LH28F320S3TD-L10   32 M-bit (2 MB x 8/1 MB x 16 x 2-Bank) Smart 3 Dual Work Flash Memory

DESCRIPTION

The LH28F320S3TD-L10 Dual Work flash memory with Smart 3 technology is a high-density, low-cost, nonvolatile, read/write storage solution for a wide range of applications, having high programming performance is achieved through highly-optimized page buffer operations. Its symmetrically-blocked architecture, flexible voltage and enhanced cycling capability provide for highly flexible component suitable for resident flash arrays, SIMMs and memory cards. Its enhanced suspend capabilities provide for an ideal solution for code + data storage applications. For secure code storage applications, such as networking, where code is either directly executed out of flash or downloaded to DRAM, the LH28F320S3TD-L10 offers three levels of protection : absolute protection with V_{PP} at GND, selective hardware block locking, or flexible software block locking. These alternatives give designers ultimate control of their code security needs. LH28F320S3TD-L10 is conformed to the flash Scalable Command Set (SCS) and the Common Flash Interface (CFI) specification which enable universal and upgradable interface, enable the highest system/device data transfer rates and minimize device and system-level implementation costs.

FEATURES

- Smart 3 Dual Work technology
  - 2.7 V or 3.3 V V_{CC}
  - 2.7 V, 3.3 V or 5 V V_{PP}
  - Capable of performing erase, write and read for each bank independently (Impossible to perform read from both banks at a time).
- High-speed write performance
  - Two 32-byte page buffers/bank
  - 2.7 µs/byte write transfer rate
- Common Flash Interface (CFI)
 - Universal & upgradable interface

- Scalable Command Set (SCS)
- High performance read access time
  - 100 ns (3.3±0.3 V)/120 ns (2.7 to 3.6 V)
- Enhanced automated suspend options
  - Write suspend to read
  - Block erase suspend to write
  - Block erase suspend to read
- Enhanced data protection features
  - Absolute protection with V_{PP} = GND
  - Flexible block locking
  - Erase/write lockout during power transitions
- SRAM-compatible write interface
- User-configurable x8 or x16 operation
- High-density symmetrically-blocked architecture
  - Sixty-four 64 k-byte erasable blocks
- Enhanced cycling capability
  - 100 000 block erase cycles
  - 3.2 million block erase cycles/bank
- Low power management
  - Deep power-down mode
  - Automatic power saving mode decreases Icc in static mode
- Automated write and erase
  - Command user interface
  - Status register
- ETOX$^{TM}*$ V nonvolatile flash technology
- Package
  - 56-pin TSOP Type I (TSOP056-P-1420)
    - Normal bend

∗ ETOX is a trademark of Intel Corporation.

PIN CONNECTIONS

56-PIN TSOP (Type I)   TOP VIEW

Left	Pin		Pin	Right
NC	1		56	WP#
BE$_{1L}$#	2		55	WE#
BE$_{1H}$#	3		54	OE#
A$_{20}$	4		53	STS
A$_{19}$	5		52	DQ$_{15}$
A$_{18}$	6		51	DQ$_7$
A$_{17}$	7		50	DQ$_{14}$
A$_{16}$	8		49	DQ$_6$
V$_{CC}$	9		48	GND
A$_{15}$	10		47	DQ$_{13}$
A$_{14}$	11		46	DQ$_5$
A$_{13}$	12		45	DQ$_{12}$
A$_{12}$	13		44	DQ$_4$
BE$_0$#	14		43	V$_{CC}$
V$_{PP}$	15		42	GND
RP#	16		41	DQ$_{11}$
A$_{11}$	17		40	DQ$_3$
A$_{10}$	18		39	DQ$_{10}$
A$_9$	19		38	DQ$_2$
A$_8$	20		37	V$_{CC}$
GND	21		36	DQ$_9$
A$_7$	22		35	DQ$_1$
A$_6$	23		34	DQ$_8$
A$_5$	24		33	DQ$_0$
A$_4$	25		32	A$_0$
A$_3$	26		31	BYTE#
A$_2$	27		30	NC
A$_1$	28		29	NC
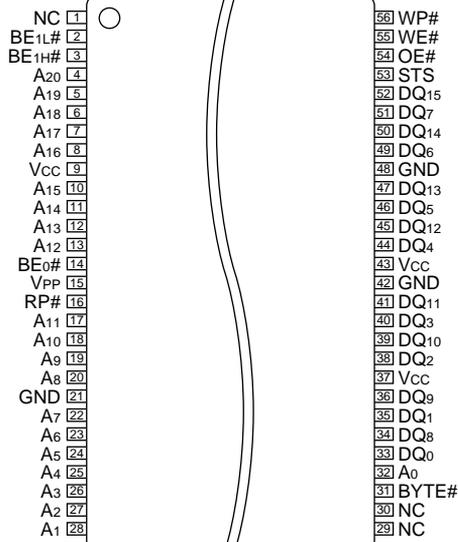
(TSOP056-P-1420)

BLOCK DIAGRAM
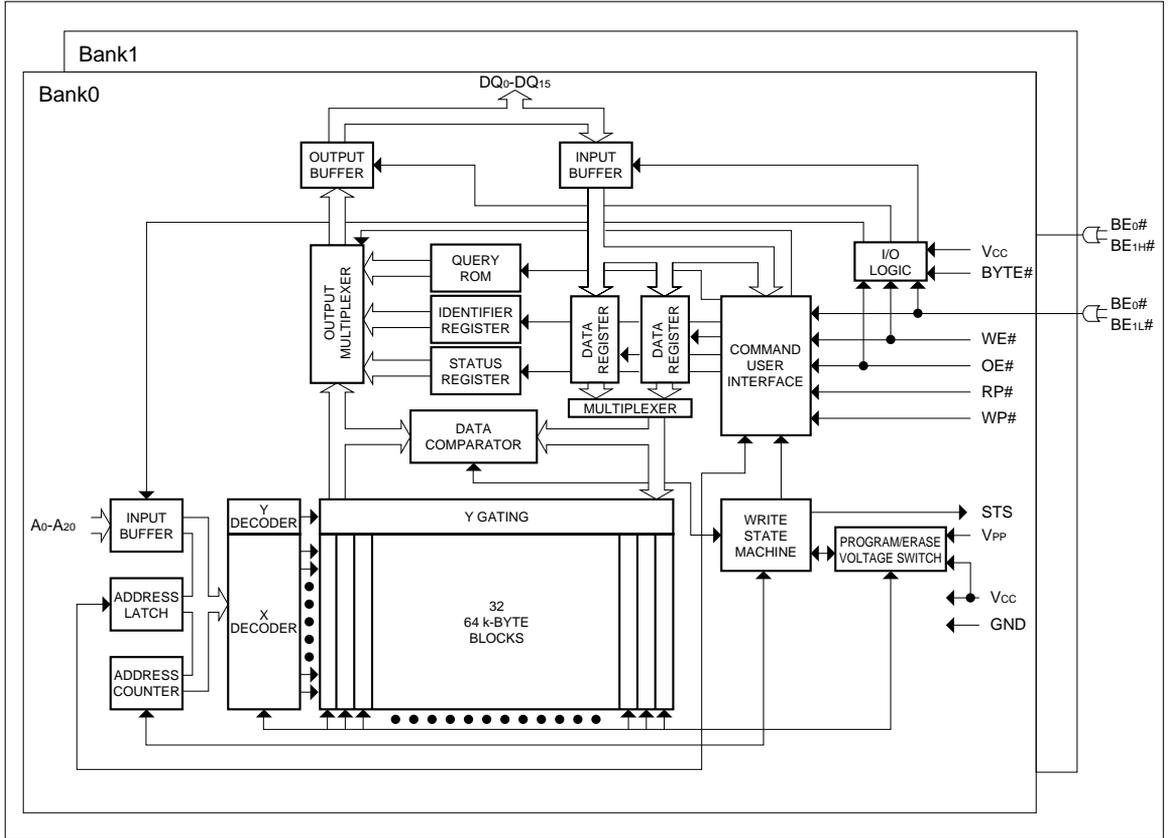
PIN DESCRIPTION

SYMBOL	TYPE	NAME AND FUNCTION
A_0-A_{20}	INPUT	**ADDRESS INPUTS :** Inputs for addresses during read and write operations. Addresses are internally latched during a write cycle. A_0 : Byte Select Address. Not used in x16 mode (can be floated). A_1-A_4 : Column Address. Selects 1 of 16-bit lines. A_5-A_{15} : Row Address. Selects 1 of 2 048-word lines. A_{16}-A_{20} : Block Address.
DQ_0-DQ_{15}	INPUT/ OUTPUT	**DATA INPUT/OUTPUTS :** DQ_0-DQ_7 : Inputs data and commands during CUI write cycles; outputs data during memory array, status register, query, and identifier code read cycles. Data pins float to high-impedance when the chip is deselected or outputs are disabled. Data is internally latched during a write cycle. DQ_8-DQ_{15} : Inputs data during CUI write cycles in x16 mode; outputs data during memory array read cycles in x16 mode; not used for status register, query and identifier code read mode. Data pins float to high-impedance when the chip is deselected, outputs are disabled, or in x8 mode (BYTE# = V_{IL}). Data is internally latched during a write cycle.
BE0#, BE1L#, BE1H#	INPUT	**BANK ENABLE :** Activates the device's control logic, input buffers, decoders, and sense amplifiers. When BE0# and BE1L# "low", bank0 is active. When BE0# and BE1H# are "low", bank1 is in active. BE0# and BE1L#, BE1H# must not be low at the same time.
RP#	INPUT	**RESET/DEEP POWER-DOWN :** Puts the device in deep power-down mode and resets internal automation. RP# V_{IH} enables normal operation. When driven V_{IL}, RP# inhibits write operations which provide data protection during power transitions. Exit from deep power-down sets the device to read array mode.
OE#	INPUT	**OUTPUT ENABLE :** Gates the device's outputs during a read cycle.
WE#	INPUT	**WRITE ENABLE :** Controls writes to the CUI and array blocks. Addresses and data are latched on the rising edge of the WE# pulse.
STS	OPEN DRAIN OUTPUT	**STS (RY/BY#) :** Indicates the status of the internal WSM. When configured in level mode (default mode) , it acts as a RY/BY# pin. When low, the WSM is performing an internal operation (block erase, bank erase, (multi) word/byte write or block lock-bit configuration). STS High Z indicates that the WSM is ready for new commands, block ease is suspended, and (multi) word/byte write is inactive, (multi) word/byte write is suspended or the device is in deep power-down mode. For alternate configurations of the STATUS pin, see the Configuration command (**Table 3** and **Section 4.14**).
WP#	INPUT	**WRITE PROTECT :** Master control for block locking. When V_{IL}, locked blocks can not be erased and programmed, and block lock-bits can not be set and reset.
BYTE#	INPUT	**BYTE ENABLE :** BYTE# V_{IL} places device in x8 mode. All data are then input or output on DQ_{0-7}, and DQ_{8-15} float. BYTE# V_{IH} places the device in x16 mode, and turns off the A_0 input buffer.
V_{PP}	SUPPLY	**BLOCK ERASE, BANK ERASE, (MULTI) WORD/BYTE WRITE, BLOCK LOCK-BIT CONFIGURATION POWER SUPPLY :** For erasing array blocks, writing bytes or configuring block lock-bits. With $V_{PP} \leq V_{PPLK}$, memory contents can not be altered. Block erase, bank erase, word/byte write, and block lock-bit configuration with an invalid V_{PP} (see **Section 6.2.3 "DC CHARACTERISTICS"**) produce spurious results and should not be attempted.
V_{CC}	SUPPLY	**DEVICE POWER SUPPLY :** Internal detection configures the device for 2.7 V or 3.3 V operation. To switch from one voltage to another, ramp V_{CC} down to GND and then ramp V_{CC} to the new voltage. Do not float any power pins. With $V_{CC} \leq V_{LKO}$, all write attempts to the flash memory are inhibited. Device operations at invalid V_{CC} voltage (see **Section 6.2.3 "DC CHARACTERISTICS"**) produce spurious results and should not be attempted.
GND	SUPPLY	**GROUND :** Do not float any ground pins.
NC		**NO CONNECT :** Lead is not internal connected; recommend to be floated.

1 INTRODUCTION

This datasheet contains LH28F320S3TD-L10 specifications. Section 1 provides a flash memory overview. Sections 2, 3, 4, and 5 describe the memory organization and functionality. Section 6 covers electrical specifications. The LH28F320S3TD-L10 flash memory documentation also includes ordering information which is referenced in Section 7.

1.1 Product Overview

The LH28F320S3TD-L10 is a high-performance 32 M-bit Smart 3 Dual Work flash memory organized as 2 MB x8/1 MB x 16 x 2-Bank. The 4 MB of data is arranged in sixty-four 64 k-byte blocks which are individually erasable, lockable, and unlockable in-system. The memory map is shown in **Fig. 1**.

Smart 3 technology provides a choice of V_{CC} and V_{PP} combinations, as shown in **Table 1**, to meet system performance and power expectations. V_{PP} at 2.7 V, 3.3 V and 5 V eliminates the need for a separate 12 V converter. In addition to flexible erase and program voltages, the dedicated V_{PP} pin gives complete data protection when $V_{PP} \le V_{PPLK}$.

Table 1 V_{CC} and V_{PP} Voltage Combinations Offered by Smart 3 Technology

V_{CC} VOLTAGE	V_{PP} VOLTAGE
2.7 V	2.7 V, 3.3 V, 5 V
3.3 V	3.3 V, 5 V

Internal V_{CC} and V_{PP} detection circuitry automatically configures the device for optimized read and write operations.

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, bank erase, (multi) word/byte write and block lock-bit configuration operations.

A block erase operation erases one of the device's 64 k-byte blocks typically within 0.41 second (3.3 V V_{CC}, 5 V V_{PP}) independent of other blocks. Each block can be independently erased 100 000 times (3.2 million block erases per bank). Block erase suspend mode allows system software to suspend block erase to read data from, or write data to any other block.

A word/byte write is performed in byte increments typically within 12.95 μs (3.3 V V_{CC}, 5 V V_{PP}). A multi word/byte write has high speed write performance of 2.7 μs/byte (3.3 V V_{CC}, 5 V V_{PP}). (Multi) word/byte write suspend mode enables the system to read data from, or write data to any other flash memory array location.

Individual block locking uses a combination of bits and WP#, sixty-four block lock-bits per bank, to lock and unlock blocks. Block lock-bits gate block erase, bank erase and (multi) word/byte write operations. Block lock-bit configuration operations (Set Block Lock-Bit and Clear Block Lock-Bits commands) set and cleared block lock-bits.

The status register indicates when the WSM's block erase, bank erase, (multi) word/byte write or block lock-bit configuration operation is finished.

The STS 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 polling using STS minimizes both CPU overhead and system power consumption. STS pin can be configured to different states using the Configuration command. The STS pin defaults to RY/BY# operation. When low, STS indicates that the WSM is performing a block erase, bank erase, (multi) word/byte write or block lock-bit configuration. STS High Z indicates that the WSM is ready for a new command, block erase is suspended and (multi) word/byte write are

inactive, (multi) word/byte write are suspended, or the device is in deep power-down mode. The other 3 alternate configurations are all pulse mode for use as a system interrupt.

The access time is 100 ns (t_{AVQV}) at the V_{CC} supply voltage range of 3.0 to 3.6 V over the temperature range, 0 to +70°C. At 2.7 to 3.6 V V_{CC}, the access time is 120 ns.

The Automatic Power Saving (APS) feature substantially reduces active current when the device is in static mode (addresses not switching). In APS mode, the typical I_{CCR} current is 3 mA at 2.7 V and 3.3 V V_{CC}.

When either BE0# or BE1L#, BE1H# and RP# pins are at V_{CC}, the I_{CC} CMOS standby mode is enabled. When the RP# pin is at GND, deep power-down mode is enabled which minimizes power consumption and provides write protection during reset. A reset time (t_{PHQV}) is required from RP# switching high until outputs are valid. Likewise, the device has a wake time (t_{PHEL}) from RP#-high until writes to the CUI are recognized. With RP# at GND, the WSM is reset and the status register is cleared.

1FFFFF	64 k-Byte Block	31
1F0000		
1EFFFF	64 k-Byte Block	30
1E0000		
1DFFFF	64 k-Byte Block	29
1D0000		
1CFFFF	64 k-Byte Block	28
1C0000		
1BFFFF	64 k-Byte Block	27
1B0000		
1AFFFF	64 k-Byte Block	26
1A0000		
19FFFF	64 k-Byte Block	25
190000		
18FFFF	64 k-Byte Block	24
180000		
17FFFF	64 k-Byte Block	23
170000		
16FFFF	64 k-Byte Block	22
160000		
15FFFF	64 k-Byte Block	21
150000		
14FFFF	64 k-Byte Block	20
140000		
13FFFF	64 k-Byte Block	19
130000		
12FFFF	64 k-Byte Block	18
120000		
11FFFF	64 k-Byte Block	17
110000		
10FFFF	64 k-Byte Block	16
100000		
0FFFFF	64 k-Byte Block	15
0F0000		
0EFFFF	64 k-Byte Block	14
0E0000		
0DFFFF	64 k-Byte Block	13
0D0000		
0CFFFF	64 k-Byte Block	12
0C0000		
0BFFFF	64 k-Byte Block	11
0B0000		
0AFFFF	64 k-Byte Block	10
0A0000		
09FFFF	64 k-Byte Block	9
090000		
08FFFF	64 k-Byte Block	8
080000		
07FFFF	64 k-Byte Block	7
070000		
06FFFF	64 k-Byte Block	6
060000		
05FFFF	64 k-Byte Block	5
050000		
04FFFF	64 k-Byte Block	4
040000		
03FFFF	64 k-Byte Block	3
030000		
02FFFF	64 k-Byte Block	2
020000		
01FFFF	64 k-Byte Block	1
010000		
00FFFF	64 k-Byte Block	0
000000		

Bank0
(BE0# = BE1L# = "L")

Bank1
(BE0# = BE1H# = "L")

Fig. 1   Memory Map

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2 PRINCIPLES OF OPERATION

The LH28F320S3TD-L10 Smart 3 Dual Work flash memory includes an on-chip WSM to manage block erase, bank erase, (multi) word/byte write and block lock-bit configuration functions. It allows for : 100% TTL-level control inputs, fixed power supplies during block erase, bank erase, (multi) word/byte write and block lock-bit configuration, and minimal processor overhead with RAM-like interface timings.

After initial device power-up or return from deep power-down mode (see **Table 2.1** and **Table 2.2 "Bus Operations"**), the device defaults to read array mode. Manipulation of external memory control pins allow array read, standby, and output disable operations.

Status register, query structure and identifier codes can be accessed through the CUI independent of the V_{PP} voltage. High voltage on V_{PP} enables successful block erase, bank erase, (multi) word/byte write and block lock-bit configuration. All functions associated with altering memory contents—lock erase, bank erase, (multi) word/byte write and block lock-bit configuration, status, query and identifier codes—are accessed via the CUI and verified through the status register.

Commands are written using standard micro-processor write timings. The CUI contents serve as input to the WSM, which controls the block erase, bank erase, (multi) word/byte write and block lock-bit configuration. The internal algorithms are regulated by the WSM, including pulse repetition, internal verification, and margining of data. Addresses and data are internally latched during write cycles. Writing the appropriate command outputs array data, accesses the identifier codes, outputs query structure or outputs status register data.

Interface software that initiates and polls progress of block erase, bank erase, (multi) word/byte write and block lock-bit configuration can be stored in any block. This code is copied to and executed from system RAM during flash memory updates. After successful completion, reads are again possible via the Read Array command. Block erase suspend allows system software to suspend a block erase to read/write data from/to blocks other than that which is suspended. Write suspend allows system software to suspend a (multi) word/byte write to read data from any other flash memory array location.

2.1 Data Protection

Depending on the application, the system designer may choose to make the V_{PP} power supply switchable (available only when block erase, bank erase, (multi) word/byte write and block lock-bit configuration are required) or hardwired to $V_{PPH1/2/3}$. The device accommodates either design practice and encourages optimization of the processor-memory interface.

When $V_{PP} \leq V_{PPLK}$, memory contents cannot be altered. The CUI, with multi-step block erase, bank erase, (multi) word/byte write and block lock-bit configuration command sequences, provides protection from unwanted operations even when high voltage is applied to V_{PP}. All write functions are disabled when V_{CC} is below the write lockout voltage V_{LKO} or when RP# is at V_{IL}. The device's block locking capability provides additional protection from inadvertent code or data alteration by gating block erase, bank erase and (multi) word/byte write operations.

3 BUS OPERATION

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.

3.1 Read

Information can be read from any block, identifier codes, query structure, or status register independent of the V_{PP} voltage. RP# must be at V_{IH}.

The first task is to write the appropriate read mode command (Read Array, Read Identifier Codes, Query or Read Status Register) to the CUI. Upon initial device power-up or after exit from deep power-down mode, the device automatically resets to read array mode. Five control pins dictate the data flow in and out of the component : BE# (BE0#, BE1L#, BE1H#), OE#, WE#, RP# and WP#. BE0#, BE1L#, BE1H# and OE# must be driven active to obtain data at the outputs. BE0#, BE1L#, BE1H# is the device selection control, and when active enables the selected memory device. OE# is the data output (DQ0-DQ15) control and when active drives the selected memory data onto the I/O bus. WE# and RP# must be at V_{IH}. **Fig. 15** and **Fig. 16** illustrate a read cycle.

3.2 Output Disable

With OE# at a logic-high level (V_{IH}), the device outputs are disabled. Output pins DQ0-DQ15 are placed in a high-impedance state.

3.3 Standby

Either BE0# or BE1L#, BE1H# at a logic-high level (V_{IH}) places the device in standby mode which substantially reduces device power consumption. DQ0-DQ15 outputs are placed in a high-impedance state independent of OE#. If deselected during block erase, bank erase, (multi) word/byte write and block lock-bit configuration, the device continues functioning, and consuming active power until the operation completes.

3.4 Deep Power-Down

RP# at V_{IL} initiates the deep power-down mode.

In read modes, RP#-low deselects the memory, places output drivers in a high-impedance state and turns off all internal circuits. RP# must be held low for a minimum of 100 ns. Time t_{PHQV} is required after return from power-down 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 80H.

During block erase, bank erase, (multi) word/byte write or block lock-bit configuration modes, RP#-low will abort the operation. STS remains low until the reset operation is complete. Memory contents being altered are no longer valid; the data may be partially erased or written. 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, bank erase, (multi) word/byte write and block lock-bit configuration. If a CPU reset occurs with no flash memory reset, proper CPU initialization may not occur because the flash memory may be providing status information instead of array data. SHARP's flash memories allow proper CPU 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.

3.5 Read Identifier Codes Operation

The read identifier codes operation outputs the manufacture code, device code, block status codes for each block (see **Fig. 2**). Using the manufacture and device codes, the system CPU can automatically match the device with its proper algorithms. The block status codes identify locked or unlocked block setting and erase completed or erase uncompleted condition.
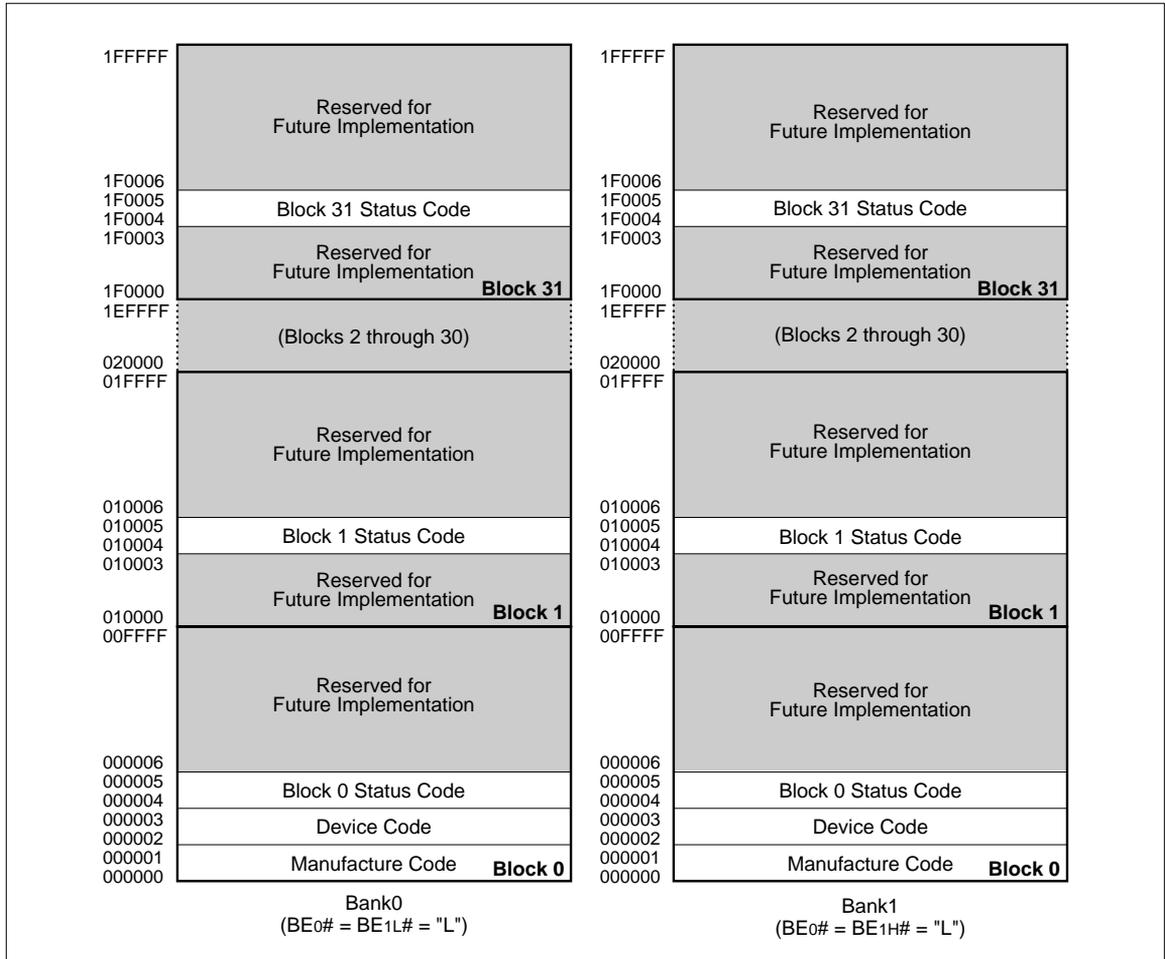
Fig. 2   Device Identifier Code Memory Map

3.6 Query Operation

The query operation outputs the query structure. Query database is stored in the 48-byte ROM per bank. Query structure allows system software to gain critical information for controlling the flash component. Query structures are always presented on the lowest-order data output (DQ0-DQ7) only.

3.7 Write

Writing commands to the CUI enable reading of device data and identifier codes. They also control inspection and clearing of the status register. When $V_{CC} = V_{CC1/2}$ and $V_{PP} = V_{PPH1/2/3}$, the CUI additionally controls block erase, bank erase, (multi) word/byte write and block lock-bit configuration.

The Block Erase command requires appropriate command data and an address within the block to be erased. The Word/Byte Write command requires the command and address of the location to be written. Set Block Lock-Bit command requires the command and block address within the device (Block Lock) 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 WE# and BE# are active. The address and data needed to execute a command are latched on the rising edge of WE# or BE# (whichever goes high first). Standard microprocessor write timings are used. **Fig. 17** and **Fig. 18** illustrate WE# and BE#-controlled write operations.

4 COMMAND DEFINITIONS

When the V_{PP} voltage V_{PPLK}, read operations from the status register, identifier codes, query, or blocks are enabled. Placing $V_{PPH1/2/3}$ on V_{PP} enables successful block erase, bank erase, (multi) word/byte write and block lock-bit configuration operations. Device operations are selected by writing specific commands into the CUI. **Table 3** defines these commands.

Table 2.1   Bus Operations (BYTE# = V_{IH})

MODE		NOTE	RP#	BE0#	BE1L#	BE1H#	OE#	WE#	ADDRESS	V_{PP}	DQ0-15	STS
Read	Bank0	1, 2, 3, 9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IL}	V_{IH}	X	X	D_{OUT}	X
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Disable			V_{IL}	V_{IL}	V_{IL}						
Output Disable		3	V_{IH}	V_{IL}	V_{IL}	V_{IL}	V_{IH}	V_{IH}	X	X	High Z	X
Standby	Bank0	3	V_{IH}	V_{IH}	X	X	X	X	X	X	High Z	X
	Bank1											
	Bank0, 1			V_{IL}	V_{IH}	V_{IH}						
Deep Power-Down		4	V_{IL}	X	X	X	X	X	X	X	High Z	High Z
Read Identifier Codes	Bank0	9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IL}	V_{IH}	See **Fig. 2**	X	(NOTE 5)	High Z
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Disable			V_{IL}	V_{IL}	V_{IL}						
Query		9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IL}	V_{IL}	V_{IH}	See **Table 6 through 10**	X	(NOTE 6)	High Z
Write	Bank0	3, 7, 8, 9	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IH}	V_{IL}	X	X	D_{IN}	X
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Bank0, 1			V_{IL}	V_{IL}	V_{IH}						

NOTES :

1. Refer to **Section 6.2.3 "DC CHARACTERISTICS"**. When $V_{PP} \leq V_{PPLK}$, memory contents can be read, but not altered.

2. X can be V_{IL} or V_{IH} for control pins and addresses, and V_{PPLK} or $V_{PPH1/2/3}$ for V_{PP}. See **Section 6.2.3 "DC CHARACTERISTICS"** for V_{PPLK} and $V_{PPH1/2/3}$ voltages.

3. STS is V_{OL} (if configured to RY/BY# mode) when the WSM is executing internal block erase, bank erase, (multi) word/byte write or block lock-configuration algorithms. It is floated during when the WSM is not busy, in block erase suspend mode with (multi) word/byte write inactive, (multi) word/byte write suspend mode, or deep power-down mode.

4. RP# at GND±0.2 V ensures the lowest deep power-down current.

5. See **Section 4.2** for read identifier code data.

6. See **Section 4.5** for query data.

7. Command writes involving block erase, bank erase, (multi) word/byte write or block lock-bit configuration are reliably executed when $V_{PP} = V_{PPH1/2/3}$ and $V_{CC} = V_{CC1/2}$.

8. Refer to **Table 3** for valid D_{IN} during a write operation.

9. Don't use the timing both OE# and WE# are V_{IL}.

10. Impossible to perform simultaneous read from both banks at a time. Both BE0# and BE1L#, BE1H# must not be low at the same time.

Table 2.2   Bus Operations (BYTE# = V_{IL})

MODE		NOTE	RP#	BE0#	BE1L#	BE1H#	OE#	WE#	ADDRESS	VPP	DQ0-7	STS
Read	Bank0	1, 2, 3, 9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IL}	V_{IH}	X	X	D_{OUT}	X
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Disable			V_{IL}	V_{IL}	V_{IL}						
Output Disable		3	V_{IH}	V_{IL}	V_{IL}	V_{IL}	V_{IH}	V_{IH}	X	X	High Z	X
Standby	Bank0	3	V_{IH}	V_{IH}	X	X	X	X	X	X	High Z	X
	Bank1			V_{IL}	V_{IH}	V_{IH}						
	Bank0, 1											
Deep Power-Down		4	V_{IL}	X	X	X	X	X	X	X	High Z	High Z
Read Identifier Codes	Bank0	9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IL}	V_{IH}	See **Fig. 2**	X	(NOTE 5)	High Z
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Disable			V_{IL}	V_{IL}	V_{IL}						
Query		9, 10	V_{IH}	V_{IL}	V_{IL}	V_{IL}	V_{IL}	V_{IH}	See **Table 6 through 10**	X	(NOTE 6)	High Z
Write	Bank0	3, 7, 8, 9	V_{IH}	V_{IL}	V_{IL}	V_{IH}	V_{IH}	V_{IL}	X	X	D_{IN}	X
	Bank1			V_{IL}	V_{IH}	V_{IL}						
	Bank0, 1			V_{IL}	V_{IL}	V_{IL}						

NOTES :

1. Refer to **Section 6.2.3 "DC CHARACTERISTICS"**. When $V_{PP} \leq V_{PPLK}$, memory contents can be read, but not altered.

2. X can be V_{IL} or V_{IH} for control pins and addresses, and V_{PPLK} or $V_{PPH1/2/3}$ for V_{PP}. See **Section 6.2.3 "DC CHARACTERISTICS"** for V_{PPLK} and $V_{PPH1/2/3}$ voltages.

3. STS is V_{OL} (if configured to RY/BY# mode) when the WSM is executing internal block erase, bank erase, (multi) word/byte write or block lock-configuration algorithms. It is floated during when the WSM is not busy, in block erase suspend mode with (multi) word/byte write inactive, (multi) word/byte write suspend mode, or deep power-down mode.

4. RP# at GND±0.2 V ensures the lowest deep power-down current.

5. See **Section 4.2** for read identifier code data.

6. See **Section 4.5** for query data.

7. Command writes involving block erase, bank erase, (multi) word/byte write or block lock-bit configuration are reliably executed when $V_{PP} = V_{PPH1/2/3}$ and $V_{CC} = V_{CC1/2}$.

8. Refer to **Table 3** for valid D_{IN} during a write operation.

9. Don't use the timing both OE# and WE# are V_{IL}.

10. Impossible to perform simultaneous read from both banks at a time. Both BE0# and BE1L#, BE1H# must not be low at the same time.

Table 3 Command Definitions [NOTE 10]

COMMAND	BUS CYCLES REQ'D.	NOTE	FIRST BUS CYCLE			SECOND BUS CYCLE		
			Oper [NOTE 1]	Addr [NOTE 2]	Data [NOTE 3]	Oper [NOTE 1]	Addr [NOTE 2]	Data [NOTE 3]
Read Array/Reset	1		Write	X	FFH			
Read Identifier Codes	≥ 2	4	Write	X	90H	Read	IA	ID
Query	≥ 2		Write	X	98H	Read	QA	QD
Read Status Register	2		Write	X	70H	Read	X	SRD
Clear Status Register	1		Write	X	50H			
Block Erase Setup/Confirm	2	5	Write	BA	20H	Write	BA	D0H
Bank Erase Setup/Confirm	2		Write	X	30H	Write	X	D0H
Word/Byte Write Setup/Write	2	5, 6	Write	WA	40H	Write	WA	WD
Alternate Word/Byte Write Setup/Write	2	5, 6	Write	WA	10H	Write	WA	WD
Multi Word/Byte Write Setup/Confirm	≥ 4	9	Write	WA	E8H	Write	WA	N–1
Block Erase and (Multi) Word/Byte Write Suspend	1	5	Write	X	B0H			
Confirm and Block Erase and (Multi) Word/Byte Write Resume	1	5	Write	X	D0H			
Block Lock-Bit Set Setup/Confirm	2	7	Write	BA	60H	Write	BA	01H
Block Lock-Bit Reset Setup/Confirm	2	8	Write	X	60H	Write	X	D0H
STS Configuration Level-Mode for Erase and Write (RY/BY# Mode)	2		Write	X	B8H	Write	X	00H
STS Configuration Pulse-Mode for Erase	2		Write	X	B8H	Write	X	01H
STS Configuration Pulse-Mode for Write	2		Write	X	B8H	Write	X	02H
STS Configuration Pulse-Mode for Erase and Write	2		Write	X	B8H	Write	X	03H

NOTES :

1. BUS operations are defined in **Table 2.1** and **Table 2.2**.
2. X = Any valid address within the device.
   IA = Identifier code address : see **Fig. 2**.
   QA = Query offset address.
   BA = Address within the block being erased or locked.
   WA = Address of memory location to be written.
3. SRD = Data read from status register. See **Table 13.1** for a description of the status register bits.
   WD = Data to be written at location WA. Data is latched on the rising edge of WE# or BE# (whichever goes high first).
   ID = Data read from identifier codes.
   QD = Data read from query database.
4. Following the Read Identifier Codes command, read operations access manufacture, device and block status codes. See **Section 4.2** for read identifier code data.

5. If the block is locked, WP# must be at V_{IH} to enable block erase or (multi) word/byte write operations. Attempts to issue a block erase or (multi) word/byte write to a locked block while RP# is V_{IH}.
6. Either 40H or 10H is recognized by the WSM as the byte write setup.
7. A block lock-bit can be set while WP# is V_{IH}.
8. WP# must be at V_{IH} to clear block lock-bits. The clear block lock-bits operation simultaneously clears all block lock-bits.
9. Following the Third Bus Cycle, inputs the write address and write data of "N" times. Finally, input the confirm command "D0H".
10. Commands other than those shown above are reserved by SHARP for future device implementations and should not be used.

4.1 Read Array Command

Upon initial device power-up and after exit from deep power-down mode, the device defaults to read array mode. This operation is also initiated by writing the Read Array command. The device remains enabled for reads until another command is written. Once the internal WSM has started a block erase, bank erase, (multi) word/byte write or block 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 Suspend and (Multi) Word/Byte Write Suspend command. The Read Array command functions independently of the V_{PP} voltage and RP# must be V_{IH}.

4.2 Read Identifier Codes Command

The identifier code operation is initiated by writing the Read Identifier Codes command. Following the command write, read cycles from addresses shown in **Fig. 2** retrieve the manufacture, device, block lock configuration and block erase status (see **Table 4** for identifier code values). To terminate the operation, write another valid command. Like the Read Array command, the Read Identifier Codes command functions independently of the V_{PP} voltage and RP# must be V_{IH}. Following the Read Identifier Codes command, the following information can be read :

Table 4   Identifier Codes

CODE	ADDRESS	DATA
Manufacture Code	00000H 00001H	B0
Device Code	00002H 00003H	D0
Block Status Code	X0004H (NOTE 1) X0005H (NOTE 1)	
• Block is Unlocked		$DQ_0 = 0$
• Block is Locked		$DQ_0 = 1$
• Last erase operation completed successfully		$DQ_1 = 0$
• Last erase operation did not completed successfully		$DQ_1 = 1$
• Reserved for Future Use		DQ_{2-7}

NOTE :
1. X selects the specific block status code to be read. See **Fig. 2** for the device identifier code memory map.

4.3 Read Status Register Command

The status register may be read to determine when a block erase, bank erase, (multi) word/byte write or block lock-bit configuration is complete and whether the operation completed successfully (see **Table 13.1**). It may be read at any time by writing the Read Status Register command. After writing this command, all subsequent read operations output data from the status register until another valid command is written. The status register contents are latched on the falling edge of OE# or BE0# or BE1# (Either BE1L# or BE1H#), whichever occurs. OE# or BE0# or BE1# (Either BE1L# or BE1H#) must toggle to V_{IH} before further reads to update the status register latch. The Read Status Register command functions independently of the V_{PP} voltage. RP# must be V_{IH}.

The extended status register may be read to determine multi byte write availability (see **Table 13.2**). The extended status register may be read at any time by writing the Multi Byte Write command. After writing this command, all subsequent read operations output data from the extended status register, until another valid command is written. The contents of the extended status register are latched on the falling edge of OE# or BE0# or BE1# (Either BE1L# or BE1H#), whichever occurs last in the read cycle. Multi Byte Write command must be re-issued to update the extended status register latch.

4.4 Clear Status Register Command

Status register bits SR.5, SR.4, SR.3 and SR.1 are set to "1"s by the WSM and can only be reset by the Clear Status Register command. These bits indicate various failure conditions (see **Table 13.1**). By allowing system software to reset these bits, several operations (such as cumulatively erasing or locking multiple blocks or writing several bytes in

sequence) may be performed. The status register may be polled to determine if an error occurs during the sequence.

To clear the status register, the Clear Status Register command (50H) is written. It functions independently of the applied V_{PP} voltage. RP# must be V_{IH}. This command is not functional during block erase, bank erase, (multi) word/byte write, block lock-bit configuration, block erase suspend or (multi) word/byte write suspend modes.

4.5   Query Command

Query database of each bank can be read by writing Query command (98H). Following the command write, read cycle from address shown in **Table 6 through Table 10** retrieve the critical information to write, erase and otherwise control the flash component. A_0 of query offset address is ignored when x8 mode (BYTE# = V_{IL}).

Query data of each bank are always presented on the low-byte data output (DQ0-DQ7). In x16 mode, high-byte (DQ8-DQ15) outputs 00H. The bytes not

assigned to any information or reserved for future use are set to "0". This command functions independently of the V_{PP} voltage. RP# must be V_{IH}.

Table 5   Example of Query Structure Output

MODE	OFFSET ADDRESS	OUTPUT	
		DQ15-8	DQ7-0
x8 mode	A_5, A_4, A_3, A_2, A_1, A_0		
	1, 0, 0, 0, 0, 0 (20H)	High Z	"Q"
	1, 0, 0, 0, 0, 1 (21H)	High Z	"Q"
	1, 0, 0, 0, 1, 0 (22H)	High Z	"R"
	1, 0, 0, 0, 1, 1 (23H)	High Z	"R"
x16 mode	A_5, A_4, A_3, A_2, A_1		
	1, 0, 0, 0, 0 (10H)	00H	"Q"
	1, 0, 0, 0, 1 (11H)	00H	"R"

4.5.1 BLOCK STATUS REGISTER

This field provides lock configuration and erase status for the specified block. These informations are only available when device is ready (SR.7 = 1). If block erase or bank erase operation is finished irregularly, block erase status bit will be set to "1". If bit 1 is "1", this block is invalid.

Table 6   Query Block Status Register

OFFSET (Word Address)	LENGTH	DESCRIPTION
(BA+2)H	01H	Block Status Register
		bit0 Block Lock Configuration
		0 = Block is unlocked
		1 = Block is locked
		bit1 Block Erase Status
		0 = Last erase operation completed successfully
		1 = Last erase operation not completed successfully
		bit2-7 Reserved for future use

NOTE :
1.   BA = The beginning of a Block Address.

4.5.2 CFI QUERY IDENTIFICATION STRING

The identification string provides verification that the component supports the Common Flash Interface specification. Additionally, it indicates which version of the spec and which vendor-specified command set(s) is(are) supported.

Table 7   CFI Query Identification String

OFFSET (Word Address)	LENGTH	DESCRIPTION
10H, 11H, 12H	03H	Query Unique ASCII string "QRY" 51H, 52H, 59H
13H, 14H	02H	Primary Vendor Command Set and Control Interface ID Code 01H, 00H (SCS ID Code)
15H, 16H	02H	Address for Primary Algorithm Extended Query Table 31H, 00H (SCS Extended Query Table Offset)
17H, 18H	02H	Alternate Vendor Command Set and Control Interface ID Code 0000H (0000H means that no alternate exists)
19H, 1AH	02H	Address for Alternate Algorithm Extended Query Table 0000H (0000H means that no alternate exists)

4.5.3 SYSTEM INTERFACE INFORMATION

The following device information can be useful in optimizing system interface software.

Table 8   System Information String

OFFSET (Word Address)	LENGTH	DESCRIPTION
1BH	01H	V_{CC} Logic Supply Minimum Write/Erase voltage 27H (2.7 V)
1CH	01H	V_{CC} Logic Supply Maximum Write/Erase voltage 55H (5.5 V)
1DH	01H	V_{PP} Programming Supply Minimum Write/Erase voltage 27H (2.7 V)
1EH	01H	V_{PP} Programming Supply Maximum Write/Erase voltage 55H (5.5 V)
1FH	01H	Typical Time-Out per Single Byte/Word Write 03H ($2^3 = 8$ µs)
20H	01H	Typical Time-Out for Maximum Size Buffer Write (32 Bytes) 06H ($2^6 = 64$ µs)
21H	01H	Typical Time-Out per Individual Block Erase 0AH (0AH = 10, $2^{10} = 1\,024$ ms)
22H	01H	Typical Time-Out for Bank Erase 0FH (0FH = 15, $2^{15} = 32\,768$ ms)
23H	01H	Maximum Time-Out per Single Byte/Word Write, 2^N times of typical. 04H ($2^4 = 16$, 8 µs x 16 = 128 µs)
24H	01H	Maximum Time-Out per Maximum Size Buffer Write, 2^N times of typical. 04H ($2^4 = 16$, 64 µs x 16 = 1 024 µs)
25H	01H	Maximum Time-Out per Individual Block Erase, 2^N times of typical. 04H ($2^4 = 16$, 1 024 ms x 16 = 16 384 ms)
26H	01H	Maximum Time-Out for Bank Erase, 2^N times of typical. 04H ($2^4 = 16$, 32 768 ms x 16 = 524 288 ms)

4.5.4 DEVICE GEOMETRY DEFINITION

This field provides critical details of the flash device geometry.

Table 9   Device Geometry Definition

OFFSET (Word Address)	LENGTH	DESCRIPTION
27H	01H	Device Size 15H (15H = 21, 2^{21} = 2 097 152 = 2 M Bytes)
28H, 29H	02H	Flash Device Interface Description 02H, 00H (x8/x16 supports x8 and x16 via BYTE#)
2AH, 2BH	02H	Maximum Number of Bytes in Multi Word/Byte Write 05H, 00H (2^5 = 32 Bytes)
2CH	01H	Number of Erase Block Regions within Device 01H (symmetrically blocked)
2DH, 2EH	02H	The Number of Erase Blocks 1FH, 00H (1FH = 31 $\Rightarrow$ 31 + 1 = 32 Blocks)
2FH, 30H	02H	The Number of "256 Bytes" Cluster in a Erase Block 00H, 01H (0100H = 256 $\Rightarrow$ 256 Bytes x 256 = 64 k Bytes in a Erase Block)

4.5.5 SCS OEM SPECIFIC EXTENDED QUERY TABLE

Certain flash features and commands may be optional in a vendor-specific algorithm specification. The optional vendor-specific query table(s) may be used to specify this and other types of information. These structures are defined solely by the flash vendor(s).

Table 10   SCS OEM Specific Extended Query Table

OFFSET (Word Address)	LENGTH	DESCRIPTION
31H, 32H, 33H	03H	PRI 50H, 52H, 49H
34H	01H	31H (1) Major Version Number , ASCII
35H	01H	30H (0) Minor Version Number, ASCII

36H, 37H, 38H, 39H	04H	0FH, 00H, 00H, 00H
		Optional Command Support
		    bit0 = 1 : Bank Erase Supported
		    bit1 = 1 : Suspend Erase Supported
		    bit2 = 1 : Suspend Write Supported
		    bit3 = 1 : Lock/Unlock Supported
		    bit4 = 0 : Queued Erase Not Supported
		    bit5-31 = 0 : Reserved for future use

3AH	01H	01H
		Supported Functions after Suspend
		    bit0 = 1 : Write Supported after Erase Suspend
		    bit1-7 = 0 : Reserved for future use

3BH, 3CH	02H	03H, 00H
		Block Status Register Mask
		    bit0 = 1 : Block Status Register Lock Bit [BSR.0] active
		    bit1 = 1 : Block Status Register Valid Bit [BSR.1] active
		    bit2-15 = 0 : Reserved for future use

3DH	01H	V_{CC} Logic Supply Optimum Write/Erase voltage (highest performance) 50H (5.0 V)
3EH	01H	V_{PP} Programming Supply Optimum Write/Erase voltage (highest performance) 50H (5.0 V)
3FH	reserved	Reserved for future versions of the SCS specification

4.6 Block Erase Command

Block 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 appropriate sequencing and an 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 status register data when read (see **Fig. 3**). The CPU can detect block erase completion by analyzing the output data of the STS pin or status register bit SR.7.

When the block erase is complete, status register bit SR.5 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 set-up followed by execution ensures that block contents are not accidentally erased. An invalid Block Erase command sequence will result in both status register bits SR.4 and SR.5 being set to "1". Also, reliable block erasure can only occur when V_{CC} = $V_{CC1/2}$ and V_{PP} = $V_{PPH1/2/3}$. In the absence of this high voltage, block contents are protected against erasure. If block erase is attempted while $V_{PP} \leq V_{PPLK}$, SR.3 and SR.5 will be set to "1". Successful block erase requires that the corresponding block lock-bit be cleared or if set, that WP# = V_{IH}. If block erase is attempted when the corresponding block lock-bit is set and WP# = V_{IL}, SR.1 and SR.5 will be set to "1".

4.7 Bank Erase Command

This command followed by a confirm command (D0H) erases all of the unlocked blocks. A bank erase setup is first written, followed by a bank erase confirm. After a confirm command is written, device erases the all unlocked blocks from block 0 to block 31 block by block. This command sequence requires appropriate sequencing. Block preconditioning, erase and verify are handled internally by the WSM (invisible to the system). After the two-cycle bank erase sequence is written, the device automatically outputs status register data when read (see **Fig. 4**). The CPU can detect bank erase completion by analyzing the output data of the STS pin or status register bit SR.7.

When the bank erase is complete, status register bit SR.5 should be checked. If 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. If error is detected on a block during bank erase operation, WSM stops erasing. Reading the block valid status by issuing Read ID Codes command or Query command informs which blocks failed to its erase.

This two-step command sequence of set-up followed by execution ensures that block contents are not accidentally erased. An invalid Bank Erase command sequence will result in both status register bits SR.4 and SR.5 being set to "1". Also, reliable bank erasure can only occur when V_{CC} = $V_{CC1/2}$ and V_{PP} = $V_{PPH1/2/3}$. In the absence of this high voltage, block contents are protected against erasure. If bank erase is attempted while $V_{PP} \leq V_{PPLK}$, SR.3 and SR.5 will be set to "1". When WP# = V_{IH}, all blocks are erased independent of block lock-bits status. When WP# = V_{IL}, only unlocked blocks are erased. In this case, SR.1 and SR.4 will not be set to "1". Bank erase can not be suspended.

4.8 Word/Byte Write Command

Word/byte write is executed by a two-cycle command sequence. Word/Byte Write setup (standard 40H or alternate 10H) 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 word/byte write and write verify algorithms internally. After the word/byte write sequence is written, the device automatically outputs status register data when read (see **Fig. 5**). The CPU can detect the completion of the word/byte write event by analyzing the STS pin or status register bit SR.7.

When word/byte write is complete, status register bit SR.4 should be checked. If word/byte write error is detected, the status register should be cleared. The internal WSM verify only detects errors for "1"s that do not successfully write to "0"s. The CUI remains in read status register mode until it receives another command.

Reliable word/byte writes can only occur when $V_{CC} = V_{CC1/2}$ and $V_{PP} = V_{PPH1/2/3}$. In the absence of this high voltage, memory contents are protected against word/byte writes. If word/byte write is attempted while $V_{PP} \leq V_{PPLK}$, status register bits SR.3 and SR.4 will be set to "1". Successful word/byte write requires that the corresponding block lock-bit be cleared or, if set, that WP# = V_{IH}. If word/byte write is attempted when the corresponding block lock-bit is set and WP# = V_{IL}, SR.1 and SR.4 will be set to "1". Word/byte write operations with $V_{IL} <$ WP# $< V_{IH}$ produce spurious results and should not be attempted.

4.9 Multi Word/Byte Write Command

Multi word/byte write is executed by at least four-cycle or up to 35-cycle command sequence. Up to 32 bytes in x8 mode (16 words in x16 mode) can be loaded into the buffer and written to the flash array. First, multi word/byte write setup (E8H) is written with the write address. At this point, the device automatically outputs extended status register data (XSR) when read (see **Fig. 6** and **Fig. 7**). If extended status register bit XSR.7 is 0, no Multi Word/Byte Write command is available and multi word/byte write setup which just has been written is ignored. To retry, continue monitoring XSR.7 by writing multi word/byte write setup with write address until XSR.7 transitions to "1". When XSR.7 transitions to "1", the device is ready for loading the data to the buffer. A word/byte count (N)−1 is written with write address. After writing a word/byte count (N)−1, the device automatically turns back to output status register data. The word/byte count (N)−1 must be less than or equal to 1FH in x8 mode (0FH in x16 mode). On the next write, device start address is written with buffer data. Subsequent writes provide additional device address and data, depending on the count. All subsequent address must lie within the start address plus the count. After the final buffer data is written, write confirm (D0H) must be written. This initiates WSM to begin copying the buffer data to the flash array. An invalid Multi Word/Byte Write command sequence will result in both status register bits SR.4 and SR.5 being set to "1". For additional multi word/byte write, write another multi word/byte write setup and check XSR.7. The Multi Word/Byte Write command can be queued while WSM is busy as long as XSR.7 indicates "1", because LH28F320S3TD-L10 has two buffers. If an error occurs while writing, the device will stop writing and flush next Multi Word/Byte Write command loaded in Multi Word/Byte Write command. Status register bit SR.4 will be set to "1". No Multi Word/Byte Write command is available if either SR.4 or SR.5 is set to "1". SR.4 and SR.5 should be cleared before issuing Multi Word/Byte Write command. If a Multi Word/Byte Write command is attempted past an erase block boundary, the device will write the data to flash array up to an erase block boundary and then stop writing. Status register bits SR.4 and SR.5 will be set to "1".

Reliable multi byte writes can only occur when V_{CC} = $V_{CC1/2}$ and V_{PP} = $V_{PPH1/2/3}$. In the absence of this high voltage, memory contents are protected against multi word/byte writes. If multi word/byte write is attempted while $V_{PP} \leq V_{PPLK}$, status register bits SR.3 and SR.4 will be set to "1". Successful multi word/byte write requires that the corresponding block lock-bit be cleared or, if set, that WP# = V_{IH}. If multi byte write is attempted when the corresponding block lock-bit is set and WP# = V_{IL}, SR.1 and SR.4 will be set to "1".

4.10 Block Erase Suspend Command

The Block Erase Suspend command allows block erase interruption to read or (multi) word/byte write 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 status register data when read after the Block Erase Suspend command is written. Polling status register bits SR.7 and SR.6 can determine when the block erase operation has been suspended (both will be set to "1"). STS will also transition to High Z. Specification t_{WHRH2} 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 (Multi) Word/Byte Write command sequence can also be issued during erase suspend to program data in other blocks. Using the (Multi) Word/Byte Write Suspend command (see **Section 4.11**), a (multi) word/byte write operation can also be suspended. During a (multi) word/byte write operation with block erase suspended, status register bit SR.7 will return to "0" and the STS (if set to RY/BY#) output will transition to V_{OL}. However, SR.6 will remain "1" to indicate block erase suspend status.

The only other valid commands while block erase is

suspended are Read Status Register and Block Erase Resume. After a Block Erase Resume command is written to the flash memory, the WSM will continue the block erase process. Status register bits SR.6 and SR.7 will automatically clear and STS will return to V_{OL}. After the Erase Resume command is written, the device automatically outputs status register data when read (see **Fig. 8**). V_{PP} must remain at $V_{PPH1/2/3}$ (the same V_{PP} level used for block erase) while block erase is suspended. RP# must also remain at V_{IH}. Block erase cannot resume until (multi) word/byte write operations initiated during block erase suspend have completed.

4.11 (Multi) Word/Byte Write Suspend Command

The (Multi) Word/Byte Write Suspend command allows (multi) word/byte write interruption to read data in other flash memory locations. Once the (multi) word/byte write process starts, writing the (Multi) Word/Byte Write Suspend command requests that the WSM suspend the (multi) word/byte write sequence at a predetermined point in the algorithm. The device continues to output status register data when read after the (Multi) Word/Byte Write Suspend command is written. Polling status register bits SR.7 and SR.2 can determine when the (multi) word/byte write operation has been suspended (both will be set to "1"). STS will also transition to High Z. Specification t_{WHRH1} defines the (multi) word/byte write 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 (multi) word/byte write is suspended are Read Status Register and (Multi) Word/Byte Write Resume. After (Multi) Word/Byte Write Resume command is written to the flash memory, the WSM will continue the (multi) word/byte write process. Status register bits SR.2

and SR.7 will automatically clear and STS will return to V_{OL}. After the (Multi) Word/Byte Write command is written, the device automatically outputs status register data when read (see **Fig. 9**). V_{PP} must remain at $V_{PPH1/2/3}$ (the same V_{PP} level used for (multi) word/byte write) while in (multi) word/byte write suspend mode. WP# must also remain at V_{IH} or V_{IL}.

4.12 Set Block Lock-Bit Command

A flexible block locking and unlocking scheme is enabled via block lock-bits. The block lock-bits gate program and erase operations. With WP# = V_{IH}, individual block lock-bits can be set using the Set Block Lock-Bit command. See **Table 12** for a summary of hardware and software write protection options.

Set block lock-bit is executed by a two-cycle command sequence. The set block lock-bit setup along with appropriate block or device address is written followed by either the set block lock-bit confirm (and an address within the block to be locked). The WSM then controls the set block lock-bit algorithm. After the sequence is written, the device automatically outputs status register data when read (see **Fig. 10**). The CPU can detect the completion of the set block lock-bit event by analyzing the STS pin output or status register bit SR.7.

When the set block lock-bit operation is complete, status register bit SR.4 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 set-up followed by execution ensures that block lock-bits are not accidentally set. An invalid Set Block Lock-Bit command will result in status register bits SR.4 and SR.5 being set to "1". Also, reliable operations occur only when $V_{CC} = V_{CC1/2}$ and $V_{PP} = V_{PPH1/2/3}$.

In the absence of this high voltage, block lock-bit contents are protected against alteration.

A successful set block lock-bit operation requires WP# = V_{IH}. If it is attempted with WP# = V_{IL}, SR.1 and SR.4 will be set to "1" and the operation will fail. Set block lock-bit operations with WP# < V_{IH} produce spurious results and should not be attempted.

4.13 Clear Block Lock-Bits Command

All set block lock-bits are cleared in parallel via the Clear Block Lock-Bits command. With WP# = V_{IH}, block lock-bits can be cleared using only the Clear Block Lock-Bits command. See **Table 12** for a summary of hardware and software write protection options.

Clear block lock-bits operation is executed by a two-cycle command sequence. A clear block lock-bits setup is first written. After the command is written, the device automatically outputs status register data when read (see **Fig. 11**). The CPU can detect completion of the clear block lock-bits event by analyzing the STS pin output or status register bit SR.7.

When the operation is complete, status register bit SR.5 should be checked. If a clear block lock-bits 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 set-up followed by execution ensures that block lock-bits are not accidentally cleared. An invalid Clear Block Lock-Bits command sequence will result in status register bits SR.4 and SR.5 being set to "1". Also, a reliable clear block lock-bits operation can only occur when $V_{CC} = V_{CC1/2}$ and $V_{PP} = V_{PPH1/2/3}$. If a clear block lock-bits operation is attempted while $V_{PP} \leq V_{PPLK}$, SR.3 and SR.5 will be set to "1". In the absence of this high voltage, the block lock-bit contents are

protected against alteration. A successful clear block lock-bits operation requires WP# = V$_{IH}$. If it is attempted with WP# = V$_{IL}$, SR.1 and SR.5 will be set to "1" and the operation will fail. Clear block lock-bits operation with V$_{IH}$ < RP# produce spurious results and should not be attempted.

If a clear block lock-bits operation is aborted due to V$_{PP}$ or V$_{CC}$ transition out of valid range or RP# active transition, 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.

4.14 STS Configuration Command

The Status (STS) pin can be configured to different states using the STS Configuration command. Once the STS pin has been configured, it remains in that configuration until another configuration command is issued, the device is powered down or RP# is set to V$_{IL}$. Upon initial device power-up and after exit from deep power-down mode, the STS pin defaults to RY/BY# operation where STS low indicates that the WSM is busy. STS High Z indicates that the WSM is ready for a new operation.

To reconfigure the STS pin to other modes, the STS Configuration is issued followed by the appropriate configuration code. The three alternate configurations are all pulse mode for use as a system interrupt. The STS Configuration command functions independently of the V$_{PP}$ voltage and RP# must be V$_{IH}$.

Table 11   STS Configuration Coding Description

CONFIGURATION BITS	EFFECTS
00H	Set STS pin to default level mode (RY/BY#). RY/BY# in the default level-mode of operation will indicate WSM status condition.
01H	Set STS pin to pulsed output signal for specific erase operation. In this mode, STS provides low pulse at the completion of Block Erase, Bank Erase and Clear Block Lock-Bits operations.
02H	Set STS pin to pulsed output signal for a specific write operation. In this mode, STS provides low pulse at the completion of (Multi) Byte Write and Set Block Lock-Bit operation.
03H	Set STS pin to pulsed output signal for specific write and erase operation. STS provides low pulse at the completion of Block Erase, Bank Erase, (Multi) Word/Byte Write and Block Lock-Bit Configuration operations.

Table 12   Write Protection Alternatives

OPERATION	BLOCK LOCK-BIT	WP#	EFFECT
Block Erase or (Multi) Word/Byte Write	0	V$_{IL}$ or V$_{IH}$	Block Erase and (Multi) Word/Byte Write Enabled
	1	V$_{IL}$	Block is Locked. Block Erase and (Multi) Word/Byte Write Disabled
		V$_{IH}$	Block Lock-Bit Override. Block Erase and (Multi) Word/Byte Write Enabled
Bank Erase	0, 1	V$_{IL}$	All unlocked blocks are erased, locked blocks are not erased
	X	V$_{IH}$	All blocks are erased
Set Block Lock-Bit	X	V$_{IL}$	Set Block Lock-Bit Disabled
		V$_{IH}$	Set Block Lock-Bit Enabled
Clear Block Lock-Bits	X	V$_{IL}$	Clear Block Lock-Bits Disabled
		V$_{IH}$	Clear Block Lock-Bits Enabled

Table 13.1 Status Register Definition

WSMS	BESS	ECBLBS	WSBLBS	VPPS	WSS	DPS	R
7	6	5	4	3	2	1	0

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

SR.6 = BLOCK ERASE SUSPEND STATUS (BESS)
   1 = Block Erase Suspended
   0 = Block Erase in Progress/Completed

SR.5 = ERASE AND CLEAR BLOCK LOCK-BITS STATUS
      (ECBLBS)
   1 = Error in Erase or Clear Block Lock-Bits
   0 = Successful Erase or Clear Block Lock-Bits

SR.4 = WRITE AND SET BLOCK LOCK-BIT STATUS
      (WSBLBS)
   1 = Error in Write or Set Block Lock-Bit
   0 = Successful Write or Set Block Lock-Bit

SR.3 = VPP STATUS (VPPS)
   1 = VPP Low Detect, Operation Abort
   0 = VPP OK

SR.2 = WRITE SUSPEND STATUS (WSS)
   1 = Write Suspended
   0 = Write in Progress/Completed

SR.1 = DEVICE PROTECT STATUS (DPS)
   1 = Block Lock-Bit and/or WP# Lock Detected,
      Operation Abort
   0 = Unlock

SR.0 = RESERVED FOR FUTURE ENHANCEMENTS (R)

NOTES :
Check STS or SR.7 to determine block erase, bank erase, (multi) word/byte write or block lock-bit configuration completion.
SR.6-0 are invalid while SR.7 = "0".

If both SR.5 and SR.4 are "1"s after a block erase, bank erase, (multi) word/byte write, block lock-bit configuration or STS configuration attempt, an improper command sequence was entered.

SR.3 does not provide a continuous indication of V_{PP} level. The WSM interrogates and indicates the V_{PP} level only after block erase, bank erase, (multi) word/byte write or block lock-bit configuration command sequences. SR.3 is not guaranteed to reports accurate feedback only when $V_{PP} \neq V_{PPH1/2/3}$.

SR.1 does not provide a continuous indication of block lock-bit values. The WSM interrogates block lock-bit, and WP# only after block erase, bank erase, (multi) word/byte write or block lock-bit configuration command sequences. It informs the system, depending on the attempted operation, if the block lock-bit is set and/or WP# is not V_{IH}. Reading the block lock configuration codes after writing the Read Identifier Codes command indicates block lock-bit status.

SR.0 is reserved for future use and should be masked out when polling the status register.

Table 13.2 Extended Status Register Definition

SMS	R	R	R	R	R	R	R
7	6	5	4	3	2	1	0

XSR.7 = STATE MACHINE STATUS (SMS)
   1 = Multi Word/Byte Write available
   0 = Multi Word/Byte Write not available
XSR.6-0 = RESERVED FOR FUTURE ENHANCEMENTS (R)

NOTES :
After issue a Multi Word/Byte Write command : XSR.7 indicates that a next Multi Word/Byte Write command is available.

XSR.6-0 are reserved for future use and should be masked out when polling the extended status register.

Start

Write 70H

Read Status Register

SR.7 =   0

1

Write 20H, Block Address

Write D0H, Block Address

Read Status Register

SR.7 =   0

Suspend Block Erase Loop

No

Suspend Block Erase   Yes

1

Full Status Check if Desired

Block Erase Complete

BUS OPERATION	COMMAND	COMMENTS
Write	Read Status Register	Data = 70H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy
Write	Erase Setup	Data = 20H Addr = Within Block to be Erased
Write	Erase Confirm	Data = D0H Addr = Within Block to be Erased
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Repeat for subsequent block erasures.

Full status check can be done after each block erase or after a sequence of block erasures.

Write FFH after the last block erase operation to place device in read array mode.

FULL STATUS CHECK PROCEDURE

Read Status Register Data (See Above)

SR.3 =   1 → V_{PP} Range Error

0

SR.1 =   1 → Device Protect Error

0

SR.4, 5 =   1 → Command Sequence Error

0

SR.5 =   1 → Block Erase Error

0

Block Erase Successful

BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = V_{PP} Error Detect
Standby		Check SR.1 1 = Device Protect Detect WP# = V_{IL}, Block Lock-Bit is Set Only required for systems implementing block lock-bit configuration
Standby		Check SR.4, 5 Both 1 = Command Sequence Error
Standby		Check SR.5 1 = Block Erase Error

SR.5, SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command in cases where multiple blocks are erased before full status is checked.

If error is detected, clear the status register before attempting retry or other error recovery.

Fig. 3   Automated Block Erase Flowchart
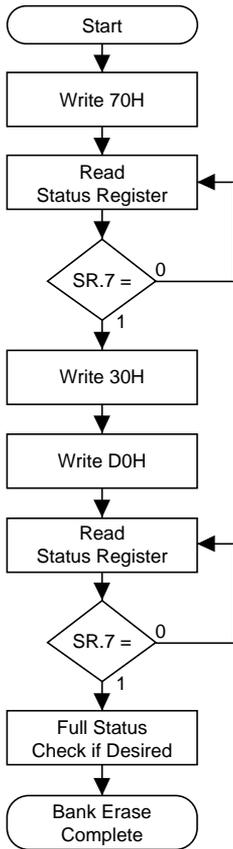
BUS OPERATION	COMMAND	COMMENTS
Write	Read Status Register	Data = 70H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy
Write	Bank Erase Setup	Data = 30H Addr = X
Write	Bank Erase Setup	Data = D0H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Full full status check can be done after each bank erase. Write FFH after the last bank erase operation to place bank in read array mode.

FULL STATUS CHECK PROCEDURE
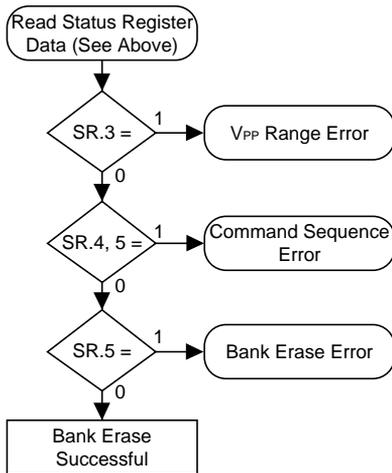
BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = VPP Error Detect
Standby		Check SR.4, 5 Both 1 = Command Sequence Error
Standby		Check SR.5 1 = Bank Erase Error

SR.5, SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command in cases where multiple blocks are erased before full status is checked.

If error is detected, clear the status register before attempting retry or other error recovery.

Fig. 4   Automated Bank Erase Flowchart

Start

Write 70H

Read
Status Register

SR.7 = 0

SR.7 = 1

Write 40H or 10H,
Address

Write Word/Byte
Data and Address

Read
Status Register

SR.7 = 0 → Suspend Word/Byte Write Loop

Suspend Word/Byte Write — No / Yes

SR.7 = 1

Full Status
Check if Desired

Word/Byte Write
Complete

BUS OPERATION	COMMAND	COMMENTS
Write	Read Status Register	Data = 70H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy
Write	Setup Word/ Byte Write	Data = 40H or 10H Addr = Location to be Written
Write	Word/Byte Write	Data = Data to be Written Addr = Location to be Written
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Repeat for subsequent word/byte writes.

SR full status check can be done after each word/byte write or after a sequence of word/byte writes.

Write FFH after the last word/byte write operation to place device in read array mode.

FULL STATUS CHECK PROCEDURE

Read Status Register Data (See Above)

SR.3 = 1 → V_{PP} Range Error

SR.3 = 0

SR.1 = 1 → Device Protect Error

SR.1 = 0

SR.4 = 1 → Word/Byte Write Error

SR.4 = 0

Word/Byte Write
Successful

BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = V_{PP} Error Detect
Standby		Check SR.1 1 = Device Protect Detect WP# = V_{IL}, Block Lock-Bit is Set Only required for systems implementing block lock-bit configuration
Standby		Check SR.4 1 = Data Write Error

SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command in cases where multiple locations are written before full status is checked.

If error is detected, clear the status register before attempting retry or other error recovery.

Fig. 5   Automated Word/Byte Write Flowchart
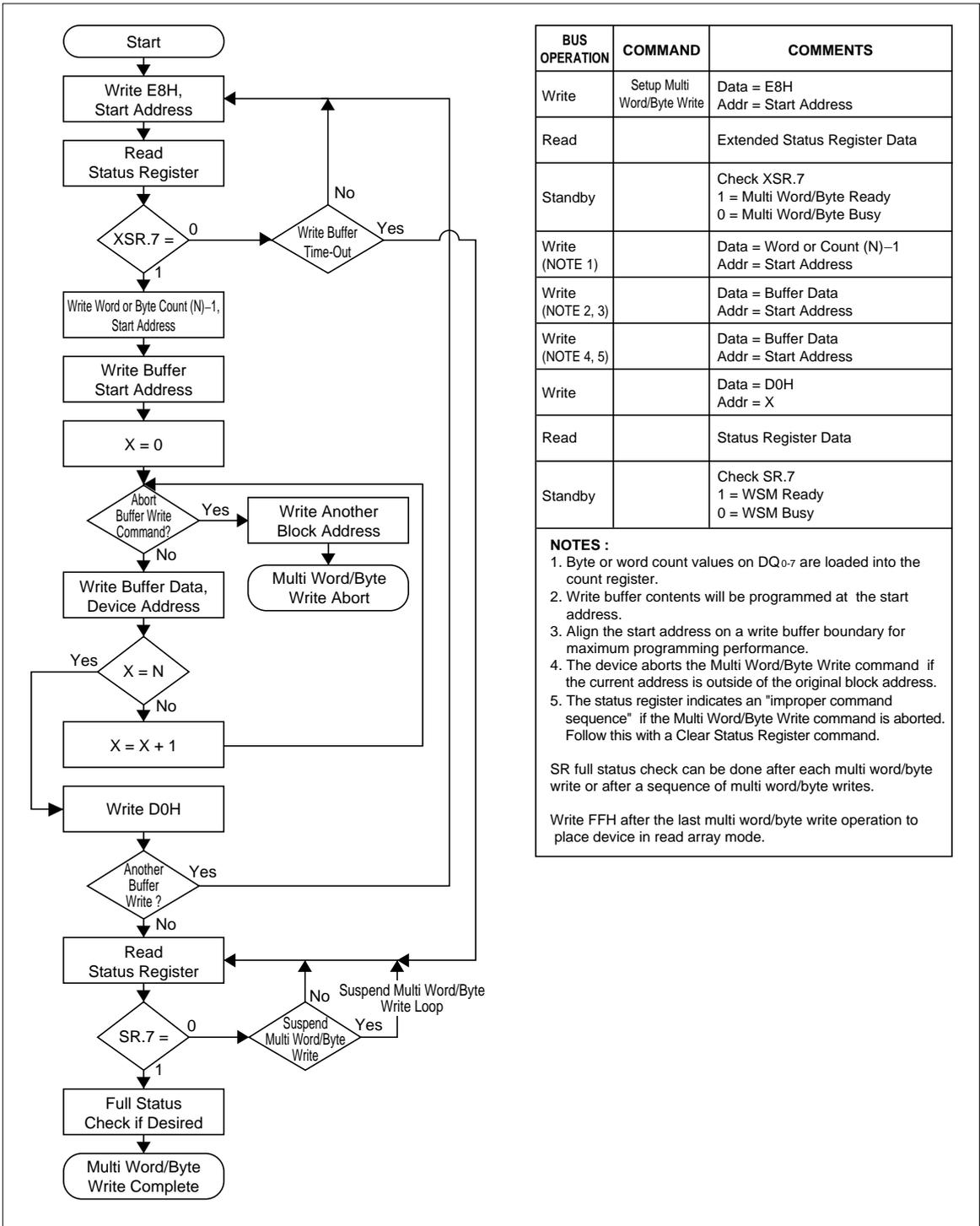
BUS OPERATION	COMMAND	COMMENTS
Write	Setup Multi Word/Byte Write	Data = E8H Addr = Start Address
Read		Extended Status Register Data
Standby		Check XSR.7 1 = Multi Word/Byte Ready 0 = Multi Word/Byte Busy
Write (NOTE 1)		Data = Word or Count (N)−1 Addr = Start Address
Write (NOTE 2, 3)		Data = Buffer Data Addr = Start Address
Write (NOTE 4, 5)		Data = Buffer Data Addr = Start Address
Write		Data = D0H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

NOTES :
1. Byte or word count values on DQ_{0-7} are loaded into the count register.
2. Write buffer contents will be programmed at the start address.
3. Align the start address on a write buffer boundary for maximum programming performance.
4. The device aborts the Multi Word/Byte Write command if the current address is outside of the original block address.
5. The status register indicates an "improper command sequence" if the Multi Word/Byte Write command is aborted. Follow this with a Clear Status Register command.

SR full status check can be done after each multi word/byte write or after a sequence of multi word/byte writes.

Write FFH after the last multi word/byte write operation to place device in read array mode.

Fig. 6   Automated Multi Word/Byte Write Flowchart

FULL STATUS CHECK PROCEDURE FOR MULTI WORD/BYTE WRITE OPERATION

| BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = V$_{PP}$ Error Detect
Standby		Check SR.1 1 = Device Protect Detect WP# = V$_{IL}$, Block Lock-Bit is Set Only required for systems implement-ing block lock-bit configuration
Standby		Check SR.4, 5 Both 1 = Command Sequence Error
Standby		Check SR.4 1 = Data Write Error
SR.5, SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command in cases where multiple locations are written before full status is checked.		
If error is detected, clear the status register before attempting retry or other error recovery.		

Fig. 7 Full Status Check Procedure for Automated Multi Word/Byte Write

BUS OPERATION	COMMAND	COMMENTS
Write	Erase Suspend	Data = B0H Addr = X
Read		Status Register Data Addr = X
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy
Standby		Check SR.6 1 = Block Erase Suspended 0 = Block Erase Completed
Write	Erase Resume	Data = D0H Addr = X
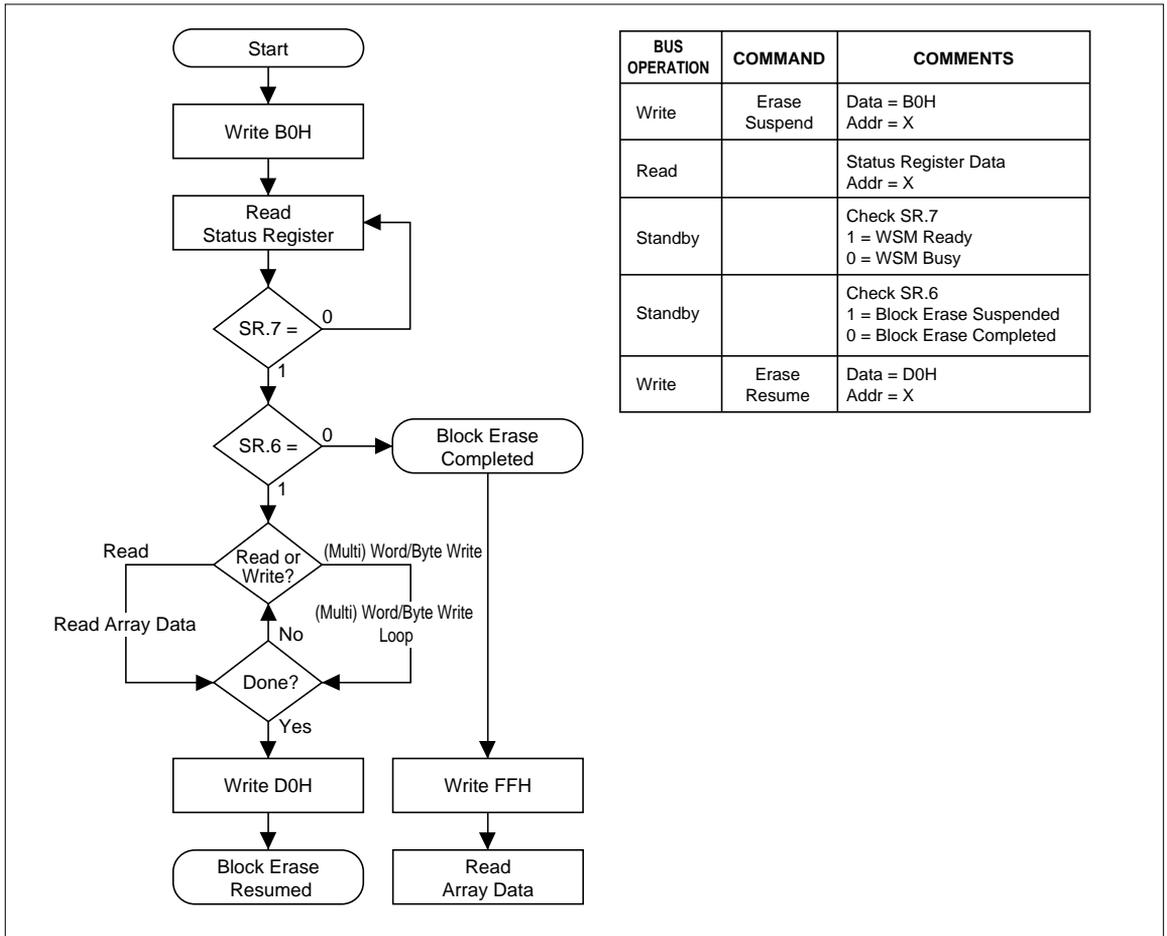
Fig. 8   Block Erase Suspend/Resume Flowchart
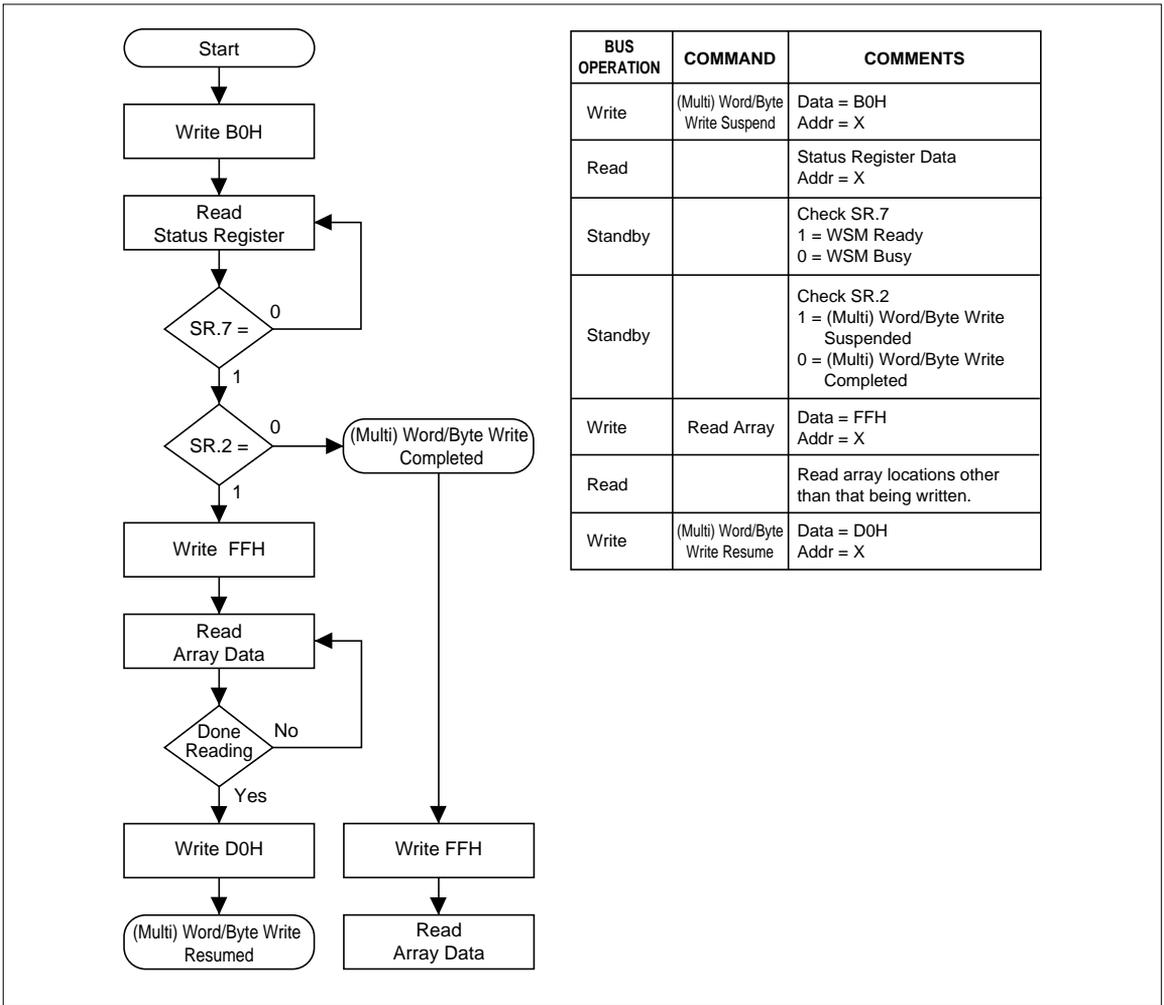
Fig. 9   (Multi) Word/Byte Write Suspend/Resume Flowchart

BUS OPERATION	COMMAND	COMMENTS
Write	(Multi) Word/Byte Write Suspend	Data = B0H Addr = X
Read		Status Register Data Addr = X
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Standby		Check SR.2
		1 = (Multi) Word/Byte Write
		   Suspended
		0 = (Multi) Word/Byte Write
		   Completed

Write	Read Array	Data = FFH Addr = X
Read		Read array locations other than that being written.
Write	(Multi) Word/Byte Write Resume	Data = D0H Addr = X
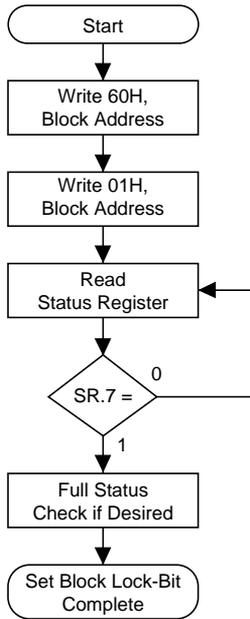
BUS OPERATION	COMMAND	COMMENTS
Write	Set Block Lock-Bit Setup	Data = 60H Addr = Block Address
Write	Set Block Lock-Bit Confirm	Data = 01H Addr = Block Address
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Repeat for subsequent block set operations.

Full status check can be done after each block lock-bit set operation or after a sequence of block lock-bit set operations.

Write FFH after the last block lock-bit set operation to place device in read array mode.
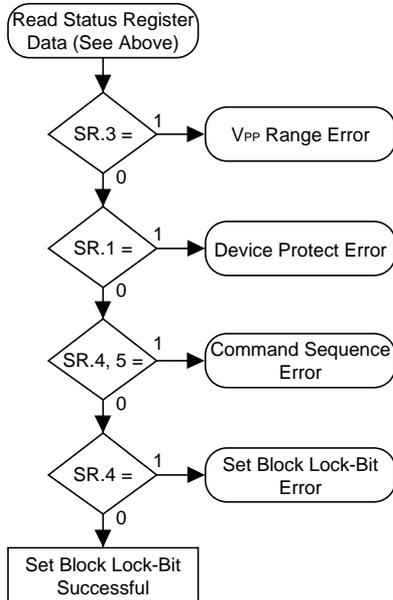
Start

Write 60H, Block Address

Write 01H, Block Address

Read Status Register

SR.7 = 0

SR.7 = 1

Full Status Check if Desired

Set Block Lock-Bit Complete

FULL STATUS CHECK PROCEDURE

Read Status Register Data (See Above)

BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = VPP Error Detect
Standby		Check SR.1 1 = Device Protect Detect WP# = VIL
Standby		Check SR.4, 5 Both 1 = Command Sequence Error
Standby		Check SR.4 1 = Set Block Lock-Bit Error

SR.5, SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command in cases where multiple block lock-bits are set before full status is checked.

If error is detected, clear the status register before attempting retry or other error recovery.

SR.3 = 1 → VPP Range Error

SR.3 = 0

SR.1 = 1 → Device Protect Error

SR.1 = 0

SR.4, 5 = 1 → Command Sequence Error

SR.4, 5 = 0

SR.4 = 1 → Set Block Lock-Bit Error

SR.4 = 0

Set Block Lock-Bit Successful

Fig. 10   Set Block Lock-Bit Flowchart
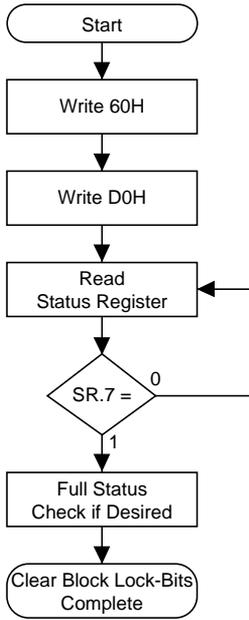
BUS OPERATION	COMMAND	COMMENTS
Write	Clear Block Lock-Bits Setup	Data = 60H Addr = X
Write	Clear Block Lock-Bits Confirm	Data = D0H Addr = X
Read		Status Register Data
Standby		Check SR.7 1 = WSM Ready 0 = WSM Busy

Write FFH after the last clear block lock-bits operation to place device in read array mode.

Start

Write 60H

Write D0H

Read Status Register

SR.7 = 0

SR.7 = 1

Full Status Check if Desired

Clear Block Lock-Bits Complete

FULL STATUS CHECK PROCEDURE

Read Status Register Data (See Above)

SR.3 = 1 → V_{PP} Range Error

SR.3 = 0

SR.1 = 1 → Device Protect Error

SR.1 = 0

SR.4, 5 = 1 → Command Sequence Error

SR.4, 5 = 0

SR.5 = 1 → Clear Block Lock-Bits Error

SR.5 = 0

Clear Block Lock-Bits Successful

BUS OPERATION	COMMAND	COMMENTS
Standby		Check SR.3 1 = V_{PP} Error Detect
Standby		Check SR.1 1 = Device Protect Detect WP# = V_{IL}
Standby		Check SR.4, 5 Both 1 = Command Sequence Error
Standby		Check SR.5 1 = Clear Block Lock-Bits Error

SR.5, SR.4, SR.3 and SR.1 are only cleared by the Clear Status Register command.

If error is detected, clear the status register before attempting retry or other error recovery.

Fig. 11   Clear Block Lock-Bits Flowchart

5 DESIGN CONSIDERATIONS

5.1 Three-Line Output Control

The device will often be used in large memory arrays. SHARP provides three control inputs to accommodate multiple memory connections. Three-line control provides for :

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

To use these control inputs efficiently, an address decoder should enable BE# 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 deselected 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.

5.2 STS and Block Erase, Bank Erase, (Multi) Word/Byte Write and Block Lock-Bit Configuration Polling

STS is an open drain output that should be connected to V_{CC} by a pullup resistor to provide a hardware method of detecting block erase, bank erase, (multi) word/byte write and block lock-bit configuration completion. In default mode, it transitions low after block erase, bank erase, (multi) word/byte write or block lock-bit configuration commands and returns to V_{OH} when the WSM has finished executing the internal algorithm. For alternate STS pin configurations, see the Configuration command (**Table 3** and **Section 4.14**).

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 (multi) word/byte write inactive), (multi) word/byte write suspend or deep power-down modes.

5.3 Power Supply Decoupling

Flash memory power switching characteristics require careful device decoupling. System designers are interested in three supply current issues; standby current levels, active current levels and transient peaks produced by falling and rising edges of BE# and OE#. Transient current magnitudes depend on the device outputs' capacitive and inductive loading. Two-line control and proper decoupling capacitor selection will suppress transient voltage peaks. Each device should have a 0.1 μF ceramic capacitor connected between its V_{CC} and GND and between its V_{PP} and GND. These high-frequency, low inductance capacitors should be placed as close as possible to package leads. Additionally, for every eight devices, a 4.7 μF electrolytic capacitor should be placed at the array's power supply connection between V_{CC} and GND. The bulk capacitor will overcome voltage slumps caused by PC board trace inductance.

5.4 V_{PP} Trace on Printed Circuit Boards

Updating flash memories that reside in the target system requires that the printed circuit board designers pay attention to the V_{PP} power supply trace. The V_{PP} pin supplies the memory cell current for block erase, bank erase, (multi) word/byte write and block lock-bit configuration. Use similar trace widths and layout considerations given to the V_{CC} power bus. Adequate V_{PP} supply traces and decoupling will decrease V_{PP} voltage spikes and overshoots.

5.5 V_{CC}, V_{PP}, RP# Transitions

Block erase, bank erase, (multi) word/byte write and block lock-bit configuration are not guaranteed if V_{PP} falls outside of a valid $V_{PPH1/2/3}$ range, V_{CC} falls outside of a valid $V_{CC1/2}$ range, or RP# = V_{IL}. If V_{PP} error is detected, status register bit SR.3 is set to "1" along with SR.4 or SR.5, depending on the attempted operation. If RP# transitions to V_{IL} during block erase, bank erase, (multi) word/byte write or block lock-bit configuration, STS (if set to

RY/BY# mode) will remain low until the reset operation is complete. Then, the operation will abort and the device will enter deep power-down. The aborted operation may leave data partially altered. Therefore, the command sequence must be repeated after normal operation is restored. Device power-off or RP# transitions to V_{IL} clear the status register.

The CUI latches commands issued by system software and is not altered by V_{PP} or BE# transitions or WSM actions. Its state is read array mode upon power-up, after exit from deep power-down or after V_{CC} transitions below V_{LKO}.

After block erase, bank erase, (multi) word/byte write or block lock-bit configuration, even after V_{PP} transitions down to V_{PPLK}, the CUI must be placed in read array mode via the Read Array command if subsequent access to the memory array is desired.

5.6   Power-Up/Down Protection

The device is designed to offer protection against accidental block and bank erasure, (multi) word/byte writing or block lock-bit configuration during power transitions. Upon power-up, the device is indifferent as to which power supply (V_{PP} or V_{CC}) powers-up first. Internal circuitry resets the CUI to read array mode at power-up.

A system designer must guard against spurious writes for V_{CC} voltages above V_{LKO} when V_{PP} is active. Since both WE# and BE# must be low for a command write, driving either to V_{IH} will inhibit writes. The CUI's two-step command sequence architecture provides added level of protection against data alteration.

In-system block lock and unlock capability prevents inadvertent data alteration. The device is disabled while RP# = V_{IL} regardless of its control inputs state.

5.7   Power Consumption

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.

In addition, deep power-down mode ensures extremely low power consumption even when system power is applied. For example, portable computing products and other power sensitive applications that use an array of devices for solid-state storage can consume negligible power by lowering RP# to V_{IL} standby or sleep modes. If access is again needed, the devices can be read following the t_{PHQV} and t_{PHWL} wake-up cycles required after RP# is first raised to V_{IH}. See **Section 6.2.4 through 6.2.6 "AC CHARACTERISTICS - READ-ONLY and WRITE OPERATIONS"** and **Fig. 15**, **Fig. 16**, **Fig. 17** and **Fig. 18** for more information.

6 ELECTRICAL SPECIFICATIONS

6.1 Absolute Maximum Ratings*

Operating Temperature

During Read, Erase, Write and
Block Lock-Bit Configuration ⋯ 0 to +70°C (NOTE 1)
Temperature under Bias ⋯⋯⋯⋯ –10 to +80°C

Storage Temperature ⋯⋯⋯⋯⋯⋯⋯ –65 to +125°C

Voltage On Any Pin
(except V_{CC}, V_{PP})⋯ –0.5 V to V_{CC}+0.5 V (NOTE 2)

V_{CC} Supply Voltage ⋯⋯⋯⋯⋯ –0.2 to +7.0 V (NOTE 2)

V_{PP} Update Voltage during
Erase, Write and
Block Lock-Bit Configuration⋯ –0.2 to +7.0 V (NOTE 2)

Output Short Circuit Current⋯⋯⋯⋯100 mA (NOTE 3)

NOTICE : The specifications are subject to change without notice. Verify with your local SHARP sales office that you have the latest datasheet before finalizing a design.

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.

NOTES :

1. Operating temperature is for commercial product defined by this specification.
2. All specified voltages are with respect to GND. Minimum DC voltage is –0.5 V on input/output pins and –0.2 V on V_{CC} and V_{PP} pins. During transitions, this level may undershoot to –2.0 V for periods < 20 ns. Maximum DC voltage on input/output pins and V_{CC} is V_{CC}+0.5 V which, during transitions, may overshoot to V_{CC}+2.0 V for periods < 20 ns.
3. Output shorted for no more than one second. No more than one output shorted at a time.

6.2 Operating Conditions

SYMBOL	PARAMETER	MIN.	MAX.	UNIT	TEST CONDITION
T_A	Operating Temperature	0	+70	°C	Ambient Temperature
V_{CC1}	V_{CC} Supply Voltage (2.7 to 3.6 V)	2.7	3.6	V	
V_{CC2}	V_{CC} Supply Voltage (3.3±0.3 V)	3.0	3.6	V	

6.2.1 CAPACITANCE (NOTE 1)
T_A = +25°C, f = 1 MHz

SYMBOL	PARAMETER	NOTE	TYP.	MAX.	UNIT	TEST CONDITION
C_{IN}	Input Capacitance	2	14	20	pF	V_{IN} = 0.0 V
C_{OUT}	Output Capacitance		18	24	pF	V_{OUT} = 0.0 V

NOTES :
1. Sampled, not 100% tested.
2. BE0# and BE1L#, BE1H# have half the value of this.

6.2.2 AC INPUT/OUTPUT TEST CONDITIONS

AC test inputs are driven at 2.7 V for a Logic "1" and 0.0 V for a Logic "0". Input timing begins, and output timing ends, at 1.35 V. Input rise and fall times (10% to 90%) < 10 ns.
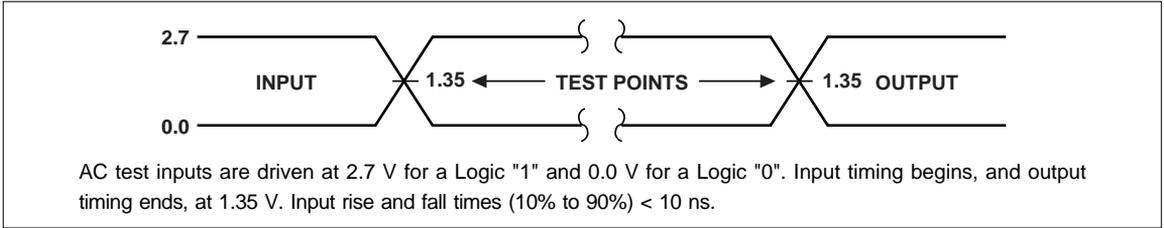
Fig. 12　Transient Input/Output Reference Waveform for V$_{CC}$ = 2.7 to 3.6 V

AC test inputs are driven at 3.0 V for a Logic "1" and 0.0 V for a Logic "0". Input timing begins, and output timing ends, at 1.5 V. Input rise and fall times (10% to 90%) < 10 ns.
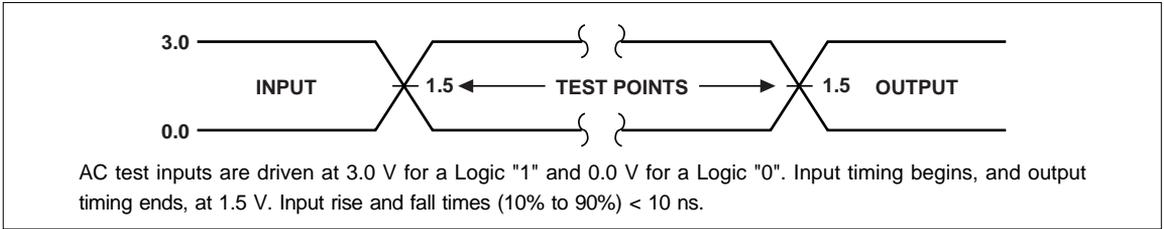
**Fig. 13　Transient Input/Output Reference Waveform for V$_{CC}$ = 3.3±0.3 V**
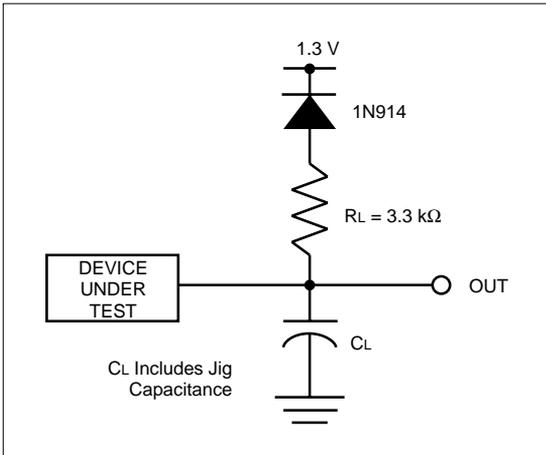
**Fig. 14　Transient Equivalent Testing
Load Circuit**

Test Configuration Capacitance Loading Value

TEST CONFIGURATION	C$_L$ (pF)
V$_{CC}$ = 3.3±0.3 V, 2.7 to 3.6 V	50

6.2.3 DC CHARACTERISTICS

Following is the supply current of one bank. For the supply current of one device total, refer to **NOTE 8**.

SYMBOL	PARAMETER	NOTE	Vcc = 2.7 to 3.6 V		Vcc = 3.3±0.3 V		UNIT	TEST CONDITIONS
			TYP.	MAX.	TYP.	MAX.		
I_{LI}	Input Load Capacitance	1		±0.5		±0.5	µA	Vcc = Vcc Max. V_{IN} = Vcc or GND
I_{LO}	Output Leakage Capacitance	1		±0.5		±0.5	µA	Vcc = Vcc Max. V_{OUT} = Vcc or GND
I_{CCS}	Vcc Standby Current	1, 3, 6, 8	20	100	20	100	µA	CMOS Inputs Vcc = Vcc Max. BE# = RP# = Vcc±0.2 V
			1	4	1	4	mA	TTL Inputs Vcc = Vcc Max. BE# = RP# = V_{IH}
I_{CCD}	Vcc Deep Power-Down Current	1		15		15	µA	RP# = GND±0.2 V I_{OUT} (STS) = 0 mA
I_{CCR}	Vcc Read Current	1, 5, 6, 8		25		25	mA	CMOS Inputs Vcc = Vcc Max. BE# = GND f = 5 MHz, I_{OUT} = 0 mA
				30		30	mA	TTL Inputs Vcc = Vcc Max. BE# = V_{IL} f = 5 MHz, I_{OUT} = 0 mA
I_{CCW}	Vcc Write Current ((Multi) W/B Write or Set Block Lock-Bit)	1, 7, 8		17	—	—	mA	V_{PP} = 2.7 to 3.6 V
				17		17	mA	V_{PP} = 3.3±0.3 V
				17		17	mA	V_{PP} = 5.0±0.5 V
I_{CCE}	Vcc Erase Current (Block Erase, Bank Erase, Clear Block Lock-Bits)	1, 7, 8		17	—	—	mA	V_{PP} = 2.7 to 3.6 V
				17		17	mA	V_{PP} = 3.3±0.3 V
				17		17	mA	V_{PP} = 5.0±0.5 V
I_{CCWS} I_{CCES}	Vcc Write or Block Erase Suspend Current	1, 2, 8	1	6	1	6	µA	BE# = V_{IH}
I_{PPS}	VPP Standby Current	1, 8	±2	±15	±2	±15	µA	V_{PP} ≤ Vcc
I_{PPR}	VPP Read Current	1	10	200	10	200	µA	V_{PP} > Vcc
I_{PPD}	VPP Deep Power-Down Current	1	0.1	5	0.1	5	mA	RP# = GND±0.2 V
I_{PPW}	VPP Write Current ((Multi) W/B Write or Set Block Lock-Bit)	1, 7, 8		80	—	—	mA	V_{PP} = 2.7 to 3.6 V
				80		80	mA	V_{PP} = 3.3±0.3 V
				80		80	mA	V_{PP} = 5.0±0.5 V
I_{PPE}	VPP Erase Current (Block Erase, Bank Erase, Clear Block Lock-Bits)	1, 7, 8		40	—	—	mA	V_{PP} = 2.7 to 3.6 V
				40		40	mA	V_{PP} = 3.3±0.3 V
				40		40	mA	V_{PP} = 5.0±0.5 V
I_{PPWS} I_{PPES}	VPP Write or Block Erase Suspend Current	1, 8	10	200	10	200	µA	V_{PP} = $V_{PPH1/2/3}$

6.2.3 DC CHARACTERISTICS (contd.)

SYMBOL	PARAMETER	NOTE	Vcc = 2.7 to 3.6 V		Vcc = 3.3±0.3 V		UNIT	TEST CONDITIONS
			MIN.	MAX.	MIN.	MAX.		
V_{IL}	Input Low Voltage	7	−0.5	0.8	−0.5	0.8	V	
V_{IH}	Input High Voltage	7	2.0	Vcc +0.5	2.0	Vcc +0.5	V	
V_{OL}	Output Low Voltage	3, 7		0.4		0.4	V	Vcc = Vcc Min. I_{OL} = 2 mA
V_{OH1}	Output High Voltage (TTL)	3, 7	2.4		2.4		V	Vcc = Vcc Min. I_{OH} = −2.5 mA
V_{OH2}	Output High Voltage (CMOS)	3, 7	0.85 Vcc		0.85 Vcc		V	Vcc = Vcc Min. I_{OH} = −2.5 mA
			Vcc −0.4		Vcc −0.4		V	Vcc = Vcc Min. I_{OH} = −100 μA
V_{PPLK}	Vpp Lockout Voltage during Normal Operations	4, 7		1.5		1.5	V	
V_{PPH1}	Vpp Voltage during Write or Erase Operations		2.7	3.6			V	
V_{PPH2}	Vpp Voltage during Write or Erase Operations		3.0	3.6	3.0	3.6	V	
V_{PPH3}	Vpp Voltage during Write or Erase Operations		4.5	5.5	4.5	5.5	V	
V_{LKO}	Vcc Lockout Voltage		2.0		2.0		V	

NOTES :

1. All currents are in RMS unless otherwise noted. Typical values at nominal Vcc voltage and T_A = +25°C.
2. I_{CCWS} and I_{CCES} are specified with the device de-selected. If reading or (multi) word/byte writing in erase suspend mode, the device's current draw is the sum of I_{CCWS} or I_{CCES} and I_{CCR} or I_{CCW}, respectively.
3. Includes STS.
4. Block erases, bank erases, (multi) word/byte writes and block lock-bit configurations are inhibited when $V_{PP} \leq$ V_{PPLK}, and not guaranteed in the range between V_{PPLK} (max.) and V_{PPH1} (min.), between V_{PPH1} (max.) and V_{PPH2} (min.), between V_{PPH2} (max.) and V_{PPH3} (min.) and above V_{PPH3} (max.).

5. Automatic Power Saving (APS) reduces typical I_{CCR} to 3 mA at 2.7 V and 3.3 V Vcc in static operation.
6. CMOS inputs are either Vcc±0.2 V or GND±0.2 V. TTL inputs are either V_{IL} or V_{IH}.
7. Sampled, not 100% tested.
8. These are the values of the current which is consumed within one bank area. The value for the bank0 and bank1 should added in order to calculate the value for the whole chip. If the bank0 is in write state and bank1 is in read state, the I_{CC} = I_{CCW} + I_{CCR}. If both banks are in standby mode, the value for the device is 2 times the value in the above table.

6.2.4 AC CHARACTERISTICS - READ-ONLY OPERATIONS (NOTE 1)

• V_{CC} = 2.7 to 3.6 V, T_A = 0 to +70°C

VERSION				LH28F320S3TD-L10		UNIT
SYMBOL	PARAMETER	NOTE	TYP.	MAX.		
t_{AVAV}	Read Cycle Time		120			ns
t_{AVQV}	Address to Output Delay			120		ns
t_{ELQV}	BE# to Output Delay	2		120		ns
t_{PHQV}	RP# High to Output Delay			600		ns
t_{GLQV}	OE# to Output Delay	2		50		ns
t_{ELQX}	BE# to Output in Low Z	3	0			ns
t_{EHQZ}	BE# High to Output in High Z	3		50		ns
t_{GLQX}	OE# to Output in Low Z	3	0			ns
t_{GHQZ}	OE# High to Output in High Z	3		20		ns
t_{OH}	Output Hold from Address, BE# or OE# Change, Whichever Occurs First	3	0			ns
t_{FLQV} t_{FHQV}	BYTE# to Output Delay	3		120		ns
t_{FLQZ}	BYTE# to Output in High Z	3		30		ns
t_{ELFL} t_{ELFH}	BE# Low to BYTE# High or Low	3		5		ns

• V_{CC} = 3.3±0.3 V, T_A = 0 to +70°C

VERSION				LH28F320S3TD-L10		UNIT
SYMBOL	PARAMETER	NOTE	TYP.	MAX.		
t_{AVAV}	Read Cycle Time		100			ns
t_{AVQV}	Address to Output Delay			100		ns
t_{ELQV}	BE# to Output Delay	2		100		ns
t_{PHQV}	RP# High to Output Delay			600		ns
t_{GLQV}	OE# to Output Delay	2		45		ns
t_{ELQX}	BE# to Output in Low Z	3	0			ns
t_{EHQZ}	BE# High to Output in High Z	3		50		ns
t_{GLQX}	OE# to Output in Low Z	3	0			ns
t_{GHQZ}	OE# High to Output in High Z	3		20		ns
t_{OH}	Output Hold from Address, BE# or OE# Change, Whichever Occurs First	3	0			ns
t_{FLQV} t_{FHQV}	BYTE# to Output Delay	3		100		ns
t_{FLQZ}	BYTE# to Output in High Z	3		30		ns
t_{ELFL} t_{ELFH}	BE# Low to BYTE# High or Low	3		5		ns

NOTES :

1. See AC Input/Output Reference Waveform (**Fig. 12** and **Fig. 13**) for maximum allowable input slew rate.

2. OE# may be delayed up to t_{ELQV}-t_{GLQV} after the falling edge of BE# without impact on t_{ELQV}.

3. Sampled, not 100% tested.
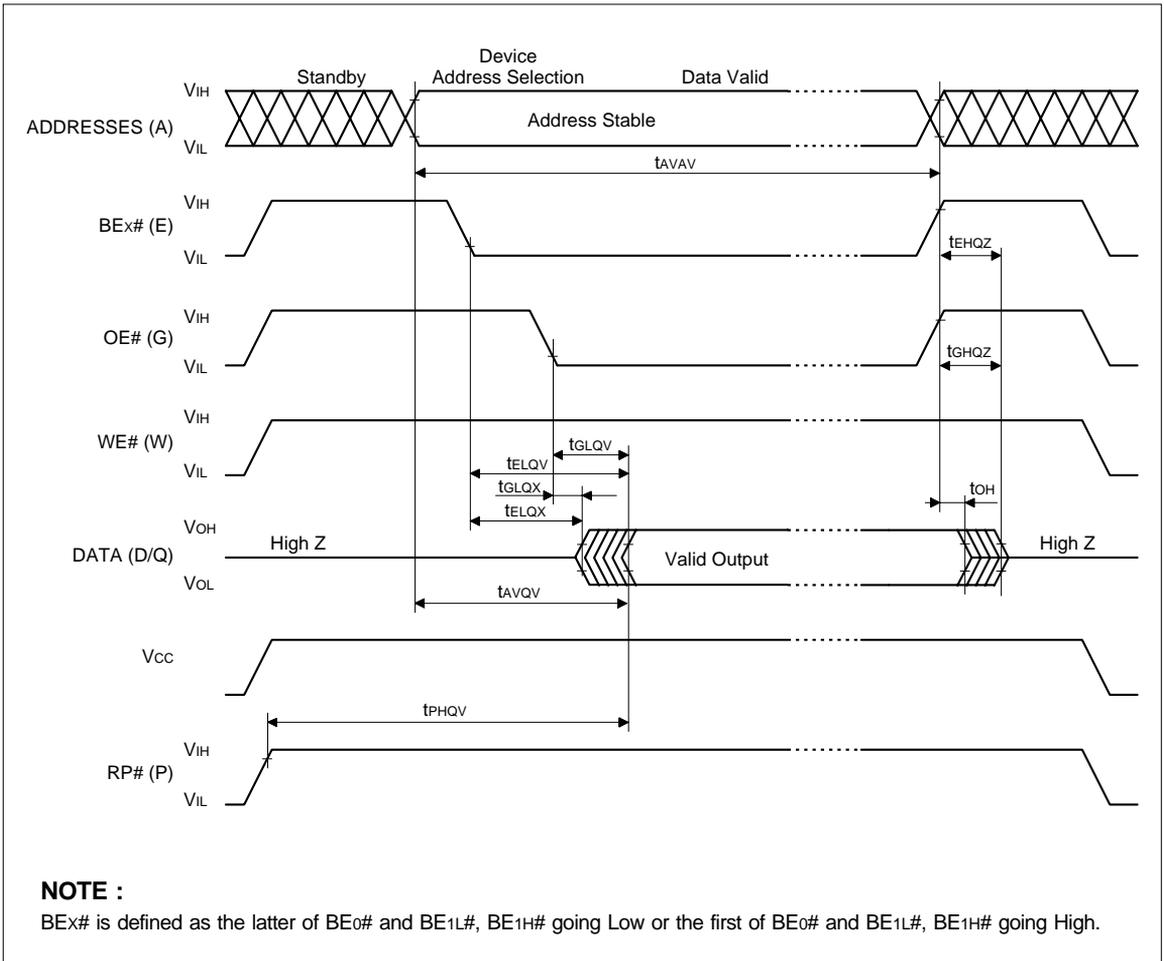
Fig. 15 AC Waveform for Read Operations

NOTE :
BEx# is defined as the latter of BE0# and BE1L#, BE1H# going Low or the first of BE0# and BE1L#, BE1H# going High.
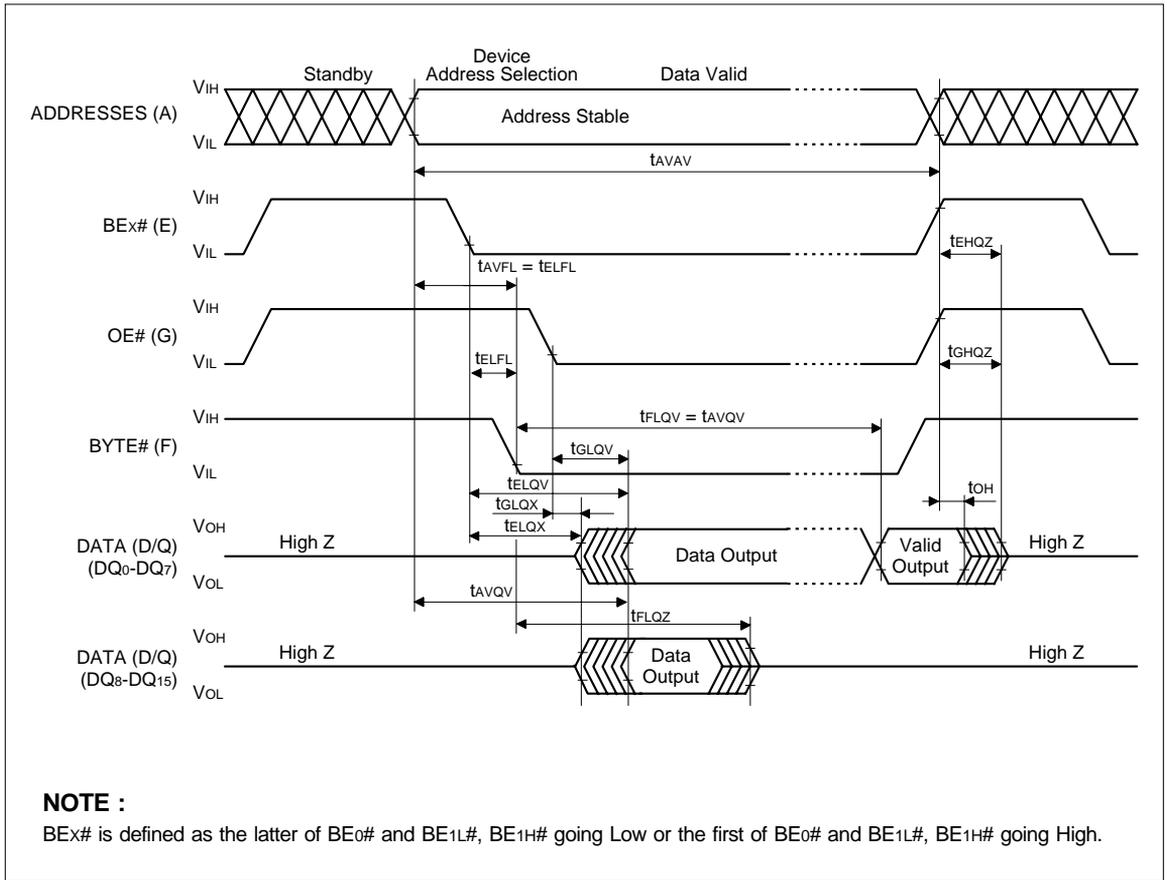
Fig. 16   BYTE# Timing Waveforms

6.2.5 AC CHARACTERISTICS - WRITE OPERATIONS (NOTE 1)

• V_{CC} = 2.7 to 3.6 V, T_A = 0 to +70°C

SYMBOL	VERSION PARAMETER	NOTE	LH28F320S3TD-L10 MIN.	MAX.	UNIT
t_{AVAV}	Write Cycle Time		120		ns
t_{PHWL}	RP# High Recovery to WE# Going Low	2	1		μs
t_{ELWL}	BE# Setup to WE# Going Low		10		ns
t_{WLWH}	WE# Pulse Width		50		ns
t_{SHWH}	WP# V_{IH} Setup to WE# Going High	2	100		ns
t_{VPWH}	V_{PP} Setup to WE# Going High	2	100		ns
t_{AVWH}	Address Setup to WE# Going High	3	50		ns
t_{DVWH}	Data Setup to WE# Going High	3	50		ns
t_{WHDX}	Data Hold from WE# High		5		ns
t_{WHAX}	Address Hold from WE# High		5		ns
t_{WHEH}	BE# Hold from WE# High		10		ns
t_{WHWL}	WE# Pulse Width High		30		ns
t_{WHRL}	WE# High to STS Going Low			100	ns
t_{WHGL}	Write Recovery before Read		0		ns
t_{QVVL}	V_{PP} Hold from Valid SRD, STS High Z	2, 4	0		ns
t_{QVSL}	WP# V_{IH} Hold from Valid SRD, STS High Z	2, 4	0		ns

• V_{CC} = 3.3±0.3 V, T_A = 0 to +70°C

SYMBOL	VERSION PARAMETER	NOTE	LH28F320S3TD-L10 MIN.	MAX.	UNIT
t_{AVAV}	Write Cycle Time		100		ns
t_{PHWL}	RP# High Recovery to WE# Going Low	2	1		μs
t_{ELWL}	BE# Setup to WE# Going Low		10		ns
t_{WLWH}	WE# Pulse Width		50		ns
t_{SHWH}	WP# V_{IH} Setup to WE# Going High	2	100		ns
t_{VPWH}	V_{PP} Setup to WE# Going High	2	100		ns
t_{AVWH}	Address Setup to WE# Going High	3	50		ns
t_{DVWH}	Data Setup to WE# Going High	3	50		ns
t_{WHDX}	Data Hold from WE# High		5		ns
t_{WHAX}	Address Hold from WE# High		5		ns
t_{WHEH}	BE# Hold from WE# High		10		ns
t_{WHWL}	WE# Pulse Width High		30		ns
t_{WHRL}	WE# High to STS Going Low			100	ns
t_{WHGL}	Write Recovery before Read		0		ns
t_{QVVL}	V_{PP} Hold from Valid SRD, STS High Z	2, 4	0		ns
t_{QVSL}	WP# V_{IH} Hold from Valid SRD, STS High Z	2, 4	0		ns

NOTES :

1. Read timing characteristics during block erase, bank erase, (multi) word/byte write and block lock-bit configuration operations are the same as during read-only operations. Refer to **Section 6.2.4 "AC CHARACTERISTICS"** for read-only operations.

2. Sampled, not 100% tested.

3. Refer to **Table 3** for valid A_{IN} and D_{IN} for block erase, bank erase, (multi) word/byte write or block lock-bit configuration.

4. V_{PP} should be held at $V_{PPH1/2/3}$ until determination of block erase, bank erase, (multi) word/byte write or block lock-bit configuration success (SR.1/3/4/5 = 0).
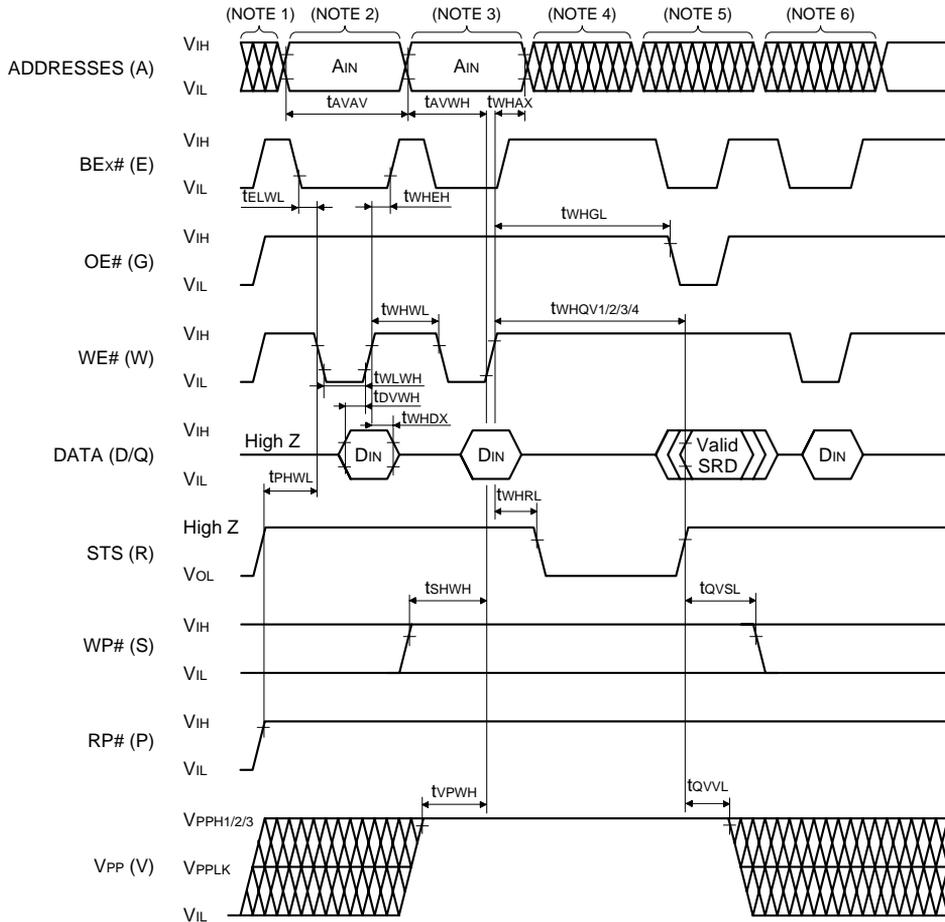
NOTES :

1. V$_{CC}$ power-up and standby.
2. Write erase or write setup.
3. Write erase confirm or valid address and data.
4. Automated erase or program delay.
5. Read status register data.
6. Write Read Array command.
7. BEx# is defined as the latter of BE0# and BE1L#, BE1H# going Low or the first of BE0# and BE1L#, BE1H# going High.

Fig. 17   AC Waveform for WE#-Controlled Write Operations

6.2.6 ALTERNATIVE BE#-CONTROLLED WRITES (NOTE 1)

• V_{CC} = 2.7 to 3.6 V, T_A = 0 to +70°C

VERSION			LH28F320S3TD-L10		UNIT
SYMBOL	PARAMETER	NOTE	MIN.	MAX.	
tAVAV	Write Cycle Time		120		ns
tPHEL	RP# High Recovery to BE# Going Low	2	1		μs
tWLEL	WE# Setup to BE# Going Low		0		ns
tELEH	BE# Pulse Width		70		ns
tSHEH	WP# V_{IH} Setup to BE# Going High	2	100		ns
tVPEH	VPP Setup to BE# Going High	2	100		ns
tAVEH	Address Setup to BE# Going High	3	50		ns
tDVEH	Data Setup to BE# Going High	3	50		ns
tEHDX	Data Hold from BE# High		5		ns
tEHAX	Address Hold from BE# High		5		ns
tEHWH	WE# Hold from BE# High		0		ns
tEHEL	BE# Pulse Width High		25		ns
tEHRL	BE# High to STS Going Low			100	ns
tEHGL	Write Recovery before Read		0		ns
tQVVL	VPP Hold from Valid SRD, STS High Z	2, 4	0		ns
tQVSL	WP# V_{IH} Hold from Valid SRD, STS High Z	2, 4	0		ns

• V_{CC} = 3.3±0.3 V, T_A = 0 to +70°C

VERSION			LH28F320S3TD-L10		UNIT
SYMBOL	PARAMETER	NOTE	MIN.	MAX.	
tAVAV	Write Cycle Time		100		ns
tPHEL	RP# High Recovery to BE# Going Low	2	1		μs
tWLEL	WE# Setup to BE# Going Low		0		ns
tELEH	BE# Pulse Width		70		ns
tSHEH	WP# V_{IH} Setup to BE# Going High	2	100		ns
tVPEH	VPP Setup to BE# Going High	2	100		ns
tAVEH	Address Setup to BE# Going High	3	50		ns
tDVEH	Data Setup to BE# Going High	3	50		ns
tEHDX	Data Hold from BE# High		5		ns
tEHAX	Address Hold from BE# High		5		ns
tEHWH	WE# Hold from BE# High		0		ns
tEHEL	BE# Pulse Width High		25		ns
tEHGL	BE# High to STS Going Low			100	ns
tEHRL	Write Recovery before Read		0		ns
tQVVL	VPP Hold from Valid SRD, STS High Z	2, 4	0		ns
tQVSL	WP# V_{IH} Hold from Valid SRD, STS High Z	2, 4	0		ns

NOTES :

1. In systems where BE# defines the write pulse width (within a longer WE# timing waveform), all setup, hold and inactive WE# times should be measured relative to the BE# waveform.

2. Sampled, not 100% tested.

3. Refer to **Table 3** for valid A_{IN} and D_{IN} for block erase, bank erase, (multi) word/byte write or block lock-bit configuration.

4. VPP should be held at VPPH1/2/3 until determination of block erase, bank erase, (multi) word/byte write or block lock-bit configuration success (SR.1/3/4/5 = 0).
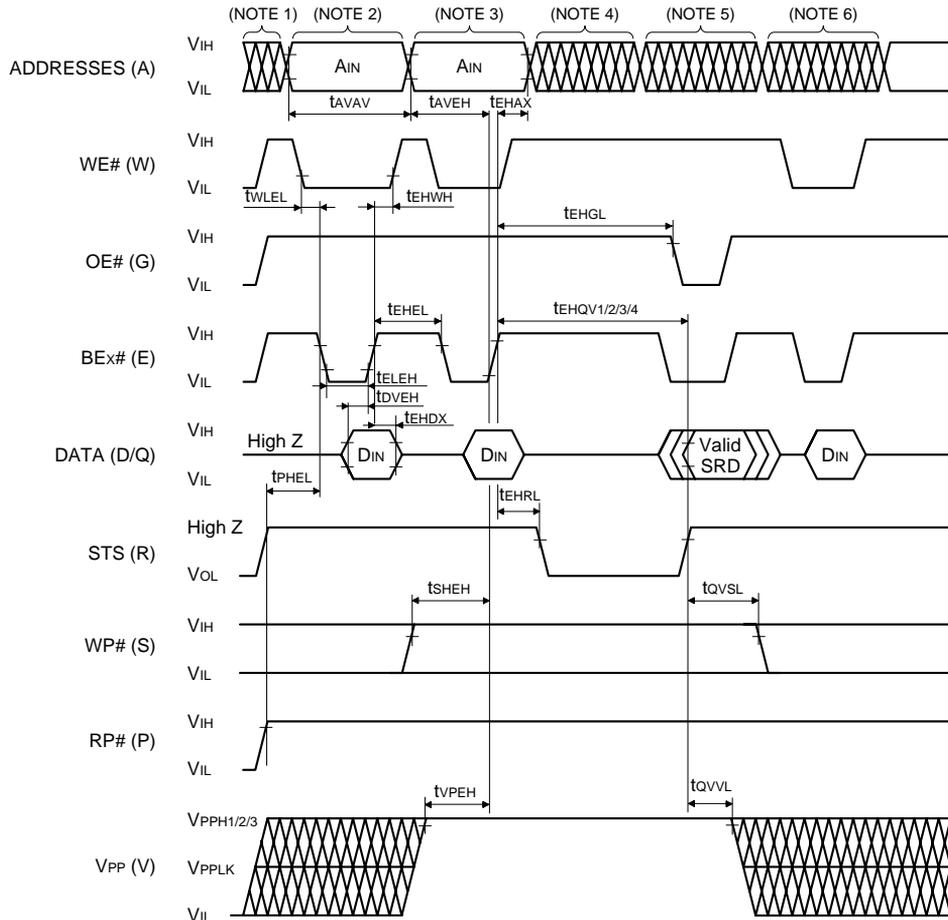
NOTES :

1. VCC power-up and standby.
2. Write erase or write setup.
3. Write erase confirm or valid address and data.
4. Automated erase or program delay.
5. Read status register data.
6. Write Read Array command.
7. BEx# is defined as the latter of BE0# and BE1L#, BE1H# going Low or the first of BE0# and BE1L#, BE1H# going High.

**Fig. 18   AC Waveform for BE#-Controlled Write Operations**

6.2.7 RESET OPERATIONS
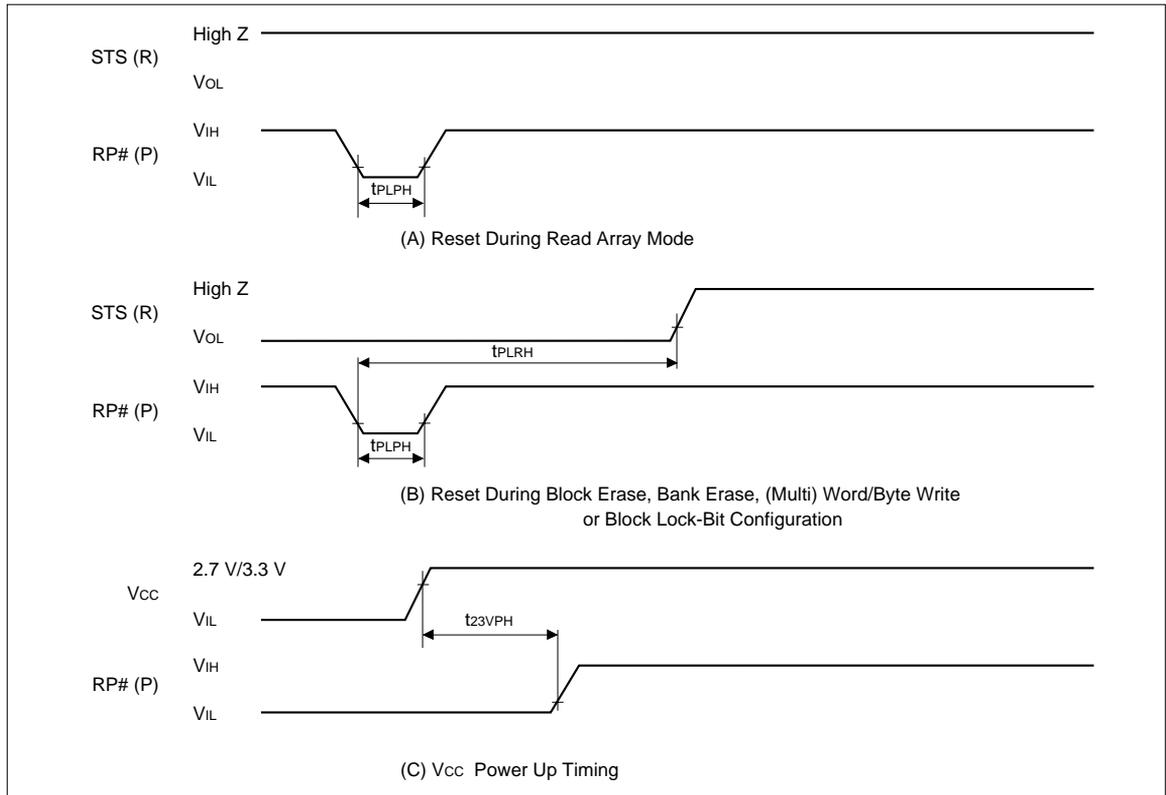
Fig. 19   AC Waveform for Reset Operation

Reset AC Specifications

SYMBOL	PARAMETER	NOTE	Vcc = 2.7 to 3.6 V		Vcc = 3.3±0.3 V		UNIT
			MIN.	MAX.	MIN.	MAX.	
tPLPH	RP# Pulse Low Time (If RP# is tied to Vcc, this specification is not applicable)		100		100		ns
tPLRH	RP# Low to Reset during Block Erase, Bank Erase, (Multi) Word/Byte Write or Block Lock-Bit Configuration	1, 2		21.5		21.1	µs
t23VPH	Vcc 2.7 V to RP# High Vcc 3.0 V to RP# High	3	100		100		ns

NOTES :

1. If RP# is asserted while a block erase, bank erase, (multi) word/byte write or block lock-bit configuration operation is not executing, the reset will complete within 100 ns.

2. A reset time, tPHQV, is required from the latter of STS going High Z or RP# going high until outputs are valid.

3. When the device power-up, holding RP#-low minimum 100 ns is required after Vcc has been in predefined range and also has been in stable there.

6.2.8 BLOCK ERASE, BANK ERASE, (MULTI) WORD/BYTE WRITE AND BLOCK LOCK-BIT CONFIGURATION PERFORMANCE (NOTE 3)

• Vcc = 2.7 to 3.6 V, TA = 0 to +70°C

SYMBOL	PARAMETER	NOTE	VPP = 2.7 to 3.6 V			VPP = 3.3±0.3 V			VPP = 5.0±0.5 V			UNIT
			MIN.	TYP.(NOTE 1)	MAX.	MIN.	TYP.(NOTE 1)	MAX.	MIN.	TYP.(NOTE 1)	MAX.	
t_{WHQV1} t_{EHQV1}	Word/Byte Write Time (using W/B write, in word mode)	2		22.17			22.17			13.2		µs
t_{WHQV1} t_{EHQV1}	Word/Byte Write Time (using W/B write, in byte mode)	2		19.89			19.89			13.2		µs
	Word/Byte Write Time (using multi word/byte write)	2		5.76			5.76			2.76		µs
	Block Write Time (using W/B write, in word mode)	2		0.91			0.91			0.44		s
	Block Write Time (using W/B write, in byte mode)	2		1.63			1.63			0.87		s
	Block Write Time (using multi word/byte write)	2		0.37			0.37			0.18		s
t_{WHQV2} t_{EHQV2}	Block Erase Time	2		0.56			0.56			0.42		s
	Bank Erase Time			17.9			17.9			13.3		s
t_{WHQV3} t_{EHQV3}	Set Block Lock-Bit Time	2		22.17			22.17			13.2		µs
t_{WHQV4} t_{EHQV4}	Clear Block Lock-Bits Time	2		0.56			0.56			0.42		s
t_{WHRH1} t_{EHRH1}	Write Suspend Latency Time to Read			7.24	10.2		7.24	10.2		6.73	9.48	µs
t_{WHRH2} t_{EHRH2}	Erase Suspend Latency Time to Read			15.5	21.5		15.5	21.5		12.54	17.54	µs

NOTES :

1. Typical values measured at TA = +25°C and nominal voltages. Assumes corresponding block lock-bits are not set. Subject to change based on device characterization.

2. Excludes system-level overhead.

3. Sampled, not 100% tested.

6.2.8 BLOCK ERASE, BANK ERASE, (MULTI) WORD/BYTE WRITE AND BLOCK LOCK-BIT CONFIGURATION PERFORMANCE (contd.) (NOTE 3)

• $V_{CC} = 3.3\pm0.3$ V, $T_A = 0$ to $+70°C$

SYMBOL	PARAMETER	NOTE	$V_{PP} = 3.3\pm0.3$ V			$V_{PP} = 5.0\pm0.5$ V			UNIT
			MIN.	TYP.(NOTE 1)	MAX.	MIN.	TYP.(NOTE 1)	MAX.	
t_{WHQV1} t_{EHQV1}	Word/Byte Write Time (using W/B write, in word mode)	2		21.75			12.95		µs
t_{WHQV1} t_{EHQV1}	Word/Byte Write Time (using W/B write, in byte mode)	2		19.51			12.95		µs
	Word/Byte Write Time (using multi word/byte write)	2		5.66			2.7		µs
	Block Write Time (using W/B write, in word mode)	2		0.89			0.43		s
	Block Write Time (using W/B write, in byte mode)	2		1.6			0.85		s
	Block Write Time (using multi word/byte write)	2		0.36			0.18		s
t_{WHQV2} t_{EHQV2}	Block Erase Time	2		0.55			0.41		s
	Bank Erase Time			17.6			13.1		s
t_{WHQV3} t_{EHQV3}	Set Block Lock-Bit Time	2		21.75			12.95		µs
t_{WHQV4} t_{EHQV4}	Clear Block Lock-Bits Time	2		0.55			0.41		s
t_{WHRH1} t_{EHRH1}	Write Suspend Latency Time to Read			7.1	10		6.6	9.3	µs
t_{WHRH2} t_{EHRH2}	Erase Suspend Latency Time to Read			15.2	21.1		12.3	17.2	µs

NOTES :

1. Typical values measured at $T_A = +25°C$ and nominal voltages. Assumes corresponding block lock-bits are not set. Subject to change based on device characterization.

2. Excludes system-level overhead.

3. Sampled, not 100% tested.

7 ORDERING INFORMATION

Product line designator for all SHARP Flash products

| L | H | 2 | 8 | F | 3 | 2 | 0 | S | 3 | T | D | - | L | 1 | 0 |

Device Density
320 = 32 M-bit

Architecture
S = Symmetrical Block

Power Supply Type
3 = Smart 3 Technology

Access Speed (ns)
10 : 100 ns (3.3±0.3 V), 120 ns (2.7 to 3.6 V)

Dual Work technology

Package
T = 56-pin TSOP (I) (TSOP056-P-1420) Normal bend

Operating Temparature = 0 to +70°C
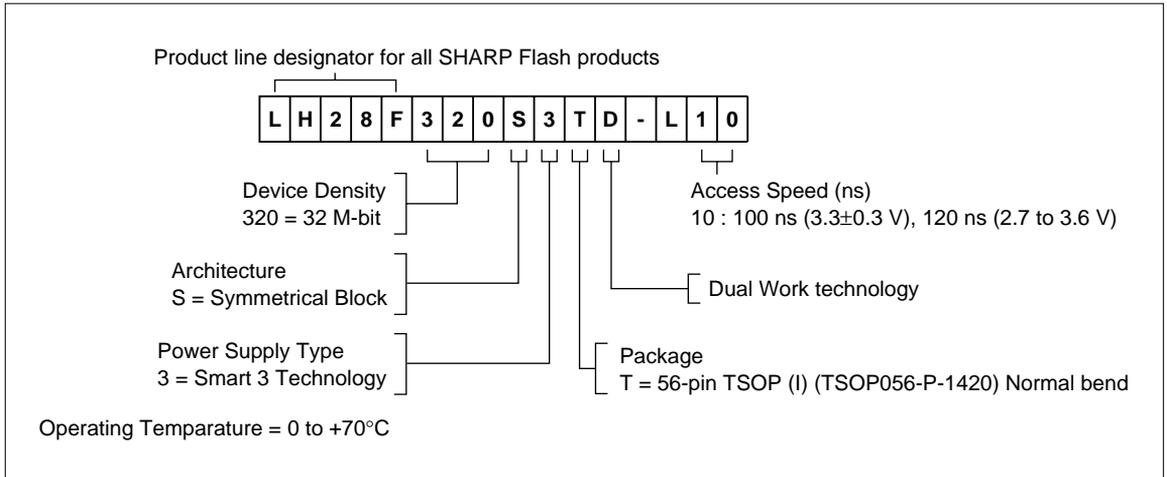
OPTION	ORDER CODE	VALID OPERATIONAL COMBINATIONS	
		V_{CC} = 2.7 to 3.6 V 50 pF load, 1.35 V I/O Levels	V_{CC} = 3.3±0.3 V 50 pF load, 1.5 V I/O Levels
1	LH28F320S3TD-L10	120 ns	100 ns

56 TSOP (TSOP056-P-1420)