
Running Webserver and TFTP Server on SmartFusion2 Devices Using lwIP and FreeRTOS - Libero SoC v11.6

DG0472 Demo Guide

Superseded

October 2015

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Confidentiality Status

This is a non-confidential document.

Superseded

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Preface

About this document

This demo is for SmartFusion[®]2 system-on-chip (SoC) field programmable gate array (FPGA) devices. It provides instructions on how to use the corresponding reference design.

Intended Audience

TSmartFusion2 devices are used by:

- FPGA designers
- Embedded designers
- System-level designers

References

The following references are used in this document:

- lwIP TCP/IP stack:
 - www.sics.se/~adam/lwip/
 - <http://download.savannah.gnu.org/releases/lwip/>
- FreeRTOS stack: www.freeRTOS.org

Microsemi Publications

- *UG0331: SmartFusion2 Microcontroller Subsystem User Guide*
- *UG0447: IGLOO2 FPGA and SmartFusion2 SoC FPGA High Speed Serial Interfaces User Guide*
- *Libero SoC User Guide*
- *UG0557: SmartFusion2 SoC FPGA Advanced Development Kit User Guide*

Refer to the following web page for a complete and up-to-date listing of SmartFusion2 device documentation: www.microsemi.com/soc/products/smartfusion2/docs.aspx.

Running Webserver and TFTP Server on SmartFusion2 Device Using lwIP and FreeRTOS

Introduction

This demo design explains the tri-speed ethernet medium access controller (TSEMAC) features of the SmartFusion2 device and implements the Webserver, trivial file transfer protocol (TFTP) server application on [UG0557: SmartFusion2 SoC FPGA Advanced Development Kit User Guide](#).

This demo describes the following:

- Use of SmartFusion2 Ethernet MAC connected to a serial gigabit media independent interface (SGMII) PHY.
- Integration of SmartFusion2 MAC driver with the lwIP TCP/IP stack and the FreeRTOS operating system.
- Implementation of Webserver on the SmartFusion2 Advanced Development Kit board.
- Implementation of TFTP server on the SmartFusion2 Advanced Development Kit board.
- Procedure to run the Webserver and TFTP server designs on the SmartFusion2 Advanced Development Kit board.

The microcontroller subsystem (MSS) of the SmartFusion2 device has an instance of the TSEMAC peripheral. The TSEMAC can be configured between the host PC and the Ethernet network at the following data transfer rates (line speeds):

- 10 Mbps
- 100 Mbps
- 1000 Mbps

Refer to the [UG0331: SmartFusion2 Microcontroller Subsystem User Guide](#) for more information on the TSEMAC interface for SmartFusion2 devices.

Webserver and TFTP Server Applications on SmartFusion2 Devices

The Webserver and TFTP server demo designs consist of the following layers:

- Application Layer
- Transport Layer (lwIP TCP/IP Stack)
- RTOS and Firmware Layer

Figure 1 shows the block diagram of the Webserver and TFTP server applications on the SmartFusion2 device.

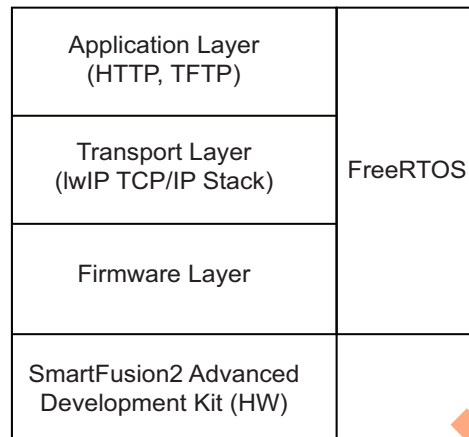


Figure 1 • Block Diagram of Webserver and TFTP Server Applications on SmartFusion2

Application Layer

The Webserver and TFTP server applications are implemented on the SmartFusion2 Advanced Development Kit board.

Webserver handles the HTTP request from the client browser and transfers the static pages to the client in response to their request. These pages run on the client (host PC) browser. When the URL with IP address (for example, <http://10.60.3.25>) is typed in the browser, the HTTP request is sent to the port on the Webserver. The Webserver then interprets the request and responds to the client with the requested page or resource.

The TFTP client (host PC) transfers the file using TFTP PUT command to the SmartFusion2 device (TFTP server). Transferred files are stored in the external flash memory on the SmartFusion2 Advanced Development Kit. External flash memory is interfaced to SmartFusion2 SPI_0. Fat file system on SPI flash is used to display the files available in SPI flash memory.

Transport Layer (lwIP TCP/IP Stack)

lwIP TCP/IP stack was developed by Adam Dunkels at the Swedish Institute of Computer Science (SICS). The lwIP stack is suitable for the embedded systems because of less resource usage. It can be used with or without the operating system. The lwIP consists of the actual implementations of the IP, ICMP, UDP, and TCP protocols, as well as the support functions such as buffer and memory management.

For more information on the design and implementation, refer to www.sics.se/~adam/lwip/doc/lwip.pdf.

The lwIP is available (under a BSD license) in C source-code format for download from the following path: <http://download.savannah.gnu.org/releases/lwip/>

RTOS and Firmware Layer

FreeRTOS is an open source real time operating system kernel. FreeRTOS is used in this demo to prioritize and schedule the tasks. Refer to <http://www.freertos.org> for more information and the latest source code.

The firmware provides the software driver implementation to configure and control the following MSS components:

- Ethernet MAC
- MMUART
- GPIO
- SPI
- RTC

Design Requirements

The following table lists the hardware and software design requirements.

Table 1 • Design Requirements

Design Requirements	Description
Hardware Requirements	
SmartFusion2 Advanced Development Kit <ul style="list-style-type: none">• 12 V adapter• FlashPro5• USB A to Mini-B cable	Rev A or later
RJ45 cable	–
Host PC or Laptop	Windows 64-bit Operating System
Software Requirements	
Libero [®] System-on-Chip (SoC) for viewing the design files	v11.6
FlashPro Programming Software	v11.6
SoftConsole	v3.4 SP1
Host PC Drivers	USB to UART drivers
One of the following serial terminal emulation programs: <ul style="list-style-type: none">• HyperTerminal• Tera-Term• PuTTY	–
Browser	Mozilla Firefox or Internet Explorer

Demo Design

Introduction

The demo design files are available for download from the following path in the Microsemi[®] website:
www.microsemi.com/soc/download/rsc/?f=m2s_dg0472_liberv11p6_df

The demo design files include:

- Libero SoC hardware project with SoftConsole firmware project
- Sample files
- Programming files
- readme.txt file

Figure 2 shows the top-level structure of the design files. For further details, refer to the `Readme.txt` file.

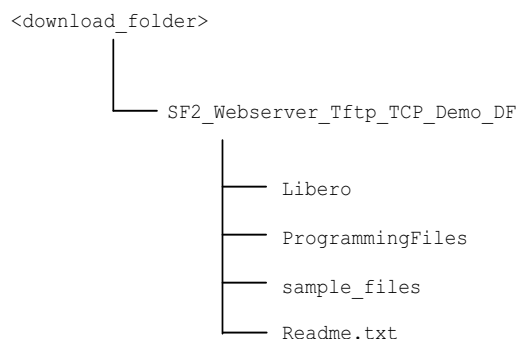


Figure 2 • Demo Design Files Top Level Structure

Demo Design Features

The demo has the following options:

- Webserver
 - RTC and Ethernet Interface data display
 - Blinking LEDs
 - HyperTerminal Display
 - SmartFusion2 Google Search
- TFTP server
 - Transfers files from the host PC to the SmartFusion2 Advanced Development Kit

Demo Design Description

The demo design is implemented using a SGMII PHY interface by configuring the TSEMAC for the ten-bit interface (TBI) operation. For more information on the TSEMAC TBI interface, refer to the [*UG0331: SmartFusion2 Microcontroller Subsystem User Guide*](#).

The demo design comprises of:

- [Libero SoC Hardware Project](#)
- [SoftConsole Firmware Project](#)

Libero SoC Hardware Project

Figure 3 shows the Libero SoC hardware design implementation for this demo design.

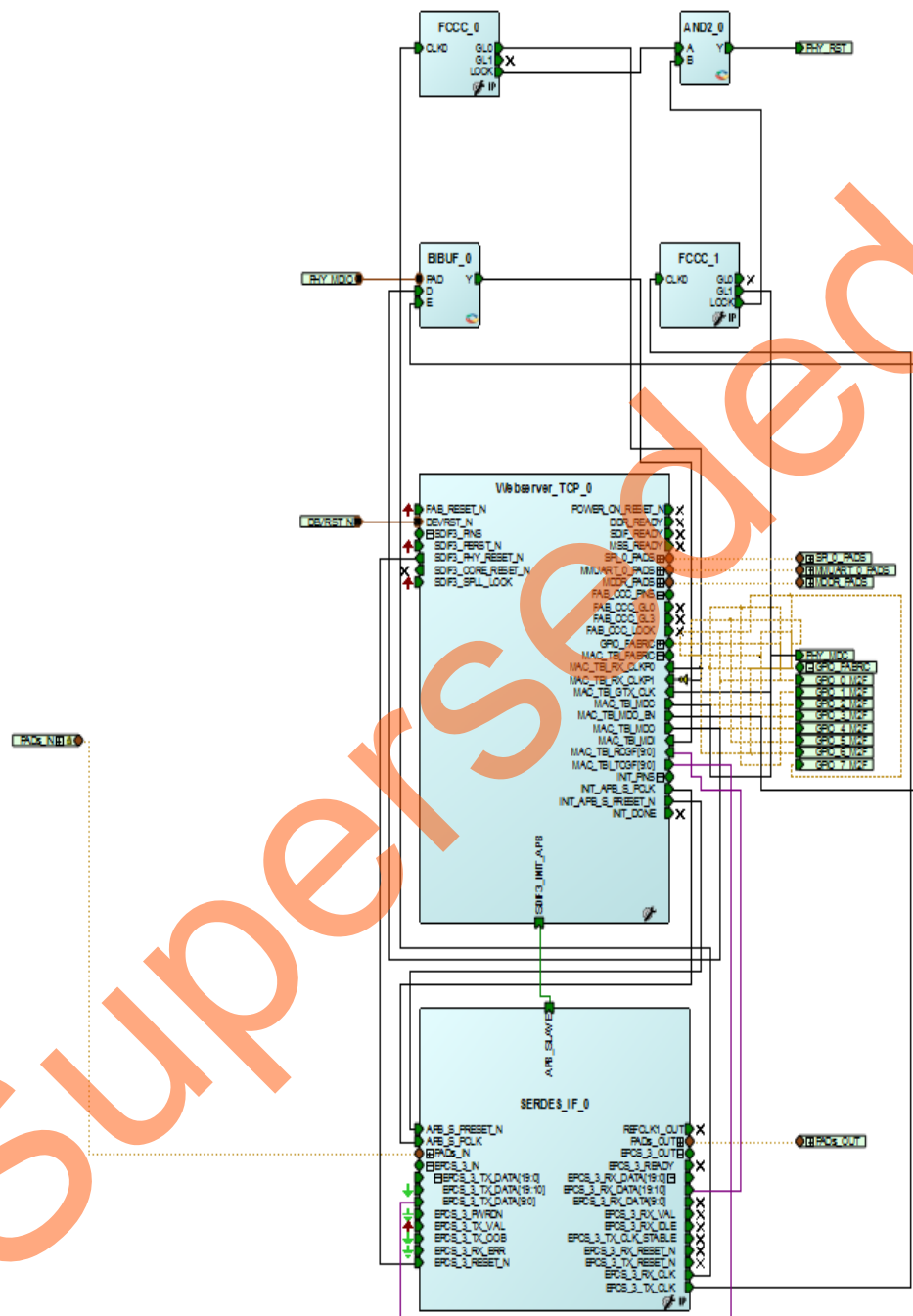


Figure 3 • Libero Top-Level Design

Libero hardware project uses the following SmartFusion2 MSS resources and IPs:

1. **TSEMAC TBI** interface
2. **MMUART_0** for RS-232 communications on the Advanced Development Kit.
3. **SPI_0**: To access external Flash memory.
4. **COREAHBLSRAM**: For TFTP application stack.
5. **General purpose input and output (GPIO)**: Interfaces the light emitting diodes (LEDs)
6. **High speed serial interface (SERDESIF) SERDES_IF IP**: Configured for **SERDESIF_3 EPCS lane3** as shown in Figure 4.

For more information on high-speed serial interfaces, refer to the [UG0447: IGLOO2 and SmartFusion2 High Speed Serial Interfaces User Guide](#).

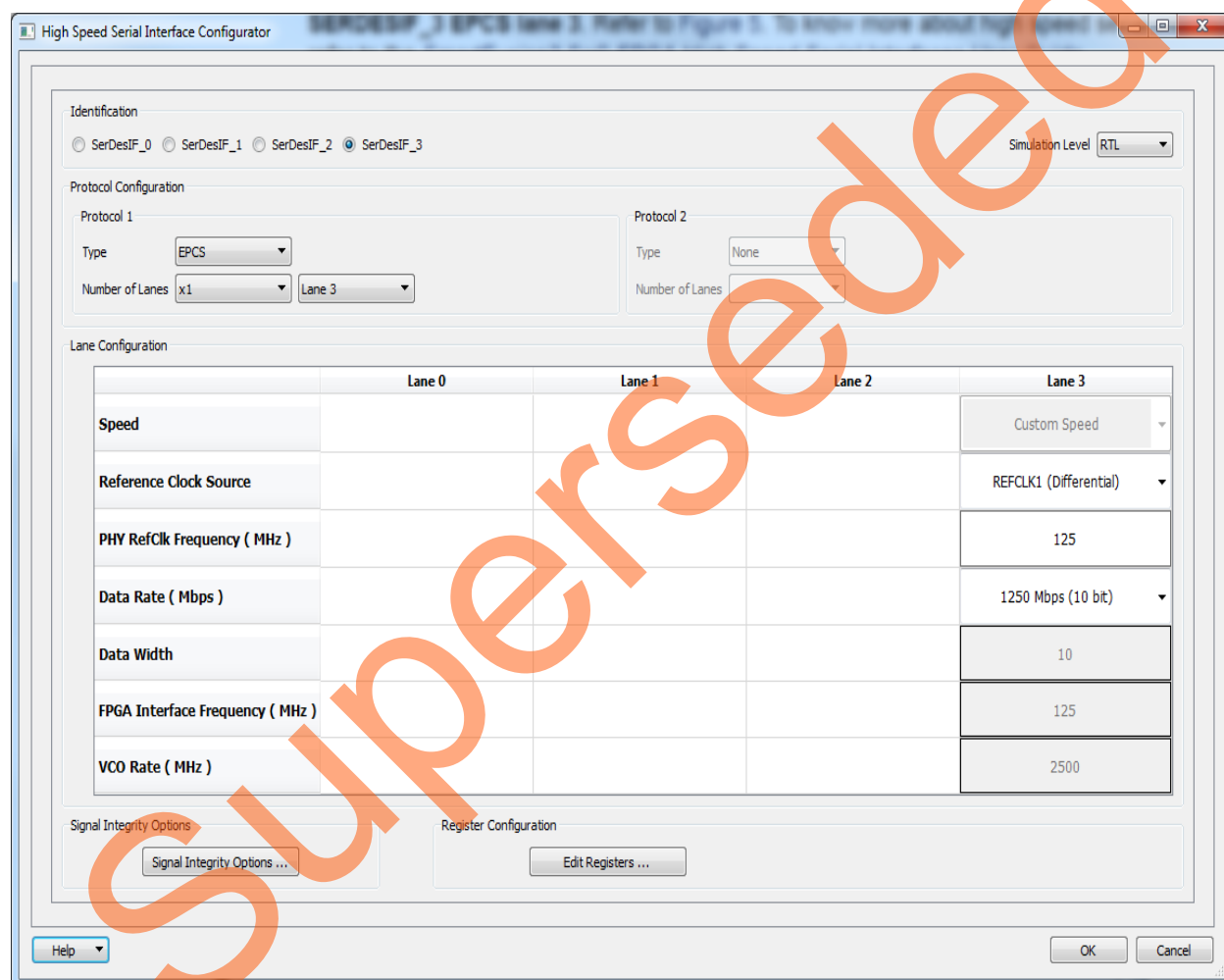


Figure 4 • High-Speed Serial Interface Configurator Window

Package Pin Assignments

Package pin assignments for LEDs and PHY interface signals are shown in Table 2 and Table 3. Table 2 shows the port names for the package pins.

Table 2 • LED to Package Pins Assignments

Port Name	Package Pin
LED_1	D26
LED_2	F26
LED_3	A27
LED_4	C26
LED_5	C28
LED_6	B27
LED_7	C27
LED_8	E26

Table 3 lists the port names and directions for the package pins.

Table 3 • PHY Interface Signals to Package Pins Assignments

Port Name	Direction	Package Pin
PHY_MDC	Output	F3
PHY_MDIO	Input	K7
PHY_RST	Output	F2

SoftConsole Firmware Project

Invoke the SoftConsole project using Standalone SoftConsole IDE.

The following stacks are used for this demo design:

- **lwIP TCP/IP** stack version 1.4.1 (www.sics.se/~adam/lwip/)
- **FreeRTOS** (www.freertos.org)

Figure 1 on page 6 shows the block diagram of the Webserver and TFTP server applications on the SmartFusion2 device used in this demo design.

Figure 5 shows SoftConsole software directory structure of the demo design.

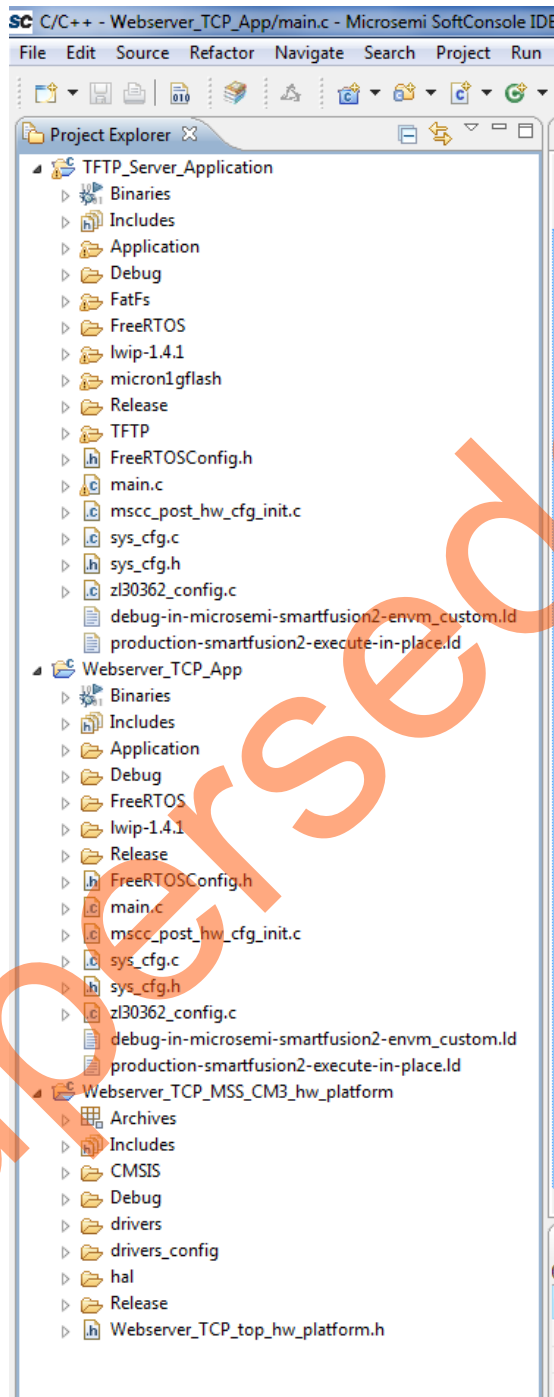


Figure 5 • SoftConsole Project Explorer Window

The SoftConsole workspace consists of the following three projects.

- **TFTP_Server_Application**: Contains TFTP server application using LWIP, FreeRTOS, and FatFs.
- **Webserver_TCP_App**: Contains Webserver application implementation using LWIP and FreeRTOS.
- **Webserver_TCP_MSS_CM3_hw_platform**: Contains all the firmware and hardware abstraction layers that correspond to the hardware design. This project is configured as a library and is referenced by Webserver_TCP_App and TFTP_Server_Application projects. The contents of this folder get overwritten every time the root design is regenerated in the Libero SoC software.

Note: To run the SoftConsole project in debug mode refer to "[Appendix 4: Running the SoftConsole Project in Debug Mode](#)" on page 34.

Setting Up the Demo Design

The following steps describe how to setup the demo for SmartFusion2 Advanced Development Kit board:

1. Connect the host PC to the **J33 Connector** using the USB A to mini-B cable. The USB to UART bridge drivers are automatically detected.
2. From the detected four COM ports, right-click any one of the COM ports and select **Properties**. The selected COM port properties window is displayed, as shown in [Figure 6](#).
3. Ensure to have the **Location** as on **USB FP5 Serial Converter C** in the **Properties** window as shown in [Figure 6](#).

Note: Make a note of the COM port number for serial port configuration and ensure that the COM port Location is specified as on **USB FP5 Serial Converter C**.

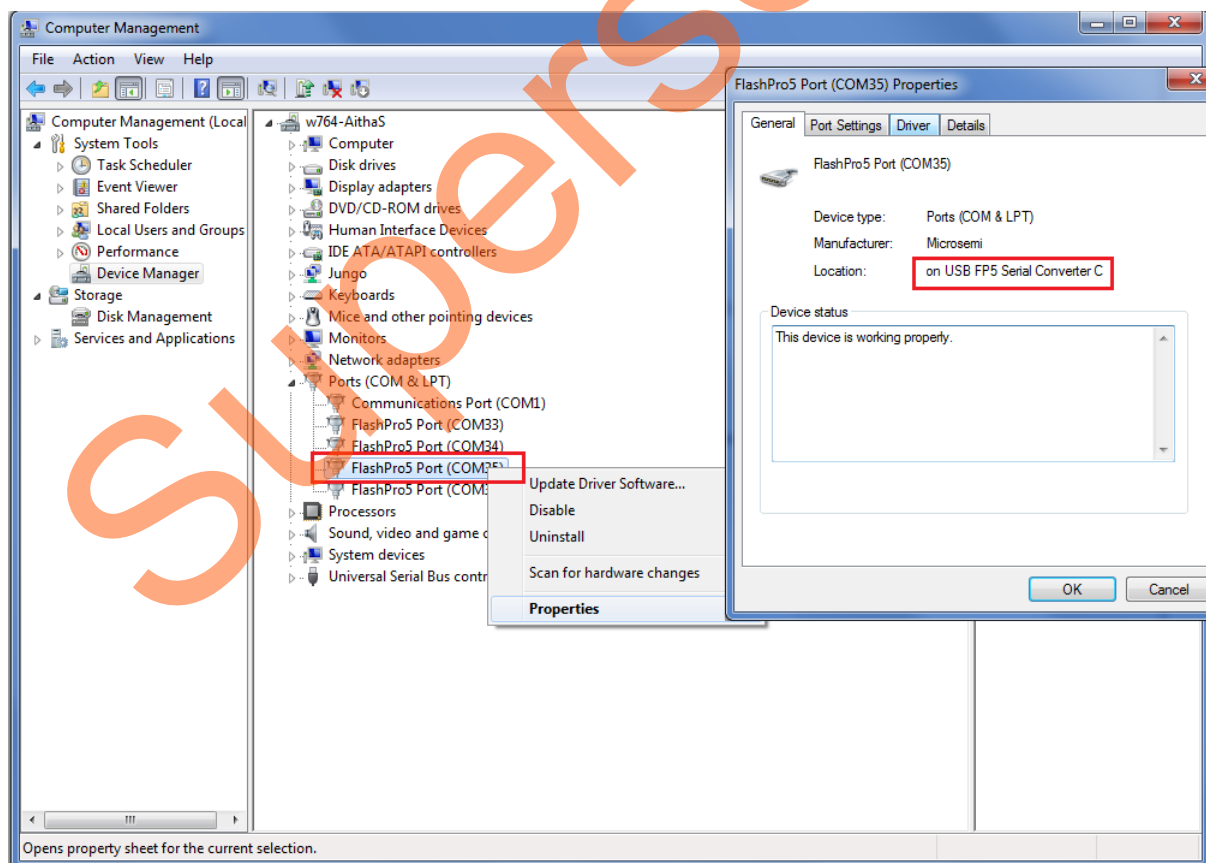


Figure 6 • Device Manager Window

4. Install the USB driver if the USB drivers are not detected automatically.
5. Install the FTDI D2XX driver for serial terminal communication through the FTDI mini USB cable.
Download the drivers and installation guide from:
www.microsemi.com/soc/documents/CDM_2.08.24_WHQL_Certified.zip

6. Connect the jumpers on the SmartFusion2 Advanced Development Kit board as shown in Table 4. For information on jumper locations, refer to "Appendix 2: Jumper Locations" on page 29.

Caution: Switch OFF the power supply switch, **SW7**, before making the jumper connections.

Table 4 • SmartFusion2 Advanced Development Kit Jumper Settings

Jumper	Pin (from)	Pin (to)	Comments
J116, J353, J354, J54	1	2	These are the default jumper settings of the Advanced Development Kit Board. Ensure these jumpers are set accordingly.
J123	2	3	
J124, J121, J32	1	2	JTAG programming via FTDI
J118, J119	1	2	Programming SPI Flash

7. Connect the power supply to the J42 connector in the SmartFusion2 Advanced Development Kit.
8. This design example can run in both Static IP and Dynamic IP modes. By default, programming files are provided for dynamic IP mode.
 - For static IP, connect the host PC to the J21 connector of the SmartFusion2 Advanced Development Kit board using an RJ45 cable.
 - For dynamic IP, connect any one of the open network ports to the J21 connector of the SmartFusion2 Advanced Development Kit board using an RJ45 cable.

Board Setup Snapshot

Snapshots of the SmartFusion2 Advanced Development Kit board with all the setup made is given in "Appendix 1: Board Setup for Running the Demo" on page 28.

Running the Demo Design

1. Download the demo design from:
www.microsemi.com/soc/download/rsc/?f=m2s_dg0472_liberov11p6_df.
2. Switch **ON** the SW7 power supply switch.
3. Start any serial terminal emulation program such as:
 - HyperTerminal
 - PuTTY
 - Tera-Term

Note: In this demo HyperTerminal is used.

The configuration for the program is:

- Baud Rate: 115200
- Eight data bits
- One stop bit
- No Parity
- No flow control

For information on configuring the serial terminal emulation programs, refer to the [Configuring Serial Terminal Emulation Programs Tutorial](#).

Running Webserver Demo

The following steps describe how to run the Webserver Demo:

1. Launch the FlashPro software.
2. Click **New Project**.
3. In the **New Project** window, enter the project name.

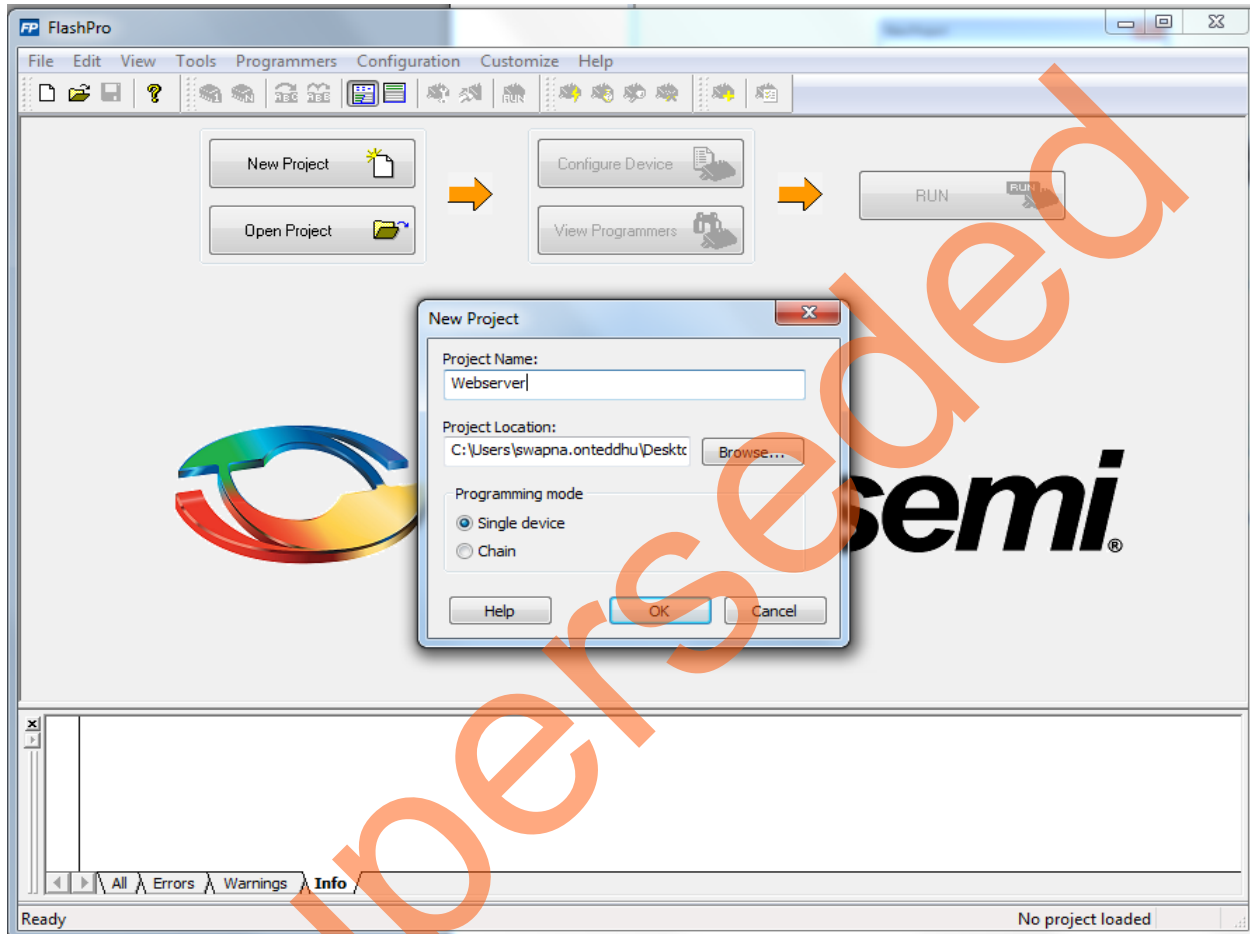


Figure 7 • FlashPro New Project

4. Click **Browse** and navigate to the location where the project is required to be saved.
5. Select **Single device** as the **Programming mode**.
6. Click **OK** to save the project.
7. Click **Configure Device**.

8. Click **Browse** and navigate to the location where the `Webserver_TCP_top.stp` file is located and select the file. The default location is:
`<download_folder>\SF2_Webserver_Tftp_TCP_Demo_DF\ProgrammingFiles\webserver\Webserver_TCP_top.stp`. The required programming file is selected and is ready to be programmed in the device.

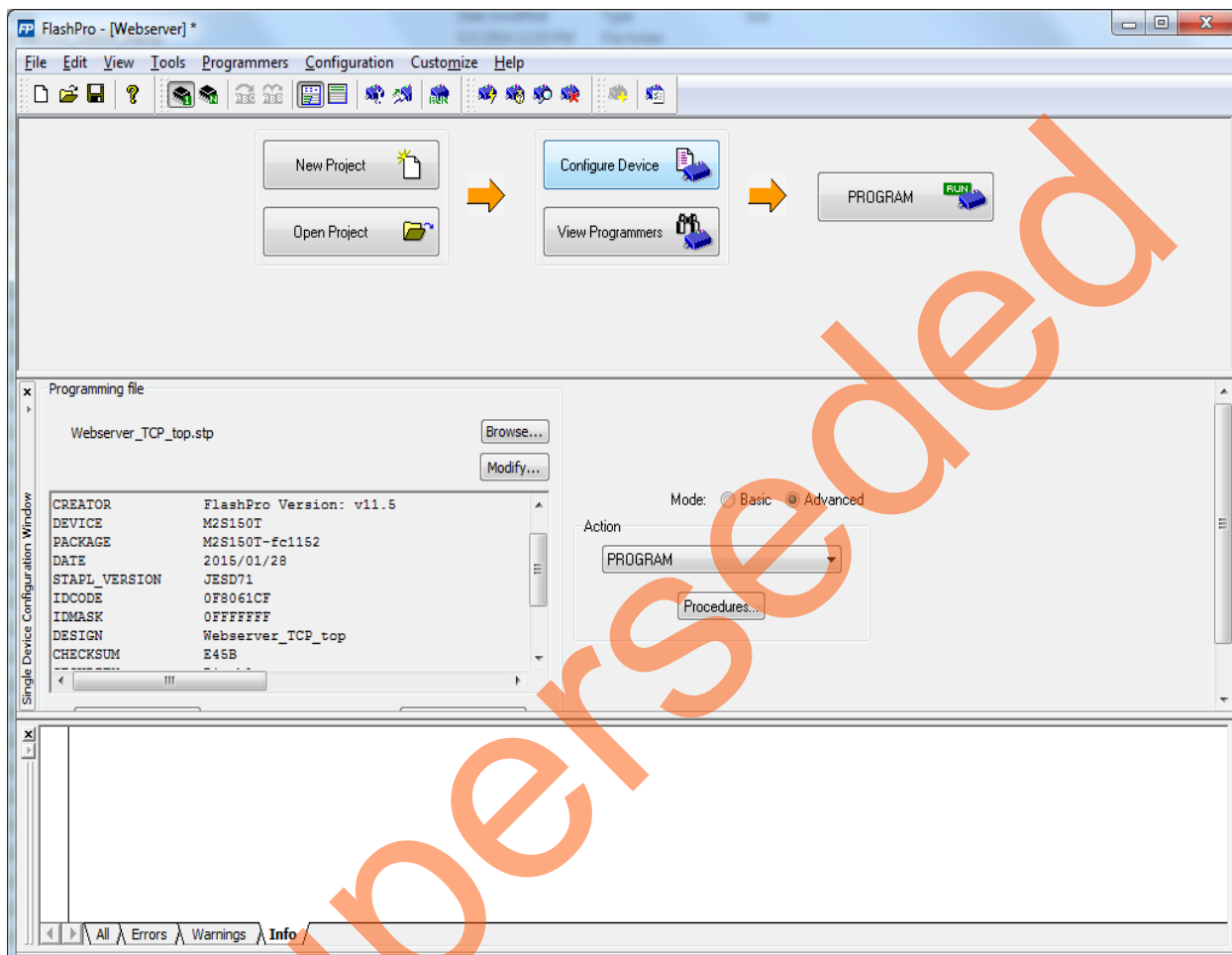


Figure 8 • FlashPro Project Configured

9. Click **PROGRAM** to start programming the device. Wait until a message is displayed indicating that the program has passed.

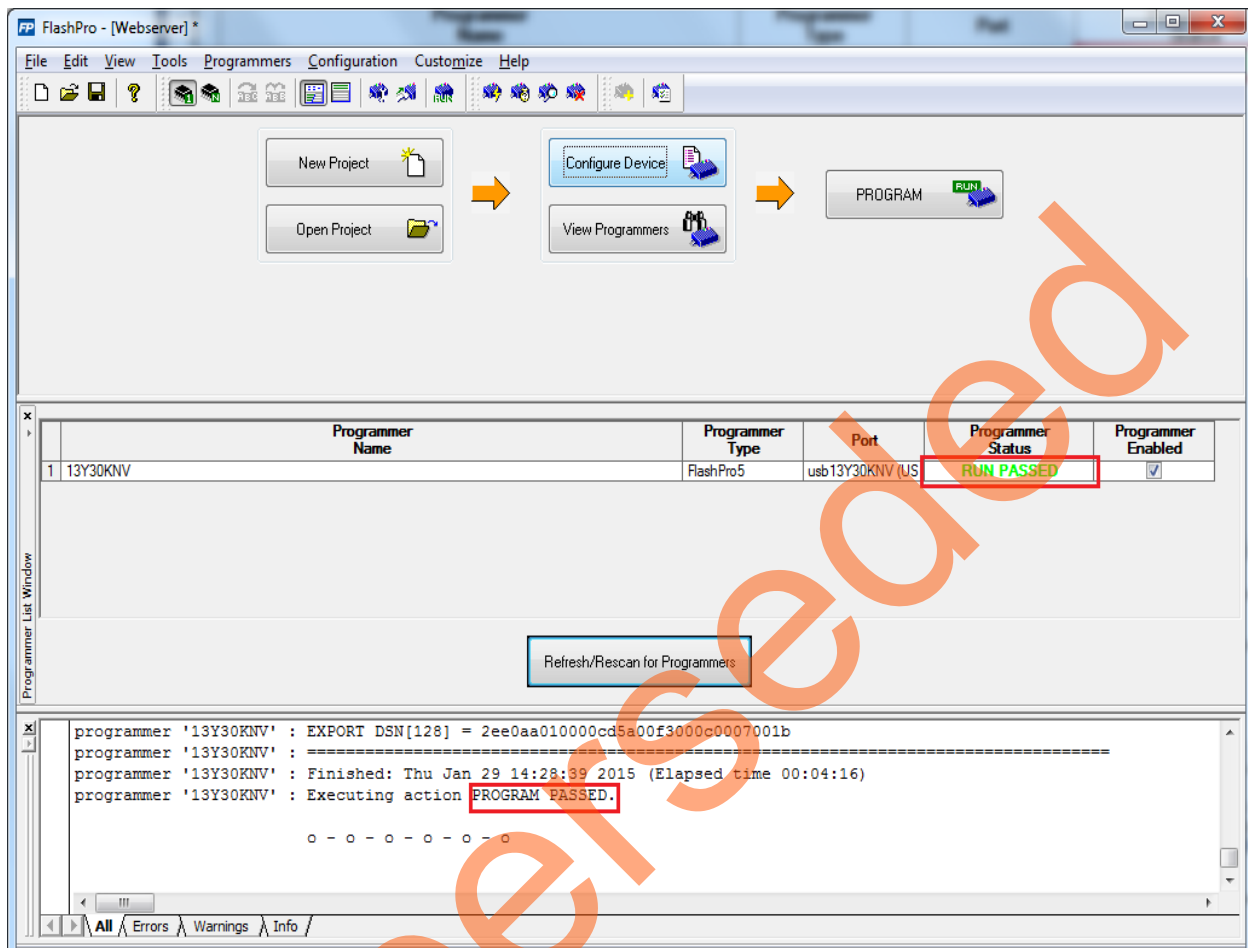


Figure 9 • FlashPro Program Passed

Note: The demo can be run in static and dynamic modes. To run the design in Static IP mode, follow the steps mentioned in the "Appendix 3: Running the Design in Static IP Mode" on page 30.

10. Power cycle the SmartFusion2 Advanced Development board.

A welcome message with the IP address is displayed in the HyperTerminal window as shown in Figure 10.

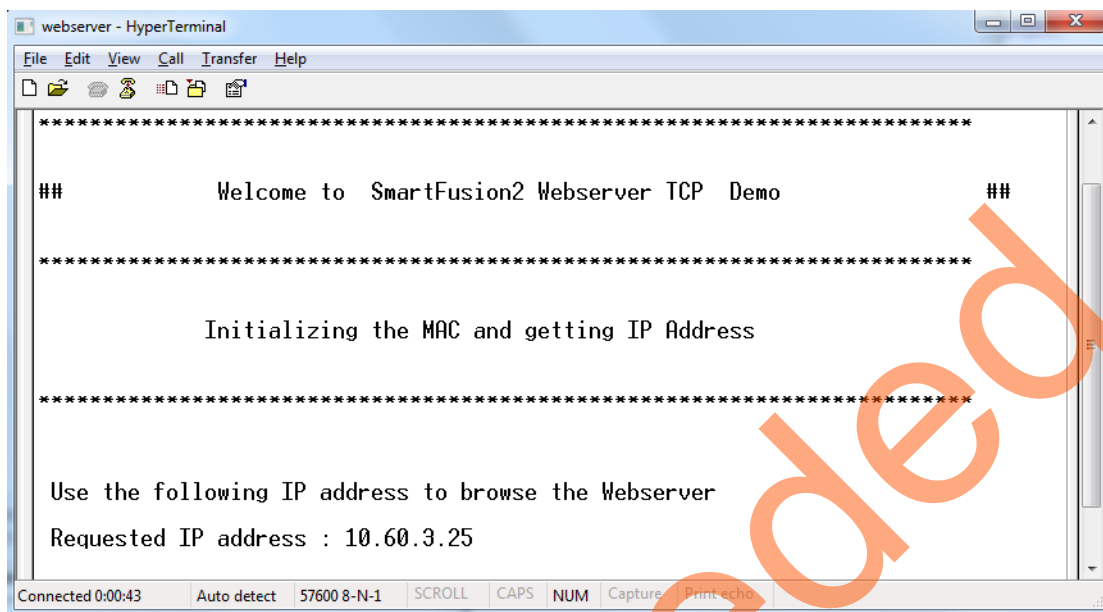


Figure 10 • HyperTerminal with IP Address

11. The IP address displayed on the HyperTerminal must be entered in the address bar of the browser (Mozilla Firefox) to run the Webserver. The main menu of the Webserver is shown in Figure 11.

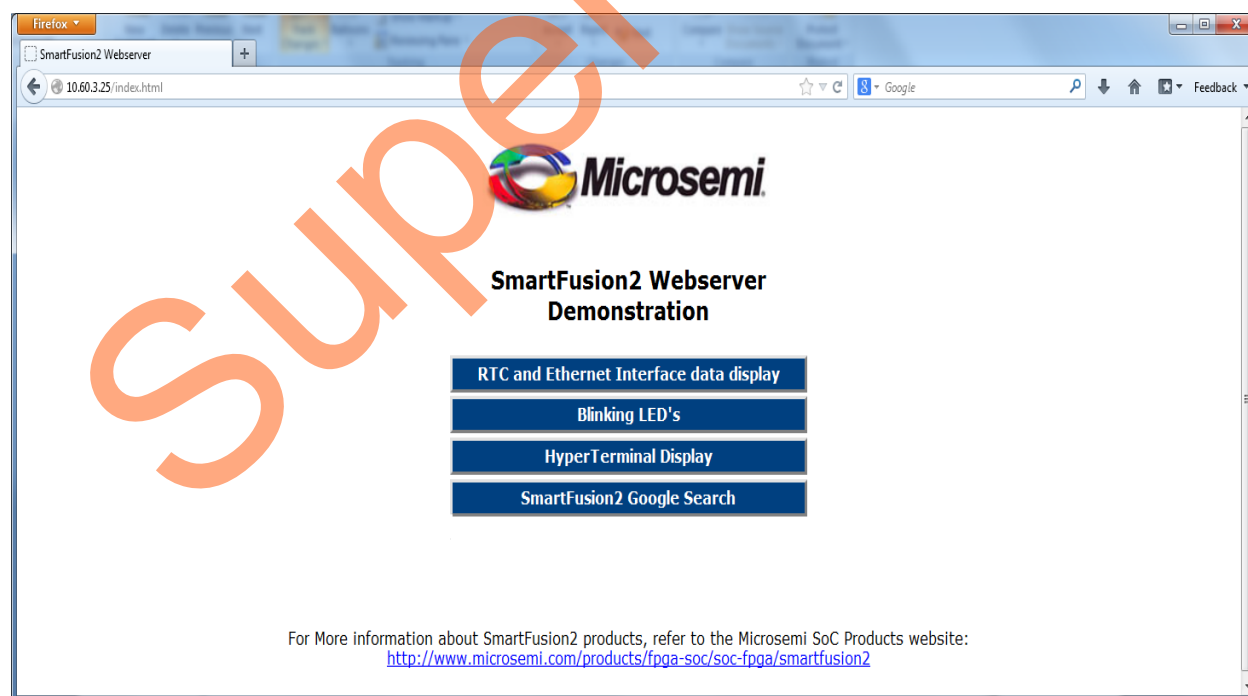


Figure 11 • Main Menu of Webserver

12. Click **RTC and Ethernet Interface data display** on the main menu of the Webserver demo.

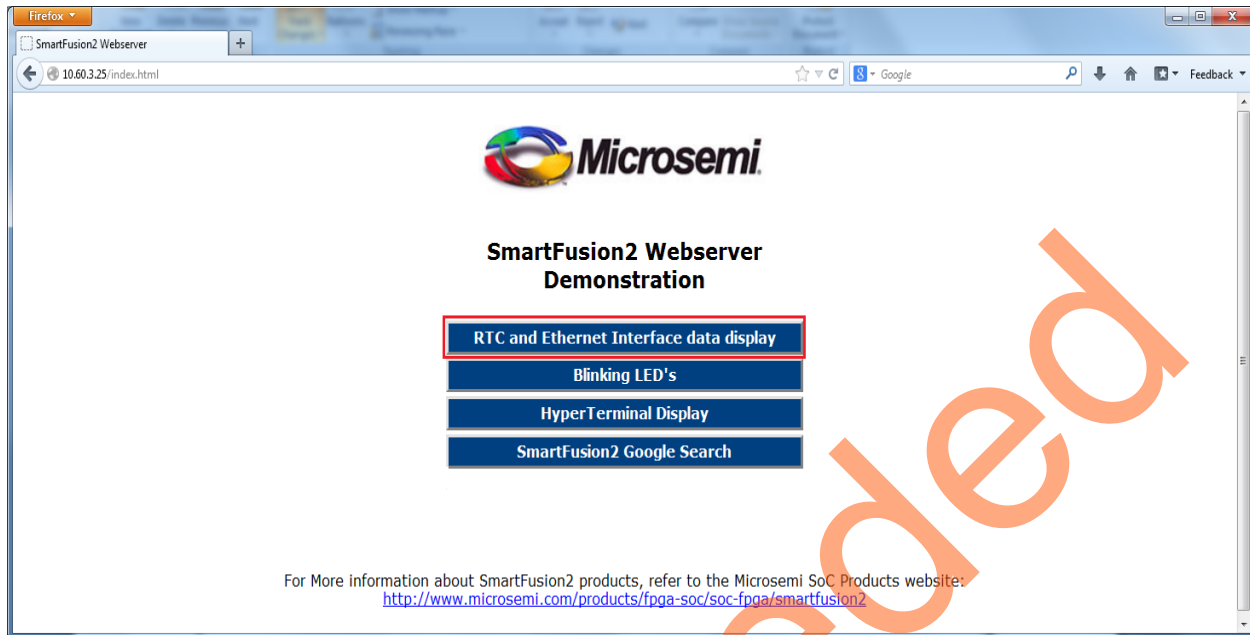


Figure 12 • Selecting RTC and Ethernet Interface Data Display

Figure 13 shows a webpage with RTC values and Ethernet MAC properties.

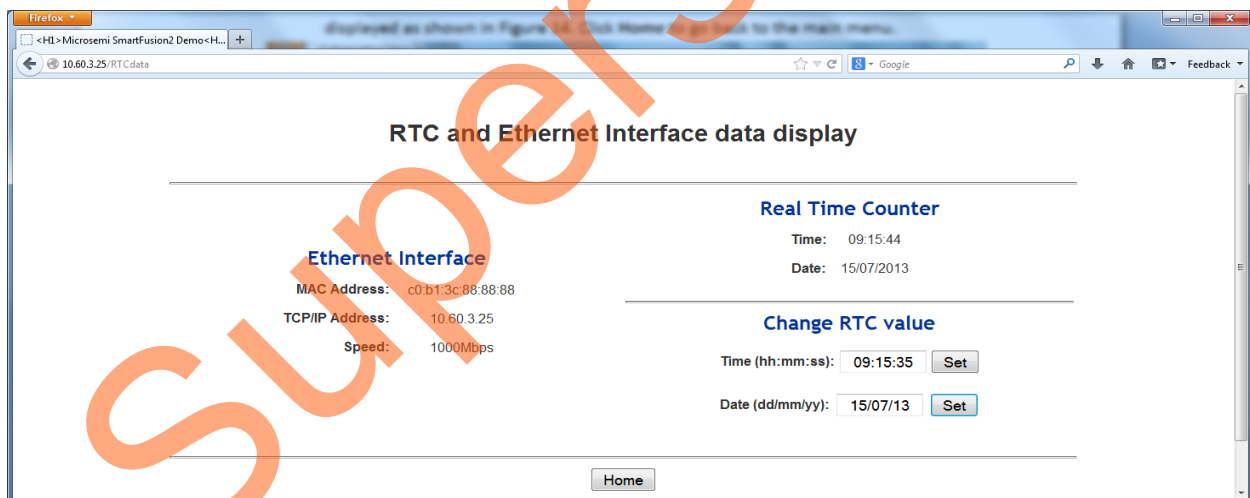


Figure 13 • Webserver RTC and Ethernet Interface Data Display

13. Click **Home** to go back to the main menu.

14. Click **Blinking LED's** on the main menu.

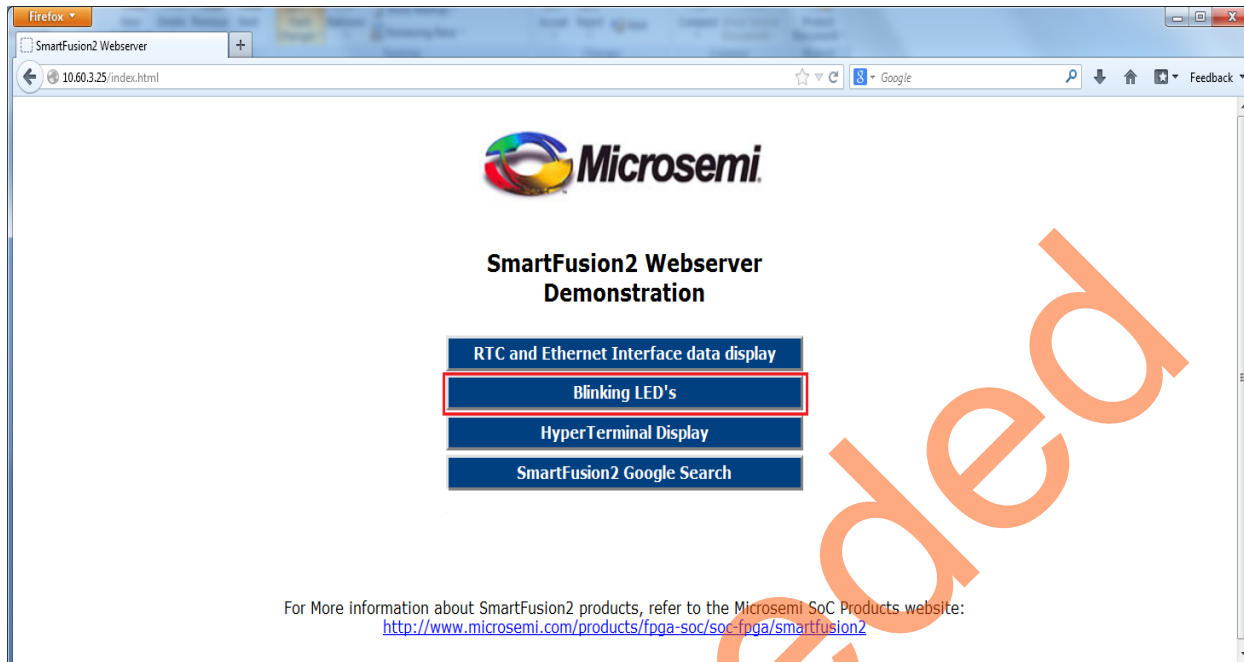


Figure 14 • Selecting Blinking LEDs

Figure 15 shows a running LED pattern on the board. The webpage gives an option to enter the values to blink the LEDs manually.

15. Enter any number between 1-255 to toggle the LEDs manually. For example, if 1 is entered, LED1 goes OFF. If 255 is entered, all the eight LEDs go OFF.

Note: The SmartFusion2 Advanced Development Kit has Active Low LEDs.

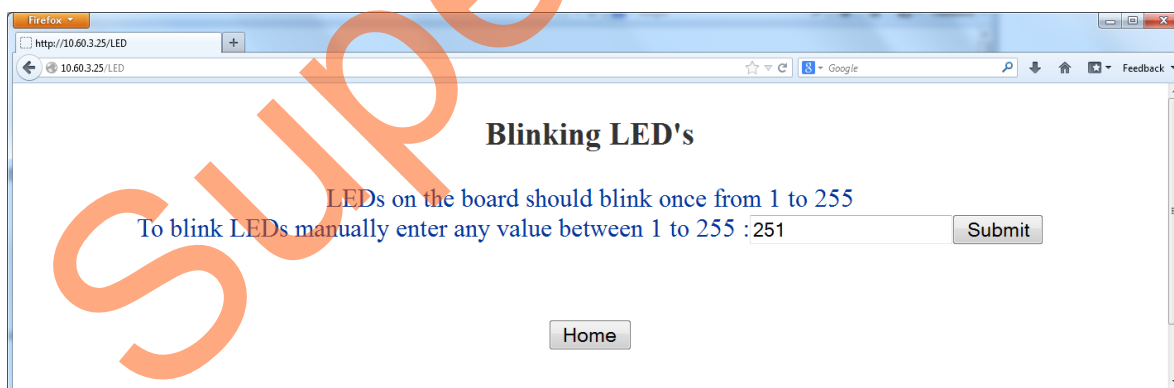


Figure 15 • Blinking LEDs

16. Click **Home** to go back to the main menu.

17. Click **HyperTerminal Display** on the main menu.

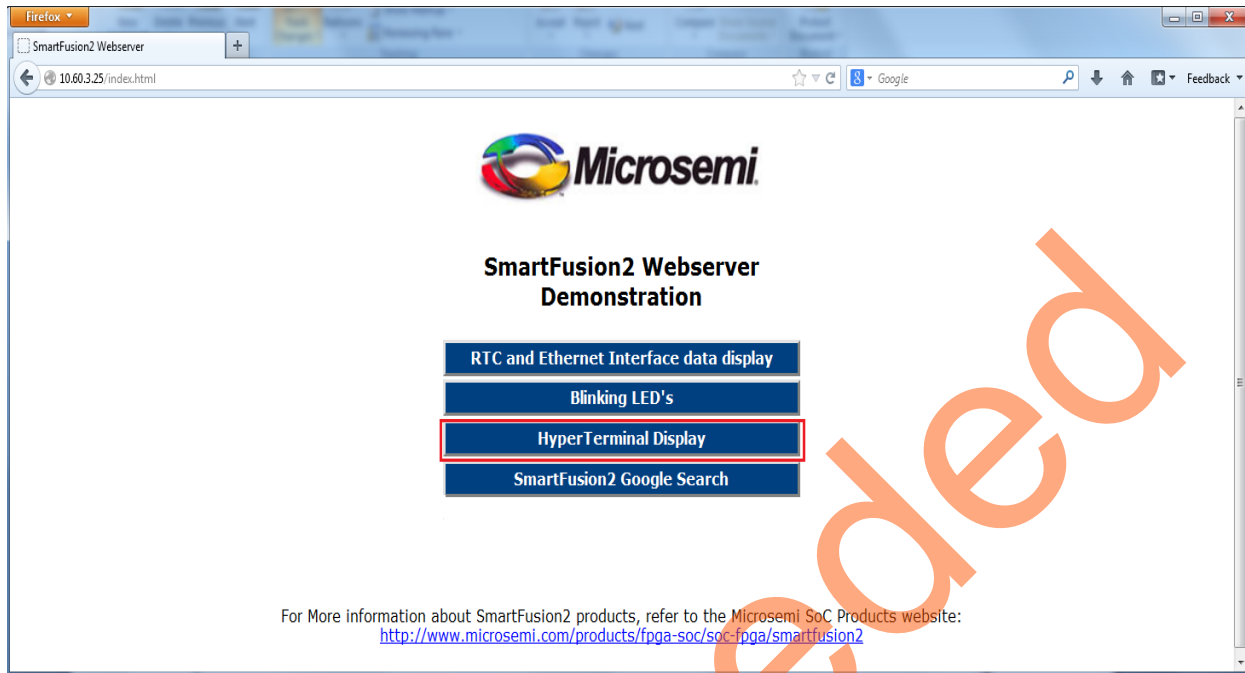


Figure 16 • Selecting HyperTerminal Display

Figure 17 shows a webpage that gives an option to enter a string value.

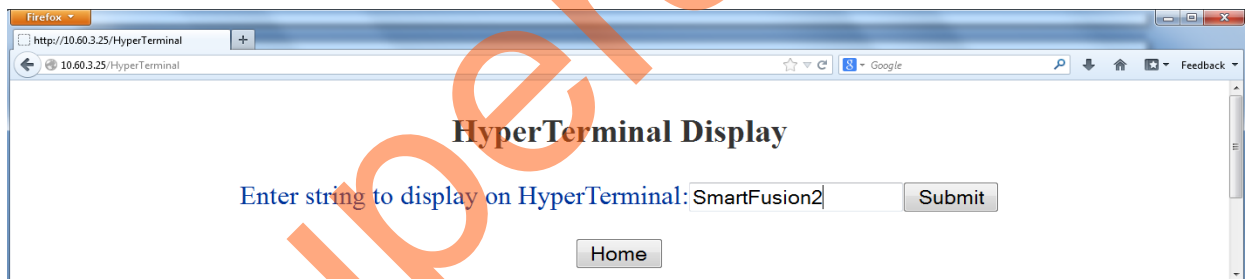


Figure 17 • Webserver HyperTerminal Display

The entered string is displayed on HyperTerminal as shown in Figure 18.

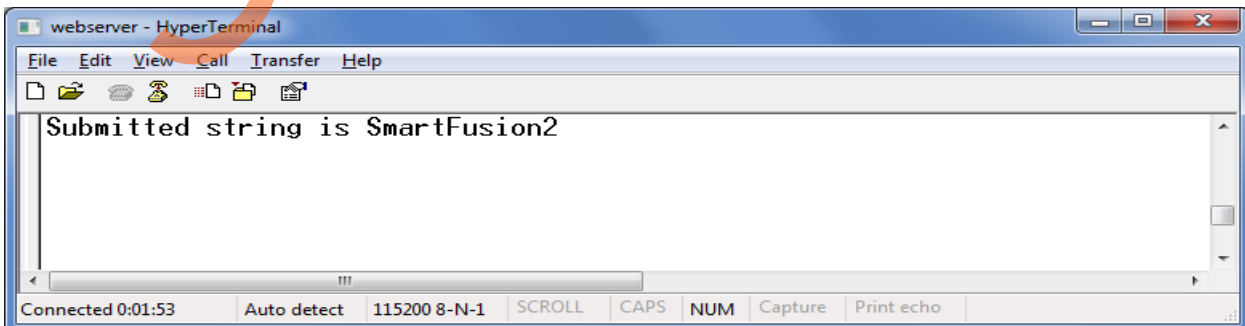


Figure 18 • String Display on HyperTerminal

18. Click **Home** to go back to the main menu.

19. Click **SmartFusion2 Google Search** on the main menu.

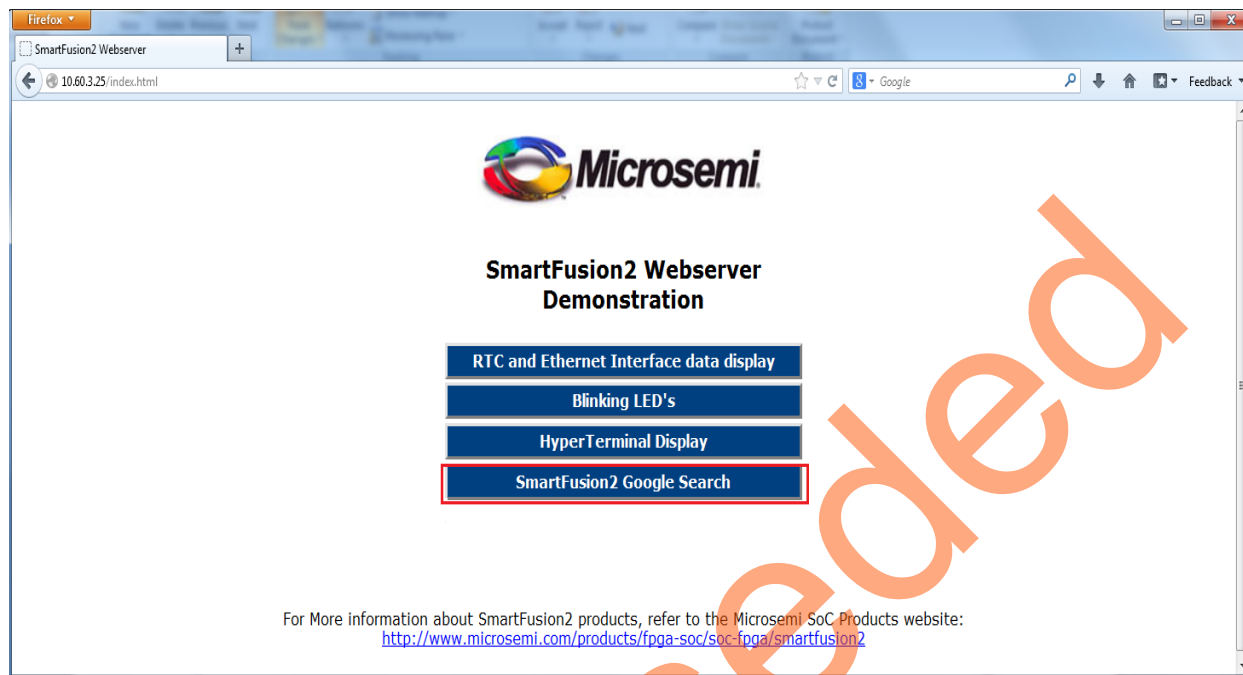


Figure 19 • Selecting SmartFusion2 Google Search

Note: Internet connection is required with proper access rights to get to the SmartFusion2 Google Search page.

Figure 20 shows a webpage with Google search option.

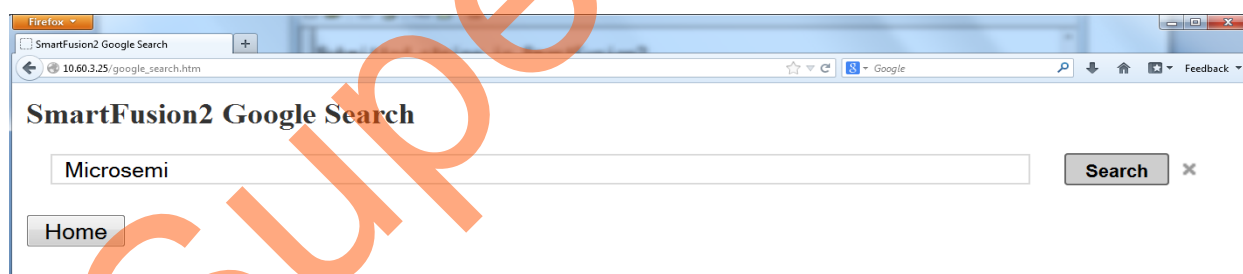


Figure 20 • Webserver SmartFusion2 Google Search

20. Click **Home** to go back to the main menu.

Running TFTP Demo

The following steps describe how to run the TFTP demo:

1. To enable the TFTP client in the host PC, navigate to **Control Panel > Programs**. Click **Turn Windows Features On or Off** and select the TFTP client in **Windows Features** as shown in Figure 21.

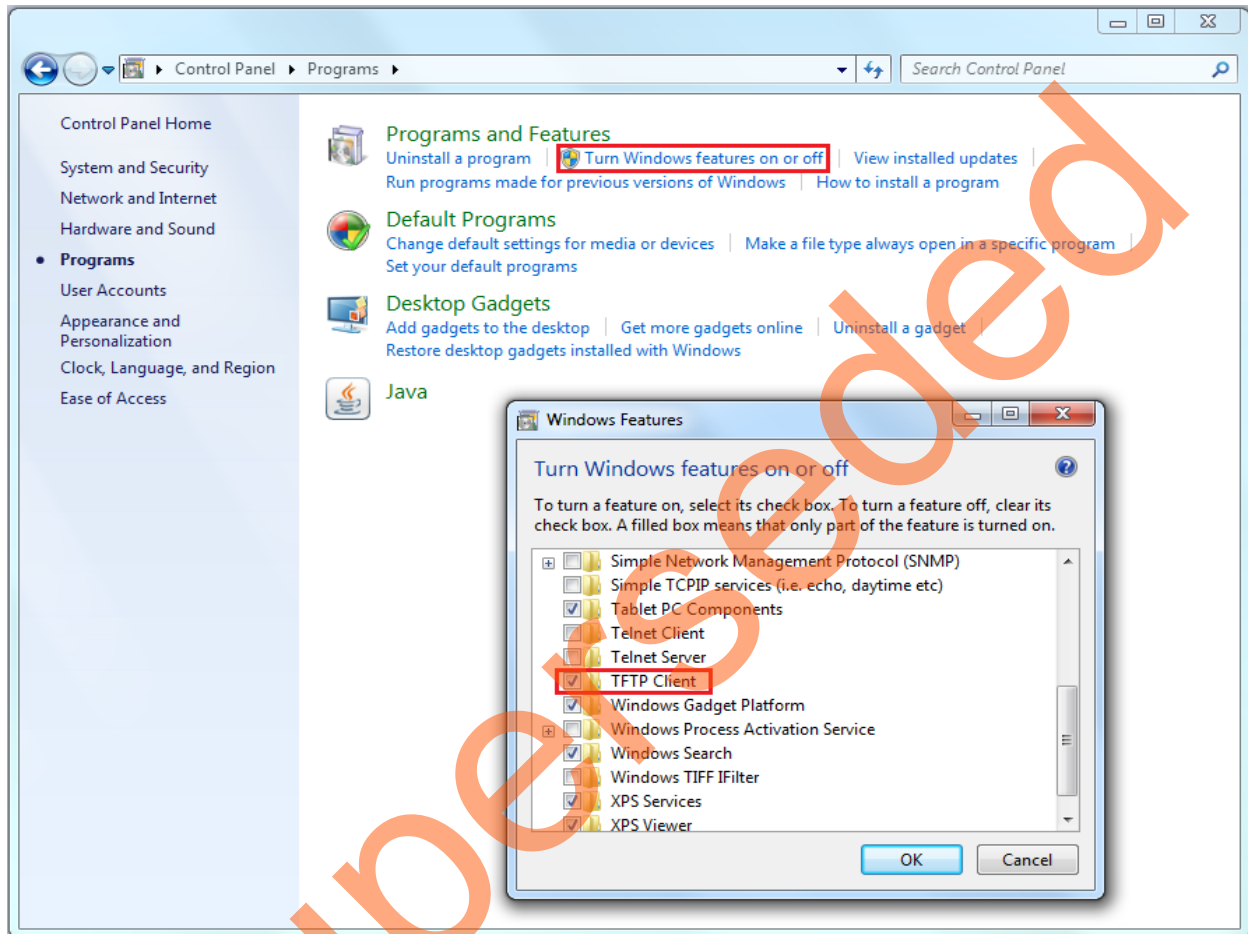


Figure 21 • Enabling TFTP Client in Host PC

2. Navigate to **Control Panel > Windows Firewall** and click **Turn Windows Firewall On or Off**. Select **Turn off Windows Firewall** under Domain network location settings as shown in Figure 22.

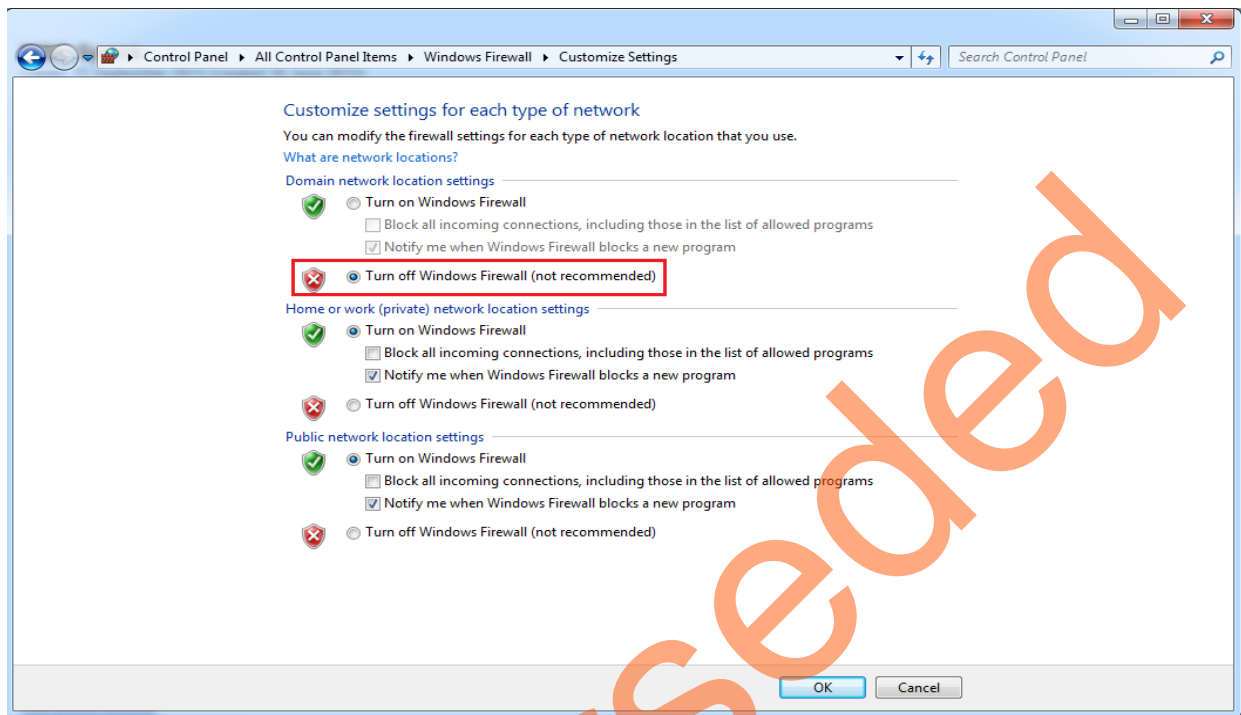


Figure 22 • Windows Firewall Settings

3. Launch the FlashPro software and program the device with `<download_folder>\SF2_Webserver_Tftp_TCP_Demo_DF\ProgrammingFiles\Tftp_Server\Webserver_TCP_top_tftp.stp`. Wait until a message indicating that the program passed is displayed. Refer to Step 1. to Step 9. of "Running Webserver Demo" section on page 15.

Note: To run the design in static IP mode, follow the steps mentioned in the "Appendix 3: Running the Design in Static IP Mode" on page 30.

4. Power cycle the SmartFusion2 Advanced Development Kit board.

HyperTerminal program displays the welcome message and option to clear the SPI Flash contents as shown in Figure 23.

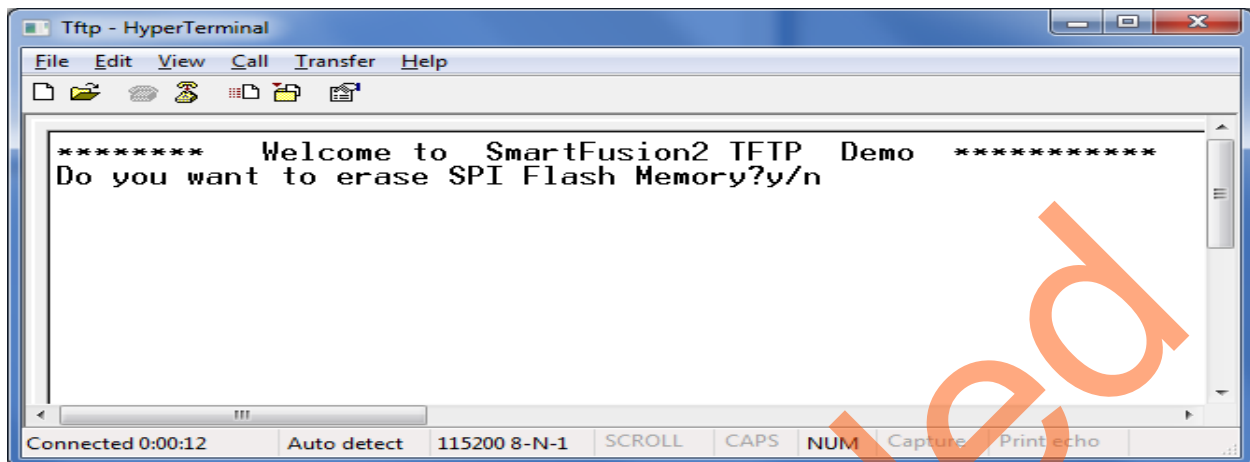


Figure 23 • HyperTerminal with Welcome Message

5. Type **y** to erase the SPI Flash memory contents, as shown in Figure 24.

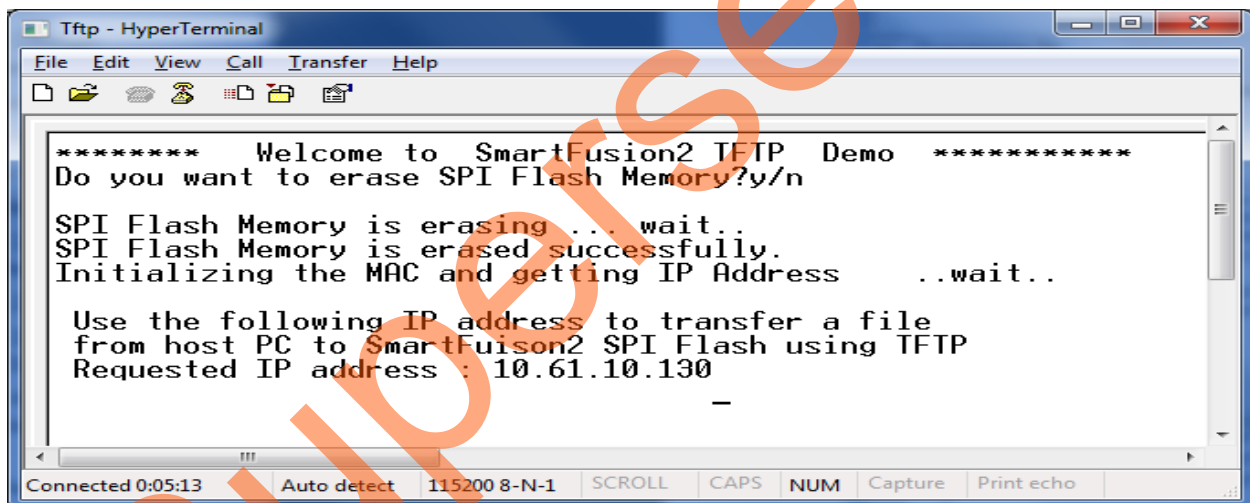


Figure 24 • HyperTerminal with IP Address - Erasing SPI Flash Memory

6. Type any key other than **y** to skip SPI Flash erasing, as shown in Figure 25 on page 26.

The HyperTerminal program displays the dynamic IP address also, as shown in Figure 24 on page 25 or Figure 25.

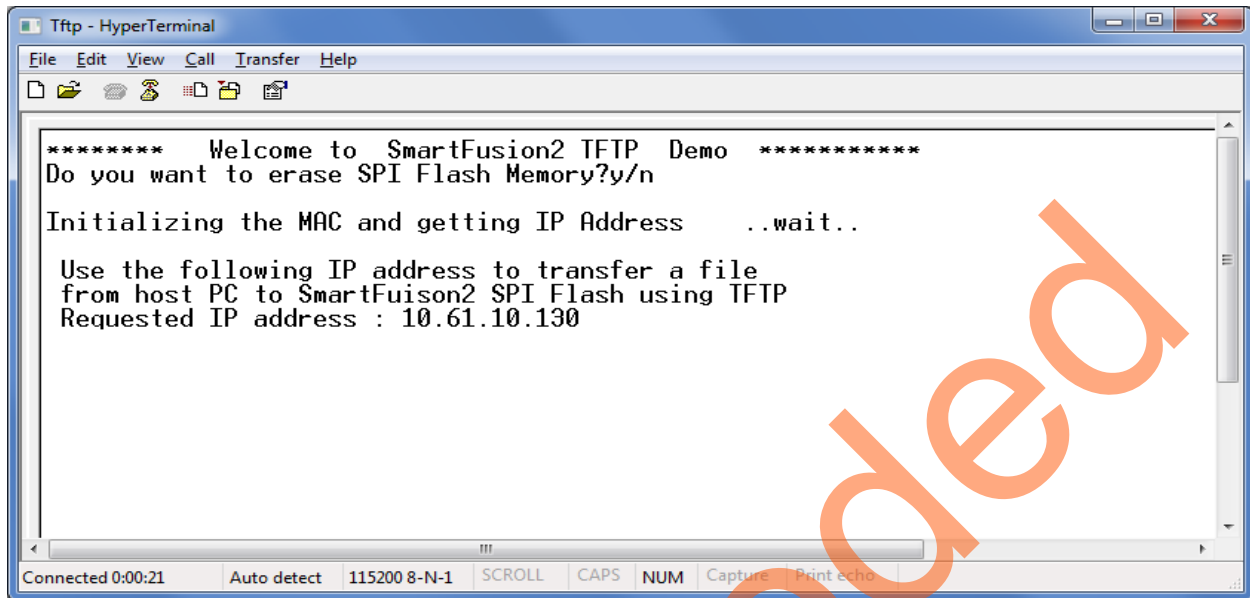


Figure 25 • HyperTerminal with IP Address

7. Open the command prompt in the host PC and navigate to the directory, where the files to be transferred to the SPI FLASH are located:
`<download_folder>\SF2_Webserver_Tftp_TCP_Demo_DF\sample_files.`
8. Type the following tftp command to transfer the file to the tftp server (SmartFusion2 Device) as shown in Figure 26.
`tftp -i < ip address> PUT <file name>`

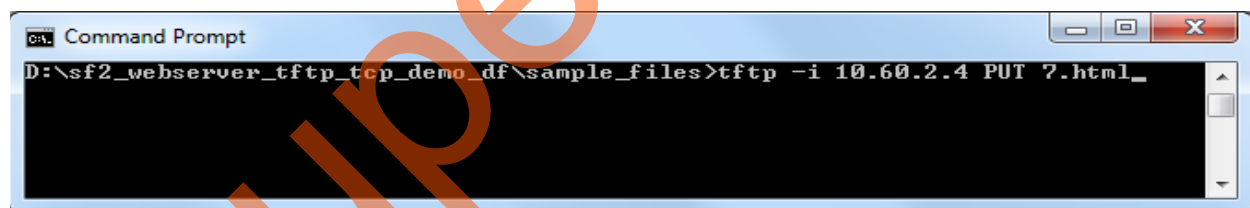


Figure 26 • Command Prompt

On successful file transfer from the host PC to the SmartFusion2 SPI-Flash, the command prompt window shows the transfer successful message as shown in Figure 27.

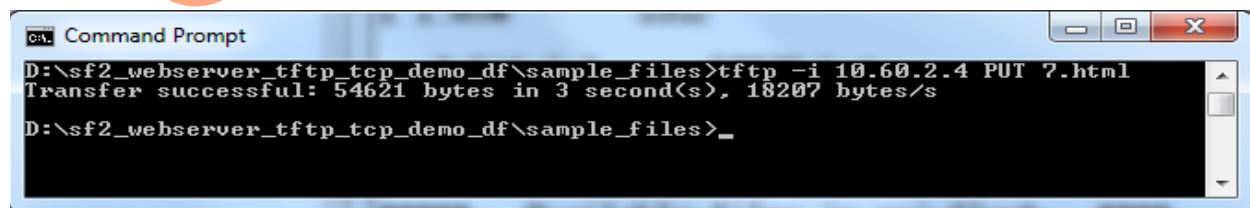


Figure 27 • Successful Transfer Message

HyperTerminal shows the available files in SPI flash as shown in Figure 28.

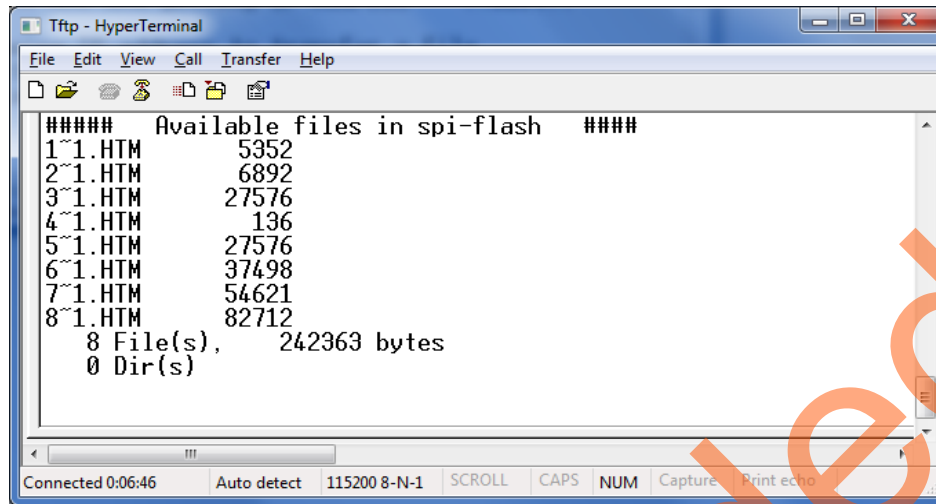


Figure 28 • HyperTerminal with Available SPI Flash Files

9. Repeat [Step 7.](#) and [Step 8.](#), if another file is required to be transferred to the SmartFusion2 SPI-Flash from host PC.
10. After running the demo, close the HyperTerminal.

Appendix 1: Board Setup for Running the Demo

Figure 29 shows the board setup for running the demo on the SmartFusion2 Advanced Development Kit board.

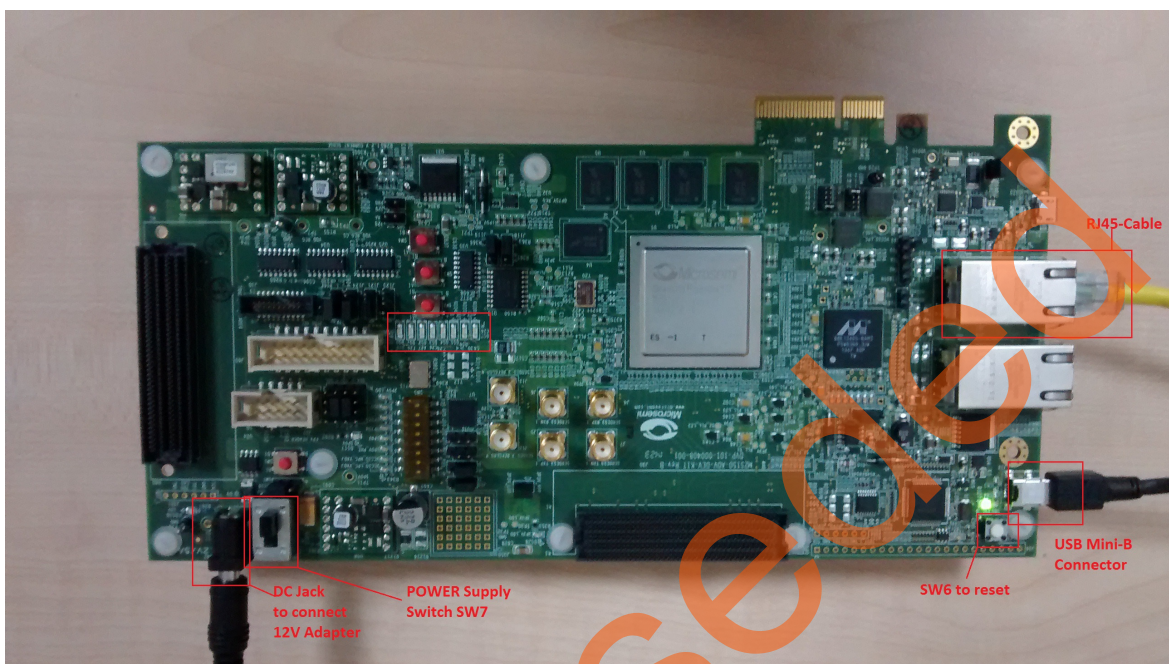


Figure 29 • SmartFusion2 Advanced Development Kit Setup

Appendix 2: Jumper Locations

Figure 30 shows the jumper locations on the SmartFusion2 Advanced Development Kit board.



Figure 30 • SmartFusion2 Advanced Development Kit Silkscreen Top View

Note:

- Jumpers highlighted in red are set by default.
- Jumpers highlighted in green must be set manually.
- The location of the jumpers in Figure 30 are searchable.

Appendix 3: Running the Design in Static IP Mode

The following steps describe how to run the design in Static IP mode:

1. To run the Webserver design in Static IP mode, right-click the **Webserver_TCP_App** project and select **Properties** as shown in Figure 31.

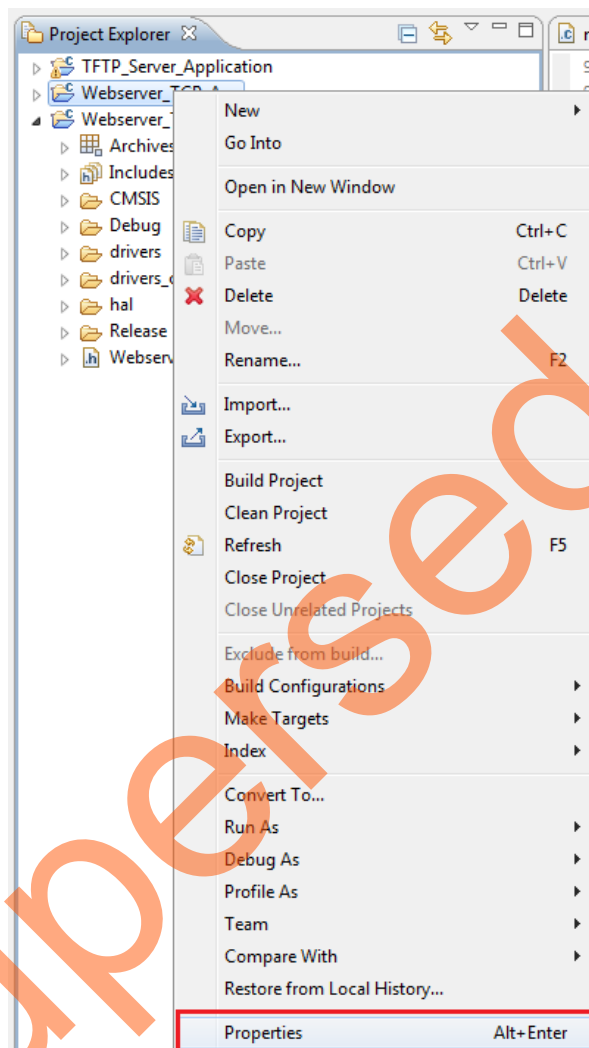


Figure 31 • Project Explorer Window of SoftConsole Project

2. Remove the symbol **NET_USE_DHCP** in **Tool Settings** of the **Properties for Webserver_TCP_App** window, as shown in [Figure 32](#).

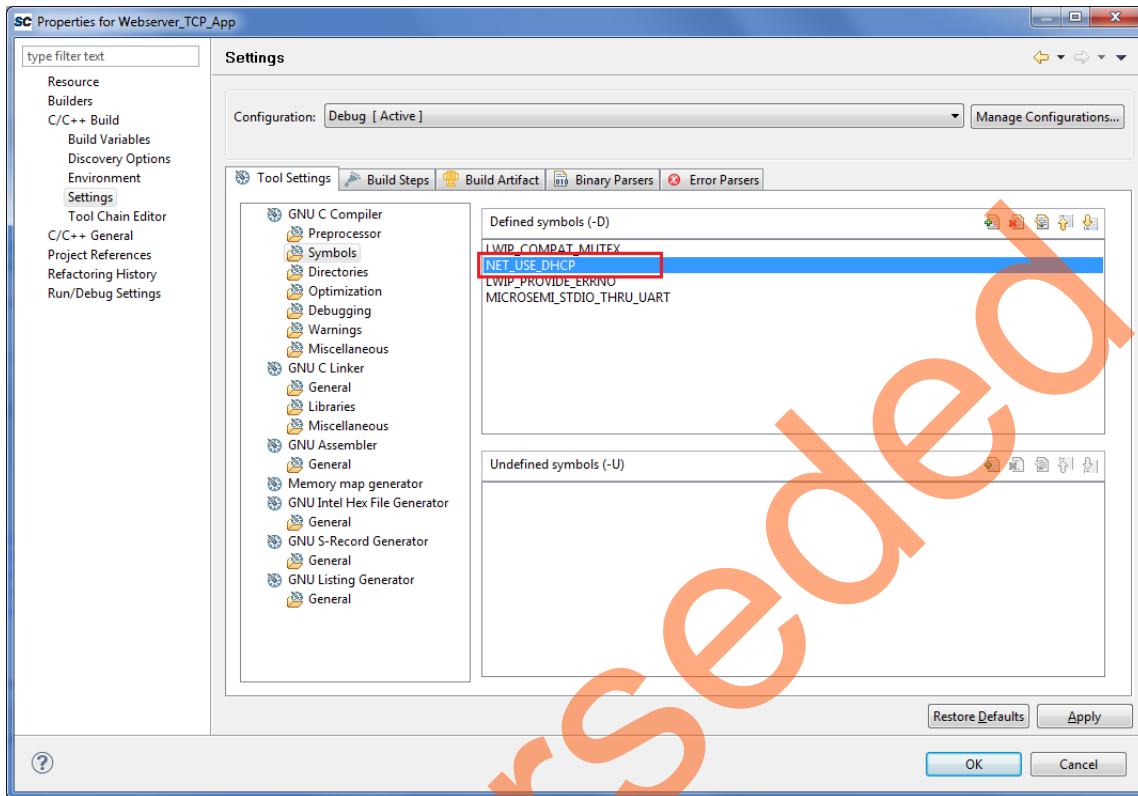


Figure 32 • Webserver_TCP_App Properties Window

Note: To run the TFTP server design in static IP mode, remove the **NET_USE_DHCP** symbol in the Properties window of **TFTP_Server_Application**, as described in [Step 1](#). and [Step 2](#).

If the device is connected in Static IP mode, the board static IP address is 169.254.1.23, then change the host TCP/IP settings to reflect the IP address. [Figure 33](#) shows Host PC TCP/IP settings.

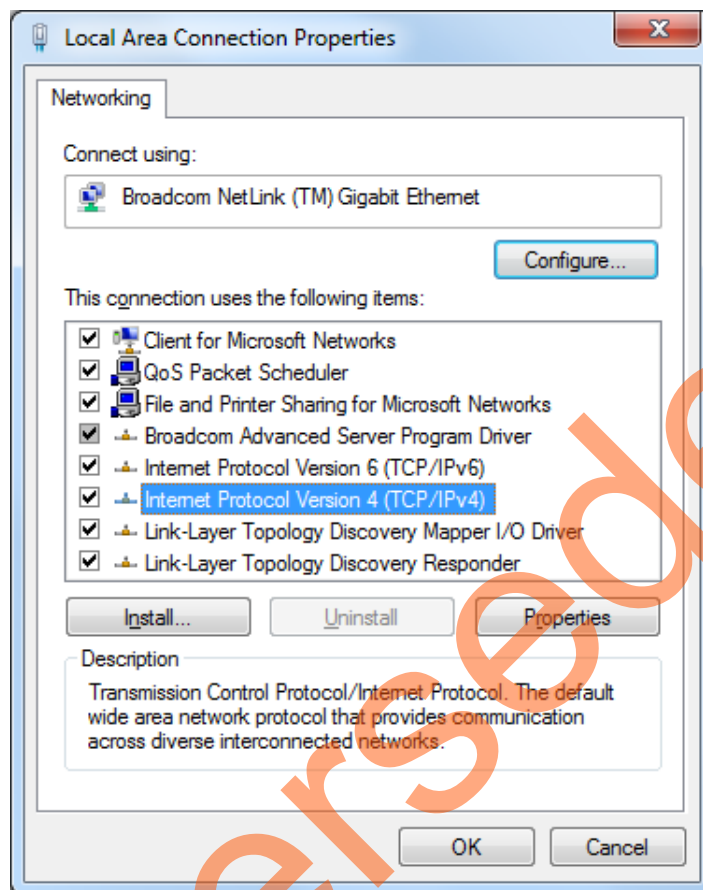


Figure 33 • Host PC TCP/IP Settings

Figure 34 shows Static IP address settings.

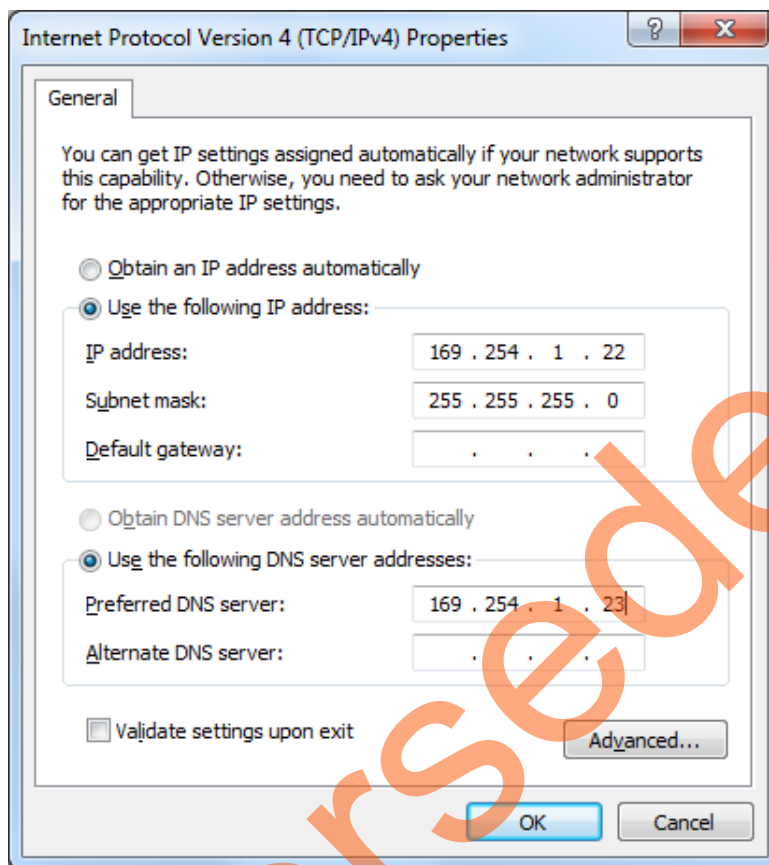


Figure 34 • Static IP Address Settings

Once these settings are made, compile the design, load the design into memory, and run the design using the SoftConsole.

Note: To run the application in debug mode, FlashPro4 JTAG programmer is required.

Appendix 4: Running the SoftConsole Project in Debug Mode

The following steps describe how to run the SoftConsole project in Debug mode:

1. Select **Debug Configurations** from **Run** menu of the SoftConsole. The **Debug Configurations** dialog box is displayed.
2. To debug TFTP_Server_Application project, select **TFTP_Server_Application Debug** as shown in [Figure 35](#).

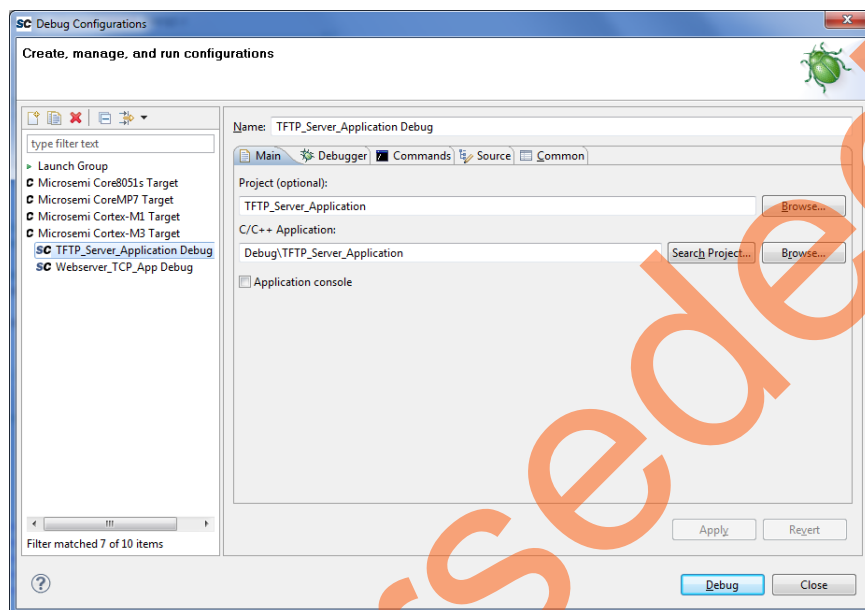


Figure 35 • Debug Configurations for TFTP_Server_Application

3. To debug Webserver_TCP_App project, select **Webserver_TCP_App Debug** as shown in Figure 36.

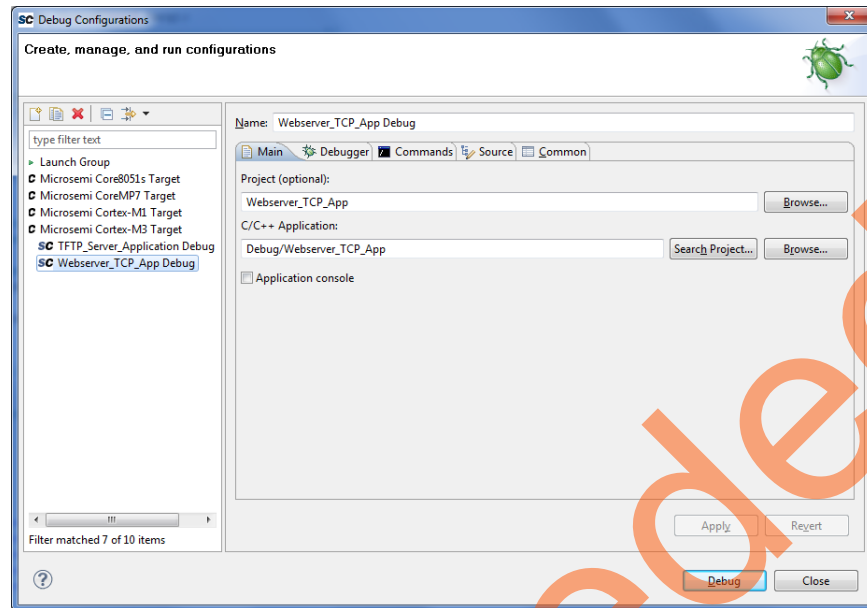


Figure 36 • Debug Configurations for Webserver_TCP_App

4. After selecting the target click **Debug**.

Note: To run the application in debug mode, FlashPro4 JTAG programmer is required.

A – List of Changes

The following table shows important changes made in this document for each revision.

Date	Changes	Page
Revision 5 (October 2015)	Updated the document for Libero v11.6 software release details (SAR 72226)	NA
Revision 4 (February 2015)	Updated the document for Libero v11.5 software release details (SAR 63974).	NA
Revision 3 (September 2014)	Updated the document for Libero v11.4 software release details (SAR 60795).	NA
	Updated the document for SmartFusion2 Advanced Development Kit Board details (SAR 60795).	NA
Revision 2 (March 2014)	Updated the document to include TFTP server (SAR 55038).	NA
Revision 1 (December 2013)	Updated the document for Libero v11.2 software release (SAR 53219).	NA
Revision 0 (October 2013)	Initial Release	NA

B – Product Support

Microsemi SoC Products Group backs its products with various support services, including Customer Service, Customer Technical Support Center, a website, electronic mail, and worldwide sales offices. This appendix contains information about contacting Microsemi SoC Products Group and using these support services.

Customer Service

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

From North America, call 800.262.1060

From the rest of the world, call 650.318.4460

Fax, from anywhere in the world, 408.643.6913

Customer Technical Support Center

Microsemi SoC Products Group staffs its Customer Technical Support Center with highly skilled engineers who can help answer your hardware, software, and design questions about Microsemi SoC Products. The Customer Technical Support Center spends a great deal of time creating application notes, answers to common design cycle questions, documentation of known issues, and various FAQs. So, before you contact us, please visit our online resources. It is very likely we have already answered your questions.

Technical Support

For Microsemi SoC Products Support, visit

<http://www.microsemi.com/products/fpga-soc/design-support/fpga-soc-support>

Website

You can browse a variety of technical and non-technical information on the SoC home page, at

<http://www.microsemi.com/products/fpga-soc/fpga-and-soc>.

Contacting the Customer Technical Support Center

Highly skilled engineers staff the Technical Support Center. The Technical Support Center can be contacted by email or through the Microsemi SoC Products Group website.

Email

You can communicate your technical questions to our email address and receive answers back by email, fax, or phone. Also, if you have design problems, you can email your design files to receive assistance. We constantly monitor the email account throughout the day. When sending your request to us, please be sure to include your full name, company name, and your contact information for efficient processing of your request.

The technical support email address is soc_tech@microsemi.com.

My Cases

Microsemi SoC Products Group customers may submit and track technical cases online by going to [My Cases](#).

Outside the U.S.

Customers needing assistance outside the US time zones can either contact technical support via email (soc_tech@microsemi.com) or contact a local sales office. Visit [About Us](#) for [sales office listings](#) and [corporate contacts](#).

ITAR Technical Support

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