

# 2716

## 16K (2K x 8) UV ERASABLE PROM

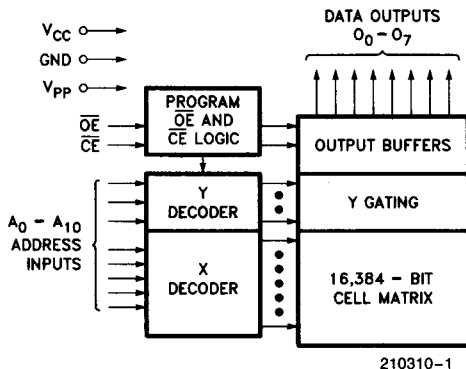
- **Fast Access Time**
  - 2716-1: 350 ns Max
  - 2716-2: 390 ns Max
  - 2716: 450 ns Max
- **Single +5V Power Supply**
- **Low Power Dissipation**
  - Active Power: 525 mW Max
  - Standby Power: 132 mW Max
- **Pin Compatible to Intel "Universal Site" EPROMs**
- **Simple Programming Requirements**
  - Single Location Programming
  - Programs with One 50 ms Pulse
- **Inputs and Outputs TTL Compatible During Read and Program**
- **Completely Static**

The Intel 2716 is a 16,384-bit ultraviolet erasable and electrically programmable read-only memory (EPROM). The 2716 operates from a single 5-volt power supply, has a static standby mode, and features fast single-address programming. It makes designing with EPROMs fast, easy and economical.

The 2716, with its single 5-volt supply and with an access time up to 350 ns, is ideal for use with high-performance +5V microprocessors such as Intel's 8085 and 8086. Selected 2716-5s and 2716-6s are also available for slower speed applications. The 2716 also has a static standby mode which reduces power consumption without increasing access time. The maximum active power dissipation is 525 mW while the maximum standby power dissipation is only 132 mW, a 75% savings.

The 2716 uses a simple and fast method for programming—a single TTL-level pulse. There is no need for high voltage pulsing because all programming controls are handled by TTL signals. Programming of any location at any time—either individually, sequentially or at random is possible with the 2716's single-address programming. Total programming time for all 16,384 bits is only 100 seconds.

5

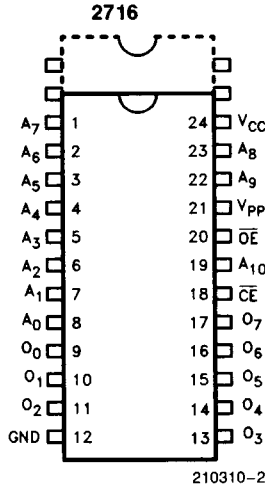


**Figure 1. Block Diagram**

### Pin Names

|                 |               |
|-----------------|---------------|
| $A_0 - A_{10}$  | Addresses     |
| $\overline{CE}$ | Chip Enable   |
| $\overline{OE}$ | Output Enable |
| $O_0 - O_7$     | Outputs       |

| 27512<br>27C512 | 27256<br>27C256 | 27128A<br>27C128 | 2764A<br>27C64<br>87C64 | 2732A          |
|-----------------|-----------------|------------------|-------------------------|----------------|
| A <sub>15</sub> | V <sub>PP</sub> | V <sub>PP</sub>  | V <sub>PP</sub>         |                |
| A <sub>12</sub> | A <sub>12</sub> | A <sub>12</sub>  | A <sub>12</sub>         |                |
| A <sub>7</sub>  | A <sub>7</sub>  | A <sub>7</sub>   | A <sub>7</sub>          | A <sub>7</sub> |
| A <sub>6</sub>  | A <sub>6</sub>  | A <sub>6</sub>   | A <sub>6</sub>          | A <sub>6</sub> |
| A <sub>5</sub>  | A <sub>5</sub>  | A <sub>5</sub>   | A <sub>5</sub>          | A <sub>5</sub> |
| A <sub>4</sub>  | A <sub>4</sub>  | A <sub>4</sub>   | A <sub>4</sub>          | A <sub>4</sub> |
| A <sub>3</sub>  | A <sub>3</sub>  | A <sub>3</sub>   | A <sub>3</sub>          | A <sub>3</sub> |
| A <sub>2</sub>  | A <sub>2</sub>  | A <sub>2</sub>   | A <sub>2</sub>          | A <sub>2</sub> |
| A <sub>1</sub>  | A <sub>1</sub>  | A <sub>1</sub>   | A <sub>1</sub>          | A <sub>1</sub> |
| A <sub>0</sub>  | A <sub>0</sub>  | A <sub>0</sub>   | A <sub>0</sub>          | A <sub>0</sub> |
| O <sub>0</sub>  | O <sub>0</sub>  | O <sub>0</sub>   | O <sub>0</sub>          | O <sub>0</sub> |
| O <sub>1</sub>  | O <sub>1</sub>  | O <sub>1</sub>   | O <sub>1</sub>          | O <sub>1</sub> |
| O <sub>2</sub>  | O <sub>2</sub>  | O <sub>2</sub>   | O <sub>2</sub>          | O <sub>2</sub> |
| GND             | GND             | GND              | GND                     | GND            |



| 2732A              | 2764A<br>27C64<br>87C64 | 27128A<br>27C128 | 27256<br>27C256 | 27512<br>27C512    |
|--------------------|-------------------------|------------------|-----------------|--------------------|
|                    | V <sub>CC</sub>         | V <sub>CC</sub>  | V <sub>CC</sub> | V <sub>CC</sub>    |
|                    | PGM                     | PGM              | A <sub>14</sub> | A <sub>14</sub>    |
| V <sub>CC</sub>    | N.C.                    | A <sub>13</sub>  | A <sub>13</sub> | A <sub>13</sub>    |
| A <sub>8</sub>     | A <sub>8</sub>          | A <sub>8</sub>   | A <sub>8</sub>  | A <sub>8</sub>     |
| A <sub>9</sub>     | A <sub>9</sub>          | A <sub>9</sub>   | A <sub>9</sub>  | A <sub>9</sub>     |
| A <sub>11</sub>    | A <sub>11</sub>         | A <sub>11</sub>  | A <sub>11</sub> | A <sub>11</sub>    |
| OE/V <sub>PP</sub> | OE                      | OE               | OE              | OE/V <sub>PP</sub> |
| A <sub>10</sub>    | A <sub>10</sub>         | A <sub>10</sub>  | A <sub>10</sub> | A <sub>10</sub>    |
| CE                 | CE<br>ALE/CE            | CE               | CE              | CE                 |
| O <sub>7</sub>     | O <sub>7</sub>          | O <sub>7</sub>   | O <sub>7</sub>  | O <sub>7</sub>     |
| O <sub>6</sub>     | O <sub>6</sub>          | O <sub>6</sub>   | O <sub>6</sub>  | O <sub>6</sub>     |
| O <sub>5</sub>     | O <sub>5</sub>          | O <sub>5</sub>   | O <sub>5</sub>  | O <sub>5</sub>     |
| O <sub>4</sub>     | O <sub>4</sub>          | O <sub>4</sub>   | O <sub>4</sub>  | O <sub>4</sub>     |
| O <sub>3</sub>     | O <sub>3</sub>          | O <sub>3</sub>   | O <sub>3</sub>  | O <sub>3</sub>     |

**NOTE:**

Intel "Universal Site" compatible EPROM configurations are shown in the blocks adjacent to the 2716 pins.

**Figure 2. Cerdip Pin Configuration**

**EXTENDED TEMPERATURE (EXPRESS) EPROMs**

The Intel EXPRESS EPROM family is a series of electrically programmable read only memories which have received additional processing to enhance product characteristics. EXPRESS processing is available for several densities of EPROM, allowing the choice of appropriate memory size to match system applications. EXPRESS EPROM products are available with 168 ± 8 hour, 125°C dynamic burn-in using Intel's standard bias configuration. This process exceeds or meets most industry specifications of burn-in. The standard EXPRESS EPROM operating temperature range is 0°C to 70°C. Extended operating temperature range (-40°C to +85°C) EXPRESS products are available. Like all Intel EPROMs, the EXPRESS EPROM family is inspected to 0.1% electrical AQL. This may allow the user to reduce or eliminate incoming inspection testing.

**EXPRESS EPROM PRODUCT FAMILY**

**PRODUCT DEFINITIONS**

| Type | Operating Temperature | Burn-In 125°C (hr) |
|------|-----------------------|--------------------|
| Q    | 0°C to +70°C          | 168 ± 8            |
| I    | -40°C to +85°C        | 44                 |

**EXPRESS OPTIONS**

**2716 Versions**

| Packaging Options |        |
|-------------------|--------|
| Speed Versions    | Cerdip |
| - 1               | Q      |
| STD               | Q, I   |

## DEVICE OPERATION

The six modes of operation of the 2716 are listed in Table 1. It should be noted that inputs for all modes are TTL levels. The power supplies required are a +5V  $V_{CC}$  and a  $V_{PP}$ . The  $V_{PP}$  power supply must be at 25V during the three programming modes, and must be at 5V in the other three modes.

### Read Mode

The 2716 has two control functions, both of which must be logically satisfied in order to obtain data at the outputs. Chip Enable ( $\overline{CE}$ ) is the power control and should be used for device selection. Output Enable ( $\overline{OE}$ ) is the output control and should be used to gate data from the output pins, independent of device selection. Assuming that addresses are stable, address access time ( $t_{ACC}$ ) is equal to the delay from  $\overline{CE}$  to output ( $t_{CE}$ ). Data is available at the outputs  $t_{OE}$  after the falling edge of  $\overline{OE}$ , assuming that  $\overline{CE}$  has been low and addresses have been stable for at least  $t_{ACC}-t_{OE}$ .

### Standby Mode

The 2716 has a standby mode which reduces the maximum active power dissipation by 75%, from 525 mW to 132 mW. The 2716 is placed in the standby mode by applying a TTL-high signal to the  $\overline{CE}$  input. When in standby mode, the outputs are in a high impedance state, independent of the  $\overline{OE}$  input.

### Output OR-Tieing

Because 2716s are usually used in larger memory arrays, Intel has provided a 2-line control function that accommodates this use of multiple memory connections. The two-line control function allows for:

- a) the lowest possible memory power dissipation, and
- b) complete assurance that output bus contention will not occur.

To use these two control lines most efficiently,  $\overline{CE}$  (pin 18) should be decoded and used as the primary device selecting function, while  $\overline{OE}$  (pin 20) should be made a common connection to all devices in the array and connected to the  $\overline{READ}$  line from the system control bus. This assures that all deselected memory devices are in their low-power standby modes and that the output pins are active only when data is desired from a particular memory device.

### Programming

Initially, and after each erasure, all bits of the 2716 are in the "1" state. Data is introduced by selectively programming "0's" into the desired bit locations. Although only "0's" will be programmed, both "1's" and "0's" can be presented in the data word. The only way to change a "0" to a "1" is by ultraviolet light erasure.

The 2716 is in the programming mode when the  $V_{PP}$  power supply is at 25V and  $\overline{OE}$  is at  $V_{IH}$ . The data to be programmed is applied 8 bits in parallel to the data output pins. The levels required for the address and data inputs are TTL.

When the address and data are stable, a 50 ms, active-high, TTL program pulse is applied to the  $\overline{CE}$  input. A pulse must be applied at each address location to be programmed. You can program any location at any time—either individually, sequentially, or at random. The program pulse has a maximum width of 55 ms. The 2716 must not be programmed with a DC signal applied to the  $\overline{CE}$  input.

5

Table 1. Mode Selection

| Pins            | $\overline{CE}$<br>(18)     | $\overline{OE}$<br>(20) | $V_{PP}$<br>(21) | $V_{CC}$<br>(24) | Outputs<br>(9-11, 13-17) |
|-----------------|-----------------------------|-------------------------|------------------|------------------|--------------------------|
| Mode            |                             |                         |                  |                  |                          |
| Read            | $V_{IL}$                    | $V_{IL}$                | +5               | +5               | $D_{OUT}$                |
| Output Disable  | $V_{IL}$                    | $V_{IH}$                | +5               | +5               | High Z                   |
| Standby         | $V_{IH}$                    | X                       | +5               | +5               | High Z                   |
| Program         | Pulsed $V_{IL}$ to $V_{IH}$ | $V_{IH}$                | +25              | +5               | $D_{IN}$                 |
| Verify          | $V_{IL}$                    | $V_{IL}$                | +25              | +5               | $D_{OUT}$                |
| Program Inhibit | $V_{IL}$                    | $V_{IH}$                | +25              | +5               | High Z                   |

**NOTE:**

1. X can be  $V_{IL}$  or  $V_{IH}$ .

**ABSOLUTE MAXIMUM RATINGS\***

Temperature Under Bias . . . . .  $-10^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$   
 Storage Temperature . . . . .  $-65^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$   
 All Input or Output Voltages with  
     Respect to Ground . . . . .  $+6\text{V}$  to  $-0.3\text{V}$   
 $V_{\text{PP}}$  Supply Voltage with Respect  
     to Ground During Program . . . . .  $+26.5\text{V}$  to  $-0.3\text{V}$

NOTICE: This is a production data sheet. The specifications are subject to change without notice.

*\*WARNING: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.*

**D.C. AND A.C. OPERATING CONDITIONS DURING READ**

|                                    | 2716                                       | 2716-1                                     | 2716-2                                     |
|------------------------------------|--|--|--|
| Temperature Range                  | $0^{\circ}\text{C}$ – $70^{\circ}\text{C}$ | $0^{\circ}\text{C}$ – $70^{\circ}\text{C}$ | $0^{\circ}\text{C}$ – $70^{\circ}\text{C}$ |
| $V_{\text{CC}}$ Power Supply(1, 2) | $5\text{V} \pm 5\%$                        | $5\text{V} \pm 5\%$                        | $5\text{V} \pm 5\%$                        |
| $V_{\text{PP}}$ Power Supply(2)    | $V_{\text{CC}}$                            | $V_{\text{CC}}$                            | $V_{\text{CC}}$                            |

**READ OPERATION**
**D.C. CHARACTERISTICS**

| Symbol                 | Parameter                         | Limits |        |                     | Units         | Test Conditions  |
|------------------------|-----------------------------------|--------|--------|---------------------|---------------|--|
|                        |                                   | Min    | Typ(3) | Max                 |               |  |
| $I_{\text{LI}}$        | Input Load Current                |        |        | 10                  | $\mu\text{A}$ | $V_{\text{IN}} = 5.25\text{V}$   |
| $I_{\text{LO}}$        | Output Leakage Current            |        |        | 10                  | $\mu\text{A}$ | $V_{\text{OUT}} = 5.25\text{V}$  |
| $I_{\text{PP1}}^{(2)}$ | $V_{\text{PP}}$ Current           |        |        | 5                   | mA            | $V_{\text{PP}} = 5.25\text{V}$   |
| $I_{\text{CC1}}^{(2)}$ | $V_{\text{CC}}$ Current (Standby) |        | 10     | 25                  | mA            | $\overline{\text{CE}} = V_{\text{IH}}, \overline{\text{OE}} = V_{\text{IL}}$ |
| $I_{\text{CC2}}^{(2)}$ | $V_{\text{CC}}$ Current (Active)  |        | 57     | 100                 | mA            | $\overline{\text{OE}} = \overline{\text{CE}} = V_{\text{IL}}$                |
| $V_{\text{IL}}$        | Input Low Voltage                 | $-0.1$ |        | 0.8                 | V             |  |
| $V_{\text{IH}}$        | Input High Voltage                | 2.0    |        | $V_{\text{CC}} + 1$ | V             |  |
| $V_{\text{OL}}$        | Output Low Voltage                |        |        | 0.45                | V             | $I_{\text{OL}} = 2.1\text{ mA}$  |
| $V_{\text{OH}}$        | Output High Voltage               | 2.4    |        |                     | V             | $I_{\text{OH}} = -400\ \mu\text{A}$  |

**A.C. CHARACTERISTICS**

| Symbol                   | Parameter   | Limits (ns) |     |        |     |        |     | Test Conditions†  |
|--------------------------|---|-------------|-----|--------|-----|--------|-----|---|
|                          |   | 2716        |     | 2716-1 |     | 2716-2 |     |   |
|                          |   | Min         | Max | Min    | Max | Min    | Max |   |
| $t_{\text{ACC}}$         | Address to Output Delay   |             | 450 |        | 350 |        | 390 | $\overline{\text{CE}} = \overline{\text{OE}} = V_{\text{IL}}$ |
| $t_{\text{CE}}$          | $\overline{\text{CE}}$ to Output Delay  |             | 450 |        | 350 |        | 390 | $\overline{\text{OE}} = V_{\text{IL}}$                        |
| $t_{\text{OE}}^{(4)}$    | Output Enable to Output Delay   |             | 120 |        | 120 |        | 120 | $\overline{\text{CE}} = V_{\text{IL}}$                        |
| $t_{\text{DF}}^{(4, 6)}$ | $\overline{\text{CE}}$ or $\overline{\text{OE}}$ High to Output Float                                 | 0           | 100 | 0      | 100 | 0      | 100 | $\overline{\text{CE}} = V_{\text{IL}}$                        |
| $t_{\text{OH}}$          | Output Hold from Addresses, $\overline{\text{CE}}$ or $\overline{\text{OE}}$ Whichever Occurred First | 0           |     | 0      |     | 0      |     | $\overline{\text{CE}} = \overline{\text{OE}} = V_{\text{IL}}$ |

Programming of multiple 2716s in parallel with the same data can be easily accomplished due to the simplicity of the programming requirements. Like inputs of the paralleled 2716s may be connected together when they are programmed with the same data. A low level TTL pulse applied to the  $\overline{CE}$  input programs the paralleled 2716s.

### Program Inhibit

Programming of multiple 2716s in parallel with different data is also easily accomplished. Except for  $\overline{CE}$ , all like inputs (including  $\overline{OE}$ ) of the parallel 2716s may be common. A TTL-level program pulse applied to a 2716's  $\overline{CE}$  input with  $V_{PP}$  at 25V will program that 2716. A low-level  $\overline{CE}$  input inhibits the other 2716 from being programmed.

### Verify

A verify should be performed on the programmed bits to determine that they were correctly programmed. The verify may be performed with  $V_{PP}$  at 25V. Except during programming and program verify,  $V_{PP}$  must be at 5V.

### ERASURE CHARACTERISTICS

The erasure characteristics of the 2716 are such that erasure begins to occur upon exposure to light with wavelengths shorter than approximately 4000 Angstroms (Å). It should be noted that sunlight and certain types of fluorescent lamps have wavelengths in the 3000–4000Å range. Data show that constant exposure to room-level fluorescent lighting could erase the typical 2716 in approximately 3 years, while it would take approximately 1 week to cause erasure when exposed to direct sunlight. If the 2716 is to be exposed to these types of lighting conditions for extended periods of time, opaque labels should be placed over the window to prevent unintentional erasure.

The recommended erasure procedure for the 2716 is exposure to shortwave ultraviolet light which has a wavelength of 2537 Angstroms (Å). The integrated dose (i.e., UV intensity  $\times$  exposure time) for erasure should be a minimum of 15 Ws/cm<sup>2</sup>. The erasure time with this dosage is approximately 15 to 20 minutes using an ultraviolet lamp with a 12000  $\mu$ W/cm<sup>2</sup> power rating. The 2716 should be placed within 1 inch of the lamp tubes during erasure.

5

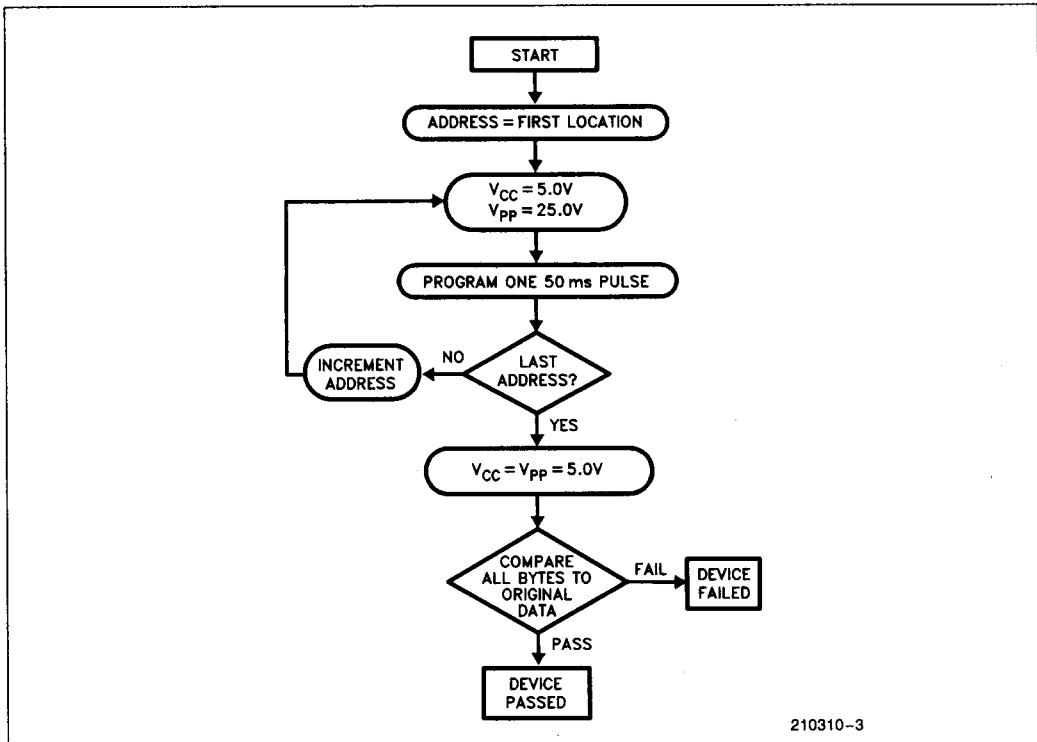


Figure 3. Standard Programming Flowchart

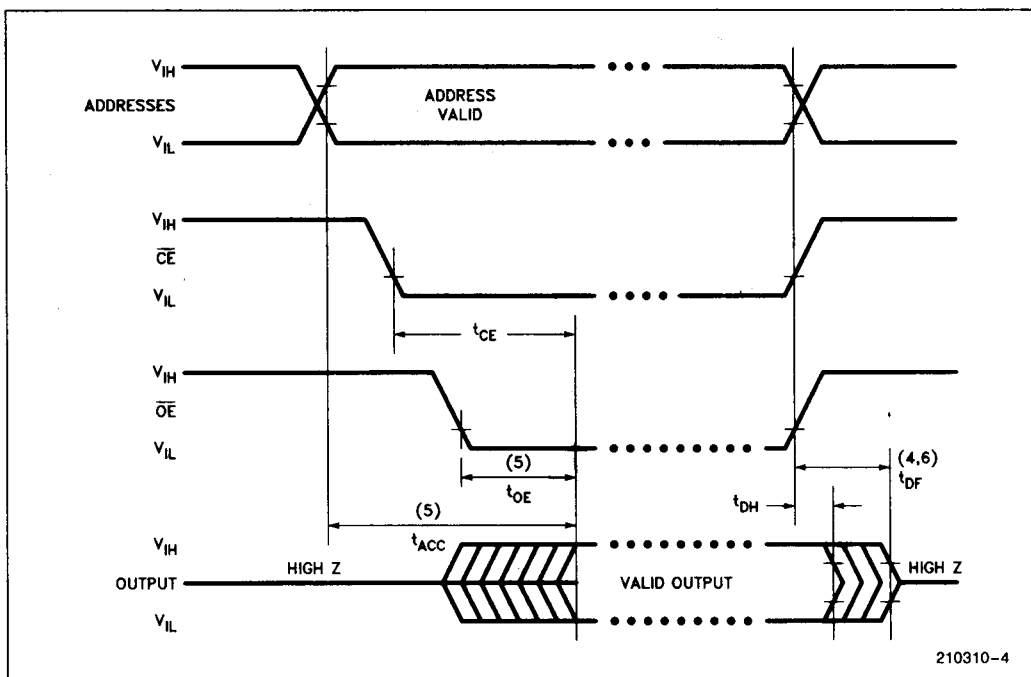
**CAPACITANCE(4)**  $T_A = 25^\circ\text{C}$ ,  $f = 1\text{ MHz}$

| Symbol    | Parameter          | Typ(3) | Max | Unit | Test Conditions       |
|-----------|--------------------|--------|-----|------|-----------------------|
| $C_{IN}$  | Input Capacitance  | 4      | 6   | pF   | $V_{IN} = 0\text{V}$  |
| $C_{OUT}$ | Output Capacitance | 8      | 12  | pF   | $V_{OUT} = 0\text{V}$ |

**†A.C. TEST CONDITIONS**

Output Load ..... 1 TTL gate and  $C_L = 100\text{ pF}$   
 Input Rise and Fall Times .....  $\leq 20\text{ ns}$   
 Input Pulse Levels ..... 0.8V to 2.2V  
 Timing Measurement Reference Level:  
 Inputs ..... 0.8V and 2V  
 Outputs ..... 0.8V and 2V

**A.C. WAVEFORMS(1)**



210310-4

**NOTES:**

1.  $V_{CC}$  must be applied simultaneously or before  $V_{PP}$  and removed simultaneously or after  $V_{PP}$ .
2.  $V_{PP}$  may be connected to  $V_{CC}$  except during programming. The supply current would then be the sum of  $I_{CC}$  and  $I_{PP1}$ .
3. Typical values are for  $T_A = 25^\circ\text{C}$  and nominal supply voltages.
4. This parameter is only sampled and is not 100% tested.
5.  $\overline{OE}$  may be delayed up to  $t_{ACC} - t_{OE}$  after the falling edge of  $\overline{CE}$  without impact on  $t_{ACC}$ .
6.  $t_{DF}$  is specified from  $\overline{OE}$  or  $\overline{CE}$ , whichever occurs first.

## PROGRAMMING CHARACTERISTICS

**D.C. PROGRAMMING CHARACTERISTICS**  $T_A = 25^\circ\text{C} \pm 5^\circ\text{C}$ ,  $V_{CC}^{(1)} = 5\text{V} \pm 5\%$ ,  $V_{PP}^{(1,2)} = 25\text{V} \pm 1\text{V}$

| Symbol    | Parameter  | Min  | Typ | Max          | Units         | Test Conditions              |
|-----------|--|------|-----|--------------|---------------|------------------------------|
| $I_{LI}$  | Input Current (for Any Input)                    |      |     | 10           | $\mu\text{A}$ | $V_{IN} = 5.25\text{V}/0.45$ |
| $I_{PP1}$ | $V_{PP}$ Supply Current                          |      |     | 5            | mA            | $\overline{CE} = V_{IL}$     |
| $I_{PP2}$ | $V_{PP}$ Supply Current during Programming Pulse |      |     | 30           | mA            | $\overline{CE} = V_{IH}$     |
| $I_{CC}$  | $V_{CC}$ Supply Current                          |      |     | 100          | mA            |                              |
| $V_{IL}$  | Input Low Level                                  | -0.1 |     | 0.8          | V             |                              |
| $V_{IH}$  | Input High Level                                 | 2.0  |     | $V_{CC} + 1$ | V             |                              |

**A.C. PROGRAMMING CHARACTERISTICS**  $T_A = 25^\circ\text{C} \pm 5^\circ\text{C}$ ,  $V_{CC}^{(1)} = 5\text{V} \pm 5\%$ ,  $V_{PP}^{(1,2)} = 25\text{V} \pm 1\text{V}$

| Symbol     | Parameter                           | Min | Typ | Max | Units         | Test Conditions*         |
|------------|-------------------------------------|-----|-----|-----|---------------|--------------------------|
| $t_{AS}$   | Address Setup Time                  | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{OES}$  | $\overline{OE}$ Setup Time          | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{DS}$   | Data Setup Time                     | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{AH}$   | Address Hold Time                   | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{OEHL}$ | $\overline{OE}$ Hold Time           | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{DH}$   | Data Hold Time                      | 2   |     |     | $\mu\text{s}$ |                          |
| $t_{DFP}$  | Output Enable to Output Float Delay | 0   |     | 200 | ns            | $\overline{CE} = V_{IL}$ |
| $t_{OE}$   | Output Enable to Output Delay       |     |     | 200 | ns            | $\overline{CE} = V_{IL}$ |
| $t_{PW}$   | Program Pulse Width                 | 45  | 50  | 55  | ms            |                          |
| $t_{PRT}$  | Program Pulse Rise Time             | 5   |     |     | ns            |                          |
| $t_{PFT}$  | Program Pulse Fall Time             | 5   |     |     | ns            |                          |

### \*A.C. CONDITIONS OF TEST

Input Rise and Fall Times (10% to 90%) . . . . . 20 ns

Input Pulse Levels . . . . . 0.8V to 2.2V

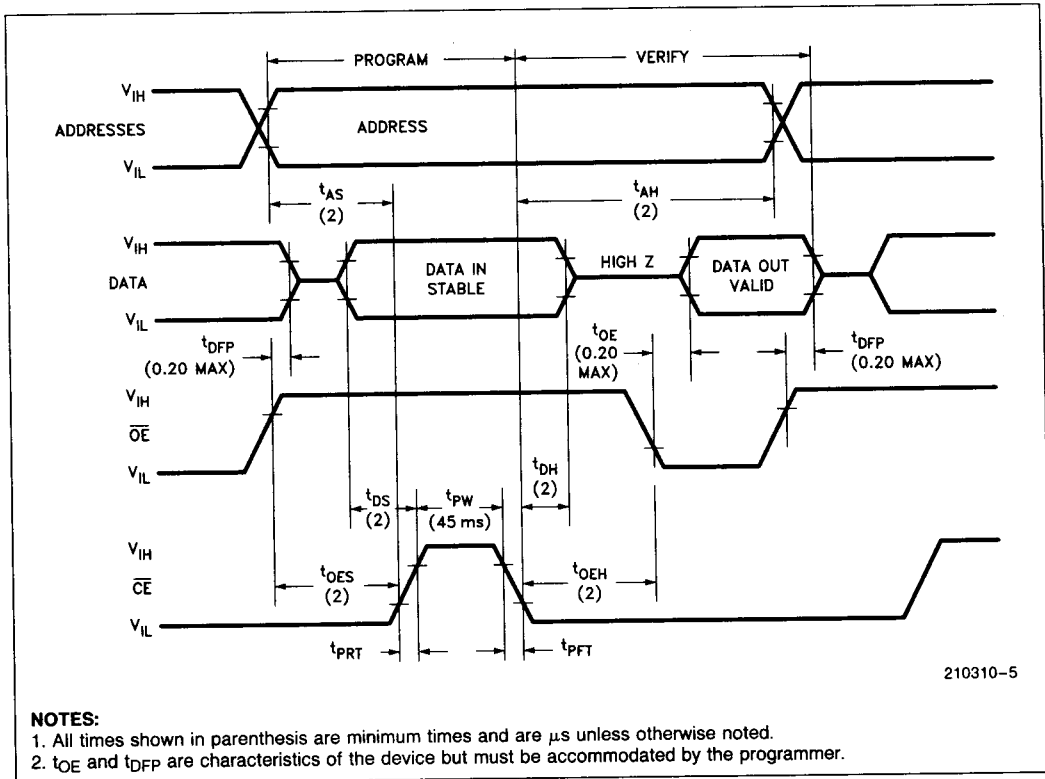
Input Timing Reference Level . . . . . 0.8V and 2V

Output Timing Reference Level . . . . . 0.8V and 2V

#### NOTES:

- $V_{CC}$  must be applied simultaneously or before  $V_{PP}$  and removed simultaneously or after  $V_{PP}$ . The 2716 must not be inserted into or removed from a board with  $V_{PP}$  at  $25 \pm 1\text{V}$  to prevent damage to the device.
- The maximum allowable voltage which may be applied to the  $V_{PP}$  pin during programming is +26V. Care must be taken when switching the  $V_{PP}$  supply to prevent overshoot exceeding this 26V maximum specification.

**PROGRAMMING WAVEFORMS**



**REVISION HISTORY**

| Number | Description   |
|--------|---|
| 03     | Deleted -5 and -6 speed bins. Added Express options.<br>Added Standard Programming Flowchart.<br>Revised Pin Configuration and Block Diagram. |