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Test report

309365-2TRFWL

Date of issue: June 30, 2016

Applicant:

Digital Security Controls a div. of Tyco Safety Products Canada Ltd.

Product:

Self-Contained Wireless Security System

Model:

WS900-29

FCC ID: F5316WS90029

IC Registration number: 160A-WS90029

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

Test location

Company name	Nemko Canada Inc.
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Province	Ontario
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Country	Canada
Telephone	+1 613 737 9680
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Toll free	+1 800 563 6336
Website	www.nemko.com
Site number	FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber)

Tested by	Andrey Adelberg, Senior Wireless/EMC Specialist
Reviewed by	Kevin Rose, Wireless/EMC Specialist
Date	June 30, 2016
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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Digital Security Controls a div. of Tyco Safety Products Ltd.
Address	3301 Langstaff Road, Concord, ON, Canada, L4K 4L2

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 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

1.3 Test methods

DA 00-705 Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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[1]
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

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 antenna is located within the enclosure of EUT and not user accessible.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.215(c)	20 dB bandwidth	Pass
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Pass
§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	Not applicable
§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	Pass
§15.247(b)(3,4)	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	Not applicable
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

Notes: None

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable[1]
7.1.3	Receiver conducted emission limits	Not applicable[1]
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
6.6	Occupied bandwidth	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	Pass
5.1 (2)	Minimum channel spacing for frequency hopping systems	Pass
5.1 (3)	Frequency hopping systems operating in the 902–928 MHz band	Pass
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	Not applicable
5.2 (2)	Maximum power spectral density	Not applicable
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	Pass
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	Not applicable
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	May 24, 2016
Nemko sample ID number	133-002706 (Conducted sample) and 133-002700 (Radiated sample, low), 133-002701 (Radiated sample, mid), 133-002702 (Radiated sample, high)

3.2 EUT information

Product name	Self-Contained Wireless Security System
Model	WS900-29
Model variant	N/A
Serial number	None

3.3 Technical information

All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-247 Issue 1, May 2015
Frequency band (MHz)	902–928
Frequency Min (MHz)	912.750
Frequency Max (MHz)	919.106
RF power Max (W), Conducted	0.032 (15 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99%)	87.34
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	FHSS - FSK
Number of hopping channels	50
Emission classification	F1D
Transmitter spurious, Units @ distance	60.22 dBµV/m Peak and 34.22 dBµV/m Average @ 3 m @ 2747.5 MHz
Power requirements	12 V_{DC} (Powered via external AC-DC adapter 90–264 V_{AC} 47–63 Hz) and via 7.5 V_{DC} battery
Hardware and software details	HW: UA707 Rev. 03 SW: Ver 1.0
Antenna information	The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator. Antenna gain is 1.0 dBi

3.4 Product description and theory of operation

The EUT (WS900-29) is a Wireless Alarm System panel that contains three RF interfaces: Wi-Fi, PowerG and Z-wave. This test report covers only the Proprietary Security RF protocol (PowerG) transmitter.

3.5 EUT exercise details

The EUT was supplied in 8 different configurations: 1) Low channel - conducted, 2) Mid channel - conducted, 3) High channel - conducted, 4) Hopping – conducted and 5) Low channel - radiated, 6) Mid channel - radiated, 7) High channel - radiated, 8) Hopping – radiated. All variants were set to continuous transmit state.

3.6 EUT setup diagram

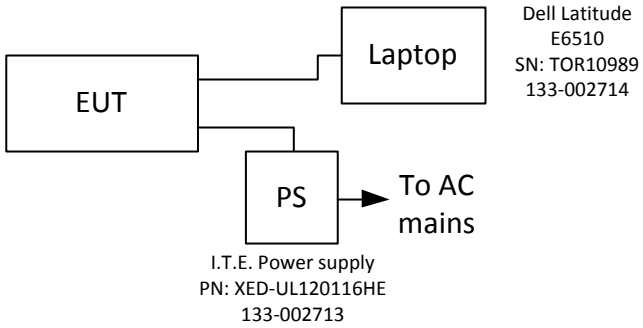


Figure 3.6-1: *Setup diagram*

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 ±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

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. 01/16
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
AC Power source	Chenwa	2700M-10k	FA002716	—	VOU
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Apr. 28/17
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	Apr. 26/17
Pre-amplifier (1–18 GHz)	JCA	JCA118-503	FA002091	1 year	April 26/17
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	Mar. 08/17

Notes: 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 §15.207 (a):
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 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.

RSS-GEN, Clause 8.8:
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: *AC power line conducted emissions limits*

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

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

8.1.2 Test summary

Verdict	Pass				
Test date	May 25, 2016	Test engineer	David Duchesne		
Temperature	23.4 °C	Relative humidity	35.7 %	Air pressure	1001 mbar

8.1.3 Notes

None

8.1.4 Setup details

Port under test	AC input (External adapter)
EUT setup configuration	Table top
Measurement details	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:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– Peak and Average (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 1000 ms (Quasi-peak final measurement) – 160 ms (CAverage final measurement)

8.1.5 Test data

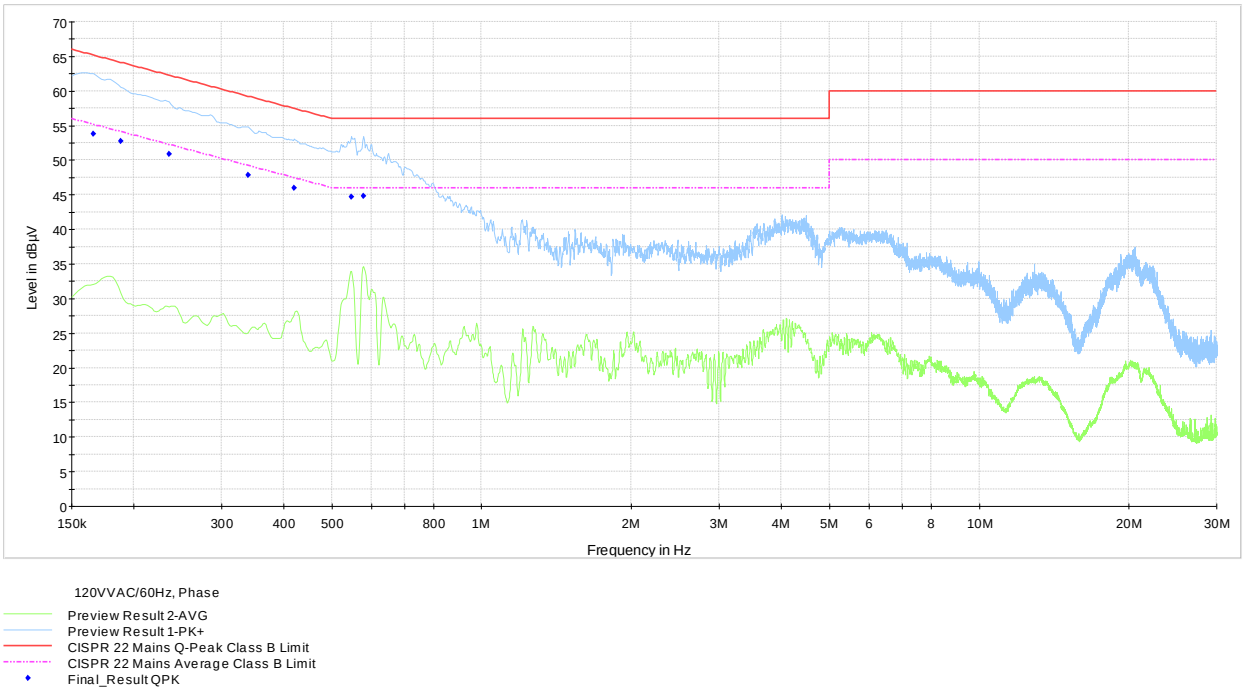


Figure 8.1-1: *AC power line conducted emissions limits – phase line*

Table 8.1-2: *Quasi-Peak results AC power line conducted emissions limits – phase line*

Frequency (MHz)	Quasi-Peak result[1 and 3] (dBµV)	Quasi-Peak limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
0.165750	53.77	65.17	11.40	1000	9	L1	ON	10.1
0.188250	52.76	64.11	11.35	1000	9	L1	ON	10.0
0.235500	50.85	62.25	11.40	1000	9	L1	ON	9.7
0.339000	47.88	59.23	11.35	1000	9	L1	ON	9.9
0.420000	45.97	57.45	11.48	1000	9	L1	ON	10.0
0.548250	44.72	56.00	11.28	1000	9	L1	ON	10.0
0.579750	44.78	56.00	11.22	1000	9	L1	ON	10.0

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] The maximum measured value observed over a period of 15 seconds was recorded.

Sample calculation: 44.78 dBµV (result) = 34.78 dBµV (receiver reading) + 10.00 dB (Correction factor)

8.1.5 Test data, continued

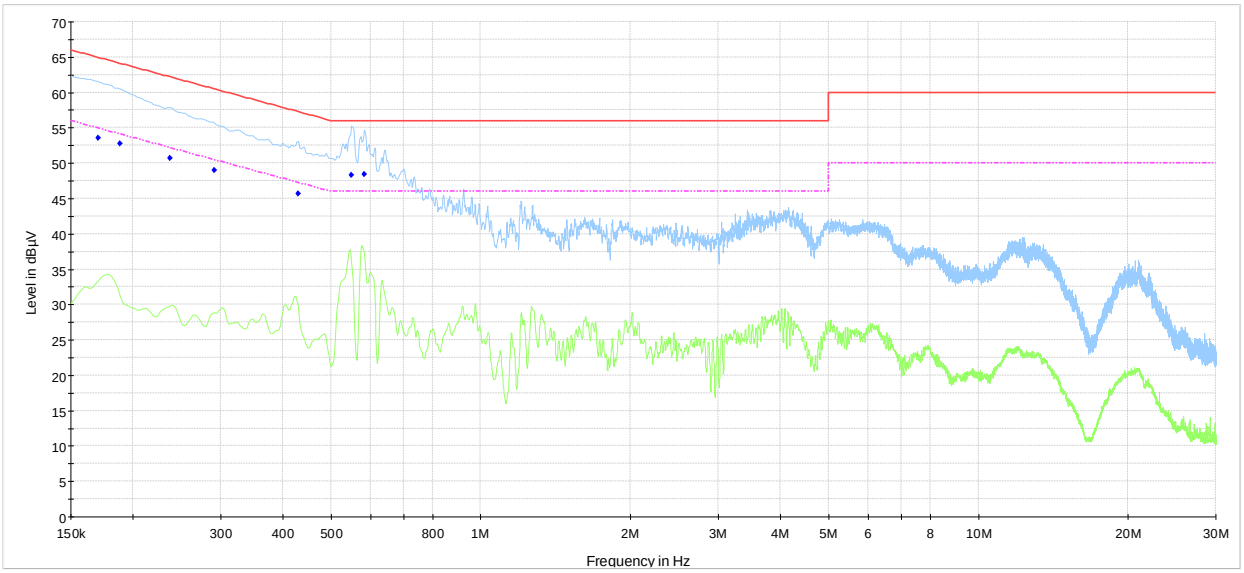


Figure 8.1-2: *AC power line conducted emissions limits – neutral line*

Table 8.1-3: *Quasi-Peak results AC power line conducted emissions limits – neutral line*

Frequency (MHz)	Quasi-Peak result[1 and 3] (dBµV)	Quasi-Peak limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
0.170250	53.57	64.95	11.38	1000	9	N	ON	10.1
0.188250	52.70	64.11	11.41	1000	9	N	ON	10.0
0.237750	50.67	62.17	11.50	1000	9	N	ON	9.7
0.291750	49.01	60.47	11.46	1000	9	N	ON	9.8
0.429000	45.73	57.27	11.54	1000	9	N	ON	10.0
0.550500	48.25	56.00	7.75	1000	9	N	ON	10.0
0.584250	48.38	56.00	7.62	1000	9	N	ON	10.0

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] The maximum measured value observed over a period of 15 seconds was recorded.

Sample calculation: 48.38 dBµV (result) = 38.38 dBµV (receiver reading) + 10.00 dB (Correction factor)

8.1.6 Setup photos

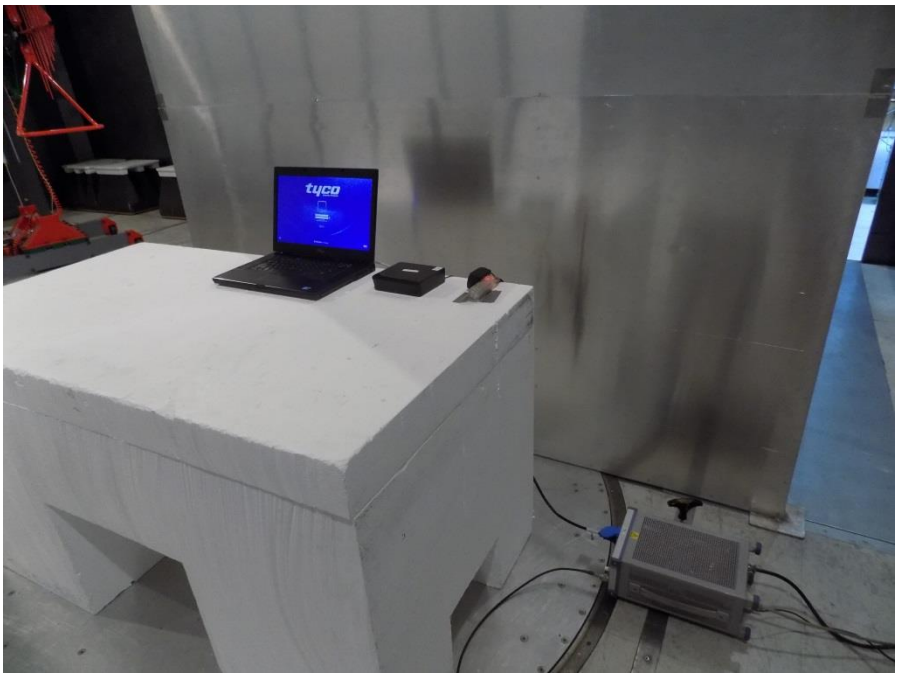


Figure 8.1-3: *AC power line conducted emissions limits setup photo*

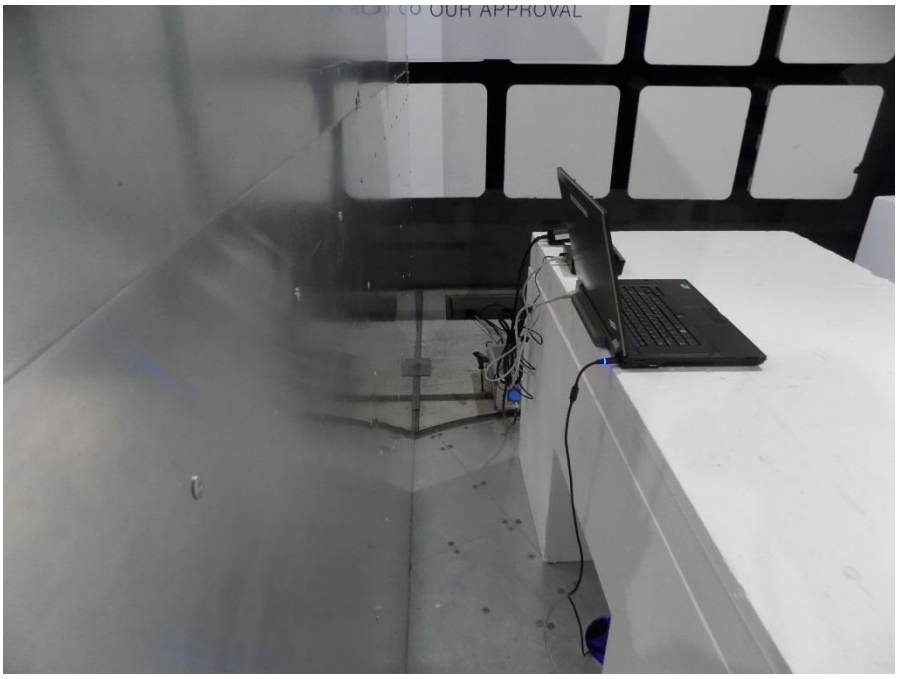


Figure 8.1-4: *AC power line conducted emissions limits setup photo*

8.2 FCC 15.215(c) and RSS-Gen (6.6): 99% bandwidth and 20 dB bandwidth

8.2.1 Definitions and limits

FCC §15.215 (c):

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

RSS-GEN, Clause 6.6:

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

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

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

Note: Video averaging is not permitted.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

The difference between the two recorded frequencies is the 99% occupied bandwidth.

8.2.2 Test summary

Verdict	Pass				
Test date	June 13, 2016	Test engineer	Andrey Adelberg		
Temperature	22 °C	Relative humidity	36 %	Air pressure	1008 mbar

8.2.3 Notes

None

8.2.4 Setup details

Spectrum analyser settings: for 20 dB and 99% bandwidth test:

Resolution bandwidth	10 kHz
Video bandwidth	≥3 × RBW
Frequency span	1 MHz
Detector mode	Peak
Trace mode	Max Hold

8.2.5 Test data

Table 8.2-1: *20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz
912.750	104.167
915.860	104.167
919.106	104.167

Table 8.2-2: *99% occupied bandwidth results*

Frequency, MHz	99% occupied bandwidth, kHz
912.750	88.141
915.860	88.141
919.106	88.141

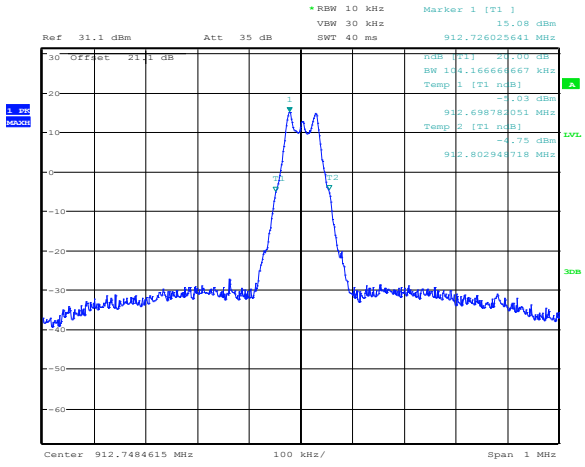


Figure 8.2-1: *20 dB bandwidth on low channel*

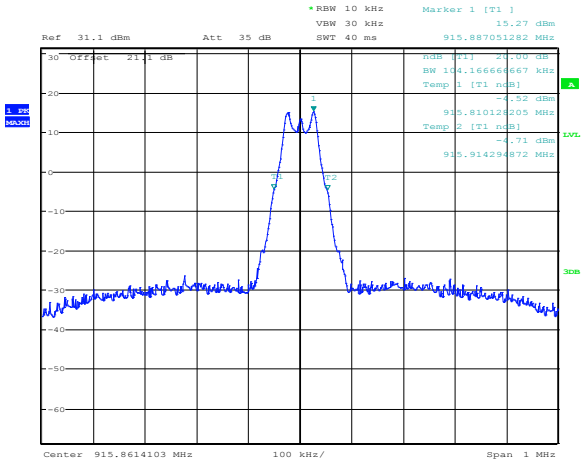


Figure 8.2-2: *20 dB bandwidth on mid channel*

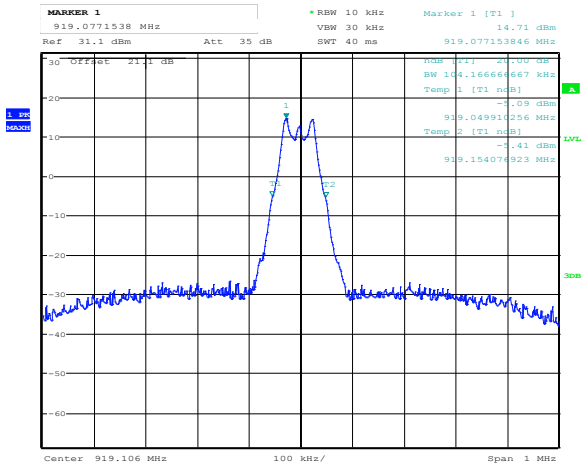


Figure 8.2-3: *20 dB bandwidth on high channel*

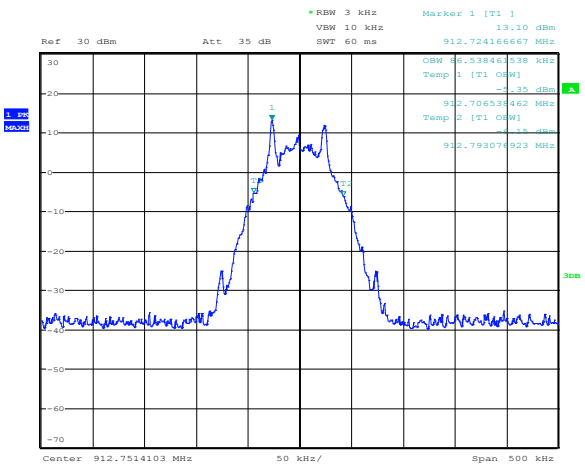


Figure 8.2-4: *99% occupied bandwidth on low channel*

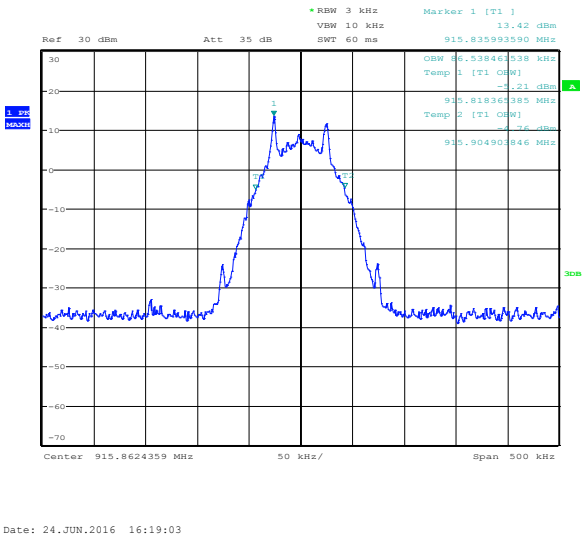


Figure 8.2-5: *99% occupied bandwidth on mid channel*

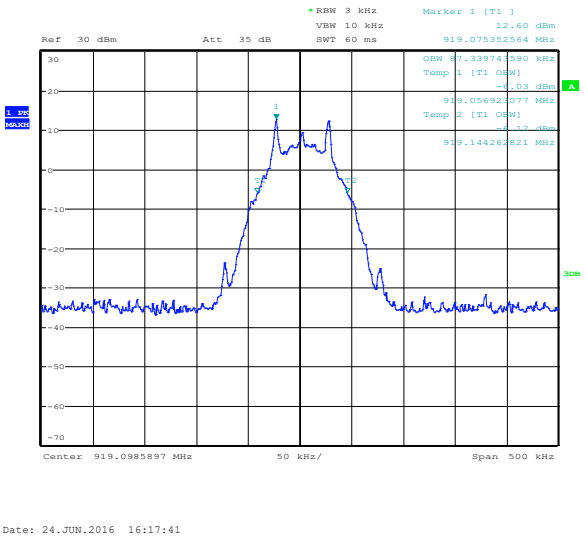


Figure 8.2-6: *99% occupied bandwidth on high channel*

8.3 FCC 15.247(b) and RSS-247 5.4 (1) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC §15.247 (b):

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

(2) For frequency hopping systems operating in the 902–928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

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

RSS-247, Clause 5.4 (1):

For FHSs operating in the band 902–928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

8.3.2 Test summary

Verdict	Pass				
Test date	June 13, 2016	Test engineer	Andrey Adelberg		
Temperature	22 °C	Relative humidity	36 %	Air pressure	1008 mbar

8.3.3 Notes

The EUT is using 50 hopping channels, therefore the output power limit is 1 W.

8.3.4 Setup details

Spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	≥3 × RBW
Frequency span	10 MHz
Detector mode	Peak
Trace mode	Max-Hold

8.3.5 Test data

Table 8.3-1: *Output power and EIRP results*

Frequency, MHz	Conducted output power, dBm	Conducted output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
912.750	14.72	30.00	15.28	1.00	15.72	36.00	20.28
915.860	15.00	30.00	15.00	1.00	16.00	36.00	20.00
919.106	14.33	30.00	15.67	1.00	15.33	36.00	20.67

Notes: EIRP = Output power + Antenna gain

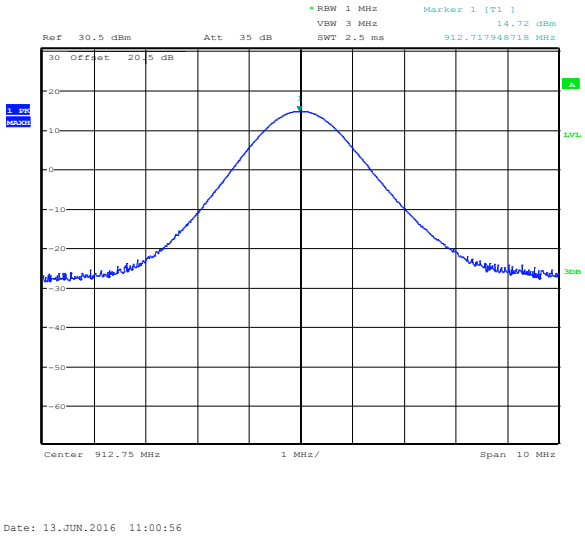


Figure 8.3-1: *Conducted output power on low channel*

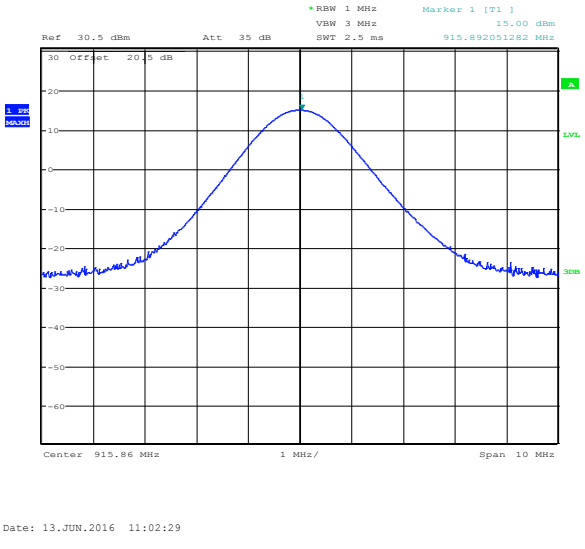


Figure 8.3-2: *Conducted output power on mid channel*

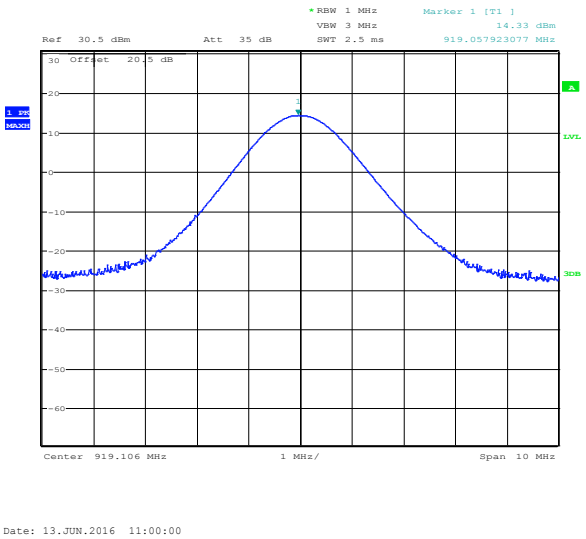


Figure 8.3-3: *Conducted output power on high channel*

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

8.4.1 Definitions and limits

FCC §15.247 (d):

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

RSS-247, Clause 5.5:

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	$67.6 - 20 \times \log_{10}(F)$	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 8.4-2: *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

Notes: 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

Verdict	Pass				
Test date	June 13, 2016	Test engineer	Andrey Adelberg		
Temperature	22 °C	Relative humidity	36 %	Air pressure	1008 mbar

8.4.3 Notes

- The spectrum was searched from 30 MHz to the 10th harmonic.
- EUT was set to transmit with 100 % duty cycle.
- Spurious emissions limit for frequencies outside restricted bands is −20 dBc/100 kHz

8.4.4 Setup details

Spectrum analyser settings for conducted (outside restricted bands) measurements:

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

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

8.4.5 Test data

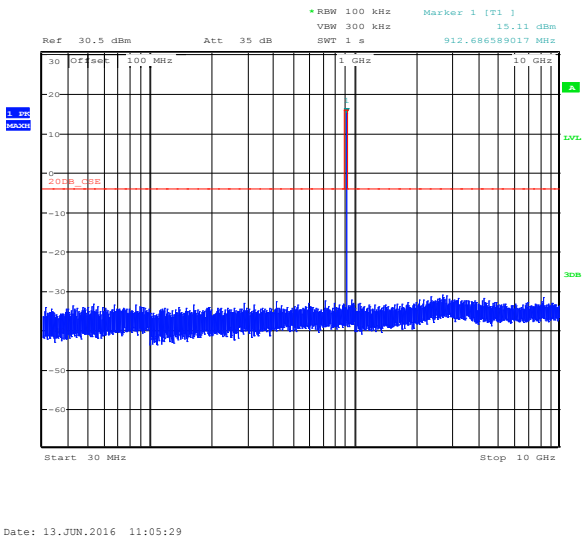


Figure 8.4-1: *Conducted spurious emissions at low channel*

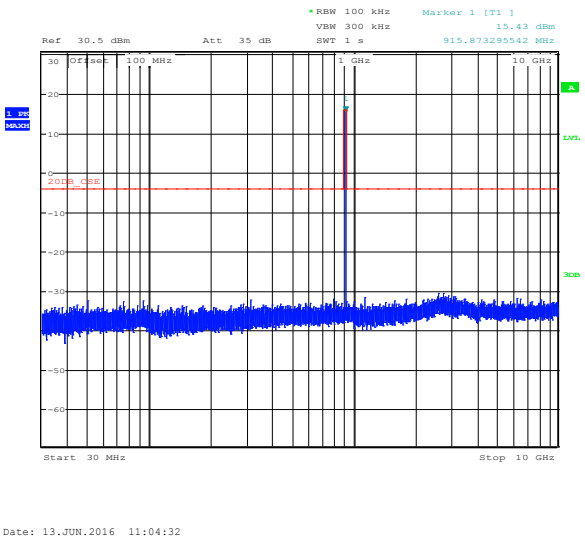


Figure 8.4-2: *Conducted spurious emissions at mid channel*

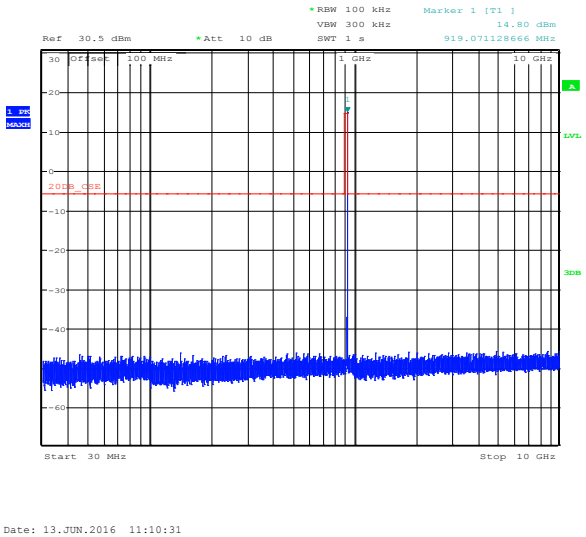


Figure 8.4-3: *Conducted spurious emissions t high channel*

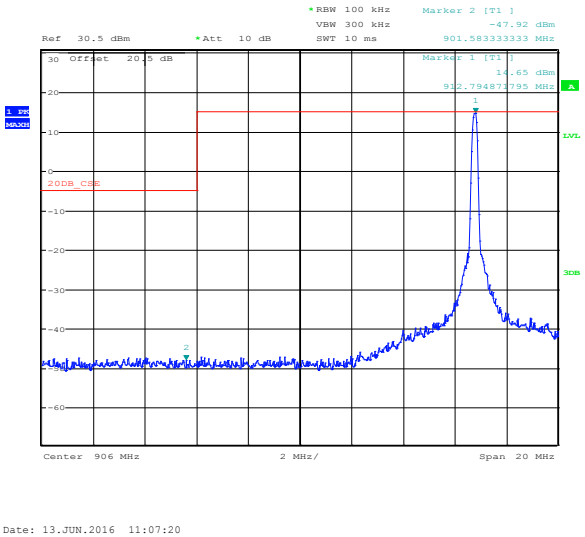


Figure 8.4-4: *Conducted spurious emissions at 902 MHz band edge, low channel*

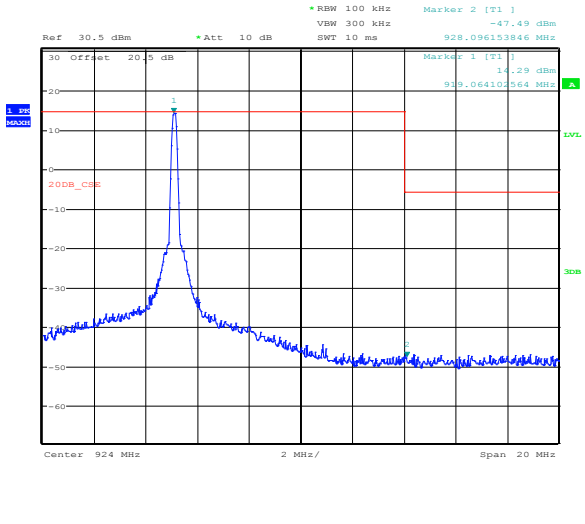


Figure 8.4-5: *Conducted spurious emissions at 928 MHz band edge, high channel*

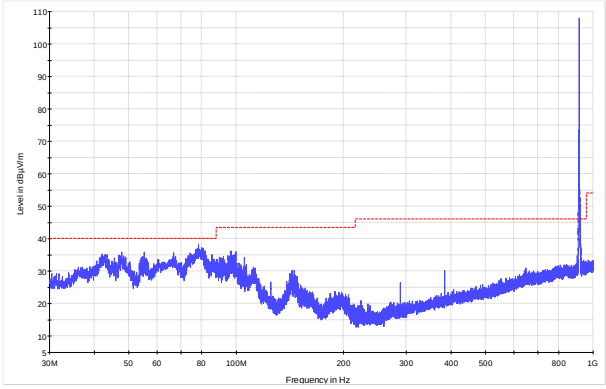


Figure 8.4-6: *Radiated spurious emissions below 1 GHz, low channel*

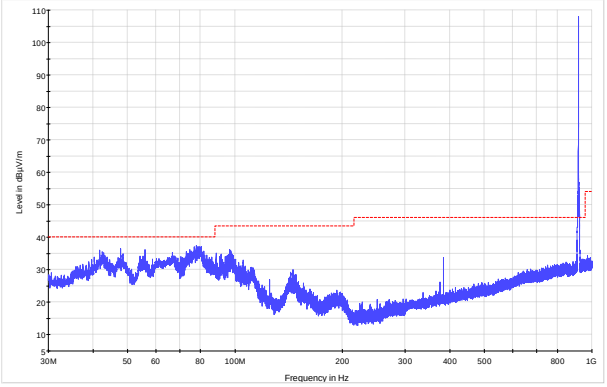


Figure 8.4-7: *Radiated spurious emissions below 1 GHz, mid channel*

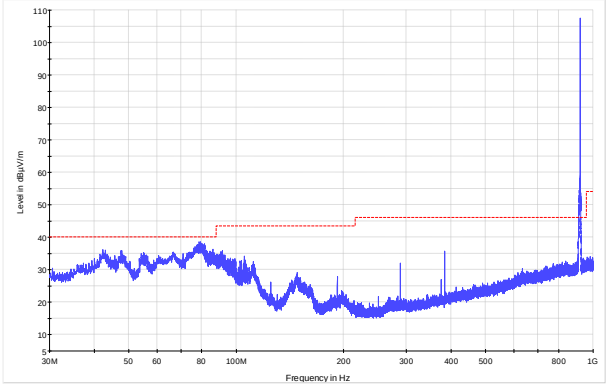


Figure 8.4-8: *Radiated spurious emissions below 1 GHz, high channel*

Duty cycle/average factor calculations

§15.35(c) When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed; the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

$$Duty\,cycle\,/\,average\,factor = 20 \times \log_{10}\left(\frac{Tx_{100ms}}{100ms}\right)$$

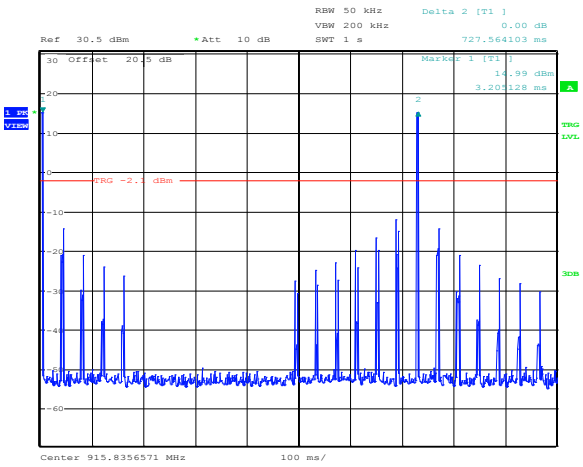


Figure 8.4-9: *Transmission pulse repetition*

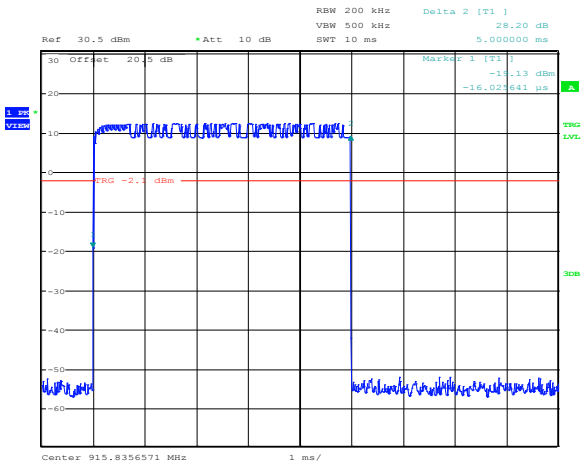


Figure 8.4-10: *Transmitter pulse width*

Duty cycle correction factor:

$$20 \times \text{Log}_{10}\,(5 \div 100) = -26\ \text{dB}$$

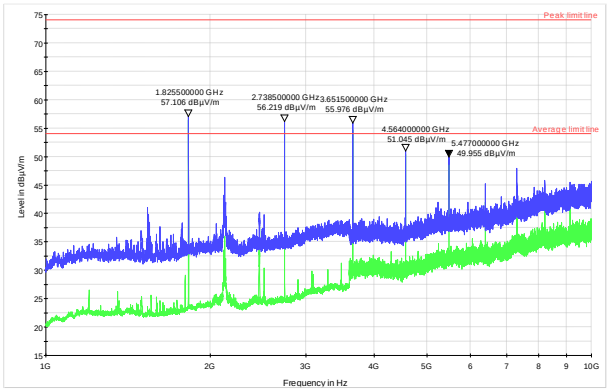


Figure 8.4-11: *Radiated spurious emissions above 1 GHz, low channel*

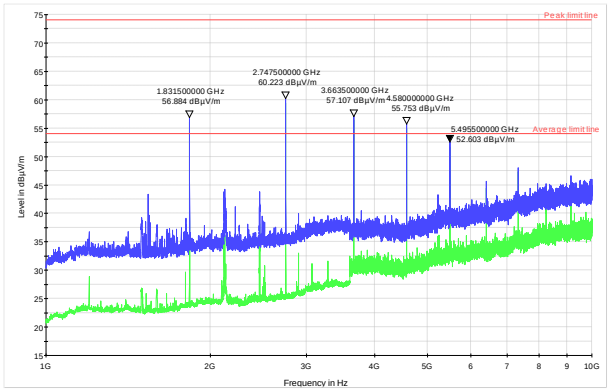


Figure 8.4-12: *Radiated spurious emissions above 1 GHz, mid channel*

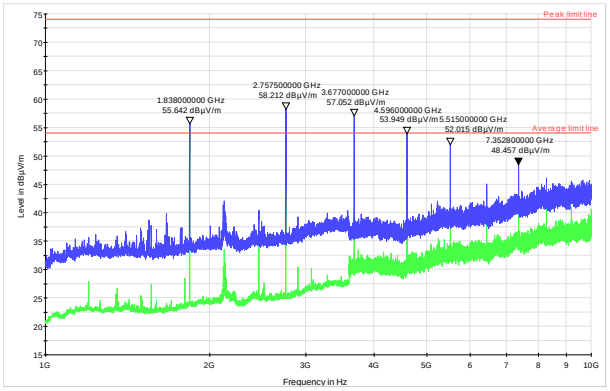


Figure 8.4-13: *Radiated spurious emissions above 1 GHz, high channel*

Table 8.4-4: *Radiated field strength measurement results*

Channel	Frequency, MHz	Peak field strength[1], dBµV/m	Peak field strength limit, dBµV/m	Peak margin, dB	Average field strength[2], dBµV/m	Average field strength limit, dBµV/m	Average margin, dB
Low	1825.5	57.11	74.00	16.89	31.11	54.00	22.89
Low	2738.5	56.22	74.00	17.78	30.22	54.00	23.78
Low	3651.5	55.98	74.00	18.02	29.98	54.00	24.02
Low	4564.0	51.05	74.00	22.95	25.05	54.00	28.95
Low	5477.0	49.96	74.00	24.04	23.96	54.00	30.04
Mid	1831.5	56.88	74.00	17.12	30.88	54.00	23.12
Mid	2747.5	60.22	74.00	13.78	34.22	54.00	19.78
Mid	3663.5	57.11	74.00	16.89	31.11	54.00	22.89
Mid	4580.0	55.75	74.00	18.25	29.75	54.00	24.25
Mid	5495.5	52.60	74.00	21.40	26.60	54.00	27.40
High	1838.0	55.64	74.00	18.36	29.64	54.00	24.36
High	2757.5	58.21	74.00	15.79	32.21	54.00	21.79
High	3677.0	57.05	74.00	16.95	31.05	54.00	22.95
High	4596.0	53.95	74.00	20.05	27.95	54.00	26.05
High	5515.0	52.02	74.00	21.98	26.02	54.00	27.98
High	7352.8	48.46	74.00	25.54	22.46	54.00	31.54

Notes: [1] Peak field strength (dBµV/m) = Spectrum analyzer value (dBµV) + transducer factors (dB)
Transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators.
[2] Average field strength = Peak field strength + DCCF (which is −26 dB)

8.5 FCC 15.247(a)(1) and RSS-247 5.1(1) Frequency Hopping Systems requirements

8.5.1 Definitions and limits

FCC:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

IC:

1. The bandwidth of a frequency hopping channel is the −20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The hopset shall be such that the near-term distribution of frequencies appears random, with sequential hops randomly distributed in both direction and magnitude of change in the hopset, whereas the long-term distribution appears evenly distributed.
2. FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the −20 dB bandwidth of the hopping channel, whichever is greater. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
3. For FHSs in the band 902–928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20‑second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10‑second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.5.2 Test summary

Verdict	Pass				
Test date	June 13, 2016	Test engineer	Andrey Adelberg		
Temperature	22 °C	Relative humidity	36 %	Air pressure	1008 mbar

8.5.3 Observations, settings and special notes

Spectrum analyser settings for carrier frequency separation:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for number of hopping frequencies:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	the frequency band of operation
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for time of occupancy (dwell time):

Resolution bandwidth	1 MHz
Video bandwidth	≥ RBW
Frequency span	Zero span
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for 20 dB bandwidth:

Resolution bandwidth	≥ 1% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.5.4 Test data

Table 8.5-1: *20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz	Limit, kHz	Margin, kHz
912.750	104.167	500.000	395.833
915.860	104.167	500.000	395.833
919.106	104.167	500.000	395.833

Table 8.5-2: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
250.000	104.167	145.833

Table 8.5-3: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
50	50	0

Table 8.5-4: *Average time of occupancy results*

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
5	27	135	400	265

Measurement Period is 20 s. Channels usage every 727 ms, hence there will be at least 20 ÷ 0.727 = 27 pulses within measurement period.

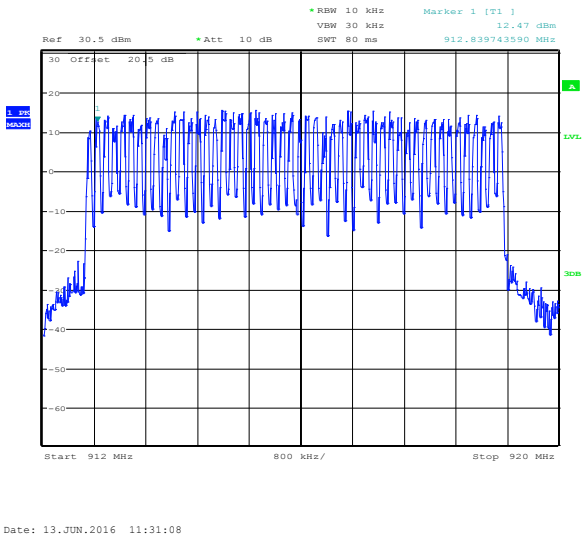


Figure 8.5-1: *Number of hopping channels*

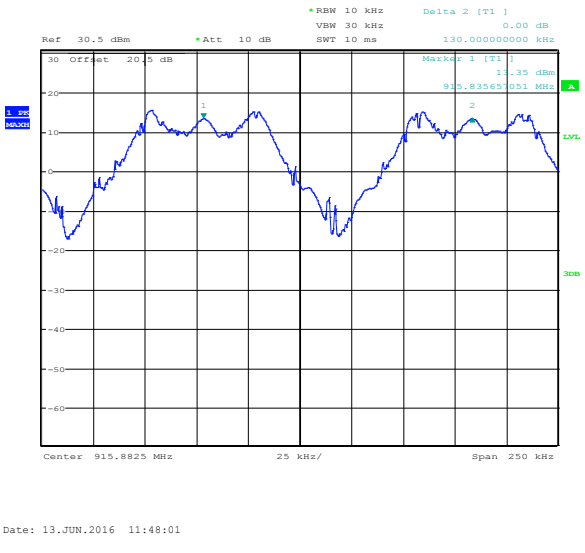


Figure 8.5-2: *Carrier frequency separation*

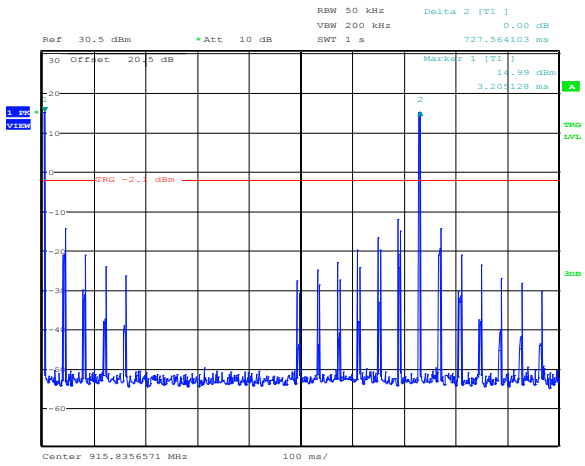


Figure 8.5-3: *Number of channel hops within 1 s*

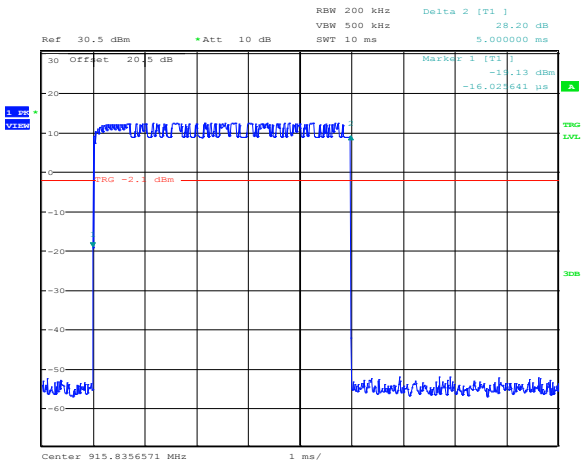
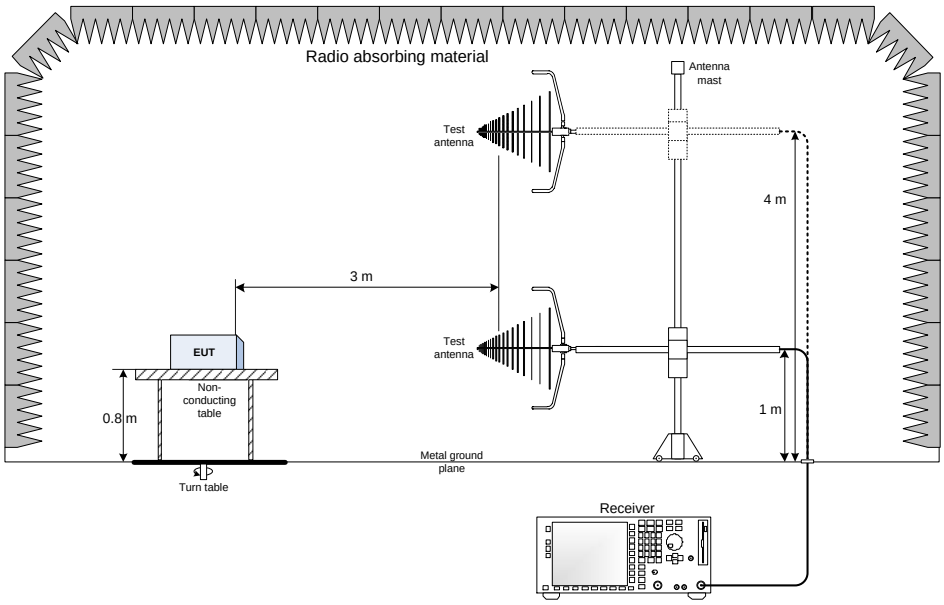


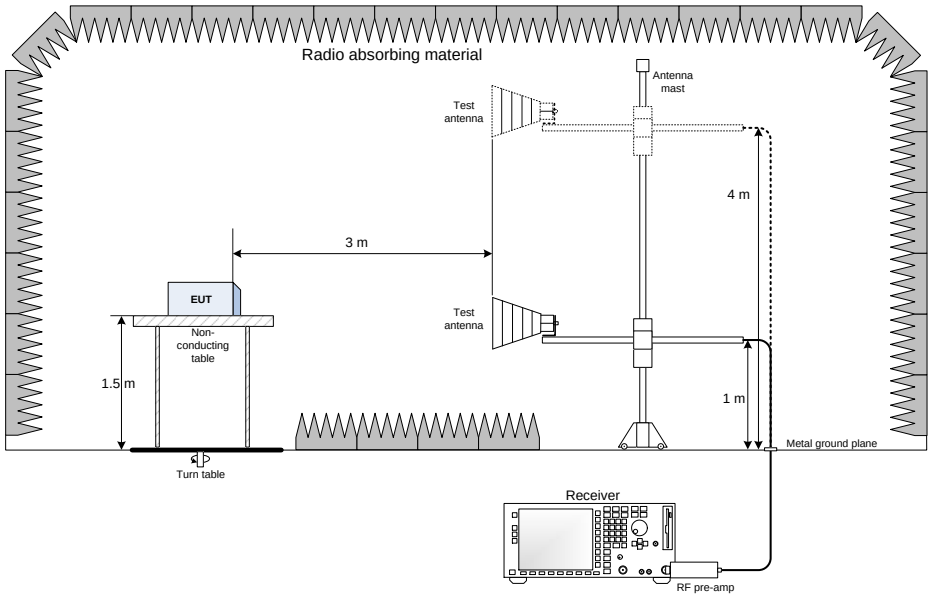
Figure 8.5-4: *Dwell time of one hop*

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