TREK1000 User Manual

HOW TO INSTALL, CONFIGURE AND EVALUATE THE DECAWAVE TREK1000 **T**WO-WAY RANGING (TWR) **R**TLS IC **E**VALUATION **K**IT

Version 1.08

This document is subject to change without notice

DOCUMENT INFORMATION

Disclaimer

Decawave reserves the right to change product specifications without notice. As far as possible changes to functionality and specifications will be issued in product specific errata sheets or in new versions of this document. Customers are advised to check with Decawave for the most recent updates on this product.

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Caution! ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

REGULATORY APPROVALS

This TREK1000 evaluation kit based on Decawave's DW1000 IC is intended solely for use by competent engineering personnel for the purposes of evaluating the use of Decawave's DW1000 IC in wireless location and communications systems.

The TREK1000, as supplied from Decawave, has not been certified for use in any particular geographic region by any regulatory body governing radio emissions in such regions.

The TREK1000 is supplied under the following conditions: -

- The distribution and sale of the TREK1000 is intended solely for use in future development of devices which may be subject to regulations or other authority governing radio emission.
- This TREK1000 may not be resold by users for any purpose.
- The TREK1000 as supplied by Decawave may not be incorporated directly into user devices or products unless such products undergo the appropriate certification.
- Operation of the TREK1000 in the development of future devices is at the discretion of the user and the user bears all responsibility for any compliance with regulations laid down by the authority governing radio emissions in the user's jurisdiction.

All products developed by the user incorporating the DW1000 must be approved by the relevant authority governing radio emissions in a jurisdiction prior to the marketing or sale of such products in that jurisdiction. User bears all responsibility for obtaining such approval.

If the user has obtained the TREK1000 for any purpose other than those listed above the user should return the TREK1000 to the supplier immediately.

FCC NOTICE: This kit is designed to allow (i) product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and (ii) software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the conditions that this device not cause harmful interference to licensed radio stations and that this device accept harmful interference. Unless the assembled kit is designed to operate under Part 15, Part 18 or Part 95 of the FCC Rules, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under Part 5 of the FCC Rules.

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1 INTRODUCTION

The TREK1000 is an evaluation kit that allows the user to evaluate the DecaWave DW1000 IC in an RTLS environment in different use cases.

TREK stands for **T**wo-**W**ay **R**anging (TWR) RTLS IC Evaluation Kit.

The Evaluation Kit enables the user to evaluate the performance of the IC in 3 different use cases:

- Tracking
- Geo-Fencing
- Navigation

Figure 1: TREK 1000

1.1 RTLS

Real-Time Location Systems (RTLS) are used across many industrial segments e.g. factory automation, warehouse logistics, building automation, healthcare, sports.

Existing solutions (e.g. Wi-Fi, BLE, ZigBee) suffer from inaccurate location estimations, high power consumption (short battery life) and costly installations & maintenance.

Decawave provides solutions to these issues by using UWB (Ultra-Wideband) technology in a single IC. UWB-based RTLS use highly reliable time-based measurements to outperform existing solutions in terms of accuracy, reliability and cost.

Decawave supplies key RTLS enabling blocks:

- UWB IC for time-of-arrival (TOA) estimation
- 2D&3D location solver algorithm using Two-Way Ranging (TWR)
- Source code examples for driving the ARM microprocessor and User Interface (UI) used in TREK

1.2 Decawave DW1000 IC

The DW1000 is a fully integrated low power, single chip CMOS radio transceiver IC compliant with the IEEE 802.15.4-2011 ultra-wideband (UWB) standard.

- It facilitates proximity detection (1-D) to an accuracy of +/- 10 cm using two-way ranging time-of-flight (TOF) measurements.
- It facilitates real time location (2-D or 3-D) of assets to an accuracy of +/- 30 cm in x and y (and z) using either two-way ranging (TOF) measurements or one-way time difference of arrival (TDOA) schemes

- It spans 6 RF bands from 3.5 GHz to 6.5 GHz
- It supports data rates of 110 kbps, 850 kbps and 6.8 Mbps
- Its high data rates allow it to keep on-air time short thereby saving power and extending battery lifetimes
- Its ability to deal with severe multipath environments makes it ideal for highly reflective RF environments

The Decawave DW1000 is optimized for applications in Real Time Location Systems and Wireless Sensor Networks across a variety of markets including agriculture, building control and automation, factory automation, healthcare, safety & security, warehousing & logistics and a range of others.

More information can be found in the DW1000 Data Sheet and User Manual.

1.3 Use Cases & Applications

The TREK1000 can be evaluated in 3 different use cases which are applicable to real-life industrial and consumer applications.

1. Tracking Use Case: Determine location of the Tag relative to fixed Anchors. Examples include asset-tracking (healthcare, farming, logistics), factory automation.

2. Geo-Fencing Use Case: Determine when Tags enter or leave a specific perimeter/zone near an Anchor. Examples include location-based payments, personal safety (forklifts, drilling machines), child-monitoring, “secure-my-valuables” and security bubble applications.

3. Navigation Use Case: Track the 2D or 3D location of the Tag relative to fixed Anchors. Examples include robotics and human navigation.

1.4 More Information

More information about the TREK1000 and the DW1000 IC can be found in the following documentation and instructional videos:

- TREK1000 Product Brief
- TREK1000 Quick Start Guide
- TREK1000 Source Code Guide: DecaRangeRTLS PC
- TREK1000 Source Code Guide: DecaRangeRTLS ARM
- Moving from TREK1000 to a Product
- TREK1000 Setup and Installation Video
- DW1000 Data Sheet
- DW1000 User Manual

2 TREK1000 KIT CONTENTS

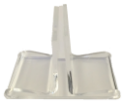
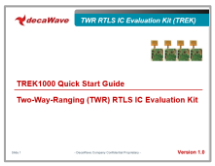
To use the TREK1000 the user needs the components of the kit box, software and documentation from the Decawave website and a few other components that are not provided for power-up and mounting.

These components are detailed below.

2.1 Supplied in the TREK1000 Box

The following items are delivered in the box when a TREK1000 kit is purchased.

Table 1: Kit Contents – In the Box

Description	Quantity	Image	Check
EVB1000 PCB	4		
UWB Antenna	4		
EVB1000 Stands	4		
DC Power Leads	4		
1.8 m USB Cable	3		
60 cm USB Cable	1		
Quick Start Guide	1		

2.2 Available from the Decawave Website

Supporting documentation, instructional videos, reference source code and the application UI should be downloaded from the Decawave website. Go to this URL to download:

http://www.decawave.com/products/TREK1000

The downloaded zip-file contains the following items: -

Table 2: Kit Contents – On the Website

Item	Description	Type	Check
Documentation			
TREK1000 Quick Start Guide	Quick Setup Instructions	pdf	
TREK1000 User Manual	Detailed description of setup, installation and usage including User Interface description	pdf	
Moving from TREK1000 to a Product	Guidance on how to proceed from evaluation to product design	pdf	
TREK1000 Expansion Options	Options for mixing TREK1000 and TREK1000 hardware to expand the system	pdf	
PC Application			
DecaRangeRTLS PC	PC Application executable	exe	

2.3 TREK1000 Source Code

TREK purchasers can get access to the ARM microcontroller source code, the PC application source code and source code documentation.

If you are interested in accessing this source code and documentation then you should login to the Decawave website (www.decawave.com) and proceed to the TREK1000 registration page at http://www.decawave.com/trekreg. If you attempt to access this registration page before you are logged in you will be redirected to the login page. Once on the registration page, you will be asked to enter the serial number of your TREK1000 which can be found on the outside of the box. Once the serial number has been verified you will be automatically redirected to the TREK source code download page. Clicking on the download will launch a disclaimer notice, which you will be asked to accept by ticking a box after which the download of the source code package will commence.

The downloaded zip-file contains the following items: -

Table 3: TREK1000 Source Code Package

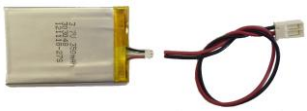
Item	Description	Type
Documentation		
TREK1000 Source Code Guide: DecaRangeRTLS PC	PC Application source code description	pdf
TREK1000 Source Code Guide: DecaRangeRTLS ARM	ARM firmware source code description	pdf
Firmware		
DecaRangeRTLS ARM	ARM firmware binary	bin
Software		
DecaRangeRTLS PC	PC Application source code	zip
DecaRangeRTLS ARM	ARM firmware source code	zip

2.4 Items Not Included in the Kit

There are other items which may be used to install and use the TREK1000. Some are required and some are useful.

These are listed in the table below.

Table 4: Kit Contents – Also Required or Useful, Not Provided

Description	Quantity	Image	Required?
PC	1	 OS should be Windows 7 or 8	Required
STM32 Virtual COM Port Driver	1	STSW-STM32102 http://www.st.com/web/en/catalog/tools/PF257938	Required
Tripods	3-4		Useful
SMA Torque Wrench	1		Recommended
Options for Powering EVB1000 Units			
USB Battery	3		
OR			
PC Connections	3		
OR			
Mobile Battery	3		
OR			
USB->Power Adaptor	3		

2.5 The EVB1000 Unit

The image below shows the key features of an EVB1000 unit.

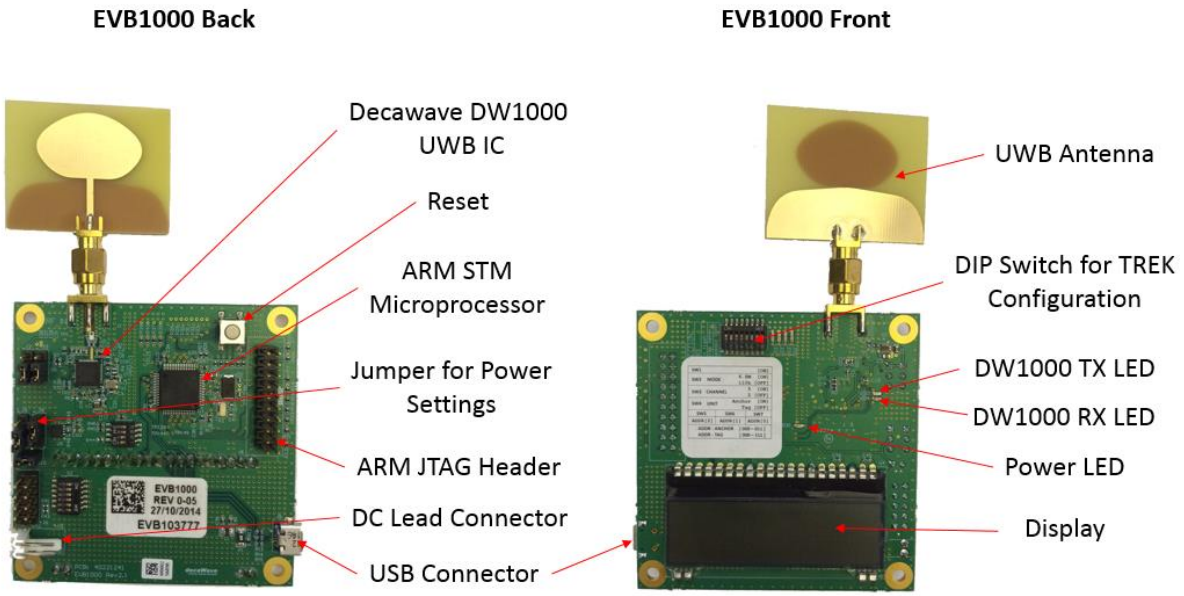


Figure 2: Back and Front Views of an EVB1000

3 TREK1000 Hardware Preparation and Setup

This section details the steps necessary to prepare the TREK1000 hardware for use.

3.1 Connect the Antenna to the EVB1000 PCB

The 4 EVB1000 PCBs come with 4 UWB (Ultra-Wideband) antennas. Each antenna must be screwed on to the EVB1000 using the SMA connector.

It is recommended that an SMA torque wrench is used to tighten the antenna to the EVB1000.

Note that poor connections can result in under performance in the system.

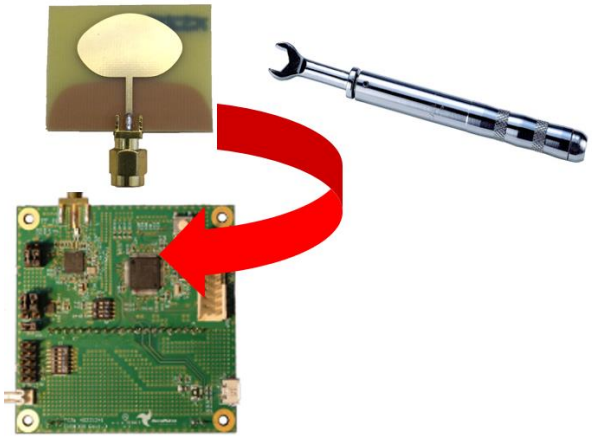


Figure 3: Connect the Antenna to the EVB1000

3.2 Mounting Option for the EVB1000 Anchors

Depending on the use case that is being evaluated, 1 or more of the EVB1000 units will be mounted.

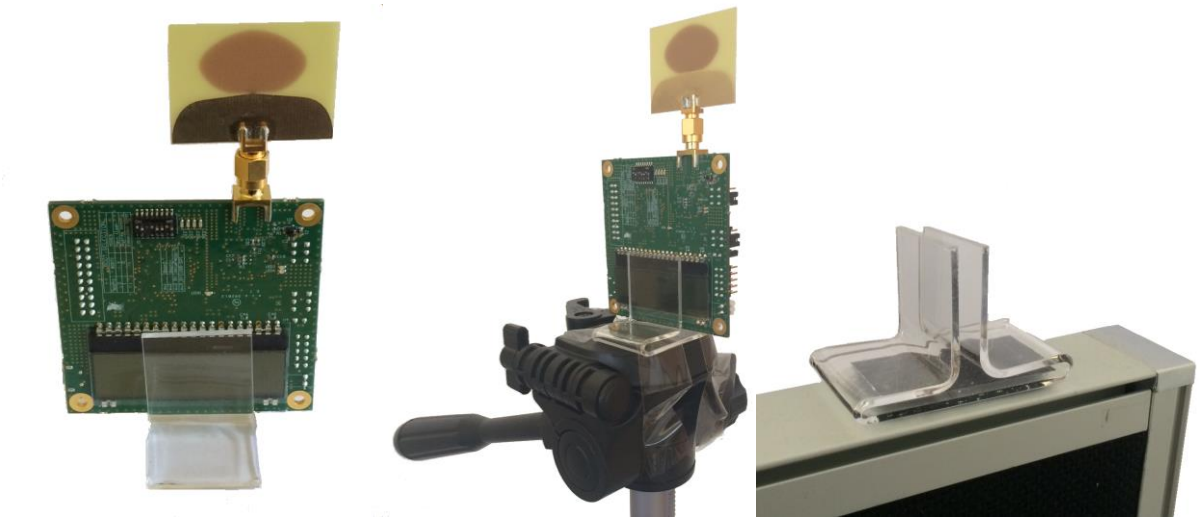


Figure 4: EVB1000 Mounting Options Using the Stands

The figure above shows the EVB1000 sitting in the stands that are provided in the box.

The stands could be attached to a tripod, an office partition or any other flat surface for the stand to sit on.

It is recommended that the stand be firmly clamped into place or fixed using tape or Velcro tape to ensure the units do not move during testing.

Figure 5: Mount EVB1000s on Tripods

When mounting the EVB1000 units **do not** place the antennas too close to walls or any other objects as this can interfere with the radiation pattern of the antennas. It is recommended that the antenna be **greater than 15 cm** away from the nearest object.

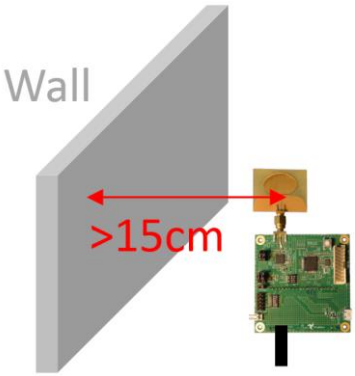


Figure 6: Do Not Place Antennas too Close to the Wall

When mounting the EVB1000 units on metal tripods or poles ensure that the top of the poles are below the ground plane of the antennas. The ground plane of the antenna is considered to be the top of the SMA connector under the antenna.

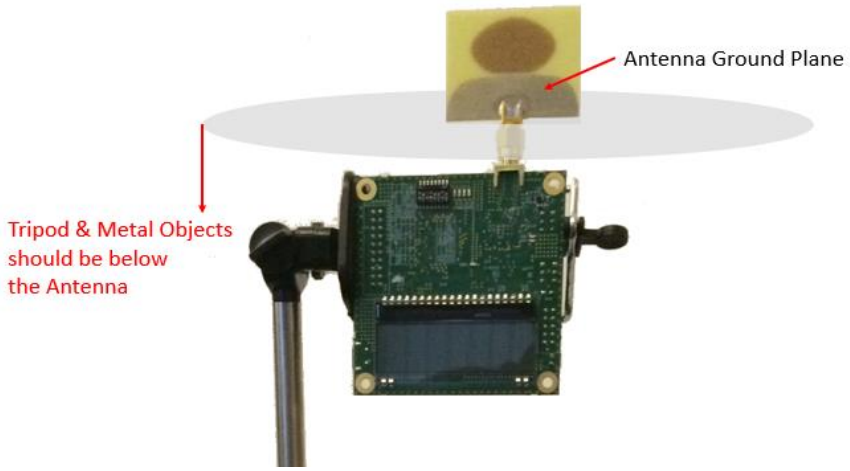


Figure 7: Keep Metal Objects below the Antenna

3.3 Powering the EVB1000

The EVB1000 can be powered either via an external DC power supply (or battery) through jumper **J7** on the back of the EVB1000 using the supplied power cable leads or via a standard 5 V 500 mA USB power supply through jumper **J5**. To change between the two, jumper **J8** is used as shown in the figure below.

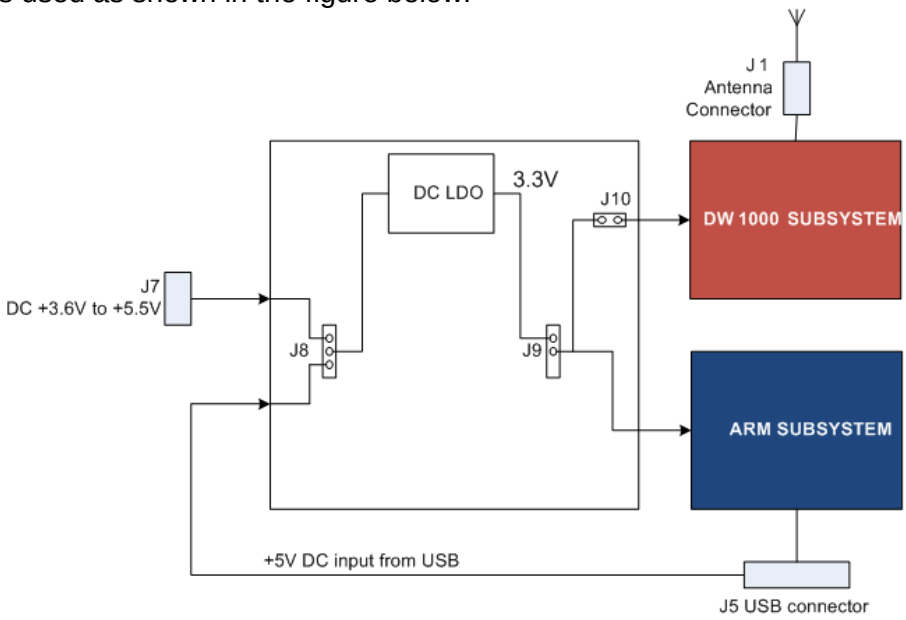


Figure 8: EVB1000 power supply options

Table 5: Power Option Settings

Power Source	J8 (Insert on pins)	Comment
USB	2 & 3	The USB port to which you connect the EVB1000 should

Power Source	J8 (Insert on pins)	Comment
		be capable of supplying at least 250 mA
3.6 V to 5.5 V	1 & 2	In this mode the externally applied supply is indirectly connected to the on-board circuitry through an LDO regulator

Changes to jumper settings should only be made with the board powered down – under no circumstances should jumper settings be changed while power is applied to the board via any of the possible off-board connectors, or damage to the board may result.

For the two power source options the positions of the jumpers are shown in Figure 9. Jumpers **J2** and **J3** can be used to select whether sections of DW1000 are powered with 1.8 V or 3.3 V, for more details on this operation see Reference [1].

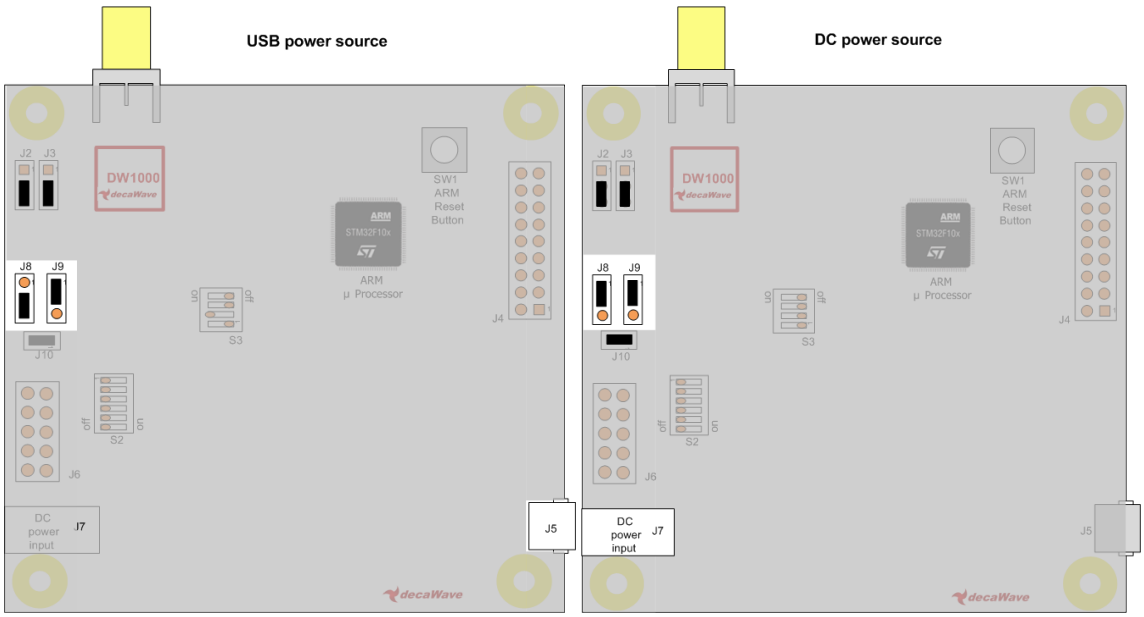


Figure 9: USB and DC 3.6V to 5.5V power source jumper connections

3.4 Configuring the EVB1000s

In the TREK1000 system there are 4 modes that can be evaluated:

Table 6: The 4 Modes of TREK1000

Mode	Mode Description	Data Rate	Channel	Location Rate	PRF	Preamble Length	Preamble Code
L2	'Long' range / Chan. 2	110 kbps	2: 3.993 GHz	3.57 Hz	16 MHz	1024	4
L5	'Long' range / Chan. 5	110 kbps	5: 6.489 GHz	3.57 Hz	16 MHz	1024	3
S2	'Short' frame / Chan. 2	6.8 Mbps	2: 3.993 GHz	10 Hz	16 MHz	128	4
S5	'Short' frame / Chan. 5	6.8 Mbps	5: 6.489 GHz	10 Hz	16 MHz	128	3

Also, each EVB1000 unit can be configured as either an Anchor or a Tag.

The configuration for each unit is set using the TREK configuration DIP switches (S1) on the PCB.

Figure 10: EVB1000 TREK Configuration DIP Switches Location

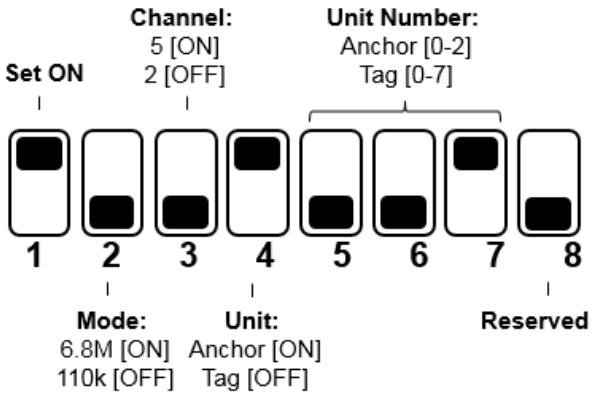


Figure 11: EVB1000 TREK Configuration DIP Switches (S1) Functions

The DIP switch settings are described in the table below.

Table 7: DIP Switch (S1) Settings on an EVB1000

Switch	Function	Function
1	Reserved	This switch should be set to ON
2	MODE	ON: Data Rate = 6.8 Mbps OFF: Data Rate = 110 kbps
3	CHANNEL	ON: Channel 5 OFF: Channel 2
4	UNIT	ON: Anchor OFF: Tag
5	UNIT ID [2]	Set the ID numbers of the EVB1000 units. Switch 7 is the LSB. ID=1 => UNIT ID[2:0] = 001
6	UNIT ID [1]	
7	UNIT ID [0]	
8	Reserved	This switch should be set to OFF

The TREK configuration DIP Switches can be found on the front of the EVB1000 unit above the display.

3.5 EVB1000 Display

When the EVB1000 is powered up there is a start-up screen appears containing the version of DecaRangeRTLS ARM software that is running on the microprocessor.

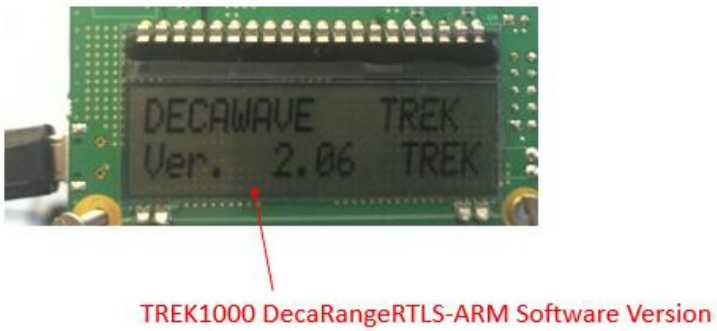


Figure 12: EVB1000 Display Startup Screen

After about 20 s the display changes to show the current operating mode and the configuration as Anchor or Tag.

Figure 13: EVB1000 Display Configuration Screen

Once the Tag and Anchors start communicating (two-way ranging) the Anchor-to-Tag measured distances appears on the display. The display will cycle through the distances from the unit with the display to the other units.

Figure 14: EVB1000 Display Ranging Screen

4 ARRANGEMENTS FOR DIFFERENT USE CASES

This section shows the arrangement of the EVB1000 units when evaluating the 3 different topologies:

1. Tracking Use Case
2. Geo-Fencing Use Case
3. Navigation Use Case

4.1 Tracking Use Case

For evaluating the tracking use case the system is configured as:

- 3 Anchors
- 1 Tag

In this case example below: Channel 2, 110 kbps is selected as the operating mode.
The 3 Anchors are configured as shown below.

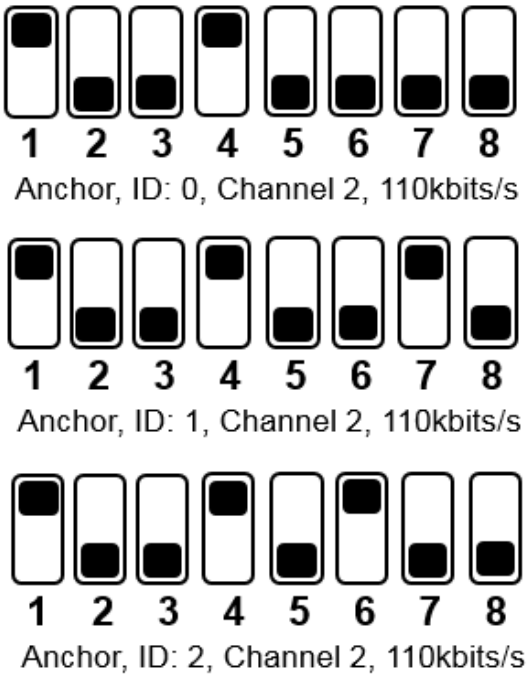


Figure 15: Tracking Use Case: Example Anchor Settings

The Tag is configured as shown below.

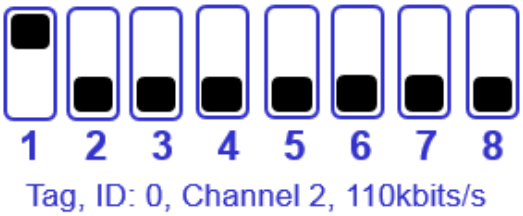


Figure 16: Tracking Use Case: Example Tag Settings

4.1.1 Arrangement

To demonstrate this use case the following setup is recommended:

- Mount the 3 Anchors at the same height
  Note: Differences in heights will result in reduced accuracy of location
- Mount the 3 Anchors high enough where there is good Line-of-Sight (LOS) with no obstructions between them e.g. mounting 2-3 m high would ensure they are above people's heads which will help avoid interference.
- Mount the 3 Anchors to create a triangle
- Ensure the antennas are >15 cm away from the nearest wall or any other objects
- Connect the PC to one of the Anchors
- Power the other 2 Anchors and the Tag using an external USB battery (or other method)

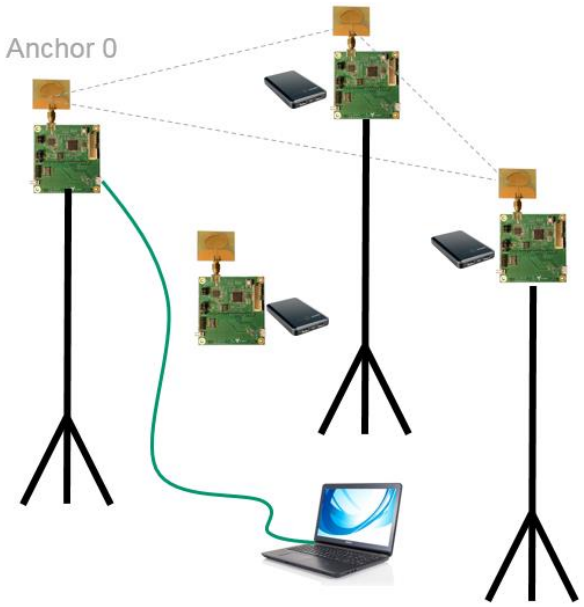


Figure 17: Tracking Use Case: Arrangement

4.2 Geo-Fencing Use Case

For evaluating the tracking use case the system is configured as:

- 1 Anchor
- 3 Tags

In this case example below: Channel 2, 110 kbps is selected as the operating mode.
The Anchor is configured as shown below.

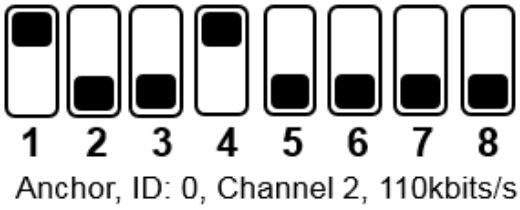


Figure 18: Geo-Fencing Use Case: Example Anchor Settings

The Tag is configured as shown below.

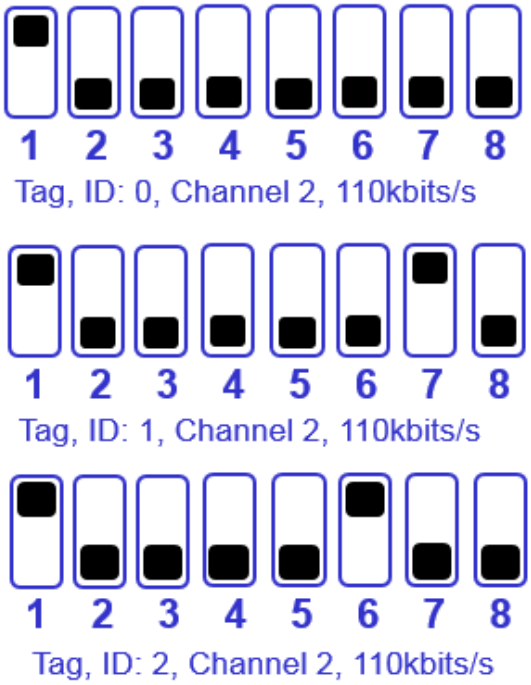


Figure 19: Geo-Fencing Use Case: Example Tag Settings

4.2.1 Arrangement

To demonstrate this use case the following setup is recommended:

- Mount 1 Anchor on a stand
- Ensure the antenna is >15 cm away from the nearest wall or any other objects
- Connect the PC to this Anchor
- Power the 3 Tags using external USB batteries (or other method)

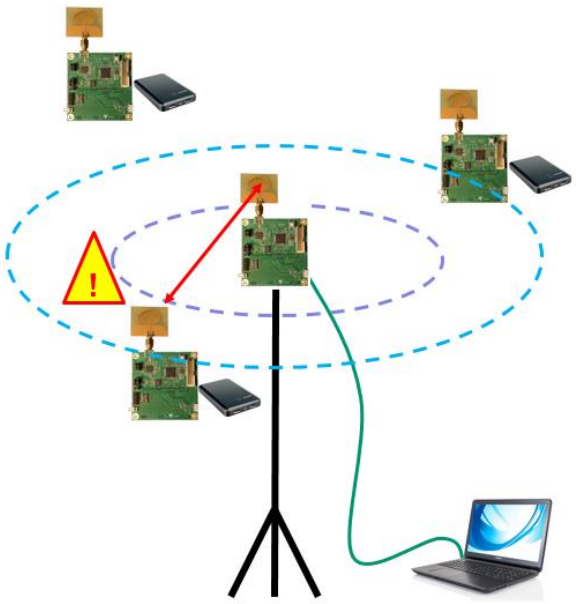


Figure 20: Geo-Fencing Use Case: Arrangement

4.3 Navigation Use Case

The setup and arrangement for the Navigation Use Case is the same as the setup and arrangement for the Tracking Use Case with the only difference being the PC is connected to the Tag rather than the Anchor.

For evaluating the tracking use case the system is configured as:

- 3 Anchors
- 1 Tag

In this case example below: Channel 2, 110 kbps is selected as the operating mode.
The 3 Anchors are configured as shown below.

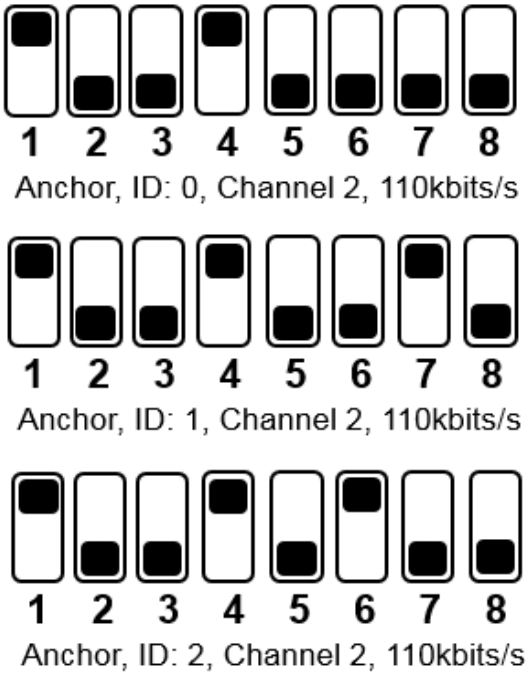


Figure 21: Navigation Use Case: Example Anchor Settings

The Tag is configured as shown below.

Figure 22: Navigation Use Case: Example Tag Settings

To demonstrate this use case the following setup is recommended:

- Mount the 3 Anchors at the same height
  Note: Differences in heights will result in reduced accuracy of location

- Mount the 3 Anchors high enough where there is good Line-of-Sight (LOS) with no obstructions between them e.g. mounting 2-3 m high would ensure they are above people's heads which will help avoid interference.
- Mount the 3 Anchors to create a triangle
- Ensure the antennas are >15 cm away from the nearest wall or any other objects
- **Connect the PC to the Tag**
- Power the 3 Anchors using external USB batteries (or other methods)

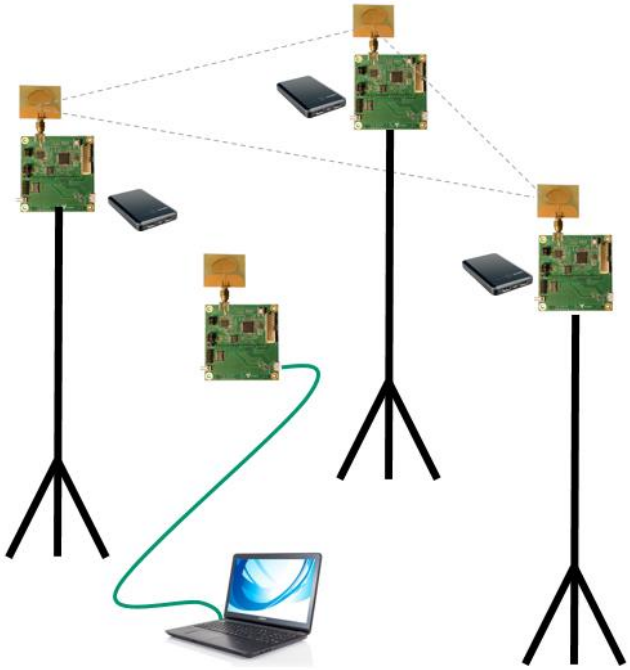


Figure 23: Navigation Use Case: Arrangement

5 TREK1000 SOFTWARE PREPARATION AND SETUP

This section details the software required to use the TREK1000.

5.1 Install the ST ARM USB Driver

In order to use the TREK1000 DecaRangeRTLS PC software the STM32 Virtual COM Port Driver must first be downloaded and installed from:

http://www.st.com/web/en/catalog/tools/PF257938

This enables the PC to communicate with the EVB1000 units.

Note: After this driver has been downloaded please ensure to read the included readme.txt as it contains further installation instructions.

5.2 Download the TREK1000 Zip-File

The TREK1000 documents and PC application can be downloaded in a zip-file from the DecaWave website: http://www.decawave.com/.

Once downloaded unzip into a folder on the PC.

The zip-file contains the following folder structure.

```
- Collateral
     -  Documents
          -  Product Brief                              .pdf
          -  Quick Start Guide                          .pdf
          -  User Manual                                .pdf
          -  Moving from TREK1000 to a Product          .pdf
          -  TREK1000 Expansion Options                 .pdf

 - DecaRangeRTLS-PC
     -  DecaRangeRTLS                                  .exe
     -  DLLs                                           .dll
     -  Configuration Files                            .xml
```

5.3 Prepare the TREK1000 Software

There is no installation sequence necessary. Launch the PC application from DecaRangeRTLS.exe in the DecaRangeRTLS-PC folder.

6 THE USER INTERFACE

This section describes the TREK1000 User Interface and usage.

6.1 Launch the User Interface

Connect the PC to Anchor 0 using any of the USB cables. Ensure the LEDs on Anchor ID turn on and the TREK software message appears on the EVB1000 display.

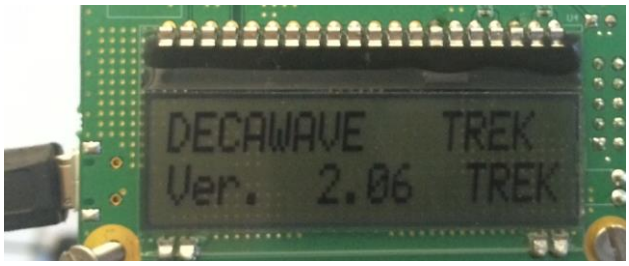


Figure 24: User Interface: Startup Message

Note that this Anchor is powered directly from the USB connection to the PC – no external power source is required.

Launch the PC application from DecaRangeRTLS.exe. This can be found in the DecaRangeRTLS-PC folder.

If there is no USB connection from the PC to Anchor 0 the following error message will appear.

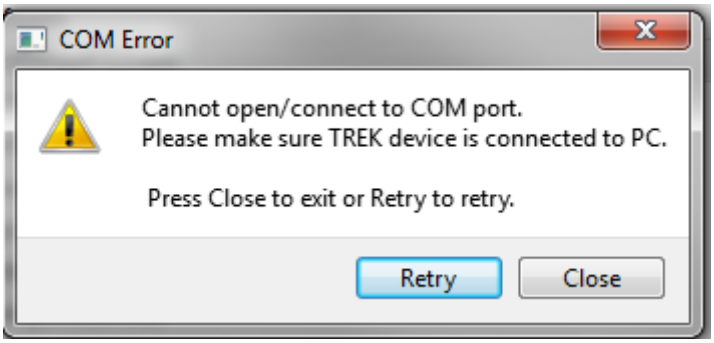


Figure 25: User Interface: Startup – Error Message

In this case, make the connection to the EVB1000 unit, wait about 20 s and then click OK.

If problems persist then it may be necessary to modify the order in which COM port numbers are assigned in the PC.

To do this, go to Device Manager -> Ports (COM and LPT), and see which devices are assigned to which COM ports.

Select "STMicroelectronics Virtual COM Port (COMx)", and right click into “Properties”. Select the “Port Settings” tab and click “Advanced”. Modify the COM port number associated with this port. The chosen port number should be lower than all other assigned ports and should be in the range 3 to 49.

If you are unsure how to do this or if problems persist contact your IT administrator.

6.2 User Interface: Startup

When the DecaRangeRTLS PC User Interface is first launched there will be 4 different panes and a menu bar visible:

1. Anchor Table Pane
2. Tag Table Pane
3. Settings Pane
4. Display Pane
5. Menu Bar

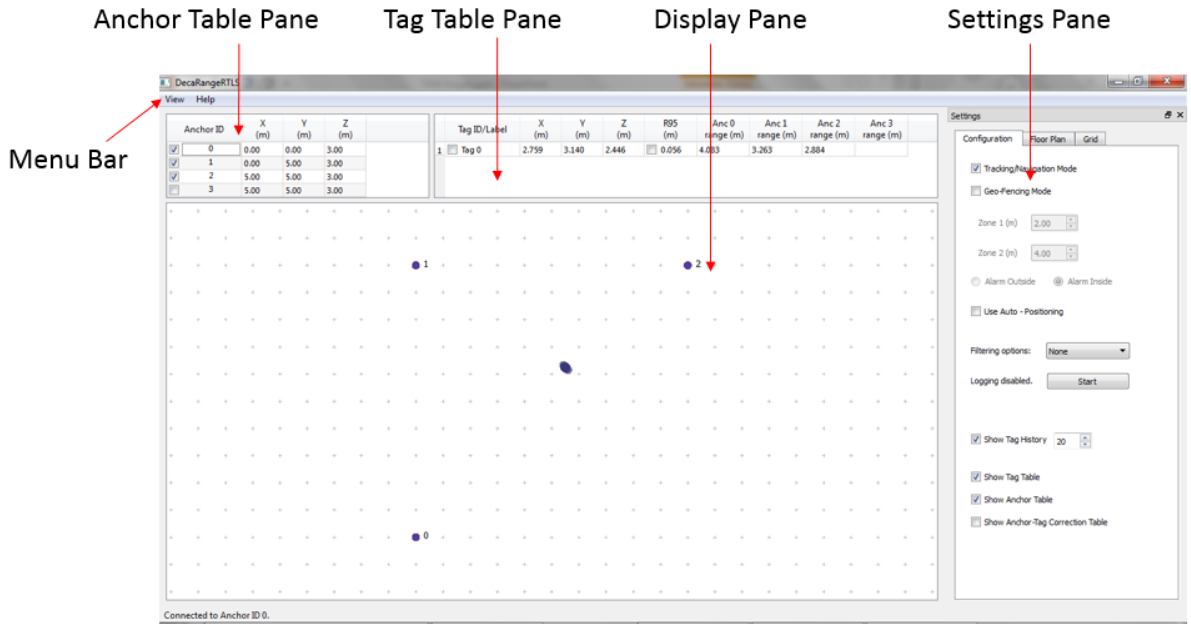


Figure 26: User Interface: Startup View

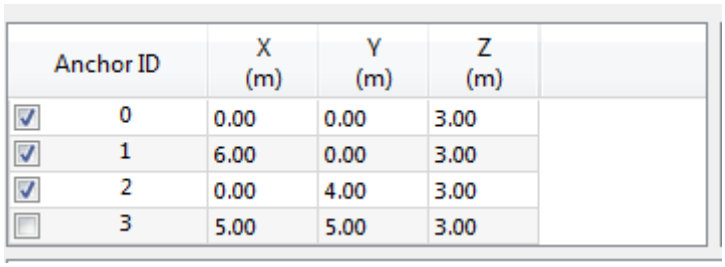
6.3 Anchor Table Pane

The Anchor Table Pane lists the Anchors and the coordinates of the locations where they were placed for the testing session.

For ease of use, it is recommended to put Anchor 0 in the (0, 0) x-y position. The user should then manually enter the X, Y locations of the Anchors 1 and 2 relative to (0, 0).

The user should enter the height (z) of the Anchors. The User Interface only allows a single value to be entered for all Anchors (for the first 3 Anchors) to remind the user that the Anchors should be placed at the same height.

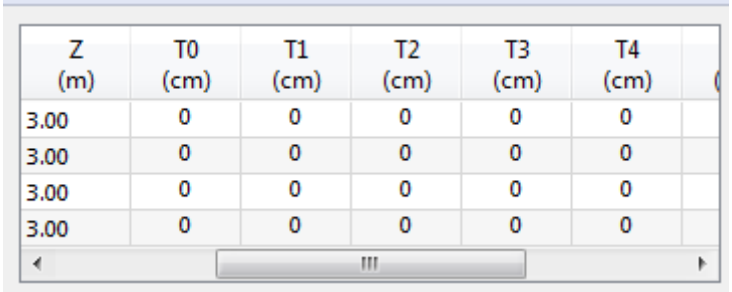
Note: The accuracy of the Tag location and tracking algorithm is strongly dependent on the accuracy of the positioning (x, y and z) of the Anchors during setup so it is recommended to take care during the setup stage. Differences in Anchor heights will result in reduced accuracy of location.



Anchor ID	X (m)	Y (m)	Z (m)
0	0.00	0.00	3.00
1	6.00	0.00	3.00
2	0.00	4.00	3.00
3	5.00	5.00	3.00

Figure 27: User Interface: Anchor Table Pane

If 'Show Anchor-Tag Correction Table' is checked in the Settings:Configuration Pane, then a table of manual adjustments appears so users can make manual location adjustments to the Tag positions. This functionality is not necessary for TREK kits and the user should ensure the values are all 0.



Z (m)	T0 (cm)	T1 (cm)	T2 (cm)	T3 (cm)	T4 (cm)
3.00	0	0	0	0	0
3.00	0	0	0	0	0
3.00	0	0	0	0	0
3.00	0	0	0	0	0

Figure 28: User Interface: Anchor Table Pane

6.4 Tag Table Pane

The Tag Table Pane displays information about the tags that are currently being tracked.

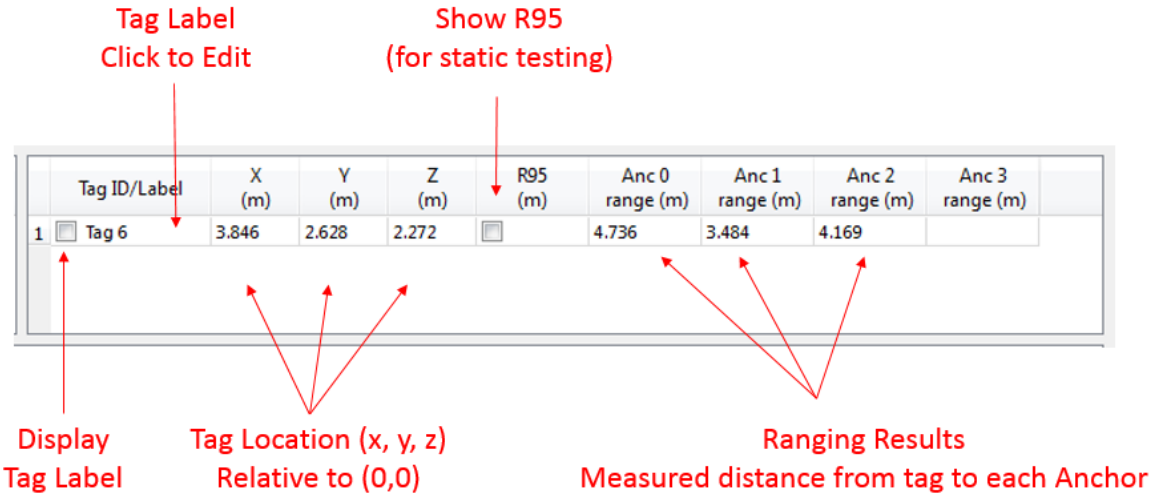


Figure 29: User Interface: Tag Table Pane – Tracking/Navigation Mode

The Tag Table Pane shows slightly different information whether the system is in Tracking/Navigation Mode or Geo-Fencing Mode.

Figure 30: User Interface: Tag Table Pane – Geo-Fencing Mode

The field in the Tag Table Pane are:

- Tag ID/Label — Show/Hide the Tag label on the Display
  Customize the label text – click on the label to edit
- X (m) — The x distance of the Tag from position (0, 0)
- Y (m) — The y distance of the Tag from position (0, 0)
- Z (m) — The z distance of the Tag from the ground
  Requires the Anchor heights to be entered correctly
- R95 (m) — A measurement of precision of a Tag
  Only meaningful for stationary Tags
  Enable or disable this calculation
- Anc 0 range (m) — Measured distance between antennas of Anchor 0 and Tag
- Anc 1 range (m) — Measured distance between antennas of Anchor 1 and Tag
- Anc 2 range (m) — Measured distance between antennas of Anchor 2 and Tag
- Anc 3 range (m) — Measured distance between antennas of Anchor 3 and Tag
  A 4th Anchor is not required in the standard TREK setup

6.5 Settings Pane

The settings pane appears to the right of the User Interface and has 3 tabs:

1. Configuration Tab
2. Floor Plan Tab
3. Grid Tab

6.5.1 Configuration Tab

The configuration tab contains general settings for use case modes and showing/hiding features.

- Switch between ‘Tracking/Navigation’ mode and ‘Geo-Fencing’ mode using the checkboxes
- In Geo-Fencing mode:
  - Set 2 zone perimeters on the Display Pane – enter the desired perimeters in metres
  - Select ‘Alarm Outside’ or ‘Alarm Inside’ depending on whether the no-go area is far from or near to the Anchor
- Use Auto-Positioning:
  - When ‘Use Auto-Positioning’ is checked, the system ignores the x, y anchor co-ordinates that the user has entered and automatically calculates the positions of the anchors.

- Anchor 0 and Anchor 1 are positioned on the x-axis and Anchor 2's position is calculated and positioned relative to them.
- The system continuously auto-positions and tunes the locations, so after the locations have settled the user should uncheck the 'Use Auto-Position' checkbox to freeze the anchor locations.
- While Auto-Positioning is enabled the user cannot write x, y values into the grid locations of Anchors 0, 1 or 2

- Some basic filtering options are provided as an example
  - None No filtering is applied
  - Moving Average A length 10 moving average filter is applied
  - Moving Avg. Ex. A length 10 moving average filter, excluding min value and max value before averaging) is applied

- Logging Enable/Disable:
  - Enable or Disable location co-ordinates estimates and Tag-to-Anchor and Anchor-to-Anchor range estimates to be written to a file
  - A unique filename is created each time it is started

- 4 User Checkboxes:
  - Show / Hide the Tag history
  - Show / Hide the Anchor Table
  - Show / Hide the Tag Table
  - Show / Hide the Anchor-Tag Correction Table

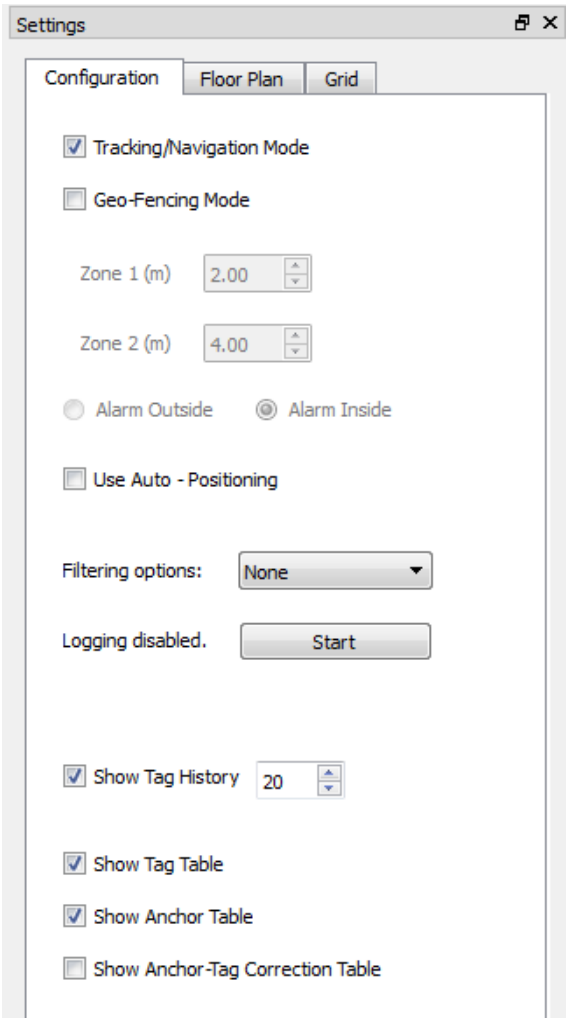


Figure 31: User Interface: Settings Pane – Configuration Tab

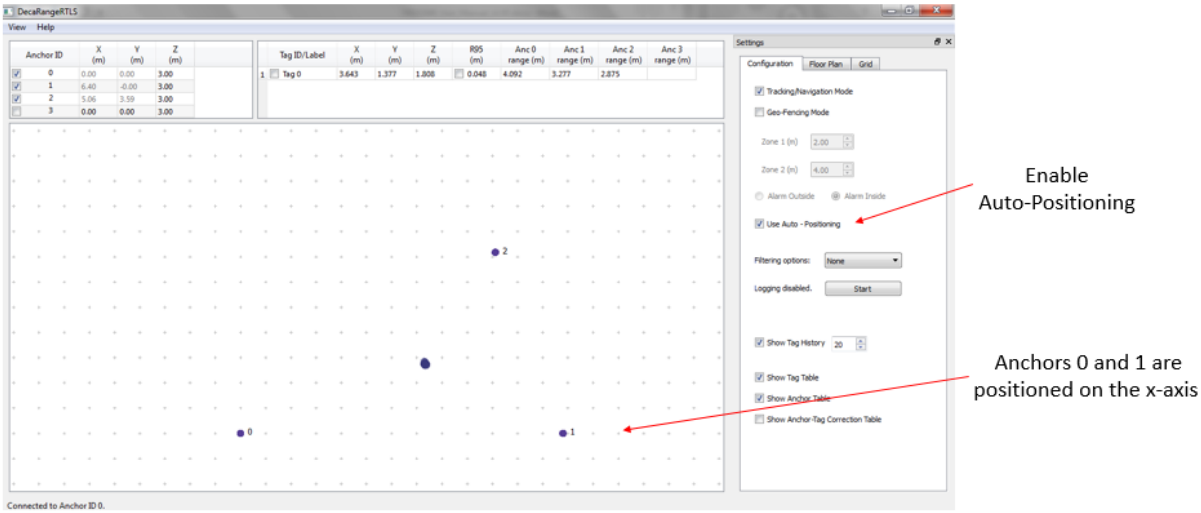


Figure 32: User Interface: Auto-Positioning

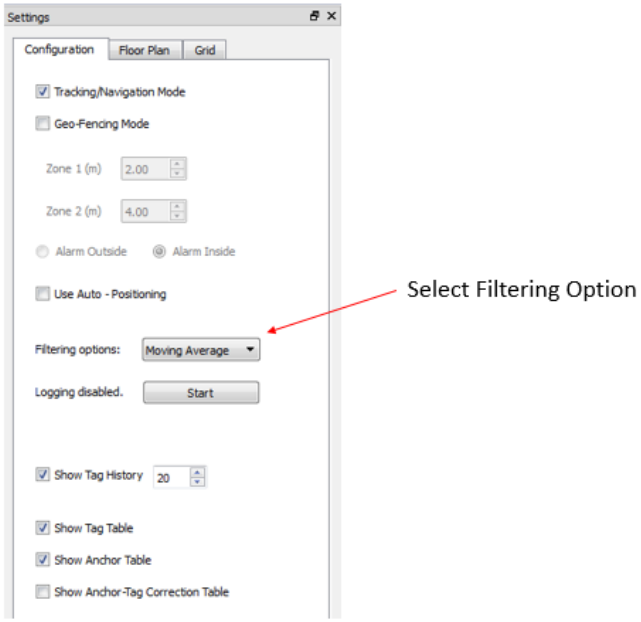


Figure 33: User Interface: Filtering Options

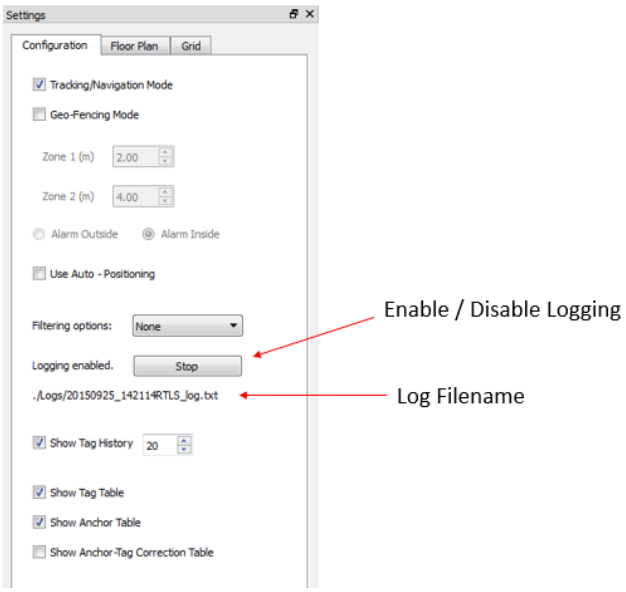


Figure 34: User Interface: Enable Location Logging

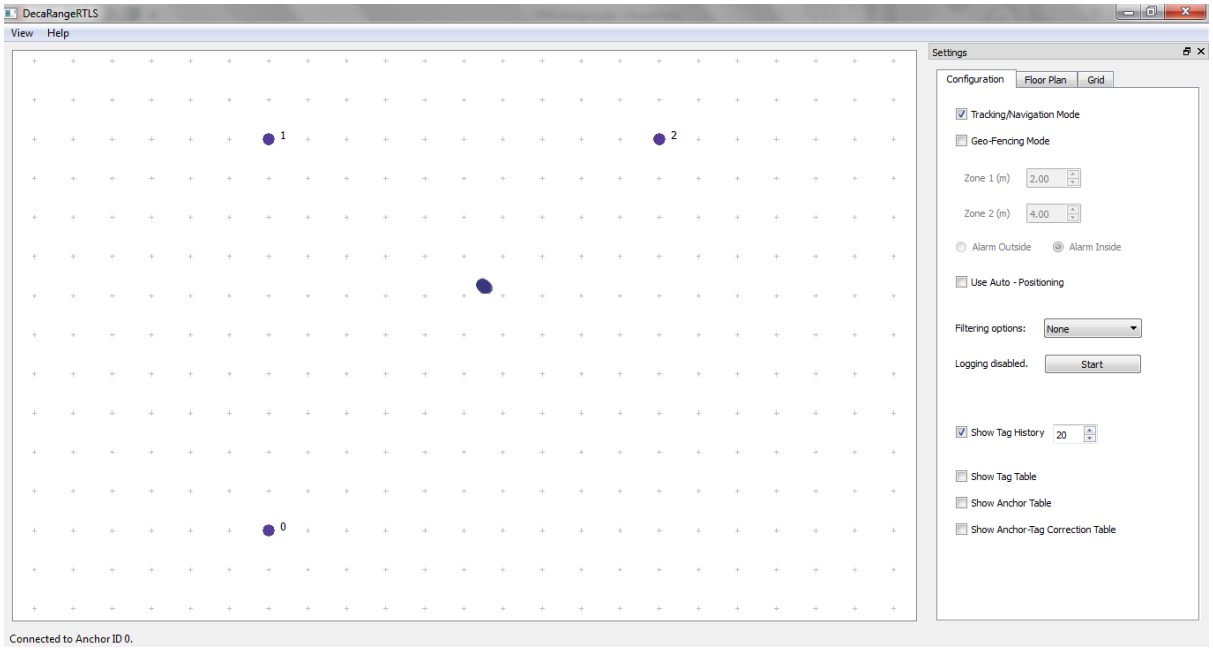


Figure 35: User Interface: Hide Anchor and Tag Table Panes

The Settings Pane can also be hidden and then the Display Pane will be full screen. Click the 'X' in the Settings Pane to remove it. To show the Settings Pane again use the View Menu to select 'Settings'.

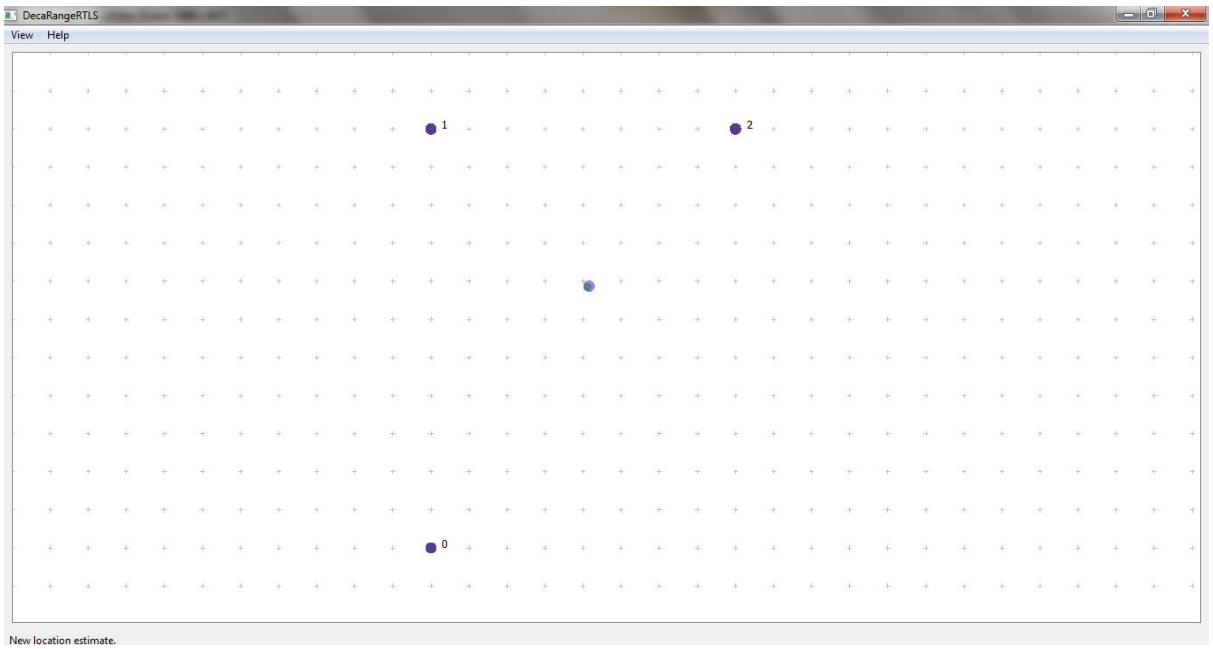


Figure 36: User Interface: Show Display Pane Only

6.5.2 Floor Plan Tab

To upload a floorplan into the User Interface click 'Open' in the Floor Plan Tab. The floorplan can be any image in .png, .jpg and .bmp formats.

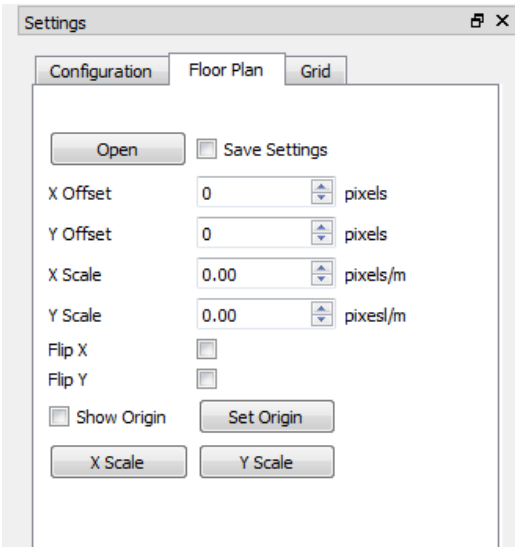


Figure 37: User Interface: Settings Pane – Floor Plan Tab

After uploading the floorplan two additional options will appear:

- Click the 'Clear' button to remove the floorplan from the GUI
- Check the 'Save Settings' checkbox to remember the settings (Floorplan filename and scaling settings). When the GUI application is closed and re-opened these settings will be automatically loaded.

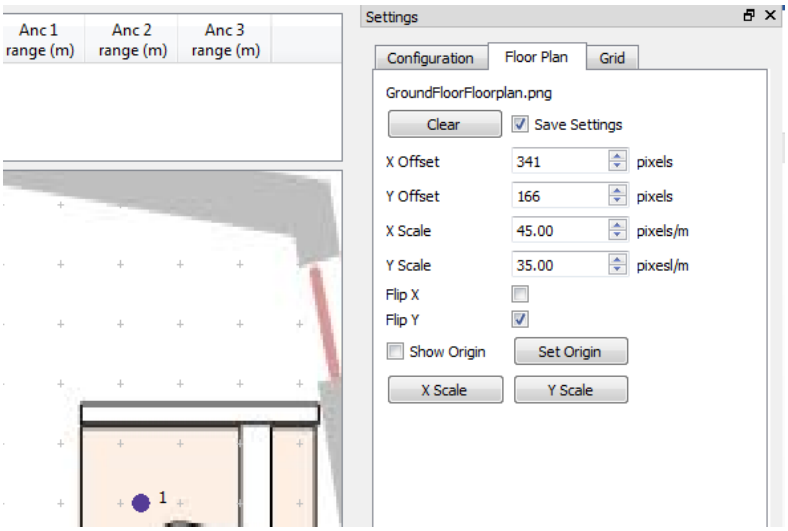


Figure 38: User Interface: Settings Pane – Floor Plan Tab – Clear & Save Settings

Once the floorplan image has been uploaded it will need to be resized, shifted and possibly flipped to align with the 3 Anchor positions in the Display Pane.

A quick way to begin is to click 'Set Origin' and then click the location on the image where Anchor 0 is placed. This automatically shifts the image so that Anchor 0 is positioned correctly. Next, use the X Scale and Y Scale fields to resize the image.

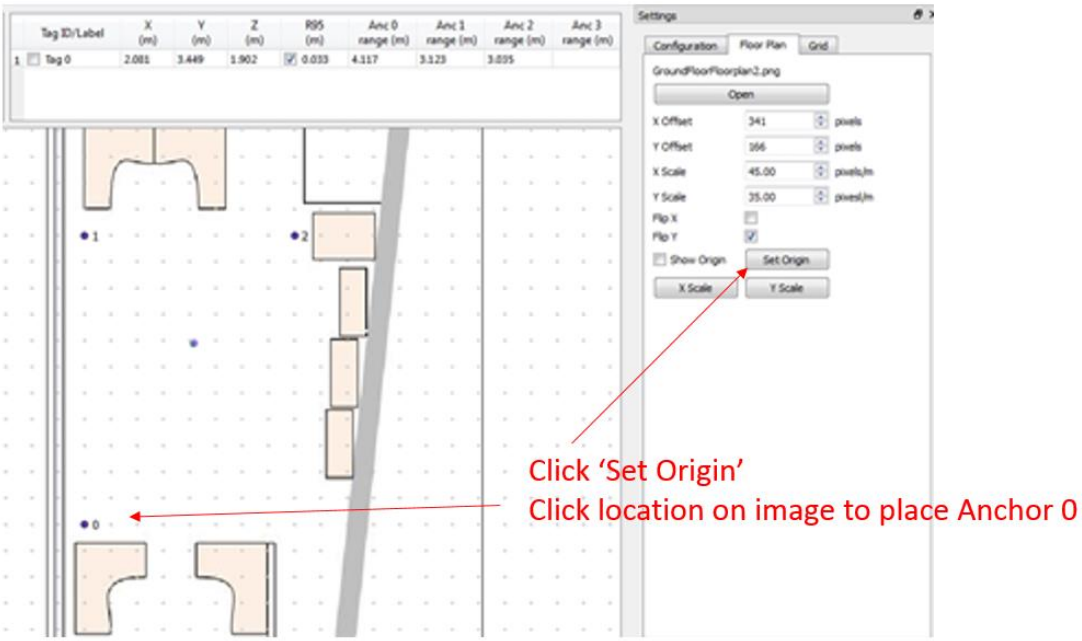


Figure 39: User Interface: Position Floorplan

These are the floorplan options:

- X Offset — X position of the origin (0,0) point from the origin of the image (i.e. bottom left hand corner) in pixels
- Y Offset — Y position of the origin (0,0) point from the origin of the image (i.e. bottom left hand corner) in pixels
- X Scale — Used to relate how many pixels (in horizontal) in the image correspond to 1m horizontal distance in reality
- Y Scale — Used to relate how many pixels (in vertical) in the image correspond to 1m vertical distance in reality
- Flip X — Flip the image along a horizontal axis
- Flip Y — Flip the image along a vertical axis
- Set Origin — Set 0,0 coordinate in the floorplan
- X Scale — Measures the x-distance between any 2 points on the display
  Select 'X Scale' and then click 2 points on the display
  The x distance between the 2 points will be displayed
- Y Scale — Measures the y-distance between any 2 points on the display
  Select 'Y Scale' and then click 2 points on the display
  The y distance between the 2 points will be displayed

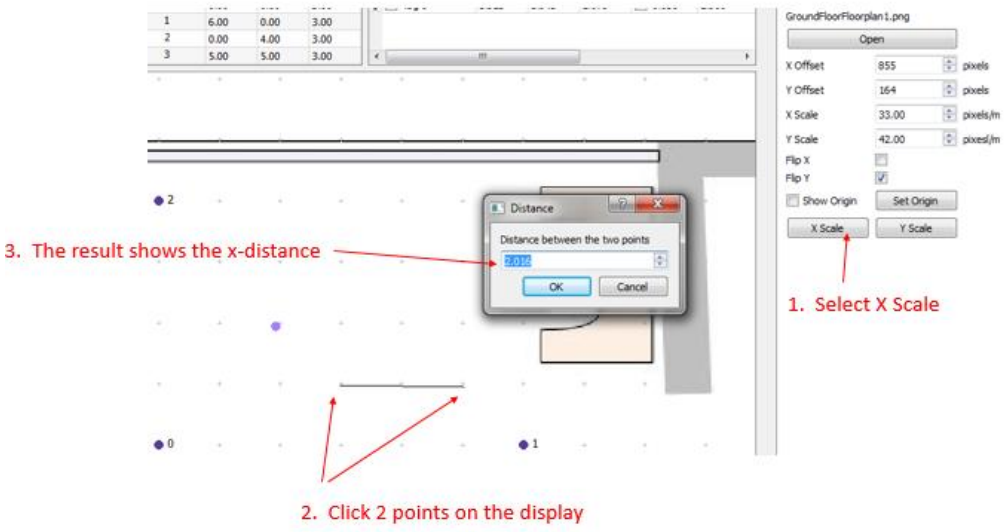


Figure 40: User Interface: Measure X-Scale on Display

6.5.3 Grid Tab

In the Grid Tab the distance between the dots shown in the Display Pane can be altered. The vertical and horizontal distances can be adjusted independently. Enter the desired distances in metres.

The grid can also be hidden or shown using the 'Show Grid' checkbox.

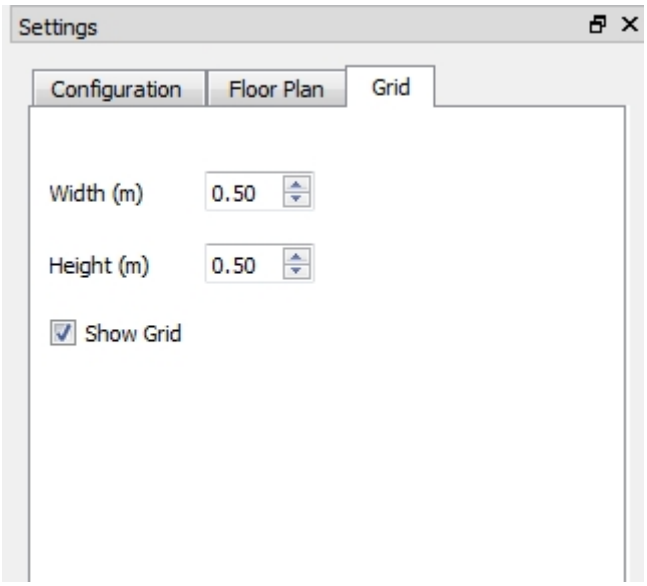


Figure 41: User Interface: Settings Pane – Grid Tab

6.6 Display Pane

The Display Pane shows the positions of the Anchors and Tags. Each Anchor and Tag can be displayed or hidden using the checkboxes in the Anchor Table Pane and the Tag Table Pane.

The Grid can be configured in the Settings Pane:Grid Tab.

The Anchor and Tag labels can be configured in the Anchor Table Pane and the Tag Table Pane.

6.7 Minimap Pane

The Minimap Pane can be made visible in the View menu. It is only operational if a floorplan has been loaded into the User Interface.

Using the mouse, the user can select different regions of the floorplan to be displayed in the Display Pane beside it.

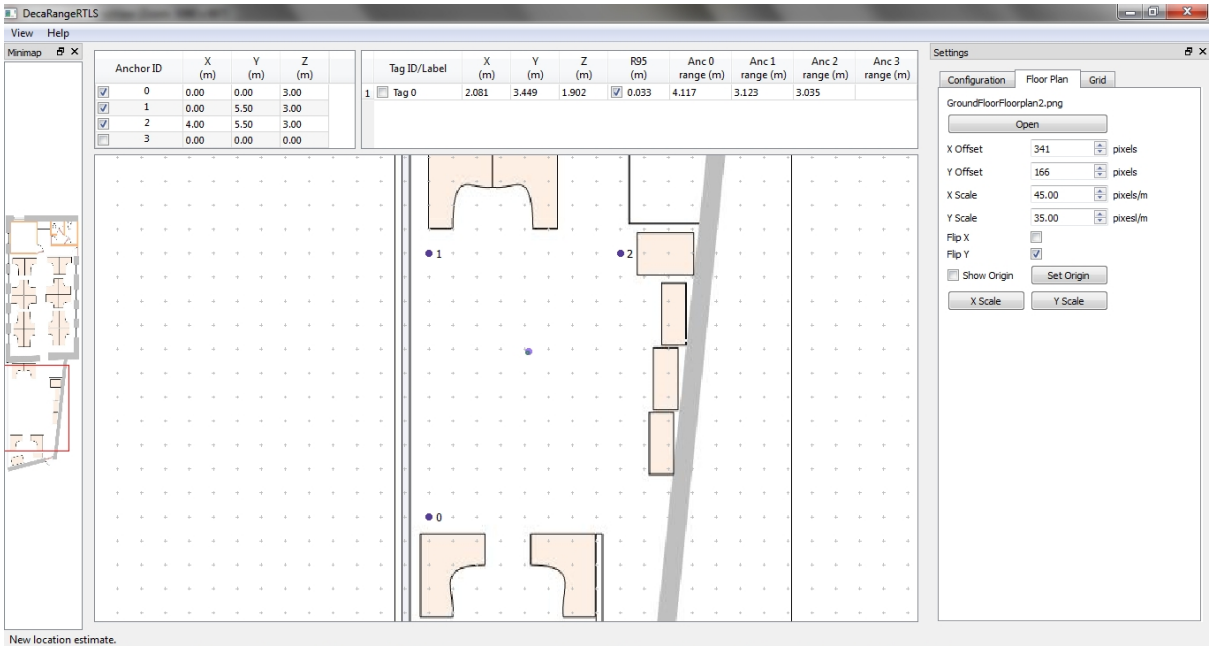


Figure 42: User Interface: Minimap Pane

6.8 Menu Bar

The DecaRangeRTLS menu options are:

- View Menu
- Help Menu

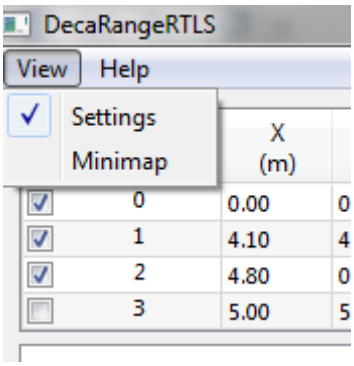


Figure 43: User Interface: Menus

6.8.1 View Menu

The View Menu contains options to enable showing or hiding of DecaRangeRTLS panes:

- Settings — Toggle between showing or hiding the Settings Pane
- Minimap — Toggle between showing or hiding the Minimap Pane (this is only operational if a floorplan has been uploaded)

6.8.2 Help Menu

The Help Menu contains an About Us message.

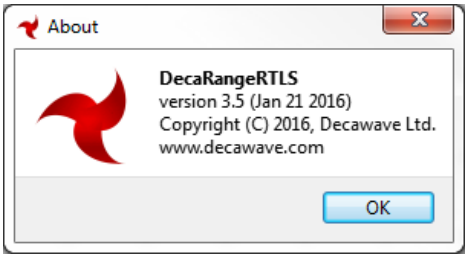


Figure 44: User Interface: About Us

7 USAGE

This section describes how to use the User Interface for evaluating the different use cases. **Note:** To change between tracking and navigation use cases the user must disconnect the USB cable from the PC, shut down the PC Application and reconnect the USB **before** restarting the PC Application.

7.1 Navigation or Tracking Use Cases

1. Configure the DIP switches on the 4 EVB1000 units[1]:
    a. Set switch 1 to [ON]
    b. Select a data rate with switch 2: 6.8 Mbps [ON], 110 kbps [OFF]
    c. Select a channel with switch 3: Channel 5 [ON], Channel 2 [OFF]
    d. Configure 3 units as Anchors: switch 4 is [ON]
    e. Configure 1 unit as a Tag: switch 4 is [OFF]
    f. Set the ID of the Tag to 0: switches 5,6 & 7 [OFF]
    g. Set the IDs of the Anchors to 0, 1 & 2: switches 5,6,7 = [000, 001, 010]
    h. Switch 8 is reserved so this can be [ON] or [OFF]
2. Mount the 3 Anchors at the same height
3. Measure the coordinates of the Anchors[3] using a laser pointer or other accurate method. Alternatively, use the Auto-Positioning feature to measure coordinates.
4. Power the Anchors and Tags using one of the following methods:
    a. USB power supply (not provided)[2]
    b. USB battery pack (not provided)
    c. Connect to a PC (not provided)
    d. Connect to a mobile battery (not provided) using the DC leads (provided)
5. Connect the PC:
    a. For Tracking Use Case: Connect Anchor 0 to the PC
    b. For Navigation Use Case: Connect the Tag to the PC
6. Wait for the start message to disappear and then the TREKs are ready (about 20 s)
7. Start the DecaRangeRTLS PC Application
    a. Check ‘Navigation/Tracking Mode’ in the Configuration Tab of Settings
8. Enter the Anchor locations into the Anchor Table Pane - note the Anchor heights (z) must be the same:
    a. Set Anchor 0 to coordinates (0, 0, z)
    b. Set Anchor 1 to measured coordinates (x1, y1, z)
    c. Set Anchor 2 to measured coordinates (x2, y2, z)
9. Track the Tag as it moves around the zone created by the Anchors

[1] **Setup Note 1**: If the system does not operate as expected when the settings of any of the DIP switches are changed it may be necessary to operate the switches a number of times. They have been known to stick and not operate correctly. Toggling them a number of times generally resolves the issue.

[2] **Setup Note 2:** Some USB battery packs **may not power** the Tag correctly. The Tag periodically goes into a sleep state before waking up to perform a two-way range and returning to sleep. During sleep the current consumption may be too low to keep the USB battery pack on and the battery may shut off. Not all battery packs turn off. For battery packs that have a torch function the user can switch the torch function on to keep the battery alive during the sleep state.

[3] **Setup Note 3:** The accuracy with which the Anchors are placed and the coordinates measured has an impact on the accuracy of the system as a whole. It is recommended to take care at this stage to ensure distances are measured correctly to ensure good performance later.

7.2 Geo-Fencing Use Case

1. Configure the DIP switches on the 4 EVB1000 units[1]:
    a. Set switch 1 to [ON]
    b. Select a data rate with switch 2: 6.8 Mbps [ON], 110 kbps [OFF]
    c. Select a channel with switch 3: Channel 5 [ON], Channel 2 [OFF]
    d. Configure 3 units as Tags: switch 4 is [OFF]
    e. Configure 1 unit as an Anchor: switch 4 is [ON]
    f. Set the ID of the Anchor to 0: switches 5,6 & 7 [OFF]
    g. Set the IDs of the Tags to 0, 1 & 2: switches 5,6,7 = [000, 001, 010]
    h. Switch 8 is reserved so can be [ON] or [OFF]
2. Mount the Anchor
3. Power the Tags using one of the following methods:
    a. USB power supply (not provided)[2]
    b. USB battery pack (not provided)
    c. Connect to a PC (not provided)
    d. Connect to a mobile battery (not provided) using the DC leads (provided)
4. Connect the PC to the Anchor
5. Wait for the start message to disappear and then the TREKs are ready (about 20 s)
6. Start the DecaRangeRTLS PC Application
    a. Check ‘Geo-Fencing Mode’ in the Configuration Tab of Settings
7. Enter the zone perimeters into the Configuration Tab
8. Select ‘Alarm Inside’ or ‘Alarm Outside’
9. In Geo-Fencing mode the Tag is displayed as a circle as opposed to a true location
10. As a Tag enters or leaves each of the zones (i.e. crosses a perimeter) the Tag’s circle changes color from red to blue to green

[1] **Setup Note 1**: If the system does not operate as expected when the settings of any of the DIP switches are changed it may be necessary to operate the switches a number of times. They have been known to stick and not operate correctly. Toggling them a number of times generally resolves the issue

[2] **Setup Note 2:** Some USB battery packs **may not power** the Tag correctly. The Tag periodically goes into a sleep state before waking up to perform a two-way range and returning to sleep. During sleep the current consumption may be too low to keep the USB battery pack on and the battery may shut off. Not all battery packs turn off. For battery packs that have a torch function the user can switch the torch function on to keep the battery

alive during the sleep state.

8 ANALYSIS

This section contains some notes about analysis and interpretation of results.

8.1 Log Files

During a TREK session each transaction between Anchor and Tag is recorded into a log file which can be post-processed and analysed after the testing session.

The log file can be found in the Logs folder and the name is of the format:

yyyymmdd_hhmmssRTLS_log.txt

8.1.1 Range Report Format

There are three ranging report messages sent over the USB port:

```
1. mr 0f 000005a4 000004c8 00000436 000003f9 0958 c0 40424042 a0:0
2. ma 07 00000000 0000085c 00000659 000006b7 095b 26 00024bed a0:0
3. mc 0f 00000663 000005a3 00000512 000004cb 095f c1 00024c24 a0:0
```

The “mr” message consists of tag to anchor raw ranges, “mc” tag to anchor range bias corrected ranges – used for tag location and “ma” anchor to anchor range bias corrected ranges – used for anchor auto-positioning.

MID MASK RANGE0 RANGE1 RANGE2 RANGE3 NRANGES RSEQ DEBUG aT:A

MID	this is the message ID, as described above: mr, mc and ma
MASK	this states which RANGEs are valid, if MASK=7 then only RANGE0, RANGE1 and RANGE2 are valid (in hex, 8-bit number)
RANGE0	this is tag to anchor ID 0 range if MID = mc/mr (in mm, 32-bit hex number)
RANGE1	this is tag to anchor ID 1 range if MID = mc/mr or anchor 0 to anchor 1 range if MID = ma (in mm, 32-bit hex number)
RANGE2	this is tag to anchor ID 2 range if MID = mc/mr or anchor 0 to anchor 2 range if MID = ma (in mm, 32-bit hex number)
RANGE3	this is tag to anchor ID 3 range if MID = mc/mr or anchor 1 to anchor 2 range if MID = ma (in mm, 32-bit hex number)
NRANGES	this is a number of ranges completed by reporting unit raw range (16-bit hex number)
RSEQ	this is the range sequence number (8-bit hex number)
DEBUG	this is the TX/RX antenna delays (if MID = ma) – two 16-bit numbers or time of last range reported – if MID = mc/mr (32 bit hex number)
aT:A	the T is the tag ID and A id the anchor ID

The figure below shows how to interpret the messages in the log files.

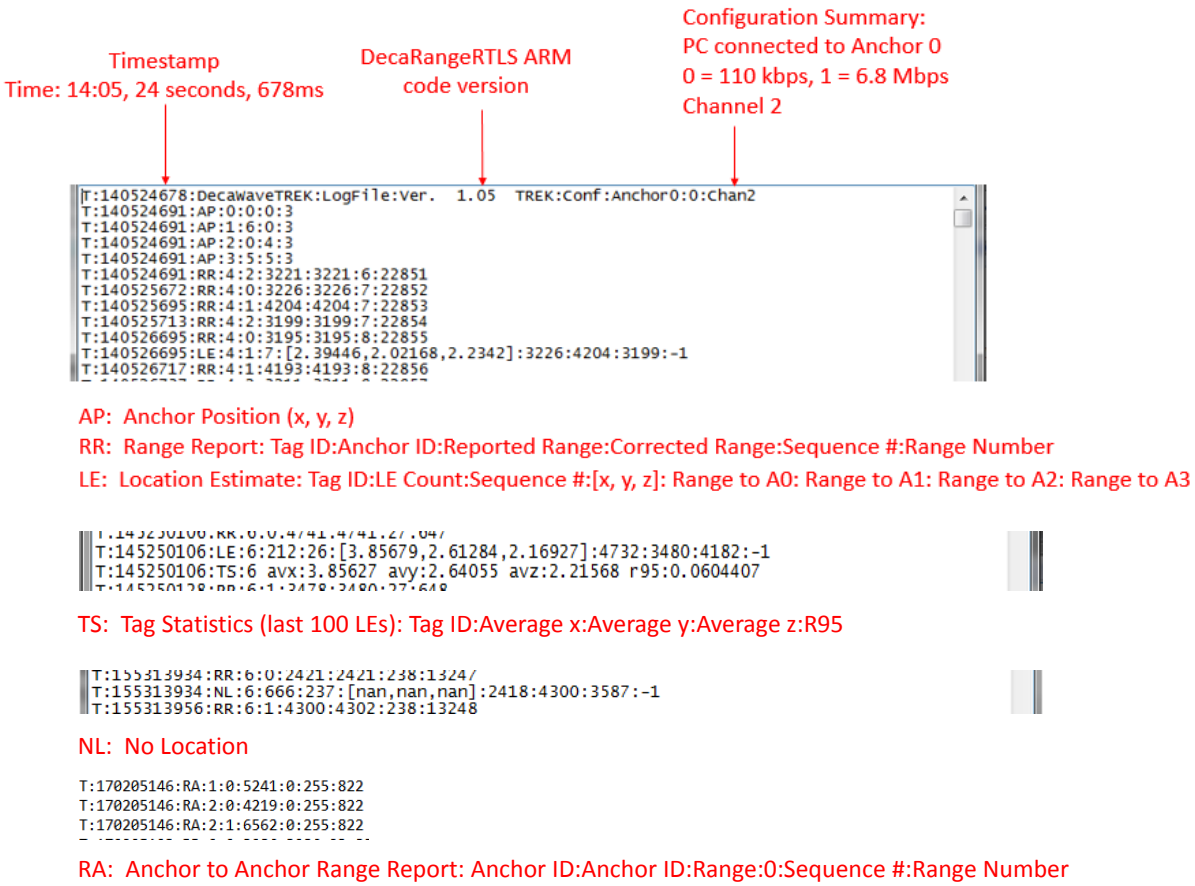


Figure 45: Reading the Log Files

```
T:140416358:RM:0:1:119:17552
T:140416638:RR:0:0:1892:1892:120:17553
T:140416638:RM:0:1:120:17553
T:140416908:RR:0:0:2164:2164:121:17554
T:140416908:RM:0:1:121:17554
T:140417758:RR:0:0:3067:3067:124:17555
T:140417758:RM:0:1:124:17555
T:140418028:RR:0:0:3212:3212:125:17556
T:140418028:RM:0:1:125:17556
T:140418308:RR:0:0:3104:3104:126:17557
T:140418308:RM:0:1:126:17557
```

The “mr” message consists of tag to anchor raw ranges, “mc” tag to anchor range bias corrected ranges – used for tag location and “ma” anchor to anchor range bias corrected ranges – used for anchor auto-positioning.

For further information on the Range Report Format see ref[5]

8.2 Z-Height

The TREK1000 system estimates x, y and z data for the Tag. The user should be aware that as there are only 3 Anchors in this system the trilateration location algorithm returns 2 solutions – one above the plane of the Anchors and one below the plane of the Anchors.

The TREK system only selects the lower of the two results thereby assuming the Anchors are above the Tag.

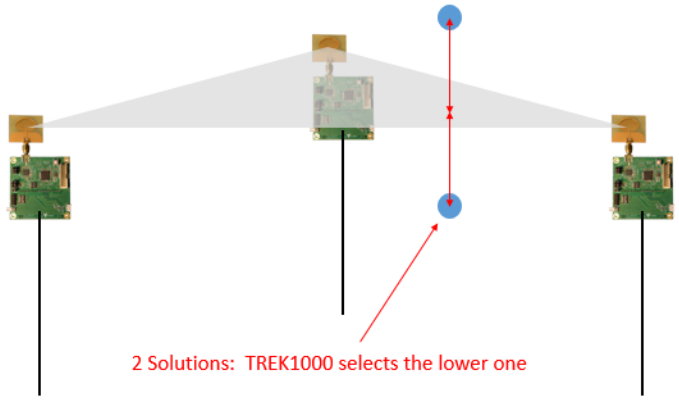


Figure 46: Trilateration – 2 Solutions Exist

For systems that only measure x and y, or systems that mount the Anchors above the Tag, this is sufficient.

8.2.1 Adding a 4th Anchor (example only)

A 4th Anchor is **not** required if:

1. the Tag is always below the plane of the 3 Anchors, or
2. the system only requires x-y co-ordinates (2D) and the z-height is not required (3D)

A 4th Anchor would be required to resolve the 2 solutions if the Tag can be located above or below the plane of the Anchors.

If a 4th Anchor is added, TREK1000 uses data from that anchor to select the correct solution from the 2 returned solutions.

Method:

Add the 4th Anchor on a different plane than the first 3 anchors. It is recommended to mount it above the other 3 Anchors to give better line-of-sight to the Tag (less obstructions from people, furniture etc.)

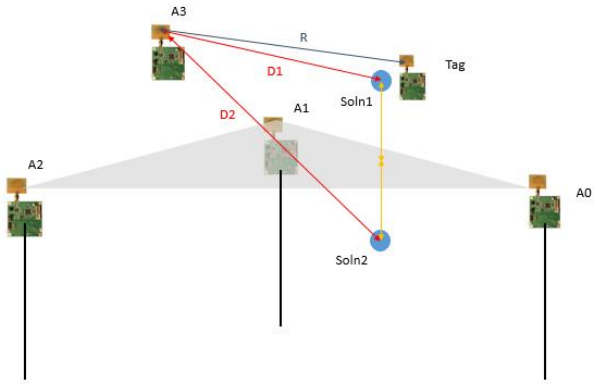


Figure 47: Adding a 4th Anchor

For best performance, the difference in height between 4th Anchor and the plane of the others should be as large as possible.

The solution selected is the minimum of ABS(R – D1) and ABS(R – D2), where D1, D2 are

estimated from the co-ordinates and R is the range from the Tag to Anchor A3.

Note: Any errors in the z-height result (e.g. from Two-Way-Ranging errors) could push the solution across the plane of the 3 Anchors and produce an incorrect solution.

Note: This is an example methodology. Other methods & algorithms may be more suited to the end application - this is left up to the system designer to investigate other algorithms and change the code as appropriate to their application.

9 OTHER EVB1000 BOARD DETAILS

This section gives further details of the EVB1000 including the pin-outs of all connectors and the function of all the on-board switches and Jumpers.

TREK1000 can be operated as described previously without knowledge of these connectors.

9.1 Off-board connector headers

9.1.1 J1 – SMA antenna connector

External antenna connector

Table 8: J1 pin out

Pin	Function
J1-Centre	RF signal
J1-Body	Ground

9.1.2 J4 – JTAG connector

The JTAG connector is intended for connection to an external ARM debug interface / development toolset. DIL Header, 20 pin, 0.1” pitch.

Table 9: J4 pin-out

Function	Pin	Pin	Function
VCC	1	2	VCC
JTRST	3	4	GND
J TDI	5	6	GND
J TMS	7	8	GND
J TCK	9	10	GND
Pulled to GND via 10kΩ resistor	11	12	GND
J TDO	13	14	GND
ARM_RESET	15	16	GND
Pulled to GND via 10kΩ resistor	17	18	GND
Pulled to GND via 10kΩ resistor	19	20	GND

9.1.3 J5 – Micro USB connector

This is the micro USB connector.

Table 10: Micro USB connector pin-out

Pin	Function
J5-1	VSUB +5 V IN
J5-2	USBDM to ARM GPIO PA11
J5-3	USBDP to ARM GPIO PA12

Pin	Function
J5-4	ID to ARM GPIO PA10
J5-5	GND

9.1.4 J6 – External SPI connector

The external SPI connector is intended for connection to an external microcontroller or to a PC via a USB to SPI converter (The pin-out of has been arranged to be compatible with that of the "Cheetah" series of SPI to USB converters provided by TotalPhase™), DIL Header, 10 pin, 0.1" pitch.

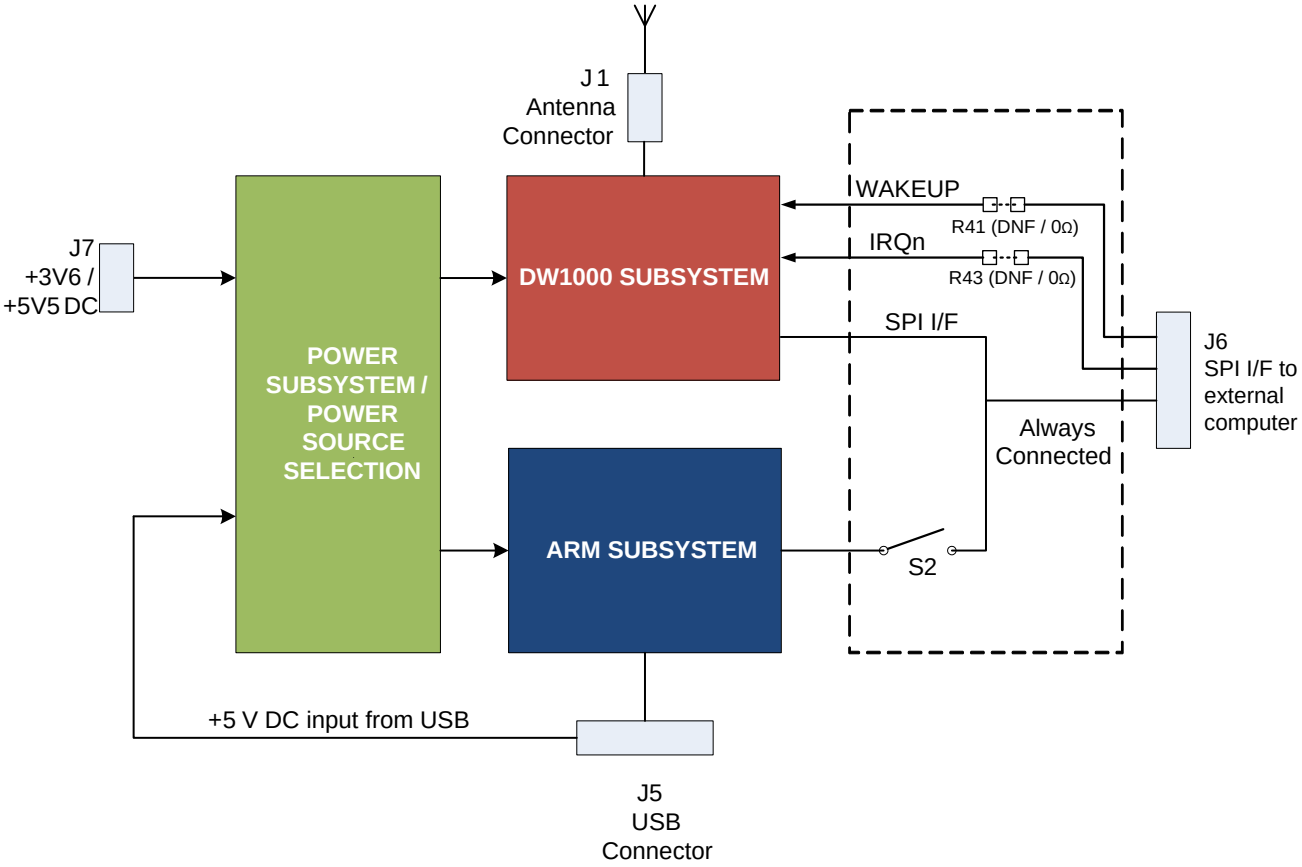


Figure 48: Logical view of the EVB1000

Table 11: J6 Pin-out

Function	Pin	Pin	Function
Not Connected	1	2	GND
WAKEUP (fit R41, 0Ω) - refer Figure 48	3	4	IRQ (fit R43, 0Ω) - refer Figure 48
MISO – SPI Data out to PC / External Micro	5	6	Not Connected
SCK – SPI Clock from PC / External Micro	7	8	MOSI – SPI Data in from PC / External Micro
SPI CSn – SPI Chip Select from PC / External Micro	9	10	GND

9.1.5 J7 – External DC supply

Optional external DC power supply pin. SIL 2 pin 0.1” pitch

Table 12: J7 pin-out

Pin	Function
J7-1 (GND)	Ground
J7-2 (+VE)	DC supply can be from +3.6 V to +5.5 V

9.2 On-board switch functions

9.2.1 S1

S1 is a SPST 8-way switch. Its various functions are described in the Section 3 above.

9.2.2 S2

S2 is a SPST 6-way switch. Its various functions are described in the table below. It disables the DW1000 SPI bus connections to the onboard ARM processor.

Table 13: S2 switch configuration descriptions

Switch	ALL Off function	All On function	Description
S2	Disables ARM SPI connection to DW1000	Enables ARM SPI connection to DW1000	If the onboard ARM functionality is not required this switch can be turned off to disable ARM SPI connection to the DW1000.

9.2.3 S3

S3 is a SPST 4-way switch. Its various functions are described in the table below.

Table 14: S3 switch configuration descriptions

Switch	Off function	On function	Description
S3-1	Disconnects onboard ARM PA0 GPIO to DW1000 RSTn pin	Connects onboard ARM PA0 GPIO to DW1000 RSTn pin	If used it allows ARM GPIO PA0 pin to connect to DW1000 RSTn pin. This allows ARM to reset the DW1000. **This should be on when running the onboard ARM application.**
S3-2	Disables LED 0	Enables LED 0	Can be used to enable or disable LED 0. (current consumption measurement)
S3-3	Selects DW1000 SPI mode	Selects DW1000 SPI mode	This switch can be used to select DW1000 SPI mode it is connected to DW1000 GPIO 5 pin. For more information see Reference [2].
S3-4	Selects DW1000 SPI mode	Selects DW1000 SPI mode	This switch can be used to select DW1000 SPI mode it is connected to DW1000 GPIO 6 pin. For more information see Reference [2].

9.2.4 SW1

This is the ARM reset button.

Table 15: SW1 ARM reset button

Switch	Pressed	Released	Description
SW1	Forces hardware reset of ARM processor	Allows ARM processor to operate normally	Is used to allow reset the ARM processor.

9.3 On-board 2-pin jumper functions

Table 16: J10 function

Jumper	In	Out	Description
J10	Connects main 3.3V power from DW1000	Disconnects main 3.3V power from DW1000	Enables DW1000 power/current measurement.

9.4 On-board 3-pin headers with jumper functions

9.4.1 J2 and J3 functions

Table 17: J2 and J3 functions

Jumper	In pins 1 & 2	In pins 2 & 3	Out	Description
J2	DW1000 uses 3.3 V supply for VDDLDO	DW1000 uses external DC-DC 1V8 supply for VDDLDO as current saving option	DW1000 VDDLDO power disconnected	For more information see Reference [2].
J3	DW1000 uses 3.3 V supply for VDDLDO2	DW1000 uses external DC-DC 1V8 supply for VDDLDO2 as current saving option	DW1000 VDDLDO2 power disconnected	For more information see Reference [2].

9.4.2 J8 and J9 functions

Table 18: J8 and J9 functions

Jumper	In pins 1 & 2	In pins 2 & 3	Out	Description
J8	Enables EVB1000 powering from J6	Enables EVB1000 powering from J5	EVB1000 is not powered	Enables different power configuration options.
J9	In this mode the externally applied supply is connected to the onboard circuitry through a 3.3V voltage regulator	n/a	Voltage regulator is disconnected – EVB1000 is not powered.	Must be connected for EVB1000 power.

10 REFERENCES

10.1 Listing

Reference is made to the following documents in the course of this Application Note: -

Table 19: Table of References

Ref	Author	Date	Version	Title
[1]	Decawave		Current	DW1000 Data Sheet
[2]	Decawave		Current	DW1000 User Manual
[3]	Decawave		Current	TREK1000 Product Brief
[4]	Decawave		Current	TREK1000 Quick Start Guide
[5]	Decawave		Current	TREK1000 Source Code Guide: DecaRangeRTLS PC
[6]	Decawave		Current	TREK1000 Source Code Guide: DecaRangeRTLS ARM
[7]	Decawave		Current	Moving from TREK1000 to a Product

11 DOCUMENT HISTORY

Table 20: Document History

Revision	Date	Description
1.08	5th June 2018	New logo update
1.07	30th June 2016	Scheduled update
1.06	9th February 2016	Updated descriptions of modes, floorplan/GUI, 4th anchor usage, displayed ranges and EVB1000 connectors.
1.05	28th September 2015	Updated to match 2.06 software release
1.04	30th June 2015	Scheduled update
1.03	31st March 2015	Initial release

12 MAJOR CHANGES

Revision 1.08

Page	Change Description
Front page	Update with new logo
	Include description of MR, MC and MA

Revision 1.07

Page	Change Description
Front page	Change revision number to 1.07
10	Modification of registration procedure for TREK source code access
40	Update log descriptions to include RA – anchor-to-anchor ranges.
44	Fix missing references in Table 11.

Revision 1.06

Page	Change Description
Front page	Change revision number to 1.06
16	Updated description of modes of operation to include configurations
17	Changed switch 8 description to be OFF
18	Changed description of ranges on screen to be a cycle of ranges
33	Updated GUI to include new floorplan functionality
37	Updated about dialog box image
41	Updated description of the usage and limitations of the 4th anchor
43	Added new section describing all board connectors and headers
48	Include this table

Revision 1.05

Page	Change Description
Front page	Change revision number to 1.05
17, 26	Update display image
27	GUI image updates
29-32	New configuration feature descriptions: Auto-Positioning, Filtering, Logging
37	Updated ‘about’ image
38	Added Auto-Position as a setup option for navigation/tracking use cases
43	Include this table

Revision 1.04

Page	Change Description
Front page	Change revision number to 1.04
25	Add note on changing COM port number assignments in PC
35, 36	Add notes on sticking DIP switches
39	Include 1.04 in revision history table
39	Include this table

Revision 1.03

Page	Change Description
All	Initial Release

13 FURTHER INFORMATION

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

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