TEST REPORT # EMCC-110010.1GD, 2019-11-26

EQUIPMENT UNDER TEST:

Trade Name:	TCM 515B
EUT Number, Serial Number(s):	EUT#1, 434503001303
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515B
IC:	5713A-TCM515B
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching GERMANY

RELEVANT STANDARD(S):

47 CFR § 15.247
RSS-247 Issue 2
RSS-102 Issue 5

MEASUREMENT PROCEDURE:

ANSI C63.10-2013, RSS Gen Issue 5 Amendment 1
KDB 558074 D01 15.247 Meas Guidance v05r02
KDB 447498 D01 General RF Exposure Guidance v06

TEST REPORT PREPARED BY:

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Tested:

Dominik Krüger

Ludwig Kraft

Approved:

Reinhard Sauerschell

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0 REVISION HISTORY

Project number	Issue date	Chapter	Description
110010.1GD	2019-11-26	n.a.	Initial issue

1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance with the 47 CFR § 15.247 and RSS-247 Issue 2 requirements for the certification of licence–exempted 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 Laboratory

Test Laboratory:	EMCCons DR. RAŠEK GmbH & Co. KG
DAkkS Accreditation No.:	D-PL-12067-01-03 D-PL-12067-01-04
FCC Test Firm Registration No.:	368753
ISED Wireless Test Sites:	3464C
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
Phone:	+49 9194 7262-0
Fax:	+49 9194 7262-199
E-Mail:	info@emcc.de
Web:	www.emcc.de

1.4 Customer

Company Name:	EnOcean GmbH
Street:	Kolpingring 18 a
City:	82041 Oberhaching
Country:	GERMANY
Name:	Mr Darius Draksas
Phone:	+49 89 6734 689-627
Fax:	+49 89 6734 689-56
E-Mail:	darius.draksas@enocean.com

1.5 Manufacturer

Company Name:	EnOcean GmbH
Street:	Kolpingring 18 a
City:	82041 Oberhaching
Country:	GERMANY
Phone:	+49 89 6734 689-0
E-Mail:	info@enocean.com

1.6 Dates and Test Location

Date of receipt of EUT: 2019-05-21
Test Date: see list below
Test Location: Lab IV

1.7 Ordering Information

Purchase Order: 11141
Date: 2019-05-14
Vendor-Number: K701624

1.8 Climatic Conditions

Date	Temperature	Relative Humidity	Air Pressure	Lab	Customer attended tests
--	°C	%	hPa	--	--
2019-07-30	27	55	973	IV	No
2019-07-31	26	56	977	IV	No
2019-09-09	23	46	972	IV	No
2019-10-11	22	45	978	IV	No
2019-10-21	22	47	978	IV	No
2019-10-22	22	47	982	IV	No

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

The following data is based on customer's information.

Manufacturer:	EnOcean GmbH
Trade name:	TCM 515B
EUT No, Serial No(s):	EUT#1, 434503001303
Application:	Wireless Remote Control
No of variants:	None
Firmware version:	1.4.0.1.
Hardware version:	DB-3
FCC ID:	SZV-TCM515B
IC:	5713A-TCM515B
Highest internal frequency:	2480 MHz
TX operating frequency range:	2402 .. 2480 MHz
Used channels during test:	Fmin: 2402 MHz (CH 37) Fmid: 2442 MHz (CH 18) Fmax: 2480 MHz (CH 39)
Modulation	GFSK
Data rate(s):	Data rate 1 Mbps and 2 Mbps (all tests in the report are done with 2 Mbps mode)
Power source:	3.3 V DC module power via Eval-Board
Voltage for testing:	5 V DC via USB (Power supply for Eval-Board)
Ports:	UART
Antenna:	External RP-SMA antenna, max. 5 dBi
Max. antenna gain:	n/a
Remarks:	None

2.2 Intended Use

The following information was delivered by the customer.

"
TCM 515B provides radio transceiver functionality (telegram transmission and reception) according to the Bluetooth Low Energy standard in the 2.4 GHz radio band. TCM 515B receives and transmits radio telegrams based on a whip or PCB antenna connected via the host PCB.

TCM 515B is primarily intended for use within energy harvesting wireless sensors where it will provide the required radio functionality. To meet this requirement, TCM 515B provides a radio application programming interface (API) for transmission and reception of 2.4 GHz BLE radio telegrams. This radio API can be used by sensor applications running on TCM 515B to transmit and receive radio telegrams.

Additionally, TCM 515B provides an ESP3 interface to an external host which can be used to transmit and receive data telegrams.

TCM 515B provides an I2C interface which can be used to connect external sensors. TCM 515B is implemented as 31 pin reflow-solderable module in an optimized form factor to enable size constrained applications. The module design is mechanically compatible with the other members of the TCM 515 radio transceiver family to enable reuse.
"

2.3 EUT Peripherals/Simulators

The EUT was connected to an Eval-Board called EOP350 which was powered by 5 V DC from USB connector. The USB connection was disconnected during the measurement. The power supply was established by bypassing the USB power lines and powering the EUTs by an external DC power supply.

2.4 Mode of operation during testing and test setup

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

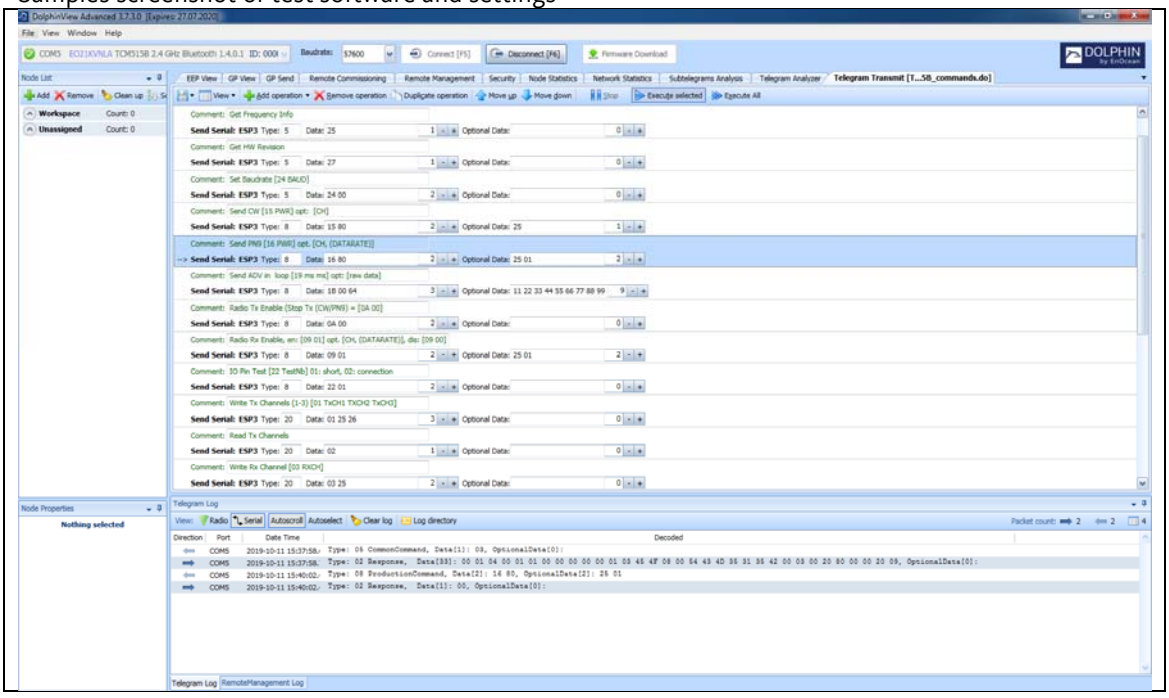
Continuous Transmit:
The EUT was continuously transmitting modulated data (2Mbps) and maximum power. The duty cycle was increased to nearly 100 % for testing purpose, only. The setting was performed via a software tool called DolphinView Advanced (version 3.7.3.0). This mode of operation was used for all tests.

List of channels and their corresponding frequencies provided by customer:

Frequency [MHz]	Channel #	Frequency [MHz]	Channel #	Frequency [MHz]	Channel #
2402	**37**	2429	53	2456	25
2403	40	2430	12	2457	67
2404	0	2431	54	2458	26
2405	41	2432	13	2459	68
2406	1	2433	55	2460	27
2407	42	2434	14	2461	69
2408	2	2435	56	2462	28
2409	43	2436	15	2463	70
2410	3	2437	57	2464	29
2411	44	2438	16	2465	71
2412	4	2439	58	2466	30
2413	45	2440	17	2467	72
2414	5	2441	59	2468	31
2415	46	**2442**	**18**	2469	73
2416	6	2443	60	2470	32
2417	47	2444	19	2471	74
2418	7	2445	61	2472	33
2419	48	2446	20	2473	75
2420	8	2447	62	2474	34
2421	49	2448	21	2475	76
2422	9	2449	63	2476	35
2423	50	2450	22	2477	77
2424	10	2451	64	2478	36
2425	51	2452	23	2479	78
2426	38	2453	65	**2480**	**39**
2427	34	2454	24	---	---
2428	11	2455	66	---	---

Note: Frequencies/channels were used for testing in bold.

Samples screenshot of test software and settings



2.5 Modifications required for compliance

None.

2.6 Duty-Cycle Correction

The following declaration was made by the customer on 2017-07-21 via email:

> *Any application firmware of TCM 515B operates with a maximum duty cycle of 20%.*
> *One telegram transmission takes a maximum time on air of 510 µs.*
> *The duty cycle limit is ensured by sending no more than 39 telegrams during any period of 100ms.*

According to the description delivered by customer, the duty cycle is limited to 20 % resulting in a maximum ON-Time of 510 µs * 39 Packages = 19.9 ms in each 100 ms interval.

For average correction purposes, a duty cycle correction factor of (19.9 ms / 100 ms) * 100 = 19.9 % was used.

Expressed in logarithmic terms, the correction factor DCF is
20 x log (19.9 ms/100 ms) = -14.0 dB.

3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: EnOcean GmbH
Device: TCM 515B
EUT#, Serial No. : EUT#1, 434503001303

Requirement	47 CFR Section	RSS Section	Report Section	Result
Antenna Requirement	§ 15.203	-	4.1	Passed
AC Power Line Conducted Emissions	§ 15.207	RSS-Gen 8.8	4.2	Passed
Occupied Bandwidth	§ 15.247	RSS-247, 5.2	4.3	Passed
Fundamental Output Power	§ 15.247	RSS-247, 5.4	4.4	Passed
Power Spectral Density	§ 15.247	RSS-247, 5.2	4.5	Passed
Band Edge Compliance	§ 15.209 § 15.247	RSS-247, 5.5, RSS-Gen 8.9	4.6	Passed
Radiated Emissions 9kHz – 30 MHz	§ 15.209 § 15.205	RSS-247, 5.5, RSS-Gen 8.9	4.7.4	Passed
Radiated Emissions 30 MHz – 1000 GHz	§ 15.209 § 15.205	RSS-247, 5.5, RSS-Gen 8.9	4.7.5 - 8	Passed
Radiated Emissions 1 GHz – 26 GHz	§ 15.209 § 15.205	RSS-247, 5.5, RSS-Gen 8.9	4.7.9 - 11	Passed
RF Exposure Evaluation	§ 2.1093	RSS-102	4.8	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 and all applicable Public Notices received prior to the date of testing.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: 2019-11-26

4 DETAILED TEST RESULTS

4.1 Antenna Requirement

4.1.1 Regulation

47 CFR §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, 15.221, or §15.236. 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: 6.8 Transmit Antenna

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.
For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).
When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.
The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.
For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

> This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

4.1.2 Test Result

The EUT has an RP (reverse polarity) SMA antenna connector.

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.2 AC Power Line Conducted Emissions

4.2.1 Regulation

47 CFR § 15.207 Conducted limits

(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

RSS-GEN 8.8 AC power-line conducted emission limits

Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in table 4, as measured using a 50 µH / 50 Ω line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.
For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in table 4 shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The lower limit applies at the boundary between the frequency ranges. The device used to power the EUT shall be representative of typical applications.

Table 4 – AC power-line conducted emissions limits

Frequency (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56[1]	56 to 46[1]
0.5-5	56	46
5-30	60	50

Note 1: The level decreases linearly with the logarithm of the frequency.

4.2.2 Test Procedures

Testing is performed acc. to ANSI C63.10-2013.

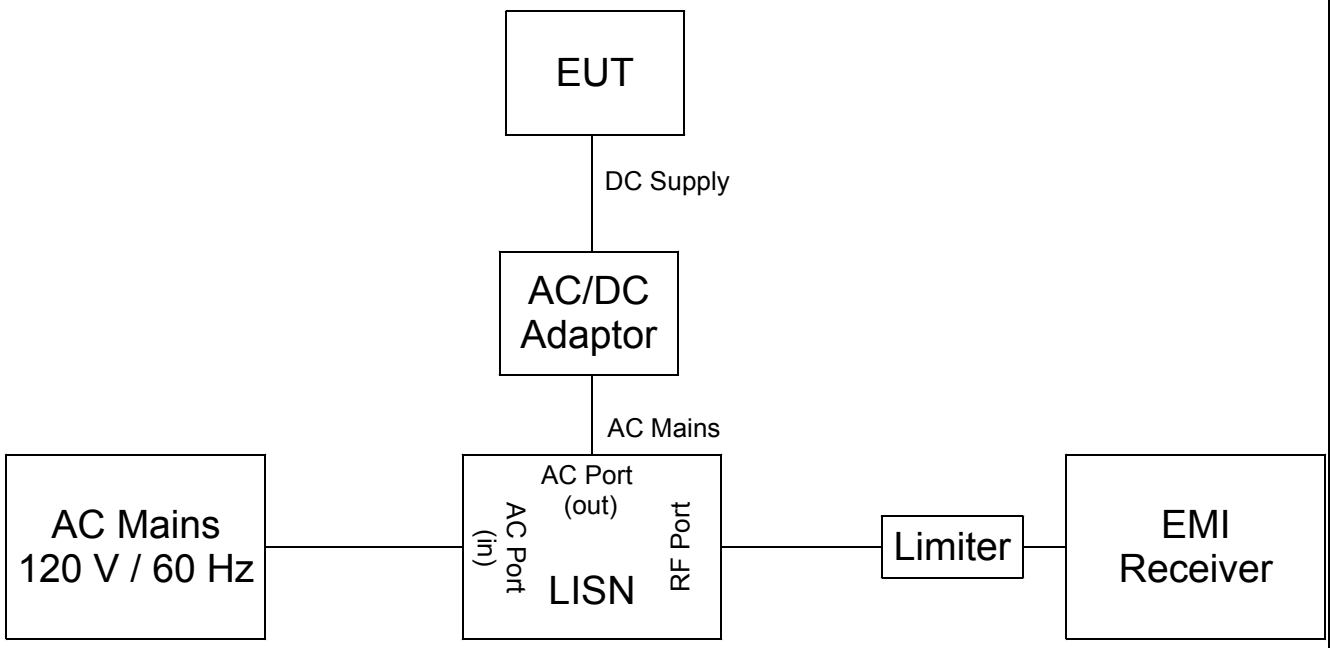
Tabletop and their ancillary devices are placed on a nonconducting table with nominal dimension of 1.0 m by 1.5 m, height 0.8 m above the ground plane. The EUT is centered laterally (left to right facing the tabletop) on the tabletop and its rear is flush with the rear of the table. Accessories or peripherals that are part of a system tested on a tabletop are being placed in a test arrangement on one or both sides of the host with a 10 cm separation between the nearest points of the cabinets.

Interconnecting cables that hang closer than 40 cm to the ground plane are folded back and forth in the center forming a bundle 30 cm to 40 cm long.

The measurement receiver is connected to the 50 Ω RF port of the LISN.

For the AC conducted measurement the EUT was connected to the Eval-Board and the Eval-Board was connected via USB to a Laptop. The power supply of the Laptop was connected to the LISN.

4.2.3 Test Setup



SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.207
Procedure: ANSI C63.10-2013

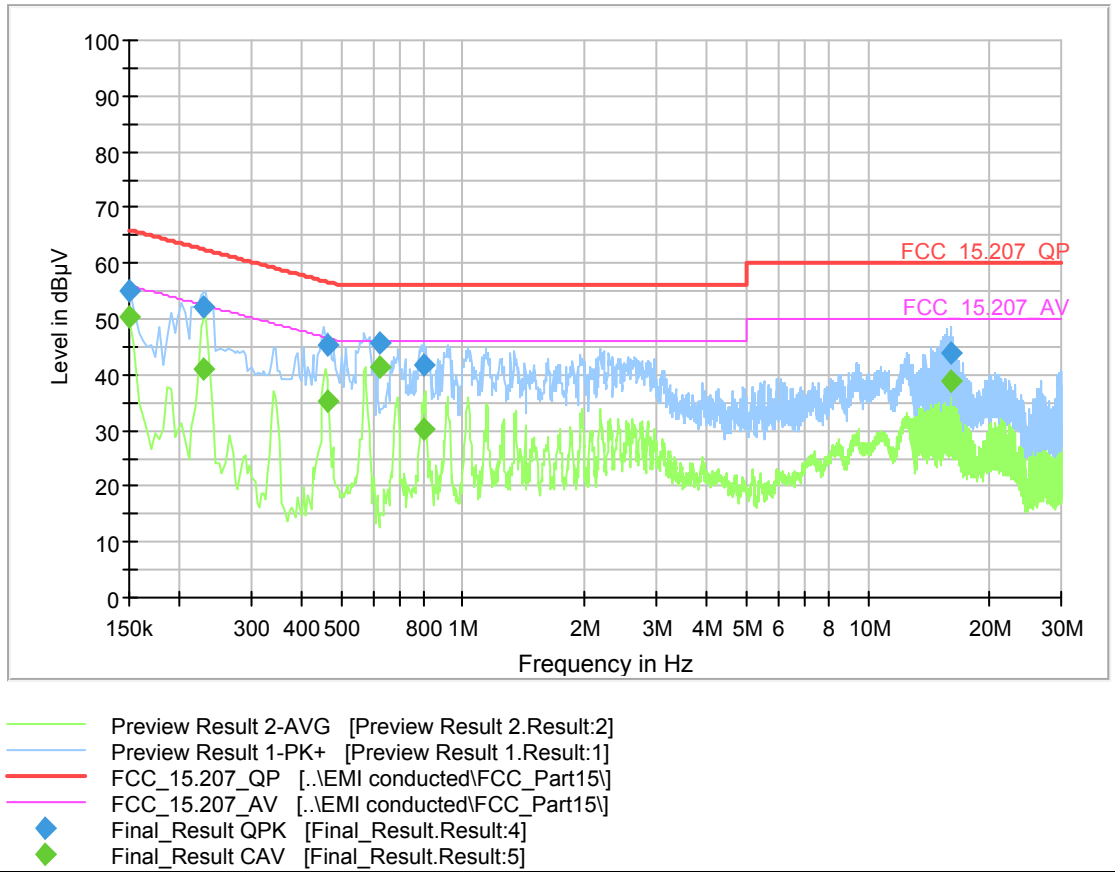
Power source: #34
Receiver: #3846
LISN: #1901

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
34, 1519, 1890, 1901, 2719, 3846, 4018, 4597, 4717, 5392, 5551

Sample photo of setup

4.2.4 Detailed Test Data

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
Serial No:	EUT#1, 434503001303
Mode:	Fmin 2402 MHz
Line:	L and N (max hold)



Final Result:

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.15	54.9	---	66.0	11.1	1000	9	N	10
0.15	---	50.4	56.0	5.6	1000	9	N	10
0.23	52.1	---	62.5	10.3	1000	9	L1	10
0.62	---	41.5	46.0	4.5	1000	9	L1	10
0.62	45.6	---	56.0	10.4	1000	9	L1	10
16.05	---	38.9	50.0	11.1	1000	9	N	10

Worst case results listed, only.

4.2.5 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-10-11
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.3 Occupied Bandwidth

4.3.1 Regulation

47CFR § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(a) (2) Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS-247, Digital transmission systems

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

a) The minimum 6 dB bandwidth shall be 500 kHz.

...

RSS-Gen 6.7 Occupied bandwidth

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

...

4.3.2 Test Procedures

Testing is performed acc. to ANSI C63.10-2013:

Chapter 11.8.1 Option 1 (DTS bandwidth, 6 dB bandwidth)

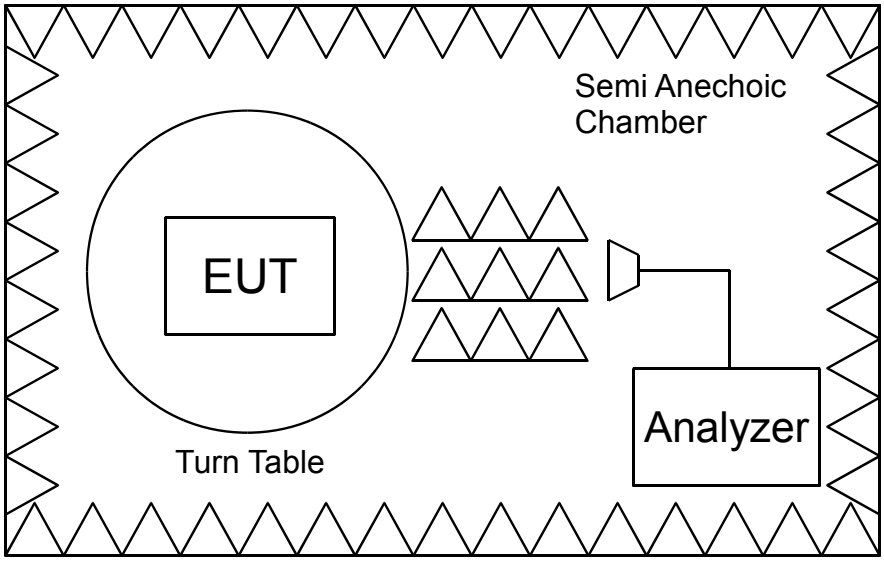
The steps for the first option are as follows:

a) Set RBW = 100 kHz.
b) Set the VBW ≥ [3 × RBW].
c) Detector = peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

99% bandwidth:

a) Set RBW = 30 kHz.
b) Set the VBW ≥ [3 × RBW].
c) Detector = peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the 99% emission using the analyser measurement.

4.3.3 Test Setup

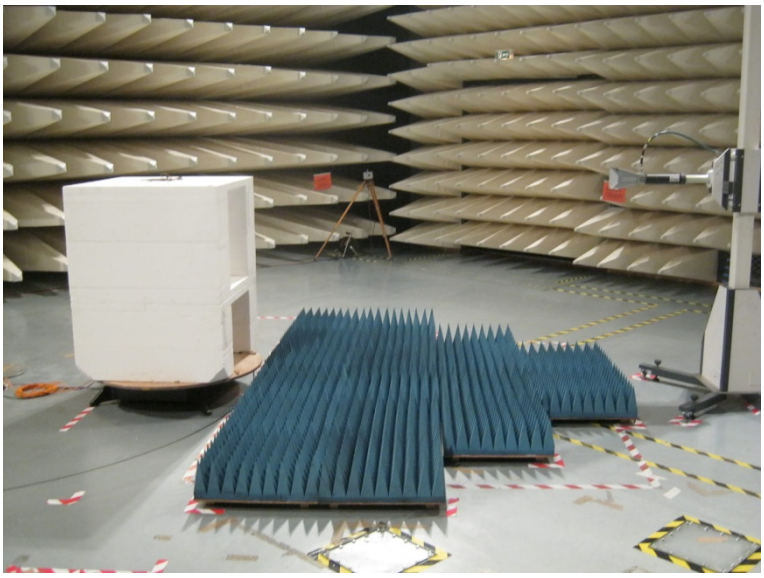


SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.247
RSS-247, RSS-Gen 6.7
Procedure: ANSI C63.10-2013

Test distance: 3 m

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
519, 1889, 3236, 3846, 4075, 4717, 5392, 5535, 5536, 5545, 5616

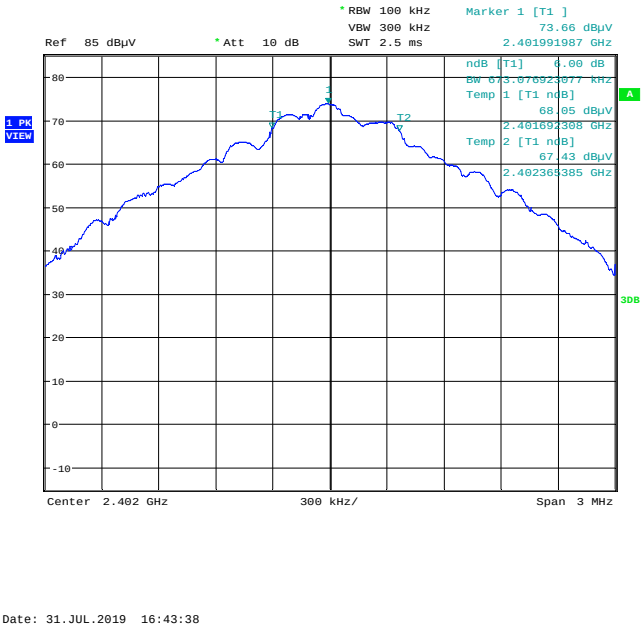


Sample photo of setup

4.3.4 Detailed Test Data

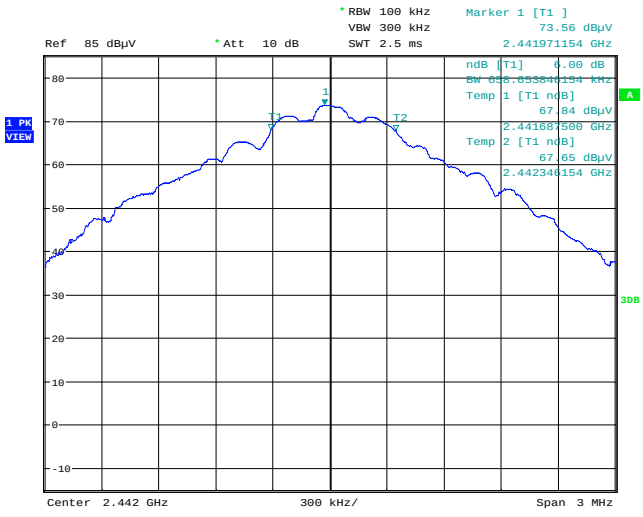
4.3.4.1 6 dB Bandwidth

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2402 MHz



Date: 31.JUL.2019 16:43:38

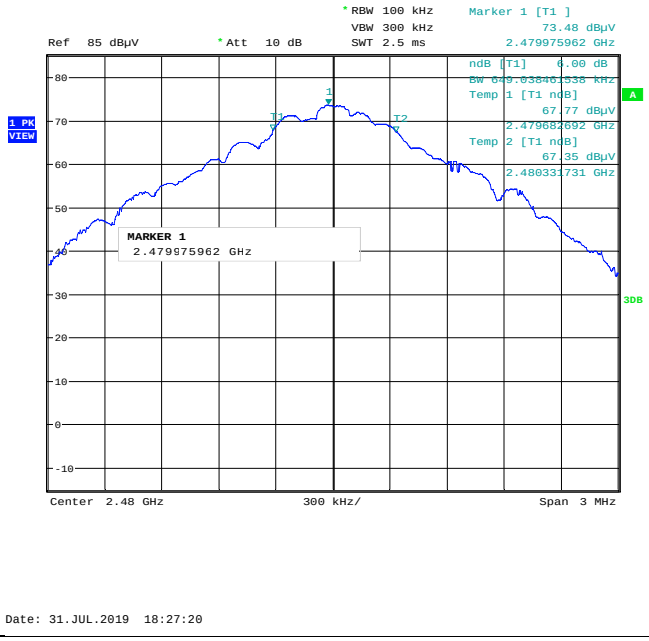
Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2442 MHz



Date: 31.JUL.2019 18:09:37

Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2480 MHz

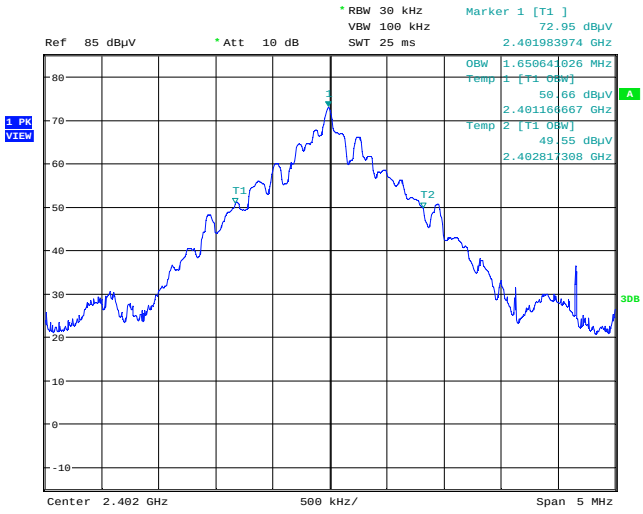


Final Result:

Operating Frequency (MHz)	Lower Edge (MHz)	Upper Edge (MHz)	Limit (MHz)	6 dB Bandwidth (MHz)
2402.0	2401.692	2402.365	≥ 0.5	0.673
2442.0	2441.688	2442.346	≥ 0.5	0.658
2480.0	2479.682	2480.332	≥ 0.5	0.650

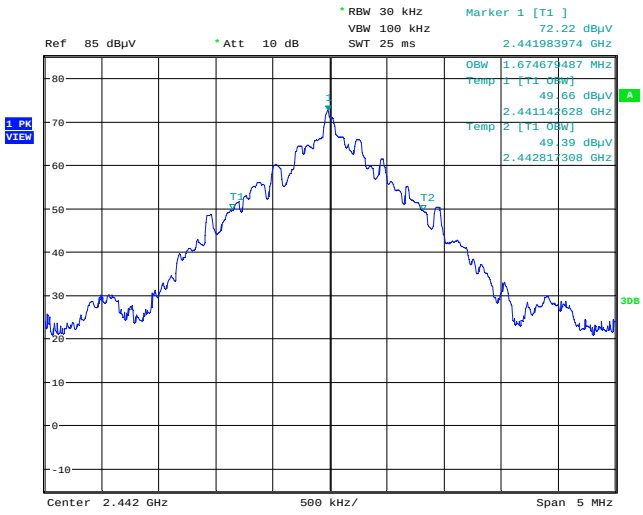
4.3.4.2 99 % Bandwidth

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2402 MHz



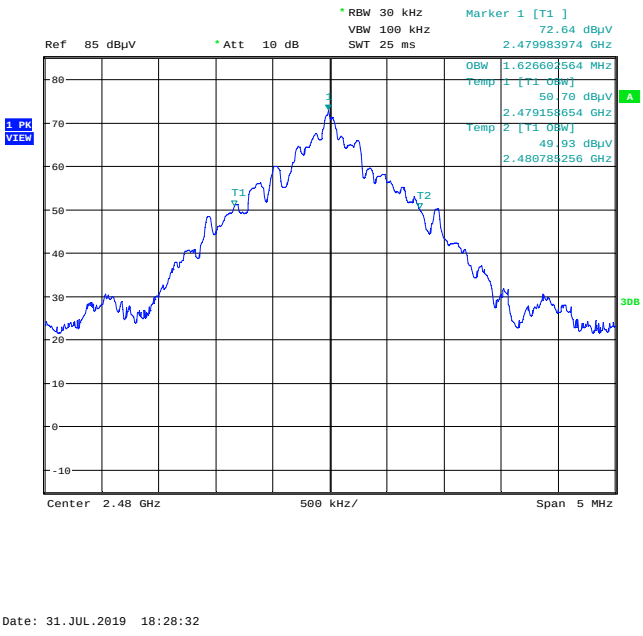
Date: 31.JUL.2019 16:42:00

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2442 MHz



Date: 31.JUL.2019 18:10:49

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2480 MHz



Final Result:

Operating Frequency (MHz)	Lower Edge (MHz)	Upper Edge (MHz)	Limit Frequency band (MHz)	99% Bandwidth (MHz)
2402.0	2401.17	2402.82	2400 .. 2483.5	1.7
2442.0	2441.14	2442.82	2400 .. 2483.5	1.7
2480.0	2479.16	2480.79	2400 .. 2483.5	1.6

4.3.4.3 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-31
Test personnel:	Dominik Krüger

The EUT meets the requirements of this section.

4.4 Fundamental Output Power

4.4.1 Regulation

47 CFR,§ 15.31

(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle.
1 to 10 MHz	2	1 near top and 1 near bottom.
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom.

47CFR § 15.247

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

...

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247, 5.4 Transmitter output power and equivalent isotropically radiated power (e.i.r.p.) requirements

Devices shall comply with the following requirements:

d) For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).
As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

4.4.2 Test Procedures

ANSI C63.10-2013, 11.9 Fundamental emission output power

11.9.1 Maximum peak conducted output power

One of the following procedures may be used to determine the maximum peak conducted output power of a DTS EUT.

11.9.1.1 RBW ≥ DTS bandwidth

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Set span ≥ [3 × RBW].
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

RSS-Gen, 6.12 Transmitter output power

Before performing this measurement, the power of the EUT shall be set or controlled to the maximum rating of the range for which equipment certification or verification is sought.

Except where otherwise specified, tests shall be performed at the ambient temperature, at the manufacturer's rated supply voltage, and with the transmitter modulating signal representative (i.e. typical) of those encountered in a real system operation.

The spectrum analyzer shall be configured with a resolution bandwidth that encompasses the entire occupied bandwidth (see section 6.7) of the EUT. If the spectrum analyzer's largest available resolution bandwidth is smaller than the occupied bandwidth of the EUT, it is permitted to use a narrower resolution bandwidth plus numerical integration, in linear power terms, over the occupied bandwidth of the transmitter in order to measure its output power, except when the emission is a wideband noise-like signal and being measured for peak power. For transmitters with constant envelope modulation, RF output power and field strength measurements performed on the fundamental frequency can be carried out with an unmodulated carrier. The method used shall be described in the test report.

If the antenna is detachable, the transmitter output power may be measured at the antenna port using conducted measurement.

If the antenna is not detachable, field strength measurements shall be made using a test site that complies with the appropriate normative reference.

The following formula[Notes 1,2] may be used to convert measured electric field strength (FS), in Volts/metre, to transmitter output power delivered to the antenna (TP), in Watts:

$$TP = (FS \times D)^2/(30 \times G)$$

where D is the distance in metres between the measurement antenna and the transmit antenna (of the EUT) and G is the numerical gain of the transmit antenna, referenced to isotropic gain, in dBi.

Note 1: When performing radiated measurements on an open area test site or alternative test site, the influence of the metal ground plane on the maximum field strength value should be considered before calculating TP.

Note 2: The above formula is only valid if the measurement is performed under far-field conditions.

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 6 GHz
Test distance	3 m
Test instrumentation resolution bandwidth	3 MHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

4.4.3 Power Calculation

The conducted power can be calculated from a receiver's reading by the use of the following equation:

P_{cond} = RA + AF + CF + 20 log D - 104.77 - G

where
P_{cond} = conducted output power in dBm
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
D = specified measurement distance in meters
G = gain of the antenna in dBi

Assume a receiver reading RA of 74.2 dBµV is obtained in a measurement distance of 3m. The Antenna Factor AF of 27.6 dB(1/m), Cable Factor CF of 1.6 dB, a constant of 104.77, the distance, expressed in logarithmic terms 20*log(3m) and the gain of the RX antenna of 5 dBi resulting in a conducted output power of 3.2 dBm.

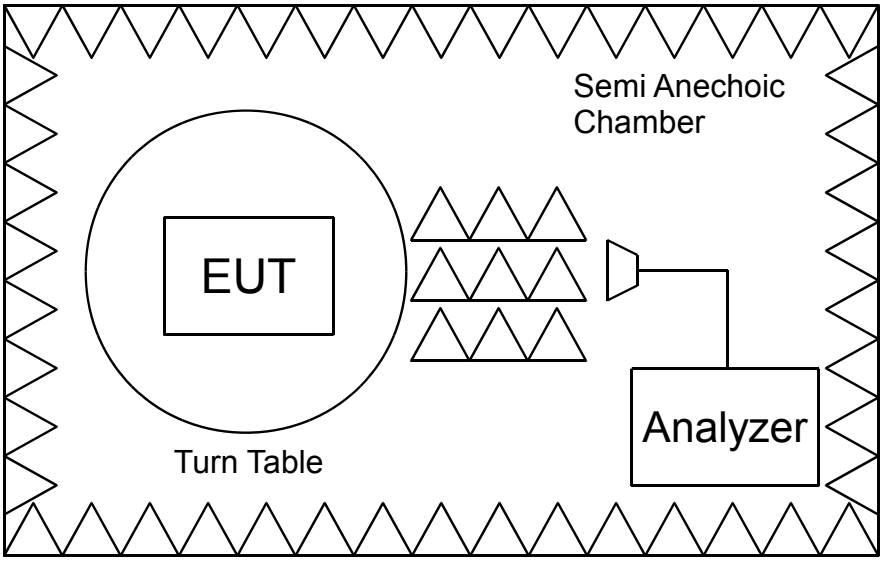
The equivalent isotropic radiated power can be calculated from a receiver's reading by the use of the following equation:

P_{EIRP} = RA + AF + CF + 20 log D - 104.77

where
P_{EIRP} = equivalent isotropic radiated power in dBm
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
D = specified measurement distance in meters

Assume a receiver reading RA of 74.2 dBµV is obtained in a measurement distance of 3m. The Antenna Factor AF of 27.6 dB(1/m), Cable Factor CF of 1.6 dB, a constant of 104.77, the distance, expressed in logarithmic terms 20*log(3m) resulting in a EIRP power of 8.2 dBm.

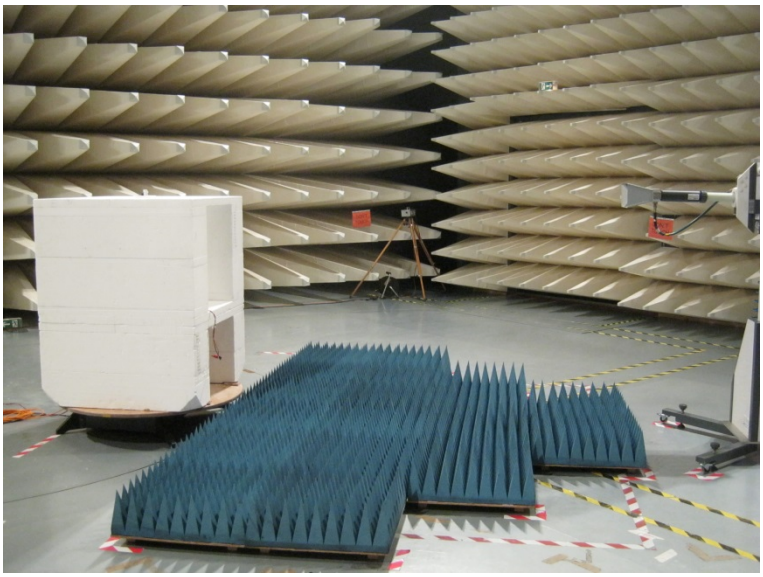
4.4.4 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.247 RSS-247
Procedure:	ANSI C63.10-2013 RSS-Gen
Test distance:	3 m (1 – 6 GHz)

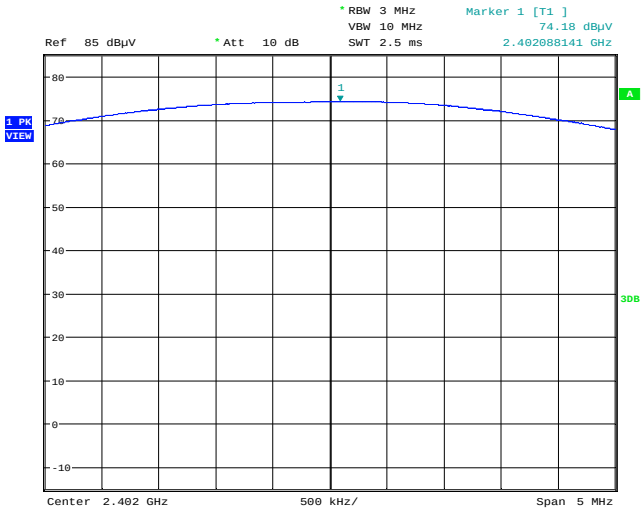
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
519, 1889, 3236, 3846, 4075, 4717, 5392, 5535, 5536, 5545, 5616



Sample photo of setup (1 – 6 GHz)

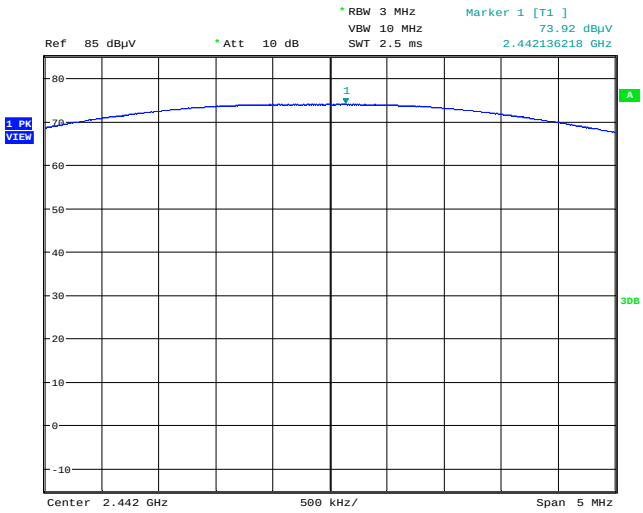
4.4.5 Detailed Test Data

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2402 MHz



Date: 31.JUL.2019 16:45:16

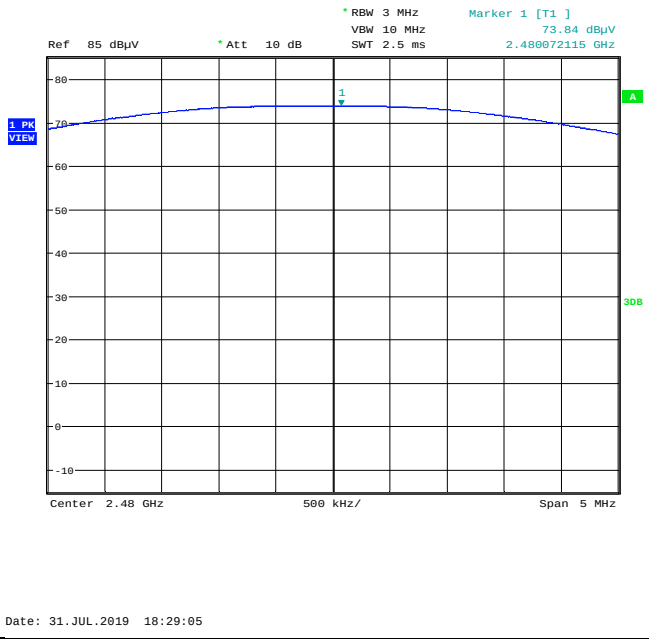
Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#2, 434503001303
Frequency:	2442 MHz



Date: 31.JUL.2019 18:11:24

Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#3, 434503001303
Frequency:	2480 MHz



Final Result

Conducted output power							
EUT Frequency (MHz)	PK Reading @ 3m dist. (dBµV)	AF (dB 1/m)	CF (dB)	Ant. Gain (dBi)	P_{cond} Result (dBm)	Limit (dBm)	Margin (dB)
2402	74.2	27.6	1.6	5	3.2	30	26.8
2442	73.9	27.6	1.6	5	2.9	30	27.1
2480	73.8	27.6	1.6	5	2.8	30	27.2

Equivalent isotropically radiated power						
EUT Frequency (MHz)	PK Reading @ 3m dist. (dBµV)	AF (dB 1/m)	CF (dB)	P_{EIRP} Result (dBm)	Limit (dBm)	Margin (dB)
2402	74.2	27.6	1.6	8.2	36	27.8
2442	73.9	27.6	1.6	7.9	36	28.1
2480	73.8	27.6	1.6	7.8	36	28.2

All tests performed at the distance of d = 3 m.

4.4.6 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-31
Test personnel:	Dominik Krüger

The EUT meets the requirements of this section.

4.5 Power Spectral Density

4.5.1 Regulation

47CFR § 15.247

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

RSS-247, 5.2 Digital transmission systems

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:
a) The minimum 6 dB bandwidth shall be 500 kHz.
b) The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

4.5.2 Test Procedures

ANSI C63.10-2013, 11.10 Maximum power spectral density level in the fundamental emission
11.10.2 Method PKPSD (peak PSD)

The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:
a) Set analyzer center frequency to DTS channel center frequency.
b) Set the span to 1.5 times the DTS bandwidth.
c) Set the RBW to 3 kHz ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ [3 × RBW].
e) Detector = peak.

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 6 GHz
Test distance	3 m
Test instrumentation resolution bandwidth	3 kHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

4.5.3 Power Calculation

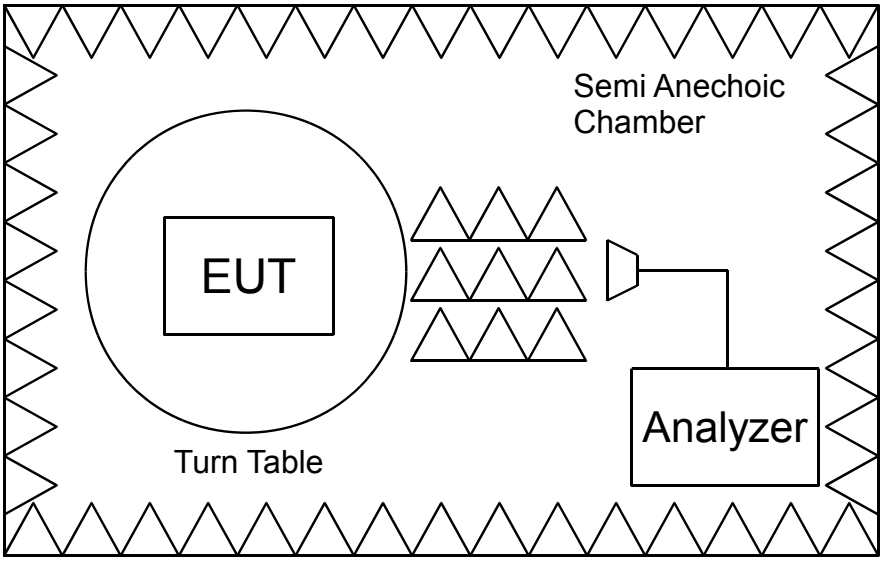
The power spectral density per defined bandwidth can be calculated from a receiver's reading by the use of the following equation:

P_{PSD} = RA + AF + CF + 20 log D - 104.77 - G

where
P_{PSD} = power spectral density in dBm per defined bandwidth
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
D = specified measurement distance in meters
G = gain of the antenna in dBi

Assume a receiver reading RA of 64.2 dBµV with a RBW of 3 kHz is obtained in a measurement distance of 3m. The Antenna Factor AF of 27.6 dB(1/m), Cable Factor CF of 1.6 dB, a constant of 104.77, the distance, expressed in logarithmic terms 20*log(3m) and the gain of the RX antenna of 5 dBi resulting in a power spectral density of -6.8 dBm / 3 kHz.

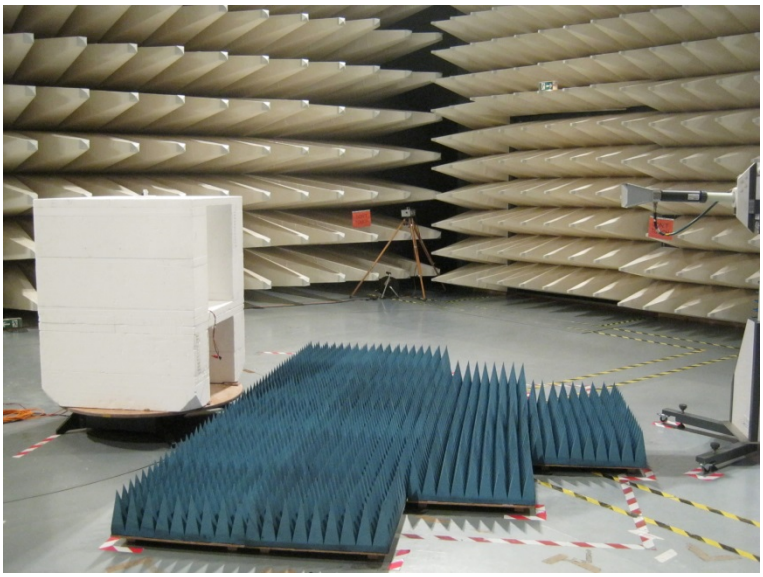
4.5.4 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.247 RSS-247
Procedure:	ANSI C63.10-2013 RSS-Gen
Test distance:	3 m (1 – 6 GHz)

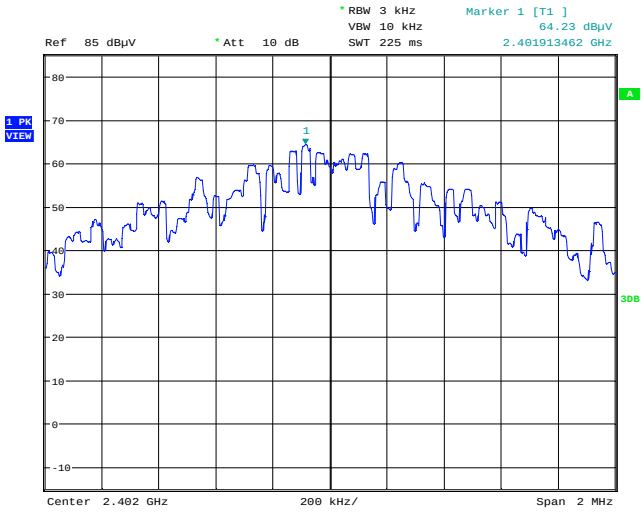
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
519, 1889, 3236, 3846, 4075, 4717, 5392, 5535, 5536, 5545, 5616



Sample photo of setup (1 – 6 GHz)

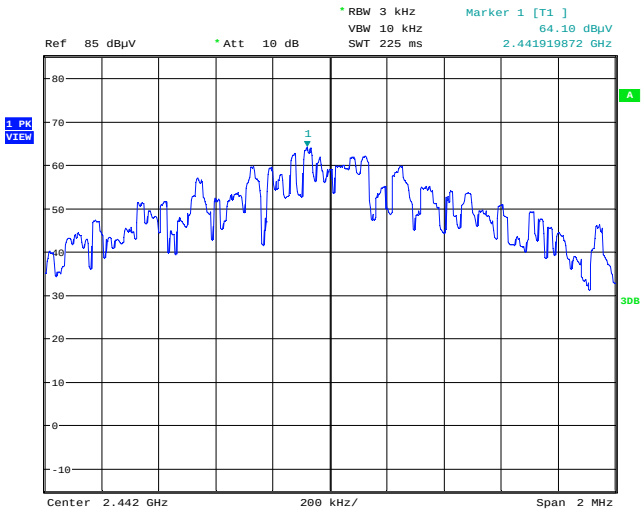
4.5.5 Detailed Test Data

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2402 MHz



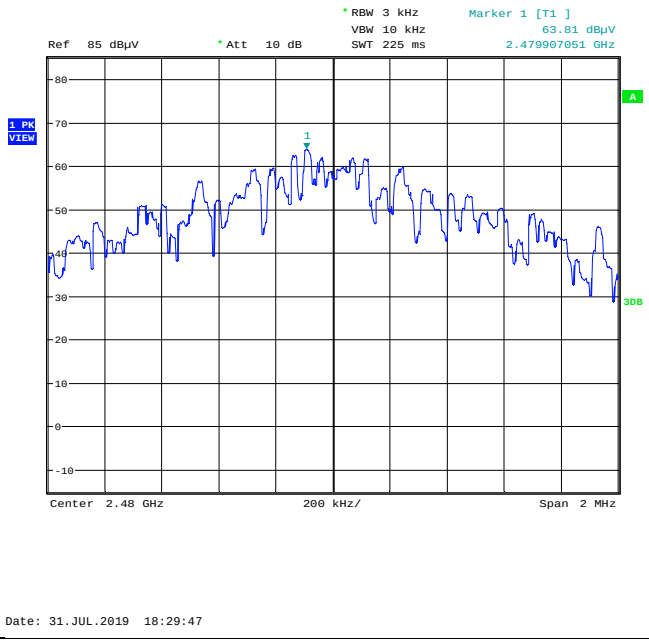
Date: 31.JUL.2019 16:57:13

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#2, 434503001303
Frequency:	2442 MHz



Date: 31.JUL.2019 18:12:16

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#3, 434503001303
Frequency:	2480 MHz



Final Result

Power Spectral Density							
EUT Frequency (MHz)	PK Reading @ 3m dist. (dBµV)	AF (dB 1/m)	CF (dB)	Ant. Gain (dBi)	P_{cond} Result (dBm)	Limit (dBm)	Margin (dB)
2402	64.2	27.6	1.6	5	-6.8	8	14.8
2442	64.1	27.6	1.6	5	-6.9	8	14.9
2480	63.8	27.6	1.6	5	-7.2	8	15.2

All tests performed at the distance of d = 3 m with RBW of 3kHz.

4.5.6 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-31
Test personnel:	Dominik Krüger

The EUT meets the requirements of this section.

4.6 Bandedge Compliance

4.6.1 Regulation

47 CFR § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

47 CFR §15.205 Restricted bands of operation.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

47 CFR § 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 (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	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.

RSS-247, 5.5 Unwanted emissions
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

RSS-Gen, 8.9 Transmitter Emission Limits for Licence-Exempt Radio Apparatus
Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table 5 and table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

Table 5 – General field strength limit at frequencies above 30 MHz

Frequency (MHz)	Field strength (µV/m @ 3 m)
30-88	100
88-216	150
216-960	200
Above 960	500

RSS-Gen, 8.10 Restricted frequency bands

Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:
(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, Emergency Position Indicating Radio Beacons (EPIRB), Emergency Locator Transmitters (ELT), Personal Locator Beacons (PLB), and Maritime Survivor Locator Devices (MSLD).

(b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.

(c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

Table 7 – Restricted frequency bands*

MHz	MHz	GHz
0.090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6
8.362 - 8.366	1660 - 1710	
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138	--	

* Certain frequency bands listed in table 7 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

4.6.2 Test Procedure

ANSI C63.10-2013, 11.13 Band-edge measurements

11.13.1 General

Emissions within a restricted band and within 2 MHz of an authorized band edge may be measured using either the marker-delta method or the integration method, which is described in 11.13.3, provided that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge. Otherwise, all unwanted emissions measurements shall be performed using the standard methods.

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).

4.6.3 Calculation of Field Strength Limits

E.g. general field strength limits 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 (in dBµV/m)

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

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

4.6.4 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 36.9 dBµV is obtained. The Antenna Factor of 27.4 dB(1/m) and a Cable Factor of 1.5 dB are added, giving a field strength of 65.8 dBµV/m in the measurement distance. The field strength of 65.8 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 36.9 + 27.4 + 1.5 = 65.8
Level (in µV/m) = Common Antilogarithm (65.8/20) = 1949.8

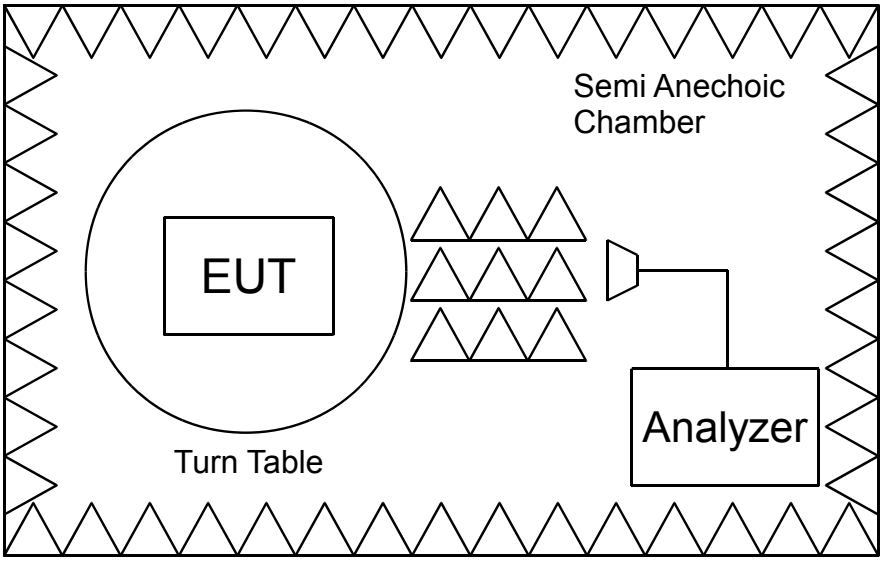
All emission measurements described in this chapter performed using the EMI receiver's transducer factor setting capability, i.e. the peak field strength value at the test distance was measured directly without the necessity of additional correction factors.

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 65.8 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -14.0 dB corresponds with 51.8 dBµV/m.

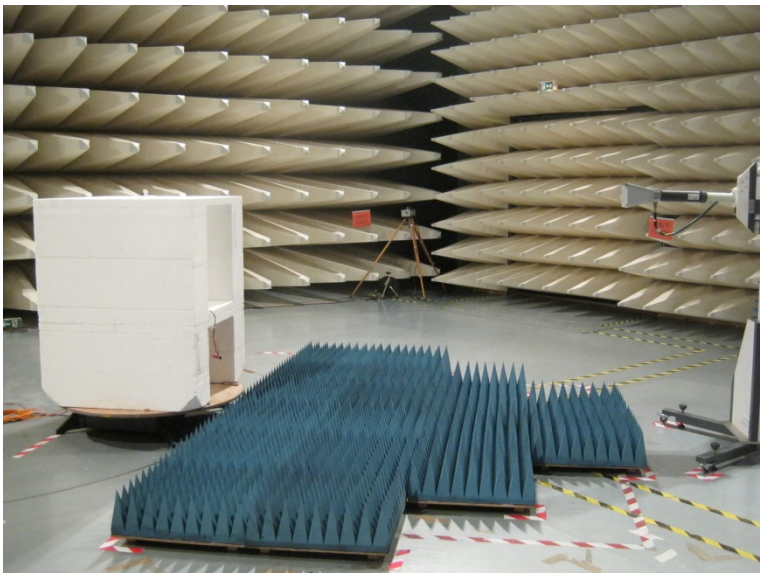
4.6.4.1 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.247 RSS-247
Procedure:	ANSI C63.10-2013 RSS-Gen
Test distance:	3 m (1 – 6 GHz)

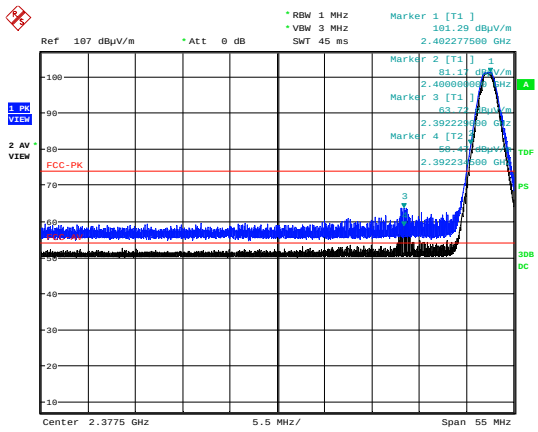
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
519, 1889, 3236, 3846, 4075, 4717, 5392, 5535, 5536, 5545, 5616



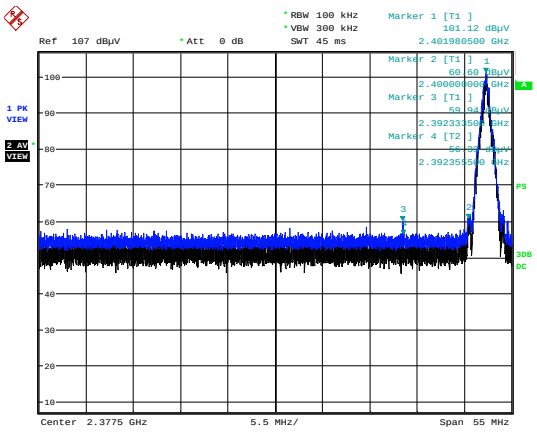
Sample photo of setup (1 – 6 GHz)

4.6.4.2 Detailed Test Data

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Frequency:	2402 MHz

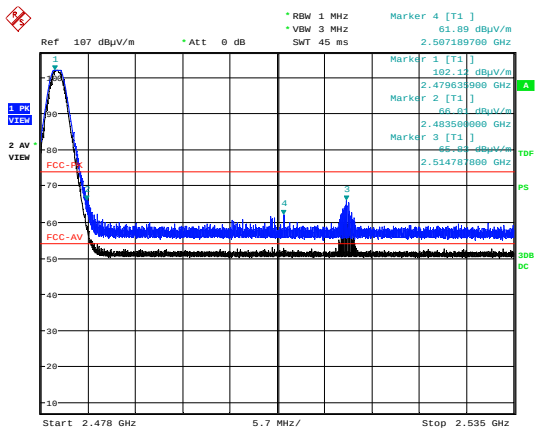


EUT: TCM 515B, EUT-Freq: 2402MHz
Date: 22.OCT.2019 10:22:25

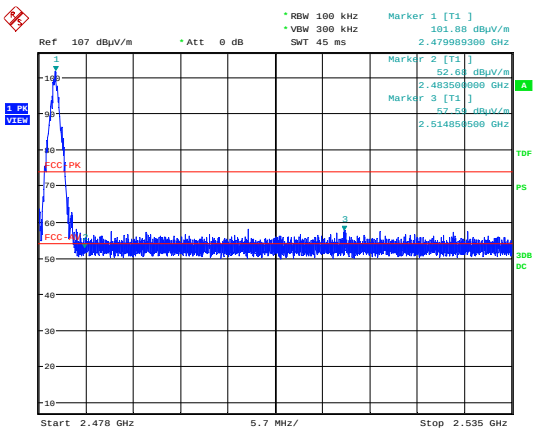


EUT: TCM 515B, EUT-Freq: 2402MHz
Date: 25.OCT.2019 15:04:57

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#3, 434503001303
Frequency:	2480 MHz



EUT: TCM 515B, EUT-Freq: 2480MHz
Date: 22.OCT.2019 11:01:24



EUT: TCM 515B, EUT-Freq: 2480MHz
Date: 22.OCT.2019 11:07:38

Note: The transducer factor (TDF) contains the Antenna Factor (AF) and the Cable Attenuation Factor (CF)

Final Result

Bandedge – Average Results						
EUT Frequency (MHz)	Frequency (MHz)	Peak Reading (dBµV/m)	DCF (dB)	Result (dBµV/m)	Limit* (dBµV/m)	Margin (dB)
2402	2400.0	60.6*	-14.0	46.6	54	7.4
2402	2392.0	63.7	-14.0	49.3	54	4.7
2480	2483.5	66.0	-14.0	52.0	54	2.0
2480	2514.8	65.8	-14.0	51.8	54	2.2

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

Bandedge – Peak Results					
EUT Frequency (MHz)	Frequency (MHz)	Peak Reading (dBµV/m)	Max Peak Carrier ((dBµV/m)	Limit (dBµV/m)	Margin (dB)
2402	2400.0	60.6**	101.1**	81.1	20.5
2402	2392.0	63.7	n.a.	74*	10.3
2480	2483.5	66.0	n.a	74*	8.0
2480	2514.8	65.8	n.a	74*	8.2

All tests performed at the distance of d = 3 m.

* Note: Limits acc. to 47 CFR §15.209 resp. RSS-Gen 8.9 were used as worst case consideration.

** RBW 100 kHz, otherwise RBW 1 MHz

4.6.4.3 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-10-22
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.7 Radiated Emissions

4.7.1 Regulation

47 CFR,§ 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). This paragraph (f) shall not apply to Access BPL devices operating below 30 MHz.

(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle.
1 to 10 MHz	2	1 near top and 1 near bottom.
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom.

47CFR § 15.33 Frequency range of radiated measurements

(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.
(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.
(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.

47 CFR § 15.35 Measurement detector functions and bandwidths.

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long at the same bandwidth as indicated for CISPR quasi-peak measurements are employed.
(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g., see §§15.250,

15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

47 CFR §15.205 Restricted bands of operation.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

47 CFR § 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 (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	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.

(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.

47 CFR § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247, 5.5 Unwanted emissions

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

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

Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table 5 and table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

Table 5 – General field strength limit at frequencies above 30 MHz

Frequency (MHz)	Field strength (µV/m @ 3 m)
30-88	100
88-216	150
216-960	200
Above 960	500

Table 6 – General field strength limit at frequencies above 30 MHz

Frequency	Magnetic field strength (H-Field) (µA/m)	Measurement distance (m)
9 - 490 kHz [1]	6.37/F (F in kHz)	300
490 – 1705 kHz	63.7/F (F in kHz)	30
1.705 – 30 MHz	0.08	30

Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.

RSS-Gen, 8.10 Restricted frequency bands
Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:
(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, Emergency Position Indicating Radio Beacons (EPIRB), Emergency Locator Transmitters (ELT), Personal Locator Beacons (PLB), and Maritime Survivor Locator Devices (MSLD).

(b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.

(c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

Table 7 – Restricted frequency bands*

MHz	MHz	GHz
0.090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6

MHz	MHz	GHz
8.362 - 8.366	1660 - 1710	
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138	--	

* Certain frequency bands listed in table 7 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

➔ IC limits for magnetic field strength were converted to µV/m, see calculation in 4.7.2

4.7.2 Calculation of Field Strength Limits

RSS Gen limit in µA/m were converted to µV/m by using the equation:

$E_{dB\mu V/m} = H_{\mu A/m}$ x 377 Ω

Example: 0.08 µA/m x 377 = 30.2 µV/m

E.g. radiated emissions field strength limits for the frequency band 1.705 - 30 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 (in dBµV/m)

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

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

Distance correction (limit)
Remark: The preferred method is the correction of the measured field strength instead of limit correction. Only one correction method shall be applied to a particular measurement.

For radiated emission from 9 kHz to 30 MHz the prescan limit was adjusted by a Distance Extrapolation Factor DF of 40 dB per decade, which is calculated by the following equation:

$DF = 40 \log (D_{test}/D_{specification})$
where

DF = Distance Extrapolation Factor (in dB)

D_{test} = Distance, where measurement was performed (in m)

$D_{specification}$ = Distance acc. to specification (in m)

Example: Assume a limit specified in 30 m and a measurement performed at 3 m: The distance correction factor is 40 log (30 / 3) = 40 dB. This factor is mathematically added to the limit by the following equation:
$E_{dB\mu V/m\_new} = E_{dB\mu V/m} + DF$
where

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

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

DF = Distance Extrapolation Factor (in dB)

Example: Assume a limit of 29.5 dBµV/m specified in 30 m distance and the measurement performed at 3 m. The limit is adjusted by the distance correction factor of 40 dB to the new limit of 69.5 dBµV/m.

4.7.3 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 30 dBµV is obtained. The Antenna Factor of 10 dB(1/m) and a Cable Factor of 1.2 dB are added, giving a field strength of 41.2 dBµV/m in the measurement distance. The field strength of 41.2 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 30 + 10 + 1.2 = 41.2
Level (in µV/m) = Common Antilogarithm (41.2/20) = 114.8

Distance correction (field strength)
Remark: The preferred method is the correction of the measured field strength instead of limit correction. Only one correction method shall be applied to a particular measurement..

If a measurement is performed at a different distance other than specified, the field strength at the specified distance can be obtained by the following equation:

$FS_{Dspecified} = FS_{Dtest} + 20 \log (D_{test}/D_{specified})$
where
$FS_{Dspecified}$ = Field Strength at specified distance $D_{specified}$ (in dBµV/m)
FS_{DTest} = Field Strength at specified distance D_{Test} (in dBµV/m)
D_{test} = Measurement distance where test was performed (in m)
$D_{specified}$ = Measurement distance as specified by the rules (in m)

Assuming a recorded field strength of 41.2 dBµV/m in a distance of 1 m. If the rules are specifying a limit in a distance of 3 m, the field strength recorded in 1 m is corrected by the distance. Therefore, the field strength $FS_{Dspecified}$ is 41.2 + 20 log (1 / 3) = 31.7 (in dBµV/m).
Remark: Using EMC32 software corrections are combined in the Corr. Factor as listed in the results' table.
"Result" represents the FS Result, "Corr." is the combined correction factor.

4.7.4 Radiated Emissions 9 kHz – 30 MHz

4.7.4.1 Test Procedures

ANSI C63.10-2013, 6.4.3 Measuring antenna selection, location, and test distance
Radiated emission tests shall be performed in the frequency range of 9 kHz to 30 MHz, using a calibrated loop antenna as specified in 4.3.2, at a suitable site and measurement distance as specified in 5.3. This method is applicable for measuring radiated RF emissions from all units, cables, power cords, and interconnect cabling or wiring of the EUT, by applying the guidance provided in 5.10 along with guidance provided subsequently.

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. 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.”

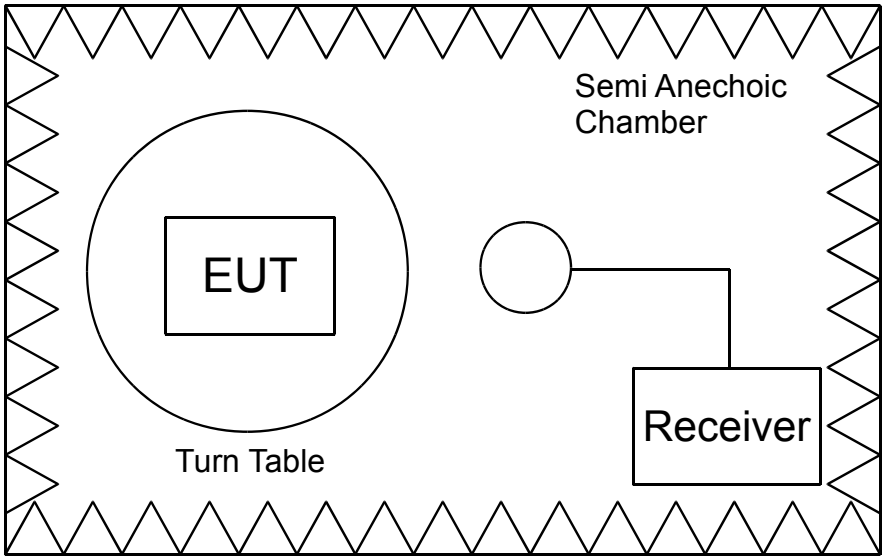
ANSI C63.10-2013, 6.4.7 Final radiated emission tests
Using the orientation and equipment arrangement of the EUT determined in 6.4.6, and applying the appropriate modulating signal to the EUT, perform final radiated emission measurements on the fundamental and highest spurious emissions.
Unless otherwise 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 (< 150 kHz) 9 kHz (≥ 150 kHz)
Receive antenna height	1 m
Receive antenna orientations	2
Measurement chamber	Semi anechoic chamber (SAC)

Following the test procedure described in KDB 414788, an open field measurement has to be performed in addition to the measurements performed in a semi anechoic chamber to evaluate a correction of the open field measurement to the semi-anechoic chamber measurement.
Since laboratory experience has shown, that the correction factor is always negative, resulting in a lower level at the open field, these open field measurements are omitted, if there are all measurement emissions more than 20 dB below the limit.

As there was no emission identified the EUT was measured in 3 orientation one with Fmin, one with Fmid and one with Fmax.

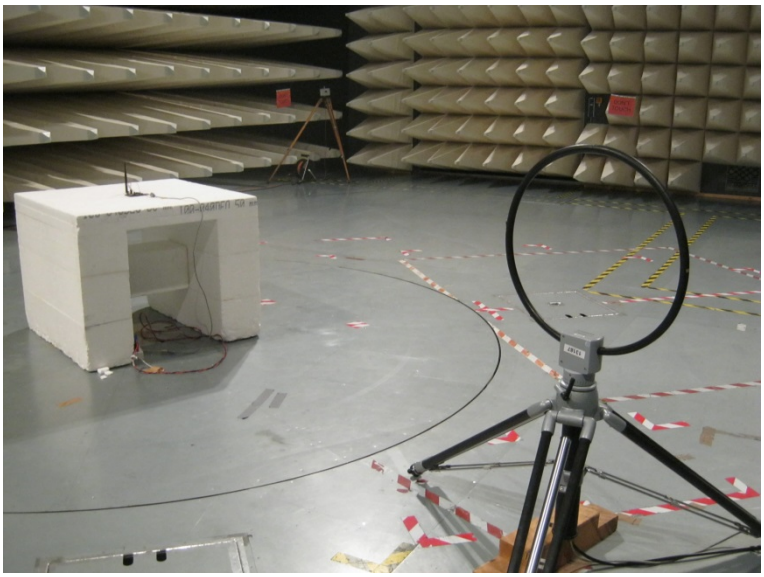
4.7.5 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209, 15.247 RSS-247, RSS-Gen
Procedure:	ANSI C63.10-2013
Receiver:	#3846
Antenna:	#374
Test distance:	3 m

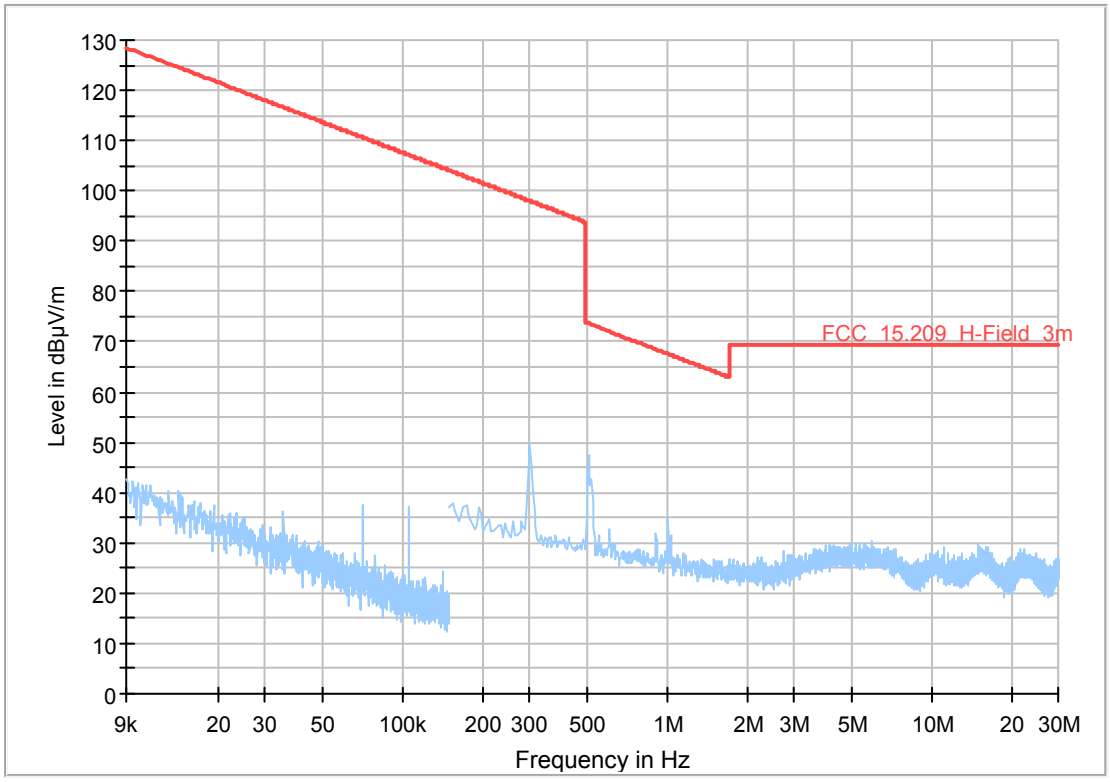
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
374, 519, 1292, 1889, 3846, 4075, 4717, 5392



Sample photo of setup

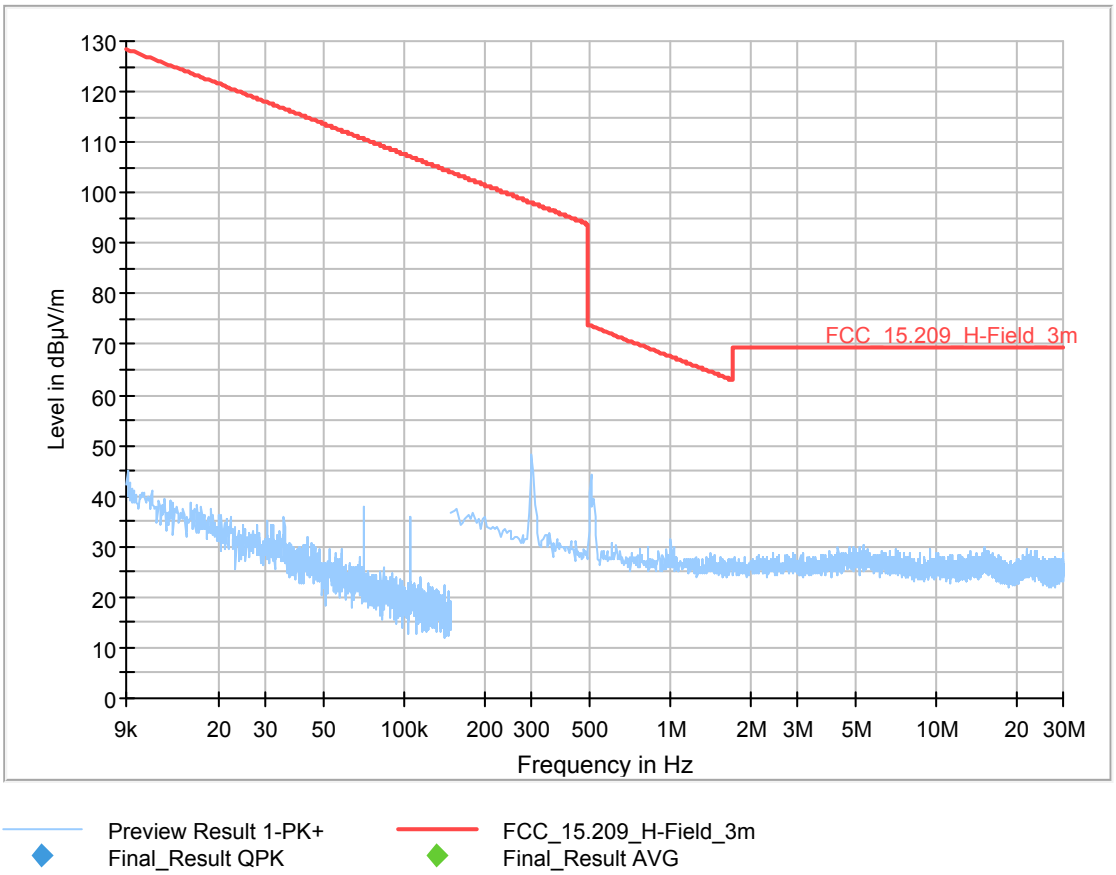
4.7.6 Detailed Test Data

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2402 MHz

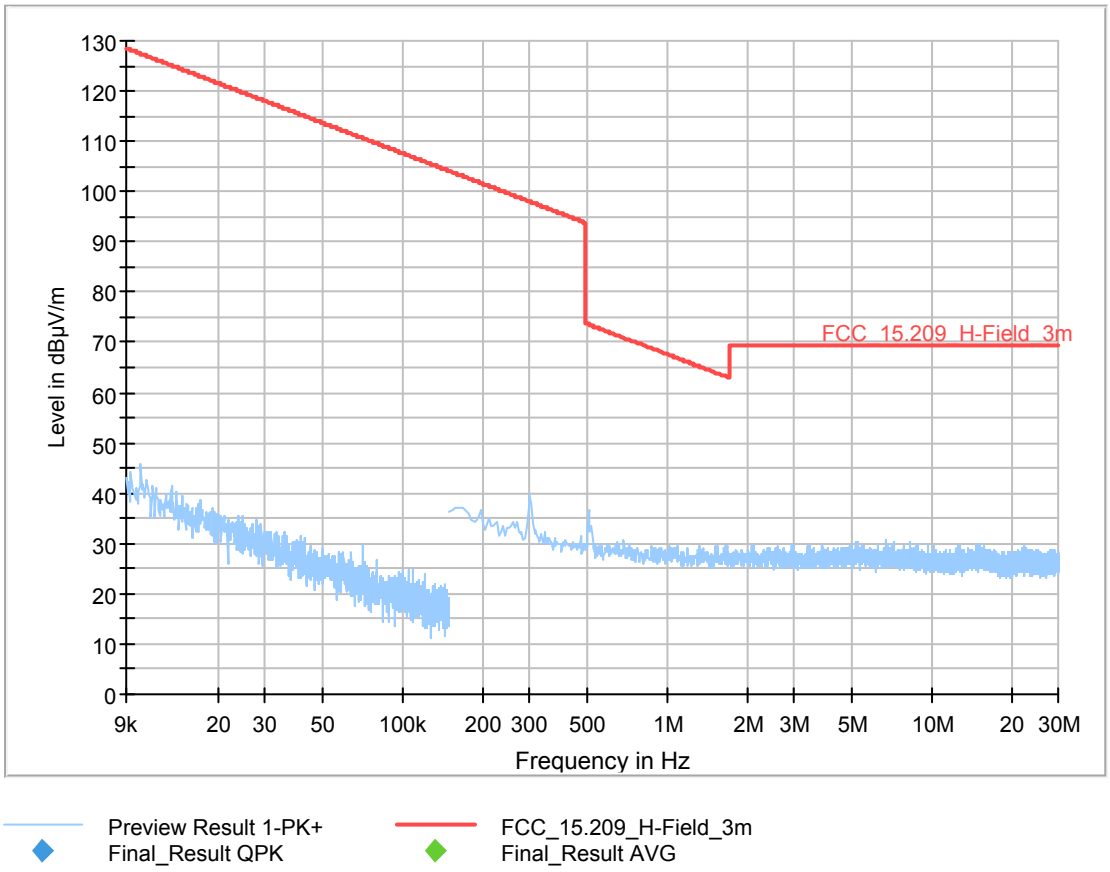


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2442 MHz



Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2480 MHz



Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol

All prescan results more than 20 dB below limit, therefore no final measurement performed.

4.7.7 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-30
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.7.8 Radiated Emissions 30 MHz – 1000 MHz

4.7.8.1 Test Procedures

ANSI C63.10-2013 6.5 Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to 1000 MHz

This subclause specifies conditions for compliance testing in the frequency range above 30 MHz and below 1 GHz. The following subclauses describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies between 30 MHz and 1000 MHz. Measurements may be performed at a distance closer than that specified in the requirements, provided the measuring antenna is beyond its near-field range as determined by the Rayleigh criteria.

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.

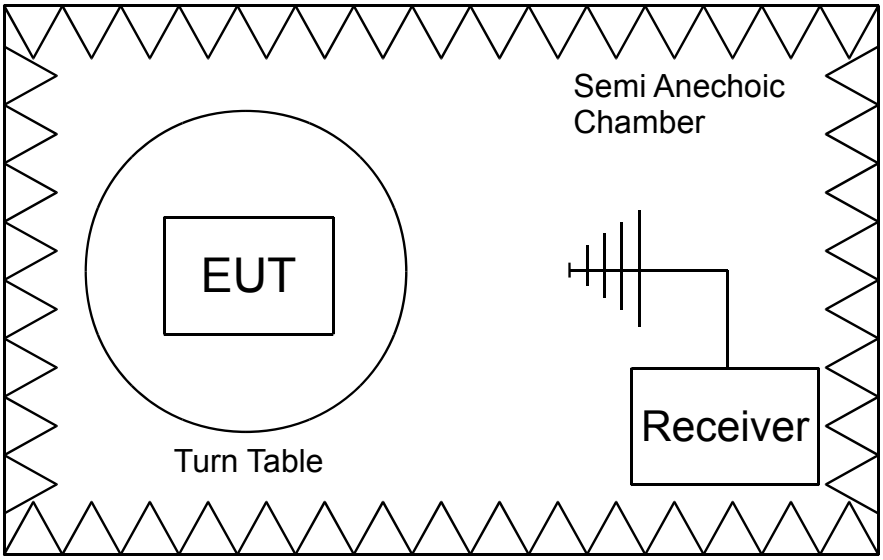
Variations in cable or wire placement shall be explored to maximize the measured emissions.

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.

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
Angular steps size during prescan:	90 °
Receive antenna polarization	Vertical/Horizontal
Measurement location	Semi Anechoic Chamber (SAC)

As there was no emission identified the EUT was measured in 3 orientation one with Fmin, one with Fmid and one with Fmax.

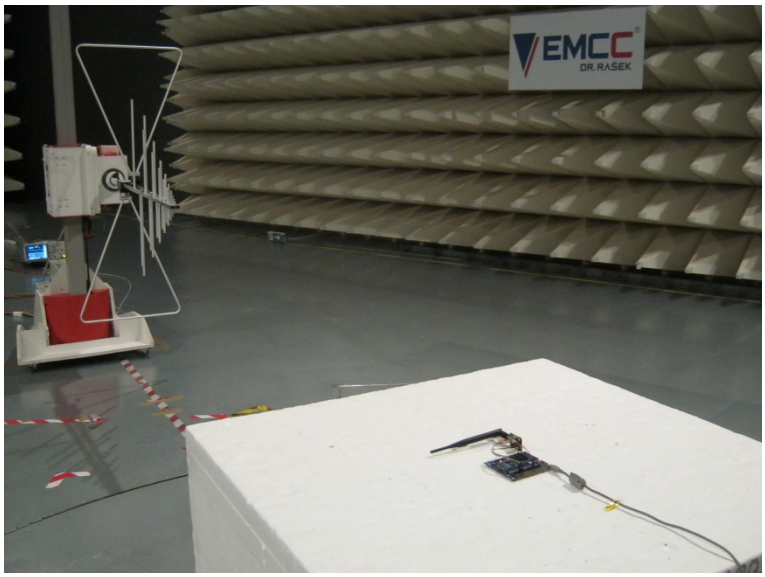
4.7.8.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209, 15.247 RSS-247, RSS-Gen
Procedure:	ANSI C63.10-2013
Receiver:	#3846
Antenna:	#6041
Test distance:	3 m

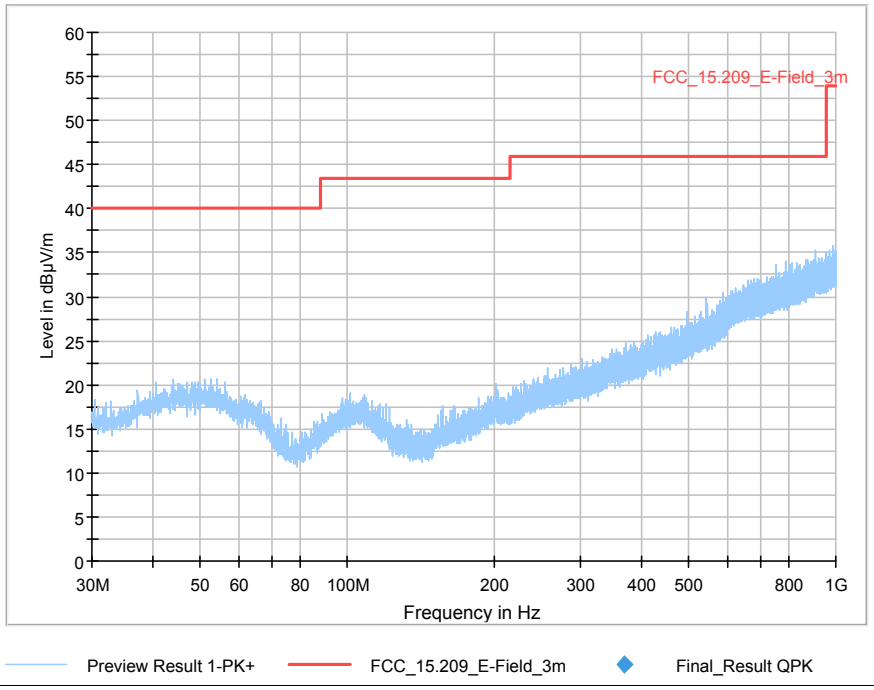
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
54, 519, 553, 554, 1291, 1292, 1889, 2724, 3846, 4075, 4717, 5392, 6041



Sample photo of setup

4.7.8.3 Detailed Test Data

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2402 MHz



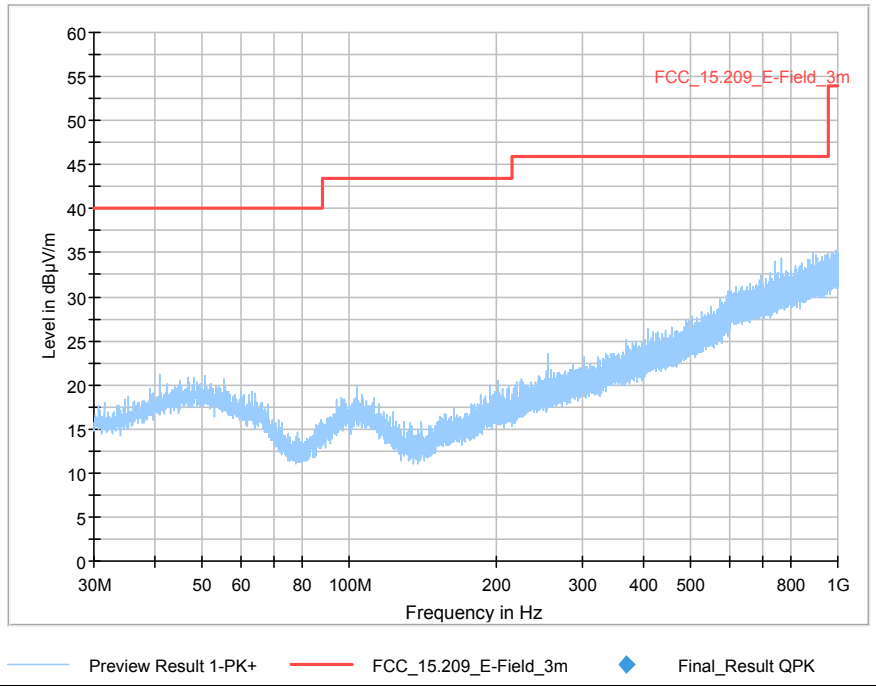
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
	All prescan results more than 20 dB below limit, therefore no final measurement performed.								

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

Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2442 MHz

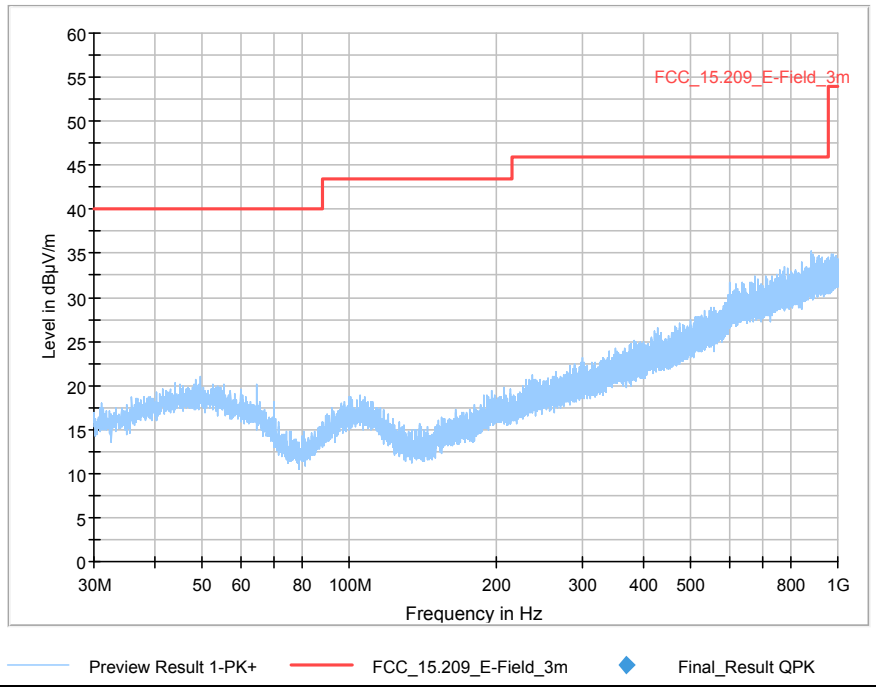


Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
	All prescan results more than 20 dB below limit, therefore no final measurement performed.								

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

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2480 MHz



Final Result:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
	All prescan results more than 20 dB below limit, therefore no final measurement performed.								

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

4.7.8.4 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-30
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.7.9 Radiated Emissions 1 – 6 GHz

4.7.9.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In 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 does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection up to the highest measurement frequency required (unless stated otherwise in the applicable requirements).

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

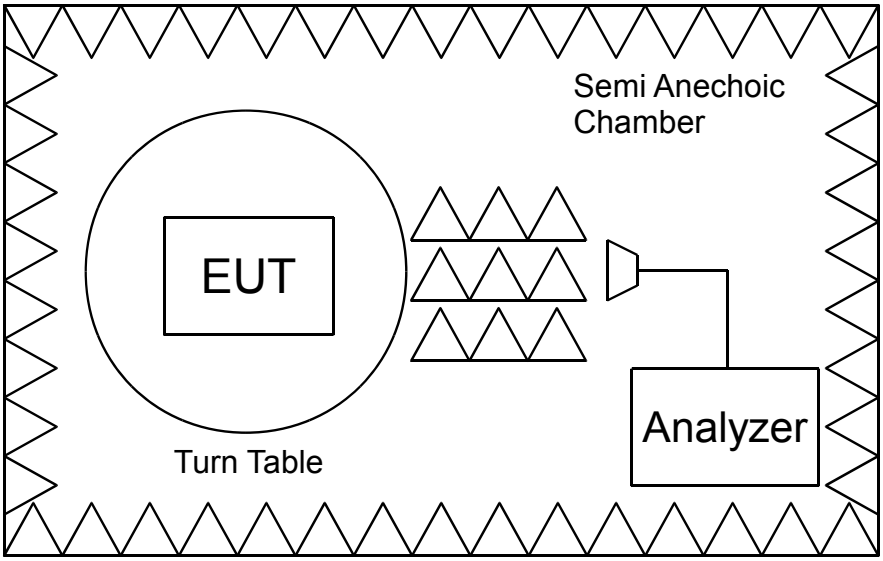
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation 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.
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.

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 6 GHz
Test distance	3 m
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC) with rf absorbers on the floor

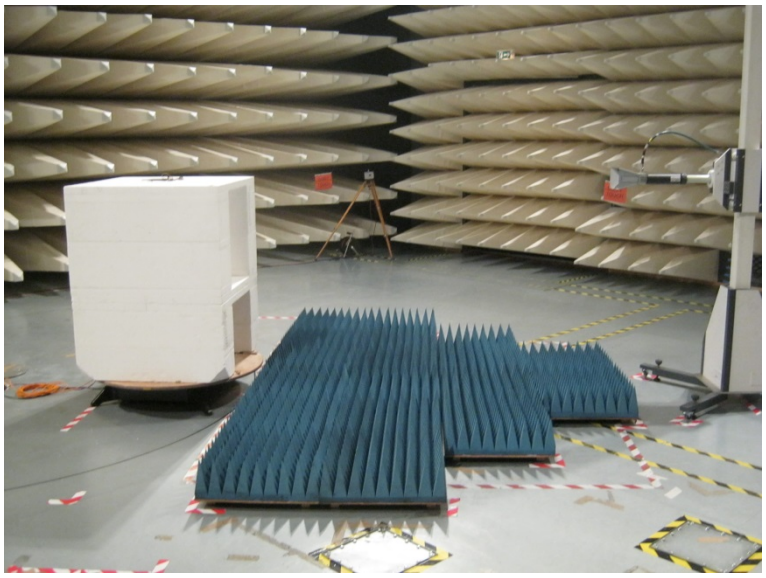
4.7.9.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209, 15.247 RSS-247, RSS-Gen
Procedure:	ANSI C63.10-2013
Receiver:	#3846
Antenna:	#3236
Test distance:	3 m

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
553, 554, 1889, 2720, 3235, 4058, 4075, 4717, 4993, 5392, 5535, 5536, 5544, 5545, 5615

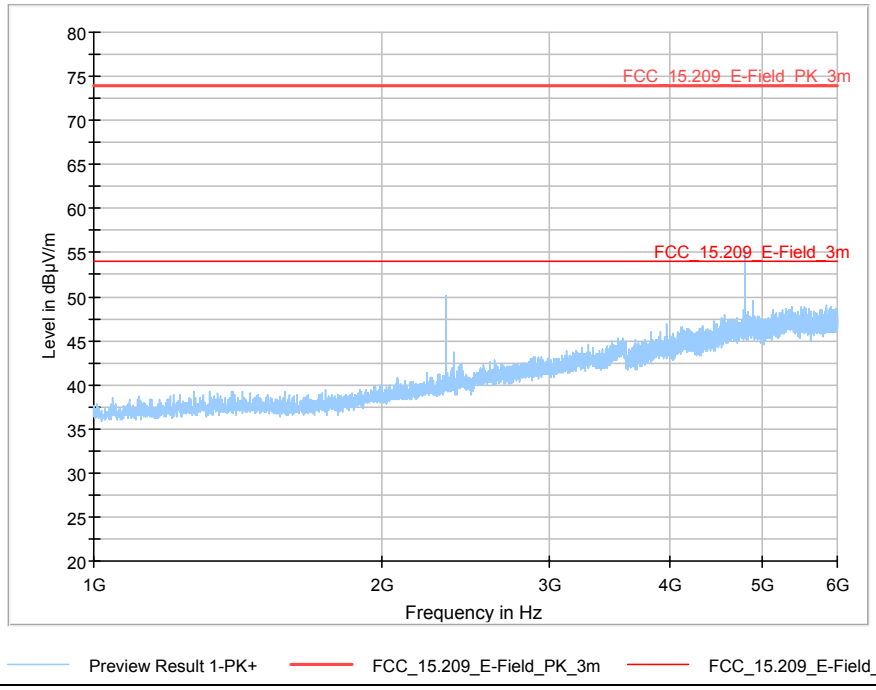


Sample photo of setup

4.7.9.3 Detailed Test Data

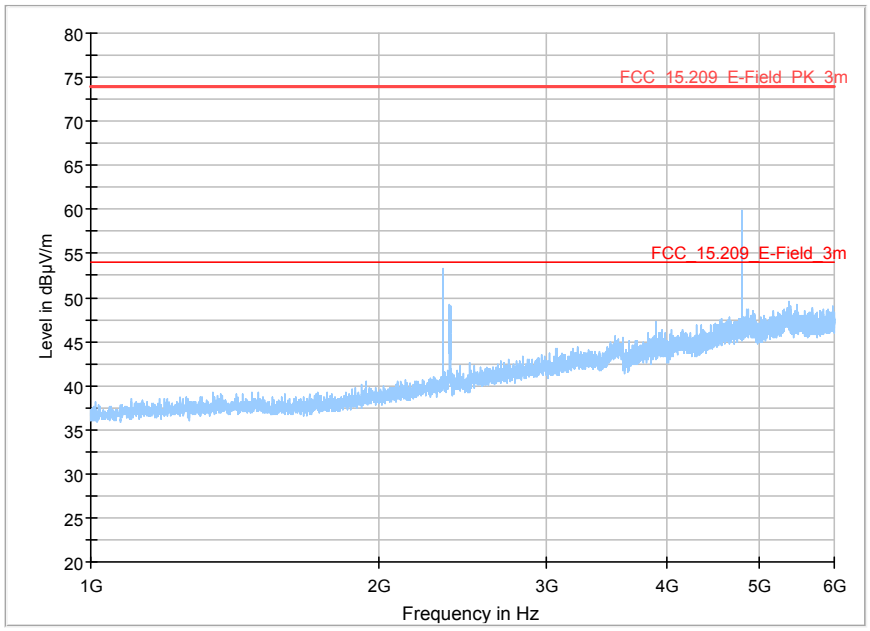
Note: A bandreject filter was used for the passband from 2400 – 2483.5 MHz. For results close to the filter refer to the bandedge measurements.

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2402 MHz

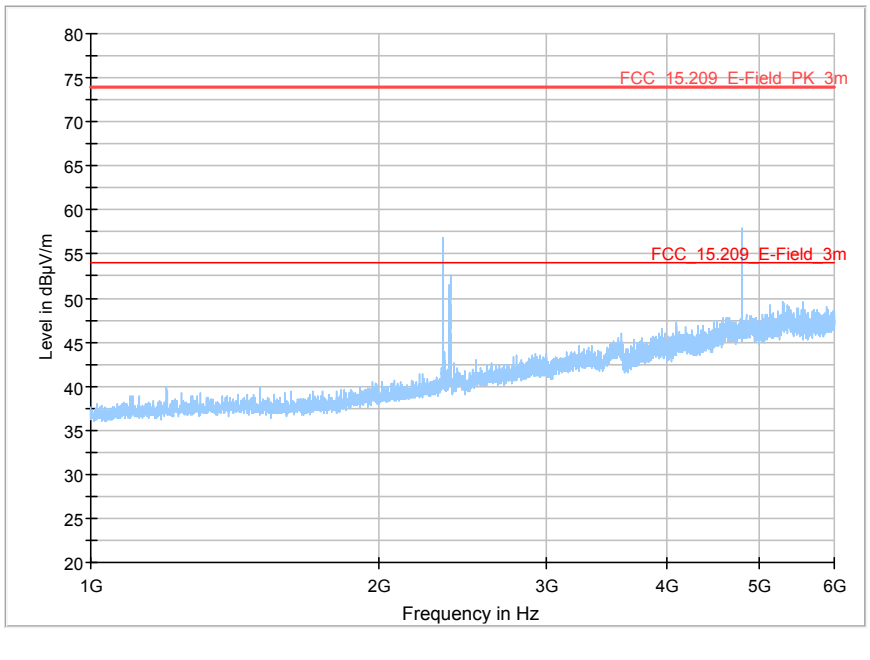


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2402 MHz

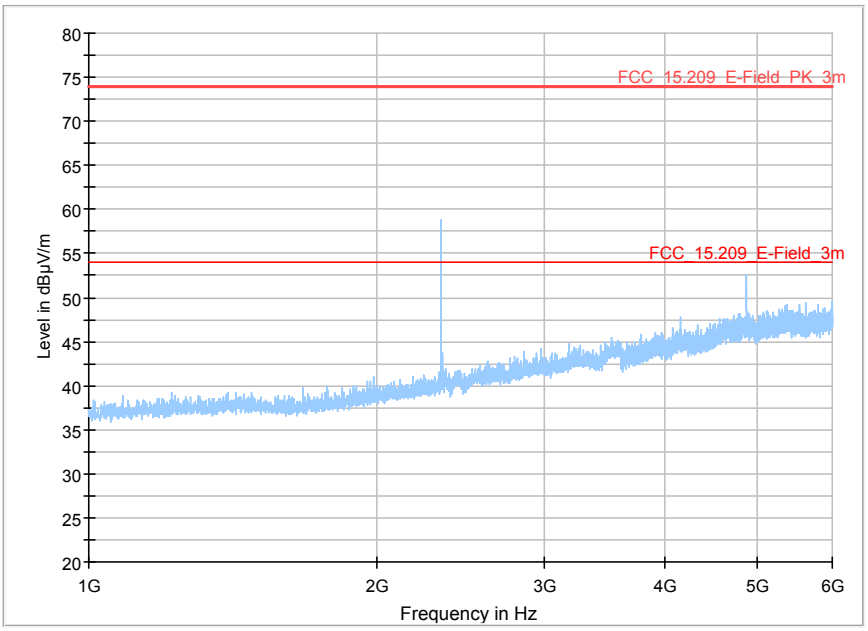


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2402 MHz

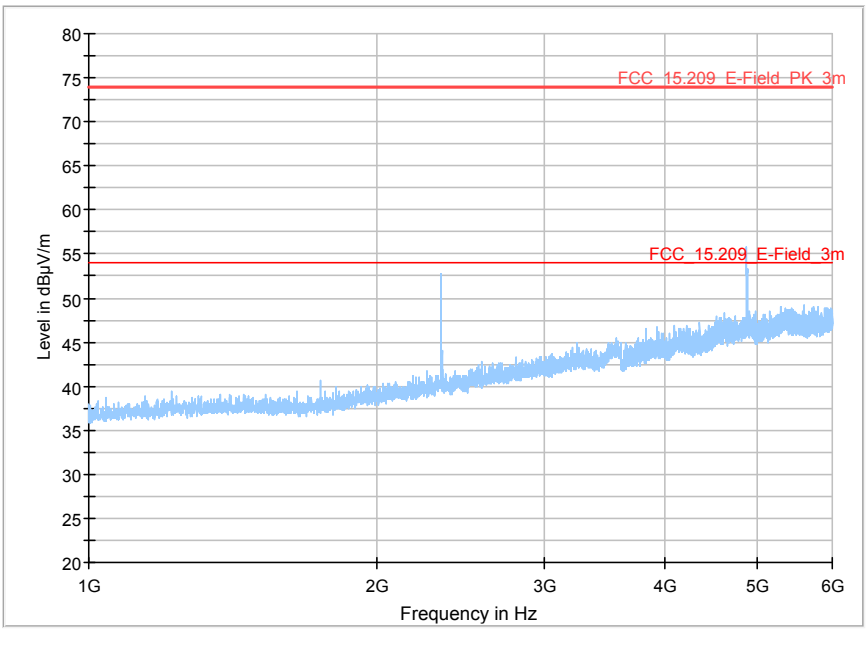


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2442 MHz

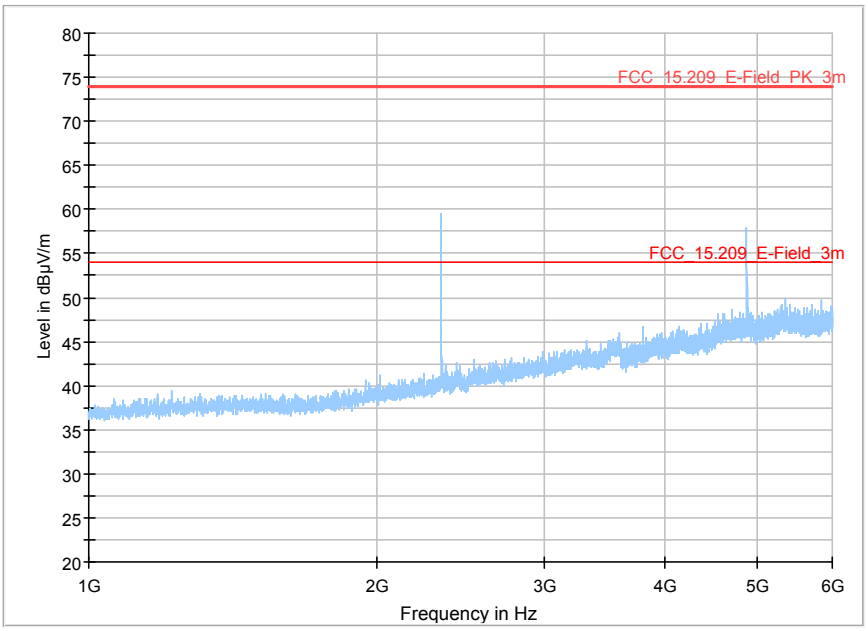


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2442 MHz

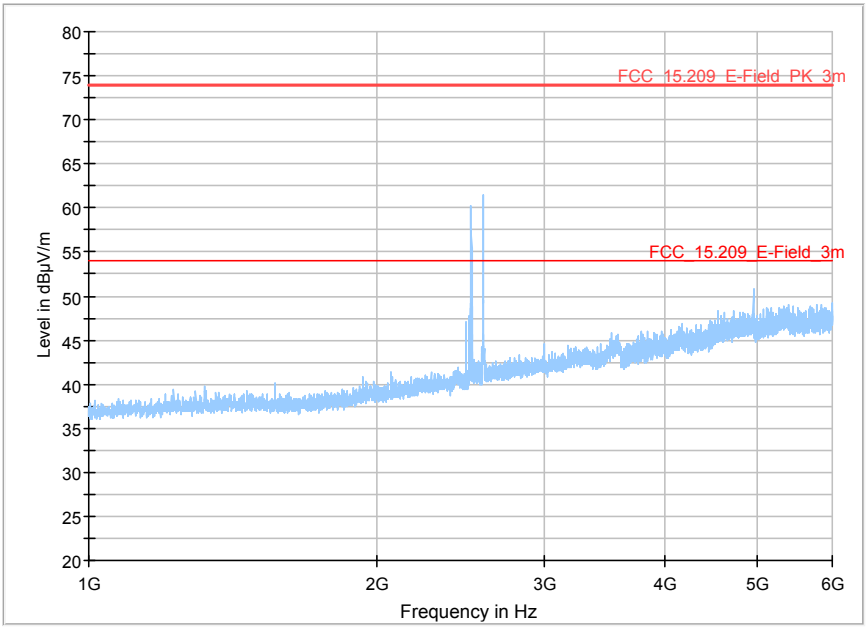


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2442 MHz

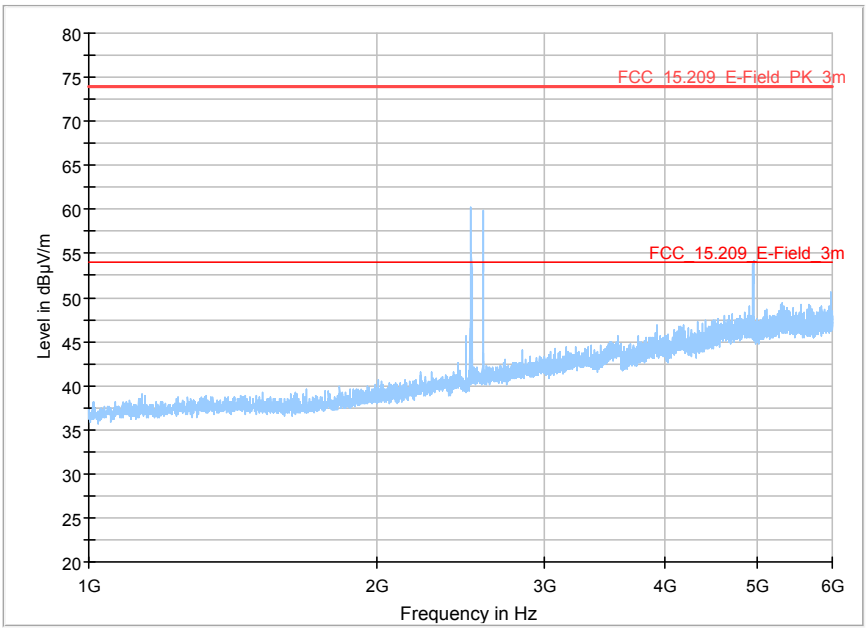


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2480 MHz

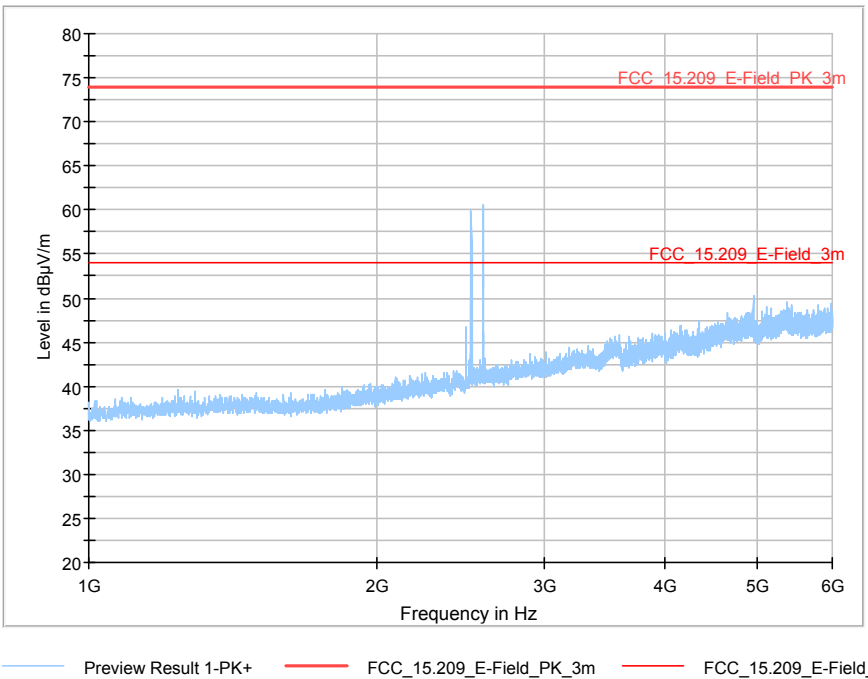


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2480 MHz

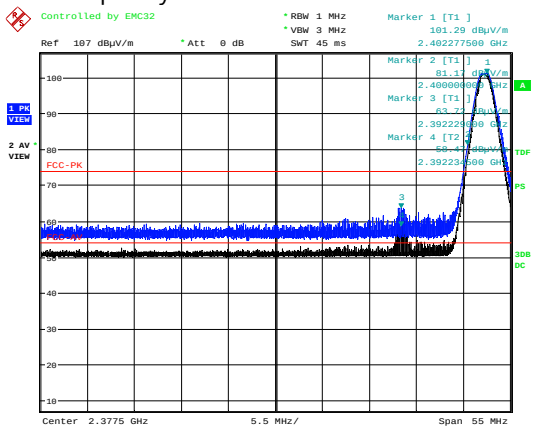


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2480 MHz



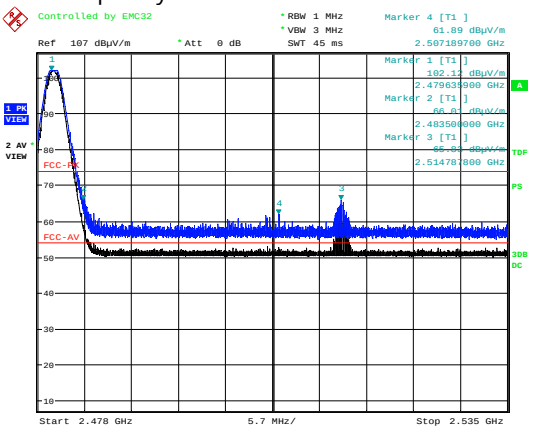
Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Prescan; Radiated Emissions at Band-Edge
EUT Frequency: 2402 MHz



EUT: TCM 515B, EUT-Freq: 2402MHz
Date: 22.OCT.2019 10:22:25

Prescan; Radiated Emissions at Band-Edge
EUT Frequency: 2480 MHz



EUT: TCM 515B, EUT-Freq: 2480MHz
Date: 22.OCT.2019 11:01:24

Note: Bandedge measurements without bandreject filter.
The transducer factor (TDF) contains the Antenna Factor (AF) and the Cable Attenuation Factor (CF)

Final Result:

Radiated Spurious Emissions 1 – 6 GHz – Average Results						
Frequency	**Field Strength**	**DCF**	**Result**	**Limit***	**Margin**	**Remarks**
[MHz]	**[dBµV/m]**	**[dB]**	**[dB(µV/m)]**	**[dB(µV/m)]**	**[dB]**	
2335.5	61.7	-14.0	47.7	54	6.3	EUT at 2402 MHz
2392.2	63.7	-14.0	49.7	54	4.3	EUT at 2402 MHz
4804.0	61.8	-14.0	47.8	54	6.2	EUT at 2402 MHz
4883.9	61.7	-14.0	47.7	54	6.3	EUT at 2442 MHz
2514.7	65.8	-14.0	51.6	54	3.4	EUT at 2480 MHz
2584.8	63.3	-14.0	49.3	54	4.7	EUT at 2480 MHz
4959.1	57.9	-14.0	43.9	54	10.1	EUT at 2480 MHz

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plot above.
Remark: Duty Cycle Correction Factor DCF added to peak reading to obtain average results.
For further details refer to chapter 2.6 of the report.

Radiated Spurious Emissions 1 – 6 GHz – Peak Results						
Frequency	**Field Strength**	**DCF**	**Result**	**Limit***	**Margin**	**Remarks**
[MHz]	**[dBµV/m]**	**[dB]**	**[dB(µV/m)]**	**[dB(µV/m)]**	**[dB]**	
2335.5	61.7	n.a.	61.7	74	12.3	EUT at 2402 MHz
2392.2	63.7	n.a.	63.7	74	10.3	EUT at 2402 MHz
4804.0	61.8	n.a.	61.8	74	12.2	EUT at 2402 MHz
4883.9	61.7	n.a.	61.7	74	12.3	EUT at 2442 MHz
2514.7	65.86	n.a.	62.6	74	11.4	EUT at 2480 MHz
2584.8	63.3	n.a.	63.3	74	10.7	EUT at 2480 MHz
4959.1	57.9	n.a.	57.9	74	16.1	EUT at 2480 MHz

The table above contains worst-case emissions, only. For further details refer to the pre-scan test plots.
* Note: Limits acc. to 47 CFR §15.209 resp. RSS-Gen 8.9 were used as worst case consideration.

4.7.9.4 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-10-21/22
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.7.10 Radiated Emissions 6 – 18 GHz

4.7.10.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In 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 does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection up to the highest measurement frequency required (unless stated otherwise in the applicable requirements).

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

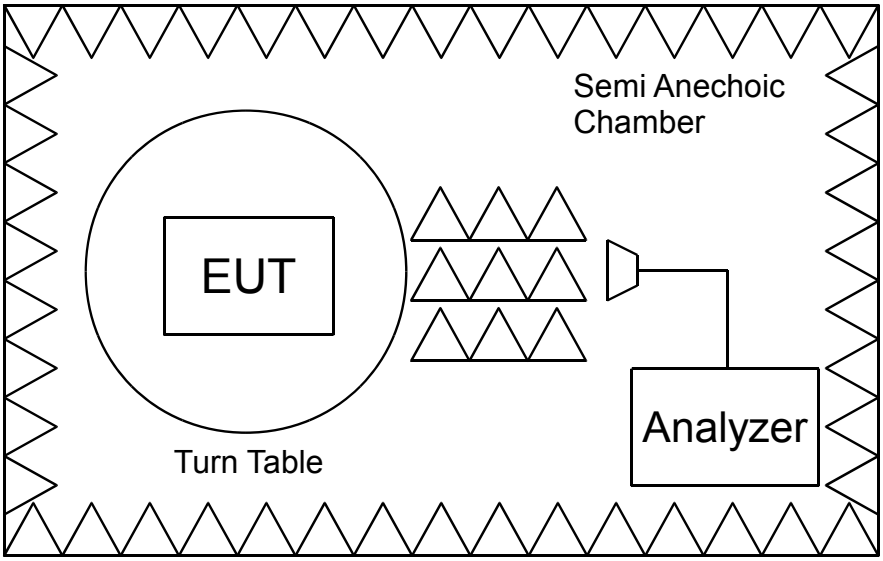
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation 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.
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.

Radiated Emissions Test Characteristics	
Frequency range	6 GHz – 18 GHz
Test distance	1 m
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

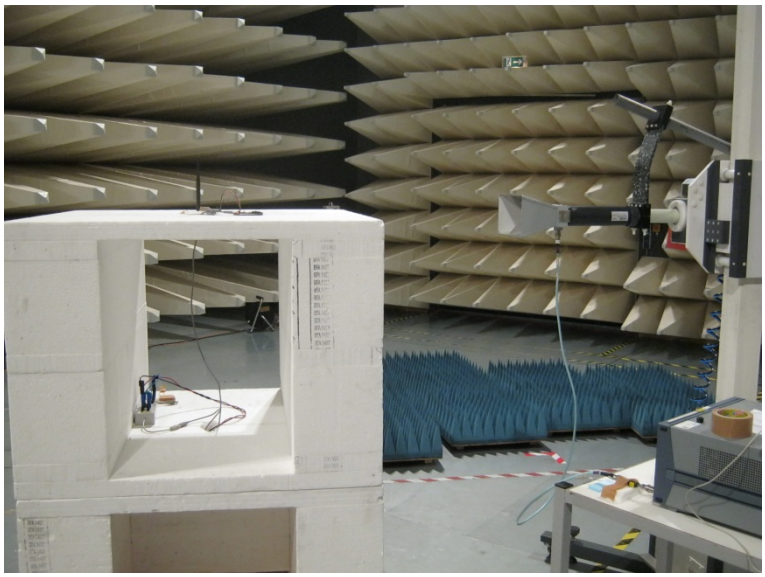
4.7.10.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209, 15.247 RSS-247, RSS-Gen
Procedure:	ANSI C63.10-2013
Receiver:	#3831
Antenna:	#3236
Test distance:	1 m

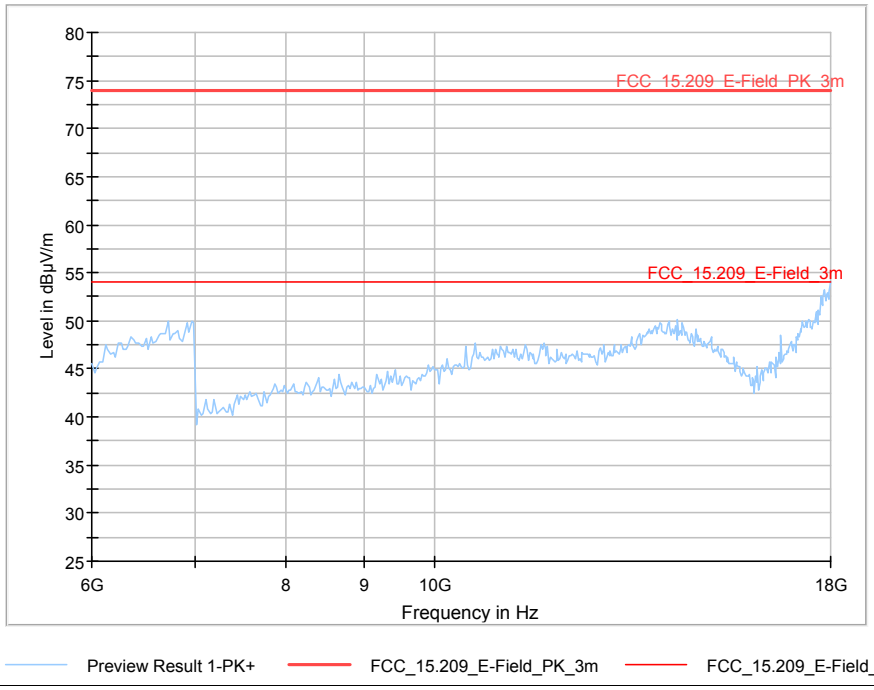
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
516, 519, 553, 554, 1889, 2720, 3236, 3831, 4058, 4075, 4717, 5366, 5392, 5535, 5536, 5544, 5545, 5620



Sample photo of setup

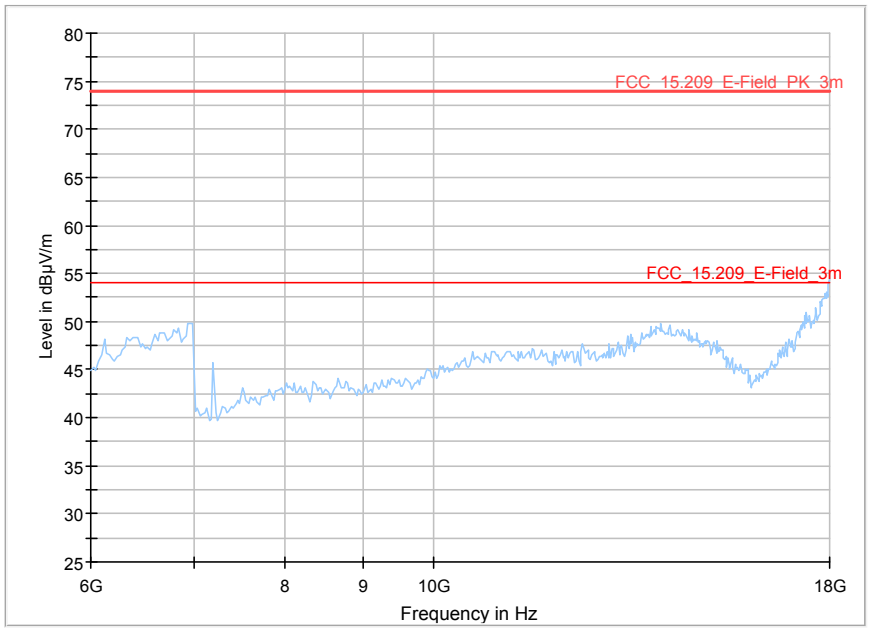
4.7.10.3 Detailed Test Data

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2402 MHz

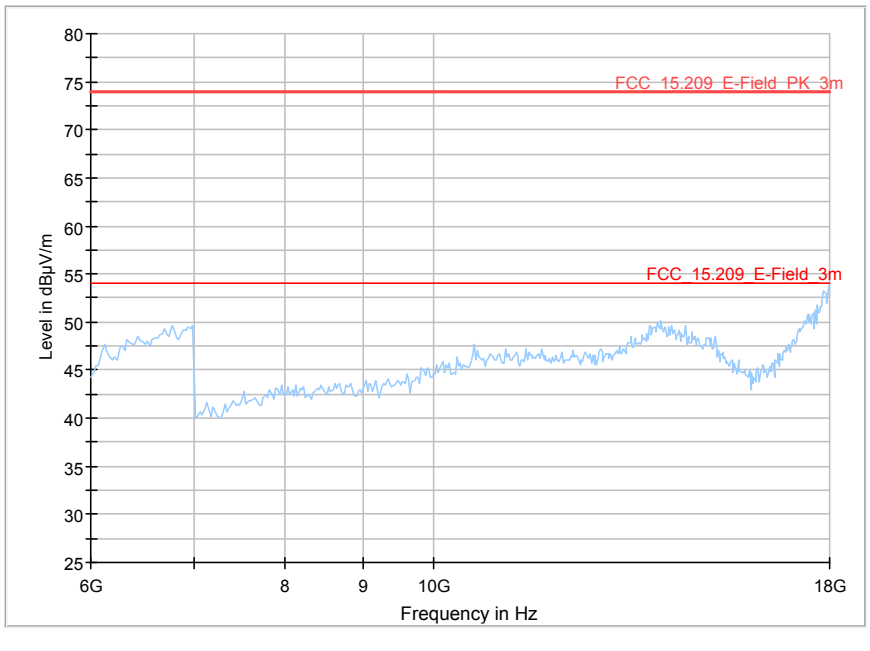


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2402 MHz

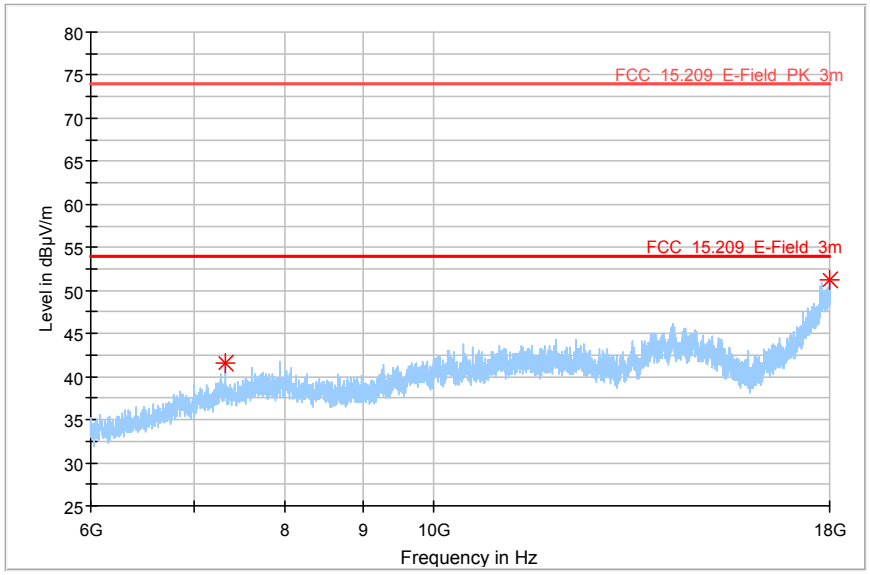


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2402 MHz



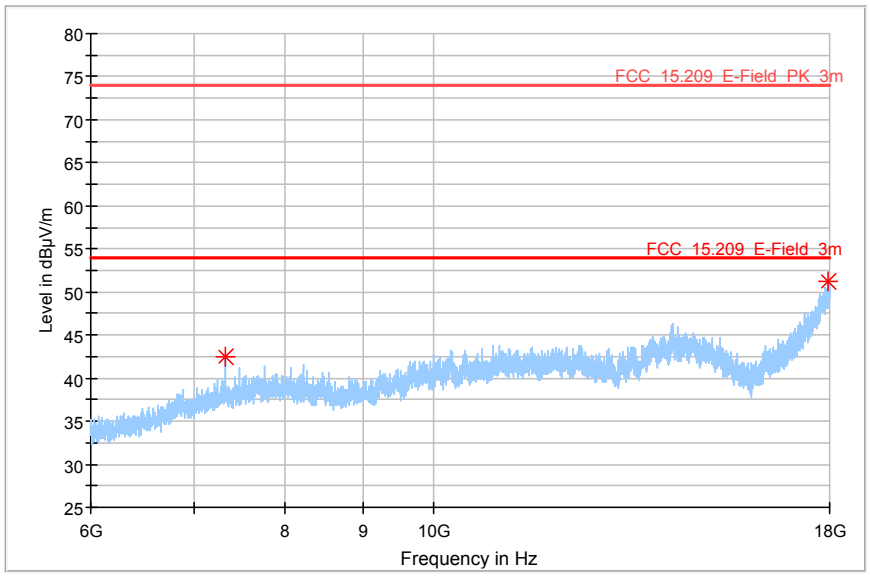
Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2442 MHz



Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
FCC_15.209_E-Field_PK_3m [..\EMI radiated\FCC_Part15\]
FCC_15.209_E-Field_3m [..\EMI radiated\FCC_Part15\]

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2442 MHz



Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
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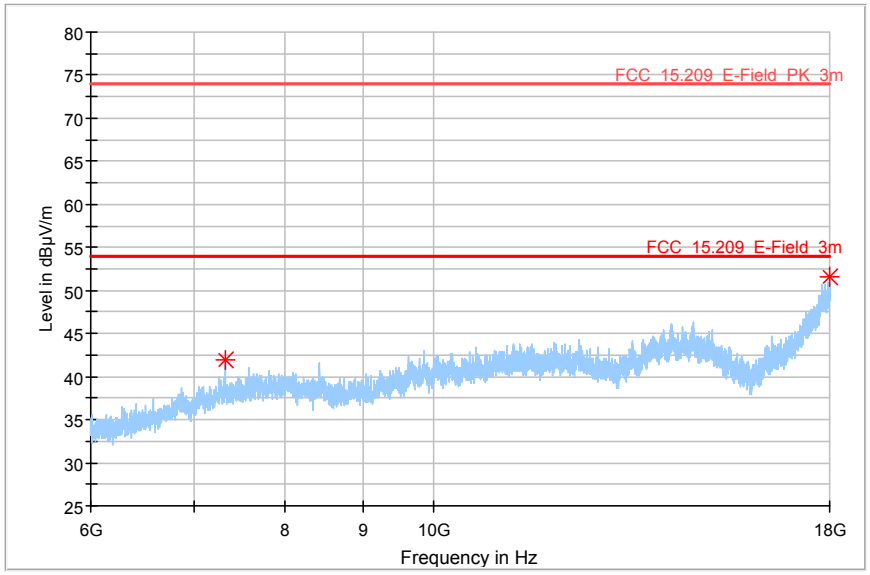
Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2442 MHz



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MaxPeak-PK+ [Critical_Freqs.Result:4]
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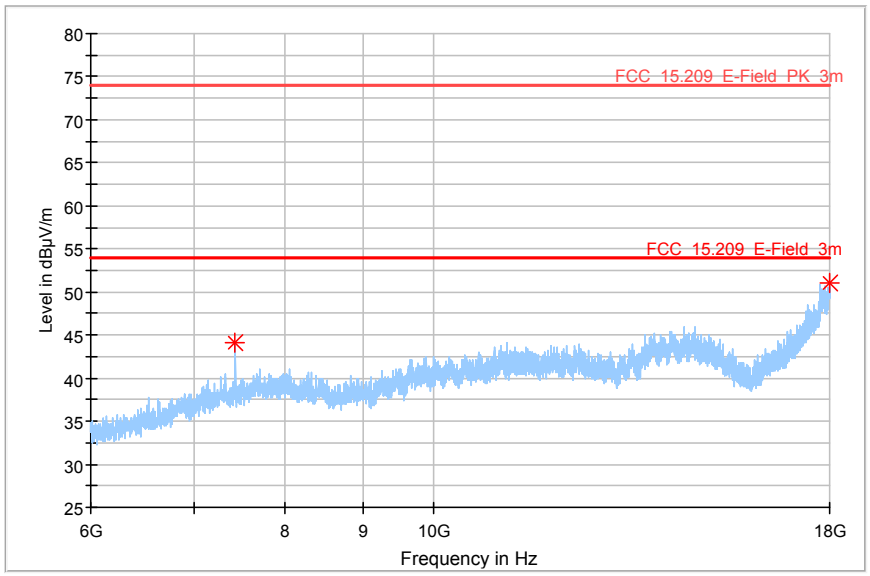
FCC_15.209_E-Field_3m [..\EMI radiated\FCC_Part15\]

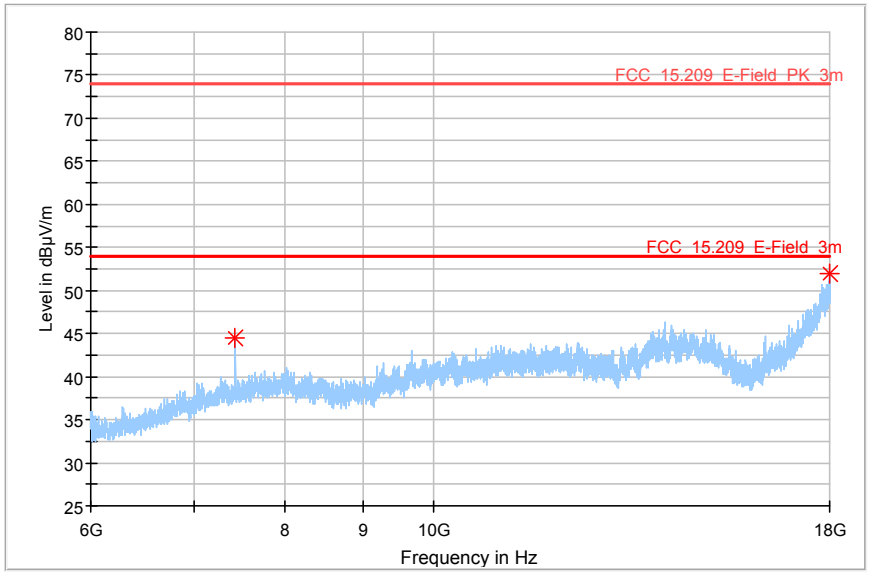
Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2480 MHz



Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
FCC_15.209_E-Field_PK_3m [..\EMI radiated\FCC_Part15\]
FCC_15.209_E-Field_3m [..\EMI radiated\FCC_Part15\]

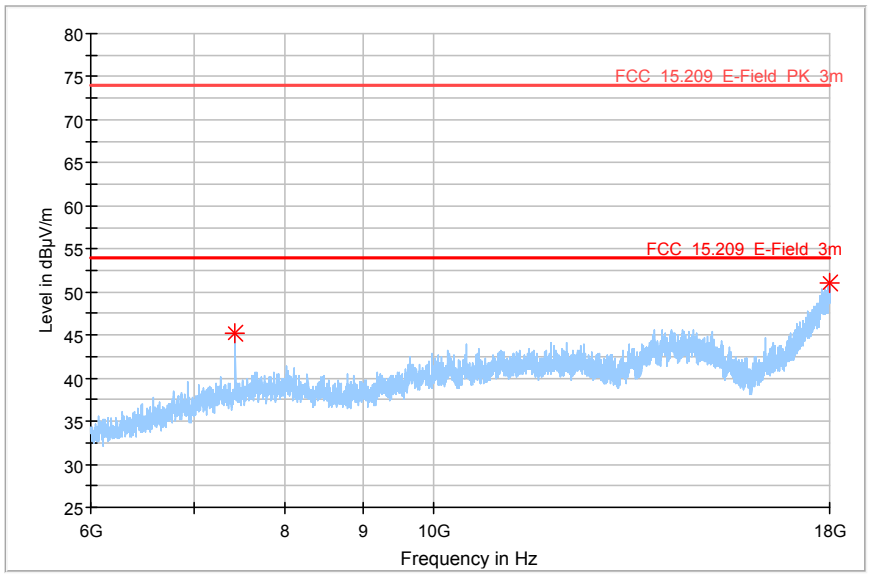
Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2480 MHz



Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
FCC_15.209_E-Field_PK_3m [..\EMI radiated\FCC_Part15\]
FCC_15.209_E-Field_3m [..\EMI radiated\FCC_Part15\]

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2480 MHz



Preview Result 1-PK+ [Preview Result 1.Result:1]
MaxPeak-PK+ [Critical_Freqs.Result:4]
FCC_15.209_E-Field_PK_3m [..\EMI radiated\FCC_Part15\]
FCC_15.209_E-Field_3m [..\EMI radiated\FCC_Part15\]

Final Result:

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)

All prescan peak results are below the average limit, therefore no final measurement performed.

All tests performed at the distance of d = 1 m.

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

4.7.10.4 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-31, 2019-10-22
Test personnel:	Dominik Krüger, Ludwig Kraft

The EUT meets the requirements of this section.

4.7.11 Radiated Emissions 18 – 26.5 GHz

4.7.11.1 Test Procedures

ANSI C63.10-2013, 6.6.4.1 General

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In 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 does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection up to the highest measurement frequency required (unless stated otherwise in the applicable requirements).

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

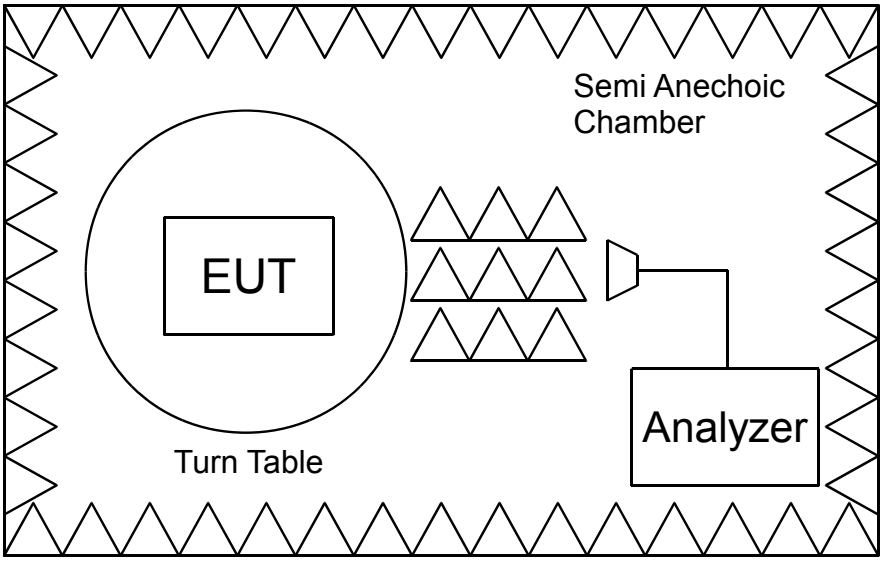
The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation 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.
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.

Radiated Emissions Test Characteristics	
Frequency range	18 GHz – 26.5 GHz
Test distance	1 m (18 – 26.5 GHz)
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1.5 m
Receive antenna polarization	Vertical/Horizontal
Measurement chamber	Semi anechoic chamber (SAC)

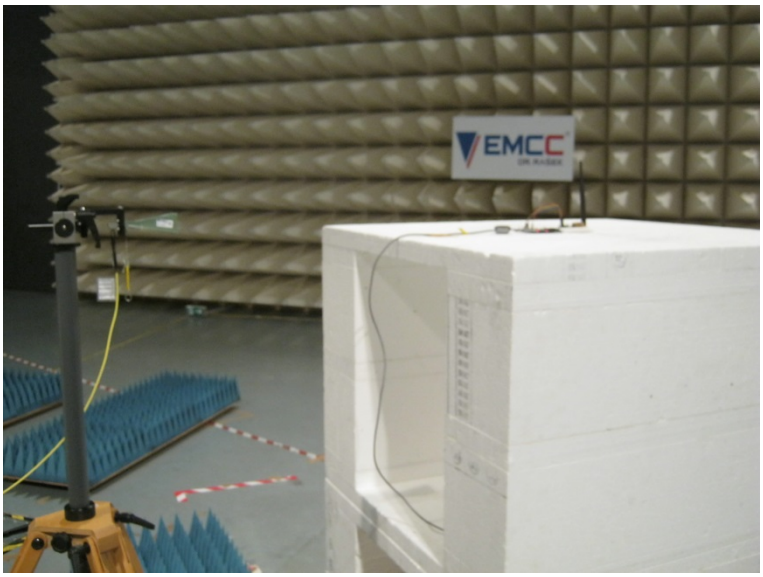
4.7.11.2 Test Setup



SCHEMATIC TEST SETUP

Requirement:	47 CFR, § 15.209, 15.247 RSS-247, RSS-Gen
Procedure:	ANSI C63.10-2013
Receiver:	#3831
Antenna:	#1300 (18 – 26.5 GHz)
Test distance:	1 m (18 – 26.5 GHz)

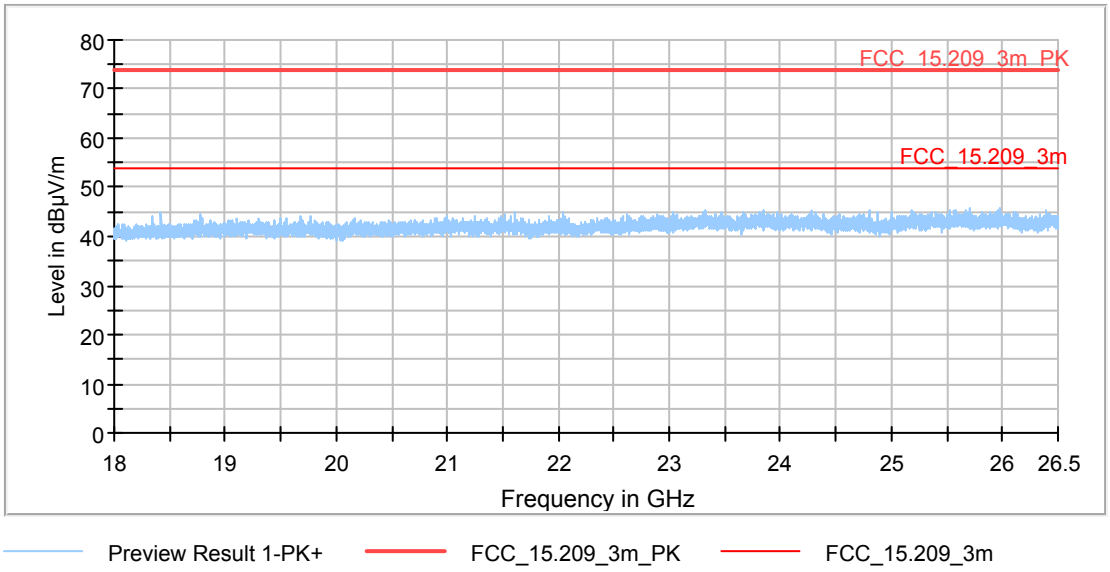
TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
519, 553, 554, 1300, 1889, 2048, 3061, 3195, 3831, 3880, 4075, 4717, 5392, 5535, 5536



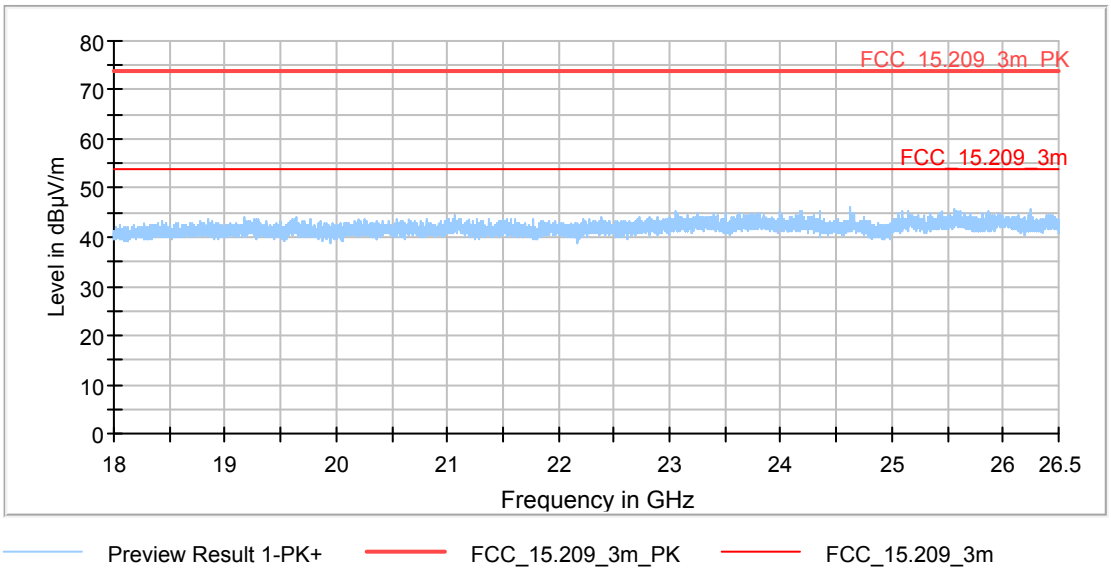
Sample photo of setup (18 – 26.5 GHz)

4.7.11.3 Detailed Test Data

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2402 MHz

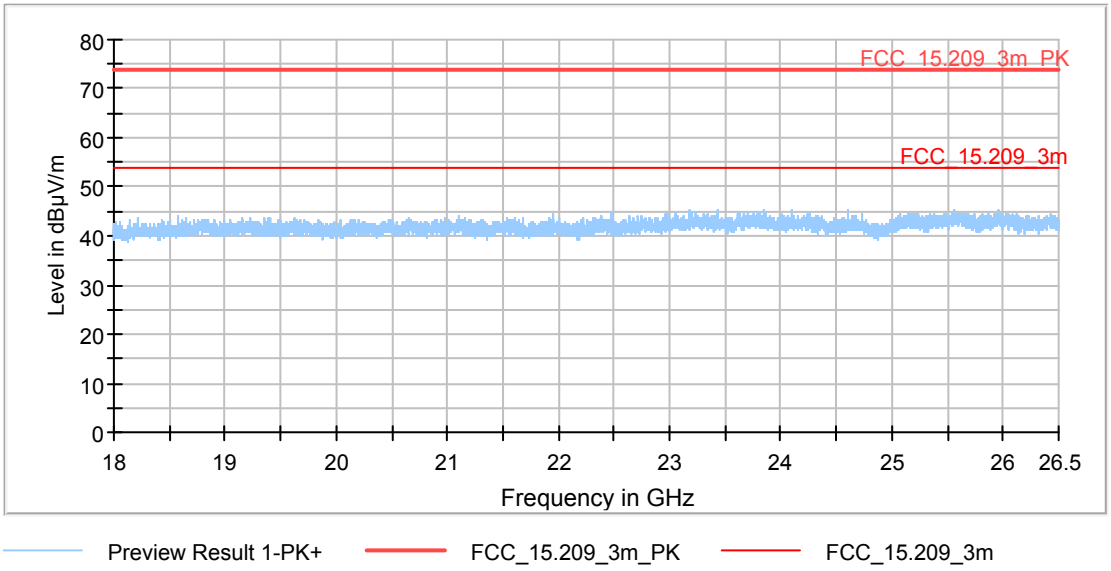


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2402 MHz

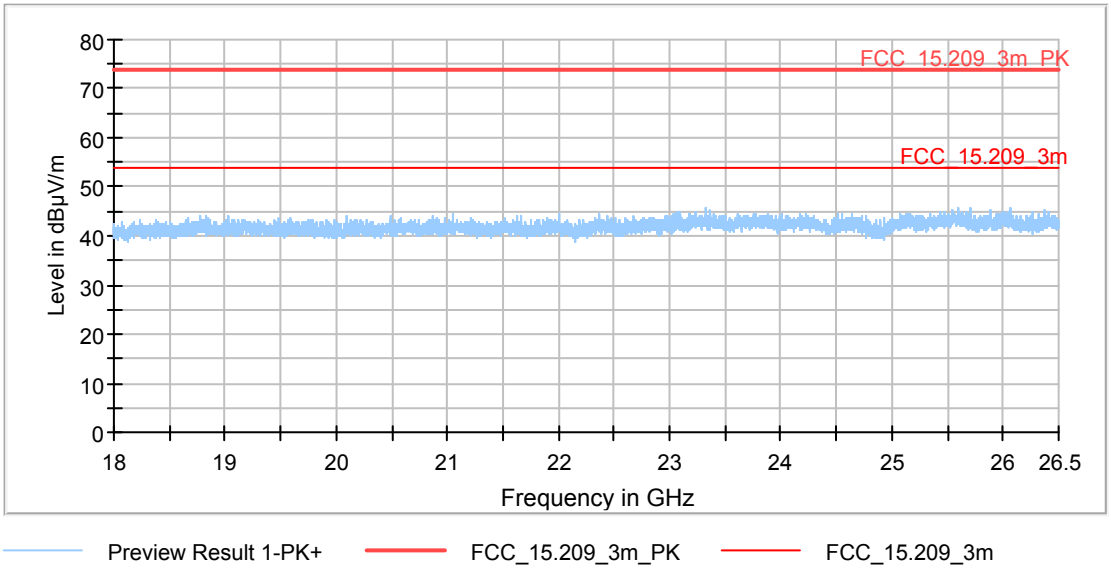


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2402 MHz

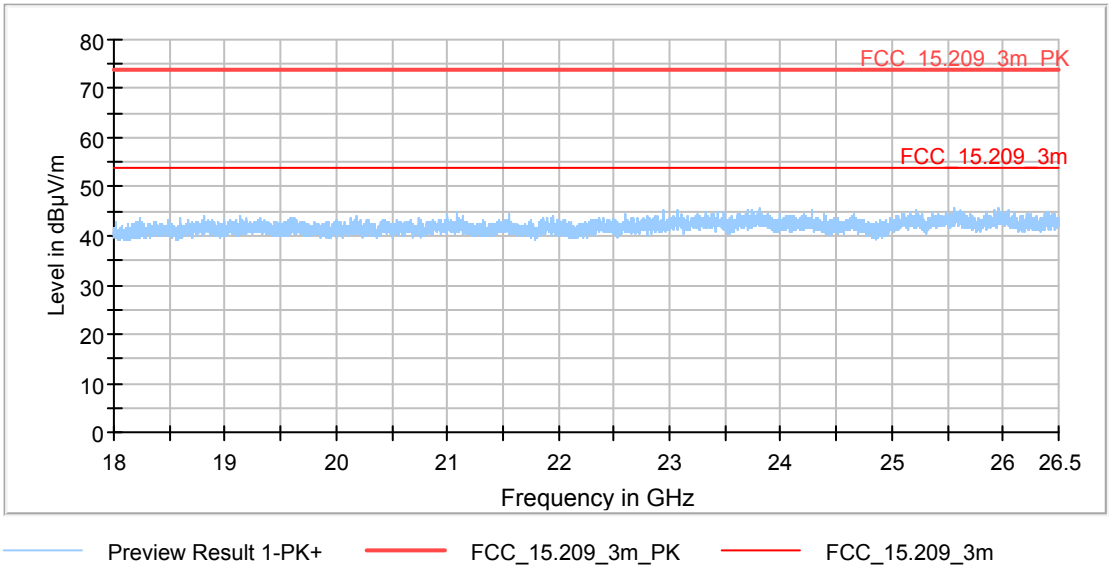


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2442 MHz

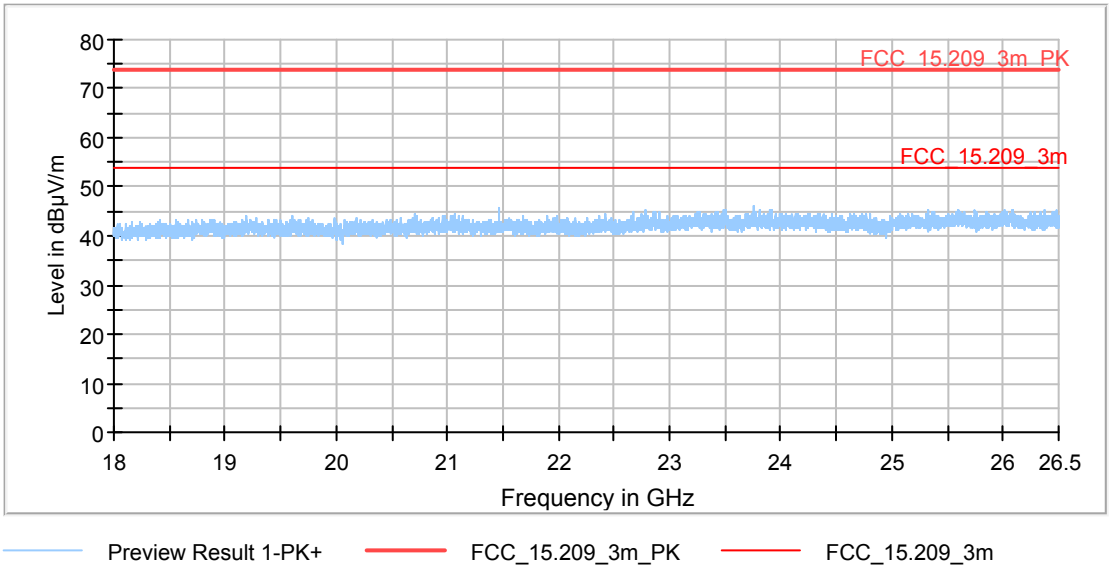


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2442 MHz

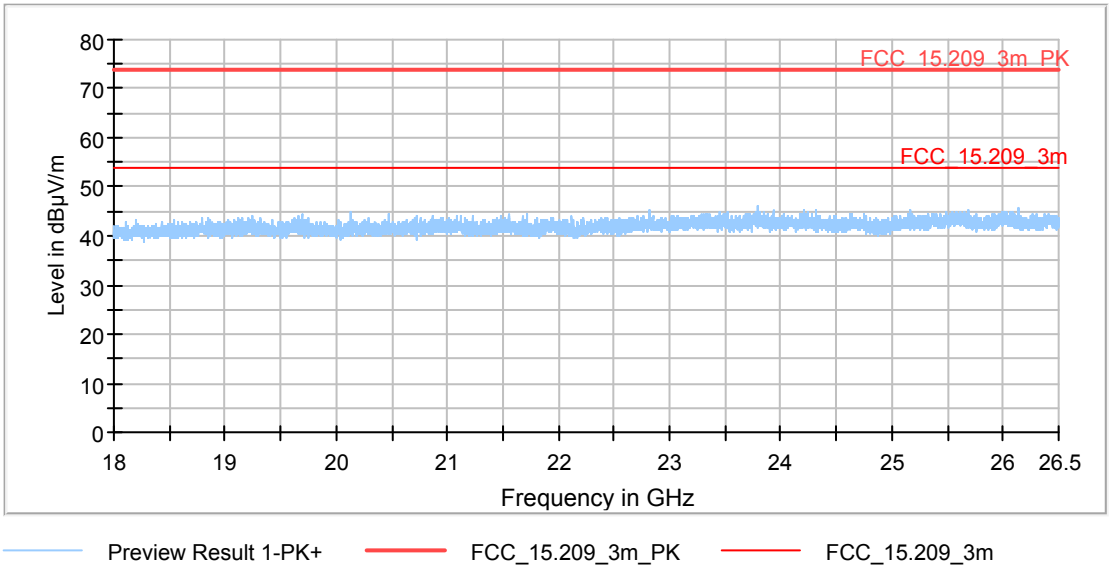


Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2442 MHz

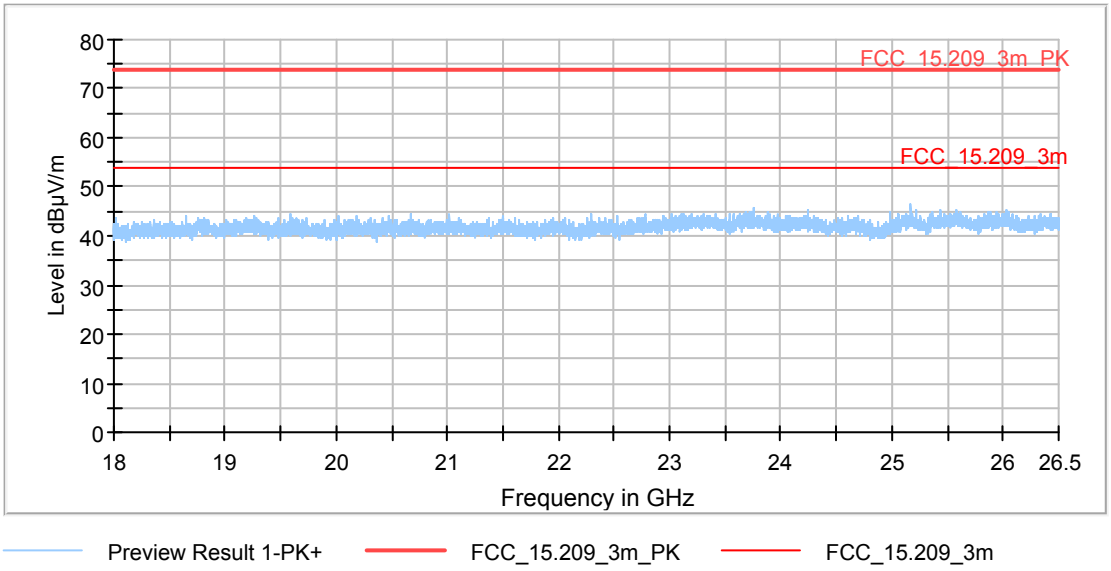


Test on EnOcean GmbH TCM 515B to 47 CFR § 15.247 and RSS-247 Issue 2

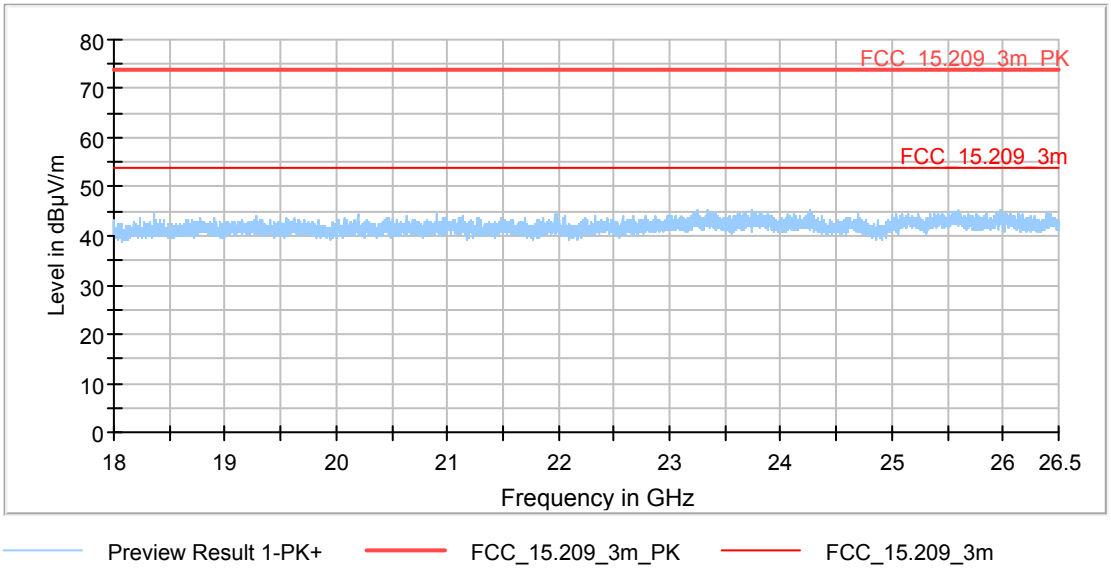
Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	1
EUT Frequency:	2480 MHz



Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	2
EUT Frequency:	2480 MHz



Manufacturer:	EnOcean GmbH
Type:	TCM 515B
EUT no., Serial No:	EUT#1, 434503001303
EUT Orientation:	3
EUT Frequency:	2480 MHz



Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)

All prescan peak results are below the average limit, therefore no final measurement performed.

All tests performed at the distance of d = 1 m (18 – 26.5 GHz).

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

4.7.11.4 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-09-09
Test personnel:	Ludwig Kraft

The EUT meets the requirements of this section.

4.8 RF Exposure Evaluation

4.8.1 Regulation

47 CFR § 2.1093 Radiofrequency radiation exposure evaluation: portable devices.

(a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular §1.1307(b).
(b) For purposes of this section, a portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.
(d) The limits to be used for evaluation are based generally on criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate ("SAR") in Section 4.2 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992, Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Section 17.4.5. Copyright NCRP, 1986, Bethesda, Maryland 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards. The criteria to be used are specified in paragraphs (d)(1) and (d)(2) of this section and shall apply for portable devices transmitting in the frequency range from 100 kHz to 6 GHz. Portable devices that transmit at frequencies above 6 GHz are to be evaluated in terms of the MPE limits specified in §1.1310 of this chapter. Measurements and calculations to demonstrate compliance with MPE field strength or power density limits for devices operating above 6 GHz should be made at a minimum distance of 5 cm from the radiating source.
(2) The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit is 4 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 30 minutes to determine compliance with general population/uncontrolled SAR limits.
(i) General Population/Uncontrolled limits apply when the general public may be exposed, or when persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or do not exercise control over their exposure.

KDB 447498 D01 General RF Exposure Guidance v06

4.3. General SAR test exclusion guidance
4.3.1. Standalone SAR test exclusion considerations
Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Threshold condition(s), listed below, is (are) satisfied. These test exclusion conditions are based on source-based time-averaged maximum conducted output power of the RF channel requiring evaluation, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions.28 The minimum test separation distance defined in 4.1 f) is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander. To qualify for SAR test exclusion, the test separation distances applied must be fully explained and justified, typically in the SAR measurement or SAR analysis report, by the operating configurations and exposure conditions of the transmitter and applicable host platform requirements, according to the required published RF exposure KDB procedures. When no other RF exposure testing or reporting are required, a statement of justification and compliance must be included in the equipment approval, in lieu of the SAR report, to qualify for SAR test exclusion. When required, the device specific conditions described in the other published RF exposure KDB procedures must be satisfied before applying these SAR test exclusion provisions; for example, handheld PTT two-way radios, handsets, laptops and tablets, etc.29
a) For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:
[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] x
[√f(GHz)] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR,

where
- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- The values 3.0 and 7.5 are referred to as numeric thresholds in step b) below

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm according to 4.1 f) is applied to determine SAR test exclusion

Appendix A

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

Approximate SAR Test Exclusion Power Thresholds at Selected Frequencies and Test Separation Distances are illustrated in the following Table. The equation and threshold in 4.3.1 must be applied to determine SAR test exclusion.

MHz	5	10	15	20	25	mm
150	39	77	116	155	194	*SAR Test Exclusion Threshold* (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	
3600	8	16	24	32	40	
5200	7	13	20	26	33	
5400	6	13	19	26	32	
5800	6	12	19	25	31	

RSS-102, 2.5.1 Exemption Limits for Routine Evaluation — SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in Table 1, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.

4.8.2 Detailed Test Data

The power levels are taken from chapter “4.4 Fundamental output power”.

The maximum measured fundamental output power is 3.2 dBm (conducted) resp. 8.2 dBm (EIRP). These values are used for further consideration as a worst case assumption.

The RF Exposure Evaluation demands a time-averaged output power. Therefore the duty cycle correction (refer to chapter 2.6) of -14 dB has to be taken into account.

FCC:

Conducted output power PK	Duty Cycle Correction Factor	Time averaged output power		Exclusion Limit
[dBm]	[dB]	[dBm]	[mW]	[mW]
3.2	-14	-10.8	0.08	10

Test exclusion calculation:
[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] x [√f(GHz)] ≤ 3.0

(0.08 mW / 5 mm) * √2.483 GHz = 0.025 ≤ 3

ISED:

Equivalent isotropically radiated power PK	Duty Cycle Correction Factor	Time averaged equivalent isotropically radiated power		Exclusion Limit
[dBm]	[dB]	[dBm]	[mW]	[mW]
8.2	-14	-5.8	0.26	4

The EUT meets the Exemption Limits for Routine Evaluation for distanced ≤ 5 mm. No further evaluation is necessary.

4.8.3 Test Result

Manufacturer:	EnOcean GmbH
Device:	TCM 515B
EUT No., Serial No:	EUT#1, 434503001303
Test date:	2019-07-31
Test personnel:	Dominik Krüger

The EUT meets the requirements of this section.

5 TEST INSTRUMENTS

Ident#	Instrument	Manufacturer	Type	Last Calibration	Calibration valid until
34	AC Power Source	California Instruments	HGA	n/a	n/a
54	N-Cable N/50	Rohde & Schwarz	HFU2-Z5	2018-12	2019-12
374	Loop Antenna	Rohde & Schwarz	HFH 2-Z2	2018-11	2021-02
516	EMI Test Receiver	Rohde & Schwarz	ESIB40	2019-04	2020-04
519	Programmable Power Source	Rohde & Schwarz	NGPE40	n/a	n/a
553	GPIB-140A	National Instruments	186135C-31	n/a	n/a
554	GPIB-140A	National Instruments	186135C-31	n/a	n/a
1291	Antenna Mast	Frankonia	FAM4	n/a	n/a
1292	Multi Device Controller	Frankonia	FC02	n/a	n/a
1300	Standard Gain Horn Antenna	Mid Century	MC 20/31B	2014-07	2024-07
1519	Pulse Limiter	Rohde & Schwarz	ESH3-Z2 357.8810.52	2019-08	2020-08
1889	SR-ULL-01, Semi-Anechoic Chamber (SAC)	EMCC/FRANK.	SAC-10	n/a	n/a
1890	SR-ULL-05, Absorber-Lined Shielded Chamber	EMCC / SIEM / FRANK	SC2-ULL	n/a	n/a
1901	V-LISN 50 ohms//(50 uH + 5 ohms)	Rohde & Schwarz	ESH2-Z5	2018-11	2019-11
2048	USB to GPIB adaptor	National Instruments	GPIB-USB-HS, 187965B-01	n/a	n/a
2719	Digital Multimeter	Agilent	U1241A	2019-07	2021-07
2720	Digital Multimeter	Agilent	U1241A	2019-04	2021-04
2724	5 W Attenuator 6dB	Weinschel	2	2019-07	2021-07
3061	K-Cable K/50	Insulated Wire	KPS-1501-600-KPS	n/a	n/a
3195	Notebook	Samsung	P560	n/a	n/a
3235	Double Ridged Guide Antenna	Schwarzbeck	BBHA 9120D	2019-01	2021-01
3236	Double Ridged Guide Antenna	Schwarzbeck	BBHA 9120D	2019-01	2021-01
3831	Spectrum Analyzer	Rohde & Schwarz	FSU50	2018-10	2019-10
3846	EMI Test Receiver	Rohde & Schwarz	ESU8	2019-02	2020-02
3880	Digital Multimeter	Agilent	U1241B	2018-07	2020-07
4018	Notebook	Dell	Latitude E6430	n/a	n/a
4058	DC Power Supply	McPower	LAB3003	n/a	n/a
4075	Workstation	Dell	Optiplex 7010	n/a	n/a
4597	USB to GPIB adapter	National Instruments	GPIB-USB-HS with NI-488.2; 187965H-01L	n/a	n/a
4717	Web-Thermo-Hygrobarograph	Wiesemann & Theis GmbH WUT	57613 Web-T/Rh/P	2018-01	2020-01
4993	Band Reject Filter	ZYSEN	ZSBR2441.75-83.5U10CS	2018-02	2020-02

Ident#	Instrument	Manufacturer	Type	Last Calibration	Calibration valid until
5366	High Pass Filter	dBd communications	DBD-FTR-15SH-U3500-O/O	2018-02	2020-02
5392	EMC Measurement Software (V10.35.02)	Rohde & Schwarz	EMC32	n/a	n/a
5535	Positioning controller	Rohde & Schwarz	HCC	n/a	n/a
5536	Rotary table	Rohde & Schwarz	HCT12	n/a	n/a
5544	Antenna Mast	innco systems GmbH	MA 5000-XPET	n/a	n/a
5545	Antenna Mast Controller	innco systems GmbH	CO 3000-1D	n/a	n/a
5551	BNC cable	EMCC	BNC003m0	n/a	n/a
5615	RF cable assembly	Rosenberger	LA2-025-7000	n/a	n/a
5616	RF cable assembly	Rosenberger	LA2-025-7000	n/a	n/a
5620	RF cable assembly	Rosenberger	LA2-001-2000	n/a	n/a
6041	TRILOG Broadband Antenna	Schwarzbeck	VULB 9163	2017-09	2019-09

6 MEASUREMENT UNCERTAINTY

Measurement	Measurement Uncertainty
Conducted Emissions, AC mains (150 kHz – 30 MHz)	±3.5 dB
Radiated Emissions below 1000 MHz	±5.6 dB
Radiated Emissions above 1 GHz	±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%.

The given values have been 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.
CISPR 16-4-2:2011+A1:2014, Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty.
JCGM 100:2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement.

7 LIST OF ANNEXES

The following annexes are separated parts from this test report.

Description	Pages
Annex 1: Photographs of test setup	5
Annex 2: Photographs of equipment under test	3
Annex 3: Photographs of ancillary equipment	3