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# ML410 Embedded Development Platform

## *User Guide*

UG085 (v1.7.2) December 11, 2008





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## Revision History

The following table shows the revision history for this document.

Date	Version	Revision
01/06/06	1.0	Initial Xilinx release.
02/10/06	1.1	Corrected pinouts in <a href="#">Table 2-20, page 53</a> .
05/26/06	1.2	Corrected pinouts in <a href="#">Table 2-5, page 33</a> and <a href="#">Table 2-21, page 54</a> . Expanded "PCI Express" section.
09/25/06	1.2.1	Updated PHY address in <a href="#">Table 2-7, page 38</a> and <a href="#">Table 2-9, page 41</a> . Miscellaneous typographical edits.
10/26/06	1.3	Updated "Clock Generation," <a href="#">page 26</a> , "Serial ATA," <a href="#">page 73</a> , and "High-Speed I/O," <a href="#">page 84</a> for RoHS-compliant revision E boards. Added <a href="#">Appendix A, "Board Revisions."</a>
11/01/06	1.4	Corrected <a href="#">Table 2-19, page 51</a> .
12/22/06	1.5	Added note to "RocketIO Transceivers," <a href="#">page 17</a> . Added board revision details to <a href="#">Table A-1, page 97</a> .
03/06/07	1.6	Updated <a href="#">Table 2-19, page 51</a> and <a href="#">Table A-1, page 97</a> .
04/06/07	1.6.1	Fixed typo in <a href="#">Figure 2-19, page 71</a> .
09/28/07	1.7	Corrected pinouts in <a href="#">Table 2-15, page 46</a> for SYSACE_FPGA_CLK, SYSACE_MPD[15], SYSACE_MPCE, and SYSACE_MPWE signals.
03/05/08	1.7.1	Fixed typo in <a href="#">Table 2-8, page 40</a> . Updated trademark statements and copyright date.
12/11/08	1.7.2	Minor edits to <a href="#">Table A-1, page 97</a> . Removed support for unbuffered DIMMs.

# Table of Contents

---

<b>Schedule of Figures</b> .....	7
<b>Schedule of Tables</b> .....	9
<b>Preface: About This Guide</b>	
<b>Additional Resources</b> .....	11
<b>Conventions</b> .....	11
Typographical.....	11
Online Document.....	12
<b>Chapter 1: Introduction to Virtex-4, ISE, and EDK</b>	
<b>Virtex-4 FPGAs</b> .....	15
Summary of Virtex-4 FX Features .....	15
PowerPC™ 405 Core .....	16
RocketIO Transceivers.....	17
<b>ISE Foundation</b> .....	17
Foundation Features .....	17
Design Entry .....	17
Synthesis.....	18
Implementation and Configuration .....	18
Board-Level Integration .....	18
<b>Embedded Development Kit</b> .....	19
EDK Components .....	19
Platform Studio Features .....	19
<b>Chapter 2: ML410 Embedded Development Platform</b>	
<b>Overview</b> .....	21
Features .....	21
Block Diagram .....	23
<b>Related Xilinx Documents</b> .....	23
<b>Detailed Description</b> .....	24
Configuration .....	25
I/O Voltage Rails .....	25
Digitally Controlled Impedance (DCI) .....	25
Clock Generation .....	26
DDR and DDR2 Memory .....	29
DDR Component Memory .....	29
DDR2 SDRAM DIMM .....	32
Tri-Mode (10/100/1000 Mb/s) Ethernet PHY.....	37
PHY0: MII/RGMII .....	38
PHY1: SGMII .....	41
RS-232 Ports .....	43
System ACE CF Controller.....	44
Introduction to JTAG .....	44

Introduction to the System ACE Configuration Solution . . . . .	44
Board Bring-Up through the JTAG Interface . . . . .	45
Non-Volatile Storage through the MPU Interface . . . . .	46
GPIO LEDs and LCD . . . . .	47
GPIO LED Interface . . . . .	49
GPIO LCD Interface . . . . .	49
CPU Debugging Interfaces . . . . .	50
CPU Debug Description . . . . .	50
CPU JTAG Header Pinout . . . . .	53
CPU JTAG Connection to FPGA . . . . .	53
VGA Output . . . . .	54
PCI Express . . . . .	55
PCI Bus . . . . .	57
ALi South Bridge Interface, M1535D+ (U15) . . . . .	62
Parallel Port Interface Connector Assembly (P1) . . . . .	63
USB Connector Assembly (J3) . . . . .	63
IDE Connectors (J15 and J16) . . . . .	64
GPIO Connector (J5) . . . . .	66
System Management Bus Controller . . . . .	66
AC'97 Audio Interface . . . . .	67
PS/2 Keyboard and Mouse Interface Connector (P2) . . . . .	68
Flash ROM (U4) . . . . .	68
IIC/SMBus Interface . . . . .	69
Introduction to IIC/SMBus . . . . .	69
IIC/SMBus Signaling . . . . .	69
IIC/SMBus on ML410 Platforms . . . . .	70
Serial Peripheral Interface . . . . .	72
SPI Signaling . . . . .	72
SPI Addressing . . . . .	73
Serial ATA . . . . .	73
Serial ATA Description . . . . .	73
FPGA to Serial ATA Connector . . . . .	73
Pushbuttons, Switches, Front Panel Interface, and Jumpers . . . . .	74
Pushbuttons . . . . .	74
Switches . . . . .	75
Front Panel Interface (J23) . . . . .	77
Jumpers . . . . .	79
ATX Power Distribution and Voltage Regulation . . . . .	80
<b>High-Speed I/O . . . . .</b>	<b>84</b>
Personality Module Connectors . . . . .	85
Z-Dok+ Connector Offsets . . . . .	85
PM1 Connector . . . . .	86
PM2 Connector . . . . .	86
Adapter Board PM Connectors . . . . .	86
Z-DOK+ Utility Pins . . . . .	87
Contact Order . . . . .	88
PM1 Power and Ground . . . . .	88
PM User I/O Pins . . . . .	89
PM1 User I/O . . . . .	89
PM2 User I/O . . . . .	91

**Appendix A: Board Revisions**

**Appendix B: References**



# Schedule of Figures

---

## Chapter 1: Introduction to Virtex-4, ISE, and EDK

## Chapter 2: ML410 Embedded Development Platform

<i>Figure 2-1: ML410 High-Level Block Diagram</i> . . . . .	23
<i>Figure 2-2: ML410 Board and Front Panel Detail</i> . . . . .	24
<i>Figure 2-3: ML410 Clock Distribution</i> . . . . .	27
<i>Figure 2-4: DDR Component Block Diagram</i> . . . . .	29
<i>Figure 2-5: DDR2 DIMM Block Diagram</i> . . . . .	37
<i>Figure 2-6: PHY0 Jumper (J28) Settings</i> . . . . .	38
<i>Figure 2-7: MII Interface</i> . . . . .	39
<i>Figure 2-8: RGMII Interface</i> . . . . .	39
<i>Figure 2-9: SGMII Interface</i> . . . . .	42
<i>Figure 2-10: FPGA UART and RS-232 Connectivity</i> . . . . .	43
<i>Figure 2-11: JTAG Connections to the FPGA and System ACE CF Controller</i> . . . . .	45
<i>Figure 2-12: PC4 JTAG Connector Pinout (J9)</i> . . . . .	46
<i>Figure 2-13: LEDs and LCD Connectivity</i> . . . . .	48
<i>Figure 2-14: Combined Trace/Debug Connector Pinout</i> . . . . .	51
<i>Figure 2-15: CPU JTAG Header (J12)</i> . . . . .	53
<i>Figure 2-16: PCI Express Power Management and Clocking</i> . . . . .	55
<i>Figure 2-17: PCI Bus and Device Connectivity</i> . . . . .	58
<i>Figure 2-18: ALi South Bridge Interface, M1535D+ (U15)</i> . . . . .	62
<i>Figure 2-19: IIC and SMBus Block Diagram</i> . . . . .	71
<i>Figure 2-20: SPI EEPROM Device Interface</i> . . . . .	73
<i>Figure 2-21: SW3: System ACE Configuration Switch Detail</i> . . . . .	76
<i>Figure 2-22: ATX Power Distribution and Voltage Regulation</i> . . . . .	81
<i>Figure 2-23: Voltage Monitors</i> . . . . .	82
<i>Figure 2-24: Personality Module Connected to Embedded Development Platform</i> . . . . .	84
<i>Figure 2-25: Edge View of Host Board Connectors</i> . . . . .	85
<i>Figure 2-26: Host Board Connector Pin Detail</i> . . . . .	85
<i>Figure 2-27: Adapter Board Connector Pin Detail</i> . . . . .	87
<i>Figure 2-28: Z-DOK+ Utility Pins (ML410 Side)</i> . . . . .	87
<i>Figure 2-29: Z-DOK+ Utility Pins (Adapter Side)</i> . . . . .	88

## Appendix A: Board Revisions

<i>Figure A-1: Clock Distribution for Revisions C and D</i> . . . . .	98
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## Appendix B: References





# Schedule of Tables

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## Chapter 1: Introduction to Virtex-4, ISE, and EDK

Table 1-1: Virtex-4 FX Family Members . . . . .	16
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## Chapter 2: ML410 Embedded Development Platform

Table 2-1: I/O Voltage Rail of FPGA Banks . . . . .	25
Table 2-2: DCI Capability of FPGA Bank . . . . .	25
Table 2-3: Clock Connections . . . . .	28
Table 2-4: Connections from FPGA to DDR1 SDRAMs (U42 and U43) . . . . .	30
Table 2-5: Connections from FPGA to DDR2 DIMM Interface (P48) . . . . .	33
Table 2-6: Marvell Alaska PHY Configurations . . . . .	37
Table 2-7: PHY0 (U60) Configuration Settings for MII/RGMII . . . . .	38
Table 2-8: PHY0 MII/RGMII Interface . . . . .	40
Table 2-9: PHY1 (U61) Configuration Settings for SGMII . . . . .	41
Table 2-10: PHY1 SGMII Interface . . . . .	41
Table 2-11: PHY1 MDIO Interface . . . . .	41
Table 2-12: FPGA RS-232 Connections for UART0 . . . . .	43
Table 2-13: FPGA RS-232 Connections for UART1 . . . . .	44
Table 2-14: JTAG Connection from System ACE CF to FPGA . . . . .	46
Table 2-15: System ACE MPU Connection from FPGA to Controller . . . . .	46
Table 2-16: GPIO LED Connection from FPGA to U36 . . . . .	49
Table 2-17: GPIO LCD Data Signals from FPGA to U35 . . . . .	49
Table 2-18: GPIO LCD Control Signals from FPGA to U33 . . . . .	50
Table 2-19: CPU Trace/Debug Connection to FPGA . . . . .	51
Table 2-20: CPU JTAG Connection to FPGA . . . . .	53
Table 2-21: Connections from FPGA to DAC . . . . .	54
Table 2-22: Connections from FPGA to PCI Express Slot A . . . . .	56
Table 2-23: Connections from FPGA to PCI Express Slot B . . . . .	57
Table 2-24: PCI Controller Connections . . . . .	59
Table 2-25: 3.3V Primary PCI Bus Information . . . . .	61
Table 2-26: 5V Secondary PCI Bus Information . . . . .	61
Table 2-27: ALi South Bridge Parallel Port Connections . . . . .	63
Table 2-28: ALi South Bridge Connections to USB Type-A . . . . .	64
Table 2-29: ALi South Bridge IDE Connections . . . . .	64
Table 2-30: Type of GPIO Available on Header J5 . . . . .	66
Table 2-31: GPIO Connections on Header J5 . . . . .	66
Table 2-32: Audio Jacks (J1, J2, and J31) . . . . .	67
Table 2-33: PS/2 Keyboard and Mouse . . . . .	68
Table 2-34: ALi M1535D+ Flash Memory Interface . . . . .	68

<i>Table 2-35: IIC and SMBus Controller Connections</i> .....	70
<i>Table 2-36: IIC Devices and Addresses</i> .....	72
<i>Table 2-37: IIC and SMBus Controller Connections</i> .....	73
<i>Table 2-38: Connections Between FPGA and Serial ATA Connector (J25 and J26)</i> .....	74
<i>Table 2-39: SW6 Output</i> .....	76
<i>Table 2-40: Outputs of the Clock Multiplexer (U6)</i> .....	77
<i>Table 2-41: Front Panel Interface Connector (J23)</i> .....	78
<i>Table 2-42: 5V Fan BERG Header Connections</i> .....	79
<i>Table 2-43: Voltage Margining Jumper Settings</i> .....	80
<i>Table 2-44: Voltage Monitor Information</i> .....	83
<i>Table 2-45: Delay Offsets</i> .....	85
<i>Table 2-46: Relative Offsets from the FPGA to the PM1 and PM2 Connectors</i> .....	86
<i>Table 2-47: PM1 Power and Ground Pins</i> .....	88
<i>Table 2-48: PM1 Pinout</i> .....	89
<i>Table 2-49: PM2 Pinout</i> .....	91

## **Appendix A: Board Revisions**

<i>Table A-1: Platforms, Devices, and Features</i> .....	97
<i>Table A-2: MGT and SATA Clock Connections for Revisions C and D</i> .....	99

## **Appendix B: References**

# About This Guide

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This manual accompanies the ML410 series of Embedded Development Platforms and contains information about the ML410 hardware and software tools.

## Guide Contents

This manual contains the following chapters:

- [Chapter 1, “Introduction to Virtex-4, ISE, and EDK,”](#) provides an overview of the hardware and software features
- [Chapter 2, “ML410 Embedded Development Platform,”](#) provides an overview of the embedded development platform and details the components and features of the ML410 board
- [Appendix A, “Board Revisions”](#) details the differences between board revisions in the ML410 series
- [Appendix B, “References”](#)

## Additional Resources

To find additional documentation, see the Xilinx® website at:

<http://www.xilinx.com/literature>.

To search the Answer Database of silicon, software, and IP questions and answers, or to create a technical support WebCase, see the Xilinx website at:

<http://www.xilinx.com/support>.

## Conventions

This document uses the following conventions. An example illustrates each convention.

### Typographical

The following typographical conventions are used in this document:

Convention	Meaning or Use	Example
Courier font	Messages, prompts, and program files that the system displays	speed grade: - 100
<b>Courier bold</b>	Literal commands that you enter in a syntactical statement	<b>ngdbuild</b> <i>design_name</i>
<b>Helvetica bold</b>	Commands that you select from a menu	<b>File</b> → <b>Open</b>
	Keyboard shortcuts	<b>Ctrl+C</b>
Italic font	Variables in a syntax statement for which you must supply values	<b>ngdbuild</b> <i>design_name</i>
	References to other manuals	See the <i>Development System Reference Guide</i> for more information.
	Emphasis in text	If a wire is drawn so that it overlaps the pin of a symbol, the two nets are <i>not</i> connected.
Square brackets [ ]	An optional entry or parameter. However, in bus specifications, such as <b>bus [7:0]</b> , they are required.	<b>ngdbuild</b> [ <i>option_name</i> ] <i>design_name</i>
Braces { }	A list of items from which you must choose one or more	<b>lowpwr</b> = { <b>on</b>   <b>off</b> }
Vertical bar	Separates items in a list of choices	<b>lowpwr</b> = { <b>on</b>   <b>off</b> }
Vertical ellipsis .	Repetitive material that has been omitted	IOB #1: Name = QOUT' IOB #2: Name = CLKIN' . . .
Horizontal ellipsis ...	Repetitive material that has been omitted	<b>allow block</b> <i>block_name loc1 loc2 ... locn</i> ;

## Online Document

The following conventions are used in this document:

Convention	Meaning or Use	Example
Blue text	Cross-reference link to a location in the current document	See the section " <a href="#">Additional Resources</a> " for details. Refer to " <a href="#">Title Formats</a> " in <a href="#">Chapter 1</a> for details.

Convention	Meaning or Use	Example
Red text	Cross-reference link to a location in another document	See <b>Figure 2-5</b> in the <i>Virtex-II Platform FPGA User Guide</i> .
<u>Blue, underlined text</u>	Hyperlink to a website (URL)	Go to <a href="http://www.xilinx.com">http://www.xilinx.com</a> for the latest speed files.



## Introduction to Virtex-4, ISE, and EDK

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### Virtex-4 FPGAs

Virtex®-4 domain-optimized FPGAs provide an ideal mix of features and the greatest choice of devices of any FPGA product line on the market today, with a column-based architecture unique to the programmable logic industry. Virtex-4 FPGAs contain three platforms: LX, FX, and SX. Choice and feature combinations are offered for all complex applications. A wide array of hard-IP core blocks complete the system solution. These cores include the PowerPC® processors (with a new APU interface), Tri-Mode Ethernet MACs, 622 Mb/s to 6.5 Gb/s serial transceivers, dedicated DSP slices, high-speed clock management circuitry, and source-synchronous interface blocks. The basic Virtex-4 building blocks allow migration of existing Virtex series designs. Virtex-4 devices are produced by a state-of-the-art 90 nm copper process, using 300 mm (12 inch) wafer technology. Combining a wide variety of flexible features, the Virtex-4 family enhances programmable logic design capabilities and is a powerful alternative to ASIC technology.

### Summary of Virtex-4 FX Features

The Virtex-4 family has an impressive collection of both programmable logic and hard IP, historically the domain of ASICs. The Virtex-4 FX FPGAs used on ML410 platforms are high-performance, full-featured solutions for embedded platform applications.

- Xesium™ clock technology
  - ◆ Digital clock manager (DCM) blocks
  - ◆ Additional phase-matched clock dividers (PMCD)
  - ◆ Differential global clocks
- XtremeDSP™ slice
  - ◆ 18 x 18, two's complement, signed multiplier
  - ◆ Optional pipeline stages
  - ◆ Built-in accumulator (48-bits) and adder/subtractor
- Smart RAM memory hierarchy
  - ◆ Distributed RAM
  - ◆ Dual-port 18 Kb RAM blocks
    - Optional pipeline stages
    - Optional programmable FIFO logic - Automatically remaps RAM signals as FIFO signals
  - ◆ High-speed memory interface support: DDR and DDR2
- SDRAM, QDR II, RLDRAM II, and FCRAM II SelectIO technology
  - ◆ 1.5V to 3.3V I/O operation



- ◆ Built-in ChipSync™ source-synchronous technology
- ◆ Digitally-controlled impedance (DCI) active termination
- ◆ Fine grained I/O banking (configuration in one bank)
- Flexible logic resources
- Secure Chip AES bitstream encryption
- 90 nm copper CMOS process
- 1.2V core voltage
- Flip-Chip packaging
- RocketIO™ 622 Mb/s to 6.5 Gb/s multi-gigabit transceivers (MGT)
- IBM PowerPC RISC processor core
  - ◆ PowerPC 405 (PPC405) core
  - ◆ Auxiliary processor unit interface (user coprocessor)
- Multiple Tri-Mode Ethernet MACs

Table 1-1: Virtex-4 FX Family Members

Device	XC4VFX12	XC4VFX20	XC4VFX40	XC4VFX60	XC4VFX100	XC4VFX140
Logic Cells	12,312	19,224	41,904	56,880	94,896	142,128
PPC405	1	1	2	2	2	2
MGTs	N/A	8	12	16	20	24
Block RAM (Kb)	648	1,224	2,592	4,176	6,768	9,936
XtremeDSP Multipliers	32	32	48	128	160	192

## PowerPC™ 405 Core

- 32-bit Harvard architecture core
- Five-stage execution pipeline
- Integrated 16 KB level 1 instruction cache and 16 KB level 1 data cache
  - ◆ Integrated level 1 cache parity generation and checking
- CoreConnect™ bus architecture
- Efficient, high-performance on-chip memory (OCM) interface to block RAM
- PLB synchronization logic (enables non-integer CPU-to-PLB clock ratios)
- Auxiliary Processor Unit (APU) interface and integrated APU controller
  - ◆ Optimized FPGA-based coprocessor connection
  - ◆ Automatic decode of PowerPC floating-point instructions
  - ◆ Allows custom instructions (decode for up to eight instructions)
  - ◆ Extremely efficient microcontroller-style interfacing

## RocketIO Transceivers

- Full-duplex serial transceiver (SERDES) capable of running 622 Mb/s - 6.5 Gb/s  
**Note:** Only Revision E boards support 6.5 Gb/s. See [Appendix A, "Board Revisions"](#) for more details.
- Full clock and data recovery
- 32-bit or 40-bit datapath support
- Optional 8B/10B, 64B/66B, or FPGA-based encode/decode
- Integrated FIFO/elastic buffer
- Support for channel bonding
- Embedded 32-bit CRC generation/checking
- Integrated comma-detect or programmable A1/A2, A1A1/A2A2 detection
- Programmable pre-emphasis (AKA transmitter equalization)
- Programmable receiver equalization
- Embedded support for:
  - ◆ Out of band (OOB) signaling: Serial ATA
  - ◆ Beaconing and electrical idle: PCI Express®
- On-chip bypassable AC coupling for receiver

## ISE Foundation

ISE Foundation is the industry's most complete programmable logic design environment. With ISE Foundation, you have everything you need to target today's most advanced CPLDs and FPGAs, including the new Virtex-4 family of FPGAs. ISE Foundation includes the industry's most advanced timing driven implementation tools available for programmable logic design, along with design entry, synthesis and verification capabilities. With its ultra-fast runtimes, an average 40% faster than the nearest competitive FPGA offering, ProActive Timing Closure technologies, and seamless integration with the industry's most advanced verification products, ISE Foundation offers a great design environment in which to create a complete programmable logic design solution.

## Foundation Features

### Design Entry

ISE greatly improves time-to-market, productivity, and design quality with robust design entry features. ISE provides support for today's most popular methods for design capture including HDL and schematic entry, integration of IP cores, and robust support for reuse of your own IP.

ISE's architecture wizards allow easy access to device features like the DCM and multi-gigabit I/O technology.

ISE also includes a tool called PACE (Pinout Area Constraint Editor) that includes a front-end pin assignment editor, a design hierarchy browser, and an area constraint editor. By using PACE, designers are able to observe and describe information regarding the connectivity and resource requirements of a design, resource layout of a target FPGA, and the mapping of the design onto the FPGA via location/area.

This rich mixture of design entry capabilities provides the easiest to use design environment available today for your logic design.

## Synthesis

Synthesis is one of the most essential steps in your design methodology. It takes your conceptual Hardware Description Language (HDL) design definition and generates the logical or physical representation for the targeted silicon device.

A state-of-the-art synthesis engine is required to produce highly optimized results with a fast compile and turnaround time. To meet this requirement, the synthesis engine needs to be tightly integrated with the physical implementation tool and have the ability to proactively meet the design timing requirements by driving the placement in the physical device. In addition, cross probing between the physical design report and the HDL design code further improves the turnaround time.

Xilinx ISE provides the seamless integration with the leading synthesis engines from Mentor Graphics, Synopsys, and Synplicity. You can use the synthesis engine of our choice. In addition, ISE includes Xilinx proprietary synthesis technology, XST. You have options to use multiple synthesis engines to obtain the best-optimized result of your programmable logic design.

## Implementation and Configuration

Programmable logic design implementation assigns the logic created during design entry and synthesis into specific physical resources of the target device.

The term “place and route” has historically been used to describe the implementation process for FPGA devices and “fitting” has been used for CPLDs. Implementation is followed by device configuration, where a bitstream is generated from the physical place and route information and downloaded into the target programmable logic device.

To ensure designers get their product to market quickly, Xilinx ISE software provides several key technologies required for design implementation:

- Ultra-fast runtimes enable multiple “turns” per day
- ProActive™ Timing Closure drives high-performance results
- Timing-driven place and route combined with pushbutton ease
- Incremental Design

## Board-Level Integration

Xilinx understands the critical issues such as complex board layout, signal integrity, high-speed bus interface, high-performance I/O bandwidth, and electromagnetic interference for system-level designers.

To ease the system level designers' challenge, ISE provides support to all Xilinx leading FPGA technologies:

- System IO
- XCITE
- Digital clock management for system timing
- EMI control management for electromagnetic interference

To ensure that your programmable logic design works in the context of your entire system, Xilinx provides complete pin configurations, packaging information, tips on signal integration, and various simulation models for your board-level verification including:

- IBIS models
- HSPICE models
- STAMP models

## Embedded Development Kit

The Embedded Development Kit (EDK) is a series of software tools for designing embedded processor systems on programmable logic and supports the IBM PowerPC hard processor core and the MicroBlaze™ soft processor core. This pre-configured kit includes the Platform Studio Tool Suite.

### EDK Components

The Embedded Development Kit is distributed as a single media installable CD image.

The components of the Xilinx EDK are:

- Hardware IP for the Xilinx embedded processors and its peripherals
- Drivers, libraries, and a microkernel for embedded software development
- Platform Studio tools
- Software Development Kit (Eclipse-based IDE)
- GNU compiler and debugger for C development for MicroBlaze and PowerPC
- Documentation
- Sample projects

### Platform Studio Features

The Xilinx Platform Studio (XPS) is a graphical user interface technology that integrates all of the processes from design entry to design debug and verification. XPS streamlines development with the embedded features of the Xilinx Virtex-4 FX family of devices, featuring the industry's only immersed dual PowerPC processors and innovative Auxiliary Processor Unit (APU) controller for accelerating processing functions.

XPS automates the configuration of user-defined hardware co-processing modules used to replace application-specific software algorithms. These hardware accelerator functions operate as extensions to the PowerPC 405 processor, thereby offloading the CPU from demanding computational tasks. Utilizing the direct processor-FPGA coupling presented by the APU controller and its high throughput interfaces, flexible design partitioning with synchronization of hardware and software is greatly simplified and overall system performance is improved. The suite also includes system profiling and analysis tools to help optimize performance and target design functions for acceleration in FPGA hardware.



# ML410 Embedded Development Platform

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## Overview

The ML410 series of Embedded Development Platforms offer designers a versatile Virtex-4 FX platform for rapid prototyping and system verification. In addition to the more than 30,000 logic cells, over 2,400 kb of block RAM, dual IBM PowerPC 405 (PPC405) processors, and RocketIO transceivers available in the FPGA, the ML410 provides an onboard Ethernet MAC PHY, DDR memory, multiple PCI bus slots, and standard front panel interface ports within an ATX form factor motherboard. An integrated System ACE™ CompactFlash (CF) controller is deployed to perform board bring-up and to load applications from the CompactFlash card.

The ML410 website contains up-to-date documentation and files, including tutorials, device data sheets, reference designs, and utilities. The EDK *Processor IP User Guide* [Ref 2] should be reviewed as well as the data sheets corresponding to the devices listed in “Detailed Description.”

The setup and quickstart documentation highlights the functionality of the ML410, using the applications contained on the CompactFlash card. The reference designs were produced using the Xilinx Embedded Development Kit (EDK), ISE, and Answer Browser solution records. Tutorials, in coordination with Xilinx documentation for EDK, ISE, and the Answer Browser, describe how the reference designs and applications were produced. These tutorials can be used to re-create the provided applications and also as a basis for the development of new designs. Xilinx EDK provides for the development of basic board-specific systems, beginning with Base System Builder (BSB), to highly customized systems that leverage the flexibility of Xilinx Platform Studio (XPS) and the EDK intellectual property (IP).

## Features

The list below is a superset of features in the ML410 series. [Appendix A, “Board Revisions”](#) describes the differences between the ML410-P and ML410 model boards.

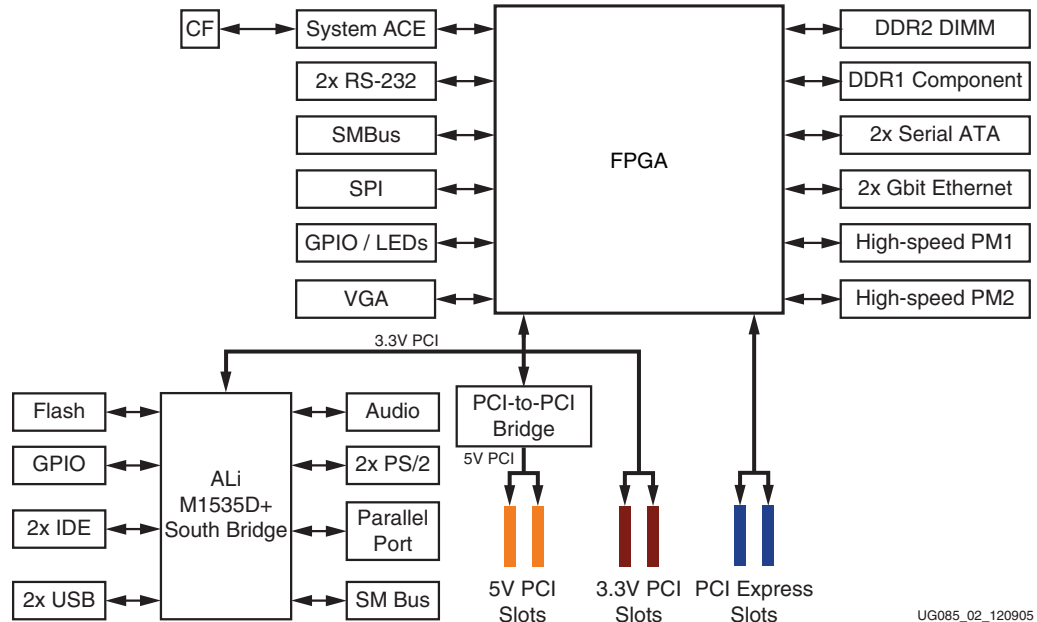
- ATX form factor motherboard and ATX-compliant power supply
- 32-bit component DDR memory and 64-bit DDR2 DIMM\*
- 512 MB CompactFlash (CF) card and System ACE CF controller for configuration\*
- Two onboard 10/100/1000 Ethernet PHYs with RJ-45 connectors
- PCI Express interface and MIC2592B PCI Express power controller
- Two UARTs with RS-232 connectors
- VGA graphics interface

- LEDs, LCD\*, and switches
- 32/33 PCI subsystem
  - ◆ Two 3.3V slots and two 5V slots
  - ◆ ALi South Bridge SuperIO controller
    - PS/2 mouse and keyboard connectors
    - 3.5mm headphone and microphone connectors
    - Two USB peripheral ports and one parallel port
    - General purpose I/O (GPIO)
    - Flash memory interface
- Two serial ATA connectors
- Xilinx Personality Module (XPM) interface for access to:
  - ◆ RocketIO transceivers
  - ◆ SPI4.2
  - ◆ GPIO
  - ◆ Power
- JTAG and trace debug ports
- Encryption battery
- Fan controller
- Onboard power regulators for all necessary voltages
- IIC/SMBus interface\*
  - ◆ LTC1694 SMBus accelerator
  - ◆ RTC8566 Real Time Clock (RTC)
  - ◆ 64 kb 24LC64 EEPROM
  - ◆ LM87 voltage/temp monitor
  - ◆ DDR2 DIMM SPD EEPROM
- SPI EEPROM\*
- High-speed I/O through RocketIO transceivers

**Note:** \* Compatible with EDK supported IP and software drivers

## Block Diagram

Figure 2-1 shows a high-level block diagram of the ML410 and its peripherals.



UG085\_02\_120905

Figure 2-1: ML410 High-Level Block Diagram

## Related Xilinx Documents

Prior to using the ML410 Embedded Development Platform, users should be familiar with Xilinx resources. See [Appendix B, “References”](#) for direct links to Xilinx documentation. See the following locations for additional documentation on Xilinx tools and solutions:

- EDK: [www.xilinx.com/edk](http://www.xilinx.com/edk)
- ISE: [www.xilinx.com/ise](http://www.xilinx.com/ise)
- Answer Browser: [www.xilinx.com/support](http://www.xilinx.com/support)
- Virtex-4 FPGAs: [www.xilinx.com/virtex-4](http://www.xilinx.com/virtex-4)



## Detailed Description

The ML410, shown in [Figure 2-2](#), is an example of the ML410 series described in this user guide.

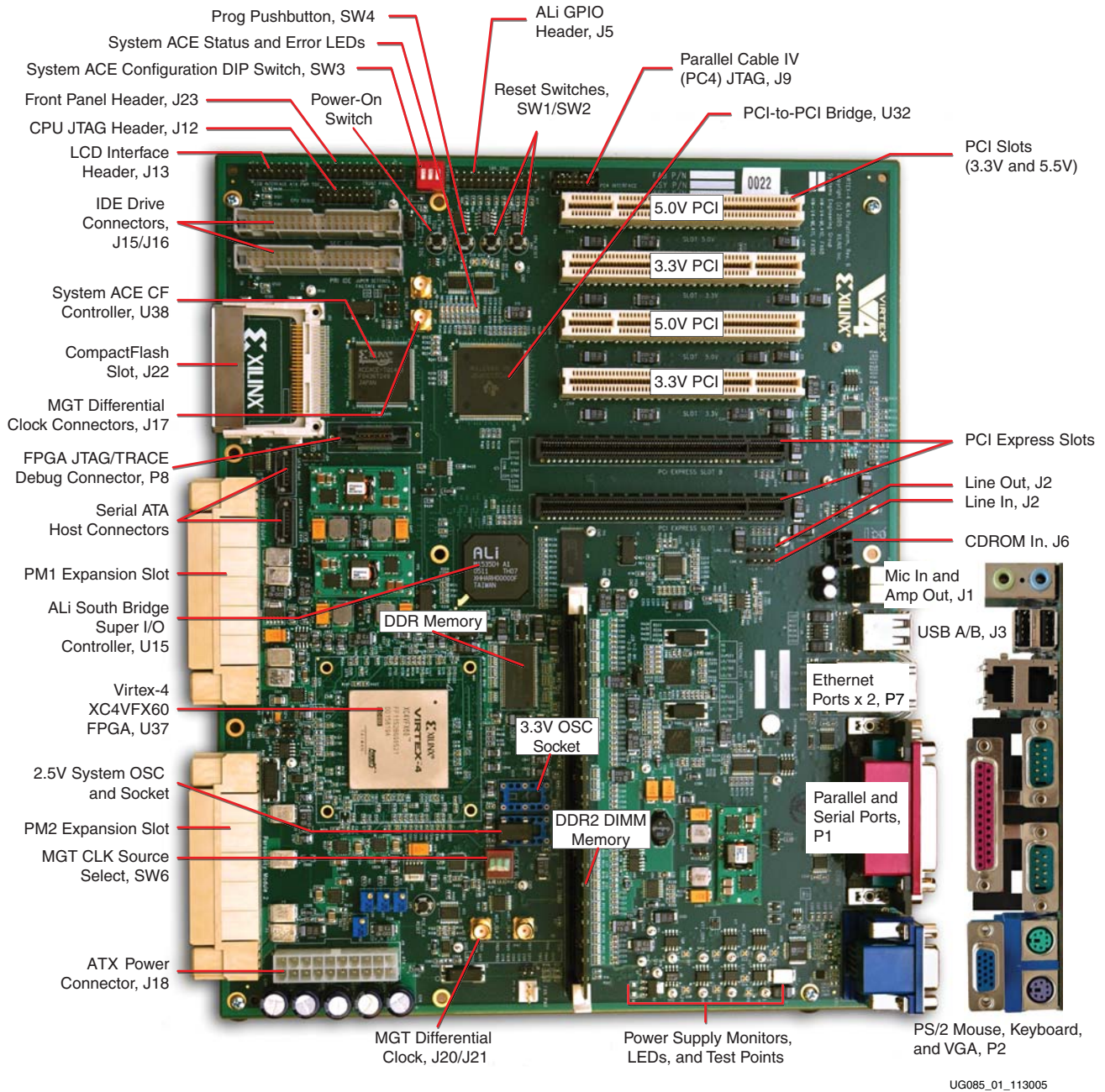


Figure 2-2: ML410 Board and Front Panel Detail

## Configuration

ML410 platforms support configuration in JTAG mode only. Configuration can be accomplished by using a Xilinx download cable (such as Parallel Cable IV or Platform Cable USB) or by using the onboard System ACE CompactFlash solution. See “[System ACE CF Controller](#),” page 44.

## I/O Voltage Rails

The FPGA requires different banking voltages that are set based on the I/O voltage interface requirements of each device directly connected to the FPGA. The Virtex-4 FPGA I/O can be configured to use different I/O standards such as SSTL18 as required on the DDR2 DIMM interface. See the *Virtex-4 Data Sheet* [Ref 3] for more information regarding I/O standards.

The voltage applied to the FPGA I/O banks used by the ML410 platforms is summarized in [Table 2-1](#).

**Table 2-1: I/O Voltage Rail of FPGA Banks**

FPGA Bank	I/O Voltage Rail	Description
1	2.5V	PCI Express controls and DDR1
2	2.5V	LCD and SPI
3	2.5V	Clocks and miscellaneous signals
4	2.5V	Clocks and miscellaneous signals
5	2.5V	DDR
6	3.0V	VGA, PHY, and both UARTs
7	2.5V	PMIO, CPU debug, and ATD
8	2.5V	PMIO and trace port
9	1.8V	DDR2
10	3.0V	PCI
11	1.8V	DDR2
12	3.0V	System ACE, PMIO_3V, and LEDs <b>Note:</b> User selectable as 3.0V (default) or 2.5V. See schematic sheet 46 (R486–R488 and R489–R491).

## Digitally Controlled Impedance (DCI)

Some FPGA banks can support the DCI feature in Virtex-4 FPGAs. Support for DCI is summarized in [Table 2-2](#).

**Table 2-2: DCI Capability of FPGA Bank**

FPGA Bank	DCI Capability	FPGA Bank	DCI Capability
1	Not supported.	7	Yes, 49.9Ω resistors are installed.
2	Not supported.	8	Yes, 49.9Ω resistors are installed.
3	Not supported.	9	Yes, 49.9Ω resistors are installed.