Virtex™-II Platform FPGAs: Introduction and Overview

DS031-1 (v1.9) September 26, 2002

Advance Product Specification

Summary of Virtex-II Features

- Industry First Platform FPGA Solution
- IP-Immersion Architecture
  - Densities from 40K to 8M system gates
  - 420 MHz internal clock speed (Advance Data)
  - 840+ Mb/s I/O (Advance Data)
- SelectRAM™ Memory Hierarchy
  - 3 Mb of dual-port RAM in 18 Kbit block SelectRAM resources
  - Up to 1.5 Mb of distributed SelectRAM resources
- High-Performance Interfaces to External Memory
  - DRAM interfaces
    - SDR / DDR SDRAM
    - Network FCRAM
    - Reduced Latency DRAM
  - SRAM interfaces
    - SDR / DDR SRAM
    - QDR™ SRAM
  - CAM interfaces
- Arithmetic Functions
  - Dedicated 18-bit x 18-bit multiplier blocks
  - Fast look-ahead carry logic chains
- Flexible Logic Resources
  - Up to 93,184 internal registers / latches with Clock Enable
  - Up to 93,184 look-up tables (LUTs) or cascadable 16-bit shift registers
  - Wide multiplexers and wide-input function support
  - Horizontal cascade chain and sum-of-products support
  - Internal 3-state bussing
- High-Performance Clock Management Circuitry
  - Up to 12 DCM (Digital Clock Manager) modules
    - Precise clock de-skew
    - Flexible frequency synthesis
    - High-resolution phase shifting
  - 16 global clock multiplexer buffers
- Active Interconnect Technology
  - Fourth generation segmented routing structure
  - Predictable, fast routing delay, independent of fanout
- SelectIO™-Ultra Technology
  - Up to 1,108 user I/Os
  - 19 single-ended and six differential standards
  - Programmable sink current (2 mA to 24 mA) per I/O
  - Digitally Controlled Impedance (DCI) I/O: on-chip termination resistors for single-ended I/O standards
  - PCI-X compatible (133 MHz and 66 MHz) at 3.3V
  - PCI compliant (66 MHz and 33 MHz) at 3.3V
  - CardBus compliant (33 MHz) at 3.3V
  - Differential Signaling
    - 840 Mb/s Low-Voltage Differential Signaling I/O (LVDS) with current mode drivers
    - Bus LVDS I/O
    - Lightning Data Transport (LDT) I/O with current driver buffers
    - Low-Voltage Positive Emitter-Coupled Logic (LVPECL) I/O
    - Built-in DDR input and output registers
  - Proprietary high-performance SelectLink Technology
    - High-bandwidth data path
    - Double Data Rate (DDR) link
    - Web-based HDL generation methodology
- Supported by Xilinx Foundation™ and Alliance Series™ Development Systems
  - Integrated VHDL and Verilog design flows
  - Compilation of 10M system gates designs
  - Internet Team Design (ITD) tool
- SRAM-Based In-System Configuration
  - Fast SelectMAP configuration
  - Triple Data Encryption Standard (DES) security option (Bitstream Encryption)
  - IEEE 1532 support
  - Partial reconfiguration
  - Unlimited reprogrammability
  - Readback capability
- 0.15 µm 8-Layer Metal Process with 0.12 µm High-Speed Transistors
- 1.5V (V_{CCINT}) Core Power Supply, Dedicated 3.3V V_{CCAUX} Auxiliary and V_{CCO} I/O Power Supplies
- IEEE 1149.1 Compatible Boundary-Scan Logic Support
- Flip-Chip and Wire-Bond Ball Grid Array (BGA) Packages in Three Standard Fine Pitches (0.80 mm, 1.00 mm, and 1.27 mm)
- 100% Factory Tested

Table 1: **Virtex-II Field-Programmable Gate Array Family Members**

Device	System Gates	CLB (1 CLB = 4 slices = Max 128 bits)			Multiplier Blocks	SelectRAM Blocks		DCMs	Max I/O Pads(1)
		Array Row x Col.	Slices	Maximum Distributed RAM Kbits		18 Kbit Blocks	Max RAM (Kbits)		
XC2V40	40K	8 x 8	256	8	4	4	72	4	88
XC2V80	80K	16 x 8	512	16	8	8	144	4	120
XC2V250	250K	24 x 16	1,536	48	24	24	432	8	200
XC2V500	500K	32 x 24	3,072	96	32	32	576	8	264
XC2V1000	1M	40 x 32	5,120	160	40	40	720	8	432
XC2V1500	1.5M	48 x 40	7,680	240	48	48	864	8	528
XC2V2000	2M	56 x 48	10,752	336	56	56	1,008	8	624
XC2V3000	3M	64 x 56	14,336	448	96	96	1,728	12	720
XC2V4000	4M	80 x 72	23,040	720	120	120	2,160	12	912
XC2V6000	6M	96 x 88	33,792	1,056	144	144	2,592	12	1,104
XC2V8000	8M	112 x 104	46,592	1,456	168	168	3,024	12	1,108

Notes:
1. See details in Table 2, “Maximum Number of User I/O Pads”.

General Description

The Virtex-II family is a platform FPGA developed for high performance from low-density to high-density designs that are based on IP cores and customized modules. The family delivers complete solutions for telecommunication, wireless, networking, video, and DSP applications, including PCI, LVDS, and DDR interfaces.

The leading-edge 0.15 µm / 0.12 µm CMOS 8-layer metal process and the Virtex-II architecture are optimized for high speed with low power consumption. Combining a wide variety of flexible features and a large range of densities up to 10 million system gates, the Virtex-II family enhances programmable logic design capabilities and is a powerful alternative to mask-programmed gates arrays. As shown in Table 1, the Virtex-II family comprises 11 members, ranging from 40K to 8M system gates.

Packaging

Offerings include ball grid array (BGA) packages with 0.80 mm, 1.00 mm, and 1.27 mm pitches. In addition to traditional wire-bond interconnects, flip-chip interconnect is used in some of the BGA offerings. The use of flip-chip interconnect offers more I/Os than is possible in wire-bond versions of the similar packages. Flip-chip construction offers the combination of high pin count with high thermal capacity.

Table 2 shows the maximum number of user I/Os available. The Virtex-II device/package combination table (Table 6 at the end of this section) details the maximum number of I/Os for each device and package using wire-bond or flip-chip technology.

Table 2: **Maximum Number of User I/O Pads**

Device	Wire-Bond	Flip-Chip
XC2V40	88	-
XC2V80	120	-
XC2V250	200	-
XC2V500	264	-
XC2V1000	328	432
XC2V1500	392	528
XC2V2000	-	624
XC2V3000	516	720
XC2V4000	-	912
XC2V6000	-	1,104
XC2V8000	-	1,108

Architecture

Virtex-II Array Overview

Virtex-II devices are user-programmable gate arrays with various configurable elements. The Virtex-II architecture is optimized for high-density and high-performance logic designs. As shown in Figure 1, the programmable device is comprised of input/output blocks (IOBs) and internal configurable logic blocks (CLBs).

Programmable I/O blocks provide the interface between package pins and the internal configurable logic. Most popular and leading-edge I/O standards are supported by the programmable IOBs.

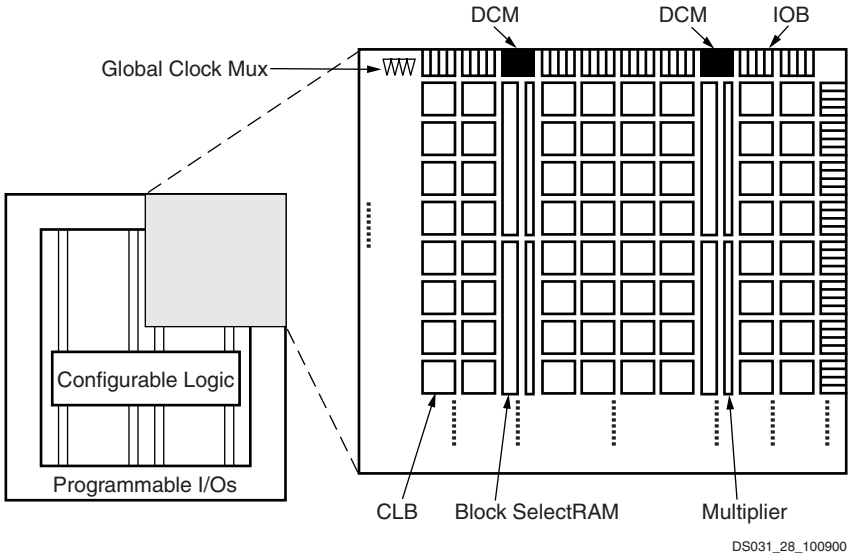

Figure 1: **Virtex-II Architecture Overview**

The internal configurable logic includes four major elements organized in a regular array.

- Configurable Logic Blocks (CLBs) provide functional elements for combinatorial and synchronous logic, including basic storage elements. BUFTs (3-state buffers) associated with each CLB element drive dedicated segmentable horizontal routing resources.
- Block SelectRAM memory modules provide large 18 Kbit storage elements of dual-port RAM.
- Multiplier blocks are 18-bit x 18-bit dedicated multipliers.
- DCM (Digital Clock Manager) blocks provide self-calibrating, fully digital solutions for clock distribution delay compensation, clock multiplication and division, coarse- and fine-grained clock phase shifting.

A new generation of programmable routing resources called Active Interconnect Technology interconnects all of these elements. The general routing matrix (GRM) is an array of routing switches. Each programmable element is tied to a switch matrix, allowing multiple connections to the general routing matrix. The overall programmable interconnection is hierarchical and designed to support high-speed designs.

All programmable elements, including the routing resources, are controlled by values stored in static memory cells. These values are loaded in the memory cells during configuration and can be reloaded to change the functions of the programmable elements.

Virtex-II Features

This section briefly describes Virtex-II features.

Input/Output Blocks (IOBs)

IOBs are programmable and can be categorized as follows:

- Input block with an optional single-data-rate or double-data-rate (DDR) register
- Output block with an optional single-data-rate or DDR register, and an optional 3-state buffer, to be driven directly or through a single or DDR register
- Bidirectional block (any combination of input and output configurations)

These registers are either edge-triggered D-type flip-flops or level-sensitive latches.

IOBs support the following single-ended I/O standards:

- LVTTL, LVCMOS (3.3V, 2.5V, 1.8V, and 1.5V)
- PCI-X compatible (133 MHz and 66 MHz) at 3.3V
- PCI compliant (66 MHz and 33 MHz) at 3.3V
- CardBus compliant (33 MHz) at 3.3V

- GTL and GTLP
- HSTL (Class I, II, III, and IV)
- SSTL (3.3V and 2.5V, Class I and II)
- AGP-2X

The digitally controlled impedance (DCI) I/O feature automatically provides on-chip termination for each I/O element.

The IOB elements also support the following differential signaling I/O standards:

- LVDS
- BLVDS (Bus LVDS)
- ULVDS
- LDT
- LVPECL

Two adjacent pads are used for each differential pair. Two or four IOB blocks connect to one switch matrix to access the routing resources.

Configurable Logic Blocks (CLBs)

CLB resources include four slices and two 3-state buffers. Each slice is equivalent and contains:

- Two function generators (F & G)
- Two storage elements
- Arithmetic logic gates
- Large multiplexers
- Wide function capability
- Fast carry look-ahead chain
- Horizontal cascade chain (OR gate)

The function generators F & G are configurable as 4-input look-up tables (LUTs), as 16-bit shift registers, or as 16-bit distributed SelectRAM memory.

In addition, the two storage elements are either edge-triggered D-type flip-flops or level-sensitive latches.

Each CLB has internal fast interconnect and connects to a switch matrix to access general routing resources.

Block SelectRAM Memory

The block SelectRAM memory resources are 18 Kb of dual-port RAM, programmable from 16K x 1 bit to 512 x 36 bits, in various depth and width configurations. Each port is totally synchronous and independent, offering three "read-during-write" modes. Block SelectRAM memory is cascadable to implement large embedded storage blocks. Supported memory configurations for dual-port and single-port modes are shown in Table 3.

Table 3: **Dual-Port And Single-Port Configurations**

16K x 1 bit	2K x 9 bits
8K x 2 bits	1K x 18 bits
4K x 4 bits	512 x 36 bits

A multiplier block is associated with each SelectRAM memory block. The multiplier block is a dedicated 18 x 18-bit multiplier and is optimized for operations based on the block SelectRAM content on one port. The 18 x 18 multiplier can be used independently of the block SelectRAM resource. Read/multiply/accumulate operations and DSP filter structures are extremely efficient.

Both the SelectRAM memory and the multiplier resource are connected to four switch matrices to access the general routing resources.

Global Clocking

The DCM and global clock multiplexer buffers provide a complete solution for designing high-speed clocking schemes.

Up to 12 DCM blocks are available. To generate de-skewed internal or external clocks, each DCM can be used to eliminate clock distribution delay. The DCM also provides 90-, 180-, and 270-degree phase-shifted versions of its output clocks. Fine-grained phase shifting offers high-resolution phase adjustments in increments of 1/256 of the clock period. Very flexible frequency synthesis provides a clock output frequency equal to any M/D ratio of the input clock frequency, where M and D are two integers. For the exact timing parameters, see **Virtex-II Electrical Characteristics**.

Virtex-II devices have 16 global clock MUX buffers, with up to eight clock nets per quadrant. Each global clock MUX buffer can select one of the two clock inputs and switch glitch-free from one clock to the other. Each DCM block is able to drive up to four of the 16 global clock MUX buffers.

Routing Resources

The IOB, CLB, block SelectRAM, multiplier, and DCM elements all use the same interconnect scheme and the same access to the global routing matrix. Timing models are shared, greatly improving the predictability of the performance of high-speed designs.

There are a total of 16 global clock lines, with eight available per quadrant. In addition, 24 vertical and horizontal long lines per row or column as well as massive secondary and local routing resources provide fast interconnect. Virtex-II buffered interconnects are relatively unaffected by net fanout and the interconnect layout is designed to minimize crosstalk.

Horizontal and vertical routing resources for each row or column include:

- 24 long lines
- 120 hex lines
- 40 double lines
- 16 direct connect lines (total in all four directions)

Boundary Scan

Boundary scan instructions and associated data registers support a standard methodology for accessing and configuring Virtex-II devices that complies with IEEE standards 1149.1 — 1993 and 1532. A system mode and a test mode are implemented. In system mode, a Virtex-II device performs its intended mission even while executing non-test boundary-scan instructions. In test mode, boundary-scan test instructions control the I/O pins for testing purposes. The Virtex-II Test Access Port (TAP) supports BYPASS, PRELOAD, SAMPLE, IDCODE, and USERCODE non-test instructions. The EXTEST, INTEST, and HIGHZ test instructions are also supported.

Configuration

Virtex-II devices are configured by loading data into internal configuration memory, using the following five modes:

- Slave-serial mode
- Master-serial mode
- Slave SelectMAP mode
- Master SelectMAP mode
- Boundary-Scan mode (IEEE 1532)

A Data Encryption Standard (DES) decryptor is available on-chip to secure the bitstreams. One or two triple-DES key sets can be used to optionally encrypt the configuration information.

Readback and Integrated Logic Analyzer

Configuration data stored in Virtex-II configuration memory can be read back for verification. Along with the configuration data, the contents of all flip-flops/latches, distributed SelectRAM, and block SelectRAM memory resources can be read back. This capability is useful for real-time debugging.

The Integrated Logic Analyzer (ILA) core and software provides a complete solution for accessing and verifying Virtex-II devices.

Virtex-II Device/Package Combinations and Maximum I/O

Wire-bond and flip-chip packages are available. Table 4 and Table 5 show the maximum possible number of user I/Os in wire-bond and flip-chip packages, respectively. Table 6 shows the number of available user I/Os for all device/package combinations.

- CS denotes wire-bond chip-scale ball grid array (BGA) (0.80 mm pitch).
- FG denotes wire-bond fine-pitch BGA (1.00 mm pitch).
- FF denotes flip-chip fine-pitch BGA (1.00 mm pitch).
- BG denotes standard BGA (1.27 mm pitch).
- BF denotes flip-chip BGA (1.27 mm pitch).

The number of I/Os per package include all user I/Os except the 15 control pins (CCLK, DONE, M0, M1, M2, PROG_B, PWRDWN_B, TCK, TDI, TDO, TMS, HSWAP_EN, DXN, DXP, and RSVD) and VBATT.

Table 4: **Wire-Bond Packages Information**

Package	CS144	FG256	FG456	FG676	BG575	BG728
Pitch (mm)	0.80	1.00	1.00	1.00	1.27	1.27
Size (mm)	12 x 12	17 x 17	23 x 23	27 x 27	31 x 31	35 x 35
I/Os	92	172	324	484	408	516

Table 5: **Flip-Chip Packages Information**

Package	FF896	FF1152	FF1517	BF957
Pitch (mm)	1.00	1.00	1.00	1.27
Size (mm)	31 x 31	35 x 35	40 x 40	40 x 40
I/Os	624	824	1,108	684

Table 6: **Virtex-II Device/Package Combinations and Maximum Number of Available I/Os (Advance Information)**

Package	Available I/Os										
	XC2V 40	XC2V 80	XC2V 250	XC2V 500	XC2V 1000	XC2V 1500	XC2V 2000	XC2V 3000	XC2V 4000	XC2V 6000	XC2V 8000
CS144	88	92	92	-	-	-	-	-	-	-	-
FG256	88	120	172	172	172	-	-	-	-	-	-
FG456	-	-	200	264	324	-	-	-	-	-	-
FG676	-	-	-	-	-	392	456	484	-	-	-
FF896	-	-	-	-	432	528	624	-	-	-	-
FF1152	-	-	-	-	-	-	-	720	824	824	824
FF1517	-	-	-	-	-	-	-	-	912	1,104	1,108
BG575	-	-	-	-	328	392	408	-	-	-	-
BG728	-	-	-	-	-	-	-	516	-	-	-
BF957	-	-	-	-	-	-	624	684	684	684	-

Notes:
1. All devices in a particular package are pinout (footprint) compatible. In addition, the FG456 and FG676 packages are compatible, as are the FF896 and FF1152 packages.

Virtex-II Ordering Information

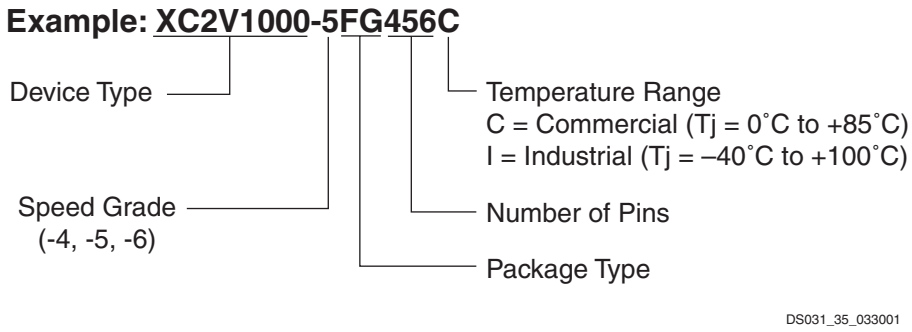

Figure 2: **Virtex-II Ordering Information**

Revision History

This section records the change history for this module of the data sheet.

Date	Version	Revision
11/07/00	1.0	Early access draft.
12/06/00	1.1	Initial release.
01/15/01	1.2	Added values to the tables in the **Virtex-II Performance Characteristics** and **Virtex-II Switching Characteristics** sections.
01/25/01	1.3	The data sheet was divided into four modules (per the current style standard).
04/02/01	1.5	Skipped v1.4 to sync up modules. Reverted to traditional double-column format.
07/30/01	1.6	Made minor changes to items listed under **Summary of Virtex-II Features**.
10/02/01	1.7	Minor edits.
07/16/02	1.8	Updated Virtex-II Device/Package Combinations shown in Table 6.
09/26/02	1.9	Updated Table 2 and Table 6 to reflect supported Virtex-II Device/Package Combinations.

Virtex-II Data Sheet

The Virtex-II Data Sheet contains the following modules:

- **Virtex™-II Platform FPGAs: Introduction and Overview (Module 1)**
- **Virtex™-II Platform FPGAs: Detailed Description (Module 2)**
- **Virtex™-II Platform FPGAs: DC and Switching Characteristics (Module 3)**
- **Virtex™-II Platform FPGAs: Pinout Information (Module 4)**