32 Megabit FlashBank Memory
LE28DW3212AT-80B

FEATURES:

- **Single 3.0-Volt Read and Write Operations**
- **Separate Memory Banks by Address Space**
  - Bank1: 16Mbit (1024K x 16 / 2048K x 8) Flash
  - Bank2: 16Mbit (1024K x 16 / 2048K x 8) Flash
  - Simultaneous Read and Write Capability
- **Superior Reliability**
  - Endurance: 10,000 Cycles
    100,000 Cycles (Sector Erase)
  - Data Retention: 10 years
- **Low Power Consumption**
  - Active Current, Read: 10 mA (typical)
  - Active Current, Read & Write: 30 mA (typical)
  - Standby Current: 5µA (typical)
  - Auto Low Power Mode Current: 5µA (typical)
- **Fast Write Operation**
  - Chip Erase + Program: 30 sec (typical)
  - Block Erase + Program: 500 ms (typical)
  - Sector Erase + Program: 45 ms (typical)
- **Read Access Time**
  - 80 ns
- **Latched Address and Data**
- **End of Write Detection**
  - Toggle Bit / Data # Polling / RY/BY#
- **Write Protection by WP# pin**
- **Flash Bank:** Two Small Erase Element Sizes
  - 2K Words per Sector or 32K Words per Block
  - Erase either element before Word Program
- **CMOS I/O Compatibility**
- **Packages Available**
  - 48-Pin TSOP (12mm x 20mm)
- **Continuous Hardware and Software Data Protection (SDP)**

Product Description

The LE28DW3212AT consists of two memory banks, 2 each contains of 1024K x 16 bits or 2048K x 8 sector mode flash EEPROM manufactured with SANYO's proprietary, high performance FlashTechnology. The LE28DW3212AT writes with a 3.0-volt-only power supply.

The LE28DW3212AT is divided into two separate memory banks. Each Flash Bank is typically used for program storage and contains 512 sectors of 2K words or 32blocks of 32K words.

Any bank may be used for executing code while writing data to a different bank. Each memory bank is controlled by separate Bank selection address (A20) lines.

LE28DW3212AT inherently uses less energy during Erase, and Program than alternative flash technologies. The total energy consumed is a function of the applied voltage, current, and time of application. Since for any given voltage range, the Flash technology uses less current to program and has a shorter Erase time, the total energy consumed during any Erase or Program operation is less than alternative flash technologies. The Auto Low Power mode automatically reduces the active read current to approximately the same as standby; thus, providing an average read current of approximately 1 mA/MHz of Read cycle time.

Device Operation

The LE28DW3212AT operates as two independent 16Megabit t Word Pogram, Sector Erase flash EEPROMs. Two memory Banks are spareted by the address space.

The Bank1 is assigned as 000000h to 0FFFFFh, Bank2 is assigned as 100000h to 1FFFFFh.

All memory banks share common I/O lines, WE#, and OE#. Memory bank selection is by bank select address(A20). WE# is used with SDP to control the Erase and Program operation in each memory bank.

The LE28DW3212AT provides the added functionality of being able to simultaneously read from one memory bank while erasing, or programming to one other memory bank. Once the internally controlled Erase or Program cycle in a memory bank has commenced, a different memory bank can be accessed for read. Also, once WE# and CE# are high during the SDP load sequence, a different bank may be accessed to read. LE28DW3212AT which selectes banks (A20) by a address. It can be used as a normal conventinal flash memory when operats erase or program operation to only a bank at non-concurrent operation.

The device ID cannot be accessed while any bank is writing, erasing, or programming.

The Auto Low Power Mode automatically puts the LE28DW3212AT in a near standby mode after data has been accessed with a valid Read operation. This reduces the I_{DD} active read current from typically 10mA to typically 5µA. The Auto Low Power mode reduces the typical I_{DD} active read current to the range of 1mA/MHz of Read cycle time. If a concurrent Read while Write is being performed, the I_{DD} is reduced to typically 40mA. The device exits the Auto Low Power mode with any address transition or control signal transition used to initiate another Read cycle, with no access time penalty.

Read

The Read operation of the LE28DW3212AT Flash banks is controlled by CE# and OE#, a chip enable and output enable both have to be low for the system to obtain data from the outputs. OE# is the output control and is used to gate data from the output pins. The data bus is in high impedance state when OE# is high. Refer to the timing waveforms for further details (Figure 3).

When the read operation is executed without address change after power switch on, CE# should be changed the level high to low. If the read operation is executed after programing , CE# should be changed the level high to low.

Write

All Write operations are initiated by first issuing the Software Data Protect (SDP) entry sequence for Chip, Block, or Sector Erase. Word Program in the selected Flash bank. Word Program and all Erase commands have a fixed duration, that will not vary over the life of the device, i.e., are independent of the number of Erase/Program cycles endured.

Either Flash bank may be read to another Flash Bank during the internally controlled write cycle.

The device is always in the Software Data Protected mode for all Write operations Write operations are controlled by toggling WE# or CE#. The falling edge of WE# or CE#, whichever occurs last, latches the address. The rising edge of WE# or CE#, whichever occurs first, latches the data and initiates the Erase or Program cycle.

For the purposes of simplification, the following descriptions will assume WE# is toggled to initiate an Erase or Program. Toggling the applicable CE# will accomplish the same function. (Note, there are separate timing diagrams to illustrate both WE# and CE# controlled Program or Write commands.)

Word Program

The Word Program operation consists of issuing the SDP Word Program command, initiated by forcing CE# and WE# low, and OE# high. The words to be programmed must be in the erased state, prior to programming. The Word Program command programs the desired addresses word by word. During the Word Program cycle, the addresses are latched by the falling edge of WE#. The data is latched by the rising edge of WE#. (See Figure 4-1 for WE# or 4-2 for CE# controlled Word Program cycle timing waveforms, Table 3 for the command sequence, and Figure 17 for a flowchart.)

During the Erase or Program operation, the only valid reads from that bank are Data# Polling and Toggle Bit. The other bank may be read.

The specified Chip, Block, or Sector Erase time is the only time required to erase. There are no preprogramming or other commands or cycles required either internally or externally to erase the chip, block, or sector.

Erase Operations

The Chip Erase is initiated by a specific six-word load sequence (See Tables 3). A Chip Erase will typically be less than 70 ms. An alternative to the Chip Erase in the Flash bank is the Block or Sector Erase. The Block Erase will erase an entire Block (32K words) in typically 15 ms. The Sector Erase will erase an entire sector (2048 words) in typically 15 ms. The Sector Erase provides a means to alter a single sector using the Sector Erase and Word Program modes. The Sector Erase is initiated by a specific six-word load sequence (see Table 3).

During any Sector, Block, or Chip Erase within a bank, any other bank may be read.

Chip Erase

The LE28DW3212AT provides a Chip Erase mode, which allows the user to clear the Flash bank to the "1"state. This is useful when the entire Flash must be quickly erased.

The software Flash Chip Erase mode is initiated by issuing the specific six-word loading sequence, as in the Software Data Protection operation. After the loading cycle, the device enters into an internally timed cycle. (See Table 3 for specific codes, Figure 5-1 for a timing waveform, Figure14 for a flowchart.)

Block Erase

The LE28DW3212AT provides a Block Erase mode, which allows the user to clear any block in the Flash bank to the "1"state.

The software Block Erase mode is initiated by issuing the specific six-word loading sequence, as in the Software Data Protect operation. After the loading cycle, the device enters into an internally timed Erase cycle. (See Table 3 for specific codes, Figure 5-2 for the timing waveform, and Figure 15 for a flowchart.) During the Erase operation, the only valid reads are Data# Polling and Toggle Bit from the selected bank, other banks may perform normal read.

Sector Erase

The LE28DW3212AT provides a Sector Erase mode, which allows the user to clear any sector in the Flash bank to the "1" state.

The software Sector Erase mode is initiated by issuing the specific six-word loading sequence, as in the Software Data Protect operation. After the loading cycle, the device enters into an internally timed Erase cycle.(See Table 3 for specific codes, Figure 5-3 for the timing waveform, and Figure 16 for a flowchart.) During the Erase operation, the only valid reads are Data# Polling and Toggle Bit from the selected bank, other banks may perform normal read.

The LE28DW3212AT has automatic verification Algorithm for

Sector Erase operation in order to rewrite the data with high reliability.

The LE28DW3212AT guarantees the endurance to the customers more than 100,000 cycle providing suitable margin to the erase sector.

The LE28DW3212AT provides the erase time 10 times shorter than other manufacture's flash memory technology, even if it is improved by the specific characteristics such as endurance.

Write Operation Status Detection

The LE28DW3212AT provides two software means to detect the completion of a Flash bank Program cycle, in order to optimize the system Write cycle time. 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 Erase or Program cycle.

The actual completion of the nonvolatile write is a synchronous with the system; therefore, either a Data# Polling or Toggle Bit read may be simultaneous with the completion of the Write cycle. If this occurs, the system will possibly get an erroneous result, i.e. valid data may appear to conflict with either DQ_7 or DQ_6. In order to prevent spurious device 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 device has completed the Write cycle, otherwise the rejection is valid.

There is no provision to abort an Erase or Program operation, once initiated. For the SANYO Flash technology, the associated Erase and Program times are so fast, relative to system reset times, there is no value in aborting the operation. Note, reads can always occur from any bank not performing an Erase or Program operation.

Should the system reset, while a Block or Sector Erase or Word Program is in progress in the bank where the boot code is stored, the system must wait for the completion of the operation before reading that bank. Since the maximum time the system would have to wait is 25 ms (for a Block Erase), the system ability to read the boot code would not be affected.

Data# Polling (DQ_7)

When the LE28DW3212AT is in the internal Flash bank Program cycle, any attempt to read DQ_7 of the last word loaded during the Flash bank Word Load cycle will receive the complement of the true data. Once the Write cycle is completed, DQ_7 will show true data. The device is then ready for the next operation. (See Figure 6 for the Flash bank Data Polling timing waveforms and Figure 18 for a flowchart.)

Toggle Bit (DQ_6)

During the Flash bank internal Write cycle, any consecutive attempts to read DQ_6 will produce alternating 0's and 1's, i.e. toggling between 0 and 1. When the Write cycle is completed, the toggling will stop. The device is then ready for the next operation. (See Figure 7 for Flash bank Toggle Bit timing waveforms and Figure 18 for a flowchart.)

Time-Over (DQ_5)

The LE28DW3212AT outputs Low to DQ5 during the internal write cycle. If the time-over is occurred (erase failure), the device outputs High to DQ5. This time-over status holds to the period during software reset is performed, no command is accepted during this period.

Operation Mode		DQ7	DQ6	DQ5	DQ3	DQ2
In Progress	Program	Data#	Toggle	L	L	H
	Erase	L	Toggle	L	H	Toggle
Time Over	Erase Failure	L	Toggle	H	H	Toggle

In Sector Erase operation, the device outputs above status when it falls down to time-over (erase failure) mode. In this case, the device holds the current status till the software reset command is performed, and no command is accepted.

Data Protection

The LE28DW3212AT provides both hardware and software features to protect nonvolatile data from inadvertent writes.

Hardware Data Protection

Noise/Glitch Protection: A WE# 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 1.5 volts.

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.

The LE28DW3212AT provides a protect area by hardware protection. The assigned address is the all area of Bank1, which is set up by WP# when low.

When this operation is executed, the functions which are Sector erase, Block erase or Word program can not be accepted.

When the Chip erase operation is executed, all area will be erased except protected area.

Hardware Reset Function

The LE28DW3212AT provides a Hardware Reset function to reset in whole chip by setting RESET# pin low.

RESET# input pin is held low for at least tRP, it forces the device to terminate any operation in progress and return to Read mode.

The wait period of tRY is required after RESET# gose down. If the reset command is executed during write operation, the data is not guranteed.

Software Data Protection (SDP)

The LE28DW3212AT provides the JEDEC approved software data protection scheme as a requirement for initiating a Write, Erase, or Program operation. With this scheme, any Write operation requires the inclusion of a series of three word-load operations to precede the Word Program operation. The three-word load sequence is used to initiate the Program cycle, providing optimal protection from inadvertent Write operations, e.g., during the system power-up or power-down. The six-word sequence is required to initiate any Chip, Block, or Sector Erase operation.

The requirements for JEDEC compliant SDP are in byte format. The LE28DW8163T is organized by word; therefore, the contents of DQ_8 to DQ_{15} are "Don't Care"during any SDP (3-word or 6-word) command sequence.

During the SDP load command sequence, the SDP load cycle is suspended when WE# is high. This means a read may occur to any other bank during the SDP load sequence.

The bank reserve in SDP load sequence is reserved by the bus cycle of command materialization. If the command sequence is aborted, e.g., an incorrect address is loaded, or incorrect data is loaded, the device will return to the Read mode within T_{RC} of execution of the load error.

Concurrent Read and Write Operations

The LE28DW3212T-90B provides the unique benefit of being able to read any bank, while simultaneously erasing, or programming one other bank. This allows data alteration code to be executed from one bank, while altering the data in another bank. The next table lists all valid states.

Concurrent Read/Write State Table

Bank1	Bank2
Read	No Operation
Read	Write
Write	Read
No Operation	Write
Write	No Operation
No Operation	Read

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

The device will ignore all SDP commands and toggling of WE# when an Erase or Program operation is in progress. Note, Product Identification entry commands use SDP; therefore, this command will also be ignored while an Erase or Program, operation is in progress.

Product Identification

The product identification mode identifies the device manufacturer as SANYO and provides a code to identify each bank. The manufacturer ID is the same for each bank; however, each bank has a separate device ID. Each bank is individually accessed using the applicable Bank Address and a software command. Users may wish to use the device ID operation to identifythe write algorithm requirements for each bank. (For details, see Table 3

Product Identification Table

	Data (Word Mode)	Data (Byte Mode)
Maker ID	0062H	62H
Device Code(Bank1)	25B3H	B3H
Device Code(Bank2)	25B4H	B4H

Device ID codes are unique to each bank. Should a chip ID be required, any of the bank IDs may be used as the chip ID. While in the read software ID mode, no other operation is allowed until after exiting these modes.

Product Identification Mode Exit

In order to return to the standard Read mode, the Product Identification mode must be exited. Exit is accomplished by issuing the Software ID exit command, which returns the device to normal operation. 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. For details, (see Table 3 for software operation and Figures 10 for timing waveforms.)

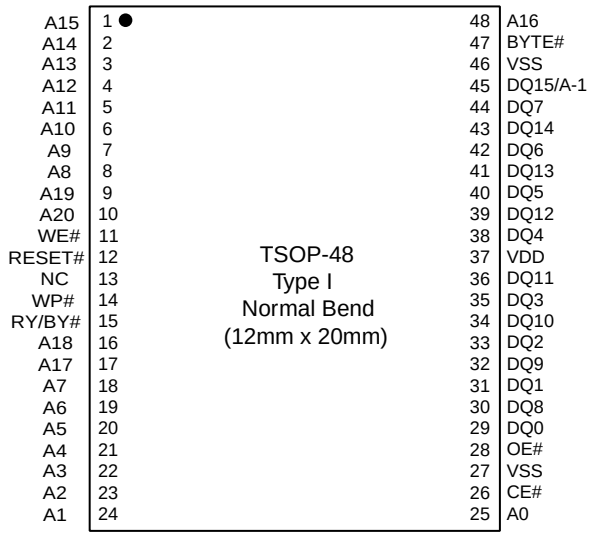


Figure 1 : Pin Description : TSOP48 (12mm x 20mm)

Symbol	Pin Name	Function
A20	Bank Select address	To activate the Bank1 when low, to activate the Bank2 when high.
A19-A0,A-1	Flash Bank addresses	To provide Flash Bank address.
A19-A15	Flash Bank Block addresses	To select a Flash Bank Block for erase.
A19-A10	Flash Bank Sector addresses	To select a Flash Bank Sector for erase.
DQ15-DQ0	Data Input/Output	To output data during read cycle and receive input data during write cycle. The outputs are in tristate when OE# is high or CE# is high.
CE#	Chip Enable	To activate the Flash Bank when CE# is low.
OE#	Output Enable	To gate the data output buffers.
WE#	Write Enable	To control the write, erase or program operations.
BYTE#	Byte selection	To select a Byte mode when low, to select a Word mode when high.
RY/BY#	Ready / Busy output	To output low when write, other case is High-Z.
WP#	Write Protect	To execute Hardware write protect when low.
RESET#	Reset	To execute Hardware reset when low.
V_{DD}	Power Supply	To provide 3.0 volts supply.(2.7volts to 3.6 volts)
Vss	Ground	
NC	No Connection	Unconnected Pins

Table1: Pin Description

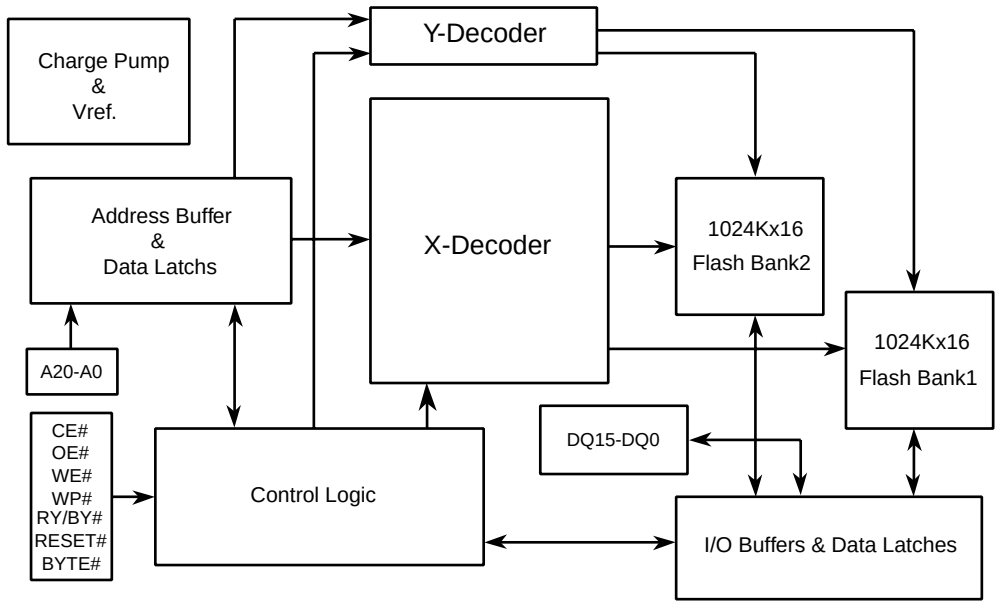
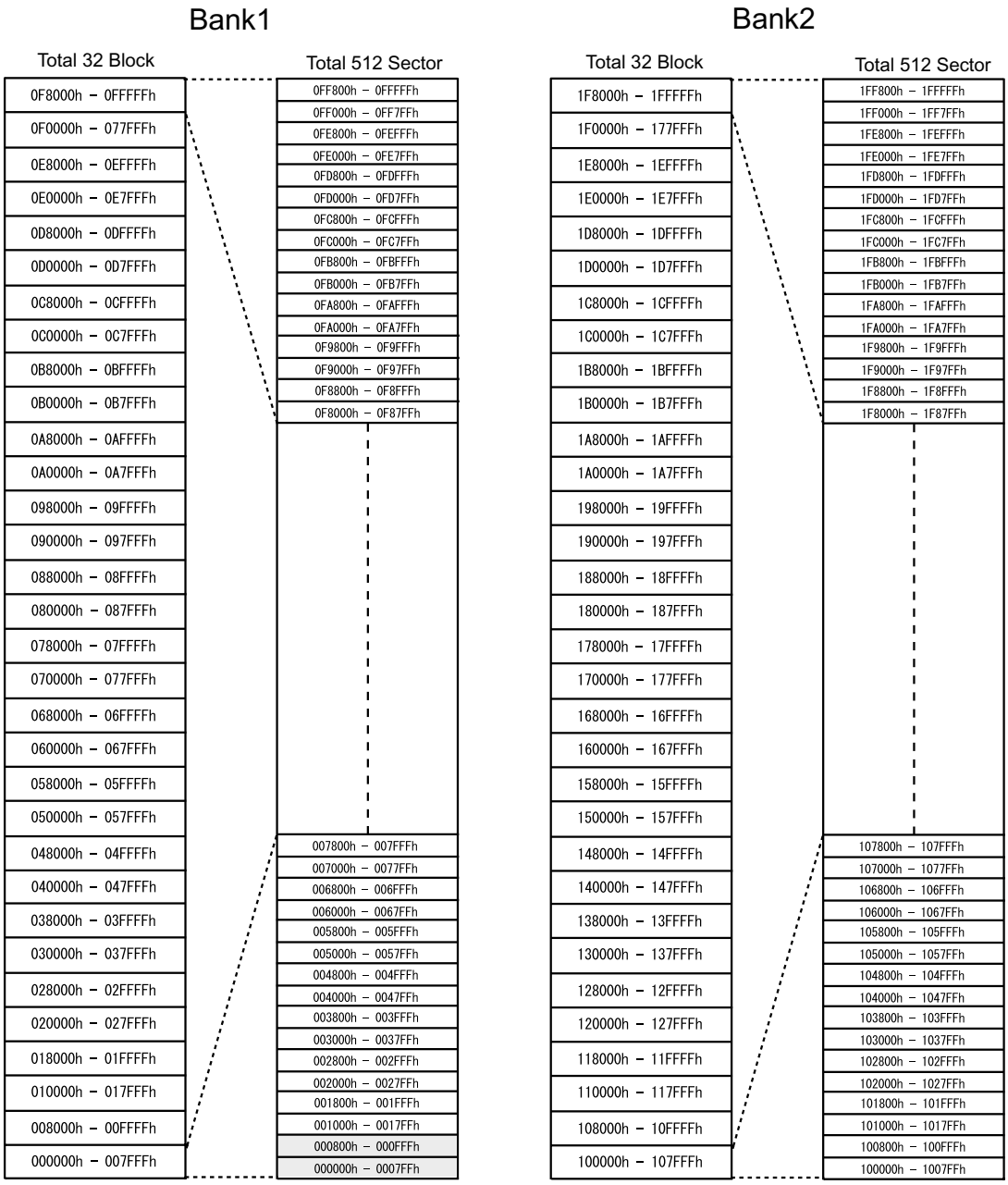


Figure2-1: Functinaly Block Diagram



Note:
1) The address from 000000h to 000FFFh in Bank1 is protect area.
2) This is a example for Word Mode

Figure 2-2: Flash Sector Structure

Table:2 Operating Modes Selection

Array Operating Mode	CE#	OE#	WE#	DQ	A20	A19-A0,A-1
Read						
Bank1	V_{IL}	V_{IL}	V_{IH}	D_{OUT}	V_{IL}	A_{IN}
Bank2	V_{IL}	V_{IL}	V_{IH}	D_{OUT}	V_{IH}	A_{IN}
Block Erase						
Bank1	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IL}	See Table 3
Bank2	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IH}	See Table 3
Sector Erase						
Bank1	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IL}	See Table 3
Bank2	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IH}	See Table 3
Program						
Bank1	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IL}	See Table 3
Bank2	V_{IL}	V_{IH}	V_{IL}	D_{IN}	V_{IH}	See Table 3
Stand-by	V_{IH}	X	X	High Z	X	X
Write Inhibit	V_{IH}	V_{IL}	V_{IL}	X	X	X
Chip Erase	V_{IL}	V_{IH}	V_{IL}	D_{IN}	X	See Table 3
Status Operating Mode	CE#	OE#	WE#	DQ	A20	A19-A0,A-1
Product Identification						
Bank1	V_{IL}	V_{IL}	V_{IH}	D_{OUT}	V_{IL}	A_{19}-A_1=V_{IL},A-1=V_{IL} Note2)
Bank2	V_{IL}	V_{IL}	V_{IH}	D_{OUT}	V_{IH}	A_0=V_{IL} or V_{IH}

Note1:

Entering an illegal state during an Erase, Program, or Write operation will not affect the operation, i.e., the erase program, or write will continue to normal completion.

Note2: Byte Mode operation

Table:3 Software Command Codes

Command Code	1stBus Cycle		2ndBus Cycle		3rdBus Cycle		4thBus Cycle		5thBus Cycle		6thBus Cycle	
	Address	Data	Address	Data	Address	Data	Address	Data	Address	Data	Address	Data
	Note1,4	Note5	Note1,4	Note5	Note1,4	Note5	Note1,4	Note5	Note1,4	Note5	Note1,4	Note5
Software ID Entry	5555	AA	2AAA	55	5555 +BAX	90	Note2					
Software ID Exit	5555	AA	2AAA	55	5555 +BAX	F0	Note3					
Word Program	5555	AA	2AAA	55	5555	A0	Word Address	Data In				
Sector Erase	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	SAX +BAX	30
Block Erase	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	LAX +BAX	50
Chip Erase	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	5555	10

Notes for Software Command Code:

1. Command Code Address format : A14 - A0 are in HEX code.
   When Byte Mode, the format is only used by A14-A0.
2. With A19 - A0 = 0;
   Sanyo Manufacturer Code = 0062H is read with A0 = 0 (Word Mode)
   Sanyo Manufacturer Code = 62H is read with A0 = 0 and A-1 = 0 (Byte Mode)
   Sanyo LE28DW3212T-90B Device code 25B3h, 25B4h is read with A0 = 1. (Word Mode)
   Sanyo LE28DW3212T-90B Device code B3h, B4h is read with A0 = 1 and A-1 = 0. (Byte Mode)
3. The device does not remain in software Product ID Mode if powered down.
4. Address A20 to A15 are 'Don't Care' for Command sequences. (Word Mode)
   Address A-1 is 'Don't Care' for Command sequences. (Byte Mode)
   A20 is bank selection address have been reserved in last bus cycle of Command sequence.
5. Data format DQ0 to DQ7 are in HEX and DQ8 to DQ15 are "Don't Care".
6. BAX = Bank address: A20, LAX = Block address:A19 to A15, SAX = Sector address: A19 to A11.
   When Byte Mode, A-1 selects Byte Mode in sector, that is the same as A9-A0.

[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.

Storage Temperature : -65ºC to +150ºC

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 : -1.0V to V_{DD} + 1.0V

RESET# pin Voltage to Ground Potential : -0.5V to +13.0V

Package Power Dissipation Capability (Ta = 25ºC) : 1.0W

[Operating Range]

Ambient Temperature : 0ºC to +70ºC

V_{DD} : 2.7V to 3.6V

[AC condition of Test]

Input Rise/Fall Time : 5 ns

Output Load(See Figures 12 and 13) : C_L = 30 pF

[DC Operating Characteristics]

Symbol	Parameter	Min	Max	Unit	Test Condition
I_{DD}	Power Supply current Read		20	mA	CE# = V_{IL}, WE# = V_{IH}, I/O's open, Address Input = V_{IL}/V_{IH}, at f =10MHz, V_{DD} = V_{DD}(Max)
	Erase / Program		40	mA	CE# = WE# = V_{IL}, OE# = V_{IH}, V_{DD} = V_{DD}(Max)
	Read + Erase / Program		60	mA	CE# = V_{IL}, OE# = WE# = V_{IH} , Address Input = V_{IL}/V_{IH}, at f =10MHz, WE# = V_{IH}, V_{DD} = V_{DD}(Max)
I_{SB}	Standby current (CMOS input)		40	µA	CE# = V_{IHC} , V_{DD} = V_{DD}(Max)
I_{LI}	Input Leak current		10	µA	V_{IN} = Vss to V_{DD}, V_{DD} = V_{DD}(Max)
I_{OL}	Output Leak current		10	µA	V_{OUT} = Vss to V_{DD}, V_{DD} = V_{DD}(Max)
V_{IL}	Input Low Voltage		V_{DD}*0.2	V	
V_{ILC}	Input Low Voltag (CMOS)		0.2	V	
V_{IH}	Input High Voltag	V_{DD}*0.8		V	
V_{IHC}	Input High Voltge (CMOS)	V_{DD}-0.2		V	
V_H	Supervoltage for RESET#	11.4	12.6	V	Continuance adding time : 15s(Min)
V_{OL}	Output Low Voltag		0.2	V	I_{OL} = 100µA, V_{DD} = V_{DD}(Min)
V_{OH}	Output High Voltag	V_{DD}-0.2		V	I_{OH} = -100µA, V_{DD} = V_{DD}(Min)

[Recommend System Power-up Timings]

Symbol	Parameter	Max	Units
$T_{PU-READ}$(1) $T_{PU-WRITE}$(1)	Power-up to Read Operation Power-up to Write Operation	200 200	µs µs

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

[Capacitance (Ta = 25ºC, f = 1MHz, other pins open)]

Symbol	Parameter	Test Condition	Max
C_{DQ}(1) C_{IN}(1)	I/O Pin Capacitance Input Capacitance	V_{DQ} = 0V V_{IN} = 0V	12PF 6PF

Note(1): This parameter is measured only for initial qualirication and after a design or process change that could affect this parameter.

[Reliability Characteristic]

Symbol	Parameter	Min Spec	Units
N_{END}(1)	Endurance	10,000(2) 100,000(3)	Cycle/Sector
T_{DR}(1)	Data Retention	10	Years

Note(1): This parameter is measured only for initial qualirication and after a design or process change that could affect this parameter.

Note(2): In case of Block Erase and Chip Erase.

Note(3): In case of Sector Erase.

[AC Characteristic]

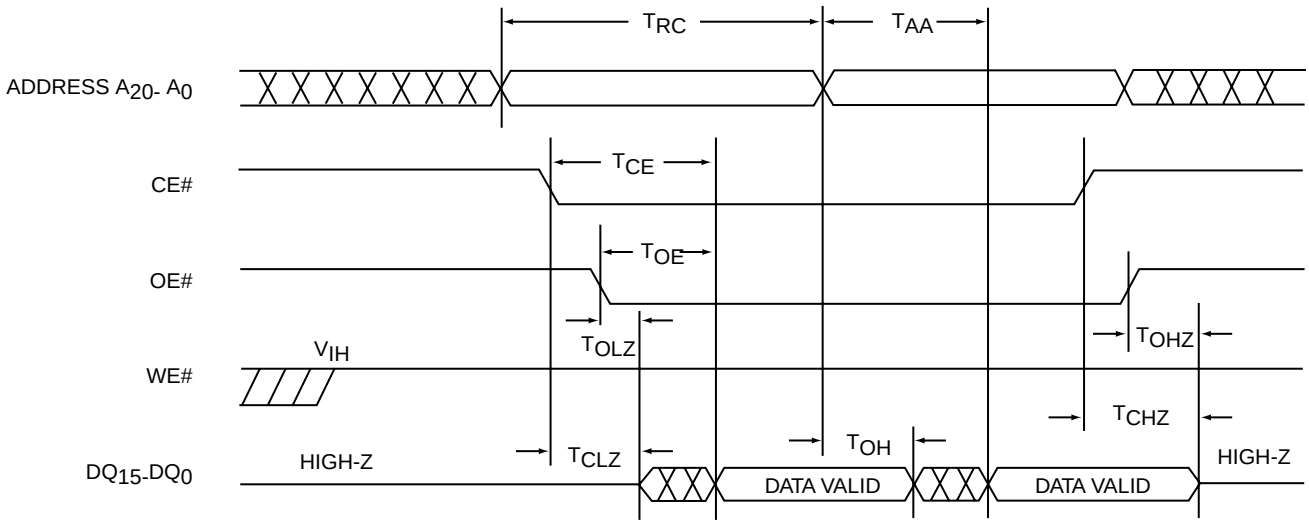
Read Cycle Timing Parameters

Symbol	Parameter	Min	Max	Units
T_{RC}	Raed Cycle Time	80		ns
T_{CE}	CE# Access Time		80	ns
T_{AA}	Address Access Time		80	ns
T_{OE}	OE# Access Time		40	ns
T_{CLZ}(1)	BE# Low to Active Output	0		ns
T_{OLZ}(1)	OE# Low to Active Output	0		ns
T_{CHZ}(1)	BE# High to High-Z Output		30	ns
T_{OHZ}(1)	OE# High to High-Z Output		30	ns
T_{OH}(1)	Output Hold from Address Change	0		ns
T_{RP}	RESET# Puls Width	500		ns
T_{RHR}	RESET# High before READ	50		ns
T_{RY}	RESET# Low to READ Mode		200	µs

Erase, Program Cycle, Timing Parameters

Symbol	Parameter	Min	Typ	Max	Units
T_{BP}	Word Program Time			20	µs
T_{SE}	Sector Erase Time		15	1200	ms
T_{LE}	Block Erase Time			25	ms
T_{BE}	Chip Erase Time			100	ms
T_{AS}	Address Setup Time	0			ns
T_{AH}	Address Hold Time	50			ns
T_{CES}	CE# Setup Time	0			ns
T_{CEH}	CE# Hold Time	0			ns
T_{WES}	WE# Setup Time	0			ns
T_{WEH}	WE# Hold Time	0			ns
T_{OES}	OE# High Setup Time	0			ns
T_{OEH}	OE# High Hold Time	0			ns
T_{WP}	WE# Puls Low Width	50			ns
T_{WPH}	WE# Puls High Time	30			ns
T_{DS}	Data Setup Time	50			ns
T_{DH}	Data Hold Time	0			ns
T_{VDDR}(1)	V_{DD} Rise Time	0.1		50	ms
T_{EVA}	Erase Verify Entry Time	150			ns
T_{IDA}	ID READ / Exit Cycle Time	150			ns
T_{BY}	RY# / BY# Delay Time	80			ns

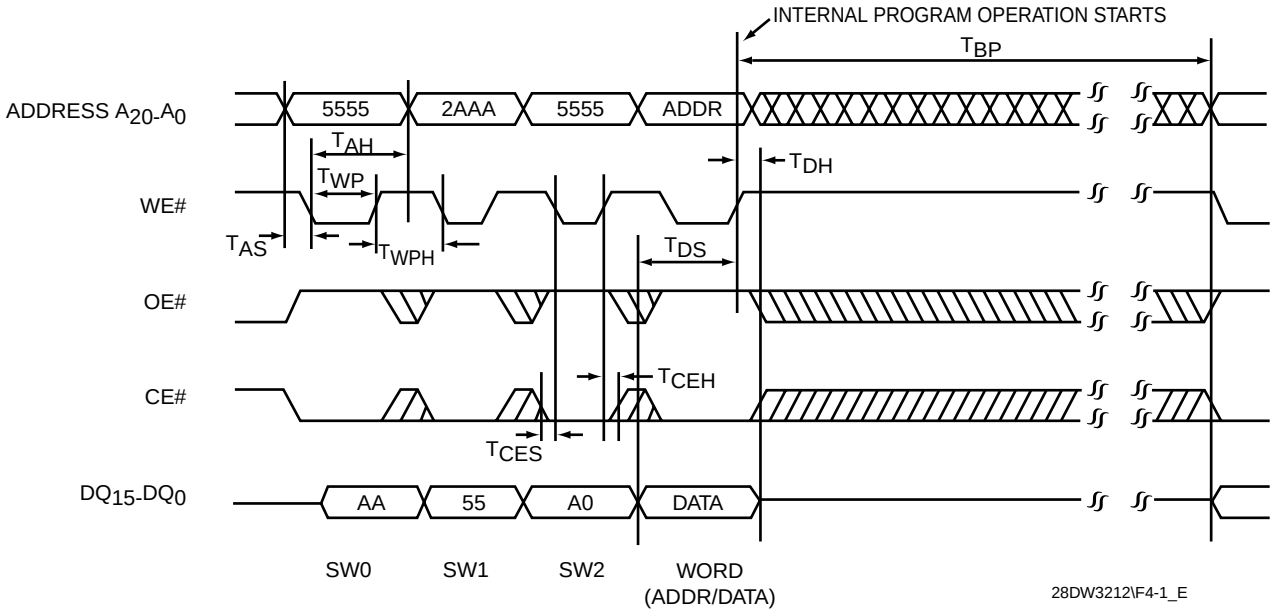
Note:(1) This parameter is measured only for initial qualification and after a desgin or process change that could affect this parameter.



Exsample for Word Mode, in Byte Mode A-1=Address Input

28DW3212\F3_E

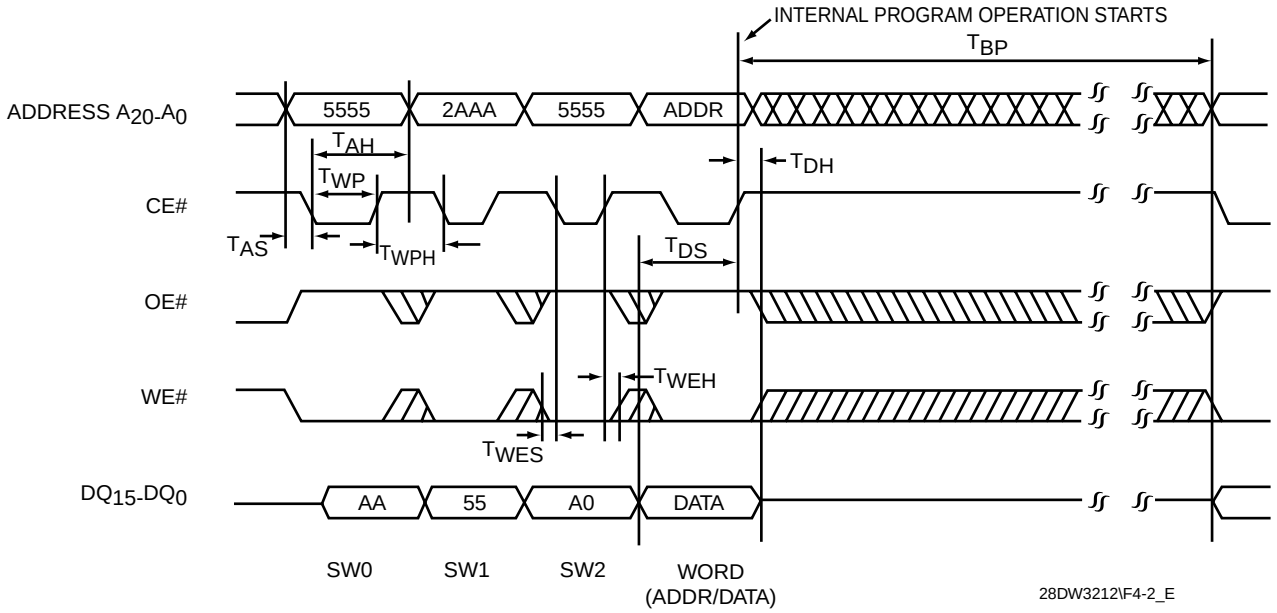
Figure 3: Read Cycle Timing Diagram



28DW3212\F4-1_E

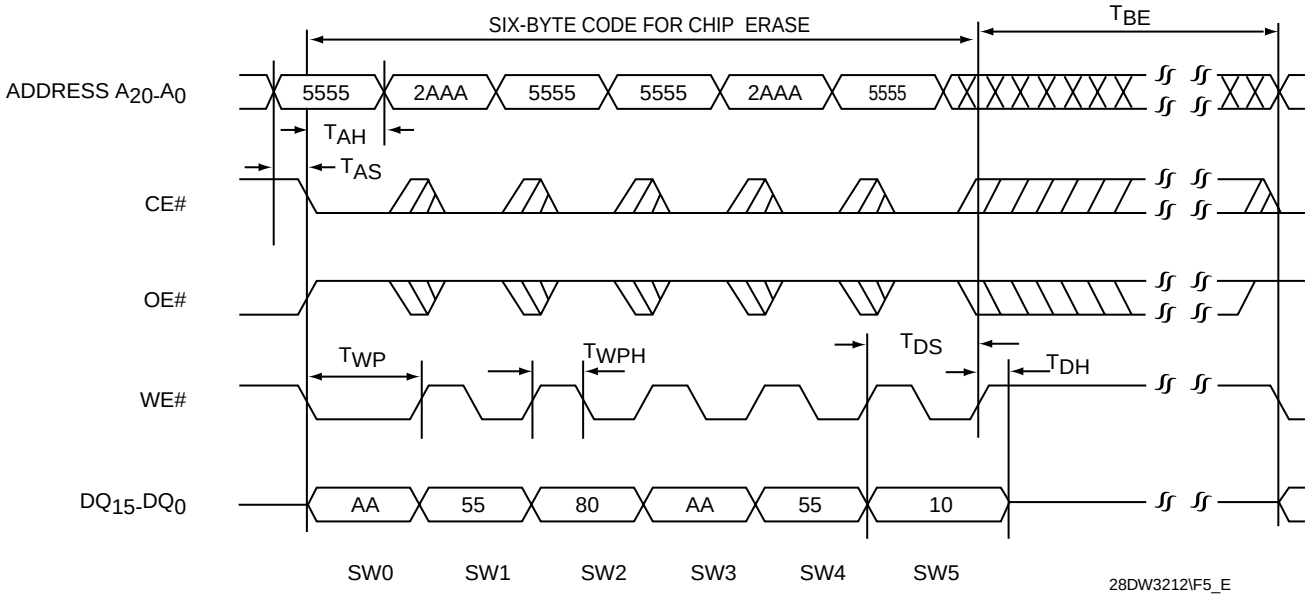
Exsample for Word Mode, in Byte Mode A-1=Address Input

Figure 4-1: WE# Controlled Word Program Cycle Timing Diagram



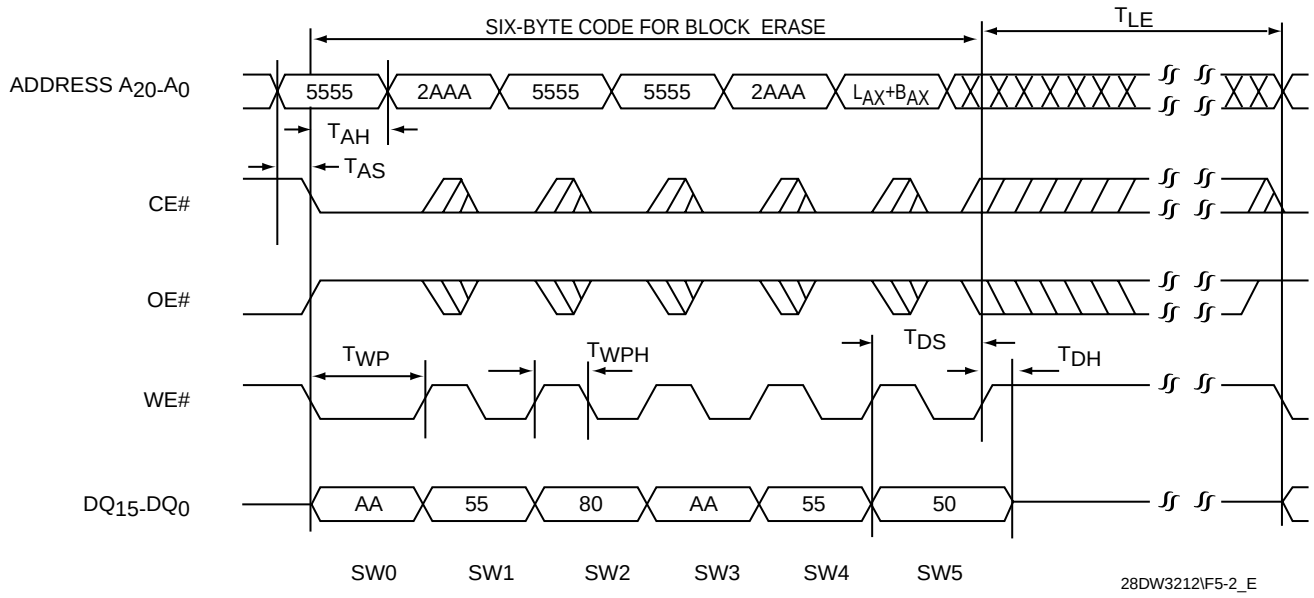
Exsample for Word Mode, in Byte Mode A-1=Address Input

Figure 4-2: CE# Controlled Word Program Cycle Timing Diagram



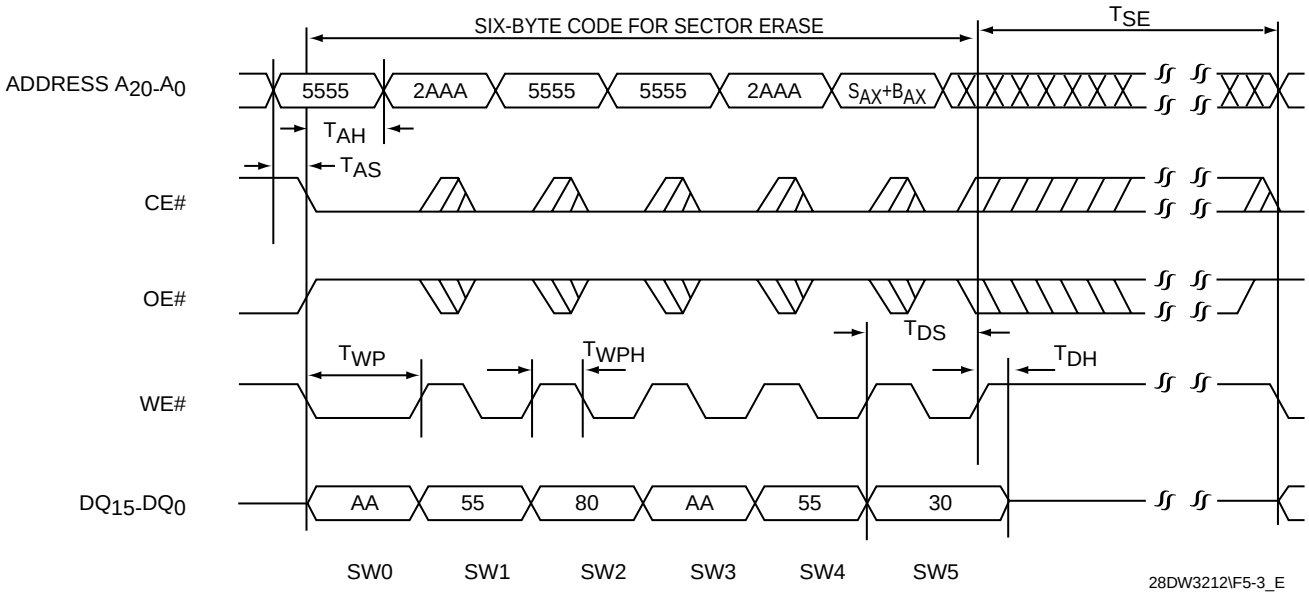
Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 5-1: Chip Erase Cycle Timing Diagram



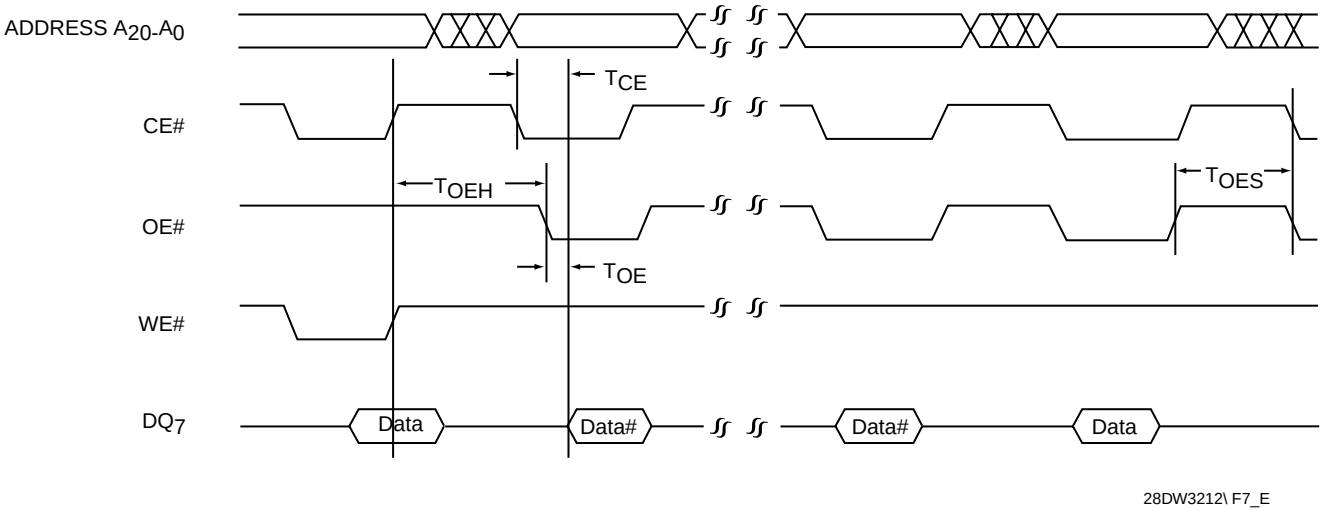
Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 5-2: Block Erase C ycle Timing Diagram



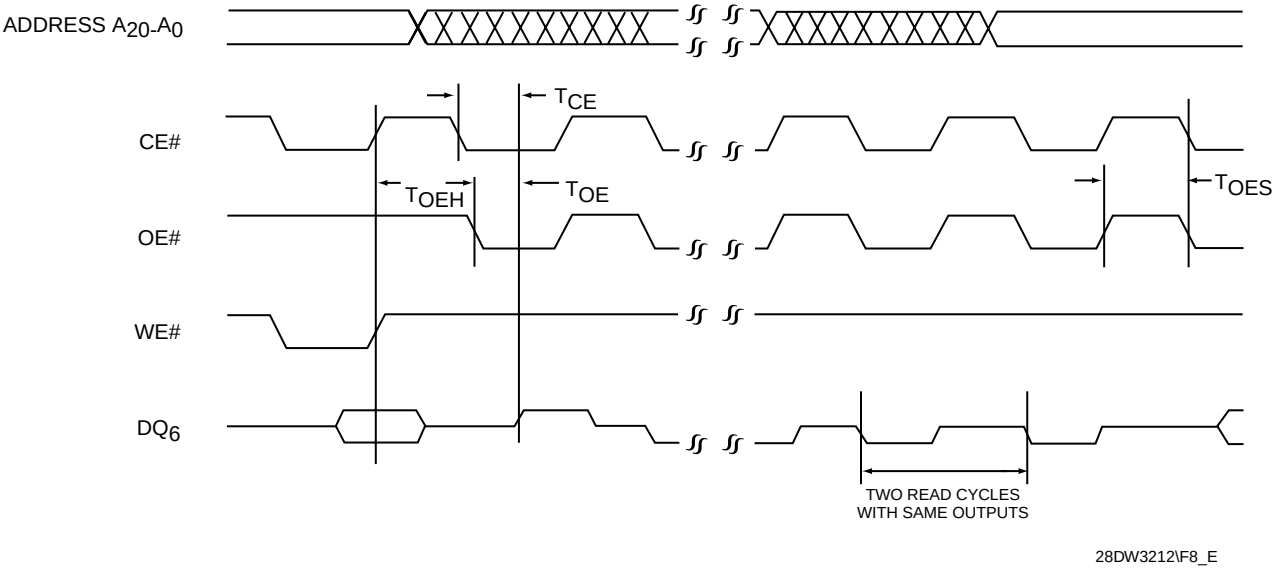
Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 5-3: Sector Erase Cycle Timing Diagram



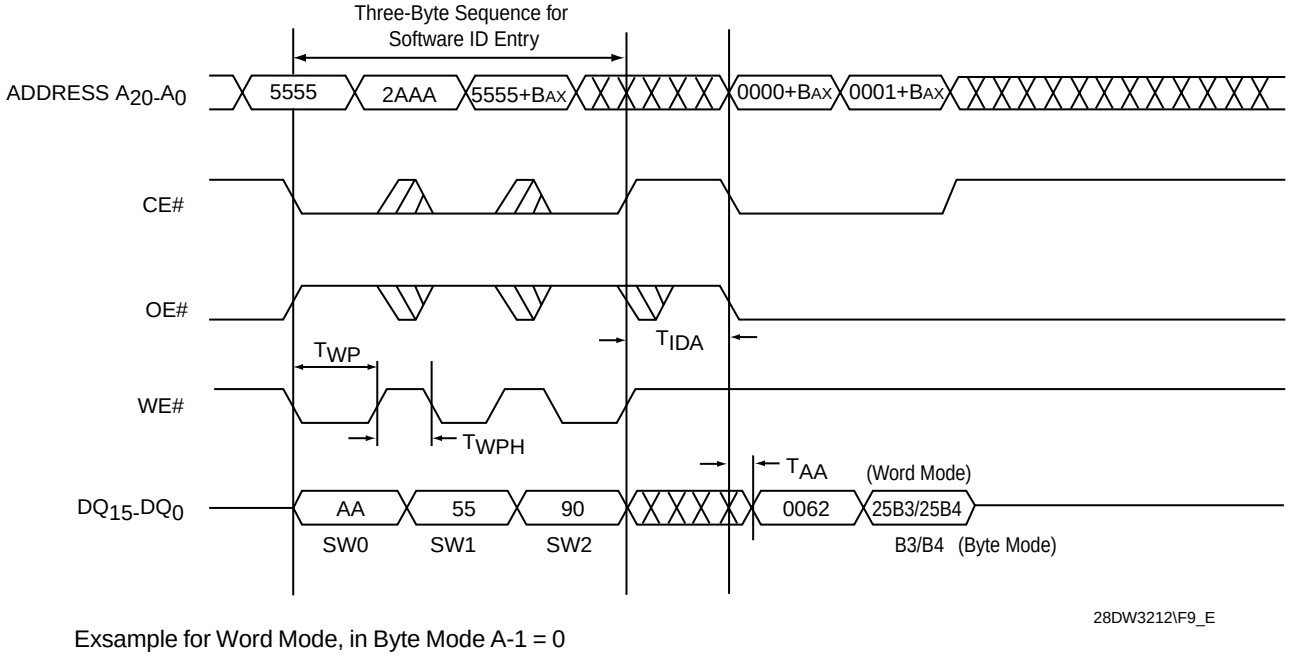
Exsample for Word Mode, in Byte Mode A-1= Address Input

Figure 6: Data# Polling Timing Diagram



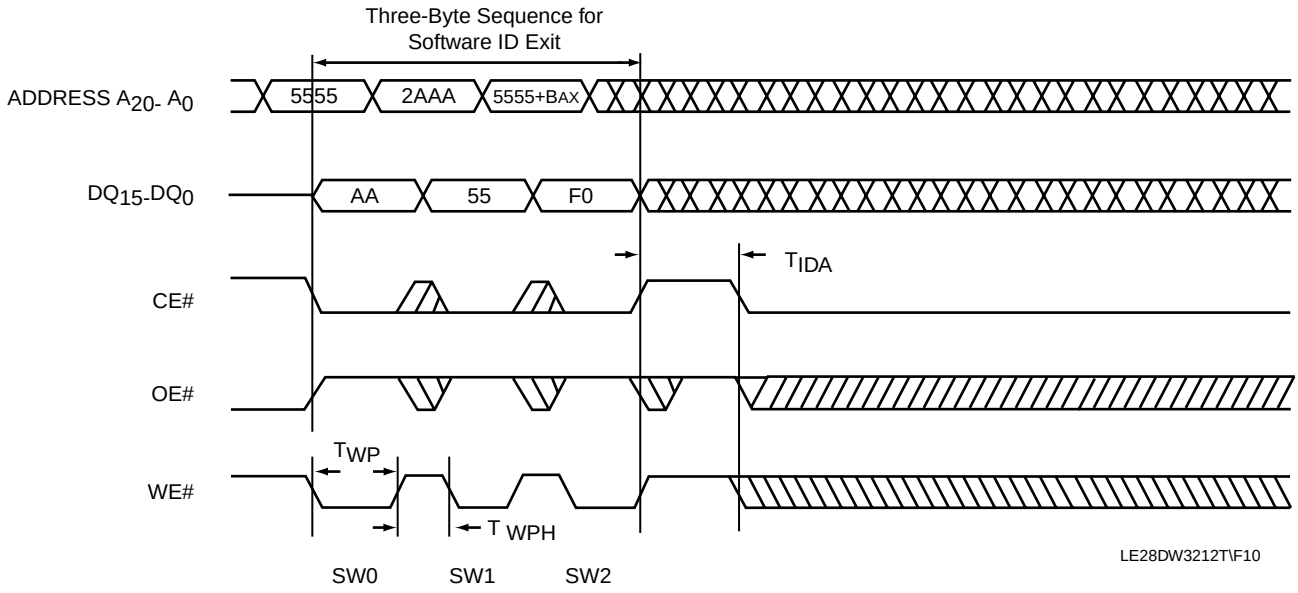
Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 7: Toggle Bit Timing Diagram



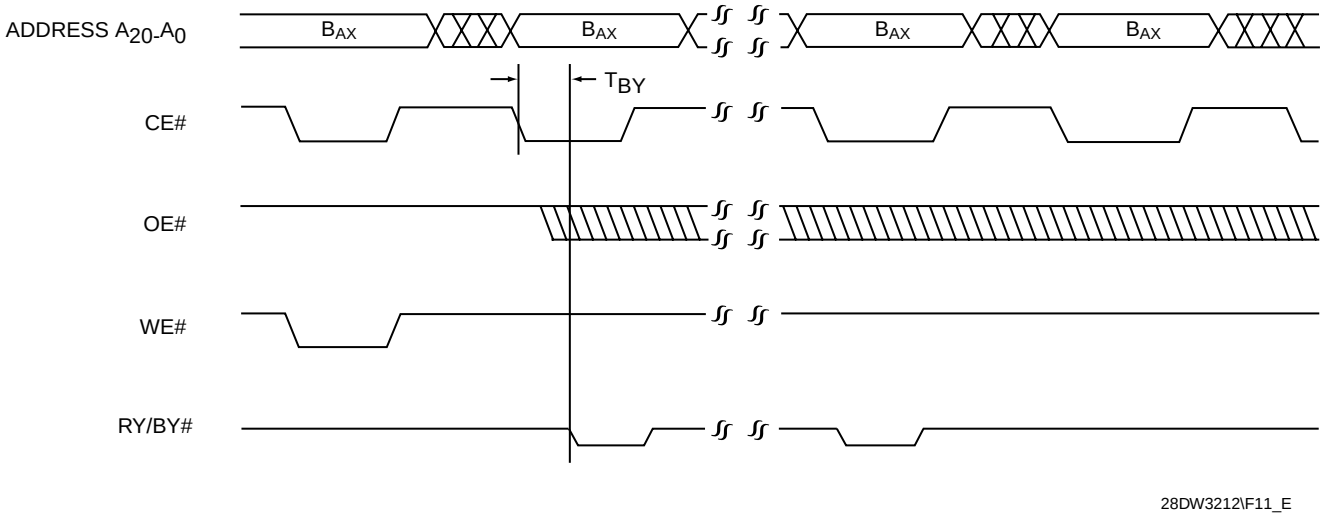
Exsample for Word Mode, in Byte Mode A-1 = 0

Figure 8: Software ID Entry and Read



Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 9: Software ID Exit



Exsample for Word Mode, in Byte Mode A-1= Don't care

Figure 10: RY/BY# Outputt

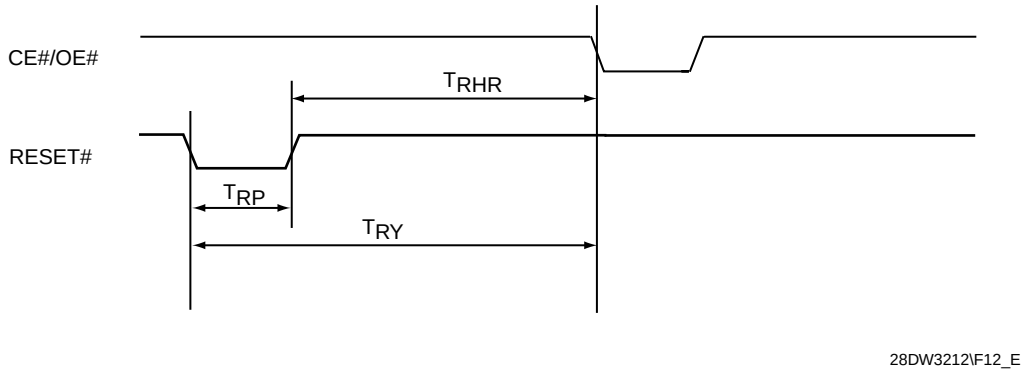
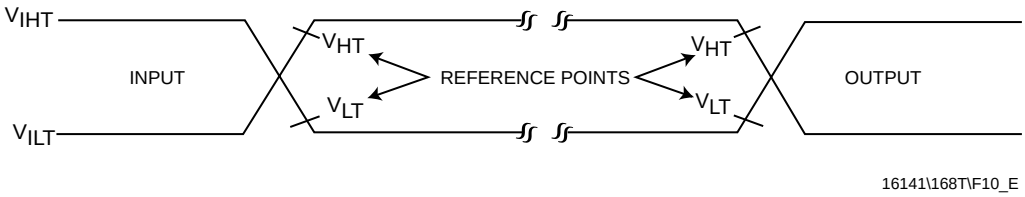


Figure 11: Reset Timing



AC test inputs are driven at V_{IHT} (V_{DD}*0.9) for a logic "1"and V_{ILT} (V_{DD}*0.1) for a logic "0" Measurement reference points for inputs and outputs are at V_{HT} (V_{DD}*0.7) and V_{LT} (V_{DD}*0.3) Input rise and fall times (10% to 90%) are <10 ns.

Figure 12: AC I/O Reference Waveforms

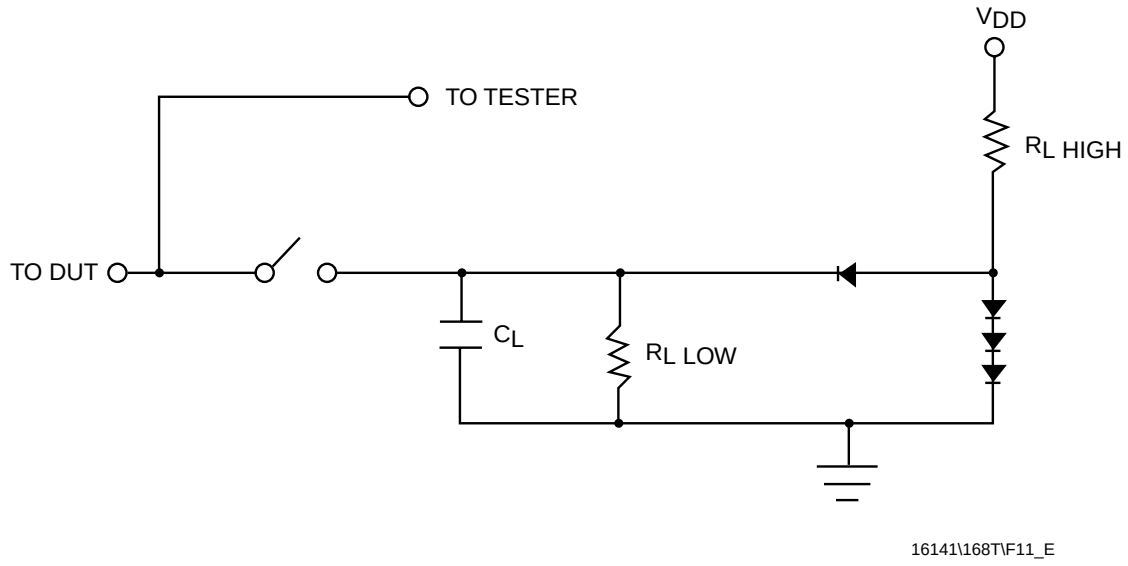


Figure 13: A Test Load Example

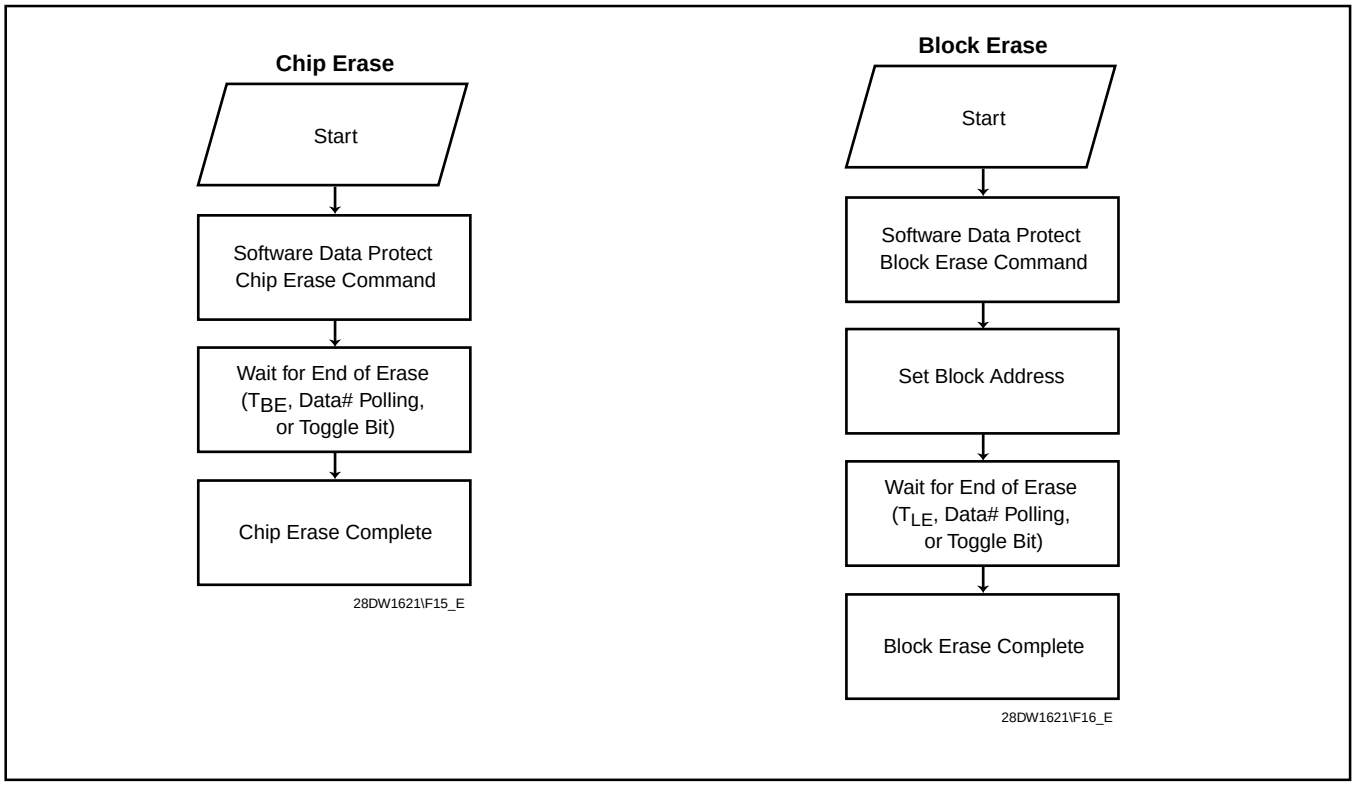


Figure 14: Chip Erase Flowchart

Figure 15: Block Erase Flowchart

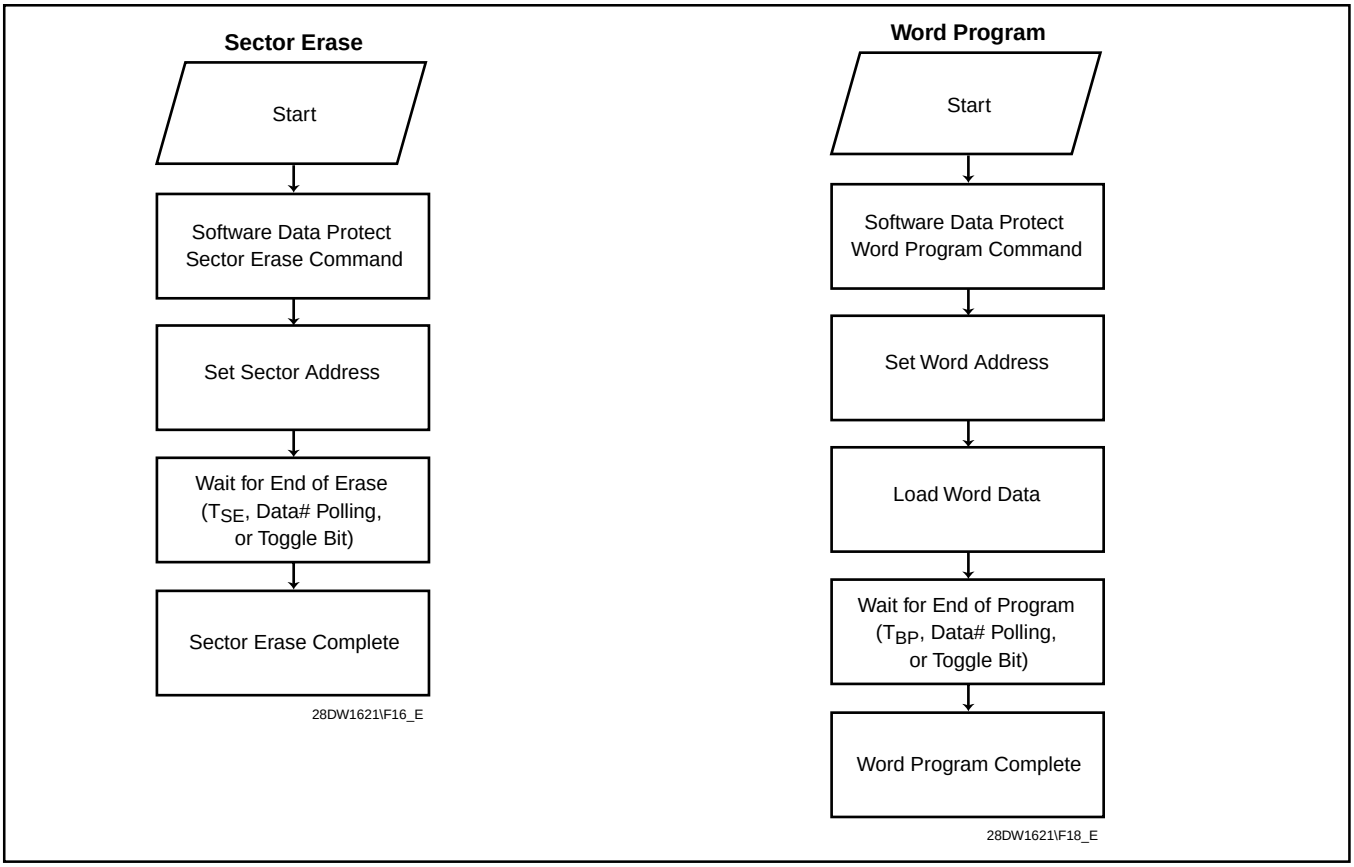


Figure 16: Sector Erase Flowchart

Figure 17: Word Program Flowchart

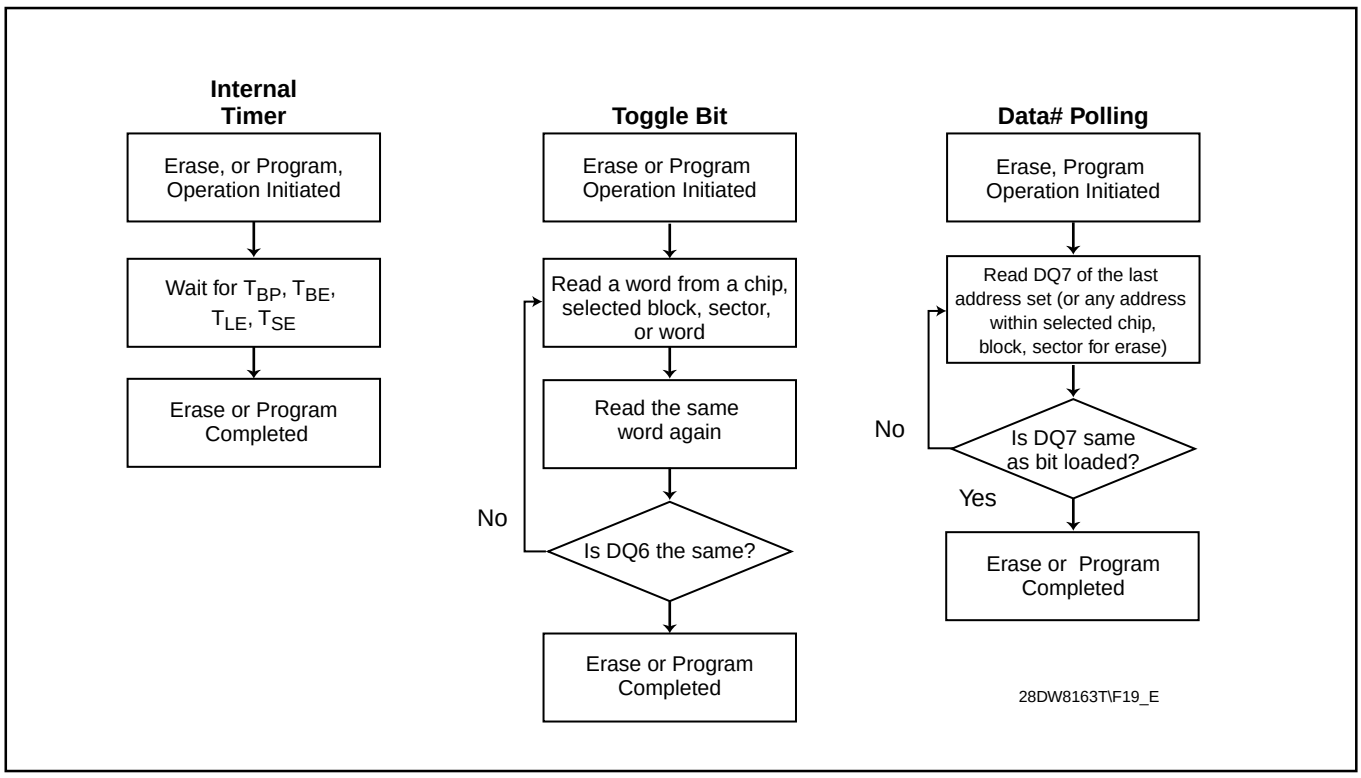


Figure 18: End of Erase or Program Wait Options Flowchart