

FCC/ISED Test Report

Prepared for: Independent Technologies, LLC

Address: 26 1st Ave SE
New London, MN 56273

Product: WESROC- MT9104RTMA1G UG5

Test Report No: R20181114-24-01

Approved By:



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Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 26 December 2018

Total Pages: 34

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REVISION PAGE

Rev. No.	Date	Description
0	26 December 2018	Original – NJohnson Prepared by KVepuri

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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 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	NA (Internal battery, not rechargeable)

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

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2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a WESROC- MT9104RTMA1G UG5, from Independent Technologies, LLC.

EUT	WESROC - MT9104RTMA1G UG5
EUT Received	4 December 2018
EUT Tested	4 December 2018- 5 December 2018
Serial No.	00004502
Operating Band	902.0 – 928.0 MHz
Device Type	DTS

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

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2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency
1	916.48

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

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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 $35 \pm 4\%$
 Temperature of $22 \pm 3^{\circ}$ Celsius

3.2 TEST PERSONNEL

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

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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 2019
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	16 April 2018*	16 April 2019*
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

*Internal Characterization

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4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Not applicable

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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 ($\mu\text{V/m}$)	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 (dB $\mu\text{V/m}$) = 20 * log * Emission level ($\mu\text{V/m}$).
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.

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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 from 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 was maximized in only one axis as it is intended to be placed in one orientation only. The results are presented in that axis.

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.

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Test setup:

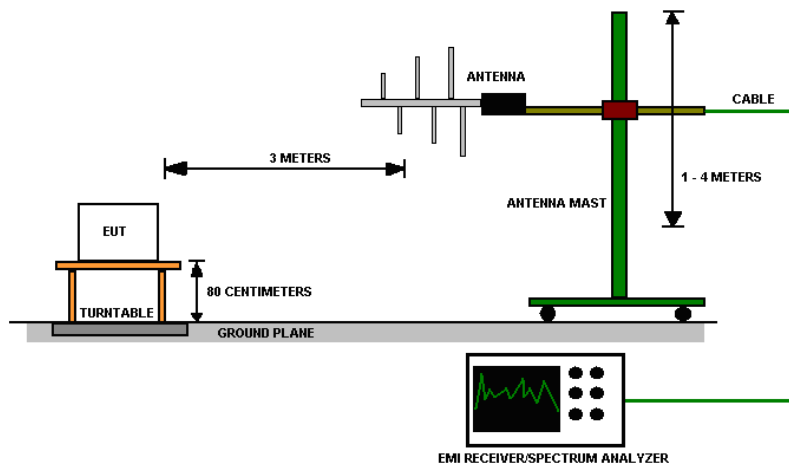


Figure 1 - Radiated Emissions Test Setup

EUT operating conditions

The EUT was powered by 3.6 VDC unless specified and set to transmit continuously on the only channel that it transmits in.

Test results:

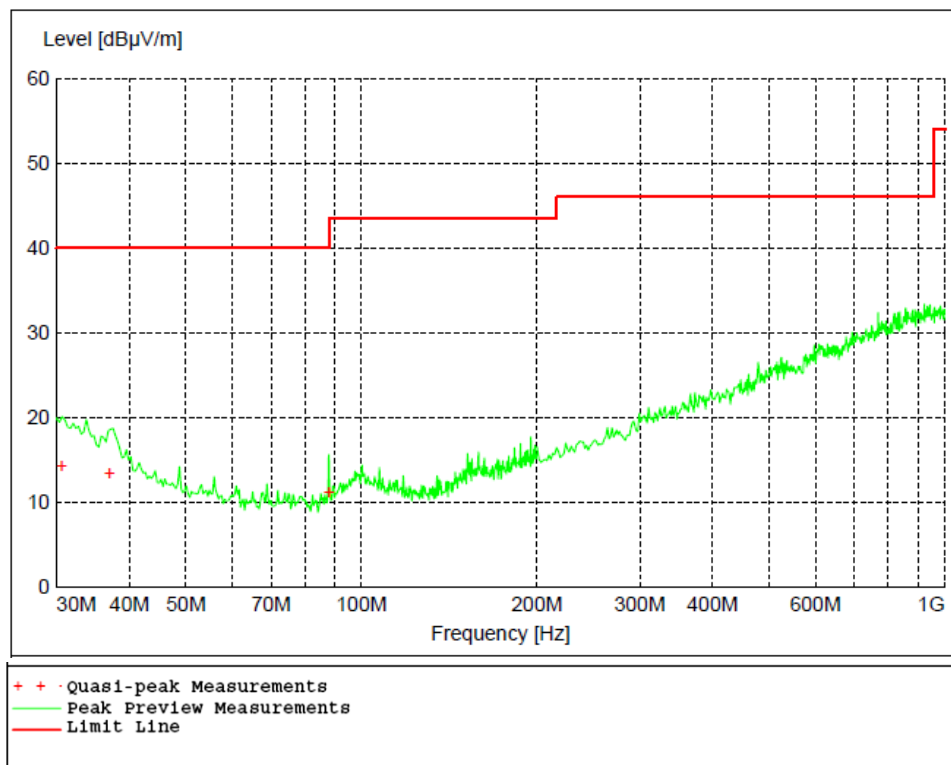


Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
30.600000	14.39	40.00	25.60	100	231	HORI
37.020000	13.48	40.00	26.50	100	360	VERT
87.960000	11.20	40.00	28.80	100	108	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	
1837.400000	34.38	54.00	19.60	399	348	HORI
2755.000000	33.14	54.00	20.90	104	34	HORI

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

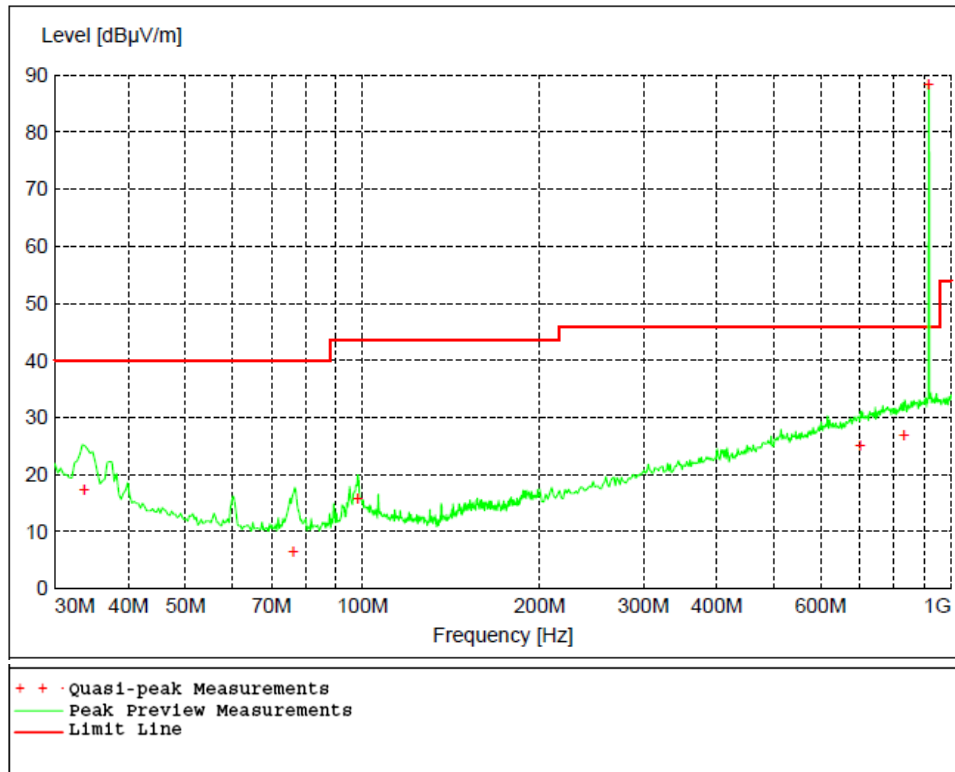


Figure 3 - Radiated Emissions Plot

Table 3 - Radiated Emissions Quasi-peak Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
33.660000	17.37	40.00	22.60	210	21	VERT
76.380000	6.68	40.00	33.30	124	206	VERT
98.220000	15.87	43.50	27.60	343	0	VERT
702.000000	25.20	46.00	20.80	206	195	HORI
831.900000	26.84	46.00	19.20	290	0	HORI
916.480000	88.48	N/A	N/A	N/A	N/A	N/A

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Table 4 - Radiated Emissions Peak Measurements vs. Average Limit

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dB μ V/m	dB μ V/m	dB	cm	deg	
1833.600000	37.42	54.00	16.60	156	15	VERT
2750.200000	39.60	54.00	14.40	99	121	HORI
3669.200000	41.14	54.00	12.90	103	22	VERT
4581.000000	42.66	54.00	11.30	150	60	VERT
5498.600000	46.94	54.00	7.10	136	107	VERT
6410.000000	44.89	54.00	9.10	167	302	VERT

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

REMARKS:

1. Emission level (dB μ V/m) = Raw Value (dB μ V) + 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 was measured in all 3 orthogonal axis. It was found that the Y-axis produced the highest emissions, and this orientation was used for all testing. See the test setup photo exhibit for details on the orientations.

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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:

All measurements were taken at a distance of 3m from the EUT and maximized

Deviations from test standard:

No deviation.

Test setup:

See Section 4.2

EUT operating conditions:

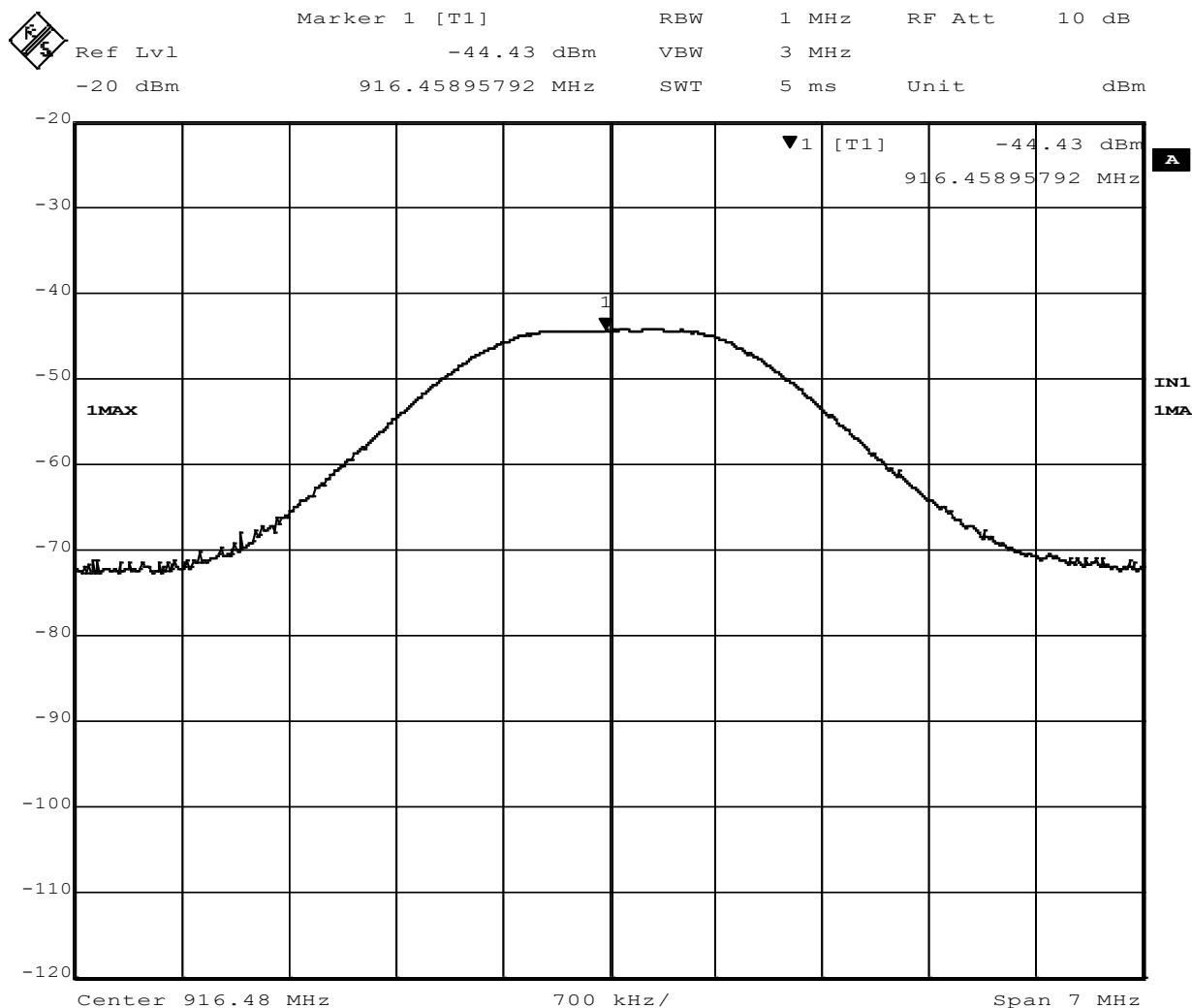
The EUT was powered by 3.6 VDC unless specified and set to transmit continuously on the only channel that it transmits in.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (W)	Method	RESULT
1	916.48	-4.36	0.00037	EIRP	Pass

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Date: 6.DEC.2018 10:08:22

Figure 4 – Output Power

Maximum power = -44.43 dBm + 107 + CL + AF - 95.23 = -4.36 dBm

CL = cable loss = 4.80 dB

AF = antenna factor = 23.50 dB

107 = conversion from dBm to dBμV on a 50Ω measurement system

-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

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4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 6.9.2, 6.9.3, 11.8

Limits of bandwidth measurements:

The Bandwidth measurements were reported for informational purposes only.

Test procedures:

The bandwidth of the fundamental frequency was measured by spectrum analyzer with 30 kHz RBW and 100 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. Automated software was used to make this measurement. .

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

Deviations from test standard:

No deviation.

Test setup:

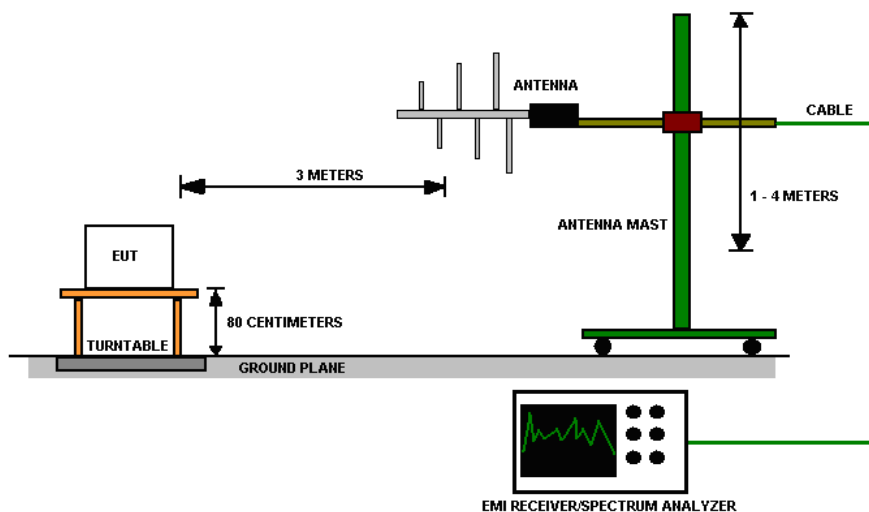


Figure 5 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 3.6 VDC unless specified and set to transmit continuously on the only channel that it transmits in.

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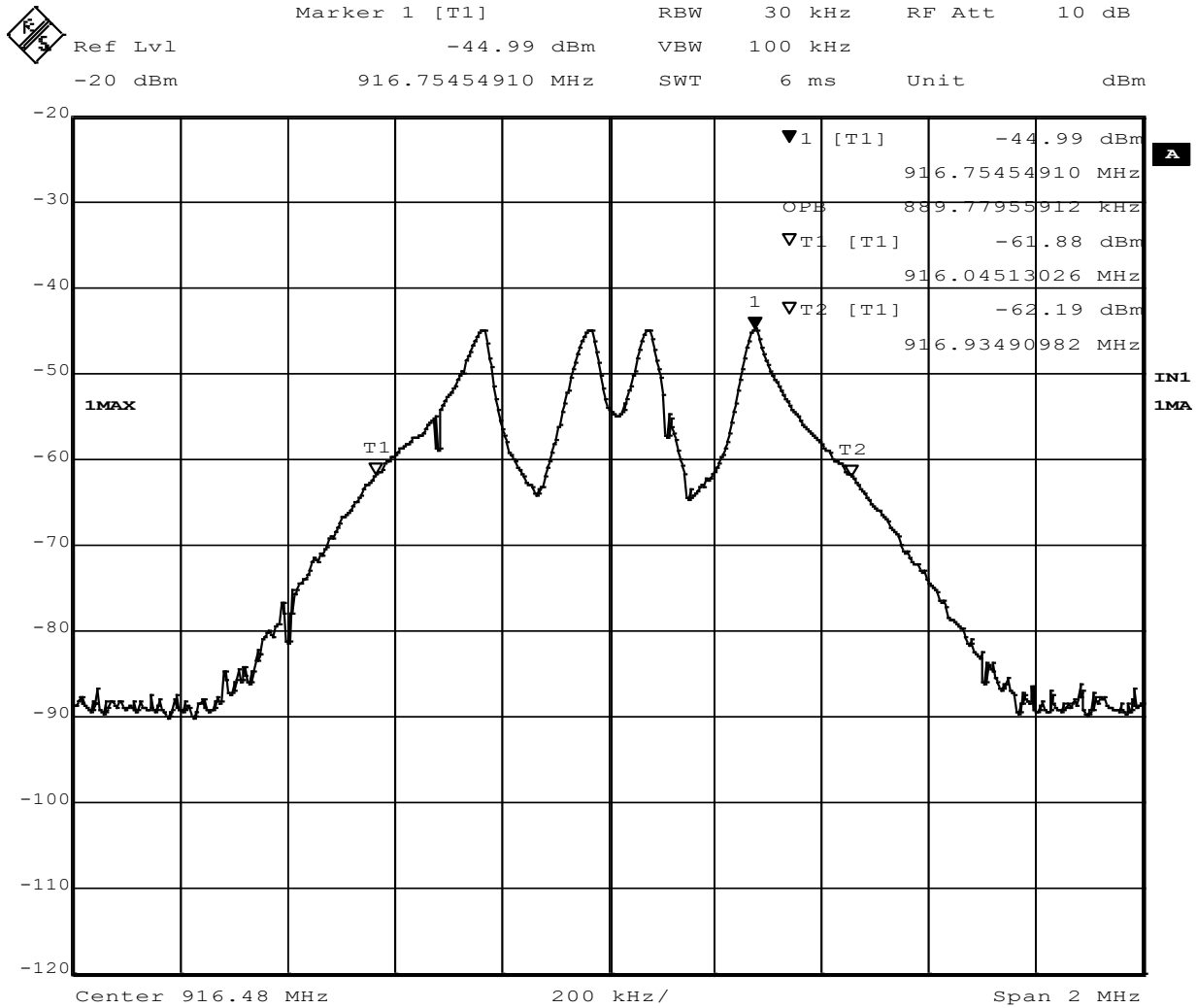
Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
1	916.48	889.78

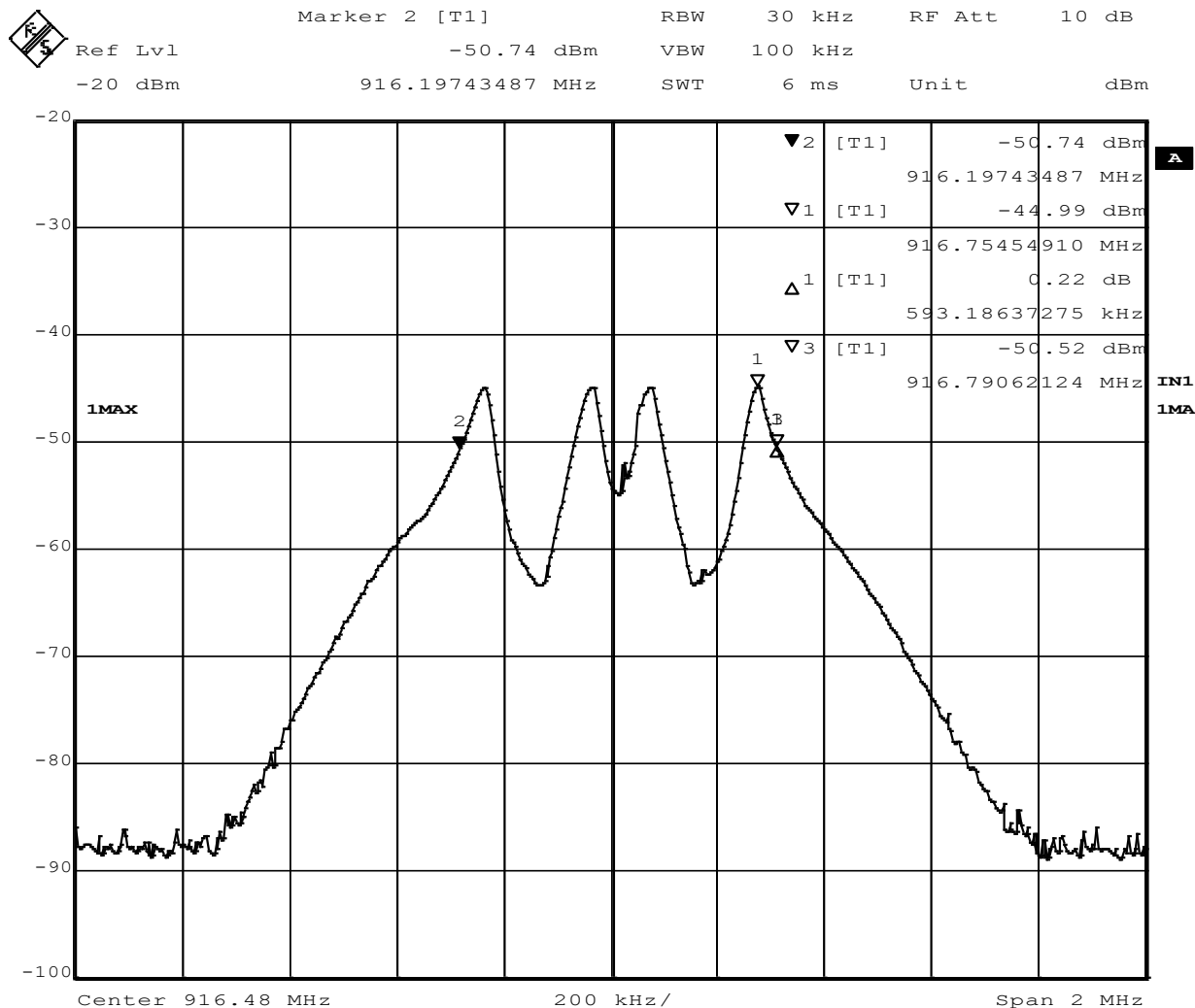
6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)
1	916.48	593.19



Date: 6.DEC.2018 10:12:47

Figure 6 - 99% Occupied Bandwidth



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Figure 7 - 6dB Bandwidth

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4.5 BAND-EDGES

Test Method: ANSI C63.10, Section(s) 6.10.6, 11.11, 11.12, 11.13

Limits of band-edge 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 100 kHz and the EMI receiver was used to scan from the band-edge to the fundamental frequency with a peak detector. The highest emissions level beyond the band-edge 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:

See Section 4.2

EUT operating conditions:

The EUT was powered by 3.6 VDC unless specified and set to transmit continuously on the only channel that it transmits in.

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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	-101.91	-44.73	57.18	42.48	PASS
High, Continuous	960.0	-101.15	-44.73	56.42	42.48	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	-80.34	-44.73	35.61	20.00	PASS
High, Continuous	928.0	-80.42	-44.73	34.11	20.00	PASS

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

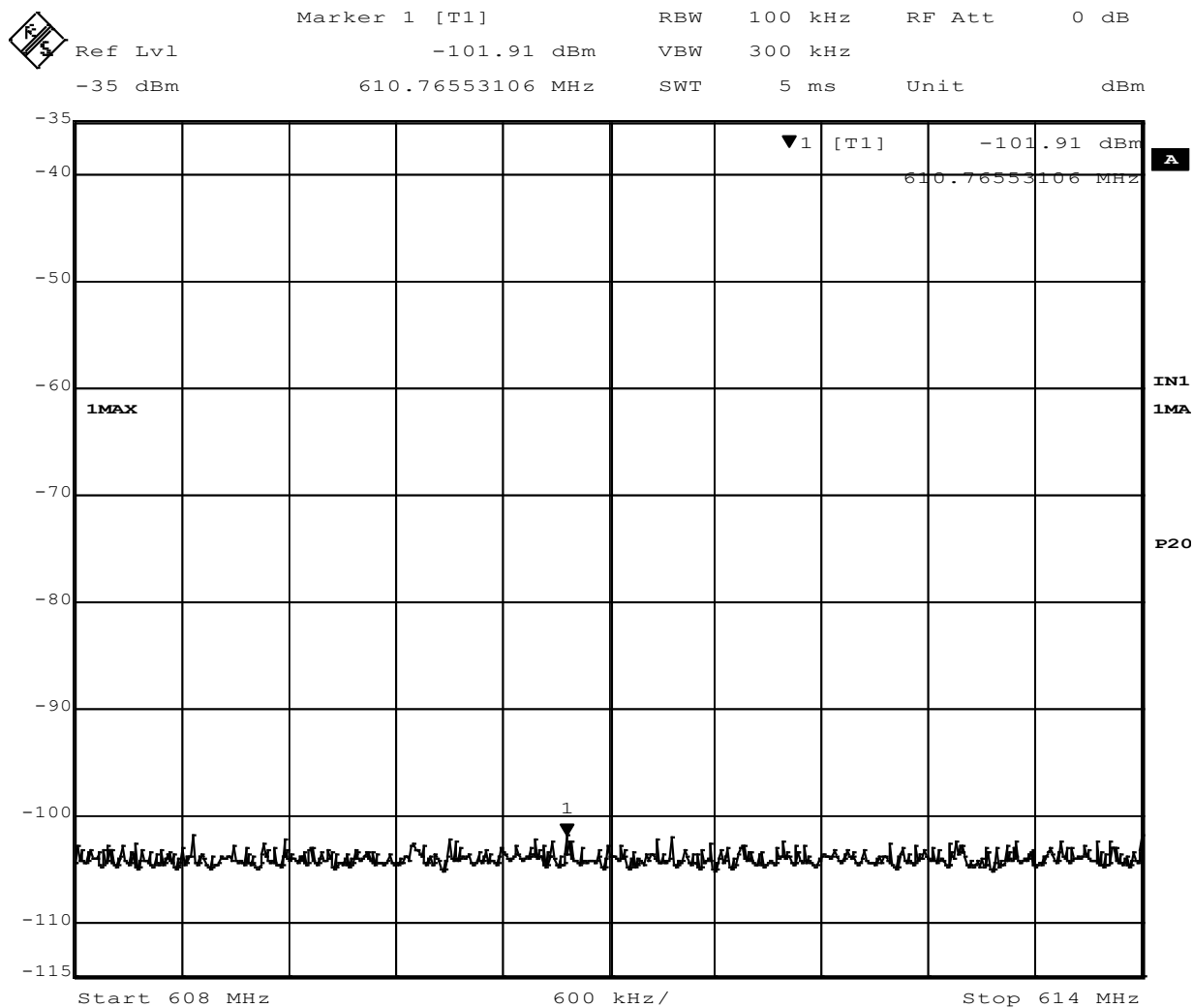
From Section 4.2

Fundamental average field strength at 916.48 MHz for low and high channel = 88.48 dB μ V/m

Low and High channel minimum delta = 88.48 – 46.0 dB μ V/m = 42.48 dBc

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

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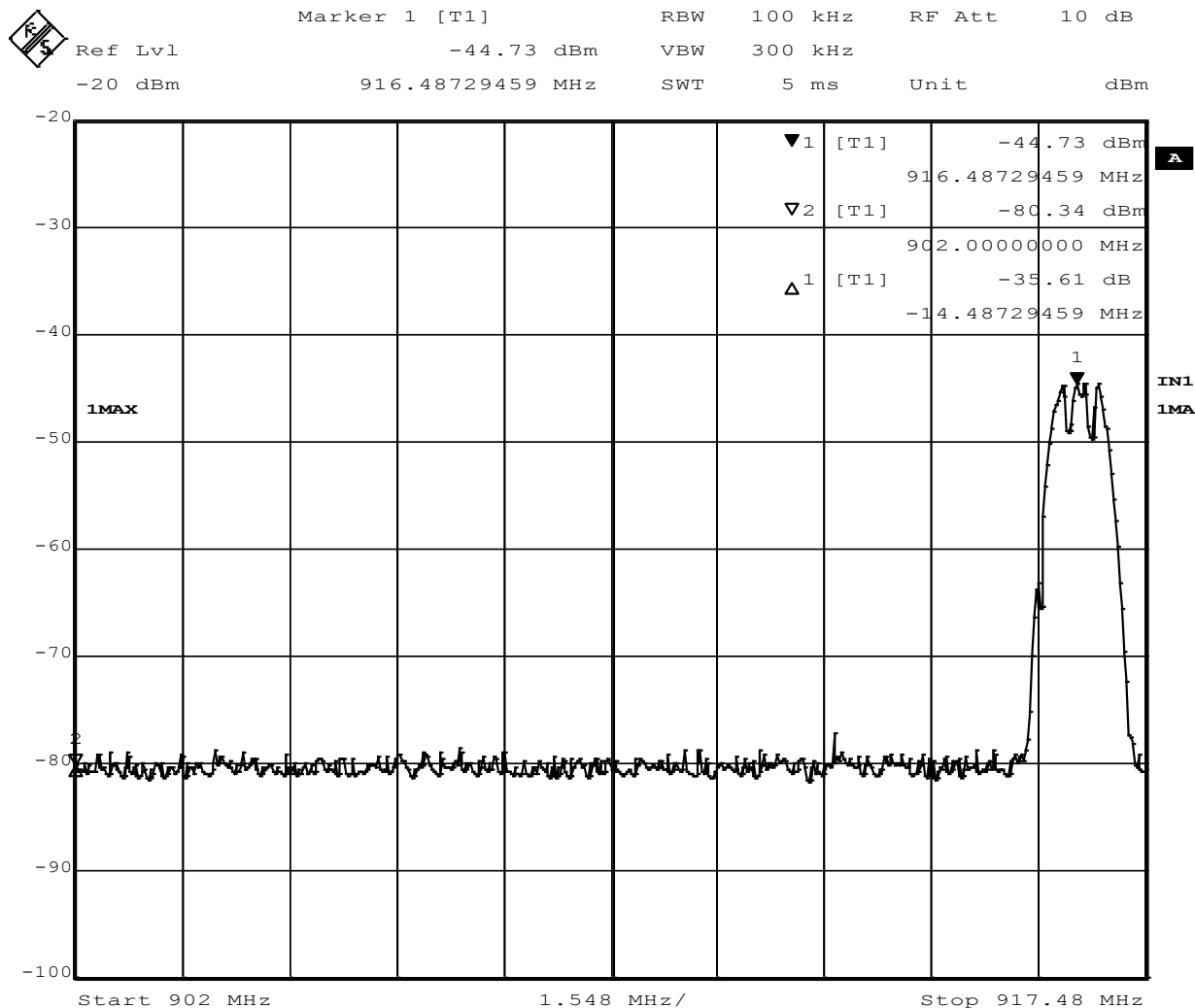


Date: 6.DEC.2018 10:16:40

Figure 8 - Band-edge Measurement, Lower Band Edge, Restricted Frequency, Continuous Transmit

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

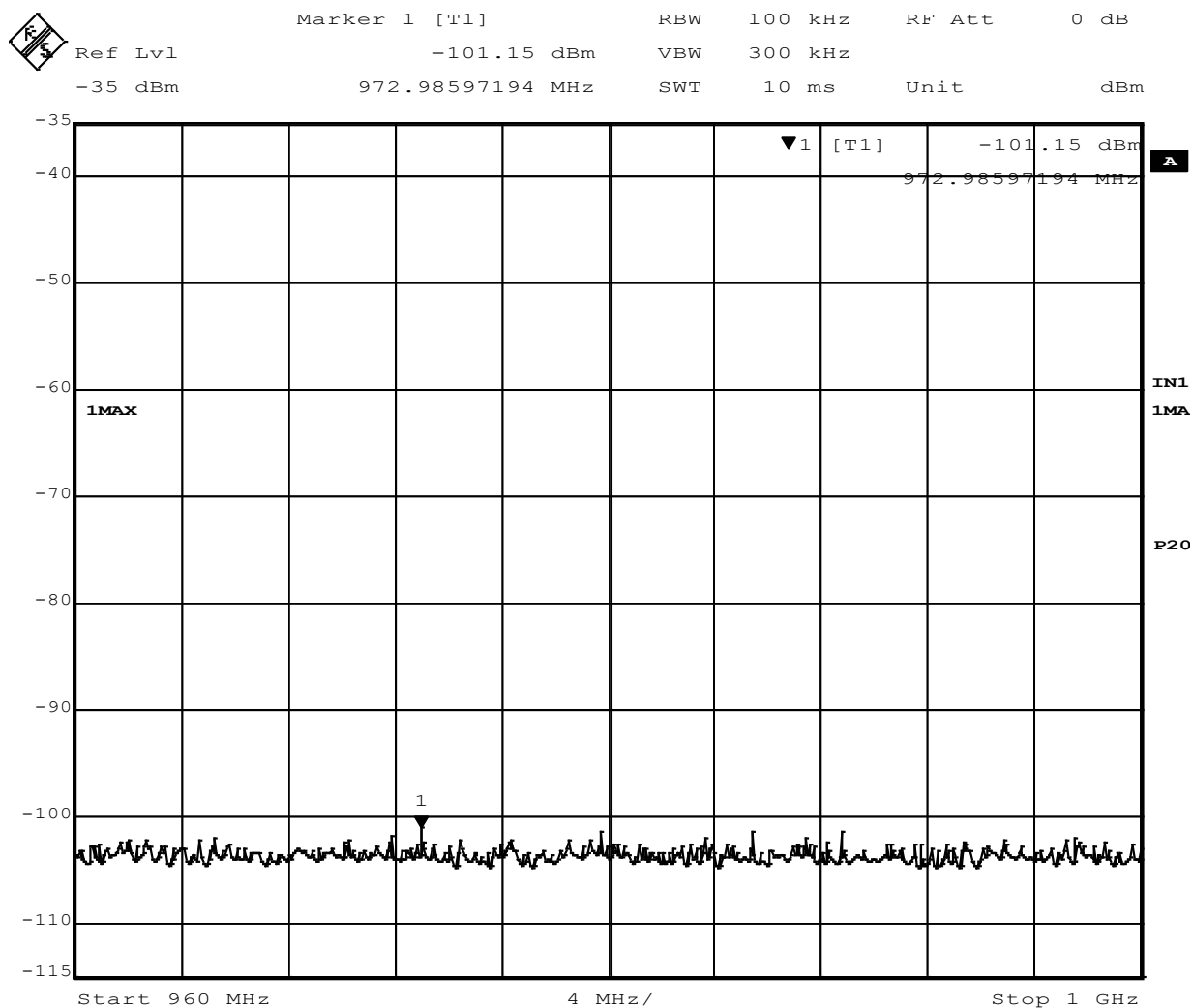
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Date: 6.DEC.2018 10:15:23

Figure 9 - Band-edge Measurement, Lower Band Edge, Fundamental, Continuous Transmit

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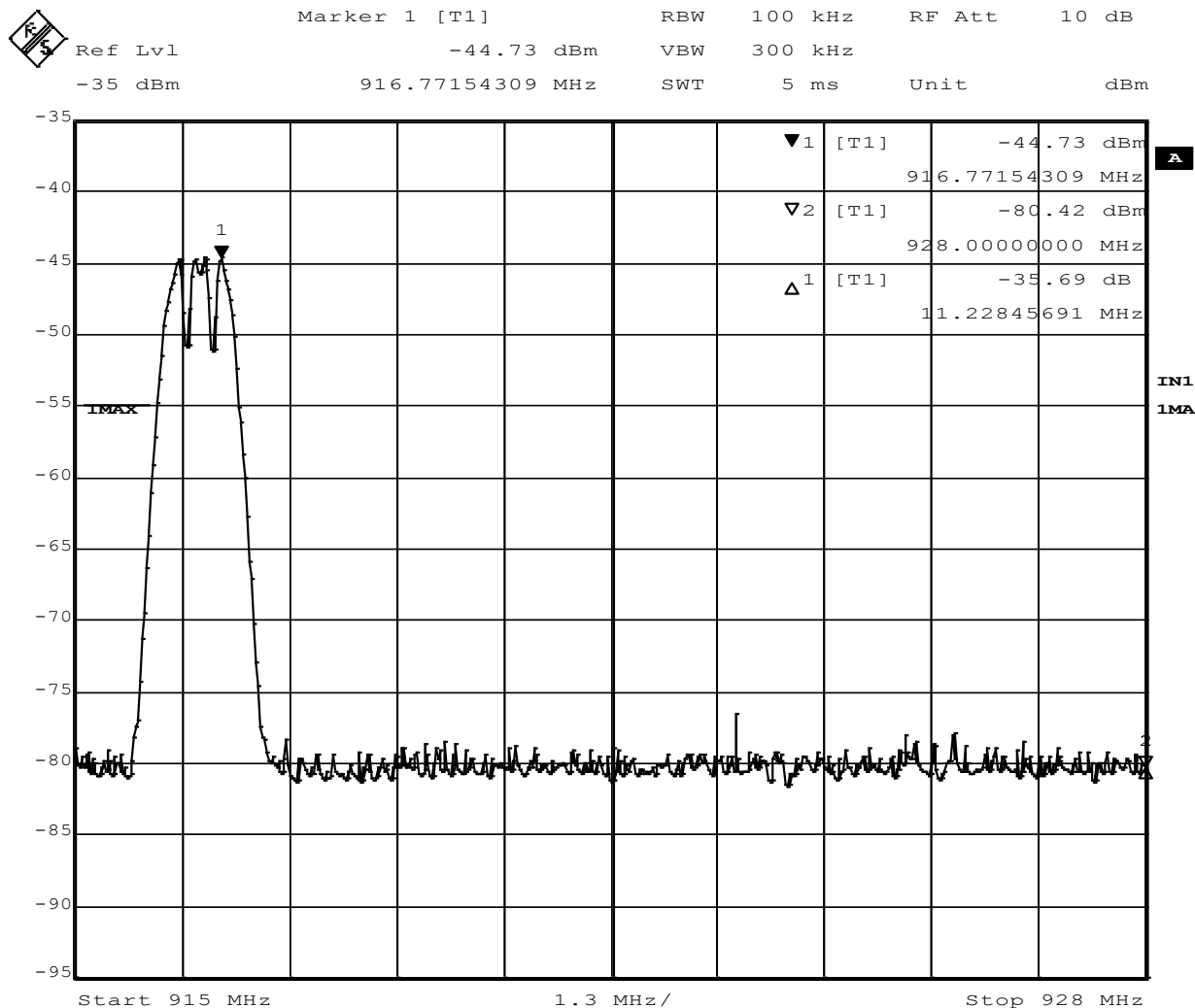


Date: 6.DEC.2018 10:17:42

Figure 10 - Band-edge Measurement, Higher Band Edge, Restricted Frequency, Continuous Transmit

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

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Date: 6.DEC.2018 10:18:37

Figure 11 - Band-edge Measurement, Higher Band Edge, Fundamental, Continuous Transmit

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4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10, Section 11.10.3

Limits of power measurements:

The maximum PSD allowed is 8 dBm.

Test procedures:

1. The EUT was tested at 3m test distance.
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:

See Section 4.2

EUT operating conditions:

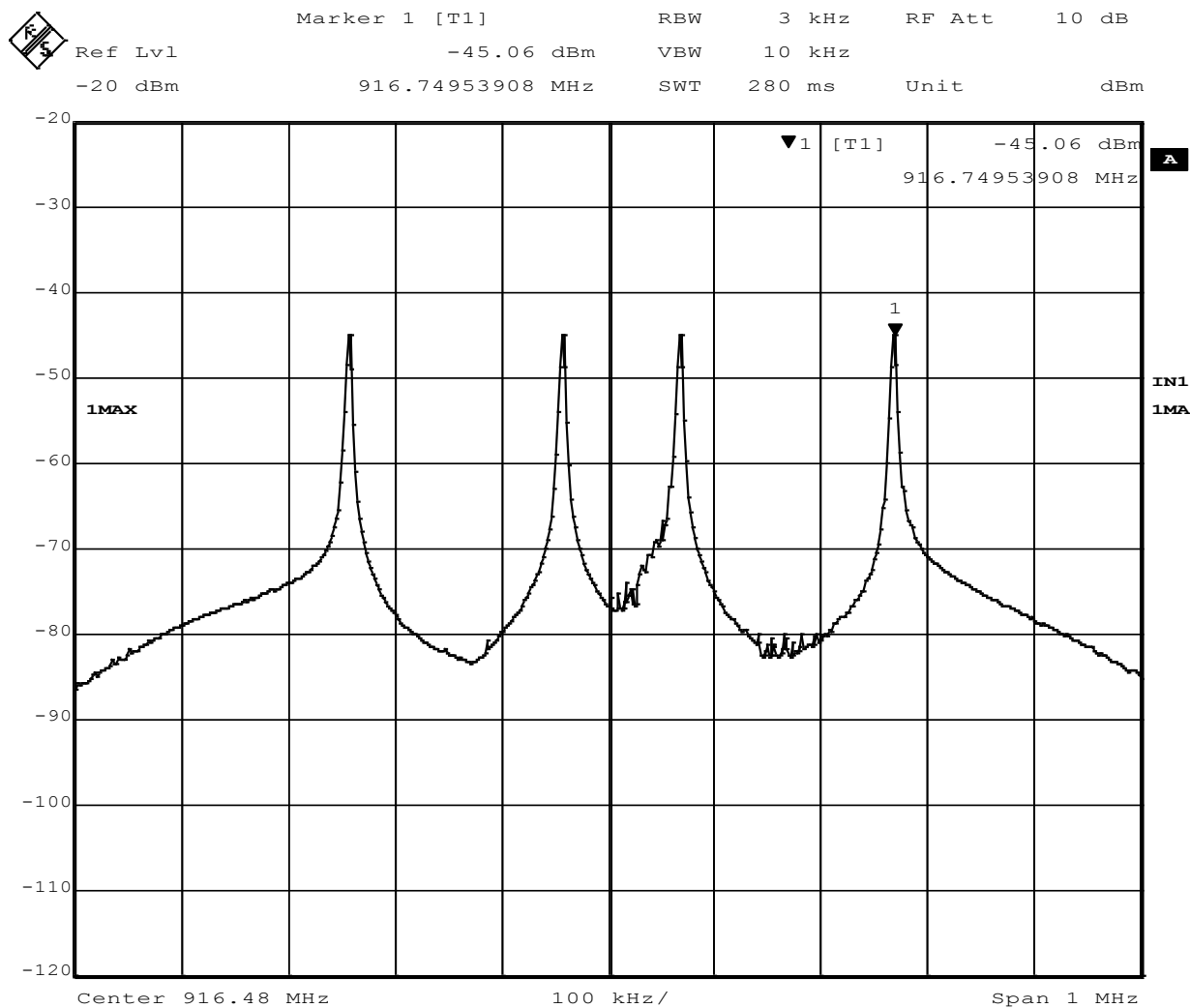
The EUT was powered by 3.6 VDC unless specified and set to transmit continuously on the only channel that it transmits in.

Test results:

Power Spectral Density

CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	Method	MAXIMUM POWER LIMIT (dBm)	RESULT
916.48	-4.99	EIRP	8	Pass

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Date: 6.DEC.2018 10:11:10

Figure 12 - Power Spectral Density, Low Channel

Maximum power = $-45.06 \text{ dBm} + 107 + \text{CL} + \text{AF} - 95.23 = -4.99 \text{ dBm}$

CL = cable loss = 4.80 dB

AF = antenna factor = 23.50 dB

107 = conversion from dBm to dBμV on a 50Ω measurement system

-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

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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 dB μ V 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 dB μ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

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

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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;

$$EIRP \text{ (Watts)} = [Field \text{ Strength (V/m)} \times antenna \text{ distance (m)}]^2 / 30$$

$$Power \text{ (watts)} = 10^{[Power \text{ (dBm)}/10]} / 1000$$

$$Voltage \text{ (dB}\mu\text{V)} = Power \text{ (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$Field \text{ Strength (V/m)} = 10^{[Field \text{ Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$Gain = 1 \text{ (numeric gain for isotropic radiator)}$$

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

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

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

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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%.

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REPORT END