



Welcome to [E-XFL.COM](https://www.e-xfl.com)

### **Understanding Embedded - FPGAs (Field Programmable Gate Array)**

Embedded - FPGAs, or Field Programmable Gate Arrays, are advanced integrated circuits that offer unparalleled flexibility and performance for digital systems. Unlike traditional fixed-function logic devices, FPGAs can be programmed and reprogrammed to execute a wide array of logical operations, enabling customized functionality tailored to specific applications. This reprogrammability allows developers to iterate designs quickly and implement complex functions without the need for custom hardware.

### **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	132
Number of Logic Elements/Cells	1320
Total RAM Bits	-
Number of I/O	171
Number of Gates	16000
Voltage - Supply	3V ~ 3.6V
Mounting Type	Surface Mount
Operating Temperature	0°C ~ 85°C (TJ)
Package / Case	208-BFQFP
Supplier Device Package	208-PQFP (28x28)
Purchase URL	<a href="https://www.e-xfl.com/product-detail/intel/epf6016aqc208-3">https://www.e-xfl.com/product-detail/intel/epf6016aqc208-3</a>

## ...and More Features

- Powerful I/O pins
  - Individual tri-state output enable control for each pin
  - Programmable output slew-rate control to reduce switching noise
  - Fast path from register to I/O pin for fast clock-to-output time
- Flexible interconnect
  - FastTrack<sup>®</sup> Interconnect continuous routing structure for fast, predictable interconnect delays
  - Dedicated carry chain that implements arithmetic functions such as fast adders, counters, and comparators (automatically used by software tools and megafunctions)
  - Dedicated cascade chain that implements high-speed, high-fan-in logic functions (automatically used by software tools and megafunctions)
  - Tri-state emulation that implements internal tri-state networks
  - Four low-skew global paths for clock, clear, preset, or logic signals
- Software design support and automatic place-and-route provided by Altera’s development system for Windows-based PCs, Sun SPARCstations, and HP 9000 Series 700/800
- Flexible package options
  - Available in a variety of packages with 100 to 256 pins, including the innovative FineLine BGA<sup>™</sup> packages (see [Table 2](#))
  - SameFrame<sup>™</sup> pin-compatibility (with other FLEX<sup>®</sup> 6000 devices) across device densities and pin counts
  - Thin quad flat pack (TQFP), plastic quad flat pack (PQFP), and ball-grid array (BGA) packages (see [Table 2](#))
  - Footprint- and pin-compatibility with other FLEX 6000 devices in the same package
- Additional design entry and simulation support provided by EDIF 2 0 0 and 3 0 0 netlist files, the library of parameterized modules (LPM), Verilog HDL, VHDL, DesignWare components, and other interfaces to popular EDA tools from manufacturers such as Cadence, Exemplar Logic, Mentor Graphics, OrCAD, Synopsys, Synplicity, VeriBest, and Viewlogic

Device	100-Pin TQFP	100-Pin FineLine BGA	144-Pin TQFP	208-Pin PQFP	240-Pin PQFP	256-Pin BGA	256-pin FineLine BGA
EPF6010A	71		102				
EPF6016			117	171	199	204	
EPF6016A	81	81	117	171			171
EPF6024A			117	171	199	218	219

### *Carry Chain*

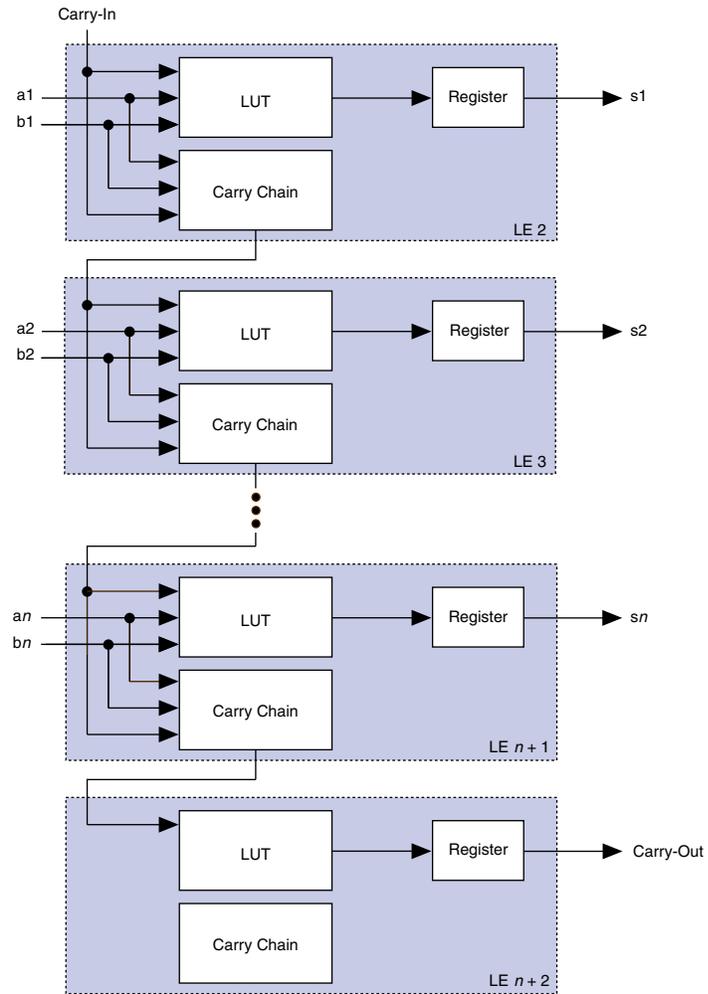
The carry chain provides a very fast (0.1 ns) carry-forward function between LEs. The carry-in signal from a lower-order bit drives forward into the higher-order bit via the carry chain, and feeds into both the LUT and the next portion of the carry chain. This feature allows the FLEX 6000 architecture to implement high-speed counters, adders, and comparators of arbitrary width. Carry chain logic can be created automatically by the Altera software during design processing, or manually by the designer during design entry. Parameterized functions such as LPM and DesignWare functions automatically take advantage of carry chains for the appropriate functions.

Because the first LE of each LAB can generate control signals for that LAB, the first LE in each LAB is not included in carry chains. In addition, the inputs of the first LE in each LAB may be used to generate synchronous clear and load enable signals for counters implemented with carry chains.

Carry chains longer than nine LEs are implemented automatically by linking LABs together. For enhanced fitting, a long carry chain skips alternate LABs in a row. A carry chain longer than one LAB skips either from an even-numbered LAB to another even-numbered LAB, or from an odd-numbered LAB to another odd-numbered LAB. For example, the last LE of the first LAB in a row carries to the second LE of the third LAB in the row. In addition, the carry chain does not cross the middle of the row. For instance, in the EPF6016 device, the carry chain stops at the 11th LAB in a row and a new carry chain begins at the 12th LAB.

Figure 5 shows how an  $n$ -bit full adder can be implemented in  $n + 1$  LEs with the carry chain. One portion of the LUT generates the sum of two bits using the input signals and the carry-in signal; the sum is routed to the output of the LE. Although the register can be bypassed for simple adders, it can be used for an accumulator function. Another portion of the LUT and the carry chain logic generates the carry-out signal, which is routed directly to the carry-in signal of the next-higher-order bit. The final carry-out signal is routed to an LE, where it is driven onto the FastTrack Interconnect.

Figure 5. Carry Chain Operation



### *Cascade Chain*

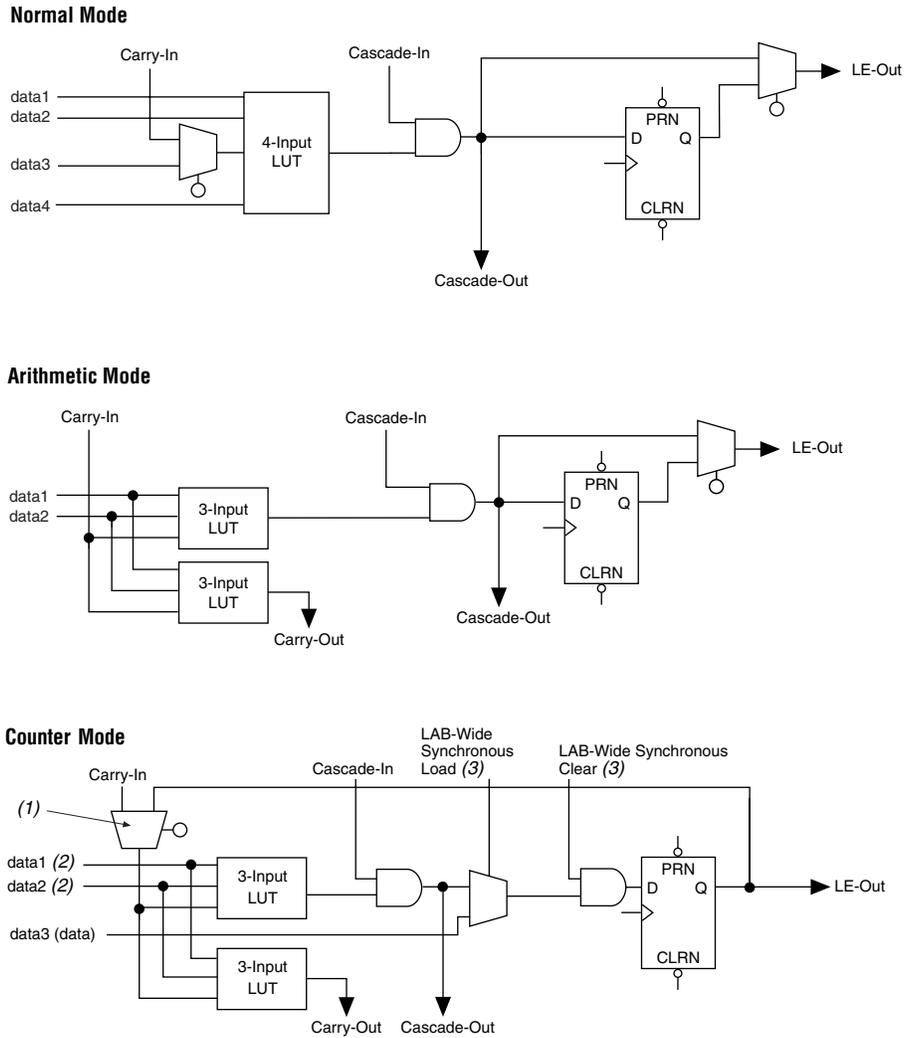
The cascade chain enables the FLEX 6000 architecture to implement very wide fan-in functions. Adjacent LUTs can be used to implement portions of the function in parallel; the cascade chain serially connects the intermediate values. The cascade chain can use a logical AND or logical OR gate (via De Morgan's inversion) to connect the outputs of adjacent LEs. Each additional LE provides four more inputs to the effective width of a function, with a delay as low as 0.5 ns per LE. Cascade chain logic can be created automatically by the Altera software during design processing, or manually by the designer during design entry. Parameterized functions such as LPM and DesignWare functions automatically take advantage of cascade chains for the appropriate functions.

A cascade chain implementing an AND gate can use the register in the last LE; a cascade chain implementing an OR gate cannot use this register because of the inversion required to implement the OR gate.

Because the first LE of an LAB can generate control signals for that LAB, the first LE in each LAB is not included in cascade chains. Moreover, cascade chains longer than nine bits are automatically implemented by linking several LABs together. For easier routing, a long cascade chain skips every other LAB in a row. A cascade chain longer than one LAB skips either from an even-numbered LAB to another even-numbered LAB, or from an odd-numbered LAB to another odd-numbered LAB. For example, the last LE of the first LAB in a row cascades to the second LE of the third LAB. The cascade chain does not cross the center of the row. For example, in an EPF6016 device, the cascade chain stops at the 11th LAB in a row and a new cascade chain begins at the 12th LAB.

Figure 6 shows how the cascade function can connect adjacent LEs to form functions with a wide fan-in. In this example, functions of  $4n$  variables are implemented with  $n$  LEs. The cascade chain requires 3.4 ns to decode a 16-bit address.

Figure 7. LE Operating Modes



**Notes:**

- (1) The register feedback multiplexer is available on LE 2 of each LAB.
- (2) The data1 and data2 input signals can supply a clock enable, up or down control, or register feedback signals for all LEs other than the second LE in an LAB.
- (3) The LAB-wide synchronous clear and LAB-wide synchronous load affect all registers in an LAB.

Either the counter enable or the up/down control may be used for a given counter. Moreover, the synchronous load can be used as a count enable by routing the register output into the data input automatically when requested by the designer.

The second LE of each LAB has a special function for counter mode; the carry-in of the LE can be driven by a fast feedback path from the register. This function gives a faster counter speed for counter carry chains starting in the second LE of an LAB.

The Altera software implements functions to use the counter mode automatically where appropriate. The designer does not have to decide how the carry chain will be used.

#### *Internal Tri-State Emulation*

Internal tri-state emulation provides internal tri-states without the limitations of a physical tri-state bus. In a physical tri-state bus, the tri-state buffers' output enable (OE) signals select which signal drives the bus. However, if multiple OE signals are active, contending signals can be driven onto the bus. Conversely, if no OE signals are active, the bus will float. Internal tri-state emulation resolves contending tri-state buffers to a low value and floating buses to a high value, thereby eliminating these problems. The Altera software automatically implements tri-state bus functionality with a multiplexer.

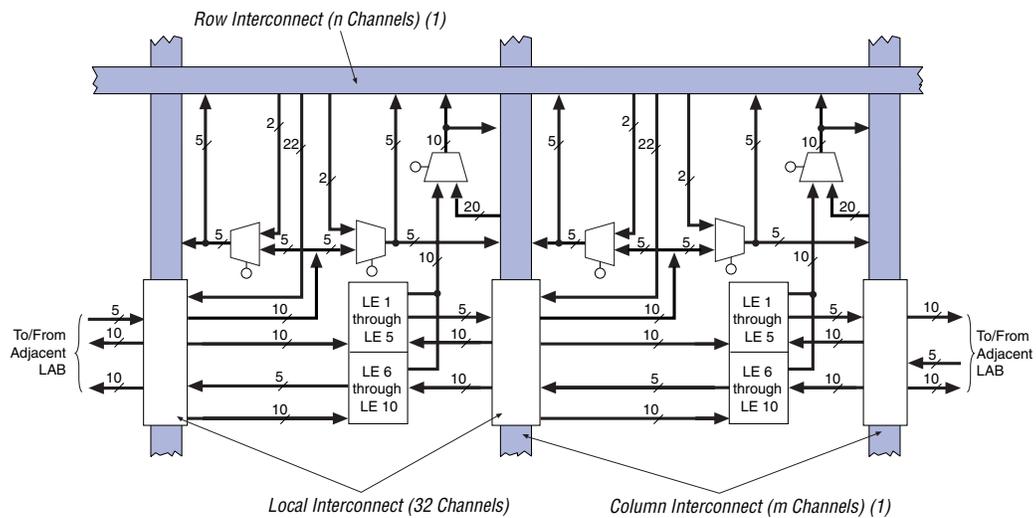
#### *Clear & Preset Logic Control*

Logic for the programmable register's clear and preset functions is controlled by the LAB-wide signals LABCTRL1 and LABCTRL2. The LE register has an asynchronous clear that can implement an asynchronous preset. Either LABCTRL1 or LABCTRL2 can control the asynchronous clear or preset. Because the clear and preset functions are active-low, the Altera software automatically assigns a logic high to an unused clear or preset signal. The clear and preset logic is implemented in either the asynchronous clear or asynchronous preset mode, which is chosen during design entry (see [Figure 8](#)).

The FastTrack Interconnect consists of column and row interconnect channels that span the entire device. Each row of LABs is served by a dedicated row interconnect, which routes signals between LABs in the same row, and also routes signals from I/O pins to LABs. Additionally, the local interconnect routes signals between LEs in the same LAB and in adjacent LABs. The column interconnect routes signals between rows and routes signals from I/O pins to rows.

LEs 1 through 5 of an LAB drive the local interconnect to the right, while LEs 6 through 10 drive the local interconnect to the left. The DATA1 and DATA3 inputs of each LE are driven by the local interconnect to the left; DATA2 and DATA4 are driven by the local interconnect to the right. The local interconnect also routes signals from LEs to I/O pins. Figure 9 shows an overview of the FLEX 6000 interconnect architecture. LEs in the first and last columns have drivers on both sides so that all LEs in the LAB can drive I/O pins via the local interconnect.

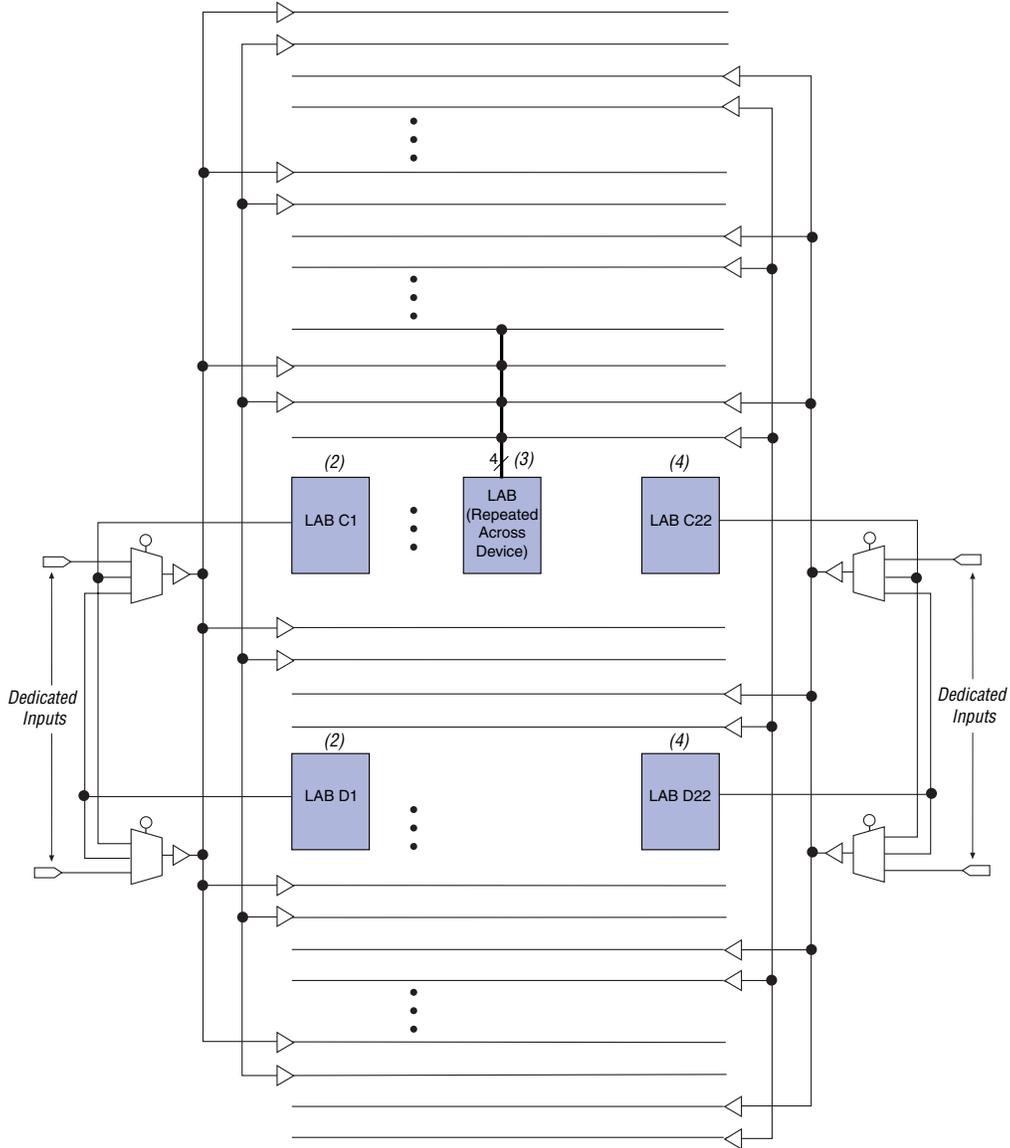
Figure 9. FastTrack Interconnect Architecture



Note:

- (1) For EPF6010A, EPF6016, and EPF6016A devices,  $n = 144$  channels and  $m = 20$  channels; for EPF6024A devices,  $n = 186$  channels and  $m = 30$  channels.

Figure 11. Global Clock & Clear Distribution *Note (1)*



**Notes:**

- (1) The global clock and clear distribution signals are shown for EPF6016 and EPF6016A devices. In EPF6010A devices, LABs in rows B and C drive global signals. In EPF6024A devices, LABs in rows C and E drive global signals.
- (2) The local interconnect from LABs C1 and D1 can drive two global control signals on the left side.
- (3) Global signals drive into every LAB as clock, asynchronous clear, preset, and data signals.
- (4) The local interconnect from LABs C22 and D22 can drive two global control signals on the right side.

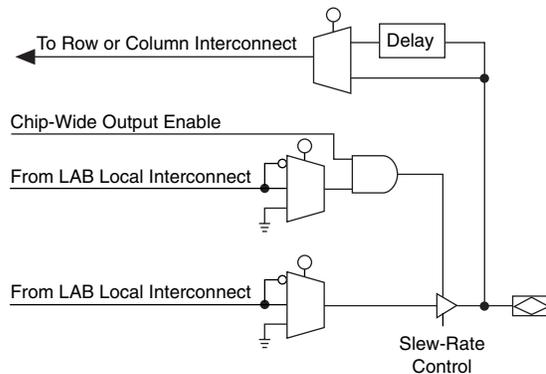
## I/O Elements

An IOE contains a bidirectional I/O buffer and a tri-state buffer. IOEs can be used as input, output, or bidirectional pins. An IOE receives its data signals from the adjacent local interconnect, which can be driven by a row or column interconnect (allowing any LE in the device to drive the IOE) or by an adjacent LE (allowing fast clock-to-output delays). A FastFLEX™ I/O pin is a row or column output pin that receives its data signals from the adjacent local interconnect driven by an adjacent LE. The IOE receives its output enable signal through the same path, allowing individual output enables for every pin and permitting emulation of open-drain buffers. The Altera Compiler uses programmable inversion to invert the data or output enable signals automatically where appropriate. Open-drain emulation is provided by driving the data input low and toggling the OE of each IOE. This emulation is possible because there is one OE per pin.

A chip-wide output enable feature allows the designer to disable all pins of the device by asserting one pin (DEV\_OE). This feature is useful during board debugging or testing.

Figure 12 shows the IOE block diagram.

**Figure 12. IOE Block Diagram**



## MultiVolt I/O Interface

The FLEX 6000 device architecture supports the MultiVolt I/O interface feature, which allows FLEX 6000 devices to interface with systems of differing supply voltages. The EPF6016 device can be set for 3.3-V or 5.0-V I/O pin operation. This device has one set of  $V_{CC}$  pins for internal operation and input buffers ( $V_{CCINT}$ ), and another set for output drivers ( $V_{CCIO}$ ).

The  $V_{CCINT}$  pins on 5.0-V FLEX 6000 devices must always be connected to a 5.0-V power supply. With a 5.0-V  $V_{CCINT}$  level, input voltages are at TTL levels and are therefore compatible with 3.3-V and 5.0-V inputs.

The  $V_{CCIO}$  pins on 5.0-V FLEX 6000 devices can be connected to either a 3.3-V or 5.0-V power supply, depending on the output requirements. When the  $V_{CCIO}$  pins are connected to a 5.0-V power supply, the output levels are compatible with 5.0-V systems. When the  $V_{CCIO}$  pins are connected to a 3.3-V power supply, the output high is 3.3 V and is therefore compatible with 3.3-V or 5.0-V systems. Devices operating with  $V_{CCIO}$  levels lower than 4.75 V incur a nominally greater timing delay of  $t_{OD2}$  instead of  $t_{OD1}$ .

On 3.3-V FLEX 6000 devices, the  $V_{CCINT}$  pins must be connected to a 3.3-V power supply. Additionally, 3.3-V FLEX 6000A devices can interface with 2.5-V, 3.3-V, or 5.0-V systems when the  $V_{CCIO}$  pins are tied to 2.5 V. The output can drive 2.5-V systems, and the inputs can be driven by 2.5-V, 3.3-V, or 5.0-V systems. When the  $V_{CCIO}$  pins are tied to 3.3 V, the output can drive 3.3-V or 5.0-V systems. MultiVolt I/Os are not supported on 100-pin TQFP or 100-pin FineLine BGA packages.

Table 7 describes FLEX 6000 MultiVolt I/O support.

$V_{CCINT}$ (V)	$V_{CCIO}$ (V)	Input Signal (V)			Output Signal (V)		
		2.5	3.3	5.0	2.5	3.3	5.0
3.3	2.5	v	v	v	v		
3.3	3.3	v	v	v	v (1)	v	v
5.0	3.3		v	v		v	v
5.0	5.0		v	v			v

**Note:**

- (1) When  $V_{CCIO} = 3.3$  V, a FLEX 6000 device can drive a 2.5-V device that has 3.3-V tolerant inputs.

Open-drain output pins on 5.0-V or 3.3-V FLEX 6000 devices (with a pull-up resistor to the 5.0-V supply) can drive 5.0-V CMOS input pins that require a  $V_{IH}$  of 3.5 V. When the open-drain pin is active, it will drive low. When the pin is inactive, the trace will be pulled up to 5.0 V by the resistor. The open-drain pin will only drive low or tri-state; it will never drive high. The rise time is dependent on the value of the pull-up resistor and load impedance. The  $I_{OL}$  current specification should be considered when selecting a pull-up resistor.

Output pins on 5.0-V FLEX 6000 devices with  $V_{CCIO} = 3.3$  V or 5.0 V (with a pull-up resistor to the 5.0-V supply) can also drive 5.0-V CMOS input pins. In this case, the pull-up transistor will turn off when the pin voltage exceeds 3.3 V. Therefore, the pin does not have to be open-drain.

### Power Sequencing & Hot-Socketing

Because FLEX 6000 family devices can be used in a mixed-voltage environment, they have been designed specifically to tolerate any possible power-up sequence. The  $V_{CCIO}$  and  $V_{CCINT}$  power planes can be powered in any order.

Signals can be driven into 3.3-V FLEX 6000 devices before and during power up without damaging the device. Additionally, FLEX 6000 devices do not drive out during power up. Once operating conditions are reached, FLEX 6000 devices operate as specified by the user.

## IEEE Std. 1149.1 (JTAG) Boundary-Scan Support

All FLEX 6000 devices provide JTAG BST circuitry that comply with the IEEE Std. 1149.1-1990 specification. Table 8 shows JTAG instructions for FLEX 6000 devices. JTAG BST can be performed before or after configuration, but not during configuration (except when you disable JTAG support in user mode).

- 1 See *Application Note 39 (IEEE 1149.1 (JTAG) Boundary-Scan Testing in Altera Devices)* for more information on JTAG BST circuitry.

JTAG Instruction	Description
SAMPLE/PRELOAD	Allows a snapshot of the signals at the device pins to be captured and examined during normal device operation, and permits an initial data pattern to be output at the device pins.
EXTEST	Allows the external circuitry and board-level interconnections to be tested by forcing a test pattern at the output pins and capturing test result at the input pins.
BYPASS	Places the 1-bit bypass register between the TDI and TDO pins, which allows the BST data to pass synchronously through the selected device to adjacent devices during normal device operation.

**Table 10. JTAG Timing Parameters & Values**

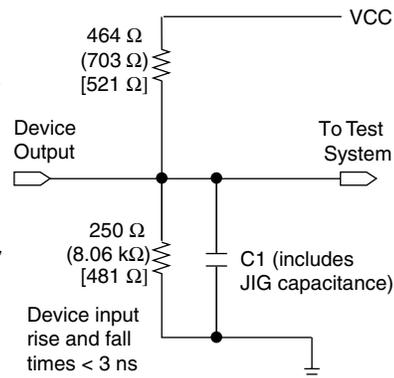
Symbol	Parameter	Min	Max	Unit
$t_{JCP}$	TCK clock period	100		ns
$t_{JCH}$	TCK clock high time	50		ns
$t_{JCL}$	TCK clock low time	50		ns
$t_{JPSU}$	JTAG port setup time	20		ns
$t_{JPH}$	JTAG port hold time	45		ns
$t_{JPCO}$	JTAG port clock-to-output		25	ns
$t_{JPZX}$	JTAG port high impedance to valid 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

## Generic Testing

Each FLEX 6000 device is functionally tested. Complete testing of each configurable SRAM bit and all logic functionality ensures 100% configuration yield. AC test measurements for FLEX 6000 devices are made under conditions equivalent to those shown in [Figure 17](#). Multiple test patterns can be used to configure devices during all stages of the production flow.

**Figure 17. AC Test Conditions**

Power supply transients can affect AC measurements. Simultaneous transitions of multiple outputs should be avoided for accurate measurement. Threshold tests must not be performed under AC conditions. Large-amplitude, fast-ground-current transients normally occur as the device outputs discharge the load capacitances. When these transients flow through the parasitic inductance between the device ground pin and the test system ground, significant reductions in observable noise immunity can result. Numbers without parentheses are for 5.0-V devices or outputs. Numbers in parentheses are for 3.3-V devices or outputs. Numbers in brackets are for 2.5-V devices or outputs.



**Table 13. FLEX 6000 5.0-V Device DC Operating Conditions** Notes (5), (6)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>IH</sub>	High-level input voltage		2.0		V <sub>CCINT</sub> + 0.5	V
V <sub>IL</sub>	Low-level input voltage		-0.5		0.8	V
V <sub>OH</sub>	5.0-V high-level TTL output voltage	I <sub>OH</sub> = -8 mA DC, V <sub>CCIO</sub> = 4.75 V (7)	2.4			V
	3.3-V high-level TTL output voltage	I <sub>OH</sub> = -8 mA DC, V <sub>CCIO</sub> = 3.00 V (7)	2.4			V
	3.3-V high-level CMOS output voltage	I <sub>OH</sub> = -0.1 mA DC, V <sub>CCIO</sub> = 3.00 V (7)	V <sub>CCIO</sub> - 0.2			V
V <sub>OL</sub>	5.0-V low-level TTL output voltage	I <sub>OL</sub> = 8 mA DC, V <sub>CCIO</sub> = 4.75 V (8)			0.45	V
	3.3-V low-level TTL output voltage	I <sub>OL</sub> = 8 mA DC, V <sub>CCIO</sub> = 3.00 V (8)			0.45	V
	3.3-V low-level CMOS output voltage	I <sub>OL</sub> = 0.1 mA DC, V <sub>CCIO</sub> = 3.00 V (8)			0.2	V
I <sub>I</sub>	Input pin leakage current	V <sub>I</sub> = V <sub>CC</sub> or ground (8)	-10		10	μA
I <sub>OZ</sub>	Tri-stated I/O pin leakage current	V <sub>O</sub> = V <sub>CC</sub> or ground (8)	-40		40	μA
I <sub>CC0</sub>	V <sub>CC</sub> supply current (standby)	V <sub>I</sub> = ground, no load		0.5	5	mA

**Table 14. FLEX 6000 5.0-V Device Capacitance** Note (9)

Symbol	Parameter	Conditions	Min	Max	Unit
C <sub>IN</sub>	Input capacitance for I/O pin	V <sub>IN</sub> = 0 V, f = 1.0 MHz		8	pF
C <sub>INCLK</sub>	Input capacitance for dedicated input	V <sub>IN</sub> = 0 V, f = 1.0 MHz		12	pF
C <sub>OUT</sub>	Output capacitance	V <sub>OUT</sub> = 0 V, f = 1.0 MHz		8	pF

**Notes to tables:**

- (1) See the *Operating Requirements for Altera Devices Data Sheet*.
- (2) Minimum DC input is -0.5 V. During transitions, the inputs may undershoot to -2.0 V or overshoot to 7.0 V for input currents less than 100 mA and periods shorter than 20 ns.
- (3) Numbers in parentheses are for industrial-temperature-range devices.
- (4) Maximum V<sub>CC</sub> rise time to 100 ms. V<sub>CC</sub> must rise monotonically.
- (5) Typical values are for T<sub>A</sub> = 25° C and V<sub>CC</sub> = 5.0 V.
- (6) These values are specified under the FLEX 6000 Recommended Operating Conditions shown in Table 12 on page 31.
- (7) The I<sub>OH</sub> parameter refers to high-level TTL or CMOS output current.
- (8) The I<sub>OL</sub> parameter refers to low-level TTL, PCI, or CMOS output current. This parameter applies to open-drain pins as well as output pins.
- (9) Capacitance is sample-tested only.

**Table 15. FLEX 6000 3.3-V Device Absolute Maximum Ratings** *Note (1)*

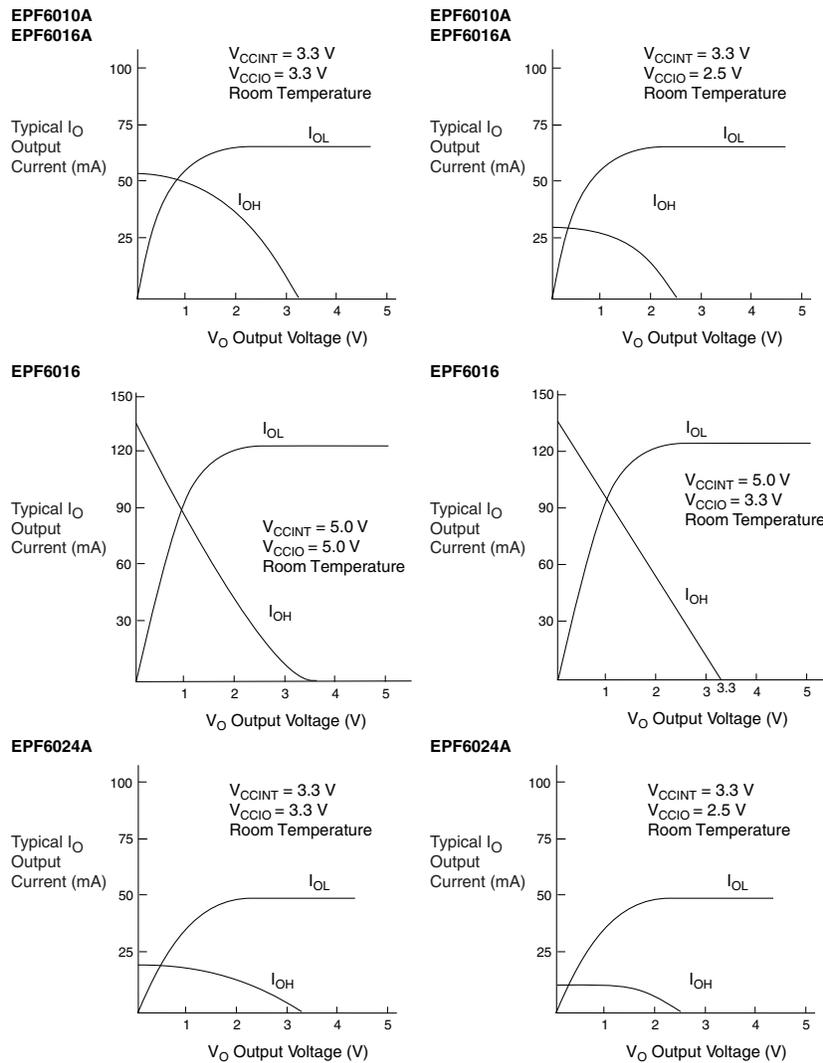
Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>CC</sub>	Supply voltage	With respect to ground (2)	-0.5	4.6	V
V <sub>I</sub>	DC input voltage		-2.0	5.75	V
I <sub>OUT</sub>	DC output current, per pin		-25	25	mA
T <sub>STG</sub>	Storage temperature	No bias	-65	150	°C
T <sub>AMB</sub>	Ambient temperature	Under bias	-65	135	°C
T <sub>J</sub>	Junction temperature	PQFP, PLCC, and BGA packages		135	°C

**Table 16. FLEX 6000 3.3-V Device Recommended Operating Conditions**

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>CCINT</sub>	Supply voltage for internal logic and input buffers	(3), (4)	3.00 (3.00)	3.60 (3.60)	V
V <sub>CCIO</sub>	Supply voltage for output buffers, 3.3-V operation	(3), (4)	3.00 (3.00)	3.60 (3.60)	V
	Supply voltage for output buffers, 2.5-V operation	(3), (4)	2.30 (2.30)	2.70 (2.70)	V
V <sub>I</sub>	Input voltage		-0.5	5.75	V
V <sub>O</sub>	Output voltage		0	V <sub>CCIO</sub>	V
T <sub>J</sub>	Operating temperature	For commercial use	0	85	°C
		For industrial use	-40	100	°C
t <sub>R</sub>	Input rise time			40	ns
t <sub>F</sub>	Input fall time			40	ns

Figure 18 shows the typical output drive characteristics of 5.0-V and 3.3-V FLEX 6000 devices with 5.0-V, 3.3-V, and 2.5-V  $V_{CCIO}$ . When  $V_{CCIO} = 5.0$  V on EPF6016 devices, the output driver is compliant with the *PCI Local Bus Specification, Revision 2.2* for 5.0-V operation. When  $V_{CCIO} = 3.3$  V on the EPF6010A and EPF6016A devices, the output driver is compliant with the *PCI Local Bus Specification, Revision 2.2* for 3.3-V operation.

Figure 18. Output Drive Characteristics





Parameter	Speed Grade						Unit
	-1		-2		-3		
	Min	Max	Min	Max	Min	Max	
$t_{CO}$		0.3		0.4		0.4	ns
$t_{CLR}$		0.4		0.4		0.5	ns
$t_C$		1.8		2.1		2.6	ns
$t_{LD\_CLR}$		1.8		2.1		2.6	ns
$t_{CARRY\_TO\_CARRY}$		0.1		0.1		0.1	ns
$t_{REG\_TO\_CARRY}$		1.6		1.9		2.3	ns
$t_{DATA\_TO\_CARRY}$		2.1		2.5		3.0	ns
$t_{CARRY\_TO\_CASC}$		1.0		1.1		1.4	ns
$t_{CASC\_TO\_CASC}$		0.5		0.6		0.7	ns
$t_{REG\_TO\_CASC}$		1.4		1.7		2.1	ns
$t_{DATA\_TO\_CASC}$		1.1		1.2		1.5	ns
$t_{CH}$	2.5		3.0		3.5		ns
$t_{CL}$	2.5		3.0		3.5		ns

Parameter	Speed Grade						Unit
	-1		-2		-3		
	Min	Max	Min	Max	Min	Max	
$t_{OD1}$		1.9		2.2		2.7	ns
$t_{OD2}$		4.1		4.8		5.8	ns
$t_{OD3}$		5.8		6.8		8.3	ns
$t_{XZ}$		1.4		1.7		2.1	ns
$t_{XZ1}$		1.4		1.7		2.1	ns
$t_{XZ2}$		3.6		4.3		5.2	ns
$t_{XZ3}$		5.3		6.3		7.7	ns
$t_{IOE}$		0.5		0.6		0.7	ns
$t_{IN}$		3.6		4.1		5.1	ns
$t_{IN\_DELAY}$		4.8		5.4		6.7	ns

**Table 30. IOE Timing Microparameters for EPF6016 Devices**

Parameter	Speed Grade				Unit
	-2		-3		
	Min	Max	Min	Max	
$t_{OD3}$		4.7		5.2	ns
$t_{XZ}$		2.3		2.8	ns
$t_{ZX1}$		2.3		2.8	ns
$t_{ZX2}$		4.6		5.1	ns
$t_{ZX3}$		4.7		5.2	ns
$t_{IOE}$		0.5		0.6	ns
$t_{IN}$		3.3		4.0	ns
$t_{IN\_DELAY}$		4.6		5.6	ns

**Table 31. Interconnect Timing Microparameters for EPF6016 Devices**

Parameter	Speed Grade				Unit
	-2		-3		
	Min	Max	Min	Max	
$t_{LOCAL}$		0.8		1.0	ns
$t_{ROW}$		2.9		3.3	ns
$t_{COL}$		2.3		2.5	ns
$t_{DIN\_D}$		4.9		6.0	ns
$t_{DIN\_C}$		4.8		6.0	ns
$t_{LEGLOBAL}$		3.1		3.9	ns
$t_{LABCARRY}$		0.4		0.5	ns
$t_{LABCASC}$		0.8		1.0	ns

**Table 32. External Reference Timing Parameters for EPF6016 Devices**

Parameter	Speed Grade				Unit
	-2		-3		
	Min	Max	Min	Max	
$t_1$		53.0		65.0	ns
$t_{DRR}$		16.0		20.0	ns

## Operating Modes

The FLEX 6000 architecture uses SRAM configuration elements that require configuration data to be loaded every time the circuit powers up. This process of physically loading the SRAM data into a FLEX 6000 device is known as configuration. During initialization—a process that occurs immediately after configuration—the device resets registers, enables I/O pins, and begins to operate as a logic device. The I/O pins are tri-stated during power-up, and before and during configuration. The configuration and initialization processes of a device are referred to as *command mode*; normal device operation is called *user mode*.

SRAM configuration elements allow FLEX 6000 devices to be reconfigured in-circuit by loading new configuration data into the device. Real-time reconfiguration is performed by forcing the device into command mode with a device pin, loading different configuration data, reinitializing the device, and resuming user-mode operation. The entire reconfiguration process requires less than 100 ms and is used to dynamically reconfigure an entire system. Also, in-field system upgrades can be performed by distributing new configuration files.

## Configuration Schemes

The configuration data for a FLEX 6000 device can be loaded with one of three configuration schemes, which is chosen on the basis of the target application. An EPC1 or EPC1441 configuration device or intelligent controller can be used to control the configuration of a FLEX 6000 device, allowing automatic configuration on system power-up.

Multiple FLEX 6000 devices can be configured in any of the three configuration schemes by connecting the configuration enable input (nCE) and configuration enable output (nCEO) pins on each device.

Table 40 shows the data sources for each configuration scheme.

<b>Configuration Scheme</b>	<b>Data Source</b>
Configuration device	EPC1 or EPC1441 configuration device
Passive serial (PS)	BitBlaster™, ByteBlasterMV™, or MasterBlaster™ download cables, or serial data source
Passive serial asynchronous (PSA)	BitBlaster, ByteBlasterMV, or MasterBlaster download cables, or serial data source

## Device Pin-Outs

See the Altera web site (<http://www.altera.com>) or the *Altera Digital Library* for pin-out information.