16 Mbit (x8/x16) Concurrent SuperFlash

GLS36VF1601E / GLS36VF1602E

Data Sheet

FEATURES:

- **Organized as 1M x16 or 2M x8**
- **Dual Bank Architecture for Concurrent Read/Write Operation**
  - 16 Mbit Bottom Sector Protection
    - GLS36VF1601E: 12 Mbit + 4 Mbit
  - 16 Mbit Top Sector Protection
    - GLS36VF1602E: 4 Mbit + 12 Mbit
- **Single 2.7-3.6V for Read and Write Operations**
- **Superior Reliability**
  - Endurance: 100,000 cycles (typical)
  - Greater than 100 years Data Retention
- **Low Power Consumption:**
  - Active Current: 6 mA typical
  - Standby Current: 4 µA typical
  - Auto Low Power Mode: 4 µA typical
- **Hardware Sector Protection/WP# Input Pin**
  - Protects the 4 outermost sectors (8 KWord) in the larger bank by driving WP# low and unprotects by driving WP# high
- **Hardware Reset Pin (RST#)**
  - Resets the internal state machine to reading array data
- **Byte# Pin**
  - Selects 8-bit or 16-bit mode
- **Sector-Erase Capability**
  - Uniform 2 KWord sectors
- **Chip-Erase Capability**
- **Block-Erase Capability**
  - Uniform 32 KWord blocks
- **Erase-Suspend / Erase-Resume Capabilities**
- **Security ID Feature**
  - Greenliant: 128 bits
  - User: 128 bits
- **Fast Read Access Time**
  - 70 ns
- **Latched Address and Data**
- **Fast Erase and Program (typical):**
  - Sector-Erase Time: 18 ms
  - Block-Erase Time: 18 ms
  - Chip-Erase Time: 35 ms
  - Program Time: 7 µs
- **Automatic Write Timing**
  - Internal V_{PP} Generation
- **End-of-Write Detection**
  - Toggle Bit
  - Data# Polling
  - Ready/Busy# pin
- **CMOS I/O Compatibility**
- **Conforms to Common Flash Memory Interface (CFI)**
- **JEDEC Standards**
  - Flash EEPROM Pinouts and command sets
- **Packages Available**
  - 48-ball TFBGA (6mm x 8mm)
  - 48-lead TSOP (12mm x 20mm)

PRODUCT DESCRIPTION

The GLS36VF1601E and GLS36VF1602E are 1M x16 or 2M x8 CMOS Concurrent Read/Write Flash Memory manufactured with Greenliant's proprietary, high performance CMOS SuperFlash memory technology. The split-gate cell design and thick oxide tunneling injector attain better reliability and manufacturability compared with alternate approaches. The devices write (Program or Erase) with a 2.7-3.6V power supply and conform to JEDEC standard pinouts for x8/x16 memories.

Featuring high performance Program, these devices provide a typical Program time of 7 µsec and use the Toggle Bit, Data# Polling, or RY/BY# to detect the completion of the Program or Erase operation. To protect against inadvertent write, the devices have on-chip hardware and Software Data Protection schemes. Designed, manufactured, and tested for a wide spectrum of applications, these devices are offered with a guaranteed endurance of 10,000 cycles. Data retention is rated at greater than 100 years.

These devices are suited for applications that require convenient and economical updating of program, configuration, or data memory. For all system applications, the devices significantly improve performance and reliability, while lowering power consumption. Since for any given voltage range, the SuperFlash technology uses less current to program and has a shorter erase time, the total energy consumed during any Erase or Program operation

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is less than alternative flash technologies. These devices also improve flexibility while lowering the cost for program, data, and configuration storage applications.

SuperFlash technology provides fixed Erase and Program times, independent of the number of Erase/Program cycles that have occurred. Therefore the system software or hardware does not have to be modified or de-rated as is necessary with alternative flash technologies, whose Erase and Program times increase with accumulated Erase/Program cycles.

To meet high-density, surface-mount requirements, these devices are offered in 48-ball TFBGA and 48-lead TSOP packages. See Figures 6 and 7 for pin assignments.

Device Operation

Memory operation functions are initiated using standard microprocessor write sequences. A command is written by asserting WE# low while keeping CE# low. The address bus is latched on the falling edge of WE# or CE#, whichever occurs last. The data bus is latched on the rising edge of WE# or CE#, whichever occurs first.

Auto Low Power Mode

These devices also have the **Auto Lower Power** mode which puts them in a near standby mode within 500 ns after data has been accessed with a valid Read operation. This reduces the I_{DD} active Read current to 4 µA typically. While CE# is low, the devices exit Auto Low Power mode with any address transition or control signal transition used to initiate another Read cycle, with no access time penalty.

Concurrent Read/Write Operation

The dual bank architecture of these devices allows the Concurrent Read/Write operation whereby the user can read from one bank while programming or erasing in the other bank. For example, reading system code in one bank while updating data in the other bank.

TABLE 1: Concurrent Read/Write State

Bank 1	Bank 2
Read	No Operation
Read	Write
Write	Read
Write	No Operation
No Operation	Read
No Operation	Write

Note: For the purposes of this table, write means to perform Block- or Sector-Erase or Program operations as applicable to the appropriate bank.

Read Operation

The Read operation is controlled by CE# and OE#; both have to be low for the system to obtain data from the outputs. CE# is used for device selection. When CE# is high, the chip is deselected and only standby power is consumed. OE# is the output control and is used to gate data from the output pins. The data bus is in a high impedance state when either CE# or OE# is high. Refer to the Read cycle timing diagram for further details (Figure 8).

Program Operation

These devices are programmed on a word-by-word or byte-by-byte basis depending on the state of the BYTE# pin. Before programming, one must ensure that the sector which is being programmed is fully erased.

The Program operation is accomplished in three steps:

1. Software Data Protection is initiated using the three-byte load sequence.
2. Address and data are loaded.

   During the Program operation, the addresses are latched on the falling edge of either CE# or WE#, whichever occurs last. The data is latched on the rising edge of either CE# or WE#, whichever occurs first.
3. The internal Program operation is initiated after the rising edge of the fourth WE# or CE#, whichever occurs first. The Program operation, once initiated, will be completed typically within 7 µs.

See Figures 9 and 10 for WE# and CE# controlled Program operation timing diagrams and Figure 24 for flowcharts. During the Program operation, the only valid reads are Data# Polling and Toggle Bit. During the internal Program operation, the host is free to perform additional tasks. Any commands issued during an internal Program operation are ignored.

Sector-Erase/Block-Erase Operation

These devices offer both Sector-Erase and Block-Erase operations. These operations allow the system to erase the devices on a sector-by-sector (or block-by-block) basis. The sector architecture is based on a uniform sector size of 2 KWord. The Block-Erase mode is based on a uniform block size of 32 KWord. The Sector-Erase operation is initiated by executing a six-byte command sequence with a Sector-Erase command (30H) and sector address (SA) in the last bus cycle. The Block-Erase operation is initiated by executing a six-byte command sequence with Block-Erase command (50H) and block address (BA) in the last bus cycle. The sector or block address is latched on the falling edge of the sixth WE# pulse, while the command (30H or 50H) is latched on the rising edge of the sixth WE# pulse. The internal Erase operation begins after the sixth WE# pulse. Any commands issued during the Sector- or Block-Erase operation are ignored except Erase-Suspend and Erase-Resume. See Figures 14 and 15 for timing waveforms.

Chip-Erase Operation

The devices provide a Chip-Erase operation, which allows the user to erase all sectors/blocks to the “1” state. This is useful when a device must be quickly erased.

The Chip-Erase operation is initiated by executing a six-byte command sequence with Chip-Erase command (10H) at address 555H in the last byte sequence. The Erase operation begins with the rising edge of the sixth WE# or CE#, whichever occurs first. During the Erase operation, the only valid Read is Toggle Bit or Data# Polling. Any commands issued during the Chip-Erase operation are ignored. See Table 6 for the command sequence, Figure 13 for timing diagram, and Figure 28 for the flowchart. When WP# is low, any attempt to Chip-Erase will be ignored.

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Erase-Suspend/Erase-Resume Operations

The Erase-Suspend operation temporarily suspends a Sector- or Block-Erase operation thus allowing data to be read from any memory location, or program data into any sector/block that is not suspended for an Erase operation. The operation is executed by issuing a one-byte command sequence with Erase-Suspend command (B0H). The device automatically enters read mode no more than 10 µs after the Erase-Suspend command had been issued. (T_{ES} maximum latency equals 10 µs.) Valid data can be read from any sector or block that is not suspended from an Erase operation. Reading at address location within erase-suspended sectors/blocks will output DQ_2 toggling and DQ_6 at "1". While in Erase-Suspend mode, a Program operation is allowed except for the sector or block selected for Erase-Suspend. To resume Sector-Erase or Block-Erase operation which has been suspended, the system must issue an Erase-Resume command. The operation is executed by issuing a one-byte command sequence with Erase Resume command (30H) at any address in the one-byte sequence.

Write Operation Status Detection

These devices provide one hardware and two software means to detect the completion of a Write (Program or Erase) cycle in order to optimize the system Write cycle time. The hardware detection uses the Ready/Busy# (RY/BY#) output pin. The software detection includes two status bits: Data# Polling (DQ_7) and Toggle Bit (DQ_6). The End-of-Write detection mode is enabled after the rising edge of WE#, which initiates the internal Program or Erase operation.

The actual completion of the nonvolatile write is asynchronous with the system; therefore, either a Ready/Busy# (RY/BY#), a Data# Polling (DQ_7), or Toggle Bit (DQ_6) Read may be simultaneous with the completion of the Write cycle. If this occurs, the system may get an erroneous result, i.e., valid data may appear to conflict with either DQ_7 or DQ_6. In order to prevent spurious rejection if an erroneous result occurs, the software routine should include a loop to read the accessed location an additional two (2) times. If both Reads are valid, then the Write cycle has completed, otherwise the rejection is valid.

Ready/Busy# (RY/BY#)

The devices include a Ready/Busy# (RY/BY#) output signal. RY/BY# is an open drain output pin that indicates whether an Erase or Program operation is in progress. Since RY/BY# is an open drain output, it allows several devices to be tied in parallel to V_{DD} via an external pull-up resistor. After the rising edge of the final WE# pulse in the command sequence, the RY/BY# status is valid.

When RY/BY# is actively pulled low, it indicates that an Erase or Program operation is in progress. When RY/BY# is high (Ready), the devices may be read or left in standby mode.

Byte/Word (BYTE#)

The device includes a BYTE# pin to control whether the device data I/O pins operate x8 or x16. If the BYTE# pin is at logic "1" (V_{IH}) the device is in x16 data configuration: all data I/0 pins DQ_0-DQ_{15} are active and controlled by CE# and OE#.

If the BYTE# pin is at logic "0", the device is in x8 data configuration: only data I/O pins DQ_0-DQ_7 are active and controlled by CE# and OE#. The remaining data pins DQ_8-DQ_{14} are at Hi-Z, while pin DQ_{15} is used as the address input A_{-1} for the Least Significant Bit of the address bus.

Data# Polling (DQ_7)

When the devices are in an internal Program operation, any attempt to read DQ_7 will produce the complement of the true data. Once the Program operation is completed, DQ_7 will produce true data. During internal Erase operation, any attempt to read DQ_7 will produce a '0'. Once the internal Erase operation is completed, DQ_7 will produce a '1'. The Data# Polling is valid after the rising edge of fourth WE# (or CE#) pulse for Program operation. For Sector-, Block-, or Chip-Erase, the Data# Polling is valid after the rising edge of sixth WE# (or CE#) pulse. See Figure 11 for Data# Polling (DQ_7) timing diagram and Figure 25 for a flowchart.

Toggle Bits (DQ_6 and DQ_2)

During the internal Program or Erase operation, any consecutive attempts to read DQ_6 will produce alternating "1"s and "0"s, i.e., toggling between 1 and 0. When the internal Program or Erase operation is completed, the DQ_6 bit will stop toggling. The device is then ready for the next operation. The toggle bit is valid after the rising edge of the fourth WE# (or CE#) pulse for Program operations. For Sector-, Block-, or Chip-Erase, the toggle bit (DQ_6) is valid after the rising edge of sixth WE# (or CE#) pulse. DQ_6 will be set to "1" if a Read operation is attempted on an Erase-suspended Sector/Block. If Program operation is initiated in a sector/block not selected in Erase-Suspend mode, DQ_6 will toggle.

An additional Toggle Bit is available on DQ_2, which can be used in conjunction with DQ_6 to check whether a particular sector is being actively erased or erase-suspended. Table 2 shows detailed status bit information. The Toggle Bit (DQ_2) is valid after the rising edge of the last WE# (or CE#) pulse of a Write operation. See Figure 12 for Toggle Bit timing diagram and Figure 25 for a flowchart.

TABLE 2: Write Operation Status

Status		DQ_7	DQ_6	DQ_2	RY/BY#
Normal Operation	Standard Program	DQ7#	Toggle	No Toggle	0
	Standard Erase	0	Toggle	Toggle	0
Erase-Suspend Mode	Read From Erase Suspended Sector/Block	1	1	Toggle	1
	Read From Non-Erase Suspended Sector/Block	Data	Data	Data	1
	Program	DQ7#	Toggle	N/A	0

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Note: DQ_7, DQ_6, and DQ_2 require a valid address when reading status information. The address must be in the bank where the operation is in progress in order to read the operation status. If the address is pointing to a different bank (not busy), the device will output array data.

Data Protection

The devices provide both hardware and software features to protect nonvolatile data from inadvertent writes.

Hardware Data Protection

Noise/Glitch Protection: A WE# or CE# pulse of less than 5 ns will not initiate a Write cycle.

V_{DD} Power Up/Down Detection: The Write operation is inhibited when V_{DD} is less than 1.5V.

Write Inhibit Mode: Forcing OE# low, CE# high, or WE# high will inhibit the Write operation. This prevents inadvertent writes during power-up or power-down.

Hardware Block Protection

The devices provide hardware block protection which protects the outermost 8 KWord in the larger bank. The block is protected when WP# is held low. See Figures 2, 3, 4, and 5 for Block-Protection location.

A user can disable block protection by driving WP# high. This allows data to be erased or programmed into the protected sectors. WP# must be held high prior to issuing the Write command and remain stable until after the entire Write operation has completed. If WP# is left floating, it is internally held high via a pull-up resistor, and the Boot Block is unprotected, enabling Program and Erase operations on that block.

Hardware Reset (RST#)

The RST# pin provides a hardware method of resetting the devices to read array data. When the RST# pin is held low for at least T_{RP}, any in-progress operation will terminate and return to Read mode (see Figure 21). When no internal Program/Erase operation is in progress, a minimum period of T_{RHR} is required after RST# is driven high before a valid Read can take place (see Figure 20).

The Erase operation that has been interrupted needs to be reinitiated after the device resumes normal operation mode to ensure data integrity.

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Software Data Protection (SDP)

These devices provide the JEDEC standard Software Data Protection scheme for all data alteration operations, i.e., Program and Erase. Any Program operation requires the inclusion of the three-byte sequence. The three-byte load sequence is used to initiate the Program operation, providing optimal protection from inadvertent Write operations, e.g., during the system power-up or power-down. Any Erase operation requires the inclusion of the six-byte sequence. The devices are shipped with the Software Data Protection permanently enabled. See Table 6 for the specific software command codes. During SDP command sequence, invalid commands will abort the device to Read mode within $T_{RC.}$ The contents of DQ_{15}-DQ_8 can be V_{IL} or $V_{IH,}$ but no other value during any SDP command sequence.

Common Flash Memory Interface (CFI)

These devices also contain the CFI information to describe the characteristics of the devices. In order to enter the CFI Query mode, the system must write the three-byte sequence, same as the Software ID Entry command with 98H (CFI Query command) to address 555H in the last byte sequence. See Figure 17 for CFI Entry and Read timing diagram. Once the device enters the CFI Query mode, the system can read CFI data at the addresses given in Tables 7 through 9. The system must write the CFI Exit command to return to Read mode from the CFI Query mode.

Security ID

The GLS36VF160xE devices offer a 256-bit Security ID space. The Secure ID space is divided into two 128-bit segments—one factory programmed segment and one user programmed segment. The first segment is programmed and locked at Greenliant with a unique, 128-bit number. The user segment is left un-programmed for the customer to program as desired. To program the user segment of the Security ID, the user must use the Security ID Program command. End-of-Write status is checked by reading the toggle bits. Data# Polling is not used for Security ID End-of-Write detection. Once programming is complete, the Sec ID should be locked using the User Sec ID Program Lock-Out. This disables any future corruption of this space. Note that regardless of whether or not the Sec ID is locked, neither Sec ID segment can be erased. The Secure ID space can be queried by executing a three-byte command sequence with Query Sec ID command (88H) at address 555H in the last byte sequence. See Figure 19 for timing diagram. To exit this mode, the Exit Sec ID command should be executed. Refer to Table 6 for more details.

Product Identification

The Product Identification mode identifies the devices and manufacturer. For details, see Table 3 for software operation, Figure 16 for the Software ID Entry and Read timing diagram and Figure 26 for the Software ID Entry command sequence flowchart. The addresses A_{19} and A_{18} indicate a bank address. When the addressed bank is switched to Product Identification mode, it is possible to read another address from the same bank without issuing a new Software ID Entry command.

TABLE 3: Product Identification

	Address	Data
Manufacturer's ID	BK0000H	00BFH
Device ID		
GLS36VF1601E	BK0001H	734BH
GLS36VF1602E	BK0001H	734AH

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Note: BK = Bank Address (A_{19}-A_{18})

Product Identification Mode Exit/CFI Mode Exit

In order to return to the standard Read mode, the Software Product Identification mode must be exited. Exit is accomplished by issuing the Software ID Exit command sequence, which returns the device to the Read mode. This command may also be used to reset the device to the Read mode after any inadvertent transient condition that apparently causes the device to behave abnormally, e.g., not read correctly. Please note that the Software ID Exit/CFI Exit command is ignored during an internal Program or Erase operation. See Table 6 for the software command code, Figure 18 for timing waveform and Figure 27 for a flowchart.

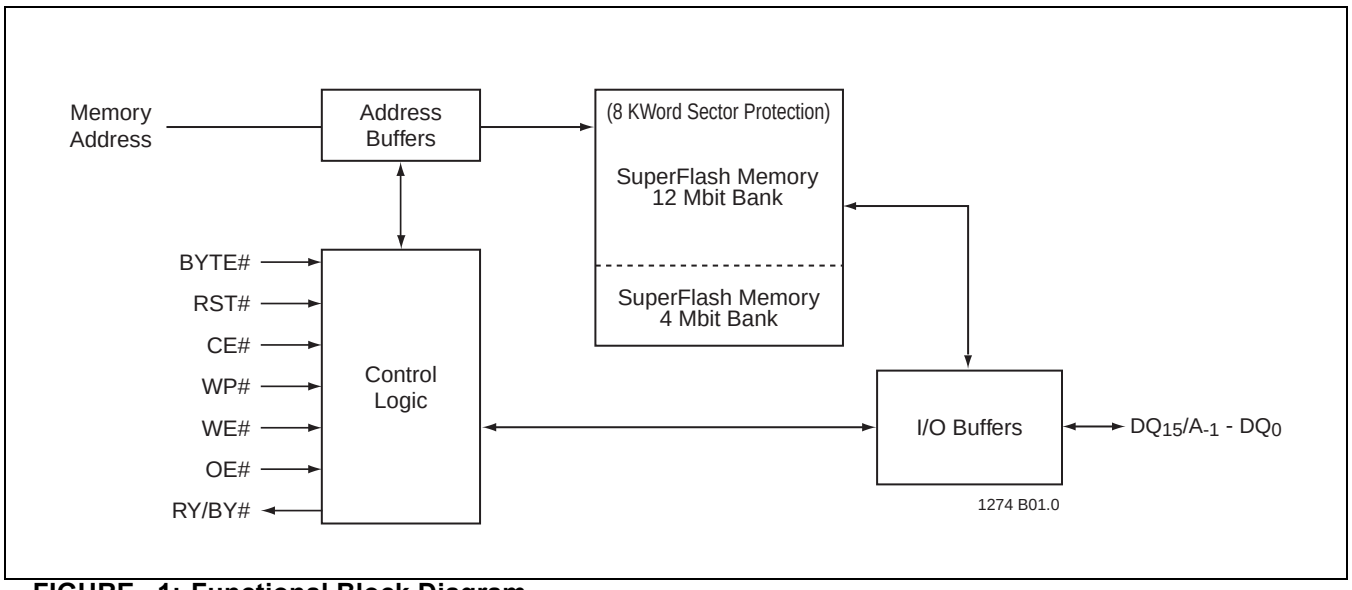

FIGURE 1: Functional Block Diagram

Bottom Sector Protection; 32 KWord Blocks; 2 KWord Sectors

FFFFFH F8000H	Block 31	Bank 2
F7FFFH F0000H	Block 30	
EFFFFH E8000H	Block 29	
E7FFFH E0000H	Block 28	
DFFFFH D8000H	Block 27	
D7FFFH D0000H	Block 26	
CFFFFH C8000H	Block 25	
C7FFFH C0000H	Block 24	
BFFFFH B8000H	Block 23	Bank 1
B7FFFH B0000H	Block 22	
AFFFFH A8000H	Block 21	
A7FFFH A0000H	Block 20	
9FFFFH 98000H	Block 19	
97FFFH 90000H	Block 18	
8FFFFH 88000H	Block 17	
87FFFH 80000H	Block 16	
7FFFFH 78000H	Block 15	
77FFFH 70000H	Block 14	
6FFFFH 68000H	Block 13	
67FFFH 60000H	Block 12	
5FFFFH 58000H	Block 11	
57FFFH 50000H	Block 10	
4FFFFH 48000H	Block 9	
47FFFH 40000H	Block 8	
3FFFFH 38000H	Block 7	
37FFFH 30000H	Block 6	
2FFFFH 28000H	Block 5	
27FFFH 20000H	Block 4	
1FFFFH 18000H	Block 3	
17FFFH 10000H	Block 2	
0FFFFH 08000H	Block 1	
07FFFH 02000H	Block 0	
01FFFH 00000H		

8 KWord Sector Protection (4-2 KWord Sectors)

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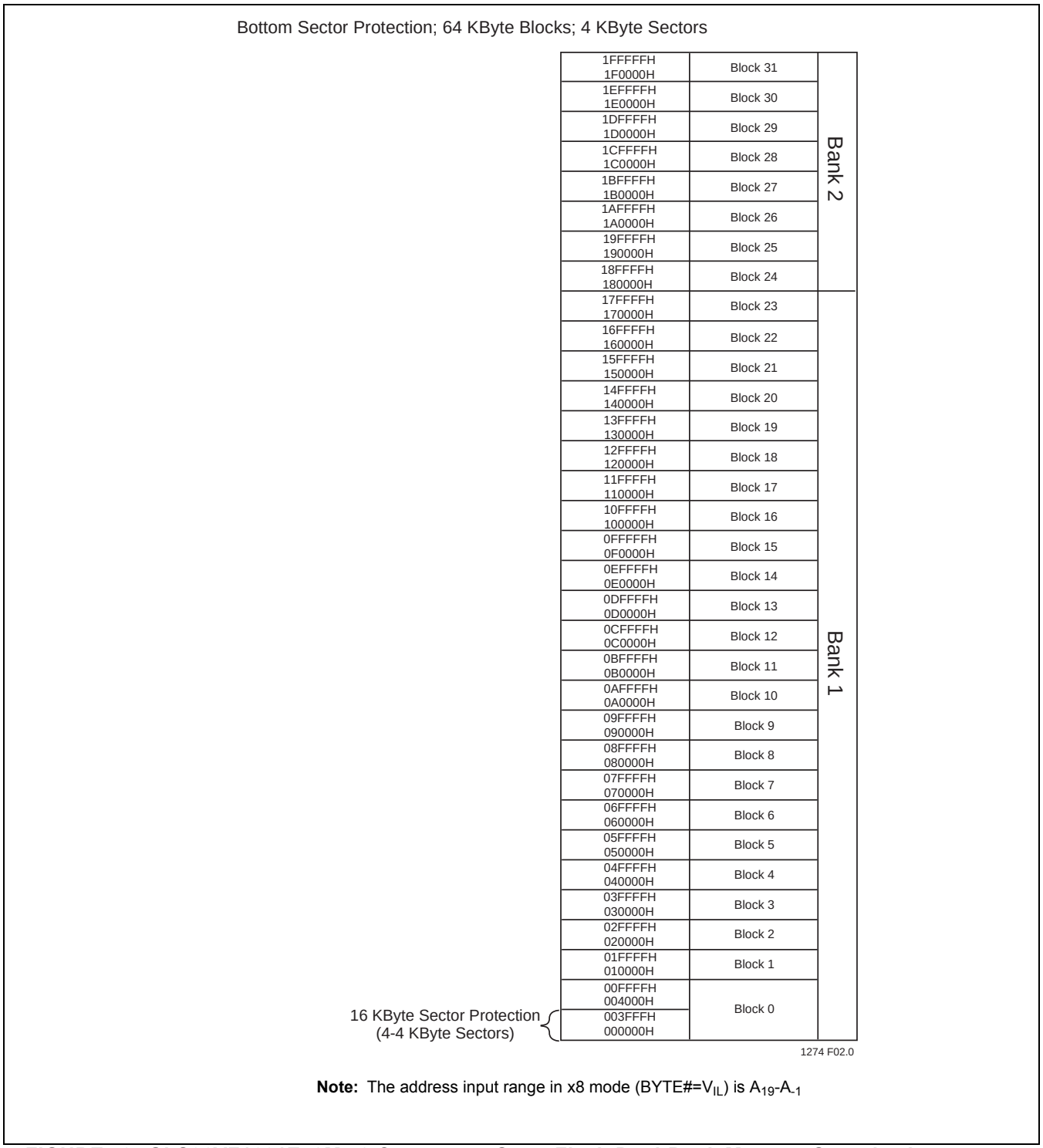
Note: The address input range in x16 mode (BYTE#=V_{IH}) is A_{19}-A_0

FIGURE 2: GLS36VF1601E, 1M x16 Concurrent SuperFlash Dual-Bank Memory Organization



Note: The address input range in x8 mode (BYTE#=V_{IL}) is A_{19}-A_{-1}

FIGURE 3: GLS36VF1601E, 2M x8 Concurrent SuperFlash Dual-Bank Memory Organization

Top Block Protection; 32 KWord Blocks; 2 KWord Sectors

8 KWord Block Protection (4 - 2 KWord Sectors)

FFFFFH FE000H	Block 31	Bank 2
FDFFFH F8000H		
F7FFFH F0000H	Block 30	
EFFFFH E8000H	Block 29	
E7FFFH E0000H	Block 28	
DFFFFH D8000H	Block 27	
D7FFFH D0000H	Block 26	
CFFFFH C8000H	Block 25	
C7FFFH C0000H	Block 24	
BFFFFH B8000H	Block 23	
B7FFFH B0000H	Block 22	
AFFFFH A8000H	Block 21	
A7FFFH A0000H	Block 20	
9FFFFH 98000H	Block 19	
97FFFH 90000H	Block 18	
8FFFFH 88000H	Block 17	
87FFFH 80000H	Block 16	
7FFFFH 78000H	Block 15	
77FFFH 70000H	Block 14	
6FFFFH 68000H	Block 13	
67FFFH 60000H	Block 12	
5FFFFH 58000H	Block 11	
57FFFH 50000H	Block 10	
4FFFFH 48000H	Block 9	
47FFFH 40000H	Block 8	
3FFFFH 38000H	Block 7	Bank 1
37FFFH 30000H	Block 6	
2FFFFH 28000H	Block 5	
27FFFH 20000H	Block 4	
1FFFFH 18000H	Block 3	
17FFFH 10000H	Block 2	
0FFFFH 08000H	Block 1	
07FFFH 00000H	Block 0	

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Note: The address input range in x16 mode (BYTE#=V_{IH}) is

FIGURE 4: GLS36VF1602E, 1M x16 Concurrent SuperFlash Dual-Bank Memory Organization

Top Block Protection; 64 KByte Blocks; 4 KByte Sectors

16 KByte Block Protection (4 - 4 KByte Sectors)

1FFFFFH 1FC000H	Block 31	Bank 2
1FBFFFH 1F0000H		
1EFFFFH 1E0000H	Block 30	
1DFFFFH 1D0000H	Block 29	
1CFFFFH 1C0000H	Block 28	
1BFFFFH 1B0000H	Block 27	
1AFFFFH 1A0000H	Block 26	
19FFFFH 190000H	Block 25	
18FFFFH 180000H	Block 24	
17FFFFH 170000H	Block 23	
16FFFFH 160000H	Block 22	
15FFFFH 150000H	Block 21	
14FFFFH 140000H	Block 20	
13FFFFH 130000H	Block 19	
12FFFFH 120000H	Block 18	
11FFFFH 110000H	Block 17	
10FFFFH 100000H	Block 16	
0FFFFFH 0F0000H	Block 15	
0EFFFFH 0E0000H	Block 14	
0DFFFFH 0D0000H	Block 13	
0CFFFFH 0C0000H	Block 12	
0BFFFFH 0B0000H	Block 11	
0AFFFFH 0A0000H	Block 10	
09FFFFH 090000H	Block 9	
08FFFFH 080000H	Block 8	
07FFFFH 070000H	Block 7	Bank 1
06FFFFH 060000H	Block 6	
05FFFFH 050000H	Block 5	
04FFFFH 040000H	Block 4	
03FFFFH 030000H	Block 3	
02FFFFH 020000H	Block 2	
01FFFFH 010000H	Block 1	
00FFFFH 000000H	Block 0	

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Note: The address input range in x8 mode (BYTE#=V_{IL}) is

FIGURE 5: GLS36VF1602E, 2M x8 Concurrent SuperFlash Dual-Bank Memory Organization

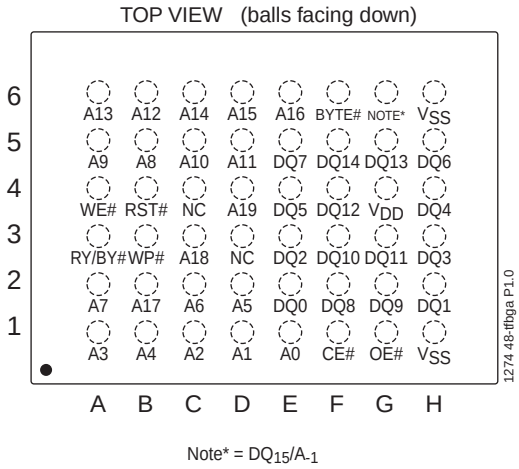

FIGURE 6: Pin Assignments for 48-ball TFBGA (6mm x 8mm)

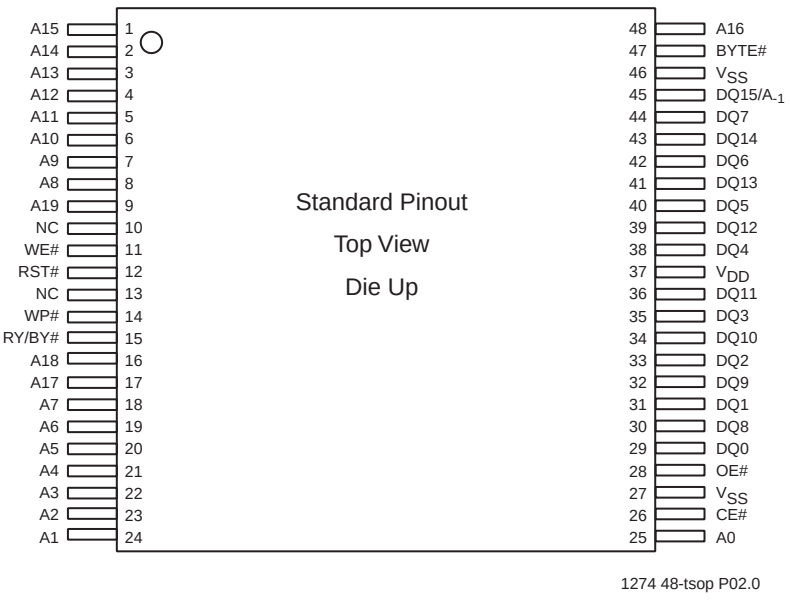

FIGURE 7: Pin Assignments for 48-lead TSOP (12mm x 20mm)

TABLE 4: Pin Description

Symbol	Name	Functions
A_{19}-A_0	Address Inputs	To provide memory addresses. During Sector-Erase and Hardware Sector Protection, A_{19}-A_{11} address lines will select the sector. During Block-Erase A_{19}-A_{15} address lines will select the block.
DQ_{14}-DQ_0	Data Input/Output	To output data during Read cycles and receive input data during Write cycles Data is internally latched during a Write cycle. The outputs are in tri-state when OE# or CE# is high.
DQ_{15}/A_{-1}	Data Input/Output and LBS Address	DQ_{15} is used as data I/O pin when in x16 mode (BYTE# = "1") A_{-1} is used as the LSB address pin when in x8 mode (BYTE# = "0")
CE#	Chip Enable	To activate the device when CE# is low.
OE#	Output Enable	To gate the data output buffers
WE#	Write Enable	To control the Write operations
RST#	Hardware Reset	To reset and return the device to Read mode
RY/BY#	Ready/Busy#	To output the status of a Program or Erase operation RY/BY# is a open drain output, so a 10KΩ - 100KΩ pull-up resistor is required to allow RY/BY# to transition high indicating the device is ready to read.
WP#	Write Protect	To protect and unprotect top or bottom 8 KWord (4 outermost sectors) from Erase or Program operation.
BYTE#	Word/Byte Configuration	To select 8-bit or 16-bit mode.
V_{DD}	Power Supply	To provide 2.7-3.6V power supply voltage
V_{SS}	Ground	
NC	No Connection	Unconnected pins

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TABLE 5: Operation Modes Selection

Mode[1]	CE#	OE#	WE#	DQ_7-DQ_0	DQ_{15}-DQ_8		Address
					BYTE# = V_{IH}	BYTE# = V_{IL}	
Read	V_{IL}	V_{IL}	V_{IH}	D_{OUT}	D_{OUT}	DQ_{14}-DQ_8 = High Z	A_{IN}
Program	V_{IL}	V_{IH}	V_{IL}	D_{IN}	D_{IN}	$DQ_{15} = A_{-1}$	A_{IN}
Erase	V_{IL}	V_{IH}	V_{IL}	X[2]	X	High Z	Sector or Block address, 555H for Chip-Erase
Standby	V_{IHC}	X	X	High Z	High Z	High Z	X
Write Inhibit	X	V_{IL}	X	High Z / D_{OUT}	High Z / D_{OUT}	High Z	X
	X	X	V_{IH}	High Z / D_{OUT}	High Z / D_{OUT}	High Z	X
Product Identification							
Software Mode	V_{IL}	V_{IL}	V_{IH}	Manufacturer's ID (BFH)	Manufacturer's ID (00H)	High Z	See Table 6
				Device ID[3]	Device ID[3]	High Z	

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1. RST# = V_{IH} for all described operation modes
2. X can be V_{IL} or V_{IH}, but no other value.
3. Device ID = GLS36VF1601E = 734BH, GLS36VF1602E = 734AH

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TABLE 6: Software Command Sequence

Command Sequence	1st Bus Write Cycle		2nd Bus Write Cycle		3rd Bus Write Cycle		4th Bus Write Cycle		5th Bus Write Cycle		6th Bus Write Cycle	
	Addr[1]	Data[2]	Addr[1]	Data[2]	Addr[1]	Data[2]	Addr[1]	Data[2]	Addr[1]	Data[2]	Addr[1]	Data[2]
Program	555H	AAH	2AAH	55H	555H	A0H	WA[3]	Data				
Sector-Erase	555H	AAH	2AAH	55H	555H	80H	555H	AAH	2AAH	55H	SA_X[4]	30H
Block-Erase	555H	AAH	2AAH	55H	555H	80H	555H	AAH	2AAH	55H	BA_X[4]	50H
Chip-Erase	555H	AAH	2AAH	55H	555H	80H	555H	AAH	2AAH	55H	555H	10H
Erase-Suspend	XXXXH	B0H										
Erase-Resume	XXXXH	30H										
Query Sec ID[5]	555H	AAH	2AAH	55H	555H	88H						
User Security ID Program	555H	AAH	2AAH	55H	555H	A5H	SIWA[6]	Data				
User Security ID Program Lock-out[7]	555H	AAH	2AAH	55H	555H	85H	XXH	0000H				
Software ID Entry[8]	555H	AAH	2AAH	55H	BK_X[9] 555H	90H						
CFI Query Entry	555H	AAH	2AAH	55H	BK_X[9] 555H	98H						
Software ID Exit/ CFI Exit/ Sec ID Exit[10,11]	555H	AAH	2AAH	55H	555H	F0H						
Software ID Exit/ CFI Exit/ Sec ID Exit[10,11]	XXH	F0H										

T6.1 1274

1. Address format A_{10}-A_0 (Hex), Addresses A_{19}-A_{11} can be V_{IL} or V_{IH}, but no other value, for the command sequence when in x16 mode. When in x8 mode, Addresses A_{19}-A_{12}, Address A_{-1} and DQ_{14}-DQ_8 can be V_{IL} or V_{IH}, but no other value, for the command sequence.
2. DQ_{15}-DQ_8 can be V_{IL} or V_{IH}, but no other value, for the command sequence
3. WA = Program word/byte address
4. SA_X for Sector-Erase; uses A_{19}-A_{11} address lines
   BA_X for Block-Erase; uses A_{19}-A_{15} address lines
5. For GLS36VF1601E,
   Greenliant ID is read with A_3 = 0 (Address range = 00000H to 00007H),
   User ID is read with A_3 = 1 (Address range = 00010H to 00017H).
   Lock Status is read with A_7-A_0 = 000FFH. Unlocked: DQ_3 = 1 / Locked: DQ_3 = 0.
   For GLS36VF1602E,
   Greenliant ID is read with A_3 = 0 (Address range = C0000H to C0007H),
   User ID is read with A_3 = 1 (Address range = C0010H to C0017H).
   Lock Status is read with A_7-A_0 = C00FFH. Unlocked: DQ_3 = 1 / Locked: DQ_3 = 0.
6. SIWA = User Security ID Program word/byte address
   For GLS36VF1601E, valid Word-Addresses for User Sec ID are from 00010H-00017H.
   For GLS36VF1602E, valid Word-Addresses for User Sec ID are from C0010H-C0017H.
   All 4 cycles of User Security ID Program and Program Lock-out must be completed before going back to Read-Array mode.
7. The User Security ID Program Lock-out command must be executed in x16 mode (BYTE#=V_{IH}).
8. The device does not remain in Software Product Identification mode if powered down.
9. A_{19} and A_{18} = BK_X (Bank Address): address of the bank that is switched to Software ID/CFI Mode
   With A_{17}-A_1 = 0; Greenliant Manufacturer's ID = 00BFH, is read with A_0 = 0
   GLS36VF1601E Device ID = 734BH, is read with A_0 = 1
   GLS36VF1602E Device ID = 734AH, is read with A_0 = 1
10. Both Software ID Exit operations are equivalent
11. If users never lock after programming, User Sec ID can be programmed over the previously unprogrammed bits (data=1) using the User Sec ID mode again (the programmed "0" bits cannot be reversed to "1").
    For GLS36VF1601E, valid Word-Addresses for User Sec ID are from 00010H-00017H.
    For GLS36VF1602E, valid Word-Addresses for User Sec ID are from C0010H-C0017H.

TABLE 7: CFI Query Identification String[1]

Address x16 Mode	Address x8 Mode	Data[2]	Description
10H	20H	0051H	Query Unique ASCII string “QRY”
11H	22H	0052H	
12H	24H	0059H	
13H	26H	0001H	Primary OEM command set
14H	28H	0007H	
15H	2AH	0000H	Address for Primary Extended Table
16H	2CH	0000H	
17H	2EH	0000H	Alternate OEM command set (00H = none exists)
18H	30H	0000H	
19H	32H	0000H	Address for Alternate OEM extended Table (00H = none exits)
1AH	34H	0000H	

T7.0 1274

1. Refer to CFI publication 100 for more details.
2. In x8 mode, only the lower byte of data is output.

TABLE 8: System Interface Information

Address x16 Mode	Address x8 Mode	Data[1]	Description
1BH	36H	0027H	V_{DD} Min (Program/Erase) DQ_7-DQ_4: Volts, DQ_3-DQ_0: 100 millivolts
1CH	38H	0036H	V_{DD} Max (Program/Erase) DQ_7-DQ_4: Volts, DQ_3-DQ_0: 100 millivolts
1DH	3AH	0000H	V_{PP} min (00H = no V_{PP} pin)
1EH	3CH	0000H	V_{PP} max (00H = no V_{PP} pin)
1FH	3EH	0004H	Typical time out for Program 2^N µs (2^4 = 16 µs)
20H	40H	0000H	Typical time out for min size buffer program 2^N µs (00H = not supported)
21H	42H	0004H	Typical time out for individual Sector/Block-Erase 2^N ms (2^4 = 16 ms)
22H	44H	0006H	Typical time out for Chip-Erase 2^N ms (2^6 = 64 ms)
23H	46H	0001H	Maximum time out for Program 2^N times typical (2^1 x 2^4 = 32 µs)
24H	48H	0000H	Maximum time out for buffer program 2^N times typical
25H	4AH	0001H	Maximum time out for individual Sector-/Block-Erase 2^N times typical (2^1 x 2^4 = 32 ms)
26H	4CH	0001H	Maximum time out for Chip-Erase 2^N times typical (2^1 x 2^6 = 128 ms)

T8.0 1274

1. In x8 mode, only the lower byte of data is output.

Data Sheet

TABLE 9: Device Geometry Information

Address x16 Mode	Address x8 Mode	Data[1]	Description
27H	4EH	0015H	Device size = 2^N Bytes (15H = 21; 2^{21} = 2 MByte)
28H	50H	0002H	Flash Device Interface description; 0002H = x8/x16 asynchronous interface
29H	52H	0000H	
2AH	54H	0000H	Maximum number of bytes in multi-byte write = 2^N (00H = not supported)
2BH	56H	0000H	
2CH	58H	0002H	Number of Erase Sector/Block sizes supported by device
2DH	5AH	00FFH	Sector Information (y + 1 = Number of sectors; z x 256B = sector size)
2EH	5CH	0001H	y = 511 + 1 = 512 sectors (01FFH = 512)
2FH	5EH	0010H	
30H	60H	0000H	z = 16 x 256 Bytes = 4 KByte/sector (0010H = 16)
31H	62H	001FH	Block Information (y + 1 = Number of blocks; z x 256B = block size)
32H	64H	0000H	y = 31 + 1 = 32 blocks (001FH = 31)
33H	66H	0000H	
34H	68H	0001H	z = 256 x 256 Bytes = 64 KByte/block (0100H = 256)

T9.1 1274

1. In x8 mode, only the lower byte of data is output.

Absolute Maximum Stress Ratings (Applied conditions greater than those listed under "Absolute Maximum Stress Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions or conditions greater than those defined in the operational sections of this data sheet is not implied. Exposure to absolute maximum stress rating conditions may affect device reliability.)

Temperature Under Bias . . . . . -55°C to +125°C
Storage Temperature . . . . . -65°C to +150°C
D. C. Voltage on Any Pin to Ground Potential . . . . . -0.5V to V_{DD}+0.5V
Transient Voltage (<20 ns) on Any Pin to Ground Potential. . . . . -2.0V to V_{DD}+2.0V
Package Power Dissipation Capability (T_A = 25°C) 1.0W
Surface Mount Solder Reflow Temperature . . . . . 260°C for 10 seconds
Output Short Circuit Current . . . . . 50 mA

Operating Range:

Range	Ambient Temp	V_{DD}
Commercial	0°C to +70°C	2.7-3.6V
Industrial	-40°C to +85°C	2.7-3.6V

AC Conditions of Test

Input Rise/Fall Time	5 ns
Output Load	C_L = 30 pF
See Figures 22 and 23	

Data Sheet

TABLE 10: DC Operating Characteristics V_{DD} = 2.7-3.6V

Symbol	Parameter	Freq	Limits			Test Conditions
			Min	Max	Units	
I_{DD}[1]	Active V_{DD} Current					
	Read	5 MHz		15	mA	CE#=V_{IL}, WE#=OE#=V_{IH}
		1 MHz		4	mA	
	Program and Erase			30	mA	CE#=WE#=V_{IL}, OE#=V_{IH}
	Concurrent Read/Write	5 MHz		45	mA	CE#=V_{IL}, OE#=V_{IH}
		1 MHz		35	mA	
I_{SB}	Standby V_{DD} Current			20	µA	CE#, RST#=V_{DD}±0.3V
I_{ALP}	Auto Low Power V_{DD} Current			20	µA	CE#=0.1V, V_{DD}=V_{DD} Max WE#=V_{DD}-0.1V Address inputs=0.1V or V_{DD}-0.1V
I_{RT}	Reset V_{DD} Current			20	µA	RST#=GND
I_{LI}	Input Leakage Current			1	µA	V_{IN} =GND to V_{DD}, V_{DD}=V_{DD} Max
I_{LIW}	Input Leakage Current on WP# pin and RST# pin			10	µA	WP#=GND to V_{DD}, V_{DD}=V_{DD} Max RST#=GND to V_{DD}, V_{DD}=V_{DD} Max
I_{LO}	Output Leakage Current			1	µA	V_{OUT} =GND to V_{DD}, V_{DD}=V_{DD} Max
V_{IL}	Input Low Voltage			0.8	V	V_{DD}=V_{DD} Min
V_{ILC}	Input Low Voltage (CMOS)			0.3	V	V_{DD}=V_{DD} Max
V_{IH}	Input High Voltage		0.7 V_{DD}	V_{DD}+0.3	V	V_{DD}=V_{DD} Max
V_{IHC}	Input High Voltage (CMOS)		V_{DD}-0.3	V_{DD}+0.3	V	V_{DD}=V_{DD} Max
V_{OL}	Output Low Voltage			0.2	V	I_{OL}=100 µA, V_{DD}=V_{DD} Min
V_{OH}	Output High Voltage		V_{DD}-0.2		V	I_{OH}=-100 µA, V_{DD}=V_{DD} Min

T10.1 1274

1. Address input = V_{ILT}/V_{IHT}, V_{DD}=V_{DD} Max (See Figure 22)

TABLE 11: Recommended System Power-up Timings

Symbol	Parameter	Minimum	Units
$T_{PU-READ}$[1]	Power-up to Read Operation	100	µs
$T_{PU-WRITE}$[1]	Power-up to Write Operation	100	µs

T11.0 1274

1. This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.

TABLE 12: Capacitance (T_A = 25°C, f=1 Mhz, other pins open)

Parameter	Description	Test Condition	Maximum
$C_{I/O}$[1]	I/O Pin Capacitance	$V_{I/O}$ = 0V	10 pF
C_{IN}[1]	Input Capacitance	V_{IN} = 0V	10 pF

T12.0 1274

1. This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.

TABLE 13: Reliability Characteristics

Symbol	Parameter	Minimum Specification	Units	Test Method
N_{END}[1]	Endurance	10,000	Cycles	JEDEC Standard A117
T_{DR}[1]	Data Retention	100	Years	JEDEC Standard A103
I_{LTH}[1]	Latch Up	100 + I_{DD}	mA	JEDEC Standard 78

T13.0 1274

1. This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.

AC CHARACTERISTICS

TABLE 14: Read Cycle Timing Parameters V_{DD} = 2.7-3.6V

Symbol	Parameter	Min	Max	Units
T_{RC}	Read Cycle Time	70		ns
T_{CE}	Chip Enable Access Time		70	ns
T_{AA}	Address Access Time		70	ns
T_{OE}	Output Enable Access Time		30	ns
T_{CLZ}[1]	CE# Low to Active Output	0		ns
T_{OLZ}[1]	OE# Low to Active Output	0		ns
T_{CHZ}[1]	CE# High to High-Z Output		16	ns
T_{OHZ}[1]	OE# High to High-Z Output		16	ns
T_{OH}[1]	Output Hold from Address Change	0		ns
T_{RP}[1]	RST# Pulse Width	500		ns
T_{RHR}[1]	RST# High before Read	50		ns
T_{RY}[1,2]	RST# Pin Low to Read Mode		20	µs

T14.1 1274

1. This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.
2. This parameter applies to Sector-Erase, Block-Erase, and Program operations.
   This parameter does not apply to Chip-Erase operations.

TABLE 15: Program/Erase Cycle Timing Parameters

Symbol	Parameter	Min	Max	Units
T_{BP}	Program Time		10	µs
T_{AS}	Address Setup Time	0		ns
T_{AH}	Address Hold Time	40		ns
T_{CS}	WE# and CE# Setup Time	0		ns
T_{CH}	WE# and CE# Hold Time	0		ns
T_{OES}	OE# High Setup Time	0		ns
T_{OEH}	OE# High Hold Time	10		ns
T_{CP}	CE# Pulse Width	40		ns
T_{WP}	WE# Pulse Width	40		ns
T_{WPH}[1]	WE# Pulse Width High	30		ns
T_{CPH}[1]	CE# Pulse Width High	30		ns
T_{DS}	Data Setup Time	30		ns
T_{DH}[1]	Data Hold Time	0		ns
T_{IDA}[1]	Software ID Access and Exit Time		150	ns
T_{SE}	Sector-Erase		25	ms
T_{BE}	Block-Erase		25	ms
T_{SCE}	Chip-Erase		50	ms
T_{ES}	Erase-Suspend Latency		10	µs
T_{BY}[1,2]	RY/BY# Delay Time		90	ns
T_{BR}[1]	Bus Recovery Time		0	µs

T15.1 1274

1. This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.

Data Sheet

2. This parameter applies to Sector-Erase, Block-Erase, and Program operations. This parameter does not apply to Chip-Erase operations.

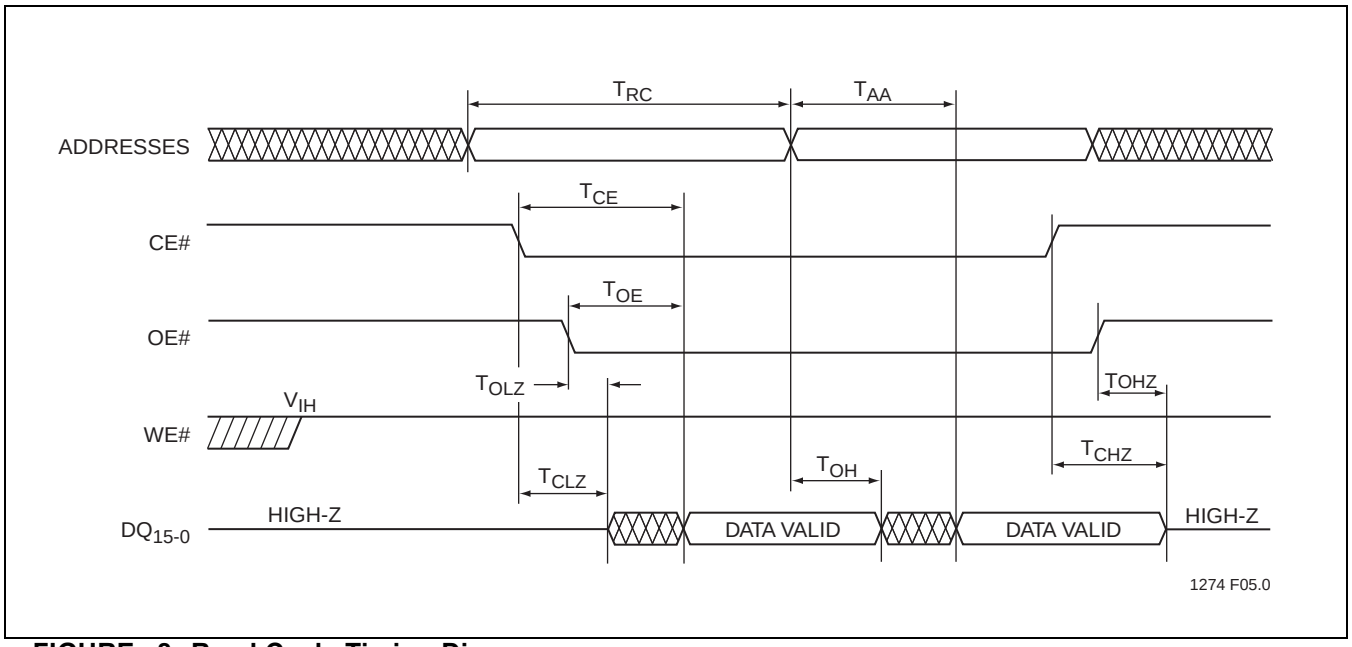
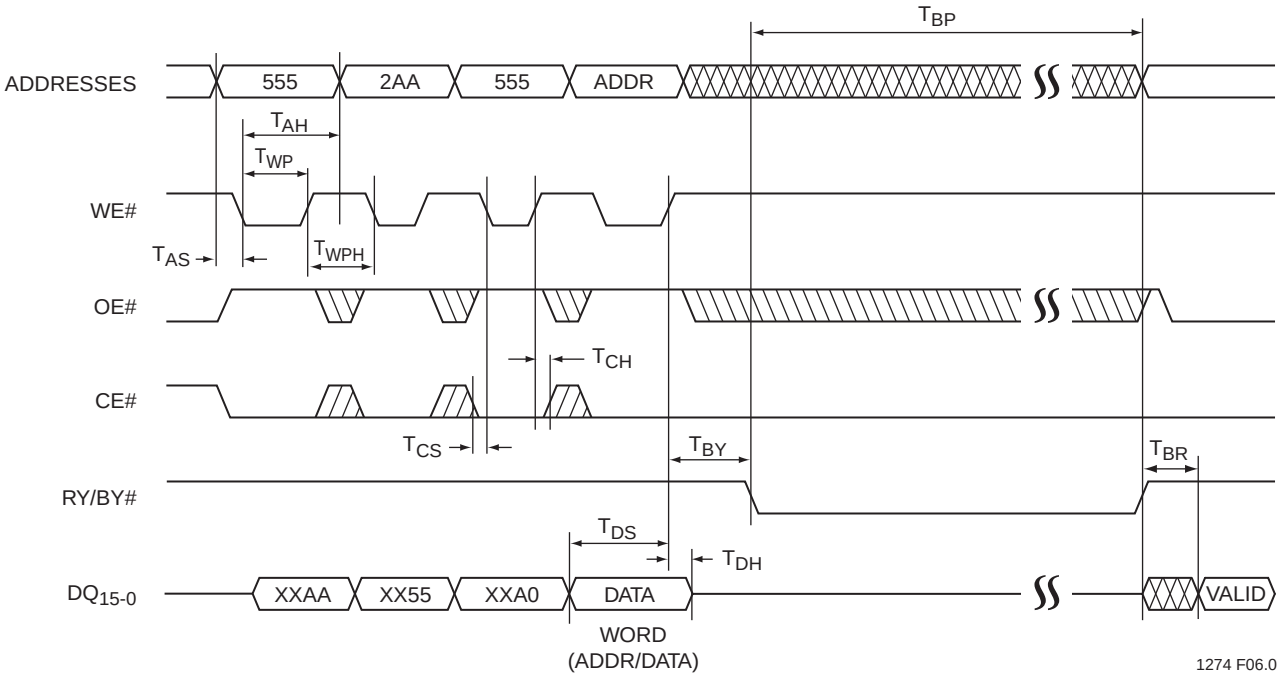
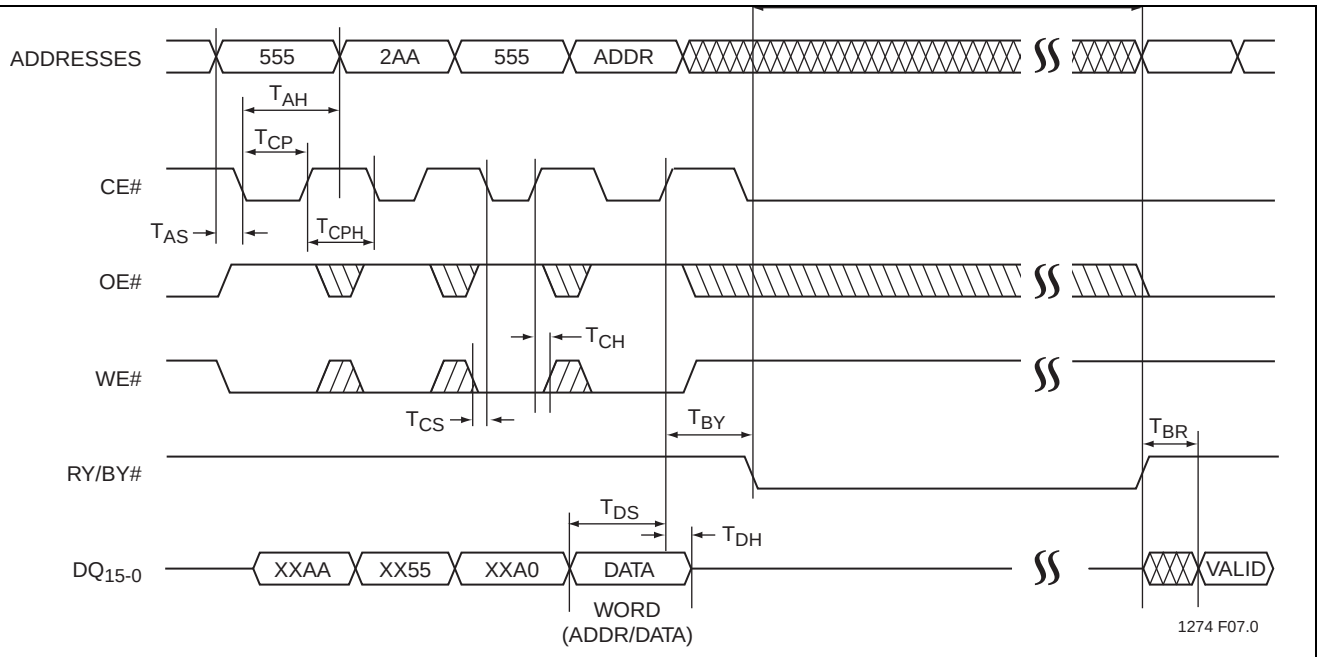


FIGURE 8: Read Cycle Timing Diagram



Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 9: WE# Controlled Program Cycle Timing Diagram



Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 10: CE# Controlled Program Cycle Timing Diagram

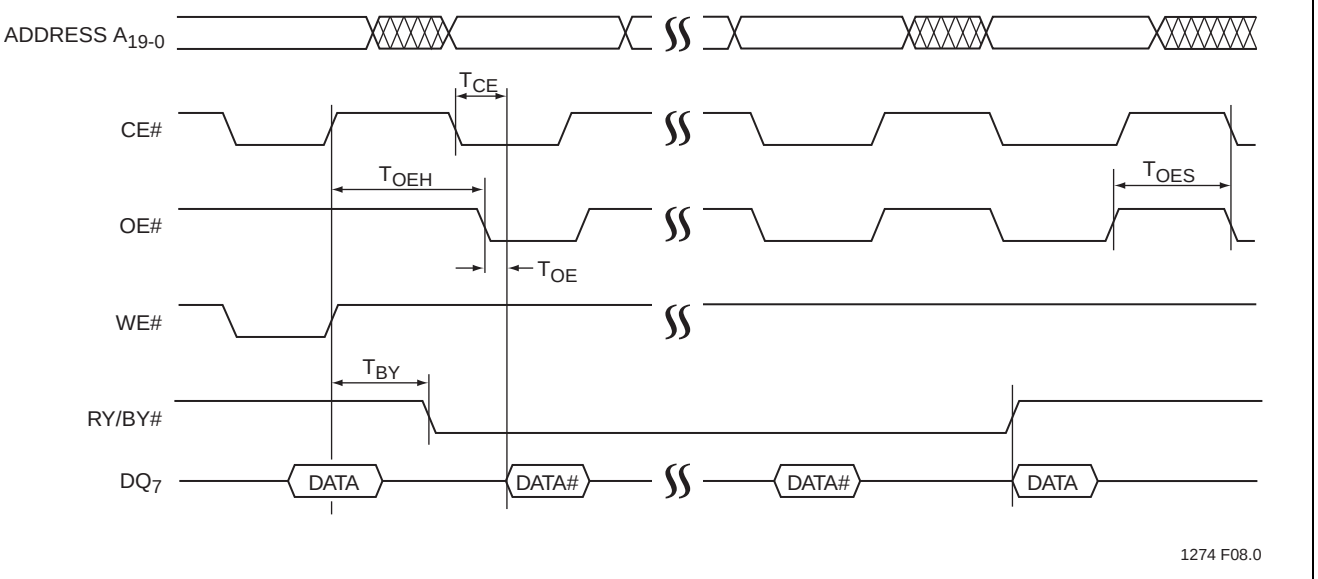


FIGURE 11: Data# Polling Timing Diagram

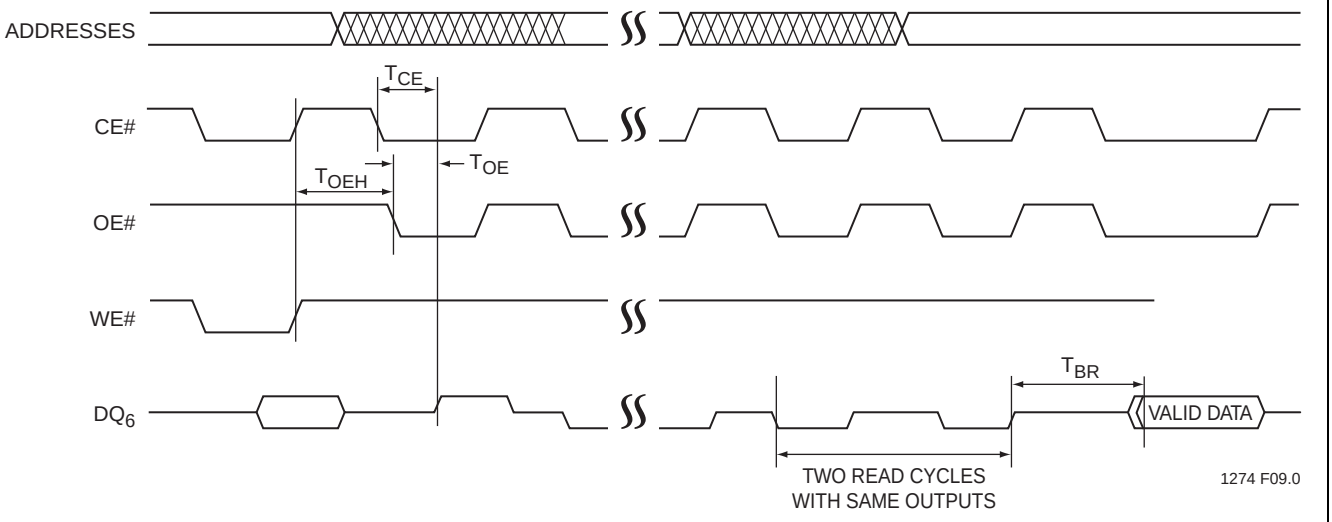
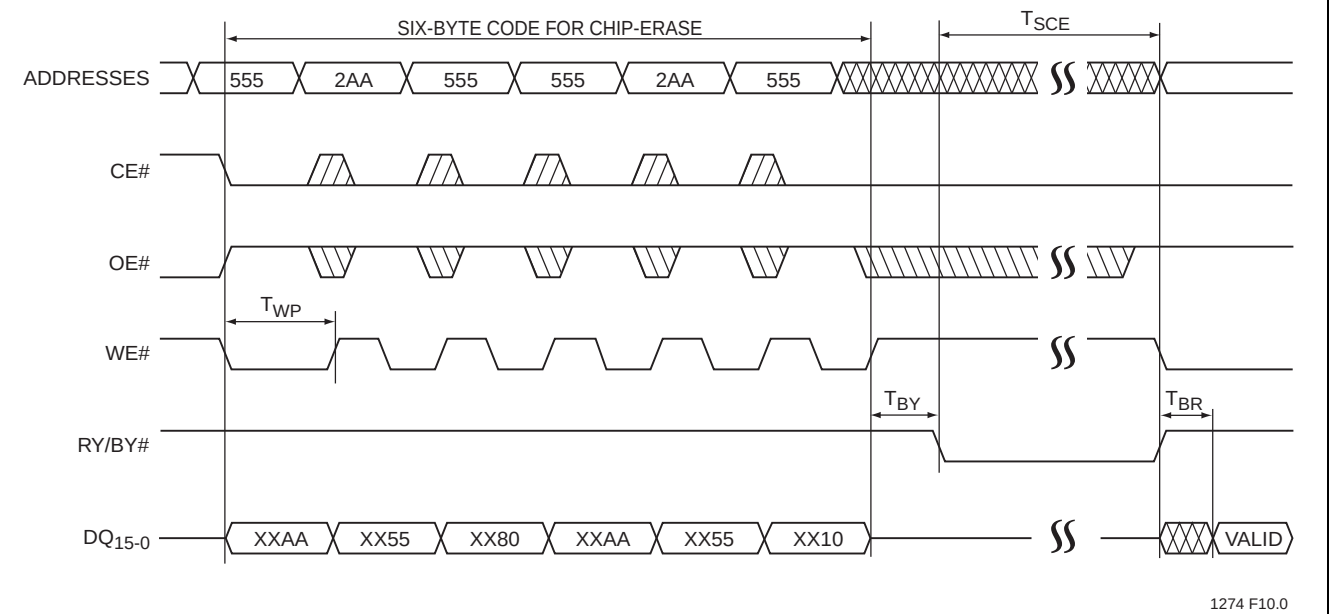
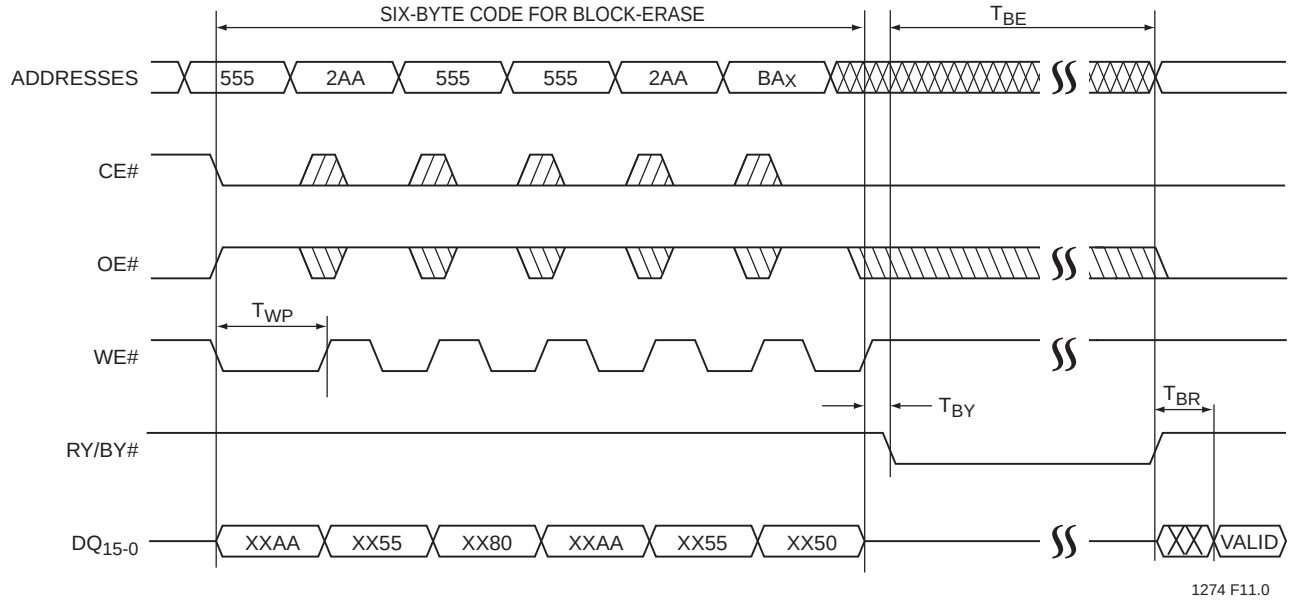


FIGURE 12: Toggle Bit Timing Diagram



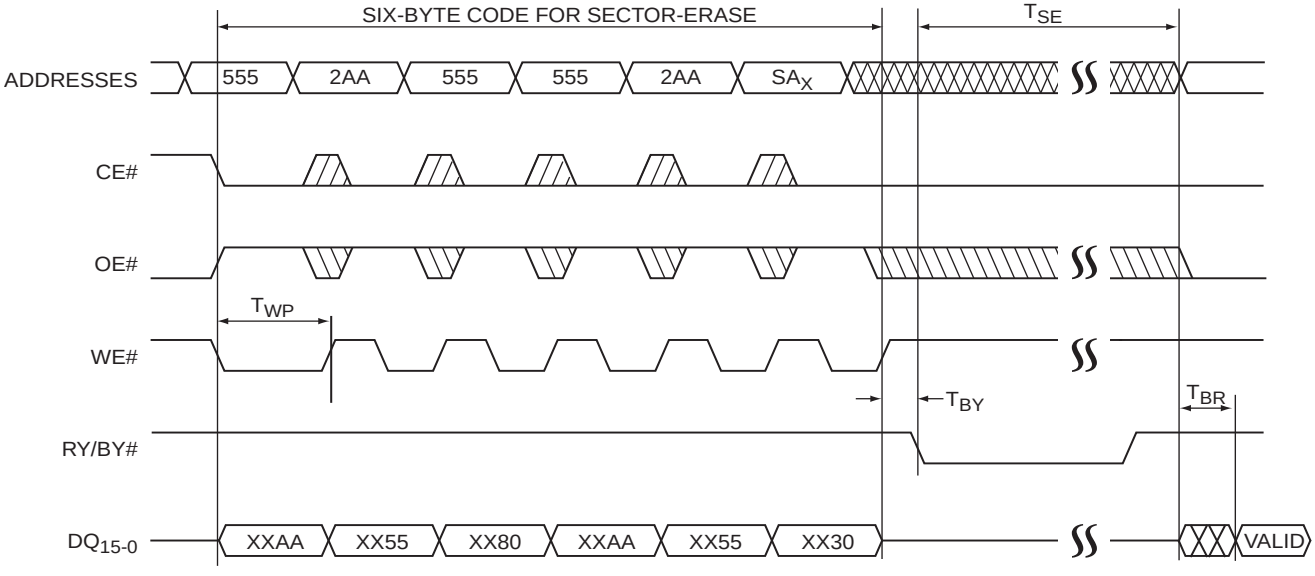
Note: This device also supports CE# controlled Chip-Erase operation. The WE# and CE# signals are interchageable as long as minimum timings are met. (See Table 14)
X can be V_{IL} or V_{IH}, but no other value.

FIGURE 13: WE# Controlled Chip-Erase Timing Diagram



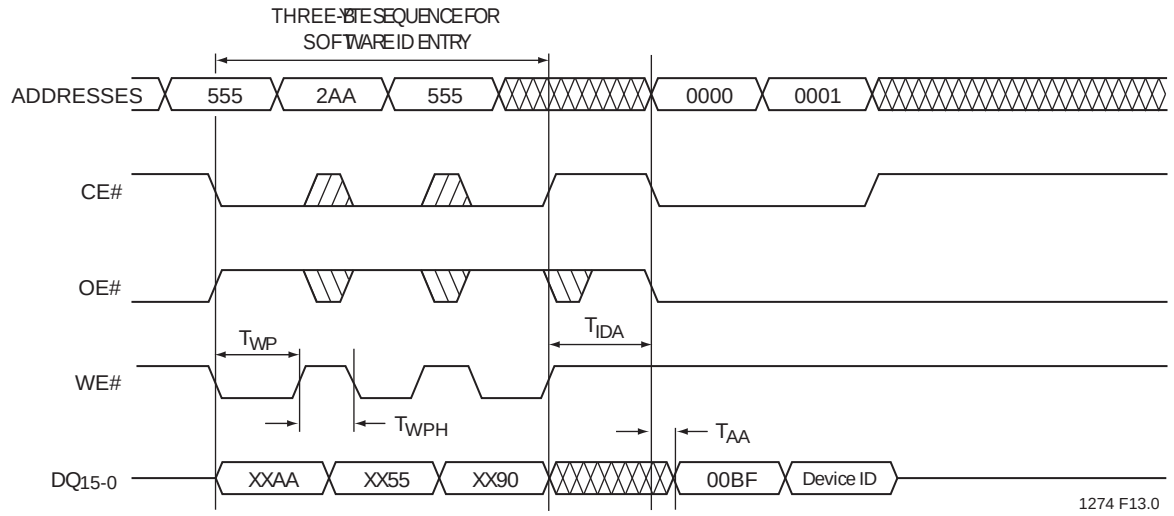
Note: This device also supports CE# controlled Block-Erase operation. The WE# and CE# signals are interchageable as long as minimum timings are met. (See Table 14)
BA_X = Block Address
X can be V_{IL} or V_{IH}, but no other value.

FIGURE 14: WE# Controlled Block-Erase Timing Diagram



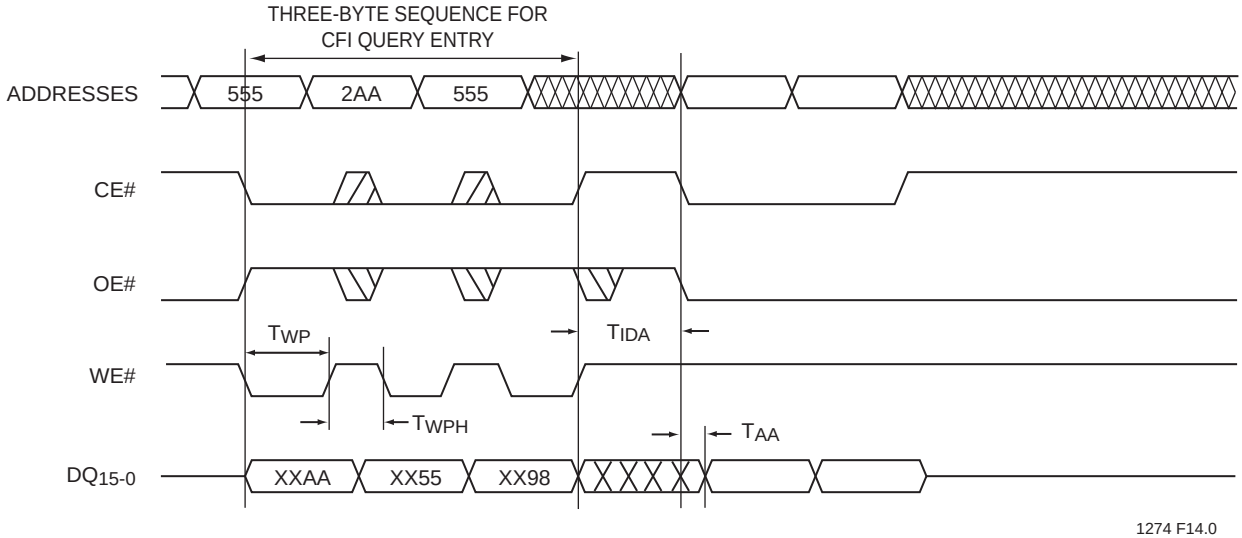
Note: This device also supports CE# controlled Sector-Erase operation. The WE# and CE# signals are interchageable as long as minimum timings are met. (See Table 14)
SA_X = Sector Address
X can be V_{IL} or V_{IH}, but no other value.

FIGURE 15: WE# Controlled Sector-Erase Timing Diagram



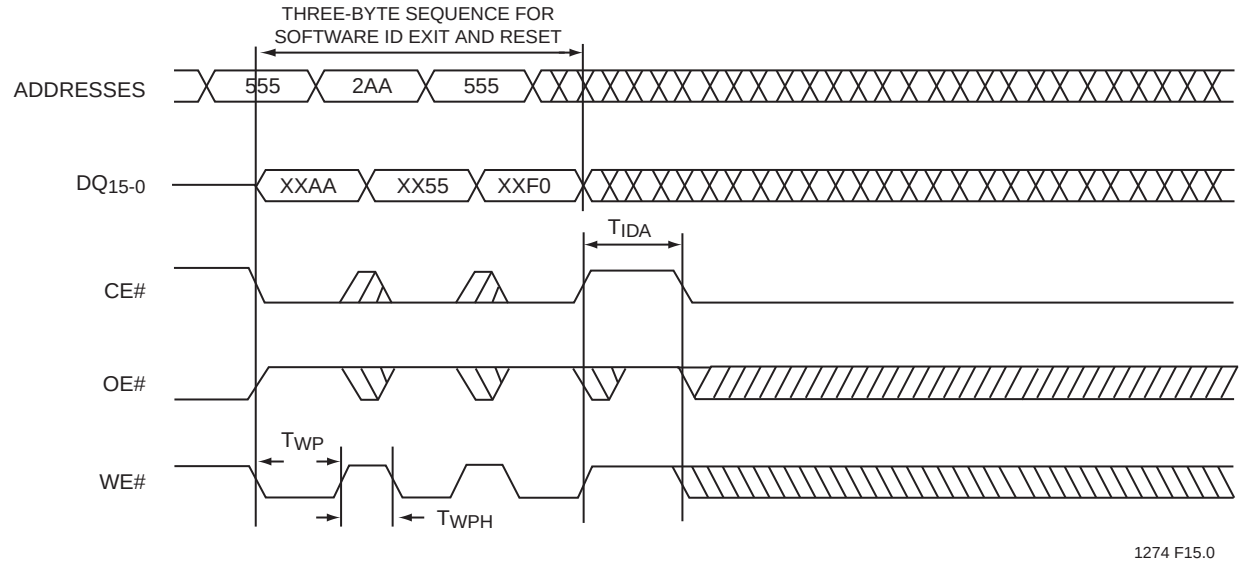
Device ID = 734BH for GLS36VF1601E and 734AH for GLS36VF1602E
Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 16: Software ID Entry and Read



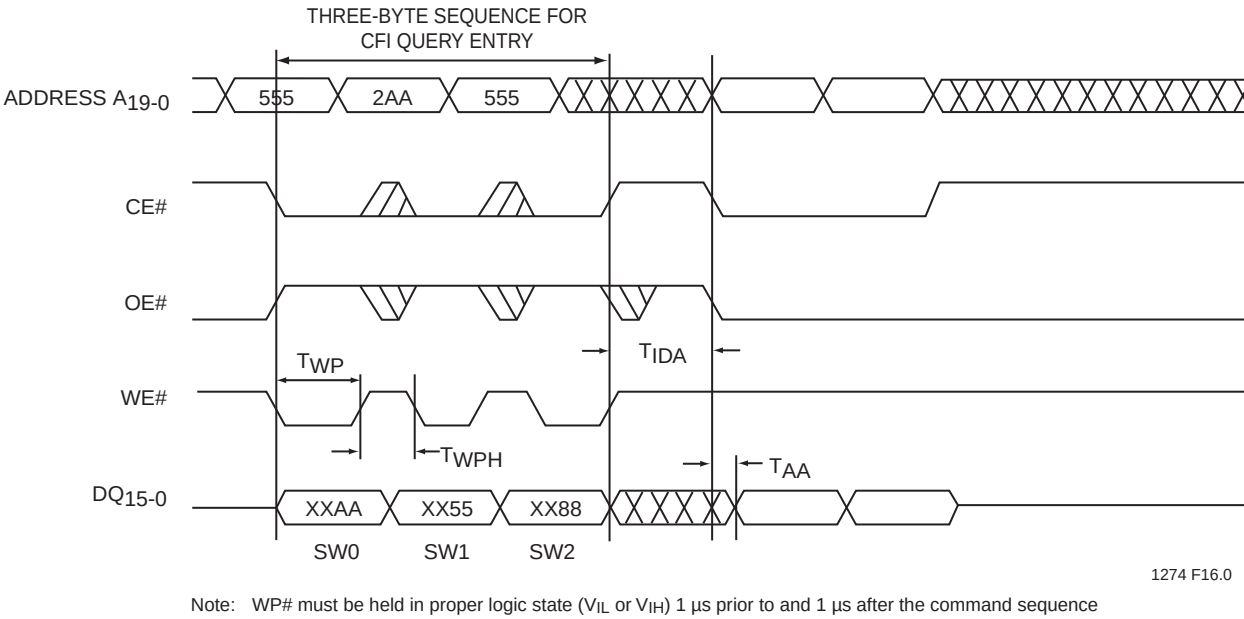
Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 17: CFI Entry and Read



Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 18: Software ID Exit/CFI Exit



Note: WP# must be held in proper logic state (V_{IL} or V_{IH}) 1 µs prior to and 1 µs after the command sequence
X can be V_{IL} or V_{IH}, but no other value.

FIGURE 19: Sec ID Entry

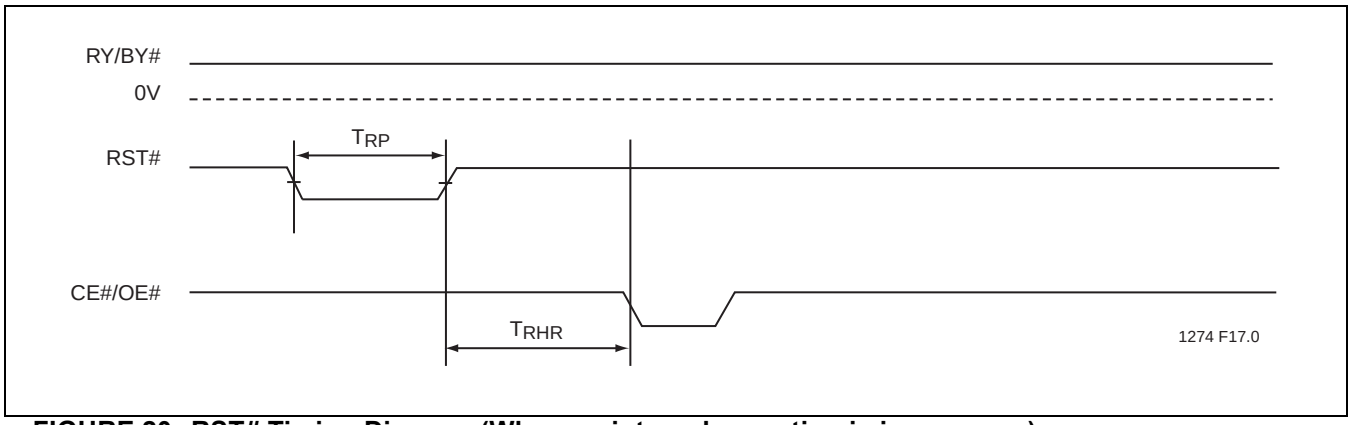


FIGURE 20: RST# Timing Diagram (When no internal operation is in progress)

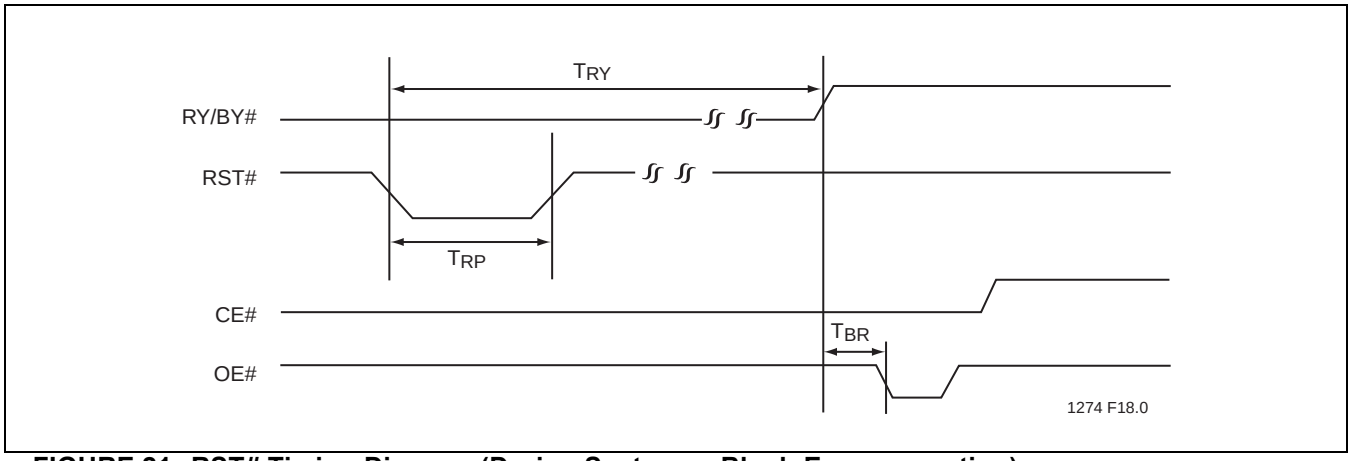
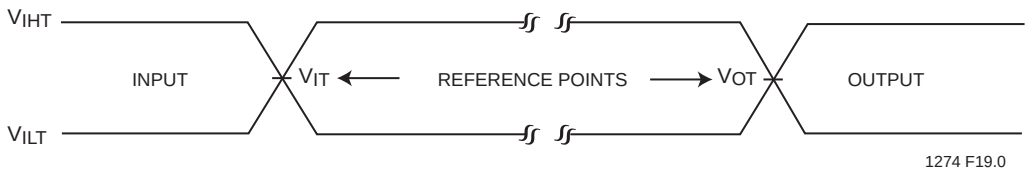


FIGURE 21: RST# Timing Diagram (During Sector- or Block-Erase operation)



AC test inputs are driven at V_{IHT} (0.9 V_{DD}) for a logic "1" and V_{ILT} (0.1 V_{DD}) for a logic "0". Measurement reference points for inputs and outputs are V_{IT} (0.5 V_{DD}) and V_{OT} (0.5 V_{DD}). Input rise and fall times (10% ↔ 90%) are <5 ns.

Note: V_{IT} - V_{INPUT} Test
V_{OT} - V_{OUTPUT} Test
V_{IHT} - V_{INPUT} HIGH Test
V_{ILT} - V_{INPUT} LOW Test

FIGURE 22: AC Input/Output Reference Waveforms

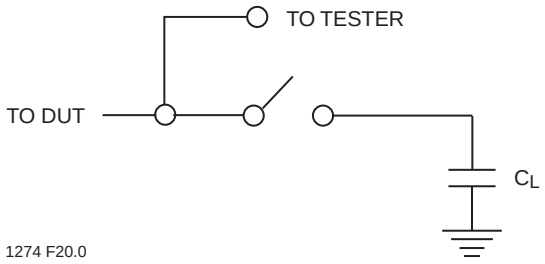
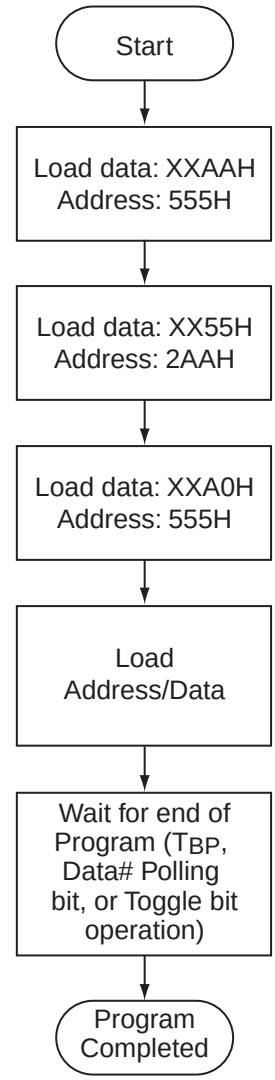


FIGURE 23: A Test Load Example



Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 24: Program Algorithm

Data Sheet

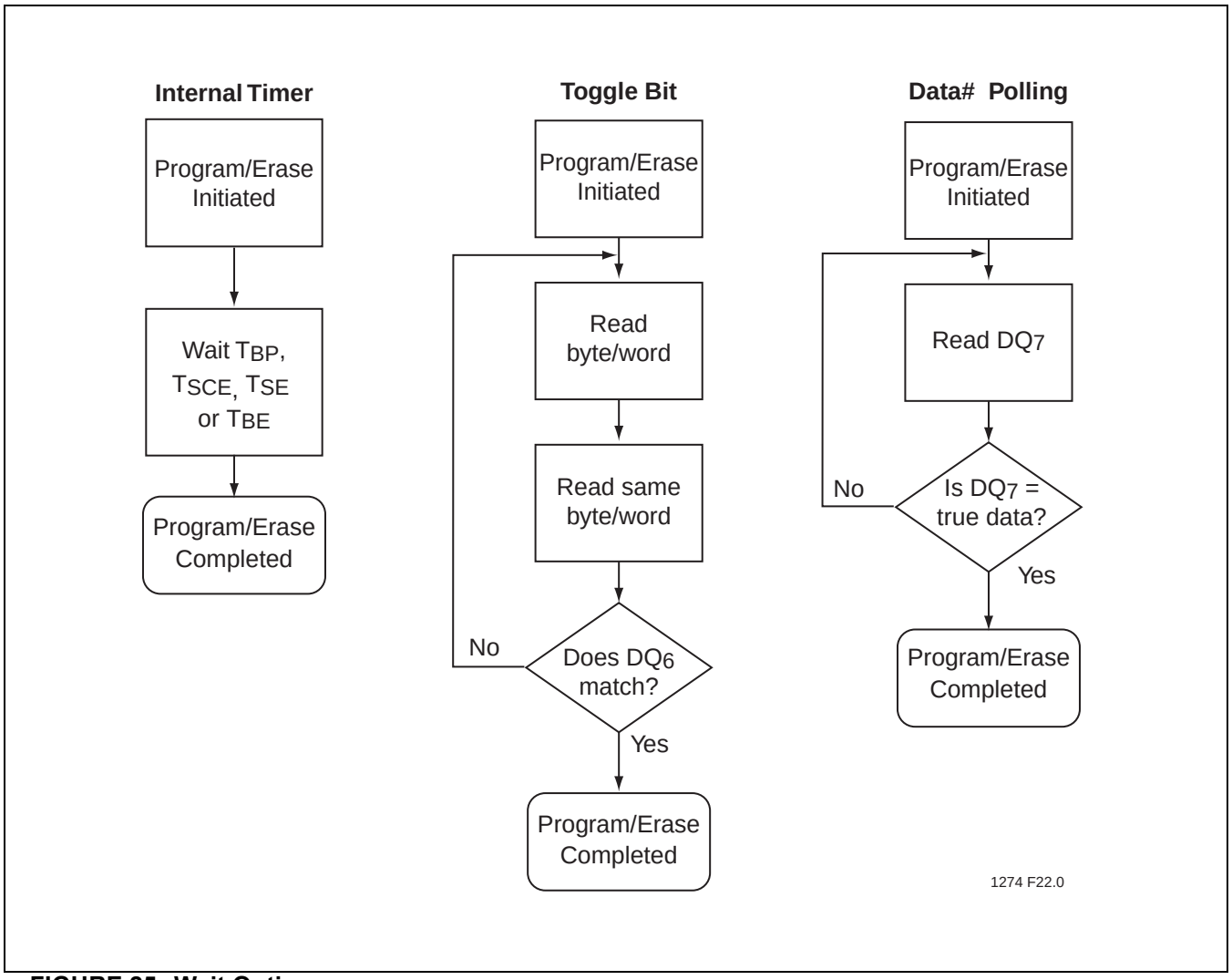


FIGURE 25: Wait Options

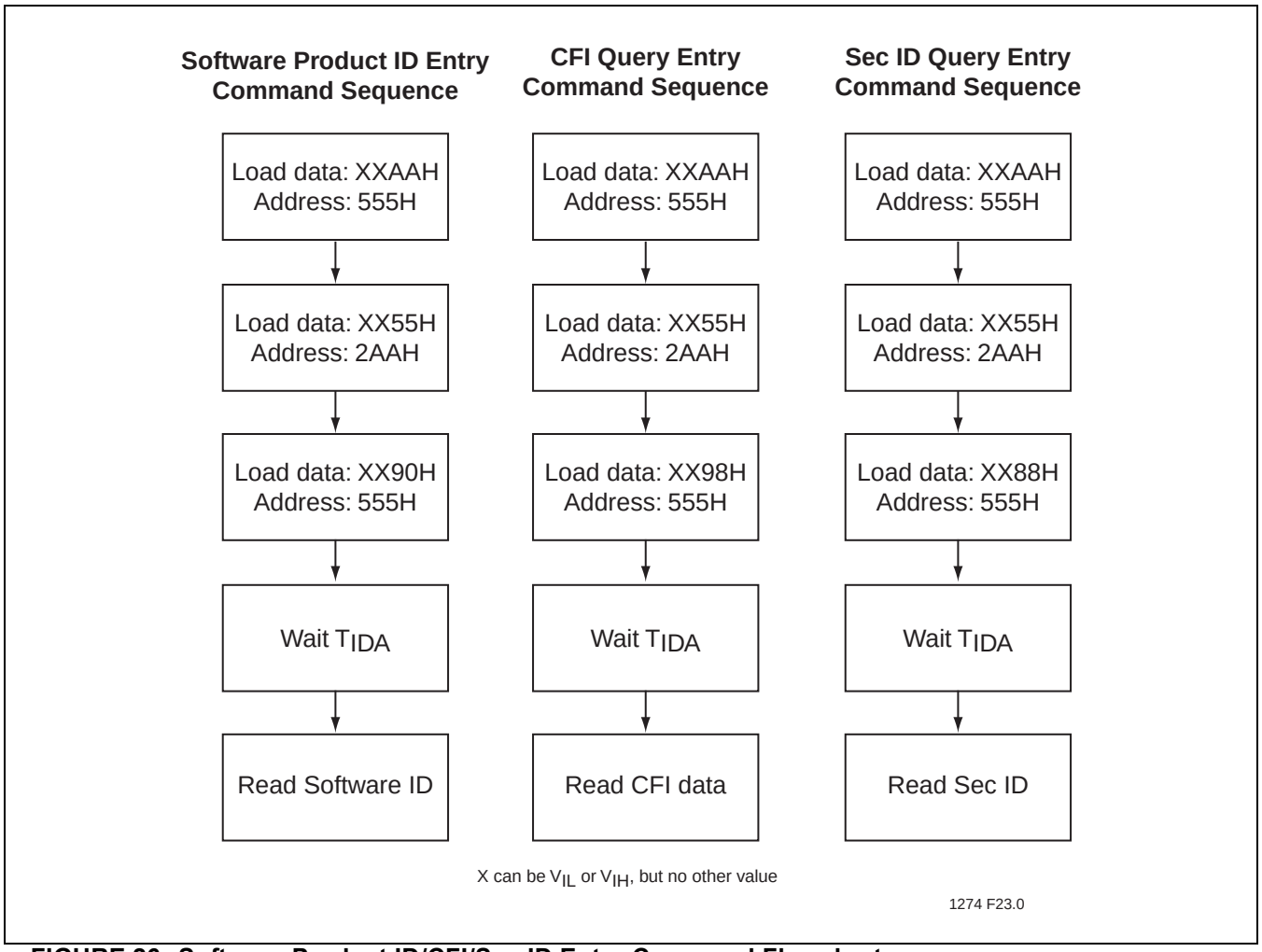


FIGURE 26: Software Product ID/CFI/Sec ID Entry Command Flowcharts

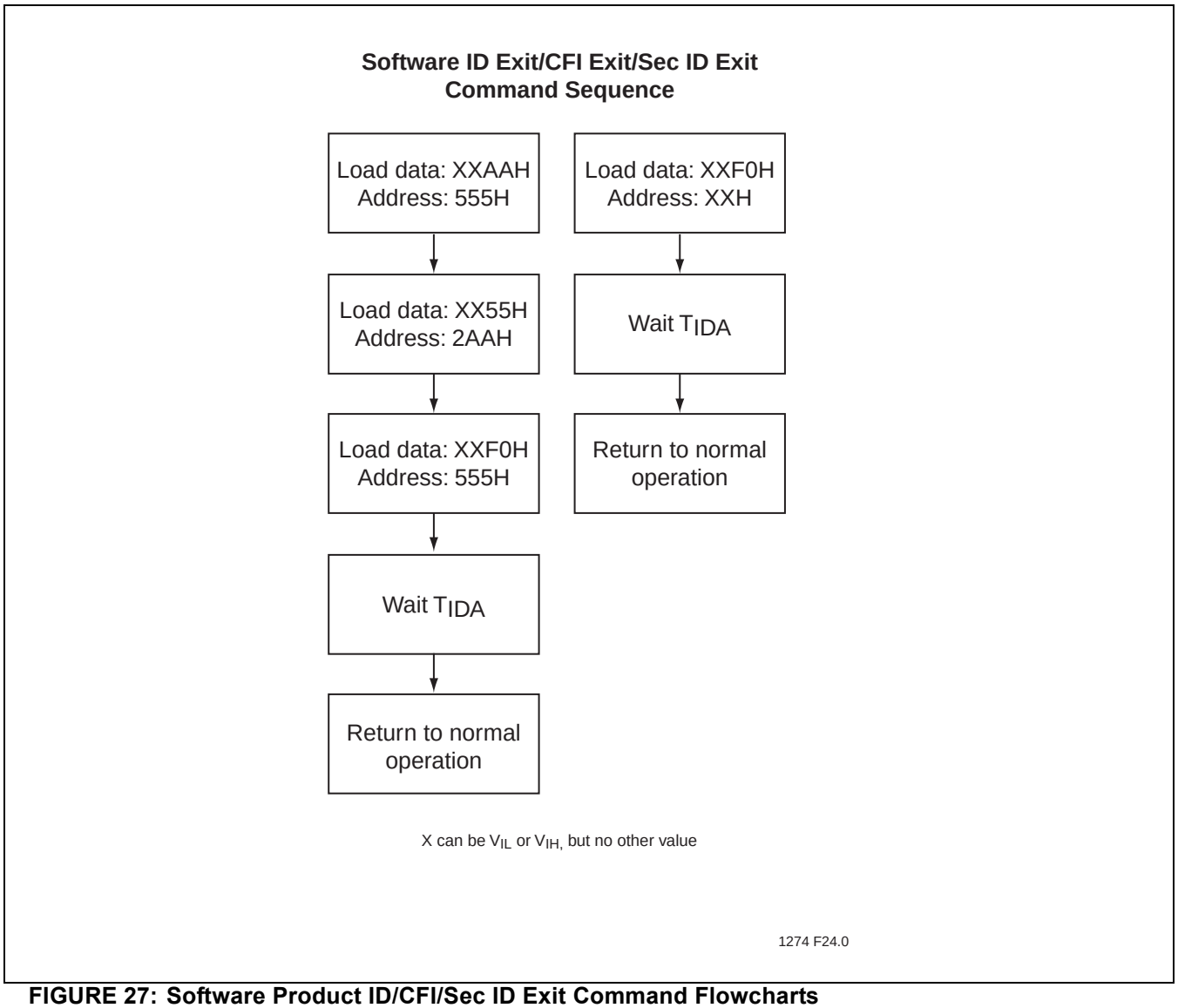
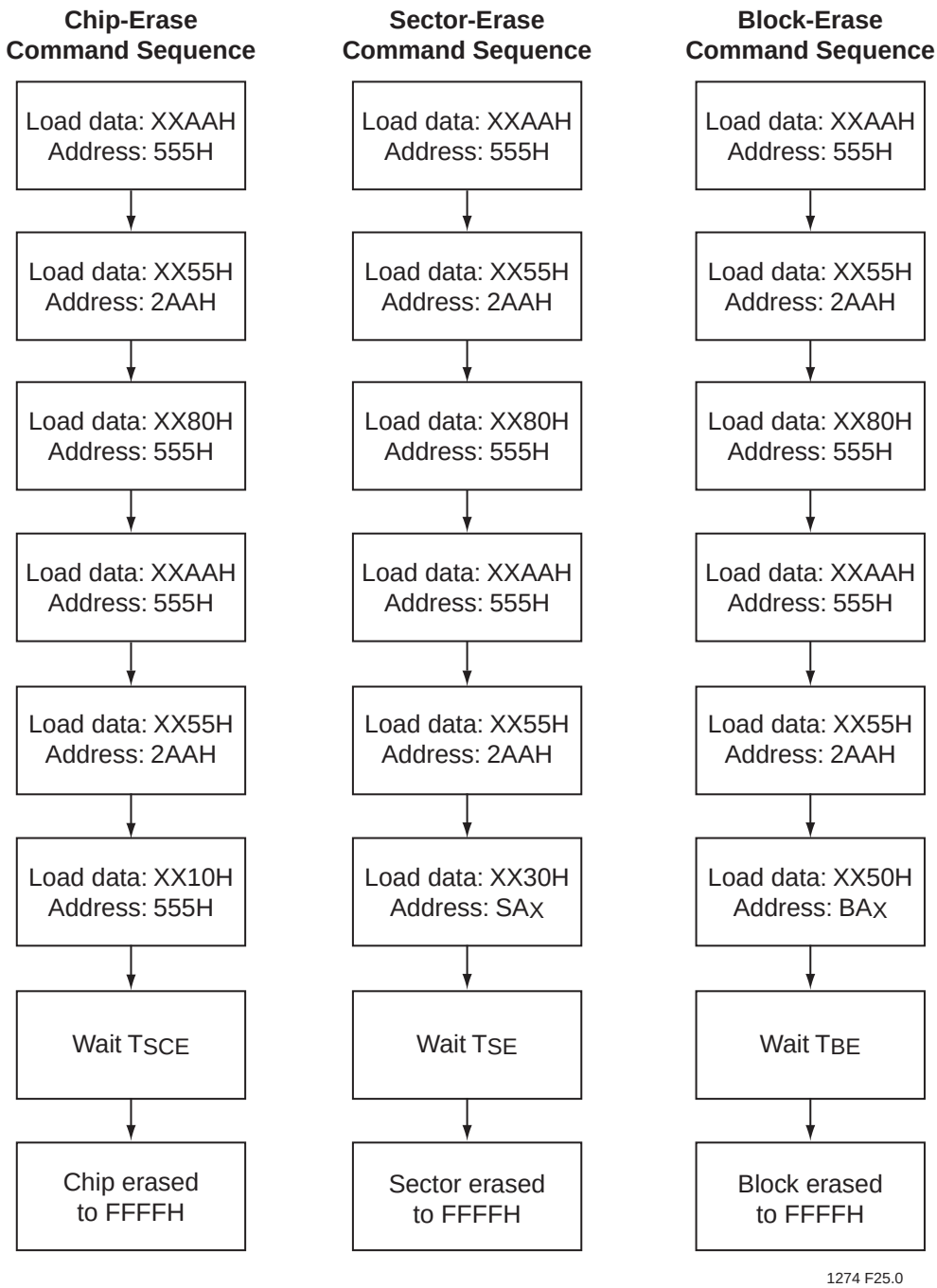


FIGURE 27: Software Product ID/CFI/Sec ID Exit Command Flowcharts

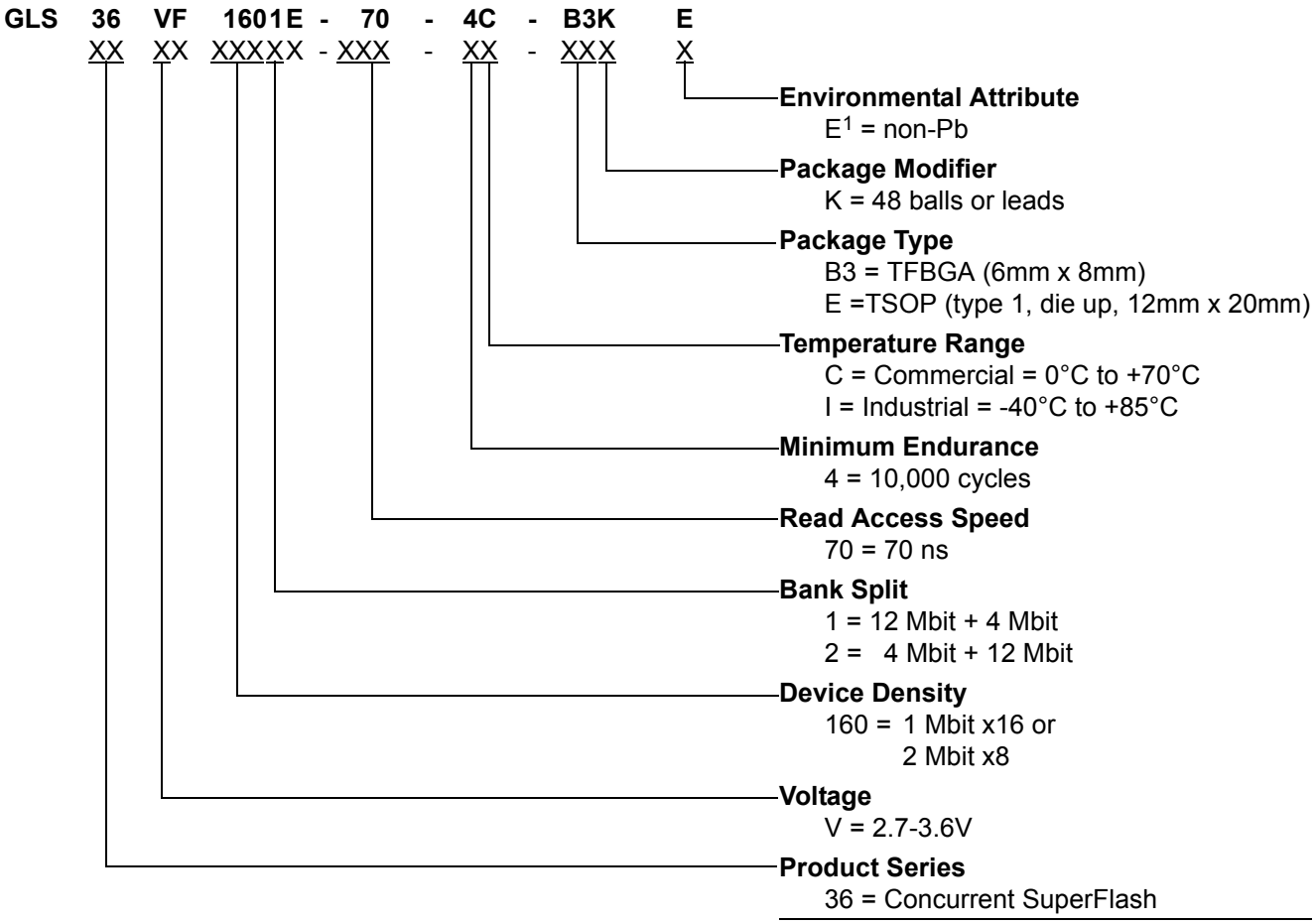


Note: X can be V_{IL} or V_{IH}, but no other value.

FIGURE 28: Erase Command Sequence

Data Sheet

PRODUCT ORDERING INFORMATION



1. Environmental suffix “E” denotes non-Pb solder. Greenliant non-Pb solder devices are “RoHS Compliant”.

Valid combinations for GLS36VF1601E

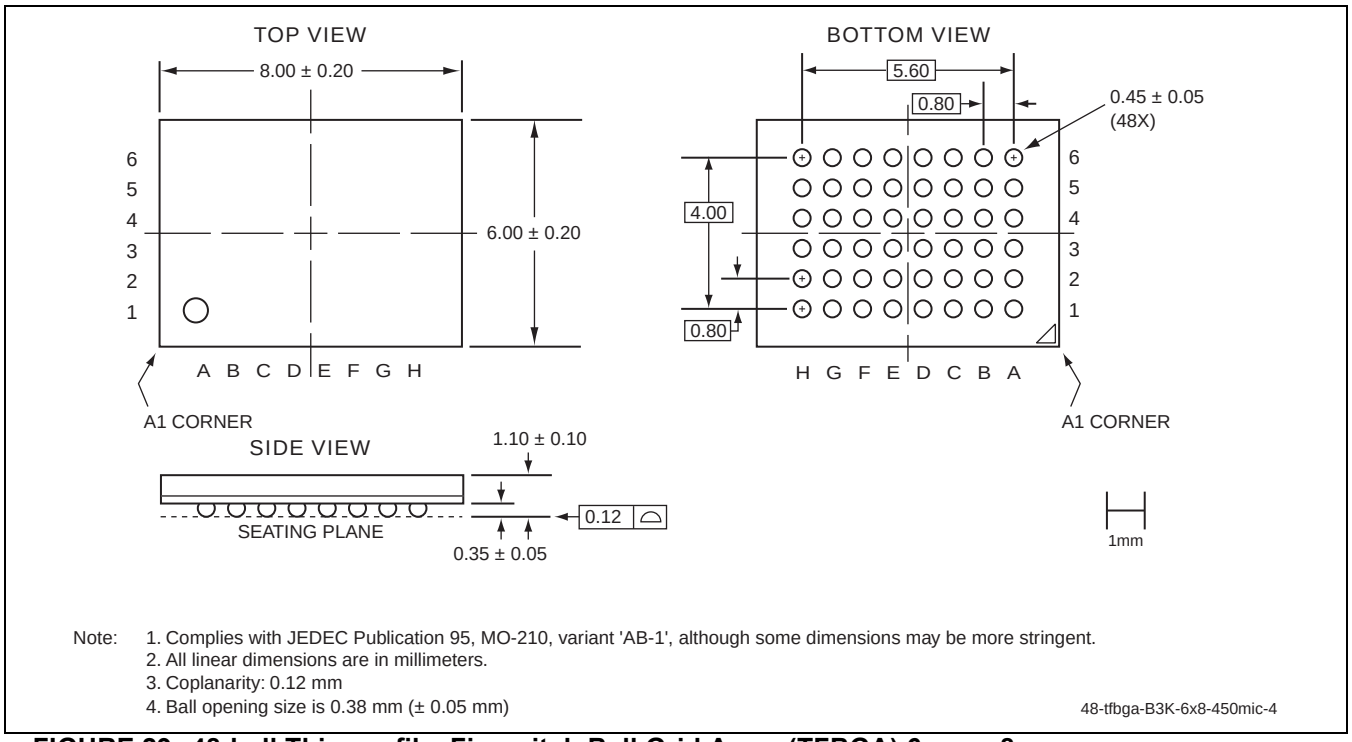
GLS36VF1601E-70-4C-B3KE	GLS36VF1601E-70-4C-EKE
GLS36VF1601E-70-4I-B3KE	GLS36VF1601E-70-4I-EKE

Valid combinations for GLS36VF1602E

GLS36VF1602E-70-4C-B3KE	GLS36VF1602E-70-4C-EKE
GLS36VF1602E-70-4I-B3KE	GLS36VF1602E-70-4I-EKE

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Greenliant sales representative to confirm availability of valid combinations and to determine availability of new combinations.

PACKAGING DIAGRAMS

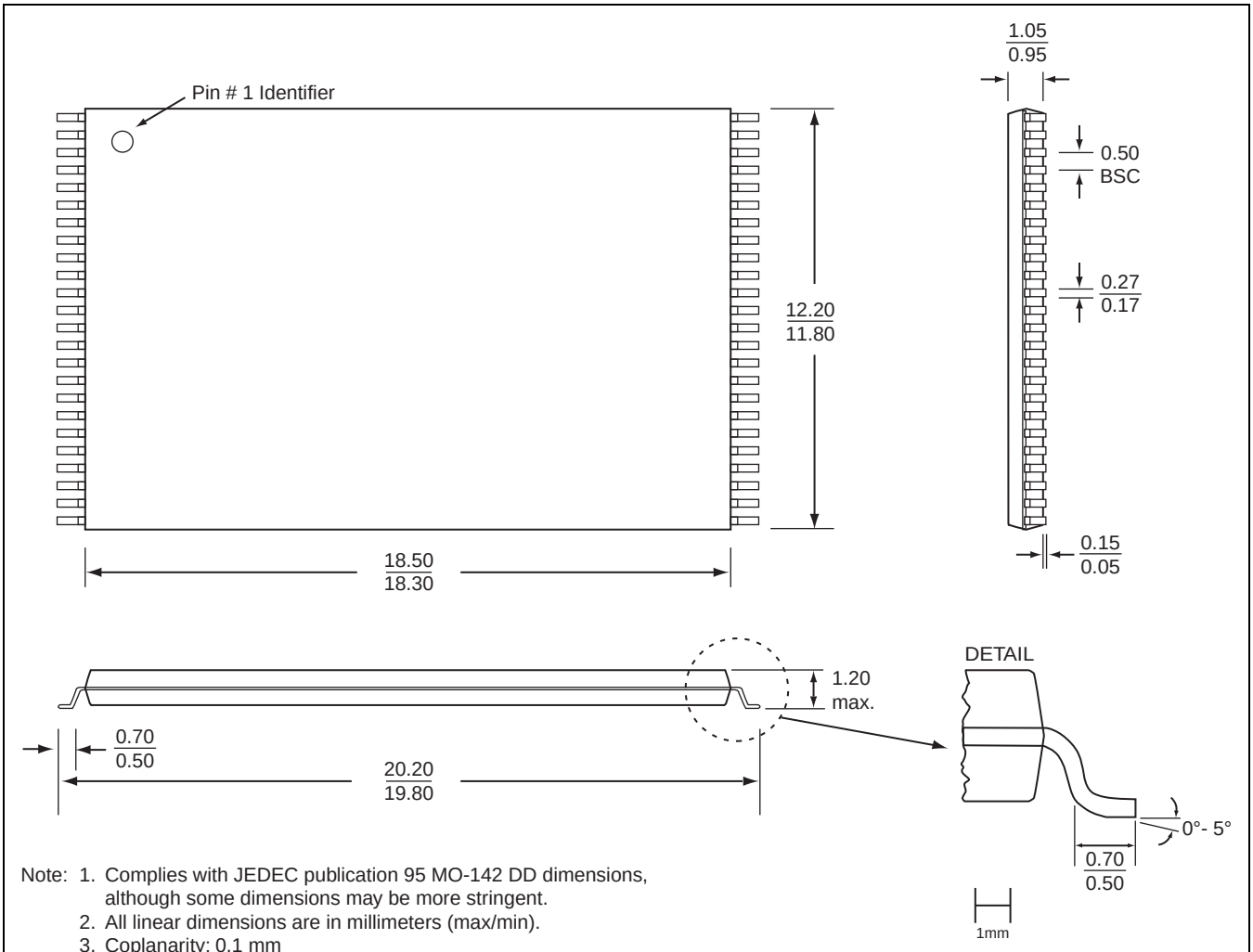


Note: 1. Complies with JEDEC Publication 95, MO-210, variant 'AB-1', although some dimensions may be more stringent.
2. All linear dimensions are in millimeters.
3. Coplanarity: 0.12 mm
4. Ball opening size is 0.38 mm (± 0.05 mm)

48-tfbga-B3K-6x8-450mic-4

FIGURE 29: 48-ball Thin-profile, Fine-pitch Ball Grid Array (TFBGA) 6mm x 8mm
Greenliant Package Code: B3K

Data Sheet



Note: 1. Complies with JEDEC publication 95 MO-142 DD dimensions, although some dimensions may be more stringent.
2. All linear dimensions are in millimeters (max/min).
3. Coplanarity: 0.1 mm
4. Maximum allowable mold flash is 0.15 mm at the package ends, and 0.25 mm between leads.

FIGURE 30: 48-lead Thin Small Outline Package (TSOP) 12mm x 20mm
Greenliant Package Code: EK

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TABLE 16: Revision History

Number	Description	Date
00	• Initial release of data sheet	Oct 2004
01	• Updates to data sheet Tables 1, 4, 5, 8, 9, and 13. Added RoHS compliance information on page 1 and in the “Product Ordering Information” on page 34 • Updated sector information in Table 9, “Device Geometry Information” on page 16 • Updated Active Current values and test conditions in Table 10 on page 18 • Updated OE timings in Table 14 on page 19 • Added a Reset footnote to Table 5 on page 13 • Updated the footnote for Table 2 on page 5 • Corrected the Address Format in footnote 1 in Table 6 on page 14 • Clarified the solder temperature profile under “Absolute Maximum Stress Ratings” on page 17	Mar 2005
02	• Updated “Erase-Suspend/Erase-Resume Operations” on page 4 • Updated T_{ES} parameter from 20 µs to 10 µs in Table 15 on page 19	Jul 2005
03	• Made changes to support Pb-free packages only	Nov 2005
04	• Edited Tby TY/BY# Delay Time in Table 15 on page 19 from 90ns Min to 90ns Max	Nov 2009
05	• Transferred from SST to Greenliant	May 2010

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