



# M58MR016C M58MR016D

16 Mbit (1Mb x16, Mux I/O, Dual Bank, Burst)  
1.8V Supply Flash Memory

PRELIMINARY DATA

- **SUPPLY VOLTAGE**
  - $V_{DD} = V_{DDQ} = 1.7V$  to  $2.0V$  for Program, Erase and Read
  - $V_{PP} = 12V$  for fast Program (optional)
- **MULTIPLEXED ADDRESS/DATA**
- **SYNCHRONOUS / ASYNCHRONOUS READ**
  - Burst mode Read: 40MHz
  - Page mode Read (4 Words Page)
  - Random Access: 100ns
- **PROGRAMMING TIME**
  - 10 $\mu$ s by Word typical
  - Two or four words programming option
- **MEMORY BLOCKS**
  - Dual Bank Memory Array: 4/12 Mbit
  - Parameter Blocks (Top or Bottom location)
- **DUAL OPERATIONS**
  - Read within one Bank while Program or Erase within the other
  - No delay between Read and Write operations
- **PROTECTION/SECURITY**
  - All Blocks protected at Power-up
  - Any combination of Blocks can be protected
  - 64 bit unique device identifier
  - 64 bit user programmable OTP cells
  - One parameter block permanently lockable
- **COMMON FLASH INTERFACE (CFI)**
- **100,000 PROGRAM/ERASE CYCLES per BLOCK**
- **ELECTRONIC SIGNATURE**
  - Manufacturer Code: 20h
  - Top Device Code, M58MR016C: 88DEh
  - Bottom Device Code, M58MR016D: 88E0h

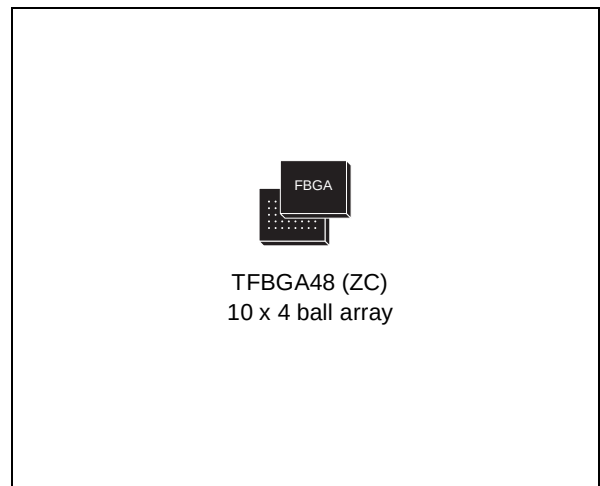


Figure 1. Logic Diagram

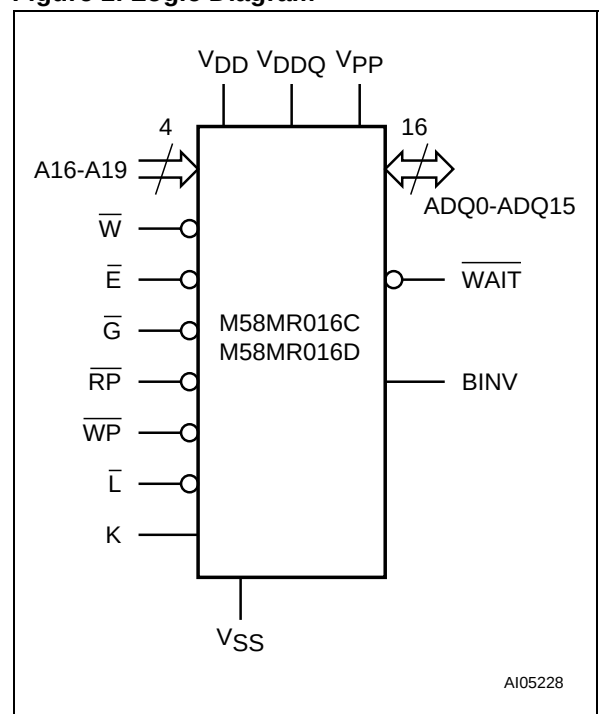
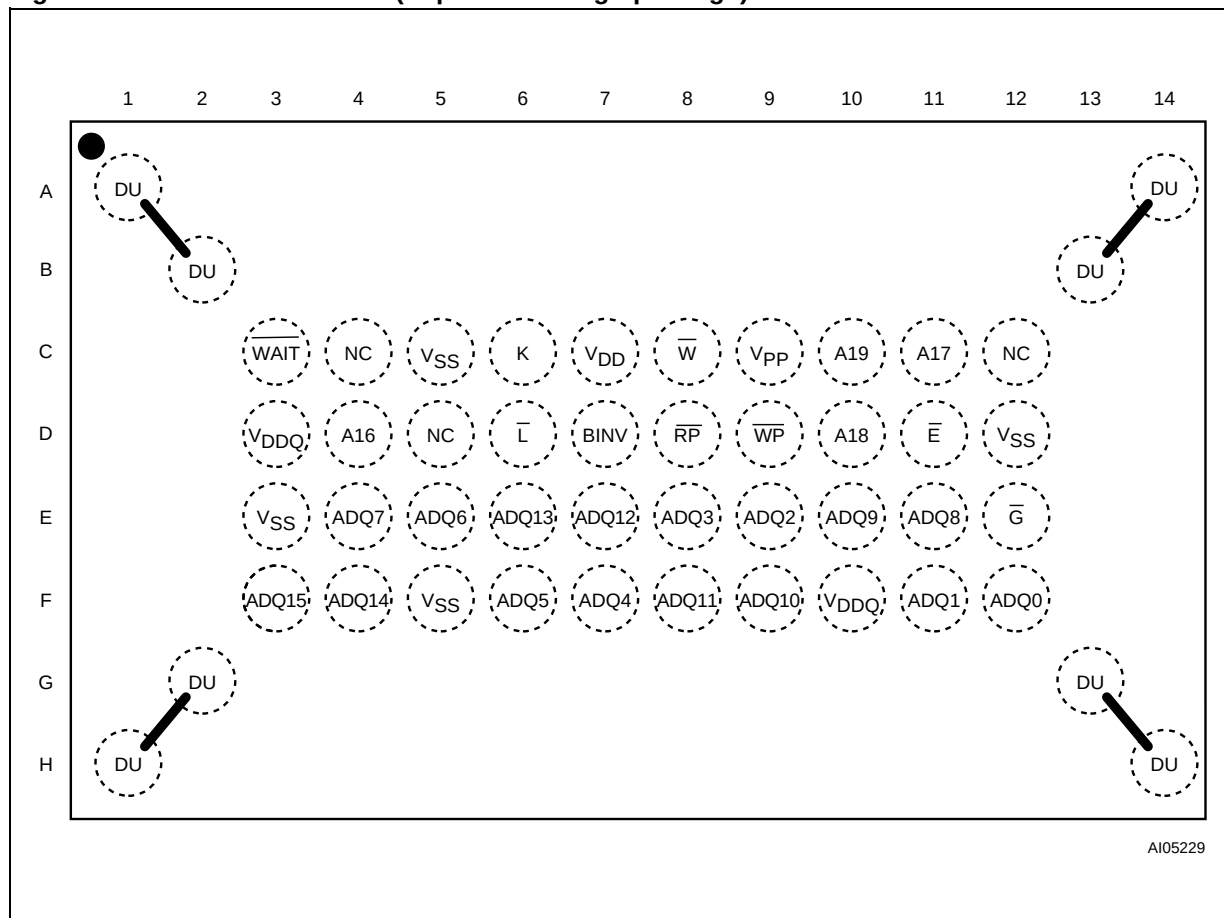


Figure 2. TFBGA Connections (Top view through package)



## DESCRIPTION

The M58MR016 is a 16 Mbit non-volatile Flash memory that may be erased electrically at block level and programmed in-system on a Word-by-Word basis using a 1.7V to 2.0V  $V_{DD}$  supply for the circuitry. For Program and Erase operations the necessary high voltages are generated internally. The device supports synchronous burst read and asynchronous read from all the blocks of the memory array; at power-up the device is configured for page mode read. In synchronous burst mode, a new data is output at each clock cycle for frequencies up to 40MHz.

The array matrix organization allows each block to be erased and reprogrammed without affecting other blocks. All blocks are protected against programming and erase at Power-up.

Blocks can be unprotected to make changes in the application and then re-protected.

A parameter block "Security block" can be permanently protected against programming and erasing

in order to increase the data security. An optional 12V  $V_{PP}$  power supply is provided to speed up the program phase at customer production. An internal command interface (C.I.) decodes the instructions to access/modify the memory content. The program/erase controller (P/E.C.) automatically executes the algorithms taking care of the timings necessary for program and erase operations. Two status registers indicate the state of each bank.

Instructions for Read Array, Read Electronic Signature, Read Status Register, Clear Status Register, Write Read Configuration Register, Program, Block Erase, Bank Erase, Program Suspend, Program Resume, Erase Suspend, Erase Resume, Block Protect, Block Unprotect, Block Locking, Protection Program, CFI Query, are written to the memory through a Command Interface (C.I.) using standard micro-processor write timings.

The memory is offered in TFBGA48, 0.5 mm ball pitch packages and it is supplied with all the bits erased (set to '1').

**Table 1. Signal Names**

|                   |                                                      |
|-------------------|------------------------------------------------------|
| A16-A19           | Address Inputs                                       |
| ADQ0-ADQ15        | Data Input/Outputs or Address Inputs, Command Inputs |
| $\overline{E}$    | Chip Enable                                          |
| $\overline{G}$    | Output Enable                                        |
| $\overline{W}$    | Write Enable                                         |
| $\overline{RP}$   | Reset/Power-down                                     |
| $\overline{WP}$   | Write Protect                                        |
| K                 | Burst Clock                                          |
| $\overline{L}$    | Latch Enable                                         |
| $\overline{WAIT}$ | Wait Data in Burst Mode                              |
| BINV              | Bus Invert                                           |
| V <sub>DD</sub>   | Supply Voltage                                       |
| V <sub>DDQ</sub>  | Supply Voltage for Input/Output Buffers              |
| V <sub>PP</sub>   | Optional Supply Voltage for Fast Program & Erase     |
| V <sub>SS</sub>   | Ground                                               |
| DU                | Don't Use as Internally Connected                    |
| NC                | Not Connected Internally                             |

**Organization**

The M58MR016 is organized as 1Mb by 16 bits. The first sixteen address lines are multiplexed with the Data Input/Output signals on the multiplexed address/data bus ADQ0-ADQ15. The remaining address lines A16-A19 are the MSB addresses.

Chip Enable  $\overline{E}$ , Output Enable  $\overline{G}$  and Write Enable  $\overline{W}$  inputs provide memory control.

The clock K input synchronizes the memory to the microprocessor during burst read.

Reset  $\overline{RP}$  is used to reset all the memory circuitry and to set the chip in power-down mode if a proper setting of the Read Configuration Register enables this function.

$\overline{WAIT}$  output indicates to the microprocessor the status of the memory during the burst mode operations.

**Memory Blocks**

The device features asymmetrically blocked architecture. M58MR016 has an array of 71 blocks and is divided into two banks A and B, providing Dual Bank operations. While programming or erasing in Bank A, read operations are possible into Bank B or vice versa. Only one bank at the time is allowed to be in program or erase mode. It is possible to perform burst reads that cross bank boundaries.

The memory features an erase suspend allowing reading or programming in another block. Once suspended the erase can be resumed. Program can be suspended to read data in another block and then resumed. The Bank Size and sectorization are summarized in Table 3. Parameter Blocks are located at the top of the memory address space for the M58MR016C, and at the bottom for the M58MR016D. The memory maps are shown in Figure 3.

**Table 2. Absolute Maximum Ratings <sup>(1)</sup>**

| Symbol                             | Parameter                                    | Value                         | Unit |
|------------------------------------|----------------------------------------------|-------------------------------|------|
| T <sub>A</sub>                     | Ambient Operating Temperature <sup>(2)</sup> | -40 to 85                     | °C   |
| T <sub>BIAS</sub>                  | Temperature Under Bias                       | -40 to 125                    | °C   |
| T <sub>STG</sub>                   | Storage Temperature                          | -55 to 155                    | °C   |
| V <sub>IO</sub> <sup>(3)</sup>     | Input or Output Voltage                      | -0.5 to V <sub>DDQ</sub> +0.5 | V    |
| V <sub>DD</sub> , V <sub>DDQ</sub> | Supply Voltage                               | -0.5 to 2.7                   | V    |
| V <sub>PP</sub>                    | Program Voltage                              | -0.5 to 13                    | V    |

Note: 1. Except for the rating "Operating Temperature Range", stresses above those listed in the Table "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

2. Depends on range.

3. Minimum Voltage may undershoot to -2V during transition and for less than 20ns.

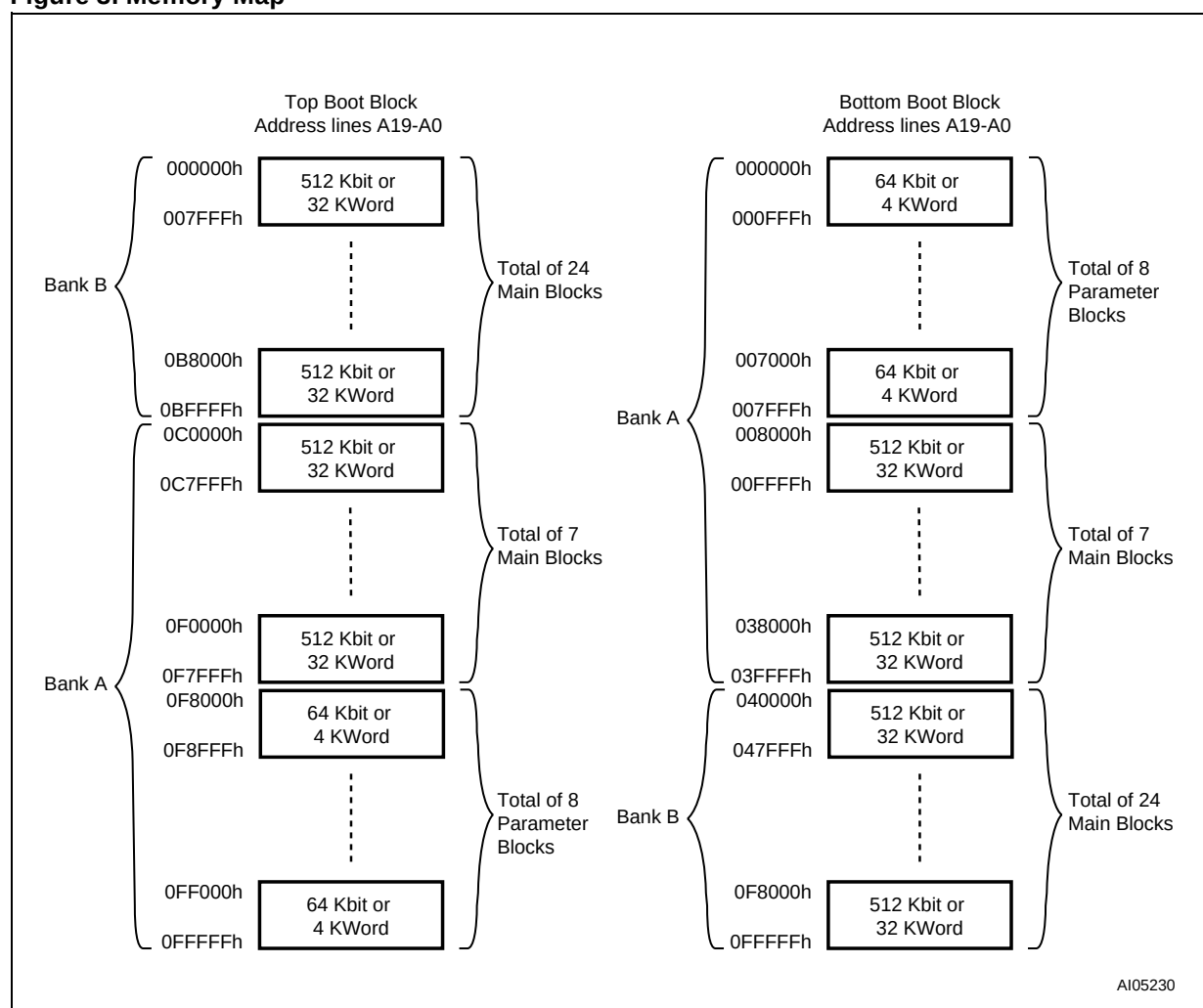
The architecture includes a 128 bit Protection register that is divided into two 64 bit segments. In the first one is written a unique device number, while the second one is programmable by the user. The user programmable segment can be permanently protected programming the bit 1 of the Protection Lock Register (see protection register and Security Block). The parameter block (# 0) is a security block. It can be permanently protected by the user

programming the bit 2 of the Protection Lock Register.

Block protection against Program or Erase provides additional data security. All blocks are protected and unlocked at Power-up. Instructions are provided to protect or un-protect any block in the application. A second register locks the protection status while WP is low (see Block Locking description).

**Table 3. Bank Size and Sectorization**

|        | Bank Size | Parameter Blocks    | Main Blocks           |
|--------|-----------|---------------------|-----------------------|
| Bank A | 4 Mbit    | 8 blocks of 4 KWord | 7 blocks of 32 KWord  |
| Bank B | 12 Mbit   | -                   | 24 blocks of 32 KWord |

**Figure 3. Memory Map**


## SIGNAL DESCRIPTIONS

See Figure 1 and Table 1.

**Address Inputs or Data Input/Output (ADQ0-ADQ15).** When Chip Enable  $\overline{E}$  is at  $V_{IL}$  and Output Enable  $\overline{G}$  is at  $V_{IH}$  the multiplexed address/data bus is used to input addresses for the memory array, data to be programmed in the memory array or commands to be written to the C.I. The address inputs for the memory array are latched on the rising edge of Latch Enable  $\overline{L}$ . The address latch is transparent when  $\overline{L}$  is at  $V_{IL}$ . In synchronous operations the address is also latched on the first rising/falling edge of K (depending on clock configuration) when  $\overline{L}$  is low. Both input data and commands are latched on the rising edge of Write Enable  $\overline{W}$ . When Chip Enable  $\overline{E}$  and Output Enable  $\overline{G}$  are at  $V_{IL}$  the address/data bus outputs data from the Memory Array, the Electronic Signature Manufacturer or Device codes, the Block Protection status, the Read Configuration Register status, the protection register or the Status Register. The address/data bus is high impedance when the chip is deselected, Output Enable  $\overline{G}$  is at  $V_{IH}$ , or  $\overline{RP}$  is at  $V_{IL}$ .

**Address Inputs (A16-A19).** The five MSB addresses of the memory array are latched on the rising edge of Latch Enable  $\overline{L}$ . In synchronous operation these inputs are also latched on the first rising/falling edge of K (depending on clock configuration) when  $\overline{L}$  is low.

**Chip Enable ( $\overline{E}$ ).** The Chip Enable input activates the memory control logic, input buffers, decoders and sense amplifiers.  $\overline{E}$  at  $V_{IH}$  deselects the memory and reduces the power consumption to the standby level.  $\overline{E}$  can also be used to control writing to the command register and to the memory array, while  $\overline{W}$  remains at  $V_{IL}$ .

**Output Enable ( $\overline{G}$ ).** The Output Enable gates the outputs through the data buffers during a read operation. When  $\overline{G}$  is at  $V_{IH}$  the outputs are High impedance.

**Write Enable ( $\overline{W}$ ).** This input controls writing to the Command Register and Data latches. Data are latched on the rising edge of  $\overline{W}$ .

**Write Protect ( $\overline{WP}$ ).** This input gives an additional hardware protection level against program or erase when pulled at  $V_{IL}$ , as described in the Block Lock instruction description.

**Reset/Power-down Input ( $\overline{RP}$ ).** The  $\overline{RP}$  input provides hardware reset of the memory, and/or Power-down functions, depending on the Read Configuration Register status. Reset/Power-down of the memory is achieved by pulling  $\overline{RP}$  to  $V_{IL}$  for

at least  $t_{PLPH}$ . When the reset pulse is given, the memory will recover from Power-down (when enabled) in a minimum of  $t_{PHEL}$ ,  $t_{PHLL}$  or  $t_{PHWL}$  (see Table 31 and Figure 15) after the rising edge of  $\overline{RP}$ . Exit from Reset/Power-down changes the contents of the Read Configuration Register bits 14 and 15, setting the memory in asynchronous page mode read and power save function disabled. All blocks are protected and unlocked after a Reset/Power-down.

**Latch Enable ( $\overline{L}$ ).**  $\overline{L}$  latches the address bits ADQ0-ADQ15 and A16-A19 on its rising edge. The address latch is transparent when  $\overline{L}$  is at  $V_{IL}$  and it is inhibited when  $\overline{L}$  is at  $V_{IH}$ .

**Clock (K).** The clock input synchronizes the memory to the micro controller during burst mode read operation; the address is latched on a K edge (rising or falling, according to the configuration settings) when  $\overline{L}$  is at  $V_{IL}$ . K is don't care during asynchronous page mode read and in write operations.

**Wait ( $\overline{WAIT}$ ).**  $\overline{WAIT}$  is an output signal used during burst mode read, indicating whether the data on the output bus are valid or a wait state must be inserted. This output is high impedance when  $\overline{E}$  or  $\overline{G}$  are high or  $\overline{RP}$  is at  $V_{IL}$ , and can be configured to be active during the wait cycle or one clock cycle in advance.

**Bus Invert (BINV).** BINV is an input/output signal used to reduce the amount of power needed to switch the external address/data bus. The power saving is achieved by inverting the data output on ADQ0-ADQ15 every time this gives an advantage in terms of number of toggling bits. In burst mode read, each new data output from the memory is compared with the previous data. If the number of transitions required on the data bus is in excess of 8, the data is inverted and the BINV signal will be driven by the memory at  $V_{OH}$  to inform the receiving system that data must be inverted before any further processing. By doing so, the actual transitions on the data bus will be less than 8.

In a similar way, when a command is given, BINV may be driven by the system at  $V_{IH}$  to inform the memory that the data input must be inverted.

Like the other input/output pins, BINV is high impedance when the chip is deselected, output enable  $\overline{G}$  is at  $V_{IH}$  or  $\overline{RP}$  is at  $V_{IL}$ ; when used as an input, BINV must follow the same set-up and hold timings of the data inputs.

### **$V_{DD}$ and $V_{DDQ}$ Supply Voltage (1.7V to 2.0V).**

$V_{DD}$  is the main power supply for all operations (Read, Program and Erase).  $V_{DDQ}$  is the supply voltage for Input and Output.

**V<sub>PP</sub> Program Supply Voltage (12V).** V<sub>PP</sub> is both a control input and a power supply pin. The two functions are selected by the voltage range applied to the pin; if V<sub>PP</sub> is kept in a low voltage range (0 to 2V) V<sub>PP</sub> is seen as a control input, and the current absorption is limited to 5μA (0.2μA typical). In this case with V<sub>PP</sub> = V<sub>IL</sub> we obtain an absolute protection against program or erase; with V<sub>PP</sub> = V<sub>PP1</sub> these functions are enabled (see Table 26). V<sub>PP</sub> value is only sampled during program or erase write cycles; a change in its value after the

operation has been started does not have any effect and program or erase are carried on regularly. If V<sub>PP</sub> is used in the 11.4V to 12.6V range (V<sub>PPH</sub>) then the pin acts as a power supply (see Table 26). This supply voltage must remain stable as long as program or erase are running. In read mode the current sunk is less than 0.5mA, while during program and erase operations the current may increase up to 10mA.

**V<sub>SS</sub> Ground.** V<sub>SS</sub> is the reference for all the voltage measurements.

## DEVICE OPERATIONS

The following operations can be performed using the appropriate bus cycles: Address Latch, Read Array (Random, and Page Modes), Write command, Output Disable, Standby, reset/Power-down and Block Locking. See Table 4.

**Address Latch.** In asynchronous operation, the address is latched on the rising edge of  $\overline{L}$  input. In burst mode the address is latched either on the rising edge of  $\overline{L}$  or on the first rising/falling edge of  $\overline{K}$  (depending on configuration settings) when  $\overline{L}$  is low.

**Read.** Read operations are used to output the contents of the Memory Array, the Electronic Sig-

nature, the Status Register, the CFI, the Block Protection Status, the Read Configuration Register status and the Protection Register.

Read operation of the Memory Array may be performed in asynchronous page mode or synchronous burst mode. In asynchronous page mode data is internally read and stored in a page buffer. The page has a size of 4 words and is addressed by ADQ0 and ADQ1 address inputs.

According to the device configuration the following Read operations: Electronic Signature - Status Register - CFI - Block Protection Status - Read Configuration Register Status - Protection Register must be accessed as asynchronous read or as single synchronous read (see Figure 4).

**Table 4. User Bus Operations <sup>(1)</sup>**

| Operation          | $\overline{E}$  | $\overline{G}$  | $\overline{W}$  | $\overline{L}$                   | $\overline{RP}$ | $\overline{WP}$ | ADQ15-ADQ0    |
|--------------------|-----------------|-----------------|-----------------|----------------------------------|-----------------|-----------------|---------------|
| Address Latch      | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub> | V <sub>IL</sub><br>(rising edge) | V <sub>IH</sub> | V <sub>IH</sub> | Address Input |
| Write              | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IL</sub> | V <sub>IH</sub>                  | V <sub>IH</sub> | V <sub>IH</sub> | Data Input    |
| Output Disable     | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub> | V <sub>IH</sub>                  | V <sub>IH</sub> | V <sub>IH</sub> | Hi-Z          |
| Standby            | V <sub>IH</sub> | X               | X               | X                                | V <sub>IH</sub> | X               | Hi-Z          |
| Reset / Power-down | X               | X               | X               | X                                | V <sub>IL</sub> | X               | Hi-Z          |
| Block Locking      | V <sub>IL</sub> | X               | X               | X                                | V <sub>IH</sub> | V <sub>IL</sub> | X             |

Note: 1. X = Don't care.

**Table 5. Read Electronic Signature (AS and Read CFI instructions) <sup>(1)</sup>**

| Code              | Device    | $\overline{E}$  | $\overline{G}$  | $\overline{W}$  | ADQ1 <sup>(3)</sup> | ADQ0 <sup>(3)</sup> | Other Address <sup>(2)</sup> | ADQ15-0 |
|-------------------|-----------|-----------------|-----------------|-----------------|---------------------|---------------------|------------------------------|---------|
| Manufacturer Code |           | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IL</sub>     | V <sub>IL</sub>     | EA <sup>(2)</sup>            | 0020h   |
| Device Code       | M58MR016C | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IL</sub>     | V <sub>IH</sub>     | EA <sup>(2)</sup>            | 88DEh   |
|                   | M58MR016D | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IL</sub>     | V <sub>IH</sub>     | EA <sup>(2)</sup>            | 88E0h   |

Note: 1. Addresses are latched on the rising edge of  $\overline{L}$  input.  
 2. EA means Electronic Signature Address (see Read Electronic Signature)  
 3. Value during address latch.

**Table 6. Read Block Protection (AS and Read CFI instructions) <sup>(1)</sup>**

| Block Status                          | $\overline{E}$  | $\overline{G}$  | $\overline{W}$  | ADQ1 <sup>(3)</sup> | ADQ0 <sup>(3)</sup> | Other Address     | ADQ15-0 |
|---------------------------------------|-----------------|-----------------|-----------------|---------------------|---------------------|-------------------|---------|
| Protected and unlocked                | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub>     | V <sub>IL</sub>     | BA <sup>(4)</sup> | 0001    |
| Unprotected and unlocked              | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub>     | V <sub>IL</sub>     | BA <sup>(4)</sup> | 0000    |
| Protected and locked                  | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub>     | V <sub>IL</sub>     | BA <sup>(4)</sup> | 0003    |
| Unprotected and locked <sup>(2)</sup> | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub>     | V <sub>IL</sub>     | BA <sup>(4)</sup> | 0002    |

Note: 1. Addresses are latched on the rising edge of  $\overline{L}$  input.  
 2. A locked block can be unprotected only with  $\overline{WP}$  at V<sub>IH</sub>.  
 3. Value during address latch.  
 4. BA means Block Address. First cycle command address should indicate the bank of the block address.

Table 7. Read Protection Register (RSIG and RCFI Instruction) <sup>(1)</sup>

| Word        | $\bar{E}$       | $\bar{G}$       | $\bar{W}$       | A19-17           | ADQ15-8          | ADQ7-0 | ADQ15-8  | ADQ7-3   | ADQ2               | ADQ1          | ADQ0     |
|-------------|-----------------|-----------------|-----------------|------------------|------------------|--------|----------|----------|--------------------|---------------|----------|
| Lock        | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 80h    | 00h      | 00000B   | Security prot.data | OTP prot.data | 0        |
| Unique ID 0 | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 81h    | ID data  | ID data  | ID data            | ID data       | ID data  |
| Unique ID 1 | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 82h    | ID data  | ID data  | ID data            | ID data       | ID data  |
| Unique ID 2 | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 83h    | ID data  | ID data  | ID data            | ID data       | ID data  |
| Unique ID 3 | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 84h    | ID data  | ID data  | ID data            | ID data       | ID data  |
| OTP 0       | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 85h    | OTP data | OTP data | OTP data           | OTP data      | OTP data |
| OTP 1       | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 86h    | OTP data | OTP data | OTP data           | OTP data      | OTP data |
| OTP 2       | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 87h    | OTP data | OTP data | OTP data           | OTP data      | OTP data |
| OTP 3       | V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | X <sup>(2)</sup> | X <sup>(2)</sup> | 88h    | OTP data | OTP data | OTP data           | OTP data      | OTP data |

Note: 1. Addresses are latched on the rising edge of  $\bar{L}$  input.

2. X = Don't care.

Table 8. Dual Bank Operations <sup>(1, 2, 3)</sup>

| Status of one bank | Commands allowed in the other bank |             |             |         |                     |                 |               |                   |
|--------------------|------------------------------------|-------------|-------------|---------|---------------------|-----------------|---------------|-------------------|
|                    | Read Array                         | Read Status | Read ID/CFI | Program | Erase/ Erase Resume | Program Suspend | Erase Suspend | Protect Unprotect |
| Idle               | Yes                                | Yes         | Yes         | Yes     | Yes                 | Yes             | Yes           | Yes               |
| Reading            | –                                  | –           | –           | –       | –                   | –               | –             | –                 |
| Programming        | Yes                                | Yes         | Yes         | –       | –                   | –               | –             | Yes               |
| Erasing            | Yes                                | Yes         | Yes         | –       | –                   | –               | –             | Yes               |
| Program Suspended  | Yes                                | Yes         | Yes         | –       | –                   | –               | –             | Yes               |
| Erase Suspended    | Yes                                | Yes         | Yes         | Yes     | –                   | Yes             | –             | Yes               |

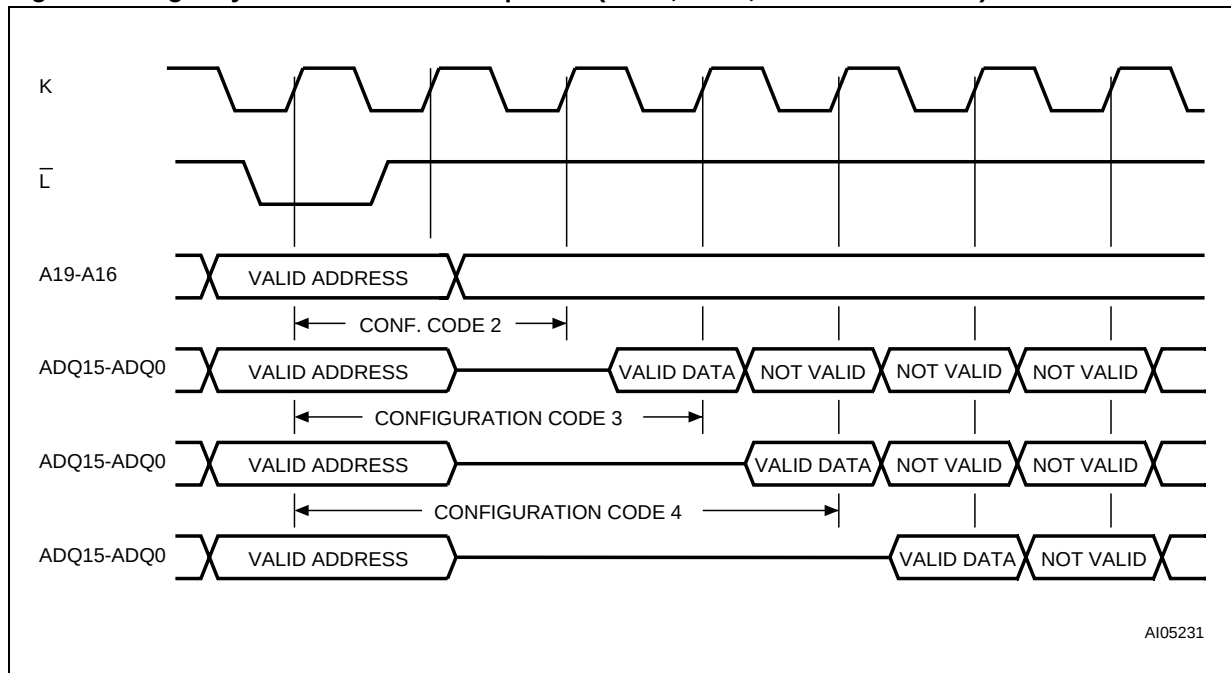
Note: 1. For detailed description of command see Table 33 and 34.

2. There is a status register for each bank; status register indicates bank state, not P/E.C. status.

3. Command must be written to an address within the block targeted by that command.



Figure 4. Single Synchronous Read Sequence (RSIG, RCFI, RSR instructions)



Both Chip Enable  $\overline{E}$  and Output Enable  $\overline{G}$  must be at  $V_{IL}$  in order to read the output of the memory.

Read array is the default state of the device when exiting power down or after power up.

**Burst Read.** The device also supports a burst read. In this mode a burst sequence is started at the first clock edge (rising or falling according to configuration settings) after the falling edge of  $\overline{L}$ . After a configurable delay of 2 to 5 clock cycles a new data is output at each clock cycle. The burst sequence may be configured for linear or interleaved order and for a length of 4, 8 words or for continuous burst mode. Wrap and no-wrap modes are also supported.

A  $\overline{WAIT}$  signal may be asserted to indicate to the system that an output delay will occur. This delay will depend on the starting address of the burst sequence; the worst case delay will occur when the sequence is crossing a 64 word boundary and the starting address was at the end of a four word boundary. See the Write Read Configuration Register (CR) Instruction for more details on all the possible settings for the synchronous burst read (see Table 14). It is possible to perform burst read across bank boundary (all banks in read array mode).

**Write.** Write operations are used to give Instruction Commands to the memory or to latch Input Data to be programmed. A write operation is initiated when Chip Enable  $\overline{E}$  and Write Enable  $\overline{W}$  are at  $V_{IL}$  with Output Enable  $\overline{G}$  at  $V_{IH}$ . Addresses are latched on the rising edge of  $\overline{L}$ . Commands and Input Data are latched on the rising edge of  $\overline{W}$  or  $\overline{E}$  whichever occurs first. Noise pulses of less than

5ns typical on  $\overline{E}$ ,  $\overline{W}$  and  $\overline{G}$  signals do not start a write cycle. Write operations are asynchronous and clock is ignored during write.

**Dual Bank Operations.** The Dual Bank allows to run different operations simultaneously in the two banks. It is possible to read array data from one bank while the other is programming, erasing or reading any data (CFI, status register or electronic signature).

Read and write cycles can be initiated for simultaneous operations in different banks without any delay. Only one bank at a time is allowed to be in program or erase mode, while the other must be in one of the read modes (see Table 8).

Commands must be written to an address within the block targeted by that command.

**Output Disable.** The data outputs are high impedance when the Output Enable  $\overline{G}$  is at  $V_{IH}$  with Write Enable  $\overline{W}$  at  $V_{IH}$ .

**Standby.** The memory is in standby when Chip Enable  $\overline{E}$  is at  $V_{IH}$  and the P/E.C. is idle. The power consumption is reduced to the standby level and the outputs are high impedance, independent of the Output Enable  $\overline{G}$  or Write Enable  $\overline{W}$  inputs.

**Automatic Standby.** When in Read mode, after 150ns of bus inactivity and when CMOS levels are driving the addresses, the chip automatically enters a pseudo-standby mode where consumption is reduced to the CMOS standby value, while outputs still drive the bus. The automatic standby feature is not available when the device is configured for synchronous burst mode.

Table 9. Identifier Codes

| Code                        |                          | Address (h)                            | Data (h)           |
|-----------------------------|--------------------------|----------------------------------------|--------------------|
| Manufacturer Code           |                          | Bank Address + 00                      | 0020               |
| Device Code                 | Top                      | Bank Address + 01                      | 88DE               |
|                             | Bottom                   | Bank Address + 01                      | 88E0               |
| Block Protection            | Protected and Unlocked   | Bank Address + 02                      | 0001               |
|                             | Unprotected and Unlocked |                                        | 0000               |
|                             | Protected and Locked     |                                        | 0003               |
|                             | Unprotected and Locked   |                                        | 0002               |
| Die Revision Code           |                          | Bank Address + 03                      | DRC <sup>(1)</sup> |
| Read Configuration Register |                          | Bank Address + 05                      | CR <sup>(1)</sup>  |
| Lock Protection Register    |                          | Bank Address + 80                      | LPR <sup>(1)</sup> |
| Protection Register         |                          | Bank Address + 81<br>Bank Address + 88 | PR <sup>(1)</sup>  |

Note: 1. DRC means Die Revision Code.  
 CR means Read Configuration Register.  
 LPR means Lock Protection Register.  
 PR means Unique Device Number and User Programmable OTP.

**Reset/Power-down.** The memory is in Power-down when the Read Configuration Register is set for Power-down and  $\overline{RP}$  is at  $V_{IL}$ . The power consumption is reduced to the Power-down level, and Outputs are in high impedance, independent of the Chip Enable  $\overline{E}$ , Output Enable  $\overline{G}$  or Write Enable  $\overline{W}$  inputs. The memory is in reset when the Read Configuration Register is set for Reset and  $\overline{RP}$  is at  $V_{IL}$ . The power consumption is the same of the standby and the outputs are in high impedance. After a Reset/Power down the device defaults to read array mode, the status register is set to 80h and the read configuration register defaults to asynchronous read.

**Block Locking.** Any combination of blocks can be temporarily protected against Program or Erase by setting the lock register and pulling  $\overline{WP}$  to  $V_{IL}$ . The following summarizes the locking operation. All blocks are protected on power-up. They can then be unprotected or protected with the Unprotect and Protect commands. The Lock command protects a block and prevents it from being unlocked when  $WP = 0$ . When  $WP = 1$ , Lock is overridden. Lock is cleared only when the device is reset or powered-down (see Protect instruction).

## INSTRUCTIONS AND COMMANDS

Eighteen instructions are available (see Tables 10 and 11) to perform Read Memory Array, Read Status Register, Read Electronic Signature, CFI Query, Block Erase, Bank Erase, Program, Tetra Word Program, Double Word Program, Clear Status Register, Program/Erase Suspend, Program/Erase Resume, Block Protect, Block Unprotect, Block Lock, Protection Register Program, Read Configuration Register and Lock Protection Program.

Status Register output may be read at any time, during programming or erase, to monitor the progress of the operation.

An internal Command Interface (C.I.) decodes the instructions while an internal Program/Erase Controller (P/E.C.) handles all timing and verifies the correct execution of the Program and Erase instructions. P/E.C. provides a Status Register whose bits indicate operation and exit status of the internal algorithms. The Command Interface is reset to Read Array when power is first applied, when exiting from Reset or whenever  $V_{DD}$  is lower than  $V_{LKO}$ . Command sequence must be followed exactly. Any invalid combination of commands will reset the device to Read Array.

### Read (RD)

The Read instruction consists of one write cycle (refer to Device Operations section) and places the addressed bank in Read Array mode. When a device reset occurs, the memory is in Read Array as default. A read array command will be ignored while a bank is programming or erasing. However in the other bank a read array command will be accepted.

### Read Status Register (RSR)

A bank's Status Register indicates when a program or erase operation is complete and the success or failure of operation itself. Issue a Read Status Register Instruction (70h) to read the Status Register content of the addressed bank. The status of the other bank is not affected by the command. The Read Status Register instruction may be issued at any time, also when a Program/Erase operation is ongoing. The following Read operations output the content of the Status Register of the addressed bank. The Status Register is latched on the falling edge of  $\bar{E}$  or  $\bar{G}$  signals, and can be read until  $\bar{E}$  or  $\bar{G}$  returns to  $V_{IH}$ . Either  $\bar{E}$  or  $\bar{G}$  must be toggled to update the latched data.

### Read Electronic Signature (RSIG)

The Read Electronic Signature instruction consists of one write cycle (refer to Device Operations section) giving the command 90h to an address

**Table 10. Commands**

| Hex Code | Command                                                  |
|----------|----------------------------------------------------------|
| 00h      | Invalid Reset                                            |
| 01h      | Protect Confirm                                          |
| 03h      | Write Read Configuration Register Confirm                |
| 10h      | Alternative Program Set-up                               |
| 20h      | Block Erase Set-up                                       |
| 2Fh      | Lock Confirm                                             |
| 30h      | Double Word Program Set-up                               |
| 40h      | Program Set-up                                           |
| 50h      | Clear Status Register                                    |
| 55h      | Tetra Word Program Set-up                                |
| 60h      | Protect Set-up and Write Read Configuration Register     |
| 70h      | Read Status Register                                     |
| 80h      | Bank Erase Set-up                                        |
| 90h      | Read Electronic Signature                                |
| 98h      | CFI Query                                                |
| B0h      | Program/Erase Suspend                                    |
| C0h      | Protection Program and Lock Protection Program           |
| D0h      | Program/Erase Resume, Erase Confirm or Unprotect Confirm |
| FFh      | Read Array                                               |

within the bank A. A subsequent read in the address of bank A will output the Manufacturer Code, the Device Code, the protection Status of Blocks of bank A, the Die Revision Code, the Protection Register, or the Read Configuration Register (see Table 9).

If the first write cycle of Read Electronic Signature instruction is issued to an address within the bank B, a subsequent read in an address of bank B will output the protection Status of Blocks of bank B. The status of the other bank is not affected by the command (see Table 8).

See Tables 5, 6, 7 and 8 for the valid address. The Electronic Signature can be read from the memory allowing programming equipment or applications to automatically match their interface to the characteristics of M58MR016C and M58MR016D.

Table 11. Instructions

|               |                     | Instruction                       | Cyc. | Operation | Address <sup>(1,2)</sup> | Data <sup>(3)</sup> | Operation           | Address <sup>(1,2)</sup> | Data <sup>(3)</sup> |
|---------------|---------------------|-----------------------------------|------|-----------|--------------------------|---------------------|---------------------|--------------------------|---------------------|
| READ          | RD                  | Read Memory Array                 | 1+   | Write     | BKA                      | FFh                 | Read <sup>(1)</sup> | Read Address             | Data                |
|               | RSR                 | Read Status Register              | 1+   | Write     | BKA                      | 70h                 | Read <sup>(1)</sup> | BKA                      | Status Register     |
|               | RSIG                | Read Electronic Signature         | 1+   | Write     | EA                       | 90h                 | Read <sup>(1)</sup> | EA                       | ED                  |
|               | RCFI                | Read CFI                          | 1+   | Write     | CFIA                     | 98h                 | Read <sup>(1)</sup> | CFIA                     | CFID                |
|               | CLRS <sup>(5)</sup> | Clear Status Register             | 1    | Write     | BKA                      | 50h                 |                     |                          |                     |
| PROGRAM/ERASE | EE                  | Block Erase                       | 2    | Write     | BA                       | 20h                 | Write               | BA                       | D0h                 |
|               | BE                  | Bank Erase                        | 2    | Write     | BKA                      | 80h                 | Write               | BKA                      | D0h                 |
|               | PG                  | Program                           | 2    | Write     | WA                       | 40h or 10h          | Write               | WA                       | WD                  |
|               | DPG                 | Double Word Program               | 3    | Write     | WA1                      | 30h                 | Write               | WA1                      | WD1                 |
|               |                     |                                   |      |           |                          |                     | Write               | WA2                      | WD2                 |
|               | TPG                 | Tetra Word Program                | 5    | Write     | WA1                      | 55h                 | Write               | WA1                      | WD1                 |
|               |                     |                                   |      |           |                          |                     | Write               | WA2                      | WD2                 |
|               |                     |                                   |      |           |                          |                     | Write               | WA3                      | WD3                 |
|               |                     |                                   |      |           |                          |                     | Write               | WA4                      | WD4                 |
|               | PES                 | Program Erase Suspend             | 1    | Write     | BKA                      | B0h                 |                     |                          |                     |
|               | PER                 | Program Erase Resume              | 1    | Write     | BKA                      | D0h                 |                     |                          |                     |
| PROTECT       | BP                  | Block Protect                     | 2    | Write     | BA                       | 60h                 | Write               | BA                       | 01h                 |
|               | BU                  | Block Unprotect                   | 2    | Write     | BA                       | 60h                 | Write               | BA                       | D0h                 |
|               | BL                  | Block Lock                        | 2    | Write     | BA                       | 60h                 | Write               | BA                       | 2Fh                 |
| CONFIGURATION | PRP                 | Protection Register Program       | 2    | Write     | PA                       | C0h                 | Write               | PA                       | PD                  |
|               | LPRP                | Lock Protection Register Program  | 2    | Write     | LPA                      | C0h                 | Write               | LPA                      | LPD                 |
|               | CR                  | Write Read Configuration Register | 2    | Write     | RCA                      | 60h                 | Write               | RCA                      | 03h                 |

- Note: 1. First cycle command address should be the same as the operation's target address. The first cycle of the RD, RSR, RSIG or RCFI instruction is followed by read operations in the bank array or special register. Any number of read cycles can occur after one command cycle.
2. BKA = Address within the bank, BA = Block Address, EA = Electronic Signature Address, CFIA = Common Flash Interface Address; WA = Word Address, PA = Protection Register Address, LPA = Lock Protection Register Address, RCA = Read Configuration Register Address, PD = Protection Data, CFID = Common Flash Interface Data, ED = Electronic Signature Data, WD = Word Data, LPD = Lock protection Register Data
3. WA1, WA2, WA3 and WA4 must be consecutive address differing only for address bits A1-A0.
4. Read cycle after CLSR instruction will output the memory array.

**CFI Query (RCFI)**

The CFI Query Mode is associated to bank A. The address of the first write cycle must be within the bank A. The status of the other bank is not affected by the command (see Table 8). Writing 98h the device enters the Common Flash Interface Query mode. Next read operations in the bank A will read the CFI data. Write a read instruction to return to Read mode (refer to the Common Flash Interface section).

**Clear Status Register (CLSR)**

The Clear Status Register uses a single write operation, which resets bits b1, b3, b4 e b5 of the status register. The Clear Status Register is executed writing the command 50h independently of the applied  $V_{PP}$  voltage. After executing this command the device returns to read array mode. The Clear Status Register command clears only the status register of the addressed bank.

**Block Erase (EE)**

Block erasure sets all the bits within the selected block to '1'. One block at a time can be erased. It is not necessary to pre-program the block as the P/E.C. will do it automatically before erasing. This instruction use two writes cycles. The first command written is the Block Erase Set up command 20h. The second command is the Erase Confirm command D0h. An address within the block to be erased should be given to the memory during the two cycles command. If the second command given is not an erase confirm, the status register bits b4 and b5 are set and the instruction aborts.

After writing the command, the device outputs status register data when any address within the bank is read. At the end of the operation the bank will remain in read status register until a read array command is written.

Status Register bit b7 is '0' while the erasure is in progress and '1' when it has completed. After completion the Status Register bit b5 returns '1' if there has been an Erase Failure. Status register bit b1 returns '1' if the user is attempting to erase a protected block. Status Register bit b3 returns a '1' if  $V_{PP}$  is below  $V_{PPLK}$ . Erase aborts if  $\overline{RP}$  turns to  $V_{IL}$ . As data integrity cannot be guaranteed when the erase operation is aborted, the erase must be repeated (see Table 12). A Clear Status Register instruction must be issued to reset b1, b3, b4 and b5 of the Status Register. During the execution of

the erase by the P/E.C., the bank with the block in erase accepts only the RSR (Read Status Register) and PES (Program/Erase Suspend) instructions. See figure 19 for Erase Flowchart and Pseudo Code.

**Bank Erase (BE)**

Bank erase sets all the bits within the selected bank to '1'. It is not necessary to pre-program the block as the P/E.C. will do it automatically before erasing.

This instruction uses two writes cycles. The first command written is the Bank Erase set-up command 80h. The second command is the Erase Confirm command D0h. An address within the bank to be erased should be given to the memory during the two cycles command. See the Block Erase command section for status register bit details.

**Program (PG)**

The Program instruction programs the array on a word-by-word basis. The first command must be given to the target block and only one partition can be programmed at a time; the other partition must be in one of the read modes or in the erase suspended mode (see Table 8).

This instruction uses two write cycles. The first command written is the Program Set-up command 40h (or 10h). A second write operation latches the Address and the Data to be written and starts the P/E.C.

Read operations in the targeted bank output the Status Register content after the programming has started.

The Status Register bit b7 returns '0' while the programming is in progress and '1' when it has completed. After completion the Status register bit b4 returns '1' if there has been a Program Failure (see Table 12). Status register bit b1 returns '1' if the user is attempting to program a protected block. Status Register bit b3 returns a '1' if  $V_{PP}$  is below  $V_{PPLK}$ . Any attempt to write a '1' to an already programmed bit will result in a program fail (status register bit b4 set) if  $V_{PP} = V_{PPH}$  and will be ignored if  $V_{PP} = V_{PP1}$ .

Programming aborts if  $\overline{RP}$  goes to  $V_{IL}$ . As data integrity cannot be guaranteed when the program operation is aborted, the block containing the memory location must be erased and reprogrammed. A Clear Status Register instruction

Table 12. Status Register Bits

| Mnemonic | Bit | Name                    | Logic Level | Definition                              | Note                                                                                                                                                                                                        |
|----------|-----|-------------------------|-------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P/ECS    | 7   | P/ECS Status            | 1           | Ready                                   | Indicates the P/E.C. status, check during Program or Erase, and on completion before checking bits b4 or b5 for Program or Erase Success.                                                                   |
|          |     |                         | 0           | Busy                                    |                                                                                                                                                                                                             |
| ESS      | 6   | Erase Suspend Status    | 1           | Suspended                               | On an Erase Suspend instruction P/ECS and ESS bits are set to '1'. ESS bit remains '1' until an Erase Resume instruction is given.                                                                          |
|          |     |                         | 0           | In Progress or Completed                |                                                                                                                                                                                                             |
| ES       | 5   | Erase Status            | 1           | Erase Error                             | ES bit is set to '1' if P/E.C. has applied the maximum number of erase pulses to the block without achieving an erase verify.                                                                               |
|          |     |                         | 0           | Erase Success                           |                                                                                                                                                                                                             |
| PS       | 4   | Program Status          | 1           | Program Error                           | PS bit set to '1' if the P/E.C. has failed to program a word.                                                                                                                                               |
|          |     |                         | 0           | Program Success                         |                                                                                                                                                                                                             |
| VPPS     | 3   | V <sub>PP</sub> Status  | 1           | V <sub>PP</sub> Invalid, Abort          | VPPS bit is set if the V <sub>PP</sub> voltage is below V <sub>PPLK</sub> when a Program or Erase instruction is executed. V <sub>PP</sub> is sampled only at the beginning of the erase/program operation. |
|          |     |                         | 0           | V <sub>PP</sub> OK                      |                                                                                                                                                                                                             |
| PSS      | 2   | Program Suspend Status  | 1           | Suspended                               | On a program Suspend instruction P/ECS and PSS bits are set to '1'. PSS remains '1' until a Program Resume Instruction is given.                                                                            |
|          |     |                         | 0           | In Progress or Completed                |                                                                                                                                                                                                             |
| BPS      | 1   | Block Protection Status | 1           | Program/Erase on protected Block, Abort | BPS bit is set to '1' if a Program or Erase operation has been attempted on a protected block.                                                                                                              |
|          |     |                         | 0           | No operation to protected blocks        |                                                                                                                                                                                                             |
|          | 0   | Reserved                |             |                                         |                                                                                                                                                                                                             |

Note: Logic level '1' is V<sub>IH</sub> and '0' is V<sub>IL</sub>.

must be issued to reset b5, b4, b3 and b1 of the Status Register.

During the execution of the program by the P/E.C., the bank in programming accepts only the RSR (Read Status Register) and PES (Program/Erase Suspend) instructions. See Figure 16 for Program Flowchart and Pseudo Code.

#### Double Word Program (DPG)

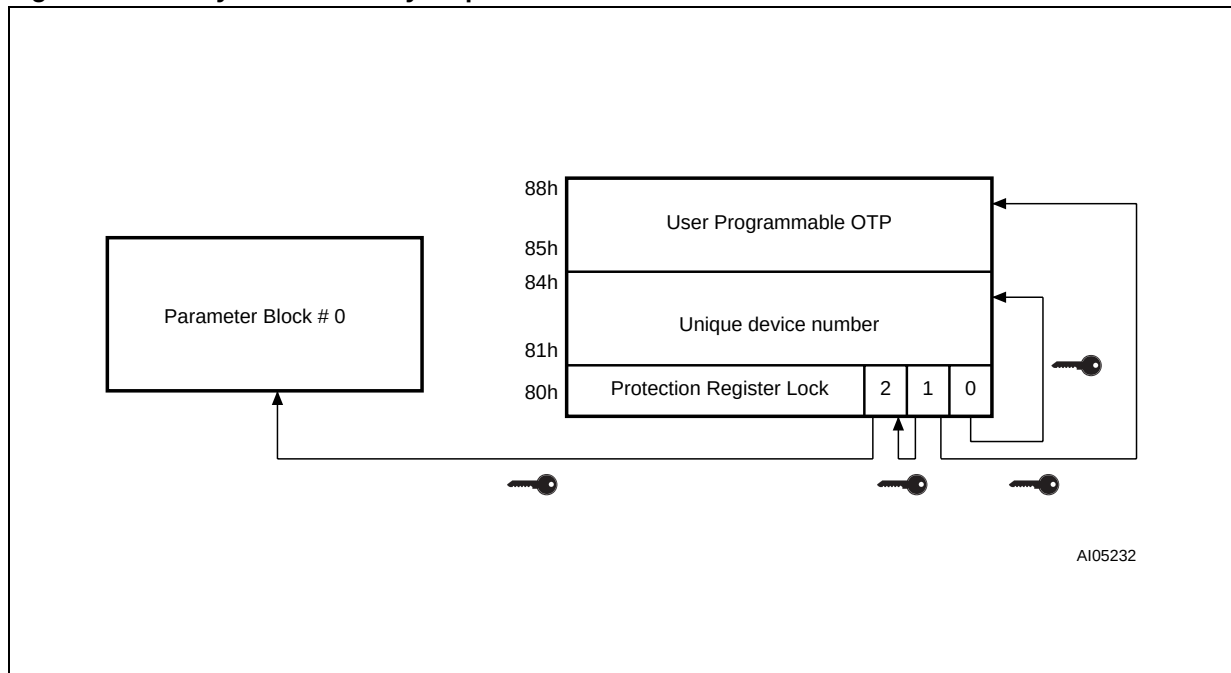
This feature is offered to improve the programming throughput, writing a page of two adjacent words in parallel. The first command must be given to the target block and only one partition can be programmed at a time; the other partition must be in one of the read modes or in the erase suspended mode (see Table 8).

The two words must differ only for the address A0. Programming should not be attempted when V<sub>PP</sub> is not at V<sub>PPH</sub>. The operation can also be executed if V<sub>PP</sub> is below V<sub>PPH</sub> but result could be uncertain.

These instruction uses three write cycles. The first command written is the Double Word Program Set-Up command 30h. A second write operation latches the Address and the Data of the first word to be written, the third write operation latches the Address and the Data of the second word to be written and starts the P/E.C. (see Table 11).

Read operations in the targeted bank output the Status Register content after the programming has started. The Status Register bit b7 returns '0' while the programming is in progress and '1' when it has completed. After completion the Status register bit b4 returns '1' if there has been a Program Failure. Status register bit b1 returns '1' if the user is attempting to program a protected block. Status Register bit b3 returns a '1' if V<sub>PP</sub> is below V<sub>PPLK</sub>. Any attempt to write a '1' to an already programmed bit will result in a program fail (status register bit b4 set). (See Table 12).

Figure 5. Security Block Memory Map

Table 13. Protection States <sup>(1)</sup>

| Current State <sup>(2)</sup><br>(WP, DQ1, DQ0) | Program/Erase<br>Allowed | Next State After Event <sup>(3)</sup> |           |      |                           |
|------------------------------------------------|--------------------------|---------------------------------------|-----------|------|---------------------------|
|                                                |                          | Protect                               | Unprotect | Lock | WP transition             |
| 100                                            | Yes                      | 101                                   | 100       | 111  | 000                       |
| 101                                            | No                       | 101                                   | 100       | 111  | 001                       |
| 110                                            | Yes                      | 111                                   | 110       | 111  | 011                       |
| 111                                            | No                       | 111                                   | 110       | 111  | 011                       |
| 000                                            | Yes                      | 001                                   | 000       | 011  | 100                       |
| 001                                            | No                       | 001                                   | 000       | 011  | 101                       |
| 011                                            | No                       | 011                                   | 011       | 011  | 111 or 110 <sup>(4)</sup> |

Note: 1. All blocks are protected at power-up, so the default configuration is 001 or 101 according to  $\overline{WP}$  status.

2. Current state and Next state gives the protection status of a block. The protection status is defined by the write protect in and by DQ1 (= 1 for a locked block) and DQ0 (= 1 for a protected block) as read in the Read Electronic Signature instruction with A1 = V<sub>IH</sub> and A0 = V<sub>IL</sub>.

3. Next state is the protection status of a block after a Protect or Unprotect or Lock command has been issued or after  $\overline{WP}$  has changed its logic value.

4. A  $\overline{WP}$  transition to V<sub>IH</sub> on a locked block will restore the previous DQ0 value, giving a 111 or 110.

Programming aborts if  $\overline{RP}$  goes to  $V_{IL}$ . As data integrity cannot be guaranteed when the program operation is aborted, the memory location must be erased and reprogrammed. A Clear Status Register instruction must be issued to reset b5, b4, b3 and b1 of the Status Register. During the execution of the program by the P/E.C., the bank in programming accepts only the RSR (Read Status Register) instruction. See Figure 17 for Double Word Program Flowchart and Pseudo code.

#### **Tetra Word Program (TPG)**

This feature is offered to improve the programming throughput, writing a page of four adjacent words in parallel. The first command must be given to the target block and only one partition can be programmed at a time; the other partition must be in one of the read modes or in the erase suspended mode (see Table 8).

The four words must differ only for the addresses A0 and A1. Programming should not be attempted when  $V_{PP}$  is not at  $V_{PPH}$ . The operation can also be executed if  $V_{PP}$  is below  $V_{PPH}$  but result could be uncertain. These instruction uses five write cycles. The first command written is the Tetra Word Program Set-Up command 55h. A second write operation latches the Address and the Data of the first word to be written, the third write operation latches the Address and the Data of the second word to be written, the fourth write operation latches the Address and the Data of the third word to be written, the fifth write operation latches the Address and the Data of the fourth word to be written and starts the P/E.C. (see Table 11).

Read operations in the targeted bank output the Status Register content after the programming has started. The Status Register bit b7 returns '0' while the programming is in progress and '1' when it has completed. After completion the Status register bit b4 returns '1' if there has been a Program Failure. Status register bit b1 returns '1' if the user is attempting to program a protected block. Status Register bit b3 returns a '1' if  $V_{PP}$  is below  $V_{PPLK}$ . Any attempt to write a '1' to an already programmed bit will result in a program fail (status register bit b4 set). (See Table 12).

Programming aborts if  $\overline{RP}$  goes to  $V_{IL}$ . As data integrity cannot be guaranteed when the program operation is aborted, the memory location must be erased and reprogrammed. A Clear Status Register instruction must be issued to reset b5, b4, b3 and b1 of the Status Register. During the execution of the program by the P/E.C., the bank in programming accepts only the RSR (Read Status Register) instruction. See Figure 17 for Tetra Word Program Flowchart and Pseudo code.

#### **Erase Suspend/Resume (PES/PER)**

The Erase Suspend freezes, after a certain latency period (within 25 $\mu$ s), the erase operation and al-

lows read in another block within the targeted bank or program in the other block.

This instruction uses one write cycle B0h and the address should be within the bank with the block in erase (see Table 11). The device continues to output status register data after the erase suspend is issued. The status register bit b7 and bit b6 are set to '1' then the erase operation has been suspended. Bit b6 is set to '0' in case the erase is completed or in progress (see Table 12).

The valid commands while erase is suspended are: Program/Erase Resume, Program, Read Memory Array, Read Status Register, Read Electronic Signature, CFI Query, Block Protect, Block Unprotect and Block Lock. The user can protect the Block being erased issuing the Block Protect or Block Lock commands.

During a block erase suspend, the device goes into standby mode by taking  $\overline{E}$  to  $V_{IH}$ , which reduces active current draw. Erase is aborted if  $\overline{RP}$  turns to  $V_{IL}$ .

If an Erase Suspend instruction was previously executed, the erase operation may be resumed by issuing the command D0h using an address within the suspended bank. The status register bit b6 and bit b7 are cleared when erase resumes and read operations output the status register after the erase is resumed. Block erase cannot resume until program operations initiated during block erase suspend have completed. It is also possible to nest suspends as follows: suspend erase in the first partition, start programming in the second or in the same partition, suspend programming and then read from the second or the same partition. The suggested flowchart for erase suspend/resume features of the memory is shown from Figure 20.

#### **Program Suspend/Resume (PES/PER)**

Program suspend is accepted only during the Program instruction execution. When a Program Suspend command is written to the C.I., the P/E.C. freezes the Program operation.

Program Resume (PER) continues the Program operation. Program Suspend (PES) consists of writing the command B0h and the address should be within the bank with the word in programming (see Table 11).

The Status Register bit b2 is set to '1' (within 5 $\mu$ s) when the program has been suspended. Bit b2 is set to '0' in case the program is completed or in progress (see Table 12).

The valid commands while program is suspended are: Program/Erase Resume, Read Array, Read Status Register, Read Electronic Signature, CFI Query. During program suspend mode, the device goes in standby mode by taking  $\overline{E}$  to  $V_{IH}$ . This re-



duces active current consumption. Program is aborted if RP turns to  $V_{IL}$ .

If a Program Suspend instruction was previously executed, the Program operation may be resumed by issuing the command D0h using an address within the suspended bank (see Table 11). The status register bit b2 and bit b7 are cleared when program resumes and read operations output the status register after the erase is resumed (see Table 12). The suggested flowchart for program suspend/resume features of the memory is shown from Figure 18.

#### Block Protect (BP)

The BP instruction use two write cycles. The first command written is the protection set-up 60h. The second command is block Protect command 01h, written to an address within the block to be protected (see Table 11). If the second command is not recognized by the C.I the bit 4 and bit 5 of the status register will be set to indicate a wrong sequence of commands (see Table 12). To read the status register write the RSR command.

#### Block Unprotect (BU)

The instruction use two write cycles. The first command written is the protection set-up 60h. The second command is block Unprotect command D0h, written to an address within the block to be protected (see Table 11). If the second command is not recognized by the C.I the bit 4 and bit 5 of the status register will be set to indicate a wrong sequence of commands (see Table 12). To read the status register write the RSR command.

#### Block Lock (BL)

The instruction use two write cycles. The first command written is the protection set-up 60h. The second command is block Lock command 2Fh, written to an address within the block to be protected (see Table 11). If the second command is not recognized by the C.I the bit 4 and bit 5 of the status register will be set to indicate a wrong sequence of commands. To read the status register write the RSR command (see Table 12).

### BLOCK PROTECTION

The M58MR016C/M58MR016D provide a flexible protection of all the memory providing the protection, un-protection and locking of any blocks. All blocks are protected at power-up. Each block of the array has two levels of protection against programming or erasing operation. The first level is set by the Block Protect instruction; a protected block cannot be programmed or erased until a Block Unprotect instruction is given for that block. A second level of protection is set by the Block Lock instruction, and requires the use of the  $\overline{WP}$  pin, according to the following scheme:

- when  $\overline{WP}$  is at  $V_{IH}$ , the Lock status is overridden and all blocks can be protected or unprotected;
- when  $\overline{WP}$  is at  $V_{IL}$ , Lock status is enabled; the locked blocks are protected, regardless of their previous protect state, and protection status cannot be changed. Blocks that are not locked can still change their protection status;
- the lock status is cleared for all blocks at power up.

The protection and lock status can be monitored for each block using the Read Electronic Signature (RSIG) instruction. Protected blocks will output a '1' on DQ0 and locked blocks will output a '1' in DQ1 (see Table 13).

### PROTECTION REGISTER PROGRAM (PRP) and LOCK PROTECTION REGISTER PROGRAM (LPRP)

The M58MR016C/M58MR016D features a 128-bit protection register and a security Block in order to increase the protection of a system design. The Protection Register is divided in two 64-bit segments. The first segment (81h to 84h) is a unique device number, while the second one (85h to 88h) can be programmed by the user. When shipped the user programmable segment is read at '1'. It can be only programmed at '0'.

The user programmable segment can be protected writing the bit 1 of the Protection Lock register (80h). The bit 1 protects also the bit 2 of the Protection Lock Register.

The M58MR016C/M58MR016D feature a security Block. The security Block is located at 0FF000-0FFFFF (M58MR016C) or at 000000-000FFF (M58MR016D) of the device. This block can be permanently protected by the user programming the bit 2 of the Protection Lock Register (see Figure 5).

The protection Register and the Protection Lock Register can be read using the RSIG and RCFI instructions. A subsequent read in the address starting from 80h to 88h, the user will retrieve respectively the Protection Lock register, the unique device number segment and the OTP user programmable register segment (see Table 23).

### WRITE READ CONFIGURATION REGISTER (CR).

This instruction uses two Coded Cycles, the first write cycle is the write Read Configuration Register set-up 60h, the second write cycle is write Read Configuration Register confirm 03h both to Read Configuration Register address (see Table 11).

This instruction writes the contents of address bits ADQ15-ADQ0 to bits CR15-CR0 of the Read Con-

figuration Register (A19-A16 are don't care). At Power-up the Read Configuration Register is set to asynchronous Read mode, Power-down disabled and bus invert (power save function) disabled. A description of the effects of each configuration bit is given in Table 14.

**Read mode (CR15).** The device supports an asynchronous page mode and a synchronous burst mode. In asynchronous page mode, the default at power-up, data is internally read and stored in a buffer of 4 words selected by ADQ0 and ADQ1 address inputs. In synchronous burst mode, the device latches the starting address and then outputs a sequence of data that depends on the Read Configuration Register settings (see Figures 10, 11 and 12).

Synchronous burst mode is supported in both parameter and main blocks; it is also possible to perform burst mode read across the banks.

**Bus Invert configuration (CR14).** This register bit is used to enable the BINV pin functionality. BINV functionality depends upon configuration bits CR14 and CR15 (see Table 14 for configuration bits definition) as shown in Table 15. As output pin BINV is active only when enabled (CR14 = 1) in Read Array burst mode (CR15 = 0). As input pin BINV is active only when enabled (CR14 = 1). BINV is ignored when ADQ0-ADQ15 lines are used as address inputs (addresses must not be inverted).

**X-Latency (CR13-CR11).** These configuration bits define the number of clock cycles elapsing from  $\overline{L}$  going low to valid data available in burst mode (see Figure 6). The correspondence between X-Latency settings and the maximum sustainable frequency must be calculated taking into account some system parameters.

Two conditions must be satisfied:

- $(n + 2) t_K \geq t_{ACC} + t_{QVK\_CPU} + t_{AVK\_CPU}$
- $t_K > t_{KQV} + t_{QVK\_CPU}$

where "n" is the chosen X-Latency configuration code,  $t_K$  is the clock period,  $t_{AVK\_CPU}$  is the address setup time guaranteed by the system CPU, and  $t_{QVK\_CPU}$  is the data setup time required by the system CPU.

**Power-down configuration (CR10).** The  $\overline{RP}$  pin may be configured to give very low power consumption when driven low (power-down state). In power-down the  $I_{CC}$  supply current is reduced to a typical figure of  $I_{CC2}$ ; if this function is disabled (default at power-up) the  $\overline{RP}$  pin causes only a reset of the device and the supply current is the stand-by value. The recovery time after a  $\overline{RP}$  pulse is significantly longer when power-down is enabled (see Table 31).

**Wait configuration (CR8).** In burst mode WAIT indicates whether the data on the output bus are valid or a wait state must be inserted. The config-

uration bit determines if WAIT will be asserted one clock cycle before the wait state or during the wait state (see Figure 7).  $\overline{WAIT}$  is asserted during a continuous burst and also during a 4 or 8 burst length if no-wrap configuration is selected.

**Burst order configuration (CR7) and Burst Wrap configuration (CR3).** See Table 16 for burst order and length.

**Clock configuration (CR6).** In burst mode determines if address is latched and data is output on the rising or falling edge of the clock.

**Burst length (CR2-CR0).** In burst mode determines the number of words output by the memory. It is possible to have 4 words, 8 words or a continuous burst mode, in which all the words are read sequentially. In continuous burst mode the burst sequence can cross the end of each of the two banks (all banks in read array mode). In continuous burst mode or in 4, 8 words no-wrap it may happen that the memory will stop the data output flow for a few clock cycles; this event is signaled by  $\overline{WAIT}$  going low until the output flow is resumed. The initial address determines if the output delay will occur as well as its duration. If the starting address is aligned to a four words boundary no wait states will be needed. If the starting address is shifted by 1, 2 or 3 positions from the four word boundary,  $\overline{WAIT}$  will be asserted for 1, 2 or 3 clock cycles when the burst sequence is crossing the first 64 word boundary.  $\overline{WAIT}$  will be asserted only once during a continuous burst access. See also Table 16.

**Table 14. Read Configuration Register (AS and Read CFI instructions) <sup>(1)</sup>**

| Configuration Register | Function                                                                                                                                                            |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CR15                   | Read mode<br>0 = Synchronous Burst mode read<br>1 = Asynchronous Page mode read (default)                                                                           |
| CR14                   | Bus Invert configuration (power save)<br>0 = disabled (default)<br>1 = enabled                                                                                      |
| CR13-CR11              | X-Latency<br>010 = 2 clock latency<br>011 = 3 clock latency<br>100 = 4 clock latency<br>101 = 5 clock latency<br>111 = reserved<br>Other configurations reserved    |
| CR10                   | Power-down configuration<br>0 = power-down disabled (default)<br>1 = power-down enabled                                                                             |
| CR9                    | Reserved                                                                                                                                                            |
| CR8                    | Wait configuration<br>0 = $\overline{\text{WAIT}}$ is active during wait state<br>1 = $\overline{\text{WAIT}}$ is active one data cycle before wait state (default) |
| CR7                    | Burst order configuration<br>0 = Interleaved<br>1 = Linear (default)                                                                                                |
| CR6                    | Clock configuration<br>0 = Address latched and data output on the falling clock edge<br>1 = Address latched and data output on the rising clock edge (default)      |
| CR5-CR4                | Reserved                                                                                                                                                            |
| CR3                    | Burst Wrap<br>0 = burst wrap within burst length set by CR2-CR0<br>1 = Don't wrap accesses within burst length set by CR2-CR0 (default)                             |
| CR2-CR0                | Burst length<br>001 = 4 word burst length<br>010 = 8 word burst length<br>111 = Continuous burst mode (requires CR7 = 1)                                            |

Note: 1. The RCR can be read via the RSIG command (90h). Bank A Address + 05h contains the RCR data. See Table 9.  
 2. All the bits in the RCR are set to default on device power-up or reset.

**Table 15. BINV Configuration Bits**

| CR15 | CR14 | BINV   |        |
|------|------|--------|--------|
|      |      | IN     | OUT    |
| 0    | 0    | X      | 0      |
| 0    | 1    | Active | Active |
| 1    | 0    | X      | 0      |
| 1    | 1    | Active | 0      |

## POWER CONSUMPTION

### Power-down

The memory provides Reset/Power-down control input  $\overline{RP}$ . The Power-down function can be activated only if the relevant Read Configuration Register bit is set to '1'. In this case, when the  $\overline{RP}$  signal is pulled at  $V_{SS}$  the supply current drops to typically  $I_{CC2}$  (see Table 26), the memory is deselected and the outputs are in high impedance. If  $\overline{RP}$  is pulled to  $V_{SS}$  during a Program or Erase operation, this operation is aborted and the memory content is no longer valid (see Reset/Power-down input description).

### Power-up

The memory Command Interface is reset on Power-up to Read Array. Either  $\overline{E}$  or  $\overline{W}$  must be tied to  $V_{IH}$  during Power-up to allow maximum security and the possibility to write a command on the first

rising edge of  $\overline{W}$ . At Power-up the device is configured as:

- Page mode: (CR15 = 1)
- Power-down disabled: (CR10 = 0)
- BINV disabled: (CR14 = 0).

All blocks are protected and unlocked.

$V_{DD}$ ,  $V_{DDQ}$  and  $V_{PP}$  are independent power supplies and can be biased in any order.

### Supply Rails

Normal precautions must be taken for supply voltage decoupling; each device in a system should have the  $V_{DD}$  rails decoupled with a 0.1 $\mu$ F capacitor close to the  $V_{DD}$ ,  $V_{DDQ}$  and  $V_{SS}$  pins. The PCB trace widths should be sufficient to carry the required  $V_{DD}$  program and erase currents.

Figure 6. X-Latency Configuration Sequence

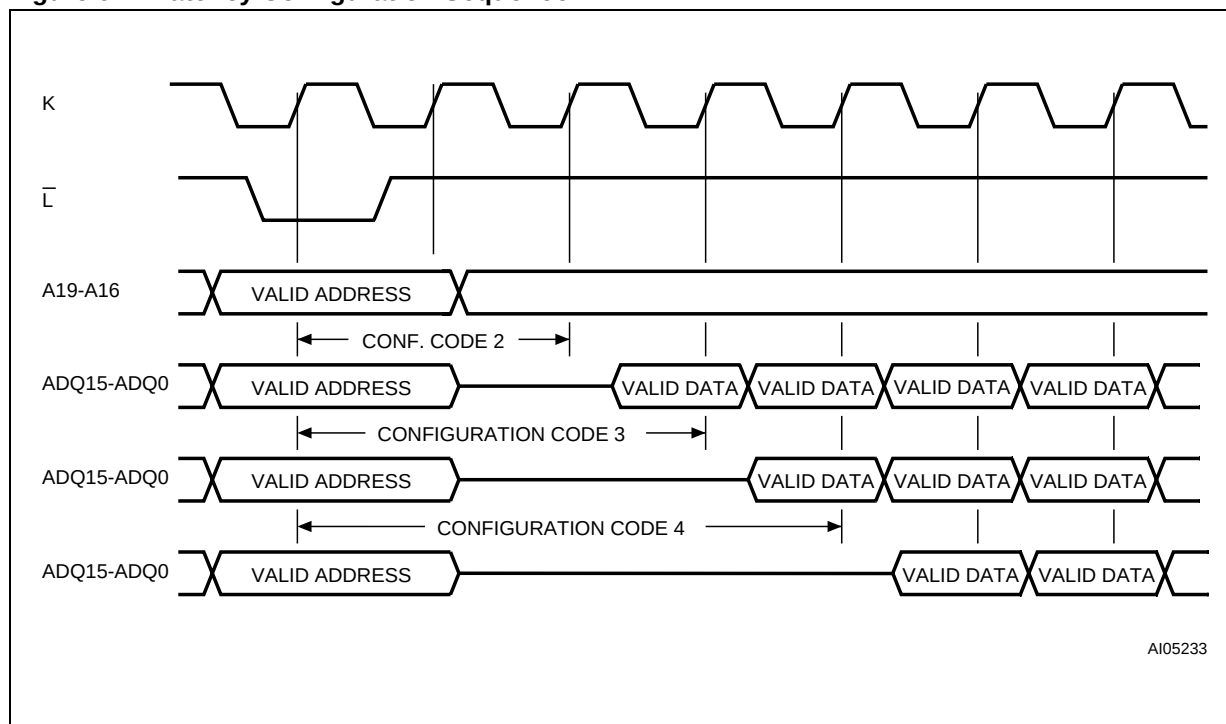


Figure 7. Wait Configuration Sequence

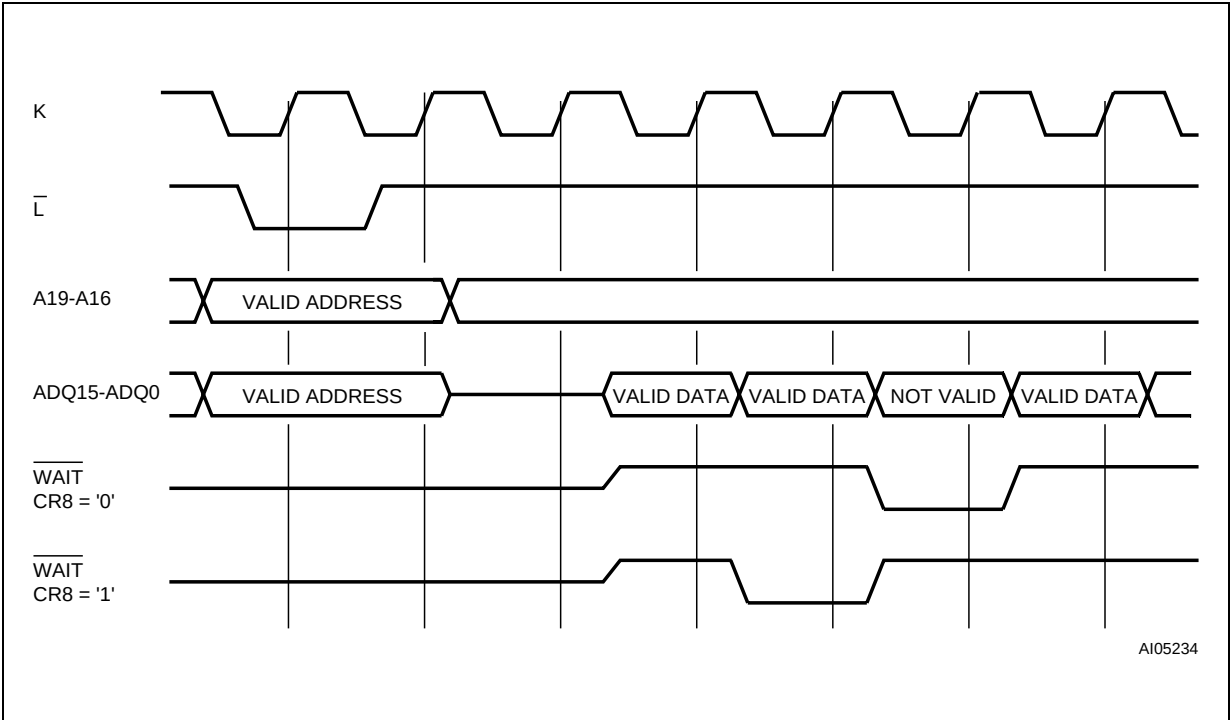


Table 16. Burst Order and Length Configuration

| Mode    | Starting Address | 4 Words                    |             | 8 Words                                |                 | Continuous Burst              |
|---------|------------------|----------------------------|-------------|----------------------------------------|-----------------|-------------------------------|
|         |                  | Linear                     | Interleaved | Linear                                 | Interleaved     |                               |
| Wrap    | 0                | 0-1-2-3                    | 0-1-2-3     | 0-1-2-3-4-5-6-7                        | 0-1-2-3-4-5-6-7 | 0-1-2-3-4-5-6...              |
|         | 1                | 1-2-3-0                    | 1-0-3-2     | 1-2-3-4-5-6-7-0                        | 1-0-3-2-5-4-7-6 | 1-2-3-4-5-6-7...              |
|         | 2                | 2-3-0-1                    | 2-3-0-1     | 2-3-4-5-6-7-0-1                        | 2-3-0-1-6-7-4-5 | 2-3-4-5-6-7-8...              |
|         | 3                | 3-0-1-2                    | 3-2-1-0     | 3-4-5-6-7-0-1-2                        | 3-2-1-0-7-6-5-4 | 3-4-5-6-7-8-9...              |
|         | ...              |                            |             |                                        |                 |                               |
|         | 7                | 7-4-5-6                    | 7-6-5-4     | 7-0-1-2-3-4-5-6                        | 7-6-5-4-3-2-1-0 | 7-8-9-10-11-12-13...          |
|         | ...              |                            |             |                                        |                 |                               |
|         | 60               |                            |             |                                        |                 | 60-61-62-63-64-65-66...       |
|         | 61               |                            |             |                                        |                 | 61-62-63-WAIT-64-65-66...     |
|         | 62               |                            |             |                                        |                 | 62-63-WAIT-WAIT-64-65-66...   |
|         | 63               |                            |             |                                        |                 | 63-WAIT-WAIT-WAIT-64-65-66... |
|         |                  | Linear                     | Interleaved | Linear                                 | Interleaved     |                               |
| No-wrap | 0                | 0-1-2-3                    |             | 0-1-2-3-4-5-6-7                        |                 | 0-1-2-3-4-5-6...              |
|         | 1                | 1-2-3-4                    |             | 1-2-3-4-5-6-7-8                        |                 | 1-2-3-4-5-6-7...              |
|         | 2                | 2-3-4-5                    |             | 2-3-4-5-6-7-8-9...                     |                 | 2-3-4-5-6-7-8...              |
|         | 3                | 3-4-5-6                    |             | 3-4-5-6-7-8-9-10                       |                 | 3-4-5-6-7-8-9...              |
|         | ...              |                            |             |                                        |                 |                               |
|         | 7                | 7-8-9-10                   |             | 7-8-9-10-11-12-13-14                   |                 | 7-8-9-10-11-12-13...          |
|         | ...              |                            |             |                                        |                 |                               |
|         | 60               | 60-61-62-63                |             | 60-61-62-63-64-65-66-67                |                 | 60-61-62-63-64-65-66...       |
|         | 61               | 61-62-63-WAIT-64           |             | 61-62-63-WAIT-64-65-66-67-68           |                 | 61-62-63-WAIT-64-65-66...     |
|         | 62               | 62-63-WAIT-WAIT-64-65      |             | 62-63-WAIT-WAIT-64-65-66-67-68-69      |                 | 62-63-WAIT-WAIT-64-65-66...   |
|         | 63               | 63-WAIT-WAIT-WAIT-64-65-66 |             | 63-WAIT-WAIT-WAIT-64-65-66-67-68-69-70 |                 | 63-WAIT-WAIT-WAIT-64-65-66... |

**COMMON FLASH INTERFACE (CFI)**

The Common Flash Interface (CFI) specification is a JEDEC approved, standardized data structure that can be read from the Flash memory device. CFI allows a system software to query the flash device to determine various electrical and timing parameters, density information and functions supported by the device. CFI allows the system to easily interface to the Flash memory, to learn about its features and parameters, enabling the software to configure itself when necessary.

Tables 17, 18, 19, 20, 21, 22 and 23 show the address used to retrieve each data. The CFI data structure gives information on the device, such as the sectorization, the command set and some electrical specifications. The CFI data structure contains also a security area; in this section, a 64 bit unique security number is written, starting at address 81h. This area can be accessed only in read mode and there are no ways of changing the code after it has been written by ST. Write a read instruction to return to Read mode (see Table 11). Refer to the CFI Query instruction to understand how the M58MR016 enters the CFI Query mode.

**Table 17. Query Structure Overview**

| Offset | Sub-section Name                                  | Description                                                              |
|--------|---------------------------------------------------|--------------------------------------------------------------------------|
| 00h    | Reserved                                          | Reserved for algorithm-specific information                              |
| 10h    | CFI Query Identification String                   | Command set ID and algorithm data offset                                 |
| 1Bh    | System Interface Information                      | Device timing & voltage information                                      |
| 27h    | Device Geometry Definition                        | Flash device layout                                                      |
| P      | Primary Algorithm-specific Extended Query table   | Additional information specific to the Primary Algorithm (optional)      |
| A      | Alternate Algorithm-specific Extended Query table | Additional information specific to the Alternate Algorithm (optional)    |
| 80h    | Security Code Area                                | Lock Protection Register, Unique device Number and User Programmable OTP |

Note: The Flash memory display the CFI data structure when CFI Query command is issued. In this table are listed the main sub-sections detailed in Tables 18, 19, 20, 21, 22 and 23. Query data are always presented on the lowest order data outputs.

**Table 18. CFI Query Identification String**

| Offset  | Sub-section Name   | Description                                                                                                                         | Value         |
|---------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 00h     | 0020h              | Manufacturer Code                                                                                                                   | ST            |
| 01h     | 88DEh<br>88E0h     | Device Code                                                                                                                         | Top<br>Bottom |
| 02h     | reserved           | Reserved                                                                                                                            |               |
| 03h     | DRC <sup>(1)</sup> | Die Revision Code                                                                                                                   |               |
| 04h-0Fh | reserved           | Reserved                                                                                                                            |               |
| 10h     | 0051h              | Query Unique ASCII String "QRY"                                                                                                     | "Q"           |
| 11h     | 0052h              |                                                                                                                                     | "R"           |
| 12h     | 0059h              |                                                                                                                                     | "Y"           |
| 13h     | 0002h              | Primary Algorithm Command Set and Control Interface ID code 16 bit ID code defining a specific algorithm                            |               |
| 14h     | 0000h              |                                                                                                                                     |               |
| 15h     | offset = P = 0039h | Address for Primary Algorithm extended Query table (see Table 20)                                                                   | p = 39h       |
| 16h     | 0000h              |                                                                                                                                     |               |
| 17h     | 0000h              | Alternate Vendor Command Set and Control Interface ID Code second vendor - specified algorithm supported ( 0000h means none exists) | NA            |
| 18h     | 0000h              |                                                                                                                                     |               |
| 19h     | value = A = 0000h  | Address for Alternate Algorithm extended Query table (0000h means none exists)                                                      | NA            |
| 1Ah     | 0000h              |                                                                                                                                     |               |

Note: Query data are always presented on the lowest - order data outputs (ADQ0-ADQ7) only. ADQ8-ADQ15 are '0'.

1. DRC means Die Revision Code.

Table 19. CFI Query System Interface Information

| Offset | Data  | Description                                                                                                                                    | Value |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1Bh    | 0017h | V <sub>DD</sub> Logic Supply Minimum Program/Erase or Write voltage<br>bit 7 to 4 BCD value in volts<br>bit 3 to 0 BCD value in 100 millivolts | 1.7V  |
| 1Ch    | 0020h | V <sub>DD</sub> Logic Supply Maximum Program/Erase or Write voltage<br>bit 7 to 4 BCD value in volts<br>bit 3 to 0 BCD value in 100 millivolts | 2V    |
| 1Dh    | 0017h | V <sub>PP</sub> [Programming] Supply Minimum Program/Erase voltage<br>bit 7 to 4 HEX value in volts<br>bit 3 to 0 BCD value in 100 millivolts  | 1.7V  |
| 1Eh    | 00C0h | V <sub>PP</sub> [Programming] Supply Maximum Program/Erase voltage<br>bit 7 to 4 HEX value in volts<br>bit 3 to 0 BCD value in 100 millivolts  | 12V   |
| 1Fh    | 0004h | Typical timeout per single byte/word program = 2 <sup>n</sup> μs                                                                               | 16μs  |
| 20h    | 0004h | Typical timeout for tetra word program = 2 <sup>n</sup> μs                                                                                     | 16μs  |
| 21h    | 000Ah | Typical timeout per individual block erase = 2 <sup>n</sup> ms                                                                                 | 1s    |
| 22h    | 0000h | Typical timeout for full chip erase = 2 <sup>n</sup> ms                                                                                        | NA    |
| 23h    | 0004h | Maximum timeout for word program = 2 <sup>n</sup> times typical                                                                                | 512μs |
| 24h    | 0004h | Maximum timeout for tetra word = 2 <sup>n</sup> times typical                                                                                  | 512μs |
| 25h    | 0004h | Maximum timeout per individual block erase = 2 <sup>n</sup> times typical                                                                      | 16s   |
| 26h    | 0000h | Maximum timeout for chip erase = 2 <sup>n</sup> times typical                                                                                  | NA    |



Table 20. Device Geometry Definition

| Offset Word Mode | Data           | Description                                                                                                                                                                                                                | Value         |
|------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 27h              | 0015h          | Device Size = $2^n$ in number of bytes                                                                                                                                                                                     | 2 MByte       |
| 28h<br>29h       | 0001h<br>0000h | Flash Device Interface Code description                                                                                                                                                                                    | x16<br>Async. |
| 2Ah<br>2Bh       | 0003h<br>0000h | Maximum number of bytes in multi-byte program or page = $2^n$                                                                                                                                                              | 8 Byte        |
| 2Ch              | 0003h          | Number of Erase Block Regions within the device<br>bit 7 to 0 = x = number of Erase Block Regions<br>It specifies the number of regions within the device containing one or more contiguous Erase Blocks of the same size. | 3             |
| M58MR016C        | 2Dh<br>2Eh     | Region 1 Information (main block - Bank B)<br>Number of identical-size erase block = 002Fh+1                                                                                                                               | 24            |
|                  | 2Fh<br>30h     | Region 1 Information (main block - Bank B)<br>Block size in Region 1 = 0100h * 256 byte                                                                                                                                    | 64 KByte      |
|                  | 31h<br>32h     | Region 2 Information (main block - Bank A)<br>Number of identical-size erase block = 0006h+1                                                                                                                               | 7             |
|                  | 33h<br>34h     | Region 2 Information (main block - Bank A)<br>Block size in Region 2 = 0100h * 256 byte                                                                                                                                    | 64 KByte      |
|                  | 35h<br>36h     | Region 3 Information (parameter block - Bank A)<br>Number of identical-size erase block = 0007h+1                                                                                                                          | 8             |
|                  | 37h<br>38h     | Region 3 Information (parameter block - Bank A)<br>Block size in Region 3 = 0020h * 256 byte                                                                                                                               | 8 KByte       |
| M58MR016D        | 2Dh<br>2Eh     | Region 1 Information (parameter block - Bank A)<br>Number of identical-size erase block = 0007h+1                                                                                                                          | 8             |
|                  | 2Fh<br>30h     | Region 1 Information (parameter block - Bank A)<br>Block size in Region 1 = 0020h * 256 byte                                                                                                                               | 8 KByte       |
|                  | 31h<br>32h     | Region 2 Information (main block - Bank A)<br>Number of identical-size erase block = 0006h+1                                                                                                                               | 7             |
|                  | 33h<br>34h     | Region 2 Information (main block - Bank A)<br>Block size in Region 2 = 0001h * 256 byte                                                                                                                                    | 64 KByte      |
|                  | 35h<br>36h     | Region 3 Information (parameter block - Bank B)<br>Number of identical-size erase block = 002Fh+1                                                                                                                          | 24            |
|                  | 37h<br>38h     | Region 3 Information (parameter block - Bank B)<br>Block size in Region 3 = 0001h * 256 byte                                                                                                                               | 64 KByte      |

Table 21. Primary Algorithm-Specific Extended Query Table

| Offset                                                  | Data                    | Description                                                                                                                                                                                                                                                                                                                                       | Value             |
|---------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| (P)h = 39h                                              | 0050h<br>0052h<br>0049h | Primary Algorithm extended Query table unique ASCII string "PRI"                                                                                                                                                                                                                                                                                  | "P"<br>"R"<br>"I" |
| (P+3)h = 3Ch                                            | 0031h                   | Major version number, ASCII                                                                                                                                                                                                                                                                                                                       | "1"               |
| (P+4)h = 3Dh                                            | 0030h                   | Minor version number, ASCII                                                                                                                                                                                                                                                                                                                       | "0"               |
| (P+5)h = 3Eh                                            | 00E6h<br>0003h          | Extended Query table contents for Primary Algorithm. Address (P+5)h contains less significant byte.                                                                                                                                                                                                                                               |                   |
| (P+7)h                                                  | 0000h                   | bit 0 Chip Erase supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                      | No                |
| (P+8)h                                                  | 0000h                   | bit 1 Erase Suspend supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                   | Yes               |
|                                                         |                         | bit 2 Program Suspend supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                 | Yes               |
|                                                         |                         | bit 3 Legacy Lock/Unlock supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                              | No                |
|                                                         |                         | bit 4 Queued Erase supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                    | No                |
|                                                         |                         | bit 5 Instant individual block locking supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                | Yes               |
|                                                         |                         | bit 6 Protection bits supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                 | Yes               |
|                                                         |                         | bit 7 Page mode read supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                  | Yes               |
|                                                         |                         | bit 8 Synchronous read supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                | Yes               |
|                                                         |                         | bit 9 Simultaneous operation supported (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                          | Yes               |
|                                                         |                         | bit 10 to 31 Reserved; undefined bits are '0'. If bit 31 is '1' then another 31 bit field of optional features follows at the end of the bit-30 field.                                                                                                                                                                                            |                   |
| (P+9)h = 42h                                            | 0001h                   | Supported Functions after Suspend<br>Read Array, Read Status Register and CFI Query<br><br>bit 0 Program supported after Erase Suspend (1 = Yes, 0 = No)<br>bit 7 to 1 Reserved; undefined bits are '0'                                                                                                                                           | Yes               |
| (P+A)h = 43h<br>(P+B)h                                  | 0003h<br>0000h          | Block Protect Status<br>Defines which bits in the Block Status Register section of the Query are implemented.<br><br>bit 0 Block protect Status Register Protect/Unprotect bit active (1 = Yes, 0 = No)<br>bit 1 Block Lock Status Register Lock-Down bit active (1 = Yes, 0 = No)<br>bit 15 to 2 Reserved for future use; undefined bits are '0' | Yes<br>Yes        |
| (P+C)h = 45h                                            | 0018h                   | V <sub>DD</sub> Logic Supply Optimum Program/Erase voltage (highest performance)<br><br>bit 7 to 4 HEX value in volts<br>bit 3 to 0 BCD value in 100 mV                                                                                                                                                                                           | 1.8V              |
| (P+D)h = 46h                                            | 00C0h                   | V <sub>PP</sub> Supply Optimum Program/Erase voltage<br><br>bit 7 to 4 HEX value in volts<br>bit 3 to 0 BCD value in 100 mV                                                                                                                                                                                                                       | 12V               |
| (P+E)h = 47h<br>(P+F)h<br>(P+10)h<br>(P+11)h<br>(P+12)h | 0000h                   | Reserved                                                                                                                                                                                                                                                                                                                                          |                   |

Table 22. Burst Read Information

| Offset        | Data  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Value     |
|---------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| (P)+13h = 48h | 0003h | Page-mode read capability<br><br>bits 0-7      'n' such that $2^n$ HEX value represents the number of read-page bytes. See offset 28h for device word width to determine page-mode data output width. 00h indicates no read page buffer.                                                                                                                                                                                                                                                                                                                                                                                                                                            | 8 Byte    |
| (P+14)h = 49h | 0003h | Number of synchronous mode read configuration fields that follow. 00h indicates no burst capability.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3         |
| (P+15)h = 4Ah | 0001h | Synchronous mode read capability configuration 1<br><br>bit 3-7      Reserved<br>bit 0-2      'n' such that $2^{n+1}$ HEX value represents the maximum number of continuous synchronous reads when the device is configured for its maximum word width. A value of 07h indicates that the device is capable of continuous linear bursts that will output data until the internal burst counter reaches the end of the device's burstable address space. This field's 3-bit value can be written directly to the read configuration register bit 0-2 if the device is configured for its maximum word width. See offset 28h for word width to determine the burst data output width. | 4         |
| (P+16)h = 4Bh | 0002h | Synchronous mode read capability configuration 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 8         |
| (P+17)h = 4Ch | 0007h | Synchronous mode read capability configuration 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Cont.     |
| (P+18)h = 4Dh | 0028h | Max operating clock frequency (MHz)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 40 MHz    |
| (P+19)h = 4Eh | 0001h | Supported handshaking signal ( $\overline{\text{WAIT}}$ pin)<br><br>bit 0      during synchronous read      (1 = Yes, 0 = No)<br>bit 1      during asynchronous read      (1 = Yes, 0 = No)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Yes<br>No |

Table 23. Security Code Area

| Offset | Data                | Description                    |
|--------|---------------------|--------------------------------|
| 80h    | 0000-0000-0000-0XX0 | Lock Protection Register       |
| 81h    | XXXX                | 64 bits: unique device number  |
| 82h    | XXXX                |                                |
| 83h    | XXXX                |                                |
| 84h    | XXXX                |                                |
| 85h    | XXXX                | 64 bits: User Programmable OTP |
| 86h    | XXXX                |                                |
| 87h    | XXXX                |                                |
| 88h    | XXXX                |                                |

Table 24. AC Measurement Conditions

|                                       |                   |
|---------------------------------------|-------------------|
| Input Rise and Fall Times             | $\leq 4\text{ns}$ |
| Input Pulse Voltages                  | 0 to $V_{DDQ}$    |
| Input and Output Timing Ref. Voltages | $V_{DDQ}/2$       |

Figure 8. Testing Input/Output Waveforms

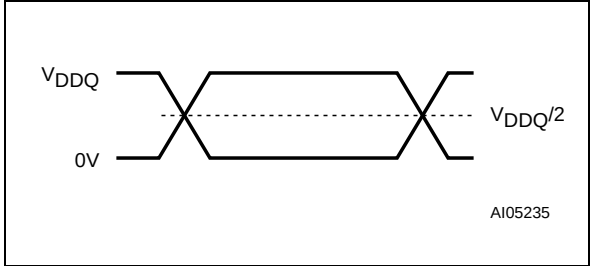


Figure 9. AC Testing Load Circuit

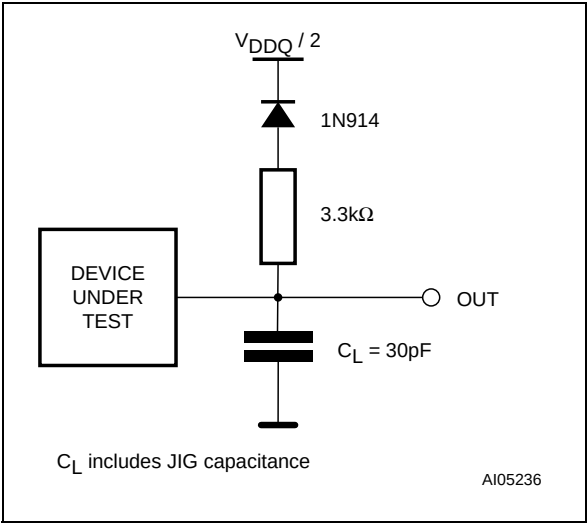


Table 25. Capacitance <sup>(1)</sup>  
( $T_A = 25^\circ\text{C}$ ,  $f = 1\text{MHz}$ )

| Symbol    | Parameter          | Test Condition        | Min | Max | Unit |
|-----------|--------------------|-----------------------|-----|-----|------|
| $C_{IN}$  | Input Capacitance  | $V_{IN} = 0\text{V}$  |     | 6   | pF   |
| $C_{OUT}$ | Output Capacitance | $V_{OUT} = 0\text{V}$ |     | 12  | pF   |

Note: 1. Sampled only, not 100% tested.

**Table 26. DC Characteristics**(T<sub>A</sub> = -40 to 85°C; V<sub>DD</sub> = V<sub>DDQ</sub> = 1.7V to 2.0V)

| Symbol               | Parameter                                               | Test Condition                                                             | Min                    | Typ | Max                    | Unit |
|----------------------|---------------------------------------------------------|----------------------------------------------------------------------------|------------------------|-----|------------------------|------|
| I <sub>LI</sub>      | Input Leakage Current                                   | 0V ≤ V <sub>IN</sub> ≤ V <sub>DDQ</sub>                                    |                        |     | ±1                     | μA   |
| I <sub>LO</sub>      | Output Leakage Current                                  | 0V ≤ V <sub>OUT</sub> ≤ V <sub>DDQ</sub>                                   |                        |     | ±5                     | μA   |
| I <sub>DD1</sub>     | Supply Current (Asynchronous Read Mode)                 | $\overline{E} = V_{IL}, \overline{G} = V_{IH}, f = 6\text{MHz}$            |                        | 10  | 20                     | mA   |
|                      | Supply Current (Synchronous Read Mode Continuous Burst) | $\overline{E} = V_{IL}, \overline{G} = V_{IH}, f = 40\text{MHz}$           |                        | 20  | 30                     | mA   |
| I <sub>DD2</sub>     | Supply Current (Power-down)                             | $\overline{RP} = V_{SS} \pm 0.2\text{V}$                                   |                        | 2   | 10                     | μA   |
| I <sub>DD3</sub>     | Supply Current (Standby)                                | $\overline{E} = V_{DD} \pm 0.2\text{V}$                                    |                        | 15  | 50                     | μA   |
| I <sub>DD4</sub> (1) | Supply Current (Program or Erase)                       | Word Program, Block Erase in progress                                      |                        | 10  | 20                     | mA   |
| I <sub>DD5</sub> (1) | Supply Current (Dual Bank)                              | Program/Erase in progress in one Bank, Asynchronous Read in the other Bank |                        | 20  | 40                     | mA   |
|                      |                                                         | Program/Erase in progress in one Bank, Synchronous Read in the other Bank  |                        | 30  | 50                     | mA   |
| I <sub>PP1</sub>     | V <sub>PP</sub> Supply Current (Program or Erase)       | V <sub>PP</sub> = 12V ± 0.6V                                               |                        | 5   | 10                     | mA   |
| I <sub>PP2</sub>     | V <sub>PP</sub> Supply Current (Standby or Read)        | V <sub>PP</sub> ≤ V <sub>CC</sub>                                          |                        | 0.2 | 5                      | μA   |
|                      |                                                         | V <sub>PP</sub> = 12V ± 0.6V                                               |                        | 100 | 400                    | μA   |
| V <sub>IL</sub>      | Input Low Voltage                                       |                                                                            | -0.5                   |     | 0.4                    | V    |
| V <sub>IH</sub>      | Input High Voltage                                      |                                                                            | V <sub>DDQ</sub> - 0.4 |     | V <sub>DDQ</sub> + 0.4 | V    |
| V <sub>OL</sub>      | Output Low Voltage                                      | I <sub>OL</sub> = 100μA                                                    |                        |     | 0.1                    | V    |
| V <sub>OH</sub>      | Output High Voltage CMOS                                | I <sub>OH</sub> = -100μA                                                   | V <sub>DDQ</sub> - 0.1 |     |                        | V    |
| V <sub>PP1</sub>     | V <sub>PP</sub> Supply Voltage                          | Program, Erase                                                             | V <sub>DDQ</sub> - 0.4 |     | V <sub>DDQ</sub> + 0.4 | V    |
| V <sub>PPH</sub>     | V <sub>PP</sub> Supply Voltage                          | Double/Tetra Word Program                                                  | 11.4                   |     | 12.6                   | V    |
| V <sub>PPLK</sub>    | Program or Erase Lockout                                |                                                                            |                        |     | 1                      | V    |

Note: 1. Sampled only, not 100% tested.

2. V<sub>PP</sub> may be connected to 12V power supply for a total of less than 100 hrs.

**Table 27. Asynchronous Read AC Characteristics**(T<sub>A</sub> = -40 to 85°C; V<sub>DD</sub> = V<sub>DDQ</sub> = 1.7V to 2.0V)

| Symbol                           | Alt                   | Parameter                                 | Test Condition                                 | M58MR016 |     |     |     | Unit |
|----------------------------------|-----------------------|-------------------------------------------|------------------------------------------------|----------|-----|-----|-----|------|
|                                  |                       |                                           |                                                | 100      |     | 120 |     |      |
|                                  |                       |                                           |                                                | Min      | Max | Min | Max |      |
| t <sub>AVAV</sub>                | t <sub>RC</sub>       | Address Valid to Next Address Valid       | $\overline{E} = V_{IL}, \overline{G} = V_{IL}$ | 100      |     | 120 |     | ns   |
| t <sub>AVLH</sub>                | t <sub>AVAVDH</sub>   | Address valid to Latch Enable High        | $\overline{G} = V_{IH}$                        | 10       |     | 10  |     | ns   |
| t <sub>AVQV</sub>                | t <sub>ACC</sub>      | Address Valid to Output Valid (Random)    | $\overline{E} = V_{IL}, \overline{G} = V_{IL}$ |          | 100 |     | 120 | ns   |
| t <sub>AVQV1</sub>               | t <sub>PAGE</sub>     | Address Valid to Output Valid (Page)      | $\overline{E} = V_{IL}, \overline{G} = V_{IL}$ |          | 45  |     | 45  | ns   |
| t <sub>EHQX</sub>                | t <sub>OH</sub>       | Chip Enable High to Output Transition     | $\overline{G} = V_{IL}$                        | 0        |     | 0   |     | ns   |
| t <sub>EHQZ</sub> <sup>(1)</sup> | t <sub>HZ</sub>       | Chip Enable High to Output Hi-Z           | $\overline{G} = V_{IL}$                        |          | 20  |     | 20  | ns   |
| t <sub>ELLH</sub>                | t <sub>ELAVDH</sub>   | Chip Enable Low to Latch Enable High      | $\overline{E} = V_{IL}, \overline{G} = V_{IH}$ | 10       |     | 10  |     | ns   |
| t <sub>ELQV</sub> <sup>(2)</sup> | t <sub>CE</sub>       | Chip Enable Low to Output Valid           | $\overline{G} = V_{IL}$                        |          | 100 |     | 120 | ns   |
| t <sub>ELQX</sub> <sup>(1)</sup> | t <sub>LZ</sub>       | Chip Enable Low to Output Transition      | $\overline{G} = V_{IL}$                        | 0        |     | 0   |     | ns   |
| t <sub>GHQX</sub>                | t <sub>OH</sub>       | Output Enable High to Output Transition   | $\overline{E} = V_{IL}$                        | 0        |     | 0   |     | ns   |
| t <sub>GHQZ</sub> <sup>(1)</sup> | t <sub>DF</sub>       | Output Enable High to Output Hi-Z         | $\overline{E} = V_{IL}$                        |          | 20  |     | 20  | ns   |
| t <sub>GLQV</sub> <sup>(2)</sup> | t <sub>OE</sub>       | Output Enable Low to Output Valid         | $\overline{E} = V_{IL}$                        |          | 25  |     | 35  | ns   |
| t <sub>GLQX</sub> <sup>(1)</sup> | t <sub>OLZ</sub>      | Output Enable Low to Output Transition    | $\overline{E} = V_{IL}$                        | 0        |     | 0   |     | ns   |
| t <sub>LHAX</sub>                | t <sub>AVDHAX</sub>   | Latch Enable High to Address Transition   | $\overline{E} = V_{IL}, \overline{G} = V_{IH}$ | 10       |     | 10  |     | ns   |
| t <sub>LHGL</sub>                |                       | Latch Enable High to Output Enable Low    | $\overline{E} = V_{IL}$                        | 10       |     | 10  |     | ns   |
| t <sub>LLLH</sub>                | t <sub>AVDLAVDH</sub> | Latch Enable Pulse Width                  | $\overline{E} = V_{IL}, \overline{G} = V_{IH}$ | 10       |     | 10  |     | ns   |
| t <sub>LLQV</sub>                | t <sub>AVDLQV</sub>   | Latch Enable Low to Output Valid (Random) | $\overline{E} = V_{IL}$                        |          | 100 |     | 120 | ns   |
| t <sub>LLQV1</sub>               |                       | Latch Enable Low to Output Valid (Page)   | $\overline{E} = V_{IL}$                        |          | 45  |     | 45  | ns   |

Note: 1. Sampled only, not 100% tested.

2.  $\bar{G}$  may be delayed by up to t<sub>ELQV</sub> - t<sub>GLQV</sub> after the falling edge of  $\bar{E}$  without increasing t<sub>ELQV</sub>.

Figure 10. Asynchronous Read AC Waveforms

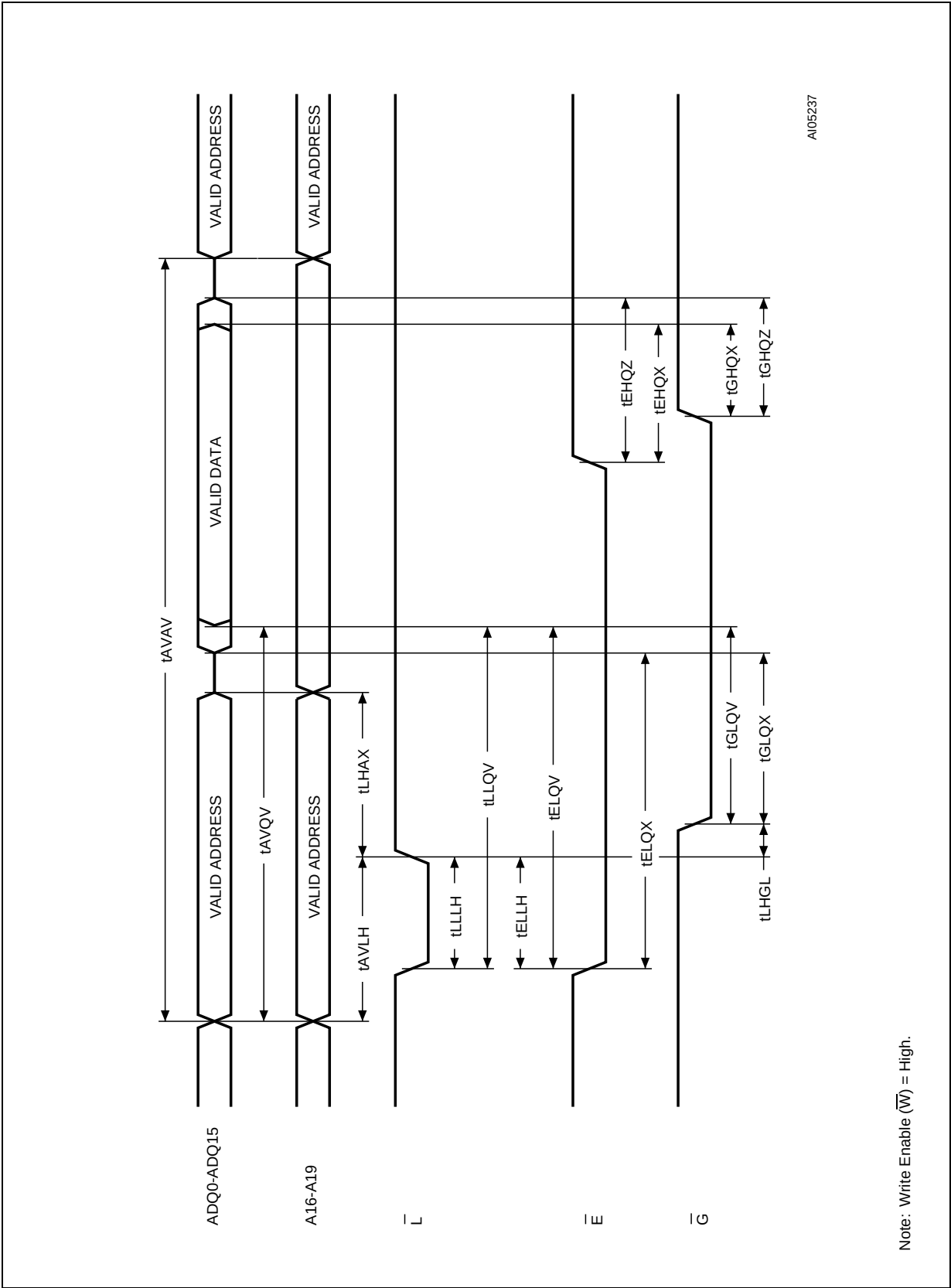
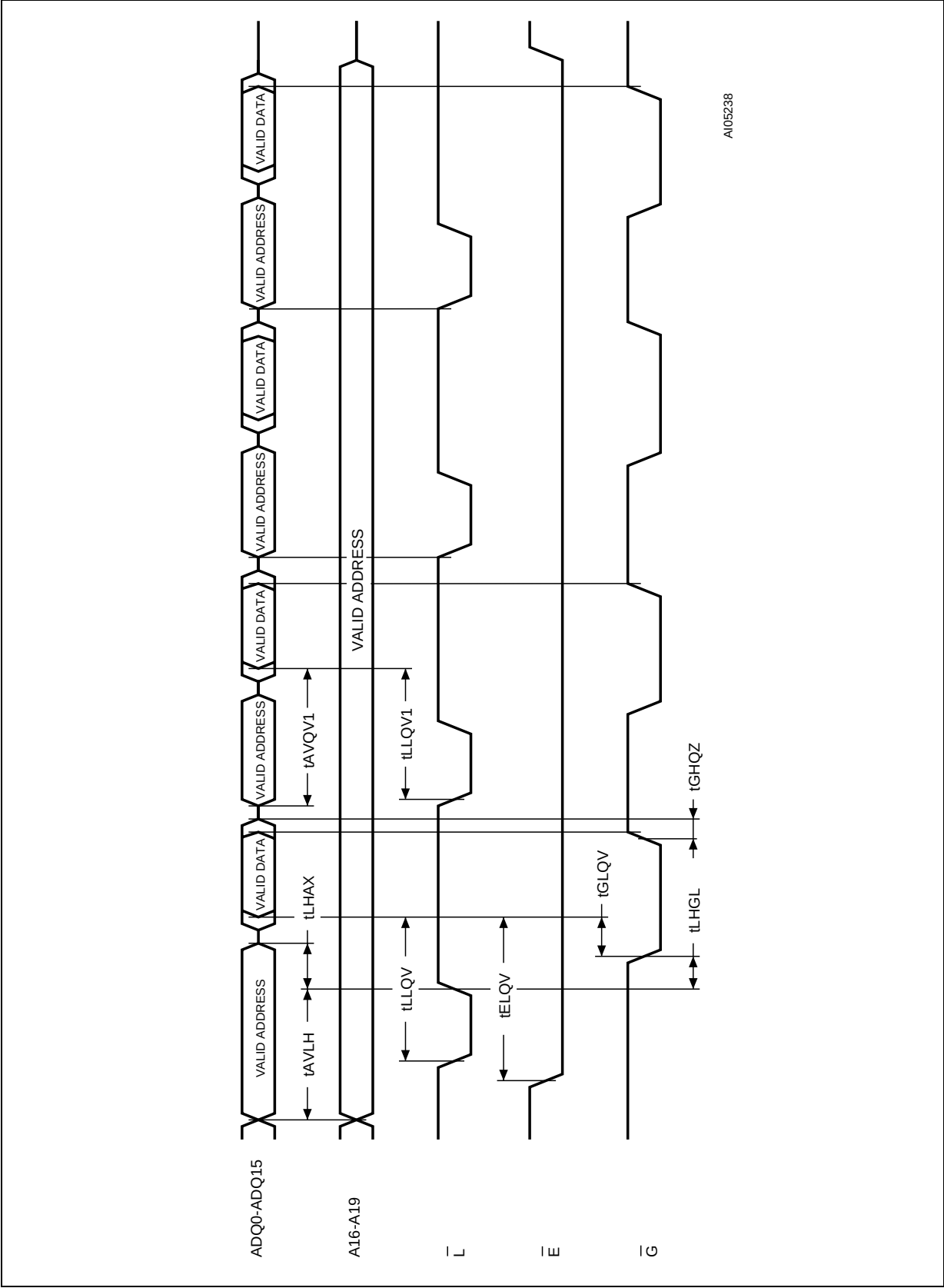


Figure 11. Page Read AC Waveforms

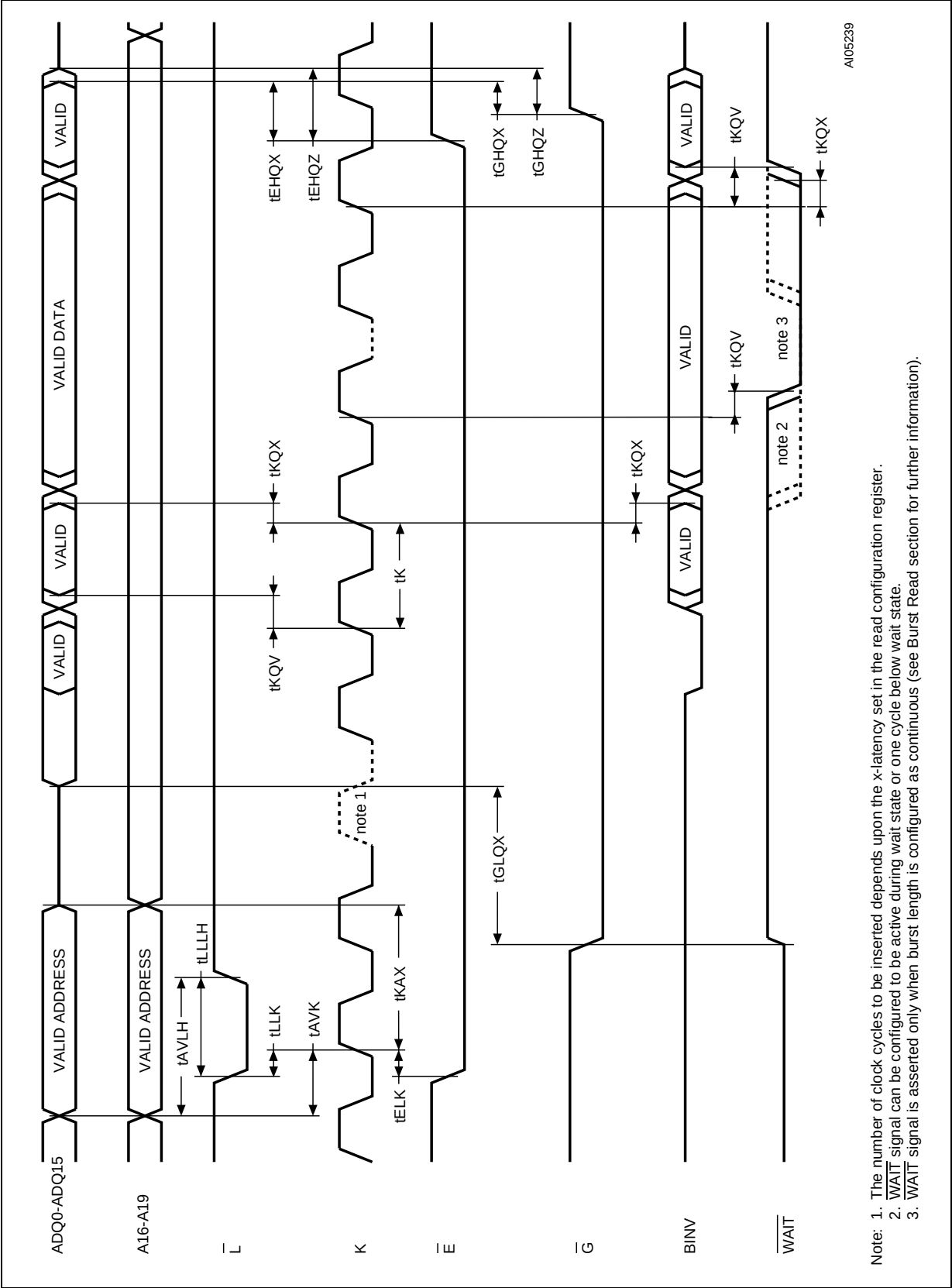




**Table 28. Synchronous Burst Read AC Characteristics**(T<sub>A</sub> = -40 to 85°C; V<sub>DD</sub> = V<sub>DDQ</sub> = 1.7V to 2.0V)

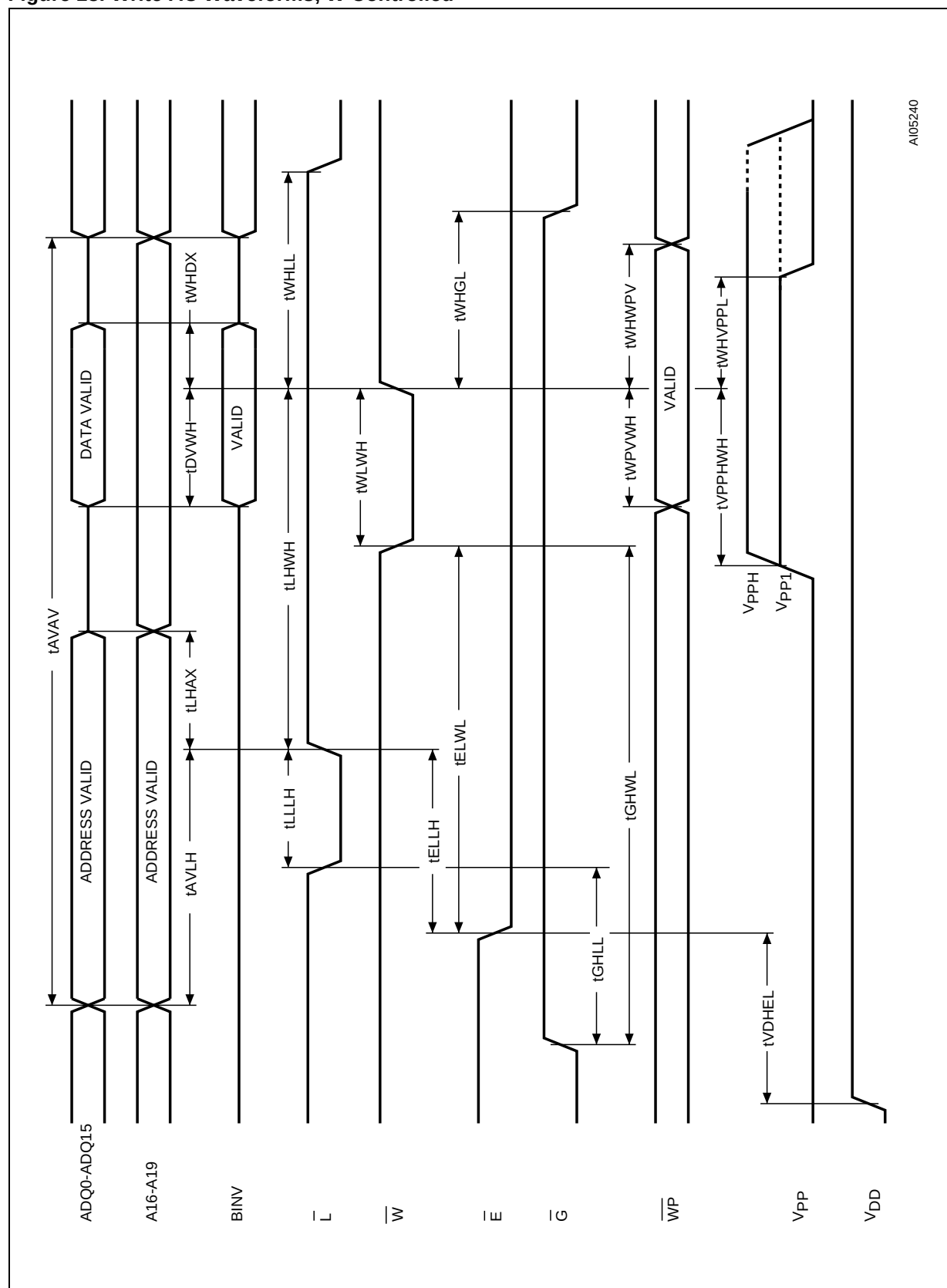
| Symbol            | Alt                   | Parameter                                                                          | Test Condition                                 | M58MR016 |     |     |     | Unit |
|-------------------|-----------------------|------------------------------------------------------------------------------------|------------------------------------------------|----------|-----|-----|-----|------|
|                   |                       |                                                                                    |                                                | 100      |     | 120 |     |      |
|                   |                       |                                                                                    |                                                | Min      | Max | Min | Max |      |
| t <sub>AVK</sub>  | t <sub>AVCLKH</sub>   | Address Valid to Clock                                                             |                                                | 7        |     | 7   |     | ns   |
| t <sub>ELK</sub>  | t <sub>CELCLKH</sub>  | Chip Enable Low to Clock                                                           |                                                | 7        |     | 7   |     | ns   |
| t <sub>K</sub>    | t <sub>CLK</sub>      | Clock Period                                                                       |                                                | 25       |     | 25  |     | ns   |
| t <sub>KAX</sub>  | t <sub>CLKHAX</sub>   | Clock to Address Transition                                                        | $\overline{E} = V_{IL}, \overline{G} = V_{IH}$ | 13       |     | 13  |     | ns   |
| t <sub>KHKL</sub> | t <sub>CLKHCLKL</sub> | Clock High                                                                         |                                                | 5        |     | 5   |     | ns   |
| t <sub>KLKH</sub> | t <sub>CLKLCLKH</sub> | Clock Low                                                                          |                                                | 5        |     | 5   |     | ns   |
| t <sub>KQV</sub>  | t <sub>CLKHQV</sub>   | Clock to Data Valid<br>Clock to BINV Valid<br>Clock to WAIT Valid                  | $\overline{E} = V_{IL}, \overline{G} = V_{IL}$ |          | 20  |     | 20  | ns   |
| t <sub>KQX</sub>  | t <sub>CLKHQX</sub>   | Clock to Output Transition<br>Clock to BINV Transition<br>Clock to WAIT Transition | $\overline{E} = V_{IL}$                        | 4        |     | 4   |     | ns   |
| t <sub>LHAX</sub> | t <sub>ADVHAX</sub>   | Latch Enable High to<br>Address transition                                         |                                                | 13       |     | 13  |     | ns   |
| t <sub>LLK</sub>  | t <sub>AVDLCLKH</sub> | Latch Enable Low to Clock                                                          |                                                | 7        |     | 7   |     | ns   |

Figure 12. Synchronous Burst Read



**Table 29. Write AC Characteristics, Write Enable Controlled**  
 ( $T_A = -40$  to  $85$  °C;  $V_{DD} = V_{DDQ} = 1.7V$  to  $2.0V$ )

| Symbol              | Alt               | Parameter                                 | M58MR016 |     |     |     | Unit |
|---------------------|-------------------|-------------------------------------------|----------|-----|-----|-----|------|
|                     |                   |                                           | 100      |     | 120 |     |      |
|                     |                   |                                           | Min      | Max | Min | Max |      |
| t <sub>AVAV</sub>   | t <sub>WC</sub>   | Address Valid to Next Address Valid       | 100      |     | 120 |     | ns   |
| t <sub>AVLH</sub>   |                   | Address Valid to Latch Enable High        | 10       |     | 10  |     | ns   |
| t <sub>DVWH</sub>   | t <sub>DS</sub>   | Input Valid to Write Enable High          | 40       |     | 40  |     | ns   |
| t <sub>ELLH</sub>   |                   | Chip Enable Low to Latch Enable High      | 10       |     | 10  |     | ns   |
| t <sub>ELWL</sub>   | t <sub>CS</sub>   | Chip Enable Low to Write Enable Low       | 0        |     | 0   |     | ns   |
| t <sub>GHLL</sub>   |                   | Output Enable High to Latch Enable Low    | 20       |     | 20  |     | ns   |
| t <sub>GHWL</sub>   |                   | Output Enable High to Write Enable Low    | 20       |     | 20  |     | ns   |
| t <sub>LHAX</sub>   |                   | Latch Enable High to Address Transition   | 10       |     | 10  |     | ns   |
| t <sub>LHWH</sub>   |                   | Latch Enable High to Write Enable High    | 10       |     | 10  |     | ns   |
| t <sub>LLLH</sub>   |                   | Latch Enable Pulse Width                  | 10       |     | 10  |     | ns   |
| t <sub>VDHEL</sub>  | t <sub>VCS</sub>  | V <sub>DD</sub> High to Chip Enable Low   | 50       |     | 50  |     | μs   |
| t <sub>VPPHWH</sub> |                   | V <sub>PP</sub> High to Write Enable High | 200      |     | 200 |     | ns   |
| t <sub>WHDX</sub>   | t <sub>DH</sub>   | Write Enable High to Input Transition     | 0        |     | 0   |     | ns   |
| t <sub>WHEH</sub>   | t <sub>CH</sub>   | Write Enable High to Chip Enable High     | 0        |     | 0   |     | ns   |
| t <sub>WHGL</sub>   | t <sub>OEHL</sub> | Write Enable High to Output Enable Low    | 0        |     | 0   |     | ns   |
| t <sub>WHLL</sub>   |                   | Write Enable High to Latch Enable Low     | 0        |     | 0   |     | ns   |
| t <sub>WHVPPL</sub> |                   | Write Enable High to V <sub>PP</sub> Low  | 200      |     | 200 |     | ns   |
| t <sub>WHWL</sub>   | t <sub>WPH</sub>  | Write Enable High to Write Enable Low     | 30       |     | 30  |     | ns   |
| t <sub>WHWPV</sub>  |                   | Write Enable High to Write Protect Valid  | 200      |     | 200 |     | ns   |
| t <sub>WLWH</sub>   | t <sub>WP</sub>   | Write Enable Low to Write Enable High     | 50       |     | 50  |     | ns   |
| t <sub>WPVWH</sub>  |                   | Write Protect Valid to Write Enable High  | 200      |     | 200 |     | ns   |



**Table 30. Write AC Characteristics, Chip Enable Controlled**  
 ( $T_A = -40$  to  $85\text{ }^{\circ}\text{C}$ ;  $V_{DD} = V_{DDQ} = 1.7\text{V}$  to  $2.0\text{V}$ )

| Symbol              | Alt              | Parameter                                | M58MR016 |     |     |     | Unit |
|---------------------|------------------|------------------------------------------|----------|-----|-----|-----|------|
|                     |                  |                                          | 100      |     | 120 |     |      |
|                     |                  |                                          | Min      | Max | Min | Max |      |
| t <sub>AVAV</sub>   | t <sub>WC</sub>  | Address Valid to Next Address Valid      | 100      |     | 120 |     | ns   |
| t <sub>AVLH</sub>   |                  | Address Valid to Latch Enable High       | 10       |     | 10  |     | ns   |
| t <sub>DVEH</sub>   | t <sub>DS</sub>  | Input Valid to Chip Enable High          | 40       |     | 40  |     | ns   |
| t <sub>EHDx</sub>   | t <sub>DH</sub>  | Chip Enable High to Input Transition     | 0        |     | 0   |     | ns   |
| t <sub>EHEL</sub>   | t <sub>CPH</sub> | Chip Enable High to Chip Enable Low      | 30       |     | 30  |     | ns   |
| t <sub>EHWLH</sub>  | t <sub>WH</sub>  | Chip Enable High to Write Enable High    | 0        |     | 0   |     | ns   |
| t <sub>ELEH</sub>   | t <sub>CP</sub>  | Chip Enable Low to Chip Enable High      | 60       |     | 60  |     | ns   |
| t <sub>ELLH</sub>   |                  | Chip Enable Low to Latch Enable High     | 10       |     | 10  |     | ns   |
| t <sub>GHLL</sub>   |                  | Output Enable High to Latch Enable Low   | 20       |     | 20  |     | ns   |
| t <sub>LHAX</sub>   |                  | Latch Enable High to Address Transition  | 10       |     | 10  |     | ns   |
| t <sub>LHEH</sub>   |                  | Latch Enable High to Chip Enable High    | 10       |     | 10  |     | ns   |
| t <sub>LLLH</sub>   |                  | Latch Enable Pulse Width                 | 10       |     | 10  |     | ns   |
| t <sub>VDHEL</sub>  | t <sub>VCS</sub> | V <sub>DD</sub> High to Chip Enable Low  | 50       |     | 50  |     | μs   |
| t <sub>VPPHEH</sub> |                  | V <sub>PP</sub> High to Chip Enable High | 200      |     | 200 |     | ns   |
| t <sub>EHVPPL</sub> |                  | Chip Enable High to V <sub>PP</sub> Low  | 200      |     | 200 |     | ns   |
| t <sub>EHWPV</sub>  |                  | Chip Enable High to Write Protect Valid  | 200      |     | 200 |     | ns   |
| t <sub>WLEL</sub>   | t <sub>WS</sub>  | Chip Enable Low to Chip Enable Low       | 0        |     | 0   |     | ns   |
| t <sub>WPVEH</sub>  |                  | Write Protect Valid to Chip Enable High  | 200      |     | 200 |     | ns   |

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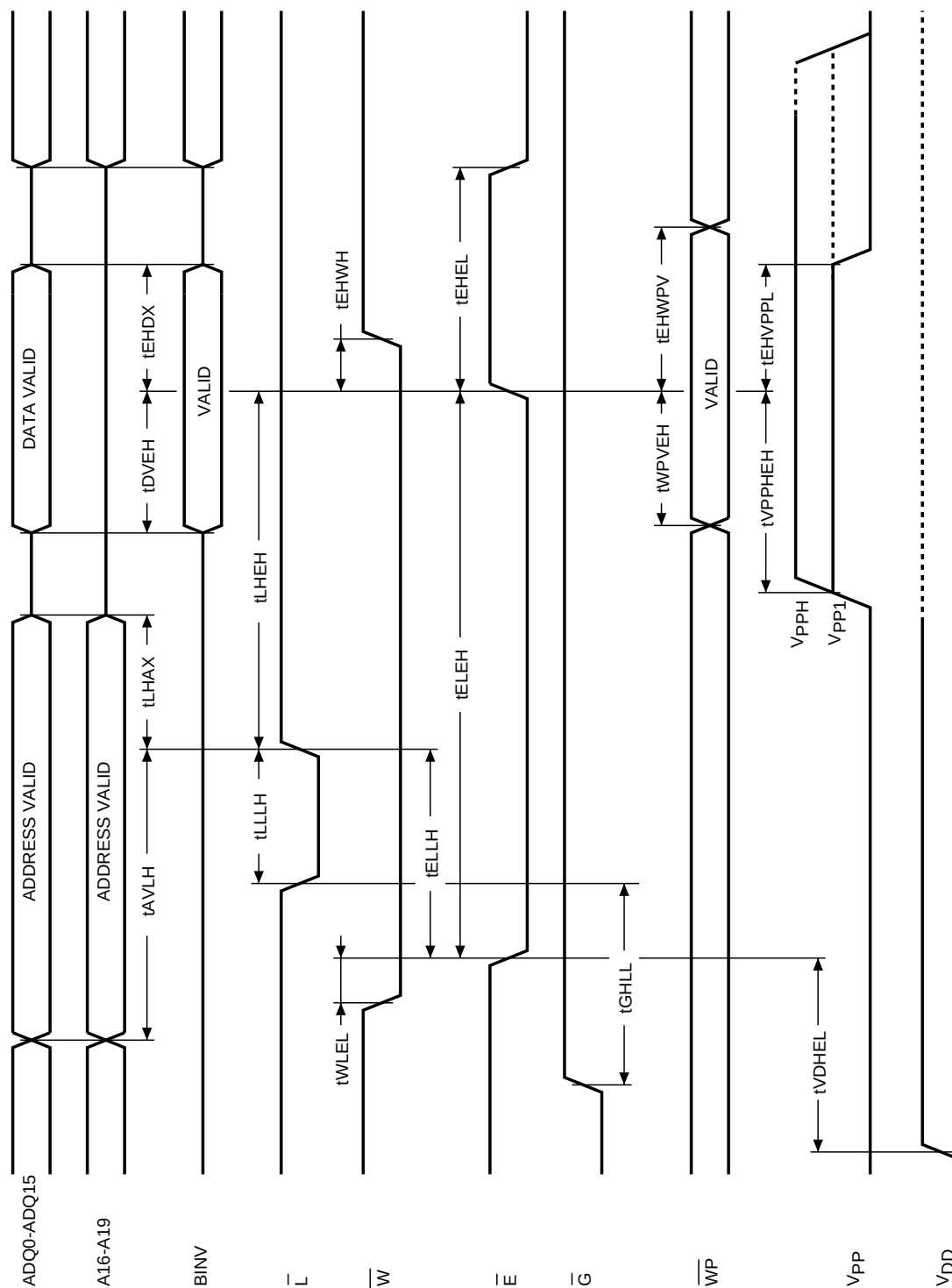
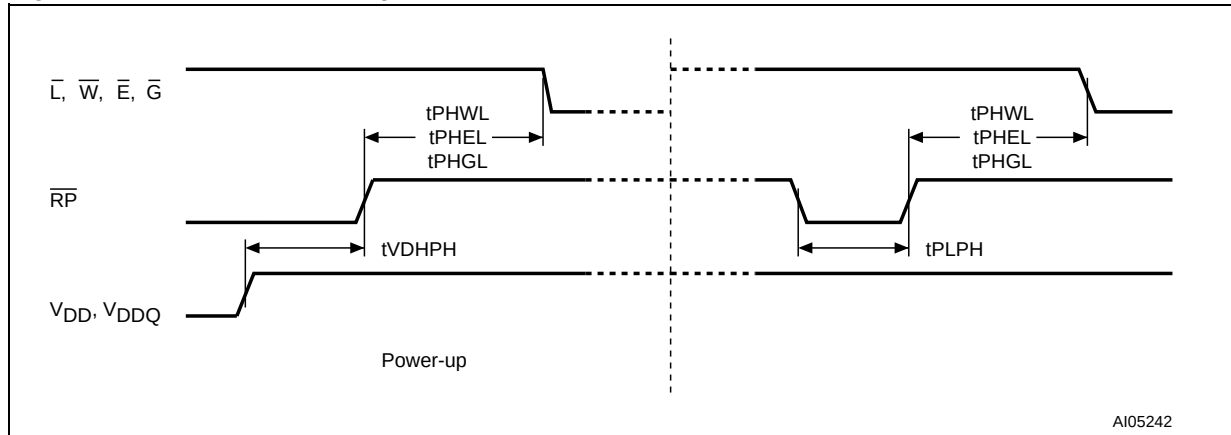


Figure 15. Reset and Power-up AC Waveforms



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Table 31. Reset and Power-up AC Characteristics

| Symbol                                 | Parameter                    | Test Condition           | Min | Unit    |
|----------------------------------------|------------------------------|--------------------------|-----|---------|
| $t_{PLPH}^{(1,2)}$                     | $\overline{RP}$ Pulse Width  |                          | 100 | ns      |
| $t_{PHEL}$<br>$t_{PHLL}$<br>$t_{PHWL}$ | Reset High to Device Enabled | During Program and Erase | 50  | $\mu s$ |
|                                        |                              | Other Conditions         | 30  | ns      |
| $t_{VDHPH}^{(3)}$                      | Supply Valid to Reset High   |                          | 50  | $\mu s$ |

Note: 1. The device Reset is possible but not guaranteed if  $t_{PLPH} < 100ns$ .

2. Sampled only, not 100% tested.

3. It is important to assert  $\overline{RP}$  in order to allow proper CPU initialization during Power-up or System reset.

Table 32. Program, Erase Times and Program, Erase Endurance Cycles

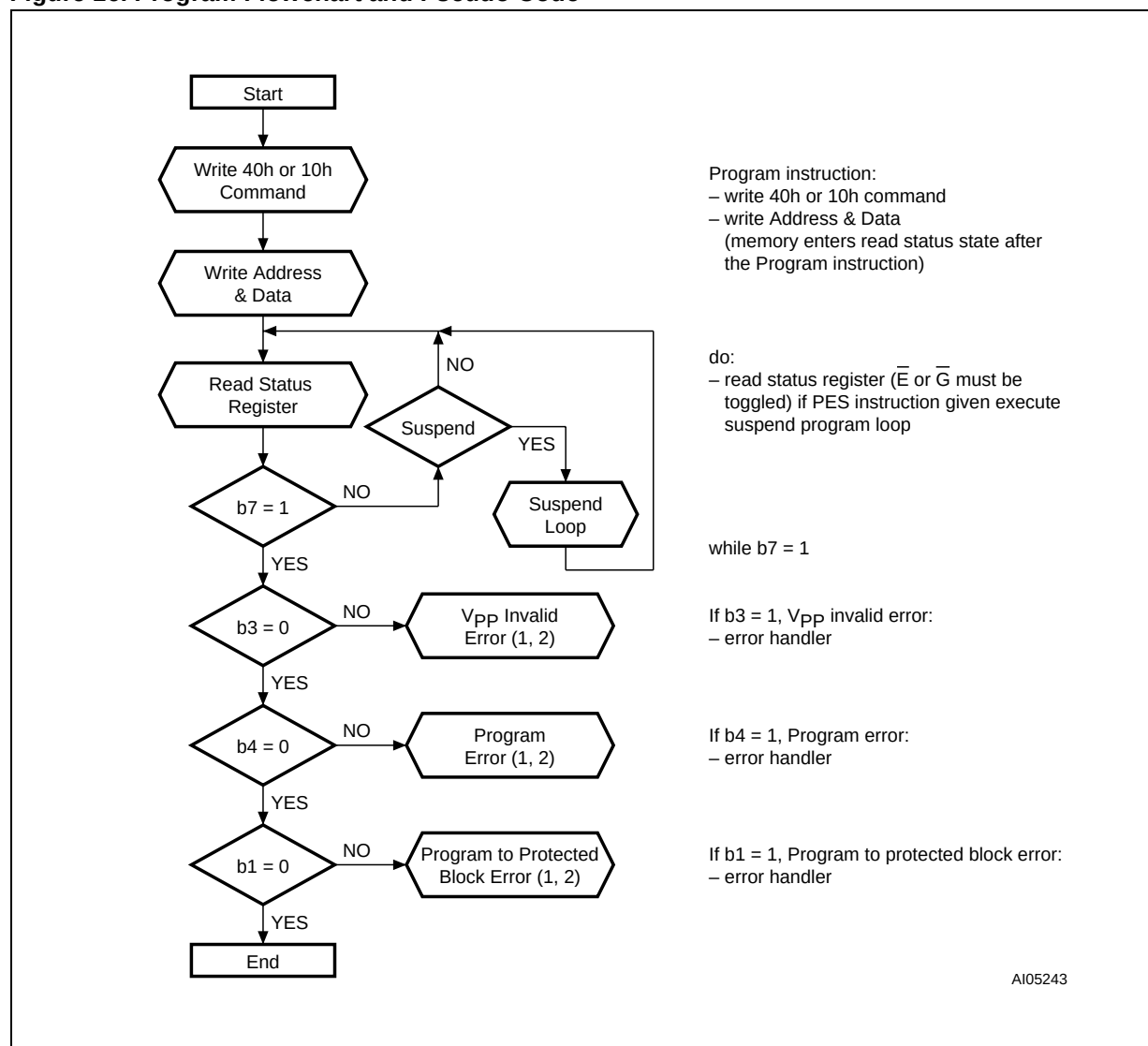
(T<sub>A</sub> = -40 to 85°C; V<sub>DD</sub> = V<sub>DDQ</sub> = 1.7V to 2.0V, V<sub>PP</sub> = V<sub>DD</sub> unless otherwise specified)

| Parameter                                                | Min     | Max <sup>(1)</sup> | Typ | Typical after 100k W/E Cycles | Unit    |
|----------------------------------------------------------|---------|--------------------|-----|-------------------------------|---------|
| Parameter Block (4 K-Word) Erase (Preprogrammed)         |         | 2.5                | 0.5 | 1                             | sec     |
| Main Block (32 K-Word) Erase (Preprogrammed)             |         | 10                 | 1   | 3                             | sec     |
| Bank Erase (Preprogrammed, Bank A)                       |         |                    | 4   |                               | sec     |
| Bank Erase (Preprogrammed, Bank B)                       |         |                    | 15  |                               | sec     |
| Chip Program <sup>(2)</sup>                              |         |                    | 40  |                               | sec     |
| Chip Program (DPG, V <sub>PP</sub> = 12V) <sup>(2)</sup> |         |                    | 20  |                               | sec     |
| Word Program <sup>(3)</sup>                              |         | 200                | 10  | 10                            | $\mu s$ |
| Double Word Program                                      |         | 200                | 10  | 10                            | $\mu s$ |
| Tetra Word Program                                       |         | 200                | 10  | 10                            | $\mu s$ |
| Program/Erase Cycles (per Block)                         | 100,000 |                    |     |                               | cycles  |

Note: 1. Max values refer to the maximum time allowed by the internal algorithm before error bit is set. Worst case conditions program or erase should perform significantly better.

2. Excludes the time needed to execute the sequence for program instruction.

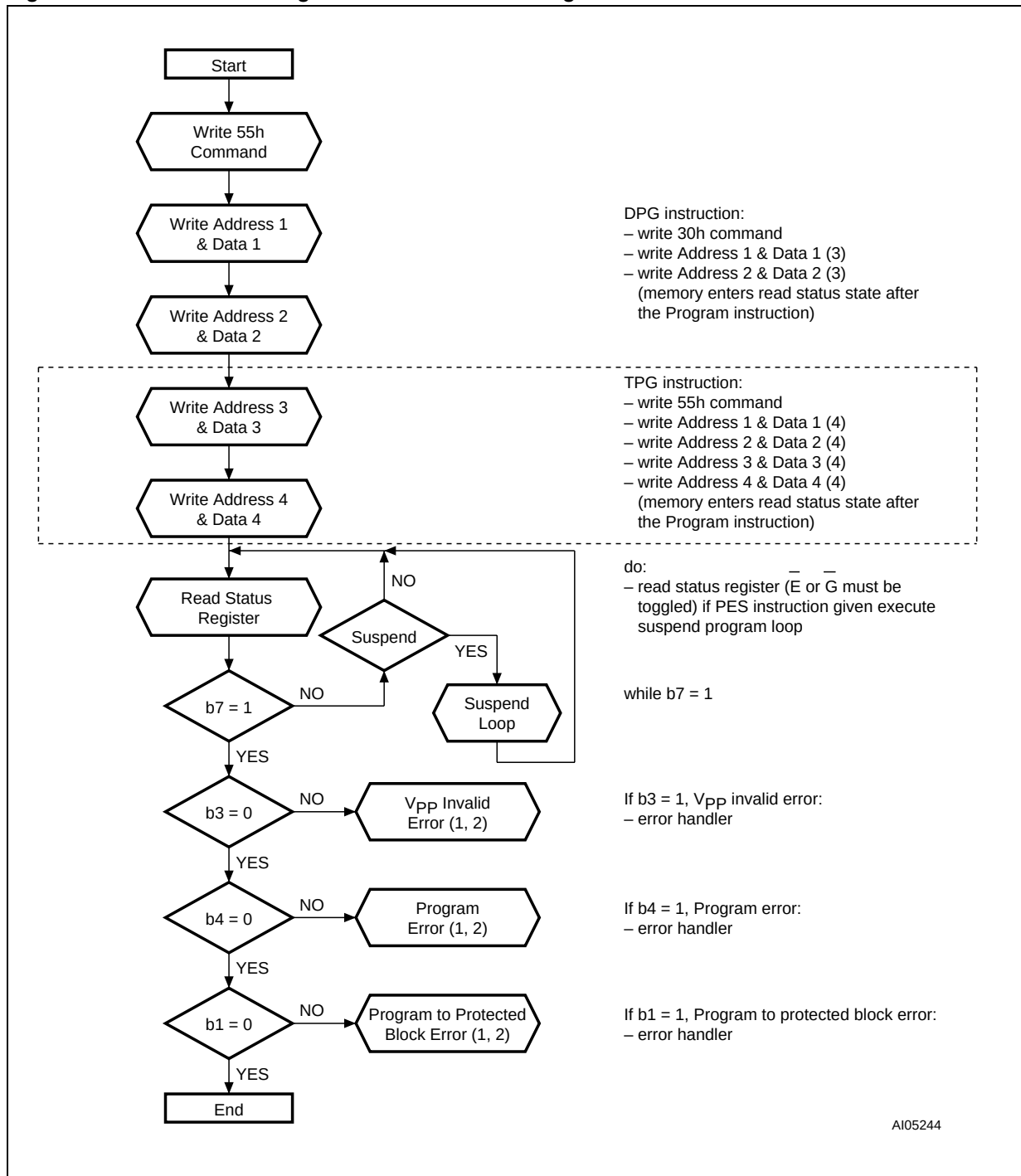
3. Same timing value if V<sub>PP</sub> = 12V.

Figure 16. Program Flowchart and Pseudo Code <sup>(1)</sup>

Note: 1. Status check of b1 (Protected Block), b3 (V<sub>pp</sub> Invalid) and b4 (Program Error) can be made after each program operation or after a program sequence.

2. If an error is found, the Status Register must be cleared (CLRS instruction) before further P/E.C. operations.



Figure 17. Double Word Program and Tetra Word Program Flowchart and Pseudo code <sup>(1)</sup>

- Note: 1. Status check of b1 (Protected Block), b3 (VPP Invalid) and b4 (Program Error) can be made after each program operation or after a program sequence.
2. If an error is found, the Status Register must be cleared (CLRS instruction) before further P/E.C. operations.
3. Address 1 and address 2 must be consecutive addresses differing only for address bit A0.
4. Address, address 2, address 3 and address 4 must be consecutive addresses differing only for address bit A1-A0.

Figure 18. Program Suspend & Resume Flowchart and Pseudo Code

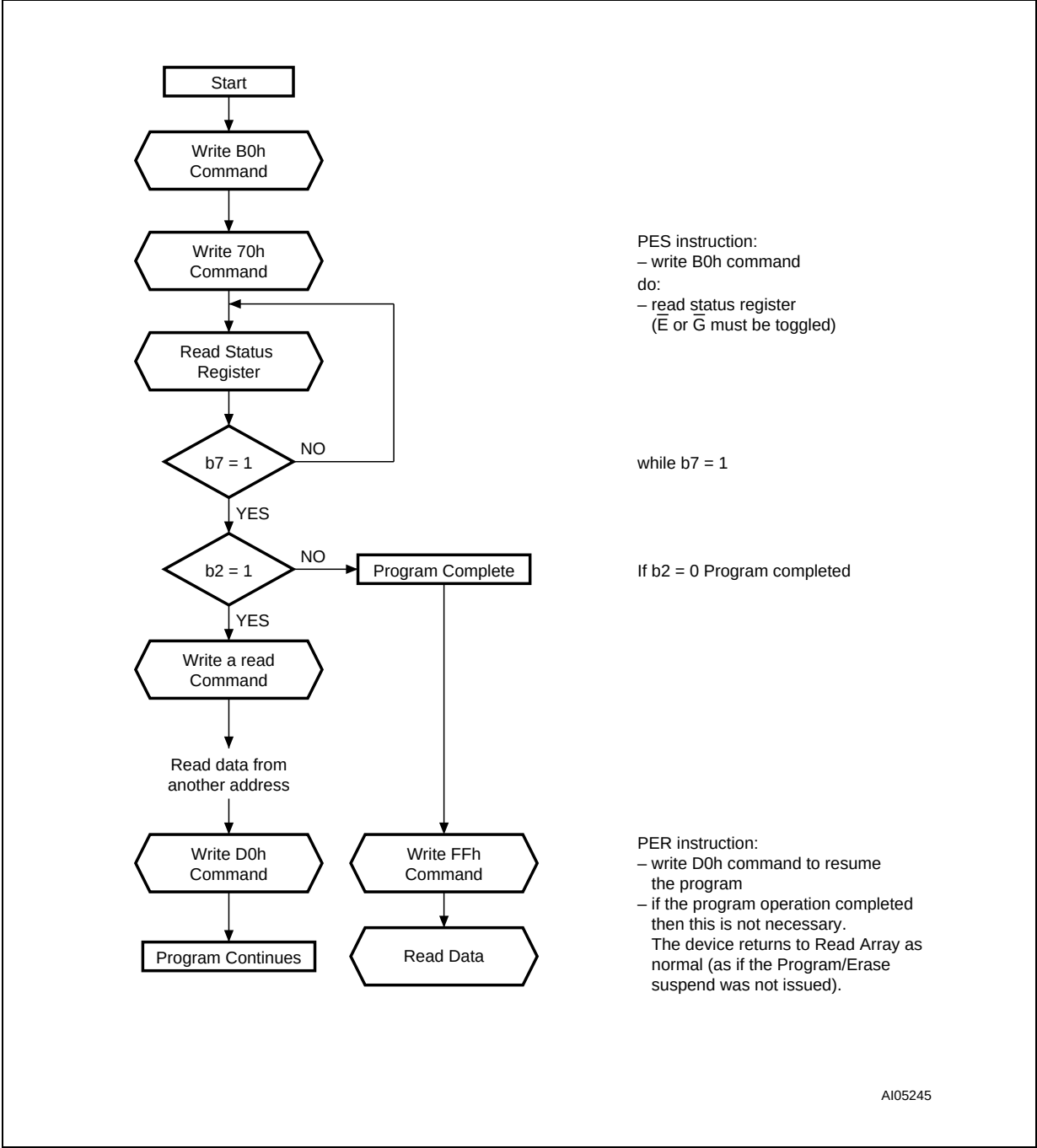


Figure 19. Block Erase Flowchart and Pseudo Code

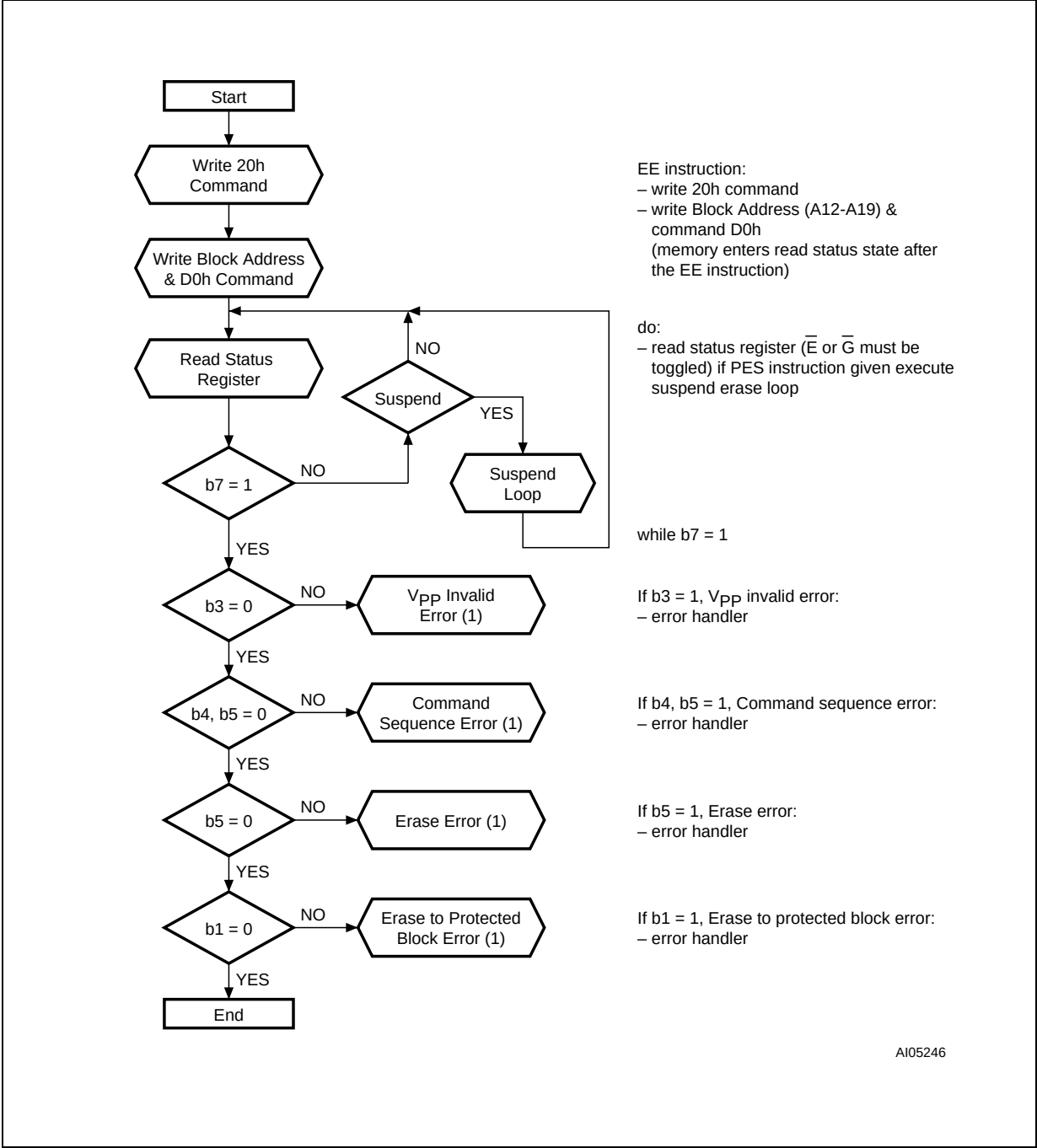


Figure 20. Erase Suspend & Resume Flowchart and Pseudo Code

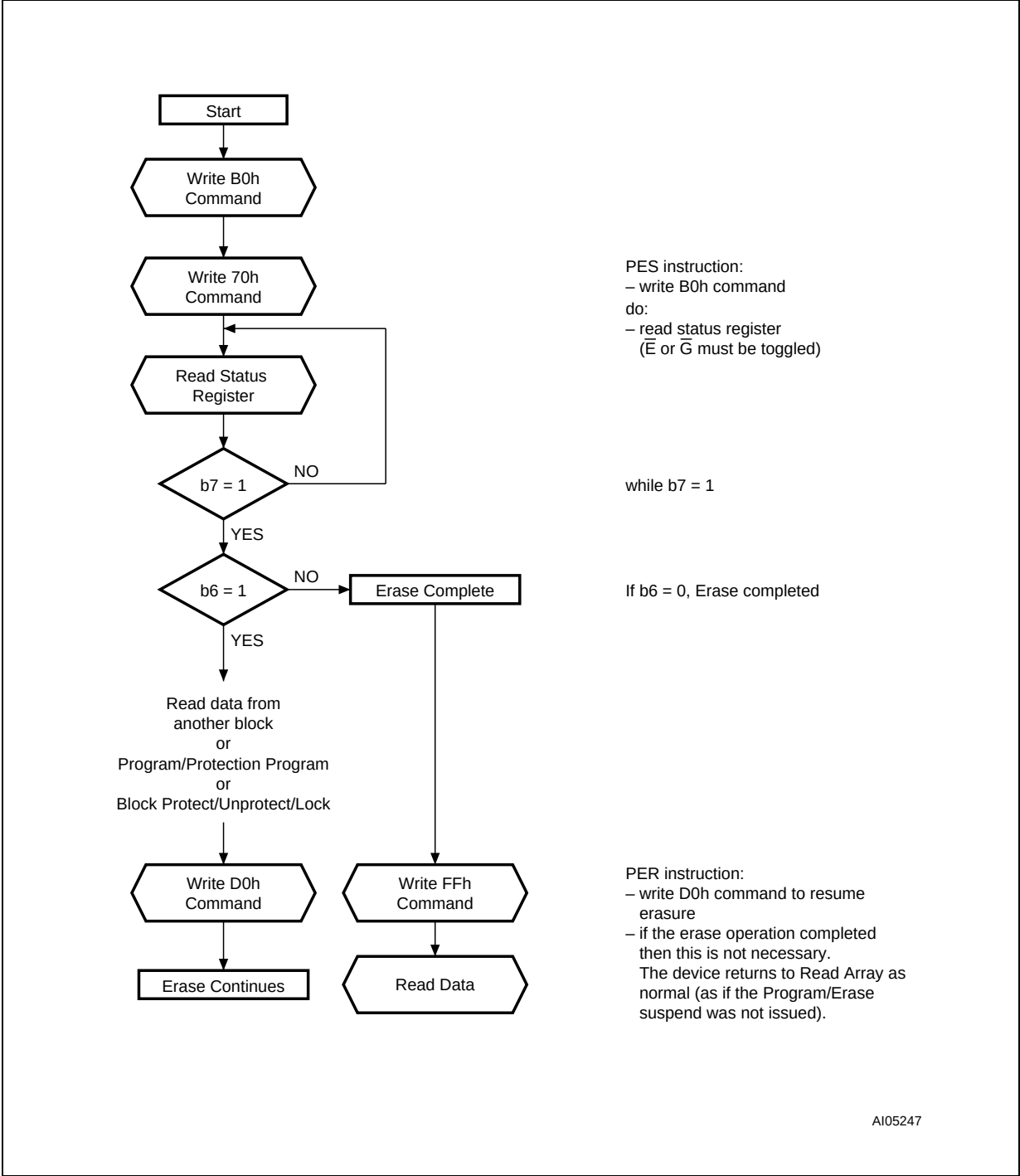


Table 33. Command Interface States - Lock table

| Current State of the Other Partition | Current State of the Current Partition |                                       | Command Input to the Current Partition (and Next State of the Current Partition) |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
|--------------------------------------|----------------------------------------|---------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|----------------------------------------------------------|-----------------------------------|-----------------------------------|-------------------------|
|                                      | Mode                                   | State                                 | Others                                                                           | Read Memory Array (FFh)                           | Erase Confirm P/E Resume BU Confirm (D0h) | Read Status Register (70h)                        | Clear Status Register (50h)                       | Read elect. sign. (90h)                           | Read CFI (98h)                                    | Block Protect-Unprotect-Lock setup write RCR setup (60h) | Block Protect Confirm (01h)       | Block Lock Confirm (2Fh)          | Write RCR Confirm (03h) |
| Any State                            | Read                                   | Array                                 | SEE MODIFY TABLE                                                                 | Read Array                                        | Read Array                                | Read Status Register                              | Read Array                                        | Read Elect. Sign.                                 | Read CFI                                          | Block Protect-Unprotect-LockSetup Write RCR Setup        | Read Array                        | Read Array                        | Read Array              |
|                                      |                                        | CFI                                   |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
|                                      |                                        | Electronic Signature                  |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
|                                      |                                        | Status                                |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Any State                            | Protect Unprotect Lock RCR             | Setup                                 | Block Protect-Unprotect-LockError Write RCR Error                                | Block Protect-Unprotect-LockError Write RCR Error | Block Protect-Unprotect-LockBlock         | Block Protect-Unprotect-LockError Write RCR Error | Block Protect-Unprotect-LockError Write RCR Error | Block Protect-Unprotect-LockError Write RCR Error | Block Protect-Unprotect-LockError Write RCR Error | Block Protect-Unprotect-LockError Write RCR Error        | Block Protect-Unprotect-LockBlock | Block Protect-Unprotect-LockBlock | Set RCR                 |
|                                      |                                        | Error                                 | SEE MODIFY TABLE                                                                 | Read Array                                        | Read Array                                | Read Status Register                              | Read Array                                        | Read Elect. Sign.                                 | Read CFI                                          | Block Protect-Unprotect-LockSetup Write RCR Setup        | Read Array                        | Read Array                        | Read Array              |
|                                      |                                        | Protect-Unprotect-LockBlock           |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
|                                      |                                        | Set RCR                               |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Any State                            | Protection Register                    | Done                                  | SEE MODIFY TABLE                                                                 | Read Array                                        | Read Array                                | Read Status Register                              | Read Array                                        | Read Elect. Sign.                                 | Read CFI                                          | Block Protect-Unprotect-LockSetup Write RCR Setup        | Read Array                        | Read Array                        | Read Array              |
| Any State                            | Program-Multiple Program               | Done                                  | SEE MODIFY TABLE                                                                 | Read Array                                        | Read Array                                | Read Status Register                              | Read Array                                        | Read Elect. Sign.                                 | Read CFI                                          | Block Protect-Unprotect-LockSetup Write RCR Setup        | Read Array                        | Read Array                        | Read Array              |
| Setup                                | Program Suspend                        | Read Array, CFI, Elect. Sign., Status | SEE MODIFY TABLE                                                                 | PS Read Array                                     | Program (Busy)                            | PS Read Status Register                           | PS Read Array                                     | PS Read Elect. Sign.                              | PS Read CFI                                       | PS Read Array                                            | PS Read Array                     | PS Read Array                     | PS Read Array           |
| Idle                                 |                                        |                                       |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Erase Suspend                        |                                        |                                       |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Idle                                 | Block-Bank Erase                       | Setup                                 | Erase Error                                                                      | Erase Error                                       | Erase (Busy)                              | Erase Error                                       | Erase Error                                       | Erase Error                                       | Erase Error                                       | Erase Error                                              | Erase Error                       | Erase Error                       | Erase Error             |
| Any State                            |                                        | Error                                 | SEE MODIFY TABLE                                                                 | Read Array                                        | Read Array                                | Read Status Register                              | Read Array                                        | Read Elect. Sign.                                 | Read CFI                                          | Block Protect-Unprotect-LockSetup Write RCR Setup        | Read Array                        | Read Array                        | Read Array              |
|                                      |                                        | Done                                  |                                                                                  |                                                   |                                           |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Setup                                | Erase Suspend                          | Read Array, CFI, Elect. Sign., Status | SEE MADIFY TABLE                                                                 | ES Read Array                                     | Erase (Busy)                              | ES Read Status Register                           | ES Read Array                                     | ES Read Elect. Sign.                              | ES Read CFI                                       | Block Protect-Unprotect-LockSetup Write RCR Setup        | ES Read Array                     | ES Read Array                     | ES Read Array           |
| Busy                                 |                                        |                                       |                                                                                  |                                                   | ES Read Array                             |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Idle                                 |                                        |                                       |                                                                                  |                                                   | Erase (Busy)                              |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |
| Program Suspend                      |                                        |                                       |                                                                                  |                                                   | ES Read Array                             |                                                   |                                                   |                                                   |                                                   |                                                          |                                   |                                   |                         |

Table 34. Command Interface States - Modify table

| Current State of the Other Partition | Current State of the Current Partition |                                                   | Command Input to the Current Partition (and Next State of the Current Partition) |                            |                            |                             |                            |                                  |                            |                            |                            |                            |                            |                            |              |                         |                |
|--------------------------------------|----------------------------------------|---------------------------------------------------|----------------------------------------------------------------------------------|----------------------------|----------------------------|-----------------------------|----------------------------|----------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------|-------------------------|----------------|
|                                      | Mode                                   | State                                             | Others                                                                           | Program Setup (10h/40h)    | Block Erase Setup (20h)    | Program-Erase Suspend (B0h) | OTP Setup (C0h)            | Multiple Program Setup (30h/55h) | Bank Erase Setup (80h)     |                            |                            |                            |                            |                            |              |                         |                |
| Setup                                | Read                                   | Array, CFI, Electronic Signature, Status Register | SEE LOCK TABLE                                                                   | Read Array                 | Read Array                 | Read Array                  | Read Array                 | Read Array                       | Read Array                 |                            |                            |                            |                            |                            |              |                         |                |
| Busy                                 |                                        |                                                   |                                                                                  | Program setup              | Block Erase Setup          |                             | OTP Setup                  | Multiple Program Setup           | Bank Erase Setup           |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 |                                        |                                                   |                                                                                  |                            | Read Array                 |                             | Read Array                 | Read Array                       | Read Array                 | Read Array                 |                            |                            |                            |                            |              |                         |                |
| Erase Suspend                        |                                        |                                                   |                                                                                  | Read Array                 |                            |                             |                            |                                  |                            |                            | Read Array                 | Read Array                 | Read Array                 | Read Array                 |              |                         |                |
| Program Suspend                      |                                        |                                                   |                                                                                  |                            | Read Array                 |                             | Read Array                 | Read Array                       | Read Array                 | Read Array                 |                            |                            |                            |                            |              |                         |                |
| Setup                                | Protect Unprotect-Lock/ RCR            | Error, Protect- Unprotect- LockBlock, Set RCR     | SEE LOCK TABLE                                                                   | Read Array                 |                            | Read Array                  |                            |                                  |                            |                            | Read Array                 | Read Array                 | Read Array                 | Read Array                 |              |                         |                |
| Busy                                 |                                        |                                                   |                                                                                  | Program setup              | Block Erase Setup          | OTP Setup                   | Multiple Program Setup     | Bank Erase Setup                 |                            |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 |                                        |                                                   |                                                                                  |                            | Read Array                 | Read Array                  | Read Array                 | Read Array                       | Read Array                 | Read Array                 |                            |                            |                            |                            |              |                         |                |
| Erase Suspend                        |                                        |                                                   |                                                                                  | Read Array                 |                            |                             |                            |                                  |                            |                            |                            | Read Array                 | Read Array                 | Read Array                 | Read Array   |                         |                |
| Program Suspend                      |                                        |                                                   |                                                                                  |                            | Read Array                 | Read Array                  | Read Array                 | Read Array                       | Read Array                 |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 | Protection Register                    | Setup                                             | Protection Register (Busy)                                                       | Protection Register (Busy) |                            |                             |                            |                                  |                            | Protection Register (Busy) | Protection Register (Busy) | Protection Register (Busy) | Protection Register (Busy) | Protection Register (Busy) |              |                         |                |
| Setup                                |                                        | Busy                                              | Protection Register (Busy)                                                       | Protection Register (Busy) | Protection Register (Busy) | Protection Register (Busy)  | Protection Register (Busy) | Protection Register (Busy)       | Protection Register (Busy) |                            |                            |                            |                            |                            |              |                         |                |
| Busy                                 |                                        | Done                                              | SEE LOCK TABLE                                                                   | Read Array                 | Read Array                 | Read Array                  | Read Array                 | Read Array                       | Read Array                 |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 |                                        |                                                   |                                                                                  | Program Setup              | Block Erase Setup          |                             | OTP Setup                  | Multiple Program Setup           | Bank Erase Setup           |                            |                            |                            |                            |                            |              |                         |                |
| Erase Suspend                        |                                        |                                                   |                                                                                  | Read Array                 | Read Array                 |                             | Read Array                 | Read Array                       | Read Array                 | Read Array                 |                            |                            |                            |                            |              |                         |                |
| Program Suspend                      |                                        |                                                   |                                                                                  |                            |                            |                             |                            |                                  |                            |                            | Read Array                 | Read Array                 | Read Array                 | Read Array                 | Read Array   |                         |                |
| Any State                            |                                        |                                                   |                                                                                  |                            |                            |                             |                            |                                  |                            |                            |                            |                            |                            |                            |              | Setup                   | Program (Busy) |
| Idle                                 | Busy                                   | Program (Busy)                                    | Program (Busy)                                                                   | Program (Busy)             | PS Read Status Register    | Program (Busy)              | Program (Busy)             | Program (Busy)                   |                            |                            |                            |                            |                            |                            |              |                         |                |
| Setup                                |                                        |                                                   |                                                                                  |                            |                            |                             |                            |                                  | Program-Multiple Program   | Done                       | SEE LOCK TABLE             | Read Array                 | Read Array                 | Read Array                 | Read Array   | Read Array              | Read Array     |
| Busy                                 | Program Setup                          | Block Erase Setup                                 | OTP Setup                                                                        | Multiple Program Setup     | Bank Erase Setup           |                             |                            |                                  |                            |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 |                                        | Read Array                                        | Read Array                                                                       | Read Array                 | Read Array                 | Read Array                  | Read Array                 | Read Array                       |                            |                            |                            |                            |                            |                            |              |                         |                |
| Erase Suspend                        | Read Array                             |                                                   |                                                                                  |                            |                            |                             |                            |                                  |                            |                            |                            | Read Array                 | Read Array                 |                            | Read Array   | Read Array              | Read Array     |
| Program Suspend                      |                                        |                                                   |                                                                                  |                            |                            |                             |                            |                                  |                            |                            |                            |                            |                            |                            |              |                         |                |
| Setup                                | Program Suspend                        | Read Array, CFI, Elect. Sign., Status Register    | SEE LOCK TABLE                                                                   | PS Read Array              | PS Read Array              | PS Read Array               | PS Read Array              | PS Read Array                    | PS Read Array              |                            |                            |                            |                            |                            |              |                         |                |
| Idle                                 |                                        |                                                   |                                                                                  | Setup                      | SEE LOCK TABLE             | Erase Error                 | Erase Error                | Erase Error                      | Erase Error                | Erase Error                | Erase Error                |                            |                            |                            |              |                         |                |
| Erase Suspend                        |                                        |                                                   |                                                                                  |                            |                            |                             |                            |                                  |                            |                            |                            | Busy                       | Erase (Busy)               | Erase (Busy)               | Erase (Busy) | ES Read Status Register | Erase (Busy)   |
| Idle                                 | Block-Bank Erase                       | Setup                                             | SEE LOCK TABLE                                                                   | Erase Error                | Erase Error                | Erase Error                 | Erase Error                | Erase Error                      | Erase Error                |                            |                            |                            |                            |                            |              |                         |                |
| Setup                                |                                        | Read Array, CFI, Elect. Sign., Status Register    | SEE LOCK TABLE                                                                   | ES Read Array              | ES Read Array              | ES Read Array               | ES Read Array              | ES Read Array                    | ES Read Array              |                            |                            |                            |                            |                            |              |                         |                |
| Busy                                 |                                        |                                                   |                                                                                  | Program Setup              |                            |                             |                            | Multiple Program Setup           |                            |                            |                            |                            |                            |                            |              |                         |                |
| Program Suspend                      |                                        |                                                   |                                                                                  | ES Read Array              |                            |                             |                            | ES Read Array                    |                            |                            |                            |                            |                            |                            |              |                         |                |

Table 35. Ordering Information Scheme

|                                                                                                                                       |           |     |    |   |   |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------|-----|----|---|---|
| Example:                                                                                                                              | M58MR016C | 100 | ZC | 6 | T |
| <b>Device Type</b>                                                                                                                    |           |     |    |   |   |
| M58                                                                                                                                   |           |     |    |   |   |
| <b>Architecture</b>                                                                                                                   |           |     |    |   |   |
| M = Multiplexed Address/Data, Dual Bank, Burst Mode                                                                                   |           |     |    |   |   |
| <b>Operating Voltage</b>                                                                                                              |           |     |    |   |   |
| R = 1.8V                                                                                                                              |           |     |    |   |   |
| <b>Device Function</b>                                                                                                                |           |     |    |   |   |
| 016C = 16 Mbit (x16), Dual Bank: 1/4-3/4 partitioning, Top Boot<br>016D = 16 Mbit (x16), Dual Bank: 1/4-3/4 partitioning, Bottom Boot |           |     |    |   |   |
| <b>Speed</b>                                                                                                                          |           |     |    |   |   |
| 100 = 100 ns<br>120 = 120 ns                                                                                                          |           |     |    |   |   |
| <b>Package</b>                                                                                                                        |           |     |    |   |   |
| ZC = TFBGA48: 0.5 mm pitch                                                                                                            |           |     |    |   |   |
| <b>Temperature Range</b>                                                                                                              |           |     |    |   |   |
| 6 = -40 to 85°C                                                                                                                       |           |     |    |   |   |
| <b>Option</b>                                                                                                                         |           |     |    |   |   |
| T = Tape & Reel packing                                                                                                               |           |     |    |   |   |

Devices are shipped from the factory with the memory content bits erased to '1'.

Table 36. Daisy Chain Ordering Scheme

|                             |          |     |   |
|-----------------------------|----------|-----|---|
| Example:                    | M58MR016 | -ZC | T |
| <b>Device Type</b>          |          |     |   |
| M58MR016                    |          |     |   |
| <b>Daisy Chain</b>          |          |     |   |
| -ZC = TFBGA48: 0.5 mm pitch |          |     |   |
| <b>Option</b>               |          |     |   |
| T = Tape & Reel Packing     |          |     |   |

For a list of available options (Speed, Package, etc...) or for further information on any aspect of this device, please contact the STMicroelectronics Sales Office nearest to you.

**Table 37. Document Revision History**

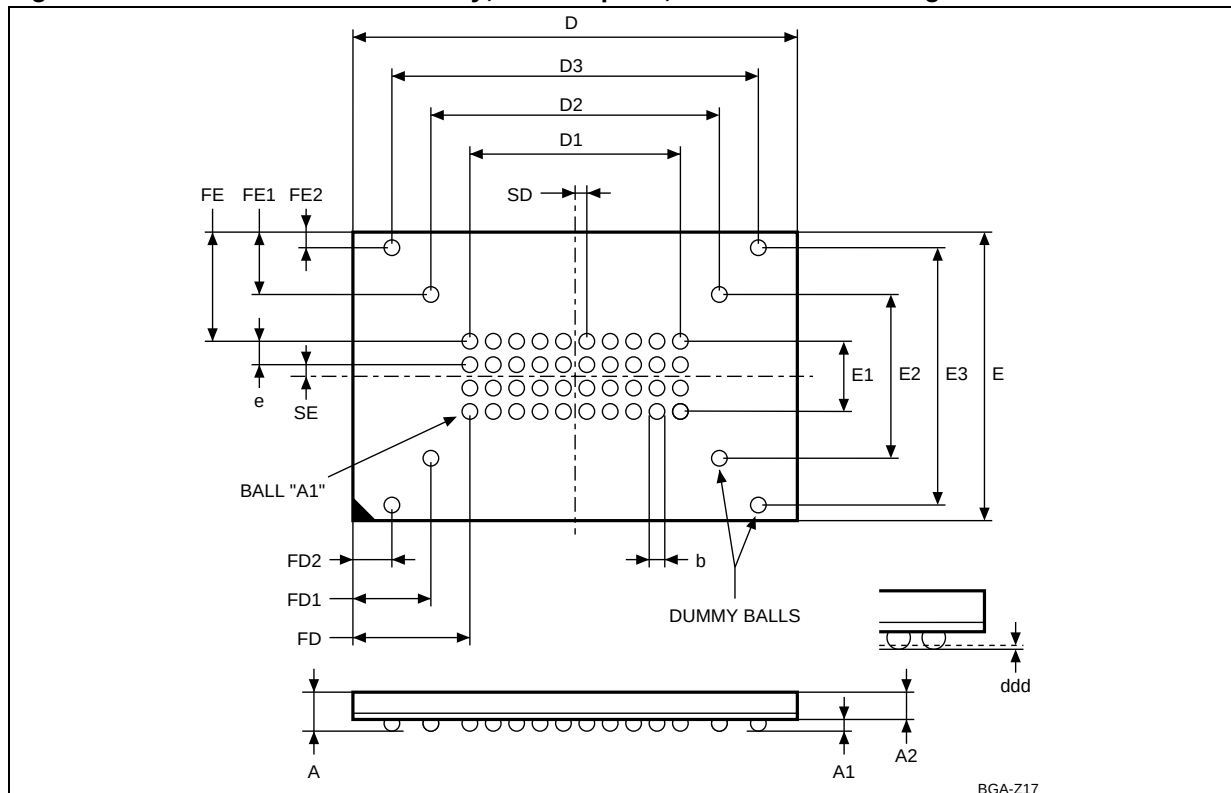
| Date        | Version | Revision Details                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12-Jun-2001 | -01     | First Issue                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 01-Aug-2002 | 1.1     | Revision numbering modified: a minor revision will be indicated by incrementing the digit after the dot, and a major revision, by incrementing the digit before the dot.(revision version 01 equals 1.0).<br>Supply voltage ranges $V_{DD}$ and $V_{DDQ}$ modified. Parameters $t_K$ , $t_{KQV}$ , $t_{KAX}$ and $t_{LHAX}$ modified in Table 28, Synchronous Burst Read AC Characteristics.<br>Document status changed from Product Preview to Preliminary Data. |



Table 38. TFBGA48 - 10 x 4 ball array, 0.5 mm pitch, Package Mechanical Data

| Symbol | millimeters |        |        | inches |        |        |
|--------|-------------|--------|--------|--------|--------|--------|
|        | Typ         | Min    | Max    | Typ    | Min    | Max    |
| A      |             | 0.950  | 1.200  |        | 0.0374 | 0.0472 |
| A1     |             | 0.200  | 0.300  |        | 0.0079 | 0.0118 |
| A2     | 0.790       |        |        | 0.0311 |        |        |
| b      | 0.300       | 0.250  | 0.350  | 0.0118 | 0.0098 | 0.0138 |
| D      | 10.530      | 10.480 | 10.580 | 0.4146 | 0.4126 | 0.4165 |
| D1     | 4.500       | —      | —      | 0.1772 | —      | —      |
| D2     | 6.500       | —      | —      | 0.2559 | —      | —      |
| D3     | 8.500       | —      | —      | 0.3346 | —      | —      |
| ddd    |             |        | 0.080  |        |        | 0.0031 |
| E      | 6.290       | 6.240  | 6.340  | 0.2476 | 0.2457 | 0.2496 |
| E1     | 1.500       | —      | —      | 0.0591 | —      | —      |
| E2     | 3.500       | —      | —      | 0.1378 | —      | —      |
| E3     | 5.500       | —      | —      | 0.2165 | —      | —      |
| e      | 0.500       | —      | —      | 0.0197 | —      | —      |
| FD     | 3.015       | —      | —      | 0.1187 | —      | —      |
| FD1    | 2.015       | —      | —      | 0.0793 | —      | —      |
| FD2    | 1.015       | —      | —      | 0.0400 | —      | —      |
| FE     | 2.395       | —      | —      | 0.0943 | —      | —      |
| FE1    | 1.395       | —      | —      | 0.0549 | —      | —      |
| FE2    | 0.395       | —      | —      | 0.0156 | —      | —      |
| SD     | 0.250       | —      | —      | 0.0098 | —      | —      |
| SE     | 0.250       | —      | —      | 0.0098 | —      | —      |

Figure 21. TFBGA48 - 10 x 4 ball array, 0.5 mm pitch, Bottom View Package Outline



Drawing is not to scale.



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