



Section I. Cyclone II Device Family Data Sheet

This section provides information for board layout designers to successfully layout their boards for Cyclone™ II devices. It contains the required PCB layout guidelines, device pin tables, and package specifications.

This section includes the following chapters:

- [Chapter 1. Introduction](#)
- [Chapter 2. Cyclone II Architecture](#)
- [Chapter 3. Configuration & Testing](#)
- [Chapter 4. Hot Socketing & Power-On Reset](#)
- [Chapter 5. DC Characteristics & Timing Specifications](#)
- [Chapter 6. Reference & Ordering Information](#)

Introduction

Altera's low-cost Cyclone™ II FPGA family is based on a 1.2-V, 90-nm SRAM process with densities over 68K logic elements (LEs) and up to 1.1 Mbits of embedded RAM. With features like embedded 18 × 18 multipliers to support high-performance DSP applications, phase-locked loops (PLLs) for system clock management, and high-speed external memory interface support for SRAM and DRAM devices, Cyclone II devices are a cost-effective solution for high-volume applications. Cyclone II devices support differential and single-ended I/O standards, including LVDS at data rates up to 805 megabits per second (Mbps) for the receiver and 640 Mbps for the transmitter, and 64-bit, 66-MHz PCI and PCI-X for interfacing with processors and ASSP and ASIC devices. Altera also offers low-cost serial configuration devices to configure Cyclone II devices. The Cyclone II FPGA family offers commercial grade, industrial grade, and lead-free devices.

Features

The Cyclone II device family offers the following features:

- High-density architecture with 4,608 to 68,416 LEs
- M4K embedded memory blocks
 - Up to 1.1 Mbits of RAM available without reducing available logic
 - 4,096 memory bits per block (4,608 bits per block including 512 parity bits)
 - Variable port configurations of ×1, ×2, ×4, ×8, ×9, ×16, ×18, ×32, and ×36
 - True dual-port (one read and one write, two reads, or two writes) operation for ×1, ×2, ×4, ×8, ×9, ×16, and ×18 modes
 - Byte enables for data input masking during writes
 - Up to 260-MHz operation
- Embedded multipliers
 - 18- × 18-bit multipliers are each configurable as two independent 9- × 9-bit multipliers with up to 250-MHz performance
 - Optional input and output registers
- Advanced I/O support
 - High-speed differential I/O standard support, including LVDS, RSDS, mini-LVDS, LVPECL, differential HSTL, and differential SSTL
 - Single-ended I/O standard support, including 2.5-V and 1.8-V SSTL class I and II, 1.8-V and 1.5-V HSTL class I and II, 3.3-V PCI

- and PCI-X 1.0, 3.3-, 2.5-, 1.8-, and 1.5-V LVCMOS, and 3.3-, 2.5-, and 1.8-V LVTTL
- Peripheral component interconnect Special Interest Group (PCI SIG) *PCI Local Bus Specification, Revision 3.0* compliance for 3.3-V operation at 33 or 66 MHz for 32- or 64-bit interfaces
- 133-MHz PCI-X 1.0 specification compatibility
- High-speed external memory support, including DDR, DDR2, and SDR SDRAM, and QDR II SRAM
- Three dedicated registers per I/O element (IOE): one input register, one output register, and one output-enable register
- Programmable bus-hold feature
- Programmable output drive strength feature
- Programmable delays from the pin to the IOE or logic array
- I/O bank grouping for unique V_{CCIO} and/or V_{REF} bank settings
- MultiVolt™ I/O standard support for 1.5-, 1.8-, 2.5-, and 3.3-V interfaces
- Hot-socketing operation support
- Tri-state with weak pull-up on I/O pins before and during configuration
- Programmable open-drain outputs
- Series on-chip termination support
- Flexible clock management circuitry
 - Hierarchical clock network for up to 402.5-MHz performance
 - Up to four PLLs per device provide clock multiplication and division, phase shifting, programmable duty cycle, and external clock outputs, allowing system-level clock management and skew control
 - Up to 16 global clock lines in the global clock network that drive throughout the entire device
- Device configuration
 - Fast serial configuration allows configuration times less than 100 ms
 - Decompression feature allows for smaller programming file storage and faster configuration times
 - Supports multiple configuration modes: active serial, passive serial, and JTAG-based configuration
 - Supports configuration through low-cost serial configuration devices
 - Device configuration supports multiple voltages (either 3.3, 2.5, or 1.8 V)
- Intellectual property
 - Altera megafunction support
 - Altera MegaCore® function support
 - Altera Megafunctions Partners Program (AMPPSM) megafunctions support

Table 1–1 lists the Cyclone II device family features. Table 1–2 lists the Cyclone II device package offerings and maximum user I/O pins.

Feature	EP2C5	EP2C8	EP2C20	EP2C35	EP2C50	EP2C70
LEs	4,608	8,256	18,752	33,216	50,528	68,416
M4K RAM blocks (4 Kbits plus 512 parity bits)	26	36	52	105	129	250
Total RAM bits	119,808	165,888	239,616	483,840	594,432	1,152,000
Embedded multipliers (1)	13	18	26	35	86	150
PLLs	2	2	4	4	4	4
Maximum user I/O pins	158	182	315	475	450	622

Note to Table 1–1:

- (1) This is the total number of 18×18 multipliers. For the total number of 9×9 multipliers per device, multiply the total number of 18×18 multipliers by 2.

Device	144-Pin TQFP (2)	208-Pin PQFP (3)	240-Pin PQFP	256-Pin FineLine BGA	484-Pin FineLine BGA	484-Pin Ultra FineLine BGA	672-Pin FineLine BGA	896-Pin FineLine BGA
EP2C5 (6)	89	142		158 (5)				
EP2C8 (6)	85	138		182				
EP2C20 (6)			142	152	315			
EP2C35 (6)					322	322	475	
EP2C50 (6)					294	294	450	
EP2C70 (6)							422	622

Notes to Table 1–2:

- (1) Cyclone II devices support vertical migration within the same package (for example, you can migrate between the EP2C20 device in the 484-pin FineLine BGA® package and the EP2C35 and EP2C50 devices in the same package).
- (2) TQFP: thin quad flat pack.
- (3) PQFP: plastic quad flat pack.
- (4) This package offering is preliminary.
- (5) Vertical migration is supported between the EP2C5F256 and the EP2C8F256 devices. However, not all of the DQ and DQS groups are supported. Vertical migration between the EP2C5 and the EP2C20 in the F256 package is not supported.
- (6) The I/O pin counts for the EP2C5 and EP2C8 devices include 8 dedicated clock pins that can be used for data inputs. The I/O counts for the EP2C20, EP2C35, EP2C50, and EP2C70 devices include 16 dedicated clock pins that can be used for data inputs.

Functional Description

Cyclone™ II devices contain a two-dimensional row- and column-based architecture to implement custom logic. Column and row interconnects of varying speeds provide signal interconnects between logic array blocks (LABs), embedded memory blocks, and embedded multipliers.

The logic array consists of LABs, with 16 logic elements (LEs) in each LAB. An LE is a small unit of logic providing efficient implementation of user logic functions. LABs are grouped into rows and columns across the device. Cyclone II devices range in density from 4,608 to 68,416 LEs.

Cyclone II devices provide a global clock network and up to four phase-locked loops (PLLs). The global clock network consists of up to 16 global clock lines that drive throughout the entire device. The global clock network can provide clocks for all resources within the device, such as input/output elements (IOEs), LEs, embedded multipliers, and embedded memory blocks. The global clock lines can also be used for other high fan-out signals. Cyclone II PLLs provide general-purpose clocking with clock synthesis and phase shifting as well as external outputs for high-speed differential I/O support.

M4K memory blocks are true dual-port memory blocks with 4K bits of memory plus parity (4,608 bits). These blocks provide dedicated true dual-port, simple dual-port, or single-port memory up to 36-bits wide at up to 260 MHz. These blocks are arranged in columns across the device in between certain LABs. Cyclone II devices offer between 119 to 1,152 Kbits of embedded memory.

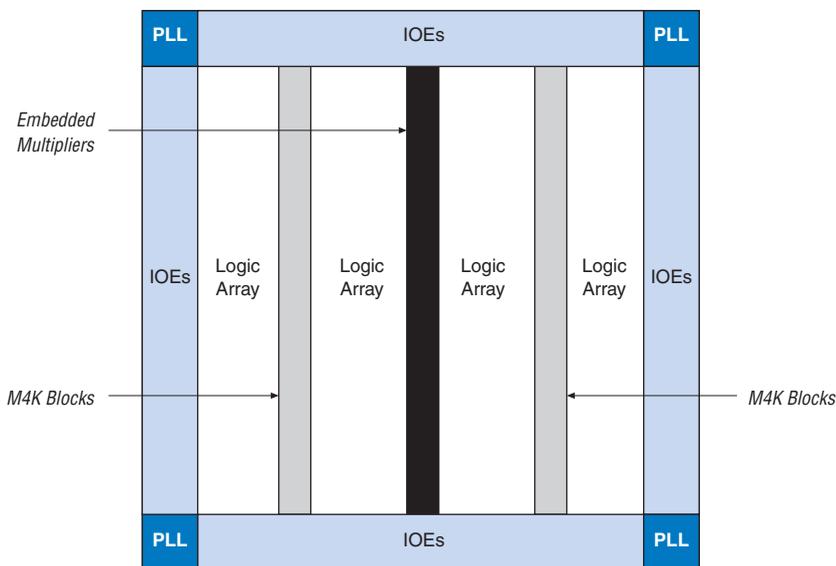
Each embedded multiplier block can implement up to either two 9×9 -bit multipliers, or one 18×18 -bit multiplier with up to 250-MHz performance. Embedded multipliers are arranged in columns across the device.

Each Cyclone II device I/O pin is fed by an IOE located at the ends of LAB rows and columns around the periphery of the device. I/O pins support various single-ended and differential I/O standards, such as the 66- and 33-MHz, 64- and 32-bit PCI standard, PCI-X, and the LVDS I/O standard at a maximum data rate of 805 megabits per second (Mbps) for inputs and 640 Mbps for outputs. Each IOE contains a bidirectional I/O buffer and three registers for registering input, output, and output-enable signals. Dual-purpose DQS, DQ, and DM pins along with delay chains (used to

phase-align double data rate (DDR) signals) provide interface support for external memory devices such as DDR, DDR2, and single data rate (SDR) SDRAM, and QDR II SRAM devices at up to 167 MHz.

Figure 2–1 shows a diagram of the Cyclone II EP2C20 device.

Figure 2–1. Cyclone II EP2C20 Device Block Diagram



The number of M4K memory blocks, embedded multiplier blocks, PLLs, rows, and columns vary per device. Table 2–1 lists the resources available in each Cyclone II device.

Table 2–1. Cyclone II Device Resources

Device	LAB Columns	LAB Rows	LEs	PLLs	M4K Memory Blocks	Embedded Multiplier Blocks
EP2C5	24	13	4,608	2	26	13
EP2C8	30	18	8,256	2	36	18
EP2C20	46	26	18,752	4	52	26
EP2C35	60	35	33,216	4	105	35
EP2C50	74	43	50,528	4	129	86
EP2C70	86	50	68,416	4	250	150

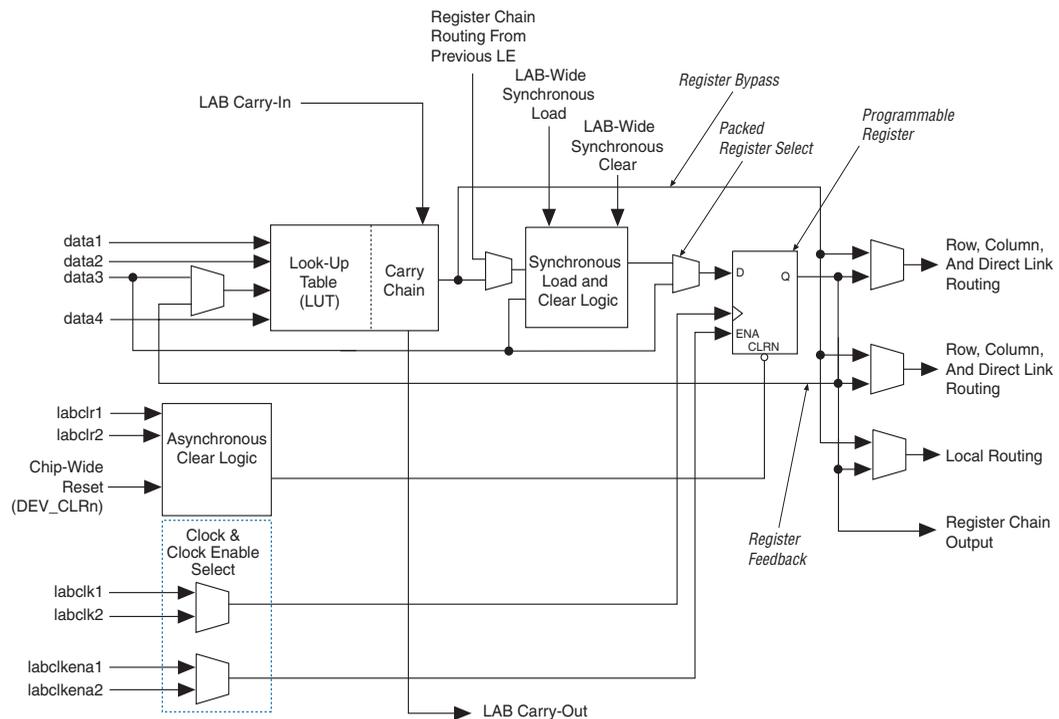
Logic Elements

The smallest unit of logic in the Cyclone II architecture, the LE, is compact and provides advanced features with efficient logic utilization. Each LE features:

- A four-input look-up table (LUT), which is a function generator that can implement any function of four variables
- A programmable register
- A carry chain connection
- A register chain connection
- The ability to drive all types of interconnects: local, row, column, register chain, and direct link interconnects
- Support for register packing
- Support for register feedback

Figure 2-2 shows a Cyclone II LE.

Figure 2-2. Cyclone II LE



Each LE's programmable register can be configured for D, T, JK, or SR operation. Each register has data, clock, clock enable, and clear inputs. Signals that use the global clock network, general-purpose I/O pins, or any internal logic can drive the register's clock and clear control signals. Either general-purpose I/O pins or internal logic can drive the clock enable. For combinational functions, the LUT output bypasses the register and drives directly to the LE outputs.

Each LE has three outputs that drive the local, row, and column routing resources. The LUT or register output can drive these three outputs independently. Two LE outputs drive column or row and direct link routing connections and one drives local interconnect resources, allowing the LUT to drive one output while the register drives another output. This feature, register packing, improves device utilization because the device can use the register and the LUT for unrelated functions. When using register packing, the LAB-wide synchronous load control signal is not available. See [“LAB Control Signals” on page 2–8](#) for more information.

Another special packing mode allows the register output to feed back into the LUT of the same LE so that the register is packed with its own fan-out LUT, providing another mechanism for improved fitting. The LE can also drive out registered and unregistered versions of the LUT output.

In addition to the three general routing outputs, the LEs within an LAB have register chain outputs. Register chain outputs allow registers within the same LAB to cascade together. The register chain output allows an LAB to use LUTs for a single combinational function and the registers to be used for an unrelated shift register implementation. These resources speed up connections between LABs while saving local interconnect resources. See [“MultiTrack Interconnect” on page 2–10](#) for more information on register chain connections.

LE Operating Modes

The Cyclone II LE operates in one of the following modes:

- Normal mode
- Arithmetic mode

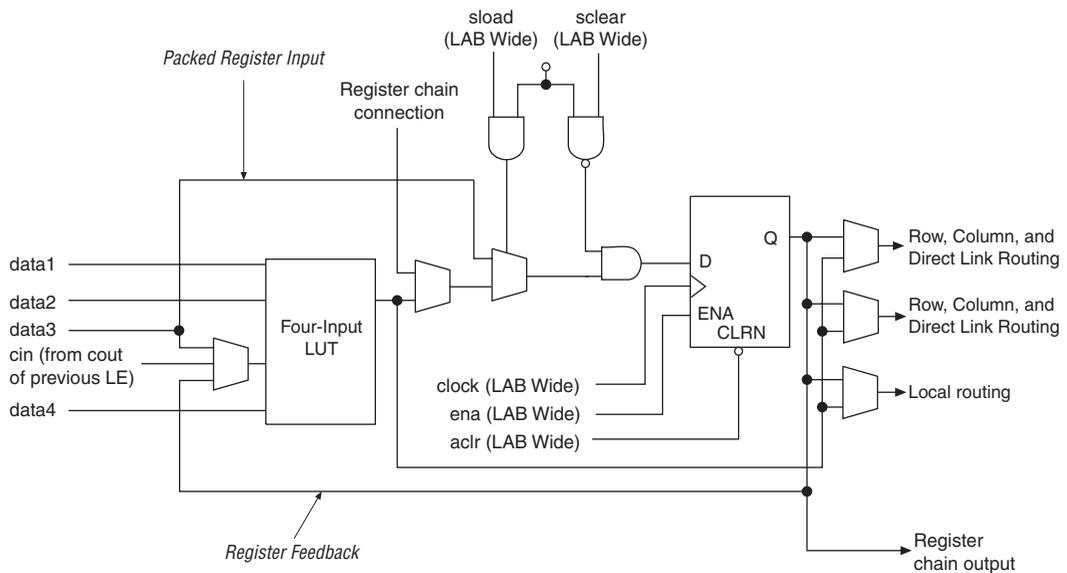
Each mode uses LE resources differently. In each mode, six available inputs to the LE—the four data inputs from the LAB local interconnect, the LAB carry-in from the previous carry-chain LAB, and the register chain connection—are directed to different destinations to implement the desired logic function. LAB-wide signals provide clock, asynchronous clear, synchronous clear, synchronous load, and clock enable control for the register. These LAB-wide signals are available in all LE modes.

The Quartus® II software, in conjunction with parameterized functions such as library of parameterized modules (LPM) functions, automatically chooses the appropriate mode for common functions such as counters, adders, subtractors, and arithmetic functions. If required, you can also create special-purpose functions that specify which LE operating mode to use for optimal performance.

Normal Mode

The normal mode is suitable for general logic applications and combinational functions. In normal mode, four data inputs from the LAB local interconnect are inputs to a four-input LUT (see Figure 2-3). The Quartus II Compiler automatically selects the carry-in or the data3 signal as one of the inputs to the LUT. LEs in normal mode support packed registers and register feedback.

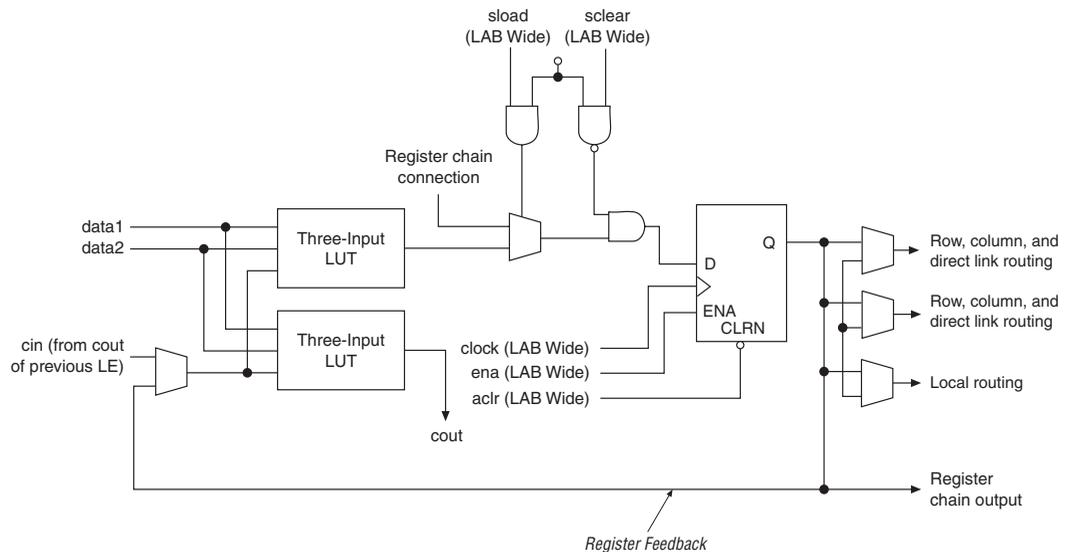
Figure 2-3. LE in Normal Mode



Arithmetic Mode

The arithmetic mode is ideal for implementing adders, counters, accumulators, and comparators. An LE in arithmetic mode implements a 2-bit full adder and basic carry chain (see Figure 2–4). LEs in arithmetic mode can drive out registered and unregistered versions of the LUT output. Register feedback and register packing are supported when LEs are used in arithmetic mode.

Figure 2–4. LE in Arithmetic Mode



The Quartus II Compiler automatically creates carry chain logic during design processing, or you can create it manually during design entry. Parameterized functions such as LPM functions automatically take advantage of carry chains for the appropriate functions.

The Quartus II Compiler creates carry chains longer than 16 LEs by automatically linking LABs in the same column. For enhanced fitting, a long carry chain runs vertically, which allows fast horizontal connections to M4K memory blocks or embedded multipliers through direct link interconnects. For example, if a design has a long carry chain in a LAB column next to a column of M4K memory blocks, any LE output can feed an adjacent M4K memory block through the direct link interconnect. Whereas if the carry chains ran horizontally, any LAB not next to the column of M4K memory blocks would use other row or column interconnects to drive a M4K memory block. A carry chain continues as far as a full column.

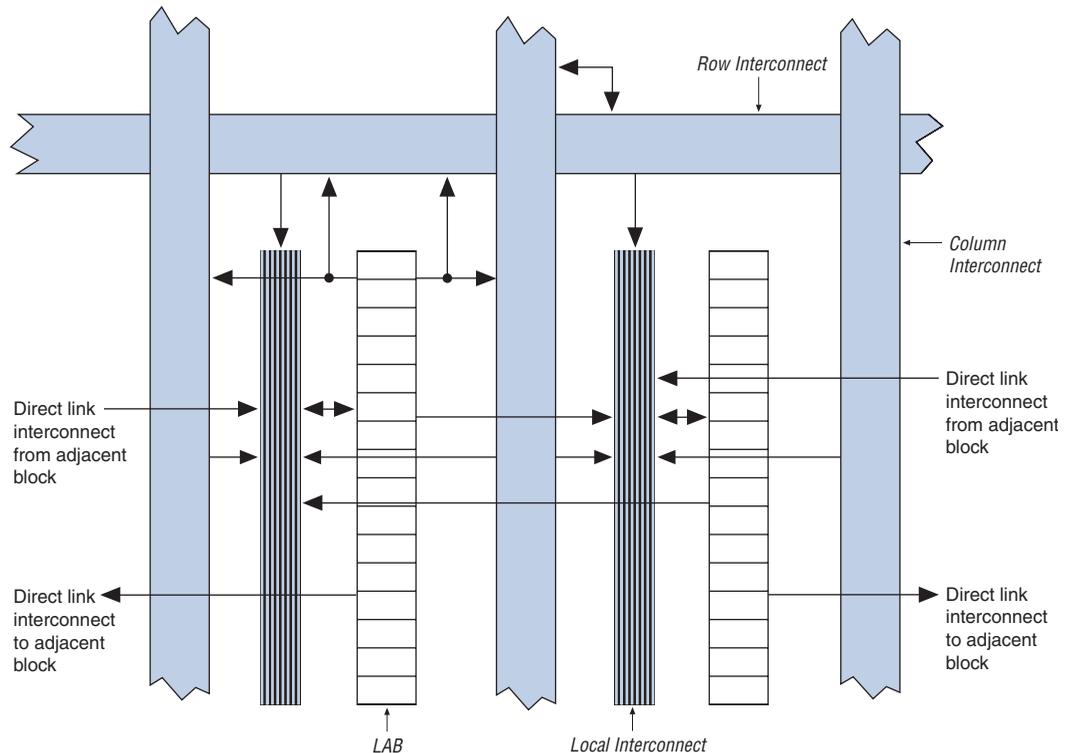
Logic Array Blocks

Each LAB consists of the following:

- 16 LEs
- LAB control signals
- LE carry chains
- Register chains
- Local interconnect

The local interconnect transfers signals between LEs in the same LAB. Register chain connections transfer the output of one LE's register to the adjacent LE's register within an LAB. The Quartus II Compiler places associated logic within an LAB or adjacent LABs, allowing the use of local, and register chain connections for performance and area efficiency. Figure 2-5 shows the Cyclone II LAB.

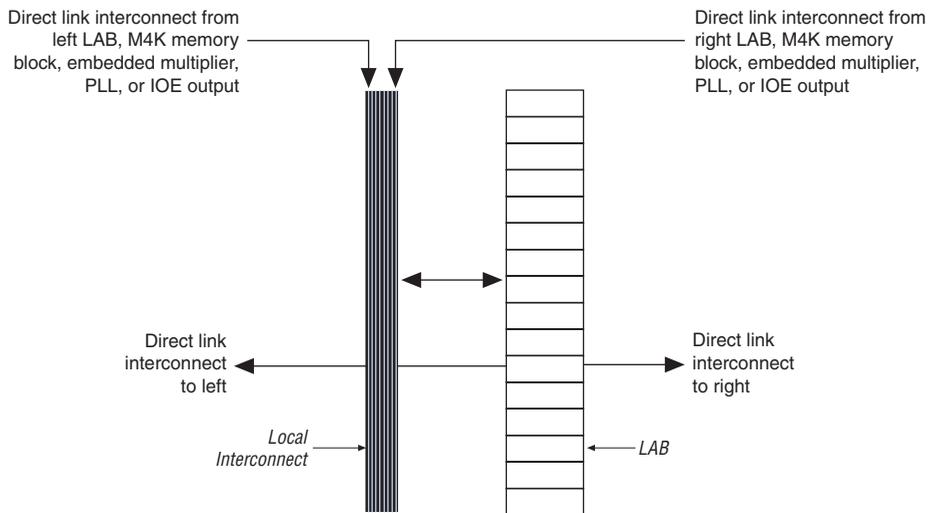
Figure 2-5. Cyclone II LAB Structure



LAB Interconnects

The LAB local interconnect can drive LEs within the same LAB. The LAB local interconnect is driven by column and row interconnects and LE outputs within the same LAB. Neighboring LABs, PLLs, M4K RAM blocks, and embedded multipliers from the left and right can also drive an LAB's local interconnect through the direct link connection. The direct link connection feature minimizes the use of row and column interconnects, providing higher performance and flexibility. Each LE can drive 48 LEs through fast local and direct link interconnects. [Figure 2-6](#) shows the direct link connection.

Figure 2-6. Direct Link Connection



LAB Control Signals

Each LAB contains dedicated logic for driving control signals to its LEs. The control signals include:

- Two clocks
- Two clock enables
- Two asynchronous clears
- One synchronous clear
- One synchronous load

This gives a maximum of seven control signals at a time. When using the LAB-wide synchronous load, the `clkena` of `labclk1` is not available. Additionally, register packing and synchronous load cannot be used simultaneously.

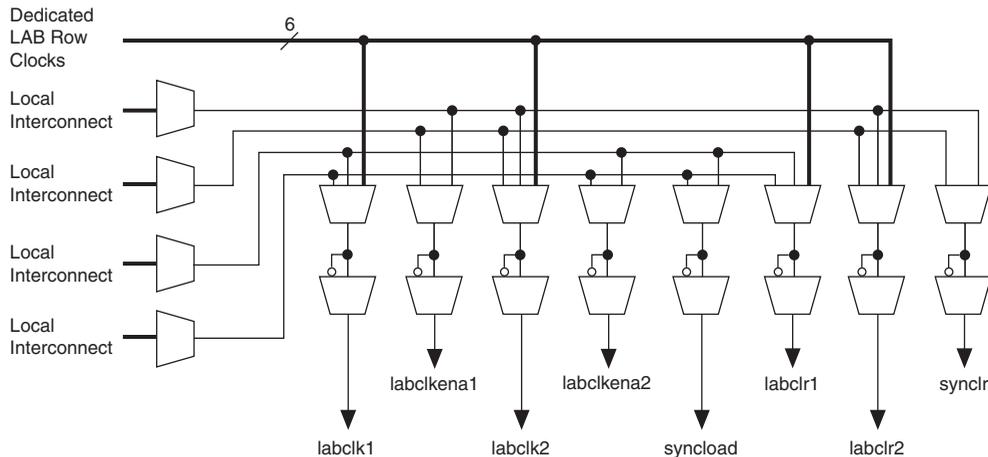
Each LAB can have up to four non-global control signals. Additional LAB control signals can be used as long as they are global signals.

Synchronous clear and load signals are useful for implementing counters and other functions. The synchronous clear and synchronous load signals are LAB-wide signals that affect all registers in the LAB.

Each LAB can use two clocks and two clock enable signals. Each LAB's clock and clock enable signals are linked. For example, any LE in a particular LAB using the `labclk1` signal also uses `labclkena1`. If the LAB uses both the rising and falling edges of a clock, it also uses both LAB-wide clock signals. De-asserting the clock enable signal turns off the LAB-wide clock.

The LAB row clocks [5..0] and LAB local interconnect generate the LAB-wide control signals. The MultiTrack™ interconnect's inherent low skew allows clock and control signal distribution in addition to data. [Figure 2-7](#) shows the LAB control signal generation circuit.

Figure 2-7. LAB-Wide Control Signals



LAB-wide signals control the logic for the register's clear signal. The LE directly supports an asynchronous clear function. Each LAB supports up to two asynchronous clear signals (`labclr1` and `labclr2`).

A LAB-wide asynchronous load signal to control the logic for the register's preset signal is not available. The register preset is achieved by using a NOT gate push-back technique. Cyclone II devices can only support either a preset or asynchronous clear signal.

In addition to the clear port, Cyclone II devices provide a chip-wide reset pin (`DEV_CLRn`) that resets all registers in the device. An option set before compilation in the Quartus II software controls this pin. This chip-wide reset overrides all other control signals.

MultiTrack Interconnect

In the Cyclone II architecture, connections between LEs, M4K memory blocks, embedded multipliers, and device I/O pins are provided by the MultiTrack interconnect structure with DirectDrive™ technology. The MultiTrack interconnect consists of continuous, performance-optimized routing lines of different speeds used for inter- and intra-design block connectivity. The Quartus II Compiler automatically places critical paths on faster interconnects to improve design performance.

DirectDrive technology is a deterministic routing technology that ensures identical routing resource usage for any function regardless of placement within the device. The MultiTrack interconnect and DirectDrive technology simplify the integration stage of block-based designing by eliminating the re-optimization cycles that typically follow design changes and additions.

The MultiTrack interconnect consists of row (direct link, R4, and R24) and column (register chain, C4, and C16) interconnects that span fixed distances. A routing structure with fixed-length resources for all devices allows predictable and repeatable performance when migrating through different device densities.

Row Interconnects

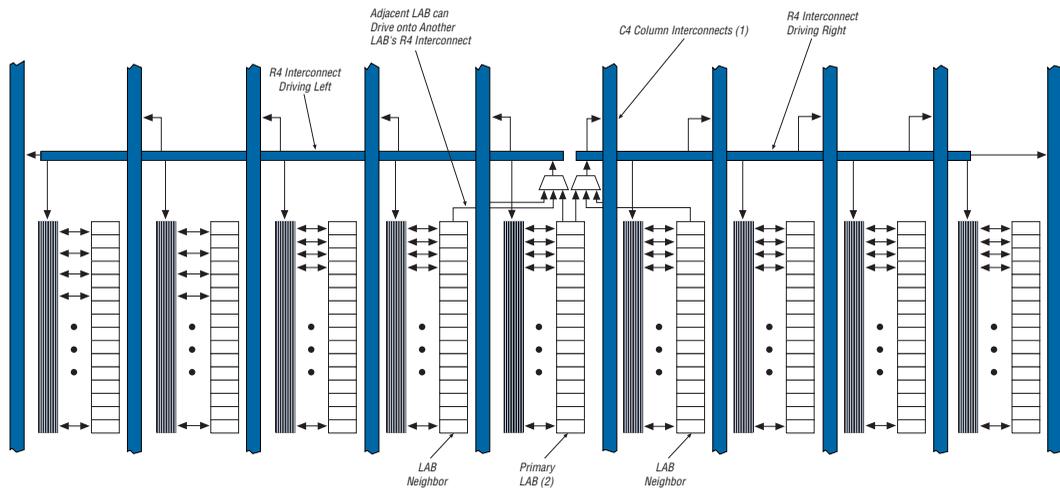
Dedicated row interconnects route signals to and from LABs, PLLs, M4K memory blocks, and embedded multipliers within the same row. These row resources include:

- Direct link interconnects between LABs and adjacent blocks
- R4 interconnects traversing four blocks to the right or left
- R24 interconnects for high-speed access across the length of the device

The direct link interconnect allows an LAB, M4K memory block, or embedded multiplier block to drive into the local interconnect of its left and right neighbors. Only one side of a PLL block interfaces with direct link and row interconnects. The direct link interconnect provides fast communication between adjacent LABs and/or blocks without using row interconnect resources.

The R4 interconnects span four LABs, three LABs and one M4K memory block, or three LABs and one embedded multiplier to the right or left of a source LAB. These resources are used for fast row connections in a four-LAB region. Every LAB has its own set of R4 interconnects to drive either left or right. [Figure 2-8](#) shows R4 interconnect connections from an LAB. R4 interconnects can drive and be driven by LABs, M4K memory blocks, embedded multipliers, PLLs, and row IOEs. For LAB interfacing, a primary LAB or LAB neighbor (see [Figure 2-8](#)) can drive a given R4 interconnect. For R4 interconnects that drive to the right, the primary LAB and right neighbor can drive on to the interconnect. For R4 interconnects that drive to the left, the primary LAB and its left neighbor can drive on to the interconnect. R4 interconnects can drive other R4 interconnects to extend the range of LABs they can drive. Additionally, R4 interconnects can drive R24 interconnects, C4, and C16 interconnects for connections from one row to another.

Figure 2-8. R4 Interconnect Connections



Notes to [Figure 2-8](#):

- (1) C4 interconnects can drive R4 interconnects.
- (2) This pattern is repeated for every LAB in the LAB row.

R24 row interconnects span 24 LABs and provide the fastest resource for long row connections between non-adjacent LABs, M4K memory blocks, dedicated multipliers, and row IOEs. R24 row interconnects drive to other row or column interconnects at every fourth LAB. R24 row interconnects drive LAB local interconnects via R4 and C4 interconnects and do not drive directly to LAB local interconnects. R24 interconnects can drive R24, R4, C16, and C4 interconnects.

Column Interconnects

The column interconnect operates similar to the row interconnect. Each column of LABs is served by a dedicated column interconnect, which vertically routes signals to and from LABs, M4K memory blocks, embedded multipliers, and row and column IOEs. These column resources include:

- Register chain interconnects within an LAB
- C4 interconnects traversing a distance of four blocks in an up and down direction
- C16 interconnects for high-speed vertical routing through the device

Cyclone II devices include an enhanced interconnect structure within LABs for routing LE output to LE input connections faster using register chain connections. The register chain connection allows the register output of one LE to connect directly to the register input of the next LE in the LAB for fast shift registers. The Quartus II Compiler automatically takes advantage of these resources to improve utilization and performance. [Figure 2-9](#) shows the register chain interconnects.

C16 column interconnects span a length of 16 LABs and provide the fastest resource for long column connections between LABs, M4K memory blocks, embedded multipliers, and IOEs. C16 column interconnects drive to other row and column interconnects at every fourth LAB. C16 column interconnects drive LAB local interconnects via C4 and R4 interconnects and do not drive LAB local interconnects directly. C16 interconnects can drive R24, R4, C16, and C4 interconnects.

Device Routing

All embedded blocks communicate with the logic array similar to LAB-to-LAB interfaces. Each block (for example, M4K memory, embedded multiplier, or PLL) connects to row and column interconnects and has local interconnect regions driven by row and column interconnects. These blocks also have direct link interconnects for fast connections to and from a neighboring LAB.

Table 2–2 shows the Cyclone II device’s routing scheme.

Table 2–2. Cyclone II Device Routing Scheme (Part 1 of 2)

Source	Destination												
	Register Chain	Local Interconnect	Direct Link Interconnect	R4 Interconnect	R24 Interconnect	C4 Interconnect	C16 Interconnect	LE	M4K RAM Block	Embedded Multiplier	PLL	Column IOE	Row IOE
Register Chain								✓					
Local Interconnect								✓	✓	✓	✓	✓	✓
Direct Link Interconnect		✓											
R4 Interconnect		✓		✓	✓	✓	✓						
R24 Interconnect				✓	✓	✓	✓						
C4 Interconnect		✓		✓	✓	✓	✓						
C16 Interconnect				✓	✓	✓	✓						

Table 2–2. Cyclone II Device Routing Scheme (Part 2 of 2)

Source	Destination												
	Register Chain	Local Interconnect	Direct Link Interconnect	R4 Interconnect	R24 Interconnect	C4 Interconnect	C16 Interconnect	LE	M4K RAM Block	Embedded Multiplier	PLL	Column IOE	Row IOE
LE	✓	✓	✓	✓		✓							
M4K memory Block		✓	✓	✓		✓							
Embedded Multipliers		✓	✓	✓		✓							
PLL			✓	✓		✓							
Column IOE						✓	✓						
Row IOE			✓	✓	✓	✓							

Global Clock Network & Phase-Locked Loops

Cyclone II devices provide global clock networks and up to four PLLs for a complete clock management solution. Cyclone II clock network features include:

- Up to 16 global clock networks
- Up to four PLLs
- Global clock network dynamic clock source selection
- Global clock network dynamic enable and disable

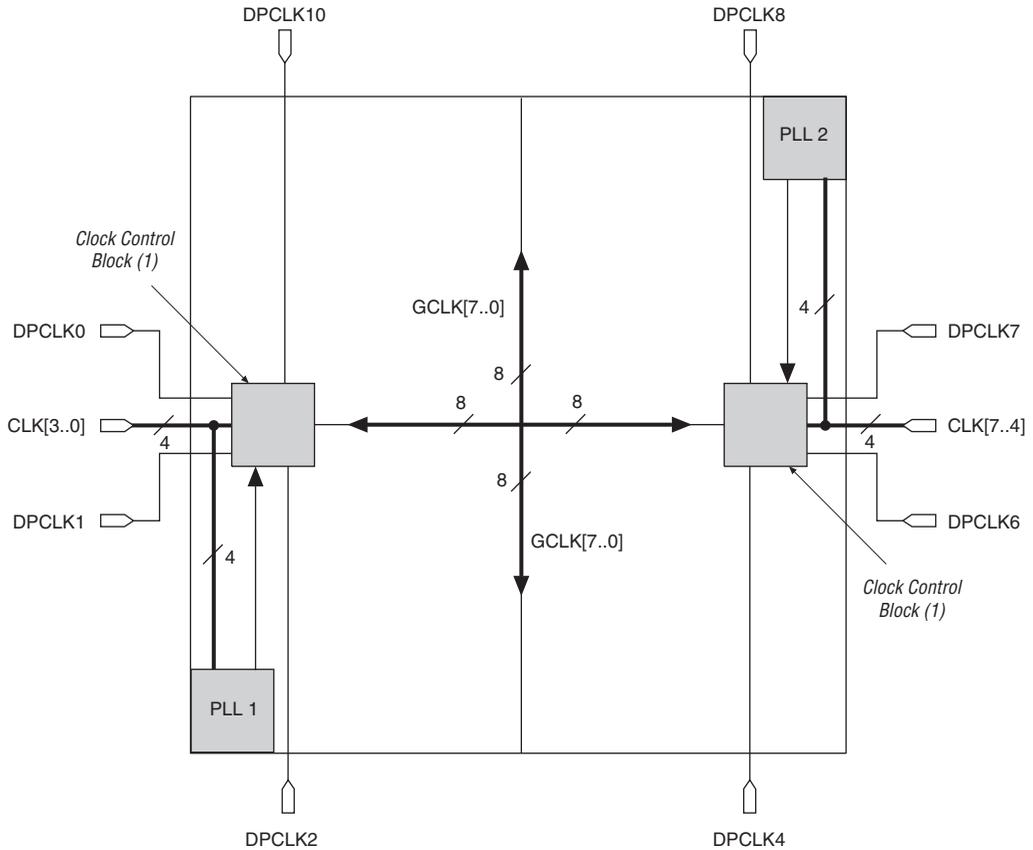
Each global clock network has a clock control block to select from a number of input clock sources (PLL clock outputs, CLK [] pins, DPCLK [] pins, and internal logic) to drive onto the global clock network. Table 2-3 lists how many PLLs, CLK [] pins, DPCLK [] pins, and global clock networks are available in each Cyclone II device. CLK [] pins are dedicated clock pins and DPCLK [] pins are dual-purpose clock pins.

Table 2-3. Cyclone II Device Clock Resources

Device	Number of PLLs	Number of CLK Pins	Number of DPCLK Pins	Number of Global Clock Networks
EP2C5	2	8	8	8
EP2C8	2	8	8	8
EP2C20	4	16	20	16
EP2C35	4	16	20	16
EP2C50	4	16	20	16
EP2C70	4	16	20	16

Figures 2-11 and 2-12 show the location of the Cyclone II PLLs, CLK [] inputs, DPCLK [] pins, and clock control blocks.

Figure 2-11. EP2C5 & EP2C8 PLL, CLK[], DPCLK[] & Clock Control Block Locations



Note to Figure 2-11:

(1) There are four clock control blocks on each side.

Dedicated Clock Pins

Larger Cyclone II devices (EP2C20 and larger devices) have 16 dedicated clock pins (CLK [15 . . 0], four pins on each side of the device). Smaller Cyclone II devices (EP2C5 and EP2C8 devices) have eight dedicated clock pins (CLK [7 . . 0], four pins on left and right sides of the device). These CLK pins drive the global clock network (GCLK), as shown in [Figures 2–11 and 2–12](#).

If the dedicated clock pins are not used to feed the global clock networks, they can be used as general-purpose input pins to feed the logic array using the MultiTrack interconnect. However, if they are used as general-purpose input pins, they do not have support for an I/O register and must use LE-based registers in place of an I/O register.

Dual-Purpose Clock Pins

Cyclone II devices have either 20 dual-purpose clock pins, DPCLK [19 . . 0] or 8 dual-purpose clock pins, DPCLK [7 . . 0]. In the larger Cyclone II devices (EP2C20 devices and higher), there are 20 DPCLK pins; four on the left and right sides and six on the top and bottom of the device. The corner CDPCLK pins are first multiplexed before they drive into the clock control block. Since the signals pass through a multiplexer before feeding the clock control block, these signals incur more delay to the clock control block than other DPCLK pins that directly feed the clock control block. In the smaller Cyclone II devices (EP2C5 and EP2C8 devices), there are eight DPCLK pins; two on each side of the device (see [Figures 2–11 and 2–12](#)).

A programmable delay chain is available from the DPCLK pin to its fan-out destinations. To set the propagation delay from the DPCLK pin to its fan-out destinations, use the **Input Delay from Dual-Purpose Clock Pin to Fan-Out Destinations** assignment in the Quartus II software.

These dual-purpose pins can connect to the global clock network for high-fanout control signals such as clocks, asynchronous clears, presets, and clock enables, or protocol control signals such as TRDY and IRDY for PCI, or DQS signals for external memory interfaces.

Global Clock Network

The 16 or 8 global clock networks drive throughout the entire device. Dedicated clock pins (CLK []), PLL outputs, the logic array, and dual-purpose clock (DPCLK []) pins can also drive the global clock network.

The global clock network can provide clocks for all resources within the device, such as IOEs, LEs, memory blocks, and embedded multipliers. The global clock lines can also be used for control signals, such as clock enables and synchronous or asynchronous clears fed from the external pin, or DQS signals for DDR SDRAM or QDR II SRAM interfaces. Internal logic can also drive the global clock network for internally generated global clocks and asynchronous clears, clock enables, or other control signals with large fan-out.

Clock Control Block

There is a clock control block for each global clock network available in Cyclone II devices. The clock control blocks are arranged on the device periphery and there are a maximum of 16 clock control blocks available per Cyclone II device. The larger Cyclone II devices (EP2C20 devices and larger) have 16 clock control blocks, four on each side of the device. The smaller Cyclone II devices (EP2C5 and EP2C8 devices) have eight clock control blocks, four on the left and right sides of the device.

The control block has these functions:

- Dynamic global clock network clock source selection
- Dynamic enable/disable of the global clock network

In Cyclone II devices, the dedicated CLK [] pins, PLL counter outputs, DPCLK [] pins, and internal logic can all feed the clock control block. The output from the clock control block in turn feeds the corresponding global clock network.

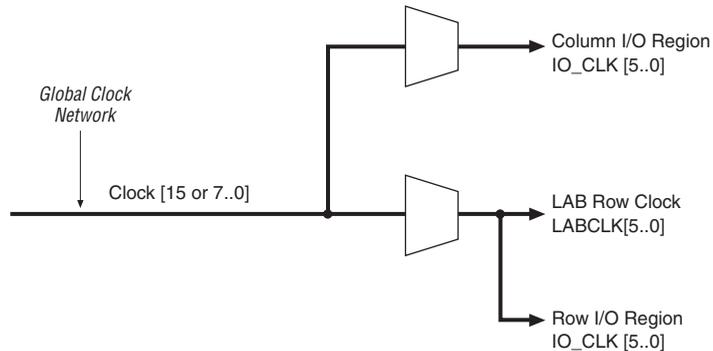
The following sources can be inputs to a given clock control block:

- Four clock pins on the same side as the clock control block
- Three PLL clock outputs from a PLL
- Four DPCLK pins (including CDPCLK pins) on the same side as the clock control block
- Four internally-generated signals

Global Clock Network Distribution

Cyclone II devices contains 16 global clock networks. The device uses multiplexers with these clocks to form six-bit buses to drive column IOE clocks, LAB row clocks, or row IOE clocks (see [Figure 2-14](#)). Another multiplexer at the LAB level selects two of the six LAB row clocks to feed the LE registers within the LAB.

Figure 2-14. Global Clock Network Multiplexers



LAB row clocks can feed LEs, M4K memory blocks, and embedded multipliers. The LAB row clocks also extend to the row I/O clock regions.

IOE clocks are associated with row or column block regions. Only six global clock resources feed to these row and column regions. [Figure 2-15](#) shows the I/O clock regions.

PLLs

Cyclone II PLLs provide general-purpose clocking as well as support for the following features:

- Clock multiplication and division
- Phase shifting
- Programmable duty cycle
- Up to three internal clock outputs
- One dedicated external clock output
- Clock outputs for differential I/O support
- Manual clock switchover
- Gated lock signal
- Three different clock feedback modes
- Control signals

Cyclone II devices contain either two or four PLLs. [Table 2-4](#) shows the PLLs available for each Cyclone II device.

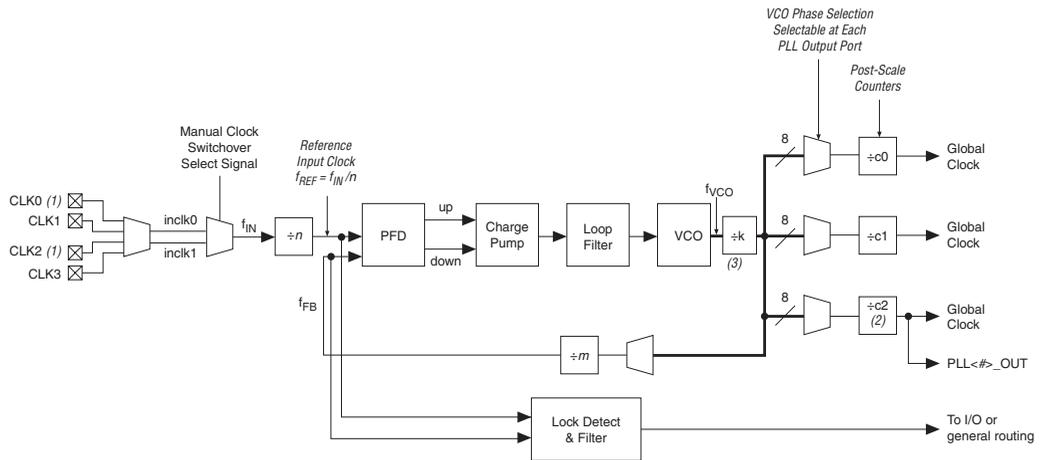
Device	PLL1	PLL2	PLL3	PLL4
EP2C5	✓	✓		
EP2C8	✓	✓		
EP2C20	✓	✓	✓	✓
EP2C35	✓	✓	✓	✓
EP2C50	✓	✓	✓	✓
EP2C70	✓	✓	✓	✓

Table 2-5 describes the PLL features in Cyclone II devices.

Table 2-5. Cyclone II PLL Features	
Feature	Description
Clock multiplication and division	$m / (n \times \text{post-scale counter})$ m and post-scale counter values (C0 to C2) range from 1 to 32. n ranges from 1 to 4.
Phase shift	Cyclone II PLLs have an advanced clock shift capability that enables programmable phase shifts in increments of at least 45°. The finest resolution of phase shifting is determined by the voltage control oscillator (VCO) period divided by 8 (for example, 1/1000 MHz/8 = down to 125-ps increments).
Programmable duty cycle	The programmable duty cycle allows PLLs to generate clock outputs with a variable duty cycle. This feature is supported on each PLL post-scale counter (C0-C2).
Number of internal clock outputs	The Cyclone II PLL has three outputs which can drive the global clock network. One of these outputs (C2) can also drive a dedicated PLL<#>_OUT pin (single ended or differential).
Number of external clock outputs	The C2 output drives a dedicated PLL<#>_OUT pin. If the C2 output is not used to drive an external clock output, it can be used to drive the internal global clock network. The C2 output can concurrently drive the external clock output and internal global clock network.
Manual clock switchover	The Cyclone II PLLs support manual switchover of the reference clock through internal logic. This enables you to switch between two reference input clocks during user mode for applications that may require clock redundancy or support for clocks with two different frequencies.
Gated lock signal	The lock output indicates that there is a stable clock output signal in phase with the reference clock. Cyclone II PLLs include a programmable counter that holds the lock signal low for a user-selected number of input clock transitions, allowing the PLL to lock before enabling the locked signal. Either a gated locked signal or an ungated locked signal from the locked port can drive internal logic or an output pin.
Clock feedback modes	In zero delay buffer mode, the external clock output pin is phase-aligned with the clock input pin for zero delay. In normal mode, the PLL compensates for the internal global clock network delay from the input clock pin to the clock port of the IOE output registers or registers in the logic array. In no compensation mode, the PLL does not compensate for any clock networks.
Control signals	The <code>pllenable</code> signal enables and disables the PLLs. The <code>areset</code> signal resets/resynchronizes the inputs for each PLL. The <code>pfdena</code> signal controls the phase frequency detector (PFD) output with a programmable gate.

Figure 2–16 shows a block diagram of the Cyclone II PLL.

Figure 2–16. Cyclone II PLL Note (1)



Notes to Figure 2–16:

- (1) This input can be single-ended or differential. If you are using a differential I/O standard, then two CLK pins are used. LVDS input is supported via the secondary function of the dedicated CLK pins. For example, the CLK0 pin's secondary function is LVDSCLK1p and the CLK1 pin's secondary function is LVDSCLK1n. If a differential I/O standard is assigned to the PLL clock input pin, the corresponding CLK (n) pin is also completely used. The Figure 2–16 shows the possible clock input connections (CLK0/CLK1) to PLL1.
- (2) This counter output is shared between a dedicated external clock output I/O and the global clock network.



For more information on Cyclone II PLLs, see the PLLs in the *Cyclone II Devices* chapter in Volume 1 of the *Cyclone II Device Handbook*.

Embedded Memory

The Cyclone II embedded memory consists of columns of M4K memory blocks. The M4K memory blocks include input registers that synchronize writes and output registers to pipeline designs and improve system performance. The output registers can be bypassed, but input registers cannot.

Each M4K block can implement various types of memory with or without parity, including true dual-port, simple dual-port, and single-port RAM, ROM, and first-in first-out (FIFO) buffers. The M4K blocks support the following features:

- 4,608 RAM bits
- 250-MHz performance
- True dual-port memory
- Simple dual-port memory
- Single-port memory
- Byte enable
- Parity bits
- Shift register
- FIFO buffer
- ROM
- Various clock modes
- Address clock enable



Violating the setup or hold time on the memory block address registers could corrupt memory contents. This applies to both read and write operations.

Table 2-6 shows the capacity and distribution of the M4K memory blocks in each Cyclone II device.

Device	M4K Columns	M4K Blocks	Total RAM Bits
EP2C5	2	26	119,808
EP2C8	2	36	165,888
EP2C20	2	52	239,616
EP2C35	3	105	483,840
EP2C50	3	129	594,432
EP2C70	5	250	1,152,000

Table 2-7 summarizes the features supported by the M4K memory.

Table 2-7. M4K Memory Features	
Feature	Description
Maximum performance (1)	250 MHz
Total RAM bits per M4K block (including parity bits)	4,608
Configurations supported	4K × 1 2K × 2 1K × 4 512 × 8 512 × 9 256 × 16 256 × 18 128 × 32 (not available in true dual-port mode) 128 × 36 (not available in true dual-port mode)
Parity bits	One parity bit for each byte. The parity bit, along with internal user logic, can implement parity checking for error detection to ensure data integrity.
Byte enable	M4K blocks support byte writes when the write port has a data width of 1, 2, 4, 8, 9, 16, 18, 32, or 36 bits. The byte enables allow the input data to be masked so the device can write to specific bytes. The unwritten bytes retain the previous written value.
Packed mode	Two single-port memory blocks can be packed into a single M4K block if each of the two independent block sizes are equal to or less than half of the M4K block size, and each of the single-port memory blocks is configured in single-clock mode.
Address clock enable	M4K blocks support address clock enable, which is used to hold the previous address value for as long as the signal is enabled. This feature is useful in handling misses in cache applications.
Memory initialization file (.mif)	When configured as RAM or ROM, you can use an initialization file to pre-load the memory contents.
Power-up condition	Outputs cleared
Register clears	Output registers only
Same-port read-during-write	New data available at positive clock edge
Mixed-port read-during-write	Old data available at positive clock edge

Note to Table 2-7:

(1) Maximum performance information is preliminary until device characterization.

Clear Signals

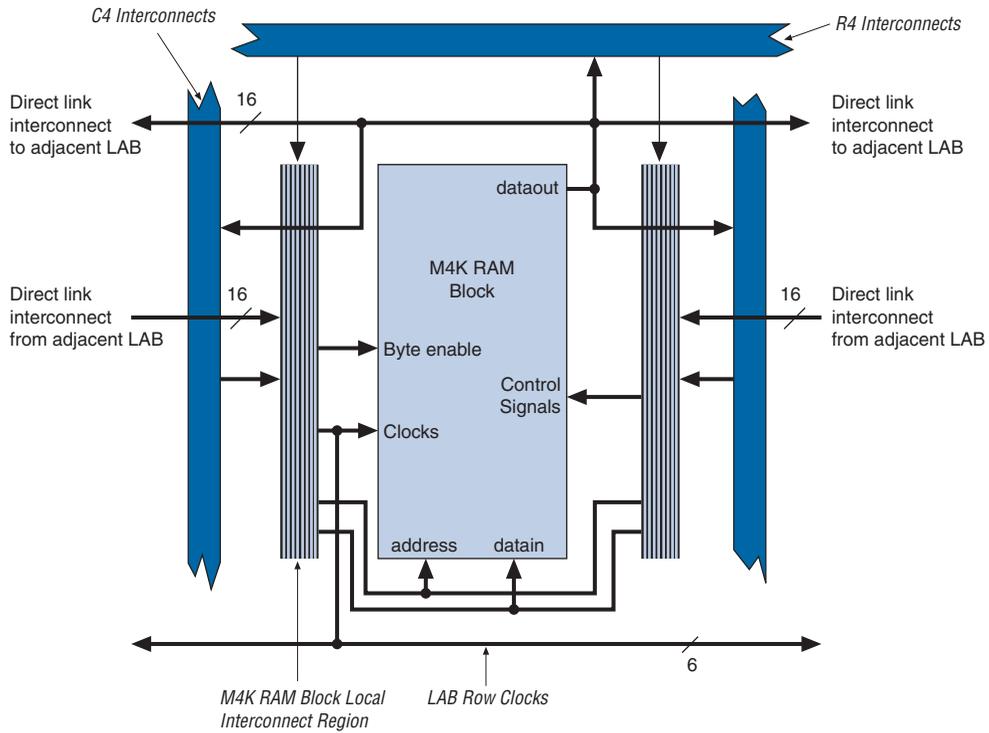
When applied to input registers, the asynchronous clear signal for the TriMatrix™ embedded memory immediately clears the input registers. However, the output of the memory block does not show the effects until the next clock edge. When applied to output registers, the asynchronous clear signal clears the output registers and the effects are seen immediately.

Memory Modes

Table 2–8 summarizes the different memory modes supported by the M4K memory blocks.

Memory Mode	Description
Single-port memory	M4K blocks support single-port mode, used when simultaneous reads and writes are not required. Single-port memory supports non-simultaneous reads and writes.
Simple dual-port memory	Simple dual-port memory supports a simultaneous read and write.
Simple dual-port with mixed width	Simple dual-port memory mode with different read and write port widths.
True dual-port memory	True dual-port mode supports any combination of two-port operations: two reads, two writes, or one read and one write at two different clock frequencies.
True dual-port with mixed width	True dual-port mode with different read and write port widths.
Embedded shift register	M4K memory blocks are used to implement shift registers. Data is written into each address location at the falling edge of the clock and read from the address at the rising edge of the clock.
ROM	The M4K memory blocks support ROM mode. A MIF initializes the ROM contents of these blocks.
FIFO buffers	A single clock or dual clock FIFO may be implemented in the M4K blocks. Simultaneous read and write from an empty FIFO buffer is not supported.

Figure 2–17. M4K RAM Block LAB Row Interface



For more information on Cyclone II embedded memory, see the *Cyclone II Memory Blocks* chapter in Volume 1 of the *Cyclone II Device Handbook*.

Embedded Multipliers

Cyclone II devices have embedded multiplier blocks optimized for multiplier-intensive digital signal processing (DSP) functions, such as finite impulse response (FIR) filters, fast Fourier transform (FFT) functions, and discrete cosine transform (DCT) functions. You can use the embedded multiplier in one of two basic operational modes, depending on the application needs:

- One 18-bit multiplier
- Up to two independent 9-bit multipliers

Embedded multipliers can operate at up to 250 MHz (for the fastest speed grade) for 18×18 and 9×9 multiplications when using both input and output registers.

Each Cyclone II device has one to three columns of embedded multipliers that efficiently implement multiplication functions. An embedded multiplier spans the height of one LAB row. [Table 2–11](#) shows the number of embedded multipliers in each Cyclone II device and the multipliers that can be implemented.

Device	Embedded Multiplier Columns	Embedded Multipliers	9×9 Multipliers	18×18 Multipliers
EP2C5	1	13	26	13
EP2C8	1	18	36	18
EP2C20	1	26	52	26
EP2C35	1	35	70	35
EP2C50	2	86	172	86
EP2C70	3	150	300	150

Note to Table 2–11:

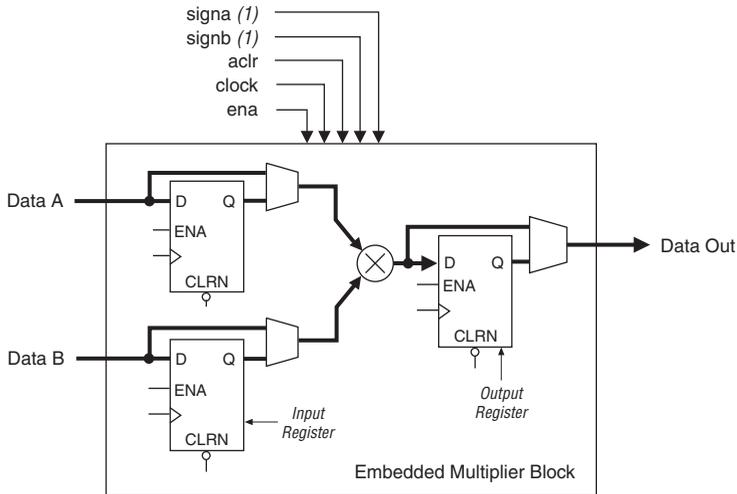
- (1) Each device has either the number of 9×9 -, or 18×18 -bit multipliers shown. The total number of multipliers for each device is not the sum of all the multipliers.

The embedded multiplier consists of the following elements:

- Multiplier block
- Input and output registers
- Input and output interfaces

[Figure 2–18](#) shows the multiplier block architecture.

Figure 2–18. Multiplier Block Architecture



Note to Figure 2–18:

- (1) If necessary, these signals can be registered once to match the data signal path.

Each multiplier operand can be a unique signed or unsigned number. Two signals, *signa* and *signb*, control the representation of each operand respectively. A logic 1 value on the *signa* signal indicates that data A is a signed number while a logic 0 value indicates an unsigned number. Table 2–12 shows the sign of the multiplication result for the various operand sign representations. The result of the multiplication is signed if any one of the operands is a signed value.

Data A (signa Value)	Data B (signb Value)	Result
Unsigned	Unsigned	Unsigned
Unsigned	Signed	Signed
Signed	Unsigned	Signed
Signed	Signed	Signed

There is only one `signa` and one `signb` signal for each dedicated multiplier. Therefore, all of the data A inputs feeding the same dedicated multiplier must have the same sign representation. Similarly, all of the data B inputs feeding the same dedicated multiplier must have the same sign representation. The `signa` and `signb` signals can be changed dynamically to modify the sign representation of the input operands at run time. The multiplier offers full precision regardless of the sign representation and can be registered using dedicated registers located at the input register stage.

Multiplier Modes

Table 2–13 summarizes the different modes that the embedded multipliers can operate in.

Multiplier Mode	Description
18-bit Multiplier	An embedded multiplier can be configured to support a single 18×18 multiplier for operand widths up to 18 bits. All 18-bit multiplier inputs and results can be registered independently. The multiplier operands can accept signed integers, unsigned integers, or a combination of both.
9-bit Multiplier	An embedded multiplier can be configured to support two 9×9 independent multipliers for operand widths up to 9-bits. Both 9-bit multiplier inputs and results can be registered independently. The multiplier operands can accept signed integers, unsigned integers or a combination of both. There is only one <code>signa</code> signal to control the sign representation of both data A inputs and one <code>signb</code> signal to control the sign representation of both data B inputs of the 9-bit multipliers within the same dedicated multiplier.

There are five dynamic control input signals that feed the embedded multiplier: `signa`, `signb`, `clk`, `clkena`, and `aclr`. `signa` and `signb` can be registered to match the data signal input path. The same `clk`, `clkena`, and `aclr` signals feed all registers within a single embedded multiplier.



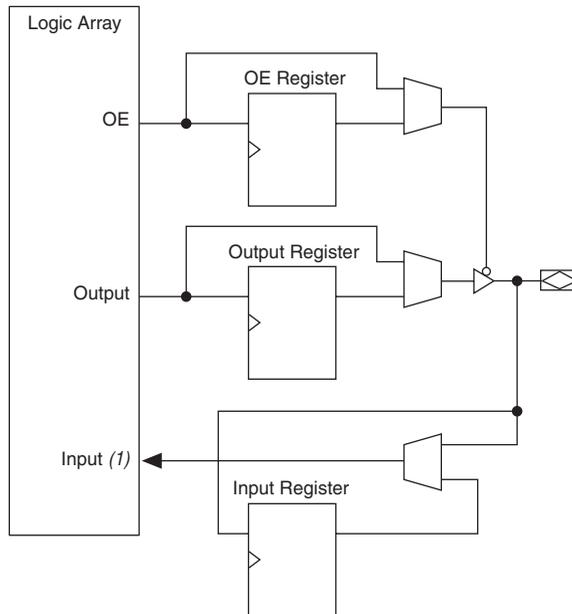
For more information on Cyclone II embedded multipliers, see the *Embedded Multipliers in Cyclone II Devices* chapter.

I/O Structure & Features

IOEs support many features, including:

- Differential and single-ended I/O standards
- 3.3-V, 64- and 32-bit, 66- and 33-MHz PCI compliance
- Joint Test Action Group (JTAG) boundary-scan test (BST) support
- Output drive strength control
- Weak pull-up resistors during configuration
- Tri-state buffers
- Bus-hold circuitry
- Programmable pull-up resistors in user mode
- Programmable input and output delays
- Open-drain outputs
- DQ and DQS I/O pins
- V_{REF} pins

Cyclone II device IOEs contain a bidirectional I/O buffer and three registers for complete embedded bidirectional single data rate transfer. [Figure 2–20](#) shows the Cyclone II IOE structure. The IOE contains one input register, one output register, and one output enable register. You can use the input registers for fast setup times and output registers for fast clock-to-output times. Additionally, you can use the output enable (OE) register for fast clock-to-output enable timing. The Quartus II software automatically duplicates a single OE register that controls multiple output or bidirectional pins. You can use IOEs as input, output, or bidirectional pins.

Figure 2–20. Cyclone II IOE Structure**Note to Figure 2–20:**

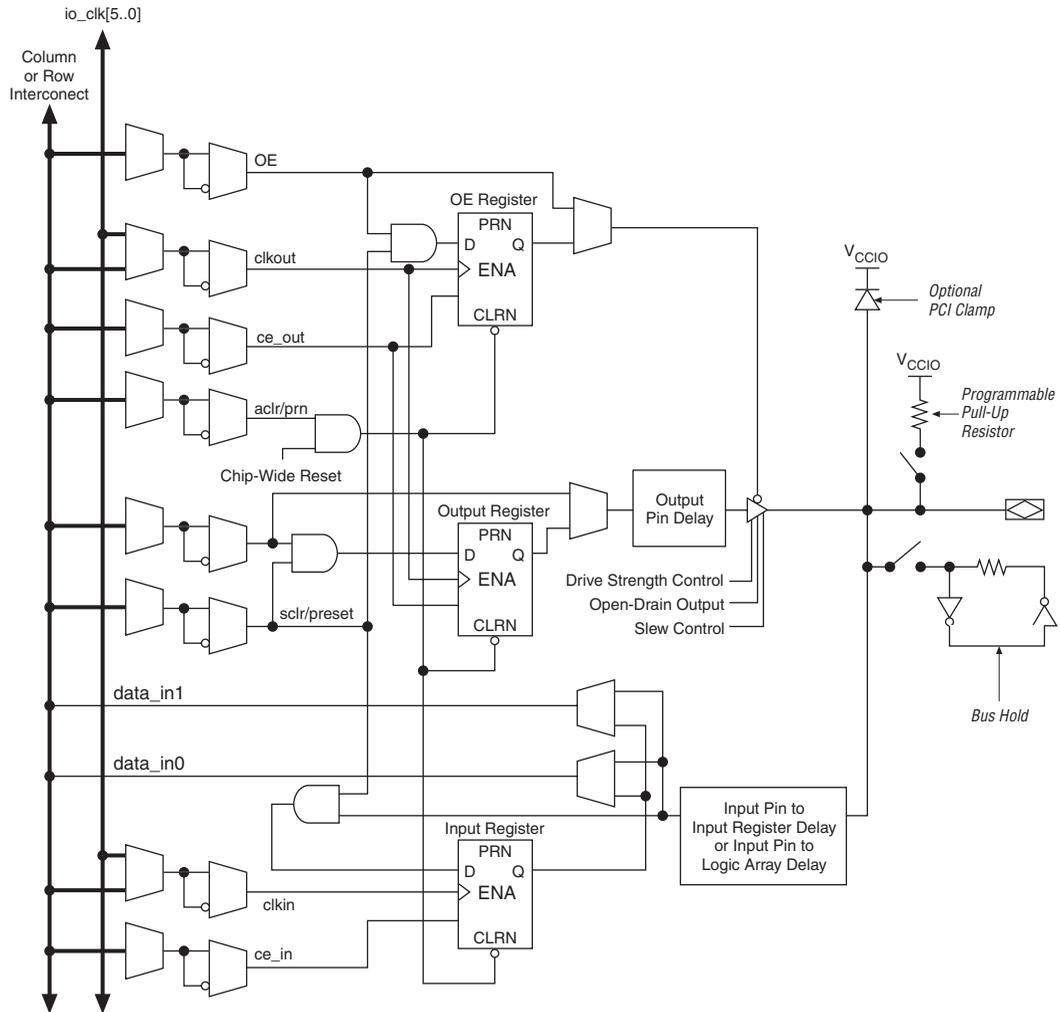
- (1) There are two paths available for combinational or registered inputs to the logic array. Each path contains a unique programmable delay chain.

The IOEs are located in I/O blocks around the periphery of the Cyclone II device. There are up to five IOEs per row I/O block and up to four IOEs per column I/O block (column I/O blocks span two columns). The row I/O blocks drive row, column (only C4 interconnects), or direct link interconnects. The column I/O blocks drive column interconnects.

Figure 2–21 shows how a row I/O block connects to the logic array.

Figure 2–22 shows how a column I/O block connects to the logic array.

Figure 2–25. Cyclone II IOE in Bidirectional I/O Configuration



The Cyclone II device IOE includes programmable delays to ensure zero hold times, minimize setup times, or increase clock to output times.

A path in which a pin directly drives a register may require a programmable delay to ensure zero hold time, whereas a path in which a pin drives a register through combinational logic may not require the delay. Programmable delays decrease input-pin-to-logic-array and IOE input register delays. The Quartus II Compiler can program these delays to automatically minimize setup time while providing a zero hold time.

Programmable delays can increase the register-to-pin delays for output registers. Table 2–14 shows the programmable delays for Cyclone II devices.

Programmable Delays	Quartus II Logic Option
Input pin to logic array delay	Input delay from pin to internal cells
Input pin to input register delay	Input delay from pin to input register
Output pin delay	Delay from output register to output pin

There are two paths in the IOE for an input to reach the logic array. Each of the two paths can have a different delay. This allows you to adjust delays from the pin to internal LE registers that reside in two different areas of the device. You set the two combinational input delays by selecting different delays for two different paths under the **Input delay from pin to internal cells logic** option in the Quartus II software. However, if the pin uses the input register, one of delays is disregarded because the IOE only has two paths to internal logic. If the input register is used, the IOE uses one input path. The other input path is then available for the combinational path, and only one input delay assignment is applied.

The IOE registers in each I/O block share the same source for clear or preset. You can program preset or clear for each individual IOE, but both features cannot be used simultaneously. You can also program the registers to power up high or low after configuration is complete. If programmed to power up low, an asynchronous clear can control the registers. If programmed to power up high, an asynchronous preset can control the registers. This feature prevents the inadvertent activation of another device's active-low input upon power up. If one register in an IOE uses a preset or clear signal then all registers in the IOE must use that same signal if they require preset or clear. Additionally a synchronous reset signal is available for the IOE registers.

External Memory Interfacing

Cyclone II devices support a broad range of external memory interfaces such as SDR SDRAM, DDR SDRAM, DDR2 SDRAM, and QDR II SRAM external memories. Cyclone II devices feature dedicated high-speed interfaces that transfer data between external memory devices at up to 167 MHz/333 Mbps for DDR and DDR2 SDRAM devices and 167 MHz/667 Mbps for QDR II SRAM devices. The programmable DQS delay chain allows you to fine tune the phase shift for the input clocks or strobes to properly align clock edges as needed to capture data.

In Cyclone II devices, all the I/O banks support SDR and DDR SDRAM memory up to 167 MHz/333 Mbps. All I/O banks support DQS signals with the DQ bus modes of $\times 8/\times 9$, or $\times 16/\times 18$. Table 2–15 shows the external memory interfaces supported in Cyclone II devices.

Memory Standard	I/O Standard	Maximum Bus Width	Maximum Clock Rate Supported (MHz)	Maximum Data Rate Supported (Mbps)
SDR SDRAM	LVTTTL (2)	72	167	167
DDR SDRAM	SSTL-2 class I (2)	72	167	333 (1)
	SSTL-2 class II (2)	72	133	267 (1)
DDR2 SDRAM	SSTL-18 class I (2)	72	167	333 (1)
	SSTL-18 class II (3)	72	125	250 (1)
QDR II SRAM (4)	1.8-V HSTL class I (2)	36	167	668 (1)
	1.8-V HSTL class II (3)	36	100	400 (1)

Notes to Table 2–15:

- (1) The data rate is for designs using the Clock Delay Control circuitry.
- (2) The I/O standards are supported on all the I/O banks of the Cyclone II device.
- (3) The I/O standards are supported only on the I/O banks on the top and bottom of the Cyclone II device.
- (4) For maximum performance, Altera recommends using the 1.8-V HSTL I/O standard because of higher I/O drive strength. QDR II SRAM devices also support the 1.5-V HSTL I/O standard.

Cyclone II devices use data (DQ), data strobe (DQS), and clock pins to interface with external memory. Figure 2–26 shows the DQ and DQS pins in the $\times 8/\times 9$ mode.

Table 2–17. Programmable Drive Strength (Part 3 of 3) *Note (1)*

I/O Standard	I _{OH} /I _{OL} Current Strength Setting (mA)	
	Top & Bottom I/O Pins	Side I/O Pins
HSTL-15 class II	16	

Note to Table 2–17:

- (1) The default current in the Quartus II software is the maximum setting for each I/O standard.

Open-Drain Output

Cyclone II devices provide an optional open-drain (equivalent to an open-collector) output for each I/O pin. This open-drain output enables the device to provide system-level control signals (that is, interrupt and write-enable signals) that can be asserted by any of several devices.

Slew Rate Control

Slew rate control is performed by using programmable output drive strength.

Bus Hold

Each Cyclone II device user I/O pin provides an optional bus-hold feature. The bus-hold circuitry can hold the signal on an I/O pin at its last-driven state. Since the bus-hold feature holds the last-driven state of the pin until the next input signal is present, an external pull-up or pull-down resistor is not necessary to hold a signal level when the bus is tri-stated.

The bus-hold circuitry also pulls undriven pins away from the input threshold voltage where noise can cause unintended high-frequency switching. You can select this feature individually for each I/O pin. The bus-hold output drives no higher than V_{CCIO} to prevent overdriving signals.



If the bus-hold feature is enabled, the device cannot use the programmable pull-up option. Disable the bus-hold feature when the I/O pin is configured for differential signals. Bus hold circuitry is not available on the dedicated clock pins.

The bus-hold circuitry is only active after configuration. When going into user mode, the bus-hold circuit captures the value on the pin present at the end of configuration.

The bus-hold circuitry uses a resistor with a nominal resistance (R_{BH}) of approximately 7 k Ω to pull the signal level to the last-driven state. Refer to the *DC Characteristics & Timing Specifications* chapter in Volume 1 of the *Cyclone II Device Handbook* for the specific sustaining current for each V_{CCIO} voltage level driven through the resistor and overdrive current used to identify the next driven input level.

Programmable Pull-Up Resistor

Each Cyclone II device I/O pin provides an optional programmable pull-up resistor during user mode. If you enable this feature for an I/O pin, the pull-up resistor (typically 25 k Ω) holds the output to the V_{CCIO} level of the output pin's bank.



If the programmable pull-up is enabled, the device cannot use the bus-hold feature. The programmable pull-up resistors are not supported on the dedicated configuration, JTAG, and dedicated clock pins.

Advanced I/O Standard Support

Table 2–18 shows the I/O standards supported by Cyclone II devices and which I/O pins support them.

I/O Standard	Type	V _{CCIO} Level		Top & Bottom I/O Pins		Side I/O Pins		
		Input	Output	CLK, DQS	User I/O Pins	CLK, DQS	PLL_OUT	User I/O Pins
3.3-V LVTTTL and LVCMOS	Single ended	3.3 V / 2.5 V	3.3 V	✓	✓	✓	✓	✓
2.5-V LVTTTL and LVCMOS	Single ended	3.3 V / 2.5 V	2.5 V	✓	✓	✓	✓	✓
1.8-V LVTTTL and LVCMOS	Single ended	1.8 V / 1.5 V	1.8 V	✓	✓	✓	✓	✓
1.5-V LVCMOS	Single ended	1.8 V / 1.5 V	1.5 V	✓	✓	✓	✓	✓
SSTL-2 class I	Voltage referenced	2.5 V	2.5 V	✓	✓	✓	✓	✓
SSTL-2 class II	Voltage referenced	2.5 V	2.5 V	✓	✓	✓	✓	✓
SSTL-18 class I	Voltage referenced	1.8 V	1.8 V	✓	✓	✓	✓	✓
SSTL-18 class II	Voltage referenced	1.8 V	1.8 V	✓	✓	(1)	(1)	(1)
HSTL-18 class I	Voltage referenced	1.8 V	1.8 V	✓	✓	✓	✓	✓
HSTL-18 class II	Voltage referenced	1.8 V	1.8 V	✓	✓	(1)	(1)	(1)
HSTL-15 class I	Voltage referenced	1.5 V	1.5 V	✓	✓	✓	✓	✓
HSTL-15 class II	Voltage referenced	1.5 V	1.5 V	✓	✓	(1)	(1)	(1)
PCI and PCI-X (2)	Single ended	3.3 V	3.3 V			✓	✓	✓
Differential SSTL-2 class I or class II	Pseudo differential (3)	(4)	2.5 V				✓	
		2.5 V	(4)	✓ (5)		✓ (5)		
Differential SSTL-18 class I or class II	Pseudo differential (3)	(4)	1.8 V				✓ (6)	
		1.8 V	(4)	✓ (5)		✓ (5)		

Table 2–18. Cyclone II Supported I/O Standards & Constraints (Part 2 of 2)

I/O Standard	Type	V _{CCIO} Level		Top & Bottom I/O Pins		Side I/O Pins		
		Input	Output	CLK, DQS	User I/O Pins	CLK, DQS	PLL_OUT	User I/O Pins
Differential HSTL-15 class I or class II	Pseudo differential (3)	(4)	1.5 V				✓ (6)	
		1.5 V	(4)	✓ (5)		✓ (5)		
Differential HSTL-18 class I or class II	Pseudo differential (3)	(4)	1.8 V				✓ (6)	
		1.8 V	(4)	✓ (5)		✓ (5)		
LVDS	Differential	2.5 V	2.5 V	✓	✓	✓	✓	✓
RSDS and mini-LVDS (7)	Differential	(4)	2.5 V		✓		✓	✓
LVPECL (8)	Differential	3.3 V/ 2.5 V/ 1.8 V/ 1.5 V	(4)	✓		✓		

Notes to Table 2–18:

- (1) These pins support SSTL-18 class II and 1.8- and 1.5-V HSTL class II inputs.
- (2) PCI-X does not meet the IV curve requirement at the linear region. PCI-clamp diode is not available on top and bottom I/O pins.
- (3) Pseudo-differential HSTL and SSTL outputs use two single-ended outputs with the second output programmed as inverted. Pseudo-differential HSTL and SSTL inputs treat differential inputs as two single-ended HSTL and SSTL inputs and only decode one of them.
- (4) This I/O standard is not supported on these I/O pins.
- (5) This I/O standard is only supported on the dedicated clock pins.
- (6) PLL_OUT does not support differential SSTL-18 class II and differential 1.8 and 1.5-V HSTL class II.
- (7) mini-LVDS and RSDS are only supported on output pins.
- (8) LVPECL is only supported on clock inputs.



For more information on Cyclone II supported I/O standards, see the *Selectable I/O Standards in Cyclone II Devices* chapter in Volume 1 of the *Cyclone II Device Handbook*.

High-Speed Differential Interfaces

Cyclone II devices can transmit and receive data through LVDS signals at a data rate of up to 640 Mbps and 805 Mbps, respectively. For the LVDS transmitter and receiver, the Cyclone II device's input and output pins support serialization and deserialization through internal logic.

I/O Standards	Target R_S (Ω)	V_{CCIO} (V)
SSTL-18 class I	50 (2)	1.8

Notes to Table 2–20:

- (1) Supported conditions are junction temperature (T_j) = 0° to 85° C and $V_{CCIO} = V_{CCIO} \pm 50$ mV.
- (2) These R_S values are nominal values. Actual impedance varies across process, voltage, and temperature conditions.



The recommended frequency range of operation is pending silicon characterization.

On-chip series termination can be supported on any I/O bank. V_{CCIO} and V_{REF} must be compatible for all I/O pins in order to enable on-chip series termination in a given I/O bank. I/O standards that support different R_S values can reside in the same I/O bank as long as their V_{CCIO} and V_{REF} are not conflicting.



When using on-chip series termination, programmable drive strength is not available.

Impedance matching is implemented using the capabilities of the output driver and is subject to a certain degree of variation, depending on the process, voltage and temperature. The actual tolerance is pending silicon characterization.

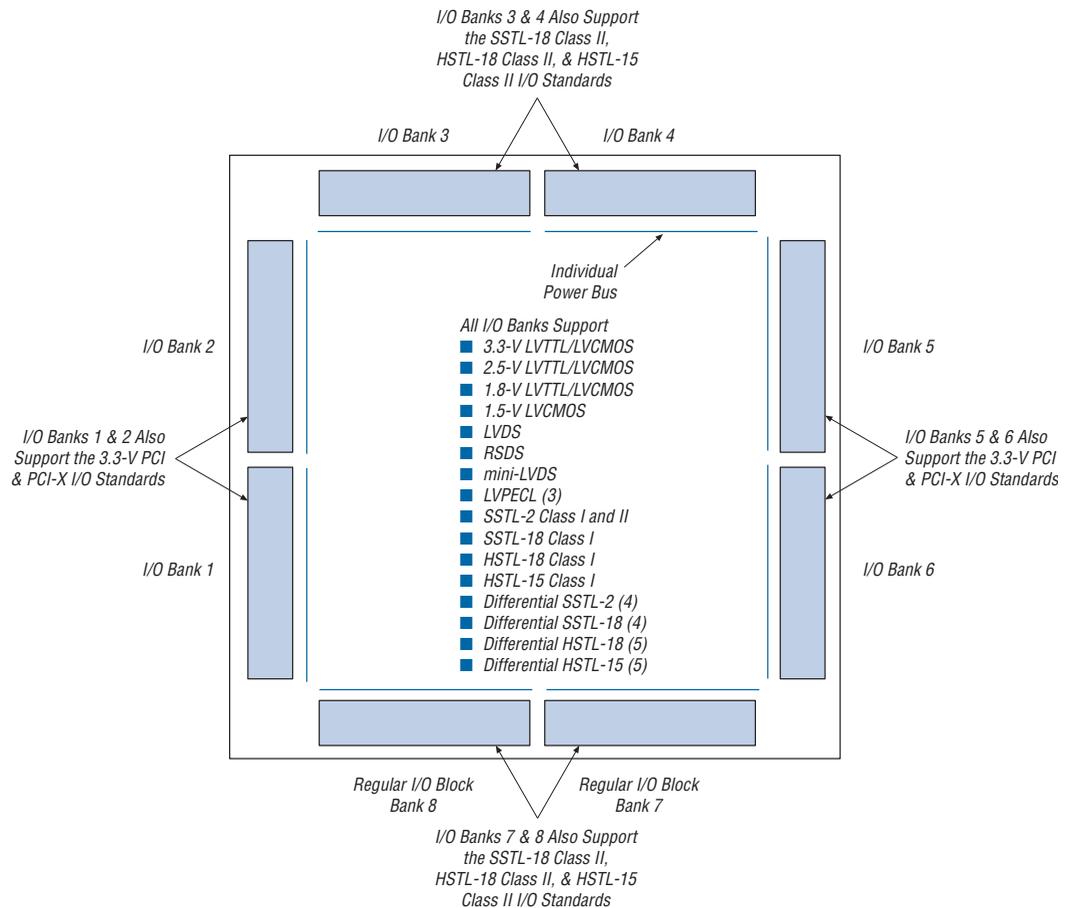
I/O Banks

The I/O pins on Cyclone II devices are grouped together into I/O banks and each bank has a separate power bus. EP2C5 and EP2C8 devices have four I/O banks (see [Figure 2–28](#)), while EP2C20, EP2C35, EP2C50, and EP2C70 devices have eight I/O banks (see [Figure 2–29](#)). Each device I/O pin is associated with one I/O bank. To accommodate voltage-referenced I/O standards, each Cyclone II I/O bank has a V_{REF} bus. Each bank in EP2C5, EP2C8, EP2C20, EP2C35, and EP2C50 devices supports two V_{REF} pins and each bank of EP2C70 supports three V_{REF} pins. When using the V_{REF} pins, each V_{REF} pin must be properly connected to the appropriate voltage level. In the event these pins are not used as V_{REF} pins, they may be used as regular I/O pins.

The top and bottom I/O banks (banks 2 and 4 in EP2C5 and EP2C8 devices and banks 3, 4, 7, and 8 in EP2C20, EP2C35, EP2C50, and EP2C70 devices) support all I/O standards listed in [Table 2–18](#), except the PCI/PCI-X I/O standards. The left and right side I/O banks (banks 1 and 3 in EP2C5 and EP2C8 devices and banks 1, 2, 5, and 6 in EP2C20, EP2C35,

EP2C50, and EP2C70 devices) support I/O standards listed in [Table 2-18](#), except SSTL-18 class II, HSTL-18 class II, and HSTL-15 class II I/O standards. See [Table 2-18](#) for a complete list of supported I/O standards.

The top and bottom I/O banks (banks 2 and 4 in EP2C5 and EP2C8 devices and banks 3, 4, 7, and 8 in EP2C20, EP2C35, EP2C50, and EP2C70 devices) support DDR2 memory up to 167 MHz/333 Mbps and QDR memory up to 167 MHz/668 Mbps. The left and right side I/O banks (1 and 3 of EP2C5 and EP2C8 devices and 1, 2, 5, and 6 of EP2C20, EP2C35, EP2C50, and EP2C70 devices) only support SDR and DDR SDRAM interfaces. All the I/O banks of the Cyclone II devices support SDR memory up to 167 MHz/167 Mbps and DDR memory up to 167 MHz/333 Mbps.

Figure 2–29. EP2C20, EP2C35, EP2C50 & EP2C70 I/O Banks *Notes (1), (2)***Notes to Figure 2–29:**

- (1) This is a top view of the silicon die.
- (2) This is a graphic representation only. Refer to the pin list and the Quartus II software for exact pin locations.
- (3) The LVPECL I/O standard is only supported on clock input pins. This I/O standard is not supported on output pins.
- (4) The differential SSTL-18 and SSTL-2 I/O standards are only supported on clock input pins and PLL output clock pins.
- (5) The differential 1.8-V and 1.5-V HSTL I/O standards are only supported on clock input pins and PLL output clock pins.

Each I/O bank has its own VCCIO pins. A single device can support 1.5-V, 1.8-V, 2.5-V, and 3.3-V interfaces; each individual bank can support a different standard with different I/O voltages. Each bank also has dual-purpose VREF pins to support any one of the voltage-referenced

standards (e.g., SSTL-2) independently. If an I/O bank does not use voltage-referenced standards, the V_{REF} pins are available as user I/O pins.

Each I/O bank can support multiple standards with the same V_{CCIO} for input and output pins. For example, when V_{CCIO} is 3.3-V, a bank can support LVTTTL, LVCMOS, and 3.3-V PCI for inputs and outputs. Voltage-referenced standards can be supported in an I/O bank using any number of single-ended or differential standards as long as they use the same V_{REF} and a compatible V_{CCIO} value.

MultiVolt I/O Interface

The Cyclone II architecture supports the MultiVolt I/O interface feature, which allows Cyclone II devices in all packages to interface with systems of different supply voltages. Cyclone II devices have one set of V_{CC} pins (V_{CCINT}) that power the internal device logic array and input buffers that use the LVPECL, LVDS, HSTL, or SSTL I/O standards. Cyclone II devices also have four or eight sets of V_{CC} pins (V_{CCIO}) that power the I/O output drivers and input buffers that use the LVTTTL, LVCMOS, or PCI I/O standards.

The Cyclone II V_{CCINT} pins must always be connected to a 1.2-V power supply. If the V_{CCINT} level is 1.2 V, then input pins are 1.5-V, 1.8-V, 2.5-V, and 3.3-V tolerant. The V_{CCIO} pins can be connected to either a 1.5-V, 1.8-V, 2.5-V, or 3.3-V power supply, depending on the output requirements. The output levels are compatible with systems of the same voltage as the power supply (i.e., when V_{CCIO} pins are connected to a 1.5-V power supply, the output levels are compatible with 1.5-V systems). When V_{CCIO} pins are connected to a 3.3-V power supply, the output high is 3.3-V and is compatible with 3.3-V systems. Table 2–21 summarizes Cyclone II MultiVolt I/O support.

V_{CCIO} (V)	Input Signal				Output Signal			
	1.5 V	1.8 V	2.5 V	3.3 V	1.5 V	1.8 V	2.5 V	3.3 V
1.5	✓	✓	✓ (2)	✓ (2)	✓			
1.8	✓ (4)	✓	✓ (2)	✓ (2)	✓ (3)	✓		
2.5			✓	✓	✓ (5)	✓ (5)	✓	

V_{CCIO} (V)	Input Signal				Output Signal			
	1.5 V	1.8 V	2.5 V	3.3 V	1.5 V	1.8 V	2.5 V	3.3 V
3.3			✓ (4)	✓	✓ (6)	✓ (6)	✓ (6)	✓

Notes to Table 2–21:

- (1) The PCI clamping diode must be disabled to drive an input with voltages higher than V_{CCIO} .
- (2) When $V_{CCIO} = 1.5\text{-V}$ or 1.8-V and a 2.5-V or 3.3-V input signal feeds an input pin, higher pin leakage current is expected.
- (3) When $V_{CCIO} = 1.8\text{-V}$, a Cyclone II device can drive a 1.5-V device with 1.8-V tolerant inputs.
- (4) When $V_{CCIO} = 3.3\text{-V}$ and a 2.5-V input signal feeds an input pin or when $V_{CCIO} = 1.8\text{-V}$ and a 1.5-V input signal feeds an input pin, the V_{CCIO} supply current will be slightly larger than expected. The reason for this increase is that the input signal level does not drive to the V_{CCIO} rail, which causes the input buffer to not completely shut off.
- (5) When $V_{CCIO} = 2.5\text{-V}$, a Cyclone II device can drive a 1.5-V or 1.8-V device with 2.5-V tolerant inputs.
- (6) When $V_{CCIO} = 3.3\text{-V}$, a Cyclone II device can drive a 1.5-V , 1.8-V , or 2.5-V device with 3.3-V tolerant inputs.



For more information on the SignalTap II, see the *Signal Tap* chapter of the *Quartus II Handbook, Volume 3*.

Configuration

The logic, circuitry, and interconnects in the Cyclone II architecture are configured with CMOS SRAM elements. Altera FPGA devices are reconfigurable and every device is tested with a high coverage production test program so you do not have to perform fault testing and can instead focus on simulation and design verification.

Cyclone II devices are configured at system power-up with data stored in an Altera configuration device or provided by a system controller. The Cyclone II device's optimized interface allows the device to act as controller in an active serial configuration scheme with EPCS serial configuration devices. The serial configuration device can be programmed via SRunner, the ByteBlaster II or USB Blaster download cable, the Altera Programming Unit (APU), or third-party programmers.

In addition to EPCS serial configuration devices, Altera offers in-system programmability (ISP)-capable configuration devices that can configure Cyclone II devices via a serial data stream using the Passive serial (PS) configuration mode. The PS interface also enables microprocessors to treat Cyclone II devices as memory and configure them by writing to a virtual memory location, simplifying reconfiguration. After a Cyclone II device has been configured, it can be reconfigured in-circuit by resetting the device and loading new configuration data. Real-time changes can be made during system operation, enabling innovative reconfigurable applications.

Operating Modes

The Cyclone II architecture uses SRAM configuration elements that require configuration data to be loaded each time the circuit powers up. The process of physically loading the SRAM data into the device is called configuration. During initialization, which occurs immediately after configuration, the device resets registers, enables I/O pins, and begins to operate as a logic device. Together, the configuration and initialization processes are called command mode. Normal device operation is called user mode.

SRAM configuration elements allow Cyclone II devices to be reconfigured in-circuit by loading new configuration data into the device. With real-time reconfiguration, the device is forced into command mode with the `nCONFIG` pin. The configuration process loads different configuration data, reinitializes the device, and resumes user-mode operation. You can perform in-field upgrades by distributing new configuration files within the system or remotely.

A built-in weak pull-up resistor pulls all user I/O pins to V_{CCIO} before and during device configuration.

The configuration pins support 1.5-V/1.8-V or 2.5-V/3.3-V I/O standards. The voltage level of the configuration output pins is determined by the V_{CCIO} of the bank where the pins reside. The bank V_{CCIO} selects whether the configuration inputs are 1.5-V, 1.8-V, 2.5-V, or 3.3-V compatible.

Configuration Schemes

You can load the configuration data for a Cyclone II device with one of three configuration schemes (see [Table 3–4](#)), chosen on the basis of the target application. You can use a configuration device, intelligent controller, or the JTAG port to configure a Cyclone II device. A low-cost configuration device can automatically configure a Cyclone II device at system power-up.

Multiple Cyclone II devices can be configured in any of the three configuration schemes by connecting the configuration enable (nCE) and configuration enable output ($nCEO$) pins on each device.

Table 3–4. Data Sources for Configuration

Configuration Scheme	Data Source
Active serial (AS)	Low-cost serial configuration device
Passive serial (PS)	Enhanced or EPC2 configuration device, MasterBlaster, ByteBlasterMV, ByteBlaster II or USB Blaster download cable, or serial data source
JTAG	MasterBlaster, ByteBlasterMV, ByteBlaster II or USB Blaster download cable or a microprocessor with a Jam or JBC file



For more information on configuration, see the *Configuring Cyclone II Devices* chapter of the *Cyclone II Handbook, Volume 2*.

Cyclone II Automated Single Event Upset Detection

Cyclone II devices offer on-chip circuitry for automated checking of single event upset (SEU) detection. Some applications that require the device to operate error free at high elevations or in close proximity to earth’s North or South Pole require periodic checks to ensure continued data integrity. The error detection cyclic redundancy code (CRC) feature controlled by the **Device & Pin Options** dialog box in the Quartus II software uses a 32-bit CRC circuit to ensure data reliability and is one of the best options for mitigating SEU.

You can implement the error detection CRC feature with existing circuitry in Cyclone II devices, eliminating the need for external logic. For Cyclone II devices, the CRC is computed by the device during configuration and checked against an automatically computed CRC during normal operation. The `CRC_ERROR` pin reports a soft error when configuration SRAM data is corrupted, triggering device reconfiguration.

Custom-Built Circuitry

Dedicated circuitry in the Cyclone II devices performs error detection automatically. This error detection circuitry in Cyclone II devices constantly checks for errors in the configuration SRAM cells while the device is in user mode. You can monitor one external pin for the error and use it to trigger a re-configuration cycle. You can select the desired time between checks by adjusting a built-in clock divider.

Software Interface

In the Quartus II software version 4.1 and later, you can turn on the automated error detection CRC feature in the Device & Pin Options dialog box. This dialog box allows you to enable the feature and set the internal frequency of the CRC checker between 400 kHz to 80 MHz. This controls the rate that the CRC circuitry verifies the internal configuration SRAM bits in the FPGA device.



For more information on CRC, refer to the *Error Detection Using CRC in Altera FPGAs* Application Note.



6. Reference & Ordering Information

CI151006-1.1

Software

Cyclone™ II devices are supported by the Altera® Quartus® II design software, which provides a comprehensive environment for system-on-a-programmable-chip (SOPC) design. The Quartus II software includes HDL and schematic design entry, compilation and logic synthesis, full simulation and advanced timing analysis, SignalTap® II logic analyzer, and device configuration. See the *Quartus II Handbook* for more information on the Quartus II software features.

The Quartus II software supports the Windows XP/2000/NT/98, Sun Solaris, Linux Red Hat v7.1 and HP-UX operating systems. It also supports seamless integration with industry-leading EDA tools through the NativeLink® interface.

Device Pin-Outs

Device pin-outs for Cyclone II devices are available on the Altera web site (www.altera.com). For more information contact Altera Applications.

Ordering Information

[Figure 6-1](#) describes the ordering codes for Cyclone II devices. For more information on a specific package, contact Altera Applications.

Figure 6–1. Cyclone II Device Packaging Ordering Information

