

LH28F016SA

16M (1M × 16, 2M × 8) Flash Memory

FEATURES

- User-Configurable x8 or x16 Operation
- User-Selectable 3.3 V or 5 V V_{CC}
- 70 ns Maximum Access Time
- 0.43 MB/sec Write Transfer Rate
- 100,000 Erase Cycles per Block
- 32 Independently Lockable Blocks (64K)
- Revolutionary Architecture
 - Pipelined Command Execution
 - Write During Erase
 - Command Superset of Sharp LH28F008SA
- 50 μ A (Typ.) I_{CC} in CMOS Standby
- 1 μ A (Typ.) Deep Power-Down
- State-of-the-Art 0.55 μ m ETOX™ Flash Technology
- 56-Pin, 1.2 mm × 14 mm × 20 mm TSOP (Type I) Package

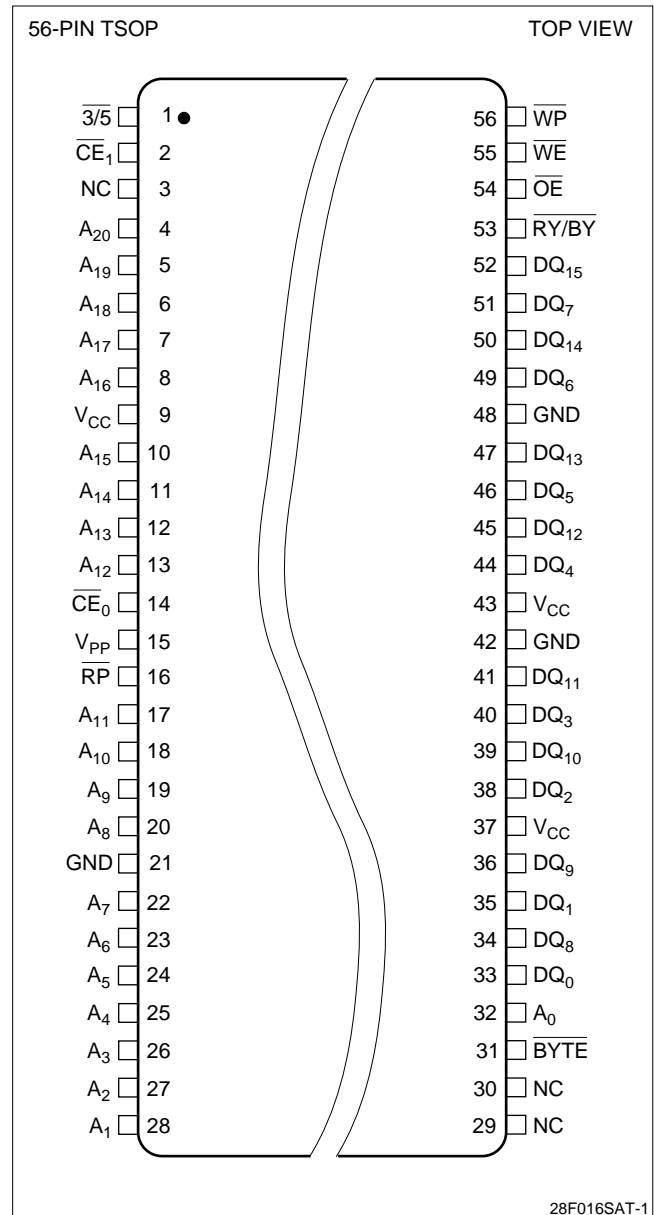
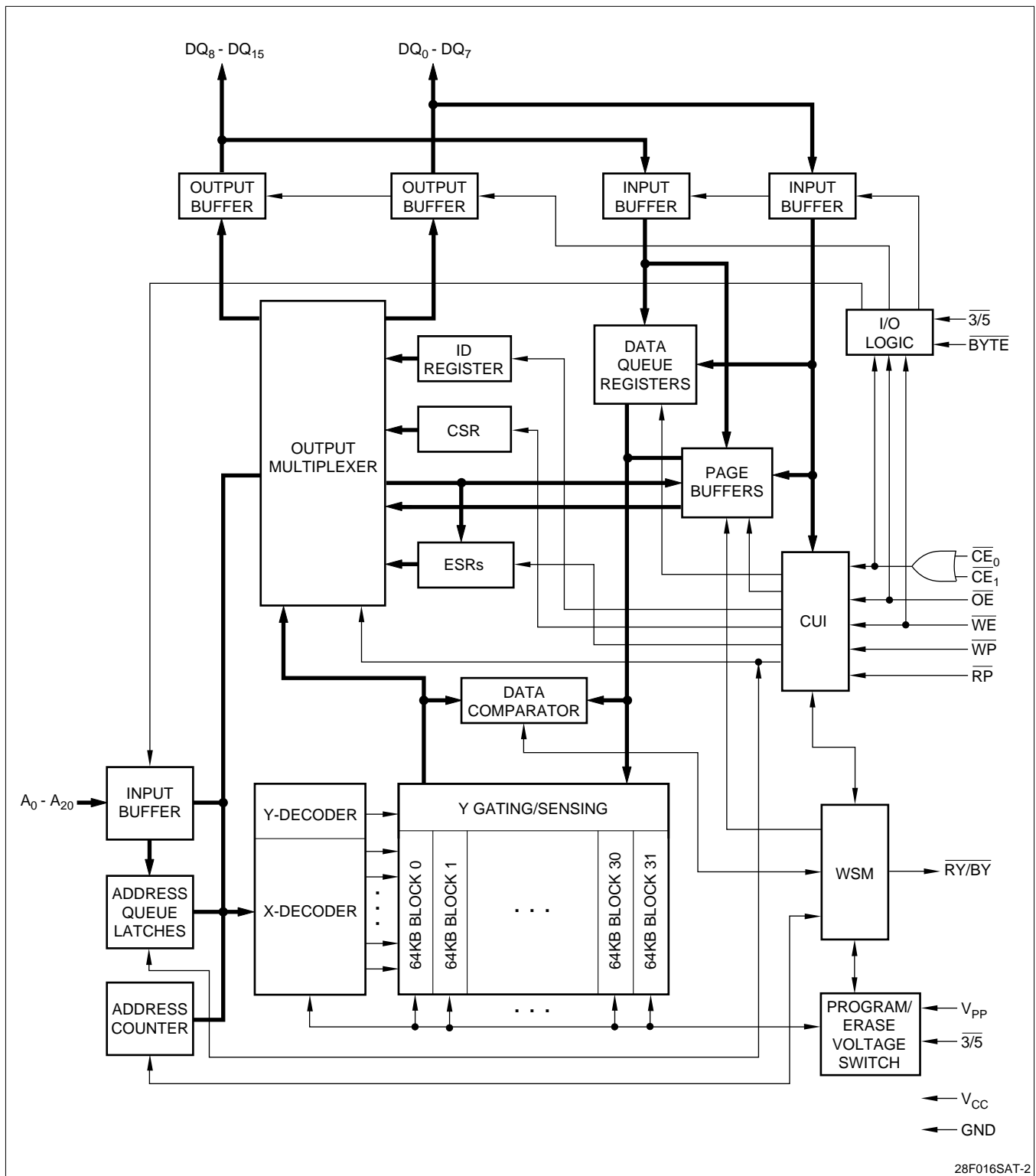


Figure 1. TSOP Configuration



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Figure 2. LH28F016SA Block Diagram (Architectural Evolution Includes Page Buffers, Queue Registers and Extended Status Registers)

PIN DESCRIPTION

| SYMBOL | TYPE | NAME AND FUNCTION |
|------------------------------------|-------------------|--|
| A_0 | INPUT | BYTE-SELECT ADDRESS: Selects between high and low byte when device is in x8 mode. This address is latched in x8 Data Writes. Not used in x16 mode (i.e., the A_0 input buffer is turned off when \overline{BYTE} is high). |
| $A_1 - A_{15}$ | INPUT | WORD-SELECT ADDRESSES: Select a word within one 64K block. $A_6 - A_{15}$ selects 1 of 1024 rows, and $A_1 - A_5$ selects 16 of 512 columns. These addresses are latched during Data Writes. |
| $A_{16} - A_{20}$ | INPUT | BLOCK-SELECT ADDRESSES: Select 1 of 32 Erase blocks. These addresses are latched during Data Writes, Erase and Lock-Block operations. |
| $DQ_0 - DQ_7$ | INPUT/OUTPUT | LOW-BYTE DATA BUS: Inputs data and commands during CUI write cycles. Outputs array, buffer, identifier or status data in the appropriate Read mode. Floated when the chip is de-selected or the outputs are disabled. |
| $DQ_8 - DQ_{15}$ | INPUT/OUTPUT | HIGH-BYTE DATA BUS: Inputs data during x16 Data-Write operations. Outputs array, buffer or identifier data in the appropriate Read mode; not used for Status register reads. Floated when the chip is de-selected or the outputs are disabled. |
| $\overline{CE}_0, \overline{CE}_1$ | INPUT | CHIP ENABLE INPUTS: Activate the device's control logic, input buffers, decoders and sense amplifiers. With either \overline{CE}_0 or \overline{CE}_1 high, the device is de-selected and power consumption reduces to Standby levels upon completion of any current Data-Write or Erase operations. Both $\overline{CE}_0, \overline{CE}_1$ must be low to select the device. All timing specifications are the same for both signals. Device Selection occurs with the latter falling edge of \overline{CE}_0 or \overline{CE}_1 . The first rising edge of \overline{CE}_0 or \overline{CE}_1 disables the device. |
| \overline{RP} | INPUT | RESET/POWER-DOWN: \overline{RP} low places the device in a Deep Power-Down state. All circuits that burn static power, even those circuits enabled in standby mode, are turned off. When returning from Deep Power-Down, a recovery time of 400 ns ($V_{CC} = 5.0 \text{ V} \pm 0.25 \text{ V}$) is required to allow these circuits to power-up. When \overline{RP} goes low, any current or pending WSM operation(s) are terminated, and the device is reset. All Status Registers return to ready (with all status flags cleared). |
| \overline{OE} | INPUT | OUTPUT ENABLE: Gates device data through the output buffers when low. The outputs float to tri-state off when \overline{OE} is high. NOTE: \overline{CE}_x overrides \overline{OE} , and \overline{OE} overrides \overline{WE} . |
| \overline{WE} | INPUT | WRITE ENABLE: Controls access to the CUI, Page Buffers, Data Queue Registers and Address Queue Latches. \overline{WE} is active low, and latches both address and data (command or array) on its rising edge. |
| $\overline{RY}/\overline{BY}$ | OPEN DRAIN OUTPUT | READY/BUSY: Indicates status of the internal WSM. When low, it indicates that the WSM is busy performing an operation. $\overline{RB}/\overline{BY}$ high indicates that the WSM is ready for new operations (or WSM has completed all pending operations), or Erase is Suspended, or the device is in deep power-down mode. This output is always active (i.e., not floated to tri-state off when \overline{OE} or $\overline{CE}_0, \overline{CE}_1$ are high), except if a $\overline{RY}/\overline{BY}$ Pin Disable command is issued. |

PIN DESCRIPTION (Continued)

| SYMBOL | TYPE | NAME AND FUNCTION |
|-------------------|--------|---|
| \overline{WP} | INPUT | WRITE PROTECT: Erase blocks can be locked by writing a non-volatile lock-bit for each block. When WP is low, those locked blocks as reflected by the Block-Lock Status bits (BSR.6), are protected from inadvertent Data Writes or Erases. When WP is high, all blocks can be Written or Erased regardless of the state of the lock-bits. The WP input buffer is disabled when \overline{RP} transitions low (deep power-down mode). |
| \overline{BYTE} | INPUT | BYTE ENABLE: \overline{BYTE} low places device in x8 mode. All data is then input or output on DQ ₀ - DQ ₇ , and DQ ₈ - DQ ₁₅ float. Address A ₀ selects between the high and low byte. \overline{BYTE} high places the device in x16 mode, and turns off the A ₀ input buffer. Address A ₁ , then becomes the lowest order address. |
| $\overline{3/5}$ | INPUT | 3.3/5.0 VOLT SELECT: $\overline{3/5}$ high configures internal circuits for 3.3 V operation. $\overline{3/5}$ low configures internal circuits for 5.0 V operation. NOTES: Reading the array with $\overline{3/5}$ high in a 5.0 V system could damage the device. There is a significant delay from $\overline{3/5}$ Switching to valid data. |
| V _{PP} | SUPPLY | ERASE/WRITE POWER SUPPLY: For erasing memory array blocks or writing words/bytes/pages into the flash array. |
| V _{CC} | SUPPLY | DEVICE POWER SUPPLY (3.3 V ±0.3 V, 5.0 V ±0.5 V): Do not leave any power pins floating. |
| GND | SUPPLY | GROUND FOR ALL INTERNAL CIRCUITRY: Do not leave any ground pins floating. |
| NC | | NO CONNECT: No internal connection to die, lead may be driven or left floating. |

INTRODUCTION

Sharp's LH28F016SA 16M Flash Memory is a revolutionary architecture which enables the design of truly mobile, high performance, personal computing and communication products. With innovative capabilities, 5V single voltage operation and very high read/write performance, the LH28F016SA is also the ideal choice for designing embedded mass storage flash memory systems.

The LH28F016SA is a very high density, highest performance non-volatile read/write solution for solid-state storage applications. Its symmetrically blocked architecture (100% compatible with the LH28F008SA 8M Flash memory), extended cycling, low power 3.3 V operation, very fast write and read performance and selective block locking provide a highly flexible memory component suitable for high density memory cards. Resident Flash Arrays and PCMCIA-ATA Flash Drives. The LH28F016SA's dual read voltage enables the design of memory cards which can interchangeably be read/written in 3.3 V and 5.0 V systems. Its x8/x16 architecture allows the optimization of memory to processor interface. The flexible block locking option enables bundling of executable application software in a Resident Flash Array or memory card. Manufactured on Sharp's 0.55 μm ETOX™ process technology, the LH28F016SA is the most cost-effective, high-density 3.3 V flash memory.

DESCRIPTION

The LH28F016SA is a high performance 16M (16,777,216 bit) block erasable non-volatile random access memory organized as either 1M × 16 or 2M × 8. The LH28F016SA includes thirty-two 64K (65,536) blocks or thirty-two 32-KW (32,768) blocks. A chip memory map is shown in Figure 3.

The implementation of a new architecture, with many enhanced features, will improve the device operating characteristics and results in greater product reliability and ease of use.

Among the significant enhancements of the LH28F016SA:

- 3.3 V Low Power Capability
- Improved Write Performance
- Dedicated Block Write/Erase Protection

A $\overline{3/5}$ input pin reconfigures the device internally for optimized 3.3 V or 5.0 V read/write operation.

The LH28F016SA will be available in a 56-pin, 1.2 mm thick × 14 mm × 20 mm TSOP (Type I) package. This form factor and pinout allow for very high board layout densities.

A Command User Interface (CUI) serves as the system interface between the microprocessor or microcontroller and the internal memory operation.

Internal Algorithm Automation allows Byte/Word Writes and Block Erase operations to be executed using a Two-Write command sequence to the CUI in the same way as the LH28F008SA 8M Flash memory.

A Superset of commands have been added to the basic LH28F008SA command-set to achieve higher write performance and provide additional capabilities. These new commands and features include:

- Page Buffer Writes to Flash
- Command Queuing Capability
- Automatic Data Writes During Erase
- Software Locking of Memory Blocks
- Two-Byte Successive Writes in 8-bit Systems
- Erase All Unlocked Blocks

Writing of memory data is performed in either byte or word increments typically within 6 μ s, a 33% improvement over the LH28F008SA. A Block Erase operation erases one of the 32 blocks in typically 0.6 seconds, independent of the other blocks, which is about 65% improvement over the LH28F008SA.

The LH28F016SA incorporates two Page Buffers of 256 Bytes (128 Words) each to allow page data writes. This feature can improve a system write performance over previous flash memory devices.

All operations are started by a sequence of Write commands to the device. Three Status Registers (described in detail later) and a $\overline{\text{RY}}/\overline{\text{BY}}$ output pin provide information on the progress of the requested operation.

While the LH28F008SA requires an operation to complete before the next operation can be requested, the LH28F016SA allows queuing of the next operation while the memory executes the current operation. This eliminates system overhead when writing several bytes in a row to the array or erasing several blocks at the same time. The LH28F016SA can also perform write operations to one block of memory while performing erase of another block.

The LH28F016SA provides user-selectable block locking to protect code or data such as Device Drivers, PCMCIA card information, ROM-Executable O/S or Application Code. Each block has an associated non-volatile lock-bit which determines the lock status of the block. In addition, the LH28F016SA has a master Write Protect pin ($\overline{\text{WP}}$) which prevents any modifications to memory blocks whose lock-bits are set.

The LH28F016SA contains three types of Status Registers to accomplish various functions:

- A Compatible Status Register (CSR) which is 100% compatible with the LH28F008SA Flash memory's Status Register. This register, when used alone, provides a straightforward upgrade capability to the LH28F016SA from a LH28F008SA-based design.
- A Global Status Register (GSR) which informs the system of command Queue status, Page Buffer status, and overall Write State Machine (WSM) status.
- 32 Block Status Registers (BSRs) which provide block-specific status information such as the block lock-bit status.

The GSR and BSR memory maps for Byte-Wide and Word-Wide modes are shown in Figures 4 and 5.

The LH28F016SA incorporates an open drain $\overline{\text{RY}}/\overline{\text{BY}}$ output pin. This feature allows the user to OR-tie many $\overline{\text{RY}}/\overline{\text{BY}}$ pins together in a multiple memory configuration such as a Resident Flash Array.

The LH28F016SA also incorporates a dual chip-enable function with two input pins, $\overline{\text{CE}}_0$ and $\overline{\text{CE}}_1$. These pins have exactly the same functionality as the regular chip-enable pin $\overline{\text{CE}}$ on the LH28F008SA. For minimum chip designs, $\overline{\text{CE}}_1$ may be tied to ground and use $\overline{\text{CE}}_0$ as the chip enable input. The LH28F016SA uses the logical combination of these two signals to enable or disable the entire chip. Both $\overline{\text{CE}}_0$ and $\overline{\text{CE}}_1$ must be active low to enable the device and if either one becomes inactive, the chip will be disabled. This feature, along with the open drain $\overline{\text{RY}}/\overline{\text{BY}}$ pin, allows the system designer to reduce the number of control pins used in a large array of 16M devices.

The $\overline{\text{BYTE}}$ pin allows either x8 or x16 read/writes to the LH28F016SA. $\overline{\text{BYTE}}$ at logic low selects 8-bit mode with address A_0 selecting between low byte and high byte. On the other hand, $\overline{\text{BYTE}}$ at logic high enables 16-bit operation with address A_1 becoming the lowest order address and address A_0 is not used (don't care). A block diagram is shown in Figure 2.

The LH28F016SA is specified for a maximum access time of each version, as follows:

| OPERATING TEMPERATURE | V _{CC} SUPPLY | MAX. ACCESS (T _{ACC}) |
|-----------------------|------------------------|---------------------------------|
| 0 - 70°C | 4.75 - 5.25 V | 70 ns |
| 0 - 70°C | 4.5 - 5.5 V | 80 ns |
| 0 - 70°C | 3.0 - 3.6 V | 120 ns |

The LH28F016SA incorporates an Automatic Power Saving (APS) feature which substantially reduces the active current when the device is in static mode of operation (addresses not switching).

In APS mode, the typical I_{CC} current is 2 mA at 5.0 V (1 mA at 3.3 V).

A Deep Power-Down mode of operation is invoked when the \overline{RP} (called \overline{PWD} on the LH28F008SA) pin transitions low. This mode brings the device power consumption to less than 5 μ A, typically, and provides additional write protection by acting as a device reset pin during power transitions. A reset time of 400 ns ($V_{CC} = 5.0 \text{ V} \pm 0.25 \text{ V}$ system) is required from \overline{RP} switching high until outputs are again valid. In the Deep Power-Down state, the WSM is reset (any current operation will abort) and the CSR, GSR and BSR registers are cleared.

A CMOS Standby mode of operation is enabled when either \overline{CE}_0 or \overline{CE}_1 transitions high and \overline{RP} stays high with all input control pins at CMOS levels. In this mode, the device typically draws an I_{CC} standby current of 10 μ A.

MEMORY MAP

| | | |
|-----------|------------|----|
| 1FFFFFFH | 64KB BLOCK | 31 |
| 1F0000H | 64KB BLOCK | 30 |
| 1EFFFFFFH | 64KB BLOCK | 29 |
| 1E0000H | 64KB BLOCK | 28 |
| 1DFFFFFFH | 64KB BLOCK | 27 |
| 1D0000H | 64KB BLOCK | 26 |
| 1CFFFFFFH | 64KB BLOCK | 25 |
| 1C0000H | 64KB BLOCK | 24 |
| 1BFFFFFFH | 64KB BLOCK | 23 |
| 1B0000H | 64KB BLOCK | 22 |
| 1AFFFFFFH | 64KB BLOCK | 21 |
| 1A0000H | 64KB BLOCK | 20 |
| 19FFFFFFH | 64KB BLOCK | 19 |
| 190000H | 64KB BLOCK | 18 |
| 18FFFFFFH | 64KB BLOCK | 17 |
| 180000H | 64KB BLOCK | 16 |
| 17FFFFFFH | 64KB BLOCK | 15 |
| 170000H | 64KB BLOCK | 14 |
| 16FFFFFFH | 64KB BLOCK | 13 |
| 160000H | 64KB BLOCK | 12 |
| 15FFFFFFH | 64KB BLOCK | 11 |
| 150000H | 64KB BLOCK | 10 |
| 14FFFFFFH | 64KB BLOCK | 9 |
| 140000H | 64KB BLOCK | 8 |
| 13FFFFFFH | 64KB BLOCK | 7 |
| 130000H | 64KB BLOCK | 6 |
| 12FFFFFFH | 64KB BLOCK | 5 |
| 120000H | 64KB BLOCK | 4 |
| 11FFFFFFH | 64KB BLOCK | 3 |
| 110000H | 64KB BLOCK | 2 |
| 10FFFFFFH | 64KB BLOCK | 1 |
| 100000H | 64KB BLOCK | 0 |
| 0FFFFFFH | 64KB BLOCK | |
| 0F0000H | 64KB BLOCK | 15 |
| 0EFFFFFFH | 64KB BLOCK | 14 |
| 0E0000H | 64KB BLOCK | 13 |
| 0DFFFFFFH | 64KB BLOCK | 12 |
| 0D0000H | 64KB BLOCK | 11 |
| 0CFFFFFFH | 64KB BLOCK | 10 |
| 0C0000H | 64KB BLOCK | 9 |
| 0BFFFFFFH | 64KB BLOCK | 8 |
| 0B0000H | 64KB BLOCK | 7 |
| 0AFFFFFFH | 64KB BLOCK | 6 |
| 0A0000H | 64KB BLOCK | 5 |
| 09FFFFFFH | 64KB BLOCK | 4 |
| 090000H | 64KB BLOCK | 3 |
| 08FFFFFFH | 64KB BLOCK | 2 |
| 080000H | 64KB BLOCK | 1 |
| 07FFFFFFH | 64KB BLOCK | 0 |
| 070000H | 64KB BLOCK | |
| 06FFFFFFH | 64KB BLOCK | 6 |
| 060000H | 64KB BLOCK | 5 |
| 05FFFFFFH | 64KB BLOCK | 4 |
| 050000H | 64KB BLOCK | 3 |
| 04FFFFFFH | 64KB BLOCK | 2 |
| 040000H | 64KB BLOCK | 1 |
| 03FFFFFFH | 64KB BLOCK | 0 |
| 030000H | 64KB BLOCK | |
| 02FFFFFFH | 64KB BLOCK | 2 |
| 020000H | 64KB BLOCK | 1 |
| 01FFFFFFH | 64KB BLOCK | 0 |
| 010000H | 64KB BLOCK | |
| 00FFFFFFH | 64KB BLOCK | 0 |
| 000000H | 64KB BLOCK | 0 |

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Figure 3. LH28F016SA Memory Map (Byte-Wide Mode)

Extended Status Registers Memory Map

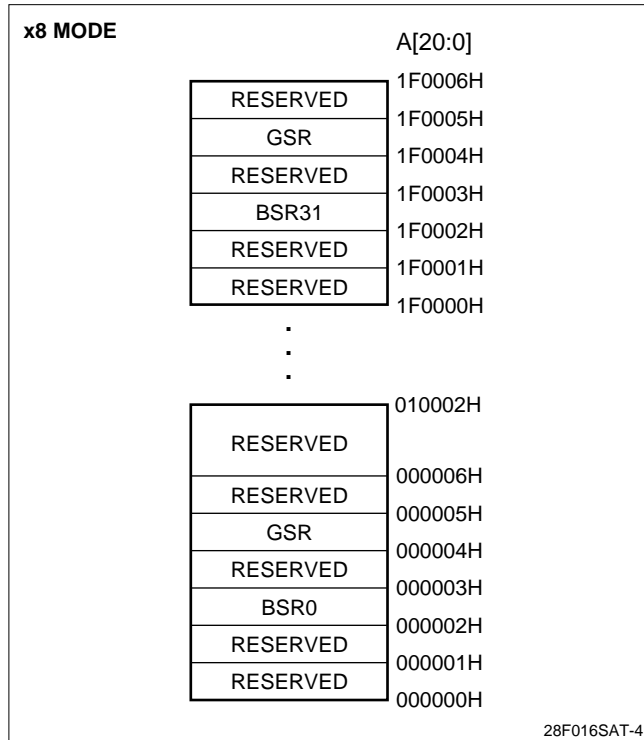


Figure 4. Extended Status Register Memory Map (Byte-Wide Mode)

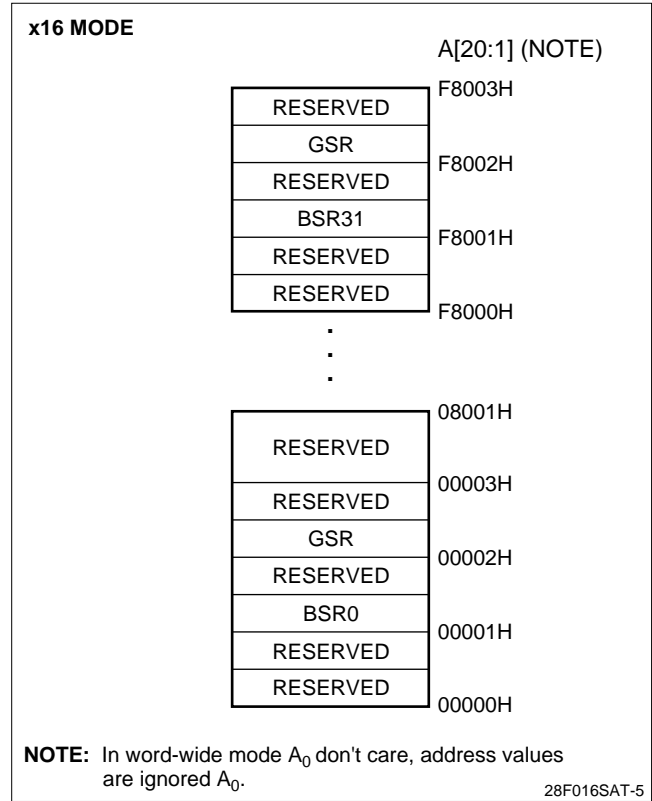


Figure 5. Extended Status Register Memory Map (Word-Wide Mode)

BUS OPERATIONS, COMMANDS AND STATUS REGISTER DEFINITIONS

Bus Operations for Word-Wide Mode ($\overline{\text{BYTE}} = V_{\text{IH}}$)

| MODE | $\overline{\text{RP}}$ | $\overline{\text{CE}}_1$ | $\overline{\text{CE}}_0$ | $\overline{\text{OE}}$ | $\overline{\text{WE}}$ | A_1 | $\text{DQ}_0 - \text{DQ}_{15}$ | $\overline{\text{RY}}/\overline{\text{BY}}$ | NOTE |
|-----------------|------------------------|---|---|------------------------|------------------------|-----------------|--------------------------------|---|---------|
| Read | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | X | D_{OUT} | X | 1, 2, 7 |
| Output Disable | V_{IH} | V_{IL} | V_{IL} | V_{IH} | V_{IH} | X | High-Z | X | 1, 6, 7 |
| Standby | V_{IH} | V_{IL} V_{IH} V_{IH} | V_{IH} V_{IL} V_{IH} | X | X | X | High-Z | X | 1, 6, 7 |
| Deep Power-Down | V_{IL} | X | X | X | X | X | High-Z | V_{OH} | 1, 3 |
| Manufacturer ID | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | V_{IL} | 0089H | V_{OH} | 4 |
| Device ID | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | V_{IH} | 66A0H | V_{OH} | 4 |
| Write | V_{IH} | V_{IL} | V_{IL} | V_{IH} | V_{IL} | X | D_{IN} | X | 1, 5, 6 |

Bus Operations For Byte-Wide Mode ($\overline{\text{BYTE}} = V_{\text{IL}}$)

| MODE | $\overline{\text{RP}}$ | $\overline{\text{CE}}_1$ | $\overline{\text{CE}}_0$ | $\overline{\text{OE}}$ | $\overline{\text{WE}}$ | A_0 | $\text{DQ}_0 - \text{DQ}_7$ | $\overline{\text{RY}}/\overline{\text{BY}}$ | NOTE |
|-----------------|------------------------|---|---|------------------------|------------------------|-----------------|-----------------------------|---|---------|
| Read | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | X | D_{OUT} | X | 1, 2, 7 |
| Output Disable | V_{IH} | V_{IL} | V_{IL} | V_{IH} | V_{IH} | X | High-Z | X | 1, 6, 7 |
| Standby | V_{IH} | V_{IL} V_{IH} V_{IH} | V_{IH} V_{IL} V_{IH} | X | X | X | High-Z | X | 1, 6, 7 |
| Deep Power-Down | V_{IL} | X | X | X | X | X | High-Z | V_{OH} | 1, 3 |
| Manufacturer ID | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | V_{IL} | 89H | V_{OH} | 4 |
| Device ID | V_{IH} | V_{IL} | V_{IL} | V_{IL} | V_{IH} | V_{IH} | A0H | V_{OH} | 4 |
| Write | V_{IH} | V_{IL} | V_{IL} | V_{IH} | V_{IL} | X | D_{IN} | X | 1, 5, 6 |

NOTES:

- X can be V_{IH} or V_{IL} for address or control pins except for $\overline{\text{RY}}/\overline{\text{BY}}$, which is either V_{OL} or V_{OH} .
- $\overline{\text{RY}}/\overline{\text{BY}}$ output is open drain. When the WSM is ready, Erase is suspended or the device is in deep power-down mode, $\overline{\text{RY}}/\overline{\text{BY}}$ will be at V_{OH} if it is tied to V_{CC} through a resistor. When the $\overline{\text{RY}}/\overline{\text{BY}}$ at V_{OH} is independent of $\overline{\text{OE}}$ while a WSM operation is in progress.
- $\overline{\text{RP}}$ at $\text{GND} \pm 0.2 \text{ V}$ ensures the lowest deep power-down current.
- A_0 and A_1 at V_{IL} provide manufacturer ID codes in x8 and x16 modes respectively. A_0 and A_1 , at V_{IH} provide device ID codes in x8 and x16 modes respectively. All other addresses are set to zero.
- Commands for different Erase operations, Data Write operations of Lock-Block operations can only be successfully completed when $V_{\text{PP}} = V_{\text{PPH}}$.
- While the WSM is running, $\overline{\text{RY}}/\overline{\text{BY}}$ in Level-Mode (default) stays at V_{OL} until all operations are complete. $\overline{\text{RY}}/\overline{\text{BY}}$ goes to V_{OH} when the WSM is not busy or in erase suspend mode.
- $\overline{\text{RY}}/\overline{\text{BY}}$ may be at V_{OL} while the WSM is busy performing various operations. For example, a status register read during a write operation.

LH28F008SA-Compatible Mode Command Bus Definitions

| COMMAND | FIRST BUS CYCLE | | | SECOND BUS CYCLE | | | NOTE |
|---------------------------------|-----------------|---------|------|------------------|---------|-------|------|
| | OPER. | ADDRESS | DATA | OPER. | ADDRESS | DATA | |
| Read Array | Write | X | FFH | Read | AA | AD | |
| Intelligent Identifier | Write | X | 90H | Read | IA | ID | 1 |
| Read Compatible Status Register | Write | X | 70H | Read | X | CSR.D | 2 |
| Clear Status Register | Write | X | 50H | | | | 3 |
| Word/Byte Write | Write | X | 40H | Write | WA | WD | |
| Alternate Word/Byte Write | Write | X | 10H | Write | WA | WD | |
| Block Erase/Confirm | Write | X | 20H | Write | BA | D0H | 4 |
| Erase Suspend/Resume | Write | X | B0H | Write | X | D0H | 4 |

ADDRESS

AA = Array Address
 BA = Block Address
 IA = Identifier Address
 WA = Write Address
 X = Don't Care

DATA

AD = Array Data
 CSR.D = CSR Data
 ID = Identifier Data
 WD = Write Data

NOTES:

- Following the intelligent identifier command, two Read operations access the manufacturer and device signature codes.
- The CSR is automatically available after device enters Data Write, Erase or Suspend operations.
- Clears CSR.3, CSR.4, and CSR.5. Also clears GSR.5 and all BSR.5 and BSR.2 bits. See Status register definitions.
- While device performs Block Erase, if you issue Erase Suspend command (B0H), be sure to confirm ESS (Erase-Suspend-Status) is set to 1 on compatible status register. In the case, ESS bit was not set to 1, also completed the Erase (ESS = 0, WASM = 1), be sure to issue Resume command (D0H) after completed next Erase command. Beside, when the Erase Suspend command is issued, while the device is not in Erase, be sure to issue Resume command (D0H) after the next erase completed. When you use Erase Suspend/Resume command, we recommend to issue serial Block Erase command (20H, D0H) and Resume command (D0H). (Refer to Performance Enhancement Command Bus Definitions.)

LH28F016SA Performance Enhancement Command Bus Definitions

| COMMAND | MODE | FIRST BUS CYCLE | | | SECOND BUS CYCLE | | | THIRD BUS CYCLE | | | NOTE |
|--|------|-----------------|-------|------|------------------|-------|--------------|-----------------|-------|-----------|-------------|
| | | OPER. | ADDR. | DATA | OPER. | ADDR. | DATA | OPER. | ADDR. | DATA | |
| Read Extended Status Register | | Write | X | 71H | Read | RA | GSRD BSRD | | | | 1 |
| Page Buffer Swap | | Write | X | 72H | | | | | | | 7 |
| Read Page Buffer | | Write | X | 75H | Read | PA | PD | | | | |
| Single Load to Page Buffer | | Write | X | 74H | Write | PA | PD | | | | |
| Sequential Load to Page Buffer | x8 | Write | X | E0H | Write | X | BCL | Write | X | BCH | 4, 6, 10 |
| | x16 | Write | X | E0H | Write | X | WCL | Write | X | WCH | 4, 5, 6, 10 |
| Page Buffer Write to Flash | x8 | Write | X | 0CH | Write | A0 | BC (L, H) | Write | WA | BC (H, L) | 3, 4, 9, 10 |
| | x16 | Write | X | 0CH | Write | X | WCL | Write | WA | WCH | 4, 5, 10 |
| Two-Byte Write | x8 | Write | X | FBH | Write | A0 | WD (L, H) | Write | WA | WD (H, L) | 3 |
| Block Erase/Confirm | | Write | X | 20H | Write | BA | D0H | Write | X | D0H | 11 |
| Lock Block/Confirm | | Write | X | 77H | Write | BA | D0H | | | | |
| Upload Status Bits/Confirm | | Write | X | 97H | Write | X | D0H | | | | 2 |
| Upload Device Information | | Write | X | 99H | Write | X | D0H | | | | |
| Erase All Unlocked Blocks/Confirm | | Write | X | A7H | Write | X | D0H | Write | X | D0H | 11 |
| $\overline{RY}/\overline{BY}$ Enable to Level-Mode | | Write | X | 96H | Write | X | 01H | | | | 8 |
| $\overline{RY}/\overline{BY}$ Pulse-On-Write | | Write | X | 96H | Write | X | 02H | | | | 8 |
| $\overline{RY}/\overline{BY}$ Pulse-On-Erase | | Write | X | 96H | Write | X | 03H | | | | 8 |
| $\overline{RY}/\overline{BY}$ Disable | | Write | X | 96H | Write | X | 04H | | | | 8 |
| Sleep | | Write | X | F0H | | | | | | | |
| Abort | | Write | X | 80H | | | | | | | |

ADDRESS

BA = Block Address
PA = Page Buffer Address
RA = Extended Register Address
WA = Write Address
X = Don't Care

DATA

AD = Array Data
PD = Page Buffer Data
BSRD = BSR Data
GSRD = GSR Data
WC (L, H) = Word Count (Low, High)
BC (L, H) = Byte Count (Low, High)
WD (L, H) = Write Data (Low, High)

NOTES:

1. RA can be the GSR address or any BSR address. See Figure 4 and 5 for Extended Status Register Memory Maps.
2. Upon device power-up, all BSR lock-bits come up locked. The Uploaded Status Bits command must be written to reflect the actual lock-bit status.
3. A_0 is automatically complemented to load second byte of data. \overline{BYTE} must be at V_{IL} . A_0 value determines which WD/BC is supplied first: $A_0 = 0$ looks at the WDL/BCL, $A_0 = 1$ looks at the WDH/BCH.
4. BCH/WCH must be at 00H for this product because of the 256-Byte (128 Word) Page Buffer size and to avoid writing the Page Buffer contents into more than one 256-Byte segment within an array block. They are simply shown for future Page Buffer expandability.
5. In x16 mode, only the lower byte $DQ_0 - DQ_7$ is used for WCL and WCH. The upper byte $DQ_8 - DQ_{15}$ is a don't care.
6. PA and PD (Whose count is given in cycles 2 and 3) are supplied starting in the 4th cycle which is not shown.
7. This command allows the user to swap between available Page Buffers (0 or 1).
8. These commands reconfigure $\overline{RY}/\overline{BY}$ output to one of two pulse-modes or enable and disable the $\overline{RY}/\overline{BY}$ function.
9. Write address, WA, is the Destination address in the flash array which must match the Source address in the Page Buffer. Refer to the LH28F016SU User's Manual.
10. BCL = 00H corresponds to a Byte count of 1. Similarly, WCL = 00H corresponds to a Word count of 1.
11. Unless you issue erase suspend command, it is not necessary to input DOH on third bus cycle.

Compatible Status Register

| WSMS | ESS | ES | DWS | VPPS | R | R | R |
|------|-----|----|-----|------|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

CSR.7 = WRITE STATE MACHINE STATUS (WSMS)
 1 = Ready
 0 = Busy

CSR.6 = ERASE-SUSPEND STATUS (ESS)
 1 = Erase Suspended
 0 = Erase in Progress/Completed

CSR.5 = ERASE STATUS (ES)
 1 = Error in Block Erasure
 0 = Successful Block Erase

CSR.4 = DATA-WRITE STATUS (DWS)
 1 = Error in Data Write
 0 = Data Write Successful

CSR.3 = V_{PP} STATUS (VPPS)
 1 = V_{PP} Low Detect, Operation Abort
 0 = V_{PP} OK

NOTES:

1. $\overline{RY}/\overline{BY}$ output or WSMS bit must be checked to determine completion of an operation (Erase Suspend, Erase or Data Write) before the appropriate Status bit (ESS, ES or DWS) is checked for success.
2. If DWS and ES are set to '1' during an erase attempt, an improper command sequence was entered. Clear the CSR and attempt the operation again.
3. The VPPS bit, unlike an A/D converter, does not provide continuous indication of V_{PP} level. The WSM interrogates V_{PP} 's level only after the Data-Write or Erase command sequences have been entered, and informs the system if V_{PP} has not been switched on. VPPS is not guaranteed to report accurate feedback between V_{PPL} and V_{PPH} .
4. CSR.2 - CSR.0 = Reserved for future enhancements. These bits are reserved for future use and should be masked out when polling the CSR.

GLOBAL STATUS REGISTER

| WSMS | OSS | DOS | DSS | QS | PBAS | PBS | PBSS |
|------|-----|-----|-----|----|------|-----|------|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

GSR.7 = WRITE STATE MACHINE STATUS (WSMS)

- 1 = Ready
- 0 = Busy

GSR.6 = OPERATION SUSPEND STATUS (OSS)

- 1 = Operation Suspended
- 0 = Operation in Progress/Completed

GSR.5 = DEVICE OPERATION STATUS (DOS)

- 1 = Operation Unsuccessful
- 0 = Operation Successful or Currently Running

GSR.4 = DEVICE SLEEP STATUS(DSS)

- 1 = Device in Sleep
- 0 = Device Not in Sleep

MATRIX 5/4

- 00 = Operation Successful or currently Running
- 01 = Device in Sleep Mode or Pending Sleep
- 10 = Operation Unsuccessful
- 11 = Operation Unsuccessful or Aborted

GSR.3 = QUEUE STATUS (QS)

- 1 = Queue Full
- 0 = Queue Available

GSR.2 = PAGE BUFFER AVAILABLE STATUS (PBAS)

- 1 = One or Two Page Buffers Available
- 0 = No Page Buffer Available

GSR.1 = PAGE BUFFER STATUS (PBS)

- 1 = Selected Page Buffer Ready
- 0 = Selected Page Buffer Busy

GSR.0 = PAGE BUFFER SELECT STATUS (PBSS)

- 1 = Page Buffer 1 Selected
- 0 = Page buffer 0 Selected

NOTES:

1. $\overline{RY}/\overline{BY}$ output or WSMS bit must be checked to determine completion of an operation (Block Lock, Suspend, any $\overline{RY}/\overline{BY}$ reconfiguration, Upload Status Bits, Erase or Data Write) before the appropriate Status bit (OSS or DOS) is checked for success.
2. If operation currently running, then GSR.7 = 0.
3. If device pending sleep, then GSR.7 = 0.
4. Operation aborted: Unsuccessful due to Abort command.
5. The device contains two Page Buffers.
6. Selected Page Buffer is currently busy with WSM operation.
7. When multiple operations are queued, checking BSR.7 only provides indication of completion for that particular block. GSR.7 provides indication when all queued operations are completed.

BLOCK STATUS REGISTER

| BS | BLS | BOS | BOAS | QS | VPPS | R | R |
|----|-----|-----|------|----|------|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

BSR.7 = BLOCK STATUS (BS)
 1 = Ready
 0 = Busy

BSR.6 = BLOCK-LOCK STATUS (BLS)
 1 = Block Unlocked for Write/Erase
 0 = Block Locked for Write/Erase

BSR.5 = BLOCK OPERATION STATUS (BOS)
 1 = Operation Unsuccessful
 0 = Operation Successful or Currently Running

BSR.4 = BLOCK OPERATION ABORT STATUS (BOAS)
 1 = Operation Aborted
 0 = Operation Not Aborted

MATRIX 5/4
 00 = Operation Successful or Currently Running
 01 = Not a valid Combination
 10 = Operation Unsuccessful
 11 = Operation Aborted

BSR.3 = QUEUE STATUS (QS)
 1 = Queue Full
 0 = Queue Available

BSR.2 = V_{PP} STATUS (V_{PPS})
 1 = V_{PP} Low Detect, Operation Abort
 0 = V_{PP} OK

NOTES:

1. $\overline{RY}/\overline{BY}$ output or BS bit must be checked to determine completion of an operation (Block Lock, Suspend, Erase or Data Write) before the appropriate Status bits (BOS, BLS) is checked for success.
2. The BOAS bit will not be set until BSR.7 = 1.
3. Operation halted via Abort command.
4. BSR.1-0 = RESERVED FOR FUTURE ENHANCEMENTS
 These bits are reserved for future use; mask them out when polling the BSRs.
5. When multiple operations are queued, checking BSR.7 only provides indication of completion for that particular block. GSR.7 provides indication when all queued operations are completed.

ELECTRICAL SPECIFICATIONS**Absolute Maximum Ratings***

Temperature under bias 0°C to +80°C

Storage temperature -65°C to +125°C

**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.*

V_{CC} = 3.3 V ± 0.3 V Systems⁴

| SYMBOL | PARAMETER | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------------|--|------|-----------------------|-------|---------------------|------|
| T _A | Operating Temperature, Commercial | 0 | 70 | °C | Ambient Temperature | 1 |
| V _{CC} | V _{CC} with Respect to GND | -0.2 | 7.0 | V | | 2 |
| V _{PP} | V _{PP} Supply Voltage with Respect to GND | -0.2 | 14.0 | V | | 2 |
| V | Voltage on any Pin (Except V _{CC} , V _{PP}) with Respect to GND | -0.5 | V _{CC} + 0.5 | V | | 2 |
| I | Current into any Non-Supply Pin | | ±30 | mA | | |
| I _{OUT} | Output Short Circuit Current | | 100 | mA | | 3 |

V_{CC} = 5.0 V ± 0.5 V Systems⁴

| SYMBOL | PARAMETER | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------------|--|------|------|-------|---------------------|------|
| T _A | Operating Temperature, Commercial | 0 | 70 | °C | Ambient Temperature | 1 |
| V _{CC} | V _{CC} with Respect to GND | -0.2 | 7.0 | V | | 2 |
| V _{PP} | V _{PP} Supply Voltage with Respect to GND | -0.2 | 14.0 | V | | 2 |
| V | Voltage on any Pin (Except V _{CC} , V _{PP}) with Respect to GND | -0.5 | 7.0 | V | | 2 |
| I | Current into any Non-Supply Pin | | ±30 | mA | | |
| I _{OUT} | Output Short Circuit Current | | 100 | mA | | 3 |

NOTES:

- Operating temperature is for commercial product defined by this specification.
- Minimum DC voltage is -0.5 V on input/output pins. During transitions, this level may undershoot to -2.0 V for periods < 20 ns. Maximum DC voltage on input/output pins 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.
- AC specifications are valid at both voltage ranges. See DC Characteristics tables for voltage range-specific specifications.

Capacitance

For 3.3 V Systems

| SYMBOL | PARAMETER | TYP. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------|--|------|------|-------|---|------|
| C_{IN} | Capacitance Looking into an Address/Control Pin | 6 | 8 | pF | $T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$ | 1 |
| C_{OUT} | Capacitance Looking into an Output Pin | 8 | 12 | pF | $T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$ | 1 |
| C_{LOAD} | Load Capacitance Driven by Outputs for Timing Specifications | | 50 | pF | For $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ | 1 |
| | Equivalent Testing Load Circuit | | 2.5 | ns | 50 Ω transmission line delay | |

For 5.0 V Systems

| SYMBOL | PARAMETER | TYP. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------|--|------|------|-------|---|------|
| C_{IN} | Capacitance Looking into an Address/Control Pin | 6 | 8 | pF | $T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$ | 1 |
| C_{OUT} | Capacitance Looking into an Output Pin | 8 | 12 | pF | $T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$ | 1 |
| C_{LOAD} | Load Capacitance Driven by Outputs for Timing Specifications | | 100 | pF | For $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$ | 1 |
| | | | 30 | pF | For $V_{CC} = 5.0\text{ V} \pm 0.25\text{ V}$ | |
| | Equivalent Testing Load Circuit $V_{CC} \pm 10\%$ | | 2.5 | ns | 25 Ω transmission line delay | |
| | Equivalent Testing Load Circuit $V_{CC} \pm 5\%$ | | 2.5 | ns | 83 Ω transmission line delay | |

NOTE:

1. Sampled, not 100% tested.

Timing Nomenclature

For 3.3V systems timings are measured from where signals cross 1.5V. For 5.0V systems use the standard JEDEC crosspoint definitions. Each timing parameter consists of 5 characters. Some common examples are defined below:

t_{CE} t_{ELQV} time (t) from \overline{CE} (E) going low (L) to the outputs (Q) becoming valid (V)
 t_{OE} t_{GLQV} time (t) from \overline{OE} (G) going low (L) to the outputs (Q) becoming valid (V)
 t_{ACC} t_{AVQV} time (t) from address (A) valid (V) to the outputs (Q) becoming valid (V)
 t_{AS} t_{AVWH} time (t) from address (A) valid (V) to \overline{WE} (W) going high (H)
 t_{DH} t_{WHDX} time (t) from \overline{WE} (W) going high (H) to when the data (D) can become undefined (X)

| | PIN CHARACTERS | | PIN STATES |
|-----|--|---|-----------------------------------|
| A | Address Inputs | H | High |
| D | Data Inputs | L | Low |
| Q | Data Outputs | V | Valid |
| E | \overline{CE} (Chip Enable) | X | Driven, but not necessarily valid |
| G | \overline{OE} (Output Enable) | Z | High Impedance |
| W | \overline{WE} (Write Enable) | | |
| P | \overline{RP} (Deep Power-Down Pin) | | |
| R | $\overline{RY}/\overline{BY}$ (Ready/Busy) | | |
| V | Any Voltage Level | | |
| Y | $\overline{3/5}$ Pin | | |
| 5 V | V_{CC} at 4.5 V Min. | | |
| 3 V | V_{CC} at 3.0 V Min. | | |

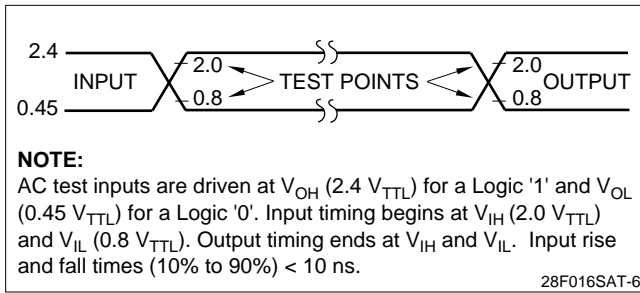


Figure 6. Transient Input/Output Reference Waveform ($V_{CC} = 5.0$ V)

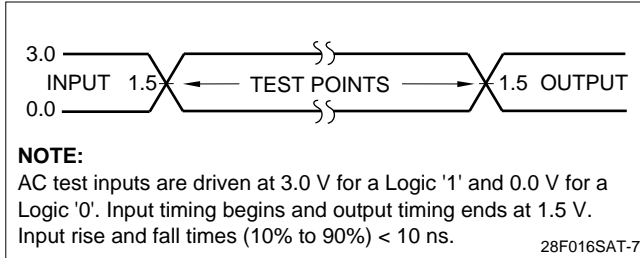


Figure 7. Transient Input/Output Reference Waveform ($V_{CC} = 3.3$ V)

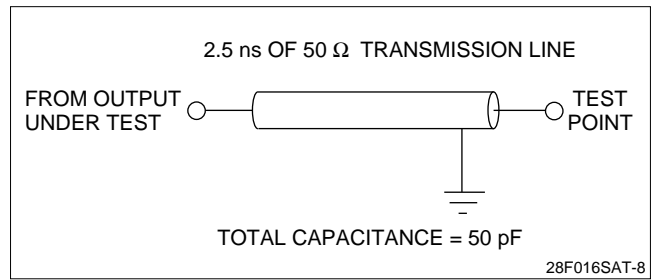


Figure 8. Transient Equivalent Testing Load Circuit ($V_{CC} = 3.3$ V)

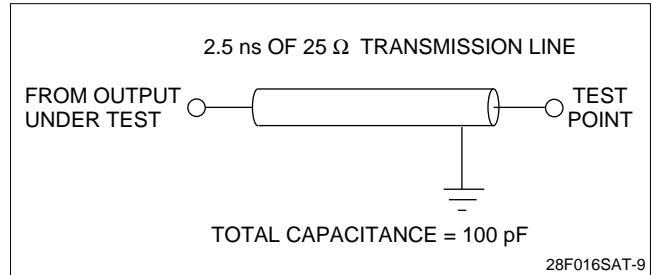


Figure 9. Transient Equivalent Testing Load Circuit ($V_{CC} = 5.0$ V)

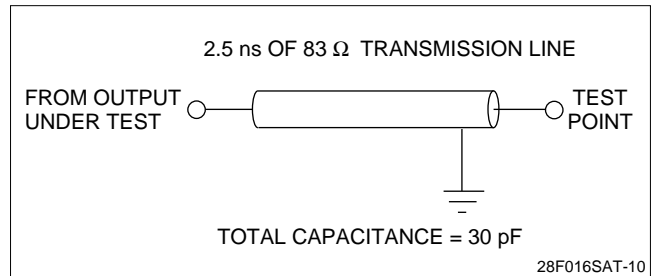


Figure 10. High Speed Transient Equivalent Testing Load Circuit ($V_{CC} = 5.0$ V $\pm 5\%$)

DC Characteristics

$$V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}, T_A = 0^\circ\text{C to } +70^\circ\text{C}$$

$$\overline{3/5} = \text{Pin Set High for 3.3 V Operations}$$

| SYMBOL | PARAMETER | TYP. | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|-------------|----------------------------------|------|------|------|-------|--|---------|
| I_{IL} | Input Load Current | | | ±1 | μA | $V_{CC} = V_{CC} \text{ MAX.}, V_{IN} = V_{CC} \text{ or GND}$ | 1 |
| I_{LO} | Output Leakage Current | | | ±10 | μA | $V_{CC} = V_{CC} \text{ MAX.}, V_{IN} = V_{CC} \text{ or GND}$ | 1 |
| I_{CCS} | V_{CC} Standby Current | 50 | | 100 | μA | $V_{CC} = V_{CC} \text{ MAX.},$ $\overline{CE}_0, \overline{CE}_1, \overline{RP} = V_{CC} \pm 0.2 \text{ V}$ $\overline{BYTE}, \overline{WP}, \overline{3/5} = V_{CC} \pm 0.2 \text{ V or GND}$ $\pm 0.2 \text{ V}$ | 1, 4 |
| | | 1 | | 4 | mA | $V_{CC} = V_{CC} \text{ MAX.},$ $\overline{CE}_0, \overline{CE}_1, \overline{RP} = V_{IH}$ $\overline{BYTE}, \overline{WP}, \overline{3/5} = V_{IH} \text{ or } V_{IL}$ | |
| I_{CCD} | V_{CC} Deep Power-Down Current | 1 | | 5 | μA | $\overline{RP} = \text{GND} \pm 0.2 \text{ V}$ | 1 |
| I_{CCR}^1 | V_{CC} Read Current | 30 | | 35 | mA | $V_{CC} = V_{CC} \text{ MAX.},$ CMOS: $\overline{CE}_0, \overline{CE}_1 = \text{GND} \pm 0.2 \text{ V}$ $\overline{BYTE} = \text{GND} \pm 0.2 \text{ V or } V_{CC} \pm 0.2 \text{ V}$ Inputs = $\text{GND} \pm 0.2 \text{ V or } V_{CC} \pm 0.2 \text{ V}$ TTL: $\overline{CE}_0, \overline{CE}_1 = V_{IL},$ $\overline{BYTE} = V_{IL} \text{ or } V_{IH}$ Inputs = $V_{IL} \text{ or } V_{IH}$ $f = 8 \text{ MHz}, I_{OUT} = 0 \text{ mA}$ | 1, 3, 4 |
| I_{CCR}^2 | V_{CC} Read Current | 15 | | 20 | mA | $V_{CC} = V_{CC} \text{ MAX.},$ CMOS: $\overline{CE}_0, \overline{CE}_1 = \text{GND} \pm 0.2 \text{ V}$ $\overline{BYTE} = V_{CC} \pm 0.2 \text{ V or GND} \pm 0.2 \text{ V}$ Inputs = $\text{GND} \pm 0.2 \text{ V or } V_{CC} \pm 0.2 \text{ V}$ TTL: $\overline{CE}_0, \overline{CE}_1 = V_{IL},$ $\overline{BYTE} = V_{IH} \text{ or } V_{IL}$ Inputs = $V_{IL} \text{ or } V_{IH}$ $f = 4 \text{ MHz}, I_{OUT} = 0 \text{ mA}$ | 1, 3, 4 |
| I_{CCW} | V_{CC} Write Current | 8 | | 12 | mA | Word/Byte Write in Progress | 1 |
| I_{CCE} | V_{CC} Block Erase Current | 6 | | 12 | mA | Block Erase in Progress | 1 |
| I_{CCES} | V_{CC} Erase Suspend Current | 3 | | 6 | mA | $\overline{CE}_0, \overline{CE}_1 = V_{IH}$ Block Erase Suspended | 1, 2 |
| I_{PPS} | V_{PP} Standby Current | ±1 | | ±10 | μA | $V_{PP} \leq V_{CC}$ | 1 |
| I_{PPD} | V_{PP} Deep Power-Down Current | 0.2 | | 5 | μA | $\overline{RP} = \text{GND} \pm 0.2 \text{ V}$ | 1 |

DC Characteristics (Continued)

$$V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}, T_A = 0^\circ\text{C to } +70^\circ\text{C}$$

$$\overline{3/5} = \text{Pin Set High for 3.3 V Operations}$$

| SYMBOL | PARAMETER | TYP. | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------|--|------|----------------|----------------|---------------|---|------|
| I_{PPR} | V_{PP} Read Current | | | 200 | μA | $V_{PP} > V_{CC}$ | 1 |
| I_{PPW} | V_{PP} Write Current | 10 | | 15 | mA | $V_{PP} = V_{PPH}$, Word/Byte Write in Progress | 1 |
| I_{PPE} | V_{PP} Erase Current | 4 | | 10 | mA | $V_{PP} = V_{PPH}$, Block Erase in Progress | 1 |
| I_{PPES} | V_{PP} Erase Suspend Current | | | 200 | μA | $V_{PP} = V_{PPH}$, Block Erase Suspended | 1 |
| V_{IL} | Input Low Voltage | | -0.3 | 0.8 | V | | |
| V_{IH} | Input High Voltage | | 2.0 | $V_{CC} + 0.3$ | V | | |
| V_{OL} | Output Low Voltage | | | 0.4 | V | $V_{CC} = V_{CC} \text{ MIN. and } I_{OL} = 4 \text{ mA}$ | |
| V_{OH}^1 | Output High Voltage | | 2.4 | | V | $I_{OH} = -2.0 \text{ mA}$ $V_{CC} = V_{CC} \text{ MIN.}$ | |
| V_{OH}^2 | | | $V_{CC} - 0.2$ | | V | $I_{OH} = -100 \mu\text{A}$ $V_{CC} = V_{CC} \text{ MIN.}$ | |
| V_{PPL} | V_{PP} during Normal Operations | | 0.0 | 6.5 | V | | |
| V_{PPH} | V_{PP} during Write/Erase Operations | 12.0 | 11.4 | 12.6 | V | | |
| V_{LKO} | V_{CC} Erase/Write Lock Voltage | | 2.0 | | V | | |

NOTES:

- All currents are in RMS unless otherwise noted. Typical values at $V_{CC} = 3.3 \text{ V}$, $V_{PP} = 5.0 \text{ V}$, $T = 25^\circ\text{C}$. These currents are valid for all product versions (package and speeds).
- I_{CCES} is specified with the device de-selected. If the device is read while in erase suspend mode, current draw is the sum of I_{CCES} and I_{CCR} .
- Automatic Power Saving (APS) reduces I_{CCR} to less than 1 mA in Static operation.
- CMOS Inputs are either $V_{CC} \pm 0.2 \text{ V}$ or $\text{GND} \pm 0.2 \text{ V}$. TTL Inputs are either V_{IL} or V_{IH} .

DC Characteristics

 $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}, T_A = 0^\circ\text{C to } +70^\circ\text{C}$
 $\overline{3.5}$ Pin Set Low for 5 V Operations

| SYMBOL | PARAMETER | TYP. | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|-------------|----------------------------------|------|------|----------|---------------|--|---------|
| I_{IL} | Input Load Current | | | ± 1 | μA | $V_{CC} = V_{CC\text{ MAX.}}, V_{IN} = V_{CC}$ or GND | 1 |
| I_{LO} | Output Leakage Current | | | ± 10 | μA | $V_{CC} = V_{CC\text{ MAX.}}, V_{IN} = V_{CC}$ or GND | 1 |
| I_{CCS} | V_{CC} Standby Current | 50 | | 100 | μA | $V_{CC} = V_{CC\text{ MAX.}},$ $\overline{CE}_0, \overline{CE}_1, \overline{RP} = V_{CC} \pm 0.2\text{ V}$ $\overline{BYTE}, \overline{WP}, \overline{3/5} \# = V_{CC} \pm 0.2\text{ V}$ or GND $\pm 0.2\text{ V}$ | 1, 4 |
| | | 2 | | 4 | mA | $V_{CC} = V_{CC\text{ MAX.}},$ $\overline{CE}_0, \overline{CE}_1, \overline{RP} = V_{IH}$ $\overline{BYTE}, \overline{WP}, \overline{3/5} = V_{IH}$ or V_{IL} | |
| I_{CCD} | V_{CC} Deep Power-Down Current | 1 | | 5 | μA | $\overline{RP} = \text{GND} \pm 0.2\text{ V}$ | 1 |
| I_{CCR}^1 | V_{CC} Read Current | 50 | | 60 | mA | $V_{CC} = V_{CC\text{ MAX.}},$ CMOS: $\overline{CE}_0, \overline{CE}_1 = \text{GND} \pm 0.2\text{ V}$ $\overline{BYTE} = \text{GND} \pm 0.2\text{ V}$ or $V_{CC} \pm 0.2\text{ V}$ Inputs = GND $\pm 0.2\text{ V}$ or $V_{CC} \pm 0.2\text{ V}$ TTL: $\overline{CE}_0, \overline{CE}_1 = V_{IL},$ $\overline{BYTE} = V_{IL}$ or V_{IH} Inputs = V_{IL} or V_{IH} $f = 10\text{ MHz}, I_{OUT} = 0\text{ mA}$ | 1, 3, 4 |
| I_{CCR}^2 | V_{CC} Read Current | 30 | | 35 | mA | $V_{CC} = V_{CC\text{ MAX.}},$ CMOS: $\overline{CE}_0, \overline{CE}_1 = \text{GND} \pm 0.2\text{ V}$ $\overline{BYTE} = V_{CC} \pm 0.2\text{ V}$ or $\text{GND} \pm 0.2\text{ V}$ Inputs = GND $\pm 0.2\text{ V}$ or $V_{CC} \pm 0.2\text{ V}$ TTL: $\overline{CE}_0, \overline{CE}_1 = V_{IL},$ $\overline{BYTE} = V_{IH}$ or V_{IL} Inputs = V_{IL} or V_{IH} $f = 5\text{ MHz}, I_{OUT} = 0\text{ mA}$ | 1, 3, 4 |
| I_{CCW} | V_{CC} Write Current | 25 | | 35 | mA | Word/Byte Write in Progress | 1 |
| I_{CCE} | V_{CC} Block Erase Current | 18 | | 25 | mA | Block Erase in Progress | 1 |
| I_{CCES} | V_{CC} Erase Suspend Current | 5 | | 10 | mA | $\overline{CE}_0, \overline{CE}_1 = V_{IH}$ Block Erase Suspended | 1, 2 |
| I_{PPS} | V_{PP} Standby Current | | | ± 10 | μA | $V_{PP} \leq V_{CC}$ | 1 |
| I_{PPD} | V_{PP} Deep Power-Down Current | 0.2 | | 5 | μA | $\overline{RP} = \text{GND} \pm 0.2\text{ V}$ | 1 |

DC Characteristics (Continued)
 $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$
 $\overline{3.5}$ Pin Set Low for 5 V Operations

| SYMBOL | PARAMETER | TYPE | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|------------|--|------|---------------------|----------------|---------------|---|------|
| I_{PPR} | V_{PP} Read Current | 65 | | 200 | μA | $V_{PP} > V_{CC}$ | 1 |
| I_{PPW} | V_{PP} Write Current | 7 | | 12 | mA | $V_{PP} = V_{PPH}$, Word/Byte Write in Progress | 1 |
| I_{PPE} | V_{PP} Erase Current | 5 | | 10 | mA | $V_{PP} = V_{PPH}$, Block Erase in Progress | 1 |
| I_{PPES} | V_{PP} Erase Suspend Current | 65 | | 200 | μA | $V_{PP} = V_{PPH}$, Block Erase Suspended | 1 |
| V_{IL} | Input Low Voltage | | -0.5 | 0.8 | V | | |
| V_{IH} | Input High Voltage | | 2.0 | $V_{CC} + 0.5$ | V | | |
| V_{OL} | Output Low Voltage | | | 0.45 | V | $V_{CC} = V_{CC\text{ MIN.}}$ and $I_{OL} = 5.8\text{ mA}$ | |
| V_{OH}^1 | Output High Voltage | | $V_{CC} \cdot 0.85$ | | V | $I_{OH} = -2.5\text{ mA}$ $V_{CC} = V_{CC\text{ MIN.}}$ | |
| V_{OH}^2 | | | $V_{CC} - 0.4$ | | V | $I_{OH} = -100\ \mu\text{A}$ $V_{CC} = V_{CC\text{ MIN.}}$ | |
| V_{PPL} | V_{PP} during Normal Operations | | 0.0 | 6.5 | V | | |
| V_{PPH} | V_{PP} during Write/Erase Operations | 12.0 | 11.4 | 12.6 | V | | |
| V_{LKO} | V_{CC} Erase/Write Lock Voltage | | 2.0 | | V | | |

NOTES:

- All currents are in RMS unless otherwise noted. Typical values at $V_{CC} = 5.0\text{ V}$, $V_{PP} = 5.0\text{ V}$, $T = 25^\circ\text{C}$. These currents are valid for all product versions (package and speeds).
- I_{CCES} is specified with the device de-selected. If the device is read while in erase suspend mode, current draw is the sum of I_{CCES} and I_{CCR} .
- Automatic Power Saving (APS) reduces I_{CCR} to less than 2 mA in Static operation.
- CMOS Inputs are either $V_{CC} \pm 0.2\text{ V}$ or $\text{GND} \pm 0.2\text{ V}$. TTL Inputs are either V_{IL} or V_{IH} .

AC Characteristics - Read Only Operations¹ $T_A = 0^\circ\text{C to } +70^\circ\text{C}$

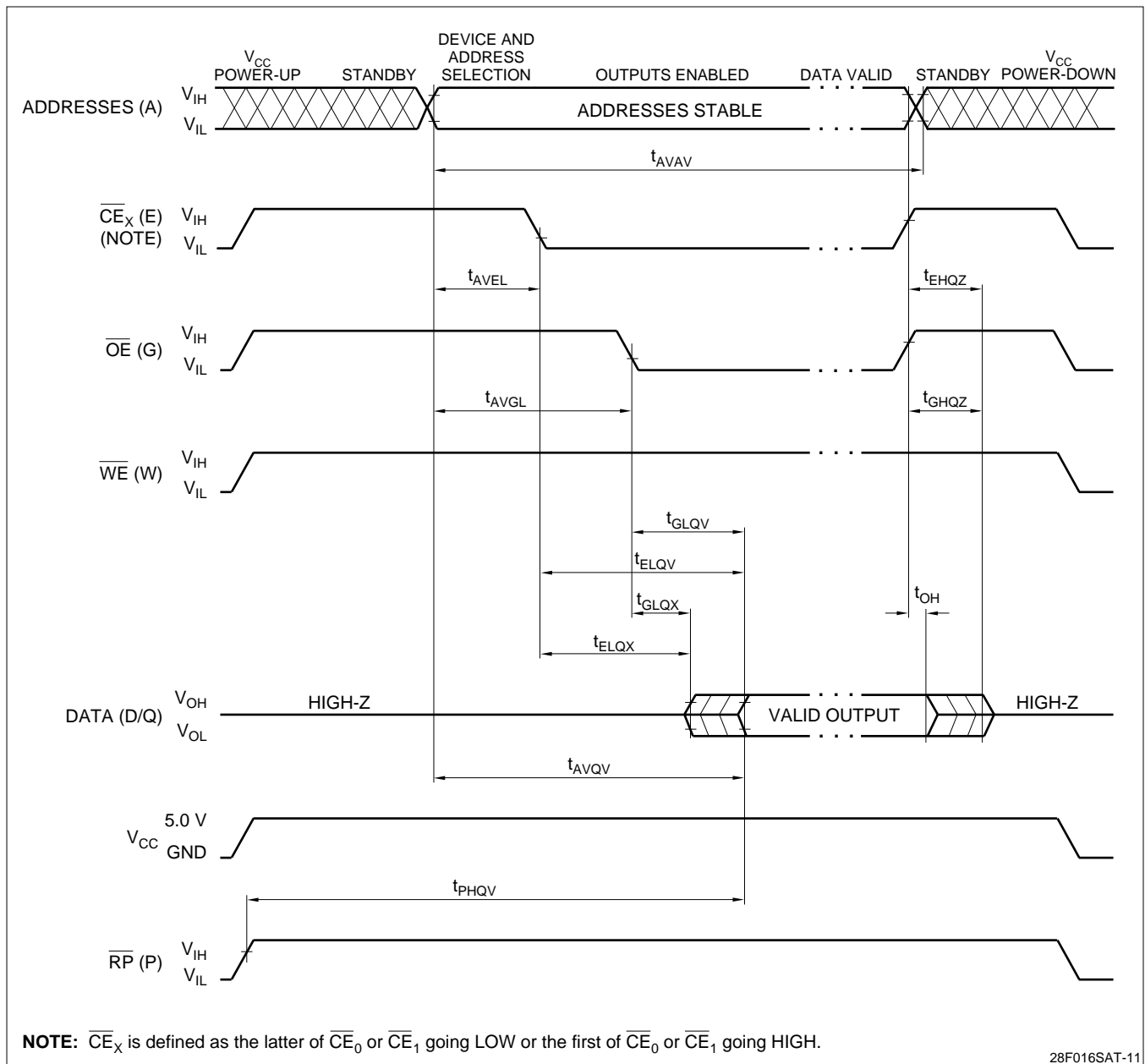
| SYMBOL | PARAMETER | $V_{CC} = 3.3\text{ V} \pm 0.3\text{V}$ | | UNITS | NOTE |
|--------------------------|---|---|------|-------|------|
| | | MIN. | MAX. | | |
| t_{AVAV} | Read Cycle Time | 120 | | ns | |
| t_{AVEL} | Address Setup to \overline{CE} Going Low | 10 | | ns | 3, 4 |
| t_{AVGL} | Address Setup to \overline{OE} Going Low | 0 | | ns | 3, 4 |
| t_{AVQV} | Address to Output Delay | | 120 | ns | |
| t_{ELQV} | \overline{CE} to Output Delay | | 120 | ns | 2 |
| t_{PHQV} | \overline{RP} High to Output Delay | | 620 | ns | |
| t_{GLQV} | \overline{OE} to Output Delay | | 45 | ns | 2 |
| t_{ELQX} | \overline{CE} to Output in Low Z | 0 | | ns | 3 |
| t_{EHQZ} | \overline{CE} to Output in High Z | | 50 | ns | 3 |
| t_{GLQX} | \overline{OE} to Output in Low Z | 0 | | ns | 3 |
| t_{GHQZ} | \overline{OE} to Output in High Z | | 30 | ns | 3 |
| t_{OH} | Output Hold from Address, \overline{CE} or \overline{OE} change, whichever occurs first | 0 | | ns | 3 |
| t_{FLQV} t_{FHQV} | \overline{BYTE} to Output Delay | | 120 | ns | 3 |
| t_{FLQZ} | \overline{BYTE} Low to Output in High Z | | 30 | ns | 3 |
| t_{ELFL} t_{ELFH} | \overline{CE} Low to \overline{BYTE} High or Low | | 5 | ns | 3 |

AC Characteristics - Read Only Operations¹ (Continued) $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 5.0\text{ V} \pm 0.25\text{ V}$ | | $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$ | | UNITS | NOTE |
|--------------------------|---|---|------|--|------|-------|------|
| | | MIN. | MAX. | MIN. | MAX. | | |
| t_{AVAV} | Read Cycle Time | 70 | | 80 | | ns | |
| t_{AVEL} | Address Setup to \overline{CE} Going Low | 10 | | 10 | | ns | 3, 4 |
| t_{AVGL} | Address Setup to \overline{OE} Going Low | 0 | | 0 | | ns | 3, 4 |
| t_{AVQV} | Address to Output Delay | | 70 | | 80 | ns | |
| t_{ELQV} | \overline{CE} to Output Delay | | 70 | | 80 | ns | 2 |
| t_{PHQV} | \overline{RP} High to Output Delay | | 400 | | 480 | ns | |
| t_{GLQV} | \overline{OE} to Output Delay | | 30 | | 35 | ns | 2 |
| t_{ELQX} | \overline{CE} to Output in Low Z | 0 | | 0 | | ns | 3 |
| t_{EHQZ} | \overline{CE} to Output in High Z | | 25 | | 30 | ns | 3 |
| t_{GLQX} | \overline{OE} to Output in Low Z | 0 | | 0 | | ns | 3 |
| t_{GHQZ} | \overline{OE} to Output in High Z | | 25 | | 30 | ns | 3 |
| t_{OH} | Output Hold from Address, \overline{CE} or \overline{OE} change, whichever occurs first | 0 | | 0 | | ns | 3 |
| t_{FLQV} t_{FHQV} | \overline{BYTE} to Output Delay | | 70 | | 80 | ns | 3 |
| t_{FLQZ} | \overline{BYTE} Low to Output in High Z | | 25 | | 30 | ns | 3 |
| t_{ELFL} t_{ELFH} | \overline{CE} Low to \overline{BYTE} High or Low | | 5 | | 5 | ns | 3 |

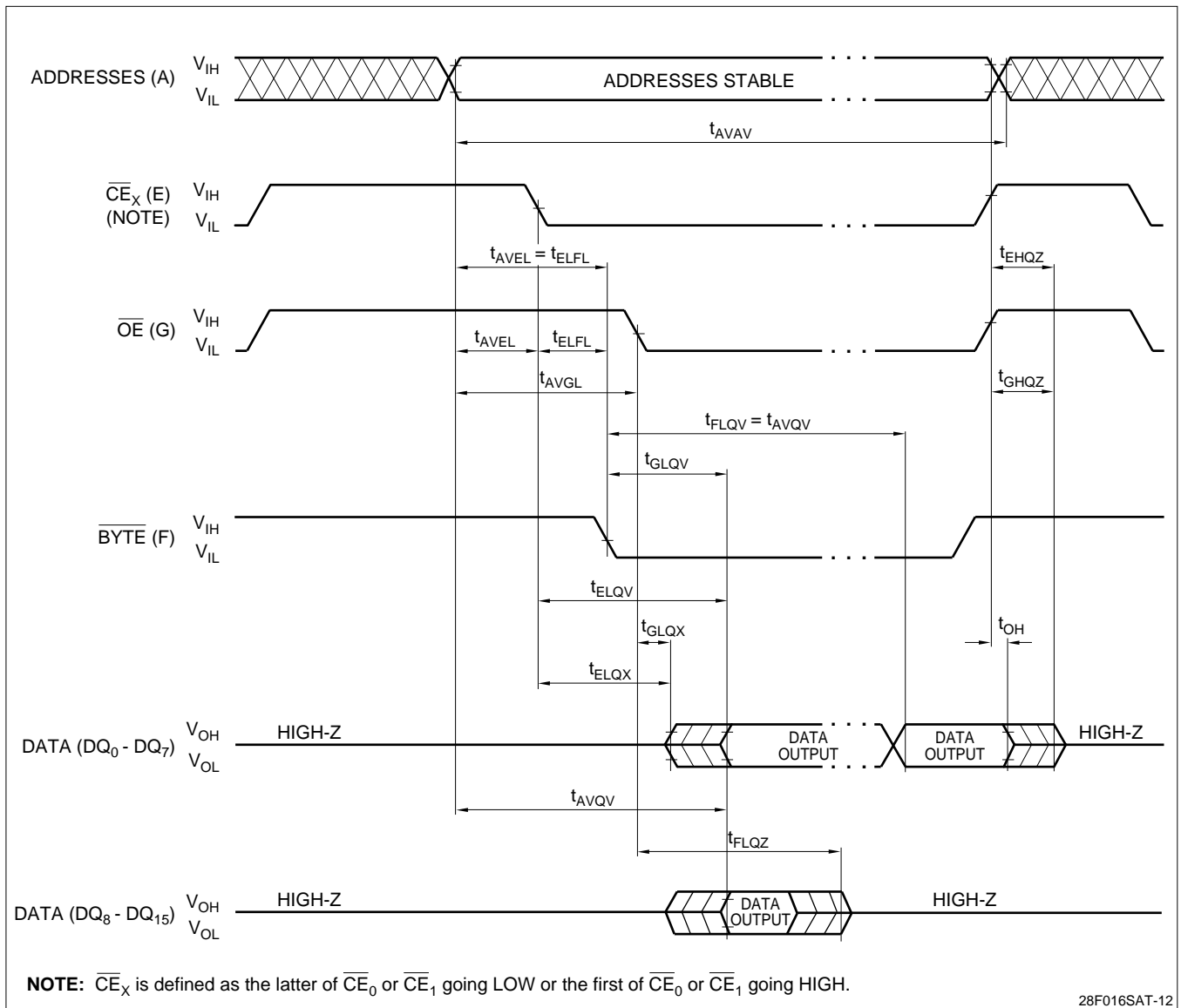
NOTES:

- See AC Input/Output Reference Waveforms for timing measurements, Figures 5 and 6.
- \overline{OE} may be delayed up to $t_{ELQV} - t_{GLQV}$ after the falling edge of \overline{CE} without impact on t_{ELQV} .
- Sampled, not 100% tested.
- This timing parameter is used to latch the correct BSR data onto the outputs.



28F016SAT-11

Figure 11. Read Timing Waveforms



28F016SAT-12

Figure 12. \overline{BYTE} Timing Waveforms

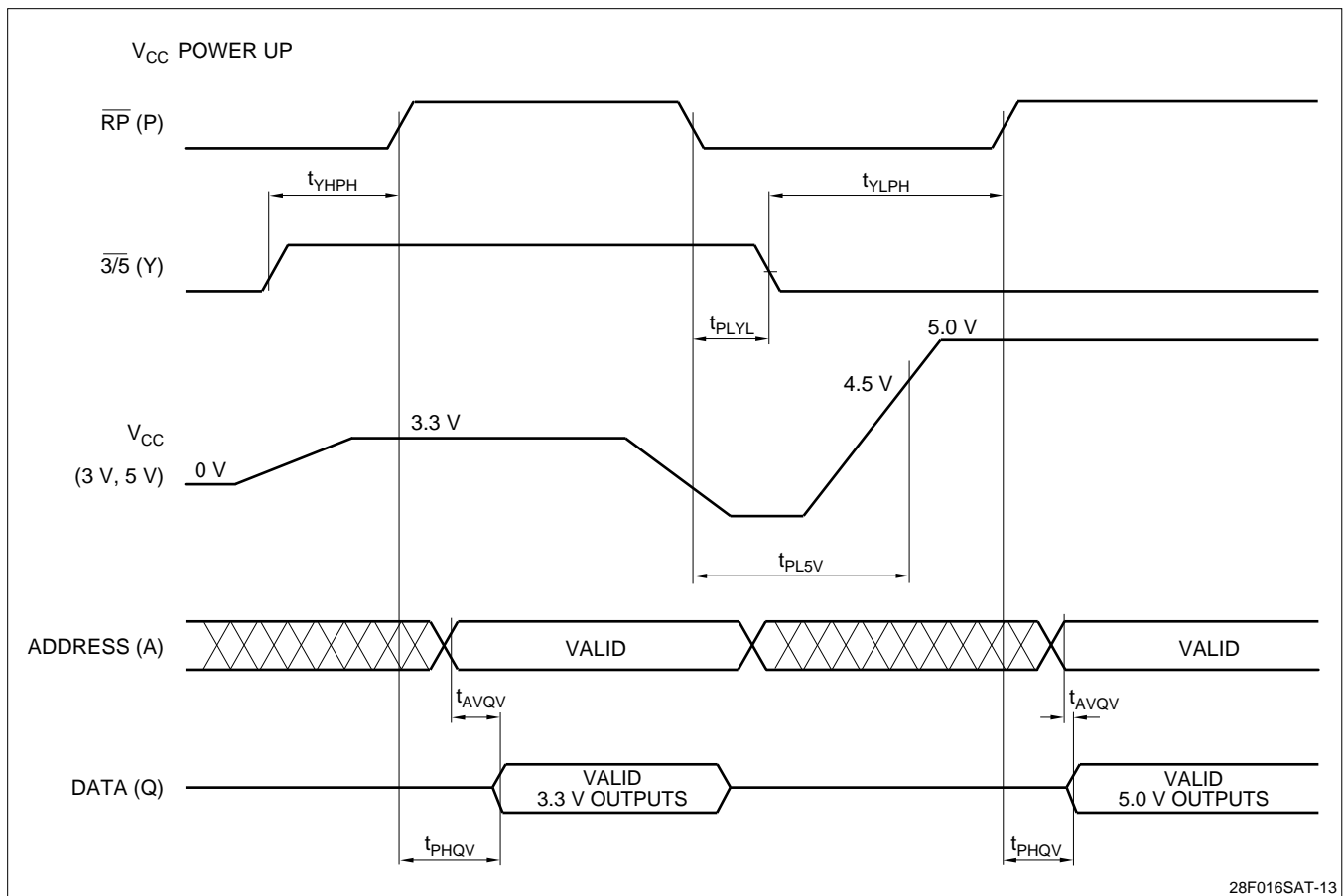


Figure 13. V_{CC} Power-Up and \overline{RP} Reset Waveforms

| SYMBOL | PARAMETER | MIN. | MAX. | UNIT | NOTE |
|--------------------------|--|------|------|---------------|------|
| t_{PLYL} t_{PLYH} | \overline{RP} Low to $\overline{3/5}$ Low (High) | 0 | | μs | |
| t_{YLPH} t_{YHPH} | $\overline{3/5}$ Low (High) to \overline{RP} High | 2 | | μs | 1 |
| t_{PL5V} t_{PL3V} | \overline{RP} Low to V_{CC} at 4.5 V MIN. (to V_{CC} at 3.0 V MIN. or 3.6 V MAX.) | 0 | | μs | 2 |
| t_{AVQV} | Address Valid to Data Valid for $V_{CC} = 5 \text{ V} \pm 10\%$ | | 80 | ns | 3 |
| t_{PHQV} | \overline{RP} High to Data Valid for $V_{CC} = 5 \text{ V} \pm 10\%$ | | 480 | ns | 3 |

NOTES:

\overline{CE}_0 , \overline{CE}_1 and \overline{OE} are switched low after Power-Up.

1. Minimum of 2 μs is required to meet the specified t_{PHQV} times.
2. The power supply may start to switch concurrently with \overline{RP} going Low.
3. The address access time and \overline{RP} high to data valid time are shown for 5 V V_{CC} operation. Refer to the AC Characteristics Read Only Operations 3.3 V V_{CC} operation and all other speed options.

AC Characteristics for \overline{WE} - Controlled Command Write Operations¹ $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 3.3 \pm 0.3 \text{ V}$ | | | UNITS | NOTE |
|--------------|--|----------------------------------|------|------|---------------|------|
| | | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 120 | | ns | |
| t_{VPWH} | V_{PP} Setup to \overline{WE} Going High | | 100 | | ns | 3 |
| t_{PHEL} | \overline{RP} Setup to \overline{CE} Going Low | | 480 | | ns | |
| t_{ELWL} | \overline{CE} Setup to \overline{WE} Going Low | | 10 | | ns | |
| t_{AVWH} | Address Setup to \overline{WE} Going High | | 75 | | ns | 2, 6 |
| t_{DVWH} | Data Setup to \overline{WE} Going High | | 75 | | ns | 2, 6 |
| t_{WLWH} | \overline{WE} Pulse Width | | 75 | | ns | |
| t_{WHDX} | Data Hold from \overline{WE} High | | 10 | | ns | 2 |
| t_{WHAX} | Address Hold from \overline{WE} High | | 10 | | ns | 2 |
| t_{WHEH} | \overline{CE} Hold from \overline{WE} High | | 10 | | ns | |
| t_{WHWL} | \overline{WE} Pulse Width High | | 45 | | ns | |
| t_{GHWL} | Read Recovery before Write | | 0 | | ns | |
| t_{WHRL} | \overline{WE} High to $\overline{RY/BY}$ Going Low | | | 100 | ns | |
| t_{RHPL} | \overline{RP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY/BY}$ High | | 0 | | ns | 3 |
| t_{PHWL} | \overline{RP} High Recovery to \overline{WE} Going Low | | 1 | | μs | |
| t_{WHGL} | Write Recovery before Read | | 95 | | ns | |
| t_{QVVL} | V_{PP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY/BY}$ High | | 0 | | μs | |
| t_{WHQV}^1 | Duration of Word/Byte Write Operation | 9 | 5 | | μs | 4, 5 |
| t_{WHQV}^2 | Duration of Block Erase Operation | | 0.3 | | s | 4 |

AC Characteristics for \overline{WE} - Controlled Command Write Operations¹ (Continued) $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 5.0 \pm 0.25 \text{ V}$ | | | $V_{CC} = 5.0 \pm 0.5 \text{ V}$ | | | UNITS | NOTE |
|--------------|---|-----------------------------------|------|------|----------------------------------|------|------|---------------|------|
| | | TYP. | MIN. | MAX. | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 70 | | | 80 | | ns | |
| t_{VPWH} | V_{PP} Setup to \overline{WE} Going High | | 100 | | | 100 | | ns | 3 |
| t_{PHEL} | \overline{RP} Setup to \overline{CE} Going Low | | 480 | | | 480 | | ns | |
| t_{ELWL} | \overline{CE} Setup to \overline{WE} Going Low | | 0 | | | 0 | | ns | |
| t_{AVWH} | Address Setup to \overline{WE} Going High | | 50 | | | 50 | | ns | 2, 6 |
| t_{DVWH} | Data Setup to \overline{WE} Going High | | 50 | | | 50 | | ns | 2, 6 |
| t_{WLWH} | \overline{WE} Pulse Width | | 40 | | | 50 | | ns | |
| t_{WHDX} | Data Hold from \overline{WE} High | | 0 | | | 0 | | ns | 2 |
| t_{WHAX} | Address Hold from \overline{WE} High | | 10 | | | 10 | | ns | 2 |
| t_{WHEH} | \overline{CE} Hold from \overline{WE} High | | 10 | | | 10 | | ns | |
| t_{WHWL} | \overline{WE} Pulse Width High | | 30 | | | 30 | | ns | |
| t_{GHWL} | Read Recovery before Write | | 0 | | | 0 | | ns | |
| t_{WHRL} | \overline{WE} High to $\overline{RY}/\overline{BY}$ Going Low | | | 100 | | | 100 | ns | |
| t_{RHPL} | \overline{RP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | | 0 | | ns | 3 |
| t_{PHWL} | \overline{RP} High Recovery to \overline{WE} Going Low | | 1 | | | 1 | | μs | |
| t_{WHGL} | Write Recovery before Read | | 60 | | | 65 | | ns | |
| t_{QVVL} | V_{PP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | | 0 | | μs | |
| t_{WHQV}^1 | Duration of Word/Byte Write Operation | 6 | 4.5 | | 6 | 4.5 | | μs | 4, 5 |
| t_{WHQV}^2 | Duration of Block Erase Operation | | 0.3 | | | 0.3 | | s | 4 |

NOTES:

\overline{CE} is defined as the latter of \overline{CE}_0 or \overline{CE}_1 going Low or the first of \overline{CE}_0 or \overline{CE}_1 going High.

1. Read timing during write and erase are the same as for normal read.
2. Refer to command definition tables for valid address and data values.
3. Sampled, but not 100% tested.
4. Write/Erase durations are measured to valid Status Register (CSR) Data.
5. Word/Byte write operations are typically performed with 1 Programming Pulse.
6. Address and Data are latched on the rising edge of \overline{WE} for all Command Write Operations.

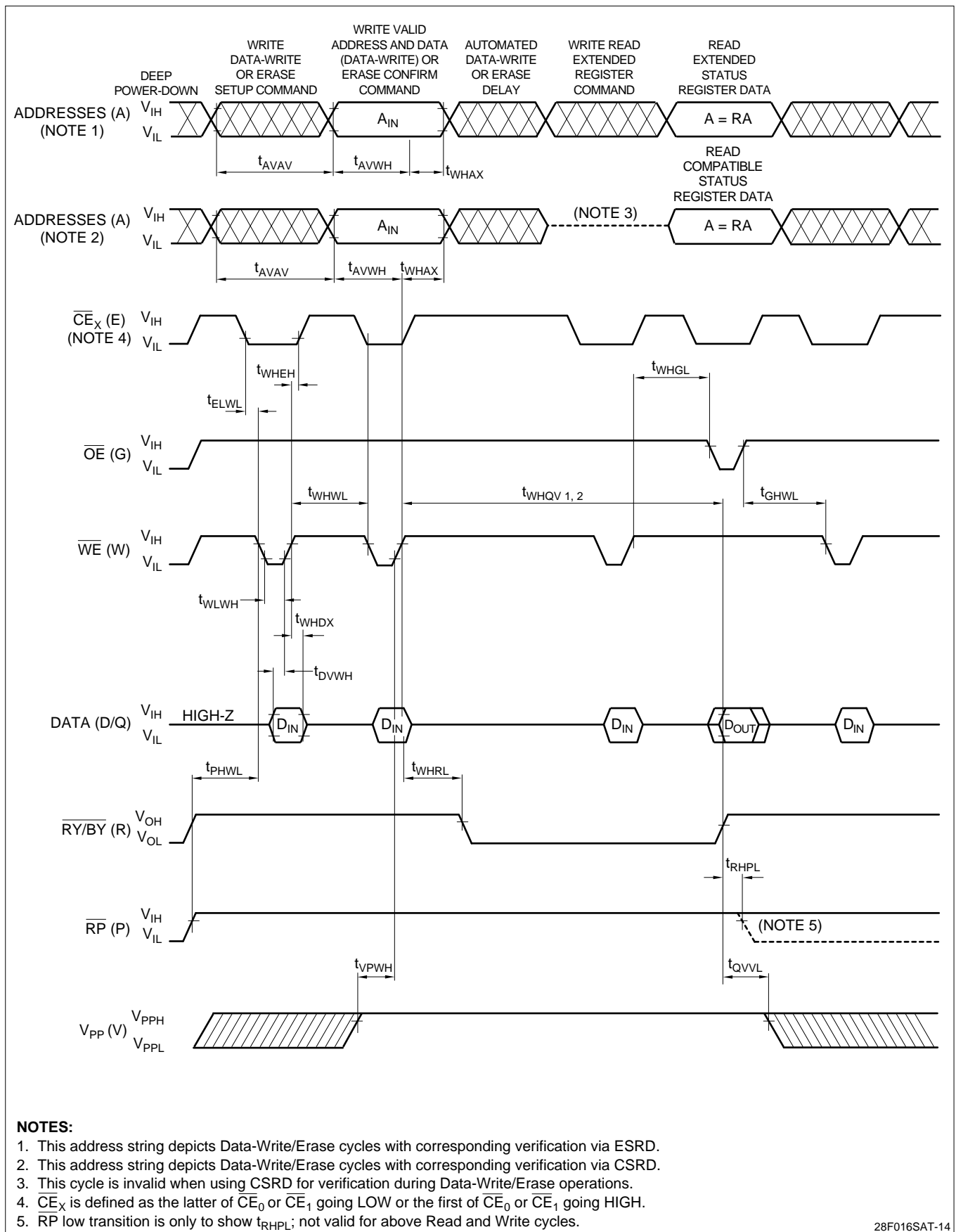


Figure 14. AC Waveforms for Command Write Operations

AC Characteristics for \overline{CE} - Controlled Command Write Operations¹ $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ | | | UNITS | NOTE |
|--------------|---|--|------|------|---------------|------|
| | | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 120 | | ns | |
| t_{PHWL} | \overline{RP} Setup to \overline{WE} Going Low | | 480 | | ns | 3 |
| t_{VPEH} | V_{PP} Set up to \overline{CE} Going High | | 100 | | ns | 3 |
| t_{WLEL} | \overline{WE} Setup to \overline{CE} Going Low | | 0 | | ns | |
| t_{AVEH} | Address Setup to \overline{CE} Going High | | 75 | | ns | 2, 6 |
| t_{DVEH} | Data Setup to \overline{CE} Going High | | 75 | | ns | 2, 6 |
| t_{ELEH} | \overline{CE} Pulse Width | | 75 | | ns | |
| t_{EHDX} | Data Hold from \overline{CE} High | | 10 | | ns | 2 |
| t_{EHAX} | Address Hold from \overline{CE} High | | 10 | | ns | 2 |
| t_{EHWH} | \overline{WE} Hold from \overline{CE} High | | 10 | | ns | |
| t_{EHEL} | \overline{CE} Pulse Width High | | 45 | | ns | |
| t_{GHEL} | Read Recovery before Write | | 0 | | ns | |
| t_{EHRL} | \overline{CE} High to $\overline{RY}/\overline{BY}$ Going Low | | | 100 | ns | |
| t_{RHPL} | \overline{RP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | ns | 3 |
| t_{PHEL} | \overline{RP} High Recovery to \overline{CE} Going Low | | 1 | | μs | |
| t_{EHGL} | Write Recovery before Read | | 95 | | ns | |
| t_{QVVL} | V_{PP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | μs | |
| t_{EHQV}^1 | Duration of Word/Byte Write Operation | 9 | 5 | | μs | 4, 5 |
| t_{EHQV}^2 | Duration of Block Erase Operation | | 0.3 | | s | 4 |

AC Characteristics for \overline{CE} - Controlled Command Write Operations¹ (Continued) $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 5.0\text{ V} \pm 0.25\text{ V}$ | | | $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$ | | | UNITS | NOTE |
|--------------|---|---|------|------|--|------|------|---------------|------|
| | | TYP. | MIN. | MAX. | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 70 | | | 80 | | ns | |
| t_{PHWL} | \overline{RP} Setup to \overline{WE} Going Low | | 480 | | | 480 | | ns | |
| t_{VPEH} | V_{PP} Setup to \overline{CE} Going High | | 100 | | | 100 | | ns | 3 |
| t_{WLEL} | \overline{WE} Setup to \overline{CE} Going Low | | 0 | | | 0 | | ns | |
| t_{AVEH} | Address Setup to \overline{CE} Going High | | 50 | | | 50 | | ns | 2, 6 |
| t_{DVEH} | Data Setup to \overline{CE} Going High | | 50 | | | 50 | | ns | 2, 6 |
| t_{ELEH} | \overline{CE} Pulse Width | | 40 | | | 50 | | ns | |
| t_{EHDX} | Data Hold from \overline{CE} High | | 0 | | | 0 | | ns | 2 |
| t_{EHAX} | Address Hold from \overline{CE} High | | 10 | | | 10 | | ns | 2 |
| t_{EHWL} | \overline{WE} Hold from \overline{CE} High | | 10 | | | 10 | | ns | |
| t_{EHEL} | \overline{CE} Pulse Width High | | 30 | | | 50 | | ns | |
| t_{GHLE} | Read Recovery before Write | | 0 | | | 0 | | ns | |
| t_{EHRL} | \overline{CE} High to $\overline{RY}/\overline{BY}$ Going Low | | | 100 | | | 100 | ns | |
| t_{RHPL} | \overline{RP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | | 0 | | ns | 3 |
| t_{PHEL} | \overline{RP} High Recovery to \overline{CE} Going Low | | 1 | | | 1 | | μs | |
| t_{EHGL} | Write Recovery before Read | | 60 | | | 80 | | ns | |
| t_{QVVL} | V_{PP} Hold from Valid Status Register (CSR, GSR, BSR) Data and $\overline{RY}/\overline{BY}$ High | | 0 | | | 0 | | μs | |
| t_{EHQV}^1 | Duration of Word/Byte Write Operation | 6 | 4.5 | | 6 | 4.5 | | μs | 4, 5 |
| t_{EHQV}^2 | Duration of Block Erase Operation | | 0.3 | | | 0.3 | | s | 4 |

NOTES:

\overline{CE} is defined as the latter of \overline{CE}_0 or \overline{CE}_1 going Low or the first of \overline{CE}_0 or \overline{CE}_1 going High.

1. Read timing during write and erase are the same as for normal read.
2. Refer to command definition tables for valid address and data values.
3. Sampled, but not 100% tested.
4. Write/Erase durations are measured to valid Status Register (CSR) Data.
5. Word/Byte write operations are typically performed with 1 Programming Pulse.
6. Address and Data are latched on the rising edge of \overline{CE} for all Command Write Operations.

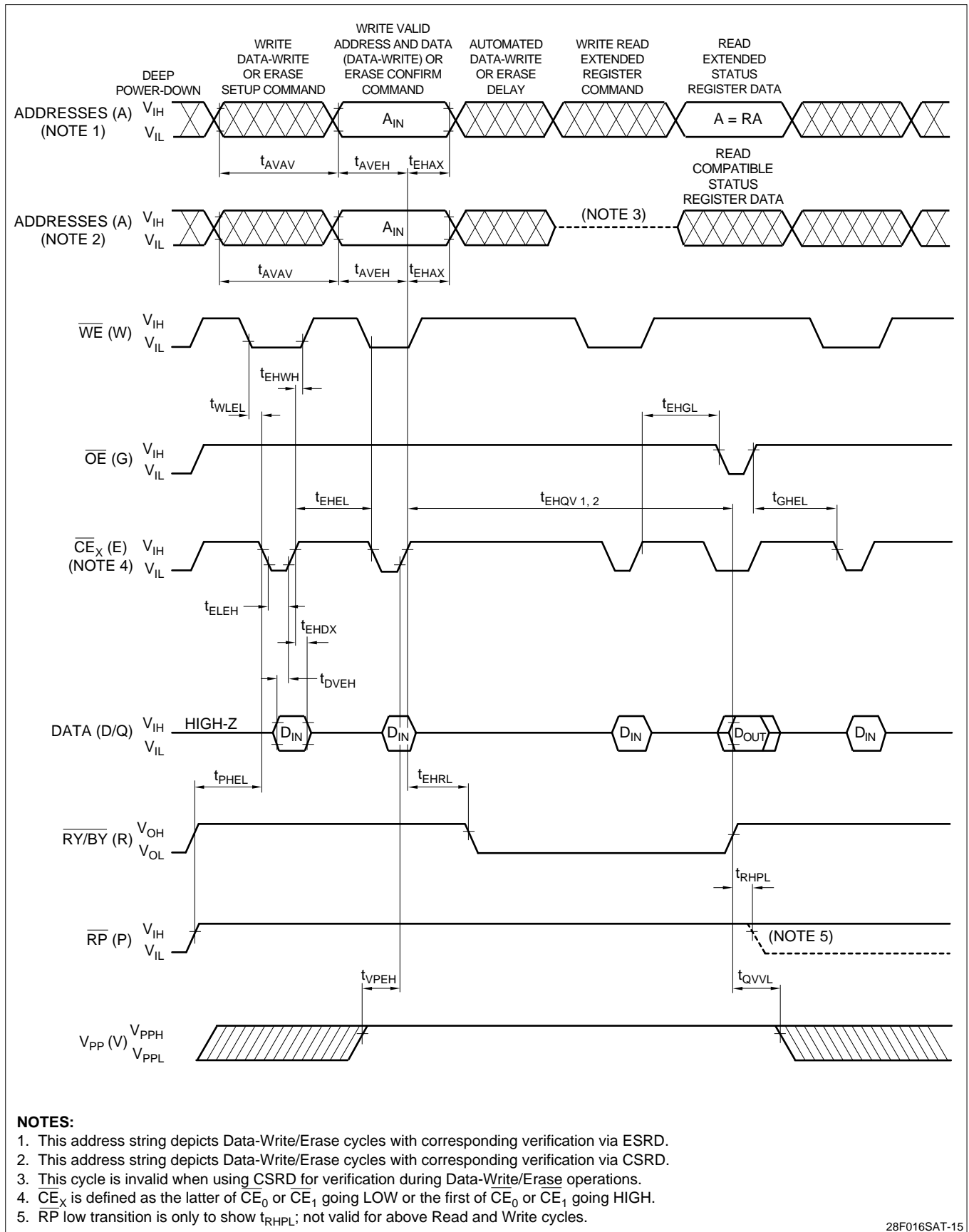


Figure 15. Alternate AC Waveforms for Command Write Operations

AC Characteristics for Page Buffer Write Operations¹ $T_A = 0^\circ\text{C to } +70^\circ\text{C}$

| SYMBOL | PARAMETER | $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ | | | UNITS | NOTE |
|------------|--|--|------|------|-------|------|
| | | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 120 | | ns | |
| t_{ELWL} | \overline{CE} Setup to \overline{WE} Going Low | | 10 | | ns | |
| t_{AVWL} | Address Setup to \overline{WE} Going Low | | 0 | | ns | 3 |
| t_{DVWH} | Data Setup to \overline{WE} Going High | | 75 | | ns | 2 |
| t_{WLWH} | \overline{WE} Pulse Width | | 75 | | ns | |
| t_{WHDX} | Data Hold from \overline{WE} High | | 10 | | ns | 2 |
| t_{WHAX} | Address Hold from \overline{WE} High | | 10 | | ns | 2 |
| t_{WHEH} | \overline{CE} Hold from \overline{WE} High | | 10 | | ns | |
| t_{WHWL} | \overline{WE} Pulse Width High | | 45 | | ns | |
| t_{GHWL} | Read Recovery before Write | | 0 | | ns | |
| t_{WHGL} | Write Recovery before Read | | 95 | | ns | |

| SYMBOL | PARAMETER | $V_{CC} = 5.0\text{ V} \pm 0.25\text{ V}$ | | | $V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$ | | | UNITS | NOTE |
|------------|--|---|------|------|--|------|------|-------|------|
| | | TYP. | MIN. | MAX. | TYP. | MIN. | MAX. | | |
| t_{AVAV} | Write Cycle Time | | 70 | | | 80 | | ns | |
| t_{ELWL} | \overline{CE} Setup to \overline{WE} Going Low | | 0 | | | 0 | | ns | |
| t_{AVWL} | Address Setup to \overline{WE} Going Low | | 0 | | | 0 | | ns | 3 |
| t_{DVWH} | Data Setup to \overline{WE} Going High | | 50 | | | 50 | | ns | 2 |
| t_{WLWH} | \overline{WE} Pulse Width | | 40 | | | 50 | | ns | |
| t_{WHDX} | Data Hold from \overline{WE} High | | 0 | | | 0 | | ns | 2 |
| t_{WHAX} | Address Hold from \overline{WE} High | | 10 | | | 10 | | ns | 2 |
| t_{WHEH} | \overline{CE} Hold from \overline{WE} High | | 10 | | | 10 | | ns | |
| t_{WHWL} | \overline{WE} Pulse Width High | | 30 | | | 30 | | ns | |
| t_{GHWL} | Read Recovery before Write | | 0 | | | 0 | | ns | |
| t_{WHGL} | Write Recovery before Read | | 60 | | | 65 | | ns | |

NOTES:

\overline{CE} is defined as the latter of \overline{CE}_0 or \overline{CE}_1 going Low or the first of \overline{CE}_0 or \overline{CE}_1 going High.

1. These are \overline{WE} controlled write timings, equivalent \overline{CE} controlled write timings apply.
2. Sampled, but not 100% tested.
3. Address must be valid during the entire \overline{WE} Low pulse.

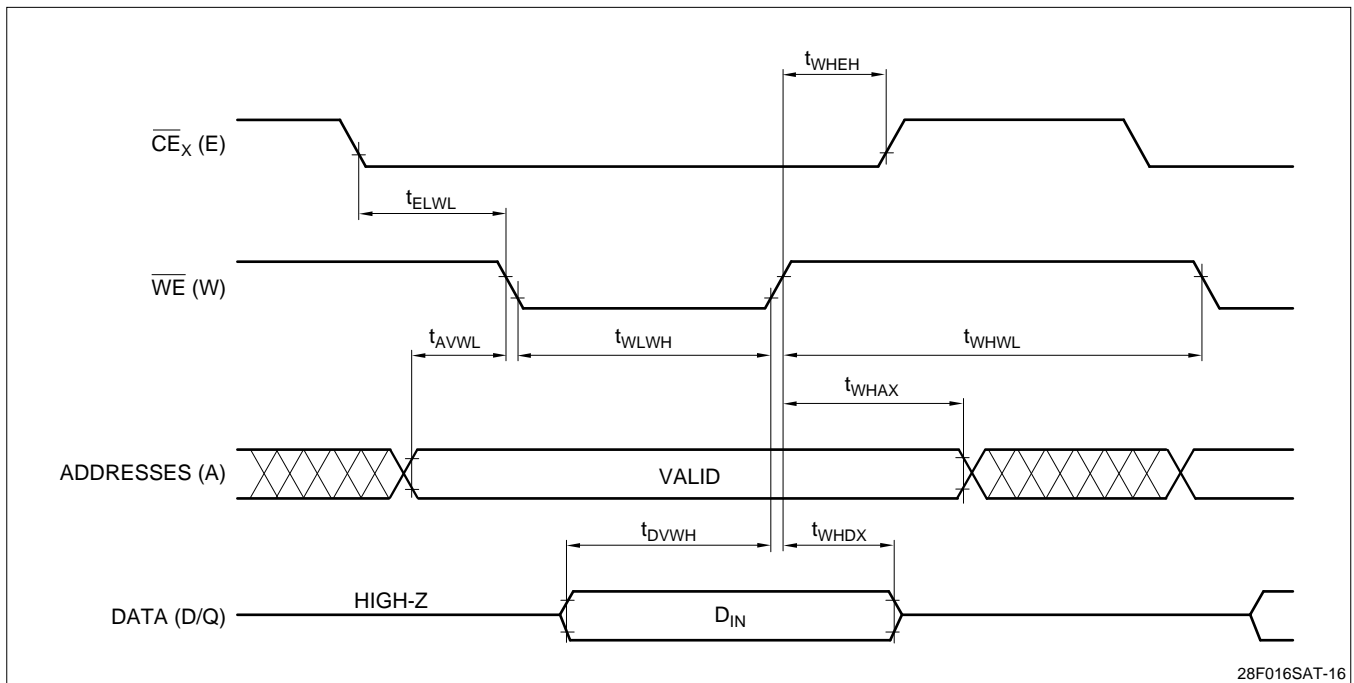


Figure 16. Page Buffer Write Timing Waveforms

Erase and Word/Byte Write Performance

$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | TYP. ⁽¹⁾ | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|--------------|----------------------|---------------------|------|------|-------|-----------------|------|
| t_{WHRH}^1 | Word/Byte Write Time | 9 | | | μs | | 2 |
| t_{WHRH}^2 | Block Write Time | 0.6 | | 2.1 | s | Byte Write Mode | 2 |
| t_{WHRH}^3 | Block Write Time | 0.3 | | 1.0 | s | Word Write Mode | 2 |
| | Block Erase Time | 0.8 | | 10 | s | | 2 |
| | Full Chip Erase Time | 25.6 | | | s | | 2 |

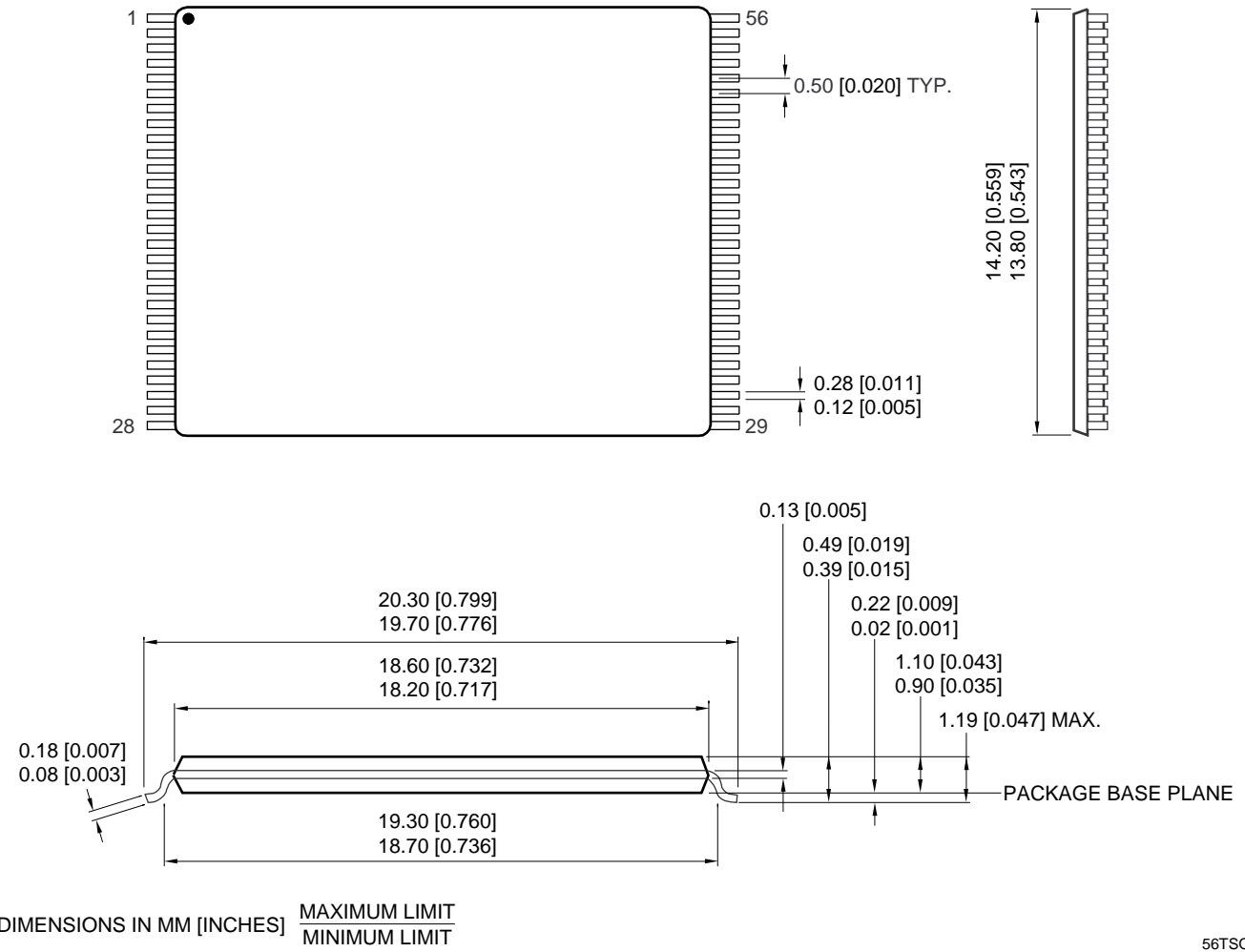
$V_{CC} = 5.0\text{ V} \pm 0.5\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| SYMBOL | PARAMETER | TYP. ⁽¹⁾ | MIN. | MAX. | UNITS | TEST CONDITIONS | NOTE |
|--------------|----------------------|---------------------|------|------|-------|-----------------|------|
| t_{WHRH}^1 | Word/Byte Write Time | 6 | | | μs | | 2 |
| t_{WHRH}^2 | Block Write Time | 0.4 | | 2.1 | s | Byte Write Mode | 2 |
| t_{WHRH}^3 | Block Write Time | 0.2 | | 1.0 | s | Word Write Mode | 2 |
| | Block Erase Time | 0.6 | | 10 | s | | 2 |
| | Full Chip Erase Time | 19.2 | | | s | | 2 |

NOTES:

- 1. 25°C, $V_{PP} = 12.0\text{ V}$ Sampled.
- 2. Excludes System-Level Overhead.

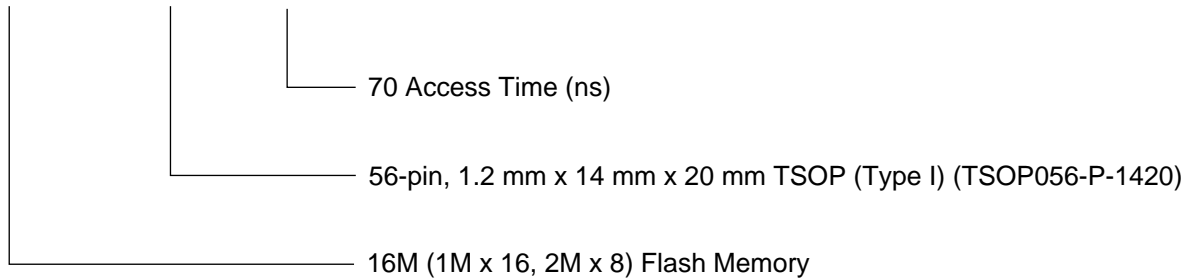
56TSOP (TSOP056-P-1420)



56TSOP

ORDERING INFORMATION

LH28F016SA T -70
Device Type Package Speed



Example: LH28F016SAT-70 (16M (1M x 16, 2M x 8) Flash Memory, 70 ns, 56-pin TSOP)

28F016SAT-17

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