ZigBeeNet Software 1.0

Range Measurement Tool Users Guide

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1. Introduction

Range Measurement Application is intended to measure radio performance of various devices based on ZigBit modules (see [1], [2]) and/or to make comparison with platforms of other manufacturers. As such, it can be employed by developers, embedded software experts and enthusiasts.

During the measurement, a specially generated data sequence is transmitted between two nodes, along with the determination of error rate. The RSSI level and LQI values are also measured. Using HyperTerminal or any other terminal application, the obtained data can be transferred to a PC for visualization and further analysis.

Related documents

[1] ZigBit™ OEM Modules Product Datasheet. MeshNetics Doc. M-251~01

[2] ZigBit™ Amp OEM Modules Product Datasheet. MeshNetics Doc. M-251~03

[3] ZigBit™ Development Kit 2.0 User's Guide. MeshNetics Doc. S-ZDK-451

[4] ZigBit™ Amp Development Kit 2.0 User's Guide. MeshNetics Doc. S-ZDK-451~02

[5] Atmel RF Accessory Kit RZ502 User Guide.
http://www.atmel.com/dyn/resources/prod_documents/doc8051.pdf

[6] Atmel AVR STK500 User Guide.
http://www.atmel.com/dyn/resources/prod_documents/doc1925.pdf

[7] Atmel AVR STK501 User Guide.
http://www.atmel.com/dyn/resources/prod_documents/doc2491.pdf

[8] Atmel ATAVRRZ200 Demonstration Kit User Guide.
http://www.atmel.com/dyn/resources/prod_documents/doc5183.pdf

[9] National Instruments LabView. http://www.ni.com/labview/

2. Application Description

Range Measurement Application consists of two firmware images: 1) for Transmitter and 2) for Receiver.

Transmitter performs the following functions:

- Periodically (each 6...10 milliseconds) generates packets containing 1024 bits of a pseudorandom sequence (polynomial, according to the ITU-T O.151 recommendation)
- Controls RF output power
- Sends a number of frames via RF using UART (in the 38400, 8N1 mode).

Receiver performs the following functions:

- Receives packets from Transmitter
- Analyzes packets
- Averages the received data
- Calculates the checksums
- Counts statistics
- Sends above data, including number of bit errors, frame errors and number of frames to PC via UART (in the 38400, 8N1 mode).

When Range Measurement Application is run on MeshBean2 board, it uses the following settings:

Table 1: Transmitter Control

Set maximum power	Set DIP-switch SW4 in following position: 1 – ON, 2 – ON, and press RESET button.
Set power to 10 dB lower than maximum	Set DIP-switch SW4 in following position: 1 – OFF, 2 – ON, and press RESET button.
Set power to 20 dB lower than maximum	Set DIP-switch SW4 in following position: 1 – ON, 2 – OFF, and press RESET button.
Channel switching	Press SW2 button several times to switch between the channels cyclically, starting from the first one (0x0B – 2405 MHz). Do not press button too fast. Check the channel setting by LEDs (see Table 3: Channel Indication).
Turn on continuous packet generation mode	Press and hold button SW1 for more than 1 second, then release it. Check packet generation mode as described in Table 4: Mode Indication.
Turn on generation of 10000 packets	Press button SW1 for a short time (less than 1 second). Check packet generation mode as described in Table 4: Mode Indication.

Table 2: Receiver Control

Channel switching	Press SW2 button several times to switch between the channels cyclically, starting from the first one (0x0B – 2405 MHz). Do not press the button too fast. Check the channel setting by LEDs (see Table 3: Channel Indication).
Reset statistics	Press SW1 button.

Table 3: Channel Indication

Channel	Frequency, MHz	MeshBean2 LEDs		
		RED	YELLOW	GREEN
0x0B	2405	OFF	OFF	OFF
0x0C	2410	OFF	OFF	ON
0x0D	2415	OFF	ON	OFF
0x0E	2420	OFF	ON	ON
0x0F	2425	ON	OFF	OFF
0x10	2430	ON	OFF	ON
0x11	2435	ON	ON	OFF
0x12	2440	ON	ON	ON
0x13	2445	OFF	OFF	OFF
0x14	2450	OFF	OFF	ON
0x15	2455	OFF	ON	OFF
0x16	2460	OFF	ON	ON
0x17	2465	ON	OFF	OFF
0x18	2470	ON	OFF	ON
0x19	2475	ON	ON	OFF
0x1A	2480	ON	ON	ON

Table 4: Mode Indication

Channel	MeshBean2
Continuous mode (transmitter)	GREEN → YELLOW → RED
Generation of 10000 packets (transmitter)	RED → YELLOW → GREEN
Receiver mode	GREEN → YELLOW → RED → YELLOW → GREEN

3. Supported Platforms

Table 5: Supported Hardware Platforms

Hardware Platforms	Descriptions
MeshBean2 board [3] with ZigBit modules: ZDM-1281-A2 ZDM-1281-B0	ZigBit with dual chip-antenna ZigBit with balanced RF input/output for PCB integrated or external antenna
MeshBean2 Amp board [4] with ZigBit Amp modules ZDM-A1281-PN/PN0	ZigBit with output power amplifier and input low-noise amplifier
Atmel RF Accessory Kit RZ502 [5] + AVR STK500 [6] + AVR STK501 [7]	Extension board with radio plugged into AVR STK500, AVR STK501 boards
Atmel ATAVRRZ200 Demonstration Kit AT86RF230 (2450 MHz band) Radio Transceiver [8]	5 RCBs plus Display Board

Use JTAGICE mkII (or JTAGICE) to upload Range Management Application for these platforms. Following software should be installed to upload the application.

Table 6: Supported Software Platforms

Software Platform	Applications
Microsoft Windows OS	AVR Studio 4.13 + Service Pack 1 + WinAVR
Linux OS	binutils-2.16.1 gcc-3.4.5 avr-libc-1.4.3 avarice-2.6 gdb-6.3 NesC 1.1-1.2.15_lux

NOTE:

Actual software versions may differ.

4. How to Program the Nodes

To burn the Application firmware into the nodes use **avarice** or **avrdude** programs under Linux or Windows OS. Alternatively, you can use **AVR Studio** for burning firmware under Windows platform.

You can find image files `transmitter.hex (transmitter.srec)` and `receiver.hex (receiver.srec)` in `Evaluation Tools/Range Measurement Tool/` subdirectory.

Be careful with fuse bits settings. Fuse bits should be set as follows:

Table 7: Fuse Bits Settings

Fuse bits	Value
Brown-out detection	Disable
JTAG Interface	Enable
Serial program downloading (SPI)	Enable
Boot Flash section size	512
Clock; Start-up time	Ext.; 6 CK + 0 ms

5. How to Use

After burning, run the nodes. Connect a node to PC and start terminal software with the following settings:

Table 8: COM Port Settings

Parameter	Value
Data Rate	38400 bps
Data Bits	8
Parity	none
Stop Bits	2
Flow Control	none

The connection status is sent to the receiver's PC (and, consequently, printed out in the HyperTerminal window) in plain text format as shown below:

```
FC=1817    FEC=15    BEC=258    LQI=222    RSSI=-83dBm (02)
FC=1871    FEC=16    BEC=259    LQI=221    RSSI=-82dBm (02)
FC=1924    FEC=17    BEC=263    LQI=222    RSSI=-83dBm (02)
FC=1978    FEC=19    BEC=266    LQI=215    RSSI=-83dBm (01)
FC=2031    FEC=21    BEC=271    LQI=216    RSSI=-83dBm (02)
FC=2085    FEC=21    BEC=271    LQI=216    RSSI=-83dBm (02)
FC=2138    FEC=22    BEC=273    LQI=220    RSSI=-82dBm (02)
FC=2191    FEC=22    BEC=273    LQI=220    RSSI=-83dBm (01)
```

Table 9: Raw Statistics Explanation

Statistics	Description
FC	Frame (packet) counter for received frames
FEC	Erroneous frame counter for received data
BEC	Erroneous bit counter for received data
LQI	Averaged Link Quality Indicator
RSSI	Received Signal Strength Indicator, in dBm, indicated by radio

NOTE:

LQI and RSSI values are relevant for MeshBean2 boards only.

You may choose either to save the output for later analysis, or to monitor its graphical representation in real time, as it is explained below by the example of LabView [9].

Arrange wireless connection between transmitter and receiver(s). Set up receiver and leave it stationary allocated aside the host PC. Start GUI application by opening

`range_tool.vi` file with LabView. The `range_tool.vi` file can be found in `Evaluation Tools/Range Measurement Tool/` subdirectory.

Set up COM port connection. Walk with a transmitting node at a range of distances tested. Measure the distance in realistic environment along with the channel quality and observe at the PC. Opposing, you may connect receiver to a portable PC with GUI application running, and walk with the PC to make measurements. Possible strategy is to find a maximum distance with acceptable connection conditions. Explore the affecting factors in real environment, considering walls and other targets.

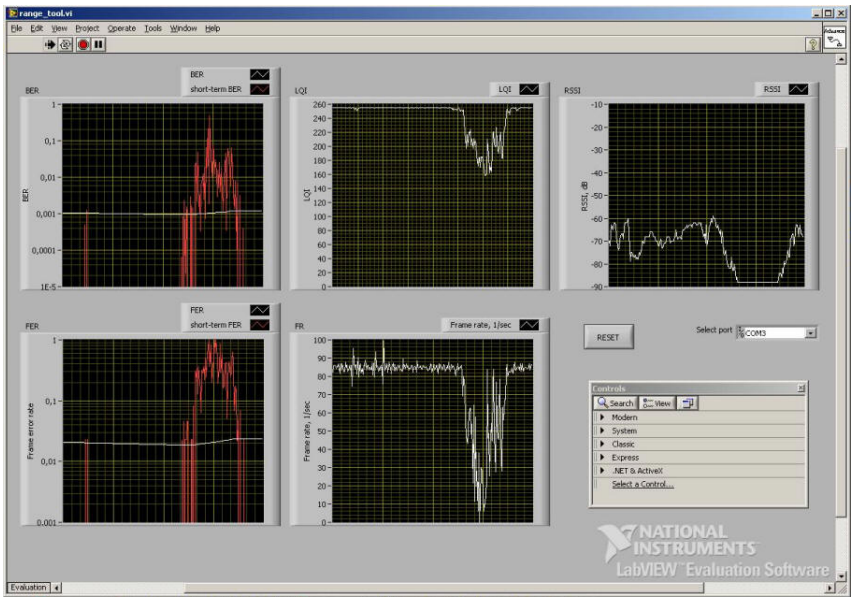

Figure 1. LabView screenshot

As shown in above figure, with decreasing the connection quality controlled with LQI/RSSI, the number of erroneous frames increases but frame rate drops down.

Table 10. Statistics Explanation

Statistics	Description
FR	Frame Rate
BER, short-term	Bit Error Rate
BER, cumulative	Bit Error Rate, cumulative
FER, short-term	Frame Error Rate
FER, cumulative	Frame Error Rate, cumulative
LQI	Averaged Link Quality Indicator
RSSI	Received Signal Strength Indicator, in dBm, indicated by radio

Indoors, channel quality is conditioned by antenna orientation, disturbing walls, the ceiling height, furniture and so on. Outdoors, it also depends on various weather conditions and affecting subjects such as trees, buildings, cars, etc. Reflection from the ground is also a significant factor. To make measurements as accurate as possible, the modules should be put at least at several meters above the ground.