

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

PTM 215B BLE Pushbutton Transmitter Module

19.09.2016



Observe precautions! Electrostatic sensitive devices!

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PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

REVISION HISTORY

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

Version	Author	Reviewer	Date	Major Changes
0.1	MKA		01.05.2016	Initial Release
0.2	MKA		03.05.2016	Added security handling
0.3	MKA		18.05.2016	Added commissioning information
0.4	MKA		30.05.2016	Added NFC information
0.5	MKA		08.06.2016	Added Optional Data field
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0.8	MKA		19.09.2016	Added regulatory information

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Packing: Please use the recycling operators known to you.

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1 GENERAL DESCRIPTION

1.1 Basic functionality

PTM 215B enables the realization of energy harvesting wireless switches for EnOcean systems communicating based on the 2.4 GHz BLE communication standard.

PTM 215B is mechanically compatible with the established PTM 21x form factor enabling quick integration into a wide range of designs. Key applications are wall-mounted or portable switches either with up to two rockers or up to four push buttons.

PTM 215B pushbutton transmitters are self-powered (no batteries) and fully maintenance-free. They can therefore be used in all environments including locations that are difficult to reach or within hermetically sealed housings. The required energy is generated by an electro-dynamic energy transducer actuated by an energy bow located on the left and right of the module. This energy bow which can be pushed from outside the module by an appropriate pushbutton or switch rocker.

When the energy bow is pushed down or released, electrical energy is created and a radio telegram according to the 2.4 GHz BLE standard is transmitted. This radio telegram transmits the operating status of all four contact nipples at the moment when the energy bow was pushed down or released.

PTM 215B radio telegrams are protected with AES-128 security based on a device-unique private key.

Figure 1 below shows PTM 215B.



Figure 1 – PTM 215B Product Outline

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1.2 Technical data

Antenna	Integrated antenna
Output Power	0 dBm
Communication Range (Guidance Only)	75 m ideal line of sight / 10 m indoor environment
Communication Standard	BLE Advertising
Radio Frequency (min / max)	2402 MHz / 2480 MHz
Default Radio Channels	BLE CH 37 / 38 / 39 (2402 MHz / 2426 MHz / 2480 MHz)
Advertising Events per action (min / max)	2 / 3
Data Rate and Modulation	1 Mbit/s GFSK
Configuration Interface	NFC Forum Type 2 Tag (ISO/IEC 14443 Part 2 and 3)
Device Identification	Individual 48 Bit Device ID (factory programmed)
Security	AES128 (CBC Mode) with Sequence Code
Power Supply	Integrated Kinetic Energy Harvester
Button Inputs	Up to four buttons or two rockers

1.3 Physical dimensions

Module Dimensions	40.0 x 40.0 x 11.2 mm
Module Weight	20 g

1.4 Environmental conditions

Operating Temperature	-25°C ... 65°C
Storage Temperature	-25°C ... 65°C
Humidity	0% to 95% r.h. (non-condensing)

1.5 Packaging information

Packaging Unit	100 units
Packaging Method	Tray / Box (10 units per tray, 10 trays per box)

1.6 Ordering information

Type	Ordering Code	Frequency
PTM 215B	S3221-A215	2.4 GHz (BLE)

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2 FUNCTIONAL INFORMATION

2.1 PTM 215B Device Overview

The pushbutton transmitter module PTM 215B from EnOcean enables the implementation of wireless remote controls without batteries. Power is provided by a built-in electro-dynamic power generator. PTM 215B device transmits data based on the 2.4GHz BLE standard.

The outer appearance of PTM 215B is shown on the picture below.

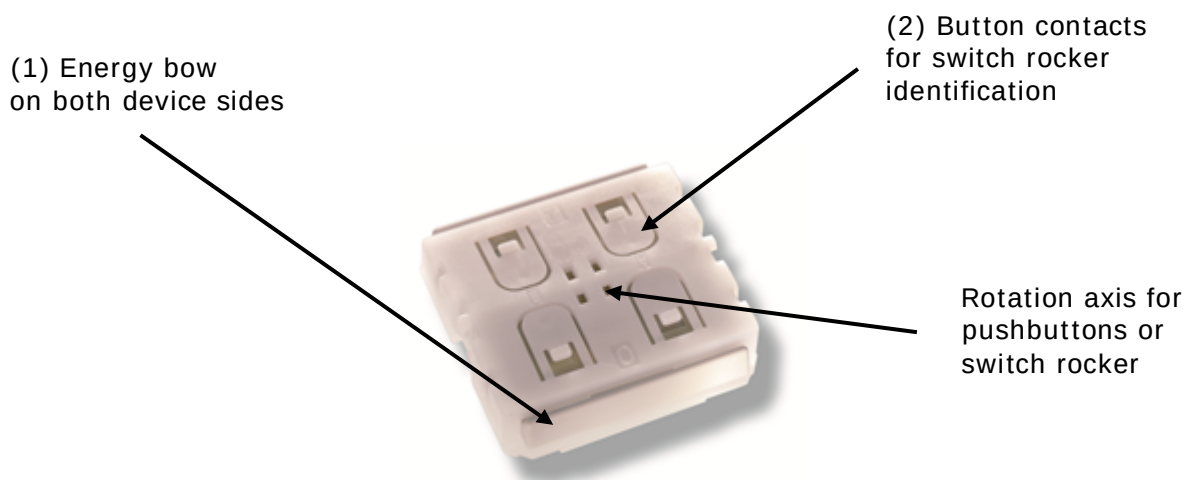


Figure 2 – Electro-dynamic powered pushbutton transmitter module PTM 215B

2.2 Basic Functionality

PTM 215B devices contain an electro-dynamic energy transducer which is actuated by an energy bow (1). This bow is pushed by an appropriate push button, switch rocker or a similar construction mounted onto the device. An internal spring will release the energy bow as soon as it is not pushed down anymore.

When the energy bow is pushed down, electrical energy is created and an BLE radio telegram is transmitted which identifies the status (pressed or not pressed) of the four button contacts (2). Releasing the energy bow similarly generates energy which is used to transmit a different radio telegram.

It is therefore possible to distinguish between radio telegrams sent when the energy bar was pushed and radio telegrams sent when the energy bar was released.

By identifying these different telegram types and measuring the time between pushing and releasing of the energy bar, it is possible to distinguish between “Long” and “Short” button contact presses. This enables simple implementation of applications such as dimming control or blinds control including slat action.

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2.3 Block Diagram

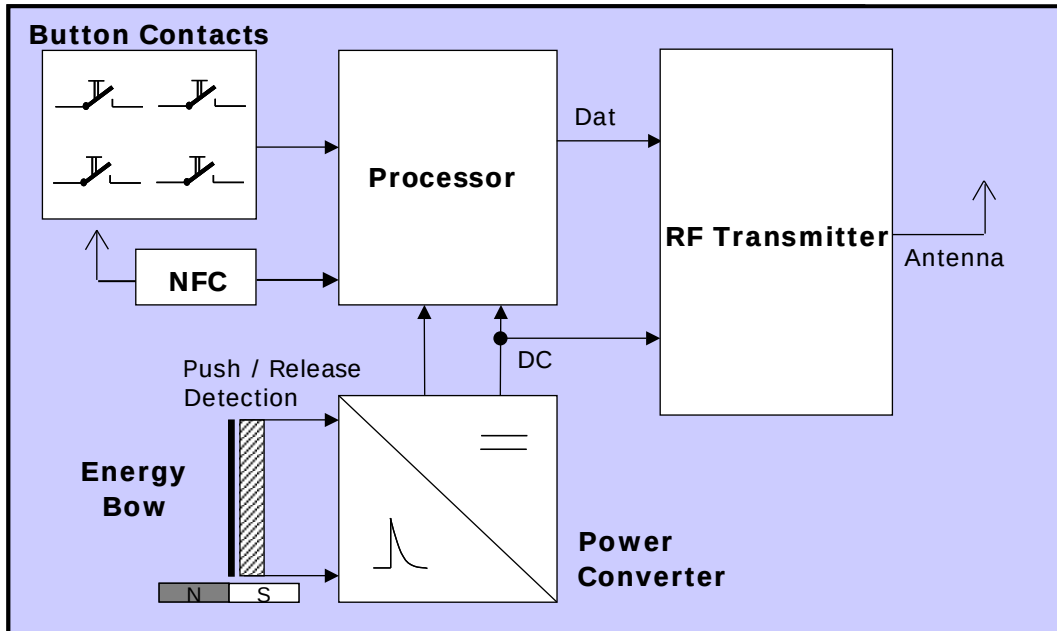


Figure 3 – Functional block diagram of PTM 215B

Energy Bow / Power Generator

Converts the motion of the energy bow into electrical energy

Power Converter

Converts the energy of the power generator into a stable DC supply voltage for the device electronics

Processor

Determines the status of the button contacts and the energy bow, encodes this status into a data word, generates the proper radio telegram structure and sends it to the radio transmitter

RF transmitter

Transmits the data in the form of a series of short BLE 2.4 GHz radio telegrams using the integrated antenna

NFC interface

Allows reading and writing certain product parameters using an NFC compliant reader / writer supporting NFC Forum Type 2 tags (as specified by ISO/IEC 14443 Part 2 and 3).

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2.4 User Interface

PTM 215B devices provide four button contacts. They are grouped into two channels (Channel A and Channel B) each containing two button contacts (State O and State I).

The state of all four button contacts (pressed or not pressed) is transmitted together with a unique device identification (48 Bit device ID) whenever the energy bow is pushed or released.

Figure 4 below shows the arrangement of the four button contacts and their designation:

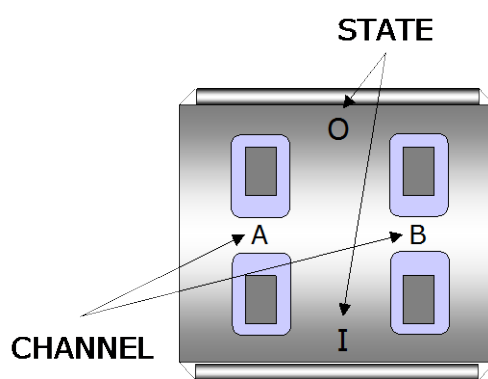


Figure 4 – Button contact designation

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2.5 PTM 215B radio channel parameters

PTM 215B transmits advertising telegrams within the 2.4 GHz radio frequency band (2402MHz ... 2482MHz) using the BLE advertising frame format.

By default, PTM 215B will use the three BLE advertising channels (Channel 37, 38 and 39) defined for transmission.

Table 1 below summarizes the radio channel assignment within the BLE standard.

Channel index	RF center frequency	Channel type
37	2402 MHz	Advertising channel
0	2404 MHz	Data channel
1	2406 MHz	Data channel
....		Data channel
10	2424 MHz	Data channel
38	2426 MHz	Advertising channel
11	2428 MHz	Data channel
12	2430 MHz	Data channel
....		Data channel
36	2478 MHz	Data channel
39	2480 MHz	Advertising channel

Table 1 – Radio channel parameters

The transmission of a radio telegram on all three advertising channels is called an Advertising Event. In order to further increase communication reliability, more than one Advertising Event might be transmitted for an individual radio telegram.

2.5.1 PTM 215B radio transmission sequence

PTM 215B transmits radio telegrams 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 this would be on BLE Channel 37, 38 and 39) one after another with minimum delay in between.

For reliability reasons, PTM 215B will send several (minimum two, maximum three) advertising events for each button input. The resulting transmission sequence is shown in Figure 5 below.

CH37	CH38	CH39	Pause (20 ms)	CH37	CH38	CH39	Pause (20 ms)	CH37	CH38	CH39
------	------	------	------------------	------	------	------	------------------	------	------	------

Figure 5 – Radio transmission sequence

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2.6 PTM 215B button action encoding

Figure 6 below shows the button action encoding used by PTM 215B.

In PTM 215B, the type of action (Press Action or Release Action) is indicated by Bit 0 (Energy Bar). If a button contact has been actuated during Press Action or Release Action then this is indicated by the according status bit set to '1'.

Note that all contacts that were pressed during Press Action will be released during Release Action. The case of continuing to hold one (or several) button contacts during Release Action is mechanically not possible.

Switch Status							
Reserved			B1	B0	A1	A0	ACTION TYPE
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Shall be 0b000			0 = No Action 1 = Action	0 = No Action 1 = Action	0 = No Action 1 = Action	0 = No Action 1 = Action	0 = Release Action 1 = Press Action

Figure 6 - PTM 215B button action encoding

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2.7 PTM 215B commissioning

Commissioning is the process by which PTM 215B is learned into a receiver (actuator, controller, gateway, etc.).

The following two tasks are required in this process:

n Device identification

The receiver needs to know how to uniquely identify this specific PTM 215B device. This is achieved by using a unique 48 Bit ID (Source Address) for each PTM 215B device as described in chapter 2.9.4. In addition, up to 4 byte of Optional Data can be configured as described in chapter 2.11.4.1

n Security parameter exchange

The receiver needs to be able to authenticate radio telegrams from PTM 215B in order to ensure that they originate from this specific device and have not been modified as described in chapter 2.10. This is achieved by exchanging the 128 Bit random security key used by PTM 215B to authenticate its radio telegrams.

PTM 215B provides the following options for these tasks:

n NFC-based commissioning

The PTM 215B parameters are read by a suitable commissioning tool (e.g. NFC smartphone) which is already part of the network into which PTM 215B will be commissioned. The commissioning tool then communicates these parameters to the intended receiver of PTM 215B radio telegrams. NFC-based commissioning is described in chapter 2.11

n Radio-based commissioning

PTM 215B can communicate its parameters via special radio telegrams (commissioning telegrams) to the intended receiver. To do so, PTM 215B can be temporarily placed into radio-based commissioning mode as described in chapter 2.8.2

n Camera-based commissioning

Each PTM 215B module contains an automatically readable Data Matrix Code (DMC) which identifies its ID and its security key. This DMC can be read by a suitable commissioning tool (e.g. smartphone) which is already part of the network into which PTM 215B will be commissioned. The commissioning tool then communicates these parameters to the intended receiver of PTM 215B radio telegrams. The DMC structure is described in chapter 3.3.1

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2.8 Operation modes

PTM 215B can operate in two modes:

- n **Data mode**
Data mode is used to transmit data telegrams reporting the status of PTM 215B button inputs
- n **Radio-based commissioning mode**
Radio-based commissioning mode is used to commission (teach-in) PTM 215B into a specific receiver or network by means of a specific commissioning telegram.
This is an alternative for scenarios where NFC commissioning cannot be used.

2.8.1 Data mode

Data mode is the standard mode of operation. In this mode, PTM 215B will transmit radio telegrams identifying the status of its four button contacts and the energy bar.

PTM 215B uses the following sequence to identify and transmit button contact status:

1. Determine direction of the energy bar movement (Push Action or Release Action)
2. Read input status of all button contacts
3. Calculate data payload
4. Calculate security signature
5. Format BLE radio telegram
6. Transmit BLE radio telegram as sequence of Advertising Events

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2.8.2 Radio-based commissioning mode

Radio-based commissioning mode is used to associate PTM 215B with other devices. To do so, PTM 215B can transmit a dedicated commissioning telegram (as described in chapter 2.9.6.2) identifying its relevant parameters. The commissioning telegram will be transmitted on the BLE advertising channels (Channels 37, 38 and 39)

Radio-based commissioning mode is intended for applications where NFC commissioning (as described in chapter 2.11) cannot be used.

Radio-based commissioning can be disabled by setting the Disable Radio Commissioning flag in the Configuration register to 0b1 (see chapter 2.11.4.2).

2.8.2.1 Commissioning mode entry

Commissioning mode is entered using a special button contact sequence. This is illustrated in Figure 7 below.

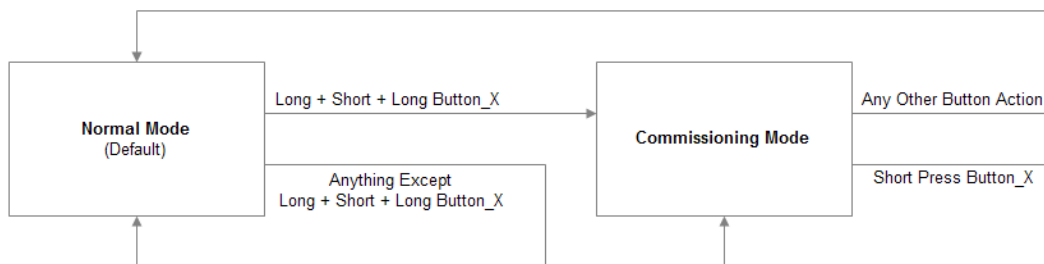


Figure 7 – Button sequence for commissioning mode

To enter commissioning mode, start by selecting one button contact of PTM 215B. Any contact of PTM 215B (A0, A1, B0, B1) can be used. This contact is referred to as Button_X in Figure 7 above.

Next, execute the following long-short-long sequence:

1. Press and hold the selected button contact together with the energy bar for more than 7 seconds before releasing it
2. Press the selected button contact together with the energy bar quickly (hold for less than 2 seconds)
3. Press and hold the selected button contact together with the energy bar again for more than 7 seconds before releasing it

Upon detection of this sequence, PTM 215B will enter commissioning mode if the Disable Radio Commissioning flag in the configuration register is not set.

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2.8.2.2 Commissioning telegram transmission

PTM 215B will transmit a commissioning telegram (as sequence of Advertising Events on the BLE advertising channels as described in chapter 2.5) upon entering commissioning mode.

The format of the commissioning telegram is described in chapter 2.9.6.2.

PTM 215B will continue to transmit commissioning telegrams whenever the button used for entry into commissioning mode (Button_X) is pressed or released again.

2.8.2.3 Exit from commissioning mode

Pressing any key except the button used for entry into commissioning mode (Button_X) will cause PTM 215B to exit commissioning mode and return to normal data mode.

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2.9 BLE frame structure

PTM 215B transmits radio telegrams in the 2.4 GHz band according to BLE frame structure. For detailed information about the BLE standard, please refer to the applicable specifications.

Figure 8 below summarizes the BLE frame structure.

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

Figure 8 – BLE frame structure

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

2.9.1 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.

2.9.2 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.

2.9.3 Header

The BLE Header identifies certain radio telegram parameters. Figure 9 below shows the structure of the BLE header.

TYPE (4 Bit)	UNUSED (2 Bit)	TX ADDR (1 Bit)	RX ADDR (1 Bit)	LENGTH (6 Bit)	UNUSED (2 Bit)
0010: TX-only Advertising (ADV_NONCONN_IND)	00	1: Random	0: Not used	Length of Address + Payload	00

Figure 9 – BLE header structure

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2.9.4 Source address

The 6 byte BLE Source Address (MAC address) uniquely identifies each PTM 215B product.

PTM 215B supports two source address modes:

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

PTM 215B uses by default the Static Source Address mode. The Private Resolvable Address mode can be selected by setting the Private Source Address flag in the Configuration register (see chapter 2.11.4.2) to 0b0.

These two address modes are described in the following chapters.

2.9.4.1 Static source address mode

By default, PTM 215B uses static source addresses meaning that the source address is constant during normal operation. The static source address can be read and configured (written) via NFC as described in chapter 2.11.

The structure of PTM 215B static addresses is as follows:

- n The upper 2 bytes of the source address are used to identify the device type and set to 0xE215 for all PTM 215B devices (to designate EnOcean PTM 215 device type).
- n The lower 4 bytes are uniquely assigned to each device.

Figure 10 below illustrates the static address structure used by PTM 215B.

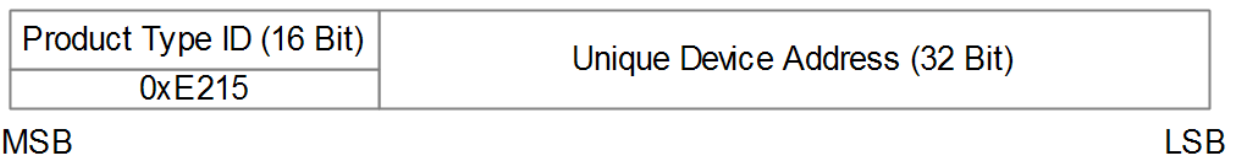


Figure 10 – BLE static source address structure

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2.9.4.2 Private resolvable source address mode

For some applications it is desirable to modify (rotate) the source address used by PTM 215B in order to prevent tracking of its radio transmissions. At the same time, each PTM 215B device must remain uniquely identifiable by the receiver.

To achieve these goals, PTM 215B can be configured via NFC to use random resolvable private addresses.

Using random resolvable private addresses requires that both PTM 215B and the receiver both know a common key – the so-called Identity Resolution Key (IRK). PTM 215B uses its device-unique random key as identity resolution key. This key can be configured via NFC as described in chapter 2.11.

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

n *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 (as described in chapter 2.5.1) use the same *prand* value.

n *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 11 below.

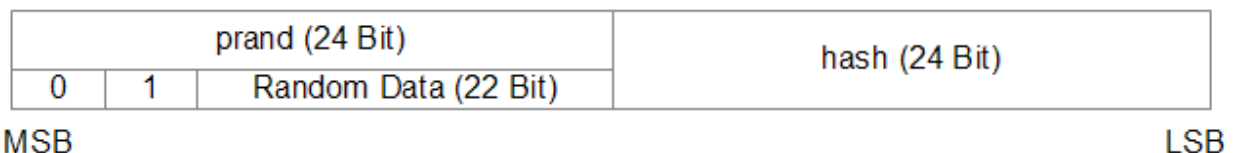


Figure 11 – BLE private resolvable source address structure

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 private resolvable source address.

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The receiving device maintains a list of IRK for all transmitters that have been commissioned to work with it.

Whenever the receiving device receives a radio telegram with private resolvable source 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 source ID while *prand* and *hash* provide a mechanism to select the correct IRK among a set of IRK.

This mechanism is illustrated in Figure 12 below.

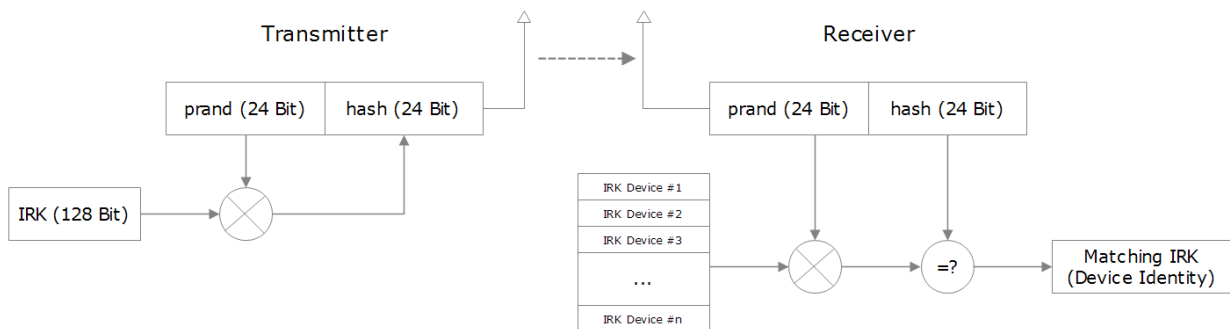


Figure 12 – Resolving private source addresses

2.9.5 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.

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2.9.6 Payload

The payload structure is depending on the telegram type (data telegram or commissioning telegram).

2.9.6.1 Data Telegram Payload

The payload of data telegrams is 13 ... 17 bytes long and consists of the following fields:

- n Length (1 byte)**
The Length field specifies the combined length of the following fields. The content of the field depends on the size of the Optional Data field (which can be 0 / 2 / 2 or 4 byte). The resulting Length setting would be 12 / 13 / 14 or 16 byte (0x0C / 0x0D / 0x0E / 0x10) respectively
- n Type (1 byte)**
The Type field identifies the data type used for this telegram. For PTM 215B data telegrams, this field is always set to 0xFF to designate manufacturer-specific data field
- n 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
- n Sequence Counter (4 byte)**
The Sequence Counter is a monotonously 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.
- n Switch Status (1 byte)**
The Switch Status field reports the button action. The encoding of this field is described in chapter 2.6.
- n Optional Data (0 / 1 / 2 or 4 byte)**
PTM 215B provides the option to transmit additional user-defined data within each data telegram. This data can be used to identify user-specific properties. The length of the Optional Data field is defined in the Configuration register as described in chapter 2.11.4.2.
- n Security Signature (4 byte)**
The Security Signature is used to authenticate PTM 215B radio telegrams as described in chapter 2.10

Figure 13 below illustrates the data telegram payload.

0x0C ... 0x10	0xFF	Manufacturer ID 0x03DA	Sequence Counter (4 Byte)	Switch Status	Optional Data (0/1/2/4 Byte)	Security Signature (4 Byte)
LEN TYPE						

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Figure 13 – Data telegram payload structure**2.9.6.2 Commissioning Telegram Payload**

The payload of commissioning telegrams is 31 bytes long and consists of the following fields:

- n Length (1 byte)**
The Length field specifies the combined length of the following fields. For PTM 215B commissioning telegrams, this field is always set to 0x06 (6 byte) for the “Short Name” field and to 0x17 (23 byte) for the “Manufacturer-specific Data” field
- n Type (1 byte)**
The Type field identifies the data type used for this telegram. For PTM 215B commissioning telegrams, this field is set to 0x08 for the “Short Name” field and to 0xFF for the “Manufacturer-specific Data” field
- n Short Name**
The Short Name field identifies PTM 215B using the string “P215B”
- n Manufacturer ID (2 byte)**
The Manufacturer ID field can be used to identify the manufacturer of BLE devices based on assigned numbers. EnOcean has been assigned 0x03DA as manufacturer ID code
- n Sequence Counter (4 byte)**
The Sequence Counter is a monotonously 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.
- n Security Key (16 byte)**
Each PTM 215B device contains its own 16 byte device-unique random security key which is generated and programmed during manufacturing. It is transmitted during commissioning to enable the receiver to authenticate PTM 215B data telegrams

Figure 14 below illustrates the commissioning telegram payload.

0x06	0x08	'P'	'2'	'1'	'5'	'B'	0x17	0xFF	Manufacturer ID 0x03DA	Sequence Counter (4 Byte)	Security Key (16 Byte)
LEN TYPE		DATA				LEN TYPE		DATA			

Figure 14 – Commissioning telegram payload structure

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2.10 Telegram authentication

PTM 215B 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 15 below and exchanged as part of the radio telegram.

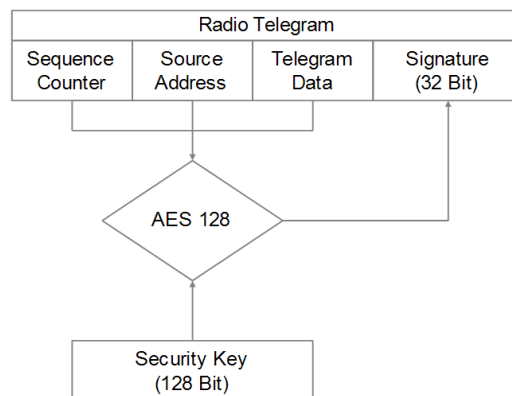


Figure 15 – Telegram authentication flow

Sequence counter, source address and the remaining telegram data together form the input data for the signature algorithm. This algorithm uses AES 128 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 PTM 215B 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:

- n Sender (PTM 215B) and receiver use the same security key
- n 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.

In order 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 PTM 215B and only accepts messages with higher sequence counter values (i.e. not accepts equal or lower sequence counter values for subsequent telegrams).

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2.10.1 Authentication implementation

PTM 215B implements telegram authentication based on AES128 in CCM (Counter with CBC-MAC) mode as described in IETF RFC 3610.

The 10 Byte CCM Nonce (number used once – unique) initialization value is constructed as concatenation of 48 bit Device ID and 32 bit Sequence Counter in little endian format (least significant byte first).

Figure 16 below shows the AES128 Nonce.

AES128 Nonce (10 Byte)									
Device ID						Sequence Counter			
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 0	Byte 1	Byte 2	Byte 3

Figure 16 – 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 telegram payload shown in Figure 17 below.

Authenticated Payload								
LEN	TYPE	MANUFACTURER	Sequence Counter				STATE	Optional Data
Byte 0	0xFF	0x03DA	Byte 0	Byte 1	Byte 2	Byte 3	Byte 0	0 / 1 / 2 / 4 byte

Figure 17 – Authenticated payload

The calculated 32 bit signature is then appended to the payload as shown in Figure **13** in chapter 2.9.6.1.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

2.11 NFC interface

PTM 215B implements NFC Forum Type 2 Tag functionality as specified in the ISO/IEC 14443 Part 2 and 3 standard.

This NFC functionality can be used to access (read and write) the PTM 215B configuration memory and thereby configure the device as described in the following chapters.

2.11.1 Configuration memory organization

The PTM 215B configuration memory is divided into the following areas:

- n Public data
- n Protected data

In addition to that, PTM 215B maintains a private configuration memory region used to store default parameters and confidential information which is not accessible to the user. Figure 18 below illustrates the configuration memory organization used by PTM 215B.

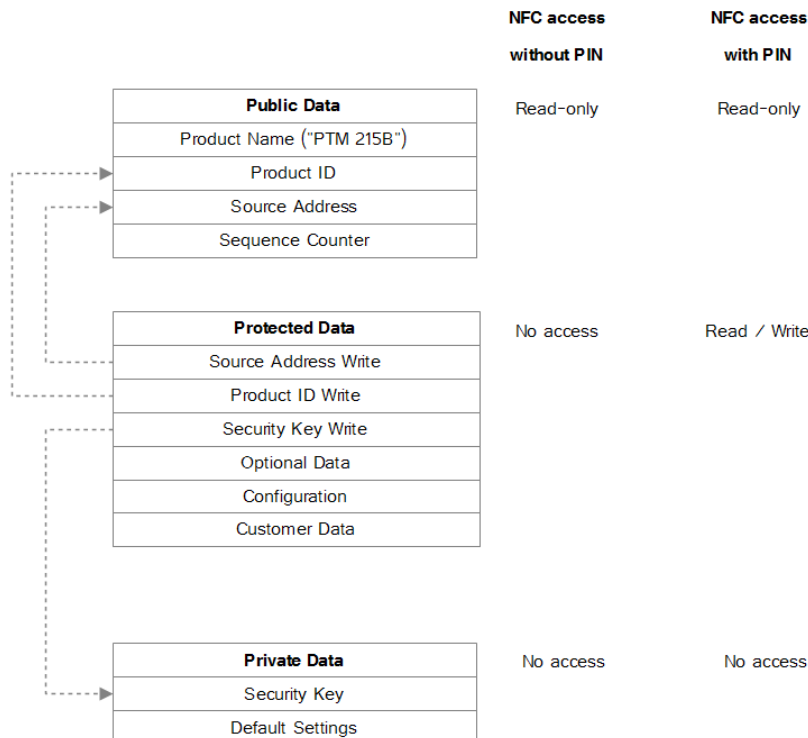


Figure 18 – Configuration memory organization

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2.11.2 Memory Address Map

The NFC-accessible configuration memory is organized in memory pages where each memory page is 4 byte wide. Each NFC access reads or writes one memory page.

The addresses map of the configuration memory is shown in Figure 19 below. The byte order is little endian, i.e. Byte 0 will be read first and Byte 3 last.

Area	NFC Page	Total Byte Offset	Byte 0 (LSB)	Byte 1	Byte 2	Byte 3 (MSB)
Public Memory Area						
Public	0x00	0	Reserved			
Public	0x01	4				
Public	0x02	8				
Public	0x03	12				
Public	0x04	16	Product Name "PTM 215B"			
Public	0x05	20				
Public	0x06	24	Product ID			
Public	0x07	28				
Public	0x08	32	Static Source Address			
Public	0x09	36	Sequence Counter			
Protected Memory Area						
Protected	0x0A	40	Configuration	Reserved		
Protected	0x0B	44	Opt Data 0	Opt Data 1	Opt Data 2	Opt Data 3
Protected	0x0C	48	Product ID Write			
Protected	0x0D	52				
Protected	0x0E	56	Source ID Write			
Protected	0x0F	60	Reserved			
Protected	0x10	64	Security Key Write			
Protected	0x11	68				
Protected	0x12	72				
Protected	0x13	76				
Protected	0x14	80	Reserved			
Protected	...	...				
Protected	0x1F	124				
Protected	0x20	128	Custom NFC Data			
Protected	...	...				
Protected	0x5F	380				
Protected	0x60	384	Reserved			
Protected	...	...				
Protected	0xE1	900				

Figure 19 – Configuration memory address map

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2.11.3 Public data

Public data can be read by any NFC-capable device supporting the ISO/IEC 14443 Part 2 and 3 standard. No specific security measures are used to restrict read access to this data.

The following items are located in the public data area:

- n PTM 215B Static Source Address (32 Bit, see chapter 2.9.4.1)
- n PTM 215B Product Name (this is always “PTM 215B”)
- n PTM 215B Product ID (up to 8 characters, to be assigned by the user)
- n Telegram sequence counter (initialized to 0 during manufacturing and incremented for each transmitted telegram)

Changing the Static Source Address and Product ID fields is only possible via protected data access as described below to prevent unauthorized modification.

For security reasons, the telegram sequence counter cannot be written or reset by any mechanism.

2.11.4 Protected Data

The following items are located in the protected data area:

- n Source Address Write register
- n Product ID Write register
- n Security Key Write register
- n Optional Data register
- n Configuration register
- n Customer Data

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2.11.4.1 PIN Code

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 0x0000E215. This pin code should be changed to a user-defined value as part of any NFC-based installation process.

2.11.4.1 Modifying product parameters

Modifying (writing) PTM 215B the following product parameters is not directly possible:

- n Static Source Address
- n Product ID
- n Security Key

In order to modify these parameters, the user has to write the new value into specific registers (*Source Address Write*, *Product ID Write* and *Security Key Write*) in the protected data area and set the according *Update* flag in the *Configuration* register.

2.11.4.2 Source Address Write register

The Source Address Write register is 6 byte wide and can be used to modify the PTM 215B source address.

In order to do so, follow these steps:

1. Write new source address into the Source Address Write register
2. Set the Update Source Address flag in the Configuration register to 0b1
3. Actuate (press and release) PTM 215B

PTM 215B will determine that it should modify the source address based on the setting of the Update Source Address flag and copy the value of the Source Address Write register to the Source Address register.

After successful execution, PTM 215B will clear the Update Source Address flag to 0b0.

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2.11.4.3 Security Key Write register

The Security Key Write register is 16 byte wide and contains the device-unique random security key.

The factory programmed key can be replaced with a user defined key by following these steps:

1. Write new security key into the Security Key Write register
 Note that for security reasons, setting the Security Key to the following values is not possible:
 - 0x00000000000000000000000000000000
 - 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 If the Security Key Write register is set to one of these values then no update of the Security Key will occur.
2. Set the Update Security Key flag in the Configuration register to 0b1
3. If the key should be write-only (not readable after the key update) then set the Private Security Key flag in the Configuration register to 0b1
4. Actuate (press and release) PTM 215B

PTM 215B will determine that it should modify the security key based on the setting of the Update Security Key flag and copy the value of the Security Key Write register to the Security Key register in private memory.

After successful execution, PTM 215B will clear the Update Security Key flag to 0b0.

If the Private Key flag in the Configuration register is set to 0b0 then the content of the Security Key Write register will be maintained at its current value. This addresses use cases where the security key shall be readable for users having the correct PIN code.

If the Private Key flag in the Configuration register is set to 0b1 then the content of the Security Key Write register will be cleared to 0x00000000000000000000000000000000 after successful execution. This addresses use cases where the security key shall never be readable (even for users having the correct PIN code). The Security Key Write register will maintain this value of 0x00000000000000000000000000000000 even if the Private Key flag in the Configuration register is subsequently cleared to 0b0. This ensures that it is not possible to read a security key which was written with the Private Key flag in the Configuration register being set.

Note that it is not possible to read the current security key via NFC if the Security Key Write register has been accidentally overwritten or cleared via NFC write. In this case it is necessary to write a new security key (as described above) or to reset the device to its default security key by means of a factory reset.

The protected memory is designed to support 1000 modifications of the security key.

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2.11.4.4 Product ID Write register

The Product ID register is 8 byte wide and can be used to specify a publicly-accessible parameter (e.g. a user-specific ID or name).

In order to do so, follow these steps:

1. Write new product ID (using ASCII encoding) into the Product ID Write register.
2. Set the Update Product ID flag in the Configuration register to 0b1
3. Actuate (press and release) PTM 215B

PTM 215B will determine that it should update the short name based on the setting of the Update Product ID flag and copy the value of the Product ID Write register to the Product ID register.

After successful execution, PTM 215B will clear the Update Product ID flag to 0b0.

2.11.4.1 Optional Data register

The Optional Data register can be used to specify up to 4 byte of custom data that will be transmitted as part of each data telegram. This optional data can store user-specific or application-specific information.

The size of the Optional Data field is specified in the Configuration register and can be 0 byte (not present, default), 1 byte, 2 byte or 4 byte.

If the size of the Optional Data field is set to a non-zero value in the Configuration register then PTM 215B will read the corresponding amount of data from the Optional Data register beginning with the least significant byte (Byte 0).

Note that using the Optional Data feature requires additional energy for the radio telegram transmission and might therefore reduce the total number of redundant telegrams which are transmitted.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

2.11.4.2 Configuration register

The Configuration register is 1 byte wide and contains configuration flags. Figure 20 below shows the structure of the Configuration register.

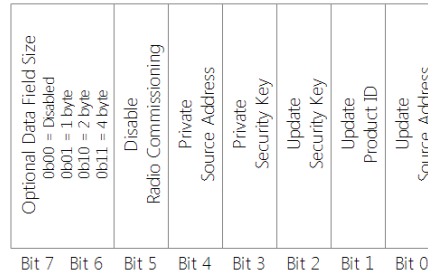


Figure 20 – Configuration register structure

2.11.4.3 Customer Data

PTM 215B allocates 64 pages (256 byte) for customer data that can be read and written via the NFC interface in protected mode.

The main intention is to enable storing OEM-specific information such as product type, revision, date code or similar. There is however no restriction (other than the maximum size of 256 byte) on the type of content that can be stored in this memory region.

PTM 215B will not access or modify this memory region.

Users should keep in mind that the content of this memory region will not be affected by a factory reset. This means that after a factory reset, the content of this memory region can be read using the default PIN code. This region should therefore not be used to store sensitive data.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

2.11.5 Private Data

The private data area stores the following items:

- n Security Key
- n Default settings

The content of the private data area is not externally accessible.

2.11.5.1 Security Key

The Security Key field contains the 128-Bit key used for authenticating PTM 215B telegrams and for resolving private source addresses.

2.11.5.2 Default Settings

The Default Settings field contains a backup of the following PTM 215B factory settings:

- n Source Address
- n Security Key
- n NFC PIN Code

These default settings can be restored by means of a factory reset as described in chapter 2.12 below.

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2.12 Factory Reset

PTM 215B can be reset to its default settings by means of a factory reset.

This ensures that PTM 215B can be reset to a known configuration in case the PIN for the NFC access has been lost or NFC access is not possible for other reasons

In order to execute such factory reset, the rocker(s) and the switch housing have to be removed from the PTM 215B module. Then, all four button contacts (A0, A1, B0 and B1) have to be pressed at the same time while the energy bow is pressed down.

The energy bow must then be held at the down position for at least 10 seconds before being released. The button contacts A0, A1, B0 and B1 can be released at any time after pressing the energy bow down, i.e. it is no requirement to hold them as well for at least 10 seconds.

Upon detecting this input, PTM 215B will restore the default settings of the following items:

- n Source Address
- n Security Key and Security Key Write register
Both registers will be restored to the value of the factory-programmed security key
- n NFC PIN Code

After such factory reset, Source Address and Security Key will again match the content of the DMC code on the unit label as described in chapter 3.3.

In addition, PTM 215B will reset the following register:

- n Configuration register (to 0x00)

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

3 Device Integration

PTM 215B is designed for integration into button or rocker based switches. It implements the established PTM 2xx mechanical form factor and can therefore be used with a wide variety of existing designs.

3.1 Mechanical Interface Characteristics

Energy bow travel / operating force	1.8 mm / typ. 10 N At room temperature Only one of the two energy bows may be actuated at the same time!
Restoring force at energy bow	typ. 0.7 N Minimum restoring force of 0.5 N is required for correct operation
Number of operations at 25°C	typ. 100.000 actuations tested according to VDE 0632 / EN 60669
Cover material	Hostaform (POM)
Energy bow material	PBT (50% GV)

3.2 Mechanical Interface Drawings

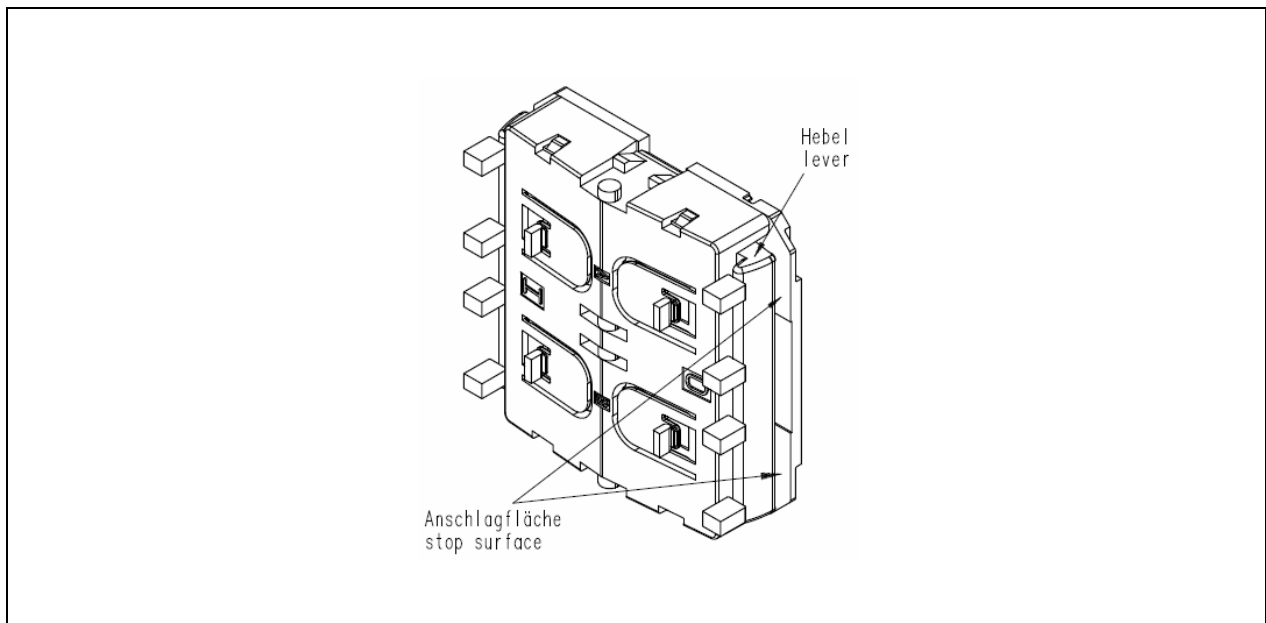
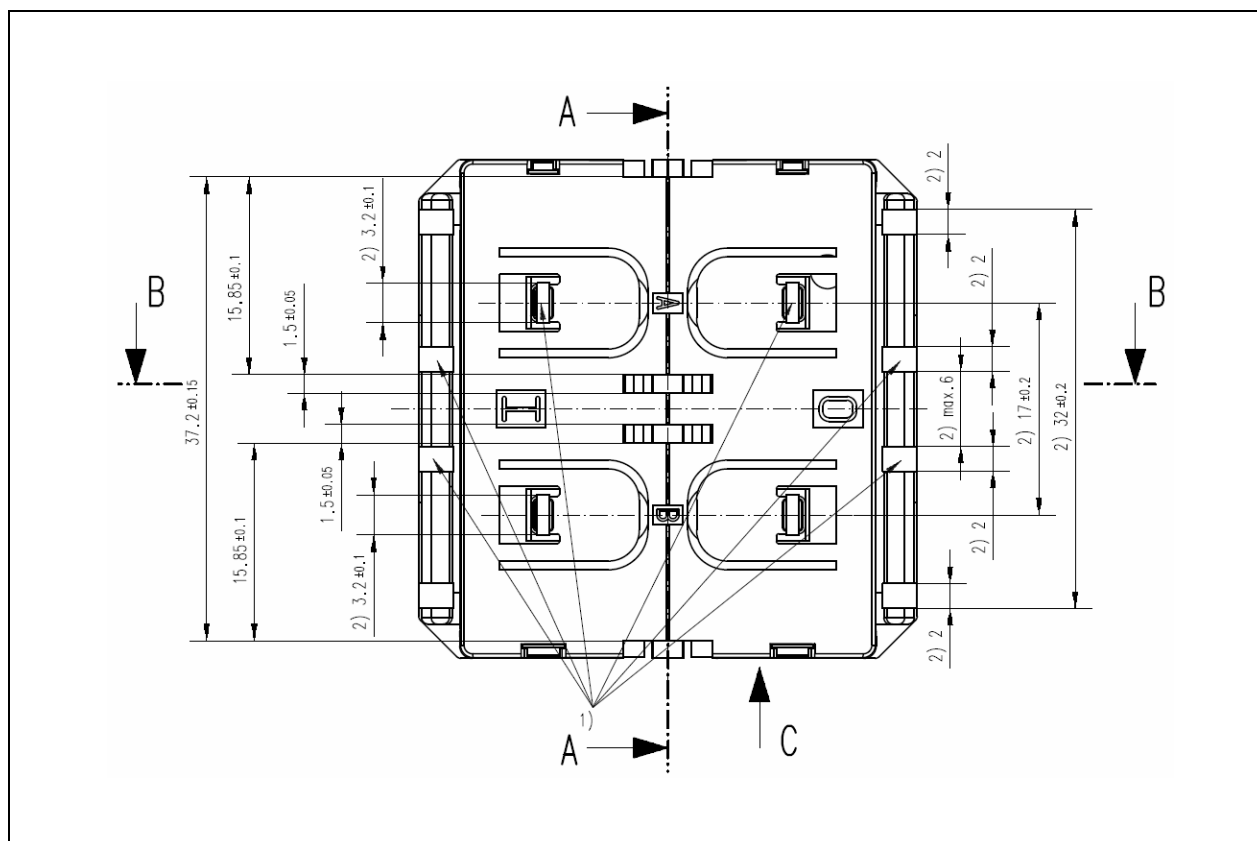


Figure 21 – PTM 215B, tilted view (including rocker catwalks)

PTM 215B – 2.4 GHZ Pusbutton Transmitter Module



1) these catwalks are not needed when using one single rocker only 2) dimensions of rocker part

Figure 22 – PTM 215B, top view (note cut A, B and C marking)

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

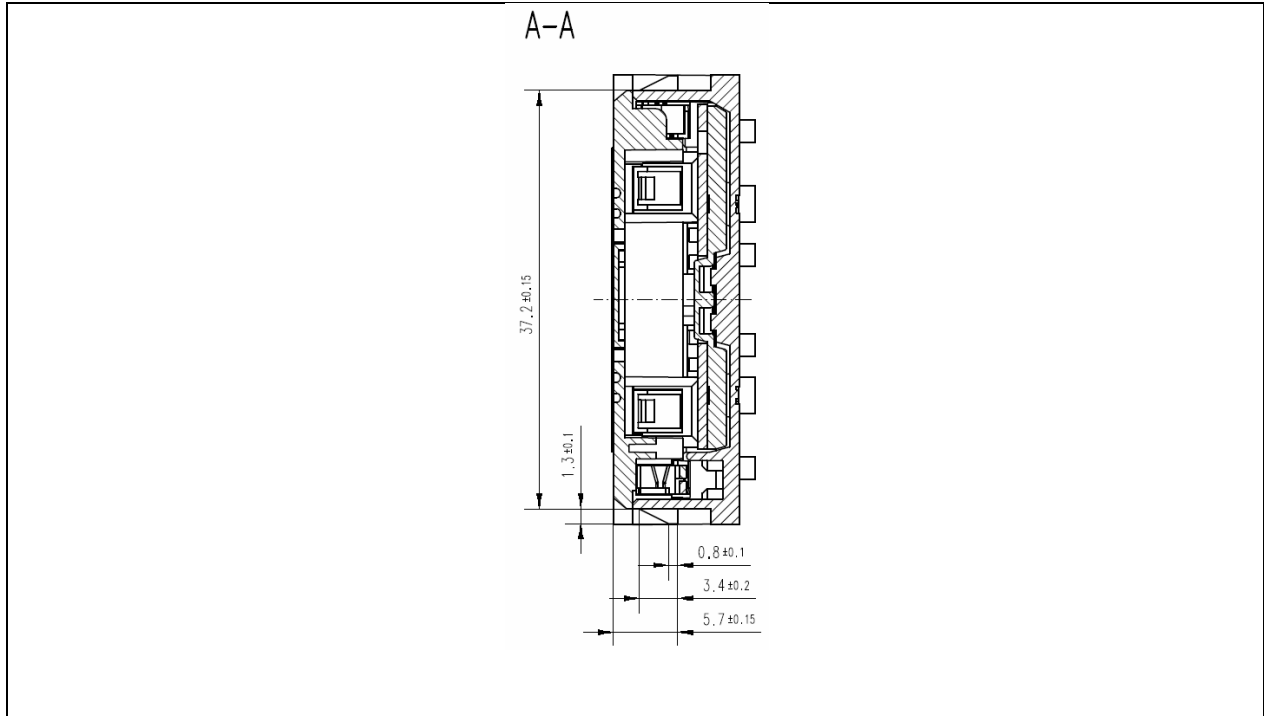
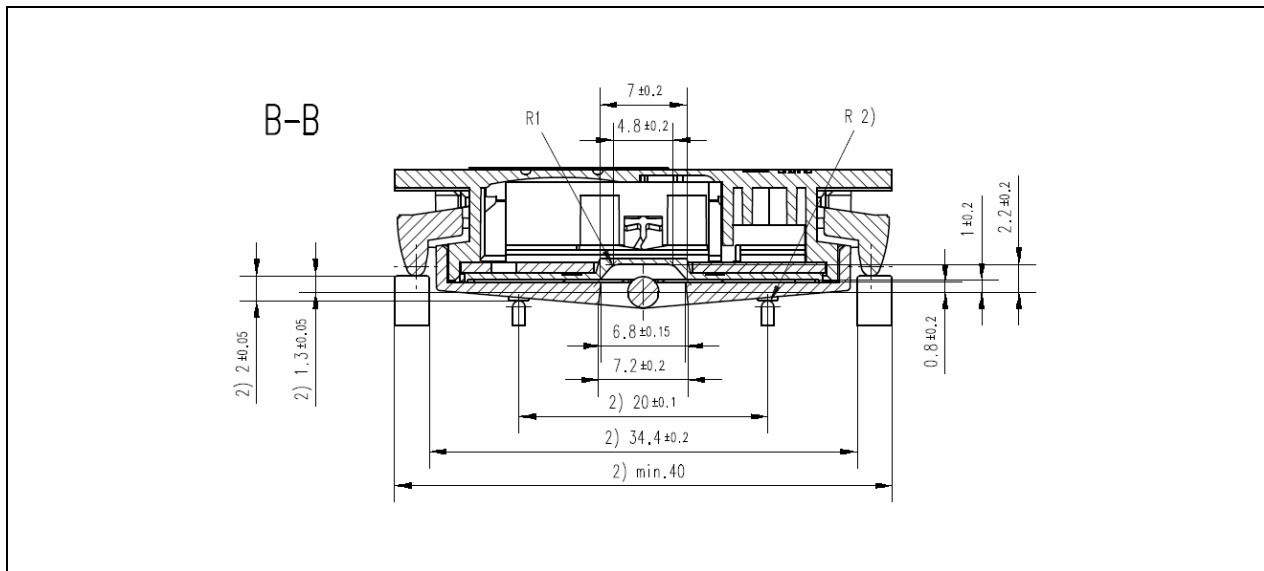


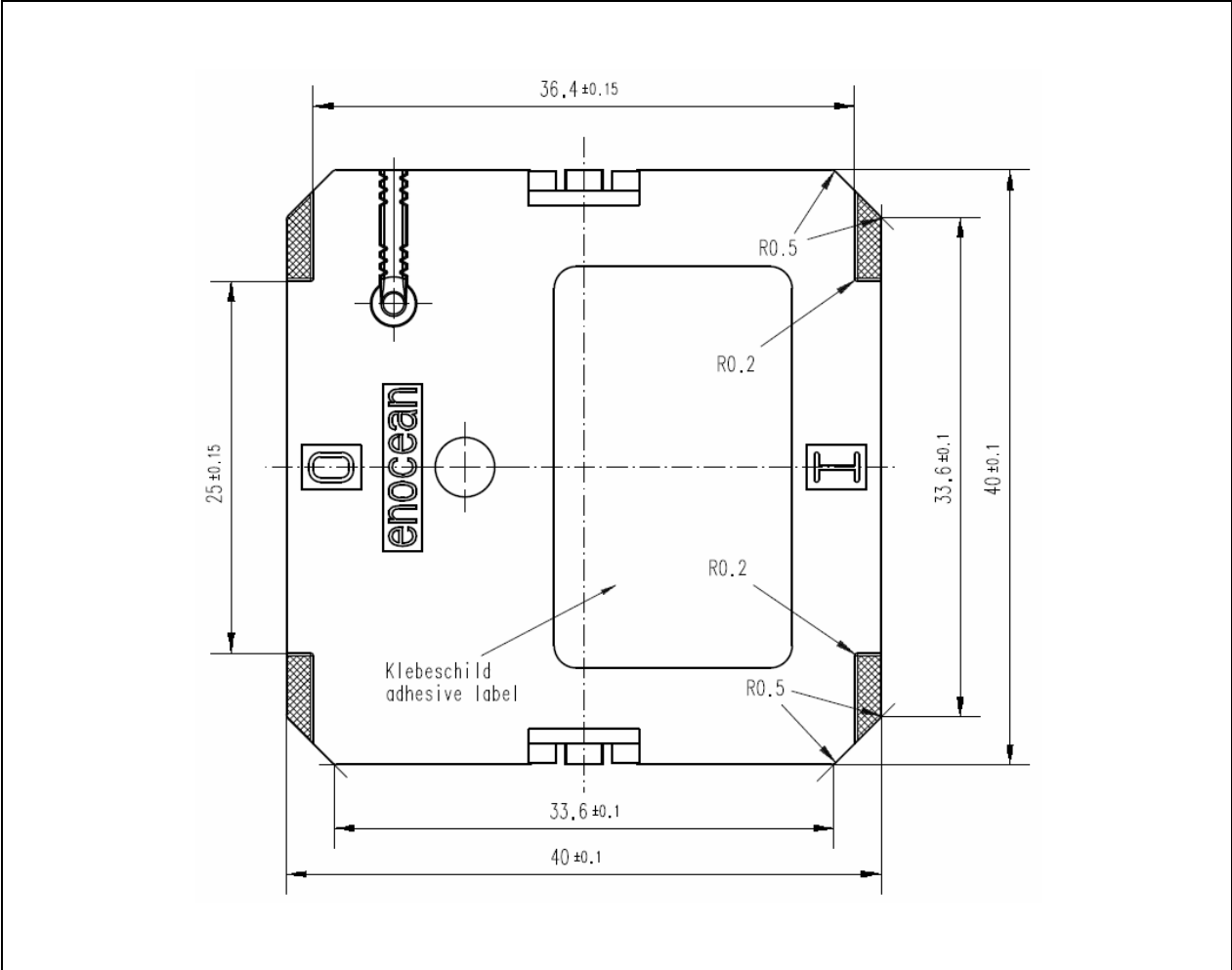
Figure 23 – PTM 215B, cut A



2) dimensions of rocker part

Figure 24 – PTM 215B, cut B and C

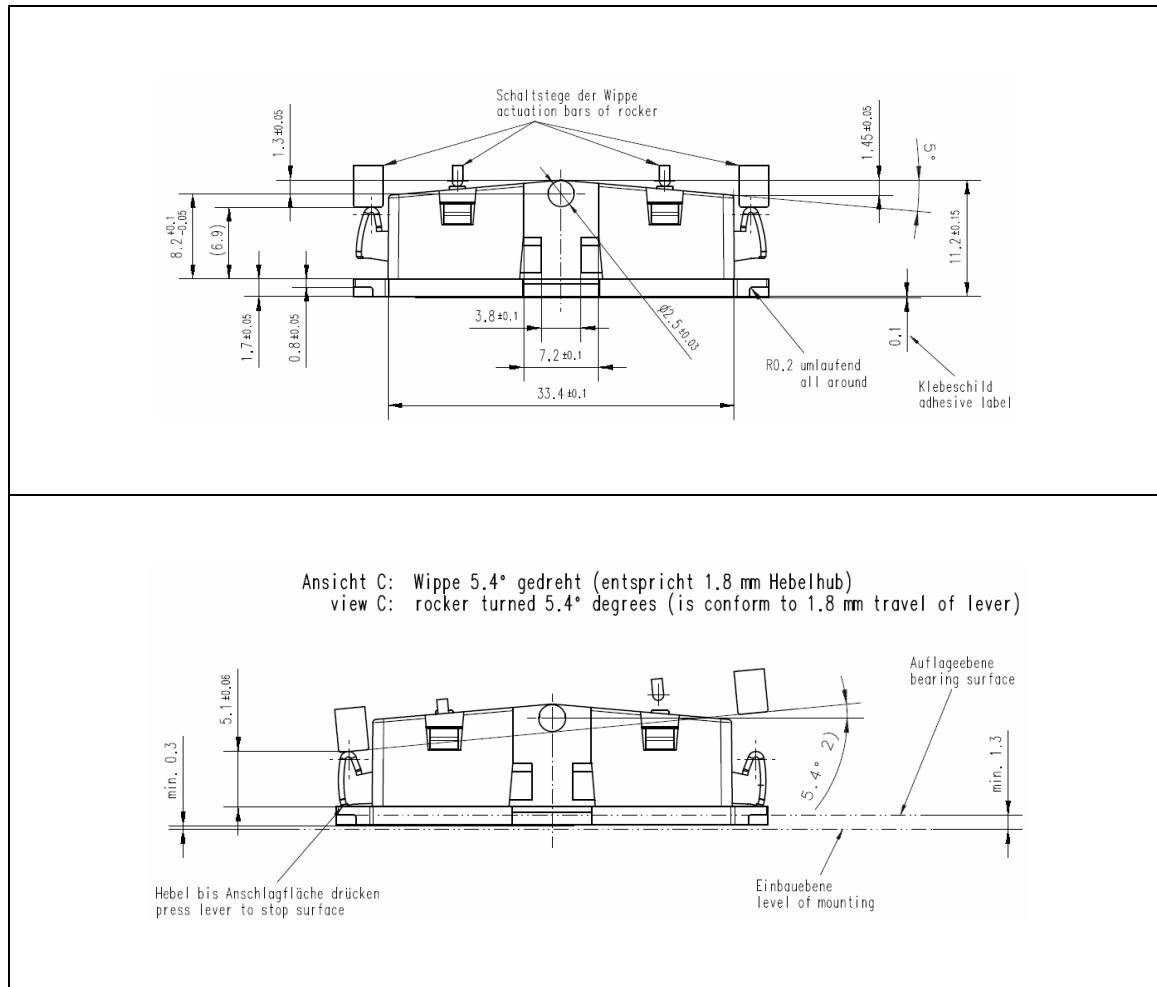
PTM 215B – 2.4 GHZ Pushbutton Transmitter Module



Hatched areas: support planes

Figure 25 – PTM 215B rear view

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module



2) dimensions of rocker part

Figure 26 – PTM 215B, side view

If the rocker is not mounted on the rotation axis of PTM 215B several tolerances have to be considered! The measure from support plane to top of the energy bow is 7.70 mm +/- 0.3 mm!



The movement of the energy bow must not be limited by mounted rockers!



Catwalks of the switch rocker must not exert continuous forces on the button contacts!

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

3.3 Device Label

Each PTM 215ZE module contains a device label as shown in Figure 27 below.

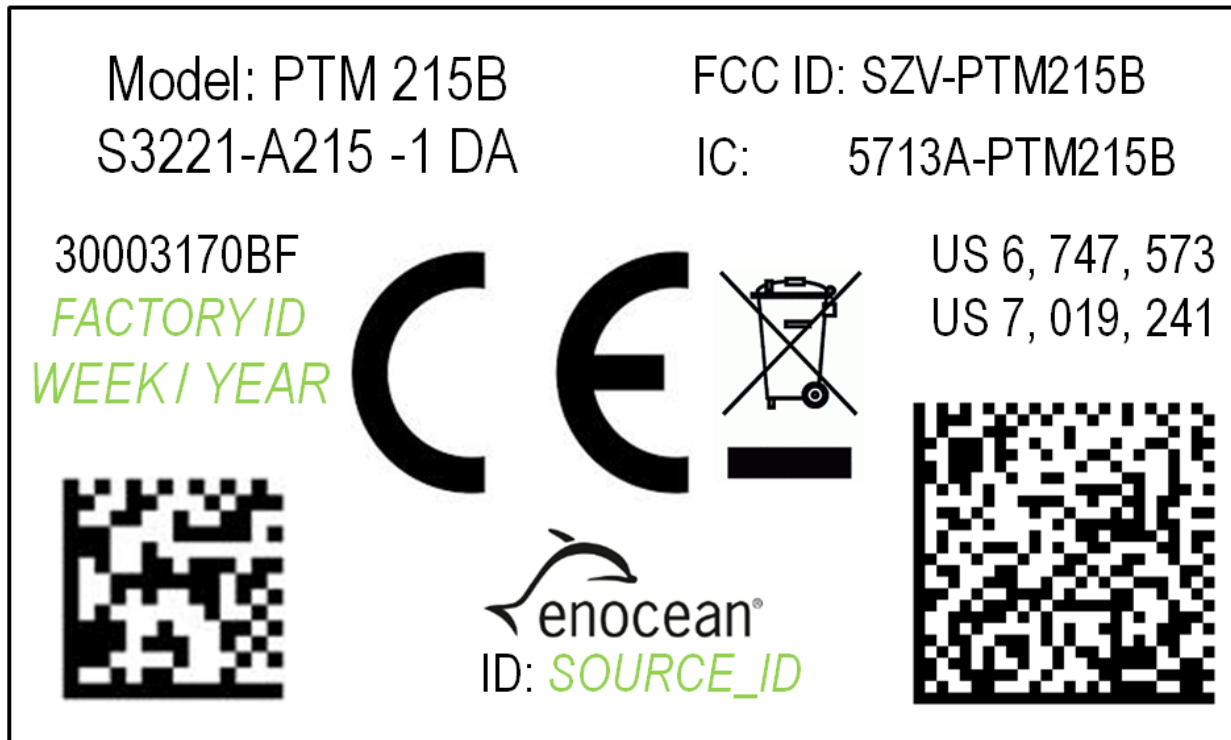


Figure 27 – PTM 215B device label

This device label identifies the following parameters in writing:

- n Manufacturing date (WEEK / YEAR)
- n Source Address (SOURCE_ID)

Note that the device label also contains a DMC code in the lower right corner as described below.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

3.3.1 Device DMC

Each PTM 215B module contains a data matrix code (DMC) on the lower right hand side of the device label which can be used to automatically scan device parameters.

The DMC uses the ECC200 standard to encode up to 52 characters. The content of the DMC uses the following format:

`<PRODUCT_NAME>ID<SOURCE_ID>OOB<DEVICE_KEY>`

This identifies the following parameters:

- n Product name
- n 32 Bit Source Address (different for each device, excludes “E215” Prefix)
- n 128 Bit device-unique random security key (different for each device)

One possible DMC reading could for instance be:

PTM215BID01500100OOB0123456789ABCDEF0123456789ABCDEF

This would identify the following parameters:

- n Product name = PTM 215B
- n Source Address = E21501500100
- n Device-unique random security key = 0123456789ABCDEF0123456789ABCDEF

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

4 APPLICATION INFORMATION

4.1 Transmission range

The main factors that influence the system transmission range are:

- Type and location of the antennas of receiver and transmitter
- Type of terrain and degree of obstruction of the link path
- Sources of interference affecting the receiver
- “Dead spots” caused by signal reflections from nearby conductive objects.

Since the expected transmission range strongly depends on this system conditions, range tests should always be performed to determine the reliably achievable range under the given conditions.

The following figures should be treated as a rough guide only:

- Line-of-sight connections
Typically 10 m range in corridors, up to 30 m in halls
- Plasterboard walls / dry wood
Typically 10 m range, through max. 2 walls
- Ferro concrete walls / ceilings
Typically 5 m range, through max. 1 ceiling (depending on thickness)
- Fire-safety walls, elevator shafts, staircases and similar areas should be considered as shielded

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided.

Other factors restricting transmission range include:

- Switch mounting on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fibre
- Lead glass or glass with metal coating, steel furniture

The distance between the receiver and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

5 REGULATORY INFORMATION

PTM 215B has been certified according to FCC, IC and CE regulations. Changes or modifications not expressly approved by EnOcean could void the user's authority to operate the equipment.

5.1 FCC (United States) Certificate

<To be inserted>

5.1.1 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.

PTM 215B – 2.4 GHZ Pushbutton Transmitter Module

5.2 IC (Industry Canada) Certificate

<To be inserted>

5.2.1 IC (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."