



# Nios Embedded Processor

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## Getting Started User Guide



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EXCALIBUR™

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This user guide provides comprehensive information about the Excalibur™ Development Kit, featuring the Nios® embedded processor.

Table 1 shows the user guide revision history.



Go to the following sources for more information:

- See <http://www.altera.com> for more information about the features of this kit, including new features in this release.
- See page 14 for a list of available Nios documentation.
- See the Nios embedded processor *readme* file for installation and licensing information.

**Table 1. User Guide Revision History**

Date	Description
April 2002	Updated PDF - version 2.1
January 2002	Printed and PDF - version 2.0
March 2001	Printed and PDF - version 1.1
August 2000	Initial release - version 1.0

## How to Find Information

- The Adobe Acrobat Find feature allows you to search the contents of a PDF file. Click the binoculars toolbar icon to open the Find dialog box.
- Bookmarks serve as an additional table of contents.
- Thumbnail icons, which provide miniature previews of each page, provide a link to the pages.
- Numerous links, shown in green text, allow you to jump to related information.

## How to Contact Altera

For the most up-to-date information about Altera® products, go to the Altera world-wide web site at <http://www.altera.com>.

For technical support on this product, go to <http://www.altera.com/mysupport>. For additional information about Altera products, consult the sources shown in [Table 2](#).

**Table 2. How to Contact Altera**

Information Type	USA & Canada	All Other Locations
Product literature	<a href="http://www.altera.com">http://www.altera.com</a>	<a href="http://www.altera.com">http://www.altera.com</a>
Altera literature services	<a href="mailto:lit_req@altera.com">lit_req@altera.com</a> (1)	<a href="mailto:lit_req@altera.com">lit_req@altera.com</a> (1)
Non-technical customer service	(800) 767-3753	(408) 544-7000 (7:30 a.m. to 5:30 p.m. Pacific Time)
Technical support	(800) 800-EPLD (3753) (7:30 a.m. to 5:30 p.m. Pacific Time) <a href="http://www.altera.com/mysupport/">http://www.altera.com/mysupport/</a>	(408) 544-7000 (1) (7:30 a.m. to 5:30 p.m. Pacific Time) <a href="http://www.altera.com/mysupport/">http://www.altera.com/mysupport/</a>
FTP site	<a href="ftp.altera.com">ftp.altera.com</a>	<a href="ftp.altera.com">ftp.altera.com</a>

**Note:**

(1) You can also contact your local Altera sales office or sales representative.






## Typographic Conventions

The *Nios Embedded Processor Getting Started User Guide* uses the typographic conventions shown in [Table 3](#).

**Table 3. Conventions**

Visual Cue	Meaning
<b>Bold Type with Initial Capital Letters</b>	Command names, dialog box titles, checkbox options, and dialog box options are shown in bold, initial capital letters. Example: <b>Save As</b> dialog box.
<b>bold type</b>	External timing parameters, directory names, project names, disk drive names, filenames, filename extensions, and software utility names are shown in bold type. Examples: <b>f<sub>MAX</sub></b> , <b>\QuartusII</b> directory, <b>d:</b> drive, <b>chiptrip.gdf</b> file.
<b><i>Bold italic type</i></b>	Book titles are shown in bold italic type with initial capital letters. Example: <b><i>1999 Device Data Book</i></b> .
<i>Italic Type with Initial Capital Letters</i>	Document titles are shown in italic type with initial capital letters. Example: <i>AN 75 (High-Speed Board Design)</i> .
<i>Italic type</i>	Internal timing parameters and variables are shown in italic type. Examples: <i>t<sub>PIA</sub></i> , <i>n + 1</i> . Variable names are enclosed in angle brackets (< >) and shown in italic type. Example: <i>&lt;file name&gt;</i> , <i>&lt;project name&gt;.pdf</i> file.
Initial Capital Letters	Keyboard keys and menu names are shown with initial capital letters. Examples: Delete key, the Options menu.

**Table 3. Conventions**

Visual Cue	Meaning
"Subheading Title"	References to sections within a document and titles of Quartus II Help topics are shown in quotation marks. Example: "Configuring a FLEX 10K or FLEX 8000 Device with the BitBlaster™ Download Cable."
Courier type	Signal and port names are shown in lowercase Courier type. Examples: <code>data1</code> , <code>tdi</code> , <code>input</code> . Active-low signals are denoted by suffix <code>n</code> , e.g., <code>resetn</code> .  Anything that must be typed exactly as it appears is shown in Courier type. For example: <code>c:\quartusII\qdesigns\tutorial\chiptrip.gdf</code> . Also, sections of an actual file, such as a Report File, references to parts of files (e.g., the AHDL keyword <code>SUBDESIGN</code> ), as well as logic function names (e.g., <code>TRI</code> ) are shown in Courier.
1., 2., 3., and a., b., c.,...	Numbered steps are used in a list of items when the sequence of the items is important, such as the steps listed in a procedure.
	Bullets are used in a list of items when the sequence of the items is not important.
	The checkmark indicates a procedure that consists of one step only.
	The hand points to information that requires special attention.
	The angled arrow indicates you should press the Enter key.
	The feet direct you to more information on a particular topic.



*Notes:*



## Getting Started

### Introduction

The Nios Development Kit includes software, hardware, accessories, and documentation to create working embedded systems projects. The Nios development board is shipped with a factory default 32-bit reference design. In addition to the factory default design loaded on the board, several other 16-bit and 32-bit reference designs are provided. You can use these reference designs as a starting point for designing your own Nios project with the included Nios peripherals and bus configuration.

The purpose of this getting started user guide is to familiarize you with all the items in the kit. This user guide tells you how to install the Nios embedded processor software and how to set up and test the Nios development board. Once set up, you are ready to begin using the Nios Development Kit to create your own Nios system module. A description of the documents is available to assist you in choosing which documents to use for designing your Nios embedded system.

### Before You Begin

Be sure to check the contents in each box of the kit to verify that you received all the items. If any of these items are missing, contact [www.altera.com/mysupport](http://www.altera.com/mysupport) before you proceed.

#### Nios Printed Documentation Box

- Nios 16-Bit Programmer's Reference Manual
- Nios 32-Bit Programmer's Reference Manual

#### Nios Embedded Processor Design Tools Box

- Nios Embedded Processor CD ROM
- GNUPro Toolkit CD ROM
- Quartus II Limited Edition CD ROM
- Leonardo Spectrum CD ROM
- Third-Party Tool Evaluation CD ROMS

#### GNUPro Printed Documentation Box

- ✓ GNUPro printed documentation

### Nios Development Board Box

- APEX 20K200E development board
- 9-V DC power supply
- 4 power cables (US, Japan, UK, Europe)
- Serial Y cable
- 6-foot 25-pin parallel port extension cable
- ByteBlasterMV cable
- LCD Module

### Important Considerations

- You will need the serial number for installing and licensing the Quartus II software. The sticker with the serial number is on the Nios Embedded Processor Design Tools CD holder.
- You will need your network identification card (NIC) number for licensing Quartus II software. To get your NIC number, go to the DOS prompt and enter `ipconfig/all`. The 12-digit hexadecimal number on the line marked "physical address" is your NIC number. When entering the NIC number, exclude the dashes.
- Do not choose a directory name with spaces, such as *Program Files*. Spaces in a directory name may cause the Quartus II software to not work properly.
- You will need administrative privileges to install parts of the Quartus II software on WinNT or Win2000.

### CD Software Description

#### Nios Embedded Processor

The SOPC Builder MegaWizard is used to create Nios embedded processor systems with either the 16-bit or 32-bit CPU core, built-in peripherals, on- and off-chip ROM and RAM support and bus support for external hardware modules.

#### *To Install the Nios Embedded Processor CD ROM*

The Nios embedded processor CD ROM is found in the Nios Embedded Processor Design Tools Box. When you insert the Nios embedded processor CD ROM in your CD-ROM drive, the install program begins. Follow the install directions.



## Quartus II Limited Edition Software

The Quartus™ II Limited Edition software is a programmable logic development tool for programming Altera devices. The Quartus II tool supports system-level solutions with block-level editing, workgroup computing, and expanded support for megafunctions. In addition, an embedded logic analysis feature allows engineers to verify chip functionality and timing by observing internal and I/O signal values at system clock speeds.



Follow the instructions in the *readme* for licensing your Quartus II software.

## Leonardo Spectrum

Leonardo Spectrum is bundled with the Nios embedded processor and installs automatically when you install the Nios embedded processor CD ROM. This version of Leonardo Spectrum is required for Nios system development. This version of Leonardo Spectrum does not conflict with any previously installed versions of the Nios embedded processor.

## Third-Party Evaluation CD ROMS

The third-party development tools included in the Nios development kit support the Nios embedded processor. Refer to the *readme* for more information about these third-party evaluation CD ROMS.

## The Nios Development Board

Use the Nios development board to begin developing embedded systems running on an Altera programmable device. A 32-bit Nios CPU running a boot monitor is pre-loaded into Flash memory and boots on power-up. The monitor provides the interface between the CPU, memory and your developed code. Custom hardware configuration and software applications can be loaded into Flash memory to create a stand-alone embedded system.



Refer to the *Nios Embedded Processor Development Board* manual and board schematics for more information by selecting **Start > Programs > Altera > Excalibur Nios 2.1 > Altera Excalibur Nios Documentation** from the Windows Start Menu.

## Setting Up the Development Board

To set up the Nios development board, follow these steps:

1. Take the Nios development board out of the box and remove its anti-static shipping bag. Take care not to expose the board to electrostatic discharge (ESD) during setup or use.

2. The Y serial cable has three labeled connectors; **board**, **main** and **debug**. Connect the **board** connector to the serial port connector (J3) on the Nios development board and the **main** connector to either the COM1 or COM2 serial port on your personal computer.



The **debug** connector is optionally available for dedicated debug communications.

3. Connect one end of the 25-pin parallel cable to the parallel port of your personal computer and the other end to the ByteBlasterMV download cable.



For more information about the ByteBlaster download cable see the *ByteBlaster MV Parallel Port Download Cable Data Sheet* on the website at <http://altera.com/literature/lit-index.html>.

4. Connect the ByteBlasterMV download cable to the JTAG connector (JP3).

5. Connect the 14-pin LCD module ribbon cable to JP12. Pin 1 on JP12 must connect to pin 1 on the LCD module. Pin 1 is marked with a small triangle arrow molded into the plastic of the connector. You will use the LCD module later for testing the system.



Pin 3 on the LCD module has been deliberately removed. This pin controls the contrast of the LCD module.

6. Connect the 9-V DC power-supply to J1. Select the appropriate power cord for your location. Connect one end to the 9-V DC power supply and the other end to an outlet.

You have finished connecting the board. LED 7, LED 3 and the dual 7-segment LED display lights and one row of the LCD module displays black squares.

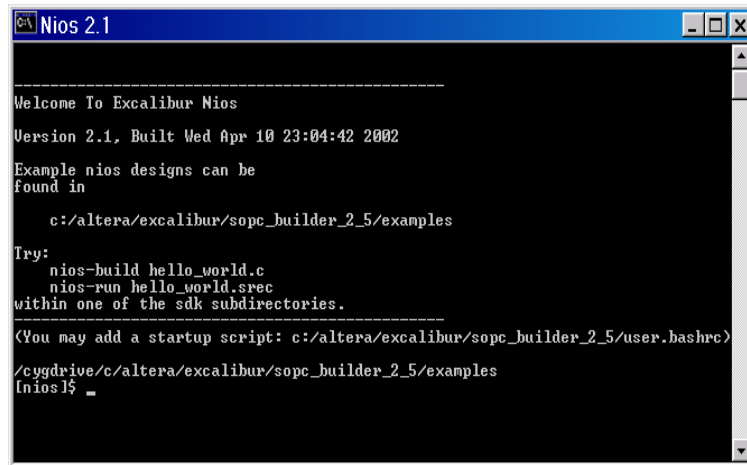


If the Nios development board LEDs are not lit, check all the connections to make sure power is supplied to the board properly. For further assistance, call (800) 800-EPLD (3753).

## Setting Up Communication with the Board

The development board is now working with the factory default settings. Nios SDK shell is the terminal communication program you will use. To establish interaction and communication with the development board, do the following:

1. From the Windows Start Menu, select **Altera> Excalibur Nios 2.1> Nios SDK Shell**. The shell window appears and displays a shell prompt, as shown in [Figure 1](#).


**Figure 1. Nios SDK Shell Prompt**

```
Nios 2.1


-----
Welcome To Excalibur Nios
Version 2.1, Built Wed Apr 10 23:04:42 2002
Example nios designs can be
found in
    c:/altera/excalibur/sopc_builder_2_5/examples
Try:
    nios-build hello_world.c
    nios-run hello_world.spec
within one of the sdk subdirectories.
<You may add a startup script: c:/altera/excalibur/sopc_builder_2_5/user.bashrc>
/cygdrive/c/altera/excalibur/sopc_builder_2_5/examples
nios1$
```



The terminal communications program for Nios is **Nios SDK Shell**. Selecting **Program> Cygwin> bash** from the Windows Start Menu accesses a previous program used for terminal communication. Do not use this method for Nios 2.1.

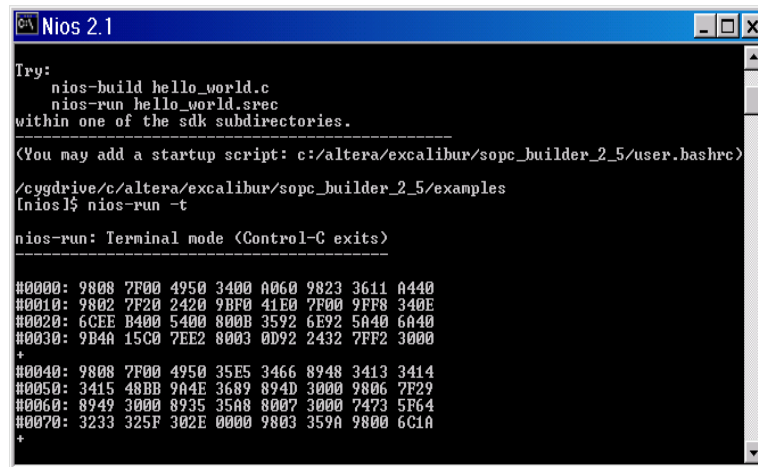
2. Type `nios-run -t`  to begin communicating with the development board.



Step 2 assumes the serial cable is connected to COM1. If you are using COM2, type `nios-run -p com2 -t` .

3. Press Enter several times. The GERMS monitor (code that executes and controls the boot process) running on the Nios CPU, displays the first few lines of memory starting at address 0000, as shown in [Figure 2](#). You have established communications and are now ready to download application software to the development board.

Figure 2. GERMS Monitor



```

Nios 2.1
Try:
  nios-build hello_world.c
  nios-run hello_world.srec
within one of the sdk subdirectories.
(You may add a startup script: c:/altera/excalibur/sopc_builder_2_5/user.bashrc)
/cygdrive/c/altera/excalibur/sopc_builder_2_5/examples
lnios1$ nios-run -t
nios-run: Terminal mode (Control-C exits)
-----
#0000: 9808 7F00 4950 3400 A060 9823 3611 A440
#0010: 9802 7F20 2420 9BF0 41E0 7F00 9FF8 340E
#0020: 6CEE B400 5400 800B 3592 6E92 5A40 6A40
#0030: 9B4A 15C0 7EE2 8003 0D92 2432 7FF2 3000
+
#0040: 9808 7F00 4950 35E5 3466 8948 3413 3414
#0050: 3415 48BB 9A4E 3689 894D 3000 9806 7F29
#0060: 8949 3000 8935 35A8 8007 3000 7473 5F64
#0070: 3233 325F 302E 0000 9803 359A 9800 6C1A
+

```



See the *Software Development Reference Manual* for a table of GERMS monitor commands and usage examples.

4. Press Ctrl + C to exit the terminal communication program and return to the Nios SDK Shell prompt.

## Testing the System

You will now compile and download the lcd demo to the Nios embedded processor system. Change directories to the standard 32-bit example design by typing the following command:

```
cd vhd1/standard_32/cpu_sdk/src
```

This command places you in the default software development directory for the vhd1 version of the example design. This design is pre-programmed into the development board Flash memory.



If you prefer working with verilog designs, type the following command:

```
cd verilog/standard_32/cpu_sdk/src
```



## Documentation List

Table 4 lists available documents and a descriptions of each document follows Table 4. Click on the title of the document to access the document at the Altera web site. These documents are also found at **Start> Programs > Altera> Excalibur Nios 2.1 > Altera Excalibur Nios Documentation** from the Windows Start menu.

Click the following link to view other available Altera literature:  
<http://www.altera.com/literature/lit-index.html>

<b>Table 4. Documentation List</b>			
<b>Document</b>	<b>Hardware Developer</b>	<b>Software Developer</b>	<b>IP Developer</b>
<i>Using SOPC Builder with Excalibur Devices Tutorial</i>	x	x	
<i>SOPC Builder Data Sheet</i>	x	x	x
<i>SOPC Builder PTF File Reference Manual (web site only)</i>			x
<i>Nios Embedded Processor Development Board Data Sheet</i>	x	x	x
<i>Nios Tutorial</i>	x	x	
<i>Nios 16-Bit Programmer's Reference Manual</i>		x	
<i>Nios 32-Bit Programmer's Reference Manual</i>		x	
<i>Nios Embedded Processor Software Reference Manual</i>		x	
<i>Nios Embedded Processor Peripherals Reference Manual</i>	x	x	
<i>Nios 2.1 CPU Data Sheet</i>	x		x
<i>Avalon Bus Specification Reference Manual</i>	x		x
<i>Custom Instruction Application Note</i>	x	x	
<i>Custom Instruction Tutorial</i>	x	x	
<i>Nios Ethernet Development Kit User Guide</i>	x	x	
<i>Simultaneous Multi-Mastering Application Note</i>	x		x
<i>Simultaneous Multi-Mastering with the Nios Processor Tutorial</i>	x		x
<i>Simulating Nios Embedded Processor Designs Application Note</i>	x		x
<i>GNUPro printed documentation</i>	x	x	

### Using SOPC Builder with Excalibur Devices Tutorial

This tutorial (*sopc\_excalibur\_devices\_tutorial.pdf*) shows the developer the steps to create the minimal\_arm reference design using SOPC Builder.

### **SOPC Builder PTF File Reference Manual (*Altera website only*)**

This reference manual (*sopc-builder-ptf-file-reference-manual*) is for IP developers who wish to create new library components for SOPC Builder. This manual contains reference material on the internal workings of the PTF file structure and the development phases of SOPC Builder. This manual is recommended for advanced system designers with basic familiarity of the SOPC Builder tool.

### **Nios Development Board Data Sheet**

This data sheet (*nios\_development\_board.pdf*) describes the features and functionality of the Nios development board and provides the technical details of its components. For Nios board schematics, select **Start > Programs > Altera > Excalibur Nios 2.1 > Altera Excalibur Nios Documentation** from the Windows Start Menu.

### **Nios Software Development Reference Manual**

This reference manual (*nios\_software\_development\_reference.pdf*) provides information for programmers developing software for the Nios embedded processor. The primary focus of this document is for developers writing code in C and includes sections addressing code written in assembly.

### **Nios 16-Bit Programmer's Reference Manual**

This reference manual (*nios\_programmers\_reference\_16.pdf*) contains details on the Nios processor architecture including registers, addressing modes, program-flow control, exceptions and pipeline implementation. It includes complete documentation on the Nios assembly language instruction set for a 16-bit CPU.

### **Nios 32-Bit Programmer's Reference Manual**

This reference manual (*nios\_programmers\_reference\_32.pdf*) contains details on the Nios processor architecture including registers, addressing modes, program-flow control, exceptions and pipeline implementation. It includes complete documentation on the Nios assembly language instruction set for a 32-bit CPU.

## **Nios Peripherals Reference Manual**

This reference manual (*nios\_peripherals\_reference\_manual.pdf*) describes the peripherals included in the Nios development kit. It includes details about peripheral registers, peripheral template file (PTF) assignments and software routines.

## **Nios 2.1 CPU Data Sheet**

This data sheet (*nios\_cpu\_datasheet.pdf*) contains an overview of the Nios CPU core which includes a description of all its configuration options.

## **SOPC Builder Data Sheet**

This data sheet (*sopc\_builder\_datasheet.pdf*) contains an overview of SOPC Builder which includes a description of the SOPC Builder library components and the PTF file structure.

## **Nios Ethernet Development Kit User Guide**

This user guide (*nios\_edk\_user\_guide.pdf*) describes installing the kit's development tools and hardware and how to access the software application examples. It includes a functional description of the daughter card and PC-board design files and the supported protocol C-language library with a plugs library reference for the software routines. The Nios Ethernet Development Kit can be purchased as an optional add-on kit.

## **Avalon Bus Specifications Reference Manual**

This reference manual (*avalon\_bus\_spec.pdf*) is for developers creating custom peripherals for the Avalon bus. It defines terms and concepts of SOPC designs based on the Avalon bus architecture used for connecting on-chip processors and peripherals into a system on a programmable chip (SOPC). Avalon bus signal functions and timing are defined.

## **Nios Tutorial**

This tutorial (*nios\_tutorial.pdf*) shows the developer how to use the SOPC Builder to build a Nios processor-based system and custom software development kit (SDK).



## Custom Instruction Tutorial

This tutorial (*custom\_instruction\_tutorial.pdf*) introduces you to custom instruction using the Nios embedded processor. The tutorial guides you through the steps for implementing two example custom instructions in a Nios system module and then describes how to access these custom instructions through software.

## Simultaneous Multi-Mastering with the Nios Processor Tutorial

This tutorial (*tt\_nios\_smm.pdf*) describes how to optimize an embedded system's performance using the simultaneous multi-master bus architecture. It describes the new features in the SOPC Builder software that allow you to customize a system bus architecture easily and shows you how to use the SOPC Builder software to define a custom bus architecture to improve the example design's performance.

## Simultaneous Multi-Mastering Avalon Bus Application Note

This application note (*nios\_an184\_avalon\_multimaster.pdf*) describes the simultaneous multi-master Avalon bus with an explanation about how it differs from existing bus arbitration schemes. It includes an in-depth explanation of bus arbitration priorities and most commonly used configurations for your Nios embedded system design.

## Custom Instruction Application Note

This application note (*nios\_an188\_custom\_instructions.pdf*) describes the custom instruction feature and how to implement custom instructions in Nios based-designs. It includes a design example that shows the benefits of using custom instructions.

## Simulating Nios Embedded Processor Designs

This application note (*nios\_an189\_simulating\_designs.pdf*) describes the simulation flow of a simulation project and walks the user through the process of simulating a design using ModelSim® created by the SOPC Builder.

## Nios FAQ

The FAQ covers both hardware and software design issues.

## For More Information

For updates and newly created Nios documentation, go to the <http://www.altera.com/literature/lit-nio.html>. If you need technical support, contact the Altera Applications department at <http://www.altera.com/mysupport>.