

# FM18L08

256Kb 2.7-3.6V Byte-wide FRAM Memory



## Features

### 256K bit Ferroelectric Nonvolatile RAM

- Organized as 32,768 x 8 bits
- 10 year data retention at 85° C
- Unlimited read/write cycles
- NoDelay™ write
- Advanced high-reliability ferroelectric process

### Superior to Battery-backed SRAM

- 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
- Equal access & cycle time for reads and writes

### Low Power Operation

- 2.7V to 3.6V operation
- 15 mA active current
- 15 µA standby current

### Industry Standard Configuration

- Industrial temperature -40° C to +85° C
- 28-pin SOP or DIP

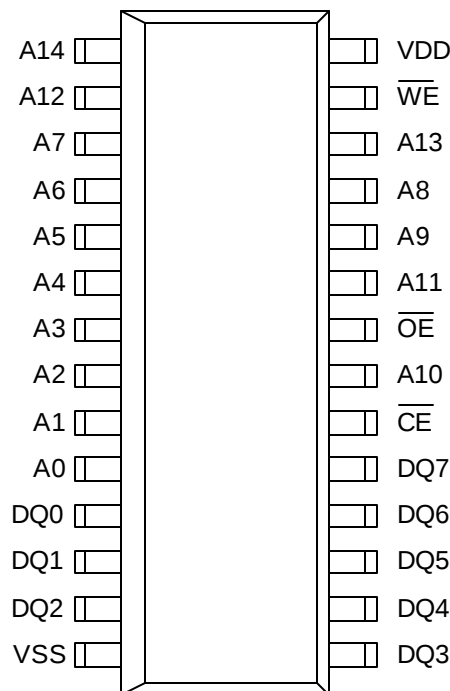
## Description

The FM18L08 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. Fast-write time and practically unlimited read/write endurance make it superior to other types of nonvolatile memory and a good substitute for ordinary SRAM.

In-system operation of the FM18L08 is very similar to other RAM based devices. Memory read- and write-cycles require equal times. The FRAM memory, however, is nonvolatile due to its unique ferroelectric memory process. Unlike BBSRAM, the FM18L08 is a truly monolithic nonvolatile memory. It provides the same functional benefits of a fast write without the serious disadvantages associated with modules and batteries or hybrid memory solutions.

These capabilities make the FM18L08 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. The FM18L08 offers guaranteed operation over an industrial temperature range of -40°C to +85°C.

## Pin Configuration

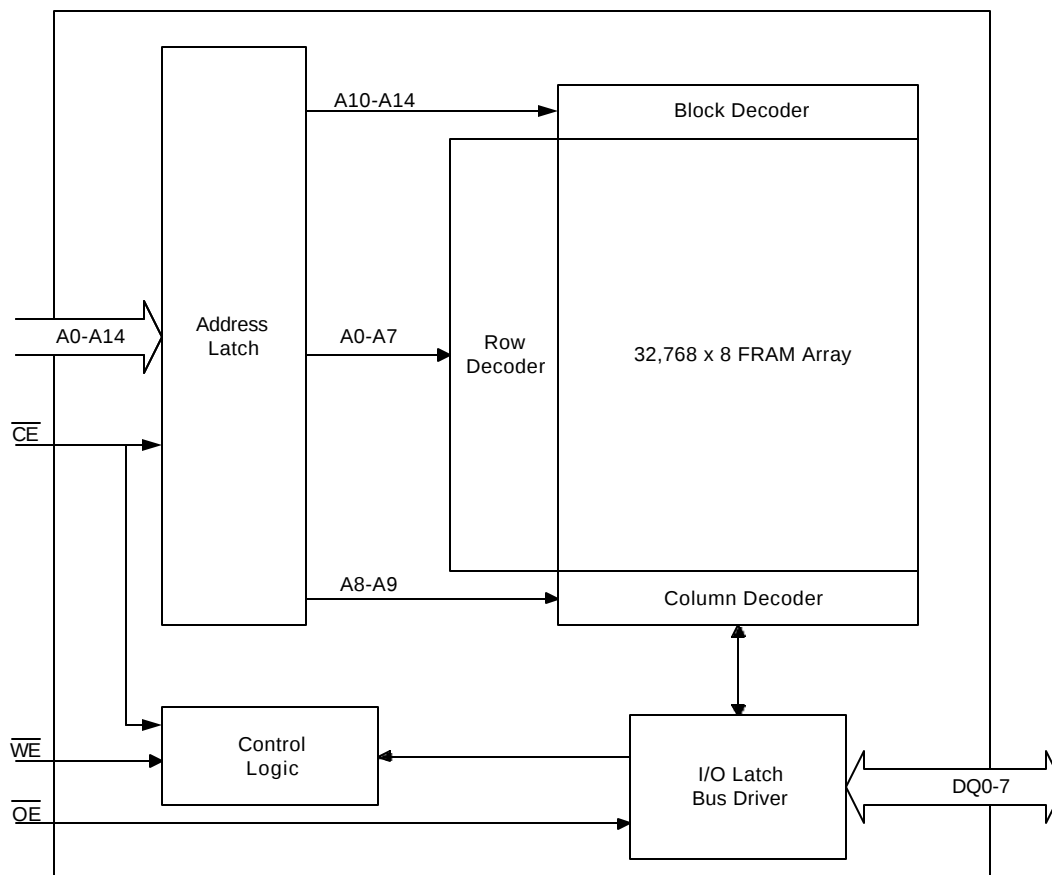


## Ordering Information

|              |                          |
|--------------|--------------------------|
| FM18L08-70-S | 70 ns access, 28-pin SOP |
| FM18L08-70-P | 70 ns access, 28-pin DIP |

This data sheet contains specifications for a product under development. Characterization is not complete; specifications may change without notice.

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**Figure 1. Block Diagram****Pin Description**

| Pin Name | Pin Number      | I/O | Pin Description                                                                                                                                                                                                      |
|----------|-----------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A0-A14   | 1-10, 21, 23-26 | I   | Address. The 15 address lines select one of 32,768 bytes in the FRAM array. The address value will be latched on the falling edge of /CE.                                                                            |
| DQ0-7    | 11-13, 15-19    | I/O | Data. 8-bit bi-directional data bus for accessing the FRAM array.                                                                                                                                                    |
| /CE      | 20              | I   | Chip Enable. /CE selects the device when low. The falling edge of /CE 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      | 22              | I   | Output Enable. When /OE is low the FM18L08 drives the data bus when valid data is available. Taking /OE high causes the DQ pins to be tri-stated.                                                                    |
| /WE      | 27              | I   | Write Enable. Taking /WE low causes the FM18L08 to write the contents of the data bus to the address location latched by the falling edge of /CE.                                                                    |
| VDD      | 28              | I   | Supply Voltage.                                                                                                                                                                                                      |
| VSS      | 14              | I   | Ground.                                                                                                                                                                                                              |

**Functional Truth Table**

| /CE | /WE | /OE | Function          |
|-----|-----|-----|-------------------|
| H   | X   | X   | Standby/Precharge |
| ↘   | X   | X   | Latch Address     |
| L   | H   | L   | Read              |
| L   | L   | X   | Write             |

## Overview

The FM18L08 is a byte-wide FRAM logically organized as 32,768 x 8. It is accessed using an industry standard parallel interface. The FM18L08 is inherently nonvolatile via its unique ferroelectric process. All data written to the part is immediately nonvolatile with no delay. Functional operation of the FRAM memory is similar to SRAM type devices. The major operating difference between the FM18L08 and an SRAM (besides nonvolatile storage) is that the FM18L08 latches the address on the falling edge of /CE.

## Memory Operation

Users access 32,768 memory locations each with 8 data bits through a parallel interface. The access and cycle time are the same for read and write memory operations. 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. A pre-charge operation, where /CE goes inactive, is a part of every memory cycle. Thus unlike SRAM, the access and cycle times are not equal.

Note that the FM18L08 contains a limited low voltage write protection circuit. This will prevent access when VDD is much lower than the specified operating range. It is still the user's responsibility to ensure that VDD is within data sheet tolerances to prevent incorrect operation.

The FM18L08 is designed to operate in a manner very similar to other byte-wide memory products. For users familiar with SRAM, 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 from unlimited 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 regardless of the state of /CE. 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 FM18L08 will drive the data bus when /OE is asserted to a low state. 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 be driven when valid data is available. This feature minimizes supply current in the system by eliminating transients due to invalid data. When /OE is inactive the data bus will remain tri-stated.

### Write Operation

Writes operations require the same time as reads. The FM18L08 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 device begins the memory cycle as a write. The FM18L08 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.

### Pre-charge Operation

The pre-charge operation is an internal condition where the state of the memory is prepared for a new

access. All memory cycles consist of a memory access and a pre-charge. The pre-charge is user initiated by taking the /CE signal high or inactive. It must remain high for at least the minimum pre-charge timing specification.

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

## Applications

As a true nonvolatile RAM, the FM18L08 fits into many diverse applications. Clearly, its monolithic nature and high performance make it superior to battery-backed SRAM in most every application. Unlimited endurance allows the FM18L08 to be used in applications that could not take advantage of the previous generation of RAM products. 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 the simple 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 numerous 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 are as follows.

#### 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, no bias, and no pressure. This is because the multi-component assemblies are vulnerable to moisture, not to mention dirt. FRAM is

qualified using HAST – highly accelerated stress test. This requires 120° C at 85% Rh, 24.4 psia at VDD.

##### 3. System reliability

Data integrity must be in question 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 SRAM, 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.

***No multi-piece assemblies, no connectors, and no modules. A real nonvolatile RAM is finally available!***

#### Direct Battery Issues

##### 5. Field maintenance

Batteries, no matter how mature, are a built-in 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 Design Considerations

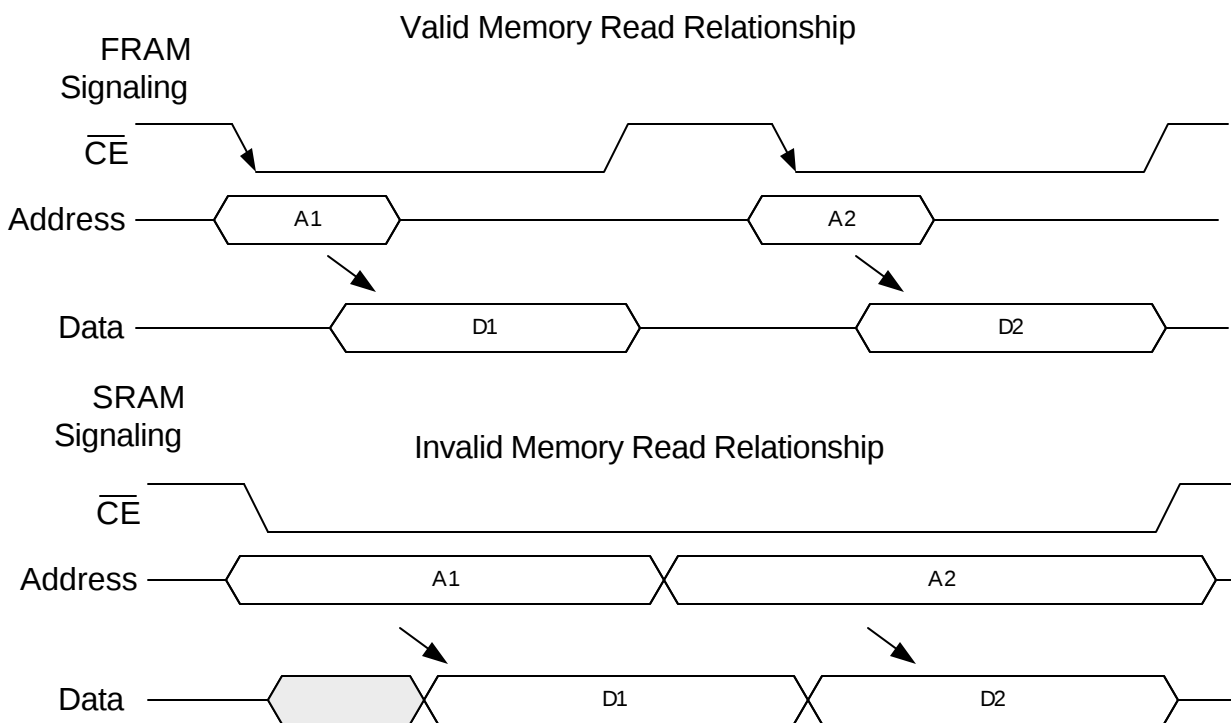
When designing with FRAM for the first time, users of SRAM will recognize a few minor differences. First, byte-wide FRAM memories latch each address on the falling edge of chip enable. This allows the address bus to change after starting the memory access. Since every access latches the memory address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

Users that are modifying existing designs to use FRAM should examine the hardware address decoders. Decoders should be modified to qualify addresses with an address valid signal if they do not

already. In many cases, this is the only change required. Systems that drive chip enable active, then inactive for each valid address may need no modifications. An example of the target signal relationships are shown in Figure 2. Also shown is a common SRAM signal relationship that will not work for the FM18L08.

The main design issue is to create a decoder scheme that will drive /CE active, then inactive for each address. This accomplishes the two goals of latching the new address and creating the precharge period.

**Figure 2. Memory Address Relationships**



## Electrical Specifications

### Absolute Maximum Ratings

| <i>Description</i>                        | <i>Ratings</i>  |
|-------------------------------------------|-----------------|
| Ambient storage or operating temperature  | -40°C to + 85°C |
| Voltage on any pin with respect to ground | -1.0V to +5.0V  |
| 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 TA = -40° C to + 85° C, VDD = 2.7V to 3.65V unless otherwise specified

| <b>Symbol</b> | <b>Parameter</b>            | <b>Min</b> | <b>Typ</b> | <b>Max</b> | <b>Units</b> | <b>Notes</b> |
|---------------|-----------------------------|------------|------------|------------|--------------|--------------|
| VDD           | Power Supply                | 2.7        |            | 3.65       | V            | 1            |
| IDD           | VDD Supply Current - Active |            | 5          | 15         | mA           | 2            |
| ISB           | Standby Current - TTL       |            |            | 400        | μA           | 3            |
| ISB           | Standby Current - CMOS      |            | 7          | 15         | μA           | 4            |
| ILI           | Input Leakage Current       |            |            | 10         | μA           | 5            |
| ILO           | Output Leakage Current      |            |            | 10         | μA           | 5            |
| VIL           | Input Low Voltage           | -1.0       |            | 0.8        | V            | 1            |
| VIH           | Input High Voltage          | 2.0        |            | VDD + 1.0  | V            | 1            |
| VOL           | Output Low Voltage          |            |            | 0.4        | V            | 1,6          |
| VOH           | Output High Voltage         | 2.4V       |            |            | V            | 1,7          |

### Notes

1. Referenced to VSS.
2. VDD = 3.65V, /CE cycling at minimum cycle time. All inputs at CMOS levels, all outputs unloaded.
3. VDD = 3.65V, /CE at VIH, All inputs at TTL levels, all outputs unloaded.
4. VDD = 3.65V, /CE at VDD, All inputs at CMOS levels, all outputs unloaded.
5. VIN, VOUT between VDD and VSS.
6. IOL = 3.2 mA
7. IOH = -1.0 mA

**Read Cycle AC Parameters** TA = -40° C to + 85° C, VDD = 2.7V to 3.65V unless otherwise specified

| Symbol | Parameter                                | Min | Max    | Units | Notes |
|--------|------------------------------------------|-----|--------|-------|-------|
| tCE    | Chip Enable Access Time ( to data valid) |     | 70     | ns    |       |
| tCA    | Chip Enable Active Time                  | 70  | 10,000 | ns    |       |
| tRC    | Read Cycle Time                          | 130 |        | ns    |       |
| tPC    | Precharge Time                           | 60  |        | ns    |       |
| tAS    | Address Setup Time                       | 0   |        | ns    |       |
| tAH    | Address Hold Time                        | 10  |        | ns    |       |
| tOE    | Output Enable Access Time                |     | 10     | ns    |       |
| tHZ    | Chip Enable to Output High-Z             |     | 15     | ns    | 1     |
| tOHZ   | Output Enable to Output High-Z           |     | 15     | ns    | 1     |

**Write Cycle AC Parameters** TA = -40° C to + 85° C, VDD = 2.7V to 3.65V unless otherwise specified

| Symbol | Parameter                          | Min | Max    | Units | Notes |
|--------|------------------------------------|-----|--------|-------|-------|
| tCA    | Chip Enable Active Time            | 70  | 10,000 | ns    |       |
| tCW    | Chip Enable to Write High          | 70  |        | ns    |       |
| tWC    | Write Cycle Time                   | 130 |        | ns    |       |
| tPC    | Precharge Time                     | 60  |        | ns    |       |
| tAS    | Address Setup Time                 | 0   |        | ns    |       |
| tAH    | Address Hold Time                  | 10  |        | ns    |       |
| tWP    | Write Enable Pulse Width           | 40  |        | ns    |       |
| tDS    | Data Setup                         | 40  |        | ns    |       |
| tDH    | Data Hold                          | 0   |        | ns    |       |
| tWZ    | Write Enable Low to Output High Z  |     | 15     | ns    | 1     |
| tWX    | Write Enable High to Output Driven | 10  |        | ns    | 1     |
| tHZ    | Chip Enable to Output High-Z       |     | 15     | ns    | 1     |
| tWS    | Write Setup                        | 0   |        | ns    | 2     |
| tWH    | Write Hold                         | 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.

**Data Retention** TA = -40° C to + 85° C, VDD = 2.7V to 3.65V unless otherwise specified

| Parameter      | Min  | Units  | Notes |
|----------------|------|--------|-------|
| Data Retention | 10   | Years  | 1     |
| Endurance      | 1E16 | Cycles | 2     |

**Notes**

1. Data retention is specified at 85° C.
2. Endurance is the guaranteed number of read- or write-cycles per address that can be performed while maintaining the specified data retention. It should be impossible to reach this limit for most applications.

**Power Cycle Timing** TA = -40° C to + 85° C, VDD = 2.7V to 3.65V unless otherwise specified

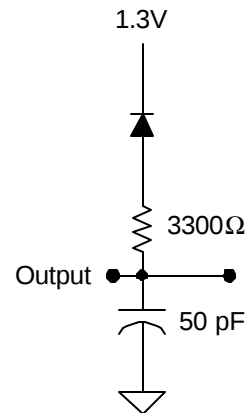
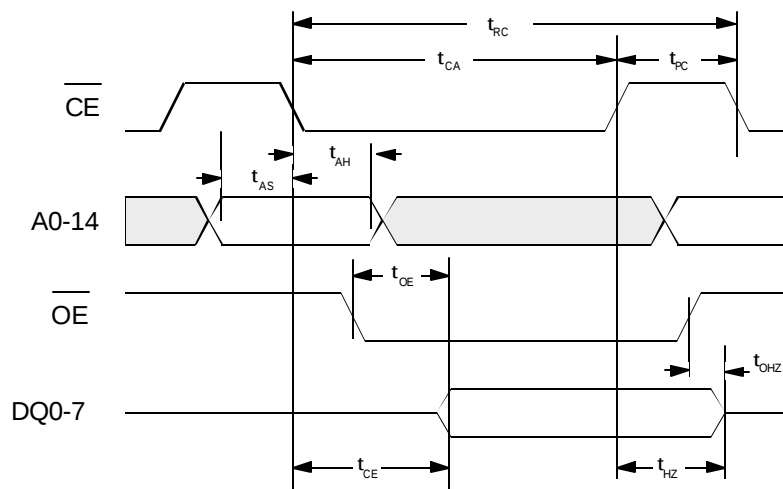
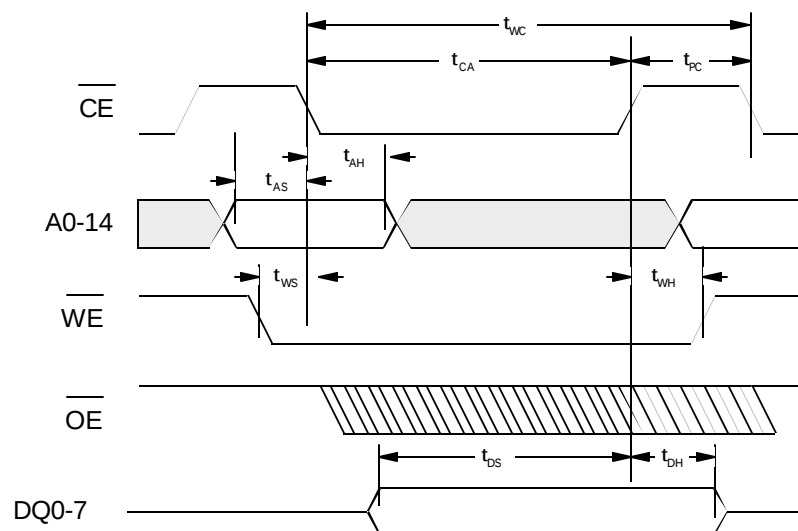
| Symbol | Parameter                       | Min | Units | Notes |
|--------|---------------------------------|-----|-------|-------|
| tPU    | VDD Min to First Access Start   | 1   | μS    |       |
| tPD    | Last Access Complete to VDD Min | 0   | μS    |       |

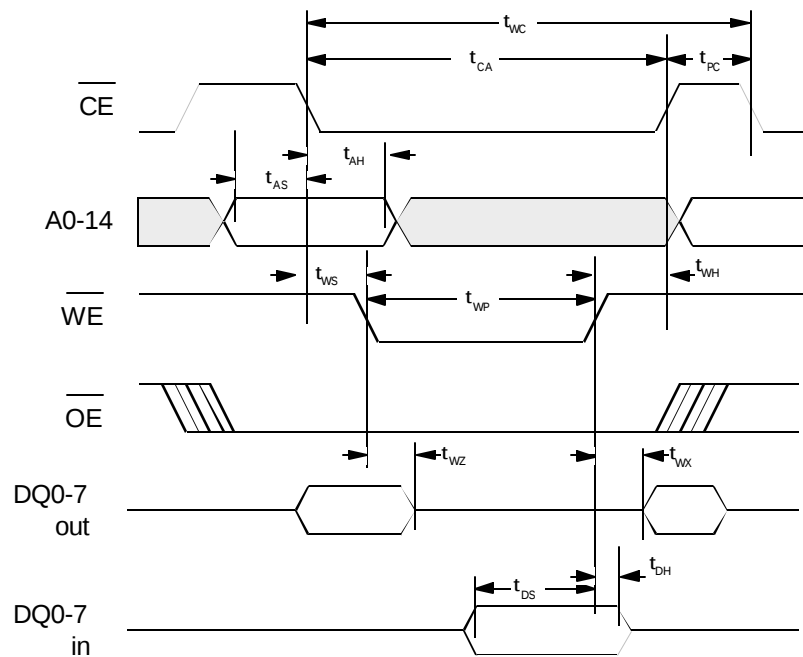
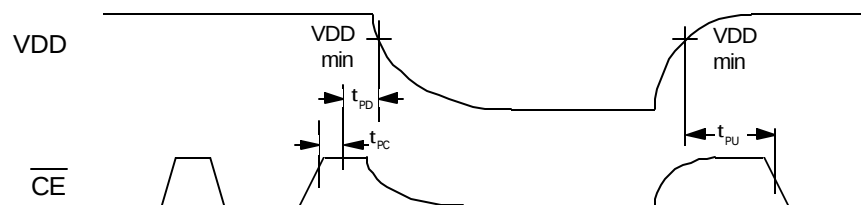
**Capacitance** TA = 25° C, f=1.0 MHz, VDD = 3V

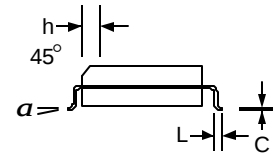
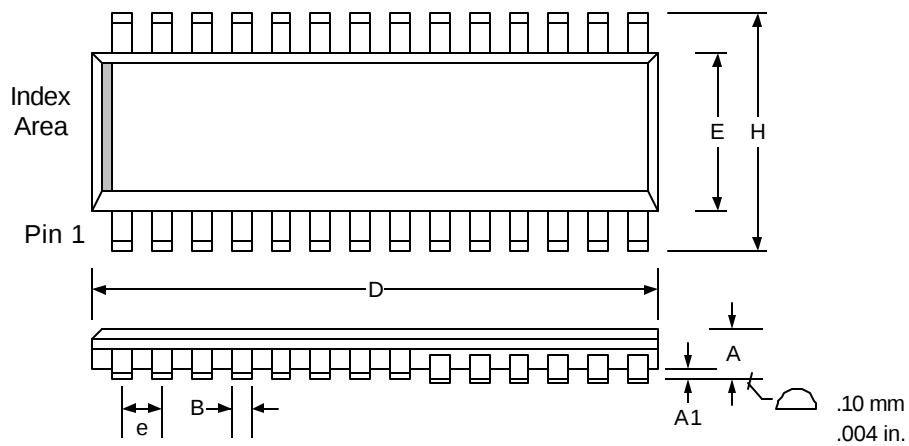
| Symbol | Parameter                | Max | Units | Notes |
|--------|--------------------------|-----|-------|-------|
| CI/O   | Input Output Capacitance | 8   | pF    |       |
| CIN    | Input Capacitance        | 6   | pF    |       |

**AC Test Conditions**

|                                |                    |
|--------------------------------|--------------------|
| Input Pulse Levels             | 0.1 VDD to 0.9 VDD |
| Input rise and fall times      | 5 ns               |
| Input and output timing levels | 1.5V               |

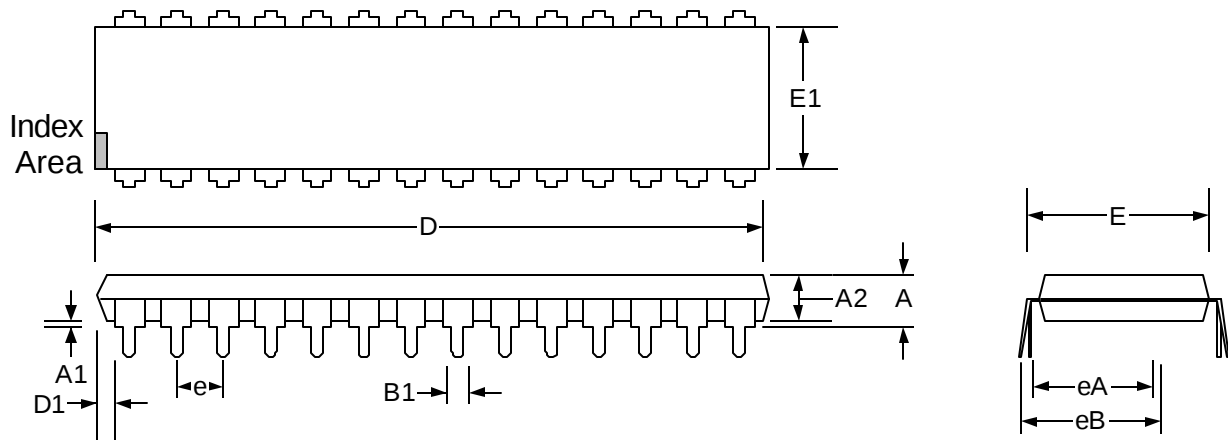
**Equivalent AC Load Circuit****Read Cycle Timing****Write Cycle Timing - /CE Controlled Timing**

**Write Cycle Timing - /WE Controlled Timing****Power Cycle Timing**

**28-pin SOP JEDEC MS-013****Selected Dimensions**

For complete dimensions and notes, refer to JEDEC MS-013  
 Controlling dimensions is in millimeters. Conversions to inches are not exact.

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

**28-pin 600-mil DIP****Selected Dimensions**

For complete dimensions and notes, refer to JEDEC MS-011  
 Controlling dimensions is in inches. Conversions to millimeters are not exact.

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