



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	832
Number of Logic Elements/Cells	8320
Total RAM Bits	106496
Number of I/O	271
Number of Gates	526000
Voltage - Supply	1.71V ~ 1.89V
Mounting Type	Surface Mount
Operating Temperature	0°C ~ 85°C (TJ)
Package / Case	356-LBGA
Supplier Device Package	356-BGA (35x35)
Purchase URL	https://www.e-xfl.com/product-detail/intel/ep20k200cb356c7

...and More Features

- Low-power operation design
 - 1.8-V supply voltage (see [Table 2](#))
 - Copper interconnect reduces power consumption
 - MultiVolt™ I/O support for 1.8-V, 2.5-V, and 3.3-V interfaces
 - ESBs offering programmable power-saving mode
- Flexible clock management circuitry with up to four phase-locked loops (PLLs)
 - Built-in low-skew clock tree
 - Up to eight global clock signals
 - ClockLock™ feature reducing clock delay and skew
 - ClockBoost™ feature providing clock multiplication and division
 - ClockShift™ feature providing programmable clock phase and delay shifting
- Powerful I/O features
 - Compliant with peripheral component interconnect Special Interest Group (PCI SIG) *PCI Local Bus Specification, Revision 2.2* for 3.3-V operation at 33 or 66 MHz and 32 or 64 bits
 - Support for high-speed external memories, including DDR synchronous dynamic RAM (SDRAM) and ZBT static RAM (SRAM)
 - 16 input and 16 output LVDS channels at 840 megabits per second (Mbps)
 - Direct connection from I/O pins to local interconnect providing fast t_{CO} and t_{SU} times for complex logic
 - MultiVolt I/O support for 1.8-V, 2.5-V, and 3.3-V interfaces
 - Programmable clamp to V_{CCIO}
 - Individual tri-state output enable control for each pin
 - Programmable output slew-rate control to reduce switching noise
 - Support for advanced I/O standards, including low-voltage differential signaling (LVDS), LVPECL, PCI-X, AGP, CTT, SSTL-3 and SSTL-2, GTL+, and HSTL Class I
 - Supports hot-socketing operation
 - Pull-up on I/O pins before and during configuration

Table 2. APEX 20KC Supply Voltages

Feature	Voltage
Internal supply voltage (V_{CCINT})	1.8 V
MultiVolt I/O interface voltage levels (V_{CCIO})	1.8 V, 2.5 V, 3.3 V, 5.0 V (1)

Note to [Table 2](#):

(1) APEX 20KC devices can be 5.0-V tolerant by using an external resistor.

Table 4. APEX 20KC FineLine BGA Package Options & I/O Count *Notes (1), (2)*

Device	484 Pin	672 Pin	1,020 Pin
EP20K200C	376		
EP20K400C		488 (3)	
EP20K600C		508 (3)	588
EP20K1000C		508 (3)	708

Notes to Tables 3 and 4:

- (1) I/O counts include dedicated input and clock pins.
- (2) APEX 20KC device package types include plastic quad flat pack (PQFP), 1.27-mm pitch ball-grid array (BGA), and 1.00-mm pitch FineLine BGA™ packages.
- (3) This device uses a thermally enhanced package, which is taller than the regular package. Consult the [Altera Device Package Information Data Sheet](#) for detailed package size information.

Table 5. APEX 20KC QFP & BGA Package Sizes

Feature	208-Pin PQFP	240-Pin PQFP	356-Pin BGA	652-Pin BGA
Pitch (mm)	0.50	0.50	1.27	1.27
Area (mm ²)	924	1,218	1,225	2,025
Length × Width (mm × mm)	30.4 × 30.4	34.9 × 34.9	35.0 × 35.0	45.0 × 45.0

Table 6. APEX 20KC FineLine BGA Package Sizes

Feature	484 Pin	672 Pin	1,020 Pin
Pitch (mm)	1.00	1.00	1.00
Area (mm ²)	529	729	1,089
Length × Width (mm × mm)	23 × 23	27 × 27	33 × 33

General Description

Similar to APEX 20K and APEX 20KE devices, APEX 20KC devices offer the MultiCore architecture, which combines the strengths of LUT-based and product-term-based devices with an enhanced memory structure. LUT-based logic provides optimized performance and efficiency for data-path, register-intensive, mathematical, or digital signal processing (DSP) designs. Product-term-based logic is optimized for complex combinatorial paths, such as complex state machines. LUT- and product-term-based logic combined with memory functions and a wide variety of MegaCore and AMPP functions make the APEX 20KC architecture uniquely suited for SOPC designs. Applications historically requiring a combination of LUT-, product-term-, and memory-based devices can now be integrated into one APEX 20KC device.

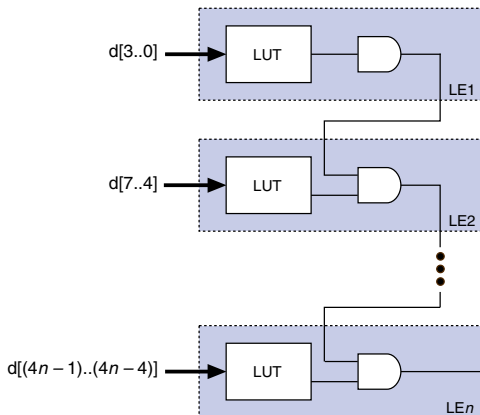
Cascade Chain

With the cascade chain, the APEX 20KC architecture can implement functions with a very wide fan-in. Adjacent LUTs can compute portions of a function in parallel; the cascade chain serially connects the intermediate values. The cascade chain can use a logical AND or logical OR (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 short cascade delay. Cascade chain logic can be created automatically by the Quartus II Compiler during design processing, or manually by the designer during design entry.

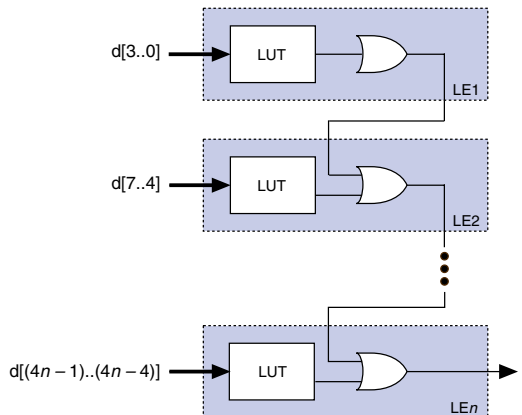
Cascade chains longer than ten LEs are implemented automatically by linking LABs together. For enhanced fitting, a long cascade chain skips alternate LABs in a MegaLAB structure. A cascade chain longer than one LAB skips either from an even-numbered LAB to the next even-numbered LAB, or from an odd-numbered LAB to the next odd-numbered LAB. For example, the last LE of the first LAB in the upper-left MegaLAB structure carries to the first LE of the third LAB in the MegaLAB structure. Figure 7 shows how the cascade function can connect adjacent LEs to form functions with a wide fan-in.

Figure 7. APEX 20KC Cascade Chain

AND Cascade Chain



OR Cascade Chain



LE Operating Modes

The APEX 20KC LE can operate in one of the following three modes:

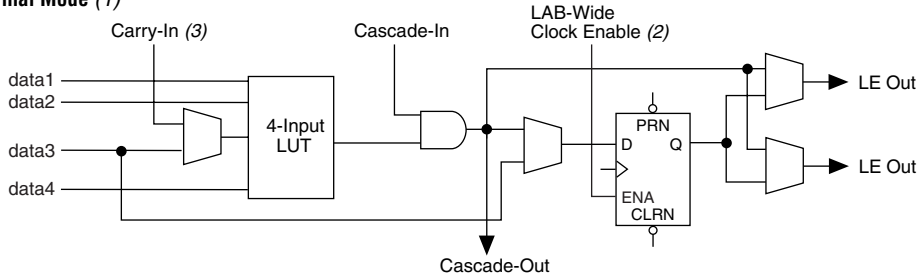
- Normal mode
- Arithmetic mode
- Counter mode

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

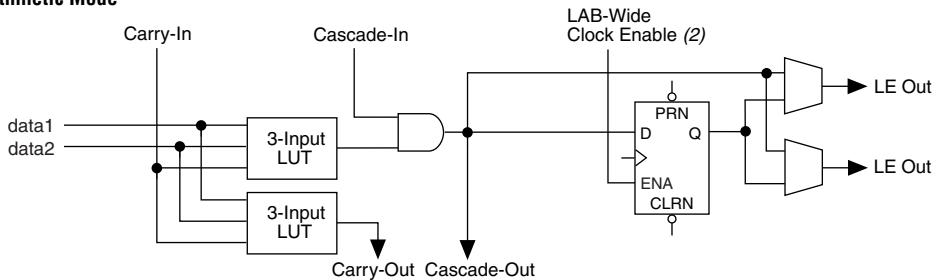
The Quartus II software, in conjunction with parameterized functions such as LPM and DesignWare functions, automatically chooses the appropriate mode for common functions such as counters, adders, and multipliers. If required, the designer can also create special-purpose functions that specify which LE operating mode to use for optimal performance. [Figure 8](#) shows the LE operating modes.

Figure 8. APEX 20KC LE Operating Modes

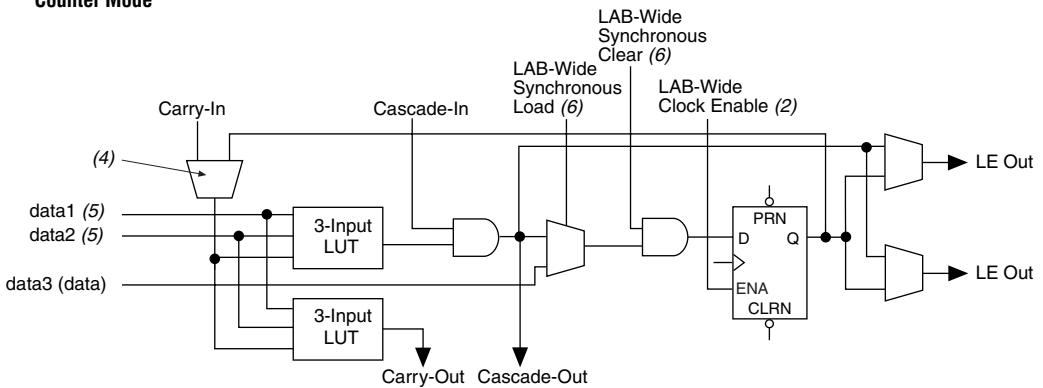
Normal Mode (1)



Arithmetic Mode



Counter Mode



Notes to Figure 8:

- (1) LEs in normal mode support register packing.
- (2) There are two LAB-wide clock enables per LAB.
- (3) When using the carry-in in normal mode, the packed register feature is unavailable.
- (4) A register feedback multiplexer is available on LE1 of each LAB.
- (5) The DATA1 and DATA2 input signals can supply counter enable, up or down control, or register feedback signals for LEs other than the second LE in an LAB.
- (6) The LAB-wide synchronous clear and LAB wide synchronous load affect all registers in an LAB.

The counter mode uses two 3-input LUTs: one generates the counter data, and the other generates the fast carry bit. A 2-to-1 multiplexer provides synchronous loading, and another AND gate provides synchronous clearing. If the cascade function is used by an LE in counter mode, the synchronous clear or load overrides any signal carried on the cascade chain. The synchronous clear overrides the synchronous load. LEs in arithmetic mode can drive out registered and unregistered versions of the LUT output.

Clear & Preset Logic Control

Logic for the register's clear and preset signals is controlled by LAB-wide signals. The LE directly supports an asynchronous clear function. The Quartus II Compiler can use a NOT-gate push-back technique to emulate an asynchronous preset or to emulate simultaneous preset and clear or asynchronous load. However, this technique uses three additional LEs per register. All emulation is performed automatically when the design is compiled. Registers that emulate simultaneous preset and load will enter an unknown state upon power-up or when the chip-wide reset is asserted.

In addition to the two clear and preset modes, APEX 20KC devices provide a chip-wide reset pin (DEV_CLRn) that resets all registers in the device. Use of this pin is controlled through an option in the Quartus II software that is set before compilation. The chip-wide reset overrides all other control signals. Registers using an asynchronous preset are preset when the chip-wide reset is asserted; this effect results from the inversion technique used to implement the asynchronous preset.

FastTrack Interconnect

In the APEX 20KC architecture, connections between LEs, ESBs, and I/O pins are provided by the FastTrack interconnect. The FastTrack interconnect is a series of continuous horizontal and vertical routing channels that traverse the device. This global routing structure provides predictable performance, even in complex designs. In contrast, the segmented routing in FPGAs requires switch matrices to connect a variable number of routing paths, increasing the delays between logic resources and reducing performance.

The FastTrack interconnect consists of row and column interconnect channels that span the entire device. The row interconnect routes signals throughout a row of MegaLAB structures; the column interconnect routes signals throughout a column of MegaLAB structures. When using the row and column interconnect, an LE, IOE, or ESB can drive any other LE, IOE, or ESB in a device. See [Figure 9](#).

Figure 10. FastTrack Connection to Local Interconnect

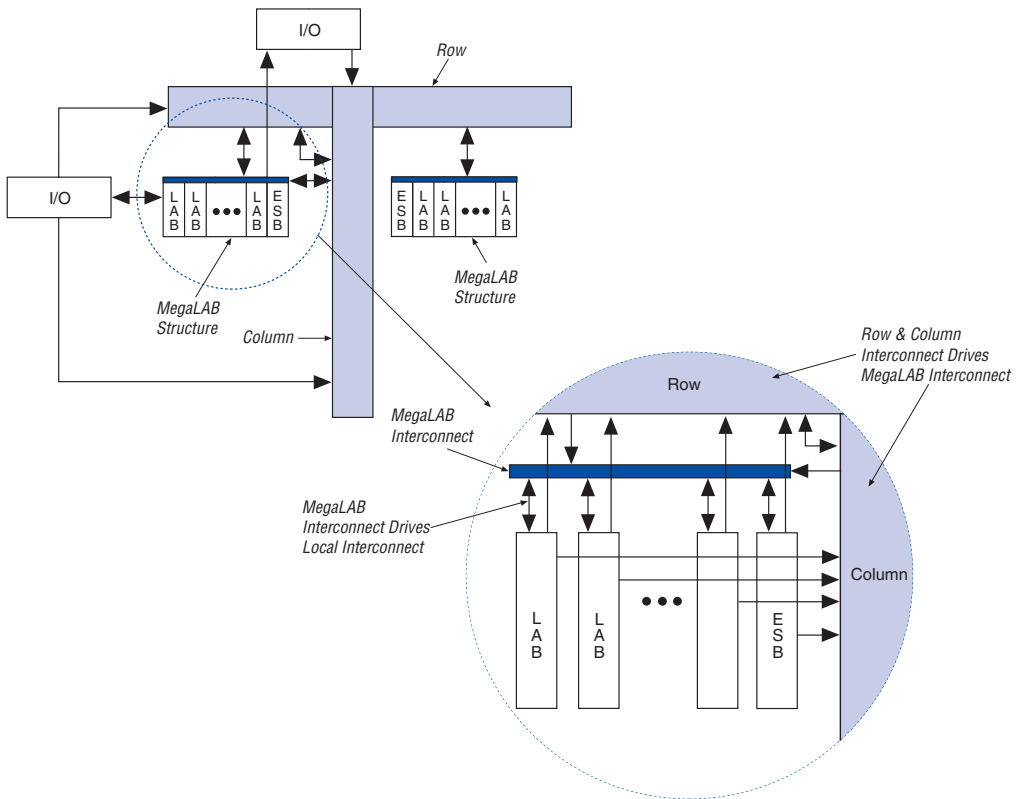


Figure 12. APEX 20KC FastRow Interconnect

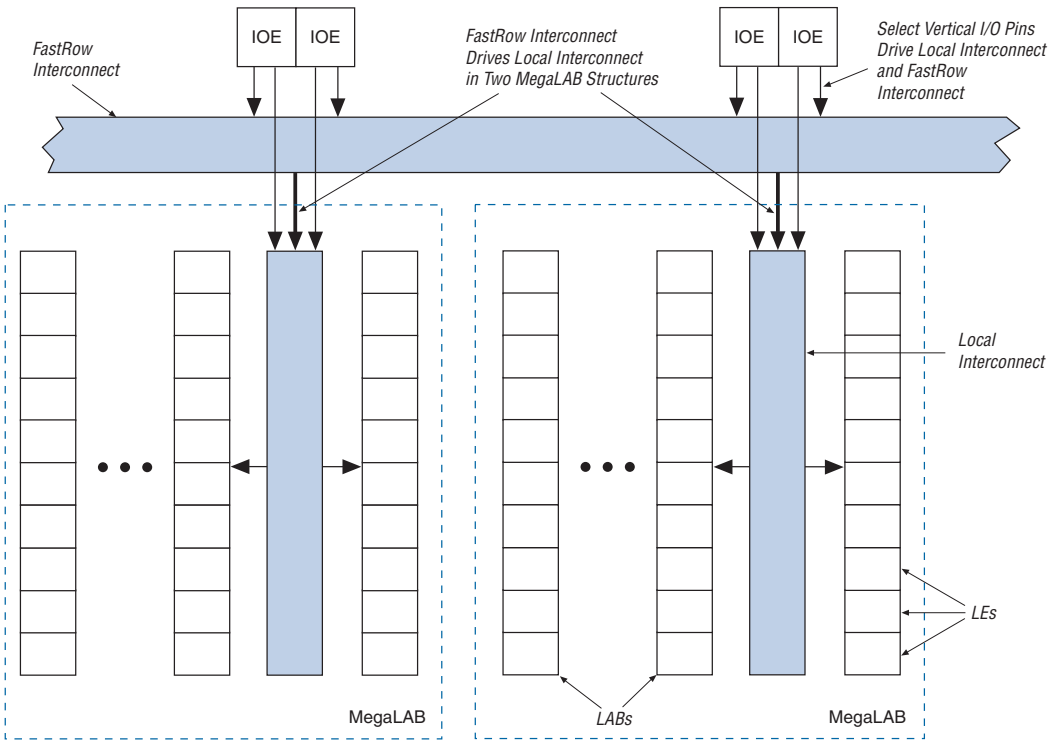
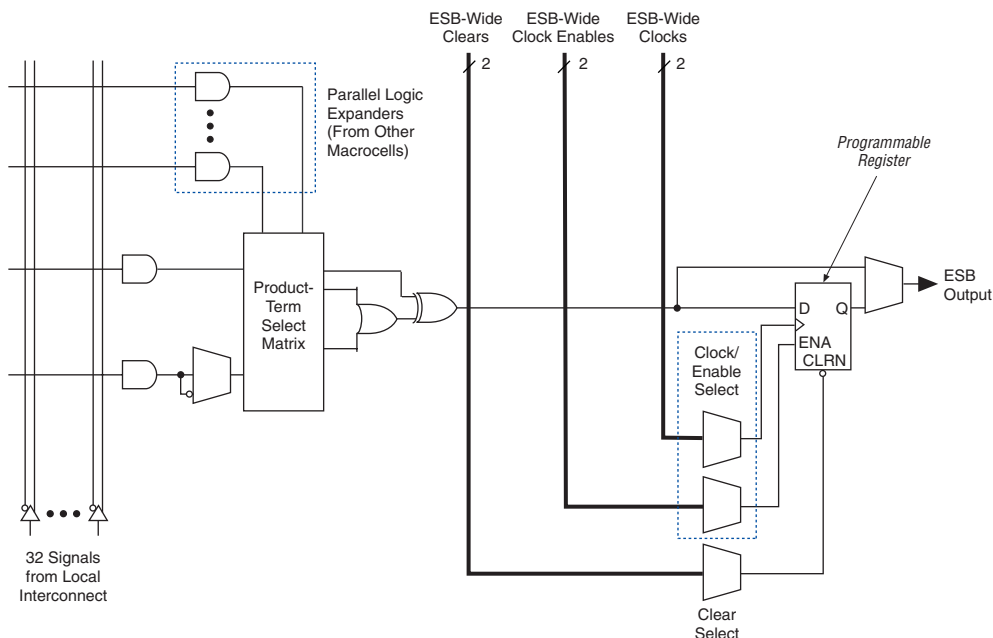


Table 8 summarizes how various elements of the APEX 20KC architecture drive each other.

Figure 14. APEX 20KC Macrocell



For registered functions, each macrocell register can be programmed individually to implement D, T, JK, or SR operation with programmable clock control. The register can be bypassed for combinatorial operation. During design entry, the designer specifies the desired register type; the Quartus II software then selects the most efficient register operation for each registered function to optimize resource utilization. The Quartus II software or other synthesis tools can also select the most efficient register operation automatically when synthesizing HDL designs.

Each programmable register can be clocked by one of two ESB-wide clocks. The ESB-wide clocks can be generated from device dedicated clock pins, global signals, or local interconnect. Each clock also has an associated clock enable, generated from the local interconnect. The clock and clock enable signals are related for a particular ESB; any macrocell using a clock also uses the associated clock enable.

If both the rising and falling edges of a clock are used in an ESB, both ESB-wide clock signals are used.

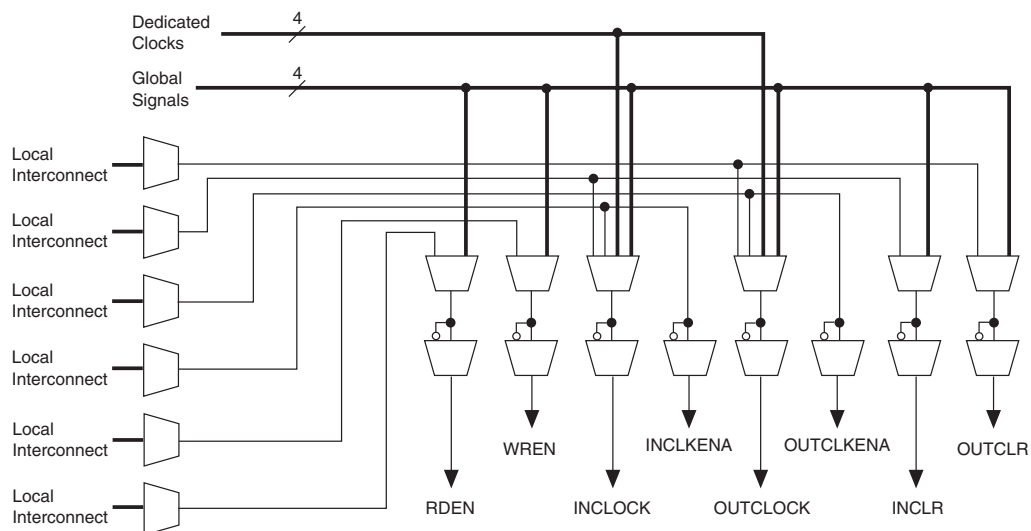


For more information on APEX 20KC devices and CAM, see *Application Note 119 (Implementing High-Speed Search Applications with APEX CAM)*.

Driving Signals to the ESB

ESBs provide flexible options for driving control signals. Different clocks can be used for the ESB inputs and outputs. Registers can be inserted independently on the data input, data output, read address, write address, WE, and RE signals. The global signals and the local interconnect can drive the WE and RE signals. The global signals, dedicated clock pins, and local interconnect can drive the ESB clock signals. Because the LEs drive the local interconnect, the LEs can control the WE and RE signals and the ESB clock, clock enable, and asynchronous clear signals. [Figure 24](#) shows the ESB control signal generation logic.

Figure 24. ESB Control Signal Generation



An ESB is fed by the local interconnect, which is driven by adjacent LEs (for high-speed connection to the ESB) or the MegaLAB interconnect. The ESB can drive the local, MegaLAB, or FastTrack interconnect routing structure to drive LEs and IOEs in the same MegaLAB structure or anywhere in the device.

IEEE Std. 1149.1 (JTAG) Boundary-Scan Support

All APEX 20KC devices provide JTAG BST circuitry that complies with the IEEE Std. 1149.1-1990 specification. JTAG boundary-scan testing can be performed before or after configuration, but not during configuration. APEX 20KC devices can also use the JTAG port for configuration with the Quartus II software or with hardware using either Jam Files (.jam) or Jam Byte-Code Files (.jbc). Finally, APEX 20KC devices use the JTAG port to monitor the logic operation of the device with the SignalTap embedded logic analyzer. APEX 20KC devices support the JTAG instructions shown in [Table 13](#).

Table 13. APEX 20KC JTAG Instructions

JTAG Instruction	Description
SAMPLE/PRELOAD	Allows a snapshot of 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. Also used by the SignalTap embedded logic analyzer.
EXTEST	Allows the external circuitry and board-level interconnections to be tested by forcing a test pattern at the output pins and capturing test results 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 selected devices to adjacent devices during normal device operation.
USERCODE	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	Selects the IDCODE register and places it between TDI and TDO, allowing the IDCODE to be serially shifted out of TDO.
ICR Instructions	Used when configuring an APEX 20KC 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.
SignalTap Instructions	Monitors internal device operation with the SignalTap embedded logic analyzer.

The APEX 20KC device instruction register length is 10 bits. The APEX 20KC device USERCODE register length is 32 bits. [Tables 14 and 15](#) show the boundary-scan register length and device IDCODE information for APEX 20KC devices.

Table 14. APEX 20KC Boundary-Scan Register Length

Device	Boundary-Scan Register Length
EP20K200C	1,164
EP20K400C	1,506
EP20K600C	1,806
EP20K1000C	2,190

Table 15. 32-Bit APEX 20KC Device IDCODE

Device	IDCODE (32 Bits) ⁽¹⁾			
	Version (4 Bits)	Part Number (16 Bits)	Manufacturer Identity (11 Bits)	1 (1 Bit) ⁽²⁾
EP20K200C	0000	1000 0010 0000 0000	000 0110 1110	1
EP20K400C	0000	1000 0100 0000 0000	000 0110 1110	1
EP20K600C	0000	1000 0110 0000 0000	000 0110 1110	1
EP20K1000C	0000	1001 0000 0000 0000	000 0110 1110	1

Notes to Table 15:

- (1) The most significant bit (MSB) is on the left.
- (2) The IDCODE's least significant bit (LSB) is always 1.

[Figure 30](#) shows the timing requirements for the JTAG signals.

Figure 30. APEX 20KC JTAG Waveforms

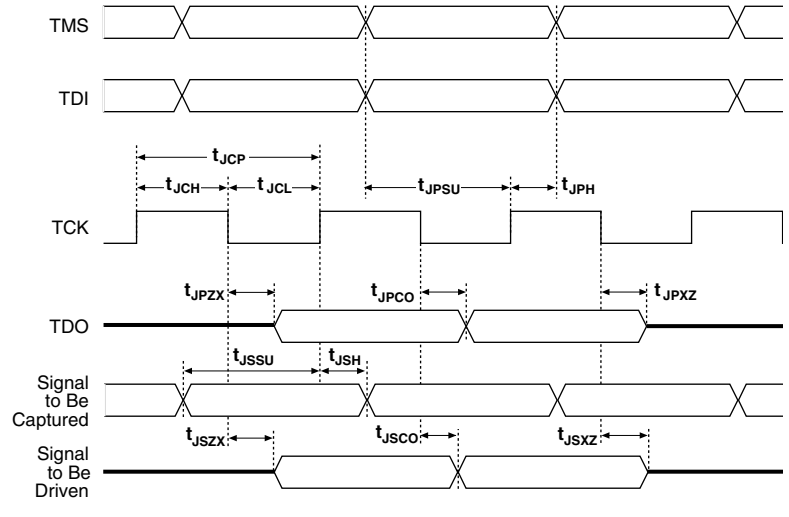


Table 16 shows the JTAG timing parameters and values for APEX 20KC devices.

Table 16. APEX 20KC 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



For more information, see the following documents:

- [Application Note 39 \(IEEE Std. 1149.1 \(JTAG\) Boundary-Scan Testing in Altera Devices\)](#)

Table 30. SSTL-2 Class II Specifications

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Units
V_{CCIO}	I/O 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		$V_{REF} + 0.18$		$V_{CCIO} + 0.3$	V
V_{IL}	Low-level input voltage		-0.3		$V_{REF} - 0.18$	V
V_{OH}	High-level output voltage	$I_{OH} = -15.2 \text{ mA}$ (1)	$V_{TT} + 0.76$			V
V_{OL}	Low-level output voltage	$I_{OL} = 15.2 \text{ mA}$ (2)			$V_{TT} - 0.76$	V

Table 31. SSTL-3 Class I Specifications

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Units
V_{CCIO}	I/O 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	$I_{OH} = -8 \text{ mA}$ (1)	$V_{TT} + 0.6$			V
V_{OL}	Low-level output voltage	$I_{OL} = 8 \text{ mA}$ (2)			$V_{TT} - 0.6$	V

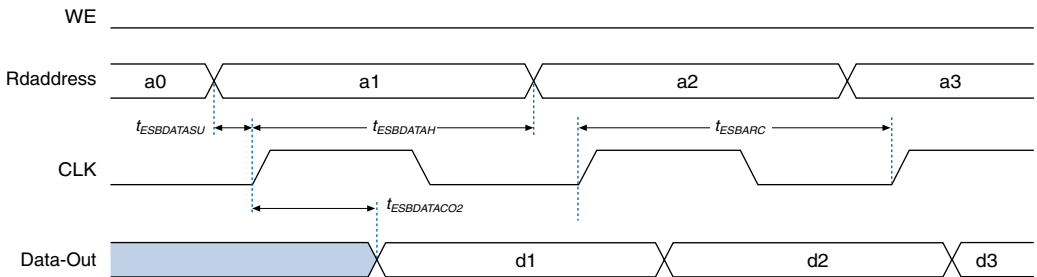
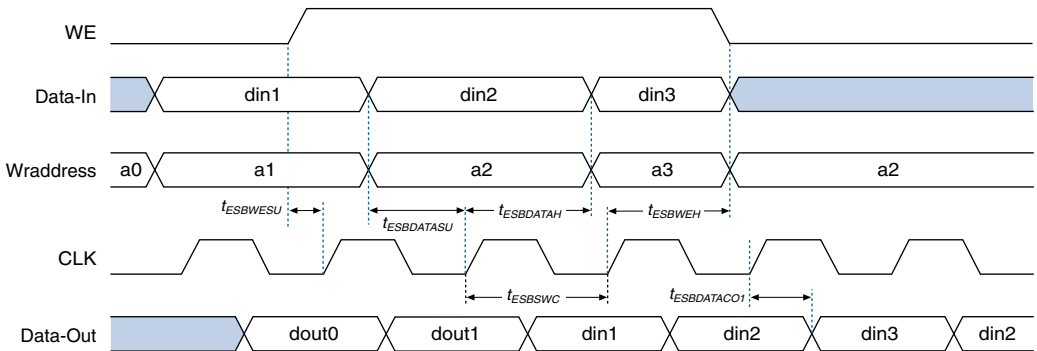
Figure 34. ESB Synchronous Timing Waveforms
ESB Synchronous Read

ESB Synchronous Write (ESB Output Registers Used)


Figure 35 shows the timing model for bidirectional I/O pin timing.

Figure 36. AC Test Conditions for LVTTL, 2.5 V, 1.8 V, PCI & GTL+ I/O Standards

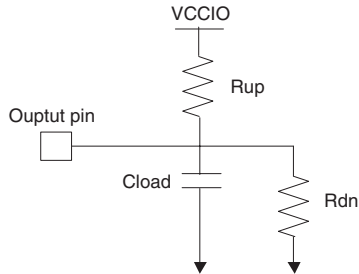


Figure 37. AC Test Conditions for SSTL-3 Class I & II I/O Standards

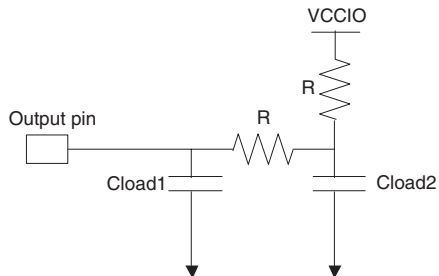


Figure 38. AC Test Conditions for the LVDS I/O Standard

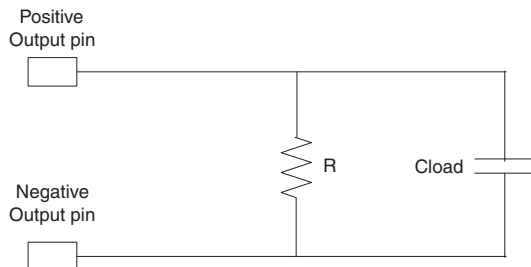


Table 51. EP20K400C t_{MAX} ESB Timing Parameters

Symbol	-7 Speed Grade		-8 Speed Grade		-9 Speed Grade		Unit
	Min	Max	Min	Max	Min	Max	
t_{ESBARC}		1.30		1.51		1.69	ns
t_{ESBSRC}		2.35		2.49		2.72	ns
t_{ESBAWC}		2.92		3.46		3.86	ns
t_{ESBSWC}		3.05		3.44		3.85	ns
$t_{ESBWASU}$	0.45		0.50		0.54		ns
t_{ESBWAH}	0.44		0.50		0.55		ns
$t_{ESBWDSU}$	0.57		0.63		0.68		ns
t_{ESBWDH}	0.44		0.50		0.55		ns
$t_{ESBRASU}$	1.25		1.43		1.56		ns
t_{ESBRAH}	0.00		0.03		0.11		ns
$t_{ESBWESU}$	0.00		0.00		0.00		ns
$t_{ESBDATASU}$	2.01		2.27		2.45		ns
$t_{ESBWADDRSU}$	-0.20		-0.24		-0.28		ns
$t_{ESBRADDRSU}$	0.02		0.00		-0.02		ns
$t_{ESBDATAO1}$		1.09		1.28		1.43	ns
$t_{ESBDATAO2}$		2.10		2.52		2.82	ns
t_{ESBDD}		2.50		2.97		3.32	ns
t_{PD}		1.48		1.78		2.00	ns
$t_{PTERMSU}$	0.58		0.72		0.81		ns
$t_{PTERMCO}$		1.10		1.29		1.45	ns

Table 52. EP20K400C t_{MAX} Routing Delays

Symbol	-7 Speed Grade		-8 Speed Grade		-9 Speed Grade		Unit
	Min	Max	Min	Max	Min	Max	
t_{F1-4}		0.15		0.17		0.19	ns
t_{F5-20}		0.94		1.06		1.25	ns
t_{F20+}		1.73		1.96		2.30	ns

Table 59. EP20K600C Minimum Pulse Width Timing Parameters

Symbol	-7 Speed Grade		-8 Speed Grade		-9 Speed Grade		Unit
	Min	Max	Min	Max	Min	Max	
t_{CH}	1.33		1.66		2.00		ns
t_{CL}	1.33		1.66		2.00		ns
t_{CLRP}	0.20		0.20		0.20		ns
t_{PREP}	0.20		0.20		0.20		ns
t_{ESBCH}	1.33		1.66		2.00		ns
t_{ESBCL}	1.33		1.66		2.00		ns
t_{ESBWP}	1.05		1.28		1.44		ns
t_{ESBRP}	0.87		1.06		1.19		ns

Table 60. EP20K600C External Timing Parameters

Symbol	-7 Speed Grade		-8 Speed Grade		-9 Speed Grade		Unit
	Min	Max	Min	Max	Min	Max	
t_{INSU}	1.28		1.40		1.45		ns
t_{INH}	0.00		0.00		0.00		ns
t_{OUTCO}	2.00	4.29	2.00	4.77	2.00	5.11	ns
$t_{INSUPLL}$	0.80		0.91		-		ns
t_{INHPLL}	0.00		0.00		-		ns
$t_{OUTCOPLL}$	0.50	2.37	0.50	2.63	-	-	ns

Table 69. Selectable I/O Standard Output Delays

Symbol	-7 Speed Grade		-8 Speed Grad		-9 Speed Grade		Unit
	Min	Max	Min	Max	Min	Max	Min
LVC MOS		0.00		0.00		0.00	ns
LVTTL		0.00		0.00		0.00	ns
2.5 V		0.00		0.00		0.00	ns
1.8 V		1.18		1.41		1.57	ns
PCI		-0.52		-0.53		-0.56	ns
GTL+		-0.18		-0.29		-0.39	ns
SSTL-3 Class I		-0.67		-0.71		-0.75	ns
SSTL-3 Class II		-0.67		-0.71		-0.75	ns
SSTL-2 Class I		-0.67		-0.71		-0.75	ns
SSTL-2 Class II		-0.67		-0.71		-0.75	ns
LVDS		-0.69		-0.70		-0.73	ns
CTT		0.00		0.00		0.00	ns
AGP		0.00		0.00		0.00	ns

Power Consumption

To estimate device power consumption, use the interactive power estimator on the Altera web site at <http://www.altera.com>.

Configuration & Operation

The APEX 20KC architecture supports several configuration schemes. This section summarizes the device operating modes and available device configuration schemes.

Operating Modes

The APEX 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. The I/O pins are tri-stated during power-up, and before and during configuration. Together, the configuration and initialization processes are called *command mode*; normal device operation is called *user mode*.

Before and during device configuration, all I/O pins are pulled to V_{CCIO} by a built-in weak pull-up resistor.



101 Innovation Drive
San Jose, CA 95134
(408) 544-7000
<http://www.altera.com>
Applications Hotline:
(800) 800-EPLD
Customer Marketing:
(408) 544-7104
Literature Services:
lit_req@altera.com

Copyright © 2002 Altera Corporation. All rights reserved. Altera, The Programmable Solutions Company, the stylized Altera logo, specific device designations, and all other words and logos that are identified as trademarks and/or service marks are, unless noted otherwise, the trademarks and service marks of Altera Corporation in the U.S. and other countries. All other product or service names are the property of their respective holders. Altera products are protected under numerous U.S. and foreign patents and pending applications, mask work rights, and copyrights. Altera warrants performance of its semiconductor products to current specifications in accordance with Altera's standard warranty, but reserves the right to make changes to any products and services at any time without notice. Altera assumes no responsibility or liability arising out of the application or use of any information, product, or service described herein except as expressly agreed to in writing by Altera Corporation. Altera customers are advised to obtain the latest version of device specifications before relying on any published information and before placing orders for products or services.



I.S. EN ISO 9001