Atmel AVR2150: RTB Evaluation Application – User's Guide

8-bit Atmel Microcontrollers

Features

- Evaluation of the Atmel® AT86RF233 phase difference measurement unit
- Design based on Atmel AT86RF233 radio transceiver supporting IEEE® 802.15.4, ZigBee®, 6LoWPAN, RF4CE, SP100, *Wireless*HART®, and ISM applications
- RTB evaluation application (RTB Eval App) with functionalities for:
  - Distance measurement based on phase difference measurement technology
  - Radio transceiver parameter configuration
  - Ranging measurement and network parameter configuration
  - Script to automate ranging measurements

Introduction

The RTB Evaluation Application – User's Guide describes how to get started with a setup and operate the RTB Eval App for evaluating the AT86RF233 [2] ranging features in depth.

The RTB Eval App uses the REB233SMAD-EK [3] hardware platform.

Figure 1.   REB233SMAD based hardware platform.

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1. Disclaimer

Typical values contained in this application note are based on simulations and testing of individual examples.

Any information about third-party materials or parts was included in this document for convenience. The vendor may have changed the information that has been published. Check the individual vendor information for the latest changes.

Note, the RTB library included in this firmware package is provided for demonstration purposes only and adapted to this specific hardware configuration and application scenario. In case of a different hardware configuration and application scenario a customized firmware port is needed.

2. Overview

The RTB Eval App, operated on a REB233SMAD-EK hardware platform, is targeted for evaluating the AT86RF233 radio transceiver phase difference measurement unit (PMU). The setup provides an ideal platform to:

- Demonstrate AT86RF233 phase difference measurement technology
- Evaluate the AT86RF233 radio transceiver performance
- Test the radio transceiver hardware support for the IEEE802.15.4 standard
- Test the enhanced radio transceiver feature set

3. Hardware Platform and Configuration

The RTB Eval App uses the REB233SMAD-EK hardware platform. For details about the evaluation kit and how to assemble and bring up the hardware platform refer to application note AVR®2160 REB233SMAD Evaluation Kit – Quick Start Guide [6].

3.1 Prerequisites: Firmware and hardware updates

Before start working with the RTB Eval App all REB233SMAD-CBB assemblies require a firmware update and one assembly has to be connected to a host-PC to operate the application.

Details how to update firmware and connect to a host-PC are given in application note AVR2151 RTB Evaluation Application – Quick Start Guide [4].

3.2 Antenna configuration

The antenna configuration requires special attention. An optimum distance measurement result is achieved with a proper antenna configuration.

For indoor application it is strongly recommended to ensure an angle of 90° between the two swivel antennas. This is achieved for example with:

- 'Open arm' configuration: each antenna 45° upwards, or
- 'One up, one straight' configuration

For outdoor applications the antenna configuration has less importance, both antennas up is possible, too.

4. Ranging Application – Functional Description

4.1 General introduction

A sequence diagram of the ranging application is shown in Figure 4-1. After power-up, a node is configured and initialized according to the parameter settings. The node is waiting for a range request in RX_AACK_ON Extended Operating Mode [2].

Assuming remote ranging, a *Coordinator* ranging request is received by the *Initiator*, including ranging parameters and *Reflector* node address, the following sequence is performed:

1. *Initiator* receives ranging request from *Coordinator*.
2. *Initiator* sends ranging init command frame to *Reflector*.
3. *Initiator* sends a timing synchronization frame to *Reflector*.
4. *Reflector* sends a ranging measurement start frame back to *Initiator*.
5. *Ranging* measurement (*Initiator* and *Reflector*).
6. Once finished, *Initiator* requests measurement data from *Reflector*.
7. *Reflector* sends measurement data to *Initiator*.
8. *Initiator* calculates distance.
9. *Initiator* reports distance to *Coordinator*.

A graphical representation of the sequence is shown in Figure 4-1.

Figure 4-1. Ranging application sequence diagram.
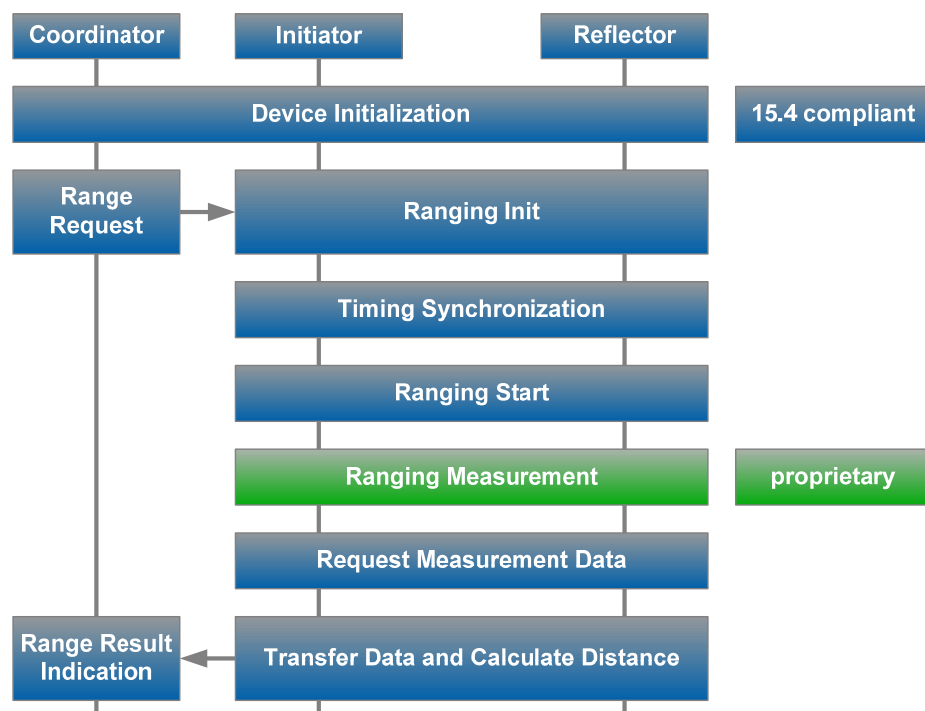
Except the ranging measurement procedure itself, all transactions are performed using IEEE802.15.4 compliant transactions.

A detailed introduction into the RTB Eval App is given in application note AVR2152 [5].

4.2   Ranging types – Remote and Local ranging

Two different ranging measurement principles are supported, see Figure 4-2:

1. Remote Ranging initiated by the *Coordinator* and performed between two other nodes (*Initiator* and *Reflector*).
2. Local Ranging between the *Coordinator* and another node (either *Initiator* or *Reflector*).

Remote Ranging is the recommended operating mode to allow unrestricted placement of a wireless node without any restrictions. Local ranging, as illustrated below, is possible too in case the *Coordinator* is capable and well equipped to perform ranging measurements.

The RTB Eval App assumes the *Coordinator* connected to a host-PC, as explained in Section 5.4, and a terminal application to control the ranging application.

Figure 4-2.   Ranging types – Remote and Local ranging.
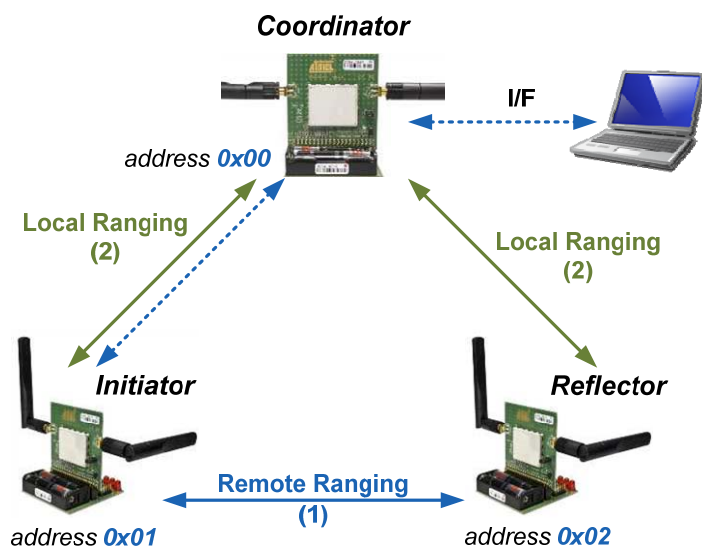
5.   Ranging Tool Box Application Example

The RTB Eval App demonstrates the AT86RF233 PMU technology and introduces the ranging toolbox hereby, see [5]. A ranging measurement is configured and started via the host-PC terminal application. For the example of a remote ranging, a distance measurement is performed between *Initiator* and *Reflector* node and reported back to the host-PC terminal application via the *Coordinator* node.

**Figure 5-1.   Simplified remote ranging setup.**
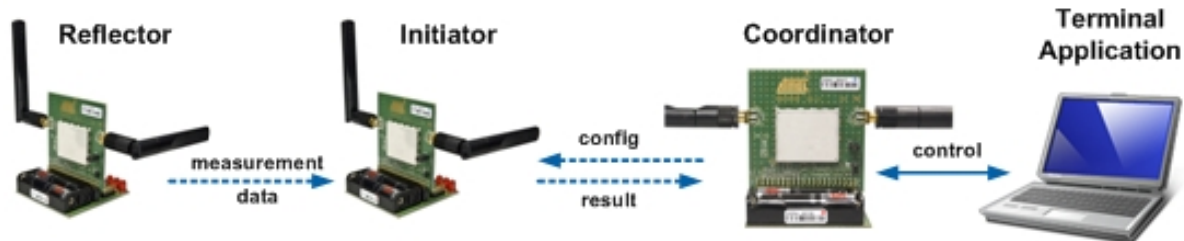
A step-by-step introduction will take you from power on the REB-CBB assemblies up to perform your own measurements and modify system parameter settings.

5.2   Power-on check

Apply power to the REB-CBB assemblies by switching on the power switch located on the top side of the CBB. The assemblies run a power-on check and indicate the successful completion by either:
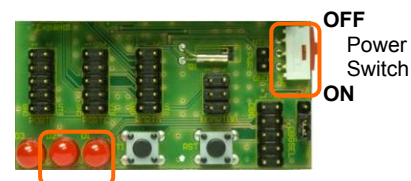
- LED D1-D3 are blinking for a short period, or

Figure 5-2.   Power ON test – LED-D1... D3 blinking.
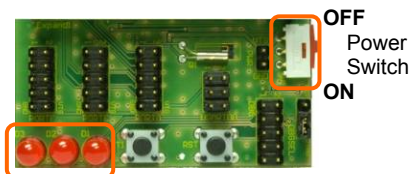
- LED D1 and/or D2 switched on for about 10sec

Figure 5-3.   Power ON test – LED-D1... D3 blinking.

Note: If LED D1-D3 flashes constantly, the correct installation of the REB has to be checked.

5.3 Node type assignment

An essential prerequisite, before starting with PMU based ranging measurements, is the assignment of a node type to a certain REB-CBB assembly. Node types are *Coordinator*, *Initiator* or *Reflector*. The mapping is realized by assigning dedicated short addresses, see Section 5.5.3.

This is required:

- the very first time the setup is switched on, or
- after restoring factory default settings, or
- if the node type of an REB-CBB assembly has to be changed

To simply select and set a node type, switch-off or reset an REB-CBB assembly, press and hold button T1 and thereby switch-on again or release the reset button. As long as button T1 is hold, the node type is changed continuously, indicated by LED-D1 and D2. A node type, and thereby an address, is selected by releasing button T1 as long as LEDs signaling an individual role.

Table 5-1.   Node type configuration.

Node type	LED D1	LED D2	Own short address [(1)]	Related address settings
Coordinator	ON	ON	0	Coordinator Short Address for Remote Ranging = 0
Initiator	ON		1	Initiator Short Address for Remote Ranging = 1
Reflector		ON	2	Reflector Short Address = 2
Various			other	Address set other than 0…2

Note: 1.   Button configurable addresses 0, 1, and 2 are addresses associated with specific roles and LED indications. However, via terminal application or script, each REB-CBB assembly can be configured with any other address setting.

Once a node type is selected, the setting (related short address) is permanently stored in the EEPROM. A power cycle or reset will restore and indicate a previous address setting, see Table 5-1. The LED node type indication is switched off after 10sec.

Alternatively, an address configuration can be performed manually using the host-PC terminal application, see Section 5.5.3.

> Important: The *Coordinator* is to be connected to the host-PC. The two other nodes, *Initiator* and *Reflector*, are to be placed in the test environment.

5.4 Terminal application

Working with the RTB Eval App requires a terminal application running on the host-PC. Depending on the host-PC operating system typical terminal applications are for instance HyperTerminal, PuTTY or TeraTerm.

Before proceeding with the next steps launch a host-PC terminal application and configure the assigned COM port accordingly:
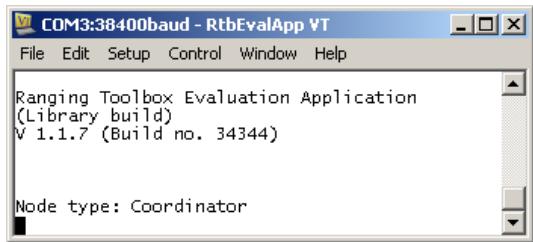
Baud rate: 38400, Parity: None, Data Bits: 8, Stop Bits: 1, Flow Control: OFF

5.5 Ranging application usage

5.5.1 Start screen

A successful setup configuration is checked as follows. Power cycle the *Coordinator* node connected to the host-PC and observe the print-out in the terminal application. The content should look like Figure 5-4.
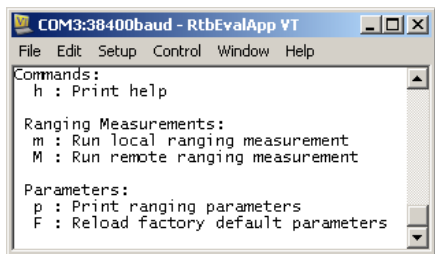
Figure 5-4. RTB Eval App – start screen.

5.5.2 "h" – Help menu

By pressing character "*h*", a help menu is listed. Commands are provided to initiate a ranging measurement, to display and modify system parameters.

Figure 5-5. RTB Eval App – help screen.

The options displayed are explained in Table 5-2.
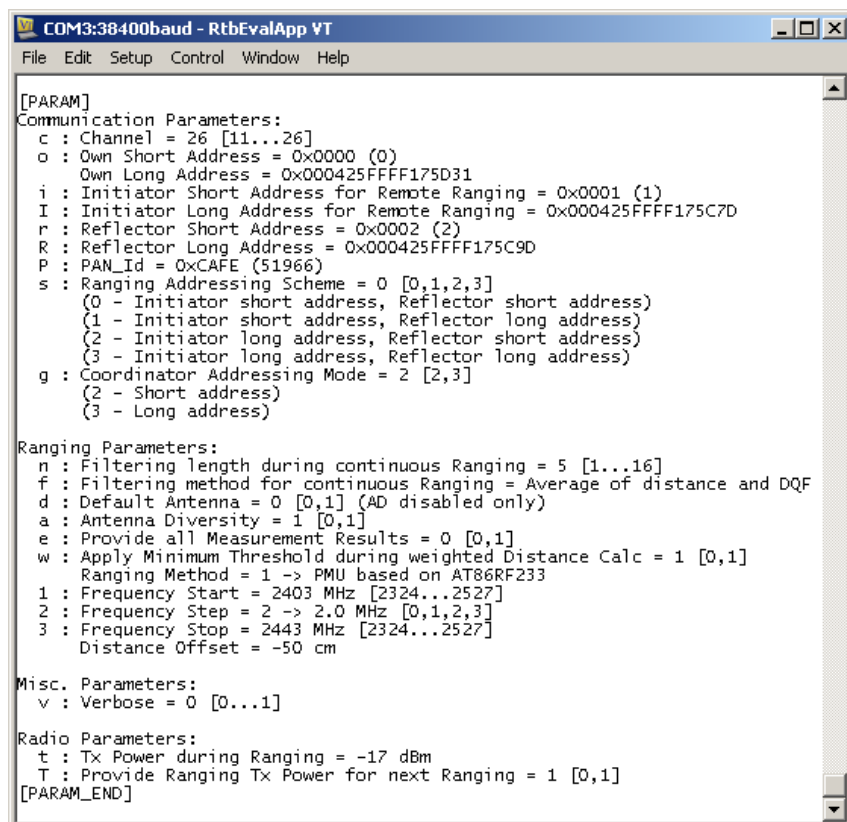
Table 5-2. Help Menu Description

Command	Description	Comment
h	Show help	
m	Start local ranging	Peer-to-peer ranging between this node (i.e. *Coordinator*) and the node defined as *Reflector* ("r" or "R"), Section 5.5.4
M	Start remote ranging	Ranging between two nodes which addresses are to be defined by "*Initiator* for Remote Ranging" ("i" or "I") and *Reflector* ("r" or "R") , Section 5.5.3
p	Ranging parameters	Refer to Section 5.5.3
F	Reload factory default parameters [1]	Restore factory settings and reload parameter set to default values

Note: 1. Pressing "F", all configurable parameters are reset to default. To continue with ranging measurements, at least node address configuration is required as explained in Section 3.1.

5.5.3 "p" – Ranging Parameters

The *Ranging Parameters Menu* lists, and allows modification of, system and ranging measurement parameters. Pressing the appropriate character, for example "*c*" to change the channel, displays a comment and requires an appropriate entry.

Figure 5-6. RTB Eval App – parameter screen.

The options displayed are explained in Table 5-3.

Table 5-3. Parameter menu description (example *Coordinator*).

Command	Description	Default [1]	Comment
Communication parameters			
c	Channel	26	IEEE802.15.4 channel for basic communication between nodes [11, 12, … 26]
o	Own Short Address	0x0000	Node Short Address [1]; Used in case of local ranging and the Ranging Addressing Scheme (s) is set to use Short Address for the *Initiator*, or in case or remote ranging and the *Coordinator* Address Mode (g) indicates the utilization of the Short Address
	Own Long Address	Actual MAC address of node	Node Long Address (Fixed) Used in case of local ranging and Ranging Addressing Scheme (s) is set to use Long Address for the *Initiator*, or in case or remote ranging and the *Coordinator* Address Mode (g) indicates the utilization of the Long Address

Command	Description	Default [1]	Comment
i	*Initiator* Short Address for Remote Ranging	0x0001	*Initiator* Short Address [1] during a remote ranging; Used if Ranging Addressing Scheme (s) indicates the utilization of the Short Address for the *Initiator*
l	*Initiator* Long Address for Remote Ranging	0x000425FFFF175C7D	*Initiator* Long Address [1] during a remote ranging; Used if Ranging Addressing Scheme (s) indicates the utilization of the Long Address for the *Initiator*
r	*Reflector* Short Address	0x0002	*Reflector* Short Address [1] for local or remote ranging; Used if Ranging Addressing Scheme (s) indicates the utilization of the Short Address for the *Reflector*
R	*Reflector* Long Address	0x000425FFFF175C9D	*Reflector* Long Address [1] for local or remote ranging; Used if Ranging Addressing Scheme (s) indicates the utilization of the Long Address for the *Reflector*
P	PAN-Id	0xCAFE	PAN-Id of ranging network
s	Ranging Addressing Scheme	0	Utilized Ranging Addressing Scheme [0,1,2,3] during the ranging procedure: 0 - *Initiator* short address, *Reflector* short address, 1 - *Initiator* short address, *Reflector* long address, 2 - *Initiator* long address, *Reflector* short address, 3 - *Initiator* long address, *Reflector* long address
g	*Coordinator* Addressing Mode	2	Utilized *Coordinator* Addressing Mode [2,3] during a remote ranging procedure: 2 - Short address, 3 - Long address
Ranging parameters			
n	Filtering length during continuous Ranging	5	A value > 1 starts a continuous ranging (*rangefinder*) with a filter depth of n, n=5 is recommended if n!=1, [1, 2, …, 5, …16] Stopped by entering 'm', 'M'
f	Filtering method for continuous Ranging	0	Filtering method applied during continuous ranging (n!=1), [0…4]: 0: Average of distance and DQF 1: Median of distance and DQF 2: Minimum of distance and DQF 3: Minimum of distance and DQF considering variance 4: Maximum of distance and DQF
d	Default Antenna	0	Utilized Default Antenna in case Antenna Diversity is switched off [0,1]
a	Antenna Diversity	1	Utilization of Antenna Diversity if supported by the PAL [0, 1]
e	Provide all Measurement Results	0	Display compact or full result set (distance and DQF) [0, 1]: 0 – The final result set only is displayed. 1 – In addition, if antenna diversity is utilized for at least one node, each individual antenna combination result set is shown. Either two or four additional result sets are displayed if one or both nodes operate antenna diversity.
w	Apply Minimum Threshold during weighted Distance Calculation	1	Enables or disables application of the minimum threshold during weighted distance calculation

Command	Description	Default [1]	Comment
1	Frequency Start	2403	Ranging measurement start frequency in MHz [2324 ... 2527]
2	Frequency Step	2	Ranging measurement frequency step mapping [0…3]: 0: 0.5MHz 1: 1.0MHz 2: 2.0MHz 3: 4.0MHz
3	Frequency Stop	2443	Ranging measurement stop frequency in MHz [2324 ... 2527]
0 [2]	Distance Offset	-50	Static distance offset in cm to handle different delay caused by external circuitry connected to the SMA port, examples are different antennas, cable, RF front-end; not saved in non-volatile memory
Miscellaneous parameters			
v	Verbose level [3]	0	Display additional result data; [0, 1]
Radio Parameters			
t	Tx Power during Ranging	-17	TX Power in dBm utilized during the actual ranging measurement cycle; [-17…4]
T	Provide Ranging Tx Power for next Ranging	1	If set, own 'Tx Power during Ranging' is applied to peer node during the actual ranging procedure; [0, 1]

Notes:
1. Default settings are defined to simplify the startup with the RTB Eval App. However, a reset to factory default parameters '*F*' causes the addresses and other parameters to be reset. To continue working with the setup, at least an address configuration according to Section 5.3 is required.
2. Default firmware delivery does not allow parameter modification. However, a recompiled firmware using Makefile parameter DEBUG set to 1 provides access to Distance Offset parameter (0) to handle different RF front-end hardware configurations, refer to [5].
3. Ineffective at the *Coordinator* node during remote ranging.

Important: Any parameter modification is automatically stored in the EEPROM. The ranging application requires at least two or three individually configured nodes, each with a unique own short or long address, refer to Section 5.3. A reset to factory default parameters deletes any address setting; however, a setting can be recovered using the above described methods.

5.5.4 RTB measurement examples

5.5.4.1 Continuous remote ranging

Initiating a remote ranging measurement (press '*M*'), and using the default configuration of the RTB Eval App application example, starts a continuous remote ranging procedure.

**Figure 5-7.   Result printout – continuous remote ranging.**
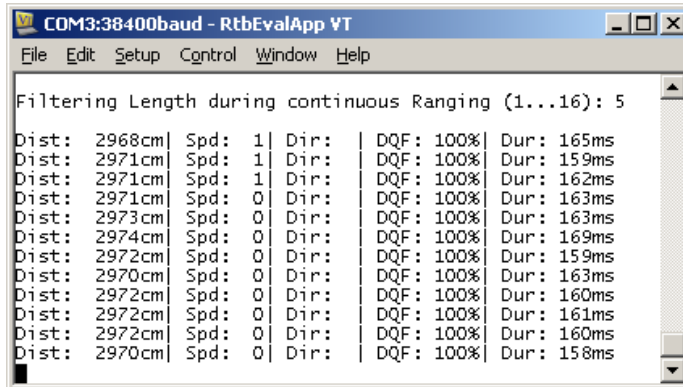
The distance is evaluated continuously, post-processed applying a basic filter method (parameter '*w*', '*f*') and displayed. Additional parameters like 'Spd', 'Dir', 'DQF', 'Dur' and 'Err' are explained in Section 6.2, see `rangefinder()` command.

The continuous ranging procedure is stopped by pressing '*m*', '*M*'.

5.5.4.2 Single remote ranging

A single remote ranging measurement requires setting parameter '*n*' to 1. A measurement is initiated by pressing '*M*'.

Figure 5-8.   Result printout – single remote ranging.
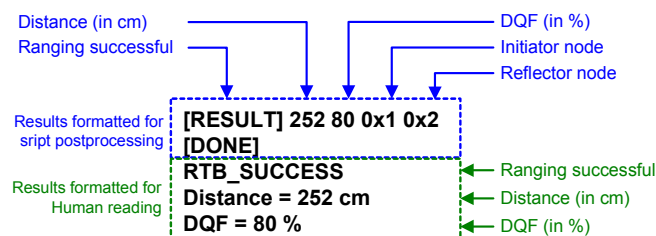
The terminal result printout shows the distance in cm, the distance quality factor (DQF) in %, as well as the *Initiator* and *Reflector* node addresses.

The DQF characterizes the environmental conditions by evaluating and weighting antenna diversity results. A high DQF value indicates an undisturbed environment with minimal interferences and multipath, whereas a low value indicates a severe multipath and/or interferer situation during the ranging measurement. A DQF of 100% is achieved if all partial antenna diversity results are undisturbed during a measurement sequence together with a final distance deviation less than 1% between all partial antenna diversity results.

The distance is calculated in the *Initiator* node and reported back to the *Coordinator*.

5.5.4.3 Local ranging

Local ranging is similar to the examples described above, however performed between *Coordinator* and another node, either *Initiator* or *Reflector*. A local ranging measurement is initiated by pressing character '*m*'.

5.5.4.4 Detailed result view

The displayed distance (Weighted Distance) is a combination of up to four individual distance measurements of the involved wireless nodes, one for each antenna pair combination. These measurements are performed during the propriatery *Ranging Measurement* phase, see Figure 4-1.

If parameter '*e*' is set to 1, these individual distance measurement results are listed, see Figure 5-9. The knowledge of this data allows individual post-processing by an application.

Figure 5-9.   Result printout – detailed result view.
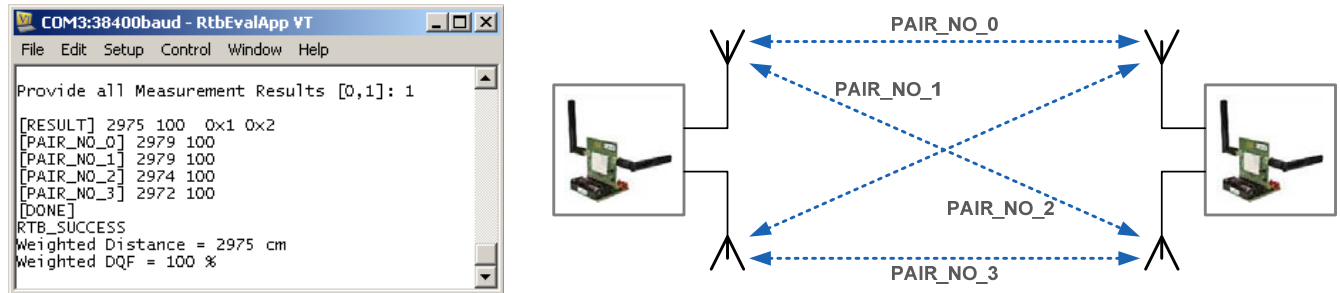
Note: Parameter '*e*' is ineffective during continuous ranging.

5.5.4.5 Error reporting

In case of a failure during the ranging procedure, an error message printout, as shown in Figure 5-10, is provided.

Figure 5-10. Result printout – ranging procedure failed.
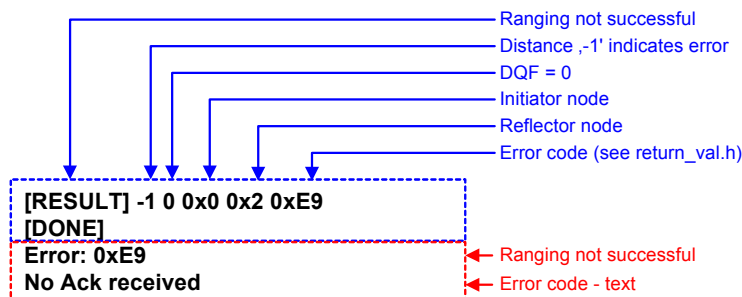
In this example the *Initiator* node is missing an acknowledgement frame from the *Reflector* node. The *Reflector* node may either switched off, set to a wrong coordination channel, or not accessible for example.

All error codes are listed in file `return_val.h`.

6. Automated Ranging Measurements

So far, manually controlled ranging measurements are performed using a host-PC terminal application. In combination with additional tools and scripts, ranging measurements are simply automated, for instance to generate series of ranging measurements in different environments and configurations.

Performing automated ranging measurements, either remote or local, Python scripts are provided to run and document ranging results.

6.1 Python tool chain and installation

The provided script requires at least the installation of Python, and additional modules. The packages can be obtained from this URL:

- Python: www.python.org/download/releases/2.6.6/
- Python for Win32: sourceforge.net/projects/pywin32/
- Python serial: pyserial.sourceforge.net/index.html
- Python readline: https://pypi.python.org/pypi/pyreadline

It is recommended to select an installation directory like `c:\Atmel\Tools\Python26\` to avoid conflicts with already existing Python installations. The Python for Win32 installation file is found following the above link and choose: `Files->pywin32->Build 214`. Select the build pywin32-214.win32-py2.6.exe supporting Python v2.6.

After successful installation of all packages, Python is ready to be used.

> Important: Ensure that the Python installation directory is added to the Environment Variable Path, see Windows®
> Device Manager (`Start->Settings->Control Panel->System->Advanced->Environment Variables`)
> and edit or add variable Path with the variable value: `%Path%;C:\Atmel\Tools\Python26\`.

6.2 Python script

To run automated ranging measurements a Python script is provided. A terminal application is no longer required and shall be closed to release the COM port. Instead, the Python uses command line instructions and must be started from a command shell.

The Python script is provided along with the RTB Eval App package.

Before start working with the python script it's strongly recommended to make a local copy of the complete RTB firmware release, e.g. into path `c:\Atmel\`, to allow saving your results and command history.

The script is started from a command shell, accessible either via `Start->Programs->Accessories->Command Prompt`, or via `Start->Run`, type `cmd` in the Open: dialog box, followed by ENTER.

If running, it's necessary to change the working directory to the RTB Evaluation Tools directory with:
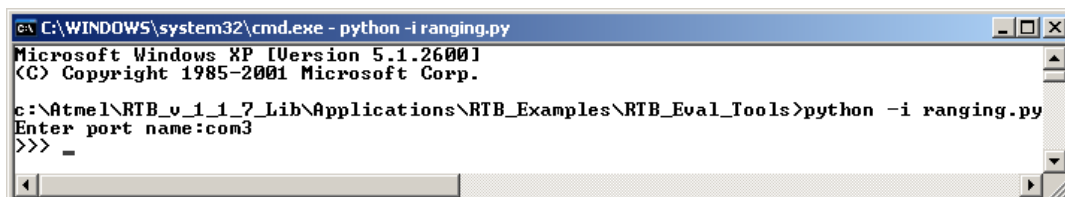
```
cd c:\Atmel\RTB_<ver>_Lib\Applications\RTB_Examples\RTB_Eval_Tools\
```

The script is started with the command:

```
python -i ranging.py
```

In consequence of, the assigned serial interface used for the *Coordinator* is requested, in this example port COM3.

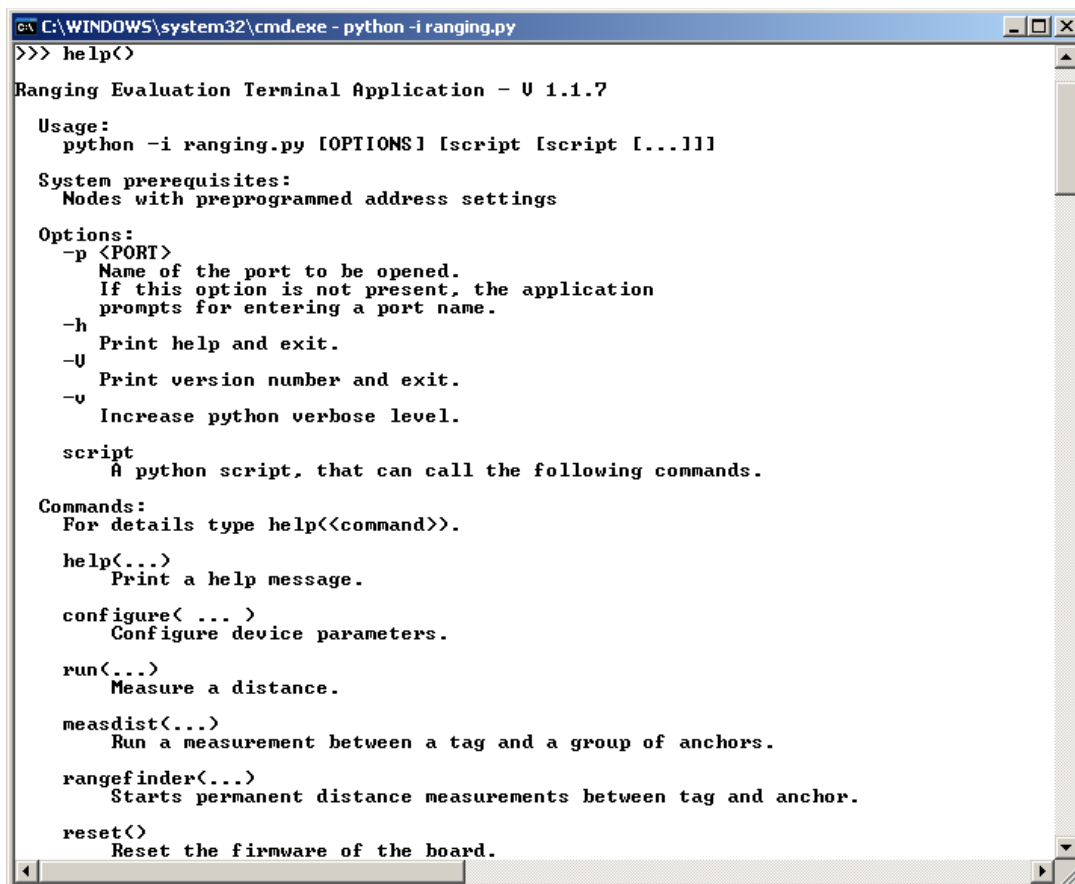**Figure 6-1.   Ranging measurement – Python interface start screen.**

A help screen, type `help()`, lists all commands provided by the script, whereas individual command options are accessible with `help(<command>)`.

Figure 6-2.   Ranging measurement – Python interface help screen.

The following interactive parameters are of interest for further usage:

- `configure()`
  - define node parameters similar to Section
- `run()`
  - start script based ranging measurement(s) and display result(s)
  - Example: `run(cnt=3, initiator=1, reflector=2)`
  - Note, the '`pp`' just improves formatting of the displayed result
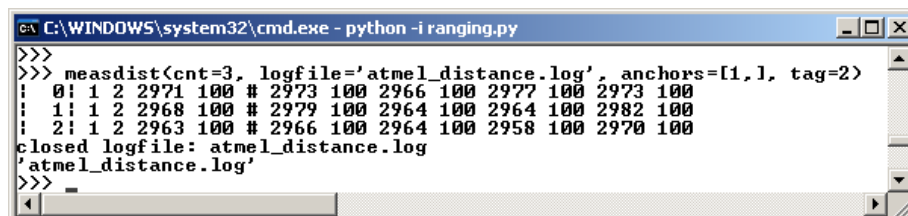
Figure 6-3.   Python interface – run(<options>) command.

This example illustrates three consecutive (remote) ranging measurements with result print-out on screen.

- `measdist()`
  - start script based ranging measurement(s) between multiple nodes with logging capabilities
  - Example: `measdist(cnt=3, logfile="atmel_distance.log", anchors=[1,], tag=2)`

Figure 6-4.   Python interface – measdist(<options>) command.

In contrast to the `run()` command, `measdist()` initiates a number `cnt` of consecutive ranging requests between several nodes (anchor(s) and tag, or *Initiator* or *Reflector*, respectively). The ranging results are stored in a data log file for further processing. The data log file, in this example '`atmel_distance.log`', is stored in the working directory, and structured as follow:

- first line
  - measurement counter: | 0|
  - first ranging measurement node pair: 1 2
  - weighted distance and DQF result [cm/%]: 2971 100
  - antenna pair distance and DQF [cm/%]:   2973 100 2966 100 …
- second line

- `rangefinder()`
  - start script based continuous ranging procedure between *Initiator* and *Reflector*, stop with `Ctrl-C`
  - Example: `rangefinder()`
  - Example: `rangefinder(ln=10)` increased history

Figure 6-5.   Python interface – rangefinder(<options>) command.

In contrast to the `run()` and `measdist()` commands, `rangefinder()` permanently performs measurements and delivers results, statistics and various status information. The screen lists the following results:

- Dist: weighted distance [cm]   2971
- Spd: speed estimation   0
  - >0:   node distance increases example: 4
  - <0:   node distance increases example: -2
- Dir: direction estimation
  - node distance increases   example: L
  - node distance increases   example: A
- DQF: weighted DQF [%]   100
- Dur: measurement duration in [ms],
                 including host-PC communication and fixed delays
- Err: error indication
  - DQF below threshold   D
  - Transaction error   T
  - Measured distance larger than weighted distance   L
  - Measured distance shorter than weighted distance   S

> Ranging result accuracy depends on correct placement, antenna configuration and environmental situation. Avoid placement of ranging nodes near ground and ensure that nodes are either sufficient far away or close to reflective areas, like concrete walls, metalized areas, etc.

7. Ranging – Do's and Don'ts

To achieve best ranging results, make yourself familiar with the RTB Eval App, especially the parameter settings, see Section 5.5.3. Important parameters influencing ranging results are Frequency Start, Step, Stop, and TX Power. It's always recommended to use antenna diversity, especially operating indoor or in harsh environments.

Before starting, the interferer situation, especially Wi-Fi presence and activity, should be checked. The RTB Eval App does not incorporate means to automatically avoid such frequency bands.

A list of further recommendations is given below:

- Using suitable, performing antennas
  - Fixed nodes can be equipped with directional antennas
  - Small size antennas performing poor
- Use antenna diversity
  - At least in indoor environments
  - At least for fixed anchor nodes
- Improve effect of antenna diversity using space diversity
  - Indoor: antennas adjusted to 90° angle, e.g. one vertical, one horizontal
  - Outdoor: antennas both vertical
- Choose an optimum placement of infrastructure node(s) (*Coordinator*, *Initiator*)
  - Place infrastructure nodes near ceiling and close to walls
  - Ensure a line-of-sight (LOS) scenario with tags (*Reflector*)
  - Do not place these nodes near ground or behind objects
- Avoid placement of mobile tag node(s) (*Reflector*)
  - Near or behind electromagnetic reflective surfaces
  - Behind objects, humans, laptop screen, walls, etc.
  - Near ground or behind objects
- Apply ranging frequency management
  - Use entire ISM band and 1MHz stepping if possible (fstart=2403MHz, fstop=2481MHz, fstep=1MHz)
  - Indoor requires use of wideband ranging, but avoid ISM band parts used by Wi-Fi services
  - Outdoor operation allows usage of sub-parts of the ISM band
  - Ensure at least 15MHz bandwidth used (fstop-fstart)
  - Select frequency step 1 or 2MHz
- Use basic result filtering if possible
  - See `rangefinder()` example, Section 6.2
- Operate lowest possible TX output power
  - For indoor/office usage of lowest possible TX power (-17dBm) is recommended

Note: Automated interference mitigation is not part of the RTB Eval App. The characterization of the entire ISM band to detect and avoid channels and ISM sub-bands occupied by other services, like Wi-Fi, Bluetooth®, IEEE802.15.4/ZigBee, cordless phones, etc., has to be implemented by the application.

8. Reference Design Note

A customized design has to follow design recommendations given in application notes [7] and related documentation. To ensure correct operation of the RTB library, the physical interface between AT86RF233 and ATxmega256A3 [8], as demonstrated by the REB233SMAD-EK hardware platform, is required. A modification of the pin assignment and use of a different hardware configuration causes malfunction of the ranging toolbox.

9.   Abbreviations

CBB   -   Controller Base Board

DQF   -   Distance Quality Factor

EEPROM -   Electrically Erasable Programmable Read-Only Memory

IEEE   -   Institute of Electrical & Electronics Engineers

ISM   -   Industrial, Scientific and Medical band

LED   -   Light Emitting Diode

PAL   -   PHY abstraction layer

PHY   -   Physical layer

PMU   -   Phase Difference Measurement Unit

RF4CE   -   Radio Frequency for Consumer Electronics

RTB   -   Ranging Toolbox

10.   References

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Appendix A.   EVALUATION BOARD/KIT IMPORTANT NOTICE

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Appendix B. Revision History

Doc. Rev.	Date	Comments
8441A	02/2013	Initial public document release

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