Tag IMU v4r7
Full Featured Mobile RTLS Locator

Features

- Real-Time Location with UWB and TDoA Technique
- Movement Detection / 3D Spatial Orientation / Sensor Data
- Identification, unique MAC address
- DecaWave UWB Radio, 3-7GHz
- Wireless Tag Configuration via RTLS Studio
- Rechargeable Battery Li-Pol 560 mAh
- Firmware Upgrade and Charging via USB
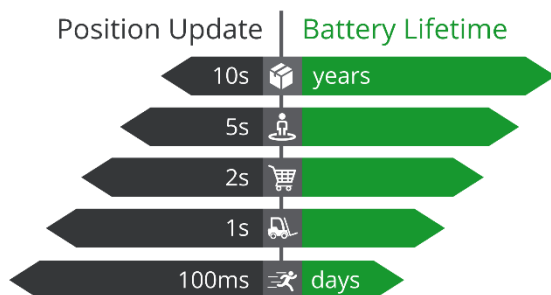- User LED and Charging LED indication

Tag is an active mobile locator. Its position is reported within selected refresh rate. Tracked object need to be equipped with this device.

Tag IMU provides positioning data, 3D spatial orientation as well as the raw sensor output from inertial sensors, pressure, and temperature sensor. It also implements movement detection feature to prolong battery lifetime. Location and sensor data are provided through the open API.

Tag IMU is powered from rechargeable Li-Pol battery and wirelessly configurable through RTLS Studio web interface. Tag is equipped with DecaWave UWB radio with an integrated omnidirectional antenna.

Accelerometer
Gyroscope
Magnetometer
Pressure Sensor
Temperature Sensor

Dimensions	70x50x21 mm
Weight	25g
Refresh Rate	10ms – 60s
Battery Lifetime*	10s – 5 years
	1 s – 1 year
	500ms – 248 days
	100ms – 53 days
Nominal Battery	560mAh
Charge Time via USB	Approx. 6h
Charge Current	100mAh
UWB Range	15-50m
Temperature Range	0 – 50°C
For Indoor Use Only	

*depended on RF Profile settings, can be significantly prolonged with the movement detection feature

Position Update | Battery Lifetime

10s	years
5s	
2s	
1s	
100ms	days

Content

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1 Power up

1) Switch on the Tag.
2) User LED should light up for 1 second.
3) If the User LED just blinks or does not light up at all, it means that the battery is discharged.

2 Tag Behavior

1) Tag is initialized after the switch is set to the ON position. If the battery is low, it goes to sleep mode immediately, otherwise it goes directly to step 2.
2) There is a two second RX window after initialization for receiving the wireless configuration.
3) Tag sends location blink message periodically with a given refresh rate. This message is received by set of Anchors. It is then forwarded to the RTLS Studio via Ethernet of WiFi backhaul, where position is calculated. Blink can be optionally equipped with sensor data. All the data is further disseminated trough the API.

| Tag Switch ON | Init | Wait for Wireless Config (2s) | Send Blink Message | Sleep | Send Blink Message | Sleep | ... |

Optional – Sleep mode can be interrupted by periodical reception. This provides an option when the Tag needs to be reconfigured remotely. However, it comes with a price of increased power consumption. Read more info in the Wireless Configuration section. *This feature is available from FW 3.118.*

2.1 Basic Blink Messages

Blink messages are briefly described in the table below.

Blink Message	Frequency	Payload
Standard blink	Set by refresh rate parameter	Blink sequence number and MAC address only
Battery blink	Every 15th blink	STD blink content + battery level
Info blink	After power-up three info blinks are sent. Then every 15th battery blink	Battery blink content + info about: Tag Type, HW & FW versions, user settings of the Tag's parameters and mounted sensors
Extended blink	Set by refresh rate parameter	Blink with sensor data

Table 1:Blink Types

For more detailed information about Tag messaging please read *AN11, AN12 Custom Tag Integration*.

2.2 Motion detection and Sleep modes

Motion detection utilizes the accelerometer's data to detect, whether the Tag is moving or not. This information gives the Tag possibility to go into sleep mode once it is stationary. This brings two benefits: it prolongs the battery lifetime and decreases communication workload over the channel.

Tag has four sleep mode options

- Disabled
- Delayed sleep
- Immediate sleep
- Keep alive
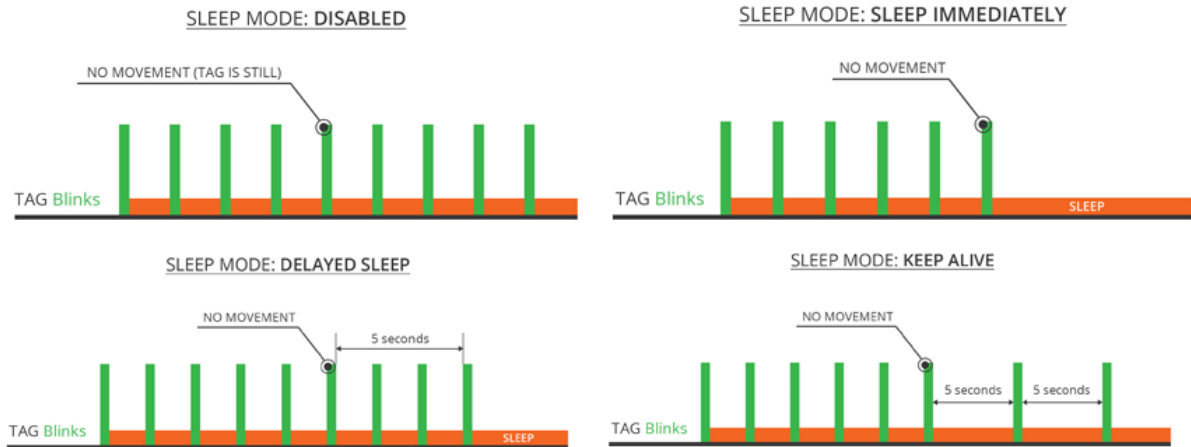
- **Disabled**
  Tag send blink message regularly and movement detection is inactive.
- **Delayed sleep (5s)**
  Once no movement is detected, tag remains sending blinks for a 5 second period and then go into sleep mode. This mode can be useful in scenarios when accurate position is required at the spot where tag was stopped.
- **Immediate sleep**
  Tag is put into deep sleep immediately after no motion event is detected.
- **Keep alive (5s)**
  Tag is put into sleep immediately after no motion event is raised, still it sends blink every 5 seconds. After the blink is sent, the tag is put back into deep sleep. This feature is useful for static tag tracking. *This mode is available from FW 3.118.*

3 Tag Charging

Charging is done via USB cable with a max. current of 100mA. The device can be charged only at temperatures between 4°C and 40°C. Never charge the device below 4°C.

Warning: This device contains lithium polymer battery; it must be handled with care and there is a flammability hazard if the package is damaged.

4 Channel Utilization

The Tag sends blinks periodically plus a random offset through a so-called ALOHA channel access method. However, once more Tags are in the same radio range their positions are estimated by the same set of Anchors and if they transmit at the same time, collision occurs. In this case, positions cannot be calculated. Therefore, one needs to think about the channel utilization for a given application. The table below shows the total Tag number for a given RF profile and refresh rate.

Note: Please keep in mind that the number of Tags calculated below applies for the multiple Tags in the same radio range (location cell). There is no limitation for total number of Tags running across the whole system.

Tag RF profile / Tag Refresh Rate	Blink TX Time [ms]	10s (0.1 Hz)	1s (1 Hz)	0.5s (2 Hz)	100ms (10Hz)
RF0, RF3	2.3	782 Tags	78 Tags	39 Tags	7 Tags
RF1, RF4	0.432	4166 Tags	416 Tags	208 Tags	41 Tags
RF2, RF5	0.175	10285 Tags	1028 Tags	514 Tags	102 Tags

Table 2 Channel Utilization - Number of Tags in one location cell without collisions for given RF profile

Calculation example: *Probability of collision depends on the blink length. ALOHA access method has 18% limit where there is high probability of transmissions without collisions. Let us calculate an example where Tags have the same refresh rate 1s and RF0 profile is used. Blink time for this profile is 2.3ms. Therefore, the number of Tags within the same physical vicinity without collisions is 78 (1000ms/2.3ms*0.18).*

Once the blink message is equipped with sensor data, the utilization of the radio channel will be higher with the same RF profile and Refresh rate. The following table shows the maximum Tag number for a given RF profile and refresh rate, if the quaternions are sent.

Tag RF profile / Tag Refresh Rate	Blink TX Time [ms]	10s (0.1 Hz)	1s (1 Hz)	0.5s (2 Hz)	100ms (10Hz)
RF0, RF3	2.64	679 Tags	67 Tags	33 Tags	6 Tags
RF1, RF4	0.468	3813 Tags	381 Tags	190 Tags	38 Tags
RF2, RF5	0.18	9917 Tags	991 Tags	495 Tags	99 Tags

Table 3 Channel Utilization - Number of Tags with sensor data in one location cell without collisions for given RF profile

Note: *Sewio provides channel utilization spreadsheet for calculating customer scenario.*

5 RF Profiles

Tag can operate in one of the six RF Profiles providing optimum performance for a given application. RF profile selection is a tradeoff between energy consumption, range and channel utilization. Tags and Anchors within the RTLS must be set to the same RF profile for blinks, otherwise the devices will not be able to communicate. For more info, please read the *RTLS TDoA Technology Basic Principles document*.

Here is a brief RF Profiles comparison, ordered from best to worst depending on the parameter:

Order	Channel Utilization	Energy Consumption	Signal Robustness and Range
Best	RF2, RF5	RF2	RF3
		RF1	RF0
	RF1, RF4	RF5	RF4
		RF4	RF1
	RF0, RF3	RF0	RF5
Worst		RF3	RF2

Table 4 RF Profiles Comparison

Tag IMU Datasheet

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5.1 RF Profile Selection

RTLS TDoA requires wireless synchronization of Anchors which is carried over the UWB channel. Therefore, the Anchor spends a small portion of time in synchronization period and rest of the time in a blink period. If both periods are selected to be on the same channel, the best practice is to set the sync period and blink period to non-interfering RF Profiles to avoid collisions. Please note that the blink period must be set equally between Tags and Anchors at all times.

Recommended profile allocation for the same channel: Sync period CH 5, RF0 and Blink period CH 5, RF4.

RF profiles are set through RTLS Studio -> RTLS Manager -> Tab Anchors Summary and Tab Tags Summary. Please see the Wireless Configuration section.

In the table below are listed profiles which may be used without interference.

RF profile	RF0	RF1	RF2	RF3	RF4	RF5
RF0	✘	✘	✘	✔	✔	✔
RF1	✘	✘	✘	✔	✔	✔
RF2	✘	✘	✘	✔	✔	✔
RF3	✔	✔	✔	✘	✘	✘
RF4	✔	✔	✔	✘	✘	✘
RF5	✔	✔	✔	✘	✘	✘
✔	Without Interferences					
✘	Interferences occurs					

Table 5 RF profiles interferences

6 Battery Lifetime Estimation

The table below shows battery estimation for a given RF profile and refresh rate.

Tag RF profile / Tag Refresh Rate	10s (0.1 Hz)	1s (1 Hz)	0.5s (2 Hz)	100ms (10Hz)
RF0	3 years	169 days	87 days	17 days
RF1	5.2 years	1.2 year	248 days	53 days
RF2	5.5 years	1.4 year	287 days	63 days
RF3	2.2 years	126 days	65 days	13 days
RF4	3.9 years	0.9 year	186 days	40 days
RF5	4.1 years	1 year	215 days	47 days

Table 6 Battery Lifetime for 600mAh Capacity – estimated as 8 hours of continuous transmissions per day. Can be further prolonged with the movement detection feature.

***Note:** Sewio provides spreadsheet to calculate battery lifetime for given application.*

6.1 Power Consumption

During the operation, the device goes through several states with different power consumption. These states states are listed in Table 7. Current consumption in all states was measured in default Tag configuration.

State	Current consumption [mA]	Duration [ms]	Description
TX state	140	2.3	Standard blink sent
RX state	150	Dependent on user setting	Wait for wireless config message
UWB sleep, MCU active	7.36	0.078	Overhead
UWB idle, MCU active	23.6	5.4	Wait for XTAL stabilization
UWB sleep, MCU sleep	0.087	Dependent on Refresh rate	Sleep

Table 7 Power consumption in various states

7 Tag IMU Sensors

Following sensors extends location capability of Tag IMU

- Accelerometer
- Gyroscope
- Magnetometer
- Barometer
- Thermometer

Accelerometer is natively used for movement detection feature. Tag can also provide 3D spatial orientation which employs data fusion over accelerometer, gyroscope, and magnetometer.

There are plenty of other applications where sensors can deliver valuable information. For this reason, Tag provides raw data output via the API. Here are some examples:

Sensor	Application Type	Description
Inertial Sensors	Sport	Movement type classification Jump analysis Impact analysis
Inertial Sensors	Security	Combination of fall analysis with location data can provide a man down event.
Accelerometer	Logistic	Deceleration and significant vibration after that can identify a forklift accident that could be automatically logged.
Barometer	General	Floor level determination
Accelerometer	Smart Office	Tag equipped on a chair can detect vibration thus occupancy within the time and provide data for seating plan optimization

Please watch the IMU Sensors Tutorial and 3D Models Tutorial videos. Please read AN01 Sensors Guide for sensor details available in partner portal.

8 Tag Default Settings

Tag can get back default settings after the device is reset.

Please notice that default config could be changed due to the new firmware revision or customer request, see news on partner portal.

Parameter	FW 3.118	FW 3.118 (from 1.10.2018)
Refresh Rate	100 ms	100 ms
Channel	5	5
RF Profile	RF3	RF4
Sleep mode (previously Acc Mode)	Immediate sleep	Immediate sleep
Sleep threshold	Low (16 mg)	Low (16 mg)
Random Deviation	Enable	Enable
Periodical RX	Disable	Disable
RX Duration	1000 ms	1000 ms
Sensors	Disable	Disable
Accelerometer Dynamic Range	±2 g	±2 g
Gyroscope Dynamic Range	±250 dps	±250 dps
Barometer mode	Disable	Disable

Table 8 Tag Default Configuration

9 Wireless Configuration

The configuration is transferred to the Tag via the UWB link from the selected Anchor. During the configuration, the Anchor is not available for location purposes.

IMU Tag must loaded with FW 3.118 and used with RTLS Studio 1.4.x or newer. Otherwise the sensor features will not be available.

Please watch our Tag Configuration *Tutorial and* Tag Features *Tutorial videos.*

9.1 RTLS Studio version 1.4.0 and higher

1) RTLS Studio -> RTLS Manager -> Tag Summary, click on Advanced Setting to access Sensor Settings

2) Please select the Tag address, otherwise set it to "All". Then set the parameters that you wish to change. You will need to select actual Tag firmware and also the Anchor address that will broadcast new configuration to the Tag.

The following parameters are available:

Parameter	Value	Description
Refresh rate [ms]	10 – 60000 [ms]	The Tag's refresh rate
Channel	1,2,3,4,5,7	The Blink radio channel
RF Profile	RF0-RF5	The RF Profile setting
Power	Min-Max	Tag's transmit power
Sleep mode (previously Acc Mode)	Keep alive (5s) Immediate sleep Delayed sleep Disable	Sleep mode for movement detection feature.
Sleep threshold	Low Medium High Custom <4;8001> [mg]	Threshold of acceleration for wakeup the tag from sleep.
FW	FW Version	Select Tag's firmware version
Anchor	MAC Address	Select which Anchor will send the configuration wirelessly

The following advanced parameters are available:

Parameter	Value	Description
Random Deviation	1 – enabled – Tag TX in defined refresh rate + random offset 0 – disabled – Tag TX in defined refresh rate	**Option 1** Random deviation enabled – Tag blinks randomly within regular refresh rate. Always use this option as it is required for Aloha. **Option 0** Random deviation disabled – Tag blinks in regularly in given refresh rate. This option is for testing purposes only.
Periodical RX	Value [ms] <100, 129 000 000>	Period for switch Tag to RX mode. Useful for application where Tag needs to be reconfigured remotely. RX have higher priority than TX, therefore if the device is in RX state, the Blink Refresh Rate is not always kept. Be aware this parameter has significant impact on power consumption.
RX Duration	Value [ms] <50, 60 000>	Duration of each RX. Be aware this parameter has significant impact on power consumption.
Sensors	Accelerometer Gyroscope Magnetometer Barometer Rotation Disable	Raw data from each sensor can be sent within extended blink message. Rotation - spatial rotation is sent to RTLS Studio and can be visualized in Sensmap 3D. Data from barometer can be sent together with raw data or with rotation.
Accelerometer Dynamic Range	± 2 g ± 4 g ± 8 g ± 16 g	Dynamic range of accelerometer data output.
Gyroscope Dynamic Range	± 250 dps ± 500 dps ± 1000 dps ± 2000 dps	Dynamic range of gyroscope data output.
Barometer mode	Low power Normal mode High precision Disable	If the data from barometer are sent together with rotation this setting will be set to high precision.

3) Press the Start/Stop (Start Update) button. The selected Anchor will start sending the new configuration.

Sleep Mode	Sleep threshold	FW	Status	Anchor	Action
▼	Skip ▼	Tags with FW 3.118 and ne ▼		d880396219e0 (Anchor #: ▼	Start Update

4) Tag receive configuration messages after the power up, therefore turn off and turn on the Tag.

Note: If Periodical RX is enabled you may wait until the tag automatically switches to the RX state and receives the new settings.

5) When the new settings are being sent, the positioning will be disabled. After the update is done, stop the transmission by clicking the Start/Stop button again.

6) New settings should appear within Online Tags table immediately.

10 Reset Tag to Defaults Settings
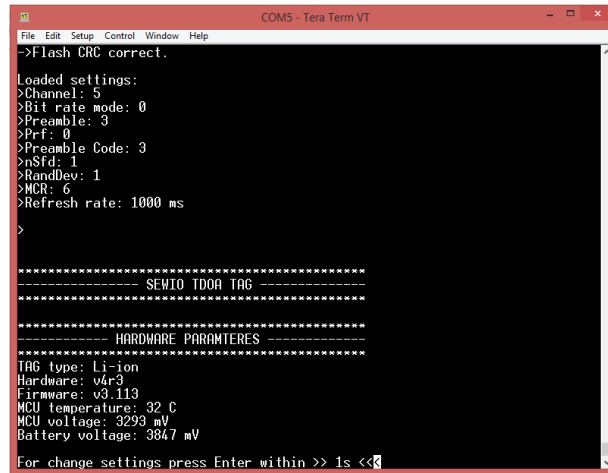
1) In order to reset the Tag into default, connect it to your computer via USB and open a console application called TeraTerm.

2) Open TeraTerm and select the correct port.
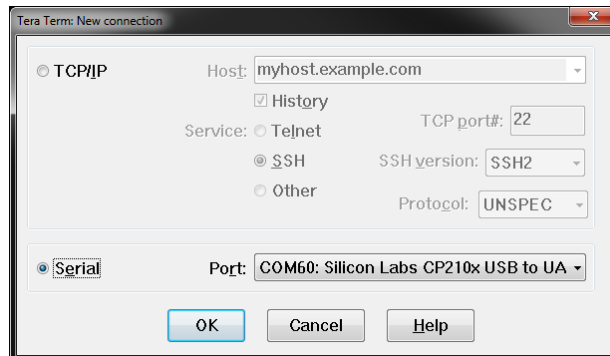
3) Turn the Tag on. The Tag will ask you if you want to load a new configuration. Press Escape or wait for five seconds.

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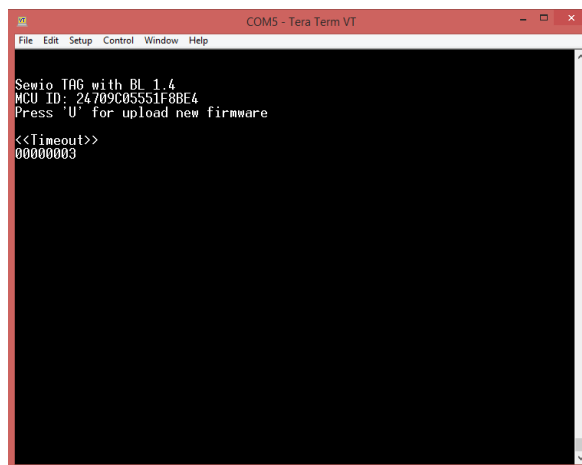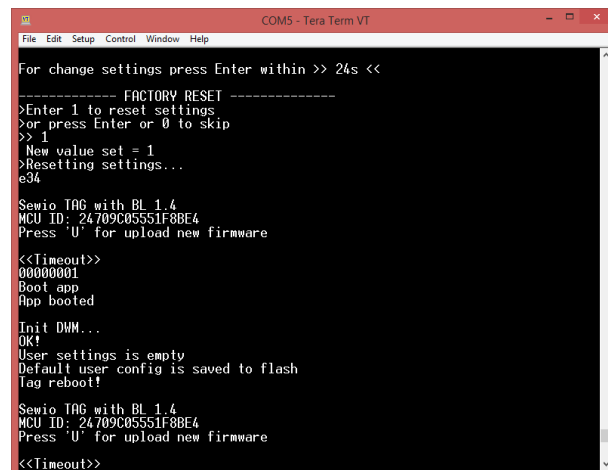
4) Then it will ask you if you want to change the default configuration. Press Enter.
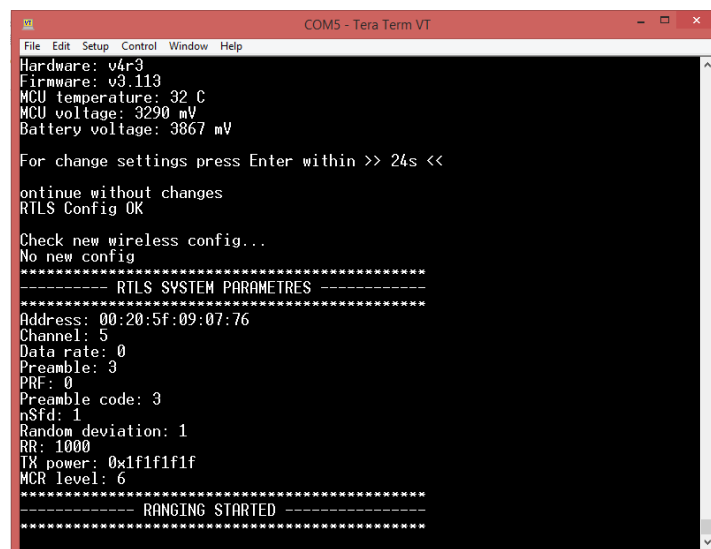
5) Then type "1" and press Enter again. This will reset the Tag to its default configuration.

6) The Tag will be restarted. Skip all following steps by using Escape, or simply wait until the intervals are finished. The Tag will resume to its normal operation once the "Ranging Started" message is shown.
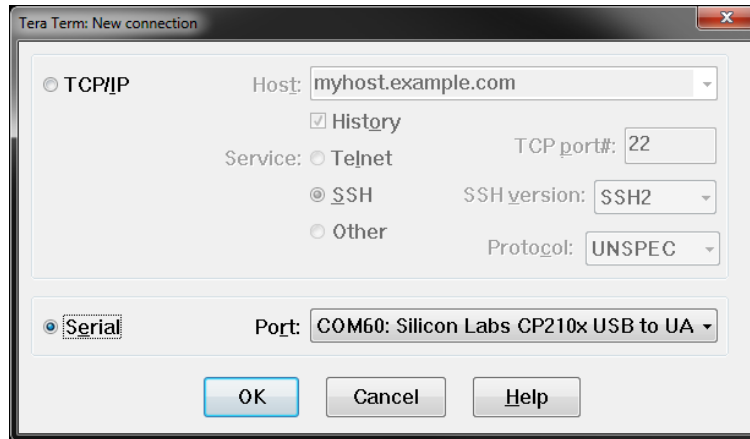
11 Firmware Upgrade

1) Hook up USB cable between Tag and computer.

2) Open TeraTerm and select the correct port and press OK.
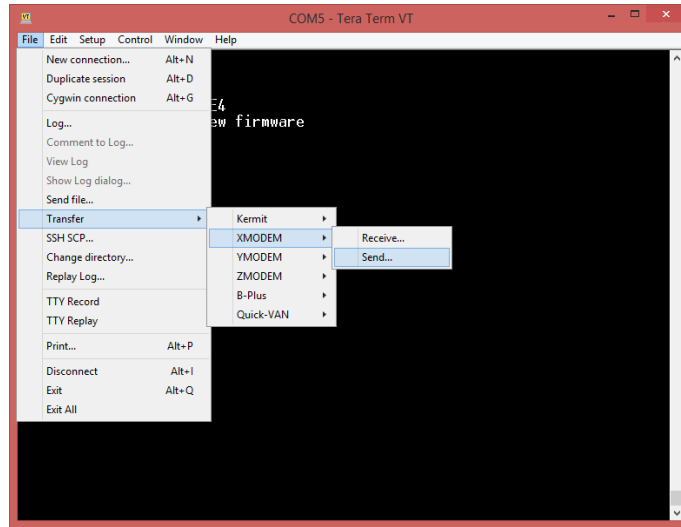

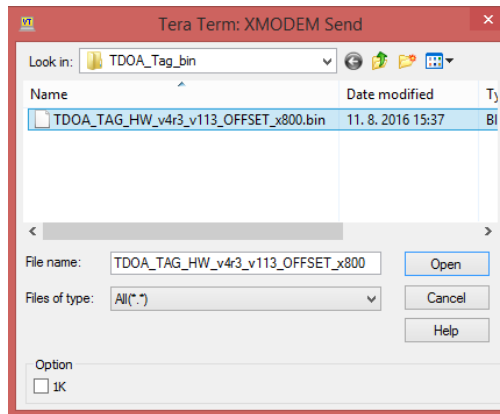3) Turn the Tag on and press "U" to upload new firmware.

   Do not press any keys during the firmware upload, otherwise firmware could be transferred inconsistently.
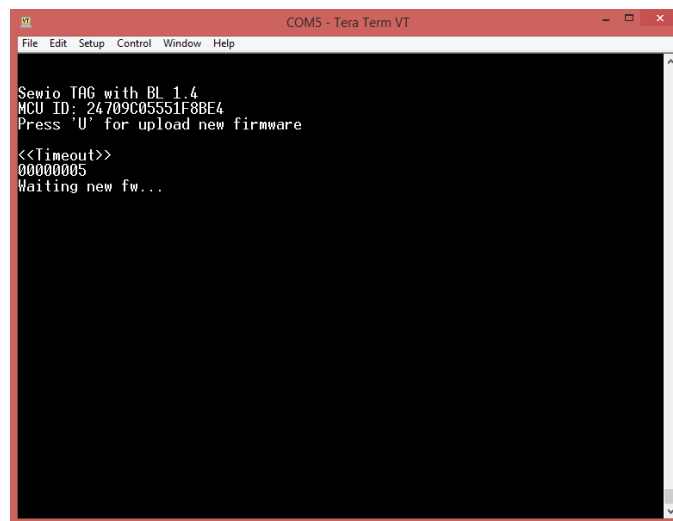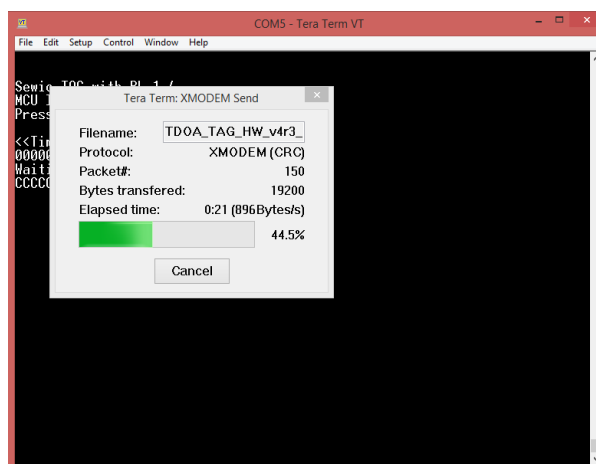
4) Click File -> Transfer -> XMODEM -> Send.

5) Find the configuration file on your computer.

6) Wait until the transfer is done.

7) Once the "Done" message shows, the firmware was uploaded successfully. Press "R" to restart the Tag.

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12 Firmware Changelog

Changelog is available within the Sewio partner portal.