



# Intel StrataFlash<sup>®</sup> Memory (J3)

28F256J3, 28F128J3, 28F640J3, 28F320J3 (x8/x16)

Datasheet

## Product Features

- **Performance**
  - 110/115/120/150 ns Initial Access Speed
  - 125 ns Initial Access Speed (256 Mbit density only)
  - 25 ns Asynchronous Page-Mode Reads
  - 30 ns Asynchronous Page-Mode Reads (256Mbit density only)
  - 32-Byte Write Buffer
    - 6.8  $\mu$ s per byte effective programming time
- **Software**
  - Program and Erase suspend support
  - Flash Data Integrator (FDI), Common Flash Interface (CFI) Compatible
- **Security**
  - 128-bit Protection Register
    - 64-bit Unique Device Identifier
    - 64-bit User Programmable OTP Cells
  - Absolute Protection with  $V_{PEN} = GND$
  - Individual Block Locking
  - Block Erase/Program Lockout during Power Transitions
- **Architecture**
  - Multi-Level Cell Technology: High Density at Low Cost
  - High-Density Symmetrical 128-Kbyte Blocks
    - 256 Mbit (256 Blocks) (0.18 $\mu$ m only)
    - 128 Mbit (128 Blocks)
    - 64 Mbit (64 Blocks)
    - 32 Mbit (32 Blocks)
- **Quality and Reliability**
  - Operating Temperature: -40 °C to +85 °C
  - 100K Minimum Erase Cycles per Block
  - 0.18  $\mu$ m ETOX<sup>™</sup> VII Process (J3C)
  - 0.25  $\mu$ m ETOX<sup>™</sup> VI Process (J3A)
- **Packaging and Voltage**
  - 56-Lead TSOP Package
  - 64-Ball Intel<sup>®</sup> Easy BGA Package
  - 48-Ball Intel<sup>®</sup> VF BGA Package (32 and 64 Mbit) (x16 only)
  - $V_{CC} = 2.7$  V to 3.6 V
  - $V_{CCQ} = 2.7$  V to 3.6 V

Capitalizing on Intel's 0.25 and 0.18 micron, two-bit-per-cell technology, the Intel StrataFlash<sup>®</sup> Memory (J3) device provides 2X the bits in 1X the space, with new features for mainstream performance. Offered in 256-Mbit (32-Mbyte), 128-Mbit (16-Mbyte), 64-Mbit, and 32-Mbit densities, the J3 device brings reliable, two-bit-per-cell storage technology to the flash market segment. Benefits include more density in less space, high-speed interface, lowest cost-per-bit NOR device, support for code and data storage, and easy migration to future devices.

Using the same NOR-based ETOX<sup>™</sup> technology as Intel's one-bit-per-cell products, the J3 device takes advantage of over one billion units of flash manufacturing experience since 1987. As a result, J3 components are ideal for code and data applications where high density and low cost are required. Examples include networking, telecommunications, digital set top boxes, audio recording, and digital imaging.

By applying FlashFile<sup>™</sup> memory family pinouts, J3 memory components allow easy design migrations from existing Word-Wide FlashFile memory (28F160S3 and 28F320S3), and first generation Intel StrataFlash<sup>®</sup> memory (28F640J5 and 28F320J5) devices.

J3 memory components deliver a new generation of forward-compatible software support. By using the Common Flash Interface (CFI) and the Scalable Command Set (SCS), customers can take advantage of density upgrades and optimized write capabilities of future Intel StrataFlash<sup>®</sup> memory devices. Manufactured on Intel<sup>®</sup> 0.18 micron ETOX<sup>™</sup> VII (J3C) and 0.25 micron ETOX<sup>™</sup> VI (J3A) process technology, the J3 memory device provides the highest levels of quality and reliability.

**Notice:** This document contains information on new products in production. The specifications are subject to change without notice. Verify with your local Intel sales office that you have the latest datasheet before finalizing a design.

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# Contents

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|            |  |    |
|------------|--|----|
| <b>1.0</b> | <b>Introduction</b> .....                | 7  |
| 1.1        | Document Purpose .....                   | 7  |
| 1.2        | Nomenclature .....                       | 7  |
| 1.3        | Conventions.....                         | 7  |
| <b>2.0</b> | <b>Device Description</b> .....          | 8  |
| 2.1        | Product Overview .....                   | 8  |
| 2.2        | Ballout Diagrams .....                   | 9  |
| 2.3        | Signal Descriptions .....                | 12 |
| 2.4        | Block Diagram .....                      | 13 |
| 2.5        | Memory Map.....                          | 14 |
| <b>3.0</b> | <b>Device Operations</b> .....           | 15 |
| 3.1        | Bus Operations .....                     | 15 |
| 3.1.1      | Bus Read Operation .....                 | 16 |
| 3.1.2      | Bus Write Operation .....                | 16 |
| 3.1.3      | Output Disable .....                     | 16 |
| 3.1.4      | Standby.....                             | 17 |
| 3.1.5      | Reset/Power-Down.....                    | 17 |
| 3.2        | Device Commands .....                    | 17 |
| <b>4.0</b> | <b>Read Operations</b> .....             | 19 |
| 4.1        | Read Array.....                          | 19 |
| 4.1.1      | Asynchronous Page-Mode Read.....         | 19 |
| 4.2        | Read Identifier Codes .....              | 20 |
| 4.2.1      | Read Status Register.....                | 20 |
| 4.3        | Read Query/CFI.....                      | 22 |
| <b>5.0</b> | <b>Programming Operations</b> .....      | 22 |
| 5.1        | Byte/Word Program .....                  | 22 |
| 5.2        | Write to Buffer .....                    | 22 |
| 5.3        | Program Suspend.....                     | 23 |
| 5.4        | Program Resume.....                      | 24 |
| <b>6.0</b> | <b>Erase Operations</b> .....            | 24 |
| 6.1        | Block Erase.....                         | 24 |
| 6.2        | Block Erase Suspend .....                | 24 |
| 6.3        | Erase Resume .....                       | 25 |
| <b>7.0</b> | <b>Security Modes</b> .....              | 26 |
| 7.1        | Set Block Lock-Bit.....                  | 26 |
| 7.2        | Clear Block Lock-Bits.....               | 26 |
| 7.3        | Protection Register Program .....        | 27 |
| 7.3.1      | Reading the Protection Register.....     | 27 |
| 7.3.2      | Programming the Protection Register..... | 27 |
| 7.3.3      | Locking the Protection Register.....     | 27 |
| 7.4        | Array Protection .....                   | 30 |

|                   |   |    |
|-------------------|---|----|
| <b>8.0</b>        | <b>Special Modes</b> .....  | 30 |
| 8.1               | Set Read Configuration Register Command .....                     | 30 |
| 8.2               | Status (STS) .....  | 30 |
| <b>9.0</b>        | <b>Power and Reset</b> .....                                      | 32 |
| 9.1               | Power-Up/Down Characteristics .....                               | 32 |
| 9.2               | Power Supply Decoupling.....                                      | 32 |
| 9.3               | Reset Characteristics.....  | 32 |
| <b>10.0</b>       | <b>Electrical Specifications</b> .....                            | 33 |
| 10.1              | Absolute Maximum Ratings .....                                    | 33 |
| 10.2              | Operating Conditions .....  | 34 |
| 10.3              | DC Current Characteristics.....                                   | 35 |
| 10.4              | DC Voltage Characteristics.....                                   | 36 |
| <b>11.0</b>       | <b>AC Characteristics</b> .....                                   | 37 |
| 11.1              | Read Operations.....  | 37 |
| 11.2              | Write Operations.....   | 40 |
| 11.3              | Block Erase, Program, and Lock-Bit Configuration Performance..... | 41 |
| 11.4              | Reset Operation.....  | 43 |
| 11.5              | AC Test Conditions.....   | 43 |
| 11.6              | Capacitance.....  | 44 |
| <b>Appendix A</b> | <b>Common Flash Interface</b> .....                               | 45 |
| <b>Appendix B</b> | <b>Flow Charts</b> .....  | 52 |
| <b>Appendix C</b> | <b>Mechanical Information</b> .....                               | 61 |
| <b>Appendix D</b> | <b>Design Considerations</b> .....                                | 64 |
| <b>Appendix E</b> | <b>Additional Information</b> .....                               | 66 |
| <b>Appendix F</b> | <b>Ordering Information</b> .....                                 | 67 |

# Revision History

| Date of Revision | Version | Description   |
|------------------|---------|---|
| 07/07/99         | -001    | Original Version  |
| 08/03/99         | -002    | A <sub>0</sub> -A <sub>2</sub> indicated on block diagram   |
| 09/07/99         | -003    | Changed Minimum Block Erase time, I <sub>OL</sub> , I <sub>OH</sub> , Page Mode and Byte Mode currents. Modified RP# on AC Waveform for Write Operations  |
| 12/16/99         | -004    | Changed Block Erase time and t <sub>AVWH</sub><br>Removed all references to 5 V I/O operation<br>Corrected <i>Ordering Information</i> , Valid Combinations entries<br>Changed Min program time to 211 μs<br>Added DU to Lead Descriptions table<br>Changed Chip Scale Package to Ball Grid Array Package<br>Changed default read mode to page mode<br>Removed erase queuing from Figure 10, <i>Block Erase Flowchart</i>   |
| 03/16/00         | -005    | Added Program Max time<br>Added Erase Max time<br>Added Max page mode read current<br>Moved tables to correspond with sections<br>Fixed typographical errors in ordering information and DC parameter table<br>Removed V <sub>CCQ1</sub> setting and changed V <sub>CCQ2/3</sub> to V <sub>CCQ1/2</sub><br>Added recommended resistor value for STS pin<br>Change operation temperature range<br>Removed note that rp# could go to 14 V<br>Removed V <sub>OL</sub> of 0.45 V; Removed V <sub>OH</sub> of 2.4 V<br>Updated I <sub>CCR</sub> Typ values<br>Added Max lock-bit program and lock times<br>Added note on max measurements  |
| 06/26/00         | -006    | Updated cover sheet statement of 700 million units to one billion<br>Corrected Table 10 to show correct maximum program times<br>Corrected error in Max block program time in section 6.7<br>Corrected typical erase time in section 6.7  |
| 2/15/01          | -007    | Updated cover page to reflect 100K minimum erase cycles<br>Updated cover page to reflect 110 ns 32M read speed<br>Removed Set Read Configuration command from Table 4<br>Updated Table 8 to reflect reserved bits are 1-7; not 2-7<br>Updated Table 16 bit 2 definition from R to PSS<br>Changed V <sub>PENLK</sub> Max voltage from 0.8 V to 2.0 V, Section 6.4, <i>DC Characteristics</i><br>Updated 32Mbit Read Parameters R1, R2 and R3 to reflect 110ns, Section 6.5, <i>AC Characteristics—Read-Only Operations</i> <sup>(1,2)</sup><br>Updated write parameter W13 (t <sub>WHL</sub> ) from 90 ns to 500 ns, Section 6.6, <i>AC Characteristics—Write Operations</i><br>Updated Max. Program Suspend Latency W16 (t <sub>WHRH1</sub> ) from 30 to 75 μs, Section 6.7, <i>Block Erase, Program, and Lock-Bit Configuration Performance</i> <sup>(1,2,3)</sup> |
| 04/13/01         | -008    | Revised Section 7.0, <i>Ordering Information</i>  |

| Date of Revision | Version | Description   |
|------------------|---------|---|
| 07/27/01         | -009    | <p>Added Figure 4, 3 Volt Intel StrataFlash® Memory VF BGA Package (32 Mbit)</p> <p>Added Figure 5, 3 Volt Intel StrataFlash® Memory VF BGA Mechanical Specifications</p> <p>Updated Operating Temperature Range to Extended (Section 6.1 and Table 22)</p> <p>Reduced <math>t_{EHQZ}</math> to 35 ns. Reduced <math>t_{WHEH}</math> to 0 ns</p> <p>Added parameter values for -40 °C operation to Lock-Bit and Suspend Latency</p> <p>Updated <math>V_{LKO}</math> and <math>V_{PENLK}</math> to 2.2 V</p> <p>Removed Note #4, Section 6.4 and Section 6.6</p> <p>Minor text edits</p> |
| 10/31/01         | -010    | <p>Added notes under lead descriptions for VF BGA Package</p> <p>Removed 3.0 V - 3.6 V <math>V_{CC}</math>, and <math>V_{CCQ}</math> columns under AC Characteristics</p> <p>Removed byte mode read current row un DC characteristics</p> <p>Added ordering information for VF BGA Package</p> <p>Minor text edits</p>  |
| 03/21/02         | -011    | <p>Changed datasheet to reflect the best known methods</p> <p>Updated max value for Clear Block Lock-Bits time</p> <p>Minor text edits</p>  |
| 12/12/02         | -012    | Added nomenclature for J3C (0.18 $\mu$ m) devices.  |
| 01/24/03         | -013    | Added 115 ns access speed 64 Mb J3C device. Added 120 ns access speed 128 Mb J3C device. Added "TE" package designator for J3C TSOP package.  |
| 12/09/03         | -014    | Revised Asynchronous Page Read description. Revised Write-to-Buffer flow chart. Updated timing waveforms. Added 256-Mbit J3C pinout.  |
| 1/3/04           | -015    | Added 256Mbit device timings, device ID, and CFI information. Also corrected VLKO specification.  |
| 1/23/04          | -016    | Corrected memory block count from 257 to 255.   |
| 1/23/04          | -016    | Memory block count fix.   |
| 5/19/04          | -018    | Restructured the datasheet layout.  |

## 1.0 Introduction

---

This document contains information pertaining to the Intel StrataFlash<sup>®</sup> Memory (J3) device. The purpose of this document is to facilitate the use of this product and describe the features, operations, and specifications of this device.

### 1.1 Nomenclature

|                         |  |
|-------------------------|--|
| <b>AMIN:</b>            | AMIN = A0 for x8<br>AMIN = A1 for x16  |
| <b>AMAX:</b>            | 32 Mbit      AMAX = A21<br>64 Mbit      AMAX = A22<br>128 Mbit     AMAX = A23<br>256 Mbit     AMAX = A24 |
| <b>Block:</b>           | A group of flash cells that share common erase circuitry and erase simultaneously                        |
| <b>Clear:</b>           | Indicates a logic zero (0)   |
| <b>CUI:</b>             | Command User Interface   |
| <b>MLC:</b>             | Multi-Level Cell   |
| <b>OTP:</b>             | One Time Programmable  |
| <b>PLR:</b>             | Protection Lock Register   |
| <b>PR:</b>              | Protection Register  |
| <b>PRD</b>              | Protection Register Data   |
| <b>Program:</b>         | To write data to the flash array   |
| <b>RFU:</b>             | Reserved for Future Use  |
| <b>Set:</b>             | Indicates a logic one (1)  |
| <b>SR:</b>              | Status Register  |
| <b>SRD:</b>             | Status Register Data   |
| <b>VPEN:</b>            | Refers to a signal or package connection name  |
| <b>V<sub>PEN</sub>:</b> | Refers to timing or voltage levels   |
| <b>WSM:</b>             | Write State Machine  |
| <b>XSR:</b>             | eXtended Status Register   |

### 1.2 Conventions

|                  |  |
|------------------|--|
| <b>0x:</b>       | Hexadecimal prefix   |
| <b>0b:</b>       | Binary prefix  |
| <b>k (noun):</b> | 1,000  |
| <b>M (noun):</b> | 1,000,000  |
| <b>Nibble</b>    | 4 bits   |
| <b>Byte:</b>     | 8 bits   |
| <b>Word:</b>     | 16 bits  |
| <b>Kword:</b>    | 1,024 words  |
| <b>Kb:</b>       | 1,024 bits   |
| <b>KB:</b>       | 1,024 bytes  |
| <b>Mb:</b>       | 1,048,576 bits   |
| <b>MB:</b>       | 1,048,576 bytes  |
| <b>Brackets:</b> | Square brackets ([ ]) will be used to designate group membership or to define a group of signals with similar function (i.e., A[21:1], SR[4,1] and D[15:0]). |

## 2.0 Functional Overview

---

The Intel StrataFlash<sup>®</sup> memory family contains high-density memories organized as 32 Mbytes or 16Mwords (256-Mbit, available on the 0.18 $\mu$ m lithography process only), 16 Mbytes or 8 Mwords (128-Mbit), 8 Mbytes or 4 Mwords (64-Mbit), and 4 Mbytes or 2 Mwords (32-Mbit). These devices can be accessed as 8- or 16-bit words. The 128-Mbit device is organized as one-hundred-twenty-eight 128-Kbyte (131,072 bytes) erase blocks. The 64-Mbit device is organized as sixty-four 128-Kbyte erase blocks while the 32-Mbit device contains thirty-two 128-Kbyte erase blocks. A 128-bit Protection Register has multiple uses, including unique flash device identification.

The device's optimized architecture and interface dramatically increases read performance by supporting page-mode reads. This read mode is ideal for non-clock memory systems.

A Common Flash Interface (CFI) permits software algorithms to be used for entire families of devices. This allows device-independent, JEDEC ID-independent, and forward- and backward-compatible software support for the specified flash device families. Flash vendors can standardize their existing interfaces for long-term compatibility.

Scalable Command Set (SCS) allows a single, simple software driver in all host systems to work with all SCS-compliant flash memory devices, independent of system-level packaging (e.g., memory card, SIMM, or direct-to-board placement). Additionally, SCS provides the highest system/device data transfer rates and minimizes device and system-level implementation costs.

A Command User Interface (CUI) serves as the interface between the system processor and internal operation of the device. A valid command sequence written to the CUI initiates device automation. An internal Write State Machine (WSM) automatically executes the algorithms and timings necessary for block erase, program, and lock-bit configuration operations.

A block erase operation erases one of the device's 128-Kbyte blocks typically within one second— independent of other blocks. Each block can be independently erased 100,000 times. Block erase suspend mode allows system software to suspend block erase to read or program data from any other block. Similarly, program suspend allows system software to suspend programming (byte/ word program and write-to-buffer operations) to read data or execute code from any other block that is not being suspended.

Each device incorporates a Write Buffer of 32 bytes (16 words) to allow optimum programming performance. By using the Write Buffer, data is programmed in buffer increments. This feature can improve system program performance more than 20 times over non-Write Buffer writes.

Blocks are selectively and individually lockable in-system. Individual block locking uses block lock-bits to lock and unlock blocks. Block lock-bits gate block erase and program operations. Lock-bit configuration operations set and clear lock-bits (Set Block Lock-Bit and Clear Block Lock-Bits commands).

The Status Register indicates when the WSM's block erase, program, or lock-bit configuration operation is finished.

The STS (STATUS) output gives an additional indicator of WSM activity by providing both a hardware signal of status (versus software polling) and status masking (interrupt masking for background block erase, for example). Status indication using STS minimizes both CPU overhead and system power consumption. When configured in level mode (default mode), it acts as a RY/ BY# signal. When low, STS indicates that the WSM is performing a block erase, program, or lock-bit configuration. STS-high indicates that the WSM is ready for a new command, block erase is



suspended (and programming is inactive), program is suspended, or the device is in reset/power-down mode. Additionally, the configuration command allows the STS signal to be configured to pulse on completion of programming and/or block erases.

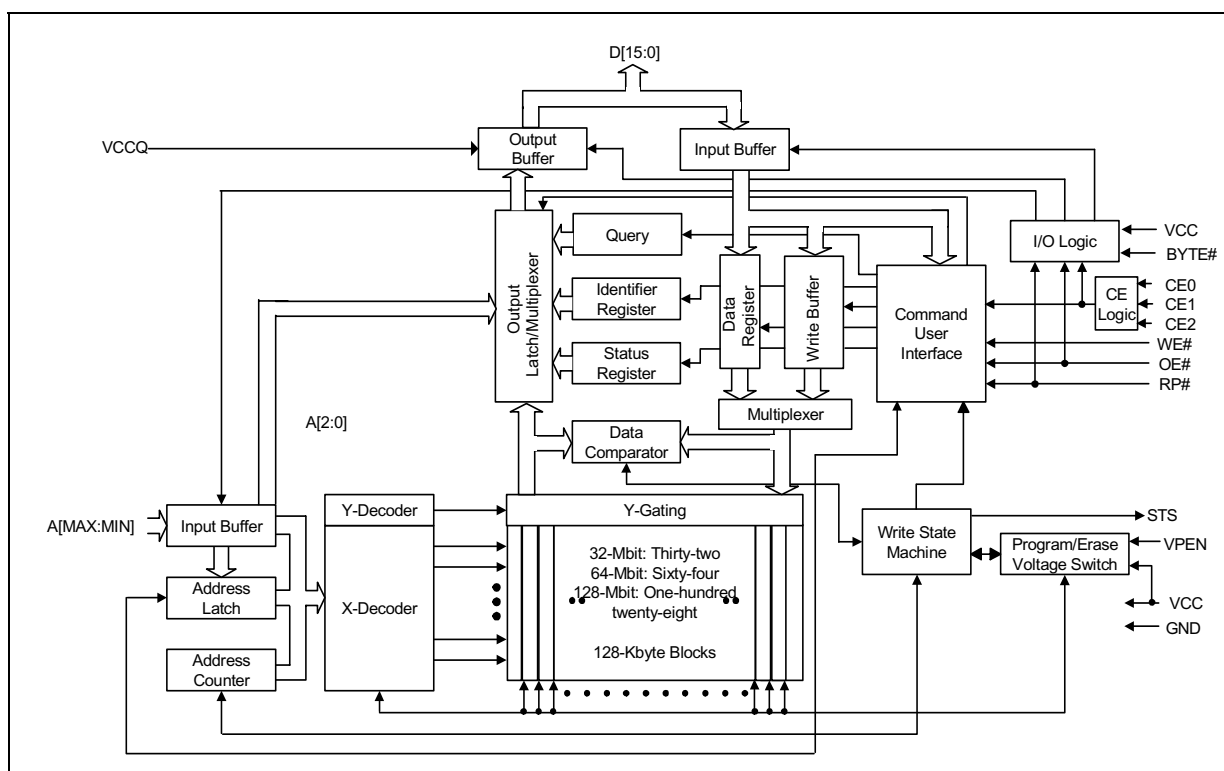
Three CE signals are used to enable and disable the device. A unique CE logic design (see Table 13, “Chip Enable Truth Table” on page 31) reduces decoder logic typically required for multi-chip designs. External logic is not required when designing a single chip, a dual chip, or a 4-chip miniature card or SIMM module.

The BYTE# signal allows either x8 or x16 read/writes to the device. BYTE#-low selects 8-bit mode; address A0 selects between the low byte and high byte. BYTE#-high enables 16-bit operation; address A1 becomes the lowest order address and address A0 is not used (don't care). A device block diagram is shown in Figure 4 on page 14.

When the device is disabled (see Table 13 on page 31), with CEx at V<sub>IH</sub> and RP# at V<sub>IH</sub>, the standby mode is enabled. When RP# is at V<sub>IL</sub>, a further power-down mode is enabled which minimizes power consumption and provides write protection during reset. A reset time (t<sub>PHQV</sub>) is required from RP# going high until data outputs are valid. Likewise, the device has a wake time (t<sub>PHWL</sub>) from RP#-high until writes to the CUI are recognized. With RP# at V<sub>IL</sub>, the WSM is reset and the Status Register is cleared.

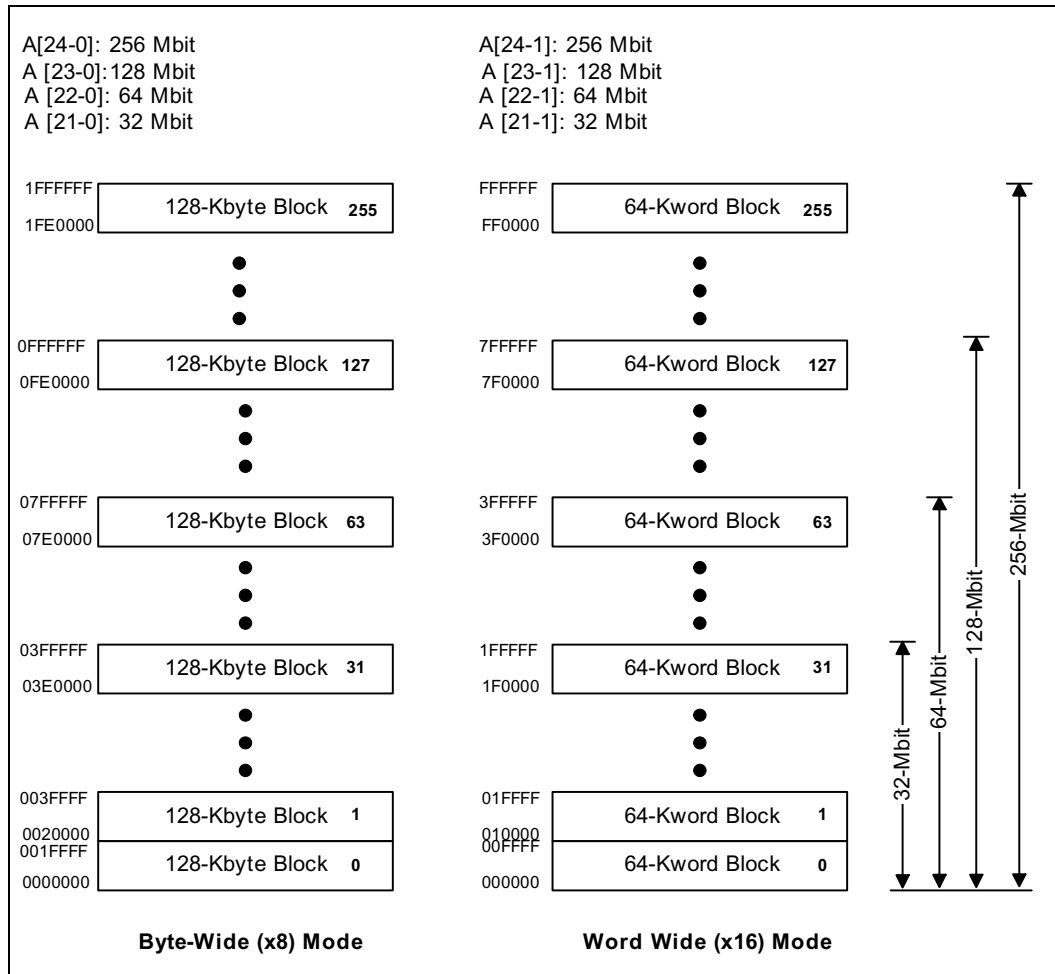
## 2.1 Block Diagram

Figure 1. 3 Volt Intel StrataFlash® Memory Block Diagram



## 2.2 Memory Map

Figure 2. Intel StrataFlash® Memory (J3) Memory Map



## 3.0 Package Information

### 3.1 56-Lead TSOP Package

Figure 3. 56-Lead TSOP Package Drawing and Specifications

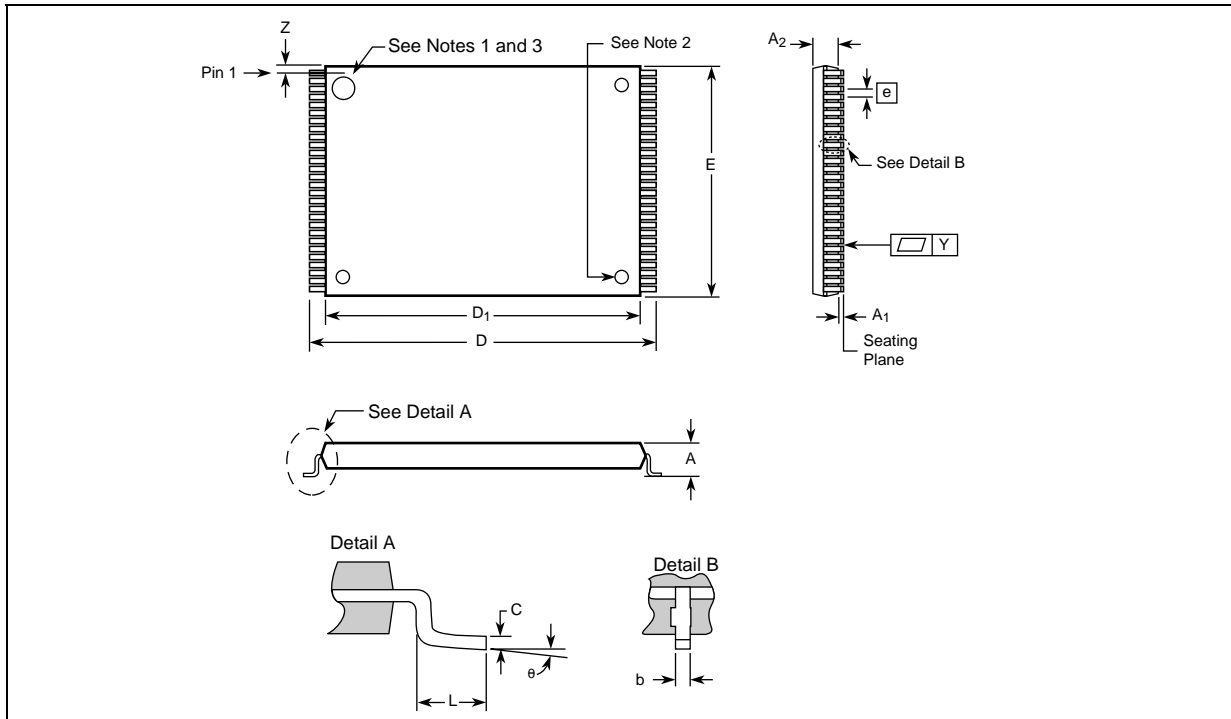


Table 1. 56-Lead TSOP Dimension Table

|                           | Sym            | Millimeters |        |        |       | Inches |        |       |       |
|---------------------------|----------------|-------------|--------|--------|-------|--------|--------|-------|-------|
|                           |                | Min         | Nom    | Max    | Notes | Min    | Nom    | Max   | Notes |
| Package Height            | A              |             |        | 1.200  |       |        |        | 0.047 |       |
| Standoff                  | A <sub>1</sub> | 0.050       |        |        |       | 0.002  |        |       |       |
| Package Body Thickness    | A <sub>2</sub> | 0.965       | 0.995  | 1.025  |       | 0.038  | 0.039  | 0.040 |       |
| Lead Width                | b              | 0.100       | 0.150  | 0.200  |       | 0.004  | 0.006  | 0.008 |       |
| Lead Thickness            | c              | 0.100       | 0.150  | 0.200  |       | 0.004  | 0.006  | 0.008 |       |
| Package Body Length       | D <sub>1</sub> | 18.200      | 18.400 | 18.600 | 4     | 0.717  | 0.724  | 0.732 | 4     |
| Package Body Width        | E              | 13.800      | 14.000 | 14.200 | 4     | 0.543  | 0.551  | 0.559 | 4     |
| Lead Pitch                | e              |             | 0.500  |        |       |        | 0.0197 |       |       |
| Terminal Dimension        | D              | 19.800      | 20.00  | 20.200 |       | 0.780  | 0.787  | 0.795 |       |
| Lead Tip Length           | L              | 0.500       | 0.600  | 0.700  |       | 0.020  | 0.024  | 0.028 |       |
| Lead Count                | N              |             | 56     |        |       |        | 56     |       |       |
| Lead Tip Angle            | ∅              | 0°          | 3°     | 5°     |       | 0°     | 3°     | 5°    |       |
| Seating Plane Coplanarity | Y              |             |        | 0.100  |       |        |        | 0.004 |       |
| Lead to Package Offset    | Z              | 0.150       | 0.250  | 0.350  |       | 0.006  | 0.010  | 0.014 |       |

## 3.2 Easy BGA (J3) Package

Figure 4. Intel StrataFlash® Memory (J3) Easy BGA Mechanical Specifications

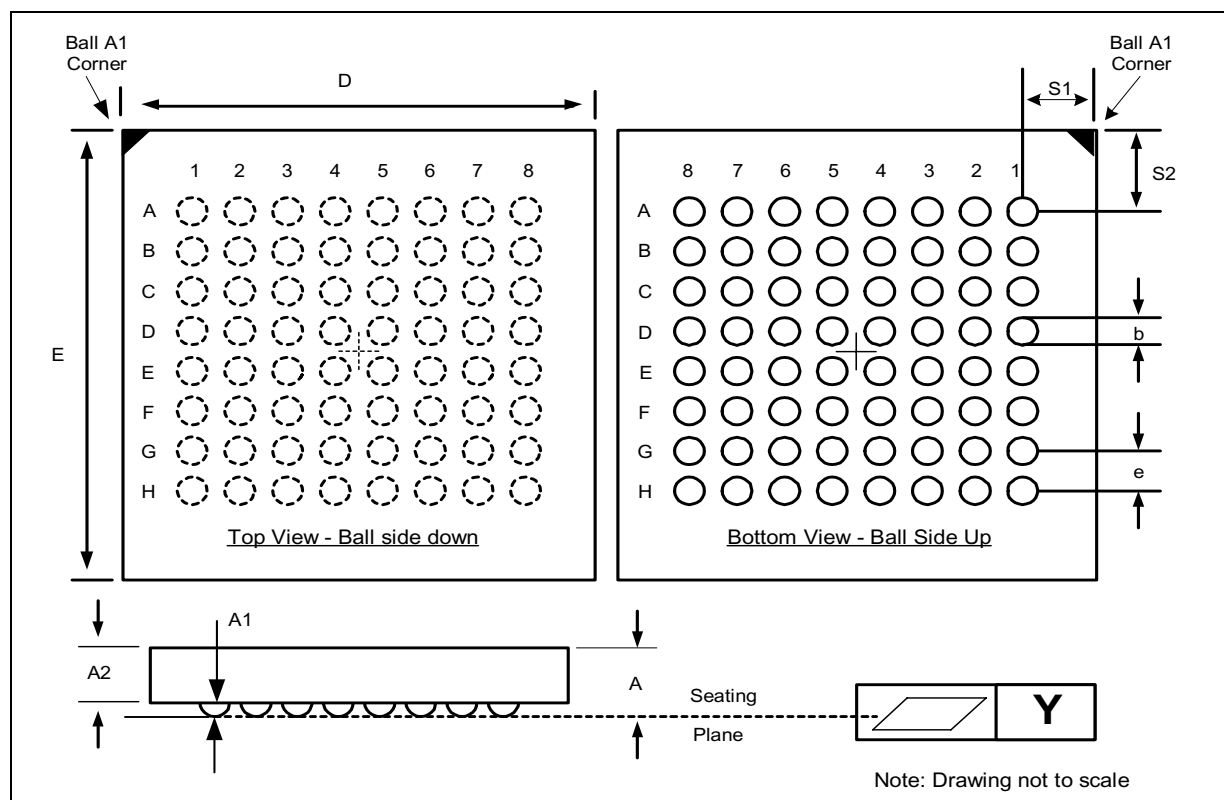


Table 2. Easy BGA Package Dimensions

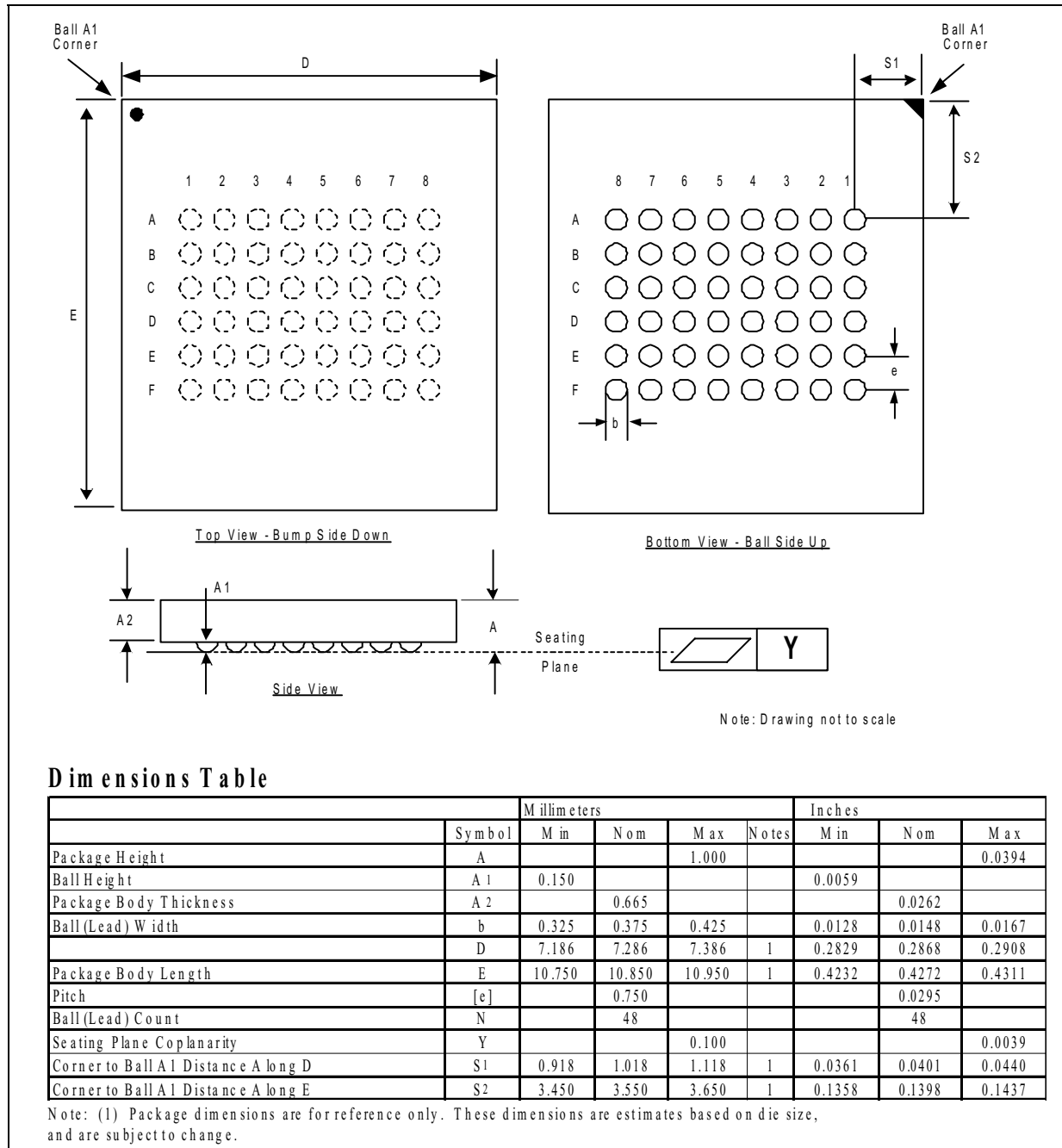
|   | Symbol | Millimeters |        |        |       | Inches |        |        |
|---|--------|-------------|--------|--------|-------|--------|--------|--------|
|   |        | Min         | Nom    | Max    | Notes | Min    | Nom    | Max    |
| Package Height  | A      |             |        | 1.200  |       |        |        | 0.0472 |
| Ball Height   | A1     | 0.250       |        |        |       | 0.0098 |        |        |
| Package Body Thickness                                | A2     |             | 0.780  |        |       |        | 0.0307 |        |
| Ball (Lead) Width                                     | b      | 0.330       | 0.430  | 0.530  |       | 0.0130 | 0.0169 | 0.0209 |
| Package Body Width (32 Mb, 64 Mb, 128 Mb, 256 Mb)     | D      | 9.900       | 10.000 | 10.100 | 1     | 0.3898 | 0.3937 | 0.3976 |
| Package Body Length (32 Mb, 64 Mb, 128 Mb)            | E      | 12.900      | 13.000 | 13.100 | 1     | 0.5079 | 0.5118 | 0.5157 |
| Package Body Length (256 Mb)                          | E      | 14.900      | 15.000 | 15.100 | 1     | 0.5866 | 0.5906 | 0.5945 |
| Pitch   | [e]    |             | 1.000  |        |       |        | 0.0394 |        |
| Ball (Lead) Count                                     | N      |             | 64     |        |       |        | 64     |        |
| Seating Plane Coplanarity                             | Y      |             |        | 0.100  |       |        |        | 0.0039 |
| Corner to Ball A1 Distance Along D (32/64/128/256 Mb) | S1     | 1.400       | 1.500  | 1.600  | 1     | 0.0551 | 0.0591 | 0.0630 |
| Corner to Ball A1 Distance Along E (32/64/128 Mb)     | S2     | 2.900       | 3.000  | 3.100  | 1     | 0.1142 | 0.1181 | 0.1220 |
| Corner to Ball A1 Distance Along E (256 Mb)           | S2     | 3.900       | 4.000  | 4.100  | 1     | 0.1535 | 0.1575 | 0.1614 |

**NOTES:**

1. For Daisy Chain Evaluation Unit information refer to the Intel Flash Memory Packaging Technology Web page at: [www.intel.com/design/packtech/index.htm](http://www.intel.com/design/packtech/index.htm)
2. For Packaging Shipping Media information see [www.intel.com/design/packtech/index.htm](http://www.intel.com/design/packtech/index.htm)

### 3.3 VF-BGA (J3) Package

Figure 5. Intel StrataFlash® Memory (J3) VF BGA Mechanical Specifications



**NOTES:**

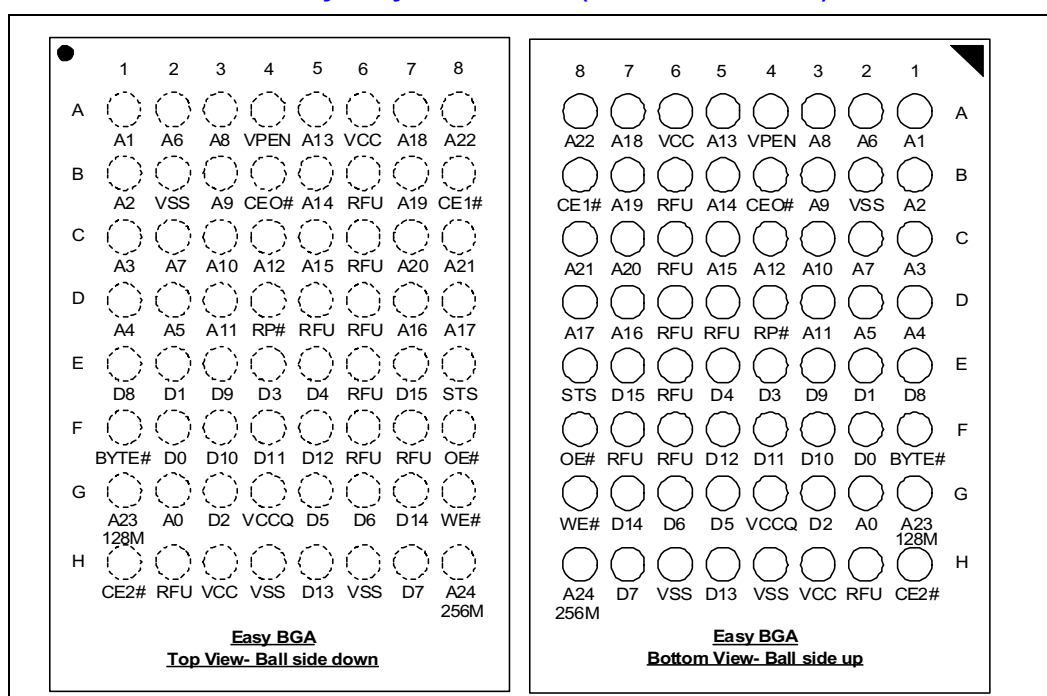
1. For Daisy Chain Evaluation Unit information refer to the Intel Flash Memory Packaging Technology Web page at; [www.intel.com/design/packtech/index.htm](http://www.intel.com/design/packtech/index.htm)
2. For Packaging Shipping Media information refer to the Intel Flash Memory Packaging Technology Web page at; [www.intel.com/design/packtech/index.htm](http://www.intel.com/design/packtech/index.htm)

## 4.0 Ballout and Signal Descriptions

Intel StrataFlash<sup>®</sup> memory is available in three package types. Each density of the J3C is supported on both 64-ball Easy BGA and 56-lead Thin Small Outline Package (TSOP) packages. A 48-ball VF BGA package is available on 32 and 64 Mbit devices. Figure 6, Figure 7, and Figure 8 show the pinouts.

### 4.1 Easy BGA Ballout (32/64/128/256 Mbit)

Figure 6. Intel StrataFlash<sup>®</sup> Memory Easy BGA Ballout (32/64/128/256 Mbit)

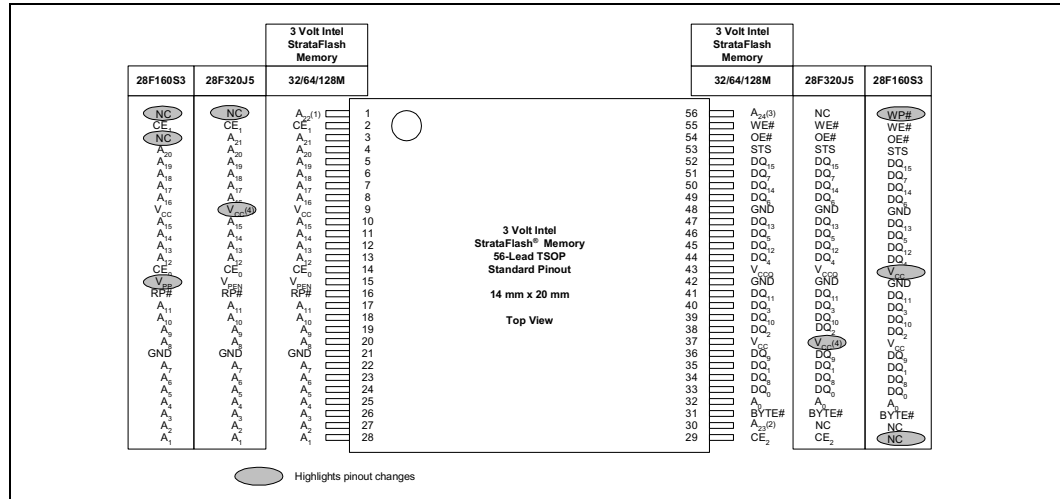


**NOTES:**

1. Address A22 is only valid on 64-Mbit densities and above, otherwise, it is a no connect (NC).
2. Address A23 is only valid on 128-Mbit densities and above, otherwise, it is a no connect (NC).
3. Address A24 is only valid on 256-Mbit densities and above, otherwise, it is a no connect (NC).

## 4.2 56-Lead TSOP (32/64/128/256 Mbit)

Figure 7. Intel StrataFlash® Memory 56-Lead TSOP (32/64/128/256 Mbit)

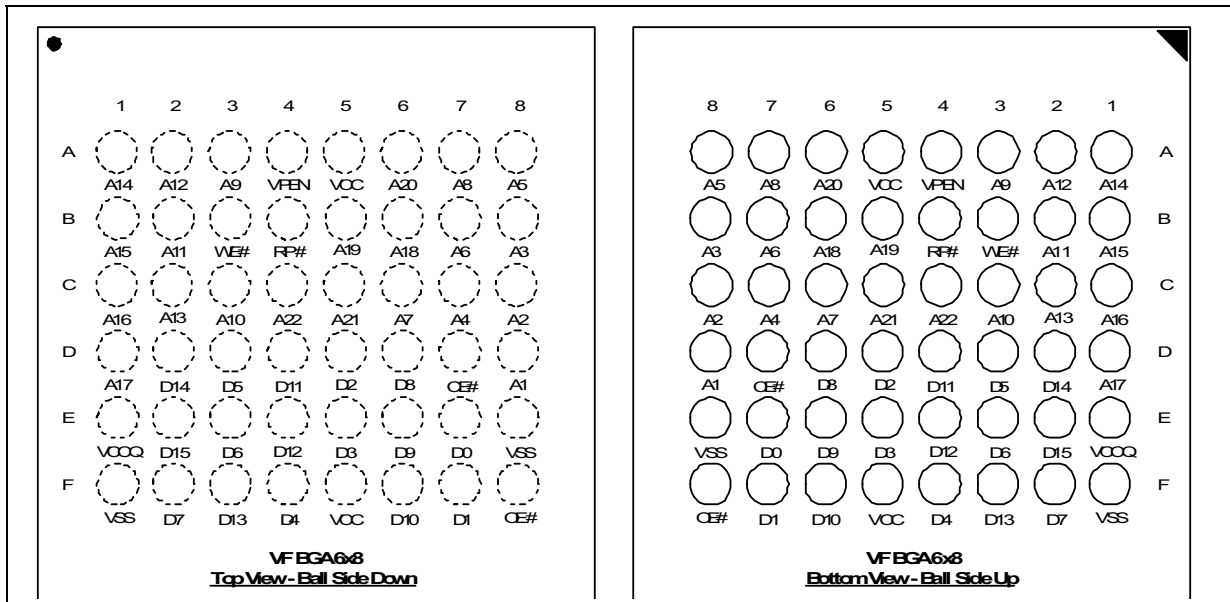


**NOTES:**

1. A22 exists on 64-, 128- and 256-Mbit densities. On 32-Mbit densities this signal is a no-connect (NC).
2. A23 exists on 128-Mbit densities. On 32- and 64-Mbit densities this signal is a no-connect (NC).
3. A24 exists on 256-Mbit densities. On 32-, 64- and 128-Mbit densities this signal is a no-connect (NC).
4.  $V_{CC} = 5 V \pm 10\%$  for the 28F640J5/28F320J5.

## 4.3 VF BGA Ballout (32 and 64 Mbit)

Figure 8. Intel StrataFlash® Memory VF BGA Ballout (32 and 64 Mbit)



**NOTES:**

1. CE# is equivalent to CE0, and CE1 and CE2 are internally grounded.
2. A22 exists on the 64 Mb density only. On the 32-Mbit density, this signal is a no-connect (NC).
3. STS not supported in this package.
4. x8 not supported in this package.

## 4.4 Signal Descriptions

Table 3 describes active signals used.

**Table 3. Signal Descriptions (Sheet 1 of 2)**

| Symbol              | Type                 | Name and Function  |
|---------------------|----------------------|--|
| A0                  | Input                | <b>BYTE-SELECT ADDRESS:</b> Selects between high and low byte when the device is in x8 mode. This address is latched during a x8 program cycle. Not used in x16 mode (i.e., the A0 input buffer is turned off when BYTE# is high).   |
| A[MAX:1]            | Input                | <b>ADDRESS INPUTS:</b> Inputs for addresses during read and program operations. Addresses are internally latched during a program cycle.<br>32-Mbit: A[21:0]<br>64-Mbit: A[22:0]<br>128-Mbit: A[23:0]<br>256-Mbit: A[24:0]   |
| D[7:0]              | Input/Output         | <b>LOW-BYTE DATA BUS:</b> Inputs data during buffer writes and programming, and inputs commands during CUI writes. Outputs array, CFI, identifier, or status data in the appropriate read mode. Data is internally latched during write operations.  |
| D[15:8]             | Input/Output         | <b>HIGH-BYTE DATA BUS:</b> Inputs data during x16 buffer writes and programming operations. Outputs array, CFI, or identifier data in the appropriate read mode; not used for Status Register reads. Data is internally latched during write operations in x16 mode. D[15-8] float in x8 mode  |
| CE0,<br>CE1,<br>CE2 | Input                | <b>CHIP ENABLES:</b> Activates the device's control logic, input buffers, decoders, and sense amplifiers. When the device is de-selected (see <a href="#">Table 13 on page 31</a> ), power reduces to standby levels.<br><br>All timing specifications are the same for these three signals. Device selection occurs with the first edge of CE0, CE1, or CE2 that enables the device. Device deselection occurs with the first edge of CE0, CE1, or CE2 that disables the device (see <a href="#">Table 13 on page 31</a> ). |
| RP#                 | Input                | <b>RESET/ POWER-DOWN:</b> RP#-low resets internal automation and puts the device in power-down mode. RP#-high enables normal operation. Exit from reset sets the device to read array mode. When driven low, RP# inhibits write operations which provides data protection during power transitions.  |
| OE#                 | Input                | <b>OUTPUT ENABLE:</b> Activates the device's outputs through the data buffers during a read cycle. OE# is active low.  |
| WE#                 | Input                | <b>WRITE ENABLE:</b> Controls writes to the CUI, the Write Buffer, and array blocks. WE# is active low. Addresses and data are latched on the rising edge of WE#.  |
| STS                 | Open Drain<br>Output | <b>STATUS:</b> Indicates the status of the internal state machine. When configured in level mode (default), it acts as a RY/BY# signal. When configured in one of its pulse modes, it can pulse to indicate program and/or erase completion. For alternate configurations of the STATUS signal, see the Configurations command. STS is to be tied to VCCQ with a pull-up resistor.   |
| BYTE#               | Input                | <b>BYTE ENABLE:</b> BYTE#-low places the device in x8 mode; data is input or output on D[7:0], while D[15:8] is placed in High-Z. Address A0 selects between the high and low byte. BYTE#-high places the device in x16 mode, and turns off the A0 input buffer. Address A1 becomes the lowest-order address bit.  |
| VPEN                | Input                | <b>ERASE / PROGRAM / BLOCK LOCK ENABLE:</b> For erasing array blocks, programming data, or configuring lock-bits.<br><br>With $V_{PEN} \leq V_{PENLK}$ , memory contents cannot be altered.  |
| VCC                 | Power                | <b>CORE POWER SUPPLY: Core (logic) source voltage. Writes to the flash array are inhibited when <math>V_{CC} \leq V_{LKO}</math>.</b> Device operation at invalid Vcc voltages should not be attempted.  |
| VCCQ                | Power                | <b>I/O POWER SUPPLY:</b> I/O Output-driver source voltage. This ball can be tied to VCC.   |



**Table 3. Signal Descriptions (Sheet 2 of 2)**

| Symbol | Type   | Name and Function  |
|--------|--------|--|
| GND    | Supply | <b>GROUND:</b> Do not float any ground signals.  |
| NC     | —      | <b>NO CONNECT:</b> Lead is not internally connected; it may be driven or floated.  |
| RFU    | —      | <b>RESERVED for FUTURE USE:</b> Balls designated as RFU are reserved by Intel for future device functionality and enhancement. |

## 5.0 Maximum Ratings and Operating Conditions

### 5.1 Absolute Maximum Ratings

This datasheet contains information on new products in production. The specifications are subject to change without notice. Verify with your local Intel Sales office that you have the latest datasheet before finalizing a design. Absolute maximum ratings are shown in [Table 4](#).

**Warning:** Stressing the device beyond the “Absolute Maximum Ratings” **may cause permanent damage**. These are stress ratings only. Operation beyond the “Operating Conditions” is not recommended and extended exposure beyond the “Operating Conditions” may affect device reliability.

**Table 4. Absolute Maximum Ratings**

| Parameter                       | Maximum Rating                  |
|---------------------------------|---------------------------------|
| Temperature under Bias Extended | –40 °C to +85 °C                |
| Storage Temperature             | –65 °C to +125 °C               |
| Voltage On Any signal           | –2.0 V to +5.0 V <sup>(1)</sup> |
| Output Short Circuit Current    | 100 mA <sup>(2)</sup>           |

**NOTES:**

- All specified voltages are with respect to GND. Minimum DC voltage is –0.5 V on input/output signals and –0.2 V on  $V_{CC}$  and  $V_{PEN}$  signals. During transitions, this level may undershoot to –2.0 V for periods <20 ns. Maximum DC voltage on input/output signals,  $V_{CC}$ , and  $V_{PEN}$  is  $V_{CC} + 0.5$  V which, during transitions, may overshoot to  $V_{CC} + 2.0$  V for periods <20 ns.
- Output shorted for no more than one second. No more than one output shorted at a time.

### 5.2 Operating Conditions

**Table 5. Temperature and  $V_{CC}$  Operating Conditions**

| Symbol    | Parameter                              | Min  | Max  | Unit | Test Condition      |
|-----------|--|------|------|------|---------------------|
| $T_A$     | Operating Temperature                  | –40  | +85  | °C   | Ambient Temperature |
| $V_{CC}$  | $V_{CC1}$ Supply Voltage (2.7 V–3.6 V) | 2.70 | 3.60 | V    | —                   |
| $V_{CCQ}$ | $V_{CCQ}$ Supply Voltage (2.7 V–3.6 V) | 2.70 | 3.60 | V    | —                   |

## 6.0 Electrical Specifications

### 6.1 DC Current Characteristics

**Table 6. DC Current Characteristics**

| Symbol                   | Parameter   | Typ  | Max      | Unit    | Test Conditions  | Notes |
|--------------------------|---|------|----------|---------|--|-------|
| $I_{LI}$                 | Input and $V_{PEN}$ Load Current                        |      | $\pm 1$  | $\mu A$ | $V_{CC} = V_{CC} \text{ Max}; V_{CCQ} = V_{CCQ} \text{ Max}$<br>$V_{IN} = V_{CCQ}$ or GND  | 1     |
| $I_{LO}$                 | Output Leakage Current                                  |      | $\pm 10$ | $\mu A$ | $V_{CC} = V_{CC} \text{ Max}; V_{CCQ} = V_{CCQ} \text{ Max}$<br>$V_{IN} = V_{CCQ}$ or GND  | 1     |
| $I_{CCS}$                | $V_{CC}$ Standby Current                                | 50   | 120      | $\mu A$ | CMOS Inputs, $V_{CC} = V_{CC} \text{ Max}$ ,<br>Device is disabled (see Table 13, "Chip Enable Truth Table" on page 31),<br>$RP\# = V_{CCQ} \pm 0.2 \text{ V}$                                       | 1,2,3 |
|                          |   | 0.71 | 2        | mA      | TTL Inputs, $V_{CC} = V_{CC} \text{ Max}$ ,<br>Device is disabled (see Table 13), $RP\# = V_{IH}$  |       |
| $I_{CCD}$                | $V_{CC}$ Power-Down Current                             | 50   | 120      | $\mu A$ | $RP\# = GND \pm 0.2 \text{ V}, I_{OUT} \text{ (STS)} = 0 \text{ mA}$   |       |
| $I_{CCR}$                | $V_{CC}$ Page Mode Read Current                         | 15   | 20       | mA      | CMOS Inputs, $V_{CC} = V_{CC} \text{ Max}, V_{CCQ} = V_{CCQ} \text{ Max}$ using standard 4 word page mode reads.<br>Device is enabled (see Table 13)<br>$f = 5 \text{ MHz}, I_{OUT} = 0 \text{ mA}$  | 1,3   |
|                          |   | 24   | 29       | mA      | CMOS Inputs, $V_{CC} = V_{CC} \text{ Max}, V_{CCQ} = V_{CCQ} \text{ Max}$ using standard 4 word page mode reads.<br>Device is enabled (see Table 13)<br>$f = 33 \text{ MHz}, I_{OUT} = 0 \text{ mA}$ |       |
| $I_{CCW}$                | $V_{CC}$ Program or Set Lock-Bit Current                | 35   | 60       | mA      | CMOS Inputs, $V_{PEN} = V_{CC}$  | 1,4   |
|                          |   | 40   | 70       | mA      | TTL Inputs, $V_{PEN} = V_{CC}$   |       |
| $I_{CCE}$                | $V_{CC}$ Block Erase or Clear Block Lock-Bits Current   | 35   | 70       | mA      | CMOS Inputs, $V_{PEN} = V_{CC}$  | 1,4   |
|                          |   | 40   | 80       | mA      | TTL Inputs, $V_{PEN} = V_{CC}$   |       |
| $I_{CCWS}$<br>$I_{CCES}$ | $V_{CC}$ Program Suspend or Block Erase Suspend Current |      | 10       | mA      | Device is enabled (see Table 13)   | 1,5   |

**NOTES:**

1. All currents are in RMS unless otherwise noted. These currents are valid for all product versions (packages and speeds). Contact Intel's Application Support Hotline or your local sales office for information about typical specifications.
2. Includes STS.
3. CMOS inputs are either  $V_{CC} \pm 0.2 \text{ V}$  or  $GND \pm 0.2 \text{ V}$ . TTL inputs are either  $V_{IL}$  or  $V_{IH}$ .
4. Sampled, not 100% tested.
5.  $I_{CCWS}$  and  $I_{CCES}$  are specified with the device selected. If the device is read or written while in erase suspend mode, the device's current draw is  $I_{CCR}$  and  $I_{CCS}$

## 6.2 DC Voltage Characteristics

Table 7. DC Voltage Characteristics

| Symbol             | Parameter  | Min                     | Max                    | Unit | Test Conditions  | Notes |
|--------------------|--|-------------------------|------------------------|------|--|-------|
| V <sub>IL</sub>    | Input Low Voltage  | -0.5                    | 0.8                    | V    |  | 2, 6  |
| V <sub>IH</sub>    | Input High Voltage   | 2.0                     | V <sub>CCQ</sub> + 0.5 | V    |  | 2,6   |
| V <sub>OL</sub>    | Output Low Voltage   |                         | 0.4                    | V    | V <sub>CCQ</sub> = V <sub>CCQ</sub> Min<br>I <sub>OL</sub> = 2 mA    | 1,2   |
|                    |  |                         | 0.2                    | V    | V <sub>CCQ</sub> = V <sub>CCQ</sub> Min<br>I <sub>OL</sub> = 100 μA  |       |
| V <sub>OH</sub>    | Output High Voltage  | 0.85 × V <sub>CCQ</sub> |                        | V    | V <sub>CCQ</sub> = V <sub>CCQ</sub> Min<br>I <sub>OH</sub> = -2.5 mA | 1,2   |
|                    |  | V <sub>CCQ</sub> - 0.2  |                        | V    | V <sub>CCQ</sub> = V <sub>CCQ</sub> Min<br>I <sub>OH</sub> = -100 μA |       |
| V <sub>PENLK</sub> | V <sub>PEN</sub> Lockout during Program, Erase and Lock-Bit Operations |                         | 2.2                    | V    |  | 2,3,4 |
| V <sub>PENH</sub>  | V <sub>PEN</sub> during Block Erase, Program, or Lock-Bit Operations   | 2.7                     | 3.6                    | V    |  | 3,4   |
| V <sub>LKO</sub>   | V <sub>CC</sub> Lockout Voltage  | 2.0                     |                        | V    |  | 5     |

**NOTES:**

1. Includes STS.
2. Sampled, not 100% tested.
3. Block erases, programming, and lock-bit configurations are inhibited when V<sub>PEN</sub> ≤ V<sub>PENLK</sub>, and not guaranteed in the range between V<sub>PENLK</sub> (max) and V<sub>PENH</sub> (min), and above V<sub>PENH</sub> (max).
4. Typically, V<sub>PEN</sub> is connected to V<sub>CC</sub> (2.7 V–3.6 V).
5. Block erases, programming, and lock-bit configurations are inhibited when V<sub>CC</sub> < V<sub>LKO</sub>, and not guaranteed in the range between V<sub>LKO</sub> (min) and V<sub>CC</sub> (min), and above V<sub>CC</sub> (max).
6. Includes all operational modes of the device including standby and power-up sequences

## 7.0 AC Characteristics

### 7.1 Read Operations

Table 8. Read Operations (Sheet 1 of 2)

| Asynchronous Specifications<br>(All units in ns unless otherwise noted) |                     |  | $V_{CC} = 2.7\text{ V} - 3.6\text{ V}^{(3)}$<br>$V_{CCQ} = 2.7\text{ V} - 3.6\text{ V}^{(3)}$ |     |      |     |      |     |      |     |      |     | Notes |       |     |
|---|---------------------|--|---|-----|------|-----|------|-----|------|-----|------|-----|-------|-------|-----|
|   |                     |  | -110  |     | -115 |     | -120 |     | -125 |     | -150 |     |       |       |     |
| #   | Sym                 | Parameter  | Density   | Min | Max  | Min | Max  | Min | Max  | Min | Max  | Min | Max   |       |     |
| R1  | $t_{AVAV}$          | Read/Write Cycle Time  | 32 Mbit   | 110 |      |     |      |     |      |     |      |     |       | 1,2   |     |
|   |                     |  | 64 Mbit   |     |      | 115 |      | 120 |      |     |      |     |       |       | 1,2 |
|   |                     |  | 128 Mbit  |     |      |     |      | 120 |      |     |      | 150 |       |       | 1,2 |
|   |                     |  | 256 Mbit  |     |      |     |      |     |      | 125 |      |     |       |       | 1,2 |
| R2  | $t_{AVQV}$          | Address to Output Delay  | 32 Mbit   |     | 110  |     |      |     |      |     |      |     |       | 1,2   |     |
|   |                     |  | 64 Mbit   |     |      |     | 115  |     | 120  |     |      |     |       | 1,2   |     |
|   |                     |  | 128 Mbit  |     |      |     |      |     | 120  |     |      |     | 150   |       | 1,2 |
|   |                     |  | 256 Mbit  |     |      |     |      |     |      |     | 125  |     |       |       | 1,2 |
| R3  | $t_{ELQV}$          | CE# to Output Delay  | 32 Mbit   |     | 110  |     |      |     |      |     |      |     |       | 1,2   |     |
|   |                     |  | 64 Mbit   |     |      |     | 115  |     | 120  |     |      |     |       | 1,2   |     |
|   |                     |  | 128 Mbit  |     |      |     |      |     | 120  |     |      |     | 150   |       | 1,2 |
|   |                     |  | 256 Mbit  |     |      |     |      |     |      |     | 125  |     |       |       | 1,2 |
| R4  | $t_{GLQV}$          | OE# to Non-Array Output Delay  |   |     | 50   |     | 50   |     | 50   |     | 50   |     | 50    | 1,2,4 |     |
| R5  | $t_{PHQV}$          | RP# High to Output Delay   | 32 Mbit   |     | 150  |     |      |     |      |     |      |     |       |       | 1,2 |
|   |                     |  | 64 Mbit   |     |      |     | 180  |     | 180  |     |      |     |       |       | 1,2 |
|   |                     |  | 128 Mbit  |     |      |     |      |     | 210  |     |      |     | 210   |       | 1,2 |
|   |                     |  | 256 Mbit  |     |      |     |      |     |      |     | 210  |     |       |       |     |
| R6  | $t_{ELQX}$          | CE# to Output in Low Z   |   | 0   |      | 0   |      | 0   |      | 0   |      | 0   |       | 1,2,5 |     |
| R7  | $t_{GLQX}$          | OE# to Output in Low Z   |   | 0   |      | 0   |      | 0   |      | 0   |      | 0   |       | 1,2,5 |     |
| R8  | $t_{EHQZ}$          | CE# High to Output in High Z   |   |     | 35   |     | 35   |     | 35   |     | 35   |     | 35    | 1,2,5 |     |
| R9  | $t_{GHQZ}$          | OE# High to Output in High Z   |   |     | 15   |     | 15   |     | 15   |     | 15   |     | 15    | 1,2,5 |     |
| R10   | $t_{OH}$            | Output Hold from Address, CE#, or OE# Change, Whichever Occurs First |   | 0   |      | 0   |      | 0   |      | 0   |      | 0   |       | 1,2,5 |     |
| R11   | $t_{ELFL}/t_{ELFH}$ | CE# Low to BYTE# High or Low   |   |     | 10   |     | 10   |     | 10   |     | 10   |     | 10    | 1,2,5 |     |

**Table 8. Read Operations (Sheet 2 of 2)**

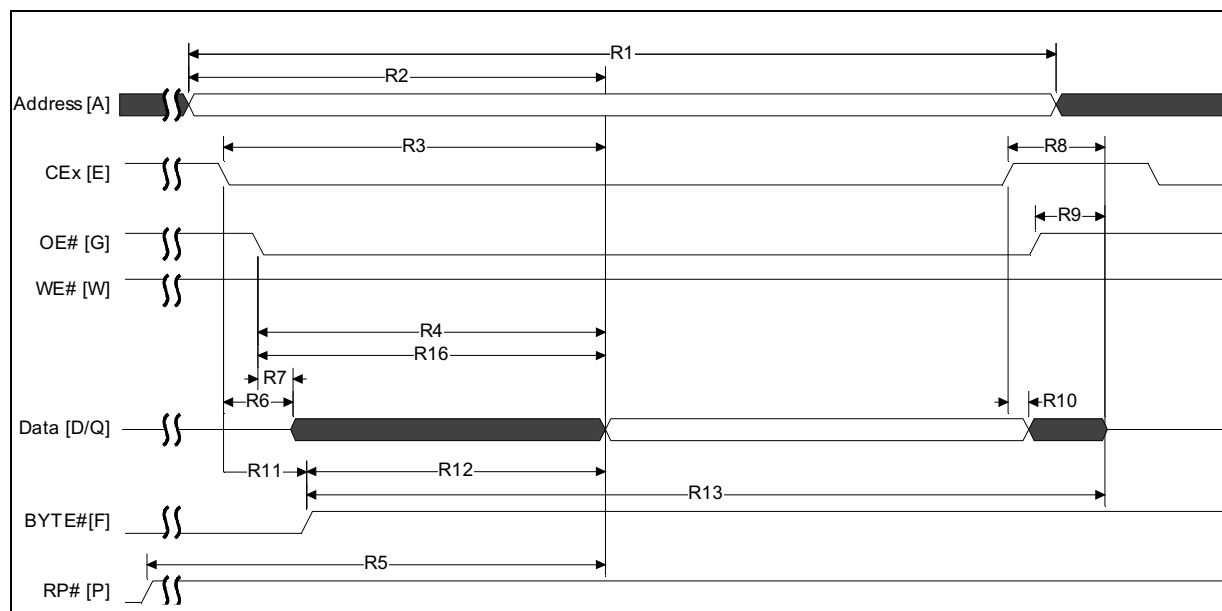
| Asynchronous Specifications<br>(All units in ns unless otherwise noted) |                     |   |         | $V_{CC} = 2.7\text{ V} - 3.6\text{ V}^{(3)}$<br>$V_{CCQ} = 2.7\text{ V} - 3.6\text{ V}^{(3)}$ |      |      |      |      |      |      |      |      |      | Notes |
|---|---------------------|---|---------|---|------|------|------|------|------|------|------|------|------|-------|
|   |                     |   |         | -110  |      | -115 |      | -120 |      | -125 |      | -150 |      |       |
| #   | Sym                 | Parameter                                   | Density | Min   | Max  | Min  | Max  | Min  | Max  | Min  | Max  | Min  | Max  |       |
| R12   | $t_{FLQV}/t_{FHQV}$ | BYTE# to Output Delay                       |         |   | 1000 |      | 1000 |      | 1000 |      | 1000 |      | 1000 | 1,2   |
| R13   | $t_{FLQZ}$          | BYTE# to Output in High Z                   |         |   | 1000 |      | 1000 |      | 1000 |      | 1000 |      | 1000 | 1,2,5 |
| R14   | $t_{EHEL}$          | CE <sub>x</sub> High to CE <sub>x</sub> Low |         | 0   |      | 0    |      | 0    |      | 0    |      | 0    |      | 1,2,5 |
| R15   | $t_{APA}$           | Page Address Access Time                    |         |   | 25   |      | 25   |      | 25   |      | 30   |      | 25   | 5, 6  |
| R16   | $t_{GLQV}$          | OE# to Array Output Delay                   |         |   | 25   |      | 25   |      | 25   |      | 25   |      | 25   | 4     |

**NOTES:**

CE<sub>x</sub> low is defined as the first edge of CE0, CE1, or CE2 that enables the device. CE<sub>x</sub> high is defined at the first edge of CE0, CE1, or CE2 that disables the device (see Table 13).

1. See AC Input/Output Reference Waveforms for the maximum allowable input slew rate.
2. OE# may be delayed up to  $t_{ELQV} - t_{GLQV}$  after the first edge of CE0, CE1, or CE2 that enables the device (see Table 13) without impact on  $t_{ELQV}$ .
3. See Figure 14, "Transient Input/Output Reference Waveform for VCCQ = 2.7 V–3.6 V" on page 27 and Figure 15, "Transient Equivalent Testing Load Circuit" on page 28 for testing characteristics.
4. When reading the flash array a faster  $t_{GLQV}$  (R16) applies. Non-array reads refer to Status Register reads, query reads, or device identifier reads.
5. Sampled, not 100% tested.
6. For devices configured to standard word/byte read mode, R15 ( $t_{APA}$ ) will equal R2 ( $t_{AVQV}$ ).

**Figure 9. Single Word Asynchronous Read Waveform**

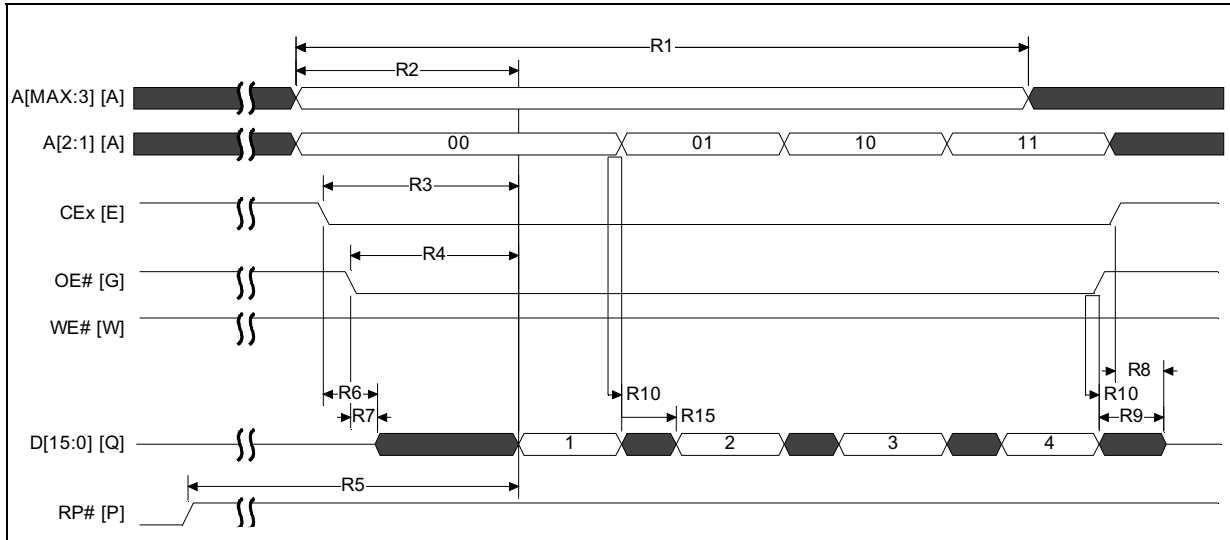


0606\_16

**NOTES:**

1.  $CE_x$  low is defined as the last edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that enables the device.  $CE_x$  high is defined at the first edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that disables the device (see Table 13).
2. When reading the flash array a faster  $t_{GLQV}$  (R16) applies. For non-array reads, R4 applies (i.e.: Status Register reads, query reads, or device identifier reads).

**Figure 10. Page Mode Read Waveform**



**NOTE:**  $CE_x$  low is defined as the last edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that enables the device.  $CE_x$  high is defined at the first edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that disables the device (see Table 13).

## 7.2 Write Operations

**Table 9. Write Operations**

| Versions |                           |   | Valid for All Speeds |     | Unit    | Notes     |
|----------|---------------------------|---|----------------------|-----|---------|-----------|
| #        | Symbol                    | Parameter                                     | Min                  | Max |         |           |
| W1       | $t_{PHWL}$ ( $t_{PHEL}$ ) | RP# High Recovery to WE# ( $CE_X$ ) Going Low | 1                    |     | $\mu s$ | 1,2,3     |
| W2       | $t_{ELWL}$ ( $t_{WLEL}$ ) | $CE_X$ (WE#) Low to WE# ( $CE_X$ ) Going Low  | 0                    |     | ns      | 1,2,4     |
| W3       | $t_{WP}$                  | Write Pulse Width                             | 70                   |     | ns      | 1,2,4     |
| W4       | $t_{DVWH}$ ( $t_{DVEH}$ ) | Data Setup to WE# ( $CE_X$ ) Going High       | 50                   |     | ns      | 1,2,5     |
| W5       | $t_{AVWH}$ ( $t_{AVEH}$ ) | Address Setup to WE# ( $CE_X$ ) Going High    | 55                   |     | ns      | 1,2,5     |
| W6       | $t_{WHEH}$ ( $t_{EHWL}$ ) | $CE_X$ (WE#) Hold from WE# ( $CE_X$ ) High    | 0                    |     | ns      | 1,2,      |
| W7       | $t_{WHDH}$ ( $t_{EHDH}$ ) | Data Hold from WE# ( $CE_X$ ) High            | 0                    |     | ns      | 1,2,      |
| W8       | $t_{WHAX}$ ( $t_{EHAX}$ ) | Address Hold from WE# ( $CE_X$ ) High         | 0                    |     | ns      | 1,2,      |
| W9       | $t_{WPH}$                 | Write Pulse Width High                        | 30                   |     | ns      | 1,2,6     |
| W11      | $t_{VPWH}$ ( $t_{VPEH}$ ) | $V_{PEN}$ Setup to WE# ( $CE_X$ ) Going High  | 0                    |     | ns      | 1,2,3     |
| W12      | $t_{WHGL}$ ( $t_{EHGL}$ ) | Write Recovery before Read                    | 35                   |     | ns      | 1,2,7     |
| W13      | $t_{WHRL}$ ( $t_{EHL}$ )  | WE# ( $CE_X$ ) High to STS Going Low          |                      | 500 | ns      | 1,2,8     |
| W15      | $t_{QVVL}$                | $V_{PEN}$ Hold from Valid SRD, STS Going High | 0                    |     | ns      | 1,2,3,8,9 |

**NOTES:**

$CE_X$  low is defined as the first edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that enables the device.  $CE_X$  high is defined at the first edge of  $CE_0$ ,  $CE_1$ , or  $CE_2$  that disables the device (see [Table 13](#)).

- Read timing characteristics during block erase, program, and lock-bit configuration operations are the same as during read-only operations. Refer to *AC Characteristics—Read-Only Operations*.
- A write operation can be initiated and terminated with either  $CE_X$  or WE#.
- Sampled, not 100% tested.
- Write pulse width ( $t_{WP}$ ) is defined from  $CE_X$  or WE# going low (whichever goes low last) to  $CE_X$  or WE# going high (whichever goes high first). Hence,  $t_{WP} = t_{WLWH} = t_{ELEH} = t_{WLEH} = t_{ELWH}$ .
- Refer to [Table 14](#) for valid  $A_{IN}$  and  $D_{IN}$  for block erase, program, or lock-bit configuration.
- Write pulse width high ( $t_{WPH}$ ) is defined from  $CE_X$  or WE# going high (whichever goes high first) to  $CE_X$  or WE# going low (whichever goes low first). Hence,  $t_{WPH} = t_{WHWL} = t_{EHEL} = t_{WHEL} = t_{EHWL}$ .
- For array access,  $t_{AVQV}$  is required in addition to  $t_{WHGL}$  for any accesses after a write.
- STS timings are based on STS configured in its RY/BY# default mode.
- $V_{PEN}$  should be held at  $V_{PENH}$  until determination of block erase, program, or lock-bit configuration success ( $SR[1,3,4:5] = 0$ ).



## 7.3 Block Erase, Program, and Lock-Bit Configuration Performance

**Table 10. Configuration Performance**

| #   | Sym                        | Parameter   | Typ | Max <sup>(8)</sup> | Unit | Notes         |
|-----|----------------------------|---|-----|--------------------|------|---------------|
| W16 |                            | Write Buffer Byte Program Time<br>(Time to Program 32 bytes/16 words) | 218 | 654                | μs   | 1,2,3,4,5,6,7 |
| W16 | $t_{WHQV3}$<br>$t_{EHQV3}$ | Byte Program Time (Using Word/Byte Program Command)                   | 210 | 630                | μs   | 1,2,3,4       |
|     |                            | Block Program Time (Using Write to Buffer Command)                    | 0.8 | 2.4                | sec  | 1,2,3,4       |
| W16 | $t_{WHQV4}$<br>$t_{EHQV4}$ | Block Erase Time  | 1.0 | 5.0                | sec  | 1,2,3,4       |
| W16 | $t_{WHQV5}$<br>$t_{EHQV5}$ | Set Lock-Bit Time   | 64  | 75/85              | μs   | 1,2,3,4,9     |
| W16 | $t_{WHQV6}$<br>$t_{EHQV6}$ | Clear Block Lock-Bits Time  | 0.5 | 0.70/1.4           | sec  | 1,2,3,4,10    |
| W16 | $t_{WHRH1}$<br>$t_{EHRH1}$ | Program Suspend Latency Time to Read                                  | 25  | 75/90              | μs   | 1,2,3,9       |
| W16 | $t_{WHRH}$<br>$t_{EHRH}$   | Erase Suspend Latency Time to Read                                    | 26  | 35/40              | μs   | 1,2,3,9       |

**NOTES:**

1. Typical values measured at  $T_A = +25\text{ °C}$  and nominal voltages. Assumes corresponding lock-bits are not set. Subject to change based on device characterization.
2. These performance numbers are valid for all speed versions.
3. Sampled but not 100% tested.
4. Excludes system-level overhead.
5. These values are valid when the buffer is full, and the start address is aligned on a 32-byte boundary.
6. Effective per-byte program time ( $t_{WHQV1}$ ,  $t_{EHQV1}$ ) is 6.8 μs/byte (typical).
7. Effective per-word program time ( $t_{WHQV2}$ ,  $t_{EHQV2}$ ) is 13.6 μs/word (typical).
8. Max values are measured at worst case temperature and  $V_{CC}$  corner after 100k cycles (except as noted).
9. Max values are expressed at  $-25\text{ °C}/-40\text{ °C}$ .
10. Max values are expressed at  $25\text{ °C}/-40\text{ °C}$ .

0606\_17

Figure 11. Asynchronous Write Waveform

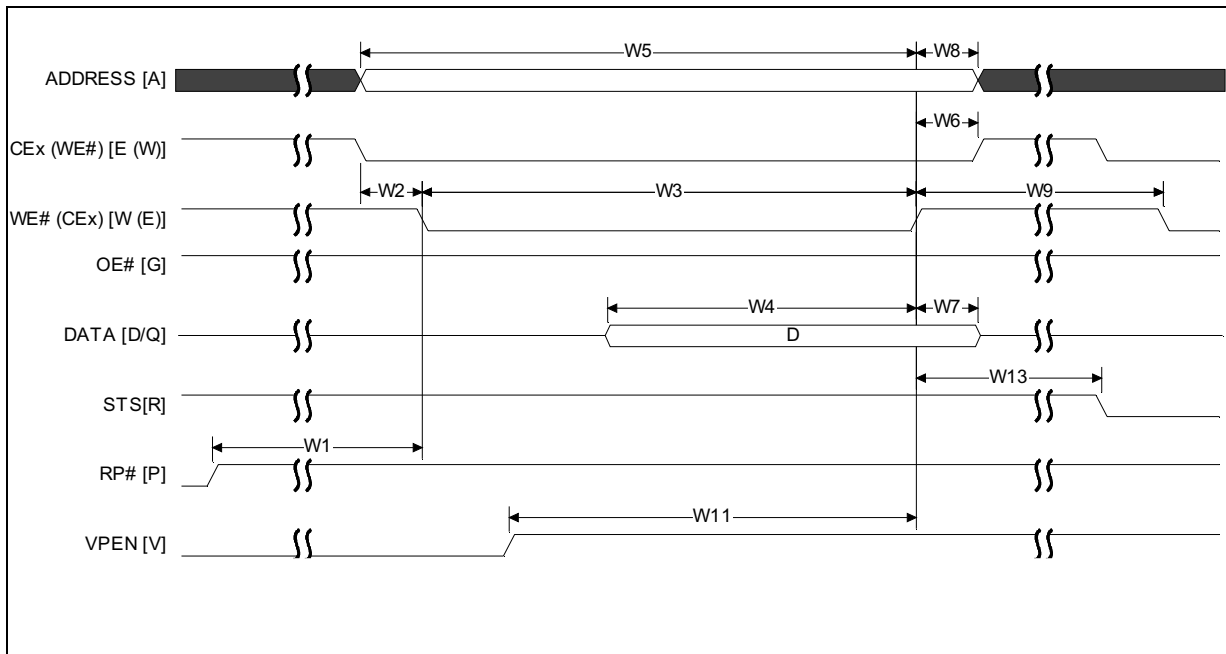
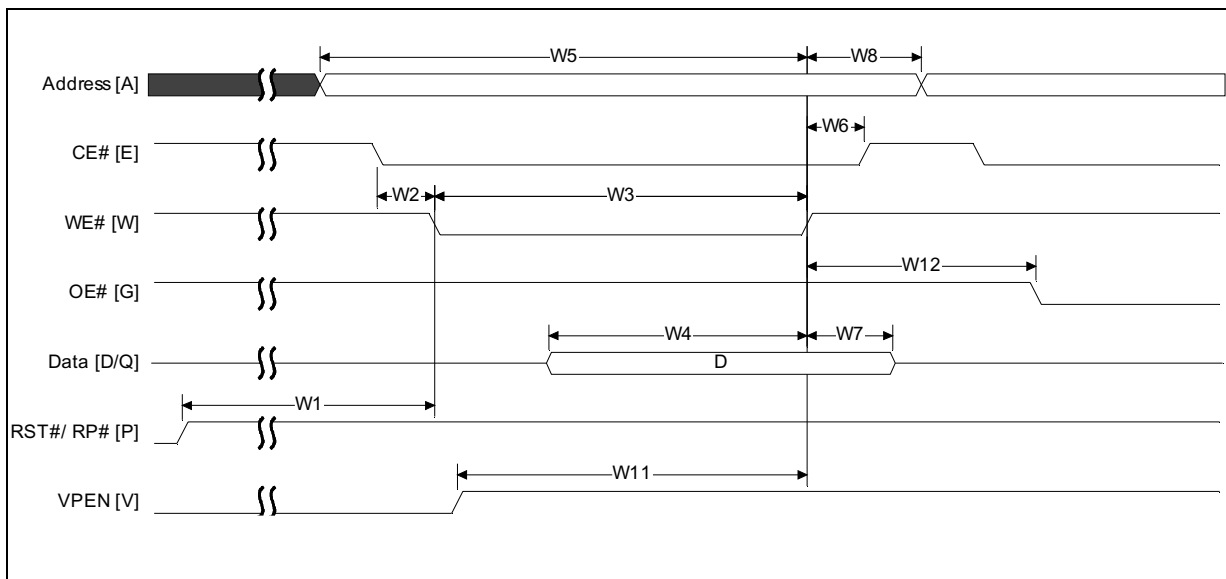
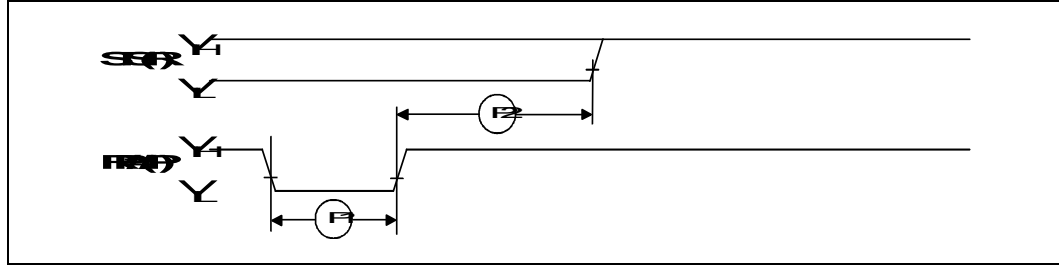


Figure 12. Asynchronous Write to Read Waveform



## 7.4 Reset Operation

Figure 13. AC Waveform for Reset Operation



NOTE: STS is shown in its default mode (RY/BY#).

Table 11. Reset Specifications

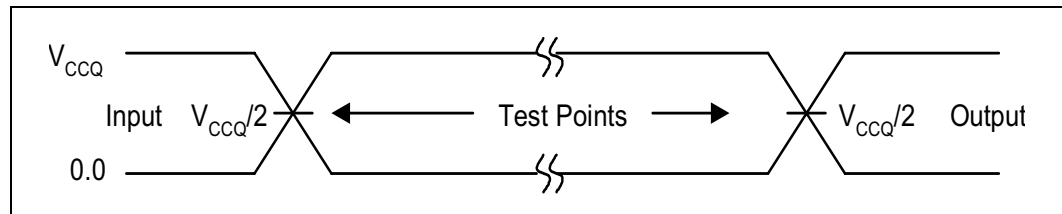
| #  | Sym        | Parameter   | Min | Max | Unit    | Notes |
|----|------------|---|-----|-----|---------|-------|
| P1 | $t_{PLPH}$ | RP# Pulse Low Time<br>(If RP# is tied to $V_{CC}$ , this specification is not applicable) | 35  |     | $\mu s$ | 1,2   |
| P2 | $t_{PHRH}$ | RP# High to Reset during Block Erase, Program, or Lock-Bit Configuration                  |     | 100 | ns      | 1,3   |

**NOTES:**

1. These specifications are valid for all product versions (packages and speeds).
2. If RP# is asserted while a block erase, program, or lock-bit configuration operation is not executing then the minimum required RP# Pulse Low Time is 100 ns.
3. A reset time,  $t_{PHQV}$ , is required from the latter of STS (in RY/BY# mode) or RP# going high until outputs are valid.

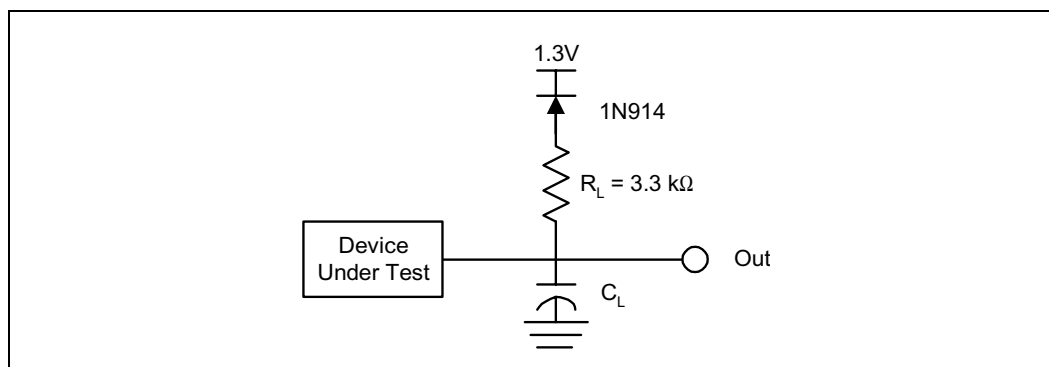
## 7.5 AC Test Conditions

Figure 14. Transient Input/Output Reference Waveform for  $V_{CCQ} = 2.7 V - 3.6 V$



NOTE: AC test inputs are driven at  $V_{CCQ}$  for a Logic "1" and 0.0 V for a Logic "0." Input timing begins, and output timing ends, at  $V_{CCQ}/2$  V (50% of  $V_{CCQ}$ ). Input rise and fall times (10% to 90%) < 5 ns.

Figure 15. Transient Equivalent Testing Load Circuit



**NOTE:**  $C_L$  Includes Jig Capacitance.

| Test Configuration                               | $C_L$ (pF) |
|--|------------|
| $V_{CCQ} = V_{CC} = 2.7\text{ V} - 3.6\text{ V}$ | 30         |

## 7.6 Capacitance

$T_A = +25\text{ }^\circ\text{C}$ ,  $f = 1\text{ MHz}$

| Symbol    | Parameter <sup>(1)</sup> | Type | Max | Unit | Condition                |
|-----------|--------------------------|------|-----|------|--------------------------|
| $C_{IN}$  | Input Capacitance        | 6    | 8   | pF   | $V_{IN} = 0.0\text{ V}$  |
| $C_{OUT}$ | Output Capacitance       | 8    | 12  | pF   | $V_{OUT} = 0.0\text{ V}$ |

**NOTES:**

1. Sampled, not 100% tested.

## 8.0 Power and Reset Specifications

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This section provides an overview of some system level considerations in regards to the flash device. This section provides a brief description of power-up, power-down, decoupling and reset design considerations.

### 8.1 Power-Up/Down Characteristics

In order to prevent any condition that may result in a spurious write or erase operation, it is recommended to power-up and power-down VCC and VCCQ together. It is also recommended to power-up VPEN with or slightly after VCC. Conversely, VPEN must power down with or slightly before VCC.

### 8.2 Power Supply Decoupling

When the device is enabled, many internal conditions change. Circuits are energized, charge pumps are switched on, and internal voltage nodes are ramped. All of this internal activities produce transient signals. The magnitude of the transient signals depends on the device and system loading. To minimize the effect of these transient signals, a 0.1  $\mu\text{F}$  ceramic capacitor is required across each VCC/VSS and VCCQ signal. Capacitors should be placed as close as possible to device connections.

Additionally, for every eight flash devices, a 4.7  $\mu\text{F}$  electrolytic capacitor should be placed between VCC and VSS at the power supply connection. This 4.7  $\mu\text{F}$  capacitor should help overcome voltage slumps caused by PCB (printed circuit board) trace inductance.

### 8.3 Reset Characteristics

By holding the flash device in reset during power-up and power-down transitions, invalid bus conditions may be masked. The flash device enters reset mode when RP# is driven low. In reset, internal flash circuitry is disabled and outputs are placed in a high-impedance state. After return from reset, a certain amount of time is required before the flash device is able to perform normal operations. After return from reset, the flash device defaults to asynchronous page mode. If RP# is driven low during a program or erase operation, the program or erase operation will be aborted and the memory contents at the aborted block or address are no longer valid. See [Figure 13, “AC Waveform for Reset Operation”](#) on page 27 for detailed information regarding reset timings.

## 9.0 Bus Operations

This section provides an overview of device bus operations. The on-chip Write State Machine (WSM) manages all erase and program algorithms. The system CPU provides control of all in-system read, write, and erase operations of the device via the system bus.

Device commands are written to the CUI to control all of the flash memory device's operations. The CUI does not occupy an addressable memory location; it's the mechanism through which the flash device is controlled.

### 9.1 Bus Operations Overview

The local CPU reads and writes flash memory in-system. All bus cycles to or from the flash memory conform to standard microprocessor bus cycles.

**Table 12. Bus Operations**

| Mode                  | RP#             | CE[2:0] <sup>(1)</sup> | OE# <sup>(2)</sup> | WE# <sup>(2)</sup> | Address        | VPEN              | Data <sup>(3)</sup>  | STS (default mode)    | Notes   |
|-----------------------|-----------------|------------------------|--------------------|--------------------|----------------|-------------------|--|-----------------------|---------|
| Read Array            | V <sub>IH</sub> | Enabled                | V <sub>IL</sub>    | V <sub>IH</sub>    | X              | X                 | D <sub>OUT</sub>   | High Z <sup>(7)</sup> | 4,5,6   |
| Output Disable        | V <sub>IH</sub> | Enabled                | V <sub>IH</sub>    | V <sub>IH</sub>    | X              | X                 | High Z   | X                     |         |
| Standby               | V <sub>IH</sub> | Disabled               | X                  | X                  | X              | X                 | High Z   | X                     |         |
| Reset/Power-Down Mode | V <sub>IL</sub> | X                      | X                  | X                  | X              | X                 | High Z   | High Z <sup>(7)</sup> |         |
| Read Identifier Codes | V <sub>IH</sub> | Enabled                | V <sub>IL</sub>    | V <sub>IH</sub>    | See Table 15   | X                 | Note 8   | High Z <sup>(7)</sup> |         |
| Read Query            | V <sub>IH</sub> | Enabled                | V <sub>IL</sub>    | V <sub>IH</sub>    | See Table 10.3 | X                 | Note 9   | High Z <sup>(7)</sup> |         |
| Read Status (WSM off) | V <sub>IH</sub> | Enabled                | V <sub>IL</sub>    | V <sub>IH</sub>    | X              | X                 | D <sub>OUT</sub>   |                       |         |
| Read Status (WSM on)  | V <sub>IH</sub> | Enabled                | V <sub>IL</sub>    | V <sub>IH</sub>    | X              | X                 | D7 = D <sub>OUT</sub><br>D[15:8] = High Z<br>D[6:0] = High Z |                       |         |
| Write                 | V <sub>IH</sub> | Enabled                | V <sub>IH</sub>    | V <sub>IL</sub>    | X              | V <sub>PENH</sub> | D <sub>IN</sub>  | X                     | 6,10,11 |

**NOTES:**

- See Table 13 on page 31 for valid CE configurations.
- OE# and WE# should never be enabled simultaneously.
- D refers to D[7:0] if BYTE# is low and D[15:0] if BYTE# is high.
- Refer to *DC Characteristics*. When  $V_{PEN} \leq V_{PENLK}$ , memory contents can be read, but not altered.
- X can be V<sub>IL</sub> or V<sub>IH</sub> for control and address signals, and V<sub>PENLK</sub> or V<sub>PENH</sub> for V<sub>PEN</sub>. See *DC Characteristics* for V<sub>PENLK</sub> and V<sub>PENH</sub> voltages.
- In default mode, STS is V<sub>OL</sub> when the WSM is executing internal block erase, program, or lock-bit configuration algorithms. It is V<sub>OH</sub> when the WSM is not busy, in block erase suspend mode (with programming inactive), program suspend mode, or reset/power-down mode.
- High Z will be V<sub>OH</sub> with an external pull-up resistor.
- See Section 10.2, "Read Identifier Codes" on page 35 for read identifier code data.
- See Section 10.3, "Read Query/CFI" on page 37 for read query data.
- Command writes involving block erase, program, or lock-bit configuration are reliably executed when  $V_{PEN} = V_{PENH}$  and V<sub>CC</sub> is within specification.

**Table 13. Chip Enable Truth Table**

| CE2             | CE1             | CE0             | DEVICE   |
|-----------------|-----------------|-----------------|----------|
| V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IL</sub> | Enabled  |
| V <sub>IL</sub> | V <sub>IL</sub> | V <sub>IH</sub> | Disabled |
| V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IL</sub> | Disabled |
| V <sub>IL</sub> | V <sub>IH</sub> | V <sub>IH</sub> | Disabled |
| V <sub>IH</sub> | V <sub>IL</sub> | V <sub>IL</sub> | Enabled  |
| V <sub>IH</sub> | V <sub>IL</sub> | V <sub>IH</sub> | Enabled  |
| V <sub>IH</sub> | V <sub>IH</sub> | V <sub>IL</sub> | Enabled  |
| V <sub>IH</sub> | V <sub>IH</sub> | V <sub>IH</sub> | Disabled |

**NOTE:** For single-chip applications, CE2 and CE1 can be connected to V<sub>IL</sub>.

### 9.1.1 Bus Read Operation

To perform a bus read operation, CEx (refer to [Table 13 on page 31](#)) and OE# must be asserted. CEx is the device-select control; when active, it enables the flash memory device. OE# is the data-output control; when active, the addressed flash memory data is driven onto the I/O bus. For all read states, WE# and RP# must be de-asserted. See [Section 7.1, “Read Operations” on page 21](#). Refer to [Section 10.0, “Read Operations” on page 34](#) for details on reading from the flash array, and refer to [Section 14.0, “Special Modes” on page 44](#) for details regarding all other available read states.

### 9.1.2 Bus Write Operation

Writing commands to the Command User Interface enables various modes of operation, including the reading of array data, CFI data, identifier codes, inspection and clearing of the Status Register, and, when V<sub>PEN</sub> = V<sub>PENH</sub>, block erasure, program, and lock-bit configuration.

The Block Erase command requires appropriate command data and an address within the block to be erased. The Byte/Word Program command requires the command and address of the location to be written. Set Block Lock-Bit commands require the command and block within the device to be locked. The Clear Block Lock-Bits command requires the command and address within the device.

The CUI does not occupy an addressable memory location. It is written when the device is enabled and WE# is active. The address and data needed to execute a command are latched on the rising edge of WE# or the first edge of CE0, CE1, or CE2 that disables the device (see [Table 13 on page 31](#)). Standard microprocessor write timings are used.

### 9.1.3 Output Disable

With CEx asserted, and OE# at a logic-high level (V<sub>IH</sub>), the device outputs are disabled. Output signals D[15:0] are placed in a high-impedance state.

## 9.1.4 Standby

CE0, CE1, and CE2 can disable the device (see [Table 13 on page 31](#)) and place it in standby mode. This manipulation of CEx substantially reduces device power consumption. D[15:0] outputs are placed in a high-impedance state independent of OE#. If deselected during block erase, program, or lock-bit configuration, the WSM continues functioning, and consuming active power until the operation completes.

## 9.1.5 Reset/Power-Down

RP# at  $V_{IL}$  initiates the reset/power-down mode.

In read modes, RP#-low deselected the memory, places output drivers in a high-impedance state, and turns off numerous internal circuits. RP# must be held low for a minimum of  $t_{PLPH}$ . Time  $t_{PHQV}$  is required after return from reset mode until initial memory access outputs are valid. After this wake-up interval, normal operation is restored. The CUI is reset to read array mode and Status Register is set to 0x80.

During block erase, program, or lock-bit configuration modes, RP#-low will abort the operation. In default mode, STS transitions low and remains low for a maximum time of  $t_{PLPH} + t_{PHRH}$  until the reset operation is complete. Memory contents being altered are no longer valid; the data may be partially corrupted after a program or partially altered after an erase or lock-bit configuration. Time  $t_{PHWL}$  is required after RP# goes to logic-high ( $V_{IH}$ ) before another command can be written.

As with any automated device, it is important to assert RP# during system reset. When the system comes out of reset, it expects to read from the flash memory. Automated flash memories provide status information when accessed during block erase, program, or lock-bit configuration modes. If a CPU reset occurs with no flash memory reset, proper initialization may not occur because the flash memory may be providing status information instead of array data. Intel® Flash memories allow proper initialization following a system reset through the use of the RP# input. In this application, RP# is controlled by the same RESET# signal that resets the system CPU.

## 9.2 Device Commands

When the  $V_{PEN}$  voltage  $\leq V_{PENLK}$ , only read operations from the Status Register, CFI, identifier codes, or blocks are enabled. Placing  $V_{PENH}$  on  $V_{PEN}$  additionally enables block erase, program, and lock-bit configuration operations. Device operations are selected by writing specific commands into the CUI. [Table 14, “Command Bus-Cycle Definitions” on page 32](#) defines these commands.

**Table 14. Command Bus-Cycle Definitions (Sheet 1 of 2)**

| Command               | Scalable or Basic Command Set <sup>(2)</sup> | Bus Cycles Req'd. | First Bus Cycle     |                     |                       | Second Bus Cycle    |                     |                       | Notes |
|-----------------------|--|-------------------|---------------------|---------------------|-----------------------|---------------------|---------------------|-----------------------|-------|
|                       |  |                   | Oper <sup>(3)</sup> | Addr <sup>(4)</sup> | Data <sup>(5,6)</sup> | Oper <sup>(3)</sup> | Addr <sup>(4)</sup> | Data <sup>(5,6)</sup> |       |
| Read Array            | SCS/BCS                                      | 1                 | Write               | X                   | 0xFF                  |                     |                     |                       | 1     |
| Read Identifier Codes | SCS/BCS                                      | $\geq 2$          | Write               | X                   | 0X90                  | Read                | IA                  | ID                    | 1,7   |
| Read Query            | SCS  | $\geq 2$          | Write               | X                   | 0x98                  | Read                | QA                  | QD                    | 1     |



**Table 14. Command Bus-Cycle Definitions (Sheet 2 of 2)**

| Command                      | Scalable or Basic Command Set <sup>(2)</sup> | Bus Cycles Req'd. | First Bus Cycle     |                     |                       | Second Bus Cycle    |                     |                       | Notes     |
|------------------------------|--|-------------------|---------------------|---------------------|-----------------------|---------------------|---------------------|-----------------------|-----------|
|                              |  |                   | Oper <sup>(3)</sup> | Addr <sup>(4)</sup> | Data <sup>(5,6)</sup> | Oper <sup>(3)</sup> | Addr <sup>(4)</sup> | Data <sup>(5,6)</sup> |           |
| Read Status Register         | SCS/BCS                                      | 2                 | Write               | X                   | 0x70                  | Read                | X                   | SRD                   | 1,8       |
| Clear Status Register        | SCS/BCS                                      | 1                 | Write               | X                   | 0x50                  |                     |                     |                       | 1         |
| Write to Buffer              | SCS/BCS                                      | > 2               | Write               | BA                  | 0xE8                  | Write               | BA                  | N                     | 1,9,10,11 |
| Word/Byte Program            | SCS/BCS                                      | 2                 | Write               | X                   | 0x40 or 0x10          | Write               | PA                  | PD                    | 1,12,13   |
| Block Erase                  | SCS/BCS                                      | 2                 | Write               | BA                  | 0x20                  | Write               | BA                  | 0xD0                  | 1,11,12   |
| Block Erase, Program Suspend | SCS/BCS                                      | 1                 | Write               | X                   | 0xB0                  |                     |                     |                       | 1,12,14   |
| Block Erase, Program Resume  | SCS/BCS                                      | 1                 | Write               | X                   | 0xD0                  |                     |                     |                       | 1,12      |
| Configuration                | SCS  | 2                 | Write               | X                   | 0xB8                  | Write               | X                   | CC                    | 1         |
| Set Block Lock-Bit           | SCS  | 2                 | Write               | X                   | 0x60                  | Write               | BA                  | 0x01                  | 1         |
| Clear Block Lock-Bits        | SCS  | 2                 | Write               | X                   | 0x60                  | Write               | X                   | 0xD0                  | 1,15      |
| Protection Program           |  | 2                 | Write               | X                   | 0xC0                  | Write               | PA                  | PD                    | 1         |

**NOTES:**

- Commands other than those shown above are reserved by Intel for future device implementations and should not be used.
- The Basic Command Set (BCS) is the same as the 28F008SA Command Set or Intel Standard Command Set. The Scalable Command Set (SCS) is also referred to as the Intel Extended Command Set.
- Bus operations are defined in [Table 12](#).
- X = Any valid address within the device.  
BA = Address within the block.  
IA = Identifier Code Address: see [Table 15](#).  
QA = Query database Address.  
PA = Address of memory location to be programmed.  
RCD = Data to be written to the read configuration register. This data is presented to the device on A[16:1]; all other address inputs are ignored.
- ID = Data read from Identifier Codes.  
QD = Data read from Query database.  
SRD = Data read from Status Register. See [Table 16](#) for a description of the Status Register bits.  
PD = Data to be programmed at location PA. Data is latched on the rising edge of WE#.  
CC = Configuration Code.
- The upper byte of the data bus (D[15:8]) during command writes is a "Don't Care" in x16 operation.
- Following the Read Identifier Codes command, read operations access manufacturer, device and block lock codes. See [Section 10.2](#) for read identifier code data.
- If the WSM is running, only D7 is valid; D[15:8] and D[6:0] float, which places them in a high-impedance state.
- After the Write to Buffer command is issued check the XSR to make sure a buffer is available for writing.
- The number of bytes/words to be written to the Write Buffer = N + 1, where N = byte/word count argument. Count ranges on this device for byte mode are N = 00H to N = 1FH and for word mode are N = 0x00 to N = 0x0F. The third and consecutive bus cycles, as determined by N, are for writing data into the Write Buffer. The Confirm command (0xD0) is expected after exactly N + 1 write cycles; any other command at that point in the sequence aborts the write to buffer operation. See [Figure 17, "Write to Buffer Flowchart" on page 53](#) for additional information
- The write to buffer or erase operation does not begin until a Confirm command (0xD0) is issued.
- Attempts to issue a block erase or program to a locked block.
- Either 0x40 or 0x10 are recognized by the WSM as the byte/word program setup.
- Program suspends can be issued after either the Write-to-Buffer or Word/Byte-Program operation is initiated.
- The clear block lock-bits operation simultaneously clears all block lock-bits.

## 10.0 Read Operations

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The device supports four types of read modes: Read Array, Read Identifier, Read Status, and CFI query. Upon power-up or return from reset, the device defaults to read array mode. To change the device's read mode, the appropriate read-mode command must be written to the device. (See [Section 9.2, "Device Commands" on page 32.](#)) See [Section 14.0, "Special Modes" on page 44](#) for details regarding read status, read ID, and CFI query modes.

Upon initial device power-up or after exit from reset/power-down mode, the device automatically resets to read array mode. Otherwise, write the appropriate read mode command (Read Array, Read Query, Read Identifier Codes, or Read Status Register) to the CUI. Six control signals dictate the data flow in and out of the component: CE0, CE1, CE2, OE#, WE#, and RP#. The device must be enabled (see [Table 13, "Chip Enable Truth Table" on page 31](#)), and OE# must be driven active to obtain data at the outputs. CE0, CE1, and CE2 are the device selection controls and, when enabled (see [Table 13](#)), select the memory device. OE# is the data output (D[15:0]) control and, when active, drives the selected memory data onto the I/O bus. WE# must be at  $V_{IH}$ .

### 10.1 Read Array

Upon initial device power-up and after exit from reset/power-down mode, the device defaults to read array mode. The read configuration register defaults to asynchronous read page mode. The Read Array command also causes the device to enter read array mode. The device remains enabled for reads until another command is written. If the internal WSM has started a block erase, program, or lock-bit configuration, the device will not recognize the Read Array command until the WSM completes its operation unless the WSM is suspended via an Erase or Program Suspend command. The Read Array command functions independently of the  $V_{PEN}$  voltage.

#### 10.1.1 Asynchronous Page-Mode Read

Asynchronous Page Mode is the default read mode on power-up or reset. In asynchronous page mode, array data is sensed four words (eight bytes) at a time and is loaded into a page buffer. After the initial access delay, the first word out of the page buffer corresponds to the initial address. Address bits A[2:1] determine which word is output from the page buffer for a x16 bus width, and A[2:0] determine which word is output from the page buffer for a x8 bus width. Subsequent reads from the device come from the page buffer. These reads are output on D[15:0] for a x16 bus width and D[7:0] for a x8 bus width after a minimum delay as long as A[2:0] are the only address bits that change.

Data can be read from the page buffer multiple times, and in any order. If address bits A[MAX:3] change at any time, or if CE# is toggled, the device will sense and load new data into the page buffer. Asynchronous Page mode is the default read mode on power-up or reset.

To perform a page mode read after any other operation, the Read Array command must be issued to read from the flash array. Asynchronous page mode reads are permitted in all blocks and are used to access register information, but only one word is loaded into the page buffer during register access.

## 10.2 Read Identifier Codes

The Read identifier codes operation outputs the manufacturer code, device-code, and the block lock configuration codes for each block (See Section 9.2, “Device Commands” on page 32 for details on issuing the Read Device Identifier command). Page-mode reads are not supported in this read mode. To terminate the operation, write another valid command. Like the Read Array command, the Read Identifier Codes command functions independently of the  $V_{PEN}$  voltage. This command is valid only when the WSM is off or the device is suspended. Following the Read Identifier Codes command, the following information can be read

**Table 15. Read Identifier Codes**

| Code                      |          | Address <sup>(1)</sup> | Data    |
|---------------------------|----------|------------------------|---------|
| Manufacture Code          |          | 00000                  | (00) 89 |
| Device Code               | 32-Mbit  | 00001                  | (00) 16 |
|                           | 64-Mbit  | 00001                  | (00) 17 |
|                           | 128-Mbit | 00001                  | (00) 18 |
|                           | 256-Mbit | 00001                  | (00) 1D |
| Block Lock Configuration  |          | X0002 <sup>(2)</sup>   |         |
| • Block Is Unlocked       |          |                        | D0 = 0  |
| • Block Is Locked         |          |                        | D0 = 1  |
| • Reserved for Future Use |          |                        | D[7:1]  |

**NOTES:**

1. A0 is not used in either x8 or x16 modes when obtaining the identifier codes. The lowest order address line is A1. Data is always presented on the low byte in x16 mode (upper byte contains 00h).
2. X selects the specific block's lock configuration code.
3. D[7:1] are invalid and should be ignored.

### 10.2.1 Read Status Register

The Status Register may be read to determine when a block erase, program, or lock-bit configuration is complete and whether the operation completed successfully. It may be read only after the specified time W12 (see Table 9, “Write Operations” on page 24). After writing this command, all subsequent read operations output data from the Status Register until another valid command is written. Page-mode reads are not supported in this read mode. The Status Register contents are latched on the falling edge of OE# or the first edge of CE0, CE1, or CE2 that enables the device (see Table 13, “Chip Enable Truth Table” on page 31). OE# must toggle to  $V_{IH}$  or the device must be disabled before further reads to update the Status Register latch. The Read Status Register command functions independently of the  $V_{PEN}$  voltage.

During a program, block erase, set lock-bit, or clear lock-bit command sequence, only SR7 is valid until the Write State Machine completes or suspends the operation. Device I/O signals D[6:0] and D[15:8] are placed in a high-impedance state. When the operation completes or suspends (check SR7), all contents of the Status Register are valid when read.

Table 16. Status Register Definitions

| WSMS                     | ESS  | ECLBS | PSLBS | VPENS | PSS   | DPS   | R     |
|--------------------------|--|-------|-------|-------|---|-------|-------|
| bit 7                    | bit 6  | bit 5 | bit 4 | bit 3 | bit 2   | bit 1 | bit 0 |
| <b>High Z When Busy?</b> | <b>Status Register Bits</b>  |       |       |       | <b>Notes</b>  |       |       |
| <b>No</b>                | SR7 = WRITE STATE MACHINE STATUS<br>1 = Ready<br>0 = Busy  |       |       |       | <p>Check STS or SR7 to determine block erase, program, or lock-bit configuration completion. SR[6:0] are not driven while SR7 = "0."</p> <p>If both SR5 and SR4 are "1"s after a block erase or lock-bit configuration attempt, an improper command sequence was entered.</p> <p>SR3 does not provide a continuous programming voltage level indication. The WSM interrogates and indicates the programming voltage level only after Block Erase, Program, Set Block Lock-Bit, or Clear Block Lock-Bits command sequences.</p> <p>SR1 does not provide a continuous indication of block lock-bit values. The WSM interrogates the block lock-bits only after Block Erase, Program, or Lock-Bit configuration command sequences. It informs the system, depending on the attempted operation, if the block lock-bit is set. Read the block lock configuration codes using the Read Identifier Codes command to determine block lock-bit status.</p> <p>SR0 is reserved for future use and should be masked when polling the Status Register.</p> |       |       |
| <b>Yes</b>               | SR6 = ERASE SUSPEND STATUS<br>1 = Block Erase Suspended<br>0 = Block Erase in Progress/Completed   |       |       |       |   |       |       |
| <b>Yes</b>               | SR5 = ERASE AND CLEAR LOCK-BITS STATUS<br>1 = Error in Block Erasure or Clear Lock-Bits<br>0 = Successful Block Erase or Clear Lock-Bits |       |       |       |   |       |       |
| <b>Yes</b>               | SR4 = PROGRAM AND SET LOCK-BIT STATUS<br>1 = Program Error / Error in Setting Lock-Bit<br>0 = Successful Program/Set Block Lock Bit      |       |       |       |   |       |       |
| <b>Yes</b>               | SR3 = PROGRAMMING VOLTAGE STATUS<br>1 = Low Programming Voltage Detected, Operation Aborted<br>0 = Programming Voltage OK                |       |       |       |   |       |       |
| <b>Yes</b>               | SR2 = PROGRAM SUSPEND STATUS<br>1 = Program suspended<br>0 = Program in progress/completed   |       |       |       |   |       |       |
| <b>Yes</b>               | SR1 = DEVICE PROTECT STATUS<br>1 = Block Lock-Bit Detected, Operation Abort<br>0 = Unlock  |       |       |       |   |       |       |
| <b>Yes</b>               | SR0 = RESERVED FOR FUTURE ENHANCEMENTS   |       |       |       |   |       |       |

Table 17. eXtended Status Register Definitions

| WBS                      | Reserved   |   |
|--------------------------|--|---|
| bit 7                    | bits 6—0   |   |
| <b>High Z When Busy?</b> | <b>Status Register Bits</b>  | <b>Notes</b>  |
| <b>No</b>                | XSR7 = WRITE BUFFER STATUS<br>1 = Write buffer available<br>0 = Write buffer not available | <p>After a Buffer-Write command, XSR7 = 1 indicates that a Write Buffer is available.</p> <p>SR[6:0] are reserved for future use and should be masked when polling the Status Register.</p> |
| <b>Yes</b>               | XSR6–XSR0 = RESERVED FOR FUTURE ENHANCEMENTS   |   |

## 10.3 Read Query/CFI

The query register contains an assortment of flash product information such as block size, density, allowable command sets, electrical specifications and other product information. The data contained in this register conforms to the Common Flash Interface (CFI) protocol. To obtain any information from the query register, execute the Read Query Register command. See [Section 9.2, “Device Commands” on page 32](#) for details on issuing the CFI Query command. Refer to [Appendix A, “Query Structure Overview” on page 47](#) for a detailed explanation of the CFI register. Information contained in this register can only be accessed by executing a single-word read.

## 11.0 Programming Operations

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The device supports two different programming methods: word programming, and write-buffer programming. Successful programming requires the addressed block to be unlocked. An attempt to program a locked block will result in the operation aborting, and SR1 and SR4 being set, indicating a programming error. The following sections describe device programming in detail.

### 11.1 Byte/Word Program

Byte/Word program is executed by a two-cycle command sequence. Byte/Word program setup (standard 0x40 or alternate 0x10) is written followed by a second write that specifies the address and data (latched on the rising edge of WE#). The WSM then takes over, controlling the program and program verify algorithms internally. After the program sequence is written, the device automatically outputs SRD when read (see [Figure 19, “Byte/Word Program Flowchart” on page 55](#)). The CPU can detect the completion of the program event by analyzing the STS signal or SR7.

When program is complete, SR4 should be checked. If a program error is detected, the Status Register should be cleared. The internal WSM verify only detects errors for “1”s that do not successfully program to “0”s. The CUI remains in Read Status Register mode until it receives another command.

Reliable byte/word programming can only occur when  $V_{CC}$  and  $V_{PEN}$  are valid. If a byte/word program is attempted while  $V_{PEN} \leq V_{PENLK}$ , SR4 and SR3 will be set. Successful byte/word programs require that the corresponding block lock-bit be cleared. If a byte/word program is attempted when the corresponding block lock-bit is set, SR1 and SR4 will be set.

### 11.2 Write to Buffer

To program the flash device, a Write to Buffer command sequence is initiated. A variable number of bytes, up to the buffer size, can be loaded into the buffer and written to the flash device. First, the Write to Buffer Setup command is issued along with the Block Address (see [Figure 17, “Write to Buffer Flowchart” on page 53](#)). At this point, the eXtended Status Register (XSR, see [Table 17](#)) information is loaded and XSR7 reverts to “buffer available” status. If XSR7 = 0, the write buffer is not available. To retry, continue monitoring XSR7 by issuing the Write to Buffer setup command with the Block Address until XSR7 = 1. When XSR7 transitions to a “1,” the buffer is ready for loading.

Next, a word/byte count is given to the part with the Block Address. On the next write, a device start address is given along with the write buffer data. Subsequent writes provide additional device addresses and data, depending on the count. All subsequent addresses must lie within the start address plus the count.

Internally, this device programs many flash cells in parallel. Because of this parallel programming, maximum programming performance and lower power are obtained by aligning the start address at the beginning of a write buffer boundary (i.e., A[4:0] of the start address = 0).

After the final buffer data is given, a Write Confirm command is issued. This initiates the WSM (Write State Machine) to begin copying the buffer data to the flash array. If a command other than Write Confirm is written to the device, an “Invalid Command/Sequence” error will be generated and SR5 and SR4 will be set. For additional buffer writes, issue another Write to Buffer Setup command and check XSR7.

If an error occurs while writing, the device will stop writing, and SR4 will be set to indicate a program failure. The internal WSM verify only detects errors for “1”s that do not successfully program to “0”s. If a program error is detected, the Status Register should be cleared. Any time SR4 and/or SR5 is set (e.g., a media failure occurs during a program or an erase), the device will not accept any more Write to Buffer commands. Additionally, if the user attempts to program past an erase block boundary with a Write to Buffer command, the device will abort the write to buffer operation. This will generate an “Invalid Command/Sequence” error and SR5 and SR4 will be set.

Reliable buffered writes can only occur when  $V_{PEN} = V_{PENH}$ . If a buffered write is attempted while  $V_{PEN} \leq V_{PENLK}$ , SR4 and SR3 will be set. Buffered write attempts with invalid  $V_{CC}$  and  $V_{PEN}$  voltages produce spurious results and should not be attempted. Finally, successful programming requires that the corresponding block lock-bit be reset. If a buffered write is attempted when the corresponding block lock-bit is set, SR1 and SR4 will be set.

## 11.3 Program Suspend

The Program Suspend command allows program interruption to read data in other flash memory locations. Once the programming process starts (either by initiating a write to buffer or byte/word program operation), writing the Program Suspend command requests that the WSM suspend the program sequence at a predetermined point in the algorithm. The device continues to output SRD when read after the Program Suspend command is written. Polling SR7 can determine when the programming operation has been suspended. When SR7 = 1, SR2 should also be set, indicating that the device is in the program suspend mode. STS in level RY/BY# mode will also transition to  $V_{OH}$ . Specification  $t_{WHRHI}$  defines the program suspend latency.

At this point, a Read Array command can be written to read data from locations other than that which is suspended. The only other valid commands while programming is suspended are Read Query, Read Status Register, Clear Status Register, Configure, and Program Resume. After a Program Resume command is written, the WSM will continue the programming process. SR2 and SR7 will automatically clear and STS in RY/BY# mode will return to  $V_{OL}$ . After the Program Resume command is written, the device automatically outputs SRD when read.  $V_{PEN}$  must remain at  $V_{PENH}$  and  $V_{CC}$  must remain at valid  $V_{CC}$  levels (the same  $V_{PEN}$  and  $V_{CC}$  levels used for programming) while in program suspend mode. Refer to [Figure 20, “Program Suspend/Resume Flowchart”](#) on page 56.

## 11.4 Program Resume

To resume (i.e., continue) a program suspend operation, execute the Program Resume command. The Resume command can be written to any device address. When a program operation is nested within an erase suspend operation and the Program Suspend command is issued, the device will suspend the program operation. When the Resume command is issued, the device will resume and complete the program operation. Once the nested program operation is completed, an additional Resume command is required to complete the block erase operation. The device supports a maximum suspend/resume of two nested routines. See [Figure 20, “Program Suspend/Resume Flowchart” on page 56](#).

## 12.0 Erase Operations

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Flash erasing is performed on a block basis; therefore, only one block can be erased at a time. Once a block is erased, all bits within that block will read as a logic level one. To determine the status of a block erase, poll the Status Register and analyze the bits. This following section describes block erase operations in detail.

### 12.1 Block Erase

Erase is executed one block at a time and initiated by a two-cycle command. A block erase setup is first written, followed by a block erase confirm. This command sequence requires an appropriate address within the block to be erased (erase changes all block data to FFH). Block preconditioning, erase, and verify are handled internally by the WSM (invisible to the system). After the two-cycle block erase sequence is written, the device automatically outputs SRD when read (see [Figure 21, “Block Erase Flowchart” on page 57](#)). The CPU can detect block erase completion by analyzing the output of the STS signal or SR7. Toggle OE#, CE0, CE1, or CE2 to update the Status Register.

When the block erase is complete, SR5 should be checked. If a block erase error is detected, the Status Register should be cleared before system software attempts corrective actions. The CUI remains in Read Status Register mode until a new command is issued.

This two-step command sequence of setup followed by execution ensures that block contents are not accidentally erased. An invalid Block Erase command sequence will result in both SR4 and SR5 being set. Also, reliable block erasure can only occur when  $V_{CC}$  is valid and  $V_{PEN} = V_{PENH}$ . If block erase is attempted while  $V_{PEN} \leq V_{PENLK}$ , SR3 and SR5 will be set. Successful block erase requires that the corresponding block lock-bit be cleared. If block erase is attempted when the corresponding block lock-bit is set, SR1 and SR5 will be set.

### 12.2 Block Erase Suspend

The Block Erase Suspend command allows block-erase interruption to read or program data in another block of memory. Once the block erase process starts, writing the Block Erase Suspend command requests that the WSM suspend the block erase sequence at a predetermined point in the algorithm. The device outputs SRD when read after the Block Erase Suspend command is written. Polling SR7 then SR6 can determine when the block erase operation has been suspended (both will be set). In default mode, STS will also transition to  $V_{OH}$ . Specification  $t_{WHRH}$  defines the block erase suspend latency.

At this point, a Read Array command can be written to read data from blocks other than that which is suspended. A program command sequence can also be issued during erase suspend to program data in other blocks. During a program operation with block erase suspended, SR7 will return to “0” and STS output (in default mode) will transition to  $V_{OL}$ . However, SR6 will remain “1” to indicate block erase suspend status. Using the Program Suspend command, a program operation can also be suspended. Resuming a suspended programming operation by issuing the Program Resume command allows continuing of the suspended programming operation. To resume the suspended erase, the user must wait for the programming operation to complete before issuing the Block Erase Resume command.

The only other valid commands while block erase is suspended are Read Query, Read Status Register, Clear Status Register, Configure, and Block Erase Resume. After a Block Erase Resume command is written to the flash memory, the WSM will continue the block erase process. SR6 and SR7 will automatically clear and STS (in default mode) will return to  $V_{OL}$ . After the Erase Resume command is written, the device automatically outputs SRD when read (see [Figure 22, “Block Erase Suspend/Resume Flowchart” on page 58](#)).  $V_{PEN}$  must remain at  $V_{PENH}$  (the same  $V_{PEN}$  level used for block erase) while block erase is suspended. Block erase cannot resume until program operations initiated during block erase suspend have completed.

## 12.3 Erase Resume

To resume (i.e., continue) an erase suspend operation, execute the Erase Resume command. The Resume command can be written to any device address. When a program operation is nested within an erase suspend operation and the Program Suspend command is issued, the device will suspend the program operation. When the Resume command is issued, the device will resume the program operations first. Once the nested program operation is completed, an additional Resume command is required to complete the block erase operation. The device supports a maximum suspend/resume of two nested routines. See [Figure 21, “Block Erase Flowchart” on page 57](#).



## 13.0 Security Modes

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This device offers both hardware and software security features. Block lock operations, PRs, and VPEN allow the user to implement various levels of data protection. The following section describes security features in detail.

### 13.1 Set Block Lock-Bit

A flexible block locking scheme is enabled via block lock-bits. The block lock-bits gate program and erase operations. Individual block lock-bits can be set using the Set Block Lock-Bit command. This command is invalid while the WSM is running or the device is suspended.

Set block lock-bit commands are executed by a two-cycle sequence. The set block setup along with appropriate block address is followed by either the set block lock-bit confirm (and an address within the block to be locked). The WSM then controls the set lock-bit algorithm. After the sequence is written, the device automatically outputs Status Register data when read (see [Figure 23 on page 59](#)). The CPU can detect the completion of the set lock-bit event by analyzing the STS signal output or SR7.

When the set lock-bit operation is complete, SR4 should be checked. If an error is detected, the Status Register should be cleared. The CUI will remain in Read Status Register mode until a new command is issued.

This two-step sequence of setup followed by execution ensures that lock-bits are not accidentally set. An invalid Set Block Lock-Bit command will result in SR4 and SR5 being set. Also, reliable operations occur only when  $V_{CC}$  and  $V_{PEN}$  are valid. With  $V_{PEN} \leq V_{PENLK}$ , lock-bit contents are protected against alteration.

### 13.2 Clear Block Lock-Bits

All set block lock-bits are cleared in parallel via the Clear Block Lock-Bits command. Block lock-bits can be cleared using only the Clear Block Lock-Bits command. This command is invalid while the WSM is running or the device is suspended.

Clear block lock-bits command is executed by a two-cycle sequence. A clear block lock-bits setup is first written. The device automatically outputs Status Register data when read (see [Figure 24 on page 60](#)). The CPU can detect completion of the clear block lock-bits event by analyzing the STS signal output or SR7.

When the operation is complete, SR5 should be checked. If a clear block lock-bit error is detected, the Status Register should be cleared. The CUI will remain in Read Status Register mode until another command is issued.

This two-step sequence of setup followed by execution ensures that block lock-bits are not accidentally cleared. An invalid Clear Block Lock-Bits command sequence will result in SR4 and SR5 being set. Also, a reliable clear block lock-bits operation can only occur when  $V_{CC}$  and  $V_{PEN}$  are valid. If a clear block lock-bits operation is attempted while  $V_{PEN} \leq V_{PENLK}$ , SR3 and SR5 will be set.

If a clear block lock-bits operation is aborted due to  $V_{PEN}$  or  $V_{CC}$  transitioning out of valid range, block lock-bit values are left in an undetermined state. A repeat of clear block lock-bits is required to initialize block lock-bit contents to known values.

## 13.3 Protection Register Program

The Intel StrataFlash<sup>®</sup> memory (J3) includes a 128-bit Protection Register that can be used to increase the security of a system design. For example, the number contained in the PR can be used to “mate” the flash component with other system components such as the CPU or ASIC, preventing device substitution.

The 128-bits of the PR are divided into two 64-bit segments. One of the segments is programmed at the Intel factory with a unique 64-bit number, which is unalterable. The other segment is left blank for customer designers to program as desired. Once the customer segment is programmed, it can be locked to prevent further programming.

### 13.3.1 Reading the Protection Register

The Protection Register is read in the identification read mode. The device is switched to this mode by issuing the Read Identifier command (0x90). Once in this mode, read cycles from addresses shown in [Table 8](#) or [Table 19](#) retrieve the specified information. To return to read array mode, write the Read Array command (0xFF).

### 13.3.2 Programming the Protection Register

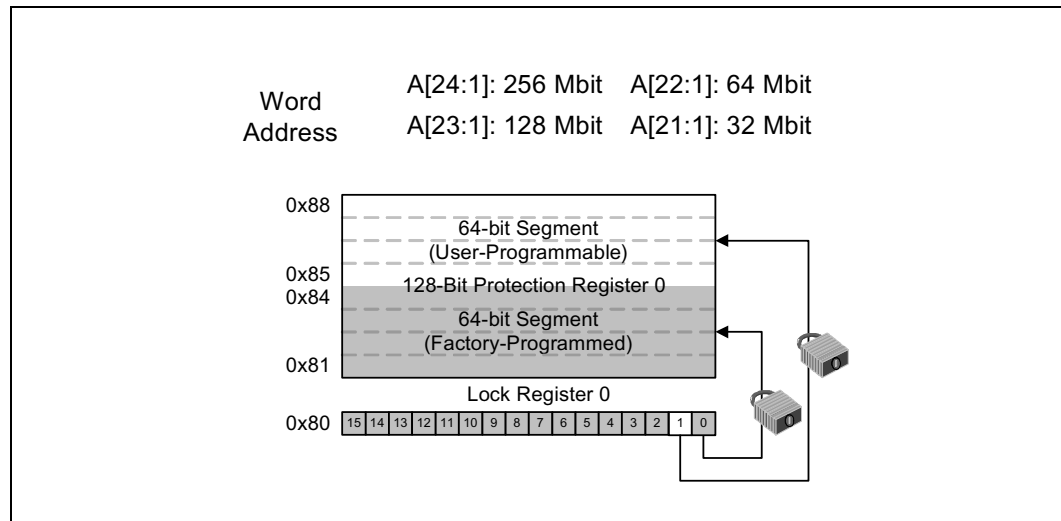
Protection Register bits are programmed using the two-cycle Protection Program command. The 64-bit number is programmed 16 bits at a time for word-wide configuration and eight bits at a time for byte-wide configuration. First write the Protection Program Setup command, 0xC0. The next write to the device will latch in address and data and program the specified location. The allowable addresses are shown in [Table 8](#) or [Table 19](#). See [Figure 25](#), “Protection Register Programming Flowchart” on page 61

Any attempt to address Protection Program commands outside the defined PR address space will result in a Status Register error (SR4 will be set). Attempting to program a locked PR segment will result in a Status Register error (SR4 and SR1 will be set).

### 13.3.3 Locking the Protection Register

The user-programmable segment of the Protection Register is lockable by programming Bit 1 of the PLR to 0. Bit 0 of this location is programmed to 0 at the Intel factory to protect the unique device number. Bit 1 is set using the Protection Program command to program “0xFFFD” to the PLR. After these bits have been programmed, no further changes can be made to the values stored in the Protection Register. Protection Program commands to a locked section will result in a Status Register error (SR4 and SR1 will be set). PR lockout state is not reversible.

**Figure 16. Protection Register Memory Map**



**NOTE:** A0 is not used in x16 mode when accessing the Protection Register map (See Table 8 for x16 addressing). For x8 mode A0 is used (See Table 19 for x8 addressing).

**Table 18. Word-Wide Protection Register Addressing**

| Word | Use     | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 |
|------|---------|----|----|----|----|----|----|----|----|
| LOCK | Both    | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| 0    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 1  |
| 1    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  |
| 2    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 1  |
| 3    | Factory | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| 4    | User    | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 1  |
| 5    | User    | 1  | 0  | 0  | 0  | 0  | 1  | 1  | 0  |
| 6    | User    | 1  | 0  | 0  | 0  | 0  | 1  | 1  | 1  |
| 7    | User    | 1  | 0  | 0  | 0  | 1  | 0  | 0  | 0  |

**Table 19. Byte-Wide Protection Register Addressing (Sheet 1 of 2)**

| Byte | Use     | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
|------|---------|----|----|----|----|----|----|----|----|----|
| LOCK | Both    | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| LOCK | Both    | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  |
| 0    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  |
| 1    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  |
| 2    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| 3    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 1  |
| 4    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 0  |
| 5    | Factory | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  |

Table 19. Byte-Wide Protection Register Addressing (Sheet 2 of 2)

|   |         |   |   |   |   |   |   |   |   |   |
|---|---------|---|---|---|---|---|---|---|---|---|
| 6 | Factory | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 7 | Factory | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 8 | User    | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 9 | User    | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| A | User    | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| B | User    | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| C | User    | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| D | User    | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| E | User    | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| F | User    | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |

**NOTE:** All address lines not specified in the above table must be 0 when accessing the Protection Register, i.e., A[MAX:9] = 0.

## 13.4 Array Protection

The  $V_{PEN}$  signal is a hardware mechanism to prohibit array alteration. When the  $V_{PEN}$  voltage is below the  $V_{PENLK}$  voltage, array contents cannot be altered. To ensure a proper erase or program operation,  $V_{PEN}$  must be set to a valid voltage level. To determine the status of an erase or program operation, poll the Status Register and analyze the bits.

## 14.0 Special Modes

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This section describes how to read the status, ID, and CFI registers. This section also details how to configure the STS signal.

### 14.1 Set Read Configuration Register Command

This command is no longer supported on J3A or J3C. The J3A device will ignore this command, while the J3C device will **result in an invalid command sequence (SR4 & SR5 =1)**.

### 14.2 Status (STS)

The Status (STS) signal can be configured to different states using the Configuration command. Once the STS signal has been configured, it remains in that configuration until another configuration command is issued or RP# is asserted low. Initially, the STS signal defaults to RY/BY# operation where RY/BY# low indicates that the WSM is busy. RY/BY# high indicates that the state machine is ready for a new operation or suspended. [Table 20, “STS Configuration Coding Definitions” on page 45](#) displays the possible STS configurations.

To reconfigure the Status (STS) signal to other modes, the Configuration command is given followed by the desired configuration code. The three alternate configurations are all pulse mode for use as a system interrupt as described below. For these configurations, bit 0 controls Erase Complete interrupt pulse, and bit 1 controls Program Complete interrupt pulse. Supplying the 0x00 configuration code with the Configuration command resets the STS signal to the default RY/BY# level mode. The possible configurations and their usage are described in [Table 20, “STS Configuration Coding Definitions” on page 45](#). The Configuration command may only be given when the device is not busy or suspended. Check SR7 for device status. An invalid configuration code will result in both SR4 and SR5 being set. When configured in one of the pulse modes, the STS signal pulses low with a typical pulse width of 250 ns.

**Table 20. STS Configuration Coding Definitions**

| D7  | D6 | D5 | D4 | D3  | D2 | D1                                   | D0                                 |
|---|----|----|----|---|----|--------------------------------------|------------------------------------|
| <b>Reserved</b>                                   |    |    |    |   |    | <b>Pulse on Program Complete (1)</b> | <b>Pulse on Erase Complete (1)</b> |
| <b>D[1:0] = STS Configuration Codes</b>           |    |    |    | <b>Notes</b>  |    |                                      |                                    |
| 00 = default, level mode; device ready indication |    |    |    | Used to control HOLD to a memory controller to prevent accessing a flash memory subsystem while any flash device's WSM is busy.   |    |                                      |                                    |
| 01 = pulse on Erase Complete                      |    |    |    | Used to generate a system interrupt pulse when any flash device in an array has completed a block erase. Helpful for reformatting blocks after file system free space reclamation or "cleanup." |    |                                      |                                    |
| 10 = pulse on Program Complete                    |    |    |    | Used to generate a system interrupt pulse when any flash device in an array has completed a program operation. Provides highest performance for servicing continuous buffer write operations.   |    |                                      |                                    |
| 11 = pulse on Erase or Program Complete           |    |    |    | Used to generate system interrupts to trigger servicing of flash arrays when either erase or program operations are completed, when a common interrupt service routine is desired.              |    |                                      |                                    |

**NOTES:**

1. When configured in one of the pulse modes, STS pulses low with a typical pulse width of 250 ns.
2. An invalid configuration code will result in both SR4 and SR5 being set.

## Appendix A Common Flash Interface

The Common Flash Interface(CFI) specification outlines device and host system software interrogation handshake which allows specific vendor-specified software algorithms to be used for entire families of devices. This allows device independent, JEDEC ID-independent, and forward- and backward-compatible software support for the specified flash device families. It allows flash vendors to standardize their existing interfaces for long-term compatibility.

This appendix defines the data structure or “database” returned by the Common Flash Interface (CFI) Query command. System software should parse this structure to gain critical information such as block size, density, x8/x16, and electrical specifications. Once this information has been obtained, the software will know which command sets to use to enable flash writes, block erases, and otherwise control the flash component. The Query is part of an overall specification for multiple command set and control interface descriptions called Common Flash Interface, or CFI.

### A.1 Query Structure Output

The Query “database” allows system software to gain information for controlling the flash component. This section describes the device’s CFI-compliant interface that allows the host system to access Query data.

Query data are always presented on the lowest-order data outputs (D[7:0]) only. The numerical offset value is the address relative to the maximum bus width supported by the device. On this family of devices, the Query table device starting address is a 10h, which is a word address for x16 devices.

For a word-wide (x16) device, the first two bytes of the Query structure, “Q” and “R” in ASCII, appear on the low byte at word addresses 10h and 11h. This CFI-compliant device outputs 00H data on upper bytes. Thus, the device outputs ASCII “Q” in the low byte (D[7:0]) and 00h in the high byte (D[15:8]).

At Query addresses containing two or more bytes of information, the least significant data byte is presented at the lower address, and the most significant data byte is presented at the higher address.

In all of the following tables, addresses and data are represented in hexadecimal notation, so the “h” suffix has been dropped. In addition, since the upper byte of word-wide devices is always “00h,” the leading “00” has been dropped from the table notation and only the lower byte value is shown. Any x16 device outputs can be assumed to have 00h on the upper byte in this mode.

**Table 21. Summary of Query Structure Output as a Function of Device and Mode**

| Device Type/ Mode      | Query start location in maximum device bus width addresses | Query data with maximum device bus width addressing |          |             | Query data with byte addressing |          |             |
|------------------------|--|---|----------|-------------|---------------------------------|----------|-------------|
|                        |  | Hex Offset  | Hex Code | ASCII Value | Hex Offset                      | Hex Code | ASCII Value |
| x16 device<br>x16 mode | 10h  | 10:   | 0051     | “Q”         | 20:                             | 51       | “Q”         |
|                        |  | 11:   | 0052     | “R”         | 21:                             | 00       | “Null”      |
|                        |  | 12:   | 0059     | “Y”         | 22:                             | 52       | “R”         |
| x16 device<br>x8 mode  | N/A <sup>(1)</sup>   | N/A <sup>(1)</sup>                                  |          |             | 20:                             | 51       | “Q”         |
|                        |  | N/A <sup>(1)</sup>                                  |          |             | 21:                             | 51       | “Q”         |
|                        |  | N/A <sup>(1)</sup>                                  |          |             | 22:                             | 52       | “R”         |

**NOTE:**

1. The system must drive the lowest order addresses to access all the device's array data when the device is configured in x8 mode. Therefore, word addressing, where these lower addresses are not toggled by the system, is "Not Applicable" for x8-configured devices.

**Table 22. Example of Query Structure Output of a x16- and x8-Capable Device**

| Word Addressing                 |                                 |           | Byte Addressing                |                                |          |
|---------------------------------|---------------------------------|-----------|--------------------------------|--------------------------------|----------|
| Offset                          | Hex Code                        | Value     | Offset                         | Hex Code                       | Value    |
| A <sub>15</sub> -A <sub>0</sub> | D <sub>15</sub> -D <sub>0</sub> |           | A <sub>7</sub> -A <sub>0</sub> | D <sub>7</sub> -D <sub>0</sub> |          |
| 0010h                           | 0051                            | “Q”       | 20h                            | 51                             | “Q”      |
| 0011h                           | 0052                            | “R”       | 21h                            | 51                             | “Q”      |
| 0012h                           | 0059                            | “Y”       | 22h                            | 52                             | “R”      |
| 0013h                           | P_ID <sub>LO</sub>              | PrVendor  | 23h                            | 52                             | “R”      |
| 0014h                           | P_ID <sub>HI</sub>              | ID #      | 24h                            | 59                             | “Y”      |
| 0015h                           | P <sub>LO</sub>                 | PrVendor  | 25h                            | 59                             | “Y”      |
| 0016h                           | P <sub>HI</sub>                 | TblAdr    | 26h                            | P_ID <sub>LO</sub>             | PrVendor |
| 0017h                           | A_ID <sub>LO</sub>              | AltVendor | 27h                            | P_ID <sub>LO</sub>             | ID #     |
| 0018h                           | A_ID <sub>HI</sub>              | ID #      | 28h                            | P_ID <sub>HI</sub>             | ID #     |
| ...                             | ...                             | ...       | ...                            | ...                            | ...      |

## A.2 Query Structure Overview

The Query command causes the flash component to display the Common Flash Interface (CFI) Query structure or “database.” The structure sub-sections and address locations are summarized below. See *AP-646 Common Flash Interface (CFI) and Command Sets* (order number 292204) for a full description of CFI.

The following sections describe the Query structure sub-sections in detail.

Table 23. Query Structure

| Offset                 | Sub-Section Name                            | Description  | Notes |
|------------------------|---|--|-------|
| 00h                    |   | Manufacturer Code  | 1     |
| 01h                    |   | Device Code  | 1     |
| (BA+2) <sup>h(2)</sup> | Block Status Register                       | Block-Specific Information   | 1,2   |
| 04-0Fh                 | Reserved                                    | <i>Reserved for Vendor-Specific Information</i>                                | 1     |
| 10h                    | CFI Query Identification String             | <i>Reserved for Vendor-Specific Information</i>                                | 1     |
| 1Bh                    | System Interface Information                | Command Set ID and Vendor Data Offset  | 1     |
| 27h                    | Device Geometry Definition                  | Flash Device Layout  | 1     |
| P <sup>(3)</sup>       | Primary Intel-Specific Extended Query Table | Vendor-Defined Additional Information Specific to the Primary Vendor Algorithm | 1,3   |

**NOTES:**

1. Refer to the Query Structure Output section and offset 28h for the detailed definition of offset address as a function of device bus width and mode.
2. BA = Block Address beginning location (i.e., 02000h is block 2's beginning location when the block size is 128 Kbyte).
3. Offset 15 defines "P" which points to the *Primary Intel-Specific Extended Query Table*.

## A.3 Block Status Register

The block status register indicates whether an erase operation completed successfully or whether a given block is locked or can be accessed for flash program/erase operations.

Table 24. Block Status Register

| Offset                 | Length | Description   | Address | Value           |
|------------------------|--------|---|---------|-----------------|
| (BA+2) <sup>h(1)</sup> | 1      | Block Lock Status Register                            | BA+2:   | --00 or --01    |
|                        |        | BSR.0 Block Lock Status<br>0 = Unlocked<br>1 = Locked | BA+2:   | (bit 0): 0 or 1 |
|                        |        | BSR 1–7: <i>Reserved for Future Use</i>               | BA+2:   | (bit 1–7): 0    |

**NOTE:**

1. BA = The beginning location of a Block Address (i.e., 008000h is block 1's (64-KB block) beginning location in word mode).

## A.4 CFI Query Identification String

The CFI Query Identification String provides verification that the component supports the Common Flash Interface specification. It also indicates the specification version and supported vendor-specified command set(s).

Table 25. CFI Identification (Sheet 1 of 2)

| Offset | Length | Description   | Add.              | Hex Code             | Value             |
|--------|--------|---|-------------------|----------------------|-------------------|
| 10h    | 3      | Query-unique ASCII string "QRY"   | 10:<br>11:<br>12: | --51<br>--52<br>--59 | "Q"<br>"R"<br>"Y" |
| 13h    | 2      | Primary vendor command set and control interface ID code.<br>16-bit ID code for vendor-specified algorithms | 13:<br>14:        | --01<br>--00         |                   |
| 15h    | 2      | Extended Query Table primary algorithm address  | 15:<br>16:        | --31<br>--00         |                   |
| 17h    | 2      | Alternate vendor command set and control interface ID code.   | 17:               | --00                 |                   |



**Table 25. CFI Identification (Sheet 2 of 2)**

| Offset | Length | Description  | Add.       | Hex Code     | Value |
|--------|--------|--|------------|--------------|-------|
|        |        | 0000h means no second vendor-specified algorithm exists                      | 18:        | --00         |       |
| 19h    | 2      | Secondary algorithm Extended Query Table address.<br>0000h means none exists | 19:<br>1A: | --00<br>--00 |       |

## A.5 System Interface Information

The following device information can optimize system interface software.

**Table 26. System Interface Information**

| Offset | Length | Description   | Add. | Hex Code | Value  |
|--------|--------|---|------|----------|--------|
| 1Bh    | 1      | V <sub>CC</sub> logic supply minimum program/erase voltage<br>bits 0–3 BCD 100 mV<br>bits 4–7 BCD volts         | 1B:  | --27     | 2.7 V  |
| 1Ch    | 1      | V <sub>CC</sub> logic supply maximum program/erase voltage<br>bits 0–3 BCD 100 mV<br>bits 4–7 BCD volts         | 1C:  | --36     | 3.6 V  |
| 1Dh    | 1      | V <sub>PP</sub> [programming] supply minimum program/erase voltage<br>bits 0–3 BCD 100 mV<br>bits 4–7 HEX volts | 1D:  | --00     | 0.0 V  |
| 1Eh    | 1      | V <sub>PP</sub> [programming] supply maximum program/erase voltage<br>bits 0–3 BCD 100 mV<br>bits 4–7 HEX volts | 1E:  | --00     | 0.0 V  |
| 1Fh    | 1      | "n" such that typical single word program time-out = 2 <sup>n</sup> μs  | 1F:  | --08     | 256 μs |
| 20h    | 1      | "n" such that typical max. buffer write time-out = 2 <sup>n</sup> μs  | 20:  | --08     | 256 μs |
| 21h    | 1      | "n" such that typical block erase time-out = 2 <sup>n</sup> ms  | 21:  | --0A     | 1 s    |
| 22h    | 1      | "n" such that typical full chip erase time-out = 2 <sup>n</sup> ms  | 22:  | --00     | NA     |
| 23h    | 1      | "n" such that maximum word program time-out = 2 <sup>n</sup> times typical                                      | 23:  | --04     | 2 ms   |
| 24h    | 1      | "n" such that maximum buffer write time-out = 2 <sup>n</sup> times typical                                      | 24:  | --04     | 2 ms   |
| 25h    | 1      | "n" such that maximum block erase time-out = 2 <sup>n</sup> times typical                                       | 25:  | --04     | 16 s   |
| 26h    | 1      | "n" such that maximum chip erase time-out = 2 <sup>n</sup> times typical  | 26:  | --00     | NA     |

## A.6 Device Geometry Definition

This field provides critical details of the flash device geometry.

**Table 27. Device Geometry Definition (Sheet 1 of 2)**

| Offset | Length | Description   | Code See Table Below |              |            |
|--------|--------|---|----------------------|--------------|------------|
| 27h    | 1      | "n" such that device size = 2 <sup>n</sup> in number of bytes   | 27:                  |              |            |
| 28h    | 2      | Flash device interface: <u>x8_async</u> <u>x16_async</u> <u>x8/x16_async</u><br>28:00,29:00 28:01,29:00 28:02,29:00 | 28:<br>29:           | --02<br>--00 | x8/<br>x16 |
| 2Ah    | 2      | "n" such that maximum number of bytes in write buffer = 2 <sup>n</sup>  | 2A:<br>2B:           | --05<br>--00 | 32         |

Table 27. Device Geometry Definition (Sheet 2 of 2)

| Offset | Length | Description  | Code See Table Below |      |   |
|--------|--------|--|----------------------|------|---|
| 2Ch    | 1      | Number of erase block regions within device:<br>1. x = 0 means no erase blocking; the device erases in "bulk"<br>2. x specifies the number of device or partition regions with one or more contiguous same-size erase blocks<br>3. Symmetrically blocked partitions have one blocking region<br>4. Partition size = (total blocks) x (individual block size) | 2C:                  | --01 | 1 |
| 2Dh    | 4      | Erase Block Region 1 Information<br>bits 0–15 = y, y+1 = number of identical-size erase blocks<br>bits 16–31 = z, region erase block(s) size are z x 256 bytes   | 2D:                  |      |   |
|        |        |  | 2E:                  |      |   |
|        |        |  | 2F:                  |      |   |
|        |        |  | 30:                  |      |   |

### Device Geometry Definition

| Address | 32 Mbit | 64 Mbit | 128 Mbit | 256Mbit |
|---------|---------|---------|----------|---------|
| 27:     | --16    | --17    | --18     | --19    |
| 28:     | --02    | --02    | --02     | --02    |
| 29:     | --00    | --00    | --00     | --00    |
| 2A:     | --05    | --05    | --05     | --05    |
| 2B:     | --00    | --00    | --00     | --00    |
| 2C:     | --01    | --01    | --01     | --01    |
| 2D:     | --1F    | --3F    | --7F     | --FF    |
| 2E:     | --00    | --00    | --00     | --00    |
| 2F:     | --00    | --00    | --00     | --00    |
| 30:     | --02    | --02    | --02     | --02    |

## A.7 Primary-Vendor Specific Extended Query Table

Certain flash features and commands are optional. The *Primary Vendor-Specific Extended Query* table specifies this and other similar information.

Table 28. Primary Vendor-Specific Extended Query (Sheet 1 of 2)

| Offset <sup>(1)</sup><br>P = 31h | Length | Description<br>(Optional Flash Features and Commands) | Add. | Hex Code | Value |
|----------------------------------|--------|---|------|----------|-------|
| (P+0)h                           | 3      | Primary extended query table                          | 31:  | --50     | "P"   |
| (P+1)h                           |        | Unique ASCII string "PRI"                             | 32:  | --52     | "R"   |
| (P+2)h                           |        |   | 33:  | --49     | "I"   |
| (P+3)h                           | 1      | Major version number, ASCII                           | 34:  | --31     | "1"   |
| (P+4)h                           | 1      | Minor version number, ASCII                           | 35:  | --31     | "1"   |

Table 28. Primary Vendor-Specific Extended Query (Sheet 2 of 2)

| Offset <sup>(1)</sup><br>P = 31h     | Length | Description<br>(Optional Flash Features and Commands)   | Add.                     | Hex Code                     | Value  |
|--------------------------------------|--------|---|--------------------------|------------------------------|--|
| (P+5)h<br>(P+6)h<br>(P+7)h<br>(P+8)h | 4      | Optional feature and command support (1=yes, 0=no)<br><i>bits 9–31 are 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.</i><br>bit 0 Chip erase supported<br>bit 1 Suspend erase supported<br>bit 2 Suspend program supported<br>bit 3 Legacy lock/unlock supported<br>bit 4 Queued erase supported<br>bit 5 Instant Individual block locking supported<br>bit 6 Protection bits supported<br>bit 7 Page-mode read supported<br>bit 8 Synchronous read supported | 36:<br>37:<br>38:<br>39: | --0A<br>--00<br>--00<br>--00 | No<br>Yes<br>Yes<br>Yes <sup>(1)</sup><br>No<br>No<br>Yes<br>Yes<br>No |
| (P+9)h                               | 1      | Supported functions after suspend: read Array, Status, Query<br>Other supported operations are:<br><i>bits 1–7 reserved; undefined bits are “0”</i><br>bit 0 Program supported after erase suspend  | 3A:                      | --01                         | Yes  |
| (P+A)h<br>(P+B)h                     | 2      | Block status register mask<br><i>bits 2–15 are Reserved; undefined bits are “0”</i><br>bit 0 Block Lock-Bit Status register active<br>bit 1 Block Lock-Down Bit Status active   | 3B:<br>3C:               | --01<br>--00                 | Yes<br>No  |
| (P+C)h                               | 1      | V <sub>CC</sub> logic supply highest performance program/erase voltage<br>bits 0–3 BCD value in 100 mV<br>bits 4–7 BCD value in volts   | 3D:                      | --33                         | 3.3 V  |
| (P+D)h                               | 1      | V <sub>PP</sub> optimum program/erase supply voltage<br>bits 0–3 BCD value in 100 mV<br>bits 4–7 HEX value in volts   | 3E:                      | --00                         | 0.0 V  |

**NOTE:**

1. Future devices may not support the described “Legacy Lock/Unlock” function. Thus bit 3 would have a value of “0.”

Table 29. Protection Register Information

| Offset <sup>(1)</sup><br>P = 31h        | Length | Description<br>(Optional Flash Features and Commands)  | Add.                     | Hex Code                     | Value                          |
|---|--------|--|--------------------------|------------------------------|--------------------------------|
| (P+E)h                                  | 1      | Number of Protection register fields in JEDEC ID space. "00h," indicates that 256 protection bytes are available   | 3F:                      | --01                         | 01                             |
| (P+F)h<br>(P+10)h<br>(P+11)h<br>(P+12)h | 4      | Protection Field 1: Protection Description<br>This field describes user-available One Time Programmable (OTP) Protection Register bytes. Some are pre-programmed with device-unique serial numbers. Others are user-programmable. Bits 0-15 point to the Protection Register lock byte, the section's first byte. The following bytes are factory pre-programmed and user-programmable.<br>bits 0-7 = Lock/bytes JEDEC-plane physical low address<br>bits 8-15 = Lock/bytes JEDEC-plane physical high address<br>bits 16-23 = "n" such that 2 <sup>n</sup> = factory pre-programmed bytes<br>bits 24-31 = "n" such that 2 <sup>n</sup> = user-programmable bytes | 40:<br>41:<br>42:<br>43: | --80<br>--00<br>--03<br>--03 | 80h<br>00h<br>8bytes<br>8bytes |

**NOTE:**

1. The variable P is a pointer which is defined at CFI offset 15h.

Table 30. Burst Read Information

| Offset <sup>(1)</sup><br>P = 31h | Length | Description<br>(Optional Flash Features and Commands)  | Add. | Hex Code | Value  |
|----------------------------------|--------|--|------|----------|--------|
| (P+13)h                          | 1      | Page Mode Read capability<br>bits 0-7 = "n" such that 2 <sup>n</sup> 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. | 44:  | --03     | 8 byte |
| (P+14)h                          | 1      | Number of synchronous mode read configuration fields that follow. 00h indicates no burst capability.   | 45:  | --00     | 0      |
| (P+15)h                          |        | <i>Reserved for future use</i>   | 46:  |          |        |

**NOTE:**

1. The variable P is a pointer which is defined at CFI offset 15h.

## Appendix B Flow Charts

Figure 17. Write to Buffer Flowchart

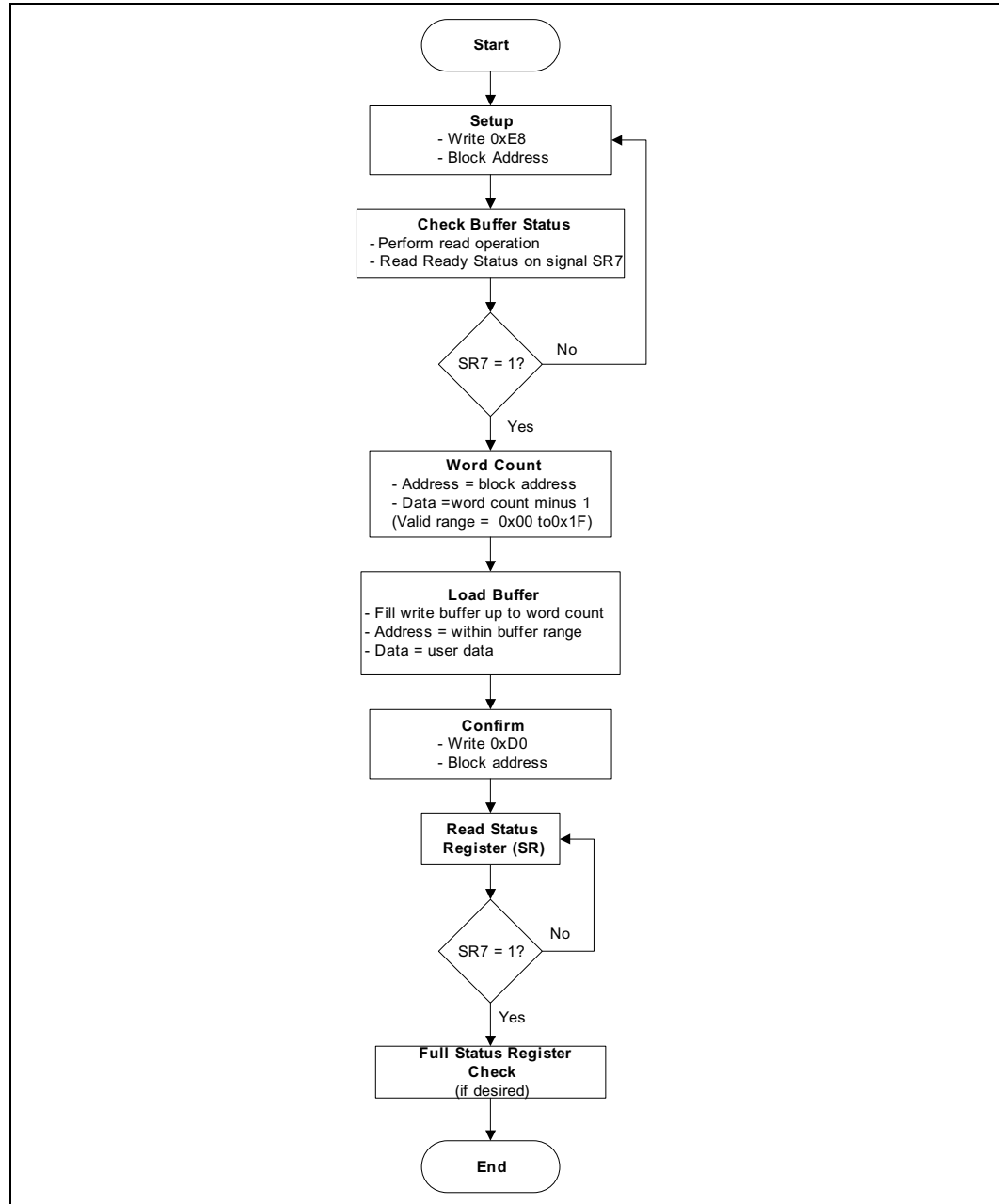
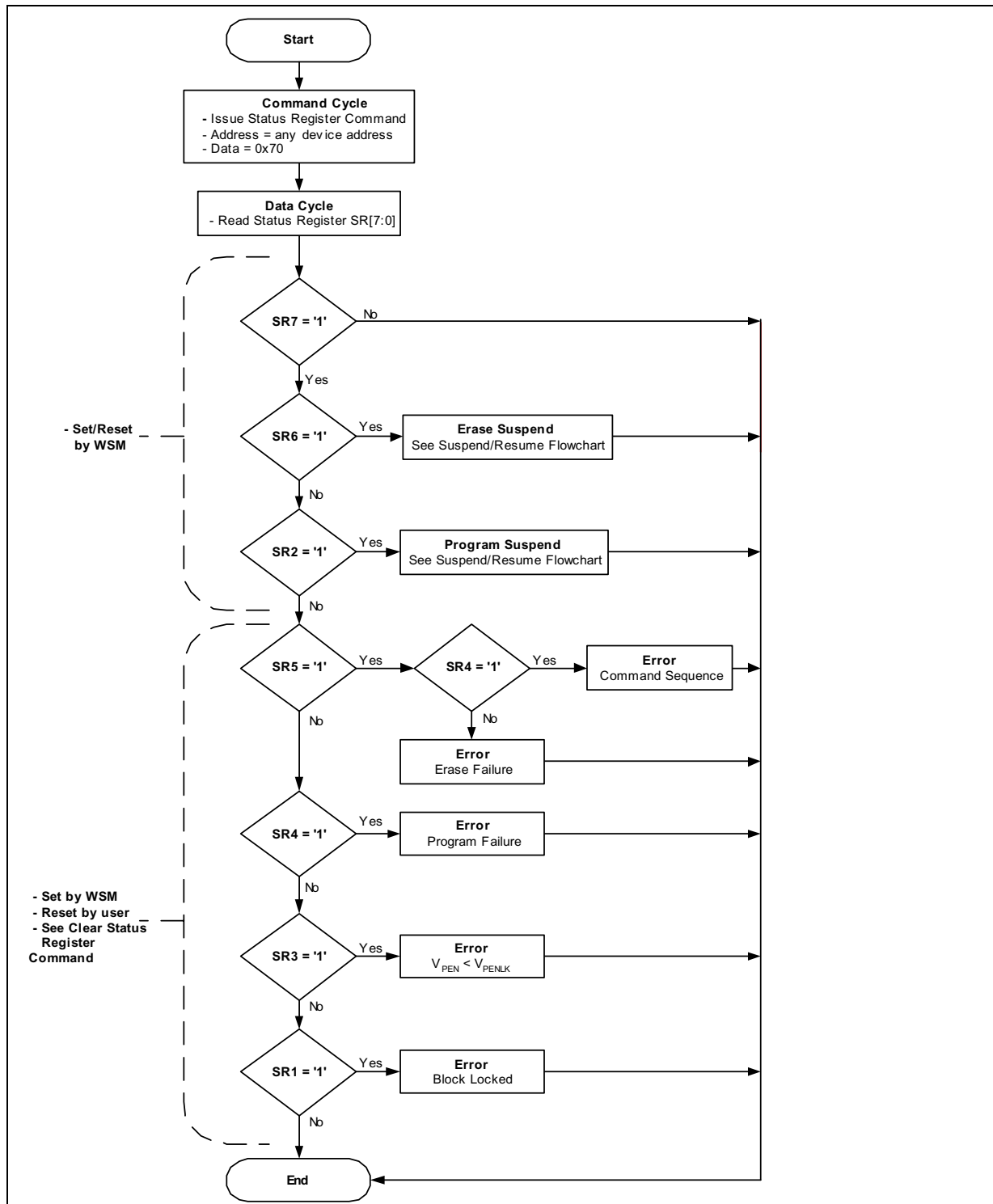


Figure 18. Status Register Flowchart



0606\_07A

Figure 19. Byte/Word Program Flowchart

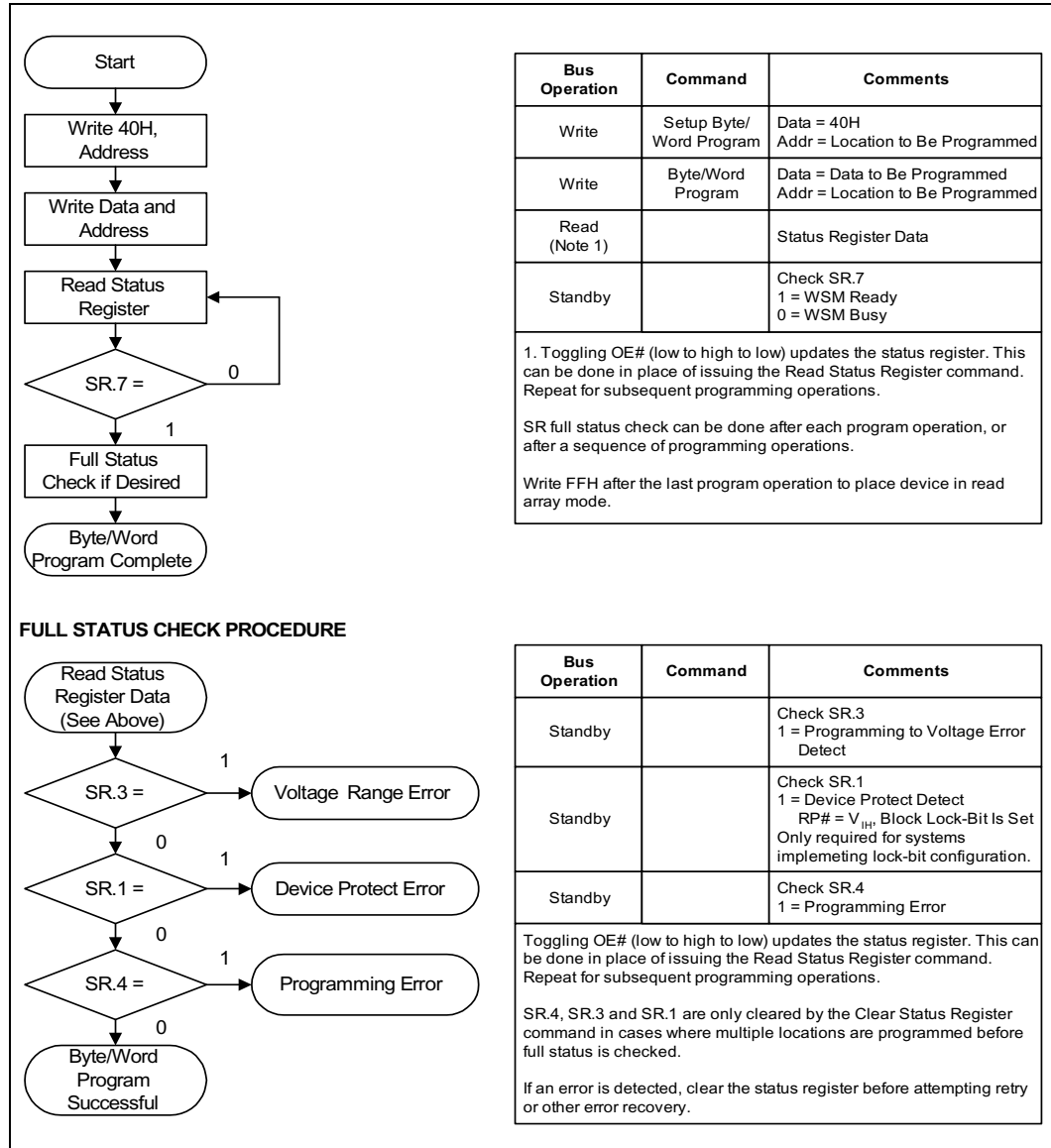
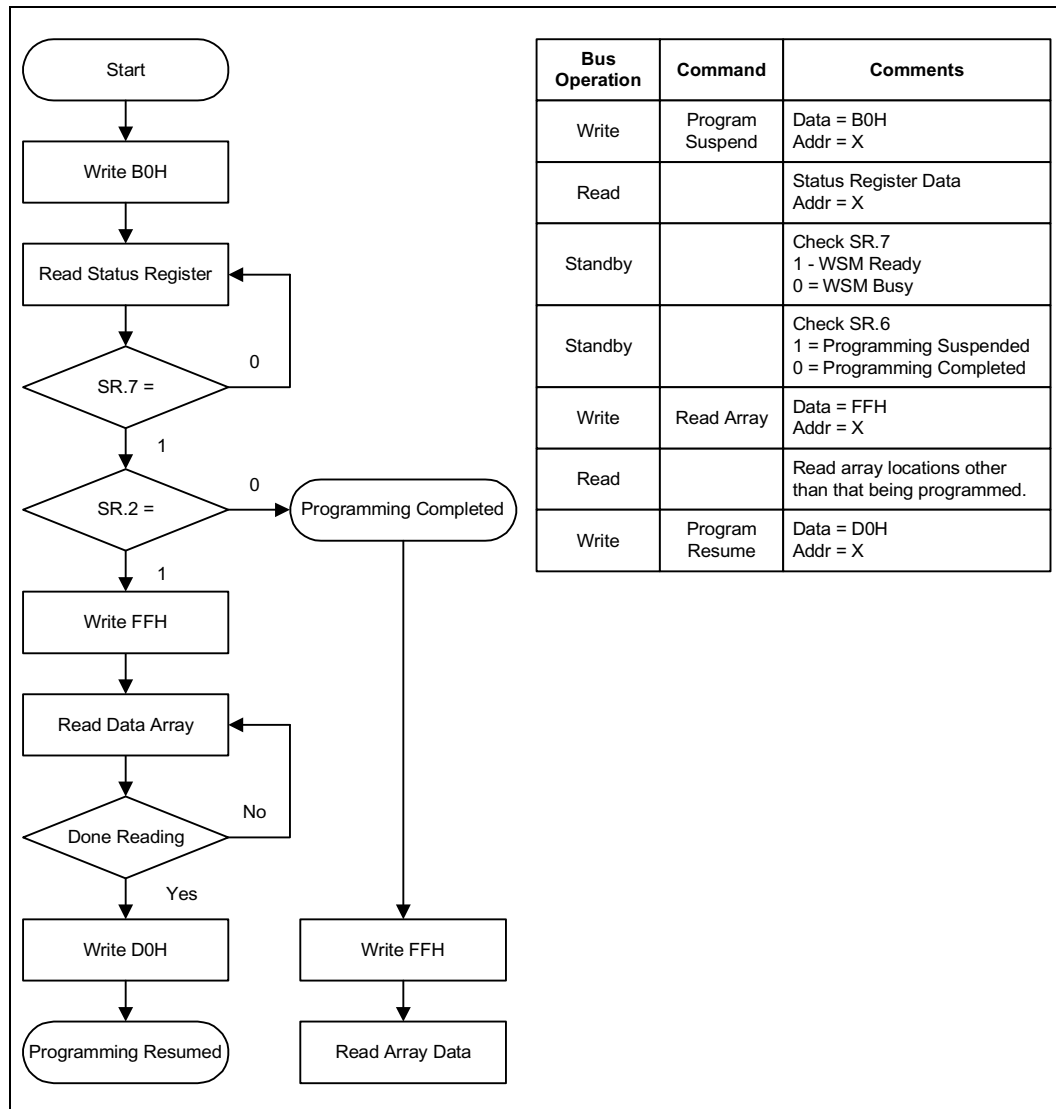


Figure 20. Program Suspend/Resume Flowchart

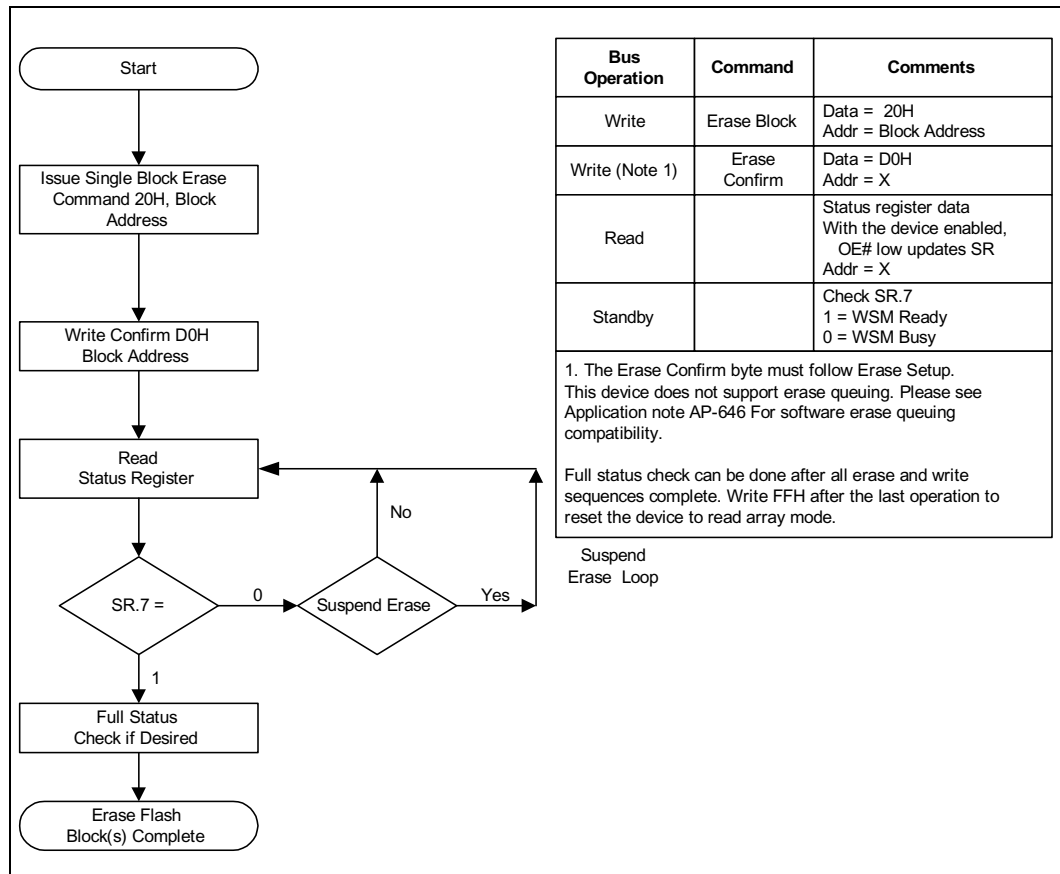


| Bus Operation | Command         | Comments   |
|---------------|-----------------|--|
| Write         | Program Suspend | Data = B0H<br>Addr = X   |
| Read          |                 | Status Register Data<br>Addr = X                                     |
| Standby       |                 | Check SR.7<br>1 - WSM Ready<br>0 = WSM Busy                          |
| Standby       |                 | Check SR.6<br>1 = Programming Suspended<br>0 = Programming Completed |
| Write         | Read Array      | Data = FFH<br>Addr = X   |
| Read          |                 | Read array locations other than that being programmed.               |
| Write         | Program Resume  | Data = D0H<br>Addr = X   |

0606\_08

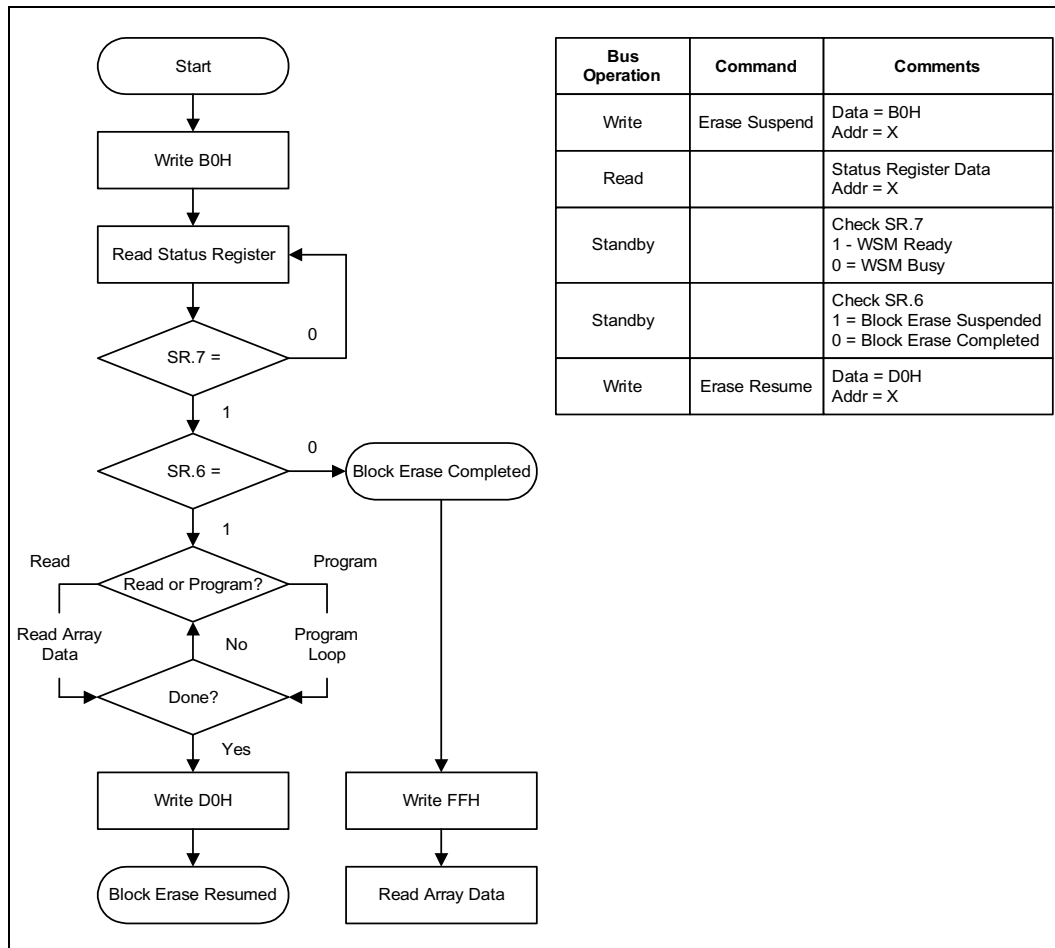


Figure 21. Block Erase Flowchart



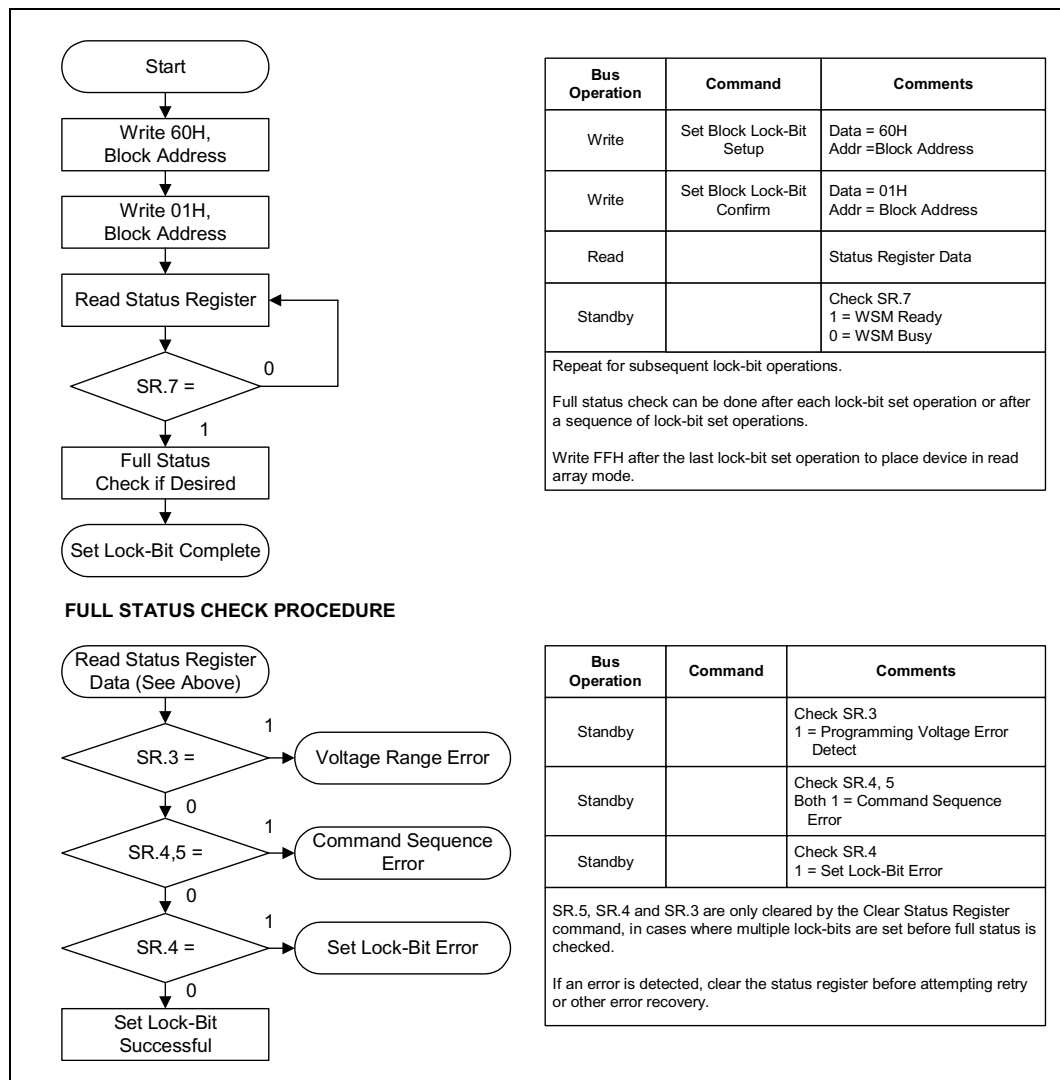
0606\_09

Figure 22. Block Erase Suspend/Resume Flowchart



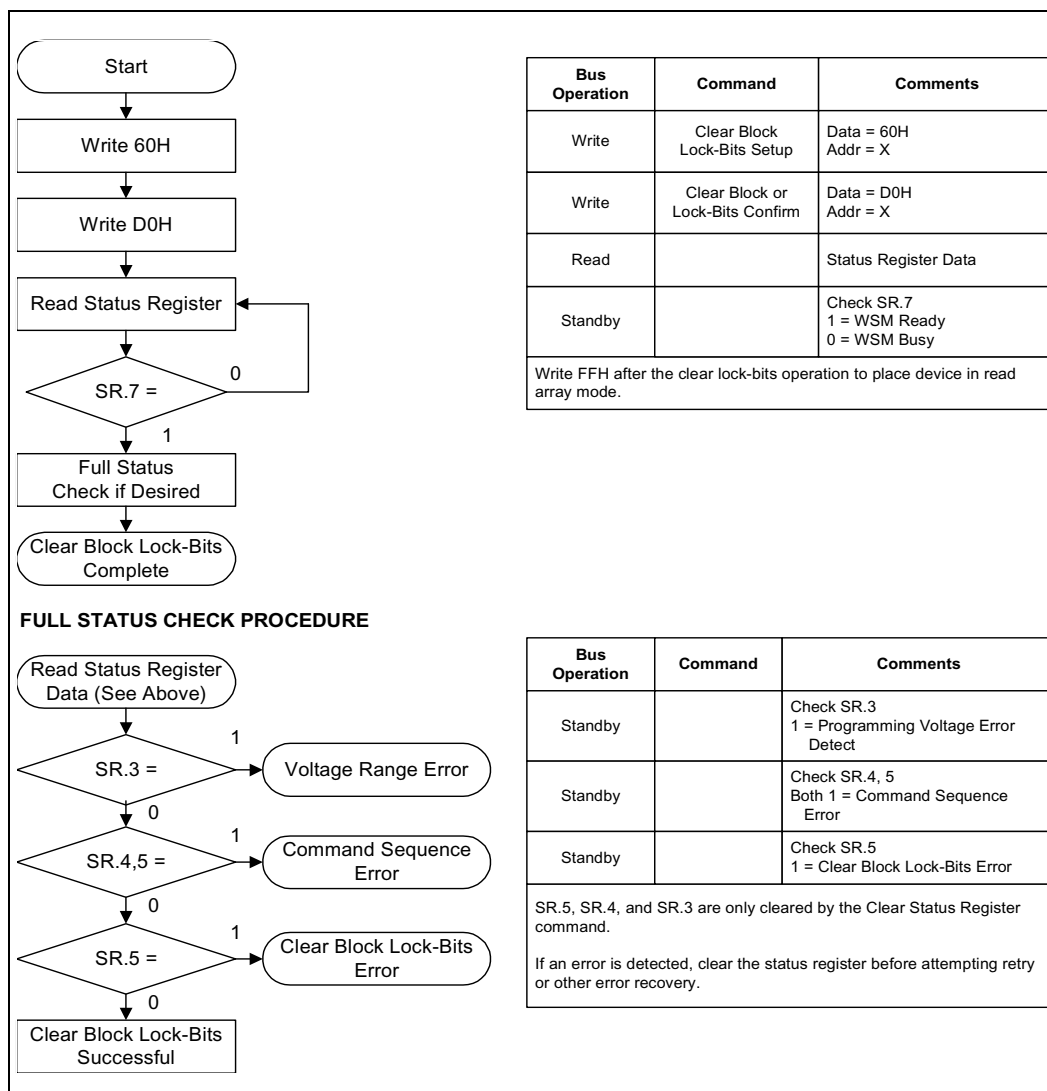
0606\_10

Figure 23. Set Block Lock-Bit Flowchart



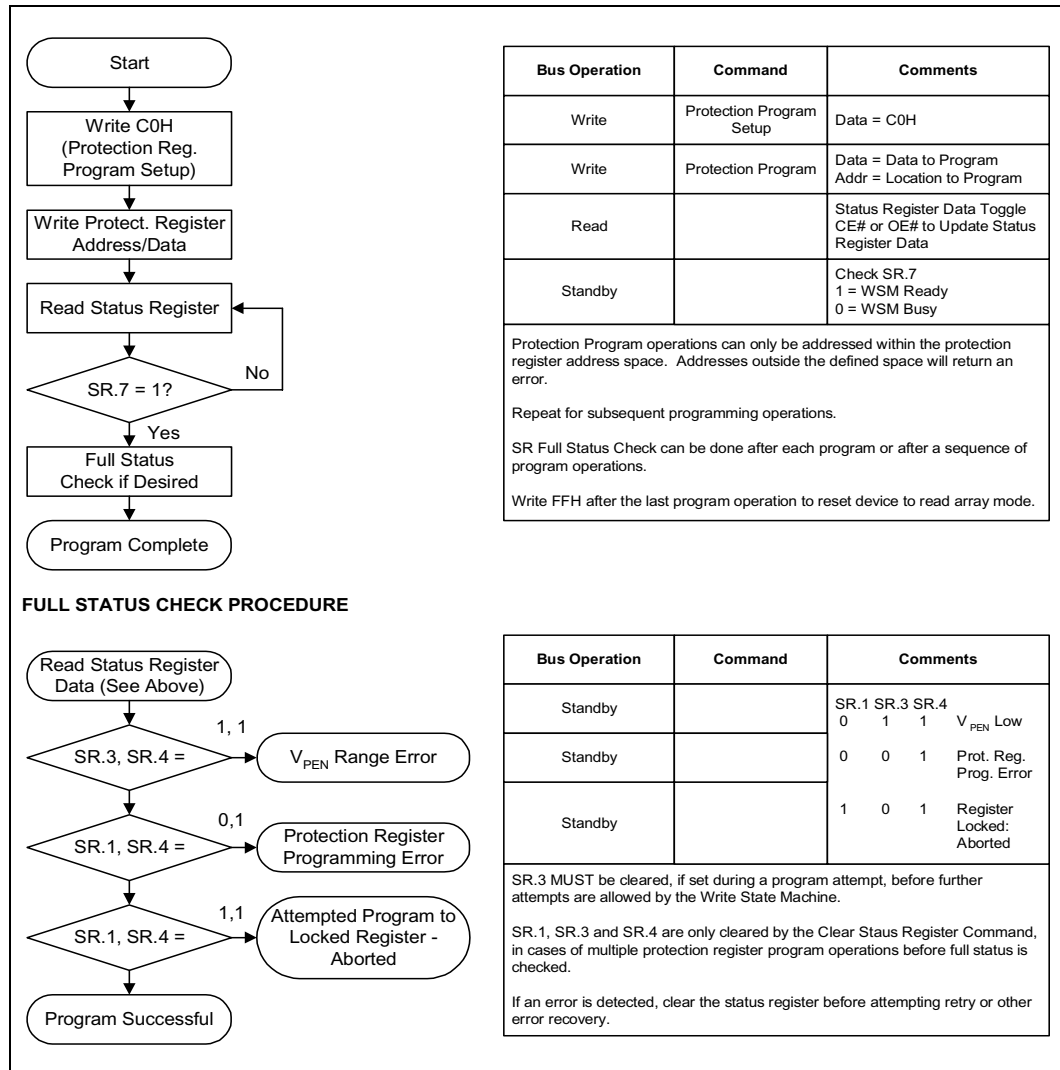
0606\_11b

Figure 24. Clear Lock-Bit Flowchart



0606\_12b

Figure 25. Protection Register Programming Flowchart



## Appendix C Design Considerations

### C.1 Three-Line Output Control

The device will often be used in large memory arrays. Intel provides five control inputs (CE0, CE1, CE2, OE#, and RP#) to accommodate multiple memory connections. This control provides for:

- a. Lowest possible memory power dissipation.
- b. Complete assurance that data bus contention will not occur.

To use these control inputs efficiently, an address decoder should enable the device (see [Table 13](#)) while OE# should be connected to all memory devices and the system's READ# control line. This assures that only selected memory devices have active outputs while de-selected memory devices are in standby mode. RP# should be connected to the system POWERGOOD signal to prevent unintended writes during system power transitions. POWERGOOD should also toggle during system reset.

### C.2 STS and Block Erase, Program, and Lock-Bit Configuration Polling

STS is an open drain output that should be connected to VCCQ by a pull-up resistor to provide a hardware method of detecting block erase, program, and lock-bit configuration completion. It is recommended that a 2.5k resistor be used between STS# and VCCQ. In default mode, it transitions low after block erase, program, or lock-bit configuration commands and returns to High Z when the WSM has finished executing the internal algorithm. For alternate configurations of the STS signal, see the Configuration command.

STS can be connected to an interrupt input of the system CPU or controller. It is active at all times. STS, in default mode, is also High Z when the device is in block erase suspend (with programming inactive), program suspend, or in reset/power-down mode.

### C.3 Input Signal Transitions—Reducing Overshoots and Undershoots When Using Buffers or Transceivers

As faster, high-drive devices such as transceivers or buffers drive input signals to flash memory devices, overshoots and undershoots can sometimes cause input signals to exceed flash memory specifications. (See “DC Voltage Characteristics” on page 20.) Many buffer/transceiver vendors now carry bus-interface devices with internal output-damping resistors or reduced-drive outputs. Internal output-damping resistors diminish the nominal output drive currents, while still leaving sufficient drive capability for most applications. These internal output-damping resistors help reduce unnecessary overshoots and undershoots. Transceivers or buffers with balanced- or light-drive outputs also reduce overshoots and undershoots by diminishing output-drive currents. When considering a buffer/transceiver interface design to flash, devices with internal output-damping resistors or reduced-drive outputs should be used to minimize overshoots and undershoots. For additional information, please refer to AP-647, *5 Volt Intel StrataFlash® Memory Design Guide* (Order Number: 292205).

## C.4 $V_{CC}$ , $V_{PEN}$ , RP# Transitions

Block erase, program, and lock-bit configuration are not guaranteed if  $V_{PEN}$  or  $V_{CC}$  falls outside of the specified operating ranges, or  $RP\# \neq V_{IH}$ . If  $RP\#$  transitions to  $V_{IL}$  during block erase, program, or lock-bit configuration, STS (in default mode) will remain low for a maximum time of  $t_{PLPH} + t_{PHRH}$  until the reset operation is complete. Then, the operation will abort and the device will enter reset/power-down mode. The aborted operation may leave data partially corrupted after programming, or partially altered after an erase or lock-bit configuration. Therefore, block erase and lock-bit configuration commands must be repeated after normal operation is restored. Device power-off or  $RP\# = V_{IL}$  clears the Status Register.

The CUI latches commands issued by system software and is not altered by  $V_{PEN}$ ,  $CE_0$ ,  $CE_1$ , or  $CE_2$  transitions, or WSM actions. Its state is read array mode upon power-up, after exit from reset/power-down mode, or after  $V_{CC}$  transitions below  $V_{LKO}$ .  $V_{CC}$  must be kept at or above  $V_{PEN}$  during  $V_{CC}$  transitions.

After block erase, program, or lock-bit configuration, even after  $V_{PEN}$  transitions down to  $V_{PENLK}$ , the CUI must be placed in read array mode via the Read Array command if subsequent access to the memory array is desired.  $V_{PEN}$  must be kept at or below  $V_{CC}$  during  $V_{PEN}$  transitions.

## C.5 Power Dissipation

When designing portable systems, designers must consider battery power consumption not only during device operation, but also for data retention during system idle time. Flash memory's nonvolatility increases usable battery life because data is retained when system power is removed.

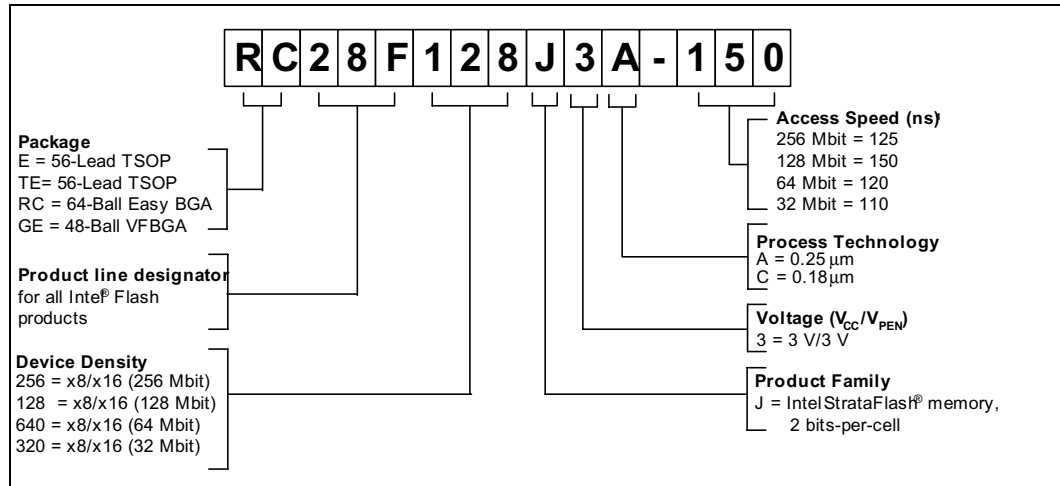
## Appendix D Additional Information

| Order Number | Document/Tool  |
|--------------|--|
| 298130       | <i>Intel® StrataFlash™ Memory (J3); 28F256J3, 28F128J3, 28F640J3, 28F320J3 Specification Update</i>                  |
| 298136       | <i>Intel® Persistent Storage Manager (IPSM) User's Guide Software Manual</i>   |
| 297833       | <i>Intel® Flash Data Integrator (FDI) User's Guide Software Manual</i>   |
| 290737       | <i>Intel StrataFlash® Synchronous Memory (K3/K18); 28F640K3, 28F640K18, 28F128K3, 28F128K18, 28F256K3, 28F256K18</i> |
| 292280       | <i>AP-732 3 Volt Intel StrataFlash® Memory J3 to K3/K18 Migration Guide</i>  |
| 292237       | <i>AP-689 Using Intel® Persistent Storage Manager</i>  |
| 290606       | <i>5 Volt Intel® StrataFlash™ Memory/28F320J5 and 28F640J5 datasheet</i>   |
| 297859       | <i>AP-677 Intel® StrataFlash™ Memory Technology</i>  |
| 292222       | <i>AP-664 Designing Intel® StrataFlash™ Memory into Intel® Architecture</i>  |
| 292221       | <i>AP-663 Using the Intel® StrataFlash™ Memory Write Buffer</i>  |
| 292218       | <i>AP-660 Migration Guide to 3 Volt Intel® StrataFlash™ Memory</i>   |
| 292204       | <i>AP-646 Common Flash Interface (CFI) and Command Sets</i>  |
| 253418       | <i>Intel® Wireless Communications and Computing Package User's Guide</i>   |

1. Please call the Intel Literature Center at (800) 548-4725 to request Intel documentation. International customers should contact their local Intel or distribution sales office.
2. Visit Intel's World Wide Web home page at <http://www.intel.com> for technical documentation and tools.
3. For the most current information on Intel StrataFlash memory, visit our website at <http://developer.intel.com/design/flash/isf>.



## Appendix E Ordering Information



**NOTE:**

1. These speeds are for either the standard asynchronous read access times or for the first access of a page-mode read sequence.

**VALID COMBINATIONS**

| 56-Lead TSOP    | 64-Ball Easy BGA | 48-Ball VF BGA  |
|-----------------|------------------|-----------------|
| E28F320J3A-110  | RC28F320J3A-110  | GE28F320J3A-110 |
| E28F640J3A-120  | RC28F640J3A-120  | GE28F320J3C-110 |
| E28F128J3A-150  | RC28F128J3A-150  | GE28F640J3C-115 |
| TE28F320J3C-110 | RC28F320J3C-110  | GE28F640J3C-120 |
| TE28F640J3C-115 | RC28F640J3C-115  |                 |
| TE28F640J3C-120 | RC28F640J3C-120  |                 |
| TE28F128J3C-120 | RC28F128J3C-120  |                 |
| TE28F128J3C-150 | RC28F128J3C-150  |                 |
| TE28F256J3C-125 | RC28F256J3C-125  |                 |

**28F256J3, 28F128J3, 28F640J3, 28F320J3**

