AVR414: User Guide - ATAVRRZ502 - Accessory Kit

Features

- **Introduction to the ATAVRRZ502 hardware.**
- **Includes evaluation application that uses the IEEE® 802.15.4 library from Atmel.**
- **An example on how to establish a peer-to-peer connection.**
- **Supports both the IAR® compiler and GCC.**

1 Introduction

This application note describes the ATAVRRZ502 Accessory Kit (RZ502). The RZ502 is designed for evaluation of the Atmel AT86RF230 2.4 GHz radio transceiver. This radio transceiver fully complies with the IEEE 802.15.4™ standard and targets low-power wireless technologies within home, building and industrial automation such as ZigBee™.

An evaluation application is available together with this document. This application shows how to set up a peer-to-peer network, with two nodes, and send data using the wireless link.

Figure 1-1. ATAVRRZ502 Accessory Kit

8-bit AVR® Microcontrollers

Application Note

Rev. 8051A-AVR-11/06

2 Getting Started with the ATAVRRZ502 Accessory Kit

This section gives an introduction to what the ATAVRRZ502 Accessory Kit contains and its system requirements. At the end brief instructions are given on how to get the Accessory Kit up and running in the shortest amount of time.

2.1 Unpacking the System

Kit contents:

- (2 pcs) RZ502 Radio boards with SMA stub antennas.
- (2 pcs) ATmega1281V AVR® microcontroller in TQFP Package.
- Technical Library CD.

2.2 System Requirements

The minimum hardware and software requirements are:

- (2 pcs) STK®500
- (2 pcs) STK501
- (2 pcs) 9 pin RS-232 cable
- (2 pcs) 6-wire cable
- (2 pcs) 2-wire cable
- Power Supply for STK500.
- PC running AVR Studio® and with two available RS-232 ports (COM port or USB-to-RS232 bridge).

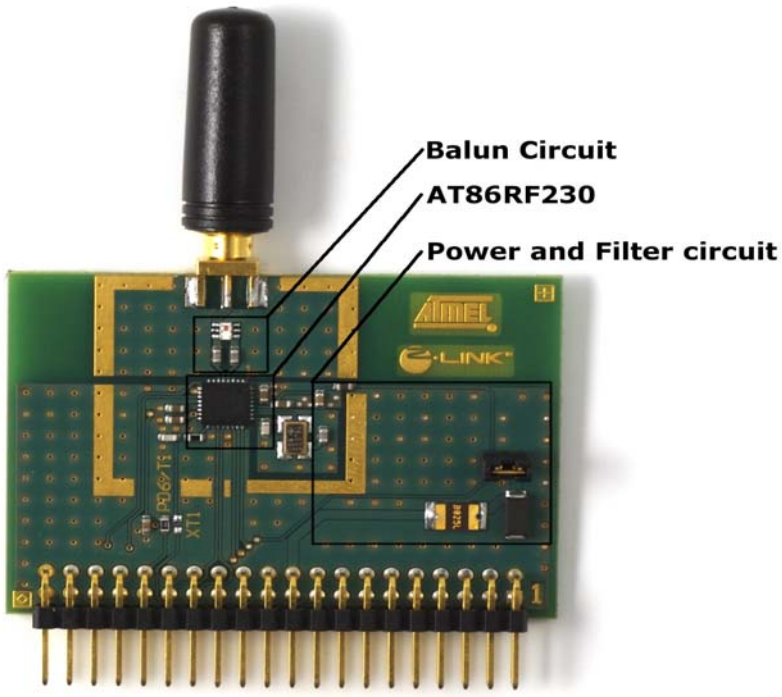
2.3 Quick Start Guide

This section goes through how to get the RZ502 kit and evaluation application up and running in the shortest amount of time.

1. Unpack the ATAVRRZ502 Accessory Kit and ensure that it contains all components listed in subsection 2.1.
2. Ensure that all the components listed in subsection 2.2 is available.
3. Go through the steps in section 4 to assemble the hardware. Repeat this step twice to build both peers.
4. Generate EEPROM file for each peer in the network using the HEXMaker application. How to use this application is described in subsection 5.1.
5. Program the ATmega1281 microcontroller by following the instructions in subsection 5.2. Repeat this step on both peers.
6. Finally, a chat client is available to interface with the evaluation application just programmed into the AVR microcontroller. Go through the instructions in section 6 on how to setup and use the chat client.

3 Hardware Description

Figure 3-1 ATAVRRZ502 Components



3.1 Description of AT86RF230

The AT86RF230 is a 2.4 GHz radio transceiver from Atmel. It is specially designed for IEEE 802.15.4 and ZigBee applications. Main features are:

- Low power consumption.
- Large link budget (104 dBm).
- True 1.8 volts operation.
- Minimized number of external components needed.

The only required external components are antenna, 16 MHz crystal and four decoupling capacitors. An easy-to-use Serial Peripheral Interface (SPI) is defined for accessing the radio's register file. Please consult the AT86RF230 radio transceiver's datasheet for further information about its specifications, operating modes, registers etc.

3.2 Description of Antenna and Balun Circuit

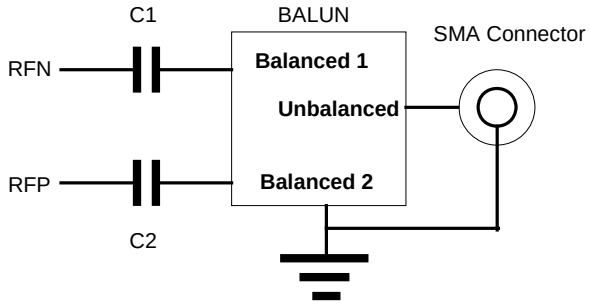
The antenna output of the AT86RF230 is differential. This configuration is beneficial because:

- Immunity to electromagnetic interference.
- Immunity to power-supply noise.
- Immunity to ground noise.
- Suppression of even-order harmonic.

- Better tolerance to less than perfect RF ground.

However, the RZ502 has a typical single ended SMA stub antenna mounted. A special circuit is required to convert the 100Ω differential RF input/output pins of the AT86RF230 to a 50Ω single ended RF port. This is solved by a BALUN circuit on the RZ502 top module. A BALUN (a compound term meaning “BAlanced-UNbalanced”) is a passive component that transforms impedance. Two capacitors are added as a DC block. Figure 3-2 depicts the BALUN circuit described above.

Figure 3-2 BALUN Circuit

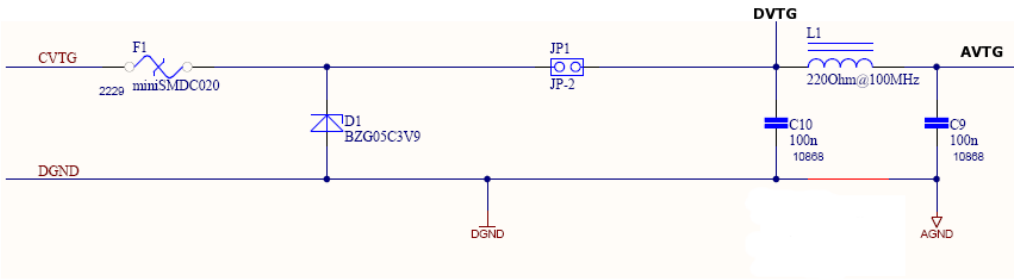


3.3 Description of Power and Filter Circuit

Figure 3-3 shows the power and filter circuit connected to the AT86RF230. The power circuit is built from three components; a SMD fuse (F1), a Zener diode (D1) and a jumper (JP1). D1 is a 3.9 Volts Zener diode connected in series with the thermal fuse. This connection prevents excessive voltages on the DVTG (Digital Voltage) and AVTG (Analog Voltage) ports when JP1 is closed, and potentially harm the AT86RF230. JP1 can also be used for current measurements.

The rightmost part of Figure 3-3 is a PI-type LC (two shunt capacitors and one series inductor) filter used to suppress noise and harmonics to enter the analog/RF part of the radio transceiver.

Figure 3-3 Power and Filter Circuit

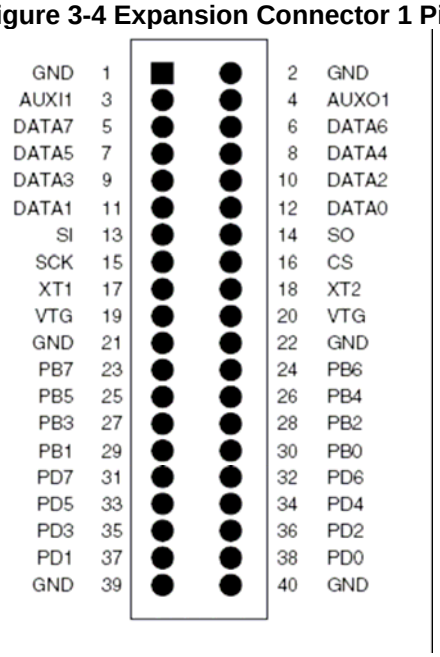


3.4 Description of STK500 Interface

The STK500 board has two expansion connectors, one on each side of the programming module. All AVR I/O ports, programming signals and control signals are routed to these connectors. Figure 3-4 depicts the pin-out of expansion connector 1. This connector is used by the RZ502 top module to mount itself to the STK500/STK501 board stack. And ultimately connect the AT86RF230 radio

transceiver to the AVR microcontroller. Only a few of the available pins are used to control the radio transceiver. The reminder of this subsection describes the interface necessary to control the radio transceiver.

Figure 3-4 Expansion Connector 1 Pin-out



3.4.1 SPI Lines

The SPI is used to program control registers as well as to transfer data frames between the AVR and the AT86RF230. Each access is initiated with the SPI master (AVR) pulling the slave select (SS/SEL) line low. Both master and slave (AT86RF230) will now prepare the data to be sent, and the master generates the necessary clock pulses on the SCLK line to interchange the data. Data is always transferred from master to slave on the Master Out – Slave In, MOSI line, and from slave to master on the Master In – Slave Out, MISO line. When a packet has been transmitted, the master will pull high the slave select line to synchronize the slave.

3.4.2 IRQ Line

The AT86RF230 has six different interrupts defined. However, all these interrupt signals are combined internally via a logical “OR” operation to one external interrupt line. An interrupt is indicated to the AVR microcontroller whenever the IRQ line is pulled high (logical 1). The controller must poll the AT86RF230 to determine the interrupt source and to clear the IRQ line.

3.4.3 SLP_TR Line

The SLP_TR signal is a multi-functional pin. It can be used as either a transmit start or a sleep signal. Pin functionality is dependant upon the transceiver’s internal state. Please consult the datasheet of the AT86RF230 for more information.

3.4.4 Reset Line

This line is used to reset the AT86RF230 radio transceiver. The reset line is controlled by one of the AVR pins and not connected to the reset button on the STK500 board.

3.4.5 Pins used by the RZ502

Table 3-1 lists the 17 pins used by the RZ502 top module and their usage. This information can be used to run the Accessory Kit on alternative platforms. Remaining pins of the expansion connector 1 is not connected.

NOTE: Be sure that none of the pins used by the RZ502 top module is connected to other circuitry. I.e. no additional circuitry can be connected to the SPI pins of the PORTB connector on the STK500 etc.

Table 3-1. Pins used by the RZ502 board

Expansion Connector 1 Pin	Name	Usage
1,2,21,22,39,40(1)	GND	Used for analog and digital ground.
19,20(1)	VTG	Target voltage. Must be within the operating range of the AT86RF230 [1.8 to 3.6 Volts].
17(2)	XT1	Can be used to connect the CLKM pin on the AT86RF230 to the AVR's XT1 pin.
25	PB5	Reset line. Connected to the RST pin on the AT86RF230.
26	PB4	Connected to the SLP_TR pin on the AT86RF230.
27	PB3	MISO line.
28	PB2	MOSI line.
29	PB1	SCK line.
30	PB0	SEL line.
32	PD6	Used to connect the CLKM pin of the AT86RF230 to the Timer1 module on the AVR.
34	PD4	Connected to the IRQ pin on the AT86RF230.

Notes: 1. Pins connected to the same net. Only one required if number of pins is scarce.

2. Not connected by default. Requires de-soldering R1 (0 Ω) and soldering onto the R2 pads.

4 Hardware Assembly

The following steps walk the reader through how to assemble and prepare the STK500 board and the STK501 top module to be used with the RZ502. Then finally how to mount the RZ502 board and configure it to run the evaluation application.

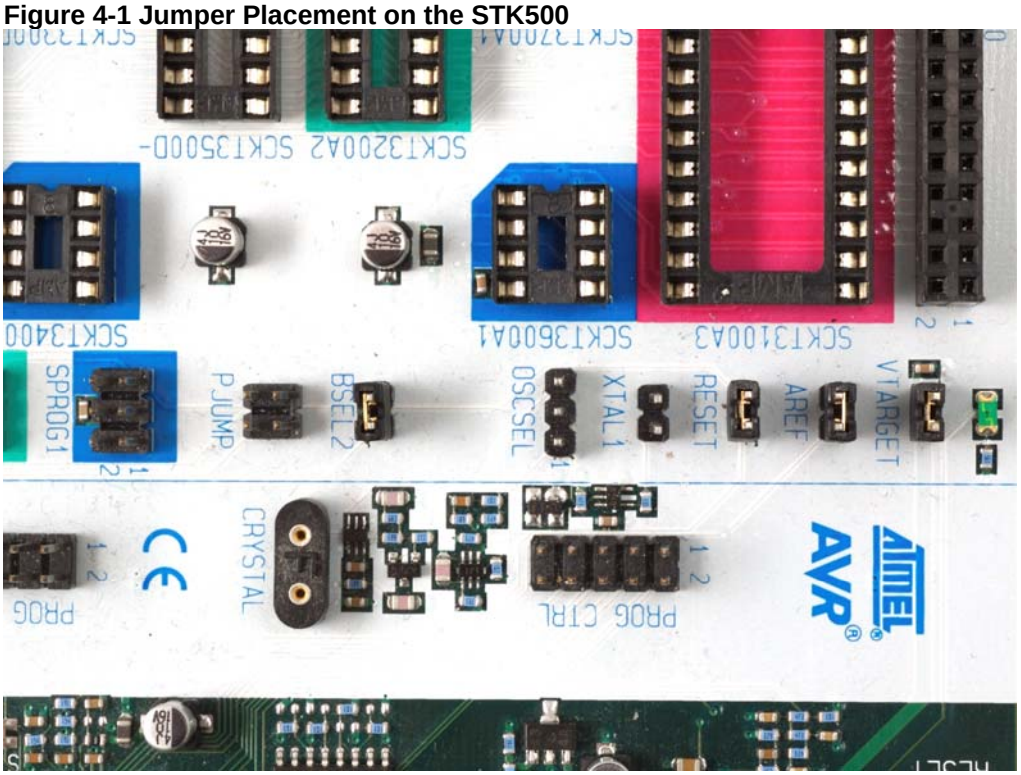
NOTE: The following steps must be completed successfully to ensure correct operation of the hardware.

Step A. Assemble and configure the STK500 board

The jumpers and operating voltage of the STK500 board must be set up correct in advance of mounting the STK501 and radio board.

1. Carefully remove any AVRs from the target sockets on the STK500.
2. Place jumpers on the following headers as shown in Figure 4-1:
   - VTARGET
   - AREF
   - RESET
   - BSEL2
3. Connect a serial cable to the connector marked RS232CTRL on the STK500 to a COM port on the PC.
4. Apply power to the STK500 by moving the power switch toward the edge of the board.
5. Start AVR Studio and press “Cancel” in the Welcome dialog window.
6. From the Tools menu, select “Program AVR” and “Connect…”.
7. Select “STK500 or AVRISP” as platform and then press “Connect…”. Verify that a window named “STK500” appears.
8. Open the Board tab. Adjust the VTarget voltage and ARef voltage to 3 Volts. Press the Write Voltages button. Close the STK500 window.

Figure 4-1 Jumper Placement on the STK500

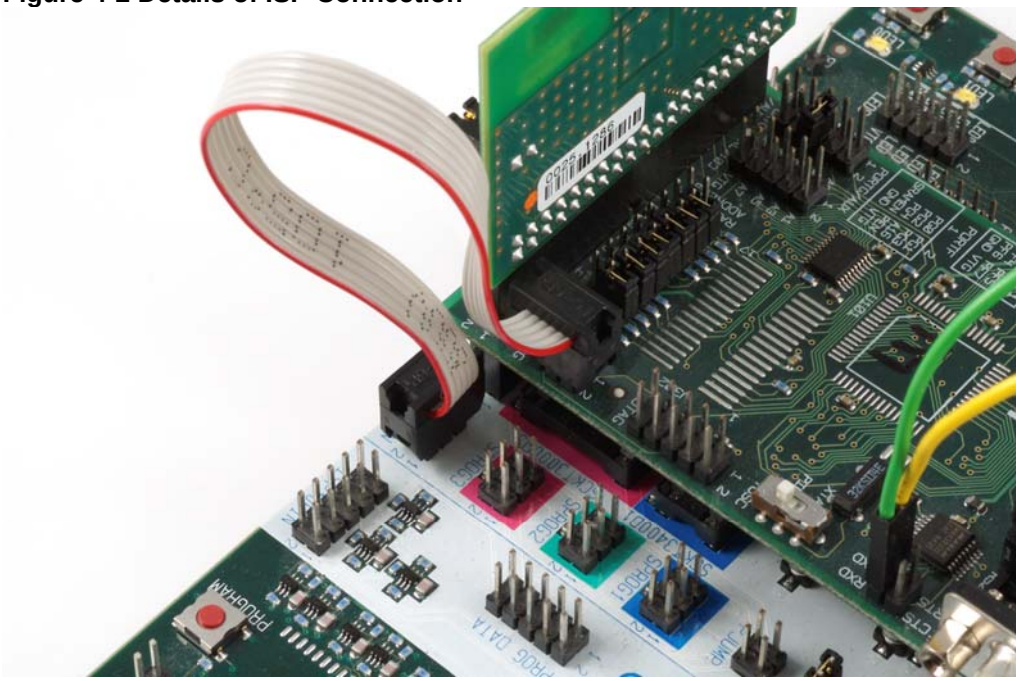


Step B. Assemble and attach the STK501 Top Module

The jumpers are now set correctly and the target voltage is set to 3 volts. This ensures that the AT86RF230 radio transceiver is not damaged and the ATmega1281 will run at 8MHz. The next steps describe how to mount the STK501 top module.

1. Insert an ATmega1281 into the Zero Insertion Force (ZIF) socket on the STK501. Press the spring-loaded top frame of the ZIF down and gently aligning the device underneath the fine-pitched wires. Verify that pin 1 on the TQFP package (dot in one of its corners) points towards the notched corner of the ZIF.
2. Ensure that power is turned off on the STK500 board.
3. Connect the STK501 to the STK500 by using expansion header 0 and 1. Ensure that the EXPAND0 written on the STK501 top module aligns with the EXPAND0 written beside the expansion header on the STK500 board.
4. Connect PINE1 and PINE2 to the RXD and TXD pins respectively. This can be done using one of the 2-wire cables included in the STK500 starter kit. The RXD and TXD pins are found close to the 9-pins RS-232 connector on the STK501.
5. To enable the In-System Programmer (ISP) interface, connect a 6-wire cable between the ISP6PIN connector on the STK500 board and the SPROG connector on the STK501 top module as shown in Figure 4-2.

Figure 4-2 Details of ISP Connection

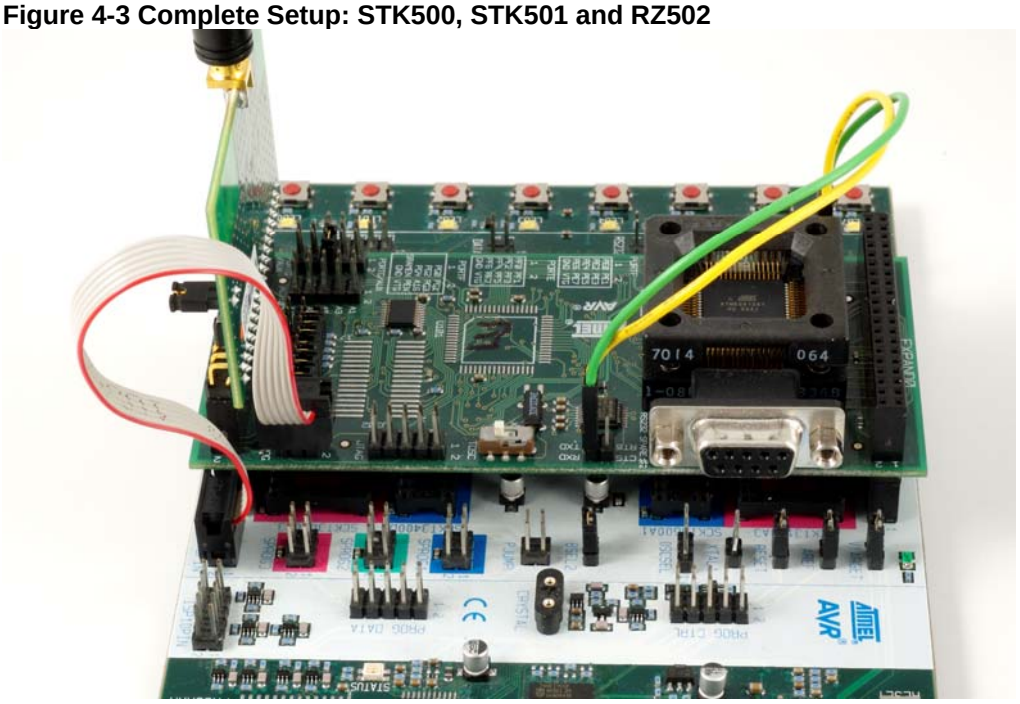


Step C. Mount the Radio Board

The RZ502 radio board is added to the STK501 by using its EXPAND1 header.

1. Find pin 1 on the radio board (Only square pad and with the digit 1 printed to its right). This is pin must align with pin 1 on STK501's EXPAND1 header.
2. Insert the radio board. Verify that the set up is equal to that shown in Figure 4-3.

Figure 4-3 Complete Setup: STK500, STK501 and RZ502



5 How to Program the ATmega1281

With the hardware successfully assembled and configured for both peers it is time to program them. This section describes how to do this using the STK500. Subsection 5.2 goes through the steps necessary to program the ATmega1281 with the precompiled evaluation application. However in advance of doing this operation, an EEPROM file must be generated that contains the 64-bit MAC address of each radio. This operation is described in subsection 5.1.

5.1 EEPROM File Generation

The IEEE 802.15.4 stack from Atmel uses the EEPROM of the AVR microcontroller to store the unique 64-bit MAC address. An EEPROM file that contains this address must be generated since the ATmega1281 is not preprogrammed with this information.

NOTE: The MAC address printed on the RZ502 top module is for evaluation only. For customer's products a separate address must be obtained.

1. Locate the MAC address on the RZ502 board. The address is a 16-byte string printed on a small white label (Ex. 00-04-25-FF-FF-17-03-E9).
2. Then start the HEXMaker command line tool found in the "bin" folder. This tool takes two inputs; filename of the .hex file and the MAC address in 16-byte string representation. Ex.:

```
>HEXMaker nodeA.hex 000425FFFF1703E9
   Filename      : nodeA.hex
   MAC address   : 00 04 25 FF FF 17 03 E9 (Byte order reversed in HEX file)
nodeA.hex created!
```

5.2 Programming the ATmega1281

The precompiled firmware used in the following subsection can be found in the “bin” folder of the .zip file accompanying this document.

1. Connect a serial cable to the connector marked RS232CTRL on the STK500 to a COM port on the PC.
2. Apply power to the STK500 by moving the power switch toward the edge of the board.
3. Start AVR Studio and press the “Cancel” button in the Welcome dialog window.
4. From the Tools menu, select “Program AVR” and “Connect…”.
5. Select STK500 or AVRISP as platform and then press “Connect…”. Verify that a dialog named “STK500 with STK501 top module” appears.
6. Open the “Program” tab. Select ATmega1281 from the Device pull down menu.
7. Select the “Fuses” tab and ensure that the Fuses are set as listed in Table 5-1:

Table 5-1. ATmega1281 Fuse Settings

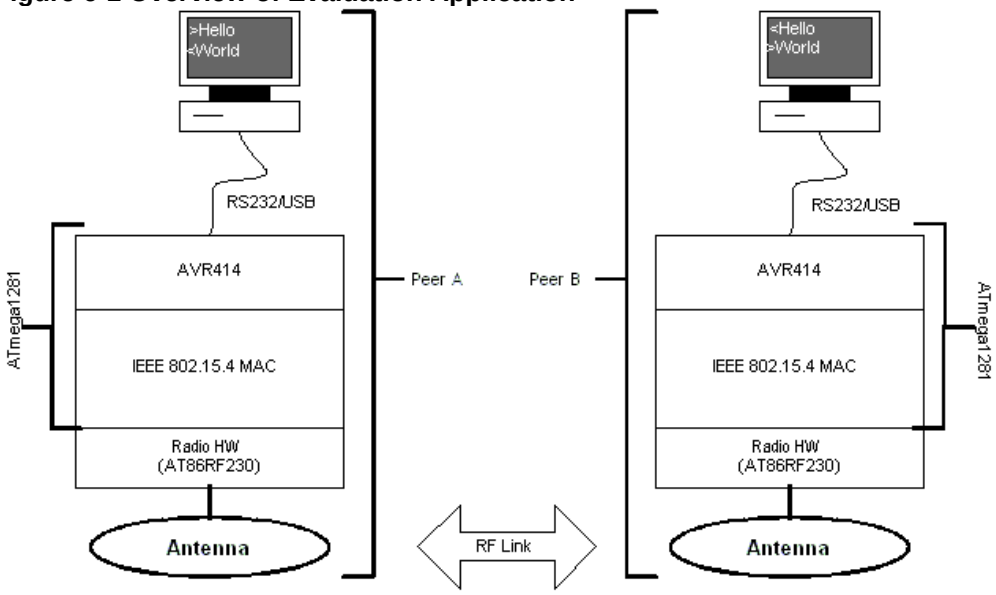
Fuse Name	Setting	Comment
Brown-out detection disabled	Checked	
Preserve EEPROM	Checked	This way the user only needs to program the EEPROM once.
Boot Flash section size=4096 words	Checked	
Divide clock by 8 internally	Not Checked	Will divide the clock by 8. This will corrupt the MAC execution.
Int. RC Osc.;Start-up time: 6CK + 65 ms	Checked	

8. Go back to the “Program” tab. Program the flash of the ATmega1281 with the “bin\AVR414_evaluation_application.hex” file found in the “bin” folder.
9. Program the EEPROM of the ATmega1281 with the .hex file generated in subsection 5.1.
10. Close the STK500 window.

6 Running the Evaluation Application

As mentioned in the introduction of this document an evaluation application is available as a part of this application note. This is a peer-to-peer chat application, where two RZ502 top modules are used to send messages back and forth. Figure 6-1 gives an overview of the evaluation application and its components from a system point of view. The reminder of this section describes two different ways to interface with the evaluation application.

Figure 6-1 Overview of Evaluation Application



6.1 Terminal Mode

In terminal mode the user can talk directly to the evaluation application programmed into the AVR microcontroller. This evaluation application is a thin layer of code that defines a command interface on top of the IEEE 802.15.4 stack from Atmel. The responsibilities of the evaluation application are:

- Start a new network.
- Associate to the network.
- Send data over the wireless link.
- Notify when new data is available.
- Reset the IEEE 802.15.4 MAC and evaluation application.

6.1.1 Command Interface

This section will describe the command interface that resides on top of the IEEE 802.15.4 MAC library. Commands are sent to the AVR microcontroller by using its serial communication interface (USART). Every command described in the latter part of this subsection can be tried out by connecting the STK501 top module to one of the PC's COM ports. Type in the test command in your favorite terminal application (Hence the name terminal mode), append CR + LF (Carriage Return + Line Feed = ASCII "\r\n") before executing.

Before continuing, the following formats are used in Table 6-1 through Table 6-5:

- Characters in quotation marks are the actual text sent to the AVR.
- Optional commands and response parameters are enclosed in brackets.

6.1.1.1 Reset (AT+R)

The "AT+R" command is used to reset the command interface and the IEEE 802.15.4 MAC. See Table 6-1 for details.

Table 6-1. AT command and possible responses

Command	Response	Comment
“AT+R”	“OK”	Reset successful.
	”ERROR: 0x80”	Syntax error.
	”ERROR: 0x83”	Reset unsuccessful.

6.1.1.2 Configure Network (AT+C)

The ”AT+C” command has two possible functions. It will either start a new network and set up the peer to become a coordinator, or associate the device to an existing network and set up the peer to be an end-device. See Table 6-2 for details.

Table 6-2. AT command and possible responses

Command	Response	Comment
“AT+C: [channel][1],[PANID][2],[role][3]”	“OK”	Network configured.
	”ERROR: 0x80”	Syntax error.
	”ERROR: 0x82”	Wrong internal state.
	”ERROR: 0x84”	Unsupported role.
	”ERROR: 0x85”	Internal state is inconsistent
	”ERROR: 0x86”	Failed during active scan.
	”ERROR: 0x87”	mlme_set_request primitive failed.
	”ERROR: 0x88”	Failed to start network.
	”ERROR: 0x89”	Failed to associate network.
	”ERROR: 0x8B”	One of the command’s parameters is invalid.

Notes:
1. Channel to start new network on or to associate. Valid channels are those defined by the IEEE 802.15.4 standard for the 2.4 GHz ISM band (channels 11 through 26). Must be in uppercase hexadecimal format. Ex.: 11 = 0B, 17 = 11.
2. PAN identifier of the network to start or associate. Valid range is that defined by the IEEE 802.15.4 standard (0x0000 through 0xFFFF). Must be in uppercase hexadecimal format. Ex.: 0 = 0000, 47789 = BAAD.
3. Role of the device. Only two valid alternatives. Either “C” for coordinator, or “E” for end-device.

6.1.1.3 Send Data (AT+T)

The ”AT+T” command is used to send data over the wireless link established between the two peers. See Table 6-3 for details.

Table 6-3. AT command and possible responses

Command	Response	Comment
“AT+T: [length][1],[data][2]”	“OK”	Data transmitted successful.
	”ERROR: 0x80”	Syntax error.
	”ERROR: 0x81”	Event buffer full.
	”ERROR: 0x82”	Wrong internal state.
	”ERROR: 0x8A”	Data transmission failed.

Command	Response	Comment
	”ERROR: 0x8B”	One of the command’s parameters is invalid.

Notes: 4. Length in bytes of data payload.
5. Array containing the data payload.

6.1.1.4 Notifications (+N and +T)

The ”+N” and ”+T” commands are used to respectively indicate that a device has associated to the network and that data was received. See Table 6-4 and Table 6-5 for details.

Table 6-4. AT command and possible responses

Command	Response	Comment
“+N”		Device associated successfully. Only valid for coordinators.

Table 6-5. AT command and possible responses

Command	Response	Comment
“+T: [length][1],[data][2]”		Data received successfully. Valid for both peers.

Notes: 1. Length in bytes of received data.
2. Array containing the received data.

6.1.2 Examples using PC

As mentioned previously all commands given in subsection 6.1.1.1 through subsection 6.1.1.3 can be tested having the STK501 top module connected to a PC using a RS232 cable. The default communication settings of the evaluation application can be found in Table 6-6. The reminder of this subsection gives some example scripts and comments.

Table 6-6. Communication Settings

Setting	Value	Comment
Bits per second	38400	
Data bits	8	
Parity	None	
Stop bits	1	
Flow control	None	CTS and DTS line not used.

6.1.2.1 Start a new network

```
AT+R              //Reset hardware and IEEE 802.15.4 Stack.

OK                //Command terminated successfully.

AT+C: 0B,BAAD,C   //Start network on channel 11 with PANID = BAAD.
```

```
OK                  //Network started.
```

6.1.2.2 Associate to network

```
AT+R                //Reset hardware and IEEE 802.15.4 Stack.

OK                  //Command terminated successfully.

AT+C: 0B,BAAD,E     //Associate to network on channel 11 with PANID =
                    //BAAD.

OK                  //Device associated. The coordinator will
                    //receive the “+N” notification.
```

6.1.2.3 Send data

This script assumes that a peer-to-peer network with two devices has successfully been established. An example on how to do this is outlined in subsection 6.1.2.1 and subsection 6.1.2.2.

```
AT+T: 3,AVR         //Send the string ”AVR” to the other peer.

OK                  //Data transmission finished. The receiving peer
                    //will be notified about the new data through the
                    //”+T” notification (“+T: 3,AVR”).
```

6.2 Graphical User Interface Mode

The Graphical User Interface (GUI) mode is the second method to interface with the evaluation application (firmware running on the AVR). A small chat client (PC) written in the Java® programming language is available that hides some of the details of the communication protocol used to control the evaluation application. The following subsections guides the user through the steps required to successfully run the Java based chat client.

NOTE: The chat client only supports the Microsoft® Windows® 2000 and XP operating system. This is not due to the Java based implementation. But merely how the serial port driver is implemented.

6.2.1 System Requirements

As mentioned in the introduction to subsection 6.2 the chat client is based on the Java programming language. This is a programming language where the source code is compiled into a byte code and then ran on a Java virtual machine (JVM). By default this virtual machine does not support serial ports. The following steps show how to install the Java virtual machine, add serial port support and ultimately how to connect the STK500/RZ502 board stack to your PC.

Step A: Install Java Runtime Environment.

The Java Runtime Environment (JRE) is a software bundle (JVM and libraries) that allows your PC to run Java based applications. Following the steps is required to ensure that the correct Java virtual machine is installed:

1. Go to Start Menu->Control Panel. Open the file named "Java". In the window that opens, select the tab named "Java" and click on the "View..." button within the "Java-Applet-Runtime-Settings" box.
2. A new dialog appears that lists the available JRE versions and their path.
3. Download and install the current JRE from Sun's Java Homepage (http://java.com/en/download/index.jsp) if no Java Runtime Environment was found, or if the installed version is below version **1.5.x**.

Step B: Install Serial Port Library.

The serial port library is installed by copying the files found in the "lib\pc" folder into the following Java system folders:

1. Copy the "win32comm.dll" file to the "...\Java\jre1.5.x\bin" folder.
2. Copy the "comm.jar" file to the "...\Java\jre1.5.x\lib\ext" folder.
3. Copy the "javax.comm.properties" file to the "...\Java\jre1.5.x\lib" folder.

Step C: Connect STK501/RZ502 to your PC.

Connect a serial cable to the connector marked “RS232 SPARE #2” on the STK501 top module to a COM port on the PC as shown in Figure 6-2.

Figure 6-2 STK501 with RS232 cable connected.

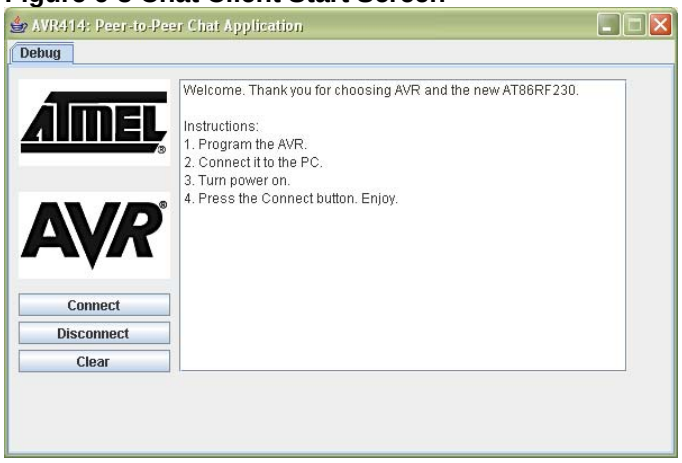
6.2.2 Running the Chat Client

This subsection assumes that all the steps listed in subsection 5.1, 5.2 and 6.2.1 were completed successfully. The chat client is started by double clicking the file

named “AVR414.jar” in the “bin” folder. A screen like that depicted in Figure 6-3 should now be visible. Now proceed with one of the following steps:

1. **Step A: Start the Coordinator:** Starts a new network. Peer becomes coordinator.
2. **Step B: Start the End-device:** Associate to an existing network. Peer becomes end-device.

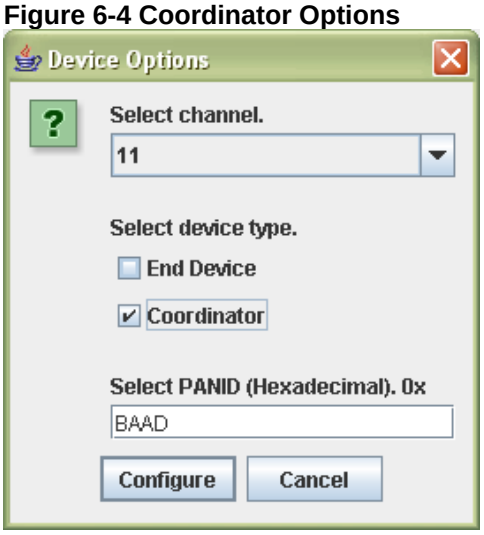
Figure 6-3 Chat Client Start Screen



Step A: Start the Coordinator

3. From the screen shown in Figure 6-3, press the “Connect” button.
4. The “COM Settings” dialog box will now appear. From the drop down list, select the serial port where the STK501 board is connected. Press “OK”.
5. Then in the “Device Options” dialog select the channel and PANID to start the network on. Check the “**Coordinator**” option as seen in Figure 6-4. Press “OK”.
6. If the channel and PANID entered was valid, a new tab will be added to the chat client containing a text area with the text: “Network not started yet”. This is just an notification that an end-device must associate before it is possible to chat.
7. Proceed with Step B to add an end-device to the network.

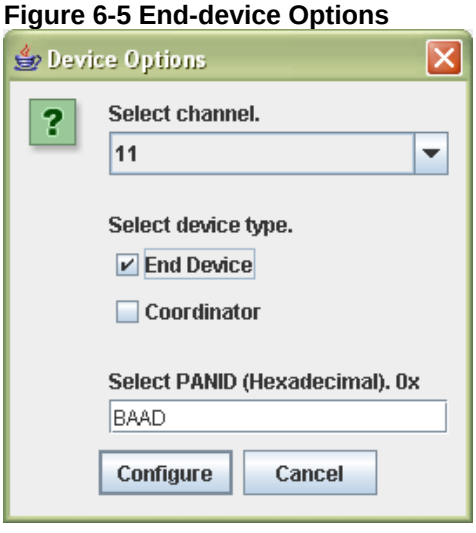
Figure 6-4 Coordinator Options



Step B: Start the End-device

1. From the screen shown in Figure 6-3, press the “Connect” button.
2. The “COM Settings” dialog box will now appear. From the drop down list, select the serial port where the STK501 board is connected. Press “OK”.
3. Then in the “Device Options” dialog select the same channel and PANID as for the coordinator. Check the “End Device” option as seen in Figure 6-5. Press “OK”.
4. If it was possible to associate with the coordinator, a new tab will be added to the chat client. It is now possible to send messages between the two peers.
5. Proceed with Step C for more information on how to chat.

Figure 6-5 End-device Options



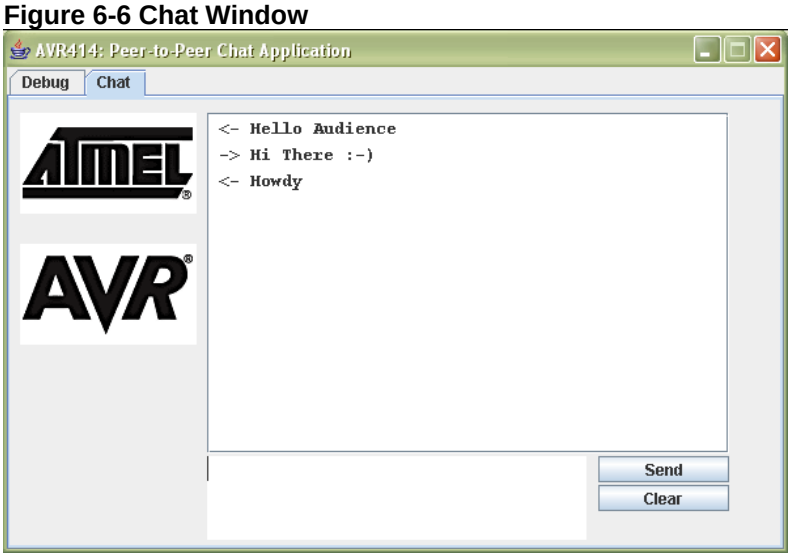
Step C: Chatting

As seen in Figure 6-6 the chat window has two text areas and two buttons. The upper text area is used to display the messages sent and received over the air. New

messages are written in the lower text area, and sent by pressing the enter key or “Send” button. “Clear” will erase the contents of the lower text area.

Going back to the initial tab (Debug) and pressing the “Disconnect” button terminates the chat session.

Figure 6-6 Chat Window



7 Troubleshooting Guide

Table 7-1. Troubleshooting Guide

Problem	Reason	Solution
Impossible to write to EEPROM	Memory LockBits enabled	Ensure that the “Mode 1: No memory lock features enabled” are selected in the LockBits tab of the STK500 programmer’s window.

8 References

The following references were used when writing this application note:

- AT86RF230 Data Sheet, available from: http://www.atmel.com/dyn/resources/prod_documents/doc5131.pdf
- IEEE 802.15.4 Standard.
- IEEE 802.15.4 MAC User Guide, available from: http://www.atmel.com/dyn/resources/prod_documents/doc5182.pdf

9 Appendix – Additional Hardware Documentation

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10 Table of Contents

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