Nios II Debug Client

This tutorial presents an introduction to the Nios II Debug Client, which is used to compile, assemble, download and debug programs for Altera's Nios II processor. This tutorial presents step-by-step instructions that illustrate the features of the Nios II Debug Client.

The process of dowloading and debugging a Nios II application requires the presence of an actual FPGA device to implement the Nios II processor. For the purposes of this tutorial, it is assumed that the user has access to the Altera DE2 Development and Education board connected to a computer that has Quartus II (version 5.1 or higher) and Nios II software installed.

The screen captures in the tutorial were obtained using the version 1.0 of the Nios II Debug Client; if other versions of the software are used, some of the images may be slightly different.

Contents:

Introduction

The Nios II Debug Client is a software application that runs on a host PC connected to a Nios II System. It allows the user to compile or assemble Nios II applications, download the application to the Nios II system and then debug the running application. The Debug Client provides functionality that allows the user to:

- Examine register and memory contents.
- Disassemble the machine code present in any memory region.
- Single step through each assembly language instruction in the Nios II application.
- Set breakpoints that trigger when certain instructions are reached or when certain data addresses are accessed.
- Examine a graphical view of an Instruction Trace that records the set of recently executed instructions before a breakpoint is hit.
- View serial output sent through the Nios II JTAG UART.

1 Installing the Nios II Debug Client

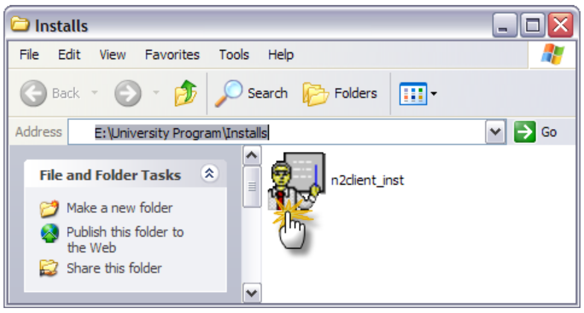
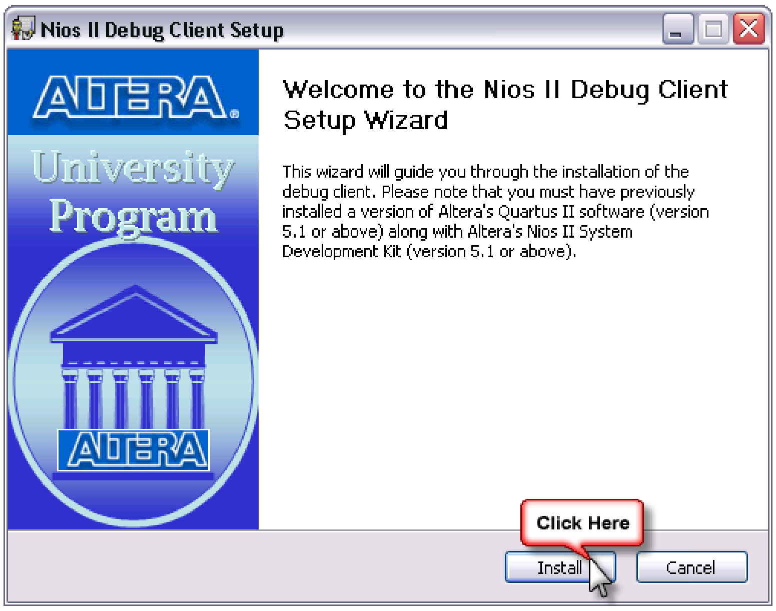


Figure 1: Install File on DE2 CD.

To install the Nios II Debug Client, proceed as follows:

1. Use **Microsoft Windows Explorer** to open the folder “University Program/Installs” from the DE2 CD-ROM. As shown in Figure 1, the folder will contain a single executable file named *n2client_inst*.
2. Double-Click on this *n2client_inst* executable file. This will bring up the first screen of the installer as illustrated in Figure 2. Click on the **Install** button and proceed to the next step. During the install, you will be asked if you would like a shortcut to the Nios II Debug Client to be placed on your **Windows Desktop**. Answering yes will install an icon similar to the one shown in Figure 3 on your desktop.
3. Assuming that the install was successful, the screen shown in Figure 4 will be displayed. Click on the **Finish** button to complete the installation. Should an error occur, a dialog box will suggest the appropriate action. Errors include:
    - Quartus II Software is not already installed or the Quartus II version is too old.
    - Nios II SDK Software is not already installed or the version is too old.


Nios II Debug Client Setup

Welcome to the Nios II Debug Client Setup Wizard

This wizard will guide you through the installation of the debug client. Please note that you must have previously installed a version of Altera's Quartus II software (version 5.1 or above) along with Altera's Nios II System Development Kit (version 5.1 or above).

Figure 2: Nios II Debug Client Install Wizard.

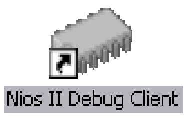
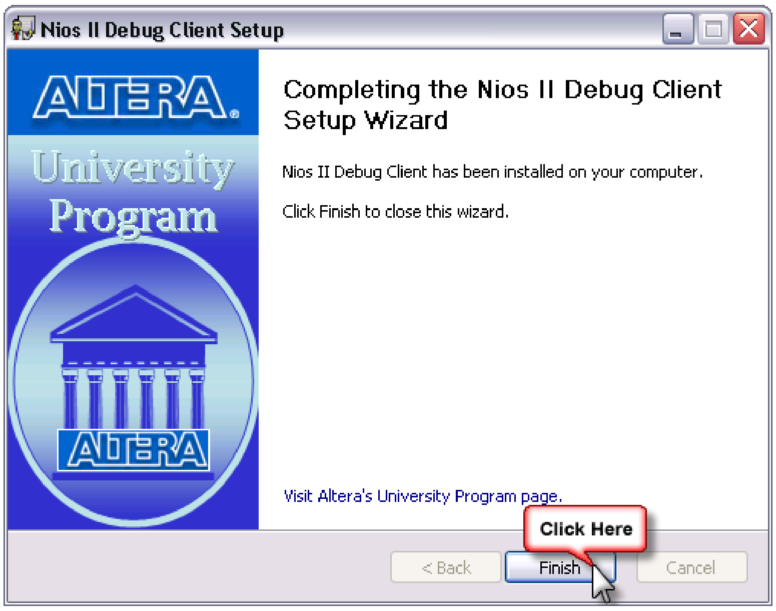


Figure 3: Nios II Debug Client Desktop Icon.


Nios II Debug Client Setup

Completing the Nios II Debug Client Setup Wizard

Nios II Debug Client has been installed on your computer.

Click Finish to close this wizard.

Visit Altera's University Program page.

Figure 4: Nios II Debug Client Install Finished.

2 Starting the Nios II Debug Client

Before starting the Nios II Debug Client, ensure that a Nios II System has been downloaded onto the DE2 Development and Education board. This tutorial assumes that the example Nios II system provided on the DE2 CD-ROM has been downloaded.

If you have chosen to install a Windows Desktop Shortcut, you may start the Nios II Debug Client by double clicking on the associated icon. If you have not installed the shortcut or wish to start the Debug Client in an alternative manner, proceed as follows:

1. Start the *Nios II SDK Shell* from the Windows Start Menu by following the links from **Altera** > **Nios II Development Kit** > **Nios II SDK Shell**. This step is illustrated in Figure 5.

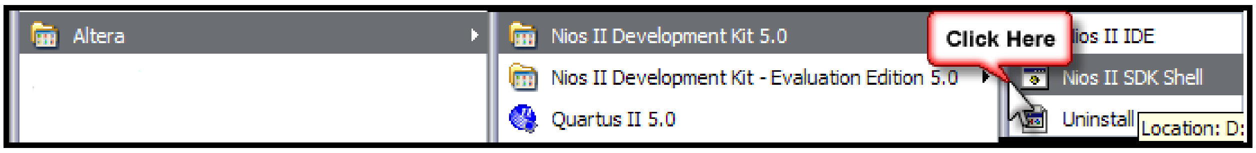
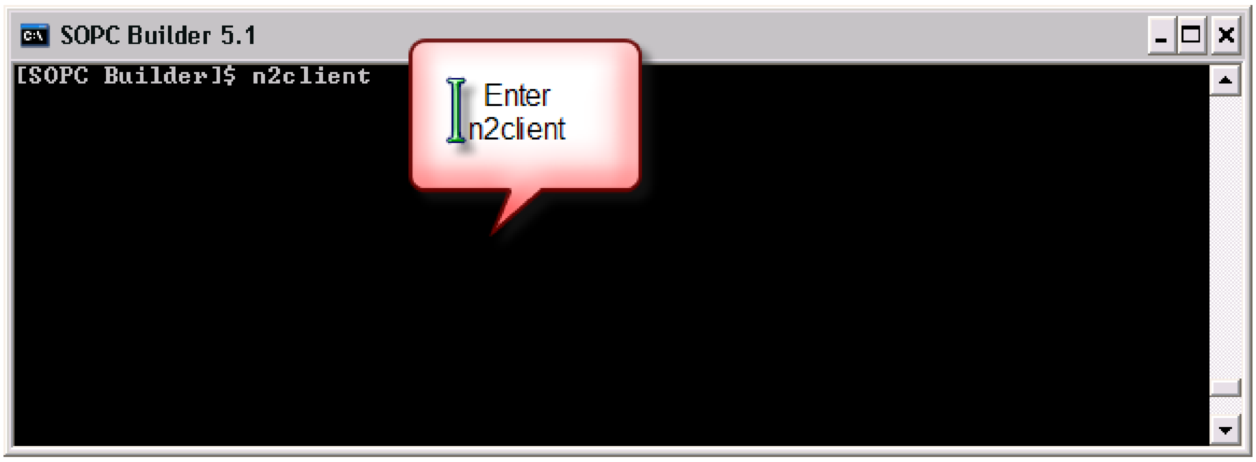


Figure 5: Starting the Nios II SDK Shell.

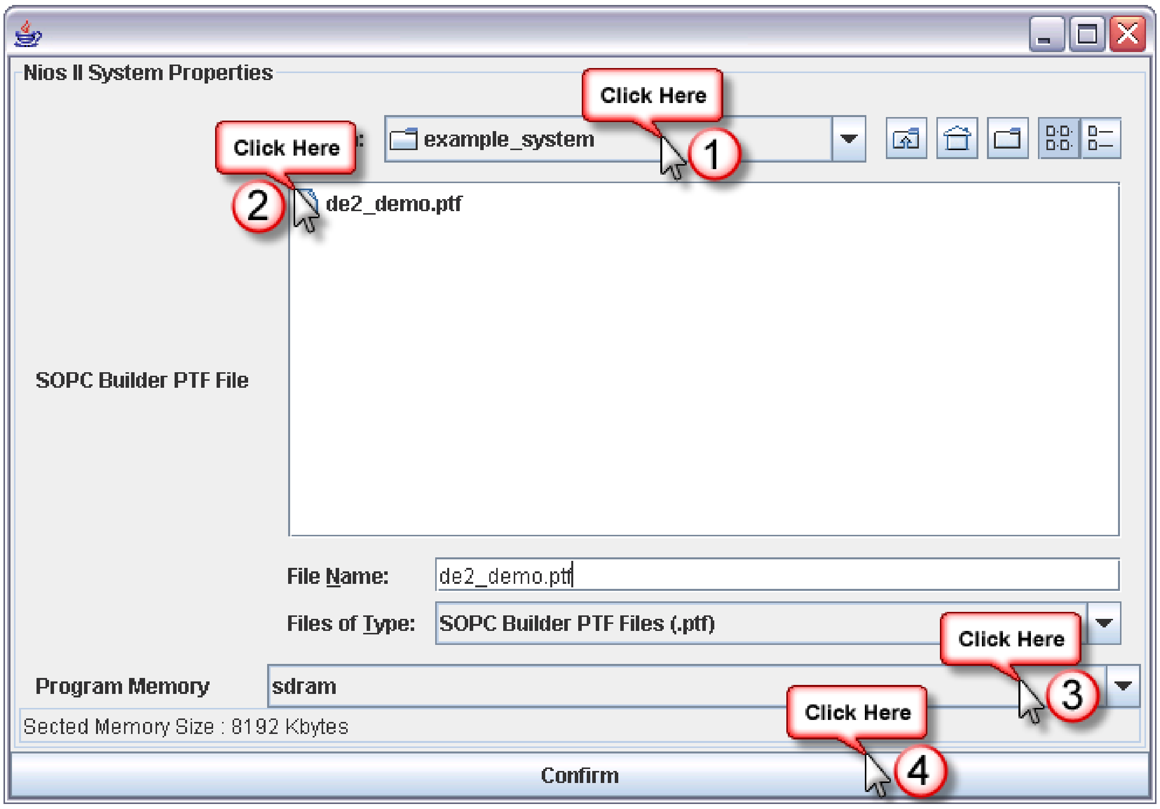
2. The Nios II Debug Client can now be started from the Nios II SDK shell as shown in Figure 6. Enter the command *n2client* in the SDK shell and press Enter.



```
[SOPC Builder]$ n2client
```

Figure 6: Starting the Nios II Debug Client.

After startup, the Nios II Debug Client **Settings Window** will appear as shown in Figure 7. Nios II systems have a user configurable architecture. The designer may choose from a variety of peripherals and memory options in Altera's SOPC Builder. The Nios II Debug Client needs information describing the Nios II system that is being targetted. Systems created by Altera's SOPC builder are described by a *.ptf* file located in the project's main directory. This file contains information about all the peripherals connected to the Nios II processor as well as the memory map. The Nios II Debug Client can use this information to debug applications for any Nios II based system.


Nios II System Properties

SOPC Builder PTF File

: example_system

de2_demo.ptf

File Name: de2_demo.ptf

Files of Type: SOPC Builder PTF Files (.ptf)

Program Memory sdram

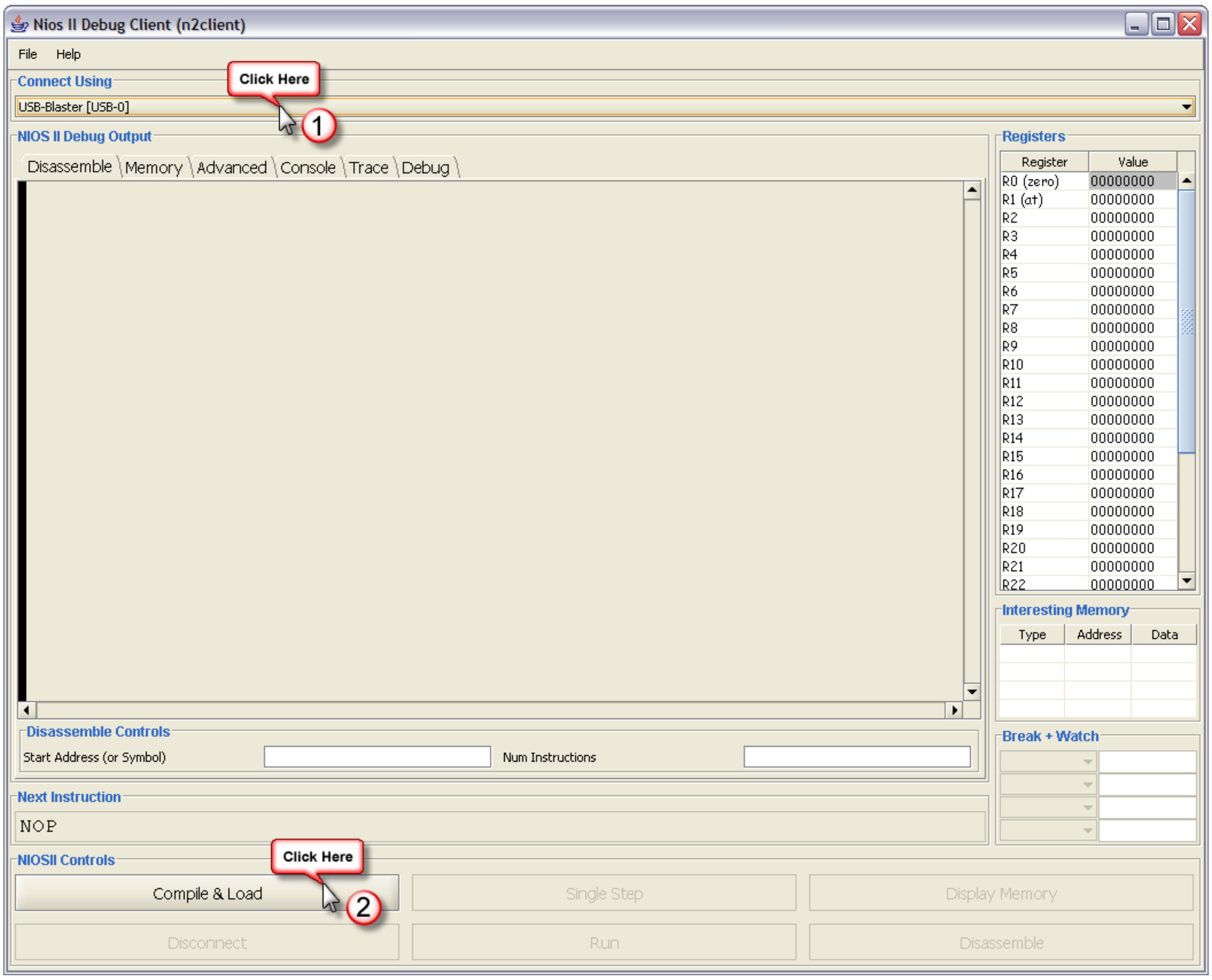
Sected Memory Size : 8192 Kbytes

Figure 7: Nios II Debug Client Settings Window.

The **Settings Window** allows the user to choose the location of the *.ptf* file that describes their particular Nios II System. It also tells the Nios II Debug Client where it should download the target software application. This will typically be a symbolic name, created in SOPC builder, that describes a memory device. By default, the first time that the Debug Client is started, a *.ptf* file describing the example Nios II System shipped with DE2 CD-ROM will be selected and the *sdram* memory will be chosen to hold the target application. To change the defaults, proceed as follows:

1. Select the directory that contains your *.ptf* file by using the **Look In:** drop down list.
2. Double Click on the appropriate *.ptf* file in the **SOPC Builder PTF File** area.
3. Select the approriate memory device from the **Program Memory** drop down list.
4. Click on the **Confirm** button. These settings will remain for all subsequent runs of the Nios II Debug Client. Only the **Confirm** button will need to be pressed if no changes are required.

After a few seconds, the Nios II Debug Client window will appear. The startup screen is shown in Figure 8.



Connect Using: USB-Blaster [USB-0]

Next Instruction: NOP

Registers

Register	Value
R0 (zero)	00000000
R1 (at)	00000000
R2	00000000
R3	00000000
R4	00000000
R5	00000000
R6	00000000
R7	00000000
R8	00000000
R9	00000000
R10	00000000
R11	00000000
R12	00000000
R13	00000000
R14	00000000
R15	00000000
R16	00000000
R17	00000000
R18	00000000
R19	00000000
R20	00000000
R21	00000000
R22	00000000

Figure 8: Nios II Debug Client.

3 Compiling and Downloading Nios II Applications

To compile and download a Nios II application, proceed with the following steps:

1. As shown in Figure 8, the first step (highlighted with the circled **1**) involves selecting the cable that will be used to communicate with the DE2 Development and Education board. This cable should have a name similar to *USB-Blaster [USB-0]*.

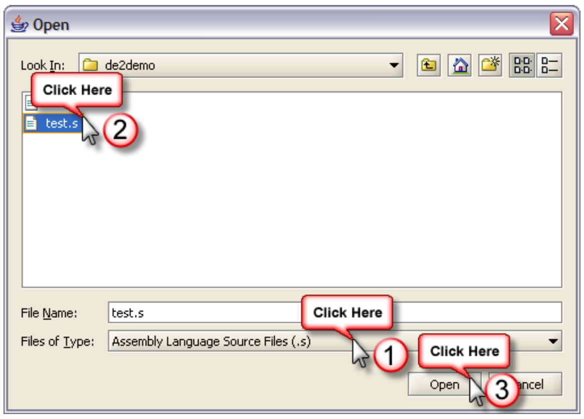


Figure 9: Open File Dialog Box.

2. Next, click on the **Compile & Load** button. A dialog box, shown in Figure 9, will appear. Select the directory that contains your application source file using the **Look In:** drop down list. Note that some sample applications are included on the DE2 CD.

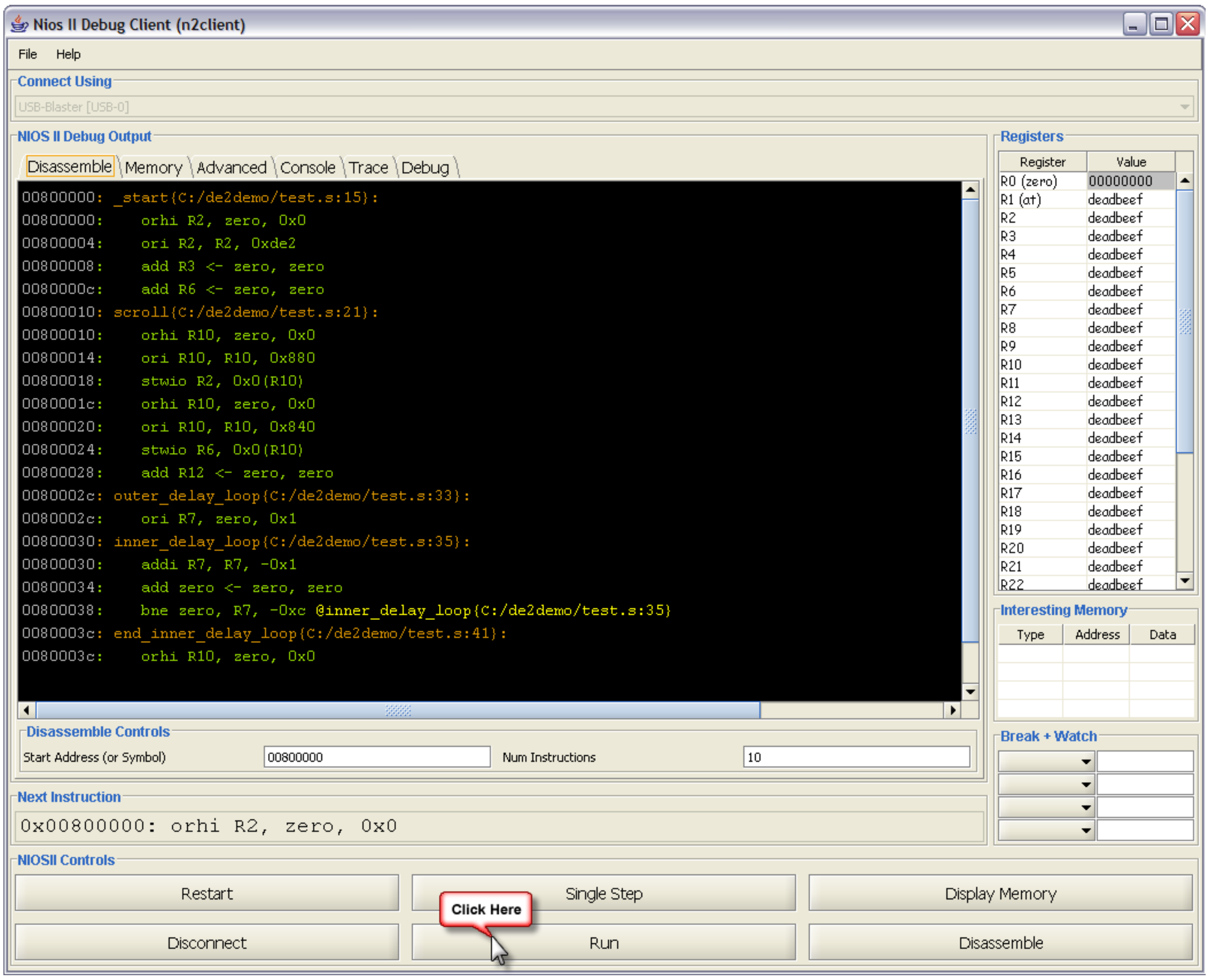
3. For the purposes of this tutorial, we assume the existance of an assembly language source file named *test.s*. The Nios II Debug Client is capable of compiling and downloading:

   - S-Record Files: These file have a *.srec* extension and contain raw machine code instructions and data.
   - Assembly Language Source Files: These files have a *.s* extension and contain human readable Nios II instructions. The Nios II Debug client will call the Nios II assembler to convert these files into an equivalent S-Record format. The S-Record file will then be downloaded into the Nios II memory space.
   - C-Language Source Files: These files have a *.c* extension and contain C-Language code. The Nios II Debug Client will call the *gcc* compiler to compile the source code into assembly language and finally to the machine code in S-Record format. Again, the S-Record file will then be downloaded.

   To select an Assembly Language source file, the user must ensure that **Assembly Language Source Files (.s)** is selected from the **Files of Type** drop down list.

4. Select the application to be downloaded. For this tutorial, the file *test.s* is selected.

5. Finally click on the **Open** button. After a few seconds, the Nios II Debug client will download the machine code into memory. The first few instructions are then disassembled and displayed as shown in Figure 10.



```
00800000: _start{C:/de2demo/test.s:15}:
00800000:    orhi R2, zero, 0x0
00800004:    ori R2, R2, 0xde2
00800008:    add R3 <- zero, zero
0080000c:    add R6 <- zero, zero
00800010: scroll{C:/de2demo/test.s:21}:
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop{C:/de2demo/test.s:33}:
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop{C:/de2demo/test.s:35}:
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop{C:/de2demo/test.s:35}
0080003c: end_inner_delay_loop{C:/de2demo/test.s:41}:
0080003c:    orhi R10, zero, 0x0
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	deadbeef
R3	deadbeef
R4	deadbeef
R5	deadbeef
R6	deadbeef
R7	deadbeef
R8	deadbeef
R9	deadbeef
R10	deadbeef
R11	deadbeef
R12	deadbeef
R13	deadbeef
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

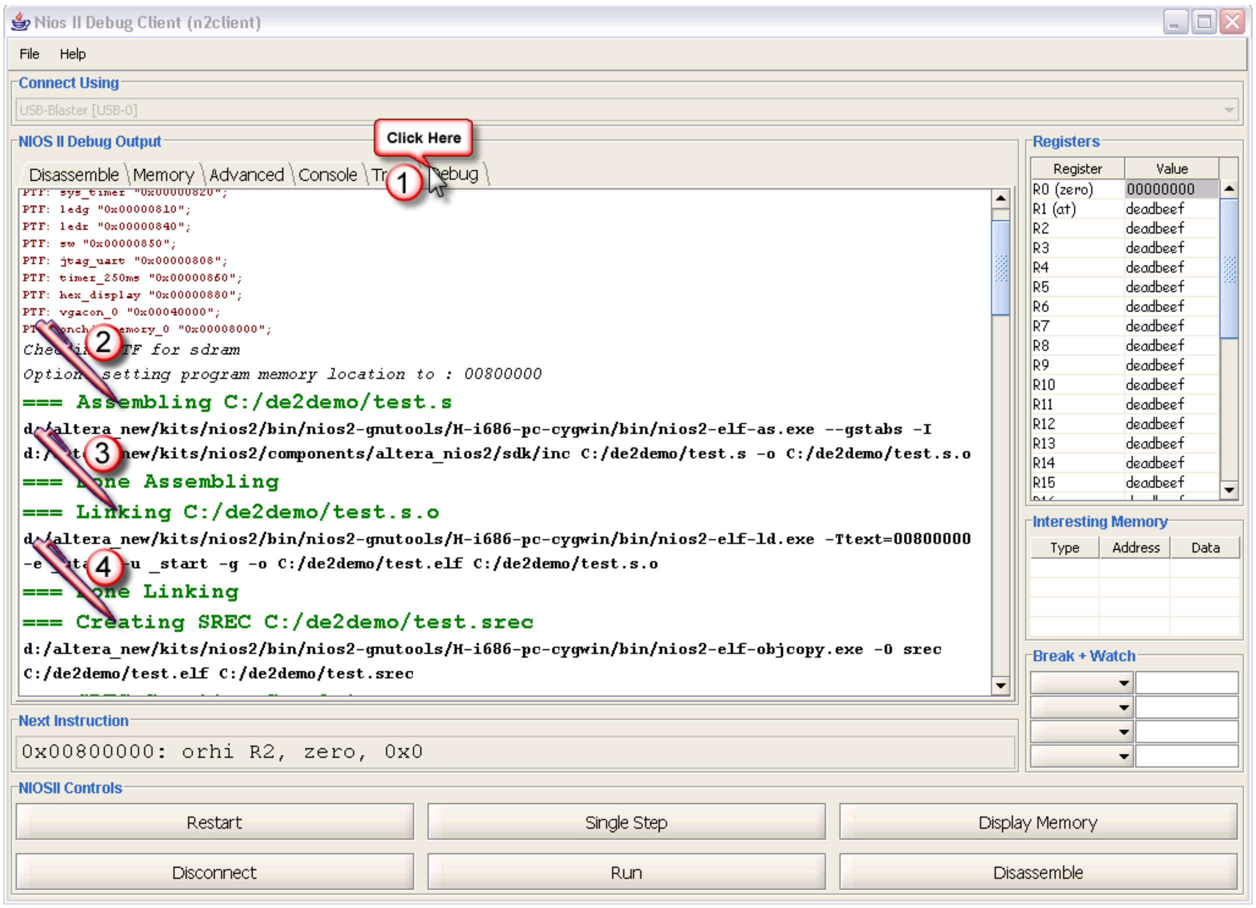
Type	Address	Data

Start Address (or Symbol) 00800000 Num Instructions 10

```
0x00800000: orhi R2, zero, 0x0
```

Figure 10: Source File loaded and Disassembled.

Users who wish to gain insight into details of the assembly or compilation process may use the **Debug** pane of the Nios II Debug Client, as illustrated in Figure 11. The first section of the **Debug** pane contains all of the commands used to convert a source file into machine code in the S-Record format. The user may choose to use these commands at the command prompt of the *Nios II SDK Shell* or use them as part of a *Makefile* in a more complex project.



```
PTF: sys_timer "0x00000820";
PTF: ledg "0x00000810";
PTF: ledr "0x00000840";
PTF: sw "0x00000850";
PTF: jtag_uart "0x00000808";
PTF: timer_250ms "0x00000860";
PTF: hex_display "0x00000880";
PTF: vgacon_0 "0x00040000";
PT   onch   emory_0 "0x00008000";
Che   i   TF for sdram
Option  setting program memory location to : 00800000
=== Assembling C:/de2demo/test.s
d:/altera_new/kits/nios2/bin/nios2-gnutools/H-i686-pc-cygwin/bin/nios2-elf-as.exe --gstabs -I
d:/  t   new/kits/nios2/components/altera_nios2/sdk/inc C:/de2demo/test.s -o C:/de2demo/test.s.o
===   one Assembling
=== Linking C:/de2demo/test.s.o
d:/altera_new/kits/nios2/bin/nios2-gnutools/H-i686-pc-cygwin/bin/nios2-elf-ld.exe -Ttext=00800000
-e  ta   -u _start -g -o C:/de2demo/test.elf C:/de2demo/test.s.o
===   one Linking
=== Creating SREC C:/de2demo/test.srec
d:/altera_new/kits/nios2/bin/nios2-gnutools/H-i686-pc-cygwin/bin/nios2-elf-objcopy.exe -O srec
C:/de2demo/test.elf C:/de2demo/test.srec
```

```
0x00800000: orhi R2, zero, 0x0
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	deadbeef
R3	deadbeef
R4	deadbeef
R5	deadbeef
R6	deadbeef
R7	deadbeef
R8	deadbeef
R9	deadbeef
R10	deadbeef
R11	deadbeef
R12	deadbeef
R13	deadbeef
R14	deadbeef
R15	deadbeef

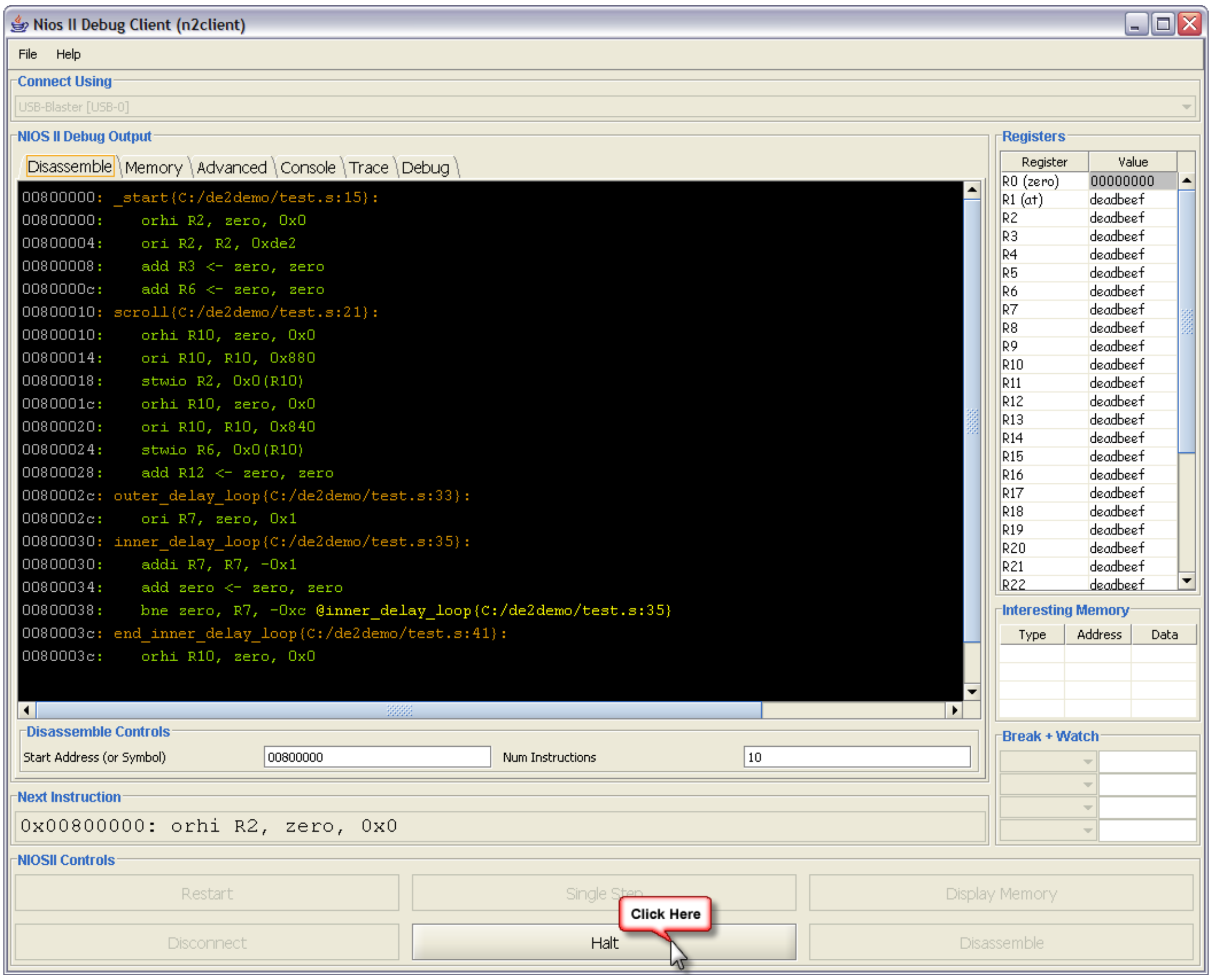
Figure 11: Debug Information.

The **Debug** pane will also be populated with other types of advanced information as the debugging session progresses. The Nios II Debug Client is a graphical interface that communicates with the *nios2-gdb-server* provided with *Altera's Nios II SDK*. The *nios2-gdb-server* provides a set of low-level routines that allow for debugging an application running on a Nios II system. A description of the commands and protocol for communicating to the server is described in `http://sourceware.org/gdb/current/onlinedocs/gdb_33.html#SEC684`. The **Debug** pane displays each of these low level commands and responses received for every action performed in the Debug Client.

4 Running an Application

To run the target application on the DE2 board, execute the following steps:

1. Return to the **Disassemble** pane and Click the **Run** button as shown in Figure 10.



Nios II Debug Client (n2client)

File Help

Connect Using: USB-Blaster [USB-0]

NIOS II Debug Output

Disassemble | Memory | Advanced | Console | Trace | Debug

```
00800000: _start(C:/de2demo/test.s:15):
00800000:    orhi R2, zero, 0x0
00800004:    ori R2, R2, 0xde2
00800008:    add R3 <- zero, zero
0080000c:    add R6 <- zero, zero
00800010: scroll(C:/de2demo/test.s:21):
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop(C:/de2demo/test.s:33):
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop(C:/de2demo/test.s:35):
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop(C:/de2demo/test.s:35)
0080003c: end_inner_delay_loop(C:/de2demo/test.s:41):
0080003c:    orhi R10, zero, 0x0
```

Disassemble Controls

Start Address (or Symbol)	00800000	Num Instructions	10

Next Instruction

```
0x00800000: orhi R2, zero, 0x0
```

Registers

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	deadbeef
R3	deadbeef
R4	deadbeef
R5	deadbeef
R6	deadbeef
R7	deadbeef
R8	deadbeef
R9	deadbeef
R10	deadbeef
R11	deadbeef
R12	deadbeef
R13	deadbeef
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

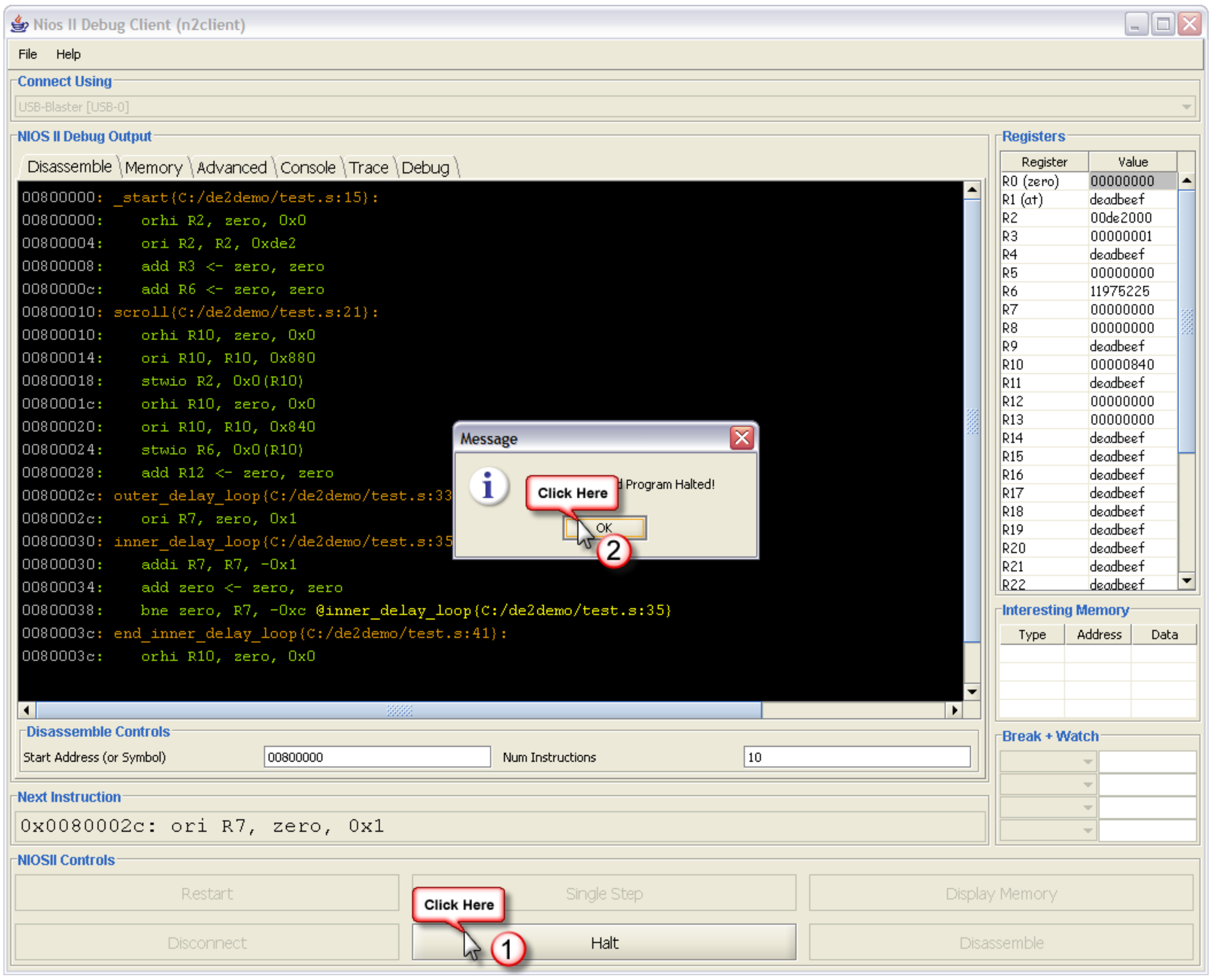
Interesting Memory

Type	Address	Data

Break + Watch

Figure 12: Program Running.

2. While the application is running, the Nios II Debug Client will only have a single button that is enabled. This is the **Halt** button and is shown in Figure 12. This button can be used to stop the execution of the target application and allow for debugging.



```
00800000: _start(C:/de2demo/test.s:15):
00800000:    orhi R2, zero, 0x0
00800004:    ori R2, R2, 0xde2
00800008:    add R3 <- zero, zero
0080000c:    add R6 <- zero, zero
00800010: scroll(C:/de2demo/test.s:21):
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop(C:/de2demo/test.s:33
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop(C:/de2demo/test.s:35
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop(C:/de2demo/test.s:35)
0080003c: end_inner_delay_loop(C:/de2demo/test.s:41):
0080003c:    orhi R10, zero, 0x0
```

d Program Halted!

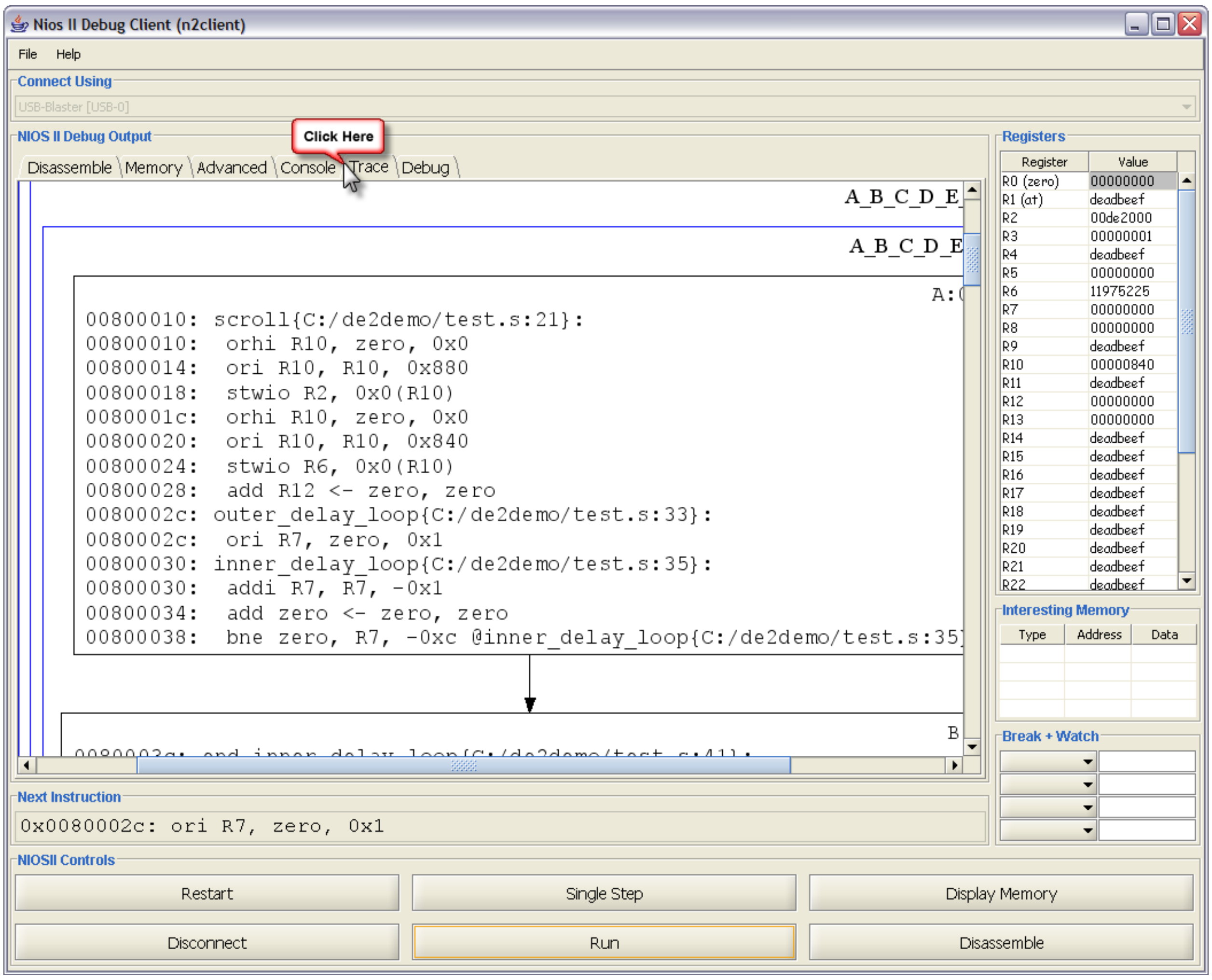
Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	00000000
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Start Address (or Symbol) 00800000   Num Instructions 10

```
0x0080002c: ori R7, zero, 0x1
```

Figure 13: Program Stopped.

3. Click on the **Halt** button as shown in Figure 13. The Nios II Debug Client will then pop up a dialog box indicating that the application has been halted. Press the **OK** button and proceed to the next step.



```
00800010: scroll{C:/de2demo/test.s:21}:
00800010:  orhi R10, zero, 0x0
00800014:  ori R10, R10, 0x880
00800018:  stwio R2, 0x0(R10)
0080001c:  orhi R10, zero, 0x0
00800020:  ori R10, R10, 0x840
00800024:  stwio R6, 0x0(R10)
00800028:  add R12 <- zero, zero
0080002c: outer_delay_loop{C:/de2demo/test.s:33}:
0080002c:  ori R7, zero, 0x1
00800030: inner_delay_loop{C:/de2demo/test.s:35}:
00800030:  addi R7, R7, -0x1
00800034:  add zero <- zero, zero
00800038:  bne zero, R7, -0xc @inner_delay_loop{C:/de2demo/test.s:35}
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	00000000
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Type	Address	Data

```
0x0080002c: ori R7, zero, 0x1
```

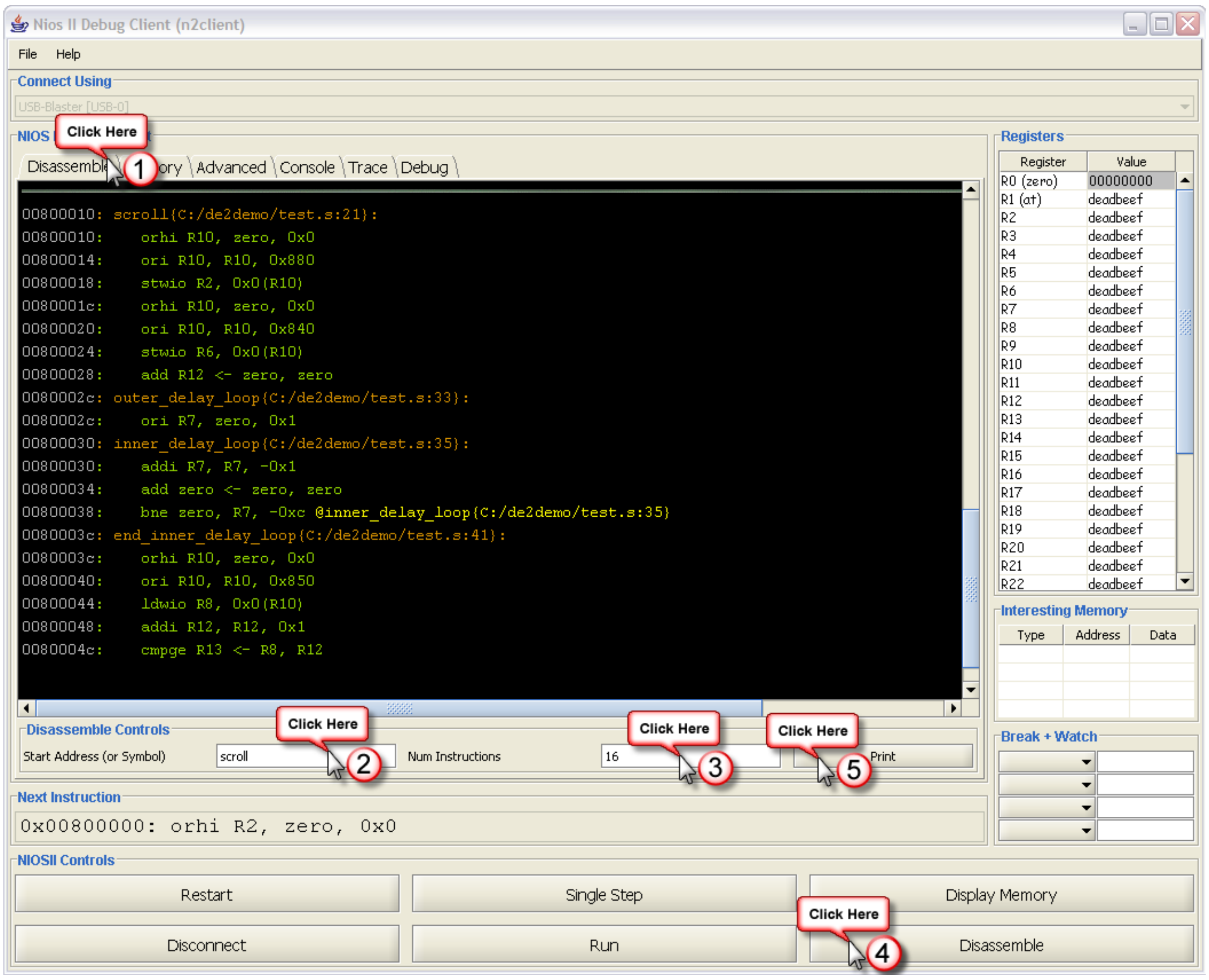
Figure 14: Instruction Trace.

4. Once the application has been halted, the user can view an instruction trace that shows the recently executed instructions just before the point at which the halt occured. This is accomplished by clicking on the **Trace** tab as shown in Figure 14.

5. Notice also that the values of the various Nios II registers have been updated in the **Registers** table. These values contain the register contents at the halt point.

5 Using the Disassembler

To disassemble the contents from a particular set of memory locations, proceed as follows:



```
00800010: scroll{C:/de2demo/test.s:21}:
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop{C:/de2demo/test.s:33}:
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop{C:/de2demo/test.s:35}:
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop{C:/de2demo/test.s:35}
0080003c: end_inner_delay_loop{C:/de2demo/test.s:41}:
0080003c:    orhi R10, zero, 0x0
00800040:    ori R10, R10, 0x850
00800044:    ldwio R8, 0x0(R10)
00800048:    addi R12, R12, 0x1
0080004c:    cmpge R13 <- R8, R12
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	deadbeef
R3	deadbeef
R4	deadbeef
R5	deadbeef
R6	deadbeef
R7	deadbeef
R8	deadbeef
R9	deadbeef
R10	deadbeef
R11	deadbeef
R12	deadbeef
R13	deadbeef
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Type	Address	Data

Start Address (or Symbol): scroll
Num Instructions: 16

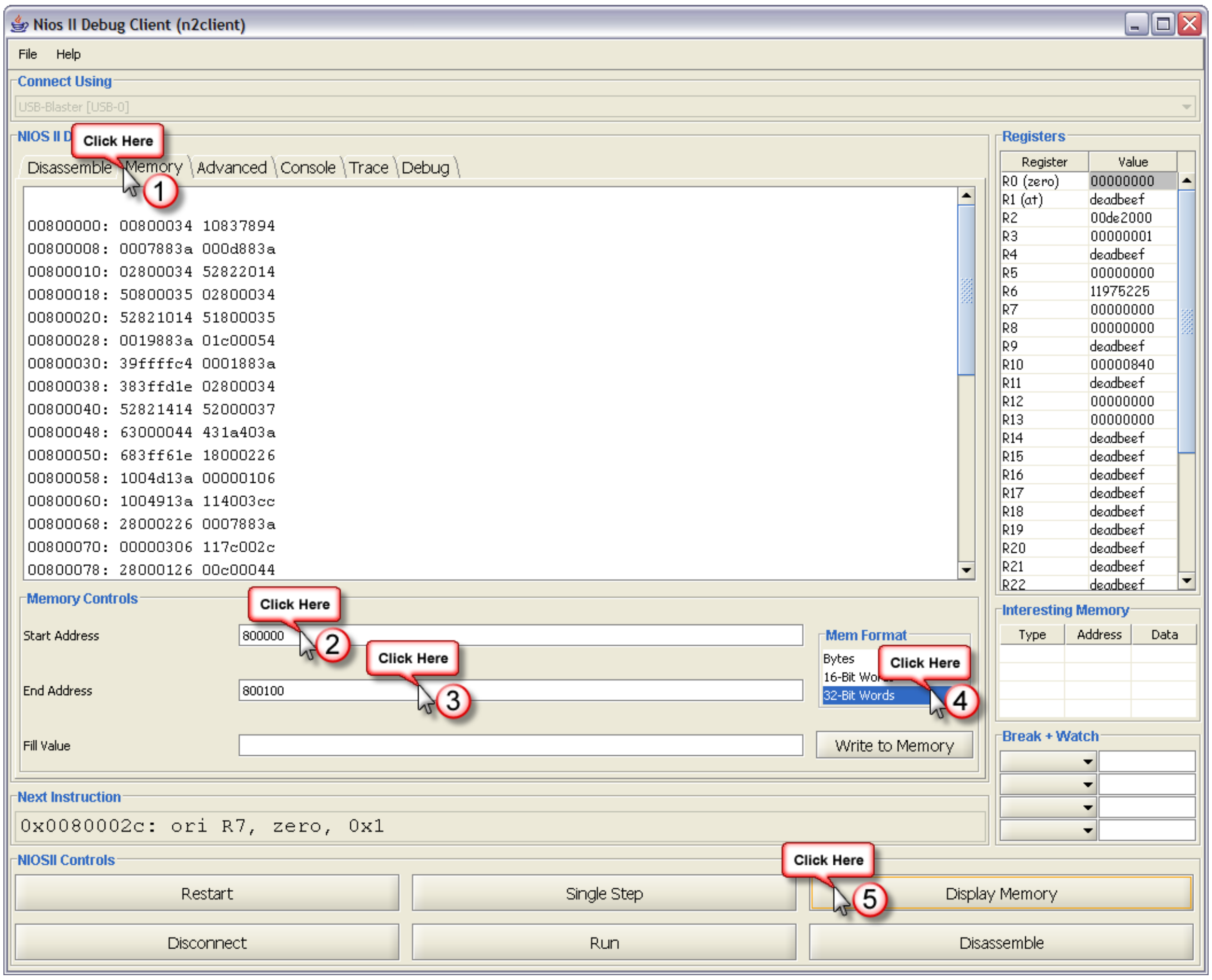
Next Instruction: `0x00800000: orhi R2, zero, 0x0`

Figure 15: Using the Disassembler.

1. Click on the **Disassemble** tab as shown in Figure 16.
2. Enter the starting address of the memory block to be displayed as a HEX value (there is no need to use a prefix such as “0x”) in the **Start Address** text field. The user may also choose to enter a symbolic name which was present in the original source file. The Nios II Debug Client will map this name to an address and use this value as the starting address. If the symbolic name is not found, an error will be issued.
3. Enter the number of instructions to be disassembled in the **Num Instructions** text field. This is a decimal value. Note that the maximum value is limited to 64 instructions.
4. Click on the **Disassemble** button and the disassembled source code will appear in the text area. Note that the disassembler will display both your original source code and the disassembled instructions if possible. This is typically possible for files that were assembled or compiled. It is not possible for manually created S-Records that contain only machine code.
5. If desired, a printed copy of the contents of the text area can be produced by clicking on the **Print** button.

6 Examining Memory Contents

To examine the contents of the Nios II memory space, execute the following steps:



```
00800000: 00800034 10837894
00800008: 0007883a 000d883a
00800010: 02800034 52822014
00800018: 50800035 02800034
00800020: 52821014 51800035
00800028: 0019883a 01c00054
00800030: 39ffffc4 0001883a
00800038: 383ffd1e 02800034
00800040: 52821414 52000037
00800048: 63000044 431a403a
00800050: 683ff61e 18000226
00800058: 1004d13a 00000106
00800060: 1004913a 114003cc
00800068: 28000226 0007883a
00800070: 00000306 117c002c
00800078: 28000126 00c00044
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	00000000
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Start Address 800000

End Address 800100

Fill Value

Mem Format: Bytes, 16-Bit Wo…, [✓ 32-Bit Words]

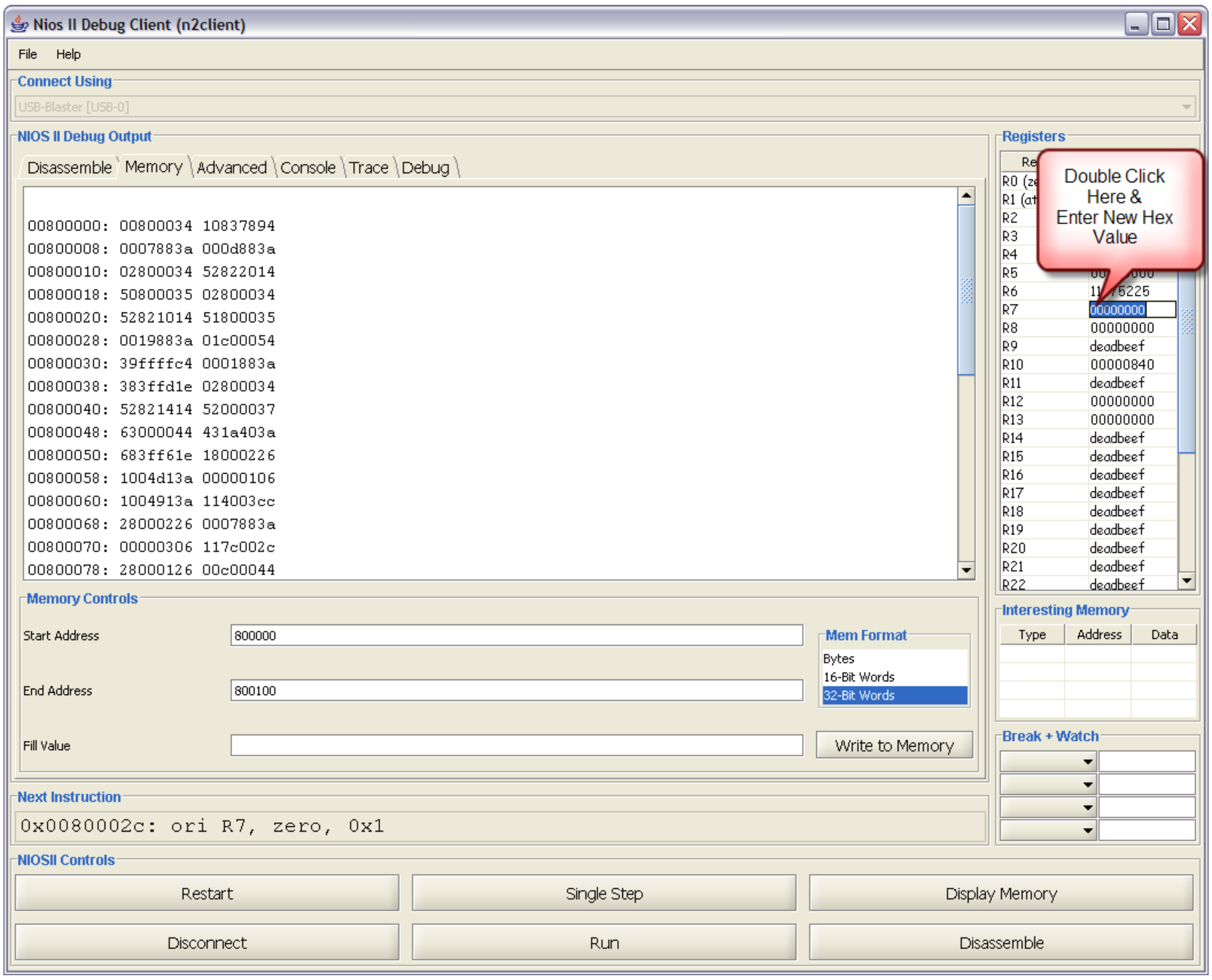
```
0x0080002c: ori R7, zero, 0x1
```

Figure 16: Examining Memory.

1. Click on the **Memory** tab as shown in Figure 16.
2. Enter the starting address of the memory block to be displayed as a HEX value (there is no need to use a prefix such as “0x”) in the **Start Address** text field.
3. Enter the ending address of the memory block to be displayed as a HEX value (again, there is no need to use a prefix such as “0x”) in the **End Address** text field.
4. Select the format of the memory display from the **Mem Format** list. In Figure 16, the value **32-bit Words** is selected.
5. Finally, click on the **Display Memory** button. The Nios II Debug client will respond by fetching the requested data and displaying it in the Memory text area.

7 Examining and Changing Register Values

The process of changing a register value is as follows:



```
00800000: 00800034 10837894
00800008: 0007883a 000d883a
00800010: 02800034 52822014
00800018: 50800035 02800034
00800020: 52821014 51800035
00800028: 0019883a 01c00054
00800030: 39ffffc4 0001883a
00800038: 383ffd1e 02800034
00800040: 52821414 52000037
00800048: 63000044 431a403a
00800050: 683ff61e 18000226
00800058: 1004d13a 00000106
00800060: 1004913a 114003cc
00800068: 28000226 0007883a
00800070: 00000306 117c002c
00800078: 28000126 00c00044
```

Re	
R0 (ze	
R1 (at	
R2	
R3	
R4	
R5	00 000
R6	11 5225
R7	00000000
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Start Address 800000

End Address 800100

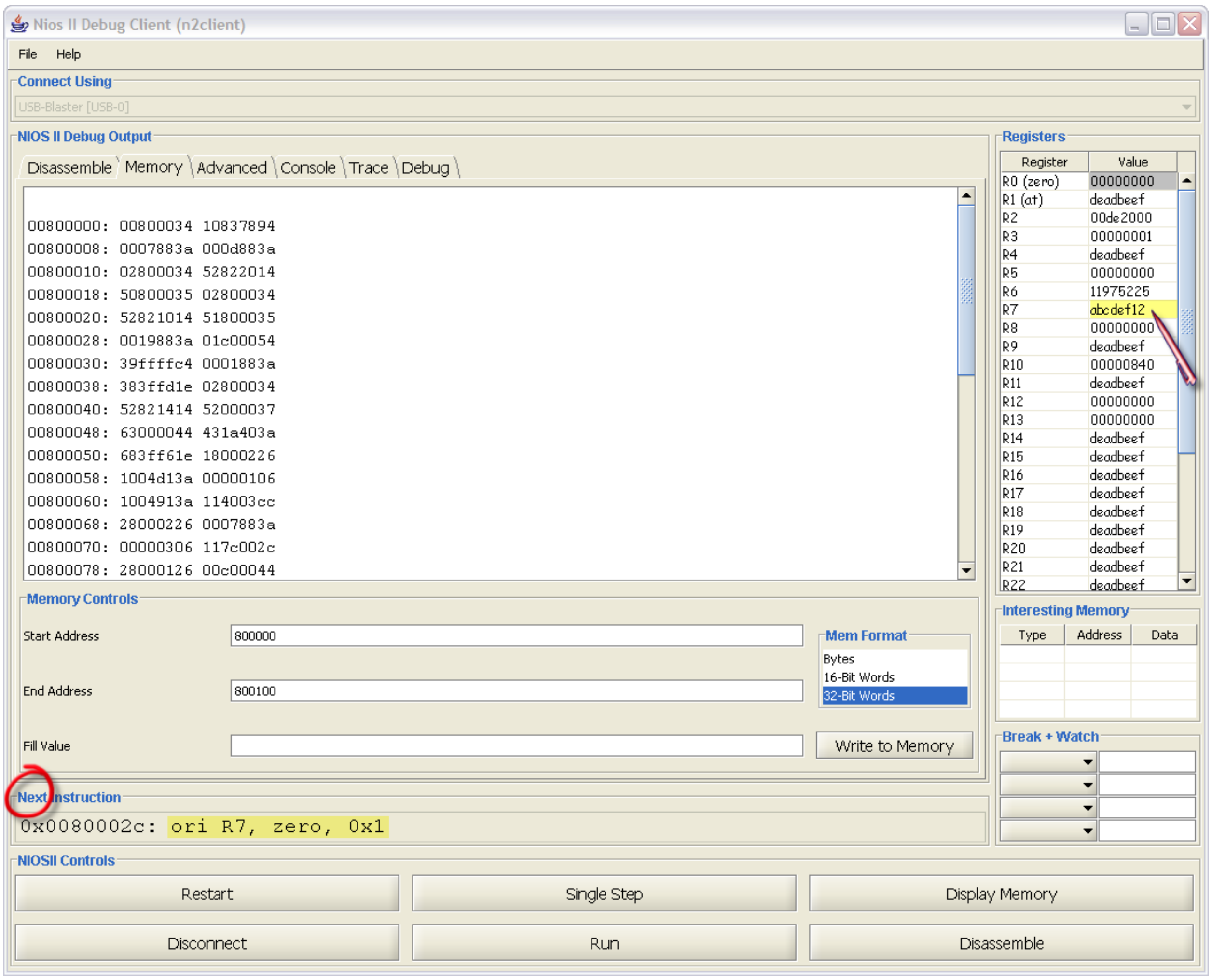
Fill Value

Mem Format: 32-Bit Words

```
0x0080002c: ori R7, zero, 0x1
```

Figure 17: Changing a Register Value.

1. Changing the value in register **R7** is illustrated in Figure 17. Double click on the text field associated with **R7** and enter a new HEX value. Press the **Enter** key to complete the change.



```
00800000: 00800034 10837894
00800008: 0007883a 000d883a
00800010: 02800034 52822014
00800018: 50800035 02800034
00800020: 52821014 51800035
00800028: 0019883a 01c00054
00800030: 39ffffc4 0001883a
00800038: 383ffd1e 02800034
00800040: 52821414 52000037
00800048: 63000044 431a403a
00800050: 683ff61e 18000226
00800058: 1004d13a 00000106
00800060: 1004913a 114003cc
00800068: 28000226 0007883a
00800070: 00000306 117c002c
00800078: 28000126 00c00044
```

Start Address: 800000

End Address: 800100

Fill Value:

```
0x0080002c: ori R7, zero, 0x1
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	abcdef12
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Figure 18: Register Value Changed.

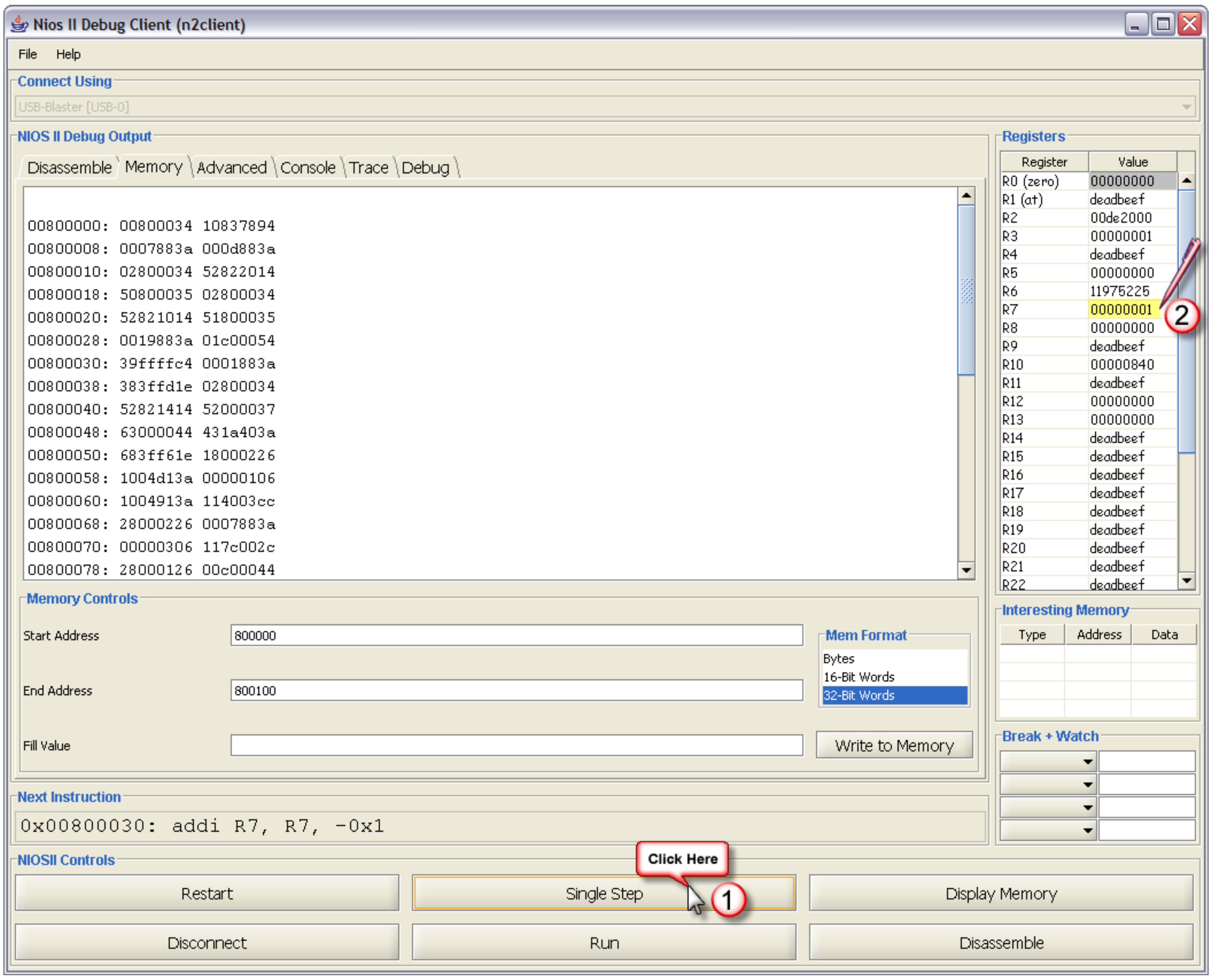
2. Figure 18 shows the result of changing the contents of register **R7** to the HEX value **abcdef123**.

   Although, only a change of **R7** has been described, all registers (including the program counter) can be changed in the same manner.

8 Single Step

The Nios II Debug Client makes it possible to single step through a downloaded program. Each step consists of executing a single assembly language instruction and returing control to the Nios II Debug Client. If the user has chosen to compile a C-program, the single steps will still correspond to assembly language generated from the C-code. The functionality of stepping through entire statements in the high level source is not supported by the Nios II Debug Client; however, the *Nios II Integrated Development Environment* supports these advanced features.

Notice in Figure 18 that the Nios II Debug Client indicates that the **Next Instruction** to be executed is one which will load the register **R7** with the value **1**. This will be different in your case depending on the application downloaded and where it was stopped; however, the general technique of the single step will remain the same.



Connect Using: USB-Blaster [USB-0]

```
00800000: 00800034 10837894
00800008: 0007883a 000d883a
00800010: 02800034 52822014
00800018: 50800035 02800034
00800020: 52821014 51800035
00800028: 0019883a 01c00054
00800030: 39ffffc4 0001883a
00800038: 383ffd1e 02800034
00800040: 52821414 52000037
00800048: 63000044 431a403a
00800050: 683ff61e 18000226
00800058: 1004d13a 00000106
00800060: 1004913a 114003cc
00800068: 28000226 0007883a
00800070: 00000306 117c002c
00800078: 28000126 00c00044
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	00000001
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Type	Address	Data

Start Address: 800000

End Address: 800100

Fill Value:

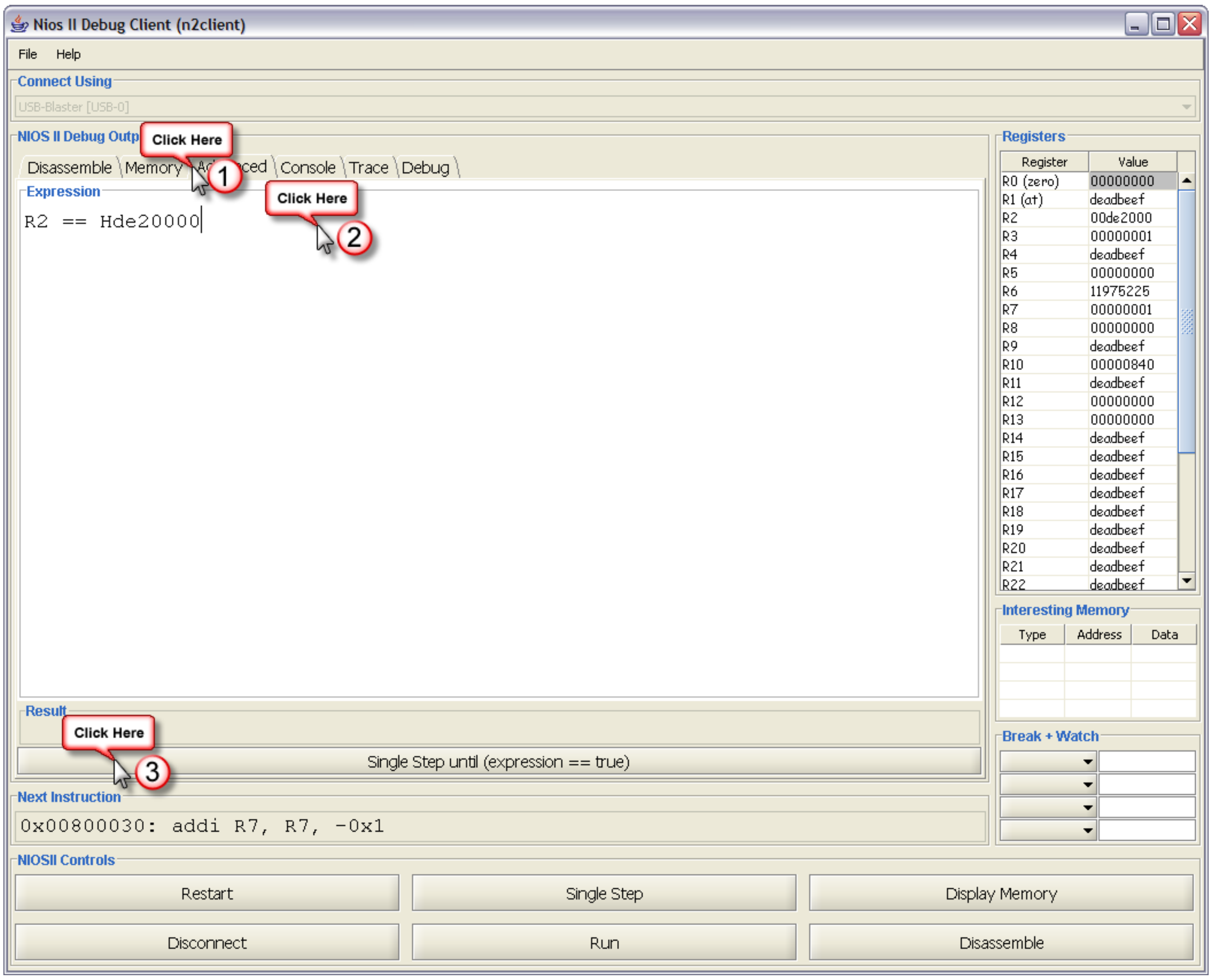
Next Instruction: 0x00800030: addi R7, R7, -0x1

Figure 19: Single Step.

Click on the **Single Step** button as shown in Figure 19. After execution of this single instruction, the Nios II Debug Client will update the register values of any affected registers. In this example, we expect **R7**= 1 and this is indeed the case.

9 Advanced Single Step

Often, a user may wish to single step through an application until some set of conditions is satisfied. In this example, we illustrate how to single step through the application until the condition **R2=DE2000** is met. The



```
R2 == Hde20000
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	00de2000
R3	00000001
R4	deadbeef
R5	00000000
R6	11975225
R7	00000001
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

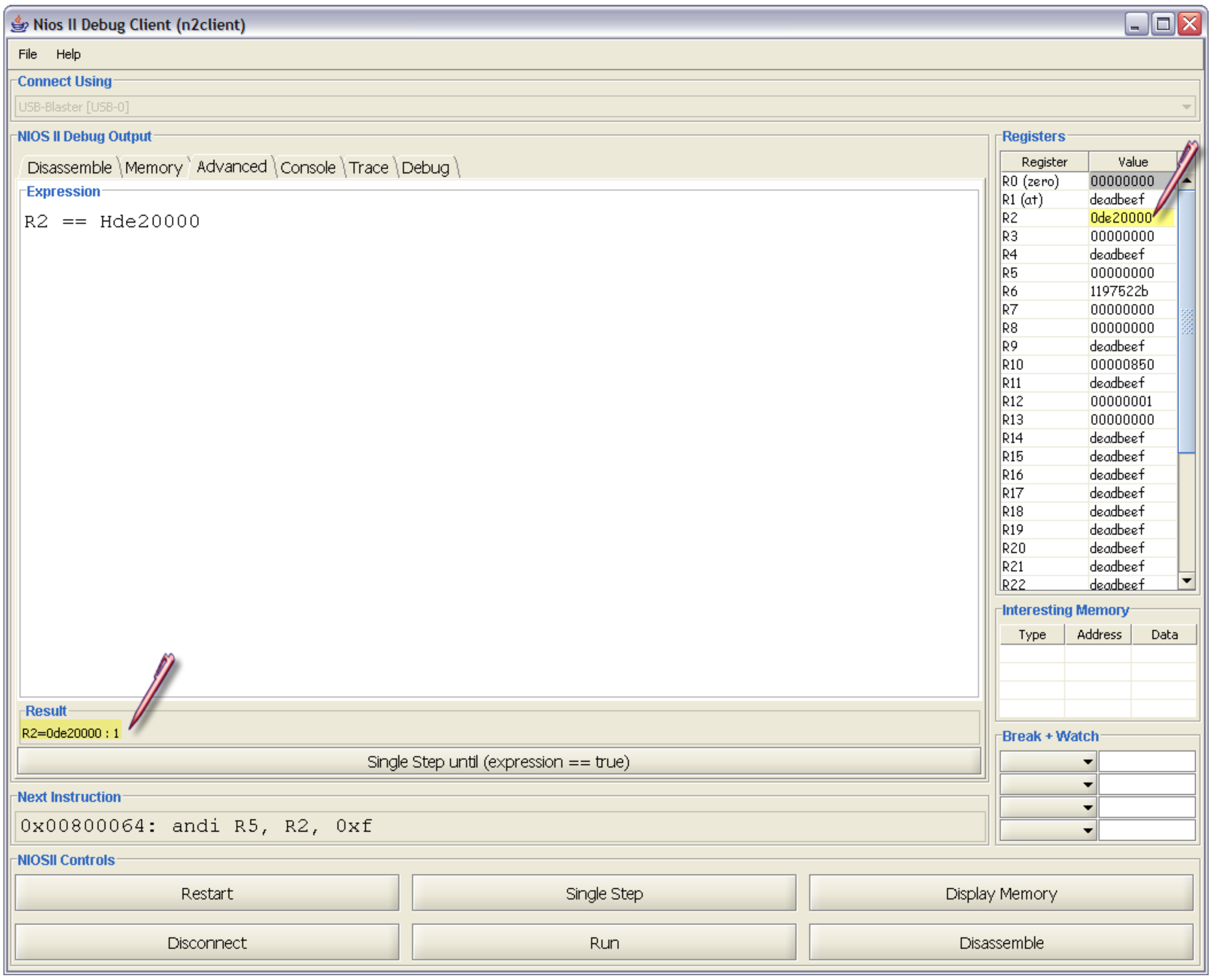
```
0x00800030: addi R7, R7, -0x1
```

Figure 20: Advanced Tab.

process is illustrated in Figure 20:

1. Click on the **Advanced** tab.
2. Enter the condition to be searched for in the **Expression** window. Notice that HEX values require the prefix **"H"**.
3. Click on the **Single step until** button to single step through the program until the condition specified in the expression expression is met.

4. Once the condition has been met, the Nios II Debug Client will stop executing single instructions and return control to the user as shown in Figure 21. Notice that the value of **R2** is as expected in the **Registers** table.



```
R2 == Hde20000
```

```
R2=0de20000 : 1
```

```
0x00800064:  andi R5, R2, 0xf
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	0de20000
R3	00000000
R4	deadbeef
R5	00000000
R6	1197522b
R7	00000000
R8	00000000
R9	deadbeef
R10	00000850
R11	deadbeef
R12	00000001
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Figure 21: Single Step Until Condition Met.

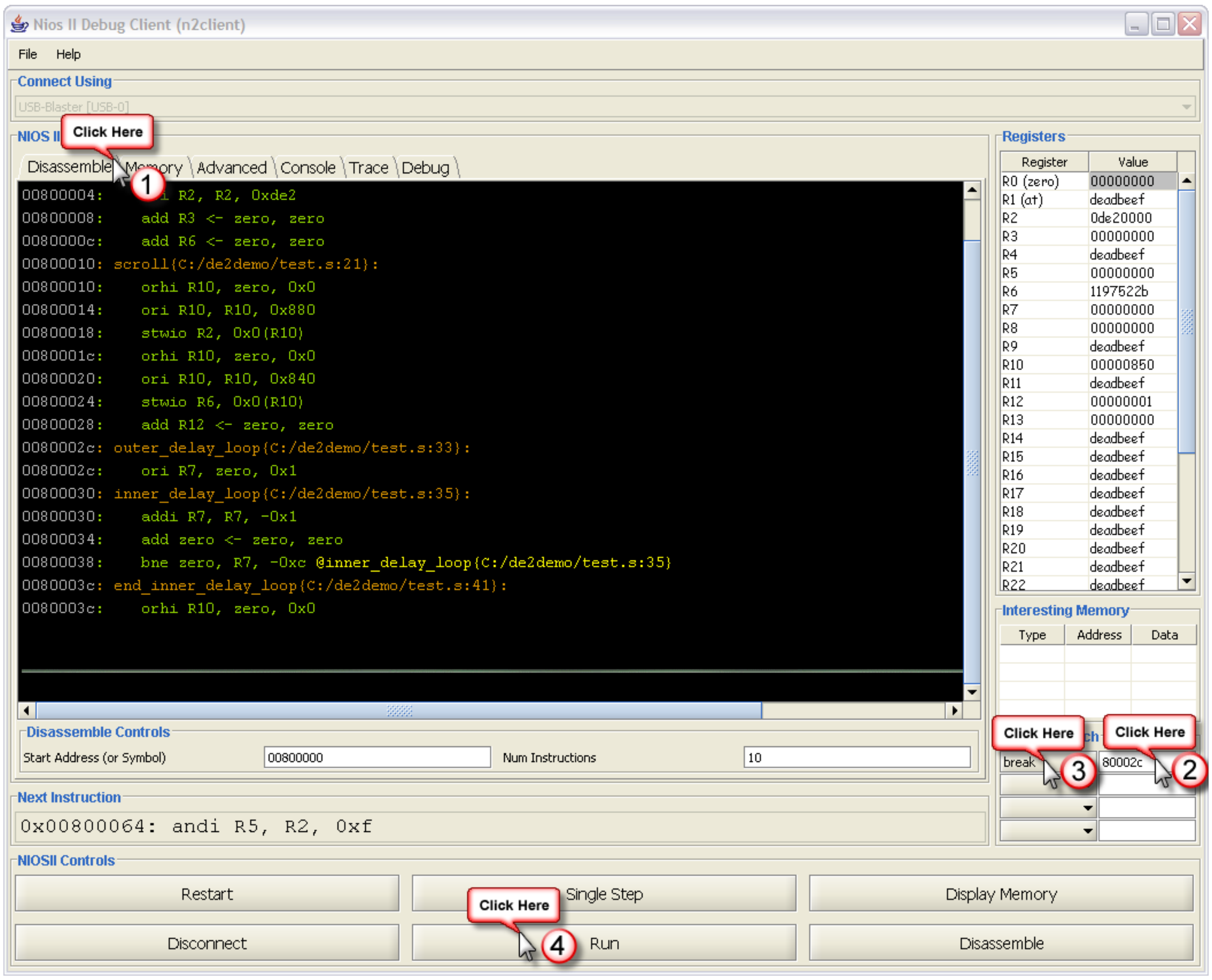
More complex expression formulations may be used as C-language style logical expressions are supported. For example, to check for the condition where registers **R1**, **R2** and **R3** all contain the same value the expression would be: **R1==R2 && R2==R3**.

10 Setting a breakpoint

Breakpoints are special conditions that are checked by dedicated hardware in the Nios II processor as the application is running in real time. The difference between a breakpoint and the **Advanced Single Step** is that breakpoints only support very limited conditions to be checked for such as:

- An instruction at a particular address has been reached.
- A particular address has been read from.
- A particular address has been written to.
- A particular address has been accessed.

Although the conditions are limited, they are checked in real time as the application is executed.



```
00800004:      i R2, R2, 0xde2
00800008:    add R3 <- zero, zero
0080000c:    add R6 <- zero, zero
00800010: scroll{C:/de2demo/test.s:21}:
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop{C:/de2demo/test.s:33}:
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop{C:/de2demo/test.s:35}:
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop{C:/de2demo/test.s:35}
0080003c: end_inner_delay_loop{C:/de2demo/test.s:41}:
0080003c:    orhi R10, zero, 0x0
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	0de20000
R3	00000000
R4	deadbeef
R5	00000000
R6	1197522b
R7	00000000
R8	00000000
R9	deadbeef
R10	00000850
R11	deadbeef
R12	00000001
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Type	Address	Data

break	80002c

Start Address (or Symbol) 00800000 Num Instructions 10

```
0x00800064: andi R5, R2, 0xf
```

Figure 22: Setting a breakpoint.

This tutorial will demonstrate setting a breakpoint based on a certain instruction being reached. This is illustrated in Figure 22. The process of setting the breakpoint is as follows:

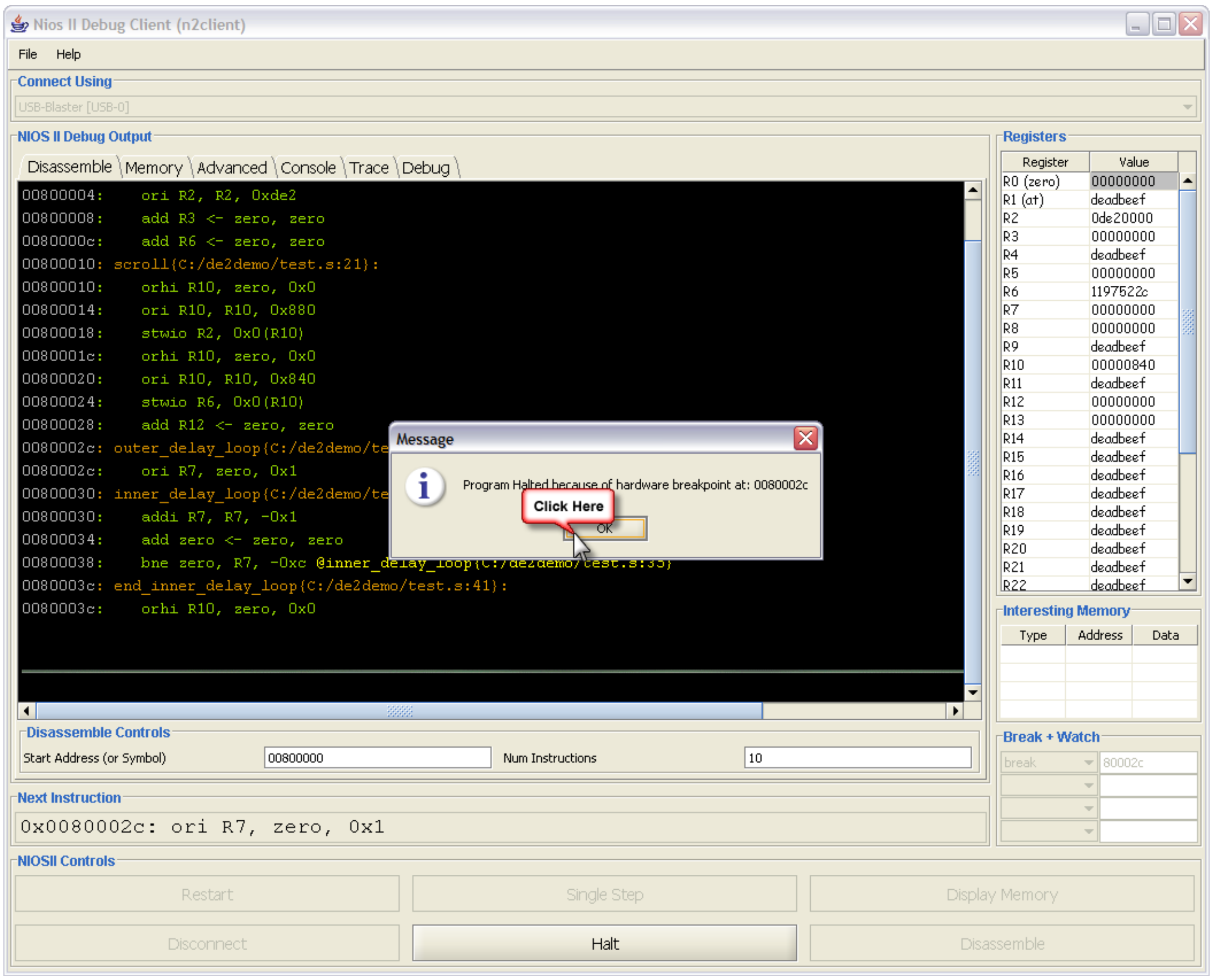
1. First click on the **Disassemble** tab to determine the instruction at which the breakpoint should be set. In this example, we choose the instruction at *outer_delay_loop:* and determine from the disassembly view that it is located at address **80002c**.

2. Click on the first text field in the **Break & Watch** section. Enter the address **80002c**.

3. Click on the drop down list next to the address just entered. Select **break**. This corresponds to a breakpoint when a particular instruction has been reached. Other choices include **rwatch** (address read from), **wwatch** (address written to) and **awatch** (address accessed either by a read or write).

4. The next step involes running the program by clicking on the **Run** button.

5. When the target instruction has been reached, the Nios II Debug Client will indicate this condition as shown in Figure 23. Click **OK** to continue debugging.



```
00800004:    ori R2, R2, 0xde2
00800008:    add R3 <- zero, zero
0080000c:    add R6 <- zero, zero
00800010: scroll{C:/de2demo/test.s:21}:
00800010:    orhi R10, zero, 0x0
00800014:    ori R10, R10, 0x880
00800018:    stwio R2, 0x0(R10)
0080001c:    orhi R10, zero, 0x0
00800020:    ori R10, R10, 0x840
00800024:    stwio R6, 0x0(R10)
00800028:    add R12 <- zero, zero
0080002c: outer_delay_loop{C:/de2demo/te
0080002c:    ori R7, zero, 0x1
00800030: inner_delay_loop{C:/de2demo/te
00800030:    addi R7, R7, -0x1
00800034:    add zero <- zero, zero
00800038:    bne zero, R7, -0xc @inner_delay_loop{C:/de2demo/test.s:35}
0080003c: end_inner_delay_loop{C:/de2demo/test.s:41}:
0080003c:    orhi R10, zero, 0x0
```

Program Halted because of hardware breakpoint at: 0080002c

Start Address (or Symbol): 00800000   Num Instructions: 10

```
0x0080002c: ori R7, zero, 0x1
```

Registers

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	0de20000
R3	00000000
R4	deadbeef
R5	00000000
R6	1197522c
R7	00000000
R8	00000000
R9	deadbeef
R10	00000840
R11	deadbeef
R12	00000000
R13	00000000
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

Interesting Memory

Type	Address	Data

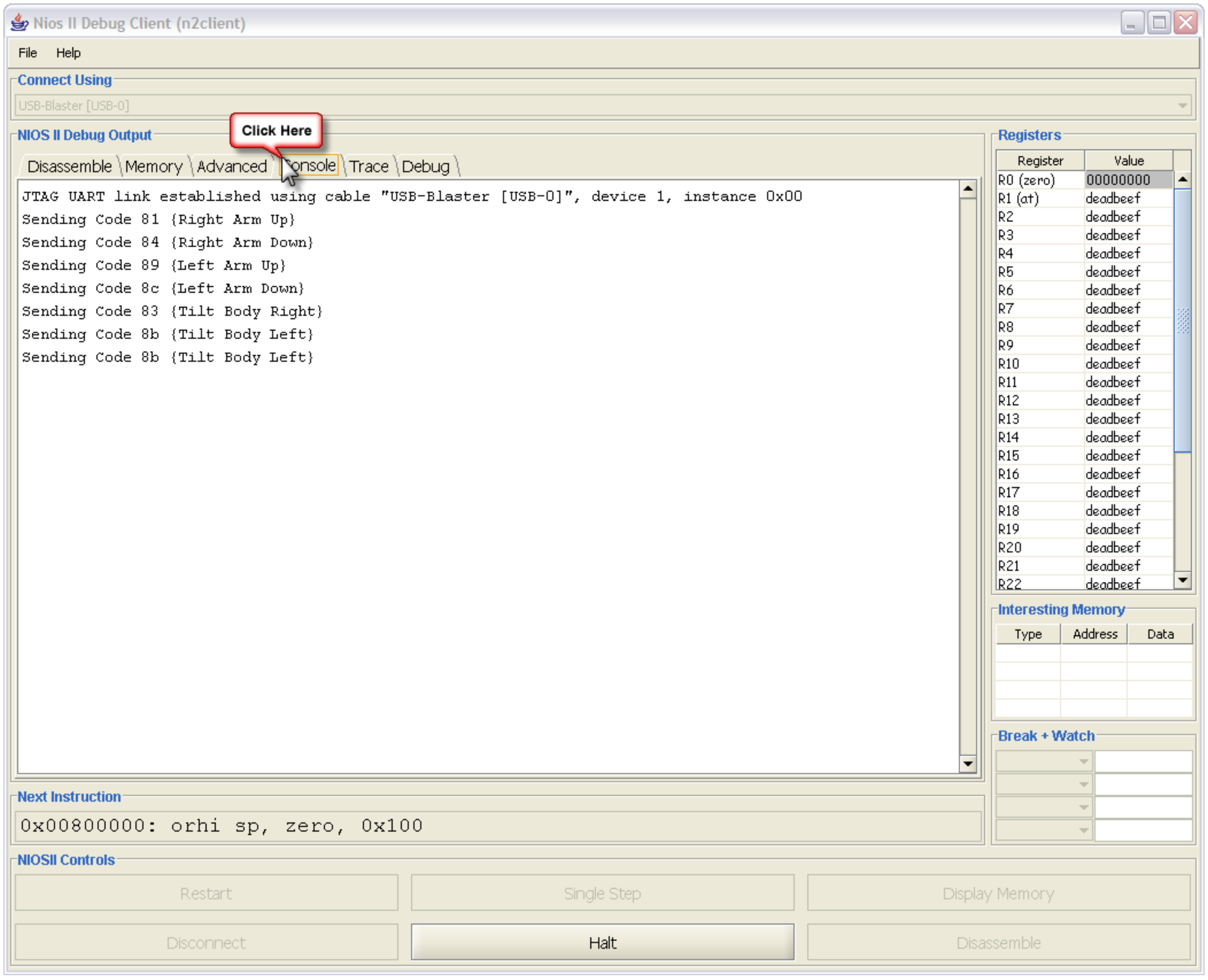
Break + Watch

break	80002c

Figure 23: Breakpoint hit.

11 JTAG UART Console

For applications that send text data through the Nios II JTAG UART (such a the *printf* routine in "C"), the Nios II Debug Client is capable of displaying this information. Click on the **Console** tab to view any output sent by the JTAG UART. Text input (i.e. *scanf*) is not supported at this time.



```
JTAG UART link established using cable "USB-Blaster [USB-0]", device 1, instance 0x00
Sending Code 81 {Right Arm Up}
Sending Code 84 {Right Arm Down}
Sending Code 89 {Left Arm Up}
Sending Code 8c {Left Arm Down}
Sending Code 83 {Tilt Body Right}
Sending Code 8b {Tilt Body Left}
Sending Code 8b {Tilt Body Left}
```

Register	Value
R0 (zero)	00000000
R1 (at)	deadbeef
R2	deadbeef
R3	deadbeef
R4	deadbeef
R5	deadbeef
R6	deadbeef
R7	deadbeef
R8	deadbeef
R9	deadbeef
R10	deadbeef
R11	deadbeef
R12	deadbeef
R13	deadbeef
R14	deadbeef
R15	deadbeef
R16	deadbeef
R17	deadbeef
R18	deadbeef
R19	deadbeef
R20	deadbeef
R21	deadbeef
R22	deadbeef

```
0x00800000: orhi sp, zero, 0x100
```

Figure 24: Console Tab.