



XCR3032: 32 Macrocell CPLD

DS038 (v1.3) October 9, 2000

Product Specification

Features

- Industry's first TotalCMOS™ PLD - both CMOS design and process technologies
- Fast Zero Power (FZP™) design technique provides ultra-low power and very high speed
- High speed pin-to-pin delays of 8ns
- Ultra-low static power of less than 35 μ A
- 100% routable with 100% utilization while all pins and all macrocells are fixed
- Deterministic timing model that is extremely simple to use
- Two clocks available
- Programmable clock polarity at every macrocell
- Support for asynchronous clocking
- Innovative XPLA™ architecture combines high speed with extreme flexibility
- 1000 erase/program cycles guaranteed
- 20 years data retention guaranteed
- Logic expandable to 37 product terms
- PCI compliant
- Advanced 0.5 μ E²CMOS process
- Security bit prevents unauthorized access
- Design entry and verification using industry standard and Xilinx CAE tools
- Reprogrammable using industry standard device programmers
- Innovative Control Term structure provides either sum terms or product terms in each logic block for:
 - Programmable 3-state buffer
 - Asynchronous macrocell register preset/reset
- Programmable global 3-state pin facilitates 'bed of nails' testing without using logic resources
- Available in both PLCC and VQFP packages

Description

The XCR3032 CPLD (Complex Programmable Logic Device) is the first in a family of CoolRunner® CPLDs from Xilinx. These devices combine high speed and zero power in a 32 macrocell CPLD. With the FZP design technique, the XCR3032 offers true pin-to-pin speeds of 8 ns, while simultaneously delivering power that is less than 35 μ A at standby without the need for "turbo bits" or other power down schemes. By replacing conventional sense amplifier methods for implementing product terms (a technique that has been used in PLDs since the bipolar era) with a cascaded chain of pure CMOS gates, the dynamic power is also substantially lower than any competing CPLD. These devices are the first TotalCMOS PLDs, as they use both a

CMOS process technology and the patented full CMOS FZP design technique. For 5V applications, Xilinx also offers the high speed XCR5032 CPLD that offers pin-to-pin speeds of 6 ns.

The Xilinx FZP CPLDs utilize the patented XPLA (eXtended Programmable Logic Array) architecture. The XPLA architecture combines the best features of both PLA and PAL type structures to deliver high speed and flexible logic allocation that results in superior ability to make design changes with fixed pinouts. The XPLA structure in each logic block provides a fast 8 ns PAL path with five dedicated product terms per output. This PAL path is joined by an additional PLA structure that deploys a pool of 32 product terms to a fully programmable OR array that can allocate the PLA product terms to any output in the logic block. This combination allows logic to be allocated efficiently throughout the logic block and supports as many as 37 product terms on an output. The speed with which logic is allocated from the PLA array to an output is only 2.5 ns, regardless of the number of PLA product terms used, which results in worst case t_{PD} 's of only 10.5 ns from any pin to any other pin. In addition, logic that is common to multiple outputs can be placed on a single PLA product term and shared across multiple outputs via the OR array, effectively increasing design density.

The XCR3032 CPLDs are supported by industry standard CAE tools (Cadence/OrCAD, Exemplar Logic, Mentor, Synopsys, Synario, Viewlogic, and Synplicity), using text (ABEL, VHDL, Verilog) and/or schematic entry. Design verification uses industry standard simulators for functional and timing simulation. Development is supported on personal computer, Sparc, and HP platforms. Device fitting uses a Xilinx developed tool, XPLA Professional (available on the Xilinx web site).

The XCR3032 CPLD is reprogrammable using industry standard device programmers from vendors such as Data I/O, BP Microsystems, SMS, and others.

XPLA Architecture

Figure 1 shows a high level block diagram of a 32 macrocell device implementing the XPLA architecture. The XPLA architecture consists of logic blocks that are interconnected by a Zero-power Interconnect Array (ZIA). The ZIA is a virtual crosspoint switch. Each logic block is essentially a 36V16 device with 36 inputs from the ZIA and 16 macrocells. Each logic block also provides 32 ZIA feedback paths from the macrocells and I/O pins.

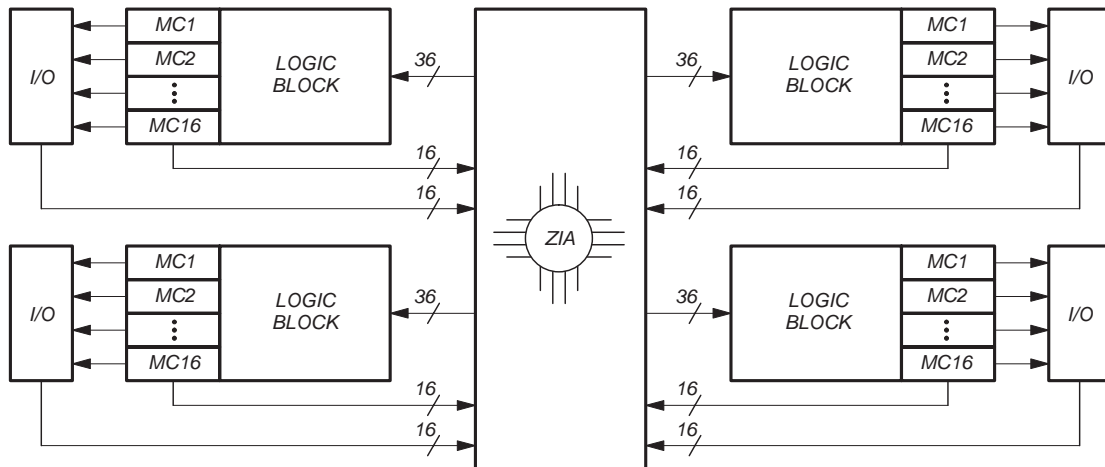
From this point of view, this architecture looks like many other CPLD architectures. What makes the CoolRunner family unique is what is inside each logic block and the design technique used to implement these logic blocks. The contents of the logic block will be described next.

Logic Block Architecture

Figure 3 illustrates the logic block architecture. Each logic block contains control terms, a PAL array, a PLA array, and 16 macrocells. The six control terms can individually be

configured as either SUM or PRODUCT terms, and are used to control the preset/reset and output enables of the 16 macrocells' flip-flops. The PAL array consists of a programmable AND array with a fixed OR array, while the PLA array consists of a programmable AND array with a programmable OR array. The PAL array provides a high speed path through the array, while the PLA array provides increased product term density.

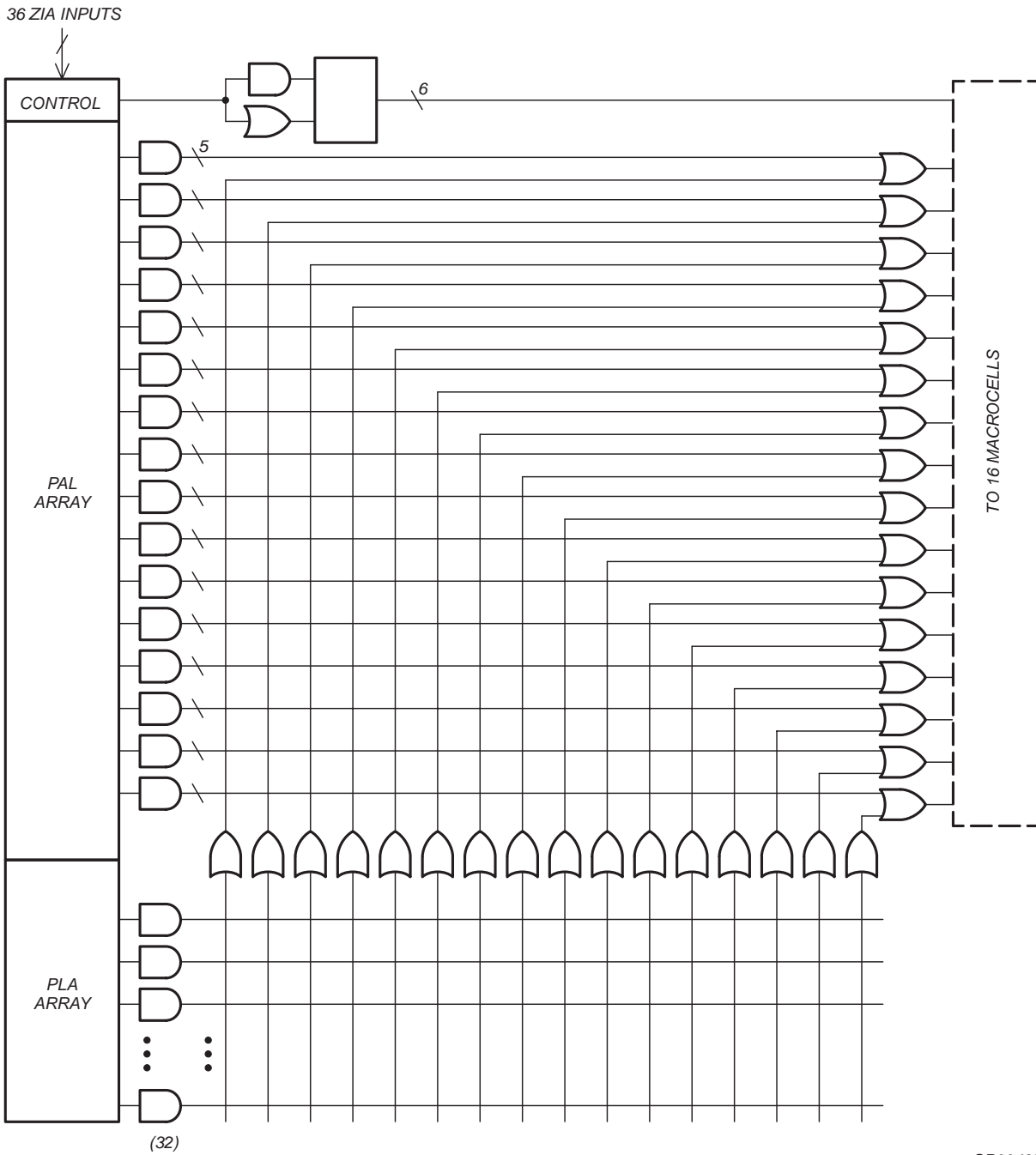
Each macrocell has five dedicated product terms from the PAL array. The pin-to-pin t_{PD} of the XCR3032 device through the PAL array is 8 ns. If a macrocell needs more than five product terms, it simply gets the additional product terms from the PLA array. The PLA array consists of 32 product terms, which are available for use by all 16 macrocells. The additional propagation delay incurred by a macrocell using one or all 32 PLA product terms is just 2.5 ns. So the total pin-to-pin t_{PD} for the XCR3032 using six to 37 product terms is 10.5 ns (8 ns for the PAL + 2.5 ns for the PLA).



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Figure 1: Xilinx XPLA CPLD Architecture

XCR3032: 32 Macrocell CPLD



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Figure 2: Xilinx XPLA Logic block Architecture

XCR3032: 32 Macrocell CPLD

Simple Timing Model

Figure 5 shows the CoolRunner Timing Model. The CoolRunner timing model looks very much like a 22V10 timing model in that there are three main timing parameters, including t_{PD} , t_{SU} , and t_{CO} . In other architectures, the user may be able to fit the design into the CPLD, but is not sure whether system timing requirements can be met until after the design has been fit into the device. This is because the timing models of competing architectures are very complex and include such things as timing dependencies on the number of parallel expanders borrowed, sharable expanders, varying number of X and Y routing channels used, etc. In the XPLA architecture, the user knows up front whether the design will meet system timing requirements. This is due to the simplicity of the timing model. For example, in the XCR3032 device, the user knows up front that if a given output uses five product terms or less, the $t_{PD} = 8$ ns, the

$t_{SU} = 6.5$ ns, and the $t_{CO} = 7.5$ ns. If an output is using six to 37 product terms, an additional 2.5 ns must be added to the t_{PD} and t_{SU} timing parameters to account for the time to propagate through the PLA array.

TotalCMOS Design Technique for Fast Zero Power

Xilinx is the first to offer a TotalCMOS CPLD, both in process technology and design technique. Xilinx employs a cascade of CMOS gates to implement its Sum of Products instead of the traditional sense amp approach. This CMOS gate implementation allows Xilinx to offer CPLDs which are both high performance and low power, breaking the paradigm that to have low power, you must have low performance. Refer to Figure 6 and Table 1 showing the I_{CC} vs. Frequency of our XCR3032 TotalCMOS CPLD.

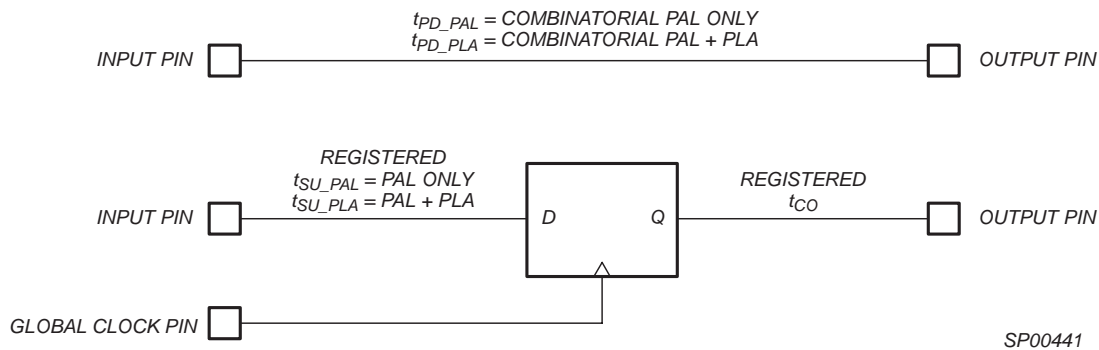
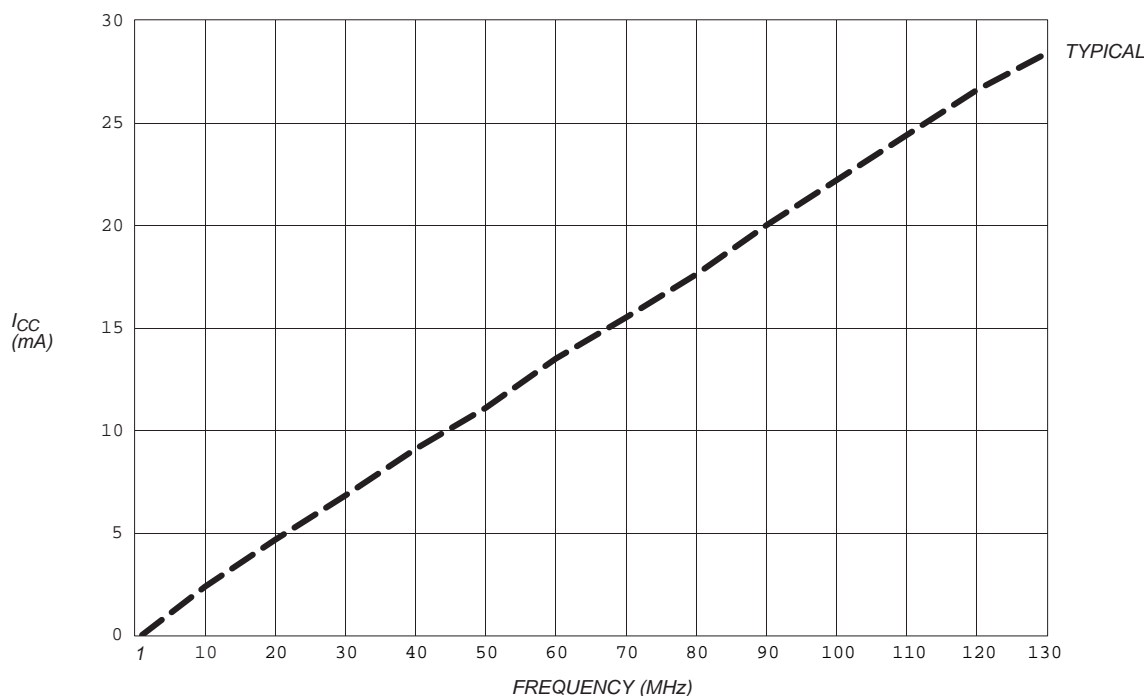


Figure 4: CoolRunner Timing Model



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Figure 5: I_{CC} vs. Frequency at $V_{CC} = 3.3V$, $25^{\circ}C$

Table 1: I_{CC} vs. Frequency ($V_{CC} = 3.3V$, $25^{\circ}C$)

Frequency (MHz)	0	10	20	30	40	50	60	70	80	90	100	110	120	130
Typical I_{CC} (mA)	0.01	2.37	4.65	6.80	9.06	11.1	13.5	15.5	17.4	20.0	22.1	24.4	26.6	28.5

XCR3032: 32 Macrocell CPLD

Absolute Maximum Ratings¹

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply voltage ²	-0.5	7.0	V
V_I	Input voltage	-1.2	$V_{CC} + 0.5$	V
V_{OUT}	Output voltage	-0.5	$V_{CC} + 0.5$	V
I_{IN}	Input current	-30	30	mA
I_{OUT}	Output current	-100	100	mA
T_J	Maximum junction temperature	-40	150	°C
T_{str}	Storage temperature	-65	150	°C

Notes:

1. Stresses above those listed may cause malfunction or permanent damage to the device. This is a stress rating only. Functional operation at these or any other condition above those indicated in the operational and programming specification is not implied.
2. The chip supply voltage must be monotonic.

Operating Range

Product Grade	Temperature	Voltage
Commercial	0 to +70°C	3.3V ± 10%
Industrial	-40 to +85°C	3.3V ± 10%

DC Electrical Characteristics For Commercial Grade Devices

Commercial: $0^{\circ}\text{C} \leq T_{\text{AMB}} \leq +70^{\circ}\text{C}$; $3.0\text{V} \leq V_{\text{CC}} \leq 3.6\text{V}$

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
V_{IL}	Input voltage low	$V_{\text{CC}} = 3.0\text{V}$		0.8	V
V_{IH}	Input voltage high	$V_{\text{CC}} = 3.6\text{V}$	2.0		V
V_{I}	Input clamp voltage	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{IN}} = -18\text{ mA}$		-1.2	V
V_{OL}	Output voltage low	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{OL}} = 8\text{ mA}$		0.5	V
V_{OH}	Output voltage high	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{OH}} = -8\text{ mA}$	2.4		V
I_{IL}	Input leakage current low	$V_{\text{CC}} = 3.6\text{V}$ (except CKO), $V_{\text{IN}} = 0\text{V}$	-10	10	μA
I_{IH}	Input leakage current high	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 3.0\text{V}$	-10	10	μA
I_{IL}	Clock input leakage current	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 0.4\text{V}$	-10	10	μA
I_{OZL}	3-stated output leakage current low	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 0.4\text{V}$	-10	10	μA
I_{OZH}	3-stated output leakage current high	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 3.0\text{V}$	-10	10	μA
I_{CCQ}^1	Standby current	$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = 0^{\circ}\text{C}$		35	μA
$I_{\text{CCD}}^{1,2}$	Dynamic current	$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = 0^{\circ}\text{C}$ at 1 MHz		0.5	mA
		$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = 0^{\circ}\text{C}$ at 50 MHz		18	mA
I_{OS}	Short circuit output current ³	One pin at a time for no longer than 1 second	-5	-100	mA
C_{IN}	Input pin capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$		8	pF
C_{CLK}	Clock input capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$	5	12	pF
$C_{\text{I/O}}$	I/O pin capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$		10	pF

Notes:

1. See Table 1 on page 6 for typical values.
2. This parameter measured with a 16-bit, loadable up/down counter loaded into every logic block, with all outputs enabled and unloaded. Inputs are tied to V_{CC} or ground. This parameter guaranteed by design and characterization, not testing.
3. Typical values, not tested.

XCR3032: 32 Macrocell CPLD

AC Electrical Characteristics¹ For Commercial Grade Devices

Commercial: $0^{\circ}\text{C} \leq T_{\text{AMB}} \leq +70^{\circ}\text{C}$; $3.0\text{V} \leq V_{\text{CC}} \leq 3.6\text{V}$

Symbol	Parameter	8		10		12		Unit
		Min.	Max.	Min.	Max.	Min.	Max.	
$t_{\text{PD_PAL}}$	Propagation delay time, input (or feedback node) to output through PAL	2	8	2	10	2	12	ns
$t_{\text{PD_PLA}}$	Propagation delay time, input (or feedback node) to output through PAL + PLA	3	10.5	3	13	3	15	ns
t_{CO}	Clock to out (global synchronous clock from pin)	2	7	2	9	2	11	ns
$t_{\text{SU_PAL}}$	Setup time (from input or feedback node) through PAL	6.5		8.5		10.5		ns
$t_{\text{SU_PLA}}$	Setup time (from input or feedback node) through PAL + PLA	9		11.5		13.5		ns
t_{H}	Hold time		0		0		0	ns
t_{CH}	Clock High time	3		4		5		ns
t_{CL}	Clock Low time	3		4		5		ns
t_{R}	Input rise time		20		20		20	ns
t_{F}	Input fall time		20		20		20	ns
f_{MAX1}	Maximum FF toggle rate ² ($1/t_{\text{CH}} + t_{\text{CL}}$)	167		125		100		MHz
f_{MAX2}	Maximum internal frequency ² ($1/t_{\text{SUPAL}} + t_{\text{CF}}$)	83		63		50		MHz
f_{MAX3}	Maximum external frequency ² ($1/t_{\text{SUPAL}} + t_{\text{CO}}$)	74		57		47		MHz
t_{BUF}	Output buffer delay time		1.5		1.5		1.5	ns
$t_{\text{PDF_PAL}}$	Input (or feedback node) to internal feedback node delay time through PAL		6.5		8.5		10.5	ns
$t_{\text{PDF_PLA}}$	Input (or feedback node) to internal feedback node delay time through PAL + PLA		9		11.5		13.5	ns
t_{CF}	Clock to internal feedback node delay time		5.5		7.5		9.5	ns
t_{INIT}	Delay from valid V_{CC} to valid reset		50		50		50	μs
t_{ER}	Input to output disable ³		15		17		19	ns
t_{EA}	Input to output valid		15		17		19	ns
t_{RP}	Input to register preset		16		18		20	ns
t_{RR}	Input to register reset		19		21		23	ns

Notes:

1. Specifications measured with one output switching. See Figure 6 and Table 2 for derating.
2. This parameter guaranteed by design and characterization, not by test.
3. Output $C_L = 5 \text{ pF}$.

DC Electrical Characteristics For Industrial Grade Devices

Industrial: $-40^{\circ}\text{C} \leq T_{\text{AMB}} \leq +85^{\circ}\text{C}$; $3.0\text{V} \leq V_{\text{CC}} \leq 3.6\text{V}$

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
V_{IL}	Input voltage low	$V_{\text{CC}} = 3.0\text{V}$		0.8	V
V_{IH}	Input voltage high	$V_{\text{CC}} = 3.6\text{V}$	2.0		V
V_{I}	Input clamp voltage	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{IN}} = -18\text{ mA}$		-1.2	V
V_{OL}	Output voltage low	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{OL}} = 8\text{ mA}$		0.5	V
V_{OH}	Output voltage high	$V_{\text{CC}} = 3.0\text{V}$, $I_{\text{OH}} = -8\text{ mA}$	2.4		V
I_{IL}	Input leakage current low	$V_{\text{CC}} = 3.6\text{V}$ (except CKO), $V_{\text{IN}} = 0.4\text{V}$	-10	10	μA
I_{IH}	Input leakage current high	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 3.0\text{V}$	-10	10	μA
I_{IL}	Clock input leakage current	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 0.4\text{V}$	-10	10	μA
I_{OZL}	3-stated output leakage current low	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 0.4\text{V}$	-10	10	μA
I_{OZH}	3-stated output leakage current high	$V_{\text{CC}} = 3.6\text{V}$, $V_{\text{IN}} = 3.0\text{V}$	-10	10	μA
I_{CCQ}^1	Standby current	$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = -40^{\circ}\text{C}$		45	μA
$I_{\text{CCD}}^{1,2}$	Dynamic current	$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = -40^{\circ}\text{C}$ at 1 MHz		0.5	mA
		$V_{\text{CC}} = 3.6\text{V}$, $T_{\text{AMB}} = -40^{\circ}\text{C}$ at 50 MHz		18	mA
I_{OS}	Short circuit output current ³	One pin at a time for no longer than 1 second	-5	-120	mA
C_{IN}	Input pin capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$		8	pF
C_{CLK}	Clock input capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$	5	12	pF
$C_{\text{I/O}}$	I/O pin capacitance ³	$T_{\text{AMB}} = 25^{\circ}\text{C}$, $f = 1\text{ MHz}$		10	pF

Notes:

1. See [Table 1 on page 6](#) for typical values.
2. This parameter measured with a 16-bit, loadable up/down counter loaded into every logic block, with all outputs enabled and unloaded. Inputs are tied to V_{CC} or ground. This parameter guaranteed by design and characterization, not testing.
3. Typical values, not tested.

XCR3032: 32 Macrocell CPLD

AC Electrical Characteristics¹ For Industrial Grade Devices

Industrial: $-40^{\circ}\text{C} \leq T_{\text{AMB}} \leq +85^{\circ}\text{C}$; $3.0\text{V} \leq V_{\text{CC}} \leq 3.6\text{V}$

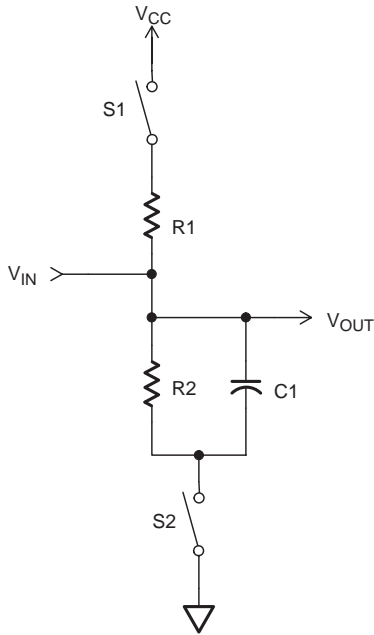
Symbol	Parameter	10		12		UNIT
		Min.	Max.	Min.	Max.	
$t_{\text{PD_PAL}}$	Propagation delay time, input (or feedback node) to output through PAL	2	10	2	12	ns
$t_{\text{PD_PLA}}$	Propagation delay time, input (or feedback node) to output through PAL + PLA	3	12.5	3	15	ns
t_{CO}	Clock to out (global synchronous clock from pin)	2	9	2	11	ns
$t_{\text{SU_PAL}}$	Setup time (from input or feedback node) through PAL	8		10.5		ns
$t_{\text{SU_PLA}}$	Setup time (from input or feedback node) through PAL + PLA	10.5		13.5		ns
t_{H}	Hold time		0		0	ns
t_{CH}	Clock High time	4		5		ns
t_{CL}	Clock Low time	4		5		ns
t_{R}	Input rise time		20		20	ns
t_{F}	Input fall time		20		20	ns
f_{MAX1}	Maximum FF toggle rate ² ($1/t_{\text{CH}} + t_{\text{CL}}$)	125		100		MHz
f_{MAX2}	Maximum internal frequency ² ($1/t_{\text{SUPAL}} + t_{\text{CF}}$)	64.5		50		MHz
f_{MAX3}	Maximum external frequency ² ($1/t_{\text{SUPAL}} + t_{\text{CO}}$)	58.8		47		MHz
t_{BUF}	Output buffer delay time		1.5		1.5	ns
$t_{\text{PDF_PAL}}$	Input (or feedback node) to internal feedback node delay time through PAL		8		10.5	ns
$t_{\text{PDF_PLA}}$	Input (or feedback node) to internal feedback node delay time through PAL + PLA		10.5		13.5	ns
t_{CF}	Clock to internal feedback delay time		7.5		9.5	ns
t_{INIT}	Delay from valid V_{CC} to valid reset		50		50	μs
t_{ER}	Input to output disable ³		16		19	ns
t_{EA}	Input to output valid		16		19	ns
t_{RP}	Input to register preset		17		20	ns
t_{RR}	Input to register reset		20		23	ns

Notes:

1. Specifications measured with one output switching. See Figure 6 and Table 2 for derating.
2. This parameter guaranteed by design and characterization, not by test.
3. Output $C_L = 5 \text{ pF}$.

Switching Characteristics

The test load circuit and load values for the AC Electrical Characteristics are illustrated below.



COMPONENT	VALUES
R1	390Ω
R2	390Ω
C1	35 pF

MEASUREMENT	S1	S2
t_{PZH}	Open	Closed
t_{PZL}	Closed	Closed
t_p	Closed	Closed

Note: For t_{PHZ} and t_{PLZ} C = 5 pF, and 3-state levels are measured 0.5V from steady-state active level.

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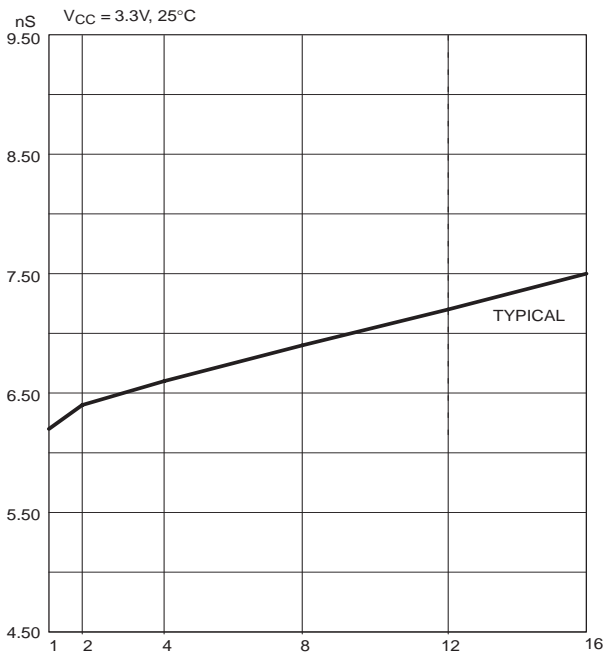
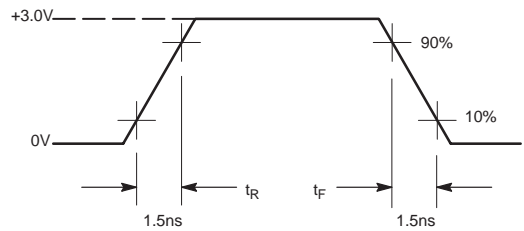


Figure 6: t_{PD_PAL} vs. Output Switching

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MEASUREMENTS:
All circuit delays are measured at the +1.5V level of inputs and outputs, unless otherwise specified.

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Input Pulses

Figure 7: Voltage Waveform

Table 2: t_{PD_PAL} vs # of Outputs Switching
($V_{CC} = 3.3$ V, $T = 25^\circ\text{C}$)

# of Outputs	1	2	4	8	12	16
Typical (ns)	6.2	6.4	6.6	6.9	7.2	7.5

XCR3032: 32 Macrocell CPLD

Pin Function and Layout

XCR3032 I/O Pins

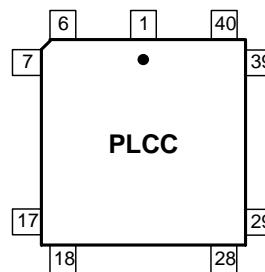
Function Block	Macrocell	PC44	VQ44	Notes
1	1	4	42	
1	2	5	43	
1	3	6	44	
1	4	7	1	
1	5	8	2	
1	6	9	3	
1	7	11	5	
1	8	12	6	
1	9	13	7	
1	10	14	8	
1	11	16	10	
1	12	17	11	
1	13	18	12	
1	14	19	13	
1	15	20	14	
1	16	21	15	
2	1	41	35	
2	2	40	34	
2	3	39	33	
2	4	38	32	
2	5	37	31	
2	6	36	30	
2	7	34	28	
2	8	33	27	
2	9	32	26	
2	10	31	25	
2	11	29	23	
2	12	28	22	
2	13	27	21	
2	14	26	20	
2	15	25	19	
2	16	24	18	

XCR3032 Global, Power, and Ground Pins

Pin Type	PC44	VQ44	Notes
IN0	43	37	
IN1	1	39	
IN2	44	38	
IN3	2	40	
gtsn	44	38	(1)
CLK0	43	37	
CLK1	4	42	
Vcc	3, 15, 23, 35	9, 17, 29, 41	
GND	10, 22, 30, 42	4, 16, 24, 36	

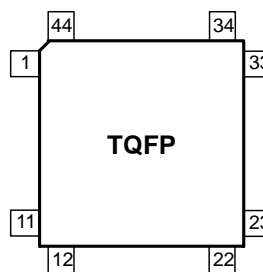
(1) Global 3-State pin facilitates bed of nails testing without using logic resources.

XCR3032 - 44-pin PLCC



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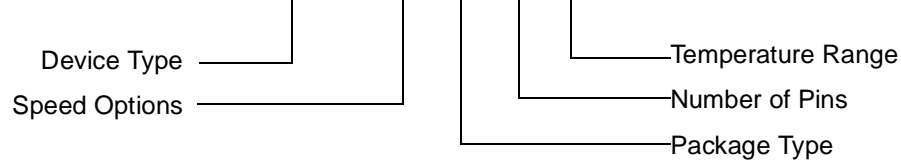
XCR3032 - 44-pin VQFP



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Ordering Information

Example: XCR3032 -8 PC 44 C



Speed Options

- 12: 12 ns pin-to-pin delay
- 10: 10 ns pin-to-pin delay
- 8: 8 ns pin-to-pin delay

Temperature Range

- C = Commercial, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$
- I = Industrial, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$

Packaging Options

- VQ44: 44-pin VQFP
- PC44: 44-pin PLCC

Component Availability

Pins		44	
Type		Plastic VQFP	Plastic PLCC
Code		VQ44	PC44
XCR3032	-12	C, I	C, I
	-10	C, I	C, I
	-8	C	C

Revision History

Date	Version #	Revision
8/4/99	1.0	Initial Xilinx release.
2/7/00	1.1	Converted to Xilinx format and updated
8/10/00	1.2	Updated pinout table and features.
10/09/00	1.3	Added Discontinuation Notice.