Test Report

FINAS
Finnish Accreditation Service
T004 (EN ISO/IEC 17025)

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C AND ISED CANADA REQUIREMENTS

Equipment Under Test:	Dental Tracking System
Type/ Model:	DTS Tray Reader
Manufacturer:	LM-Instruments Norrbyn rantatie 8 FI-21601 Parainen FINLAND
Customer:	LM-Instruments Norrbyn rantatie 8 FI-21601 Parainen FINLAND
FCC Rule Part:	15.247: 2017 RSS-247, Issue 2, 2017 RSS-GEN Issue 5, 2018
KDB:	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems DA 00-705 (March 30, 2000)

Date:	21 June 2018	Date:	21 June 2018
Issued by:	Mikko Halonen Testing Engineer	Checked by:	Rauno Repo Testing Engineer

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Equipment Under Test (EUT)

Dental Tracking System	
Type/ Model:	DTS Tray Reader
Serial Number:	201550.00135
FCC ID:	2AGUB70010
IC:	20970-70010

The EUT is a Dental Tracking System using RFID 902-928 MHz frequency band.
The EUT has integral antenna.

Classification of the device

Fixed device	☐
Mobile Device (Human body distance > 20cm)	☒
Portable Device (Human body distance < 20cm)	☐

Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing

Ratings and declarations

Operating Frequency Range:	902.750 – 927.250 MHz
Channels:	50
Channel separation:	500 kHz
Conducted power:	19.77 dBm
Transmission technique:	FHSS
Modulation:	PR-ASK
Integral antenna, Cross Dipole antenna:	0 dBi

Power Supply

DC Output:	12 VDC (1.25A max)
Operating voltage:	100 – 240 VAC, 50/60 Hz
Type:	FSG GROUP INC, FSPO15-RCMM, s/n: H5401000092

Disclaimer

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§15.207(a) / RSS-GEN 8.8	Conducted Emissions on Power Supply Lines	**PASS**
§15.247(b)(2) / RSS-247 5.4	Maximum Peak Conducted Output Power	**PASS**
§15.247(a)(1)(i) / RSS-247 5.1	Hopping Channel Carrier Frequency Separation	**PASS**
§15.247(a) (1)(i) / RSS-247 5.1	Number of Hopping Frequencies	**PASS**
§15.247(a) (1)(i) / RSS-247 5.1	Average Time of Occupancy of Hopping Frequency	**PASS**
§15.247(a)(1)(i) / RSS-247 5.1	20 dB Bandwidth	**PASS**
RSS-GEN 6.6	99 % Occupied Bandwidth	**PASS**
§15.247(d) / RSS-247 5.5	100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions	**PASS**
§15.209(a), §15.247(d) / RSS-247 5.5	Radiated Emissions Within The Restricted Bands	**PASS**
§15.209 / RSS-GEN 6.13	Unintentional Radiated Emissions	**PASS**
§15.109 / RSS-GEN 7.1	Unintentional Radiated Emissions	**PASS**

Following standards RSS-247 and RSS-GEN are not in the accreditation scope of the testing laboratory.

EUT Test Conditions during Testing

The EUT was in continuous transmit mode during the tests where hopping was stopped. The hopping was stopped and the EUT was configured into the wanted channel using software provided by the manufacturer.

Following channels were used during the tests:

Channel	Frequency/ MHz
LOW	902.750
MID	915.250
HIGH	927.250

Test Facility

Testing Laboratory / address: FCC registration number: **904175**	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
Test Site:	☐ Kara 10, ISED Canada registration number: **8708A-1** ☒ Kara 5, ISED Canada registration number: **8708A-2** ☐ Laru 3 ☐ Kallio 10

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz.

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	19 June 2018	
Temperature:	21 °C	
Humidity:	47 % RH	
Barometric pressure:	-	
Measurement uncertainty:	± 2.9 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.207 (a)
RSS-GEN 8.8

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors. During the test the EUT was powered from the separate power supply through the LISN.

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

*Decreases with the logarithm of the frequency.

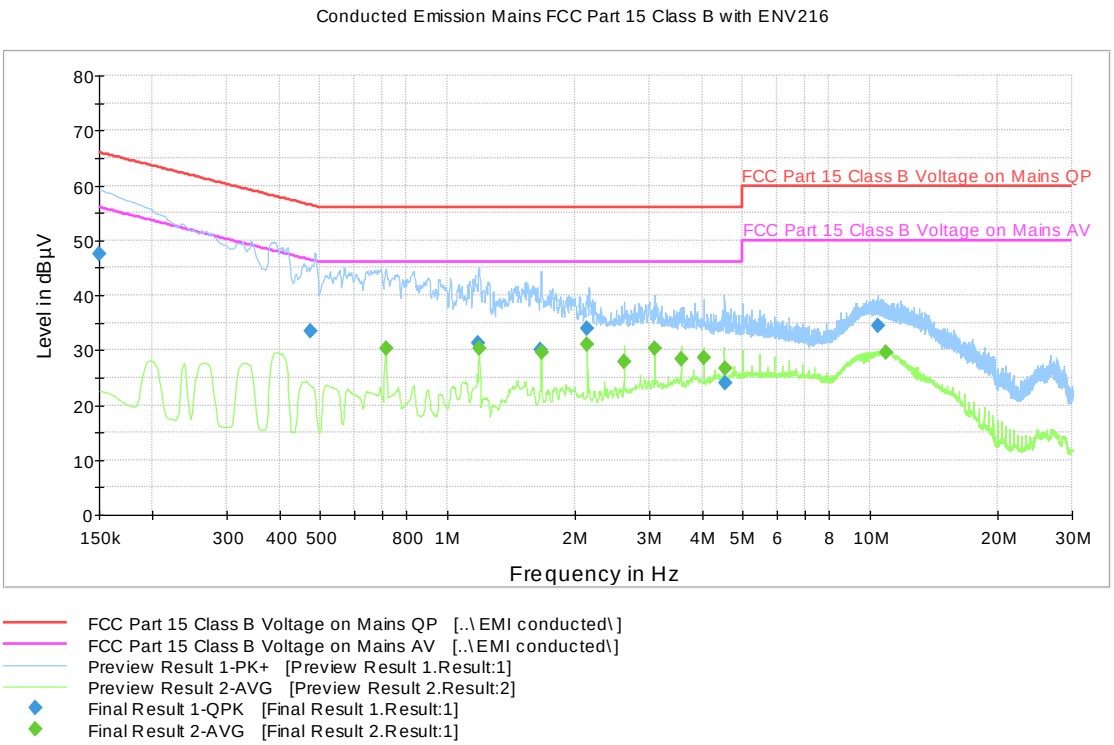


Figure 1. The measured curves with peak- and average detector

Final measurements from the worst frequencies

Table 1. Final results

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	47.5	1000	9.000	GND	L1	9.9	18.5	66.0
0.474750	33.4	1000	9.000	GND	N	10.3	23.0	56.4
1.180250	31.3	1000	9.000	GND	N	10.3	24.7	56.0
1.661250	30.1	1000	9.000	GND	N	10.4	25.9	56.0
2.144250	33.9	1000	9.000	GND	N	10.4	22.1	56.0
4.522250	23.9	1000	9.000	GND	N	10.4	32.1	56.0
10.397250	34.3	1000	9.000	GND	L1	10.3	25.7	60.0

Table 2. Final results

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.714000	30.3	1000	9.000	GND	L1	10.0	15.7	46.0
1.190500	30.4	1000	9.000	GND	L1	9.9	15.6	46.0
1.665250	29.7	1000	9.000	GND	L1	9.9	16.3	46.0
2.144000	31.0	1000	9.000	GND	L1	9.9	15.0	46.0
2.617000	27.9	1000	9.000	GND	L1	10.0	18.1	46.0
3.095750	30.3	1000	9.000	GND	L1	10.0	15.7	46.0
3.570500	28.4	1000	9.000	GND	L1	10.0	17.6	46.0
4.047500	28.7	1000	9.000	GND	L1	10.0	17.3	46.0
4.522250	26.6	1000	9.000	GND	L1	10.0	19.4	46.0
10.893250	29.5	1000	9.000	GND	L1	10.3	20.5	50.0

Maximum Peak Conducted Output Power

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	19 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	
Measurement uncertainty	± 2.87dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(b) (2)
RSS-247 5.4(d)

For frequency hopping systems operating in the 902 - 928 MHz band: 1 watt for systems employing at least 50 hopping channels. Maximum Conducted Output Power is defined as 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 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.

Results:

Table 3. Final results

Channel	Conducted Power [dBm]	Limit [dBm]	Result
Low	19.36	30	PASS
Mid	19.58	30	PASS
High	19.77	30	PASS

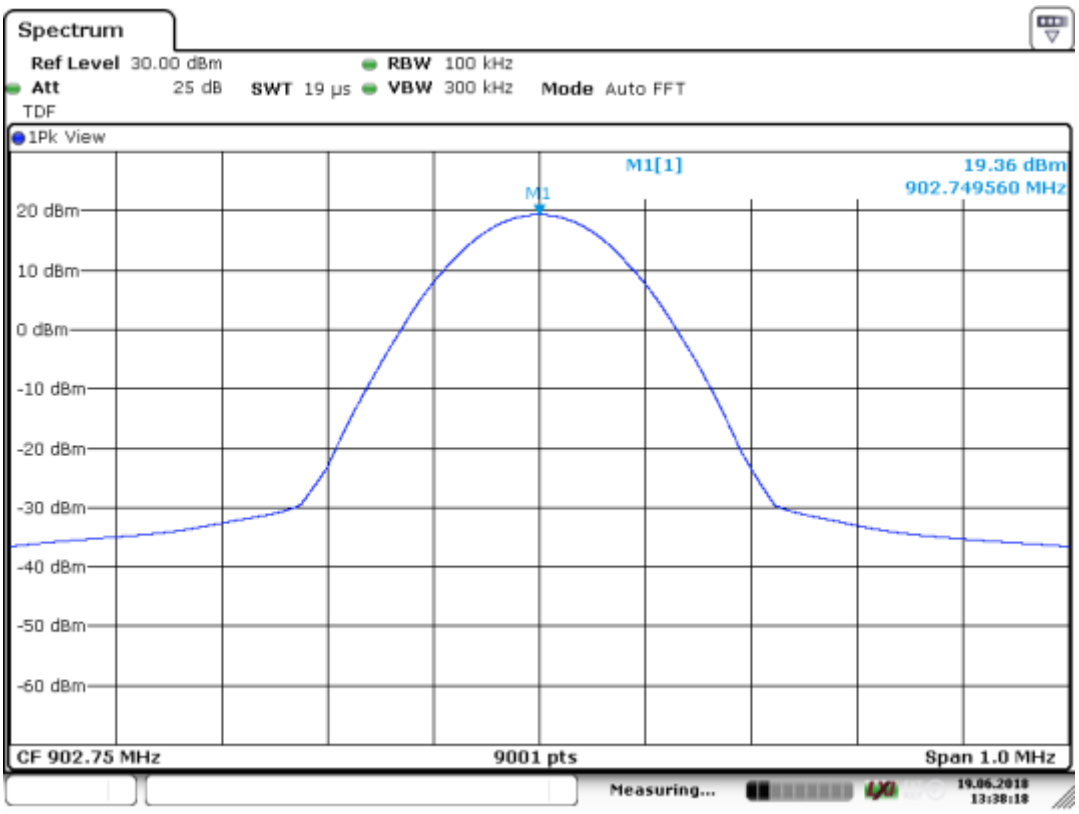


Figure 2. Channel LOW

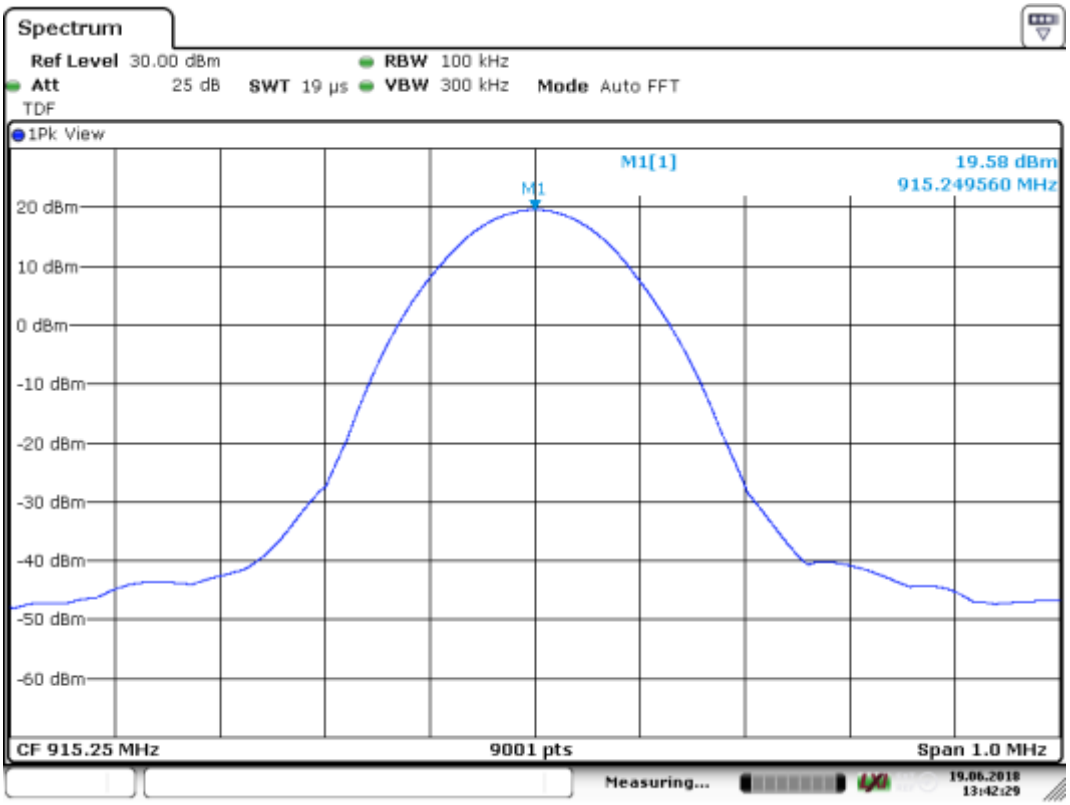


Figure 3. Channel MID

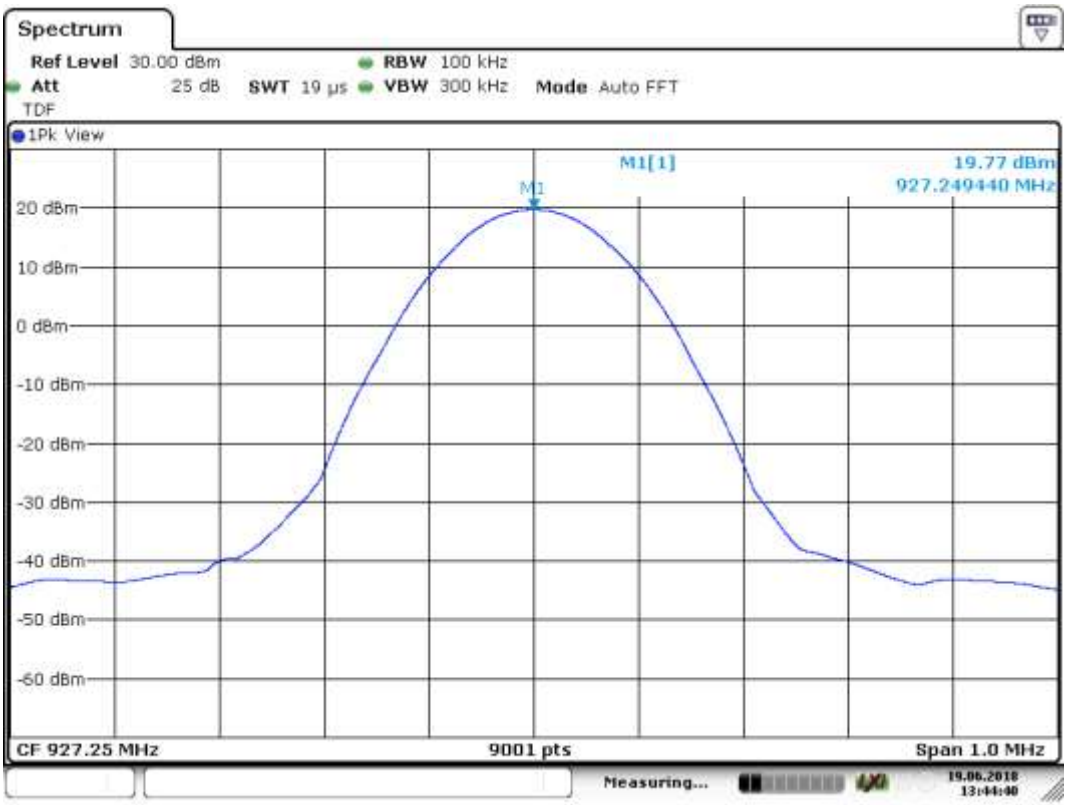


Figure 4. Channel HIGH

Transmitter and Receiver Radiated Emissions 30 MHz to 10 GHz

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	18 – 19 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	
Measurement uncertainty	± 4.51 dB	Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a), 15.109
RSS-247 5.5, RSS-GEN 6.13, RSS-GEN 7.1

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 Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a)**.**

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables).
The result value is the measured value corrected with the correction factor.

Frequency range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector
30 - 80	100	40.0	Quasi-peak
88 - 216	150	43.5	Quasi-peak
216 - 960	200	46.0	Quasi-peak
960 - 1000	500	53.9	Quasi-peak
Above 1000	500	53.9	Average
Above 1000	5000	73.9	Peak

Low channel

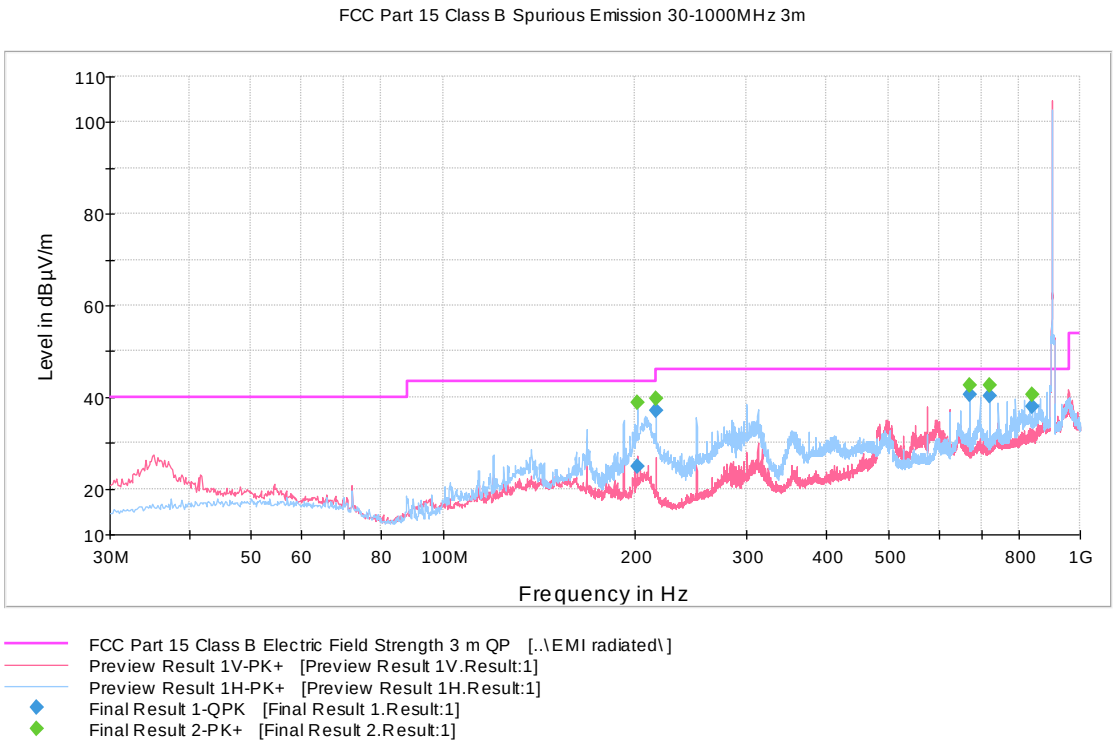


Figure 5. Measured curve with peak-detector. 30-1000 MHz channel LOW

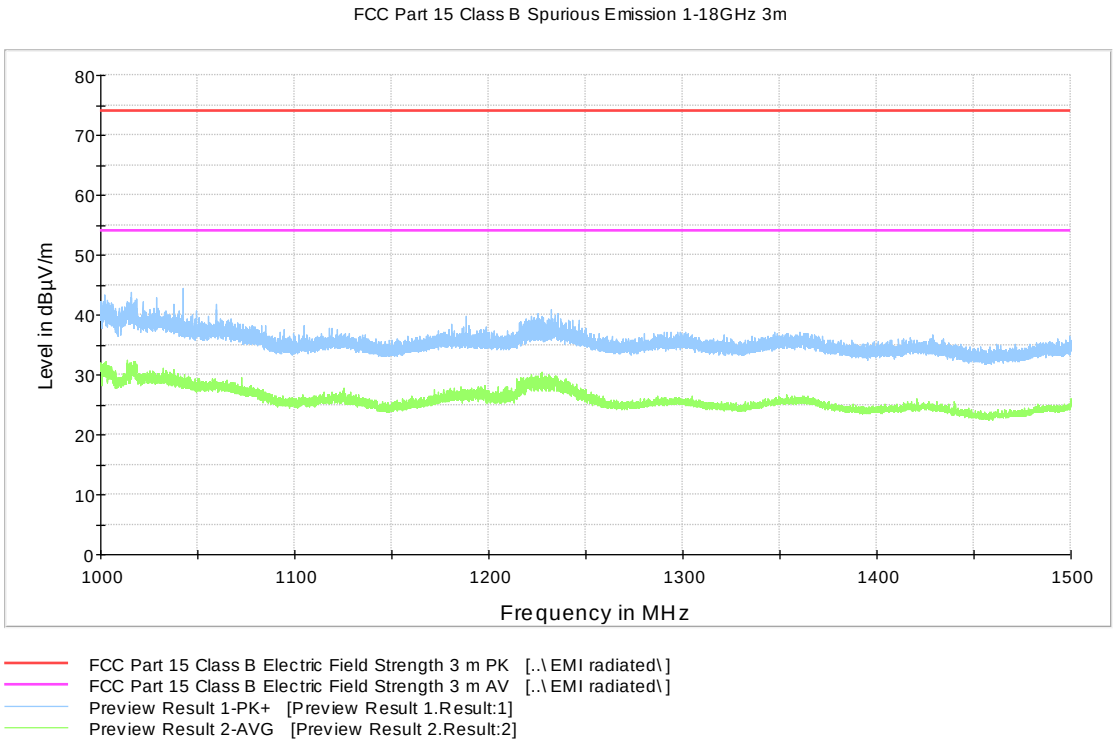


Figure 6. Measured curve with peak- and average detector. 1.0-1.5 GHz channel LOW

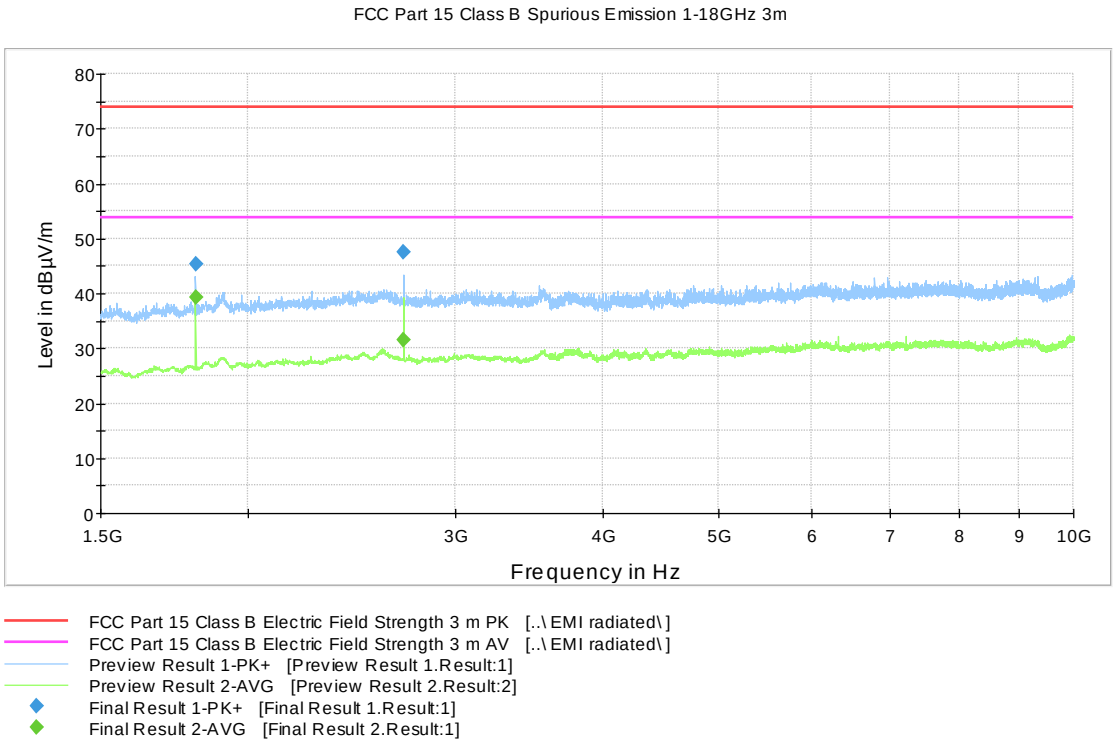


Figure 7. Measured curve with peak- and average detector. 1.5-10 GHz channel LOW

Table 4. Final measurements from the worst frequencies 30 – 10000 MHz channel LOW

Frequency (MHz)	Result (dBµV/m)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBµV/m)	Comment
201.635000	24.8	QP	120	18.7	43.5	PASS
216.035000	36.9	QP	120	9.1	46.0	PASS
672.035000	40.6	QP	120	5.4	46.0	PASS
720.035000	40.4	QP	120	5.6	46.0	PASS
840.035000	37.9	QP	120	8.1	46.0	PASS
1805.450000	45.3	Peak	1000	28.6	73.9	PASS
2708.200000	47.4	Peak	1000	26.5	73.9	PASS
1805.450000	39.3	AVG	1000	14.6	53.9	PASS
2708.200000	31.4	AVG	1000	22.5	53.9	PASS

Middle channel

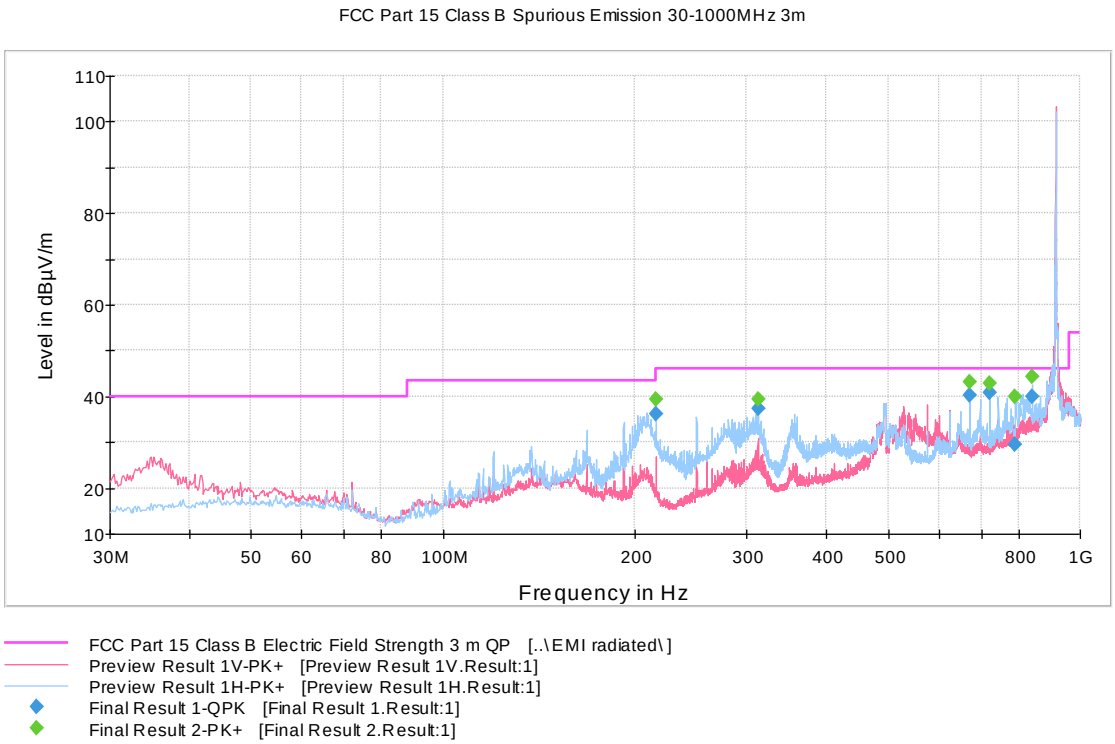


Figure 8. Measured curve with peak-detector. 30-1000 MHz channel MID

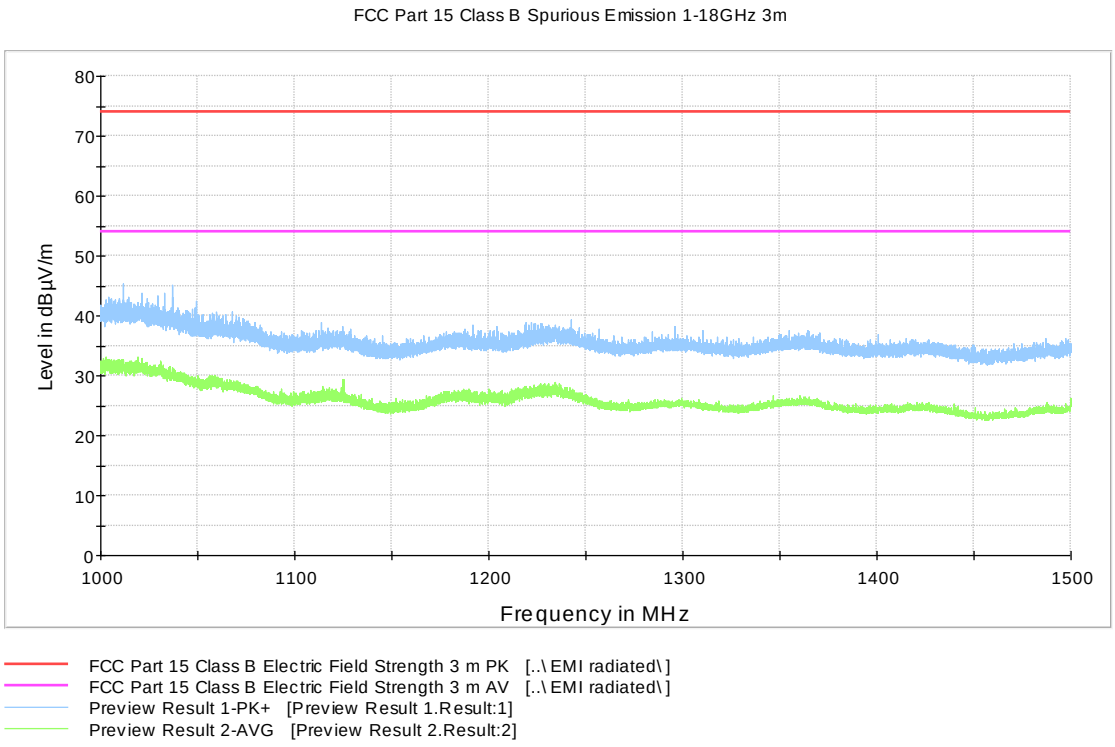


Figure 9. Measured curve with peak- and average detector. 1.0-1.5 GHz channel MID

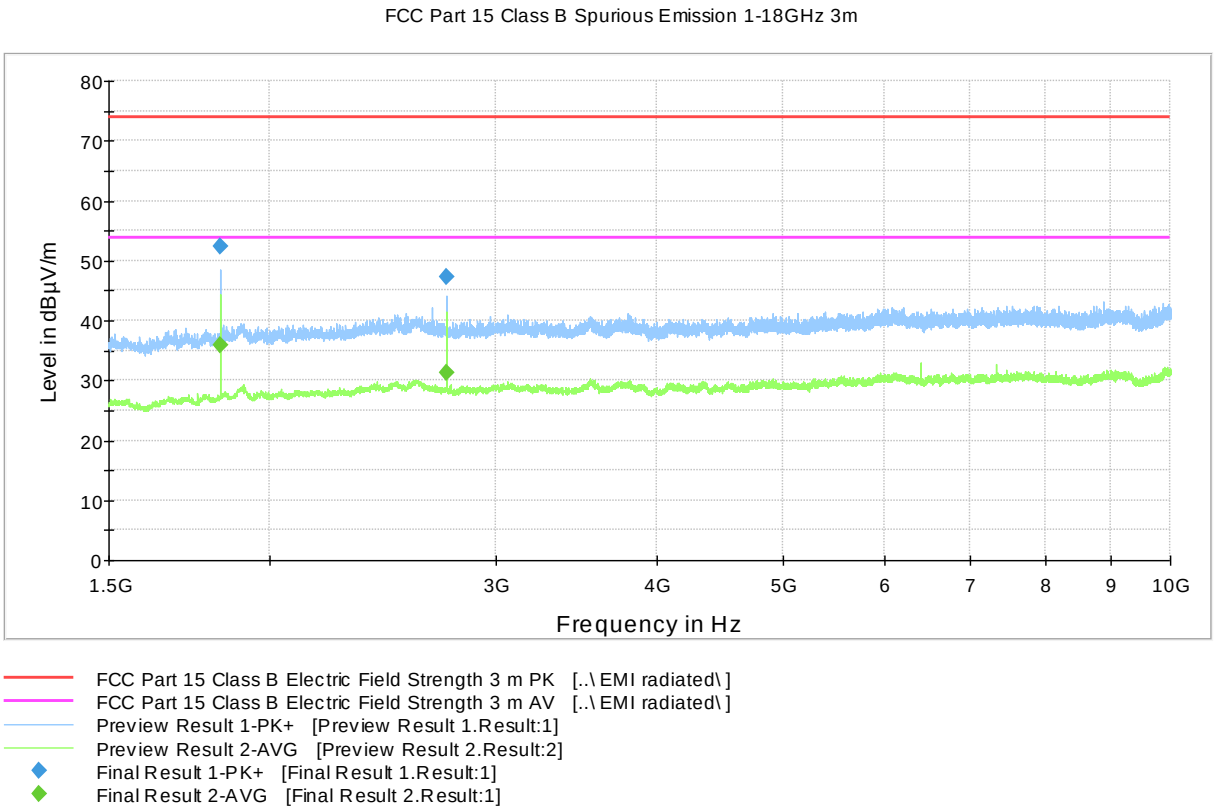


Figure 10. Measured curve with peak- and average detector. 1.5-10 GHz channel MID

Table 5. Final measurements from the worst frequencies 30 – 10000 MHz.channel MID

Frequency (MHz)	Result (dBµV/m)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBµV/m)	Comment
216.035000	36.2	QP	120	9.8	46.0	PASS
312.015000	37.4	QP	120	8.6	46.0	PASS
672.035000	40.3	QP	120	5.7	46.0	PASS
720.035000	40.7	QP	120	5.3	46.0	PASS
790.965000	29.5	QP	120	16.5	46.0	PASS
840.035000	39.9	QP	120	6.1	46.0	PASS
1830.425000	52.4	Peak	1000	21.5	73.9	PASS
2745.675000	47.2	Peak	1000	26.7	73.9	PASS
1830.425000	35.9	AVG	1000	18.0	53.9	PASS
2745.675000	31.3	AVG	1000	22.6	53.9	PASS

High channel

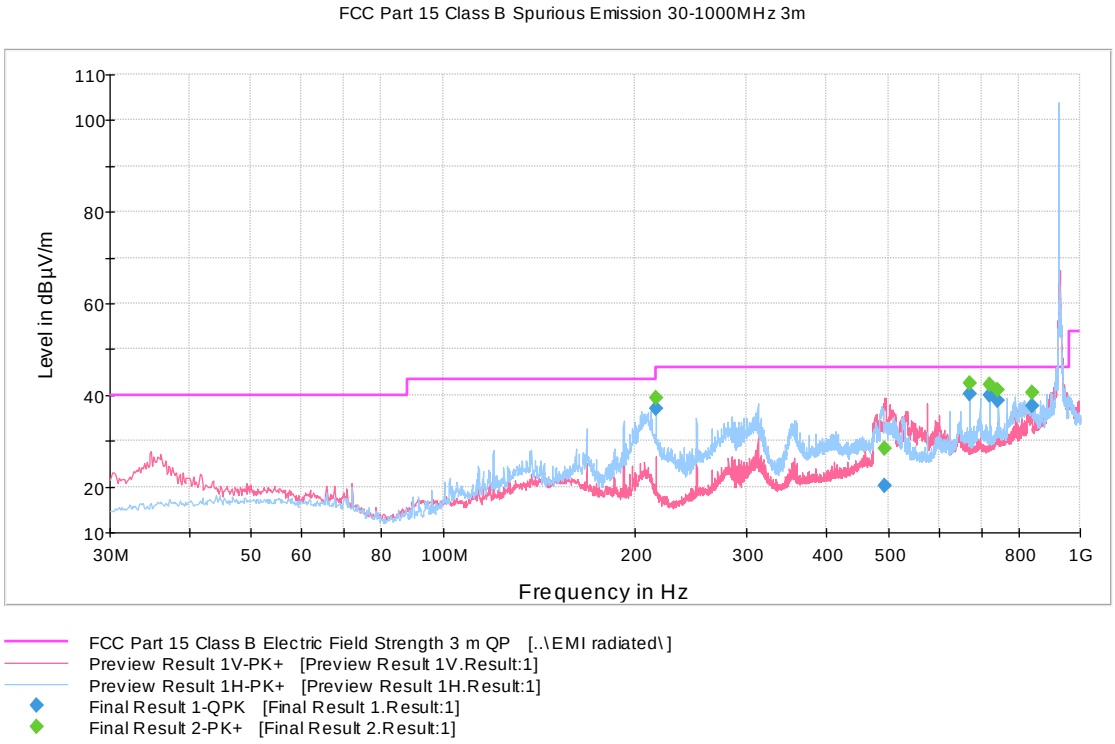


Figure 11. Measured curve with peak-detector. 30-1000 MHz channel HIGH

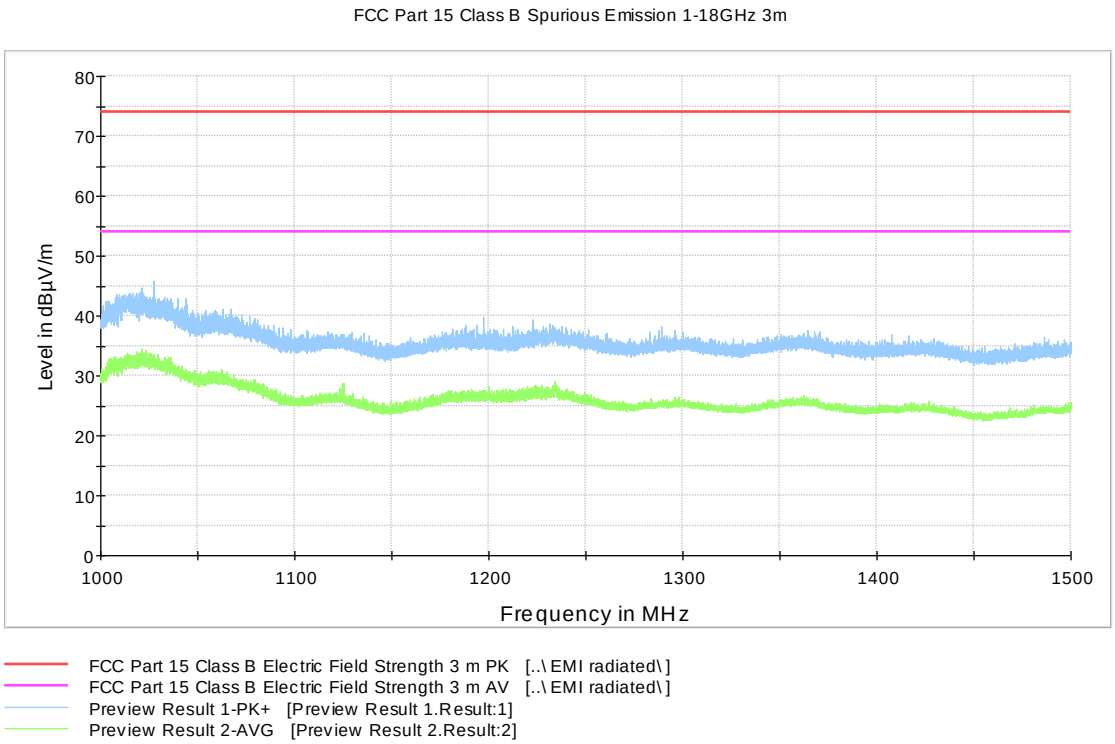


Figure 12. Measured curve with peak- and average detector. 1.0-1.5 GHz channel HIGH

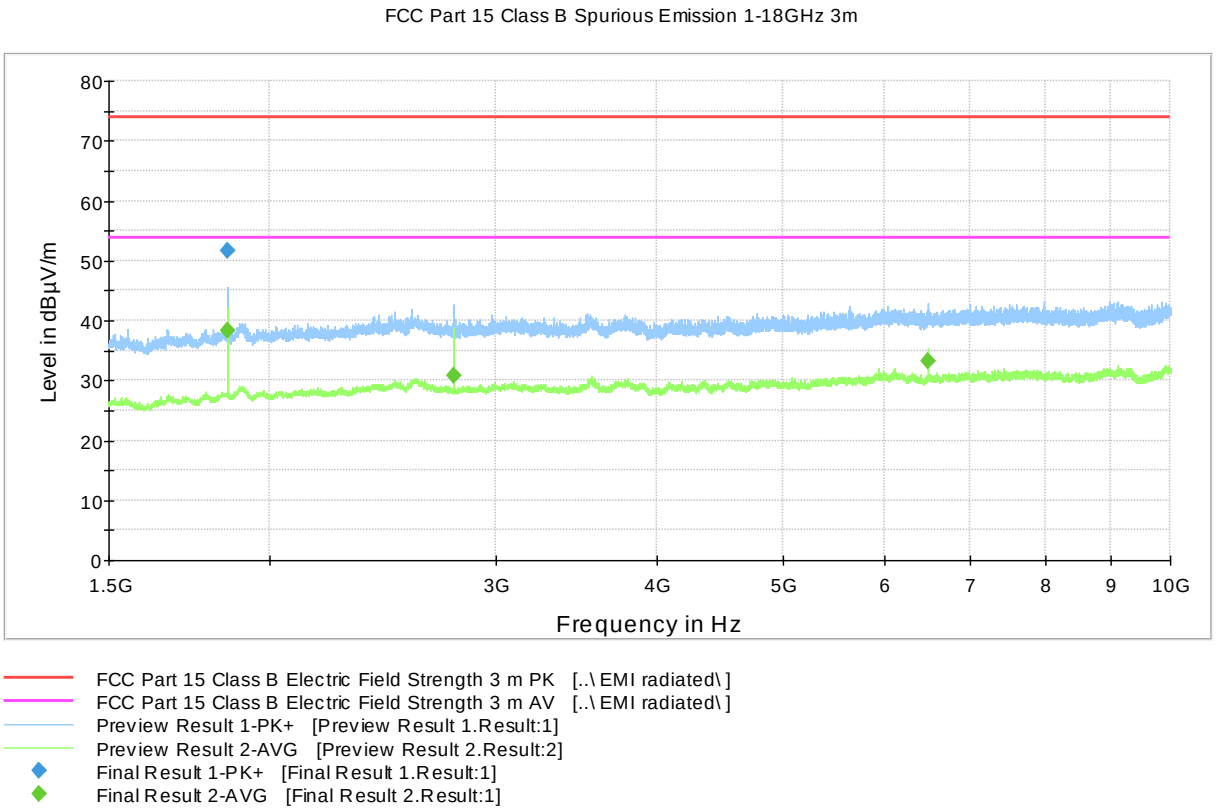


Figure 13. Measured curve with peak- and average detector. 1.5-10 GHz channel HIGH

Table 6. Final measurements from the worst frequencies 30 – 10000 MHz channel HIGH

Frequency (MHz)	Result (dBµV/m)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBµV/m)	Comment
216.005000	36.9	QP	120	9.1	46.0	PASS
492.645000	20.3	QP	120	25.8	46.0	PASS
672.035000	40.2	QP	120	5.8	46.0	PASS
720.015000	40.1	QP	120	5.9	46.0	PASS
744.035000	38.7	QP	120	7.3	46.0	PASS
840.035000	37.7	QP	120	8.3	46.0	PASS
1854.425000	51.6	Peak	1000	22.3	73.9	PASS
1854.425000	38.2	AVG	1000	15.7	53.9	PASS
2781.600000	30.7	AVG	1000	23.2	53.9	PASS
6490.775000	33.1	AVG	1000	20.8	53.9	PASS

Conducted Spurious Emissions 9kHz to 10 GHz and Band Edge

Standard: ANSI C63.10 (2013)
Tested by: MIH
Date: 19 – 20 June 2018
Temperature: 15 - 30 °C
Humidity: 10 - 90 %

FCC Rule: 15.247 (d)
RSS-247 5.5

Table 7. Final measurements from the worst frequencies 9 kHz – 10000 MHz. Channel low

Frequency (MHz)	Result (dBc)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBc)	Comment
0.09-0.15	-	Peak	1	>20	-20	PASS
0.15-30	-	Peak	10	>20	-20	PASS
30-1000	-	Peak	100	>20	-20	PASS
1000-10000	-	Peak	100	>20	-20	PASS

Table 8. Final measurements from the worst frequencies 9 kHz – 10000 MHz. Channel mid

Frequency (MHz)	Result (dBc)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBc)	Comment
0.09-0.15	-	Peak	1	>20	-20	PASS
0.15-30	-	Peak	10	>20	-20	PASS
30-1000	-	Peak	100	>20	-20	PASS
1000-10000	-	Peak	100	>20	-20	PASS

Table 9. Final measurements from the worst frequencies 9 kHz – 10000 MHz. Channel high

Frequency (MHz)	Result (dBc)	Detector	Bandwidth (kHz)	Margin (dB)	Limit (dBc)	Comment
0.09-0.15	-	Peak	1	>20	-20	PASS
0.15-30	-	Peak	10	>20	-20	PASS
30-1000	-	Peak	100	>20	-20	PASS
1000-10000	-	Peak	100	>20	-20	PASS

Table 10. Conducted band edge

Channel	Non hopping Power [dBc]	Hopping Power [dBc]
Low	-50.51	-62.98
High	-45.80	-47.72

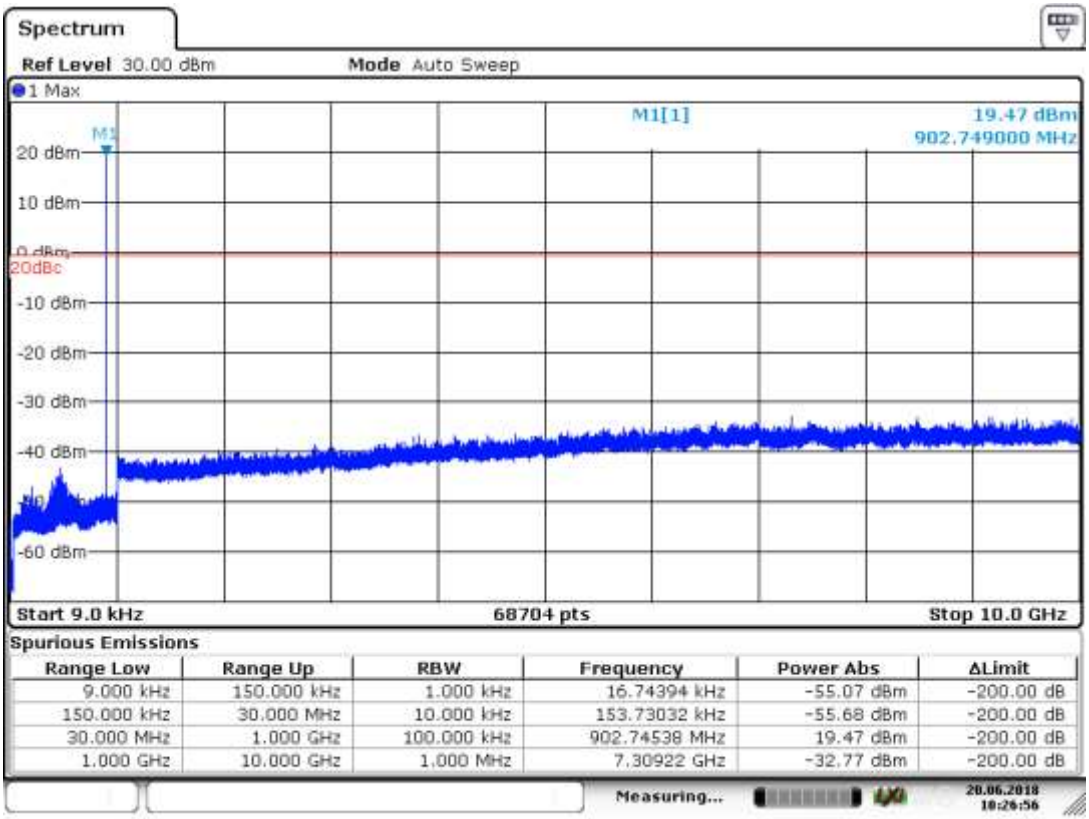


Figure 14. Low channel conducted emission 9 kHz to 10 GHz

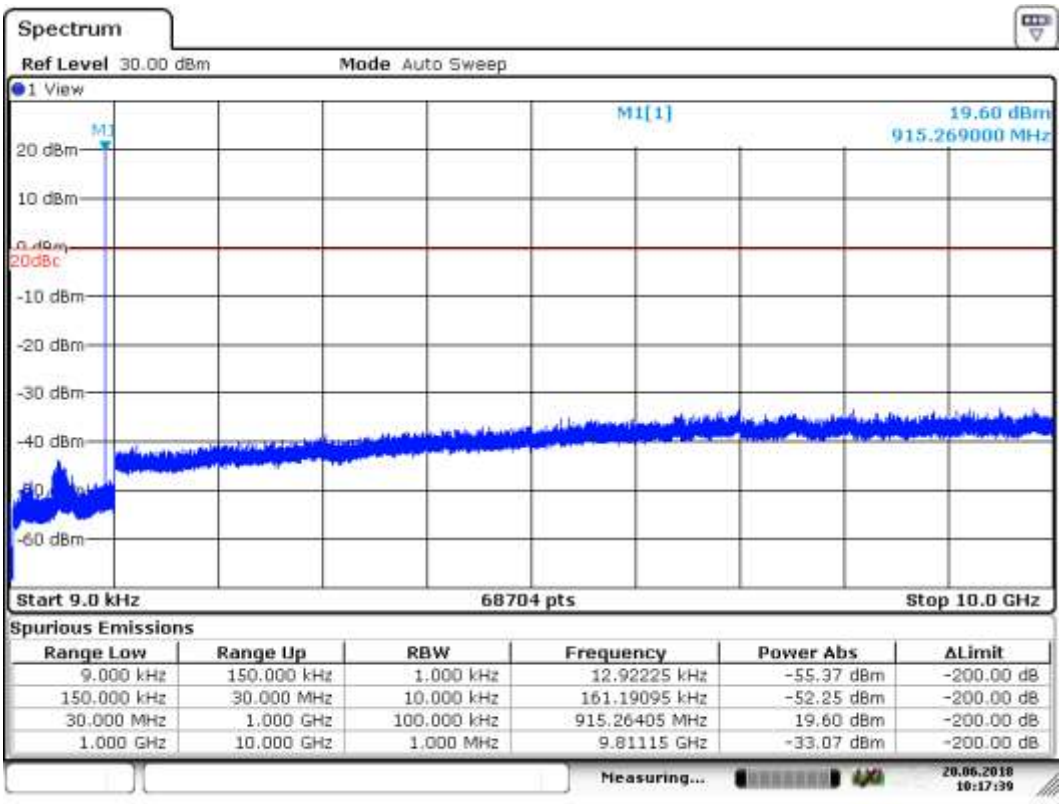


Figure 15. Mid channel conducted emission 9 kHz to 10 GHz

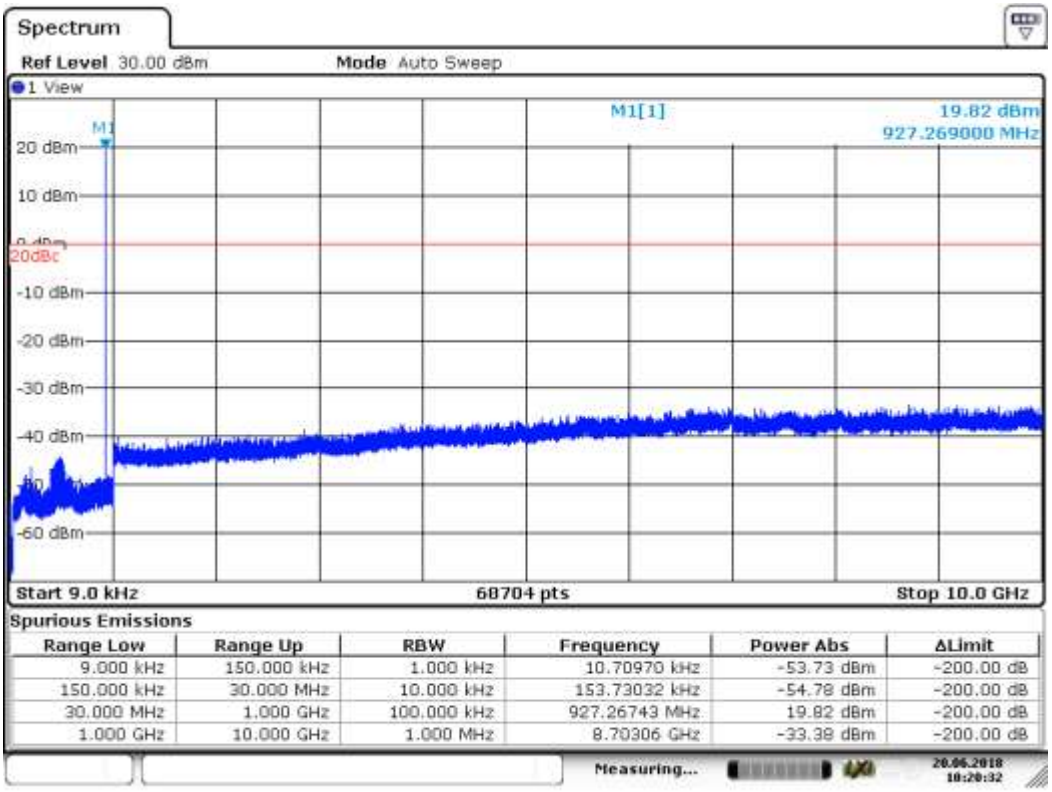


Figure 16. High channel conducted emission 9 kHz to 10 GHz

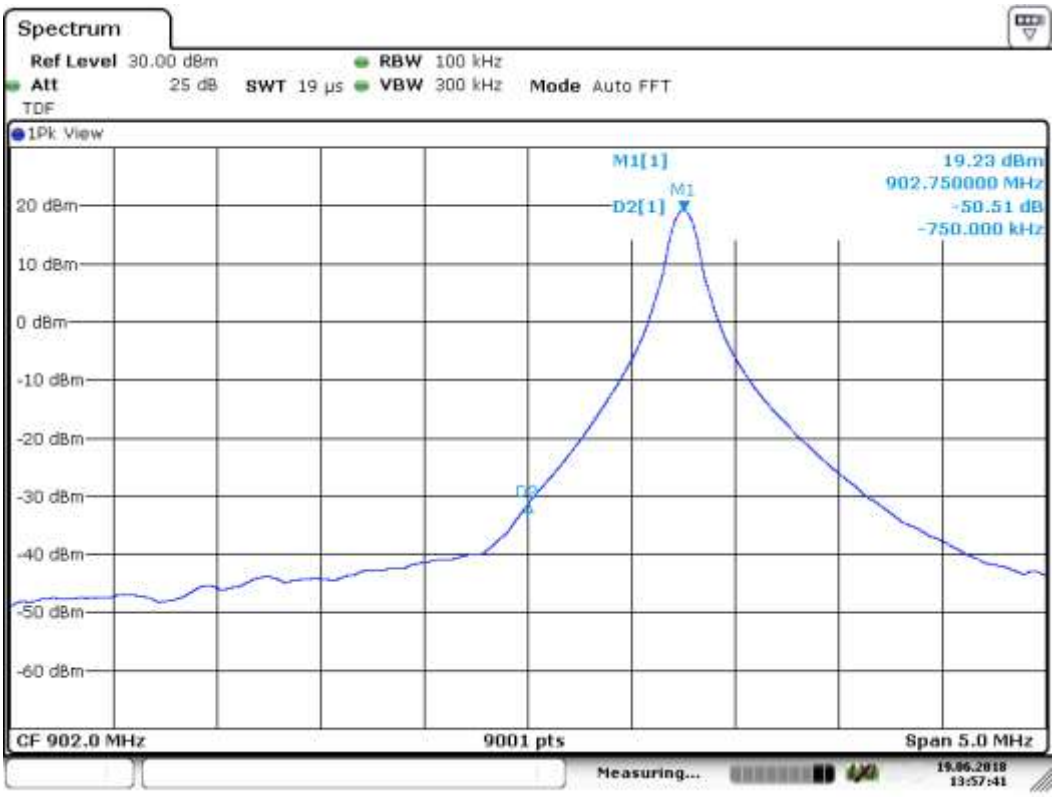


Figure 17. Conducted emission at low band edge hopping disabled

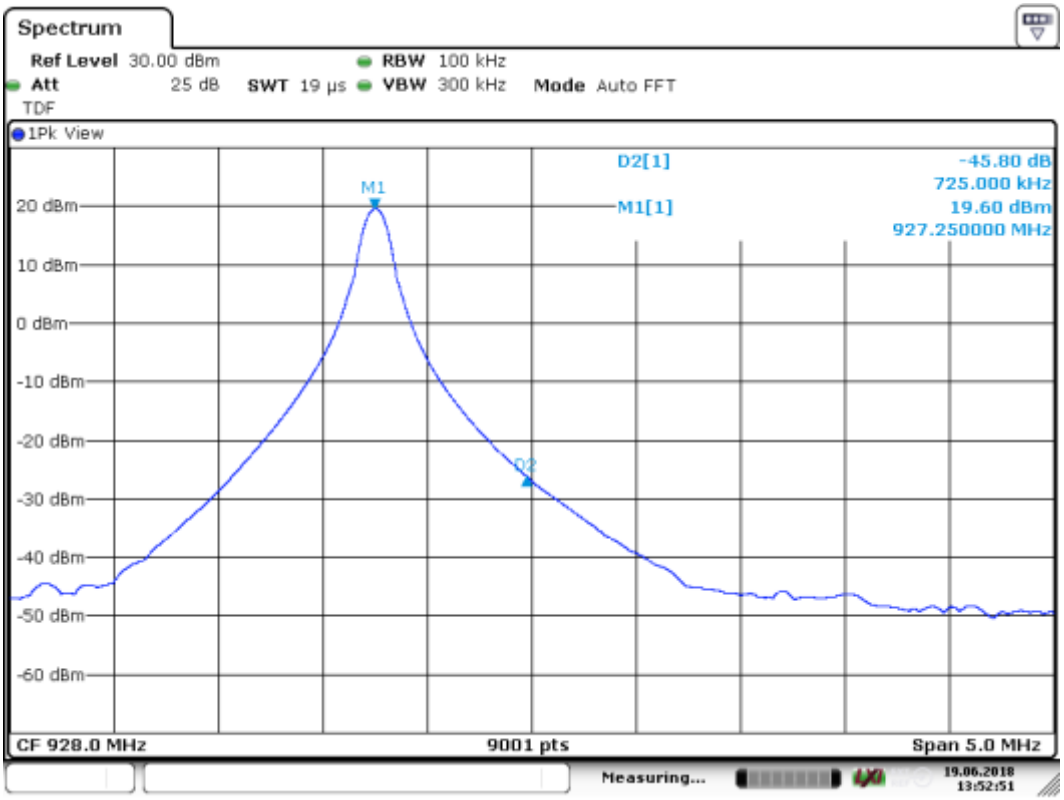


Figure 18. Conducted emission at high band edge hopping disabled

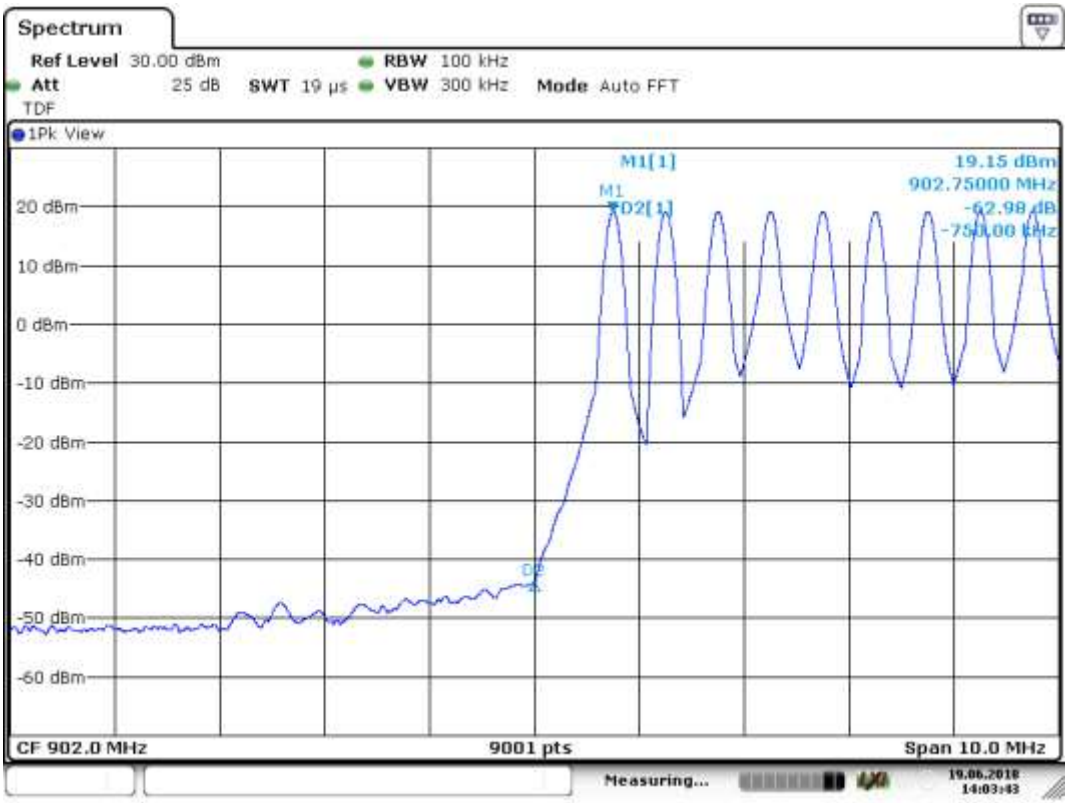


Figure 19. Conducted emission at low band edge hopping enabled

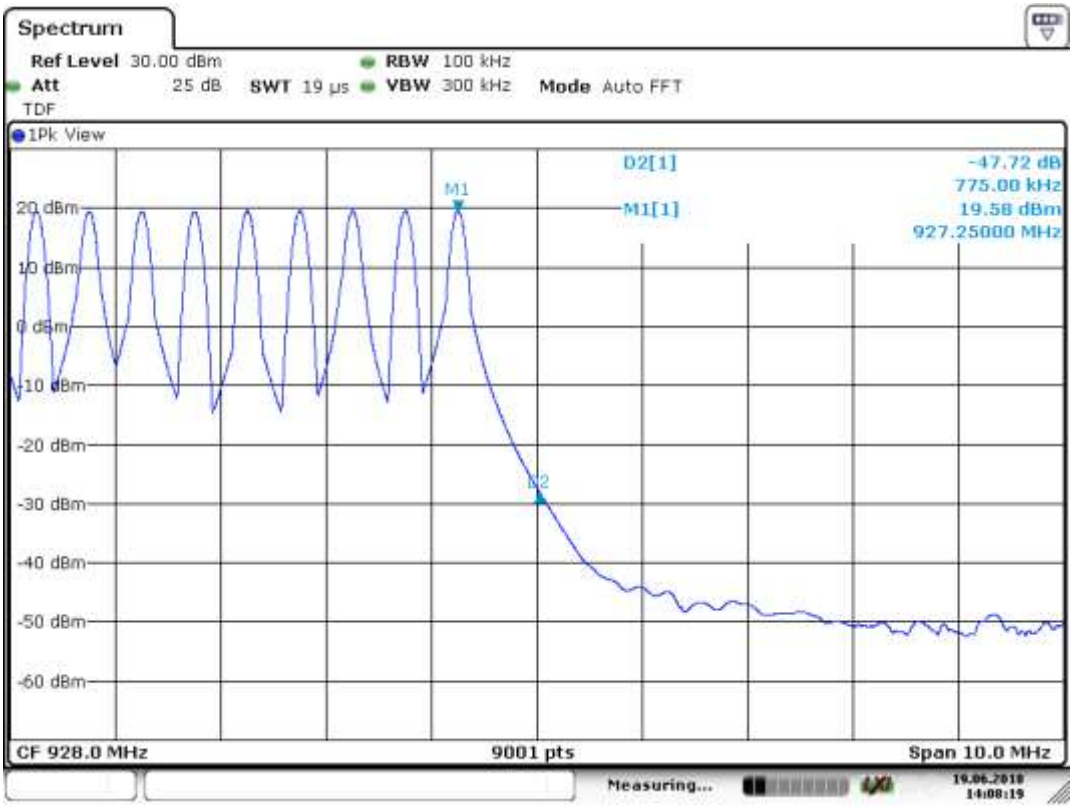


Figure 20. Conducted emission at high band edge hopping enabled

20 dB Bandwidth of the Hopping Channel

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	19 June 2015	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	

FCC Rule: §15.247(a)(1)(i)
RSS-247 5.1

Results:

Table 11. 20 dB bandwidth test results

Channel	20 dB BW [kHz]	Minimum limit [kHz]	Result
Low	47.86	-	PASS
Mid	48.00		PASS
High	47.88		PASS

Figure 21. 20 dB channel BW channel LOW

Figure 22. 20 dB channel BW channel MID

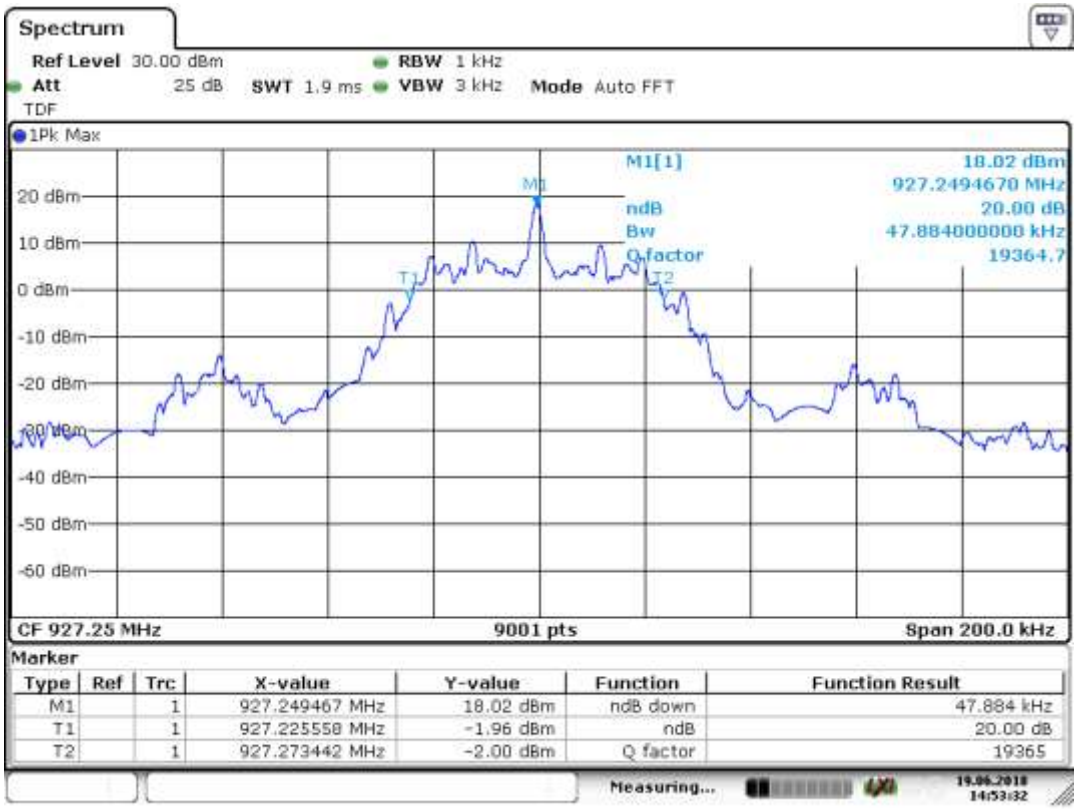


Figure 23. 20 dB channel BW channel HIGH

Hopping Channel Carrier Frequencies Separation

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	19 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	

FCC Rule: 15.247(a)(1)(i)
RSS-247 5.1

Test result

Table 12. Hopping channel carrier frequencies separation test result

Channel Separation [kHz]	Minimum limit	Result
500	20dB BW	PASS

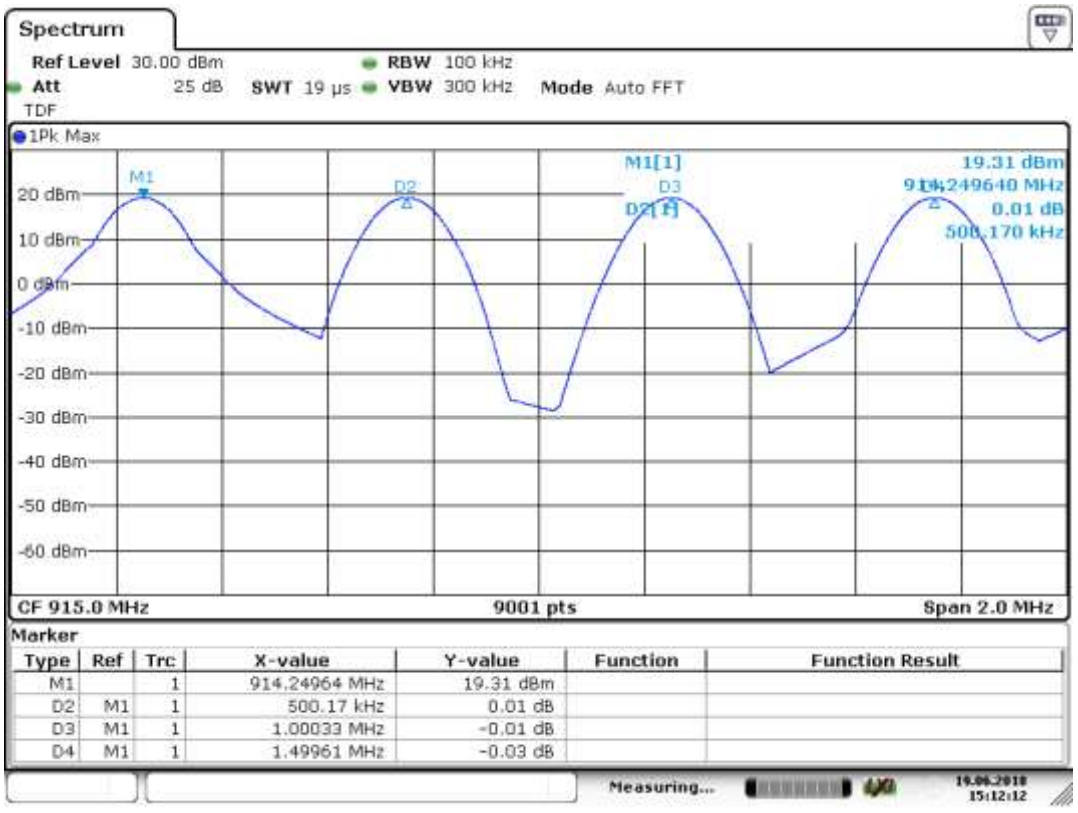


Figure 24. Measured hopping channels carrier frequency separation

Number of Hopping Channels

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	19 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	

FCC Rule: 15.247(a)(1)(i)
RSS-247 5.1

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 channels.

Test result

Table 13. Number of hopping channels

Operating frequency [MHz]	Number of channels	Total Number of channels	Minimum Limit	Result
902.75 - 927.25	50	50	50	PASS

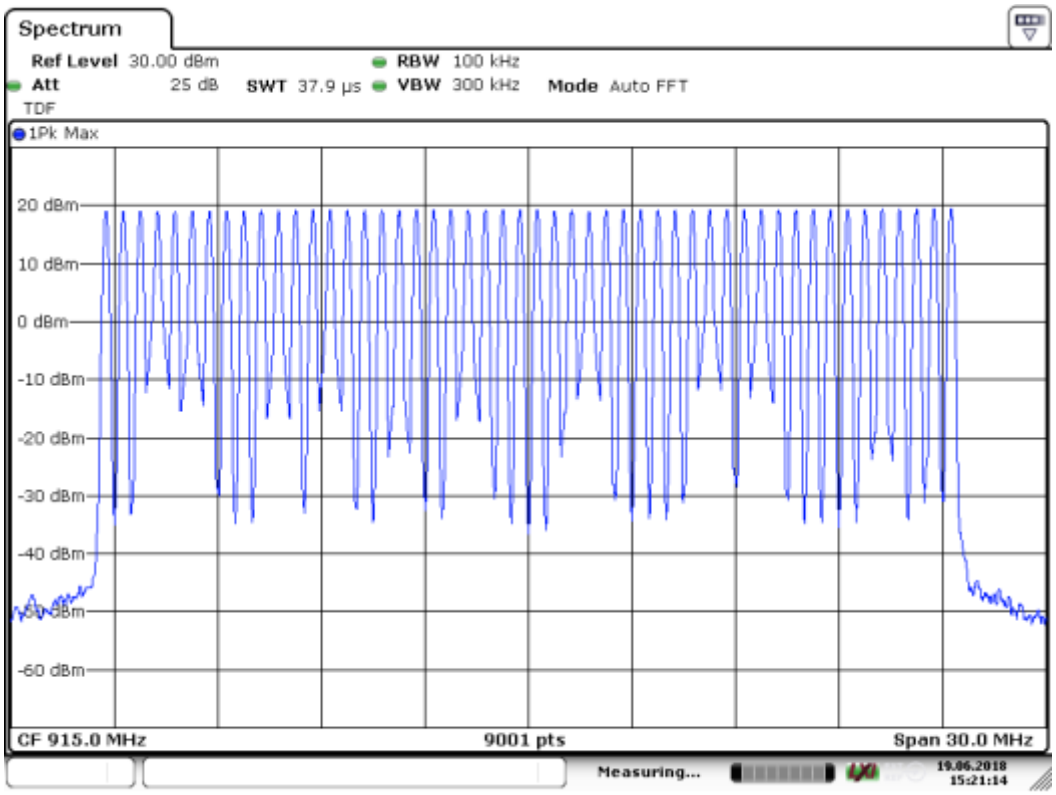


Figure 25. 50 channels

Average Time of Occupancy of Hopping Frequency

Standard:	ANSI C63.10	(2013)
Tested by:	MIH	
Date:	20 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	

FCC Rule: 15.247(a)(1)(i)
RSS-247 5.1

The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Time of occupancy calculation:
Number of channels = 50
Measurement period = 20 s
One channel occupancy time = 252.2 ms
Number of transmission cycles in measurement period = 1
Time of occupancy = (single duration) x (repetition) = 20.83 ms x 12 + 2.2 ms = 252.2 ms

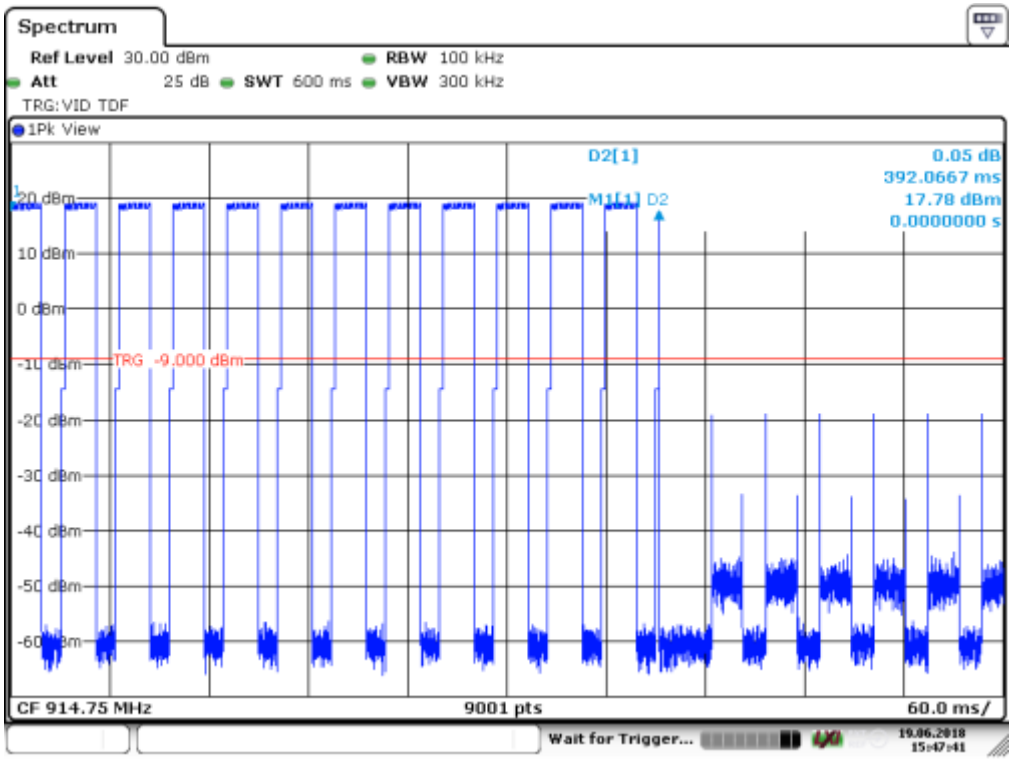


Figure 26. One channel dwell time

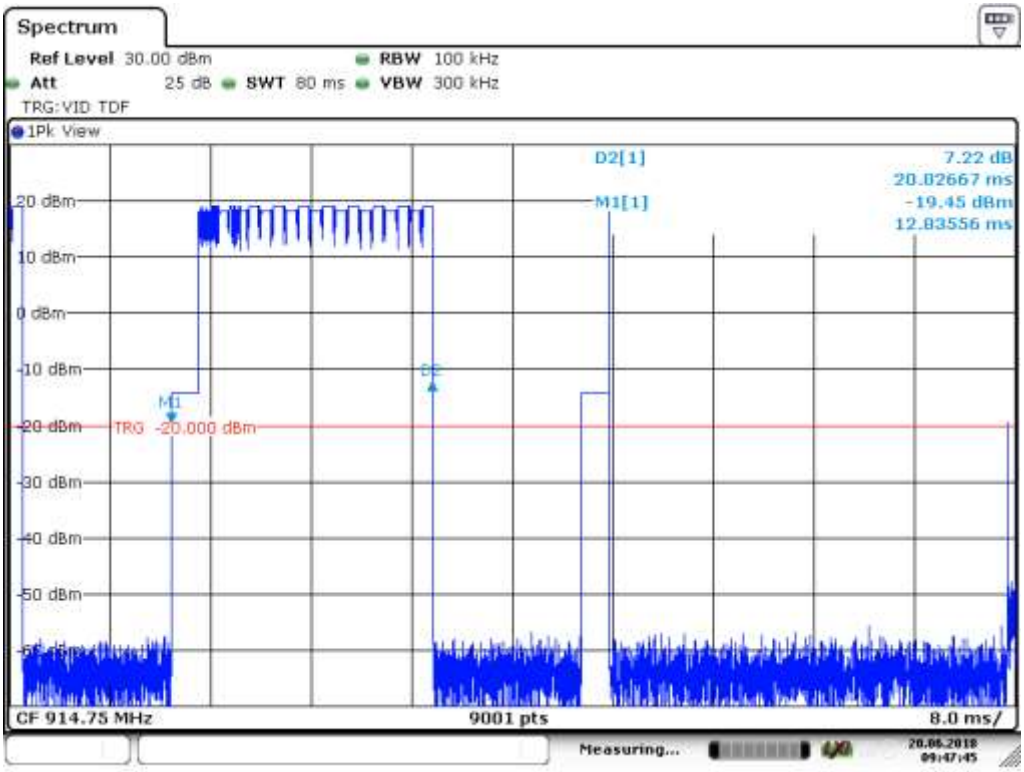


Figure 27. Time of single pulse

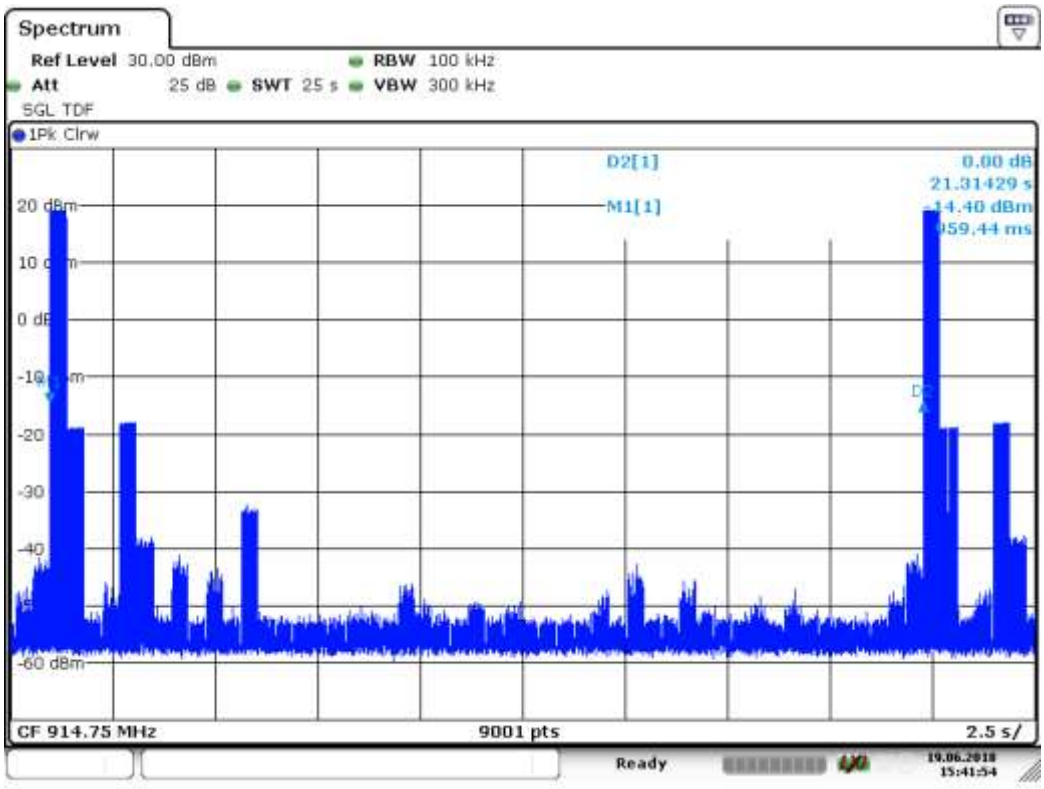


Figure 28. Measured repetition of the channel occupancy

99% Occupied Power Bandwidth

Standard:	RSS-GEN	(2013)
Tested by:	MIH	
Date:	19 June 2018	
Temperature:	15 - 30 °C	
Humidity:	10 - 90 %	

RSS-GEN 6.6

Results:

Table 14. 99% Occupied Bandwidth

Channel	99% BW [kHz]	Limit	Result
Low	54.88	-	PASS
Mid	54.71	-	PASS
High	54.91	-	PASS

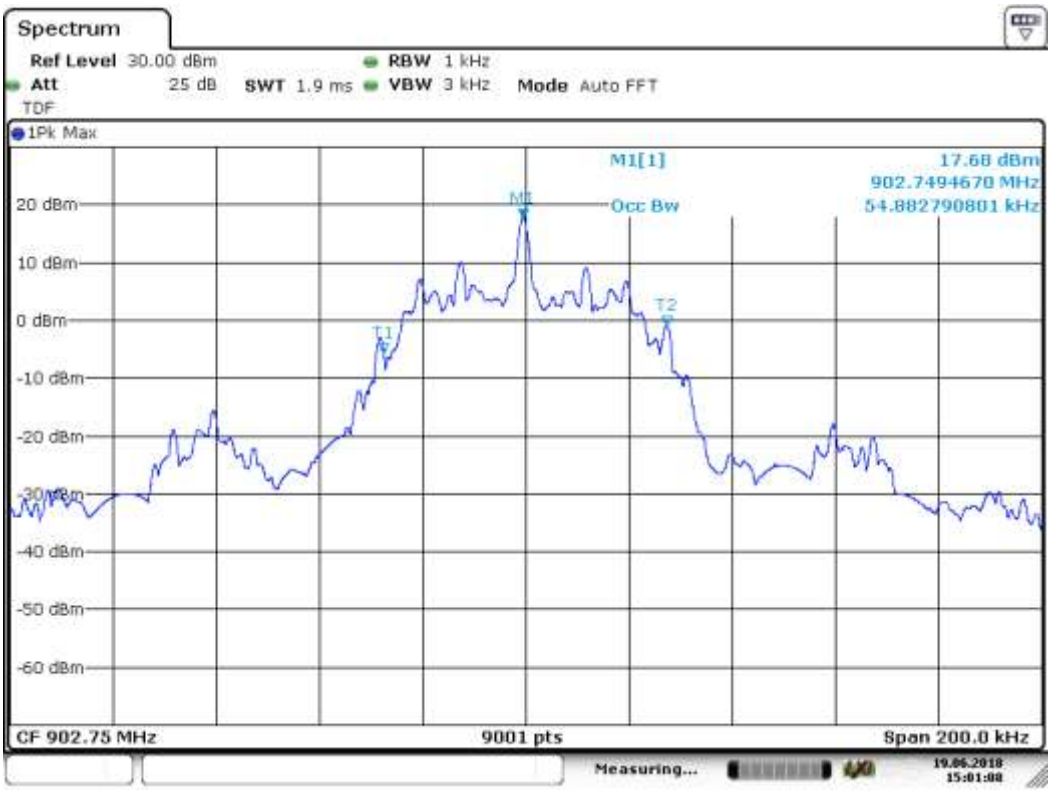


Figure 29. Low channel 99% Occupied Power Bandwidth

Figure 30. Mid channel 99% Occupied Power Bandwidth

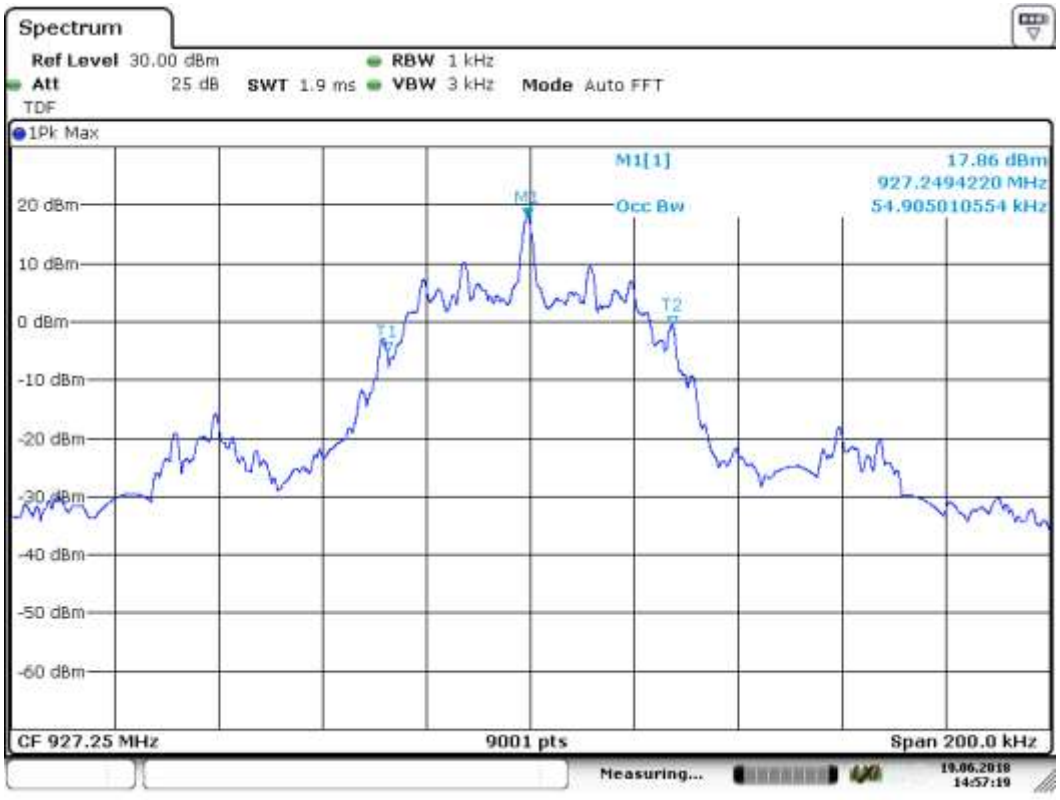


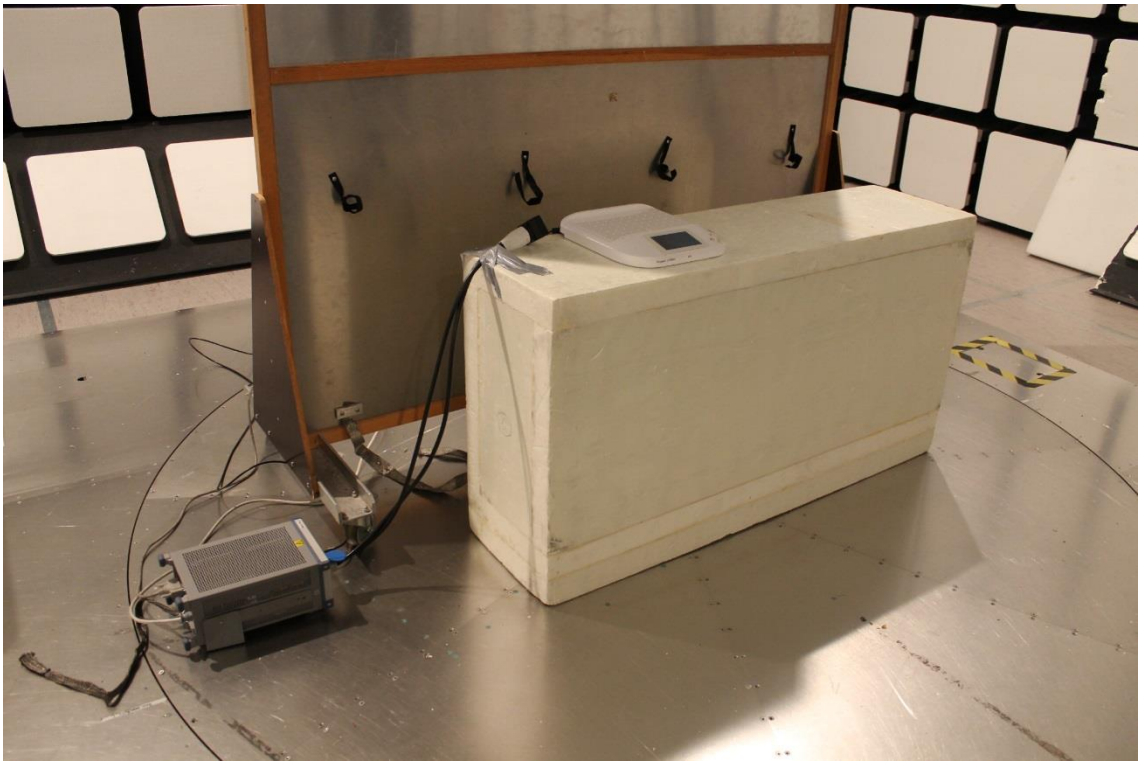
Figure 31. High channel 99% Occupied Power Bandwidth

TEST EQUIPMENT

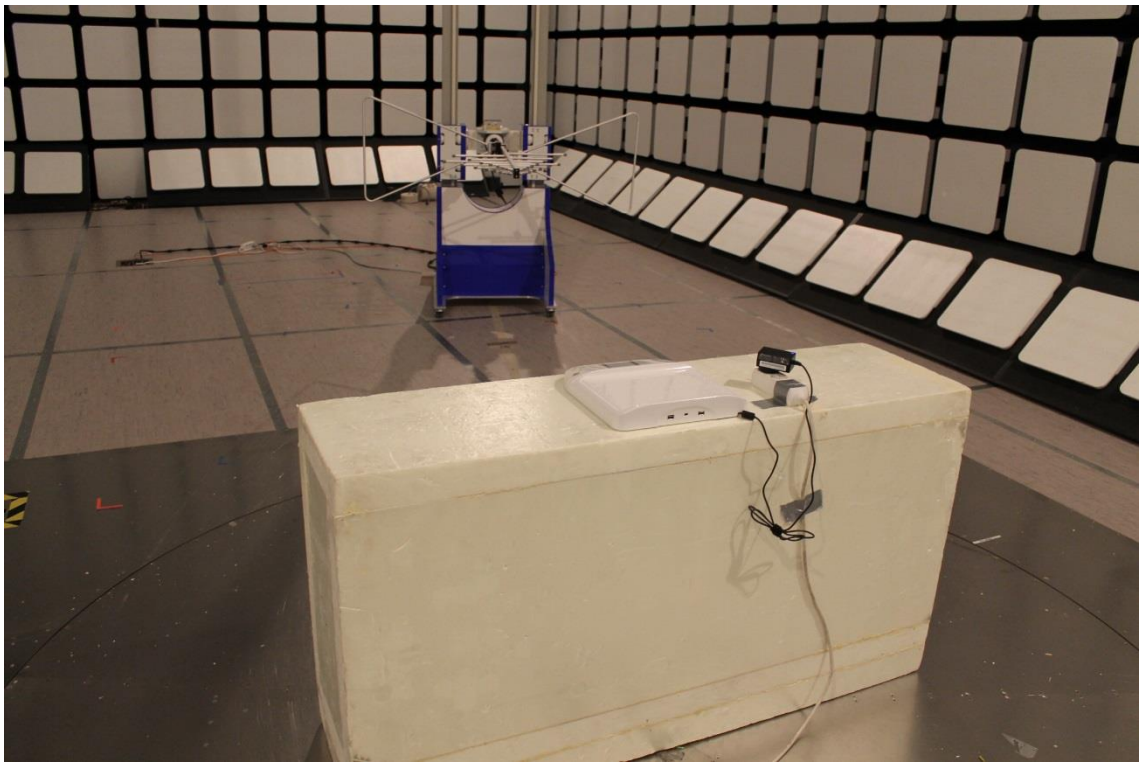
RF-Test Equipment

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
ANTENNA	A.H. SYSTEMS	SAS-200/518	inv:7873	-	-
SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2018-01-08	2020-01-08
PREAMPLIFIER	CIAO	CA118-3123	inv:10278	2017-11-16	2018-11-16
ANTENNA	EMCO	3117	inv:7293	2018-03-14	2020-03-14
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	-	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	-	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	-	-
ATTENUATOR	PASTERNACK	PE 7004-4	inv:10126	2017-12-01	2019-12-01
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	inv:8453	2017-07-10	2018-07-10
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	inv:9093	2017-07-07	2018-07-07
ANTENNA	SCHWARZBECK	VULB 9168	inv:8911	2016-10-25	2018-10-25
TEMPERATURE/ HUMIDITY METER	VAISALA	HMT 333	inv:8638	2018-04-05	2019-04-05
HIGH PASS FILTER	WAINWRIGHT	WHKX1.0/15G-10SS	inv:8267	2017-03-01	2019-03-01
HIGH PASS FILTER	WAINWRIGHT	WHKX1.5/15G-12SS	inv:8267	2017-03-01	2019-03-01
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv:7826	-	-
LISN	ROHDE & SCHWARZ	ENV216	inv:9611	2018-03-01	2019-03-01
MULTIMETER	FLUKE	21	inv:8253	2017-12-19	2018-12-19

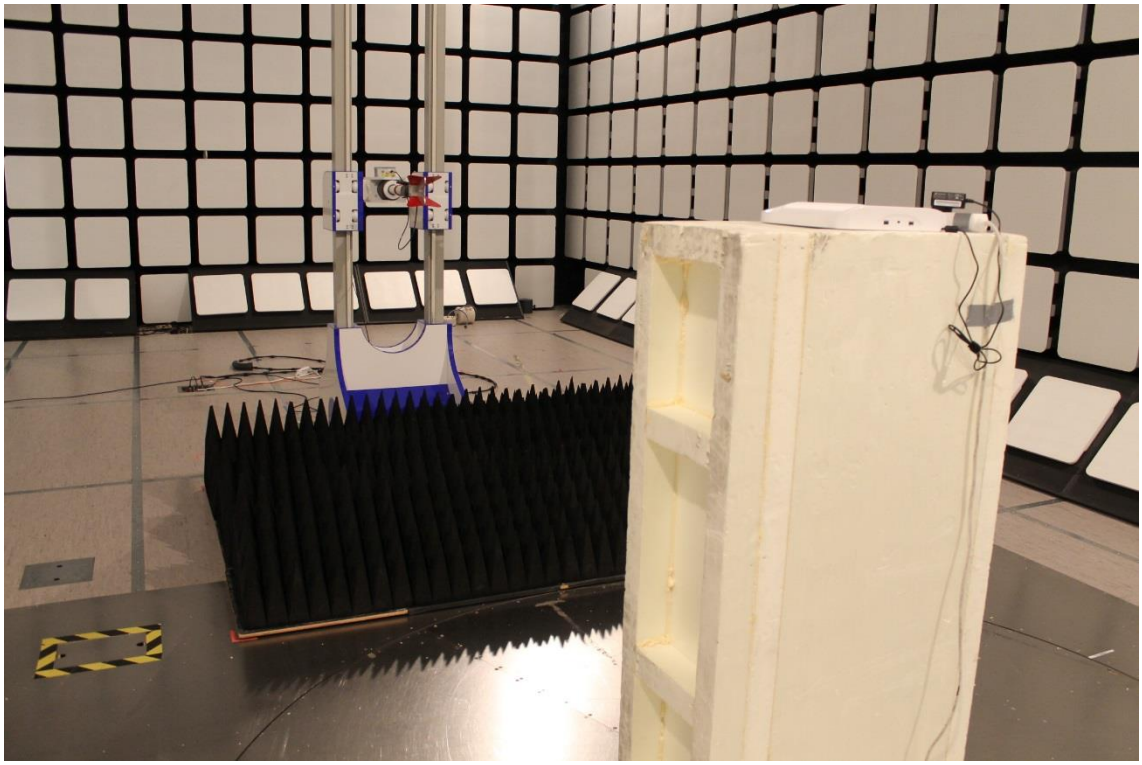
Photograph 1. EUT on the test table



Photograph 2. Conducted emission test setup



Photograph 3. Radiated Spurious Emissions 30 – 1000 MHz



Photograph 4. Radiated Spurious Emissions 1 – 10 GHz