TEST REPORT # EMCC-110010UB, 2017-04-12

EQUIPMENT UNDER TEST:

Device:	TCM 515Z
Serial Number:	363603001278 363603001268 363603001281
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515Z
IC ID:	5713A-TCM515Z
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone :	+49 89 6734689-49
Fax :	+49 89 6734689-56

RELEVANT STANDARD(S) : 47 CFR § 15.247:2015-10
RSS-247 Issue 2

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☒ 558074 D01 DTS Meas Guidance v03r05

TEST REPORT PREPARED BY:

Patrick Reusch
EMCCons DR. RAŠEK GmbH & Co. KG
Boelwiese 8
91320 Ebermannstadt
Germany
Phone: +49 9194 7262-0
Fax: +49 9194 7262-199
E-Mail: p.reusch@emcc.de

TEST PERSONNEL:

Patrick Reusch

HEAD OF COMMERCIAL EMC AND RADIO DEPT.:

Wolfgang Döring

CONTENTS

Page

1 General Information 4
1.1 Purpose 4
1.2 Limits and Reservations 4
1.3 Test Location 4
1.4 Customer 5
1.5 Manufacturer 5
1.6 Dates and Test Location 5
1.7 Ordering Information 5
1.8 Climatic Conditions 5
2 Product Description 6
2.1 Equipment Under Test (EUT) 6
2.2 Intended Use 7
2.3 EUT Peripherals/Simulators 7
2.4 Mode of operation during testing and test set-up 7
2.5 Modifications required for compliance 8
2.6 Duty-Cycle Correction 8
3 Test Results Summary 9
4 Antenna Requirement 10
4.1 Regulation 10
4.2 Test Equipment 10
4.3 Test Procedures 10
4.4 Test Result 10
5 Occupied Bandwidth 11
5.1 Regulation 11
5.2 Test Equipment 11
5.3 Test Procedures 11
5.4 Test Result 13
5.5 Detailed Measurement Data 14
6 Fundamental emission output power 19
6.1 Regulation 19
6.2 Test Equipment 20
6.3 Test Procedures 20
6.4 Power calculation 21
6.5 Test Result 22
6.6 Detailed Measurement Data 23
7 Power Spectral Density 26
7.1 Regulation 26
7.2 Test Equipment 26
7.3 Test Procedures 27
7.4 Power calculation 27
7.5 Test Result 28
7.6 Detailed Measurement Data 29
8 Band-Edge Compliance 32
8.1 Regulation 32
8.2 Test Equipment 34
8.3 Test Procedures 34
8.4 Calculation of Field Strength Limits 35
8.5 Field Strength Calculation 35
8.6 Marker-Delta Method Calculation 36
8.7 Test Result 37
8.8 Detailed Measurement Data 38
9 Radiated Emissions 9 kHz – 30 MHz 41
9.1 Regulation 41

9.2 Test Equipment 43
9.3 Test Procedures 43
9.4 Calculation of Field Strength Limits 44
9.5 Field Strength Calculation 45
9.6 Final Test Results 45
9.7 Detailed Measurement Data 46
10 Radiated Emissions 30 MHz – 1000 MHz 51
10.1 Regulation 51
10.2 Test Equipment 53
10.3 Test Procedures 53
10.4 Calculation of Field Strength Limits 54
10.5 Field Strength Calculation 55
10.6 Final Test Results 55
10.7 Detailed Measurement Data 56
11 Radiated Emissions 1 GHz – 25 GHz 61
11.1 Regulation 61
11.2 Test Equipment 63
11.3 Test Procedures 63
11.4 Calculation of Field Strength Limits 65
11.5 Field Strength Calculation 65
11.6 Final Test Results 67
11.7 Detailed Measurement Data 68
12 Measurement Uncertainty 80
13 List of Annexes 81

1 GENERAL INFORMATION

1.1 Purpose

The purpose of this report is to show compliance with the 47 CFR § 15.247:2015-10 and RSS-247 Issue 2 requirements for the certification of licence-exempt Intentional Radiator.

1.2 Limits and Reservations

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

1.3 Test Location

Test Laboratory:	EMCCons DR. RAŠEK GmbH & Co. KG
DAkkS Accreditation No.:	D-PL-12067-01-02
Address of Labs I, II, III and Head Office:	EMCCons DR. RAŠEK GmbH & Co. KG Boelwiese 8 91320 Ebermannstadt GERMANY
Address of Labs IV and V:	EMCCons DR. RAŠEK GmbH & Co. KG Stoernhofer Berg 15 91364 Unterleinleiter GERMANY
Laboratory:	Test Laboratory IV The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to the FCC and accepted in the letter dated December 23, 2016, Registration Number 878769. The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to ISED. This 3m/10m alternative test side is approved by Innovation, Science and Economic Development Canada under file number 3464C-1.
Phone:	+49 9194 7262-0
Fax:	+49 9194 7262-199
E-Mail:	emc.cons@emcc.de
Web:	www.emcc.de

1.4 Customer

Company Name:	EnOcean GmbH
Street:	Kolpingring 18 a
City:	82041 Oberhaching
Country:	Germany
Name for contact purposes:	Mr Dirk Lumbeck
Phone:	+49 89 6734689-49
Fax:	+49 89 6734689-56
E-Mail:	dirk.lumbeck@enocean.com

1.5 Manufacturer

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

1.6 Dates and Test Location

Date of receipt of EUT:	2017-01-09 (Variant #1 and #2)
	2017-01-24 (Variant #3)
Test Date:	CW 2/2017 to 5/2017
Test Location:	Lab IV

1.7 Ordering Information

Purchase Order:	8835
Date:	2017-01-03
Vendor Number:	K701624

1.8 Climatic Conditions

Date	Temperature [°C]	Relative Humidity [%]	Air Pressure [hPa]	Lab	Customer attended tests
2017-01-09	20	27	984	IV	yes, Mr Lumbeck
2017-01-10	20	27	971	IV	no
2017-01-11	20	25	970	IV	no
2017-01-25	21	21	988	IV	no
2017-01-30	21	21	975	IV	no
2017-01-31	21	27	973	IV	no
2017-02-01	22	27	977	IV	no

2 PRODUCT DESCRIPTION

2.1 Equipment Under Test (EUT)

The following data is based on customer's information.

Trade Name:	TCM 515Z
Serial Number:	Variant #1: 363603001278
	Variant #2: 363603001268
	Variant #3: 363603001281
No. of Variants:	3
Variant #1	equipped with 50 Ohm whip antenna
Variant #2	equipped with printed PCB Antenna
Variant #3	equipped with RP-SMA connector for external 50 Ohm antenna
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515Z
IC ID:	5713A-TCM515Z
Radio Standard:	IEEE 802.15.4
Frequency Range:	2400 - 2483.5 MHz
No. of Channels:	16 (Ch. 11 .. 26)
Tested channels:	11 (2405 MHz)
	18 (2440 MHz)
	26 (2480 MHz)
Modulation:	QPSK
Power Supply:	3.3 V DC (Variant #1 and #3)
	5 V DC via USB (Variant #2)
Ports:	UART
Antenna and Gain:	Whip antenna, max. 2 dBi
	Printed PCB antenna, max. 0 dBi
	External RP-SMA antenna, max. 5 dBi
Remarks:	None

2.2 Intended Use

The following information was delivered by the customer (excerpt from device's datasheet):

2.4 GHz IEEE 802.15.4 Transceiver TCM 515Z

TCM 515Z enables the realization of transparent transceiver gateways and for EnOcean systems communicating based on the 2.4 GHz IEEE 802.15.4 radio standard. It provides a transparent radio link between EnOcean 2.4 GHz devices and an external host connected via the standardized ESP3 interface (EnOcean Serial Protocol V3). The TCM 515Z receives and transmits radio telegrams based on an antenna connected to or printed onto the host PCB. It forwards received 2.4 GHz IEEE 802.15.4 radio telegrams to an externally connected host processor or host PC via the ESP3 interface. IEEE 802.15.4 messages received from an external host via the ESP3 interface will be transmitted by TCM 515Z as 2.4 GHz radio telegrams. The ESP3 interface of TCM 515Z provides the option to select a higher ESP3 interface speed (460.800 Bit per second). TCM 515Z is implemented as 31 pin reflow-solderable module in an optimized form factor to enable size constrained applications.

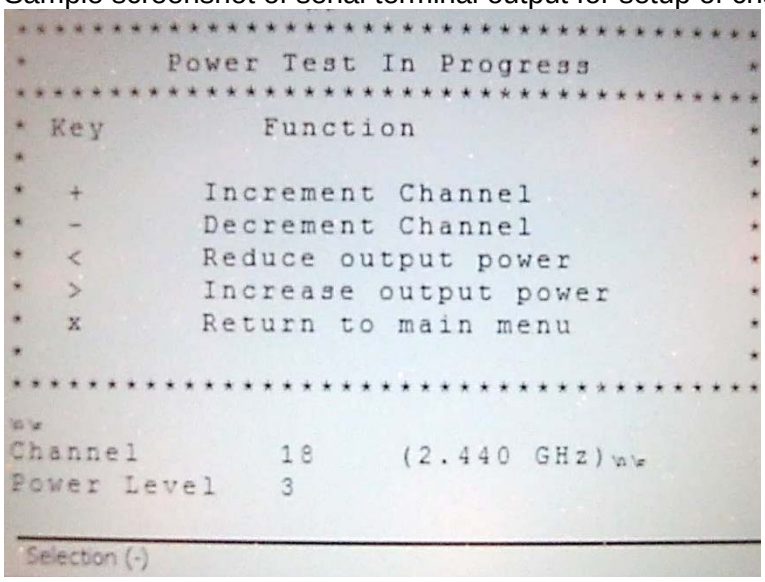
2.3 EUT Peripherals/Simulators

Variant #1 and Variant #3 were mounted on an Eval-Board called EOP350 which was powered by 3.3V DC from external power supply during all tests.
Variant #2 is soldered on a demo board called USB500Z-V1.0 which was power by 5V DC from a notebook's USB port.

2.4 Mode of operation during testing and test set-up

The test mode was set up via serial terminal program using standard RS232 protocol.

Sample screenshot of serial terminal output for setup of channel 18:



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

Continuous Transmit:
The EUT was continuously transmitting modulated data with a duty cycle of 100% and maximum power (setting = 3). This mode of operation was used for all tests.

2.5 Modifications required for compliance

None.

2.6 Duty-Cycle Correction

The following declaration was made by the customer on 2017-02-08 via email:

The TCM 515Z is a UART to IEEE802.15.4 gateway. It forwards received RF frames to the UART and vice versa. The UART supports two data rates – 57.6kbps and 460.8kbps. The IEEE802.15.4 protocol has a data rate of 250kbps.

- *When the UART is driven with 57.6kbps, It's technically impossible to exceed a duty cycle of approx. 23% as the UART's data rate act as bottleneck.*
- *When the UART is driven with 460.8kbps, the TCM 515Z will monitor its duty cycle in a sliding 100ms window. The device will delay messages if a duty cycle of 30% would be exceeded.*

According to the description delivered by customer, the duty cycle is limited to 23 % (case 1) resp. 30 % (case 2) resulting in a maximum ON-Time of 30ms in each 100 ms interval.

For average correction purposes, a duty cycle correction factor of (30 ms / 100 ms) * 100 = 30 % was used.

Expressed in logarithmic terms, the correction factor DCF is
20 x log (30 ms/100 ms) = -10.5 dB.

3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: Variant #1: 363603001278
Variant #2: 363603001268
Variant #3: 363603001281

Requirement	47 CFR Section	RSS Section	Report Section	Tested Variants	Result
Antenna Requirement	§ 15.203	---	4	#1, #2, #3	Passed
Occupied Bandwidth	§ 15.247	RSS-247, 5.2	5	#1, #2, #3	Passed
Fundamental Emission Output Power	§ 15.247	RSS-247, 5.4	6	#1, #2, #3	Passed
Power Spectral Density	§ 15.247	RSS-247, 5.2	7	#1, #2, #3	Passed
Band-Edge Compliance	§ 15.247	RSS-247, 5.5 RSS-Gen, 8.9	8	#1, #2, #3	Passed
Radiated Emissions 9 kHz – 30 MHz	§ 15.247, § 15.209	RSS-247, 5.5 RSS-Gen, 8.9	9	#1, #2, #3	Passed
Radiated Emissions 30 MHz – 1000 MHz	§ 15.247, § 15.209	RSS-247, 5.5 RSS-Gen, 8.9	10	#1, #2, #3	Passed
Radiated Emissions 1 GHz – 25 GHz	§ 15.247, § 15.209	RSS-247, 5.5 RSS-Gen, 8.9	11	#1, #2, #3	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: Patrick Reusch
Issuance Date: 2017-04-12

4 ANTENNA REQUIREMENT

Test Requirement: 47 CFR, § 15.203
Test Procedure: none

4.1 Regulation

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

4.2 Test Equipment

None.

4.3 Test Procedures

None.

4.4 Test Result

Variant #1 is equipped with a whip antenna, which is soldered directly to the PCB.
Variant #2 is equipped with a printed PCB antenna.
Variant #3 is equipped with an RP-SMA antenna connector.

Manufacturer:	EnOcean GmbH
Device:	TCM 515Z
Serial No:	363603001278
	363603001268
	363603001281
Test date:	2017-01-25

The EUT meets the requirements of this section.

5 OCCUPIED BANDWIDTH

Test Requirement: 47 CFR, § 15.247
RSS-247, 5.2
Test Procedure: 558074 D01 DTS Meas Guidance
RSS-Gen, 6.6

5.1 Regulation

§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, 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.

5.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3235	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2016-08	2017-08
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
RF cable assembly	Rosenberger / LA2-025-7000	5616	2016-08	2017-08

5.3 Test Procedures

558074 D01 DTS Meas Guidance, 8.0 DTS bandwidth

The following procedure was used to determine the modulated DTS bandwidth:

8.1 Option 1
a) Set RBW = 100 kHz.
b) Set the video bandwidth (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.

RSS-Gen, 6.6 Occupied Bandwidth

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

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

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

5.4 Test Result

6 dB Bandwidth						
EUT	**Operating Channel**	**Nominal Tx Frequency [MHz]**	**Lower Edge [MHz]**	**Upper Edge [MHz]**	**6 dB Bandwidth [MHz]**	**Limit [MHz]**
#1	11	2405	2404.37	2405.71	1.34	≥ 0.5
#1	18	2440	2439.35	2440.79	1.43	≥ 0.5
#1	26	2480	2479.32	2480.77	1.45	≥ 0.5
#2	11	2405	2404.35	2405.72	1.37	≥ 0.5
#2	18	2440	2439.29	2440.77	1.48	≥ 0.5
#2	26	2480	2479.31	2480.77	1.46	≥ 0.5
#3	11	2405	2404.34	2405.68	1.34	≥ 0.5
#3	18	2440	2439.34	2440.70	1.35	≥ 0.5
#3	26	2480	2479.30	2480.77	1.47	≥ 0.5

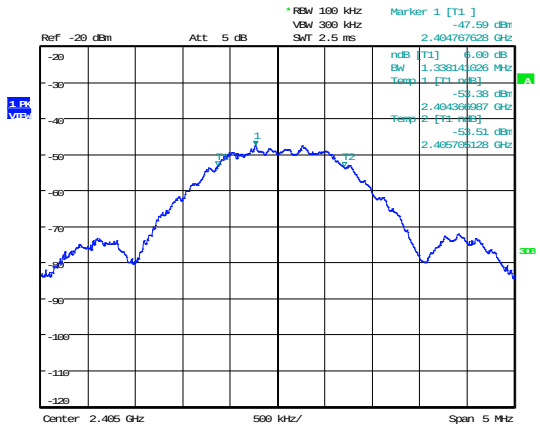
99 % Bandwidth						
EUT	**Operating Channel**	**Nominal Tx Frequency [MHz]**	**Lower Edge [MHz]**	**Upper Edge [MHz]**	**99 % Bandwidth [MHz]**	**Limit [MHz]**
#1	11	2405	2403.91	2406.15	2.24	---
#1	18	2440	2438.88	2441.16	2.28	---
#1	26	2480	2478.86	2481.17	2.31	---
#2	11	2405	2403.87	2406.18	2.31	---
#2	18	2440	2438.84	2441.19	2.36	---
#2	26	2480	2478.84	2481.17	2.33	---
#3	11	2405	2403.90	2406.10	2.20	---
#3	18	2440	2438.89	2441.13	2.24	---
#3	26	2480	2478.85	2481.15	2.30	---

Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: 363603001278
363603001268
363603001281
Test date: 2017-01-25

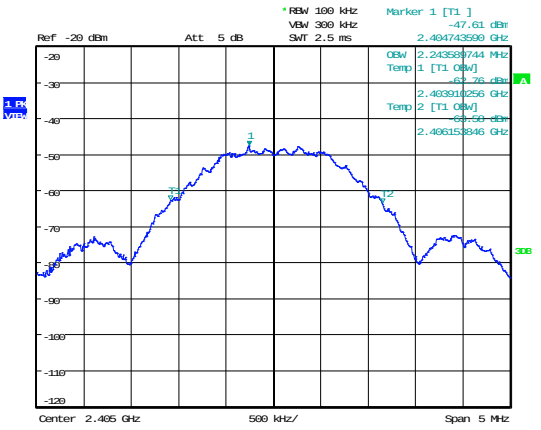
The EUT meets the requirements of this section.

5.5 Detailed Measurement Data

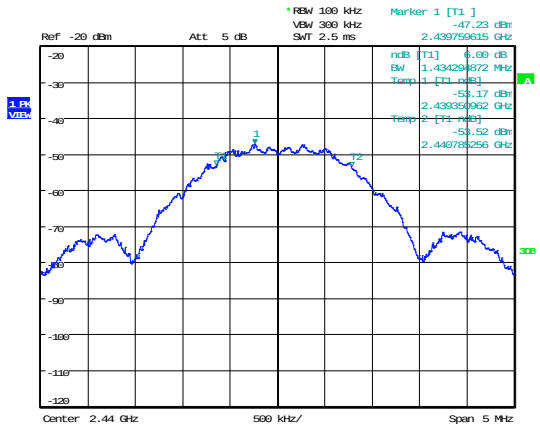
6dB Bandwidth
Variant #1
Channel: 11



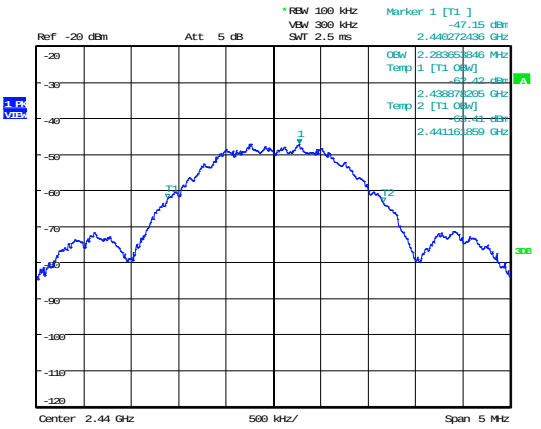
99% Bandwidth
Variant #1
Channel: 11



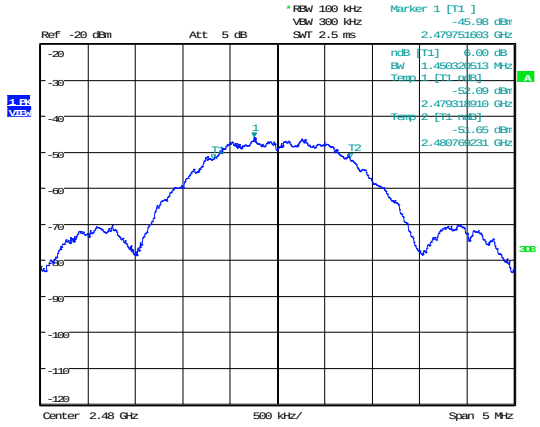
6dB Bandwidth
Variant #1
Channel: 18



99% Bandwidth
Variant #1
Channel: 18

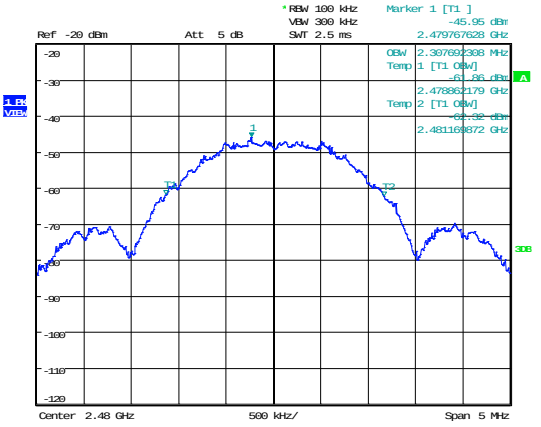


6dB Bandwidth
Variant #1
Channel: 26



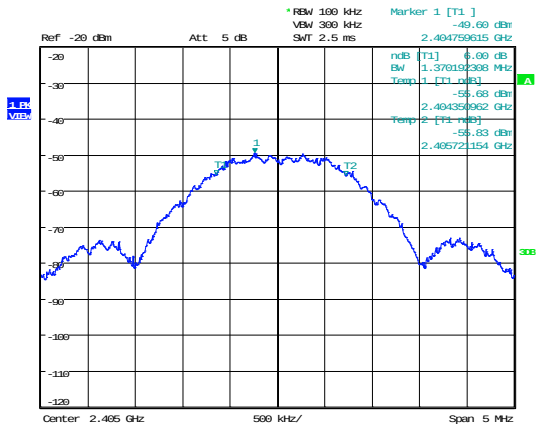
EUT 1; CH.26
Date: 25.JAN.2017 11:26:30

99% Bandwidth
Variant #1
Channel: 26



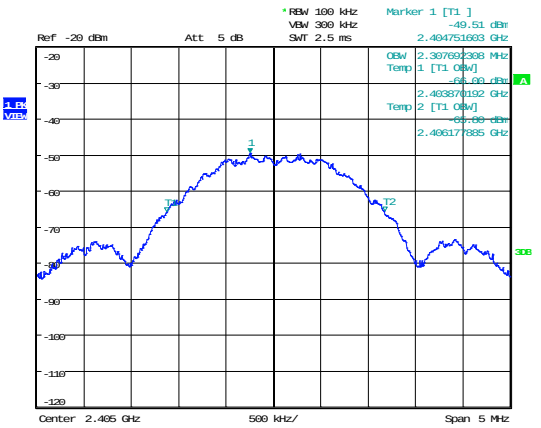
EUT 1; CH.26
Date: 25.JAN.2017 11:25:36

6dB Bandwidth
Variant #2
Channel: 11



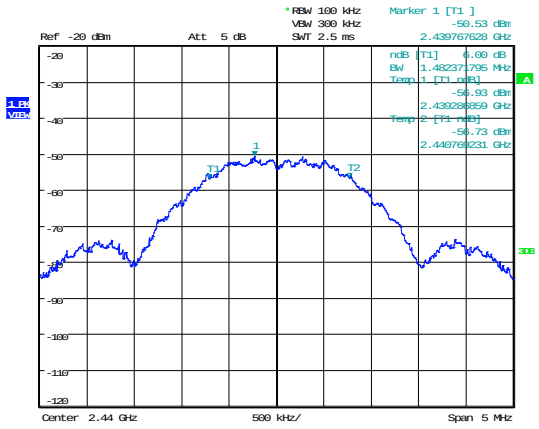
EUT 2; CH.11
Date: 25.JAN.2017 11:30:31

99% Bandwidth
Variant #2
Channel: 11



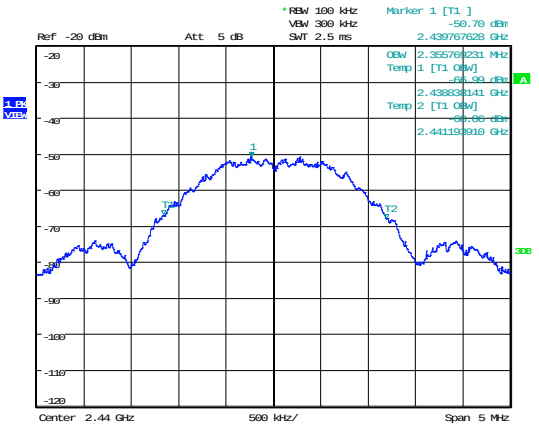
EUT 2; CH.11
Date: 25.JAN.2017 11:30:57

6dB Bandwidth
Variant #2
Channel: 18



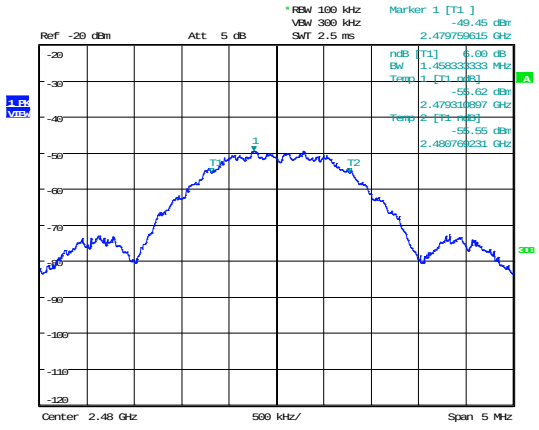
EUT 2; CH.18
Date: 25.JAN.2017 11:32:10

99% Bandwidth
Variant #2
Channel: 18



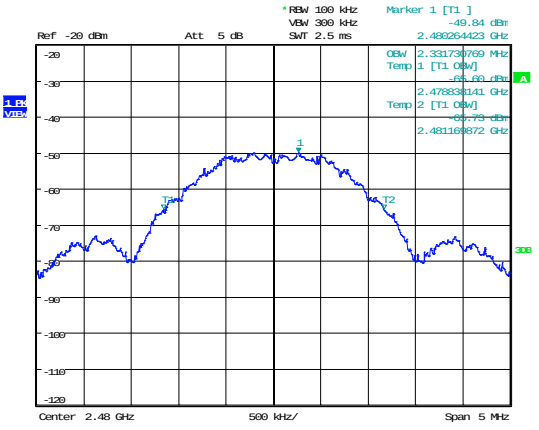
EUT 2; CH.18
Date: 25.JAN.2017 11:31:38

6dB Bandwidth
Variant #2
Channel: 26



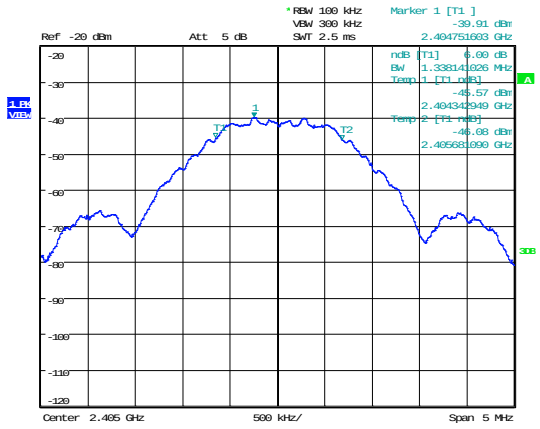
EUT 2; CH.26
Date: 25.JAN.2017 11:32:57

99% Bandwidth
Variant #2
Channel: 26



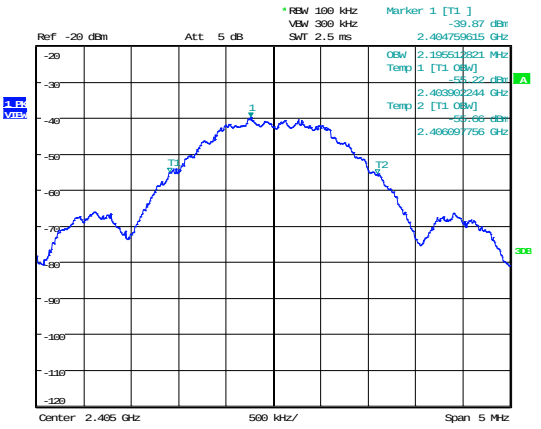
EUT 2; CH.26
Date: 25.JAN.2017 11:33:29

6dB Bandwidth
Variant #3
Channel: 11



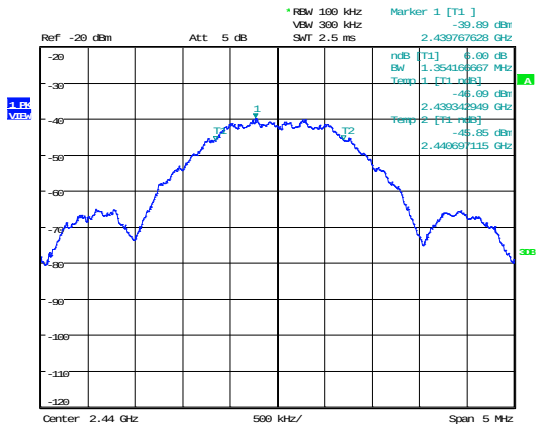
EUT 3; CH.11
Date: 25.JAN.2017 11:17:31

99% Bandwidth
Variant #3
Channel: 11



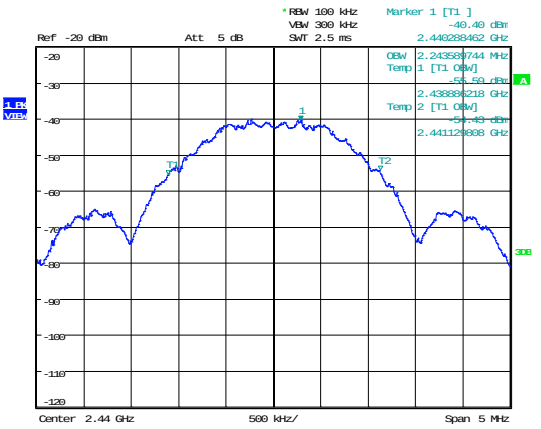
EUT 3; CH.11
Date: 25.JAN.2017 11:18:11

6dB Bandwidth
Variant #3
Channel: 18



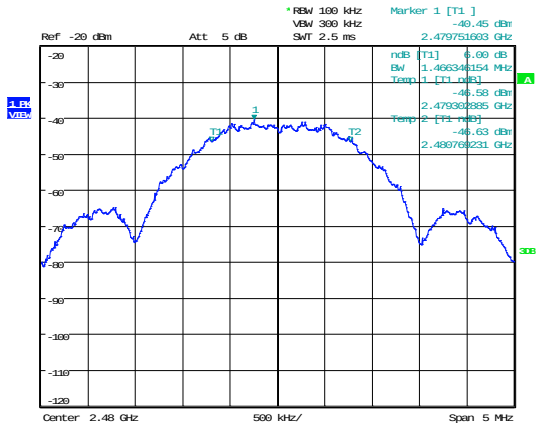
EUT 3; CH.18
Date: 25.JAN.2017 11:19:47

99% Bandwidth
Variant #3
Channel: 18



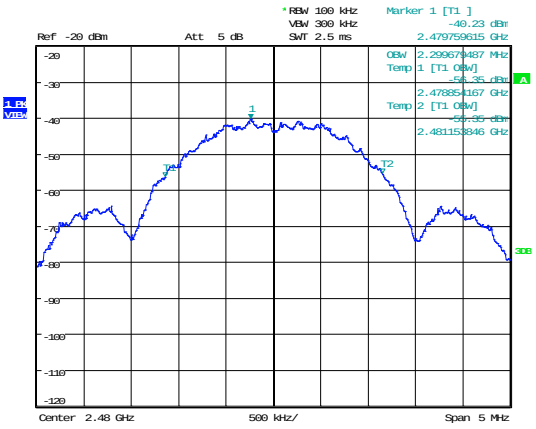
EUT 3; CH.18
Date: 25.JAN.2017 11:19:10

6dB Bandwidth
Variant #3
Channel: 26



EUT 3; CH.26
Date: 25.JAN.2017 11:20:33

99% Bandwidth
Variant #3
Channel: 26



EUT 3; CH.26
Date: 25.JAN.2017 11:21:10

6 FUNDAMENTAL EMISSION OUTPUT POWER

Test Requirement: 47 CFR, § 15.247
RSS-247, 5.4
Test Procedure: 558074 D01 DTS Meas Guidance
RSS-Gen, 6.12

6.1 Regulation

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
(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, where applicable:
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 1 W. 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.

6.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3235	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2016-08	2017-08
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
RF cable assembly	Rosenberger / LA2-025-7000	5616	2016-08	2017-08

6.3 Test Procedures

558074 D01 DTS Meas Guidance, 9.0 Fundamental emission output power

9.1.1 RBW ≥ DTS bandwidth
This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.

a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ 3 x RBW.
c) Set span ≥ 3 x 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
If the RF output power is internally or externally adjustable or remotely controllable, set or control the power to the maximum rating of the range for which equipment certification is sought.

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

If the antenna is not detachable, field strength measurements shall be made using a calibrated open area test site or alternative test site.

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

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

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain. (Note: 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.)

Measure and record the transmitter output power using a measurement bandwidth equal to or greater than the emission bandwidth of the transmitter, or use power summation as described above. When power summation is used, the transmitter output power shall be integrated over the equipment's occupied bandwidth.

6.4 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 67.3 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 2 dBi resulting in a conducted output power of -0.7 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 67.3 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 1.3 dBm.

6.5 Test Result

Conducted output power								
EUT	**Channel**	**PK-Reading [dBµV]**	**AF [dB(1/m)]**	**CF [dB]**	**Gain [dBi]**	**P_{cond} [dBm]**	**Limit [dBm]**	**Margin [dB]**
#1	11	67.3	27.6	1.6	2.0	-0.7	30	30.7
#1	18	68.7	27.6	1.6	2.0	0.7	30	29.3
#1	26	70.9	27.6	1.6	2.0	2.9	30	27.1
#2	11	63.2	27.6	1.6	0.0	-2.8	30	32.8
#2	18	60.4	27.6	1.6	0.0	-5.6	30	35.6
#2	26	63.8	27.6	1.6	0.0	-2.2	30	32.2
#3	11	73.7	27.6	1.6	5.0	2.7	30	27.3
#3	18	72.2	27.6	1.6	5.0	1.2	30	28.8
#3	26	71.7	27.6	1.6	5.0	0.7	30	29.3

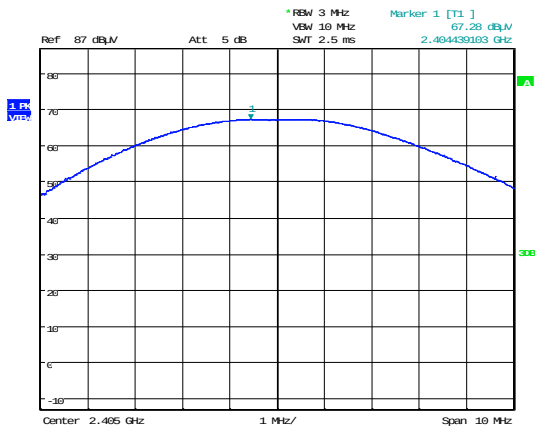
EIRP							
EUT	**Channel**	**PK-Reading [dBµV]**	**AF [dB(1/m)]**	**CF [dB]**	**P_{EIRP} [dBm]**	**Limit [dBm]**	**Margin [dB]**
#1	11	67.3	27.6	1.6	1.3	36	34.7
#1	18	68.7	27.6	1.6	2.7	36	33.3
#1	26	70.9	27.6	1.6	4.9	36	31.1
#2	11	63.2	27.6	1.6	-2.8	36	38.8
#2	18	60.4	27.6	1.6	-5.6	36	41.6
#2	26	63.8	27.6	1.6	-2.2	36	38.2
#3	11	73.7	27.6	1.6	7.7	36	28.3
#3	18	72.2	27.6	1.6	6.2	36	29.8
#3	26	71.7	27.6	1.6	5.7	36	30.3

Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: 363603001278
363603001268
363603001281
Test date: 2017-01-30

The EUT meets the requirements of this section.

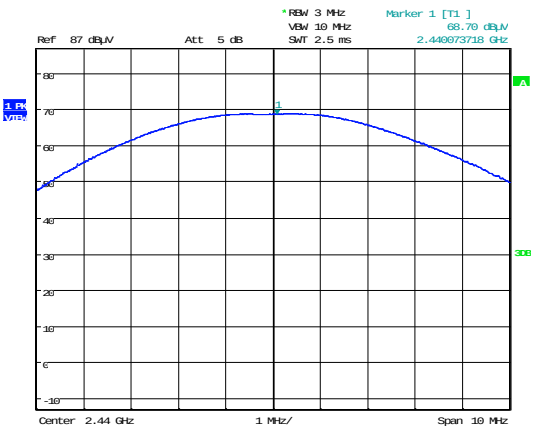
6.6 Detailed Measurement Data

Fundamental emission output power
Variant #1
Channel: 11



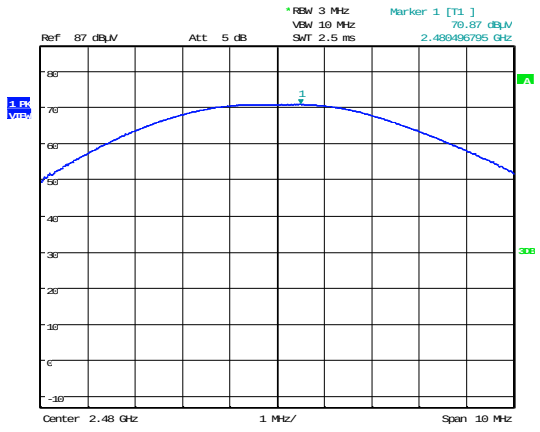
EUT 1; CH.11
Date: 30.JAN.2017 14:59:17

Fundamental emission output power
Variant #1
Channel: 18



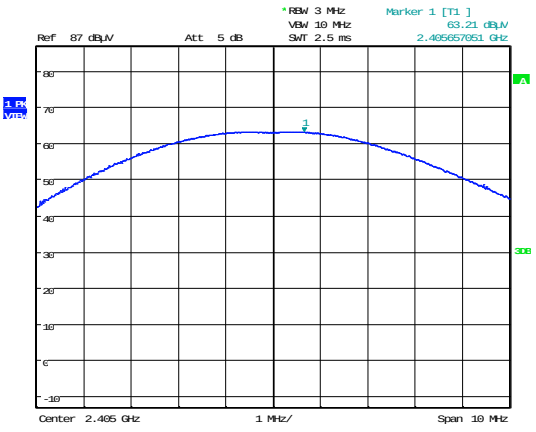
EUT 1; CH.18
Date: 30.JAN.2017 15:01:56

Fundamental emission output power
Variant #1
Channel: 26



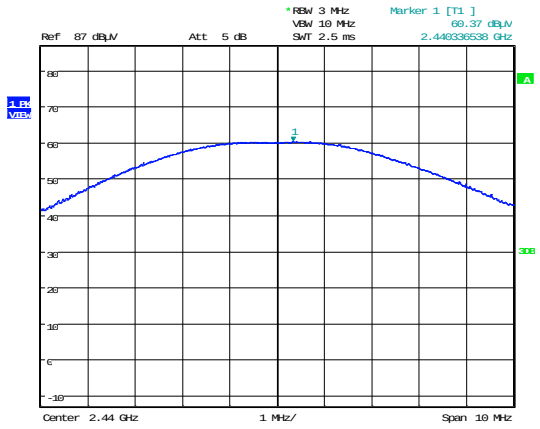
EUT 1; CH.26
Date: 30.JAN.2017 15:03:33

Fundamental emission output power
Variant #2
Channel: 11



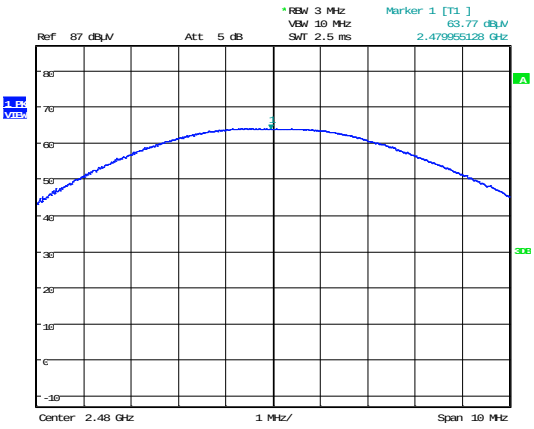
EUT 2; CH.11
Date: 30.JAN.2017 14:52:42

Fundamental emission output power
Variant #2
Channel: 18



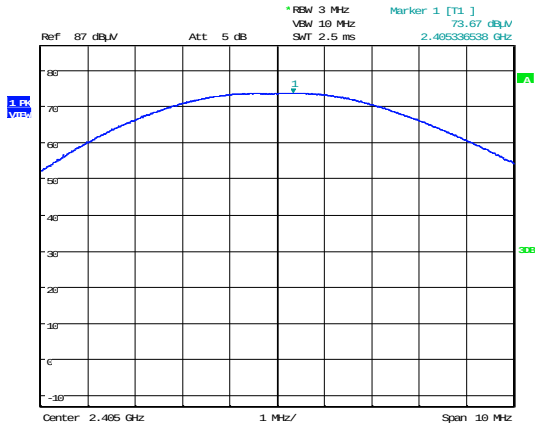
EUT 2; CH.18
Date: 30.JAN.2017 14:53:59

Fundamental emission output power
Variant #2
Channel: 26



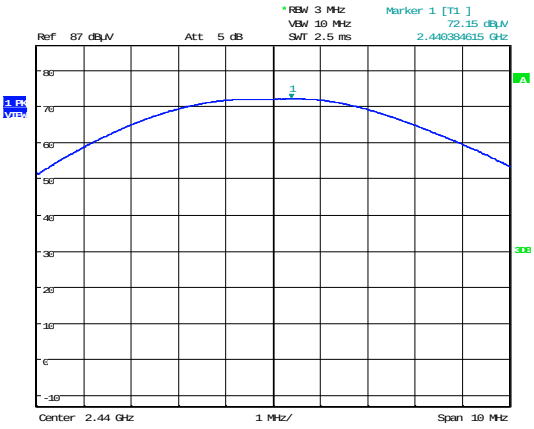
EUT 2; CH.26
Date: 30.JAN.2017 14:56:46

Fundamental emission output power
Variant #3
Channel: 11



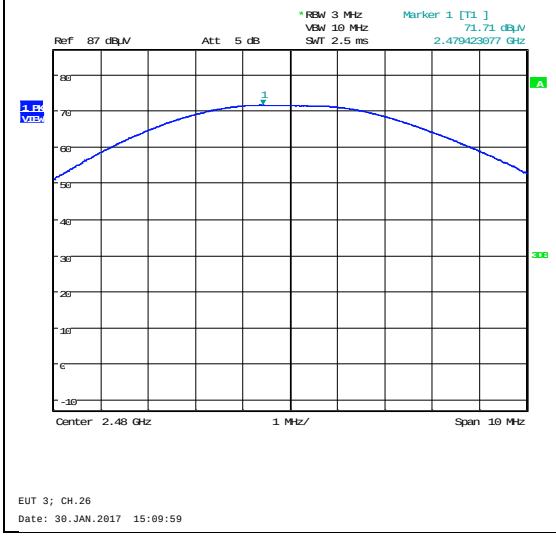
EUT 3; CH.11
Date: 30.JAN.2017 15:06:56

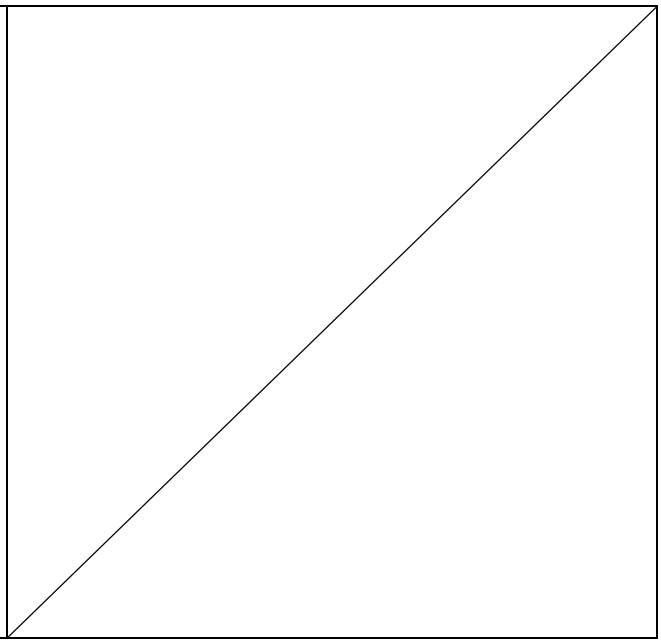
Fundamental emission output power
Variant #3
Channel: 18



EUT 3; CH.18
Date: 30.JAN.2017 15:07:44

Fundamental emission output power
Variant #3
Channel: 26





7 POWER SPECTRAL DENSITY

Test Requirement: 47 CFR, § 15.247
RSS-247, 5.2
Test Procedure: 558074 D01 DTS Meas Guidance

7.1 Regulation

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
(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:
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).

7.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3235	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2016-08	2017-08
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
RF cable assembly	Rosenberger / LA2-025-7000	5616	2016-08	2017-08

7.3 Test Procedures

558074 D01 DTS Meas Guidance, 10.0 Maximum power spectral density level in the fundamental emission

10.2 Method PKPSD (peak PSD)

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance, and is optional if the maximum conducted (average) output power was used to demonstrate 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 x RBW.
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level within the RBW.
j) If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

7.4 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 54.5 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 2 dBi resulting in a power spectral density of -13.5 dBm / 3 kHz.

7.5 Test Result

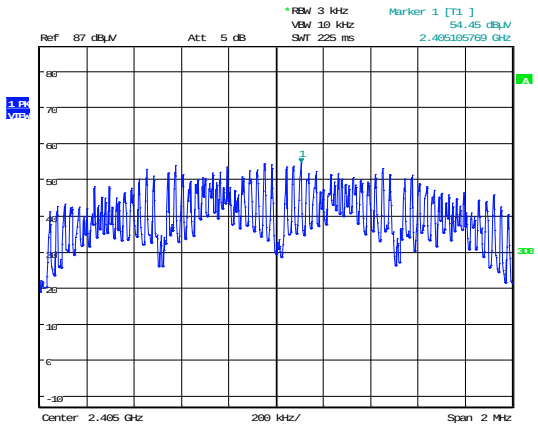
Power Spectral Density								
EUT	Channel	PK-Reading [dBµV]	AF [dB(1/m)]	CF [dB]	Gain [dBi]	P_{PSD} [dBm/ 3 kHz]	Limit [dBm]	Margin [dB]
#1	11	54.5	27.6	1.6	2.0	-13.5	8	21.5
#1	18	54.9	27.6	1.6	2.0	-13.1	8	21.1
#1	26	55.0	27.6	1.6	2.0	-13.0	8	21.0
#2	11	49.0	27.6	1.6	0.0	-17.0	8	25.0
#2	18	44.5	27.6	1.6	0.0	-21.5	8	19.5
#2	26	46.8	27.6	1.6	0.0	-19.2	8	27.2
#3	11	61.4	27.6	1.6	5.0	-9.6	8	17.6
#3	18	60.0	27.6	1.6	5.0	-11.0	8	19.0
#3	26	59.3	27.6	1.6	5.0	-11.7	8	19.7

Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: 363603001278
363603001268
363603001281
Test date: 2017-01-30

The EUT meets the requirements of this section.

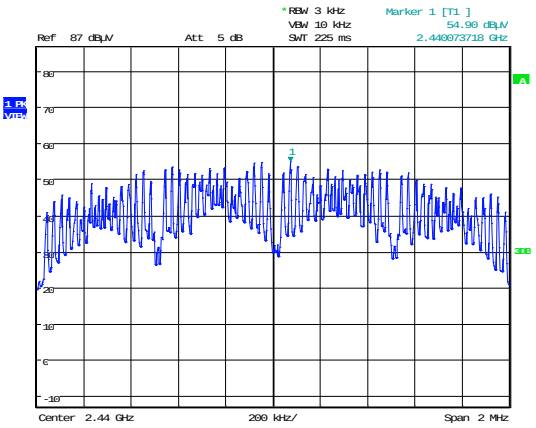
7.6 Detailed Measurement Data

Power Spectral Density
Variant #1
Channel: 11



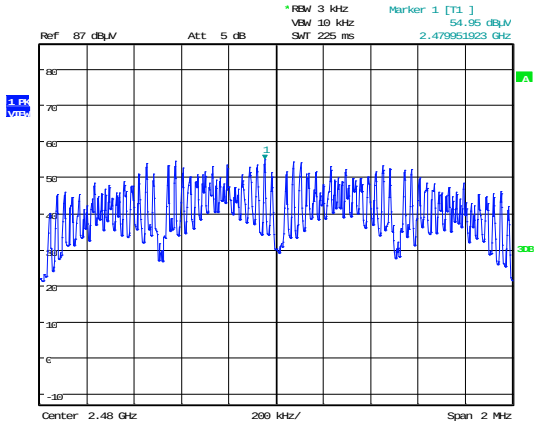
EUT 1; CH.11
Date: 30.JAN.2017 15:00:18

Power Spectral Density
Variant #1
Channel: 18



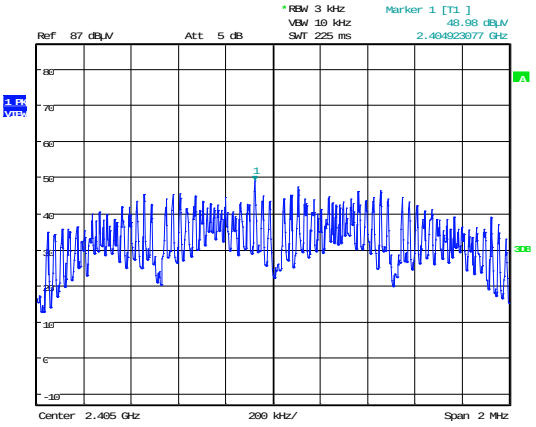
EUT 1; CH.18
Date: 30.JAN.2017 15:01:11

Power Spectral Density
Variant #1
Channel: 26



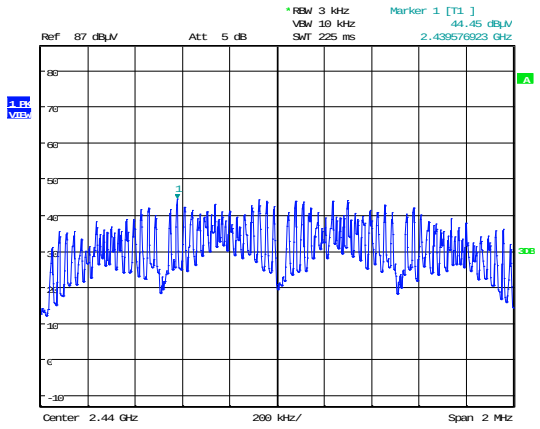
EUT 1; CH.26
Date: 30.JAN.2017 15:04:22

Power Spectral Density
Variant #2
Channel: 11



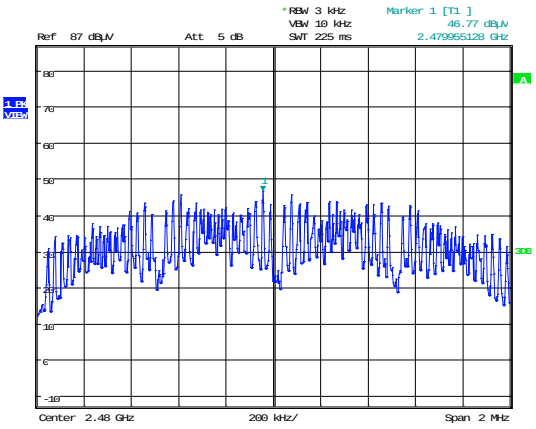
EUT 2; CH.11
Date: 30.JAN.2017 14:51:33

Power Spectral Density
Variant #2
Channel: 18



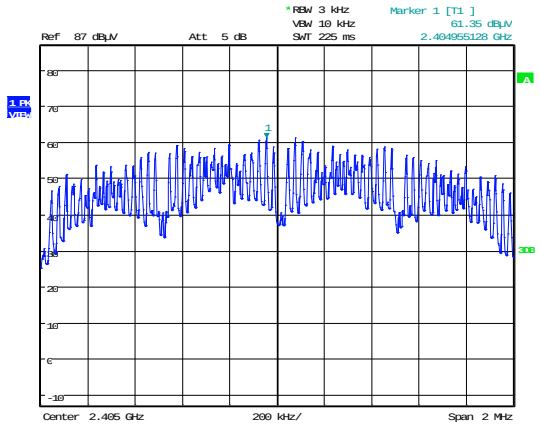
EUT 2; CH.18
Date: 30.JAN.2017 14:55:00

Power Spectral Density
Variant #2
Channel: 26



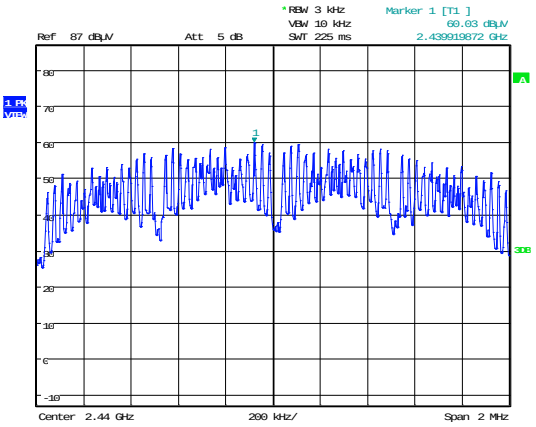
EUT 2; CH.26
Date: 30.JAN.2017 14:58:29

Power Spectral Density
Variant #3
Channel: 11



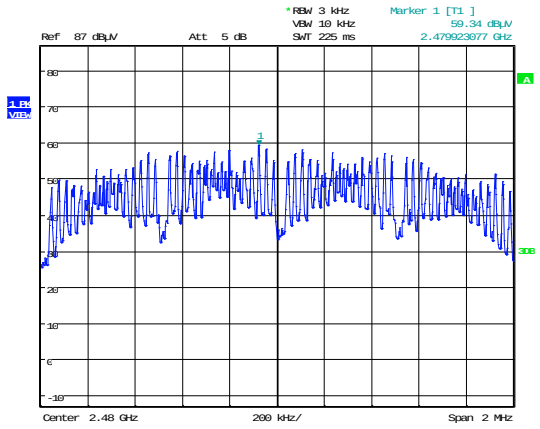
EUT 3; CH.11
Date: 30.JAN.2017 15:06:09

Power Spectral Density
Variant #3
Channel: 18



EUT 3; CH.18
Date: 30.JAN.2017 15:08:33

Power Spectral Density
Variant #3
Channel: 26



8 BAND-EDGE COMPLIANCE

Test Requirement: 47 CFR, §§ 15.209, 15.247
RSS-247, 5.5; RSS-Gen 8.9
Test Procedure: 558074 D01 DTS Meas Guidance
ANSI C63.10

8.1 Regulation

§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)).

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

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

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

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

(e) The provisions in §§ 15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

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

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz	
Frequency (MHz)	Field Strength (µv/m at 3 metres
30-88	100
88-216	150
216-960	200
Above 960	500

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

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

8.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3235	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2016-08	2017-08
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
RF cable assembly	Rosenberger / LA2-025-7000	5616	2016-08	2017-08

8.3 Test Procedures

558074 D01 DTS Meas Guidance, 12.0 Emissions in restricted frequency bands

The DTS rules specify that emissions which fall into restricted frequency bands shall comply with the general radiated emission limits.

12.1 Radiated emission measurements
Since the emission limits are specified in terms of radiated field strength levels, measurements performed to demonstrate compliance have traditionally relied on a radiated test configuration. Radiated measurements remain the principal method for demonstrating compliance to the specified limits; however antenna-port conducted measurements are also now acceptable to demonstrate compliance (see below for details). When radiated measurements are utilized, test site requirements and procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 shall be followed.

ANSI C63.10, 6.10.6 Marker-delta method

6.10.6.2 Marker-delta procedure
The following procedure shall be used for the marker-delta method:

a) Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function required for the frequency being measured. For example, for a device operating in the 902 MHz to 928 MHz band,56 use a 120 kHz RBW with a CISPR QP detector (a peak detector with 100 kHz RBW alternatively may be used). For transmitters operating above 1 GHz, use a 1 MHz RBW, a 3 MHz VBW, and a peak detector, as required. Repeat the measurement with an average detector (or alternatively, a peak detector and reduced VBW). For pulsed emissions, other factors shall be included; see 4.1.4.2.6.

b) Choose an EMI receiver or spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the instrument RBW to 1% of the total span (but never less than 30 kHz), with a VBW equal to or greater than three times the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the

amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.

c) Subtract the delta measured in step b) from the field strengths measured in step a). The resulting field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge emissions compliance, where required.

8.4 Calculation of Field Strength Limits

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

500 µV/m at 3 meters

Using the equation:

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

where

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

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

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

8.5 Field Strength Calculation

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

FS = RA + AF + CF
where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB

Assume a receiver reading of 19.4 dBµV is obtained. The Antenna Factor of 27.6 dB(1/m) and a Cable Factor of 1.6 dB are added, giving a field strength of 48.6 dBµV/m. The 48.6 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 19.4 + 27.6 + 1.6 = 48.6 [dBµV/m]
Level in µV/m = Common Antilogarithm (48.6/20) = 269

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 48.6 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -10.5 dB corresponds with 38.1 dBµV/m.

8.6 Marker-Delta Method Calculation

According to ANSI-C63.10:2013, the Marker-Delta-Method has to be performed in three steps:

Step 1:
The field strength of the fundamental is measured with a RBW of 1 MHz, leading to a value FFS (Fundamental Field Strength) in dBµV/m.

Step 2:
The second step demands a measurement with reduced RBW to determine a delta value (DELTA) between the fundamental and the highest level outside the band.

Step 3:
The result is calculated by subtracting the delta value obtained in step 2 from the fundamental field strength obtained in step 1.

The equation used for the calculation is:

FS = FFS – DELTA

where
FS = Field Strength of the out of band emission in dBµV/m
FFS = Fundamental field strength with RBW = 1 MHz in dBµV/m
DELTA = Delta between fundamental and out of band emission with reduced RBW in dB

8.7 Test Result

Band-edge Emissions – Lower Edge Channel: 11							
EUT	**Freq. [MHz]**	**Detector**	**PK-Reading [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit * [dBµV/m]**	**Margin [dB]**
#1	2400	PK	48.6	0.0	48.6	74	25.4
#1	2400	PK	48.6	-10.5	38.1	54	15.9
#2	2400	PK	45.0	0.0	45.0	74	29.0
#2	2400	PK	45.0	-10.5	34.5	54	19.5
#3	2400	PK	53.9	0.0	53.9	74	20.1
#3	2400	PK	53.9	-10.5	43.4	54	10.6

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

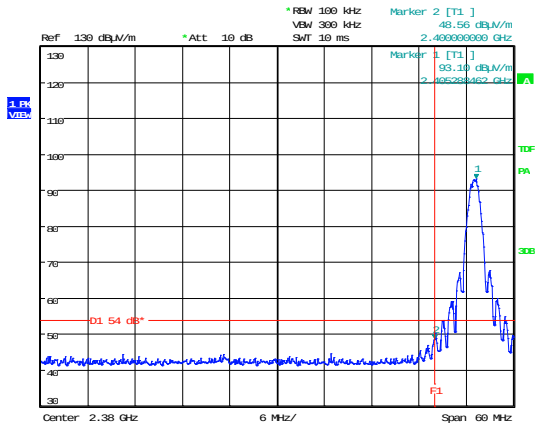
Band-edge Emissions – Upper Edge Channel: 26								
EUT	**Freq. [MHz]**	**Detector**	**FFS [dBµV/m]**	**DELTA [dB]**	**DCF [dB]**	**Result (FS) [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**
#1	2484.1	PK	99.5	-38.4	0.0	61.1	74	12.9
#1	2484.1	AV	95.8	-38.4	-10.5	46.9	54	7.1
#2	2483.8	PK	93.4	-38.1	0.0	55.3	74	18.7
#2	2483.8	AV	88.5	-38.1	-10.5	39.9	54	14.1
#3	2483.9	PK	102.3	-37.5	0.0	64.8	74	9.2
#3	2483.9	AV	98.6	-37.5	-10.5	50.6	54	3.4

Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: 363603001278
363603001268
363603001281
Test date: 2017-01-30

The EUT meets the requirements of this section.

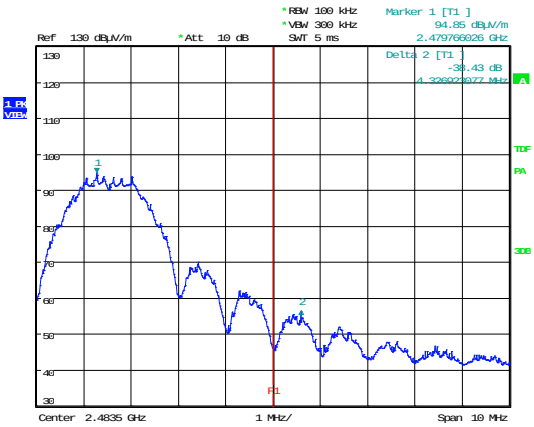
8.8 Detailed Measurement Data

Band-Edge Compliance – Lower Edge
Variant #1
Channel: 11



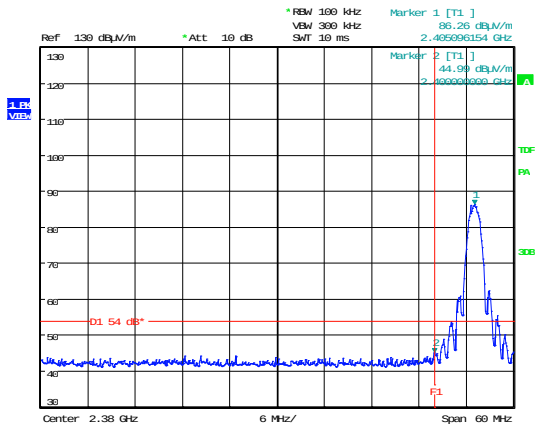
EUT 1; CH.11
Date: 31.JAN.2017 09:31:38

Band-Edge Compliance – Upper Edge
Variant #1 – 100 kHz BW
Channel: 26



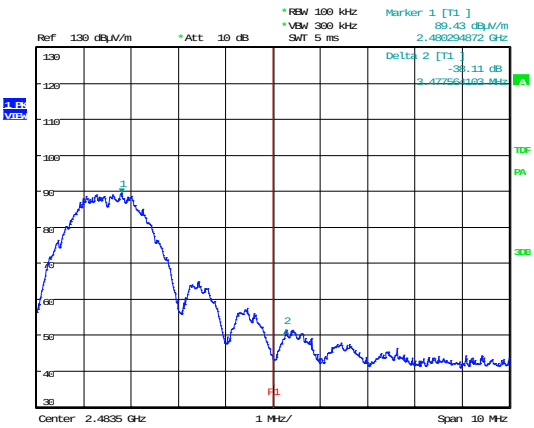
EUT 1; CH. 26
Date: 31.JAN.2017 11:13:58

Band-Edge Compliance – Lower Edge
Variant #2
Channel: 11



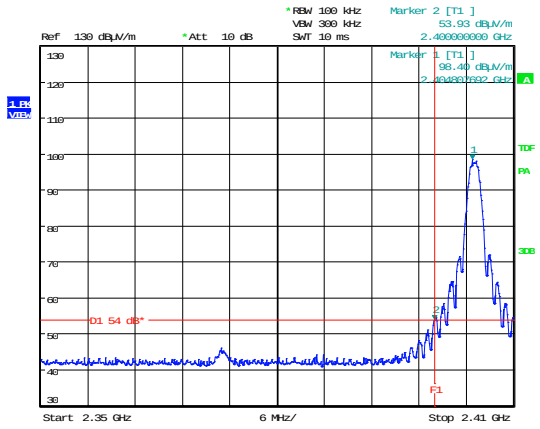
EUT 2; CH.11
Date: 31.JAN.2017 09:47:58

Band-Edge Compliance – Upper Edge
Variant #2 – 100 kHz BW
Channel: 26



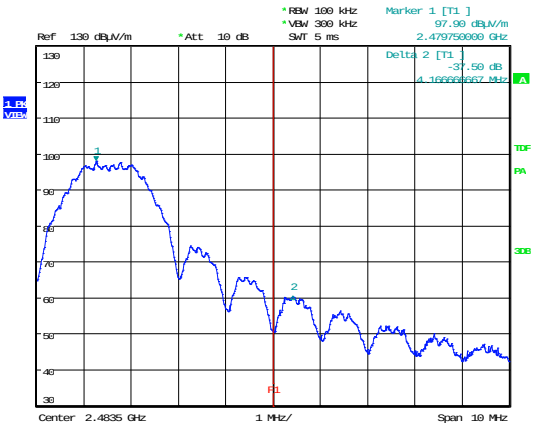
EUT 2; CH. 26
Date: 31.JAN.2017 11:19:43

Band-Edge Compliance – Lower Edge
Variant #3
Channel: 11



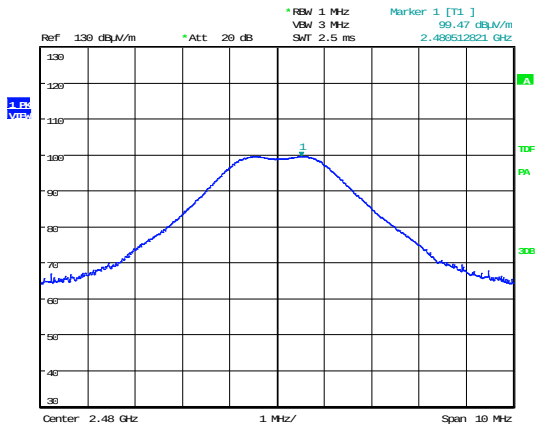
EUT 3; CH.11
Date: 31.JAN.2017 09:26:34

Band-Edge Compliance – Upper Edge
Variant #3 – 100 kHz BW
Channel: 26



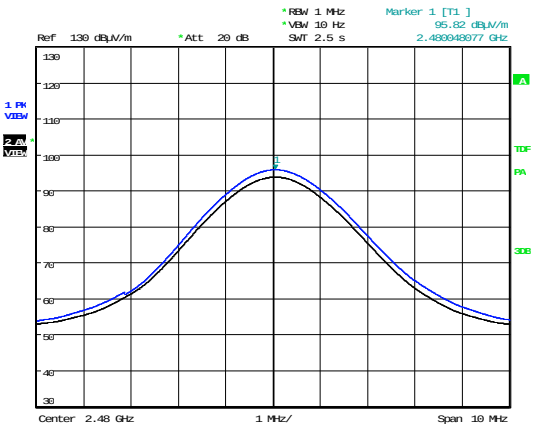
EUT 3; CH. 26
Date: 31.JAN.2017 11:01:32

Band-Edge Compliance – Fundamental PK
Variant #1
Channel: 26



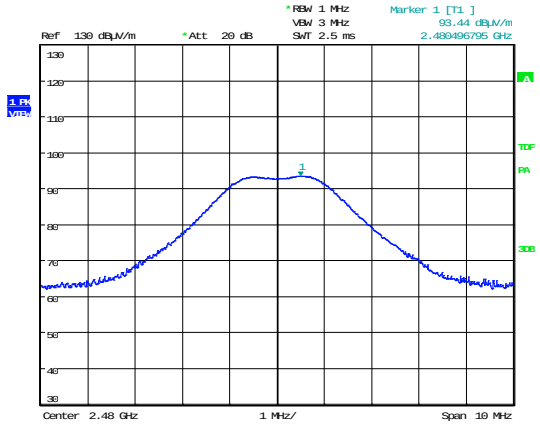
EUT 1; CH. 26
Date: 31.JAN.2017 11:11:20

Band-Edge Compliance – Fundamental AV
Variant #1
Channel: 26



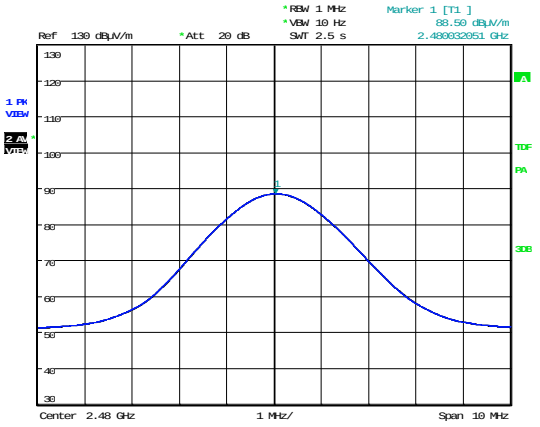
EUT 1; CH. 26
Date: 31.JAN.2017 11:10:23

Band-Edge Compliance – Fundamental PK
Variant #2
Channel: 26



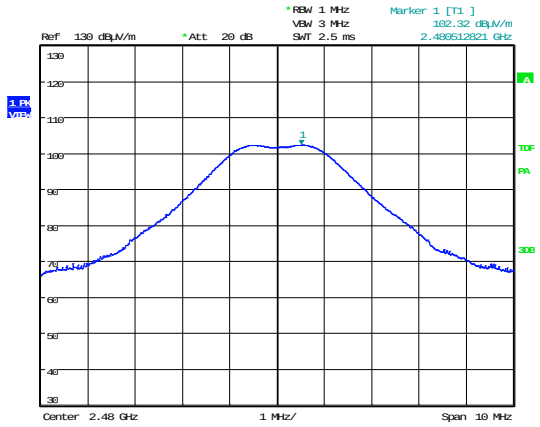
EUT 2; CH. 26
Date: 31.JAN.2017 11:20:41

Band-Edge Compliance – Fundamental AV
Variant #2
Channel: 26



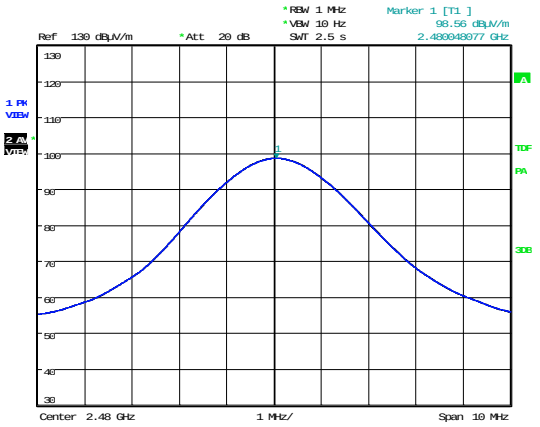
EUT 2; CH. 26
Date: 31.JAN.2017 11:22:45

Band-Edge Compliance – Fundamental PK
Variant #3
Channel: 26



EUT 3; CH. 26
Date: 31.JAN.2017 11:03:03

Band-Edge Compliance – Fundamental AV
Variant #3
Channel: 26



EUT 3; CH. 26
Date: 31.JAN.2017 11:07:13

9 RADIATED EMISSIONS 9 kHz – 30 MHz

Test requirement: 47 CFR, §§ 15.247, 15.209
RSS-247, 5.5; RSS-Gen, 8.9
Test procedure: ANSI C63.10

9.1 Regulation

§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)).

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

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

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

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

emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

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

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

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

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

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

Table 5 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Below 30 MHz

Frequency	Electric Field Strength (µV/m)	Magnetic Field Strength (H-Field) (µA/m)	Measurement Distance (metres)
9-490 kHz	2,400/F (F in kHz)	2,400/377F (F in kHz)	300
490-1,705 kHz	24,000/F (F in kHz)	24,000/377F (F in kHz)	30
1,705-30 MHz	30	N/A	30

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

9.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Loop Antenna	R&S / HFH 2-Z2	374	2016-07	2018-07
EMI Test Receiver	R&S / ESU8	3846	2017-01	2018-01
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
EMI Test Software	R&S / EMC32 v10.00.00	5392	n.a.	n.a.

9.3 Test Procedures

ANSI C63.10, 5.3.2 Test distance for frequencies below 30 MHz
Radiated emissions limits are usually defined at a specific distance from the EUT. Where possible, measurements shall be made at the distance specified in the limits. This might not be possible in all cases, however, due to the physical limitations of the test facility, physical access problems at the required distance (especially for measurements that must be made in situ or on-site), or levels of ambient noise or other radiated signals present at the time and location where measurements are made. See 6.4.3 for more information about antenna selection, location, and test distance. If measurements cannot practically be made at the EUT limit distance, then they may be made at a different distance (usually closer) and extrapolated to the limit distance using one of the procedures described in 6.4.4, 6.4.5, or 7.7, depending on the EUT source and size.31 The test report shall specify the extrapolation method used to determine compliance of the EUT.

ANSI C63.10, 6.4.6 Exploratory radiated emission tests
The tests shall be performed in the frequency range specified in 5.5 and 5.6, using the procedures in Clause 5, applying the appropriate modulating signal to the EUT, to determine cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit.
Exploratory measurements below 30 MHz are useful in determining the maximum level of emissions while manipulating and rotating the EUT; however, exploratory and final measurements may be made concurrently, provided care is taken to determine the maximum level of emissions for all configurations and orientations.
The test arrangement, measuring antenna guidelines and operational configurations in 6.3.1 and 6.3.2, shall be followed. The measurement antenna shall be positioned with its plane perpendicular to the ground at the specified distance. When perpendicular to the ground plane, the lowest height of the magnetic antenna shall be 1 m above the ground and shall be positioned at the specified distance from the EUT.50 When the EUT contains a loop antenna that can only be placed in a vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, and then orthogonal to the axis. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. When the EUT contains a loop antenna that can be placed in a horizontal or vertical axis, normal measurements shall be made aligning the measurement antenna along the site axis, orthogonal to the axis, and then with the measurement antenna horizontal. For each measurement antenna alignment, the EUT shall be rotated through 0° to 360° on a turntable. The report shall list the six emissions with the smallest margin relative to the limit, for each of the three antenna orientations (parallel, perpendicular, and ground-parallel) unless the margin is greater than 20 dB, then the following statement shall be made: “all emissions were greater than 20 dB below the limit.”

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

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

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

9.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for the restricted band 2.1735 - 2.1905 MHz:

30 µV/m at 30 meters

Using the equation:

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

where

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

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

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

9.5 Field Strength Calculation

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

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

Assume the tests performed at a reduced Test Distance of 3 m instead of the Specified Distance of 300 m giving a Distance Extrapolation Factor of DF = 40 log (3 m/300 m) = -80 dB.

Assuming a measured field strength of 55.8 dBµV/m (reading 35.8 dBµV and antenna factor 20 dB(1/m)) is obtained. The Distance Factor of -80 dB is added, giving a field strength of -24.2 dBµV/m. The -24.2 dBµV/m value can be mathematically converted to its corresponding level in µV/m.
FS = 55.8 - 80 = -24.2 [dBµV/m]
Level in µV/m = Common Antilogarithm (-24.2/20) = 0.06

9.6 Final Test Results

Freq. [MHz]	Meas. [PK / QPK]	Reading [dB(µV)]	Ant. factor [dB(1/m)]	DF [dB]	Result [dB(µV/m)]	Limit [dB(µV/m)]	Margin [dB]
0.075	PK	35.8	20	-80	-24.2	50.1	74.3
0.075	QPK	32.2	20	-80	-27.8	30.1	57.9
0.376	PK	36.2	20	-80	-23.8	36.2	60.0
0.376	QPK	35.3	20	-80	-24.8	16.2	40.9
0.746	PK	29.4	20	-40	9.4	50.2	40.8
0.746	QPK	27.4	20	-40	7.4	30.2	22.8
1.120	PK	23.7	20	-40	3.7	46.6	42.9
1.120	QPK	19.2	20	-40	-0.8	26.6	27.4

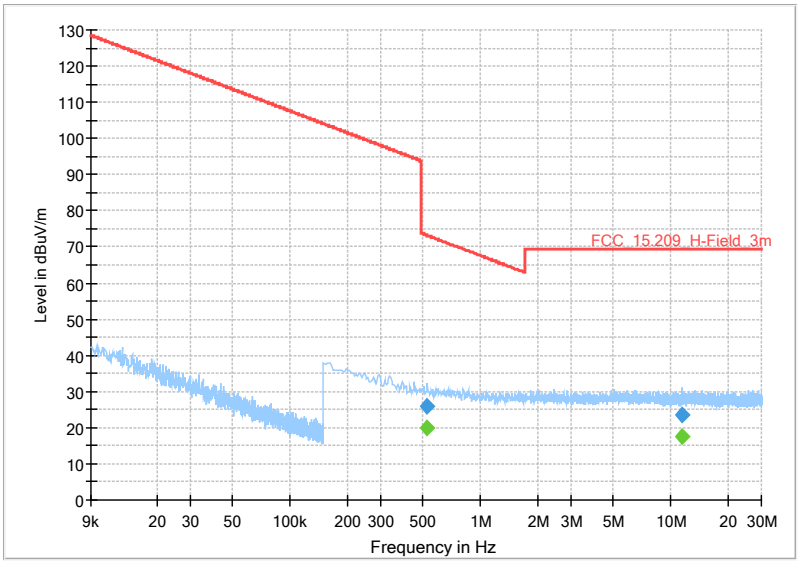
Manufacturer: EnOcean GmbH
Device: TCM 515Z
Serial No: 363603001278
363603001268
363603001281
Test date: 2017-01-10/11
2017-02-01

The EUT meets the requirements of this section.

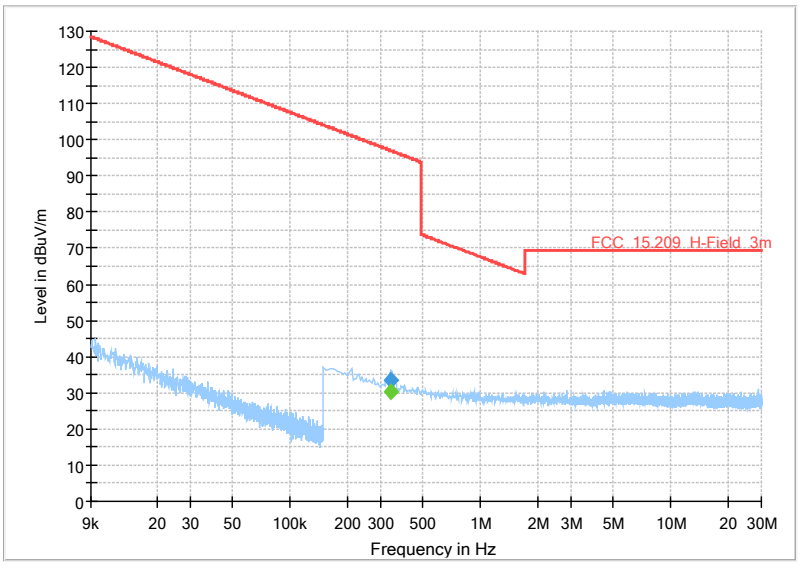
9.7 Detailed Measurement Data

Measurement was performed at 3 m distance. Plots show field strength reading at 3 m distance. In order to compare the 3 m reading with the specified field strength limits a distance correction as described in 9.5 (40 dB/decade) was applied to the limit (represented by the limit line „FCC_15.209_HField_3m“).

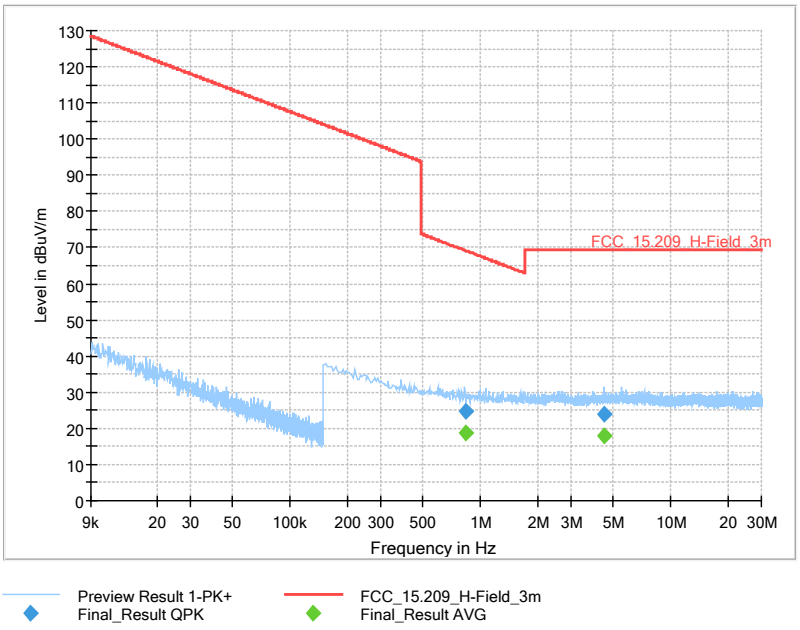
Radiated Emissions 9kHz – 30 MHz
Variant #1
Channel: 11



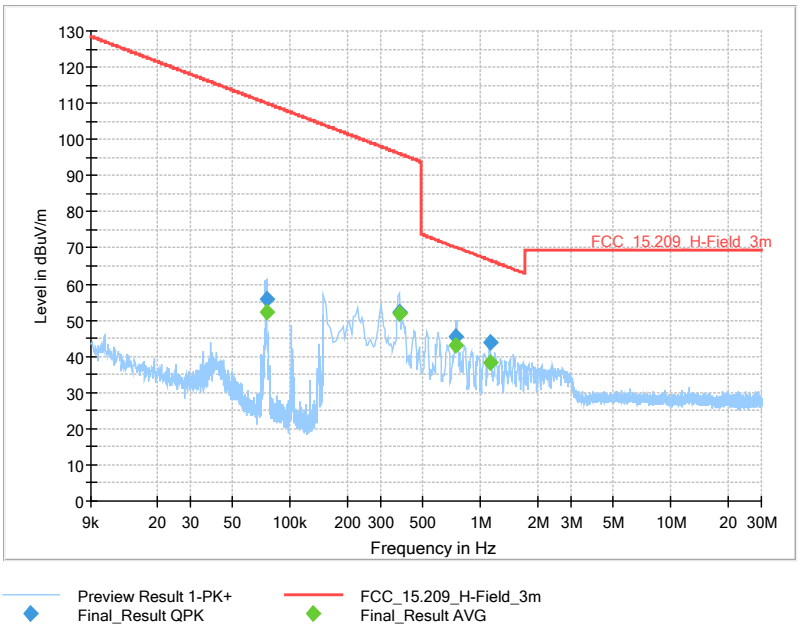
Radiated Emissions 9kHz – 30 MHz
Variant #1
Channel: 18



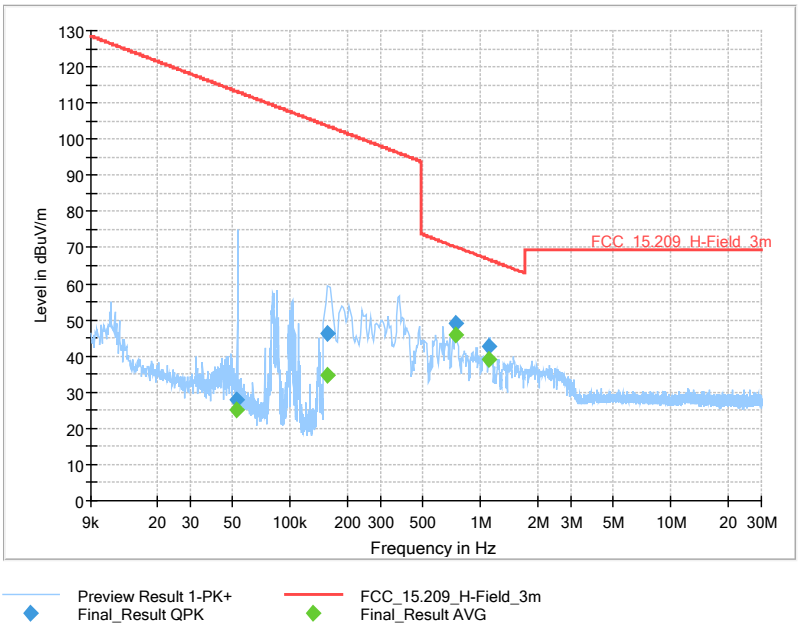
Radiated Emissions 9kHz – 30 MHz
Variant #1
Channel: 26



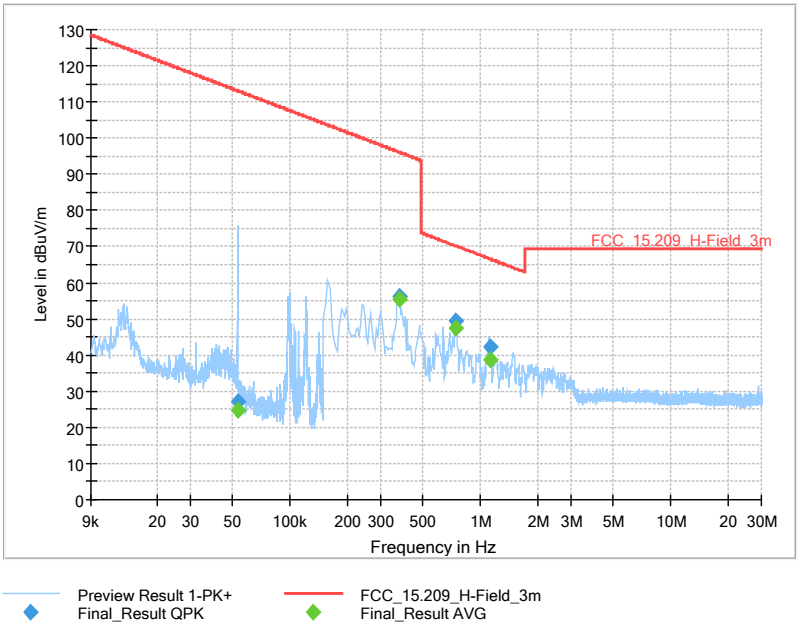
Radiated Emissions 9kHz – 30 MHz
Variant #2
Channel: 11



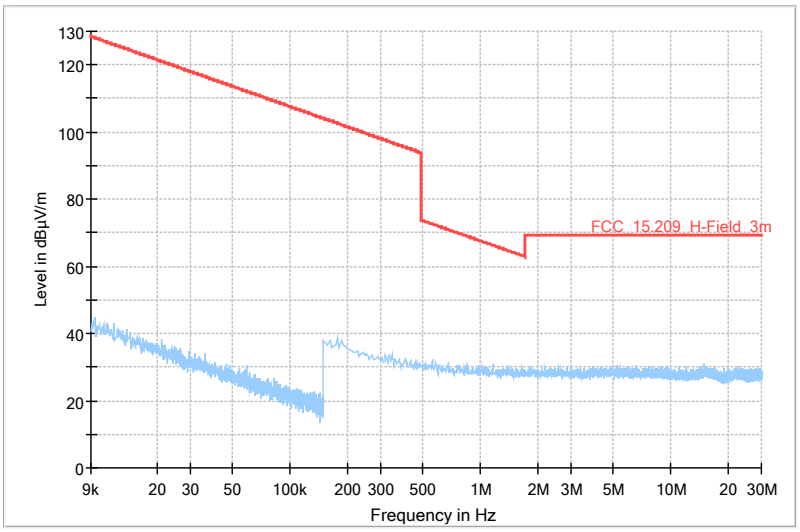
Radiated Emissions 9kHz – 30 MHz
Variant #2
Channel: 18



Radiated Emissions 9kHz – 30 MHz
Variant #2
Channel: 26

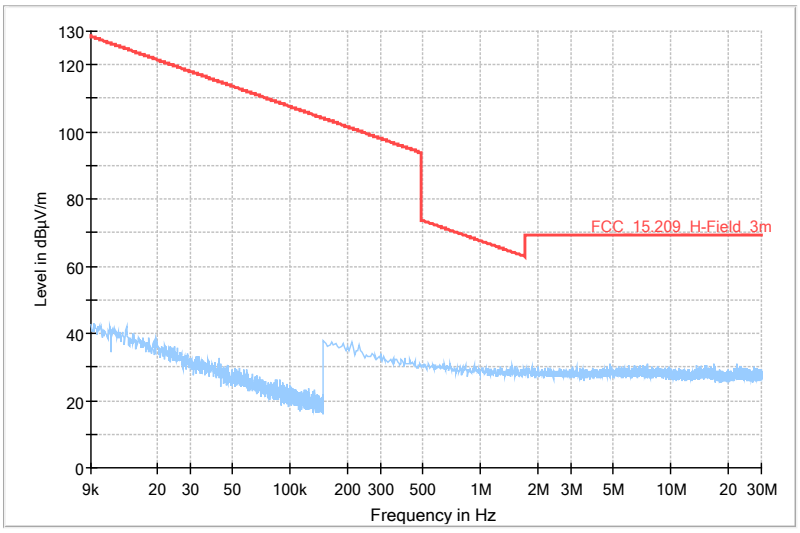


Radiated Emissions 9kHz – 30 MHz
Variant #3
Channel: 11



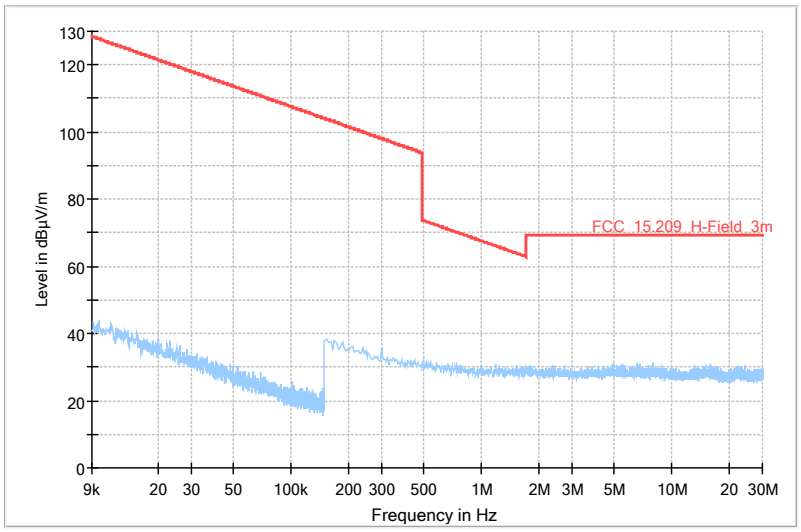
Preview Result 1-PK+ [Preview Result 1.Result:1]
FCC_15.209_H-Field_3m [..\EMI radiated\FCC_Part15\]
Final_Result QPK [Final_Result.Result:4]
Final_Result AVG [Final_Result.Result:5]

Radiated Emissions 9kHz – 30 MHz
Variant #3
Channel: 18



Preview Result 1-PK+ [Preview Result 1.Result:1]
FCC_15.209_H-Field_3m [..\EMI radiated\FCC_Part15\]
Final_Result QPK [Final_Result.Result:4]
Final_Result AVG [Final_Result.Result:5]

Radiated Emissions 9kHz – 30 MHz
Variant #3
Channel: 26



Preview Result 1-PK+ [Preview Result 1.Result:1]
FCC_15.209_H-Field_3m [..\EMI radiated\FCC_Part15\]
Final_Result QPK [Final_Result.Result:4]
Final_Result AVG [Final_Result.Result:5]

10 RADIATED EMISSIONS 30 MHz – 1000 MHz

Test requirement: 47 CFR, §§ 15.247, 15.209
RSS-247, 5.5; RSS-Gen, 8.9
Test procedure: ANSI C63.10

10.1 Regulation

§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)).

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

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

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

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

emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

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

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

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

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

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

10.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
N-Cable N/50	R&S / HFU2-Z4	55	2016-08	2017-08
VHF Test Dipole RX	Schwarzbeck / VHA 9103	899	2015-05	2017-05
Log Per. Antenna	Schwarzbeck / VUSLP 9111B	3203	2017-01	2019-01
EMI Test Receiver	R&S / ESU8	3846	2017-01	2018-01
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
EMI Test Software	R&S / EMC32 v10.00.00	5392	n.a.	n.a.

10.3 Test Procedures

ANSI C63.10, 6.3.1 Test arrangement

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

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

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

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

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

10.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits in restricted bands (e.g. 108 to 121.94 MHz (FCC) or 108 to 138 MHz (ISED)) acc. to §15.209 for the frequency band 88-216 MHz:

150 µV/m at 3 meters

Using the equation:

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

where

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

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

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

10.5 Field Strength Calculation

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

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]

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

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

10.6 Final Test Results

Frequency [MHz]	Result [dBµV/m]	Limit * [dBµV/m]	Margin [dB]	Remarks
48.02	29.2	40	10.8	Variant #2, Ch. 11
166.5	30.9	43.5	12.6	Variant #2, Ch. 26
232.4	31.4	46	14.6	Variant #2, Ch. 18
358.0	38.6	46	7.4	Variant #2, Ch. 26
365.2	39.0	46	7.0	Variant #2, Ch. 18
365.3	37.4	46	8.6	Variant #2, Ch. 26

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

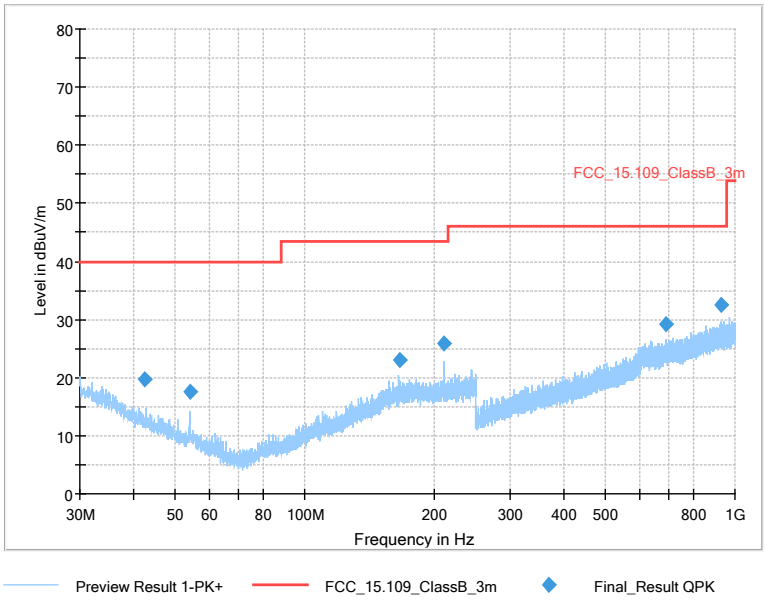
* Note: Limits acc. to 47 CFR §15.209 resp. RSS-Gen 8.9 were used as worst case consideration.

Manufacturer:	EnOcean GmbH
Device:	TCM 515Z
Serial No:	363603001278
	363603001268
	363603001281
Test date:	2017-01-09/11
	2017-01-31

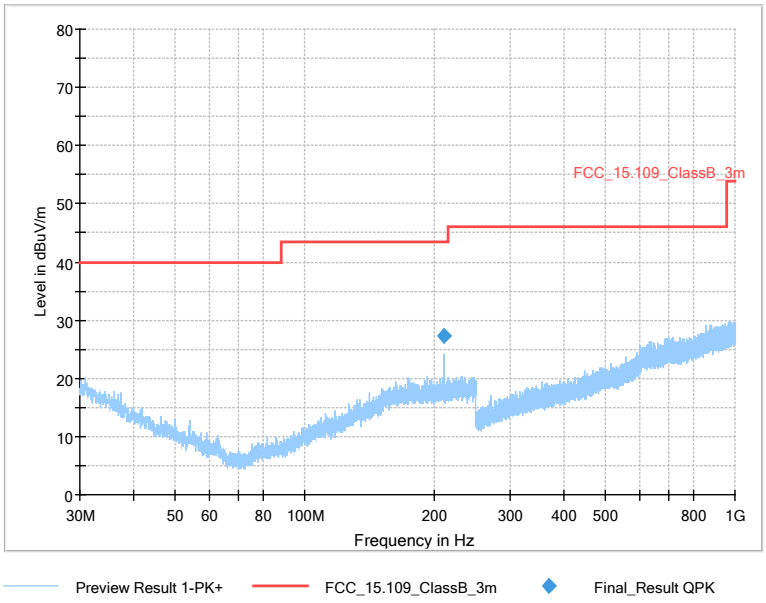
The EUT meets the requirements of this section.

10.7 Detailed Measurement Data

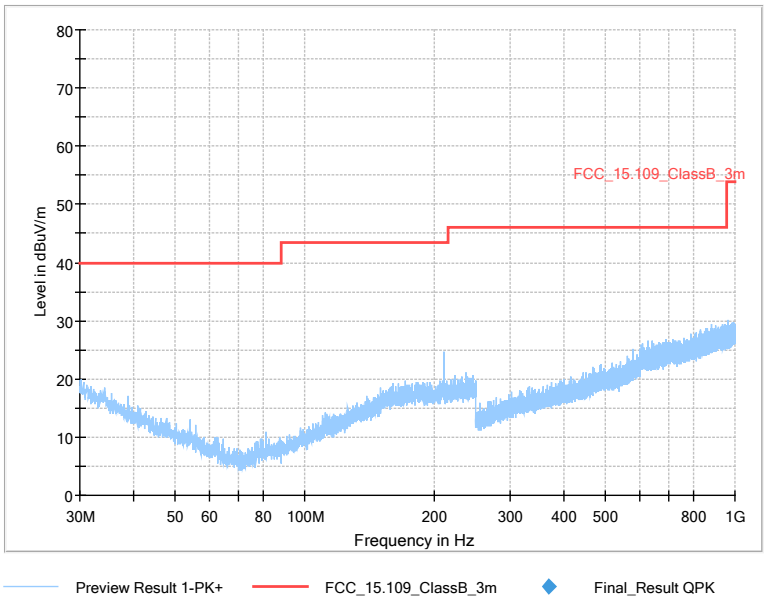
Radiated Emissions 30 MHz – 1000 MHz
Variant #1
Channel: 11



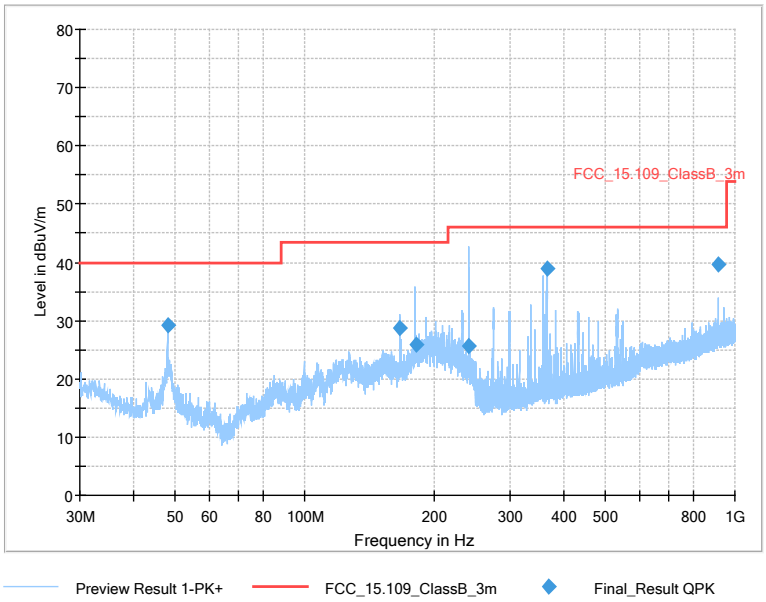
Radiated Emissions 30 MHz – 1000 MHz
Variant #1
Channel: 18



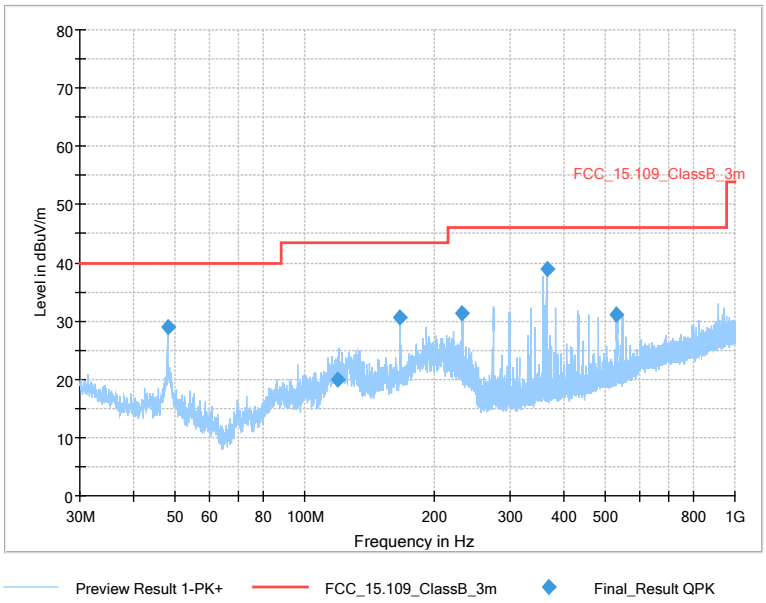
Radiated Emissions 30 MHz – 1000 MHz
Variant #1
Channel: 26



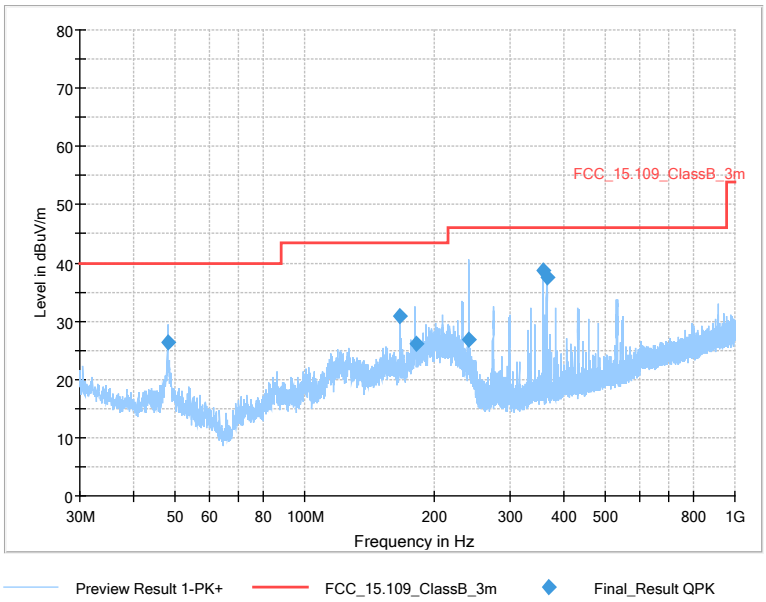
Radiated Emissions 30 MHz – 1000 MHz
Variant #2
Channel: 11



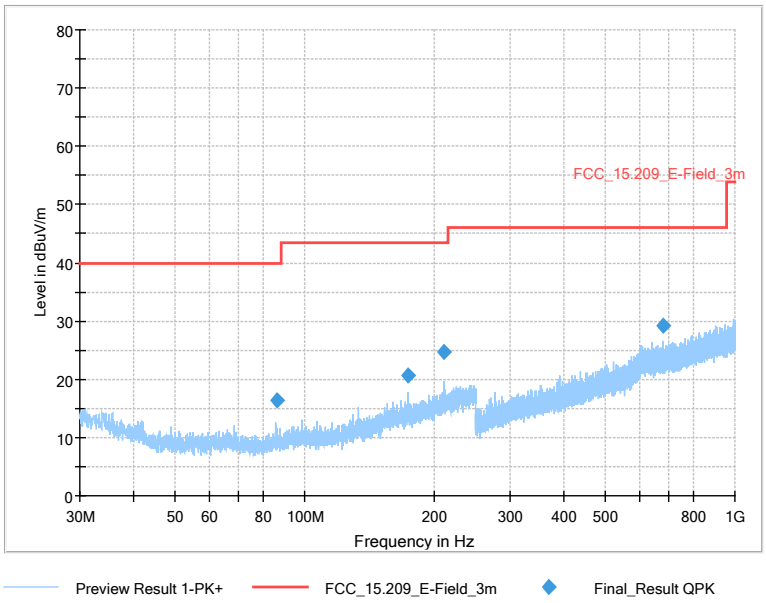
Radiated Emissions 30 MHz – 1000 MHz
Variant #2
Channel: 18



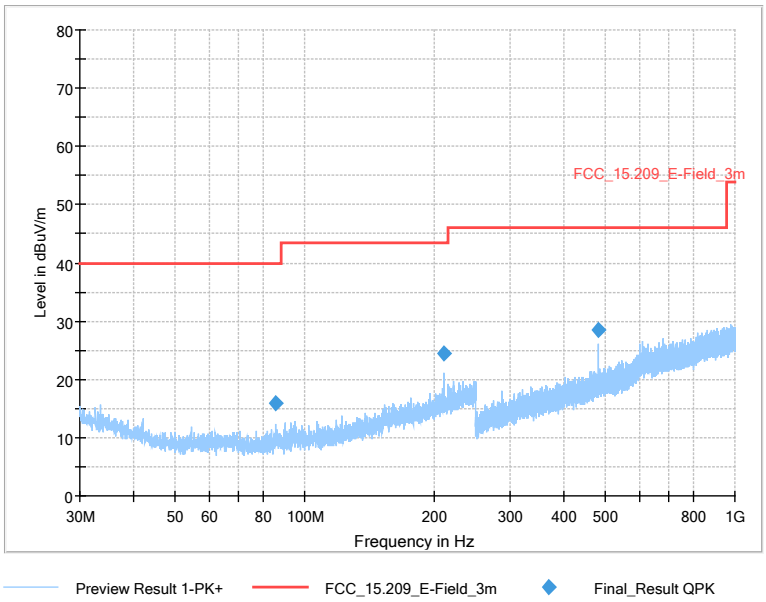
Radiated Emissions 30 MHz – 1000 MHz
Variant #2
Channel: 26



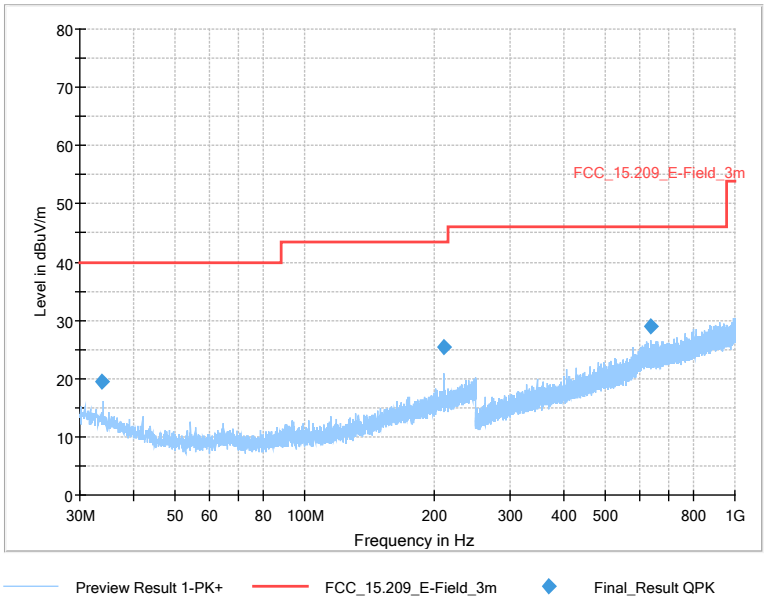
Radiated Emissions 30 MHz – 1000 MHz
Variant #3
Channel: 11



Radiated Emissions 30 MHz – 1000 MHz
Variant #3
Channel: 18



Radiated Emissions 30 MHz – 1000 MHz
Variant #3
Channel: 26



11 RADIATED EMISSIONS 1 GHz – 25 GHz

Test requirement: 47 CFR, §§ 15.247, 15.209
RSS-247, 5.5; RSS-Gen, 8.9
Test procedure: ANSI C63.10

11.1 Regulation

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

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

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

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

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

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz	
Frequency (MHz)	Field Strength (µv/m at 3 metres
30-88	100
88-216	150
216-960	200
Above 960	500

Footnote

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

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

11.2 Test Equipment

Type	Manufacturer/ Model No.	EMCC Ident No.	Last Calibration	Next Calibration
Standard Gain Horn Ant.	Mid Century / MC 20/31B	1300	2016-08	2018-08
Double Ridged Guide Ant.	Schwarzbeck / BBHA 9120D	3235	2015-06	2017-06
Spectrum Analyzer	R&S / FSU50	3831	2016-08	2017-08
Digital Multimeter	Agilent / U124B	3880	2016-05	2018-05
Web-Thermo-Hygrobarograph	W&T / 57613 Web-T/Rh/P	4717	2016-04	2018-04
DC Power Supply	Tektronix / PWS205	4721	n/a	n/a
Band Reject Filter	ZYSEN / ZSBR2441.75-83.5U10CS	4993	2015-03	2017-03
High Pass Filter	dBd com / DBD-FTR-15SH-U3500-O/O	5366	2015-09	2017-09
RF cable assembly	Rosenberger / LA1-008-1500	5612	2016-08	2017-08
RF cable assembly	Rosenberger / LA2-025-7000	5616	2016-08	2017-08

11.3 Test Procedures

ANSI C63.10, 6.6.3.1 Tabletop equipment

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

ANSI C63.10, 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, 6.6.4.3 Final radiated emissions measurements

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

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

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

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

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

Radiated Emissions Test Characteristics	
Frequency range	1 GHz – 25 GHz
Test distance	3 m [1)]
Test instrumentation resolution bandwidth	1 MHz
Receive antenna height	1 m – 4 m
Receive antenna polarization	Vertical/Horizontal

[1)] Explorative measurements performed at closer distance

11.4 Calculation of Field Strength Limits

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

500 µV/m at 3 meters

Using the equation:

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

where

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

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

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

11.5 Field Strength Calculation

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

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

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

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

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

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

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

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

Assuming a peak field strength of 57.7 dBµV/m, the value for the average field strength with a Duty Cycle correction factor DCF of -32.8 dB corresponds with 24.9 dBµV/m.

11.6 Final Test Results

Radiated Spurious Emissions 1 – 25 GHz – Average Results						
Frequency [MHz]	**Field Strength [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit * [dBµV/m]**	**Margin [dB]**	**Remarks**
4809	53.6	-10.5	43.1	54	10.9	Variant #1, Ch. 11
4879	54.2	-10.5	43.7	54	10.3	Variant #1, Ch. 18
4961	51.2	-10.5	40.7	54	13.3	Variant #1, Ch. 26
7214	58.8	-10.5	48.3	54	5.7	Variant #1, Ch. 11
7321	58.3	-10.5	47.8	54	6.2	Variant #1, Ch. 18
7442	58.8	-10.5	48.3	54	5.7	Variant #1, Ch. 26

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

Radiated Spurious Emissions 1 – 25 GHz – Peak Results						
Frequency [MHz]	**Field Strength [dBµV/m]**	**DCF [dB]**	**Result [dBµV/m]**	**Limit * [dBµV/m]**	**Margin [dB]**	**Remarks**
4809	53.6	0.0	53.6	74	20.4	Variant #1, Ch. 11
4879	54.2	0.0	54.2	74	19.8	Variant #1, Ch. 18
4961	51.2	0.0	51.2	74	22.8	Variant #1, Ch. 26
7214	58.8	0.0	58.8	74	15.2	Variant #1, Ch. 11
7321	58.3	0.0	58.3	74	15.7	Variant #1, Ch. 18
7442	58.8	0.0	58.8	74	15.2	Variant #1, Ch. 26

Remark:
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.

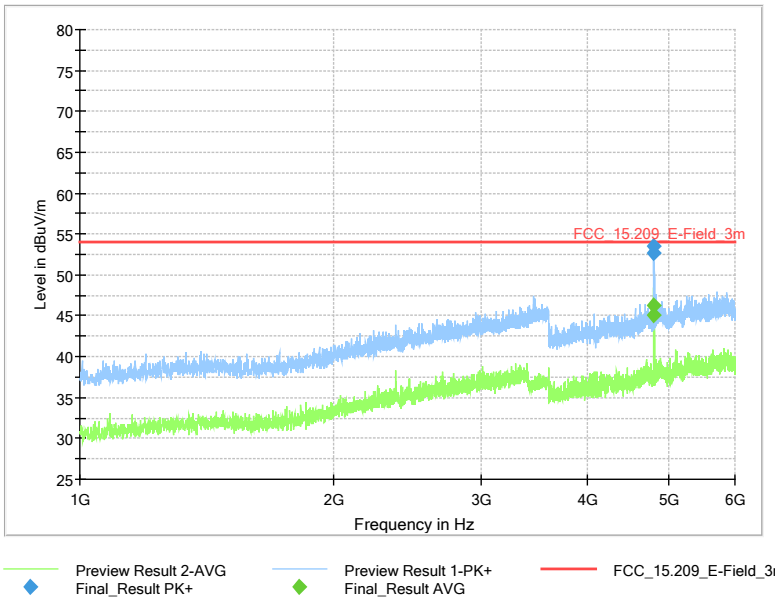
Manufacturer:	EnOcean GmbH
Device:	TCM 515Z
Serial No:	363603001278
	363603001268
	363603001281
Test date:	2017-01-25
	2017-01-30/31

The EUT meets the requirements of this section.

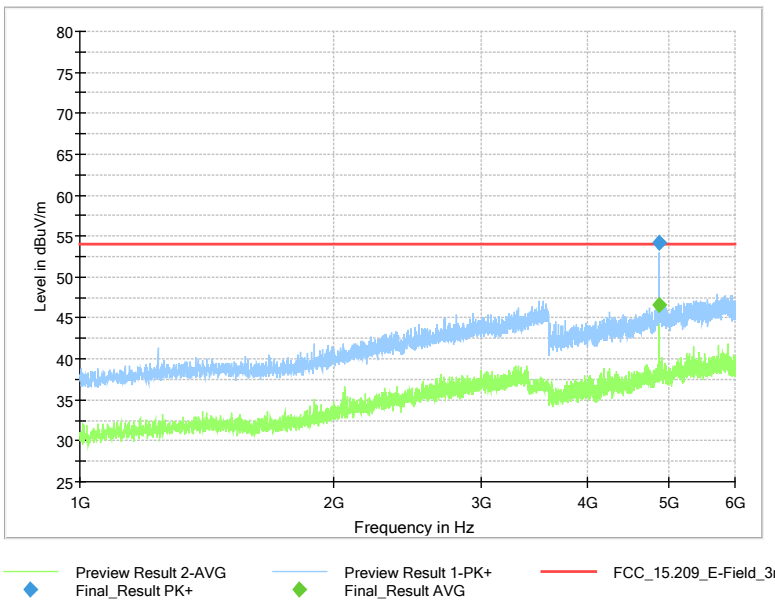
11.7 Detailed Measurement Data

Prescan measurements below 6 GHz were performed at 3 m distance, above 6 GHz measurement was performed as explorative measurement in close distance of approx. 20 cm. All final measurements were performed at 3m distance.

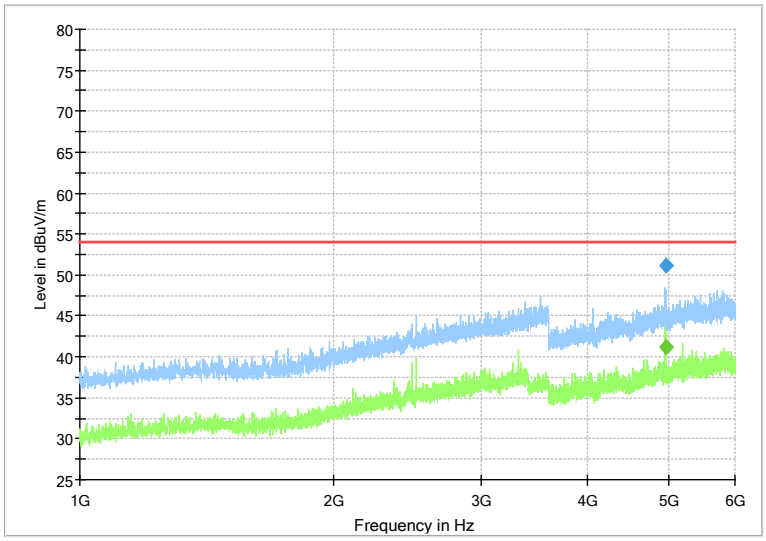
Radiated Emissions 1 – 6 GHz
Variant #1
Channel: 11



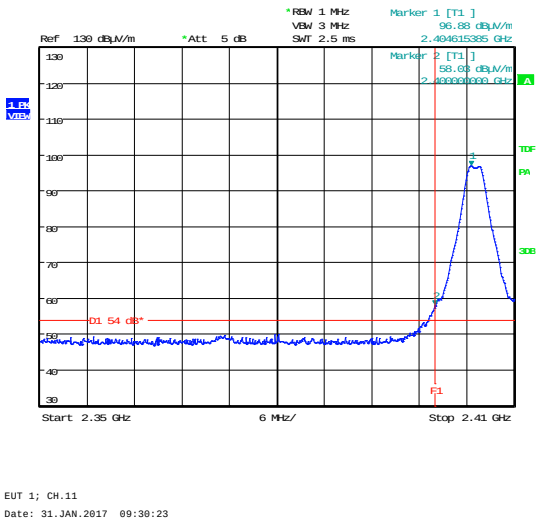
Radiated Emissions 1 – 6 GHz
Variant #1
Channel: 18



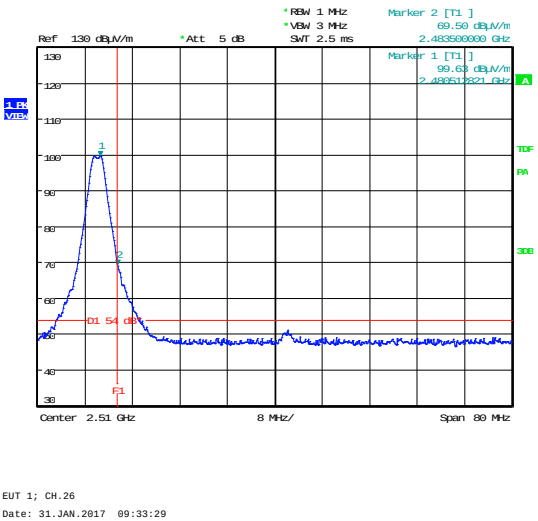
Radiated Emissions 1 – 6 GHz
Variant #1
Channel: 26



Prescan; Radiated Emissions at Band-Edge
Variant #1
Channel: 11

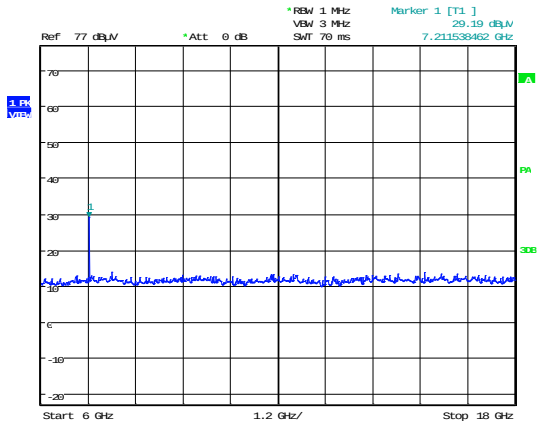


Prescan; Radiated Emissions at Band-Edge
Variant #1
Channel: 26



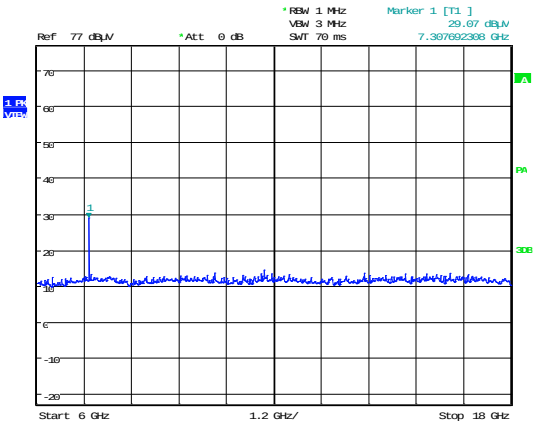
Note: due to the use of a band reject filter with a pass band of DC to 2350 MHz and 2550 to 6000 MHz, separate radiated emission measurements with RBW = 1 MHz at the edges of the assigned band were performed to show compliance outside the filter's pass band. Exceedances close to the band-edge, which were covered by the band-edge measurement, were not taken into account for this consideration.

Prescan; Radiated Emissions 6-18 GHz
Variant #1
Channel: 11



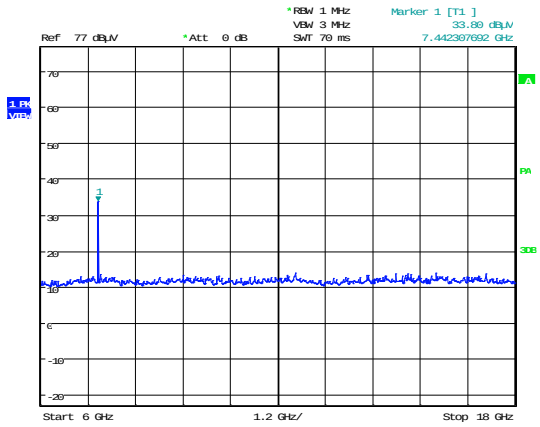
EUT 1; CH. 11; d= 0.1m
Date: 31.JAN.2017 09:56:25

Prescan; Radiated Emissions 6-18 GHz
Variant #1
Channel: 18



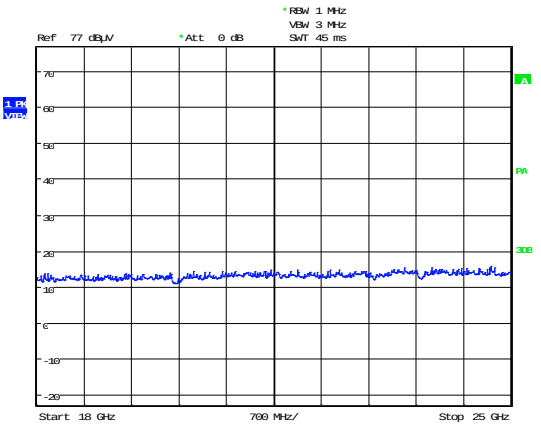
EUT 1; CH. 18; d= 0.1m
Date: 31.JAN.2017 09:57:07

Prescan; Radiated Emissions 6-18 GHz
Variant #1
Channel: 26



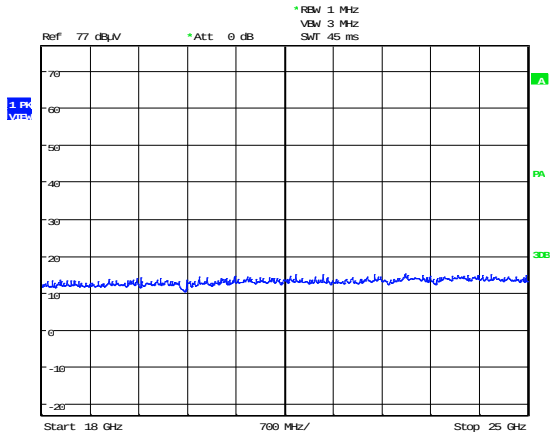
EUT 1; CH. 26; d= 0.1m
Date: 31.JAN.2017 09:57:56

Exploratory rad. emission meas. 18-25 GHz
Variant #1
Channel: 11



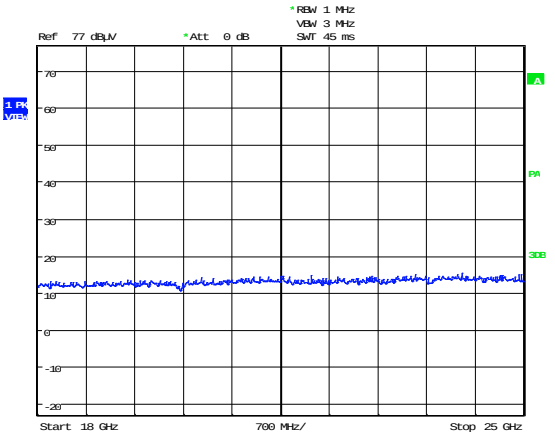
EUT 1; CH. 11; d= 0.1m
Date: 25.JAN.2017 10:08:16

Exploratory rad. emission meas. 18-25 GHz
Variant #1
Channel: 18



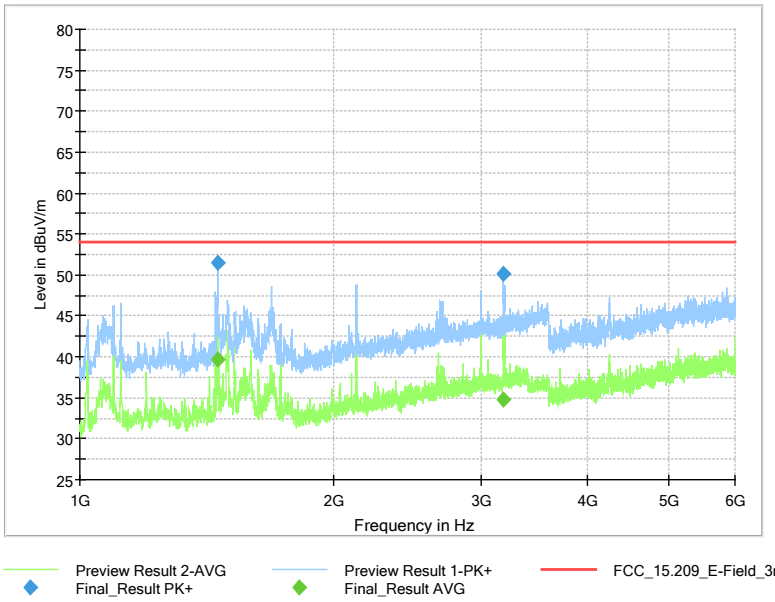
EUT 1; CH. 18; d= 0.1m
Date: 25.JAN.2017 10:09:22

Exploratory rad. emission meas. 18-25 GHz
Variant #1
Channel: 26

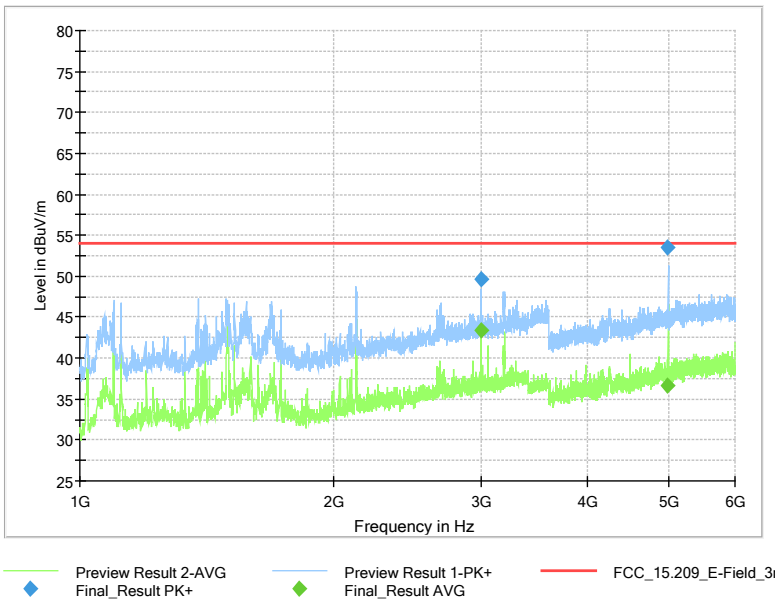


EUT 1; CH. 26; d= 0.1m
Date: 25.JAN.2017 10:10:13

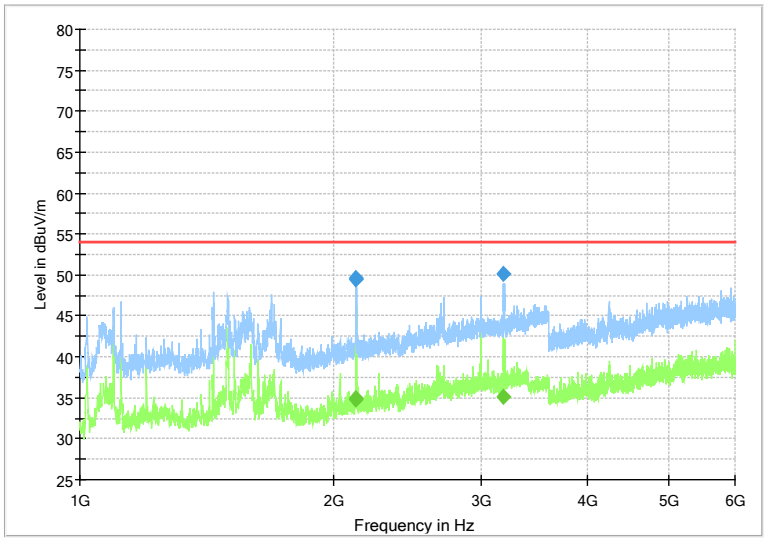
Radiated Emissions 1 – 6 GHz
Variant #2
Channel: 11



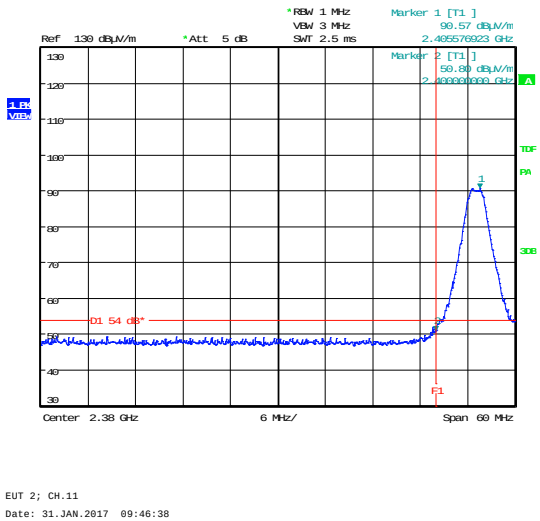
Radiated Emissions 1 – 6 GHz
Variant #2
Channel: 18



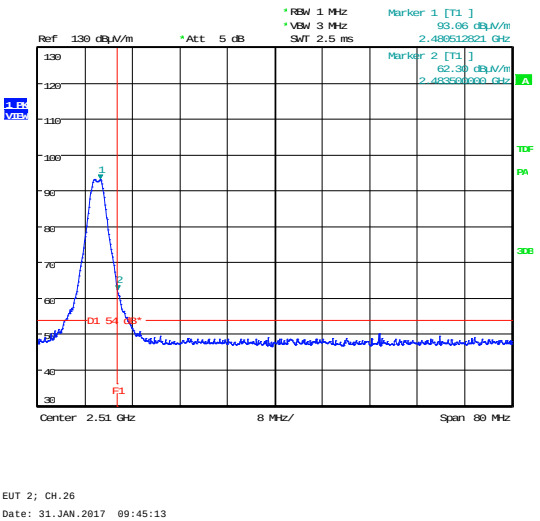
Radiated Emissions 1 – 6 GHz
Variant #2
Channel: 26



Prescan; Radiated Emissions at Band-Edge
Variant #2
Channel: 11

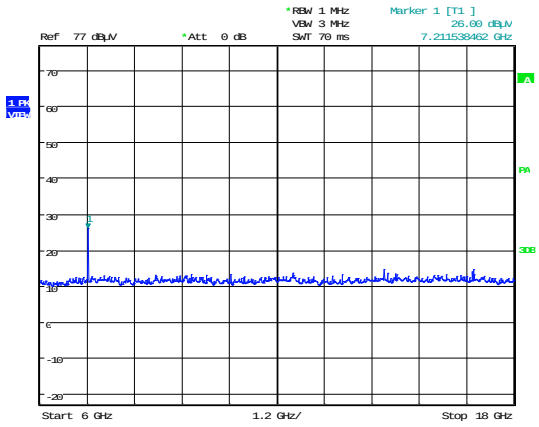


Prescan; Radiated Emissions at Band-Edge
Variant #2
Channel: 26



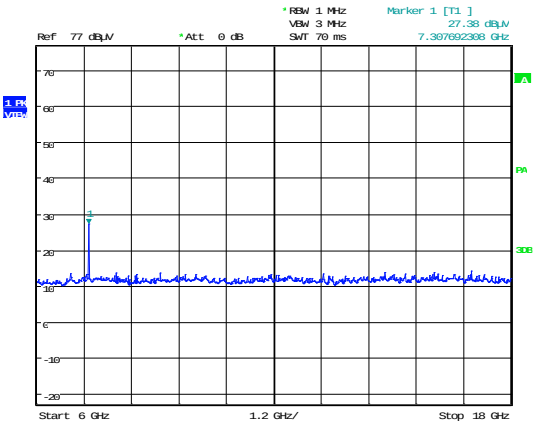
Note: due to the use of a band reject filter with a pass band of DC to 2350 MHz and 2550 to 6000 MHz, separate radiated emission measurements with RBW = 1 MHz at the edges of the assigned band were performed to show compliance outside the filter's pass band. Exceedances close to the band-edge, which were covered by the band-edge measurement, were not taken into account for this consideration.

Prescan; Radiated Emissions 6-18 GHz
Variant #2
Channel: 11



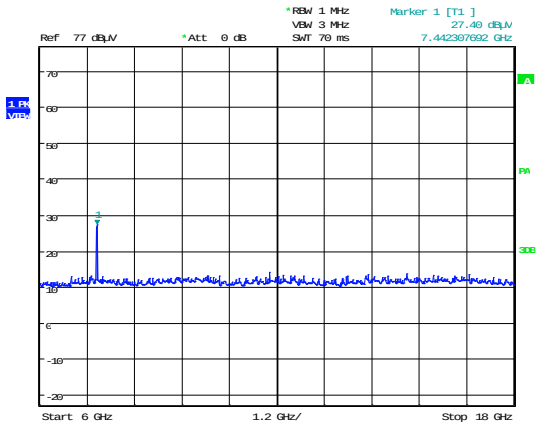
EUT 2; CH. 11; d= 0.1m
Date: 31.JAN.2017 09:53:07

Prescan; Radiated Emissions 6-18 GHz
Variant #2
Channel: 18



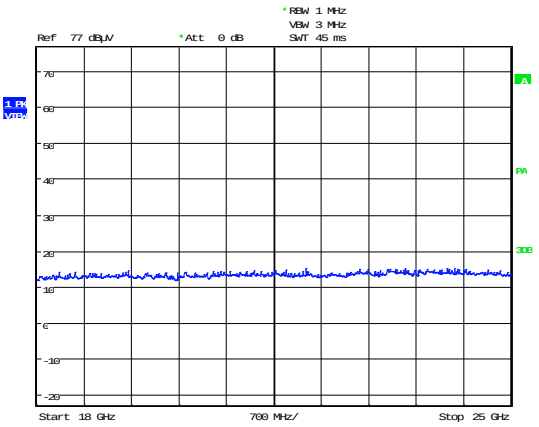
EUT 2; CH. 18; d= 0.1m
Date: 31.JAN.2017 09:54:10

Prescan; Radiated Emissions 6-18 GHz
Variant #2
Channel: 26



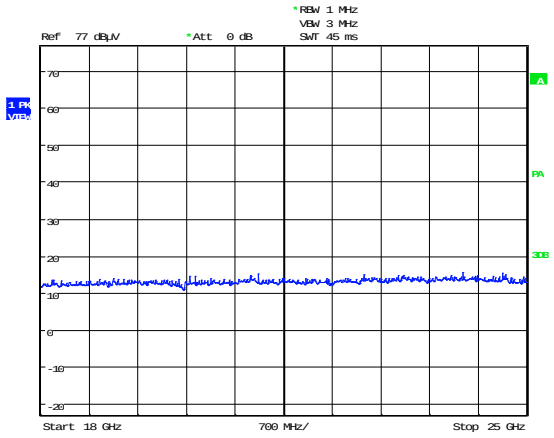
EUT 2; CH. 26; d= 0.1m
Date: 31.JAN.2017 09:55:07

Exploratory rad. emission meas. 18-25 GHz
Variant #2
Channel: 11



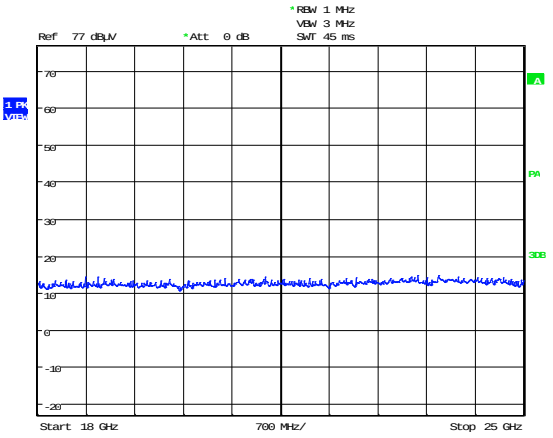
EUT 2; CH. 11; d= 0.1m
Date: 25.JAN.2017 10:32:21

Exploratory rad. emission meas. 18-25 GHz
Variant #2
Channel: 18



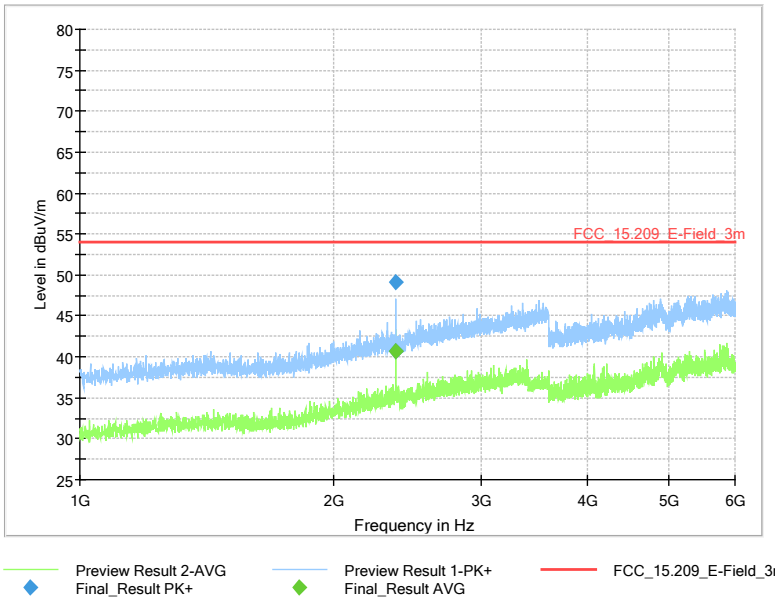
EUT 2; CH. 18; d= 0.1m
Date: 25.JAN.2017 10:33:35

Exploratory rad. emission meas. 18-25 GHz
Variant #2
Channel: 26

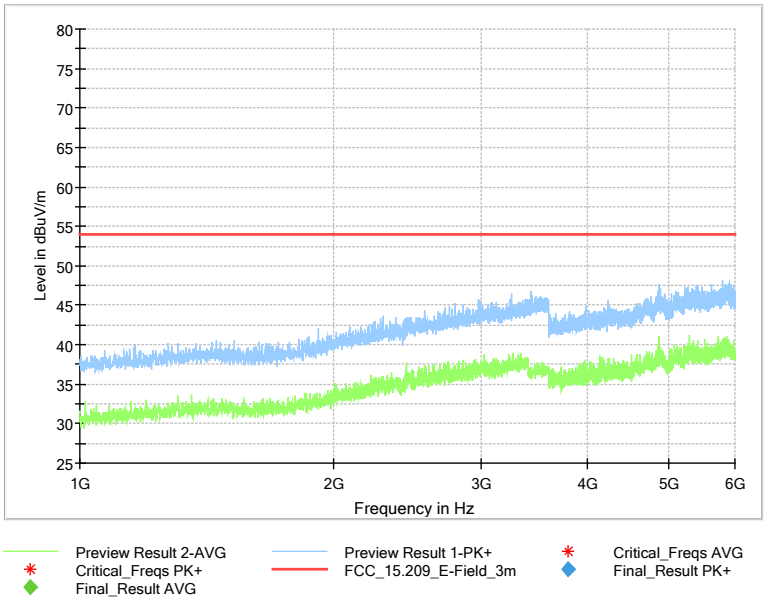


EUT 2; CH. 26; d= 0.1m
Date: 25.JAN.2017 10:34:13

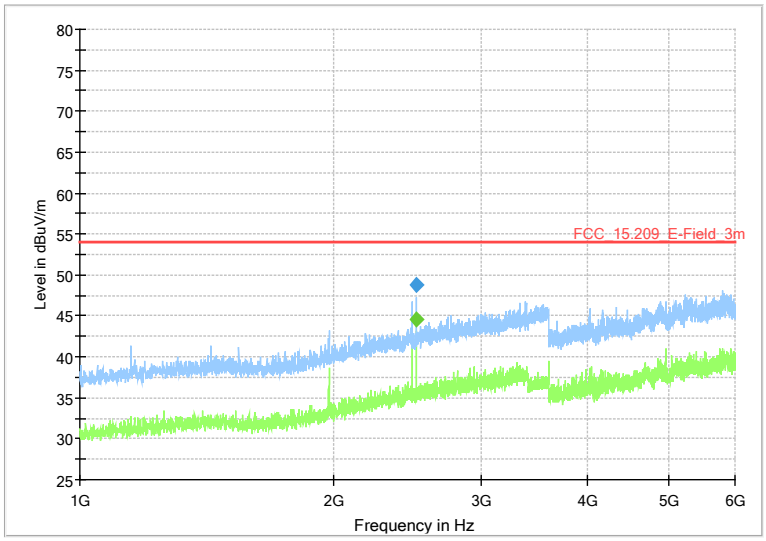
Radiated Emissions 1 – 6 GHz
Variant #3
Channel: 11



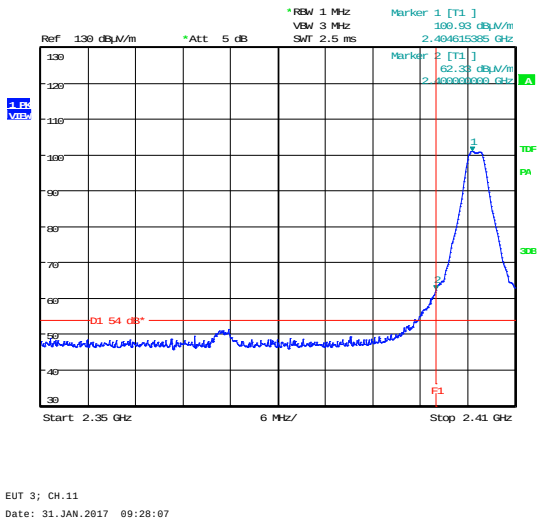
Radiated Emissions 1 – 6 GHz
Variant #3
Channel: 18



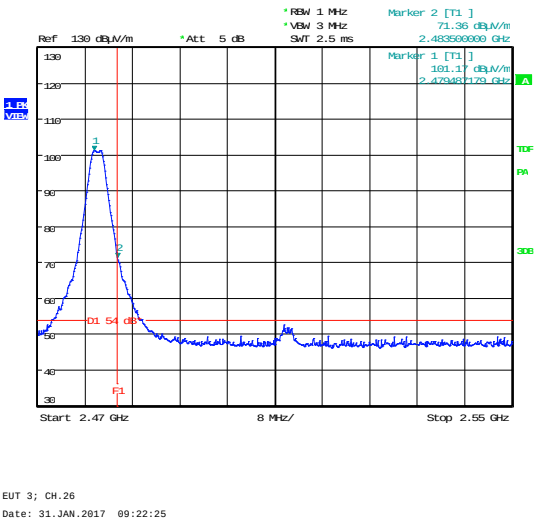
Radiated Emissions 1 – 6 GHz
Variant #3
Channel: 26



Prescan; Radiated Emissions at Band-Edge
Variant #3
Channel: 11

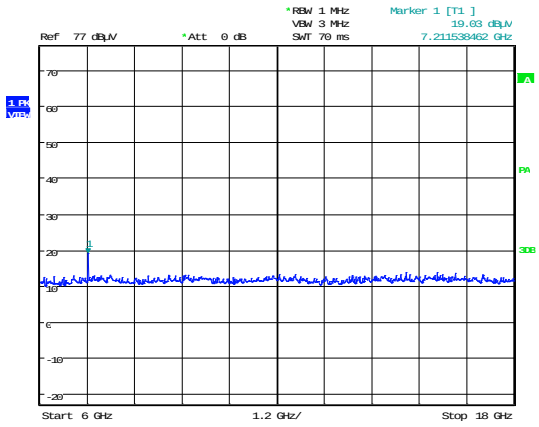


Prescan; Radiated Emissions at Band-Edge
Variant #3
Channel: 26



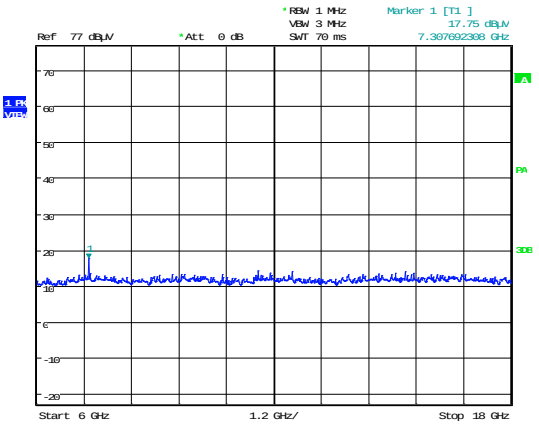
Note: due to the use of a band reject filter with a pass band of DC to 2350 MHz and 2550 to 6000 MHz, separate radiated emission measurements with RBW = 1 MHz at the edges of the assigned band were performed to show compliance outside the filter's pass band. Exceedances close to the band-edge, which were covered by the band-edge measurement, were not taken into account for this consideration.

Prescan; Radiated Emissions 6-18 GHz
Variant #3
Channel: 11



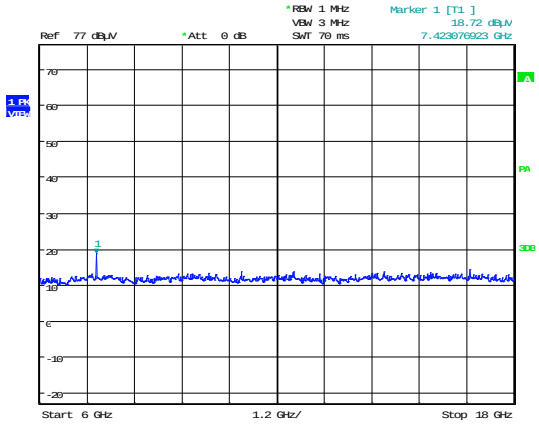
EUT 3; CH. 26; d= 0.1m
Date: 31.JAN.2017 09:59:41

Prescan; Radiated Emissions 6-18 GHz
Variant #3
Channel: 18



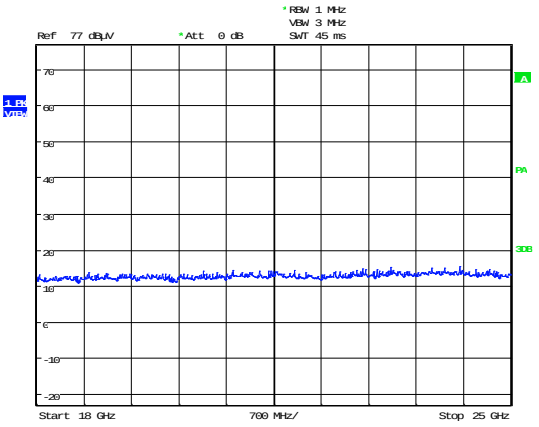
EUT 3; CH. 18; d= 0.1m
Date: 31.JAN.2017 10:01:06

Prescan; Radiated Emissions 6-18 GHz
Variant #3
Channel: 26



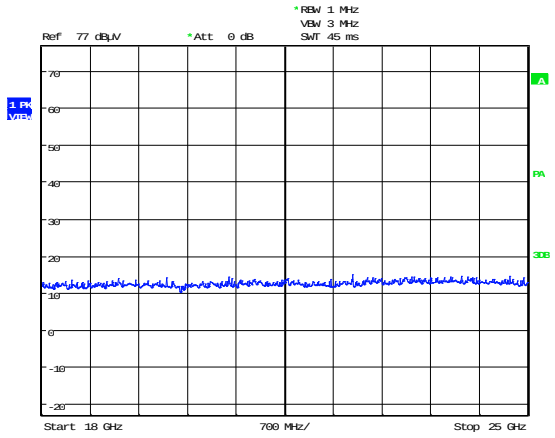
EUT 3; CH. 26; d= 0.1m
Date: 31.JAN.2017 10:01:58

Exploratory rad. emission meas. 18-25 GHz
Variant #3
Channel: 11



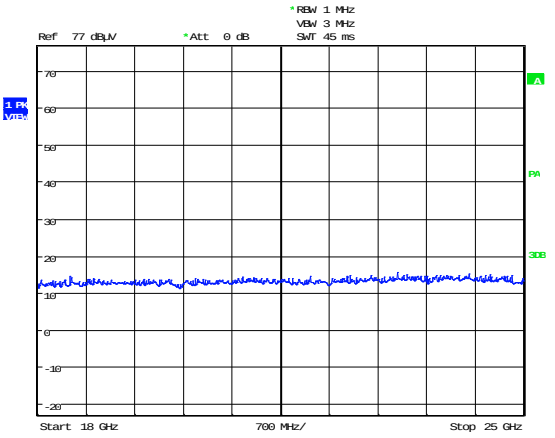
EUT 3; CH. 11; d= 0.1m
Date: 25.JAN.2017 10:25:22

Exploratory rad. emission meas. 18-25 GHz
Variant #3
Channel: 18



EUT 3; CH. 18; d= 0.1m
Date: 25.JAN.2017 10:35:23

Exploratory rad. emission meas. 18-25 GHz
Variant #3
Channel: 26



EUT 3; CH. 26; d= 0.1m
Date: 25.JAN.2017 10:27:59

12 MEASUREMENT UNCERTAINTY

Measurement	Measurement Uncertainty
Radiated emissions, H field (9 kHz – 30 MHz)	± 3.0 dB
Radiated Emissions (30 MHz – 1000 MHz)	± 5.7 dB
Radiated Emissions (Above 1000 MHz)	± 5.3 dB

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

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

13 LIST OF ANNEXES

Following annexes are separated parts from this test report.

Description	Pages
Annex 1: Photographs of test set-up	4
Annex 2: Internal photographs of equipment under test (EUTs)	6
Annex 3: Photographs of ancillary equipment	3

Annex 1 to Test Report # EMCC-110010UB, 2017-04-12

PHOTOGRAPHS OF TEST SET-UP

EQUIPMENT UNDER TEST:

Device:	TCM 515Z
Serial Number:	363603001278 363603001268 363603001281
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515Z
IC ID:	5713A-TCM515Z
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone :	+49 89 6734689-49
Fax :	+49 89 6734689-56

RELEVANT STANDARD(S) : 47 CFR § 15.247:2015-10
RSS-247 Issue 2

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☒ 558074 D01 DTS Meas Guidance v03r05

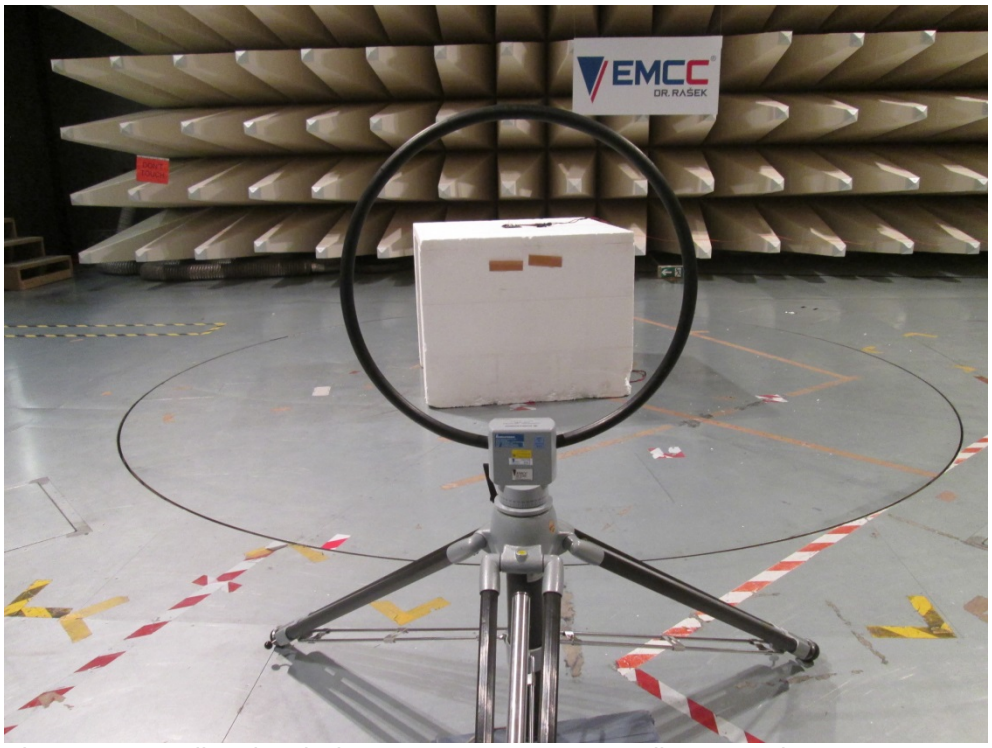


Photo A1-1: Radiated emissions measurement at 3 m distance, 9 kHz – 30 MHz

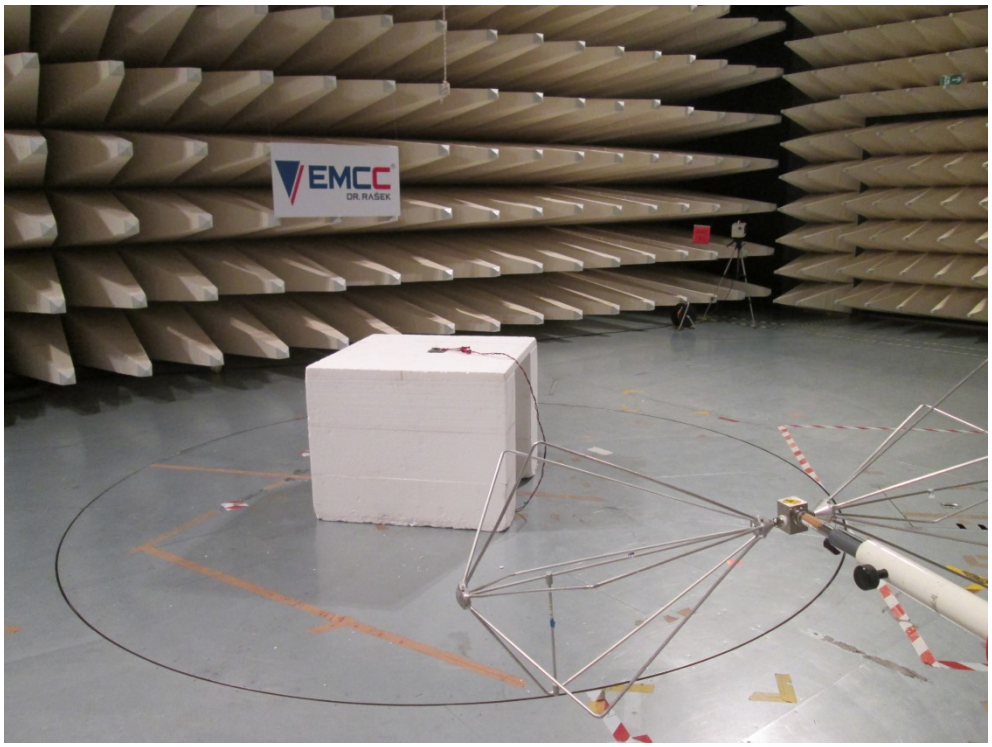


Photo A1-2: Radiated emissions measurement at 3 m distance, 30 MHz – 250 MHz

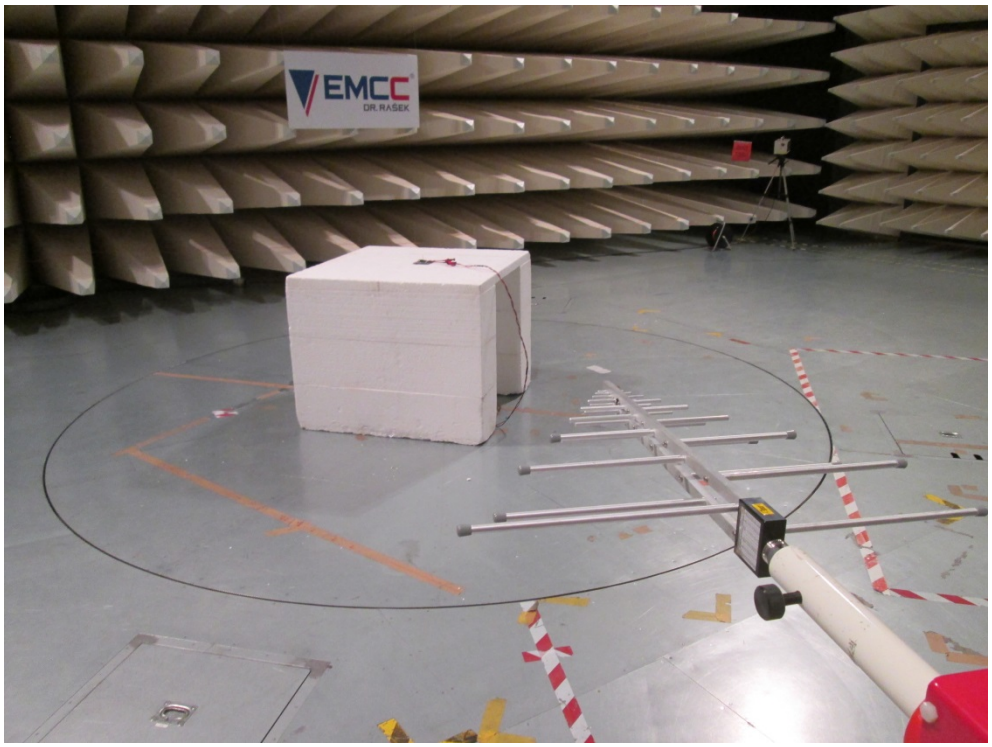


Photo A1-3: Radiated emissions measurement at 3 m distance, 250 MHz – 1000 MHz

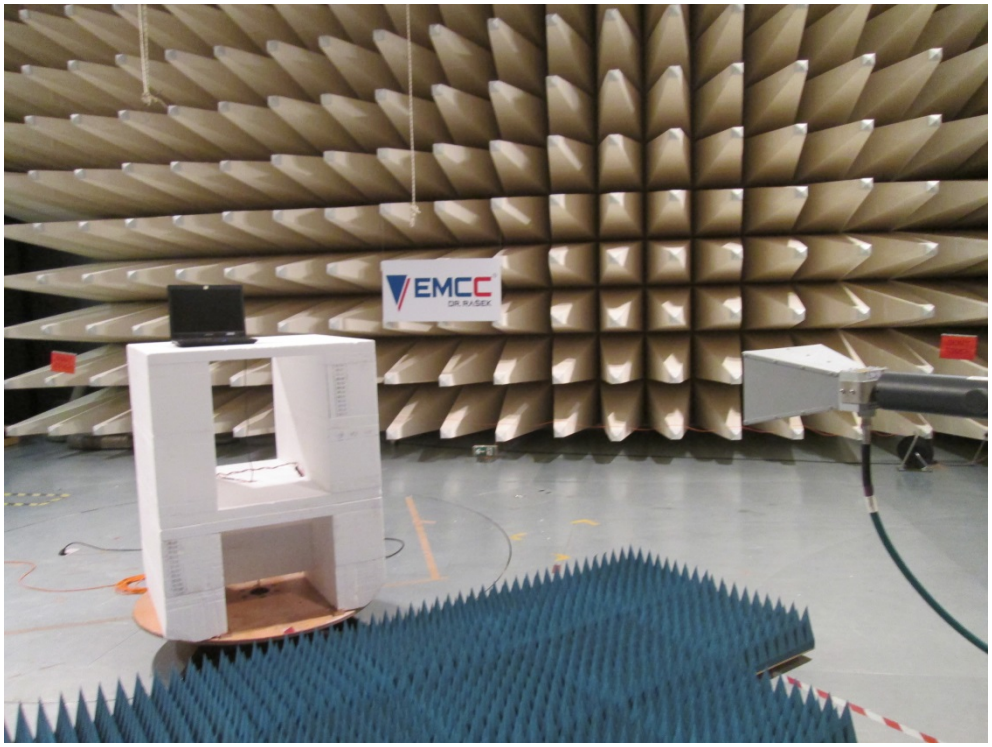


Photo A1-4: Radiated emissions measurement at 3 m distance, 1 GHz – 6 GHz

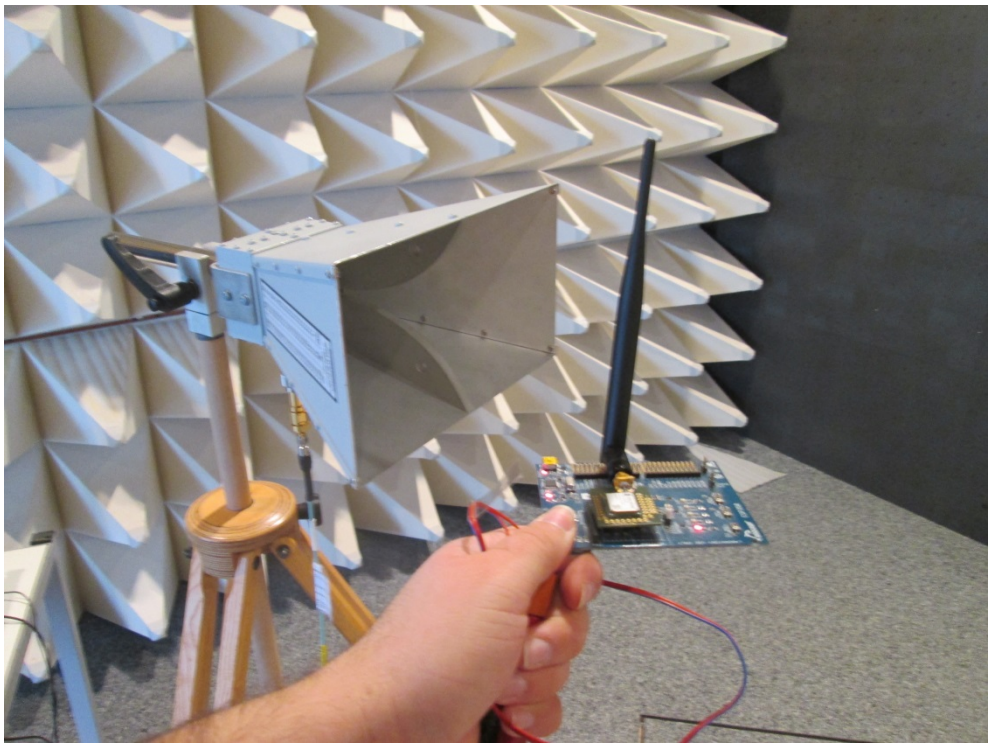


Photo A1-5: Exploratory radiated emissions measurements at closer distance, 6 GHz – 18 GHz

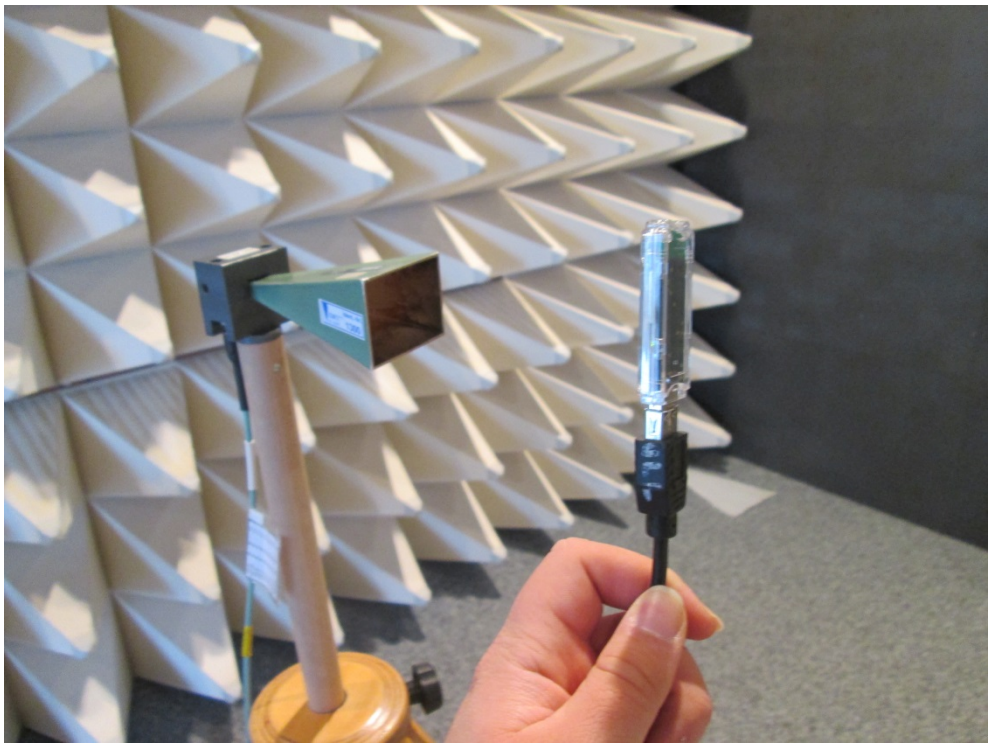


Photo A1-6: Exploratory radiated emissions measurements at closer distance, 18 GHz – 25 GHz

Annex 2 to Test Report # EMCC-110010UB, 2017-04-12

INTERNAL PHOTOGRAPHS OF EUT

EQUIPMENT UNDER TEST:

Device:	TCM 515Z
Serial Number:	363603001278 363603001268 363603001281
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515Z
IC ID:	5713A-TCM515Z
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone :	+49 89 6734689-49
Fax :	+49 89 6734689-56

RELEVANT STANDARD(S) : 47 CFR § 15.247:2015-10
RSS-247 Issue 2

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☒ 558074 D01 DTS Meas Guidance v03r05

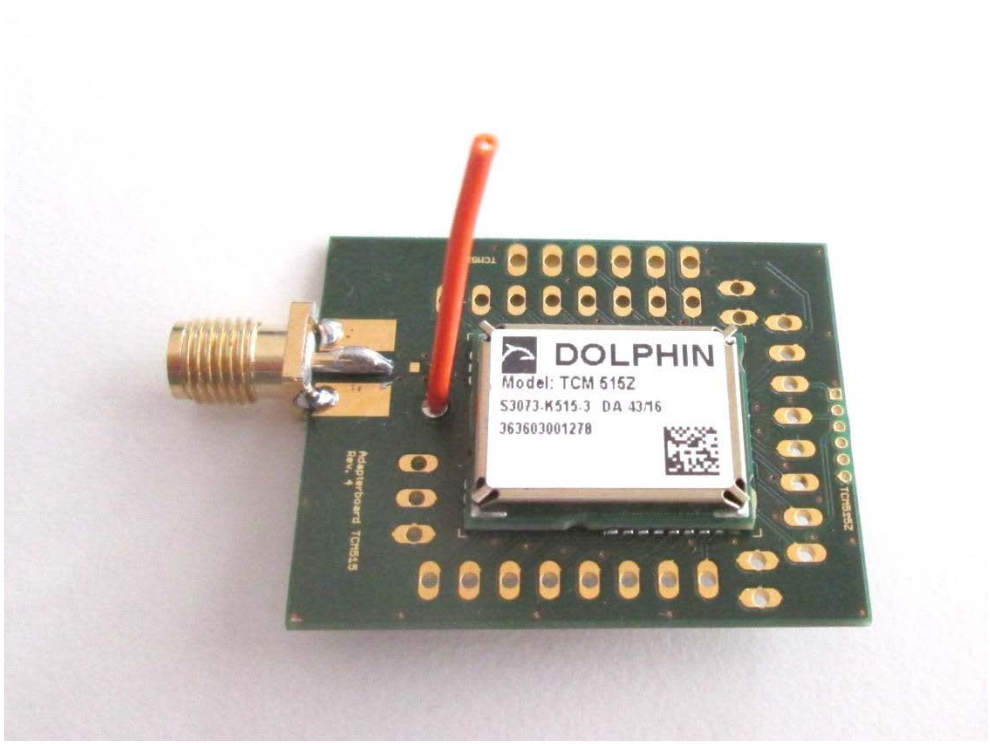


Photo A2-1: EUT Variant #1 – Top view

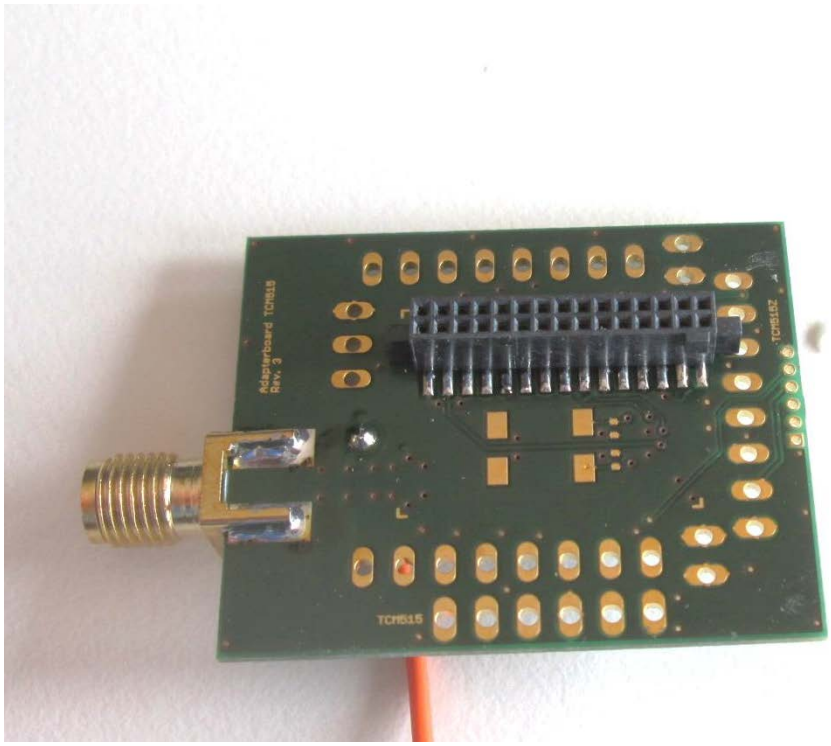


Photo A2-2: EUT Variant #1 – Bottom view

Photo A2-3: EUT Variant #1 – Label

Photo A2-4: EUT Variant #2– Top view

Photo A2-5: EUT Variant #2 – Bottom view

Photo A2-6: EUT Variant #2 – Label

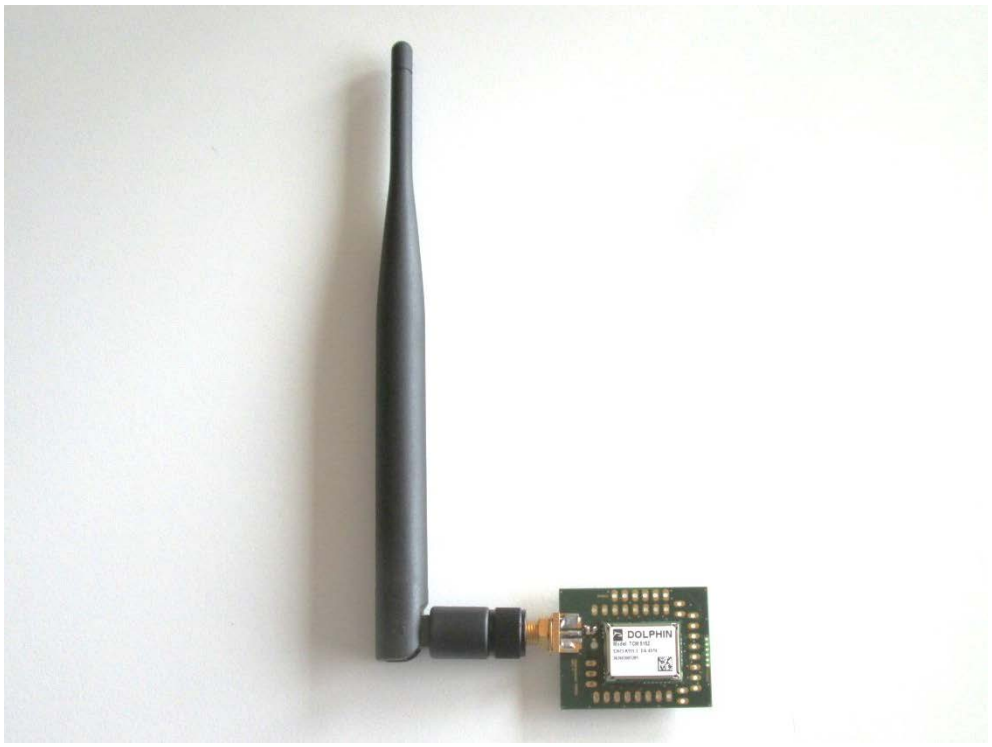


Photo A2-7: EUT Variant #3– Top view

Photo A2-8: EUT Variant #3 – Bottom view

Photo A2-9: EUT Variant #3 – Label

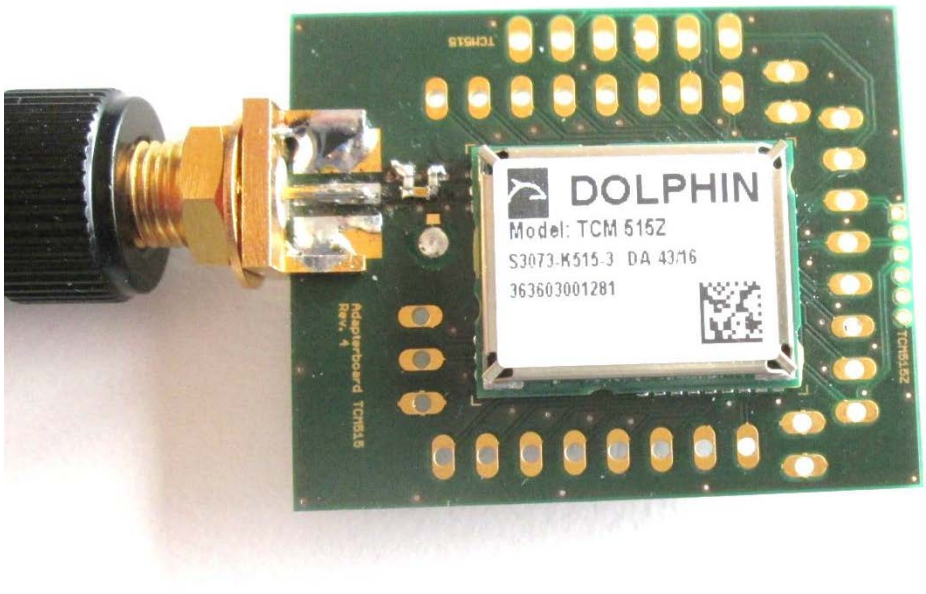


Photo A2-10: EUT Variant #3–PCB view

Annex 3 to Test Report # EMCC-110010UB, 2017-04-12

PHOTOGRAPHS OF ANCILLARY EQUIPMENT

EQUIPMENT UNDER TEST:

Device:	TCM 515Z
Serial Number:	363603001278 363603001268 363603001281
Application:	Wireless Remote Control
FCC ID:	SZV-TCM515Z
IC ID:	5713A-TCM515Z
Manufacturer:	EnOcean GmbH
Address:	Kolpingring 18 a 82041 Oberhaching Germany
Phone :	+49 89 6734689-49
Fax :	+49 89 6734689-56

RELEVANT STANDARD(S) : 47 CFR § 15.247:2015-10
RSS-247 Issue 2

MEASUREMENT PROCEDURE:

☒ ANSI C63.10-2013 ☒ RSS-Gen Issue 4 ☒ 558074 D01 DTS Meas Guidance v03r05

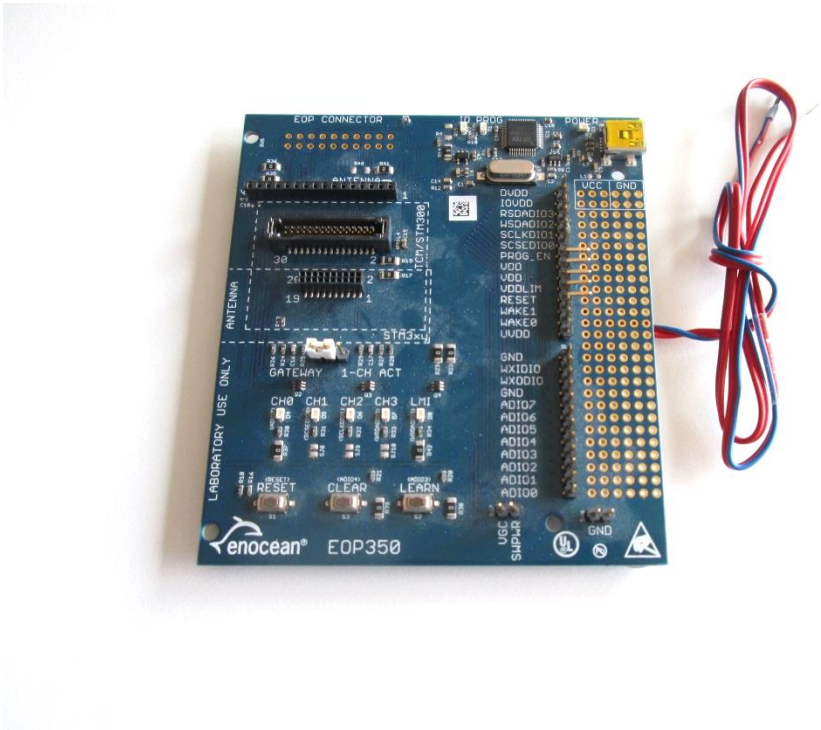


Photo A3-1: Eval-Board EOP350 – Top view

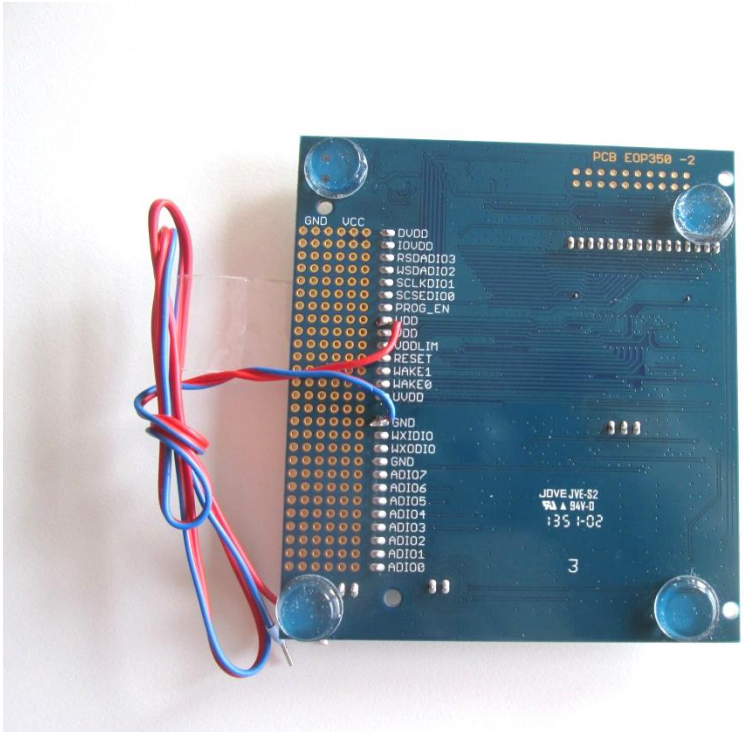


Photo A3-2: Eval-Board EOP350 – Bottom view

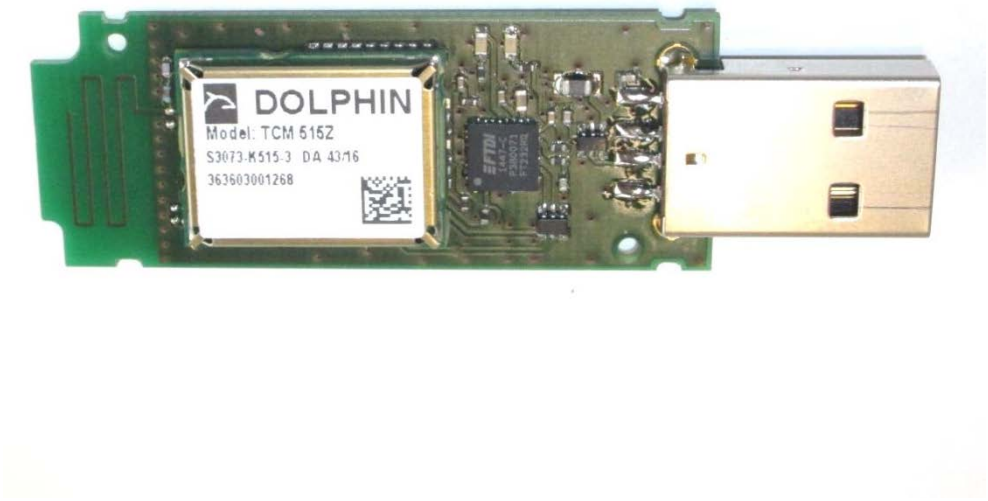


Photo A3-4: Demo-Board USB500Z-V1.0 – Top view

Photo A3-4: Demo-Board USB500Z-V1.0 – Bottom view