One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

ADuCRF101 Development System Getting Started Tutorial

INTRODUCTION

The ADuCRF101 is a fully integrated data acquisition solution designed for low power wireless applications. It features a 12-bit ADC, a low power Cortex™-M3 core from ARM, a 431 MHz to 464 MHz and 862 MHz to 928 MHz RF transceiver, and Flash/EE memory packaged in a 9 mm × 9 mm LFCSP.

Refer to the ADuCRF101 product page for future updates.

Additional support for the ADuCRF101 is available through the EngineerZone® website.

GENERAL DESCRIPTION

The ADuCRF101 development system allows evaluation of ADuCRF101 silicon. This getting started guide introduces the support features and tools supplied with the evaluation kit. In addition, it shows and describes how to connect the evaluation hardware and explains when external components are required for operation.

This guide describes the software files that are included on the DVD and explains how to download them. This guide works as a tutorial by providing a step-by-step account of how to download evaluation versions of third-party software tools. Instructions are provided for how to load code examples that are supplied on the DVD. These examples demonstrate the simple operation of the ADuCRF101.

Working through this guide brings the user to a stage where they can start to generate and download their own user code to use in their own unique end-system requirements.

The radio interface engine (RIE) is the software programming interface that controls the ADuCRF101 radio. This interface allows users to easily configure and use the radio.

The Analog Devices, Inc., ADRadioNet™ wireless networking solution is available on request.

ADuCRF101 MINI BOARD AND EMULATOR BOARD

Figure 1.

TABLE OF CONTENTS

REVISION HISTORY

1/15—Revision 0: Initial Version

DEVELOPMENT SYSTEMS OVERVIEW

Different systems are available that are optimized for the various types of evaluation requirements.

Table 1 lists the contents available for each type of system.

Table 1. Development Systems Content

Content	Mini Kit (MK)	QuickStart (QS)	QuickStart Plus (QSP)
Mini Board	1	1	2
Antenna	1	1	2
Emulator Board	0	1	1
Battery Holder	0	0	1
DVD	1	1	1

The mini board is optimized for 433 MHz or 868 MHz/915 MHz operation. Table 2 lists the models and their optimized communication frequency.

Table 2. Development Systems Models

Model	Description	Frequency
EV-ADuCRF101MK1Z	Mini kit	868 MHz/915 MHz
EV-ADuCRF101MK3Z	Mini kit	433 MHz
EV-ADuCRF101QS1Z	QuickStart	868 MHz/915 MHz
EV-ADuCRF101QS3Z	QuickStart	433 MHz
EV-ADuCRF101QSP1Z	QuickStart Plus	868 MHz/915 MHz
EV-ADuCRF101QSP3Z	QuickStart Plus	433 MHz

This getting started guide assumes that a mini board and an emulator board are available.

ADRadioNet WIRELESS NETWORKING

ADRadioNet is a wireless networking solution for the ISM band. It uses IPv6 addresses and combines most of the features expected in such solutions, that is, low power, multi-hop, end-to-end acknowledgement, self-healing, and so on. Even with all of these features, the main feature of ADRadioNet is ease of use.

ASSEMBLING THE HARDWARE

Do not plug in the hardware before the software is installed (see the Software Installation section).

Figure 2. ADuCRF101 Mini Board and Emulator Board

DVD CONTENTS

Each kit contains a DVD with the following contents:

- Documentation
- Analog Devices utilities
- Third-party software
- Comprehensive example code

SOFTWARE INSTALLATION

Each kit includes a DVD containing software to be installed on the PC before the evaluation board is used.

WARNING

The J-Link OB driver must be installed before plugging the emulator board USB device into the PC.

SOFTWARE CONTENT PROVIDED

Table 3 shows the tools provided on the DVD.

Table 3. Tools

Tools	Functions
Keil µVision®	For compiling/debugging and code development, a 32 kB limited version
IAR Embedded Workbench®	For compiling/debugging and code development, a 32 kB limited version
Segger J-Link Software	J-Link software and documentation pack includes USB drivers for the emulator, J-Link Commander, and J-Mem
CM3WSD	A utility that accepts a hex file and allows it to be downloaded via the USB interface to the ADuCRF101 device on your evaluation board
Elves	An application that helps a C programmer choose appropriate functions from Analog Devices libraries and simplifies deciding which values to place in the function parameters

There are three parts to the installation:

- ADuCRF101 documentation and code example copy.
- J-Link OB driver installation.
- Integrated software development tool installation (Keil µVision or IAR Embedded Workbench for ARM (EWARM)).

COPYING THE CONTENTS FROM THE DVD

To copy documentation, code examples, and utilities, insert the DVD into the CD-ROM drive, and copy the **ADuCRF101v1.0** folder to the PC hard drive.

All subsequent steps assume that this folder has been copied directly onto the C drive.

CM3WSD.exe

The folder **\ADuCRF101V1.0\Software Tools\CM3WSD** provides an executable called **CM3WSD.exe**. This software accepts a hex file and allows it to be downloaded via the USB interface to the ADuCRF101 device on your evaluation board.

You may want to add a shortcut link for this executable to your desktop.

Elves.exe

The **\ADuCRF101V1.0\Software Tools\Elves** folder contains the **elves.exe** files. These files are useful tools that accompany the software function libraries in **\ADuCRF101v1.0\Code\ADuCRF101\DasLib**. Again, installation is not required, but you may want to add a shortcut link for this executable to your desktop.

INSTALLING THE J-LINK OB DRIVER

The J-Link OB USB driver is required to be installed before using a serial wire interface, such as the interface of the IAR Embedded Workbench, to download and debug code.

To install the J-Link OB USB driver,

1. Double-click the **Setup_JLinkARM_V470.exe** executable file located in the Segger folder on the DVD.
2. Follow the on-screen instructions to complete the installation. Ensure that the **Install USB Driver for J-Link-OB with CDC** option is checked as shown in Figure 3.

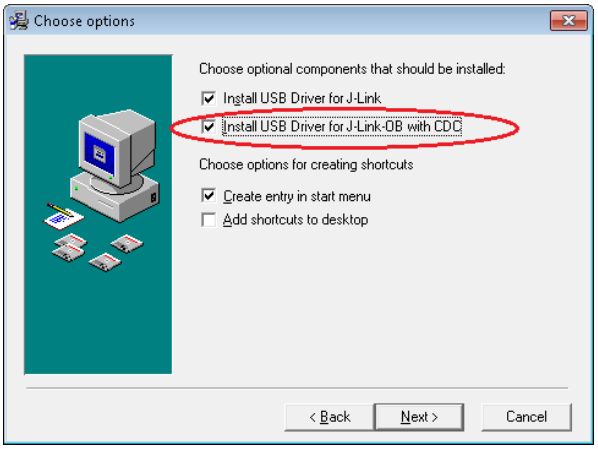


Figure 3. Segger Driver Install Options

3. Plug in the emulator board and check the device manager (see Figure 4).
4. Check that the emulator board appears in the Windows® Device Manager in both the communications port and the USB controllers lists.

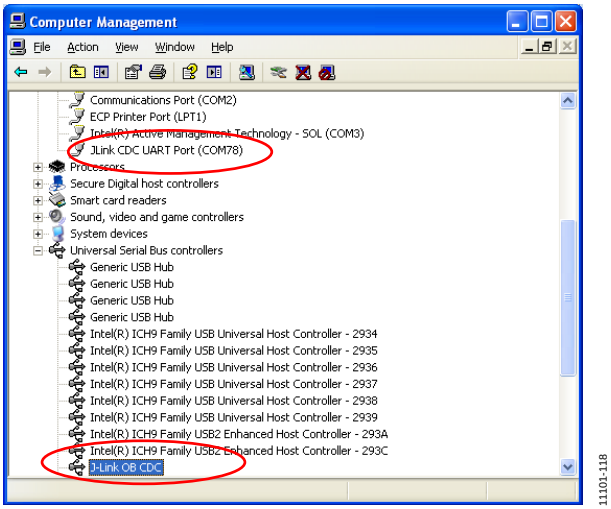


Figure 4. Device Manager

CONCLUSION

After following the software installation procedures, the USB driver for the J-Link OB is installed and verified.

You can, therefore, proceed to developing code and downloading it to the ADuCRF101.

IAR INSTALLATION AND TOOLS

IAR TOOLS INSTALLATION

The IAR Embedded Workbench is required for building the supplied examples and for downloading and debugging applications via the serial wire interface.

To install the IAR Embedded Workbench, double-click the **EWARM-CD-6503.exe** executable file located in the **IAR** folder on the DVD—this folder was not copied onto the hard drive during the software installation procedure.

Note that installing the IAR Embedded Workbench requires an active Internet connection to register on the IAR website and to obtain a free license key.

Follow the on-screen instructions to install the IAR Embedded Workbench.

IAR DEMO CODE

Several example projects are available in the IAR workspace located in the following directory:

C:\ ADuCRF101v1.0\Code\Examples\ADUCRF101.eww

To open this workspace, from the **File** menu, choose **Open>Workspace…**, and navigate to the workspace file.

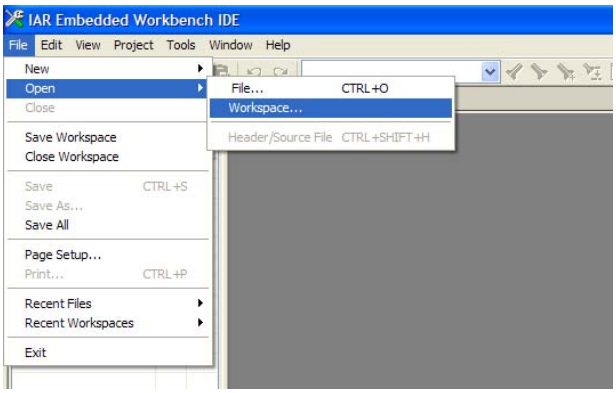


Figure 5. Opening the IAR Workspace

Several relevant projects are available within this workspace as shown in Figure 6.

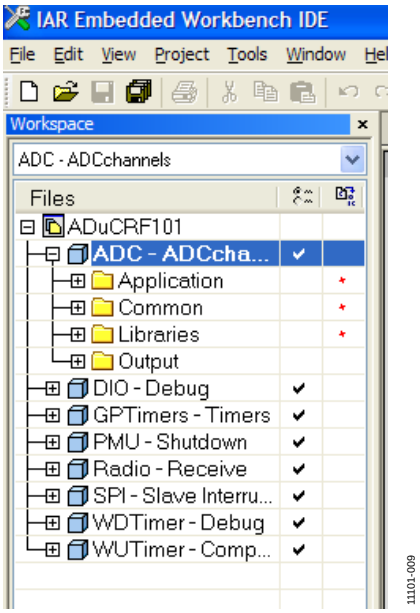


Figure 6. Available Projects in the Workspace

Each example includes a comprehensive low level peripheral function library called DasLib, which can be used to interface to the peripherals of the ADuCRF101.

Comprehensive documentation for both the libraries and the examples are included as shown in Figure 7.

ADuCRF101v1.0\Documentation\DasLib\index.html

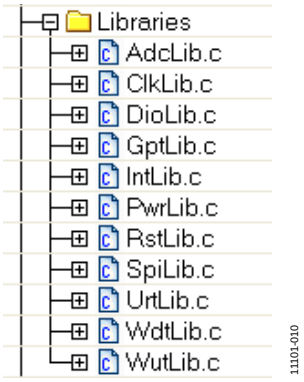


Figure 7. DasLib Library Set

Changing Projects

To change projects, right-click on a different project in the workspace and click **Set as Active** from the menu that appears (see Figure 8).

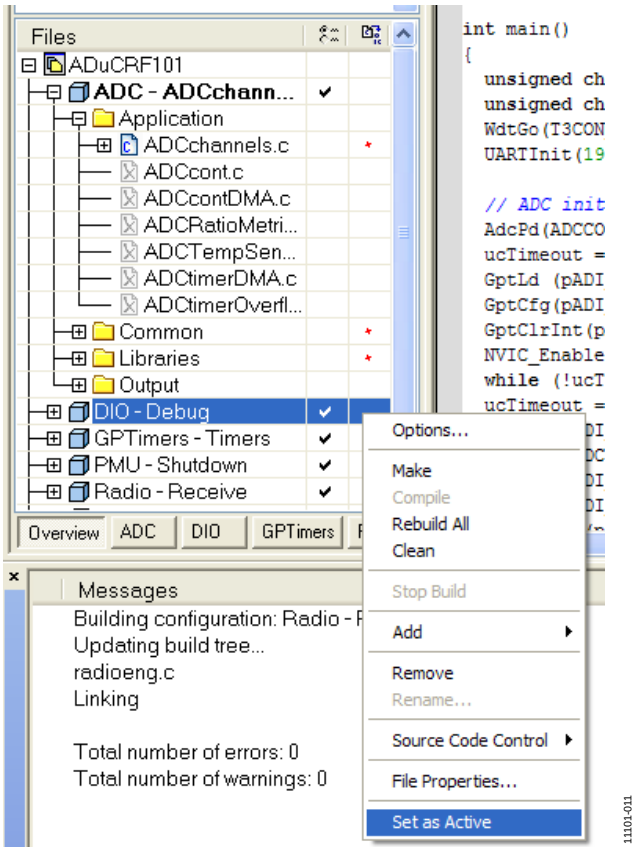


Figure 8. Changing Projects

Modifying a Project

To modify a project,

1. Make a change to one of the source files contained in the project.
2. Save the file. (The project then requires recompiling before downloading to the ADuCRF101.)
3. Click **make** (see Figure 9) to recompile the project as shown in Figure 10.

Figure 9. IAR Make Toolbar Button

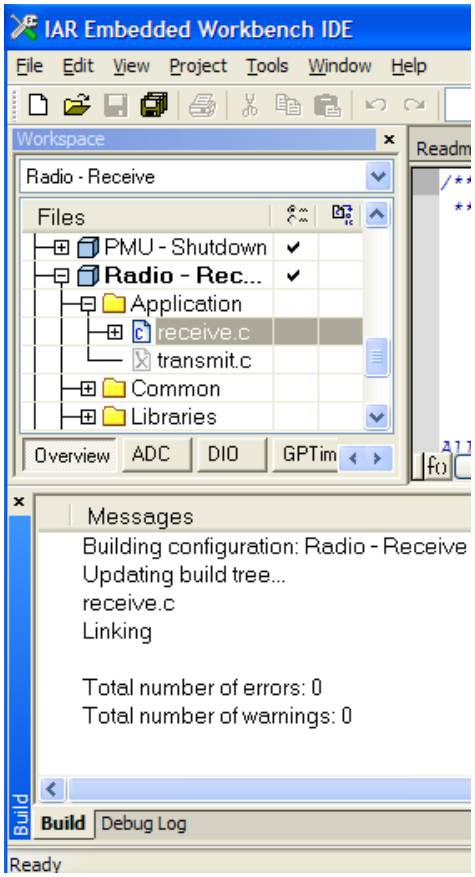


Figure 10. Recompiling Projects

Downloading and Debugging a Project

To download and debug a project,

1. Click **debug**. (Debugging of the code execution starts at the beginning of the main function. The following debug features can be used: single step, step over, breakpoint.)

Figure 11. IAR Debug Toolbar Button

2. Click **go** as shown in Figure 12.

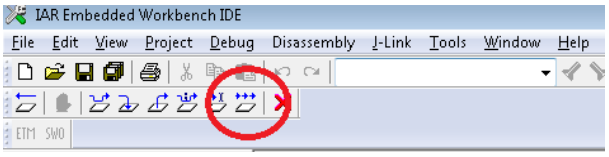


Figure 12. IAR Go Toolbar Button

The code then executes on the ADuCRF101.

USING THE RADIO EXAMPLE

INTRODUCTION

The following is required for use with the radio example project:

- Two mini boards
- Two emulator boards
- Two antennas
- Two USB cables

The example workspace described in the IAR Demo Code section should still be opened within the IAR Embedded Workbench.

The following two radio examples are provided in the example workspace:

- Radio transmit (see **Radio – Transmit** in Figure 15)
- Radio receive (see **Radio – Receive** in Figure 15)

One mini board is used to demonstrate how to transmit a radio packet. The other mini board is used to receive the radio packet that was transmitted.

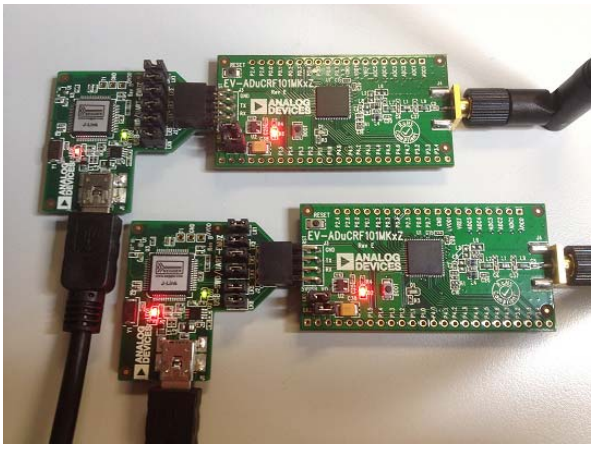
These examples use the radio interface engine, which is the mechanism for accessing the radio on the ADuCRF101.

The full documentation for the radio interface engine functions can be found in the following document in the **Documentation** folder:

ADuCRF101RadioInterfaceEngineFunctions_Rev0_1326.pdf

HARDWARE SETUP

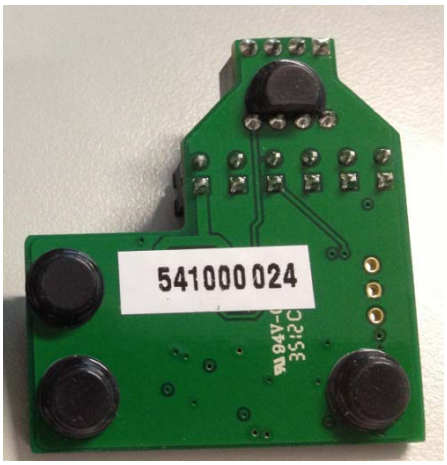
For the purpose of this example, designate one mini board as the transmitter and the other as the receiver. The hardware contained within these kits should be connected as shown in Figure 13.



11101-105

Figure 13. Radio Demo Hardware Setup

Note the serial number of the emulator board connected to the transmitter and also of that connected to the receiver. The serial number of the emulator board is marked on the underside of the emulator board as shown in Figure 14. It will be needed to identify the transmitter and receiver to IAR EWARM in a later step.



11101-106

Figure 14. Emulator Board Serial Number

DOWNLOADING THE RADIO TRANSMIT EXAMPLE

To download the radio transmit example to the mini board designated as the transmitter,

1. Select the **Radio – Transmit** example program in the IAR Embedded Workspace as shown in Figure 15.

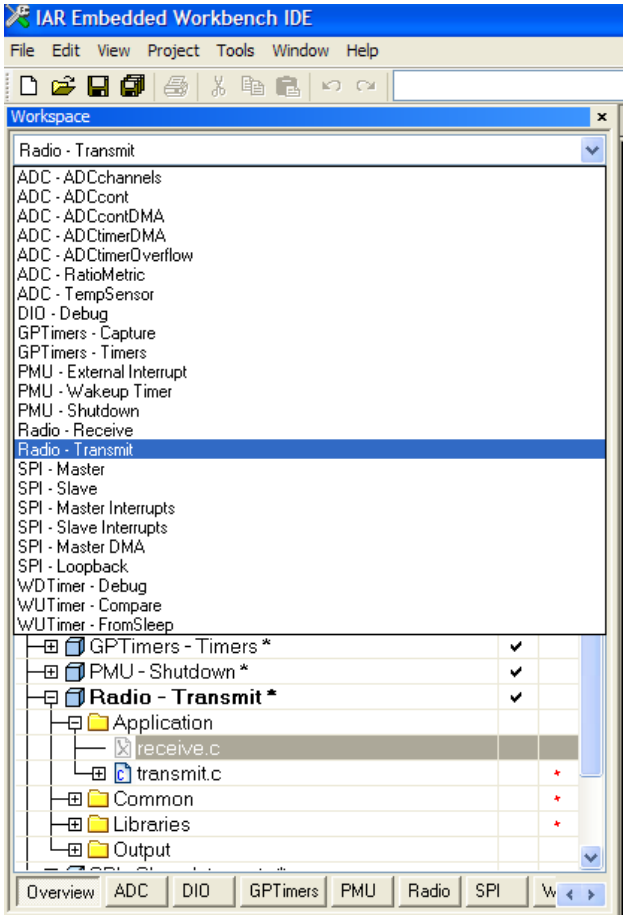


Figure 15. Selecting the Radio Transmit Example Program

2. Select **Rebuild All** from the **Project** menu, as shown in Figure 16. (Note that you should always perform a **Rebuild All** action after switching projects.)

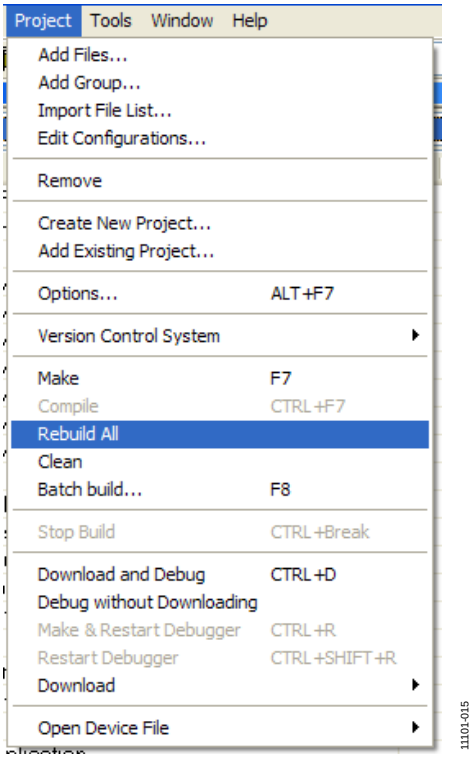


Figure 16. Rebuild the Project

3. Download the project by selecting **Download active application** as shown in Figure 17. You will be prompted to select the correct emulator board as shown in Figure 18. Select the serial number of the emulator board that you designated previously as the transmitter.

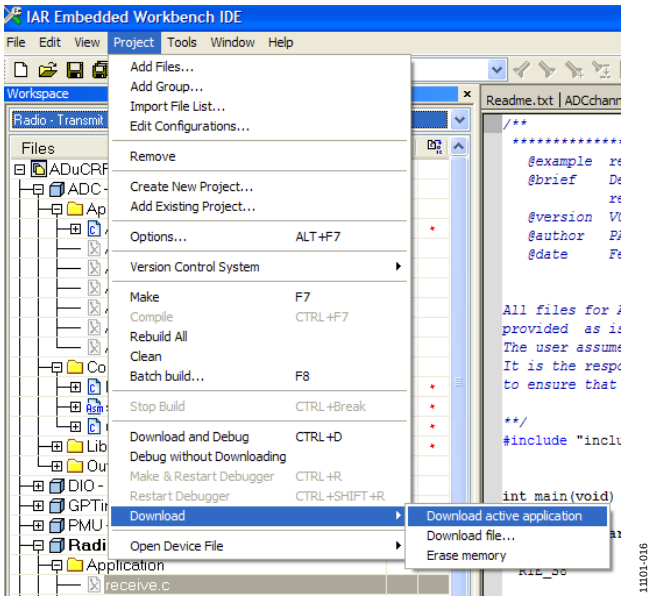


Figure 17. Download the Radio Transmit Example

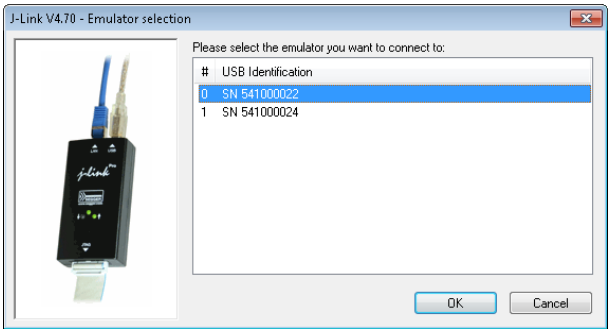


Figure 18. Selecting the Transmitter Mini Board

An example of a radio transmit program is shown in Figure 19.

```
// Initialise the Radio
if (RIE_Response == RIE_Success)
   RIE_Response = RadioInit(DR_38_4kbps_Dev20kbps);
// Set the Frequency to operate at 915 MHz
if (RIE_Response == RIE_Success)
   RIE_Response = RadioSetFrequency(915000000);
// Set the PA and Power Level
if (RIE_Response == RIE_Success)
   RIE_Response = RadioTxSetPA(DifferentialPA,PowerLevel15);

if (RIE_Response == RIE_Success)
{
  if (VAR_LENGTH)
    RIE_Response = RadioTxPacketVariableLen(12, "HELLO WORLD");
  else
    RIE_Response = RadioTxPacketFixedLen(12, "HELLO WORLD");
}
```

11101-119

Figure 19. Transmit Example Program

DOWNLOADING THE RADIO RECEIVE EXAMPLE

To download the radio receive example to the mini board designated as the receiver,

1. Select the **Radio – Receive** example program in IAR Embedded Workspace as shown in Figure 20.

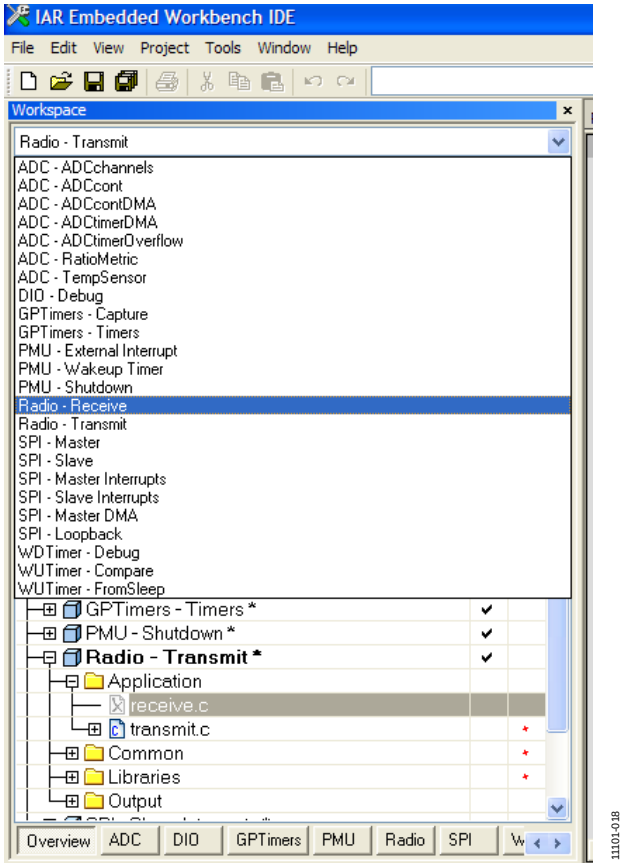


Figure 20. Selecting the Radio Receive Example Program

2. Select **Rebuild All** from the **Project** menu as shown in Figure 16. (Note that you should always perform a **Rebuild All** action when switching projects.)
3. Download the project by selecting **Download active application** as shown in Figure 17. You will be prompted to select the correct emulator board as shown in Figure 21. Select the serial number of the emulator board that you designated previously as the receiver.

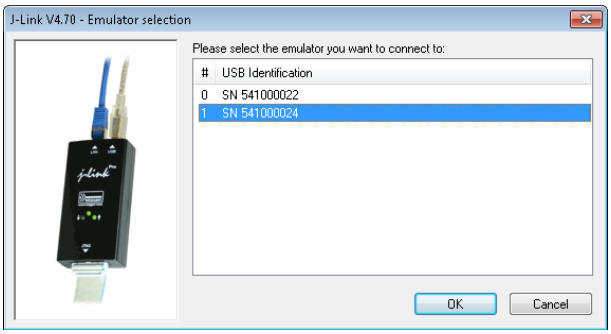


Figure 21. Selecting the Receiver Mini Board

An example of a radio receive program is shown in Figure 22.

```
// Initialise the Radio
if (RIE_Response == RIE_Success)
   RIE_Response = RadioInit(DR_38_4kbps_Dev20kbps);
// Set the Frequency to operate at 915 MHz
if (RIE_Response == RIE_Success)
   RIE_Response = RadioSetFrequency(915000000);

if (RIE_Response == RIE_Success)
{
  if (VAR_LENGTH)
    RIE_Response = RadioRxPacketVariableLen();
  else
    RIE_Response = RadioRxPacketFixedLen(12);
   printf("waiting for a packet\n");
}

if (RIE_Response == RIE_Success)
   {
   while (!RadioRxPacketAvailable());
   }
```

11101-120

Figure 22. Receive Example Program

RUNNNING THE EXAMPLE

To run an example,

1. Press the RESET switch on the mini board designated as the receiver to place the board in receive mode. (Observe that the LED on this board is not blinking.)
2. Press the RESET switch on the mini board designated as the transmitter to transmit a single packet.
3. The LED on the mini board designated as the receiver should begin blinking, indicating that a packet has been received.
4. A terminal program, such as HyperTerminal, can be connected to the COM port of the receiver to get a visual indicator of the packet received.

```
waiting for a packet


-> HELLO WORLD @ RSSI -28
```

11101-109

Figure 23. Receiver Terminal Program Output

APPENDIX A

SOFTWARE DOCUMENTATION

The documentation described in Table 4 is available on the DVD. Any user of the ADuCRF101 development systems should consult these documents before proceeding to explore the ADuCRF101.

Table 4. Software Documentation Included on DVD

Folder	File Name	Description
Beta_ADuCRF101v1.0\Documentation\	ADuCRF101GetStarted_UG481.pdf	ADuCRF101 tutorial guide for use with the ADuCRF101 development system
Beta_ADuCRF101v1.0\Documentation\DasLib\	index.html	DasLib low level function library reference
Beta_ADuCRF101v1.0\Documentation\DataSheet\	ADuCRF101Datasheet.pdf ADuCRF101_UG_231.pdf	ADuCRF101 Sp0 data sheet ADuCRF101 user guide
Beta_ADuCRF101v1.0\Documentation\Evaluation Board\	ADuCRF101_EvalBrdGuide_UG480.pdf	ADuCRF101 Evaluation Board User Guide
Beta_ADuCRF101v1.0\Documentation\RadioInterfaceEngine\	ADuCRF101RadioInterfaceEngineFunctions.pdf	Describes the RIE functions implemented on the ADuCRF101
Beta_ADuCRF101v1.0\Documentation\Technotes\	AN-772.pdf AN-1159.pdf AN-1160.pdf	A Design and Manufacturing Guide for the Lead Frame Chip Scale Package (LFCSP) I^2C-Compatible Interface on Cortex-M3 Based Precision Analog Microcontroller (ADuCxxx Family) Cortex-M3 Based ADuCxxx Serial Download Protocol

APPENDIX B

IAR DOWNLOAD INITIAL SETUP AND TROUBLESHOOTING

To set up the configuration for an IAR project,

1. Right-click the project name in the workspace area or in the project pull-down menu to access the project configuration.
2. Click **General Options** in the **Category** box, and select **AnalogDevices ADUCRF101** as the device in the **Target** tab as shown in Figure 24.

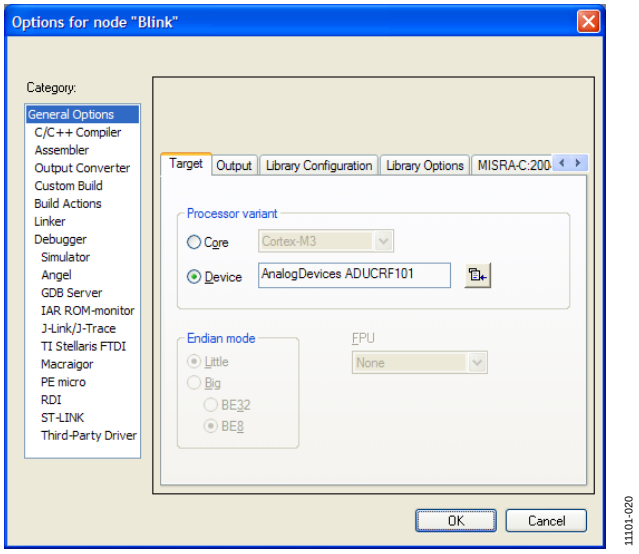


Figure 24. Selecting the Device

3. Click **C/C++ Compiler** in the **Category** box, and specify the include directory as shown in Figure 25 in the **Preprocessor** tab.

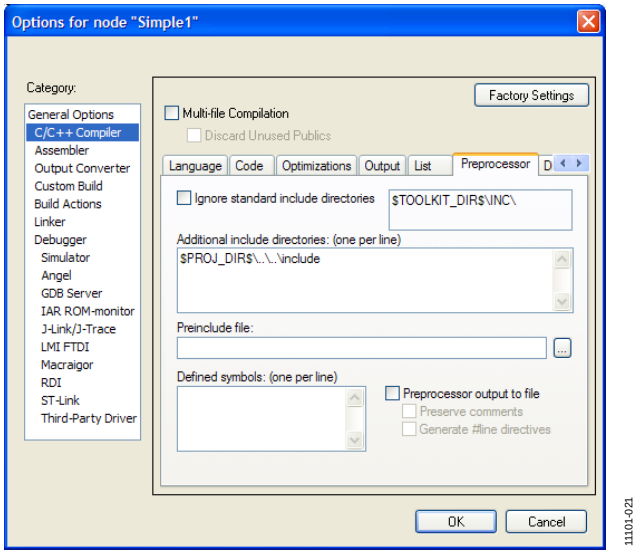


Figure 25. Specifying the Include Directory

4. Click **Linker** in the **Category** box, and override the linker configuration file by selecting **Override default** in the **Linker configuration file** section of the **Config** tab as shown in Figure 26.

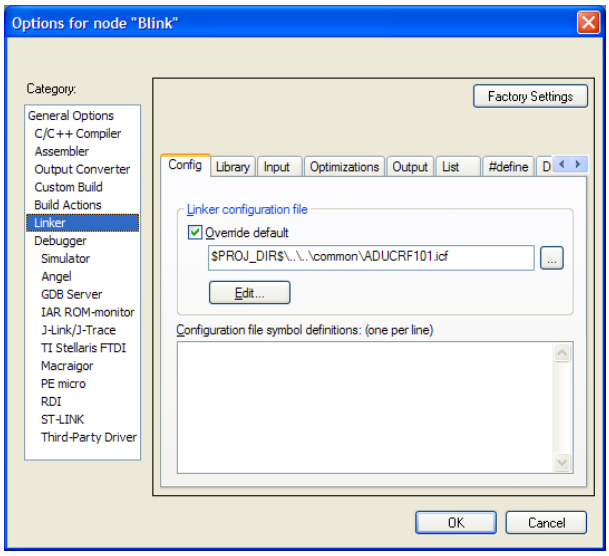


Figure 26. Overriding the Linker Configuration File

5. Click **Debugger** in the **Category** box, and select **J-Link/J-Trace** from the **Driver** box and **Run to main** in the **Setup** tab as shown in Figure 27.

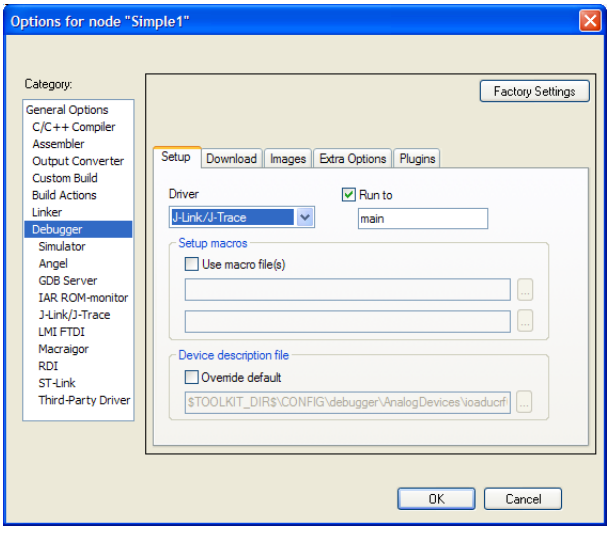


Figure 27. Setting Up the Driver

6. Click **Debugger** in the **Category** box, select **Verify download** and **Use flash loader(s)** in the **Download** tab as shown in Figure 28.

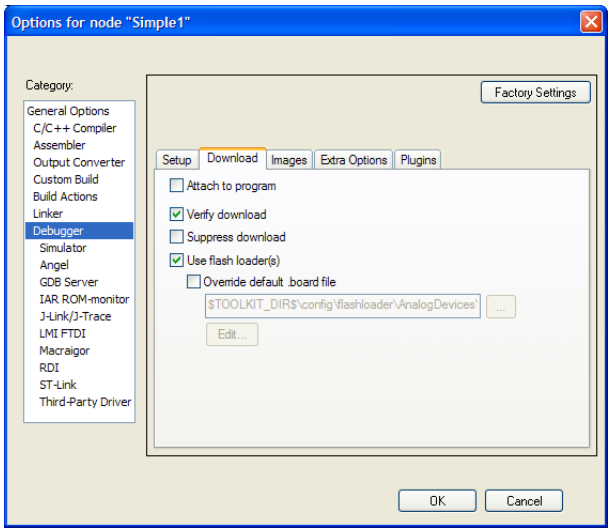


Figure 28. Setting the Debugger Download Options

7. Click **J-Link/J-Trace** in the **Category** box, and configure the **Setup** tab as shown in Figure 29.

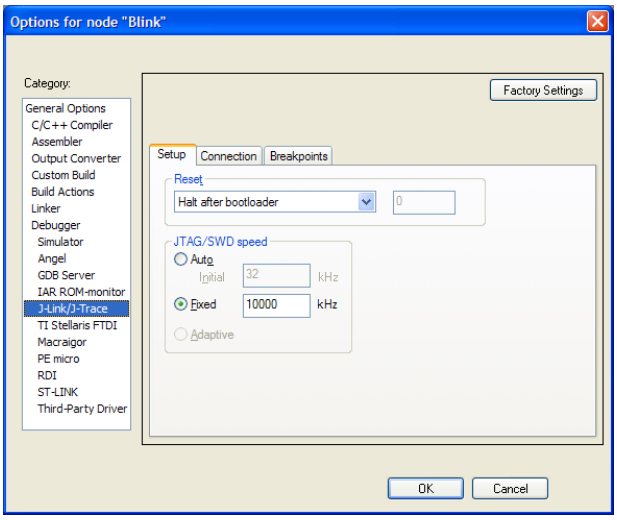


Figure 29. Configuring the J-Link/J-Trace Settings

8. With **J-Link/J-Trace** still selected in the **Category** box, configure the **Connection** tab as shown in Figure 30.

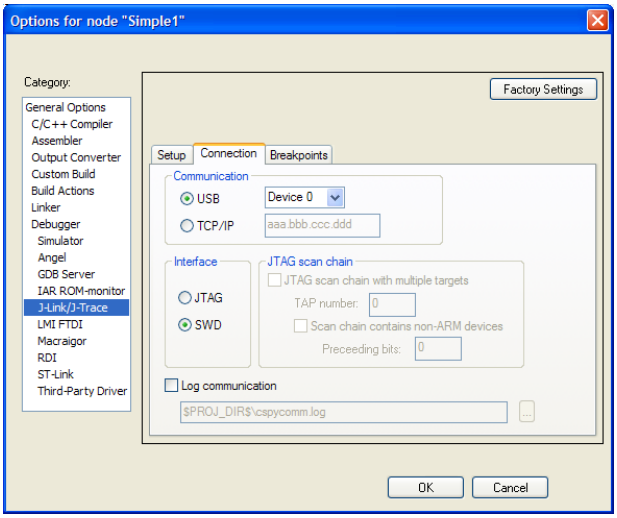


Figure 30. Selecting the Connection Options

APPENDIX C

WINDOWS SERIAL DOWNLOADER

The Windows serial downloader for a Cortex-M3 based part (CM3WSD) is a Windows software program that allows a user to serially download Intel extended hex files as created by assembler/compilers to the ADuCRF101 via the serial port. The Intel extended hex file is downloaded into the on-chip Flash/EE program memory via a selected PC serial port.

See the Installing the J-Link OB Driver section for information on how to determine the correct COM port to use on the PC. This COM port should be used in all subsequent steps.

The emulator board USB driver should be installed as per the Installing the J-Link OB Driver section before proceeding.

Preparing for Downloading

Prepare the system for downloading by configuring the board as follows:

1. Connect the ADuCRF101 mini board to the emulator board.
2. Connect the interface board to the PC using a USB cable.

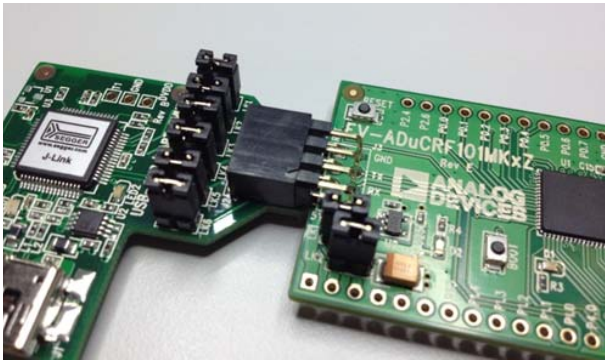


Figure 31. ADuCRF101 Mini Board Connected to Emulator Board

3. Place the ADuCRF101 into serial download mode using the following sequence:
   a. Hold down the BOOT switch on the mini board.
   b. Press and release the RESET switch on the mini board.
   c. Release the BOOT switch on the mini board.

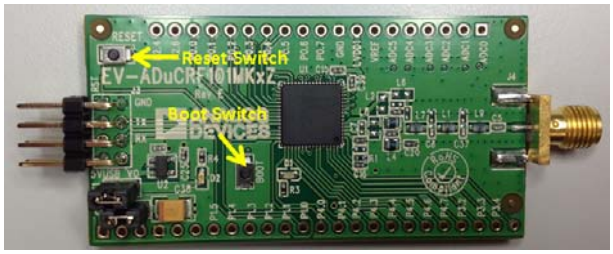


Figure 32. Boot and Reset Switches

Downloading

To begin a download,

1. Launch the Windows serial downloader by double-clicking **CM3WSD.exe** in the following directory: **C:\ADuCRF101v1.0\Software Tools\CM3WSD**

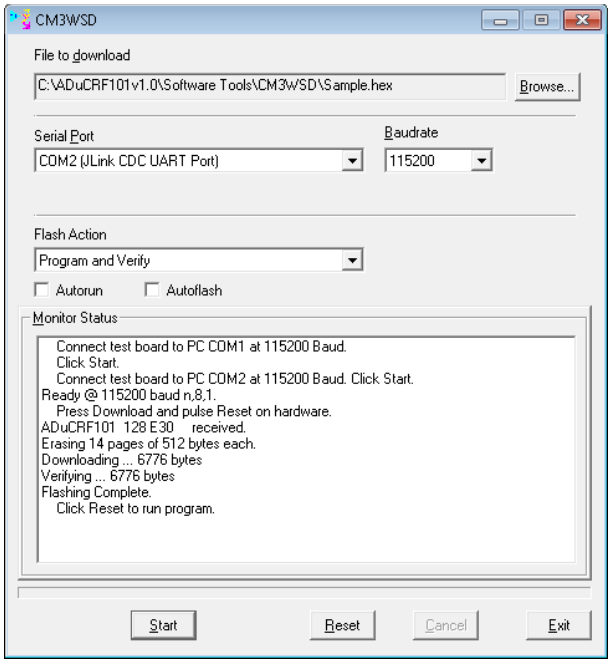


Figure 33. Downloading Using CM3WSD

2. Select the following file: **C:\ADuCRF101v1.0\Software Tools\CM3WSD\ sample.hex** (The **sample.hex** file is a simple program that causes an LED to continuously blink, indicating the successful download of code.)
3. Select the correct JLINK CDC UART COM port from the **Serial Port** box.
4. Select a baud rate of **115200** from the **Baudrate** box.
5. Click **Start** in the **CM3WSD** dialog box. The CM3WSD sends a reset command to the ADuCRF101.
   a. If the ADuCRF101 is in serial download mode and the COM port between the PC and the mini board is set up correctly, the CM3WSD starts downloading the .hex file and display a progress bar.
   b. After the file is successfully downloaded, the **Monitor Status** box displays the message **Flashing Complete**.
6. Click **Reset** in the **CM3WSD** dialog box to run the program.
   a. An LED begins blinking on the mini board indicating that the .hex file has been downloaded and is executing.
   b. The **Monitor Status** box displays the message **Running**.

APPENDIX D

USING ELVES.EXE

Elves is a useful tool for generating simple C function libraries to get started on evaluating any peripheral. All the user needs to do is choose the required parameters for each function and Elves generates the C source code that configures all the appropriate ADuCRF101 registers.

1. In the folder, **C:\ADuCRF101v1.0\Software Tools\Elves**, double click the file **Elves.exe** to launch Elves.

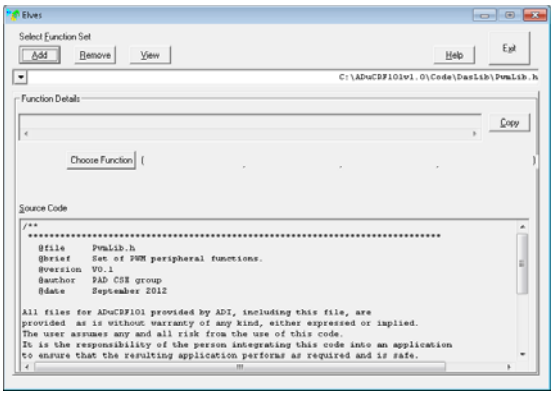


Figure 34. Launching Elves

2. To add a library, click **Add** and go to the directory **C:\ADuCRF101v1.0\Code\DasLib**.

A list of header files is available. Add the header file(s) that you wish to use.

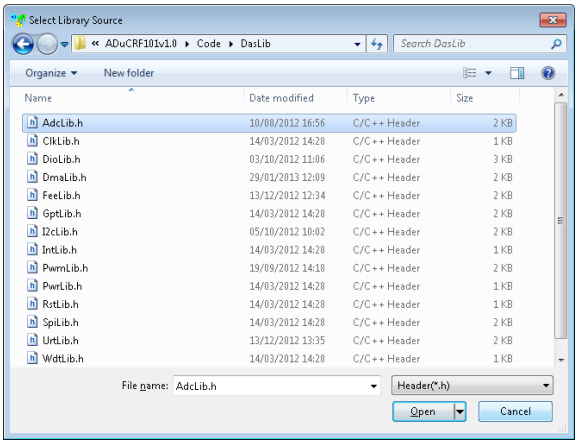


Figure 35. Select Source Library

For example, if the AdcLib.h library is added (see Figure 35), the user can generate functions to control the ADC.

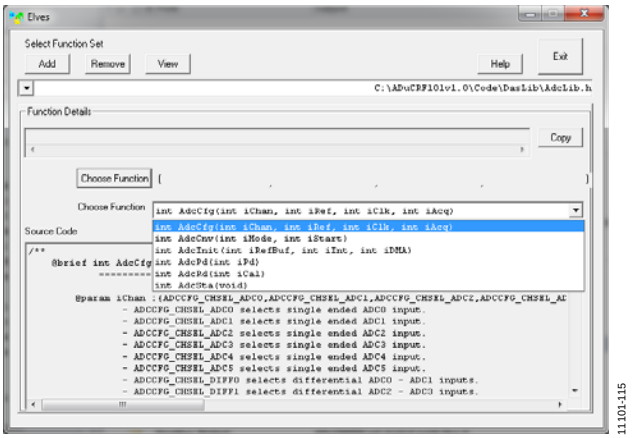


Figure 36. List of Functions

Take, for example, the function **AdcCfg**, in the **Choose Function** section as shown in Figure 36. The user configures the parameters to meet their needs and each parameter is explained in the **Source Code** section of the window shown in Figure 37.

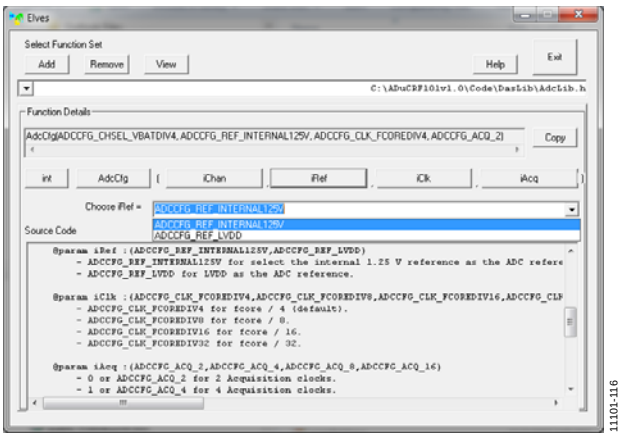


Figure 37. Selecting Parameters

3. Once satisfied with the register settings, select **Copy** and then paste this function into your source code in Keil or IAR.

APPENDIX E

SERIAL COMMUNICATION WITH THE PC

Examples that use the UART can be communicated with using the following HyperTerminal setup:

1. Open HyperTerminal or an equivalent serial communication tool.
2. Select the COM port that corresponds with the USB emulator board.
3. Configure this COM port as shown in Figure 38.

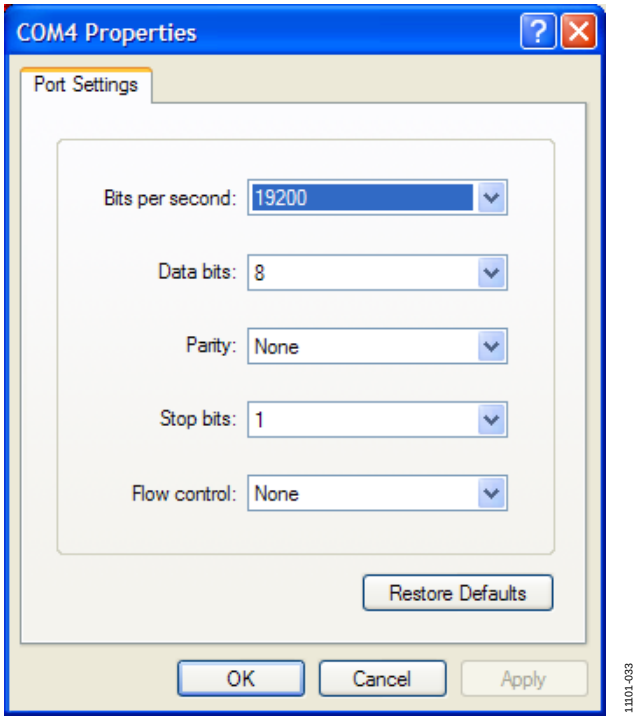


Figure 38. COM Port Setup

RELATED LINKS

Resource	Description
ADuCRF101	Product Page, ADuCRF101 Precision Analog Microcontroller ARM Cortex-M3 with ISM Band Transceiver
AN-772	Application Note, A Design and Manufacturing Guide for the Lead Frame Chip Scale Package (LFCSP)
AN-1160	Application Note, Cortex-M3 Based ADuCxxx Serial Download Protocol
AN-1159	Application Note, I²C-Compatible Interface on Cortex-M3 Based Precision Analog Microcontroller (ADuCxxx Family)

NOTES

NOTES

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

UG11101-0-1/15(0)

www.analog.com