
AVR2014: AT86RF230 Receiver sensitivity measurements

Features

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1 Introduction

The Atmel AT86RF230 radio transceiver has a specified receiver sensitivity of -101 dBm. The following document shall provide the information that is required for measuring this value with available Hard- and Software.

2 HW Setup description

For the measurement setup the standard Atmel ATAVR[®]RZ502 kit is used. This kit consists of two radio boards, each with one AT86RF230 transceiver chip and a standard SMA antenna connector.

Figure 2-1. ATAVRRZ502 - single radio extender board



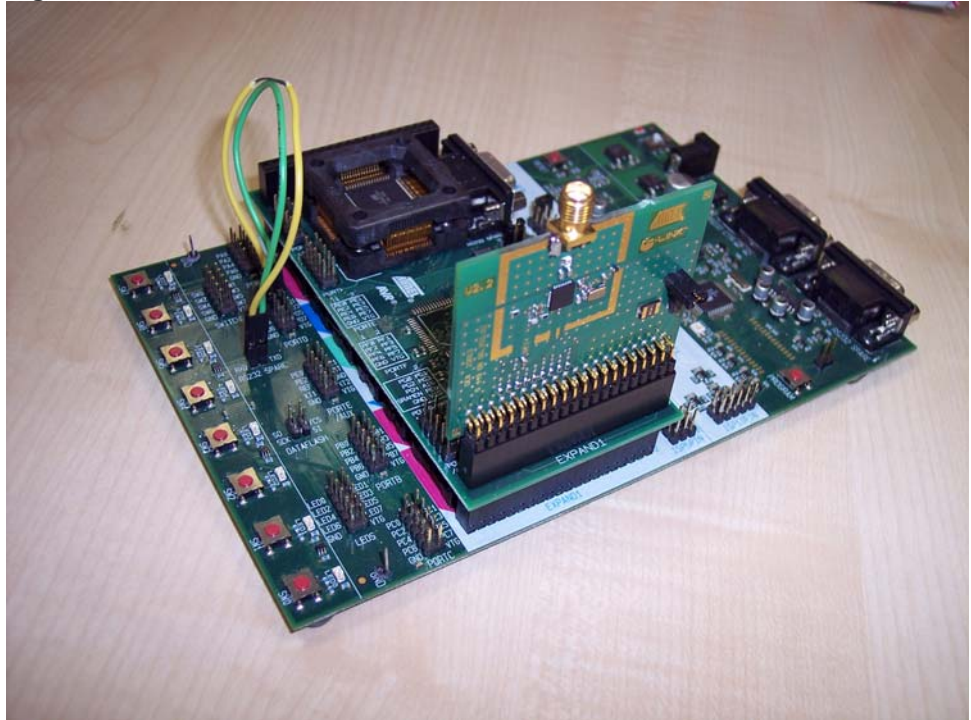
Application Note

Rev. 8115A-AVR-04/08



Each radio extender board is connected to a setup which consists of an AVR STK[®]500 with an AVR STK501 board on top. The AVR STK501 board is equipped with an AVR ATmega1281 microcontroller chip.

Figure 2-2. STK500+STK501+RZ502



Both setups are identical and are connected via cables with an adjustable attenuator in between. The Attenuator setup that is used for this measurement consists of one Agilent 8494H and one Agilent 8496H attenuator blocks and an Agilent 11713A attenuator driver.

Figure 2-3. Agilent 8494H + 8496H attenuator blocks



Figure 2-4. Agilent 11713A attenuator driver



The two STK-board setups are placed approximately 1.5 m away from each other with the radio extender boards facing outwards.

Figure 2-5. Transmitter setup

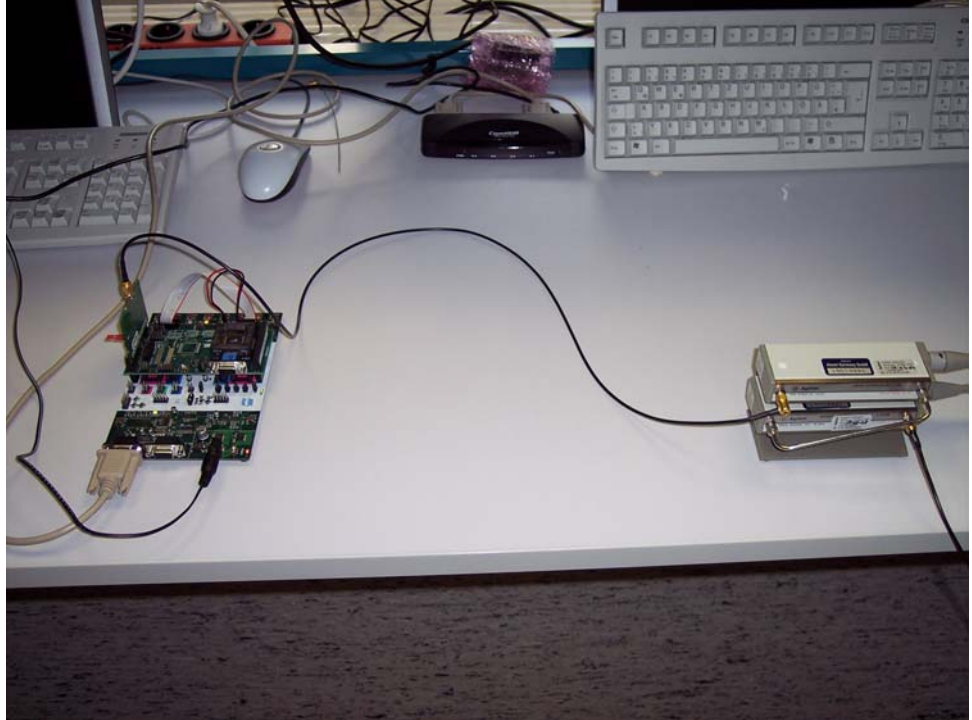
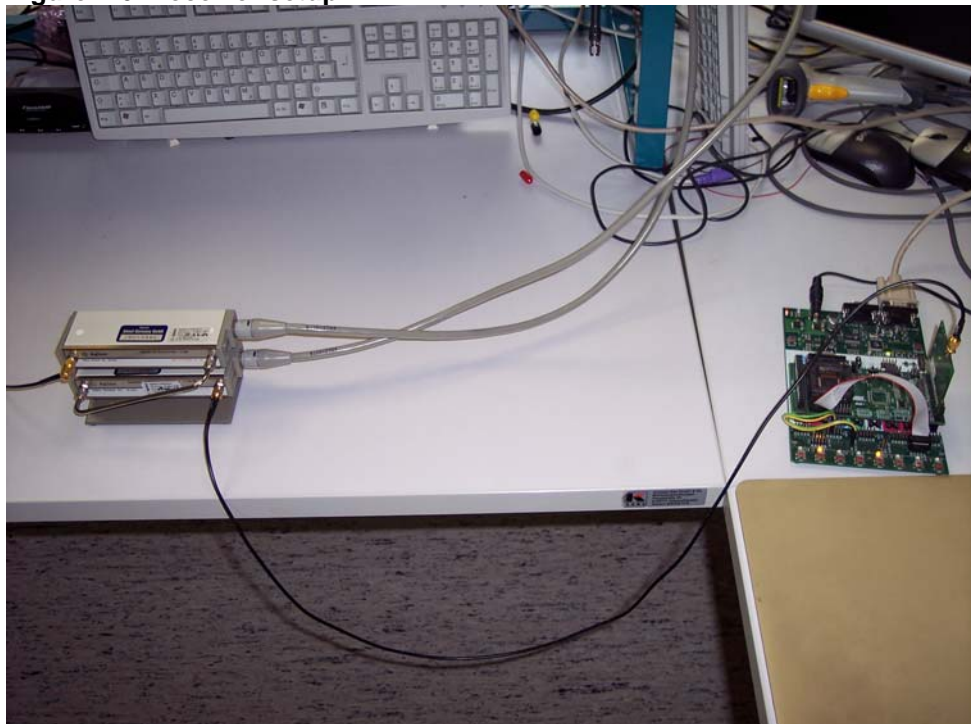


Figure 2-6. Receiver setup



3 SW setup preparation

For the measurements both AVR ATmega 1281 microcontrollers are programmed from AVR Studio® over a standard AVR JTAGICE mkII with a software package that is called Radio Evaluation Software (RES). This software is offering low level functions to use the Atmel AT86RF230 transceiver to generate data frames and do radio measurements.

The software has a terminal command interface which is accessible over the UART interface of the STK500 boards. The RES software on the Transmitter setup (called "A") will be configured to transmit a fixed number of data frames with a payload of 20 octets. To get a significant measurement result the number of packets is set to 10000 packets.

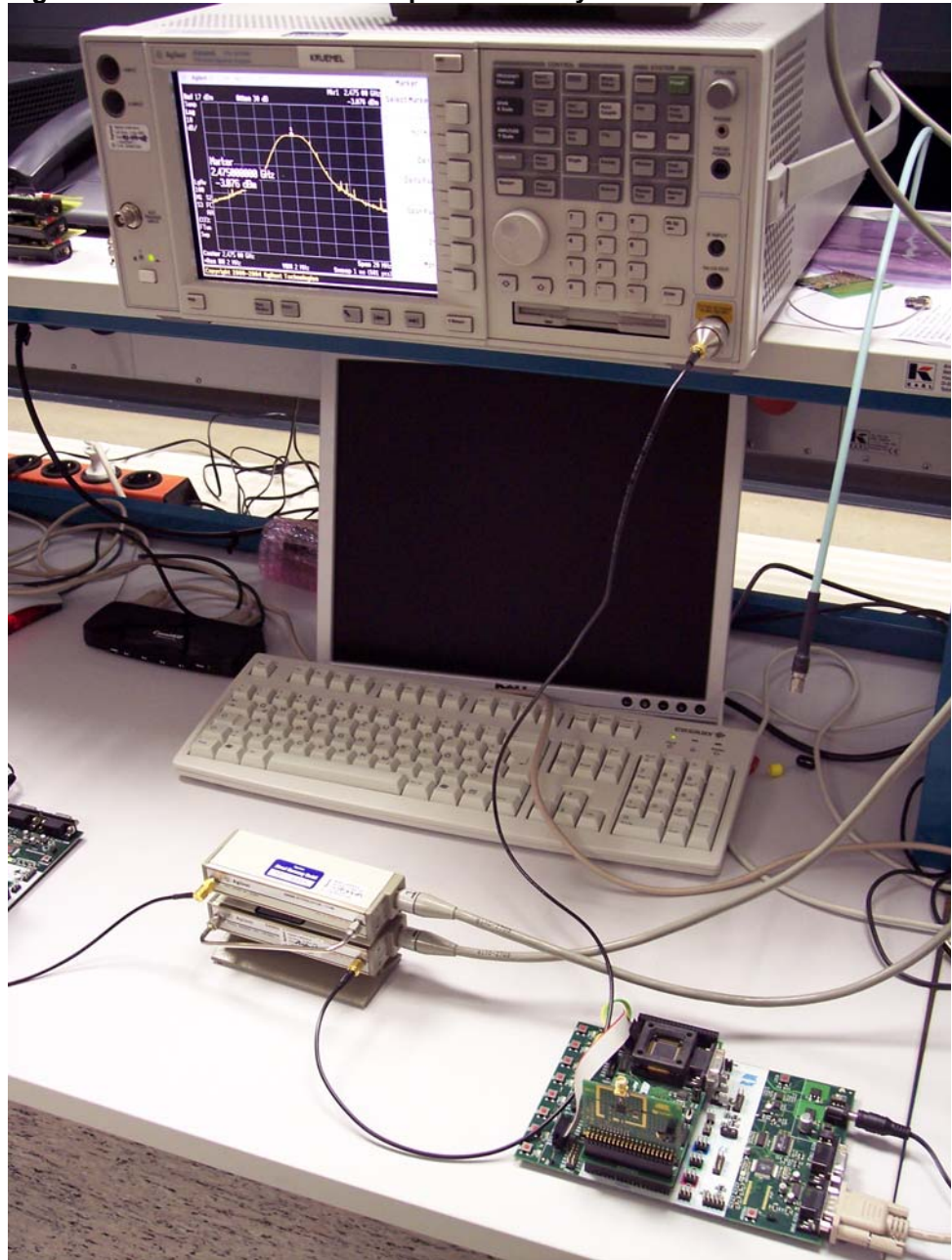
The RES software on the Receiver setup (called "B") is configured to receive these 10000 frames. The software will count the received packets and will then directly calculate the resulting Packet Error Rate (PER). To have a statistical method all measurements are repeated three times. The UART interfaces of both STK 500 boards are connected to the serial ports of a control Laptop or PC.

4 Cable loss measurement

In order to have dedicated signal strength on the receiver side there is the need to measure also the loss of the cables and connectors as well as of the attenuator block itself.

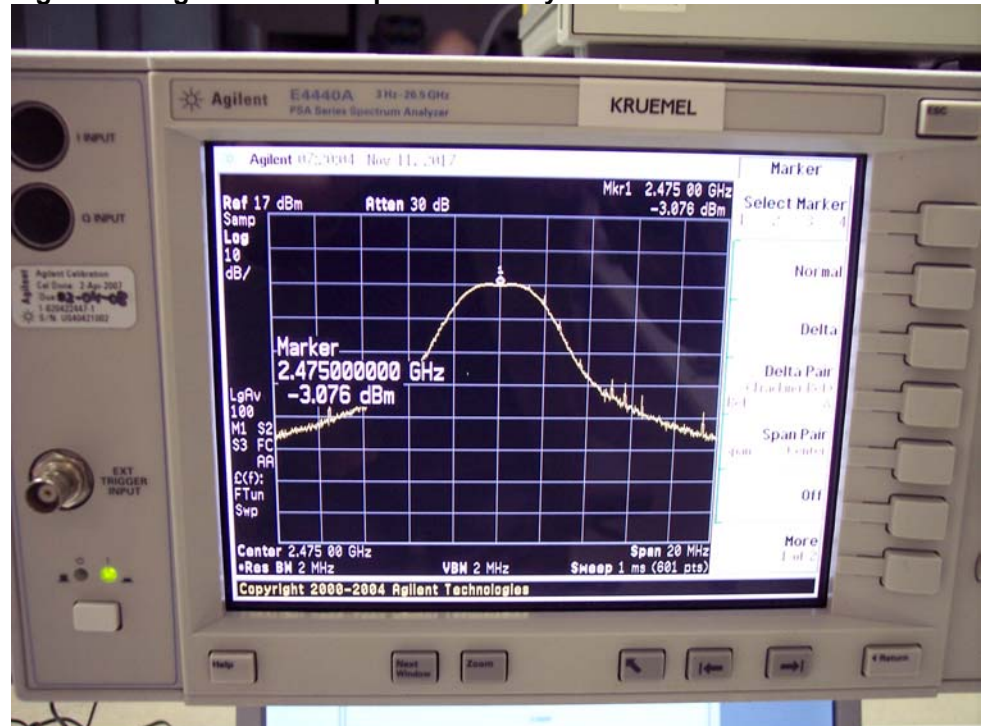
Setup "A" is configured to send 10000 frames. The attenuator setting is 0 dB which means the attenuator is off. The SMA connector on Setup "B" is now disconnected and will be connected to an Agilent E4440A Spectrum Analyzer.

Figure 4-1. cable connected to Spectrum Analyzer



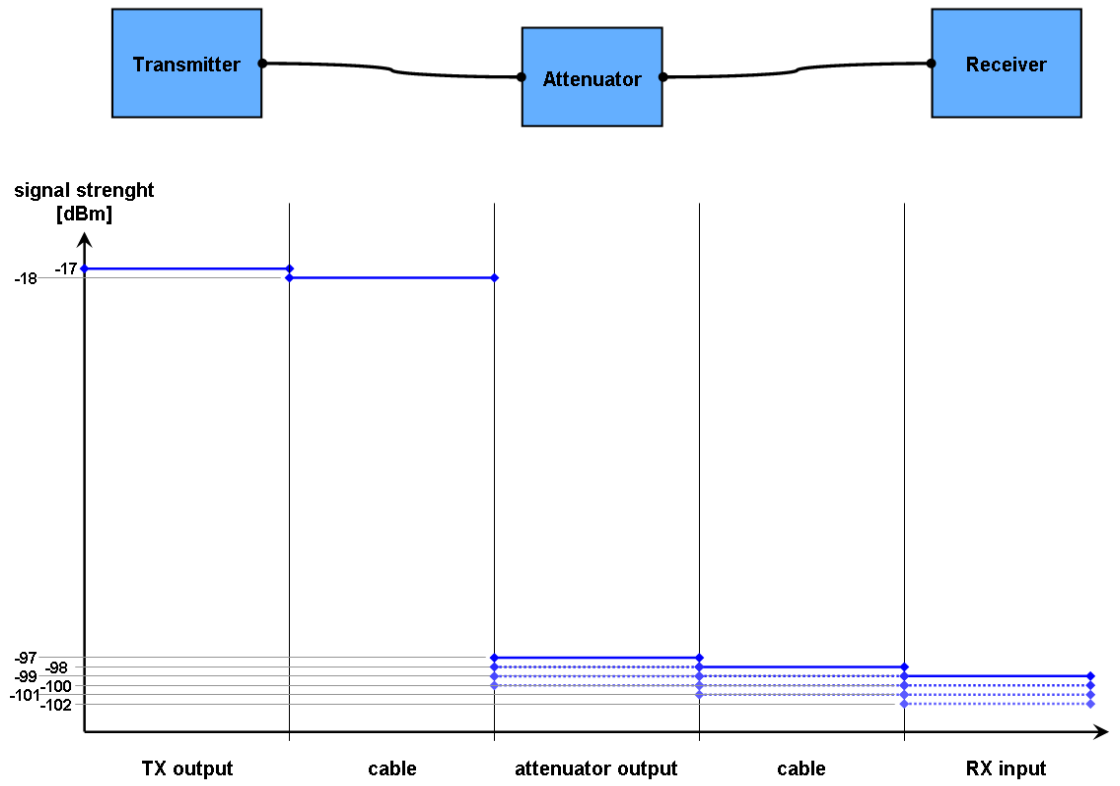
The RES allows the user to adjust the output power of the AT86RF230 transceiver in the steps described in [2]. For this measurement the output power is set to 0 dBm (actual register setting is -0.2 dBm).

Figure 4-2. Agilent E4440A Spectrum Analyzer



The measurement result shows that the used cables and connectors have an attenuation of approximately 3dB. This value will be added to the attenuation settings applied by the attenuator block and will be used in the PER calculation. A schematic block diagram of the measurement setup including the related signal loss diagram is shown in the next figure.

Figure 4-3. Signal loss diagram



5 Measurement execution

The measurement is performed in different steps where each step is using a different attenuator setting. The PER is measured as described in [1].

To avoid any reception of packets through the air over some line of sight path the receiver or transmitter setup could be separated from each other by an absorbing material as shown in the following figure.

In order to get more accurate results its is recommended to do the measurements in a shielded box environment, but since this might not be possible for all users this method is not shown here.

To further reduce the level of unwanted transmissions from the transmitting board the measurement is done with a output level of -17dBm (actual register value in AT86RF230 is -17.2dBm).

Figure 5-1. absorbing material



The user interface of the RES gives the user the possibility to adjust the parameters of the radios with easy commands. The complete command reference is part of the RES software package [3].

Once the RES firmware is programmed into the STK-501 boards AVR 1281 microcontroller the STK's spare RS232 connector is connected to a PC or Laptop running a standard terminal program. On the STK-500 the RS232 SPARE Pin Header needs to be connected to the PORTD Pin Header with the following configuration: RXD – PD2, TXD – PD3

The serial interface needs to be configured with the following settings:

38400 bps, 8 data bits, 1 stop bit, no parity, no flow control



Once the computer and the STK-boards RS232 are connected a reset is made on the STK-board. On the terminal software the user needs to press CTRL+t to switch the RES into the terminal command mode. The complete command set is displayed on some kind of a help menu when the “?” is pressed. The required commands to start the test on the receiver as well as on the transmitter side are highlighted in the next figure.

Figure 5-2. RES commands

```
RCB>?
RES Ver. 1.00
Commands: r=rx, t=tx, S=stop, R=reset d=dump n=sniffer c=cwmod
s=sleep f=fmtx m=report-metrics, e=edit params, x=exit term mode
RCB>

RCB>e
1. Channel = 11
2. Power = -17.2dBm
3. Packets/test = 1000
4. Packet size = 20
5. SFD = 0xA7
0. Exit
Select an option:1
Enter channel:24
1. Channel = 24
2. Power = -17.2dBm
3. Packets/test = 1000
4. Packet size = 20
5. SFD = 0xA7
0. Exit
Select an option:3
Enter number of packets/test:10000
1. Channel = 24
2. Power = -17.2dBm
3. Packets/test = 10000
4. Packet size = 20
5. SFD = 0xA7
0. Exit
Select an option:0
RCB>
```

The software parameters used for this test are as follows:

| Transmitter settings | Receiver settings |
|-----------------------|---------------------------|
| Channel: 24 | Channel: 24 |
| No. of packets: 10000 | No. of packets:10000 |
| Power: -17.2 dBm | Power: -0.2 dBm (default) |
| | |

After the transmitter setup as well as the receiver setup have been configured with these parameters the receiver side needs to be switched into receiving mode by using the “r” command from the main RES command menu. Then the receiver is waiting until the first packet gets received.

The transmission test will be initiated by using the “t” command from the main RES command interface. The transmitter will start to transmit the configured number of frames and the terminal window should show a visual indication of this.



6 Measurement results

The results of the tests showed that with a basic measurement setup it is easily possible to verify the specified receiver sensitivity of the Atmel AT86RF230. The accuracy of the measurements described here varies by +/- 0.5 dBm due to the basic setup without a shielded box, but it should be very easy to reproduce these results by using the described procedures.

The results are listed in the following table:

Table 6-1. Measurement results

| Attenuation Block setting | Signal strength @ receiver | No. of tx packets | 1st run | | 2nd run | | 3rd run | | average RSSI value |
|---------------------------|----------------------------|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------------|
| | | | rec. packets | PER | rec. packets | PER | rec. packets | PER | |
| | | | [in dB] | [in -dBm] | | % | | % | |
| 63 | 83 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 3 |
| 69 | 89 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 1 |
| 70 | 90 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 1 |
| 72 | 92 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 0 |
| 74 | 94 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 0 |
| 76 | 96 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 0 |
| 78 | 98 | 10000 | 10000 | 0 | 10000 | 0 | 10000 | 0 | 0 |
| 79 | 99 | 10000 | 9999 | 0,01 | 9999 | 0,01 | 10000 | 0 | 0 |
| 80 | 100 | 10000 | 9999 | 0,01 | 9999 | 0,01 | 10000 | 0 | 0 |
| 81 | 101 | 10000 | 9997 | 0,03 | 9989 | 0,11 | 9992 | 0,08 | 0 |
| 82 | 102 | 10000 | 8597 | 14,03 | 8486 | 15,14 | 8732 | 12,68 | 0 |
| 83 | 103 | 10000 | 7114 | 28,86 | 6744 | 32,56 | 6837 | 31,63 | 0 |

7 References

- [1] IEEE 802.15.4 – 2003, section 6.1.6 Receiver sensitivity definitions
- [2] Atmel AT86RF230 Datasheet Rev.D, section 10 register reference
- [3] Atmel ZLink Radio Evaluation Software User Guide, Rev.1.



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