27C040
4M (512K x 8) CHMOS EPROM

- **JEDEC Approved EPROM Pinout**
  - **— 32-Pin DIP**
  - **— Simple Upgrade from Lower Densities**
- **Easy Upgrade Capability to 8 Mbit Density**
- **Versatile EPROM Features**
  - **— CMOS and TTL Compatibility**
  - **— Two Line Control**
- **Fast Programming**
  - **— Quick-Pulse Programming™ Algorithm**
  - **— Programming Time as Fast as 60 Seconds**
- **High-Performance**
  - **— 150 ns, ±10% V_{CC}**
  - **— 50 mA I_{CC} Active**

The Intel 27C040 is a 5V-only, 4,194,304-bit Erasable Programmable Read Only Memory, organized as 524,288 words of 8 bits each. It is pin compatible with lower density DIP EPROMs (JEDEC) and provides for simple upgrade to 8 Mbits in the future.

The 27C040 represents state-of-the-art 1 micron CMOS manufacturing technology while providing unequaled performance. Its 150 ns speed (T_{ACC}) offers no-wait-state operation with high performance CPUs in applications ranging from numerical control to office automation to telecommunications.

The 27C040 is equally at home in both a TTL or CMOS environment. It programs as fast as 60 seconds using Intel's industry leading Quick-Pulse Programming algorithm.

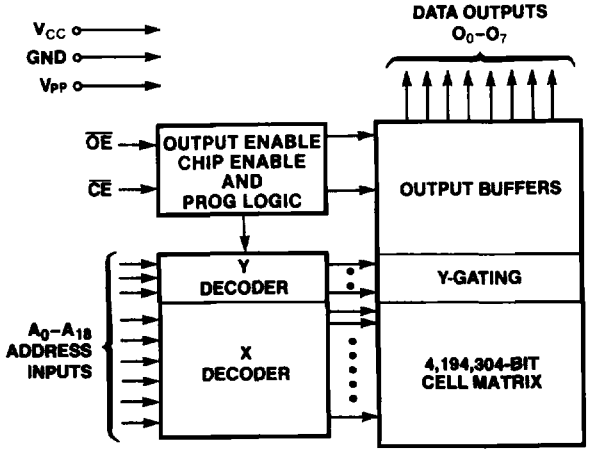


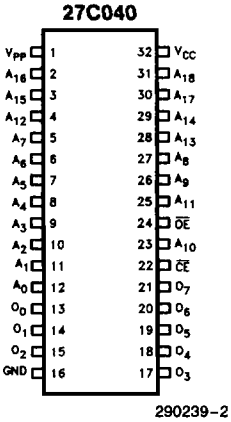
Figure 1. Block Diagram

September 1990
Order Number: 290239-002

Pin Names

A_0–A_{19}	ADDRESSES
$\overline{CE}$	CHIP ENABLE
$\overline{OE}$	OUTPUT ENABLE
$\overline{PGM}$	PROGRAM
O_0-O_7	OUTPUTS
NC	NO INTERNAL CONNECT

8Mbit	2Mbit	1Mbit	512K	256K
A_{19}	V_{PP}	V_{PP}		
A_{16}	A_{16}	A_{16}		
A_{15}	A_{15}	A_{15}	A_{15}	V_{PP}
A_{12}	A_{12}	A_{12}	A_{12}	A_{12}
A_7	A_7	A_7	A_7	A_7
A_6	A_6	A_6	A_6	A_6
A_5	A_5	A_5	A_5	A_5
A_4	A_4	A_4	A_4	A_4
A_3	A_3	A_3	A_3	A_3
A_2	A_2	A_2	A_2	A_2
A_1	A_1	A_1	A_1	A_1
A_0	A_0	A_0	A_0	A_0
O_0	O_0	O_0	O_0	O_0
O_1	O_1	O_1	O_1	O_1
O_2	O_2	O_2	O_2	O_2
GND	GND	GND	GND	GND



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256K	512K	1Mbit	2Mbit	8Mbit
		V_{CC}	V_{CC}	V_{CC}
		$\overline{PGM}$	$\overline{PGM}$	A_{18}
V_{CC}	V_{CC}	NC	A_{17}	A_{17}
A_{14}	A_{14}	A_{14}	A_{14}	A_{14}
A_{13}	A_{13}	A_{13}	A_{13}	A_{13}
A_8	A_8	A_8	A_8	A_8
A_9	A_9	A_9	A_9	A_9
A_{11}	A_{11}	A_{11}	A_{11}	A_{11}
$\overline{OE}$	$\overline{OE}/V_{PP}$	$\overline{OE}$	$\overline{OE}$	$\overline{OE}/V_{PP}$
A_{10}	A_{10}	A_{10}	A_{10}	A_{10}
$\overline{CE}$	$\overline{CE}$	$\overline{CE}$	$\overline{CE}$	$\overline{CE}$
O_7	O_7	O_7	O_7	O_7
O_6	O_6	O_6	O_6	O_6
O_5	O_5	O_5	O_5	O_5
O_4	O_4	O_4	O_4	O_4
O_3	O_3	O_3	O_3	O_3

Figure 2. DIP Pin Configuration

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ABSOLUTE MAXIMUM RATINGS*

Operating Temperature ..... 0°C to 70°C(1)

Temperature Under Bias ..... −10°C to 80°C

Storage Temperature ..... −65°C to 125°C

Voltage on Any Pin (except A_9, V_{CC} and V_{PP}) with Respect to GND ..... −0.6V to 6.5V(2)

Voltage on A_9 with Respect to GND ..... −0.6V to 13.0V(2)

V_{PP} Supply Voltage with Respect to GND ..... −0.6V to 14V(2)

V_{CC} Supply Voltage with Respect to GND ..... −0.6V to 7.0V(2)

NOTICE: This data sheet contains information on products in the sampling and initial production phases of development. 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.*

READ OPERATION DC CHARACTERISTICS V_{CC} = 5.0V ±10%

Symbol	Parameter	Notes	Min	Typ	Max	Unit	Test Condition
I_{LI}	Input Load Current	7		0.01	1.0	µA	V_{IN} = 0V to 5.5V
I_{LO}	Output Leakage Current				±10	µA	V_{OUT} = 0V to 5.5V
I_{SB}	V_{CC} Standby Current				1.0	mA	$\overline{CE}$ = V_{IH}
					100	µA	$\overline{CE}$ = V_{CC} ±0.2V
I_{CC}	V_{CC} Operating Current	3			50	mA	$\overline{CE}$ = V_{IL}, f = 5 MHz, I_{OUT} = 0 mA
I_{PP}	V_{PP} Operating Current	3			10	µA	V_{PP} = V_{CC}
I_{OS}	Output Short Circuit Current	4, 6			100	mA	
V_{IL}	Input Low Voltage		−0.5		0.8	V	
V_{IH}	Input High Voltage		2.0		V_{CC} + 0.5	V	
V_{OL}	Output Low Voltage				0.45	V	I_{OL} = 2.1 mA
V_{OH}	Output High Voltage		2.4			V	I_{OH} = −400 µA
V_{PP}	V_{PP} Operating Voltage	5	V_{CC} − 0.7		V_{CC}	V	

NOTES:
1. Operating temperature is for commercial product defined by this specification.
2. Minimum DC voltage is −0.5V on input/output pins. During transitions, this level may undershoot to −2.0V for periods < 20 ns. Maximum DC voltage on input/output pins is V_{CC} + 0.5V which, during transitions, may overshoot to V_{CC} + 2.0V for periods < 20 ns.
3. Maximum active power usage is the sum I_{PP} + I_{CC}. Maximum current is with outputs O_0 to O_7 unloaded.
4. Output shorted for no more than one second. No more than one output shorted at a time.
5. V_{PP} may be connected directly to V_{CC}, or may be one diode voltage drop below V_{CC}. V_{CC} must be applied simultaneously or before V_{PP} and removed simultaneously or after V_{PP}.
6. Sampled, not 100% tested.
7. Typical limits are at V_{CC} = 5V, T_A = 25°C.

READ OPERATION AC CHARACTERISTICS[1] V_{CC} = 5.0V ±10%

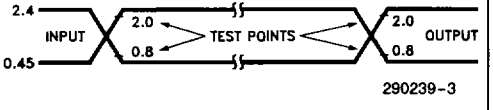
Versions[4]		V_{CC} ±10%	27C040-150V10		27C040-200V10		Units
Symbol	Parameter	Notes	Min	Max	Min	Max	
t_{ACC}	Address to Output Delay			150		200	ns
t_{CE}	$\overline{CE}$ to Output Delay	2		150		200	ns
t_{OE}	$\overline{OE}$ to Output Delay	2		60		70	ns
t_{DF}	$\overline{OE}$ High to Output High Z	3		50		60	ns
t_{OH}	Output Hold from Addresses, $\overline{CE}$ or $\overline{OE}$ Change-Whichever is First	3	0		0		ns

NOTES:
1. See AC Input/Output Reference Waveform for timing measurements.
2. $\overline{OE}$ may be delayed up to $t_{CE}-t_{OE}$ after the falling edge of $\overline{CE}$ without impact on t_{CE}.
3. Sampled, not 100% tested.
4. Model number prefixes: No prefix = CERDIP.
5. Typical values are for T_A = 25°C and nominal supply voltages.

CAPACITANCE[3] T_A = 25°C, f = 1MHz

Symbol	Parameter	Typ[5]	Max	Unit	Conditions
C_{IN}	Input Capacitance	4	8	pF	V_{IN} = 0V
C_{OUT}	Output Capacitance	8	12	pF	V_{OUT} = 0V
C_{VPP}	V_{PP} Capacitance	18	25	pF	V_{PP} = 0V

AC INPUT/OUTPUT REFERENCE WAVEFORM



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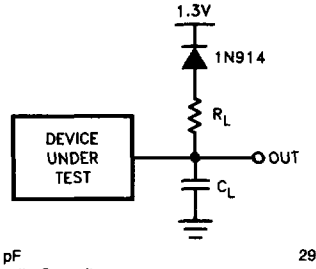
AC test inputs are driven at V_{OH} (2.4 V_{TTL}) for a logic "1" and V_{OL} (0.45 V_{TTL}) for a logic "0". Input timing begins at V_{IH} (2.0 V_{TTL}) and V_{IL} (0.8 V_{TTL}). Output timing ends at V_{IH} and V_{IL}. Input rise and fall times (10% to 90%) ≤ 10 ns.

AC TESTING LOAD CIRCUIT



C_L = 100 pF
C_L Includes Jig Capacitance
R_L = 3.3 KΩ

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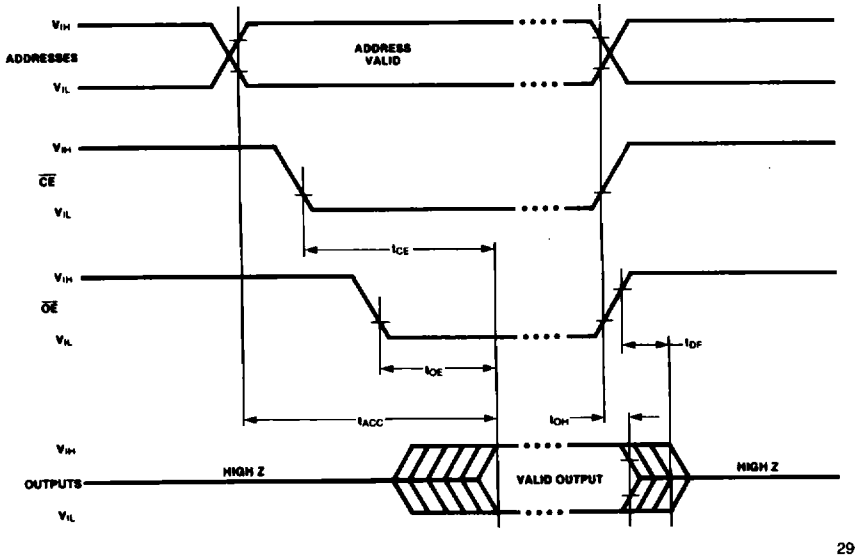
AC WAVEFORMS



DEVICE OPERATION

The Mode Selection table lists 27C040 operating modes. Read Mode requires a single 5V power supply. All inputs, except V_{CC} and V_{PP}, and A_9 during int$_e$ligent Identifier Mode, are TTL or CMOS.

Table 1. Mode Selection

Mode		Notes	$\overline{CE}$	$\overline{OE}$	A_9	A_0	V_{PP}	V_{CC}	Outputs
Read		1	V_{IL}	V_{IL}	X	X	V_{CC}	V_{CC}	D_{OUT}
Output Disable			V_{IL}	V_{IH}	X	X	V_{CC}	V_{CC}	High Z
Standby			V_{IH}	X	X	X	V_{CC}	V_{CC}	High Z
Program		2	V_{IL}	V_{IH}	X	X	V_{PP}	V_{CP}	D_{IN}
Program Verify			V_{IH}	V_{IL}	X	X	V_{PP}	V_{CP}	D_{OUT}
Program Inhibit			V_{IH}	V_{IH}	X	X	V_{PP}	V_{CP}	High Z
int$_e$ligent Identifier	Manufacturer	2, 3	V_{IL}	V_{IL}	V_{ID}	V_{IL}	V_{CC}	V_{CC}	89 H
	Device		V_{IL}	V_{IL}	V_{ID}	V_{IH}	V_{CC}	V_{CC}	3D H

NOTES:
1. X can be V_{IL} or V_{IH}
2. See DC Programming Characteristics for V_{CP}, V_{PP} and V_{ID} voltages.
3. A_1–A_8, A_{10}–A_{18} = V_{IL}

Read Mode

The 27C040 has two control functions; both must be enabled to obtain data at the outputs. $\overline{CE}$ is the power control and device select. $\overline{OE}$ controls the output buffers to gate data to the outputs. With addresses stable, the address access time (t_{ACC}) equals the delay from $\overline{CE}$ to output (t_{CE}). Outputs display valid data t_{OE} after $\overline{OE}$'s falling edge, assuming t_{ACC} and t_{CE} times are met.

V_{CC} must be applied simultaneously or before V_{PP} and removed simultaneously or after V_{PP}.

Two Line Output Control

EPROMs are often used in larger memory arrays. Intel provides two control inputs to accommodate multiple memory connections. Two-line control provides for:

a) lowest possible memory power dissipation

b) complete assurance that data bus contention will not occur

To efficiently use these two control inputs, and address decoder should enable $\overline{CE}$, while $\overline{OE}$ should be connected to all memory devices and the system's $\overline{READ}$ control line. This assures that only selected memory devices have active outputs while deselected memory devices are in Standby Mode.

Standby Mode

Standby Mode substantially reduces V_{CC} current. When $\overline{CE}$ = V_{IH}, the outputs are in a high impedance state, independent of $\overline{OE}$.

Program Mode

Caution: Exceeding 14V on V_{PP} will permanently damage the device.

Initially, and after each erasure, all EPROM bits are in the "1" state. Data is introduced by selectively programming "0s" into the desired bit locations. Although only "0s" are programmed, the data word can contain both "1s" and "0s". Ultraviolet light erasure is the only way to change "0s" to "1s".

Program Mode is entered when V_{PP} is raised to 12.75V. Data is introduced by applying an 8-bit word to the output pins. Pulsing $\overline{CE}$ low while $\overline{OE}$ = V_{IH} programs that data into the device.

Program Verify

A verify should be performed following a program operation to determine that bits have been correctly programmed. With V_{CC} at 6.25V a substantial program margain is ensured. The verify is performed with $\overline{CE}$ at V_{IH}. Valid data is available t_{OE} after $\overline{OE}$ falls low.

Program Inhibit

Program Inhibit Mode allows parallel programming of multiple EPROMs with different data. $\overline{CE}$-high inhibits programming of non-targeted devices. Except for $\overline{CE}$ and $\overline{OE}$, parallel EPROMs may have common inputs.

int$_e$ligent Identifier™ Mode

The int$_e$ligent Identifier Mode will determine an EPROM's manufacturer and device type, allowing programming equipment to automatically match a device with its proper programming algorithm.

This mode is activated when a programmer forces 12V ±0.5V on A_9. With $\overline{CE}$, $\overline{OE}$, A_1–A_8, and A_{10}–A_{18} at V_{IL}, A_0 = V_{IL} will present the manufacturer code and A_0 = V_{IH} the device code. This mode functions in the 25°C ±5°C ambient temperature range required during programming.

UPGRADE PATH

Future upgrade to the 8 Mbit density is easily accomplished due to the standardized pin configuration of the 27C040. A jumper between V_{CC} and A_{19} allows upgrade using the V_{PP} pin. Systems designed for 4 Mbit program memories today can be upgraded to 8 Mbit in the future with no circuit board changes.

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SYSTEM CONSIDERATIONS

EPROM power switching characteristics require careful device decoupling. System designers are interested in 3 supply current issues: standby current levels (I_{SB}), active current levels (I_{CC}), and transient current peaks produced by falling and rising edges of $\overline{CE}$. Transient current magnitudes depend on the device output's capacitive and inductive loading. Two-line control and proper decoupling capacitor selection will suppress transient voltage peaks. Each device should have a 0.1 μF ceramic capacitor connected between its V_{CC} and GND. This high frequency, low inherent-inductance capacitor should be placed as close as possible to the device. Additionally, for every 8 devices, a 4.7 μF electrolytic capacitor should be placed at the array's power supply connection between V_{CC} and GND. The bulk capacitor will overcome voltage slumps caused by PC board trace inductances.

ERASURE CHARACTERISTICS

Erasure begins when EPROMs are exposed to light with wavelengths shorter than approximately 4000 Angstroms (Å). It should be noted that sunlight and certain fluorescent lamps have wavelengths in the 3000–4000Å range. Data shows that constant exposure to room level fluorescent lighting can erase an EPROM in approximately 3 years, while it takes approximately 1 week when exposed to direct sunlight. If the device is exposed to these lighting conditions for extended periods, opaque labels should be placed over the window to prevent unintentional erasure.

The recommended erasure procedure is exposure to ultraviolet light of wavelength 2537Å. The integrated dose (UV intensity $\times$ exposure time) for erasure should be a minimum of 15 Wsec/cm^2. Erasure time is approximately 15 to 20 minutes using an ultraviolet lamp with a 12000 μW/cm^2 power rating. The EPROM should be placed within 1 inch of the lamp tubes. An EPROM can be permanently damaged if the integrated dose exceeds 7258 Wsec/cm^2 (1 week @ 12000 μW/cm^2).

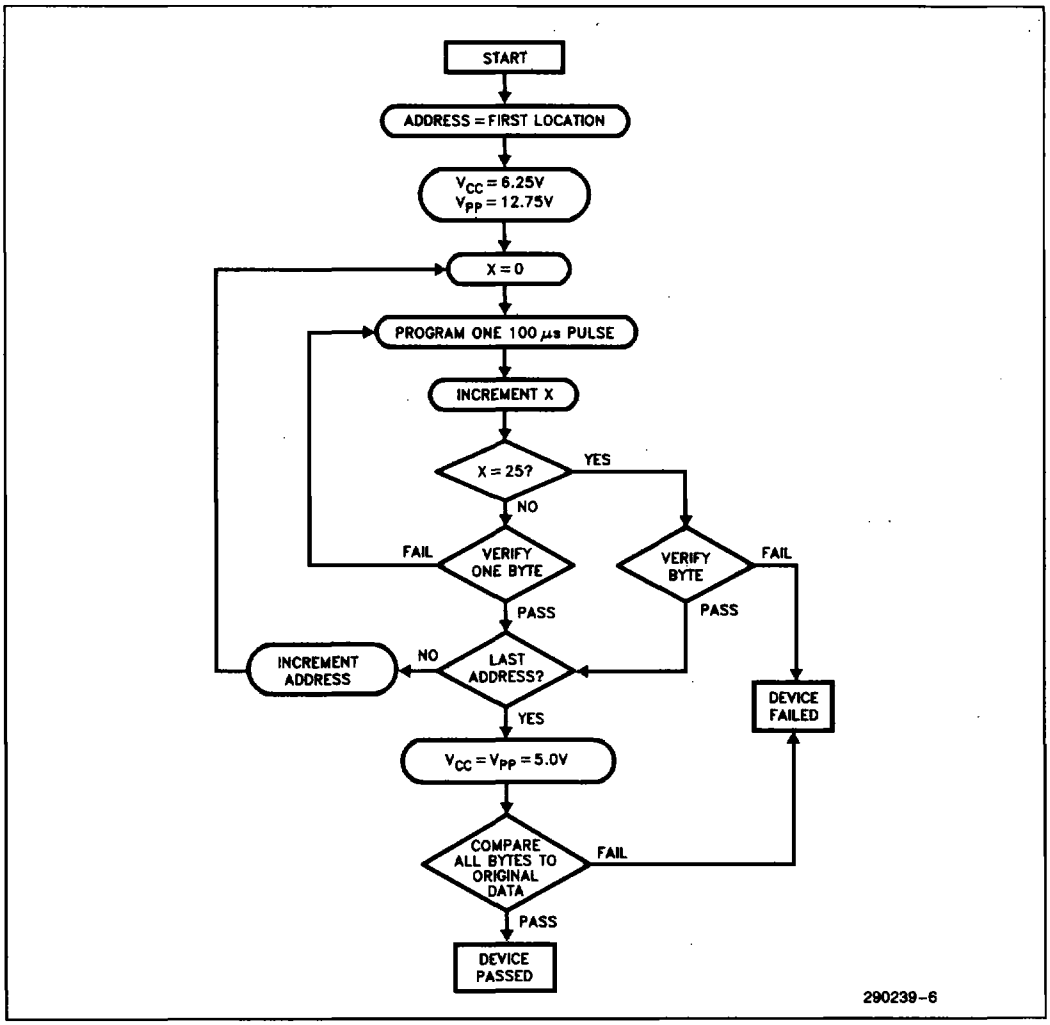


Figure 3. Quick-Pulse Programming Algorithm

Quick-Pulse Programming™ Algorithm

The Quick-Pulse Programming Algorithm programs Intel's 27C040. Developed to substantially reduce programming throughput, this algorithm can program the 27C040 as fast as 60 seconds. Actual programming time depends on programmer overhead.

The Quick-Pulse Programming Algorithm employs a 100 µs pulse followed by a byte verification to determine when the addressed byte has been successfully programmed. The algorithm terminates if 25 attempts fail to program a byte.

The entire program pulse/byte verify sequence is performed with V_{PP} = 12.75V and V_{CC} = 6.25V. When programming is complete, all bytes are compared to the original data with V_{CC} = V_{PP} = 5.0V.

DC PROGRAMMING CHARACTERISTICS $T_A = 25°C \pm 5°C$

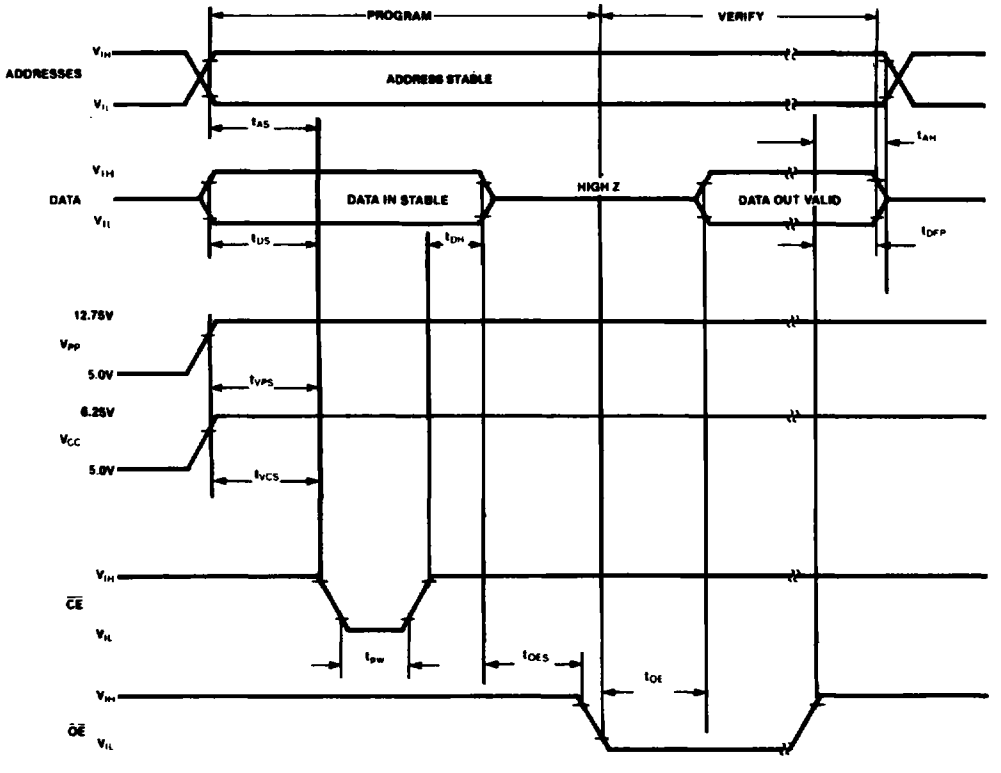
Symbol	Parameter	Notes	Min	Typ	Max	Unit	Test Condition
I_{LI}	Input Load Current				1	μA	$V_{IN} = V_{IL}$ or V_{IH}
I_{CP}	V_{CC} Program Current	1			50	mA	$\overline{CE} = V_{IL}$
I_{PP}	V_{PP} Program Current	1			50	mA	$\overline{CE} = V_{IL}$
V_{IL}	Input Low Voltage		−0.1		0.8	V	
V_{IH}	Input High Voltage		2.4		6.5	V	
V_{OL}	Output Low Voltage (Verify)				0.45	V	$I_{OL} = 2.1$ mA
V_{OH}	Output High Voltage (Verify)		3.5			V	$I_{OH} = -2.5$ mA
V_{ID}	A_9 int$_e$ligent Identifier Voltage		11.5	12.0	12.5	V	
V_{PP}	V_{PP} Program Voltage	2, 3	12.5	12.75	13.0	V	
V_{CP}	V_{CC} Supply Voltage (Program)	2	6.0	6.25	6.5	V	

AC PROGRAMMING CHARACTERISTICS(4) $T_A = 25°C \pm 5°C$

Symbol	Parameter	Notes	Min	Typ	Max	Unit
t_{VCS}	V_{CP} Setup Time	2	2			μs
t_{VPS}	V_{PP} Setup Time	2	2			μs
t_{AS}	Address Setup Time		2			μs
t_{DS}	Data Setup Time		2			μs
t_{PW}	$\overline{CE}$ Program Pulse Width		95	100	105	μs
t_{DH}	Data Hold Time		2			μs
t_{OES}	$\overline{OE}$ Setup Time		2			μs
t_{OE}	Data Valid from $\overline{OE}$	5			150	ns
t_{DFP}	$\overline{OE}$ High to Output High Z	5, 6	0		130	ns
t_{AH}	Address Hold Time		0			μs

NOTES:
1. Maximum current is with outputs O_0–O_7 unloaded.
2. V_{CP} must be applied simultaneously or before V_{PP} and removed simultaneously or after V_{PP}.
3. When programming, a 0.1 μF capacitor is required across V_{PP} and ground to suppress spurious voltage transients which can damage the device.
4. See AC Input/Output Reference Waveform for timing measurements.
5. t_{OE} and t_{DFP} are device characteristics but must be accommodated by the programmer.
6. Sampled, not 100% tested.

PROGRAMMING WAVEFORMS



REVISION HISTORY

Number	Description
02	Revised general datasheet structure, text to improve clarity. Combined TTL/NMOS and CMOS Read Operation DC Characteristics Tables. Mode Selection table-Program Inhibit-$\overline{OE}$ revised from **X** to V_{IH}.