

DWUSB Development Kit Instructions

Rev 0.5.1 : June 25, 2015

1 Installation

1.1 System Requirements

Installation of the User Interface (UI) requires a PC running Ubuntu 14.04 or later. It is assumed that the user has super user privileges and the ability to install software and libraries to the system.

1.2 Installing Dependencies and Configuring User

The development kit user interface requires a library that is available through the Ubuntu repository. To install the library, type the following at a terminal prompt:

```
sudo apt-get install libqt5serialport5
```

Follow the on-screen instructions to finish installation of the library. The user also needs to have access to the dialout group in order to use the serial port. To add the user to this group, type the following at a terminal prompt:

```
sudo usermod -aG dialout [user name]
```

The '[user name]' portion of the command above should be filled in with your user name. After the above command has been run log out then log back in to ensure the user group setting are updated.

1.3 Unpacking and Marking the UI Program as Executable

At a terminal prompt, browse to the directory where you placed the '*dwusb_gui-0.5.0.0.tar.gz*' archive and run the following commands:

```
tar xvzf dwusb_gui-0.5.0.0.tar.gz
cd dwusb_gui-0.5.0.0
chmod +x dwusb_gui
```

1.4 Running the Program

Once you have unpacked the program and installed the required libraries, you are now ready to run the user interface program. Run the following at a terminal (assumed to be in the *dwusb_gui-0.5.0.0* directory):

```
./dwusb_gui
```

It is also possible to browse to the folder using a graphical file browser and double-click on the '*dwusb_gui*' icon to run the program. It is recommended that the user run the program through a terminal command in order to see debug and error information printed by the program.

1.5 Network Configuration

The software runs with two basic threads; one thread that acts as a host collecting data and generating position information and a gui thread that plots the data for the user. These threads communicate using a multicast socket connection. The purpose of this setup is to allow the host to be run on one machine and the gui to be run on one or more separate machines. See [Running the Host and Gui Separately](#) section below.

In order for the software to work properly, the system must have a network connection for communication. When working on a system with no network connection, the user must configure a loopback device to allow the program to communicate internally. To set up a loopback, type the following at a terminal prompt:

```
sudo ifconfig lo multicast
sudo route add -net 224.0.0.0 netmask 240.0.0.0 dev lo
```

1.6 Running the Host and Gui Separately

Running the host and gui portions of the software separately is not recommended for initial setup and learning of the system. These modes should only be used once the user is familiar with the system and there is a need to have the display operate in a location different from the host PC.

To run the host and gui separately, first ensure that the PCs running the program are on the same network. The PC connected to the master dwusb must run the host. To run the software in host only mode type the following at a command line:

```
./dwusb_gui --host-only
```

Once started, the host will use the default configuration file. See the [Configuration](#) section below for instructions on creating a default configuration. To start in host only mode with a different configuration file, type the following:

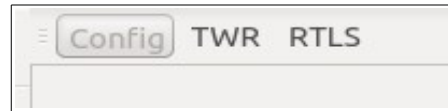
```
./dwusb_gui --host-only --config [ConfigFile]
```

To launch the software in gui only mode, type the following at a terminal prompt:

```
./dwusb_gui --gui-only
```

2 UI Navigation

2.1 Modes



The user interface software currently operates in three basic modes; Configuration Mode, TWR Mode, and RTLS mode. To switch between modes, click on the 'Config', 'TWR', or 'RTLS' buttons in the upper left corner of the screen.

2.2 Definitions

Config - This page contains the setup utilities to configure the system for various tasks.

TWR – Two Way Ranging (TWR) is an algorithm used to determine the distance between two RF devices capable of sending and receiving signals and accurately measuring transmit and receive times. The DWUSB evaluation kit is capable of TWR between any two devices configured either as an Anchor or a Tag. This page of the UI shows the distance between two selected devices along with other information regarding the devices being monitored.

RTLS – Real Time Location Services (RTLS) is an algorithm used to determine the location of a device transmitting RF beacons in 3D spacing using RF receivers positioned at known locations. This page of the user interface allows the user to see the position of the various pieces of the system with relation to one another.

3 Configuration


3.1 Definitions

Master – The master is a dwusb device connected to the host PC (or PC running the UI software). The master serves to configure the network, collect data from the devices, and create a global time reference for the system.

Anchor – An anchor is a dwusb device that is capable of collecting and timestamping transmissions from other devices. The timestamps are transferred to the master where they are collected by the PC for analysis. When using the TWR demo, anchors are capable of ranging between one another and the master. When using the RTLS demo, anchors are assumed to be stationary or “anchored” in position.

Tag – A tag is a dwusb device that emits a periodic beacon that is received and timestamped by the anchors. The beacon contains information regarding the state of the tag (ie., sensor data from IMU and barometric sensor). Tags beacon at a fixed interval of 20Hz. Timestamps from the beacons are used by the RTLS algorithm to determine the location of the tag.

3.2 Setting up the Serial Port and LCM Communications Port

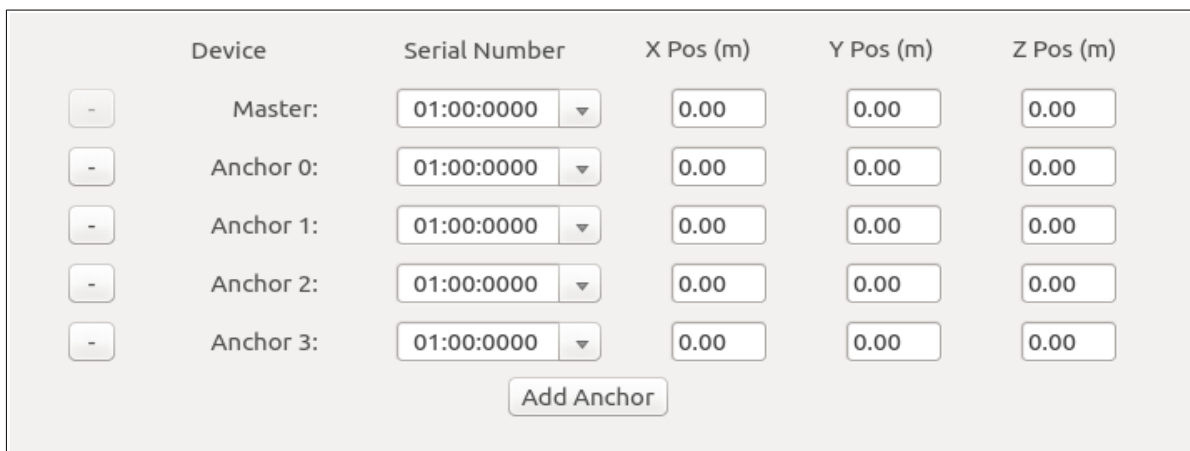


The screenshot shows a configuration window with four buttons at the top: 'Apply', 'Save As...', 'Save As Default', and 'Load Config'. Below the buttons, there are two input fields: 'Serial Port:' followed by a dropdown menu, and 'LCM Port:' followed by a text input field containing the value '7667'.

When the master dwusb is plugged in to the PC, it is recognized and configured by the OS. In the Config window under 'Serial Port', you will need to set the location of the device to allow the PC to communicate with the master. The value for this field is typically “/dev/ttyACM1”.

The LCM port is the IP port to which the LCM messages containing distance information will be published. In general the default value of '7667' should be left in this field.

3.3 Setting up Master and Anchors



	Device	Serial Number	X Pos (m)	Y Pos (m)	Z Pos (m)
-	Master:	01:00:0000	0.00	0.00	0.00
-	Anchor 0:	01:00:0000	0.00	0.00	0.00
-	Anchor 1:	01:00:0000	0.00	0.00	0.00
-	Anchor 2:	01:00:0000	0.00	0.00	0.00
-	Anchor 3:	01:00:0000	0.00	0.00	0.00

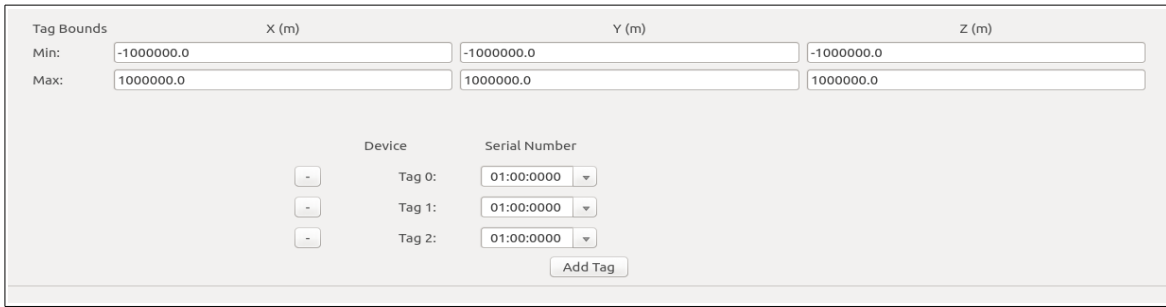
Setting up a system to use TWR mode takes less preparation than a system that will be used with RTLS. Any device that is configured as a master or anchor can TWR with another device configured as a master or anchor. To setup an environment for TWR, fill in the serial numbers of the hardware in the serial number column. *Note: the device connected to the PC must be configured as the master.*

Once the devices have been setup as anchors, you are ready to switch to the TWR tab. When using only TWR, the X Pos, Y Pos, and Z Pos field values on the configuration page do not matter.

Systems configured to demonstrate RTLS take more preparation. In order to use the system in RTLS mode you will first need to survey the locations of the anchors that you wish to use. The position of each anchor relative to one another must be measured and recorded in the 'X Pos', 'Y Pos', 'Z Pos' fields shown above. All positions should be recorded and entered in meters.

Care should be taken when doing the system survey. The quality of the survey will impact the systems ability to accurately determine position. See [RTLS Survey Tips](#) below regarding creating a good survey.

3.4 Setting up Tags



Tags need to have their serial numbers entered on the configuration page. The serial number should be filled in to the 'Serial Number' field listed next to the tags.

Additionally, tags can be bounded in the XYZ axis to aid the RTLS algorithm. To bound the tags, enter the minimum and maximum values allowed for the axis in the Tag Bounds min and max fields. For example, if you have a system where the ground is considered height zero it would make sense to have the minimum Z allowed be 0 meters. All values should be entered in meters.



3.5 Saving Configurations

Once you have finished configuring the system you should save the configuration and hit 'Apply'. The 'Apply' button loads the current configuration to the system for use. The 'Save As...' button allows you to save the configuration file with a readable name for use at a later date. For example, you may wish to use your RTLS system in multiple locations and save the configuration file with the name of the location. 'Load Config' allows you to load previously saved configuration files.

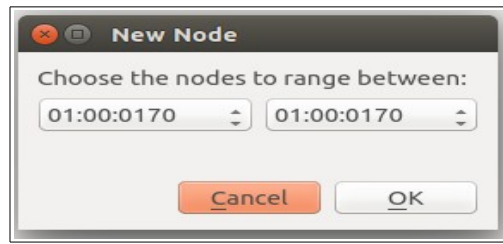
The 'Save as Default' button saves this configuration as the default configuration. If a default configuration file exists, it will be loaded when the UI is started allowing the user to skip the configuration page.

4 TWR Screen

4.1 Launching a TWR Window

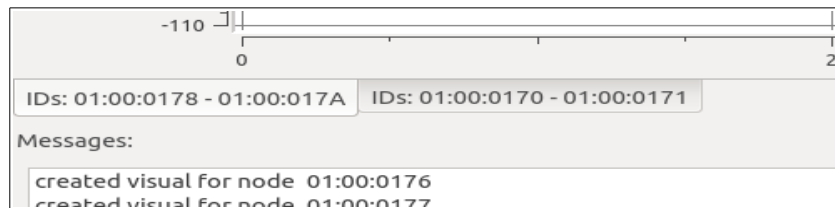


After switching to TWR mode, the user will be presented with a mostly blank screen. In order to start a TWR plot, select 'TWR->New Tab...' from the menu bar. A dialogue box will be presented showing a list of devices available for ranging.



Select two devices for ranging and click the 'OK' button. A scrolling plot will be displayed showing information about the devices.

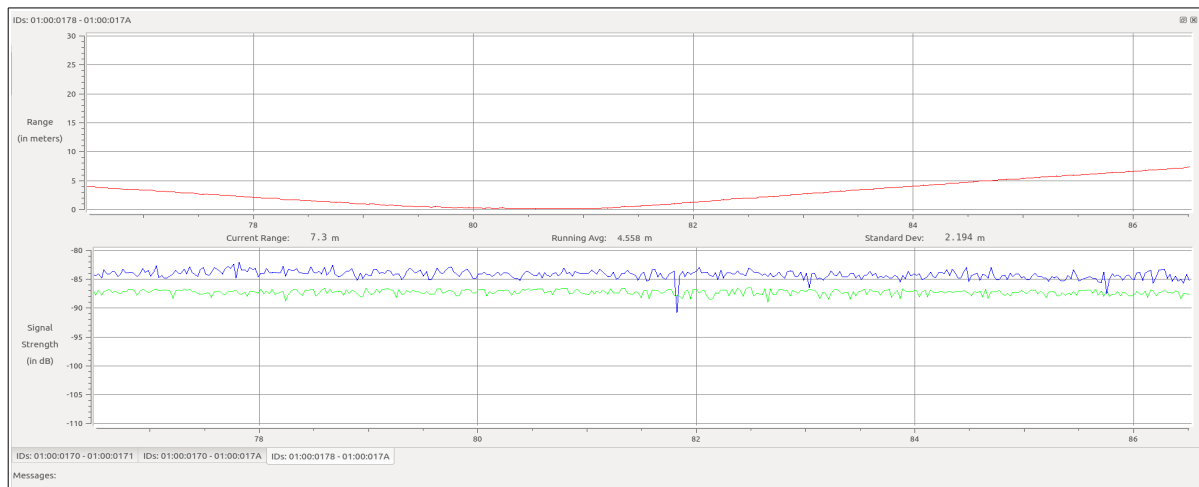
4.2 Switching Between Tabs



If multiple TWR tabs have been launched, switch between the tabs by clicking on the tab at the bottom of the plot display above the 'Messages' window. *Note: new tabs are launched under the current tab. When creating a new tab you will need to click on the tab before seeing the data from the selected devices.*

To close a tab, click on the 'x' located to the upper right of the plot display.

4.3 Interpreting the On-Screen Data



The plot data is a strip-line chart of the information exchanged between the devices. The devices are doing TWR operations at a 20Hz repeat rate. When packet drop or loss of data occurs, the charts will update when the next data is available.

The first chart shows the distance between the devices in red. The output is displayed in meters. The current measured range is shown to one decimal underneath the plot. A running average of

the range is displayed to three decimals, and the standard deviation of the data is shown to three decimals.

The signal strength of the last transmission is shown in a plot below the range data. The blue plot shows the calculated total path energy. The green plot shows the calculated first path energy. The RF signal strength plot can be used to assess the quality of the communications between the devices as well as indicate whether or not a multi-path situation has occurred.

4.4 Pan and Zoom the Plot

To pan and zoom on the plots use the following keyboard-mouse combinations:

right-click – Return plot to auto-zoom default.

scroll wheel – Pan the plot up/down depending on scroll direction.

shift-scroll wheel – Pan plot left or right depending on scroll direction.

left-click drag – Zoom to the selected portion of the screen

ctrl-shift-scroll wheel – Horizontal axis zoom in/out depending on direction of scroll.

ctrl-scroll wheel – Vertical axis zoom in/out depending on direction of scroll.

4.5 TWR Tools

There are several tools, located in the menu bar under TWR, that can be used with the TWR plotting screen. The following describes how each is used:

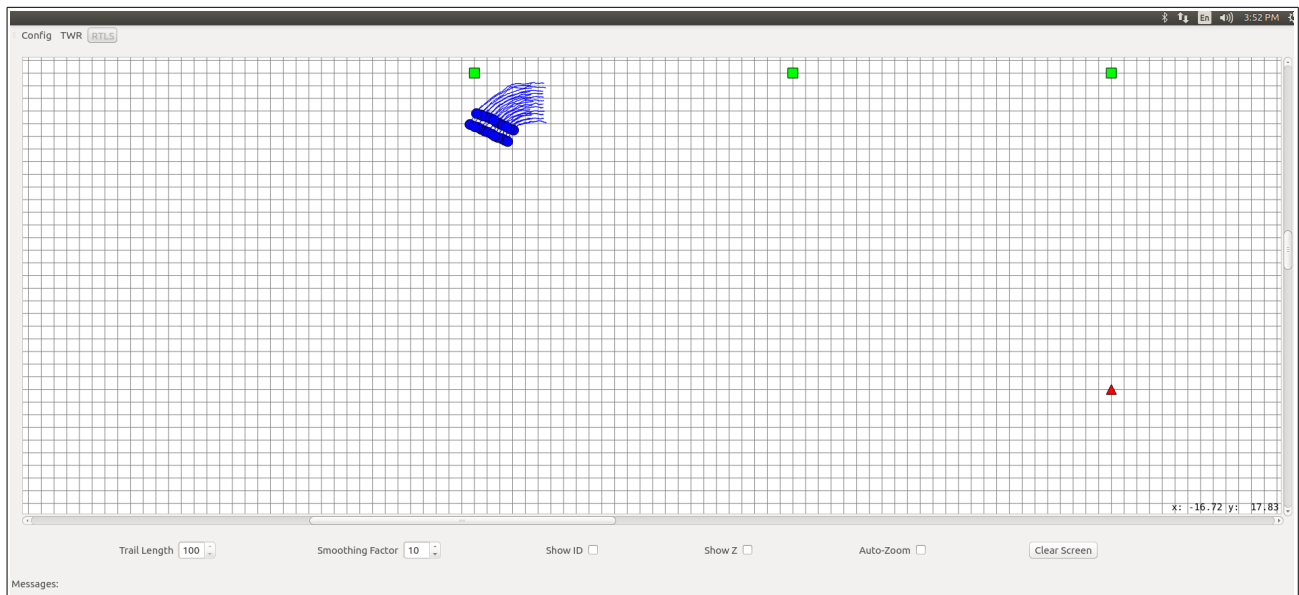
Auto Scroll – Turn on/off auto scrolling. This allows the user to stop the display and use the pan/zoom tools to look through the plotted data. *Note: the plotter continues to add data to the end of the plot when auto scroll is off.*

Display Range Graph – Toggle display of the range data.

Display Signal Strength Graph – Toggle display of the signal strength data.

5 RTLS Screen

5.1 Interpreting the On-Screen Data



Once the system is properly configured, the RTLS screen will display a grid representing XY coordinates for various pieces of the system. The master device is represented as a red triangle, the anchors as green squares, and the tags as blue dots. *Note: it may take a moment for all devices to show on-screen. The software refreshes the anchor and master positions roughly every 7 seconds and tag position updates happen at 20Hz.*

5.2 Configurable Parameters

Below the XY coordinate map are several configurable parameters. These parameters affect the display in the following way:

Trail Length – This parameter causes a thin blue line to trail the tags to give the user an indicator of the path, or trail, the tag has taken. The value can be adjusted from 0 to 100 representing the total number of historic hits to display for the tags. At 20Hz a value of 100 will show 5 seconds worth of trailing data.

Smoothing Factor – This parameter causes the displayed data to be smoothed and can be adjusted from 0 to 100. A value of 0 represents no smoothing. A value of 100 represents averaging the last 1 second of readings to produce the answer.

Show ID – Toggles display of the tag and anchor ID values.

Show Z – Toggles display of the tag and anchor Z-axis values. Z-axis values are displayed in parenthesis next to the device.

Auto-Zoom – Zoom to the full extent of the devices. It is useful to check this box at the

beginning of testing then un-check once all of the anchors are shown on screen.

Clear Screen – Clears current map display.

5.3 RTLS Tools

In the menu bar located under RTLS, there are several tools that can be used with the RTLS mapping screen. The following describes how each is used:

Cursor Tracking – Turns on/off cursor tracking on the map view. The current location of the cursor is displayed in the lower right corner of the map screen when this option is enabled.

Cursor Ruler Mode – Cursor ruler mode switches the cursor behavior when clicking on the screen. When this option is disabled (default mode), clicking and dragging in the map display allows the user to drag the map. When ruler mode is enabled, clicking and dragging causes a line to be drawn on the screen starting at the initial cursor position and ending where the mouse button is released. The length of the line is displayed allowing the user to quickly measure between devices.

Logo Display – Turns on/off display of logo in the background of the map.

6 RTLS Survey Tips

6.1 System Orientation

Before choosing an XYZ orientation consider where the PC will be setup for viewing. On the screen the X axis is horizontal and the Y axis is vertical. It is typically best to orient the anchors in the same direction that the PC will be viewed in order to avoid confusion when watching tag movement during RTLS playback

6.2 Quick Setup

Surveying the locations of the anchors can take time. The system will perform better with a good survey. To make installations easier, particularly while learning how to use the system, it is recommended that anchors be placed in a box or rectangle making the relative positions easy to calculate once distances between devices are recorded.

6.3 Checking Master Synchronization

To ensure best performance it is highly recommended that all tags and anchors are visible to each other in regard to RF communications. The best installations typically have the anchors elevated to help with the line of sight between anchor and tags. It is also important that all anchors can see the master tag transmission for synchronization of time. To ensure that the anchors are visible to the master we recommend using the TWR tabs to check RF parameters before launching the RTLS demo. Anchors should have reasonable RF signal strength, be stable in range, and have no noticeable packet loss in the TWR plots.

6.4 Using Tag Bounds

The current location engine is very good at converging on an XYZ position when the tag is located within the perimeter of the anchors. As the tag moves outside of the bounds, it is more likely that the position will become unstable and push away from the field. The tag boundaries

can be configured to keep the tag within certain limits that are typically represented by physical obstruction (ie., the floor and walls of a building).

When setting up anchors on a plane, it is possible to generate good Z-axis position data. When doing this, the tags should be confined to one side of the plane both physically and in the boundary configuration. An example of this would be a warehouse where all of the anchors are placed on the ceiling and the tags are limited to travel from 0-2m above the ground. If the boundary limits include the plane of the anchors the tags will converge on the same height as the anchors and Z-axis data will not be possible.

7 Log, Playback, and Subscribe to XYZ Position Data

7.1 *Lightweight Communications and Marshalling (LCM)*

The DWUSB evaluation kit software is compatible with LCM messaging. LCM is a communication protocol providing a publish/subscribe message passing model. Messages are published from the host and gui software over a multicast UDP port.

Future versions of the software are targeted to include log and playback of data natively. However, at the current moment it is necessary to install and use LCM tools to play and record the data.

7.2 *Installing LCM (assumed Linux OS, see LCM site for support for other operating systems)*

Download the LCM code from the GitHub repository at the following location:

<https://github.com/lcm-proj/lcm/archive/v1.2.0.tar.gz>

At a Linux terminal prompt run the following commands from the same directory where you saved the LCM tarball downloaded above. This step installs the dependencies needed in order to build the LCM tools.

```
sudo apt-get install build-essential
sudo apt-get install libglib2.0-dev
sudo apt-get install openjdk-6-jdk
sudo apt-get install python-dev
```

Next, extract the source code and change to the extracted directory to build:

```
tar xvzf lcm-1.1.0.tar.gz
cd lcm-1.1.0
```

After extracting the LCM source code, configure and build the executables using the following commands:

```
./configure
make
sudo make install
sudo ldconfig
```

You should now have LCM installed on your system. You can confirm that the installation worked by typing '*lcm-logplayer*' on the command line to get a usage message.

7.3 Using LCM to start a log file containing position data

To start logging files from the GUI all that is needed is to run the following at a command prompt, where *[LogFileName]* is the name you wish to give this log file:

```
lcm-logger [LogFileName]
```

Once done logging data, switch to the terminal window where the lcm-logger program was launched and hit 'Ctrl-C' to stop the program.

7.4 Using LCM to playback previously recorded data

To play back data, run the GUI in *gui only* mode, and launch the LCM logplayer using the following command where *[LogFileName]* is the name of the log file you wish to play:

```
lcm-logplayer-gui [LogFileName]
```

The logplayer will automatically begin playing data from the log file. There are a number of features within the logplayer, such as fast-forward and rewind, that are beyond the scope of this document. For further information on using the logplayer please visit the LCM [website](#).

7.5 Use your own program to subscribe to the XYZ positional data published by the host software

It is possible to write a program to listen to the LCM data and convert the ultra-wideband (uwbtalk) messages into positional data for your use. Start by downloading the 'uwbtalk.tar.gz' archive file from the Ciholas [DWUSB project website](#). Once you have downloaded the archive, un-pack by running the following commands from a terminal prompt in the directory the file was stored:

```
tar xvzf uwbtalk.tar.gz
cd uwbtalk
./buildc.sh
```

After extracting the files, find the 'uwbtalk_howto.txt' file in the uwbtalk directory. The document provides a pseudo code example of how to connect to the LCM stream and access the messages containing the *[id, X, Y, Z, t]* data that is being published by the host software.

Additionally, the 'buildjar.sh' script can be run to build java class definitions for the packets. At the moment example java code is not available.

8 Contact Us

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