UWB Sniffer

Datasheet

# UWB Sniffer

## Debugging platform for RTLS Integrators and Developers

- Fully integrated with industry standard Wireshark
- 6 channels (802.15.4a UWB PHY)
- Ethernet Communication interface
- Easy to automate via HTTP interface
- Received Signal Strength Indication
- Injection Mode for sending packet
- Support for dissecting Decawave Two Way Ranging protocol
- Dimensions: 51 x 51 mm


| Package Content | |
|---|---|
| 1x | UWB Sniffer |
| 1x | USB to DC 1.3mm Power Cable |
| 1x | Ethernet Cable |

| Requirements |
|---|
| Wireshark (Linux/ Windows) |
| USB port or DC Adapter 5V/500mA |
| Ethernet port |



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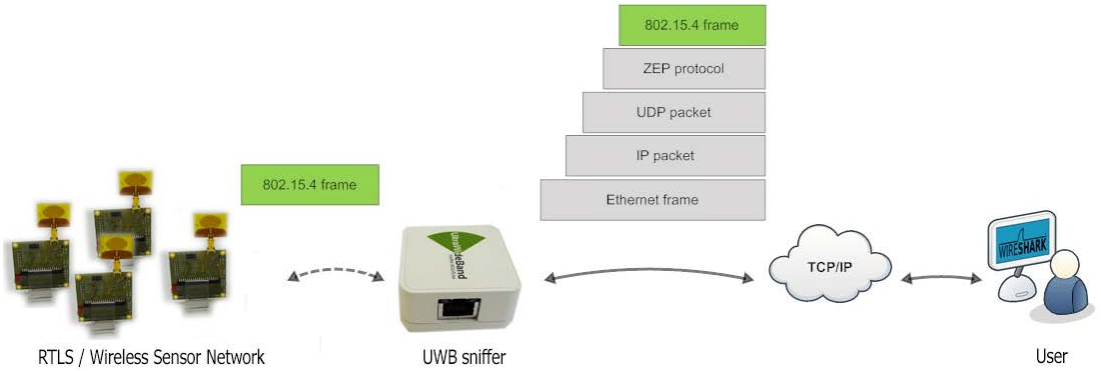
# 1 UWB Sniffer Operation

UWB Sniffer provides following two operation modes: Sniffing and Injection. In the first one the sniffer device captures all the 802.15.4 UWB frames transmitted over the air and forward them to Wireshark. Injection mode enables to send arbitrary UWB frames directly from the sniffer's web interface.




## Sniffing Mode

This is default mode of operation for the UWB Sniffer device. User needs to select desired channel and some other parameters. All captured frames on the particular channel are feed to Wireshark which is an open source industry-standard software for analyzing wired and wireless networks. Data encapsulation is depicted in picture above. Captured 802.15.4 frames are wrapped in ZEP (Zigbee Encapsulation Protocol) which is native protocol included within Wireshark. ZEP basically adding some interesting information to raw 802.15.4 frame such as RSSI or timestamp.

## Injection Mode

In this mode an user may set frame payload, channel, number of packets which are going to be sent over the air from UWB Sniffer. This mode is useful for a device development, testing or auditing. Thanks to the HTTP interface, this might be very powerful tool driven from a script language.



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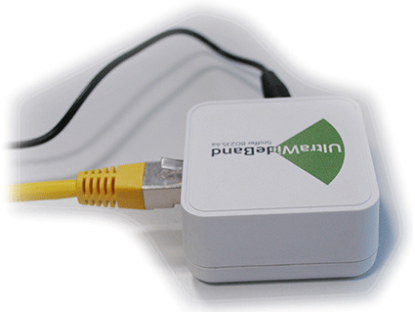
# 2 Sniffer Installation

## 2.1 Hook up cables to UWB Sniffer

Connect Ethernet cable and power cable to UWB Sniffer as it is depicted in picture below.



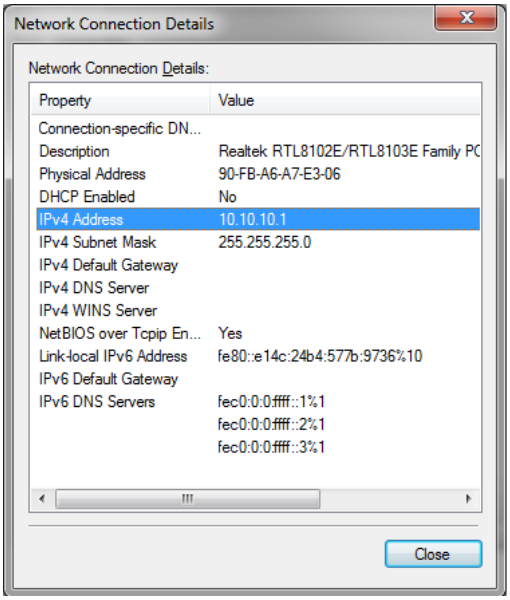

## 2.2 Setting TCP/IP at the host side

In this section we are going to adjust TCP/IP settings at PC host in order to be able to communicate with the UWB Sniffer device.

Default sniffer's settings are: IP address 10.10.10.2, mask 255.255.255.0

Host's IP address must be within the same network scope as the UWB Sniffer device. Set host IP to 10.10.10.1 and network mask to 255.255.255.0.

This can be done via "Network and Sharing Center" in Windows. Press CTRL+R and type "ncpa.cpl" Enter. Then you need to select network interface, where you have attached the sniffer and set IP and network address.



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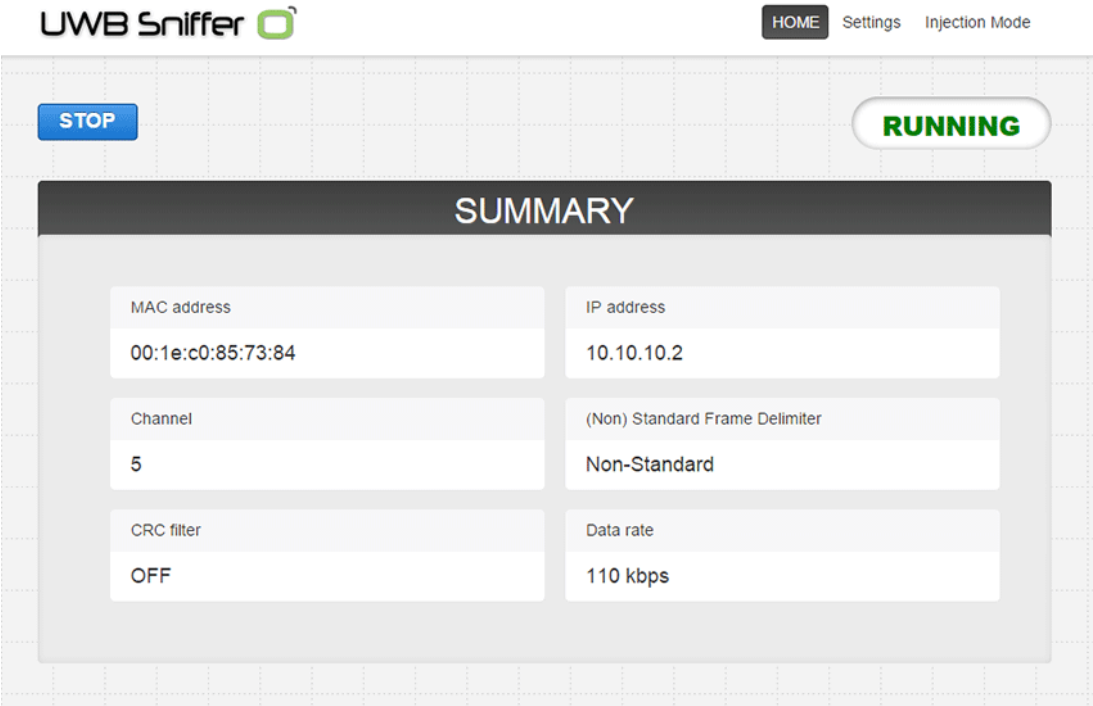
## 2.3 Connect to the UWB Sniffer homepage

Now, point a browser to sniffer's home address http://10.10.10.2, homepage should appear.



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# 3 Wireshark Settings

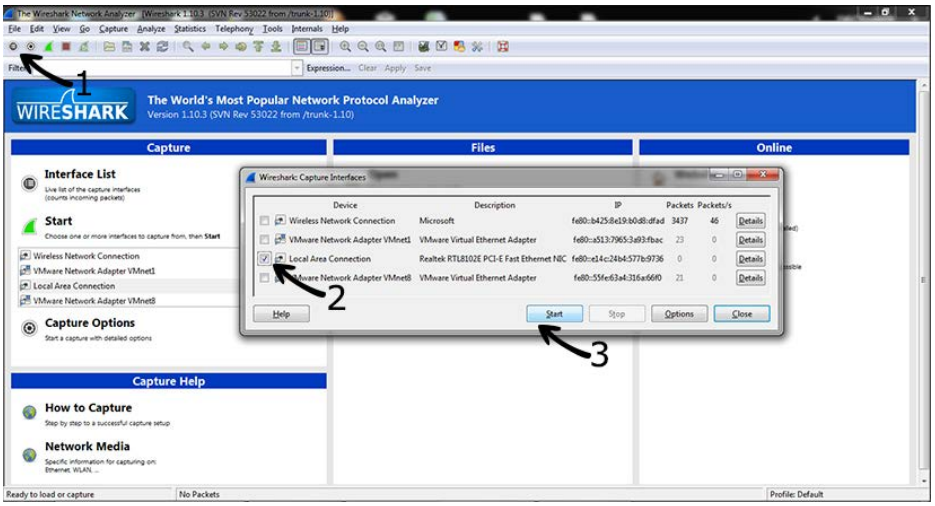
UWB Sniffer acts as a probe which capturing 802.15.4 frames and forwards them to a remote host computer. In order to be able to work with those frames Wireshark software is used.

## 3.1 Wireshark installation

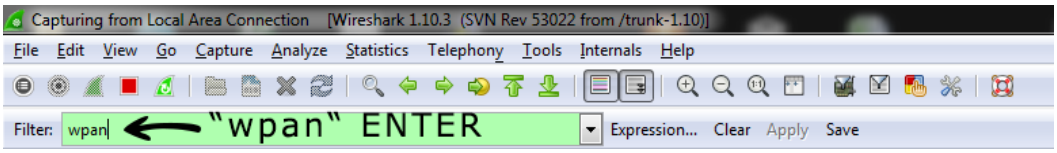
Download, install and run Wireshark. Please select the latest stable appropriate for your operating system and architecture.

## 3.2 Capture Frames

Select the Ethernet interface (linked to UWB Sniffer) from the available capture interfaces and start capturing frames.

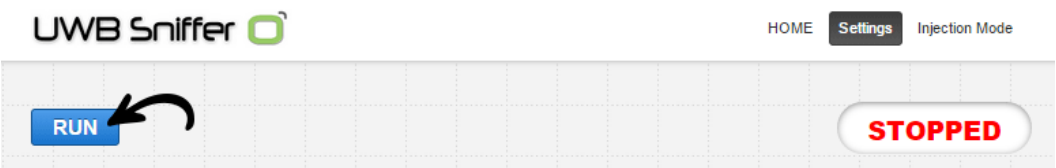



Wireshark implicitly shows all frames from wired and wireless networks delivered to the selected interface. Therefore, it is useful to apply 802.15.4 filter which is referred as “wpan”.




## 3.3 Start UWB Sniffer

Now the host side is ready and you need to start UWB Sniffer via web interface. Point the browser to sniffer’s IP address and press RUN.




## 3.4 Let’s sniff some communication

Sniff your own UWB hardware or download our captured file.



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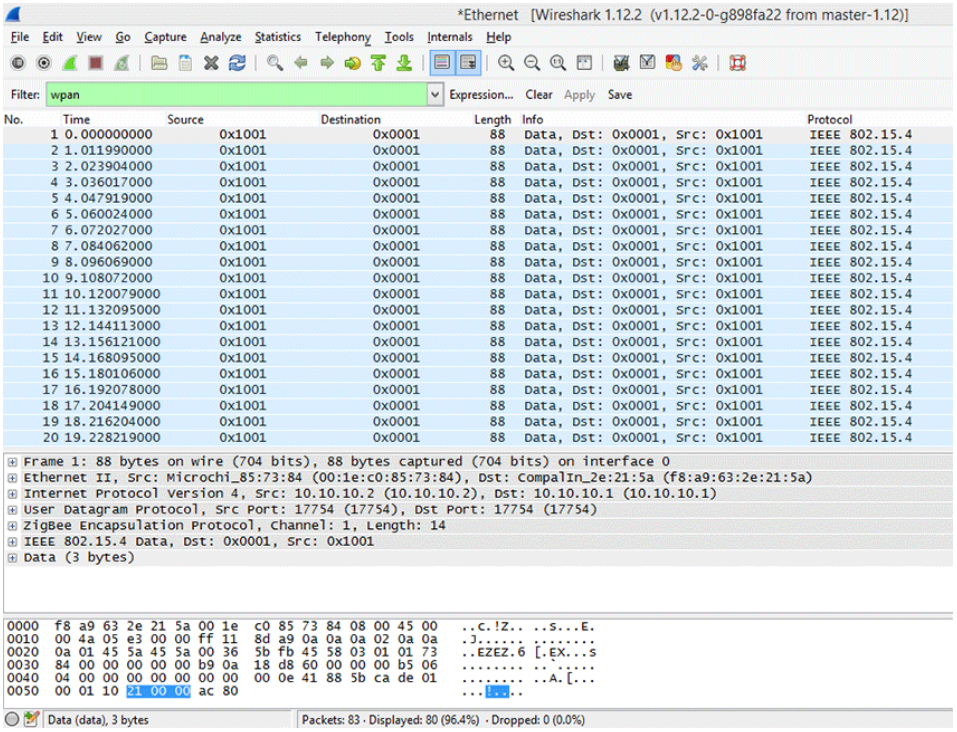
## 3.5 Adjusting Wireshark for IEEE 802.15.4 Networks

The previous chapter describes process of data capture and initial Wireshark configuration. User may download the sample file uwb_twr_demo.

## 3.6 Wireshark columns

Wireshark has default columns settings for wired Ethernet network, see picture below.




Columns are defined for the default Wireshark profile as follows:

| Column name | Description |
|---|---|
| No. | Frame number counted from the start of capture in Wireshark. This is NOT number of a frame received from UWB Sniffer. It includes all packets (wired&wireless) delivered to the host's ethernet interface |
| Time | Ethernet timestamp of the frame assigned by the operating system. This is NOT precise timestamp from UWB Sniffer. |
| Source | Source Address |
| Destination | Destination Address |
| Protocol | Protocol |
| Length | Length of entire Ethernet frame including transportation overhead. This is NOT length of 802.15.4 frame |
| Info | Protocol details |



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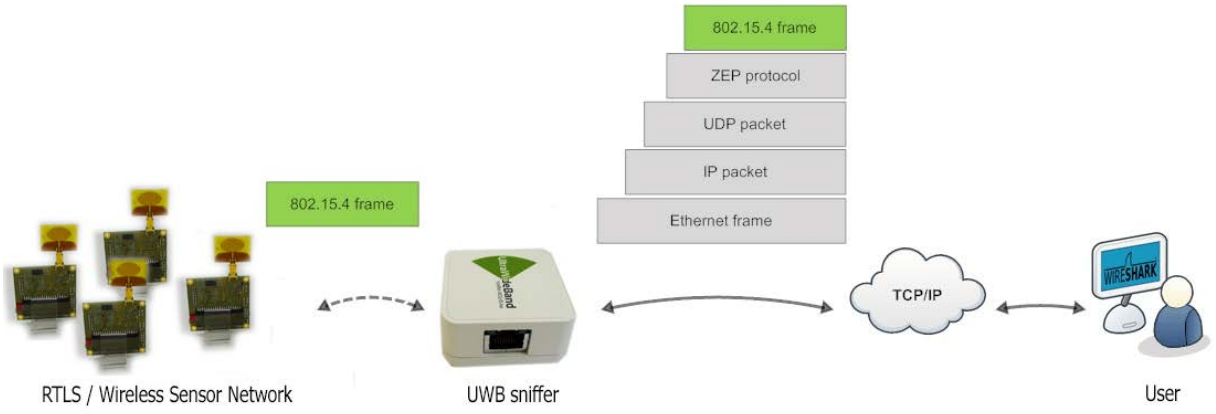
From the table above it is obvious the default column settings are not associated with 802.15.4. Therefore, user can adjust them to the 802.15.4 frame info. Let's refresh the encapsulation scheme for each 802.15.4 frame delivered to the host (see picture below). While the grey colored protocols are used only to transport the 802.15.4 frame through a network infrastructure, the ZEP – Zigbee Encapsulated Protocol carries all the important information such as sequence number, timestamp or channel number related to the every 802.15.4 captured by the UWB Sniffer device.




## 3.7 Install ZEPv3 plugin

Although, Wireshark natively contains ZEP protocol v2, we provide ZEPv3 which is backwards compatible and brings additional information related to band, channel page and precise timestamp information. In case that additional information are not interesting for user, just skip this chapter.

1. Download ZEPv3 plugin.
2. Extract and copy plugin to the Wireshark plugin folder.
   Windows `c:\Program Files\Wireshark\plugins\1.x.x\`,
   Linux `/usr/local/lib/wireshark/plugins/1.x.x/`.
3. Start Wireshark. menu Analyze -> Enabled Protocols (CTRL+SHIFT+E)
4. Uncheck ZEP, check ZEPv3
5. Apply, OK.
6. If frames are not decoded with ZEPv3 go to menu Analyze -> Decode as -> ZEPv3 -> Apply, OK.

ZEPv3 contains fields depicted in picture below:

```
⊞ Frame 1: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0
⊞ Ethernet II, Src: Microchi_85:73:84 (00:1e:c0:85:73:84), Dst: CompalIn_2e:21:5a (f8:a9:63:2e:21:5a)
⊞ Internet Protocol Version 4, Src: 10.10.10.2 (10.10.10.2), Dst: 10.10.10.1 (10.10.10.1)
⊞ User Datagram Protocol, Src Port: 17754 (17754), Dst Port: 17754 (17754)
⊟ ZigBee Encapsulation Protocol, Channel: 1, Length: 14
    Protocol ID String: EX
    Protocol Version: 3
    Type: 1 (Data)
    Channel ID: 1
    Device ID: 29572
    LQI/CRC Mode: LQI
    Link Quality Indication: 0
    Timestamp: 185.169400416 seconds
    Relative Timestamp: 0.000000000 seconds
    Absolute Timestamp: Nov 28, 2014 15:29:43.468917000 Central Europe Standard Time
    Differential Timestamp: 0.000000000 seconds (First packet)
    Sequence Number: 181
    Frequency band: UWB Low band (6)
    Channel page: 4
    Length: 14 Bytes
⊞ IEEE 802.15.4 Data, Dst: 0x0001, Src: 0x1001
⊞ Data (3 bytes)
```



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| Zepv3 Field | description |
|---|---|
| zepv3.version | zep version |
| zepv3.type | type of packet |
| zepv3.channel_id | channel number |
| zepv3.device_id | unique ID of the sniffer, based on MAC address |
| zepv3_lqi_mode | LQI/CRC either LQI is send to Wireshark or CRC value |
| zepv3.lqi | LQI value, not used in UWB Sniffer |
| zepv3.time | Time elapsed since sniffing was started at UWB Sniffer |
| zepv3.reltime | Relative time since sniffing was started at UWB Sniffer |
| zepv3.abstime | Absolute time converted to host timezone |
| zepv3.difftime | Differential time among packets |
| zepv3.seqno | Sequence number of packet send from UWB Sniffer |
| zepv3.band | IEEE 802.15.4 frequency band |
| zepv3.chanpage | IEEE 802.15.4 channel page |
| zepv3.length | IEEE 802.15.4 frame length |

## 3.8 Adjusting Wireshark columns to IEEE 802.15.4 compliant frame

*Note: The procedure below describes how to adapt Wireshark columns to 802.15.4 frames. You may skip this section if you are satisfied with default settings.*

Adjusting columns procedure:

a. Right click on the columns header
b. Select Column Preferences
c. Adjust columns to 802.15.4


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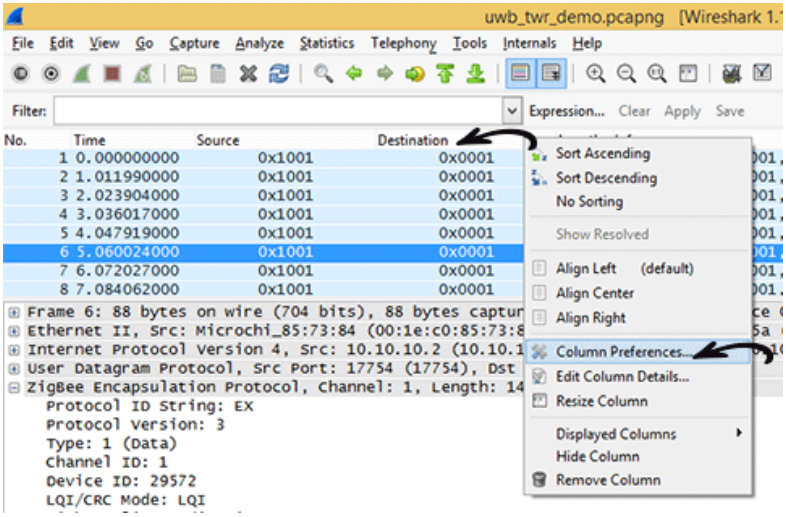


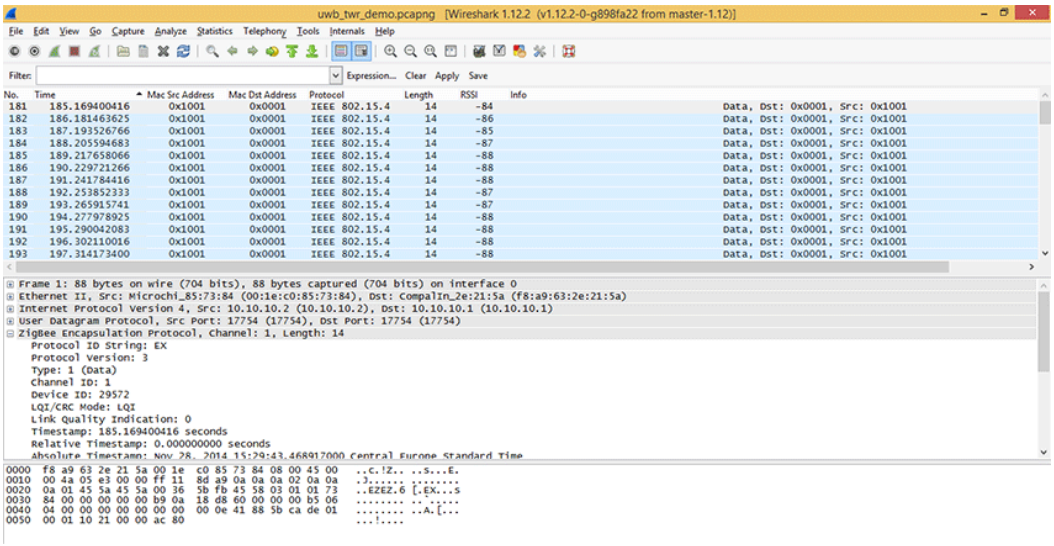

Default column settings

| Displayed | Title | Field type |
|---|---|---|
| ☑ | No. | Number |
| ☑ | Time | Time (format as specified) |
| ☑ | Source | Source address |
| ☑ | Destination | Destination address |
| ☑ | Protocol | Protocol |
| ☑ | Length | Packet length (bytes) |
| ☑ | Info | Information |

Recommended column settings for 802.15.4

| Displayed | Title | Field type |
|---|---|---|
| ☑ | No. | Custom (zepv3.seqno) |
| ☑ | Time | Custom (zepv3.time) |
| ☑ | Mac Src Address | Source address |
| ☑ | Mac Dst Address | Destination address |
| ☑ | Protocol | Protocol |
| ☑ | Length | Custom (zepv3.length) |
| ☑ | RSSI | Custom (wpan.rssi) |
| ☑ | Info | Information |

Adjusted Wireshark columns should seem like this:



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# 4 UWB Sniffer Configuration

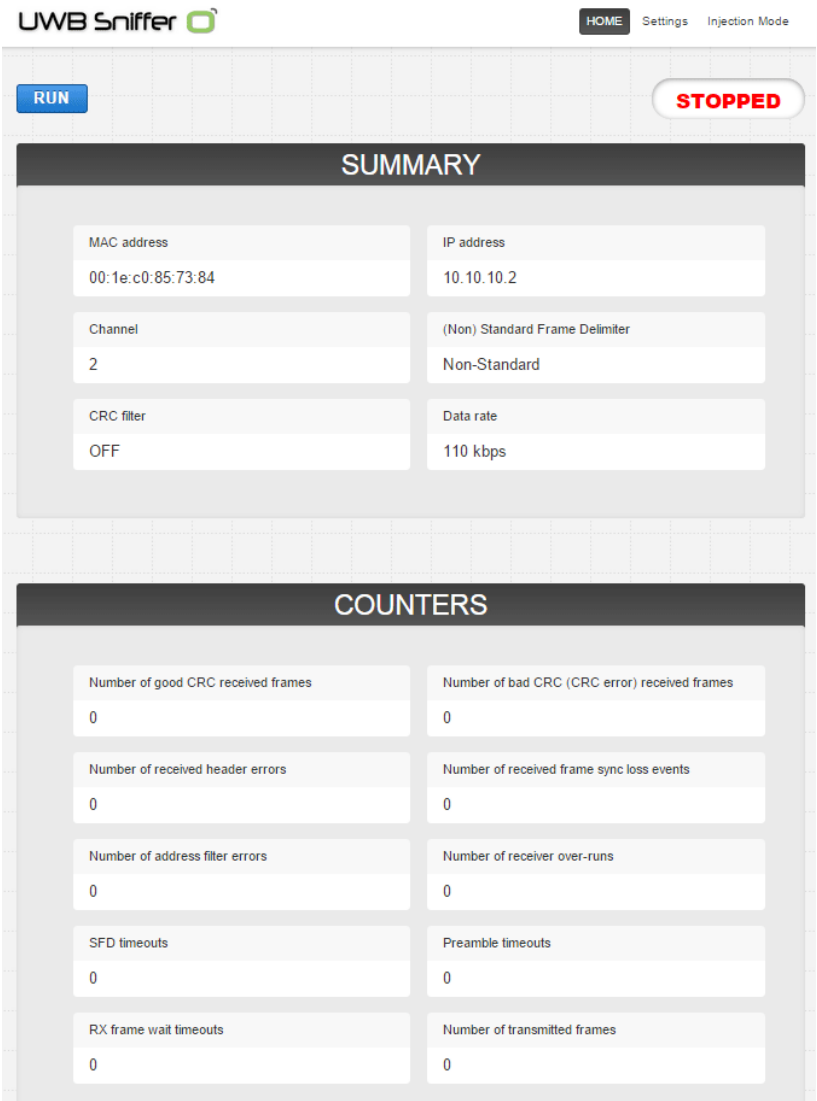
## 4.1 Home Page

RUN/STOP button and status field are located below the top menu. RUN/STOP button is present on every subpage and always refers to packet sniffing or capturing frames on defined channel.

Home page contains following summary information about an analyzer: MAC address, IP address, current channel, (non)standard frame delimiter, crc filter and data rate.

Below summary section the counters are displayed. Counters (see picture below) have 12 bit resolution and they are related to selected events on PHY UWB layer. They might be quite useful during the network debugging and trouble shooting.

At the very bottom of the homepage a firmware version is displayed.



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## 4.2 Setting Page

Radio parameters, network configuration and host settings are done via this page

Available Channels

| Channel | Center Frequency (MHz) | Band (MHz) | Bandwdth (MHz) |
|---|---|---|---|
| 1 | 3494.4 | 3244.8 – 3744 | 499.2 |
| 2 | 3993.6 | 3774 – 4243.2 | 499.2 |
| 3 | 4492.8 | 4243.2 – 4742.4 | 499.2 |
| 4 | 3993.6 | 3328 – 4659.2 | 1331.2 (real approx. 900) |
| 5 | 6489.6 | 6240 – 6739.2 | 499.2 |
| 7 | 6489.6 | 5980.3 – 6998.9 | 1081.6 (real approx. 900) |

Pulse Repetition Frequencies (PRF)

16 MHz / 64 MHz

Preamble Length

4096, 2048, 1536, 1024, 512, 256, 128, 64

Data Rate

110 / 850 / 6800 kbps

Preamble Code

1,2,3,4,5,6,7,8,9,10,11,12,17,18,19,20

PAC Size (symbols)

8 / 16 / 32 / 64

Frame Delimiter

Standard / Non Standard

LQI/CRC mode

LQI mode – frames are forwarded to Wireshark with signal strength values

CRC mode – frames are forwarded to Wireshark with CRC value received

CRC filter On/Off – 802.15.4 frames with wrong CRC are discarded



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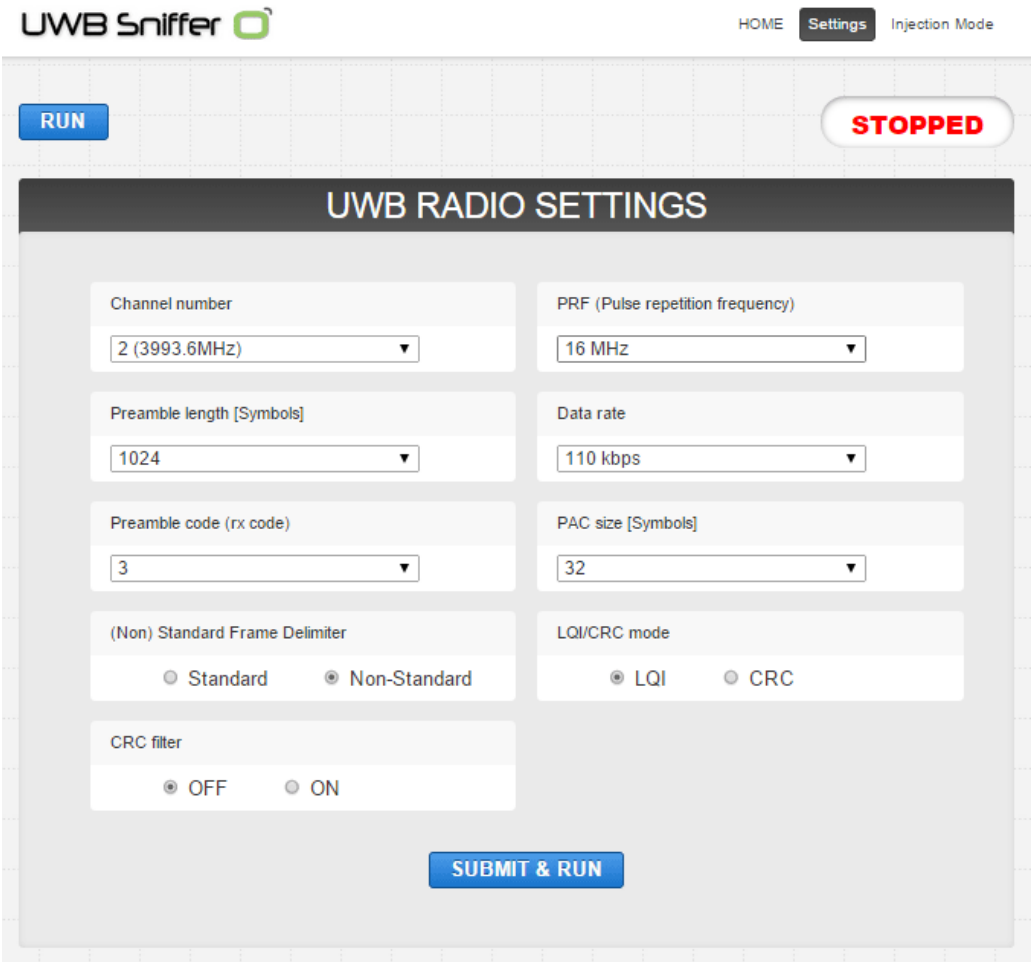


## 4.3 Sniffer IPv4 Settings

- IP mode – DHCP client / Static IP address
- IP address
- Netmask
- Gateway

## 4.4 Host Settings

- Host IP address – IP address of the host computer where Wireshark is running
- Host UDP port – should be set 17754, this identifies 802.15.4 flow in Wireshark

## 4.5 Injection Mode

This mode is dedicated for a frame transmission. User needs to set UWB PHY settings as well as the payload, number of packet repetition and time gap among the packets. User might also set whether sniffing mode should be started right after the transmission ends.



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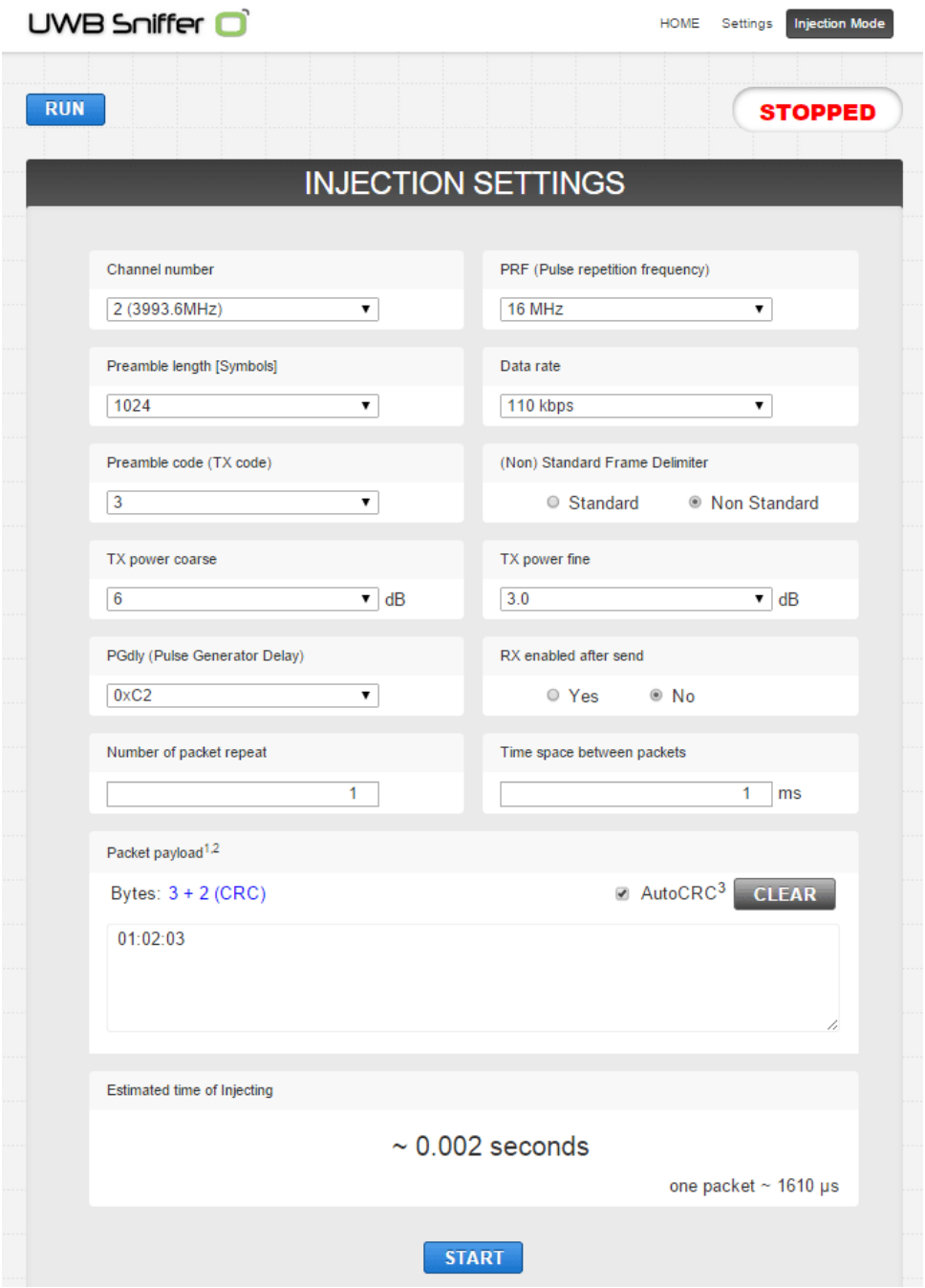




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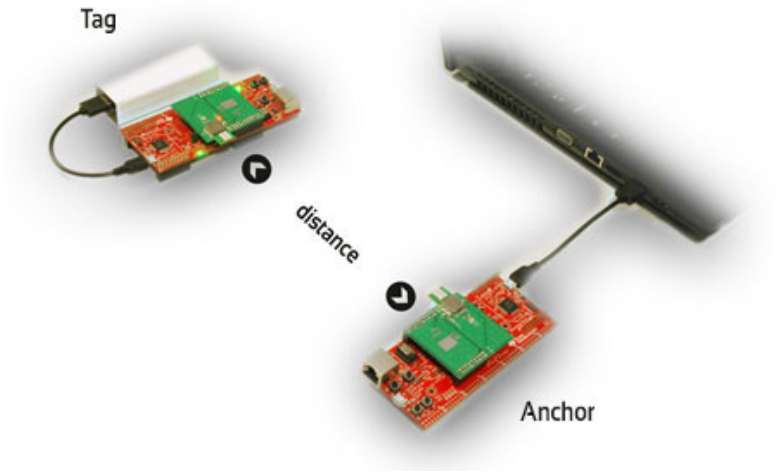
# 5 Analyzing Decawave Two Way Ranging (TWR)

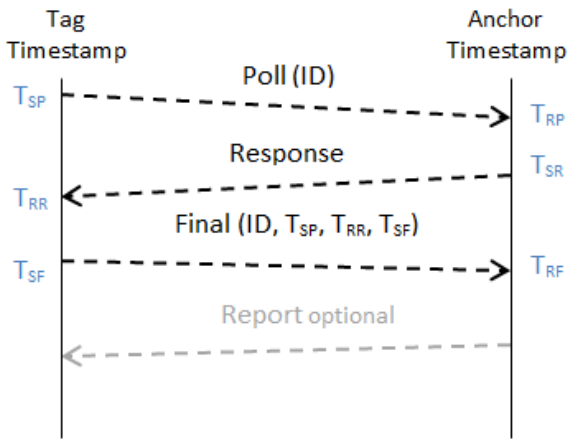
Decawave Two Way Ranging protocol is aimed for precise distance measurement based on UWB IEEE 802.15.4a standard. We provide feature-rich Ranging evaluation kit here.




There are three messages Poll, Response, Final exchanged between Tag and Anchor in order to get a precise distance. It is calculated based on Tag (TSP, TRR, TSF) and Anchor (TRP, TSR, TRF) timestamps. Distance is calculated on Anchor therefore Report message might be employed in order to transfer distance measurement from Anchor back to Tag.

**Distance** = ToF * speed of light

**ToF** = $( (T_{RR} - T_{SP}) - (T_{SR} - T_{RP}) + (T_{RF} - T_{SR}) - (T_{SF} - T_{RR}) ) / 4$



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Ranging messages are encapsulated within 802.15.4 frame, see details in picture below:

| IEEE 802.15.4 Frame | 2 Bytes | 1 Byte | 2 Bytes | 2/8 Bytes | 2/8 Bytes | | 2 Bytes |
|---|---|---|---|---|---|---|---|
| | Frame Control | Sequence Number | PAN ID | Destination Address | Source Address | Payload | FCS |

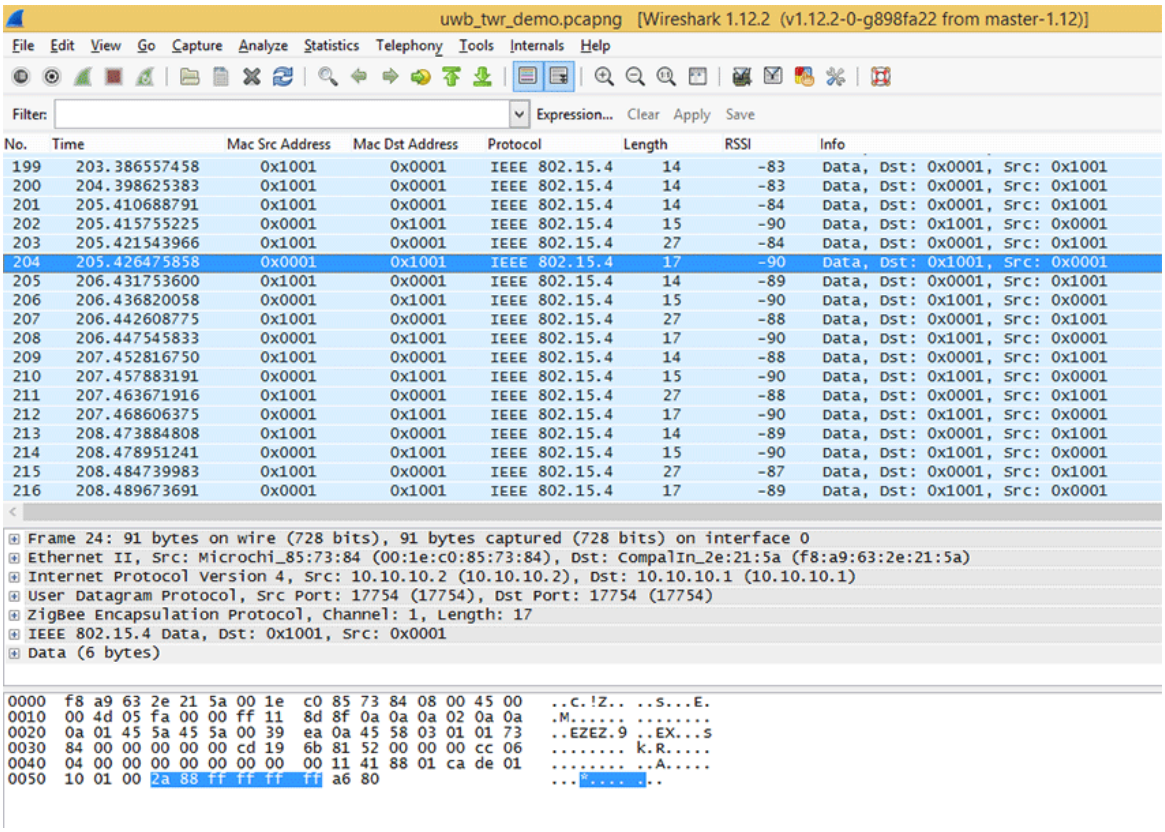
| Poll Message | 1 Byte | 0-85 Bytes | | |
|---|---|---|---|---|
| | Packet ID | User Payload | | |
| | 0x21 | - | - | - |

| Response Message | 1 Byte | 1 Byte | 2 Byte | 0-85 Bytes |
|---|---|---|---|---|
| | Packet ID | Activity | Activity Parameter | User Payload |
| | 0x10 | 0x02 | 0x0000 | - |

| Final Message | 1 Byte | 6 Bytes | 6 Bytes | 6 Bytes | 0-85 Bytes | |
|---|---|---|---|---|---|---|
| | Packet ID | Poll Message Tx Timestamp | Response Message RX Timestamp | Predicted Final TX Timestamp | User Payload | |
| | 0x29 | - | - | - | - | - |

| Report Message | 1 Byte | 6 Bytes | 0-85 Bytes | | | |
|---|---|---|---|---|---|---|
| | Packet ID | Calculated ToF | User Payload | | | |
| | 0x2A | - | - | - | - | - |

Raw captured frames between Tag and Anchor in Wireshark are displayed as follows



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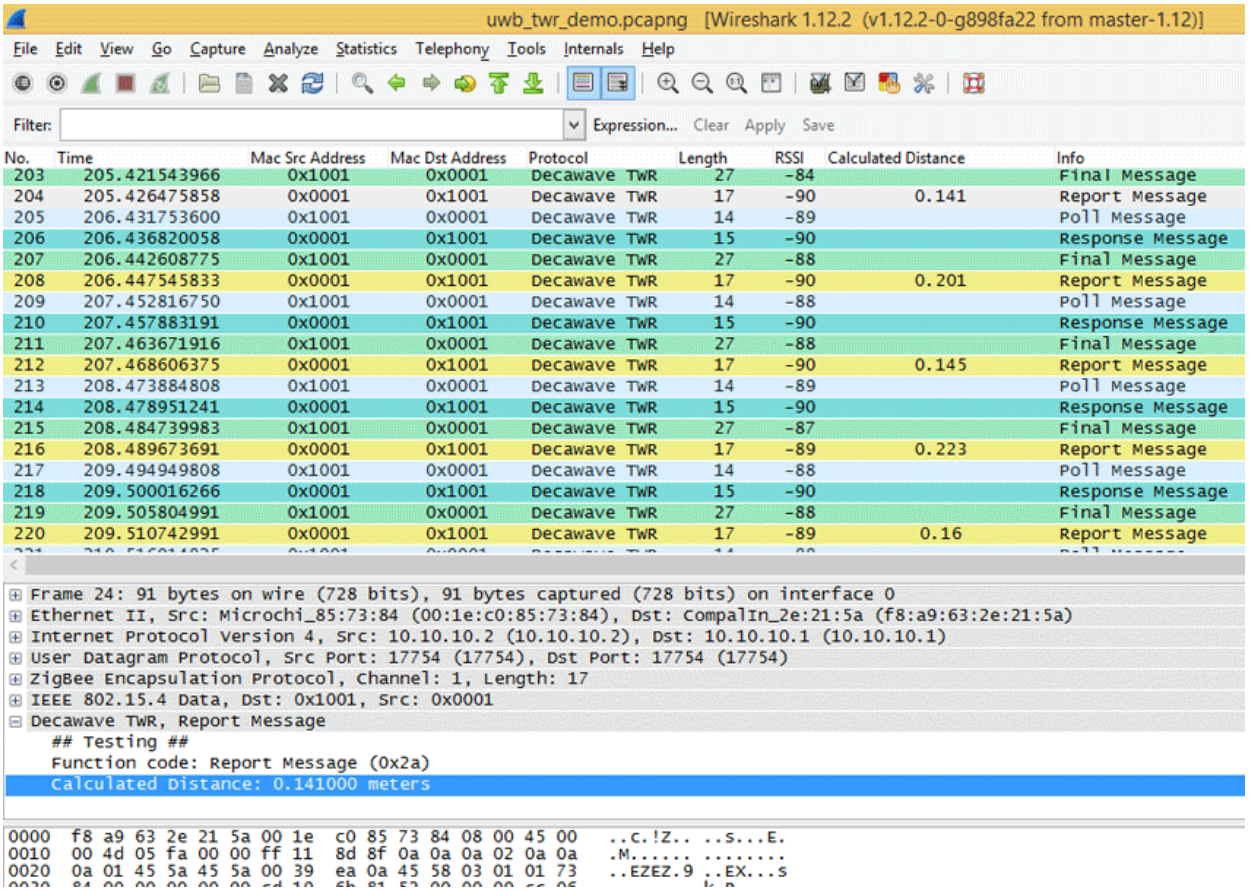
TWR Wireshark plugin which is equipped with UWB Sniffer might further dissect those frames. Payload from frame is decoded as Poll, Response, Final or Report message with calculated distance.




## 5.1 Wireshark dissector for Decawave Two Way Ranging

a. Download Decawave TWR plugin.
b. Extract and copy plugin to the Wireshark plugin folder.
   Windows c:\Program Files\Wireshark\plugins\1.x.x\,
   Linux /usr/local/lib/wireshark/plugins/1.x.x/.
c. Start Wireshark. menu Analyze -> Enabled Protocols (CTRL+SHIFT+E)
d. Check Decawave-TWR
e. Apply, OK.



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# UWB Sniffer

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