a

Wireless test report – 381043-1TRFWL

Type of assessment:

C2PC

Applicant:

Alert Labs Inc.

Product type:

Alert Labs Sub 1 GHz Radio Module

Model:	FCC ID:	IC Registration number:
ALML001	2AKXF-ALB040	22365-ALB040

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: February 13, 2020

Kevin Rose, Wireless/EMC Specialist

Tested by

Signature

David Duchesne, Senior EMC/Wireless Specialist

Reviewed by

Signature

Test location(s)

Company name	Nemko Canada Inc.		
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Address	303 River Road	292 Labrosse Avenue	130 Saltsman Drive, Unit #1
City	Ottawa	Pointe-Claire	Cambridge
Province	Ontario	Quebec	Ontario
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Country	Canada	Canada	Canada
Telephone	+1 613 737 9680	+1 514 694 2684	Tel: +1 519 680 4811
Facsimile	+1 613 737 9691	+1 514 694 3528	
Toll free	+1 800 563 6336		
Website	www.nemko.com	www.nemko.com	www.nemko.com
Site number (3 m SAC)	FCC: CA2040; IC: 2040A-4	FCC: CA2041; IC: 2040G-5	FCC/IC: CA0101

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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Alert Labs Inc.
Address	132 Queen Street South, Unit #2, Kitchener, ON, Canada, N2G 1V9

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 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

1.3 Test methods

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5 Amendment 1, March 2019	General Requirements for Compliance of Radio Apparatus

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against 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

None

1.6 Test report revision history

Table 1.6-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	February 13, 2020	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

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: [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.

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

Table 2.2-1: *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

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

Table 2.3-1: *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 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
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

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[1]
7.4	Receiver conducted emission limits	Not applicable[1]
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Pass

Notes: [1] 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 an AC powered device. Sensor relay

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	September 9, 2019
Nemko sample ID number	1 (903 MHz) 2 (915 MHz) 3 (927.5 MHz)-Flowie-O 4 (903 MHz) 5 (915 MHz) 6 (927.5 MHz) Sensor relay

3.2 EUT information

Product type	Alert Labs Sub 1 GHz radio module
Model	ALML001
Configuration	ALF-000044 (Flowie-O) ALF-000045 (Sensor relay)
Configuration variant	ALF-000046 (Sensor relay)
Serial number	Pre-Production

3.3 Technical information

Applicant IC company number	22365
IC UPN number	ALB040
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	902-928 MHz
Frequency Min (MHz)	903
Frequency Max (MHz)	927.5
RF power Max (W), Conducted	0.069 W (18.40 dBm) Flowie-O 0.068 W (18.35 dBm) Sensor relay
Field strength, dBµV/m @ 3 m	N/A
Measured BW (kHz), 99% OBW	612.6 kHz (Flowie-O) 575.63 kHz (Sensor relay)
Type of modulation	Chirp Spread spectrum
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, dBµV/m @ 3 m	48.80 dBµV/m at 8347.00 MHz – Flowie-O 49.70 dBµV/m at 1805.38 MHz - Sensor relay
Power requirements	3 V_{DC} from 2 D-cell alkaline – Flowie-O 5 V_{DC} (via external 100–240 V_{AC}, 50/60 Hz power adapter)- Sensor Relay
Antenna information	Printed helical PCB antenna, gain 0.01 dBi

3.4 Product description and theory of operation

Module consists of two units
1)Flowie-O Controller
2)Sensor relay
Flowie-O is intended to be attached to a residential or commercial water meter. Flowie-O's main purpose is to measure the same water flow as the water meter. Flowie-O also contains an accelerometer/gyroscope used to detect its position and to detect sudden orientation changes. Flowie-O sends its data to an Alert Labs Sensor Relay via a point-to-point radio link, and the Sensor Relay then sends the data up to a secure sever via a cellular radio link.

Alert Labs Sensor Relay acts as cloud connected hub for the Alert Labs Flowie-O Water Flow Sensor

3.5 EUT exercise details

Flowie-O:
Insert the D-cell batteries with the polarity marks embossed Flowie-O's enclosure into the battery compartment. Press the top enclosure into place until the latches on either side of the product click into place. Flowie-O's LED glows and after 30 seconds, FLowie-O is ready for test
Sensor relay:
Ensure one end of the power cable is plugged in to Sensor Relay and the other end is plugged in to the 10W power supply. Plug the power supply in to the AC mains outlet. After 30 seconds the LED will glow and Sensor Relay is ready to test.

3.6 EUT setup diagram

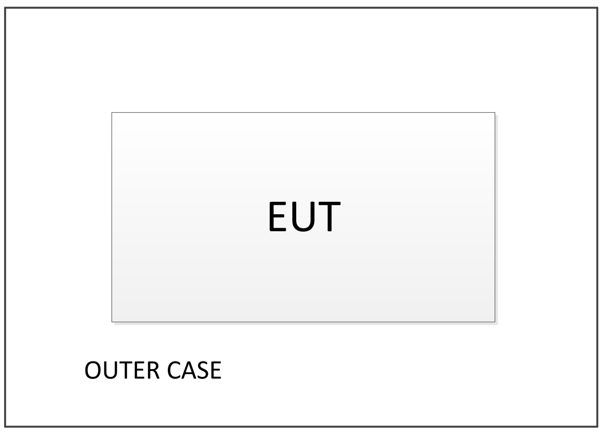


Figure 3.6-1: *Setup diagram-Flowie-o*

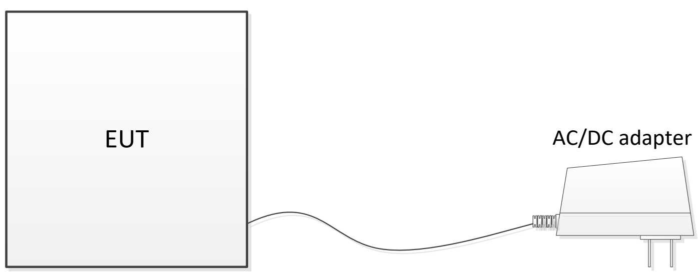


Figure 3.6-2: *Setup diagram- Sensor relay*

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 ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

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

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	FA003012	1 year	November. 12/19
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	June 4/20
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	June 21/20
Horn antenna (1–18 GHz)	Electro-Metrics	3115	FA000649	1 year	Nov. 28/ 19
Preamp (1–18 GHz)	ETS-Lindgren	124334	FA002956	1 year	Sept 18/19
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	Nov. 6/19
Radiated Emissions cable set	Huber + Suhner Inc	-	FA003047	---	NCR
Radiated Emissions cable set	Huber + Suhner Inc	-	FA003044	---	NCR

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

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 µH/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.

ANSI: C63.10 subclause 6.2
If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is
operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.
For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

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	Conducted limit, dBµV	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Note: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.1.2 Test date

Start date	September 20, 2019

8.1.3 Observations, settings and special notes

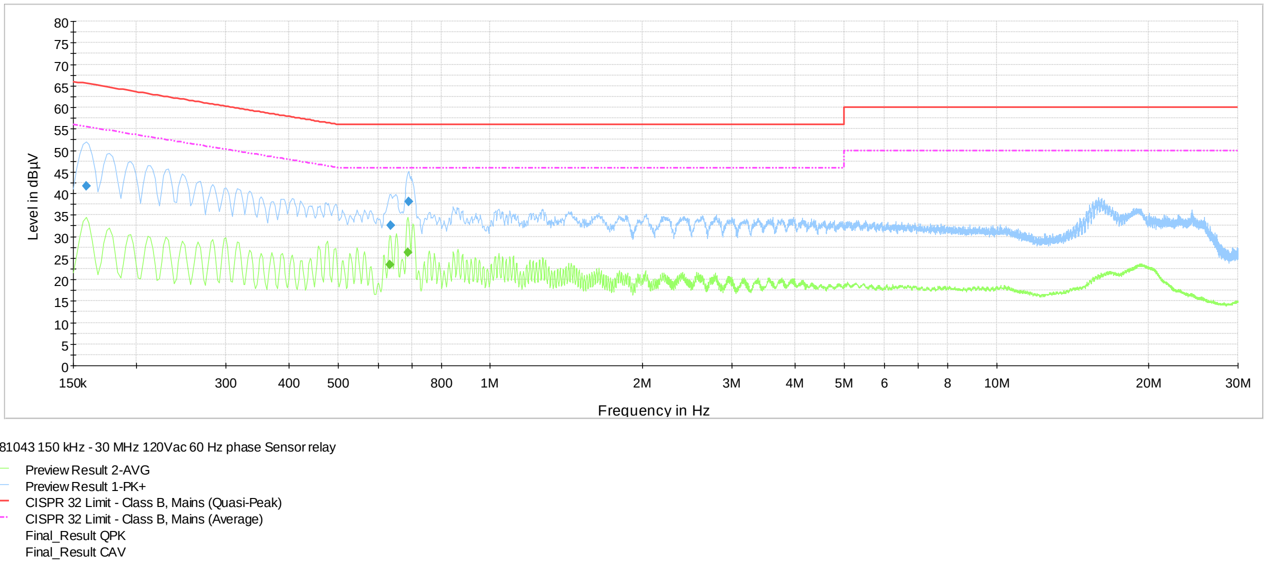
- The spectral plots within this section have been corrected with applicable transducer factors.
- Where tabular data has not been provided, no emissions were observed within 10 dB of the specified limit when measured with the appropriate detector. Additionally; where less than 6 measurements per detector has been provided, fewer than 6 emissions were observed within 10 dB of the specified limit when measured with the appropriate detector.

Port under test – Coupling device	AC input – Artificial Mains Network (AMN)
EUT power input during test	120 V_{AC}, 60 Hz
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview), Quasi-peak and CAverage (Final)
Trace mode	Max Hold
Measurement time	100 ms (Preview), 160 ms (Final)

8.1.4 Test data



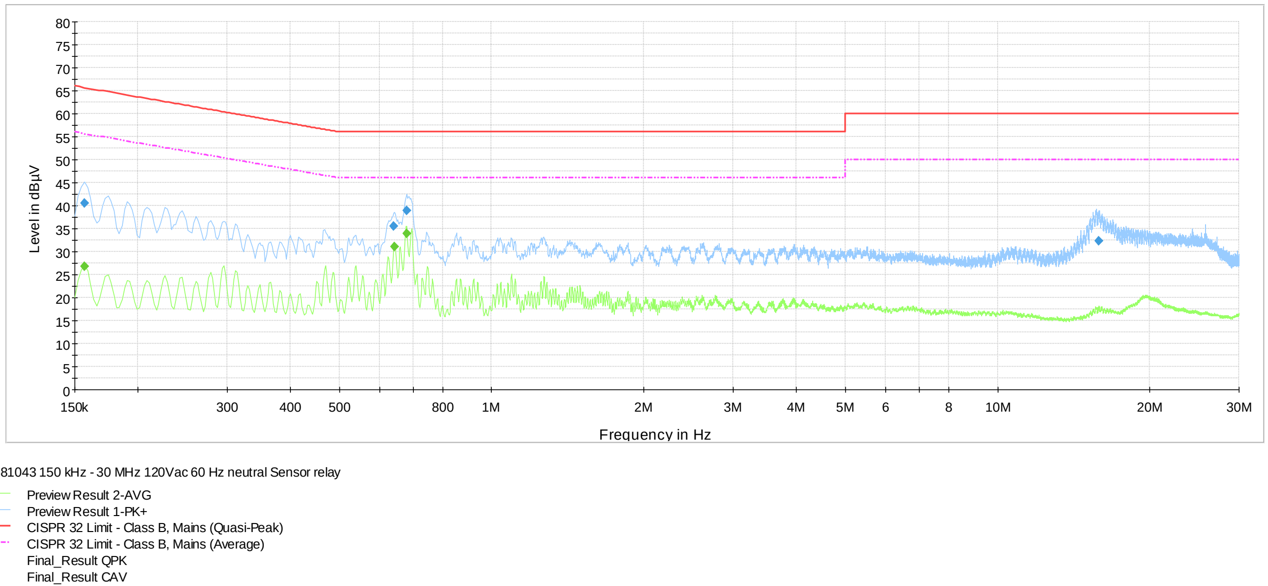
Plot 8.1-1: *Conducted emissions on phase line*

Table 8.1-2: *Results on phase line*

Frequency, MHz	Q-Peak result, dBµV	Limit, dBµV	Margin, dB	Correction, dB
0.16	41.8	65.5	23.8	15.4
0.64	32.6	56.0	23.4	15.5
0.69	38.2	56.0	17.8	15.5
Frequency, MHz	**Average result, dBµV**	**Limit, dBµV**	**Margin, dB**	**Correction, dB**
0.63	23.5	46.0	22.5	15.5
0.69	26.2	46.0	19.8	15.5

Note: 41.8 dBµV = 26.4 dBµV (receiver reading) + 15.4 dB (correction factor)

8.1.4 Test data, continued



Plot 8.1-2: *Conducted emissions on neutral line*

Table 8.1-3: *Results on neutral line*

Frequency, MHz	Q-Peak result, dBµV	Limit, dBµV	Margin, dB	Correction, dB
0.16	40.6	65.6	25.0	15.4
0.64	35.6	56.0	20.4	15.5
0.68	38.9	56.0	17.1	15.5
15.85	32.3	60.0	27.7	15.8
Frequency, MHz	**Average result, dBµV**	**Limit, dBµV**	**Margin, dB**	**Correction, dB**
0.16	26.8	55.6	28.9	15.4
0.64	31.1	46.0	14.9	15.5
0.68	34.0	46.0	12.0	15.5

Note: 40.6 dBµV = 25.2 dBµV (receiver reading) + 15.4 (correction factor)

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

8.2.1 Definitions and limits

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.

8.2.2 Test date

Start date	February 12, 2020

8.2.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.

DTS bandwidth Spectrum analyzer settings

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	1.5 × OBW
Detector mode	Peak
Trace mode	Max Hold

99% occupied bandwidth Spectrum analyzer settings

Resolution bandwidth	10 kHz
Video bandwidth	≥3 × RBW
Frequency span	≥1.5 × OBW
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: *99% occupied bandwidth results Senor relay*

Frequency, MHz	99% occupied bandwidth, kHz
903.0	532.55
915.0	575.63
927.5	515.72

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.2-2: *6dB bandwidth results Sensor relay*

Frequency, MHz	6dB bandwidth, kHz	Limit, kHz	Margin, kHz
903.0	629.07	500.00	129.07
915.0	690.66	500.00	190.66
927.5	759.05	500.00	259.05

Table 8.2-3: *99% occupied bandwidth results Flowie*

Frequency, MHz	99% occupied bandwidth, kHz
903.0	580.83
915.0	611.33
927.5	612.62

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.2-4: *6dB bandwidth results Flowie*

Frequency, MHz	6dB bandwidth, kHz	Limit, kHz	Margin, kHz
903.0	736.25	500.00	236.25
915.0	756.25	500.00	256.25
927.5	749.05	500.00	249.05

8.2.4 Test data, continued

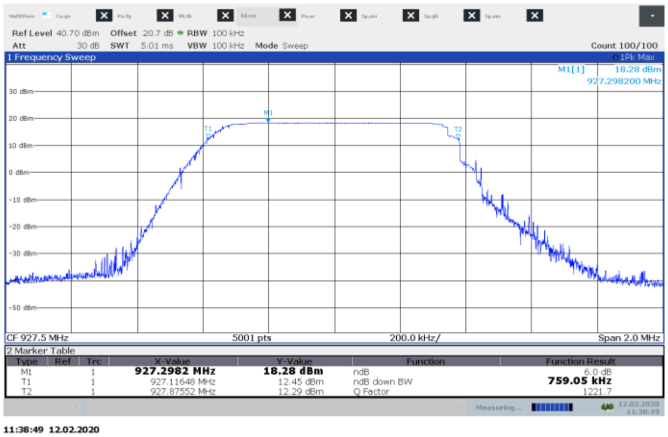


Figure 8.2-1: *6 dB bandwidth sensor – sample plot*

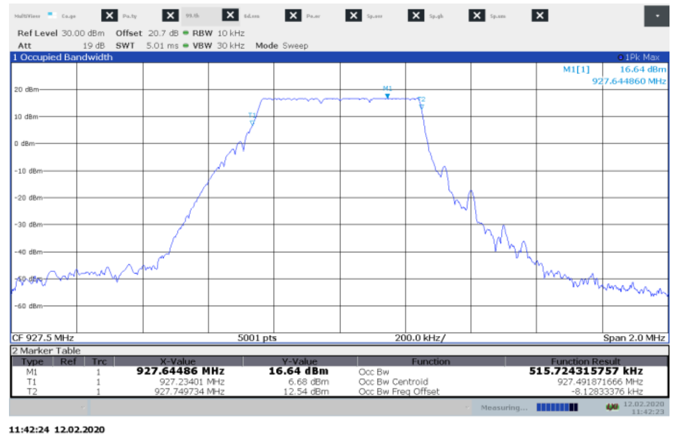


Figure 8.2-2: *99% Occupied bandwidth sensor – sample plot*

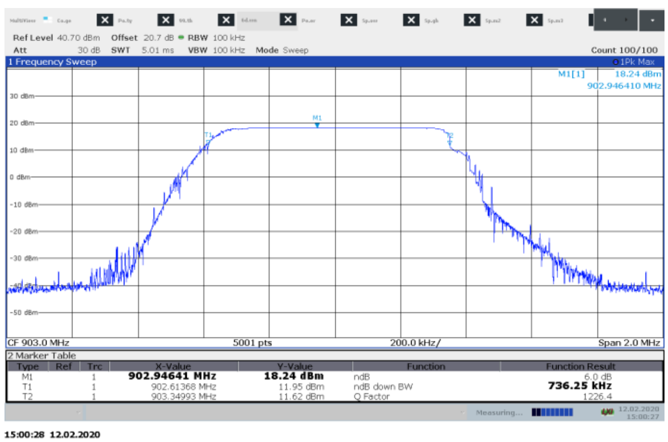


Figure 8.2-3: *6 dB bandwidth Flowie – sample plot*

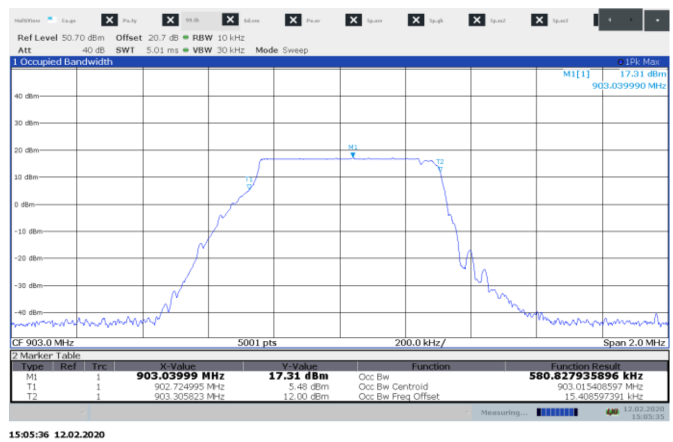


Figure 8.2-4: *99% Occupied bandwidth Flowie – sample plot*

8.3 FCC 15.247(b) and RSS-247 5.4(d) Transmitter output power and e.i.r.p. requirements for DTS in 900 MHz

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 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:

(iii) 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.

ISED:

d. For DTSs employing digital modulation techniques operating in the 902–928 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.

8.3.2 Test date

Start date	September 10, 2019

8.3.3 Observations, settings and special notes

The test was performed as per KDB 558074. With reference to ANSI C63.10 subclause 11.9.

– The test was performed using method AVGSA-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction).

Spectrum analyser settings:

Resolution bandwidth	3 MHz
Video bandwidth	≥3 × RBW
Frequency span	20 MHz
Detector mode	Peak
Trace mode	Maxhold

8.3.4 Test data

Table 8.3-1: *Output power measurements results for Flowie-o*

Frequency, MHz	Conducted output power, dBm			Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	DCCF	Limit					
903.0	16.94	1.46	30.00	11.60	0.01	18.41	36.00	17.59
915.0	16.79	1.46	30.00	11.75	0.01	18.26	36.00	17.74
927.5	16.65	1.46	30.00	11.89	0.01	18.12	36.00	17.88

Note: DCCF and measured = output power

Table 8.3-2: *DCCF measurements results for Flowie-o*

Pulses	On time of pulses, ms	Total on time, ms	DCCF	1/DCCF	DCCF, dB
7	102.9531	1000	0.720672	-0.14226	1.42

Duty cycle calculation: $10 \times \log_{10} (Tx_{on}/ Tx_{off}) = 10 \times \log_{10} (7 \times 102.95$ µs / 10 sec) = 1.46 dB

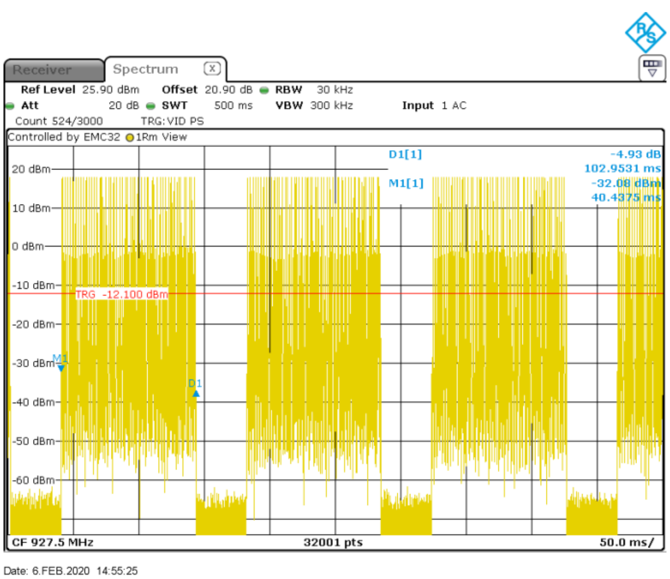


Figure 8.3-1: *Duty cycle correction 1*

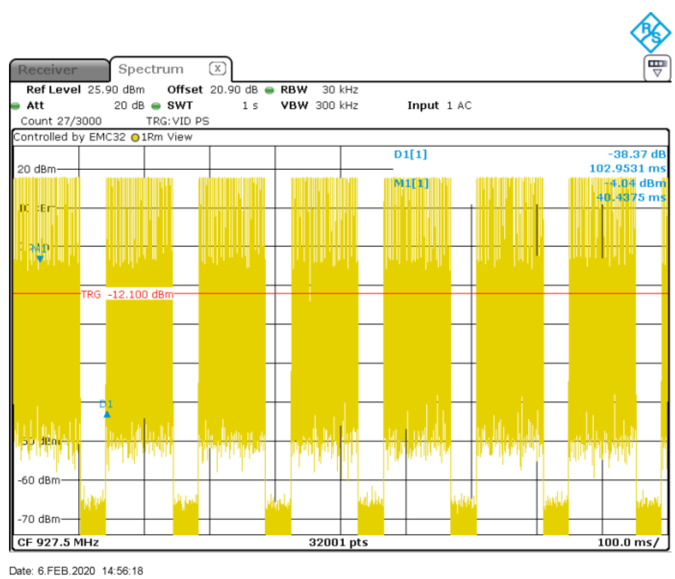


Figure 8.3-2: *Duty cycle correction 2*

8.3.4 Test data, continued

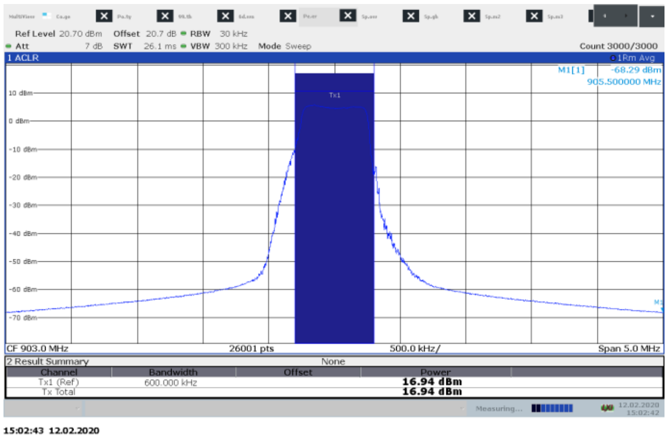


Figure 8.3-3: Output power on low channel

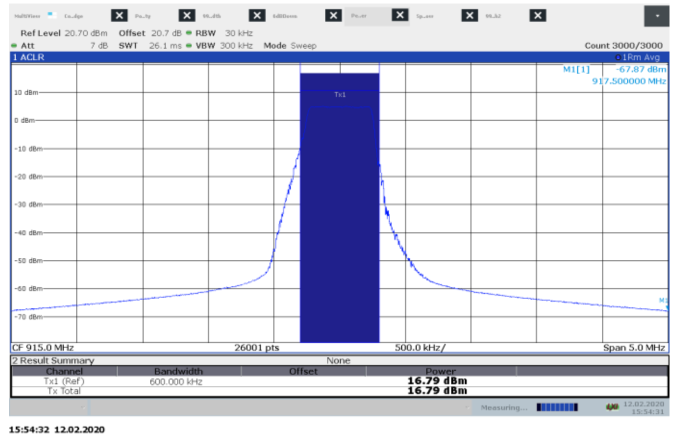


Figure 8.3-4: Output power on mid channel

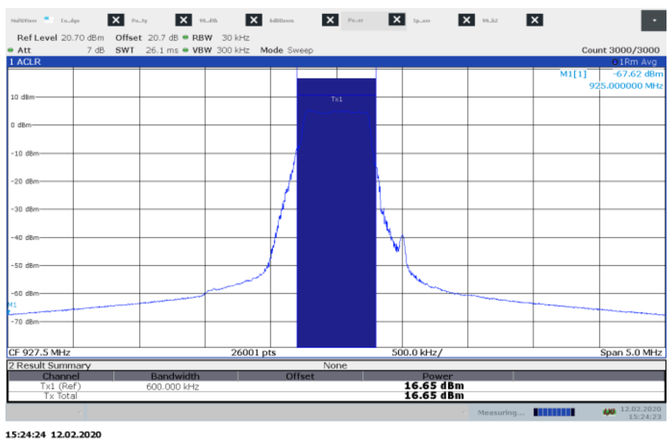


Figure 8.3-5: Output power on high channel

8.3.4 Test data, continued

Table 8.3-3: *Output power measurements results for Sensor relay*

Frequency, MHz	Conducted output power, dBm			Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	DCCF	Limit					
903.0	10.17	7.83	30.00	12.00	0.01	18.01	36.00	17.99
915.0	10.52	7.83	30.00	11.65	0.01	18.36	36.00	17.64
927.5	10.10	7.83	30.00	12.07	0.01	17.94	36.00	18.06

Note: DCCF and measured = output power

Table 8.3-4: *DCCF measurements results for Flowie-o*

Pulses	On time of pulses, ms	Total on time, ms	DCCF	1/DCCF	DCCF, dB
10	164.5	10000	0.1645	-0.7838	7.84

Duty cycle calculation: 10 × $\log_{10}$ (Tx_{on}/ Tx_{off}) = 10 × $\log_{10}$ (10 × 164.5 µs / 10 sec) = 7.84 dB

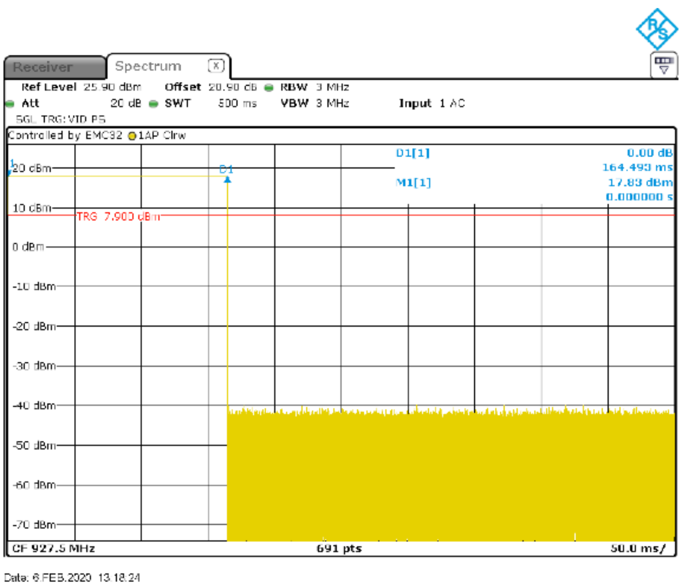
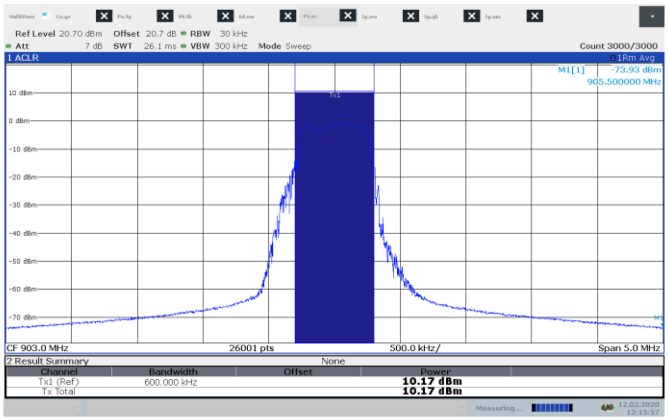


Figure 8.3-6: *Duty cycle plot 1*

Figure 8.3-7: *Duty cycle plot 2*

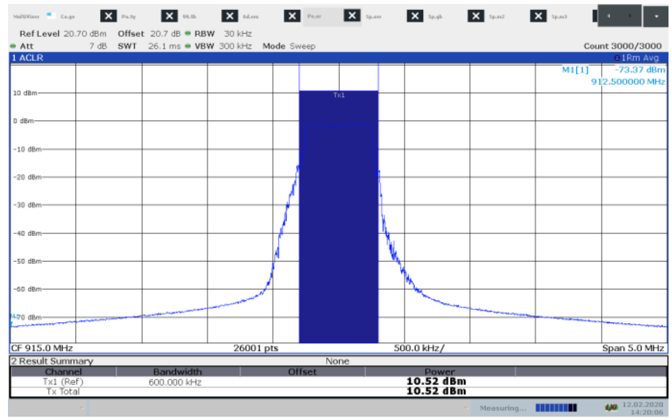
Duty cycle calculation: 10 × $\log_{10}$ (Tx_{on}/ Tx_{off}) = 10 × $\log_{10}$ (10 × 164.5 µs / 10 sec) = 7.83 dB

8.3.4 Test data, continued



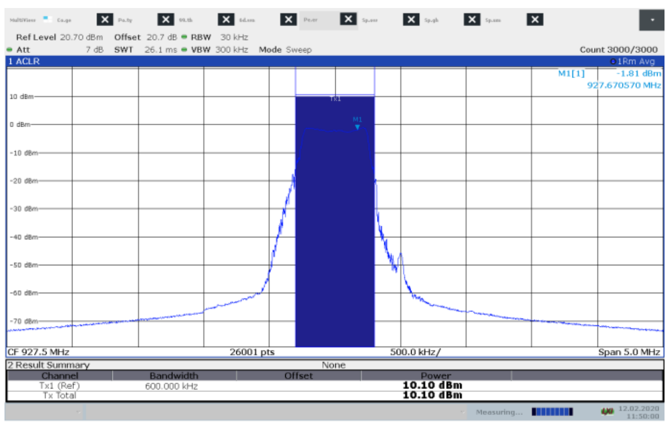
12:15:57 12.02.2020

Figure 8.3-8: *Output power on low channel Sensor*



14:20:07 12.02.2020

Figure 8.3-9: *Output power on mid channel Sensor*



11:50:00 12.02.2020

Figure 8.3-10: *Output power on high channel Sensor*

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

8.4.1 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.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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).

5.3 Hybrid systems
Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

a. With the frequency hopping turned off, the digital transmission operation shall comply with the power spectral density requirements for digital modulation systems set out in of section 5.2(b) or section 6.2.4 for hybrid devices operating in the band 5725–5850 MHz.

8.4.1 Test date

Start date	February 6, 2020

8.4.2 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10.
The test was performed using method AVGPSD-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction).

Spectrum analyser settings:

Resolution bandwidth:	3 kHz ≤ RBW ≤ 100 kHz
Video bandwidth:	≥3 × RBW
Frequency span:	1.5 times the OBW (Average)
Detector mode:	RMS
Trace mode:	AVG
Averaging sweeps number:	3000

8.4.3 Test data

Table 8.4-1: *PSD measurements results sensor*

Frequency, MHz	Measured, dBm	DCCF, dB	PSD, dBm/30 kHz	PSD limit, dBm/3 kHz	Margin, dB
903.0	-1.30	7.83	6.53	8	1.47
915.0	-1.23	7.83	6.60	8	1.40
927.5	-1.27	7.83	6.56	8	1.44

Note: PSD = measured conducted + DCCF

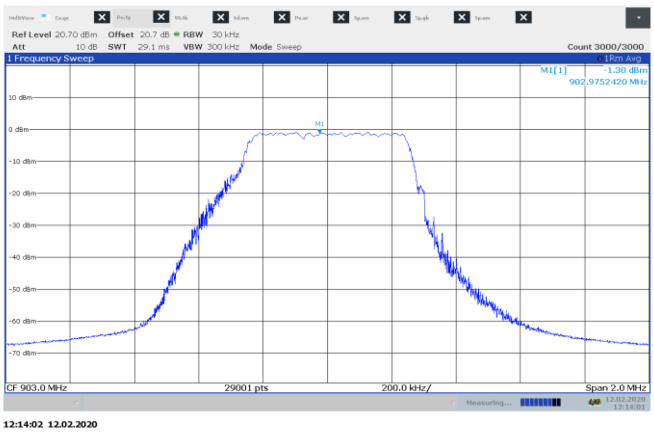


Figure 8.4-1: *PSD low channel sensor relay*

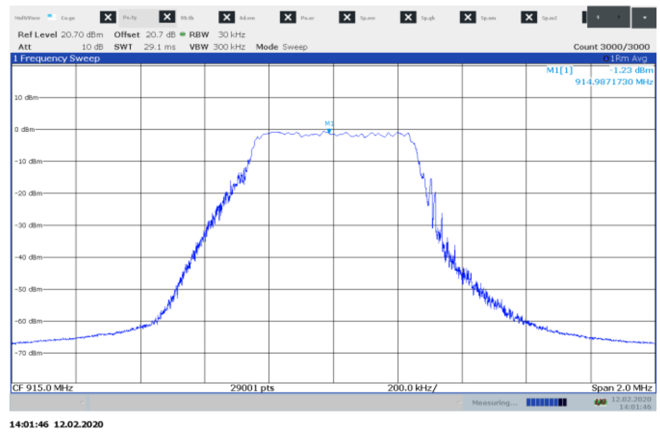


Figure 8.4-2: *PSD mid channel sensor relay*

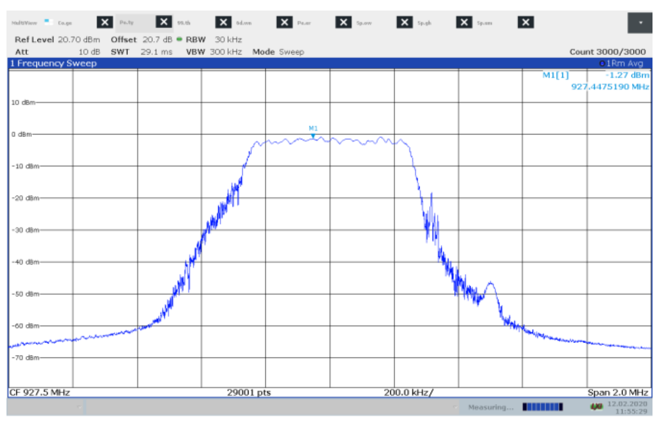


Figure 8.4-3: *PSD high channel sensor relay*

8.4.4 Test data, continued

Table 8.4-2: *PSD measurements results Flowie*

Frequency, MHz	Measured, dBm	DCCF, dB	PSD, dBm/30 kHz	PSD limit, dBm/3 kHz	Margin, dB
903.0	3.29	1.46	4.75	8.00	3.25
915.0	4.94	1.46	6.40	8.00	1.60
927.5	4.51	1.46	5.97	8.00	2.03

PSD = measured conducted + DCCF

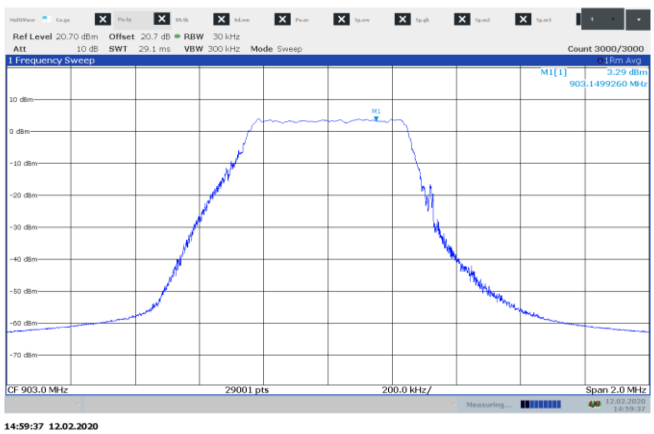


Figure 8.4-4: *PSD low channel Flowie*

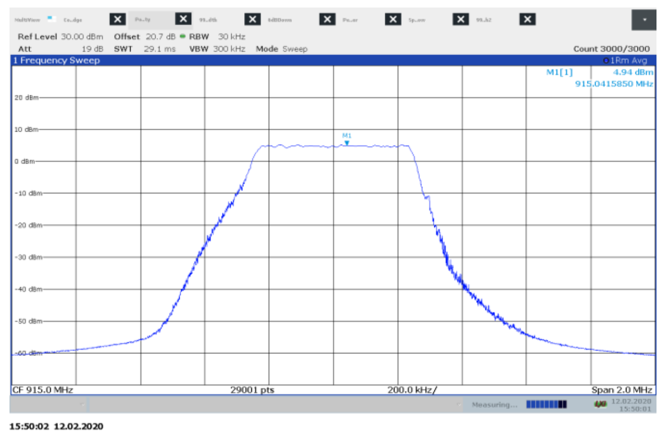


Figure 8.4-5: *PSD mid channel Flowie*

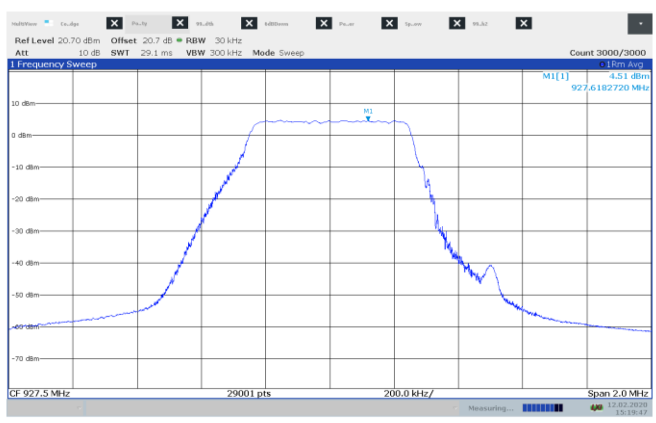


Figure 8.4-6: *PSD high channel Flowie*

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

8.5.1 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 8.5-1: *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	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	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 8.5-2: *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	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.5-2 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.

8.5.1 Definitions and limits, continued

Table 8.5-3: *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			

8.5.2 Test date

Start date	September 10, 2019

8.5.3 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.
- Radiated measurements were performed at a distance of 3 m,
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11. (conducted measurements)
- 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.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

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

8.5.4 Test data

Table 8.5-4: *Radiated field strength measurement results for Flowie-o*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	7226.00	63.02	74.00	10.98	47.90	54.00	6.10
Low	8125.93	56.10	74.00	17.90	41.00	54.00	13.00
Low	9034.50	54.90	74.00	19.10	39.20	54.00	14.80
Mid	7320.99	64.40	74.00	9.60	50.20	54.00	3.80
Mid	8235.01	62.50	74.00	11.50	47.50	54.00	6.50
Mid	9152.00	53.00	74.00	21.00	37.70	54.00	16.30
High	6493.49	49.44	74.00	24.56	35.85	54.00	18.15
High	7420.00	58.63	74.00	15.37	44.47	54.00	9.53
High	8347.00	63.90	74.00	10.10	48.80	54.00	5.20

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

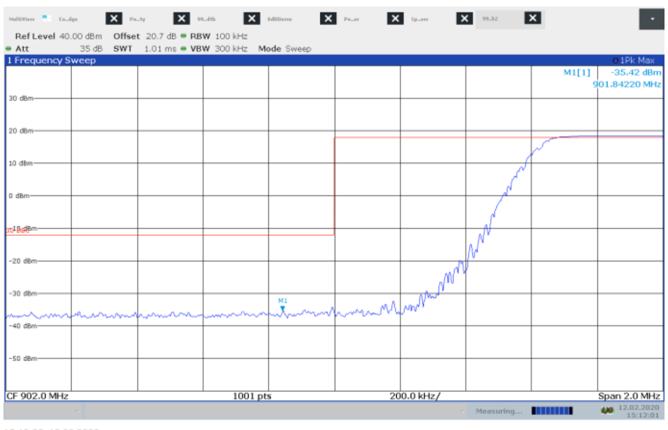


Figure 8.5-1: *Conducted spurious emissions at lower band edge Flowie*

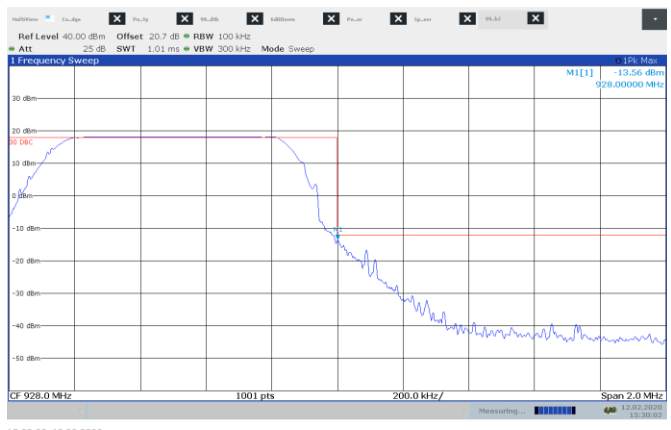


Figure 8.5-2: *Conducted spurious emissions at higher band edge Flowie*

8.5.4 Test data, continued

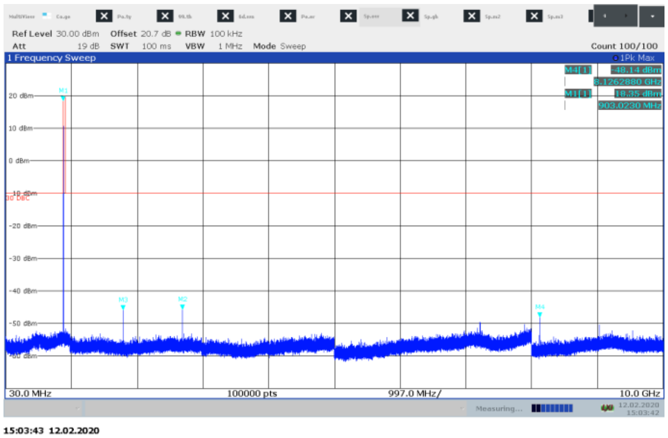


Figure 8.5-3: *Conducted spurious emissions low channel Flowie*

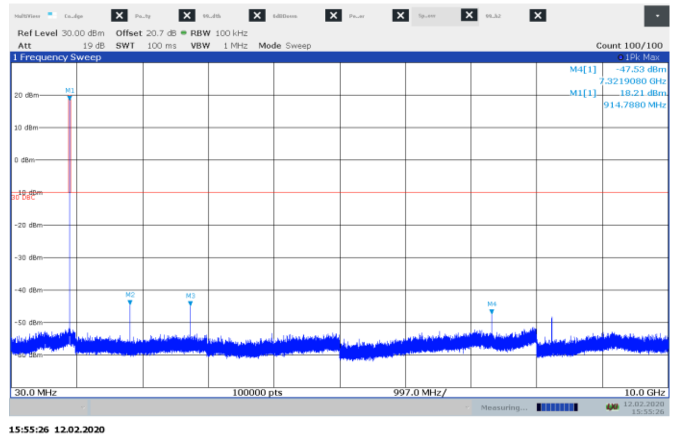


Figure 8.5-4: *Conducted spurious emissions mid channel Flowie*

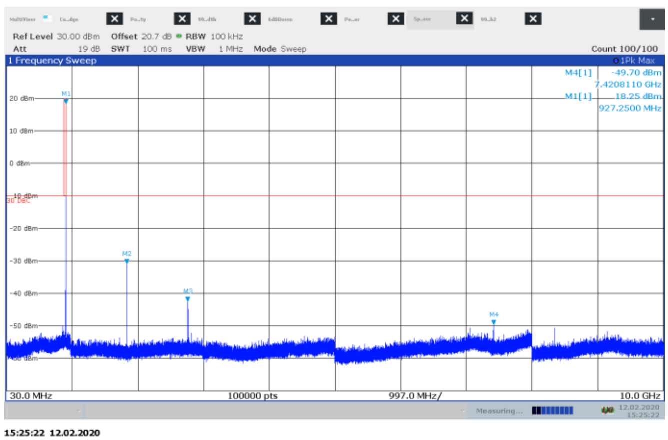


Figure 8.5-5: *Conducted spurious emissions high channel Flowie*

8.5.4 Test data, continued

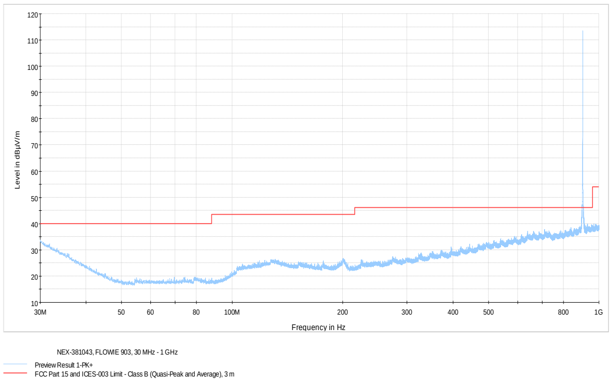


Figure 8.5-6: *Radiated spurious emissions below 1 GHz low channel Flowie*

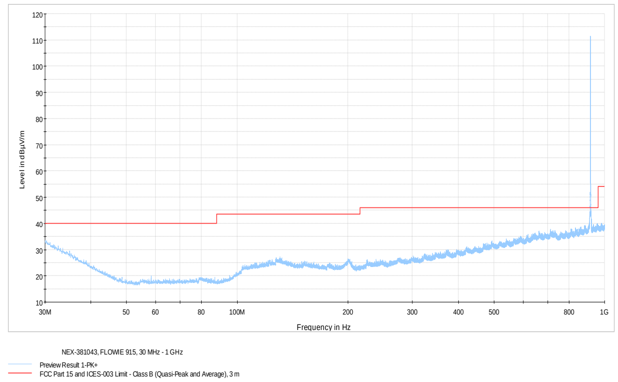


Figure 8.5-7: *Radiated spurious emissions below 1GHz mid channel Flowie*

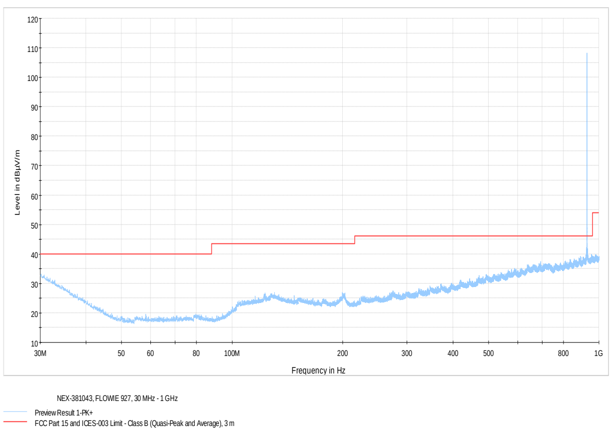


Figure 8.5-8: *Radiated spurious emissions below 1 GHz high channel Flowie*

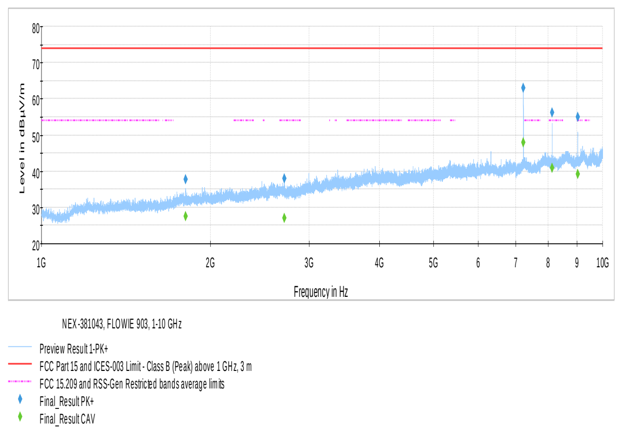


Figure 8.5-9: *Radiated spurious emissions 1 – 10 GHz low channel Flowie*

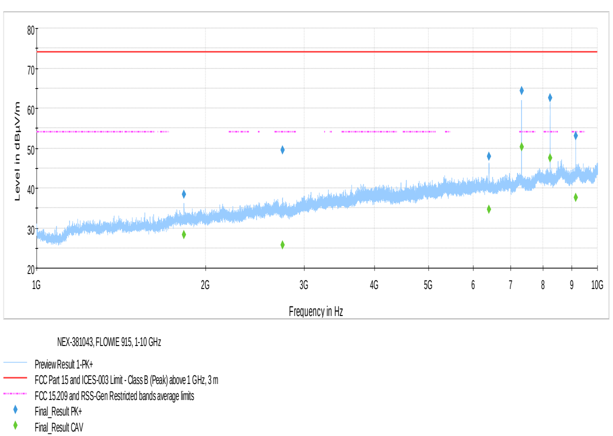


Figure 8.5-10: *Radiated spurious emissions 1- 10 GHz mid channel Flowie*

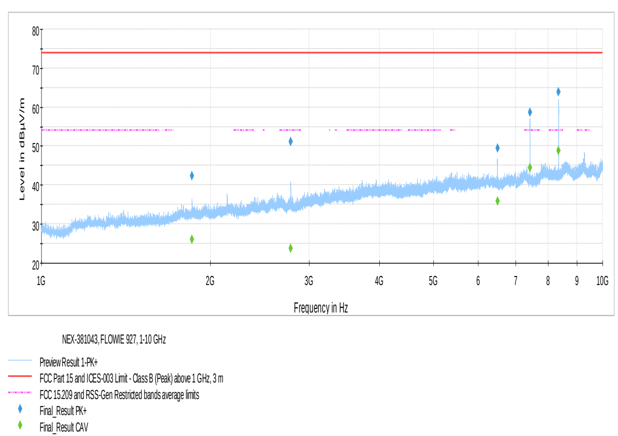


Figure 8.5-11: *Radiated spurious emissions 1- 10 GHz high channel Flowie*

8.5.4 Test data, continued

Table 8.5-5: *Radiated field strength measurement results for Sensor relay*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	1805.38	64.60	74.00	9.40	49.70	54.00	4.30
Low	2708.99	57.00	74.00	17.00	46.80	54.00	7.20
Low	7225.28	57.20	74.00	16.80	40.80	54.00	13.20
Low	8128.00	62.30	74.00	11.70	45.10	54.00	8.90
Low	9030.67	55.70	74.00	18.30	38.10	54.00	15.90
Mid	1830.39	62.50	74.00	11.50	49.30	54.00	4.70
Mid	2744.98	62.10	74.00	11.90	51.50	54.00	2.50
Mid	7319.50	60.80	74.00	13.20	44.40	54.00	9.60
Mid	8236.00	61.00	74.00	13.00	43.90	54.00	10.10
Mid	9152.50	53.50	74.00	20.50	37.60	54.00	16.40
High	1854.37	58.00	74.00	16.00	31.80	54.00	22.20
High	2782.46	62.60	74.00	11.40	53.20	54.00	0.80
High	7420.55	63.00	74.00	11.00	46.50	54.00	7.50
High	8347.75	54.60	74.00	19.40	38.10	54.00	15.90
High	9275.29	52.30	74.00	21.70	36.80	54.00	17.20

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

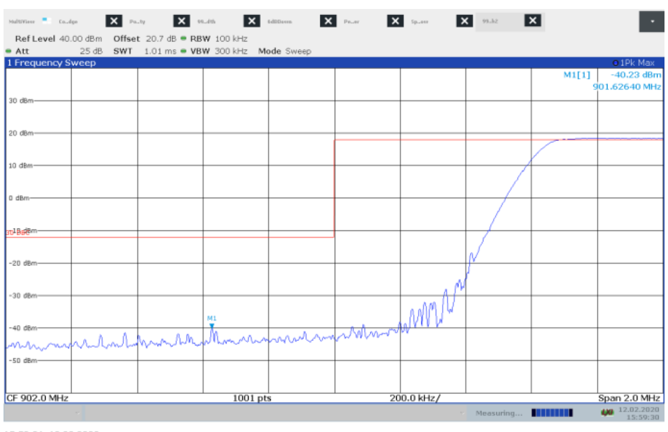


Figure 8.5-12: *Conducted spurious emissions at lower band edge sensor relay*

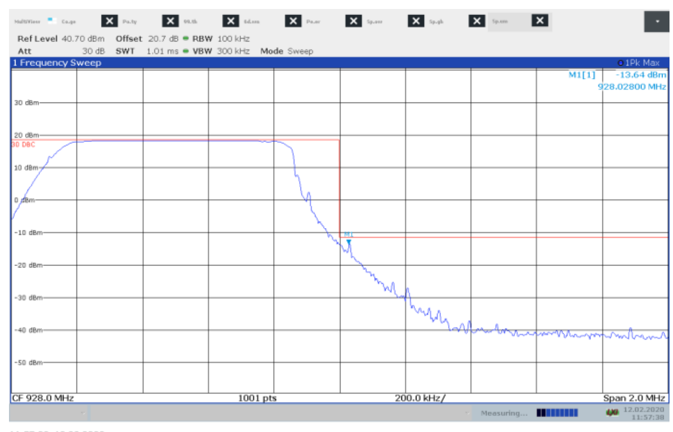


Figure 8.5-13: *Conducted spurious emissions at higher band edge sensor relay*

8.5.4 Test data, continued

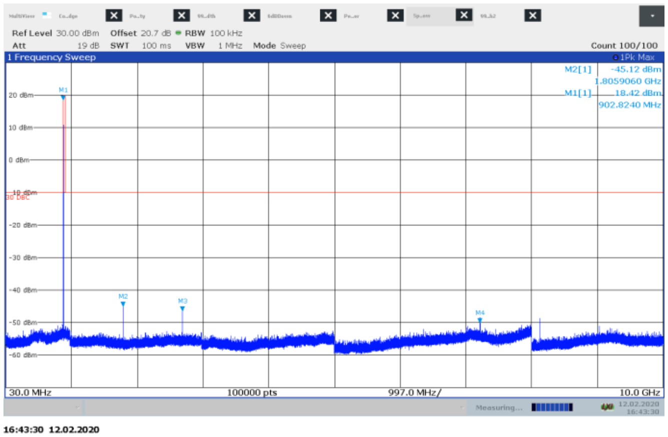


__Figure 8.5-14:__ Conducted spurious emissions for low channel Sensor

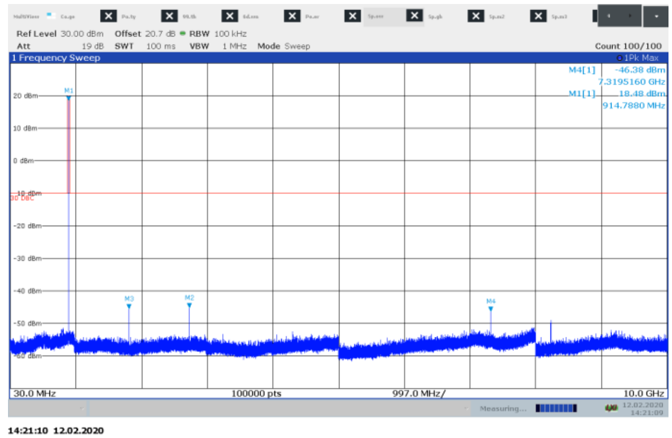


__Figure 8.5-15:__ Conducted spurious emissions for mid channel Sensor

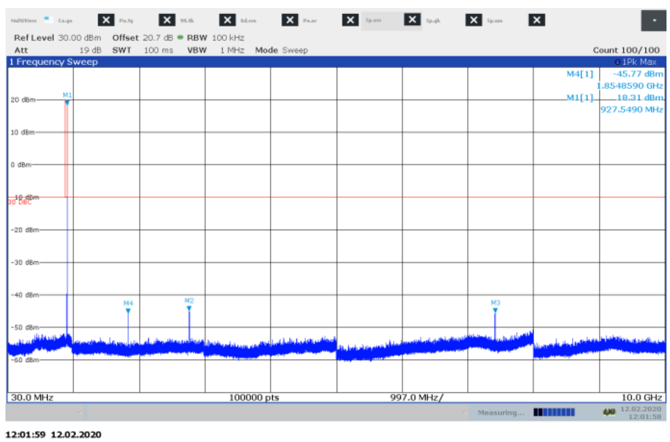


__Figure 8.5-16:__ Conducted spurious emissions for high channel Sensor

8.5.4 Test data, continued

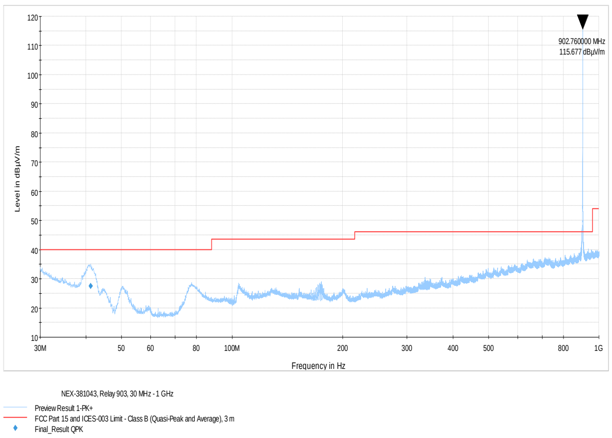


Figure 8.5-17: *Radiated spurious emissions below 1 GHz low channel Sensor*

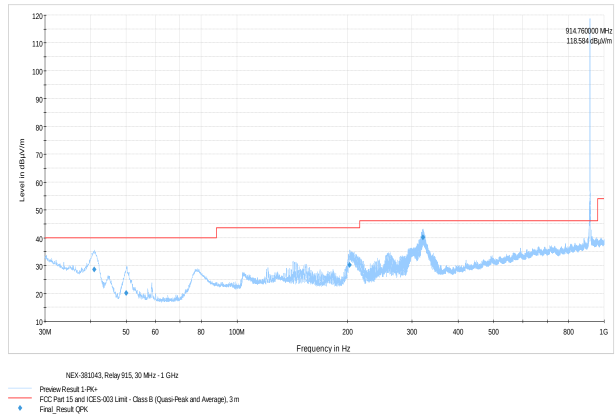


Figure 8.5-18: *Radiated spurious emissions below 1GHz mid channel Sensor*

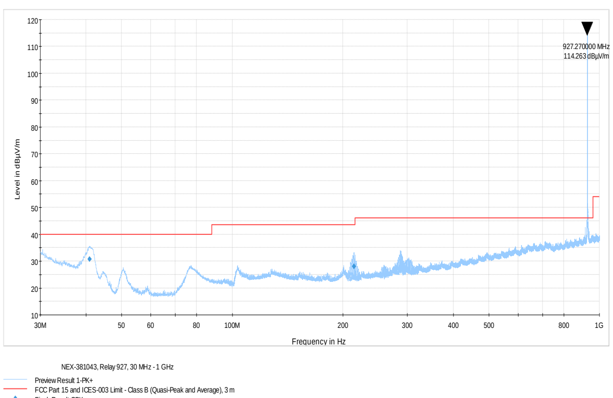


Figure 8.5-19: *Radiated spurious emissions below 1 GHz high channel Sensor*

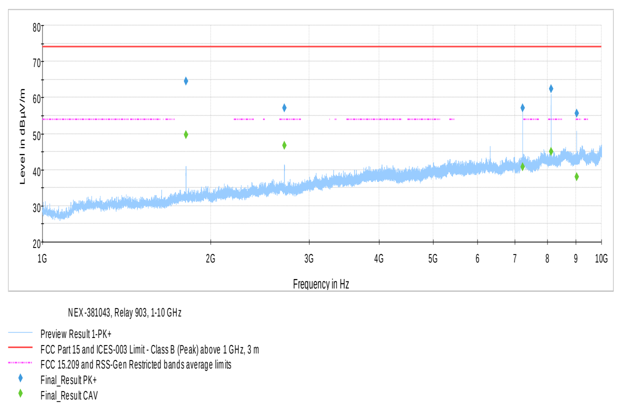


Figure 8.5-20: *Radiated spurious emissions 1 – 10 GHz low channel Sensor*

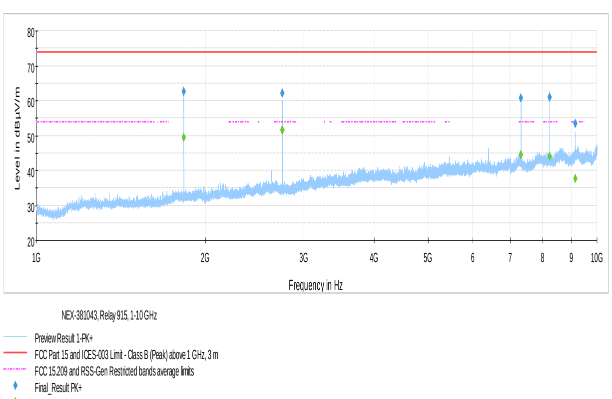


Figure 8.5-21: *Radiated spurious emissions 1- 10 GHz mid channel Sensor*

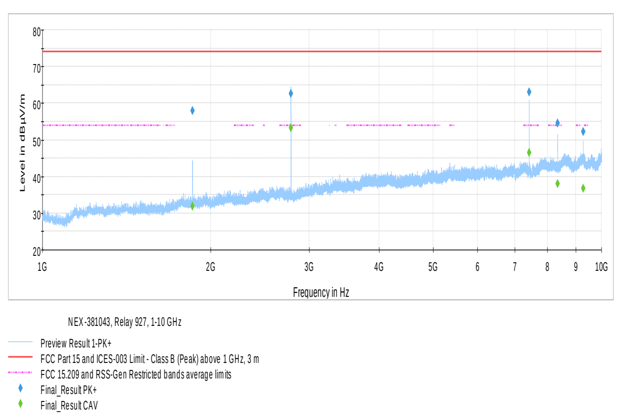
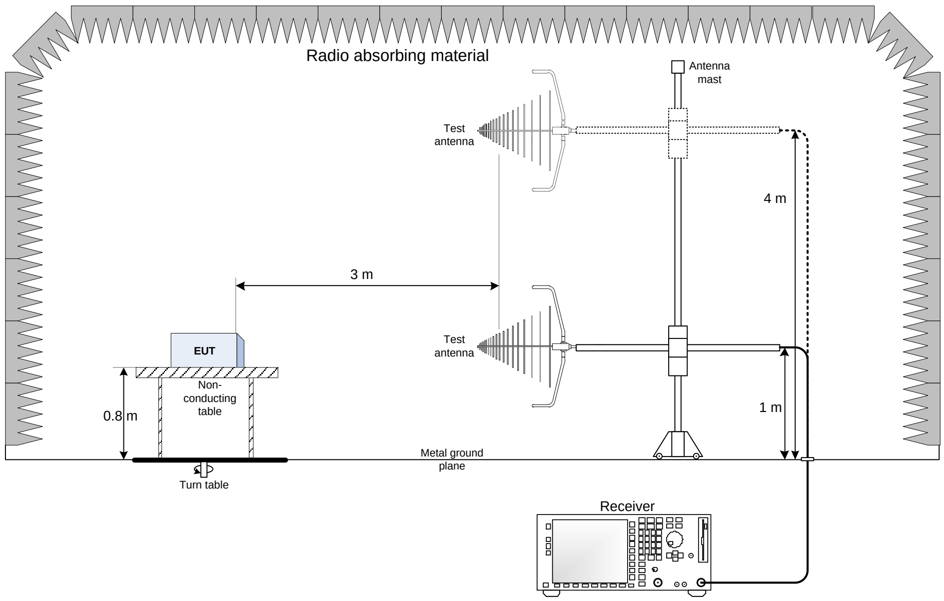


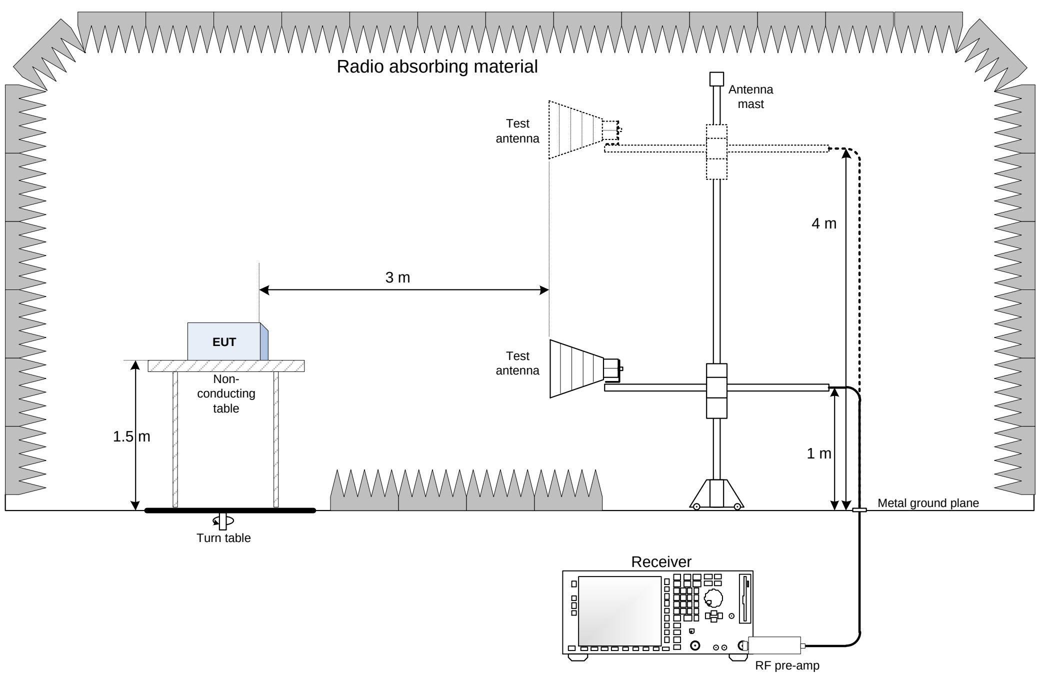
Figure 8.5-22: *Radiated spurious emissions 1- 10 GHz high channel Sensor*

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 Antenna port set-up