TEST REPORT # EMCC-110010WB, 2016-09-22

This Test Report cancels and replaces Test Report # EMCC-110010W, 2016-09-02

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	Sample #1: none Sample #3: none
Application:	Wireless Remote Control
FCC ID:	SVZ-PTM215B
IC:	5713A-PTM215B
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone :	+49 89 6734689-627
Fax :	+49 89 6734689-56

RELEVANT STANDARD(S) : 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

TEST REPORT PREPARED BY:

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TEST PERSONNEL:

Ludwig Kraft

HEAD OF COMMERCIAL EMC AND RADIO DEPT.:

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1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance with the 47 CFR § 15.249 and RSS-210 Issue 9, Annex B.10 requirements for the certification of licence-exempt Intentional Radiator.

1.2 Limits and Reservations

The test results in this report apply only to the particular equipment under test (EUT) as declared in this report. This test report shall not be reproduced except in full without the written permission of EMCCons DR. RAŠEK GmbH & Co. KG.

1.3 Test Location

Test Laboratory:	EMCCons DR. RAŠEK GmbH & Co. KG
Accreditation No.:	D-PL-12067-01-02
Address of Labs I, II, III and Head Office:	EMCCons DR. RAŠEK GmbH & Co. KG Boelwiese 8 91320 Ebermannstadt GERMANY
Address of Labs IV and V:	EMCCons DR. RAŠEK GmbH & Co. KG Stoernhofer Berg 15 91364 Unterleinleiter GERMANY
Laboratory:	Test Laboratory IV The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to the FCC and accepted in the letter dated December 24, 2013, Registration Number 878769. The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to Innovation, Science and Economic Development Canada (ISED). This 3m/10m alternative test side is approved by Industry Canada under file number 3464C-1.
Phone:	+49 9194 7262-0
Fax:	+49 9194 7262-199
E-Mail:	emc.cons@emcc.de
Web:	www.emcc.de

1.4 Customer

Company Name:	EnOcean GmbH
Street:	Kolpingring 18 a
City:	82041 Oberhaching
Country:	Germany
Name for contact purposes:	Mr Darius Draksas
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56
E-Mail:	darius.draksas@enocean.com

1.5 Manufacturer

Company Name:	EnOcean GmbH
Street:	Kolpingring 18 a
City:	82041 Oberhaching
Country:	Germany

1.6 Dates and Test Location

Date of receipt of EUT:	2016-06-09
Test Date:	CW 23, 26/2016
Test Location:	Lab IV

1.7 Ordering Information

Purchase Order:	8380
Date:	2016-05-25
Vendor Number:	K701624

1.8 Climatic Conditions

Date	Temperature [°C]	Relative Humidity [%]	Air Pressure [hPa]	Lab	Customer attended tests
2016-06-09	25	50	975	IV	yes, Mr Purkovic
2016-06-10	24	46	972	IV	no
2016-06-27	25	47	979	IV	no
2016-06-28	25	50	978	IV	no
2016-06-29	25	57	974	IV	no

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

Trade Name:	PTM 215B
Serial Number:	Sample #1: none Sample: #3: none*
No. of Variants:	None
Application:	Wireless Remote Control
FCC ID:	SVZ-PTM215B
IC:	5713A-PTM215B
Radio Standard:	IEEE 802.15.4
Transmit Frequency Range:	2402-2480 MHz
Modulation:	GFSK
Power Supply:	External power generator (typically ECO 200)
Ports:	none
Antenna:	Internal (see variants)
Remarks:	None

* Sample #1 was powered by an external 3.6 V battery and used for all tests.
Sample #3 was provided for photographs.

2.2 Intended Use

The following information was taken from device's preliminary user manual:

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 maintenancefree. 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 2.4GHz radio telegram according to the 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.

2.3 EUT Peripherals/Simulators

The EUT was powered by a 3.6V battery during all tests because the use of the intended external power generator was not suitable.

2.4 Mode of Operation during Testing and Test Set-up

The equipment under test (EUT) was operated during the tests under the following conditions:

Continuous Transmit:
The EUT was continuously transmitting modulated data with a duty cycle of 100 % and maximum power. This mode of operation was used for all tests.

2.5 Modifications Required for Compliance

None.

2.6 Duty-Cycle Correction

The following calculation is based on customer's information (please refer to annex 5 for detailed information provided by customer):

According to the description delivered by customer, in worst case the EUT generates 6 events within 100 ms (press and release of the switch). One event consists of 1 telegram per channel. One telegram transmits worst case 33 bytes with a duration of 0.320 ms (9.7 µs per byte).
The resulting ON-time per channel is 6 x 0.320 ms = 1.9 ms.

For average correction purposes, a duty cycle correction factor of (1.9 ms / 100 ms) * 100 = 1.9 % was used. Expressed in logarithmic terms, the correction factor DCF is 20 x log (1.9 ms / 100 ms) = -34.4 dB.

3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: EnOcean GmbH
Device: PTM 215B
Serial No: Sample #1: none

Requirement	47 CFR Section	RSS Section	Report Section	Result
Antenna Requirement	15.203	---	4	Passed
Occupied Bandwidth	15.215	RSS-Gen 6.6	5	Passed
Field Strength of Fundamental	15.249	RSS-210 Annex B10	6	Passed
Band Edge Compliance	15.209	RSS-Gen 8.9	7	Passed
Radiated Emissions 9 kHz – 30 MHz	15.209	RSS-Gen 8.9	8	Passed
Radiated Emissions 30 MHz – 1000 MHz	15.209	RSS-Gen 8.9	9	Passed
Radiated Emissions 1 GHz – 25 GHz	15.209	RSS-Gen 8.9	10	Passed

N.A. – not applicable; N.T. – Not tested acc. to applicant's order.

The client has made the determination that EUT Condition, Characterization and Mode of Operation are representative of production units and meet the requirements of the specifications referenced herein.
Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) are factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.
The measurements contained in this report were made in accordance with the procedures described in ANSI C63.10-2013. All requirements were found to be within the limits outlined in this report.
The test results in this report apply only to the particular equipment under test (EUT) as declared in this report.

Test Personnel: Ludwig Kraft
Issuance Date: 2016-09-22

4 ANTENNA REQUIREMENT

Test Requirement: FCC 47 CFR, § 15.203, ISED RSS-Gen
Test Procedure: none

4.1 Regulation

§15.203 Antenna requirement
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

RSS-Gen: 8.3 Transmitter Antenna for Licence-Exempt Radio Apparatus
The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the licence-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.
Licence-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the licence-exempt apparatus.
Testing shall be performed using the highest gain antenna of each combination of licence-exempt transmitter and antenna type, with the transmitter output power set at the maximum level.[9] When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna manufacturer.
User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:
This radio transmitter (identify the device by certification number or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi).

[9] Compliance is required under all operational combinations of transmitter output power and antenna gain.

No applicable antenna requirement specified in **RSS-210**.

4.2 Test Equipment

None.

4.3 Test Procedures

None.

4.4 Test Result

The EUT is equipped with a PCB antenna.

Manufacturer:	EnOcean GmbH
Device:	PTM 215B
Serial No:	none
Test date:	2016-06-30

The EUT meets the requirements of this section.

5 OCCUPIED BANDWIDTH

Test Requirement: FCC 47 CFR, § 15.215
ISED RSS-Gen, 6.6
Test Procedure: ANSI C63.10-2013

5.1 Regulation

§15.215 Additional provisions to the general radiated emission limitations

(a) The regulations in §§15.217 through 15.257 provide alternatives to the general radiated emission limits for intentional radiators operating in specified frequency bands. Unless otherwise stated, there are no restrictions as to the types of operation permitted under these sections.

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Gen, 6.6 Occupied Bandwidth

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3× the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3×RBW.

5.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3236	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2015-07	2016-07
HF-Cable	IW / NPS-2801AN-2756-NPS	4393	2015-10	2016-10
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04

5.3 Test Procedures

ANSI C63.10-2013, 6.9.2 Occupied bandwidth—relative measurement procedure

The occupied bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are −6 dB, −20 dB, and −26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this subclause, the ratio is designated by "−xx dB." The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the "−xx dB" bandwidth; other requirements might specify that the "−xx dB" bandwidth be entirely contained within the authorized or designated frequency band.

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Steps a) through c) might require iteration to adjust within the specified tolerances.

e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.

f) Set detection mode to peak and trace mode to max hold.

g) Determine the reference value: Set the EUT to transmit an unmodulated carrier [comment: not applicable] or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).

h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.

i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).

j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "−xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "−xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

5.4 Test Result

20 dB Bandwidth:

EUT	Operating Frequency [MHz]	Lower Edge [MHz]	Upper Edge [MHz]	Limit Frequency band [MHz]		20 dB Bandwidth [kHz]
#1	2402	2401.519	2402.562	2400	2483.5	1043
#1	2441	2441.529	2442.515.	2400	2483.5	986
#1	2480	2479.500	2480.534	2400	2483.5	1034

99 % Bandwidth:

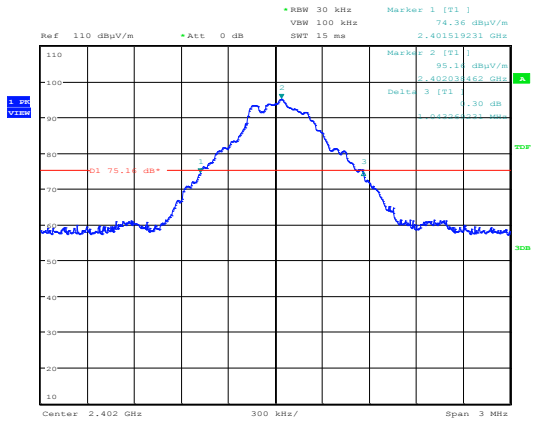
EUT	Operating Frequency [MHz]	Lower Edge [MHz]	Upper Edge [MHz]	Limit Frequency band [MHz]		99% Bandwidth [kHz]
#1	2402	2401.572	2402.500	2400	2483.5	928
#1	2441	2440.562	2441.495	2400	2483.5	933
#1	2480	2479.553	2480.500	2400	2483.5	947

Manufacturer: EnOcean GmbH
Device: PTM 215B
Serial No: none
Test date: 2016-06-09

The EUT meets the requirements of this section.

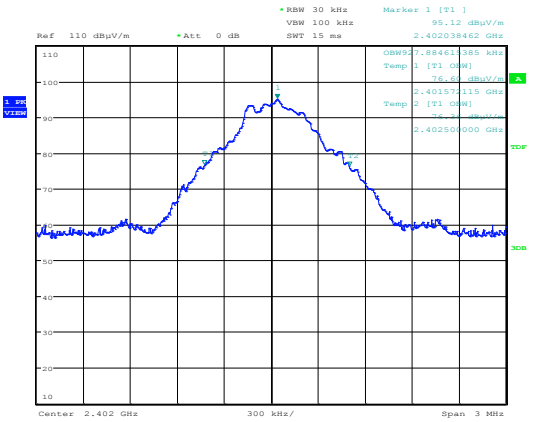
5.5 Detailed Measurement Data

20dB Bandwidth
EUT: #1
EUT Frequency: 2402 MHz



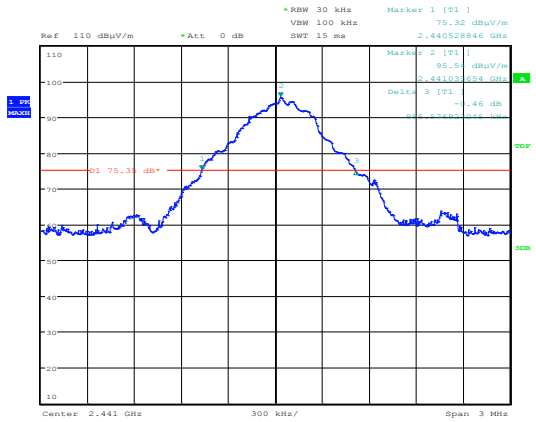
EUT: Sample 1; Carrier: 2402 MHz; Mode: Mod
Date: 9.JUN.2016 16:50:19

99% Bandwidth
EUT: #1
EUT Frequency: 2402 MHz



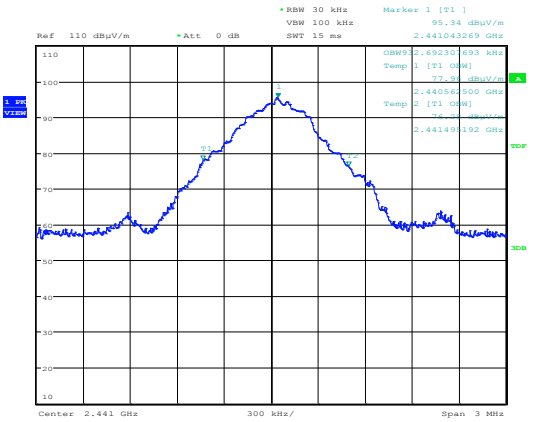
EUT: Sample 1; Carrier: 2402 MHz; Mode: Mod
Date: 9.JUN.2016 16:44:32

20dB Bandwidth
EUT: #1
EUT Frequency: 2441 MHz



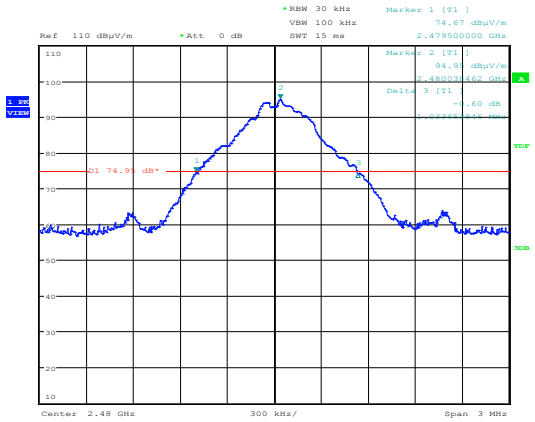
EUT: Sample 1; Carrier: 2441 MHz; Mode: Mod
Date: 9.JUN.2016 17:40:41

99% Bandwidth
EUT: #1
EUT Frequency: 2441 MHz



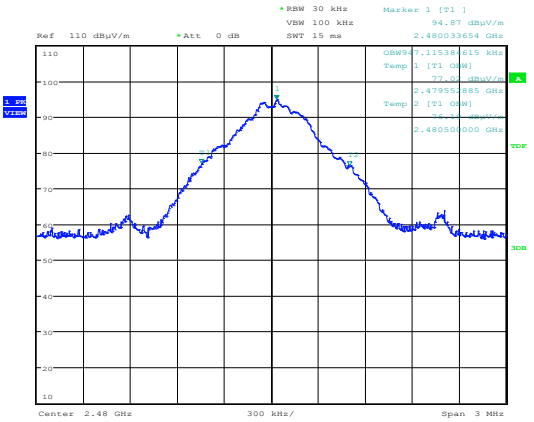
EUT: Sample 1; Carrier: 2441 MHz; Mode: Mod
Date: 9.JUN.2016 17:37:59

20dB Bandwidth
EUT: #1
EUT Frequency: 2480 MHz



EUT: Sample 1; Carrier: 2480 MHz; Mode: Mod
Date: 9.JUN.2016 18:20:26

99% Bandwidth
EUT: #1
EUT Frequency: 2480 MHz



EUT: Sample 1; Carrier: 2480 MHz; Mode: Mod
Date: 9.JUN.2016 18:17:01

6 FIELD STRENGTH OF FUNDAMENTAL

Test Requirement: FCC 47 CFR, § 15.249
ISED RSS-210, Annex B.10
Test Procedure: ANSI C63.10-2013

6.1 Regulation

§15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz.
(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental (millivolts/meter)	Field Strength of Harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

(c) Field strength limits are specified at a distance of 3 meters.
(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter at 3 meters along the antenna azimuth.

RSS-210, Annex B.10 Bands 902–928, 2400–2483.5 and 5725–5875 MHz
Devices shall comply with the following requirements:

(a) The field strength of fundamental and harmonic emissions, measured at 3 m, shall not exceed 50 mV/m and 0.5 mV/m respectively.

The field strength limits shall be measured using an average detector, except for the fundamental emission in the frequency band 902-928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

(b) Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

The provisions of RSS-Gen regarding pulsed operation do not apply to CISPR measurement for the band 902-928 MHz.

6.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3236	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2015-07	2016-07
HF-Cable	IW / NPS-2801AN-2756-NPS	4393	2015-10	2016-10
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04

6.3 Test Procedures

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10-2013, 6.6.4.3 Final radiated emissions measurements

The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the

measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna a tan angle toward the source of the emission or by testing the EUT as described in 6.6.3.3. If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.

As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.

Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

ANSI C63.10-2013, 4.1.4.2.4 Average value of pulsed emissions

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission and pulsed operation is employed, the average measurement shall be determined from the peak field strength after correcting for the worst-case duty cycle as described in 7.5. The exact method of calculating the average field strength shall be included in the test report.

ANSI C63.10-2013, 7.5 Procedure for determining the average value of pulsed emissions

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval.
The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in Equation (10):

$$\delta(dB) = 20\log(\Delta) \qquad (10)$$

where

δ is the duty cycle correction factor (dB)

Δ is the duty cycle (dimensionless)

6.4 Calculation of Field Strength Limits

E.g. fundamental emissions field strength limits for the band 2400-2483.5 MHz:

50 mV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 50 mV/m corresponds with 94 dBµV/m.

6.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m

RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB

Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]
Level in µV/m = Common Antilogarithm (32/20) = 39.8

All emission measurements described in this chapter performed using the EMI receiver's transducer factor setting capability, i.e. the peak field strength value at the test distance was measured directly without the necessity of additional correction factors.

For average measurements, the measured peak field strength is corrected additionally by a Duty Cycle correction factor DCF. Please refer to chapter 2.6 for details.

$FS_{AV} = FS + DCF$
where
FS_{AV} = Average Field Strength in dBµV/m
FS = Peak Field Strength in dBµV/m
DCF = Correction Factor in dB

Assuming a peak field strength of 96.4 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -34.4 dB corresponds with 62.0 dBµV/m.

6.6 Test Result

Field Strength of Fundamental - Average Results						
EUT	**EUT Frequency [MHz]**	**PK-Reading [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**
#1	2402	96.4	-34.4	62.0	94	32.0
#1	2441	96.6	-34.4	62.2	94	31.8
#1	2480	96.3	-34.4	61.9	94	32.1

Remark: Duty Cycle Correction Factor DCF added to peak reading to obtain average results.

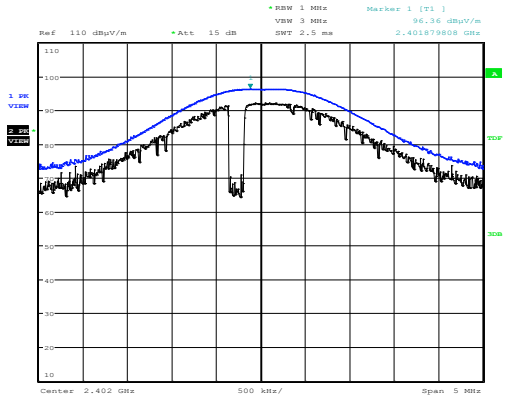
Field Strength of Fundamental - Peak Results						
EUT	**Channel**	**PK-Reading [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**
#1	2402	96.4	n.a.	96.4	114	17.6
#1	2441	96.6	n.a.	96.6	114	17.4
#1	2480	96.3	n.a.	96.3	114	17.7

Manufacturer: EnOcean GmbH
Device: PTM 215B
Serial No: none
Test date: 2016-06-09

The EUT meets the requirements of this section.

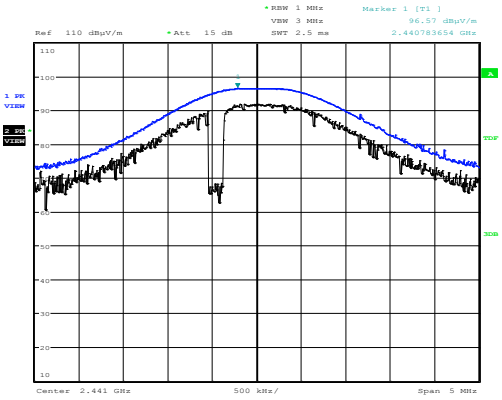
6.7 Detailed Measurement Data

Fundamental Field Strength
EUT: #1
Frequency: 2402 MHz



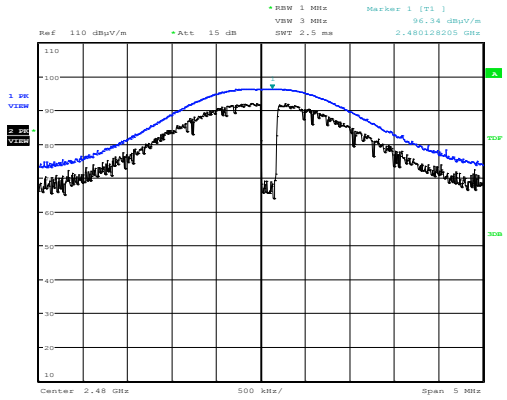
EUT: Sample 1; Carrier: 2402 MHz; Mode: Mod; EUT 30deg; Pol
: H
Date: 9.JUN.2016 16:00:59

Fundamental Field Strength
EUT: #1
Frequency: 2441 MHz



EUT: Sample 1; Carrier: 2441 MHz; Mode: Mod; EUT 30deg; Pol
: H
Date: 9.JUN.2016 17:07:35

Fundamental Field Strength
EUT: #1
Frequency: 2480 MHz



EUT: Sample 1; Carrier: 2480 MHz; Mode: Mod; EUT 0deg; Pol:
H
Date: 9.JUN.2016 17:49:49

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7 BAND EDGE COMPLIANCE

Test Requirement: FCC 47 CFR, § 15.249
ISED RSS-210, Annex B.10
Test Procedure: ANSI C63.10-2013

7.1 Regulation

§15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24.0-24.25 GHz.
(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental (millivolts/meter)	Field Strength of Harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

(c) Field strength limits are specified at a distance of 3 meters.
(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.
(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter at 3 meters along the antenna azimuth.

RSS-210, Annex B.10 Bands 902–928, 2400–2483.5 and 5725–5875 MHz
Devices shall comply with the following requirements:

(a) The field strength of fundamental and harmonic emissions, measured at 3 m, shall not exceed 50 mV/m and 0.5 mV/m respectively.

The field strength limits shall be measured using an average detector, except for the fundamental emission in the frequency band 902-928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

(b) Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

The provisions of RSS-Gen regarding pulsed operation do not apply to CISPR measurement for the band 902-928 MHz.

7.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3236	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2015-07	2016-07
HF-Cable	IW / NPS-2801AN-2756-NPS	4393	2015-10	2016-10
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04

7.3 Test Procedures

ANSI C63.10-2013, 6.10.4 Authorized-band band-edge measurements (relative method)
These procedures are applicable for determining compliance at authorized-band band-edges where the requirements are expressed as a value relative to the in-band signal level. Procedures for determining compliance with field strength limits at or close to the band-edges are given in 6.10.6 (see also Table A.2).

[..]When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3.

For other than frequency-hopping devices, this test sequence shall be performed once. For devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned OFF and then repeated with the hopping function turned ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON. Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods. Particular attention to the hopping sequence requirements specified below is needed in the case of adaptive frequency-hopping devices:

a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).

b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).

c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.

d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.

e) Perform the test as follows:

1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.

2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

3) Attenuation: Auto (at least 10 dB preferred).

4) Sweep time: Coupled.

5) Resolution bandwidth: 100 kHz.

6) Video bandwidth: 300 kHz.

7) Detector: Peak.

8) Trace: Max hold.

f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.

g) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

h) Repeat step c) through step e) for every applicable modulation.

i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).

j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Note 56: See specification for spread spectrum device operation under 47 CFR 15.247 and RSS-210 Annex 8; otherwise, per applicable regulation.

ANSI C63.10-2013, 6.10.5 Restricted-band band-edge measurements

The following test methodology shall be used for the restricted-band band-edge measurements:
a) For frequency-hopping systems, the hopping shall be turned OFF during this test.
b) Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
c) Set the unlicensed wireless device to the lowest frequency channel.
d) Set the unlicensed wireless device to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.
e) Perform the test as follows:
1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
2) Reference level offset: Corrected for gains and losses of test antenna factor, preamp gain and cable loss, so as to indicate field strength, in units of dBµV/m at 3 m, directly on the instrument display. Alternatively, the reference level offset may be set to zero and calculations shall be provided showing the conversion of raw measured data to the field strength in dBµV/m at 3 m.
3) Reference level: As required to keep the signal from exceeding the maximum spectrum analyzer input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
4) Attenuation: Auto (at least 10 dB preferred).
5) Sweep time: Coupled.
6) Resolution bandwidth:

iv) Above 1 GHz: 1 MHz
7) Video bandwidth:
i) VBW for Peak, Quasi-peak, or Average Detector Function: 3 × RBW
ii) VBW for alternative average measurements using peak detector function; refer to 4.1.4.2.3
8) Detector (unless specified otherwise):
ii) Peak and average above 1 GHz
9) Trace: Max hold for final measurement; a combination of two traces, clear-write and max hold, is recommended for maximizing the emission.
f) Using the applicable procedure(s) of 6.4, 6.5, or 6.6, orient the EUT and measurement antenna positions to produce the highest emission level.
g) Set the marker on the emission at the restricted band edge, or on the highest modulation product within the restricted band, if this level is greater than that at the band edge.
h) Repeat step d) through step g) for every applicable modulation.
i) Repeat step d) through step h) for the highest gain of each type of antenna to be used with the EUT.
j) Set the EUT to the highest frequency channel and repeat step d) through step i).
k) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the axes and the scale units per division shall be clearly labelled. Tabular data may be reported in addition to the plot(s).

7.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits acc. to §15.209 for frequencies above 960 MHz:

500 µV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 500 µV/m corresponds with 54 dBµV/m.

7.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]
Level in µV/m = Common Antilogarithm (32/20) = 39.8

All emission measurements described in this chapter performed using the EMI receiver's transducer factor setting capability, i.e. the peak field strength value at the test distance was measured directly without the necessity of additional correction factors.

For average measurements, the measured peak field strength is corrected additionally by a Duty Cycle correction factor DCF. Please refer to chapter 2.6 for details.

$FS_{AV} = FS + DCF$
where
FS_{AV} = Average Field Strength in dBµV/m
FS = Peak Field Strength in dBµV/m
DCF = Correction Factor in dB

Assuming a peak field strength of 68.4 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -34.4 dB corresponds with 34.0 dBµV/m.

7.6 Test Result

Bandedge Emissions – Average Results							
EUT	**EUT Frequency [MHz]**	**Frequency [MHz]**	**PK-Reading [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**
#1	2402	2400.0	68.4	-34.4	34.0	54	20
#1	2402	2377.2	59.9	-34.4	25.5	54	29.5
#1	2482	2483.5	55.8	-34.4	21.4	54	32.6
#1	2482	2497.6	63.3	-34.4	28.9	54	25.1

Remark: Duty Cycle Correction Factor DCF added to peak reading to obtain average results.

Bandedge Emissions – Peak Results							
EUT	**EUT Frequency [MHz]**	**Frequency [MHz]**	**PK-Reading [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**
#1	2402	2400.0	68.4	n.a.	68.4	74	5.6
#1	2402	2377.2	59.9	n.a.	59.9	74	14.1
#1	2482	2483.5	55.8	n.a.	55.8	74	18.2
#1	2482	2497.6	63.3	n.a.	63.3	74	10.7

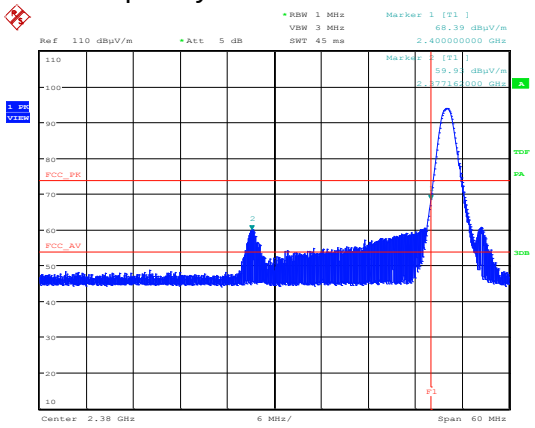
For further details, refer to measurement plots on the following pages.

Manufacturer: EnOcean GmbH
Device: PTM 215B
Serial No: none
Test date: 2016-06-09

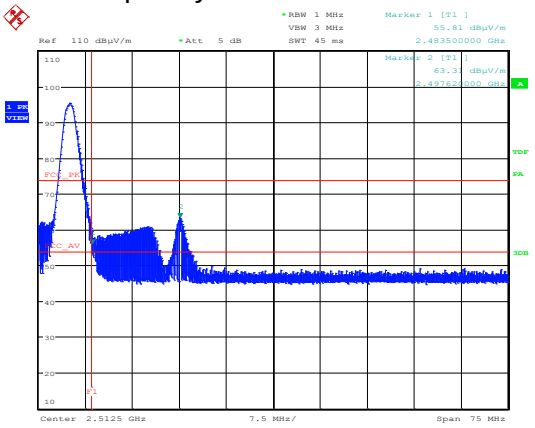
The EUT meets the requirements of this section.

7.7 Detailed Measurement Data

Band Edge Compliance – Lower Edge
EUT: #1
EUT Frequency: 2402 MHz



Band Edge Compliance – Upper Edge
EUT: #1
EUT Frequency: 2480 MHz



8 RADIATED EMISSIONS 9 kHz – 30 MHz

Test requirement: FCC 47 CFR, §§ 15.249, 15.209
ISED RSS-210, Annex B.10, RSS-Gen 8.9
Test procedure: ANSI C63.10-2013

8.1 Regulation

§ 15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24.0-24.25 GHz
(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

§15.209 Radiated emission limits; general requirements
(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency	Field Strength		Measurement Distance
[MHz]	[µV/m]	[dB(µV/m)]	[m]
0.009–0.490	2400/F[kHz]	67.6 – 20 logF[kHz]	300
0.490–1.705	24000/F[kHz]	87.6 – 20 logF[kHz]	30
1.705–30.0	30	29.5	30

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

(b) In the emission table above, the tighter limit applies at the band edges.
(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
(e) The provisions in §§ 15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

RSS-210, Annex B.10 Bands 902–928, 2400–2483.5 and 5725–5875 MHz

Devices shall comply with the following requirements:

(a) The field strength of fundamental and harmonic emissions, measured at 3 m, shall not exceed 50 mV/m and 0.5 mV/m respectively.

The field strength limits shall be measured using an average detector, except for the fundamental emission in the frequency band 902-928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

(b) Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

The provisions of RSS-Gen regarding pulsed operation do not apply to CISPR measurement for the band 902-928 MHz.

RSS-Gen, 8.9 Transmitter Emission Limits for Licence-Exempt Radio Apparatus

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in Table 4 and Table 5 below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz

Frequency (MHz)	Field Strength (µv/m at 3 metres
30-88	100
88-216	150
216-960	200
Above 960	500

Footnote

Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

Table 5 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Below 30 MHz			
Frequency	Electric Field Strength (µV/m)	Magnetic Field Strength (H-Field) (µA/m)	Measurement Distance (metres)
9-490 kHz	2,400/F (F in kHz)	2,400/377F (F in kHz)	300
490-1,705 kHz	24,000/F (F in kHz)	24,000/377F (F in kHz)	30
1,705-30 MHz	30	N/A	30

Note: The emission limits for the bands 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector. Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the relevant RSS.

8.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Loop Antenna	R&S / HFH 2-Z2	374	2014-06	2016-06
EMI Test Receiver	R&S / ESU8	3846	2015-08	2016-08
EMI Test Software	R&S / EMC32 V9.25.00	5392	n.a.	n.a.
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04

8.3 Test Procedures

ANSI C63.10-2013, 5.3.2 Test distance for frequencies below 30 MHz

Radiated emissions limits are usually defined at a specific distance from the EUT. Where possible, measurements shall be made at the distance specified in the limits. This might not be possible in all cases, however, due to the physical limitations of the test facility, physical access problems at the required distance (especially for measurements that must be made in situ or on-site), or levels of ambient noise or other radiated signals present at the time and location where measurements are made. See 6.4.3 for more information about antenna selection, location, and test distance. If measurements cannot practically be made at the EUT limit distance, then they may be made at a different distance (usually closer) and extrapolated to the limit distance using one of the procedures described in 6.4.4, 6.4.5, or 7.7, depending on the EUT source and size.31 The test report shall specify the extrapolation method used to determine compliance of the EUT.

ANSI C63.10-2013, 6.4.6 Exploratory radiated emission tests

The tests shall be performed in the frequency range specified in 5.5 and 5.6, using the procedures in Clause 5, applying the appropriate modulating signal to the EUT, to determine cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit.

Exploratory measurements below 30 MHz are useful in determining the maximum level of emissions while manipulating and rotating the EUT; however, exploratory and final measurements may be made concurrently, provided care is taken to determine the maximum level of emissions for all configurations and orientations.

The test arrangement, measuring antenna guidelines and operational configurations in 6.3.1 and 6.3.2, shall be followed. The measurement antenna shall be positioned with its plane perpendicular to the ground at the specified distance. When perpendicular to the ground plane, the lowest height

of the magnetic antenna shall be 1 m above the ground and shall be positioned at the specified distance from the EUT.50 When the EUT contains a loop antenna that can only be placed in a vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, and then orthogonal to the axis. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. When the EUT contains a loop antenna that can be placed in a horizontal or vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, orthogonal to the axis, and then with the measurement antenna horizontal. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. The report shall list the six emissions with the smallest margin relative to the limit, for each of the three antenna orientations (parallel, perpendicular, and ground-parallel) unless the margin is greater than 20 dB, then the following statement shall be made: “all emissions were greater than 20 dB below the limit.”

ANSI C63.10-2013, 6.4.7 Final radiated emission tests
Using the orientation and equipment arrangement of the EUT determined in 6.4.6, and applying the appropriate modulating signal to the EUT, perform final radiated emission measurements on the fundamental and highest spurious emissions.
Unless otherwise specified by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

Radiated Emissions Test Characteristics	
Frequency range	9 kHz - 30 MHz
Test distance	3 m*
Test instrumentation resolution bandwidth	200 Hz (9 kHz - 150 kHz)
	10 kHz (150 kHz - 30 MHz)
Receive antenna height	1 m
Receive antenna polarization	Vertical, two orientations

* According to Section 15.31 (f)(2): At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). The 40 dB/decade factor was used.

8.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for the restricted band 1.705–30.0 MHz:

30 µV/m at 30 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 30 µV/m corresponds with 29.5 dBµV/m.

8.5 Field Strength Calculation

All emission measurements described in this chapter performed using the EMI test program transducer factor setting capability, i.e. the field strength value at the test distance was measured directly without the necessity of additional correction factors.
For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f)(2) the field strength result is calculated by adding additionally an extrapolation factor of 40 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = FST + DF
where
FS = Field Strength in dBµV/m
FST = Field Strength at test distance in dBµV/m
DF = Distance Extrapolation Factor in dB,
where DF = 40 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified distance

Assume the tests performed at a reduced Test Distance of 3 m instead of the Specified Distance of 30 m giving a Distance Extrapolation Factor of DF = 40 log (3 m/30 m) = -40 dB.
Assuming a measured field strength level of 58.8 dBµV/m is obtained. The Distance Factor of -40 dB is added, giving a field strength of 18.8 dBµV/m. The 18.8 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 58.8 - 40 = 18.8 [dBµV/m]
Level in µV/m = Common Antilogarithm (18.8/20) = 8.7

8.6 Final Test Results

Frequency [MHz]	Meas. [PK / QPK]	Reading [dB(µV)]	Ant. factor [dB(1/m)]	Result [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB]
		All prescan peak measurement values are more than 20 dB below the specified limits. Therefore, no final measurements performed.				

Note: EUT variant #1 tested, only.

Manufacturer:	EnOcean GmbH
Device:	PTM 215B
Serial No:	none
Test date:	2016-06-29

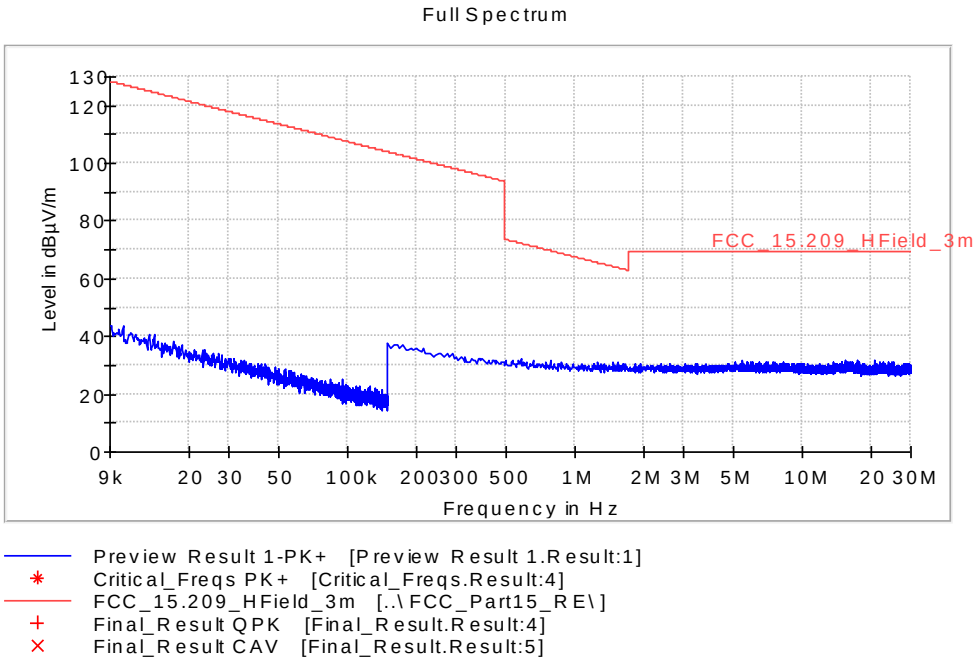
All measured emissions in the range 9 kHz to 30 MHz are below the specified limits.

The EUT meets the requirements of this section.

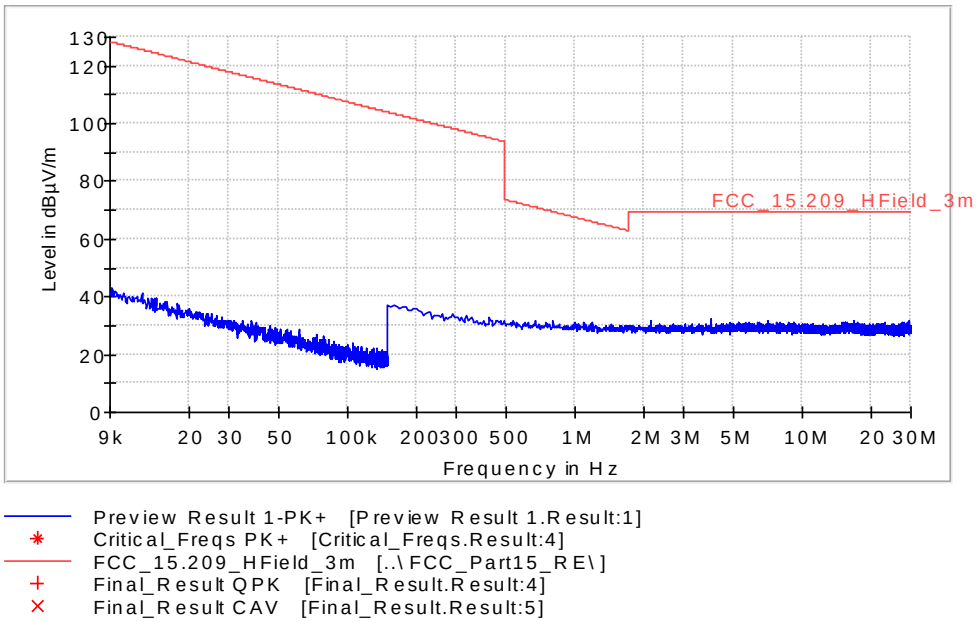
8.7 Detailed Measurement Data

Measurement was performed at 3 m distance. Plots show field strength reading at 3 m distance. In order to compare the 3 m reading with the specified field strength limits a distance correction as described in 8.5 (40 dB/decade) was applied to the limit (represented by the limit line „FCC_15.209_HField_3m“).

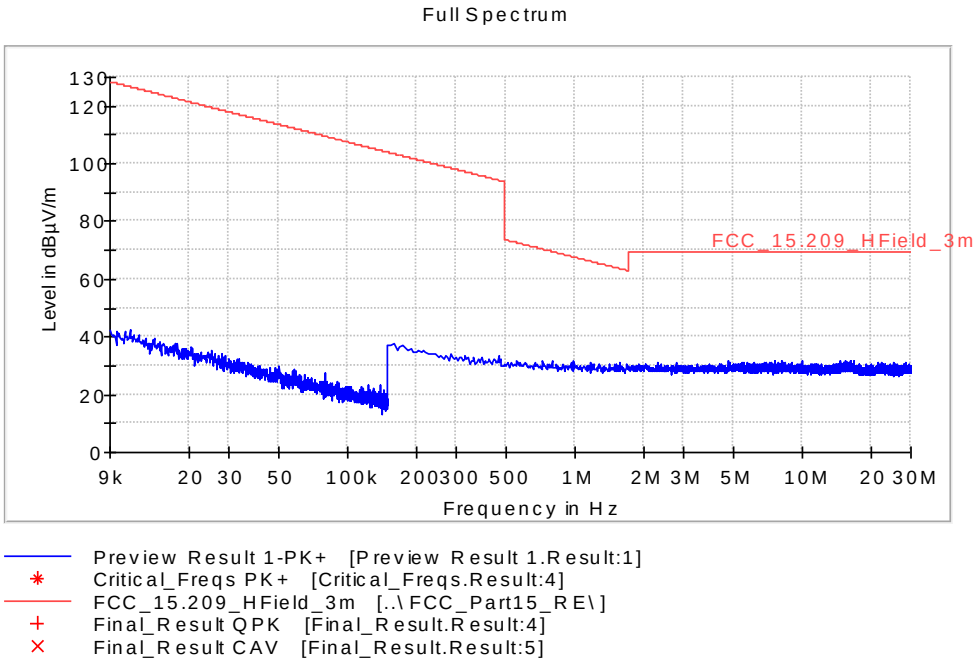
Radiated Emissions 9kHz – 30 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency: 2402 MHz



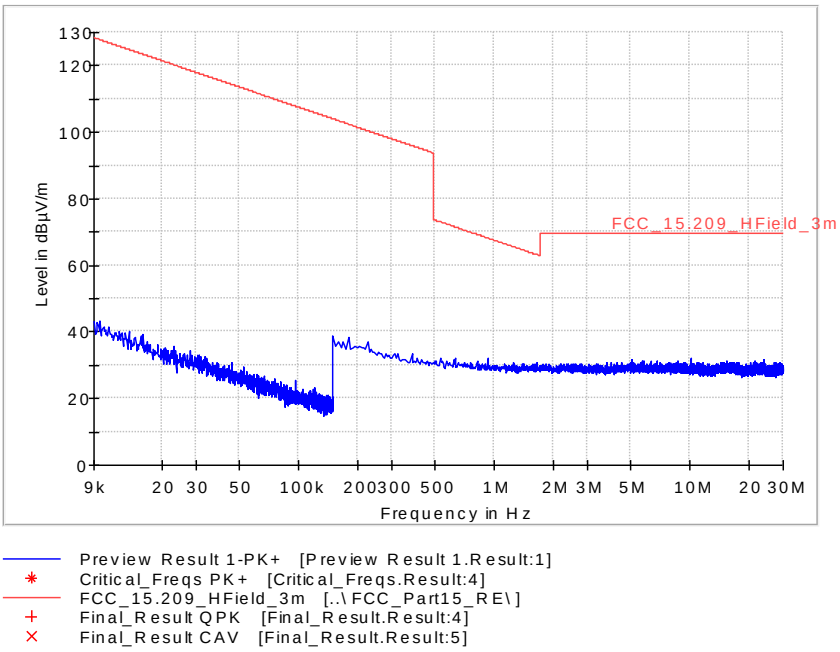
Radiated Emissions 9kHz – 30 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency: 2441 MHz



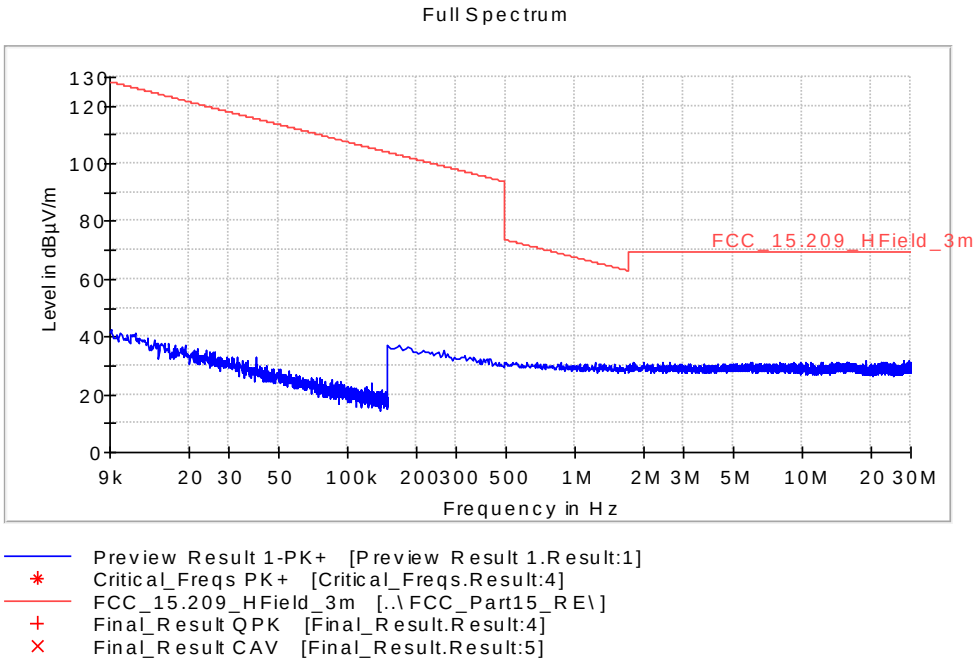
Radiated Emissions 9kHz – 30 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency 2480MHz



Radiated Emissions 9kHz – 30 MHz, EUT Pos.: 2
EUT: #1
EUT Frequency: 2402 MHz



Radiated Emissions 9kHz – 30 MHz, EUT Pos.: 3
EUT: #1
EUT Frequency: 2402 MHz



9 RADIATED EMISSIONS 30 MHz – 1000 MHz

Test requirement: FCC 47 CFR, §§ 15.249, 15.209
ISED RSS-210, Annex B.10, RSS-Gen 8.9
Test procedure: ANSI C63.10-2013

9.1 Regulation

§ 15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24.0-24.25 GHz
(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

§15.209 Radiated emission limits; general requirements
(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency	Field Strength		Measurement Distance
[MHz]	[µV/m]	[dB(µV/m)]	[m]
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46.0	3
Above 960	500	54	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

(b) In the emission table above, the tighter limit applies at the band edges.
(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
(e) The provisions in §§ 15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

RSS-210, Annex B.10 Bands 902–928, 2400–2483.5 and 5725–5875 MHz

Devices shall comply with the following requirements:

(a) The field strength of fundamental and harmonic emissions, measured at 3 m, shall not exceed 50 mV/m and 0.5 mV/m respectively.

The field strength limits shall be measured using an average detector, except for the fundamental emission in the frequency band 902-928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

(b) Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

The provisions of RSS-Gen regarding pulsed operation do not apply to CISPR measurement for the band 902-928 MHz.

RSS-Gen, 8.9 Transmitter Emission Limits for Licence-Exempt Radio Apparatus

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in Table 4 and Table 5 below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz

Frequency (MHz)	Field strength (µv/m at 3 metres
30-88	100
88-216	150
216-960	200
Above 960	500

Footnote

Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

9.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
N-Cable N/50	R&S / HFU2-Z4	55	2015-07	2016-07
VHF Test Dipole RX	Schwarzbeck / VHA 9103	899	2015-05	2017-05
Logper. Antenna	Schwarzbeck VUSLP 9111B	3203	2015-05	2017-05
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3236	2015-06	2017-06
EMI Test Receiver	R&S / ESU8	3846	2015-08	2016-08
EMI Test Software	R&S / EMC32 V9.25.00	5392	n.a.	n.a.
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04

9.3 Test Procedures

ANSI C63.10-2013, 6.3.1 Test arrangement

Figure 4 shows the typical arrangement of an unlicensed wireless device on a tabletop on a test site. Tabletop devices shall be placed on a nonconducting platform with nominal top surface dimensions 1 m by 1.5 m. For emissions testing at or below 1 GHz, the table height shall be 80 cm above the reference ground plane. For emission measurements above 1 GHz, the table height shall be 1.5 m (see 6.6.3.1). A method for evaluating the effects of the table on EUT radiated emissions is given in 5.5 of CISPR 16-1-4:2010 for frequencies up to 18 GHz. The EUT shall be set up in its typical configuration and arrangement and operated in its various modes as described in 5.10. An antenna shall be connected to the EUT in accordance with 5.8 and 5.10.4. The EUT and transmitting antenna shall be centered on the turntable. For devices with multiple antennas that are active simultaneously, the EUT shall be positioned, to the extent possible, with the antennas equally distributed around the center of the device. The exact setup shall be documented in the test report.

Any controlling device (e.g., notebook, laptop, or desktop computer) shall be positioned such that it shall not significantly influence the measurement results. No other peripherals are required to be connected to the controlling device for this test unless the radio is being tested as part of the notebook or PDA qualifications.

ANSI C63.10-2013, 6.5.3 Exploratory radiated emission tests

Exploratory measurements are used to identify the frequencies and amplitudes of the emissions while manipulating and rotating the EUT.

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT. At near distances, for EUTs of comparably small size, it is relatively easy to determine the spectrum signature of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. Exploratory measurements shall be made on a test site per 5.2. Shielded rooms, not treated with RF absorption material, shall not be used for exploratory measurements.

For each mode of operation required to be tested, the frequency spectrum shall be monitored. The highest signal levels relative to the limit shall be determined by rotating the EUT from 0° to 360° and with varying the measurement antenna height between 1 m and 4 m in vertical and horizontal polarizations.

ANSI C63.10-2013, 6.5.4 Final radiated emission tests
Using the orientation and equipment arrangement of the EUT, and based on the measurement results found during the exploratory measurement in 6.5.3, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable) and the frequency and amplitude of the six highest spurious emissions relative to the limit; emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°, the antenna height scanned between 1 m and 4 m, and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

Radiated Emissions Test Characteristics	
Frequency range	30 MHz – 1000 MHz
Test distance	3 m
Test instrumentation resolution bandwidth	120 kHz
Receive antenna height	1 m - 4 m
Receive antenna polarization	Vertical/Horizontal

9.4 Calculation of Field Strength Limits

Acc. to § 15.249 radiated spurious emissions shall be attenuated by at least 50 dB below the level of the fundamental or the general radiated emission limits in § 15:209, whichever is lesser attenuation.

Limit: Fundamental – 50 dB:

Peak: 46.3 dBµV/m, Average: 11.9 dBµV/m

Limits acc. to § 15.209 apply.

E.g. radiated spurious emissions field strength limits acc. to § 15.209 for the frequency band 88-216 MHz:

150 µV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 150 µV/m corresponds with 43.5 dBµV/m.

9.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:
FS = RA + AF + CF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]

Level in µV/m = Common Antilogarithm (32/20) = 39.8

Remark: All emission measurements described in this chapter performed using the EMI test program transducer factor setting capability, i.e. the field strength value at the test distance was measured directly without the necessity of additional correction factors.

9.6 Final Test Results

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
210.020000	28.70	43.50	14.80	1000.0	120.000	100.1	H	-45.0	17.6

EUT Freq. 2402 MHz ; Pos: 2

All tests performed at 3 m distance. The table above contains worst-case emissions, only. For further details refer to the detailed measurement data.

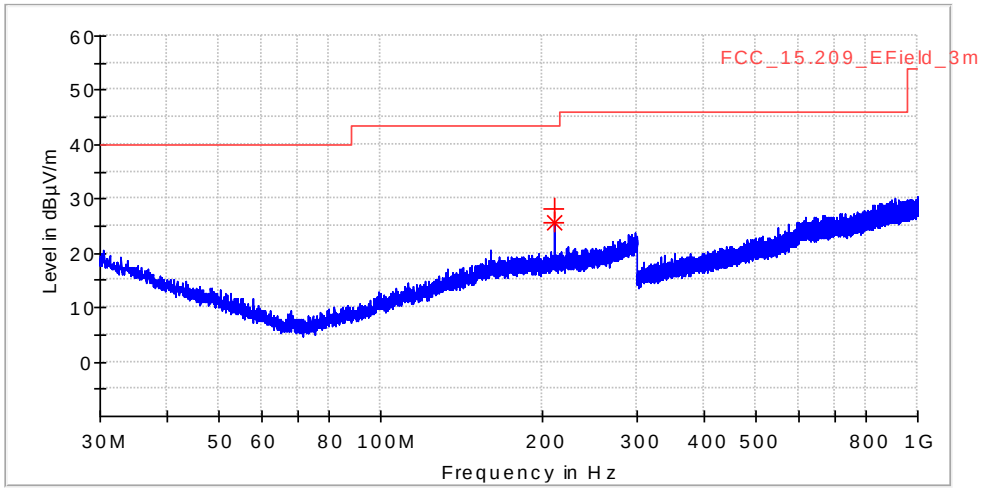
Manufacturer:	EnOcean GmbH
Device:	PTM 215B
Serial No:	none
Test date:	2016-06-28

All measured emissions in the range 30 MHz to 1000 MHz are below the specified limits.

The EUT meets the requirements of this section.

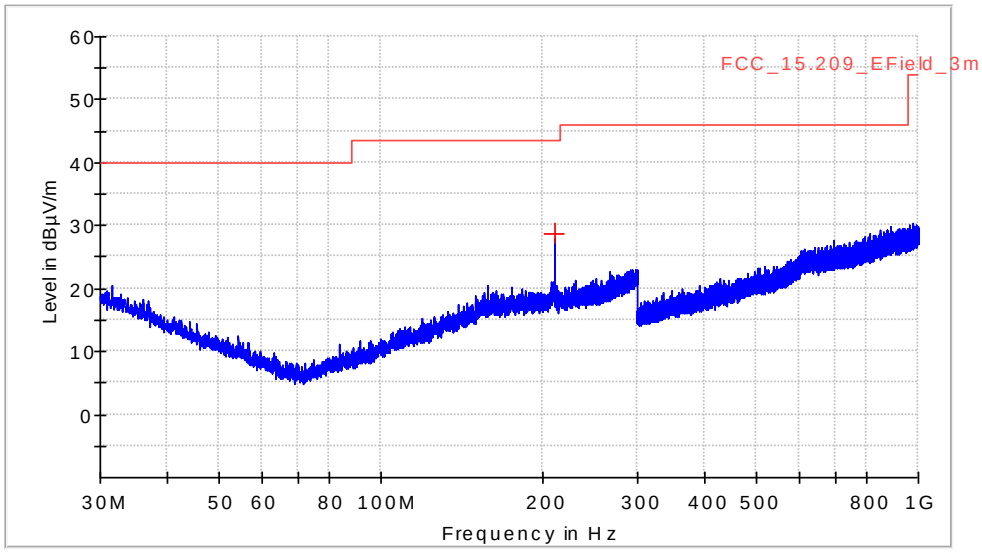
9.7 Detailed Measurement Data

Radiated Emissions 30 MHz – 1000 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency: 2402 MHz



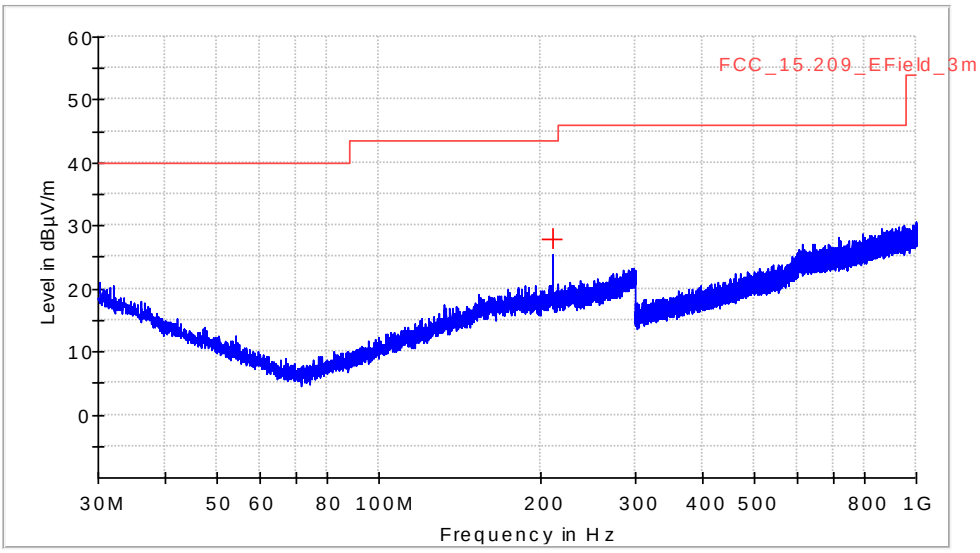
Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
FCC_15.209_EField_3m [..\FCC_Part15_RE\]
Final_Result QPK [Final_Result.Result:4]
MaxPeak-PK+ (Single) [Result Table_Single.Result:1]
QuasiPeak-QPK (Single) [Result Table_Single.Result:2]

Radiated Emissions 30 MHz – 1000 MHz, EUT Pos.: 2
EUT: #1
EUT Frequency: 2402 MHz

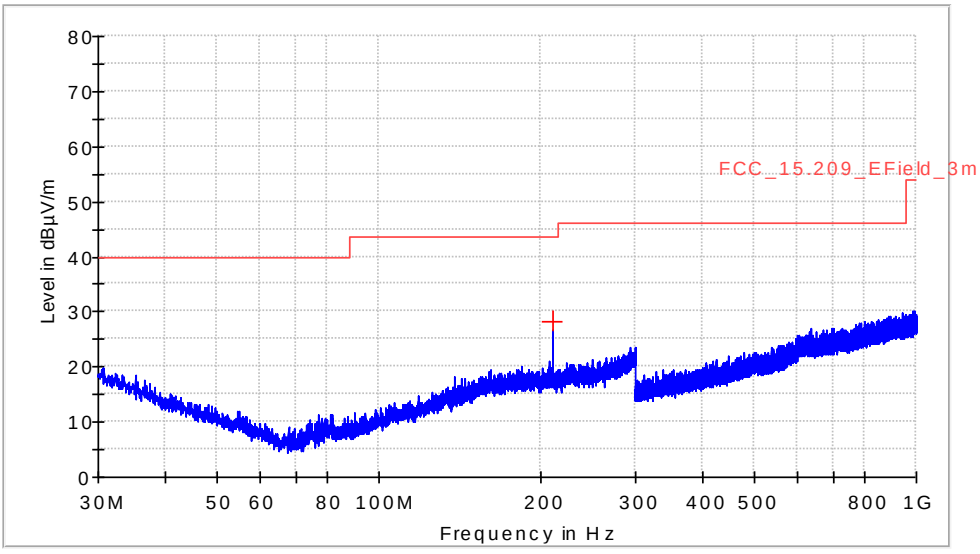


Preview Result 1-PK+ [Preview Result 1.Result:1]
FCC_15.209_EField_3m [..\FCC_Part15_RE\]
Final_Result QPK [Final_Result.Result:4]

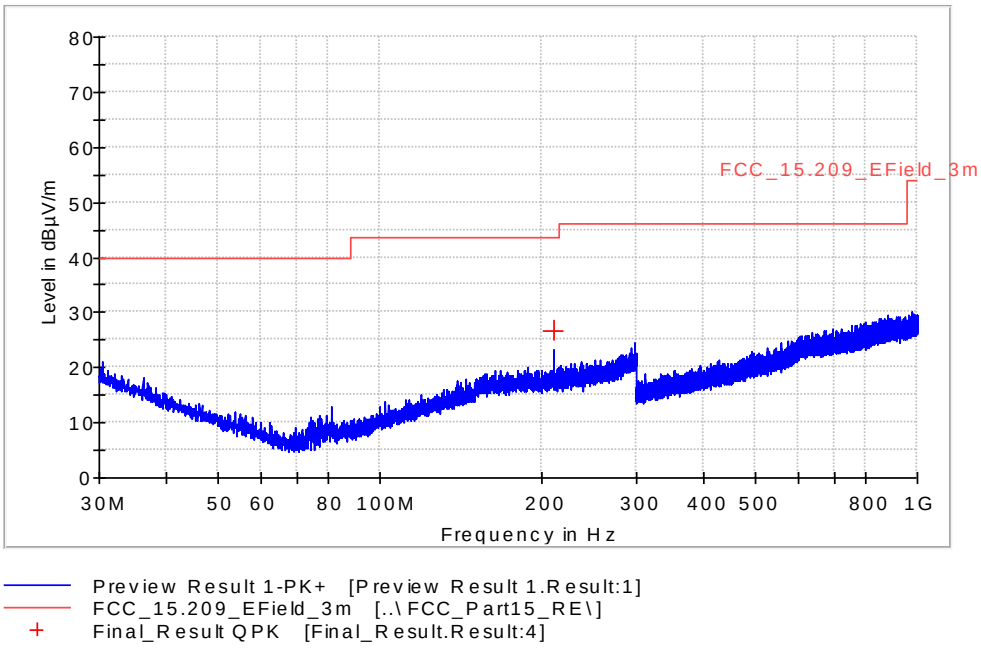
Radiated Emissions 30 MHz – 1000 MHz, EUT Pos.:3
EUT: #1
EUT Frequency: 2402 MHz



Radiated Emissions 30 MHz – 1000 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency: 2441 MHz



Radiated Emissions 30 MHz – 1000 MHz, EUT Pos.: 1
EUT: #1
EUT Frequency: 2480 MHz



10 RADIATED EMISSIONS 1 GHz – 25 GHz

Test requirement: FCC 47 CFR, §§ 15.249, 15.209
ISED RSS-210, Annex B.10, RSS-Gen 8.9
Test procedure: ANSI C63.10-2013

10.1 Regulation

§ 15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24.0-24.25 GHz
(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

§15.209 Radiated emission limits; general requirements
(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency	Field Strength		Measurement Distance
[MHz]	[µV/m]	[dB(µV/m)]	[m]
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46.0	3
Above 960	500	54	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

(b) In the emission table above, the tighter limit applies at the band edges.
(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
(e) The provisions in §§ 15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

RSS-210, Annex B.10 Bands 902–928, 2400–2483.5 and 5725–5875 MHz

Devices shall comply with the following requirements:

(a) The field strength of fundamental and harmonic emissions, measured at 3 m, shall not exceed 50 mV/m and 0.5 mV/m respectively.

The field strength limits shall be measured using an average detector, except for the fundamental emission in the frequency band 902-928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

(b) Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

The provisions of RSS-Gen regarding pulsed operation do not apply to CISPR measurement for the band 902-928 MHz.

RSS-Gen, 8.9 Transmitter Emission Limits for Licence-Exempt Radio Apparatus

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in Table 4 and Table 5 below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz

Frequency (MHz)	Field strength (µv/m at 3 metres
30-88	100
88-216	150
216-960	200
Above 960	500

Footnote

Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

10.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Standard Gain Horn Ant.	Mid Century / MC 20/31B	1300	2014-07	2016-07
K-Cable K/50	IW / KPS-1501-600-KPS	3061	2016-01	2017-01
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3236	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2015-07	2016-07
HF-Cable	IW / NPS-2801N-1180-NPS	4390	2015-06	2016-06
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
Band Reject Filter	ZYSEN / ZSBR2441.75-83.5U10CS	4993	2015-03	2017-03
High Pass Filter	dBd com / DBD-FTR-15SH-U3500-O/O	5366	2015-09	2017-09

10.3 Test Procedures

ANSI C63.10-2013, 6.6.3.1 Tabletop equipment

For emission measurements above 1 GHz, the EUT shall be placed at a height of 1.5 m above the floor on a support that is RF transparent for the frequencies of interest. The 1.5 m height EUT support shall be constructed using a low permittivity and low loss tangent (tanδ) material with a height of 1.5 m, or a low permittivity and low loss tangent (tanδ) material may be placed on top of a typical table with a height of 0.8 m or 1 m. One typical low-permittivity and low-loss tangent material is styrene. Due to its dielectric properties for frequencies above 1 GHz, the use of styrene or building insulation foam is recommended, rather than, for example, wood. Support equipment shall be placed far enough away from the EUT, such that changes in relative position of the EUT and support equipment do not cause changes in measured values. Final measurements for the EUT require a measurement antenna height scan of 1 m to 4 m.
Where possible, the methods for portable, handheld, or body-worn equipment detailed in 6.6.3.3 may be employed for smaller tabletop equipment to allow the use of shorter cabling between measurement antennas and measuring receiver/spectrum analyzer by restricting the upper height of the measurement antenna.

ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.
Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be

tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.
Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

ANSI C63.10-2013, 6.6.4.3 Final radiated emissions measurements

The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.

If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.

As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 25 GHz
Test distance	3 m*
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal
EUT Orientation	0° / 30° / 60° / 90° / 120° / 150°

* decreased test distance to 1m at frequencies above 6 GHz.

10.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits acc. to §15.209 for frequencies above 960 MHz:

500 µV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log (E_{\mu V/m})$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 500 µV/m corresponds with 54 dBµV/m.

10.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m

RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]
Level in µV/m = Common Antilogarithm (32/20) = 39.8

Remark: All emission measurements described in this chapter performed using the EMI test program transducer factor setting capability, i.e. the field strength value at the test distance was measured directly without the necessity of additional correction factors.

For average measurements, the measured peak field strength is corrected by a Duty Cycle correction factor DCF. Please refer to chapter 2.6 for details.

$FS_{AV} = FS + DCF$
where
FS_{AV} = Average Field Strength in dBµV/m
FS = Peak Field Strength in dBµV/m
DCF = Correction Factor in dB

Assuming a peak field strength of 59.8 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -34.4 dB corresponds with 25.4 dBµV/m.

10.6 Final Test Results

Radiated Spurious Emissions 1 – 25 GHz – Average Results						
Frequency	**Field Strength**	**DCF**	**Result**	**Limit**	**Margin**	**Remarks**
[MHz]	**[dBµV/m]**	**[dB]**	**[dB(µV/m)]**	**[dB(µV/m)]**	**[dB]**	
2322	59.82	-34.4	25.42	54	28.58	EUT 2402 MHz
4804	61.96	-34.4	27.56	54	26.44	EUT 2402 MHz
2567	62.83	-34.4	28.43	54	25.57	EUT 2441 MHz
4882	62.34	-34.4	27.94	54	26.06	EUT 2441 MHz
2567	62.06	-34.4	27.66	54	26.34	EUT 2480 MHz
4960	63.15	-34.4	28.75	54	25.25	EUT 2480 MHz

Remark: Duty Cycle Correction Factor DCF added to peak reading to obtain average results.
For further details refer to chapter 2.1 of the report.

Radiated Spurious Emissions 1 – 25 GHz – Peak Results						
Frequency	**Field Strength**	**DCF**	**Result**	**Limit**	**Margin**	**Remarks**
[MHz]	**[dBµV/m]**	**[dB]**	**[dB(µV/m)]**	**[dB(µV/m)]**	**[dB]**	
2322	59.82	n.a.	59.82	74	14.18	EUT 2402 MHz
4804	61.96	n.a.	61.96	74	12.04	EUT 2402 MHz
2567	62.83	n.a.	62.83	74	11.17	EUT 2441 MHz
4882	62.34	n.a.	62.34	74	11.66	EUT 2441 MHz
2567	62.06	n.a.	62.06	74	11.94	EUT 2480 MHz
4960	63.15	n.a.	63.15	74	10.85	EUT 2480 MHz

Remark:
The table above contains worst-case emissions, only. For further details refer to the pre-scan test plots.

Manufacturer: EnOcean GmbH
Device: PTM 215B
Serial No: none
Test date: 2016-06-10/27/28

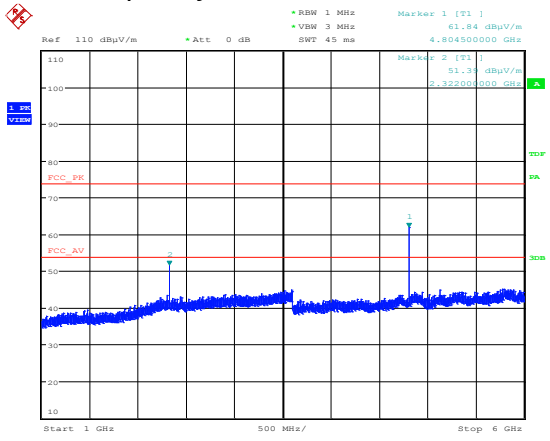
All measured emissions in the range 1 GHz to 25 GHz are below the specified limits.

The EUT meets the requirements of this section.

10.7 Detailed Measurement Data

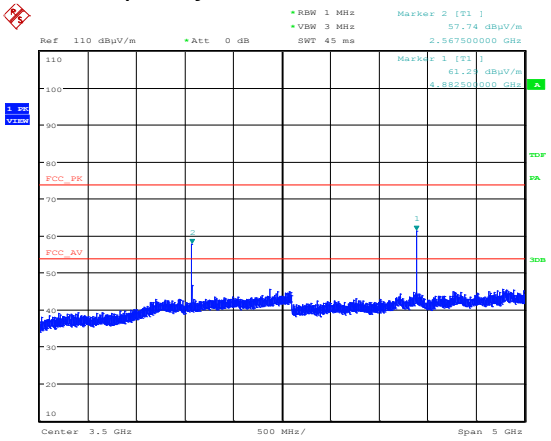
Prescan measurements below 6 GHz were performed at 3 m distance, above 6 GHz at 1m distance. All final measurements were performed at 3m distance.

Prescan; Radiated Emissions 1-6 GHz
EUT: #1
EUT Frequency: 2402 MHz



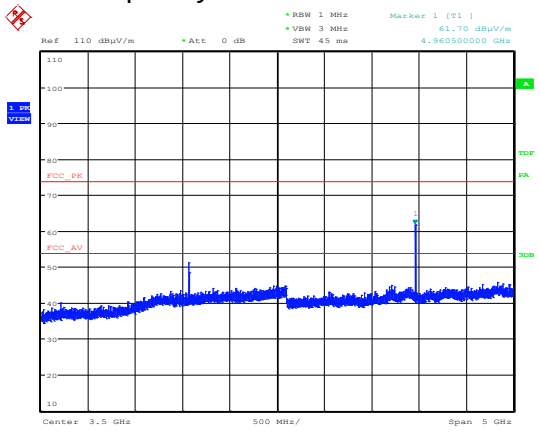
Prescan; EUT: 2402MHz Mode: Mod; Pol:H/V; EUT: 150deg
Date: 10.JUN.2016 15:35:27

Prescan; Radiated Emissions 1-6 GHz
EUT: #1
EUT Frequency 2441 MHz



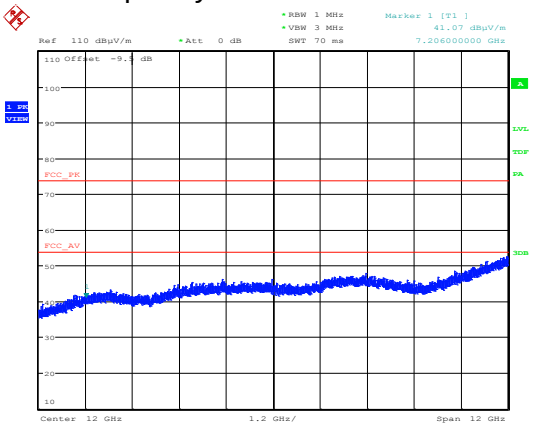
Prescan; EUT: 2441MHz Mode: Mod; Pol:H/V; EUT: 0deg
Date: 10.JUN.2016 16:10:05

Prescan; Radiated Emissions 1-6 GHz
EUT: #1
EUT Frequency: 2480 MHz



Prescan; EUT: 2480 MHz Mode: Mod; Pol:H/V; EUT: 0deg
Date: 10.JUN.2016 16:44:34

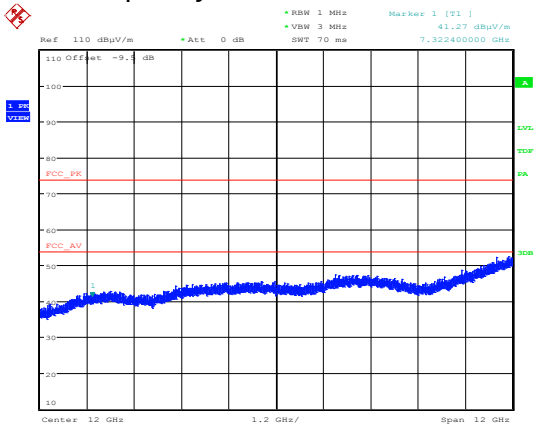
Prescan; Radiated Emissions 6-18 GHz
EUT: #1
EUT Frequency: 2402 MHz



Prescan EUT: 2402 MHz; Mode: Mod; Pol: h/v EUT 0deg
Date: 27.JUN.2016 16:11:21

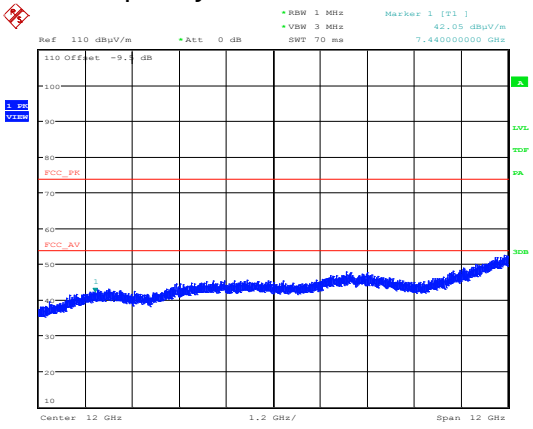
Note: Measurements in worst case orientations are shown, only

Prescan; Radiated Emissions 6-18 GHz
EUT: #1
EUT Frequency: 2441 MHz



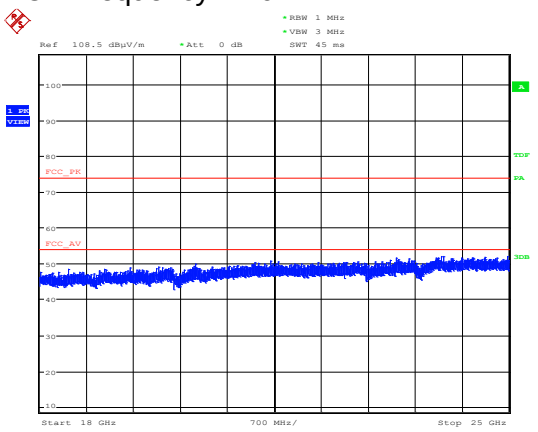
Prescan EUT: 2441 MHz; Mode: Mod; Pol: h/v EUT 0deg
Date: 27.JUN.2016 17:03:09

Prescan; Radiated Emissions 6-18 GHz
EUT: #1
EUT Frequency: 2480 MHz



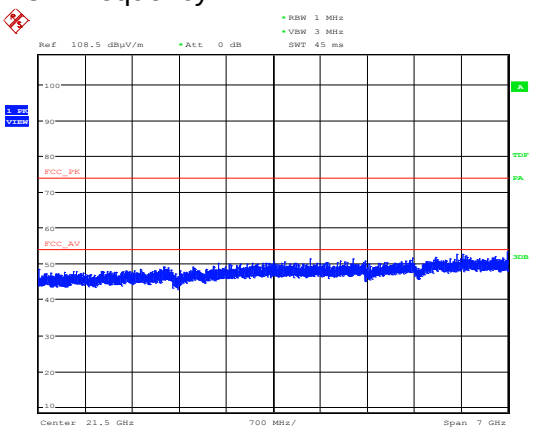
Prescan EUT: 2441 MHz; Mode: Mod; Pol: h/v EUT 150deg
Date: 27.JUN.2016 17:31:54

Exploratory rad. emission meas. 18-25 GHz
EUT: #1
EUT Frequency: 2402 MHz



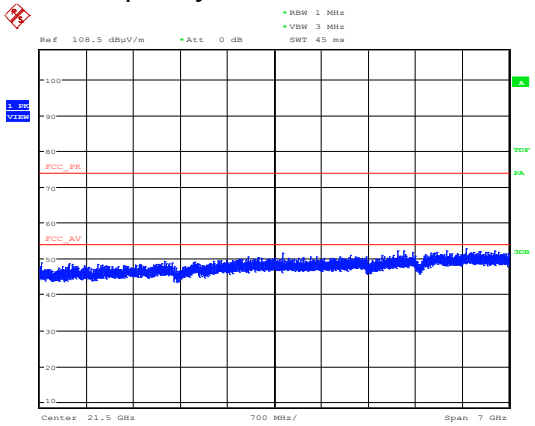
Investigation scan EUT: 2402 MHz; Mode: Mod
Date: 28.JUN.2016 10:05:50

Exploratory rad. emission meas. 18-25 GHz
EUT: #1
EUT Frequency: 2441 MHz



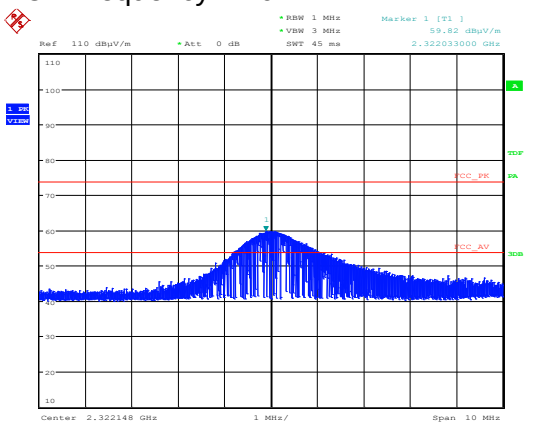
Investigation scan EUT: 2441 MHz; Mode: Mod
Date: 28.JUN.2016 10:19:06

Exploratory rad. emission meas. 18-25 GHz
EUT: #1
EUT Frequency: 2480 MHz



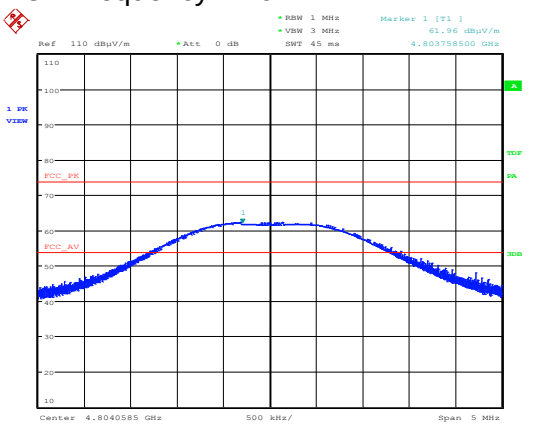
Investigation scan EUT: 2480 MHz; Mode: Mod
Date: 28.JUN.2016 10:36:48

Final Peak Measurement 2322 MHz
EUT: #1
EUT Frequency: 2402 MHz



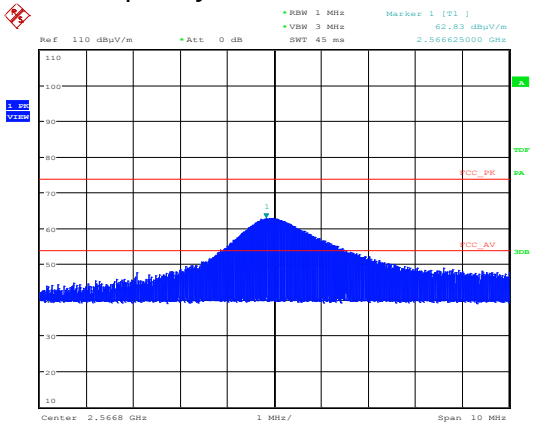
Prescan; EUT: 2402MHz Mode: Mod; max. PK
Date: 10.JUN.2016 15:59:01

Final Peak Measurement 4804 MHz
EUT: #1
EUT Frequency: 2402 MHz



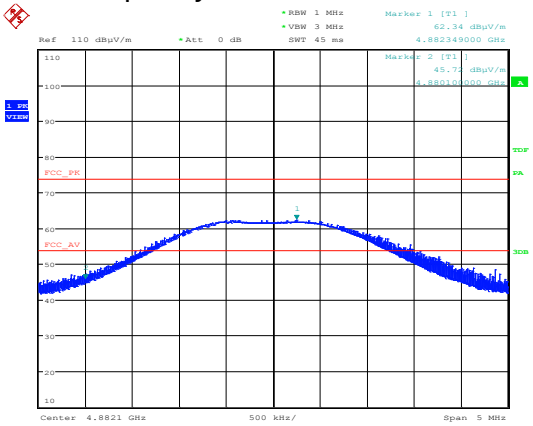
Prescan; EUT: 2402MHz Mode: Mod; max 4.80GHz PK
Date: 10.JUN.2016 15:42:01

Final Peak Measurement 2567 MHz
EUT: #1
EUT Frequency: 2441 MHz



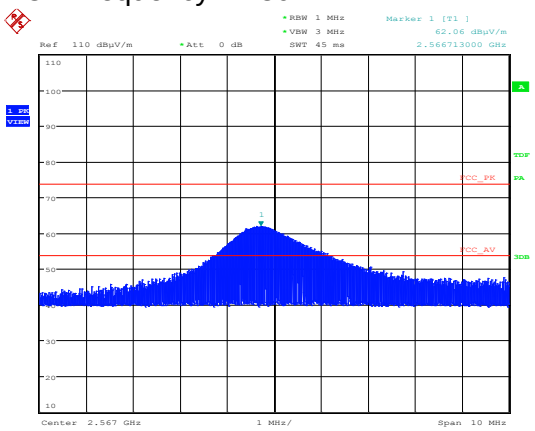
Prescan; EUT: 2441MHz Mode: Mod; max
Date: 10.JUN.2016 16:34:59

Final Peak Measurement 4882 MHz
EUT: #1
EUT Frequency: 2441 MHz



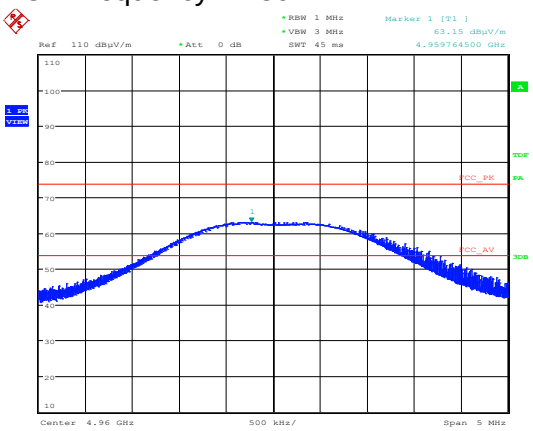
Prescan; EUT: 2441MHz Mode: Mod; max
Date: 10.JUN.2016 16:27:44

Final Peak Measurement 2567 MHz
EUT: #1
EUT Frequency: 2480 MHz



Prescan; EUT: 2480 MHz Mode: Mod; max
Date: 10.JUN.2016 17:10:33

Final Peak Measurement 4960 MHz
EUT: #1
EUT Frequency: 2480 MHz



Prescan; EUT: 2480 MHz Mode: Mod; max
Date: 10.JUN.2016 17:04:53

11 MEASUREMENT UNCERTAINTY

Measurement	Measurement Uncertainty
Radiated emissions, H field (9 kHz – 30 MHz)	± 3.0 dB
Radiated Emissions (Above 30 MHz)	± 5.3 dB

The reported uncertainty values are based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of 95%.

If not otherwise stated, the given values are worst case values calculated on the basis of the following documents:
TR 100 028-1 V1.4.1 (2001-12)
TR 100 028-2 V1.4.1 (2001-12)
ISO: Guide to the Expression of Uncertainty in Measurement: 1993.

12 LIST OF ANNEXES

Following annexes are separated parts from this test report.

Description	Pages
Annex 1: Photographs of test set-up	4
Annex 2: Externa photographs of equipment under test (EUTs)	2
Annex 3: Internal photographs of equipment under test (EUTs)	4
Annex 4: Photographs of ancillary equipment	2
Annex 5: Detailed information about duty cycle provided by customer	4

Annex 1 to Test Report # EMCC-110010WB, 2016-09-22

PHOTOGRAPHS OF TEST SET-UP

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	none
Application:	Wireless Remote Control
Manufacturer:	EnOcean GmbH
FCC ID:	SVZ-PTM215B
IC ID:	5713A-PTM215B
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56

RELEVANT STANDARD(S): 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

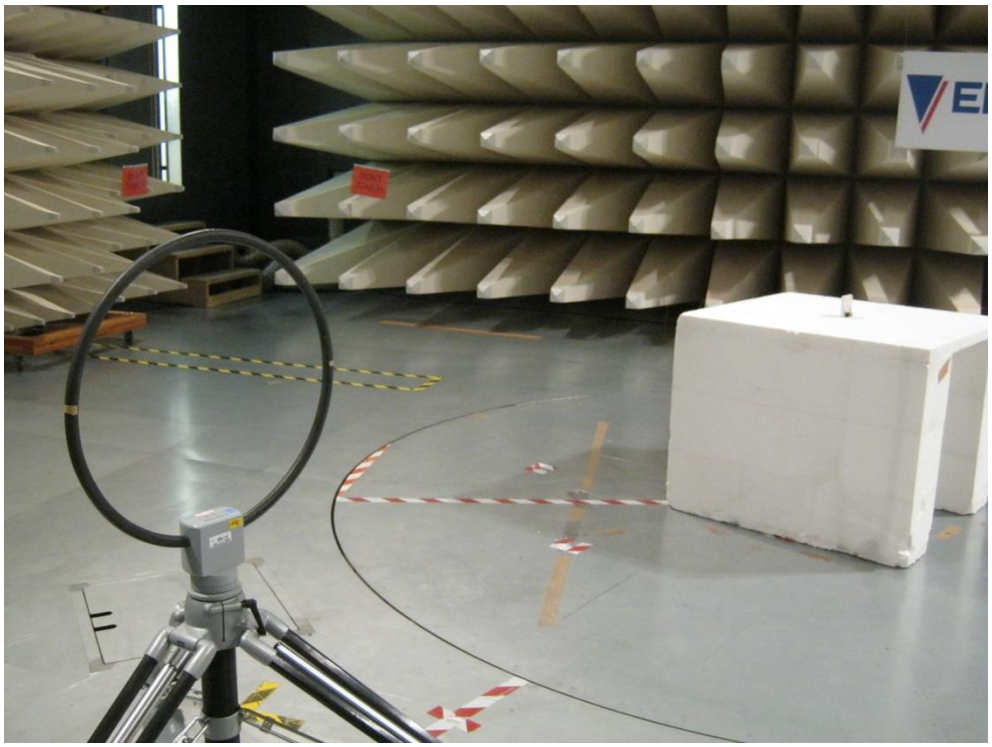


Photo A1-1: Radiated emissions measurement at 3 m distance, 9 kHz – 30 MHz

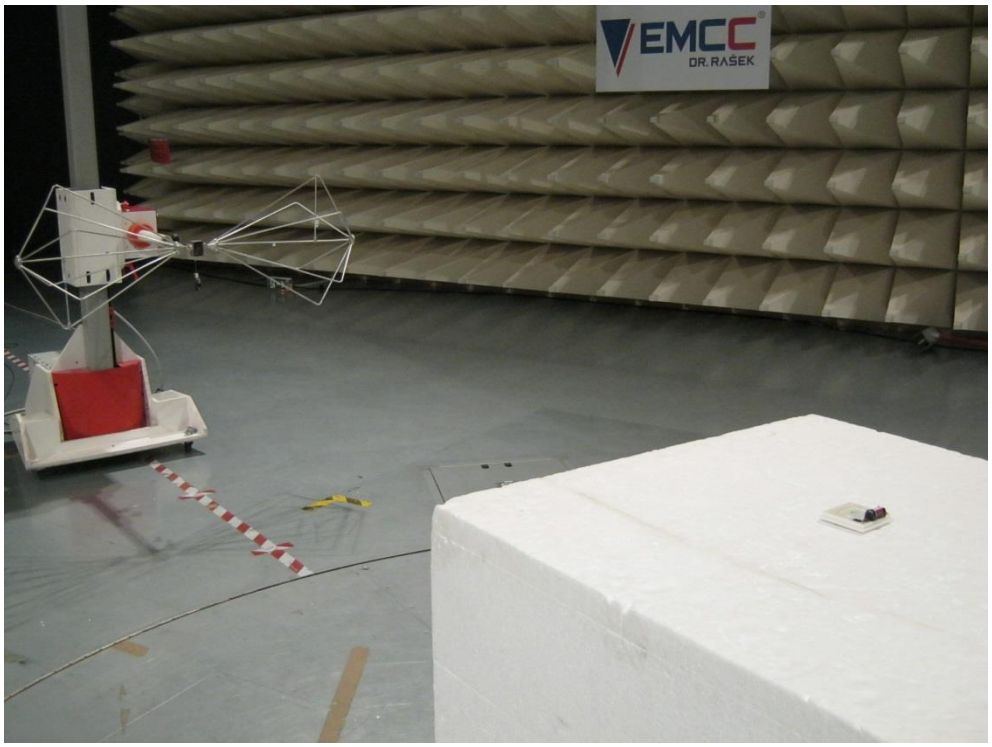


Photo A1-2: Radiated emissions measurement at 3 m distance, 30 MHz – 300 MHz

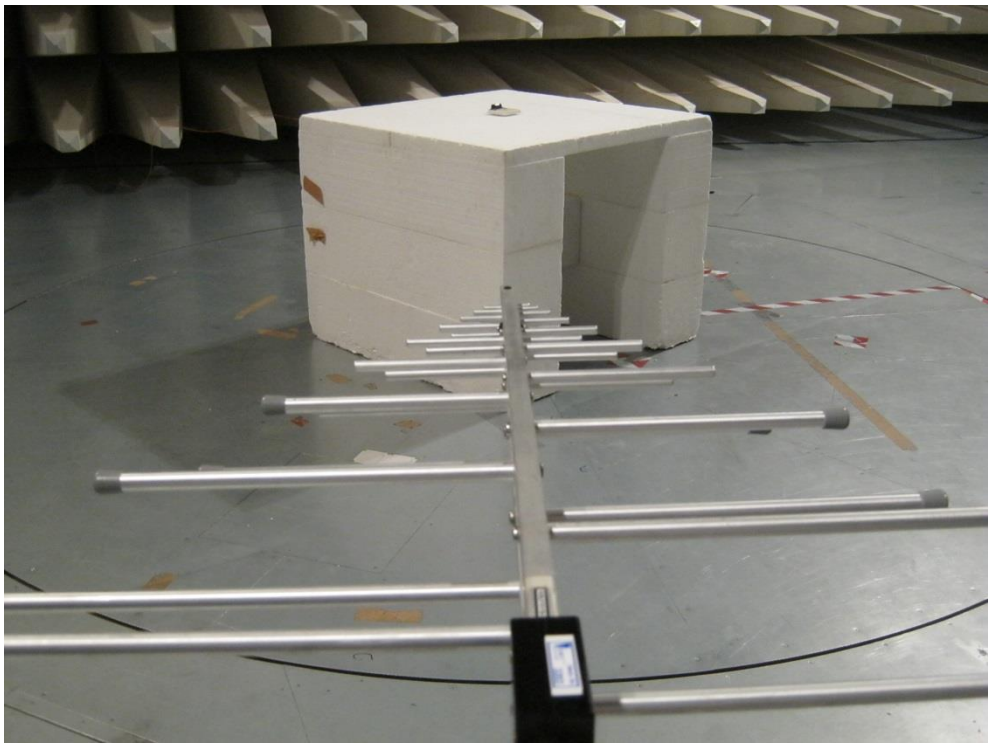


Photo A1-3: Radiated emissions measurement at 3 m distance, 300 MHz – 1000 MHz

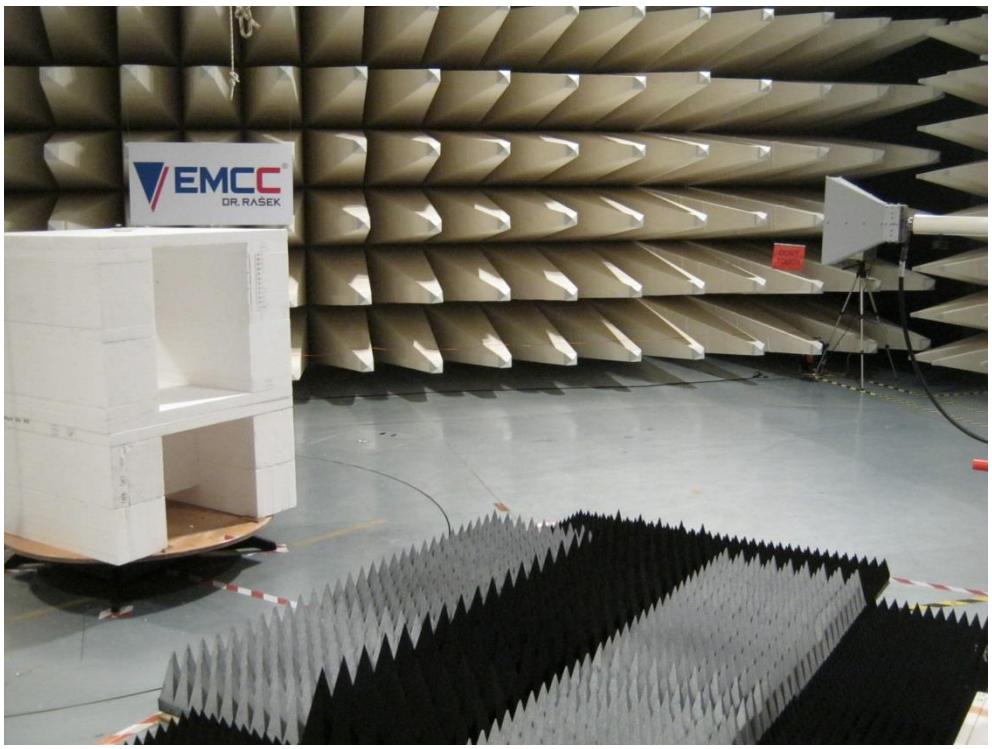


Photo A1-4: Radiated emissions measurement at 3 m distance, 1 GHz – 6 GHz

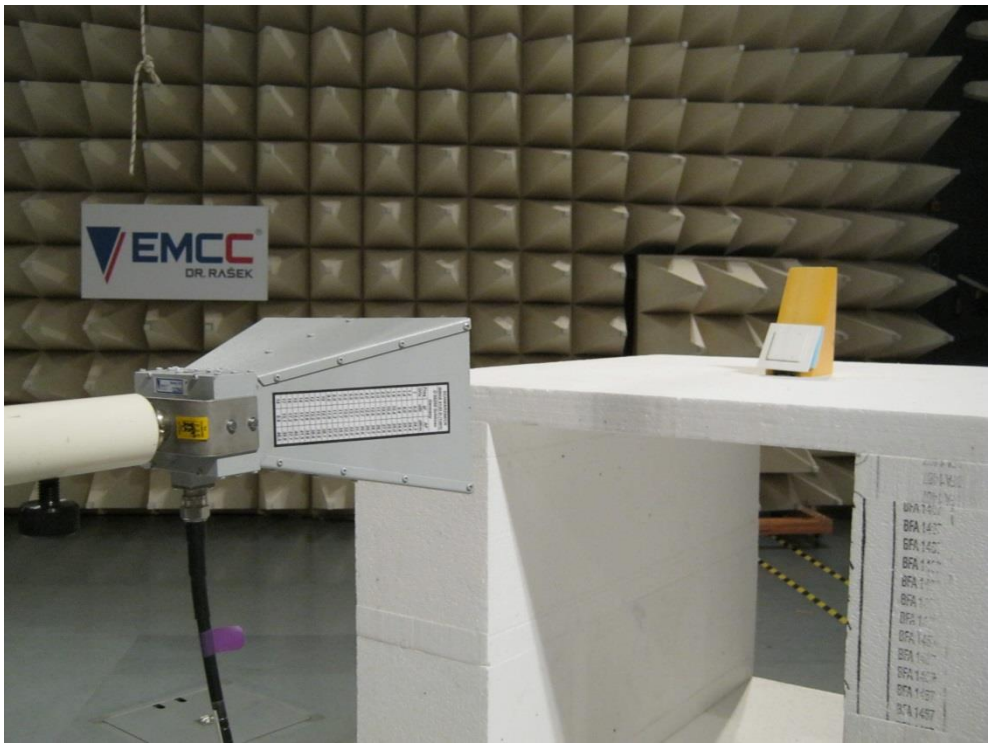


Photo A1-5: Radiated emissions measurement at 1 m distance, 6 GHz – 18 GHz

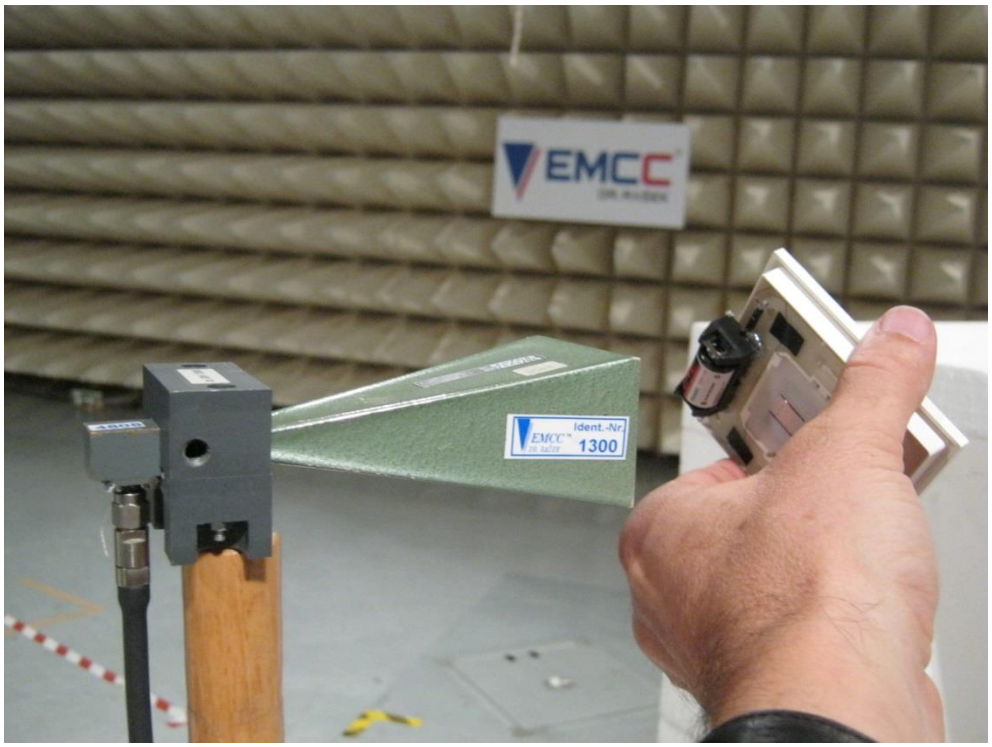


Photo A1-6: Exploratory radiated emissions measurements at closer distance, 18 GHz – 25 GHz

Annex 2 to Test Report # EMCC-110010WB, 2016-09-22

EXTERNAL PHOTOGRAPHS OF EUT

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	none
Application:	Wireless Remote Control
Manufacturer:	EnOcean GmbH
FCC ID:	SVZ-PTM215B
IC ID:	5713A-PTM215B
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56

RELEVANT STANDARD(S): 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

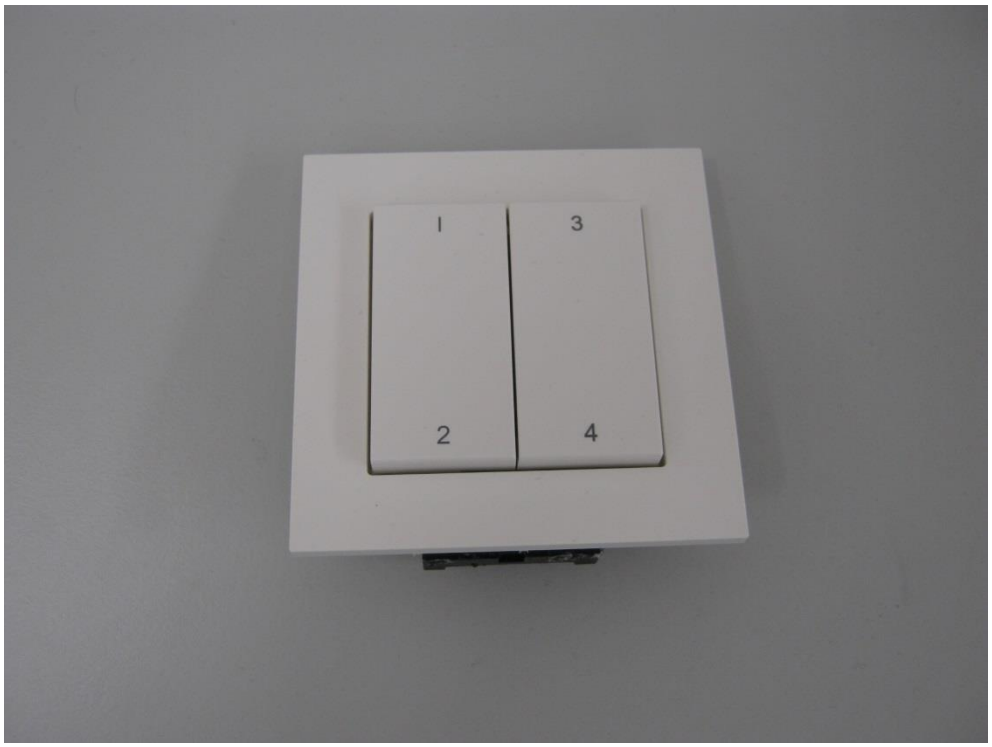


Photo A2-1: EUT #1 – Top view

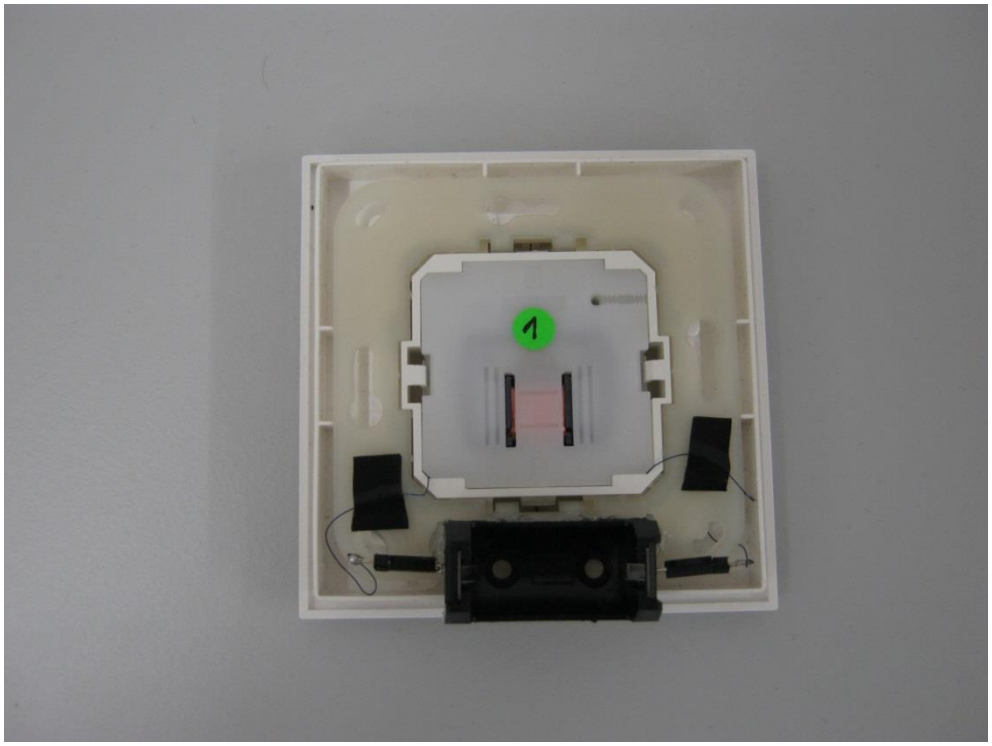


Photo A2-2: EUT #1 – Bottom view

Annex 3 to Test Report # EMCC-110010WB, 2016-09-22

INTERNAL PHOTOGRAPHS OF EUT

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	none
Application:	Wireless Remote Control
Manufacturer:	EnOcean GmbH
FCC ID:	SVZ-PTM215B
IC ID:	5713A-PTM215B
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56

RELEVANT STANDARD(S): 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

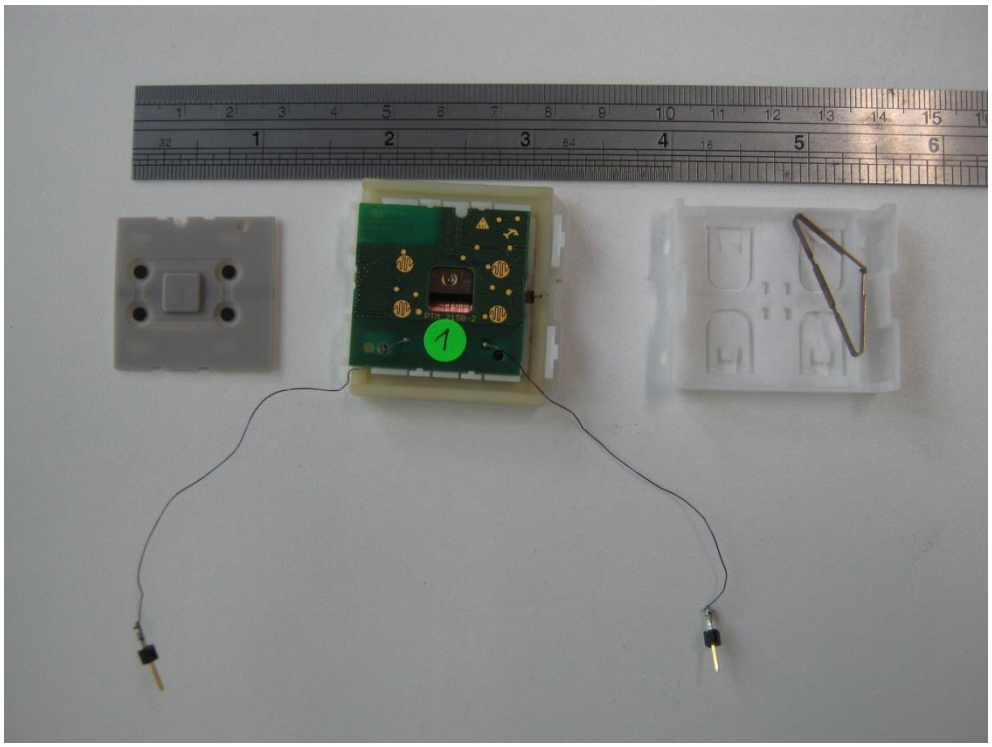


Photo A3-1: EUT #1 – Top view

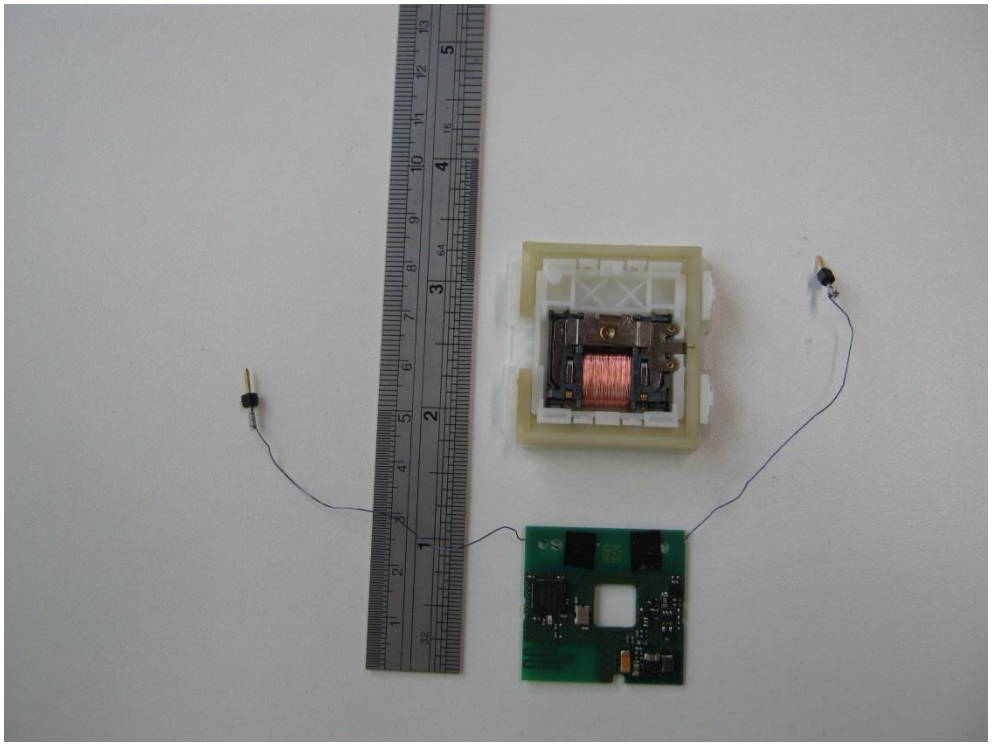


Photo A3-2: EUT #1 – Bottom view

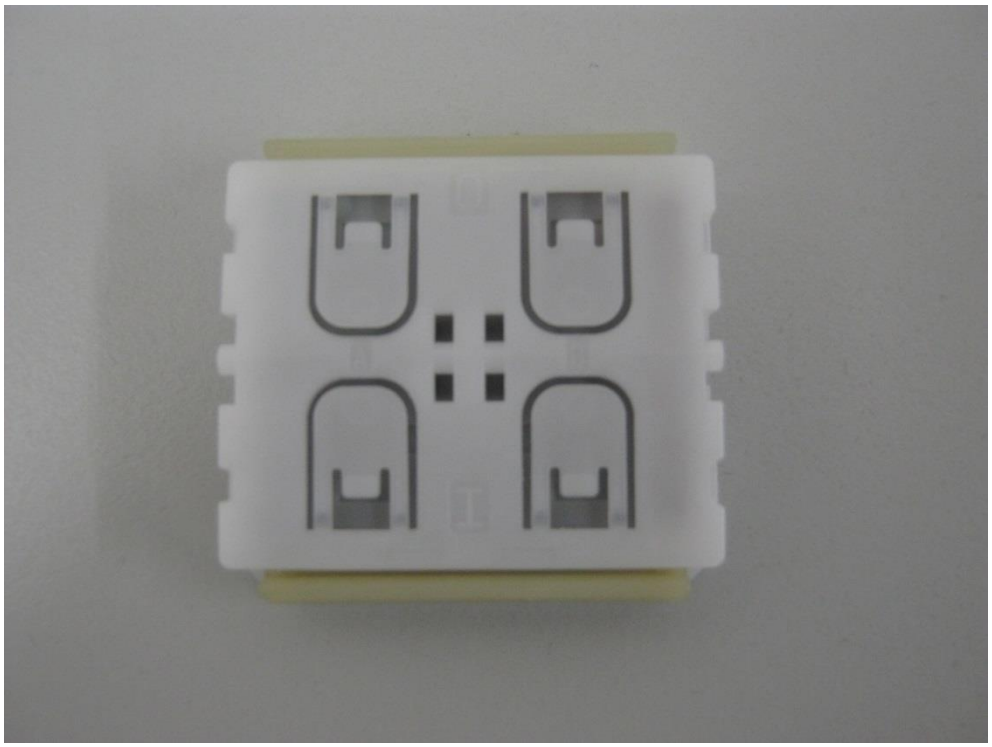


Photo A3-3: EUT #3 (not tested) – Top view

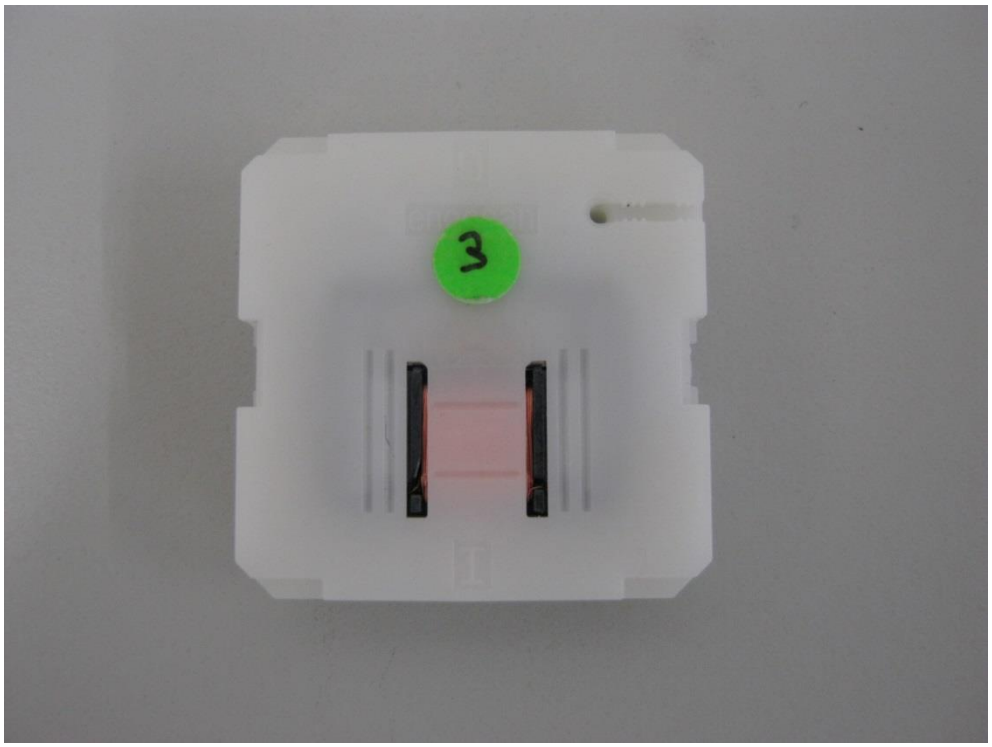


Photo A3-4: EUT #3 (not tested) – Bottom view

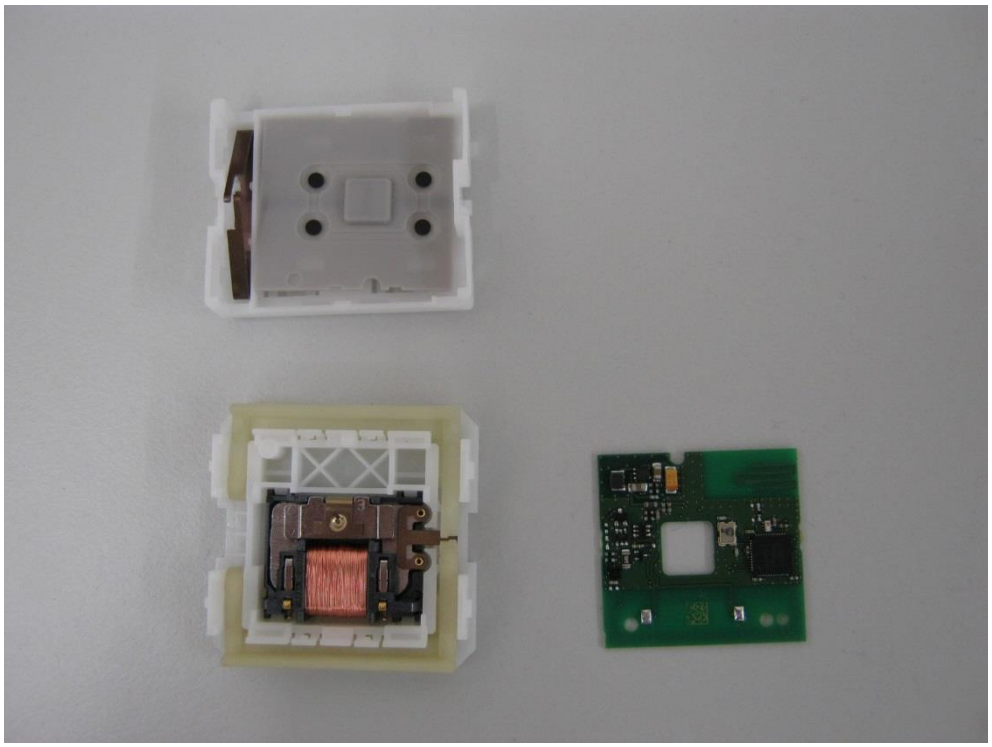


Photo A3-5: EUT #3 (not tested) – Disassembled - Bottom view

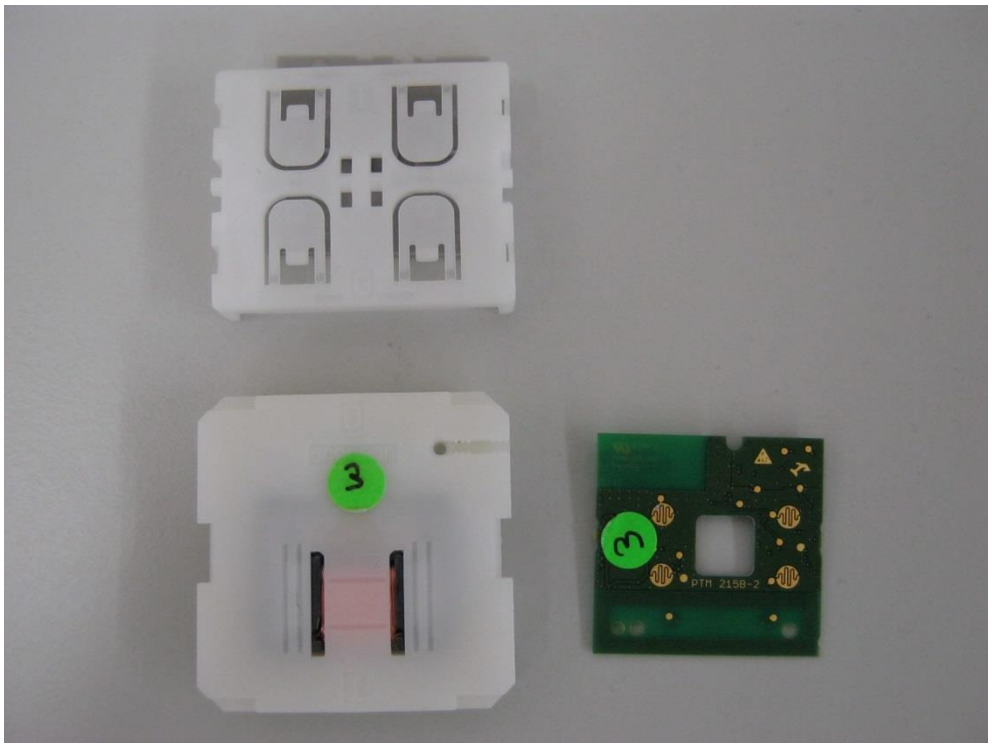


Photo A3-6: EUT #3 (not tested) – Disassembled - Top view

I

Annex 4 to Test Report # EMCC-110010WB, 2016-09-22

PHOTOGRAPHS OF ANCILLARY EQUIPMENT

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	none
Application:	Wireless Remote Control
Manufacturer:	EnOcean GmbH
FCC ID:	SVZ-PTM215B
IC ID:	5713A-PTM215B
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56

RELEVANT STANDARD(S): 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

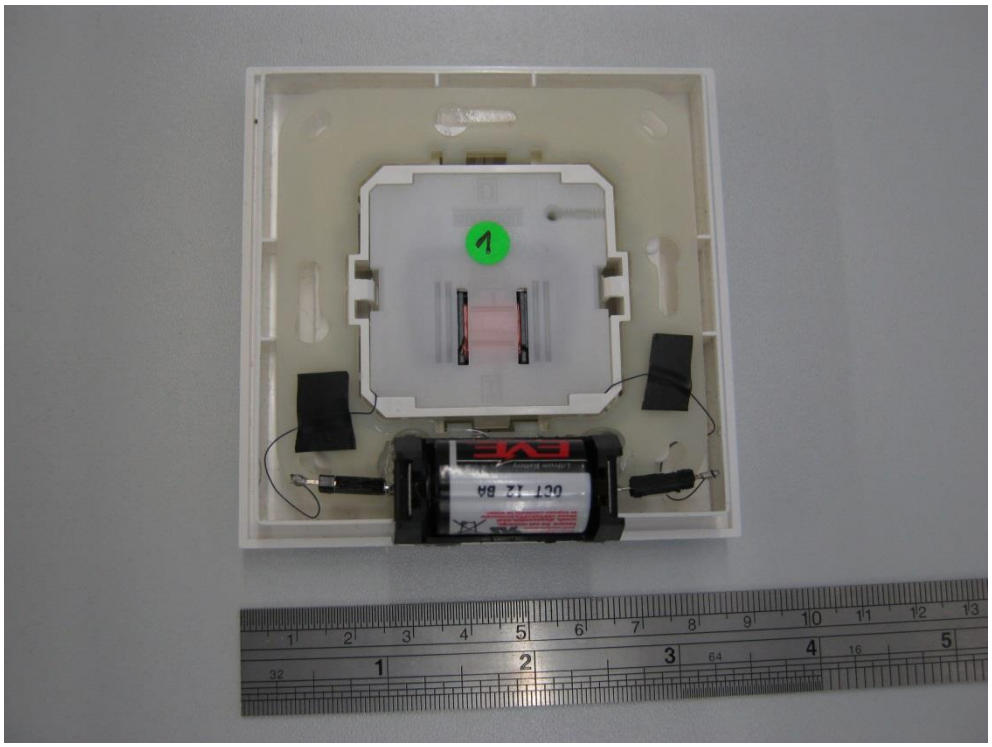


Photo A4-1: EUT #1 with battery power supply

Photo A4-2: – Example of battery used

Annex 5 to Test Report # EMCC-110010WB, 2016-09-22

DETAILED INFORMATION ABOUT DUTY CYCLE PROVIDED BY CUSTOMER

EQUIPMENT UNDER TEST:

Device:	PTM 215B
Serial Number:	none
Application:	Wireless Remote Control
Manufacturer:	EnOcean GmbH
FCC ID:	SVZ-PTM215B
IC ID:	5713A-PTM215B
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone:	+49 89 6734689-627
Fax:	+49 89 6734689-56

RELEVANT STANDARD(S): 47 CFR § 15.249
RSS-210 Issue 9, Annex B.10

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☐ Other

PTM 215B duty cycle

DOLPHIN
Self-powered IoT by EnOcean

Index

General

PTM 215B is device which transmits limited amount of telegrams when triggered to send.

Device transmits radio signal in 3 different channels.

The standard radio channels are fixed:
CH 37: 2402 MHz
CH 38: 2426 MHz
CH 39: 2480 MHz

There is an option for the customer to choose any other 3 frequency within the spectrum from 2402 MHz to 2480 MHz.

PTM 215B can operate in two modes:

- Data mode is used to transmit data telegrams reporting the status of PTM 215B button inputs
- 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.

Data Mode

Telegram sending is triggered when pulse from energy harvesting generator is detected.

PTM 215B duty cycle

EnOcean ECO 200 generates pulse on press and on release of the rockers. This means that by one press and then release of the switch max. number of events sent is 6 in one channel as shown on figure 1.

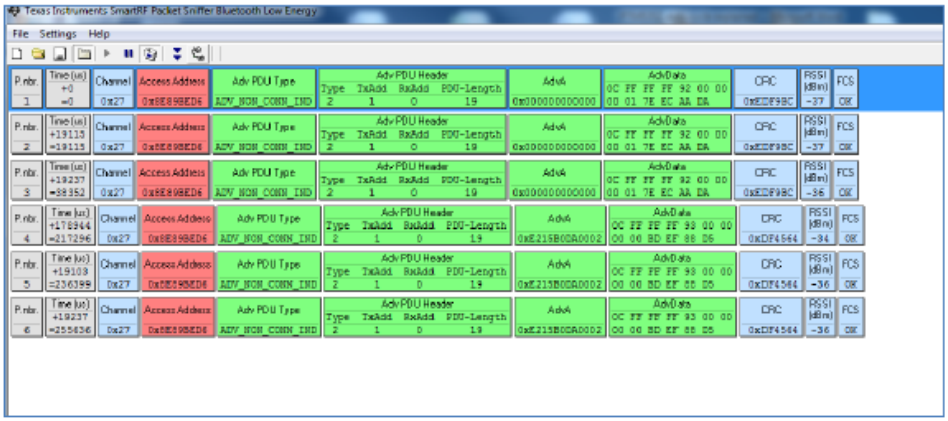


Figure 1. Press and release of the switch

Figure 1 shows data telegrams captured during one press and release in channel 37. The executed Radio transmission sequence does the same in another 2 channels CH 38 and CH 39 respectively.

Figure 2. Radio transmission sequence

Within 100 ms is not possible physically to have more than one press and release.
On one press three events are created and each event consists of three telegrams (figure 2.).

Total transmission time

Total number of bytes we transmit in the air per telegram is 29 bytes.
There is an option to transmit extra 4 bytes on customer request.
Each telegram, if we transmit standard 29 bytes is 281 µs long and pause between each is 102 µs (Figure 3).
Duration per one byte is then 9.7 µs. In case we transmit 4 extra bytes (total 33 bytes) each telegram will be 320 µs long.
After 3 telegrams (1 event) there is pause of around 20 ms (Figure 4).

PTM 215B duty cycle

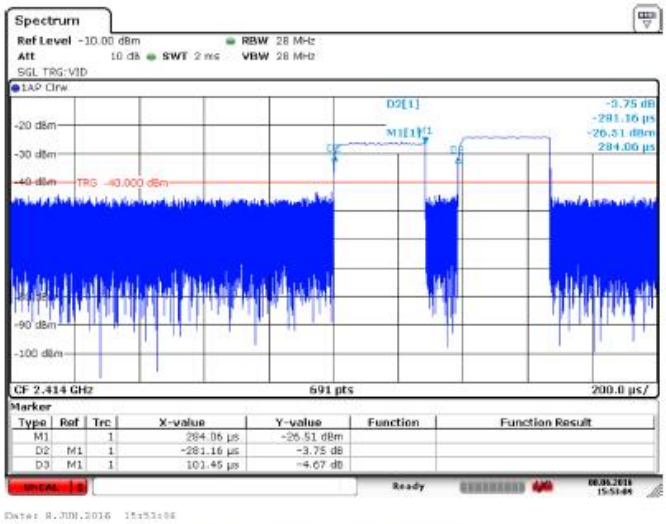


Figure 3. Length of data telegrams

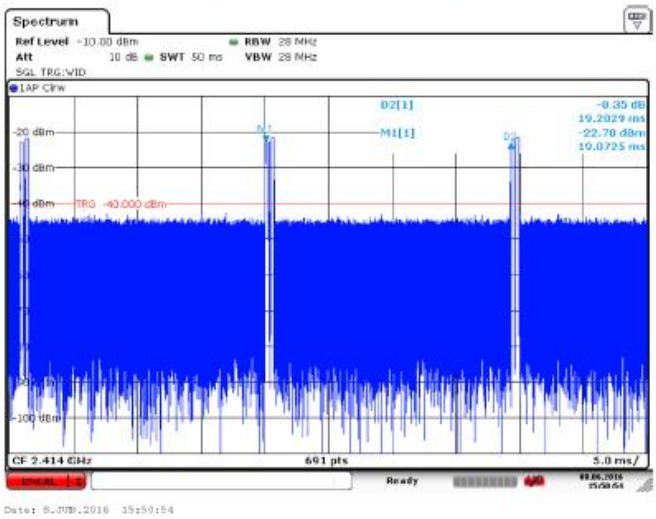


Figure 4. Transmission of data events on press of the rocker
(3rd telegram is missing due to the limited bandwidth of the measuring device)

Duty cycle calculation for data telegrams in case of one press and release

If we observe 100 ms period, max. number of events transmitted is 3 events on press of the rocker and 3 events on release of the rocker. Physically we cannot press and release rockers more than 1 time in 100 ms.
This result in total 18 telegrams being transmitted in 100 ms period.

Since each telegram is 281 µs long, total on time in 100 ms period when we sum all channels is:
281µs x 18 = 4215µs = 5.1 ms

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Total on time per single channel is 281 µs x 6 = 1.7 ms.

Duty cycle is then:

If we observe total on time in all channels:

- Total on time = 5.1 ms
- Interval = 100 ms
- Duty cycle = 5.1 %

If we observe total on time per channel:

- Total on time = 1.7 ms
- Interval = 100 ms
- Duty cycle = 1.7 %

Worst case duty cycle

Worst case we have when we transmit data telegrams with extra 4 bytes which result in telegram length of 320 µs (33 bytes).

Duty cycle is then:

Total on time: 320 µs x 3 Events x 3 Telegrams/Event x 2 = 5.8 ms

- Total on time = 5.8 ms
- Interval = 100 ms
- Duty cycle = 5.8 %

Total on time per channel: 320 µs x 3 Events x 1 Telegram/Event x 2 = 1.9 ms

- Total on time per channel = 1.9 ms
- Interval = 100 ms
- Duty cycle = 1.9 %

Duty cycle calculation in data mode with one press of the rocker

If we observe 100 ms period, max. number of events transmitted is 3 events on press of the rocker. Physically we cannot press rockers more than 1 time in 100 ms.
This result in total 9 telegrams being transmitted in 100 ms period.

Since each telegram is 281 µs long, total on time in 100 ms period when we sum all channels is: 281µs x 9 = 2529µs = 2.53 ms

Total on time per single channel is 281 µs x 3 = 0.84 ms.

Duty cycle is then:

If we observe total on time in all channels:

- Total on time = 2.53 ms

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- Interval = 100 ms
- Duty cycle = 2.53 %

If we observe total on time per channel:

- Total on time = 0.84 ms
- Interval = 100 ms
- Duty cycle = 0.84 %

Worst case duty cycle

Worst case we have when user chooses to transmit data telegrams with extra 4 bytes which result in telegram length of 320 µs (33 bytes).

Duty cycle is then:

Total on time: 320 µs x 3 Events x 3 Telegrams/Event = 2.88 ms

- Total on time = 2.88 ms
- Interval = 100 ms
- Duty cycle = 2.88 %

Total on time per channel: 320 µs x 3 Events x 1 Telegram/Event = 0.96 ms

- Total on time per channel = 0.96 ms
- Interval = 100 ms
- Duty cycle = 0.96 %

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Commissioning mode

Device can also transmit in commissioning mode. In this case we transmit 47 bytes per telegram.
In commissioning mode we transmit only 2 events on press of the rockers and 2 events on release of the rockers which result in total 12 transmitted telegrams (figure 6). This is max. what we can transmit in 100 ms period.
Total on time in 100 ms period when we sum all channels is 422 µs x 12 = 5.1 ms.
Total on time per channel is 422 µs x 4 = 1.7 ms.

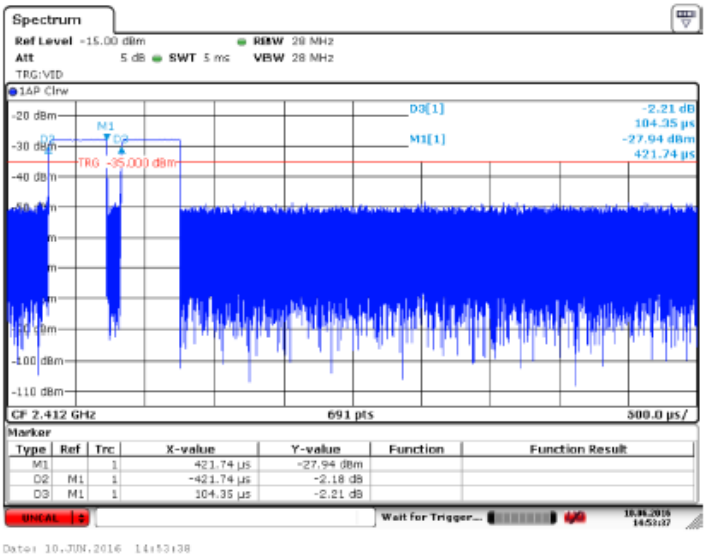

Figure 5. Length of Commissioning telegram

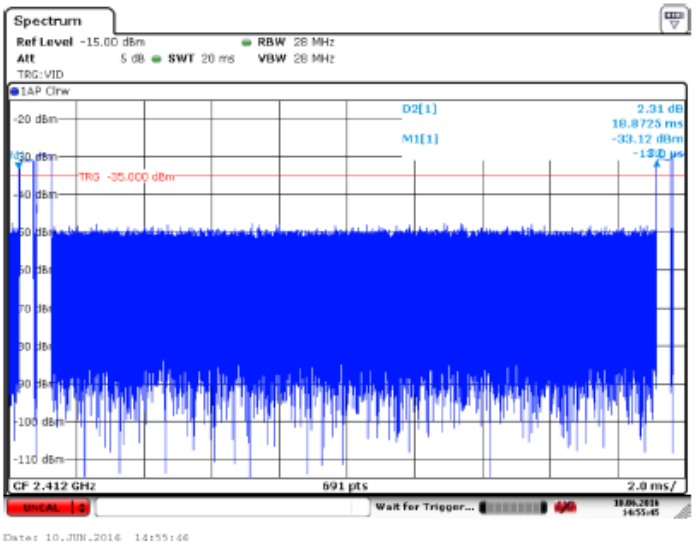

Figure 6. Transmission of commissioning events on press of the rocker
(3rd telegram is missing due to the limited bandwidth of the measuring device)

PTM 215B duty cycle

Duty cycle calculation for commissioning telegrams

If we observe 100 ms period, max. number of events transmitted in this mode is 2 events on press of the rocker and 2 events on release of the rocker. Physically we cannot press and release rockers more than 1 time in 100 ms.
This result in total 12 telegrams being transmitted in 100 ms period.

Since each telegram is 422 µs long, total on time in 100 ms period when we sum all channels is: 422 µs x 12 = 5.1 ms

Total on time per single channel is 422 µs x 4 = 1.7 ms.

Duty cycle is then:

If we observe total on time in all channels:

- Total on time = 5.1 ms
- Interval = 100 ms
- **Duty cycle = 5.1 %**

If we observe total on time per channel:

- Total on time = 1.7 ms
- Interval = 100 ms
- Duty cycle = 1.7 %

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PTM 215B duty cycle

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Conclusion

PTM 215 B observed in 100 ms transmission period does not have duty cycle bigger than 6%.

The maximums show that in operation mode worst case duty cycle is 5.8% when extra 4 bytes bytes are transmitted over all 3 radio channels.

Standard operation mode transmissions (29 bytes) or commissioning mode transmissions duty cycle have the same value of 5.1 % over all 3 radio channels.

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