

# FM1808

## 256Kb Byte-wide FRAM Memory



### Features

#### 256Kbit Ferroelectric Nonvolatile RAM

- Organized as 32,768 x 8 bits
- High Endurance 10 Billion ( $10^{10}$ ) Read/Writes
- 10 year Data Retention
- NoDelay™ Writes
- Advanced High-Reliability Ferroelectric Process

#### Superior to BBSRAM Modules

- No Battery Concerns
- Monolithic Reliability
- True Surface Mount Solution, No Rework Steps
- Superior for Moisture, Shock, and Vibration
- Resistant to Negative Voltage Undershoots

#### SRAM & EEPROM Compatible

- JEDEC 32Kx8 SRAM & EEPROM pinout
- 70 ns Access Time
- 130 ns Cycle Time

#### Low Power Operation

- 25 mA Active Current
- 20  $\mu$ A Standby Current

#### Industry Standard Configuration

- Industrial Temperature -40° C to +85° C
- 28-pin SOIC or DIP

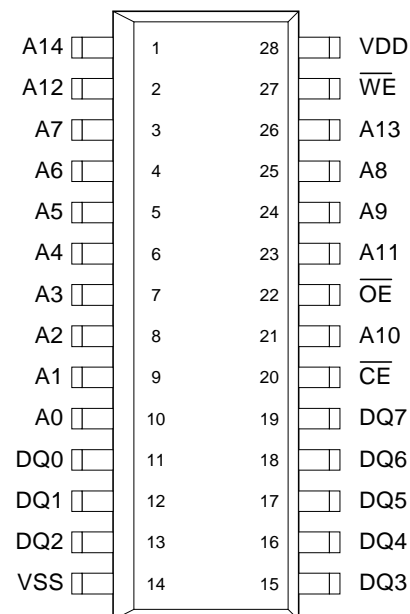
### Description

The FM1808 is a 256-kilobit nonvolatile memory employing an advanced ferroelectric process. A ferroelectric random access memory or FRAM is nonvolatile but operates in other respects as a RAM. It provides data retention for 10 years while eliminating the reliability concerns, functional disadvantages and system design complexities of battery-backed SRAM (BBSRAM). Fast write timing and high write endurance make FRAM superior to other types of nonvolatile memory.

In-system operation of the FM1808 is very similar to other RAM devices. Minimum read- and write-cycle times are equal. The FRAM memory, however, is nonvolatile due to its unique ferroelectric memory process. Unlike BBSRAM, the FM1808 is a truly monolithic nonvolatile memory. It provides the same functional benefits of a fast write without the disadvantages associated with modules and batteries or hybrid memory solutions.

These capabilities make the FM1808 ideal for nonvolatile memory applications requiring frequent or rapid writes in a byte-wide environment. The availability of a true surface-mount package improves the manufacturability of new designs, while the DIP package facilitates simple design retrofits. Device specifications are guaranteed over an industrial temperature range of -40°C to +85°C.

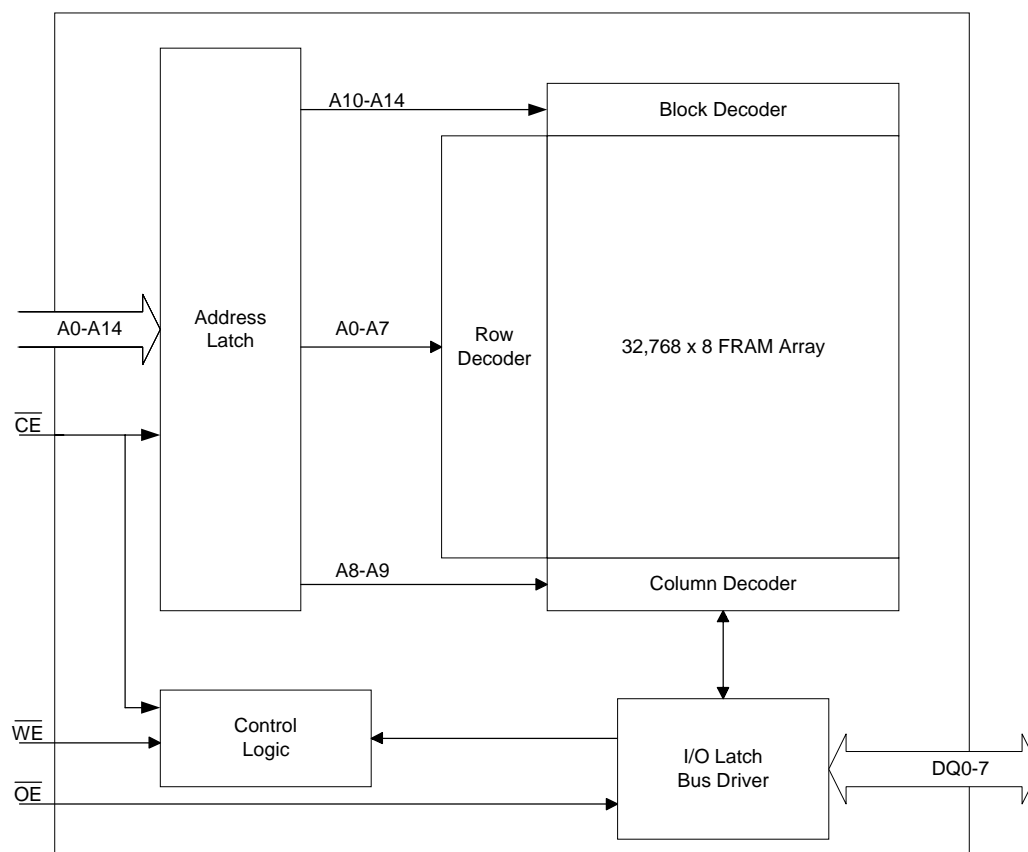
### Pin Configuration



### Ordering Information

FM1808-70-P	70 ns access, 28-pin plastic DIP
FM1808-70-S	70 ns access, 28-pin SOIC
FM1808-120-P	120 ns access, 28-pin plastic DIP
FM1808-120-S	120 ns access, 28-pin SOIC

This product conforms to specifications per the terms of the Ramtron standard warranty. Production processing does not necessarily include testing of all parameters.



**Figure 1. Block Diagram**

### Pin Description

Pin Name	Type	Description
A0-A14	Input	Address: The 15 address lines select one of 32,768 bytes in the FRAM array. The address value is latched on the falling edge of /CE.
DQ0-7	I/O	Data: 8-bit bi-directional data bus for accessing the FRAM array.
/CE	Input	Chip Enable: /CE selects the device when low. Asserting /CE low causes the address to be latched internally. Address changes that occur after /CE goes low will be ignored until the next falling edge occurs.
/OE	Input	Output Enable: Asserting /OE low causes the FM1808 to drive the data bus when valid data is available. Deasserting /OE high causes the DQ pins to be tri-stated.
/WE	Input	Write Enable: Asserting /WE low causes the FM1808 to write the contents of the data bus to the address location latched by the falling edge of /CE.
VDD	Supply	Supply Voltage: 5V
VSS	Supply	Ground

### Functional Truth Table

/CE	/WE	Function
H	X	Standby/Precharge
↓	X	Latch Address (and Begin Write if /WE=low)
L	H	Read
L	↓	Write

Note: The /OE pin controls only the DQ output buffers.

## Overview

The FM1808 is a byte-wide FRAM memory. The memory array is logically organized as 32,768 x 8 and is accessed using an industry standard parallel interface. All data written to the part is immediately nonvolatile with no delay. Functional operation of the FRAM memory is the same as SRAM type devices, except the FM1808 requires a falling edge of /CE to start each memory cycle.

## Memory Architecture

Users access 32,768 memory locations each with 8 data bits through a parallel interface. The complete 15-bit address specifies each of the 32,768 bytes uniquely. Internally, the memory array is organized into 32 blocks of 8Kb each. The 5 most-significant address lines decode one of 32 blocks. This block segmentation has no effect on operation, however the user may wish to group data into blocks by its endurance characteristics as explained on page 4.

The cycle time is the same for read and write memory operations. This simplifies memory controller logic and timing circuits. Likewise the access time is the same for read and write memory operations. When /CE is deasserted high, a precharge operation begins, and is required of every memory cycle. Thus unlike SRAM, the access and cycle times are not equal. Writes occur immediately at the end of the access with no delay. Unlike an EEPROM, it is not necessary to poll the device for a ready condition since writes occur at bus speed.

Note that the FM1808 has no special power-down requirements. It will not block user access and it contains no power-management circuits other than a simple internal power-on reset. It is the user's responsibility to ensure that VDD remains within datasheet tolerances to prevent incorrect operation. Also proper voltage level and timing relationships between VDD and /CE must be maintained in power-up and power-down events.

## Memory Operation

The FM1808 is designed to operate in a manner similar to other byte-wide memory products. For users familiar with BBSRAM, the performance is comparable but the byte-wide interface operates in a slightly different manner as described below. For users familiar with EEPROM, the obvious differences result from the higher write performance of FRAM technology including NoDelay writes and much higher write endurance.

## Read Operation

A read operation begins on the falling edge of /CE. At this time, the address bits are latched and a memory cycle is initiated. Once started, a full memory cycle must be completed internally even if /CE goes inactive. Data becomes available on the bus after the access time has been satisfied.

After the address has been latched, the address value may be changed upon satisfying the hold time parameter. Unlike an SRAM, changing address values will have no effect on the memory operation after the address is latched.

The FM1808 will drive the data bus when /OE is asserted low. If /OE is asserted after the memory access time has been satisfied, the data bus will be driven with valid data. If /OE is asserted prior to completion of the memory access, the data bus will not be driven until valid data is available. This feature minimizes supply current in the system by eliminating transients caused by invalid data being driven onto the bus. When /OE is inactive the data bus will remain tri-stated.

## Write Operation

Writes occur in the FM1808 in the same time interval as reads. The FM1808 supports both /CE- and /WE-controlled write cycles. In all cases, the address is latched on the falling edge of /CE.

In a /CE controlled write, the /WE signal is asserted prior to beginning the memory cycle. That is, /WE is low when /CE falls. In this case, the part begins the memory cycle as a write. The FM1808 will not drive the data bus regardless of the state of /OE.

In a /WE controlled write, the memory cycle begins on the falling edge of /CE. The /WE signal falls after the falling edge of /CE. Therefore, the memory cycle begins as a read. The data bus will be driven according to the state of /OE until /WE falls. The timing of both /CE- and /WE-controlled write cycles is shown in the electrical specifications.

Write access to the array begins asynchronously after the memory cycle is initiated. The write access terminates on the rising edge of /WE or /CE, whichever is first. Data set-up time, as shown in the electrical specifications, indicates the interval during which data cannot change prior to the end of the write access.

Unlike other truly nonvolatile memory technologies, there is no write delay with FRAM. Since the read and write access times of the underlying memory are

the same, the user experiences no delay through the bus. The entire memory operation occurs in a single bus cycle. Therefore, any operation including read or write can occur immediately following a write. Data polling, a technique used with EEPROMs to determine if a write is complete, is unnecessary.

### **Precharge Operation**

The precharge operation is an internal condition that prepares the memory for a new access. All memory cycles consist of a memory access and a precharge. The precharge is initiated by deasserting the /CE pin high. It must remain high for at least the minimum precharge time  $t_{PC}$ .

The user determines the beginning of this operation since a precharge will not begin until /CE rises. However, the device has a maximum /CE low time specification that must be satisfied.

### **Endurance**

Internally, a FRAM operates with a read and restore mechanism. Therefore, each read and write cycle involves a change of state. The memory architecture is based on an array of rows and columns. Each read or write access causes an endurance cycle for an entire row. In the FM1808, a row is 32 bits wide. Every 4-byte boundary marks the beginning of a new row. Endurance can be optimized by ensuring frequently accessed data is located in different rows. Regardless, FRAM offers substantially higher write endurance than other nonvolatile memories. The rated endurance limit of  $10^{10}$  cycles will allow 30 accesses per second to the same row for over 10 years.

### **Applications**

As the first truly nonvolatile RAM, the FM1808 fits into many diverse applications. Clearly, its monolithic nature and high performance make it superior to battery-backed SRAM in many applications. This applications guide is intended to facilitate the transition from BBSRAM to FRAM. It is divided into two parts. First is a treatment of the advantages of FRAM memory compared with battery-backed SRAM. Second is a design guide, which highlights design considerations that should be reviewed in both retrofit and new design situations.

### **FRAM Advantages**

Although battery-backed SRAM is a mature and established solution, it has many weaknesses. These stem directly or indirectly from the presence of the battery. FRAM uses an inherently nonvolatile storage mechanism that requires no battery. It therefore

eliminates these weaknesses. The major considerations in upgrading to FRAM follow:

#### Construction Issues

##### **1. Cost**

The cost of both the component and the manufacturing overhead of battery-backed SRAM is high. FRAM with its monolithic construction is inherently a lower cost solution. In addition, there is no 'built-in' rework step required for battery attachment when using surface mount parts. Therefore assembly is streamlined and more cost effective. In the case of DIP battery-backed modules, the user is constrained to through-hole assembly techniques and a board wash using no water.

##### **2. Humidity**

A typical battery-backed SRAM module is qualified at 60° C, 90% Rh, but under no bias and no pressure. These conditions are chosen because multi-component assemblies are vulnerable to moisture and dirt. FRAM is qualified using HAST – highly accelerated stress test. This requires 120° C at 85% Rh, 24.4 psia at 5.5V.

##### **3. System reliability**

Data integrity must be questioned when using a battery-backed SRAM. They are inherently vulnerable to shock and vibration. If the battery contact comes loose, data will be lost. In addition a negative voltage, even a momentary undershoot, on any pin of a battery-backed SRAM can cause data loss. The negative voltage causes current to be drawn directly from the battery. These momentary short circuits can greatly weaken a battery and reduce its capacity over time. In general, there is no way to monitor the lost battery capacity. Should an undershoot occur in a battery backed system during a power down, data can be lost immediately.

##### **4. Space**

Certain disadvantages of battery-backed, such as susceptibility to shock, can be reduced by using the old fashioned DIP module. However, this alternative takes up board space, height, and dictates through-hole assembly. FRAM offers a true surface-mount solution that uses 25% of the board space.

#### Direct Battery Issues

##### **5. Field maintenance**

No matter how mature batteries become, they are a maintenance problem. They eventually must be replaced. Despite long life projections, it is impossible to know if any individual battery will last considering all of the factors that can degrade them.

#### 6. Environmental

Lithium batteries are widely regarded as an environmental problem. They are a potential fire hazard and proper disposal can be a burden. In addition, shipping of lithium batteries may be restricted.

#### 7. Style!

Backing up an SRAM with a battery is an old-fashioned approach. In many cases, such modules are the only through-hole component in sight. FRAM is the latest memory technology and it is changing the way systems are designed.

*FRAM is nonvolatile and writes fast -- no battery required.*

## FRAM Design Considerations

When designing with FRAM for the first time, users of SRAM will recognize a few minor differences. First, byte-wide FRAM memories latch each address on the falling edge of chip enable. This allows the address bus to change after starting the memory access. Since every access latches the memory address on the falling edge of  $\overline{\text{CE}}$ , users cannot ground it as they might with SRAM.

Users who are modifying existing designs to use FRAM should examine the memory controller for timing compatibility of address and control pins. Each memory access must be qualified with a low transition of  $\overline{\text{CE}}$ . In many cases, this is the only change required. An example of the signal relationships is shown in Figure 2 below. Also shown is a common SRAM signal relationship that will not work for the FM1808.

The reason for  $\overline{\text{CE}}$  to strobe for each address is two-fold: it latches the new address and creates the necessary precharge period while  $\overline{\text{CE}}$  is high.

A second design consideration relates to the level of  $V_{\text{DD}}$  during operation. Battery-backed SRAMs are forced to monitor  $V_{\text{DD}}$  in order to switch to battery backup. They typically block user access below a certain  $V_{\text{DD}}$  level in order to prevent loading the battery with current demand from an active SRAM. The user can be abruptly cut off from access to the nonvolatile memory in a power down situation with no warning or indication.

FRAM memories do not need this system overhead. The memory will not block access at any  $V_{\text{DD}}$  level. The user, however, should prevent the processor from accessing memory when  $V_{\text{DD}}$  is out-of-tolerance. The common design practice of holding a processor in reset when  $V_{\text{DD}}$  drops is adequate; no special provisions must be taken for FRAM design.

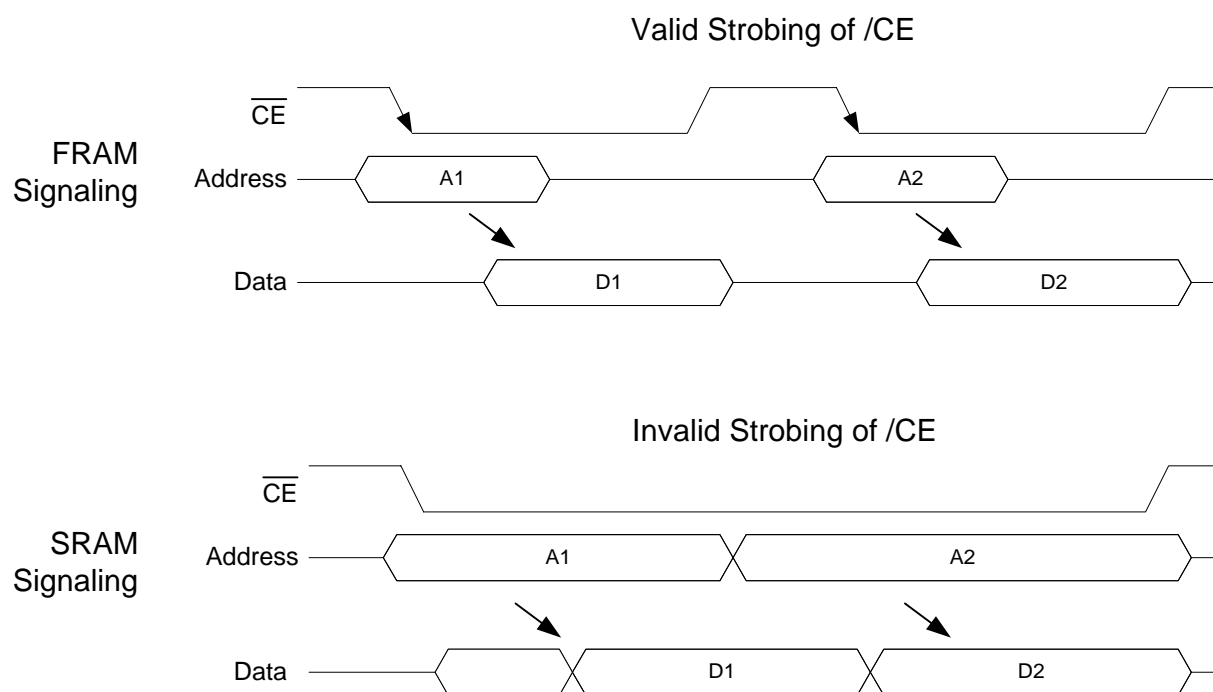


Figure 2. Chip Enable and Memory Address Relationships

## Electrical Specifications

### Absolute Maximum Ratings

Symbol	Description	Ratings
$V_{DD}$	Power Supply Voltage with respect to $V_{SS}$	-1.0V to +7.0V
$V_{IN}$	Voltage on any pin with respect to $V_{SS}$	-1.0V to +7.0V and $V_{IN} < V_{DD} + 1.0V$
$T_{STG}$	Storage Temperature	-40°C to +85°C
$T_{LEAD}$	Lead Temperature (Soldering, 10 seconds)	300° C

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

### DC Operating Conditions ( $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ , $V_{DD} = 4.5V$ to $5.5V$ unless otherwise specified)

Symbol	Parameter	Min	Typ	Max	Units	Notes
$V_{DD}$	Power Supply	4.5	5.0	5.5	V	
$I_{DD1}$	VDD Supply Current (180 ns cycle)		7	15	mA	1
$I_{DD2}$	VDD Supply Current (130 ns cycle)		12	25	mA	1
$I_{SB1}$	Standby Current – TTL input levels			400	$\mu\text{A}$	2
$I_{SB2}$	Standby Current – CMOS input levels		7	20	$\mu\text{A}$	3
$I_{LI}$	Input Leakage Current	-		10	$\mu\text{A}$	4
$I_{LO}$	Output Leakage Current	-		10	$\mu\text{A}$	4
$V_{IH}$	Input High Voltage	2.0		$V_{DD} + 0.3$	V	
$V_{IL}$	Input Low Voltage	-0.3		0.8	V	
$V_{OH}$	Output High Voltage ( $I_{OH} = -2.0\text{ mA}$ )	2.4		-	V	
$V_{OL}$	Output Low Voltage ( $I_{OL} = -4.2\text{ mA}$ )	-		0.4	V	

#### Notes

- $V_{DD} = 5.5V$ , /CE cycling at minimum cycle time, 130 ns for -70 and 180 ns for -120. All inputs at CMOS levels, all outputs unloaded.
- $V_{DD} = 5.5V$ , /CE at  $V_{IH}$ , All inputs at TTL levels, all outputs unloaded.
- $V_{DD} = 5.5V$ , /CE at  $V_{IH}$ , All inputs at CMOS levels, all outputs unloaded.
- $V_{IN}$ ,  $V_{OUT}$  between  $V_{DD}$  and  $V_{SS}$ .

### Data Retention ( $V_{DD} = 4.5V$ to $5.5V$ unless otherwise specified)

Parameter	Min	Units	Notes
Data Retention	10	years	1

#### Notes

The relationship between retention, temperature, and the associated reliability level is characterized in a separate reliability report.

**Read Cycle AC Parameters** ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 4.5\text{V}$  to  $5.5\text{V}$  unless otherwise specified)

Symbol	Parameter	-70		-120		Units	Notes
		Min	Max	Min	Max		
$t_{CE}$	Chip Enable Access Time (to data valid)		70		120	ns	
$t_{CA}$	Chip Enable Active Time	70	10,000	120	10,000	ns	
$t_{RC}$	Read Cycle Time	130		180		ns	
$t_{PC}$	Precharge Time	60		60		ns	
$t_{AS}$	Address Setup Time	4		4		ns	
$t_{AH}$	Address Hold Time	10		10		ns	
$t_{OE}$	Output Enable Access Time		10		10	ns	
$t_{HZ}$	Chip Enable to Output High-Z		15		15	ns	1
$t_{OHZ}$	Output Enable to Output High-Z		15		15	ns	1

**Write Cycle AC Parameters** ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 4.5\text{V}$  to  $5.5\text{V}$  unless otherwise specified)

Symbol	Parameter	-70		-120		Units	Notes
		Min	Max	Min	Max		
$t_{CA}$	Chip Enable Active Time	70	10,000	120	10,000	ns	
$t_{CW}$	Chip Enable to Write High	70		120		ns	
$t_{WC}$	Write Cycle Time	130		180		ns	
$t_{PC}$	Precharge Time	60		60		ns	
$t_{AS}$	Address Setup Time	4		4		ns	
$t_{AH}$	Address Hold Time	10		10		ns	
$t_{WP}$	Write Enable Pulse Width	40		40		ns	
$t_{DS}$	Data Setup	30		40		ns	
$t_{DH}$	Data Hold	5		5		ns	
$t_{WZ}$	Write Enable Low to Output High Z		15		15	ns	1
$t_{WX}$	Write Enable High to Output Driven	10		10		ns	1
$t_{HZ}$	Chip Enable to Output High-Z		15		15	ns	1
$t_{WS}$	Write Setup	0		0		ns	2
$t_{WH}$	Write Hold	0		0		ns	2

**Notes**

- 1 This parameter is periodically sampled and not 100% tested.
- 2 The relationship between /CE and /WE determines if a /CE- or /WE-controlled write occurs. There is no timing specification associated with this relationship.

**Power Cycle Timing** ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 4.5\text{V}$  to  $5.5\text{V}$  unless otherwise specified)

Symbol	Parameter	Min	Max	Units	Notes
$t_{PU}$	$V_{DD}(\text{min})$ to First Access Start	1	-	$\mu\text{S}$	
$t_{PD}$	Last Access Complete to $V_{DD}(\text{min})$	0	-	$\mu\text{S}$	1
$t_{POFF}$	Power Off Time	1	-	$\mu\text{S}$	1
$V_{DD}(\text{off})$	Power Off Voltage	-0.1	0.1	V	1

**Notes**

- 1 Anytime that the power to the device ( $V_{DD}$ ) drops below 4.0 volts, the power supply must be taken to 0 volts ( $\pm 0.1$  volts) for a minimum time of 1.0 microseconds  $t_{POFF}$  before power is restored to the device. It is recommended that the  $V_{DD}$  pin be actively driven to ground through a low impedance path to ensure reliable power-up operation.



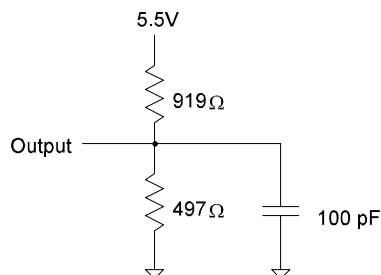
Capacitance ( $T_A = 25^\circ\text{C}$ ,  $f = 1.0\text{ MHz}$ ,  $V_{DD} = 5\text{V}$ )

Symbol	Parameter	Min	Max	Units	Notes
CI/O	Input Output Capacitance	-	8	pF	
CIN	Input Capacitance	-	6	pF	

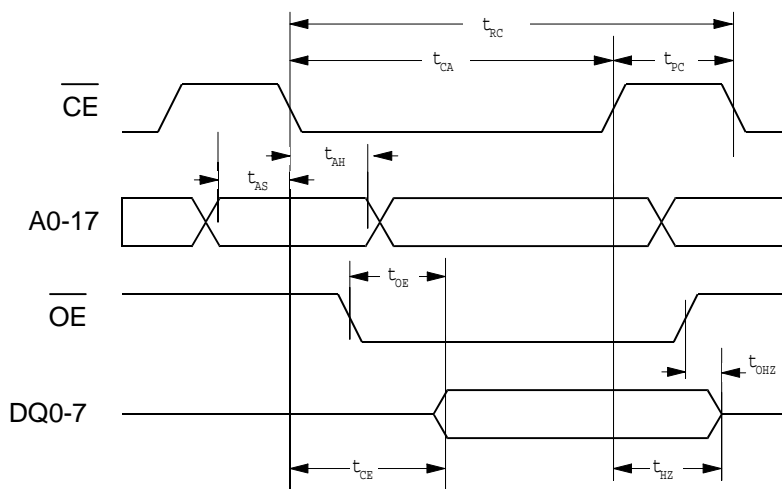
### AC Test Conditions

Input Pulse Levels 0 to 3V  
Input rise and fall times 10 ns  
Input and output timing levels 1.5V

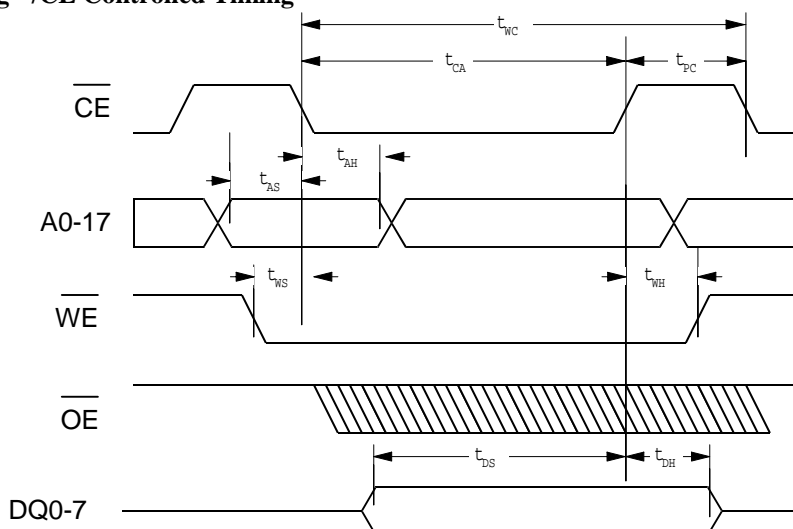
### Equivalent AC Load Circuit



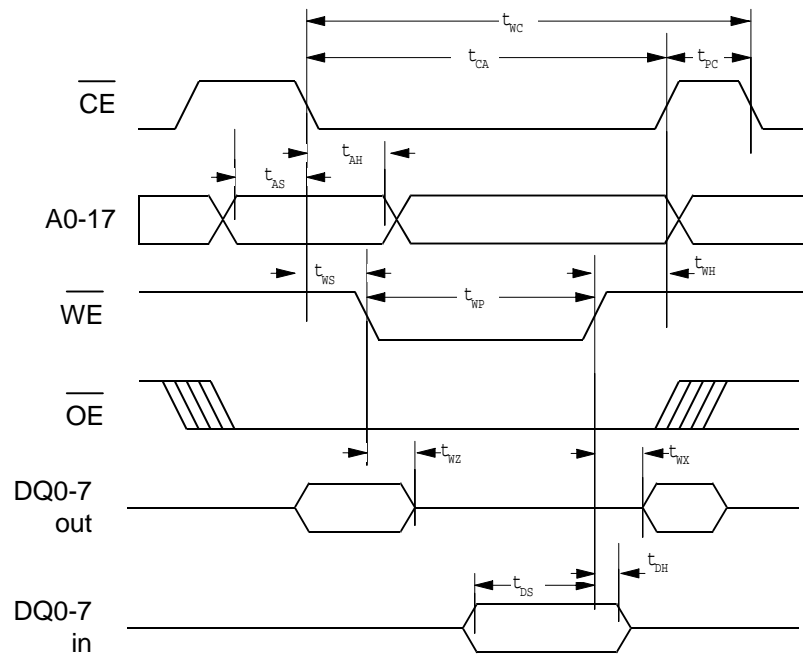
### Read Cycle Timing



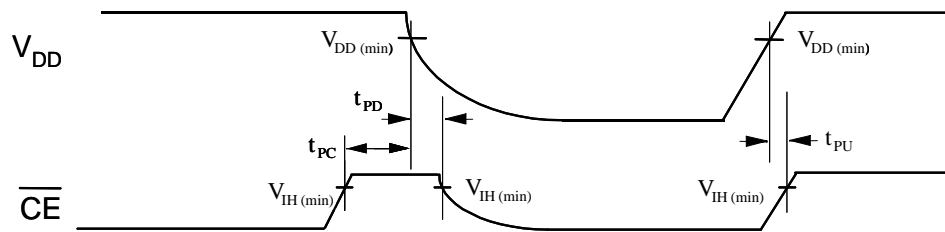
### Write Cycle Timing - /CE Controlled Timing



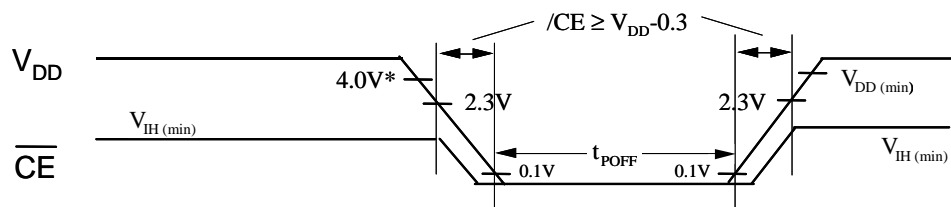
## Write Cycle Timing - /WE Controlled Timing



## Power Cycle Timing

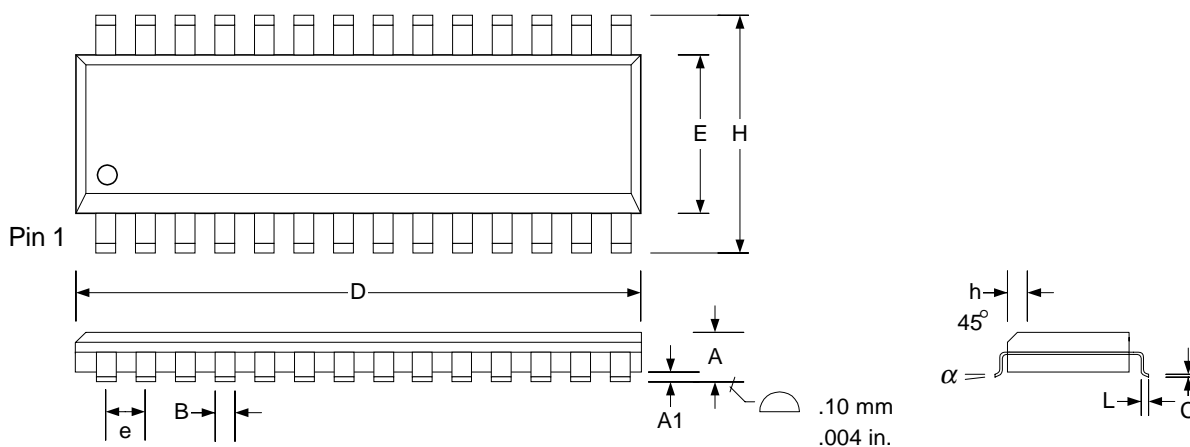


## Power Down Sequence



\*  $V_{\text{DD}}$  brownout limit. Once the power supply voltage goes below this limit,  $V_{\text{DD}}$  must go to  $V_{\text{DD}}(\text{off})$ .

## 28-pin SOIC (JEDEC MS-013 variation AE)



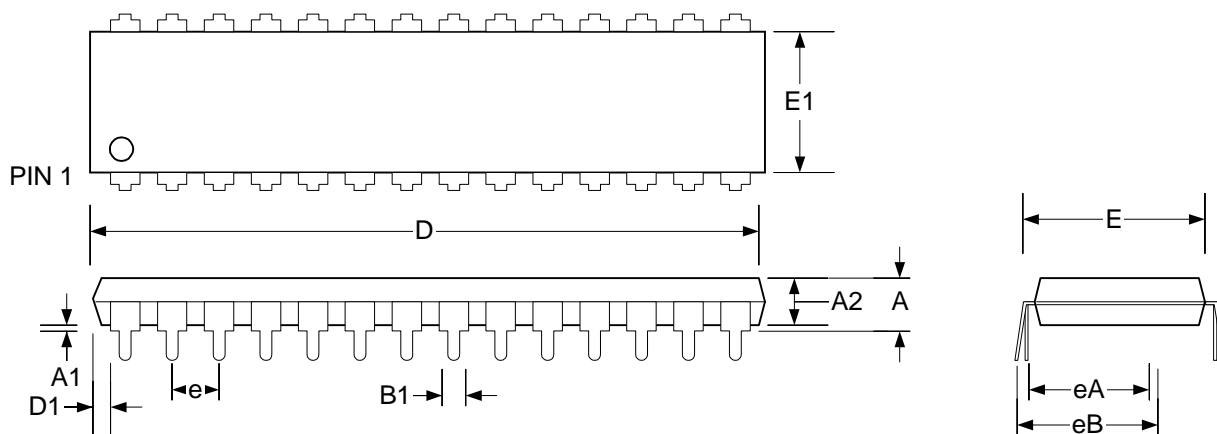
### Selected Dimensions

For complete dimensions and notes, refer to JEDEC MS-013

Controlling dimensions in millimeters.

Conversions to inches are not exact.

Symbol	Dim	Min	Nom.	Max
A	mm in.	2.35 0.0926		2.65 0.1043
A1	mm in.	0.10 0.004		0.30 0.0118
B	mm in.	0.33 0.013		0.51 0.020
C	mm in.	0.23 0.0091		0.32 0.0125
D	mm in.	17.70 0.6969		18.10 0.7125
E	mm in.	7.40 0.2914		7.60 0.2992
e	mm in.		1.27 BSC 0.050 BSC	
H	mm in.	10.00 0.394		10.65 0.419
h	mm in.	0.25 0.010		0.75 0.029
L	mm in.	.40 0.016		1.27 0.050
α		0°		8°

**28-pin DIP JEDEC MS-011**

**Selected Dimensions**

For complete dimensions and notes, refer to JEDEC MS-011

Controlling dimensions in inches.

Conversions to millimeters are not exact.

Symbol	Dim	Min	Nom.	Max
A	in. mm			0.250 6.35
A1	in. mm	0.015 0.39		
A2	in. mm	0.125 3.18		0.195 4.95
B	in. mm	0.014 0.356		0.022 0.558
B1	in. mm	0.030 0.77		0.070 1.77
D	in. mm	1.380 35.1		1.565 39.7
D1	in. mm	0.005 0.13		
E	in. mm	0.600 15.24		0.625 15.87
E1	in. mm	0.485 12.32		0.580 14.73
e	in. mm		0.100 BSC 2.54 BSC	
eA	in. mm		0.600 BSC 15.24 BSC	
eB	in. mm			0.700 17.78
L	in. mm	0.115 2.93		0.200 5.08