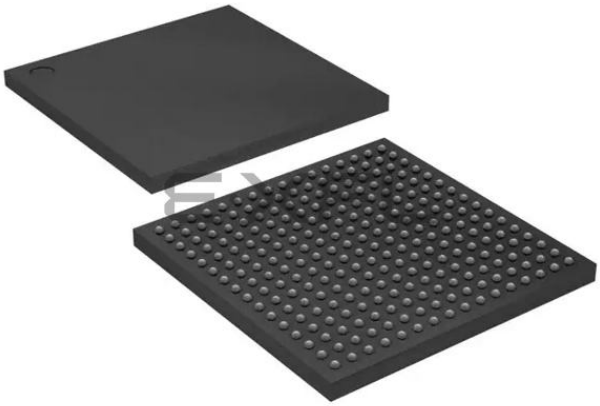

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Applications of Embedded - FPGAs

The versatility of Embedded - FPGAs makes them indispensable in numerous fields. In telecommunications.

Details	
Product Status	Obsolete
Number of LABs/CLBs	1206
Number of Logic Elements/Cells	12060
Total RAM Bits	239616
Number of I/O	185
Number of Gates	-
Voltage - Supply	1.425V ~ 1.575V
Mounting Type	Surface Mount
Operating Temperature	0°C ~ 85°C (TJ)
Package / Case	256-BGA
Supplier Device Package	256-FBGA (17x17)
Purchase URL	https://www.e-xfl.com/product-detail/intel/ep1c12f256c6

Table 1–1. Cyclone Device Features (Part 2 of 2)

Feature	EP1C3	EP1C4	EP1C6	EP1C12	EP1C20
Total RAM bits	59,904	78,336	92,160	239,616	294,912
PLLs	1	2	2	2	2
Maximum user I/O pins *(1)*	104	301	185	249	301

Note to Table 1–1:
(1) This parameter includes global clock pins.

Cyclone devices are available in quad flat pack (QFP) and space-saving FineLine® BGA packages (see Tables 1–2 through 1–3).

Table 1–2. Cyclone Package Options and I/O Pin Counts

Device	100-Pin TQFP *(1)*	144-Pin TQFP *(1), (2)*	240-Pin PQFP *(1)*	256-Pin FineLine BGA	324-Pin FineLine BGA	400-Pin FineLine BGA
EP1C3	65	104	—	—	—	—
EP1C4	—	—	—	—	249	301
EP1C6	—	98	185	185	—	—
EP1C12	—	—	173	185	249	—
EP1C20	—	—	—	—	233	301

Notes to Table 1–2:
(1) TQFP: thin quad flat pack.
PQFP: plastic quad flat pack.
(2) Cyclone devices support vertical migration within the same package (i.e., designers can migrate between the EP1C3 device in the 144-pin TQFP package and the EP1C6 device in the same package).

Vertical migration means you can migrate a design from one device to another that has the same dedicated pins, JTAG pins, and power pins, and are subsets or supersets for a given package across device densities. The largest density in any package has the highest number of power pins; you must use the layout for the largest planned density in a package to provide the necessary power pins for migration.

For I/O pin migration across densities, cross-reference the available I/O pins using the device pin-outs for all planned densities of a given package type to identify which I/O pins can be migrated. The Quartus® II software can automatically cross-reference and place all pins for you when given a device migration list. If one device has power or ground pins, but these same pins are user I/O on a different device that is in the migration path,the Quartus II software ensures the pins are not used as user I/O in the Quartus II software. Ensure that these pins are connected

Dynamic Arithmetic Mode

The dynamic arithmetic mode is ideal for implementing adders, counters, accumulators, wide parity functions, and comparators. An LE in dynamic arithmetic mode uses four 2-input LUTs configurable as a dynamic adder/subtractor. The first two 2-input LUTs compute two summations based on a possible carry-in of 1 or 0; the other two LUTs generate carry outputs for the two chains of the carry select circuitry. As shown in Figure 2–7, the LAB carry-in signal selects either the `carry-in0` or `carry-in1` chain. The selected chain's logic level in turn determines which parallel sum is generated as a combinatorial or registered output. For example, when implementing an adder, the sum output is the selection of two possible calculated sums:

```
data1 + data2 + carry-in0
```

or

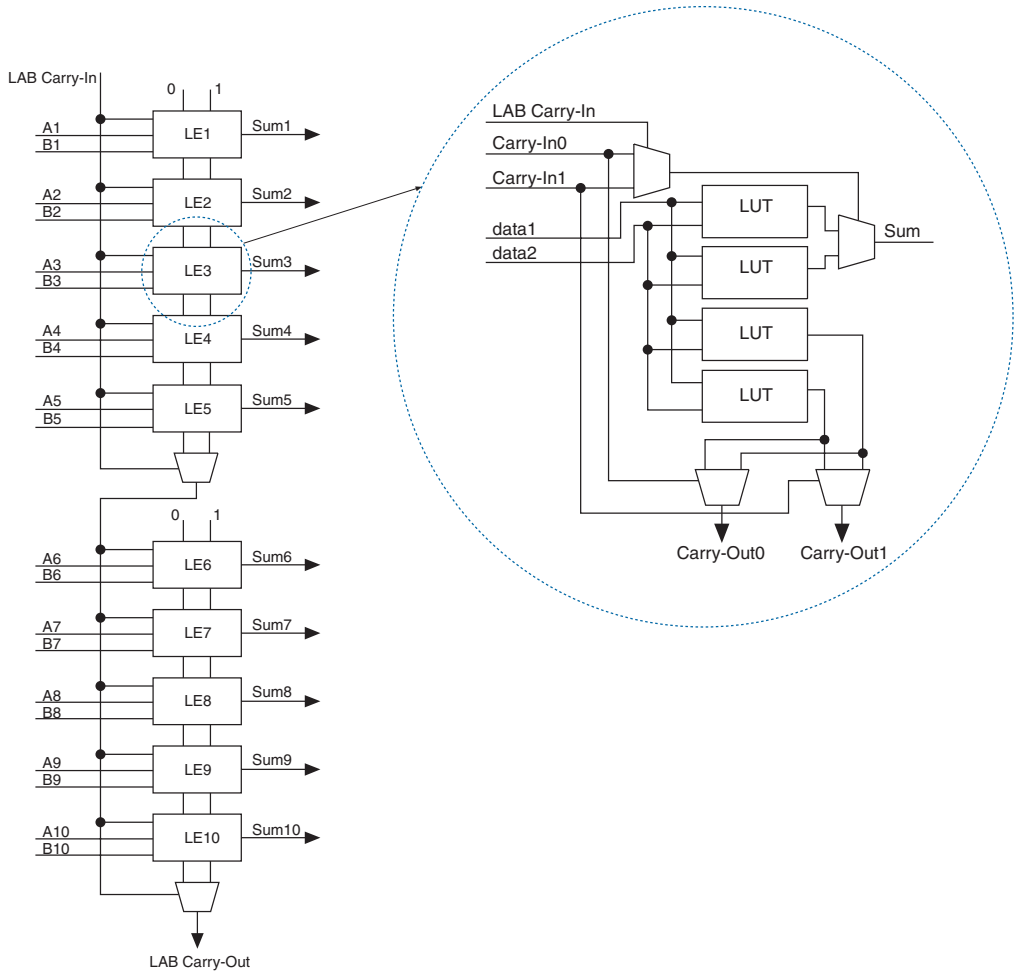
```
data1 + data2 + carry-in1
```

The other two LUTs use the `data1` and `data2` signals to generate two possible carry-out signals—one for a carry of 1 and the other for a carry of 0. The `carry-in0` signal acts as the carry select for the `carry-out0` output and `carry-in1` acts as the carry select for the `carry-out1` output. LEs in arithmetic mode can drive out registered and unregistered versions of the LUT output.

The dynamic arithmetic mode also offers clock enable, counter enable, synchronous up/down control, synchronous clear, synchronous load, and dynamic adder/subtractor options. The LAB local interconnect data inputs generate the counter enable and synchronous up/down control signals. The synchronous clear and synchronous load options are LAB-wide signals that affect all registers in the LAB. The Quartus II software automatically places any registers that are not used by the counter into other LABs. The `addnsub` LAB-wide signal controls whether the LE acts as an adder or subtractor.

Figure 2–8 shows the carry-select circuitry in a LAB for a 10-bit full adder. One portion of the LUT generates the sum of two bits using the input signals and the appropriate carry-in bit; the sum is routed to the output of the LE. The register can be bypassed for simple adders or used for accumulator functions. Another portion of the LUT generates carry-out bits. A LAB-wide carry-in bit selects which chain is used for the addition of given inputs. The carry-in signal for each chain, `carry-in0` or `carry-in1`, selects the carry-out to carry forward to the carry-in signal of the next-higher-order bit. The final carry-out signal is routed to an LE, where it is fed to local, row, or column interconnects.

Figure 2–8. Carry Select Chain



migrating through different device densities. Dedicated row interconnects route signals to and from LABs, PLLs, and M4K memory blocks 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

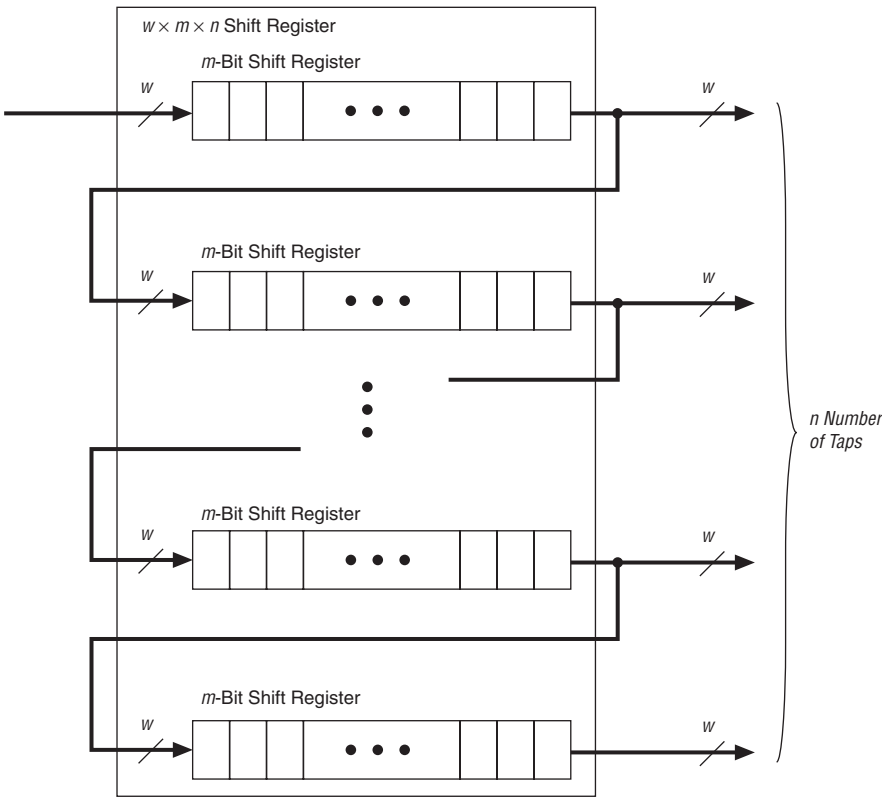
The direct link interconnect allows a LAB or M4K memory block to drive into the local interconnect of its left and right neighbors. Only one side of a PLL block interfaces with direct link and row interconnects. The direct link interconnect provides fast communication between adjacent LABs and/or blocks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

The R4 interconnects span four LABs, or two LABs and one M4K RAM block. 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 2–9 shows R4 interconnect connections from a LAB. R4 interconnects can drive and be driven by M4K memory blocks, PLLs, and row IOEs. For LAB interfacing, a primary LAB or LAB neighbor 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. R4 interconnects can also drive C4 interconnects for connections from one row to another.

register outputs (number of taps n × width w) must be less than the maximum data width of the M4K RAM block (×36). To create larger shift registers, multiple memory blocks are cascaded together.

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. The shift register mode logic automatically controls the positive and negative edge clocking to shift the data in one clock cycle. Figure 2–14 shows the M4K memory block in the shift register mode.

Figure 2–14. Shift Register Memory Configuration



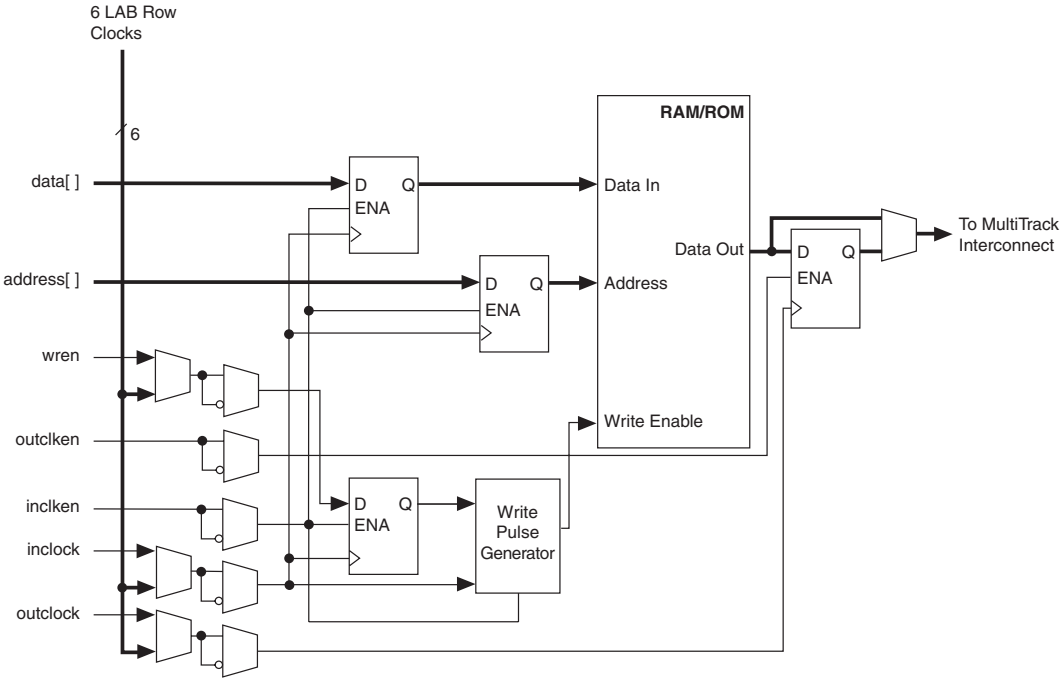
Memory Configuration Sizes

The memory address depths and output widths can be configured as 4,096 × 1, 2,048 × 2, 1,024 × 4, 512 × 8 (or 512 × 9 bits), 256 × 16 (or 256 × 18 bits), and 128 × 32 (or 128 × 36 bits). The 128 × 32- or 36-bit configuration

Single-Port Mode

The M4K memory blocks also support single-port mode, used when simultaneous reads and writes are not required. See Figure 2–21. A single M4K memory block can support up to two single-port mode RAM blocks if each RAM block is less than or equal to 2K bits in size.

Figure 2–21. Single-Port Mode *Note (1)*



Note to Figure 2–21:

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

Global Clock Network and Phase-Locked Loops

Cyclone devices provide a global clock network and up to two PLLs for a complete clock management solution.

Global Clock Network

There are four dedicated clock pins (`CLK[3..0]`, two pins on the left side and two pins on the right side) that drive the global clock network, as shown in Figure 2–22. PLL outputs, logic array, and dual-purpose clock (`DPCLK[7..0]`) pins can also drive the global clock network.

Table 2–6 shows the PLL features in Cyclone devices. Figure 2–25 shows a Cyclone PLL.

Table 2–6. Cyclone PLL Features

Feature	PLL Support
Clock multiplication and division	*m*/(*n* × post-scale counter) *(1)*
Phase shift	Down to 125-ps increments *(2)*, *(3)*
Programmable duty cycle	Yes
Number of internal clock outputs	2
Number of external clock outputs	One differential or one single-ended *(4)*

Notes to Table 2–6:

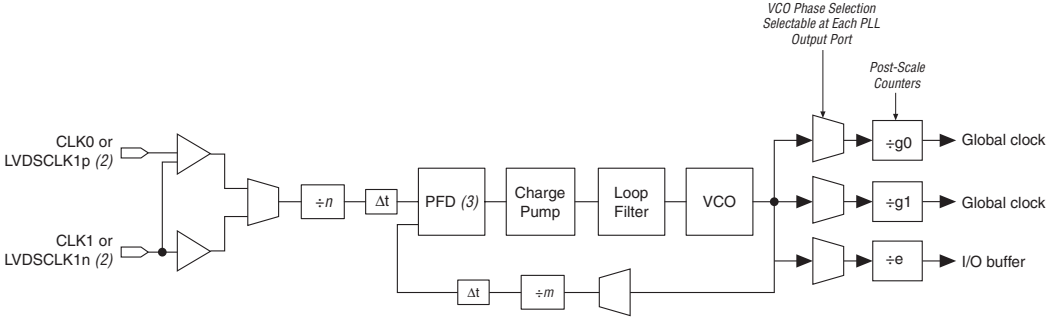
(1) The *m* counter ranges from 2 to 32. The *n* counter and the post-scale counters range from 1 to 32.

(2) The smallest phase shift is determined by the voltage-controlled oscillator (VCO) period divided by 8.

(3) For degree increments, Cyclone devices can shift all output frequencies in increments of 45°. Smaller degree increments are possible depending on the frequency and divide parameters.

(4) The EP1C3 device in the 100-pin TQFP package does not support external clock output. The EP1C6 device in the 144-pin TQFP package does not support external clock output from PLL2.

Figure 2–25. Cyclone PLL *Note (1)*



Notes to Figure 2–25:

(1) The EP1C3 device in the 100-pin TQFP package does not support external outputs or LVDS inputs. The EP1C6 device in the 144-pin TQFP package does not support external output from PLL2.

(2) LVDS input is supported via the secondary function of the dedicated clock pins. For PLL 1, the `CLK0` pin's secondary function is `LVDSCLK1p` and the `CLK1` pin's secondary function is `LVDSCLK1n`. For PLL 2, the `CLK2` pin's secondary function is `LVDSCLK2p` and the `CLK3` pin's secondary function is `LVDSCLK2n`.

(3) PFD: phase frequency detector.

Table 2–7. Global Clock Network Sources (Part 2 of 2)

Source		GCLK0	GCLK1	GCLK2	GCLK3	GCLK4	GCLK5	GCLK6	GCLK7
Dual-Purpose Clock Pins	DPCLK0 *(3)*	—	—	—	✓	—	—	—	—
	DPCLK1 *(3)*	—	—	✓	—	—	—	—	—
	DPCLK2	✓	—	—	—	—	—	—	—
	DPCLK3	—	—	—	—	✓	—	—	—
	DPCLK4	—	—	—	—	—	—	✓	—
	DPCLK5 *(3)*	—	—	—	—	—	—	—	✓
	DPCLK6	—	—	—	—	—	✓	—	—
	DPCLK7	—	✓	—	—	—	—	—	—

Notes to Table 2–7:
(1) EP1C3 devices only have one PLL (PLL 1).
(2) EP1C3 devices in the 100-pin TQFP package do not have dedicated clock pins `CLK1` and `CLK3`.
(3) EP1C3 devices in the 100-pin TQFP package do not have the `DPCLK0`, `DPCLK1`, or `DPCLK5` pins.

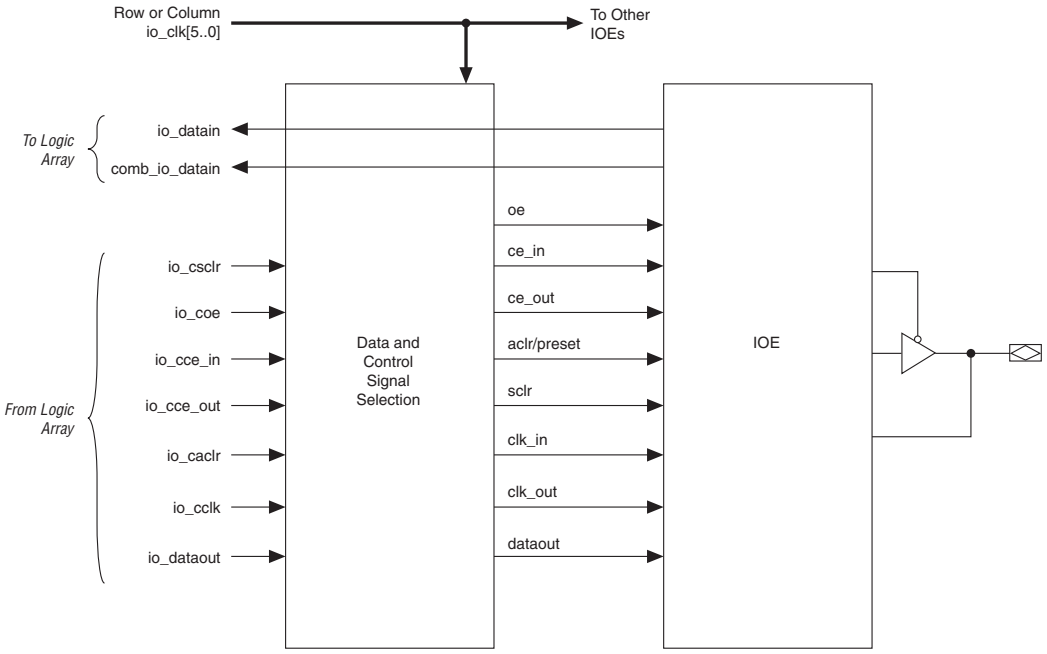
Clock Multiplication and Division

Cyclone PLLs provide clock synthesis for PLL output ports using $m/(n \times$ post scale counter) scaling factors. The input clock is divided by a pre-scale divider, n, and is then multiplied by the m feedback factor. The control loop drives the VCO to match $f_{IN} \times (m/n)$. Each output port has a unique post-scale counter to divide down the high-frequency VCO. For multiple PLL outputs with different frequencies, the VCO is set to the least-common multiple of the output frequencies that meets its frequency specifications. Then, the post-scale dividers scale down the output frequency for each output port. For example, if the output frequencies required from one PLL are 33 and 66 MHz, the VCO is set to 330 MHz (the least-common multiple in the VCO's range).

Each PLL has one pre-scale divider, n, that can range in value from 1 to 32. Each PLL also has one multiply divider, m, that can range in value from 2 to 32. Global clock outputs have two post scale G dividers for global clock outputs, and external clock outputs have an E divider for external clock output, both ranging from 1 to 32. The Quartus II software automatically chooses the appropriate scaling factors according to the input frequency, multiplication, and division values entered.

The pin's datain signals can drive the logic array. The logic array drives the control and data signals, providing a flexible routing resource. The row or column IOE clocks, `io_clk[5..0]`, provide a dedicated routing resource for low-skew, high-speed clocks. The global clock network generates the IOE clocks that feed the row or column I/O regions (see "Global Clock Network and Phase-Locked Loops" on page 2–29). Figure 2–30 illustrates the signal paths through the I/O block.

Figure 2–30. Signal Path through the I/O Block



Each IOE contains its own control signal selection for the following control signals: `oe`, `ce_in`, `ce_out`, `aclr/preset`, `sclr/preset`, `clk_in`, and `clk_out`. Figure 2–31 illustrates the control signal selection.

Slew-Rate Control

The output buffer for each Cyclone device I/O pin has a programmable output slew-rate control that can be configured for low noise or high-speed performance. A faster slew rate provides high-speed transitions for high-performance systems. However, these fast transitions may introduce noise transients into the system. A slow slew rate reduces system noise, but adds a nominal delay to rising and falling edges. Each I/O pin has an individual slew-rate control, allowing the designer to specify the slew rate on a pin-by-pin basis. The slew-rate control affects both the rising and falling edges.

Bus Hold

Each Cyclone device 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. The designer can select this feature individually for each I/O pin. The bus-hold output will drive 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.

The bus-hold circuitry uses a resistor with a nominal resistance (RBH) of approximately 7 kΩ to pull the signal level to the last-driven state. Table 4–15 on page 4–6 gives the specific sustaining current for each V_{CCIO} voltage level driven through this resistor and overdrive current used to identify the next-driven input level.

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.

Programmable Pull-Up Resistor

Each Cyclone device I/O pin provides an optional programmable pull-up resistor during user mode. If the designer enables this feature for an I/O pin, the pull-up resistor (typically 25 kΩ) holds the output to the V_{CCIO} level of the output pin's bank. Dedicated clock pins do not have the optional programmable pull-up resistor.

Table 3–1. Cyclone JTAG Instructions (Part 2 of 2)

JTAG Instruction	Instruction Code	Description
USERCODE	00 0000 0111	Selects the 32-bit USERCODE register and places it between the TDI and TDO pins, allowing the USERCODE to be serially shifted out of TDO.
IDCODE	00 0000 0110	Selects the IDCODE register and places it between TDI and TDO, allowing the IDCODE to be serially shifted out of TDO.
HIGHZ *(1)*	00 0000 1011	Places the 1-bit bypass register between the TDI and TDO pins, which allows the BST data to pass synchronously through selected devices to adjacent devices during normal device operation, while tri-stating all of the I/O pins.
CLAMP *(1)*	00 0000 1010	Places the 1-bit bypass register between the TDI and TDO pins, which allows the BST data to pass synchronously through selected devices to adjacent devices during normal device operation while holding I/O pins to a state defined by the data in the boundary-scan register.
ICR instructions	—	Used when configuring a Cyclone device via the JTAG port with a MasterBlaster™ or ByteBlasterMV™ download cable, or when using a Jam File or Jam Byte-Code File via an embedded processor.
PULSE_NCONFIG	00 0000 0001	Emulates pulsing the nCONFIG pin low to trigger reconfiguration even though the physical pin is unaffected.
CONFIG_IO	00 0000 1101	Allows configuration of I/O standards through the JTAG chain for JTAG testing. Can be executed before, after, or during configuration. Stops configuration if executed during configuration. Once issued, the CONFIG_IO instruction will hold nSTATUS low to reset the configuration device. nSTATUS is held low until the device is reconfigured.
SignalTap II instructions	—	Monitors internal device operation with the SignalTap II embedded logic analyzer.

Note to Table 3–1:
(1) Bus hold and weak pull-up resistor features override the high-impedance state of HIGHZ, CLAMP, and EXTEST.

In the Quartus II software, there is an Auto Usercode feature where you can choose to use the checksum value of a programming file as the JTAG user code. If selected, the checksum is automatically loaded to the USERCODE register. Choose Assignments > Device > Device and Pin Options > General. Turn on **Auto Usercode**.

Figure 3–1 shows the timing requirements for the JTAG signals.

Figure 3–1. Cyclone JTAG Waveforms

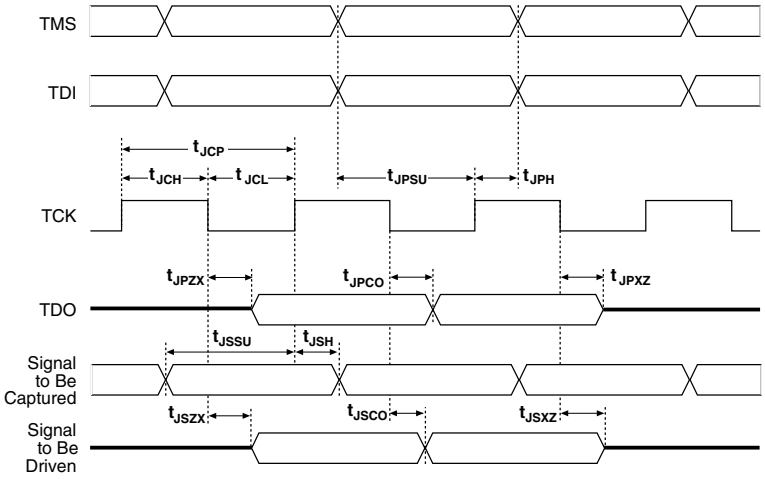


Table 3–4 shows the JTAG timing parameters and values for Cyclone devices.

Table 3–4. Cyclone JTAG Timing Parameters and Values

Symbol	Parameter	Min	Max	Unit
t_{JCP}	TCK clock period	100	—	ns
t_{JCH}	TCK clock high time	50	—	ns
t_{JCL}	TCK clock low time	50	—	ns
t_{JPSU}	JTAG port setup time	20	—	ns
t_{JPH}	JTAG port hold time	45	—	ns
t_{JPCO}	JTAG port clock to output	—	25	ns
t_{JPZX}	JTAG port high impedance to valid output	—	25	ns
t_{JPXZ}	JTAG port valid output to high impedance	—	25	ns
t_{JSSU}	Capture register setup time	20	—	ns
t_{JSH}	Capture register hold time	45	—	ns
t_{JSCO}	Update register clock to output	—	35	ns
t_{JSZX}	Update register high impedance to valid output	—	35	ns
t_{JSXZ}	Update register valid output to high impedance	—	35	ns

Multiple Cyclone 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 3–5. Data Sources for Configuration

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

Referenced Documents

This chapter references the following document:

- *AN 39: IEEE Std. 1149.1 (JTAG) Boundary-Scan Testing in Altera Devices*
- *Jam Programming & Test Language Specification*

Document Revision History

Table 3–6 shows the revision history for this chapter.

Table 3–6. Document Revision History

Date and Document Version	Changes Made	Summary of Changes
May 2008 v1.4	Minor textual and style changes. Added "Referenced Documents" section.	—
January 2007 v1.3	• Added document revision history. • Updated handpara note below Table 3–4.	—
August 2005 V1.2	Minor updates.	—
February 2005 V1.1	Updated JTAG chain limits. Added information concerning test vectors.	—
May 2003 v1.0	Added document to Cyclone Device Handbook.	—

4. DC and Switching Characteristics

C51004-1.7

Operating Conditions

Cyclone® devices are offered in both commercial, industrial, and extended temperature grades. However, industrial-grade and extended-temperature-grade devices may have limited speed-grade availability.

Tables 4–1 through 4–16 provide information on absolute maximum ratings, recommended operating conditions, DC operating conditions, and capacitance for Cyclone devices.

Table 4–1. Cyclone Device Absolute Maximum Ratings *Notes (1), (2)*

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{CCINT}	Supply voltage	With respect to ground *(3)*	–0.5	2.4	V
V_{CCIO}			–0.5	4.6	V
V_{CCA}	Supply voltage	With respect to ground *(3)*	–0.5	2.4	V
V_I	DC input voltage		–0.5	4.6	V
I_{OUT}	DC output current, per pin		–25	25	mA
T_{STG}	Storage temperature	No bias	–65	150	°C
T_{AMB}	Ambient temperature	Under bias	–65	135	°C
T_J	Junction temperature	BGA packages under bias	—	135	°C

Table 4–2. Cyclone Device Recommended Operating Conditions (Part 1 of 2)

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{CCINT}	Supply voltage for internal logic and input buffers	*(4)*	1.425	1.575	V
V_{CCIO}	Supply voltage for output buffers, 3.3-V operation	*(4)*	3.00	3.60	V
	Supply voltage for output buffers, 2.5-V operation	*(4)*	2.375	2.625	V
	Supply voltage for output buffers, 1.8-V operation	*(4)*	1.71	1.89	V
	Supply voltage for output buffers, 1.5-V operation	*(4)*	1.4	1.6	V
V_I	Input voltage	*(3)*, *(5)*	–0.5	4.1	V

Table 4–8. 1.5-V I/O Specifications

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{CCIO}	Output supply voltage	—	1.4	1.6	V
V_{IH}	High-level input voltage	—	0.65 × V_{CCIO}	V_{CCIO} + 0.3 *(12)*	V
V_{IL}	Low-level input voltage	—	–0.3	0.35 × V_{CCIO}	V
V_{OH}	High-level output voltage	I_{OH} = –2 mA *(11)*	0.75 × V_{CCIO}	—	V
V_{OL}	Low-level output voltage	I_{OL} = 2 mA *(11)*	—	0.25 × V_{CCIO}	V

Table 4–9. 2.5-V LVDS I/O Specifications *Note (13)*

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	I/O supply voltage	—	2.375	2.5	2.625	V
V_{OD}	Differential output voltage	R_L = 100 Ω	250	—	550	mV
Δ V_{OD}	Change in V_{OD} between high and low	R_L = 100 Ω	—	—	50	mV
V_{OS}	Output offset voltage	R_L = 100 Ω	1.125	1.25	1.375	V
Δ V_{OS}	Change in V_{OS} between high and low	R_L = 100 Ω	—	—	50	mV
V_{TH}	Differential input threshold	V_{CM} = 1.2 V	–100	—	100	mV
V_{IN}	Receiver input voltage range	—	0.0	—	2.4	V
R_L	Receiver differential input resistor	—	90	100	110	Ω

Table 4–10. 3.3-V PCI Specifications (Part 1 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	Output supply voltage	—	3.0	3.3	3.6	V
V_{IH}	High-level input voltage	—	0.5 × V_{CCIO}	—	V_{CCIO} + 0.5	V
V_{IL}	Low-level input voltage	—	–0.5	—	0.3 × V_{CCIO}	V

Table 4–10. 3.3-V PCI Specifications (Part 2 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{OH}	High-level output voltage	I_{OUT} = –500 µA	0.9 × V_{CCIO}	—	—	V
V_{OL}	Low-level output voltage	I_{OUT} = 1,500 µA	—	—	0.1 × V_{CCIO}	V

Table 4–11. SSTL-2 Class I Specifications

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	Output supply voltage	—	2.375	2.5	2.625	V
V_{TT}	Termination voltage	—	V_{REF} – 0.04	V_{REF}	V_{REF} + 0.04	V
V_{REF}	Reference voltage	—	1.15	1.25	1.35	V
V_{IH}	High-level input voltage	—	V_{REF} + 0.18	—	3.0	V
V_{IL}	Low-level input voltage	—	–0.3	—	V_{REF} – 0.18	V
V_{OH}	High-level output voltage	I_{OH} = –8.1 mA *(11)*	V_{TT} + 0.57	—	—	V
V_{OL}	Low-level output voltage	I_{OL} = 8.1 mA *(11)*	—	—	V_{TT} – 0.57	V

Table 4–12. SSTL-2 Class II Specifications

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	Output supply voltage	—	2.3	2.5	2.7	V
V_{TT}	Termination voltage	—	V_{REF} – 0.04	V_{REF}	V_{REF} + 0.04	V
V_{REF}	Reference voltage	—	1.15	1.25	1.35	V
V_{IH}	High-level input voltage	—	V_{REF} + 0.18	—	V_{CCIO} + 0.3	V
V_{IL}	Low-level input voltage	—	–0.3	—	V_{REF} – 0.18	V
V_{OH}	High-level output voltage	I_{OH} = –16.4 mA *(11)*	V_{TT} + 0.76	—	—	V
V_{OL}	Low-level output voltage	I_{OL} = 16.4 mA *(11)*	—	—	V_{TT} – 0.76	V

Table 4–13. SSTL-3 Class I Specifications (Part 1 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	Output supply voltage	—	3.0	3.3	3.6	V
V_{TT}	Termination voltage	—	V_{REF} – 0.05	V_{REF}	V_{REF} + 0.05	V

Table 4–13. SSTL-3 Class I Specifications (Part 2 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{REF}	Reference voltage	—	1.3	1.5	1.7	V
V_{IH}	High-level input voltage	—	V_{REF} + 0.2	—	V_{CCIO} + 0.3	V
V_{IL}	Low-level input voltage	—	–0.3	—	V_{REF} – 0.2	V
V_{OH}	High-level output voltage	I_{OH} = –8 mA *(11)*	V_{TT} + 0.6	—	—	V
V_{OL}	Low-level output voltage	I_{OL} = 8 mA *(11)*	—	—	V_{TT} – 0.6	V

Table 4–14. SSTL-3 Class II Specifications

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCIO}	Output supply voltage	—	3.0	3.3	3.6	V
V_{TT}	Termination voltage	—	V_{REF} – 0.05	V_{REF}	V_{REF} + 0.05	V
V_{REF}	Reference voltage	—	1.3	1.5	1.7	V
V_{IH}	High-level input voltage	—	V_{REF} + 0.2	—	V_{CCIO} + 0.3	V
V_{IL}	Low-level input voltage	—	–0.3	—	V_{REF} – 0.2	V
V_{OH}	High-level output voltage	I_{OH} = –16 mA *(11)*	V_{TT} + 0.8	—	—	V
V_{OL}	Low-level output voltage	I_{OL} = 16 mA *(11)*	—	—	V_{TT} – 0.8	V

Table 4–15. Bus Hold Parameters

Parameter	Conditions	V_{CCIO} Level								Unit
		1.5 V		1.8 V		2.5 V		3.3 V		
		Min	Max	Min	Max	Min	Max	Min	Max	
Low sustaining current	$V_{IN} > V_{IL}$ (maximum)	—	—	30	—	50	—	70	—	µA
High sustaining current	$V_{IN} < V_{IH}$ (minimum)	—	—	–30	—	–50	—	–70	—	µA
Low overdrive current	0 V < V_{IN} < V_{CCIO}	—	—	—	200	—	300	—	500	µA
High overdrive current	0 V < V_{IN} < V_{CCIO}	—	—	—	–200	—	–300	—	–500	µA

Table 4–22. IOE Internal Timing Microparameter Descriptions	
Symbol	**Parameter**
t_{SU}	IOE input and output register setup time before clock
t_{H}	IOE input and output register hold time after clock
t_{CO}	IOE input and output register clock-to-output delay
$t_{PIN2COMBOUT\_R}$	Row input pin to IOE combinatorial output
$t_{PIN2COMBOUT\_C}$	Column input pin to IOE combinatorial output
$t_{COMBIN2PIN\_R}$	Row IOE data input to combinatorial output pin
$t_{COMBIN2PIN\_C}$	Column IOE data input to combinatorial output pin
t_{CLR}	Minimum clear pulse width
t_{PRE}	Minimum preset pulse width
t_{CLKHL}	Minimum clock high or low time

Table 4–23. M4K Block Internal Timing Microparameter Descriptions	
Symbol	**Parameter**
t_{M4KRC}	Synchronous read cycle time
t_{M4KWC}	Synchronous write cycle time
$t_{M4KWERESU}$	Write or read enable setup time before clock
$t_{M4KWEREH}$	Write or read enable hold time after clock
$t_{M4KBESU}$	Byte enable setup time before clock
t_{M4KBEH}	Byte enable hold time after clock
$t_{M4KDATAASU}$	A port data setup time before clock
$t_{M4KDATAAH}$	A port data hold time after clock
$t_{M4KADDRASU}$	A port address setup time before clock
$t_{M4KADDRAH}$	A port address hold time after clock
$t_{M4KDATABSU}$	B port data setup time before clock
$t_{M4KDATABH}$	B port data hold time after clock
$t_{M4KADDRBSU}$	B port address setup time before clock
$t_{M4KADDRBH}$	B port address hold time after clock
$t_{M4KDATACO1}$	Clock-to-output delay when using output registers
$t_{M4KDATACO2}$	Clock-to-output delay without output registers
$t_{M4KCLKHL}$	Minimum clock high or low time
t_{M4KCLR}	Minimum clear pulse width

Table 4–49. Cyclone Maximum Input Clock Rate for Row Pins				
I/O Standard	-6 Speed Grade	-7 Speed Grade	-8 Speed Grade	Unit
LVTTL	464	428	387	MHz
2.5 V	392	302	207	MHz
1.8 V	387	311	252	MHz
1.5 V	387	320	243	MHz
LVCMOS	405	374	333	MHz
SSTL-3 class I	405	356	293	MHz
SSTL-3 class II	414	365	302	MHz
SSTL-2 class I	464	428	396	MHz
SSTL-2 class II	473	432	396	MHz
3.3-V PCI *(1)*	464	428	387	MHz
LVDS	567	549	531	MHz

Note to Tables 4–48 through 4–49:
(1) EP1C3 devices do not support the PCI I/O standard. These parameters are only available on row I/O pins.

Tables 4–50 and 4–51 show the maximum output clock rate for column and row pins in Cyclone devices.

Table 4–50. Cyclone Maximum Output Clock Rate for Column Pins				
I/O Standard	-6 Speed Grade	-7 Speed Grade	-8 Speed Grade	Unit
LVTTL	304	304	304	MHz
2.5 V	220	220	220	MHz
1.8 V	213	213	213	MHz
1.5 V	166	166	166	MHz
LVCMOS	304	304	304	MHz
SSTL-3 class I	100	100	100	MHz
SSTL-3 class II	100	100	100	MHz
SSTL-2 class I	134	134	134	MHz
SSTL-2 class II	134	134	134	MHz
LVDS	320	320	275	MHz

Note to Table 4–50:
(1) EP1C3 devices do not support the PCI I/O standard.

5. Reference and Ordering Information

C51005-1.4

Software

Cyclone® 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 analysis, and device configuration.

For more information about the Quartus II software features, refer to the *Quartus II Handbook*.

The Quartus II software supports the Windows 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 devices are available on the Altera website (www.altera.com) and in the *Cyclone Device Handbook*.

Ordering Information

Figure 5–1 describes the ordering codes for Cyclone devices. For more information about a specific package, refer to the *Package Information for Cyclone Devices* chapter in the *Cyclone Device Handbook*.