Thank you for using the Altera DE1 Development and Education board.

The purpose of this board is to provide the ideal vehicle for learning about digital logic, computer organization, and FPGAs. It uses the state-of-the-art technology in both hardware and CAD tools to expose students and professionals to a wide range of topics. The board offers a rich set of features that make it suitable for use in alaboratory environment for university and college courses, for a variety of design projects, as well as for the development of sophisticated digital systems. Altera provides a suite of supporting materials for the DE1 board, including tutorials, "ready-to-teach" laboratory exercises, and illustrative demonstrations.

DE1 Board Features

The DE1 board features a state-of-the-art Cyclone® II 2C20 FPGA in a 484-pin package. All important components on the board are connected to pins of this chip, allowing the user to control all aspects of the board's operation. For simple experiments, the DE1 board includes a sufficient number of robust switches (of both toggle and push-button type), LEDs, and 7-segment displays. For more advanced experiments, there are SRAM, SDRAM, and Flash memory chips. For experiments that require a processor and simple I/O interfaces, it is easy to instantiate Altera's Nios II processor and use interface standards such as RS-232 and PS/2. For experiments that involve sound or video signals, there are standard connectors for microphone, line-in, line-out (24-bit audio CODEC), SD memory card connector, and VGA; these features can be used to create CD-quality audio applications and video. Finally, it is possible to connect other user defined boards to the DE1 board by means of two expansion headers.
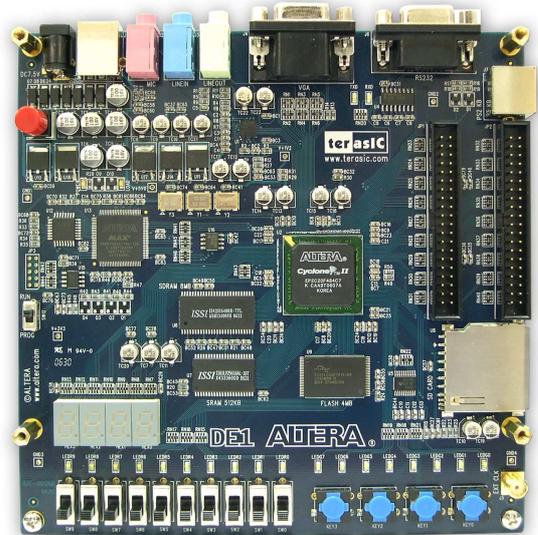
Supporting Material

Software provided with the DE1 board features the Quartus® II Web Edition CAD system, and the Nios® II Embedded Processor. Also included are several aids to help students and professionals experiment with features of the board, such as tutorials and example applications.

Traditionally, manufacturers of educational FPGA boards have provided a variety of hardware features and software CAD tools needed to implement designs on these boards, but very little material has been offered that could be used directly for teaching purposes. Altera's DE1 board is a significant departure from this trend. In addition to the DE1 board's hardware and software, Altera Corporation provides a full set of associated *laboratory exercises* that can be performed in a laboratory setting for typical courses on logic design and computer organization. In effect, the DE1 board and the available exercises can be used as a ready-to-teach platform for both university and college courses.

University and College Courses

Courses on the design of logic circuits and computer organization usually include a laboratory component. In a modern curriculum the laboratory equipment should ideally exemplify state-of-the-art technology and design tools, but be suitable for exercises that range from simple tasks illustrating fundamental concepts to challenging

designs that require knowledge of advanced topics. The DE1 board is designed to be the ideal equipment in all of these cases.

Engineering Professionals

With its advanced Cyclone® II FPGA, flexible memory options, and a plethora of advanced I/O devices, the DE1 board is an ideal platform for the implementation of many types of digital systems. Engineering professionals will appreciate the wealth of design examples provided with the board, and will enjoy experimenting with audio, video. The DE1 board is an ideal vehicle for implementing embedded applications such as those that feature the Altera Nios II embedded processor.

Specifications

DE1 Package Contents

FPGA
- Cyclone II EP2C20F484C7 FPGA and EPCS4 serial configuration device

I/O Devices
- Built-in USB Blaster for FPGA configuration RS-232 port
- VGA DAC resistor network (4096 colors)
- PS/2 mouse or keyboard port
- Line-in, Line-out, microphone-in (24-bit audio CODEC)
- Expansion headers (76 signal pins)

Memory
- 8-MB SDRAM, 512-KB SRAM, 4-MB Flash
- SD memory card slot

Switches, LEDs, Displays, and Clocks
- 10 toggle switches
- 4 debounced pushbutton switches
- 10 red LEDs, 8 green LEDs
- Four 7-segment displays
- 27-MHz and 50-MHz oscillators, external SMA clock input

Examples of Advanced Applications

The DE1 board can be used to implement a wide assortment of interesting design projects. Some example applications are shown on the next page.

Electronic Keyboard

- CD quality 24-bit audio
- VGA monitor
- Ideal platform for audio processing applications
- All software driver source code for Nios II included
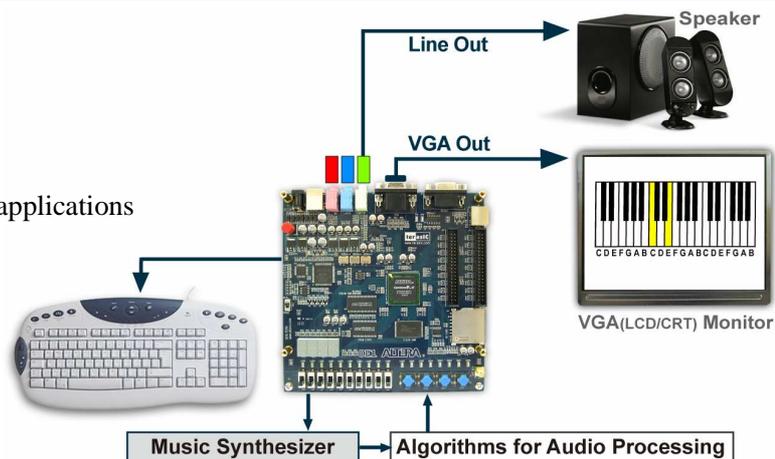
Karaoke Machine and SD Music Player

- CD quality 24-bit audio
- Ideal platform for audio applications
- All software driver source code for Nios II included

Installing the Software:

1. The **Altera Design Software Suite** contains two CD-ROM disks:

   - **Quartus II Web Edition CD-ROM**: Users of the DE1 board need to install the software on this CD-ROM disk. It supports all stages of the design process for logic circuits, including design entry, synthesis, placement and routing, simulation, and device programming. This software is an ideal tool for designing any type of logic circuits, from simple ones that may be used for learning purposes to multi-million gate designs that are found in modern commercial products. To install the Quartus II software, simply insert the disk into your CD drive and follow the instructions. Tutorials for using the Quartus II software are included in the **DE1 System** CD-ROM (**Terasic Lab CD-ROM**), described below.
   - **Nios II Embedded Processor CD-ROM**: The software on this CD-ROM disk is needed for using the Nios II embedded processor. The Nios II processor is widely used in the industry as a powerful and easy-to-use processor, but it is also an excellent vehicle for learning about topics in computer organization.

2. Install the USB Blaster driver software, as explained in the tutorial *Getting Started with Altera's DE1 Board.*

3. The **DE1 System** CD-ROM provides a variety of material for use with the board. To examine the disk, insert it into your computer's CD drive and use a utility like Windows Explorer to peruse the disk's contents:

- **DE1 User Manual and Data Sheets**: the complete manual for using the DE1 board is provided in the **DE1_user_manual** folder on the CD-ROM. Data Sheets for each of the I/O devices on the DE2 board, such as the memory chips, Audio CODEC, and RS232 are provided in the **Datasheets** folder.
- **DE1 Schematic Diagrams**: detailed schematic diagrams for all circuits on the DE2 board are provided in the folder called **DE1_schematics**.
- **Tutorials**: a set of tutorials are included in the **DE1_tutorials** folder on the CD-ROM that illustrate how to use the Quartus II software and the DE2 board. Topics covered in the tutorials include *Quartus II Introduction, Getting Started with Altera's DE2 Board, Using the Library of Parameterized Modules(LPMs)*, *Timing Considerations*, *Quartus II Simulation*, and (coming soon) *Using Nios II and SOPC Builder with the Quartus II Software*.
- **Laboratory Exercises**: a set of ready-to-teach laboratory exercises are included on the CD-ROM. These exercises can be used for self-study, or they can serve as a significant part of the laboratory component of a university or college course in digital logic. The early exercises are simple ones that illustrate fundamental concepts and perform simple operations on the DE2 board, like using switches and controlling LEDs and 7-segment displays. Later exercises progress to more advanced topics such as arithmetic circuits, counters, state machines, memory devices, datapaths, and simple processors. The tutorials are found in the folder **DE1_lab_exercises** on the CD-ROM, with subfolders provided for versions of the exercises that use VHDL and Verilog hardware description languages.
- **Demonstrations**: a set of demonstrations that illustrate the DE1 board's features are provided in the **DE1_demonstrations** folder. Examples include: VGA Graphics Generator, Electronic Keyboard, Music Player, SD Card Sound Player, PS/2 Keyboard, SDRAM Controller, Flash Controller, and RS-232 Controller. A programming file that can be downloaded into the DE1 board is provided for each demonstration example, as well as the source code in Verilog HDL.
- **DE1 Control Panel**: This application, which runs on PC platforms under Windows XP, allows remote control of the DE2 board through a USB cable. The DE1 Control Panel is found in the folder called **DE1_control_panel**; instructions for its use are given in the DE1 User Manual.

Power on Test

To design and implement circuits on the DE1 board, it is necessary to install the accompanying software, as described on the previous page. Without installing any software, a simple power on test can be done:

1. Plug the supplied 7.5 volt DC power supply into an AC power outlet (100V - 240V), and then connect this power supply to the DE1 board. Make sure the RUN/PROG switch is in the RUN position

2. Connect the DE1 board to your computer using the supplied USB cable

3. Optionally connect the DE1 board VGA connector to a VGA monitor, and the line-out (green) audio connector to a speaker or headset

4. Turn on the DE1 power by pressing the red power button. You should be able to observe the following:

- The blue POWER LED is on
- The 7-segment displays show a sequence of characters
- The red and green LEDs are flashing
- The VGA monitor is displaying a color pattern
- A humming sound is produced by the audio line-out if switch SW9 is DOWN.
- Change SW9 to be UP and use microphone-in or line-in to hear sound