

FINAL



AmC0XXDFLKA

4, 8, 20, or 32 Megabyte 5.0 Volt-only Flash Memory PC Card

DISTINCTIVE CHARACTERISTICS

- **High performance**
 - 150 ns maximum access time
- **Single supply operation**
 - Write and erase voltage, 5.0 V $\pm$ 5%
 - Read voltage, 5.0 V $\pm$ 5%
- **CMOS low power consumption**
 - 45 mA maximum active read current (x8 mode)
 - 65 mA maximum active write/erase current (x8 mode)
- **High write endurance**
 - Minimum 100,000 program/erase cycles per sector
 - 1,000,000 typical program/erase cycles per card
- **PCMCIA/JEIDA 68-pin standard**
 - Selectable byte-/or word-wide configuration
- **Write protect switch**
 - Prevents accidental data loss
- **Zero data retention power**
 - Batteries not required for data storage
- **Enhanced power management for standby mode**
 - 1 μ A typical standby current
 - Standard access time from standby mode
- **Separate attribute memory**
- **Automated write and erase operations increase system write performance**
 - 64K byte memory sectors for faster automated erase speed
 - Typically 1 s per single memory sector erase
 - Random address writes to previously erased bytes (8 μ s typical per byte)
- **Total system integration solution**
 - Support from independent software and hardware vendors
- **Low insertion and removal force**
 - State-of-the-art connector allows for minimum card insertion and removal effort
- **Erase Suspend/Resume**
 - Supports **reading or programming** data to a sector not being erased within the same device
- **Support for RY/ $\overline{B}$ Y and RESET signals**

GENERAL DESCRIPTION

AMD's 5.0 Volt-only Flash Memory PC Card provides the highest system level performance for data and file storage solutions to the portable PC market segment and a wide range of embedded applications. Manufactured with AMD's Negative Gate Erase, 5.0 Volt-only technology, the AMD 5.0 Volt-only Flash Memory Cards are the most cost-effective and reliable approach to single-supply Flash memory cards. Data files and application programs can be stored on the D-Series cards. This allows OEM manufacturers of portable systems to eliminate the weight, high-power consumption and reliability issues associated with electro-mechanical disk-based systems. The D-Series cards also allow today's bulky and heavy battery packs to be reduced in weight and size. AMD's Flash Memory PC Cards provide the most efficient method to transfer useful work between different hardware platforms. The enabling technology of the D-Series cards enhances the productivity of mobile workers.

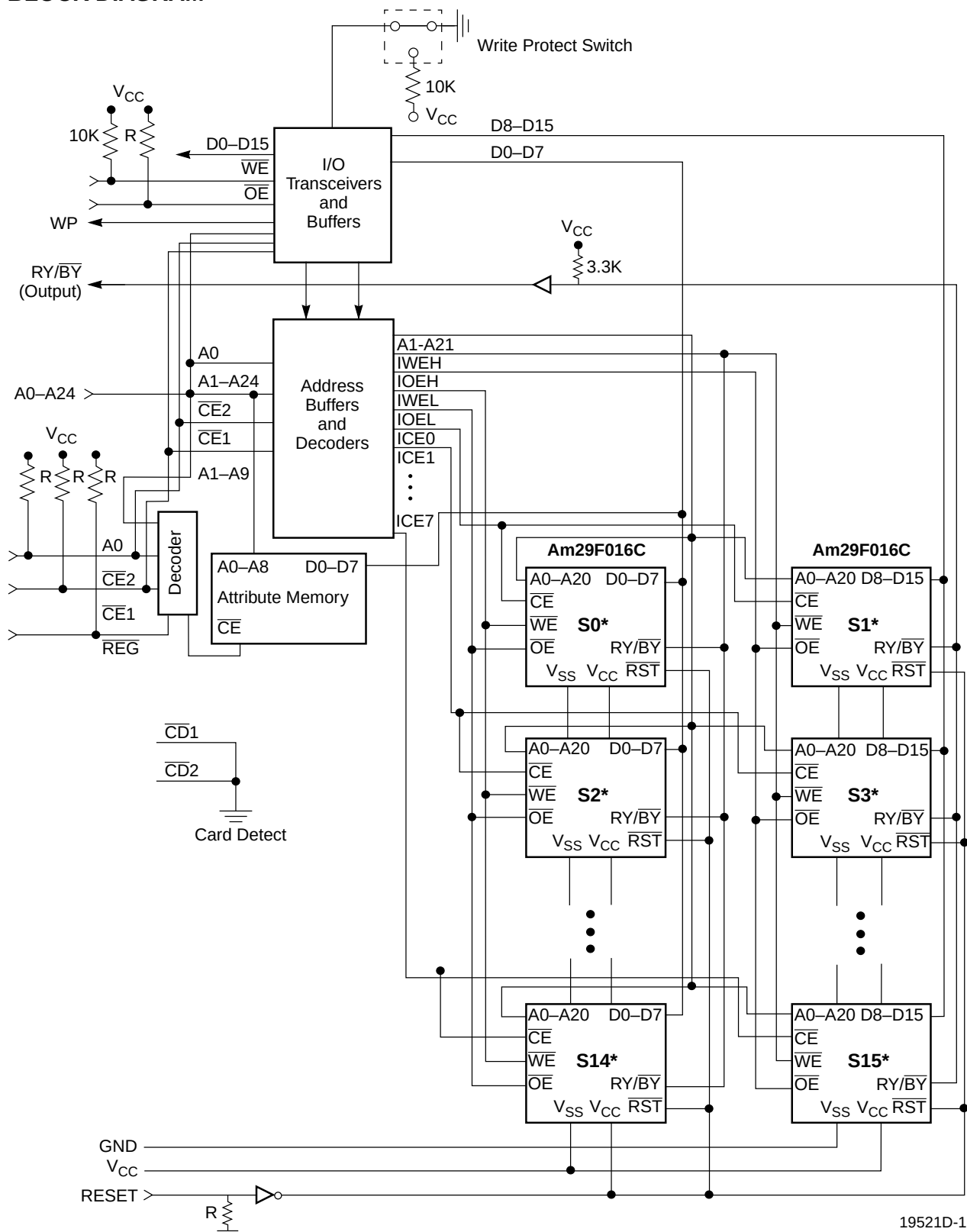
Widespread acceptance of the D-Series cards is assured due to their compatibility with the

68-pin PCMCIA/JEIDA international standard. AMD's Flash Memory Cards can be read in either a byte-wide or word-wide mode which allows for flexible integration into various system platforms. Compatibility is assured at the hardware interface and software interchange specification. The Card Information Structure (CIS) or Metaformat, can be written by the OEM into the memory card's attribute memory address space beginning at address 00000H by using a format utility. The CIS appears at the beginning of the Card's attribute memory space and defines the low-level organization of data on the PC Card. The D-Series cards contains a separate EEPROM memory for the cards' attribute memory space. This allows all of the Flash memory to be used for the common memory space.

Third party software solutions such as Microsoft's and SystemSoft's Flash File System (FFS2), SCM's SCM-FTL, and Datalight's Cardtrick enable AMD's Flash Memory PC Card to replicate the function of traditional disk-based memory systems.



BLOCK DIAGRAM



19521D-1

Notes:

$R = 20\text{ K}(\min)/140\text{ K}(\max)$

*4 Mbyte card = S0 + S1, 8 Mbyte card = S0...S3, 20 Mbyte card = S0...S9, 32 Mbyte card = S0...S15

PC CARD PIN ASSIGNMENTS

Pin#	Signal	I/O	Function	Pin#	Signal	I/O	Function
1	GND		Ground	35	GND		Ground
2	D3	I/O	Data Bit 3	36	$\overline{CD}1$	O	Card Detect 1 (Note 3)
3	D4	I/O	Data Bit 4	37	D11	I/O	Data Bit 11
4	D5	I/O	Data Bit 5	38	D12	I/O	Data Bit 12
5	D6	I/O	Data Bit 6	39	D13	I/O	Data Bit 13
6	D7	I/O	Data Bit 7	40	D14	I/O	Data Bit 14
7	$\overline{CE}1$	I	Card Enable 1 (Note 3)	41	D15	I/O	Data Bit 15
8	A10	I	Address Bit 10	42	$\overline{CE}2$	I	Card Enable 2 (Note 3)
9	$\overline{OE}$	I	Output Enable	43	NC		No Connect
10	A11	I	Address Bit 11	44	NC		No Connect
11	A9	I	Address Bit 9	45	NC		No Connect
12	A8	I	Address Bit 8	46	A17	I	Address Bit 17
13	A13	I	Address Bit 13	47	A18	I	Address Bit 18
14	A14	I	Address Bit 14	48	A19	I	Address Bit 19
15	$\overline{WE}$	I	Write Enable	49	A20	I	Address Bit 20
16	RY/ $\overline{BY}$		Ready/Busy	50	A21	I	Address Bit 21
17	V_{CC1}		Power Supply	51	V_{CC2}		Power Supply
18	NC		No Connect (Note 1)	52	NC		No Connect (Note 1)
19	A16	I	Address Bit 16	53	A22	I	Address Bit 22
20	A15	I	Address Bit 15	54	A23	I	Address Bit 23
21	A12	I	Address Bit 12	55	A24	I	Address Bit 24
22	A7	I	Address Bit 7	56	NC		No Connect
23	A6	I	Address Bit 6	57	NC		No Connect
24	A5	I	Address Bit 5	58	RESET		RESET
25	A4	I	Address Bit 4	59	NC		No Connect
26	A3	I	Address Bit 3	60	NC		No Connect
27	A2	I	Address Bit 2	61	$\overline{REG}$	I	Register Select
28	A1	I	Address Bit 1	62	$\overline{BVD}2$	O	Battery Vltg Detect 2 (Note 2)
29	A0	I	Address Bit 0	63	$\overline{BVD}1$	O	Battery Vltg Detect 1 (Note 2)
30	D0	I/O	Data Bit 0	64	D8	I/O	Data Bit 8
31	D1	I/O	Data Bit 1	65	D9	I/O	Data Bit 9
32	D2	I/O	Data Bit 2	66	D10	I/O	Data Bit 10
33	WP	O	Write Protect (Note 3)	67	$\overline{CD}2$	O	Card Detect 2 (Note 3)
34	GND		Ground	68	GND		Ground

Notes:

I = Input to card, O = Output from card

I/O = Bidirectional

NC = No connect

In systems which switch V_{CC} individually to cards, no signal should be directly connected between cards other than ground.

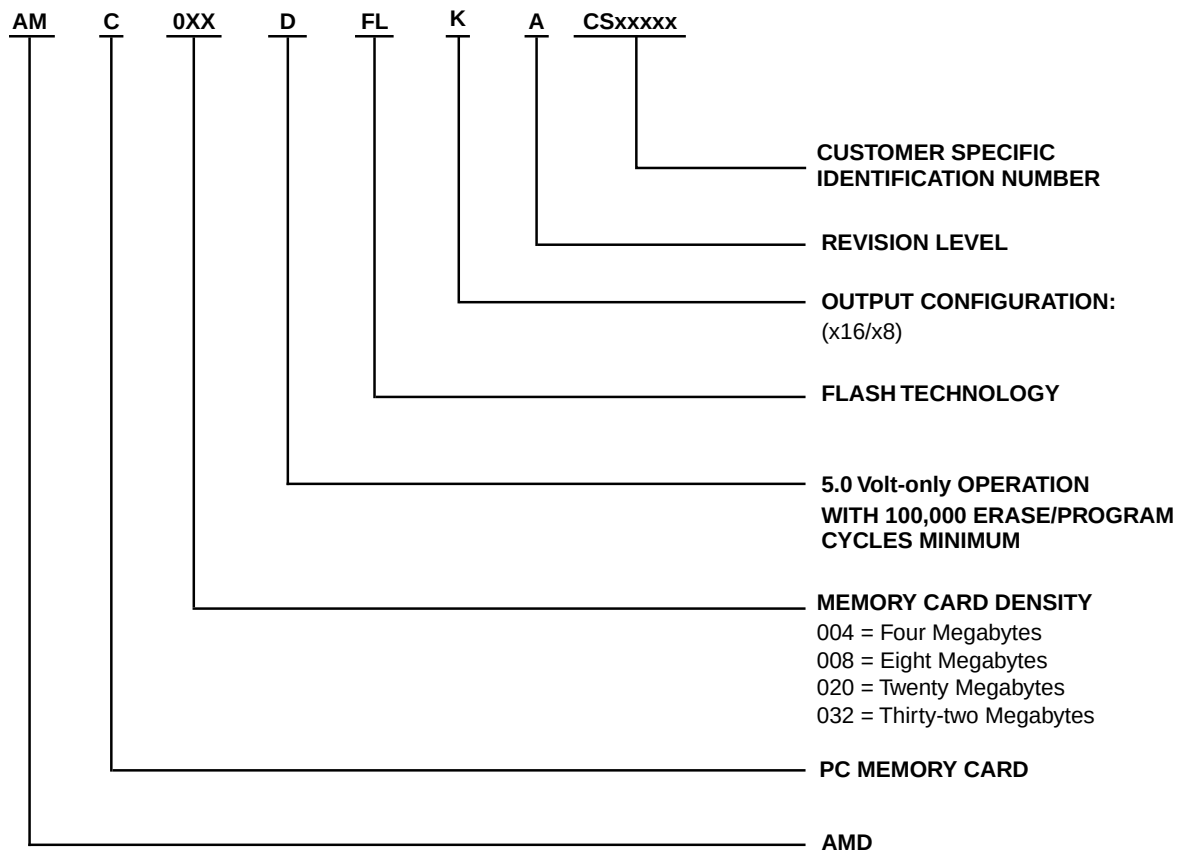
1. V_{PP} not required for Programming or Reading operations.
2. $\overline{BVD}$ = Internally pulled-up.
3. Signal must not be connected between cards.



ORDERING INFORMATION

Standard Products

AMD standard products are available in several packages and operating ranges. The order number (Valid Combination) is formed by a combination of:



Differences Between the D-Series and C-Series Cards

The differences between the D-Series Card and the earlier C-Series Cards are as follows:

- The D-Series Cards are based on AMD's latest 16 MBit 5.0 Volt-only device, the Am29F016C. The earlier C-Series Cards were based on the 4 MBit 5.0 Volt-only device, the Am29F040.
- The D-Series Cards program faster than the C-Series Cards. This is due to faster byte write times and an optimized address unlock sequence for write operations.
- The D-Series Cards are offered in higher densities. The D-Series Cards are available in densities of 4 MBytes, 8 MBytes, 20 MBytes, and 32 MBytes. The earlier C-Series Cards were available in densities of 1 MByte, 2 MBytes, 4 MBytes and 10 MBytes.

The additional features that are supported in the new D-Series Cards include

- The D-Series Cards support the RESET feature. This allows you to asynchronously RESET the Card into the read state.
- The D-Series Cards also provide the $\overline{RY}/\overline{BY}$ functionality. This feature provides a quick way of determining if the Card is busy doing a write or erase operation, or if it is in a position to undertake the next operation.
- Availability of an additional Toggle bit (D2) to determine if the Card is in the Embedded Erase or Erase Suspend mode.
- Programming operations can be executed in 8 μ s pulses, down from the 16 μ s on the C-Series Cards (typical).
- Time out from the rising edge of the $\overline{WE}$ pulse for sector erase command reduced from 100 μ s to 50 μ s.
- The D-Series Cards offers a low power standby mode with fast recovery time to read. The typical standby current (I_{CCS}) is $<1 \mu$ A with recovery at standard read access time.

PIN DESCRIPTION

A0–A24

Address Inputs

These inputs are internally latched during write cycles. All address lines should be driven.

$\overline{\text{BVD1}}$, $\overline{\text{BVD2}}$

Battery Voltage Detect

Internally pulled-up.

$\overline{\text{CD1}}$, $\overline{\text{CD2}}$

Card Detect

When card detect 1 and 2 = ground the system detects the card.

$\overline{\text{CE1}}$, $\overline{\text{CE2}}$

Card Enable

This input is active low. The memory card is deselected and power consumption is reduced to standby levels when $\overline{\text{CE}}$ is high. $\overline{\text{CE}}$ activates the internal memory card circuitry that controls the high and low byte control logic of the card, input buffers segment decoders, and associated memory devices.

D0–D15

Data Input/Output

Data inputs are internally latched on write cycles. Data outputs during read cycles. Data pins are active high. When the memory card is deselected or the outputs are disabled the outputs float to tristate.

GND

Ground

NC

No Connect

Corresponding pin is not connected.

$\overline{\text{OE}}$

Output Enable

This input is active low and enables the data buffers through the card outputs during read cycles.

$\text{RY}/\overline{\text{BY}}$

This signal is output from the card and indicates the status of the operation in progress in the card. If this signal is low, then the card is still busy with the current operation. Otherwise, the card is ready to accept anew operation.

$\overline{\text{REG}}$

Attribute Memory Select

This input is active low and enables reading the CIS from the EEPROM.

RESET

This input to the Card is used to reset all the Flash devices inside the Card to a read mode state. If you drive or assert RESET high during a write or erase operation, then the state of the devices for the purpose of the operation is undefined. In order to RESET, you need to hold the RESET pin high for 500 ns, and it takes 20 μs before the internal circuit is RESET. When RESET is driven high, the data bus is in a high impedance state.

V_{CC}

PC Card Power Supply

For device operation (5.0 V $\pm$ 5%).

$\overline{\text{WE}}$

Write Enable

This input is active low and controls the write function of the command register to the memory array. The target address is latched on the falling edge of the $\overline{\text{WE}}$ pulse and the appropriate data is latched on the rising edge of the pulse.

WP

Write Protect

This output is active high and disables all Card write operations (including writes to the attribute memory).

MEMORY CARD OPERATIONS

The D-Series Flash Memory Card is organized as an array of individual devices. Each device is 2 Mbytes in size with thirty-two 64K byte sectors. Although the address space is continuous, each physical device defines a logical address segment size.

Erase operations can be performed on two 64KByte sectors simultaneously. Once a memory sector or memory segment is erased any address location may be programmed. Flash technology allows any logical “1” data bit to be programmed to a logical “0”. The only way to reset bits to a logical “1” is to erase the entire memory sector of 64K bytes or memory segment of 2 Mbytes.

Erase operations are the only operations that work on entire memory sectors or memory segments. All other operations such as word-wide programming are not affected by the physical memory segments.

The common memory space data contents are altered in a similar manner as writing to individual Flash memory devices. On-card address and data buffers activate the appropriate Flash device in the memory array. Each device internally latches address and data during write cycles. Refer to Table 1.

Attribute memory is a separately accessed card memory space. The attribute memory space is active when the REG pin is driven low. The Card Information Structure (CIS) describes the capabilities and specification

of a card. The CIS is stored in the attribute memory space beginning at address 00000H. The D-Series cards contain a separate EEPROM for the Card Information Structure. D0–D7 are active during attribute memory accesses. D8–D15 should be ignored. Odd order bytes present invalid data. Refer to Table 2.

Word-Wide Operations

The D-Series cards provide the flexibility to operate on data in a byte-wide or word-wide format. In word-wide operations the $\overline{CE1}$ and $\overline{CE2}$ must be low and A0 is not used for any addressing.

Table 1. Common Memory Bus Operations

Function	$\overline{REG}$	$\overline{CE2}$	$\overline{CE1}$	$\overline{OE}$	$\overline{WE}$	A0	D8–D15	D0–D7
Read Mode								
Standby Mode	X	H	H	X	X	X	High-Z	High-Z
Word Access	H	L	L	L	H	X	Data Out-Odd	Data Out-Even
Low Byte Access	H	H	L	L	H	L	High-Z	Data Out-Even
Odd Byte Access	H	H	L	L	H	H	High-Z	Data Out-Odd
Odd-Byte-Only Access	H	L	H	L	H	X	Data Out-Odd	High-Z
Write Mode								
Standby Mode	X	H	H	X	X	X	X	X
Word Access (Note 3)	H	L	L	H	L	X	Data In-Odd	Data In-Even
Even Byte Access (Note 4)	H	H	L	H	L	L	High-Z	Data In-Even
Odd Byte Access (Note 4)	H	H	L	H	L	H	High-Z	Data In-Odd
Odd-Byte-Only Access (Note 4)	H	L	H	H	L	X	Data In-Odd	High-Z
Output Disable	H	X	X	H	H	X	High-Z	High-Z

Notes:

1. X indicates a don't care value.
2. V_{PP} pins are not connected in the 5.0 Volt-only Flash Memory Card.
3. Refer to Table 5 for valid D_{IN} during a word write operation.
4. Refer to Table 3 and 4 for valid D_{IN} during a byte write operation.
5. During odd byte access, A0 = V_{IH} outputs or inputs the "odd" byte (high byte) of the x16 word on D0–D7. This is accomplished internal to the card by transposing D8–D15 to D0–D7.
6. During odd-byte-only access, A0 = X outputs or inputs the "odd" byte (high byte) of the x16 word on D8–D15.

Table 2. Attribute Memory Bus Operations

Pins/Operation	$\overline{\text{REG}}$	$\overline{\text{CE2}}$	$\overline{\text{CE1}}$	$\overline{\text{OE}}$	$\overline{\text{WE}}$	A0	D8–D15	D0–D7
READ/WRITE								
Read Mode (Note 3)								
Standby Mode	X	H	H	X	X	X	High-Z	High-Z
Word Access (Note 4)	L	L	L	L	H	X	Not Valid	Data Out-Even
Even Byte Access	L	H	L	L	H	L	High-Z	Data Out-Even
Odd Byte Access (Note 4)	L	H	L	L	H	H	High-Z	Not Valid
Odd-Byte-Only Access (Note 4)	L	L	H	L	H	X	Not Valid	High-Z
Write Mode (Note 5,6)								
Standby Mode	X	H	H	X	X	X	X	X
Word Access	L	L	L	H	L	X	X	Data In-Even
Low Byte Access	L	H	L	H	L	L	X	Data In-Even
Odd Byte Access	L	H	L	H	L	H	X	X
Odd-Byte-Only Access	L	L	H	X	H	L	X	X
Output Disable	L	X	X	H	H	X	High-Z	High-Z

Notes:

1. X indicates any value.
2. V_{PP} pins are not connected in the 5.0 Volt-Only Flash Memory Card.
3. During Attribute Memory Read function, $\overline{\text{REG}}$ and $\overline{\text{OE}}$ must be active for the entire cycle.
4. Only even-byte data is valid during Attribute Memory Read function.
5. During Attribute Memory Write function, $\overline{\text{REG}}$ and $\overline{\text{WE}}$ must be active for the entire cycle, $\overline{\text{OE}}$ must be inactive for the entire cycle.
6. The first 128 bytes of the attribute memory is not writable as it contains the CIS. Only the remaining 384 bytes are writable.

Byte-Wide Operations

Byte-wide data is available on D0–D7 for read and write operations ($\overline{CE}1 = \text{low}$, $\overline{CE}2 = \text{high}$). Even and odd bytes are stored in separate memory segments (i.e., S0 and S1) and are accessed when A0 is low and high respectively. The even byte is the low order byte and the odd byte is the high order byte of a 16-bit word.

Erase operations in the byte-wide mode must account for data multiplexing on D0–D7 by changing the state of A0. Each memory sector or memory segment pair must be addressed separately for erase operations.

Card Detection

Each $\overline{CD}$ (output) pin should be read by the host system to determine if the memory card is adequately seated in the socket. $\overline{CD}1$ and $\overline{CD}2$ are internally tied to ground. If both bits are not detected, the system should indicate that the card must be reinserted.

Write Protection

The AMD Flash memory card has three types of write protection. The PCMCIA/JEIDA socket itself provides the first type of write protection. Power supply and control pins have specific pin lengths in order to protect the card with proper power supply sequencing in the case of hot insertion and removal.

A mechanical write protect switch provides a second type of write protection. When this switch is activated, $\overline{WE}$ is internally forced high. The Flash memory command register is disabled from accepting any write commands.

The third type of write protection is achieved with V_{CC1} and V_{CC2} below 3.2 V V_{LKO} . Each Flash memory device that comprises a Flash memory segment will reset the command register to the read-only mode when V_{CC} is below V_{LKO} . V_{LKO} is the voltage below which write operations to individual command registers are disabled.

MEMORY CARD BUS OPERATIONS

Read Enable

Two Card Enable ($\overline{CE}$) pins are available on the memory card. Both $\overline{CE}$ pins must be active low for word-wide read accesses. Only one $\overline{CE}$ is required for byte-wide accesses. The $\overline{CE}$ pins control the selection and gates power to the high and low memory segments. The Output Enable ($\overline{OE}$) controls gating accessed data from the memory segment outputs.

The device will automatically power-up in the read/reset state. In this case, a command sequence is not required to read data. Standard microprocessor read cycles will retrieve array data. This default value ensures that no spurious alteration of the memory content occurs during the power transition. Refer to the AC

Read Characteristics and Waveforms for the specific timing parameters.

Output Disable

Data outputs from the card are disabled when $\overline{OE}$ is at a logic-high level. Under this condition, outputs are in the high-impedance state.

Standby Operations

Byte-wide read accesses only require half of the read/write output buffer (x16) to be active. In addition, only one memory segment is active within either the high order or low order bank. Activation of the appropriate half of the output buffer is controlled by the combination of both $\overline{CE}$ pins. The $\overline{CE}$ pins also control power to the high and low-order banks of memory. Outputs of the memory bank not selected are placed in the high impedance state. The individual memory segment is activated by the address decoders. The other memory segments operate in standby. An active memory segment continues to draw power until completion of a write or erase operation if the card is deselected in the process of one of these operations.

Auto Select Operation

A host system or external card reader/writer can determine the on-card manufacturer and device I.D. codes. Codes are available after writing the 90H command to the command register of a memory segment per Tables 3 and 4. Reading from address location 00000H in any segment provides the manufacturer I.D. while address location 00002H provides the device I.D.

To terminate the Auto Select operation, it is necessary to write the Read/Reset command sequence into the register.

Write Operations

Write and erase operations are valid only when V_{CC1} and V_{CC2} are above 4.75 V. This activates the state machine of an addressed memory segment. The command register is a latch which saves address, commands, and data information used by the state machine and memory array.

When Write Enable ($\overline{WE}$) and appropriate $\overline{CE}(s)$ are at a logic-level low, and Output Enable ($\overline{OE}$) is at a logic-high, the command register is enabled for write operations. The falling edge of $\overline{WE}$ latches address information and the rising edge latches data/command information.

Write or erase operations are performed by writing appropriate data patterns to the command register of accessed Flash memory sectors or memory segments.

The byte-wide and word-wide commands are defined in Tables 3, 4, and 5, respectively.

Table 3. Even Byte Command Definitions (Note 5)

Embedded Command Sequence	Bus Write Cycles Req'd	First Bus Write Cycle		Second Bus Write Cycle		Third Bus Write Cycle		Fourth Bus Read/Write Cycle		Fifth Bus Write Cycle		Sixth Bus Write Cycle	
		Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data
Reset/Read	1	XXXXH	F0										
Reset/Read	4	XXXXH	AA	XXXXH	55	XXXXH	F0	RA	RD				
Autoselect	4	XXXXH	AA	XXXXH	55	XXXXH	90	00H	01				
								02H	3D				
Byte Write	4	XXXXH	AA	XXXXH	55	XXXXH	A0	PA	PD				
Segment Erase	6	XXXXH	AA	XXXXH	55	XXXXH	80	XXXXH	AA	XXXXH	55	XXXXH	10
Sector Erase	6	XXXXH	AA	XXXXH	55	XXXXH	80	XXXXH	AA	XXXXH	55	SA	30
Sector Erase Suspend		XXXXH	B0	Erase can be suspended during sector erase with Addr (don't care), Data (B0H)									
Sector Erase Resume		XXXXH	30	Erase can be resumed after suspend with Addr (don't care), Data (30H)									

* Address for Memory Segment 0 (S0) only. Address for the higher even memory segments (S2–S14) = (Addr) + (N/2)* 400000H where N = Memory Segment number (0) for 4 Mbyte, N = (0, 2) for 8 Mbyte, N = (0, 2, 4) for 12 Mbyte, N = (0...8) for 20 Mbyte, N = (0...14) for 32 Mbyte.

Notes:

- Address bits = X = Don't Care for all address commands except for Program Address (PA), Read Address (RA) and Sector Address (SA).
- Bus operations are defined in Table 1.
- RA = Address of the memory location to be read.
PA = Address of the memory location to be programmed. Addresses are latched on the falling edge of the $\overline{WE}$ pulse.
SA = Address of the sector to be erased. The combination of A17, A18, A19, A20, A21 will uniquely select any sector of a segment.
To select the memory segment: 4 Mbyte: Use $\overline{CE}1$
8 Mbyte: Use $\overline{CE}1$ and A22
20 and 32 Mbyte: Use $\overline{CE}1$ and A22-A24.
- RD = Data read from location RA during read operation.
PD = Data to be programmed at location PA. Data is latched on the rising edge of $\overline{WE}$ pulse.
- A0 = 0 and $\overline{CE}1 = 0$.

Table 4. Odd Byte Command Definitions (Notes 1–5)

Embedded Command Sequence	Bus Write Cycles Req'd	First Bus Write Cycle		Second Bus Write Cycle		Third Bus Write Cycle		Fourth Bus Read/Write Cycle		Fifth Bus Write Cycle		Sixth Bus Write Cycle	
		Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data
Reset/Read	1	XXXXH	F0										
Reset/Read	4	XXXXH	AA	XXXXH	55	XXXXH	F0	RA	RD				
Autoselect	4	XXXXH	AA	XXXXH	55	XXXXH	90	00H	01				
								02H	3D				
Byte Write	4	XXXXH	AA	XXXXH	55	XXXXH	A0	PA	PD				
Segment Erase	6	XXXXH	AA	XXXXH	55	XXXXH	80	XXXXH	AA	XXXXH	55	XXXXH	10
Sector Erase	6	XXXXH	AA	XXXXH	55	XXXXH	80	XXXXH	AA	XXXXH	55	SA	30
Sector Erase Suspend		XXXXH	AA	Erase can be suspended during sector erase with Addr (don't care), Data (B0H)									
Sector Erase Resume		XXXXH	AA	Erase can be resumed after suspend with Addr (don't care), Data (30H)									

* Address for Memory Segment 1 (S1) only. Address for the higher odd memory segments (S3–S15) = (Addr) + ((N–1)/2)* 400000H + 200000H where N = Memory Segment number (1) for 4 Mbyte, N = (1, 3) for 8 Mbyte, N = (1, 3, 5) for 12 Mbyte, N = (1...9) for 20 Mbyte, N = (1...15) for 32 Mbyte.

Notes:

- Address bits = X = Don't Care for all address commands except for Program Address (PA), Read Address (RA) and Sector Address (SA).
- Bus operations are defined in Table 1.
- RA = Address of the memory location to be read.
PA = Address of the memory location to be programmed. Addresses are latched on the falling edge of the $\overline{WE}$ pulse.
SA = Address of the sector to be erased. The combination of A17, A18, A19, A20, A21 will uniquely select any sector of a segment.
To select the memory segment: 4 Mbyte: Use $\overline{CE2}$
 8 Mbyte: Use $\overline{CE2}$ and A22
 20 and 32 Mbyte: Use $\overline{CE2}$ and A22–A24.
- RD = Data read from location RA during read operation.
PD = Data to be programmed at location PA. Data is latched on the rising edge of $\overline{WE}$ pulse.
- A0 = 1 and $\overline{CE1}$ = 0 or A0 = X and $\overline{CE2}$ = 0.

Table 5. Word Command Definitions (Notes 1–7)

Embedded Command Sequence	Bus Write Cycles Req'd	First Bus Write Cycle		Second Bus Write Cycle		Third Bus Write Cycle		Fourth Bus Read/Write Cycle		Fifth Bus Write Cycle		Sixth Bus Write Cycle	
		Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data	Addr*	Data
Reset/Read	1	XXXXH	F0F0										
Reset/Read	4	XXXXH	AAAA	XXXXH	5555	XXXXH	F0	RA	RW				
Autoselect	4	XXXXH	AAAA	XXXXH	5555	XXXXH	90	00H	0101				
								02H	3D3D				
Byte Write	4	XXXXH	AAAA	XXXXH	5555	XXXXH	A0A0	PA	PW				
Segment Erase	6	XXXXH	AAAA	XXXXH	5555	XXXXH	8080	XXXXH	AAAA	5554H	5555	XXXXH	1010
Sector Erase	6	XXXXH	AAAA	XXXXH	5555	XXXXH	8080	XXXXH	AAAA	5554H	5555	SA	3030
Sector Erase Suspend		XXXXH	B0B0	Erase can be suspended during sector erase with Addr (don't care), Data (B0B0H)									
Sector Erase Resume		XXXXH	3030	Erase can be resumed after suspend with Addr (don't care), Data (3030H)									

Notes:

- Address bits = X = Don't Care for all address commands except for Program Address (PA) and Sector Address (SA).
- Bus operations are defined in Table 1.
- RA = Address of the memory location to be read.
PA = Address of the memory location to be programmed. Addresses are latched on the falling edge of the $\overline{WE}$ pulse.
SA = Address of the sector to be erased. The combination of A17, A18, A19, A20, A21 will uniquely select any sector of a segment.
To select the memory segment: 4 Mbyte: Use $\overline{CE}1$, $\overline{CE}2$
8 Mbyte: Use $\overline{CE}1$, $\overline{CE}2$
20 and 32 Mbyte: Use $\overline{CE}1$, $\overline{CE}2$, A22–A24.
- RW = Data read from location RA during read operation. (Word Mode).
PW = Data to be programmed at location PA. Data is latched on the rising edge of $\overline{WE}$ (Word Mode).
- Address for Memory Segment Pair 0 (S0 and S1) only. Address for the higher Memory Segment Pairs (S2, S3 = Pair 1; S4, S5 = Pair 2; S6, S7 = Pair 3...) is equal to (Addr) + M* (40000H) where M = Memory Segment Pair number.
- Word = 2 bytes = odd byte and even byte.
- $\overline{CE}1 = 0$ and $\overline{CE}2 = 0$.

FLASH MEMORY PROGRAM/ERASE OPERATIONS

Details of AMD's Embedded Write and Erase Operations

Embedded Erase Algorithm

The automatic memory sector or memory segment erase does not require the device to be entirely pre-programmed prior to executing the Embedded Erase command. Upon executing the Embedded Erase command sequence, the addressed memory sector or memory segment will automatically write and verify the entire memory segment or memory sector for an all "zero" data pattern. The system is not required to provide any controls or timing during these operations.

When the memory sector or memory segment is automatically verified to contain an all "zero" pattern, a self-timed chip erase-and-verify begins. The erase and verify operations are complete when the data on D7 (D15 on the odd byte) of the memory sector or memory segment is "1" (see Write Operation Status section) at which time the device returns to the Read mode. The system is not required to provide any control or timing during these operations. A Reset command after the device has begun execution will stop the device but the data in the operated segment will be undefined. In that case, restart the erase on that sector and allow it to complete.

When using the Embedded Erase algorithm, the erase automatically terminates when adequate erase margin has been achieved for the memory array (no erase verify command is required). The margin voltages are internally generated in the same manner as when the standard erase verify command is used.

The Embedded Erase command sequence is a command only operation that stages the memory sector or memory segment for automatic electrical erasure of all bytes in the array. The automatic erase begins on the rising edge of the $\overline{WE}$ and terminates when the data on D7 of the memory sector or memory segment is "1" (see Write Operation Status section) at which time the device returns to the Read mode. Please note that for the memory segment or memory sector erase operation, $\overline{Data}$ Polling may be performed at any address in that segment or sector.

Figure 1 and Table 6 illustrate the Embedded Erase Algorithm, a typical command string and bus operations.

As described earlier, once the memory sector in a device or memory segment completes the Embedded Erase operation it returns to the Read mode and addresses are no longer latched. Therefore, the device requires that the address of the sector being erased is supplied by the system at this particular instant of time. Otherwise, the system will never read a "1" on D7. A

Table 6. Embedded Erase Algorithm

Bus Operation	Command	Comments
Standby		Wait for V_{CC} ramp
Write	Embedded Erase command sequence	6 bus cycle operation
Read		$\overline{Data}$ Polling to verify erasure

system designer has two choices to implement the Embedded Erase algorithm:

1. The system (CPU) keeps the sector address (within any of the sectors being erased) valid during the entire Embedded Erase operation, or
2. Once the system executes the Embedded Erase command sequence, the CPU takes away the address from the device and becomes free to do other tasks. In this case, the CPU is required to keep track of the valid sector address by loading it into a temporary register. When the CPU comes back for performing $\overline{Data}$ Polling, it should reassert the same address.

Since the Embedded Erase operation takes a significant amount of time (1 s–30 s), option 2 makes more sense. However, the choice of these two options has been left to the system designer.

Figure 1 and Table 6 illustrate the Embedded Erase Algorithm, a typical command string and bus operations.

Sector Erase

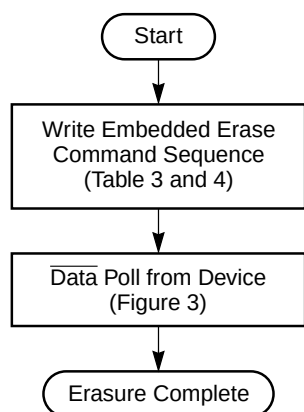
Sector erase is a six bus cycle operation. There are two "unlock" write cycles. These are followed by writing the "set up" command. Two more "unlock" write cycles are then followed by the sector erase command. The sector address (any address location within the desired sector) is latched on the falling edge of $\overline{WE}$, while the command (data) is latched on the rising edge of $\overline{WE}$. A time-out of 50 μ s from the rising edge of the last sector erase command will initiate the sector erase command(s).

Multiple sectors may be erased by writing the six bus cycle operations as described above. This sequence is followed with writes of the sector erase command 30H to addresses in other sectors to be erased. A time-out of 50 μ s from the rising edge of the $\overline{WE}$ pulse for the last sector erase command will initiate the sector erase. If another sector erase command is written within the 50 μ s time-out window the timer is reset. Any command other than sector erase within the time-out window will reset the device to the read mode, ignoring the previous command string (refer to Write Operation Status section for Sector Erase Timer operation). Loading the sector erase buffer may be done in any sequence and with any sector number.

Sector erase does not require the user to program the device prior to erase. The device automatically programs all memory locations to “0” in the sector(s) to be erased prior to electrical erase. When erasing a sector or sectors the remaining unselected sectors are not affected. The system is not required to provide any controls or timings during these operations. A Reset command after the device has begun execution will stop the device but the data in the operated sector will be undefined. In that case, restart the erase on that sector and allow it to complete.

The automatic sector erase begins after the 50 μ s time out from the rising edge of the $\overline{WE}$ pulse for the last sector erase command pulse and terminates when the data on D7 is “1” (see Write Operation Status section) at which time the device returns to read mode. Data Polling must be performed at an address within any of the sectors being erased.

Figure 1 illustrates the Embedded Erase Algorithm using typical command strings and bus operations.



19521D-2

Figure 1. Embedded Erase Algorithm

Embedded Program Algorithm

The Embedded Program setup is a four bus cycle operation that stages the addressed memory sector or memory segment for automatic programming.

Once the Embedded Program setup operation is performed, the next $\overline{WE}$ pulse causes a transition to an active programming operation. Addresses are internally latched on the falling edge of the $\overline{WE}$ pulse. Data is internally latched on the rising edge of the $\overline{WE}$ pulse. The rising edge of $\overline{WE}$ also begins the programming operation. The system is not required to provide further control or timing. The device will automatically provide an adequate internally generated write pulse and verify margin. The automatic programming operation is completed when the data on D7 of the addressed memory sector or memory segment is equivalent to data written

to this bit (see Write Operation Status section) at which time the device returns to the Read mode (no write verify command is required).

Addresses are latched on the falling edge of $\overline{WE}$ during the Embedded Program command execution and hence the system is not required to keep the addresses stable during the entire Programming operation. However, once the device completes the Embedded Program operation, it returns to the Read mode and addresses are no longer latched. Therefore, the device requires that a valid address input to the device is supplied by the system at this particular instant of time. Otherwise, the system will never read a valid data on D7. A system designer has two choices to implement the Embedded Programming algorithm:

1. The system (CPU) keeps the address valid during the entire Embedded Programming operation, or
2. Once the system executes the Embedded Programming command sequence, the CPU takes away the address from the device and becomes free to do other tasks. In this case, the CPU is required to keep track of the valid address by loading it into a temporary register. When the CPU comes back for performing Data Polling, it should reassert the same address.

However, since the Embedded Programming operation takes only 8 μ s typically, it may be easier for the CPU to keep the address stable during the entire Embedded Programming operation instead of reasserting the valid address during Data Polling. Anyway, this has been left to the system designer's choice to go for either operation. Any commands written to the segment during this period will be ignored.

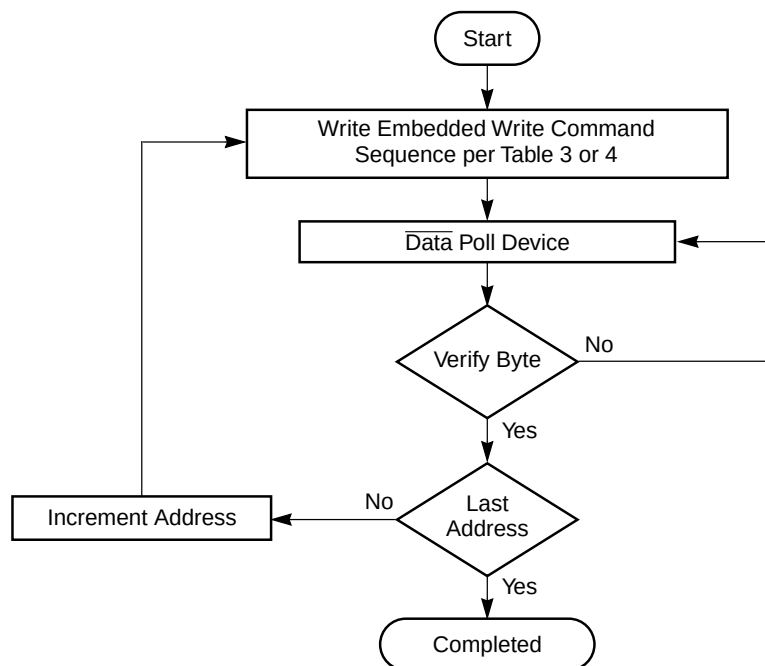
Figure 2 and Table 7 illustrate the Embedded Program Algorithm, a typical command string, and bus operation.

Table 7. Embedded Program Algorithm

Bus Operation	Command	Comments
Standby		Wait for V_{CC} ramp
Write	Embedded Program command sequence	3 bus cycle operation
Write	Program Address/ Data	1 bus cycle operation
Read		Data Polling to verify program

Reset Command

The Reset command initializes the sector or segment to the read mode. Please refer to Tables 3 and 4, “Byte Command Definitions,” and Table 5, “Word Command Definitions” for the Reset command operation. The sector or segment remains enabled for reads until the command register contents are altered.



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Figure 2. Embedded Programming Algorithm in Byte-Wide Mode

The Reset command will safely reset the segment memory to the Read mode. Memory contents are not altered. Following any other command, write the Reset command once to the segment. This will safely abort any operation and reset the device to the Read mode.

The Reset is needed to terminate the auto select operation. It can be used to terminate an Erase or Sector Erase operation, but the data in the sector or segment being erased would then be undefined.

Write Operation Status

$\overline{\text{RY}}/\overline{\text{BY}}$

Ready/Busy

The D-Series Card provides a $\overline{\text{RY}}/\overline{\text{BY}}$ output pin as a way to indicate to the host system that the Embedded Algorithms are either in progress or has been completed. If the output is low, the card is busy with either a program or erase operation. If the output is high, the card is ready to accept any read/write or erase operation. When the $\overline{\text{RY}}/\overline{\text{BY}}$ pin is low, the card will not accept any additional program or erase commands with the exception of the Erase Suspend command to the same device pair, one can still write or erase to a different device pair. If the card is placed in an Erase Suspend mode, the $\overline{\text{RY}}/\overline{\text{BY}}$ output will be high.

During programming, the $\overline{\text{RY}}/\overline{\text{BY}}$ pin is driven low after the rising edge of the fourth $\overline{\text{WE}}$ pulse. During an erase operation, the $\overline{\text{RY}}/\overline{\text{BY}}$ pin is driven low after the rising edge of the sixth $\overline{\text{WE}}$ pulse. The $\overline{\text{RY}}/\overline{\text{BY}}$ pin will indicate

a busy condition during the RESET pulse. Refer to Figure 21 for a detailed timing diagram. The $\overline{\text{RY}}/\overline{\text{BY}}$ pin is pulled high in standby mode. $\overline{\text{RY}}/\overline{\text{BY}}$ is best used to interrupt the CPU when an erase completes. Polling is best for byte programming.

$\overline{\text{Data}}$ Polling—D7 (D15 on Odd Byte)

The Flash Memory PC Card features $\overline{\text{Data}}$ Polling as a method to indicate to the host system that the Embedded algorithms are either in progress or completed.

While the Embedded Programming algorithm is in operation, an attempt to read the device will produce the complement of expected valid data on D7 of the addressed memory sector or memory segment. Upon completion of the Embedded Program algorithm an attempt to read the device will produce valid data on D7. The $\overline{\text{Data}}$ Polling feature is valid after the rising edge of the fourth $\overline{\text{WE}}$ pulse of the four write pulse sequence.

While the Embedded Erase algorithm is in operation, D7 will read “0” until the erase operation is completed. Upon completion of the erase operation, the data on D7 will read “1”.

The $\overline{\text{Data}}$ Polling feature is only active during the Embedded Programming or Erase algorithms. Please note that the AmC0XXDFLKA data pin (D7) may change asynchronously while Output Enable ($\overline{\text{OE}}$) is asserted low. This means that the device is driving status information on D7 at one instant of time and then the byte's valid data at the next instant of time. Depending on

when the system samples the D7 output, it may read either the status or valid data. Even if the device has completed the Embedded operation and D7 has a valid data, the data outputs on D0–D6 may be still invalid since the switching time for data bits (D0–D7) will not be the same. This happens since the internal delay paths for data bits (D0–D7) within the device are different. The valid data will be provided only after a certain time delay ($<t_{OE}$). Please refer to Figure 5 for detailed timing diagrams.

See Figures 3 and 5 for the $\overline{\text{Data}}$ Polling timing specifications and diagrams.

Toggle Bit 1—D6 (D14 on Odd Byte)

The Flash Memory PC Card also features a “Toggle Bit” as a method to indicate to the host system that the Embedded algorithms are either in progress or have been completed.

While the Embedded Program or Erase algorithm is in progress, successive attempts to read data from the device will result in D6 toggling between one and zero. Once the Embedded Program or Erase algorithm is completed, D6 will stop toggling and valid data on D0–D7 will be read on the next successive read attempt. The Toggle bit is also used for entering Erase Suspend mode. Please refer to the section entitled *Sector Erase Suspend*.

Please note that even if the device completes the Embedded algorithm operation and D6 stops toggling, data bits D0–D7 (including D6) may not be valid during the current bus cycle. This may happen since the internal circuitry may be switching from status mode to the Read mode. There is a time delay associated with this mode switching. Since this time delay is always less than t_{OE} (OE access time), the next successive read attempt (OE going low) will provide the valid data on D0–D7. Also note that once the D6 bit has stopped toggling and the output enable $\overline{OE}$ is held low thereafter (without toggling) the data bits (D0–D7) will be valid after t_{OE} time delay.

See Figures 4 and 6 for the $\overline{\text{Data}}$ Polling diagram and timing specifications.

Exceeded Timing Limits—D5

D5 will indicate if the program or erase time has exceeded the specified limits (internal pulse count). Under these conditions D5 will produce a “1”. This is a failure condition which indicates that the program or erase cycle was not successfully completed. $\overline{\text{Data}}$ Polling is the only operating function of the device under this condition. The $\overline{CE}$ circuit will partially power down the device under these conditions (to approximately 2 mA). The OE and WE pins will control the output disable functions as described in Table1.

The D5 failure condition will also appear if a user tries to program a 1 to a location that is previously programmed to 0. In this case the device locks out and never completes the Embedded Program Algorithm. Hence, the system never reads a valid data on D7 bit and D6 never stops toggling. Once the device has exceeded timing limits, the D5 bit will indicate a “1.” Please note that this is not a device failure condition since the device was incorrectly used. If this occurs, reset the device.

Sector Erase Timer—D3

After the completion of the initial sector erase command sequence the sector erase time-out will begin. D3 will remain low until the time-out is complete. $\overline{\text{Data}}$ Polling and Toggle Bit 1 are valid after the initial sector erase command sequence.

If $\overline{\text{Data}}$ Polling or the Toggle Bit 1 indicates the device has been written with a valid erase command, D3 may be used to determine if the sector erase timer window is still open. If D3 is high (“1”) the internally controlled erase cycle has begun; attempts to write subsequent commands (other than Erase Suspend) to the device will be ignored until the erase operation is completed as indicated by $\overline{\text{Data}}$ Polling or Toggle Bit 1. If D3 is low (“0”), the device will accept additional sector erase commands. To insure the command has been accepted, the system software should check the status of D3 prior to and following each subsequent sector erase command. If D3 were high on the second status check, the command may not have been accepted.

Refer to Table 7: Write Operation Status.

Toggle Bit II—D2

This toggle bit, along with D6, can be used to determine whether the device is in the Embedded Erase Algorithm or in Erase Suspend.

Successive reads from the erasing sector will cause D2 to toggle during the Embedded Erase Algorithm. If the device is in the erase-suspended-read mode, successive reads from the erase-suspended sector will cause D2 to toggle. When the device is in the erase-suspended-program mode, successive reads from the byte address of the non-erase suspended sector will indicate a logic ‘1’ at the D2 bit.

D6 is different from D2 in that D6 toggles only when the standard Program or Erase, or Erase Suspend Program operation is in progress. The behavior of these

two status bits, along with that of D7, is summarized as follows:

Mode	D7	D6	D2
Program	$\overline{D7}$	toggles	1
Erase	0	toggles	toggles
Erase Suspend Read (Note 1) (Erase-Suspended Sector)	1	1	toggles
Erase Suspend Program	$\overline{D7}$ (Note 2)	toggles	1 (Note 2)

Notes:

1. These status flags apply when outputs are read from a sector that has been erase-suspended.
2. These status flags apply when outputs are read from the byte address of the non-erase suspended sector.

Sector Erase Suspend

Sector Erase Suspend command allows the user to interrupt the chip and then do data reads (or program) from a non-busy sector while it is in the middle of a Sector Erase operation (which may take up to several seconds). This command is applicable ONLY during the Sector Erase operation and will be ignored if written during the Chip Erase or Programming operation. The Erase Suspend command (B0H) will be allowed only during the Sector Erase Operation that will include the sector erase time-out period after the Sector Erase commands (30H). Writing this command during the time-out will result in immediate termination of the time-out period and suspension of the erase operation.

Any other command written during the Erase Suspend mode will be ignored except the Erase Resume command. Writing the Erase Resume command resumes the erase operation. The addresses are “don’t-cares” when writing the Erase Suspend or Erase Resume command.

When the Erase Suspend command is written during the Sector Erase operation, the device will take a maximum of 15 μ s to suspend the erase operation. When the device has entered the erase-suspended mode, the RY/ $\overline{BY}$ output pin and the D7 bit will be at logic “1”, and D6 will stop toggling. The user must use the address of the erasing sector for reading D6 and D7 to determine if the erase operation has been suspended. Further writes of the Erase Suspend command are ignored.

When the erase operation has been suspended, the device defaults to the erase-suspend-read mode. Reading data in this mode is the same as reading from the standard read mode except that the data must be read from sectors that have not been

erase-suspended. Successively reading from the erase-suspended sector while the device is in the erase-suspend-read mode will cause D2 to toggle. (See the section on D2).

After entering the erase-suspend-read mode, the user can program the device by writing the appropriate command sequence for Byte Program. This program mode is known as the erase-suspend-program mode. Again, programming in this mode is the same as programming in the regular Byte Program mode except that the data must be programmed to sectors that are not erase-suspended. Successively reading from the erase-suspended sector while the device is in the erase-suspend-program mode will cause D2 to toggle. The end of the erase-suspended program operation is detected by the RY/ $\overline{BY}$ output pin, $\overline{Data}$ Polling of D7, or by the Toggle Bit 1 (D6) which is the same as the regular Byte Program operation. Note that D7 must be read from the byte program address while D6 can be read from any address.

Every time a Sector Erase Suspend command followed by an Erase Resume command is written, the internal (pulse) counters are reset. These counters are used to count the number of high voltage pulses the memory cell requires to program or erase. If the count exceeds a certain limit, then the D5 bit will be set (Exceeded Time Limit flag). This resetting of the counters is necessary since the Erase Suspend command can potentially interrupt or disrupt the high voltage pulses.

To resume the operation of Sector Erase, the Resume command (30H) should be written. Any further writes of the Resume command at this point will be ignored. Another Sector Erase Suspend command can be written after the chip has resumed erasing.

RESET

Hardware Reset

The D-Series Card may be reset by driving the RESET pin to V_{IL} . The RESET pin must be kept low (V_{IL}) for at least 500 ns. Any operation in progress will be terminated and the internal state machine will be reset to the read mode 20 μ s after the RESET pin is driven low. If a hardware reset occurs during a program operation, the data at that particular location will be indeterminate.

When the RESET pin is low and the internal reset is complete, the Card goes to standby mode and cannot be accessed. Also, note that all the data output pins are tri-stated for the duration of the RESET pulse. Once the RESET pin is taken high, the Card requires 500 ns of wake up time until outputs are valid for read access.

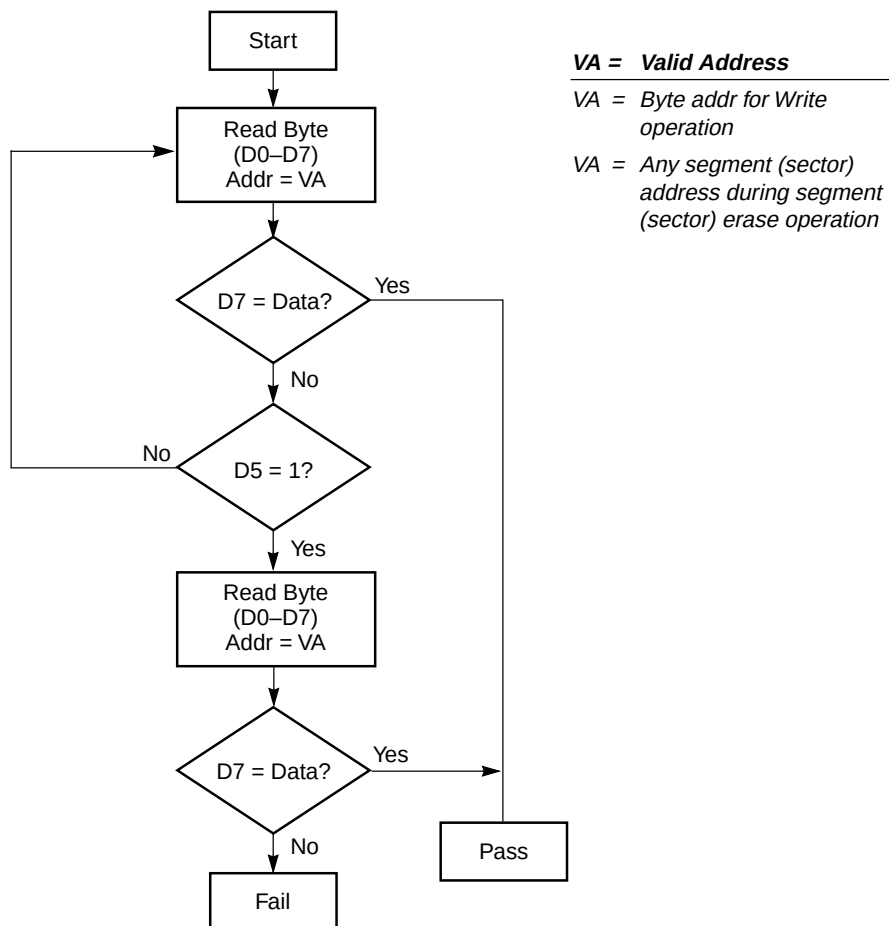
Write Operation Status

Table 8. Write Operation Status

Status			$\overline{D7}$	D6	D5	D3	D2
In Progress	Byte Program in Embedded Program Algorithm		$\overline{D7}$	Toggle	0	0	1
	Embedded Erase Algorithm		0	Toggle	0	1	Toggle
	Erase Suspended Mode	Erase Suspend Read (Erase Suspended Sector)	1	1	0	0	Toggle (Note 1)
		Erase Suspend Read (Non-Erase Suspended Sector)	Data	Data	Data	Data	Data
		Erase Suspend Program (Non-Erase Suspended Sector)	$\overline{D7}$	Toggle (Note 2)	0	1	1 (Note 3)
Exceeded Time Limits	Byte Program in Embedded Program Algorithm		$\overline{D7}$	Toggle	1	0	1
	Program/Erase in Embedded Erase Algorithm		0	Toggle	1	1	N/A
	Erase Suspended Mode	Erase Suspend Program (Non-Erase Suspended Sector)	$\overline{D7}$	Toggle	1	1	N/A

Notes:

1. Performing successive read operations from the erase-suspended sector will cause D2 to toggle.
2. Performing successive read operations from any address will cause D6 to toggle.
3. Reading the byte address being programmed while in the erase-suspend program mode will indicate logic "1" at the D2 bit. However, successive reads from the erase-suspended sector will cause D2 to toggle.

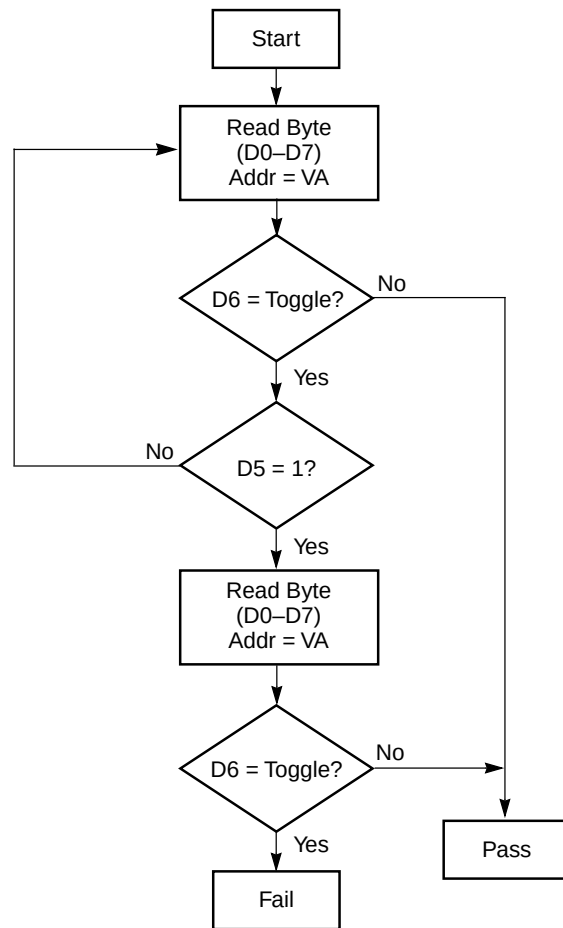


19521D-4

Note:

D7 is rechecked even if D5 = 1 because D7 may change simultaneously with D5.

Figure 3. Data Polling Algorithm

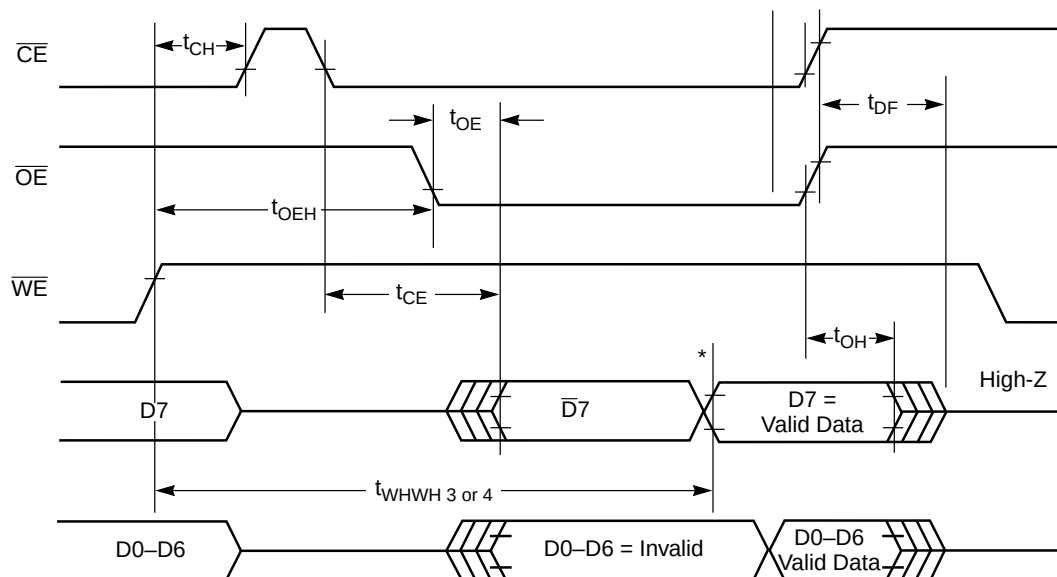


19521D-5

Note:

D6 is rechecked even if D5 = 1 because D6 may stop toggling at the same time as D5 changes to "1".

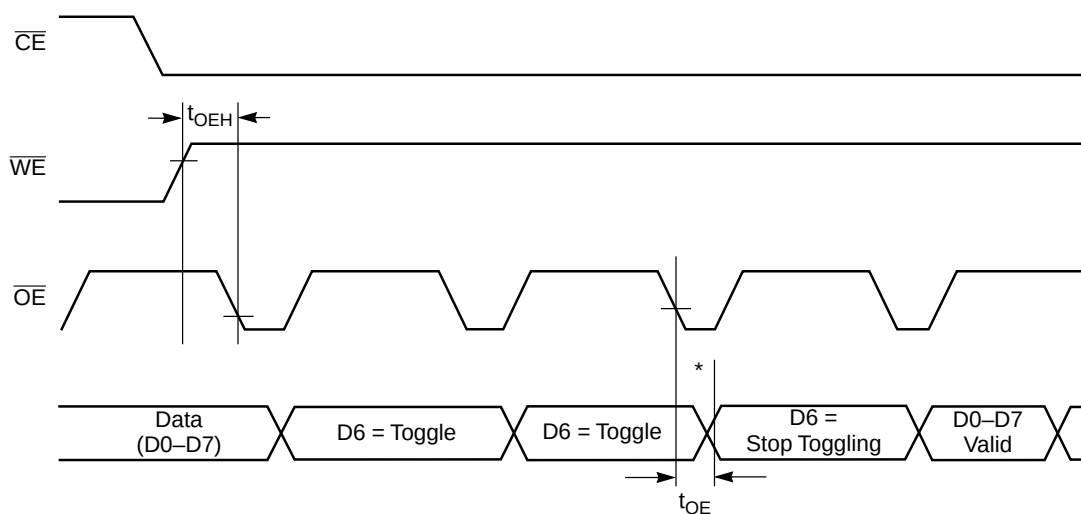
Figure 4. Toggle Bit 1 Algorithm



19521D-6

* D7 = Valid Data (The device has completed the Embedded operation.)

Figure 5. AC Waveforms for Data Polling During Embedded Algorithm Operations

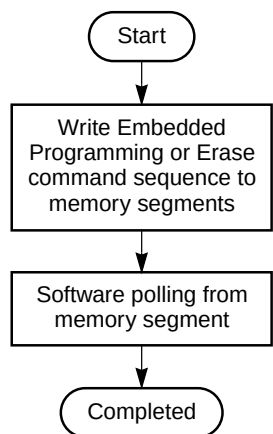


19521D-7

* D6 stops toggling (The device has completed the Embedded operation.)

Figure 6. AC Waveforms for Toggle Bit 1 During Embedded Algorithm Operations

EMBEDDED ALGORITHMS



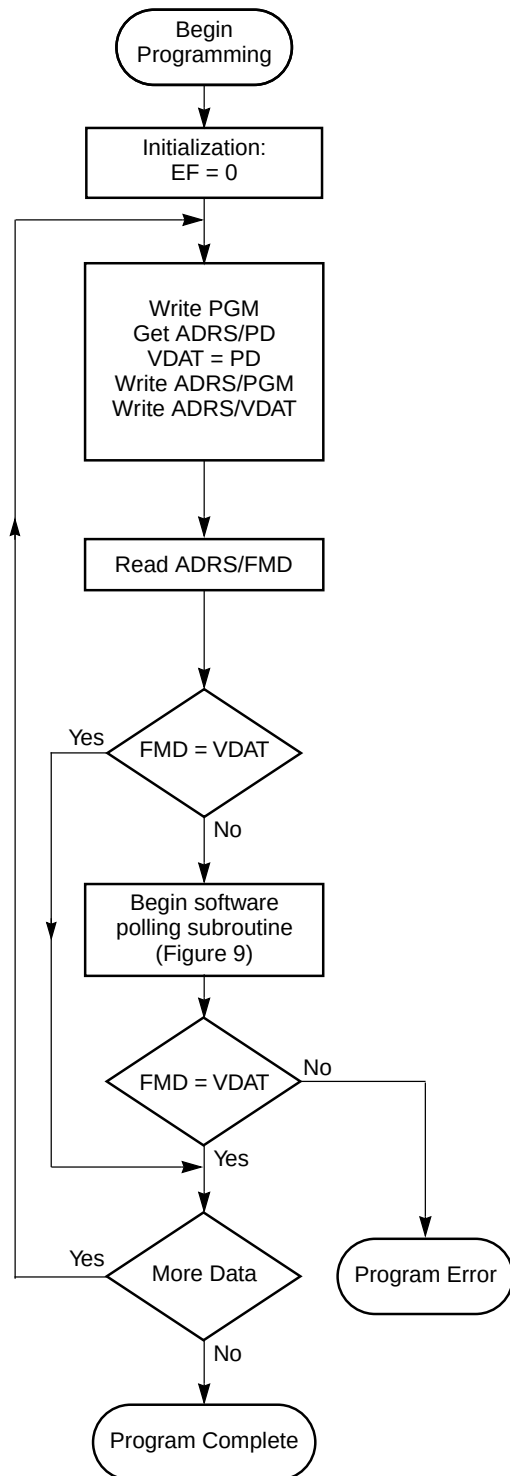
The Embedded Algorithm operations completely automate the programming and erase procedure by internally executing the algorithmic command sequence of original AMD devices. The devices automatically provide Write Operation Status information with standard read operations.

See Table 3 or 4 for Program Command Sequence.

19521D-8

Figure 7. Byte-Wide Programming and Erasure Overview

EMBEDDED ALGORITHMS



Activity

Initialize Programming Variables:

EF = Error Flag

EF = 0 = No Programming error

EF = 1 = Programming error

PGM = Embedded Byte Write Command

Sequence Cycle #1–3 (Table 3 or 4)

ADRS = Appropriate address for memory segment

VDAT = Valid Data

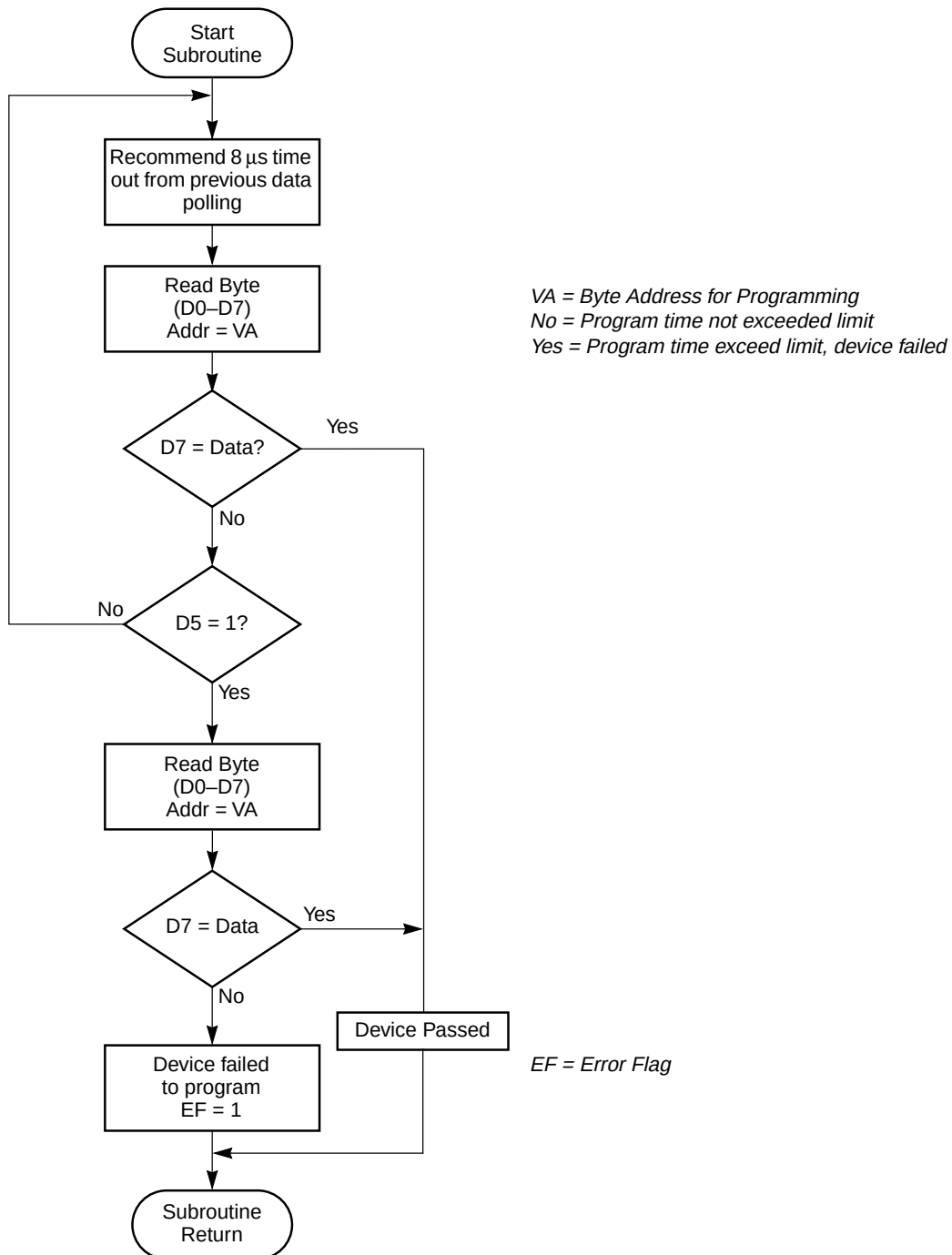
PD = Program Data

FMD = Flash Memory Data

19521D-9

Figure 8. Byte-Wide Programming Flow Chart

EMBEDDED ALGORITHMS



19521D-10

Note:

D7 is checked even if D5 = 1 because D7 may have changed simultaneously with D5 or immediately after D5.

Figure 9. Byte-Wide Software Polling for Programming Subroutine

EMBEDDED ALGORITHMS

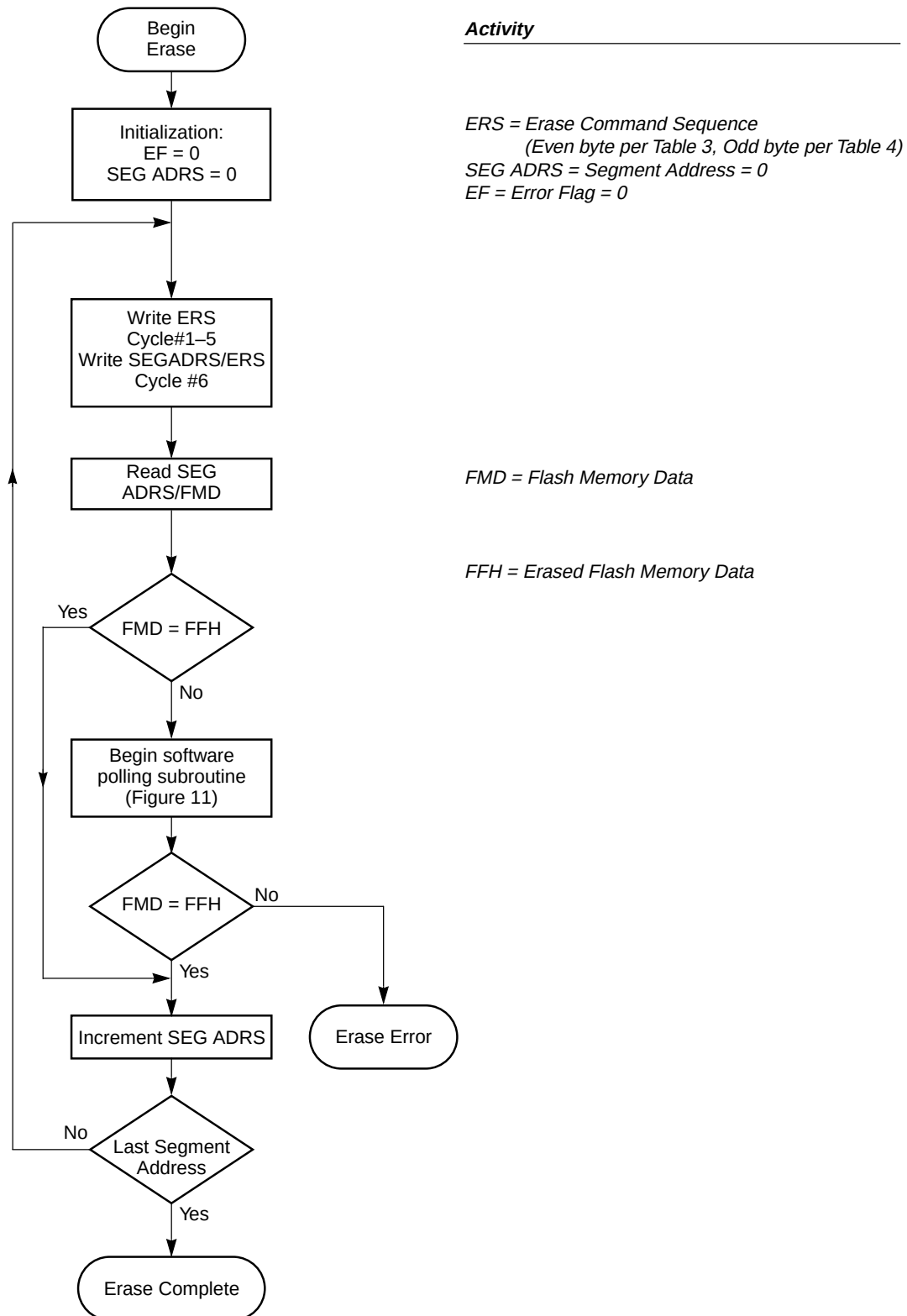
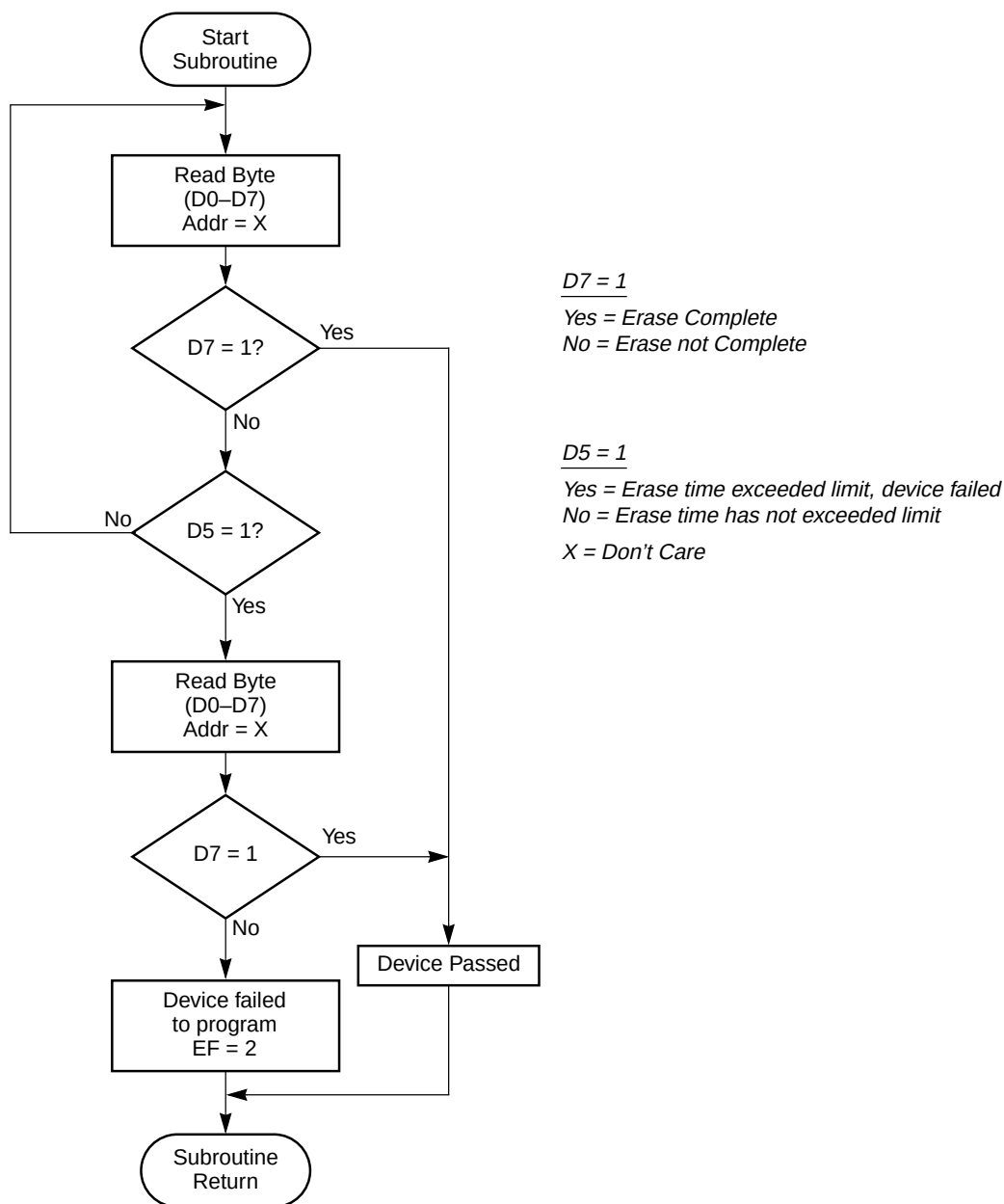


Figure 10. Byte-Wide Erasure Flow Chart

19521D-11

EMBEDDED ALGORITHMS



19521D-12

Figure 11. Byte-Wide Software Polling Erase Subroutine

WORD-WIDE PROGRAMMING AND ERASING

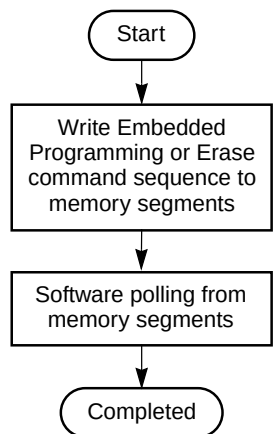
Word-Wide Programming

The word-wide programming sequence will be as usual per Table 5. The Program word command is A0A0H. Each byte is independently programmed. For example, if the high byte of the word indicates the successful completion of programming via one of its write status bits such as D15, software polling should continue to monitor the low byte for write completion and data verification, or vice versa. During the Embedded Programming operations the device executes programming pulses in 8 μ s increments. Status reads provide information on the

progress of the byte programming relative to the last complete write pulse. Status information is automatically updated upon completion of each internal write pulse. Status information does not change within the 8 μ s write pulse width.

Word-Wide Sector Erasing

The word-wide erasing of a memory sector pair is similar to word-wide programming. The erase word command is a 6 bus cycle command sequence per Table 5. Each byte is independently erased and verified. Word-wide erasure reduces total erase time when compared to byte erasure. Each Flash memory device in the card may erase at different rates. Therefore each device (byte) must be verified separately.



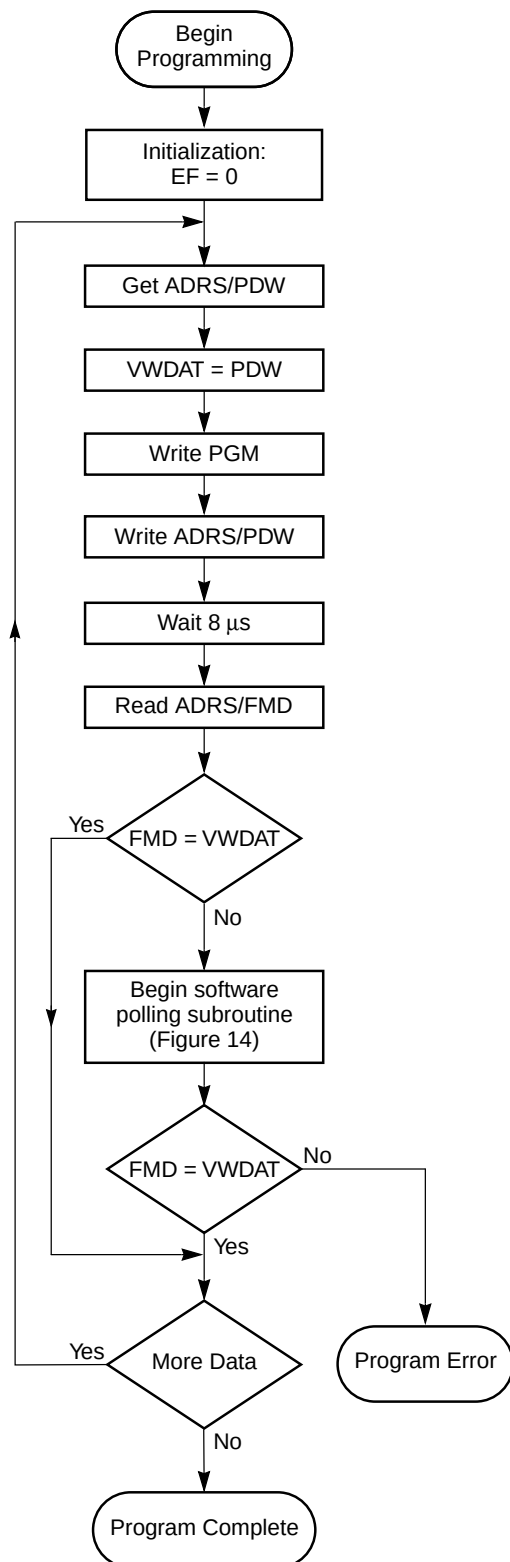
The Embedded Algorithm operations completely automate the parallel programming and erase procedures by internally executing the algorithmic command sequences of AMD's Flashrite and Flasherase algorithms. The devices automatically provide Write Operation Status information with standard read operations.

See Table 5 for Program Command Sequence.

19521D-13

Figure 12. Embedded Algorithm Word-Wide Programming and Erasure Overview

EMBEDDED ALGORITHMS



Activity

Initialize Programming Variables:

*PGM = Embedded Word Write Command
Sequence Cycle #1–3 (Table 5)*

EF = Error Flag

*ADRS = Appropriate address for Memory Segment
(Cycle #4)*

PDW = Program Data Word

VWDAT = Valid Word Data

EF = Error Flag

EF = 0 = No failure

EF = 1 = Low byte program error

EF = 2 = High byte program error

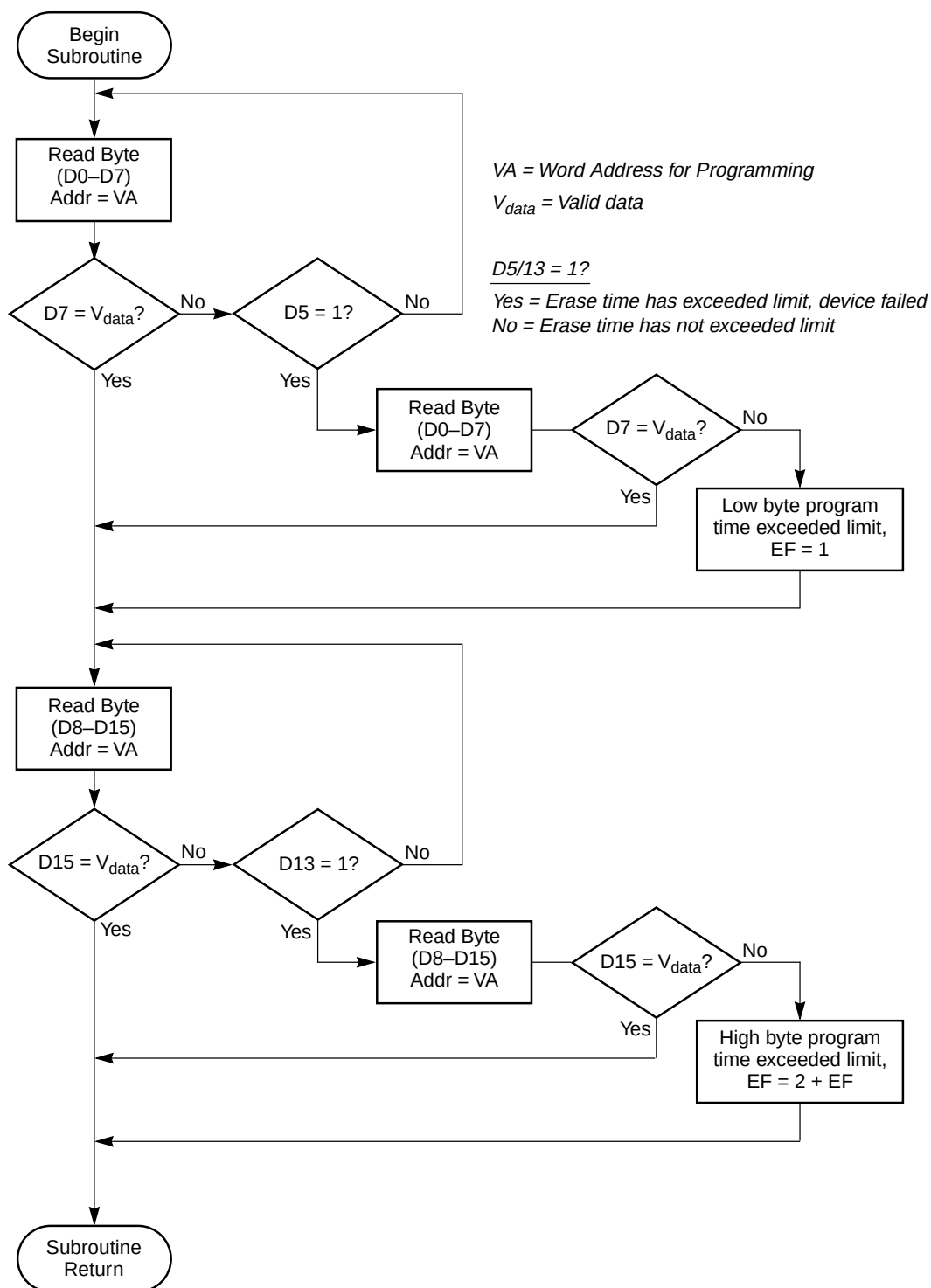
EF = 3 = Word-wide program error

FMD = Flash Memory Data

Figure 13. Word-Wide Programming Flow Chart

19521D-14

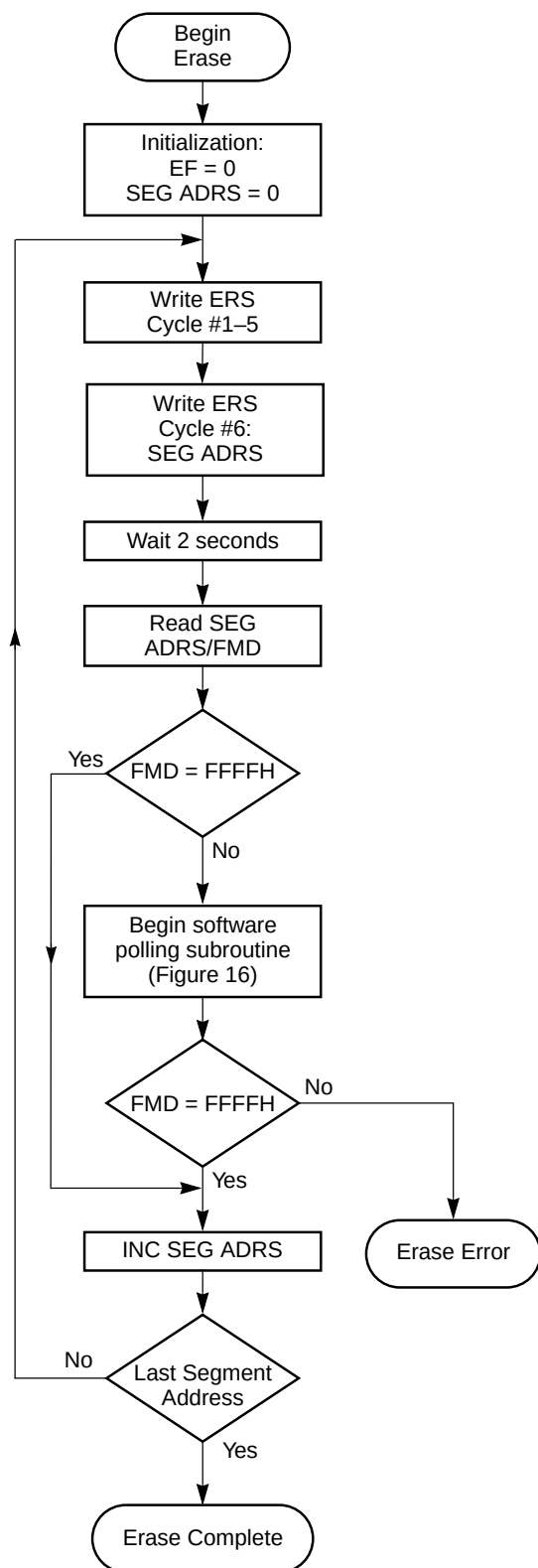
EMBEDDED ALGORITHMS



19521D-15

Figure 14. Word-Wide Software Polling Program Subroutine

EMBEDDED ALGORITHMS



Activity

ERS = Segment Erase Command Sequence (Table 5)

SEG ADRS = Segment Address

EF = Error Flag

EF = 0 = No failure

EF = 1 = Low byte erase error

EF = 2 = High byte erase error

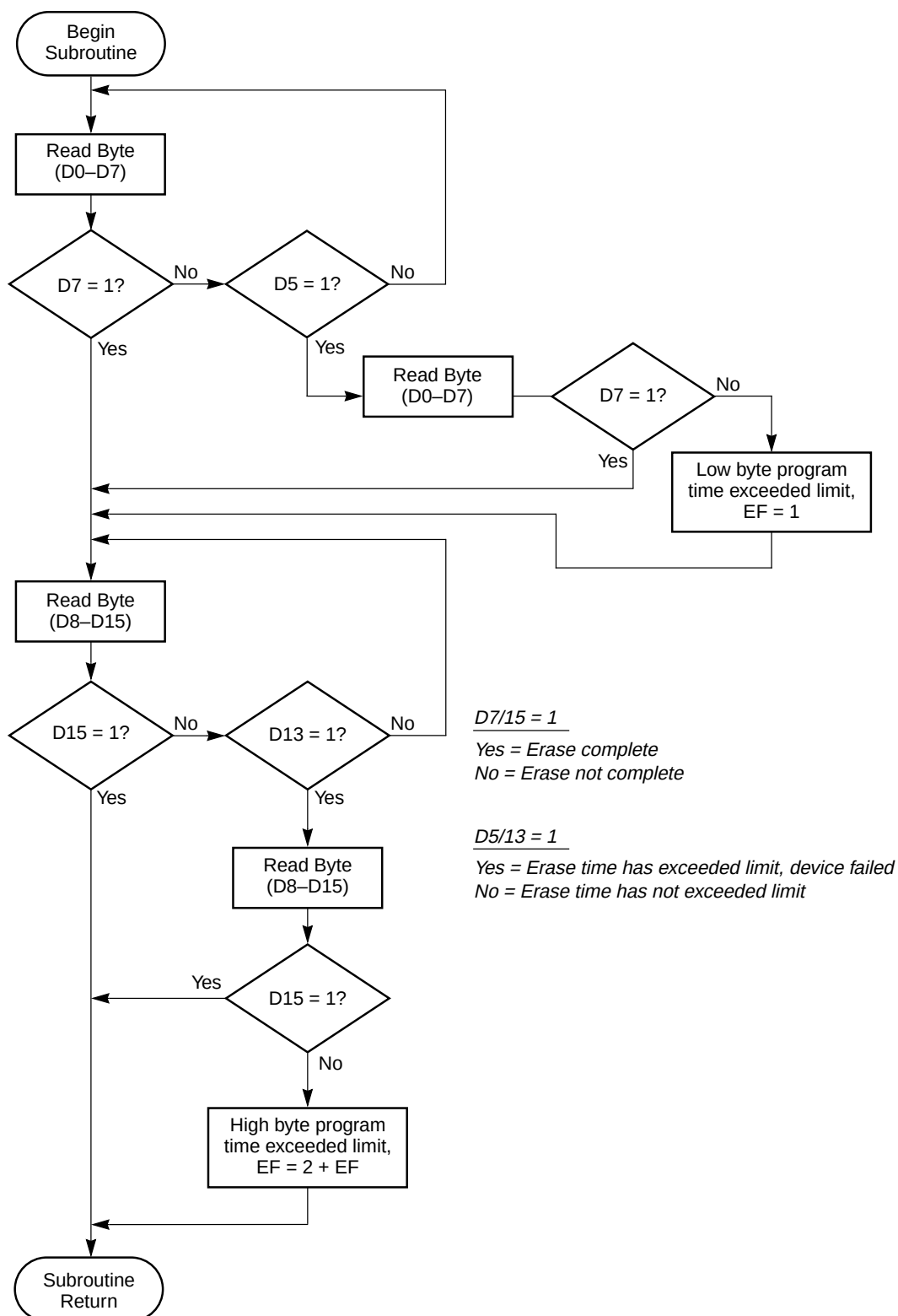
EF = 3 = Word-wide erase error

FMD = Flash Memory Data

Figure 15. Word-Wide Erasure Flow Chart

19521D-16

EMBEDDED ALGORITHMS



19521D-17

Figure 16. Word-Wide Software Polling Erase Subroutine

ABSOLUTE MAXIMUM RATINGS

Storage Temperature -30°C to $+70^{\circ}\text{C}$
 Ambient Temperature
 with Power Applied. 0°C to $+70^{\circ}\text{C}$
 Voltage at All Pins (Note 1) -0.5 V to $+7.0\text{ V}$
 V_{CC} (Note 1). -0.5 V to $+6.0\text{ V}$
 Output Short Circuit Current (Note 2) 40 mA

Notes:

1. Minimum DC voltage on input or I/O pins is -0.5 V . During voltage transitions, inputs may overshoot V_{SS} to -2.0 V for periods of up to 20 ns . Maximum DC voltage on output and I/O pins is $V_{\text{CC}} + 0.5\text{ V}$. During voltage transitions, outputs may overshoot to $V_{\text{CC}} + 2.0\text{ V}$ for periods up to 20 ns .
2. No more than one output shorted at a time. Durations of the short circuit should not be greater than one second. Conditions equal $V_{\text{OUT}} = 0.5\text{ V}$ or 5.0 V , $V_{\text{CC}} = V_{\text{CC max}}$. These values are chosen to avoid test problems caused by tester ground degradation. This parameter is sampled and not 100% tested, but guaranteed by characterization.

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure of the device to absolute maximum rating conditions for extended periods may affect device reliability.

OPERATING RANGES

Commercial (C) Devices

Case Temperature (T_{C}) 0°C to $+70^{\circ}\text{C}$
 V_{CC} Supply Voltages $+4.75\text{ V}$ to 5.25 V
Operating ranges define those limits between which the functionality of the device is guaranteed.

DC CHARACTERISTICS

Byte-Wide Operation

Parameter Symbol	Parameter Description	Test Description	Min	Max	Unit
I_{LI}	Input Leakage Current	$V_{CC} = V_{CC} \text{ Max}, V_{IN} = V_{CC} \text{ or } V_{SS}$ For all cards: $\overline{CE}, \overline{REG}, \overline{WE}, \overline{RESET}$	4 MB	+ 20	μA
			8 MB	+ 20	
			20 MB	+ 20	
			32 MB	+ 20	
I_{LO}	Output Leakage Current	$V_{CC} = V_{CC} \text{ Max},$ $V_{OUT} = V_{CC} \text{ or } V_{SS}$	4 MB	± 20	μA
			8 MB	± 20	
			20 MB	± 20	
			32 MB	± 20	
I_{CCS}	V_{CC} Standby Current (see note)	$V_{CC} = V_{CC} \text{ Max}$ $\overline{CE} = V_{CC} \pm 0.2 \text{ V}$ $V_{IN} = V_{CC} \text{ or } GND$	4 MB	1.7	mA
			8 MB	1.7	
			20 MB	1.7	
			32 MB	1.7	
I_{CC1}	V_{CC} Active Read Current (see note)	$V_{CC} = V_{CC} \text{ Max}, \overline{CE} = V_{IL},$ $\overline{OE} = V_{IH}, I_{OUT} = 0 \text{ mA}, \text{ at } 3.3 \text{ MHz}$		45	mA
I_{CC2}	V_{CC} Write/Erase Current (see note)	$\overline{CE} = V_{IL}$ Programming in Progress		65	mA
V_{IL}	Input Low Voltage		-0.5	0.8	V
V_{IH}	Input High Voltage		$0.7V_{CC}$	$V_{CC} + 0.3$	V
V_{OL}	Output Low Voltage	$I_{OL} = 3.2 \text{ mA}, V_{CC} = V_{CC} \text{ Min}$		0.40	V
V_{OH}	Output High Voltage	$I_{OH} = 2.0 \text{ mA}, V_{CC} = V_{CC} \text{ Min}$	3.8	V_{CC}	V
V_{LKO}	Low V_{CC} Lock-Out Voltage		3.2	4.2	V

Note: One Flash device active, all the others in standby.

Word-Wide Operation

Parameter Symbol	Parameter Description	Test Description	Min	Max	Unit
I_{LI}	Input Leakage Current	$V_{CC} = V_{CC} \text{ Max}, V_{IN} = V_{CC} \text{ or } V_{SS}$ For all cards: $\overline{CE}, \overline{REG}, \overline{WE}, \overline{RESET}$	4 MB	+20	μA
			8 MB	+20	
			20 MB	+20	
			32 MB	+20	
I_{LO}	Output Leakage Current	$V_{CC} = V_{CC} \text{ Max},$ $V_{OUT} = V_{CC} \text{ or } V_{SS}$	4 MB	± 20	μA
			8 MB	± 20	
			20 MB	± 20	
			32 MB	± 20	
I_{CCS}	V_{CC} Standby Current (see note)	$V_{CC} = V_{CC} \text{ Max}$ $\overline{CE} = V_{CC} \pm 0.2 \text{ V}$ $V_{IN} = V_{CC} \text{ or } GND$	4 MB	1.7	mA
			8 MB	1.7	
			20 MB	1.7	
			32 MB	1.7	
I_{CC1}	V_{CC} Active Read Current (see note)	$V_{CC} = V_{CC} \text{ Max}, \overline{CE} = V_{IL},$ $\overline{OE} = V_{IH}, I_{OUT} = 0 \text{ mA}, \text{ at } 3.3 \text{ MHz}$		45	mA
I_{CC2}	V_{CC} Programming Current (see note)	$\overline{CE} = V_{IL}$ Programming in Progress		65	mA
V_{IL}	Input Low Voltage		-0.3	0.8	V
V_{IH}	Input High Voltage		$0.7V_{CC}$	$V_{CC} + 0.3$	V
V_{OL}	Output Low Voltage	$I_{OL} = 3.2 \text{ mA}, V_{CC} = V_{CC} \text{ Min}$		0.40	V
V_{OH}	Output High Voltage	$I_{OH} = 2.0 \text{ mA}, V_{CC} = V_{CC} \text{ Min}$	3.8	V_{CC}	V
V_{LKO}	Low V_{CC} Lock-Out Voltage		3.2	4.2	V

Note: Two Flash devices active, all the others in standby.

PIN CAPACITANCE

Parameter Symbol	Parameter Description	Test Conditions	Max	Unit
C_{IN1}	All except A1–A9	$V_{IN} = 0\text{ V}$	2	pF
C_{OUT}	Output Capacitance	$V_{OUT} = 0\text{ V}$	2	pF
C_{IN2}	A1–A9	$V_{IN} = 0\text{ V}$	2	pF
$C_{I/O}$	I/O Capacitance D0–D15	$V_{I/O} = 0\text{ V}$	2	pF

Notes:

1. Sampled, not 100% tested.
2. Test conditions $T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$.

SWITCHING AC CHARACTERISTICS

Read Only Operation (Note 1)

			Card Speed		
Parameter Symbol		Parameter Description	-150 ns		Unit
JEDEC	Standard		Min	Max	
t _{AVAV}	t _{RC}	Read Cycle Time	150		ns
t _{ELQV}	t _{CE}	Chip Enable Access Time		150	ns
t _{AVQV}	t _{ACC}	Address Access Time		150	ns
t _{GLQV}	t _{OE}	Output Enable Access Time		75	ns
t _{ELQX}	t _{LZ}	Chip Enable to Output in Low-Z	5		ns
t _{EHQZ}	t _{DF}	Chip Disable to Output in High-Z		75	ns
t _{GLQX}	t _{OLZ}	Output Enable to Output in Low-Z	5		ns
t _{GHQZ}	t _{DF}	Output Disable to Output in High-Z		75	ns
t _{AXQX}	t _{OH}	Output Hold from First of Address, $\overline{CE}$, or $\overline{OE}$ Change	5		ns

Note:

1. Input Rise and Fall Times (10% to 90%): $\leq 10\text{ ns}$, Input Pulse levels: V_{OL} and V_{OH} , Timing Measurement Reference Level: Inputs: V_{IL} and V_{IH}
Outputs: V_{IL} and V_{IH}

AC CHARACTERISTICS

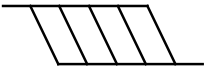
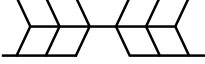
Write/Erase/Program Operations

			Card Speed			
Parameter Symbol		Parameter Description	-150 ns			Unit
JEDEC	Standard		Min	Typ	Max	
t _{AVAV}	t _{WC}	Write Cycle Time	150			ns
t _{AVWL}	t _{AS}	Address Setup Time	20			ns
t _{WLAX}	t _{AH}	Address Hold Time	20			ns
t _{DVWH}	t _{DS}	Data Setup Time	50			ns
t _{WHDX}	t _{DH}	Data Hold Time	20			ns
t _{OEHL}		Output Enable Hold Time for Embedded Algorithm	0			ns
t _{WHGL}	t _{WR}	Write Recovery Time before Read	6			μs
t _{GHWL}		Read Recovery Time before Write	20			μs
t _{ELWL}	t _{CS}	$\overline{CE}$ Setup Time	0			ns
t _{WHEH}	t _{CH}	$\overline{CE}$ Hold Time	20			ns
t _{WLWH}	t _{WP}	Write Pulse Width	45			ns
t _{WHWL}	t _{WPH}	Write Pulse Width HIGH	50			ns
t _{WHWH3}		Embedded Programming Operation (Notes 1, 2, 3)		8		μs
					2	ms
t _{WHWH4}		Embedded Erase Operation for each 64K Byte Memory Sector (Notes 1, 2)			15	s
t _{VCS}		V _{CC} Setup Time to $\overline{CE}$ LOW		50		μs

Notes:

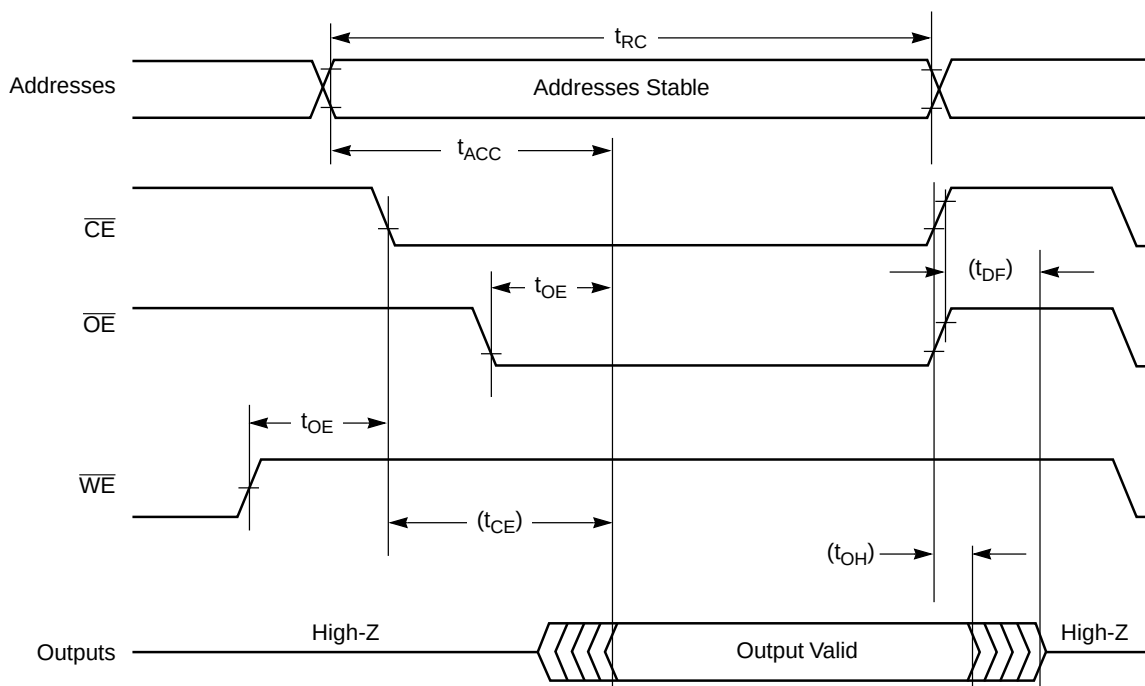
1. Rise/Fall ≤ 10 ns.
2. Maximum specification not needed due to the devices internal stop timer that will stop any erase or write operation that exceed the device specification.
3. Embedded Program Operation of 8 μ s consist of 6 μ s program pulse and 2 μ s write recovery before read. This is the minimum time for one pass through the programming algorithm. D5 = "1" only after a byte takes longer than 2 ms to Write.

KEY TO SWITCHING WAVEFORMS

WAVEFORM	INPUTS	OUTPUTS
	Must be Steady	Will be Steady
	May Change from H to L	Will be Changing from H to L
	May Change from L to H	Will be Changing from L to H
	Don't Care, Any Change Permitted	Changing, State Unknown
	Does Not Apply	Center Line is High-Impedance "Off" State

KS000010

SWITCHING WAVEFORMS

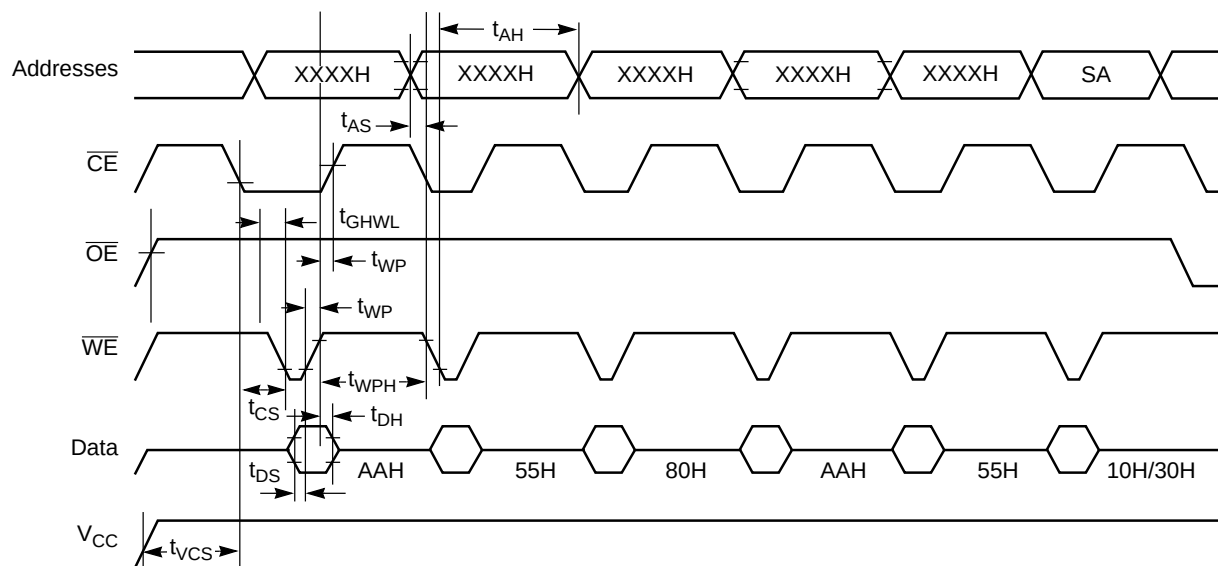


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Note: $\overline{CE}$ refers to $\overline{CE}1$ and $\overline{CE}2$.

Figure 17. AC Waveforms for Read Operations

SWITCHING WAVEFORMS



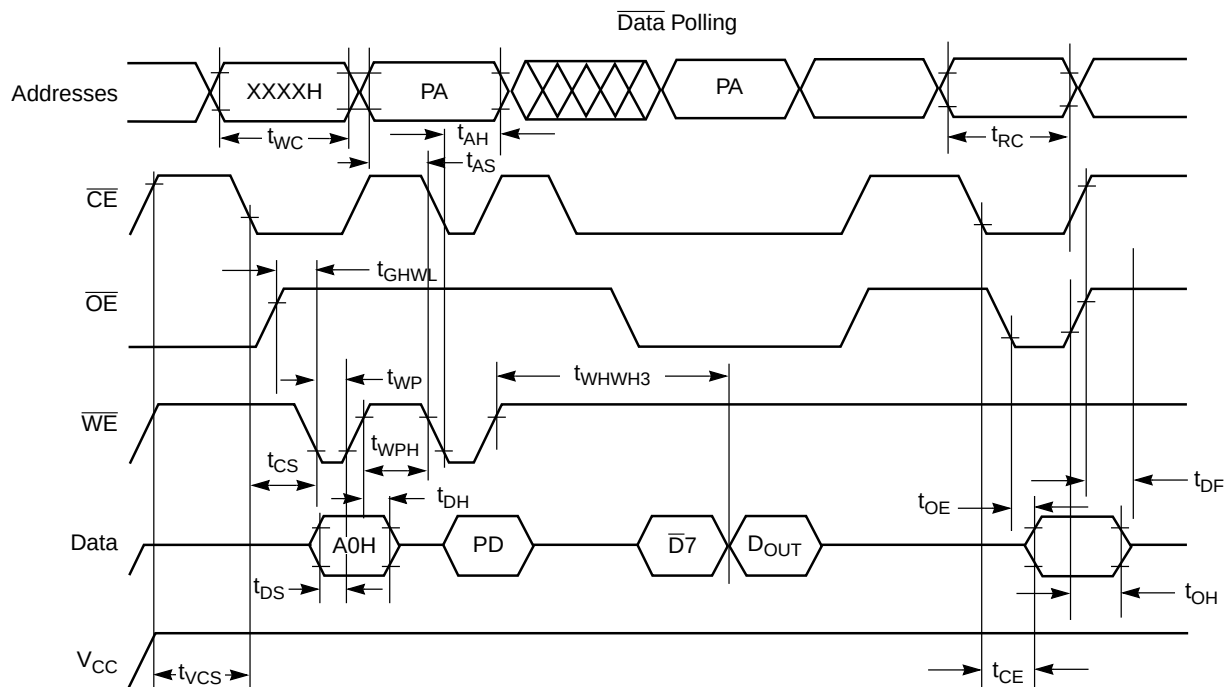
19521D-19

Note:

SA is the sector address for Sector Erase per Table 6.

Figure 18. AC Waveforms Segment/Sector Byte Erase Operations

SWITCHING WAVEFORMS



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Notes:

1. Figure indicates last two bus cycles of four bus cycle sequence.
2. PA is address of the memory location to be programmed.
3. PD is data to be programmed at byte address.
4. $\overline{D7}$ is the output of the complement of the data written to the device.
5. D_{OUT} is the output of the data written to the device.

Figure 19. AC Waveforms for Byte Write Operations

AC CHARACTERISTICS—ALTERNATE $\overline{\text{CE}}$ CONTROLLED WRITES

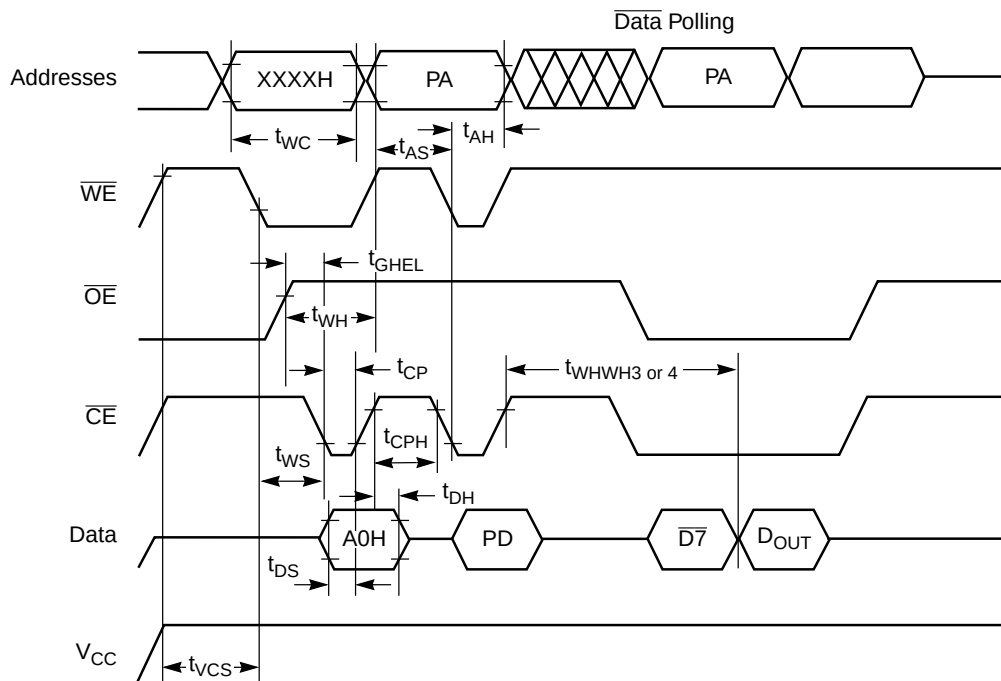
Write/Erase/Program Operations

			Card Speed		
Parameter Symbol		Parameter Description	-150 ns		Unit
JEDEC	Standard		Min	Max	
t _{AVAV}	t _{WC}	Write Cycle Time	150		ns
t _{AVEL}	t _{AS}	Address Setup Time	20		ns
t _{ELAX}	t _{AH}	Address Hold Time	55		ns
t _{DVEH}	t _{DS}	Data Setup Time	50		ns
t _{EHDH}	t _{DH}	Data Hold Time	20		ns
t _{GLDV}	t _{OE}	Output Enable Hold Time for Embedded Algorithm	20		ns
t _{GHEL}		Read Recovery Time before Write	20		ns
t _{WLEL}	t _{WS}	$\overline{\text{WE}}$ Setup Time before $\overline{\text{CE}}$	0		ns
t _{EHWL}	t _{WH}	$\overline{\text{WE}}$ Hold Time	0		ns
t _{ELEH}	t _{CP}	$\overline{\text{CE}}$ Pulse Width	80		ns
t _{EHEL}	t _{CPH}	$\overline{\text{CE}}$ Pulse Width HIGH (Note 3)	50		ns
t _{EHEH3}		Embedded Programming Operation (Notes 3, 4)	8		μs
				2	ms
t _{EHEH4}		Embedded Erase Operation for each 64K byte Memory Sector (Notes 1, 2)			s
t _{VCS}		V _{CC} Setup Time to Write Enable LOW	50		ms

Notes:

1. Rise/Fall ≤ 10 ns.
2. Maximum specification not needed due to the internal stop timer that will stop any erase or write operation that exceed the device specification.
3. Card Enable Controlled Programming:
Flash Programming is controlled by the valid combination of the Card Enable ($\overline{\text{CE1}}$, $\overline{\text{CE2}}$) and Write Enable ($\overline{\text{WE}}$) signals. For systems that use the Card Enable signal(s) to define the write pulse width, all Setup, Hold, and inactive Write Enable timing should be measured relative to the Card Enable signal(s).
4. Embedded Program Operation of $8\mu\text{s}$ consist of $6\mu\text{s}$ program pulse and $2\mu\text{s}$ write recovery before read. This is the minimum time for one pass through the programming algorithm. D5 = "1" only after a byte takes longer than 2 ms to Write.

SWITCHING WAVEFORMS

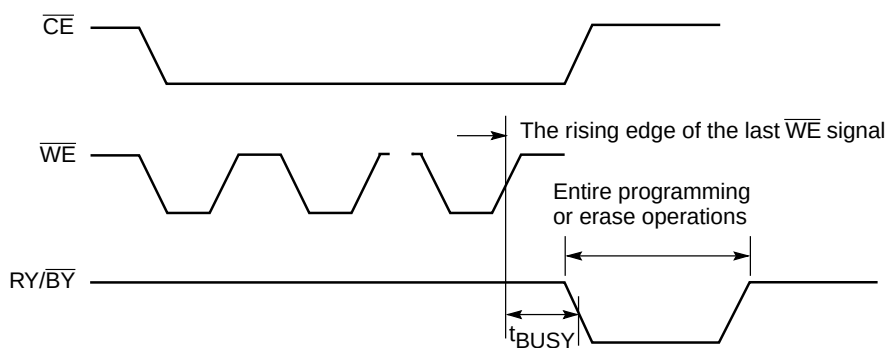


19521D-21

Notes:

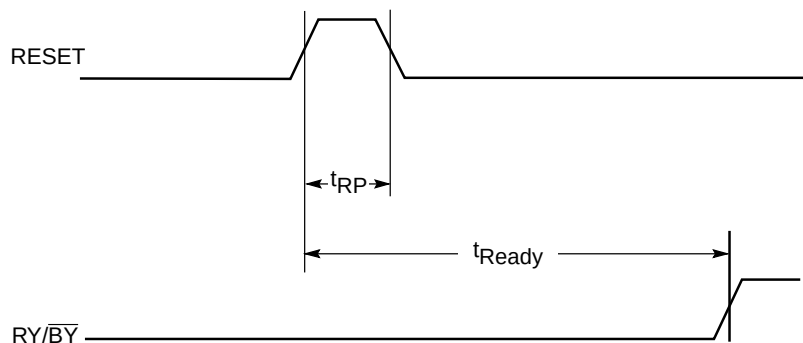
1. Figure indicates last two bus cycles of four bus cycle sequence.
2. PA is address of the memory location to be programmed.
3. PD is data to be programmed at byte address.
4. $\overline{D7}$ is the output of the complement of the data written to the device.
5. D_{OUT} is the output of the data written to the device.

Figure 20. Alternate $\overline{CE}$ Controlled Byte Write Operation Timings



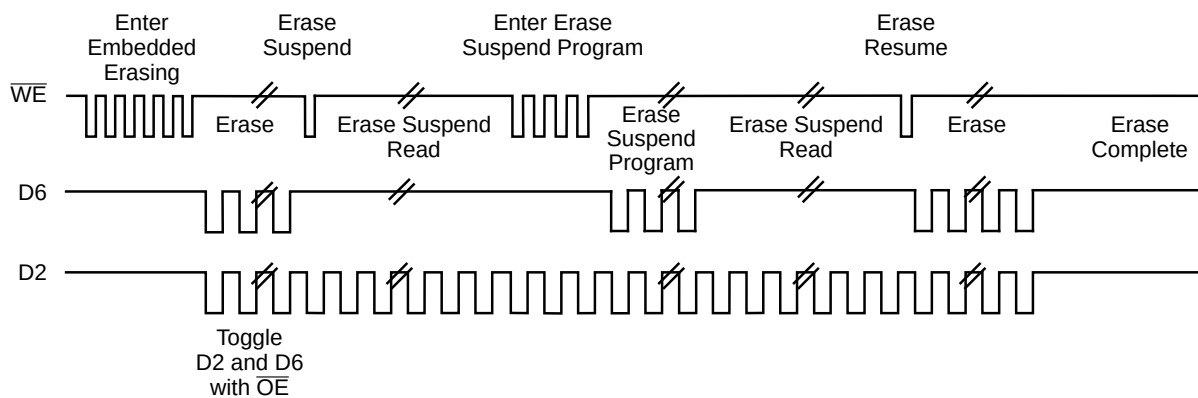
19521D-22

Figure 21. $\overline{RY/BY}$ Timing Diagram During Program/Erase Operations



19521D-23

Figure 22. RESET Timing Diagram



19521D-24

Note:

D2 is read from the erase suspended sector.

Figure 23. D2 vs. D6

CARD INFORMATION STRUCTURE

The D-Series card contains a separate EEPROM memory for the Card Information Structure (CIS).

This allows all of the Flash memory to be used for the common memory space. Part of the common memory space could also be used to store the CIS.

The EEPROM used in the D-Series card is designed to operate from a 5 V single power supply. Table 9 shows the CIS information stored in the AMD Flash memory card.

SYSTEM DESIGN AND INTERFACE INFORMATION

Power Up and Power Down Protection

AMD's Flash memory devices are designed to protect against accidental programming or erasure caused by spurious system signals that might exist during power

transitions. The AMD PC Card will power-up into a READ mode when V_{CC} is greater than V_{LKO} of 3.2 V. Erasing of memory sectors or memory segments can be accomplished only by writing the proper Erase command to the card along with the proper Chip Enable, Output Enable and Write Enable control signals. Hot insertion of PC cards is not permitted by the PCMCIA standard.

Note: Hot insertion is defined as the socket condition where the card is inserted or removed with any or all of the following conditions present: $V_{CC} = V_{CCH}$, $V_{PP} = V_{PPH}$, address and/or data lines are active.

System Power Supply Decoupling

The AMD Flash memory card has a 0.1 μ F decoupling capacitor between the V_{CC} and the GND pins. It is recommended the system side also have a 4.7 μ F capacitor between the V_{CC} and the GND pins.

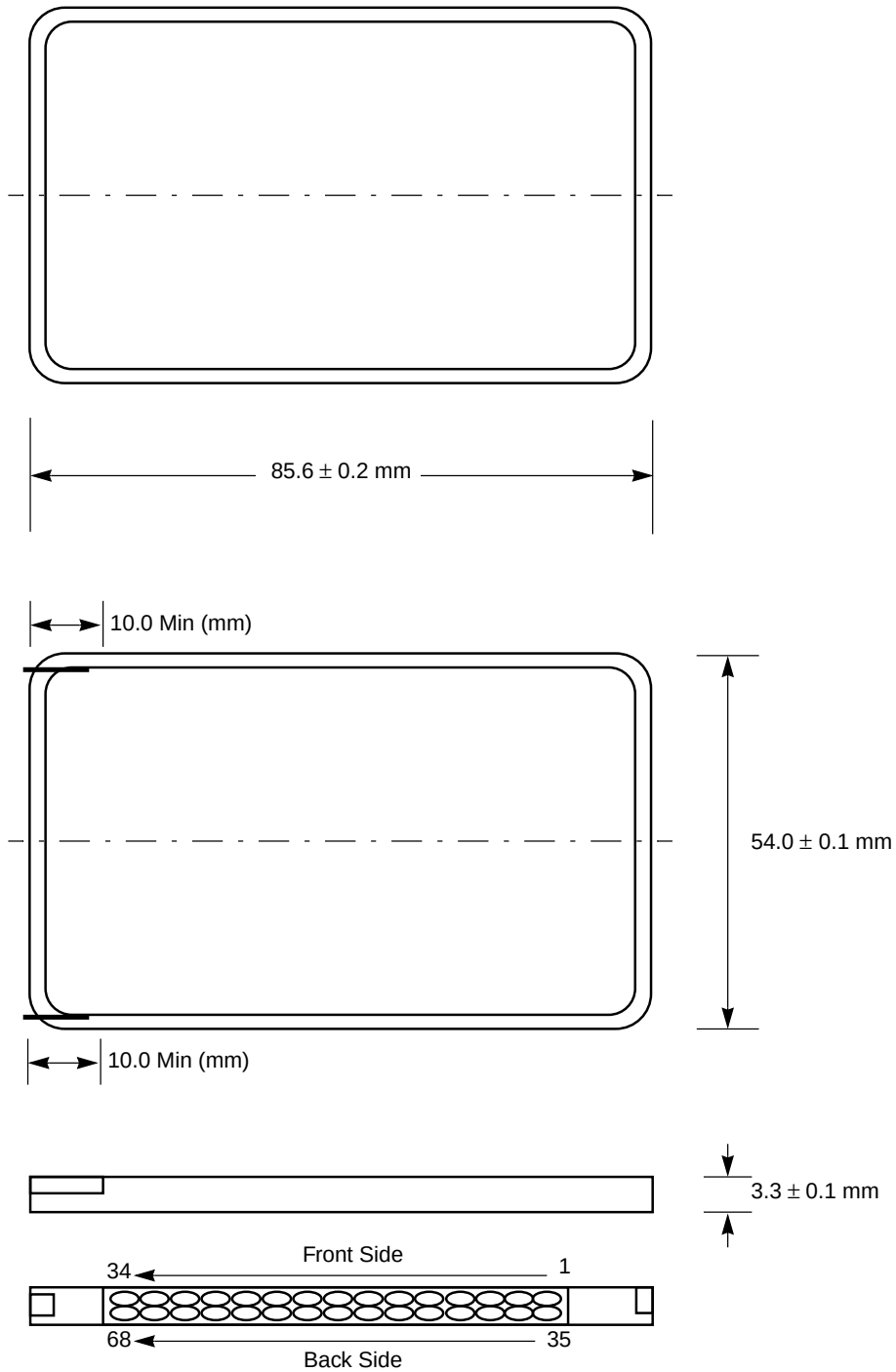
Table 9. AMD's CIS for D-Series Cards

Tuple Address	2 Mbyte Card Tuple Value	Tuples and Remarks
00h	01h	CISTPL_DEVICE [Common Memory]
02h	03h	TPL_LINK
04h	53h	Flash Device, Card Speed: 53h = 150 ns (52h for 200 ns)
06h	0Eh	Card Size: 0Eh = 4 MB, 1Eh = 8 MB, 4Eh = 20 MB, 7Eh = 32 MB (Note 1)
08h	FFh	End of Tuple
0Ah	18h	CISTPL_JEDEC [Common Memory]
0Ch	03h	TPL_LINK
0Eh	01h	AMD MFG ID Code
10h	3Dh	Device ID Code: 3Dh = 16 Mbit Device, Am29F016C
12h	FFh	End of Tuple
14h	1Eh	CISTPL_DEVICEGEO
16h	07h	TPL_LINK no FFh terminator
18h	02h	DGTPL_BUS: Bus Width
1Ah	11h	DGTPL_EBS: 11h = 64K Byte Erase Block size
1Ch	01h	DGTPL_RBS: Read Byte Size
1Eh	01h	DGTPL_WBS: Write Byte Size
20h	01h	DGTPL_PART: Number of partition
22h	01h	FL DEVICE INTERLEAVE: No interleave
24h	FFh	End of Tuple
26h	15h	CISTPL_VERS1
28h	03h	TPL_LINK
2Ah	04h	Major version number 1
2Ch	01h	Minor version for PCMCIA Std. 2.0
2Eh	FFh	End of Tuple
30h	17h	CISTPL_DEVICE_A [Attribute Memory]
32h	04h	TPL_LINK
34h	47h	EEPROM with extended speed
36h	3Ah	Extended speed = 250 ns
38h	00h	Device Size = 1 unit of 512 byte
3Ah	FFh	End of Tuple
3Ch	80h	Vendor-Specific Tuple
3Eh	05h	TPL_LINK
40h	41h	"A"
42h	4Dh	"M"
44h	44h	"D"
46h	00h	END TEXT
48h	FFh	End of Tuple
4Ah	81h	Vendor Specific Tuples: 81h
:	xxh	ASCII Characters
:	xxh	:
6Ah	xxh	ASCII Characters
6Ch	FFh	CISTPL_END

Note: See PCMCIA specifications for parsing and card size values.

PHYSICAL DIMENSIONS

Type 1 PC Card



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REVISION SUMMARY FOR AMC0XXDFLKA**Global**

Added 32 MByte Card availability.

Deleted 200 ns speed option.

Block Diagram

Updated schematic to show correct number of flash devices for 32 MByte card.

Pin Description

A24-A0 should all be driven.

Memory Card Operations

Simplified description of erase operations.

Table 1, Common Memory Bus Operations

Simplified bus operation table.

Table 2, Attribute Memory Bus Operations

Simplified attribute memory bus operation table.

Absolute Maximum Ratings & Operating Ranges

Increased operating & maximum temperature range to +70°C

DC Characteristics

Revised V_{IH} to 0.7 V_{CC}

AC Characteristics

Removed 200 ns timing characteristics

Table 9, AMD CIS for D-Series Cards

Corrected CIS values for card density