XILINX®

XC3100™ Logic Cell™ Array Family

January 1993

Product Specification

FEATURES

- 100% architecture, pin out, and software compatible with XC3000 devices
- Ultra-High speed, up to twice that of XC3000-125
  - 50-80 MHz system clock rates
  - Flip-flop toggle rates of 190 to 270 MHz
  - Performance equivalent to 10 ns PALs in many applications
- Advanced Second-Generation Field-Programmable Gate Array
  - Programmable logic blocks, I/O blocks, and interconnect structure
  - Low-power, CMOS, static-memory technology
- Flexible Array Architecture
  - Compatible arrays, 2,000 to 13,500 gate logic complexity
  - Extensive register and I/O capability
  - Internal 3-state bus capabilities
  - Unlimited re-programmability
  - TTL or CMOS input thresholds
  - Rail-to-rail output swing
  - 2,000-V electrostatic-discharge input protection
  - 8-mA sink current per output
- Extensive Packaging Options
  - Common 84-pin plastic leaded chip carrier (PLCC) footprint
  - 44- to 223-pin plastic and ceramic surface mount and pin grid array packages
- Standard, off-the-shelf product availability
  - 100% factory pre-tested
- Complete XACT® Development System
  - Schematic capture, automatic place and route
  - Logic and timing simulation
  - Interactive design editor for design optimization
  - Library and user macros
  - Timing calculator
  - Standard PROM File Interface

DESCRIPTION

The XC3100 family of Field-Programmable Gate Arrays (FPGAs) provides the benefits of high-speed, custom CMOS VLSI while avoiding the initial cost, time delay, and inherent risk of a conventional masked gate array.

The XC3100 is a performance-optimized relative of the industry-leading XC3000 family. While both families are bitstream and footprint compatible, the XC3100 family extends in-system performance to 80 MHz and beyond.

The table below provides a comparison between the XC3100 family and the XC3000.

		T_{ILO}	Toggle Rate
XC3100	-3	2.7	270
	-4	3.3	230
	-5	4.1	190
XC3000	-125	5.5	125
	-100	7.0	100
	-70	9.0	70

The regular, flexible, re-programmable array architecture is composed of three standard types of programmable elements: a perimeter of Input/Output Blocks (IOBs), a core array of Configurable Logic Blocks (CLBs), and resources for interconnection. Xilinx FPGAs can be reprogrammed an unlimited number of times.

The devices are customized by the configuration program data stored in internal memory cells. The FPGA can either actively read its configuration data out of an external serial or byte-parallel PROM (master modes), or the configuration can be written into the FPGA (slave and peripheral modes). Xilinx offers a variety of companion serial-configuration PROMs for convenient program storage in a one-time programmable device.

The XACT development system delivers a powerful software tool set for design implementation: from schematic capture, to simulation, auto place-and-route, and finally the creation of the configuration bit stream.

Device	Nominal Gates	Typical Gates	CLBs	Max User I/Os	Program Data Bits
XC3120	2,000	1.3-1.8 k	64	64	14,779
XC3130	3,000	2.0-2.7 k	100	80	22,176
XC3142	4,200	2.5-3.7 k	144	96	30,784
XC3164	6,400	4.0-5.5 k	224	120	46,064
XC3190	9,000	5.0-7.5 k	320	144	64,160
XC3195	13,500	7.0-9.0 k	484	176	94,944

The XC3100 family follows the XC4000 speed-grade nomenclature, indicating device performance based on the internal logic block delay.

The block logic functions are implemented by programmed look-up tables. Functional options are implemented by program-controlled multiplexers. Interconnecting networks between blocks are implemented with metal segments joined by program-controlled pass transistors.

These LCA™ functions are established by a configuration program which is loaded into an internal, distributed array of configuration memory cells. The configuration program is loaded into the LCA device at power-up and may be reloaded on command. The Logic Cell Array includes logic and control signals to implement automatic or passive configuration. Program data may be either bit serial or byte parallel. The XACT development system generates the configuration program bitstream used to configure the Logic Cell Array. The memory loading process is independent of the user logic functions.

Configuration Memory

The static memory cell used for the configuration memory in the Logic Cell Array has been designed specifically for high reliability and noise immunity. Integrity of the LCA device configuration memory based on this design is assured even under adverse conditions. Compared with other programming alternatives, static memory provides the best combination of high density, high performance, high reliability and comprehensive testability. As shown in Figure 2, the basic memory cell consists of two CMOS inverters plus a pass transistor used for writing and reading cell data. The cell is only written during configuration and only read during readback. During normal operation, the cell provides continuous control and the pass transistor is "off" and does not affect cell stability. This is quite different from the operation of conventional memory devices, in which the cells are frequently read and re-written.

The memory cell outputs Q and $\overline{Q}$ use ground and Vcc levels and provide continuous, direct control. The additional capacitive load together with the absence of address decoding and sense amplifiers provide high stability to the cell. Due to the structure of the configuration memory cells,

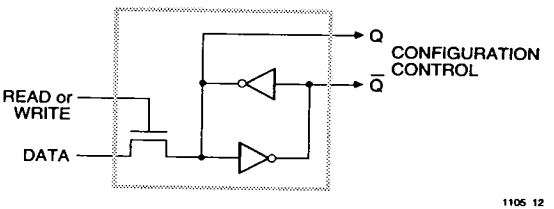


Figure 2. Static Configuration Memory Cell. It is loaded with one bit of configuration program and controls one program selection in the Logic Cell Array.

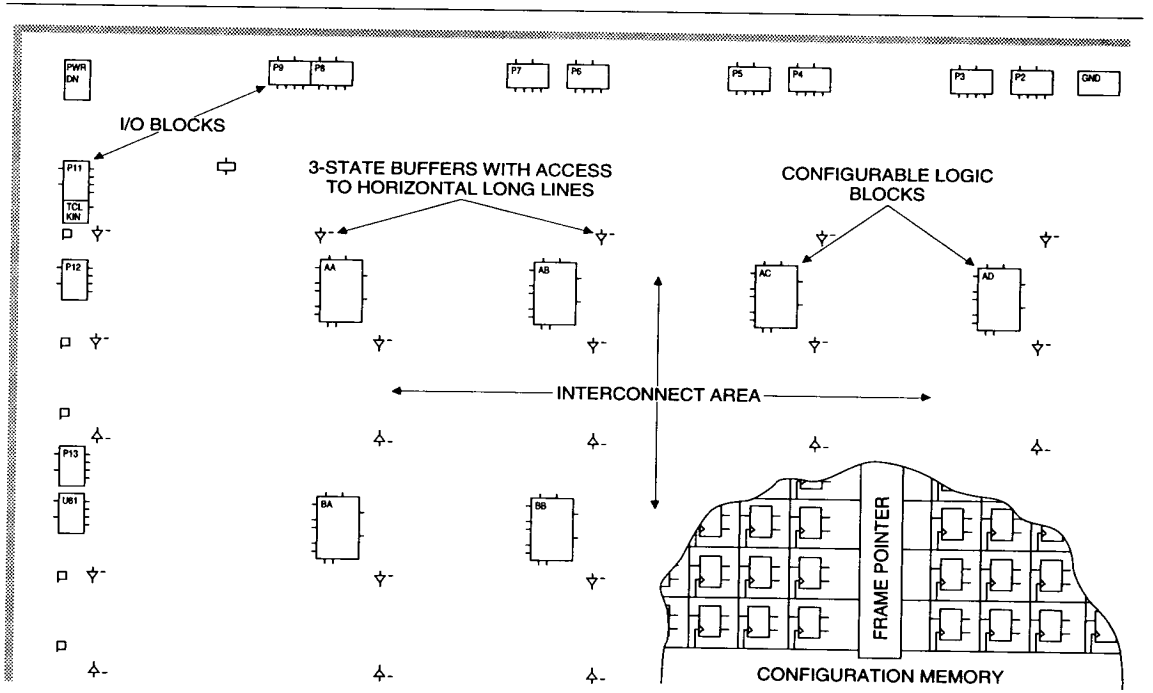


Figure 1. Logic Cell Array Structure. It consists of a perimeter of programmable I/O blocks, a core of configurable logic blocks and their interconnect resources. These are all controlled by the distributed array of configuration program memory cells.

they are not affected by extreme power-supply excursions or very high levels of alpha particle radiation. In reliability testing, no soft errors have been observed even in the presence of very high doses of alpha radiation.

The method of loading the configuration data is selectable. Two methods use serial data, while three use byte-wide data. The internal configuration logic utilizes framing information, embedded in the program data by the XACT development system, to direct memory-cell loading. The serial-data framing and length-count preamble provide programming compatibility for mixes of various LCA device devices in a synchronous, serial, daisy-chain fashion.

I/O Block

Each user-configurable IOB shown in Figure 3, provides an interface between the external package pin of the device and the internal user logic. Each IOB includes both registered and direct input paths. Each IOB provides a programmable 3-state output buffer, which may be driven by a registered or direct output signal. Configuration options allow each IOB an inversion, a controlled slew rate and a high impedance pull-up. Each input circuit also provides input clamping diodes to provide electro-static protection, and circuits to inhibit latch-up produced by input currents.

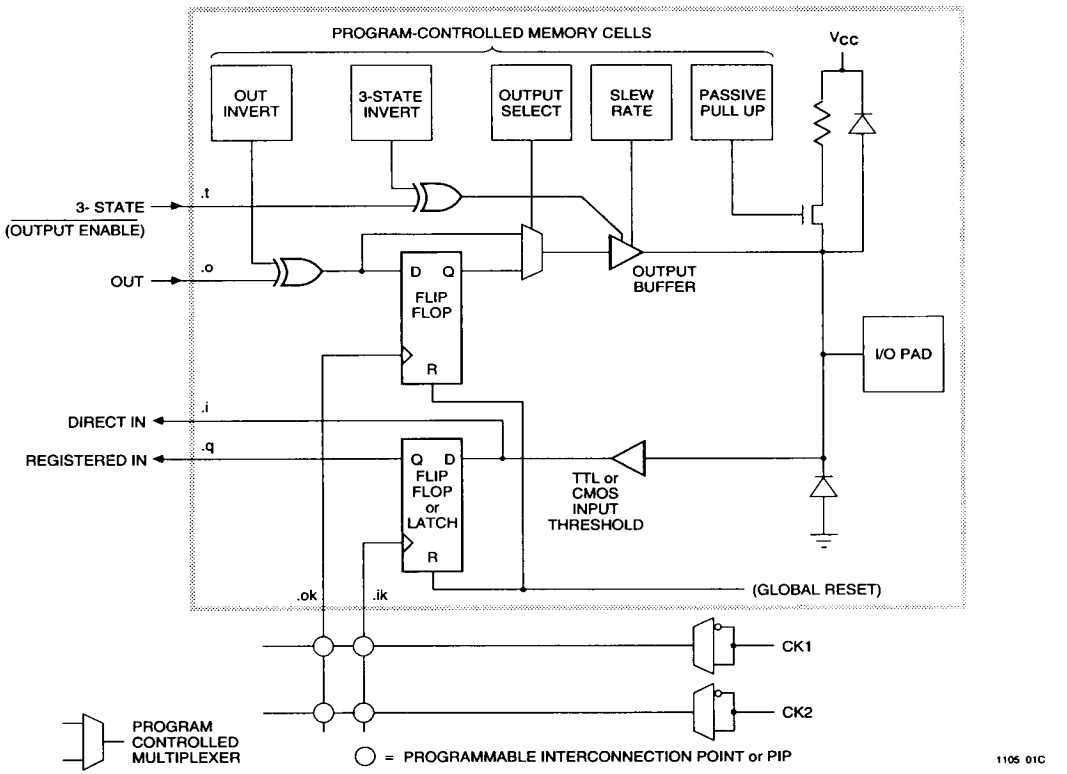


Figure 3. Input/Output Block. Each IOB includes input and output storage elements and I/O options selected by configuration memory cells. A choice of two clocks is available on each die edge. The polarity of each clock line (not each flip-flop or latch) is programmable. A clock line that triggers the flip-flop on the rising edge is an active Low Latch Enable (Latch transparent) signal and vice versa. Passive pull-up can only be enabled on inputs, not on outputs. All user inputs are programmed for TTL or CMOS thresholds.

The input-buffer portion of each IOB provides threshold detection to translate external signals applied to the package pin to internal logic levels. The global input-buffer threshold of the IOBs can be programmed to be compatible with either TTL or CMOS levels. The buffered input signal drives the data input of a storage element, which may be configured as either a flip-flop or a latch. The clocking polarity (rising/falling edge-triggered flip-flop, High/Low transparent latch) is programmable for each of the two clock lines on each of the four die edges. Note that a clock line driving a *rising* edge-triggered flip-flop makes any latch driven by the same line on the same edge *Low*-level transparent and vice versa (*falling* edge, *High* transparent). All Xilinx primitives in the supported schematic-entry packages, however, are positive edge-triggered flip-flops or High transparent latches. When one clock line must drive flip-flops as well as latches, it is necessary to compensate for the difference in clocking polarities with an additional inverter either in the flip-flop clock input or the latch-enable input. I/O storage elements are reset during configuration or by the active-Low chip $\overline{\text{RESET}}$ input. Both direct input [from IOB pin *.i*] and registered input [from IOB pin *.q*] signals are available for interconnect.

For reliable operation, inputs should have transition times of less than 100 ns and should not be left floating. Floating CMOS input-pin circuits might be at threshold and produce oscillations. This can produce additional power dissipation and system noise. A typical hysteresis of about 300 mV reduces sensitivity to input noise. Each user IOB includes a programmable high-impedance pull-up resistor, which may be selected by the program to provide a constant High for otherwise undriven package pins. Although the Logic Cell Array provides circuitry to provide input protection for electrostatic discharge, normal CMOS handling precautions should be observed.

Flip-flop loop delays for the IOB and logic-block flip-flops are about 3 ns. This short delay provides good performance under asynchronous clock and data conditions. Short loop delays minimize the probability of a metastable condition that can result from assertion of the clock during data transitions. Because of the short-loop-delay characteristic in the Logic Cell Array, the IOB flip-flops can be used to synchronize external signals applied to the device. Once synchronized in the IOB, the signals can be used internally without further consideration of their clock relative timing, except as it applies to the internal logic and routing-path delays.

IOB output buffers provide CMOS-compatible 8-mA source-or-sink drive for high fan-out CMOS or TTL-compatible signal levels. The network driving IOB pin .o becomes the registered or direct data source for the output buffer. The 3-state control signal [IOB pin *.t*] can control output activity. An open-drain-type output may be obtained by using the same signal for driving the output and 3-state signal nets so that the buffer output is enabled only for a Low.

Configuration program bits for each IOB control features such as optional output register, logical signal inversion, and 3-state and slew-rate control of the output.

The program-controlled memory cells of Figure 3 control the following options:

- Logic **inversion of the output** is controlled by one configuration program bit per IOB.

- Logic **3-state control** of each IOB output buffer is determined by the states of configuration program bits which turn the buffer on, or off, or select the output buffer 3-state control interconnection [IOB pin *.t*]. When this IOB output control signal is High, a logic one, the buffer is **disabled** and the package pin is high impedance. When this IOB output control signal is Low, a logic zero, the buffer is **enabled** and the package pin is active. Inversion of the buffer 3-state control logic sense (output enable) is controlled by an additional configuration program bit.

- **Direct or registered output** is selectable for each IOB. The register uses a positive-edge, clocked flip-flop. The clock source may be supplied [IOB pin *.ok*] by either of two metal lines available along each die edge. Each of these lines is driven by an invertible buffer.

- Increased **output transition speed** can be selected to improve critical timing. Slower transitions reduce capacitive-load peak currents of non-critical outputs and minimize system noise.

- A high-impedance **pull-up resistor** may be used to prevent unused inputs from floating.

Summary of I/O Options

- Inputs
  - Direct
  - Flip-flop/latch
  - CMOS/TTL threshold (chip inputs)
  - Pull-up resistor/open circuit
- Outputs
  - Direct/registered
  - Inverted/not
  - 3-state/on/off
  - Full speed/slew limited
  - 3-state/output enable (inverse)

Configurable Logic Block

The array of Configurable Logic Blocks (CLBs) provides the functional elements from which the user's logic is constructed. The logic blocks are arranged in a matrix within the perimeter of IOBs. The XC3120 has 64 such blocks arranged in 8 rows and 8 columns. The XACT development system is used to compile the configuration data which are to be loaded into the internal configuration memory to define the operation and interconnection of each block. User definition of configurable logic blocks and their interconnecting networks may be done by automatic translation from a schematic capture logic diagram or optionally by installing library or user macros.

Each configurable logic block has a combinatorial logic section, two flip-flops, and an internal control section. See Figure 4. There are: five logic inputs [*.a, .b, .c, .d* and *.e*]; a common clock input [*.k*]; an asynchronous direct reset input [*.rd*]; and an enable clock [*.ec*]. All may be driven from the interconnect resources adjacent to the blocks. Each CLB also has two outputs [*.x* and *.y*] which may drive interconnect networks.

Data input for either flip-flop within a CLB is supplied from the function F or G outputs of the combinatorial logic, or the block input, data-in [*.di*]. Both flip-flops in each CLB share the asynchronous reset [*.rd*] which, when enabled and High, is dominant over clocked inputs. All flip-flops are

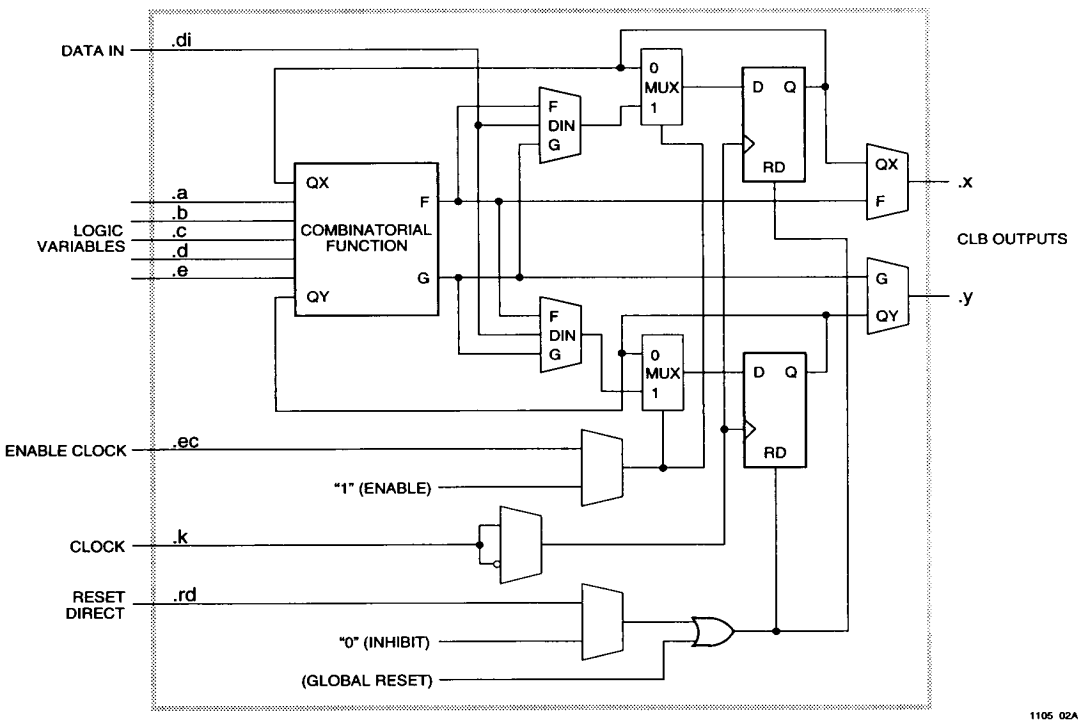


Figure 4. Configurable Logic Block. Each CLB includes a combinatorial logic section, two flip-flops and a program memory controlled multiplexer selection of function.

It has: five logic variable inputs .a, .b, .c, .d and .e.
a direct data in .di
an enable clock .ec
a clock (invertible) .k
an asynchronous reset .rd
two outputs .x and .y

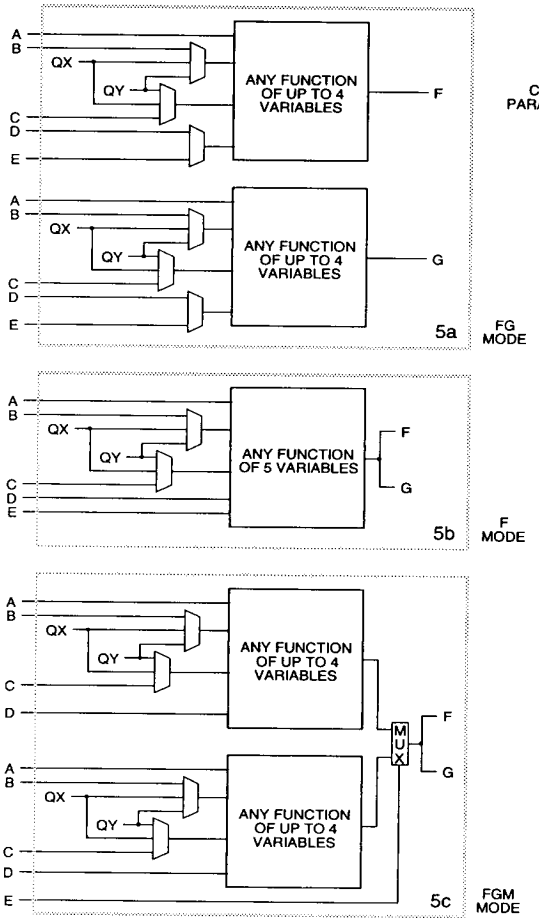


Figure 5

5a. Combinatorial Logic Option FG generates two functions of four variables each. One variable, A, must be common to both functions. The second and third variable can be any choice of of B, C, Qx and Qy. The fourth variable can be any choice of D or E.

5b. Combinatorial Logic Option F generates any function of five variables: A, D, E and and two choices out of B, C, Qx, Qy.

5c. Combinatorial Logic Option FGM allows variable E to select between two functions of four variables: Both have common inputs A and D and any choice out of B, C, Qx and Qy for the remaining two variables. Option 3 can then implement some functions of six or seven variables.

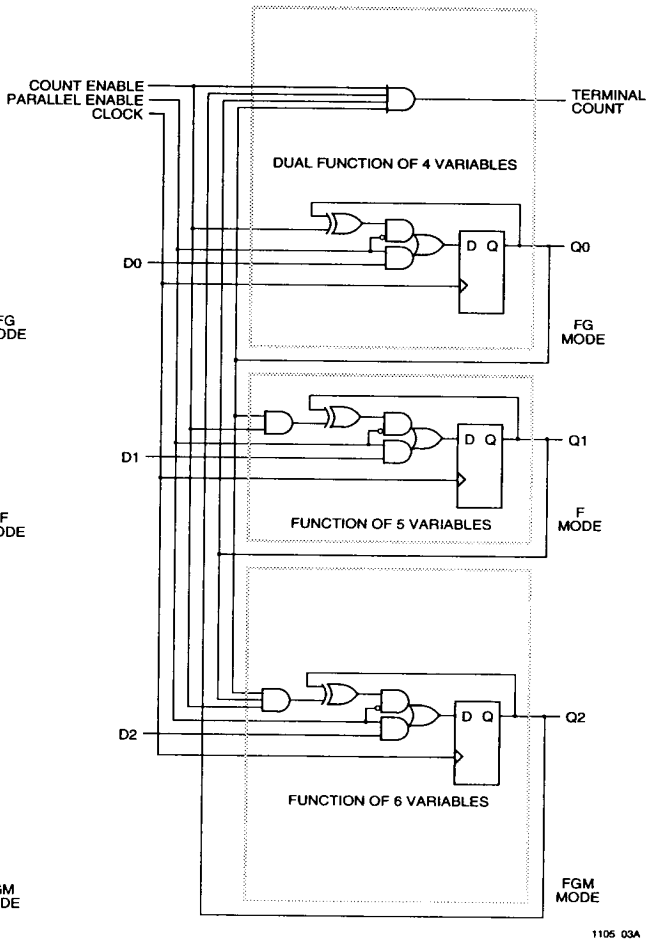


Figure 6. C8BCP Macro. TheC8BCP macro (modulo-8 binary counter with parallel enable and clock enable) uses one combinatorial logic block of each option.

reset by the active Low chip input, $\overline{\text{RESET}}$, or during the configuration process. The flip-flops share the enable clock [.*ec*] which, when Low, recirculates the flip-flops' present states and inhibits response to the data-in or combinatorial function inputs on a CLB. The user may enable these control inputs and select their sources. The user may also select the clock net input [.*k*], as well as its active sense within each logic block. This programmable inversion eliminates the need to route both phases of a clock signal throughout the device. Flexible routing allows use of common or individual CLB clocking.

The combinatorial-logic portion of the logic block uses a 32 by 1 look-up table to implement Boolean functions. Variables selected from the five logic inputs and two internal block flip-flops are used as table address inputs. The combinatorial propagation delay through the network is independent of the logic function generated and is spike free for single input variable changes. This technique can generate two independent logic functions of up to four variables each as shown in Figure 5a, or a single function of five variables as shown in Figure 5b, or some functions of seven variables as shown in Figure 5c. Figure 6 shows a modulo 8 binary counter with parallel enable. It uses one CLB of each type. The partial functions of six or seven variables are implemented using the input variable [.*e*] to dynamically select between two functions of four different variables. For the two functions of four variables each, the independent results (F and G) may be used as data inputs to either flip-flop or either logic block output. For the single function of five variables and merged functions of six or seven variables, the F and G outputs are identical. Symmetry of the F and G functions and the flip-flops allows the interchange of CLB outputs to optimize routing efficiencies of the networks interconnecting the logic blocks and IOBs.

PROGRAMMABLE INTERCONNECT

Programmable-interconnection resources in the Logic Cell Array provide routing paths to connect inputs and outputs of the I/O and logic blocks into logic networks. Interconnections between blocks are composed from a two-layer grid of metal segments. Specially designed pass transistors, each controlled by a configuration bit, form programmable interconnect points (PIPs) and switching matrices used to implement the necessary connections between selected metal segments and block pins. Figure 7 is an example of a routed net. The XACT development system provides automatic routing of these interconnections. Interactive routing (Editnet) is also available for design optimization. The inputs of the logic or IOBs are multiplexers which can be programmed to select an input network from the adjacent interconnect segments. ***As the switch connections to block inputs are unidirectional (as are block outputs) they are usable only for block input connection and not routing.*** Figure 8 illustrates routing access to logic block input variables, control inputs and block outputs. Three types of metal resources are provided to accommodate various network interconnect requirements:

- General Purpose Interconnect
- Direct Connection
- Longlines (multiplexed busses and wide AND gates)

General Purpose Interconnect

General purpose interconnect, as shown in Figure 9, consists of a grid of five horizontal and five vertical metal segments located between the rows and columns of logic and IOBs. Each segment is the "height" or "width" of a logic block. Switching matrices join the ends of these segments and allow programmed interconnections between the metal grid segments of adjoining rows and columns. The switches of an unprogrammed device are all non-conducting. The connections through the switch matrix may be established by the automatic routing or by using Editnet to select the desired pairs of matrix pins to be connected or disconnected. The legitimate switching matrix combinations for each pin are indicated in Figure 10 and may be highlighted by the use of the Show-Matrix command in XACT.

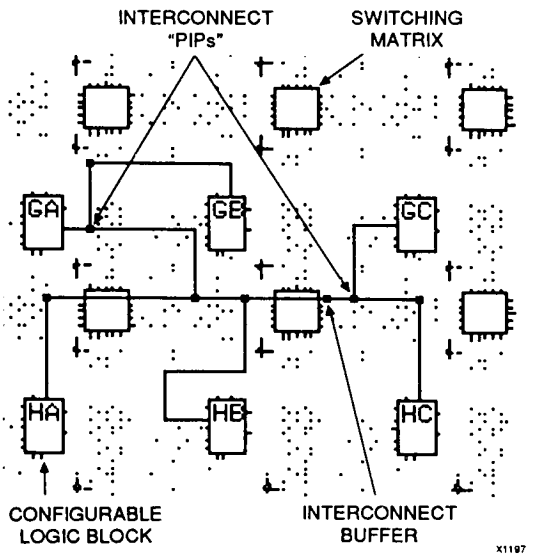


Figure 7. An XACT view of routing resources used to form a typical interconnection network from CLB GA.

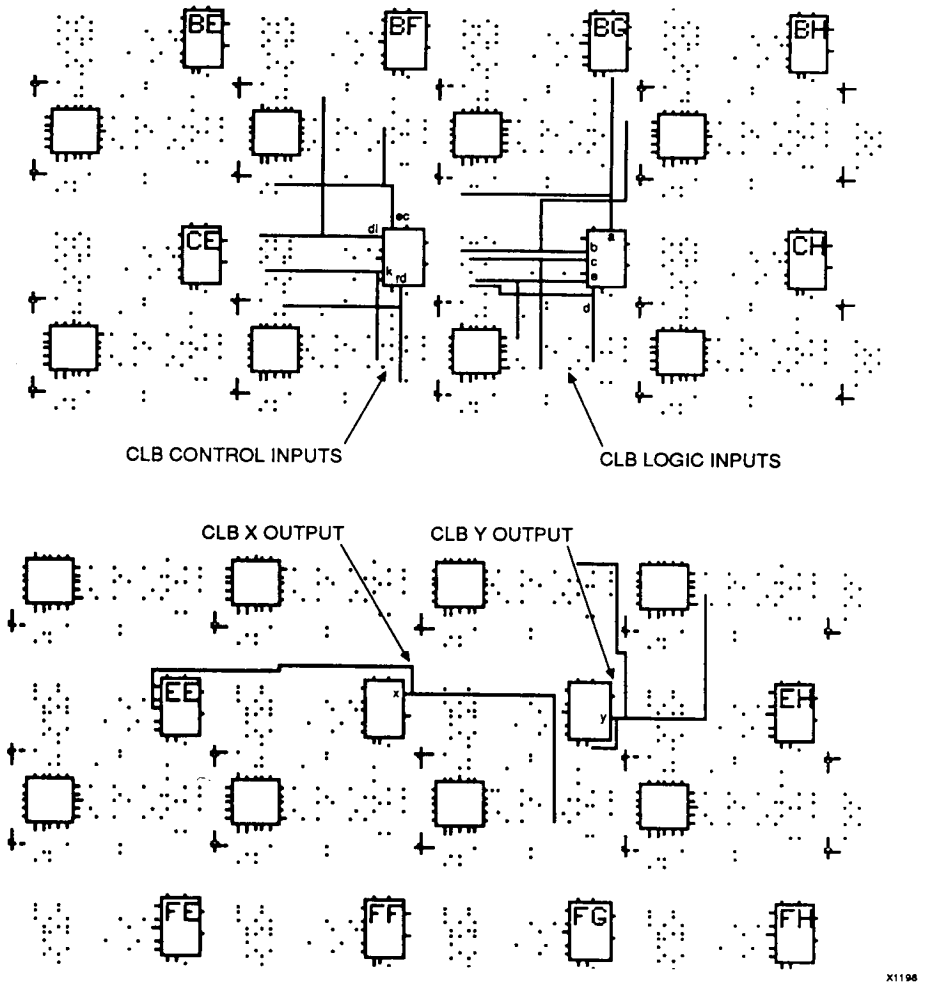


Figure 8. XACT Development System Locations of interconnect access, CLB control inputs, logic inputs and outputs. The dot pattern represents the available programmable interconnection points (PIPs).

Some of the interconnect PIPs are directional. This is indicated on the XACT design editor status line:

ND is a nondirectional interconnection.
D:H->V is a PIP that drives from a horizontal to a vertical line.
D:V->H is a PIP that drives from a vertical to a horizontal line.
D:C->T is a "T" PIP that drives from a cross of a T to the tail.
D:CW is a corner PIP that drives in the clockwise direction.
P0 indicates the PIP is non-conducting , P1 is "on."

Special buffers within the general interconnect areas provide periodic signal isolation and restoration for improved performance of lengthy nets. The interconnect buffers are available to propagate signals in either direction on a given general interconnect segment. These bidirectional (bidi) buffers are found adjacent to the switching matrices, above and to the right and may be highlighted by the use of the "Show BIDI" command in XACT. The other PIPs adjacent to the matrices are accessed to or from Longlines. The development system automatically defines the buffer direction based on the location of the interconnection network source. The delay calculator of the XACT development system automatically calculates and displays the block, interconnect and buffer delays for any paths selected. Generation of the simulation netlist with a worst-case delay model is provided by an XACT option.

Direct Interconnect

Direct interconnect, shown in Figure 11, provides the most efficient implementation of networks between adjacent logic or I/O Blocks. Signals routed from block to block using the direct interconnect exhibit minimum interconnect propagation and use no general interconnect resources. For each CLB, the *.x* output may be connected directly to the *.b* input of the CLB immediately to its right and to the *.c* input of the CLB to its left. The *.y* output can use direct interconnect to drive the *.d* input of the block immediately

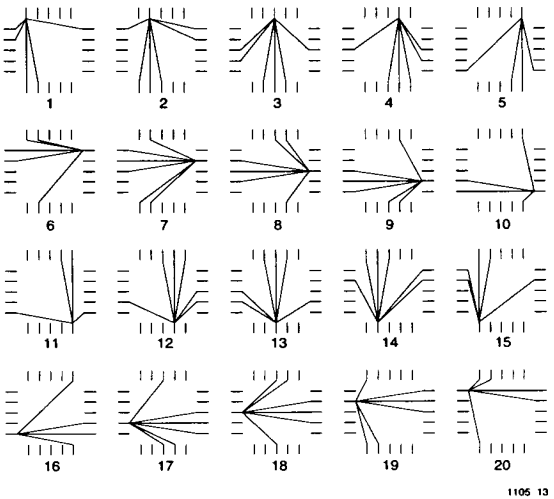


Figure 10. Switch Matrix Interconnection Options for Each Pin. Switch matrices on the edges are different. Use Show Matrix menu option in XACT

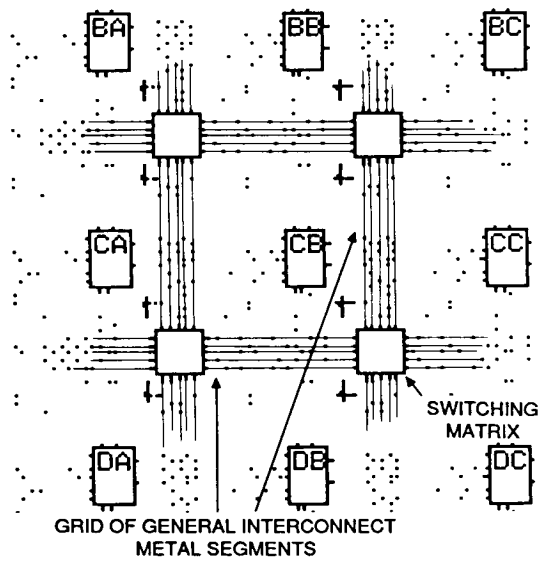


Figure 9. LCA General-Purpose Interconnect. Composed of a grid of metal segments that may be interconnected through switch matrices to form networks for CLB and IOB inputs and outputs.

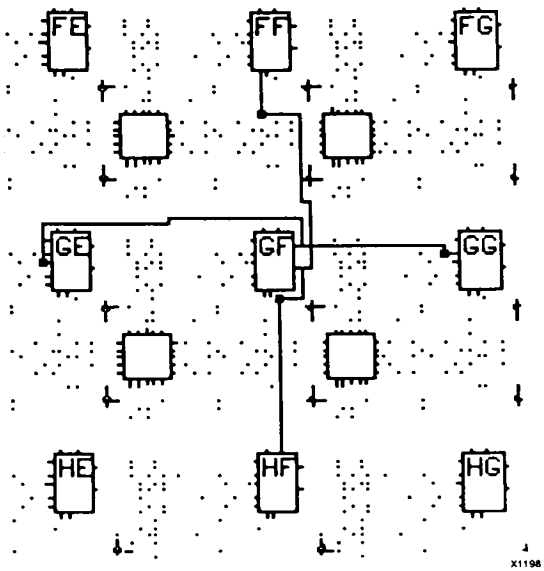


Figure 11. CLB .X and .Y Outputs. The .x and .y outputs of each CLB have single contact, direct access to inputs of adjacent CLBs.

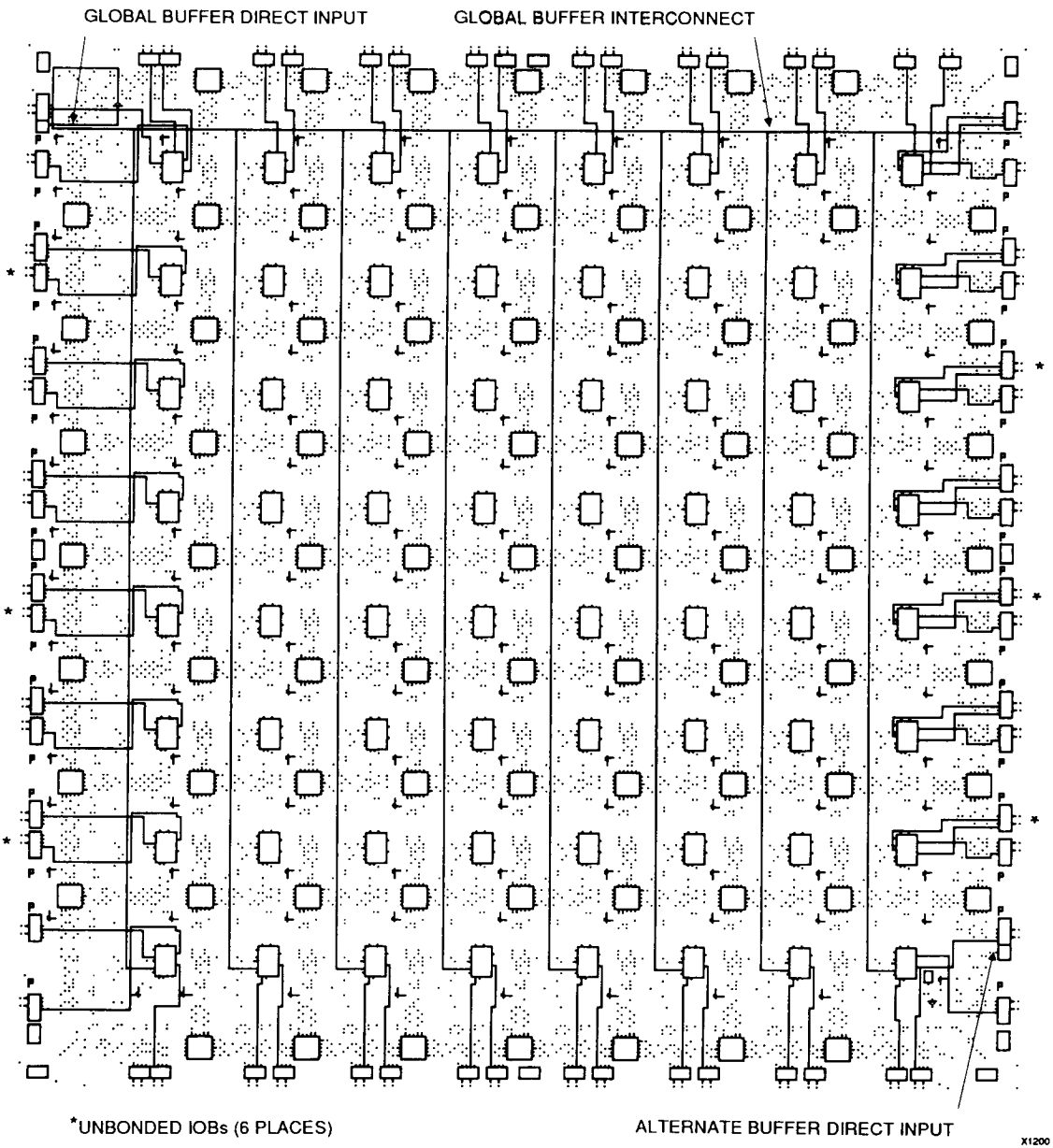


Figure 12. X3120 Die-Edge IOBs. The X3120 die-edge IOBs are provided with direct access to adjacent CLBs.

above and the *.a* input of the block below. Direct interconnect should be used to maximize the speed of high-performance portions of logic. Where logic blocks are adjacent to IOBs, direct connect is provided alternately to the IOB inputs [*.I*] and outputs [*.O*] on all four edges of the die. The right edge provides additional direct connects from CLB outputs to adjacent IOBs. Direct interconnections of IOBs with CLBs are shown in Figure 12.

Longlines

The Longlines bypass the switch matrices and are intended primarily for signals that must travel a long distance, or must have minimum skew among multiple destinations. Longlines, shown in Figure 13, run vertically and horizontally the height or width of the interconnect area. Each interconnection column has three vertical Longlines, and each interconnection row has two horizontal Longlines. Two additional Longlines are located adjacent to the outer sets of switching matrices. In devices larger than the XC3120, two vertical Longlines in each column are connectable half-length lines. On the XC3120, only the outer Longlines are connectable half-length lines.

Longlines can be driven by a logic block or IOB output on a column-by-column basis. This capability provides a common low skew control or clock line within each column of logic blocks. Interconnections of these Longlines are shown in Figure 14. Isolation buffers are provided at each input to a Longline and are enabled automatically by the development system when a connection is made.

A buffer in the upper left corner of the LCA chip drives a global net which is available to all *.k* inputs of logic blocks. Using the global buffer for a clock signal provides a skew-free, high fan-out, synchronized clock for use at any or all of the I/O and logic blocks. Configuration bits for the *.k* input to each logic block can select this global line or another routing resource as the clock source for its flip-flops. This net may also be programmed to drive the die edge clock lines for IOB use. An enhanced speed, CMOS threshold, direct access to this buffer is available at the second pad from the top of the left die edge.

A buffer in the lower right corner of the array drives a horizontal Longline that can drive programmed connections to a vertical Longline in each interconnection column. This alternate buffer also has low skew and high fan-out. The network formed by this alternate buffer's Longlines can be selected to drive the *.k* inputs of the logic blocks. CMOS threshold, high speed access to this buffer is available from the third pad from the bottom of the right die edge.

Internal Busses

A pair of 3-state buffers, located adjacent to each CLB, permits logic to drive the horizontal Longlines. Logic operation of the 3-state buffer controls allows them to implement wide multiplexing functions. Any 3-state buffer input can be selected as drive for the horizontal long-line bus by applying a Low logic level on its 3-state control line. See Figure 15a. The user is required to avoid contention

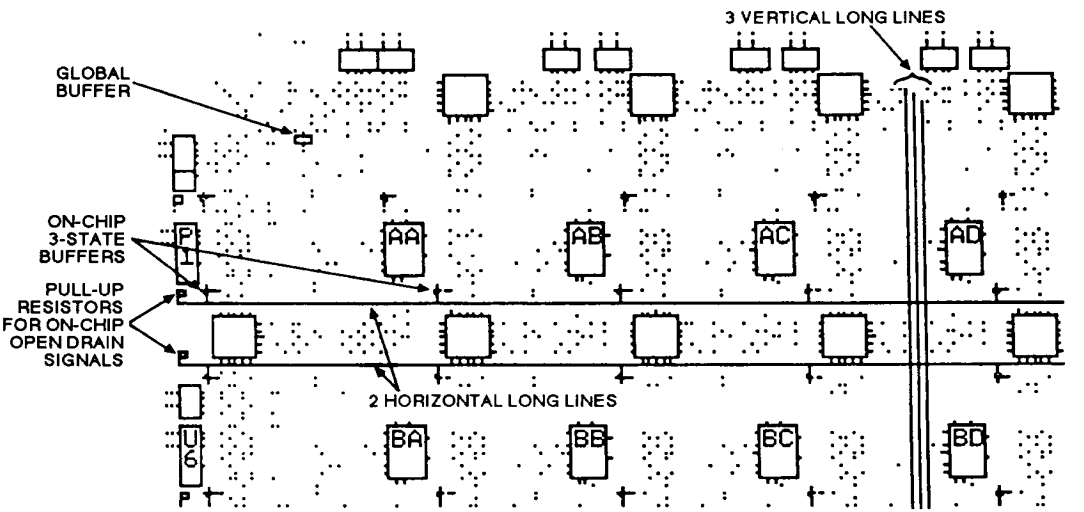


Figure 13. Horizontal and Vertical Longlines. These Longlines provide high fan-out, low-skew signal distribution in each row and column. The global buffer in the upper left die corner drives a common line throughout the LCA device.

which can result from multiple drivers with opposing logic levels. Control of the 3-state input by the same signal that drives the buffer input, creates an open-drain wired-AND function. A logic High on both buffer inputs creates a high impedance, which represents no contention. A logic Low enables the buffer to drive the Longline Low. See Figure 15b. Pull-up resistors are available at each end of the Longline to provide a High output when all connected buffers are non-conducting. This forms fast, wide gating functions. When data drives the inputs, and separate signals drive the 3-state control lines, these buffers form multiplexers (3-state busses). In this case, care must be

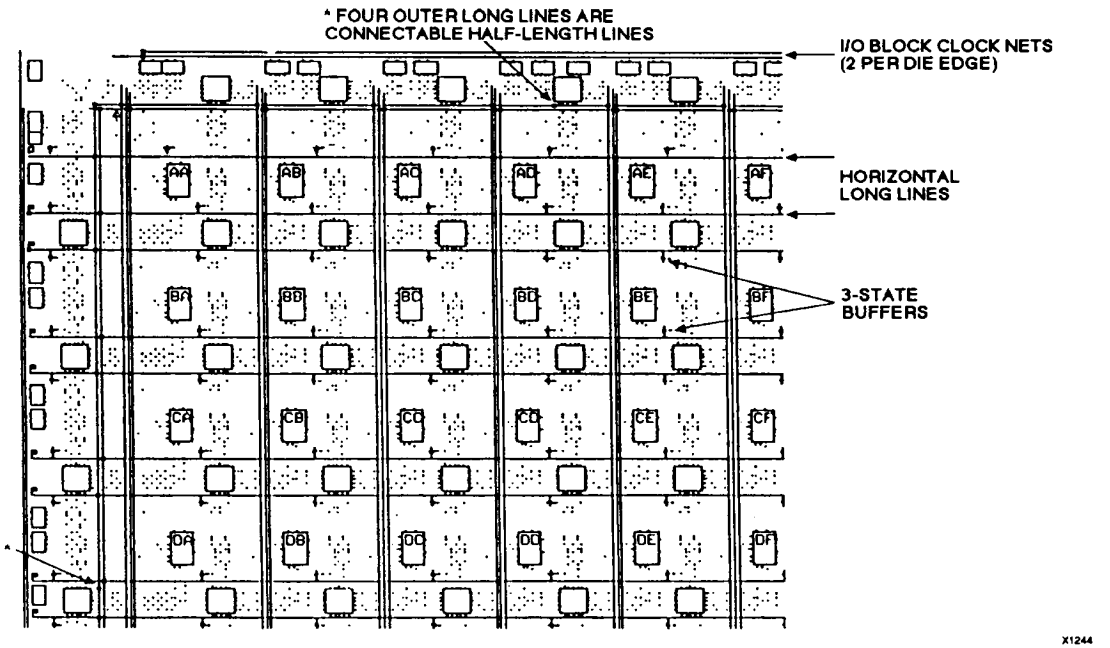


Figure 14. Programmable Interconnection of Longlines. This is provided at the edges of the routing area. Three-state buffers allow the use of horizontal Longlines to form on-chip wired-AND and multiplexed buses. The left two non-clock vertical long lines per column (except XC3120) and the outer perimeter Longlines may be programmed as connectible half-length lines.

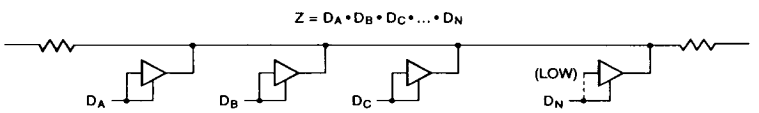
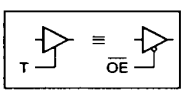


Figure 15a. 3-State Buffers Implement a Wired-AND Function. When all the buffer 3-state lines are High, (high impedance), the pull-up resistor(s) provide the High output. The buffer inputs are driven by the control signals or a Low.



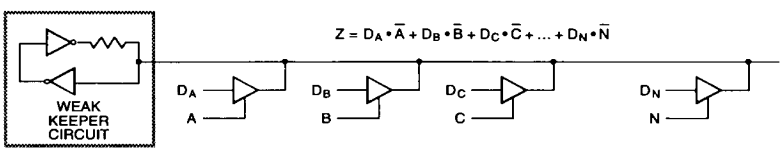


Figure 15b. 3-State Buffers Implement a Multiplexer.
The selection is accomplished by the buffer 3-state signal.

used to prevent contention through multiple active buffers of conflicting levels on a common line. Each horizontal Longline is also driven by a weak keeper circuit that prevents undefined floating levels by maintaining the previous logic level when the line is not driven by an active buffer or a pull-up resistor. Figure 16 shows 3-state buffers, Longlines and pull-up resistors.

CRYSTAL OSCILLATOR

Figure 16 also shows the location of an internal high speed inverting amplifier which may be used to implement an on-chip crystal oscillator. It is associated with the auxiliary buffer in the lower right corner of the die. When the oscillator is configured by MAKEBITS and connected as a signal source, two special user IOBs are also configured to connect the oscillator amplifier with external crystal oscillator components as shown in Figure 17. A divide by two option is available to assure symmetry. The oscillator circuit becomes active before configuration is complete in order to allow the oscillator to stabilize. Actual internal connection is delayed until completion of configuration. In Figure 17 the feedback resistor R1, between the output and input, biases the amplifier at threshold. The value should be as large as practical to minimize loading of the crystal. The inversion of the amplifier, together with the R-C networks and an AT-cut series resonant crystal, produce the 360-degree phase shift of the Pierce oscillator. A series resistor R2 may be included to add to the amplifier output impedance when needed for phase-shift control, crystal resistance matching, or to limit the amplifier input swing to control clipping at large amplitudes. Excess feedback voltage may be corrected by the ratio of C2/C1. The amplifier is designed to be used from 1 MHz to one-

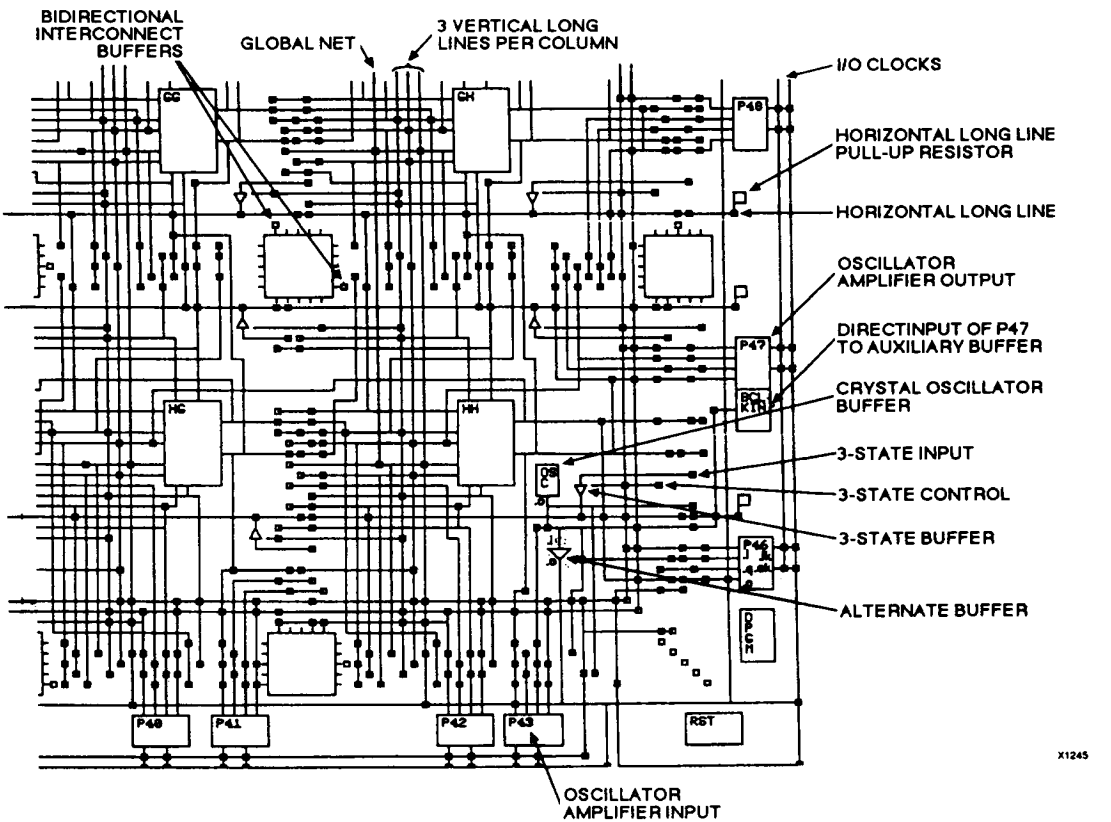


Figure 16. XACT Development System. An extra large view of possible interconnections in the lower right corner of the XC3120.

half the specified CLB toggle frequency. Use at frequencies below 1 MHz may require individual characterization with respect to a series resistance. Crystal oscillators above 20 MHz generally require a crystal which operates in a third overtone mode, where the fundamental frequency must be suppressed by the R-C networks. When the oscillator inverter is not used, these IOBs and their package pins are available for general user I/O.

PROGRAMMING

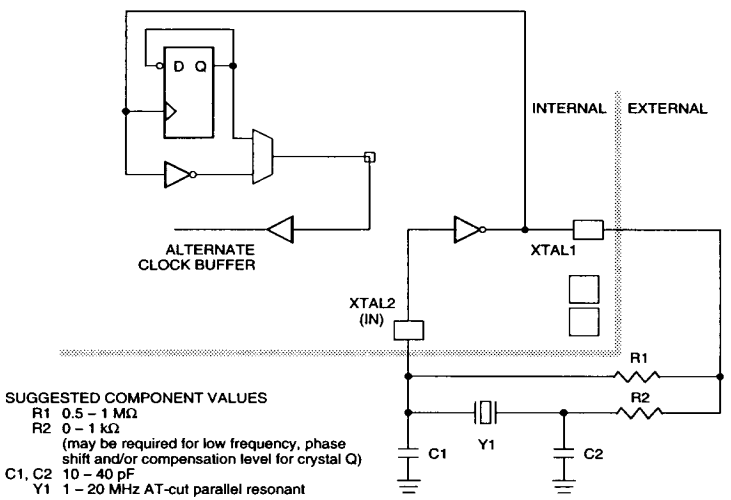
Initialization Phase

An internal power-on-reset circuit is triggered when power is applied. When Vcc reaches the voltage at which portions of the LCA device begin to operate (nominally 2.5 to 3 V), the programmable I/O output buffers are disabled and a high-impedance pull-up resistor is provided for the user I/O pins. A time-out delay is initiated to allow the power supply voltage to stabilize. During this time the power-down mode is inhibited. The Initialization state time-out (about 11 to 33 ms) is determined by a 14-bit counter driven by a self-generated internal timer. This nominal 1-MHz timer is subject to variations with process, temperature and power supply. As shown in Table 1, five configuration mode choices are available as determined by the input levels of three mode pins; M0, M1 and M2.

In Master configuration modes, the LCA device becomes the source of the Configuration Clock (CCLK). The beginning of configuration of devices using Peripheral or Slave modes must be delayed long enough for their initialization to be completed. An LCA device with mode lines selecting a Master configuration mode extends its initialization state using four times the delay (43 to 130 ms) to assure that all daisy-chained slave devices, which it may be driving, will be ready even if the master is very fast, and the slave(s)

Table 1

M0	M1	M2	Clock	Mode	Data
0	0	0	active	Master	Bit Serial
0	0	1	active	Master	Byte Wide Addr. = 0000 up
0	1	0	—	reserved	—
0	1	1	active	Master	Byte Wide Addr. = FFFF down
1	0	0	—	reserved	—
1	0	1	passive	Peripheral	Byte Wide
1	1	0	—	reserved	—
1	1	1	passive	Slave	Bit Serial



	44 PIN	68 PIN	84 PIN		100 PIN		132 PIN	160 PIN	164 PIN	175 PIN
	PLCC	PLCC	PLCC	PGA	CQFP	PQFP	PGA	PQFP	CQFP	PGA
XTAL 1 (OUT)	30	47	57	J11	67	82	P13	82	105	T14
XTAL 2 (IN)	26	43	53	L11	61	76	M13	76	99	P15

X1555

Figure 17. Crystal Oscillator Inverter. When activated in the MAKEBITS program and by selecting an output network for its buffer, the crystal oscillator inverter uses two unconfigured package pins and external components to implement an oscillator. An optional divide-by-two mode is available to assure symmetry.

very slow. Figure 18 shows the state sequences. At the end of Initialization the LCA enters the Clear state where it clears the configuration memory. The active Low, open-drain initialization signal $\overline{INIT}$ indicates when the Initialization and Clear states are complete. The LCA tests for the absence of an external active Low $\overline{RESET}$ before it makes a final sample of the mode lines and enters the Configuration state. An external wired-AND of one or more $\overline{INIT}$ pins can be used to control configuration by the assertion of the active low $\overline{RESET}$ of a master mode device or to signal a processor that the LCA devices are not yet initialized.

If a configuration has begun, a re-assertion of $\overline{RESET}$ for a minimum of three internal timer cycles will be recognized and the LCA device will initiate an abort, returning to the Clear state to clear the partially loaded configuration memory words. The LCA device will then re-sample $\overline{RESET}$ and the mode lines before re-entering the Configuration state. A re-program is initiated when a configured LCA device senses a High to Low transition on the DONE/$\overline{PROG}$ package pin. The LCA device returns to the Clear state where the configuration memory is cleared and mode lines re-sampled, as for an aborted configuration. The complete configuration program is cleared and loaded during each configuration program cycle.

Length count control allows a system of multiple Logic Cell Arrays, of assorted sizes, to begin operation in a synchronized fashion. The configuration program generated by the MakePROM program of the XACT development system begins with a preamble of 111111110010 followed by a 24-bit 'length count' representing the total number of configuration clocks needed to complete loading of the configuration program(s). The data framing is shown in Figure 19. All LCA devices connected in series read and shift preamble and length count in on positive and out on negative configuration clock edges. An LCA device which has received the preamble and length count then presents a High Data Out until it has intercepted the appropriate number of data frames. When the configuration program memory of an LCA device is full and the length count does not compare, the LCA device shifts any additional data through, as it did for preamble and length count.

When the LCA device configuration memory is full and the length count compares, the LCA device will execute a synchronous start-up sequence and become operational. See Figure 20. Three CCLK cycles after the completion of loading configuration data the user I/O pins are enabled as configured. As selected in MAKEBITS, the internal user-logic reset is released either one clock cycle before or after the I/O pins become active. A similar timing selection is programmable for the DONE/$\overline{PROG}$ output signal. DONE/$\overline{PROG}$ may also be programmed to be an open drain or include a pull-up resistor to accommodate wired ANDing. The High During Configuration (HDC) and Low During Configuration (LDC) are two user I/O pins which are driven active when an LCA device is in its Initialization, Clear or Configure states. They and DONE/$\overline{PROG}$ provide signals for control of external logic signals such as reset, bus enable or PROM enable during configuration. For parallel Master configuration modes these signals provide PROM enable control and allow the data pins to be shared with user logic signals.

User I/O inputs can be programmed to be either TTL or CMOS compatible thresholds. At power-up, all inputs

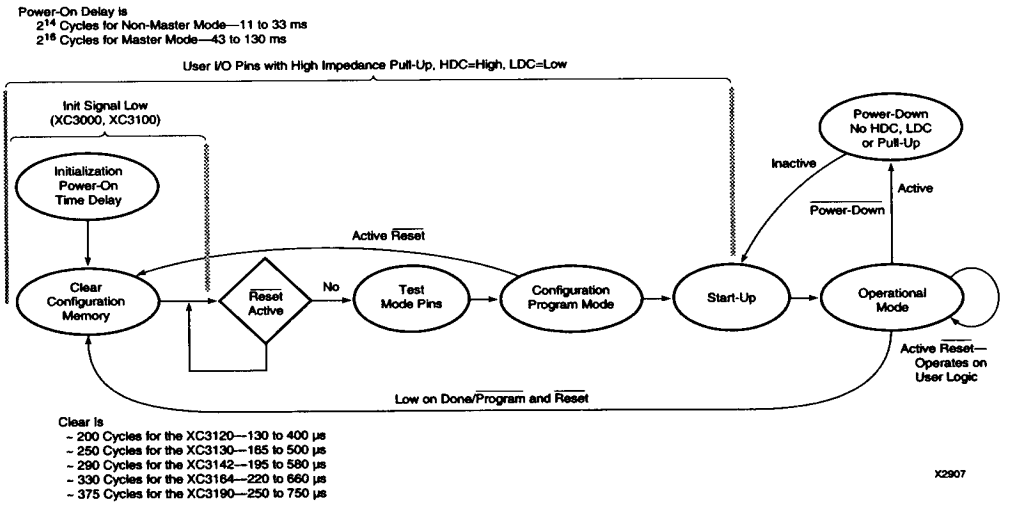


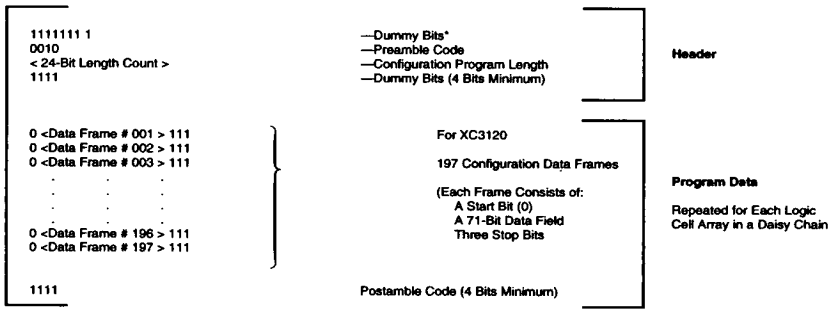
Figure 18. A State Diagram of the Configuration Process for Power-up and Reprogram.

have TTL thresholds and can change to CMOS thresholds at the completion of configuration if the user has selected CMOS thresholds. The threshold of $\overline{\text{PWRDWN}}$ and the direct clock inputs are fixed at a CMOS level.

If the crystal oscillator is used, it will begin operation before configuration is complete to allow time for stabilization before it is connected to the internal circuitry.

Configuration Data

Configuration data to define the function and interconnection within a Logic Cell Array are loaded from an external storage at power-up and on a re-program signal. Several methods of automatic and controlled loading of the required data are available. Logic levels applied to mode



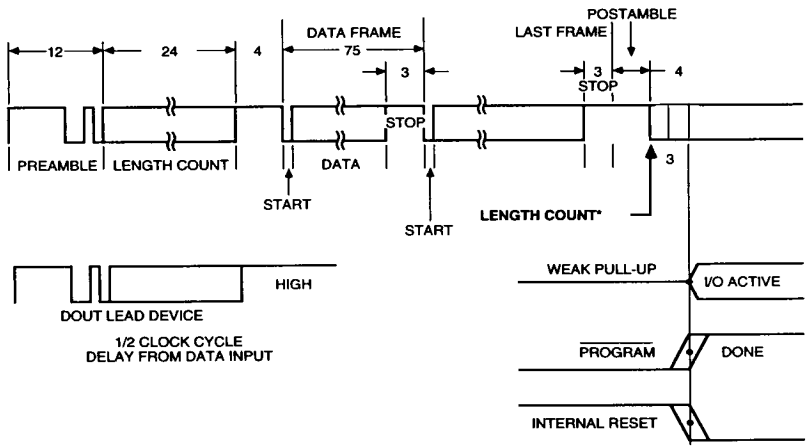
Device	XC3120	XC3130	XC3142	XC3164	XC3190	XC3195
Gates	2,000	3,000	4,200	6,400	9,000	13,500
CLBs Row x Col	64 (8 x 8)	100 (10 x 10)	144 (12 x 12)	224 (16 x 14)	320 (20 x 16)	484 (22 x 22)
IOBs	64	80	96	120	144	176
Flip-flops	256	360	480	688	928	1,320
Horizontal Longlines	16	20	24	32	40	44
TBUFs/Horizontal LL	9	11	13	15	17	23
Bits per Frame (including1 start and 3 stop bits)	75	92	108	140	172	188
Frames	197	241	285	329	373	505
Program Data = Bits x Frames + 4 bits (excludes header)	14,779	22,176	30,784	46,064	64,160	94,944
PROM size (bits) = Program Data + 40-bit Header	14,819	22,216	30,824	46,104	64,200	94,984

Figure 19. Internal Configuration Data Structure for an LCA Device. This shows the preamble, length count and data frames which are generated by the XACT Development System.

The Length Count produced by the MAKEBIT program = [(40-bit preamble + sum of program data + 1 per daisy chain device) rounded up to multiple of 8] – ($2 \le K \le 4$) where K is a function of DONE and RESET timing selected. An additional 8 is added if roundup increment is less than K. K additional clocks are needed to complete start-up after length count is reached.

selection pins at the start of configuration time determine the method to be used. See Table 1. The data may be either bit-serial or byte-parallel, depending on the configuration mode. Various Xilinx Field Programmable Gate Arrays have different sizes and numbers of data frames. To maintain compatibility between various device types, the Xilinx 3000 and 3100 product families use compatible configuration formats. For the XC3120, configuration requires 14779 bits for each device, arranged in 197 data frames. An additional 40 bits are used in the header. See Figure 20. The specific data format for each device is produced by the MAKEBITS command of the development system and one or more of these files can then be combined and appended to a length count preamble and be transformed into a PROM format file by the 'MAKE PROM' command of the XACT development system. A compatibility exception precludes the use of a 2000-series device as the master for 3100-series devices if their DONE or RESET are programmed to occur after their outputs become active. The "tie" option of the MAKEBITS program defines output levels of unused blocks of a design and connects these to unused routing resources. This prevents indeterminate levels that might produce parasitic supply currents. If unused blocks are not sufficient to complete the 'tie,' the FLAGNET command of EDITLCA can be used to indicate nets which must not be used to drive the remaining unused routing, as that might affect timing of user nets. NORESTORE will retain the results of TIE for timing analysis with QUERYNET before RESTORE returns the design to the untied condition. TIE can be omitted for quick breadboard iterations where a few additional milliamps of Icc are acceptable.

The configuration bitstream begins with High preamble bits, a 4-bit preamble code and a 24-bit length count. When configuration is initiated, a counter in the LCA device is set to zero and begins to count the total number of configuration clock cycles applied to the device. As each configuration data frame is supplied to the LCA device, it is internally assembled into a data word. As each data word is completely assembled, it is loaded in parallel into one word of the internal configuration memory array. The configuration loading process is complete when the current length count equals the loaded length count and the required configuration program data frames have been written. Internal user flip-flops are held reset during configuration.



* The configuration data consists of a composite 40-bit preamble/length count, followed by one or more concatenated LCA programs, separated by 4-bit postambles. An additional final postamble bit is added for each slave device and the result rounded up to a byte boundary. The length count is two less than the number of resulting bits.

Timing of the assertion of DONE and termination of the INTERNAL RESET may each be programmed to occur one cycle before or after the I/O outputs become active.

1105 06B

Figure 20. Configuration and Start-up of One or More LCA Devices.

Two user-programmable pins are defined in the unconfigured Logic Cell array. High During Configuration (HDC) and Low During Configuration ($\overline{LDC}$) as well as DONE/$\overline{PROG}$ may be used as external control signals during configuration. In Master mode configurations it is convenient to use $\overline{LDC}$ as an active-Low EPROM Chip Enable. After the last configuration data bit is loaded and the length count compares, the user I/O pins become active. Options in the MAKEBITS program allow timing choices of one clock earlier or later for the timing of the end of the internal logic reset and the assertion of the DONE signal. The open-drain DONE/$\overline{PROG}$ output can be AND-tied with multiple LCA devices and used as an active-High READY, an active-Low PROM enable or a RESET to other portions of the system. The state diagram of Figure 18 illustrates the configuration process.

Master Mode

In Master mode, the LCA device automatically loads configuration data from an external memory device. There are three Master modes that use the internal timing source to supply the configuration clock (CCLK) to time the incoming data. Serial Master mode uses serial configuration data supplied to Data-in (DIN) from a synchronous serial source such as the Xilinx Serial Configuration PROM shown in Figure 21. Parallel Master Low and Master High modes automatically use parallel data sup-

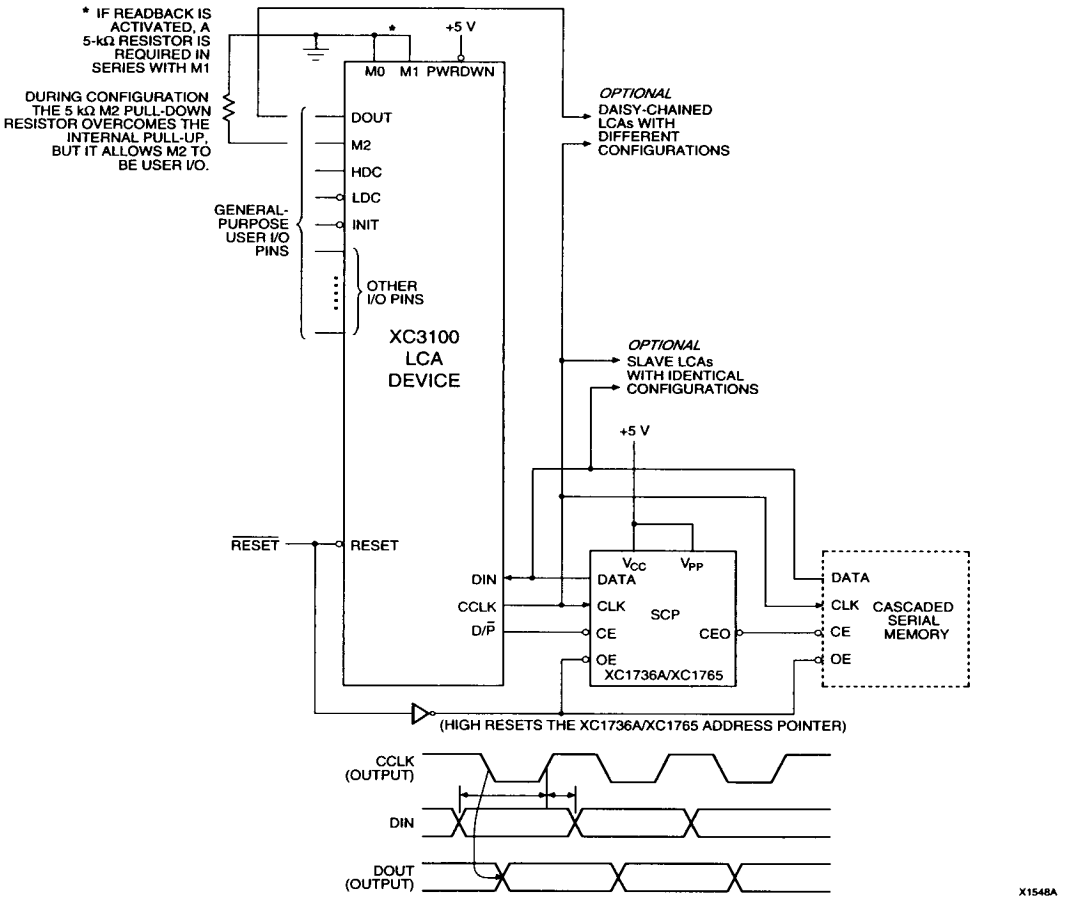


Figure 21. Master Serial Mode. The one-time-programmable XC1736A/XC1765 Serial Configuration PROM supports automatic loading of configuration programs up to 36K/64K bits. Multiple devices can be cascaded to support additional LCA devices. An early D/$\overline{P}$ inhibits the PROM data output a CCLK cycle before the LCA I/Os become active.

plied to the D0–D7 pins in response to the 16-bit address generated by the LCA device. Figure 22 shows an example of the parallel Master mode connections required. The LCA HEX starting address is 0000 and increments for Master Low mode and it is FFFF and decrements for Master High mode. These two modes provide address compatibility with microprocessors which begin execution from opposite ends of memory. For Master High or Low, data bytes are read in parallel by each Read Clock (RCLK) and internally serialized by the Configuration Clock. As each data byte is read, the least significant bit of the next byte, D0, becomes the next bit in the internal serial configuration word. One Master-mode LCA device can be used to interface the configuration program-store and pass additional concatenated configuration data to additional LCA devices in a serial daisy-chain fashion. CCLK is provided for the slaved devices and their serialized data is supplied from DOUT to DIN - DOUT to DIN etc.

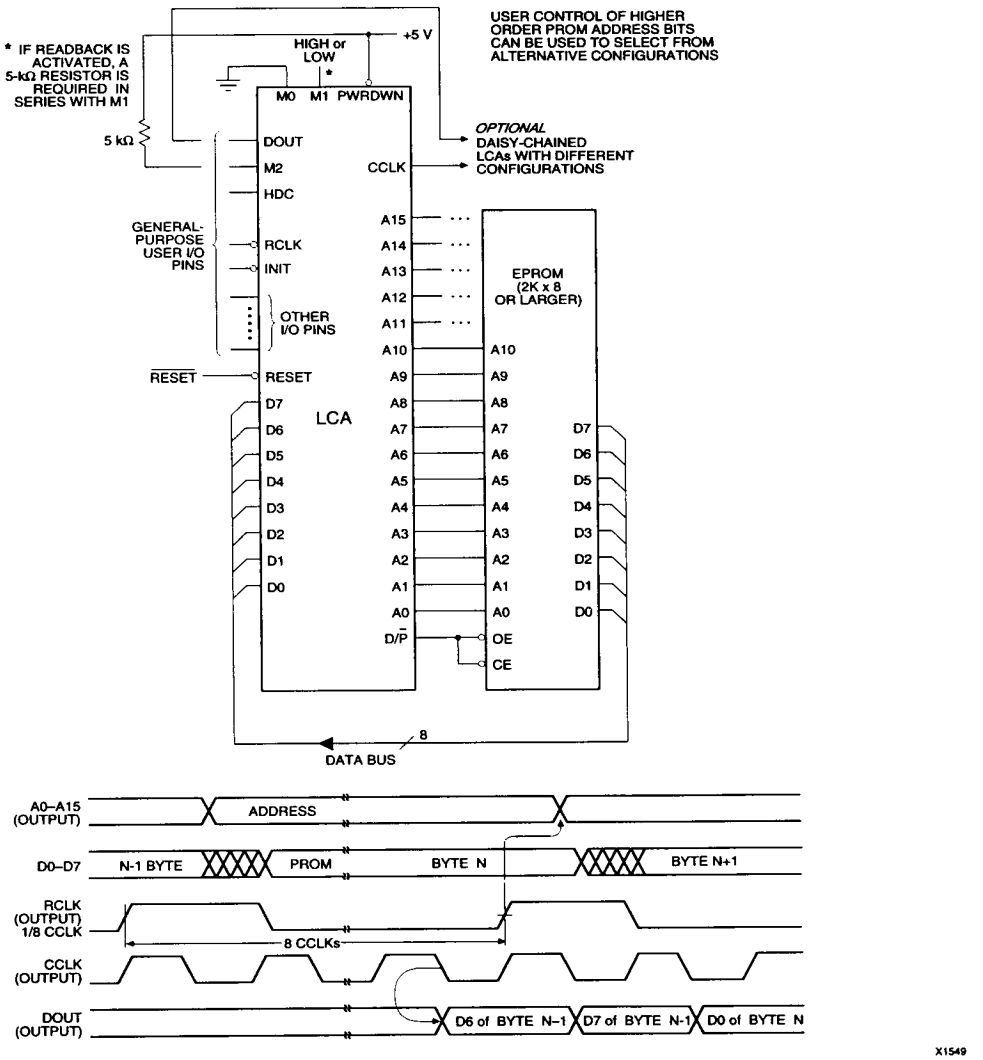


Figure 22. Master Parallel Mode. Configuration data are loaded automatically from an external byte wide PROM. An early D/$\overline{P}$ inhibits the PROM outputs a CCLK cycle before the LCA I/Os become active.

Peripheral Mode

Peripheral mode provides a simplified interface through which the device may be loaded byte-wide, as a processor peripheral. Figure 23 shows the peripheral mode connections. Processor write cycles are decoded from the common assertion of the active low Write Strobe ($\overline{WS}$), and two active low and one active high Chip Selects ($\overline{CS0}$, $\overline{CS1}$, CS2). If all these signals are not available, the unused inputs should be driven to their respective active levels. The Logic Cell Array will accept one byte of configuration data on the D0–D7 inputs for each selected processor Write cycle. Each byte of data is loaded into a buffer register. The LCA device generates a configuration clock from the internal timing generator and serializes the parallel input data for internal framing or for succeeding slaves on Data Out (DOUT). A output High on READY/$\overline{BUSY}$ pin indicates the completion of loading for each byte when the input register is ready for a new byte. As with Master modes, Peripheral mode may also be used as a lead device for a daisy-chain of slave devices.

Slave Mode

Slave mode provides a simple interface for loading the Logic Cell Array configuration as shown in Figure 24. Serial data are supplied in conjunction with a synchronizing input clock. Most Slave mode applications are in daisy-chain configurations in which the data input are supplied by the previous Logic Cell Array's data out, while the clock is supplied by a lead device in Master or Peripheral mode. Data may also be supplied by a processor or other special circuits.

Daisy-Chain

The XACT development system is used to create a composite configuration for selected LCA devices including: a

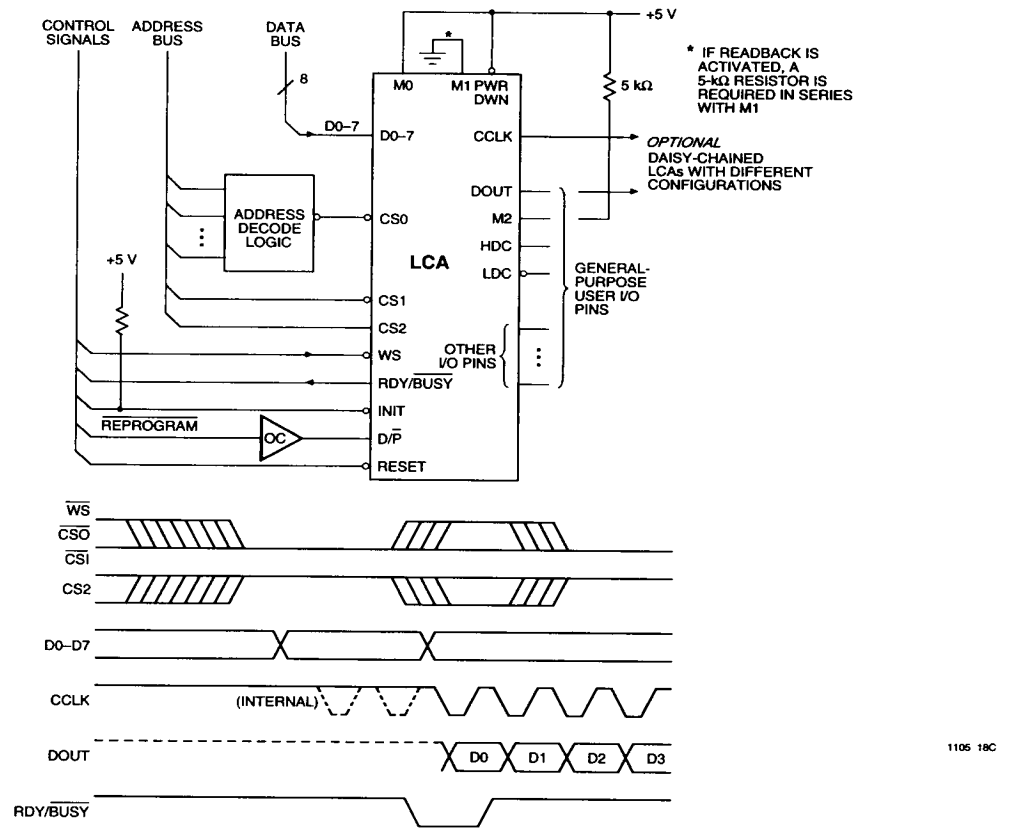


Figure 23. Peripheral Mode. Configuration data are loaded using a byte-wide data bus from a microprocessor.

preamble, a length count for the total bitstream, multiple concatenated data programs and a postamble plus an additional fill bit per device in the serial chain. After loading and passing-on the preamble and length count to a possible daisy-chain, a lead device will load its configuration data frames while providing a High DOUT to possible down-stream devices as shown in Figure 25. Loading continues while the lead device has received its configuration program and the current length count has not reached the full value. The additional data are passed through the lead device and appear on the Data Out (DOUT) pin in serial form. The lead device also generates the Configuration Clock (CCLK) to synchronize the serial output data and data in of down-stream LCA devices. Data are read in on DIN of slave devices by the positive edge of CCLK and shifted out the DOUT on the negative edge of CCLK. A parallel Master mode device uses its internal timing generator to produce an internal CCLK of 8 times its EPROM address rate, while a Peripheral mode device produces a burst of 8 CCLKs for each chip select and write-strobe cycle. The internal timing generator continues to operate for general timing and synchronization of inputs in all modes.

SPECIAL CONFIGURATION FUNCTIONS

The configuration data include control over several special functions in addition to the normal user logic functions and interconnect:

- Input thresholds
- Readback disable
- DONE pull-up resistor
- DONE timing
- RESET timing
- Oscillator frequency divided by two

Each of these functions is controlled by configuration data bits which are selected as part of the normal XACT development system bitstream generation process.

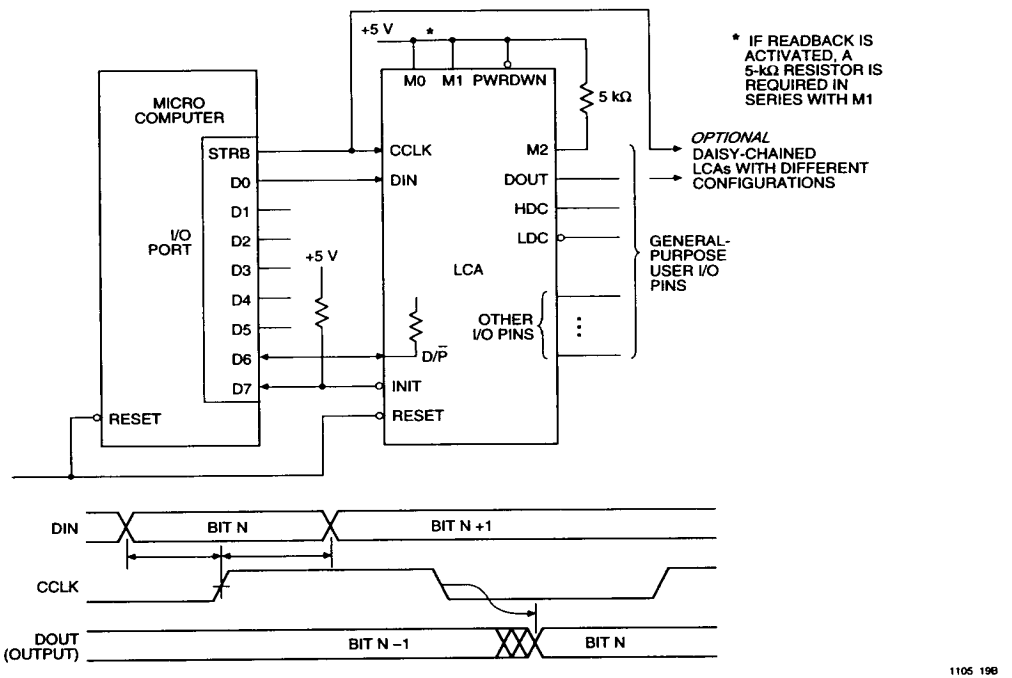


Figure 24. Slave Mode. Bit-serial configuration data are read at rising edge of the CCLK. Data on DOUT are provided on the falling edge of CCLK.

Input Thresholds

Prior to the completion of configuration all LCA device input thresholds are TTL compatible. Upon completion of configuration the input thresholds become either TTL or CMOS compatible as programmed. The use of the TTL threshold option requires some additional supply current for threshold shifting. The exception is the threshold of the $\overline{\text{PWRDWN}}$ input and direct clocks which always have a CMOS input. Prior to the completion of configuration the user I/O pins each have a high impedance pull-up. The configuration program can be used to enable the IOB pull-up resistors in the Operational mode to act either as an input load or to avoid a floating input on an otherwise unused pin.

Readback

The contents of a Logic Cell Array may be read back if it has been programmed with a bitstream in which the Readback option has been enabled. Readback may be used for verification of configuration and as a method of determining the state of internal logic nodes during debugging. There are three options in generating the configuration bitstream:

- "Never" inhibits the Readback capability.
- "One-time," inhibits Readback after one Readback has been executed to verify the configuration.
- "On-command" allows unrestricted use of Readback.

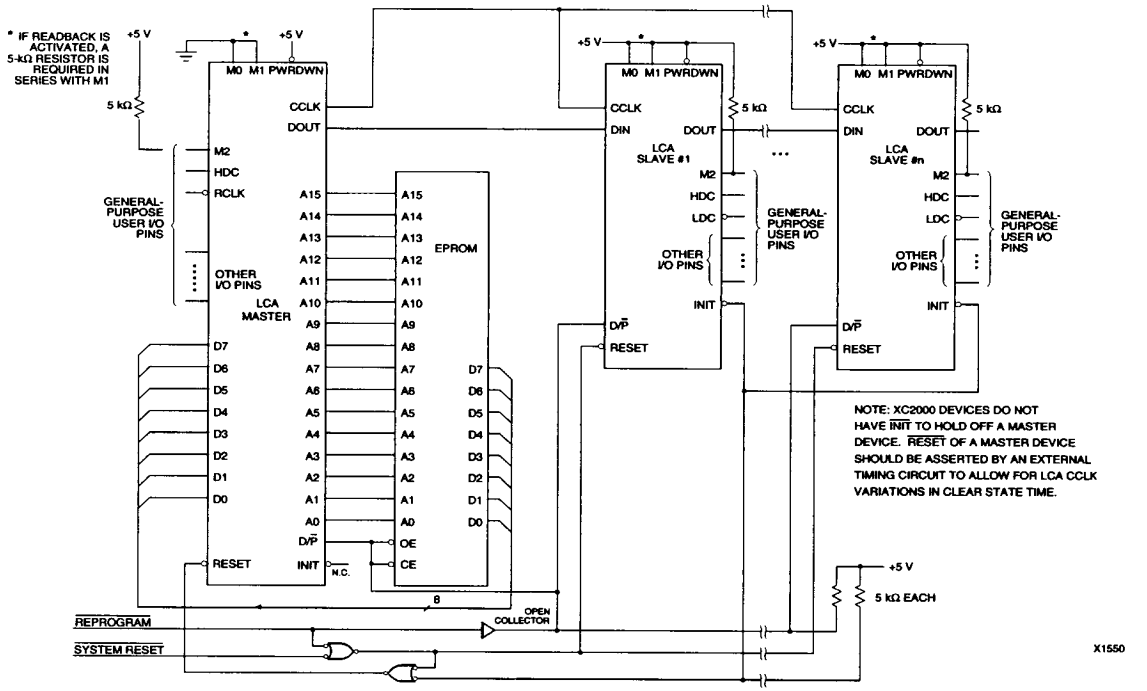


Figure 25. Master Mode Configuration with Daisy Chained Slave Mode Devices.
All are configured from the common EPROM source. The Slave mode device $\overline{\text{INIT}}$ signals delay the Master device configuration until they are initialized. A well defined termination of SYSTEM RESET is needed when controlling multiple LCA devices.

Any XC3100 slave driven by an XC2000 master mode device must use "early D/$\overline{\text{P}}$ and early internal RESET". (The XC2000 master will not supply the extra clock required by a "late" programmed XC3100.)

Readback is accomplished without the use of any of the user I/O pins; only M0, M1 and CCLK are used. The initiation of Readback is produced by a Low to High transition of the M0/RTRIG (Read Trigger) pin. The CCLK input must then be driven by external logic to read back the configuration data. The first three Low-to-High CCLK transitions clock out dummy data. The subsequent Low-to-High CCLK transitions shift the data frame information out on the M1/$\overline{\text{RDATA}}$ (Read Data) pin. Note that the logic polarity is always inverted, a zero in configuration becomes a one in Readback, and vice versa. Note also that each Readback frame has one Start bit (read back as a one) but, unlike in configuration, each Readback frame has only one Stop bit (read back as a zero). The third leading dummy bit mentioned above can be considered the Start bit of the first frame. All data frames must be read back to complete the process and return the Mode Select and CCLK pins to their normal functions.

Readback data includes the current state of each CLB flip-flop, each input flip-flop or latch, and each device pad. These data are imbedded into unused configuration bit positions during Readback. This state information is used by the XACT development system In-Circuit Verifier to provide visibility into the internal operation of the logic while the system is operating. To readback a uniform time-sample of all storage elements, it may be necessary to inhibit the system clock.

Reprogram

The LCA device configuration memory can be re-written while the device is operating in the user's system. To initiate a re-programming cycle, the dual-function pin DONE/$\overline{\text{PROG}}$ must be given a High-to-Low transition. To reduce sensitivity to noise, the input signal is filtered for two cycles of the LCA device internal timing generator. When re-program begins, the user-programmable I/O output buffers are disabled and high-impedance pull-ups are provided for the package pins. The device returns to the Clear state and clears the configuration memory before it indicates 'initialized'. Since this Clear operation uses chip-individual internal timing, the master might complete the clear operation and then start configuration before the slave has completed the Clear operation. To avoid this problem, the slave $\overline{\text{INIT}}$ pins are AND-wired and used to force a $\overline{\text{RESET}}$ on the master (see Figure 25). Reprogram control is often implemented using an external open-collector driver which pulls DONE/$\overline{\text{PROG}}$ Low. Once it recognizes a stable request, the Logic Cell Array will hold a Low until the new configuration has been completed. Even if the re-program request is externally held Low beyond the configuration period, the Logic Cell Array will begin operation upon completion of configuration.

DONE Pull-up

DONE/$\overline{\text{PROG}}$ is an open-drain I/O pin that indicates the LCA is in the operational state. An optional internal pull-up resistor can be enabled by the user of the XACT development system when MAKE BITS is executed. The DONE/$\overline{\text{PROG}}$ pins of multiple LCA devices in a daisy-chain may be connected together to indicate all are DONE or to direct them all to re-program.

DONE Timing

The timing of the DONE status signal can be controlled by a selection in the MAKEBITS program to occur a CCLK cycle before, or after, the timing of outputs being activated. See Figure 20. This facilitates control of external functions such as a PROM enable or holding a system in a wait state.

RESET Timing

As with DONE timing, the timing of the release of the internal RESET can be controlled by a selection in the MAKEBITS program to occur a CCLK cycle before, or after, the timing of outputs being enabled. See Figure 20. This reset maintains all user programmable flip-flops and latches in a zero state during configuration.

Crystal Oscillator Division

A selection in the MAKEBITS program allows the user to incorporate a dedicated divide-by-two flip-flop in the crystal oscillator function. This provides higher assurance of a symmetrical timing signal. Although the frequency stability of crystal oscillators is high, the symmetry of the waveform can be affected by bias or feedback drive.

PERFORMANCE

Device Performance

The XC3100 family FPGAs can achieve very high performance. This is the result of

- A sub-micron manufacturing process, developed and continuously being enhanced for the production of state-of-the-art CMOS SRAMs.
- Careful optimization of transistor geometries, circuit design, and lay-out, based on years of experience with the XC3000 family.
- A look-up table based, coarse-grained architecture that can collapse multiple-layer combinatorial logic into a single function generator. One CLB can implement up to four layers of conventional logic in as little as 2.7 ns.

Actual system performance is determined by the timing of critical paths, including the delay through the combinatorial and sequential logic elements within CLBs and IOBs, plus the delay in the interconnect routing. The ac timing specifications, shown starting on page 31, state the worst-case timing parameters for the various logic resources available in the XC3100 architecture.

Logic block performance is expressed as the propagation time from the interconnect point at the input to the block to the output of the block in the interconnect area. Since combinatorial logic is implemented with a memory lookup table within a CLB, the combinatorial delay through the CLB, called T_{ILO}, is always the same, regardless of the function being implemented.

Interconnect performance depends on the routing resources used to implement the signal path. Direct interconnects to the neighboring CLB provide an extremely fast path. Local interconnects go through switch matrices (magic boxes) and suffer an RC delay, equal to the resistance of the pass transistor multiplied by the capacitance of the driven metal line. Longlines carry the signal across the length or breadth of the chip with only one access delay. Generous on-chip signal buffering makes performance relatively insensitive to signal fan-out; increasing fan-out from 1 to 8 changes the CLB delay by only 10%. Clocks can be distributed with two low-skew clock distribution networks.

The tools in the XACT Development System used to place and route a design in an XC3100 FPGA (the Automatic Place and Route [APR] program and the XACT Design Editor) automatically calculate the actual maximum worst-case delays along each signal path. This timing information can be back-annotated to the design's netlist for use in timing simulation or examined with X-DELAY, a static timing analyzer.

Actual system performance is applications dependent. The maximum clock rate that can be used in a system is determined by the critical path delays within that system. These delays are combinations of incremental logic and routing delays, and vary from design to design. In a synchronous system, the maximum clock rate depends on the number of combinatorial logic layers between re-synchronizing flip-flops. Figure 26 shows the achievable clock rate as a function of the number of CLB layers; Table 1 gives a list of typical applications.

As with the XC4000 family, available XC3100 speed grades are specified in terms of the combinatorial propagation delay. The speed designator for XC3100 family devices is an approximation of T_{ILO}, the combinatorial delay through one CLB, expressed in nanoseconds. (For example, "-3" speed grade indicates a T_{ILO} of 2.7 ns.) Thus, faster parts have lower numbers to designate their speed grade.

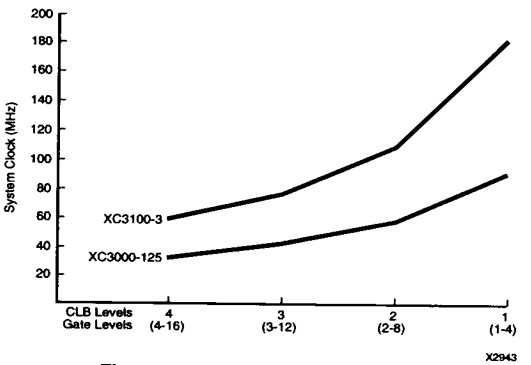
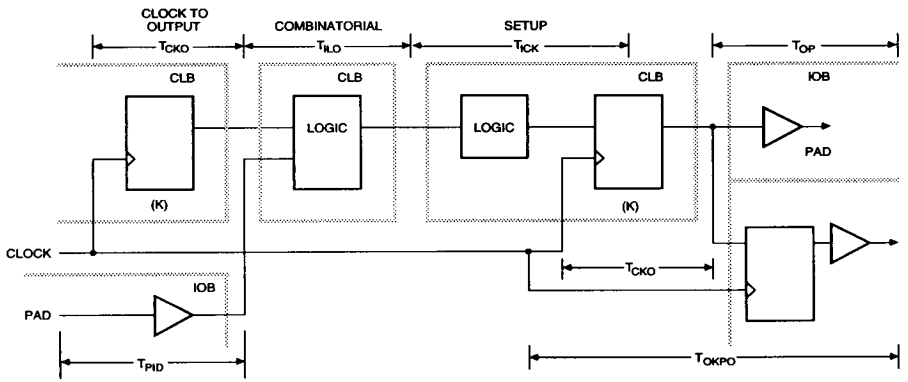


Figure 26. XC3100-3 vs XC3100-125

CLB Levels	Approx. System Clock (XC3100-3)	Typical Applications
1	150 - 200 MHz	Shift registers Linear feedback shift registers Carry-save adders
2	80 - 120 MHz	16-bit nonloadable counter 9-bit parity generator/checker
3	50 - 85 MHz	16-bit loadable up-down counters State machines, typical control functions
4	40 - 65 MHz	32-bit loadable up-down counters Complex control functions

Table 1. Typical XC3100-3 system clock speeds as a function of levels of CLBs between flip-flops in a synchronous system.



		Speed Grade	-5		-4		-3		Units
	Description	Symbol	Min	Max	Min	Max	Min	Max	
Logic input to Output	Combinatorial	T_{ILO}		4.1		3.3		2.7	ns
K Clock	To output	T_{CKO}		3.1		2.5		2.1	ns
	Logic-input setup	T_{ICK}	3.1		2.5		2.1		ns
	Logic-input hold	T_{CKI}	0		0		0		ns
Input/Output	Pad to input (direct)	T_{PID}		6.8		6.5		5.6	ns
	Output to pad (fast)	T_{OPF}		4.1		3.7		3.3	ns
	I/O clock to pad (fast)	T_{OKPO}		5.5		5.0		4.4	ns

Figure 27. Examples of Primary Block Speed Factors.
Actual timing is a function of various block factors combined with routing factors.
Overall performance can be evaluated with the XACT timing calculator or by an optional simulation.

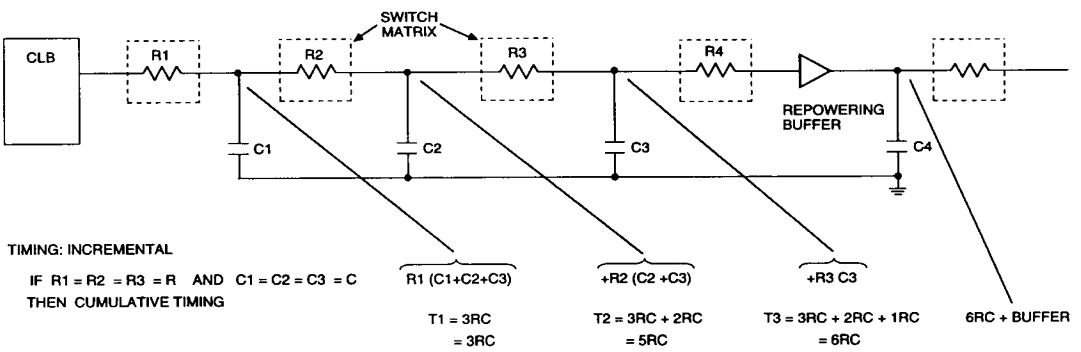


Figure 28. Interconnection Timing Example. Use of the XACT timing calculator or XACT-generated simulation model provides actual worst-case performance information.

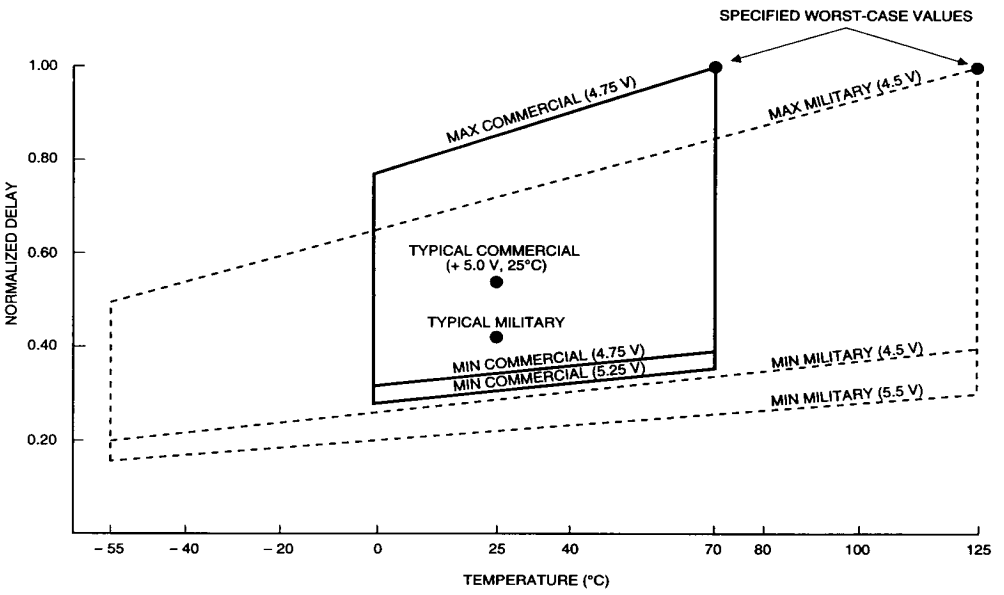


Figure 29. Relative Delay as a Function of Temperature, Supply Voltage and Processing Variations.

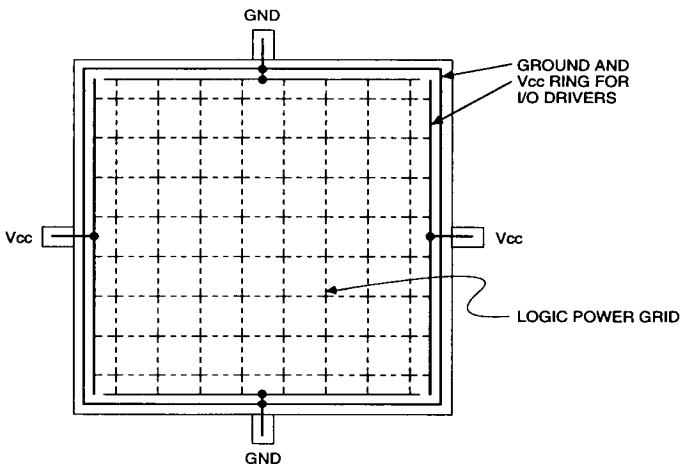


Figure 30. LCA Device Power Distribution.

POWER

Power Distribution

Power for the LCA device is distributed through a grid to achieve high noise immunity and isolation between logic and I/O. Inside the LCA device, a dedicated V_{CC} and ground ring surrounding the logic array provides power to the I/O drivers. See Figure 30. An independent matrix of V_{CC} and ground lines supplies the interior logic of the device. This power distribution grid provides a stable supply and ground for all internal logic, providing the external package power pins are all connected and appropriately decoupled. Typically a 0.1-µF capacitor connected near the VCC and ground pins will provide adequate decoupling.

Output buffers capable of driving the specified 8-mA loads under worst-case conditions may be capable of driving 10 to 20 times that current in a best case. Noise can be reduced by minimizing external load capacitance and reducing simultaneous output transitions in the same direction. It may also be beneficial to locate heavily loaded output buffers near the ground pads. The I/O Block output buffers have a slew-limited mode which should be used where output rise and fall times are not speed critical. Slew-limited outputs maintain their dc drive capability, but generate less external reflections and internal noise. A maximum total external capacitive load for simultaneous fast mode switching in the same direction is 200 pF per power/ground pin pair. For slew-rate limited outputs, this total is four times larger.

Power Consumption

The Logic Cell Array exhibits the low power consumption characteristic of CMOS ICs. The configuration option of TTL chip input threshold requires power for the threshold reference. The power required by the static memory cells that hold the configuration data is very low and may be maintained in a power-down mode.

Typically, most of power dissipation is produced by external capacitive loads on the output buffers. This load and frequency dependent power is 25 µW/pF/MHz per output. Another component of I/O power is the external dc loading on all output pins.

Internal power dissipation is a function of the number and size of the nodes, and the frequency at which they change. In an LCA device, the fraction of nodes changing on a given clock is typically low (10–20%). For example, in a long binary counter, the total activity of all counter flip-flops is equivalent to that of only two CLB outputs toggling at the clock frequency. Typical global clock-buffer power is between 1.7 mW/MHz for the XC3120 and 2.1 mW/MHz for the XC3190. The internal capacitive load is more a function of interconnect than fan-out. With a typical load of three general interconnect segments, each CLB output requires about 0.25 mW per MHz of its output frequency.

$$\text{Total Power} = V_{CC} \bullet I_{CCO} + \text{external (dc + capacitive)} + \text{internal (CLB + IOB + long line + pull-up)}$$

Because the control storage of the Logic Cell Array is CMOS static memory, its cells require a very low standby current for data retention. In some systems, this low data retention current characteristic can be used as a method of preserving configurations in the event of a primary power loss. The Logic Cell Array has built in power-down logic which, when activated, will disable normal operation of the device and retain only the configuration data. All internal operation is suspended and output buffers are placed in their high-impedance state with no pull-ups. Different from the XC3000 family which can be powered down to a current consumption of a few microamps, the XC3100 draws 5 mA, even in power-down. This makes power-down operation less meaningful.

To force the Logic Cell Array into the Power-Down state, the user must pull the $\overline{\text{PWRDWN}}$ pin Low and continue to supply a retention voltage to the VCC pins. When normal power is restored, VCC is elevated to its normal operating voltage and $\overline{\text{PWRDWN}}$ is returned to a High. The Logic Cell Array resumes operation with the same internal sequence that occurs at the conclusion of configuration. Internal-I/O and logic-block storage elements will be reset, the outputs will become enabled and the DONE/$\overline{\text{PROG}}$ pin will be released.

When V_{CC} is shut down or disconnected, some power might unintentionally be supplied from an incoming signal driving an I/O pin. The conventional electro-static input protection is implemented with diodes to the supply and ground. A positive voltage applied to an input (or output) will cause the positive protection diode to conduct and drive the V_{CC} connection. This condition can produce invalid power conditions and should be avoided. A large series resistor might be used to limit the current or a bipolar buffer may be used to isolate the input signal.

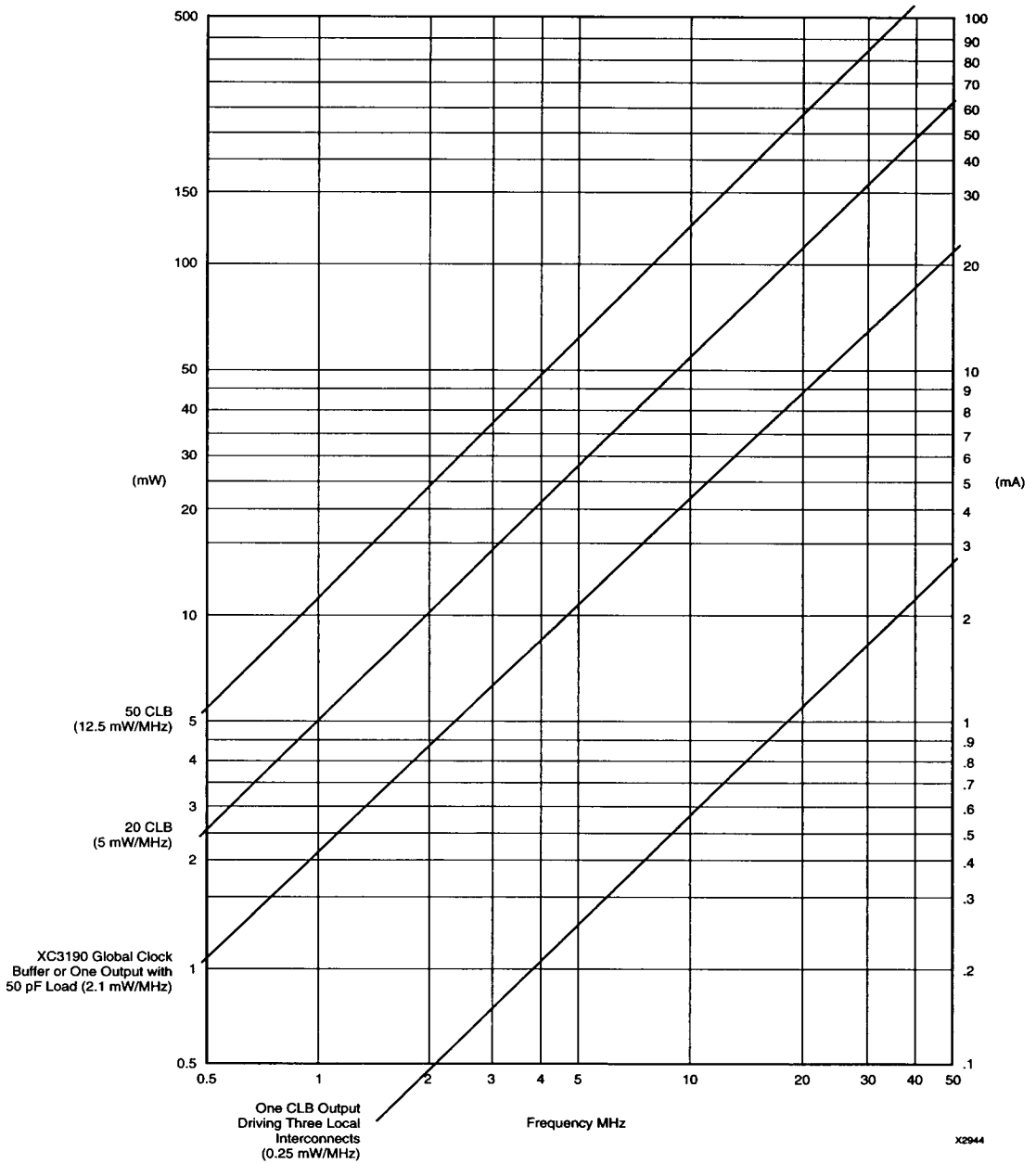


Figure 31. LCA Device Power Consumption by Element. Total chip power is the sum of Vcc•Icco plus effective internal and external values of frequency dependent capacitive charging currents and duty factor dependent resistive loads.

Xilinx maintains test specifications for each product as controlled documents. To insure the use of the most recently released device performance parameters, please request a copy of the current test-specification revision.

ABSOLUTE MAXIMUM RATINGS

Symbol	Description		Units
V_{CC}	Supply voltage relative to GND	–0.5 to +7.0	V
V_{IN}	Input voltage with respect to GND	–0.5 to Vcc +0.5	V
V_{TS}	Voltage applied to 3-state output	–0.5 to Vcc +0.5	V
T_{STG}	Storage temperature (ambient)	–65 to +150	°C
T_{SOL}	Maximum soldering temperature (10 s @ 1/16 in.)	+260	°C
T_J	Junction temperature plastic	+125	°C
	Junction temperature ceramic	+150	°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 Recommended 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}	Supply voltage relative to GND Commercial 0°C to +70°C	4.75	5.25	V
	Supply voltage relative to GND Industrial –40°C to +85°C	4.5	5.5	V
V_{IHT}	High-level input voltage — TTL configuration	2.0	Vcc	V
V_{ILT}	Low-level input voltage — TTL configuration	0	0.8	V
V_{IHC}	High-level input voltage — CMOS configuration	70%	100%	V_{CC}
V_{ILC}	Low-level input voltage — CMOS configuration	0	20%	V_{CC}
T_{IN}	Input signal transition time		250	ns

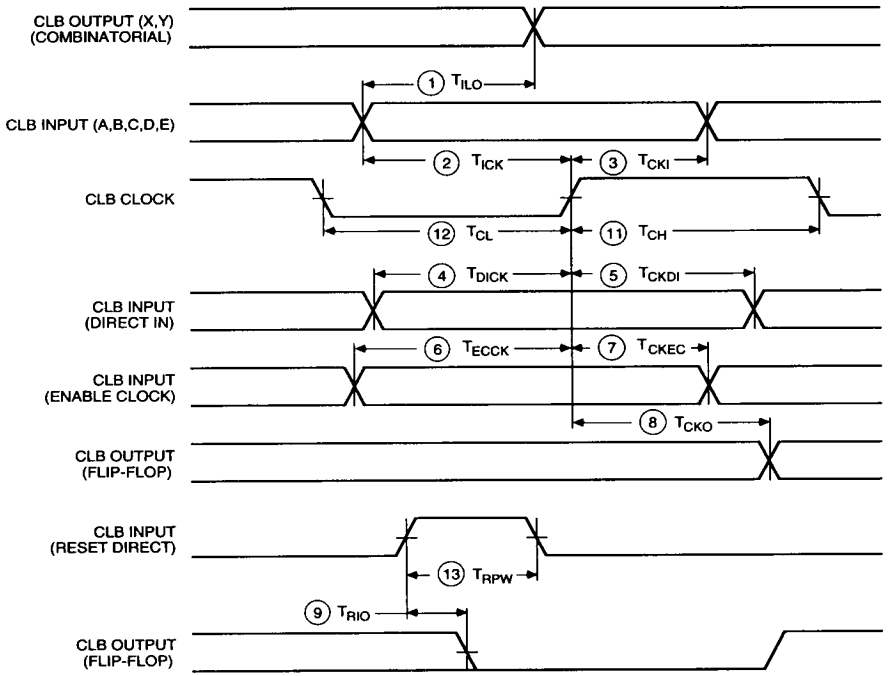
DC CHARACTERISTICS OVER OPERATING CONDITIONS

Symbol	Description		Min	Max	Units
V_{OH}	High-level output voltage (@ I_{OH} = –8.0 mA, V_{CC} min)	Commercial	3.86		V
V_{OL}	Low-level output voltage (@ I_{OL} = 8.0 mA, V_{CC} max)			0.40	V
V_{OH}	High-level output voltage (@ I_{OH} = –8.0 mA, V_{CC} min)	Industrial	3.76		V
V_{OL}	Low-level output voltage (@ I_{OL} = 8.0 mA, V_{CC} max)			0.40	V
V_{CCPD}	Power-down supply voltage ($\overline{PWRDWN}$ must be Low)		2.30		V
I_{CCO}	Quiescent LCA supply current Chip thresholds programmed as CMOS levels[1]			5	mA
	Chip thresholds programmed as TTL levels			14	mA
I_{IL}	Input Leakage Current		–10	+10	µA
C_{IN}	Input capacitance, all packages except PGA175 (sample tested) All Pins except XTL1 and XTL2 XTL1 and XTL2			 10 15	 pF pF
	Input capacitance, PGA 175 (sample tested) All Pins except XTL1 and XTL2 XTL1 and XTL2			 15 20	 pF pF
I_{RIN}	Pad pull-up (when selected) @ V_{IN} = 0V (sample tested)		0.02	0.17	mA
I_{RLL}	Horizontal long line pull-up (when selected) @ logic Low		0.20	2.80	mA

Note: 1. With no output current loads, no active input or long line pull-up resistors, all package pins at Vcc or GND, and the LCA configured with a MakeBits tie option.

2. Total continuous output sink current may not exceed 100 mA per ground pin. The number of ground pins varies from two for the XC3120 in the PLCC 84 package, to eight for the XC3190 in the PG175 package.

CLB SWITCHING CHARACTERISTIC GUIDELINES



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BUFFER (Internal) SWITCHING CHARACTERISTIC GUIDELINES

	Speed Grade	-5	-4	-3	Units
Description	Symbol	Max	Max	Max	
Global and Alternate Clock Distribution*					
Either: **Normal** IOB input pad through clock buffer to any CLB or IOB clock input	T_{PID}	6.8	6.5	5.6	ns
Or: **Fast** (CMOS only) input pad through clock buffer to any CLB or IOB clock input	T_{PIDC}	5.4	5.1	4.3	ns
TBUF driving a Horizontal Long line (L.L.)*					
I to L.L. while T is Low (buffer active)	T_{IO}	4.1	3.7	3.1	ns
T↓ to L.L. active and valid with single pull-up resistor	T_{ON}	5.6	5.0	4.2	ns
T↓ to L.L. active and valid with pair of pull-up resistors	T_{ON}	7.1	6.5	5.7	ns
T↑ to L.L. High with single pull-up resistor	T_{PUS}	15.6	13.5	11.4	ns
T↑ to L.L. High with pair of pull-up resistors	T_{PUF}	12.0	10.5	8.8	ns
BIDI Bidirectional buffer delay	T_{BIDI}	1.4	1.2	1.0	ns

* Timing is based on the XC3142, for other devices see XACT timing calculator.

CLB SWITCHING CHARACTERISTIC GUIDELINES (Continued)

Testing of the switching parameters is modeled after testing methods specified by MIL-M-38510/605. All devices are 100% functionally tested. Since many internal timing parameters cannot be measured directly, they are derived from benchmark timing patterns. The following guidelines reflect worst-case values over the recommended operating conditions. For more detailed, more precise, and more up-to-date timing information, use the values provided by the XACT timing calculator and used in the simulator.

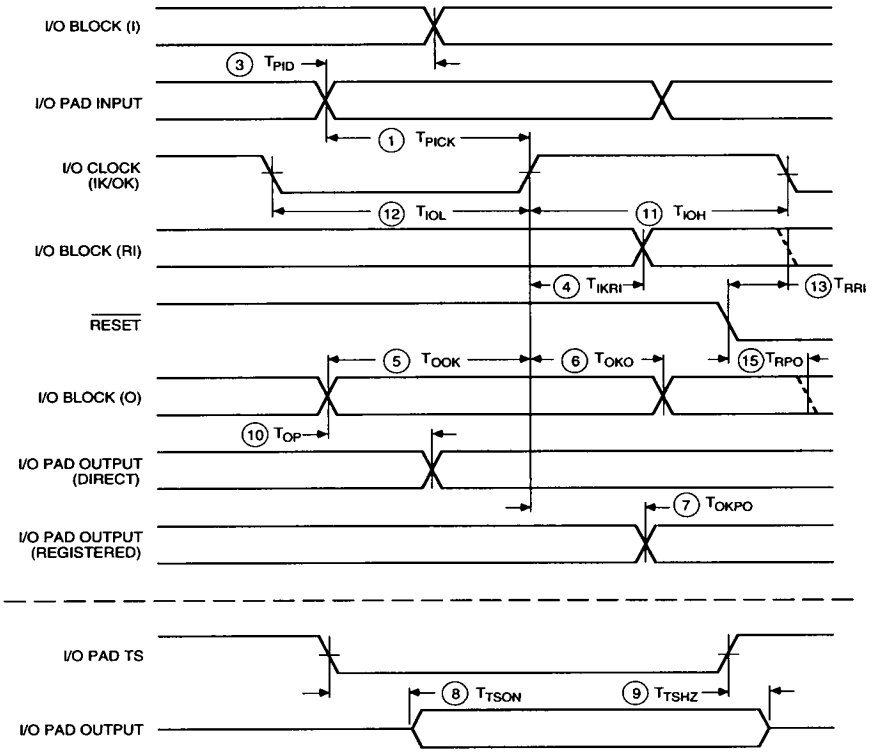
	Speed Grade		-5		-4		-3		Units
Description	Symbol		Min	Max	Min	Max	Min	Max	
Combinatorial Delay									
Logic Variables a, b, c, d, e, to outputs x or y	1	T_{ILO}		4.1		3.3		2.7	ns
Sequential delay									
Clock k to outputs x or y	8	T_{CKO}		3.1		2.5		2.1	ns
Clock k to outputs x or y when Q is returned through function generators F or G to drive x or y		T_{QLO}		6.3		5.2		4.3	ns
Set-up time before clock K									
Logic Variables a, b, c, d, e	2	T_{ICK}	3.1		2.5		2.1		ns
Data In di	4	T_{DICK}	2.0		1.6		1.4		ns
Enable Clock ec	6	T_{ECCK}	3.8		3.2		2.7		ns
Reset Direct inactive rd			1.0		1.0		1.0		ns
Hold Time after clock k									
Logic Variables a, b, c, d, e	3	T_{CKI}	0		0		0		ns
Data In di	5	T_{CKDI}	1.2		1.0		0.9		ns
Enable Clock ec	7	T_{CKEC}	1.0		0.8		0.7		ns
Clock									
Clock High time	11	T_{CH}	2.4		2.0		1.6		ns
Clock Low time	12	T_{CL}	2.4		2.0		1.6		ns
Max. flip-flop toggle rate		F_{CLK}	190		230		270		MHz
Reset Direct (rd)									
rd width	13	T_{RPW}	3.8		3.2		2.7		ns
delay from rd to outputs x or y	9	T_{RIO}		4.4		3.7		3.1	ns
Global Reset ($\overline{\text{RESET}}$ Pad)*									
$\overline{\text{RESET}}$ width (Low)		T_{MRW}	18.0		15.0		13.0		ns
delay from $\overline{\text{RESET}}$ pad to outputs x or y		T_{MRQ}		17.0		14.0		12.0	ns

*Timing is based on the XC3142, for other devices see XACT timing calculator.

Notes: The CLB K to Q output delay (T_{CKO}, #8) of any CLB, plus the shortest possible interconnect delay, is always longer than the Data In hold time requirement (T_{CKDI}, #5) of any CLB on the same die.

T_{ILO}, T_{QLO} and T_{ICK} are specified for 4-input functions. For 5-input functions or base FGM functions, each specification increases by 0.8 ns (-5), 0.6 ns (-4) and 0.5 ns (-3).

IOB SWITCHING CHARACTERISTIC GUIDELINES



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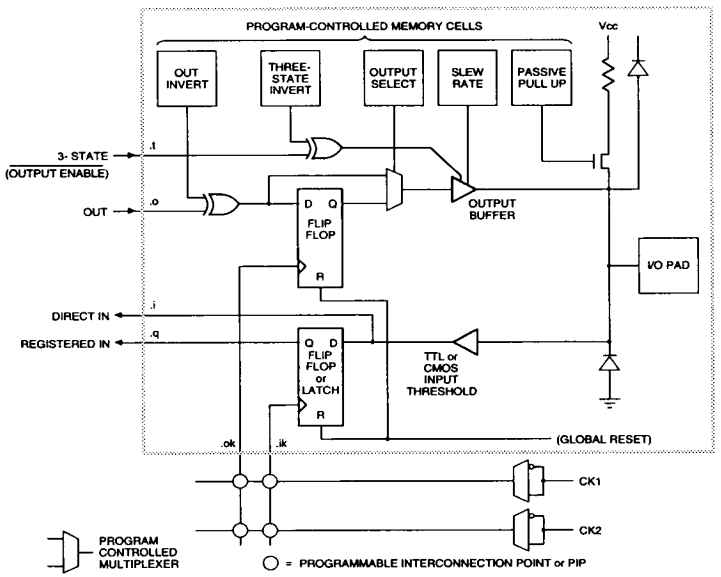

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IOB SWITCHING CHARACTERISTIC GUIDELINES (Continued)

Testing of the switching parameters is modeled after testing methods specified by MIL-M-38510/605. All devices are 100% functionally tested. Since many internal timing parameters cannot be measured directly, they are derived from benchmark timing patterns. The following guidelines reflect worst-case values over the recommended operating conditions. For more detailed, more precise, and more up-to-date timing information, use the values provided by the XACT timing calculator and used in the simulator.

	Speed Grade		-5		-4		-3		Units
Description	Symbol		Min	Max	Min	Max	Min	Max	
Propagation Delays (Input)									
Pad to Direct In (i)	3	T_{PID}		2.8		2.5		2.2	ns
Pad to Registered In (q) with latch transparent		T_{PTG}		16.0		15.0		13.0	ns
Clock (ik) to Registered In (q)	4	T_{IKRI}		2.8		2.5		2.2	ns
Set-up Time (Input)									
Pad to Clock (ik) set-up time	1	T_{PICK}	15.0		14.0		12.0		ns
Propagation Delays (Output)									
Clock (ok) to Pad (fast)	7	T_{OKPO}		5.5		5.0		4.4	ns
same (slew rate limited)	7	T_{OKPO}		14.0		12.0		10.0	ns
Output (o) to Pad (fast)	10	T_{OPF}		4.1		3.7		3.3	ns
same (slew-rate limited)	10	T_{OPS}		13.0		11.0		9.0	ns
3-state to Pad begin hi-Z (fast)	9	T_{TSHZ}		6.9		6.2		5.5	ns
same (slew-rate limited)	9	T_{TSHZ}		6.9		6.2		5.5	ns
3-state to Pad active and valid (fast)	8	T_{TSON}		12.0		10.0		9.0	ns
same (slew -rate limited)	8	T_{TSON}		20.0		17.0		15.0	ns
Set-up and Hold Times (Output)									
Output (o) to clock (ok) set-up time	5	T_{OOK}	6.2		5.6		5.0		ns
Output (o) to clock (ok) hold time	6	T_{OKO}	0		0		0		ns
Clock									
Clock High time	11	T_{IOH}	2.4		2.0		1.6		ns
Clock Low time	12	T_{IOL}	2.4		2.0		1.6		ns
Max. flip-flop toggle rate		F_{CLK}	190		230		270		MHz
Global Reset Delays (based on XC3042)									
$\overline{\text{RESET}}$ Pad to Registered In (q)	13	T_{RRI}		18.0		15.0		13.0	ns
$\overline{\text{RESET}}$ Pad to output pad (fast)	15	T_{RPO}		24.0		20.0		17.0	ns
(slew-rate limited)	15	T_{RPO}		32.0		27.0		23.0	ns

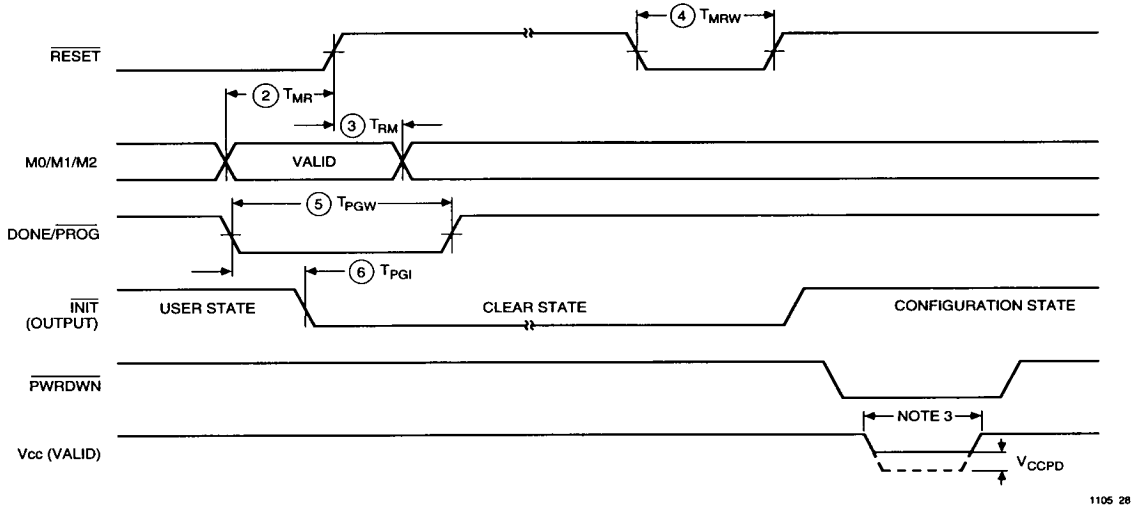
Notes: 1. Timing is measured at pin threshold, with 50 pF external capacitive loads (incl. test fixture).
For larger capacitive loads, see page 6-9 in the Programmable Gate Array Data Book.
Typical slew rate limited output rise/fall times are approximately four times longer.
A maximum total external capacitive load for simultaneous fast mode switching in the same direction is 200 pF per power/ground pin pair. For slew-rate limited outputs this total is four times larger. Exceeding this maximum capacitive load can result in ground bounce of >1.5 V amplitude, <5 ns duration, which might cause problems when the LCA device drives clocks and other asynchronous signals.

2. Voltage levels of unused (bonded and unbonded) pads must be valid logic levels. Each can be configured with the internal pull-up resistor or alternatively configured as a driven output or driven from an external source.

3. Input pad set-up time is specified with respect to the internal clock (.ik)
In order to calculate system set-up time, subtract clock delay (pad to ik) from the input pad set-up time value.
Input pad holdtime with respect to the internal clock (ik) is negative. This means that pad level changes immediately before the internal clock edge (ik) will not be recognized.
For a more detailed description see pages 6-11 through 6-14 in the Programmable Gate Array Data Book.

4. T_{PID}, T_{PTG}, and T_{PICK} are 3 ns higher for XTAL2 when the pin is configured as a user input.

GENERAL LCA SWITCHING CHARACTERISTICS



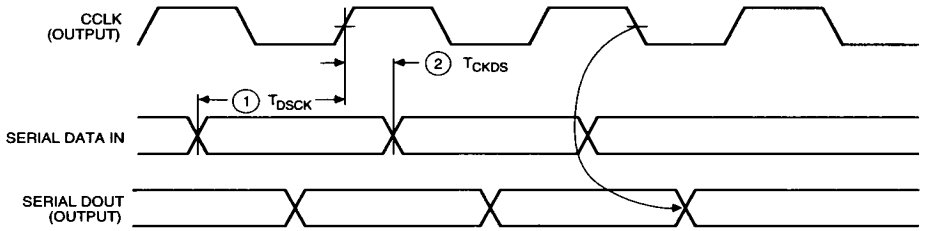
		Speed Grade		-5		-4		-3		Units
	Description	Symbol		Min	Max	Min	Max	Min	Max	
RESET (2)	M0, M1, M2 setup time required	2	T_{MR}	1		1		1		µs
	M0, M1, M2 hold time required	3	T_{RM}	1		1		1		µs
	RESET Width (Low) req. for Abort	4	T_{MRW}	6		6		6		µs
DONE/PROG	Width (Low) required for Re-config.	5	T_{PGW}	6		6		6		µs
	INIT response after D/P is pulled Low	6	T_{PGI}		7		7		7	µs
PWRDWN (3)	Power Down Vcc		V_{CCPD}	2.3		2.3		2.3		V

Notes: 1. At power-up, Vcc must rise from 2.0 V to Vcc min in less than 25 ms. If this is not possible, configuration can be delayed by holding RESET Low until Vcc has reached 4.0 V. A very long Vcc rise time of >100 ms, or a non-monotonically rising Vcc may require a >1-µs High level on RESET, followed by a >6-µs Low level on RESET and D/P after Vcc has reached 4.0 V.

2. RESET timing relative to valid mode lines (M0, M1, M2) is relevant when RESET is used to delay configuration.

3. PWRDWN transitions must occur while Vcc >4.0 V.

MASTER SERIAL MODE PROGRAMMING SWITCHING CHARACTERISTICS



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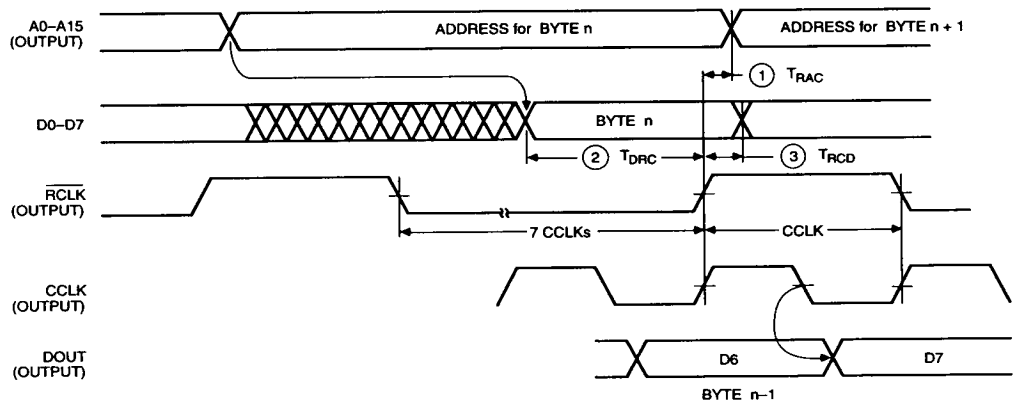
		Speed Grade		-5		-4		-3		Units
	Description	Symbol		Min	Max	Min	Max	Min	Max	
CCLK[3]	Data In setup	1	T_{DSCK}	60		60		60		ns
	Data In hold	2	T_{CKDS}	0		0		0		ns

Notes: 1. At power-up, Vcc must rise from 2.0 V to Vcc min in less than 25 ms. If this is not possible, configuration can be delayed by holding $\overline{\text{RESET}}$ Low until Vcc has reached 4.0 V. A very long Vcc rise time of >100 ms, or a non-monotonically rising Vcc may require >1-µs High level on $\overline{\text{RESET}}$, followed by a >6-µs Low level on $\overline{\text{RESET}}$ and D/$\overline{\text{P}}$ after Vcc has reached 4.0 V.

2. Configuration can be controled by holding $\overline{\text{RESET}}$ Low with or until after the $\overline{\text{INIT}}$ of all daisy-chain slave-mode devices is High.
3. Master-serial-mode timing is based on slave-mode testing.

MASTER PARALLEL MODE PROGRAMMING SWITCHING CHARACTERISTICS



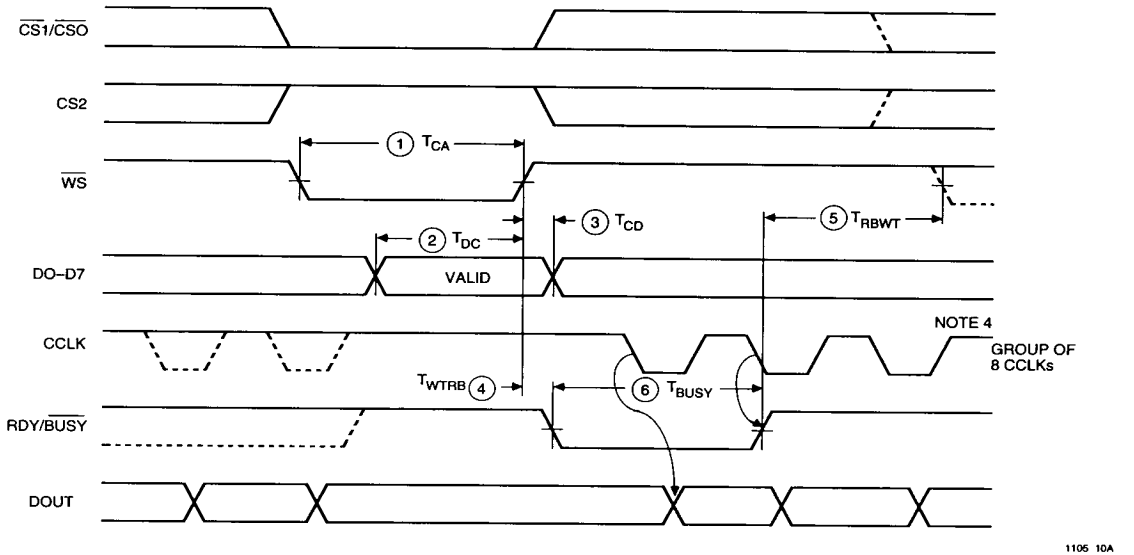
		Speed Grade		-5		-4		-3		Units
	Description	Symbol		Min	Max	Min	Max	Min	Max	
RCLK	To address valid	1	T_{RAC}	0	200	0	200	0	200	ns
	To data setup	2	T_{DRC}	60		60		60		ns
	To data hold	3	T_{RCD}	0		0		0		ns
	RCLK high		T_{RCH}	600		600		600		ns
	RCLK low		T_{RCL}	4.0		4.0		4.0		µs

Notes: 1. At power-up, Vcc must rise from 2.0 V to Vcc min in less than 25 ms. If this is not possible, configuration can be delayed by holding $\overline{RESET}$ Low until Vcc has reached 4.0 V. A very long Vcc rise time of >100 ms, or a non-monotonically rising Vcc may require a >1-µs High level on $\overline{RESET}$, followed by a >6-µs Low level on $\overline{RESET}$ and D/$\overline{P}$ after Vcc has reached 4.0 V.

2. Configuration can be controlled by holding $\overline{RESET}$ Low with or until after the $\overline{INIT}$ of all daisy-chain slave-mode devices is High.

This timing diagram shows that the EPROM requirements are extremely relaxed: EPROM access time can be longer than 4000 ns. EPROM data output has no hold time requirements.

PERIPHERAL MODE PROGRAMMING SWITCHING CHARACTERISTICS

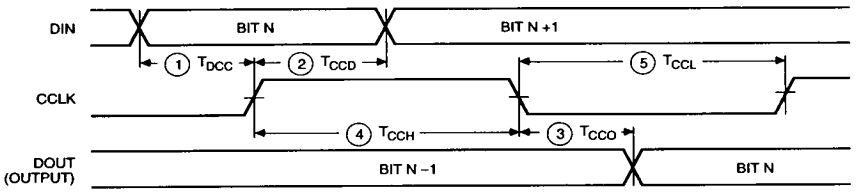


		Speed Grade		-5		-4		-3		Units
	Description	Symbol		Min	Max	Min	Max	Min	Max	
Write	Effective Write time required ($\overline{CS0} \bullet \overline{CS1} \bullet CS2 \bullet \overline{WS}$)	1	T_{CA}	100		100		100		ns
	DIN Setup time required	2	T_{DC}	60		60		60		ns
	DIN Hold time required	3	T_{CD}	0		0		0		ns
	RDY/$\overline{BUSY}$ delay after end of $\overline{WS}$	4	T_{WTRB}		60		60		60	ns
RDY	Earliest next $\overline{WS}$ after end of $\overline{BUSY}$	5	T_{RBWT}	0		0		0		ns
	$\overline{BUSY}$ Low time generated	6	T_{BUSY}	2	9	2	9	2	9	CCLK Periods

Notes:
1. At power-up, Vcc must rise from 2.0 V to Vcc min in less than 25 ms. If this is not possible, configuration can be delayed by holding $\overline{RESET}$ Low until Vcc has reached 4.0 V. A very long Vcc rise time of >100 ms, or a non-monotonically rising Vcc may require a >1-µs High level on $\overline{RESET}$, followed by a >6-µs Low level on $\overline{RESET}$ and D/$\overline{P}$ after Vcc has reached 4.0 V.
2. Configuration must be delayed until the $\overline{INIT}$ of all LCAs is High.
3. Time from end of $\overline{WS}$ to CCLK cycle for the new byte of data depends on completion of previous byte processing and the phase of the internal timing generator for CCLK.
4. CCLK and DOUT timing is tested in slave mode.

This timing diagram shows very relaxed requirements:
Data need not be held beyond the rising edge of $\overline{WS}$. $\overline{BUSY}$ will go active within 60 ns after the end of $\overline{WS}$. $\overline{BUSY}$ will stay active for several microseconds. $\overline{WS}$ may be asserted immediately after the end of $\overline{BUSY}$.

SLAVE MODE PROGRAMMING SWITCHING CHARACTERISTICS

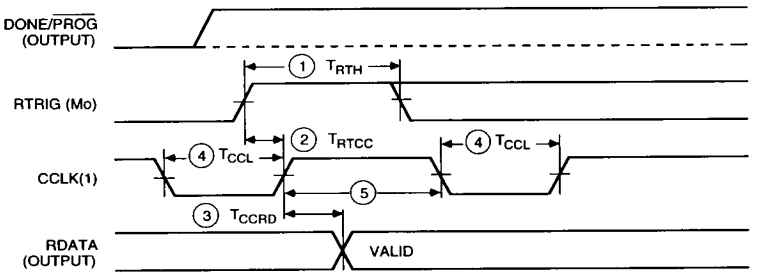


1105 31

		Speed Grade		-5		-4		-3		
	Description	Symbol		Min	Max	Min	Max	Min	Max	Units
CCLK	To DOUT	3	T_{CCO}		100		100		100	ns
	DIN setup	1	T_{DCC}	60		60		60		ns
	DIN hold	2	T_{CCD}	0		0		0		ns
	High time	4	T_{CCH}	0.05		0.05		0.05		µs
	Low time (Note 1)	5	T_{CCL}	0.05	5.0	0.05	5.0	0.05	5.0	µs
	Frequency		F_{CC}		10		10		10	MHz

Notes: 1. The max limit of CCLK Low time is caused by dynamic circuitry inside the LCA device.
2. Configuration must be delayed until the $\overline{INIT}$ of all LCAs is High.
3. At power-up, Vcc must rise from 2.0 V to Vcc min in less than 25 ms. If this is not possible, configuration can be delayed by holding $\overline{RESET}$ Low until Vcc has reached 4.0 V. A very long Vcc rise time of >100 ms, or a non-monotonically rising Vcc may require a >1-µs High level on $\overline{RESET}$, followed by a >6-µs Low level on $\overline{RESET}$ and D/$\overline{P}$ after Vcc has reached 4.0 V.

PROGRAM READBACK SWITCHING CHARACTERISTICS



X1753

		Speed Grade		-5		-4		-3		
	Description	Symbol		Min	Max	Min	Max	Min	Max	Units
RTRIG	RTRIG High	1	T_{RTH}	250		250		250		ns
CCLK	RTRIG setup	2	T_{RTCC}	200		200		200		ns
	RDATA delay	3	T_{CCRD}		100		100		100	ns
	High time	5	T_{CCH}	0.5		0.5		0.5		µs
	Low time	4	T_{CCL}	0.5	5	0.5	5	0.5	5	µs

Notes: 1. During Readback, CCLK frequency may not exceed 1 MHz.
2. RETRIG (M0 positive transition) shall not be done until after one clock following active I/O pins.
3. Readback should not be initiated until configuration is complete.

PIN DESCRIPTIONS

Permanently Dedicated Pins.

V_{CC}
Two to eight (depending on package type) connections to the nominal +5 V supply voltage. All must be connected.

GND
Two to eight (depending on package type) connections to ground. All must be connected.

$\overline{PWRDWN}$
A Low on this CMOS-compatible input stops all internal activity, but retains configuration. All flip-flops and latches are reset, all outputs are 3-stated, and all inputs are interpreted as High, independent of their actual level. While $\overline{PWRDWN}$ is Low, current consumption is reduced to 5 mA (not to just a few µA, as in the XC3000 family) and V_{CC} may be reduced to any value >2.3 V. When $\overline{PWDWN}$ returns High, the LCA device becomes operational with DONE Low for two cycles of the internal 1-MHz clock. During configuration, $\overline{PWRDWN}$ must be High. If not used, $\overline{PWRDWN}$ must be tied to V_{CC}.

$\overline{RESET}$
This is an active Low input which has three functions.

Prior to the start of configuration, a Low input will delay the start of the configuration process. An internal circuit senses the application of power and begins a minimal time-out cycle. When the time-out and $\overline{RESET}$ are complete, the levels of the M lines are sampled and configuration begins.

If $\overline{RESET}$ is asserted during a configuration, the LCA device is re-initialized and restarts the configuration at the termination of $\overline{RESET}$.

If $\overline{RESET}$ is asserted after configuration is complete, it provides a global asynchronous reset of all IOB and CLB storage elements of the LCA device.

CCLK
During configuration, Configuration Clock is an output of an LCA in Master mode or Peripheral mode, but an input in Slave mode. During Readback, CCLK is a clock input for shifting configuration data out of the LCA device

CCLK drives dynamic circuitry inside the LCA device. The Low time may, therefore, not exceed a few microseconds. When used as an input, CCLK must be "parked High". An internal pull-up resistor maintains High when the pin is not being driven.

DONE/$\overline{PROG}$ (D/$\overline{P}$)
DONE is an open-drain output, configurable with or without an internal pull-up resistor. At the completion of configuration, the LCA device circuitry becomes active in a synchronous order; DONE is programmed to go active High one cycle either before or after the outputs go active.

Once configuration is done, a High-to-Low transition of this pin will cause an initialization of the LCA device and start a reconfiguration.

M0/RTRIG
As Mode 0, this input and M1, M2 are sampled before the start of configuration to establish the configuration mode to be used.

A Low-to-High input transition, after configuration is complete, acts as a Read Trigger and initiates a Readback of configuration and storage-element data clocked by CCLK. By selecting the appropriate Readback option when generating the bitstream, this operation may be limited to a single Readback, or be inhibited altogether.

M1/$\overline{RDATA}$
As Mode 1, this input and M0, M2 are sampled before the start of configuration to establish the configuration mode to be used. If Readback is never used, M1 can be tied directly to ground or V_{CC}. If Readback is ever used, M1 must use a 5-kΩ resistor to ground or V_{CC}, to accommodate the $\overline{RDATA}$ output.

As an active Low Read Data, after configuration is complete, this pin is the output of the Readback data.

User I/O Pins that can have special functions.

M2
During configuration, this input has a weak pull-up resistor. Together with M0 and M1, it is sampled before the start of configuration to establish the configuration mode to be used. After configuration, this pin is a user-programmable I/O pin.

HDC
During configuration, this output is held at a High level to indicate that configuration is not yet complete. After configuration, this pin is a user-programmable I/O pin.

$\overline{LDC}$
During Configuration, this output is held at a Low level to indicate that the configuration is not yet complete. After configuration, this pin is a user-programmable I/O pin. $\overline{LDC}$ is particularly useful in Master mode as a Low enable for an EPROM, but it must then be programmed as a High after configuration.

$\overline{INIT}$
This is an active Low open-drain output which is held Low during the power stabilization and internal clearing of the configuration memory. It can be used to indicate status to a configuring microprocessor or, as a wired AND of several slave mode devices, a hold-off signal for a master mode device. After configuration this pin becomes a user-programmable I/O pin.

BCLKIN
This is a direct CMOS level input to the alternate clock buffer (Auxiliary Buffer) in the lower right corner.

XTL1
This user I/O pin can be used to operate as the output of an amplifier driving an external crystal and bias circuitry.

XTL2
This user I/O pin can be used as the input of an amplifier connected to an external crystal and bias circuitry. The I/O Block is left unconfigured. The oscillator configuration is activated by routing a net from the oscillator buffer symbol output and by the MakeBits program.

$\overline{CS0}$, $\overline{CS1}$, CS2, $\overline{WS}$
These four inputs represent a set of signals, three active Low and one active High, that are used to control configuration-data entry in the Peripheral mode. Simultaneous assertion of all four inputs generates a Write to the internal data buffer. The removal of any assertion clocks in the D0-D7 data. In Master-Parallel mode, $\overline{WS}$ and CS2 are the A0 and A1 outputs. After configuration, these pins are user-programmable I/O pins.

$\overline{RCLK}$
During Master parallel mode configuration $\overline{RCLK}$ represents a "read" of an external dynamic memory device (normally not used). After configuration is complete, this pin becomes a user-programmed I/O pin.

RDY/$\overline{BUSY}$
During Peripheral parallel mode configuration this pin indicates when the chip is ready for another byte of data to be written to it. After configuration is complete, this pin becomes a user-programmed I/O pin.

D0–D7
This set of eight pins represents the parallel configuration byte for the parallel Master and Peripheral modes. After configuration is complete, they are user-programmed I/O pins.

A0–A15
During Master Parallel mode, these 16 pins present an address output for a configuration EPROM. After configuration, they are user-programmable I/O pins.

DIN
During Slave or Master Serial configuration, this pin is used as a serial-data input. In the Master or Peripheral configuration, this is the Data 0 input. After configuration is complete, this pin becomes a user-programmed I/O pin.

DOUT
During configuration this pin is used to output serial-configuration data to the DIN pin of a daisy-chained slave. After configuration is complete, this pin becomes a user-programmed I/O pin.

TCLKIN
This is a direct CMOS-level input to the global clock buffer. This pin can also be configured as a user programmable I/O pin. However, since TCLKIN is the preferred input to the global clock net, and the global clock net should be used as the primary clock source, this pin is usually the clock input to the chip.

Unrestricted User I/O Pins.

I/O
An I/O pin may be programmed by the user to be an Input or an Output pin following configuration. All unrestricted I/O pins, plus the special pins mentioned on the following page, have a weak pull-up resistor of 50 kΩ to 100 kΩ that becomes active as soon as the device powers up, and stays active until the end of configuration.

XC3100 Family Configuration Pin Assignments

Configuration Mode <M2:M1:M0>					***									****	
SLAVE <1:1:1>	MASTER-SER <0:0:0>	PERIPHERAL <1:0:1>	MASTER-HIGH <1:1:0>	MASTER-LOW <1:0:0>	44 PLCC	68 PLCC	84 PLCC	84 PGA	100 PQFP	100 TQFP	132 PGA	160 PQFP	175 PGA	208 PQFP	User Operation
PWRDWN (I)	PWRDWN (I)	PWRDWN (I)	PWRDWN (I)	PWRDWN (I)	7	10	12	B2	29	26	A1	159	B2	3	PWRDWN (I)
VCC	VCC	VCC	VCC	VCC	12	18	22	F3	41	38	C8	20	D9	26	VCC
M1 (HIGH) (I)	M1 (LOW) (I)	M1 (LOW) (I)	M1 (HIGH) (I)	M1 (LOW) (I)	16	25	31	J2	52	49	B13	40	B14	48	RDATA
M0 (HIGH) (I)	M0 (LOW) (I)	M0 (HIGH) (I)	M0 (LOW) (I)	M0 (LOW) (I)	17	26	32	L1	54	51	A14	42	B15	50	RTRIG (I)
M2 (HIGH) (I)	M2 (LOW) (I)	M2 (HIGH) (I)	M2 (HIGH) (I)	M2 (HIGH) (I)	18	27	33	K2	56	53	C13	44	C15	56	I/O
HDC (HIGH)	HDC (HIGH)	HDC (HIGH)	HDC (HIGH)	HDC (HIGH)	19	28	34	K3	57	54	B14	45	E14	57	I/O
LDC (LOW)	LDC (LOW)	LDC (LOW)	LDC (LOW)	LDC (LOW)	20	30	36	L3	59	56	D14	49	D16	61	I/O
INIT*	INIT*	INIT*	INIT*	INIT*	22	34	42	K6	65	62	G14	59	H15	77	I/O
GND	GND	GND	GND	GND	23	35	43	J6	66	63	H12	19	J14	79	GND
					26	43	53	L11	76	73	M13	76	P15	100	XTL2 OR I/O
RESET (I)	RESET (I)	RESET (I)	RESET (I)	RESET (I)	27	44	54	K10	78	75	P14	78	R15	102	RESET (I)
DONE	DONE	DONE	DONE	DONE	28	45	55	J10	80	77	N13	80	R14	107	PROGRAM (I)
		DATA 7 (I)	DATA 7 (I)	DATA 7 (I)		46	56	K11	81	78	M12	81	N13	109	I/O
					30	47	57	J11	82	79	P13	82	T14	110	XTL1 OR I/O
		DATA 6 (I)	DATA 6 (I)	DATA 6 (I)		48	58	H10	83	80	N11	86	P12	115	I/O
		DATA 5 (I)	DATA 5 (I)	DATA 5 (I)		49	60	F10	87	84	M9	92	T11	122	I/O
		CS0 (I)				50	61	G10	88	85	N9	93	R10	123	I/O
		DATA 4 (I)	DATA 4 (I)	DATA 4 (I)		51	62	G11	89	86	N8	98	R9	128	I/O
VCC	VCC	VCC	VCC	VCC	34	52	64	F9	91	88	M8	100	N9	130	Vcc
		DATA 3 (I)	DATA 3 (I)	DATA 3 (I)		53	65	F11	92	89	N7	102	P8	132	I/O
		CS1 (I)				54	66	E11	93	90	P6	103	R8	133	I/O
		DATA 2 (I)	DATA 2 (I)	DATA 2 (I)		55	67	E10	94	91	M6	108	R7	138	I/O
		DATA 1 (I)	DATA 1 (I)	DATA 1 (I)		56	70	D10	98	95	M5	114	R5	145	I/O
		RDY/BUSY	RCLK	RCLK		57	71	C11	99	96	N4	115	P5	146	I/O
DIN (I)	DIN (I)	DATA 0 (I)	DATA 0 (I)	DATA 0 (I)	38	58	72	B11	100	97	N2	119	R3	151	I/O
DOUT	DOUT	DOUT	DOUT	DOUT	39	59	73	C10	1	98	M3	120	N4	152	I/O
CCLK (I)	CCLK	CCLK	CCLK	CCLK	40	60	74	A11	2	99	P1	121	R2	153	CCLK (I)
		WS (I)	A0	A0		61	75	B10	5	2	M2	124	P2	161	I/O
		CS2 (I)	A1	A1		62	76	B9	6	3	N1	125	M3	162	I/O
			A2	A2		63	77	A10	8	5	L2	128	P1	165	I/O
			A3	A3		64	78	A9	9	6	L1	129	N1	66	I/O
			A15	A15		65	81	B6	12	9	K1	132	M1	172	I/O
			A4	A4		66	82	B7	13	10	J2	133	L2	173	I/O
			A14	A14		67	83	A7	14	11	H1	136	K2	178	I/O
			A5	A5		68	84	C7	15	12	H2	137	K1	179	I/O
GND	GND	GND	GND	GND	1	1	1	C6	16	13	H3	139	J3	182	GND
			A13	A13		2	4	A6	17	14	G2	141	H2	184	I/O
			A6	A6		3	5	A5	18	15	G1	142	H1	185	I/O
			A12	A12		4	6	B5	19	16	F2	147	F2	192	I/O
			A7	A7		5	7	C5	20	17	E1	148	E1	193	I/O
			A11	A11		6	8	A3	23	20	D1	151	D1	199	I/O
			A8	A8		7	9	A2	24	21	D2	152	C1	200	I/O
			A10	A10		8	10	B3	25	22	B1	155	E3	203	I/O
			A9	A9		9	11	A1	26	26	C2	156	C2	204	I/O
						X	X	X	X						XC3120
					X	X	X	X	X	X					XC3130
							X	X	X	X	X				XC3142
							X**				X				XC3164
							X**					X	X	X	XC3190
							X					X	X	X	XC3195

Represents a 58 kilohm to 100 kilohm pull-up

* INIT is an open drain output during configuration

(I) Represents an input

** Pin assignment for the XC3164/XC3190 and XC3195 differ from those shown. See page 45.

*** Peripheral mode and master parallel mode are not supported in the PC44 package. See page 43.

**** Pin assignments for the XC3195 PQ208 differ from those shown. See page 49.

X2665

Note: Pin assignments of "PGA Footprint" PLCC sockets and PGA packages are not electrically identical. Generic I/O pins are not shown.

XC3100 FAMILY PIN ASSIGNMENTS

Xilinx offers the five different devices of the XC3100 family in a variety of surface-mount and through-hole package types, with pin counts from 44 to 223.

Each chip is offered in several package types to accomodate the available pc board space and manufacturing technology. Most package types are also offered with different chips to accomodate design changes without the need for pc board changes.

Note that there is no perfect match between the number of bonding pads on the chip and the number of pins on a package. In some cases, the chip has more pads than there are pins on the package, as indicated by the information ("unused" pads) below the line in the following table. The IOBs of the unconnected pads can still be used as storage elements if the specified propagation delays and set-up times are acceptable.

In other cases, the chip has fewer pads than there are pins on the package; therefore, some package pins are not connected (n.c.), as shown above the line in the following table.

Number of Package Pins

Device	Pads	44	68	84	100	132	160	175	208	223
XC3120	74	—	6 unused	10 n.c.	26 n.c.	—	—	—	—	—
XC3130	98	54 unused	30 unused	14 unused	2 n.c.	—	—	—	—	—
XC3142	118	—	—	34 unused	18 unused	14 n.c.	—	—	—	—
XC3164	142	—	—	58 unused	—	10 unused	18 n.c.	—	—	—
XC3190	166	—	—	82 unused	—	—	6 unused	9 n.c.	42 n.c.	—
XC3195	198	—	—	114 unused	—	—	—	9 n.c. 32 unused	10 n.c.	25 n.c.

n.c.= Unconnected package pin
unused = Unbonded device pad

XC3100 Family 44-Pin PLCC Pinouts

Pin No.	XC3130
1	**GND**
2	I/O
3	I/O
4	I/O
5	I/O
6	I/O
7	$\overline{\text{PWRDWN}}$
8	TCLKIN-I/O
9	I/O
10	I/O
11	I/O
12	**VCC**
13	I/O
14	I/O
15	I/O
16	M1-$\overline{\text{RDATA}}$
17	M0-RTRIG
18	M2-I/O
19	HDC-I/O
20	$\overline{\text{LDC}}$-I/O
21	I/O
22	$\overline{\text{INIT}}$-I/O

Pin No.	XC3130
23	**GND**
24	I/O
25	I/O
26	XTL2(IN)-I/O
27	$\overline{\text{RESET}}$
28	DONE-$\overline{\text{PGM}}$
29	I/O
30	XTL1(OUT)-BCLK-I/O
31	I/O
32	I/O
33	I/O
34	**VCC**
35	I/O
36	I/O
37	I/O
38	DIN-I/O
39	DOUT-I/O
40	CCLK
41	I/O
42	I/O
43	I/O
44	I/O

Peripheral mode and Master Parallel mode are not supported in the PC44 package

XC3100 Family 68-Pin PLCC, 84-Pin PLCC and PGA Pinouts

68 PLCC		XC3120		
XC3130	XC3120	XC3130, XC3142	84 PLCC	84 PGA
10	10	PWRDN	12	B2
11	11	TCLKIN-I/O	13	C2
12	—	**I/O***	14	B1
13	12	I/O	15	C1
14	13	I/O	16	D2
—	—	I/O	17	D1
15	14	I/O	18	E3
16	15	I/O	19	E2
—	16	I/O	20	E1
17	17	I/O	21	F2
18	18	**VCC**	22	F3
19	19	I/O	23	G3
—	—	I/O	24	G1
20	20	I/O	25	G2
—	21	I/O	26	F1
21	22	I/O	27	H1
22	—	I/O	28	H2
23	23	I/O	29	J1
24	24	I/O	30	K1
25	25	M1-RDATA	31	J2
26	26	M0-RTRIG	32	L1
27	27	M2-I/O	33	K2
28	28	HDC-I/O	34	K3
29	29	I/O	35	L2
30	30	LDC-I/O	36	L3
—	31	I/O	37	K4
—		**I/O***	38	L4
31	32	I/O	39	J5
32	33	I/O	40	K5
33	—	**I/O***	41	L5
34	34	INIT-I/O	42	K6
35	35	**GND**	43	J6
36	36	I/O	44	J7
37	37	I/O	45	L7
38	38	I/O	46	K7
39	39	I/O	47	L6
—	40	I/O	48	L8
—	41	I/O	49	K8
40		**I/O***	50	L9
41		**I/O***	51	L10
42	42	I/O	52	K9
43	43	XTL2(IN)-I/O	53	L11

68 PLCC XC3130 XC3120	XC3120 XC3130, XC3142	84 PLCC	84 PGA
44	RESET	54	K10
45	DONE-PG	55	J10
46	D7-I/O	56	K11
47	XTL1(OUT)-BCLKIN-I/O	57	J11
48	D6-I/O	58	H10
—	I/O	59	H11
49	D5-I/O	60	F10
50	CS0-I/O	61	G10
51	D4-I/O	62	G11
—	I/O	63	G9
52	**VCC**	64	F9
53	D3-I/O	65	F11
54	CS1-I/O	66	E11
55	D2-I/O	67	E10
—	I/O	68	E9
—	**I/O***	69	D11
56	D1-I/O	70	D10
57	RDY/BUSY-RCLK-I/O	71	C11
58	D0-DIN-I/O	72	B11
59	DOUT-I/O	73	C10
60	CCLK	74	A11
61	A0-WS-I/O	75	B10
62	A1-CS2-I/O	76	B9
63	A2-I/O	77	A10
64	A3-I/O	78	A9
—	**I/O***	79	B8
—	**I/O***	80	A8
65	A15-I/O	81	B6
66	A4-I/O	82	B7
67	A14-I/O	83	A7
68	A5-I/O	84	C7
1	**GND**	1	C6
2	A13-I/O	2	A6
3	A6-I/O	3	A5
4	A12-I/O	4	B5
5	A7-I/O	5	C5
—	**I/O***	6	A4
—	**I/O***	7	B4
6	A11-I/O	8	A3
7	A8-I/O	9	A2
8	A10-I/O	10	B3
9	A9-I/O	11	A1

Unprogrammed IOBs have a default pull-up. This prevents an undefined pad level for unbonded or unused IOBs. Programmed outputs are default slew-rate limited.

This table describes the pinouts of three different chips in three different packages. The second column lists 84 of the 118 pads on the XC3142 (and 84 of the 98 pads on the XC3130) that are connected to the 84 package pins. Ten pads, indicated by an asterisk, do not exist on the XC3120, which has 74 pads; therefore the corresponding pins on the 84-pin packages have no connections to an XC3120. Six pads on the XC3120 and 16 pads on the XC3130, indicated by a dash (—) in the 68 PLCC column, have no connection to the 68 PLCC, but are connected to the 84-pin packages.

XC3164/XC3190/XC3195 84-Pin PLCC Pinouts

PLCC Pin Number	XC3164, XC3190, XC3195
12	PWRDN
13	TCLKIN-I/O
14	I/O
15	I/O
16	I/O
17	I/O
18	I/O
19	I/O
20	I/O
21	**GND***
22	VCC
23	I/O
24	I/O
25	I/O
26	I/O
27	I/O
28	I/O
29	I/O
30	I/O
31	M1-RDATA
32	M0-RTRIG
33	M2-I/O
34	HDC-I/O
35	I/O
36	LDC-I/O
37	I/O
38	I/O
39	I/O
40	I/O
41	INIT/I/O*
42	**VCC***
43	**GND**
44	I/O
45	I/O
46	I/O
47	I/O
48	I/O
49	I/O
50	I/O
51	I/O
52	I/O
53	XTL2(IN)-I/O

PLCC Pin Number	XC3164, XC3190, XC3195
54	RESET
55	DONE-PG
56	D7-I/O
57	XTL1(OUT)-BCLKIN-I/O
58	D6-I/O
59	I/O
60	D5-I/O
61	CS0-I/O
62	D4-I/O
63	I/O
64	VCC
65	**GND***
66	D3-I/O*
67	CS1-I/O*
68	D2-I/O*
69	I/O
70	D1-I/O
71	RDY/BUSY-RCLK-I/O
72	D0-DIN-I/O
73	DOUT-I/O
74	CCLK
75	A0-WS-I/O
76	A1-CS2-I/O
77	A2-I/O
78	A3-I/O
79	I/O
80	I/O
81	A15-I/O
82	A4-I/O
83	A14-I/O
84	A5-I/O
1	**GND**
2	**VCC***
3	A13-I/O*
4	A6-I/O*
5	A12-I/O*
6	A7-I/O*
7	I/O
8	A11-I/O
9	A8-I/O
10	A10-I/O
11	A9-I/O

Unprogrammed IOBs have a default pull-up. This prevents an undfined pad level for unbonded or unused IOBs. Programmed ouptuts are default slew-rate limited.

* Different pin definition than 3120/3130/3142 PC84 package

XC3100 Family 100-Pin QFP Pinouts

Pin No.			XC3120 XC3130 XC3142
CQFP	PQFP	TQFP	
1	16	13	GND
2	17	14	A13-I/O
3	18	15	A6-I/O
4	19	16	A12-I/O
5	20	17	A7-I/O
6	21	18	I/O*
7	22	19	I/O*
8	23	20	A11-I/O
9	24	21	A8-I/O
10	25	22	A10-I/O
11	26	23	A9-I/O
12	27	24	VCC*
13	28	25	GND*
14	29	26	$\overline{\text{PWRDN}}$
15	30	27	TCLKIN-I/O
16	31	28	I/O**
17	32	29	I/O*
18	33	30	I/O*
19	34	31	I/O
20	35	32	I/O
21	36	33	I/O
22	37	34	I/O
23	38	35	I/O
24	39	36	I/O
25	40	37	I/O
26	41	38	VCC
27	42	39	I/O
28	43	40	I/O
29	44	41	I/O
30	45	42	I/O
31	46	43	I/O
32	47	44	I/O
33	48	45	I/O
34	49	46	I/O

Pin No.			XC3120 XC3130 XC3142
CQFP	PQFP	TQFP	
35	50	47	I/O*
36	51	48	I/O*
37	52	49	M1-$\overline{\text{RD}}$
38	53	50	GND*
39	54	51	MO-RT
40	55	52	VCC*
41	56	53	M2-I/O
42	57	54	HDC-I/O
43	58	55	I/O
44	59	56	$\overline{\text{LDC}}$-I/O
45	60	57	I/O*
46	61	58	I/O*
47	62	59	I/O
48	63	60	I/O
49	64	61	I/O
50	65	62	$\overline{\text{INIT}}$-I/O
51	66	63	GND
52	67	64	I/O
53	68	65	I/O
54	69	66	I/O
55	70	67	I/O
56	71	68	I/O
57	72	69	I/O
58	73	70	I/O
59	74	71	I/O*
60	75	72	I/O*
61	76	73	XTAL2-I/O
62	77	74	GND*
63	78	75	$\overline{\text{RESET}}$
64	79	76	VCC*
65	80	77	DONE-$\overline{\text{PG}}$
66	81	78	D7-I/O
67	82	79	BCLKIN-XTAL1-I/O
68	83	80	D6-I/O

Pin No.			XC3120 XC3130 XC3142
CQFP	PQFP	TQFP	
69	84	81	I/O*
70	85	82	I/O*
71	86	83	I/O
72	87	84	D5-I/O
73	88	85	$\overline{\text{CS0}}$-I/O
74	89	86	D4-I/O
75	90	87	I/O
76	91	88	VCC
77	92	89	D3-I/O
78	93	90	$\overline{\text{CS1}}$-I/O
79	94	91	D2-I/O
80	95	92	I/O
81	96	93	I/O*
82	97	94	I/O*
83	98	95	D1-I/O
84	99	96	$\overline{\text{RCLK}}$-$\overline{\text{BUSY}}$/RDY-I/O
85	100	97	DO-DIN-I/O
86	1	98	DOUT-I/O
87	2	99	CCLK
88	3	100	VCC*
89	4	1	GND*
90	5	2	AO-$\overline{\text{WS}}$-I/O
91	6	3	A1-CS2-I/O
92	7	4	I/O**
93	8	5	A2-I/O
94	9	6	A3-I/O
95	10	7	I/O*
96	11	8	I/O*
97	12	9	A15-I/O
98	13	10	A4-I/O
99	14	11	A14-I/O
100	15	12	A5-I/O

Unprogrammed IOBs have a default pull-up.
This prevents an undefined pad level for unbonded or unused IOBs.
Programmed outputs are default slew-rate limited.

* This table describes the pinouts of three different chips in three different packges. The third column lists 100 of the 118 pads on the XC3142 that are connected to the 100 package pins. Two pads, indicated by double asterisks, do not exist on the XC3130, which has 98 pads; therefore the corresponding pins have no connections. Twenty-six pads, indicated by single or double asterisks, do not exist on the XC3120, which has 74 pads; therefore, the corresponding pins have no connections. (See table on page 43.)

XC3100 Family 132-Pin Ceramic and Plastic PGA Pinouts

PGA Pin Number	XC3142 XC3164
C4	**GND**
A1	PWRDN
C3	I/O-TCLKIN
B2	I/O
B3	I/O
A2	**I/O***
B4	I/O
C5	I/O
A3	**I/O***
A4	I/O
B5	I/O
C6	I/O
A5	I/O
B6	I/O
A6	I/O
B7	I/O
C7	**GND**
C8	**VCC**
A7	I/O
B8	I/O
A8	I/O
A9	I/O
B9	I/O
C9	I/O
A10	I/O
B10	I/O
A11	**I/O***
C10	I/O
B11	I/O
A12	**I/O***
B12	I/O
A13	**I/O***
C12	I/O

PGA Pin Number	XC3142 XC3164
B13	M1-RD
C11	**GND**
A14	M0-RT
D12	**VCC**
C13	M2-I/O
B14	HDC-I/O
C14	I/O
E12	I/O
D13	I/O
D14	LDC-I/O
E13	**I/O***
F12	I/O
E14	I/O
F13	I/O
F14	I/O
G13	I/O
G14	INIT-I/O
G12	**VCC**
H12	**GND**
H14	I/O
H13	I/O
J14	I/O
J13	I/O
K14	I/O
J12	I/O
K13	I/O
L14	**I/O***
L13	I/O
K12	I/O
M14	I/O
N14	I/O
M13	XTAL2(IN)-I/O
L12	**GND**

PGA Pin Number	XC3142 XC3164
P14	RESET
M11	**VCC**
N13	DONE-PG
M12	D7-I/O
P13	XTAL1-I/O-BCLKIN
N12	I/O
P12	I/O
N11	D6-I/O
M10	I/O
P11	**I/O***
N10	I/O
P10	I/O
M9	D5-I/O
N9	CS0-I/O
P9	**I/O***
P8	**I/O***
N8	D4-I/O
P7	I/O
M8	**VCC**
M7	**GND**
N7	D3-I/O
P6	CS1-I/O
N6	**I/O***
P5	**I/O***
M6	D2-I/O
N5	I/O
P4	I/O
P3	I/O
M5	D1-I/O
N4	RCLK-BUSY/RDY-I/O
P2	I/O
N3	I/O
N2	D0-DIN-I/O

PGA Pin Number	XC3142 XC3164
M3	DOUT-I/O
P1	CCLK
M4	**VCC**
L3	**GND**
M2	A0-WS-I/O
N1	A1-CS2-I/O
M1	I/O
K3	I/O
L2	A2-I/O
L1	A3-I/O
K2	I/O
J3	I/O
K1	A15-I/O
J2	A4-I/O
J1	**I/O***
H1	A14-I/O
H2	A5-I/O
H3	**GND**
G3	**VCC**
G2	A13-I/O
G1	A6-I/O
F1	**I/O***
F2	A12-I/O
E1	A7-I/O
F3	I/O
E2	I/O
D1	A11-I/O
D2	A8-I/O
E3	I/O
C1	I/O
B1	A10-I/O
C2	A9-I/O
D3	**VCC**

Unprogrammed IOBs have a default pull-up. This prevents an undefined pad level for unbonded or unused IOBs. Programmed outputs are default slew-rate limited.

* Indicates unconnected package pins (14) for the XC3142.

XC3100 Family 160-Pin PQFP Pinouts

PQFP Pin Number	XC3164, XC3190, XC3195
1	I/O*
2	I/O*
3	I/O*
4	I/O
5	I/O
6	I/O
7	I/O
8	I/O
9	I/O
10	I/O
11	I/O
12	I/O
13	I/O
14	I/O
15	I/O
16	I/O
17	I/O
18	I/O
19	GND
20	VCC
21	I/O*
22	I/O
23	I/O
24	I/O
25	I/O
26	I/O
27	I/O
28	I/O
29	I/O
30	I/O
31	I/O
32	I/O
33	I/O
34	I/O
35	I/O
36	I/O
37	I/O
38	I/O*
39	I/O*
40	M1-RDATA

PQFP Pin Number	XC3164, XC3190, XC3195
41	GND
42	M0–RTRIG
43	VCC
44	M2-I/O
45	HDC-I/O
46	I/O
47	I/O
48	I/O
49	LDC-I/O
50	I/O*
51	I/O*
52	I/O
53	I/O
54	I/O
55	I/O
56	I/O
57	I/O
58	I/O
59	INIT-I/O
60	VCC
61	GND
62	I/O
63	I/O
64	I/O
65	I/O
66	I/O
67	I/O
68	I/O
69	I/O
70	I/O
71	I/O
72	I/O
73	I/O
74	I/O
75	I/O*
76	XTAL2-I/O
77	GND
78	RESET
79	VCC
80	DONE/PG

PQFP Pin Number	XC3164, XC3190, XC3195
81	D7-I/O
82	XTAL1-I/O-BCLKIN
83	I/O*
84	I/O
85	I/O
86	D6-I/O
87	I/O
88	I/O
89	I/O
90	I/O
91	I/O
92	D5-I/O
93	CS0-I/O
94	I/O*
95	I/O*
96	I/O
97	I/O
98	D4-I/O
99	I/O
100	VCC
101	GND
102	D3-I/O
103	CS1-I/O
104	I/O
105	I/O
106	I/O*
107	I/O*
108	D2-I/O
109	I/O
110	I/O
111	I/O
112	I/O
113	I/O
114	D1-I/O
115	RDY-BSY/RCLK-I/O
116	I/O
117	I/O
118	I/O*
119	D0-DIN-I/O
120	DOUT-I/O

PQFP Pin Number	XC3164, XC3190, XC3195
121	CCLK
122	VCC
123	GND
124	A0-WS-I/O
125	A1-CS2-I/O
126	I/O
127	I/O
128	A2-I/O
129	A3-I/O
130	I/O
131	I/O
132	A15-I/O
133	A4-I/O
134	I/O
135	I/O
136	A14-I/O
137	A5-I/O
138	I/O*
139	GND
140	VCC
141	A13-I/O
142	A6-I/O
143	I/O*
144	I/O*
145	I/O
146	I/O
147	A12-I/O
148	A7-I/O
149	I/O
150	I/O
151	A11-I/O
152	A8-I/O
153	I/O
154	I/O
155	A10-I/O
156	A9-I/O
157	VCC
158	GND
159	PWRDWN
160	TCLKIN-I/O

Unprogrammed IOBs have a default pull-up. This prevents an undefined pad level for unbonded or unused IOBs. Programmed IOBs are default slew-rate limited.

*Indicates unconnected package pins (18) for the XC3164.

XC3195 Family Pinouts (prilliminary)

Pin Description	PG223	PQ208 *
A9	B1	206
A10	E3	205
I/O	E4	204
I/O	C2	203
I/O	C1	202
I/O	D2	201
A8	E2	200
A11	F4	199
I/O	F3	198
I/O	D1	197
I/O	F2	196
I/O	G2	194
A7	G4	193
A12	G1	192
I/O	H2	191
I/O	H3	190
I/O	H1	189
I/O	H4	188
I/O	J3	187
I/O	J2	186
A6	J1	185
A13	K3	184
VCC	J4	183
GND	K4	182
I/O	K2	181
I/O	K1	180
A5	L2	179
A14	L4	178
I/O	L3	177
I/O	L1	176
I/O	M1	175
I/O	M2	174
A4	M4	173
A15	N2	172
I/O	N3	171
I/O	P2	169
I/O	R1	168
I/O	N4	167
A3	T1	166
A2	R2	165
I/O	P3	164
I/O	T2	163
I/O	P4	162
I/O	U1	161
A1	V1	160
A0	T3	159
GND	R3	158
VCC	R4	157
CCLK	U2	156
DOUT	V2	155

Pin Description	PG223	PQ208 *
D0/DIN	U3	154
I/O	V3	153
I/O	R5	152
I/O	T4	151
I/O	V4	150
RDY/BUSY	U4	149
D1	U5	148
I/O	R6	147
I/O	T5	146
I/O	U6	145
I/O	T6	144
I/O	V7	141
I/O	R7	140
I/O	U7	139
D2	V8	138
I/O	U8	137
I/O	T8	136
I/O	R8	135
I/O	V9	134
$\overline{CS1}$	U9	133
D3	T9	132
GND	R9	131
VCC	R10	130
I/O	T10	129
D4	U10	128
I/O	V10	127
I/O	R11	126
I/O	T11	125
I/O	U11	124
$\overline{CS0}$	V11	123
D5	U12	122
I/O	R12	121
I/O	V12	120
I/O	T13	119
I/O	U13	118
I/O	T14	117
I/O	R13	116
I/O	U14	115
D6	U15	114
I/O	V15	113
I/O	T15	112
I/O	R14	111
I/O	V16	110
XTAL1	U16	109
D7	T16	108
DONE/PGM	V17	107
VCC	R15	106
RESET	U17	105
GND	R16	104
XTAL2	V18	103

Pin Description	PG223	PQ208 *
I/O	U18	102
I/O	P15	101
I/O	T17	100
I/O	T18	99
I/O	P16	98
I/O	R17	97
I/O	N15	96
I/O	R18	95
I/O	P17	94
I/O	N17	93
I/O	N16	92
I/O	M15	89
I/O	M18	88
I/O	M17	97
I/O	L18	86
I/O	L17	85
I/O	L15	84
I/O	L16	83
I/O	K18	82
I/O	K17	81
I/O	K16	80
GND	K15	79
VCC	J15	78
INIT	J16	77
I/O	J17	76
I/O	J18	75
I/O	H16	74
I/O	H15	73
I/O	H17	72
I/O	H18	71
I/O	G17	70
I/O	G18	69
I/O	G15	68
I/O	F16	67
I/O	F17	66
I/O	E17	63
I/O	C18	62
I/O	F15	61
I/O	D17	60
LDC	E16	59
I/O	C17	58
I/O	B18	57
I/O	E15	56
HDC	A18	55
M2	A17	54
VCC	D16	53
MORT	B17	52
GND	D15	51
M1RD	C16	50

Pin Description	PG223	PQ208 *
I/O	B16	49
I/O	A16	48
I/O	D14	47
I/O	C15	46
I/O	B15	45
I/O	A15	44
I/O	C14	43
I/O	D13	42
I/O	B14	41
I/O	C13	40
I/O	B13	39
I/O	B12	38
I/O	D12	37
I/O	A12	36
I/O	B11	35
I/O	C11	34
I/O	A11	33
I/O	D11	32
I/O	A10	31
I/O	B10	30
I/O	C10	29
I/O	C9	28
VCC	D10	27
GND	D9	26
I/O	B9	25
I/O	A9	24
I/O	C8	23
I/O	D8	22
I/O	B8	21
I/O	A8	20
I/O	B7	19
I/O	A7	18
I/O	D7	17
I/O	B6	14
I/O	C6	13
I/O	B5	12
I/O	A4	11
I/O	D6	10
I/O	C5	9
I/O	B4	8
I/O	B3	7
I/O	C4	6
I/O	D5	5
I/O	C3	4
I/O	A3	3
TCLKN	A2	2
PWRDN	B2	1
GND	D4	208
VCC	D3	207

*Different pin defination than XC3190 PQ208 package.

XC3190 Family 208-Pin PQFP Pinouts

Pin Number	XC3190
1	–
2	GND
3	PWRDWN
4	TCLKIN-I/O
5	I/O
6	I/O
7	I/O
8	I/O
9	I/O
10	I/O
11	I/O
12	I/O
13	I/O
14	I/O
15	–
16	I/O
17	I/O
18	I/O
19	I/O
20	I/O
21	I/O
22	I/O
23	I/O
24	I/O
25	GND
26	VCC
27	I/O
28	I/O
29	I/O
30	I/O
31	I/O
32	I/O
33	I/O
34	I/O
35	I/O
36	I/O
37	–
38	I/O
39	I/O
40	I/O
41	I/O
42	I/O
43	I/O
44	I/O
45	I/O
46	I/O
47	I/O
48	M1-RDATA
49	GND
50	M0-RTRIG
51	–
52	–

Pin Number	XC3190
53	–
54	–
55	VCC
56	M2-I/O
57	HDC-I/O
58	I/O
58	I/O
60	I/O
61	LDC-I/O
62	I/O
63	I/O
64	–
65	–
66	–
67	–
68	I/O
69	I/O
70	I/O
71	I/O
72	–
73	–
74	I/O
75	I/O
76	I/O
77	INIT-I/O
78	VCC
79	GND
80	I/O
81	I/O
82	I/O
83	–
84	–
85	I/O
86	I/O
87	I/O
88	I/O
89	I/O
90	–
91	–
92	–
93	I/O
94	I/O
95	I/O
96	I/O
97	I/O
98	I/O
99	I/O
100	XTAL2-I/O
101	GND
102	RESET
103	–
104	–

Pin Number	XC3190
105	–
106	VCC
107	DONE-PG
108	–
109	D7-I/O
110	XTAL-BCLKIN-I/O
111	I/O
112	I/O
113	I/O
114	I/O
115	D6-I/O
116	I/O
117	I/O
118	I/O
119	–
120	I/O
121	I/O
122	D5-I/O
123	$\overline{CS0}$-I/O
124	I/O
125	I/O
126	I/O
127	I/O
128	D4-I/O
129	I/O
130	VCC
131	GND
132	D3-I/O
133	$\overline{CS1}$-I/O
134	I/O
135	I/O
136	I/O
137	I/O
138	D2-I/O
139	I/O
140	I/O
141	I/O
142	–
143	I/O
144	I/O
145	D1-I/O
146	BUSY/RDY-RCLK-I/O
147	I/O
148	I/O
149	I/O
150	I/O
151	DIN-D0-I/O
152	DOUT-I/O
153	CCLK
154	VCC
155	–
156	–

Pin Number	XC3190
157	–
158	–
159	–
160	GND
161	WS-A0-I/O
162	CS2-A1-I/O
163	I/O
164	I/O
165	A2-I/O
166	A3-I/O
167	I/O
168	I/O
169	–
170	–
171	–
172	A15-I/O
173	A4-I/O
174	I/O
175	I/O
176	–
177	–
178	A14-I/O
179	A5-I/O
180	I/O
181	I/O
182	GND
183	VCC
184	A13-I/O
185	A6-I/O
186	I/O
187	I/O
188	–
189	–
190	I/O
191	I/O
192	A12-I/O
193	A7-I/O
194	–
195	–
196	–
197	I/O
198	I/O
199	A11-I/O
200	A8-I/O
201	I/O
202	I/O
203	A10-I/O
204	A9-I/O
205	VCC
206	–
207	–
208	–

XC3100 Family 175-Pin Ceramic and Plastic PGA Pinouts

PGA Pin Number	XC3190, XC3195
B2	PWRDN
D4	TCLKIN-I/O
B3	I/O
C4	I/O
B4	I/O
A4	I/O
D5	I/O
C5	I/O
B5	I/O
A5	I/O
C6	I/O
D6	I/O
B6	I/O
A6	I/O
B7	I/O
C7	I/O
D7	I/O
A7	I/O
A8	I/O
B8	I/O
C8	I/O
D8	**GND**
D9	**VCC**
C9	I/O
B9	I/O
A9	I/O
A10	I/O
D10	I/O
C10	I/O
B10	I/O
A11	I/O
B11	I/O
D11	I/O
C11	I/O
A12	I/O
B12	I/O
C12	I/O
D12	I/O
A13	I/O
B13	I/O
C13	I/O
A14	I/O

PGA Pin Number	XC3190, XC3195
D13	I/O
B14	M1-RDATA
C14	**GND**
B15	M0-RTRIG
D14	**VCC**
C15	M2-I/O
E14	HDC-I/O
B16	I/O
D15	I/O
C16	I/O
D16	LDC-I/O
F14	I/O
E15	I/O
E16	I/O
F15	I/O
F16	I/O
G14	I/O
G15	I/O
G16	I/O
H16	I/O
H15	INIT-I/O
H14	**VCC**
J14	**GND**
J15	I/O
J16	I/O
K16	I/O
K15	I/O
K14	I/O
L16	I/O
L15	I/O
M16	I/O
M15	I/O
L14	I/O
N16	I/O
P16	I/O
N15	I/O
R16	I/O
M14	I/O
P15	XTAL2(IN)-I/O
N14	**GND**
R15	RESET
P14	**VCC**

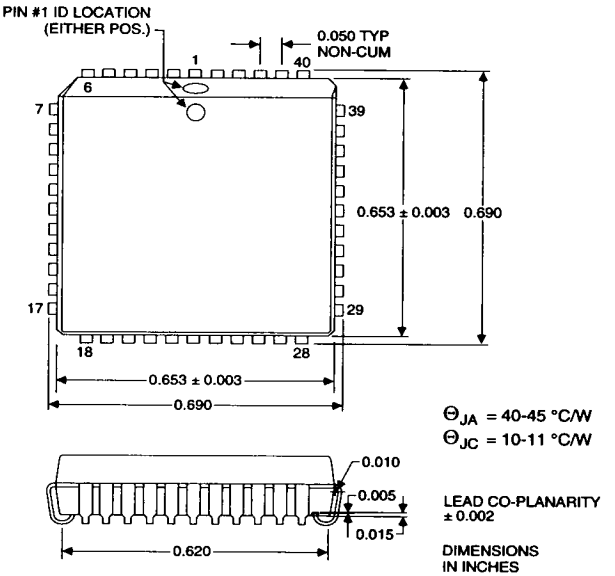
PGA Pin Number	XC3190, XC3195
R14	DONE-PG
N13	D7-I/O
T14	XTAL1(OUT)-BCLKIN-I/O
P13	I/O
R13	I/O
T13	I/O
N12	I/O
P12	D6-I/O
R12	I/O
T12	I/O
P11	I/O
N11	I/O
R11	I/O
T11	D5-I/O
R10	CS0-I/O
P10	I/O
N10	I/O
T10	I/O
T9	I/O
R9	D4-I/O
P9	I/O
N9	**VCC**
N8	**GND**
P8	D3-I/O
R8	CS1-I/O
T8	I/O
T7	I/O
N7	I/O
P7	I/O
R7	D2-I/O
T6	I/O
R6	I/O
N6	I/O
P6	I/O
T5	I/O
R5	D1-I/O
P5	RDY/BUSY-RCLK-I/O
N5	I/O
T4	I/O
R4	I/O
P4	I/O

PGA Pin Number	XC3190, XC3195
R3	D0-DIN-I/O
N4	DOUT-I/O
R2	CCLK
P3	**VCC**
N3	**GND**
P2	A0-WS-I/O
M3	A1-CS2-I/O
R1	I/O
N2	I/O
P1	A2-I/O
N1	A3-I/O
L3	I/O
M2	I/O
M1	A15-I/O
L2	A4-I/O
L1	I/O
K3	I/O
K2	A14-I/O
K1	A5-I/O
J1	I/O
J2	I/O
J3	**GND**
H3	**VCC**
H2	A13-I/O
H1	A6-I/O
G1	I/O
G2	I/O
G3	I/O
F1	I/O
F2	A12-I/O
E1	A7-I/O
E2	I/O
F3	I/O
D1	A11-I/O
C1	A8-I/O
D2	I/O
B1	I/O
E3	A10-I/O
C2	A9-I/O
D3	**VCC**
C3	**GND**

Unprogrammed IOBs have a default pull-up. This prevents an undefined pad level for unbonded or unused IOBs. Programmed outputs are default slew-rate limited.

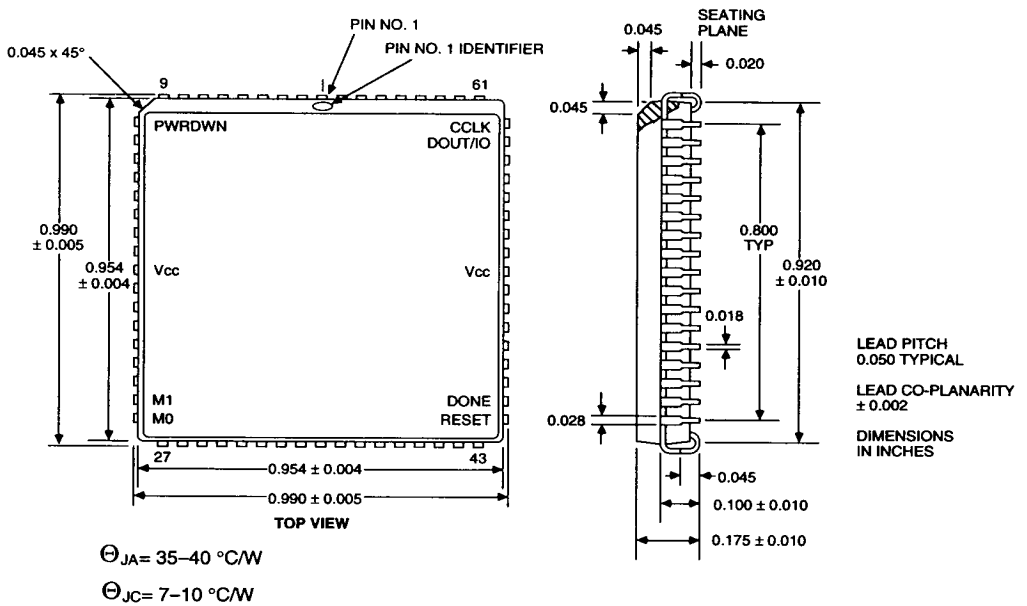
Pins A2, A3, A15, A16, T1, T2, T3, T15 and T16 are not connected.
Pin A1 does not exist.

PHYSICAL DIMENSIONS



1105 42B

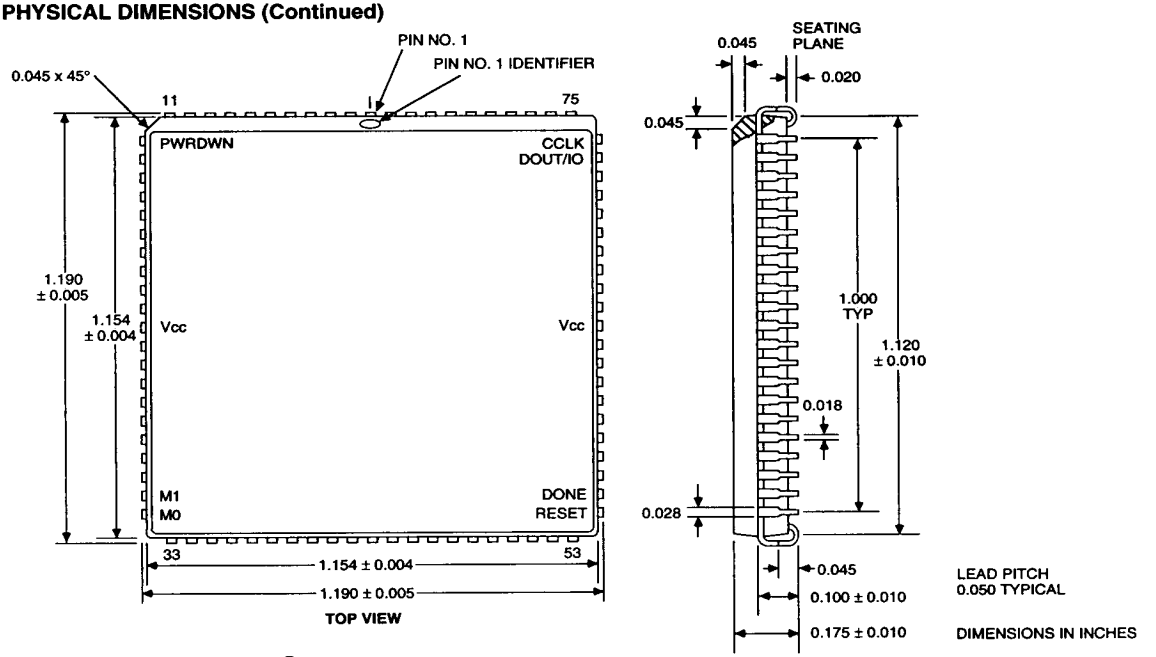
44-Pin PLCC Package



1105 34C

68-Pin PLCC Package

PHYSICAL DIMENSIONS (Continued)

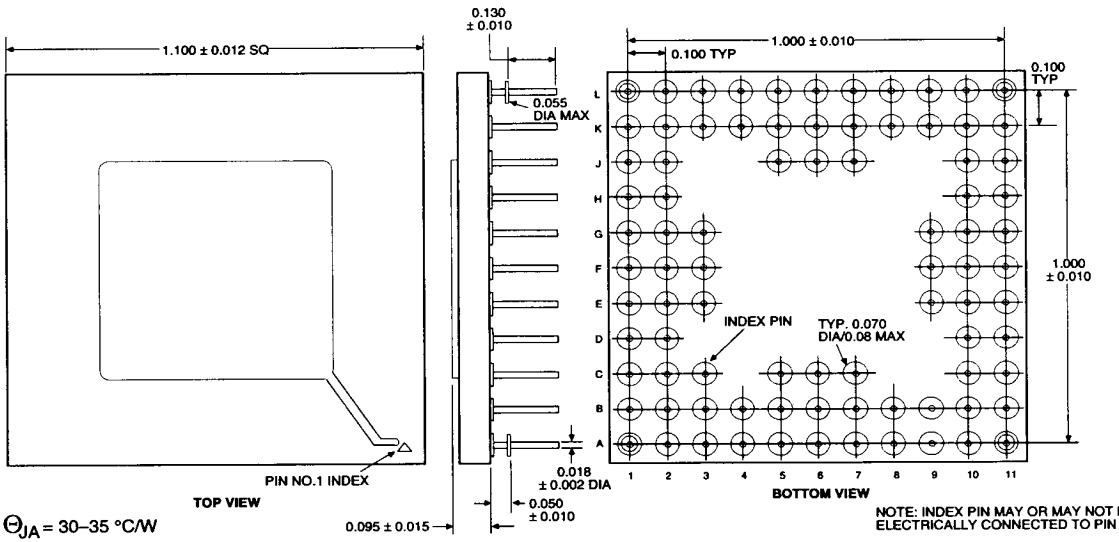


Θ_{JA}= 30–35 °C/W

Θ_{JC}= 3–7 °C/W

1105 36C

84-Pin PLCC Package



Θ_{JA} = 30–35 °C/W

Θ_{JC} = 4–7 °C/W

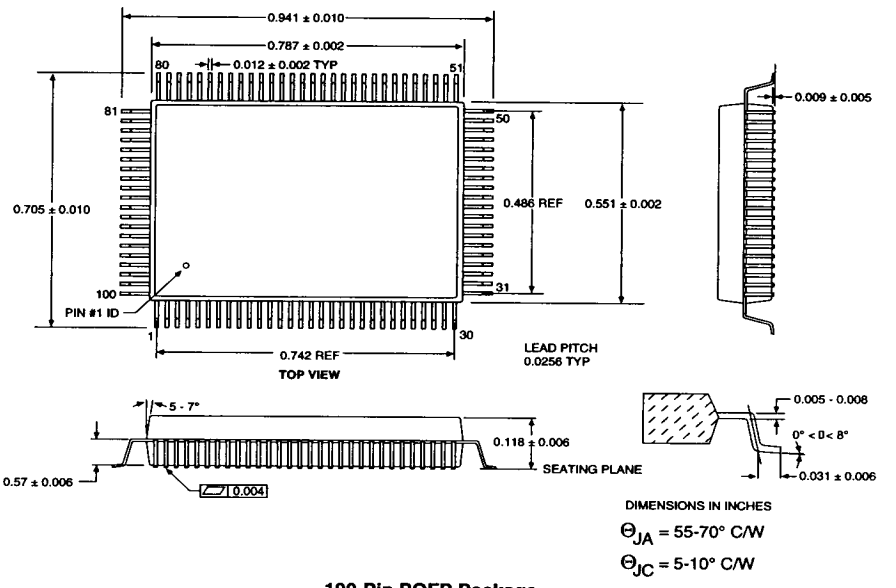
NOTE: INDEX PIN MAY OR MAY NOT BE ELECTRICALLY CONNECTED TO PIN C2.

DIMENSIONS IN INCHES

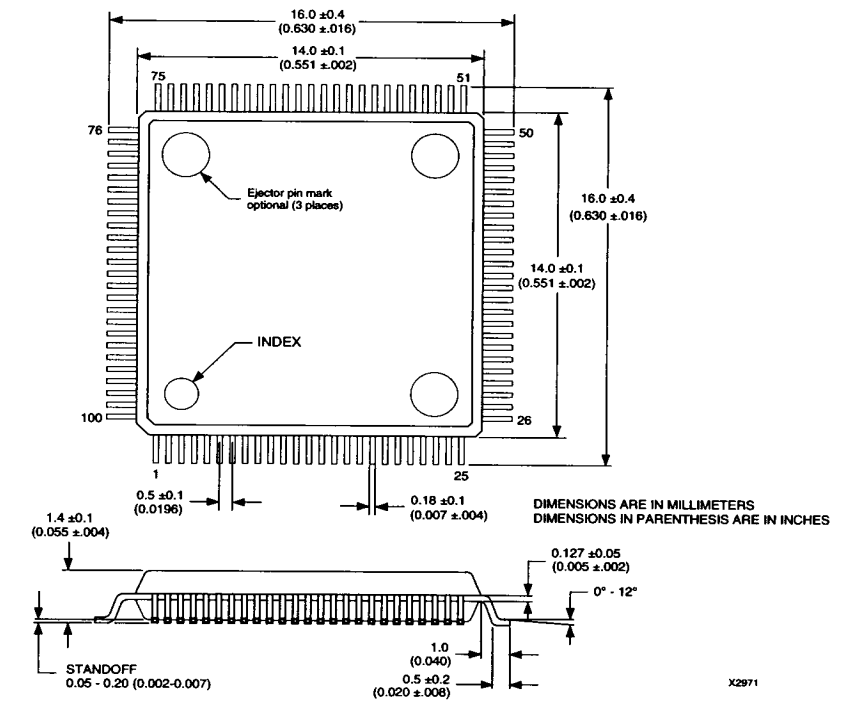
1105 35C

84-Pin PGA Package

PHYSICAL DIMENSIONS (Continued)

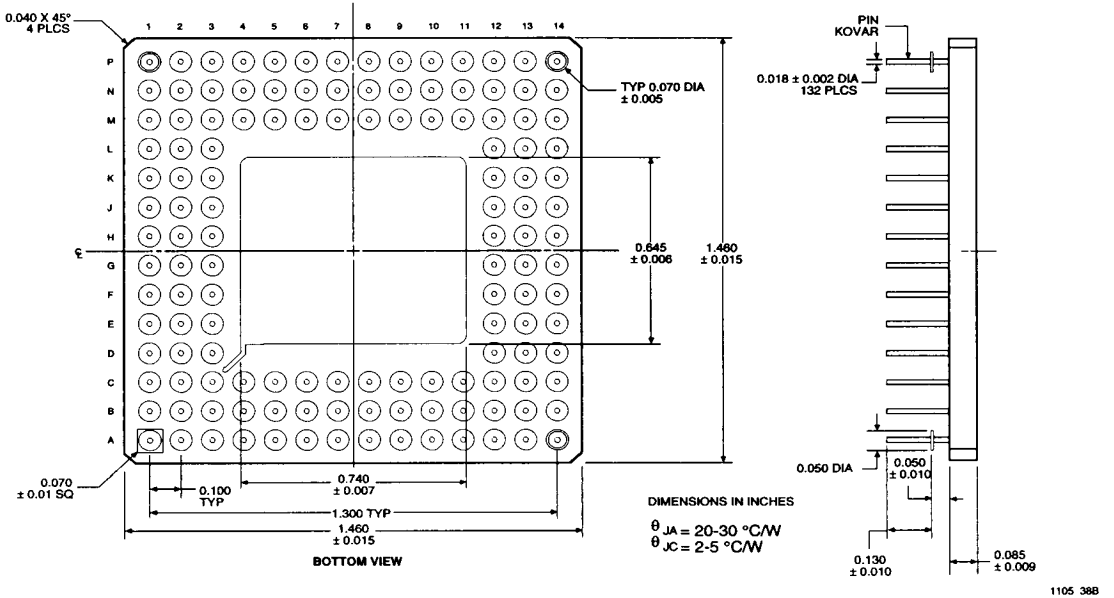


100-Pin PQFP Package

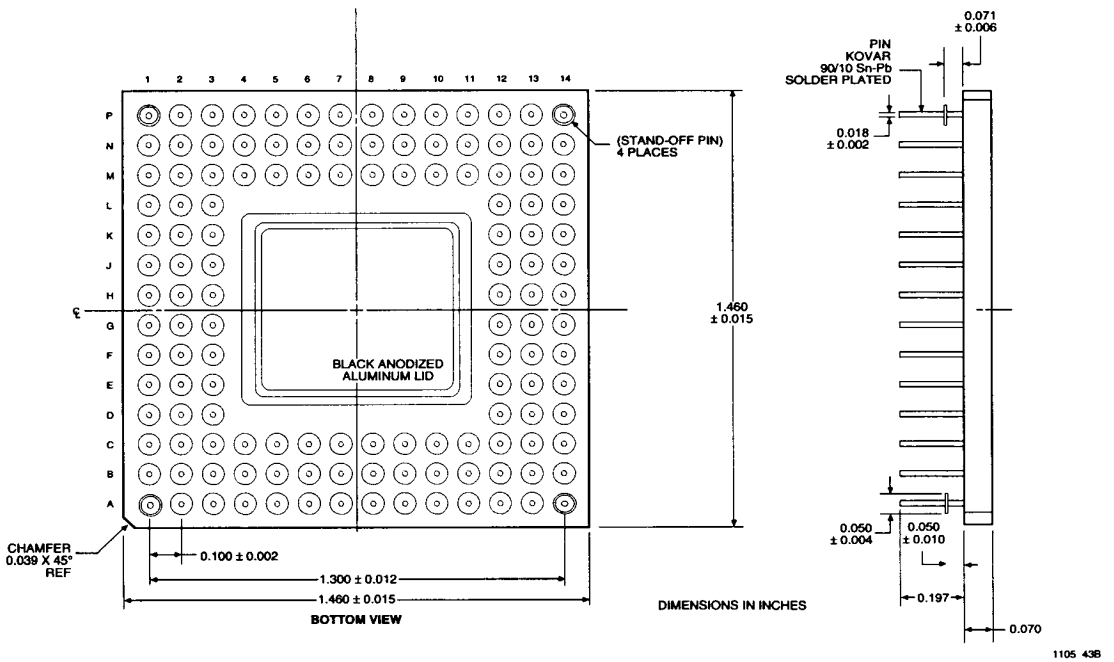


100-Pin TQFP Package

PHYSICAL DIMENSIONS (Continued)

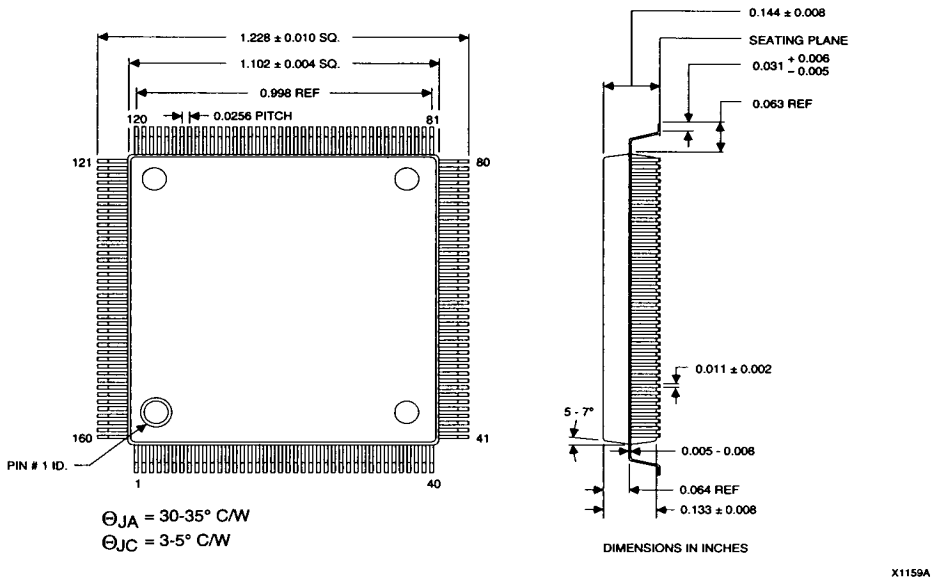


132-Pin PGA Package



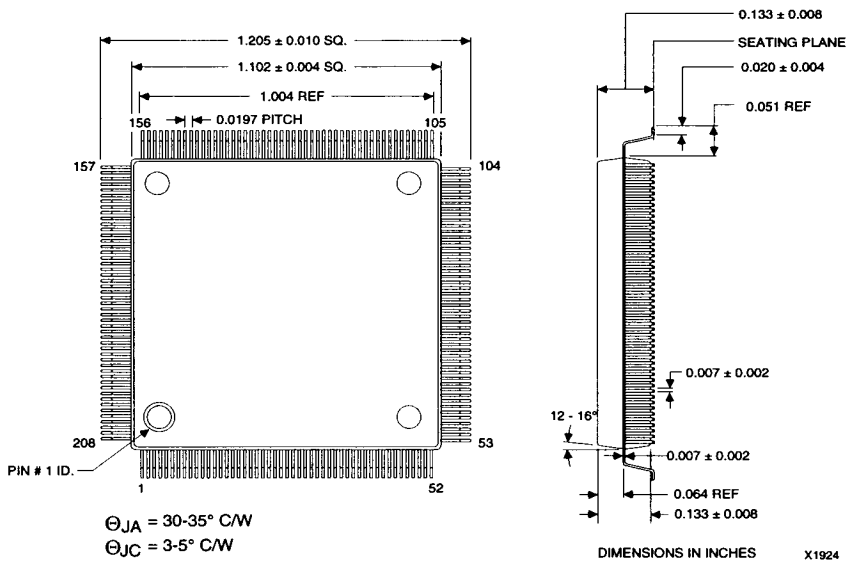
132-Pin PPGA Package

PHYSICAL DIMENSIONS (Continued)



Θ_{JA} = 30-35° C/W
Θ_{JC} = 3-5° C/W

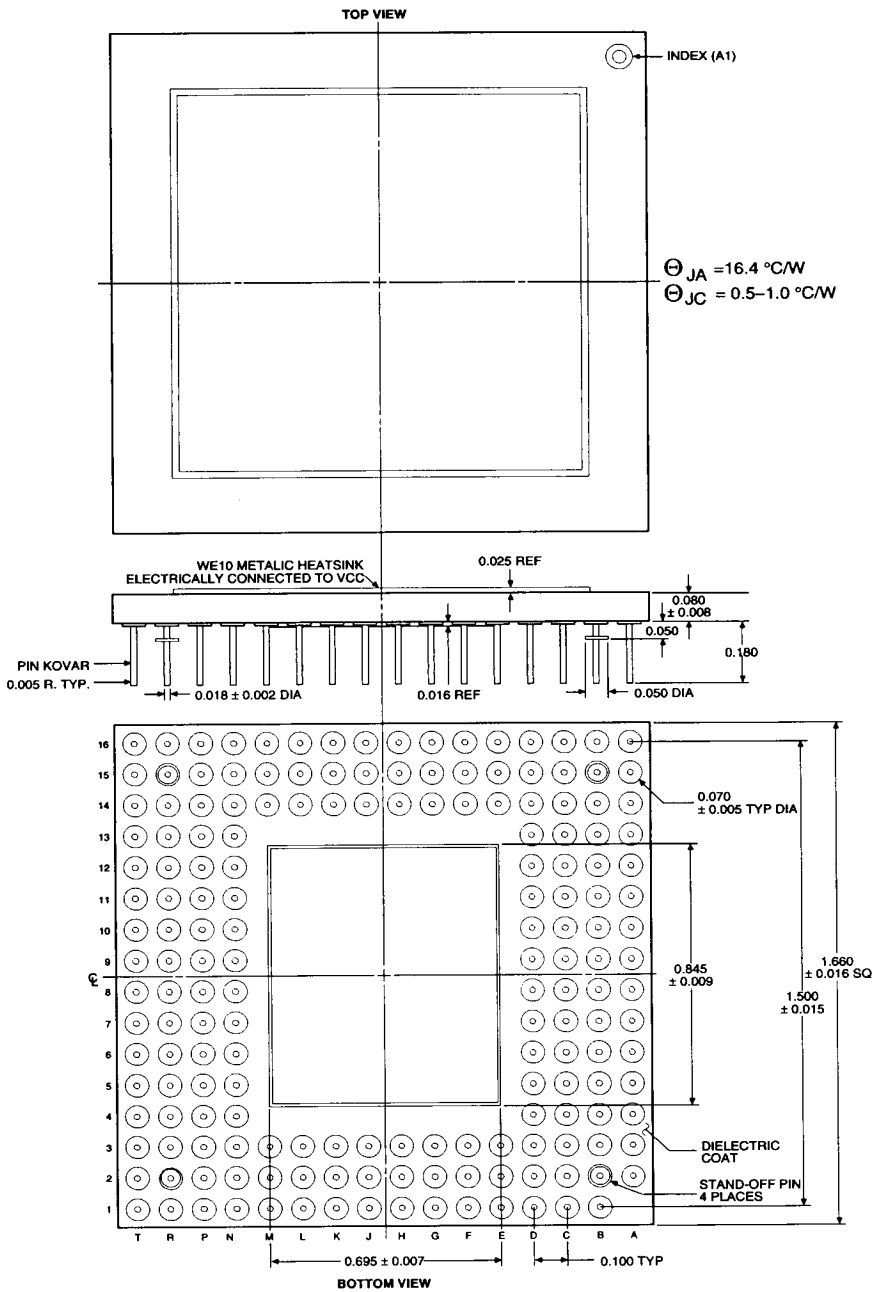
160-Pin PQFP Package



Θ_{JA} = 30-35° C/W
Θ_{JC} = 3-5° C/W

208-Pin CQFP Package

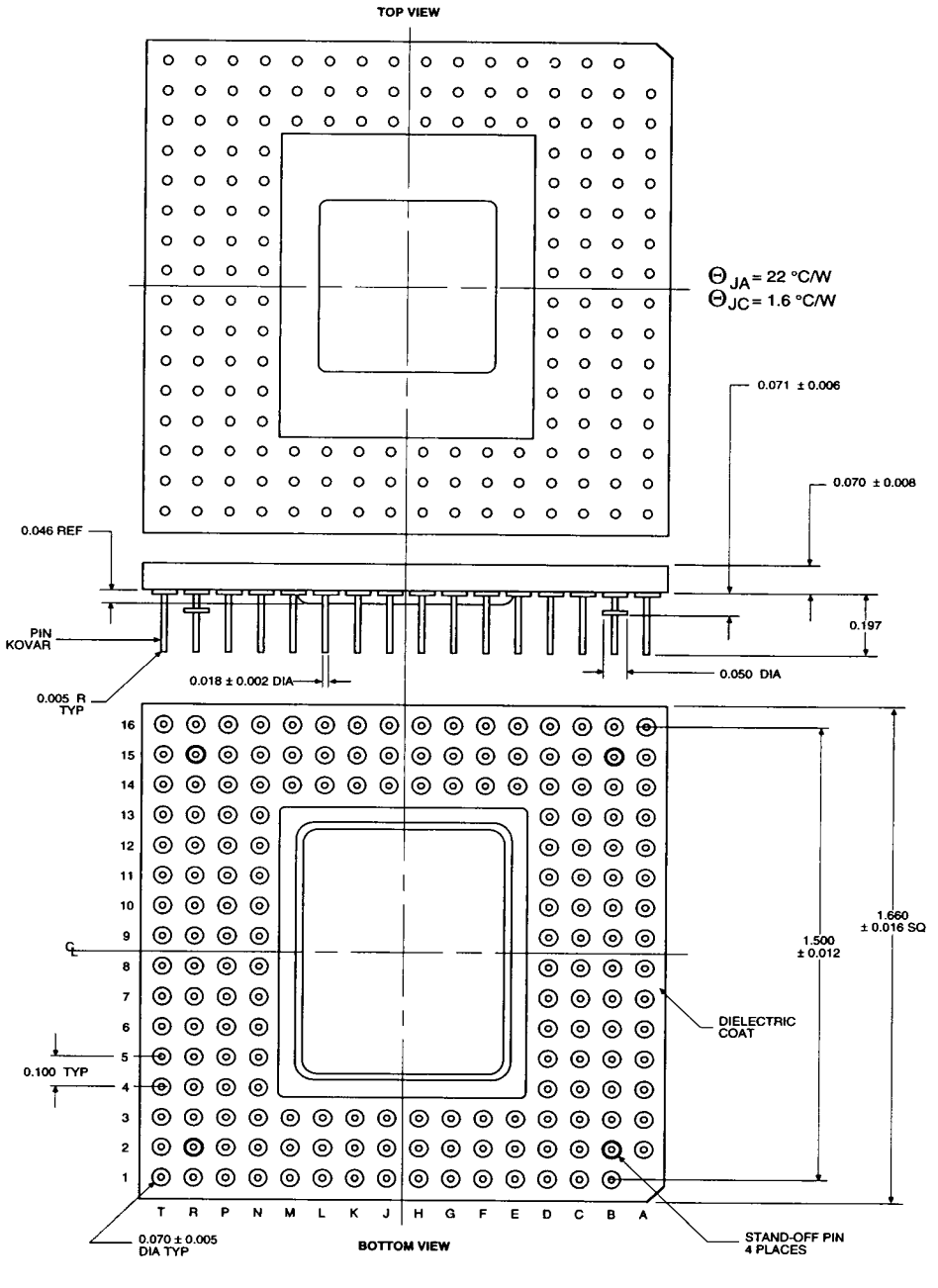
PHYSICAL DIMENSIONS (Continued)



1105 37C

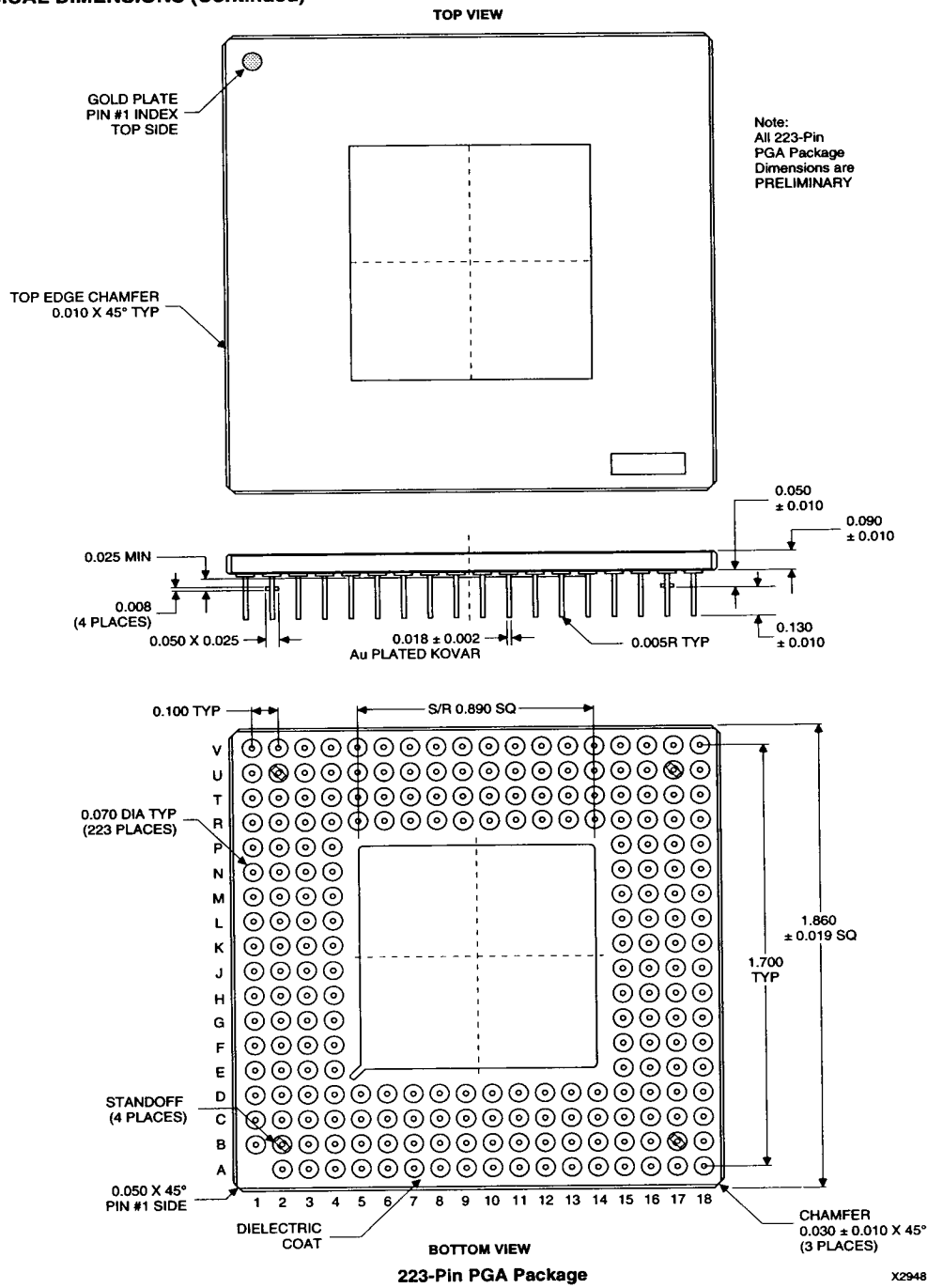
175-Pin PGA Package (Ceramic)

PHYSICAL DIMENSIONS (Continued)



175-Pin PPGA Package (Plastic)

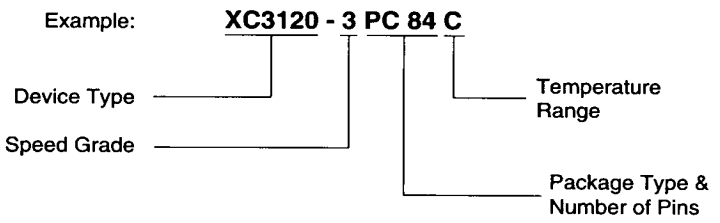
PHYSICAL DIMENSIONS (Continued)



223-Pin PGA Package

X2948

ORDERING INFORMATION



LCA TEMPERATURE OPTIONS

Description	Symbol	Range
Commercial	C	0°C to 70°C
Industrial	I	-40°C to 85°C

PACKAGING OPTIONS

	44 PIN	68 PIN	84 PIN		100 PIN		132 PIN		160 PIN	175 PIN		208 PIN	223 PIN
	PLASTIC PLCC	PLASTIC PLCC	PLASTIC PLCC	CERAMIC PGA	PLASTIC PQFP	PLASTIC TQFP	PLASTIC PGA	CERAMIC PGA	PLASTIC PQFP	PLASTIC PGA	CERAMIC PGA	PLASTIC PQFP	CERAMIC PGA
	PC44	PC68	PC84	PG84	PQ100	TQ100	PP132	PG132	PQ160	PP175	PG175	PQ208	PG223
XC3120		✔	✔	✔	✔								
XC3130	✔	✔	✔	✔	✔	✔							
XC3142			✔	✔	✔	✔	✔	✔					
XC3164			✔				✔	✔	✔				
XC3190			✔						✔	✔	✔	✔	
XC3195			✔						✔	✔	✔	✔	✔

X2649