



ONE WORLD ◊ OUR APPROVAL

Test report

304245-1TRFWL

Date of issue: January 12, 2017

Applicant:

Conspec Controls Ltd.

Product:

Wireless Card

Model:

T1427

FCC ID:

2AKMET1427

IC Registration number:

22260-T1427

Specifications:

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

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

◆ **RSS-247, Issue 1, May 2015, Section 5**

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

www.nemko.com

Nemko Canada Inc., a testing laboratory, is
accredited by the Standards Council of
Canada. The tests included in this report
are within the scope of this accreditation

FCC 15.247 and RSS-247.docx; Date: July 2015



Test location

Company name	Nemko Canada Inc.
Address	303 River Road
City	Ottawa
Province	Ontario
Postal code	K1V 1H2
Country	Canada
Telephone	+1 613 737 9680
Facsimile	+1 613 737 9691
Toll free	+1 800 563 6336
Website	www.nemko.com
Site number	FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber)

Tested by	Kevin Rose, Wireless/EMC Specialist
Reviewed by	Andrey Adelberg, Senior Wireless/EMC Specialist
Review date	January 12, 2017
Reviewer signature	

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.

Copyright notification

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

© Nemko Canada Inc.

Table of contents

Table of contents	3
Section 1. Report summary	4
1.1 Applicant and manufacturer	4
1.2 Test specifications	4
1.3 Test methods	4
1.4 Statement of compliance	4
1.5 Exclusions	4
1.6 Test report revision history	4
Section 2. Summary of test results	5
2.1 FCC Part 15 Subpart C, general requirements test results	5
2.2 FCC Part 15 Subpart C, intentional radiators test results	5
2.3 IC RSS-GEN, Issue 4, test results	5
2.4 IC RSS-247, Issue 1, test results	6
Section 3. Equipment under test (EUT) details	7
3.1 Sample information	7
3.2 EUT information	7
3.3 Technical information	7
3.4 Product description and theory of operation	8
3.5 EUT exercise details	8
3.6 EUT setup diagram	9
Section 4. Engineering considerations	11
4.1 Modifications incorporated in the EUT	11
4.2 Technical judgment	11
4.3 Deviations from laboratory tests procedures	11
Section 5. Test conditions	12
5.1 Atmospheric conditions	12
5.2 Power supply range	12
Section 6. Measurement uncertainty	13
6.1 Uncertainty of measurement	13
Section 7. Test equipment	14
7.1 Test equipment list	14
Section 8. Testing data	15
8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits	15
8.2 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques	18
8.3 FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements	20
8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions	23
8.5 FCC 15.247(e) and RSS-247 5.2(2) Power spectral density for digitally modulated devices	29
Section 9. Block diagrams of test set-ups	31
9.1 Radiated emissions set-up for frequencies below 1 GHz	31
9.2 Radiated emissions set-up for frequencies above 1 GHz	32
9.3 Conducted emissions set-up	32

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Conspec Controls Ltd.
Address	25 Klondike Drive
City	Toronto
Province/State	ON
Postal/Zip code	M9L1S1
Country	Canada

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz
RSS-247, Issue 1, May 2015, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

ANSI C63.10 v2013 558074 D01 DTS Meas Guidance v03r05 (April 8, 2016)	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
---	---

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. 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

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass ¹
§15.203	Antenna requirement	Pass ^{2, 3}

Notes: ¹ Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

² The Antennas are located within the enclosure of EUT and not user accessible.

³ The second antenna is a whip with a reverse SMA connector.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation 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 for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

Notes: ¹ According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.4 IC RSS-247, Issue 1, test results

Part	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (1)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (2)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (3)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (4)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (5)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
5.2 (1)	Minimum 6 dB bandwidth	Pass
5.2 (2)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (1)	Digital modulation turned off	Not applicable
5.3 (2)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (4)	Systems employing digital modulation techniques	Pass
5.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	March 29, 2016
Nemko sample ID number	133-001698

3.2 EUT information

Product name	Wireless Card
Model	T1427
Model variant	Rev C
Serial number	N/A

3.3 Technical information

Applicant IC company number	22260
IC UPN number	Conspec Controls Ltd.
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-247 Issue 1, May 2015
Frequency band	902–928 MHz
Frequency Min (MHz)	903
Frequency Max (MHz)	927
RF power Min (W), Conducted	16.08 dBm (0.0406)
RF power Max (W), Conducted	16.60 dBm (0.0457)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	580
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	LoRa and FSK
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, Units @ distance	7.268 GHz, 30.09 dB μ V/m @ 3 m average
Power requirements	120 Vac 60 Hz Or 3.3 Vdc
Antenna information	The Solexy ANH53-CNRU has a gain of 3 dBi. (Highest gain) The EUT uses a unique antenna coupling

3.4 Product description and theory of operation

Product capabilities:

The wireless module uses a System on Chip (SoC) transceiver (transmitter and receiver) which is the core component of the system. The transceiver has a number of different capabilities including: frequency channel selection within the 900MHz ISM band, transmit output power variation up to +13dBm, excellent sensitivity and blocking immunity, and a digital processing engine. The transceiver is an easy to use SoC device with many built-in high level modem-like capabilities to manage data exchange between different wireless modules and low level network management.

Circuit Description:

The circuit's core component is the transceiver device. The transceiver requires a number of different passive components to ensure steady voltage regulation, filtering, and clean transmit power, etc. In addition, the circuit includes a RF switch before the antenna connector that allows switching between transmit and receive. The circuit does not include a printed PCB antenna on board, instead an external antenna is needed. The interface to the module is via a 20 pin through-hole connector. The connector can be plugged into host board via female header, or soldered directly to the board.

RF Specifications:

- 1) Controllable output power up to +13dBm (+1dBm) max at approximately 30mA (+3mA) current consumption
- 2) Low power receiver operation at approximately 10mA (+1mA)
- 3) Internal RSSI measurement capabilities with high dynamic range up to 125 dB (+2dB)
- 4) Sensitivity down to -145 dBm (+3dBm)
- 5) Programmable data-rate up to 300Kbps in addition to baseband digital coding
- 6) Programmable modulations: FSK, GFSK, MSK, GMSK, OOK
- 7) Operates in the standard 900MHz ISM band (North America)
- 8) Built in baseband digital processor and CRC generator
- 9) Absolute maximum ratings: +10 dBm RF input, supply voltage range: -0.5V to +3.9V, Operating Temperature: -40C to 85C

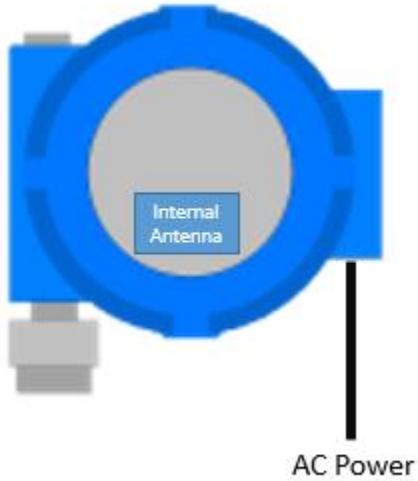
3.5 EUT exercise details

The radio test firmware continuously transmits data (as fixed-size packets) using a user-configurable modulation (FSK or LoRa) and a user-selectable transmission power (-1dBm to 14dBm) at a user-selectable frequency channel between 903MHz and 927MHz (with 1MHz spacing between channels). The firmware also gives the user the ability to setup the selected modulation parameters, such as bandwidth and datarate.

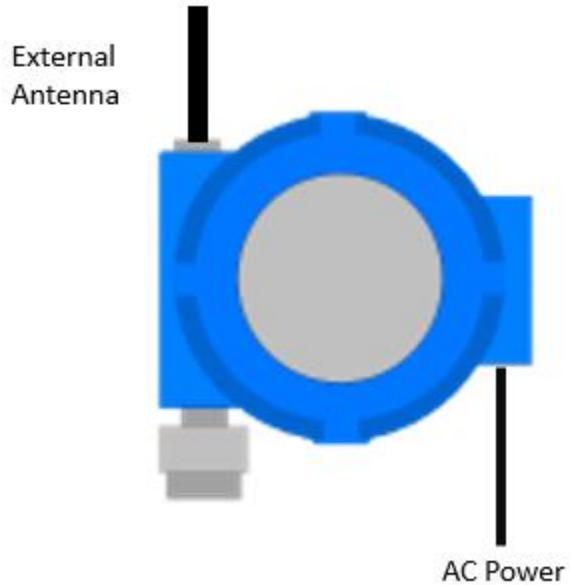
3.6 EUT setup diagram

The Module will be tested with two major setups:

1. Internal Antenna Fully Assembled: Using the internal antenna, the unit will be built and housed as it would be deployed in the field. The wireless Module will be placed inside the housing.



2. External Antenna Fully Assembled: The internal antenna is disconnected and instead an external antenna is connected. The module is still placed inside the housing.



3. External Antenna + External Wireless Module: In this application, the Wireless Module is removed from the housing and placed 10-15cm away from the housing. The Module will be tested on its own. Attached to the module will be the external antenna.

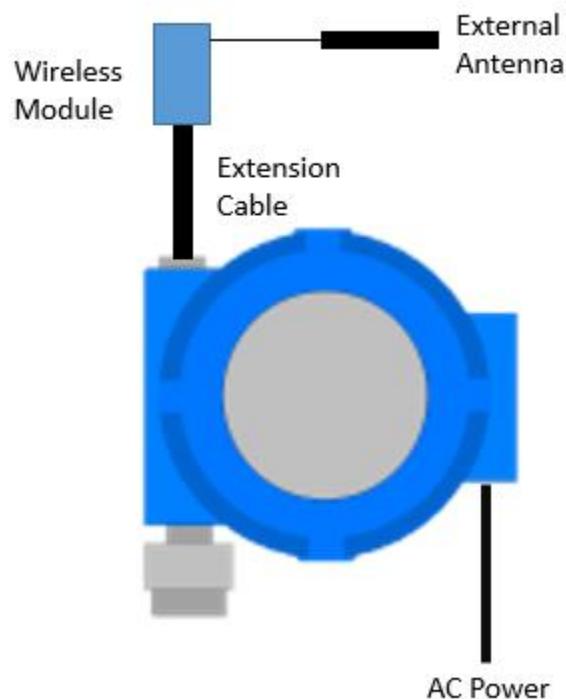


Figure 3.6-1: Setup diagram

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

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

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

6.1 Uncertainty of measurement

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

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	FA002047	1 year	Dec. 01/17
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	Apr. 26/17
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Apr. 28/17
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 07/17
Pre-amplifier (1–18 GHz)	JCA	JCA118-503	FA002091	1 year	April 26/17
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	Mar. 08/17

Note: None

Section 8. Testing data

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

8.1.1 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 μ H/50 Ω 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 8.1-1: Conducted emissions limit

Frequency of emission, MHz	Quasi-peak	Conducted limit, dB μ 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.

8.1.2 Test summary

Test date	March 30, 2016	Temperature	23 °C
Test engineer	Kevin Rose	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	43 %

8.1.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

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.

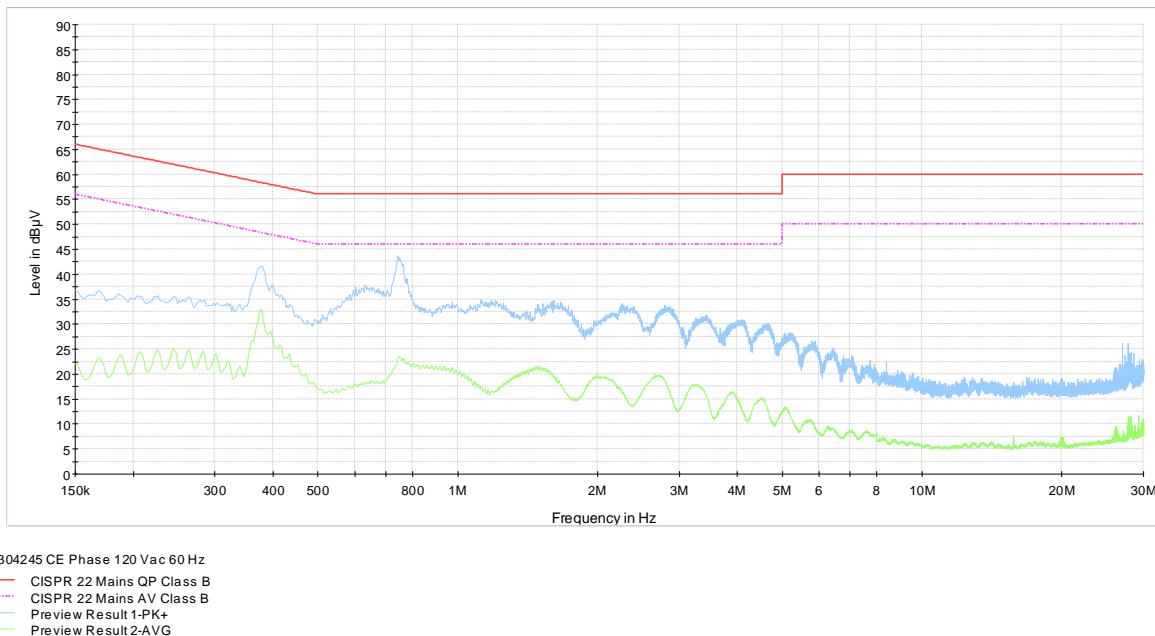
Receiver settings for preview measurements:

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

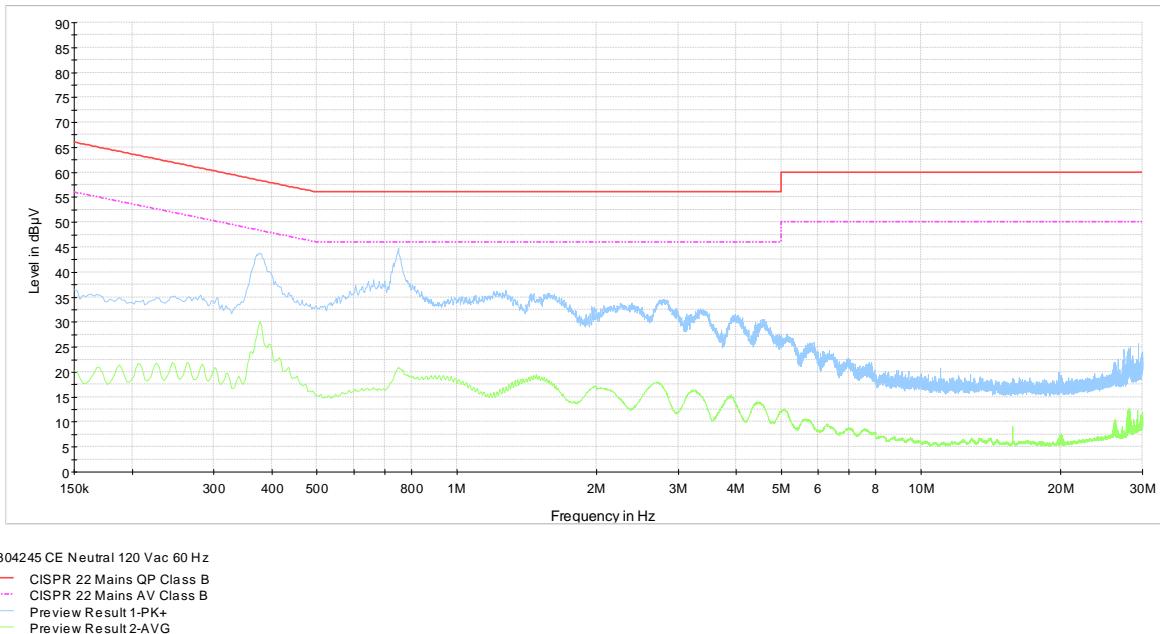
Receiver settings for final measurements:

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

8.1.4 Test data



Plot 8.1-1: Conducted emissions on phase line



Plot 8.1-2: Conducted emissions on neutral line

8.2 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.2.1 Definitions and limits

FCC and IC:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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.

8.2.2 Test summary

Test date	January 12, 2017	Temperature	22 °C
Test engineer	Kevin Rose	Air pressure	1006 mbar
Verdict	Pass	Relative humidity	35 %

8.2.3 Observations, settings and special notes

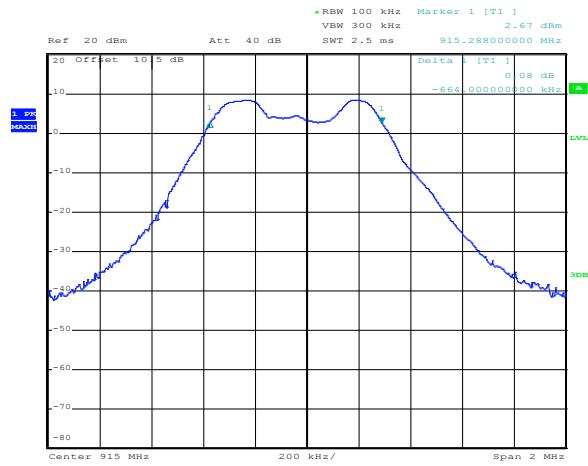
Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

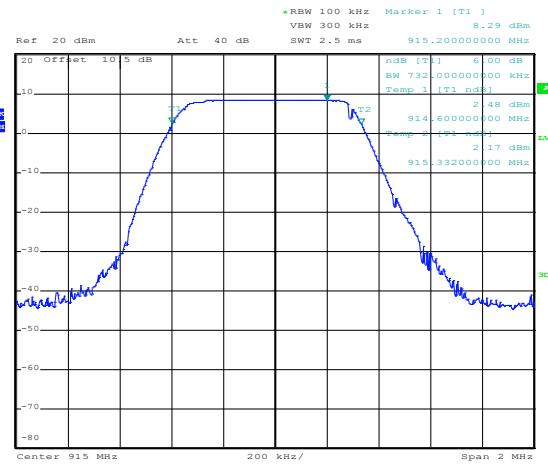
Table 8.2-1: 6 dB bandwidth results

Modulation	Frequency, MHz	6 dB bandwidth, kHz	Limit, MHz	Margin, kHz
LoRa	903	736.0	0.50	236
	921	732.0	0.50	232
	928	724.0	0.50	224
FSK	903	672.0	0.50	172
	921	664.0	0.50	164
	928	660.0	0.50	160



Date: 12.JAN.2017 10:32:12

Figure 8.2-1: 6 dB bandwidth on FSK, sample plot



Date: 12.JAN.2017 10:33:17

Figure 8.2-2: 6 dB bandwidth on LoRa, sample plot

8.3 FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements

8.3.1 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 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 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.
 - (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 peak 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.

Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(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 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.

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

- (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 $10 \log (\text{number of array elements or staves})$ plus the directional gain of the element or stave having the highest gain.

IC:

For DTSS employing digital modulation techniques operating in the bands 902–928 MHz and 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W.

Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz 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.

8.3.2 Test summary

Test date	March 30, 2016	Temperature	23 °C
Test engineer	Kevin Rose	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	43 %

8.3.3 Observations, settings and special notes

Spectrum analyser settings for output power:

Resolution bandwidth	3 MHz
Video bandwidth	≥ RBW
Frequency span	10 MHz
Detector mode	Peak
Trace mode	Max Hold

8.3.4 Test data

Table 8.3-1: LoRa Modulation Output power and EIRP results

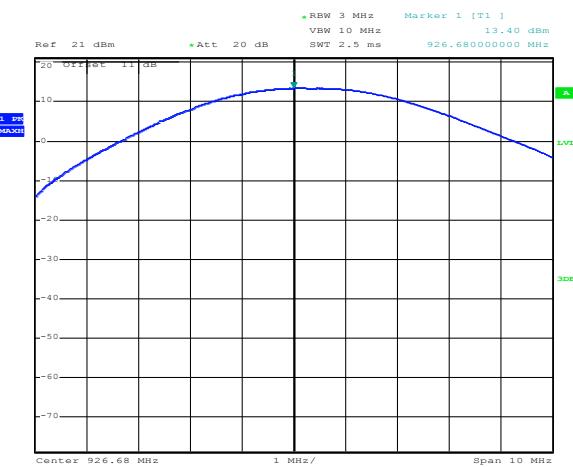
Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
903	13.89	30	16.11	3.0	16.89	36	19.11
921	13.52	30	16.48	3.0	16.52	36	19.48
927	13.43	30	16.57	3.0	16.43	36	19.57

EIRP = Output power + Antenna gain

Table 8.3-2: FSK Modulation Output power and EIRP results

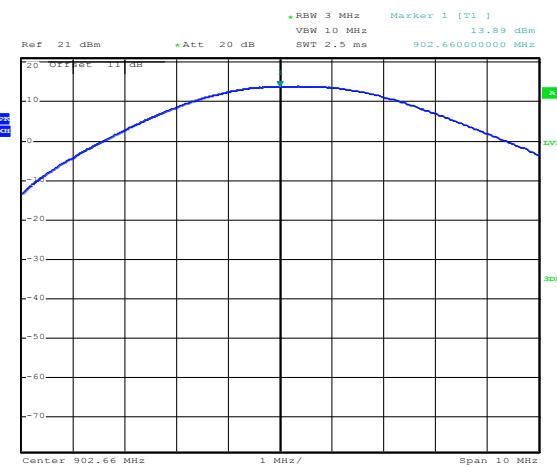
Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
903	13.92	30	16.08	3.0	16.92	36	19.08
921	13.55	30	16.45	3.0	16.55	36	19.45
927	13.40	30	16.6	30.	16.40	36	19.60

EIRP = Output power + Antenna gain



Date: 30.MAR.2016 12:10:54

Figure 8.3-1: Output power FSK Sample plot



Date: 30.MAR.2016 12:12:03

Figure 8.3-2: Output power LoRa sample plot

8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.4.1 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)).

IC:

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(4), 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 8.4-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	67.6 – 20 × log ₁₀ (F)	300
0.490–1.705	24000/F	87.6 – 20 × log ₁₀ (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 8.4-2: IC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677–5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: 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			

8.4.2 Test summary

Test date	January 12, 2017	Temperature	22 °C
Test engineer	Kevin Rose	Air pressure	1004 mbar
Verdict	Pass	Relative humidity	34 %

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.
Since fundamental power was tested using Peak method, the spurious emissions limit is –20 dBc/100 kHz
No radiated emission were detected within 20 dB below the limit

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

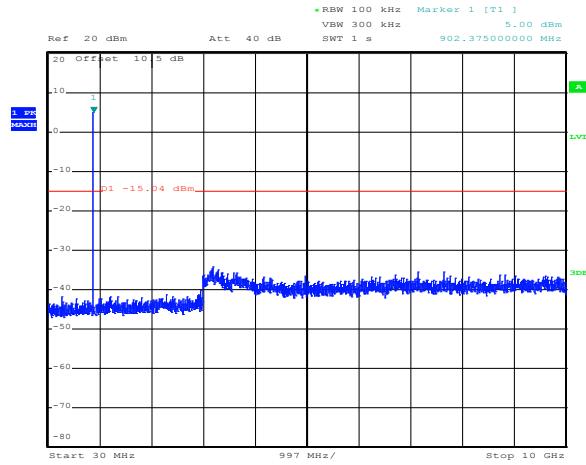
Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

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

Spectrum analyser settings for conducted spurious emissions measurements:

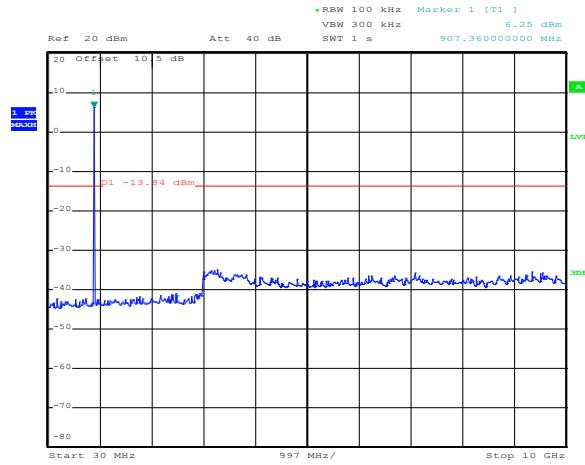
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.4.4 Test data



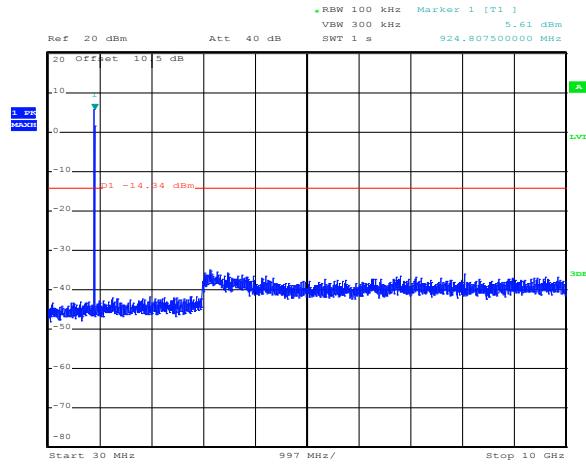
Date: 12.JAN.2017 10:41:25

Figure 8.4-1: Conducted spurious emissions for FSK low channel



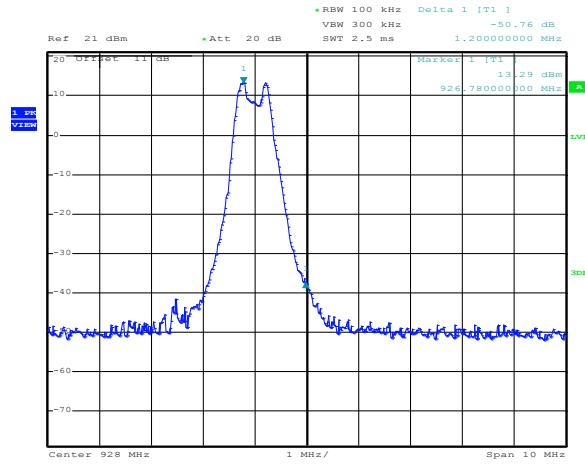
Date: 12.JAN.2017 10:39:42

Figure 8.4-2: Conducted spurious emissions for FSK mid channel



Date: 12.JAN.2017 10:41:58

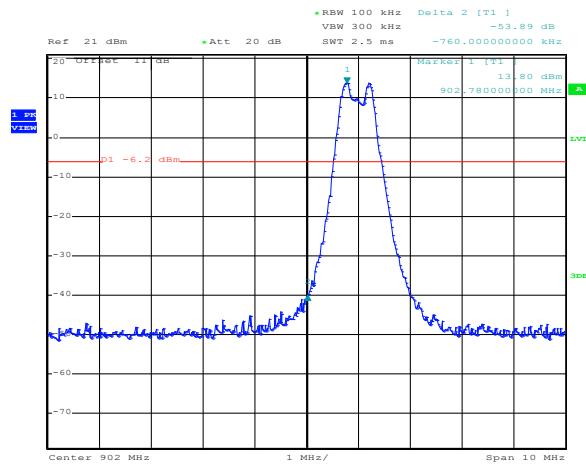
Figure 8.4-3: Conducted spurious emissions for FSK high channel



Date: 30.MAR.2016 19:02:01

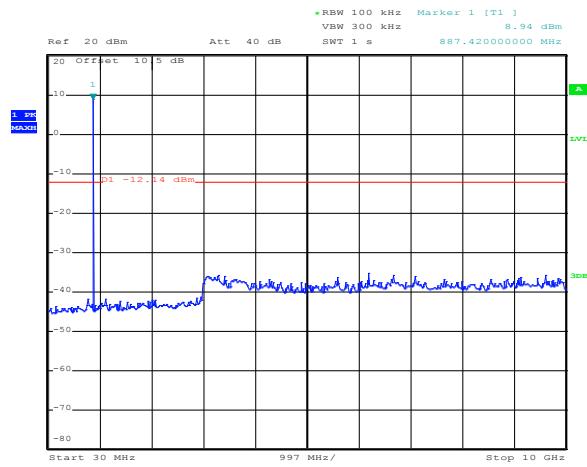
Figure 8.4-4: Conducted spurious emissions for FSK upper band edge

8.4.4 Test data continued



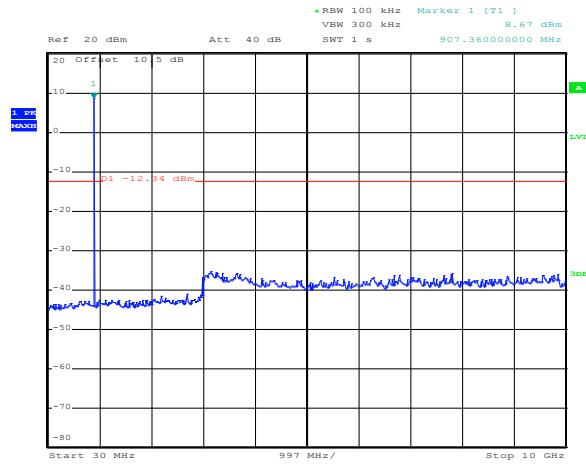
Date: 30.MAR.2016 19:10:42

Figure 8.4-5: Conducted spurious emissions for FSK lower band edge



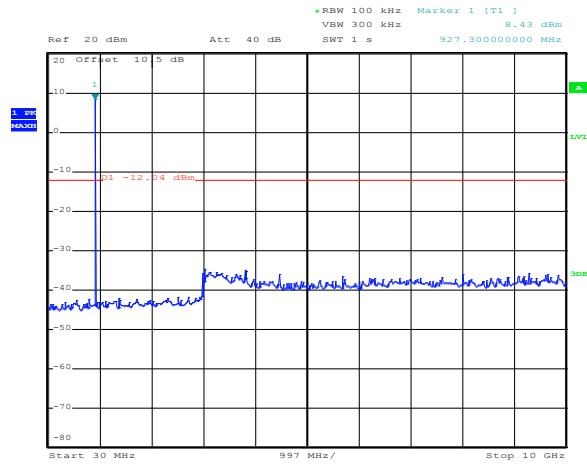
Date: 12.JAN.2017 10:37:36

Figure 8.4-6: Conducted spurious emissions for LoRa low channel



Date: 12.JAN.2017 10:38:22

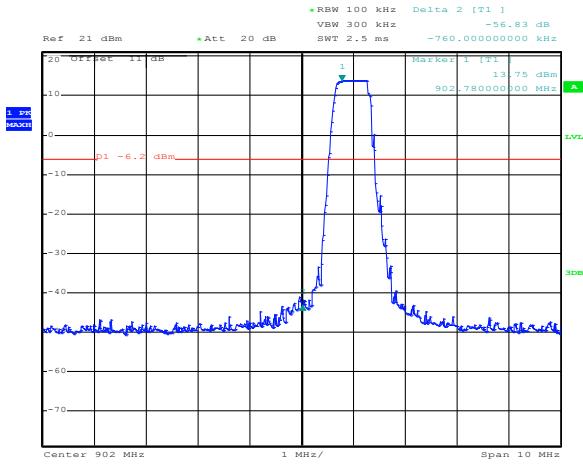
Figure 8.4-7: Conducted spurious emissions for LoRa mid channel



Date: 12.JAN.2017 10:37:04

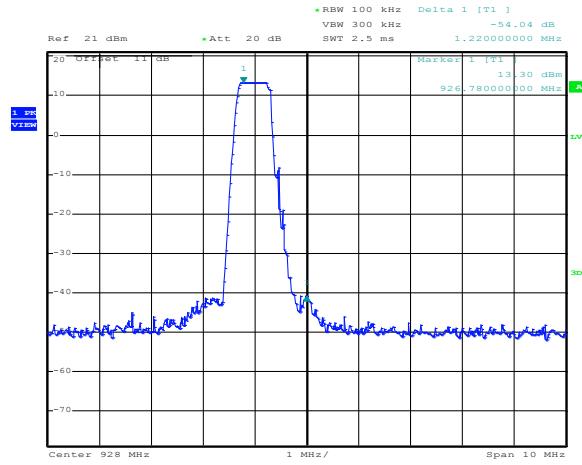
Figure 8.4-8: Conducted spurious emissions for LoRa high channel

8.4.1 Test data continued



Date: 30.MAR.2016 19:11:14

Figure 8.4-9: Conducted spurious emissions for LoRa lower band edge



Date: 30.MAR.2016 19:04:05

Figure 8.4-10: Conducted spurious emissions for LoRa upper band edge

8.5 FCC 15.247(e) and RSS-247 5.2(2) Power spectral density for digitally modulated devices

8.5.1 Definitions and limits

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.

IC:

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(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.5.2 Test summary

Test date	March 30, 2016	Temperature	23 °C
Test engineer	Kevin Rose	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	36 %

8.5.3 Observations, settings and special notes

The test was performed using method described in section 10.2 Method PKPSD (peak PSD)). Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Frequency span:	2 MHz
Detector mode:	Peak
Trace mode:	Max hold
Averaging sweeps number:	100

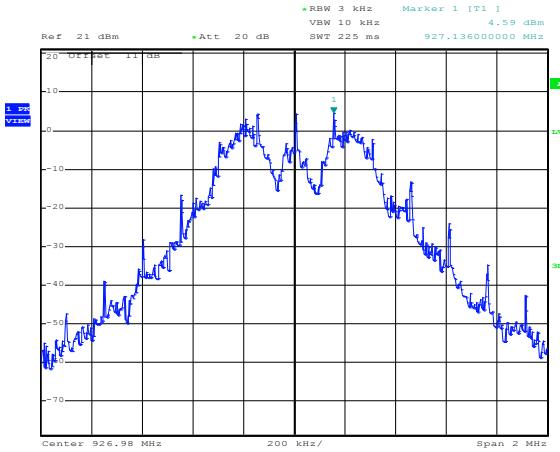
8.5.4 Test data

Table 8.5-1: PSD measurements results FSK

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
903	5.42	8.00	2.58
2437	5.18	8.00	2.82
927	4.59	8.00	3.41

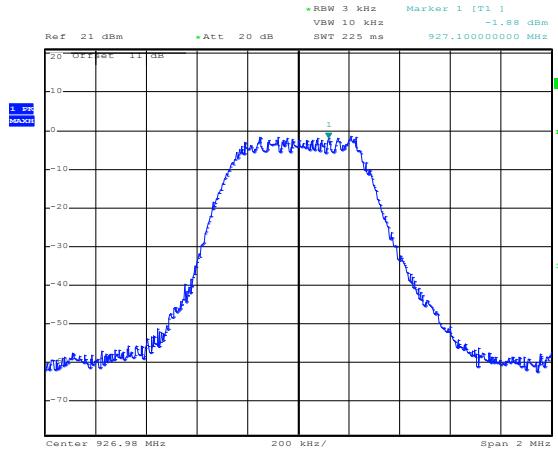
Table 8.5-2: PSD measurements results LoRa

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
903	-1.17	8.00	9.17
2437	-1.63	8.00	9.63
2462	-1.88	8.00	9.88



Date: 30.MAR.2016 12:15:35

Figure 8.5-1: PSD sample plot on FSK

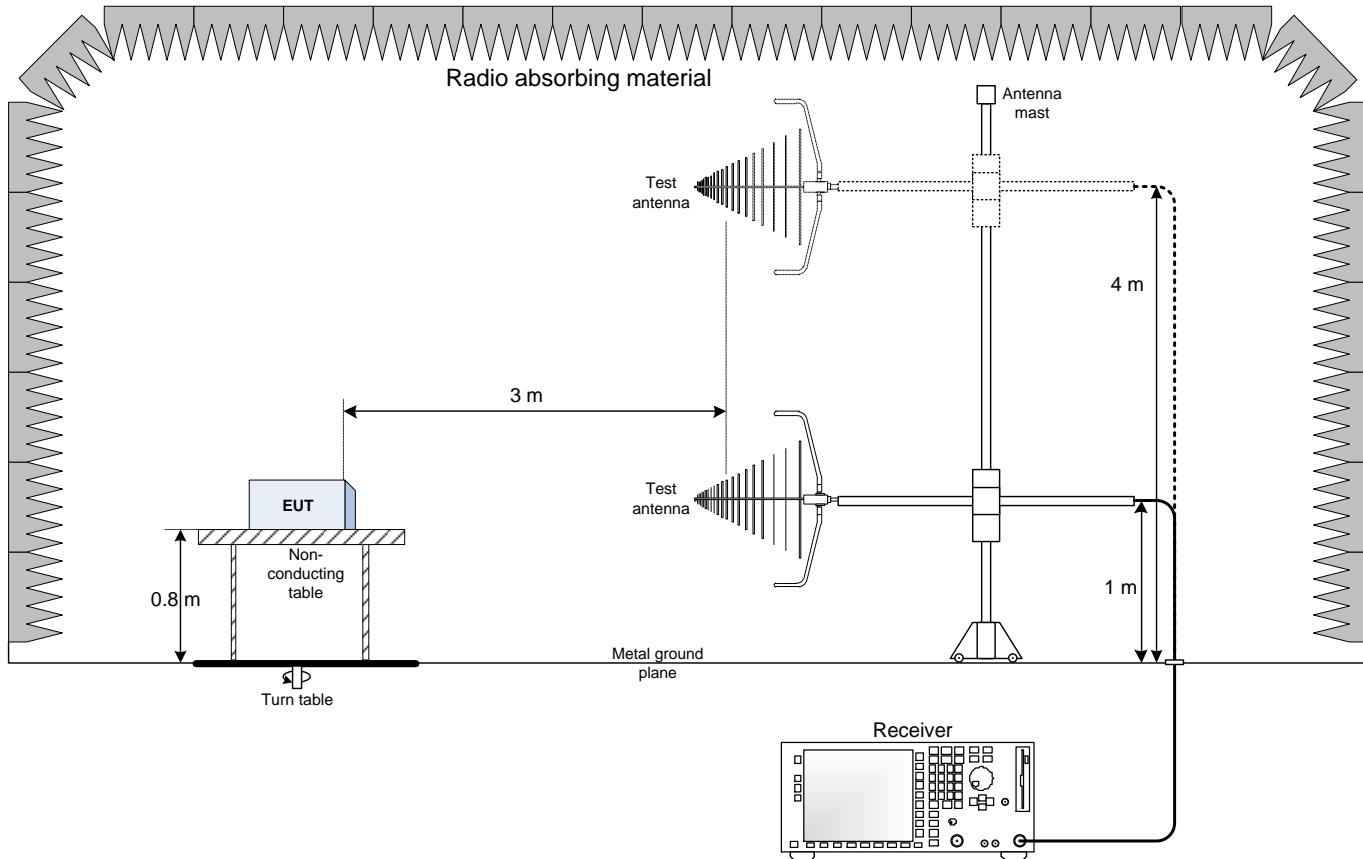


Date: 30.MAR.2016 12:15:02

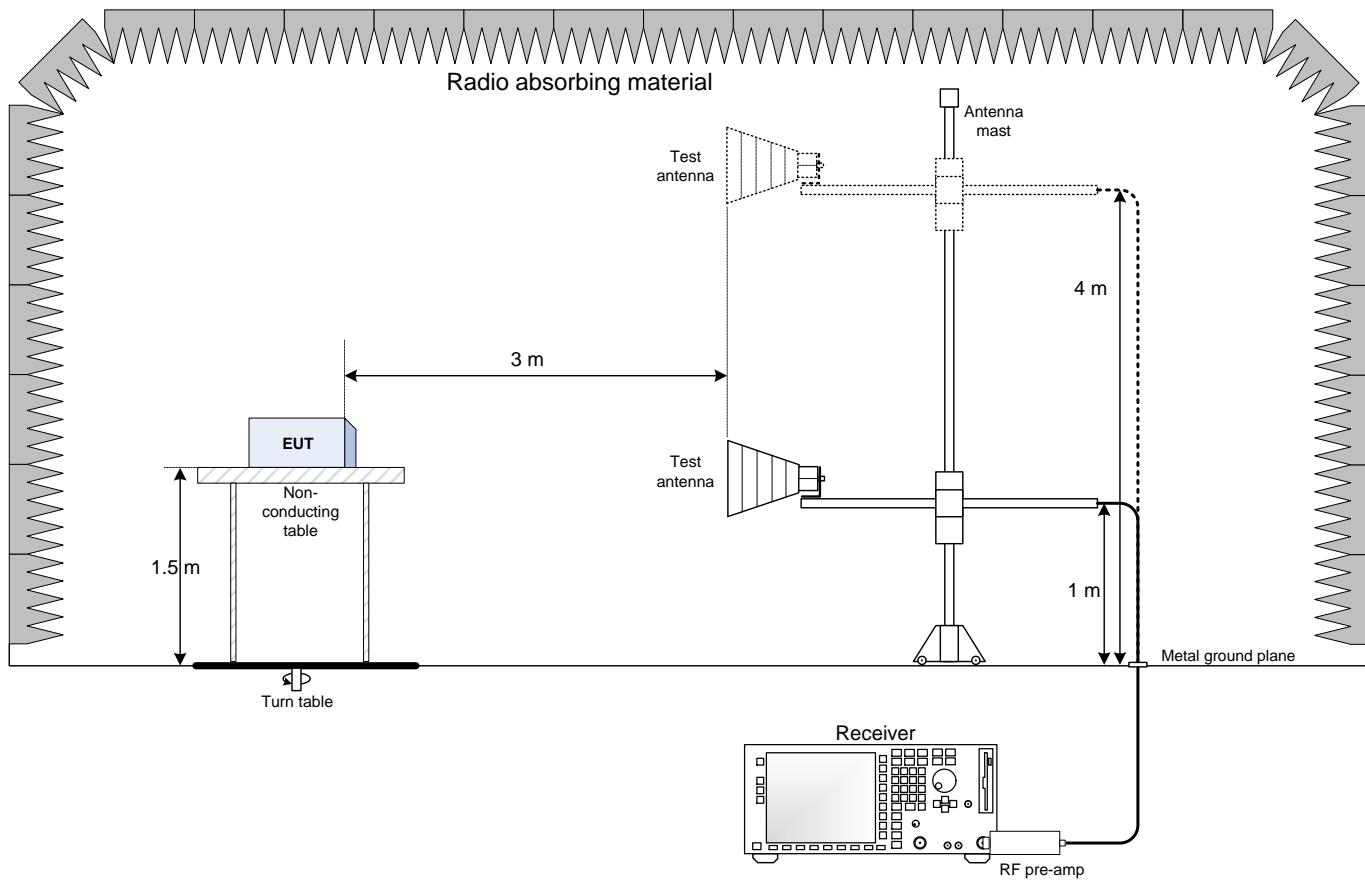
Figure 8.5-2: PSD sample plot on LoRa

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

