

## Features

- Serial Configuration one-time programmable (OTP) read-only memory designed to store configuration bitstreams of Xilinx FPGA devices
- Simple interface to the FPGA requires only one user I/O pin
- Cascadable for storing longer or multiple bitstreams
- Programmable reset polarity (active High or active Low) for compatibility with different FPGA solutions
- Supports the XC4000EX/XL fast configuration mode (15.0 MHz)
- Low-power CMOS floating gate process
- Available in 5 V and 3.3 V versions
- Available in compact plastic 8-pin DIP, 8-pin SOIC, 8-pin VOIC, or 20-pin PLCC packages.
- Programming support by leading programmer manufacturers.
- Design support using the Xilinx Alliance and Foundation series software packages.

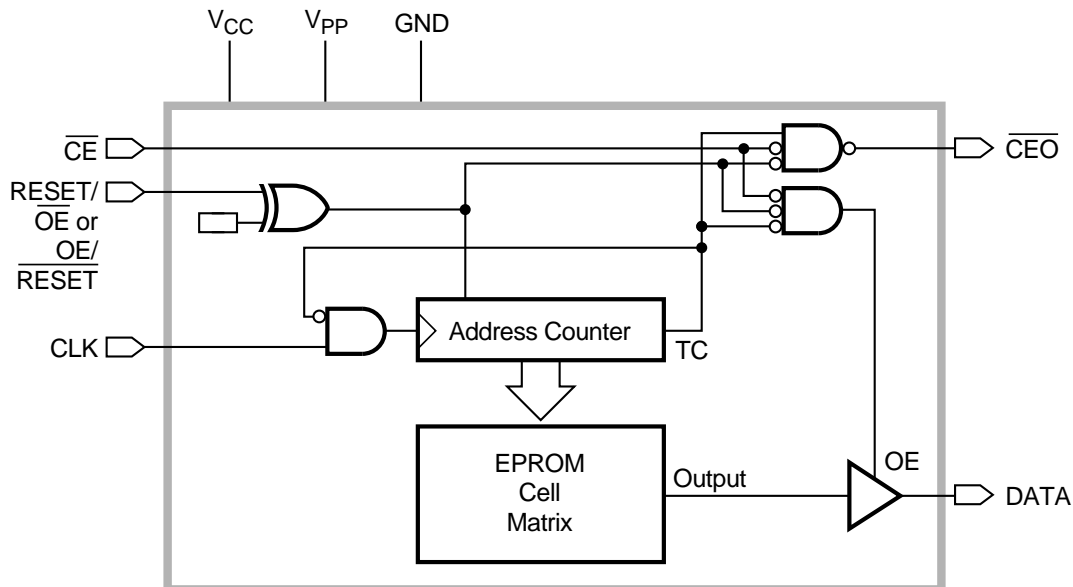
## Description

The XC1700 family of serial configuration PROMs (SCPs) provides an easy-to-use, cost-effective method for storing Xilinx FPGA configuration bitstreams.

When the FPGA is in Master Serial mode, it generates a configuration clock that drives the SCP. A short access time after the rising clock edge, data appears on the SCP DATA output pin that is connected to the FPGA DIN pin. The FPGA generates the appropriate number of clock pulses to complete the configuration. Once configured, it disables the SCP. When the FPGA is in Slave Serial mode, the SCP and the FPGA must both be clocked by an incoming signal.

Multiple devices can be concatenated by using the  $\overline{CEO}$  output to drive the  $\overline{CE}$  input of the following device. The clock inputs and the DATA outputs of all SCPs in this chain are interconnected. All devices are compatible and can be cascaded with other members of the family.

For device programming, either the Xilinx Alliance or the Foundation series development systems compiles the FPGA design file into a standard HEX format which is then transferred to most commercial PROM programmers.



X3185

Figure 1: Simplified Block Diagram (does not show programming circuit)

## Pin Description

### DATA

Data output, 3-stated when either  $\overline{CE}$  or  $\overline{OE}$  are inactive. During programming, the DATA pin is I/O. Note that  $\overline{OE}$  can be programmed to be either active High or active Low.

### CLK

Each rising edge on the CLK input increments the internal address counter, if both  $\overline{CE}$  and  $\overline{OE}$  are active.

### RESET/ $\overline{OE}$

When High, this input holds the address counter reset and 3-states the DATA output. The polarity of this input pin is programmable as either RESET/ $\overline{OE}$  or OE/RESET. To avoid confusion, this document describes the pin as RESET/ $\overline{OE}$ , although the opposite polarity is possible on all devices. When RESET is active, the address counter is held at zero, and the DATA output is 3-stated. The polarity of this input is programmable. The default is active High RESET, but the preferred option is active Low  $\overline{RESET}$ , because it can be driven by the FPGA's  $\overline{INIT}$  pin.

The polarity of this pin is controlled in the programmer interface. This input pin is easily inverted using the Xilinx HW-130 programmer software. Third-party programmers have different methods to invert this pin.

### $\overline{CE}$

When High, this pin disables the internal address counter, 3-states the DATA output, and forces the device into low- $I_{CC}$  standby mode.

### $\overline{CEO}$

Chip Enable output, to be connected to the  $\overline{CE}$  input of the next SCP in the daisy chain. This output is Low when the  $\overline{CE}$  and  $\overline{OE}$  inputs are both active AND the internal address counter has been incremented beyond its Terminal Count (TC) value. In other words: when the PROM has been read,  $\overline{CEO}$  will follow  $\overline{CE}$  as long as  $\overline{OE}$  is active. When  $\overline{OE}$  goes inactive,  $\overline{CEO}$  stays High until the PROM is reset. Note that  $\overline{OE}$  can be programmed to be either active High or active Low.

### $V_{PP}$

Programming voltage. No overshoot above the specified max voltage is permitted on this pin. For normal read operation, this pin *must* be connected to  $V_{CC}$ . Failure to do so may lead to unpredictable, temperature-dependent operation and severe problems in circuit debugging. *Do not leave  $V_{PP}$  floating!*

### $V_{CC}$ and GND

$V_{CC}$  is positive supply pin and GND is ground pin.

## Serial PROM Pinouts

Pin Name	8-Pin	20-Pin
DATA	1	2
CLK	2	4
RESET/ $\overline{OE}$ (OE/RESET)	3	6
$\overline{CE}$	4	8
GND	5	10
$\overline{CEO}$	6	14
$V_{PP}$	7	17
$V_{CC}$	8	20

## Capacity

Device	Configuration Bits
XC1736E	36,288
XC1765E or EL	65,536
XC17128E or EL	131,072
XC17256E or EL	262,144
XC17512L	524,288
XC1701 or L	1,048,576

**Note:** The XC1701L, XC17512L and the XC1701 are specified in a separate datasheet.

## Number of Configuration Bits, Including Header for Xilinx FPGAs and Compatible SCP Types

Device	Configuration Bits	SCP
XC4003E	53,984	XC17128E <sup>1</sup>
XC4005E	95,008	XC17128E
XC4006E	119,840	XC17128E
XC4008E	147,552	XC17256E
XC4010E	178,144	XC17256E
XC4013E	247,968	XC17256E
XC4020E	329,312	XC1701
XC4025E	422,176	XC1701
XC4002XL	61,100	XC17128EL <sup>1</sup>
XC4005XL	151,960	XC17256EL
XC4010XL	283,424	XC17512L
XC4013XL	393,632	XC17512L
XC4020XL	521,880	XC17512L
XC4028EX/XL	668,184	XC1701L
XC4036EX/XL	832,528	XC1701L
XC4044XL	1,014,928	XC1701L
XC4052XL	1,215,368	XC1702L
XC4062XL	1,433,864	XC1702L
XC4085XL	1,924,992	XC1702L
XC5202	42,416	XC1765E
XC5204	70,704	XC17128E
XC5206	106,288	XC17128E
XC5210	165,488	XC17256E
XC5215	237,744	XC17256E

**Note:** 1. SCP type is determined by compatibility with the higher configuration frequency of the Xilinx FPGA CCLK. Designers using the default slow configuration frequency (CCLK) can use the XC1765E or XC1765EL for the noted FPGA devices.

## Controlling Serial PROMs

Most connections between the FPGA device and the Serial PROM are simple and self-explanatory.

- The DATA output(s) of the Serial PROM(s) drives the DIN input of the lead FPGA device.
- The master FPGA CCLK output drives the CLK input(s) of the Serial PROM(s).
- The  $\overline{CE}$  output of a Serial PROM drives the  $\overline{CE}$  input of the next Serial PROM in a daisy chain (if any).
- The  $\overline{RESET/OE}$  input of all Serial PROMs is best driven by the  $\overline{INIT}$  output of the XC4000 lead FPGA device. This connection assures that the Serial PROM address counter is reset before the start of any (re)configuration, even when a reconfiguration is initiated by a  $V_{CC}$  glitch. Other methods – such as driving  $\overline{RESET/OE}$  from  $\overline{LDC}$  or system reset – assume that the Serial PROM internal power-on-reset is always in step with the FPGA's internal power-on-reset, which may not be a safe assumption.
- The  $\overline{CE}$  input of the lead (or only) Serial PROM is driven by the  $\overline{DONE/PRGM}$  or  $\overline{DONE}$  output of the lead FPGA device, provided that  $\overline{DONE/PRGM}$  is not permanently grounded. Otherwise,  $\overline{LDC}$  can be used to drive  $\overline{CE}$ , but must then be unconditionally High during user operation.  $\overline{CE}$  can also be permanently tied Low, but this keeps the DATA output active and causes an unnecessary supply current of 10 mA maximum.

## FPGA Master Serial Mode Summary

The I/O and logic functions of the Configurable Logic Blocks and their associated interconnections are established by a configuration program. The program is loaded either automatically upon power up, or on command, depending on the state of the three FPGA mode pins. In Master Serial mode, the FPGA automatically loads the configuration program from an external memory. The Serial Configuration PROM has been designed for compatibility with the Master Serial mode.

Upon power-up or reconfiguration, an FPGA enters the Master Serial mode whenever all three of the FPGA mode-select pins are Low ( $M0=0$ ,  $M1=0$ ,  $M2=0$ ). Data is read from the Serial Configuration PROM sequentially on a single data line. Synchronization is provided by the rising edge of the temporary signal CCLK, which is generated during configuration.

Master Serial Mode provides a simple configuration interface. Only a serial data line and two control lines are required to configure an FPGA. Data from the Serial Configuration PROM is read sequentially, accessed via the internal address and bit counters which are incremented on every valid rising edge of CCLK.

If the user-programmable, dual-function DIN pin on the FPGA is used only for configuration, it must still be held at a defined level during normal operation. The XC4000 fam-

ily takes care of this automatically with an on-chip default pull-up resistor.

### Programming the FPGA With Counters Unchanged Upon Completion

When multiple FPGA-configurations for a single FPGA are stored in a Serial Configuration PROM, the  $\overline{OE}$  pin should be tied Low. Upon power-up, the internal address counters are reset and configuration begins with the first program stored in memory. Since the  $\overline{OE}$  pin is held Low, the address counters are left unchanged after configuration is complete. Therefore, to reprogram the FPGA with another program, the  $D/\overline{P}$  line is pulled Low and configuration begins at the last value of the address counters.

This method fails if a user applies  $\overline{RESET}$  during the FPGA configuration process. The FPGA aborts the configuration and then restarts a new configuration, as intended, but the Serial PROM does not reset its address counter, since it never saw a High level on its  $\overline{OE}$  input. The new configuration, therefore, reads the remaining data in the PROM and interprets it as preamble, length count etc. Since the FPGA is the master, it issues the necessary number of CCLK

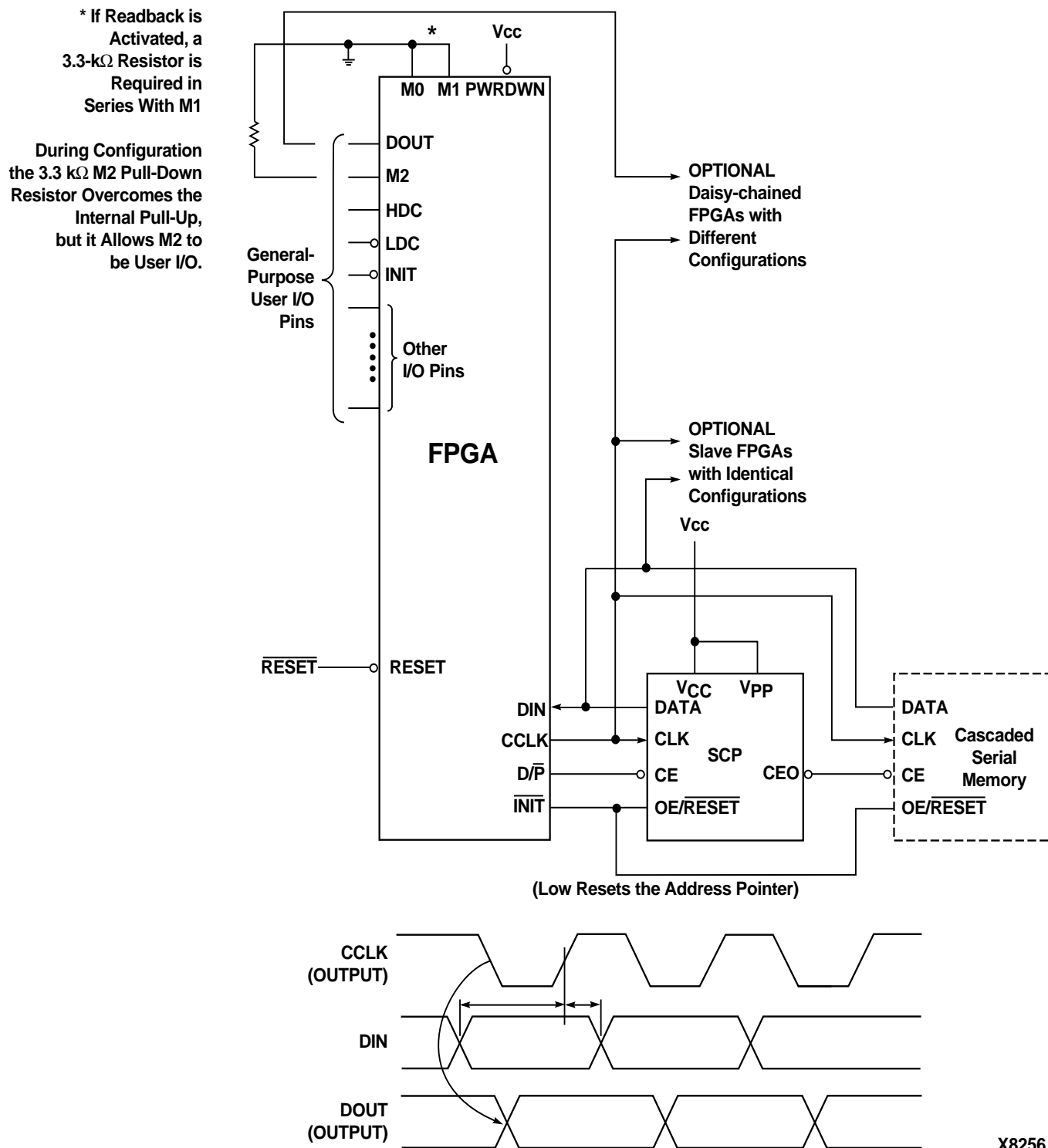
pulses, up to 16 million ( $2^{24}$ ) and  $D/\overline{P}$  goes High. However, the FPGA configuration will be completely wrong, with potential contentions inside the FPGA and on its output pins. This method must, therefore, never be used when there is any chance of external reset during configuration.

### Cascading Serial Configuration PROMs

For multiple FPGAs configured as a daisy-chain, or for future FPGAs requiring larger configuration memories, cascaded SCPs provide additional memory. After the last bit from the first SCP is read, the next clock signal to the SCP asserts its  $\overline{CEO}$  output Low and disables its DATA line. The second SCP recognizes the Low level on its  $\overline{CE}$  input and enables its DATA output. See [Figure 2](#).

After configuration is complete, the address counters of all cascaded SCPs are reset if the FPGA  $\overline{RESET}$  pin goes Low, assuming the SCP reset polarity option has been inverted.

To reprogram the FPGA with another program, the  $D/\overline{P}$  line goes Low and configuration begins where the address counters had stopped. In this case, avoid contention between DATA and the configured I/O use of DIN.



**Figure 2: Master Serial Mode.** The one-time-programmable Serial Configuration PROM supports automatic loading of configuration programs. Multiple devices can be cascaded to support additional FPGA. An early D/P inhibits the PROM data output one CCLK cycle before the FPGA I/Os become active.

## Standby Mode

The PROM enters a low-power standby mode whenever  $\overline{CE}$  is asserted High. The output remains in a high impedance state regardless of the state of the  $\overline{OE}$  input.

## Programming the XC1700 Family Serial PROMs

The devices can be programmed on programmers supplied by Xilinx or qualified third-party vendors. The user must ensure that the appropriate programming algorithm and the latest version of the programmer software are used. The wrong choice can permanently damage the device.

Table 1: Truth Table for XC1700 Control Inputs

Control Inputs		Internal Address	Outputs		
RESET	CE		DATA	CEO	I <sub>cc</sub>
Inactive	Low	if address ≤ TC: increment if address > TC: don't change	active 3-state	High Low	active reduced
Active	Low	Held reset	3-state	High	active
Inactive	High	Not changing	3-state	High	standby
Active	High	Held reset	3-state	High	standby

**Notes:** 1. The XC1700 RESET input has programmable polarity  
 2. TC = Terminal Count = highest address value. TC+1 = address 0.

**Important:** Always tie the V<sub>PP</sub> pin to V<sub>CC</sub> in your application. Never leave V<sub>PP</sub> floating.

## XC1736E, XC1765E, XC17128E and XC17256E

### Absolute Maximum Ratings

Symbol	Description		Units
$V_{CC}$	Supply voltage relative to GND	-0.5 to +7.0	V
$V_{PP}$	Supply voltage relative to GND	-0.5 to +12.5	V
$V_{IN}$	Input voltage relative to GND	-0.5 to $V_{CC} + 0.5$	V
$V_{TS}$	Voltage applied to 3-state output	-0.5 to $V_{CC} + 0.5$	V
$T_{STG}$	Storage temperature (ambient)	-65 to +150	°C
$T_{SOL}$	Maximum soldering temperature (10 s @ 1/16 in.)	+260	°C

**Note:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time may affect device reliability.

### Operating Conditions

Symbol	Description		Min	Max	Units
$V_{CC}$	Commercial	Supply voltage relative to GND ( $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$ )	4.75	5.25	V
	Industrial	Supply voltage relative to GND ( $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ )	4.50	5.50	V

**Note:** During normal read operation  $V_{PP}$  *must* be connected to  $V_{CC}$

### DC Characteristics Over Operating Condition

Symbol	Description		Min	Max	Units
$V_{IH}$	High-level input voltage		2.0	$V_{CC}$	V
$V_{IL}$	Low-level input voltage		0	0.8	V
$V_{OH}$	High-level output voltage ( $I_{OH} = -4$ mA)	Commercial	3.86		V
$V_{OL}$	Low-level output voltage ( $I_{OL} = +4$ mA)				
$V_{OH}$	High-level output voltage ( $I_{OH} = -4$ mA)	Industrial	3.76		V
$V_{OL}$	Low-level output voltage ( $I_{OL} = +4$ mA)				
$I_{CCA}$	Supply current, active mode (at maximum frequency)			10.0	mA
$I_{CCS}$	Supply current, standby mode			50.0	$\mu\text{A}$
$I_L$	Input or output leakage current		-10.0	10.0	$\mu\text{A}$
$C_{IN}$	Input Capacitance ( $V_{IN} = \text{GND}$ , $f = 1.0\text{MHz}$ )			10.0	pF
$C_{OUT}$	Output Capacitance ( $V_{IN} = \text{GND}$ , $f = 1.0\text{MHz}$ )			10.0	pF

## XC1765EL, XC17128EL and XC17256EL

### Absolute Maximum Ratings

Symbol	Description		Units
$V_{CC}$	Supply voltage relative to GND	-0.5 to +4.0	V
$V_{PP}$	Supply voltage relative to GND	-0.5 to +12.5	V
$V_{IN}$	Input voltage with respect to GND	-0.5 to $V_{CC} + 0.5$	V
$V_{TS}$	Voltage applied to 3-state output	-0.5 to $V_{CC} + 0.5$	V
$T_{STG}$	Storage temperature (ambient)	-65 to +150	°C
$T_{SOL}$	Maximum soldering temperature (10 s @ 1/16 in.)	+260	°C

**Note:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time may affect device reliability.

### Operating Conditions

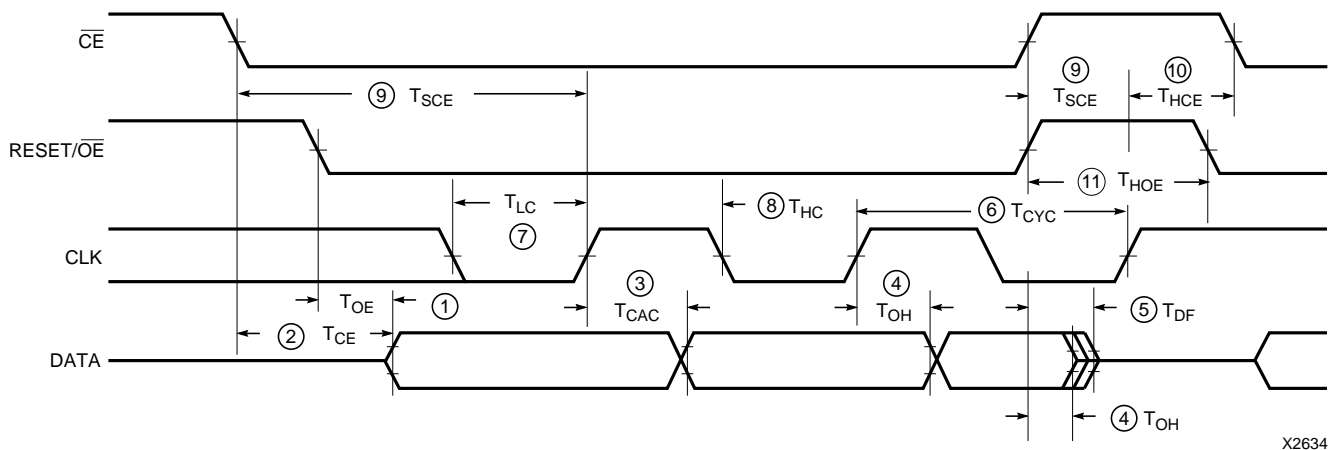
Symbol	Description		Min	Max	Units
$V_{CC}$	Commercial	Supply voltage relative to GND ( $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$ )	3.0	3.6	V
	Industrial	Supply voltage relative to GND ( $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ )	3.0	3.6	V

**Note:** During normal read operation  $V_{PP}$  *must* be connected to  $V_{CC}$

### DC Characteristics Over Operating Condition

Symbol	Description	Min	Max	Units
$V_{IH}$	High-level input voltage	2.0	$V_{CC}$	V
$V_{IL}$	Low-level input voltage	0	0.8	V
$V_{OH}$	High-level output voltage ( $I_{OH} = -3$ mA)	2.4		V
$V_{OL}$	Low-level output voltage ( $I_{OL} = +3$ mA)		0.4	V
$I_{CCA}$	Supply current, active mode (at maximum frequency)		5.0	mA
$I_{CCS}$	Supply current, standby mode		50.0	$\mu\text{A}$
$I_L$	Input or output leakage current	-10.0	10.0	$\mu\text{A}$
$C_{IN}$	Input Capacitance ( $V_{IN} = \text{GND}$ , $f = 1.0\text{MHz}$ )		10.0	pF
$C_{OUT}$	Output Capacitance ( $V_{IN} = \text{GND}$ , $f = 1.0\text{MHz}$ )		10.0	pF

## AC Characteristics Over Operating Condition

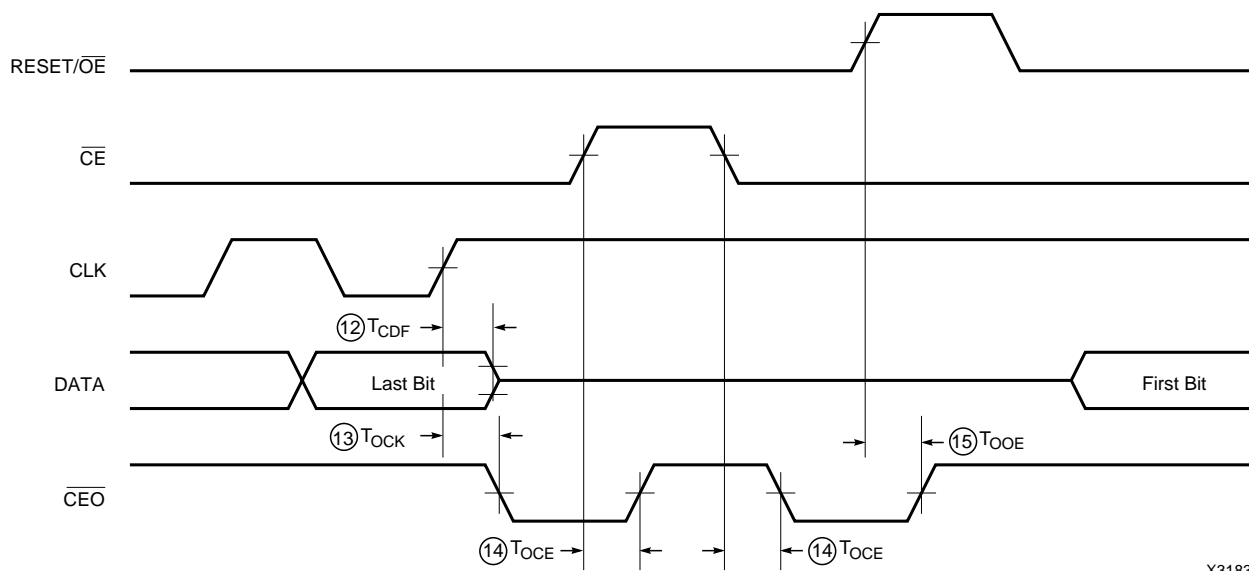


X2634

Symbol	Description	XC1736E XC1765E		XC1765EL		XC17128E XC17256E		XC17128EL XC17256EL		Units
		Min	Max	Min	Max	Min	Max	Min	Max	
1	$T_{OE}$		45		45		25		30	ns
2	$T_{CE}$		60		60		45		45	ns
3	$T_{CAC}$		80		200		45		45	ns
4	$T_{OH}$	0		0		0		0		ns
5	$T_{DF}$		50		50		50		50	ns
6	$T_{CYC}$	100		400		67		67		ns
7	$T_{LC}$	50		100		20		25		ns
8	$T_{HC}$	50		100		20		25		ns
9	$T_{SCE}$	25		40		20		25		ns
10	$T_{HCE}$	0		0		0		0		ns
11	$T_{HOE}$	100		100		20		25		ns

- Notes:**
1. AC test load = 50 pF
  2. Float delays are measured with 5 pF AC loads. Transition is measured at +200mV from steady state active levels.
  3. Guaranteed by design, not tested.
  4. All AC parameters are measured with  $V_{IL} = 0.0$  V and  $V_{IH} = 3.0$  V.

## AC Characteristics Over Operating Condition When Cascading

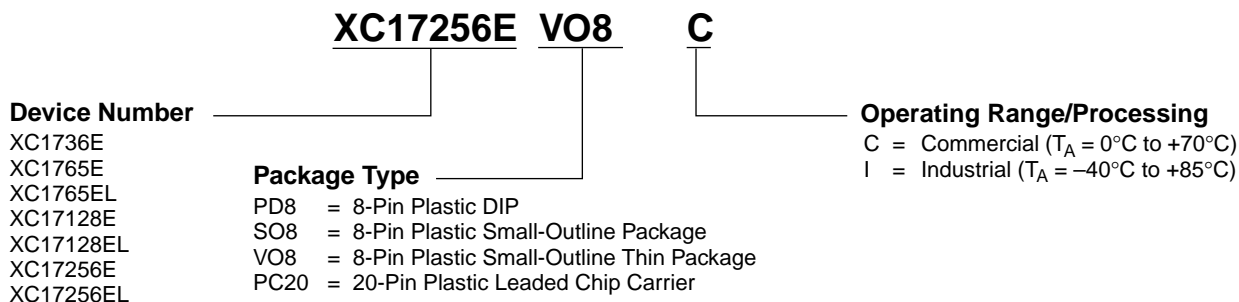


X3183

Symbol	Description	Min	Max	Units
12	T <sub>CDF</sub> CLK to Data Float Delay <sup>2, 3</sup>		50	ns
13	T <sub>OCK</sub> CLK to $\overline{CEO}$ Delay <sup>3</sup>		30	ns
14	T <sub>OCE</sub> CE to $\overline{CEO}$ Delay <sup>3</sup>		35	ns
15	T <sub>OOE</sub> RESET/ $\overline{OE}$ to $\overline{CEO}$ Delay <sup>3</sup>		30	ns

- Notes:**
1. AC test load = 50 pF
  2. Float delays are measured with 5 pF AC loads. Transition is measured at +200mV from steady state active levels.
  3. Guaranteed by design, not tested.
  4. All AC parameters are measured with V<sub>IL</sub> = 0.0 V and V<sub>IH</sub> = 3.0 V.

## Ordering Information

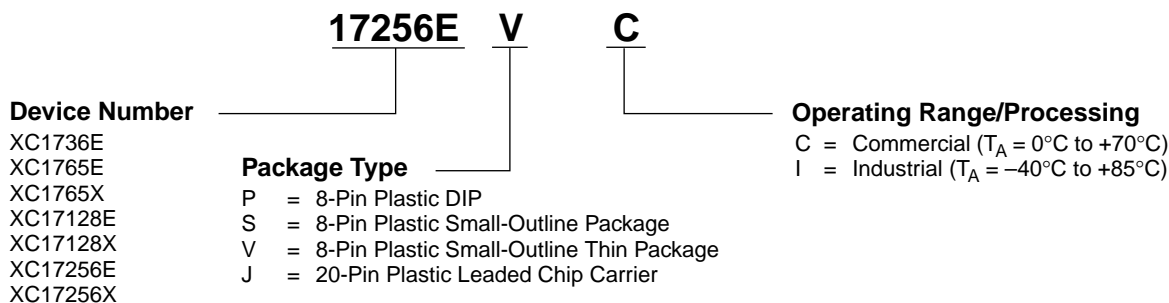


## Valid Ordering Combinations

XC17128EPD8C	XC17256EPD8C	XC1736EPD8C	XC1765EPD8C
XC17128EVO8C	XC17256EVO8C	XC1736ESO8C	XC1765ESO8C
XC17128EPC20C	XC17256EPC20C	XC1736EVO8C	XC1765EVO8C
XC17128EPD8I	XC17256EPD8I	XC1736EPC20C	XC1765EPC20C
XC17128EVO8I	XC17256EVO8I	XC1736EPD8I	XC1765EPD8I
XC17128EPC20I	XC17256EPC20I	XC1736ESO8I	XC1765ESO8I
		XC1736EVO8I	XC1765EVO8I
		XC1736EPC20I	XC1765EPC20I
XC17128ELPD8C	XC17256ELPD8C		XC1765ELPD8C
XC17128ELVO8C	XC17256ELVO8C		XC1765ELSO8C
XC17128ELPC20C	XC17256ELPC20C		XC1765ELVO8C
XC17128ELPD8I	XC17256ELPD8I		XC1765ELPC20C
XC17128ELVO8I	XC17256ELVO8I		XC1765ELPD8I
XC17128ELPC20I	XC17256ELPC20I		XC1765ELSO8I
			XC1765ELVO8I
			XC1765ELPC20I

## Marking Information

Due to the small size of the serial PROM package, the complete ordering part number cannot be marked on the package. The XC prefix is deleted and the package code is simplified. Device marking is as follows.



**Note:** When marking the device number on the EL parts, an X is used in place of an EL.

## Revision Control

Date	Revision
7/14/98	Revised $I_{CCS}$ on pages 5-17 & 5-18; revised $V_{CC}$ specifications for $T_A$ on pages 5-17 & 5-18; revised $V_{CC}$ on page 5-18; revised Note 2 on page 5-19 and 5-20; clarified title on page 5-20; added $T_A$ to operating range specifications on page 5-21.