RF RECEIVER SENSITIVITY VALIDATION

25 June 2026

Observe precautions! Electrostatic sensitive devices!

REVISION HISTORY

The following major modifications and improvements have been made to this document:

Version	Author	Reviewer	Date	Major Changes
1.0	BE		2013	Original version
2.0	AZ	SA, JB	2026	Document maintenance

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1 Introduction

The test procedure in this application note verifies the sensitivity of an EnOcean wireless receiver integrated into a finished product. Receiver sensitivity (RX sensitivity) defines the minimum signal power at which radio signals can be reliably decoded. It is influenced by factors such as power supply stability, RF filter performance, and self-generated in-band electromagnetic interference.

RX sensitivity is a key parameter of the RF link budget and directly influences the maximum communication range between devices. The measured sensitivity can also be compared with that of individual EnOcean modules to evaluate the effectiveness of the final design.

2 References

Familiarity with the following will be useful for this test procedure:

[1] EnOcean Equipment Profiles (EEP) v3.1

[2] Remote Management Specification v2.91

[3] EnOcean Radio Protocol v1.0

[4] TCM 3xx User Manuals

[5] Dolphin Studio graphical user interface for easy configuration of TCM 3xx/STM 3xx modules – Help Guide V 2.6.3.0

[6] DolphinView Advanced Help Guide V 3.9.0.0

Useful web sites:

[7] EnOcean website https://www.enocean.com/

[8] EnOcean Alliance website https://www.enocean-alliance.org/

[9] MiniCircuits website https://www.minicircuits.com/

3 Terminology

DUT – Device under test, a finished EnOcean based product that will be tested for its receive sensitivity.
1BS – One byte sensor, an EnOcean telegram type.
VLD – Variable length data, an EnOcean telegram type.
Gateway – EnOcean based hardware that translates EnOcean telegrams to ESP3.
ESP3 – EnOcean Serial Protocol 3, the latest version of EnOcean's serial protocol.
RSSI – Receive signal strength indicator, a measurement to determine the power of a received signal.
LTRSSI – Long term RSSI, a measurement to determine the ambient power levels of the frequency used in the DUT.
Trigger Telegrams – 1BS telegrams with 0xBE as the data byte. These trigger the DUT to transmit RSSI VLD debug telegrams.

Transmit Gateway – RF-Isolated gateway that will be sending trigger telegrams to the DUT via DolphinView Advanced.
Receive Gateway – Gateway that will be receiving VLD debug telegrams from the DUT via DolphinView Advanced.

4 Theory

For an RF signal to be received, it must first be detected and then decoded. The receiver detects a transmission when the input power rises above a threshold relative to the ambient level, known as the noise floor (long-term received signal strength). This noise floor represents power from all unintended emitters.
If the received power increases sufficiently for a sustained period, the receiver attempts to decode it as a valid signal. Successful decoding depends on the signal-to-noise ratio (SNR). A high SNR minimizes noise impact and improves bit detection, while a low SNR reduces decoding reliability. Good RF layout and antenna design help maximize received signal power, whereas reducing noise is more challenging.
In an ideal noise-free environment, even extremely weak signals could be decoded over long distances. In practice, fundamental noise sources cannot be eliminated. The most significant is thermal noise, which is constant across frequencies and depends on temperature and receiver bandwidth. The equation for thermal noise power is given below.

$$P_n = k_B T B$$

$$k_B = 1.3807 * 10^{-23}$$

$$T = 298.15°K \ (25℃)$$

$$B = 300kHz \ (EnOcean\ Dolphin\ ASIC)$$

Table 1 Noise Floors

Freq:	315MHz	868MHz	902MHz
$\boldsymbol{P_n}$**(dBm)**	-119.1	-119.1	-119.1

An ideal EnOcean receiver, without additional noise sources, can decode radio telegrams above the sensitivity levels specified in Table 1. In practice, other factors degrade signal quality: amplifiers and filters introduce noise and attenuation, and decoders require a minimum signal level above the noise floor. Together, these effects define the practical operating noise floor of EnOcean receivers.

Table 2 EnOcean modules RX sensitivities

Freq:	315MHz	868MHz	902MHz
RX Sensitivity (dBm)	-98	-96	-98

To account for all noise sources within the receiver's filtered bandwidth, the noise floor is measured directly at the receiver. This value is available via the long-term signal strength indicator and should approximate the levels shown in Table 2 under isolated RF conditions.

5 Test Setup

The test setup uses three EnOcean modules. The DUT measures the received power from the TX gateway and reports this data to an RX gateway. The RF-shielded TX gateway sends telegrams using DolphinView Advanced on a connected PC, while a second EnOcean gateway, also running DolphinView, receives telegrams from the DUT and can be any device with a serial interface. All devices must be programmed with the appropriate firmware.
Initially, the DUT responds to all received telegrams with signal strength data. To restrict responses to the TX gateway only, a remote management action command is sent from the TX gateway. After this, the DUT reports RSSI values for the TX gateway when triggered by its telegrams.

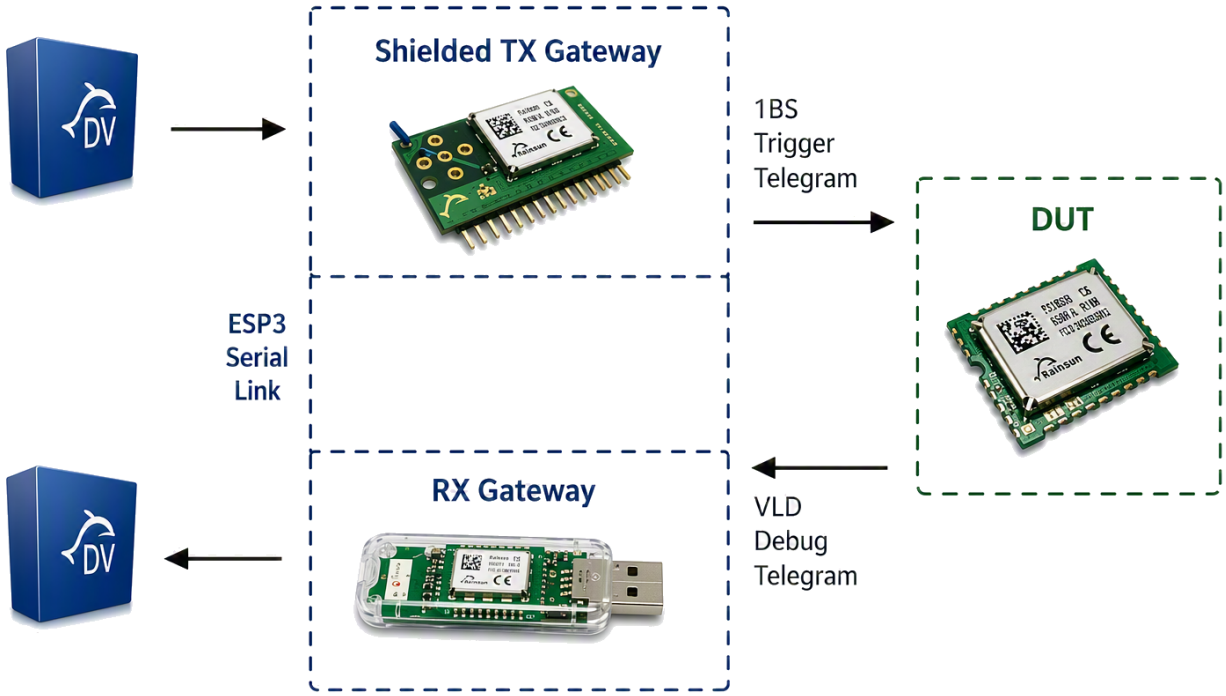

Figure 1 Simplified Test Setup – Operating Mode

5.1 Required materials

1) The device under test
2) A TCM320 with external SMA antenna connector (shielded gateway)
3) A TCM3xx with Serial output or USB300 (gateway)
4) An external antenna
5) DolphinView Advanced
6) RF isolation box or Faraday cage
7) EVA300 development board or similar hardware
8) EOPX programmer board including cables
9) Dolphin Sniffer firmware (via DolphinView Advanced)
10) RX_Sensitivity_Test Firmware (*.hex and *_cfg.hex)
11) RF attenuators designed for the test frequency

5.2 Hardware setup

5.2.1 RF-Isolated gateway

The TCM320 gateway and associated hardware should be placed in an RF isolation box (e.g., an ungrounded metal enclosure or Faraday cage) to minimize RF leakage from PCB traces and connectors. Without proper isolation, stray emissions can affect the measured receive power. Isolating the transmitter ensures that all RF energy is radiated through the external antenna, where output power can be controlled. The transmitter must also be connected to a PC running DolphinView Advanced, typically via an EnOcean programming board (EOPX) or a custom interface.
To use an external antenna, the TCM320 hardware may require modification, including removal of the onboard antenna. Refer to section 4.3.2 "*Mounting 50 Ω antennas*" of the TCM 320 user manual for frequency-specific instructions.

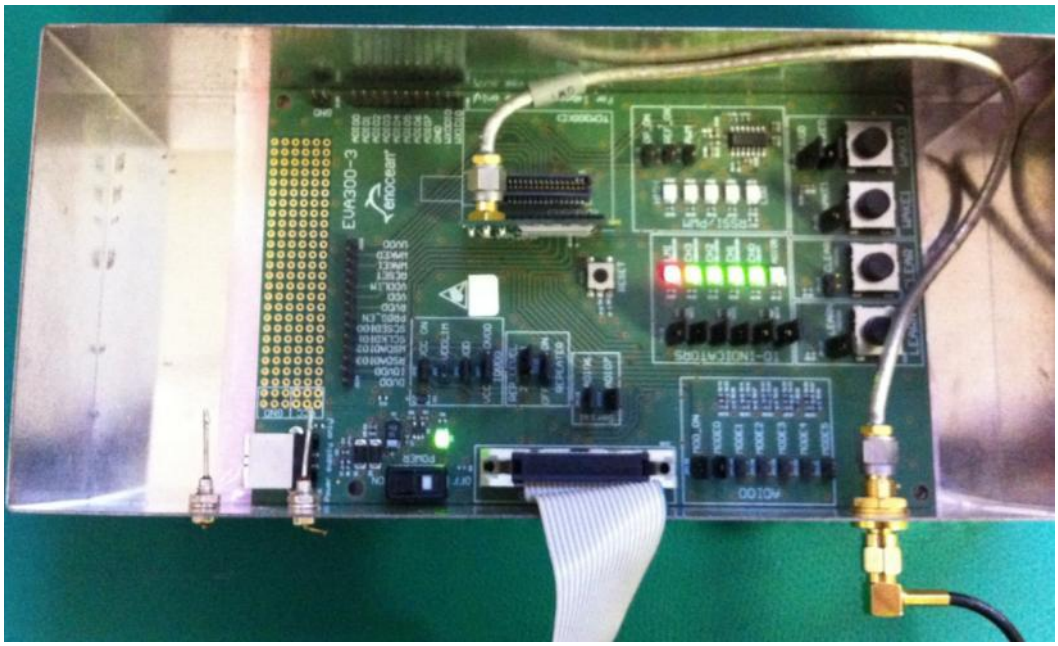

Figure 2 Example gateway in an RF-isolation enclosure with external antenna connector

5.2.2 External antenna

The RF-Isolated gateway should be positioned away from the DUT to minimize any emissions escaping the enclosure. Ensure all RF connections are secure and place the antenna approximately 100 cm from the DUT. Standard spacing guidelines between the antenna and nearby metal surfaces should be followed. The antenna should also be easily detachable to allow adjustment of output attenuation.

Figure 3 External Antenna and DUT

5.2.3 Device under test

The DUT should be oriented as in its final installation and operated using its onboard power supply and, if possible, all relevant peripheral hardware. It should be positioned at least 1 m away from external interference sources such as power supplies, lighting drivers, electromechanical devices, and lighting fixtures—unless these are part of the intended operating environment.

5.2.4 EnOcean gateway

This device should be placed within RF range of the DUT. Access to the serial interface is required to communicate with DolphinView Advanced via ESP3. A TCM3xx with the EDK development board is recommended.

5.3 Firmware setup

5.3.1 RF-Isolated Gateway Firmware

The gateway must run the Dolphin Sniffer firmware. This can be programmed onto the TCM320 using the Firmware Download function in DolphinView Advanced, after selecting the correct COM port from the dropdown menu.

5.3.2 Device under test

The DUT must run the RX_Sensitivity_Test firmware provided by EnOcean. This firmware can be programmed onto the TCM3xx using Dolphin Studio and the appropriate programming interface.

5.3.3 EnOcean Gateway

This TCM3xx must run the Dolphin Sniffer firmware, although a USB300 can also be used. It should be connected to a separate instance of DolphinView Advanced, which may run on the same computer as the RF-isolated gateway's instance.

5.4 Software setup

DolphinView Advanced is used to send and receive radio telegrams via the gateway. The TX gateway runs the Dolphin Sniffer firmware. Select the correct COM port and connect. The same procedure applies to the RX gateway.

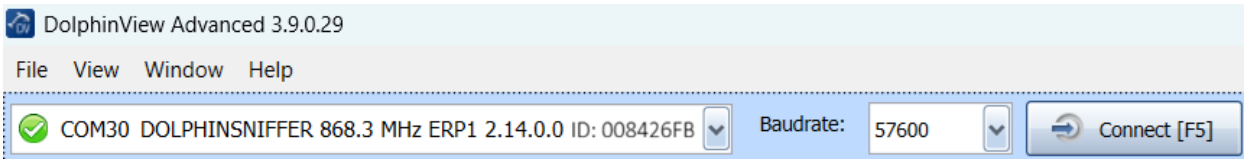

Figure 4 DolphinView Advanced Connected to the Sniffer

6 Test procedure

6.1 RX_Sensitivity Test overview

The RX_Sensitivity_Test firmware, developed by EnOcean, enables measurement of received radio telegram power without external RF tools.
At startup, the DUT transmits a single SYS telegram (RORG 0xA4) with four data bytes set to 0x00, allowing identification of the DUT and filtering of other devices in DolphinView Advanced.
During operation, the DUT responds to each received telegram with a VLD debug telegram containing the sender ID, status, RSSI, long-term RSSI, and level 1 and level 2 repeated RSSI. This data can be visualized using EEP D2-3F-DE from the debug.xml profile in DolphinView Advanced.

Table 3 VLD Debug Telegram Format

Description	Size (Bytes)	Offset (Bytes)
RX Telegram RORG[1]	1	0
RX Telegram Sender ID	4	1
RX Telegram Status	1	5
RX Telegram RSSI	1	6
RX Telegram Sub-Telegrams Received	1	7
DUT Long Term RSSI	1	8

To ensure RSSI debug telegrams are triggered only by the RF-isolated gateway, a filter can be configured using a remote management action command [2]. After receiving this command, the DUT responds only to telegrams from that sender ID. Successful filter setup is confirmed by a SYS telegram containing the filtered ID in its data bytes. The DUT accepts action commands only within 30 minutes of startup; after this, commands are ignored unless the device is power-cycled.

Once filtering is active, the DUT requires a 1BS telegram with data byte 0xBE from the filtered sender to trigger an RSSI debug telegram. The filter is cleared on reset or power loss, and each new action command updates the filter to the latest sender ID. Ensure no additional action commands are sent during testing.

To avoid repeater influence on RSSI, all transmitted telegrams should have the least significant nibble set to 0xF, indicating that they must not be repeated.
Please see 4.2.3 of the EnOcean Radio Protocol for more information on repeaters.

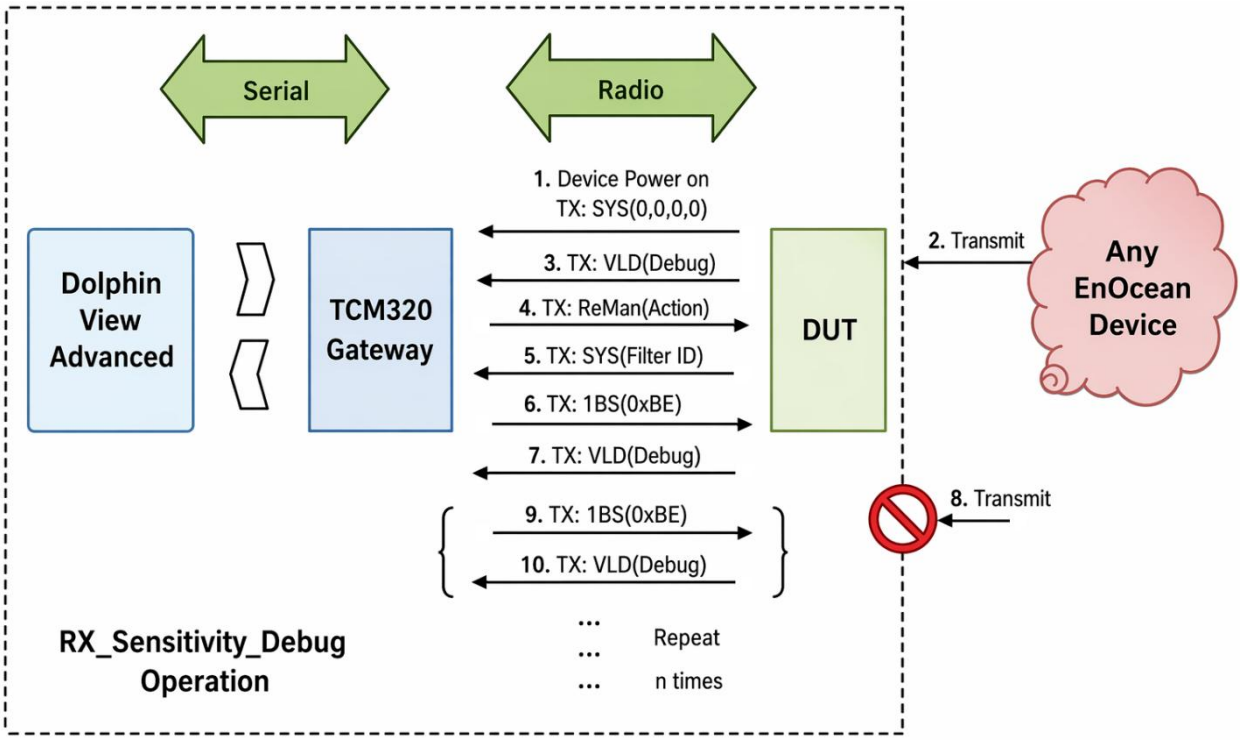

Figure 5 Example Operation of RX_Sensitivity_Debug Firmware

6.2 Process

1. Follow the steps in section 5 Test Setup.
2. In DolphinView, locate the DUT and apply the RX Debug EEP from the debug.xml profile file on the instance connected to the EnOcean gateway.

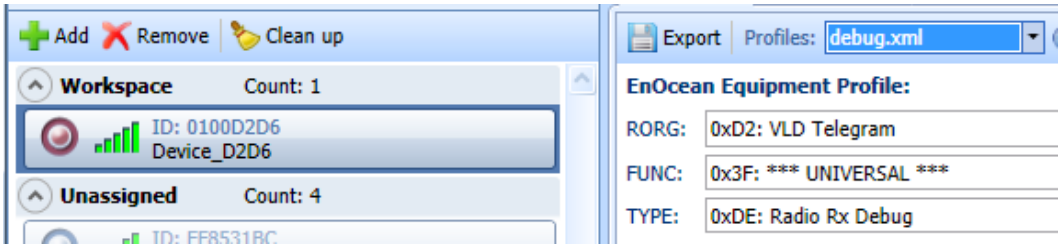

Figure 6 Add the Debug EEP Profile

Figure 7 EEP Debug Profile

To restrict VLD debug telegrams to the RF-isolated gateway, configure the DUT to filter by its sender ID. In DolphinView (connected to the TX gateway), open the remote management window and click the Action button.

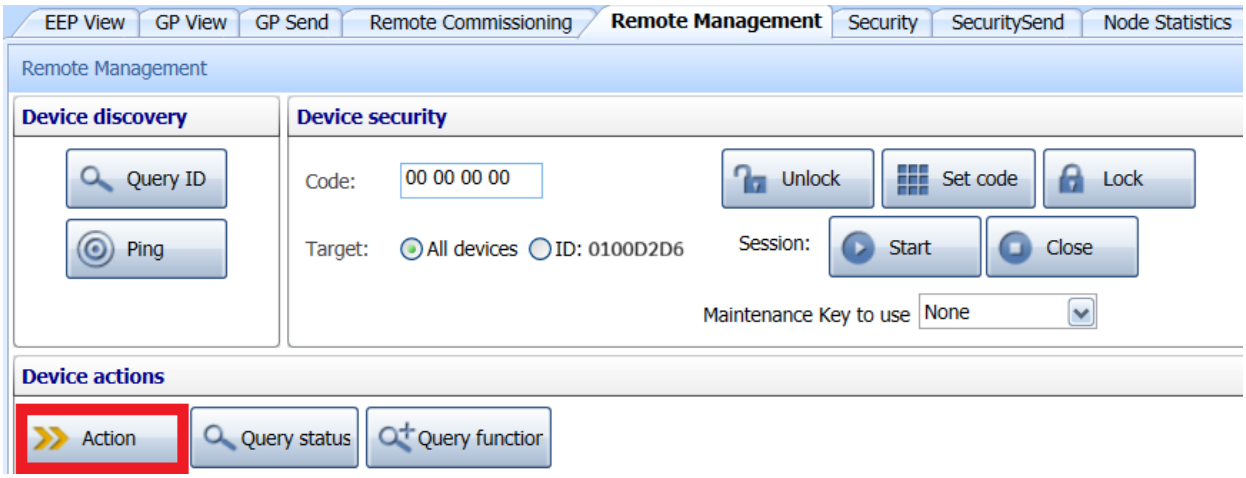

Figure 8 ReMan Action Command

To confirm receipt of the action telegram, the DUT sends a SYS telegram containing the ID it is now filtering on. Verify that this matches the TX gateway ID. Once the filter is active, VLD debug telegrams from other EnOcean devices within range will no longer be received.

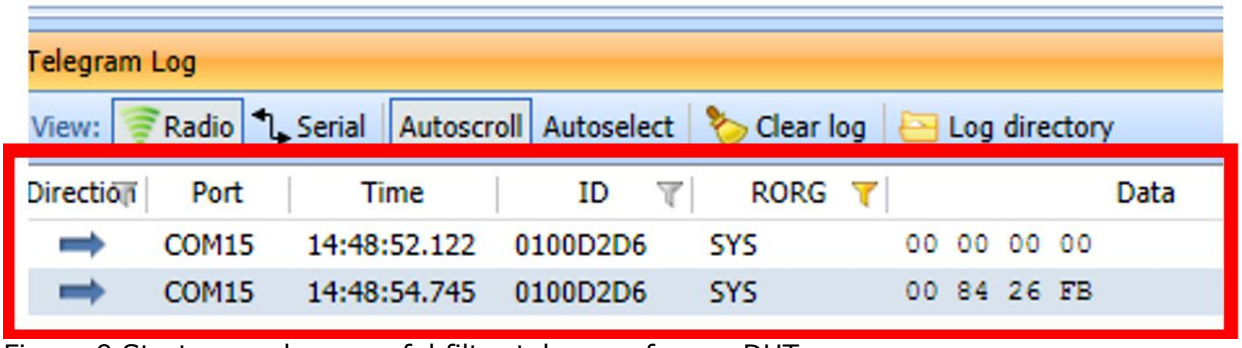

Figure 9 Start up and successful filter telegram from a DUT

To trigger VLD RSSI telegrams, send 1BS telegrams with data byte 0xBE using DolphinView's Telegram Transmit tool. In the DolphinView instance for the RF-isolated gateway, open the Telegram Transmit tab, select File → Load, and load RX_Sensitivity_Trigger.do. This script sends a trigger telegram once per second. Ensure the least significant nibble of the status byte is set to 0xF to prevent repetition by repeaters.

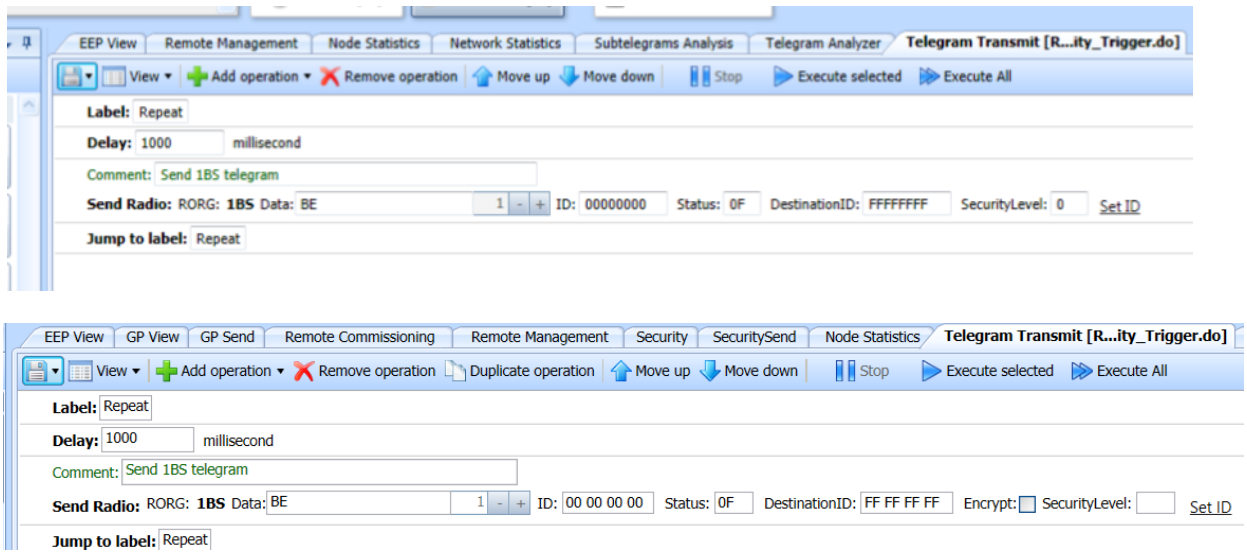

Figure 10 Transmitting 1BS Trigger Telegrams

Start the trigger sequence by selecting Execute All. Then switch to the EEP view of the receiving gateway, where you should observe stable signal strength, a consistent sub-telegram count of 3, and the long-term RSSI value.

Figure 11 Operation with no attenuation, all sub-telegrams received

To determine the receiver sensitivity of the DUT, gradually increase the attenuation between the transmitting gateway and the DUT until sub-telegrams begin to be lost occasionally. In a typical setup, around 43 dB of attenuation can be added before the sensitivity limit is reached. The point at which intermittent sub-telegram loss occurs can be considered the receiver sensitivity of the DUT. This value should be equal to or better than the DUT's reported LTRSSI value.

Figure 12 Operation at RX Sensitivity level

6.3 Alternative Procedure

The procedure can also be performed using a USB gateway running Dolphin Sniffer firmware instead of a TCM320 with an external antenna and RF attenuators. In this case, adjust the RF power at the DUT by increasing the distance between devices. Some trial-and-error adjustment may be required to find a position where the received power approaches the RX sensitivity level. Note that this method determines RX sensitivity only, not maximum range.

For analysis, the receiving gateway should be connected to a stationary computer within RF range of the DUT. This setup may require a second person to operate and monitor the system.

6.4 Conclusions

Each Dolphin module has a specified RX sensitivity (see Table 2), and telegrams should be reliably received down to this level. If the DUT's RX sensitivity meets or is better than the LTRSSI value, the receiver performance can be considered acceptable.

If the measured sensitivity does not match the specification, common causes include external transmissions at the test frequency or unintended noise from the DUT (e.g., switching power supplies or PWM signals), both of which can corrupt telegrams.

The external RF environment can be checked without specialized tools by using a reference device, such as a TCM3xx running RX_Sensitivity_Test firmware on an EnOcean development board (e.g., EDK 300). If the measured sensitivity is still worse than LTRSSI, the environment is unsuitable and the test setup should be relocated.

If performance remains below LTRSSI in a low-noise environment, the DUT is likely generating internal interference. In this case, investigate emissions and validate the RF design, potentially using a spectrum analyzer. Contact EnOcean for further support if needed.

Finally, note that wireless operating range depends on the overall link budget, which includes both receiver sensitivity and transmitter performance. Please see AN102, Antenna Basics – Basic Antenna Design Considerations for EnOcean-based Products

DISCLAIMER

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