

FLASH AND SRAM COMBO MEMORY

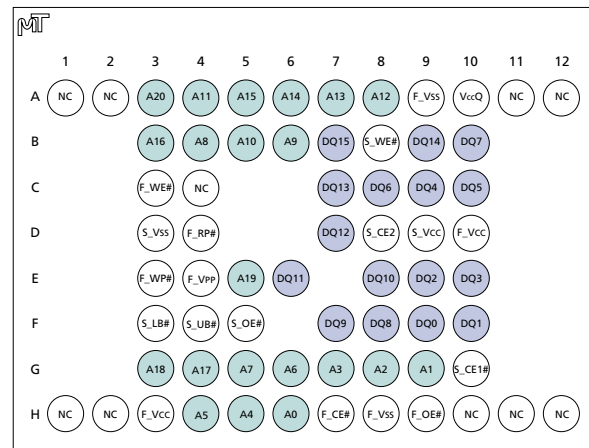
MT28C3214P2FL MT28C3214P2NFL

Low Voltage, Extended Temperature

FEATURES

- Flexible dual-bank architecture
- Support for true concurrent operations with no latency:
 - Read bank *b* during program bank *a* and vice versa
 - Read bank *b* during erase bank *a* and vice versa
- Organization: 2,048K x 16 (Flash)
256K x 16 (SRAM)
- Basic configuration:
 - Flash*
 - Bank *a* (4Mb Flash for data storage)
 - Eight 4K-word parameter blocks
 - Seven 32K-word blocks
 - Bank *b* (28Mb Flash for program storage)
 - Fifty-six 32K-word main blocks
 - SRAM*
 - 4Mb SRAM for data storage
 - 256K-words
- F_VCC , $VCCQ$, F_VPP , S_VCC voltages¹
 - 1.65V (MIN)/1.95V (MAX) F_VCC read voltage or 1.80V (MIN)/2.20V (MAX) F_VCC read voltage
 - 1.65V (MIN)/1.95V (MAX) S_VCC read voltage or 1.80V (MIN)/2.20V (MAX) S_VCC read voltage
 - 1.65V (MIN)/1.95V (MAX) $VCCQ$ or 1.80V (MIN)/2.20V (MAX) $VCCQ$
 - 1.80V (TYP) F_VPP (in-system PROGRAM/ERASE)
 - 0.0V (MIN)/2.20V (MAX) F_VPP (in-system PROGRAM/ERASE)²
 - 12V \pm 5% (HV) F_VPP (production programming compatibility)
- Asynchronous access time¹
 - Flash access time: 100ns or 110ns @ 1.65V F_VCC
 - SRAM access time: 100ns @ 1.65V S_VCC
- Page Mode read access¹
 - Interpage read access: 100ns/110ns @ 1.65V F_VCC
 - Intrapage read access: 35ns/45ns @ 1.65V F_VCC
- Low power consumption
- Enhanced suspend options
 - ERASE-SUSPEND-to-READ within same bank
 - PROGRAM-SUSPEND-to-READ within same bank
 - ERASE-SUSPEND-to-PROGRAM within same bank
- Read/Write SRAM during program/erase of Flash
- Dual 64-bit chip protection registers for security purposes
- PROGRAM/ERASE cycles
 - 100,000 WRITE/ERASE cycles per block

BALL ASSIGNMENT 66-Ball FBGA (Top View)



- Cross-compatible command set support
 - Extended command set
 - Common flash interface (CFI) compliant

NOTE: 1. These specifications are guaranteed for operation within either one of two voltage ranges, 1.65V–1.95V or 1.80V–2.20V. Use only one of the two voltage ranges for PROGRAM and ERASE operations.
2. MT28C3214P2NFL only.

OPTIONS

- Timing
 - 100ns -10
 - 110ns -11
- Boot Block
 - Top T
 - Bottom B
- $VPP1$ Range
 - 0.9V–2.2V None
 - 0.0V–2.2V N
- Operating Temperature Range
 - Commercial Temperature (0°C to +70°C) None
 - Extended Temperature (-40°C to +85°C) ET
- Package
 - 66-ball FBGA (8 x 8 grid) FL

MARKING

Part Number Example:

MT28C3214P2FL-10 TET

GENERAL DESCRIPTION

The MT28C3214P2FL and MT28C3214P2NFL combination Flash and SRAM memory devices provide a compact, low-power solution for systems where PCB real estate is at a premium. The dual-bank Flash is a high-performance, high-density, nonvolatile memory device with a revolutionary architecture that can significantly improve system performance.

This new architecture features:

- A two-memory-bank configuration supporting dual-bank burst operation;
- A high-performance bus interface providing a fast page data transfer; and
- A conventional asynchronous bus interface.

The device also provides soft protection for blocks by configuring soft protection registers with dedicated command sequences. For security purposes, dual 64-bit chip protection registers are provided.

The embedded WORD WRITE and BLOCK ERASE functions are fully automated by an on-chip write state machine (WSM). The WSM simplifies these operations and relieves the system processor of secondary tasks. An on-chip status register, one for each bank, can be used to monitor the WSM status to determine the progress of a PROGRAM/ERASE command.

The erase/program suspend functionality allows compatibility with existing EEPROM emulation software packages.

The device takes advantage of a dedicated power source for the Flash device (F_{VCC}) and a dedicated power source for the SRAM device (S_{VCC}), both at 1.65V–1.95V or 1.80V–2.20V for optimized power consumption and improved noise immunity. The MT28C3214P2FL and MT28C3214P2NFL devices support two V_{PP} voltage ranges, V_{PP1} and V_{PP2} . V_{PP1} is an in-circuit voltage of 0.9V–2.2V (MT28C3214P2FL) or 0.0V–2.2V (MT28C3214P2NFL). V_{PP2} is the production compatibility voltage of 12V \pm 5%. The 12V \pm 5% V_{PP2} is supported for a maximum of 100 cycles and 10 cumulative hours. See Table 1.

The MT28C3214P2FL and MT28C3214P2NFL devices contain an asynchronous 4Mb SRAM organized as 256K-words by 16 bits. These devices are fabricated using an advanced CMOS process and high-speed/ultra-low-power circuit technology.

The MT28C3214P2FL and MT28C3214P2NFL devices are packaged in a 66-ball FBGA package with 0.80mm pitch.

DEVICE MARKING

Due to the size of the package, Micron's standard part number is not printed on the top of each device. Instead, an abbreviated device mark comprised of a five-digit alphanumeric code is used. The abbreviated device marks are cross referenced to Micron part numbers in Table 2.

ARCHITECTURE AND MEMORY ORGANIZATION

The Flash memory device contains two separate memory banks (bank *a* and bank *b*) for simultaneous READ and WRITE operations. Bank *a* is 4Mb deep and contains 8 x 4K-word parameter blocks and seven 32K-word blocks. Bank *b* is 28Mb deep, is equally sectorized, and contains fifty-six 32K-word blocks.

Figures 2 and 3 show the top and bottom memory organizations.

Table 1
 V_{PP} Voltage Ranges

| DEVICE | VOLTAGE RANGE | |
|----------------|---------------|-------------|
| | V_{PP1} | V_{PP2} |
| MT28C3214P2FL | 0.9V–2.2V | 11.4V–12.6V |
| MT28C3214P2NFL | 0.0V–2.2V | 11.4V–12.6V |

Table 2
Cross Reference for Abbreviated Device Marks

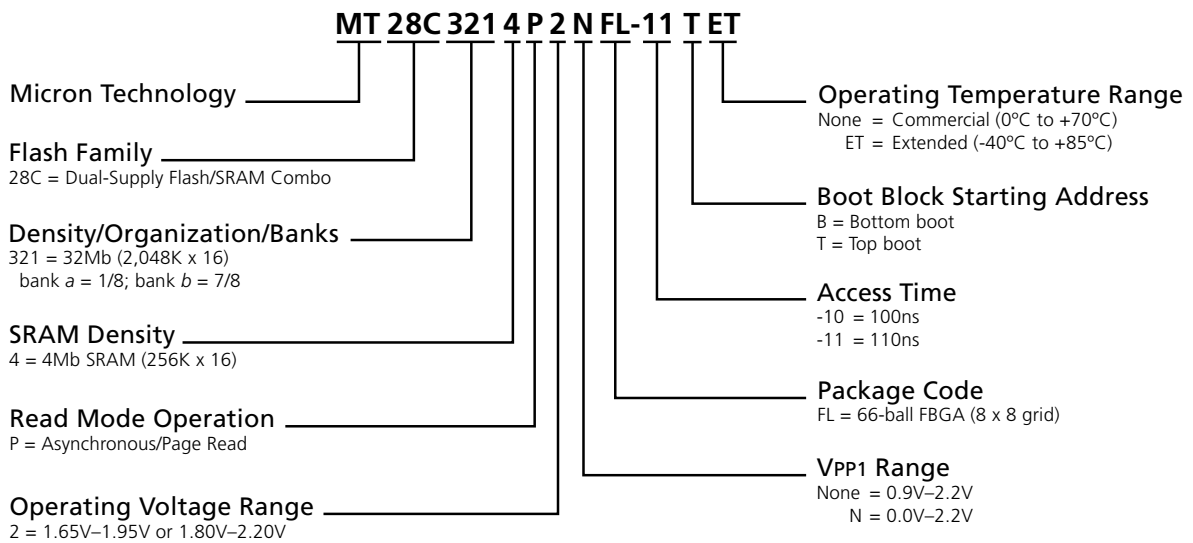
| PART NUMBER | PRODUCT MARKING | SAMPLE MARKING | MECHANICAL SAMPLE MARKING |
|-----------------------|-----------------|----------------|---------------------------|
| MT28C3214P2FL-10 BET | FW420 | FX420 | FY420 |
| MT28C3214P2FL-10 TET | FW421 | FX421 | FY421 |
| MT28C3214P2FL-11 BET | FW437 | FX437 | FY437 |
| MT28C3214P2FL-11 TET | FW431 | FX431 | FY431 |
| MT28C3214P2NFL-11 TET | FW439 | FX439 | FY439 |

PART NUMBERING INFORMATION

Micron's low-power devices are available with several different combinations of features (see Figure 1).

Valid combinations of features and their corresponding part numbers are listed in Table 3.

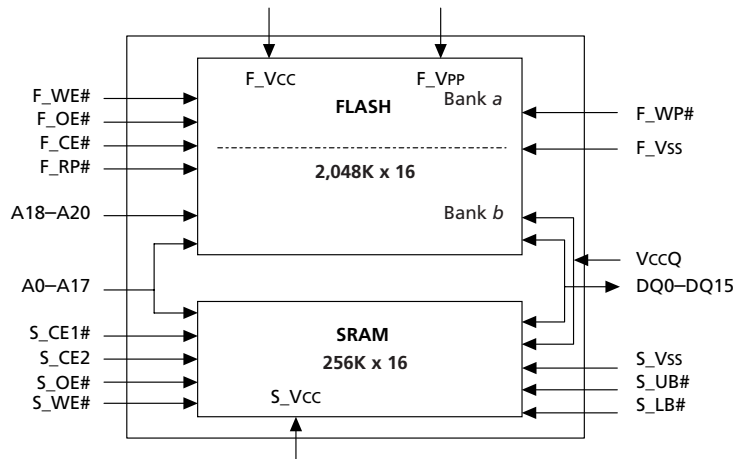
**Figure 1
Part Number Chart**



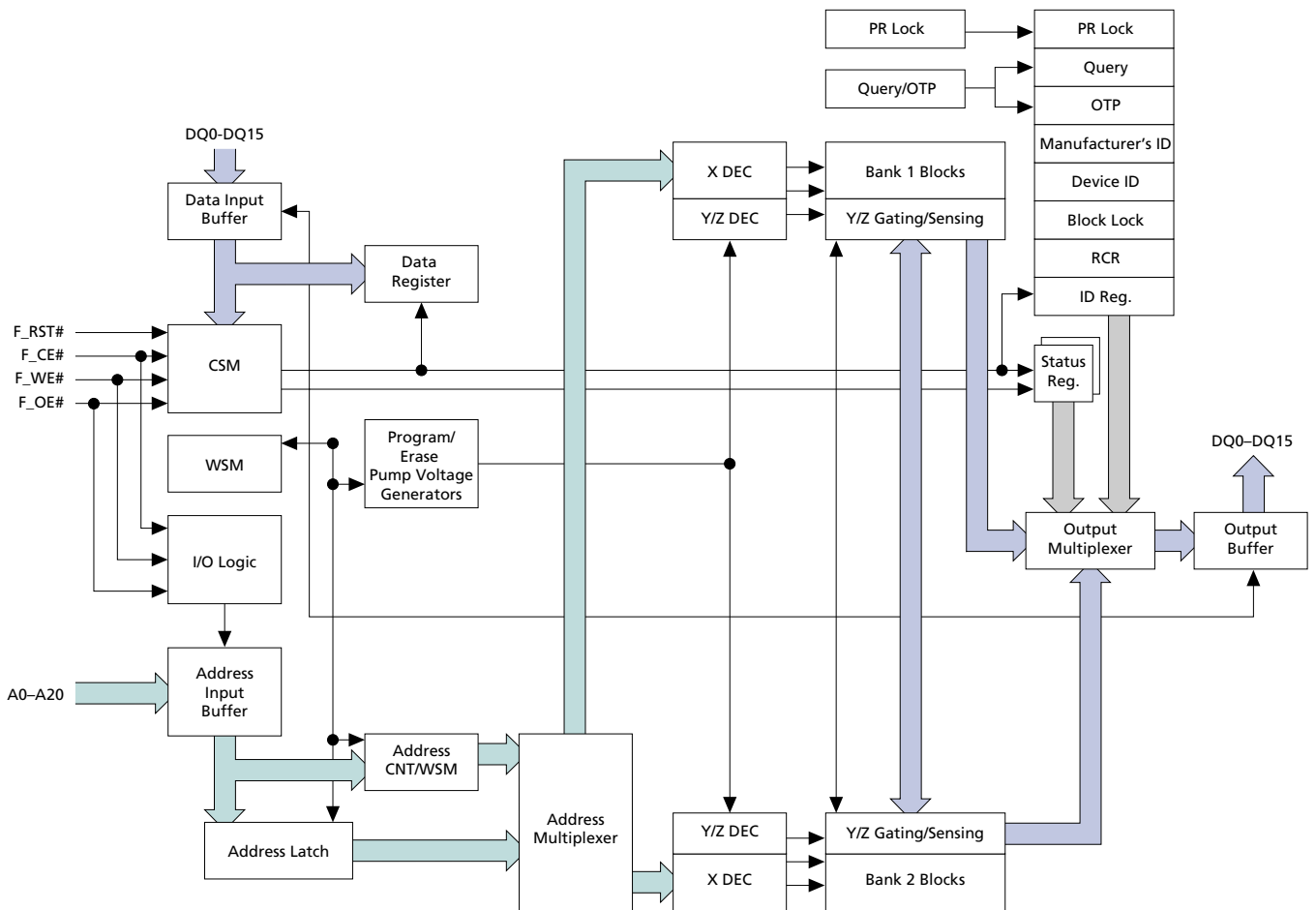
**Table 3
Valid Part Number Combinations**

| PART NUMBER | V _{PP1} RANGE | ACCESS TIME (ns) | BOOT BLOCK STARTING ADDRESS | OPERATING TEMPERATURE RANGE |
|-----------------------|------------------------|------------------|-----------------------------|-----------------------------|
| MT28C3214P2FL-10 BET | 0.9V–2.2V | 100 | Bottom | -40°C to +85°C |
| MT28C3214P2FL-10 TET | 0.9V–2.2V | 100 | Top | -40°C to +85°C |
| MT28C3214P2FL-11 BET | 0.9V–2.2V | 110 | Bottom | -40°C to +85°C |
| MT28C3214P2FL-11 TET | 0.9V–2.2V | 110 | Top | -40°C to +85°C |
| MT28C3214P2NFL-11 TET | 0.0V–2.2V | 110 | Top | -40°C to +85°C |

BLOCK DIAGRAM



FLASH FUNCTIONAL BLOCK DIAGRAM





BALL DESCRIPTIONS

| 66-BALL FBGA NUMBERS | SYMBOL | TYPE | DESCRIPTION |
|--|----------|--------------|--|
| A3, A4, A5, A6, A7, A8, B3, B4, B5, B6, E5, G3, G4, G5, G6, G7, G8, G9, H4, H5, H6 | A0–A20 | Input | Address Inputs: Inputs for the addresses during READ and WRITE operations. Addresses are internally latched during READ and WRITE cycles. Flash: A0–A20; SRAM: A0–A17. |
| H7 | F_CE# | Input | Flash Chip Enable: Activates the device when LOW. When CE# is HIGH, the device is disabled and goes into standby power mode. |
| H9 | F_OE# | Input | Flash Output Enable: Enables Flash output buffers when LOW. When F_OE# is HIGH, the output buffers are disabled. |
| C3 | F_WE# | Input | Flash Write Enable: Determines if a given cycle is a Flash WRITE cycle. F_WE# is active LOW. |
| D4 | F_RP# | Input | Reset. When F_RP# is a logic LOW, the device is in reset, which drives the outputs to High-Z and resets the WSM. When F_RP# is a logic HIGH, the device is in standard operation. When F_RP# transitions from logic LOW to logic HIGH, the device resets all blocks to locked and defaults to the read array mode. |
| E3 | F_WP# | Input | Flash Write Protect. Controls the lock down function of the flexible locking feature. |
| G10 | S_CE1# | Input | SRAM Chip Enable1: Activates the SRAM when it is LOW. HIGH level deselected the SRAM and reduces the power consumption to standby levels. |
| D8 | S_CE2 | Input | SRAM Chip Enable2: Activates the SRAM when it is HIGH. LOW level deselected the SRAM and reduces the power consumption to standby levels. |
| F5 | S_OE# | Input | SRAM Output Enable: Enables SRAM output buffers when LOW. When S_OE# is HIGH, the output buffers are disabled. |
| B8 | S_WE# | Input | SRAM Write Enable: Determines if a given cycle is an SRAM WRITE cycle. S_WE# is active LOW. |
| F3 | S_LB# | Input | SRAM Lower Byte: When LOW, it selects the SRAM address lower byte (DQ0–DQ7). |
| F4 | S_UB# | Input | SRAM Upper Byte: When LOW, it selects the SRAM address upper byte (DQ8–DQ15). |
| B7, B9, B10, C7, C8, C9, C10, D7, E6, E8, E9, E10, F7, F8, F9, F10 | DQ0–DQ15 | Input/Output | Data Inputs/Outputs: Input array data on the second CE# and WE# cycle during PROGRAM command. Input commands to the command user interface when CE# and WE# are active. Output data when CE# and OE# are active. |

(continued on next page)



BALL DESCRIPTIONS (continued)

| 66-BALL FBGA NUMBERS | SYMBOL | TYPE | DESCRIPTION |
|---|---------------|--------------|---|
| E4 | F_VPP | Input/Supply | Flash Program/Erase Power Supply: [0.9V–2.2V or 11.4V–12.6V]. Operates as input at logic levels to control complete device protection. Provides backward compatibility for factory programming when driven to 11.4V–12.6V. A lower F_VPP voltage range (0.0V–2.2V) is available on the MT28C3214P2NFL device. |
| D10, H3 | F_Vcc | Supply | Flash Power Supply: [1.65V–1.95V or 1.80V–2.20V]. Supplies power for device operation. |
| A9, H8 | F_Vss | Supply | Flash Specific Ground: Do not float any ground pin. |
| D9 | S_Vcc | Supply | SRAM Power Supply: [1.65V–1.95V or 1.80V–2.20V]. Supplies power for device operation. |
| D3 | S_Vss | Supply | SRAM Specific Ground: Do not float any ground pin. |
| A10 | VccQ | Supply | I/O Power Supply: [1.65–1.95V or 1.80V–2.20V]. This input should be tied directly to Vcc. |
| A1, A2, A11, A12, C4, H1, H2, H10, H11, H12 | NC | – | No Connect: Lead is not internally connected; it may be driven or floated. |



TRUTH TABLE – FLASH

| MODES | FLASH SIGNALS | | | | SRAM SIGNALS | | | | | | MEMORY OUPUT | | NOTES |
|----------------|---------------|-------|-------|-------|-------------------------|-------|-------|-------|-------|-------|--------------------|----------|---------|
| | F_RP# | F_CE# | F_OE# | F_WE# | S_CE1# | S_CE2 | S_OE# | S_WE# | S_UB# | S_LB# | MEMORY BUS CONTROL | DQ0-DQ15 | |
| Read | H | L | L | H | SRAM must be High-Z | | | | | | Flash | Dout | 1, 2, 3 |
| Write | H | L | H | L | SRAM must be High-Z | | | | | | Flash | Din | 1 |
| Standby | H | H | X | X | SRAM any mode allowable | | | | | | Other | High-Z | 4 |
| Output Disable | H | L | H | H | SRAM any mode allowable | | | | | | Other | High-Z | 4, 5 |
| Reset | L | X | X | X | SRAM any mode allowable | | | | | | Other | High-Z | 4, 6 |

TRUTH TABLE – SRAM

| MODES | FLASH SIGNALS | | | | SRAM SIGNALS | | | | | | MEMORY OUPUT | | NOTES |
|----------------|--------------------------|-------|-------|-------|-------------------------|-------|-------|-------|-------|-------|--------------------|----------|-------|
| | F_RP# | F_CE# | F_OE# | F_WE# | S_CE1# | S_CE2 | S_OE# | S_WE# | S_UB# | S_LB# | MEMORY BUS CONTROL | DQ0-DQ15 | |
| Read | Flash must be High-Z | | | | SRAM must be High-Z | | | | | | SRAM | | 1, 3 |
| DQ0-DQ15 | | | | | L | H | L | H | L | L | SRAM | Dout | |
| DQ0-DQ7 | | | | | L | H | L | H | H | L | SRAM | Dout LB | |
| DQ8-DQ15 | | | | | L | H | L | H | L | H | SRAM | Dout UB | 8 |
| Write | Flash must be High-Z | | | | SRAM must be High-Z | | | | | | SRAM | | 1, 3 |
| DQ0-DQ15 | | | | | L | H | H | L | L | L | SRAM | Din | |
| DQ0-DQ7 | | | | | L | H | H | L | H | L | SRAM | Din LB | |
| DQ8-DQ15 | | | | | L | H | H | L | L | H | SRAM | Din UB | 10 |
| Standby | Flash any mode allowable | | | | SRAM any mode allowable | | | | | | Other | | 4 |
| Output Disable | | | | | H | X | X | X | X | X | Other | High-Z | |
| Output Disable | Flash any mode allowable | | | | SRAM any mode allowable | | | | | | Other | | 4 |
| Output Disable | | | | | X | L | X | X | X | X | Other | High-Z | |
| Output Disable | Flash any mode allowable | | | | SRAM any mode allowable | | | | | | Other | | 4 |
| Output Disable | | | | | L | H | X | X | X | X | Other | High-Z | |

- NOTE:**
- Two devices may not drive the memory bus at the same time.
 - Allowable flash read modes include read array, read query, read configuration, and read status.
 - Outputs are dependent on a separate device controlling bus outputs.
 - Modes of the Flash and SRAM can be interleaved so that while one is disabled, the other controls outputs.
 - SRAM is enabled and/or disabled with the logical function: S_CE1# or S_CE2.
 - Simultaneous operations can exist, as long as the operations are interleaved such that only one device attempts to control the bus outputs at a time.
 - Data output on lower byte only; upper byte High-Z.
 - Data output on upper byte only; lower byte High-Z.
 - Data input on lower byte only.
 - Data input on upper byte only.

Figure 2
Bottom Boot Block Device

FLASH

| Bank b = 28Mb | | |
|---------------|---------------------------------|------------------------|
| Block | Block Size (K-bytes/K-words) | Address Range (x16) |
| 70 | 64/32 | 1F8000h-1FFFFFFh |
| 69 | 64/32 | 1F0000h-1F7FFFh |
| 68 | 64/32 | 1E8000h-1EFFFFh |
| 67 | 64/32 | 1E0000h-1E7FFFh |
| 66 | 64/32 | 1D8000h-1DFFFFh |
| 65 | 64/32 | 1D0000h-1D7FFFh |
| 64 | 64/32 | 1C8000h-1CFFFFh |
| 63 | 64/32 | 1C0000h-1C7FFFh |
| 62 | 64/32 | 1B8000h-1BFFFFh |
| 61 | 64/32 | 1B0000h-1B7FFFh |
| 60 | 64/32 | 1A8000h-1AFFFFh |
| 59 | 64/32 | 1A0000h-1A7FFFh |
| 58 | 64/32 | 198000h-19FFFFh |
| 57 | 64/32 | 190000h-197FFFh |
| 56 | 64/32 | 188000h-18FFFFh |
| 55 | 64/32 | 180000h-187FFFh |
| 54 | 64/32 | 178000h-17FFFFh |
| 53 | 64/32 | 170000h-177FFFh |
| 52 | 64/32 | 168000h-16FFFFh |
| 51 | 64/32 | 160000h-167FFFh |
| 50 | 64/32 | 158000h-15FFFFh |
| 49 | 64/32 | 150000h-157FFFh |
| 48 | 64/32 | 148000h-14FFFFh |
| 47 | 64/32 | 140000h-147FFFh |
| 46 | 64/32 | 138000h-13FFFFh |
| 45 | 64/32 | 130000h-137FFFh |
| 44 | 64/32 | 128000h-12FFFFh |
| 43 | 64/32 | 120000h-127FFFh |
| 42 | 64/32 | 118000h-11FFFFh |
| 41 | 64/32 | 110000h-117FFFh |
| 40 | 64/32 | 108000h-10FFFFh |
| 39 | 64/32 | 100000h-107FFFh |
| 38 | 64/32 | 0F8000h-0FFFFFh |
| 37 | 64/32 | 0F0000h-0F7FFFh |
| 36 | 64/32 | 0E8000h-0EFFFFh |
| 35 | 64/32 | 0E0000h-0E7FFFh |
| 34 | 64/32 | 0D8000h-0DFFFFh |
| 33 | 64/32 | 0D0000h-0D7FFFh |
| 32 | 64/32 | 0C8000h-0CFFFFh |
| 31 | 64/32 | 0C0000h-0C7FFFh |
| 30 | 64/32 | 0B8000h-0BFFFFh |
| 29 | 64/32 | 0B0000h-0B7FFFh |
| 28 | 64/32 | 0A8000h-0AFFFFh |
| 27 | 64/32 | 0A0000h-0A7FFFh |
| 26 | 64/32 | 098000h-097FFFh |
| 25 | 64/32 | 090000h-097FFFh |
| 24 | 64/32 | 088000h-087FFFh |
| 23 | 64/32 | 080000h-087FFFh |
| 22 | 64/32 | 078000h-07FFFFh |
| 21 | 64/32 | 070000h-077FFFh |
| 20 | 64/32 | 068000h-067FFFh |
| 19 | 64/32 | 060000h-067FFFh |
| 18 | 64/32 | 058000h-05FFFFh |
| 17 | 64/32 | 050000h-057FFFh |
| 16 | 64/32 | 048000h-04FFFFh |
| 15 | 64/32 | 040000h-047FFFh |

| Bank a = 4Mb | | |
|--------------|---------------------------------|------------------------|
| Block | Block Size (K-bytes/K-words) | Address Range (x16) |
| 14 | 64/32 | 038000h-03FFFFh |
| 13 | 64/32 | 030000h-037FFFh |
| 12 | 64/32 | 028000h-02FFFFh |
| 11 | 64/32 | 020000h-027FFFh |
| 10 | 64/32 | 018000h-01FFFFh |
| 9 | 64/32 | 010000h-017FFFh |
| 8 | 64/32 | 008000h-00FFFFh |
| 7 | 8/4 | 007000h-007FFFh |
| 6 | 8/4 | 006000h-006FFFh |
| 5 | 8/4 | 005000h-005FFFh |
| 4 | 8/4 | 004000h-004FFFh |
| 3 | 8/4 | 003000h-003FFFh |
| 2 | 8/4 | 002000h-002FFFh |
| 1 | 8/4 | 001000h-001FFFh |
| 0 | 8/4 | 000000h-000FFFh |

**Figure 3
Top Boot Block Device**

FLASH

| Bank a = 4Mb | | |
|--------------|---------------------------------|------------------------|
| Block | Block Size (K-bytes/K-words) | Address Range (x16) |
| 70 | 8/4 | 1FF000h-1FFFFFFh |
| 69 | 8/4 | 1FE000h-1FEFFFFh |
| 68 | 8/4 | 1FD000h-1FDFFFFh |
| 67 | 8/4 | 1FC000h-1FCFFFFh |
| 66 | 8/4 | 1FB000h-1FBFFFFh |
| 65 | 8/4 | 1FA000h-1FAFFFFh |
| 64 | 8/4 | 1F9000h-1F9FFFFh |
| 63 | 8/4 | 1F8000h-1F8FFFFh |
| 62 | 64/32 | 1F0000h-1F7FFFFh |
| 61 | 64/32 | 1E8000h-1E7FFFFh |
| 60 | 64/32 | 1E0000h-1E7FFFFh |
| 59 | 64/32 | 1D8000h-1D7FFFFh |
| 58 | 64/32 | 1D0000h-1D7FFFFh |
| 57 | 64/32 | 1C8000h-1C7FFFFh |
| 56 | 64/32 | 1C0000h-1C7FFFFh |

| Bank b = 28Mb | | |
|---------------|---------------------------------|------------------------|
| Block | Block Size (K-bytes/K-words) | Address Range (x16) |
| 55 | 64/32 | 1B8000h-1BFFFFFFh |
| 54 | 64/32 | 1B0000h-1B7FFFFh |
| 53 | 64/32 | 1A8000h-1AFFFFFFh |
| 52 | 64/32 | 1A0000h-1A7FFFFh |
| 51 | 64/32 | 198000h-19FFFFFFh |
| 50 | 64/32 | 190000h-197FFFFh |
| 49 | 64/32 | 188000h-18FFFFFFh |
| 48 | 64/32 | 180000h-187FFFFh |
| 47 | 64/32 | 178000h-17FFFFFFh |
| 46 | 64/32 | 170000h-177FFFFh |
| 45 | 64/32 | 168000h-16FFFFFFh |
| 44 | 64/32 | 160000h-167FFFFh |
| 43 | 64/32 | 158000h-15FFFFFFh |
| 42 | 64/32 | 150000h-157FFFFh |
| 41 | 64/32 | 148000h-14FFFFFFh |
| 40 | 64/32 | 140000h-147FFFFh |
| 39 | 64/32 | 138000h-13FFFFFFh |
| 38 | 64/32 | 130000h-137FFFFh |
| 37 | 64/32 | 128000h-12FFFFFFh |
| 36 | 64/32 | 120000h-127FFFFh |
| 35 | 64/32 | 118000h-11FFFFFFh |
| 34 | 64/32 | 110000h-117FFFFh |
| 33 | 64/32 | 108000h-10FFFFFFh |
| 32 | 64/32 | 100000h-107FFFFh |
| 31 | 64/32 | 0F8000h-0FFFFFFh |
| 30 | 64/32 | 0F0000h-0F7FFFFh |
| 29 | 64/32 | 0E8000h-0EFFFFFFh |
| 28 | 64/32 | 0E0000h-0E7FFFFh |
| 27 | 64/32 | 0D8000h-0DFFFFFFh |
| 26 | 64/32 | 0D0000h-0D7FFFFh |
| 25 | 64/32 | 0C8000h-0CFFFFFFh |
| 24 | 64/32 | 0C0000h-0C7FFFFh |
| 23 | 64/32 | 0B8000h-0BFFFFFFh |
| 22 | 64/32 | 0B0000h-0B7FFFFh |
| 21 | 64/32 | 0A8000h-0AFFFFFFh |
| 20 | 64/32 | 0A0000h-0A7FFFFh |
| 19 | 64/32 | 098000h-09FFFFFFh |
| 18 | 64/32 | 090000h-097FFFFh |
| 17 | 64/32 | 088000h-08FFFFFFh |
| 16 | 64/32 | 080000h-087FFFFh |
| 15 | 64/32 | 078000h-07FFFFFFh |
| 14 | 64/32 | 070000h-077FFFFh |
| 13 | 64/32 | 068000h-06FFFFFFh |
| 12 | 64/32 | 060000h-067FFFFh |
| 11 | 64/32 | 058000h-05FFFFFFh |
| 10 | 64/32 | 050000h-057FFFFh |
| 9 | 64/32 | 048000h-04FFFFFFh |
| 8 | 64/32 | 040000h-047FFFFh |
| 7 | 64/32 | 038000h-03FFFFFFh |
| 6 | 64/32 | 030000h-037FFFFh |
| 5 | 64/32 | 028000h-02FFFFFFh |
| 4 | 64/32 | 020000h-027FFFFh |
| 3 | 64/32 | 018000h-01FFFFFFh |
| 2 | 64/32 | 010000h-017FFFFh |
| 1 | 64/32 | 008000h-00FFFFFFh |
| 0 | 64/32 | 000000h-007FFFFh |

FLASH MEMORY OPERATING MODES

COMMAND STATE MACHINE

Commands are issued to the command state machine (CSM) using standard microprocessor write timings. The CSM acts as an interface between external microprocessors and the internal write state machine (WSM). The available commands are listed in Table 4, their definitions are given in Table 5 and their descriptions in Table 6. Program and erase algorithms are automated by the on-chip WSM. For more specific information about the CSM transition states, see Micron technical note TN-28-33, "Command State Machine Description and Command Definition."

Once a valid PROGRAM/ERASE command is entered, the WSM executes the appropriate algorithm, which generates the necessary timing signals to control the device internally. A command is valid only if the exact sequence of WRITES is completed. After the WSM completes its task, the write state machine status (WSMS) bit (SR7) (see Table 8) is set to a logic HIGH level (V_{IH}), allowing the CSM to respond to the full command set again.

OPERATIONS

Device operations are selected by entering a standard JEDEC 8-bit command code with conventional microprocessor timings into an on-chip CSM through I/Os DQ0–DQ7. The number of bus cycles required to activate a command is typically one or two. The first operation is always a WRITE. Control signals $F_{CE\#}$ and $F_{WE\#}$ must be at a logic LOW level (V_{IL}), and $F_{OE\#}$ and $F_{RP\#}$ must be at logic HIGH (V_{IH}). The second operation, when needed, can be a WRITE or a READ depending upon the command. During a READ operation, control signals $F_{CE\#}$ and $F_{OE\#}$ must be at a

logic LOW level (V_{IL}), and $F_{WE\#}$ and $F_{RP\#}$ must be at logic HIGH (V_{IH}).

Table 7 illustrates the bus operations for all the modes: write, read, reset, standby, and output disable.

When the device is powered up, internal reset circuitry initializes the chip to a read array mode of operation. Changing the mode of operation requires that a command code be entered into the CSM. For each one of the two Flash memory partitions, an on-chip status register is available. These two registers allow the monitoring of the progress of various operations that can take place on a memory bank. One of the two status registers is interrogated by entering a READ STATUS REGISTER command onto the CSM (cycle 1), specifying an address within the memory partition boundary, and reading the register data on I/O pins DQ0–DQ7 (cycle 2). Status register bits SR0–SR7 correspond to DQ0–DQ7 (see Table 8).

COMMAND DEFINITION

Once a specific command code has been entered, the WSM executes an internal algorithm, generating the necessary timing signals to program, erase, and verify data. See Table 5 for the CSM command definitions and data for each of the bus cycles.

STATUS REGISTER

The status register allows the user to determine whether the state of a PROGRAM/ERASE operation is pending or complete. The status register is monitored by toggling $F_{OE\#}$ and $F_{CE\#}$ and reading the resulting status code on I/Os DQ0–DQ7. The high-order I/Os (DQ8–DQ15) are set to 00h internally, so only the low-

Table 4
Command State Machine Codes For Device Mode Selection

| COMMAND DQ0–DQ7 | CODE ON DEVICE MODE |
|-----------------|--|
| 40h/10h | Program setup/alternate program setup |
| 20h | Block erase setup |
| 50h | Clear status register |
| 60h | Protection configuration setup |
| 70h | Read status register |
| 90h | Read protection configuration register |
| 98h | Read query |
| B0h | Program/erase suspend |
| C0h | Protection register program/lock |
| D0h | Program/erase resume – erase confirm |
| FFh | Read array |

order I/O signals (DQ0–DQ7) need to be interpreted. Address lines select the status register pertinent to the selected memory partition.

Register data is updated and latched on the rising edge of F_OE# or F_CE#, whichever occurs first. The latest falling edge of either of these two signals updates the latch within a given READ cycle. Latching the data prevents errors from occurring if the register input changes during a status register read.

The status register provides the internal state of the WSM to the external microprocessor. During periods when the WSM is active, the status register can be polled to determine the WSM status. Table 8 defines the status register bits.

After monitoring the status register during a PROGRAM/ERASE operation, the data appearing on DQ0–DQ7 remains as status register data until a new command is issued to the CSM. To return the device to other modes of operation, a new command must be issued to the CSM.

COMMAND STATE MACHINE OPERATIONS

The CSM decodes instructions for the commands listed in Table 4. The 8-bit command code is input to the device on DQ0–DQ7 (see Table 5 for command definitions). During a PROGRAM or ERASE cycle, the CSM informs the WSM that a PROGRAM or ERASE cycle has been requested.

During a PROGRAM cycle, the WSM controls the program sequences and the CSM responds to a PROGRAM SUSPEND command only.

During an ERASE cycle, the CSM responds to an ERASE SUSPEND command only. When the WSM has completed its task, the WSMS bit (SR7) is set to a logic HIGH level and the CSM responds to the full command set. The CSM stays in the current command state until the microprocessor issues another command.

The WSM successfully initiates an ERASE or PROGRAM operation only when V_{PP} is within its correct voltage range.

Table 5
Command Definitions

| COMMAND | FIRST BUS CYCLE | | | SECOND BUS CYCLE | | |
|--|-----------------|---------|---------|------------------|---------|------|
| | OPERATION | ADDRESS | DATA | OPERATION | ADDRESS | DATA |
| READARRAY | WRITE | WA | FFh | | | |
| READ PROTECTION CONFIGURATION REGISTER | WRITE | IA | 90h | READ | IA | ID |
| READ STATUS REGISTER | WRITE | BA | 70h | READ | BA | SRD |
| CLEAR STATUS REGISTER | WRITE | BA | 50h | | | |
| READ QUERY | WRITE | QA | 98h | READ | QA | QD |
| BLOCK ERASE SETUP | WRITE | BA | 20h | WRITE | BA | D0h |
| PROGRAM SETUP/ALTERNATE PROGRAM SETUP | WRITE | WA | 40h/10h | WRITE | WA | WD |
| PROGRAM/ERASE SUSPEND | WRITE | BA | B0h | | | |
| PROGRAM/ERASE RESUME – ERASE CONFIRM | WRITE | BA | D0h | | | |
| LOCK BLOCK | WRITE | BA | 60h | WRITE | BA | 01h |
| UNLOCK BLOCK | WRITE | BA | 60h | WRITE | BA | D0h |
| LOCK DOWN BLOCK | WRITE | BA | 60h | WRITE | BA | 2Fh |
| PROTECTION REGISTER PROGRAM | WRITE | PA | C0h | WRITE | PA | PD |
| PROTECTION REGISTER LOCK | WRITE | LPA | C0h | WRITE | LPA | FFDh |

- NOTE:**
1. WA: Word address of memory location to be written, or read
 2. IA: Identification code address
 3. BA: Address within the block
 4. ID: Identification code data
 5. SRD: Data read from the status register
 6. QA: Query code address
 7. QD: Query code data
 8. WD: Data to be written at the location WA
 9. PA: Protection register address
 10. LPA: Lock protection register address
 11. PD: Protection register data

**Table 6
Command Descriptions**

| CODE | DEVICE MODE | BUS CYCLE | DESCRIPTION |
|------|------------------------------------|-----------|---|
| 10h | Alt. Program Setup | First | Operates the same as a PROGRAM SETUP command. |
| 20h | Erase Setup | First | Prepares the CSM for an ERASE CONFIRM command. If the next command is not ERASE CONFIRM, the CSM sets both SR4 and SR5 of the status register to a "1," places the device into read status register mode, and waits for another command. |
| 40h | Program Setup | First | A two-cycle command: The first cycle prepares for a PROGRAM operation, the second cycle latches addresses and data and initiates the WSM to execute the program algorithm. The Flash outputs status register data on the falling edge of F_OE# or F_CE#, whichever occurs first. |
| 50h | Clear Status Register | First | The WSM can set the program status (SR4), and erase status (SR5) bits in the status register to "1," but it cannot clear them to "0." Issuing this command clears those bits to "0." |
| 60h | Protection Configuration Setup | First | Prepares the CSM for changes to the block locking status. If the next command is not BLOCK UNLOCK, BLOCK LOCK or BLOCK LOCK DOWN, then the CSM sets both the program and erase status register bits to indicate a command sequence error. |
| 70h | Read Status Register | First | Places the device into read status register mode. Reading the device outputs the contents of the status register, regardless of the address presented to the device. The device automatically enters this mode after a PROGRAM or ERASE operation has been initiated. |
| 90h | Read Protection Configuration | First | Puts the device into the read protection configuration mode so that reading the device outputs the manufacturer/device codes or block lock status. |
| 98h | Read Query | First | Puts the device into the read query mode so that reading the device outputs common Flash interface information. |
| B0h | Program Suspend | First | Suspends the currently executing PROGRAM/ERASE operation. The status register indicates when the operation has been successfully suspended by setting either the program suspend (SR2) or erase suspend (SR6) and the WSMS bit (SR7) to a "1" (ready). The WSM continues to idle in the suspend state, regardless of the state of all input control pins except F_RP#, which immediately shuts down the WSM and the remainder of the chip if F_RP# is driven to V _{IL} . |
| | Erase Suspend | First | |
| C0h | Program Device Protection Register | First | Writes a specific code into the device protection register. |
| | Lock Device Protection register | First | Locks the device protection register; data can no longer be changed. |

(continued on the next page)

**Table 6
Command Descriptions (continued)**

| CODE | DEVICE MODE | BUS CYCLE | DESCRIPTION |
|------|----------------------|-----------|--|
| D0h | Erase Confirm | First | If the previous command was an ERASE SETUP command, then the CSM closes the address and data latches, and it begins erasing the block indicated on the address pins. During programming/erase, the device responds only to the READ STATUS REGISTER, PROGRAM SUSPEND, or ERASE SUSPEND commands and outputs status register data on the falling edge of F_OE# or F_CE#, whichever occurs last. |
| | Program/Erase Resume | First | If a PROGRAM or ERASE operation was previously suspended, this command resumes the operation. |
| FFh | Read Array | First | During the array mode, array data is output on the data bus. |
| 01h | Lock Block | Second | If the previous command was PROTECTION CONFIGURATION SETUP, the CSM latches the address and locks the block indicated on the address bus. |
| 2Fh | Lock Down | Second | If the previous command was PROTECTION CONFIGURATION SETUP, the CSM latches the address and locks down the block indicated on the address bus. |
| D0h | Unlock Block | Second | If the previous command was PROTECTION CONFIGURATION SETUP, the CSM latches the address and unlocks the block indicated on the address bus. If the block had been previously set to lock down, this operation has no effect. |
| 00h | Invalid/Reserved | | Unassigned command that should not be used. |

CLEAR STATUS REGISTER

The internal circuitry can set, but not clear, the block lock status bit (SR1), the V_{PP} status bit (SR3), the program status bit (SR4), and the erase status bit (SR5) of the status register. The CLEAR STATUS REGISTER command (50h) allows the external microprocessor to clear these status bits and synchronize to the internal operations. When the status bits are cleared, the device returns to the read array mode.

READ OPERATIONS

The following READ operations are available: READ ARRAY, READ PROTECTION CONFIGURATION REGISTER, READ QUERY and READ STATUS REGISTER.

READ ARRAY

The array is read by entering the command code FFh on DQ0–DQ7. Control signals F_{CE#} and F_{OE#} must be at a logic LOW level (V_{IL}), and F_{WE#} and F_{RP#} must be at a logic HIGH level (V_{IH}) to read data from the array. Data is available on DQ0–DQ15. Any valid address within any of the blocks selects that address and allows data to be read from that address. Upon initial power-up, the device defaults to the read array mode.

READ CHIP PROTECTION IDENTIFICATION DATA

The chip identification mode outputs three types of information: the manufacturer/device identifier, the block locking status, and the protection register. Two bus cycles are required for this operation: the chip identification data is read by entering the command code 90h on DQ0–DQ7 to the bank containing address 00h

and the identification code address on the address lines. Control signals F_{CE#} and F_{OE#} must be at a logic LOW level (V_{IL}), and F_{WE#} and F_{RP#} must be at a logic HIGH level (V_{IH}) to read data from the protection configuration register. Data is available on DQ0–DQ15. After data is read from the protection configuration register, the READ ARRAY command, FFh, must be issued to the bank containing address 00h prior to issuing other commands. See Table 10 for further details.

READ QUERY

The read query mode outputs common flash interface (CFI) data when the device is read (see Table 12). Two bus cycles are required for this operation. It is possible to access the query by writing the read query command code 98h on DQ0–DQ7. Control signals F_{CE#} and F_{OE#} must be at a logic LOW level (V_{IL}), and F_{WE#} and F_{RP#} must be at a logic HIGH level (V_{IH}) to read data from the query. The CFI data structure contains information such as block size, density, command set, and electrical specifications. To return to read array mode, write the read array command code FFh on DQ0–DQ7.

READ STATUS REGISTER

The status register is read by entering the command code 70h on DQ0–DQ7. Two bus cycles are required for this operation: one to enter the command code and a second to read the status register. In a READ cycle, the address is latched and register data is updated on the falling edge of F_{OE#} or F_{CE#}, whichever occurs last.

PROGRAMMING OPERATIONS

There are two CSM commands for programming: PROGRAM SETUP and ALTERNATE PROGRAM SETUP (see Table 4).

After the desired command code is entered (10h or 40h command code on DQ0–DQ7), the WSM takes over and correctly sequences the device to complete the PROGRAM operation. The WRITE operation may be monitored through the status register (see the Status Register section). During this time, the CSM only responds to a PROGRAM SUSPEND command until the PROGRAM operation has been completed, after which time all commands to the CSM become valid again. The PROGRAM operation can be suspended by issuing a PROGRAM SUSPEND command (B0h). Once the WSM reaches the suspend state, it allows the CSM to respond only to READ ARRAY, READ STATUS REGISTER, READ PROTECTION CONFIGURATION, READ QUERY, PROGRAM SETUP, or PROGRAM RESUME. During the PROGRAM SUSPEND operation, array data should be read from an address other than the one being programmed. To resume the PROGRAM operation, a PROGRAM RESUME command (D0h) must be issued to cause the CSM to clear the suspend state previously set (see Figure 4 for programming operation and Figure 5 for program suspend and program resume).

Taking F_RP# to V_{IL} during programming aborts the PROGRAM operation.

ERASE OPERATIONS

An ERASE operation must be used to initialize all bits in an array block to “1s.” After BLOCK ERASE confirm is issued, the CSM responds only to an ERASE SUSPEND command until the WSM completes its task.

Block erasure inside the memory array sets all bits within the address block to logic 1s. Erase is accom-

plished only by blocks; data at single address locations within the array cannot be erased individually. The block to be erased is selected by using any valid address within that block. Block erasure is initiated by a command sequence to the CSM: BLOCK ERASE setup (20h) followed by BLOCK ERASE CONFIRM (D0h) (see Table 5). A two-command erase sequence protects against accidental erasure of memory contents.

When the BLOCK ERASE CONFIRM command is complete, the WSM automatically executes a sequence of events to complete the block erasure. During this sequence, the block is programmed with logic 0s, data is verified, all bits in the block are erased, and finally verification is performed to ensure that all bits are correctly erased. Monitoring of the ERASE operation is possible through the status register (see the Status Register section).

During the execution of an ERASE operation, the ERASE SUSPEND command (B0h) can be entered to direct the WSM to suspend the ERASE operation. Once the WSM has reached the suspend state, it allows the CSM to respond only to the READ ARRAY, READ STATUS REGISTER, READ QUERY, READ CHIP PROTECTION CONFIGURATION, PROGRAM SETUP, PROGRAM RESUME, ERASE RESUME and LOCK SETUP (see the Block Locking section). During the ERASE SUSPEND operation, array data must be read from a block other than the one being erased. To resume the ERASE operation, an ERASE RESUME command (D0h) must be issued to cause the CSM to clear the suspend state previously set (see Figure 7). It is also possible that an ERASE in any bank can be suspended and a WRITE to another block in the same bank can be initiated. After the completion of a WRITE, an ERASE can be resumed by writing an ERASE RESUME command.

**Table 7
Bus Operations**

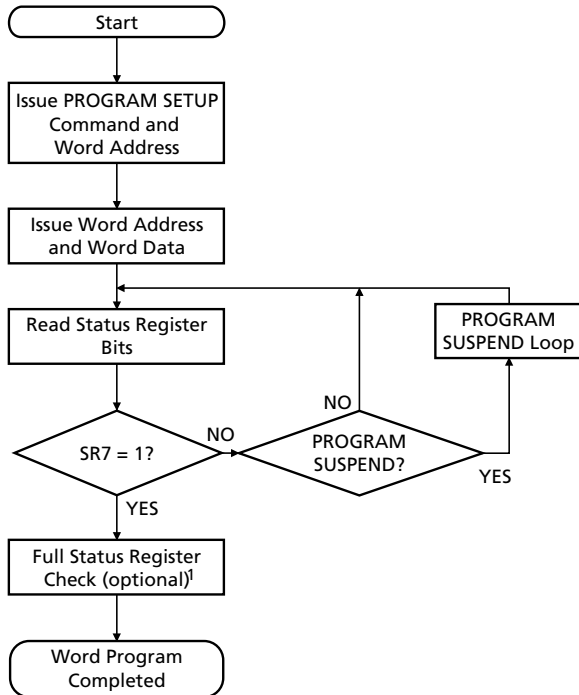
| MODE | F_RP# | F_CE# | F_OE# | F_WE# | ADDRESS | DQ0–DQ15 |
|--|-----------------|-----------------|-----------------|-----------------|---------|------------------|
| Read (array, status registers, device identification register, or query) | V _{IH} | V _{IL} | V _{IL} | V _{IH} | X | D _{OUT} |
| Standby | V _{IH} | V _{IH} | X | X | X | High-Z |
| Output Disable | V _{IH} | V _{IH} | X | X | X | High-Z |
| Reset | V _{IL} | X | X | X | X | High-Z |
| Write | V _{IH} | V _{IL} | V _{IH} | V _{IL} | X | D _{IN} |

**Table 8
Status Register Bit Definition**

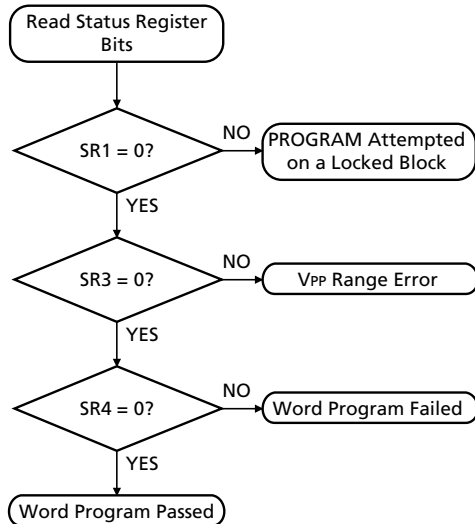
| WSMS | ESS | ES | PS | V_{PP}S | PSS | BLS | R |
|-------------|------------|-----------|-----------|------------------------|------------|------------|----------|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

| STATUS BIT # | STATUS REGISTER BIT | DESCRIPTION |
|---------------------|--|--|
| SR7 | WRITE STATE MACHINE STATUS (WSMS) 1 = Ready 0 = Busy | Check write state machine bit first to determine word program or block erase completion, before checking program or erase status bits. |
| SR6 | ERASE SUSPEND STATUS (ESS) 1 = BLOCK ERASE Suspended 0 = BLOCK ERASE in Progress/Completed | When ERASE SUSPEND is issued, WSM halts execution and sets both WSMS and ESS bits to "1." ESS bit remains set to "1" until an ERASE RESUME command is issued. |
| SR5 | ERASE STATUS (ES) 1 = Error in Block Erasure 0 = Successful BLOCK ERASE | When this bit is set to "1," WSM has applied the maximum number of erase pulses to the block and is still unable to verify successful block erasure. |
| SR4 | PROGRAM STATUS (PS) 1 = Error in PROGRAM 0 = Successful PROGRAM | When this bit is set to "1," WSM has attempted but failed to program a word. |
| SR3 | V _{PP} STATUS (V _{PP} S) 1 = V _{PP} Low Detect, Operation Abort 0 = V _{PP} = OK | The V _{PP} status bit does not provide continuous indication of the V _{PP} level. The WSM interrogates the V _{PP} level only after the program or erase command sequences have been entered and informs the system if V _{PP} < 0.9V. The V _{PP} level is also checked before the PROGRAM/ERASE operation is verified by the WSM. The MT28C3214P2NFL device allows PROGRAM or ERASE at 0V, in which case SR3 is held at "0." |
| SR2 | PROGRAM SUSPEND STATUS (PSS) 1 = PROGRAM Suspended 0 = PROGRAM in Progress/Completed | When PROGRAM SUSPEND is issued, WSM halts execution and sets both WSM and PSS bits to "1." PSS bit remains set to "1" until a PROGRAM RESUME command is issued. |
| SR1 | BLOCK LOCK STATUS (BLS) 1 = PROGRAM/ERASE Attempted on a Locked Block; Operation Aborted 0 = No Operation to Locked Blocks | If a PROGRAM or ERASE operation is attempted to one of the locked blocks, this is set by the WSM. The operation specified is aborted, and the device is returned to read status mode. |
| SR0 | RESERVED FOR FUTURE ENHANCEMENT | This bit is reserved for future. |

**Figure 4
Automated Word Programming
Flowchart**



FULL STATUS REGISTER CHECK FLOW

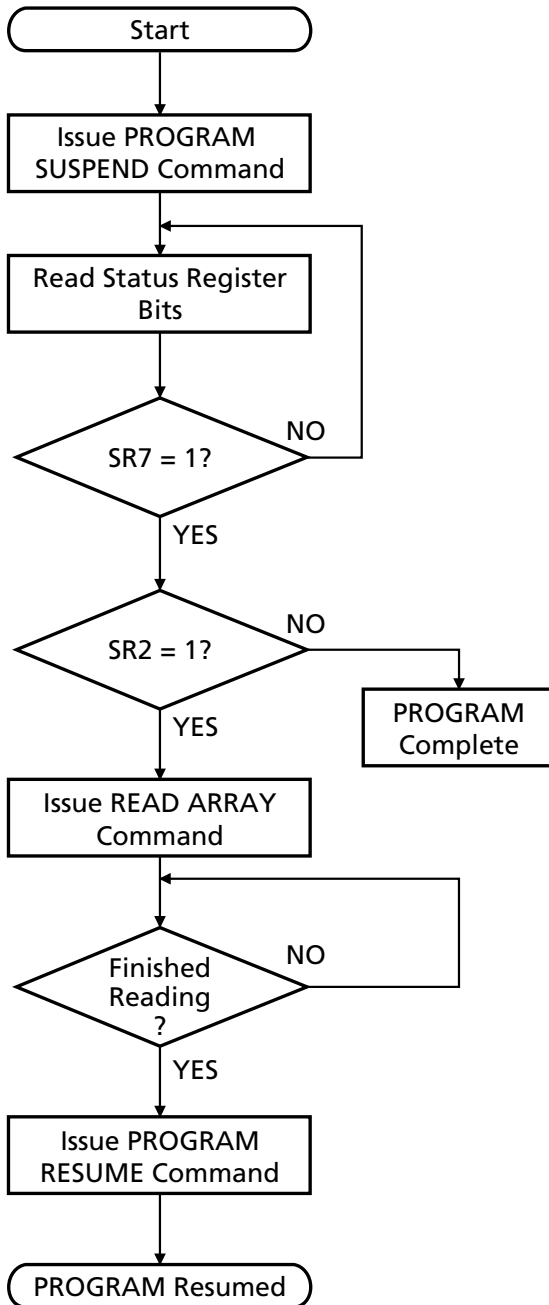


| BUS OPERATION | COMMAND | COMMENTS |
|---|---------------------|---|
| WRITE | WRITE PROGRAM SETUP | Data = 40h or 10h Addr = Address of word to be programmed |
| WRITE | WRITE DATA | Data = Word to be programmed Addr = Address of word to be programmed |
| READ | | Status register data; toggle OE# or CE# to update status register. |
| Standby | | Check SR7 1 = Ready, 0 = Busy |
| Repeat for subsequent words. Write FFh after the last word programming operation to reset the device to read array mode. | | |

| BUS OPERATION | COMMAND | COMMENTS |
|---------------|---------|--|
| Standby | | Check SR1 1 = Detect locked block |
| Standby | | Check SR3 ² 1 = Detect VPP low |
| Standby | | Check SR4 ³ 1 = Word program error |

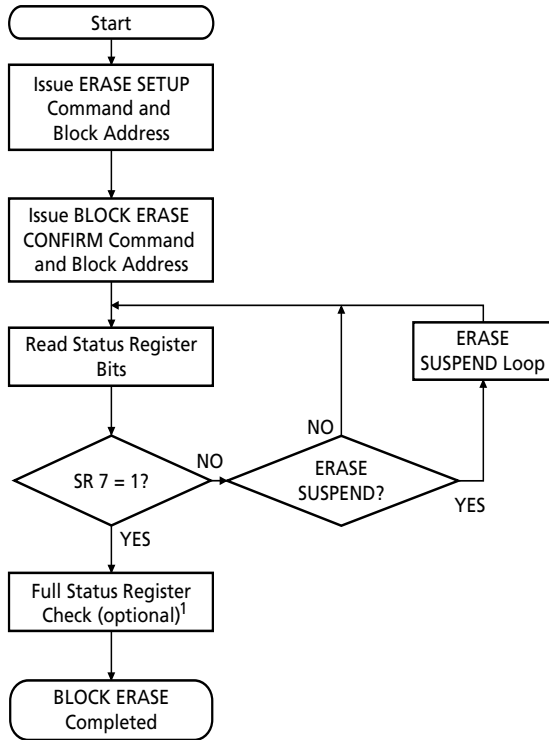
- NOTE:**
1. Full status register check can be done after each word or after a sequence of words.
 2. SR3 must be cleared before attempting additional PROGRAM/ERASE operations.
 3. SR4 is cleared only by the CLEAR STATUS REGISTER command, but it does not prevent additional program operation attempts.

**Figure 5
PROGRAM SUSPEND/
PROGRAM RESUME Flowchart**

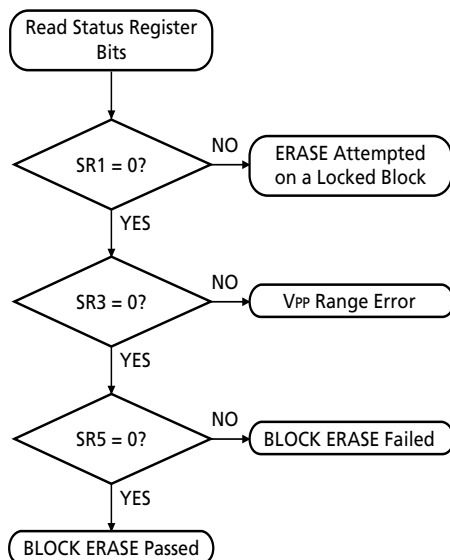


| BUS OPERATION | COMMAND | COMMENTS |
|---------------|-----------------|--|
| WRITE | PROGRAM SUSPEND | Data = B0h |
| READ | | Status register data; toggle OE# or CE# to update status register. |
| Standby | | Check SR7 1 = Ready |
| Standby | | Check SR2 1 = Suspended |
| WRITE | READ MEMORY | Data = FFh |
| READ | | Read data from block other than that being programmed. |
| WRITE | PROGRAM RESUME | Data = D0h |

**Figure 6
BLOCK ERASE Flowchart**



FULL STATUS REGISTER CHECK FLOW

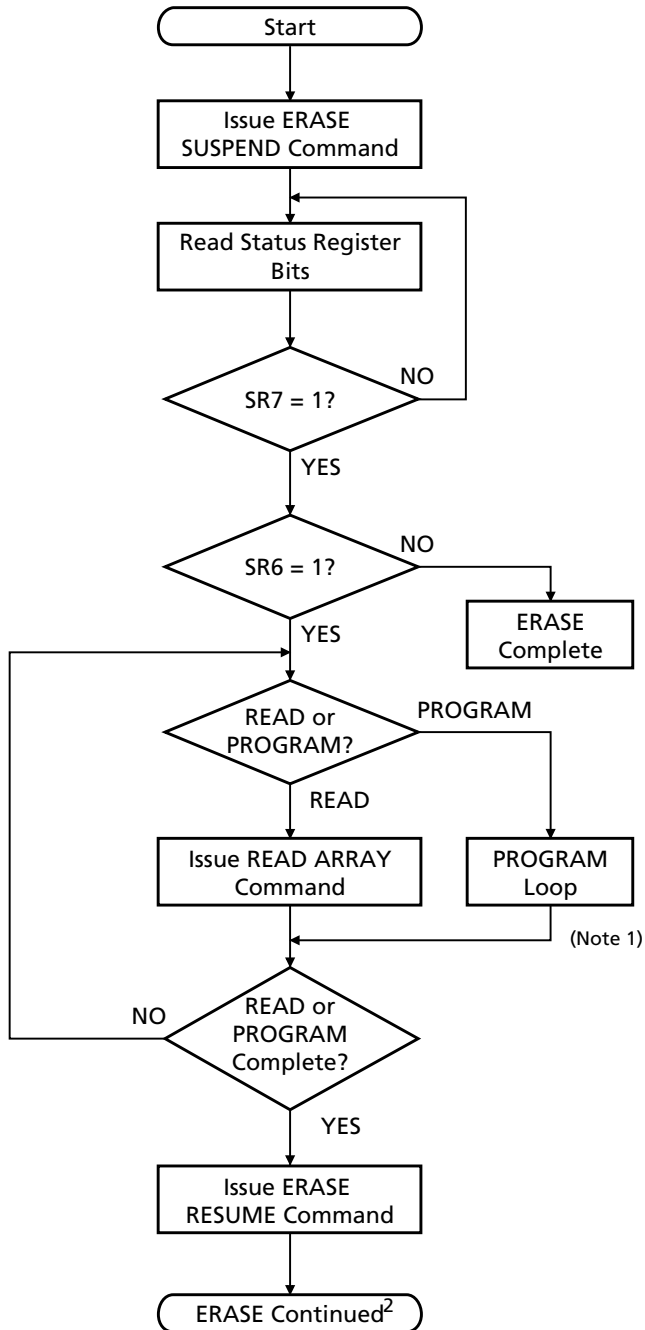


| BUS OPERATION | COMMAND | COMMENTS |
|---|-------------------|--|
| WRITE | WRITE ERASE SETUP | Data = 20h Block Addr = Address within block to be erased |
| WRITE | ERASE | Data = D0h Block Addr = Address within block to be erased |
| READ | | Status register data; toggle OE# or CE# to update status register. |
| Standby | | Check SR7 1 = Ready, 0 = Busy |
| Repeat for subsequent blocks. Write FFh after the last BLOCK ERASE operation to reset the device to read array mode. | | |

| BUS OPERATION | COMMAND | COMMENTS |
|---------------|---------|--|
| Standby | | Check SR1 1 = Detect locked block |
| Standby | | Check SR3 ² 1 = Detect V _{PP} block |
| Standby | | Check SR4 and SR5 1 = BLOCK ERASE command error |
| Standby | | Check SR5 ³ 1 = BLOCK ERASE error |

- NOTE:**
1. Full status register check can be done after each block or after a sequence of blocks.
 2. SR3 must be cleared before attempting additional PROGRAM/ERASE operations.
 3. SR5 is cleared only by the CLEAR STATUS REGISTER command in cases where multiple blocks are erased before full status is checked.

**Figure 7
ERASE SUSPEND/ERASE RESUME
Flowchart**



| BUS OPERATION | COMMAND | COMMENTS |
|---------------|---------------|--|
| WRITE | ERASE SUSPEND | Data = B0h |
| READ | | Status register data; toggle OE# or CE# to update status register. |
| Standby | | Check SR7 1 = Ready |
| Standby | | Check SR6 1 = Suspended |
| WRITE | READ MEMORY | Data = FFh |
| READ | | Read data from block other than that being erased. |
| WRITE | ERASE RESUME | Data = D0h |

NOTE: 1. See BLOCK ERASE Flowchart for complete erasure procedure.
2. See Word Programming Flowchart for complete programming procedure.

READ-WHILE-WRITE/ERASE CONCURRENCY

It is possible for the device to read from one bank while erasing/writing to another bank. Once a bank enters the WRITE/ERASE operation, the other bank automatically enters read array mode. For example, during a READ CONCURRENCY operation, if a PROGRAM/ERASE command is issued in bank *a*, then bank *a* changes to the read status mode and bank *b* defaults to the read array mode. The device reads from bank *b* if the latched address resides in bank *b* (see Figure 8). Similarly, if a PROGRAM/ERASE command is issued in bank *b*, then bank *b* changes to read status mode and bank *a* defaults to read array mode. When returning to bank *a*, the device reads program/erase status if the latched address resides in bank *a*. A correct bank address must be specified to read status register after returning from concurrent read in the other bank.

When reading the CFI area, or the chip protection register, the possible concurrent operations are reported in Figures 9a and 9b.

BLOCK LOCKING

The Flash memory of the MT28C3214P2FL or MT28C3214P2NFL device provides a flexible locking scheme which allows each block to be individually locked or unlocked with no latency.

The device offers two-level protection for the blocks. The first level allows software-only control of block locking (for data which needs to be changed frequently), while the second level requires hardware interaction before locking can be changed (code which does not require frequent updates).

Control signals F_WP#, DQ0, and DQ1 define the state of a block; for example, state [001] means F_WP# = 0, DQ0 = 0 and DQ1 = 1.

Table 9 defines all of the possible locking states.

NOTE: All blocks are software-locked upon completion of the power-up sequence.

LOCKED STATE

After a power-up sequence completion, or after a reset sequence, all blocks are locked (states [001] or [101]). This means full protection from alteration. Any PROGRAM or ERASE operations attempted on a locked block will return an error on bit SR1 of the status register. The status of a locked block can be changed to unlocked or lock down using the appropriate software commands. Writing the lock command sequence, 60h followed by 01h, can lock an unlocked block.

UNLOCKED STATE

Unlocked blocks (states [000], [100], [110]) can be programmed or erased. All unlocked blocks return to the locked state when the device is reset or powered down. An unlocked block can be locked or locked down using the appropriate software command sequence, 60h followed by D0h. (See Table 5.)

LOCKED DOWN STATE

Blocks locked down (state [011]) are protected from PROGRAM and ERASE operations, but their protection status cannot be changed using software commands

Figure 8
READ-While-WRITE Concurrency

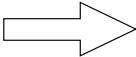
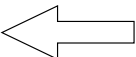
| Bank a | Bank b |
|---|---|
| 1 - Erasing/writing to bank a 2 - Erasing in bank a can be suspended, and a WRITE to another block in bank a can be initiated. 3 - After the WRITE in that block is complete, an ERASE can be resumed by writing an ERASE RESUME command. |  1 - Reading from bank b |
| 1 - Reading bank a  | 1 - Erasing/writing to bank b 2 - Erasing in bank b can be suspended, and a WRITE to another block in bank b can be initiated. 3 - After the WRITE in that block is complete, an ERASE can be resumed by writing an ERASE RESUME command. |

Figure 9a
Top Boot Block Device

| | | BANK a | BANK b |
|---|----------------|---------------|---------------|
| Reading the CFI or Chip Protection Register | READ | Not Supported | Not Supported |
| | WRITE ERASE | Not Supported | Not Supported |

Figure 9b
Bottom Boot Block Device

| | | BANK a | BANK b |
|---|----------------|---------------|-----------|
| Reading the CFI or Chip Protection Register | READ | Not Supported | Supported |
| | WRITE ERASE | Not Supported | Supported |

**Table 9
Block Locking State Transition**

| F_WP# | DQ1 | DQ0 | NAME | ERASE/PROGRAM ALLOWED | LOCK | UNLOCK | LOCK DOWN |
|-------|-----|-----|--------------------|-----------------------|----------|----------|-----------|
| 0 | 0 | 0 | Unlocked | Yes | To [001] | – | To [011] |
| 0 | 0 | 1 | Locked (Default) | No | – | To [000] | To [011] |
| 0 | 1 | 1 | Lock Down | No | – | – | – |
| 1 | 0 | 0 | Unlocked | Yes | To [101] | – | To [111] |
| 1 | 0 | 1 | Locked | No | – | To [100] | To [111] |
| 1 | 1 | 0 | Lock Down Disabled | Yes | To [111] | – | To [111] |
| 1 | 1 | 1 | Lock Down Disabled | No | – | To [110] | – |

alone. A locked or unlocked block can be locked down by writing the lock down command sequence, 60h followed by 2Fh. Locked down blocks revert to the locked state when the device is reset or powered down.

The LOCK DOWN function is dependent on the F_WP# input. When F_WP# = 0, blocks in lock down [011] are protected from program, erase, and lock status changes. When F_WP# = 1, the LOCK DOWN function is disabled ([111]) and locked down blocks can be individually unlocked by a software command to the [110] state, where they can be erased and programmed. These blocks can then be relocked [111] and unlocked [110], as desired, as long as F_WP# remains HIGH. When F_WP# goes LOW, blocks that were previously locked down return to the lock down state [011] regard-

less of any changes made while F_WP# was HIGH. Device reset or power-down resets all locks, including those in lock down, to the locked state (see Table 9).

READING A BLOCK'S LOCK STATUS

The lock status of every block can be read in the read device identification mode. To enter this mode, write 90h to the bank containing address 00h. Subsequent READs at block address +00002 will output the lock status of that block. The lowest two outputs, DQ0 and DQ1, represent the lock status. DQ0 indicates the block lock/unlock status and is set by the LOCK command and cleared by the UNLOCK command. It is also automatically set when entering lock down. DQ1 indicates lock down status and is set by the LOCK DOWN

**Table 10
Chip Protection Configuration Addressing¹**

| ITEM | ADDRESS ² | DATA |
|--|----------------------|---------------------------------------|
| Manufacturer Code (x16) | 00000h | 002Ch |
| Device Code • Top boot configuration • Bottom boot configuration | 00001h | 44A2h 44A3h |
| Block Lock Configuration • Block is unlocked • Block is locked • Block is locked down | XX002h | Lock DQ0 = 0 DQ0 = 1 DQ1 = 1 |
| Chip Protection Register Lock | 80h | PR Lock |
| Chip Protection Register 1 | 81h–84h | Factory Data |
| Chip Protection Register 2 | 85h–88h | User Data |

- NOTE:**
1. Other locations within the configuration address space are reserved by Micron for future use.
 2. "XX" specifies the block address of lock configuration.

command. It can only be cleared by reset or power-down, not by software. Table 9 shows the block locking state transition scheme. The READ ARRAY command, FFh, must be issued to the bank containing address 00h prior to issuing other commands.

LOCKING OPERATIONS DURING ERASE SUSPEND

Changes to block lock status can be performed during an ERASE SUSPEND by using the standard locking command sequences to unlock, lock, or lock down. This is useful in the case when another block needs to be updated while an ERASE operation is in progress.

To change block locking during an ERASE operation, first write the ERASE SUSPEND command (B0h), then check the status register until it indicates that the ERASE operation has been suspended. Next, write the desired lock command sequence to block lock, and the lock status will be changed. After completing any desired LOCK, READ, or PROGRAM operations, resume the ERASE operation with the ERASE RESUME command (D0h).

If a block is locked or locked down during an ERASE SUSPEND on the same block, the locking status bits are changed immediately. When the ERASE is resumed, the ERASE operation completes.

A locking operation cannot be performed during a PROGRAM SUSPEND.

STATUS REGISTER ERROR CHECKING

Using nested locking or program command sequences during ERASE SUSPEND can introduce ambiguity into status register results.

Following protection configuration setup (60h), an invalid command produces a lock command error (SR4 and SR5 are set to "1") in the status register. If a lock command error occurs during an ERASE SUSPEND, SR4 and SR5 are set to "1" and remain at "1" after the ERASE SUSPEND command is issued. When the ERASE is complete, any possible error during the ERASE cannot be detected via the status register because of the previous locking command error.

A similar situation happens if an error occurs during a program operation error nested within an ERASE SUSPEND.

CHIP PROTECTION REGISTER

A 128-bit protection register can be used to fulfill the security considerations in the system (preventing device substitution).

The 128-bit security area is divided into two 64-bit segments. The first 64 bits are programmed at the manufacturing site with a unique 64-bit number. The other segment is left blank for customers to program as desired. (See Figure 10).

READING THE CHIP PROTECTION REGISTER

The chip protection register is read in the device identification mode. To enter this mode, load the 90h command to the bank containing address 00h. Once in this mode, READ cycles from addresses shown in Table 10 retrieve the specified information. To return to the read array mode, write the READ ARRAY command (FFh). The READ ARRAY command, FFh, must be issued to the bank containing address 00h prior to issuing other commands.

PAGE READ MODE

The initial portion of the page mode cycle is the same as the asynchronous access cycle. Holding CE# LOW and toggling addresses A0–A1 allows random access of other words in the page.

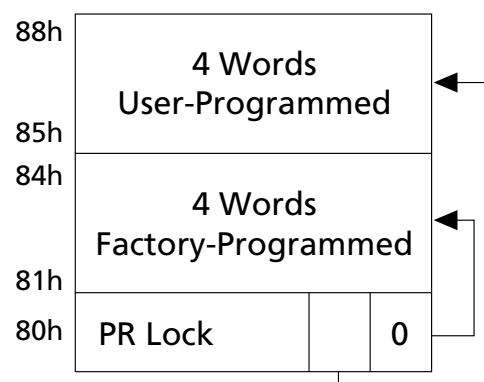
The page size can be customized at the factory to four or eight words as required; but if no specification is made, the normal size is four words.

ASYNCHRONOUS READ CYCLE

When accessing addresses in a random order or when switching between pages, the access time is given by tAA.

When F_CE# and F_OE# are LOW, the data is placed on the data bus and the processor can read the data.

Figure 10
Protection Register Memory Map



STANDBY MODE

Icc supply current is reduced by applying a logic HIGH level on F_CE# and F_RP# to enter the standby mode. In the standby mode, the outputs are placed in High-Z. Applying a CMOS logic HIGH level on F_CE# and F_RP# reduces the current to Icc2 (MAX). If the device is deselected during an ERASE operation or during programming, the device continues to draw current until the operation is complete.

AUTOMATIC POWER SAVE (APS) MODE

Substantial power savings are realized during periods when the Flash array is not being read and the device is in the active mode. During this time the device switches to the automatic power save (APS) mode. When the device switches to this mode, Icc is reduced to Icc2. The low level of power is maintained until another operation is initiated. In this mode, the I/Os retain the data from the last memory address read until a new address is read. This mode is entered automatically if no addresses or control signals toggle.

VPP/VCC PROGRAM AND ERASE VOLTAGES

The MT28C3214P2FL Flash memory provides in-system programming and erase with VPP in the 0.9V–2.2V range (VPP1). In addition to the flexible block locking, the VPP programming voltage can be held LOW for absolute hardware write protection of all blocks in the Flash device. When VPP is below VPP1, any PROGRAM or ERASE operation results in an error, prompting the corresponding status register bit (SR3) to be set.

The MT28C3214P2NFL Flash memory provides in-system programming and erase with VPP in the 0.0V–2.2V range (VPP1).

VPP at 12V ±5% (VPP2) is supported for a maximum of 100 cycles and 10 cumulative hours. The device can withstand 100,000 WRITE/ERASE operations when VPP = VCC.

During WRITE and ERASE operations, the WSM monitors the VPP voltage level. WRITE/ERASE operations are allowed only when VPP is within the ranges specified in Table 11.

When VCC is below VLKO or VPP is below VPP1, any WRITE/ERASE operation is prevented.

DEVICE RESET

To correctly reset the device, the RST# signal must be asserted (RST# = VIL) for a minimum of tRP. After reset, the device can be accessed for a READ operation with a delayed access time of tRWH from the rising edge of RST#. The circuitry used for generating the RST# signal needs to be common with the rest of the system reset to ensure that correct system initialization occurs. Please refer to the timing diagram for further details.

POWER-UP SEQUENCE

The following power-up sequence must be observed to properly initialize the device:

- RST# must be at VIL.
- Power on Vcc/VccQ (Vcc ≥ VccQ at all times).
- Wait 2μS after Vcc reaches Vcc (MIN).
- Take RST# from VIL to VIH.
- The RST# transition from VIL to VIH must be less than 10μS.

Table 11
VPP Ranges (V)

| DEVICE | IN-SYSTEM | | IN-FACTORY | |
|----------------|-----------|-----|------------|------|
| | MIN | MAX | MIN | MAX |
| MT28C3214P2FL | 0.9 | 2.2 | 11.4 | 12.6 |
| MT28C3214P2NFL | 0.0 | 2.2 | 11.4 | 12.6 |

FLASH ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS*

| | |
|--|-------------------|
| Voltage to Any Pin Except V _{CC} and V _{PP} with Respect to V _{SS} | -0.5V to +2.45V |
| V _{PP} Voltage (for BLOCK ERASE and PROGRAM with Respect to V _{SS}) | -0.5V to +13.5V** |
| V _{CC} and V _{CCQ} Supply Voltage with Respect to V _{SS} | -0.3V to +2.45V |
| Output Short Circuit Current | 100mA |
| Operating Temperature Range | -40°C to +85°C |
| Storage Temperature Range | -55°C to +125°C |
| Soldering Cycle | 260°C for 10s |

*Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

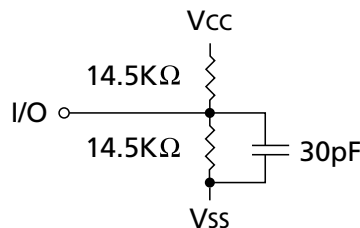
**Maximum DC voltage on V_{PP} may overshoot to +13.5V for periods <20ns.

RECOMMENDED OPERATING CONDITIONS

| PARAMETER | SYMBOL | MIN | MAX | UNITS | NOTES |
|--|---------------------------------------|------|---------|--------|-------|
| Operating temperature | t _A | -40 | +85 | °C | |
| V _{CC} supply voltage | F_V _{CC} , S_V _{CC} | 1.65 | 2.2 | V | |
| I/O supply voltage (V _{CC} = 1.65V–1.95V) | V _{CCQ} | 1.65 | 1.95 | V | 1 |
| I/O supply voltage (V _{CC} = 1.80V–2.20V) | V _{CCQ} | 1.80 | 2.20 | V | 1 |
| V _{PP} voltage (MT28C3214P2FL only) | V _{PP1} | 0.9 | 2.2 | V | |
| V _{PP} voltage (MT28C3214P2NFL only) | V _{PP1} | 0.0 | 2.2 | V | |
| V _{PP} in-factory programming voltage | V _{PP2} | 11.4 | 12.6 | V | 2 |
| Data retention supply voltage | S_V _{DR} | 1.0 | – | V | |
| Block erase cycling | | – | 100,000 | Cycles | |

- NOTE:** 1. Use only one of the two I/O supply voltage ranges, 1.65V–1.95V or 1.80V–2.20V.
2. 12V V_{PP} is supported for a maximum of 100 cycles and may be connected for up to 10 cumulative hours.

**Figure 11
Output Load Circuit**





COMBINED DC CHARACTERISTICS¹

| DESCRIPTION | CONDITIONS | SYMBOL | V _{CC} = 1.65V–1.95V or 1.80V–2.20V | | | UNITS | NOTES |
|---|------------|----------------------------------|---|-----|-------------------------|-------|-------|
| | | | V _{CCQ} = 1.65V–1.95V or 1.80V–2.20V | | | | |
| | | | MIN | TYP | MAX | | |
| Input low voltage | | V _{IL} | -0.4 | – | 0.4 | V | |
| Input high voltage | | V _{IH} | V _{CCQ} - 0.4V | – | V _{CCQ} + 0.3V | V | |
| Output low voltage I _{OL} = 100µA (Flash) | | V _{OL} | – | – | 0.10 | V | |
| Output low voltage I _{OL} = 100µA (SRAM) | | V _{OL} | 0.3 | – | 0.3 | V | |
| Output high voltage I _{OH} = 100µA (Flash) | | V _{OH} | V _{CCQ} - 0.1V | – | – | V | |
| Output high voltage I _{OH} = 100µA (SRAM) | | V _{OH} | V _{CCQ} - 0.3V | – | – | V | |
| V _{PP} lock out voltage | | V _{PPLK} | – | – | 0.4 | V | |
| V _{PP} during PROGRAM/ERASE operations (MT28C3214P2FL only) | | V _{PP1} | 0.9 | – | 2.2 | V | |
| | | V _{PP2} | 11.4 | – | 12.6 | V | 2 |
| V _{PP} during PROGRAM/ERASE operations (MT28C3214P2NFL only) | | V _{PP1} | 0.0 | – | 2.2 | V | |
| | | V _{PP2} | 11.4 | – | 12.6 | V | 2 |
| V _{CC} PROGRAM/ERASE lock voltage | | V _{LKO} | 1.0 | – | – | V | |
| Input leakage current | | I _L | – | – | 1 | µA | |
| Output leakage current | | I _{OZ} | – | – | 1 | µA | |
| F_V _{CC} asynchronous read current at 95ns | | I _{CC1} | – | – | 15 | mA | |
| F_V _{CC} page mode read current at 35ns | | I _{CC2} | – | – | 5 | mA | |
| F_V _{CC} plus S_V _{CC} standby current | | I _{CC3} | – | 25 | 60 | µA | |
| F_V _{CC} program current | | I _{CC4+I_{PP3}} | – | – | 55 | mA | |
| F_V _{CC} erase current | | I _{CC5+I_{PP4}} | – | – | 65 | mA | |
| F_V _{CC} /S_V _{CC} erase suspend current | | I _{CC6} | – | – | 60 | µA | |
| F_V _{CC} /S_V _{CC} program suspend current | | I _{CC7} | – | – | 60 | µA | |
| Read-while-write current | | I _{CC8} | – | – | 80 | mA | |

- NOTE:**
- All currents are in RMS unless otherwise noted.
 - 12V V_{PP} is supported for a maximum of 100 cycles and may be connected for up to 10 cumulative hours.
 - Operating current is a linear function of operating frequency and voltage. Operating current can be calculated using the formula shown with operating frequency (f) expressed in MHz and operating voltage (V) in volts.
Example: When operating at 2 MHz at 2V, the device will draw a typical active current of 0.8*2* 2 = 3.2mA in the page access mode. This parameter is specified with the outputs disabled to avoid external loading effects. The user must add current required to drive output capacitance expected in the actual system.

(continued on the next page)



COMBINED DC CHARACTERISTICS¹ (continued)

| DESCRIPTION | CONDITIONS | SYMBOL | V _{CC} = 1.65V–1.95V or 1.80V–2.20V | | | UNITS | NOTES |
|--|---|-------------------|---|-----|-----|-------|-------|
| | | | V _{CCQ} = 1.65V–1.95V or 1.80V–2.20V | | | | |
| | | | MIN | TYP | MAX | | |
| S_V _{CC} read/write operating supply current – page access mode | V _{IN} = V _{IH} or V _{IL} chip enabled, I _{OL} = 0 | I _{CC9} | – | 12 | 25 | mA | 3 |
| S_V _{CC} read/write operating supply current – word access mode | V _{IN} = V _{IH} or V _{IL} chip enabled, I _{OL} = 0 | I _{CC10} | – | 3 | 8 | mA | 3 |
| V _{PP} read current | V _{PP} ≤ V _{CC} | I _{PP1} | – | – | 1 | μA | |
| | V _{PP} ≥ V _{CC} | | – | – | 200 | μA | |
| V _{PP} standby current | V _{PP} ≤ V _{CC} | I _{PP2} | – | – | 1 | μA | |
| | V _{PP} ≥ V _{CC} | | – | – | 200 | μA | |
| V _{PP} erase suspend current | V _{PP} = V _{PP1} | I _{PP5} | – | – | 1 | μA | |
| | V _{PP} = V _{PP2} | | – | – | 200 | μA | |
| V _{PP} program suspend current | V _{PP} = V _{PP1} | I _{PP6} | – | – | 1 | μA | |
| | V _{PP} = V _{PP2} | | – | – | 200 | μA | |

- NOTE:**
1. All currents are in RMS unless otherwise noted.
 2. 12V V_{PP} is supported for a maximum of 100 cycles and may be connected for up to 10 cumulative hours.
 3. Operating current is a linear function of operating frequency and voltage. Operating current can be calculated using the formula shown with operating frequency (f) expressed in MHz and operating voltage (V) in volts.
Example: When operating at 2 MHz at 2V, the device will draw a typical active current of 0.8*2* 2 = 3.2mA in the page access mode. This parameter is specified with the outputs disabled to avoid external loading effects. The user must add current required to drive output capacitance expected in the actual system.



2 MEG x 16 PAGE FLASH 256K x 16 SRAM COMBO MEMORY

FLASH

FLASH READ CYCLE TIMING REQUIREMENT

V_{CC} = 1.65V–1.95V

| PARAMETER | SYMBOL | -10 | | -11 | | UNITS |
|---|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | | V _{CC} = 1.65V–1.95V | | V _{CC} = 1.65V–1.95V | | |
| | | MIN | MAX | MIN | MAX | |
| Address to output delay | t _{AA} | | 100 | | 110 | ns |
| CE# LOW to output delay | t _{ACE} | | 100 | | 110 | ns |
| Page address access | t _{APA} | | 35 | | 45 | ns |
| OE# LOW to output delay | t _{AOE} | | 30 | | 30 | ns |
| F_RP# HIGH to output delay | t _{RWH} | | 200 | | 200 | ns |
| F_RP# LOW pulse width | t _{RP} | 125 | | 125 | | ns |
| CE# or OE# HIGH to output High-Z | t _{OD} | | 25 | | 25 | ns |
| Output hold from address, CE# or OE# change | t _{OH} | 0 | | 0 | | ns |
| READ cycle time | t _{RC} | | 100 | | 110 | ns |

FLASH READ CYCLE TIMING REQUIREMENT

V_{CC} = 1.80V–2.20V

| PARAMETER | SYMBOL | -10 | | -11 | | UNITS |
|---|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | | V _{CC} = 1.80V–2.20V | | V _{CC} = 1.80V–2.20V | | |
| | | MIN | MAX | MIN | MAX | |
| Address to output delay | t _{AA} | | 95 | | 100 | ns |
| CE# LOW to output delay | t _{ACE} | | 95 | | 100 | ns |
| Page address access | t _{APA} | | 35 | | 45 | ns |
| OE# LOW to output delay | t _{AOE} | | 30 | | 30 | ns |
| F_RP# HIGH to output delay | t _{RWH} | | 150 | | 150 | ns |
| F_RP# LOW pulse width | t _{RP} | 100 | | 100 | | ns |
| CE# or OE# HIGH to output High-Z | t _{OD} | | 25 | | 25 | ns |
| Output hold from address, CE# or OE# change | t _{OH} | 0 | | 0 | | ns |
| READ cycle time | t _{RC} | | 95 | | 100 | ns |



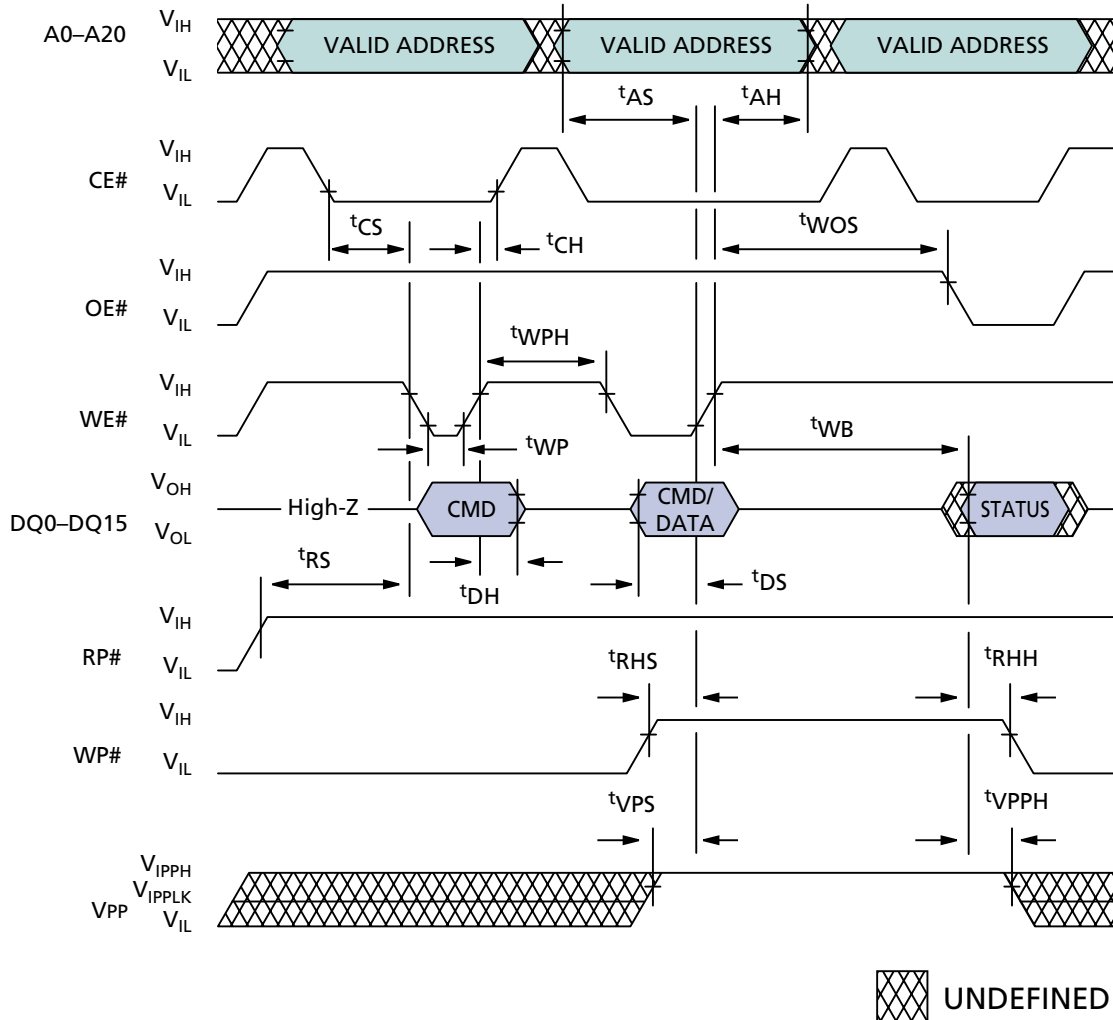
FLASH WRITE CYCLE TIMING REQUIREMENTS

| PARAMETER | SYMBOL | -10/-11 | | UNITS |
|---|------------------|--|---------------------|-------|
| | | V _{CC} = 1.65V–1.95V or 1.80V–2.20V | | |
| | | MIN | MAX | |
| Reset HIGH recovery to WE# going LOW | t _{RS} | 150 | | ns |
| CE# setup to WE# going LOW | t _{CS} | 0 | | ns |
| Write pulse width | t _{WP} | 50 | | ns |
| Data setup to WE# going HIGH | t _{DS} | 50 | | ns |
| Address setup to WE# going HIGH | t _{AS} | 50 | | ns |
| CE# hold from WE# HIGH | t _{CH} | 0 | | ns |
| Data hold from WE# HIGH | t _{DH} | 0 | | ns |
| Address hold from WE# HIGH | t _{AH} | 9 | | ns |
| Write pulse width HIGH | t _{WPH} | 30 | | ns |
| WP# setup to WE# going HIGH | t _{RHS} | 200 | | ns |
| V _{PP} setup to WE# going HIGH | t _{VPS} | 200 | | ns |
| Write recovery before READ | t _{WOS} | 50 | | ns |
| WP# hold from valid SRD | t _{RHH} | 0 | | ns |
| V _{PP} hold from valid SRD | t _{VPH} | 0 | | ns |
| WE# HIGH to data valid | t _{WB} | | t _{AA} +50 | ns |

FLASH ERASE AND PROGRAM CYCLE TIMING REQUIREMENTS

| PARAMETER | -10/-11 | | UNITS |
|-----------------------------------|--|-----|-------|
| | V _{CC} = 1.65V–1.95V or 1.80V–2.20V | | |
| | TYP | MAX | |
| 4KW parameter block program time | 0.1 | 0.3 | s |
| 32KW parameter block program time | 0.8 | 2.4 | s |
| Word program time | 8 | 185 | μs |
| 4KW parameter block erase time | 1 | 4 | s |
| 32KW parameter block erase time | 1.5 | 5 | s |
| Program suspend latency | 5 | 10 | μs |
| Erase suspend latency | 5 | 20 | μs |

TWO-CYCLE PROGRAMMING/ERASE OPERATION



UNDEFINED

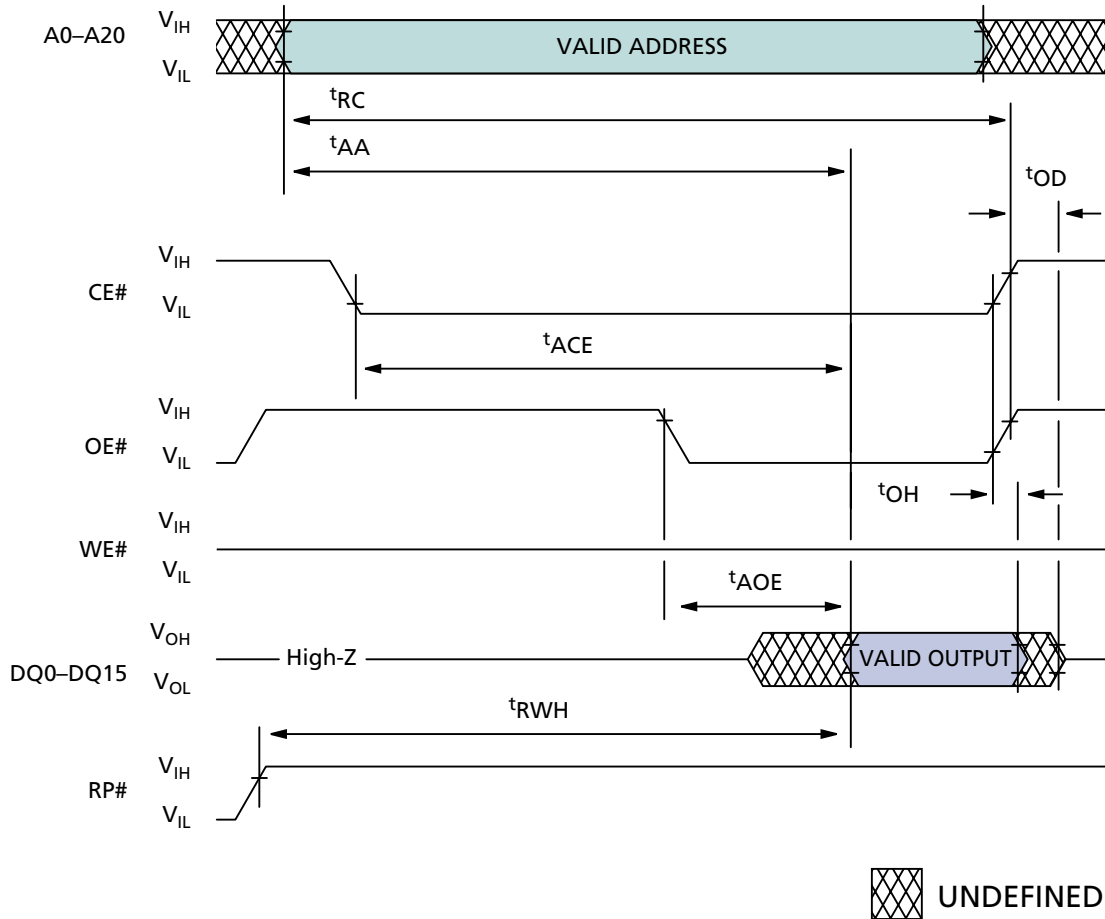
WRITE TIMING PARAMETERS

| SYMBOL | -10/-11 | | UNITS |
|-----------------|--|-----|-------|
| | V _{CC} = 1.65V-1.95V or 1.80V-2.20V | | |
| | MIN | MAX | |
| t _{RS} | 150 | | ns |
| t _{CS} | 0 | | ns |
| t _{WP} | 50 | | ns |
| t _{DS} | 50 | | ns |
| t _{AS} | 50 | | ns |
| t _{CH} | 0 | | ns |
| t _{DH} | 0 | | ns |

| SYMBOL | -10/-11 | | UNITS |
|------------------|--|---------------------|-------|
| | V _{CC} = 1.65V-1.95V or 1.80V-2.20V | | |
| | MIN | MAX | |
| t _{AH} | 9 | | ns |
| t _{RHS} | 200 | | ns |
| t _{VPS} | 200 | | ns |
| t _{WOS} | 50 | | ns |
| t _{RHH} | 0 | | ns |
| t _{VPH} | 0 | | ns |
| t _{WB} | | t _{AA} +50 | ns |

NOTE: 1. The WRITE cycles for the WORD PROGRAMMING command are followed by a READ ARRAY DATA cycle.

SINGLE ASYNCHRONOUS READ OPERATION



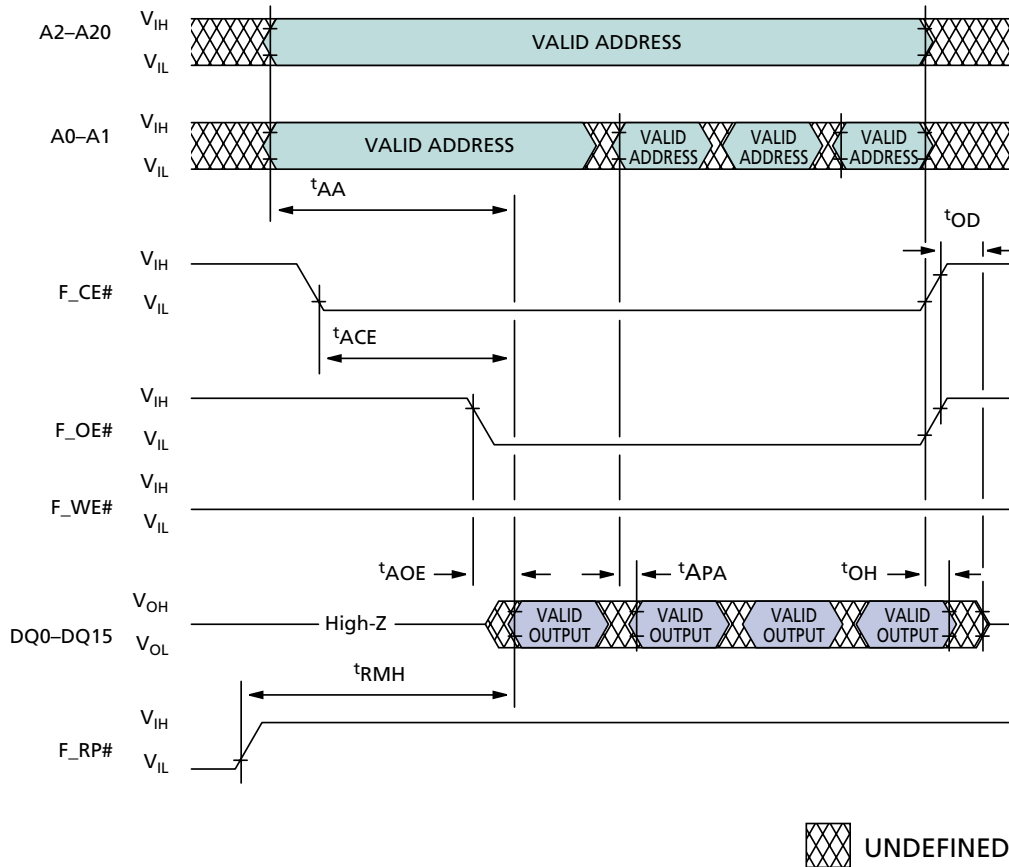
READ TIMING PARAMETERS (V_{CC} = 1.65V–1.95V)

| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V–1.95V | | V _{CC} = 1.65V–1.95V | | |
| | MIN | MAX | MIN | MAX | |
| t _{AA} | | 100 | | 110 | ns |
| t _{ACE} | | 100 | | 110 | ns |
| t _{AOE} | | 30 | | 30 | ns |
| t _{RWH} | | 200 | | 200 | ns |
| t _{OD} | | 25 | | 25 | ns |
| t _{OH} | 0 | | 0 | | ns |
| t _{RC} | | 100 | | 110 | ns |

READ TIMING PARAMETERS (V_{CC} = 1.80V–2.20V)

| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.80V–2.20V | | V _{CC} = 1.80V–2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{AA} | | 95 | | 100 | ns |
| t _{ACE} | | 95 | | 100 | ns |
| t _{AOE} | | 30 | | 30 | ns |
| t _{RWH} | | 150 | | 150 | ns |
| t _{OD} | | 25 | | 25 | ns |
| t _{OH} | 0 | | 0 | | ns |
| t _{RC} | | 95 | | 100 | ns |

ASYNCHRONOUS PAGE MODE READ OPERATION



READ TIMING PARAMETERS

(V_{CC} = 1.65V–1.95V)

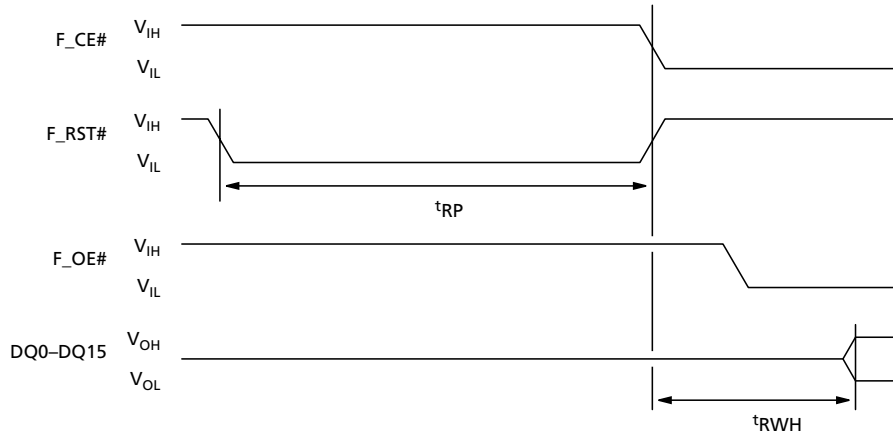
| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V–1.95V | | V _{CC} = 1.65V–1.95V | | |
| | MIN | MAX | MIN | MAX | |
| t _{AA} | | 100 | | 110 | ns |
| t _{ACE} | | 100 | | 110 | ns |
| t _{APA} | | 35 | | 45 | ns |
| t _{AOE} | | 30 | | 30 | ns |
| t _{RWH} | | 200 | | 200 | ns |
| t _{OD} | | 25 | | 25 | ns |
| t _{OH} | 0 | | 0 | | ns |

READ TIMING PARAMETERS

(V_{CC} = 1.80V–2.20V)

| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.80V–2.20V | | V _{CC} = 1.80V–2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{AA} | | 95 | | 100 | ns |
| t _{ACE} | | 95 | | 100 | ns |
| t _{APA} | | 35 | | 45 | ns |
| t _{AOE} | | 30 | | 30 | ns |
| t _{RWH} | | 150 | | 150 | ns |
| t _{OD} | | 25 | | 25 | ns |
| t _{OH} | 0 | | 0 | | ns |

RESET OPERATION



READ TIMING PARAMETERS (Vcc = 1.65V–1.95V)

| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------|-----|-------------------|-----|-------|
| | Vcc = 1.65V–1.95V | | Vcc = 1.65V–1.95V | | |
| | MIN | MAX | MIN | MAX | |
| t _{RWH} | | 200 | | 200 | ns |
| t _{RP} | 125 | | 125 | | ns |

READ TIMING PARAMETERS (Vcc = 1.80V–2.20V)

| SYMBOL | -10 | | -11 | | UNITS |
|------------------|-------------------|-----|-------------------|-----|-------|
| | Vcc = 1.80V–2.20V | | Vcc = 1.80V–2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{RWH} | | 150 | | 150 | ns |
| t _{RP} | 100 | | 100 | | ns |

**Table 12
CFI**

| OFFSET | DATA | DESCRIPTION |
|--------|------------|--|
| 00 | 2Ch | Manufacturer Code |
| 01 | A2h | Top Boot Block Device Code |
| | A3h | Bottom Boot Block Device Code |
| 02–0F | reserved | Reserved |
| 10, 11 | 0051,0052 | “QR” |
| 12 | 0059 | “Y” |
| 13, 14 | 0003, 0000 | Primary OEM Command Set |
| 15, 16 | 0039, 0000 | Address for Primary Extended Table |
| 17, 18 | 0000, 0000 | Alternate OEM Command Set |
| 19, 1A | 0000, 0000 | Address for OEM Extended Table |
| 1B | 0017 | V _{CC} MIN for Erase/Write; Bit7–Bit4 Volts in BCD; Bit3–Bit0 100mV in BCD |
| 1C | 0022 | V _{CC} MAX for Erase/Write; Bit7–Bit4 Volts in BCD; Bit3–Bit0 100mV in BCD |
| 1D | 00B4 | V _{PP} MIN for Erase/Write; Bit7–Bit4 Volts in Hex; Bit3–Bit0 100mV in BCD |
| 1E | 00C6 | V _{PP} MAX for Erase/Write; Bit7–Bit4 Volts in Hex; Bit3–Bit0 100mV in BCD |
| 1F | 0003 | Typical timeout for single byte/word program, 2 ⁿ μs, 0000 = not supported |
| 20 | 0000 | Typical timeout for maximum size multiple byte/word program, 2 ⁿ μs, 0000 = not supported |
| 21 | 0009 | Typical timeout for individual block erase, 2 ⁿ ms, 0000 = not supported |
| 22 | 0000 | Typical timeout for full chip erase, 2 ⁿ ms, 0000 = not supported |
| 23 | 000C | Maximum timeout for single byte/word program, 2 ⁿ μs, 0000 = not supported |
| 24 | 0000 | Maximum timeout for maximum size multiple byte/word program, 2 ⁿ μs, 0000 = not supported |
| 25 | 0003 | Maximum timeout for individual block erase, 2 ⁿ ms, 0000 = not supported |
| 26 | 0000 | Maximum timeout for full chip erase, 2 ⁿ ms, 0000 = not supported |
| 27 | 0016 | Device size, 2 ⁿ bytes |
| 28 | 0001 | Bus Interface x8 = 0, x16 = 1, x8/x16 = 2 |
| 29 | 0000 | Flash device interface description 0000 = async |
| 2A, 2B | 0000, 0000 | Maximum number of bytes in multi-byte program or page, 2 ⁿ |
| 2C | 0003 | Number of erase block regions within device (4K words and 32K words) |
| 2D, 2E | 0037, 0000 | Top boot block device erase block region information 1, 8 blocks ... |
| | 0007, 0000 | Bottom boot block device erase block region information 1, 8 blocks ... |
| 2F, 30 | 0000, 0001 | Top boot block device ...of 8KB |
| | 0020, 0000 | Bottom boot block device ...of 8KB |
| 31, 32 | 0006, 0000 | 7 blocks of ... |
| 33, 34 | 0000, 0001 |64KB |
| 35, 36 | 0007, 0000 | Top boot block device 56 blocks of |
| | 0037, 0000 | Bottom boot block device 56 blocks of |

(continued on the next page)

**Table 12
CFI (continued)**

| OFFSET | DATA | DESCRIPTION |
|--------|------------|--|
| 37, 38 | 0020, 0000 | Top boot block device.....64KB |
| | 0000, 0001 | Bottom boot block device.....64KB |
| 39, 3A | 0050, 0052 | "PR" |
| 3B | 0049 | "I" |
| 3C | 0030 | Major version number, ASCII |
| 3D | 0031 | Minor Version Number, ASCII |
| 3E | 00E6 | Optional Feature and Command Support |
| 3F | 0002 | Bit 0 Chip erase supported no = 0 |
| 40 | 0000 | Bit 1 Suspend erase supported = yes = 1 |
| 41 | 0000 | Bit 2 Suspend program supported = yes = 1 |
| | | Bit 3 Chip lock/unlock supported = no = 0 |
| | | Bit 4 Queued erase supported = no = 0 |
| | | Bit 5 Instant individual block locking supported = yes = 1 |
| | | Bit 6 Protection bits supported = yes = 1 |
| | | Bit 7 Page mode read supported = yes = 1 |
| | | Bit 8 Synchronous read supported = yes = 1 |
| | | Bit 9 Simultaneous operation supported = yes = 1 |
| 42 | 0001 | Program supported after erase suspend = yes |
| 43, 44 | 0003,0000 | Bit 0 Block Lock Status active = yes; Bit 1 Block Lock Down active = yes |
| 45 | 0018 | Vcc supply optimum; Bit7–Bit4 Volts in BCD; Bit3–Bit0 100mV in BCD |
| 46 | 00C0 | Vpp supply optimum; Bit7–Bit4 Volts in Hex; Bit3–Bit0 100mV in BCD |
| 47 | 0001 | Number of protection register fields in JEDEC ID space |
| 48, 49 | 0080, 0000 | Lock bytes LOW address, lock bytes HIGH address |
| 4A, 4B | 0003, 0003 | 2 ⁿ factory programmed bytes, 2 ⁿ user programmable bytes |
| 4C | 0002 | Background Operation 0000 = Not used 0001 = 4% block split 0002 = 12% block split 0003 = 25% block split 0004 = 50% block split |
| 4D | 0000 | Burst Mode Type 0000 = No burst mode 00x1 = 4 words max 00x2 = 8 words max 00x3 = 16 words max 001x = Linear burst, and/or 002x = Interleaved burst, and/or 004x = Continuous burst |
| 4E | 0002 | Page Mode Type 0000 = No page mode 0001 = 4-word page 0002 = 8-word page 0003 = 16-word page 0004 = 32-word page |
| 4F | 0004 | SRAM density, 4Mb (256K x 16) |

SRAM OPERATING MODES

SRAM READ ARRAY

The operational state of the SRAM is determined by S_CE1#, S_CE2, S_WE#, S_OE#, S_UB#, and S_LB#, as indicated in the Truth Table. To perform an SRAM READ operation, S_CE1#, and S_OE#, must be at V_{IL}, and S_CE2 and S_WE# must be at V_{IH}. When in this state, S_UB# and S_LB# control whether the lower byte is read (S_UB# V_{IH}, S_LB# V_{IL}), the upper byte is read (S_UB# V_{IL}, S_LB# V_{IH}), both upper and lower bytes are read (S_UB# V_{IL}, S_LB# V_{IL}), or neither are read (S_UB# V_{IH}, S_LB# V_{IH}) and the device is in a standby state.

While performing an SRAM READ operation, current consumption may be reduced by reading within a 16-word page. This is done by holding S_CE1# and

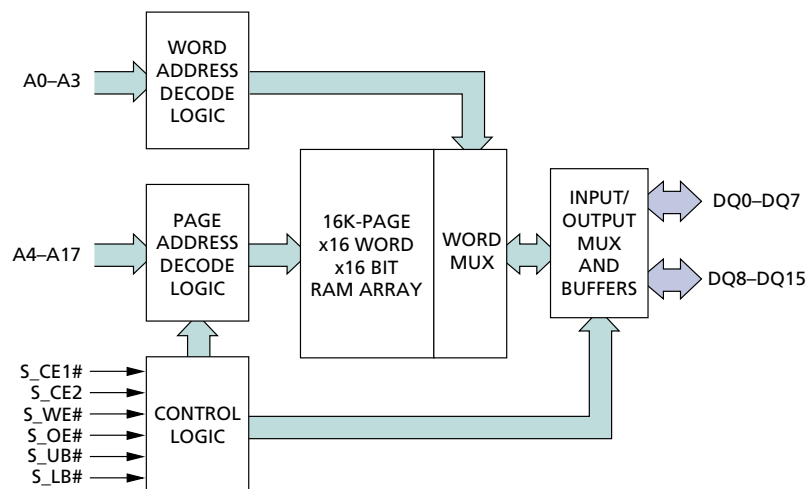
S_OE# at V_{IL}, S_WE# and S_CE2 at V_{IH}, and toggling addresses A0-A3. S_UB# and S_LB# control the data width as described above.

SRAM WRITE ARRAY

In order to perform an SRAM WRITE operation, S_CE1# and S_WE# must be at V_{IL}, and S_CE2 and S_OE# must be at V_{IH}. When in this state, S_UB# and S_LB# control whether the lower byte is written (S_UB# V_{IH}, S_LB# V_{IL}), the upper byte is written (S_UB# V_{IL}, S_LB# V_{IH}), both upper and lower bytes are written (S_UB# V_{IL}, S_LB# V_{IL}), or neither are written (S_UB# V_{IH}, S_LB# V_{IH}) and the device is in a standby state.

SRAM

SRAM FUNCTIONAL BLOCK DIAGRAM





TIMING TEST CONDITIONS

| | |
|--------------------------------------|--|
| Input pulse levels | 0.1V V _{CC} to 0.9V V _{CC} |
| Input rise and fall times | 5ns |
| Input timing reference levels | 0.5V |
| Output timing reference levels | 0.5V |
| Operating Temperature | -40°C to +85°C |

SRAM READ CYCLE TIMING

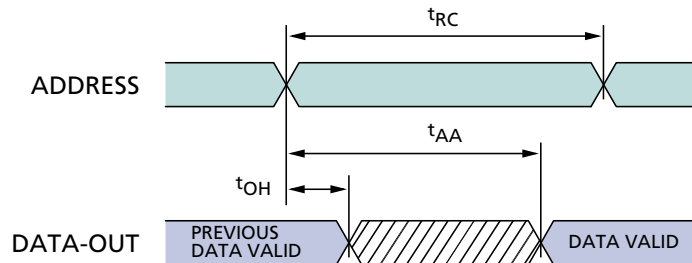
| DESCRIPTION | SYMBOL | -10/-11 | | | | UNITS |
|--------------------------------------|---------------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | | MIN | MAX | MIN | MAX | |
| Read cycle time | t _{RC} | | 100 | | 85 | ns |
| Address access time | t _{AA} | | 100 | | 85 | ns |
| Chip enable to valid output | t _{CO} | | 100 | | 85 | ns |
| Output enable to valid output | t _{OE} | | 35 | | 35 | ns |
| Byte select to valid output | t _{LB} , t _{UB} | | 100 | | 85 | ns |
| Chip enable to Low-Z output | t _{LZ} | 0 | | 0 | | ns |
| Output enable to Low-Z output | t _{OLZ} | 0 | | 0 | | ns |
| Byte select to Low-Z output | t _{LBZ} , t _{UBZ} | 0 | | 0 | | ns |
| Chip enable to High-Z output | t _{HZ} | 0 | 15 | 0 | 15 | ns |
| Output disable to High-Z output | t _{OHZ} | 0 | 15 | 0 | 15 | ns |
| Byte select disable to High-Z output | t _{LBHZ} , t _{UBHZ} | 0 | 15 | 0 | 15 | ns |
| Output hold from address change | t _{OH} | 5 | | 5 | | ns |

SRAM WRITE CYCLE TIMING

| DESCRIPTION | SYMBOL | -10/-11 | | | | UNITS |
|-------------------------------|-------------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | | MIN | MAX | MIN | MAX | |
| Write cycle time | t _{WC} | | 100 | | 85 | ns |
| Chip enable to end of write | t _{CW} | | 100 | | 85 | ns |
| Address valid to end of write | t _{AW} | | 100 | | 85 | ns |
| Byte select to end of write | t _{LBW} , t _{UBW} | | 100 | | 85 | ns |
| Address setup time | t _{AS} | 0 | | 0 | | ns |
| Write pulse width | t _{WP} | 50 | | 50 | | ns |
| Write recovery time | t _{WR} | 0 | | 0 | | ns |
| Write to High-Z output | t _{WHZ} | 0 | 15 | 0 | 15 | ns |
| Data to write time overlap | t _{DW} | 50 | | 50 | | ns |
| Data hold from write time | t _{DH} | 0 | | 0 | | ns |
| End write to Low-Z output | t _{OW} | 0 | | 0 | | ns |

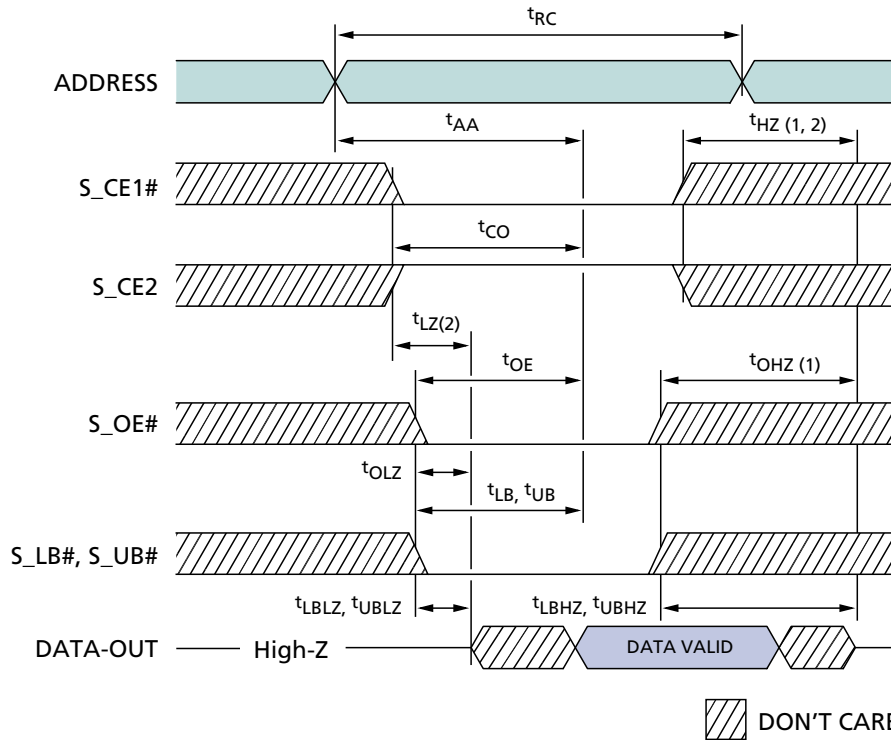
READ CYCLE 1

(S_CE1# = S_OE# = V_{IL}; S_CE2, S_WE# = V_{IH})



READ CYCLE 2

(S_WE# = V_{IH})



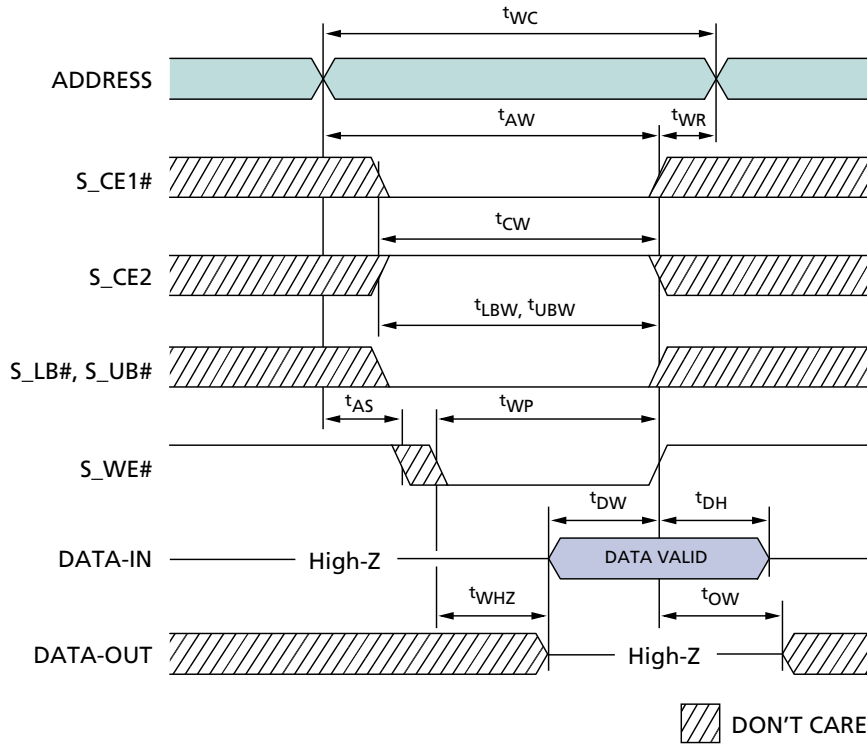
DON'T CARE

READ TIMING PARAMETERS

| SYMBOL | -10/-11 | | | | UNITS |
|-----------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{RC} | | 100 | | 85 | ns |
| t _{AA} | | 100 | | 85 | ns |
| t _{CO} | | 100 | | 85 | ns |
| t _{OE} | | 35 | | 35 | ns |
| t _{LB} , t _{UB} | | 100 | | 85 | ns |
| t _{LZ} | 0 | | 0 | | ns |

| SYMBOL | -10/-11 | | | | UNITS |
|---------------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{OLZ} | 0 | | 0 | | ns |
| t _{HZ} | 0 | 15 | 0 | 15 | ns |
| t _{OHZ} | 0 | 15 | 0 | 15 | ns |
| t _{LBHZ} , t _{UBHZ} | 0 | 15 | 0 | 15 | ns |
| t _{OH} | 5 | | 5 | | ns |

WRITE CYCLE (S_WE# CONTROL)

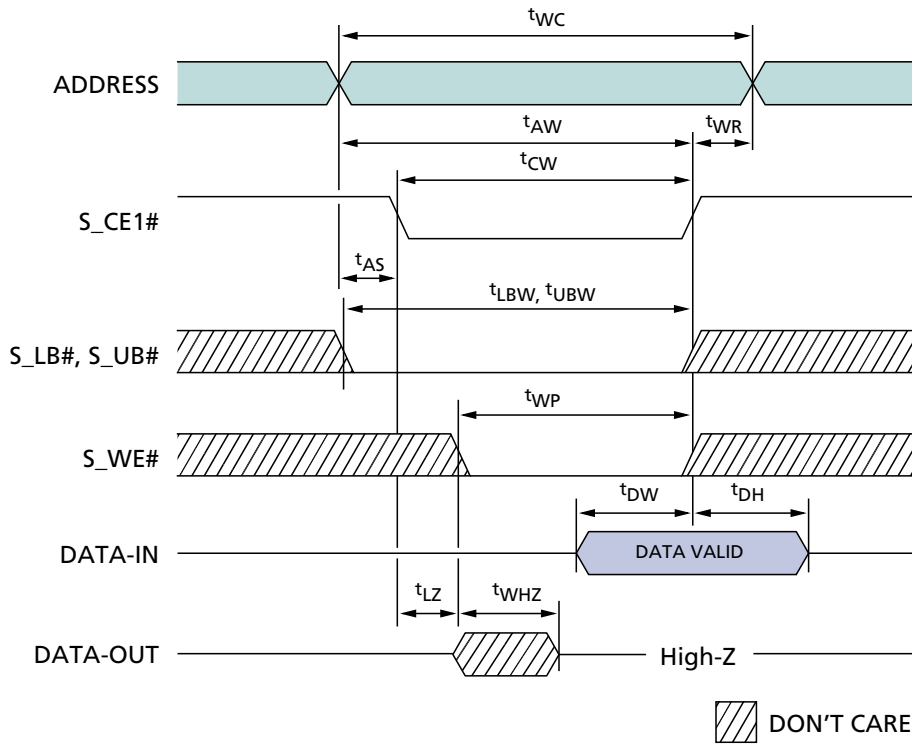


WRITE TIMING PARAMETERS

| SYMBOL | -10/-11 | | | | UNITS |
|-------------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{WC} | | 100 | | 85 | ns |
| t _{CW} | | 100 | | 85 | ns |
| t _{AW} | | 100 | | 85 | ns |
| t _{LBW} , t _{UBW} | | 100 | | 85 | ns |
| t _{AS} | 0 | | 0 | | ns |
| t _{WP} | 50 | | 50 | | ns |

| SYMBOL | -10/-11 | | | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{WR} | 0 | | 0 | | ns |
| t _{WHZ} | 0 | 15 | 0 | 15 | ns |
| t _{DW} | 50 | | 50 | | ns |
| t _{DH} | 0 | | 0 | | ns |
| t _{OW} | 0 | | 0 | | ns |

**WRITE CYCLE 2
(S_CE1# CONTROL)**

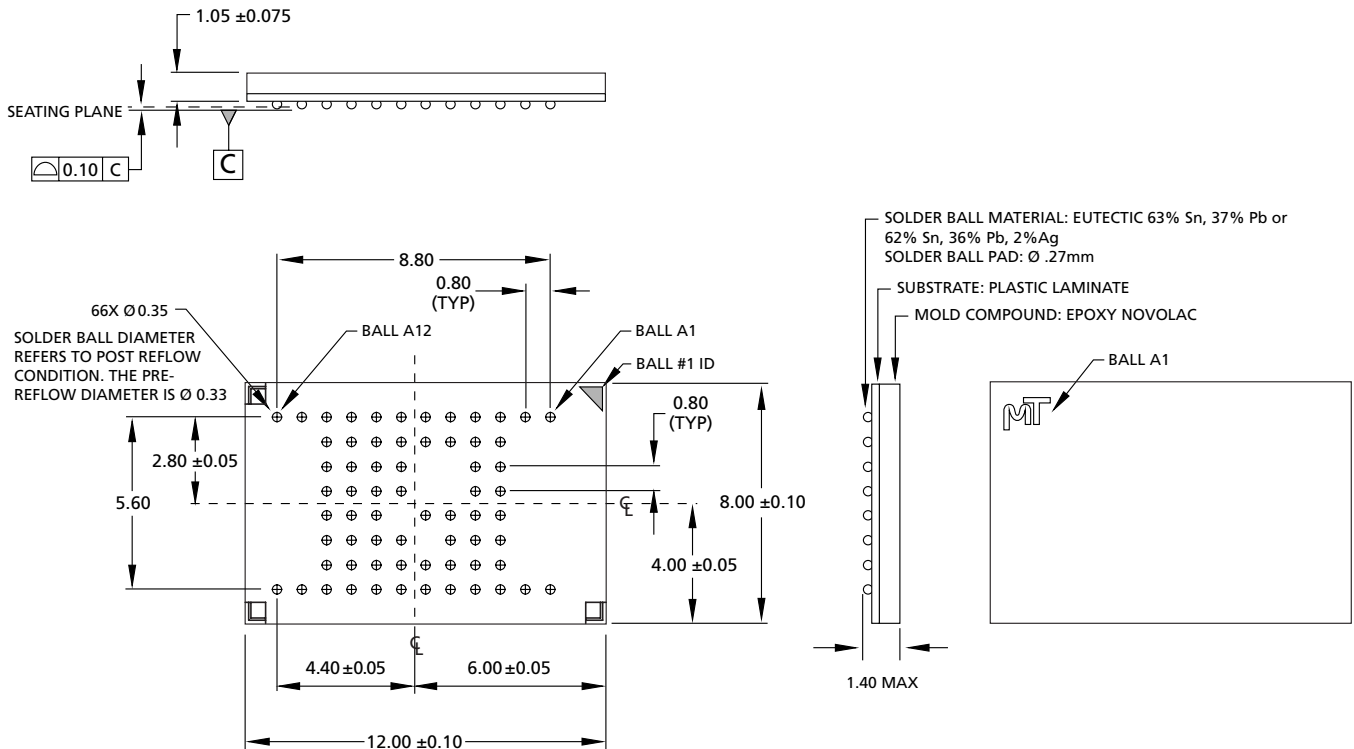


WRITE TIMING PARAMETERS

| SYMBOL | -10/-11 | | | | UNITS |
|-------------------------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{WC} | | 100 | | 85 | ns |
| t _{CW} | | 100 | | 85 | ns |
| t _{AW} | | 100 | | 85 | ns |
| t _{LBW} , t _{UBW} | | 100 | | 85 | ns |
| t _{AS} | 0 | | 0 | | ns |
| t _{WP} | 50 | | 50 | | ns |

| SYMBOL | -10/-11 | | | | UNITS |
|------------------|-------------------------------|-----|-------------------------------|-----|-------|
| | V _{CC} = 1.65V-1.95V | | V _{CC} = 1.80V-2.20V | | |
| | MIN | MAX | MIN | MAX | |
| t _{WR} | 0 | | 0 | | ns |
| t _{WHZ} | 0 | 15 | 0 | 15 | ns |
| t _{DW} | 50 | | 50 | | ns |
| t _{DH} | 0 | | 0 | | ns |
| t _{OW} | 0 | | 0 | | ns |

66-BALL FBGA



- NOTE:**
1. All dimensions in millimeters $\frac{\text{MAX}}{\text{MIN}}$ or typical where noted.
 2. Package width and length do not include mold protrusion; allowable mold protrusion is 0.27mm per side.

DATA SHEET DESIGNATION

This data sheet contains minimum and maximum limits specified over the complete power supply and temperature range for production devices. Although considered final, these specifications are subject to change, as further product development and data characterization sometimes occur.



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REVISION HISTORY

| | |
|--|-------|
| Rev. 4, Pub. 4/02 | 4/02 |
| • Removed the ^t CBPH parameter. | |
| • Updated the chip protection mode and register information. | |
| • Updated the block locking information. | |
| Rev. 4, Pub. 9/01 | 9/01 |
| • Added minimum spec for SRAM output high voltage (V _{OH}) | |
| • Removed CSM Table | |
| Rev. 3, Pub. 6/01 | 6/01 |
| • Data sheet designation change (removed “Advance”) | |
| Rev. 2, Pub. 5/01, Advance | 5/01 |
| • Added V _{PP1} range | |
| • Added second V _{CC} range | |
| Initial published release, Rev. 1, Advance | 11/00 |