ncee labs
Product Compliance Solutions

4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

Amended

FCC/ISED Test Report

Prepared for:	**RealmFive, Inc.**
Address:	**3300 Folkways Cir. Lincoln, NE 68504**
Product:	**WeatherFront**
Test Report No:	**R20190618-20C**
Approved By:	**Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**22 June 2023**
Total Pages:	**52**

The Nebraska Center for Excellence in Electronics (NCEE) authorizes the above named company to reproduce this report provided it is reproduced in its entirety for use by the company's employees only. Any use that a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. NCEE accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report applies only to the items tested.

ilac-MRA
ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	23 July 2019	Original – NJohnson Prepared by KVepuri
A	16 September 2019	Modified Section 2.2 Includes NCEE Labs report R20190618-20 and its amendment in full. -NJ
B	21 June 2023	Added note on pg 47 and corrected duty cycle on pg 48
C	30 June 2023	Corrected typo on pg 48

CONTENTS

Revision PAge....2

1.0 Summary of test results....4

2.0 EUT Description....5

2.1 Equipment under test....5
2.2 Description of test modes....6
2.3 Description of support units....6

3.0 Laboratory description....7

3.1 Laboratory description....7
3.2 Test Personnel....7
3.3 Test equipment....8

4.0 Detailed results....9

4.1 Duty Cycle....9
4.2 Radiated emissions....10
4.3 Peak Output Power....19
4.4 Bandwidth....23
4.5 Bandedges....31
4.6 Power Spectral Density....41
4.7 Carrier frequency seperation, number of hopping channels, time of occupancy....45

Appendix A: Sample Calculation....49

Appendix B – Measurement Uncertainty....51

REPORT END....52

1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 4, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency Hopping System	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Not applicable. Battery power only, no charger.
FCC 15.203	Unique Antenna Requirement	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless Weather Station module used to collect data from sensors and transmit it. It has transmit and receive capabilities.

EUT	Weather Station
EUT Received	19 June 2018
EUT Tested	19 June 2018 - 20 June 2019
Serial No.	NCEETEST1 (Assigned)
Operating Band	902.0 – 928.0 MHz
Device Type	Hybrid
Power Supply	Internal Battery/ Solar Powered

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	902.3
Middle	908.5
High	914.9

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, highest and one channel in the middle.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

All testing was performed by Karthik Vepuri of NCEE Labs. The results were reviewed by Nic Johnson.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*

*Internal Characterization

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

N/A

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013, Section 6.5, 6.6, 11.11, 11.12

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (µV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT is intended to be mounted in only one direction. So only that axis is investigated.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

Test setup:

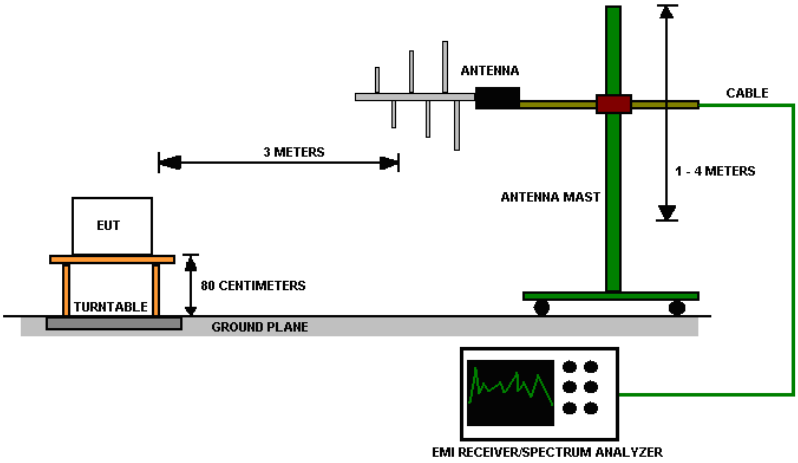

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions

The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

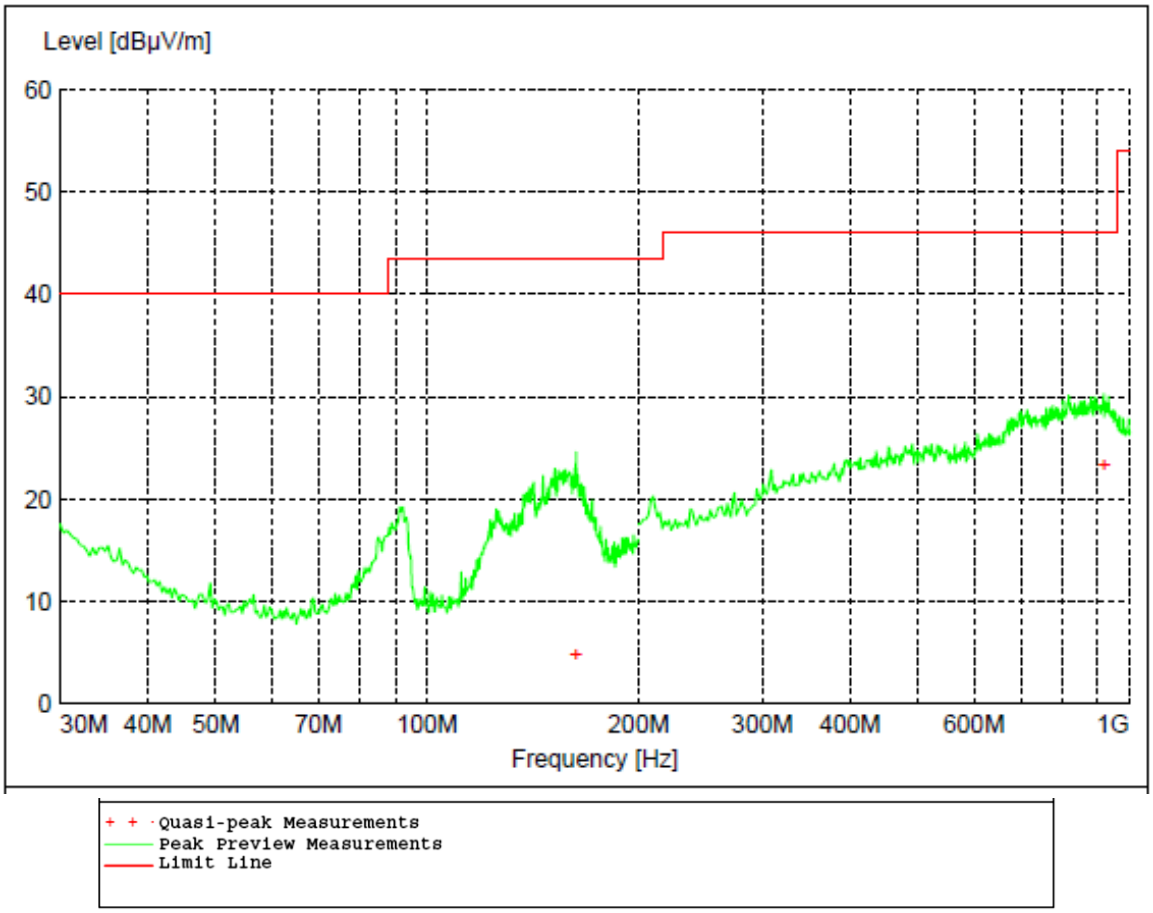

Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
162.780000	4.82	43.50	38.70	323	114	HORI
919.620000	23.34	46.00	22.70	397	121	VERT

Table 2 - Radiated Emissions Peak Measurements vs. Average Limit, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1836.400000	32.63	54.00	21.40	362	132	HORI
2464.200000	47.16	54.00	6.80	105	253	VERT
2751.400000	28.09	54.00	25.90	359	214	HORI
3666.600000	39.33	54.00	14.70	342	219	VERT

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

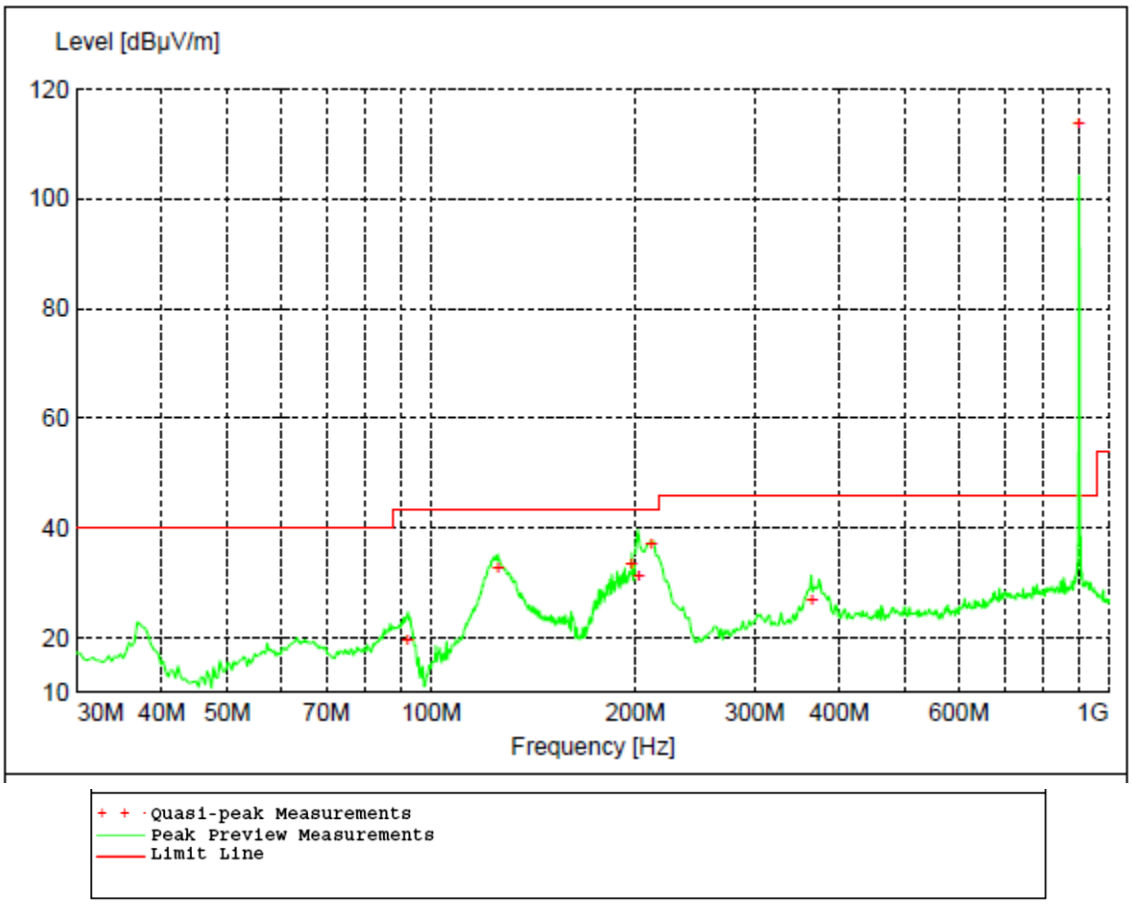

Figure 3 - Radiated Emissions Plot, Low Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
92.220000	19.66	43.50	23.90	102	117	HORI
125.640000	32.72	43.50	10.80	100	230	VERT
197.280000	33.53	43.50	10.00	100	129	HORI
202.380000	31.10	43.50	12.40	100	134	HORI
211.260000	36.85	43.50	6.70	401	142	HORI
364.620000	26.87	46.00	19.10	100	118	VERT
902.280000	113.64	46.00	-67.60	146	262	VERT

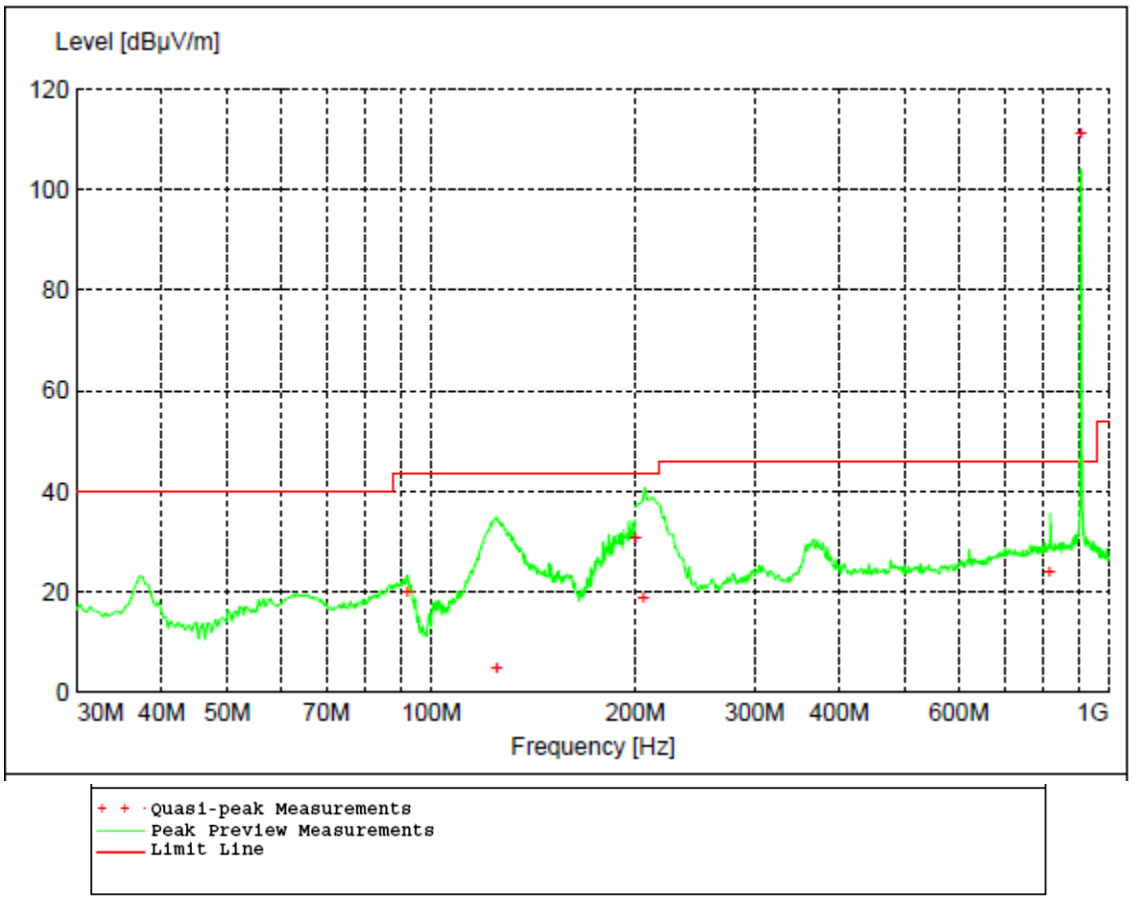

Figure 4 - Radiated Emissions Plot, Mid Channel

Table 4 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
92.220000	20.07	43.50	23.50	186	287	HORI
125.040000	4.70	43.50	38.80	100	279	VERT
199.980000	30.83	43.50	12.70	100	158	HORI
205.560000	18.77	43.50	24.80	237	55	VERT
817.320000	23.81	46.00	22.20	325	131	HORI
908.460000	111.15	46.00	-65.20	196	124	VERT

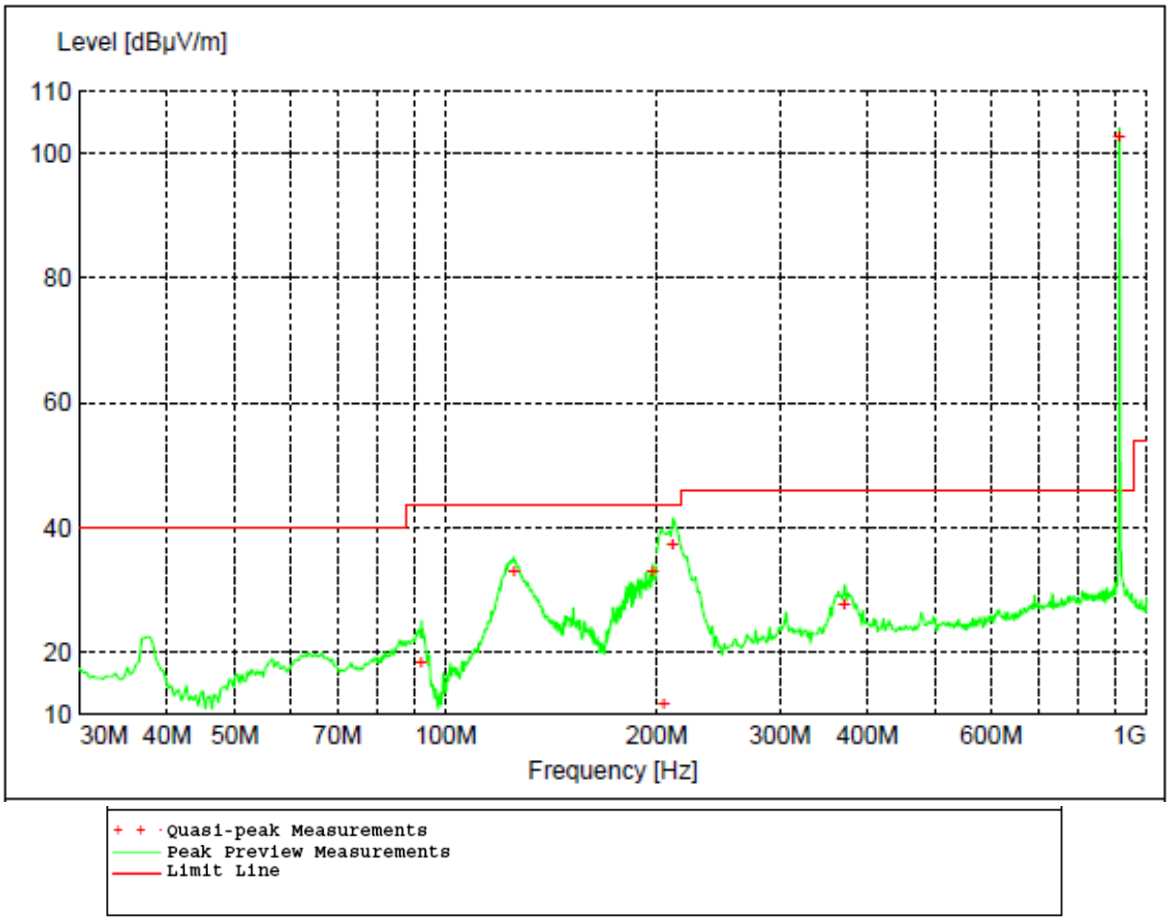

Figure 5 - Radiated Emissions Plot, High Channel

Table 5 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
92.220000	18.21	43.50	25.30	102	294	HORI
125.280000	33.01	43.50	10.50	99	138	VERT
197.280000	32.85	43.50	10.70	186	95	VERT
204.720000	11.72	43.50	31.80	119	99	VERT
210.780000	37.22	43.50	6.30	206	100	VERT
370.740000	27.68	46.00	18.30	100	109	VERT
914.940000	102.49	46.00	-56.50	143	130	VERT

Table 6 - Radiated Emissions Peak Measurements vs. Average Limit, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1804.600000	38.72	54.00	15.30	146	239	VERT
2707.000000	39.51	54.00	14.50	177	102	HORI
3609.200000	42.93	54.00	11.10	174	65	HORI
4511.600000	41.84	54.00	12.20	100	190	VERT
5394.000000	39.64	54.00	14.40	374	360	VERT
6331.200000	43.64	54.00	10.40	383	183	HORI
8101.200000	49.23	54.00	4.80	387	146	HORI

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

Table 7 - Radiated Emissions Peak Measurements vs. Average Limit, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1722.200000	33.15	54.00	20.90	144	204	VERT
2725.600000	36.75	54.00	17.20	184	258	HORI
3634.000000	44.27	54.00	9.70	184	139	VERT
4542.400000	42.44	54.00	11.60	99	62	HORI
7210.800000	46.53	54.00	7.50	151	200	VERT
9077.600000	47.91	54.00	6.10	99	346	VERT

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

Table 8 - Radiated Emissions Peak Measurements vs. Average Limit, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.000000	41.36	54.00	12.60	153	74	HORI
2744.600000	40.80	54.00	13.20	194	153	HORI
3659.800000	41.49	54.00	12.50	258	142	VERT
4526.000000	42.19	54.00	11.80	230	68	VERT
5360.400000	40.91	54.00	13.10	219	318	VERT
6329.200000	44.29	54.00	9.70	155	0	HORI
8116.600000	48.98	54.00	5.00	367	309	VERT
9090.200000	48.04	54.00	6.00	379	349	VERT

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. The EUT is intended to be mounted in only one direction. So only that axis is investigated.
See the test setup photo exhibit for details on the orientations.

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10, Section(s) 11.9.1.1

Limits of bandwidth measurements:
The maximum allowed peak output power is 30 dBm.

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 10 MHz RBW and 10 MHz VBW. The RBW was set to a value larger than the DTS bandwidth.

Deviations from test standard:
No deviation.

Test setup:

Figure 6 – Peak Output Power Measurements Test Setup
*cable loss was less than 0.1 dB, So it was not accounted in the plots.

EUT operating conditions:
The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	Method	RESULT
Low	902.3	16.752	Conducted	PASS
Middle	908.5	16.675	Conducted	PASS
High	914.9	16.568	Conducted	PASS

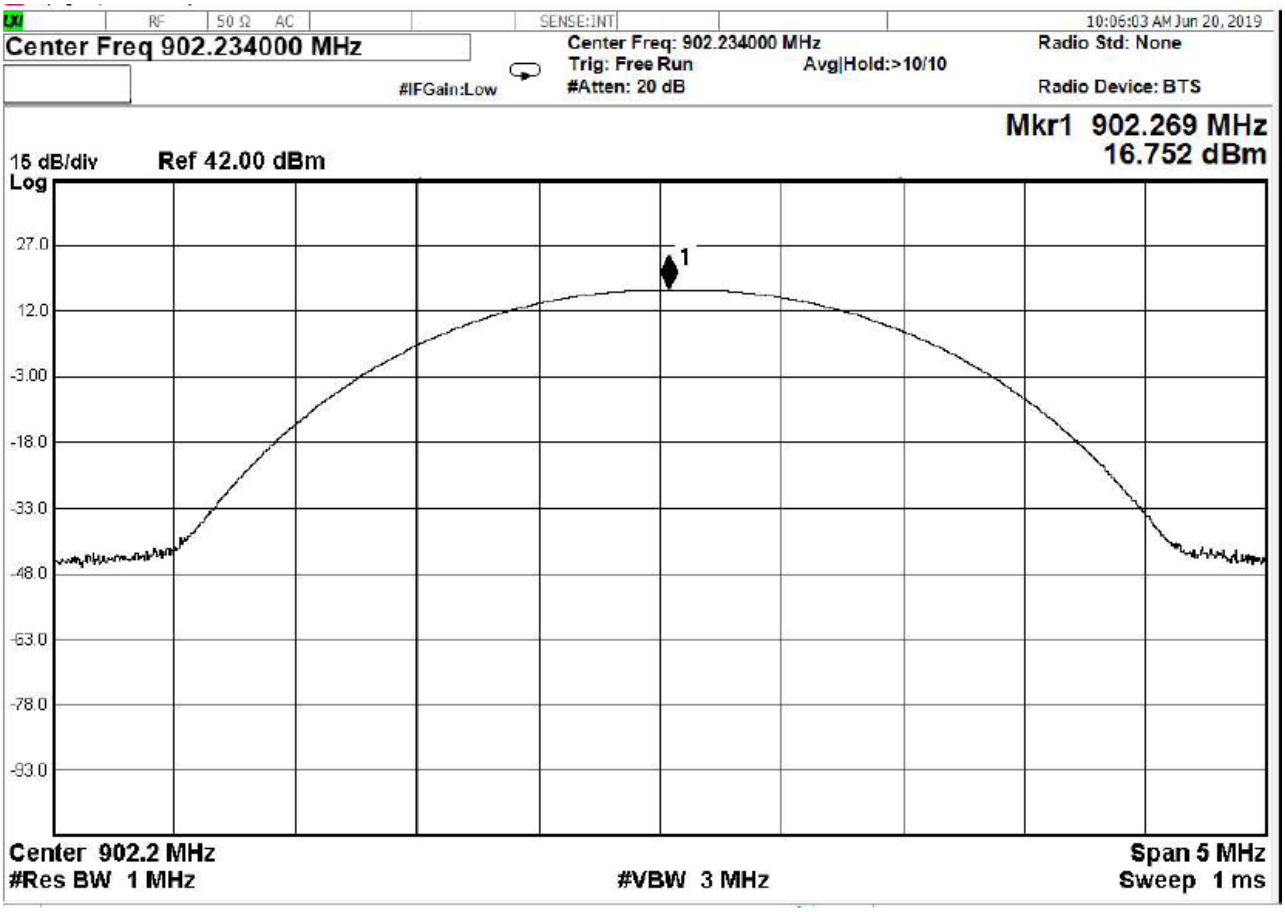

Figure 7 – Output Power, Low Channel

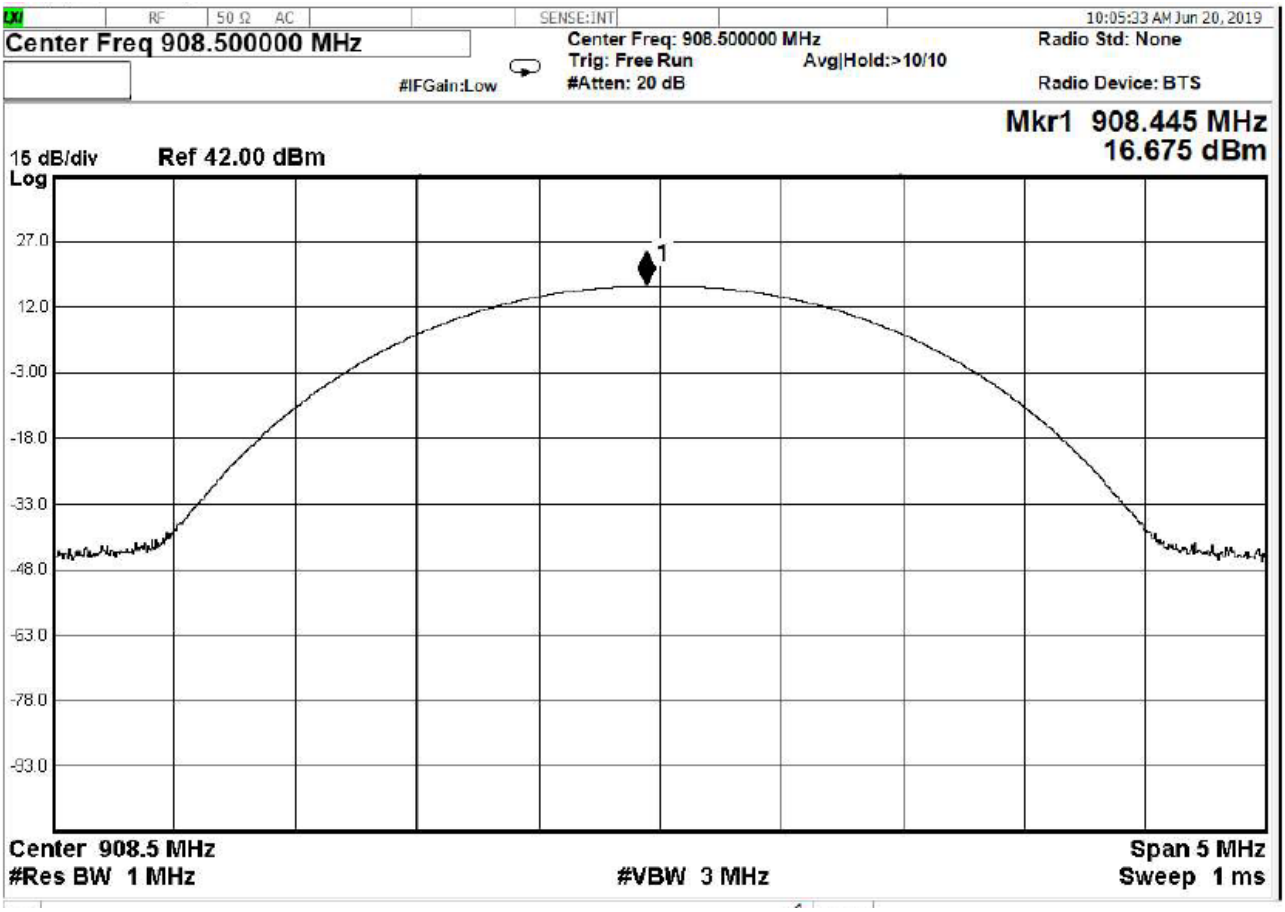

Figure 8 - Output Power, Mid Channel

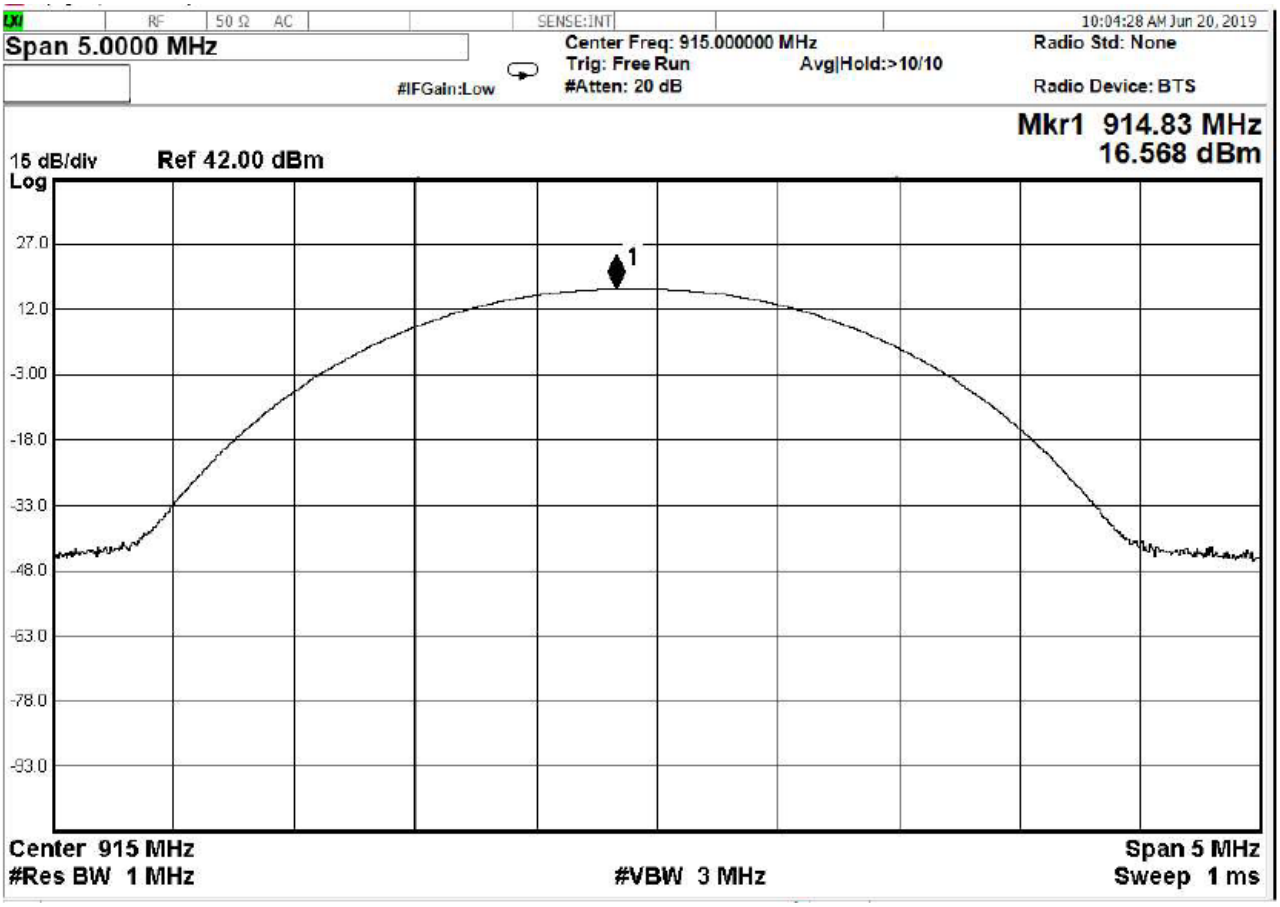

Figure 9 - Output Power, High Channel

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 11.8.1

Limits of bandwidth measurements:
The 99% occupied bandwidth and peak output powers are displayed. The maximum allowed peak output power is 30 dBm.

The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 1 MHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

For peak output power measurements, the EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW.

Deviations from test standard:
No deviation.

Test setup:

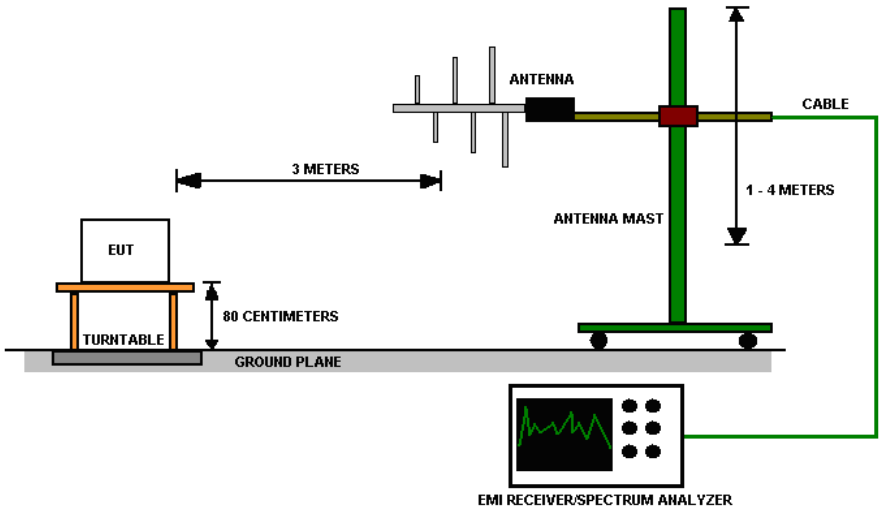

Figure 10 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
1	902.3	125.13
2	908.5	125.30
3	914.9	125.51

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)
1	902.3	266.0
2	908.5	265.6
3	914.9	265.7

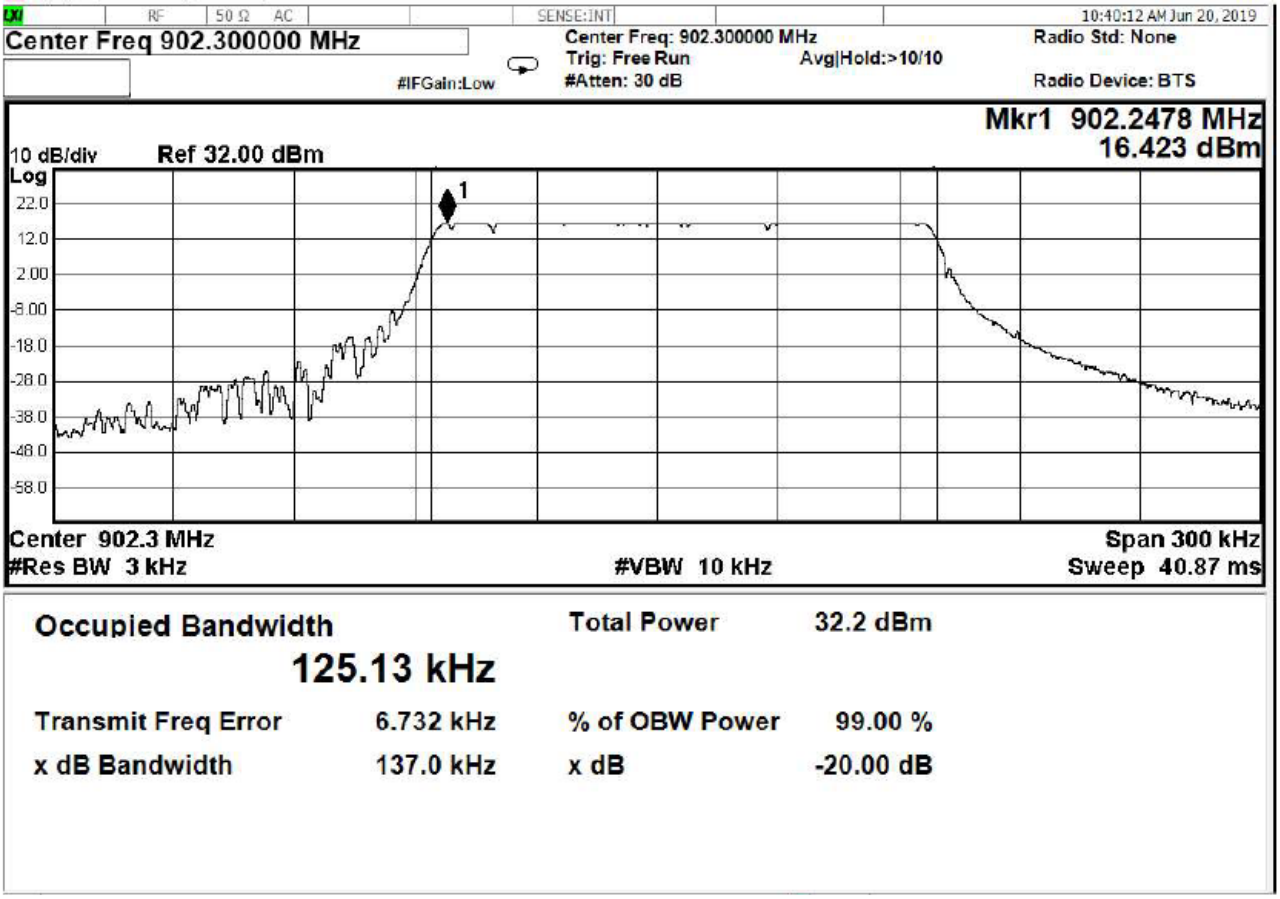

Figure 11 - Bandwidth, Low Channel

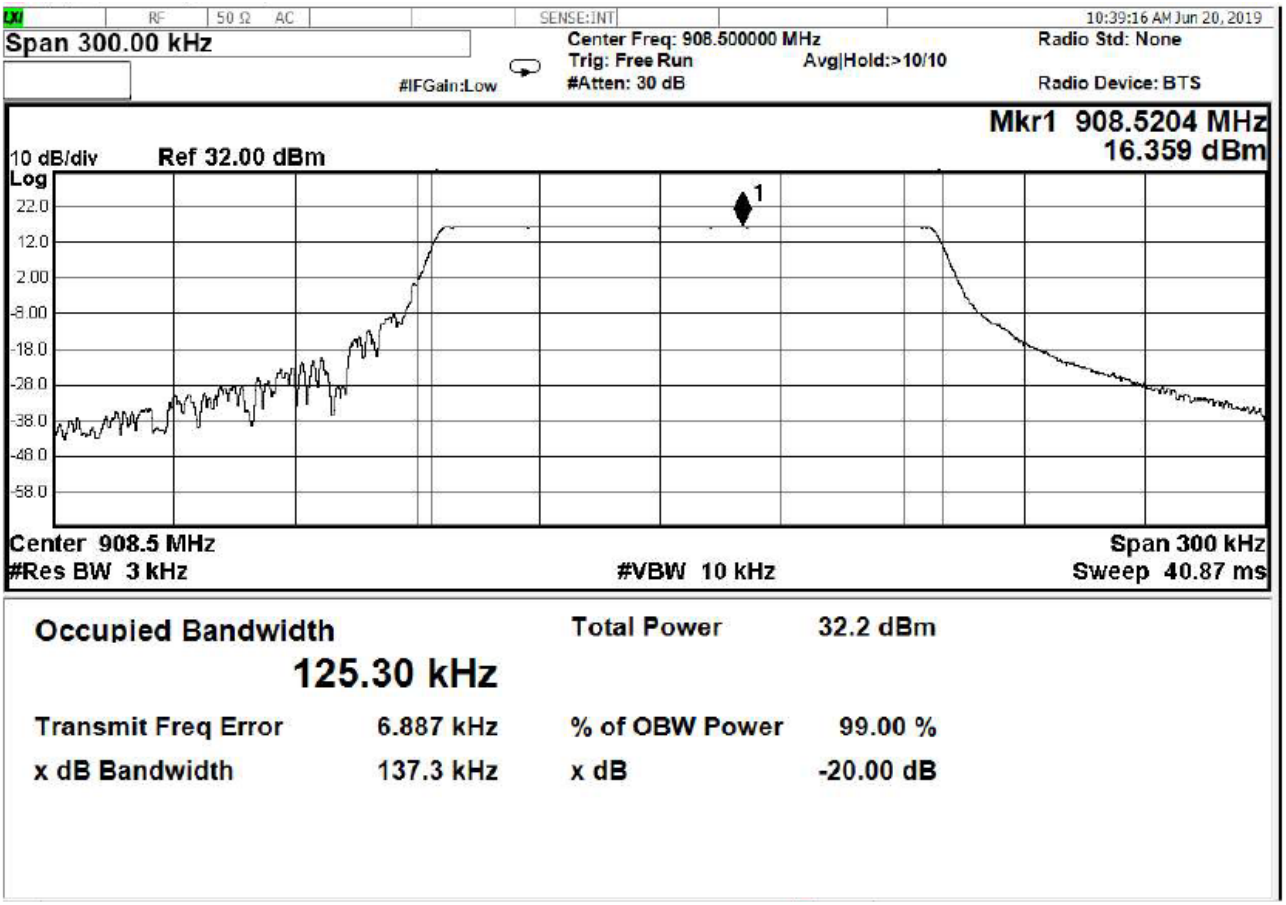

Figure 12 - Bandwidth, Mid Channel

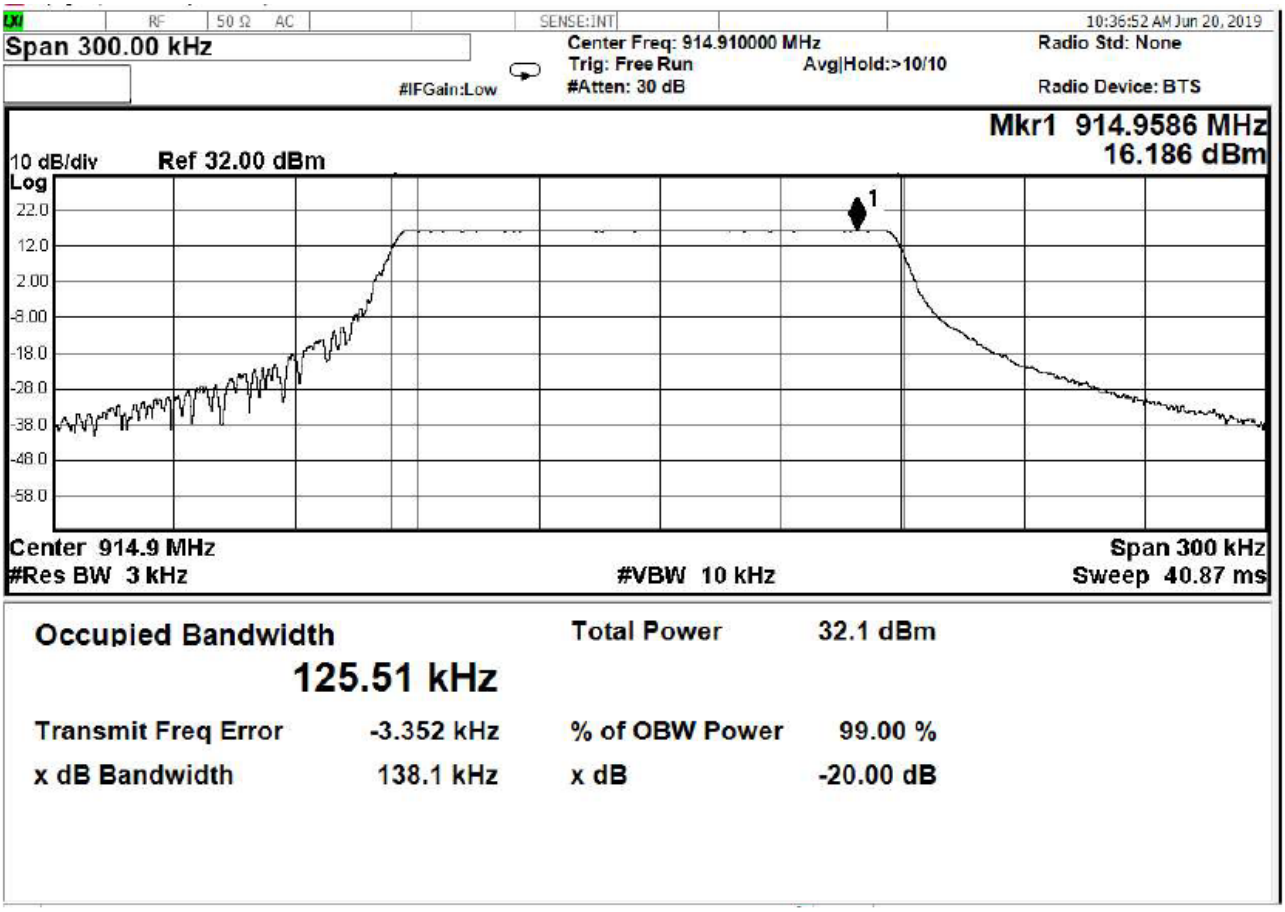

Figure 13 – 99% Bandwidth, High Channel

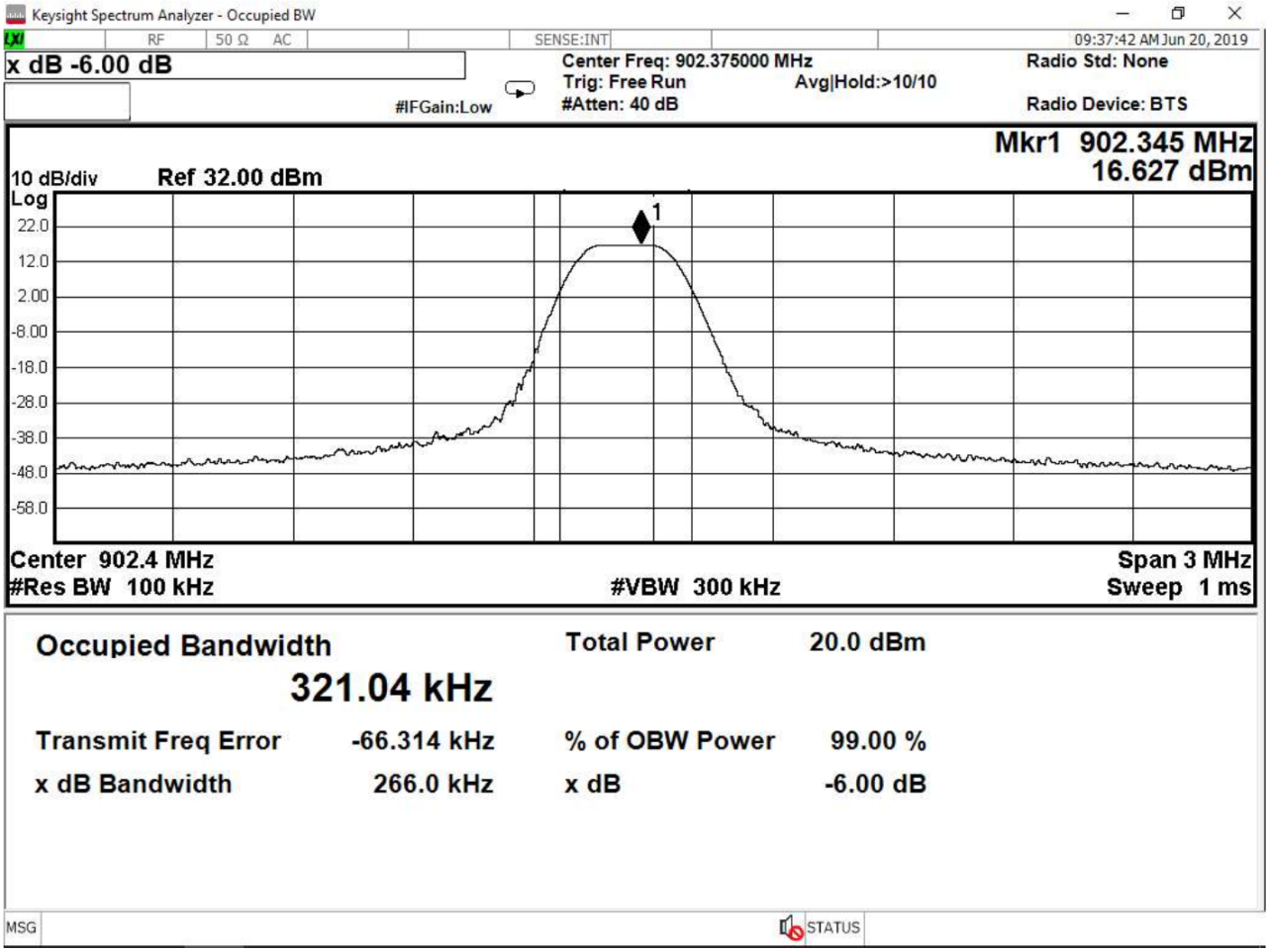

Figure 14 - 6 dB Bandwidth, Low Channel

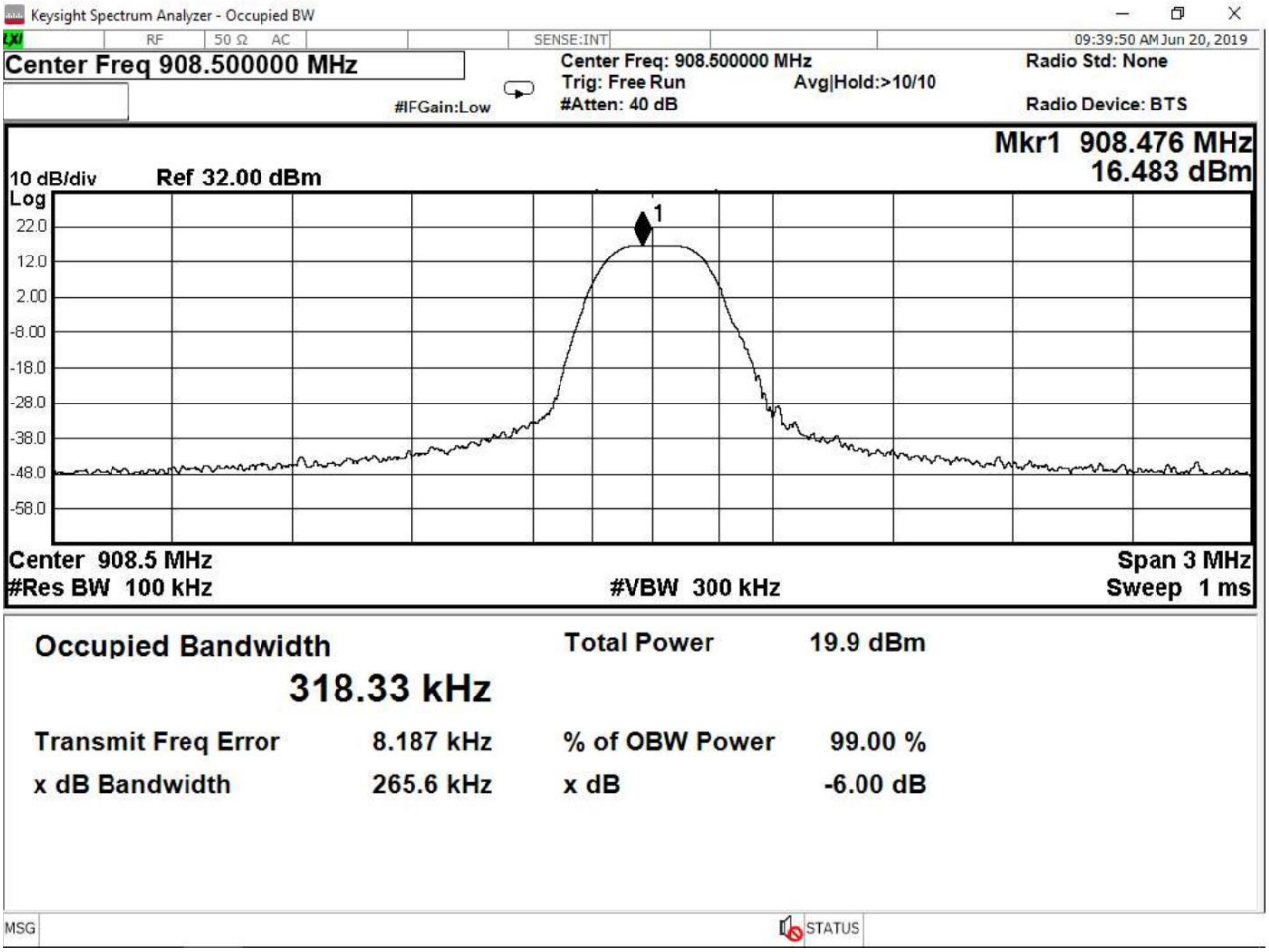

Figure 15 - 6 dB Bandwidth, Mid Channel

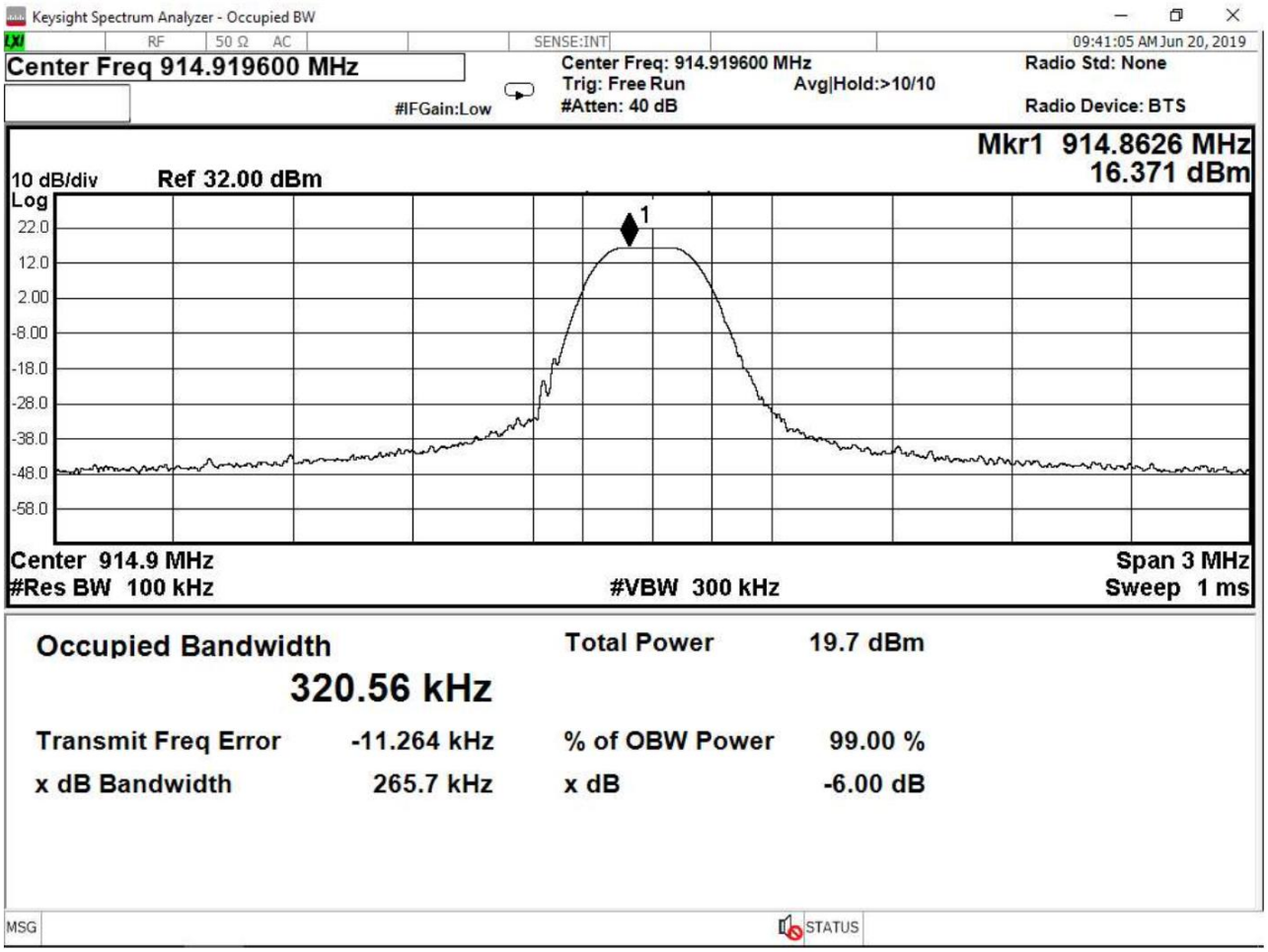

Figure 16 - 6 dB Bandwidth, High Channel

.

4.5 BANDEDGES

Test Method: ANSI C63.10, Section(s) 6.10.6

Limits of bandedge measurements:
For emissions outside of the allowed band of operation (902 – 928MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:
The EUT was tested in the same method as described in section *4.4 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

Deviations from test standard:
No deviation.

Test setup:
All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Highest Out of Band Emissions, Restricted Band

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low, Continuous	614.0	-104.64	-19.30	85.34	67.64	PASS
High, Continuous	960.0	-106.50	-35.39	71.11	56.49	PASS
Low Hopping	614.0	-104.43	-30.19	74.24	67.64	PASS
High, Hopping	960.0	-107.18	-32.80	74.38	56.49	PASS

Highest Out of Band Emissions, Unrestricted bands

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low, Continuous	902.0	-49.18	-19.30	29.88	20.00	PASS
High, Continuous	928.0	-82.05	-35.39	46.46	20.00	PASS
Low Hopping	902.0	-77.81	-30.19	47.62	20.00	PASS
High, Hopping	928.0	-78.86	-32.80	46.07	20.00	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

From Section 4.2

Fundamental average field strength at 902.3 MHz for low channel = 113.64 dBµV/m
Fundamental average field strength at 914.9 MHz for high channel = 102.49 dBµV/m

Low channel minimum delta = 113.64 – 46.0 dBµV/m = 67.64 dBc
High channel minimum delta = 102.49 – 46.0 dBµV/m = 56.49 dBc

Measurements do not include correction factors and are intended to be relative measurements only.

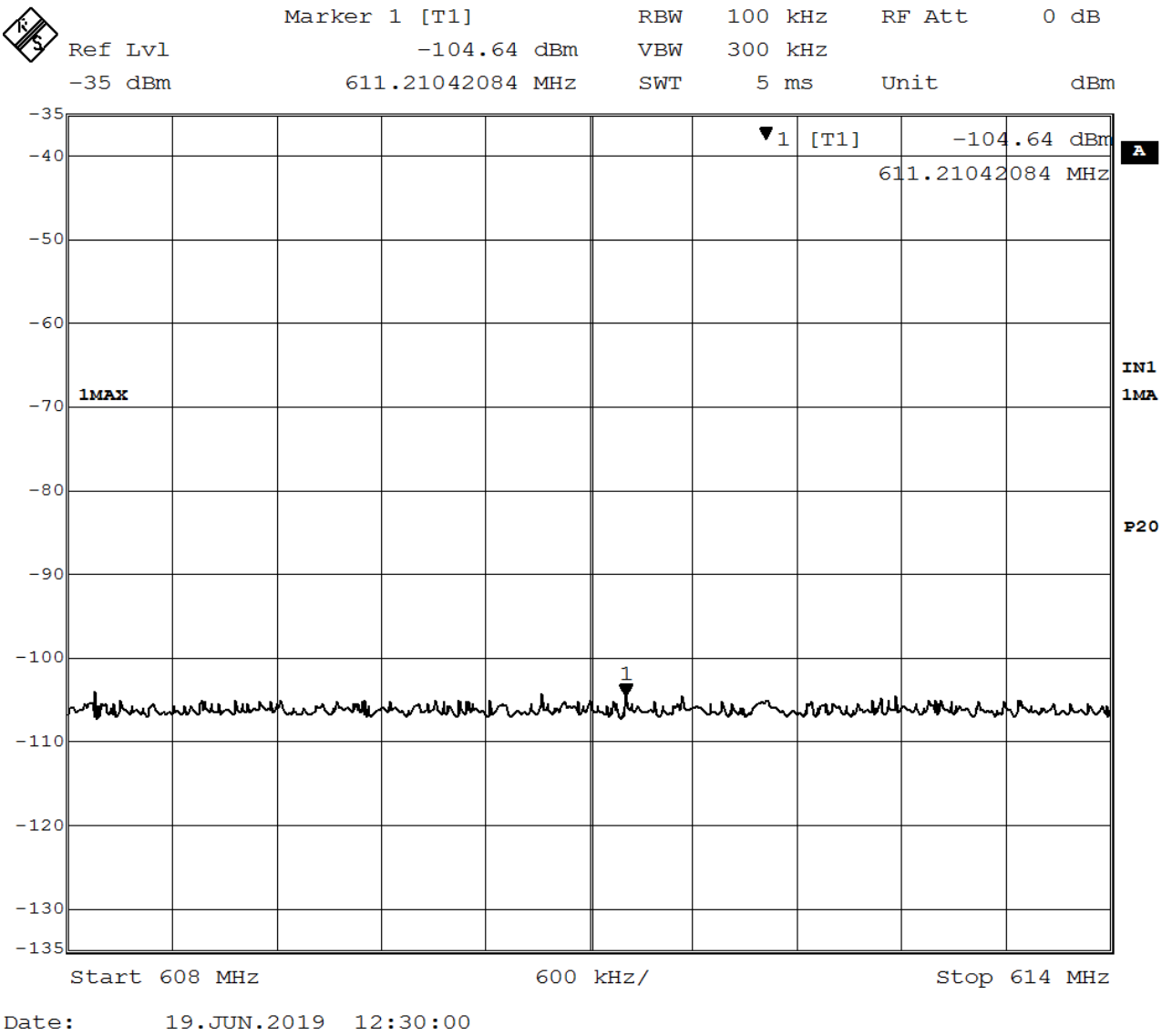

Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

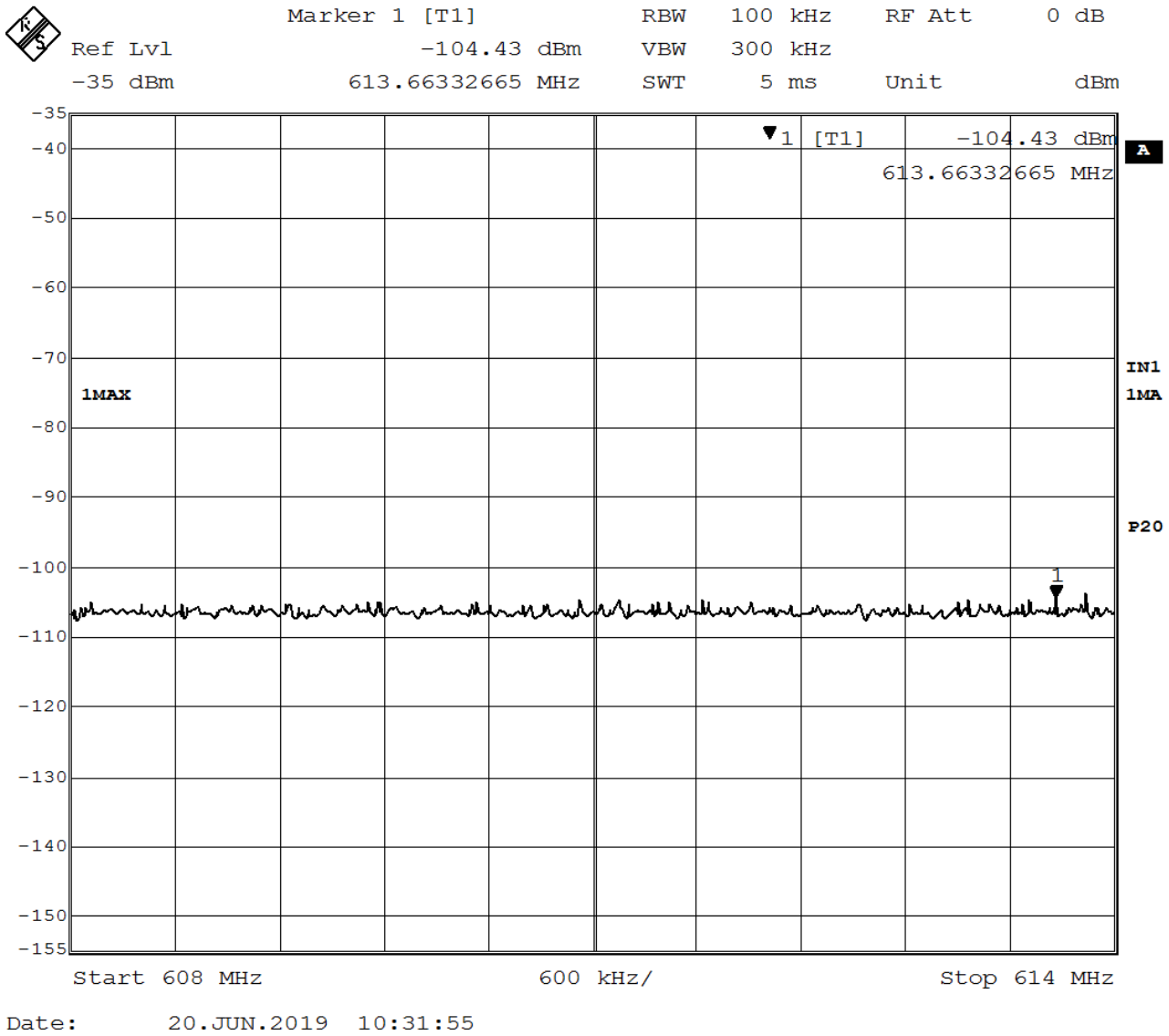

Figure 18 - Band-edge Measurement, Low Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

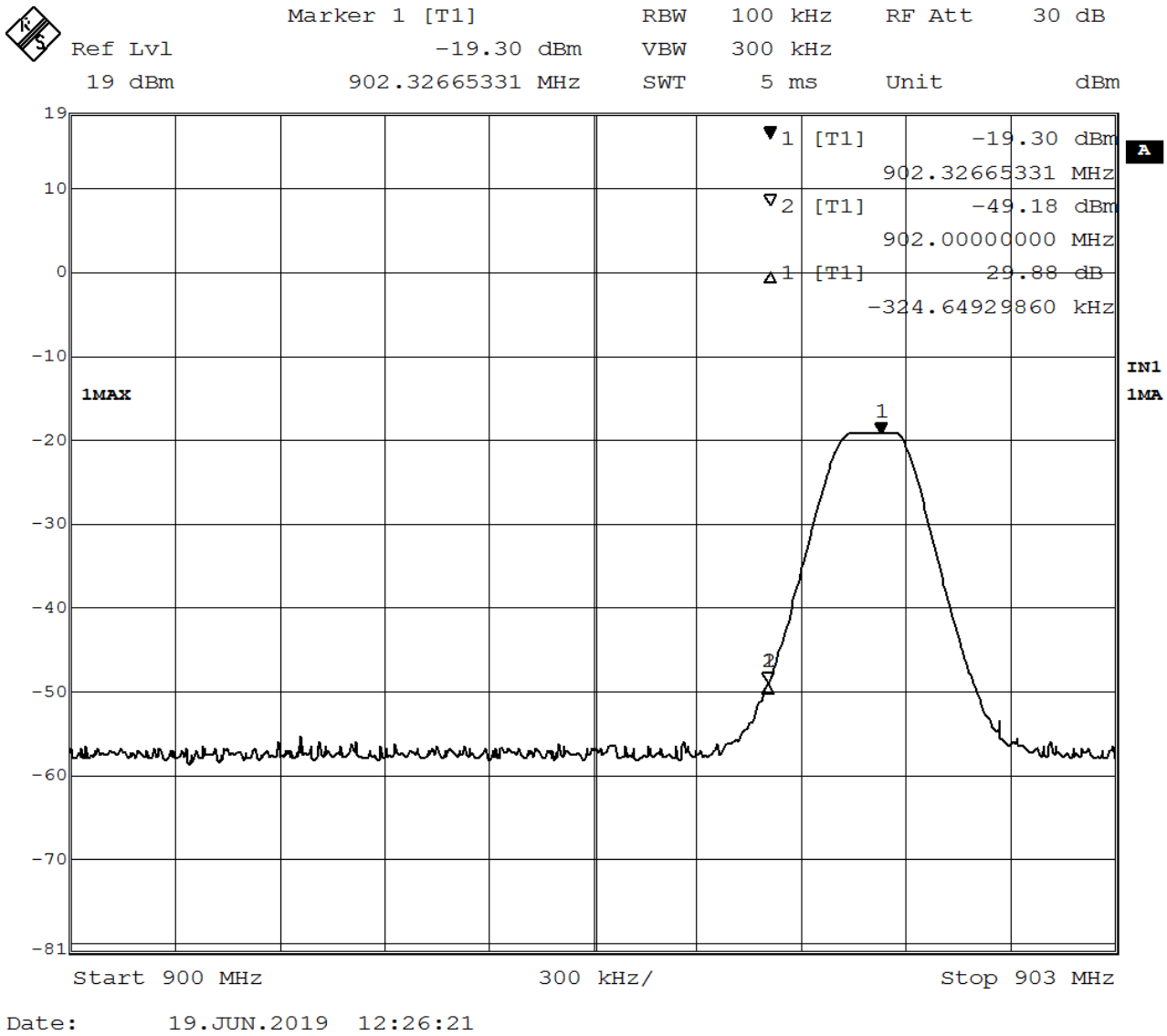

Figure 19 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 29.88 dB > 20 dB minimum

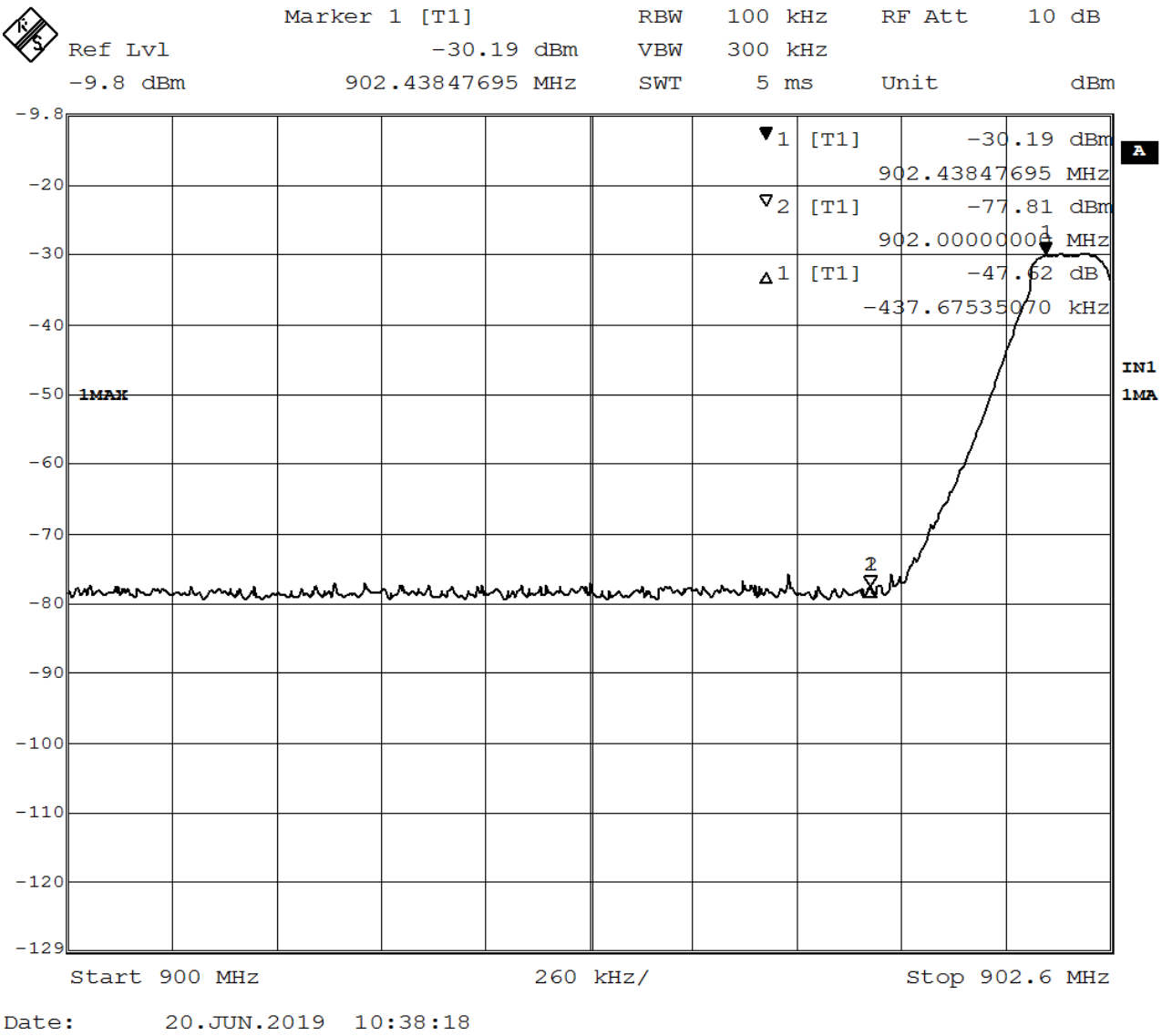

Figure 20 - Band-edge Measurement, Low Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 47.62 dB > 20 dB minimum

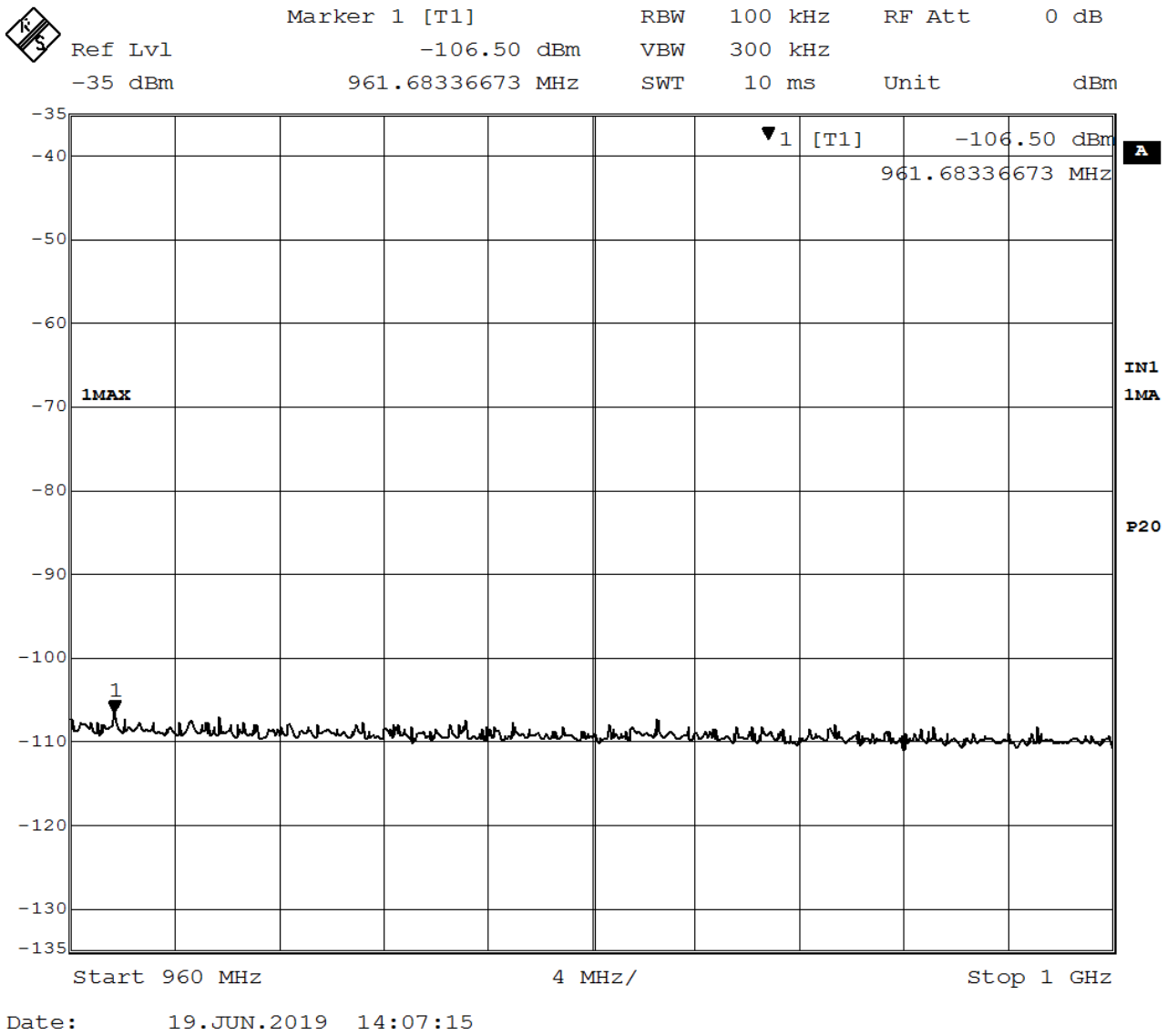

Figure 21 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

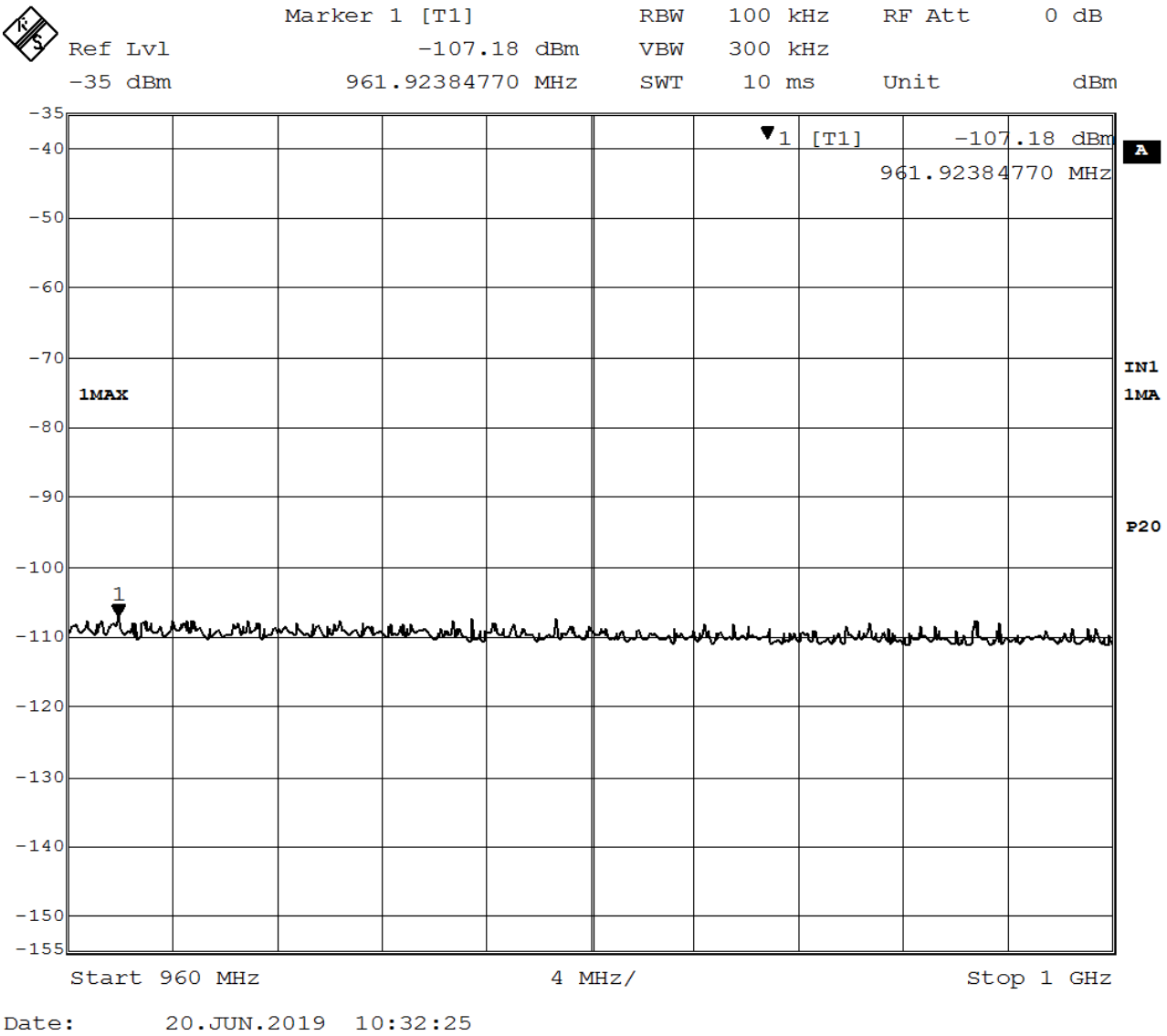

Figure 22 - Band-edge Measurement, High Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

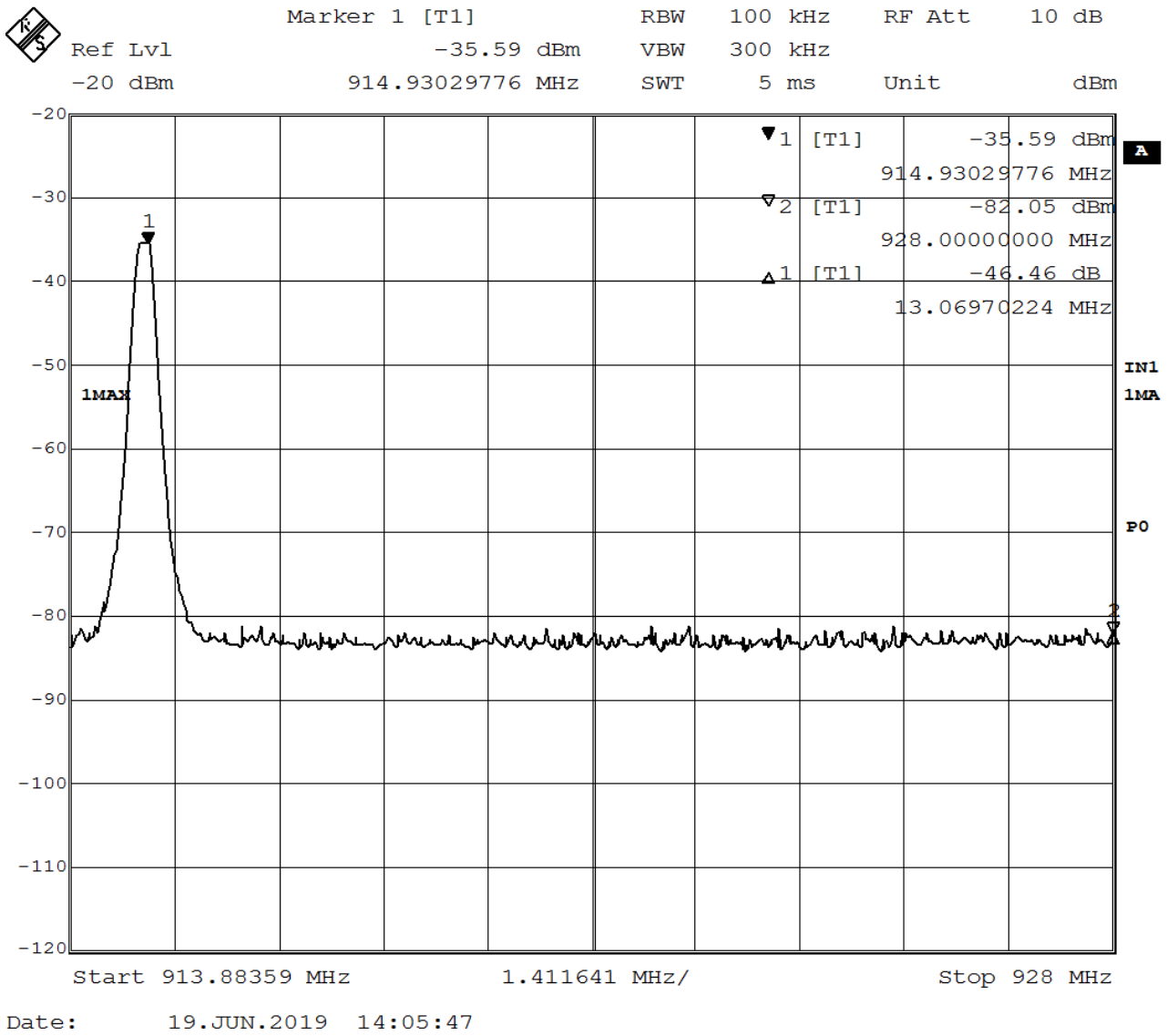

Figure 23 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 46.46 dB > 20 dB minimum

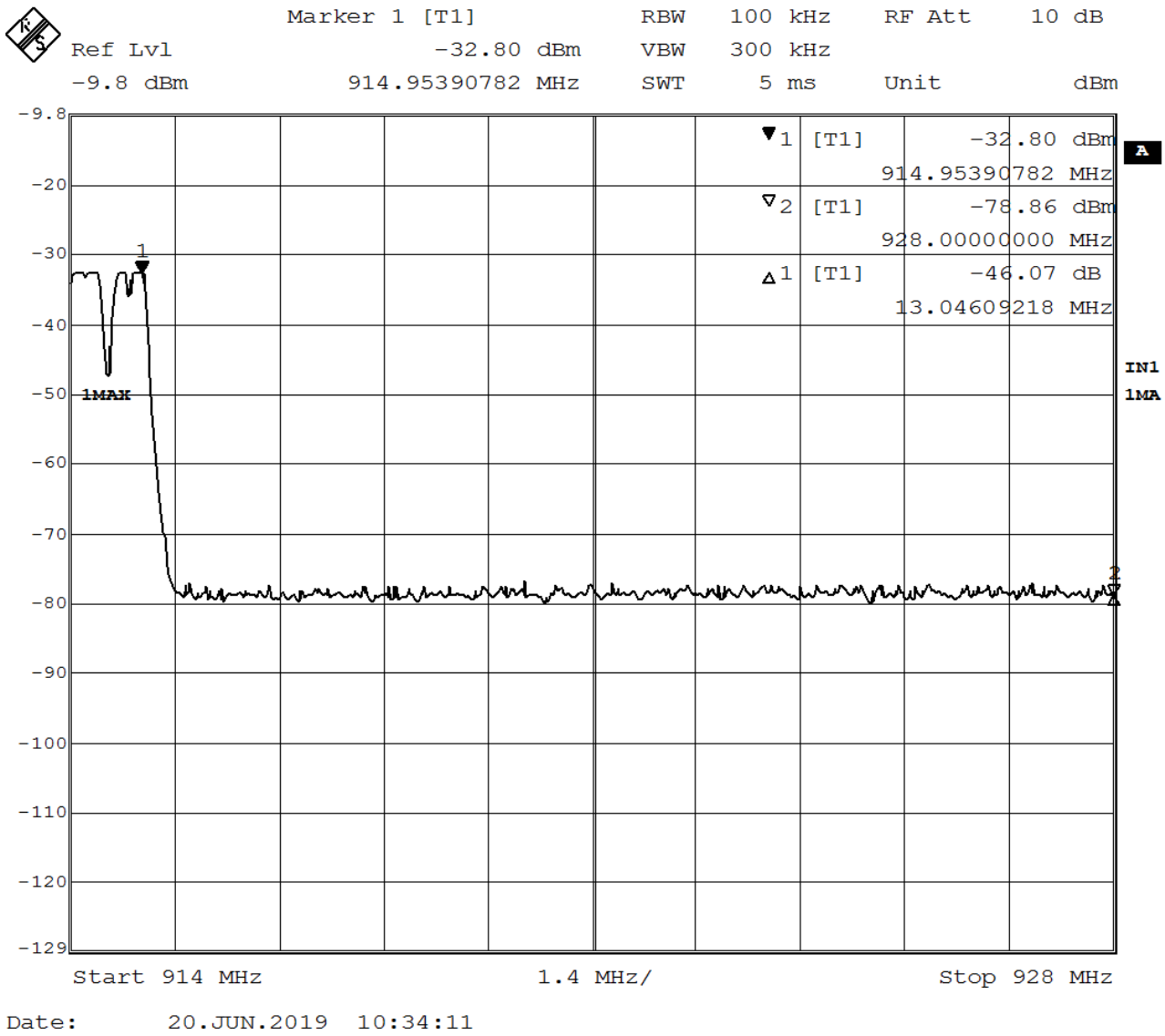

Figure 24 - Band-edge Measurement, High Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 46.07 dB > 20 dB minimum

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10, Section 11.10.2

Limits of power measurements:
The maximum PSD allowed is 8 dBm.

Test procedures:
1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

2. The resolution bandwidth was set to 3 kHz and the video bandwidth was set to 10 kHz to capture the signal. The analyzer used a peak detector in max hold mode.

Test setup:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable on a bench top.

EUT operating conditions:
The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	Method	MAXIMUM POWER LIMIT (dBm)	RESULT
1	902.3	0.509	Conducted	8.00	PASS
2	908.5	0.698	Conducted	8.00	PASS
3	914.9	0.577	Conducted	8.00	PASS

Figure 25 - Power Spectral Density, Low Channel

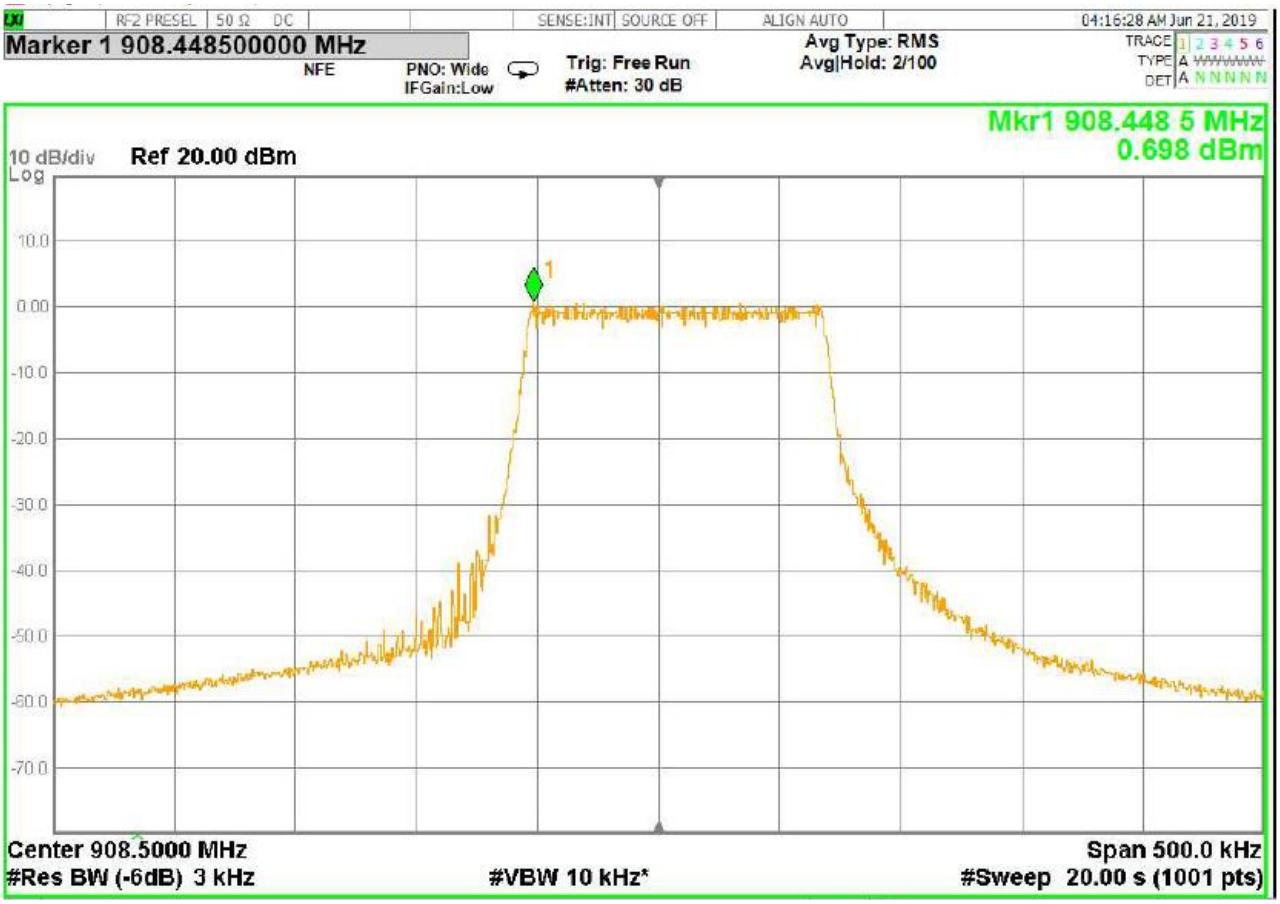

Figure 26 - Power Spectral Density, Mid Channel

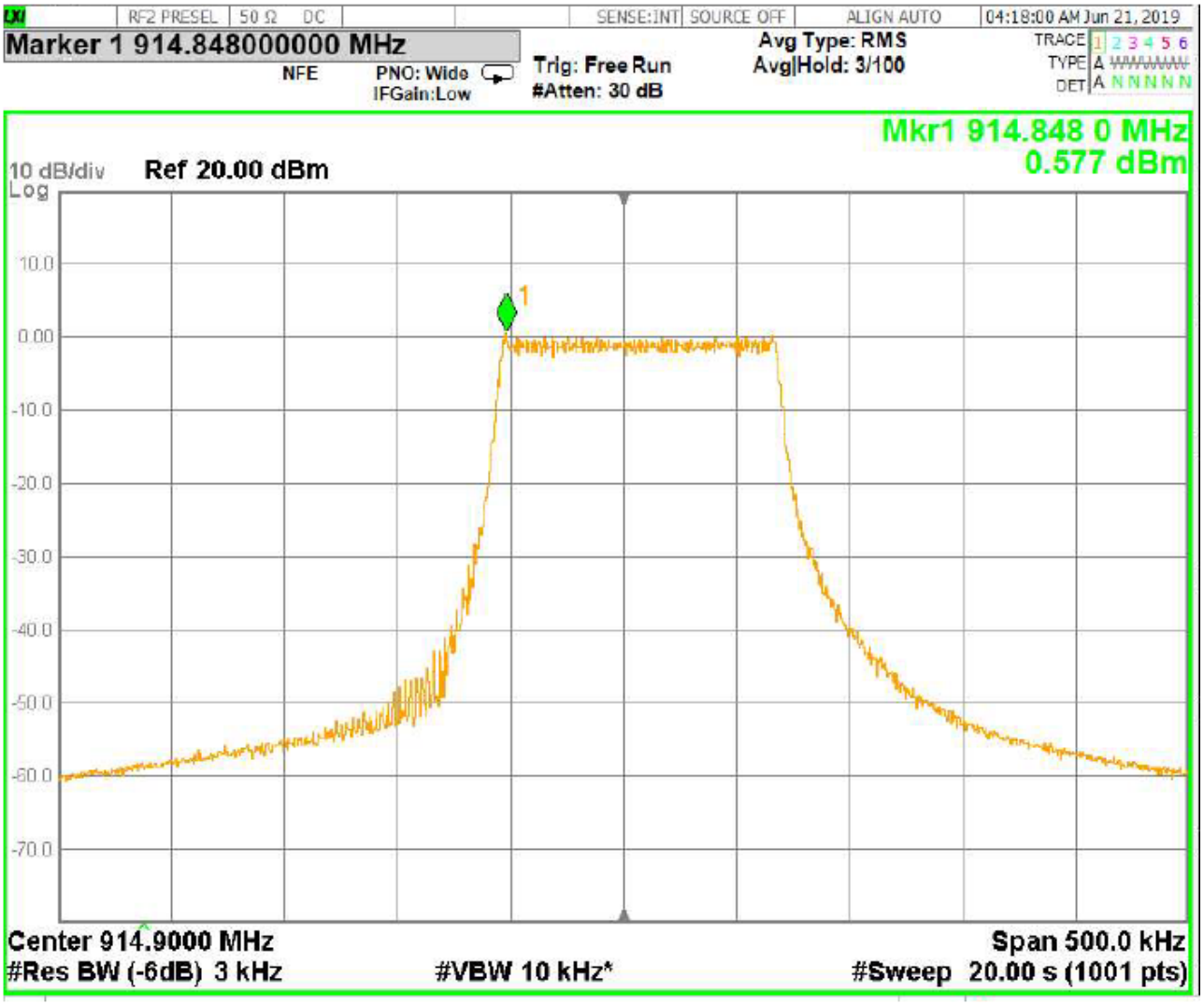

Figure 27 - Power Spectral Density, High Channel

4.7 CARRIER FREQUENCY SEPERATION, NUMBER OF HOPPING CHANNELS, TIME OF OCCUPANCY

Test Method: ANSI C63.10, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy
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.
Test procedures:
The method from FCC DA 00-705

Test setup:
All the measurements were done on the bench while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 3.3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

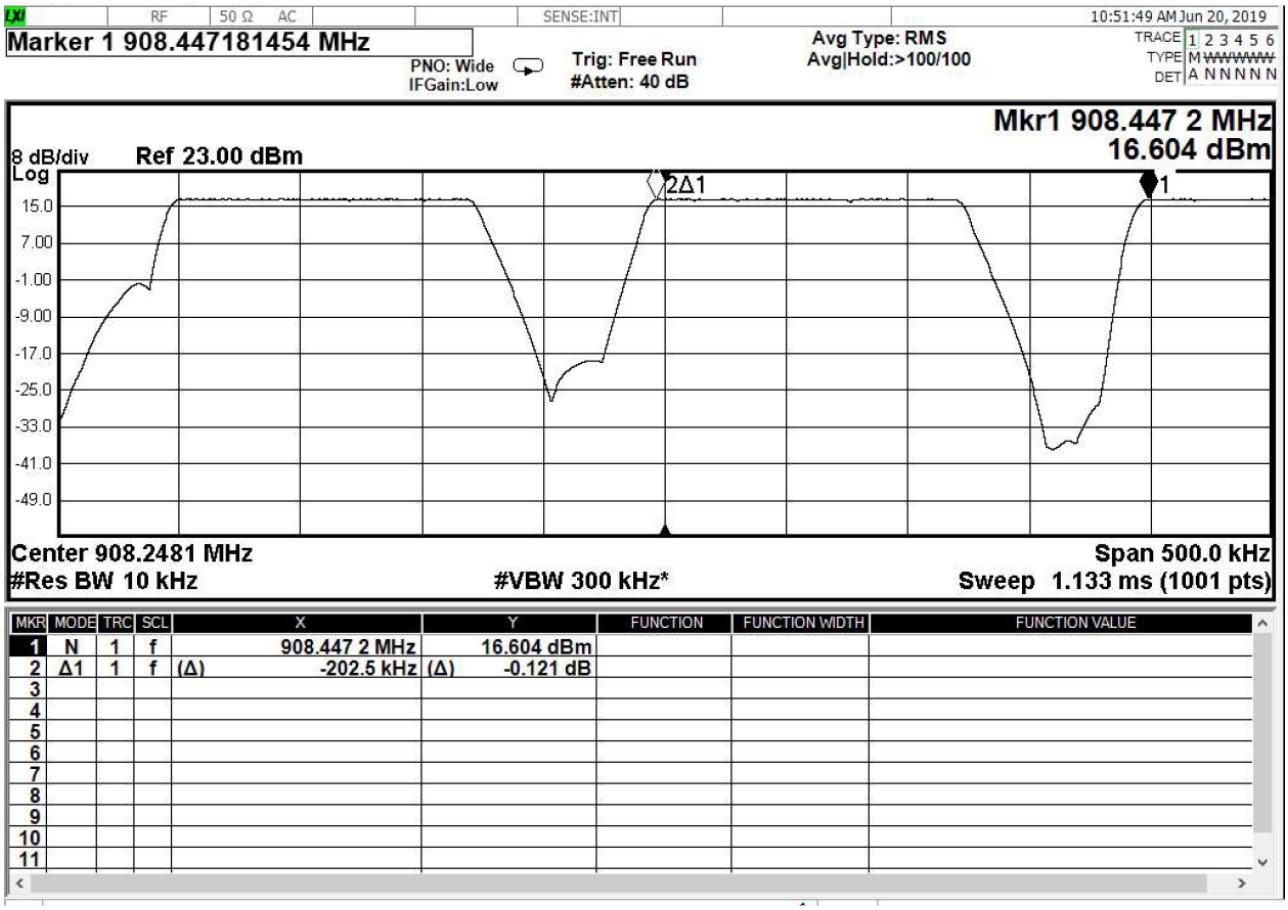

Figure 28 – Frequency Separation, 202.50 kHz

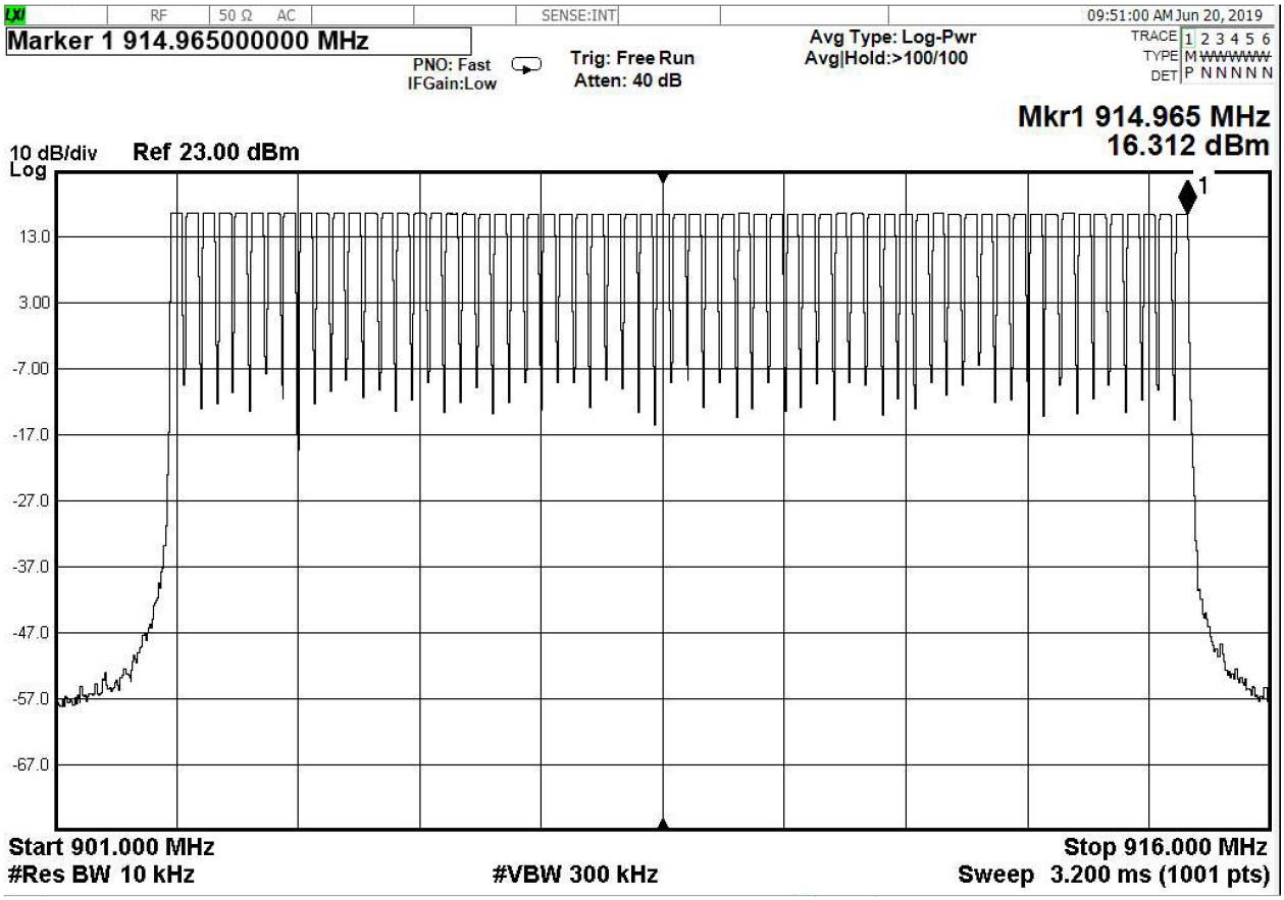

Figure 29 – Hop Count, 63 Hops

Note that not all channels are active in the device. All channels were tested for potential future use. See the operational description for further details on the channels used

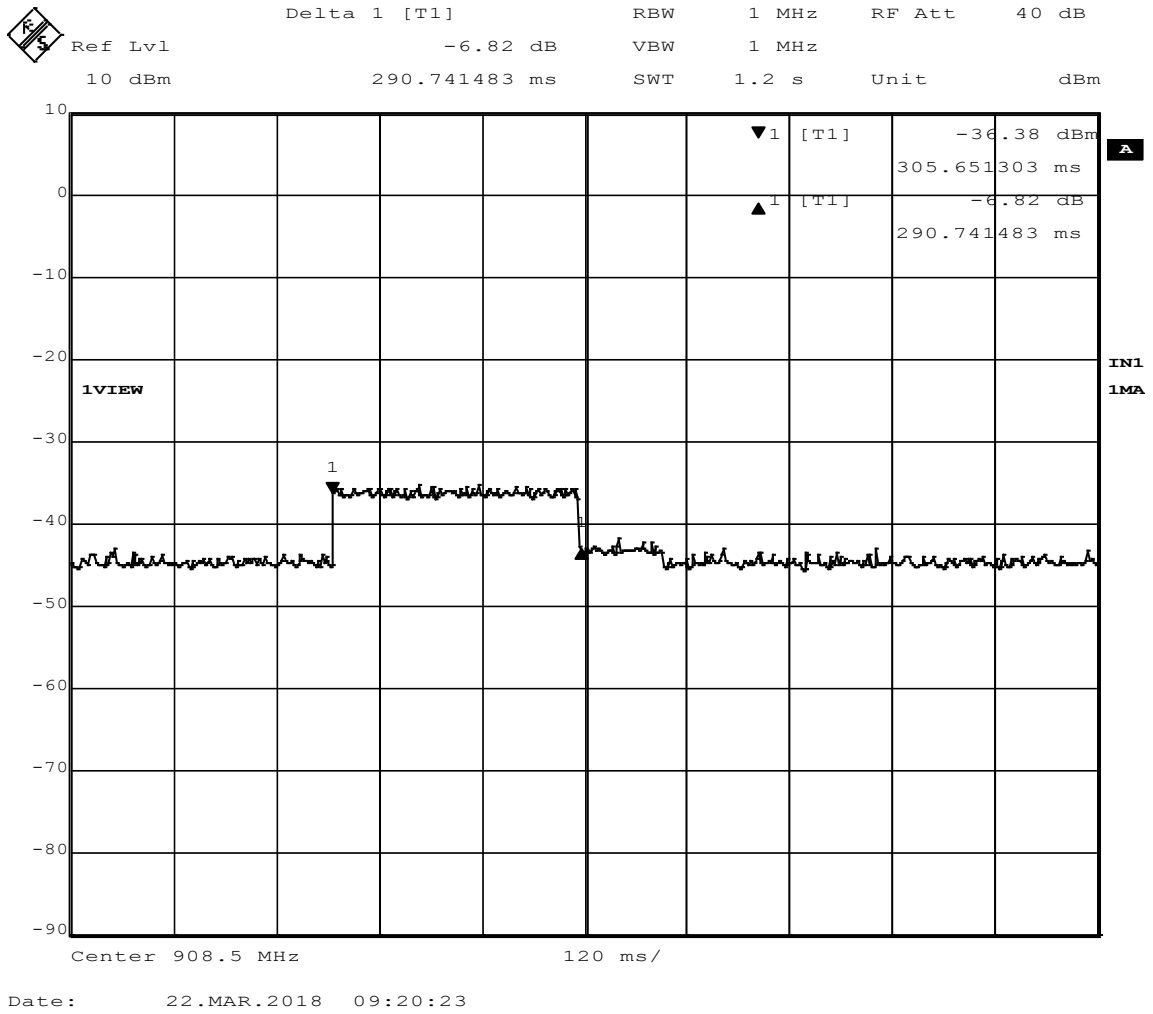

Figure 30 – Time of Occupancy, On Time

*Maximum of 1 transmissions can occur in a given channel in any 10 s so the average time of occupancy is 290.74 ms x 1 = 0.291 s < 0.4 s – Pass

Duty cycle in 10 second period is 0.03 %

**Note that the time of occupancy is from the Gateway manufactured by the same manufacturer, as manufacturer declared that the time of occupancy is exactly same as the EUT listed in this report.

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

REPORT END