

# Wireless test report – 362189-1TRFWL

Applicant:

**Zimmer CAS**

Product name:

**Controller Radio**

Model:

**400.047**

FCC ID:

**CVO-CORA**

IC Registration number:

**10254A-400047**

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.247**

Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

◆ **RSS-247, Issue 2, Feb 2017, Section 5**

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs)  
and Licence-Exempt Local Area Network (LE-LAN) Devices

5) Standard specifications for frequency hopping systems and digital transmission systems operating in the  
bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: Click here to enter a date.

Test engineer(s):

**Yong Huang, Wireless/EMC Specialist**

Signature:



Reviewed by:

**Kevin Rose, Wireless/EMC Specialist**

Signature:



---

**Test location(s)**

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Site number	FCC: CA2040; IC: 2040A-4 (3 m SAC)	FCC: CA2041; IC: 2040G-5 (3 m SAC)

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**Limits of responsibility**

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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## Section 1. Report summary

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### 1.1 Applicant and manufacturer

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Company name	Zimmer CAS
Address	75 Queen St, suite 3300 H3C 2N6 Montreal QC Canada

### 1.2 Test specifications

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FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

### 1.3 Test methods

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558074 D01 DTS Meas Guidance v05r01 (February 11, 2019)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus

### 1.4 Statement of compliance

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In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 below. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

### 1.5 Exclusions

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None

### 1.6 Test report revision history

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Revision #	Date of issue	Details of changes made to test report
TRF	November 14, 2018	Original report issued

## Section 2. Summary of test results

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### 2.1 FCC Part 15 Subpart C, general requirements test results

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*Table 2.1-1: FCC general requirements results*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is a DC powered device, which powered via USB of the host computer, power line conducted emissions tests were perform on AC input of the host.

### 2.2 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems

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*Table 2.2-1: FCC 15.247 results for FHSS*

Part	Test description	Verdict
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Not applicable
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Not applicable
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Not applicable
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

### 2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

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*Table 2.3-1: FCC 15.247 results for DTS*

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

## 2.4 ISED RSS-Gen, Issue 5, test results

**Table 2.4-1: RSS-Gen results**

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Pass

Notes: <sup>1</sup> According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

EUT is a DC powered device, which powered via USB of the host computer, power line conducted emissions tests were perform on AC input of the host

## 2.5 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

**Table 2.5-1: RSS-247 results for FHSS**

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing	Not applicable
5.1 (c)	Systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (a)	Systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Not applicable

Notes: None

## 2.6 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)

**Table 2.6-1: RSS-247 results for DTS**

Part	Test description	Verdict
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (d)	Systems employing digital modulation techniques	Pass
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Pass

Notes: None

## Section 3. Equipment under test (EUT) details

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### 3.1 Sample information

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Receipt date	October 19, 2018
Nemko sample ID number	1

### 3.2 EUT information

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Product name	Controller Radio
Model	400.047
Model variant	None
Serial number	1

### 3.3 Technical information

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Applicant IC company number	10254A
IC UPN number	400047
All used IC test site(s) Reg. number	2040G-5
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	2400 to 2483.25 MHz
Frequency Min (MHz)	2405
Frequency Max (MHz)	2480
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted	0.0012(1.1 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	1605
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	OQPSK
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, Units @ distance	53.6 dB $\mu$ V/m, average @ 3m, at 2483.5 MHz
Power requirements	5 V <sub>DC</sub> via USB from laptop
Antenna information	Integrated chip antenna with Max peak of 2.2 dBi

### 3.4 Product description and theory of operation

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Device that allows bidirectional wireless transmission between a controller and sensors

### 3.5 EUT exercise details

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The device is configured in forced transmit mode using special port commands.

## 3.6 EUT setup diagram

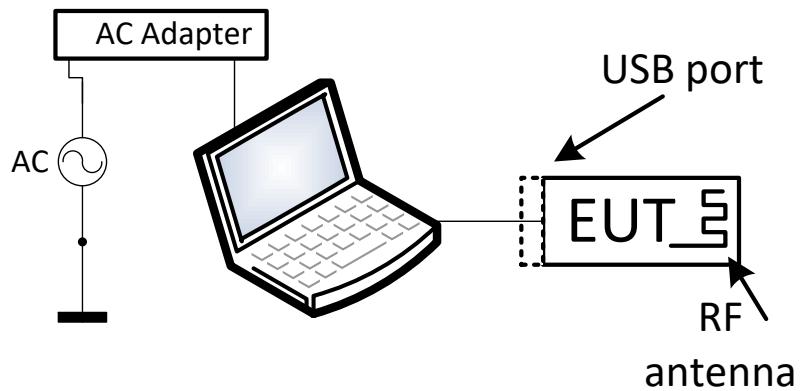


Figure 3.6-1: Setup diagram

## 3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
Laptop	Dell	MN:P02T	00186-071-540-861
AC Adapter for laptop	Dell	PA-1650-05D2	CN-0F7970-71615-57I-2617

## Section 4. Engineering considerations

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### 4.1 Modifications incorporated in the EUT

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There were no modifications performed to the EUT during this assessment.

### 4.2 Technical judgment

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None

### 4.3 Deviations from laboratory tests procedures

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No deviations were made from laboratory procedures.

## Section 5. Test conditions

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### 5.1 Atmospheric conditions

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Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

### 5.2 Power supply range

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The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages  $\pm 5\%$ , for which the equipment was designed.

## Section 6. Measurement uncertainty

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### 6.1 Uncertainty of measurement

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UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of  $K = 2$  with 95% certainty.

*Table 6.1-1: Measurement uncertainty*

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

## Section 7. Test equipment

### 7.1 Test equipment list

*Table 7.1-1: Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002532	2 year	June 5/19
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
Spectrum analyzer	Rohde & Schwarz	FSV 40	FA002731	1 year	Sep 30/19
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	Dec. 6/18
Horn antenna (1–18 GHz)	EMCO	3115	FA001452	1 year	Nov. 20/18
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	2 year	Sep 11/19
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	Sept. 19/19
Pre-amplifier (18–40 GHz)	COM-POWER	PAM-840	FA002508	1 year	May 8/19
50 Ω coax cable	C.C.A.	None	FA002603	—	VOU
50 Ω coax cable	Sucoflex	None	FA002563	—	VOU
50 Ω coax cable	C.C.A.	None	FA002831	—	VOU
2300–2583.5 MHz Notch Filter	Microwave Circuits	N0324413	FA002693	—	VOU

Note: NCR - no calibration required, VOU - verify on use

## Section 8. Testing data

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### 8.1 FCC 15.31(e) Variation of power source

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#### 8.1.1 Definitions and limits

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For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

#### 8.1.2 Test date

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Start date October 19, 2018

#### 8.1.3 Observations, settings and special notes

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EUT is powered via USB from the host, tests were performed on the AC input of host computer provided by customer.

#### 8.1.4 Test data

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EUT Power requirements:

If EUT is an AC or a DC powered, was the noticeable output power variation observed?	<input type="checkbox"/> AC	<input checked="" type="checkbox"/> DC	<input type="checkbox"/> Battery
If EUT is battery operated, was the testing performed using fresh batteries?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO	<input type="checkbox"/> N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A
	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A

## 8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

### 8.2.1 Definitions and limits

**FCC:**

Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

**ISED:**

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

*Table 8.2-1: Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Note: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

### 8.2.2 Test date

Start date      October 19, 2018

### 8.2.3 Observations, settings and special notes

None

### 8.2.4 Test data

*Table 8.2-2: Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400	2483.5	83.5	2405	2440	2480

## 8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement

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### 8.3.1 Definitions and limits

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**FCC:**

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 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.

**ISED:**

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

### 8.3.2 Test date

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Start date

October 19, 2018

### 8.3.3 Observations, settings and special notes

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None

### 8.3.4 Test data

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Must the EUT be professionally installed?

YES  NO

Does the EUT have detachable antenna(s)?

YES  NO

If detachable, is the antenna connector(s) non-standard?

YES  NO  N/A

## 8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

### 8.4.1 Definitions and limits

#### FCC:

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

#### IC:

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

**Table 8.4-1: Conducted emissions limit**

Frequency of emission, MHz	Quasi-peak	Conducted limit, dB $\mu$ V	Average**
0.15–0.5	66 to 56*	56 to 46*	56 to 46*
0.5–5	56	46	46
5–30	60	50	50

Note: \* - The level decreases linearly with the logarithm of the frequency.

\*\* - A linear average detector is required.

### 8.4.2 Test date

Start date

November 1, 2018

#### 8.4.3 Observations, settings and special notes

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The EUT was set up as tabletop configuration.

EUT is powered via USB from the host, tests were performed on the AC input of host computer provided by customer.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

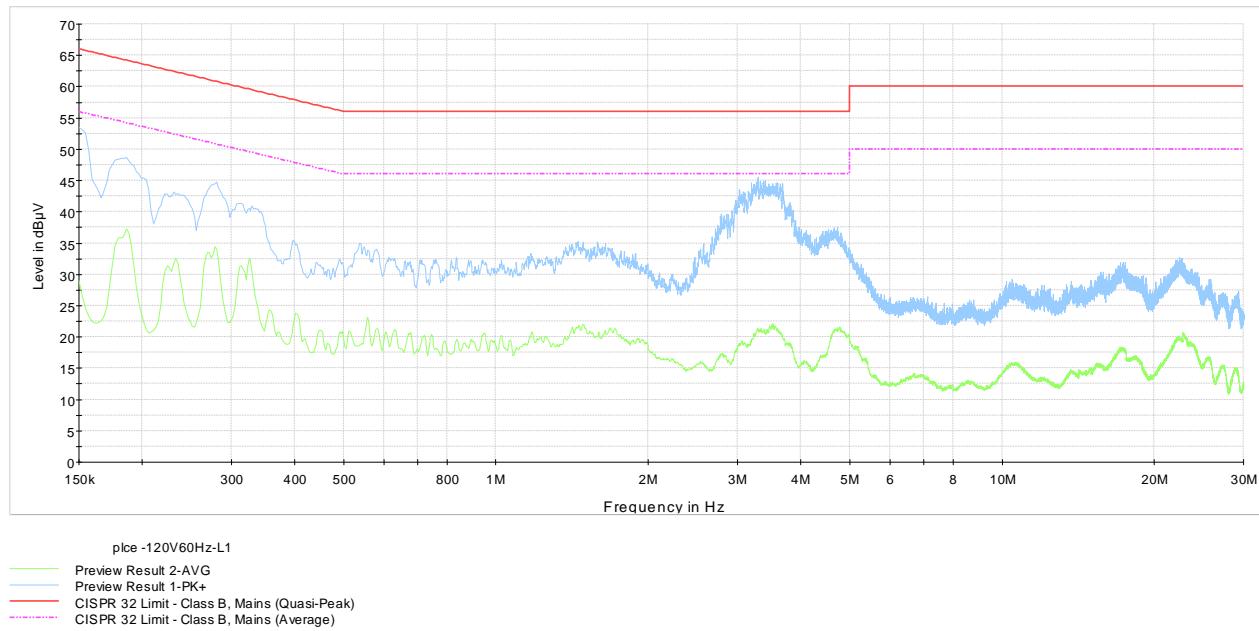
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

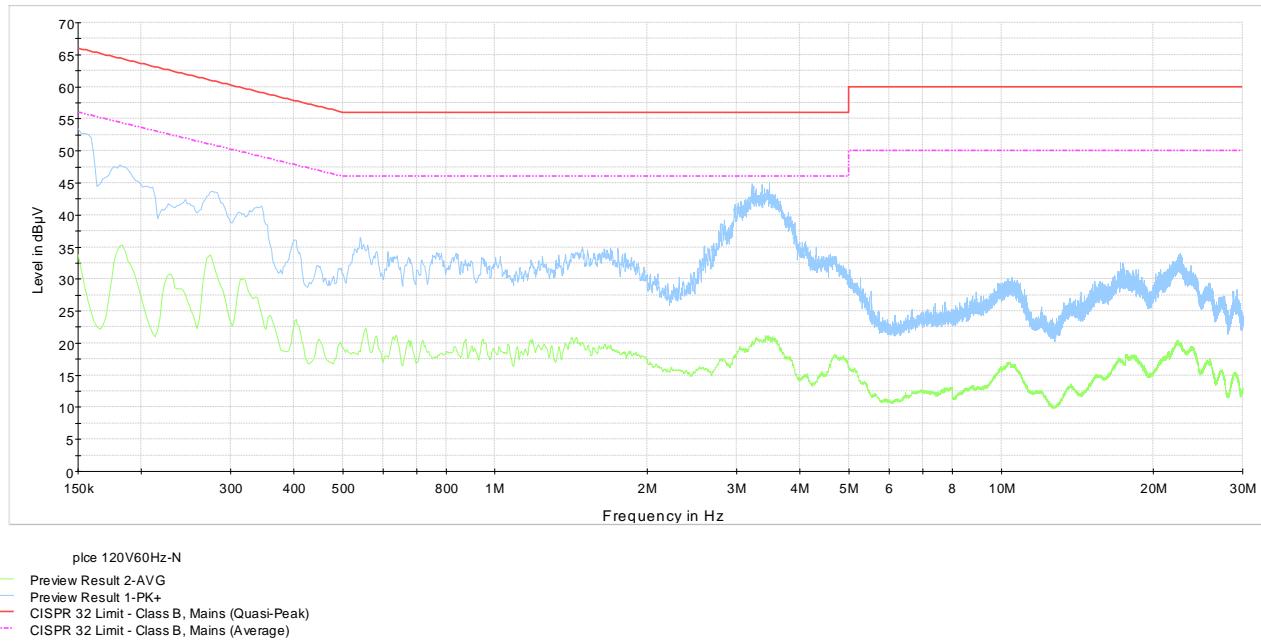
Receiver settings for final measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

#### 8.4.4 Test data



**Plot 8.4-1: Conducted emissions on phase line**



## 8.5 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for DTS systems

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### 8.5.1 Definitions and limits

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**FCC:**

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.

**ISED:**

The minimum 6 dB bandwidth shall be 500 kHz.

### 8.5.1 Test date

---

Start date

October 19, 2018

### 8.5.2 Observations, settings and special notes

---

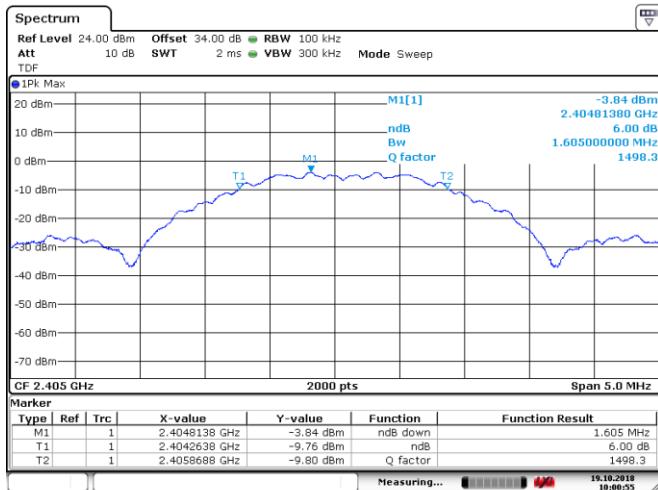
Spectrum analyzer settings for 6 dB bandwidth:

Resolution bandwidth	100 kHz
Video bandwidth	$\geq 3 \times$ RBW
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

### 8.5.3 Test data

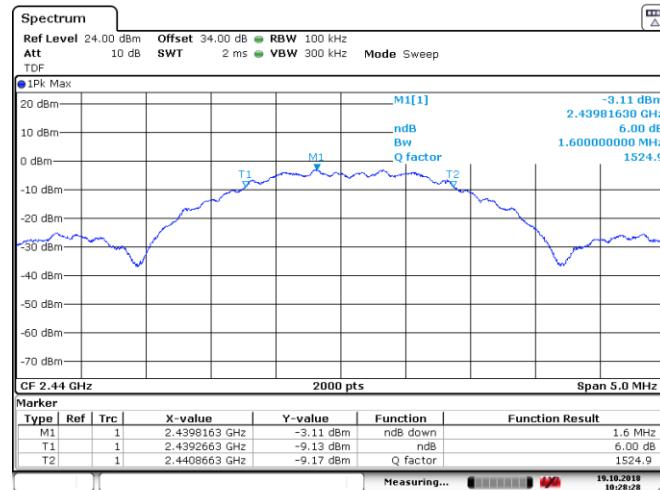
Table 8.5-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum Limit, kHz	Margin, kHz
2405	1605	500	1105
2440	1600	500	1100
2480	1605	500	1105



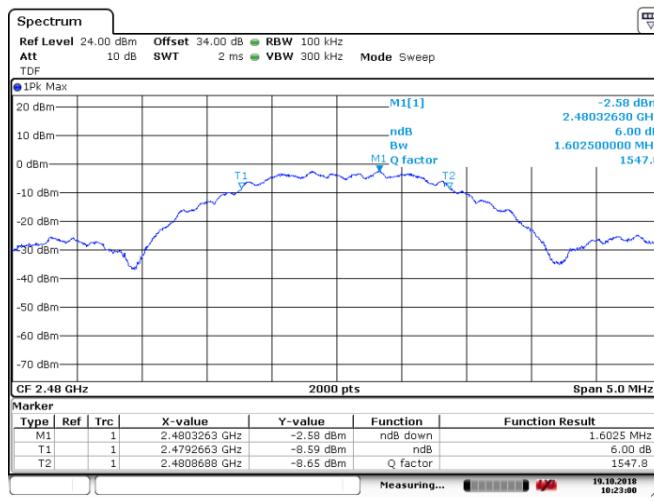
Date: 19.OCT.2018 10:00:55

Figure 8.5-1: 6 dB bandwidth on low channel



Date: 19.OCT.2018 10:28:28

Figure 8.5-2: 6 dB bandwidth on mid channel

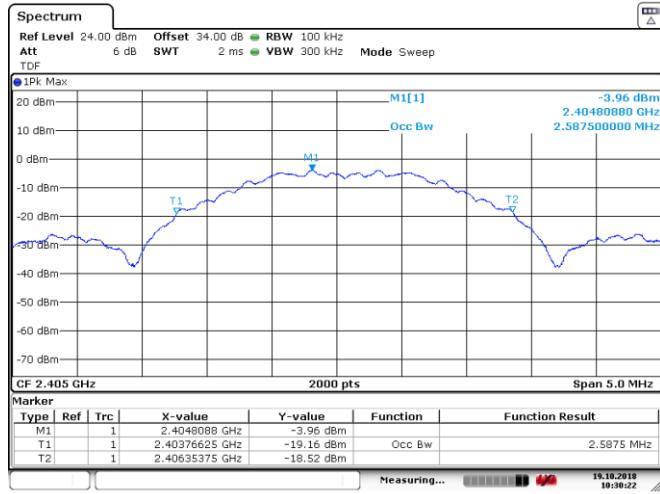


Date: 19.OCT.2018 10:23:01

Figure 8.5-3: 6 dB bandwidth on high channel

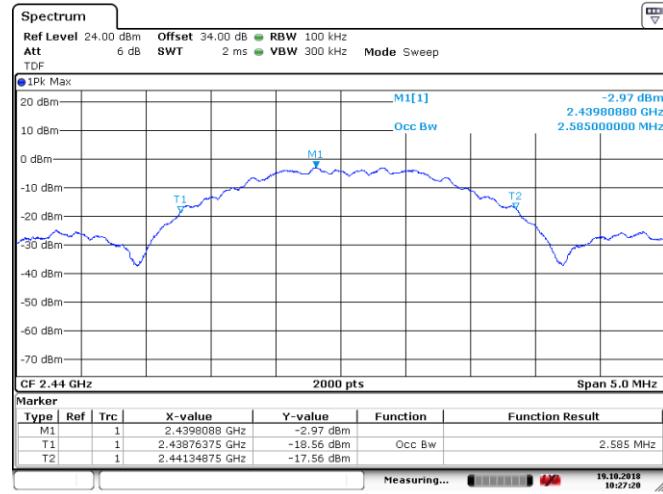
Table 8.5-2: 99% bandwidth results

Frequency, MHz	99% bandwidth, kHz
2402	2588
2440	2585
2480	2563



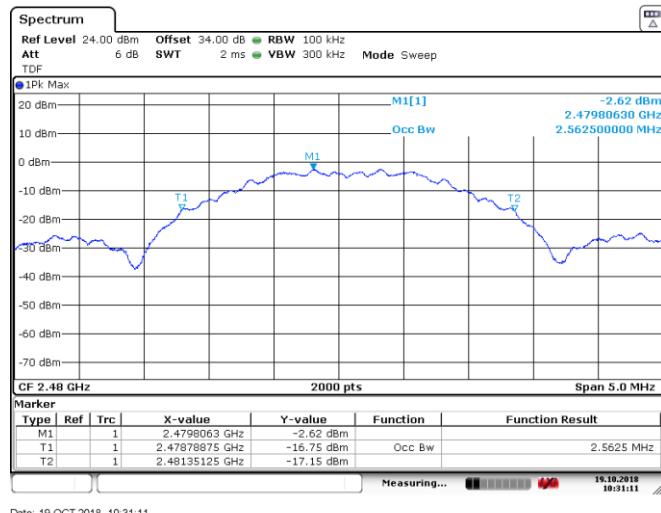
Date: 19.OCT.2018 10:30:22

Figure 8.5-4: 99% bandwidth on low channel



Date: 19.OCT.2018 10:27:20

Figure 8.5-5: 99% bandwidth on mid channel



Date: 19.OCT.2018 10:31:11

Figure 8.5-6: 99% bandwidth on high channel

## 8.6 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements for DTS in 2 GHz

### 8.6.1 Definitions and limits

#### FCC:

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

- (3) For systems using digital modulation in the 2400–2483.5 MHz band: 1 W (30 dBm). 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.

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

- (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.
- (ii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.
- (2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:
  - (i) Different information must be transmitted to each receiver.
  - (ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
    - (A) The directional gain shall be calculated as the sum of  $10 \log$  (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.
    - (B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.
  - (iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.
  - (iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

**ISED:**

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 MHz band, 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.

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

- i Different information must be transmitted to each receiver.
- ii If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.
- iii If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.
- iv Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

#### 8.6.1 Test date

Start date      October 19, 2018

#### 8.6.2 Observations, settings and special notes

Conducted measurement was performed at the coupling test port of EUT, path loss were included in the offset of reference level.

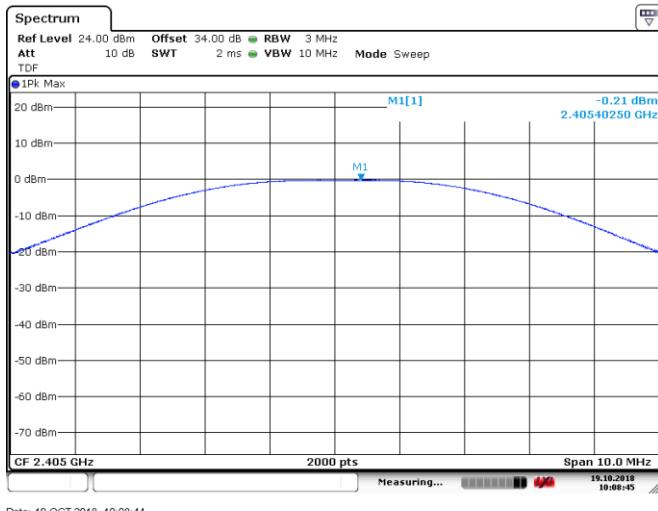
The test was performed using spectrum analyzer setting as below:

Resolution bandwidth	3 MHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	10 MHz
Detector mode	Peak
Trace mode	Max Hold

### 8.6.3 Test data

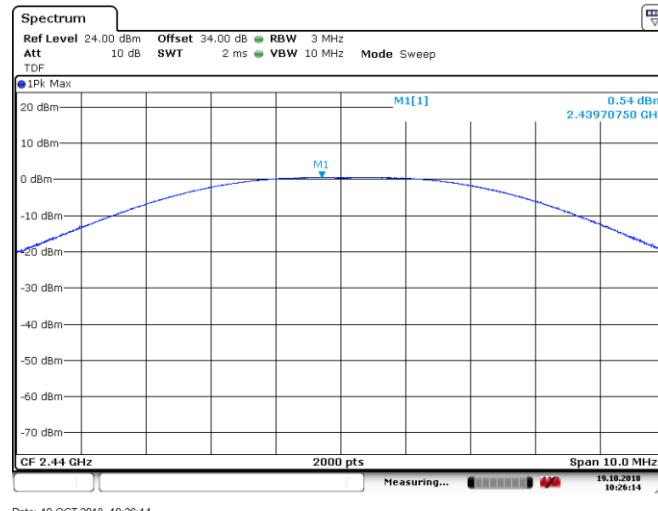
Table 8.6-1: Output power measurements results

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2405	-0.2	30	30.2	2.2	2.0	36	34.0
2440	0.5	30	29.5	2.2	2.7	36	33.3
2480	1.1	30	28.9	2.2	3.3	36	32.7



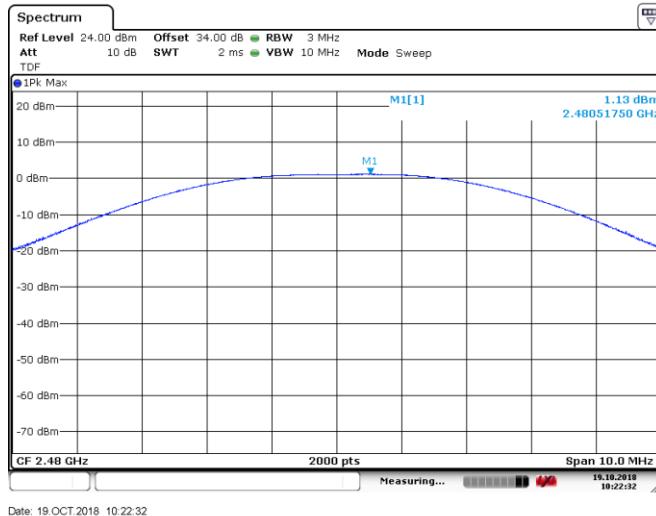
Date: 19.OCT.2018 10:08:44

Figure 8.6-1: Output power on low channel



Date: 19.OCT.2018 10:26:14

Figure 8.6-2: Output power on mid channel



Date: 19.OCT.2018 10:22:32

Figure 8.6-3: Output power on high channel

## 8.7 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions

### 8.7.1 Definitions and limits

**FCC:**

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)).

**ISED:**

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.

**Table 8.7-1: FCC §15.209 and RSS-Gen – Radiated emission limits**

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, m
0.009–0.490	2400/F	67.6 – 20 × log <sub>10</sub> (F)	300
0.490–1.705	24000/F	87.6 – 20 × log <sub>10</sub> (F)	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

**Table 8.7-2: ISED restricted frequency bands**

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	Above 38.6
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.7-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

**Table 8.7-3: FCC restricted frequency bands**

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

#### 8.7.1 Test date

Start date

October 19, 2018

## 8.7.2 Observations, settings and special notes

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The spectrum was searched from 30 MHz to the 10<sup>th</sup> harmonic.

EUT was set to transmit with 100 % duty cycle.

Radiated measurements were performed at a distance of 3 m. The level of spurious emissions were measured as their effective radiated power when radiated by cabinet and antenna in case of integral antenna equipment with no antenna connectors.

Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is -20 dBc/100 kHz.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

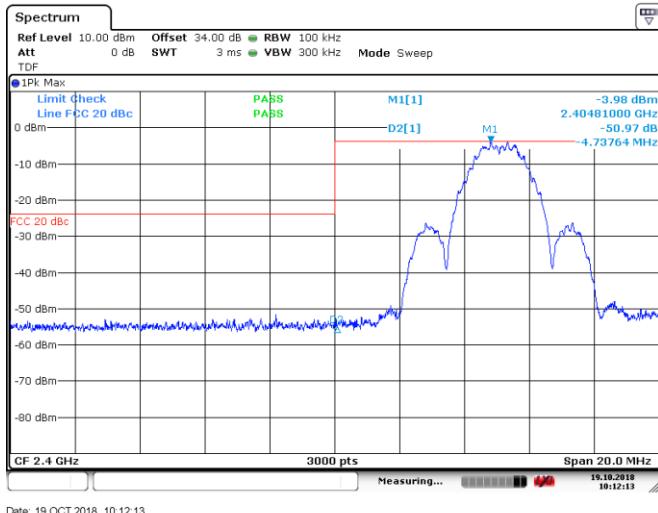
Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

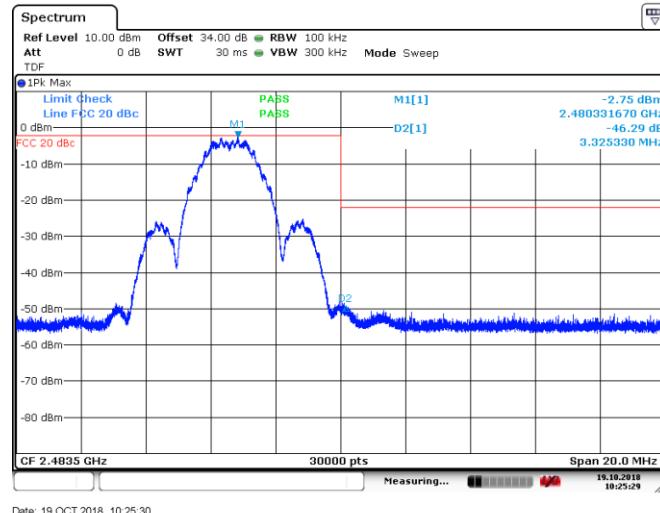
Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

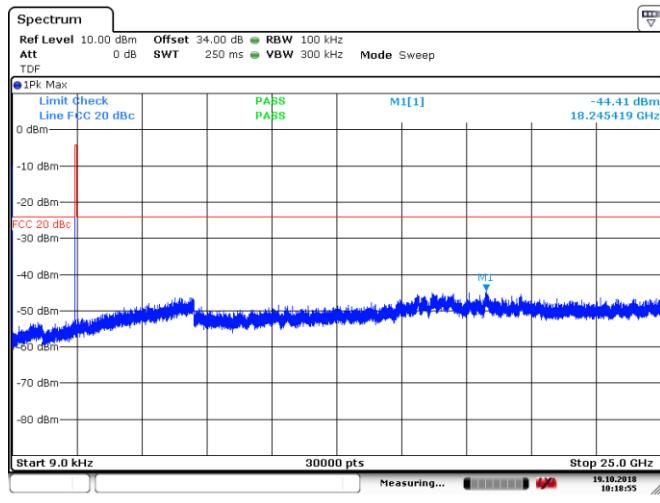
#### 8.7.4 Test data



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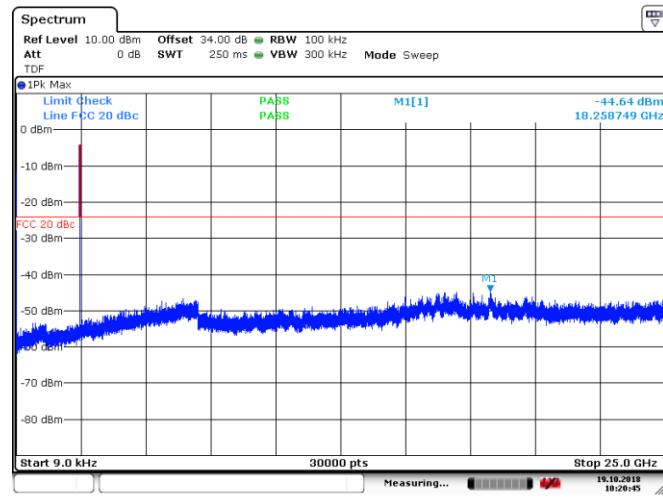


Date: 19.OCT.2018 10:25:30



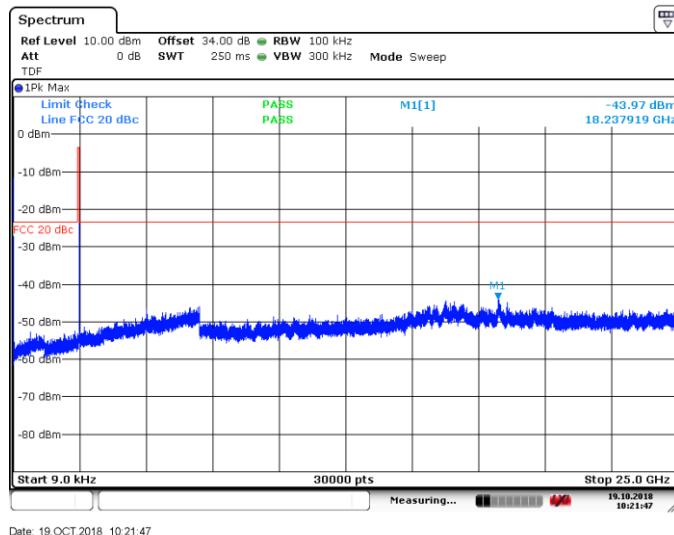
Date: 19.OCT.2018 10:18:55

**Figure 8.7-3: Conducted spurious emissions outside restricted band, Low channel**



Date: 19.OCT.2018 10:20:46

**Figure 8.7-4: Conducted spurious emissions outside restricted band, Mid channel**



Date: 19.OCT.2018 10:21:47

**Figure 8.7-5: Conducted spurious emissions outside restricted band, High channel**

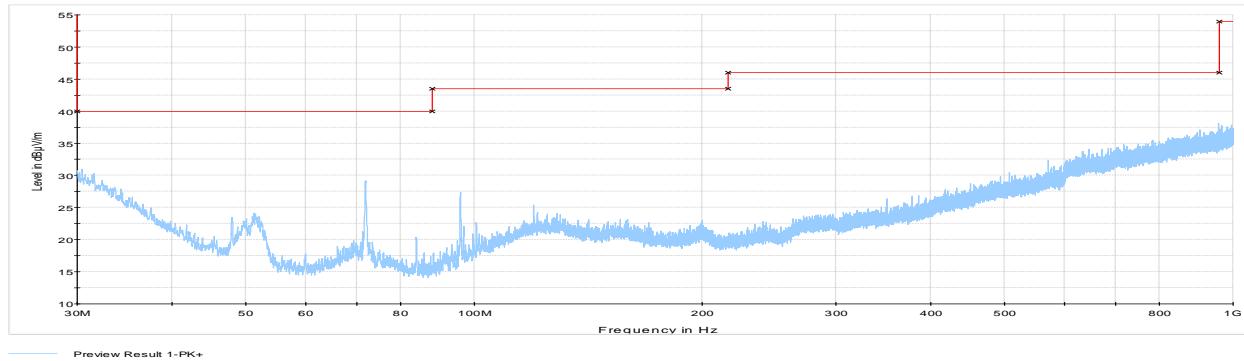


figure 8.7-6: Radiated spurious emissions 30 MHz to 1 GHz, Low channel

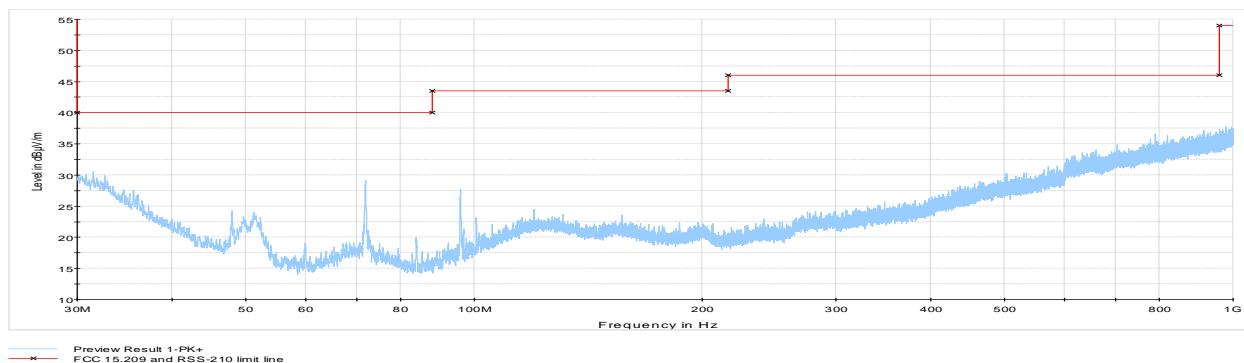


Figure 8.7-7: Radiated spurious emissions 30 MHz to 1 GHz, mid channel

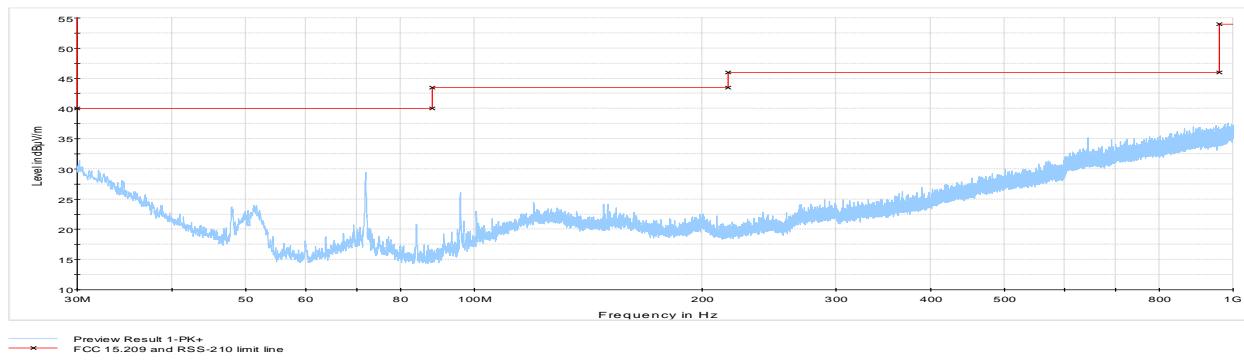
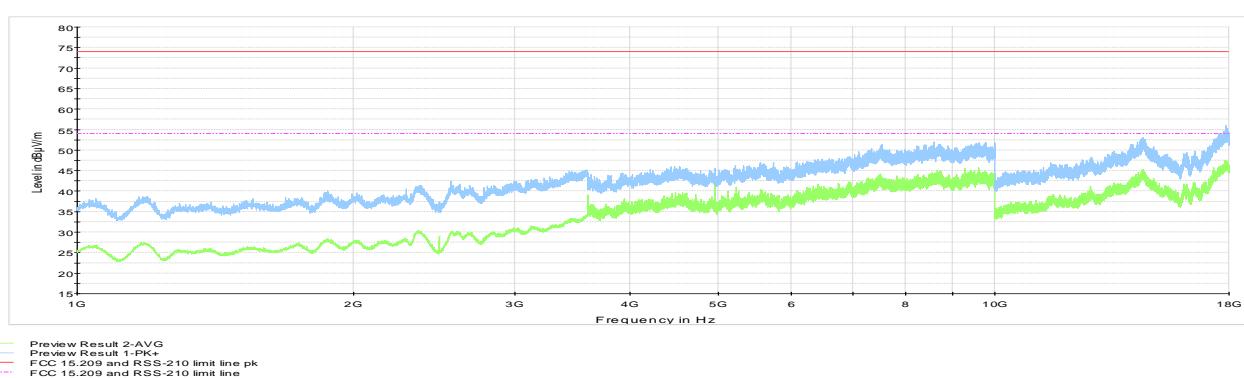
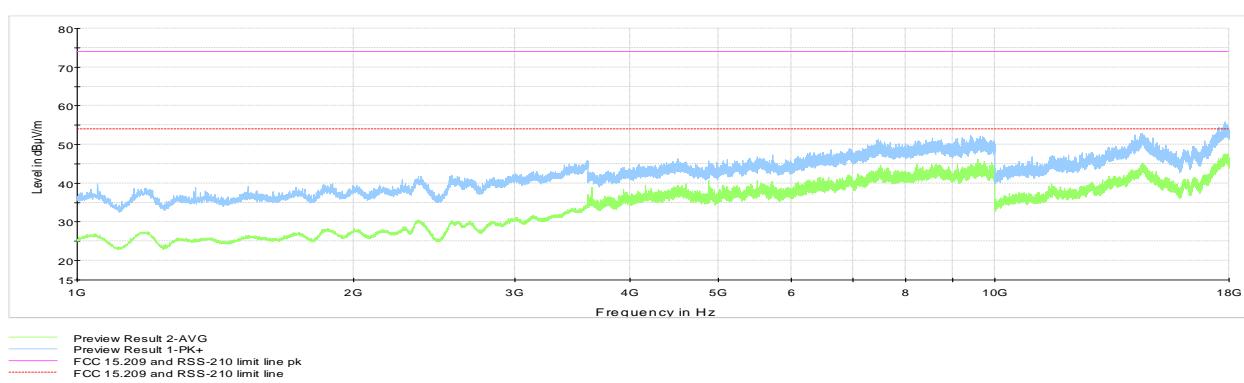
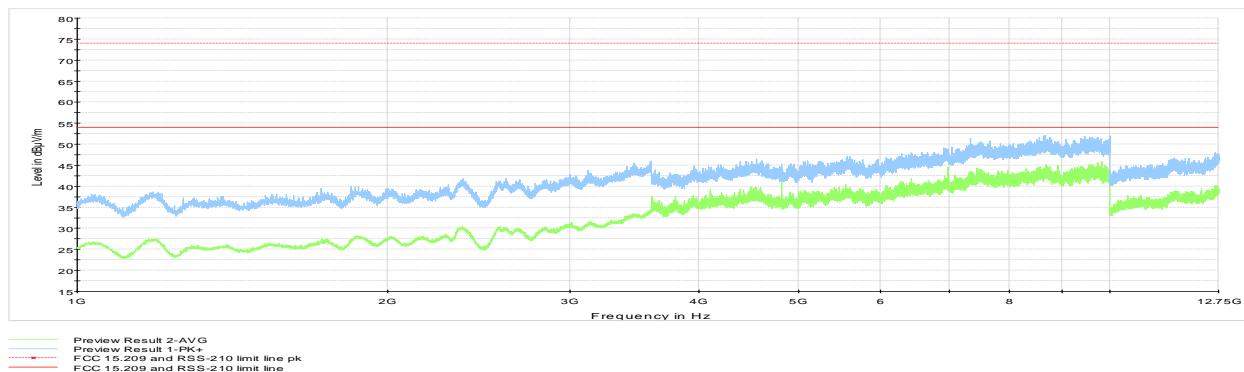


Figure 8.7-8: Radiated spurious emissions 30 MHz to 1 GHz, High channel



Note: Spectrum was investigated from 30 MHz to 25 GHz. Above 18 GHz, no emission related to RF portion were detected within 6 dB below the limit

**Table 8.7-4: Radiated field strength measurement results above 1 GHz**

Channel	Frequency, MHz	Peak Field strength, dB $\mu$ V/m		Margin, dB	Average Field strength, dB $\mu$ V/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390	60.1	74.0	13.9	49.1	54	4.9
Low	4810	45.3	74.0	28.7	41.2	54	12.8
Mid	4880	45.7	74.0	28.3	40.7	54	13.3
High	2483.5	68.1	74.0	5.9	53.6	54	0.4
High	4960	43.7	74.0	30.3	39.6	54	14.4

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

## 8.8 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices

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### 8.8.1 Definitions and limits

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**FCC:**

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.

**ISED:**

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).

### 8.8.1 Test date

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Start date October 19, 2018

### 8.8.1 Observations, settings and special notes

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The test was performed using method PKPSD (peak PSD).

Spectrum analyser settings:

Resolution bandwidth:	100 kHz
Video bandwidth:	$\geq 3 \times$ RBW
Frequency span:	5 Mhz
Detector mode:	Peak
Trace mode:	Maxhold

## 8.8.2 Test data

Table 8.8-1: PSD measurements results

Frequency, MHz	PSD, dBm/100 kHz	PSD limit, dBm/3 kHz	Margin, dB
2405	-3.8	8	11.8
2440	-3.1	8	11.1
2480	-2.6	8	10.6

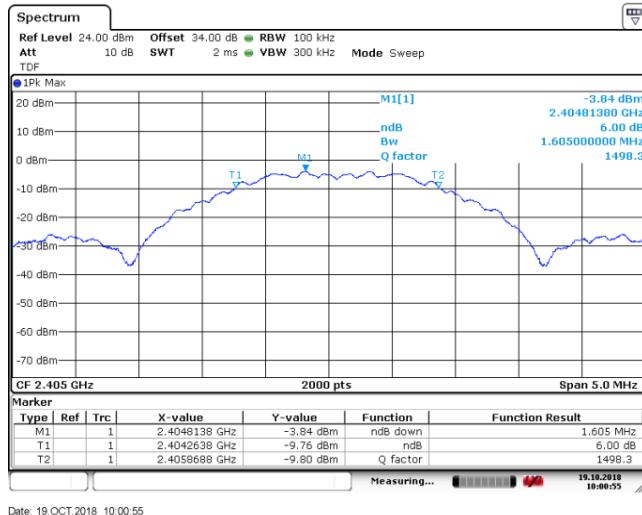


Figure 8.8-1: PSD plot on Low channel

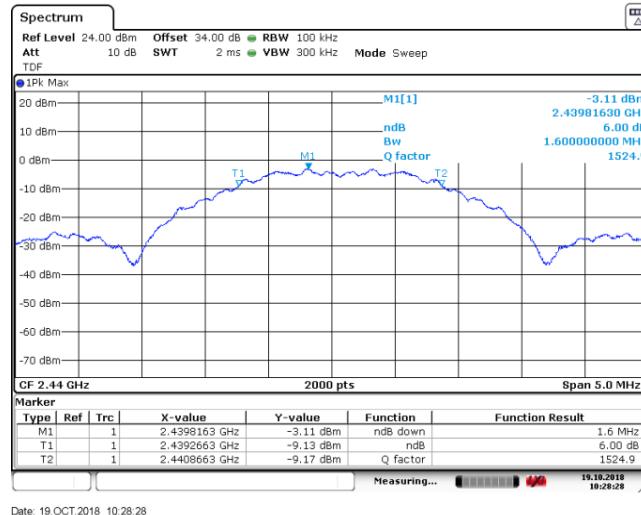


Figure 8.8-2: PSD plot on Mid channel

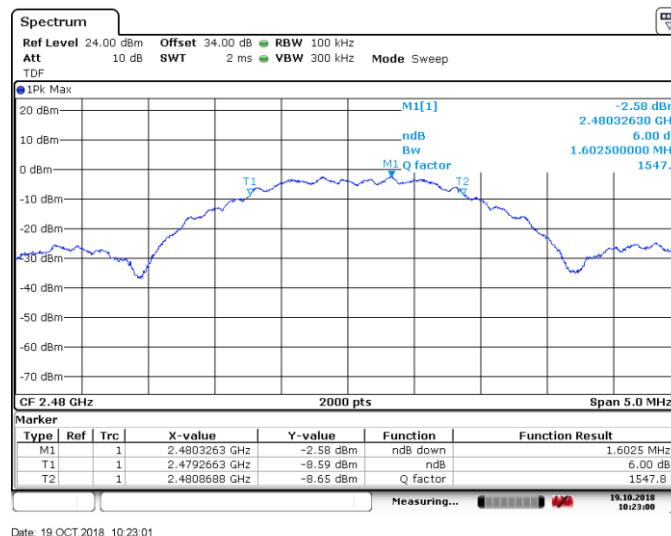
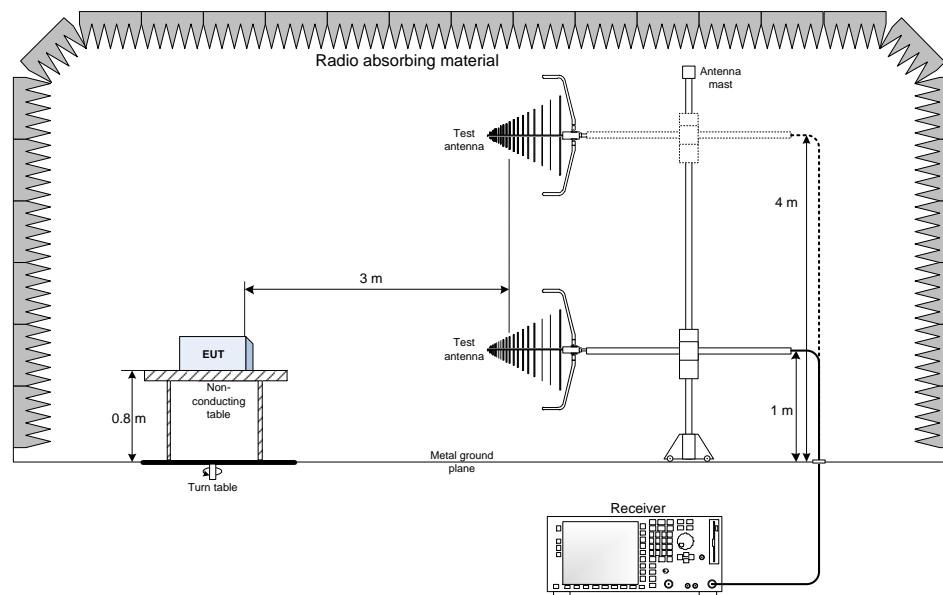


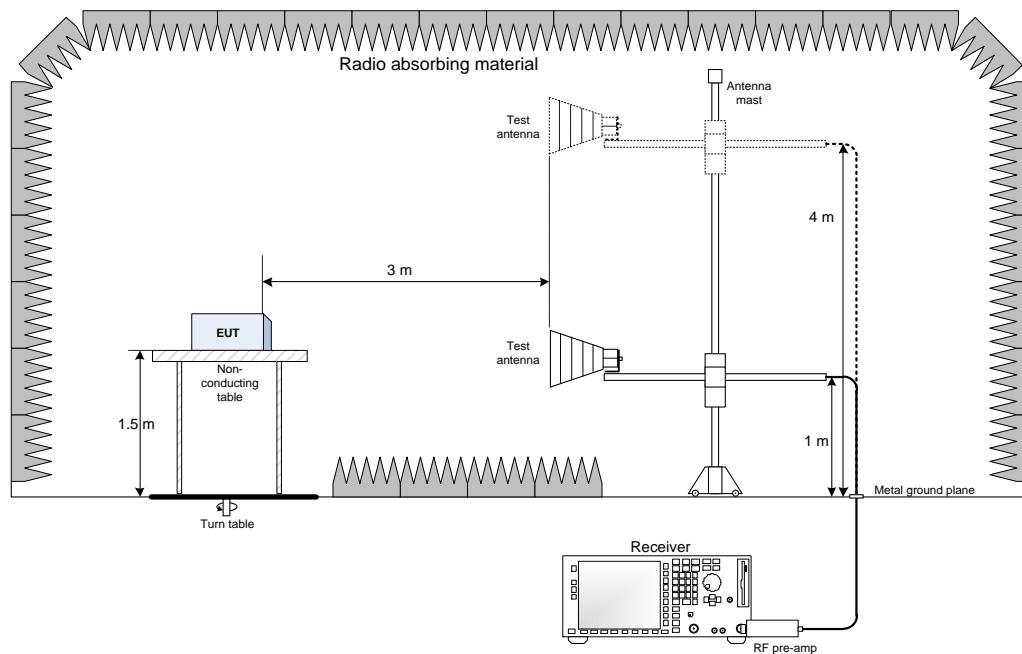
Figure 8.8-3: PSD plot on High channel

## Section 9. Block diagrams of test set-ups

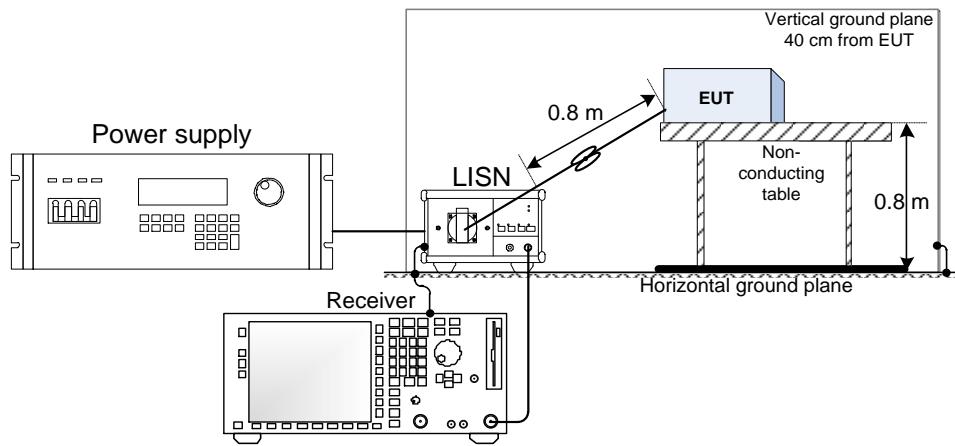
### 9.1 Radiated emissions set-up for frequencies below 1 GHz



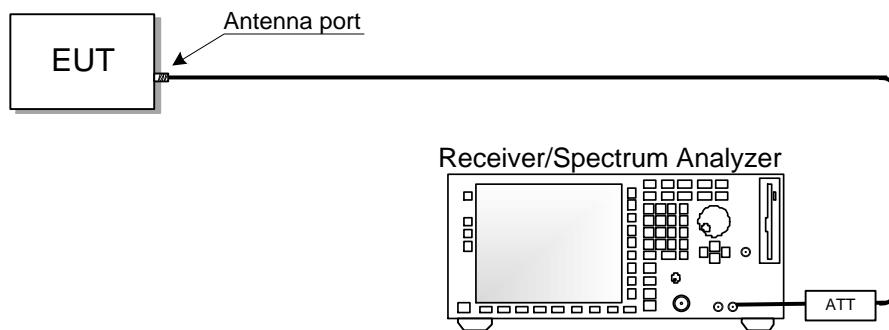
### 9.2 Radiated emissions set-up for frequencies above 1 GHz



## 9.3 Conducted emissions set-up



## 9.4 Antenna port set-up



(End of the report)