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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	384
Number of Logic Elements/Cells	1728
Total RAM Bits	32768
Number of I/O	94
Number of Gates	57906
Voltage - Supply	2.375V ~ 2.625V
Mounting Type	Surface Mount
Operating Temperature	0°C ~ 85°C (TJ)
Package / Case	144-TFBGA, CSPBGA
Supplier Device Package	144-LCSBGA (12x12)
Purchase URL	https://www.e-xfl.com/product-detail/xilinx/xcv50-6cs144c



Virtex™ 2.5 V Field Programmable Gate Arrays

DS003-2 (v4.0) March 1, 2013

Product Specification

Architectural Description

Virtex Array

The Virtex user-programmable gate array, shown in [Figure 1](#), comprises two major configurable elements: configurable logic blocks (CLBs) and input/output blocks (IOBs).

- CLBs provide the functional elements for constructing logic
- IOBs provide the interface between the package pins and the CLBs

CLBs interconnect through a general routing matrix (GRM). The GRM comprises an array of routing switches located at the intersections of horizontal and vertical routing channels. Each CLB nests into a VersaBlock™ that also provides local routing resources to connect the CLB to the GRM.

The VersaRing™ I/O interface provides additional routing resources around the periphery of the device. This routing improves I/O routability and facilitates pin locking.

The Virtex architecture also includes the following circuits that connect to the GRM.

- Dedicated block memories of 4096 bits each
- Clock DLLs for clock-distribution delay compensation and clock domain control
- 3-State buffers (BUFTs) associated with each CLB that drive dedicated segmentable horizontal routing resources

Values stored in static memory cells control the configurable logic elements and interconnect resources. These values load into the memory cells on power-up, and can reload if necessary to change the function of the device.

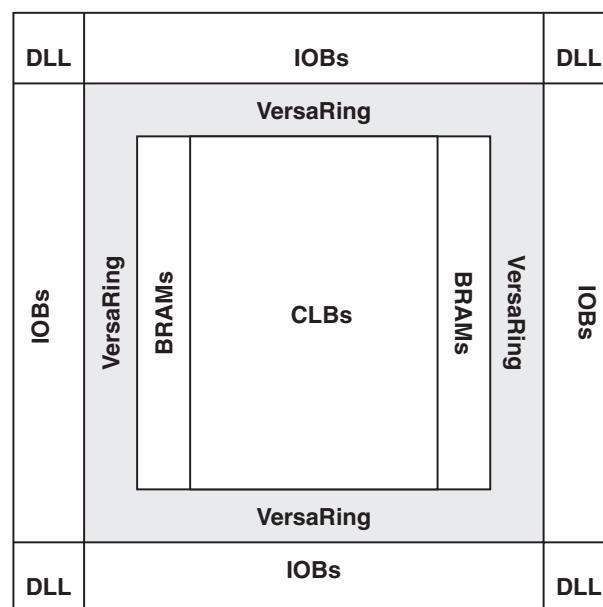
Input/Output Block

The Virtex IOB, [Figure 2](#), features SelectIO™ inputs and outputs that support a wide variety of I/O signalling standards, see [Table 1](#).

The three IOB storage elements function either as edge-triggered D-type flip-flops or as level sensitive latches. Each IOB has a clock signal (CLK) shared by the three flip-flops and independent clock enable signals for each flip-flop.

In addition to the CLK and CE control signals, the three flip-flops share a Set/Reset (SR). For each flip-flop, this signal can be independently configured as a synchronous Set, a synchronous Reset, an asynchronous Preset, or an asynchronous Clear.

The output buffer and all of the IOB control signals have independent polarity controls.



vao_b.eps

Figure 1: Virtex Architecture Overview

All pads are protected against damage from electrostatic discharge (ESD) and from over-voltage transients. Two forms of over-voltage protection are provided, one that permits 5 V compliance, and one that does not. For 5 V compliance, a Zener-like structure connected to ground turns on when the output rises to approximately 6.5 V. When PCI 3.3 V compliance is required, a conventional clamp diode is connected to the output supply voltage, V_{CCO} .

Optional pull-up and pull-down resistors and an optional weak-keeper circuit are attached to each pad. Prior to configuration, all pins not involved in configuration are forced into their high-impedance state. The pull-down resistors and the weak-keeper circuits are inactive, but inputs can optionally be pulled up.

The activation of pull-up resistors prior to configuration is controlled on a global basis by the configuration mode pins. If the pull-up resistors are not activated, all the pins will float. Consequently, external pull-up or pull-down resistors must be provided on pins required to be at a well-defined logic level prior to configuration.

All Virtex IOBs support IEEE 1149.1-compatible boundary scan testing.

General Purpose Routing

Most Virtex signals are routed on the general purpose routing, and consequently, the majority of interconnect resources are associated with this level of the routing hierarchy. The general routing resources are located in horizontal and vertical routing channels associated with the rows and columns CLBs. The general-purpose routing resources are listed below.

- Adjacent to each CLB is a General Routing Matrix (GRM). The GRM is the switch matrix through which horizontal and vertical routing resources connect, and is also the means by which the CLB gains access to the general purpose routing.
- 24 single-length lines route GRM signals to adjacent GRMs in each of the four directions.
- 12 buffered Hex lines route GRM signals to another GRMs six-blocks away in each one of the four directions. Organized in a staggered pattern, Hex lines can be driven only at their endpoints. Hex-line signals can be accessed either at the endpoints or at the midpoint (three blocks from the source). One third of the Hex lines are bidirectional, while the remaining ones are uni-directional.

- 12 Longlines are buffered, bidirectional wires that distribute signals across the device quickly and efficiently. Vertical Longlines span the full height of the device, and horizontal ones span the full width of the device.

I/O Routing

Virtex devices have additional routing resources around their periphery that form an interface between the CLB array and the IOBs. This additional routing, called the VersaRing, facilitates pin-swapping and pin-locking, such that logic redesigns can adapt to existing PCB layouts. Time-to-market is reduced, since PCBs and other system components can be manufactured while the logic design is still in progress.

Dedicated Routing

Some classes of signal require dedicated routing resources to maximize performance. In the Virtex architecture, dedicated routing resources are provided for two classes of signal.

- Horizontal routing resources are provided for on-chip 3-state busses. Four partitionable bus lines are provided per CLB row, permitting multiple busses within a row, as shown in [Figure 8](#).
- Two dedicated nets per CLB propagate carry signals vertically to the adjacent CLB.

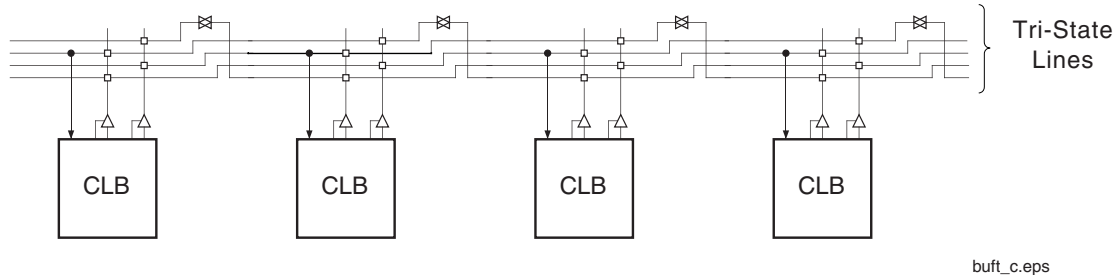


Figure 8: BUFT Connections to Dedicated Horizontal Bus Lines

Global Routing

Global Routing resources distribute clocks and other signals with very high fanout throughout the device. Virtex devices include two tiers of global routing resources referred to as primary global and secondary local clock routing resources.

- The primary global routing resources are four dedicated global nets with dedicated input pins that are designed to distribute high-fanout clock signals with minimal skew. Each global clock net can drive all CLB, IOB, and block RAM clock pins. The primary global nets can only be driven by global buffers. There are four global buffers, one for each global net.

- The secondary local clock routing resources consist of 24 backbone lines, 12 across the top of the chip and 12 across bottom. From these lines, up to 12 unique signals per column can be distributed via the 12 longlines in the column. These secondary resources are more flexible than the primary resources since they are not restricted to routing only to clock pins.

Clock Distribution

Virtex provides high-speed, low-skew clock distribution through the primary global routing resources described above. A typical clock distribution net is shown in [Figure 9](#).

Four global buffers are provided, two at the top center of the device and two at the bottom center. These drive the four primary global nets that in turn drive any clock pin.

Four dedicated clock pads are provided, one adjacent to each of the global buffers. The input to the global buffer is

selected either from these pads or from signals in the general purpose routing.

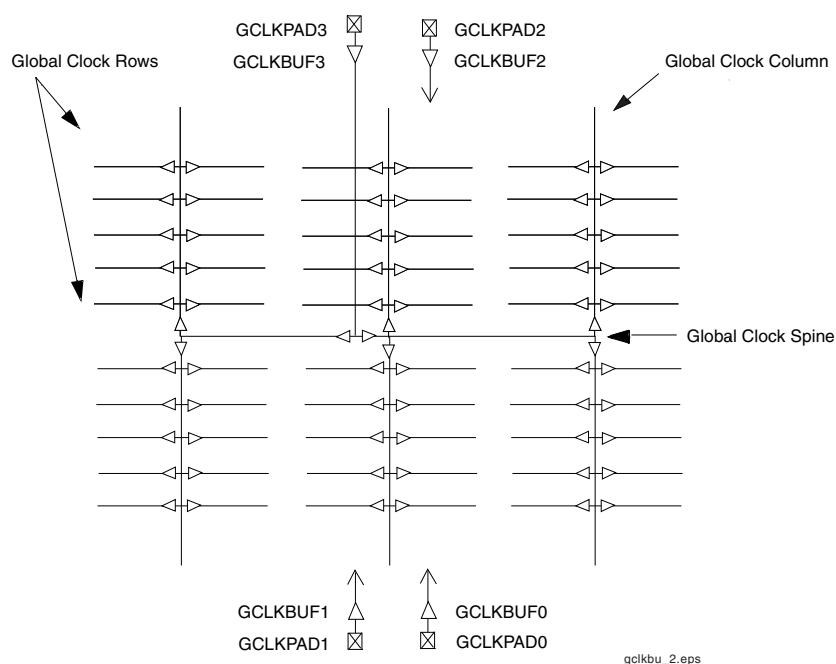


Figure 9: Global Clock Distribution Network

Delay-Locked Loop (DLL)

Associated with each global clock input buffer is a fully digital Delay-Locked Loop (DLL) that can eliminate skew between the clock input pad and internal clock-input pins throughout the device. Each DLL can drive two global clock networks. The DLL monitors the input clock and the distributed clock, and automatically adjusts a clock delay element. Clock edges reach internal flip-flops one to four clock periods after they arrive at the input. This closed-loop system effectively eliminates clock-distribution delay by ensuring that clock edges arrive at internal flip-flops in synchronism with clock edges arriving at the input.

In addition to eliminating clock-distribution delay, the DLL provides advanced control of multiple clock domains. The DLL provides four quadrature phases of the source clock, can double the clock, or divide the clock by 1.5, 2, 2.5, 3, 4, 5, 8, or 16.

The DLL also operates as a clock mirror. By driving the output from a DLL off-chip and then back on again, the DLL can be used to de-skew a board level clock among multiple Virtex devices.

In order to guarantee that the system clock is operating correctly prior to the FPGA starting up after configuration, the DLL can delay the completion of the configuration process until after it has achieved lock.

See **DLL Timing Parameters**, page 21 of Module 3, for frequency range information.

Boundary Scan

Virtex devices support all the mandatory boundary-scan instructions specified in the IEEE standard 1149.1. A Test Access Port (TAP) and registers are provided that implement the EXTEST, INTEST, SAMPLE/PRELOAD, BYPASS, IDCODE, USERCODE, and HIGHZ instructions. The TAP also supports two internal scan chains and configuration/readback of the device. The TAP uses dedicated package pins that always operate using LVTTTL. For TDO to operate using LVTTTL, the V_{CCO} for Bank 2 should be 3.3 V. Otherwise, TDO switches rail-to-rail between ground and V_{CCO} .

Boundary-scan operation is independent of individual IOB configurations, and unaffected by package type. All IOBs, including un-bonded ones, are treated as independent 3-state bidirectional pins in a single scan chain. Retention of the bidirectional test capability after configuration facilitates the testing of external interconnections, provided the user design or application is turned off.

Table 5 lists the boundary-scan instructions supported in Virtex FPGAs. Internal signals can be captured during EXTEST by connecting them to un-bonded or unused IOBs. They can also be connected to the unused outputs of IOBs defined as unidirectional input pins.

Before the device is configured, all instructions except USER1 and USER2 are available. After configuration, all instructions are available. During configuration, it is recommended that those operations using the boundary-scan register (SAMPLE/PRELOAD, INTEST, EXTEST) not be performed.

Configuration

Virtex devices are configured by loading configuration data into the internal configuration memory. Some of the pins used for this are dedicated configuration pins, while others can be re-used as general purpose inputs and outputs once configuration is complete.

The following are dedicated pins:

- Mode pins (M2, M1, M0)
- Configuration clock pin (CCLK)
- $\overline{\text{PROGRAM}}$ pin
- DONE pin
- Boundary-scan pins (TDI, TDO, TMS, TCK)

Depending on the configuration mode chosen, CCLK can be an output generated by the FPGA, or it can be generated externally and provided to the FPGA as an input. The $\overline{\text{PROGRAM}}$ pin must be pulled High prior to reconfiguration.

Note that some configuration pins can act as outputs. For correct operation, these pins can require a V_{CCO} of 3.3 V to permit LVTTTL operation. All the pins affected are in banks 2 or 3. The configuration pins needed for SelectMap (CS, Write) are located in bank 1.

Table 7: Configuration Codes

Configuration Mode	M2	M1	M0	CCLK Direction	Data Width	Serial D _{out}	Configuration Pull-ups
Master-serial mode	0	0	0	Out	1	Yes	No
Boundary-scan mode	1	0	1	N/A	1	No	No
SelectMAP mode	1	1	0	In	8	No	No
Slave-serial mode	1	1	1	In	1	Yes	No
Master-serial mode	1	0	0	Out	1	Yes	Yes
Boundary-scan mode	0	0	1	N/A	1	No	Yes
SelectMAP mode	0	1	0	In	8	No	Yes
Slave-serial mode	0	1	1	In	1	Yes	Yes

Slave-Serial Mode

In slave-serial mode, the FPGA receives configuration data in bit-serial form from a serial PROM or other source of serial configuration data. The serial bitstream must be setup at the DIN input pin a short time before each rising edge of an externally generated CCLK.

For more information on serial PROMs, see the PROM data sheet at:

<http://www.xilinx.com/bvdocs/publications/ds026.pdf>.

Multiple FPGAs can be daisy-chained for configuration from a single source. After a particular FPGA has been configured, the data for the next device is routed to the DOUT pin. The data on the DOUT pin changes on the rising edge of CCLK.

The change of DOUT on the rising edge of CCLK differs from previous families, but does not cause a problem for

After Virtex devices are configured, unused IOBs function as 3-state OBUFTs with weak pull downs. For a more detailed description than that given below, see the XAPP138, Virtex Configuration and Readback.

Configuration Modes

Virtex supports the following four configuration modes.

- Slave-serial mode
- Master-serial mode
- SelectMAP mode
- Boundary-scan mode

The Configuration mode pins (M2, M1, M0) select among these configuration modes with the option in each case of having the IOB pins either pulled up or left floating prior to configuration. The selection codes are listed in Table 7.

Configuration through the boundary-scan port is always available, independent of the mode selection. Selecting the boundary-scan mode simply turns off the other modes. The three mode pins have internal pull-up resistors, and default to a logic High if left unconnected. However, it is recommended to drive the configuration mode pins externally.

mixed configuration chains. This change was made to improve serial configuration rates for Virtex-only chains.

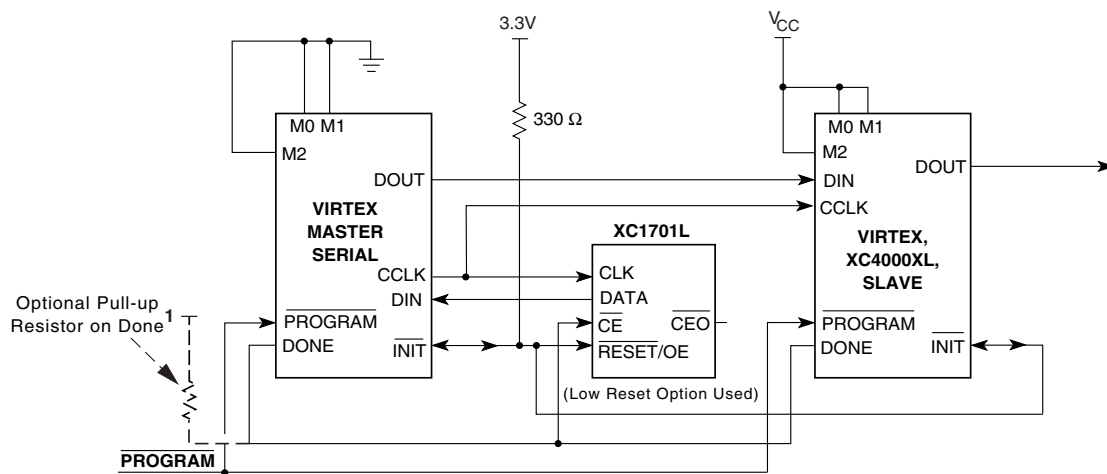
Figure 12 shows a full master/slave system. A Virtex device in slave-serial mode should be connected as shown in the third device from the left.

Slave-serial mode is selected by applying <111> or <011> to the mode pins (M2, M1, M0). A weak pull-up on the mode pins makes slave-serial the default mode if the pins are left unconnected. However, it is recommended to drive the configuration mode pins externally. Figure 13 shows slave-serial mode programming switching characteristics.

Table 8 provides more detail about the characteristics shown in Figure 13. Configuration must be delayed until the $\overline{\text{INIT}}$ pins of all daisy-chained FPGAs are High.

Table 8: Master/Slave Serial Mode Programming Switching

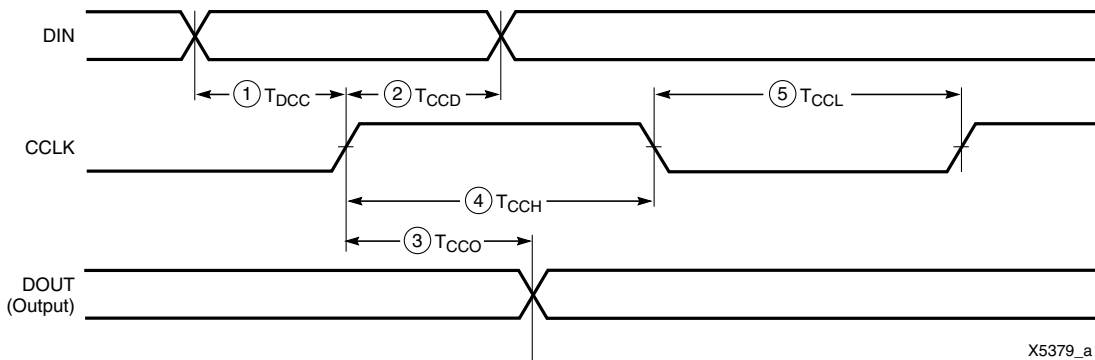
	Description	Figure References	Symbol	Values	Units
CCLK	DIN setup/hold, slave mode	1/2	T_{DCC}/T_{CCD}	5.0 / 0	ns, min
	DIN setup/hold, master mode	1/2	T_{DSCK}/T_{CKDS}	5.0 / 0	ns, min
	DOUT	3	T_{CCO}	12.0	ns, max
	High time	4	T_{CCH}	5.0	ns, min
	Low time	5	T_{CCL}	5.0	ns, min
	Maximum Frequency		F_{CC}	66	MHz, max
	Frequency Tolerance, master mode with respect to nominal			+45% -30%	



Note 1: If none of the Virtex FPGAs have been selected to drive DONE, an external pull-up resistor of 330 Ω should be added to the common DONE line. (For Spartan-XL devices, add a 4.7K Ω pull-up resistor.) This pull-up is not needed if the DriveDONE attribute is set. If used, DriveDONE should be selected only for the last device in the configuration chain.

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Figure 12: Master/Slave Serial Mode Circuit Diagram



X5379_a

Figure 13: Slave-Serial Mode Programming Switching Characteristics



Figure 18: SelectMAP Write Abort Waveforms

Boundary-Scan Mode

In the boundary-scan mode, configuration is done through the IEEE 1149.1 Test Access Port. Note that the **PROGRAM** pin must be pulled High prior to reconfiguration. A Low on the **PROGRAM** pin resets the TAP controller and no JTAG operations can be performed.

Configuration through the TAP uses the **CFG_IN** instruction. This instruction allows data input on TDI to be converted into data packets for the internal configuration bus.

The following steps are required to configure the FPGA through the boundary-scan port (when using TCK as a start-up clock).

1. Load the **CFG_IN** instruction into the boundary-scan instruction register (IR)
2. Enter the Shift-DR (SDR) state
3. Shift a configuration bitstream into TDI
4. Return to Run-Test-Idle (RTI)
5. Load the **JSTART** instruction into IR
6. Enter the SDR state
7. Clock TCK through the startup sequence
8. Return to RTI

Configuration and readback via the TAP is always available. The boundary-scan mode is selected by a <101> or 001> on the mode pins (M2, M1, M0). For details on TAP characteristics, refer to XAPP139.

Configuration Sequence

The configuration of Virtex devices is a three-phase process. First, the configuration memory is cleared. Next, configuration data is loaded into the memory, and finally, the logic is activated by a start-up process.

Configuration is automatically initiated on power-up unless it is delayed by the user, as described below. The configuration process can also be initiated by asserting **PROGRAM**.

The end of the memory-clearing phase is signalled by **INIT** going High, and the completion of the entire process is signalled by **DONE** going High.

The power-up timing of configuration signals is shown in Figure 19. The corresponding timing characteristics are listed in Table 10.

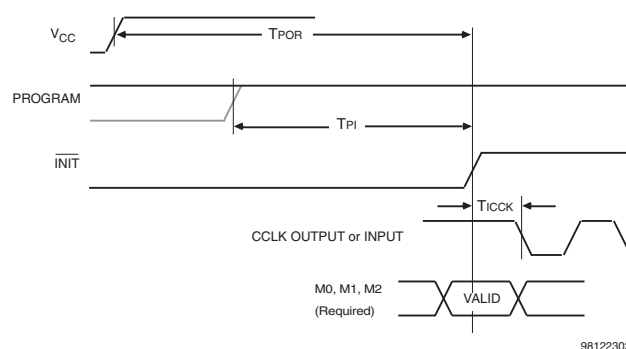


Figure 19: Power-Up Timing Configuration Signals

Table 10: Power-up Timing Characteristics

Description	Symbol	Value	Units
Power-on Reset	T _{POR}	2.0	ms, max
Program Latency	T _{PL}	100.0	μs, max
CCLK (output) Delay	T _{ICCK}	0.5	μs, min
		4.0	μs, max
Program Pulse Width	T _{PROGRAM}	300	ns, min

Delaying Configuration

INIT can be held Low using an open-drain driver. An open-drain is required since **INIT** is a bidirectional open-drain pin that is held Low by the FPGA while the configuration memory is being cleared. Extending the time that the pin is Low causes the configuration sequencer to wait. Thus, configuration is delayed by preventing entry into the phase where data is loaded.

Start-Up Sequence

The default Start-up sequence is that one CCLK cycle after **DONE** goes High, the global 3-state signal (GTS) is released. This permits device outputs to turn on as necessary.

One CCLK cycle later, the Global Set/Reset (GSR) and Global Write Enable (GWE) signals are released. This permits the internal storage elements to begin changing state in response to the logic and the user clock.

The relative timing of these events can be changed. In addition, the GTS, GSR, and GWE events can be made dependent on the **DONE** pins of multiple devices all going High, forcing the devices to start in synchronism. The sequence can also be paused at any stage until lock has been achieved on any or all DLLs.

Data Stream Format

Virtex devices are configured by sequentially loading frames of data. Table 11 lists the total number of bits required to configure each device. For more detailed information, see application note XAPP151 “Virtex Configuration Architecture Advanced Users Guide”.

Table 11: Virtex Bit-Stream Lengths

Device	# of Configuration Bits
XCV50	559,200
XCV100	781,216
XCV150	1,040,096
XCV200	1,335,840
XCV300	1,751,808
XCV400	2,546,048
XCV600	3,607,968
XCV800	4,715,616
XCV1000	6,127,744

Readback

The configuration data stored in the Virtex configuration memory can be readback for verification. Along with the configuration data it is possible to readback the contents all flip-flops/latches, LUTRAMs, and block RAMs. This capability is used for real-time debugging.

For more detailed information, see Application Note XAPP138: *Virtex FPGA Series Configuration and Readback*, available online at www.xilinx.com.

Revision History

Date	Version	Revision
11/98	1.0	Initial Xilinx release.
01/99	1.2	Updated package drawings and specs.
02/99	1.3	Update of package drawings, updated specifications.
05/99	1.4	Addition of package drawings and specifications.
05/99	1.5	Replaced FG 676 & FG680 package drawings.
07/99	1.6	Changed Boundary Scan Information and changed Figure 11, Boundary Scan Bit Sequence. Updated IOB Input & Output delays. Added Capacitance info for different I/O Standards. Added 5 V tolerant information. Added DLL Parameters and waveforms and new Pin-to-pin Input and Output Parameter tables for Global Clock Input to Output and Setup and Hold. Changed Configuration Information including Figures 12, 14, 17 & 19. Added device-dependent listings for quiescent currents ICCINTQ and ICCOQ. Updated IOB Input and Output Delays based on default standard of LVTTTL, 12 mA, Fast Slew Rate. Added IOB Input Switching Characteristics Standard Adjustments.
09/99	1.7	Speed grade update to preliminary status, Power-on specification and Clock-to-Out Minimums additions, “0” hold time listing explanation, quiescent current listing update, and Figure 6 ADDRA input label correction. Added T _{IJITCC} parameter, changed T _{OJIT} to T _{OPHASE} .
01/00	1.8	Update to speed.txt file 1.96. Corrections for CRs 111036, 111137, 112697, 115479, 117153, 117154, and 117612. Modified notes for Recommended Operating Conditions (voltage and temperature). Changed Bank information for V _{CCO} in CS144 package on p.43.

Virtex DC Characteristics

Absolute Maximum Ratings

Symbol	Description ⁽¹⁾			Units
V_{CCINT}	Supply voltage relative to GND ⁽²⁾		–0.5 to 3.0	V
V_{CCO}	Supply voltage relative to GND ⁽²⁾		–0.5 to 4.0	V
V_{REF}	Input Reference Voltage		–0.5 to 3.6	V
V_{IN}	Input voltage relative to GND ⁽³⁾	Using V_{REF}	–0.5 to 3.6	V
		Internal threshold	–0.5 to 5.5	V
V_{TS}	Voltage applied to 3-state output		–0.5 to 5.5	V
V_{CC}	Longest Supply Voltage Rise Time from 1V-2.375V		50	ms
T_{STG}	Storage temperature (ambient)		–65 to +150	°C
T_J	Junction temperature ⁽⁴⁾	Plastic Packages	+125	°C

Notes:

- Stresses beyond those listed under Absolute Maximum Ratings can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time can affect device reliability.
- Power supplies can turn on in any order.
- For protracted periods (e.g., longer than a day), V_{IN} should not exceed V_{CCO} by more than 3.6 V.
- For soldering guidelines and thermal considerations, see the "Device Packaging" information on www.xilinx.com.

Recommended Operating Conditions

Symbol	Description		Min	Max	Units
$V_{CCINT}^{(1)}$	Input Supply voltage relative to GND, $T_J = 0\text{ °C to }+85\text{ °C}$	Commercial	2.5 – 5%	2.5 + 5%	V
	Input Supply voltage relative to GND, $T_J = -40\text{ °C to }+100\text{ °C}$	Industrial	2.5 – 5%	2.5 + 5%	V
$V_{CCO}^{(4)}$	Supply voltage relative to GND, $T_J = 0\text{ °C to }+85\text{ °C}$	Commercial	1.4	3.6	V
	Supply voltage relative to GND, $T_J = -40\text{ °C to }+100\text{ °C}$	Industrial	1.4	3.6	V
T_{IN}	Input signal transition time			250	ns

Notes:

- Correct operation is guaranteed with a minimum V_{CCINT} of 2.375 V (Nominal V_{CCINT} –5%). Below the minimum value, all delay parameters increase by 3% for each 50-mV reduction in V_{CCINT} below the specified range.
- At junction temperatures above those listed as Operating Conditions, delay parameters do increase. Please refer to the TRCE report.
- Input and output measurement threshold is ~50% of V_{CC} .
- Min and Max values for V_{CCO} are I/O Standard dependant.

Virtex Switching Characteristics

All devices are 100% functionally tested. Internal timing parameters are derived from measuring internal test patterns. Listed below are representative values. For more specific, more precise, and worst-case guaranteed data, use the values reported by the static timing analyzer (TRCE

in the Xilinx Development System) and back-annotated to the simulation net list. All timing parameters assume worst-case operating conditions (supply voltage and junction temperature). Values apply to all Virtex devices unless otherwise noted.

IOB Input Switching Characteristics

Input delays associated with the pad are specified for LVTTTL levels. For other standards, adjust the delays with the values shown in , page 6.

Description	Device	Symbol	Speed Grade				Units
			Min	-6	-5	-4	
Propagation Delays							
Pad to I output, no delay	All	T _{IOPI}	0.39	0.8	0.9	1.0	ns, max
Pad to I output, with delay	XCV50	T _{IOPID}	0.8	1.5	1.7	1.9	ns, max
	XCV100		0.8	1.5	1.7	1.9	ns, max
	XCV150		0.8	1.5	1.7	1.9	ns, max
	XCV200		0.8	1.5	1.7	1.9	ns, max
	XCV300		0.8	1.5	1.7	1.9	ns, max
	XCV400		0.9	1.8	2.0	2.3	ns, max
	XCV600		0.9	1.8	2.0	2.3	ns, max
	XCV800		1.1	2.1	2.4	2.7	ns, max
	XCV1000		1.1	2.1	2.4	2.7	ns, max
Pad to output IQ via transparent latch, no delay	All	T _{IOPLI}	0.8	1.6	1.8	2.0	ns, max
Pad to output IQ via transparent latch, with delay	XCV50	T _{IOPLID}	1.9	3.7	4.2	4.8	ns, max
	XCV100		1.9	3.7	4.2	4.8	ns, max
	XCV150		2.0	3.9	4.3	4.9	ns, max
	XCV200		2.0	4.0	4.4	5.1	ns, max
	XCV300		2.0	4.0	4.4	5.1	ns, max
	XCV400		2.1	4.1	4.6	5.3	ns, max
	XCV600		2.1	4.2	4.7	5.4	ns, max
	XCV800		2.2	4.4	4.9	5.6	ns, max
	XCV1000		2.3	4.5	5.1	5.8	ns, max
Sequential Delays							
Clock CLK	All						
Minimum Pulse Width, High		T _{CH}	0.8	1.5	1.7	2.0	ns, min
Minimum Pulse Width, Low		T _{CL}	0.8	1.5	1.7	2.0	ns, min
Clock CLK to output IQ		T _{IOCKIQ}	0.2	0.7	0.7	0.8	ns, max

IOB Input Switching Characteristics Standard Adjustments

Description	Symbol	Standard ⁽¹⁾	Speed Grade				Units
			Min	-6	-5	-4	
Data Input Delay Adjustments							
Standard-specific data input delay adjustments	T _{ILVTTL}	LVTTL	0	0	0	0	ns
	T _{ILVCMOS2}	LVC MOS2	−0.02	−0.04	−0.04	−0.05	ns
	T _{IPCI33_3}	PCI, 33 MHz, 3.3 V	−0.05	−0.11	−0.12	−0.14	ns
	T _{IPCI33_5}	PCI, 33 MHz, 5.0 V	0.13	0.25	0.28	0.33	ns
	T _{IPCI66_3}	PCI, 66 MHz, 3.3 V	−0.05	−0.11	−0.12	−0.14	ns
	T _{IGTL}	GTL	0.10	0.20	0.23	0.26	ns
	T _{IGTLP}	GTL+	0.06	0.11	0.12	0.14	ns
	T _{IHSTL}	HSTL	0.02	0.03	0.03	0.04	ns
	T _{ISSTL2}	SSTL2	−0.04	−0.08	−0.09	−0.10	ns
	T _{ISSTL3}	SSTL3	−0.02	−0.04	−0.05	−0.06	ns
	T _{ICTT}	CTT	0.01	0.02	0.02	0.02	ns
	T _{IAGP}	AGP	−0.03	−0.06	−0.07	−0.08	ns

Notes:

- Input timing for LVTTL is measured at 1.4 V. For other I/O standards, see [Table 3](#).

IOB Output Switching Characteristics

Output delays terminating at a pad are specified for LVTTL with 12 mA drive and fast slew rate. For other standards, adjust the delays with the values shown in [IOB Output Switching Characteristics Standard Adjustments, page 9](#).

Description	Symbol	Speed Grade				Units
		Min	-6	-5	-4	
Propagation Delays						
O input to Pad	T _{IOOP}	1.2	2.9	3.2	3.5	ns, max
O input to Pad via transparent latch	T _{IOOLP}	1.4	3.4	3.7	4.0	ns, max
3-State Delays						
T input to Pad high-impedance ⁽¹⁾	T _{IOTHZ}	1.0	2.0	2.2	2.4	ns, max
T input to valid data on Pad	T _{IOTON}	1.4	3.1	3.3	3.7	ns, max
T input to Pad high-impedance via transparent latch ⁽¹⁾	T _{IOTLPHZ}	1.2	2.4	2.6	3.0	ns, max
T input to valid data on Pad via transparent latch	T _{IOTLPON}	1.6	3.5	3.8	4.2	ns, max
GTS to Pad high impedance ⁽¹⁾	T _{GTS}	2.5	4.9	5.5	6.3	ns, max
Sequential Delays						
Clock CLK						
Minimum Pulse Width, High	T _{CH}	0.8	1.5	1.7	2.0	ns, min
Minimum Pulse Width, Low	T _{CL}	0.8	1.5	1.7	2.0	ns, min

Description	Symbol	Speed Grade				Units
		Min	-6	-5	-4	
Clock CLK to Pad delay with OBUFT enabled (non-3-state)	T_{IOCKP}	1.0	2.9	3.2	3.5	ns, max
Clock CLK to Pad high-impedance (synchronous) ⁽¹⁾	T_{IOCKHZ}	1.1	2.3	2.5	2.9	ns, max
Clock CLK to valid data on Pad delay, plus enable delay for OBUFT	T_{IOCKON}	1.5	3.4	3.7	4.1	ns, max
Setup and Hold Times before/after Clock CLK⁽²⁾		Setup Time / Hold Time				
O input	T_{IOOCK}/T_{IOCKO}	0.51 / 0	1.1 / 0	1.2 / 0	1.3 / 0	ns, min
OCE input	$T_{IOOCECK}/T_{IOCKOCE}$	0.37 / 0	0.8 / 0	0.9 / 0	1.0 / 0	ns, min
SR input (OFF)	$T_{IOSRCKO}/T_{IOCKOSR}$	0.52 / 0	1.1 / 0	1.2 / 0	1.4 / 0	ns, min
3-State Setup Times, T input	T_{IOTCK}/T_{IOCKT}	0.34 / 0	0.7 / 0	0.8 / 0	0.9 / 0	ns, min
3-State Setup Times, TCE input	$T_{IOTCECK}/T_{IOCKTCE}$	0.41 / 0	0.9 / 0	0.9 / 0	1.1 / 0	ns, min
3-State Setup Times, SR input (TFF)	$T_{IOSRCKT}/T_{IOCKTSR}$	0.49 / 0	1.0 / 0	1.1 / 0	1.3 / 0	ns, min
Set/Reset Delays						
SR input to Pad (asynchronous)	T_{IOSRP}	1.6	3.8	4.1	4.6	ns, max
SR input to Pad high-impedance (asynchronous) ⁽¹⁾	T_{IOSRHZ}	1.6	3.1	3.4	3.9	ns, max
SR input to valid data on Pad (asynchronous)	T_{IOSRON}	2.0	4.2	4.6	5.1	ns, max
GSR to Pad	T_{IOGSRQ}	4.9	9.7	10.9	12.5	ns, max

Notes:

1. 3-state turn-off delays should not be adjusted.
2. A Zero "0" Hold Time listing indicates no hold time or a negative hold time. Negative values can not be guaranteed "best-case", but if a "0" is listed, there is no positive hold time.

IOB Output Switching Characteristics Standard Adjustments

Output delays terminating at a pad are specified for LVTTTL with 12 mA drive and fast slew rate. For other standards, adjust the delays by the values shown.

Description	Symbol	Standard ⁽¹⁾	Speed Grade				Unit s
			Min	-6	-5	-4	
Output Delay Adjustments							
Standard-specific adjustments for output delays terminating at pads (based on standard capacitive load, Csl)	T _{OLVTTL_S2}	LVTTL, Slow, 2 mA	4.2	14.7	15.8	17.0	ns
	T _{OLVTTL_S4}	4 mA	2.5	7.5	8.0	8.6	ns
	T _{OLVTTL_S6}	6 mA	1.8	4.8	5.1	5.6	ns
	T _{OLVTTL_S8}	8 mA	1.2	3.0	3.3	3.5	ns
	T _{OLVTTL_S12}	12 mA	1.0	1.9	2.1	2.2	ns
	T _{OLVTTL_S16}	16 mA	0.9	1.7	1.9	2.0	ns
	T _{OLVTTL_S24}	24 mA	0.8	1.3	1.4	1.6	ns
	T _{OLVTTL_F2}	LVTTL, Fast, 2mA	1.9	13.1	14.0	15.1	ns
	T _{OLVTTL_F4}	4 mA	0.7	5.3	5.7	6.1	ns
	T _{OLVTTL_F6}	6 mA	0.2	3.1	3.3	3.6	ns
	T _{OLVTTL_F8}	8 mA	0.1	1.0	1.1	1.2	ns
	T _{OLVTTL_F12}	12 mA	0	0	0	0	ns
	T _{OLVTTL_F16}	16 mA	−0.10	−0.05	−0.05	−0.05	ns
	T _{OLVTTL_F24}	24 mA	−0.10	−0.20	−0.21	−0.23	ns
	T _{OLVCMOS2}	LVC MOS2	0.10	0.10	0.11	0.12	ns
	T _{OPCI33_3}	PCI, 33 MHz, 3.3 V	0.50	2.3	2.5	2.7	ns
	T _{OPCI33_5}	PCI, 33 MHz, 5.0 V	0.40	2.8	3.0	3.3	ns
	T _{OPCI66_3}	PCI, 66 MHz, 3.3 V	0.10	−0.40	−0.42	−0.46	ns
	T _{OGTL}	GTL	0.6	0.50	0.54	0.6	ns
	T _{OGTLP}	GTL+	0.7	0.8	0.9	1.0	ns
	T _{OHSTL_I}	HSTL I	0.10	−0.50	−0.53	−0.5	ns
	T _{OHSTL_III}	HSTL III	−0.10	−0.9	−0.9	−1.0	ns
	T _{OHSTL_IV}	HSTL IV	−0.20	−1.0	−1.0	−1.1	ns
	T _{OSSTL2_I}	SSTL2 I	−0.10	−0.50	−0.53	−0.5	ns
	T _{OSSTL2_II}	SSTL2 II	−0.20	−0.9	−0.9	−1.0	ns
	T _{OSSTL3_I}	SSTL3 I	−0.20	−0.50	−0.53	−0.5	ns
	T _{OSSTL3_II}	SSTL3 II	−0.30	−1.0	−1.0	−1.1	ns
	T _{OCTT}	CTT	0	−0.6	−0.6	−0.6	ns
	T _{OAGP}	AGP	0	−0.9	−0.9	−1.0	ns

Notes:

- Output timing is measured at 1.4 V with 35 pF external capacitive load for LVTTTL. For other I/O standards and different loads, see [Table 2](#) and [Table 3](#).

Clock Distribution Guidelines

Description	Device	Symbol	Speed Grade			Units
			-6	-5	-4	
Global Clock Skew ⁽¹⁾						
Global Clock Skew between IOB Flip-flops	XCV50	T _{GSKEWIOB}	0.10	0.12	0.14	ns, max
	XCV100		0.12	0.13	0.15	ns, max
	XCV150		0.12	0.13	0.15	ns, max
	XCV200		0.13	0.14	0.16	ns, max
	XCV300		0.14	0.16	0.18	ns, max
	XCV400		0.13	0.13	0.14	ns, max
	XCV600		0.14	0.15	0.17	ns, max
	XCV800		0.16	0.17	0.20	ns, max
	XCV1000		0.20	0.23	0.25	ns, max

Notes:

- These clock-skew delays are provided for guidance only. They reflect the delays encountered in a typical design under worst-case conditions. Precise values for a particular design are provided by the timing analyzer.

Clock Distribution Switching Characteristics

Description	Symbol	Speed Grade				Units
		Min	-6	-5	-4	
GCLK IOB and Buffer						
Global Clock PAD to output.	T _{GPIO}	0.33	0.7	0.8	0.9	ns, max
Global Clock Buffer I input to O output	T _{GIO}	0.34	0.7	0.8	0.9	ns, max

Minimum Clock-to-Out for Virtex Devices

I/O Standard	With DLL	Without DLL									
	All Devices	V50	V100	V150	V200	V300	V400	V600	V800	V1000	Units
*LVTTTL_S2	5.2	6.0	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	ns
*LVTTTL_S4	3.5	4.3	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	ns
*LVTTTL_S6	2.8	3.6	3.6	3.6	3.6	3.7	3.7	3.7	3.7	3.7	ns
*LVTTTL_S8	2.2	3.1	3.1	3.1	3.1	3.1	3.1	3.2	3.2	3.2	ns
*LVTTTL_S12	2.0	2.9	2.9	2.9	2.9	2.9	2.9	3.0	3.0	3.0	ns
*LVTTTL_S16	1.9	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.9	ns
*LVTTTL_S24	1.8	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.8	ns
*LVTTTL_F2	2.9	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.9	3.9	ns
*LVTTTL_F4	1.7	2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7	ns
*LVTTTL_F6	1.2	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.2	ns
*LVTTTL_F8	1.1	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	ns
*LVTTTL_F12	1.0	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	ns
*LVTTTL_F16	0.9	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	ns
*LVTTTL_F24	0.9	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.9	ns
LVCMS2	1.1	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	ns
PCI33_3	1.5	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	ns
PCI33_5	1.4	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.4	ns
PCI66_3	1.1	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1	ns
GTL	1.6	2.5	2.5	2.5	2.5	2.5	2.5	2.6	2.6	2.6	ns
GTL+	1.7	2.5	2.5	2.6	2.6	2.6	2.6	2.6	2.6	2.7	ns
HSTL I	1.1	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	ns
HSTL III	0.9	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.9	ns
HSTL IV	0.8	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.8	ns
SSTL2 I	0.9	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	ns
SSTL2 II	0.8	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	ns
SSTL3 I	0.8	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	ns
SSTL3 II	0.7	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.7	ns
CTT	1.0	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	2.0	ns
AGP	1.0	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	2.0	ns

*S = Slow Slew Rate, F = Fast Slew Rate

Notes:

1. Listed above are representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible IOB and CLB flip-flops are clocked by the global clock net.
2. Input and output timing is measured at 1.4 V for LVTTTL. For other I/O standards, see [Table 3](#). In all cases, an 8 pF external capacitive load is used.

Table 3: Virtex Pinout Tables (BGA) (Continued)

Pin Name	Device	BG256	BG352	BG432	BG560
V_{REF} Bank 3 (V _{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V _{REF} pins are general I/O.	XCV50	M18, V20	N/A	N/A	N/A
	XCV100/150	... + R19	R4, V4, Y3	N/A	N/A
	XCV200/300	... + P18	... + AC2	V2, AB4, AD4, AF3	N/A
	XCV400	N/A	N/A	... + U2	V4, W5, AD3, AE5, AK2
	XCV600	N/A	N/A	... + AC3	... + AF1
	XCV800	N/A	N/A	... + Y3	... + AA4
	XCV1000	N/A	N/A	N/A	... + AH4
V_{REF} Bank 4 (V _{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V _{REF} pins are general I/O.	XCV50	V12, Y18	N/A	N/A	N/A
	XCV100/150	... + W15	AC12, AE5, AE8,	N/A	N/A
	XCV200/300	... + V14	... + AE4	AJ7, AL4, AL8, AL13	N/A
	XCV400	N/A	N/A	... + AK15	AL7, AL10, AL16, AM4, AM14
	XCV600	N/A	N/A	... + AK8	... + AL9
	XCV800	N/A	N/A	... + AJ12	... + AK13
	XCV1000	N/A	N/A	N/A	... + AN3
V_{REF} Bank 5 (V _{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V _{REF} pins are general I/O.	XCV50	V9, Y3	N/A	N/A	N/A
	XCV100/150	... + W6	AC15, AC18, AD20	N/A	N/A
	XCV200/300	... + V7	... + AE23	AJ18, AJ25, AK23, AK27	N/A
	XCV400	N/A	N/A	... + AJ17	AJ18, AJ25, AL20, AL24, AL29
	XCV600	N/A	N/A	... + AL24	... + AM26
	XCV800	N/A	N/A	... + AH19	... + AN23
	XCV1000	N/A	N/A	N/A	... + AK28
V_{REF} Bank 6 (V _{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V _{REF} pins are general I/O.	XCV50	M2, R3	N/A	N/A	N/A
	XCV100/150	... + T1	R24, Y26, AA25,	N/A	N/A
	XCV200/300	... + T3	... + AD26	V28, AB28, AE30, AF28	N/A
	XCV400	N/A	N/A	... + U28	V29, Y32, AD31, AE29, AK32
	XCV600	N/A	N/A	... + AC28	... + AE31
	XCV800	N/A	N/A	... + Y30	... + AA30
	XCV1000	N/A	N/A	N/A	... + AH30

Table 3: Virtex Pinout Tables (BGA) (Continued)

Pin Name	Device	BG256	BG352	BG432	BG560
V_{REF} Bank 7 (V _{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V _{REF} pins are general I/O.	XCV50	G3, H1	N/A	N/A	N/A
	XCV100/150	... + D1	D26, G26, L26	N/A	N/A
	XCV200/300	... + B2	... + E24	F28, F31, J30, N30	N/A
	XCV400	N/A	N/A	... + R31	E31, G31, K31, P31, T31
	XCV600	N/A	N/A	... + J28	... + H32
	XCV800	N/A	N/A	... + M28	... + L33
	XCV1000	N/A	N/A	N/A	... + D31
GND	All	C3, C18, D4, D5, D9, D10, D11, D12, D16, D17, E4, E17, J4, J17, K4, K17, L4, L17, M4, M17, T4, T17, U4, U5, U9, U10, U11, U12, U16, U17, V3, V18	A1, A2, A5, A8, A14, A19, A22, A25, A26, B1, B26, E1, E26, H1, H26, N1, P26, W1, W26, AB1, AB26, AE1, AE26, AF1, AF2, AF5, AF8, AF13, AF19, AF22, AF25, AF26	A2, A3, A7, A9, A14, A18, A23, A25, A29, A30, B1, B2, B30, B31, C1, C31, D16, G1, G31, J1, J31, P1, P31, T4, T28, V1, V31, AC1, AC31, AE1, AE31, AH16, AJ1, AJ31, AK1, AK2, AK30, AK31, AL2, AL3, AL7, AL9, AL14, AL18, AL23, AL25, AL29, AL30	A1, A7, A12, A14, A18, A20, A24, A29, A32, A33, B1, B6, B9, B15, B23, B27, B31, C2, E1, F32, G2, G33, J32, K1, L2, M33, P1, P33, R32, T1, V33, W2, Y1, Y33, AB1, AC32, AD33, AE2, AG1, AG32, AH2, AJ33, AL32, AM3, AM7, AM11, AM19, AM25, AM28, AM33, AN1, AN2, AN5, AN10, AN14, AN16, AN20, AN22, AN27, AN33
GND ⁽¹⁾	All	J9, J10, J11, J12, K9, K10, K11, K12, L9, L10, L11, L12, M9, M10, M11, M12	N/A	N/A	N/A
No Connect	All	N/A	N/A	N/A	C31, AC2, AK4, AL3

Notes:

1. 16 extra balls (grounded) at package center.

Table 4: Virtex Pinout Tables (Fine-Pitch BGA) (Continued)

Pin Name	Device	FG256	FG456	FG676	FG680
V_{REF} Bank 7 (V_{REF} pins are listed incrementally. Connect all pins listed for both the required device and all smaller devices listed in the same package.) Within each bank, if input reference voltage is not required, all V_{REF} pins are general I/O.	XCV50	C1, H3	N/A	N/A	N/A
	XCV100/150	... + D1	E2, H4, K3	N/A	N/A
	XCV200/300	... + B1	... + D2	N/A	N/A
	XCV400	N/A	N/A	F4, G4, K6, M2, M5	N/A
	XCV600	N/A	N/A	... + H1	E38, G38, L36, N36, U36, U38
	XCV800	N/A	N/A	... + K1	... + N38
	XCV1000	N/A	N/A	N/A	... + F36
GND	All	A1, A16, B2, B15, F6, F7, F10, F11, G6, G7, G8, G9, G10, G11, H7, H8, H9, H10, J7, J8, J9, J10, K6, K7, K8, K9, K10, K11, L6, L7, L10, L11, R2, R15, T1, T16	A1, A22, B2, B21, C3, C20, J9, J10, J11, J12, J13, J14, K9, K10, K11, K12, K13, K14, L9, L10, L11, L12, L13, L14, M9, M10, M11, M12, M13, M14, N9, N10, N11, N12, N13, N14, P9, P10, P11, P12, P13, P14, Y3, Y20, AA2, AA21, AB1, AB22	A1, A26, B2, B9, B14, B18, B25, C3, C24, D4, D23, E5, E22, J2, J25, K10, K11, K12, K13, K14, K15, K16, K17, L10, L11, L12, L13, L14, L15, L16, L17, M10, M11, M12, M13, M14, M15, M16, M17, N2, N10, N11, N12, N13, N14, N15, N16, N17, P10, P11, P12, P13, P14, P15, P16, P17, P25, R10, R11, R12, R13, R14, R15, R16, R17, T10, T11, T12, T13, T14, T15, T16, T17, U10, U11, U12, U13, U14, U15, U16, U17, V2, V25, AB5, AB22, AC4, AC23, AD3, AD24, AE2, AE9, AE13, AE18, AE25, AF1, AF26	A1, A2, A3, A37, A38, A39, AA5, AA35, AH4, AH5, AH35, AH36, AR5, AR12, AR19, AR20, AR21, AR28, AR35, AT4, AT12, AT20, AT28, AT36, AU1, AU3, AU20, AU37, AU39, AV1, AV2, AV38, AV39, AW1, AW2, AW3, AW37, AW38, AW39, B1, B2, B38, B39, C1, C3, C20, C37, C39, D4, D12, D20, D28, D36, E5, E12, E19, E20, E21, E28, E35, M4, M5, M35, M36, W5, W35, Y3, Y4, Y5, Y35, Y36, Y37

TQ144 Pin Function Diagram

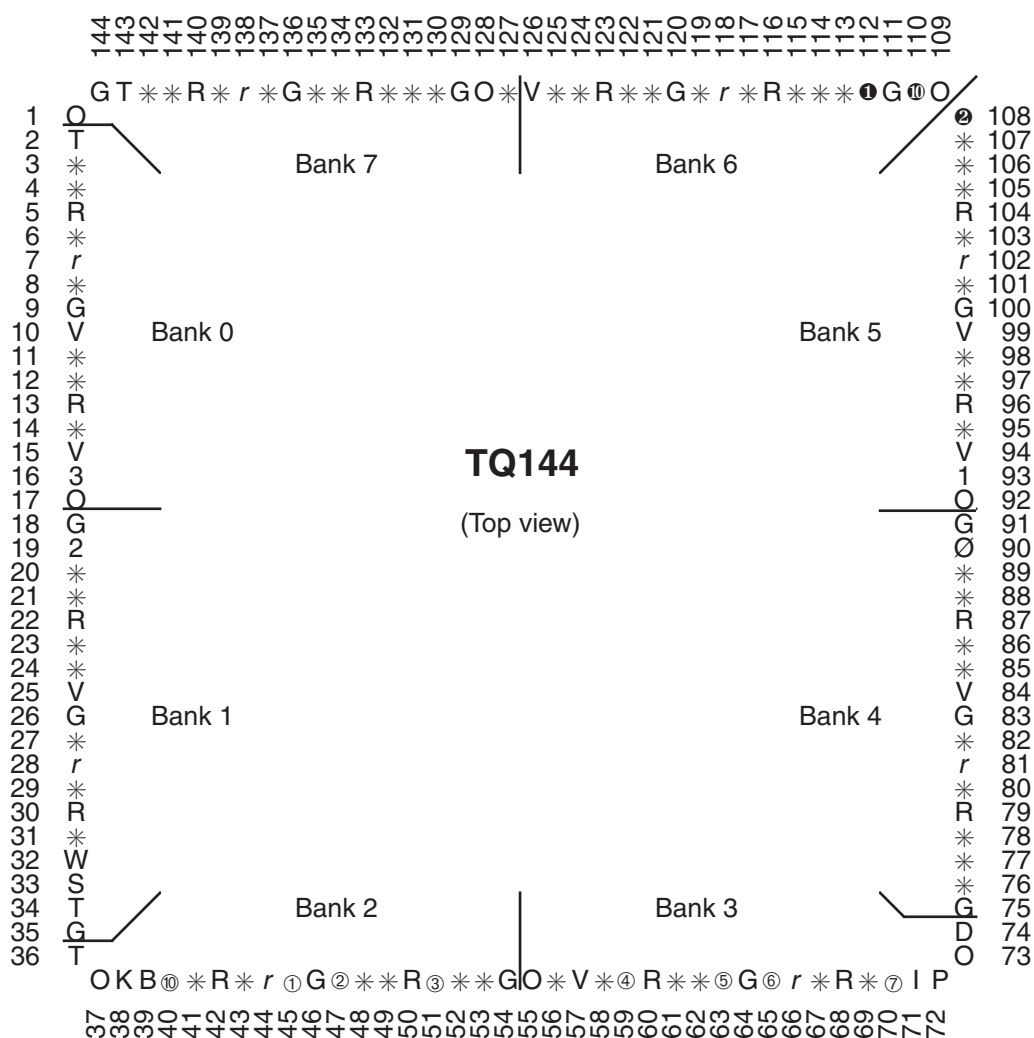
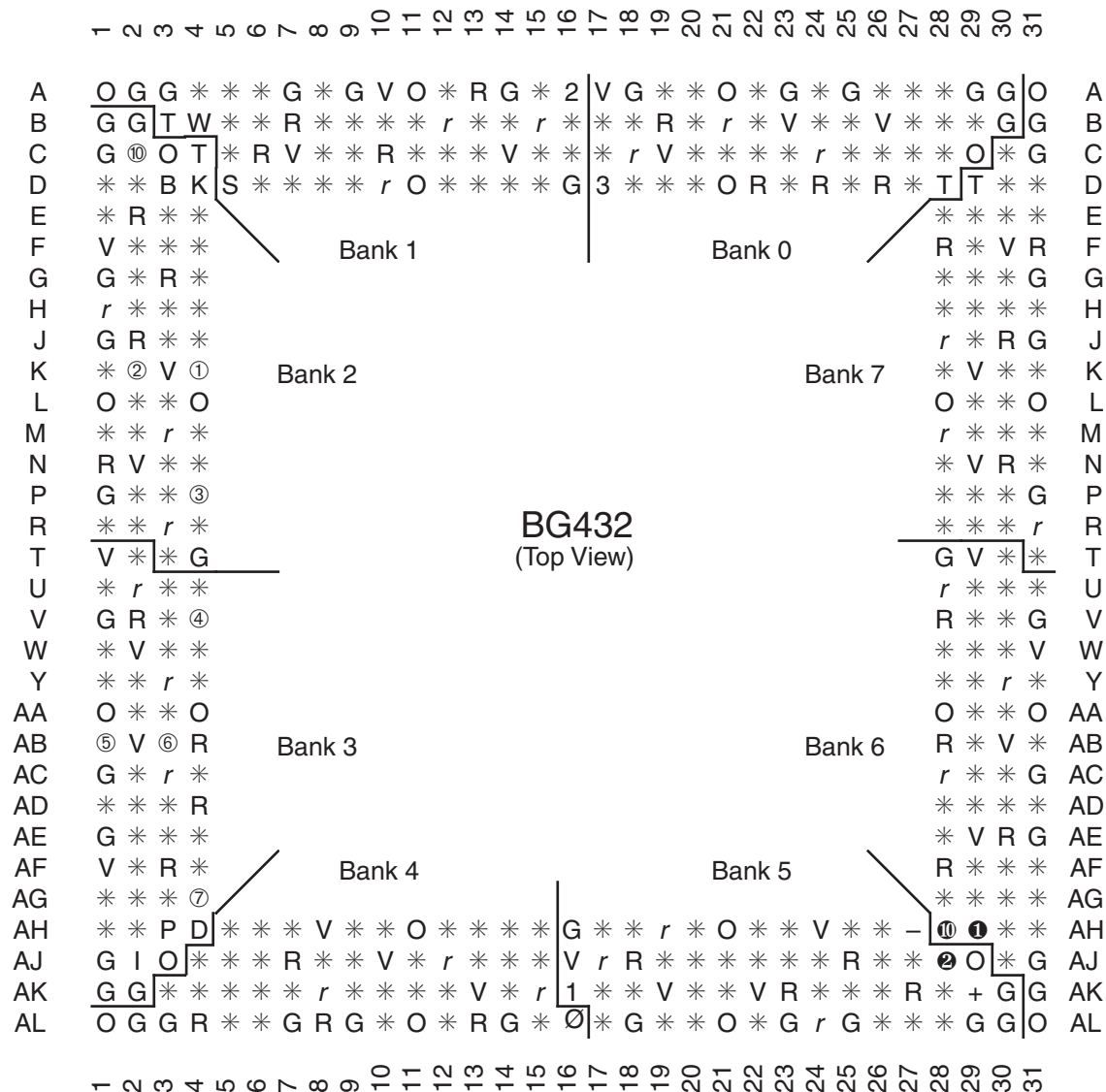


Figure 2: TQ144 Pin Function Diagram

BG432 Pin Function Diagram



DS003_21_100300

Figure 6: BG432 Pin Function Diagram

