PALCE16V8Z FAMILY

Zero-Power 20-Pin EE CMOS Universal Programmable Array Logic

Advanced Micro Devices

DISTINCTIVE CHARACTERISTICS

- **Zero-Power CMOS technology**
  - 15-μA Standby Current (-15/25)
  - 30-μA Standby Current (-12)
  - 12-ns propagation delay for "-12" version
  - 15-ns propagation delay for "-15" version
- **Unused product term disable for reduced power consumption**
- **Available in Industrial operating range**
  - T_C = –40°C to +85°C
  - V_{CC} = +4.5 V to +5.5 V
- **HC- and HCT-Compatible inputs and outputs**
- **Pin and function compatible with all 20-pin GAL devices**
- **Electrically-erasable CMOS technology provides reconfigurable logic and full testability**

- **Direct plug-in replacement for the PAL16R8 series and most of the PAL10H8 series**
- **Outputs programmable as registered or combinatorial in any combination**
- **Programmable output polarity**
- **Programmable enable/disable control**
- **Preloadable output registers for testability**
- **Automatic register reset on power up**
- **Cost-effective 20-pin plastic DIP and PLCC packages**
- **Extensive third-party software and programmer support through FusionPLD partners**
- **Fully tested for 100% programming and functional yields and high reliability**

GENERAL DESCRIPTION

The PALCE16V8Z is an advanced PAL device built with zero-power, high-speed, electrically-erasable CMOS technology. It is functionally compatible with all 20-pin GAL devices. The macrocells provide a universal device architecture. The PALCE16V8Z will directly replace the PAL16R8 and PAL10H8 series devices, with the exception of the PAL16C1.

The PALCE16V8Z provides zero standby power and high speed. At 30-μA maximum standby current, the PALCE16V8Z allows battery powered operation for an extended period.
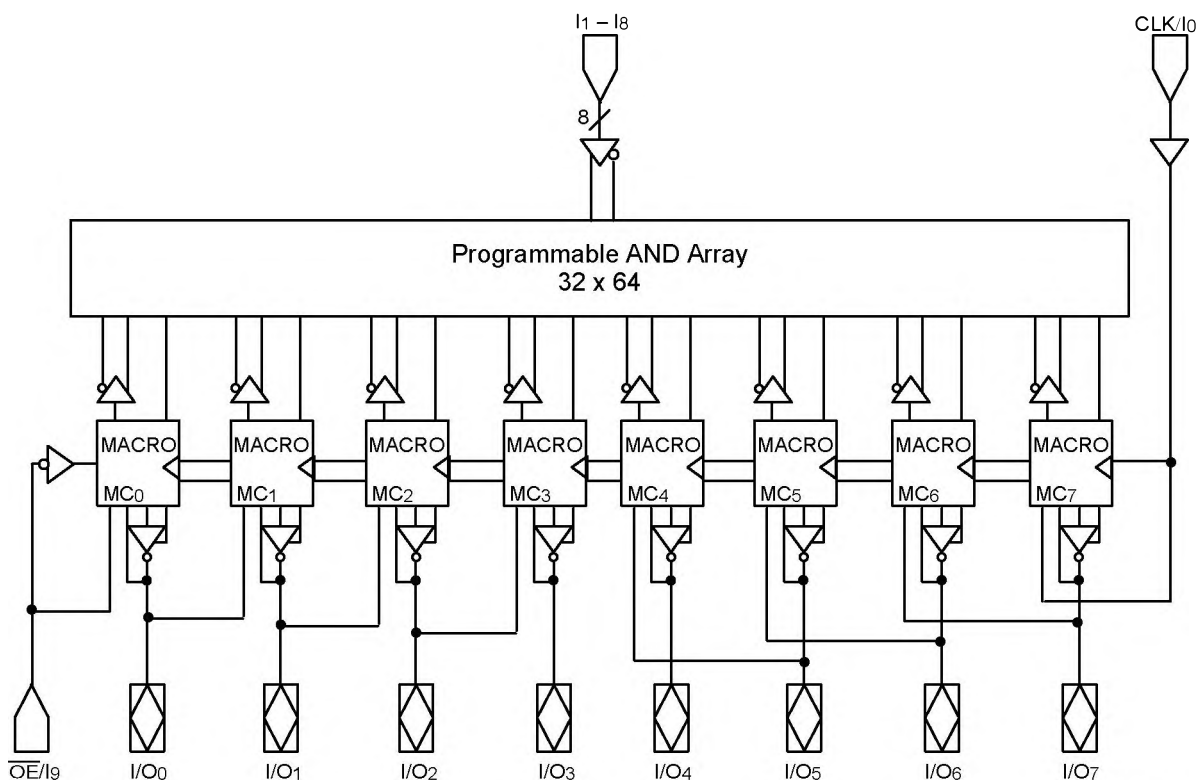
The PALCE16V8Z utilizes the familiar sum-of-products (AND/OR) architecture that allows users to implement complex logic functions easily and efficiently. Multiple levels of combinatorial logic can always be reduced to sum-of-products form, taking advantage of the very wide input gates available in PAL devices. The equations are programmed into the device through

floating-gate cells in the AND logic array that can be erased electrically.

The fixed OR array allows up to eight data product terms per output for logic functions. The sum of these products feeds the output macrocell. Each macrocell can be programmed as registered or combinatorial with an active-high or active-low output. The output configuration is determined by two global bits and one local bit controlling four multiplexers in each macrocell.

AMD's FusionPLD program allows PALCE16V8Z designs to be implemented using a wide variety of popular industry-standard design tools. By working closely with the FusionPLD partners, AMD certifies that the tools provide accurate, quality support. By ensuring that third-party tools are available, costs are lowered because a designer does not have to buy a complete set of new tools for each device. The FusionPLD program also greatly reduces design time since a designer can use a tool that is already installed and familiar.
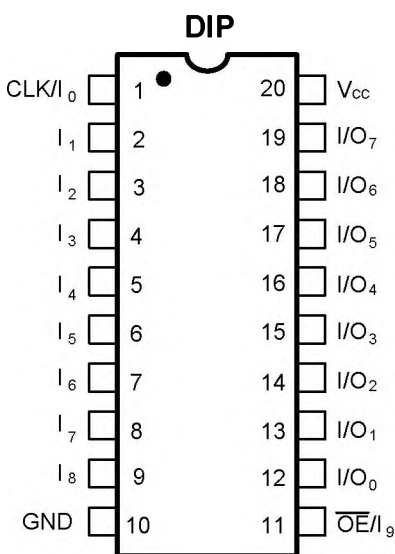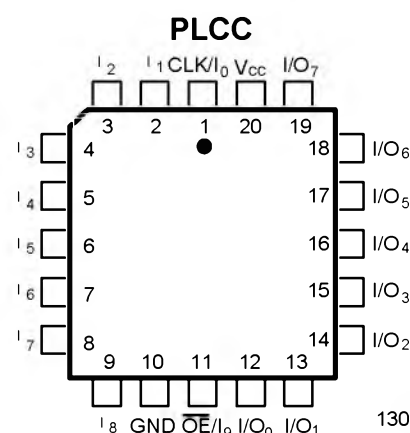
BLOCK DIAGRAM

$I_1 - I_8$ CLK/I_0

Programmable AND Array
32 x 64

MACRO MC0   MACRO MC1   MACRO MC2   MACRO MC3   MACRO MC4   MACRO MC5   MACRO MC6   MACRO MC7

$\overline{OE}/I_9$ I/O$_0$ I/O$_1$ I/O$_2$ I/O$_3$ I/O$_4$ I/O$_5$ I/O$_6$ I/O$_7$

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CONNECTION DIAGRAMS
Top View

DIP

CLK/I$_0$	1	20	V$_{CC}$
I$_1$	2	19	I/O$_7$
I$_2$	3	18	I/O$_6$
I$_3$	4	17	I/O$_5$
I$_4$	5	16	I/O$_4$
I$_5$	6	15	I/O$_3$
I$_6$	7	14	I/O$_2$
I$_7$	8	13	I/O$_1$
I$_8$	9	12	I/O$_0$
GND	10	11	$\overline{OE}/I_9$

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PLCC

I$_2$ I$_1$ CLK/I$_0$ V$_{CC}$ I/O$_7$

I$_3$	4	18	I/O$_6$
I$_4$	5	17	I/O$_5$
I$_5$	6	16	I/O$_4$
I$_6$	7	15	I/O$_3$
I$_7$	8	14	I/O$_2$

I$_8$ GND $\overline{OE}/I_9$ I/O$_0$ I/O$_1$

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Note:

Pin 1 is marked for orientation

PIN DESIGNATIONS

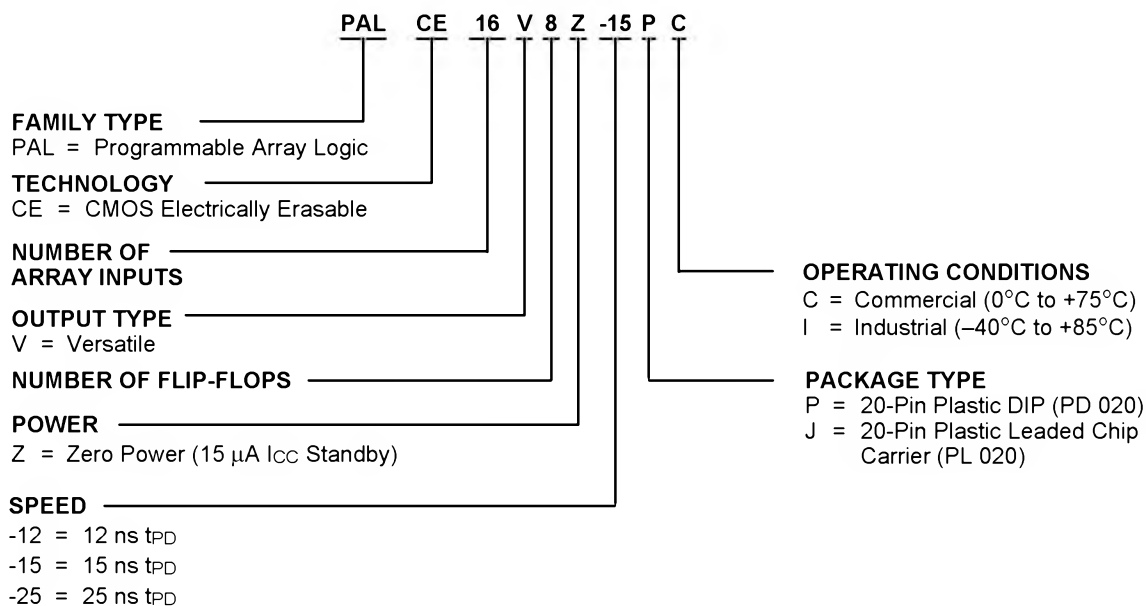|		
CLK	=	Clock
GND	=	Ground
I	=	Input
I/O	=	Input/Output
$\overline{OE}$	=	Output Enable
V$_{CC}$	=	Supply Voltage

ORDERING INFORMATION

Commercial and Industrial Products

AMD programmable logic products for commercial and industrial applications are available with several ordering options. The order number (Valid Combination) is formed by a combination of:

PAL CE 16 V 8 Z -15 P C

FAMILY TYPE
PAL = Programmable Array Logic

TECHNOLOGY
CE = CMOS Electrically Erasable

NUMBER OF ARRAY INPUTS

OUTPUT TYPE
V = Versatile

NUMBER OF FLIP-FLOPS

POWER
Z = Zero Power (15 μA I_{CC} Standby)

SPEED
-12 = 12 ns t_{PD}
-15 = 15 ns t_{PD}
-25 = 25 ns t_{PD}

OPERATING CONDITIONS
C = Commercial (0°C to +75°C)
I = Industrial (–40°C to +85°C)

PACKAGE TYPE
P = 20-Pin Plastic DIP (PD 020)
J = 20-Pin Plastic Leaded Chip
Carrier (PL 020)

Valid Combinations	
PALCE16V8Z-12	PI, JI
PALCE16V8Z-15	PI, JI,
PALCE16V8Z-25	PC, JC

Valid Combinations

Valid Combinations lists configurations planned to be supported in volume for this device. Consult the local AMD sales office to confirm availability of specific valid combinations and to check on newly released combinations.

FUNCTIONAL DESCRIPTION

The PALCE16V8Z is the zero-power version of the PALCE16V8. It has all the architectural features of the PALCE16V8. In addition, the PALCE16V8Z has zero standby power and unused product term disable.

The PALCE16V8Z is a universal PAL device. It has eight independently configurable macrocells (MC_0–MC_7). Each macrocell can be configured as registered output, combinatorial output, combinatorial I/O or dedicated input. The programming matrix implements a programmable AND logic array, which drives a fixed OR logic array. Buffers for device inputs have complementary outputs to provide user-programmable input signal polarity. Pins 1 and 11 serve either as array inputs or as clock (CLK) and output enable ($\overline{OE}$), respectively, for all flip-flops.

Unused input pins should be tied directly to V_{CC} or GND. Product terms with all bits unprogrammed (disconnected) assume the logical HIGH state and product terms with both true and complement of any input signal connected assume a logical LOW state.

The programmable functions on the PALCE16V8Z are automatically configured from the user's design specification, which can be in a number of formats. The design specification is processed by development software to verify the design and create a programming file. This file, once downloaded to a programmer, configures the device according to the user's desired function.

The user is given two design options with the PALCE16V8Z. First, it can be programmed as a standard PAL device from the PAL16R8 and PAL10H8 series. The PAL programmer manufacturer will supply device codes for the standard PAL device architectures to be used with the PALCE16V8Z. The programmer will program the PALCE16V8Z in the corresponding architecture. This allows the user to use existing standard PAL device JEDEC files without making any changes to them. Alternatively, the device can be programmed as a PALCE16V8Z. Here the user must use the PALCE16V8Z device code. This option allows full utilization of the macrocell.
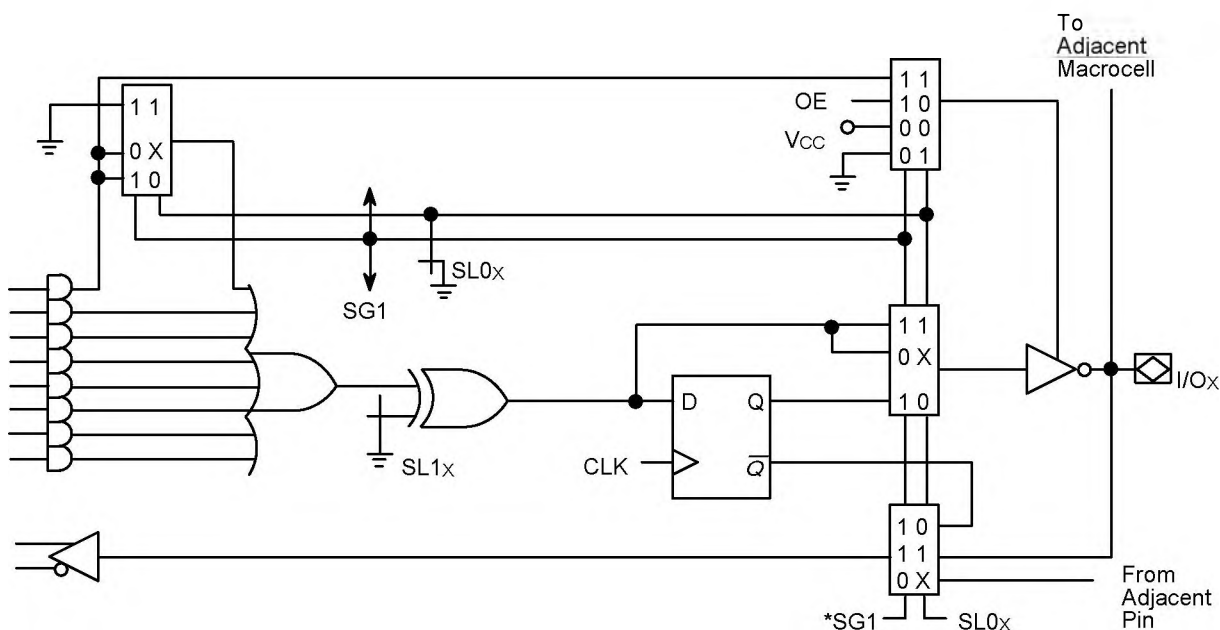
*In macrocells MC_0 and MC_7, SG1 is replaced by $\overline{SG0}$ on the feedback multiplexer.

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Figure 1. PALCE16V8Z Macrocell

Configuration Options

Each macrocell can be configured as one of the following: registered output, combinatorial output, combinatorial I/O, or dedicated input. In the registered output configuration, the output buffer is enabled by the $\overline{OE}$ pin. In the combinatorial configuration, the buffer is either controlled by a product term or always enabled. In the dedicated input configuration, it is always disabled. With the exception of MC_0 and MC_7, a macrocell configured as a dedicated input derives the input signal from an adjacent I/O. MC_0 derives its input from pin 11 ($\overline{OE}$) and MC_7 from pin 1 (CLK).

The macrocell configurations are controlled by the configuration control word. It contains 2 global bits (SG0 and SG1) and 16 local bits (SL0$_0$ through SL0$_7$ and SL1$_0$ through SL1$_7$). SG0 determines whether registers will be allowed. SG1 determines whether the PALCE16V8Z will emulate a PAL16R8 family or a PAL10H8 family device. Within each macrocell, SL0$_x$, in conjunction with SG1, selects the configuration of the macrocell, and SL1$_x$ sets the output as either active low or active high for the individual macrocell.

The configuration bits work by acting as control inputs for the multiplexers in the macrocell. There are four multiplexers: a product term input, an enable select, an output select, and a feedback select multiplexer. SG1 and SL0$_x$ are the control signals for all four multiplexers. In MC_0 and MC_7, $\overline{SG0}$ replaces SG1 on the feedback multiplexer. This accommodates CLK being the adjacent pin for MC_7 and $\overline{OE}$ the adjacent pin for MC_0.

Registered Output Configuration

The control bit settings are SG0 = 0, SG1 = 1 and SL0$_x$ = 0. There is only one registered configuration. All eight product terms are available as inputs to the OR gate. Data polarity is determined by SL1$_x$. The flip-flop is loaded on the LOW-to-HIGH transition of CLK. The feedback path is from $\overline{Q}$ on the register. The output buffer is enabled by $\overline{OE}$.

Combinatorial Configurations

The PALCE16V8Z has three combinatorial output configurations: dedicated output in a non-registered device, I/O in a non-registered device and I/O in a registered device.

Dedicated Output In a Non-Registered Device

The control bit settings are SG0 = 1, SG1 = 0 and SL0$_x$ = 0. All eight product terms are available to the OR gate. Although the macrocell is a dedicated output, the feedback is used, with the exception of MC_3 and MC_4. MC_3 and MC_4 do not use feedback in this mode. Because CLK and $\overline{OE}$ are not used in a non-registered device, pins 1 and 11 are available as input signals. Pin 1 will use the feedback path of MC_7 and pin 11 will use the feedback path of MC_0.

Combinatorial I/O In a Non-Registered Device

The control bit settings are SG0 = 1, SG1 = 1, and SL0$_x$ = 1. Only seven product terms are available to the OR gate. The eighth product term is used to enable the output buffer. The signal at the I/O pin is fed back to the AND array via the feedback multiplexer. This allows the pin to be used as an input.

Because CLK and $\overline{OE}$ are not used in a non-registered device, pins 1 and 11 are available as inputs. Pin 1 will use the feedback path of MC_7 and pin 11 will use the feedback path of MC_0.

Combinatorial I/O in a Registered Device

The control bit settings are SG0 = 0, SG1 = 1 and SL0$_x$ = 1. Only seven product terms are available to the OR gate. The eighth product term is used as the output enable. The feedback signal is the corresponding I/O signal.

Dedicated Input Configuration

The control bit settings are SG0 = 1, SG1 = 0 and SL0$_x$ = 1. The output buffer is disabled. Except for MC_0 and MC_7 the feedback signal is an adjacent I/O. For MC_0 and MC_7 the feedback signals are pins 1 and 11. These configurations are summarized in Table 1 and illustrated in Figure 2.
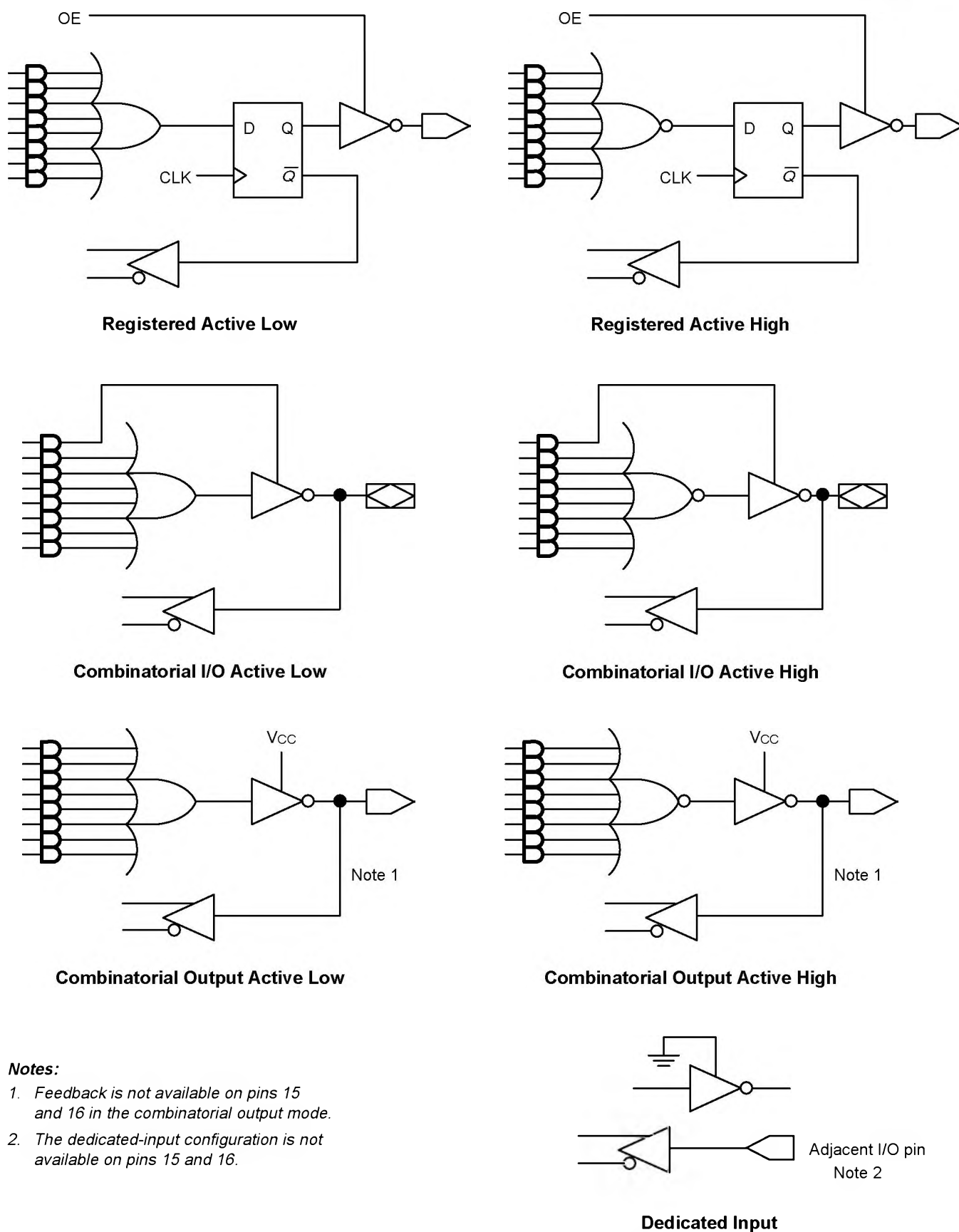
Table 1. Macrocell Configuration

SG0	SG1	SL0x	Cell Configuration	Devices Emulated
Device Uses Registers				
0	1	0	Registered Output	PAL16R8, 16R6, 16R4
0	1	1	Combinatorial I/O	PAL16R6, 16R4
Device Uses No Registers				
1	0	0	Combinatorial Output	PAL10H8, 12H6, 14H4, 16H2, 10L8, 12L6, 14L4, 16L2
1	0	1	Input	PAL12H6, 14H4, 16H2, 12L6, 14L4, 16L2
1	1	1	Combinatorial I/O	PAL16L8

Programmable Output Polarity

The polarity of each macrocell can be active-high or active-low, either to match output signal needs or to reduce product terms. Programmable polarity allows Boolean expressions to be written in their most compact form (true or inverted), and the output can still be of the desired polarity. It can also save "DeMorganizing" efforts.

Selection is through a programmable bit SL1$_x$ which controls an exclusive-OR gate at the output of the AND/OR logic. The output is active high if SL1$_x$ is 1 and active low if SL1$_x$ is 0.

Registered Active Low

Registered Active High

Combinatorial I/O Active Low

Combinatorial I/O Active High

Combinatorial Output Active Low

Combinatorial Output Active High

Notes:

1. *Feedback is not available on pins 15 and 16 in the combinatorial output mode.*

2. *The dedicated-input configuration is not available on pins 15 and 16.*

Adjacent I/O pin
Note 2

Dedicated Input

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Figure 2.   Macrocell Configurations

Zero-Standby Power Mode

The PALCE16V8Z features a zero-standby power mode. When none of the inputs switch for an extended period (typically 50 ns), the PALCE16V8Z will go into standby mode, shutting down most of its internal circuitry. The current will go to almost zero (I_{CC} < 15 μA). The outputs will maintain the states held before the device went into the standby mode. There is no speed penalty associated with coming out of standby mode.

When any input switches, the internal circuitry is fully enabled and power consumption returns to normal. This feature results in considerable power savings for operation at low to medium frequencies. This savings is illustrated in the I_{CC} vs. frequency graph.

Product-Term Disable

On a programmed PALCE16V8Z, any product terms that are not used are disabled. Power is cut off from these product terms so that they do not draw current. As shown in the I_{CC} vs frequency graph, product-term disabling results in considerable power savings. This savings is greater at the higher frequencies.

Further hints on minimizing power consumption can be found in the Application Note, "Minimizing Power Consumption with Zero-Power PLDs".

Power-Up Reset

All flip-flops power up to a logic LOW for predictable system initialization. Outputs of the PALCE16V8Z will depend on whether they are selected as registered or combinatorial. If registered is selected, the output will be HIGH. If combinatorial is selected, the output will be a function of the logic.

Register Preload

The register on the PALCE16V8Z can be preloaded from the output pins to facilitate functional testing of complex state machine designs. This feature allows direct loading of arbitrary states, making it unnecessary to cycle through long test vector sequences to reach a desired state. In addition, transitions from illegal states can be verified by loading illegal states and observing proper recovery.

The preload function is not disabled by the security bit. This allows functional testing after the security bit is programmed.

Security Bit

A security bit is provided on the PALCE16V8Z as a deterrent to unauthorized copying of the array configuration patterns. Once programmed, this bit defeats readback of the programmed pattern by a device programmer, securing proprietary designs from competitors. However, programming and verification are also defeated by the security bit. The bit can only be erased in conjunction with the array during an erase cycle.

Electronic Signature Word

An electronic signature word is provided in the PALCE16V8Z device. It consists of 64 bits of programmable memory that can contain user-defined data. The signature data is always available to the user independent of the security bit.

Programming and Erasing

The PALCE16V8Z can be programmed on standard logic programmers. It also may be erased to reset a previously configured device back to its unprogrammed state. Erasure is automatically performed by the programming hardware. No special erase operation is required.

Quality and Testability

The PALCE16V8Z offers a very high level of built-in quality. The erasability if the device provides a direct means of verifying performance of all the AC and DC parameters. In addition, this verifies complete programmability and functionality of the device to yield the highest programming yields and post-programming function yields in the industry.

Technology

The high-speed PALCE16V8Z is fabricated with AMD's advanced electrically-erasable (EE) CMOS process. The array connections are formed with proven EE cells. Inputs and outputs are designed to be compatible with HC and HCT devices. This technology provides strong input-clamp diodes, output slew-rate control, and a grounded substrate for clean switching.

LOGIC DIAGRAM
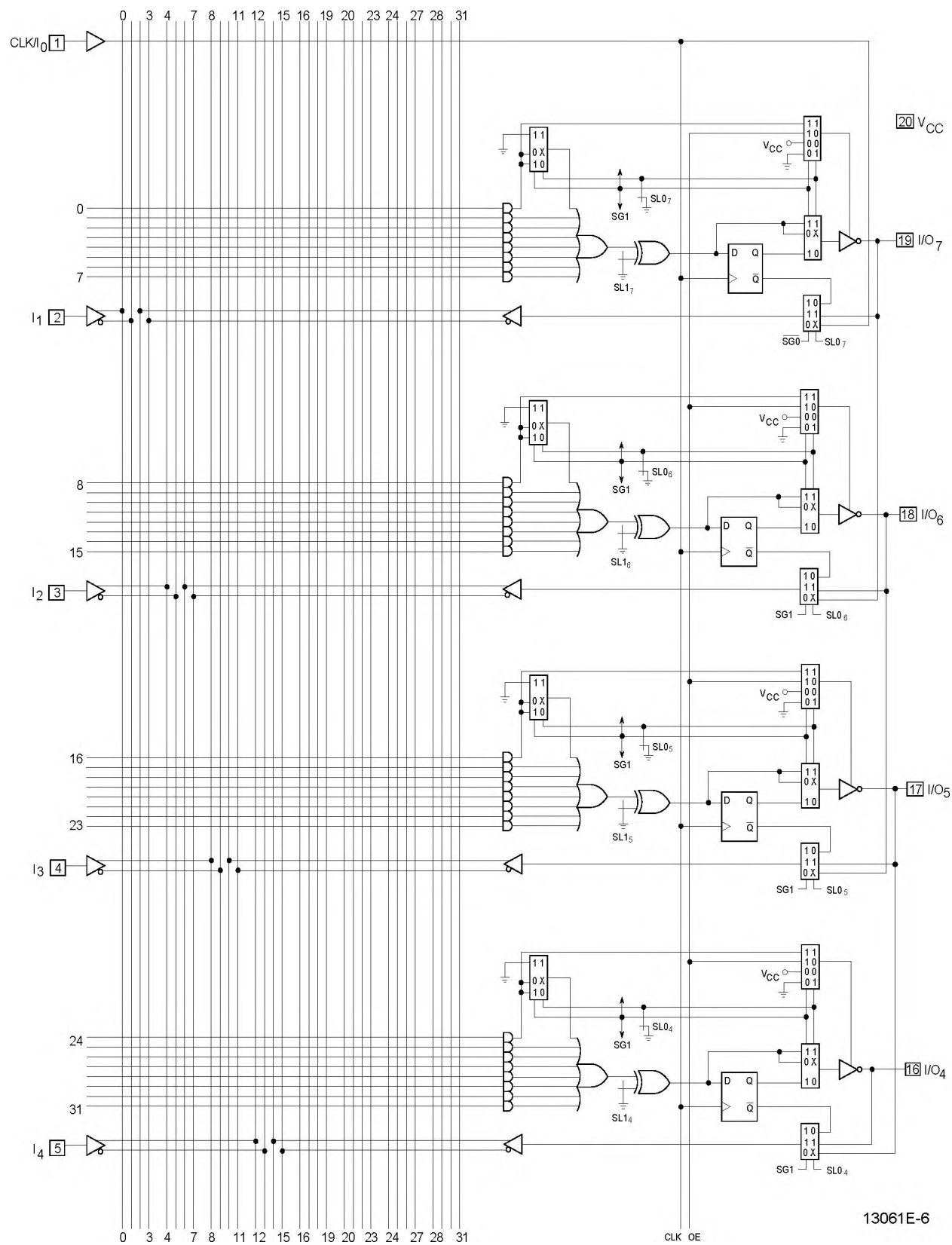
13061E-6

LOGIC DIAGRAM (continued)
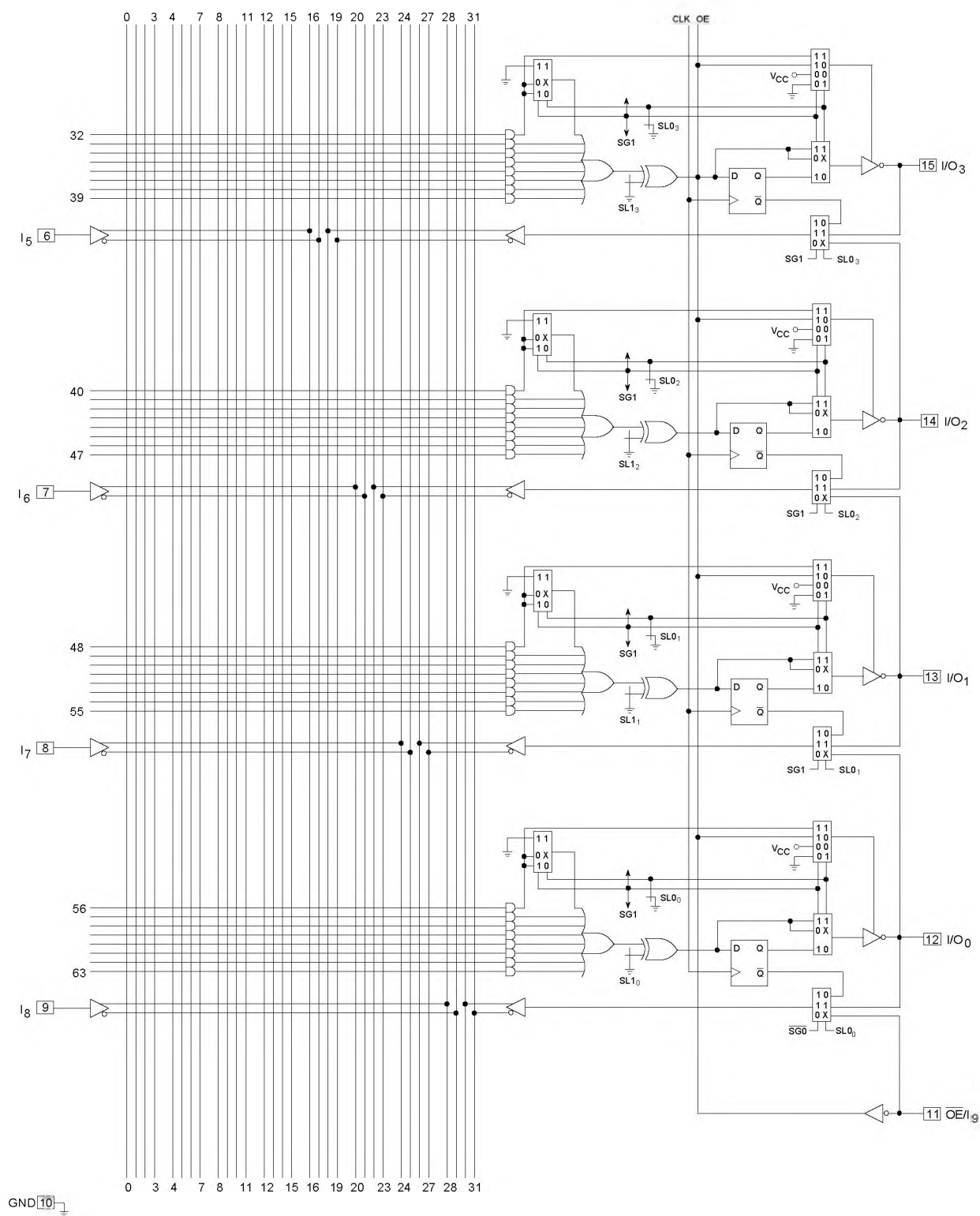
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(concluded)

ABSOLUTE MAXIMUM RATINGS

Storage Temperature . . . . –65°C to +150°C

Ambient Temperature
with Power Applied . . . . –55°C to +125°C

Supply Voltage with
Respect to Ground . . . . –0.5 V to + 7.0 V

DC Input Voltage . . . . –0.5 V to V_{CC} + 0.5 V

DC Output or I/O
Pin Voltage . . . . –0.5 V to V_{CC} + 0.5 V

Static Discharge Voltage . . . . 2001 V

Latchup Current
(T_A = –40°C to +85°C) . . . . 100 mA

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Industrial (I) Devices

Operating Case
Temperature (T_C) . . . . –40°C to +85°C

Supply Voltage (V_{CC}) with
Respect to Ground . . . . +4.5 V to +5.5 V

Operating ranges define those limits between which the functionality of the device is guaranteed.

DC CHARACTERISTICS over INDUSTRIAL operating ranges unless otherwise specified

Parameter Symbol	Parameter Description	Test Conditions		Min	Max	Unit
V_{OH}	Output HIGH Voltage	V_{IN} = V_{IH} or V_{IL} V_{CC} = Min	I_{OH} = 6 mA	3.84		V
			I_{OH} = 20 μA	V_{CC} – 0.1 V		V
V_{OL}	Output LOW Voltage	V_{IN} = V_{IH} or V_{IL} V_{CC} = Min	I_{OL} = 24 mA		0.5	V
			I_{OL} = 6 mA		0.33	V
			I_{OL} = 20 μA		0.1	V
V_{IH}	Input HIGH Voltage	Guaranteed Input Logical HIGH Voltage for all Inputs (Notes 1 and 2)		2.0		V
V_{IL}	Input LOW Voltage	Guaranteed Input Logical LOW Voltage for all Inputs (Notes 1 and 2)			0.9	V
I_{IH}	Input HIGH Leakage Current	V_{IN} = V_{CC}, V_{CC} = Max (Note 3)			10	μA
I_{IL}	Input LOW Leakage Current	V_{IN} = 0 V, V_{CC} = Max (Note 3)			–10	μA
I_{OZH}	Off-State Output Leakage Current HIGH	V_{OUT} = V_{CC}, V_{CC} = Max V_{IN} = V_{IH} or V_{IL} (Note 3)			10	μA
I_{OZL}	Off-State Output Leakage Current LOW	V_{OUT} = 0 V, V_{CC} = Max V_{IN} = V_{IH} or V_{IL} (Note 3)			–10	μA
I_{SC}	Output Short-Circuit Current	V_{OUT} = 0.5 V V_{CC} = Max (Note 4)		–30	–150	mA
I_{CC}	Supply Current (Static)	Outputs Open (I_{OUT} = 0 mA)	f = 0 MHz		30	μA
	Supply Current (Dynamic)	V_{CC} = Max	f = 15 MHz		75	mA

Notes:

1. *These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.*

2. *Represents the worst case of HC and HCT standards, allowing compatibility with either.*

3. *I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).*

4. *Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.*
   V_{OUT} = 0.5 V has been chosen to avoid test problems caused by tester ground degradation.

CAPACITANCE (Note 1)

Parameter Symbol	Parameter Description	Test Condition		Typ	Unit
C_IN	Input Capacitance	V_IN = 2.0 V	V_CC = 5.0 V, T_A = 25°C,	5	pF
C_OUT	Output Capacitance	V_OUT = 2.0 V	f = 1 MHz	8	pF

Note:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*

SWITCHING CHARACTERISTICS over INDUSTRIAL operating ranges (Note 2)

Parameter Symbol	Parameter Description			(Note 5) Min	Max	Unit
t_PD	Input or Feedback to Combinatorial Output (Note 3)				12	ns
t_S	Setup Time from Input or Feedback to Clock			8		ns
t_H	Hold Time			0		ns
t_CO	Clock to Output				8	ns
t_WL	Clock Width	LOW		5		ns
t_WH		HIGH		5		ns
f_MAX	Maximum Frequency (Notes 4 and 6)	External Feedback	1/(t_S + t_CO)	62.5		MHz
		Internal Feedback (f_CNT)	1/(t_S + t_CF)	77		MHz
		No Feedback	1/(t_WH + t_WL)	100		MHz
t_PZX	$\overline{OE}$ to Output Enable				8	ns
t_PXZ	$\overline{OE}$ to Output Disable				8	ns
t_EA	Input to Output Enable Using Product Term Control				13	ns
t_ER	Input to Output Disable Using Product Term Control				13	ns

Notes:

2. *See Switching Test Circuit for test conditions.*

3. *This parameter is tested in standby mode.*

4. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where frequency may be affected.*

5. *Output delay minimum for t_PD, t_CO, t_PZD, t_EA, and t_ER are defined under best case conditions. Future process improvements may alter these values therefore, minimum values are recommended for simulation purposes only.*

6. *t_CF is a calculated value and is not guaranteed. t_CF can be found using the following equation:*
   $t_{CF} = 1/f_{MAX}$ (internal feedback) $- t_S$.

ABSOLUTE MAXIMUM RATINGS

Storage Temperature . . . . –65°C to +150°C
Ambient Temperature
with Power Applied . . . . –55°C to +125°C
Supply Voltage with
Respect to Ground . . . . –0.5 V to + 7.0 V
DC Input Voltage . . . . –0.5 V to V_{CC} + 0.5 V
DC Output or I/O
Pin Voltage . . . . –0.5 V to V_{CC} + 0.5 V
Static Discharge Voltage . . . . 2001 V
Latchup Current
(T_A = 0°C to 75°C) . . . . 100 mA

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

Ambient Temperature (T_A)
Operating in Free Air . . . . 0°C to +75°C

Supply Voltage (V_{CC}) with
Respect to Ground . . . . +4.75 V to +5.25 V

Industrial (I) Devices

Operating Case
Temperature (T_C) . . . . –40°C to +85°C

Supply Voltage (V_{CC}) with
Respect to Ground . . . . +4.5 V to +5.5 V

Operating ranges define those limits between which the functionality of the device is guaranteed.

DC CHARACTERISTICS over COMMERCIAL and INDUSTRIAL operating ranges

Parameter Symbol	Parameter Description	Test Conditions		Min	Max	Unit
V_{OH}	Output HIGH Voltage	V_{IN} = V_{IH} or V_{IL} V_{CC} = Min	I_{OH} = 6 mA	3.84		V
			I_{OH} = 20 µA	V_{CC} – 0.1 V		V
V_{OL}	Output LOW Voltage	V_{IN} = V_{IH} or V_{IL} V_{CC} = Min	I_{OL} = 24 mA		0.5	V
			I_{OL} = 6 mA		0.33	V
			I_{OL} = 20 µA		0.1	V
V_{IH}	Input HIGH Voltage	Guaranteed Input Logical HIGH Voltage for all Inputs (Notes 1 and 2)		2.0		V
V_{IL}	Input LOW Voltage	Guaranteed Input Logical LOW Voltage for all Inputs (Notes 1 and 2)			0.9	V
I_{IH}	Input HIGH Leakage Current	V_{IN} = V_{CC}, V_{CC} = Max (Note 3)			10	µA
I_{IL}	Input LOW Leakage Current	V_{IN} = 0 V, V_{CC} = Max (Note 3)			–10	µA
I_{OZH}	Off-State Output Leakage Current HIGH	V_{OUT} = V_{CC}, V_{CC} = Max V_{IN} = V_{IH} or V_{IL} (Note 3)			10	µA
I_{OZL}	Off-State Output Leakage Current LOW	V_{OUT} = 0 V, V_{CC} = Max V_{IN} = V_{IH} or V_{IL} (Note 3)			–10	µA
I_{SC}	Output Short-Circuit Current	V_{OUT} = 0.5 V V_{CC} = Max (Note 4)		–30	–150	mA
I_{CC}	Supply Current (Static)	Outputs Open (I_{OUT} = 0 mA)	f = 0 MHz		15	µA
	Supply Current (Dynamic)	V_{CC} = Max	f = 25 MHz		75	mA

Notes:

1. These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.

2. Represents the worst case of HC and HCT standards, allowing compatibility with either.

3. I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).

4. Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second. V_{OUT} = 0.5 V has been chosen to avoid test problems caused by tester ground degradation.

CAPACITANCE (Note 1)

Parameter Symbol	Parameter Description	Test Condition		Typ	Unit
C_{IN}	Input Capacitance	$V_{IN} = 2.0$ V	$V_{CC} = 5.0$ V, $T_A = 25°C$,	5	pF
C_{OUT}	Output Capacitance	$V_{OUT} = 2.0$ V	$f = 1$ MHz	8	pF

Note:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*

SWITCHING CHARACTERISTICS over COMMERCIAL and INDUSTRIAL operating ranges (Note 2)

Parameter Symbol	Parameter Description			Min	Max	Unit
t_{PD}	Input or Feedback to Combinatorial Output				15	ns
t_S	Setup Time from Input or Feedback to Clock			10		ns
t_H	Hold Time			0		ns
t_{CO}	Clock to Output				10	ns
t_{WL}	Clock Width	LOW		8		ns
t_{WH}		HIGH		8		ns
f_{MAX}	Maximum Frequency (Notes 3 and 4)	External Feedback	$1/(t_S + t_{CO})$	50		MHz
		Internal Feedback (f_{CNT})	$1/(t_S + t_{CF})$	58.8		MHz
		No Feedback	$1/(t_{WH} + t_{WL})$	62.5		MHz
t_{PZX}	$\overline{OE}$ to Output Enable				15	ns
t_{PXZ}	$\overline{OE}$ to Output Disable				15	ns
t_{EA}	Input to Output Enable Using Product Term Control				15	ns
t_{ER}	Input to Output Disable Using Product Term Control				15	ns

Notes:

2. *See Switching Test Circuit for test conditions.*

3. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where frequency may be affected.*

4. *t_{CF} is a calculated value and is not guaranteed. t_{CF} can be found using the following equation:*
   $t_{CF} = 1/f_{MAX}$ *(internal feedback)* $- t_S$.

ABSOLUTE MAXIMUM RATINGS

Storage Temperature . . . . –65°C to +150°C
Ambient Temperature
with Power Applied . . . . –55°C to +125°C
Supply Voltage with
Respect to Ground . . . . –0.5 V to + 7.0 V
DC Input Voltage . . . . –0.5 V to V_{CC} + 0.5 V
DC Output or I/O
Pin Voltage . . . . –0.5 V to V_{CC} + 0.5 V
Static Discharge Voltage . . . . 2001 V
Latchup Current
  (T_A = 0°C to 75°C) . . . . 100 mA

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

Ambient Temperature (T_A)
Operating in Free Air . . . . 0°C to +75°C

Supply Voltage (V_{CC}) with
Respect to Ground . . . . +4.75 V to +5.25 V

Industrial (I) Devices

Operating Case
Temperature (T_C) . . . . –40°C to +85°C

Supply Voltage (V_{CC}) with
Respect to Ground . . . . +4.5 V to +5.5 V

Operating ranges define those limits between which the functionality of the device is guaranteed.

DC CHARACTERISTICS over COMMERCIAL and INDUSTRIAL operating ranges

Parameter Symbol	Parameter Description	Test Conditions		Min	Max	Unit
V_{OH}	Output HIGH Voltage	$V_{IN} = V_{IH}$ or V_{IL} V_{CC} = Min	I_{OH} = 6 mA	3.84		V
			I_{OH} = 20 μA	$V_{CC} – 0.1$ V		V
V_{OL}	Output LOW Voltage	$V_{IN} = V_{IH}$ or V_{IL} V_{CC} = Min	I_{OL} = 24 mA		0.5	V
			I_{OL} = 6 mA		0.33	V
			I_{OL} = 20 μA		0.1	V
V_{IH}	Input HIGH Voltage	Guaranteed Input Logical HIGH Voltage for all Inputs (Notes 1 and 2)		2.0		V
V_{IL}	Input LOW Voltage	Guaranteed Input Logical LOW Voltage for all Inputs (Notes 1 and 2)			0.9	V
I_{IH}	Input HIGH Leakage Current	$V_{IN} = V_{CC}$, V_{CC} = Max (Note 3)			10	μA
I_{IL}	Input LOW Leakage Current	V_{IN} = 0 V, V_{CC} = Max (Note 3)			–10	μA
I_{OZH}	Off-State Output Leakage Current HIGH	$V_{OUT} = V_{CC}$, V_{CC} = Max $V_{IN} = V_{IH}$ or V_{IL} (Note 3)			10	μA
I_{OZL}	Off-State Output Leakage Current LOW	V_{OUT} = 0 V, V_{CC} = Max $V_{IN} = V_{IH}$ or V_{IL} (Note 3)			–10	μA
I_{SC}	Output Short-Circuit Current	V_{OUT} = 0.5 V V_{CC} = Max (Note 4)		–30	–150	mA
I_{CC}	Supply Current	Outputs Open (I_{OUT} = 0 mA) V_{CC} = Max	f = 0 MHz		15	μA
			f = 25 MHz		90	mA

Notes:

1. These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.

2. Represents the worst case of HC and HCT standards, allowing compatibility with either.

3. I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).

4. Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second. V_{OUT} = 0.5 V has been chosen to avoid test problems caused by tester ground degradation.

CAPACITANCE (Note 1)

Parameter Symbol	Parameter Description	Test Condition		Typ	Unit
C$_{IN}$	Input Capacitance	V$_{IN}$ = 2.0 V	V$_{CC}$ = 5.0 V, T$_A$ = 25°C,	5	pF
C$_{OUT}$	Output Capacitance	V$_{OUT}$ = 2.0 V	f = 1 MHz	8	pF

Note:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*

SWITCHING CHARACTERISTICS over COMMERCIAL and INDUSTRIAL operating ranges (Note 2)

Parameter Symbol	Parameter Description			Min	Max	Unit
t$_{PD}$	Input or Feedback to Combinatorial Output (Note 3)				25	ns
t$_S$	Setup Time from Input or Feedback to Clock			20		ns
t$_H$	Hold Time			0		ns
t$_{CO}$	Clock to Output				10	ns
t$_{WL}$	Clock Width	LOW		8		ns
t$_{WH}$		HIGH		8		ns
f$_{MAX}$	Maximum Frequency (Notes 4 and 5)	External Feedback	1/(t$_S$ + t$_{CO}$)	33.3		MHz
		Internal Feedback (f$_{CNT}$)	1/(t$_S$ + t$_{CF}$)	50		MHz
		No Feedback	1/(t$_S$ + t$_H$)	50		MHz
t$_{PZX}$	$\overline{OE}$ to Output Enable				25	ns
t$_{PXZ}$	$\overline{OE}$ to Output Disable				25	ns
t$_{EA}$	Input to Output Enable Using Product Term Control				25	ns
t$_{ER}$	Input to Output Disable Using Product Term Control				25	ns

Notes:

2. *See Switching Test Circuit for test conditions.*

3. *This parameter is tested in Standby Mode. When the device is not in Standby Mode, the t$_{PD}$ will typically be 2 ns faster.*

4. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where frequency may be affected.*

5. *t$_{CF}$ is a calculated value and is not guaranteed. t$_{CF}$ can be found using the following equation:*
    t$_{CF}$ = 1/f$_{MAX}$ (internal feedback) – t$_S$.

SWITCHING WAVEFORMS

Combinatorial Output

13061E-7

Registered Output

13061E-8

Clock Width

13061E-9

Input to Output Disable/Enable

13061E-10

$\overline{OE}$ to Output Disable/Enable

13061E-11
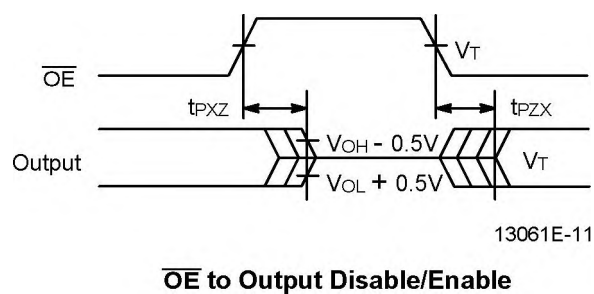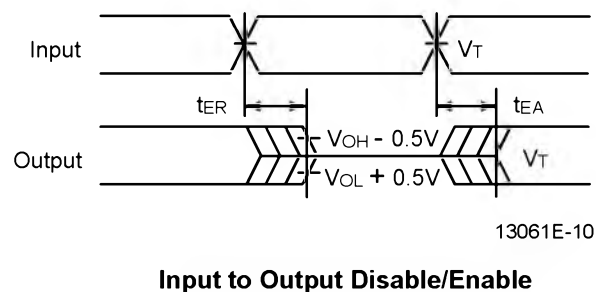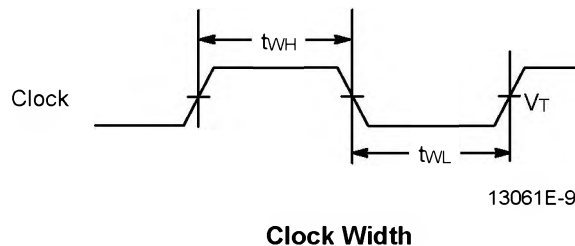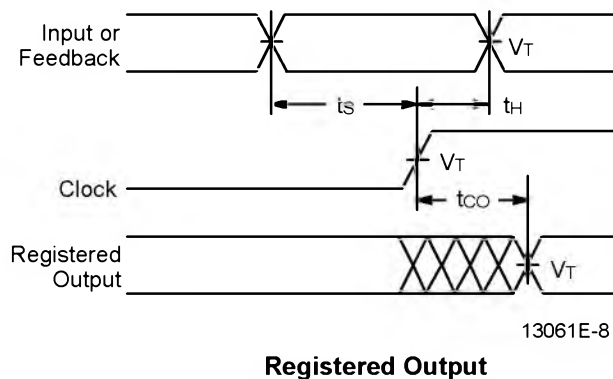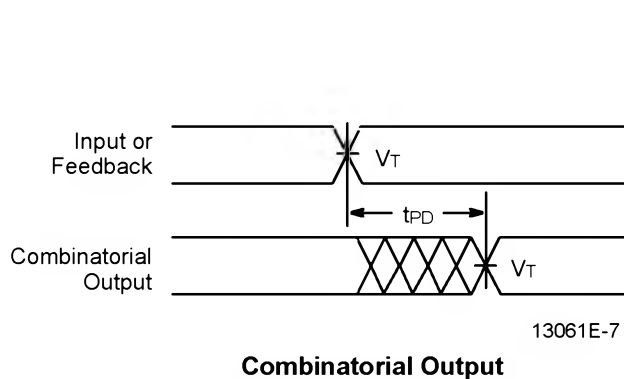
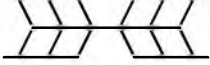*Notes:*

1. *V_T = 1.5 V for input signals and V_{CC}/2 for output signals.*

2. *Input pulse amplitude 0 V to 3.0 V.*

3. *Input rise and fall times 2 ns – 5 ns typical.*

KEY TO SWITCHING WAVEFORMS

| WAVEFORM	INPUTS	OUTPUTS
	Must be Steady	Will be Steady
	May Change from H to L	Will be Changing from H to L
	May Change from L to H	Will be Changing from L to H
	Don't Care, Any Change Permitted	Changing, State Unknown
	Does Not Apply	Center Line is High-Impedance "Off" State

KS000010-PAL

SWITCHING TEST CIRCUIT
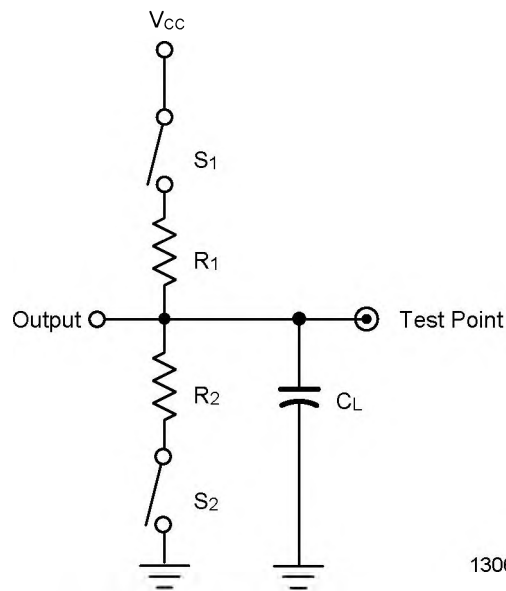
13061E-12

Specification	S$_1$	S$_2$	C$_L$	R$_1$	R$_2$	Measured Output Value
t$_{PD}$, t$_{CO}$	Closed	Closed				V$_{CC}$/2
t$_{PZX}$, t$_{EA}$	Z → H: Open Z → L: Closed	Z → H: Closed Z → L: Open	30 pF	820 Ω	820 Ω	V$_{CC}$/2
t$_{PXZ}$, t$_{ER}$	H → Z: Open L → Z: Closed	H → Z: Closed L → Z: Open	5 pF			H → Z: V$_{OH}$ − 0.5 V L → Z: V$_{OL}$ + 0.5 V

TYPICAL I_{CC} CHARACTERISTICS FOR THE PALCE16V8Z-12/15
V_{CC} = 5.0 V, T_A = 25°C
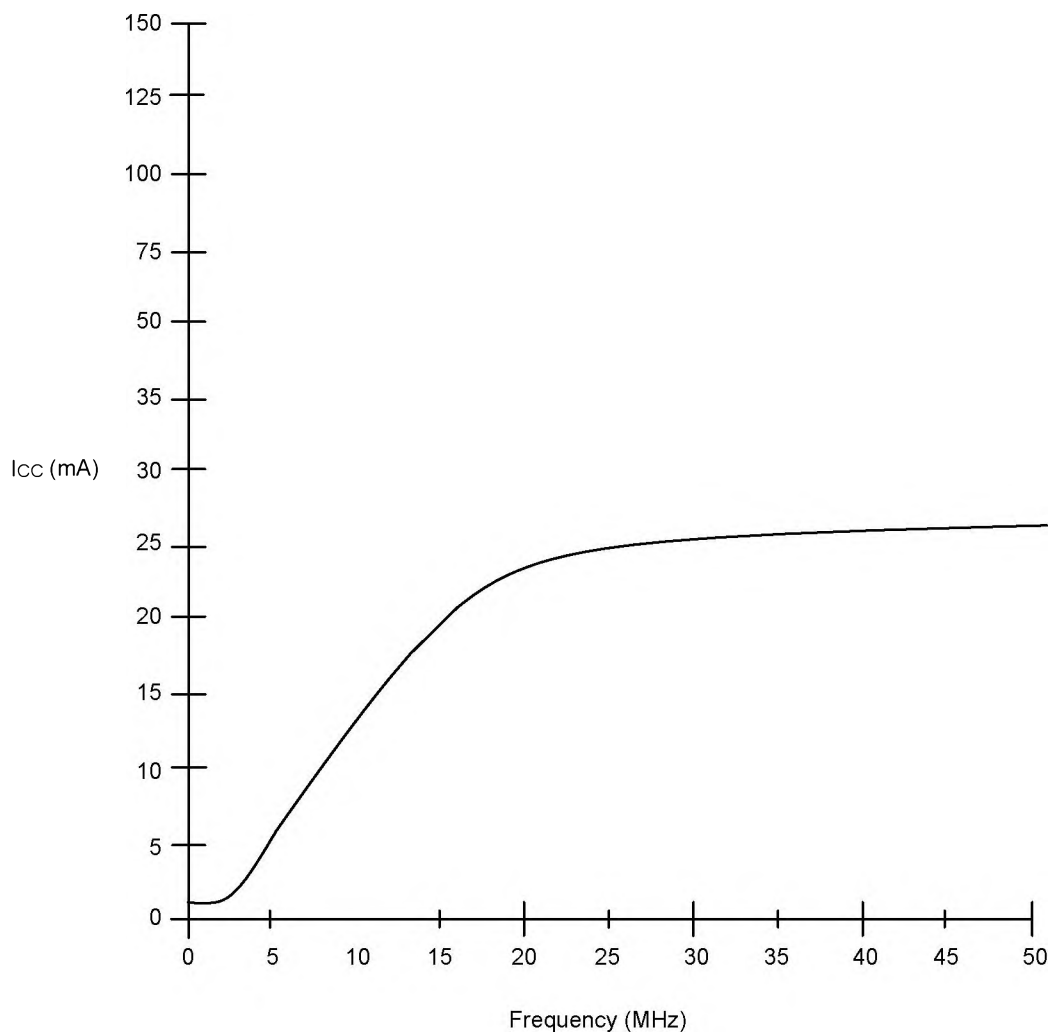

13061E-13
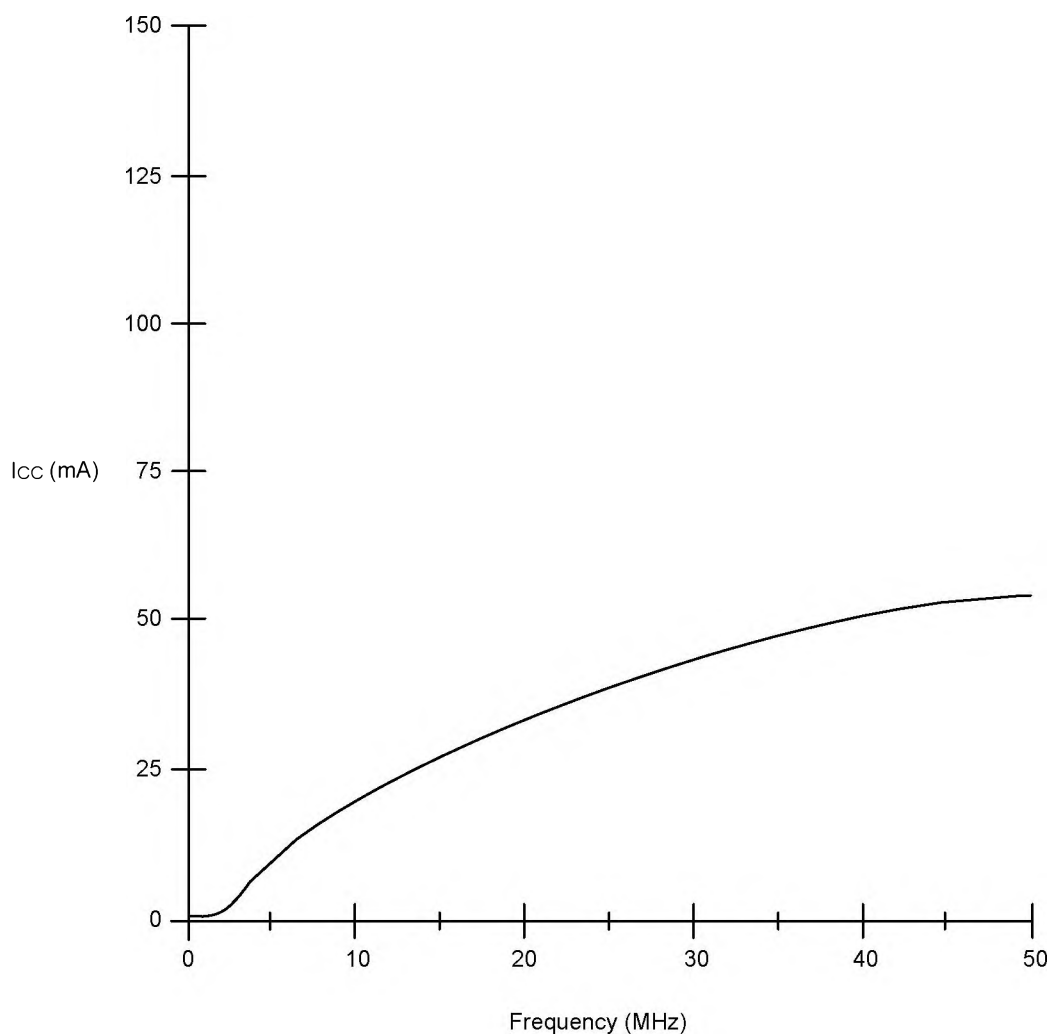
I_{CC} vs. Frequency
Graph for the PALCE16V8Z-12/15

The selected "typical" pattern utilized 50% of the device resources. Half of the macrocells were programmed as registered, and the other half were programmed as combinatorial. Half of the available product terms were used for each macrocell. On any vector, half of the outputs were switching.

By utilizing 50% of the device, a midpoint is defined for I_{CC}. From this midpoint, a designer may scale the I_{CC} graphs up or down to estimate the I_{CC} requirements for a particular design.

TYPICAL I_CC CHARACTERISTICS FOR THE PALCE16V8Z-25
V_CC = 5.0 V, T_A = 25°C

13061E-14

I_CC vs. Frequency
Graph for the PALCE16V8Z-25

The selected "typical" pattern utilized 50% of the device resources. Half of the macrocells were programmed as registered, and the other half were programmed as combinatorial. Half of the available product terms were used for each macrocell. On any vector, half of the outputs were switching.

By utilizing 50% of the device, a midpoint is defined for I_CC. From this midpoint, a designer may scale the I_CC graphs up or down to estimate the I_CC requirements for a particular design.

ENDURANCE CHARACTERISTICS

The PALCE16V8Z is manufactured using AMD's advanced Electrically Erasable process. This technology uses an EE cell to replace the fuse link used in bipolar parts. As a result, the device can be erased and reprogrammed – a feature which allows 100% testing at the factory.

Endurance Characteristics

| Symbol	Parameter	Test Conditions	Min	Unit
t$_{DR}$	Min Pattern Data Retention Time	Max Storage Temperature	10	Years
		Max Operating Temperature	20	Years
N	Min Reprogramming Cycles	Normal Programming Conditions	100	Cycles

ROBUSTNESS FEATURES

The PALCE16V8Z has some unique features that make it extremely robust, especially when operating in high-speed design environments. Input clamping circuitry limits negative overshoot, eliminating the possibility of false clocking caused by subsequent ringing. A special noise filter makes the programming circuitry completely insensitive to any positive overshoot that has a pulse width of less than about 100 ns.

INPUT/OUTPUT EQUIVALENT SCHEMATICS
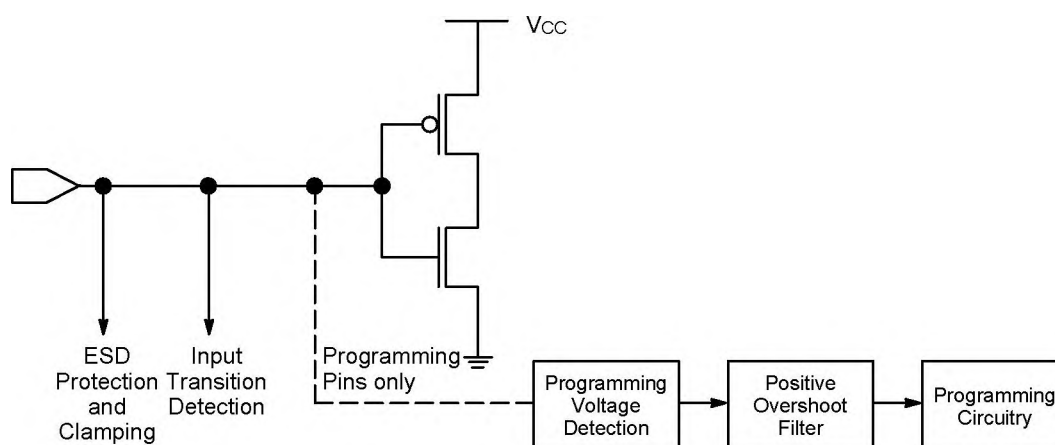
Typical Input
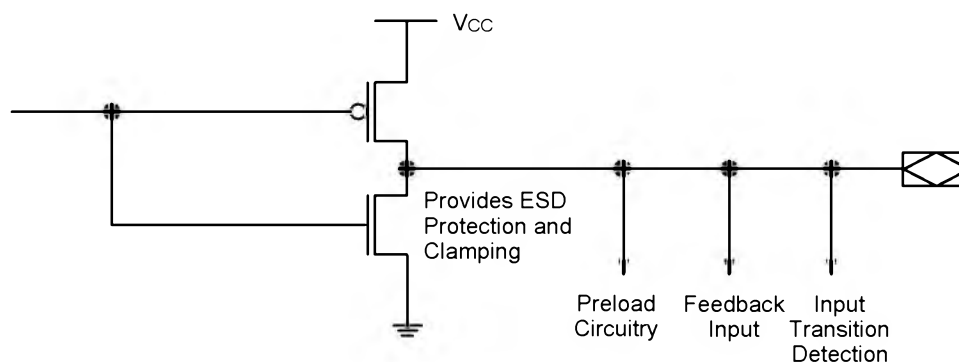

Typical Output

13061E-16

POWER-UP RESET

The PALCE16V8Z has been designed with the capability to reset during system power-up. Following power-up, all flip-flops will be reset to LOW. The output state will be HIGH independent of the logic polarity. This feature provides extra flexibility to the designer and is especially valuable in simplifying state machine initialization. A timing diagram and parameter table are shown below. Due to the synchronous operation of the power-up reset and the wide range of ways V_{CC} can rise to its steady state, two conditions are required to insure a valid power-up reset. These conditions are:

■ The V_{CC} rise must be monotonic.

■ Following reset, the clock input must not be driven from LOW to HIGH until all applicable input and feedback setup times are met.

Parameter Symbol	Parameter Descriptions	Min	Max	Unit
t_{PR}	Power-Up Reset Time		1000	ns
t_S	Input or Feedback Setup Time	See Switching Characteristics		
t_{WL}	Clock Width LOW			
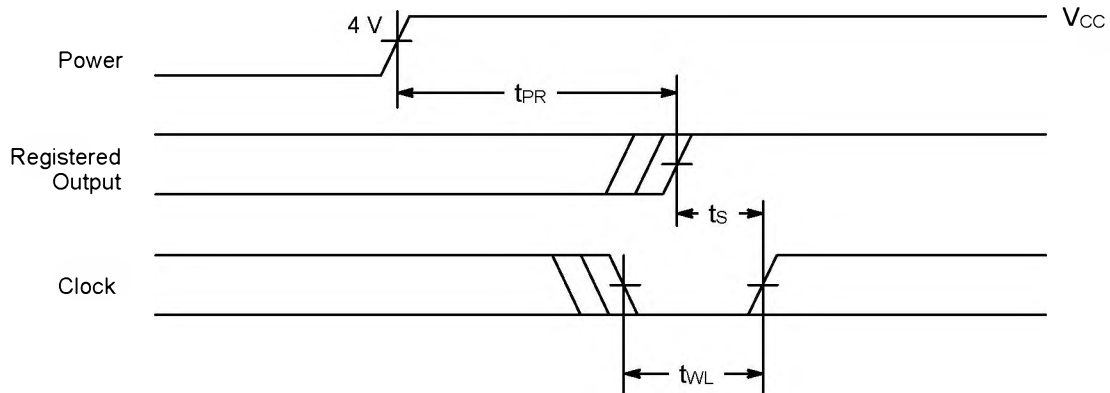
13061E-17

TYPICAL THERMAL CHARACTERISTICS

Measured at 25°C ambient. These parameters are not tested.

PALCE16V8Z-25

Parameter Symbol	Parameter Description		Typ		Unit
			PDIP	PLCC	
θ_{jc}	Thermal impedance, junction to case		20	19	°C/W
θ_{ja}	Thermal impedance, junction to ambient		65	57	°C/W
θ_{jma}	Thermal impedance, junction to ambient with air flow	200 lfpm air	58	41	°C/W
		400 lfpm air	51	37	°C/W
		600 lfpm air	47	35	°C/W
		800 lfpm air	44	33	°C/W

Plastic θjc Considerations

The data listed for plastic θjc are for reference only and are not recommended for use in calculating junction temperatures. The heat-flow paths in plastic-encapsulated devices are complex, making the θjc measurement relative to a specific location on the package surface. Tests indicate this measurement reference point is directly below the die-attach area on the bottom center of the package. Furthermore, θjc tests on packages are performed in a constant-temperature bath, keeping the package surface at a constant temperature. Therefore, the measurements can only be used in a similar environment.