D-2: Optional Output Registers Section

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 FPGA: Output Register Configurations

To tailor register options for Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA configurations, two selections for port A and two selections for port B are provided on Screen 3 of the CORE Generator GUI in the Optional Output Registers section. The embedded output registers for the corresponding port(s) are enabled when Register Port [A|B] Output of Memory Primitives is selected. Similarly, registers at the output of the core for the corresponding port(s) are enabled by selecting Register Port [A|B] Output of Memory Core. [Figure D-3](#) through [Figure D-10](#) illustrate the Zynq-7000, 7 series, Virtex-6, Virtex-5 and Virtex-4 FPGA output register configurations.

For Zynq-7000, 7 series, and Virtex-6, when only Register Port [A|B] Output of Memory Primitives and the corresponding Use RST[A|B] Pin are selected, the special reset behavior (option to reset the memory latch, in addition to the primitive output register) becomes available. For more information on this reset behavior, see [Special Reset Behavior in Chapter 3](#).

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 FPGA: Memory with Primitive and Core Output Registers

With both Register Port [A|B] Output of Memory Primitives and the corresponding Register Port [A|B] Output of Memory Core selected, a memory core is generated with the Zynq-7000, 7 series, Virtex-6, Virtex-5 or Virtex-4 FPGA embedded output registers and a register on the output of the core for the selected port(s), as shown in Figure D-3. This configuration may provide improved performance for building large memory constructs.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core

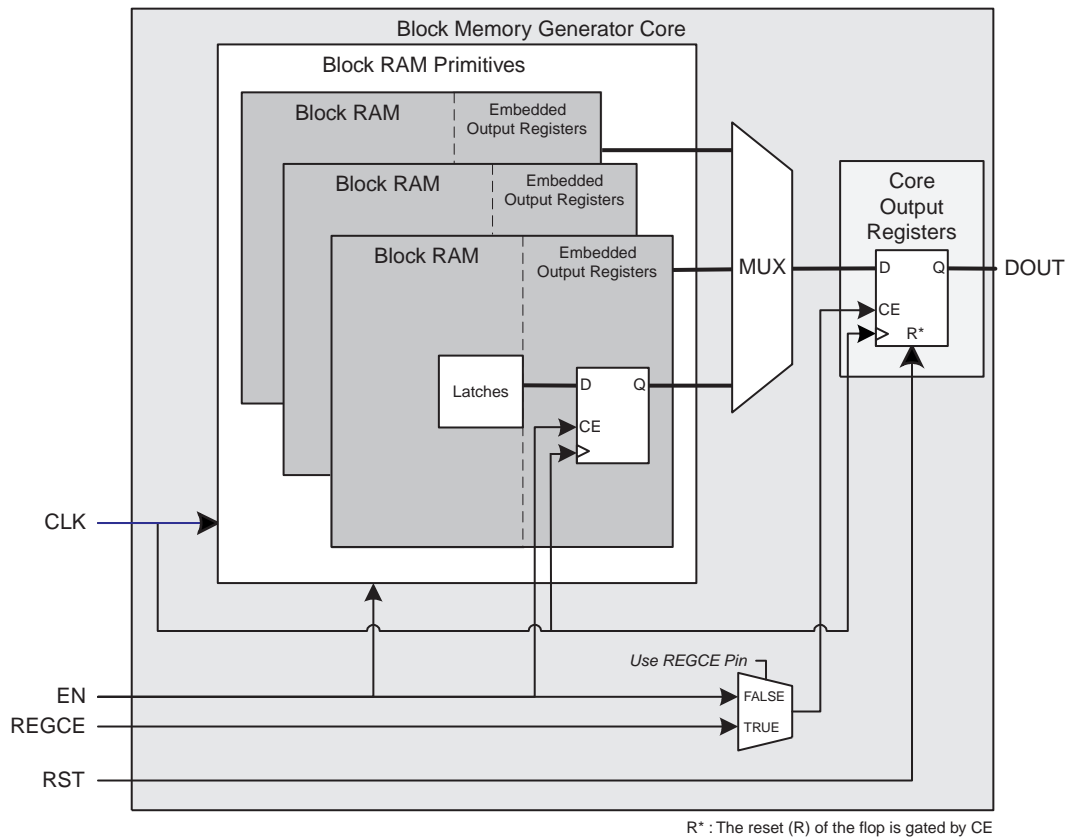


Figure D-3: Zynq-7000, 7 Series, Virtex-6, Virtex-5, or Virtex-4 FPGA Block Memory Generated with Register Port [A|B] Output of Memory Primitives and Register Port [A|B] Output of Memory Core Enabled

Zynq-7000, 7 Series, and Virtex-6 FPGAs: Memory with Primitive Output Registers and without Special Reset Behavior option

If Use RSTA Pin (set/reset pin) or Use RSTB Pin (set/reset pin) is selected, and the special reset behavior (to reset the memory latch besides the primitive output register) is not

selected, then the input reset signal is only connected to the RSTREG pin of the Zynq-7000, 7 series, and Virtex-6 devices' block RAM primitive, as illustrated in Figure D-4.

Note: This will result in reset similar to that of Spartan-3, Spartan-3A, Virtex-5 and Virtex-4 devices.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)
<input type="checkbox"/> Reset Memory Latch		<input type="checkbox"/> Reset Memory Latch

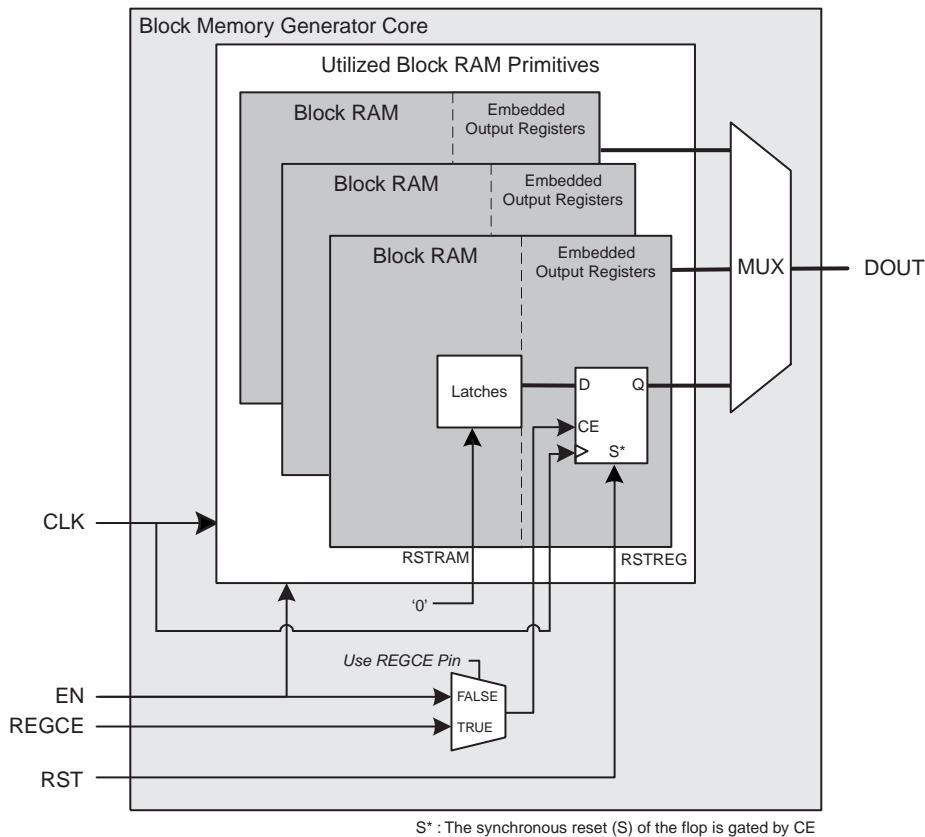


Figure D-4: Zynq-7000, 7 Series, and Virtex-6 Block Memory Generated with Register Port [A|B]

Output of Memory Primitives Enabled and without Special Reset Behavior

Zynq-7000, 7 Series, and Virtex-6 FPGAs: Memory with Primitive Output Registers and with Special Reset Behavior option

When Register Port [A|B] Output of Memory Primitives, Use RSTA Pin (set/reset pin) or Use RSTB Pin (set/reset pin), and the special reset behavior (to reset the memory latch besides the primitive output register) are selected, then the input reset signal is connected to both

the RSTRAM and RSTREG pins of the Zynq-7000, 7 series, and Virtex-6 devices' block RAM primitive, as illustrated in Figure D-5.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)
<input checked="" type="checkbox"/> Reset Memory Latch		<input checked="" type="checkbox"/> Reset Memory Latch

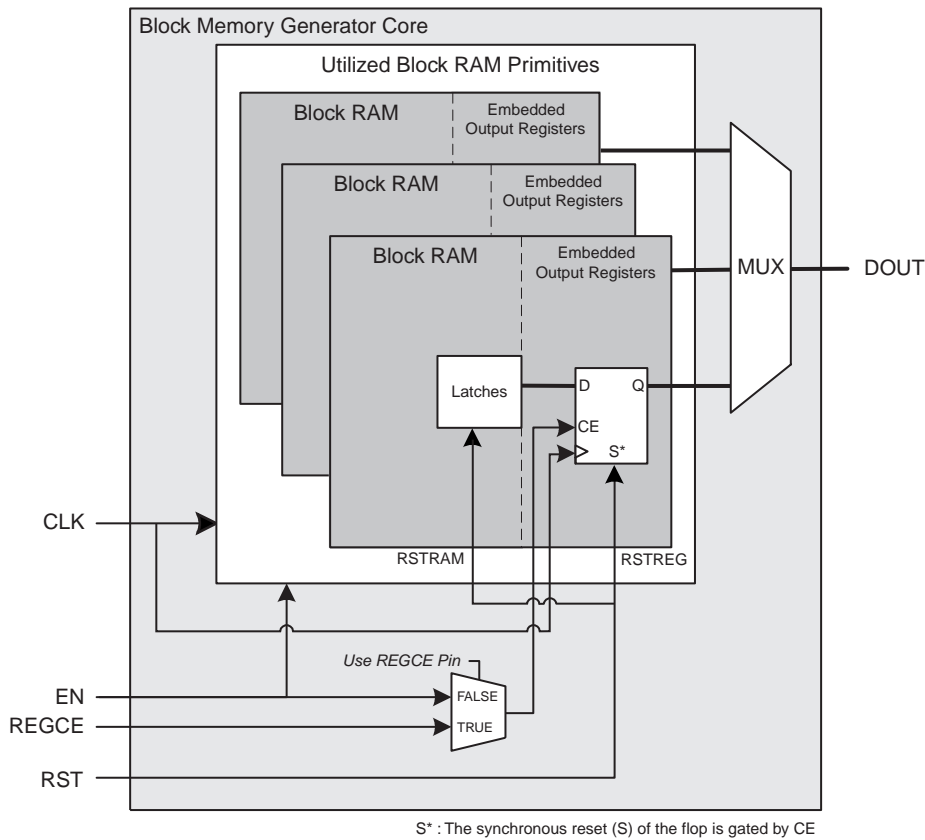


Figure D-5: Zynq-7000, 7 Series, and Virtex-6 Block Memory Generated with Register Port [A|B] Output of Memory Primitives Enabled and with Special Reset Behavior

Virtex-5 FPGA: Memory with Primitive Output Registers

When Register Port [A|B] Output of Memory Primitives is selected, a memory core that registers the output of the block RAM primitives for the selected port(s) is generated. In Virtex-5 devices, these registers are always implemented using the output registers embedded in the Virtex-5 FPGA block RAM architecture. The output of any multiplexing that may be required to combine multiple primitives is not registered in this configuration, as shown in Figure D-6.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core

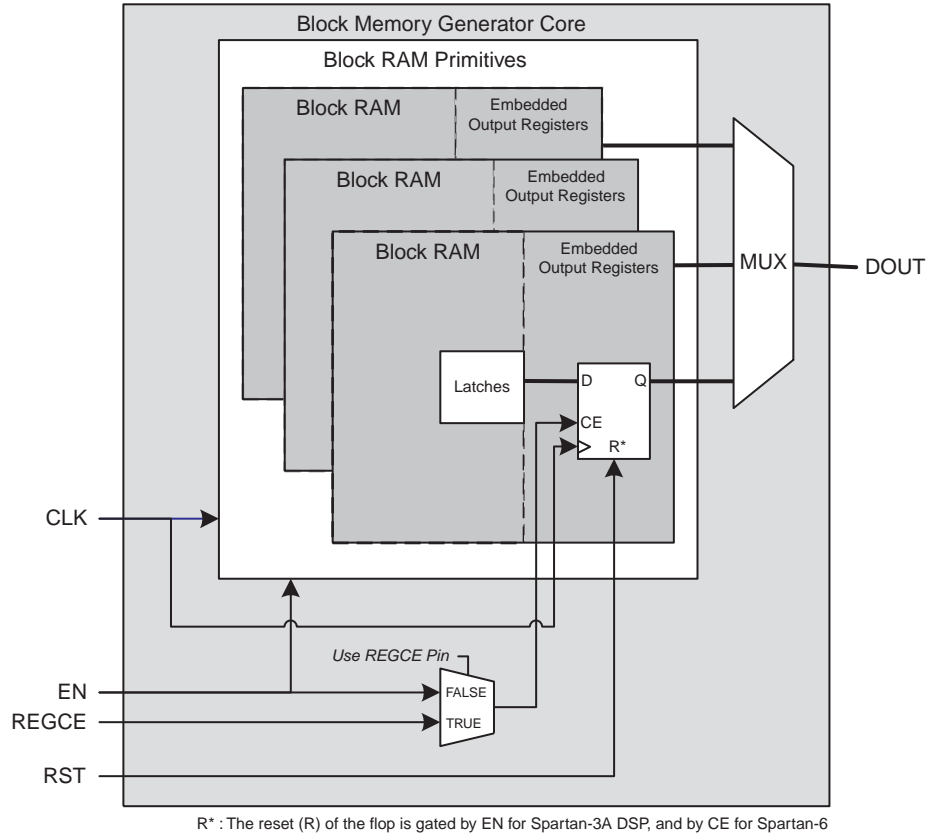


Figure D-6: Virtex-5 FPGA Block Memory Generated with Register Port [A|B] Output of Memory Primitives Enabled

Virtex-4 FPGA: Memory with Primitive Output Registers without RST

When Register Port [A|B] Output of Memory Primitives is selected and the corresponding Use RST [A|B] Pin (set/reset pin) is unselected, a memory core that registers the output of the block RAM primitives for the selected port(s) using the output registers embedded in Virtex-4 FPGA architecture is generated. The output of any multiplexing that may be required to combine multiple primitives is not registered in this configuration, as shown in Figure D-7.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input type="checkbox"/> Use RSTA Pin (set/reset pin)		<input type="checkbox"/> Use RSTB Pin (set/reset pin)

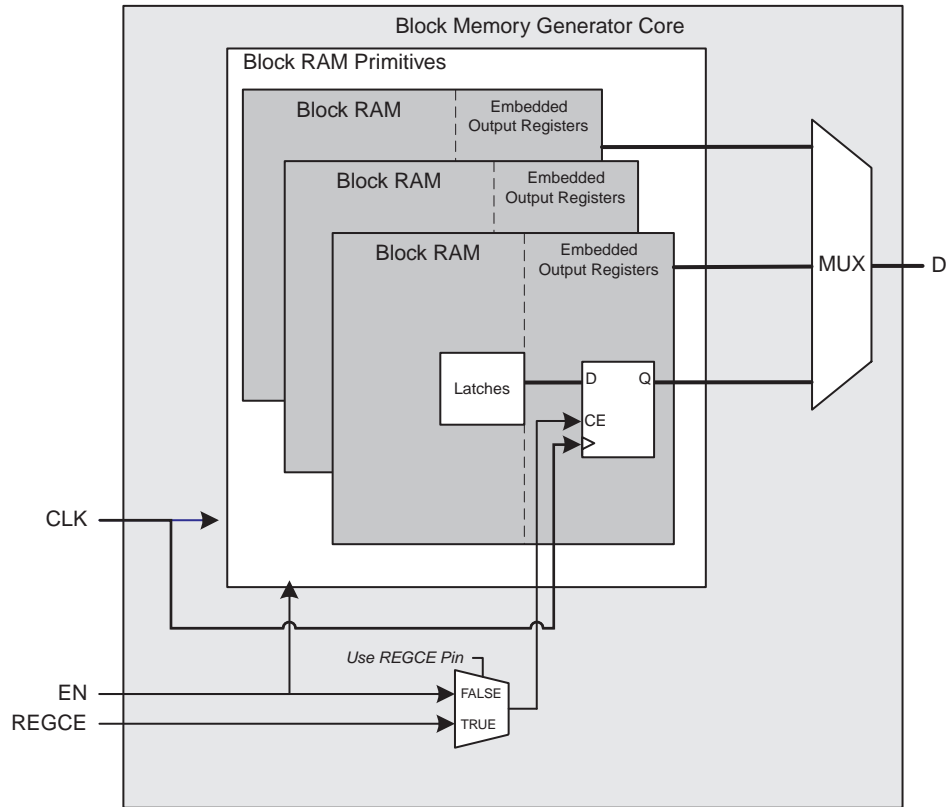


Figure D-7: Virtex-4 Block Memory Generated with only Register Port [A | B] Output of Memory Primitives Enabled

Virtex-4 FPGA: Memory with Primitive Output Registers with RST

If either Use RSTA Pin (set/reset pin) or Use RSTB Pin (set/reset pin) is selected from the Output Reset section of the Port Options screen(s), the Virtex-4 embedded block RAM registers cannot be used for the corresponding port(s). The primitive output registers are built from FPGA fabric, as shown in Figure D-8.

Port A	or	Port B
<input checked="" type="checkbox"/> Register A Output of Memory Primitives		<input checked="" type="checkbox"/> Register B Output of Memory Primitives
<input type="checkbox"/> Register A Output of Memory Core		<input type="checkbox"/> Register B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)

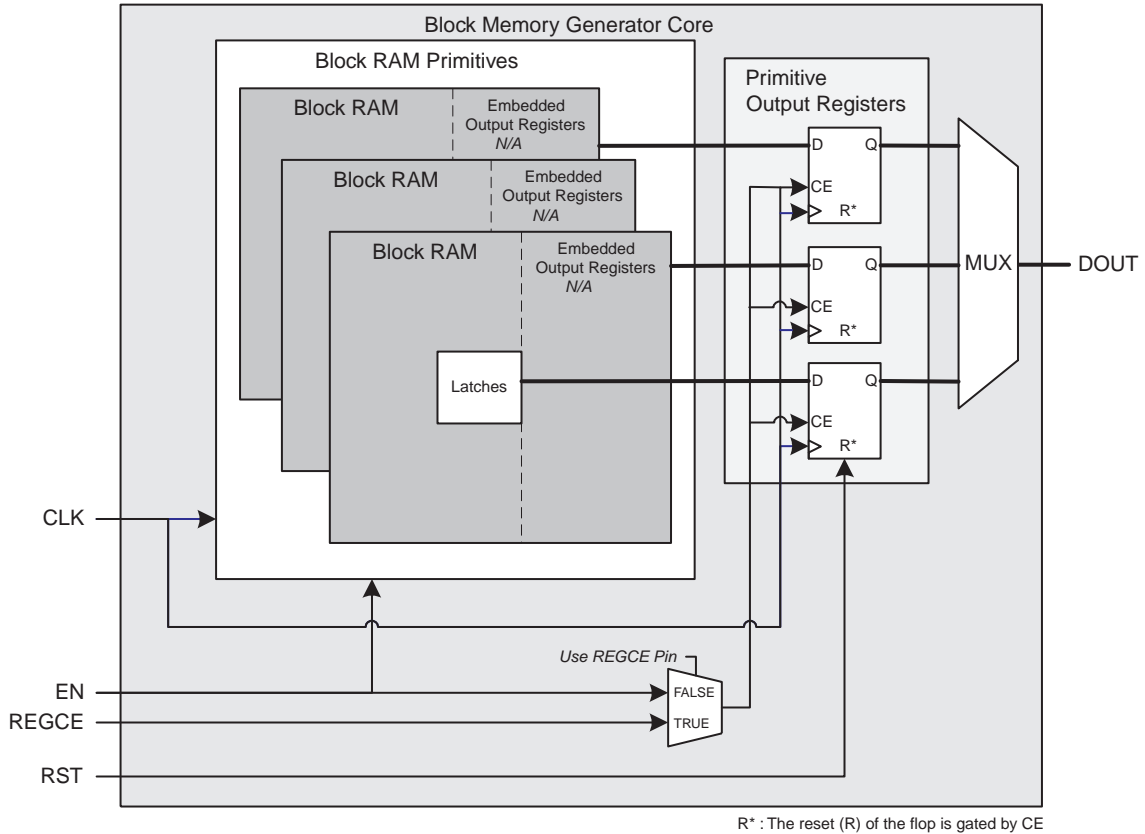


Figure D-8: Virtex-4 Block Memory Generated with Register Output of Memory Primitives and Use RST[A|B] Pin Options Enabled

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 FPGA: Memory with Core Output Registers

When only Register Port [A|B] Output of Memory Core is selected, the Zynq-7000/7 series/Virtex-6/Virtex-6/Virtex-5/Virtex-4 device's embedded registers are disabled for the selected ports in the generated core, as shown in Figure D-9.

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core

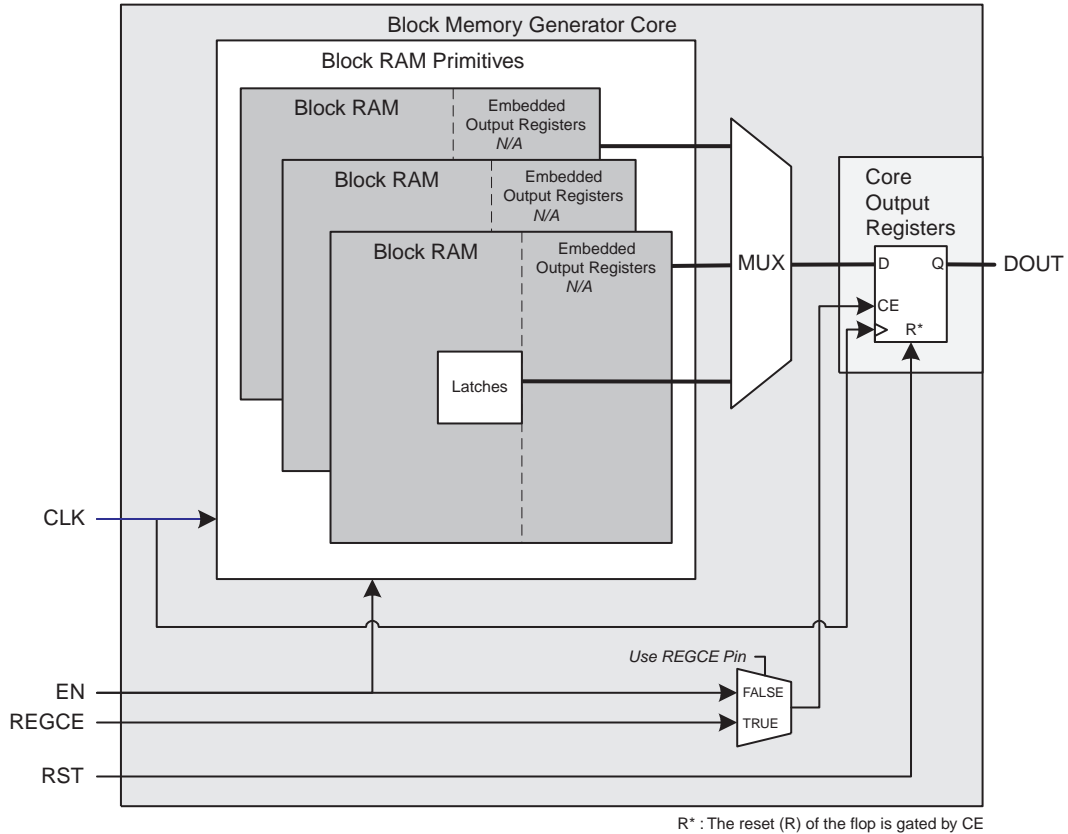


Figure D-9: Zynq-7000, 7 Series, Virtex-6, Virtex-5, or Virtex-4 Block Memory Generated with Register Port [A|B] Output of Memory Core Enabled

Zynq-7000, 7 Series, Virtex-6, Virtex-5 and Virtex-4 FPGA: Memory with No Output Registers

If neither of the output registers is selected for ports A or B, output of the memory primitives is driven directly from the RAM primitive latches. In this configuration, as shown in Figure D-10, there are no additional clock cycles of latency, but the clock-to-out delay for a Read operation can impact design performance.

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core

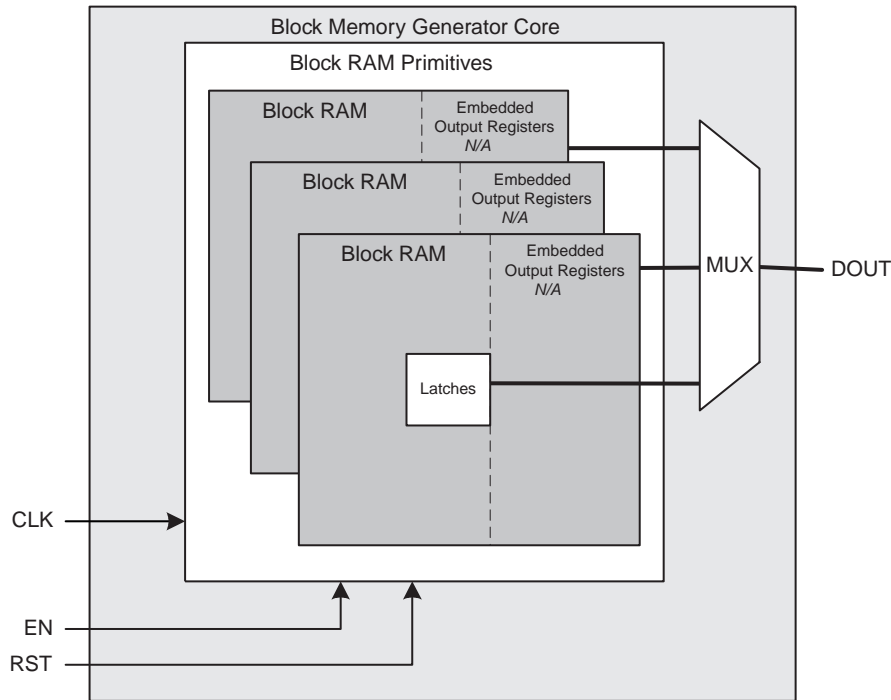


Figure D-10: Zynq-7000, 7 Series, Virtex-6, Virtex-5 or Virtex-4 Block Memory Generated with No Output Registers Enabled

Spartan-6 or Spartan-3A DSP FPGA: Output Register Configurations

To tailor register options for Spartan-6 or Spartan-3A DSP device configurations, two selections for port A and two selections for port B are provided on screen 3 of the CORE Generator GUI in the Optional Output Registers section. The embedded output registers for the corresponding port(s) are enabled when Register Port [A|B] Output of Memory Primitives is selected. Similarly, registers at the output of the core for the corresponding port(s) are enabled by selecting Register Port [A|B] Output of Memory Core. Figure D-11 through Figure D-16 illustrate the Spartan-6 or Spartan-3A DSP output register configurations.

When only Register Port [A|B] Output of Memory Primitives and the corresponding Use RST[A|B] Pin (set/reset pin) is selected, the special reset behavior (option to reset the memory latch besides the primitive output register) becomes available. This option is displayed as the **Reset Memory Latch** option on the Spartan-6 and Spartan-3A DSP GUI. Selecting this option forces the core to use the Spartan-6 or Spartan-3A DSP embedded output registers, but changes the behavior of the core. For detailed information, see the sections that follow.

Spartan-6 or Spartan-3A DSP FPGA: Memory with Primitive and Core Output Registers

With both Register Port [A|B] Output of Memory Primitives and the corresponding Register Port [A|B] Output of Memory Core selected, a memory core is generated with both the embedded output registers and a register on the output of the core for the selected port(s), as shown in Figure D-11. This configuration may improve performance when building a large memory construct.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core

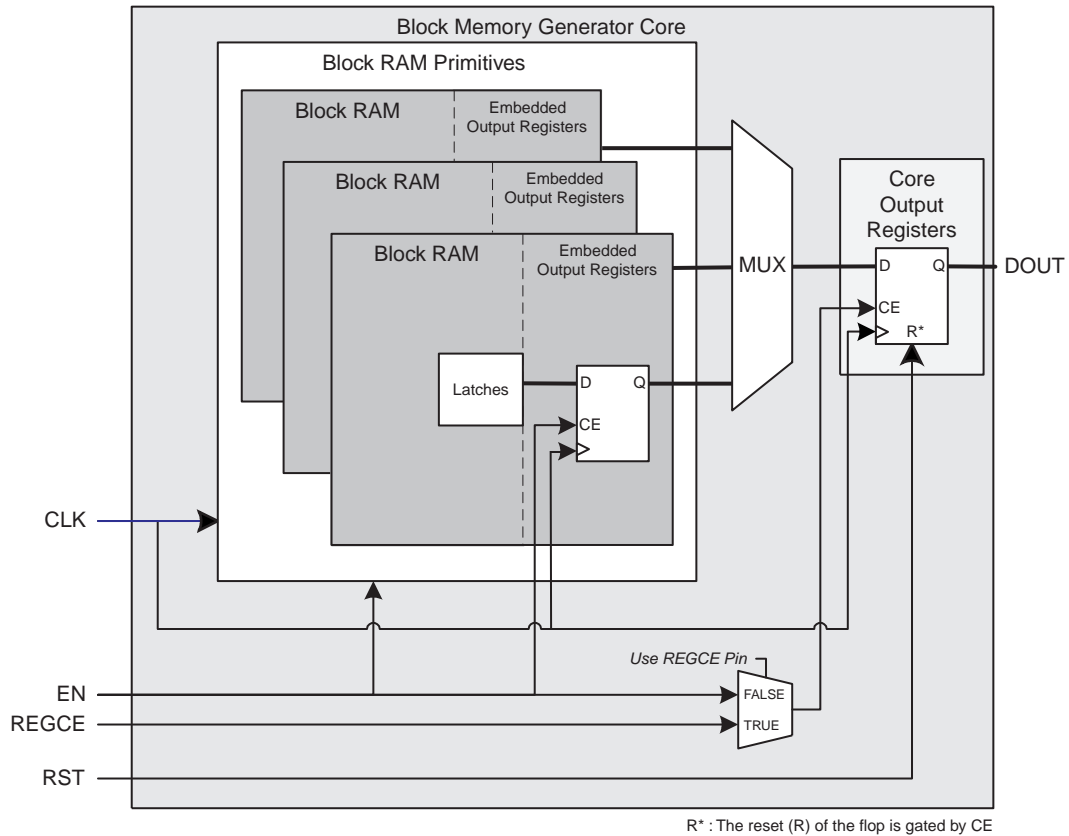


Figure D-11: Spartan-6 or Spartan-3A DSP Block Memory Generated with Register Port [A|B] Output of Memory Primitives and Register Port [A|B] Output of Memory Core Enabled

Spartan-6 or Spartan-3A DSP FPGA: Memory With Primitive Output Registers – Without RST Pin

When Register Port [A|B] Output of Memory Primitives is selected, and the corresponding Use RST Pin (set/reset pin) is not selected, a memory core that registers the output of the block RAM primitives for the selected port using the output registers embedded in

Spartan-6 and Spartan-3A DSP FPGA architectures is generated. The output of any multiplexing that may be required to combine multiple primitives is not registered in this configuration (Figure D-12).

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input type="checkbox"/> Use RSTA Pin (set/reset pin)		<input type="checkbox"/> Use RSTB Pin (set/reset pin)

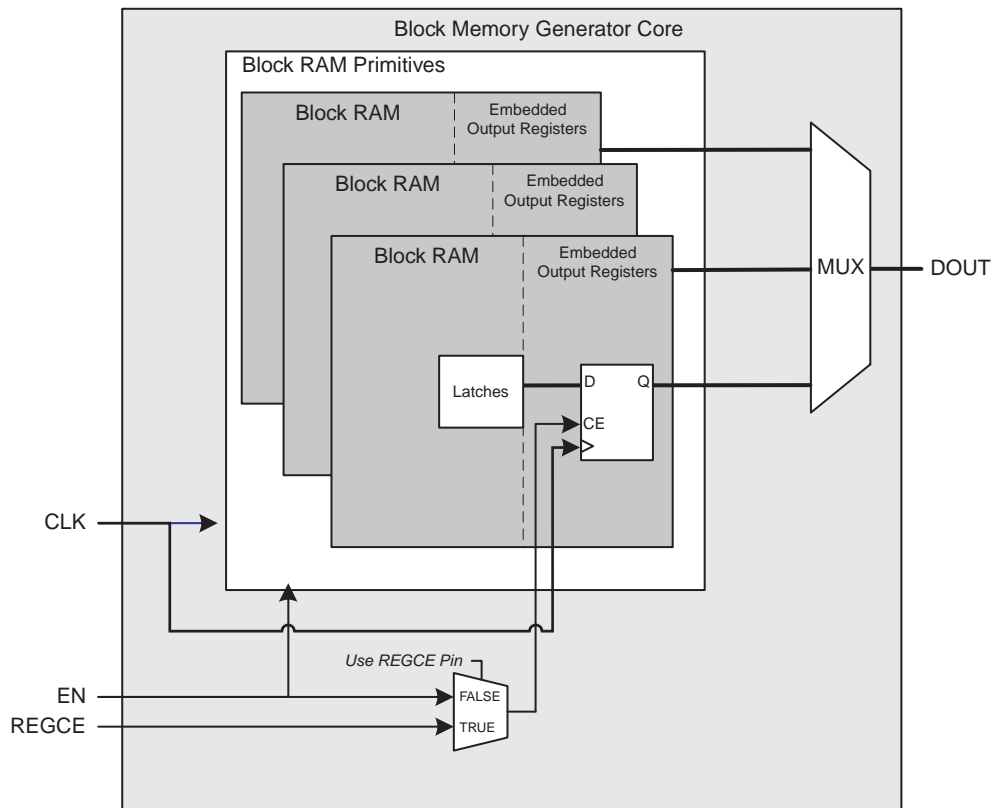


Figure D-12: Spartan-6 or Spartan-3A DSP Block Memory Generated with Register Port [A|B] Output of Memory Primitives Enabled (No RST)

Spartan-6 or Spartan-3A DSP FPGA: Memory with Primitive Output Registers and without Special Reset Behavior Option

If Use RSTA Pin (set/reset pin) or Use RSTB Pin (set/reset pin) is selected, and the Reset Behavior option (resets the memory latch in addition to the primitive output register) is not selected, the embedded block RAM registers of the Spartan-6 or Spartan-3ADSP device cannot be used. The primitive output registers are built from FPGA fabric, as illustrated in Figure D-13.

Note: This behavior is the same as that of Spartan-3, Spartan-3A, Virtex-5 and Virtex-4 devices.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)
<input type="checkbox"/> Reset Memory Latch		<input type="checkbox"/> Reset Memory Latch

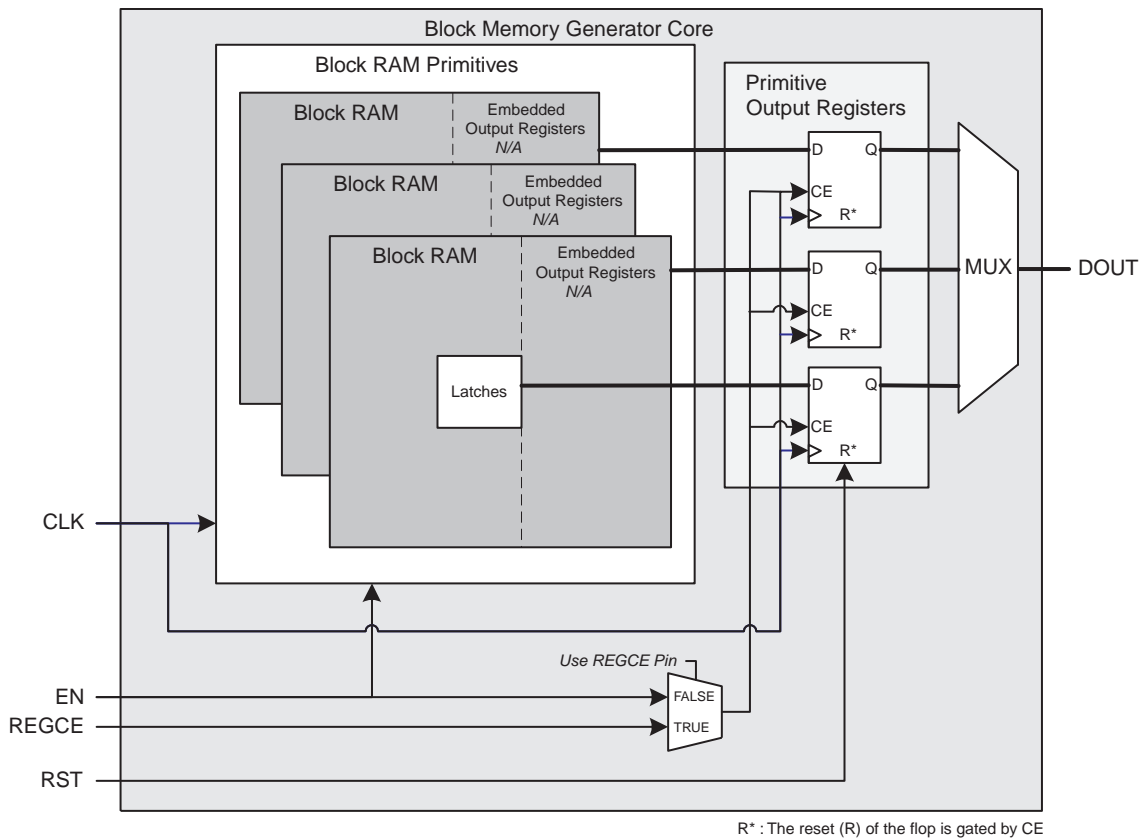


Figure D-13: Spartan-6 or Spartan-3A DSP Block Memory Generated with Register Port [A|B] Output of Memory Primitives, Use RST[A|B] Pin Options (With RST), without Special Reset Behavior

Spartan-6 or Spartan-3A DSP FPGA: Memory with Primitive Output Registers and with Special Reset Behavior Option (Embedded Registers)

When Register Port [A|B] Output of Memory Primitives, Use RSTA Pin (set/reset pin) or Use RSTB Pin (set/reset pin), and the special reset behavior (resets the memory latch in addition to the primitive output register) are selected, the Spartan-6 or Spartan-3A DSP embedded registers are enabled for the selected port in the generated core, as displayed in [Figure D-14](#).

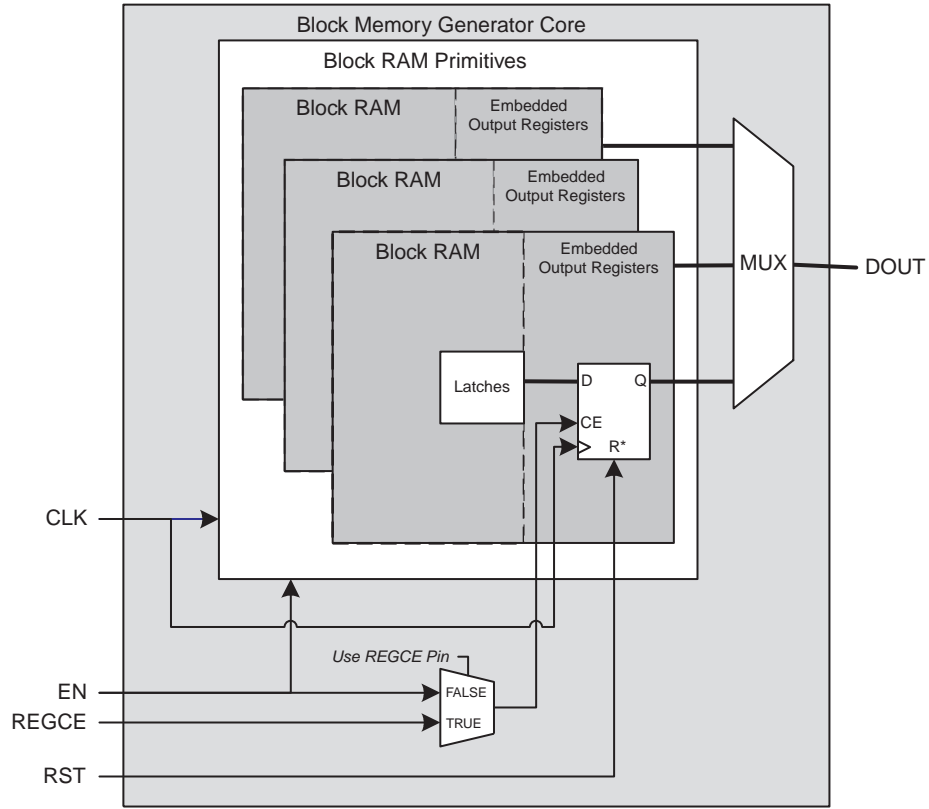
If the special reset behavior option is selected, the Spartan-6 or Spartan-3A DSP FPGA's embedded output registers are used, but the reset behavior of the core changes as

described in [Special Reset Behavior in Chapter 3](#). The functional differences between this and other implementations are that the RST[A|B] input resets *both* the embedded output registers *and* the block RAM output latches.

For Spartan-3ADSP devices, if EN and REGCE are held high, the output value is set to the reset value for two clock cycles following a reset. In addition, the synchronous reset for both the latches and the embedded output registers are gated by the EN input to the core, independent of the state of REGCE, as shown in [Figure D-14](#). This differs from all other configurations of the Block Memory Generator where RST is typically gated by REGCE.

For Spartan-6 devices, if REGCE is held high, the output value is set to the reset value for two clock cycles following a reset. Unlike Spartan-3A DSP devices, and similar to other architectures, reset is gated by REGCE.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)
<input checked="" type="checkbox"/> Reset Memory Latch		<input checked="" type="checkbox"/> Reset Memory Latch



R* : The reset (R) of the flop is gated by EN for Spartan-3A DSP, and by CE for Spartan-6

Figure D-14: Spartan-6 or Spartan-3A DSP Block Memory Generated with Register Port [A|B] Gated by EN in Spartan-3A DSP and by CE in Spartan-6 Output of Memory Primitives, Use RST[A|B] Pin Options (With RST), and Special Reset Behavior Enabled

Spartan-6 or Spartan-3A DSP FPGA: Memory with Core Output Registers

When Register Port [A|B] Output of Memory Core is selected, the Spartan-6 or Spartan-3A DSP FPGA embedded registers are disabled in the generated core, as illustrated in Figure D-15.

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core
<input checked="" type="checkbox"/> Use RSTA Pin (set/reset pin)		<input checked="" type="checkbox"/> Use RSTB Pin (set/reset pin)

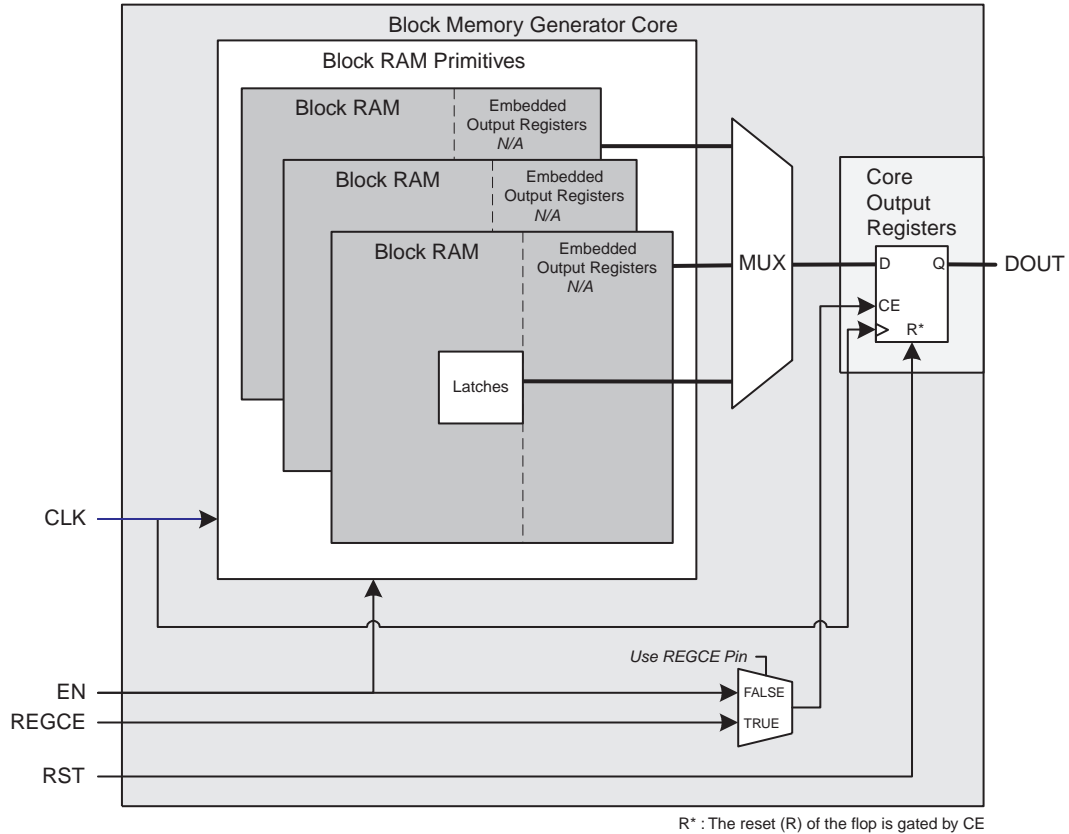


Figure D-15: Spartan-6 or Spartan-3A DSP Block Memory Generated with Register Port [A|B] Output of Memory Core Enabled

Spartan-6 or Spartan-3A DSP FPGA: Memory with No Output Registers

If no output registers are selected for port A or B, output of the memory primitive is driven directly from the RAM primitive latches. In this configuration, as shown in Figure D-16, there are no additional clock cycles of latency, but the clock-to-out delay for a Read operation can impact design performance.

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core

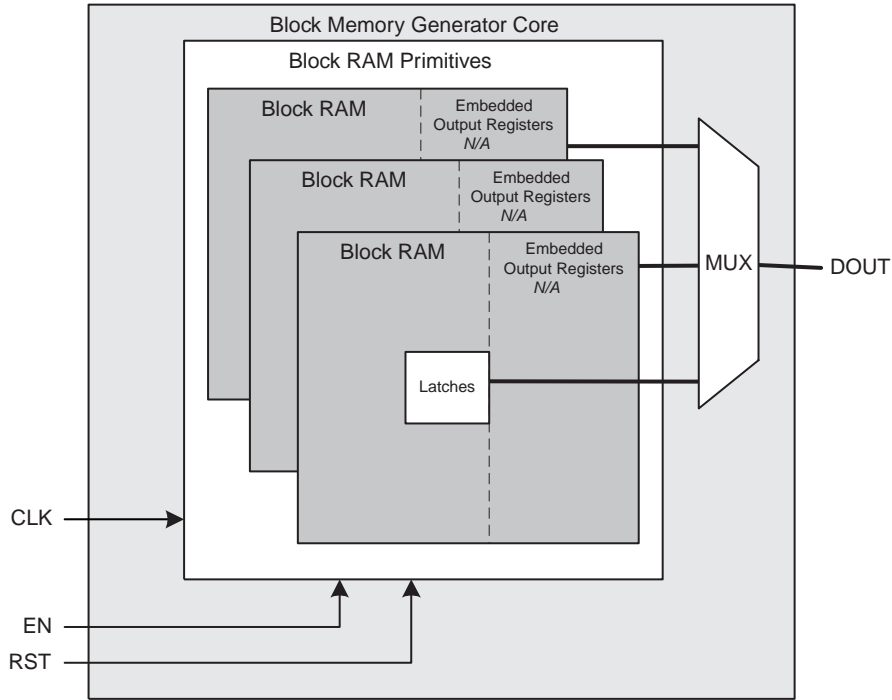


Figure D-16: Spartan-6 or Spartan-3A DSP Block Memory Generated with No Output Port Registers Enabled

Spartan-3 FPGA: Output Register Configurations

To tailor register options for Spartan-3 FPGA architectures, two selections for port A and two selections for port B are provided in the CORE Generator GUI on screen 4 in the Optional Output Registers section. For implementing registers on the outputs of the individual block RAM primitives, Register Output of Memory Primitives is selected. In the same way, registering the output of the core is enabled by selecting Register Port [A|B] Output of Memory Core. Four implementations are available for each port. Figure D-17, Figure D-18, Figure D-19, and Figure D-20 illustrate the Spartan-3 FPGA output register configurations.

Spartan-3 FPGA: Memory with Primitive and Core Output Registers

With Register Port [A|B] Output of Memory Primitives and the corresponding Register Port [A|B] Output of Memory Core selected, a memory core is generated with registers on the outputs of the individual RAM primitives and on the core output, as displayed in Figure D-17. Selecting this configuration may provide improved performance for building large memory constructs.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core

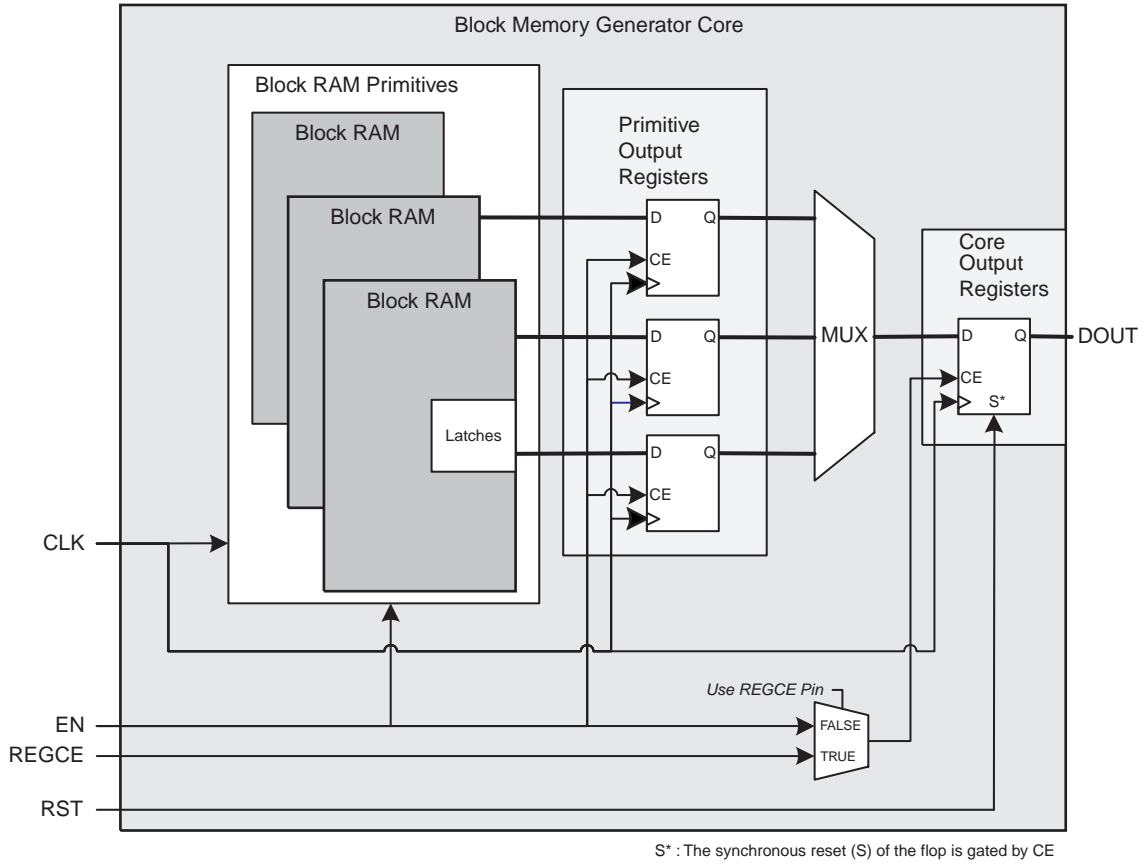


Figure D-17: Spartan-3 Block Memory Generated with Register Port [A|B] Output of Memory Primitives and Register Port [A|B] Output of Memory Core Options Enabled

Spartan-3 FPGA: Memory with Primitive Output Registers

When Register Port [A|B] Output of Memory Primitives is selected, a core that only registers the output of the RAM primitives is generated. Note that the output of any multiplexing required to combine multiple primitives are not registered in this configuration, as shown in Figure D-18.

Port A	or	Port B
<input checked="" type="checkbox"/> Register Port A Output of Memory Primitives		<input checked="" type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core

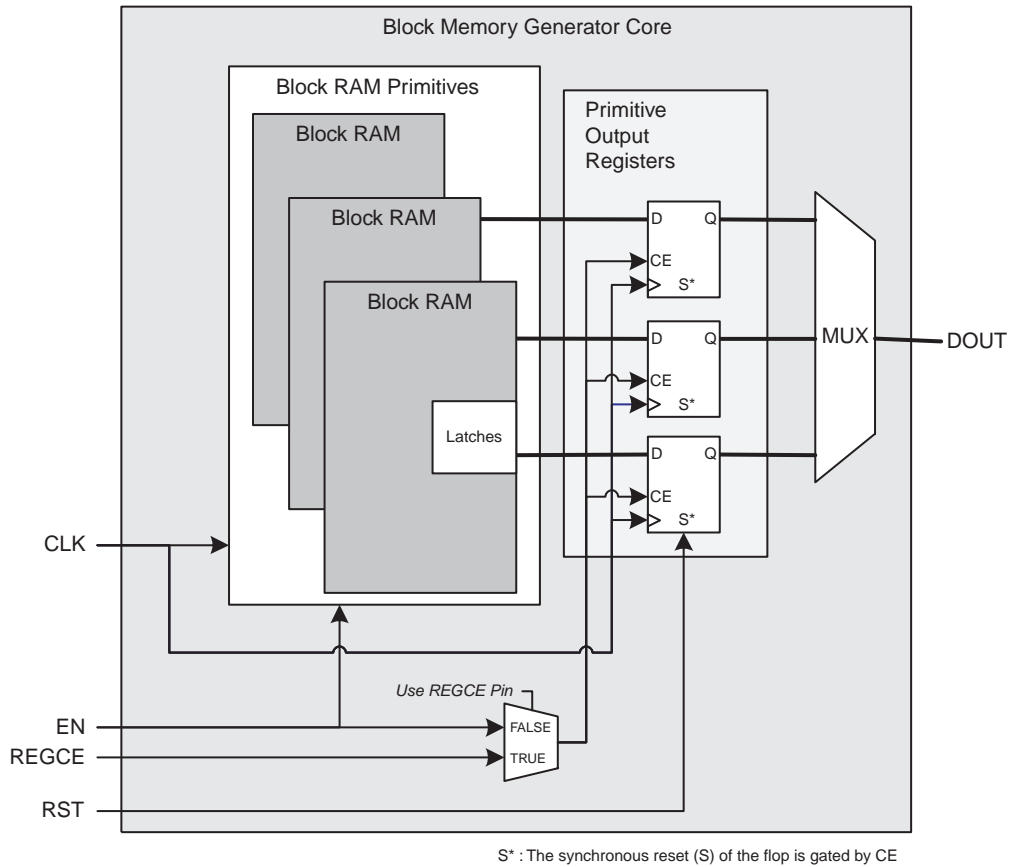


Figure D-18: Spartan-3 Block Memory Generated with Register Port [A|B] Output of Memory Primitives Enabled

Spartan-3 FPGA: Memory with Core Output Registers

Figure D-19 illustrates a memory configured with Register Port [A|B] Output of Memory Core selected.

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input checked="" type="checkbox"/> Register Port A Output of Memory Core		<input checked="" type="checkbox"/> Register Port B Output of Memory Core

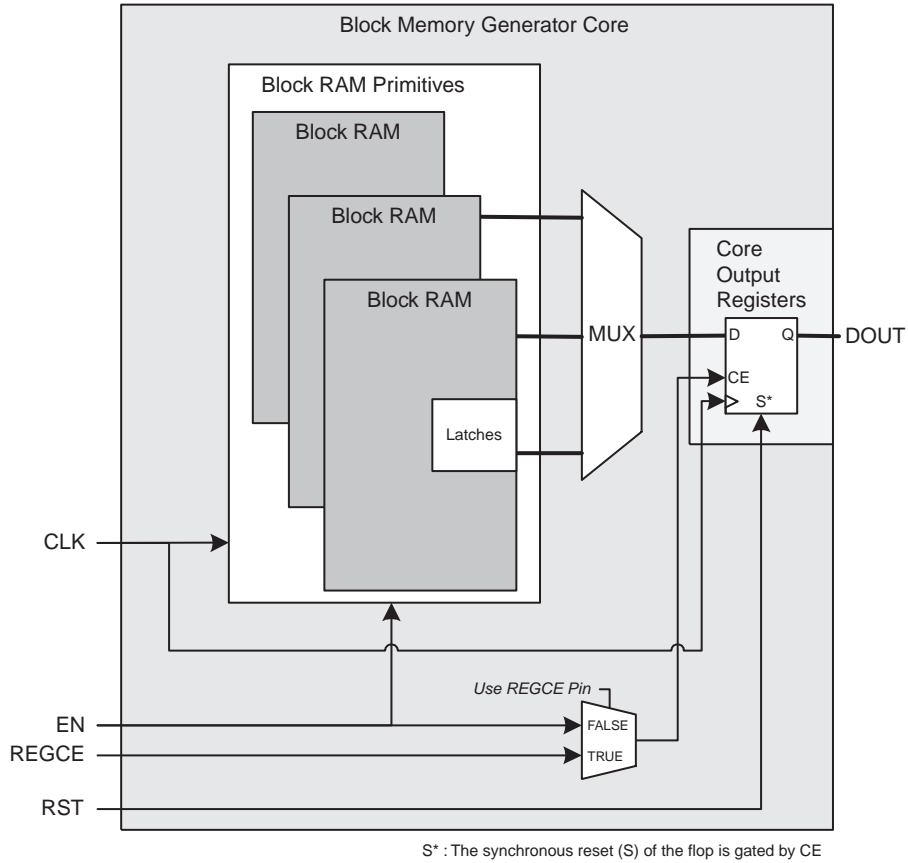


Figure D-19: Spartan-3 Block Memory Generated with Register Port [A|B] Output of Memory Core Enabled

Spartan-3 FPGA: Memory with No Output Registers

When no output register options are selected for either port A or port B, the output of the memory primitive is driven directly from the memory latches. In this configuration, there are no additional clock cycles of latency, but the clock-to-out delay for a Read operation can impact design performance. See [Figure D-20](#).

Port A	or	Port B
<input type="checkbox"/> Register Port A Output of Memory Primitives		<input type="checkbox"/> Register Port B Output of Memory Primitives
<input type="checkbox"/> Register Port A Output of Memory Core		<input type="checkbox"/> Register Port B Output of Memory Core

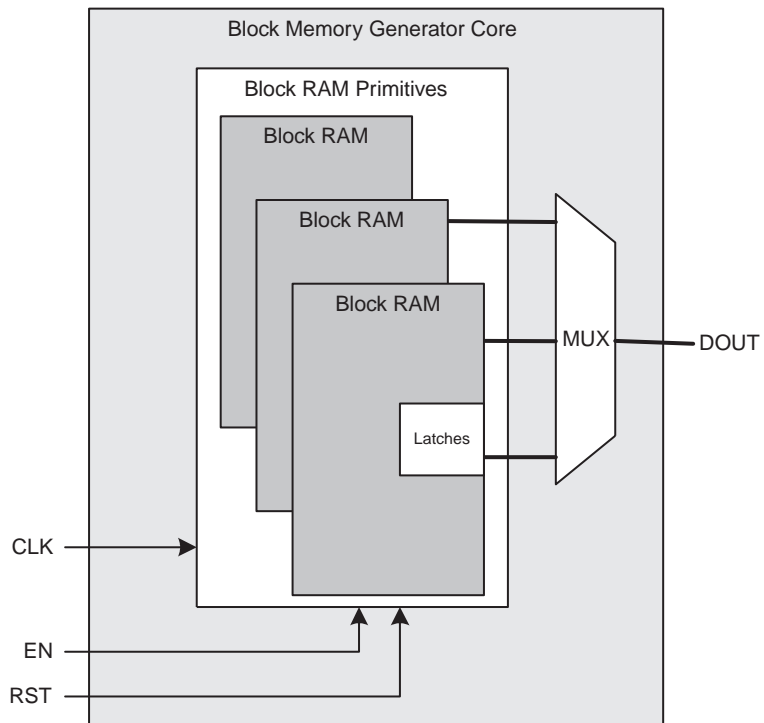


Figure D-20: Spartan-3 Block Memory Generated with No Output Registers Enabled

Additional Resources

Xilinx Resources

For support resources such as Answers, Documentation, Downloads, and Forums, see the Xilinx Support website at:

www.xilinx.com/support.

For a glossary of technical terms used in Xilinx documentation, see:

www.xilinx.com/company/terms.htm.

References

These documents provide supplemental material useful with this product guide:

1. *AMBA AXI4-Stream Protocol Specification*
 2. *Xilinx AXI Reference Guide*
 3. Vivado™ Design Suite user documentation (www.xilinx.com/cgi-bin/docs/rdoc?v=2012.4;t=vivado+docs)
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Technical Support

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

See the IP Release Notes Guide ([XTP025](#)) for more information on this core. For each core, there is a master Answer Record that contains the Release Notes and Known Issues list for the core being used. The following information is listed for each version of the core:

- New Features
- Resolved Issues
- Known Issues

Revision History

The following table shows the revision history for this document.

Date	Version	Description of Revisions
7/25/12	1.0	Initial Xilinx release. Added support for Vivado Design Suite. This document replaces DS512, <i>Block Memory Generator Data Sheet</i> , and XAPP917, <i>Block Memory Generator Migration Guide</i> .
10/16/12	2.0	Updated core to v7.3, ISE Design Suite to 14.3 and Vivado Design Suite to 2012.3. Added the C_USE_BRAM_BLOCK and C_ENABLE_32BIT_ADDRESS parameters.
12/18/12	2.1	Updated ISE Design Suite to 14.4 and Vivado Design Suite to 2012.4. Added Virtex-7 device performance data in Single Primitive in Chapter 2 .

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