

STM 550B / EMSIB (Revision DB)

Multisensor For IoT Applications (2.4 GHz BLE)

11 March 2025



Observe precautions! Electrostatic sensitive devices!

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STM 550B / EMSIB – BLE MULTISENSOR FOR IOT APPLICATIONS (REVISION DB)

REVISION HISTORY

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1.0	MKA	RS, TM	14.01.2020	First public release
1.1	MKA	MKA	23.04.2020	Added packaging information Added detailed mechanical interface
1.2	MKA	MKA	01.06.2020	Update with DA-04 feature set Addition of acceleration test mode
1.3	MKA	MKA	30.06.2020	Added illustration of backup battery interface
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**Published by EnOcean GmbH, Kolpingring 18a, 82041 Oberhaching, Germany
www.enocean.com, info@enocean.com, phone +49 (89) 6734 6890**

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Components of the modules are considered and should be disposed of as hazardous waste. Local government regulations are to be observed.

Packing: Please use the recycling operators known to you.

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1 General description

This user manual describes the functionality of the STM 550B EnOcean multisensor module, the STM 550B Installation Kit and the EMSIB Easyfit Multisensor in product revision DB. For documentation regarding previous revisions, please contact EnOcean GmbH.

The term “STM 550B” is used throughout this user manual to describe both STM 550B multisensor module, STM 550B Installation Kit and EMSIB Easyfit Multisensor unless otherwise noted.

1.1 Basic functionality

STM 550B is a flexible self-powered multi-sensor module capable of measuring temperature, humidity, illumination, magnet contact status and acceleration. It enables the realization of energy-harvesting wireless sensors for lighting control and building or industrial control systems communicating using the 2.4 GHz Bluetooth Low Energy (BLE) standard.

STM 550B uses the same mechanical form factor as the industry-standard PTM 21x modules from EnOcean.

STM 550B integrates the following sensors:

- Temperature
- Humidity
- Ambient light level (measured via the calibrated solar cell)
- Acceleration
- Magnet contact

STM 550B will report regularly (approximately every 2 minutes by default, configurable via NFC) the latest measurements of these sensors. In addition, STM 550B can report its internal energy level and the backup battery voltage (if a backup battery is present).

STM 550B will report immediately if the status (open / closed) of the magnet contact changes or if an acceleration change detected by the acceleration sensor exceeds a user-defined threshold for the first time after a period without such change.

Radio telegrams transmitted by STM 550B are authenticated AES-128 security (CCM) based on a device-unique private key and a sequence counter. This ensures integrity and authenticity of the transmitted telegrams and prevents telegram replay (retransmission of previously transmitted telegrams).

STM 550B is self-supplied via an integrated solar cell which generates the energy required for its operation. For use cases where ambient light is not sufficiently available, STM 550B provides the option to mount a CR1632 backup battery.

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1.2 Product variants

STM 550B is available in two different product and packaging variants:

- STM 550B is the multisensor module in original PTM module form factor intended for integration into OEM housings. It is provided in tray and box packaging of 100 units per box.
- STM 550B Installation Kit combines the STM 550B multisensor module with a wall mount, a design frame, a magnet (for magnet sensor functionality) and an adhesive mounting tape into a ready to use product (EMSIB). It is provided in tray and box packing of 100 units per box.

Figure 1 below shows the STM 550B module on the left and the finished product EMSIB combining the STM 550B module with wall mount and design frame on the right.



Figure 1 – STM 550B (left) and EMSIB (right)

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1.3 Technical data

Antenna	Integrated antenna
Transmission power (at antenna base)	+4 dBm
Communication range (guidance only)	30 m line of sight / 10 m indoor environment
Communication standard	Bluetooth (BLE Advertising)
Radio frequency (min / max)	2402 / 2480 MHz
Radio channels	BLE CH 37 / 38 / 39 (2402 / 2426 / 2480 MHz)
Temperature measurement range / accuracy	-5 °C ... +45 °C / ± 0.3 K
Humidity measurement range / accuracy	0 ... 90 % r.h. / ± 3% r.h.
Illumination measurement range / accuracy	0 ... 2000 lux / ± 5 % of full scale
Acceleration measurement range / accuracy	+ - 2 g / ± 5 % of full scale
Acceleration threshold for immediate report	0.03 g
Update rate (excl. random offset)	Every 2 minutes
Device configuration	LRN button and NFC interface
User notification	Bi-color LED (red, green)
Device identification	Unique 48 Bit Device ID (factory programmed)
Security	AES-128 (CCM) with sequence counter
Power supply	Integrated solar cell
Minimum light level for self-supplied operation	200 lux for 6 hours per day
Operating time in darkness	4 days after full charge
Backup battery type (optional)	CR1632
Operation time with backup battery	Renata CR1632 (137 mAh)
Infrequent bright light (200 lux for 2 hrs per day)	8 years
Consistent low light (50 lux for 6 hrs per day)	7 years
Total Darkness	5 years
Dimensions (STM 550B Module)	40 mm x 40 mm x 13 mm
Dimensions (EMSIB Finished Product)	49 mm x 49 mm x 13 mm

Notes: STM 550B is designed for indoor use only and should only be used in the specified environmental conditions
If a parameter depends on the device configuration, then the value corresponding to default settings is provided

1.4 Environmental conditions

Operating Temperature	-5 °C ... +45 °C (indoor use in dry rooms only)
Humidity	0% to 90% r.h. (non-condensing)

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1.5 Packaging information

1.5.1 STM 550B

STM 550B is delivered in a box of 100 units packed onto 10 trays of 10 units each.

Packaging Unit	100 units
Packaging Method	10 modules per tray, 10 trays per box
Tray Dimensions	205 mm x 166 mm x 20 mm
Box Dimensions	232 mm x 176 mm x 174 mm

1.5.2 STM 550B Installation Kit

The STM 550B installation kit consists of one box with 100 units STM 550B modules (as described above) together with one box of 100 units of installation material to assemble 100 units of EMSIB.

Packaging Unit	100 units
Packaging Method	1 large outer box containing 2 smaller inner boxes Inner box 1: 100 units STM 550B (same as above) Inner box 2: 100 units installation material
Outer Box Dimensions	360 mm x 234 mm x 178 mm
Inner Box Dimensions	232 mm x 176 mm x 174 mm

1.6 Ordering information

Product	Type	Ordering Code	Frequency
STM 550B	Module only 100 unit packaging	S6221-K516:DB	2.4 GHz (BLE)
STM 550B KIT	Module with installation material 100 unit packaging	B6221-K516:DB	2.4 GHz (BLE)

2 Functional overview

2.1 Product description

The energy-harvesting multi-sensor module STM 550B from EnOcean provides wireless sensing functionality without batteries. Power is provided by an integrated solar cell. STM 550B transmits sensor data using the 2.4 GHz Bluetooth Low Energy (BLE) standard.

STM 550B operates fully self-powered (no batteries required) when sufficient ambient light (200 lux for 6 hours per day) is available. In this configuration, STM 550B operates fully maintenance-free.

For cases where sufficient ambient light is not available, STM 550B provides the option to mount a CR1632 backup battery.

Radio telegrams transmitted by STM 550B are authenticated using the AES-128 (CCM) security algorithm in conjunction with a device-unique private key and a sequence counter. This ensures integrity and authenticity of the transmitted telegrams and prevents telegram replay (retransmission of previously transmitted telegrams).

The user interface of STM 550 consists of one button for simple configuration tasks and one bi-color LED to provide user feedback. Configuration of STM 550B parameters is also possible via an integrated NFC (ISO 14443) interface using a PC tool or a mobile application.

2.2 Product interface

The STM 550 product interface consists of the following elements:

- LRN button and bi-color LED
- Solar cell to harvest energy from ambient light and measure the ambient light level
- Magnet contact sensor
- Ventilation slots to ensure airflow to the temperature and humidity sensor
- Backup battery slot for a CR1632 battery
- Backup battery ejector slot (on the back side)
- Product label (on the back side)

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2.2.1 Front side (STM 550B)

Figure 2 below shows the external interfaces on the front side of the STM 550B module.

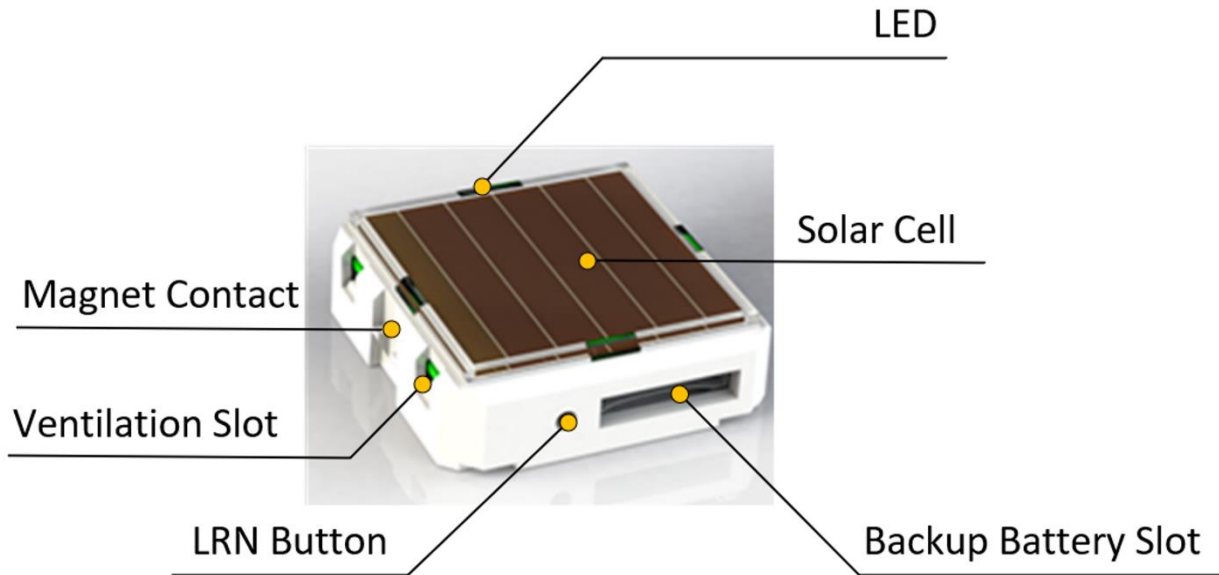


Figure 2 – STM 550B product interface (front side)

2.2.2 Front side (EMSIB)

Figure 4 below shows the external interfaces on the front side of the EMSIB product.

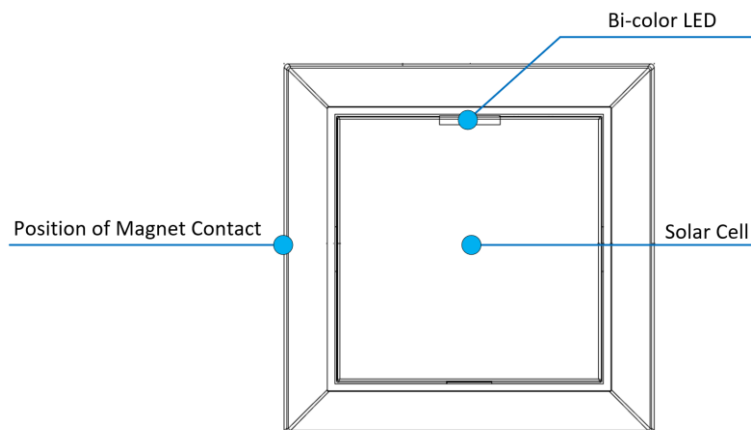


Figure 3 – EMSIB product interface (front side)

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2.2.3 Back side (STM 550B)

Figure 4 below shows the external interfaces on the back side of the STM 550B module. The orientation indicator points towards the side where the magnet contact is located.

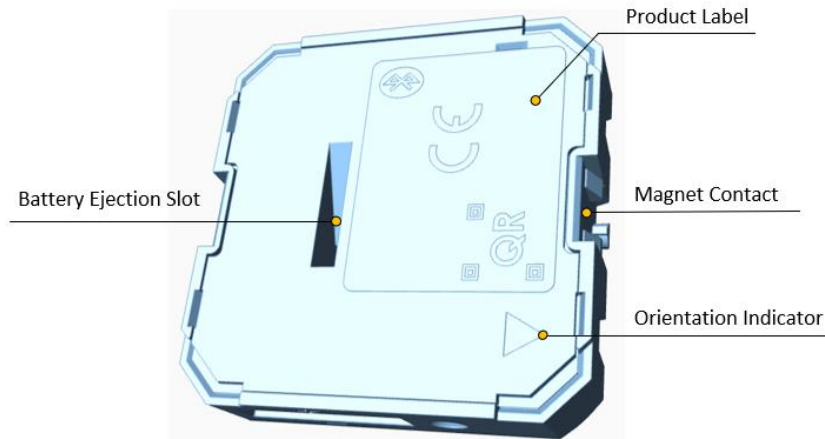


Figure 4 – STM 550B product interface (back side)

2.2.4 Back side (EMSIB)

Figure 5 below shows the external interfaces on the back side of the EMSIB finished product. The orientation indicator points towards the side where the magnet contact is located. The ventilation slots ensure air flow towards the temperature and humidity sensor and should not be obstructed.

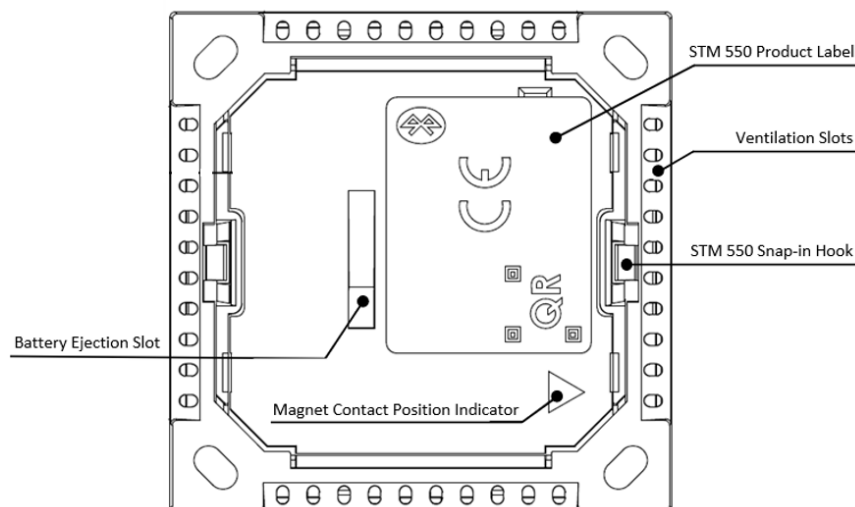


Figure 5 – EMSIB product interface (back side)

2.3 Functional modes

STM 550B supports six functional modes:

- Standard Operation mode
- Standby (Sleep) mode
- Learn mode
- Function Test mode
- Illumination Test mode
- Factory Reset mode



Out of the box (factory-new), STM 550B is configured to be in Standby mode to conserve energy during transport and storage and to comply with regulation regarding radio transmissions during transport.

Upon initial setup, STM 550B has to be set to Standard Operation mode by exposing it to light and pressing the LRN button shortly as described in chapter 10.1 or via the NFC interface described in chapter 8.

2.3.1 Standard Operation mode

During standard (normal) operation, STM 550B wakes up periodically and reports the current sensor status using data telegrams. The STM 550B wake-up timer is by default configured to wake-up STM 550B approximately every 2 minutes. The wake-up intervals are affected at random (meaning that a small random offset is added to the timing interval) to increase the robustness of the radio transmission and to comply with regulatory requirements.

If acceleration exceeding the configured threshold is detected for the first time after a period without exceeding this threshold, then STM 550B wakes up immediately (wake on acceleration event). Likewise, if the status of the magnet contact changes (from open to closed or vice versa) then this is reported immediately as well (wake on magnet contact event).

2.3.2 Standby (Sleep) mode

Standby (Sleep) mode is the lowest power mode of STM 550B and is the out of the box state of STM 550B upon delivery. It is intended to be used during extended periods without operation such as device storage or transport. In standby mode, STM 550B stops operation and conserves as much energy as possible. All functionality – except those needed to return to standard operation mode – are disabled in this mode.

In Standby mode, STM 550B stops operation and conserves as much energy as possible. All functionality – except those needed to return to Standard Operation mode – are disabled in this mode.

Standby mode can be selected using the LRN button as described in chapter 4.2 or via NFC interface as described in chapter 8.

2.3.3 Learn mode

In Learn mode, STM 550B will transmit a commissioning telegram as described in chapter 7.1 to communicate the device source address and security key to a receiver. After that transmission, STM 550B will return to Standard Operation mode.

Learn mode can be selected using the LRN button as described in chapter 4.2 or via NFC interface as described in chapter 8.

2.3.4 Function Test mode

In Function Test mode, STM 550B will measure and report the status of the integrated sensors at the highest possible rate to verify the sensor functionality. Additionally, the status of the acceleration detection is reported by the LED (green = acceleration detected, red = no acceleration detected) if reporting of acceleration is enabled.

STM 550B can be set into Function Test mode via the LRN button as described in chapter 4.2 or via NFC interface as described in chapter 8.

Function Test Mode will be active for approximately 120 seconds; it can be stopped by pressing the LRN button or changing the functional mode via the NFC interface.

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2.3.5 Illumination Test mode

During installation, STM 550B can measure and report the amount of ambient light using its solar cell to determine a suitable installation location as discussed in chapter 10.7 by means of Illumination Test mode.

Illumination Test mode can be activated via the NFC interface as described in chapter 8. Activation of Illumination Test mode will be indicated by the LED of STM 550B using a green blink followed by a red blink.

Upon activation of Illumination Test mode, STM 550B will first wait for 20 seconds so that the installer can vacate the area in front of the sensor to ensure an accurate measurement result. STM 550B will indicate this waiting period using red blinks at a rate of one blink every 3 seconds.

After that, STM 550B will take measurements of the ambient light level using its solar cell every 5 seconds for a period of approximately one minute and indicate each measurement using a green blink.

After completion of the measurements, STM 550B will compute the average illumination based on those measurements. STM 550B will signal the completion of the Illumination Test using a green blink followed by a red blink and the computed average illumination can then be read-out via NFC interface as described in chapter 8.

Illumination Test mode can be selected via NFC interface as described in chapter 8.

2.3.6 Factory Reset mode

STM 550B can be reset to its standard settings using Factory Reset mode. Upon entering this mode, STM 550B will reset all configuration registers to their default settings and then restart operation in standard operation mode.

Factory Reset mode can be selected using the LRN button as described in 4.2 or via the NFC interface as described in chapter 8. Note that Factory Reset mode is not available under the following conditions:

- STM 550B is in Standby mode and the LRN button is used to trigger Factory Reset
Factory Reset by LRN button action is not available during Standby (Sleep) mode to prevent unintended wake-up.
- STM 550B has insufficient available energy
Factory reset is not available if the available energy in STM 550 is insufficient to safely execute this operation. STM 550 will signal that the available energy is insufficient by blinking 5 times red.

Upon entering Factory Reset mode, STM 550 will reset all configuration registers to their default settings, restart operation in standard operation mode and indicate successful completion of this procedure by blinking 5 times green.

2.4 Energy management

The standard reporting interval of 120 seconds (one update every 2 minutes) is adjustable using the NFC interface. The minimum possible reporting interval is 3 seconds, and the maximum possible transmission interval is 65535 seconds.

Lowering the reporting interval of STM 550B will increase its power consumption since it will measure and transmit more often. Likewise, increasing the reporting interval of STM 550 will reduce its power consumption since it will measure and transmit less often.

STM 550B will measure the available energy and stop operation if this is insufficient to execute the required functions. Specifically, STM 550 will stop operation of the sensors and not transmit radio telegrams under such low energy conditions.

Additionally, STM 550B will not update the device configuration via NFC, execute a Function Test, an Illumination Test or a Factory Reset if the available energy is insufficient.

STM 550B will re-evaluate available energy approximately every 60 seconds, restart operation and re-accept Function Test, Illumination Test, Factory Reset or NFC configuration update requests once the energy level becomes sufficient.

2.5 Reporting intervals

2.5.1 Standard reporting interval

In absence of external events, STM 550B will transmit its status as data telegram at a regular interval which is defined by the parameter `STANDARD_TX_INTERVAL`.

By default, `STANDARD_TX_INTERVAL` is set to 120 seconds, i.e. STM 550B will measure and report its status approximately once every 2 minutes. The value of `STANDARD_TX_INTERVAL` can be configured via the NFC interface as described in chapter 8.

Lowering the reporting interval of STM 550B will increase its power consumption since it will measure and transmit more often. Likewise, increasing the reporting interval of STM 550B will reduce its power consumption since it will measure and transmit less often.

STM 550B is designed to apply fluctuations up to $\pm 10\%$ to transmission intervals to increase transmission reliability and meet regulatory requirements.

STM 550B will report the initial acceleration detection after a period without detected acceleration immediately. Likewise, STM 550B will report any change in the status of the magnet contact sensor (open -> closed or closed -> open) immediately.

STM 550B can be configured to automatically use a lower reporting interval, i.e. provide updates more often, based on certain conditions as described in the subsequent chapters.

Figure 6 below illustrates the use of `STANDARD_TX_INTERVAL`.

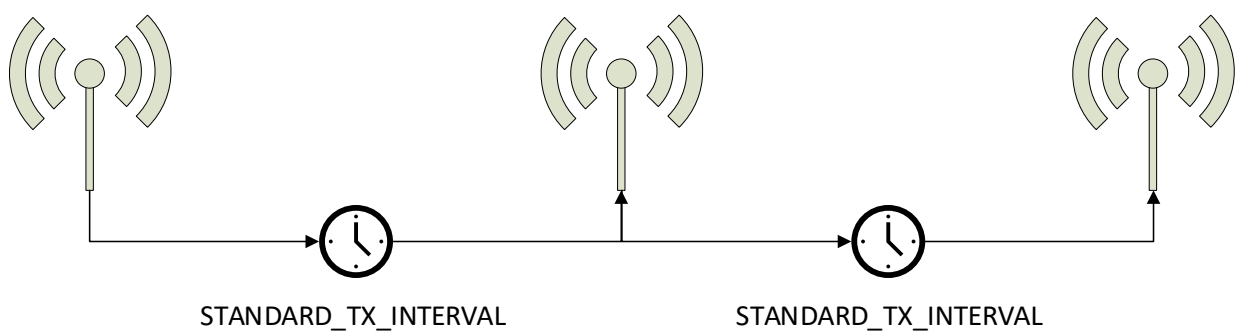


Figure 6 – Standard reporting interval

2.5.2 Illumination-controlled reporting interval

If sufficient ambient light is available, then it might be desirable to receive status updates more often. Use cases for this functionality include:

- Adjust the update rate based on the ambient light available for harvesting
- Report more often during daytime (or when an office is lit) and less often during night-time (or when an office is dark) to adapt the reporting to the usage pattern

For such cases, STM 550B can be configured to use a higher update rate whenever the ambient light level (measured by the solar cell) is above a certain threshold.

The higher update rate is defined by `SOLAR_TX_INTERVAL` and the threshold above which this higher update rate is used is defined by `SOLAR_TX_TRESHOLD`. These parameters can be configured via the NFC interface as described in chapter 8.

Figure 7 below illustrates that functionality.

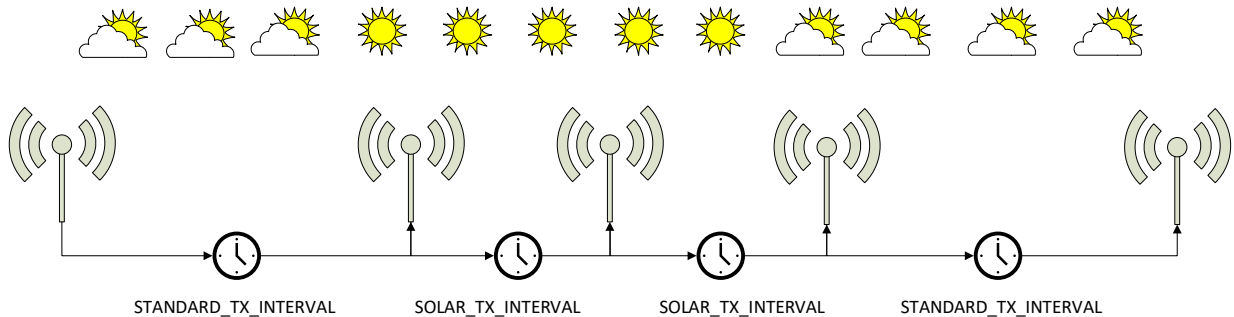


Figure 7 – Illumination-controlled reporting interval

2.5.3 Temperature-controlled reporting interval

In HVAC (heating, ventilation, air conditioning) or in temperature monitoring applications, it might be desirable to receive status updates more often if the measured temperature is above or below a certain threshold.

For such cases, STM 550B can be configured to use a higher update rate whenever the measured temperature is either above or below a certain threshold.

The higher update rate is defined by `TEMPERATURE_TX_INTERVAL` and the threshold above or below which this higher update rate is used is defined by `TEMPERATURE_TX_TRESHOLD`. These parameters can be configured via the NFC interface as described in chapter 8.

Figure 8 below illustrates the use of the temperature-controlled reporting interval.

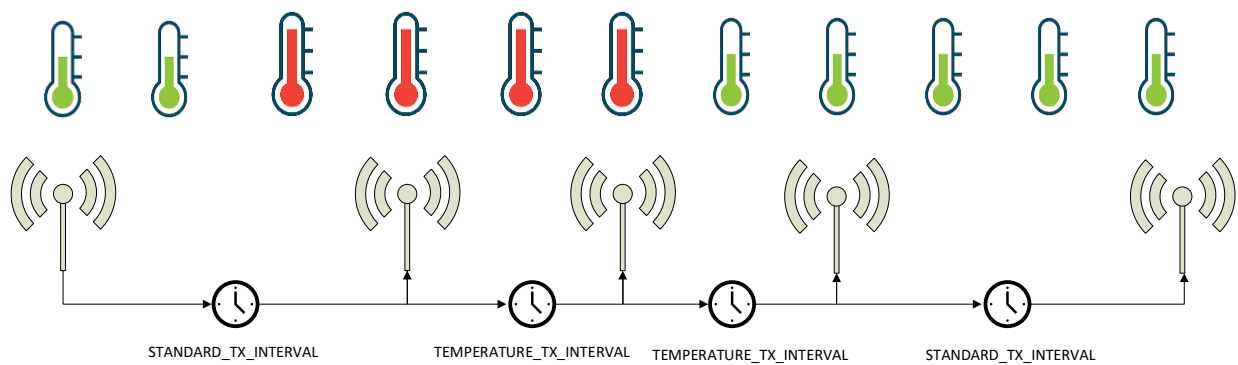


Figure 8 – Temperature-controlled reporting interval

2.5.4 Humidity-controlled reporting interval

In HVAC (heating, ventilation, air conditioning) applications it might be desirable to receive status updates more often if the measured humidity is significantly above or below the target value.

For such cases, STM 550B can be configured to use a higher update rate whenever the measured humidity is either above or below a certain threshold.

The higher update rate is defined by HUMIDITY_TX_INTERVAL and the threshold above or below which this higher update rate is used is defined by HUMIDITY_TX_TRESHOLD. These parameters can be configured via the NFC interface as described in chapter 8.

Figure 9 below illustrates the use of the humidity-controlled reporting interval.

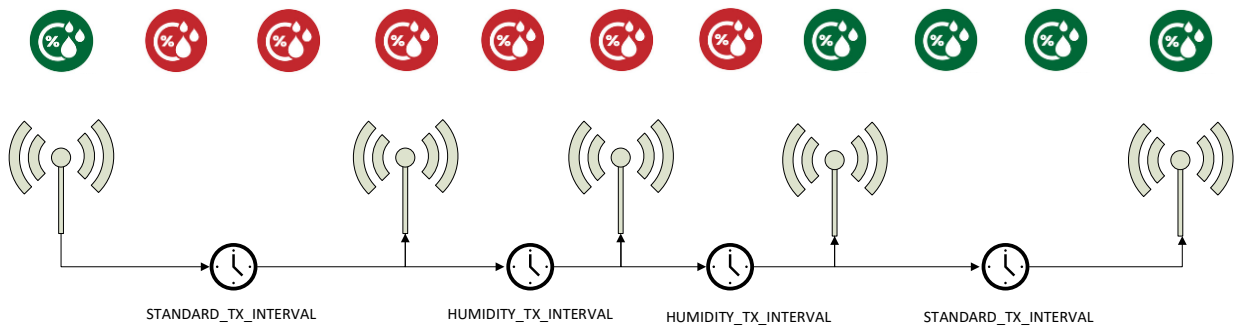


Figure 9 – Humidity-controlled reporting interval

2.5.5 Acceleration-controlled reporting interval

If an asset is in operation or it is being moved, then it might be desirable to receive status updates more often to determine its status or location.

For such cases, STM 550B can be configured to use a higher update rate whenever the measured acceleration is above a certain threshold.

The higher update rate is defined by `ACCELERATION_TX_INTERVAL` and the threshold above or below which this higher update rate is used is defined by `ACCELERATION_TX_TRESHOLD`. These parameters can be configured via the NFC interface as described in chapter 8.

Figure 10 below illustrates the use of the acceleration-controlled reporting interval.

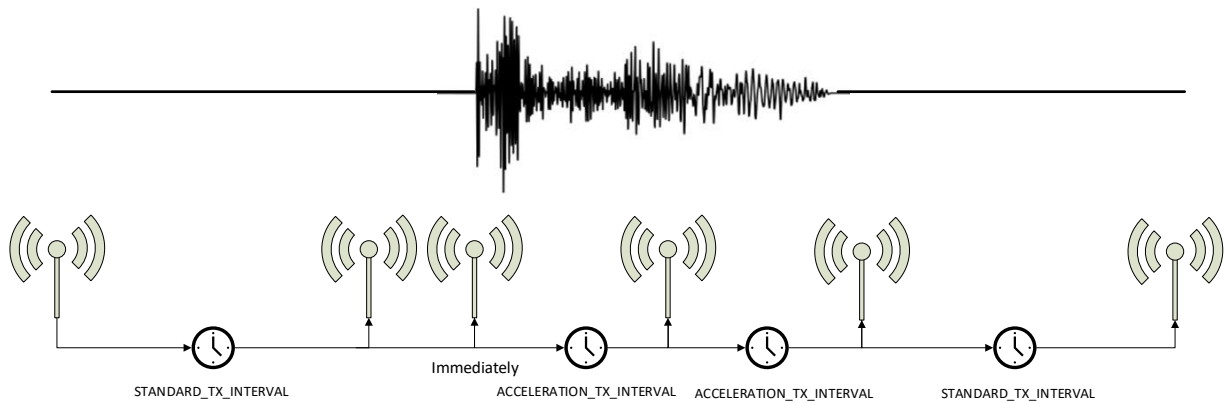


Figure 10 – Acceleration-controlled reporting interval

2.5.6 Magnet contact sensor-controlled reporting interval

If a door or a window is opened when it normally should be closed (or vice versa), then it might be desirable to receive status updates more often to monitor its status.

STM 550B can therefore be configured to use a lower reporting interval, i.e. a higher update rate, for one of the two magnet contact sensor status options (open or closed).

The higher update rate is defined by CONTACT_TX_INTERVAL and the state (open or closed) where the higher update rate is used is defined by CONTACT_TX_STATE. These parameters can be configured via the NFC interface as described in chapter 8.

Figure 11 below illustrates the use of the magnet contact sensor-controlled reporting interval for the case where a higher update rate applies if the magnet contact state is open.

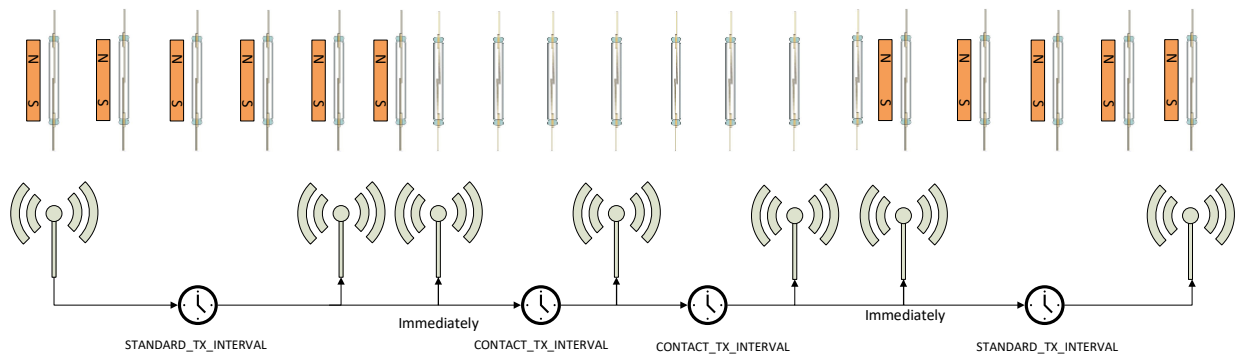


Figure 11 – Magnet contact sensor-controlled reporting interval

2.5.7 Arbitration between reporting intervals

If more than one condition for a lower reporting interval applies – e.g. both an acceleration exceeding the acceleration threshold is detected and the room is brightly lit (above the configured light level threshold), then the lowest of the corresponding reporting intervals will be selected.

3 Sensor functionality

STM 550B integrates a set of sensors used to measure environmental parameters. The following chapters described their characteristics in detail.

3.1 Temperature sensor

STM 550B integrates a high-performance temperature sensor achieving accuracy of better than ± 0.3 °C throughout the entire operation temperature range and an accuracy of better than ± 0.2 °C for the typical indoor temperature range.

Figure 12 below shows the typical accuracy of the STM 550B temperature sensor as a function of the ambient temperature. To determine the overall system accuracy, the quantization error (reporting step size) determined by the selected EnOcean Equipment Profile (EEP) must be added to this value.

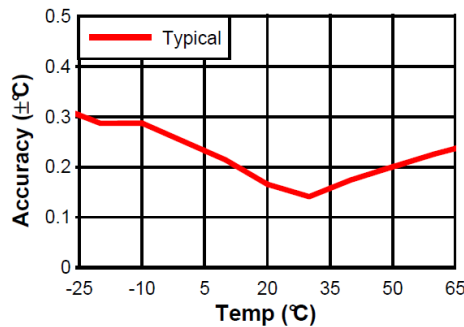


Figure 12 – Temperature sensor accuracy

3.2 Humidity sensor

STM 550B integrates a high-performance humidity sensor achieving accuracy of better than ± 3 % r.h. throughout the entire operation temperature range and an accuracy of better than ± 2 % r.h. for the typical indoor humidity range.

Figure 13 below shows the typical accuracy of the STM 550B humidity sensor as a function of the ambient humidity. To determine the overall system accuracy, the quantization error (reporting step size) determined by the selected EnOcean Equipment Profile (EEP) has to be added to this value.

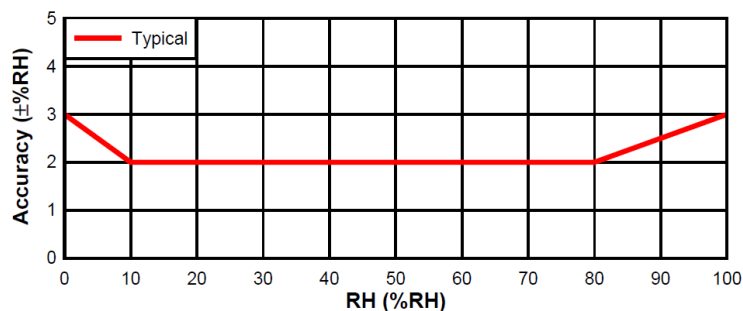


Figure 13 – Humidity sensor accuracy

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3.3 Acceleration sensor

STM 550B integrates an acceleration sensor which enables two key use cases:

- Measuring device orientation relative to the earth gravity vector
This allows determining the direction into which STM 550B is oriented relative to the earth gravity vector. See chapter 10.4 for an example.
- Measuring device acceleration by external force
This enables detecting cases where the device is moved or shaken

The second case (acceleration vector change) can be used to determine the presence or absence of small vibrations (acceleration vector changes). Examples use cases causing such small vibrations include asset utilization (e.g. a motor to which STM 550B is attached is running) or asset movement (e.g. an asset to which STM 550B is attached changes its location).

If such change in acceleration is above a certain threshold, then this will be reported as part of the regular data telegram. If the acceleration exceeds this threshold for the first time, then this will be reported immediately (wake-on-acceleration).

Figure 14 below shows the orientation of the reported acceleration vector relative to STM 550B. This means that:

- If STM 550 was be positioned stationary on a flat surface parallel to the earth surface with the solar cell oriented away from the earth surface (STM 550 "laying" on the device label side, like in the illustration below), then STM 550 would report:
 $x = 0g$; $y = 0g$; $z = 1g$ (earth gravity)
- If STM 550 was be positioned stationary on a flat surface parallel to the earth surface with the battery insertion slot oriented towards the earth surface (STM 550 "standing" on the battery insertion slot), then STM 550 would report:
 $x = 0g$; $y = -1g$ (earth gravity); $z = 0g$

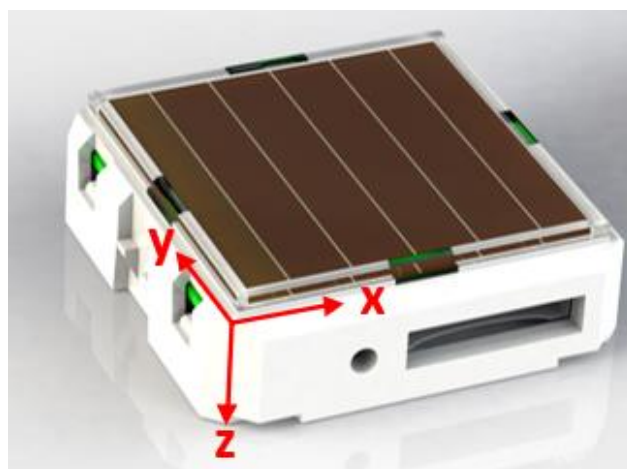


Figure 14 – Acceleration sensor orientation

3.3.1 Wake on acceleration

If acceleration exceeding the configured threshold is detected for the first time after a period without exceeding this threshold, then STM 550B wakes up immediately (wake on acceleration event).

Wake-on acceleration can be used to immediately trigger the transmission of a message when an item is moved or starts to vibrate. The threshold for the wake on acceleration feature is adjustable as described below.

3.3.2 Acceleration sensor parameters

The acceleration sensor integrate in STM 550B allows configuring the following parameters:

- Full-scale magnitude
The full-scale magnitude determines the maximum acceleration magnitude that will be reported. Higher settings allow reporting higher magnitudes but will result in less resolution and thereby less sensitivity. The default full scale magnitude of ± 2 g should be appropriate for most use cases.
- Acceleration threshold
The acceleration threshold determines the threshold of acceleration vector change required to trigger a wake-on vibration event as described above or to reduce the transmission interval as described in chapter 2.5.5.
Setting a lower acceleration threshold results in a higher sensitivity to acceleration vector changes. STM 550B uses by default the minimum possible threshold corresponding to 1/64 of its full-scale magnitude.
- Sampling rate
The sampling rate determines how often the acceleration vector will be measured. Higher sampling rates allow detecting shorter vibrations but require more energy to do so. Higher sampling rates should only be used if minor vibrations are not detected when using the minimum acceleration threshold.

Table 1 below shows the supported configuration options for each of these parameters and their default settings in STM 550B. These parameters can be configured via the NFC interface as described in chapter 8.

Parameter	Supported Options (bold = default)
Full scale	± 2 g , ± 4 g, ± 8 g, ± 16 g
Sampling rate	1.6 Hz, 12.5 Hz , 25 Hz, 50 Hz
Wake threshold	1/64 ... 63/64 of full scale
Measurement resolution	10 bit for each (x, y, z) direction

Table 1 – Acceleration sensor parameters



Note that increasing the sampling rate will proportionally increase the power consumption of STM 550B. The sampling rate should only be increased if sufficient ambient light is available or if a backup battery is used.

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3.3.3 Acceleration sensor accuracy

The acceleration sensor in STM 550B is optimized to detect vibrations or significant changes in its orientation relative to earth gravity. Chapter 10.5 describes typical acceleration sensor use cases.

The accuracy of the reported acceleration sensor values is determined by a wide range of parameters including the following:

- Housing to surface alignment
STM 550B might be attached to a surface by means of adhesive tape or by screwing as described in chapter 10.3. Both ways of attachment may result in alignment errors where the sensor is not fully parallel to the mounting surface.
- PCB to housing alignment
The acceleration sensor is mounted on a PCB which held in place by fixation point on the bottom housing. This fixation allows for travel of the PCB relative to the housing to avoid mechanical stress in case of thermal expansion.
- Sensor to PCB alignment
The PCB on which the acceleration sensor is mounted will experience thermal expansion and contraction if the ambient temperature rises or falls. The rate of thermal expansion or contraction of the PCB is different from that of the sensor which can result in a mechanical force from the PCB towards the sensor affecting the sensor readings.
- Ambient temperature changes
Changes in ambient temperature can cause expansion or contraction of the acceleration sensor, the STM 550 PCB, the STM 550 housing and the equipment to which STM 550 is attached (desk, door, window, machinery, etc.).
- Sensor reporting resolution
STM 550B reports the measured acceleration value using 10-bit encoding covering a ± 5 g interval as described in chapter 5.5.5 which limits the resolution of reported values.

The combined effect of the above points can limit the accuracy of the reported acceleration sensor status to $\pm 5\%$ of the full-scale value.

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3.4 Magnet contact sensor

STM 550B integrates a magnet contact sensor detecting presence or absence of a magnetic field in the proximity of it. Refer to chapter 2.2 for the location of the magnet contact sensor within STM 550B and to chapter 10.7 for mounting instructions.

3.4.1 Suitable magnets

STM 550 KIT includes a block magnet suitable for use with its magnet contact sensor. Figure 15 shows the outer appearance of this magnet.

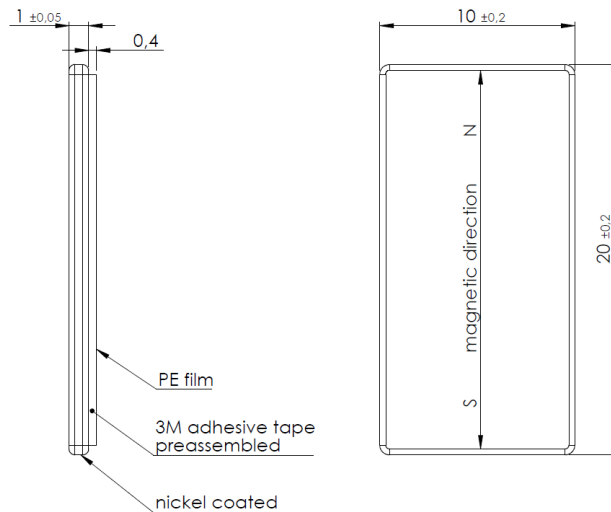


Figure 15 – Magnet outline

The magnet is made from N35 grade Neodymium material. Table 2 below lists the key parameters of this material for reference if using alternative magnets.

	Br		Hcb		Hcj		(BH) _{max}		TW
	T	KGs	KA/m	KOe	KA/m	KOe	KJ/m ³	MGOe	°C
N35	1.17-1.21	11.7-12.1	876-899	11.0-11.3	≥955	≥12	263-279	33-35	≤80

Table 2 – N35 material parameters

3.5 Solar cell-based light level measurement

STM 550B uses the calibrated solar cell response to measure and report the ambient light level. This approach is designed for reporting indoor lighting conditions between 0 and 2000 lux with an accuracy of ± 5% of the full-scale value.

4 User interface

The STM 550B product interface contains a bi-color LED, an LRN button and a backup battery interface as described in chapter 2.2.

4.1 LED

STM 550B contains a bi-colour (red / green) indication LED used to provide user feedback. By default, the LED will blink shortly whenever a telegram is transmitted. This indication can be disabled via NFC interface as described in chapter 8. In addition to that, the LED provides a response to LRN button inputs as described below.

4.2 LRN button

STM 550B device parameters can be configured using the NFC interface as described in chapter 8. Some of the most common parameters or states can additionally be configured using the LRN button.

Table 3 below lists those LRN button actions with the corresponding STM 550B response and LED feedback.

Event / User Action	Action	LED Indication
<i>Telegram Transmission</i> (No Button Action)	Data Telegram Transmission Indication of data telegram transmission	1 blink green
<i>NFC Configuration</i> (Not Button Action)	NFC Configuration Event Configuration Update via NFC Factory Reset via NFC	Config Success: 4 blink green Config Error: 4 blink red Reset Success: 5 blink green Reset Error: 5 blink red
<i>Single Short Press</i> (Press < 1s)	LRN Telegram Transmission <i>If in Standard Operation Mode:</i> Send Commissioning Telegram <i>If in Sleep Mode:</i> Wake up to Standard Operation Mode Send Commissioning Telegram	2 blink green 2 blink green
<i>Double Short Press</i> (Each Press <1s Pause in between <1s)	Start Function Test Measure and report sensor status every 3 seconds Indicate acceleration detection status (above threshold or not) via LED Function test ends after 2 minutes or upon any button press	Start: 2 blink red-green Measurement with acceleration not above threshold: 1 blink red Measurement with acceleration above threshold: 1 blink green

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<i>Single Long Press</i> (Press 3s ... 5s)	Transition to Sleep Mode <i>If in Sleep Mode:</i> Stay in Sleep Mode <i>If in any other mode:</i> Enter Sleep Mode	3 blink red 3 blink red
<i>Double Long Press</i> (Each Press 3s ... 5s Pause in between <1s)	Toggle LED Indication <i>If LED Indication is Enabled:</i> Disable LED Indication <i>If LED Indication is Disabled:</i> Enable LED Indication	4 blink red 4 blink green
<i>Single Very Long Press</i> (Press >= 7s)	Factory Reset Reset device configuration (to default configuration values)	Success: 5 blink green Insufficient energy: 5 blink red

Table 3 – STM 550B user interface actions

4.2.1 LRN button timing

To guide users on the expected duration of long and very long button presses, STM 550B will indicate the timing of a long button press by one short red blink and the timing of a very long button press by two red blinks as shown in Table 4.

Type of press	Duration	LED Timing Indication
Short	< 3 seconds	None
Long	> 3 seconds	One short red blink after 3 seconds
Very long	> 7 seconds	One short red blink after 3 seconds Two short red blinks after 7 seconds

Table 4 – LED timing indication

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4.3 Backup battery

STM 550B provides a backup battery interface to mount a CR1632 battery for cases with insufficient ambient light. The backup battery must be installed with the negative pole pointing upwards (i.e. towards the side of the solar cell). Check the '+' and '-' polarity markings on the housing for correct battery orientation as shown in Figure 16 below.

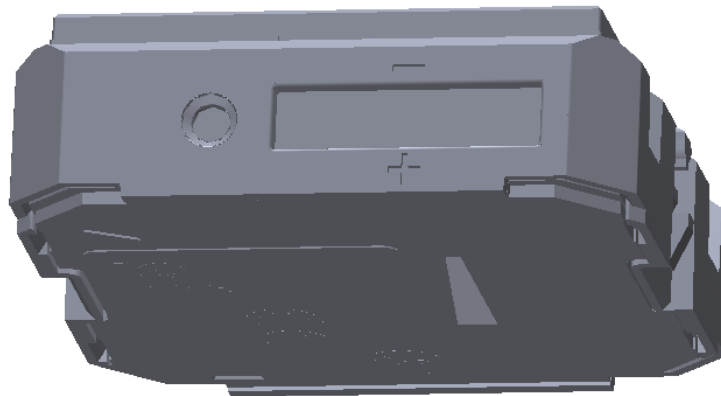


Figure 16 – Backup battery slot with polarity markings

EnOcean recommends Renata CR1632 due to its low self-discharge and high capacity. Gloves should be used when installing a backup battery to avoid contamination of the isolation area between the contacts that could lead to a higher self-discharge.

The backup battery can be removed (ejected) by using a small, non-conductive item (e.g. wooden toothpick) to push the battery out via the battery ejector slot on the back side of STM 550B as shown in chapter 2.2.3.

4.3.1 Safety remarks

Please familiarize yourself with the following safety remarks before using a backup battery:



Do not insert any tools into the battery slot or the battery ejection slot. Doing so could create a short circuit or damage the PCB resulting in permanent damage.



CAUTION: Risk of damage or explosion if a battery of incorrect type is used. The battery shall be rated for operation up to 60°C.



This product can contain a coin/button cell battery. If the coin/button cell battery is swallowed, it can cause severe internal burns in just 2 hours and can lead to death.



Keep new and used batteries away from children.

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4.4 Product label

Each STM 550B module contains a product label with a commissioning QR code. Figure 17 below shows this label. The commissioning QR code (described in chapter 7.2) is located on the bottom left side.

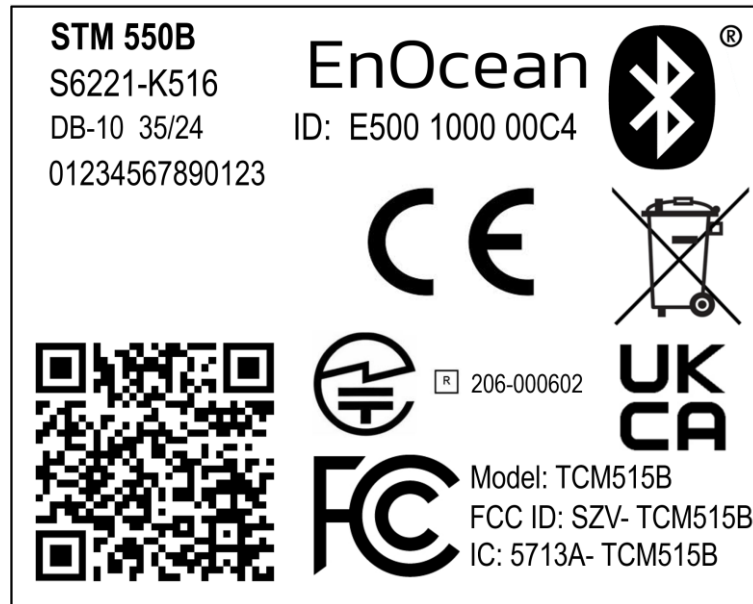


Figure 17 – STM 550B product label

5 Radio communication

STM 550B transmits BLE advertising telegrams within the 2.4 GHz radio frequency band (2400 MHz ... 2483.5 MHz) using the BLE advertising format in 1 Mbit / s mode or a proprietary transmission format in 2 Mbit / s mode.

5.1 Radio channels

STM 550B can use up to three radio channels for the redundant transmission (same telegram on different radio channels) of its telegrams.

By default, the three BLE advertising channels (Channel 37, 38 and 39) will be used for transmission. Use of different radio channels within the frequency band from 2402 MHz to 2480 MHz is possible via the NFC interface as described in chapter 8.

Table 5 below summarizes the radio channels supported by STM 550B.

Radio Channel	Frequency	Channel Type
BLE Radio Channels		
37	2402 MHz	BLE Advertising Channel
0	2404 MHz	BLE Data Channel
1	2406 MHz	BLE Data Channel
...		
10	2424 MHz	BLE Data Channel
38	2426 MHz	BLE Advertising Channel
11	2428 MHz	BLE Data Channel
12	2430 MHz	BLE Data Channel
...		
36	2478 MHz	BLE Data Channel
39	2480 MHz	BLE Advertising Channel
Custom Radio Channels		
40	2403 MHz	Custom Radio Channel
41	2405 MHz	Custom Radio Channel
...		
77	2477 MHz	Custom Radio Channel
78	2479 MHz	Custom Radio Channel

Table 5 – Supported radio channels

5.2 Default radio transmission sequence

STM 550B transmits telegrams in its standard configuration by using so-called Advertising Events.

An advertising event is defined as the transmission of the same radio telegram on all selected radio channels (by default on BLE Channel 37, 38 and 39) one after another with minimum delay in between.

For reliability reasons, STM 550B will send three advertising events for each telegram.

The default interval between consecutive advertising events is 20 ms. It is possible to reduce this interval to 10 ms via the NFC interface as described in chapter 8.

Figure 18 below shows the default radio transmission sequence.



Figure 18 – Default radio transmission sequence

5.3 User-defined radio transmission sequences

In certain situations, it might be desirable to transmit radio telegrams on channels other than the three advertising channels.

STM 550B therefore allows selecting the radio channels to be used for the transmission of data telegrams and commissioning telegrams. The following transmission modes are supported:

- Both commissioning telegrams and data telegrams are transmitted on the advertising channels as three advertising events. This is the default configuration and described in chapter 5.2 above.
- Commissioning telegrams are transmitted on the advertising channels as three advertising events while data telegrams are transmitted in a user-defined sequence as described below.
- Both commissioning and data telegrams are transmitted in a user-defined sequence as described below.

The selection of the transmission mode can be done via the NFC interface as described in chapter 8.

5.3.1 User-defined radio transmission sequences

STM 550B supports the following user-defined radio transmission sequences:

- Three-channel sequence
This sequence is similar to the default Advertising Event with the difference that the user can select the radio channels to be used. The three-channel sequence is described in chapter 5.3.2 below.
- Two-channel sequence
In this sequence the radio telegram is transmitted using six transmissions on two radio channels. It is described in chapter 5.3.3 below.
- One-channel sequence
In this sequence the radio telegram is transmitted using nine transmissions on one radio channel. It is described in chapter 5.3.4 below.

5.3.2 Three-channel sequence

The three-channel radio transmission sequence is similar to the default transmission sequence with the difference that the radio channels (BLE Channel 37, 38 and 39 in the default transmission sequence) can be selected via the NFC interface as described in chapter 8.

In this mode, the telegram will be transmitted on the radio channel selected by CH_REG1 first, immediately followed by a transmission on the radio channel selected by CH_REG2 and a transmission on the radio channel selected by CH_REG3.

The telegram will be transmitted using this sequence three times in total as shown in Figure 19 below.

This transmission uses a default INTERVAL setting of 20 ms; an alternative setting of 10 ms can be configured via the NFC interface as described in chapter 8.



Figure 19 – Three channel radio transmission sequence

5.3.3 Two-channel sequence

The two-channel radio transmission sequence transmits radio telegrams on two user-defined radio channels (configured via the NFC interface as described in chapter 8) six times in total.

The telegram will in this mode be transmitted on the radio channel selected by CH_REG1 first, immediately followed by a transmission on the radio channel selected by CH_REG2. This is shown in Figure 20 below.

This transmission sequence uses a default INTERVAL setting of 20 ms; an alternative setting of 10 ms can be configured via the NFC interface as described in chapter 8.

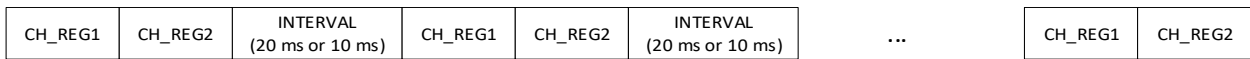


Figure 20 – Two channel radio transmission sequence

5.3.4 One channel sequence

The one-channel radio transmission sequence transmits radio telegrams on one user-defined radio channel (selected via the NFC interface as described in chapter 8) nine times in total. This is shown in Figure 21 below.

This transmission sequence uses a default INTERVAL setting of 20 ms; an alternative setting of 10 ms can be configured via the NFC interface as described in chapter 8.

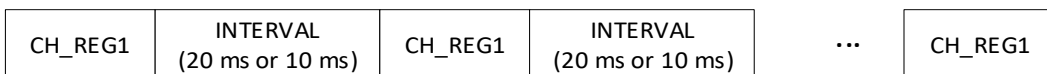


Figure 21 – Single channel radio transmission sequence

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5.4 Telegram format

STM 550B transmits Bluetooth Low Energy (BLE) radio telegrams in the 2.4 GHz band. For detailed information about the Bluetooth Low Energy standard, please refer to the applicable specifications.

Figure 22 below summarizes the general BLE frame structure.

Preamble 0xAA	Access Address 0x8E89BED6	Header (2 Byte)	Source Address (6 Byte)	Payload (0 ... 31 Byte)	Check Sum (3 Byte)
------------------	------------------------------	--------------------	----------------------------	----------------------------	-----------------------

Figure 22 – BLE frame structure

Figure 23 below shows specific properties used by STM 550B within the general BLE frame structure.

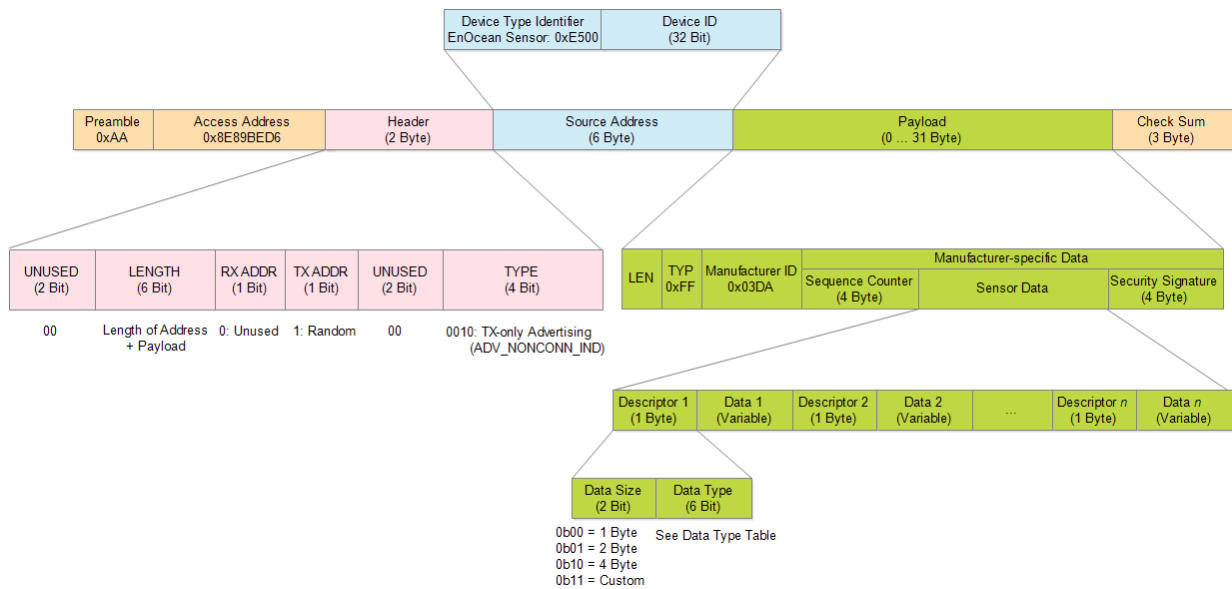


Figure 23 – BLE frame structure

The content of these fields is described in more detail below.

5.4.1 Preamble

The BLE Preamble is 1 byte long and identifies the start of the BLE frame. The value of the BLE Preamble is always set to 0xAA.

5.4.2 Access Address

The 4-byte BLE Access Address identifies the radio telegram type. For advertising frames, the value of the Access Address is always set to 0x8E89BED6.

5.4.3 Header

The BLE Header identifies certain radio telegram parameters. Figure 24 below shows the structure of the BLE header.

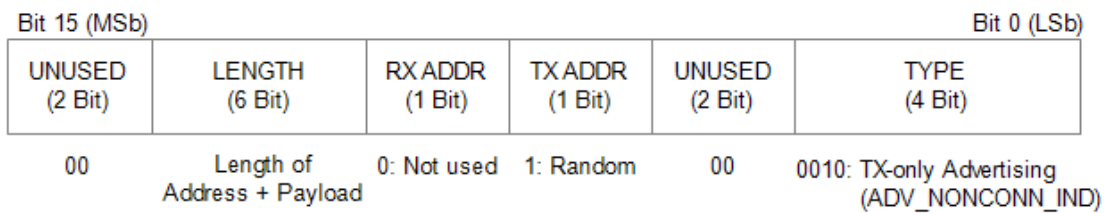


Figure 24 – BLE header structure

5.4.4 Source address

The 6-byte BLE Source Address (MAC address) uniquely identifies each STM 550B product. STM 550B supports two source address modes:

- Static Source Address mode (default)
In this mode, the source address is constant (but its lower 32 bit can be configured via NFC interface)
- Resolvable Private Address mode (NFC configurable)
In this mode, the source address changes for each transmission

STM 550B uses by default Static Source Address mode. Resolvable Private Address mode can be selected via the NFC interface as described in chapter 8.

5.4.5 Static source address mode

By default, STM 550B uses static source addresses meaning that the source address is constant during normal operation. The lower 4 byte of the static source address can be modified via the NFC interface as described in chapter 8.

The structure of STM 550B static addresses is therefore as follows:

- The upper 2 bytes of the source address are for EnOcean Bluetooth sensors always set to 0xE500 to enable filtering according to product type
- The lower 4 bytes are uniquely assigned to each device. They can be read and changed using the NFC configuration interface as described in chapter.

Figure 25 below illustrates the static address structure used by STM 550B.



Figure 25 – BLE static source address structure

5.4.6 Resolvable Private Address mode

For some applications it is desirable to modify (rotate) the source address used by STM 550B to prevent tracking of its radio transmissions. At the same time, each STM 550B device must remain uniquely identifiable by the receiver. To achieve these goals, STM 550B can be configured via NFC to use resolvable private addresses (RPA).

Using resolvable private addresses requires that both STM 550B and the receiver both know a common key – the so-called Identity Resolution Key (IRK).

STM 550B uses its device-unique random key as identity resolution key. This key can be modified via the NFC interface as described in chapter 8.

For resolvable private addresses, the 48-bit address field is split into two sub-fields:

- **prand**
This field contains a random number which always starts (two most significant bits) with 0b10. The prand value is changed for each telegram that is transmitted. Individual advertising events used to transmit one telegram use the same prand value.
- **hash**
This field contains a verification value (hash) generated from prand using the IRK

The structure of a random resolvable private address is shown in Figure 26 below.

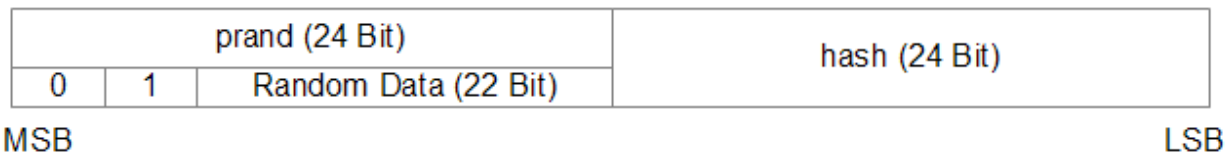


Figure 26 – BLE resolvable private address structure

The prand value is encrypted using the IRK. The lowest 24-bit of the result (encrypted value) are then used as hash. The concatenation of 24-bit prand and 24-bit hash will be transmitted as 48-bit resolvable private address.

The receiver maintains a list of IRK for all transmitters that are known to it (have been commissioned to work with it). Whenever it receives a radio telegram with resolvable private address (identified by the most significant bits being set to 0b10), it will itself generate a 24-bit hash from the 24-bit prand sequentially using the IRK of each device that it has been learned into it. If an IRK matches (i.e. when prand is encoded with this specific IRK then the result matches hash), then the receiver has established the identity of the transmitter.

So conceptually the IRK takes the role of the device source address while prand and hash provide a mechanism to select the correct IRK among a set of IRK.

Figure 27 below illustrates the address resolving scheme for random private addresses.

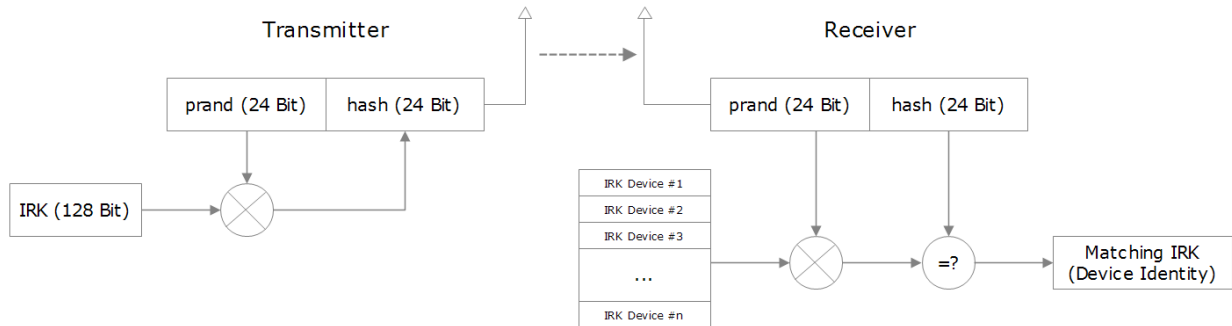


Figure 27 – Resolving resolvable private addresses

5.4.7 Check Sum

The 3-byte BLE Check Sum is used to verify data integrity of received BLE radio telegrams. It is calculated as CRC (cyclic redundancy check) of the BLE Header, Source Address and Payload fields.

5.5 Payload structure

The payload of STM 550B data telegrams can in general be up to 31 bytes long (depending on the size of the sensor data) and consists of the following fields:

- Length (1 byte)
 The Length field specifies the combined length of the following fields and depends on the size of the Sensor Status field. The minimum length is 13 byte and the maximum length is 31 byte
- Type (1 byte)
 The Type field identifies the data type used for this telegram. For STM 550B data telegrams, this field is always set to 0xFF to designate manufacturer-specific data field
- Manufacturer ID (2 byte)
 The Manufacturer ID field is used to identify the manufacturer of BLE devices based on assigned numbers. EnOcean has been assigned 0x03DA as manufacturer ID code.
- Sequence Counter (4 byte)
 The Sequence Counter is a continuously incrementing counter used for security processing. It is initialized to 0 at the time of production and incremented for each telegram (data telegram or commissioning telegram) sent.
- Sensor Data (variable size)
 The Sensor Data field reports the measured values of the sensors. The encoding of this field is described in chapter 5.5.1.
- Security Signature (4 byte)
 The Security Signature is used to authenticate EnOcean BLE sensor data telegrams

Figure 28 below illustrates the general telegram payload structure.

LEN	TYP 0xFF	Manufacturer ID 0x03DA	Manufacturer-specific Data		
			Sequence Counter (4 Byte)	Sensor Data (2 ... 19 Byte)	Security Signature (4 Byte)

Figure 28 – Telegram payload structure

5.5.1 Sensor status encoding

The Sensor Status field within the Payload data identifies the status of the connected sensors. The Sensor Status field is composed of sub-fields (one per sensor attribute).

Each sub-field consists of two items:

- Sensor Data Descriptor
The descriptor identifies the type and the size of the following sensor data
- Sensor Data
The sensor data field encodes the measured value

Figure 29 below shows the structure of the sensor status field.

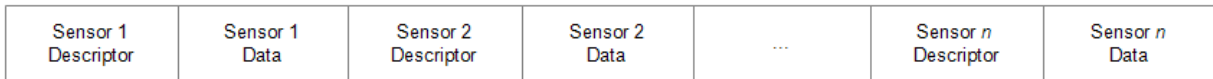


Figure 29 – Sensor Status field structure

5.5.2 Sensor Data Descriptor

The Sensor Data Descriptor describes type and size of the following sensor data field. It explicitly specifies the size to ensure forward compatibility, i.e. to enable future receivers to parse sensor telegrams containing unknown data types.

The Sensor Data Descriptor structure is shown in Figure 30 below.

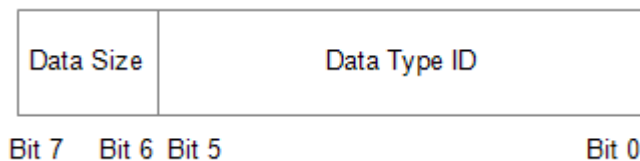


Figure 30 – Sensor Data Descriptor field structure

The sensor data descriptor explicitly specifies the data size to ensure forward compatibility for the case where an existing sensor does not “understand” subsequently introduced measurement parameters and therefore can’t determine the size of their data field.

In this case, the sensor can use the length information provided by this field to determine the start of the next sensor descriptor field (which might contain usable data).

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5.5.3 Data Size

The following values are possible for the Data Size field:

- 0b00 = 8-bit size (or implicit definition, e.g. commissioning telegram = 22 byte)
- 0b01 = 16-bit size
- 0b10 = 32-bit size
- 0b11 = Extended size, the first byte of the Sensor Data field specifies the size of the data (in byte) that follows (this feature is not used in STM 550B)

5.5.4 Supported parameters

STM 550B can report a variety of parameters depending on the product configuration. Parameter reporting can be configured via the NFC interface as described in chapter 8.

Keep in mind that the combined parameter length of all items cannot exceed 19 bytes due to the BLE Frame structure as shown in Figure 28. Each parameter requires 1 byte Type ID in addition to the Data Length shown in Table 6 below. It is therefore not possible to report all supported parameters.

Table 6 below summarizes the parameters that can be reported by STM 550B and notes the ones that are enabled by default. Please refer to Appendix A for examples of how to interpret an STM 550B data and an STM 550B commissioning telegram.

TYPE ID	Size	Content	Min Value	Max Value	Resolution	Encoding	Default Reporting	
Data Telegrams								
0x00	2	Temperature	-327.67°C	327.66°C	0.01 °C	16 bit signed int	Enabled	
0x01	2	Voltage	-16383.5mV	16383 mV	0.5 mV	16 bit signed int	Adaptive	
0x02	1	Energy Level	0%	100%	0.5 %	8 bit unsigned int (0 ... 200)	Adaptive	
0x04	2	Illumination (Wide area)	0 lx	65 533 lx	1 lx	16 bit unsigned int	Enabled	
0x06	1	Relative Humidity	0 % r.h.	100 % r.h.	0.5 % rh	8 bit unsigned int (0 ... 200)	Enabled	
0x0A	4	Acceleration Vector	See Table 3 and Table 4					Enabled
0x23	1	Magnet Contact	0x01 = Open, 0x02 = Closed			Enumeration	Enabled	
0x3C	1, 2, 4	Optional Data	User-defined data					Disabled
Commissioning Telegrams								
0x3E	22	Commissioning Info	16 byte AES key followed by 6 byte advertising address					LRN button

Table 6 – Supported parameters

5.5.5 Acceleration vector encoding

The 32-bit acceleration vector is encoded as shown in Figure 31 below.

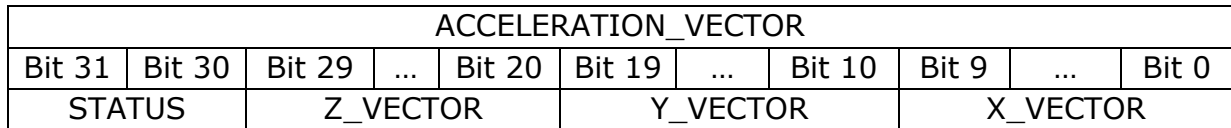


Figure 31 – ACCELARATION_VECTOR structure

The encoding of the STATUS bit field of the acceleration vector is shown in Table 7 below.

STATUS	Interpretation
0b00	Acceleration value out of bound
0b01	Periodic update
0b10	Acceleration wake
0b11	Sensor disabled

Table 7 – Status field encoding for acceleration vector

The X_VECTOR, Y_VECTOR and Z_VECTOR fields encode the acceleration vector as 10-bit value ranging from 0 ... 1023 according to the following transformation equation:

$$Acceleration = \frac{VECTOR - 512}{100}$$

Table 8 below illustrates this encoding.

VECTOR	Decimal value	Interpretation
0b00:0000:0000	0	- 5.12 g
0b10:0000:0000	512	0 g
0b11:1111:1111	1023	+ 5.11 g

Table 8 – VECTOR field encoding for acceleration vector

Please see Appendix B.1.3 for a step-by-step data parsing example including the acceleration vector.

6 Security

STM 550B implements telegram authentication to ensure that only telegrams from senders using a previously exchanged security key will be accepted. Authentication relies on a 32-bit telegram signature which is calculated as shown in Figure 32 below and exchanged as part of the radio telegram.

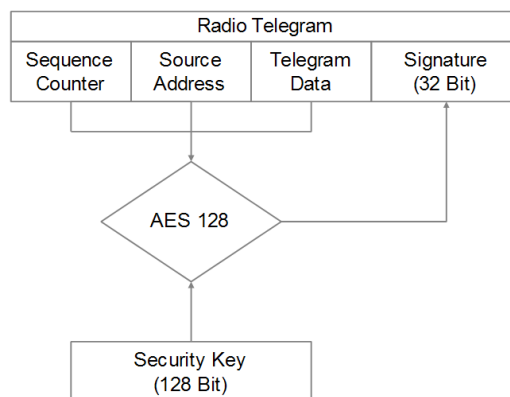


Figure 32 – Telegram authentication flow

Sequence counter, source address and the remaining telegram data together form the input data for the signature algorithm. This algorithm uses AES128 encryption based on the device-unique random security key to generate a 32-bit signature which will be transmitted as part of the radio telegram.

The signature is therefore dependent both on the current value of the sequence counter, the device source address and the telegram payload. Changing any of these three parameters will therefore result in a different signature.

The receiver performs the same signature calculation based on sequence counter, source address and the remaining telegram data of the received telegram using the security key it received from STM 550B during commissioning.

The receiver then compares the signature reported as part of the telegram with the signature it has calculated. If these two signatures match, then the following statements are true:

- Sender (STM 550B) and receiver use the same security key
- The message content (address, sequence counter, data) has not been modified

At this point, the receiver has validated that the message originates from a trusted sender (as identified by its security key) and that its content is valid.

To avoid message replay (capture and retransmission of a valid message), it is required that the receiver tracks the value of the sequence counter used by STM 550B and only accepts messages with higher sequence counter values (i.e. not accepts equal or lower sequence counter values for subsequent telegrams).

6.1 Security implementation

STM 550B implements telegram authentication based on AES128 in CCM (Counter with CBC-MAC) mode as described in IETF RFC3610. At the time of writing, the RFC3610 standard could be found here: <https://www.ietf.org/rfc/rfc3610.txt>

The 13 Byte CCM Nonce (number used once – unique) initialization value is constructed as concatenation of 6-byte Source Address, 4-byte Sequence Counter and 3 bytes of value 0x00 (for padding).

Note that both Source Address and Sequence Counter use little endian format (least significant byte first).

Figure 33 below shows the structure of the AES128 Nonce.

AES128 Nonce (13 Byte)												
Source Address						Sequence Counter				Padding		
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 0	Byte 1	Byte 2	Byte 3	0x00	0x00	0x00

Figure 33 – AES128 Nonce structure

The AES128 Nonce and the 128-bit device-unique security key are then used to calculate a 32-bit signature of the authenticated telegram payload shown in Figure 34 below.

Authenticated Sensor Telegram Data									
LEN	TYPE	MANUFACTURER	SENSOR DATA						
Length	0xFF	0x03DA	DESC1	DATA1	DESC2	DATA2	...	DESC _n	DATA _n

Figure 34 – Authenticated payload

The calculated 32-bit signature is then appended to the data telegram payload as shown in in chapter 5.5.

7 Commissioning

Commissioning is the process by which STM 550B is learned into a receiver (actuator, controller, gateway, etc.).

The following two tasks are required in this process:

- **Device identification**
The receiver needs to know how to uniquely identify this specific STM 550B module. This is achieved by using a unique 48-bit ID (Source Address) for each STM 550B module.
- **Security parameter exchange**
The receiver needs to be able to authenticate radio telegrams from STM 550B in order to ensure that they originate from this specific device and have not been modified. This is achieved by exchanging a 128-bit random security key used by STM 550B to authenticate its radio telegrams.

STM 550B provides the following options for these tasks:

- **Radio-based commissioning**
STM 550B can communicate its parameters via special radio telegrams (commissioning telegrams) to the intended receiver. Transmission of such telegrams can be triggered by using the LRN button.
- **QR code commissioning**
Each STM 550B module contains an optically readable Quick Response (QR) Code which identifies its ID and its security key. This QR code can be read by a suitable commissioning tool (e.g. smartphone) which is already part of the network into which STM 550B will be commissioned. The commissioning tool then communicates these parameters to the intended receiver of STM 550B radio telegrams.
- **NFC commissioning**
Each STM 550B module contains an NFC interface allowing to read device parameters and to configure the device.

7.1 Radio-based commissioning

Radio-based commissioning is used to associate STM 550B with other devices by sending a dedicated radio telegram (a so-called commissioning telegram).

To do so, STM 550B can transmit a dedicated commissioning telegram identifying its relevant parameters as described in chapter 5.5.4. Appendix B.2 gives an example how to parse such commissioning telegram.

The commissioning telegram will by default be transmitted on the BLE advertising channels (CH 37, 38 and 39). Use of custom radio channels is possible as described in chapter 5.3.

The transmission of the commissioning telegram is triggered by pressing the LRN button or by via the NFC interface as described in chapter 8.

Radio-based commissioning mode is intended for applications where NFC commissioning cannot be used. Radio-based commissioning can be disabled via NFC.

7.2 QR code-based commissioning

QR code-based commissioning reads the required parameters from a dedicated QR code in the product label (described in chapter 4.4). The parameters are encoded according to the ANSI/MH10.8.2-2013 industry standard. The QR code on the product label in chapter 4.4 encodes the following string:

```
30SE50012345678+Z0123456789ABCDEF0123456789ABCDEF+31Z0000E500+30PS6221-K516+2PDB10+S01234567890123
```

Identifier	Length of data (excluding identifier)	Value
30S	12 characters	Static Source Address (hex)
Z	32 characters	Security Key (hex)
31Z	8 characters	NFC PIN Code (hex)
30P	Up to 10 characters	Ordering Code (S6221-K516)
2P	4 characters	Step Code - Revision (DB-10)
S	14 characters	Serial Number

Table 9 – QR code format

From this content, it is possible to extract the device address (E50012345678) and the security key (0123456789ABCDEF0123456789ABCDEF) which can then be used to commission STM 550B into a receiver and to authenticate STM 550B data telegrams.

7.3 Commissioning via NFC interface

STM 550B implements NFC Forum Type 2 Tag functionality as specified in the ISO/IEC 14443 Part 2 and 3 standards.

This NFC functionality can be used to read the device address and the security key of STM 550B as described in chapter 8.

8 NFC interface

STM 550B implements an NFC configuration interface that can be used to access (read and write) the STM 550B configuration memory and thereby configure the device as described in the following chapters.

NFC communication distance is for security reasons set to require direct contact between the NFC reader and the STM 550B module.



Note that STM 550B temporarily stops operation to ensure configuration data integrity while the NFC reader is connected to the NFC interface of STM 550. STM 550B will automatically resume operation approximately 5 seconds after the NFC reader has been disconnected. Care must be taken not to configure unsupported values as product behavior is undefined in that case.

8.1 NFC interface parameters

The NFC interface of STM 550B uses NFC Forum Type 2 Tag functionality as specified in the ISO/IEC 14443 Part 2 and 3 standards. It is implemented using an NXP NT3H2111 Mifare Ultralight tag.

8.2 NFC access protection

Protected data access is only possible after unlocking the configuration memory with the correct 32-bit PIN code.

By default, the protected area is locked and the default pin code for unlocking access is `0x0000E500`. The default pin code must be changed to a user-defined value as part of the installation process.

8.2.1 Write-only security key mode

For cases with high confidentiality requirements, it is possible to configure STM 550B such that the security key can only be read from the PIN-protected NFC area or not be read at all (write only mode).

8.3 Using the NFC interface

Using the NFC interface requires the following:

- NFC reader
This can be either a USB NFC reader connected to a PC or a suitable smartphone with NFC functionality
- NFC SW with read, write, PIN lock, PIN unlock and PIN change functionality
This can be either a PC application or an Android / iOS app

These options are described in more detail below.

8.3.1 PC with dedicated NFC reader

For PC-based applications, EnOcean provides a dedicated PC application called EnOcean NFC configurator which works in conjunction with the TWN4 Multitech 2 HF NFC Reader.

EnOcean NFC Configurator can be obtained available from the EnOcean homepage:
<https://www.enocean.com/en/product/enocean-nfc-configurator/>

The TWN4 Multitech 2 HF NFC Reader is available from Elatec RFID Systems (sales-rfid@elatec.com) using order code T4BT-FB2BEL2-SIMPL. It is shown in Figure 35 below.



Figure 35 – Elatec TWN4 MultiTech Desktop NFC Reader

8.3.2 Android or iOS smartphone with NFC

NFC functionality is available in most Android (e.g. Samsung Galaxy S7 or newer) and iOS (starting from iPhone7 with firmware version 13 or newer) smartphones.

EnOcean provides the configuration app “EnOcean Tool” for these devices which can be downloaded directly from the respective app store.

At the time of writing, the tool was available from the Google Play Store using this link:
<https://play.google.com/store/apps/details?id=de.enocean.easytool&hl=en>

Likewise, the tool was available from the Apple Store using this link:
<https://apps.apple.com/de/app/enocean-tool/id1497283202>

9 Mechanical interface

9.1 STM 550B

STM 550B implements the mechanical interface of the PTM 21x module which is described in more detail in this chapter. All dimensions and tolerances given are in millimetres unless otherwise noted.

9.1.1 Top view

Figure 36 below shows the STM 550B module seen from the top. The cut view along the A-A line is shown in chapter 9.1.3.

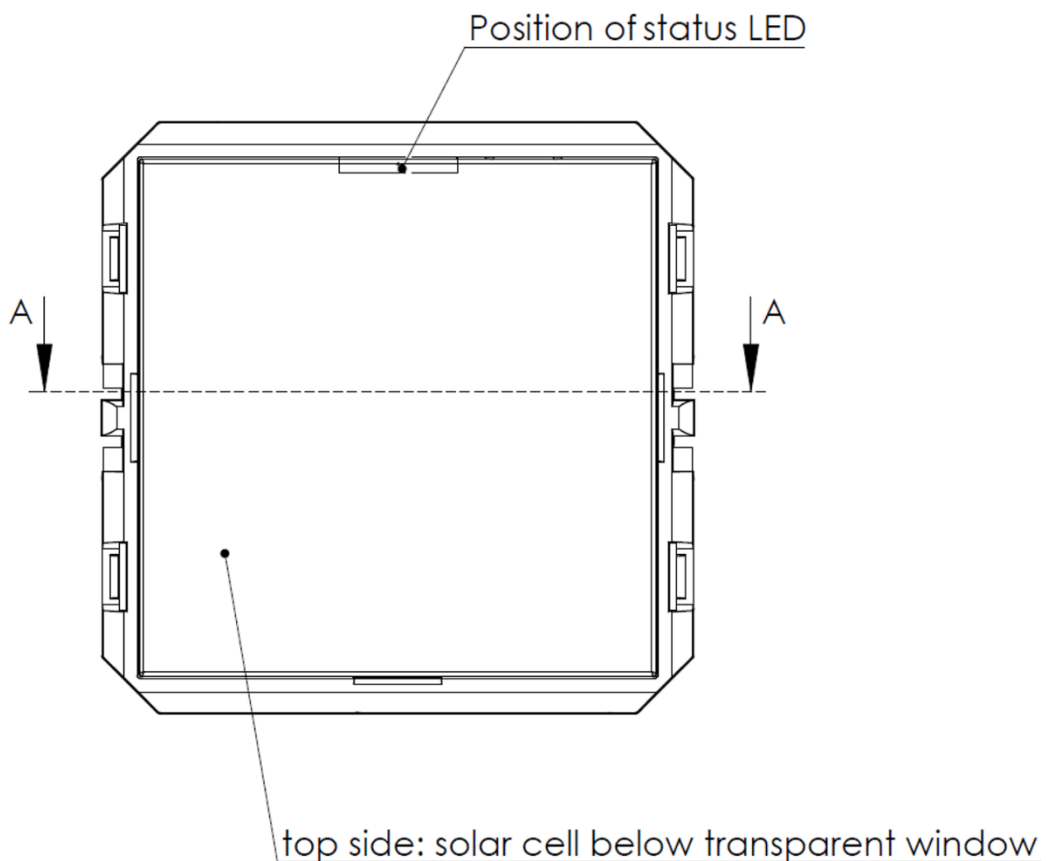


Figure 36 – Top view of STM 550B module

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9.1.2 Bottom view

Figure 37 below shows the STM 550B module seen from the bottom.

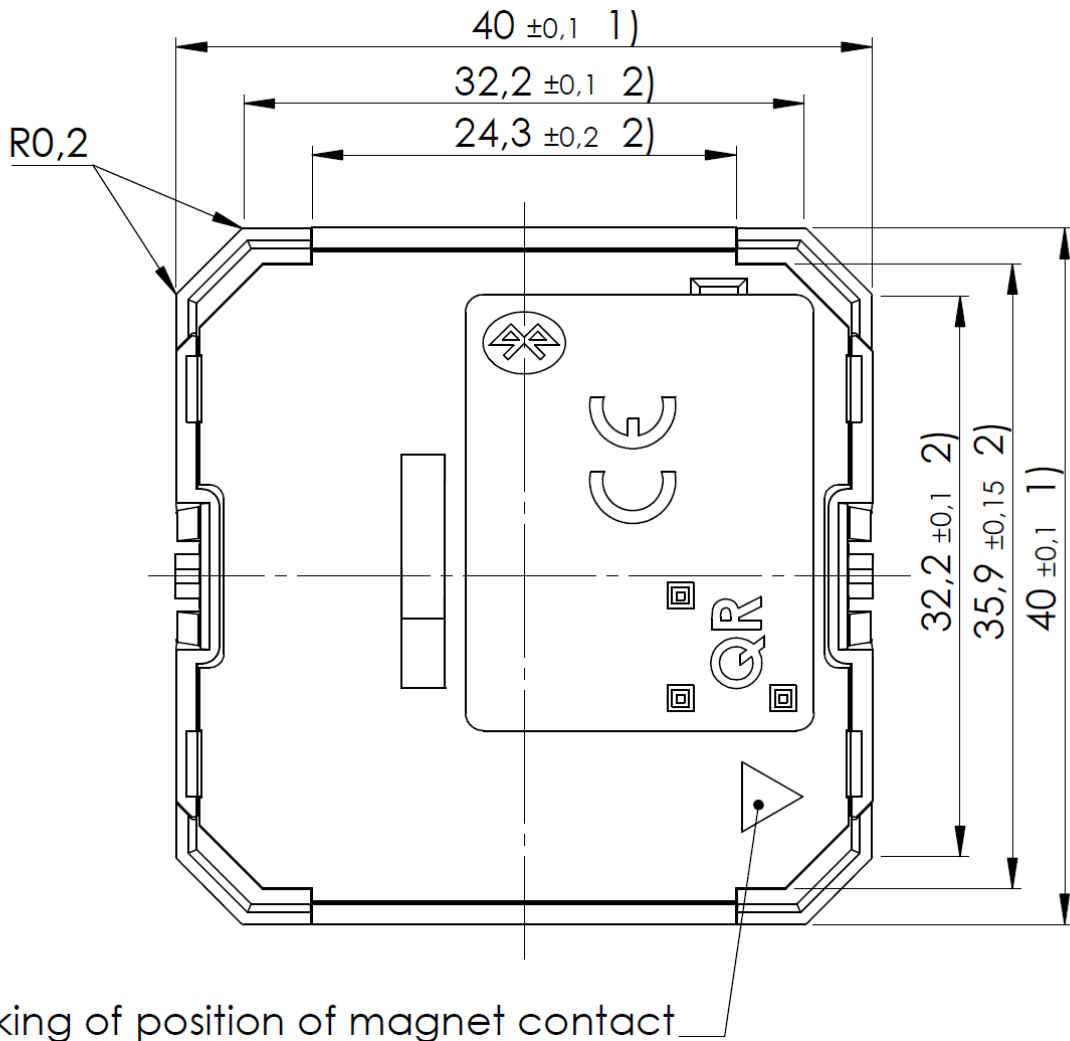


Figure 37 – Bottom view of STM 550B module

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9.1.3 Cut view (A-A)

Figure 38 below shows a cut along the A-A line of Figure 36 and highlights the area of the mounting structure (B region) in more detail.

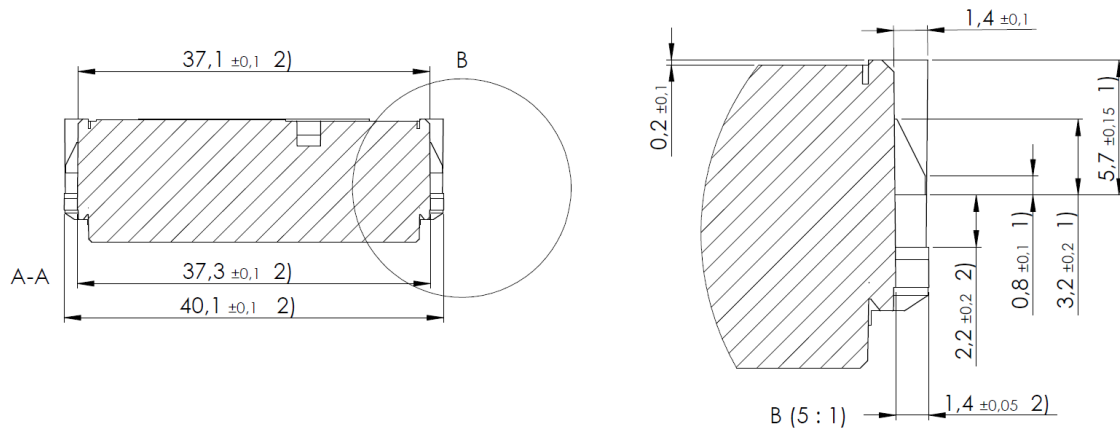


Figure 38 – Cut view (A-A) of STM 550B module

9.1.4 Front view

Figure 39 below shows the STM 550B module seen from the front.

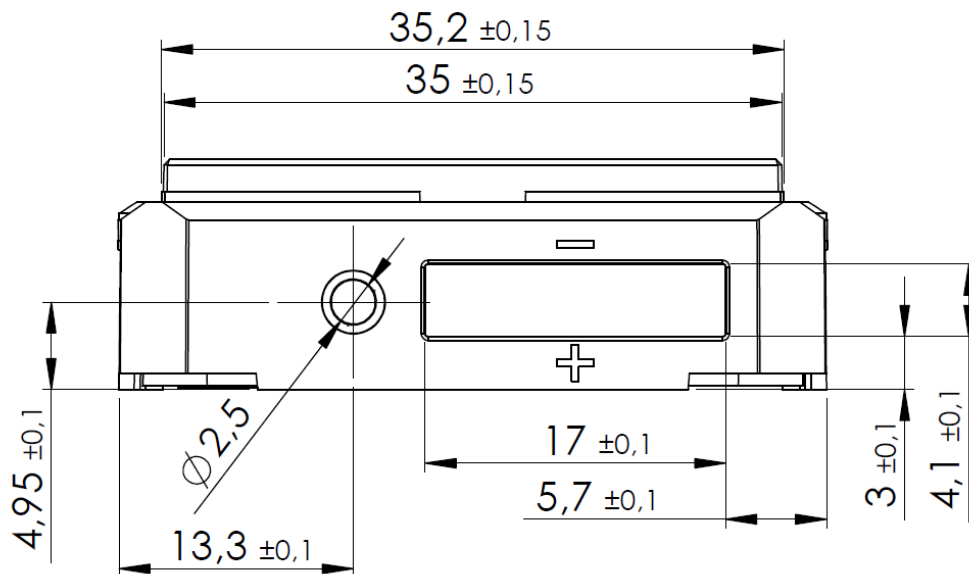


Figure 39 – Front view of STM 550B module

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9.1.5 Side view

Figure 40 below shows the STM 550B module seen from the side.

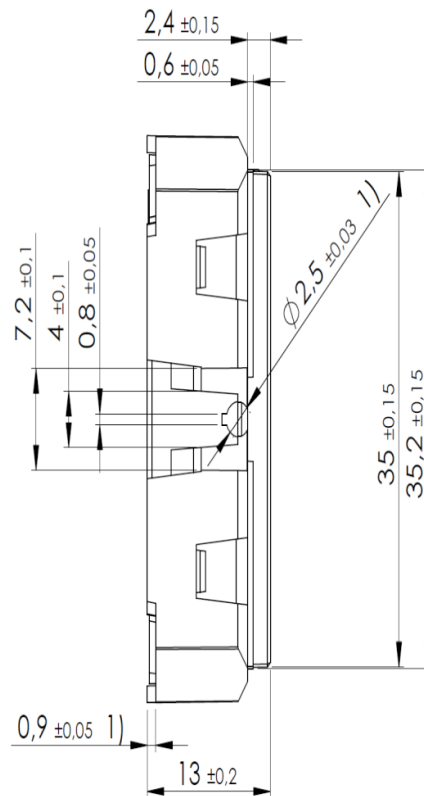


Figure 40 – Side view of STM 550B module

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9.2 EMSIB

EMSIB integrates the STM 550B module into a housing. Figure 41 below shows the mechanical interface of EMSIB.

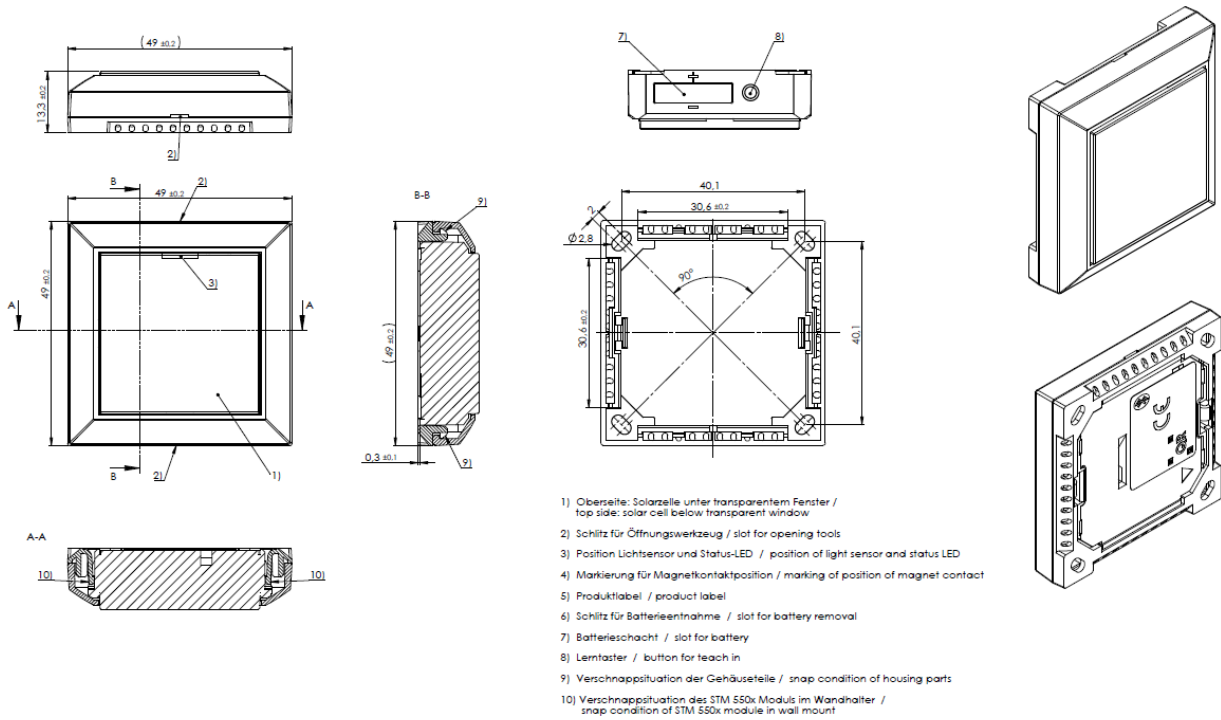


Figure 41 – Mechanical interface of EMSIB

EMSIB can be attached to a variety of surfaces using the provided adhesive pad. Figure 42 below shows the dimensions of this pad.

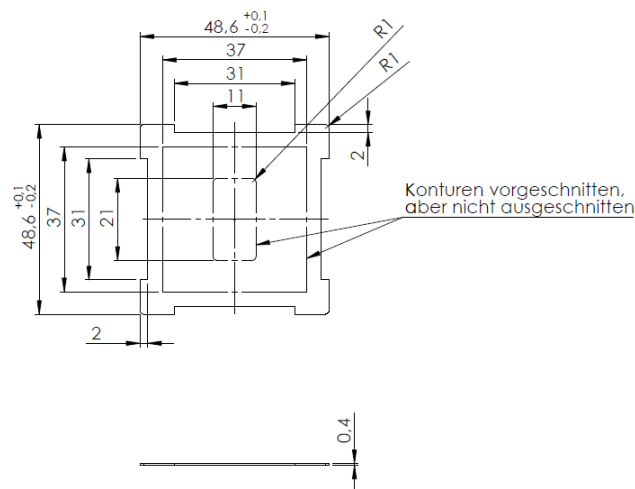


Figure 42 – Adhesive pad

10 Installation recommendations

10.1 Setup instructions

Before installing STM 550B into its intended location, a sufficient initial charge should be provided to STM 550B and its correct operation should be verified.

To do so, follow these steps:

1. Expose STM 550B to bright light (near a window or a bright light source) for 5 minutes to provide an initial charge
2. Press the LRN button once so that STM 550B will start operation
3. Check that STM 550B transmits radio telegrams at the configured update interval (by default once every 2 minutes). The LED will blink every time a telegram is transmitted (unless this has been disabled via NFC).
4. Maximize the amount of available light for energy harvesting by selecting a suitable installation position and device orientation (orient the solar cell towards the primary light source if possible).
5. Note that it will not always be possible to install STM 550B in the location with the highest ambient light level as this might impact measurement accuracy. For instance, an installation location with exposure to direct sunlight should be avoided for temperature or acceleration measurements.
6. Verify the available light level at the intended installation location by executing an Illumination Test as described in chapter 2.3.5.
7. Consider disabling the measurement of non-required parameters (especially acceleration) to conserve energy for cases where the available light is not optimal.
8. Use a suitable tool (for instance, EnOcean Tool running on an Android or iOS device) to receive STM 550B data telegrams and verify the intended functionality.

After those steps, STM 550B is ready for installation into its intended location.

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10.2 Installation location

Before selecting the installation location for STM 550B, please consider the following general guidance:

- STM 550B is designed for indoor use only
- STM 550B shall be operated within a temperature range of -5 °C ... +45 °C
Excessive heat-up due to direct exposure to sun light must be avoided
- STM 550B should be used within a humidity range of 0 % ... 90 % r.h.
Avoid environments with condensation (e.g. near entry doors to air-conditioned rooms)
- STM 550B should not be used on fast moving or strongly vibrating parts
If used as a door sensor, STM 550B should be attached to the stationary frame
- STM 550B should not be exposed to direct sunlight outdoors to avoid overheating of the device and overexposure of the solar cell which might permanently damage the device

Additionally, application-specific guidance (for specific use cases) is provided in subsequent chapters.

10.3 Mounting options (EMSIB only)

EMSIB combines the STM 550B module with a wall mount and a design frame into a ready to use product. The wall mount can be attached to most surfaces either by screws (using the four screw holes) or via an adhesive pad. Mounting via an adhesive pad is the recommended approach.

EMSIB includes a suitable two-zone adhesive pad as shown in below. Use of the outer adhesive zone (marked blue) is sufficient for most applications and enables easy removal of EMSI from the mounting surface. The inner adhesive zone (marked green) can be additionally used if firm attachment to the mounting surface is desired.

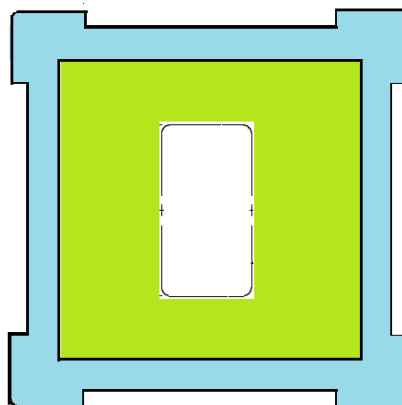


Figure 43 – Adhesive zones

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10.4 Temperature and humidity measurement

The dedicated temperature and humidity sensor integrated into STM 550B accurately measures and reports temperature and humidity present at its surface. To achieve the best possible accuracy, it is important to consider the following points:

- **Installation height**
The sensor should be installed at a height that is representative for the use case. For the case of an office, the sensor should be mounted at desk level.
- **Sun light or heat exposure**
The sensor should be mounted such that it is not directly exposed to sunlight or heat (e.g. close to a radiator)
- **Disturbances**
The sensor should be mounted such that the influence from disturbances such as the air stream from air condition units is minimized. Consider also the possible temperature gradient between wall and room when mounting the sensor directly onto a wall.
- **Airflow**
The sensor should be mounted such that the airflow from the target measurement area towards the air inlets is maximized. This will ensure the lowest possible response time of the sensor.
Avoid mounting the sensor in niches or slots with little air flow. The sensor should be mounted such that the airflow from the target measurement area towards the air inlets is maximized. This will ensure the lowest possible response time of the sensor. Avoid mounting the sensor in niches or slots with little air flow.
When designing your own housing around the STM 550B module, consider the location of the ventilation slots (there are four of them in total) as shown in Figure 44. Housing design should maximize the airflow towards these slots focusing especially on the two slots nearest to the sensor which are marked with a green dot.

Figure 44 below shows the location of the temperature and relative humidity (TRH) sensor and of the ventilation slots.

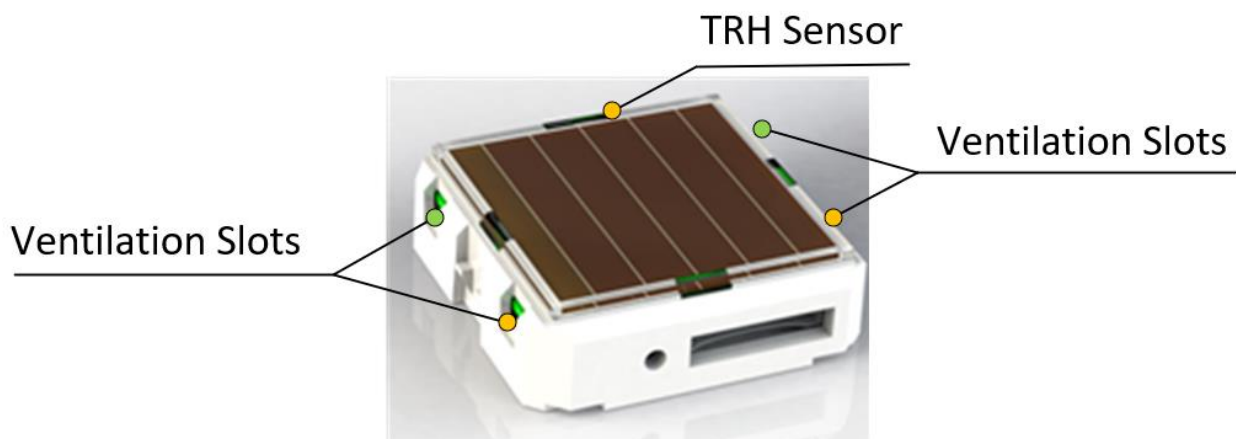


Figure 44 – Location of temperature / humidity sensor and ventilation slots

10.5 Acceleration sensor

Acceleration sensors measure the acceleration vector in all three dimensions {x; y; z}. This sensor can be used both to determine the device orientation (relative to the earth gravity vector) and the device acceleration (e.g. if a device is moved or shaken). Both cases will be discussed below.

10.5.1 Device orientation use cases

If an object is at rest or continuously moving at the same speed, then the magnitude of the vector will be 1 g (i.e. the magnitude of the measured acceleration vector will be equivalent to the magnitude of the earth gravity vector at the location of the device which will be approximately 1 g).

Measuring the magnitude in all three dimensions allows determining the orientation of an object relative to the earth gravity as shown in Figure 45 below. This illustration assumes that STM 550B is placed flat onto a surface parallel to the earth surface (e.g. a table).

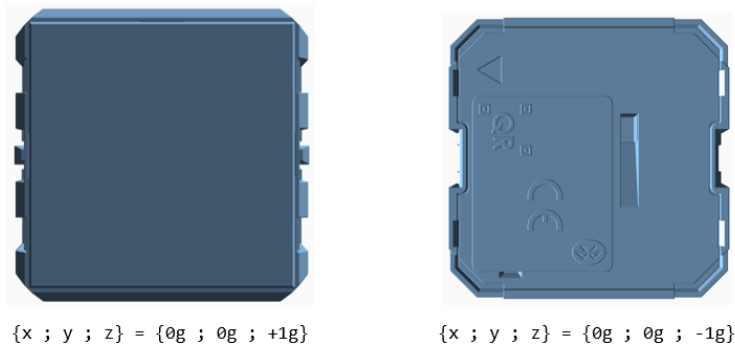


Figure 45 – Acceleration vector based on device orientation

Note that it is not possible to distinguish cases where STM 550B is rotated but its orientation relative to the direction of earth gravity remains the same. This is shown in Figure 46 below for the case of device rotation across the earth gravity vector axis.

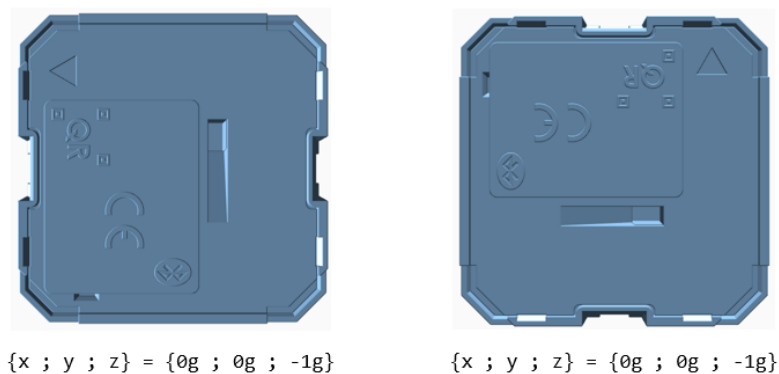


Figure 46 – Device rotation across earth gravity vector axis

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Figure 47 below illustrates this issue in a practical use case:

- The position of the window in the left case (window tilt) could be detected if STM 550B is attached to the window part that is tilted since the orientation of STM 550B relative to the gravity vector would change
- The position of the window in the right case (window open / rotation) could not be detected if STM 550B is attached to the window part that is rotated since the orientation of STM 550B relative to the gravity vector would remain the same. STM 550B would however report that the window was moved due to the resulting acceleration and deceleration.

The surface towards which STM 550B is attached should therefore be chosen to maximize orientation changes relative to the gravity vector.

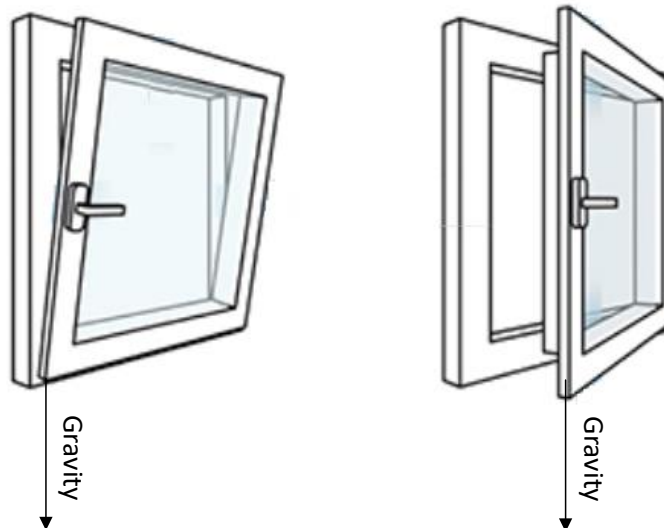


Figure 47 – Tilt versus gravity vector

Consider the limitations described in chapter 3.3.3 for use cases that require high accuracy of the reported orientation (for instance for precise inclination measurements). Installation where STM 550B is exposed to significant temperature changes must be avoided for such applications.

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10.5.2 Device acceleration use cases

If an object vibrates or is moved after being, then the acceleration vector measured by the acceleration sensor will change. Figure 48 below illustrates this.

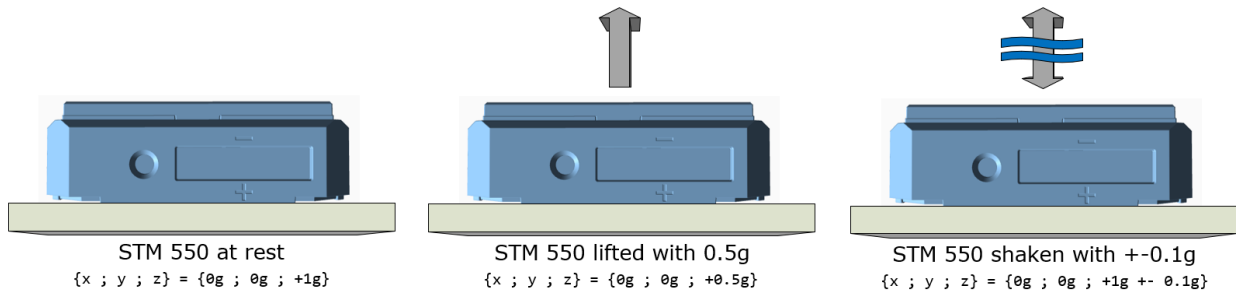


Figure 48 – Acceleration vector changes based on motion or vibration

This principle can be used for two major use cases:

- The approximate location of an object can be tracked based on the strength of the received periodic data telegrams. Movement of the object (e.g. from one room to another) can be detected based on the reported acceleration vector change.
- The utilization of an object (a machine that is running, a chair that is occupied, ...) can be tracked based on the characteristic vibrations associated with this utilization.

In both cases, STM 550B should be attached to the object for which location or utilization shall be monitored. The following chapter gives general guidelines how to do so.

10.5.3 Installation suggestions

The following points should be considered to maximize the reliability of acceleration measurement:

- STM 550B should be firmly attached to the asset without any damping to ensure that any vibration of the asset will be properly propagated to STM 550
- STM 550B should be attached to the asset at the location where the vibration is maximized. For instance, when tracking the utilization of office chairs, the highest acceleration is typically observed at the back rest.
- The acceleration threshold for wake-on-acceleration should be selected such that utilization / motion is reliably detected without false triggers due to spurious vibration (e.g. people walking by). Should the default sensitivity be insufficient even at the lowest threshold then the sampling rate should be increased
- Exposure to heat or direct sunlight should be minimized to comply with the required operation conditions and to minimize mechanical expansion of the device.

Use function test mode as described in chapter 2.3.4 to verify correct installation.

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10.6 Light level measurement

Light level (or illuminance) is the amount of light measured in a plane surface. STM 550B measures the ambient light level via the solar cell as this provides a plane surface with a large active area.

Note that for non-uniform lighting conditions, the measured light level is an average value depending on the lighting conditions across the measurement surface which strongly depends on the shape and the orientation of this surface. Devices using spherical surface lenses to capture a wider aperture might report different values from plane surface sensors.

Note also that the solar cell does not apply a spectral response curve close to the human eye's perception of ambient light to the received illumination. For these reasons, calibration at the receiver is suggested to obtain best results for the given lighting situation.

10.7 Magnet contact sensing

If STM 550B is used to detect the presence of a magnet using its magnet contact sensor (e.g. for door or window monitoring), then the magnet must be in close proximity to the magnet contact sensor for the case where a "Magnet Present" (or "Closed") condition shall be detected. Refer to chapter 2.2 for the location of the magnet contact sensor.

Attach the magnet to the intended surface (e.g. door or window) such that the centre of the large side of the magnet is oriented towards the location of the magnet contact sensor in STM 550B and that the distance between magnet and STM 550B housing is less than 1 cm for the "Magnet Present" condition. Verify that the state (e.g. door open or closed) is reported as expected.



Note that the magnet contact sensor uses a Reed (mechanic) contact to detect the proximity of the magnet. Exposing STM 550 to strong vibration might cause the magnet contact sensor to temporarily close also in absence of a magnet.

10.8 Energy harvesting

STM 550B is powered by ambient light using its integrated solar cell. For best performance it is therefore essential to maximize the amount of light available for harvesting.

Harvestable light will typically be either natural light (daylight coming in through windows etc) or artificial light (direct or reflected light from indoor luminaires). If natural light is available (e.g. from a window) then the solar cell of STM 550B should be oriented as much as possible towards that. The amount of available light can be determined by executing an illumination test as described in chapter 2.3.5.

STM 550B is designed to operate self-supplied with its standard parameters based on 200 lux of illumination at its solar cell for at least 6 hours per day. The exact amount of available light can be determined by executing an illumination test as described in chapter 2.3.5.

Lower levels of available light can be addressed by configuring a lower reporting rate via NFC as discussed in chapter 8 or by using a CR1632 backup battery as described in chapter 4.

10.9 NFC configuration

STM 550B can be flexibly configured for a wide range of application scenarios using the NFC configuration interface as described in chapter 8.



Updating the device configuration via the NFC interface requires that STM 550B has sufficient energy to read and process the new parameters.

It is therefore recommended to provide an initial charge to STM 550B by placing it under bright light for 5 minutes before starting the configuration process.

Before making any configuration changes, be sure to familiarize yourself with the device functionality and determine the available ambient light as discussed in chapter 2.3.5. Be especially careful not to configure higher update rates (low reporting intervals) before ensuring that sufficient light is available.

Should you be unsure about the current NFC configuration, then execute a factory reset as described in chapter 2.3.6 to reset all configuration registers to their default setting.

After changing the NFC configuration, remove the device from the NFC reader (or disconnect the NFC interface) to trigger the read and update process. STM 550B will indicate the successful completion of this process by two short red blinks of the LED.

Once STM 550B has been configured to the intended parameters and correct functionality has been verified, the NFC configuration interface must be locked by changing the NFC PIN code from its default value to a different (secret) value. Make sure the new PIN code is properly noted down.

11 Regulatory notes

11.1 European Union

11.1.1 Declaration of conformity

Hereby, EnOcean GmbH, declares that this radio equipment is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU. A copy of the Declaration of Conformity can be obtained from the product webpage at www.enocean.com

11.1.2 Waste treatment

WEEE Directive Statement of the European Union

The marking below indicates that this product should not be disposed with other household wastes throughout the EU. To prevent possible harm to the environment or human health from uncontrolled waste disposal, recycle it responsibly to promote the sustainable reuse of material resources.

Germany: WEEE-Reg-No.: DE 93770561

BATTERY Directive

The symbol below indicates that batteries must not be disposed of in the domestic waste as they contain substances which can be damaging to the environment and health. Please dispose of batteries in designated collection points.

Germany: UBA Reg-No.: 21008516



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11.2 FCC (United States)

11.2.1 FCC (United States) certificate

TCB

**GRANT OF EQUIPMENT
AUTHORIZATION**

TCB

**Certification
Issued Under the Authority of the
Federal Communications Commission
By:**

**EMCCert Dr. Rasek GmbH
Stoernhofer Berg 15
91364 Unterleinleiter,
Germany**

**Date of Grant: 12/15/2017
Application Dated: 12/15/2017**

**EnOcean GmbH
Kolpingring 18a
Oberhaching, 82041
Germany**

Attention: Armin Anders , Director Product Marketing

NOT TRANSFERABLE

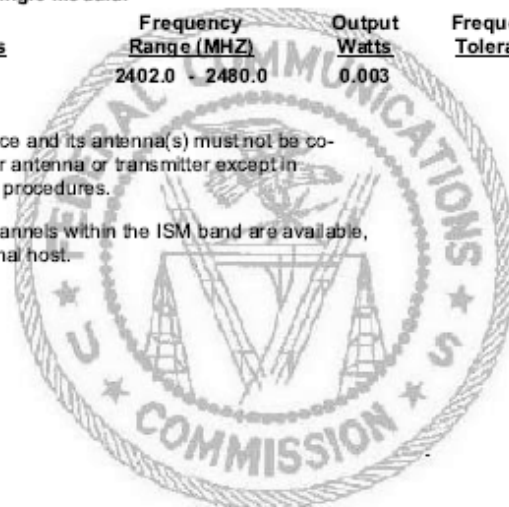
EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER: SZV-TCM515B
Name of Grantee: EnOcean GmbH
Equipment Class: Digital Transmission System
Notes: 2.4 GHz Bluetooth Low Energy (BLE) Transceiver
Modular Type: Single Modular

<u>Grant Notes</u>	<u>FCC Rule Parts</u>	<u>Frequency Range (MHZ)</u>	<u>Output Watts</u>	<u>Frequency Tolerance</u>	<u>Emission Designator</u>
	15C	2402.0 - 2480.0	0.003		

Power output listed is peak conducted. This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC accepted multi-transmitter procedures.

In addition to the 40 BLE channels, further 39 channels within the ISM band are available, activated by an application software or the external host.



11.2.2 FCC (United States) regulatory statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

11.2.3 FCC usage conditions

TCM 515B is a RF module approved for Single Modular use. It is incorporated into EMDCB as OEM installation using an approved antenna.

The module is optimized to operate using small amounts of energy and may be powered by a battery. The module transmits short radio packets comprised of control signals, (in some cases the control signal may be accompanied with data) such as those used with alarm systems, door openers, remote switches, and the like.

The module does not support continuous streaming of voice, video, or any other forms of streaming data; it sends only short packets containing control signals and possibly data. The module is designed to comply with, has been tested according to 15.231(a-c), and has been found to comply with each requirement.

Thus, STM 550B and EMSIB containing the TCM 515B radio module can be operated in the United States without additional Part 15 FCC approval (approval(s) for unintentional radiators may be required for the OEM's finished product), under EnOcean's FCC ID number if the OEM requirements are met.

11.2.4 FCC OEM requirements

In order to use EnOcean's FCC ID number, the OEM must ensure that the following conditions are met:

- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted.
- The label must include the following text:
Contains FCC ID: SZV-TCM515B
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.
- The FCC identifier or the unique identifier, as appropriate, must be displayed on the device.
- The user manual for the end product must also contain the text given above.

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11.3 ISED (Industry Canada)

11.3.1 ISED (Industry Canada) certificate



FCB under the Canada-EC MRA
 TCB under the USA-EC MRA
 RFCAB under the Japan-EC MRA
 Notified Body RE Directive 2014/53/EU
 Notified Body EMC Directive 2014/30/EU

No. CA001791J

TECHNICAL ACCEPTANCE
 CERTIFICATE
 CANADA

CERTIFICAT D'ACCEPTABILITÉ
 TECHNIQUE
 CANADA

CERTIFICATION No. ► 5713A-TCM515B
 No. DE CERTIFICATION

ISSUED TO ► EnOcean GmbH
 DELIVRE A

Street Address ► Kolpingring 18 a
 Numéro et rue

Province or State ► Germany
 Province ou Etat

City ► Oberhaching
 Ville

Postal Code ► 82041
 Code postal

TYPE OF EQUIPMENT ► Bluetooth Device, Modular Approval
 GENRE DE MATERIEL

ANTENNA ► Integrated ANTENNA GAIN ► max. 5 dBi
 ANTENNE Incorporé GAIN D'ANTENNE

PMN ► TCM 515B

HVIN ► TCM 515B

FVIN ► N/A

FREQUENCY RANGE BANDE DE FRÉQUENCES	EMISSION TYPE GENRE D'ÉMISSION	RF POWER PUISSANCE H.F.	SPECIFICATION / ISSUE / DATE SPÉCIFICATION / ÉDITION / DATE
2402 - 2480 MHz	1M10G1D	0.003 Watt	R55-247 / 2 / February 2017

TEST LABORATORY ► EMCCons DR. RAŠEK GmbH & Co. KG
 LABORATOIRE D'ESSAY

Street Address ► Störnhofer Berg 15
 Numéro et rue

Province or State ► Germany
 Province ou Etat

Name ► Ludwig Kraft
 Nom

E-mail ► lkraft@emcc.de

CN 3464C OATS 3464C-1

City ► Unterleinleiter
 Ville

Postal Code ► 91364
 Code Postal

Tel ► +49 9194 7263-301

Fax ► +49 9194 7263-309

Certification of equipment means only that the equipment has met the requirements of the above-noted specification. Licence applications, where applicable to use certified equipment, are acted on accordingly by the ISED issuing office and will depend on the existing radio environment, service and location of operation. This certificate is issued on condition that the holder complies and will continue to comply with the requirements and procedures issued by ISED. The equipment for which this certificate is issued shall not be manufactured, imported, distributed, leased, offered for sale or sold unless the equipment complies with the applicable technical specifications and procedures issued by ISED.

La certification du matériel signifie seulement que le matériel a satisfait aux exigences de la norme indiquée ci-dessus. Les demandes de licences nécessaires pour l'utilisation du matériel certifié sont traitées en conséquence par le bureau de délivrance d'ISDE et dépendent des conditions radio ambiantes, du service et de l'emplacement d'exploitation. Le présent certificat est délivré à la condition que le titulaire satisfasse et continue de satisfaire aux exigences et aux procédures d'ISDE. Le matériel à l'égard duquel le présent certificat est délivré ne doit pas être fabriqué, importé, distribué, loué, mis en vente ou vendu à moins d'être conforme aux procédures et aux spécifications techniques applicables publiées par ISDE.

I hereby attest that the subject equipment was tested and found in compliance with the above-noted specification.

J'atteste par la présente que le matériel a fait l'objet d'essai et jugé conforme à la spécification ci-dessus.

DATE 15 December 2017

Certification Officer

11.3.2 ISED (Industry Canada) regulatory statement

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions:

- (1) this device may not cause interference, and
- (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

- (1) l'appareil ne doit pas produire de brouillage, et
- (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

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11.4 ARIB (Japan)

11.4.1 ARIB certificate



Notified Body EMC Directive 2014/30/EU
 Notified Body Directive 2014/53/EU
 RF CAB under the Japan-EC MRA
 FCB under the Canada-EC MRA
 TCB under the USA-EC MRA

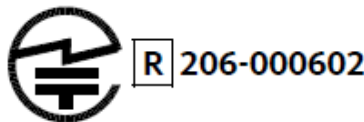
RF CAB ID No. 206

Designated by the German Regulator Bundesnetzagentur to act as a
 Recognised Foreign Conformity Assessment Body in accordance with the Japan-EC MRA

CONSTRUCTION TYPE CONFORMITY CERTIFICATE
 for
Specified Radio Equipment

Registration No.	JU000602M
Certificate Holder	EnOcean GmbH Kolpingring 18a 82041 Oberhaching Germany
Product Category	Article 2, Paragraph 1, Item 19 (WW)
Product Designation	TCM 515B, STM 550B, EMSIB, EMDCB
Product Description	Bluetooth Low Energy Transmitter
Software Release No.	1.4.0.1
Manufacturer	Katek GmbH Bahnhofstraße 108 83224 Grassau Germany

When the product is placed on the Japanese market, it must carry the Specified Radio Equipment marking as shown on the right



The scope of evaluation relates to the submitted documents only.

This Certificate confirms that the listed product has demonstrated conformity with the relevant technical regulations defined in the attached Annex. It is only valid in conjunction with the Annex.

Unterleinleiter,
 2020-04-06



 Ludwig Kraft
 Recognised Foreign Conformity Assessment Body

12 Product history

Table 10 below lists the product history of STM 550B.

Revision	Release Date	Key changes versus previous revision
DB-11	March 2025	Product update Reporting interval changed to 2 minutes Light measurement via calibrated solar cell Change from single colour to bi-colour LED
DA-04	June 2020	Market release

Table 10 – Product History

A Receiver configuration

STM 550B transmits sensor information as a set of advertising events either on the BLE advertising channels or on user-defined radio channels.

To maximize the likelihood of reception of advertising events, it is necessary that the receiver is either permanently in receive mode on one of the radio channels used by STM 550B or – if this is not possible – periodically in receive mode for a sufficiently long duration.

A.1 Scanning parameters

Three key timing parameters must be considered when configuring a receiver (scanner) for periodical reception of advertising events sent by a transmitter (advertiser). These three parameters are:

- Advertising interval
Time between two advertising events sent by the transmitter
- Scan interval
Time between the start of two consecutive scanning cycles of the receiver
- Scan window
Duration for which the receiver will scan within each scanning cycle

Figure 49 below illustrates these three parameters.

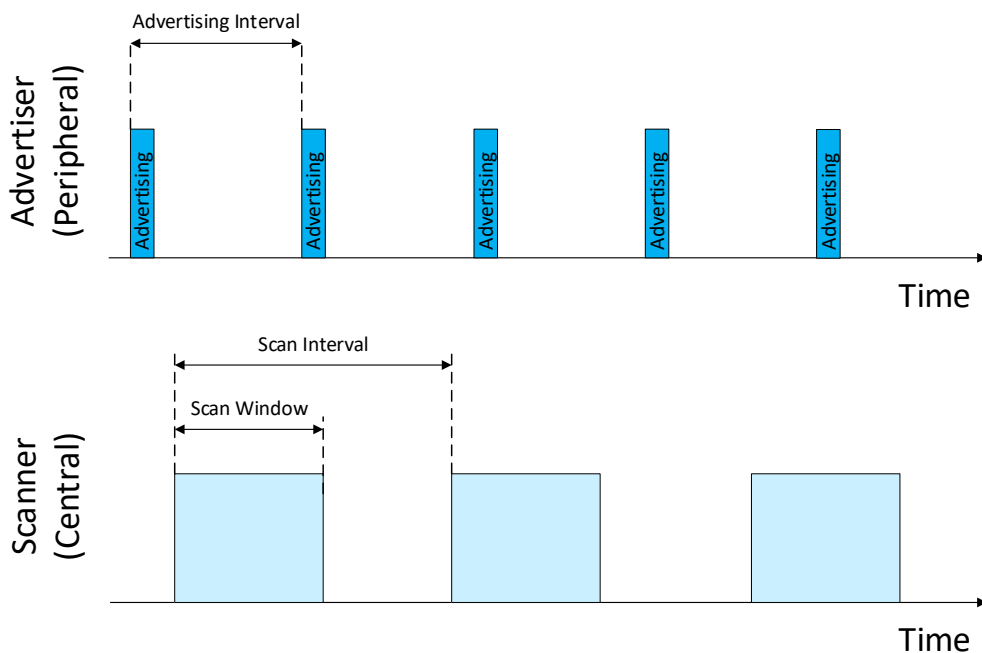


Figure 49 – Scanning parameters

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A.1.1 Advertising interval

STM 550B transmits advertising events with an advertising interval of either 20 ms (default setting) or 10 ms (NFC configurable setting).

The time required to transmit each advertising telegram within the advertising event is approximately 0.5 ms and the time required to transmit the entire advertising event (transmission of three advertising telegrams on three different radio channels including radio channel change) is approximately 2.5 ms.

A.1.2 Scan window

The scan window must be selected such that the receiver will under all conditions receive at least one full advertising telegram.

To determine when this requirement is met, we consider the worst-case condition where the receiver starts scanning directly after the start of one transmission and therefore misses a part of this transmission. Under these conditions, it is necessary that the receiver remains active until the next advertising telegram has been fully transmitted. This is illustrated in Figure 50 below.

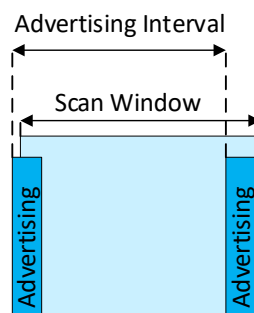


Figure 50 – Scan window setting

From Figure 50 above, we see that the minimum duration of the scan window is dependent on the advertising interval:

- If STM 550B uses 20 ms advertising intervals, then the scan window has to be at least 20 ms (advertising interval) plus 0.5 ms (telegram duration) plus a timing margin to account for the random time offset at the transmitter. Using a scan window of at least 23 ms is recommended for this case.
- If STM 550B uses 10 ms advertising intervals, then the scan window has to be at least 10 ms (advertising interval) plus 0.5 ms (telegram duration) plus a timing margin to account for the random time offset at the transmitter. Using a scan window of at least 13 ms is recommended for this case.

A.1.3 Scan interval

The scan interval must be selected such that the receiver will not be inactive so long that it misses all three advertising events.

The longest period for which the receiver can be inactive is given by the time between the end of the first advertising events (assuming the receiver exactly misses the last bit of it) and the beginning of the third advertising event (so that this will certainly be received). Figure 51 illustrates this.

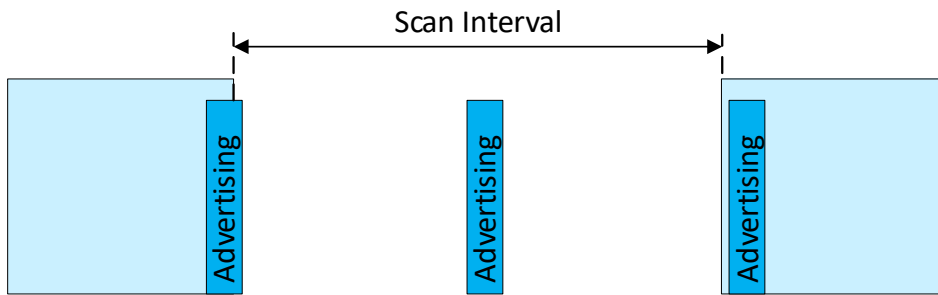


Figure 51 – Scan interval setting

From Figure 51 above, we see that the maximum duration of the scan interval is dependent on the advertising interval:

- If STM 550B uses 20 ms advertising intervals, then the scan interval has to be less than the time between the end of the first advertising event and the begin of the third advertising event ($2 * 20 \text{ ms} = 40 \text{ ms}$) minus 0.5 ms (telegram duration) minus a timing margin to account for the random time offset at the transmitter. Using a scan interval of no more than 37 ms is recommended for this case.
- If STM 550B uses 10 ms advertising intervals, then the scan interval has to be less than the time between the end of the first advertising event and the begin of the third advertising event ($2 * 10 \text{ ms} = 20 \text{ ms}$) minus 0.5 ms (telegram duration) minus a timing margin to account for the random time offset at the transmitter. Using a scan interval of no more than 17 ms is recommended for this case.

A.1.4 Summary

Table 11 below summarizes the recommended receiver scan settings.

STM 550B Advertising Interval	Receiver Scan Window (Minimum)	Receiver Scan Interval (Maximum)
20 ms	23 ms	37 ms
10 ms	13 ms	17 ms

Table 11 – Recommended receiver scan settings

B Telegram parsing

This chapter provides examples of STM 550B telegrams and shows how to interpret them.

B.1 Data telegram example

We consider the following telegram data (excluding CRC):

```
D6 BE 89 8E 42 23 00 00 01 77 00 E5 1C FF DA 03 FB 27 00 00 02 68 44 8D 01 40 42 09 06
57 8A F7 91 E6 5E 23 01 0F 01 57 D3
```

B.1.1 BLE advertising frame structure

The message above can be parsed according to the Bluetooth standard for advertising messages as shown below.

Field	Length	Data	Interpretation
BLE Access Address	4 byte	0x8E89BED6	Constant (always used)
BLE Frame Control	2 byte	0x2342	Length = 35 byte
BLE Source Address	6 byte	0xE50077010000	Device-unique address
Length of payload	1 byte	0x1C	28 byte of payload follow
Type of payload	1 byte	0xFF	Manufacturer-specific data
Manufacturer ID	2 byte	0x03DA	EnOcean GmbH
Payload	25 byte	FB 27 00 00 02 68 44 8D 01 40 42 09 06 57 8A F7 91 E6 5E 23 01 0F 01 57 D3	

Table 12 – Advertising message parsing

B.1.2 Data telegram payload

The EnOcean payload can be parsed as shown below.

Field	Length	Data	Interpretation
Sequence Counter	4 byte	0x000027FB	Incrementing message counter
Sensor Data	17 byte	02 68 44 8D 01 40 42 09 06 57 8A F7 91 E6 5E 23 01	
Telegram Signature	4 byte	0x0F0157D3	Authentication signature

Table 13 – EnOcean payload parsing

B.1.3 Sensor data

The sensor data can be parsed as shown below.

Descr	Length	Type	Data	Value
0x02	0b00 (8 bit)	0b000010 (Energy Level)	0x68	52 %
0x44	0b01 (16 bit)	0b000101 (Wide Area Illuminance)	0x018D	397 lx
0x40	0b01 (16 bit)	0b000000 (Temperature)	0x0942	23.70°C
0x06	0b00 (8 bit)	0b000110 (Relative humidity)	0x57	43.5 % r.h.
0x8A	0b10 (32 bit)	0b001010 (Acceleration vector)	0x5EE691F7 0b01 0b0111101110 0b0110100100 0b0111101111	Periodic Update X = -0.18g Y = -0.92g Z = -0.09g
0x23	0b00 (8 bit)	0b100011 (Contact Sensor)	0x01	Open

Table 14 – Sensor data parsing

The acceleration data of 0x5EE691F7 can be parsed as follows:

Binary representation: 0b01011110111001101001000111110111

```

Status   Data && 0xC0000000 >> 30 = 0b01           -> Periodic Update
X        Data && 0x3FF00000 >> 20 = 0b0111101110   = (494 - 512) / 100 = -0.18g
Y        Data && 0x000FFC00 >> 10 = 0b0110100100   = (420 - 512) / 100 = -0.92g
Z        Data && 0x000003FF           = 0b0111101111   = (503 - 512) / 100 = -0.09g
    
```

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B.2 Commissioning telegram example

We consider the following raw data (excluding CRC) captured from the same STM 550B module as in the previous chapter:

D6 BE 89 8E 42 25 00 00 01 77 00 E5 1E FF DA 03 E4 2D 00 00 3E 4D B3 4D B3 07 0E FC 67
13 FE 39 E1 3C F3 C9 39 00 00 01 77 00 E5

B.2.1 BLE advertising frame

The message above can be parsed according to the Bluetooth standard for advertising messages as shown below.

Field	Length	Data	Interpretation
BLE Access Address	4 byte	0x8E89BED6	Constant (always used)
BLE Frame Control	2 byte	0x2542	Length = 37 byte
BLE Source Address	6 byte	0xE50077010000	Device-unique address
Length of payload	1 byte	0x1E	30 byte of payload follow
Type of payload	1 byte	0xFF	Manufacturer-specific data
Manufacturer ID	2 byte	0x03DA	EnOcean GmbH
Payload	27 byte	E4 2D 00 00 3E 4D B3 4D B3 07 0E FC 67 13 FE 39 E1 3C F3 C9 39 00 00 01 77 00 E5	

Table 15 – Advertising message parsing

B.2.2 Commissioning telegram payload

The EnOcean payload can be parsed as shown below.

Field	Length	Data	Interpretation
Sequence Counter	4 byte	00002DE4	Incrementing message counter
Field Identifier	1 byte	0x3E	Commissioning Telegram (22 byte)
Device Key	16 byte	4DB34DB3070EFC6713FE39E13CF3C939	
Source Address	6 byte	0xE50077010000	

Table 16 – EnOcean commissioning telegram payload parsing