

PL310 MBIST Controller

Revision: r0p0

Technical Reference Manual



PL310 MBIST Controller

Technical Reference Manual

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Release Information

Change history

Date	Issue	Confidentiality	Change
30 November 2007	A	Non-Confidential	First release for r0p0

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The information in this document is final, that is for a developed product.

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Preface

This preface introduces the *PL310 MBIST Controller Revision r0p0 Technical Reference Manual*. It contains the following sections:

- *About this manual* on page x
- *Feedback* on page xiv.

About this manual

This is the *Technical Reference Manual* (TRM) for the PL310 MBIST Controller. In this manual the generic term MBIST controller means the PL310 MBIST Controller, and cache controller means the PL310 Cache Controller.

Product revision status

The *rn**pn* identifier indicates the revision status of the product described in this manual, where:

- | | |
|-----------|--|
| rn | Identifies the major revision of the product. |
| pn | Identifies the minor revision or modification status of the product. |

Intended audience

This manual is written for hardware engineers who are familiar with ARM technology and want to use the MBIST controller to test the RAM blocks used by the cache controller. The AXI protocol is not specified but some familiarity with AXI is assumed.

Using this manual

This manual is organized into the following chapters:

Chapter 1 *Introduction*

Read this chapter for an introduction to MBIST technology.

Chapter 2 *Functional Description*

Read this chapter for a description of the cache controller interface to the MBIST controller and MBIST testing of the data RAM and tag RAMs. Also read this chapter for a description of the timing sequences for loading MBIST instructions, starting the MBIST test, detecting failures, and retrieving the data log.

Chapter 3 *MBIST Instruction Register*

Read this chapter for a description on how to use the MBIST Instruction Register to configure the mode of operation of the MBIST engine.

Appendix A *Signal Descriptions*

Read this appendix for a description of the MBIST controller input and output signals.

Conventions

Conventions that this manual can use are described in:

- *Typographical*
- *Timing diagrams*
- *Signals* on page xii
- *Numbering* on page xiii.

Typographical

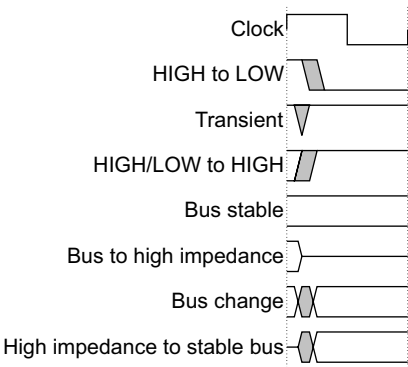
The typographical conventions are:

<i>italic</i>	Highlights important notes, introduces special terminology, denotes internal cross-references, and citations.
bold	Highlights interface elements, such as menu names. Denotes ARM processor signal names. Also used for terms in descriptive lists, where appropriate.
<code>monospace</code>	Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.
<u><code>monospace</code></u>	Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.
<i>monospace italic</i>	Denotes arguments to monospace text where the argument is to be replaced by a specific value.
monospace bold	Denotes language keywords when used outside example code.
< and >	Angle brackets enclose replaceable terms for assembler syntax where they appear in code or code fragments. They appear in normal font in running text. For example: <ul style="list-style-type: none"> • MRC p15, 0 <Rd>, <CRn>, <CRm>, <Opcode_2> • The Opcode_2 value selects which register is accessed.

Timing diagrams

The figure named *Key to timing diagram conventions* on page xii explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.



Key to timing diagram conventions

Signals

The signal conventions are:

Signal level	The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW. Asserted means: <ul style="list-style-type: none">HIGH for active-HIGH signalsLOW for active-LOW signals.
Lower-case n	At the start or end of a signal name denotes an active-LOW signal.
Prefix A	Denotes global <i>Advanced eXtensible Interface</i> (AXI) signals.
Prefix AR	Denotes AXI read address channel signals.
Prefix AW	Denotes AXI write address channel signals.
Prefix B	Denotes AXI write response channel signals.
Prefix C	Denotes AXI low-power interface signals.
Prefix H	Denotes <i>Advanced High-performance Bus</i> (AHB) signals.
Prefix P	Denotes <i>Advanced Peripheral Bus</i> (APB) signals.
Prefix R	Denotes AXI read data channel signals.
Prefix W	Denotes AXI write data channel signals.

Numbering

The numbering convention is:

<size in bits>'<base><number>

This is a Verilog method of abbreviating constant numbers. For example:

- 'h7B4 is an unsized hexadecimal value.
- 'o7654 is an unsized octal value.
- 8'd9 is an eight-bit wide decimal value of 9.
- 8'h3F is an eight-bit wide hexadecimal value of 0x3F. This is equivalent to b00111111.
- 8'b1111 is an eight-bit wide binary value of b00001111.

Additional reading

This section lists publications by ARM and by third parties.

See <http://infocenter.arm.com/help/index.jsp> for access to ARM documentation.

ARM publications

This manual contains information that is specific to the MBIST controller. See the following documents for other relevant information:

- *AMBA AXI Protocol Specification* (ARM IHI 0022)
- *ARM Architecture Reference Manual* (ARM DDI 0406)
- *ARM PL310 Cache Controller Technical Reference Manual* (ARM DDI 0246)
- *ARM PL310 Cache Controller Implementation Guide* (ARM DII 0045).

Feedback

ARM welcomes feedback on the MBIST controller and its documentation.

Feedback on this product

If you have any comments or suggestions about this product, contact your supplier giving:

- the product name
- a concise explanation of your comments.

Feedback on this manual

If you have any comments on this manual, send email to errata@arm.com giving:

- the title
- the number
- the relevant page number(s) to which your comments apply
- a concise explanation of your comments.

ARM also welcomes general suggestions for additions and improvements.

Chapter 1

Introduction

This chapter introduces the MBIST controller. It contains the following sections:

- *About the MBIST controller* on page 1-2
- *MBIST controller interface* on page 1-3
- *Product revisions* on page 1-7.

1.1 About the MBIST controller

MBIST is the industry-standard method of testing embedded memories. MBIST works by performing sequences of reads and writes to the memory according to a test algorithm. Many industry-standard test algorithms exist.

An MBIST controller generates the correct sequence of reads and writes to all locations of the RAM to ensure that the cells are operating correctly. In doing this, some additional test coverage is achieved in the address and data paths that the MBIST uses. You must only use the MBIST controller with the cache controller to perform memory testing of the *Level 2* (L2) cache RAM.

———— Note ————

The example integration files provided with the MBIST controller only support a 16-way cache design.

MBIST mode takes priority over all other modes, for example SCAN, in that the L2 RAMs are only accessible to the MBIST controller when MBIST mode is activated with the **MTESTON** pin. You must keep the **MTESTON** signal LOW during functional mode, and the AXI interfaces LOW during MBIST mode.

The MBIST controller controls the MBIST testing of the L2 RAMs through the MBIST port of the cache controller. Figure 1-1 shows the cache controller MBIST configuration.

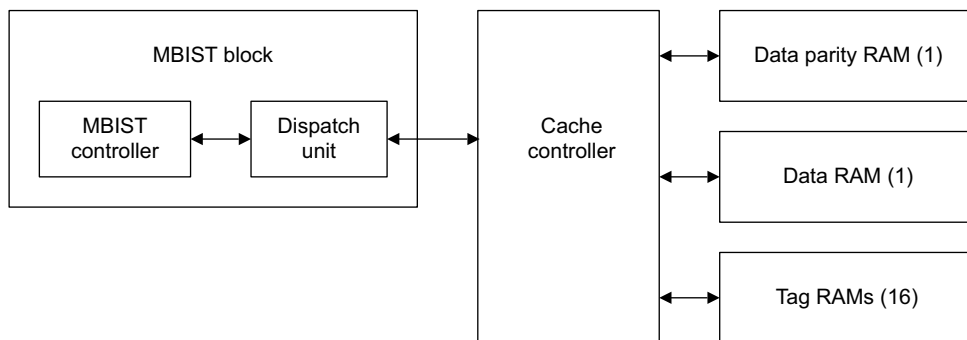


Figure 1-1 Cache controller MBIST configuration

1.2 MBIST controller interface

Figure 1-2 shows the MBIST controller interface to the *Automated Test Equipment* (ATE) and to the MBIST interface of the cache controller.

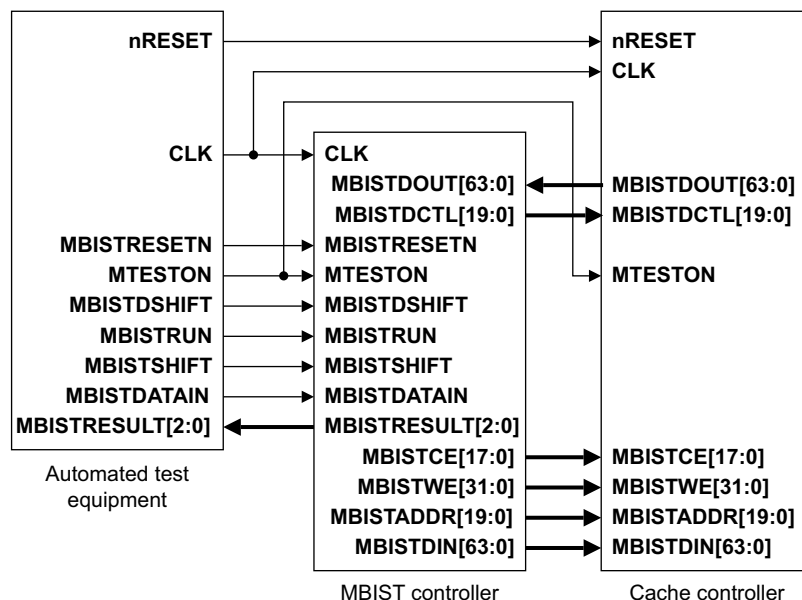


Figure 1-2 MBIST controller wiring diagram

Figure 1-3 on page 1-4 shows the traditional method of accessing a cache RAM for MBIST.

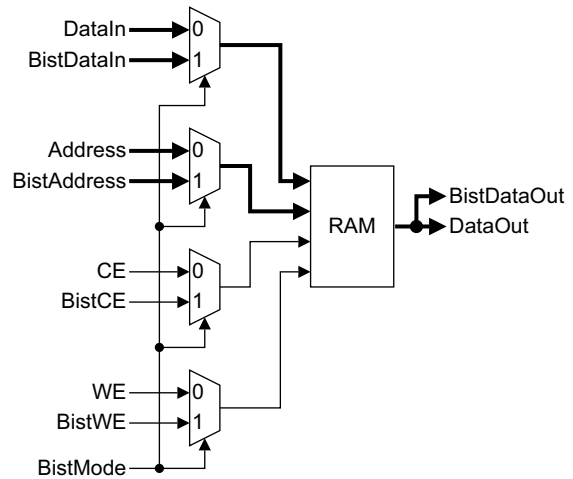


Figure 1-3 Traditional method of interfacing MBIST

Because this method significantly reduces the maximum operating frequency, it is not suitable for high-performance designs. Instead, the MBIST controller uses an additional input to the existing functional multiplexors without reducing maximum operating frequency.

Figure 1-4 on page 1-5 shows the five pipeline stages used to access the cache RAM arrays.

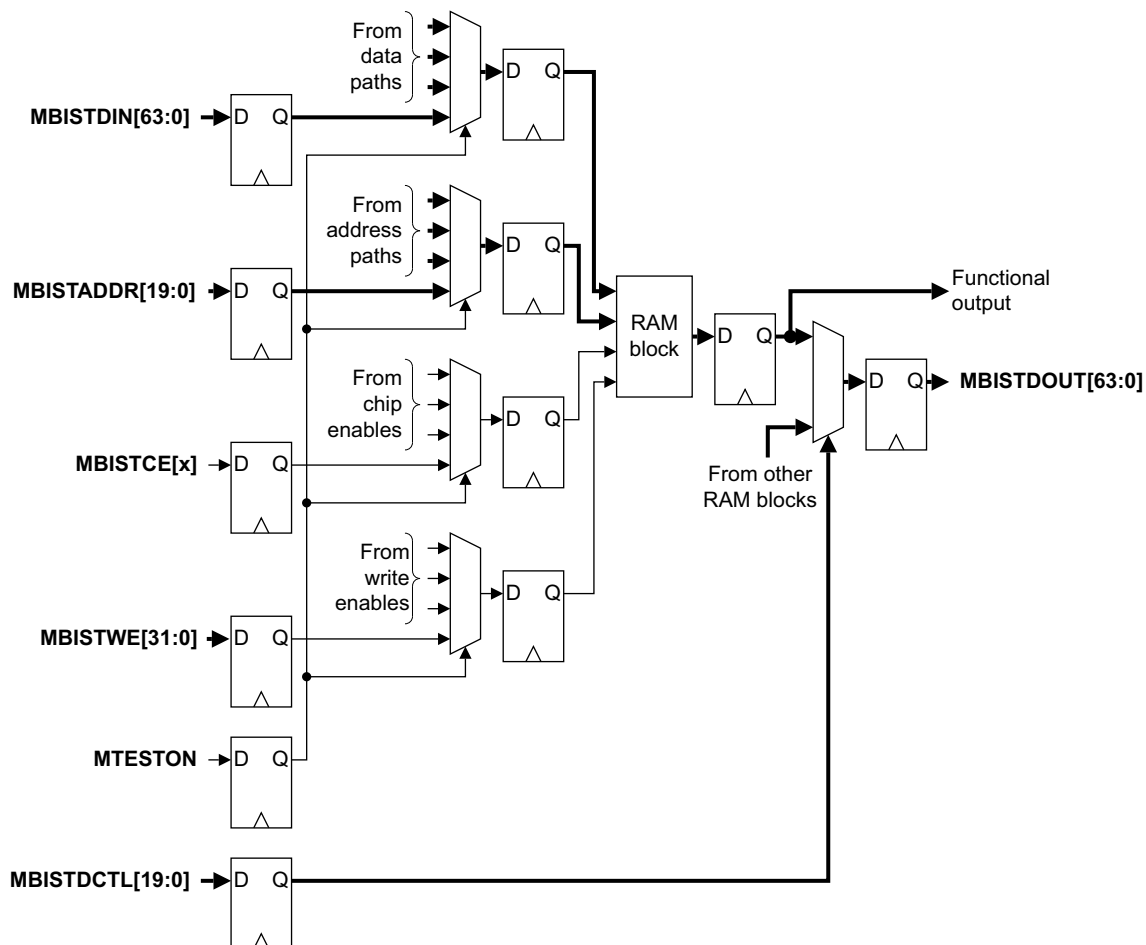


Figure 1-4 Cache controller MBIST interface

The MBIST controller accesses memory through the MBIST interface of the cache controller. Table 1-1 lists the cache controller MBIST interface signals.

Table 1-1 Cache controller MBIST interface signals

Name	Type	Description
nRESET	Input	Global active LOW reset signal.
CLK	Input	Active HIGH clock signal. This clock drives the cache controller logic.
MBISTDOUT[63:0]	Output	Data out bus from all cache RAM blocks.

Table 1-1 Cache controller MBIST interface signals (continued)

Name	Type	Description
MBISTDCTL[19:0]	Input	Delayed versions of the MBISTCE[17:0] signal and the doubleword select signal, MBISTADDR[1:0] . Selects the correct read data after it passes through the MBIST pipeline stages. MBISTDCTL[19:0] = delayed { MBISTCE[17:0] , MBISTADDR[1:0] }.
MTESTON	Input	Select signal for cache RAM array. This signal is the select input to the multiplexors that access the cache RAM arrays for test. When asserted, MTESTON takes priority over all other select inputs to the multiplexors.
MBISTCE[17:0]	Input	One-hot chip enables to select cache RAM arrays for test.
MBISTWE[31:0]	Input	Global write enable signal for all RAM arrays.
MBISTADDR[19:0]	Input	Address signal for cache RAM array. MBISTADDR[1:0] is the doubleword select value. See <i>Y-address and X-address fields, MBIR[36:33] and MBIR[40:37]</i> on page 3-9 for a description of the doubleword select. Not all RAM arrays use the full address width.
MBISTDIN[63:0]	Input	Data bus to the cache RAM arrays. Not all RAM arrays use the full data width.

———— **Note** ————

The interface of the MBIST controller communicates with both the ATE and the MBIST interface of the cache controller. See Appendix A *Signal Descriptions* for descriptions of the MBIST controller interface signals. See the *PL310 Cache Controller Technical Reference Manual* for more information about the MBIST interface.

—————

1.3 Product revisions

This is the first release of this manual.

Chapter 2

Functional Description

This chapter contains a functional overview and MBIST controller implementation. The functional operation provides timing sequences for loading instructions, starting the MBIST engine, detecting failures, and retrieving the data log. It contains the following sections:

- *Functional overview* on page 2-2
- *Functional operation* on page 2-12.

2.1 Functional overview

This section describes:

- *MBIST controller interface*
- *MBIST controller implementation* on page 2-8.

2.1.1 MBIST controller interface

The MBIST controller has one MBIST port, see Appendix A *Signal Descriptions*. Only one RAM is accessed by the MBIST controller at any time.

The MBIST controller must be able to account for the different latencies of the RAMs. You can configure RAM latencies for the cache controller RAMS. You can configure the following RAMs for up to eight cycles of latency:

- data read
- data write
- tag read
- tag write.

See also *Compiled RAM latencies* on page 2-3.

You can use the MBIST controller for testing the cache controller compiled RAMs. You can also choose to design your own MBIST controller. You can only access one RAM by the MBIST port at a time.

Note

For the MBIST to run correctly on the cache controller, set the signals on the cache controller interface as follows:

- set **ASSOCIATIVITY** to the relevant value for your design
 - set **DATAWAIT**, **DATAERR**, **TAGWAIT**, and **TAGERR** to 0
 - set the AXI ports to 0.
-

Figure 2-1 on page 2-3 shows the interfaces between the MBIST controller and the RAMs that MBIST tests.

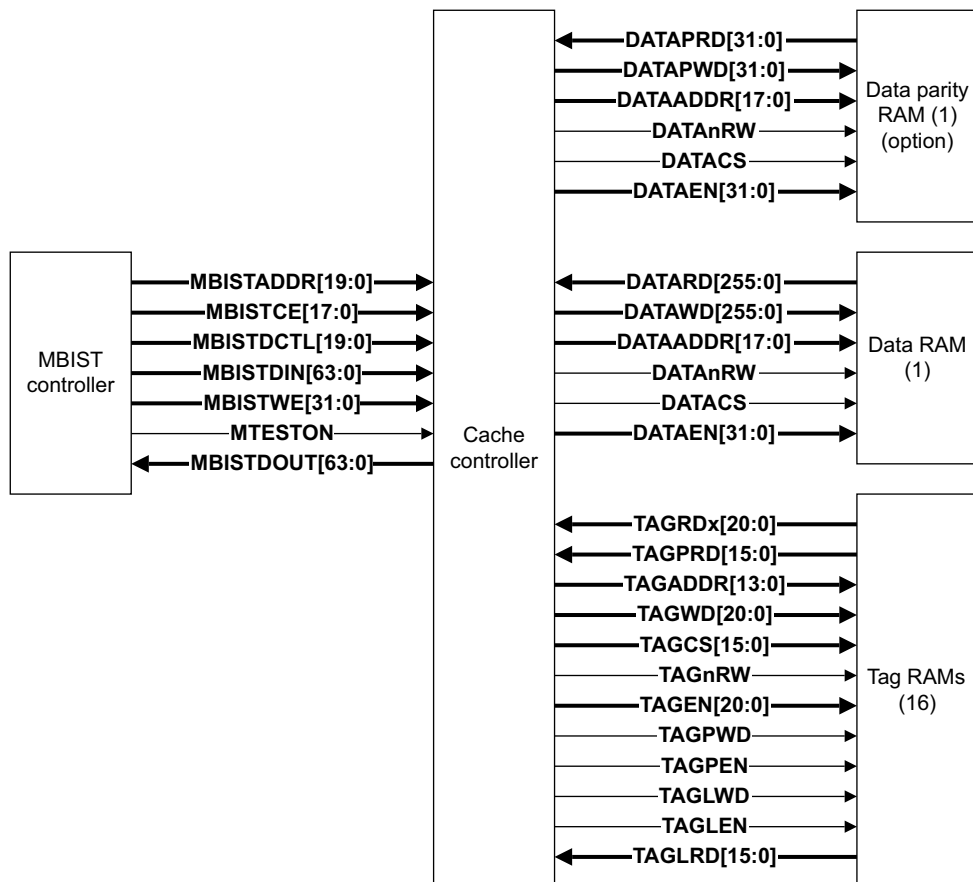


Figure 2-1 Cache controller MBIST and RAM Interfaces

This section describes RAM latencies and the two MBIST RAM tests:

- *Compiled RAM latencies*
- *MBIST testing of cache controller data RAM on page 2-4*
- *MBIST testing of cache controller tag RAMs on page 2-6.*

Compiled RAM latencies

The cache controller resets assuming the slowest compiled RAMs are being used. This means eight cache controller clock cycles are used for each access. In terms of reads, this means that the read data is sampled eight clock edges after the edge on which the read request is sampled by the RAM. Using this nomenclature, the shortest latency is one. During functional mode, the latencies for each RAM are programmed in the cache

controller Auxiliary Control Register. For MBIST, you must know the latencies of the RAMs being tested. The MBIST controller defaults to one cycle of latency, but must reprogram this during the instruction load before MBIST testing can begin. The latency of the current RAM being tested is passed to the MBIST controller in the MBIST instruction. Table 2-1 shows the cache controller compiled RAM latency.

Table 2-1 Cache controller compiled RAM Latency

Latency bits [2:0]	Cycles of latency
3'b000	1 cycle of latency. No additional latency. This is the default.
3'b001	2 cycles of latency.
3'b010	3 cycles of latency.
3'b011	4 cycles of latency.
3'b100	5 cycles of latency.
3'b101	6 cycles of latency.
3'b110	7 cycles of latency.
3'b111	8 cycles of latency.

Figure 2-2 shows the cache controller compiled RAM latency.

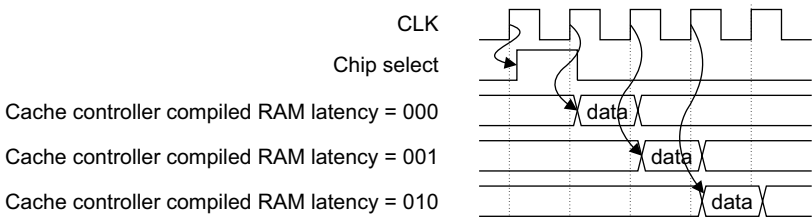


Figure 2-2 Cache controller compiled RAM Latency

MBIST testing of cache controller data RAM

The cache controller data RAM is 256 bits wide, and the size of the **MBISTDIN** and **MBISTDOUT** buses on the cache controller MBIST interface is 64 bits, so four reads and four writes are required for each index of the data RAM. The cache controller handles this by using the **MBISTADDR[1:0]** signal as a doubleword select for each index of the data RAM for writes. For reads from a previous MBIST transaction you use the **MBISTDCTL[1:0]** signal. You require separate pins because the MBIST transactions are pipelined. The MBIST controller takes into account the data RAM

latency and issues the correct control signals. Table 2-2 shows the address range of the **MBISTADDR** bus used to test the data RAM, based on the L2 cache size and configured to be 8-way.

Table 2-2 MBISTADDR and MBISTDIN mapping for data RAM, 8-way

L2 cache size	Number of data RAM indexes	MBISTADDR to data RAM mapping	MBISTDIN to data RAM mapping
128KB	4,096	DATAADDR[11:0]=MBISTADDR[18:16,10:2]	DATAWD[63:0]=MBISTDIN[63:0]
256KB	8,192	DATAADDR[12:0]=MBISTADDR[18:16,11:2]	DATAWD[63:0]=MBISTDIN[63:0]
512KB	16,384	DATAADDR[13:0]=MBISTADDR[18:16,12:2]	DATAWD[63:0]=MBISTDIN[63:0]
1MB	32,768	DATAADDR[14:0]=MBISTADDR[18:16,13:2]	DATAWD[63:0]=MBISTDIN[63:0]
2MB	65,536	DATAADDR[15:0]=MBISTADDR[18:16,14:2]	DATAWD[63:0]=MBISTDIN[63:0]
4MB	131,072	DATAADDR[16:0]=MBISTADDR[18:2]	DATAWD[63:0]=MBISTDIN[63:0]

For a 16-way cache, you can remove one bit from the lower address range and add it to the upper address range as compared to an 8-way cache of the same size. Table 2-3 shows the address range of the **MBISTADDR** bus used to test the data RAM, based on the L2 cache size and configured to be 16-way.

Table 2-3 MBISTADDR and MBISTDIN mapping for data RAM, 16-way

L2 cache size	Number of data RAM indexes	MBISTADDR to data RAM mapping	MBISTDIN to data RAM mapping
256KB	8,192	DATAADDR[12:0]=MBISTADDR[19:16,10:2]	DATAWD[63:0]=MBISTDIN[63:0]
512KB	16,384	DATAADDR[13:0]=MBISTADDR[19:16,11:2]	DATAWD[63:0]=MBISTDIN[63:0]
1MB	32,768	DATAADDR[14:0]=MBISTADDR[19:16,12:2]	DATAWD[63:0]=MBISTDIN[63:0]
2MB	65,536	DATAADDR[15:0]=MBISTADDR[19:16,13:2]	DATAWD[63:0]=MBISTDIN[63:0]
4MB	131,072	DATAADDR[15:0]=MBISTADDR[19:16,14:2]	DATAWD[63:0]=MBISTDIN[63:0]
8MB	262,144	DATAADDR[16:0]=MBISTADDR[19:2]	DATAWD[63:0]=MBISTDIN[63:0]

The cache controller has a 256-bit wide *Line Read Buffer* (LRB) in each slave. One of these holds data for MBIST testing. The cache controller always adds two register delays to the MBIST data read path for the data RAM.

When using the MBIST controller you must account for the data RAM latency in the pipeline. The latency can be from one to eight clock cycles. See *Compiled RAM latencies* on page 2-3. The signal **MBISTCE[0]** is for the chip enable to the data RAM. The signal **MBISTDCTL[2:0]** is for reads from previous MBIST transactions.

Figure 2-3 shows the cache controller MBIST paths for data RAM testing.

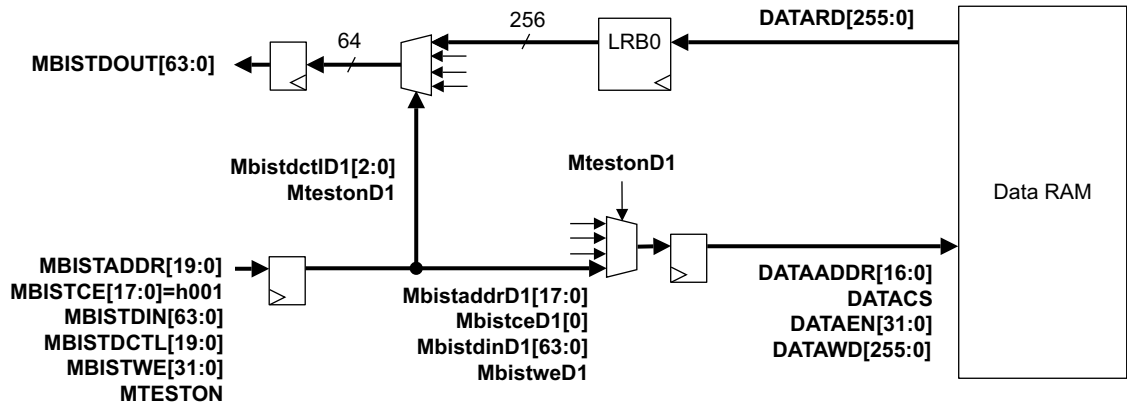


Figure 2-3 Cache controller MBIST paths for data RAM testing

Table 2-4 shows the write sequences for data RAM testing.

Table 2-4 Writes for data RAM testing

MBISTADDR[1:0]	DATAEN[31:0]	DATAWD used
b00	0x000F	[63:0]
b01	0x00F0	[127:64]
b10	0x0F00	[191:128]
b11	0xF000	[255:192]

MBIST testing of cache controller tag RAMs

There is one Tag RAM for each way of the L2 cache. The maximum number of tag RAMs the MBIST controller has to test is 16. Only one tag RAM is tested at a time. Table 2-5 on page 2-7 shows the address range of the **MBISTADDR** bus used to test a tag RAM, based on the L2 cache size and configured to be 8-way. The parity for each

tag RAM present is tested along with the rest of the tag and is mapped to **MBISTDIN[22]**. Lockdown by line is tested with the rest of the tag and is mapped to **MBISTDIN[21]**.

Table 2-5 MBISTADDR and MBISTDIN mapping for tag RAM, 8-way

L2 cache size	Way size	Number of tag RAM indexes	MBISTADDR to tag RAM mapping	MBISTDIN to tag RAM mapping
128KB	16KB	512	TAGADDR[8:0]=MBISTADDR[10:2]	TAGWD[20:0]=MBISTDIN[20:0]
256KB	32KB	1,024	TAGADDR[9:0]=MBISTADDR[11:2]	TAGWD[20:1]=MBISTDIN[20:1]
512KB	64KB	2,048	TAGADDR[10:0]=MBISTADDR[12:2]	TAGWD[20:2]=MBISTDIN[20:2]
1MB	128KB	4,096	TAGADDR[11:0]=MBISTADDR[13:2]	TAGWD[20:3]=MBISTDIN[20:3]
2MB	256KB	8,192	TAGADDR[12:0]=MBISTADDR[14:2]	TAGWD[20:4]=MBISTDIN[20:4]
4MB	512KB	16,384	TAGADDR[13:0]=MBISTADDR[15:2]	TAGWD[20:5]=MBISTDIN[20:5]

For all cases:

- lockdown by line **TAGLWD=MBISTDIN[21]**
- parity **TAGPWD=MBISTDIN[22]**.

Table 2-6 shows the address range of the **MBISTADDR** bus used to test the tag RAM, based on the L2 cache size and configured to be 16-way.

Table 2-6 MBISTADDR and MBISTDIN mapping for tag RAM, 16-way

L2 cache size	Way size	Number of tag RAM indexes	MBISTADDR to tag RAM mapping	MBISTDIN to tag RAM mapping
256KB	16KB	512	TAGADDR[8:0]=MBISTADDR[10:2]	TAGWD[20:0]=MBISTDIN[20:0]
512KB	32KB	1,024	TAGADDR[9:0]=MBISTADDR[11:2]	TAGWD[20:1]=MBISTDIN[20:1]
1MB	64KB	2,048	TAGADDR[10:0]=MBISTADDR[12:2]	TAGWD[20:2]=MBISTDIN[20:2]
2MB	128KB	4,096	TAGADDR[11:0]=MBISTADDR[13:2]	TAGWD[20:3]=MBISTDIN[20:3]
4MB	256KB	8,192	TAGADDR[12:0]=MBISTADDR[14:2]	TAGWD[20:4]=MBISTDIN[20:4]
8MB	512KB	16,384	TAGADDR[13:0]=MBISTADDR[15:2]	TAGWD[20:5]=MBISTDIN[20:5]

The data from the tag RAMs is always registered by the cache controller, plus there is a register on the MBIST port of the cache controller. Consequently, to the MBIST controller, the cache controller always adds two register delays to the MBIST data read path for the tag RAMs.

When using the MBIST controller you must account for the Tag RAM latency in the pipeline. The signal **MBISTCE[16:1]** is for chip enables to the tag RAMs. The signal **MBISTDCTL[18:3]** is for reads from previous MBIST transactions. The latency of the tag RAMs can be from one to eight clock cycles. See *Compiled RAM latencies* on page 2-3.

Figure 2-4 shows the cache controller MBIST paths for tag RAM testing.

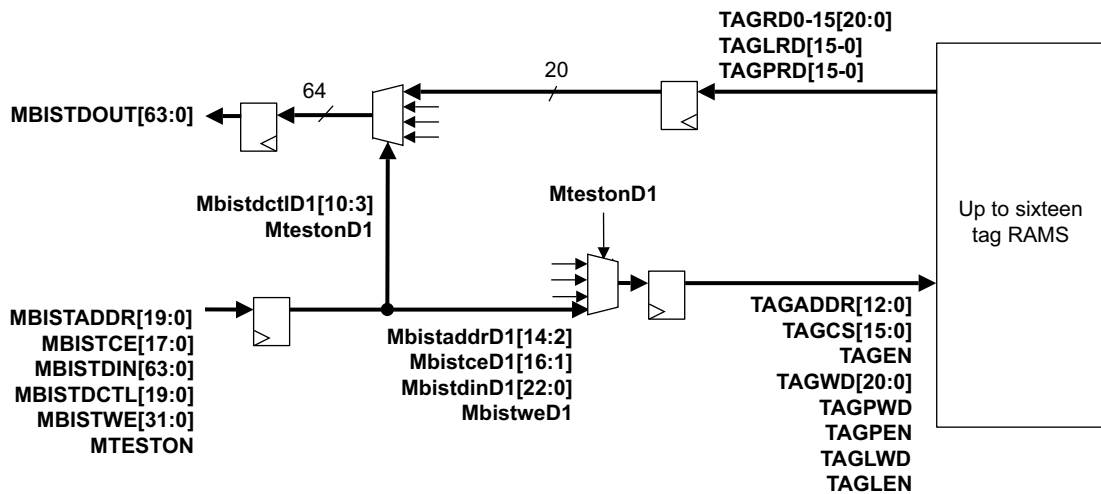


Figure 2-4 Cache controller MBIST paths for tag RAM testing

Note

- **MBISTCE[16:1]** corresponds to **TAGCS[15:0]**
- **MBISTDCL[18:3]** corresponds to **TAG[15:0]**
- Only [22:0] of **MBISTDIN** and **MBISTDOUT** are used.

2.1.2 MBIST controller implementation

The MBIST controller block shown in Figure 2-5 on page 2-9 consists of two major blocks:

- MBIST controller
- dispatch unit.

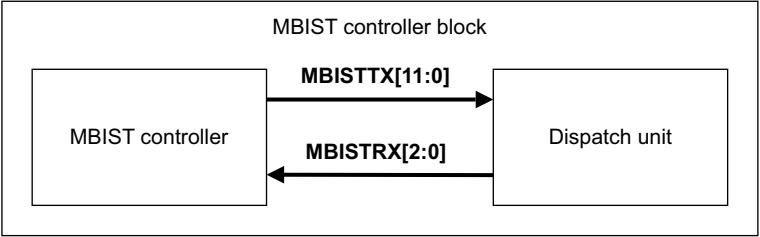


Figure 2-5 MBIST controller block

This section describes:

- *MBIST controller and dispatch unit interface*
- *MBIST controller block top level I/O* on page 2-10.

MBIST controller and dispatch unit interface

The MBIST controller and the dispatch unit communicate using the following signals:

MBISTTX[11:0]

This signal is an output of the MBIST controller that goes to the dispatch unit. Table 2-7 shows the signals.

Table 2-7 MBISTTX signals

MBISTTX bit	Description
0	Reset address
1	Increment address
2	Access sacrificial row, used during bang patterns
3	Invert data/instruction data in
4	Checkerboard data
5	Write data
6	Read data
7	Yfast/nXfast
8	Direction

Table 2-7 MBISTTX signals (continued)

MBISTTX bit	Description
9	Enable bitmap mode
10	Increment go/nogo dataword selection
11	Latency stall control

When the instruction shift is enabled, data shifts between the two parts of the BIST engine are on bit 3. In run test mode, this bit is used as invert data information. The **MBISTTX[11:0]** interface is ARM-specific and intended for use only with the MBIST controller.

MBISTRX[2:0]

This signal is an output of the dispatch unit that goes to the MBIST controller. The behavior of **MBISTRX[2:0]** is ARM-specific and is intended for use only with the MBIST controller. The address expire signal is set when both the row and column address counters expire. Table 2-8 shows the signals.

Table 2-8 MBISTRX signals

MBISTRX bit	Description
0	Address/instruction data out/fail data out
1	Shadow pipeline empty
2	Nonsticky fail flag

MBIST controller block top level I/O

The top level I/O of the MBIST controller consists of the cache controller interface. See Appendix A *Signal Descriptions* and the inputs and outputs shown in Table 2-9.

Table 2-9 MBIST controller top level I/O

Signal	Direction	Function	Value, MBIST mode	Value, function mode
MBISTDATAIN	Input	Serial data in	Toggle	0
MBISTDSHIFT	Input	Data log shift	Toggle	0
MBISTRESETN	Input	MBIST reset	Toggle	0 ^a

Table 2-9 MBIST controller top level I/O (continued)

Signal	Direction	Function	Value, MBIST mode	Value, function mode
MBISTRESULT[2:0]	Output	Output status bus	Strobe	-
MBISTRUN	Input	Run MBIST test	Toggle	0
MBISTSHIFT	Input	Instruction shift	Toggle	0
MTESTON	Input	MBIST path enable	Toggle	0
SE	Input	ATPG signal	0	0
SCANMODE	Input	ATPG signal	0	0

- a. **MBISTRESETN** and **MTESTON** must be LOW in functional mode.

Note

nRESET of the cache controller must be HIGH in MBIST test mode.

The following signals have additional information:

SE Preservation of array state is required when performing multiload ATPG runs or when performing **IDDQ** testing. After performing MBIST tests to initialize the arrays to a required background, the *Automatic Test Pattern Generator* (ATPG) test procedures must assert **SE** during all test setup cycles in addition to load/unload. Any clocking during **IDDQ** capture cycles must have array chip select signals constrained.

MBISTRESULT[2:0]

During tests, the **MBISTRESULT[1]** signal indicates failures. You can operate using two modes, by configuring bit 5 of the engine control section of the instruction register. If bit 5 is set, the **MBISTRESULT[1]** signal is asserted for a single cycle for each failed compare. If bit 5 is not set, the **MBISTRESULT[1]** signal is sticky, and is asserted from the first failure until the end of the test.

At the completion of the test, the **MBISTRESULT[2]** signal goes HIGH. The **MBISTRESULT[0]** signal indicates that an address expire has occurred and enables you to measure sequential progress through the test algorithms.

2.2 Functional operation

The functional operation is described in:

- *Timing*
- *Bitmap mode* on page 2-15.

2.2.1 Timing

A 46-bit instruction, loaded serially at the start of each test, controls the operation of the MBIST controller. Chapter 3 *MBIST Instruction Register* describes how to write the instruction.

The timing diagrams in this section show the clock running at two different speeds:

- the slower clock relates to the clock driven by your ATE
- the faster clock relates to the clock driven by an on-chip *Phase Locked Loop* (PLL).

If you do not have an on-chip PLL, both clocks relate to the clock driven by your ATE.

Timing diagrams in the following sections show the procedures for operating the MBIST controller:

- *Instruction load*
- *Starting MBIST* on page 2-13
- *Failure detection* on page 2-13
- *Data log retrieval* on page 2-13.

Instruction load

To load an MBIST instruction, drive **MBISTSHIFT** HIGH. At the next rising clock edge, the 46-bit shift sequence begins as shown in Figure 2-6. To enable data input from the ATE, the PLL is in bypass mode, and the clock is not running at test frequency.

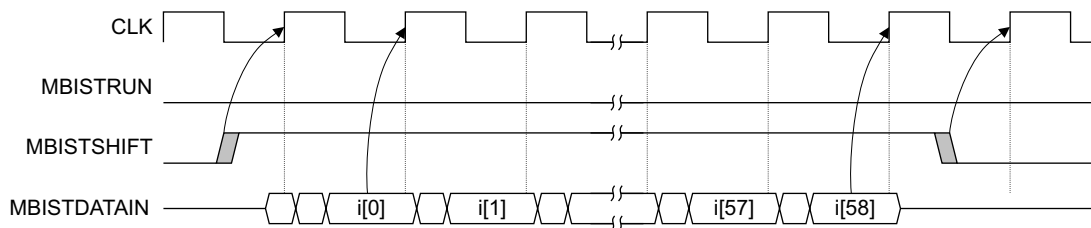


Figure 2-6 Loading the MBIST controller instruction

Starting MBIST

After loading the MBIST instruction, drive **MBISTSHIFT** LOW and disable **CLK**. With **CLK** disabled, drive **MBISTRUN** HIGH and, after an **MBISTRUN** setup time, start the PLL at the test frequency as shown in Figure 2-7.

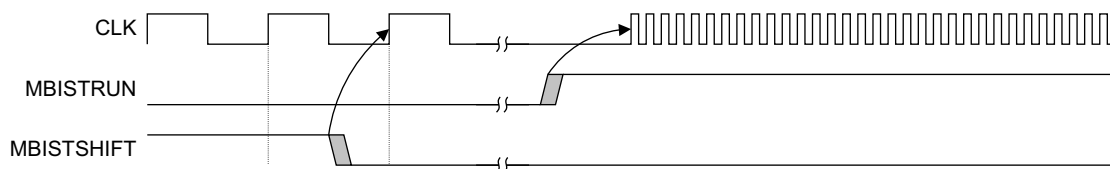


Figure 2-7 Starting the MBIST test

Failure detection

The **MBISTRESULT[1]** flag goes HIGH two **CLK** cycles after the controller detects a failure, as Figure 2-8 shows. It stays HIGH if sticky fail is enabled. If stop on fail is enabled, the **MBISTRESULT[2]** flag goes HIGH two cycles later.

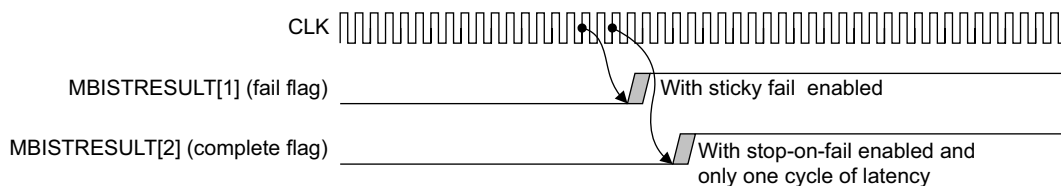


Figure 2-8 Detecting an MBIST failure

Note

To ensure that the ATE can observe a failure at test speed, specify a sticky fail in the MBIST instruction. See *Control field, MBIR[52:47]* on page 3-7.

Data log retrieval

During a test, the MBIST controller automatically logs the first detected failure. If required, you can retrieve the data log at the end of the test to generate failure statistics. Figure 2-9 on page 2-14 and Figure 2-10 on page 2-14 show the method of retrieving a data log.

Note

MBISTRESULT[0] is the serial data output for instructions and the data log.

After the **MBISTRESULT[2]** flag goes HIGH, stop the test by putting the PLL in bypass mode and driving **MBISTRUN** LOW as Figure 2-9 shows. To begin shifting out the data log on **MBISTRESULT[0]**, drive **MBISTDSHIFT** HIGH. The **MBISTRESULT[2]** flag goes LOW two cycles after **MBISTRUN** goes LOW. Data begins shifting out on **MBISTRESULT[0]** two cycles after **MBISTDSHIFT** goes HIGH.

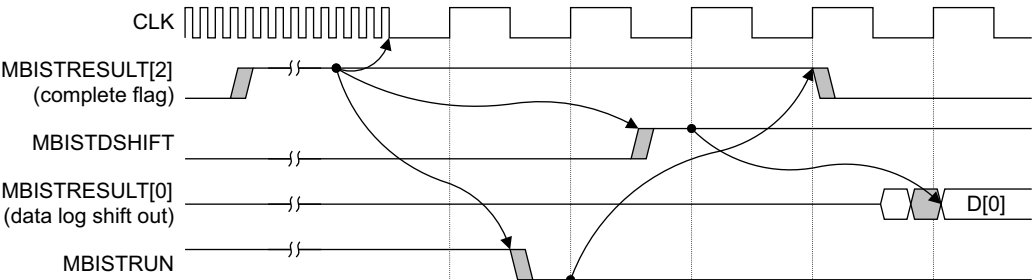


Figure 2-9 Start of data log retrieval

When the last data log bit shifts out, drive **MBISTDSHIFT** LOW as Figure 2-10 shows.

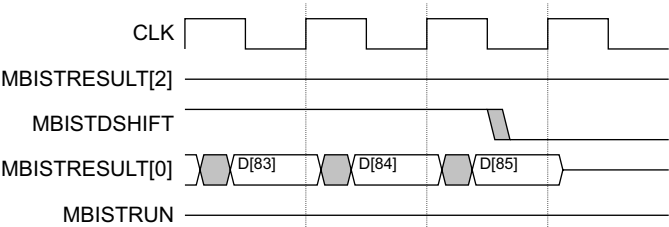


Figure 2-10 End of data log retrieval

Table 2-10 shows the format of the data log.

Table 2-10 Data log format

Bits	Description
[87:68]	Address of the failing location.
[67:4]	Failing data bits. These bits are set for faulty bits and cleared for passing bits.
[3:0]	The data seed used in the test. See <i>Data seed field, MBIR[32:29]</i> on page 3-14.

The address contained in the data log refers to the full address of the failing location as it appears on the **MBISTADDR[19:0]** port of the MBIST interface of the cache controller. It always includes the doubleword select value in the least significant two bits. See *Y-address and X-address fields, MBIR[36:33] and MBIR[40:37]* on page 3-9 for more information on the doubleword select value. Contact ARM if you require more information.

2.2.2 Bitmap mode

In bitmap mode, you can identify all failing locations in a RAM. Each time a failure occurs, the controller stops executing the current test and waits for you to begin shifting out the data log as Figure 2-11 shows.

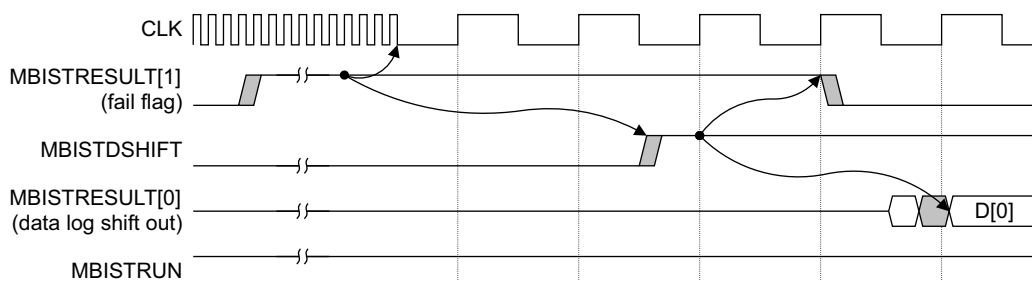


Figure 2-11 Start of bitmap data log retrieval

After you finish shifting and drive **MBISTDSHIFT** LOW, the controller then resumes testing where it stopped as Figure 2-12 shows. This process continues until the test algorithm completes. A fault can cause a failure to occur several times during a given test algorithm. The fault might be logged multiple times depending on the number of reads performed by the algorithm and the exact nature of the fault.

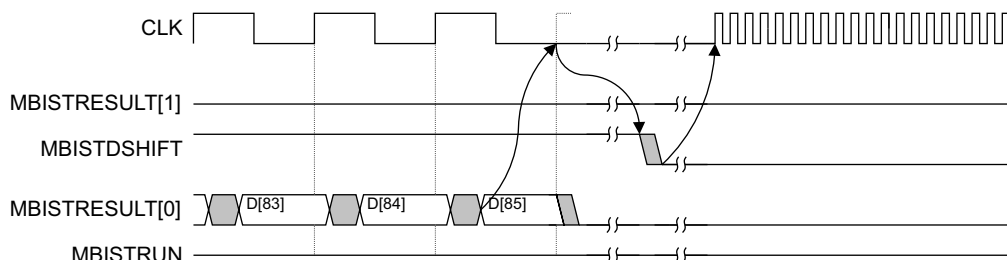


Figure 2-12 End of bitmap data log retrieval

Loading a new instruction resets bitmap mode.

Chapter 3

MBIST Instruction Register

This chapter describes how to use the *MBIST Instruction Register* (MBIR) to configure the mode of operation of the MBIST controller. It contains the following sections:

- *About the MBIST Instruction Register* on page 3-2
- *Field descriptions* on page 3-4.

3.1 About the MBIST Instruction Register

Figure 3-1 shows the bit fields of the MBIR.

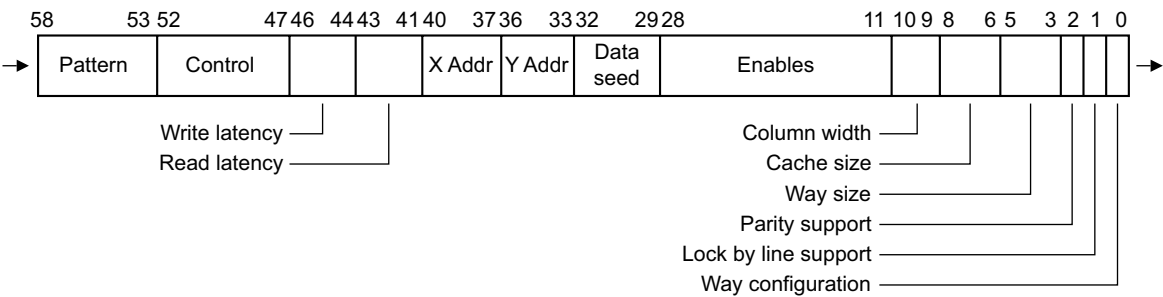


Figure 3-1 MBIST Instruction Register

The MBIR fields set up the behavior of the MBIST engine:

Pattern	Specifies the test algorithm.
Control	Specifies MBIST mode of operation and sticky or nonsticky fail flag.
Write latency	Specifies the number of cycles to enable a RAM write.
Read latency	Specifies the number of cycles to enable a RAM read.
X addr	Specifies the number of bits in the X-address counter.
Y addr	Specifies the number of bits in the Y-address counter.
Data seed	Specifies the four-bit data background.
Enables	Specifies the RAM under test.
Column width	Specifies 4, 8, 16, or 32 columns per block of RAM.
Cache size	Specifies a cache size of 128KB, 256KB, 512KB, 1MB, 2MB, 4MB, or 8MB.
Way size	Specifies a way size of 16KB, 32KB, 64KB, 128KB, 256KB, or 512KB.
Parity support	Specifies if parity is supported.
Lockdown by line support	Specifies if lockdown by line is supported.

Way configuration Specifies an 8-way or 16-way configuration.

Field descriptions on page 3-4 describes the MBIR fields in more detail.

3.2 Field descriptions

The following sections describe the MBIR fields:

- *Pattern field, MBIR[58:53]*
- *Control field, MBIR[52:47]* on page 3-7
- *Read latency and write latency fields, MBIR[43:41] and MBIR[46:44]* on page 3-7
- *Y-address and X-address fields, MBIR[36:33] and MBIR[40:37]* on page 3-9
- *Data seed field, MBIR[32:29]* on page 3-14
- *Enables field, MBIR[28:11]* on page 3-15
- *Column width field, MBIR[10:9]* on page 3-16
- *Cache size field, MBIR[8:6]* on page 3-16
- *Way size field, MBIR[5:3]* on page 3-17
- *Parity support field, MBIR[2]* on page 3-17
- *Lockdown by line support field, MBIR[1]* on page 3-17
- *Way configuration field, MBIR[0]* on page 3-17.

3.2.1 Pattern field, MBIR[58:53]

The MBIST controller is supplied with industry-standard pattern algorithms and a bit-line stress algorithm. You can group algorithms together to create a specific memory test methodology for your product.

Table 3-1 describes the supported algorithms, and *Pattern specification* on page 3-5 describes their use. The N values in the table indicate the number of RAM accesses per address location and give an indication of the test time when using that algorithm.

Table 3-1 Pattern field encoding

Pattern MBIR[58:53]	Algorithm name	N	Description
b000000	Write Solids	1N	Write a solid pattern to memory
b000001	Read Solids	1N	Read a solid pattern from memory
b000010	Write Checkerboard	1N	Write a checkerboard pattern to memory
b000011	Read Checkerboard	1N	Read a checkerboard pattern from memory
b000100	March C+ (x-fast)	14N	March C+ algorithm, incrementing X-address first
b001011	March C+ (y-fast)	14N	March C+ algorithm, incrementing Y-address first
b000101	Fail Pattern	6N	Tests memory failure detection capability

Table 3-1 Pattern field encoding (continued)

Pattern MBIR[58:53]	Algorithm name	N	Description
b000110	Read Write March (x-fast)	6N	Read write march pattern, incrementing X-address first
b000111	Read Write March (y-fast)	6N	Read write march pattern incrementing Y-address first
b001000	Read Write Read March (x-fast)	8N	Read write read march pattern, incrementing X-address first
b001001	Read Write Read March (y-fast)	8N	Read write read march pattern, incrementing y-address first
b001010	Bang	18N	Bit-line stress pattern
b111111	Go/No-Go	30N	See Table 3-2 on page 3-6

Pattern specification

This section describes the MBIST test patterns. An x-fast pattern increments or decrements the X-address counter first. A y-fast pattern increments or decrements the Y-address counter first. *Y-address and X-address fields, MBIR[36:33] and MBIR[40:37]* on page 3-9 describes the X-address and Y-address counters.

The first four patterns are useful for data retention or I_{DDQ} testing.

Write Solids This initializes the RAM with the supplied data seed.

Read Solids This reads each RAM location once expecting the supplied data seed.

Write Checkerboard

This initializes the RAM with a physical checkerboard pattern created by alternating the supplied data seed and its inverse.

Read Checkerboard

This reads back the physical checkerboard pattern created by alternating the supplied data seed and its inverse.

For the next set of patterns, the following notation describes the algorithm:

- 0 represents the data seed
- 1 represents the inverse data seed
- w indicates a write operation
- r indicates a read operation
- ↑ indicates that the address is incremented

- \Downarrow indicates that the address is decremented.

March C+ (x-fast or y-fast)

This is the industry-standard March C+ algorithm:

$(w0) (r0, w1, r1) (r1, w0, r0) \Downarrow (r0, w1, r1) \Downarrow (r1, w0, r0) (r0)$

Read Write March (x-fast or y-fast)

$(w0) (r0, w1) \Downarrow (r1, w0) (r0)$

Read Write Read March (x-fast or y-fast)

$(w0) (r0, w1, r1) \Downarrow (r1, w0, r0) (r0)$

Bang This test is always performed in x-fast. It executes multiple consecutive writes and reads effectively stressing a bit-line pair. While this pattern does detect stuck-at faults, its primary intent is to address the analog characteristics of the memory. In the following algorithm description, row 0 indicates a read or write of the data seed to the sacrificial row, this is always the first row of the column being addressed.

$(w0) (r0, w0, w0(row\ 0) \times 6) (r0 \times 5, w0(row\ 0), r0) (r0)$

Go/No-Go If you do not want to implement your own memory test strategy, use the Go/No-Go test pattern that performs the algorithms that Table 3-2 shows.

Table 3-2 Go/No-Go test pattern

Sequence	Algorithm	Data
1	Write Checkerboard	Data seed
2	Read Checkerboard	Data seed
3	Write Checkerboard	Data seed
4	Read Checkerboard	Data seed
5	Read Write Read March (y-fast)	0x6
6	Bang	0xF

This test suite provides a comprehensive test of the arrays. The series of tests in Go/No-Go are the result of the experience in memory testing by ARM memory test engineers.

3.2.2 Control field, MBIR[52:47]

The control field specifies the MBIST function. Table 3-3 shows how the control field affects the behavior of the MBIST controller.

Table 3-3 Control field encoding

Control MBIR[52:47]	Behavior	Description
bx00000	Default	Test runs to completion. If MBIR[52] = 0, sticky fail present after first failure.
bx00001	Stop on fail	End of test on failure.
bx00011	Bitmap mode	Enables logging of each failure. See <i>Bitmap mode</i> on page 2-15.

MBIR[52] selects a nonsticky or sticky fail flag, **MBISTRESULT[1]**:

- When MBIR[52] is set, the fail bit toggles in real time. It goes HIGH for failing comparisons and LOW for passing comparisons.

———— **Note** ————

Setting MBIR[52] can cause the fail bit to toggle at the test frequency. It is not recommended when the external pin or the ATE cannot follow the test frequency.

- When MBIR[52] is cleared, the fail bit is sticky. It remains HIGH after the first failure until a new MBIST instruction shifts in or until the data log shifts out.

3.2.3 Read latency and write latency fields, MBIR[43:41] and MBIR[46:44]

The read latency and write latency fields of the MBIR are used to specify the read and write latency of the RAM under test. Read and write latencies are the numbers of cycles that the RAM requires to complete read and write operations. For example, in a write to a RAM with a write latency of two cycles, the RAM inputs are valid for a single cycle. The next cycle is a NOP cycle with the chip enable negated. Similarly, in a read from a RAM with a read latency of three cycles, the RAM inputs are valid for a single cycle. After two NOP cycles, the read data is valid on the RAM outputs.

———— **Note** ————

Even if the RAM under test uses the same latency for both read and write operations, you must still program both the read latency and write latency fields of the MBIR with the same value.

Table 3-4 shows the latency settings for read operations.

Table 3-4 Read latency field encoding

Read latency MBIR[43:41]	Number of cycles per read operation
b000	1
b001	2
b010	3
b011	4
b100	5
b101	6
b110	7
b111	8

Table 3-5 shows the latency settings for write operations.

Table 3-5 Write latency field encoding

Write latency MBIR[46:44]	Number of cycles per write operation
b000	1
b001	2
b010	3
b011	4
b100	5
b101	6
b110	7
b111	8

3.2.4 Y-address and X-address fields, MBIR[36:33] and MBIR[40:37]

You can determine the number of address bits you must specify for a RAM from the MBIR fields:

- X-address
- Y-address.

This enables you to specify your address range in two dimensions, this represents the topology of the physical implementation of the RAM more accurately. These two dimensions are controlled by two separate address counters, the X-address counter and the y-address counter. One counter can be incremented or decremented only when the other counter has expired. The chosen test algorithm determines the counter that moves faster.

Use this procedure to determine how many bits to assign to the X-address and Y-address counters:

1. Determine the column width of the RAM array. The Y-address must have at least that many bits for the column select. If it is a Data RAM, add two bits to that number for the doubleword select.
2. Determine how many address bits the RAM requires. See *Cache controller RAMs* on page 3-13. Subtract the current Y-address bit number from that number. If the result is eight or fewer bits, they are all assigned to the X-address for the row select. Otherwise, eight bits are used for the X-address and any unassigned bits are added to the bits already assigned to the Y-address and used for the block select.

Figure 3-2 on page 3-10 shows an example topology for the Data RAM in a 256K level-2 cache.

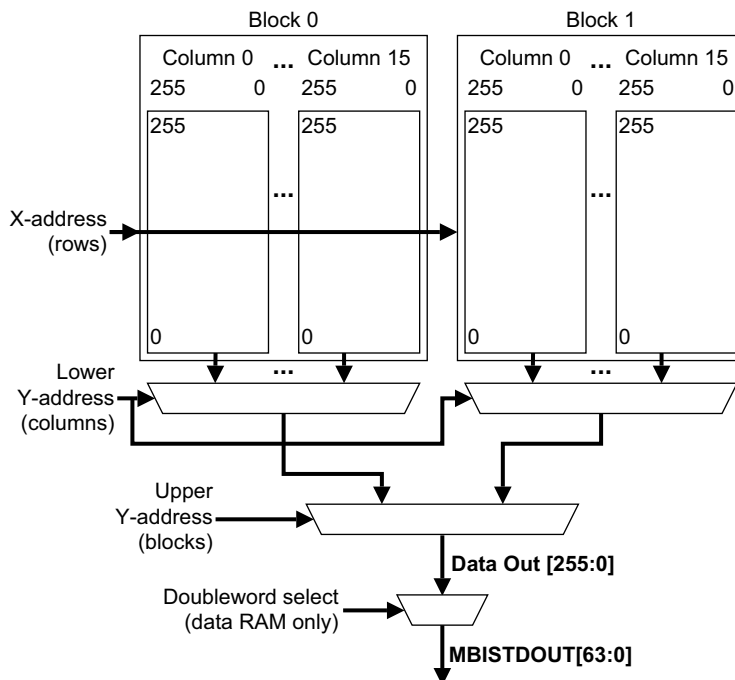


Figure 3-2 Example data RAM topology

The cache RAM in Figure 3-2 has a column width of 16, so it uses four bits for the column address. These four bits map to the least significant bits of the Y-address counter. Because this is a data RAM, it requires two additional doubleword select bits. The doubleword select bits choose between the four 64-bit groups of RAM data before sending the data to the 64-bit **MBISTDOUT[63:0]** bus. These two bits always map to the Y-address counter bits between the column address and the block address.

Because this cache RAM has 256 rows per column, it uses eight bits for the row address, this uses up all eight bits of the X-address counter. This RAM also contains two blocks of 16 columns each, so it uses one bit for the block address. This maps to the most significant bit of the Y-address counter. To correctly test this RAM, the Y-address field must have a value of seven, **MBIR[36:33] = b0111**, and the X-address field must have a value of eight, **MBIR[40:37] = b1000**. Values higher or lower than these produce incorrect results.

Note

If the columns have fewer than 256 rows, you must still assign address bits to the row address until all eight bits are used before assigning any to the block address. If the cache RAM has more than 256 rows per column, then the additional bits must be assigned to the block address. This does not have any detrimental effects on the test coverage of the RAM.

Figure 3-3 shows how the MBIST controller builds the address output. The doubleword select bits are the least significant two bits of the address. These two bits are ignored unless the data RAM is selected. The exclusive OR of the two least significant bits of the Y-address counter is the least significant bit of the column address for physical addressing of the columns. This is followed by the row address from the X-address counter and, if required, the block address.

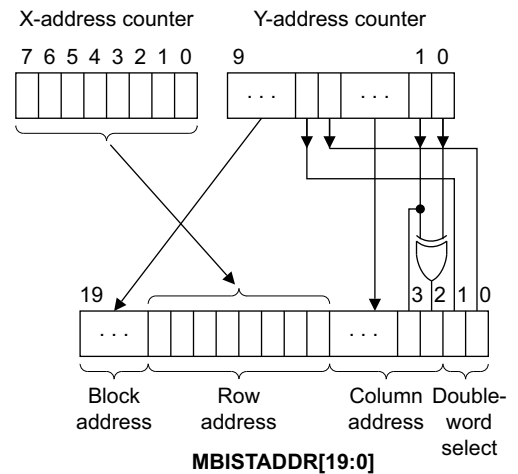


Figure 3-3 MBIST address scrambling

Y-address

The Y-address field specifies the number of Y-address counter bits to use during test. Table 3-6 shows the Y-address settings.

Table 3-6 Y-address field encoding

Y-address MBIR[36:33]	Number of counter bits
<b0010	Unsupported
b0010	2
b0011	3
b0100	4
b0101	5
b0110	6
b0111	7
b1000	8
b1001	9
b1010	10
>b1010	Reserved

X-address

The X-address field specifies the number of X-address counter bits to use during test. Table 3-7 shows the X address settings.

Table 3-7 X-address field encoding

X-address MBIR[40:37]	Number of counter bits
<b0010	Unsupported
b0010	2
b0011	3
b0100	4

Table 3-7 X-address field encoding (continued)

X-address MBIR[40:37]	Number of counter bits
b0101	5
b0110	6
b0111	7
b1000	8
b1001	9
b1010	10
>b1010	Reserved

Cache controller RAMs

Table 3-8 shows the required sums of the X-address and Y-address fields for testing of data RAM.

Table 3-8 Required sums of X-address and Y-address fields for data RAM

Cache size	Data RAM
128KB	14
256KB	15
512KB	16
1MB	17
2MB	18
4MB	19
8MB	20

Table 3-9 shows the required sums of the X-address and Y-address fields for testing of tag RAM.

Table 3-9 Required sums of X-address and Y-address fields for tag RAM

Way size	Tag RAM
16KB	9
32KB	10
64KB	11
128KB	12
256KB	13
512KB	14

3.2.5 Data seed field, MBIR[32:29]

The four-bit data seed field supplies the background data for the test algorithm at instruction load.

———— **Note** —————

In the Go/No-Go algorithm, the Read Write Read March (y-fast) and Bang algorithms do not use the data seed value. Table 3-2 on page 3-6 shows the data that the Go/No-Go algorithm uses.

The data seed enables you to select values stored into arrays for **I_{DDQ}** ATPG, or to select data words to search for unexpected sensitivities during march or bit-line stress tests. The MBIST engine replicates the four bits of data 16 times to give the full 64 bits of data required on the **MBISTDIN[63:0]** port of the MBIST interface.

3.2.6 Enables field, MBIR[28:11]

Table 3-10 shows how each bit in the enables field selects the cache RAM array to be tested. You can select only one array at a time. Selecting multiple arrays produces unpredictable behavior.

Table 3-10 Enables field encoding

Enables MBIR[28:11]	RAM name
b00000000000000000001	Data
b00000000000000000010	Tag 0
b00000000000000000100	Tag 1
b00000000000000001000	Tag 2
b0000000000000010000	Tag 3
b0000000000000100000	Tag 4
b0000000000001000000	Tag 5
b0000000000010000000	Tag 6
b0000000000100000000	Tag 7
b0000000010000000000	Tag 8
b0000000100000000000	Tag 9
b0000001000000000000	Tag 10
b0000010000000000000	Tag 11
b0000100000000000000	Tag 12
b0001000000000000000	Tag 13
b0010000000000000000	Tag 14
b0100000000000000000	Tag 15
b1000000000000000000	Data parity RAM

3.2.7 Column width field, MBIR[10:9]

The column width field specifies the number of columns in each block of RAM in the array under test. The column address is always encoded in the least significant bits of the RAM address, so the number of columns determines the number of bits used. This information is important for the correct operation of certain MBIST operations, such as bit-line stress testing and writing a true physical checkerboard pattern to the array.

Table 3-11 shows the supported column widths along with the number of LSB address bits used for each and the MBIR encodings required to select them.

Table 3-11 Column width field encoding

Column width MBIR[10:9]	Number of columns	Number of address bits
b00	4	2
b01	8	3
b10	16	4
b11	32	5

3.2.8 Cache size field, MBIR[8:6]

The cache size field specifies the size of the cache in your implementation of the module. Table 3-12 shows the supported cache sizes.

Table 3-12 Cache size field encoding

Cache size MBIR[8:6]	Cache size
b000	Reserved
b001	128KB
b010	256KB
b011	512KB
b100	1MB
b101	2MB
b110	4MB
b111	8MB

3.2.9 **Way size field, MBIR[5:3]**

The way size field specifies the size of the way in your implementation. Table 3-13 shows the supported way sizes.

Table 3-13 Way size field encoding

Way size MBIR[5:3]	Way size
b000	Reserved
b001	16KB
b010	32KB
b011	64KB
b100	128KB
b101	256KB
b110	512KB
b111	Reserved

3.2.10 **Parity support field, MBIR[2]**

The parity support field specifies if parity is supported in your implementation. Set to 1 if parity is enabled.

3.2.11 **Lockdown by line support field, MBIR[1]**

The lockdown by line support field specifies if lockdown by line is supported in your implementation. Set to 1 if lockdown by line is enabled.

3.2.12 **Way configuration field, MBIR[0]**

The way configuration field specifies an 8-way or 16-way configuration in your implementation. Set to 0 for an 8-way configuration or 1 for a 16-way configuration.

Appendix A

Signal Descriptions

This appendix describes the MBIST controller signals. It contains the following sections:

- *MBIST controller interface signals* on page A-2
- *Miscellaneous signals* on page A-4.

A.1 MBIST controller interface signals

Table A-1 shows the MBIST controller interface signals.

Table A-1 MBIST controller interface signals

Signal	Type	Description
MBISTDOUT[63:0]	Input	MBIST data out, from cache controller MBISTDOUT[63:0] = MBIST data out for Data RAM MBISTDOUT[20:0] = MBIST data out for Tag RAM
MBISTADDR[19:0]	Output	MBIST address MBISTADDR[18:0] used for Data RAM, two LSBs used as doubleword select MBISTADDR[14:2] used for Tag RAM
MBISTCE[17:0]	Output	MBIST RAM chip enables, for writes MBISTCE[0] = Data RAM chip enable MBISTCE[1] = Tag RAM 0 chip enable MBISTCE[2] = Tag RAM 1 chip enable MBISTCE[3] = Tag RAM 2 chip enable MBISTCE[4] = Tag RAM 3 chip enable MBISTCE[5] = Tag RAM 4 chip enable MBISTCE[6] = Tag RAM 5 chip enable MBISTCE[7] = Tag RAM 6 chip enable MBISTCE[8] = Tag RAM 7 chip enable MBISTCE[9] = Tag RAM 8 chip enable MBISTCE[10] = Tag RAM 9 chip enable MBISTCE[11] = Tag RAM 10 chip enable MBISTCE[12] = Tag RAM 11 chip enable MBISTCE[13] = Tag RAM 12 chip enable MBISTCE[14] = Tag RAM 13 chip enable MBISTCE[15] = Tag RAM 14 chip enable MBISTCE[16] = Tag RAM 15 chip enable MBISTCE[17] = Data parity chip enable ^a

Table A-1 MBIST controller interface signals (continued)

Signal	Type	Description
MBISTDCTL[19:0]	Output	<p>MBIST control, for reads</p> <p>MBISTDCTL[1:0] = MBIST data select for 64 bits of 256 wide data RAM</p> <p>MBISTDCTL[2] = MBIST RAM select for Data RAM</p> <p>MBISTDCTL[3] = MBIST RAM select for Tag RAM 0</p> <p>MBISTDCTL[4] = MBIST RAM select for Tag RAM 1</p> <p>MBISTDCTL[5] = MBIST RAM select for Tag RAM 2</p> <p>MBISTDCTL[6] = MBIST RAM select for Tag RAM 3</p> <p>MBISTDCTL[7] = MBIST RAM select for Tag RAM 4</p> <p>MBISTDCTL[8] = MBIST RAM select for Tag RAM 5</p> <p>MBISTDCTL[9] = MBIST RAM select for Tag RAM 6</p> <p>MBISTDCTL[10] = MBIST RAM select for Tag RAM 7</p> <p>MBISTDCTL[11] = MBIST RAM select for Tag RAM 8</p> <p>MBISTDCTL[12] = MBIST RAM select for Tag RAM 9</p> <p>MBISTDCTL[13] = MBIST RAM select for Tag RAM 10</p> <p>MBISTDCTL[14] = MBIST RAM select for Tag RAM 11</p> <p>MBISTDCTL[15] = MBIST RAM select for Tag RAM 12</p> <p>MBISTDCTL[16] = MBIST RAM select for Tag RAM 13</p> <p>MBISTDCTL[17] = MBIST RAM select for Tag RAM 14</p> <p>MBISTDCTL[18] = MBIST RAM select for Tag RAM 15</p> <p>MBISTDCTL[19] = MBIST RAM select for data parity</p>
MBISTDIN[63:0]	Output	<p>MBIST Data In, to cache controller</p> <p>MBISTDIN[63:0] = MBIST data in for Data RAM</p> <p>MBISTDIN[20:0] = MBIST data in for Tag RAM</p>
MBISTWE[31:0]	Output	MBIST Write enable

- a. Data parity enable is **MBISTCE[17]** on the MBIST controller. However, the cache controller interface is configurable as 16-way or 8-way. For a 16-way configuration, connect **MBISTCE[17]** from the MBIST controller to **MBISTCE[17]** on the cache controller. For an 8-way configuration, connect **MBISTCE[17]** from the MBIST controller to **MBISTCE[9]** on the cache controller.

A.2 **Miscellaneous signals**

Table A-2 shows the miscellaneous signals.

Table A-2 Miscellaneous signals

Signal	Type	Description
nRESET	Input	Global active LOW reset signal
CLK	Input	Clock
MBISTDATAIN	Input	Serial data in
MBISTDSHIFT	Input	Data log shift
MBISTRESETN	Input	MBIST reset
MBISTRESULT[2:0]	Output	Output status bus
MBISTRUN	Input	Run MBIST test
MBISTSHIFT	Input	Instruction shift
MTESTON	Input	MBIST Mode Enable