ENGINEERING TEST REPORT

QT-5000 Module
Model No.: QT-5000
FCC ID: Q5N-QT5000

Applicant: **Quantum5X Systems Inc.**
30 Adelaide Street North, Suite 12
London, Ontario
Canada, N6B 3N5

Tested in Accordance With

Federal Communications Commission (FCC)
CFR 47, PARTS 2 and 74 (Subpart H)

UltraTech's File No.: 15Q5X044_FCC74

This Test report is Issued under the Authority of Tri M. Luu, Vice President of Engineering UltraTech Group of Labs Date: September 28, 2015	
Report Prepared by: Tri Luu Issued Date: September 28, 2015	Tested by: Hung Trinh Test Dates: September 17 - 22, 2015

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 74 (Subpart H)
Title:	Telecommunication - Code of Federal Regulations, CFR 47, Parts 2 and 74 (Subpart H)
Purpose of Test:	To obtain FCC Certification Authorization for Radio operating in the frequency bands 614.225 - 697.775 MHz.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

1.2. RELATED SUBMITAL(S)/GRANT(S)

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2015	Code of Federal Regulations – Telecommunication
ANSI C63.4	2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
TIA/EIA 603, Edition D	2010	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
CISPR 22 & EN 55022	2008-09, 2006	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
CISPR 16-1-1 +A1 +A2	2006 2006 2007	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Quantum5X Systems Inc.
Address:	30 Adelaide Street North, Suite 12 London, Ontario Canada, N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

MANUFACTURER	
Name:	Quantum5X Systems Inc.
Address:	30 Adelaide Street North, Suite 12 London, Ontario Canada, N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Quantum5X Systems Inc.
Product Name:	QT-5000 Module
Model Name or Number:	QT-5000
Serial Number:	Preproduction
Type of Equipment:	Low power auxiliary transmitter
Input Power Supply Type:	3.7V Rechargeable Internal Non-removable Battery
Primary User Functions of EUT:	Wireless Audio Microphone transmitter

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	Module for Mobile and Specific Portable Host Application
Intended Operating Environment:	Commercial, Industrial or Business environment
Power Supply Requirement:	3.7V Rechargeable Internal Battery
RF Output Power Rating:	81.1 mw (conducted)
Operating Frequency Range:	614.225 - 697.775 MHz
RF Output Impedance:	50 Ohms
Occupied Bandwidth (99%):	133.7 kHz
Emission Designation*:	132KF3E
Antenna Connector Type:	Integral, Permanently soldered to PCB
Antenna Type:	¼ Wave Wire antenna, Max Gain: 3.0dBi, Freq Range: 614-698 MHz

Necessary Bandwidth Calculation for Sound Broadcasting:

Bn = 2M + 2DK = 2x15 kHz + 2x51.1 kHz = 132.2 kHz
Where: M = 15 kHz, D = 51.1 kHz as measured, K =1

2.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Battery charging port	1	Micro USB	Non-shielded

2.5. ANCILLARY EQUIPMENT

None

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	3.7 V Rechargeable Battery

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	N/A
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the transmitter antenna port terminated to a 50 Ohms RF Load.

Transmitter Test Signals	
Frequency Band(s): ▪ 614 – 698 MHz band:	Lowest, Middle & Highest frequencies in each frequency bands that the transmitter covers: ▪ 614.225, 656.0 and 697.775 MHz
Transmitter Wanted Output Test Signals: ▪ RF Power Output (measured maximum output power): ▪ Normal Test Modulation ▪ Modulating signal source:	 ▪ 81.1 mW ▪ FM voice ▪ Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).

- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with FCC office (FCC File No.: 91038) and Industry Canada office (Industry Canada File No.: 2049A-3). Expiry Date: 2017-04-02.

4.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
74.861(e)(1) & 2.1046	RF Power Output	Yes
74.861(e)(2)	Transmitters may be either crystal controlled or frequency synthesized	The transmitter is frequency synthesized
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
74.861(e)(4) & 2.1055	Frequency Stability	Yes
2.1047(a)	Audio Frequency Response	Yes
74.861(e)(3) & 2.1047(b)	Modulation Limiting	Yes
74.861(e)(5)	Operating Bandwidth	Yes
74.861(e)(6) & 2.1049	Emission Limitation	Yes
74.861(e)(6), 2.1057 & 2.1051	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
74.861(e)(6), 2.1057 & 2.1053	Emission Limits - Field Strength of Spurious Emissions	Yes
QT-5000 Module, **Model No.: QT-5000**, by **Quantum5X Systems Inc.** has also been tested and found to comply with **FCC Part 15, Subpart B - Radio Receivers and Class B Digital Devices**. The engineering test report has been documented and kept in file and it is available anytime upon FCC request.		

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None

EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

5.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 8 of this report.

5.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement. Refer to Exhibit 7 for Measurement Uncertainties.

5.3. MEASUREMENT EQUIPMENT USED:

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C63.4 and CISPR 16-1-1.

5.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER:

The essential function of the EUT is to correctly transmit audio signals to Gateway over RF link.

5.5. RF POWER OUTPUT @ FCC 2.1046 & 74.861(E)(1)

5.5.1. Limits

FCC 74.861(e)(1)(ii) - The power of the measured un-modulated carrier power at the output of the transmitter power amplifier (antenna input power) may not exceed the following:

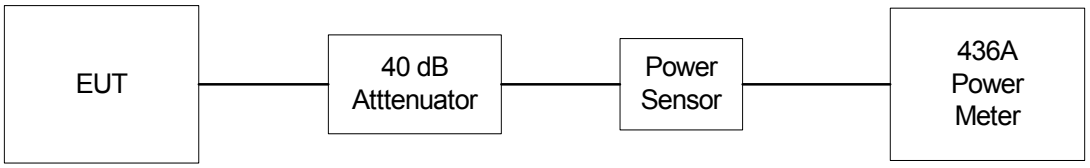
(i) 54-72, 76-88, and 174-216 MHz bands--50 mW
(ii) 470-608 and 614-698 MHz bands--250 mW

5.5.2. Method of Measurements

Refer to Exhibit 8, § 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details.

5.5.3. Test Arrangement

- Power at RF Antenna Power Output Terminal.



5.5.4. Test Data

Conducted Power

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured Conducted Power (mWatts)	Conducted Power Limit (mWatts)
Lowest	614.225	80.35	250.0
Middle	656.000	81.10	250.0
Highest	697.775	79.62	250.0

Note: Max Antenna Gain = 3.0 dBi

5.6. RF EXPOSURE REQUIRMENTS @ 1.1310, 2.1091 & 2.1093

5.6.1. Limits

FCC has specified the general guidance for meeting RF Exposure requirements in KDB 447498 D01 General RF Exposure Guidance v05r02, the following are the applicable sections for this module summarized from this guidance.

1) The RF exposure requirements for devices operating in mobile and portable exposure conditions are different. When both exposure conditions apply to a device, compliance is determined according to the rules and policies established for both exposure conditions. Equipment authorization for devices that are categorically excluded from routine RF exposure evaluation according to §2.1091(c) and §2.1093(c).
2) Standalone and simultaneous transmission use conditions for mobile and portable exposure conditions must be determined according to the host platform and product operating configuration requirements
3) Transmitter modules must be approved according to one of the following host platform exposure conditions, with respect to the product configurations tested or evaluated for equipment approval for incorporation in qualified host products. The approved host platform exposure condition(s) must be identified on the grant of equipment certification. When transmitter modules are incorporated in host devices that qualify for RF exposure test exclusion and no other testing or equipment approval is required, the standalone and simultaneous transmission configurations and test exclusion conditions must be fully documented in the grantee's records.
4) *(a) Mobile exposure host* platform evaluation procedures can only be applied if all transmitters in the host devices support mobile exposure conditions. Transmitters and modules approved only for use in the *mobile exposure host* platform cannot operate in hosts and product configurations that require standalone or simultaneous transmission operations in portable exposure conditions. The *portable exposure host* platform or the *mixed mobile and portable exposure* platform is required to support portable exposure conditions in qualified host configurations.
5) *(b) Portable exposure host* platform evaluation procedures can only be applied if all transmitters in the host devices support portable exposure conditions. Transmitters and modules approved for use in the *portable exposure host* platform may be used for standalone operations in *mobile exposure host* platforms, without further equipment approval, only when the same identical transmitter and antenna required for portable exposure conditions are used.
6) Transmitters operating in consumer products must satisfy the general population exposure limits required for either mobile or portable RF exposure conditions as appropriate. The test configurations used to qualify for test exclusion or used for compliance testing must be sufficiently conservative for all required operations to demonstrate compliance.
7) As required by §§ 2.1033(b)(3) and 2.1033(c)(3), users and installers shall be furnished with the required operating and installation instructions. These are reviewed for acceptance during equipment approval. The applicable instructions must be provided to installers, integrators and end users to ensure proper installation and operation of the devices for meeting compliance.
8) Extremity exposure conditions: Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. 10-g extremity *SAR Test Exclusion Thresholds* in section 4.3 should be applied to determine SAR test requirements.

Appendix A

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

Approximate SAR Test Exclusion Power Thresholds at Selected Frequencies and Test Separation Distances are illustrated in the following Table. The equation and threshold in section 4.3.1 must be applied to determine SAR test exclusion.

MHz	5	10	15	20	25	mm
150	39	77	116	155	194	SAR Test Exclusion Threshold (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	

Note: 10-g Extremity SAR Test Exclusion Power Thresholds are 2.5 times higher than the 1-g SAR Test Exclusion Thresholds indicated above. These thresholds do not apply, by extrapolation or other means, to occupational exposure limits.

In order to verify the SAR test exclusion as specified in Sec 4.3.1; for Standalone SAR test exclusion consideration and Sec 4.3.2; for Simultaneous transmission SAR test exclusion considerations for this module to be qualified with only the specified host (tap shoes), the following calculations performed. SAR extremity exposure condition applied.

Standalone SAR test exclusion threshold condition for each radio is verified as per below.

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:
   [(*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR,[25] where
   - $f_{(GHz)}$ is the RF channel transmit frequency in GHz
   - Power and distance are rounded to the nearest mW and mm before calculation[26]
   - The result is rounded to one decimal place for comparison
   - 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

1. UHF Radio: 697.8 MHz with Max 81.1 mw conducted power

= (81.1)/(X) (√.6978) < 7.5

So minimum separation distance X = 9.1 mm so we use **10 mm.**

2. 802.15.4 Radio: 2.48 GHz with Max 0.7 mw conducted power @ 10 mm separation distance

= (.7)/10 x (√2.48) < 7.5

= 0.11 < 7.5, so it comfortably satisfies with 10 mm separation distance.

Since it is possible that both radios can transmit simultaneously, we shall also verify the **Simultaneous transmission SAR test exclusion** condition as given in Sec 4.3.2 as shown below for the 10mm separation distance from the user.

2) When the standalone SAR test exclusion of section 4.3.1 is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion:[30]

- *(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]·[$\sqrt{f_{(GHz)}}/x$]* W/kg for *test separation distances* ≤ 50 mm;

  where $x = 7.5$ for 1-g SAR, and $x = 18.75$ for 10-g SAR.

This SAR estimation formula has been considered, in conjunction with the *SAR Test Exclusion Thresholds*, to result in substantially conservative SAR values of ≤ 0.4 W/kg. When SAR is

1. UHF Radio: 697.8 MHz @ 81.1 mw conducted power

= (81.1)/(10) (√.6978/18.75) = 0.36 W/kg < 0.4 W/kg

2. 802.15.4 Radio: 2.48 GHz @ .7 mw

= (0.7)/(10) (√2.48/18.75) = 0.006 W/kg < 0.4 W/kg

The estimated SAR is only used to determine simultaneous transmission SAR test exclusion; it should not be reported as the standalone SAR. When SAR is estimated, it must be applied to determine the sum of 1-g SAR test exclusion.

Combined Estimated SAR = 0.366 W/kg < 0.4 W/kg

So we demonstrate compliance with SAR exclusion threshold when final installation of this module into the qualified host shall always maintain more than 10mm separation distance from the user feet.

5.7. FREQUENCY STABILITY @ FCC 2.1055 & 74.861(E)(4)

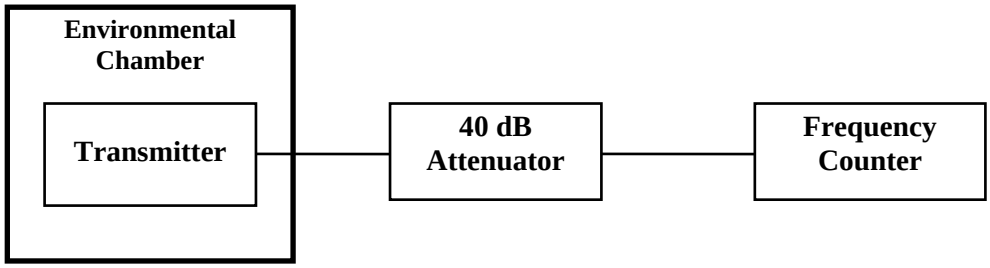
5.7.1. Limits

FCC 74.861(e)(4) - The frequency tolerance of the transmitter shall be 0.005 percent

5.7.2. Method of Measurements

Refer to Exhibit 8, § 8.3 of this report for measurement details

5.7.3. Test Arrangement



5.7.4. Test Data

Center Frequency:	614.225 MHz
Full Power Level:	19.05 dBm
Frequency Tolerance Limit (Worst Case):	0.005% or ±50 ppm or 30711 Hz
Max. Frequency Tolerance Measured:	-558 Hz or 0.9 ppm
Input Voltage Rating:	3.7 VDC

Ambient Temperature (^{o}C)	**Frequency Drift (Hz)**		
	Supply Voltage (Nominal) 3.7 Volts	**Supply Voltage (Minimum before switch-off) 3.3 Volts**	**Supply Voltage (115% of Nominal) 4.26 Volts**
-30	-177	--	--
-20	-272	--	--
-10	-232	--	--
0	-357	--	--
10	-123	--	--
20	-116	-103	-128
30	**-558**	--	--
40	-493	--	--
50	-479	--	--

5.8. AUDIO FREQUENCY RESPONSE / MODULATION REQUIREMENTS @ FCC 2.1047(A)

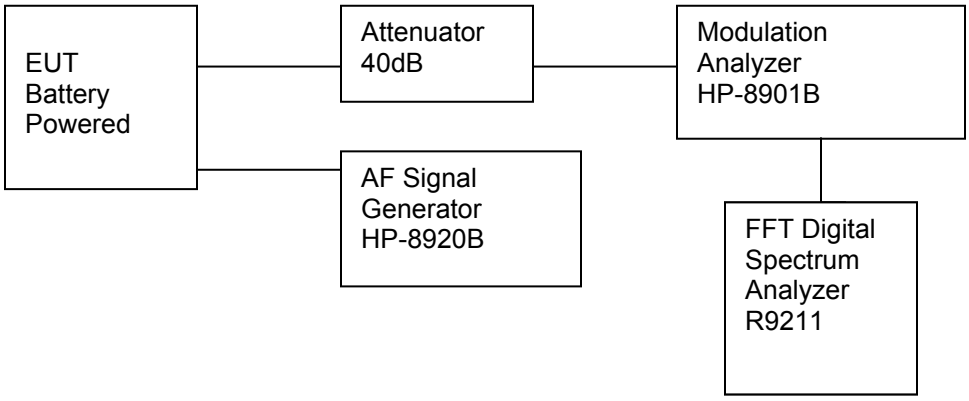
5.8.1. Limits

No limits. Tests are performed for information only.

5.8.2. Method of Measurements

The rated audio input signal was applied to the input of the audio low-pass filter (or of all modulation stages) using an audio oscillator, this input signal level and its corresponding output signal were then measured and recorded using the FFT (Audio) spectrum analyzer. Tests were repeated at different audio signal frequencies from 0 to 30 kHz.

5.8.3. Test Arrangement



5.8.4. Test Data

Note: Due to the difficulty of measuring the Frequency Response of the internal low-pass filter, the Frequency Response of All Modulation States are performed to show the roll-off at 3 kHz in comparison with the limit for audio low-pass filter.

- **Minimum Attenuation Rel. to 1 kHz Attenuation**

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 3 kHz (dB)	Recommended FCC Limit (dB)
0.1	-29.37	3.37	32.7	0.5	--
0.2	-29.37	3.46	32.8	0.5	--
0.4	-29.37	2.39	31.8	-0.5	--
0.6	-29.37	2.20	31.6	-0.7	--
0.8	-29.37	2.65	32.0	-0.3	--
1.0	-29.37	2.92	32.3	0.0	--
1.5	-29.37	3.49	32.9	0.6	--
2.0	-29.37	4.21	33.6	1.3	--
2.5	-29.37	4.96	34.3	2.0	--
3.0	-29.37	5.63	35.0	2.7	0
3.5	-29.37	6.10	35.5	3.2	-4
4.0	-29.37	6.45	35.8	3.5	-7
4.5	-29.37	6.72	36.1	3.8	-11
5.0	-29.37	6.94	36.3	4.0	-13
6.0	-29.37	7.16	36.5	4.2	-18
7.0	-29.37	7.22	36.6	4.3	-22
8.0	-29.37	7.29	36.7	4.4	-26
9.0	-29.37	7.33	36.7	4.4	-29
10.0	-29.37	7.34	36.7	4.4	-31
11.0	-29.37	7.27	36.6	4.4	-36
12.0	-29.37	7.15	36.5	4.2	-40
13.0	-29.37	7.01	36.4	4.1	-44
14.0	-29.37	6.85	36.2	3.9	-47
15.0	-29.37	6.68	36.1	3.8	-49
20.0	-29.37	5.39	34.8	2.5	-50
25.0	-29.37	-1.82	27.6	-4.7	-50
30.0	-29.37	-1.85	27.5	-4.8	-50

5.9. MODULATION LIMITING @ FCC 2.1047(B) & 74.861(E)(3)

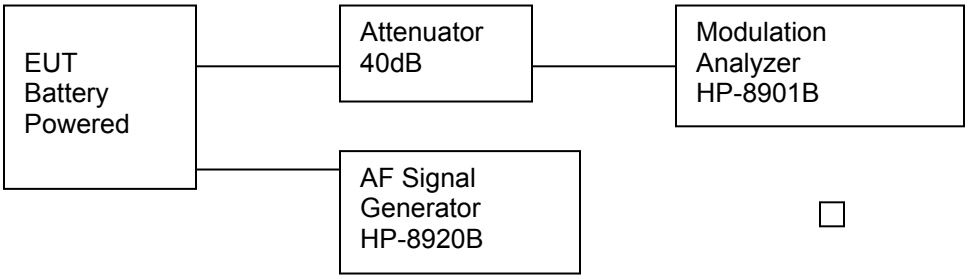
5.9.1. Limits

FCC 74.861(e)(3) - Any form of modulation may be used. A maximum deviation of ± 75 kHz is permitted when frequency modulation is employed.

5.9.2. Method of Measurements

For Audio Transmitter:- The carrier frequency deviation was measured with the tone input signal level varied from 0 Vp to audio input rating level plus 16 dB at frequencies 0.1, 0.5, 1.0, 3.0 and 5.0 kHz. The maximum deviation was recorded at each test condition.

5.9.3. Test Arrangement



5.9.4. Test Data

5.9.4.1. Voice Modulation Limiting:

Modulating Signal Level	Peak Frequency Deviation (kHz)							Maximum Limit
(mVrms)	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 KHz	10 KHz	15.0 kHz	(kHz)
5	16.57	15.26	28.33	34.22	21.03	34.47	34.82	75.0
10	19.78	17.86	35.36	21.09	26.95	34.99	34.82	75.0
20	24.57	21.88	21.79	27.33	31.89	34.99	34.81	75.0
30	28.50	25.18	25.11	31.73	33.53	34.94	34.80	75.0
40	31.48	27.84	27.93	31.95	34.75	34.83	34.75	75.0
50	34.58	30.28	30.42	31.71	34.48	34.60	34.50	75.0
60	37.15	32.58	32.34	31.74	34.41	34.48	34.34	75.0
70	39.51	33.45	32.51	34.79	34.42	34.37	34.22	75.0
80	42.30	33.51	32.03	34.73	34.42	34.24	34.13	75.0
90	43.40	33.51	31.95	34.75	34.39	34.20	34.08	75.0
100	44.60	33.54	33.88	34.77	34.42	34.18	34.01	75.0
200	48.90	32.25	34.53	34.81	34.59	33.95	33.94	75.0
300	50.10	33.10	34.61	34.85	34.66	33.99	34.05	75.0
400	50.40	33.71	34.58	34.85	34.71	34.09	34.15	75.0
500	50.60	33.69	34.48	34.85	34.74	34.20	34.26	75.0
600	50.80	33.71	34.54	34.85	34.78	34.26	34.31	75.0
700	50.80	33.81	34.57	34.85	34.78	34.34	34.35	75.0
800	50.90	33.76	34.55	34.85	34.81	34.38	34.43	75.0
900	51.00	33.79	34.53	34.85	34.83	34.38	34.44	75.0
1000	51.10	33.81	34.55	34.85	34.85	34.38	34.49	75.0

STD Modulation Level = 34 mV

Voice Signal Input Level = STD MOD Level + 16 dB = 46.63 dB(mVrms) = 214.53 mVrms		
Modulation Frequency (KHz)	**Peak Deviation (KHz)**	**Maximum Limit (KHz)**
0.1	51.10	75.0
0.2	38.80	75.0
0.4	35.10	75.0
0.6	33.92	75.0
0.8	34.30	75.0
1.0	34.55	75.0
1.2	34.83	75.0
1.4	34.92	75.0
1.6	34.96	75.0
1.8	35.02	75.0
2.0	35.01	75.0
2.5	35.02	75.0
3.0	34.85	75.0
3.5	34.99	75.0
4.0	34.92	75.0
4.5	34.96	75.0
5.0	35.01	75.0
6.0	34.30	75.0
7.0	34.31	75.0
8.0	34.31	75.0
9.0	34.31	75.0
10.0	34.29	75.0
15.0	34.40	75.0
20.0	32.96	75.0
25.0	23.83	75.0
30.0	17.51	75.0

5.10. OPERATING BANDWIDTH @ FCC 74.861(E)(5)

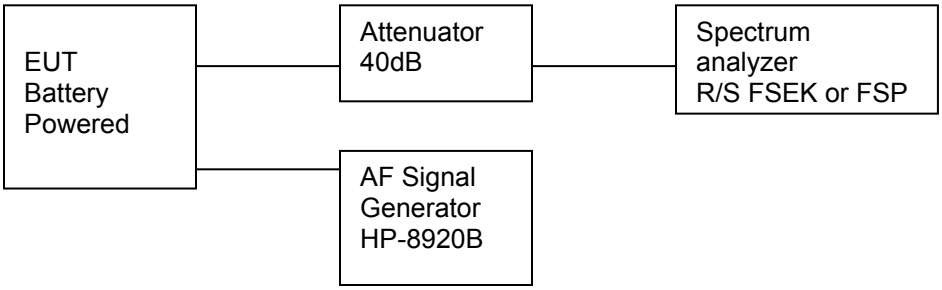
5.10.1. Limits

FCC 74.861(e)(5) - The operating bandwidth shall not exceed 200 kHz.

5.10.2. Method of Measurements

Refer to Exhibit 8, § 8.4 of this report for measurement details

5.10.3. Test Arrangement

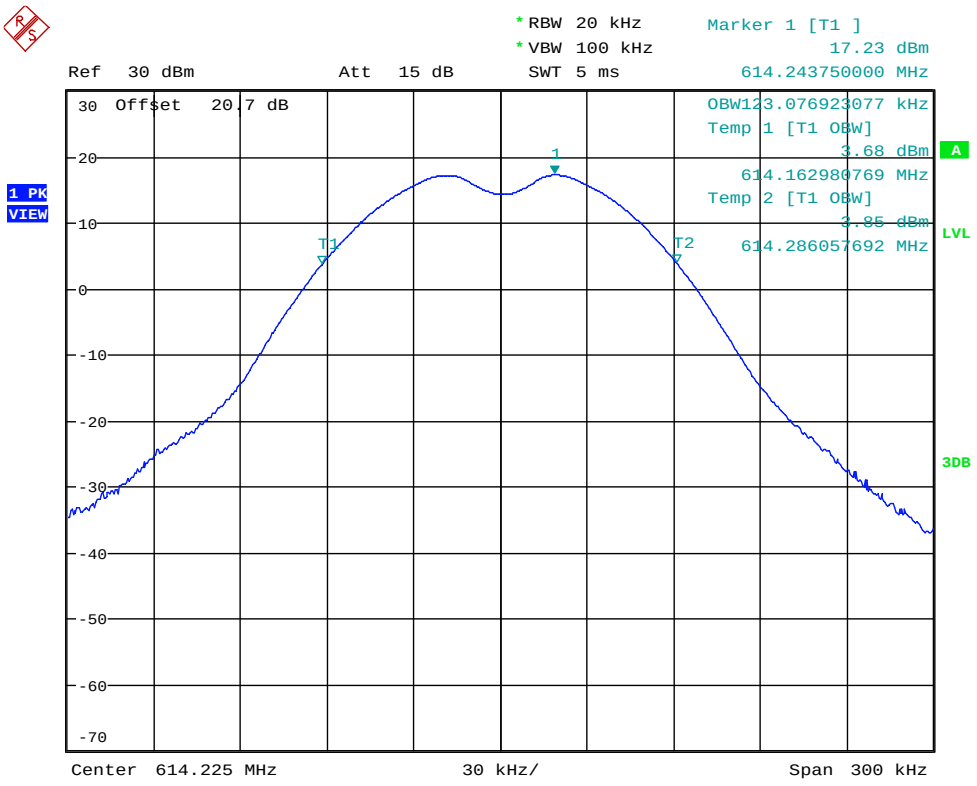


5.10.4. Test Data

Frequency (MHz)	Measured 99% OBW (kHz)	99% OBW Limit (kHz)
614.225	123.1	200
656.0	133.7	200
697.775	130.8	200

Note: The above tests were performed with the audio input of 15 kHz modulating sine wave signal as per FCC guidance.

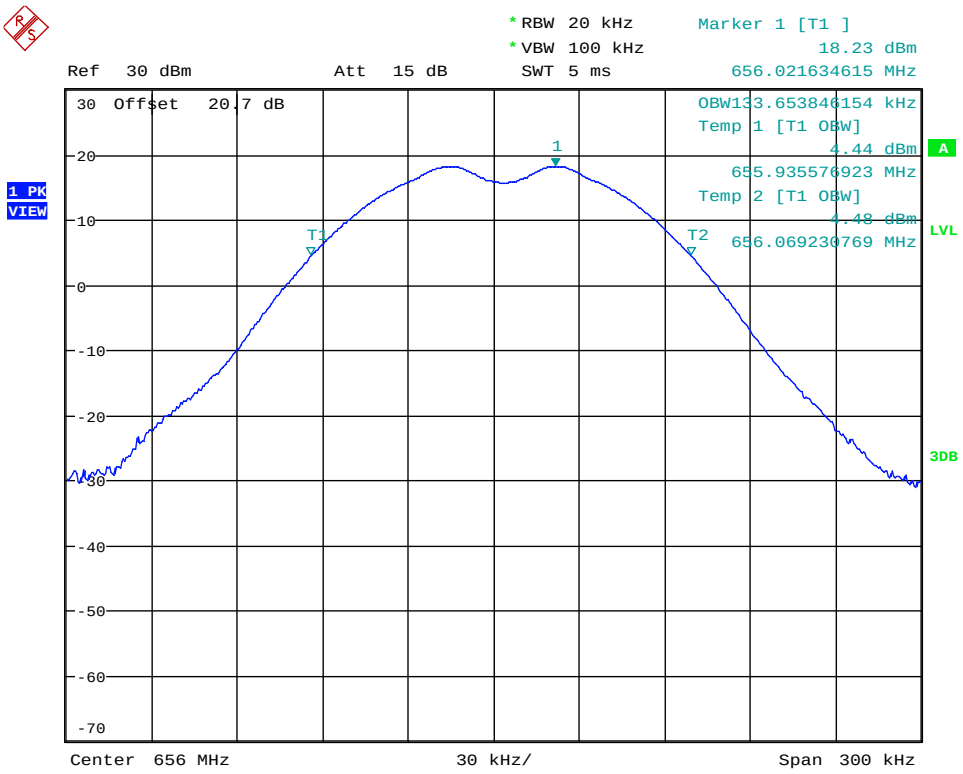
Plot # 1: 99% OBW - Low Channel, 614.225 MHz, FM Modulation with 15kHz Sine Wave signal



Date: 18.SEP.2015 15:10:26

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

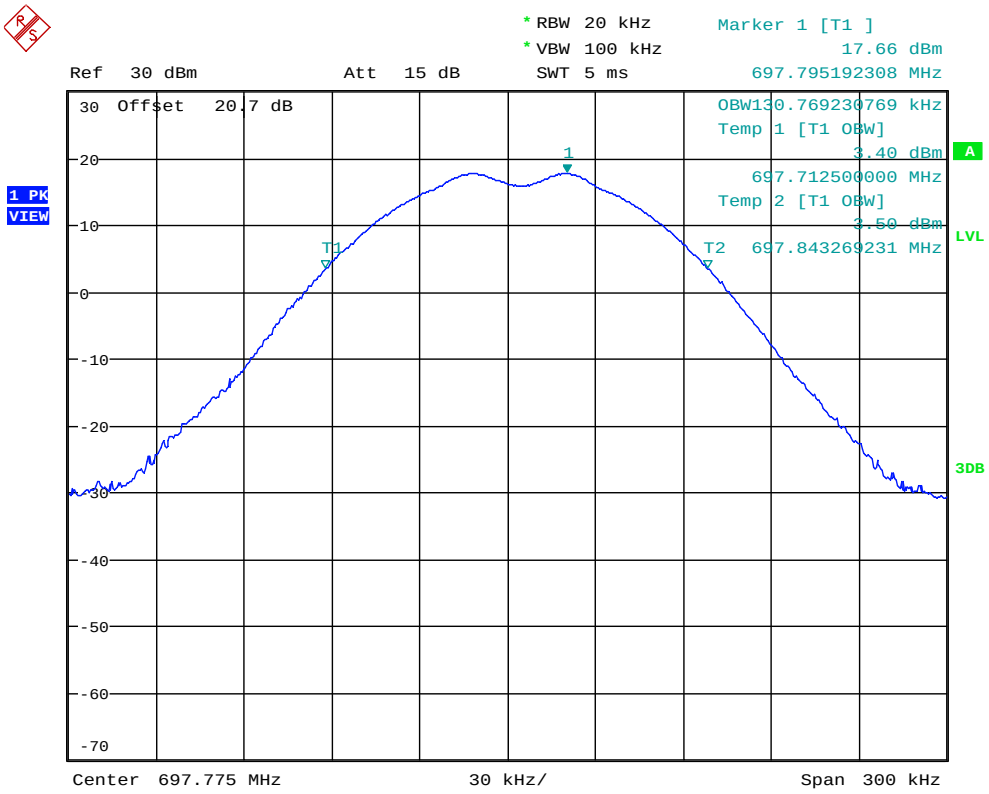
Plot # 2: 99% OBW - Mid Channel, 656.0 MHz, FM Modulation with 15kHz Sine Wave Signal



Date: 18.SEP.2015 15:06:08

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 3: 99% OBW - High Channel, 697.775 MHz, FM Modulation with 15kHz Sine Wave Signal



Date: 18.SEP.2015 14:51:08

5.11. EMISSION LIMITATION @ FCC 2.1049, 74.861(E)(6)

5.11.1. Limits

FCC 74.861(e)(6) - The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

i) On any frequency removed from the operating frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: at least 25 dB;

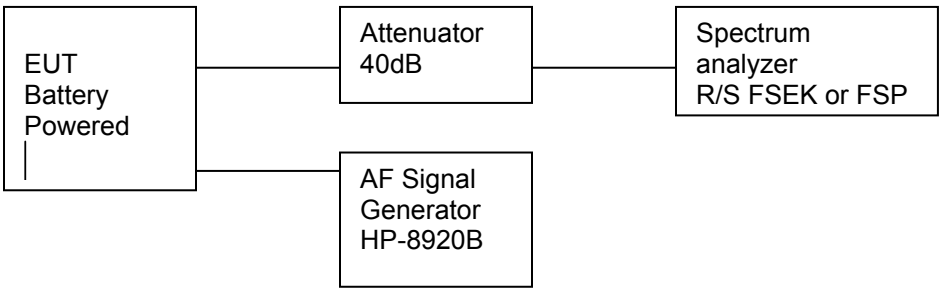
ii) On any frequency removed from the operating frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: at least 35 dB;

iii) On any frequency removed from the operating frequency by more than 250 percent of the authorized bandwidth: at least $43+10\log_{10}$ (mean output power in watts) dB.

5.11.2. Method of Measurements

Refer to Exhibit 8, § 8.4 of this report for measurement details.

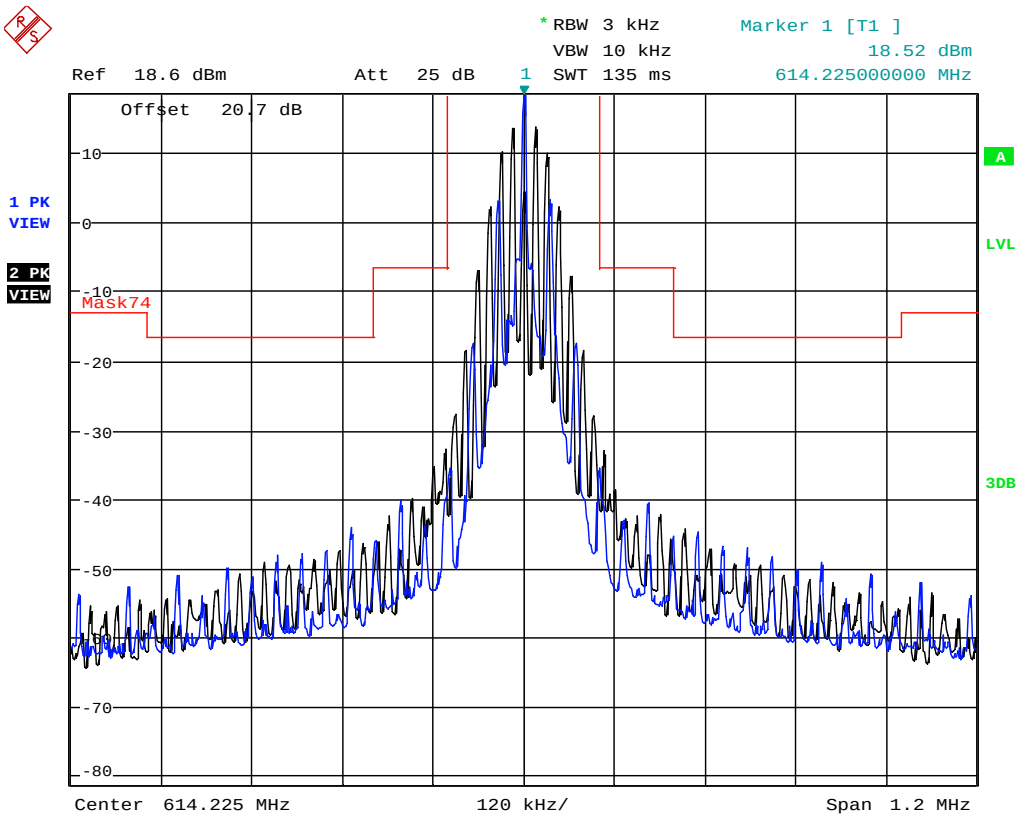
5.11.3. Test Arrangement



5.11.4. Test Data

Conform. Please refer to Plots # 4 through # 9 for details of measurements.

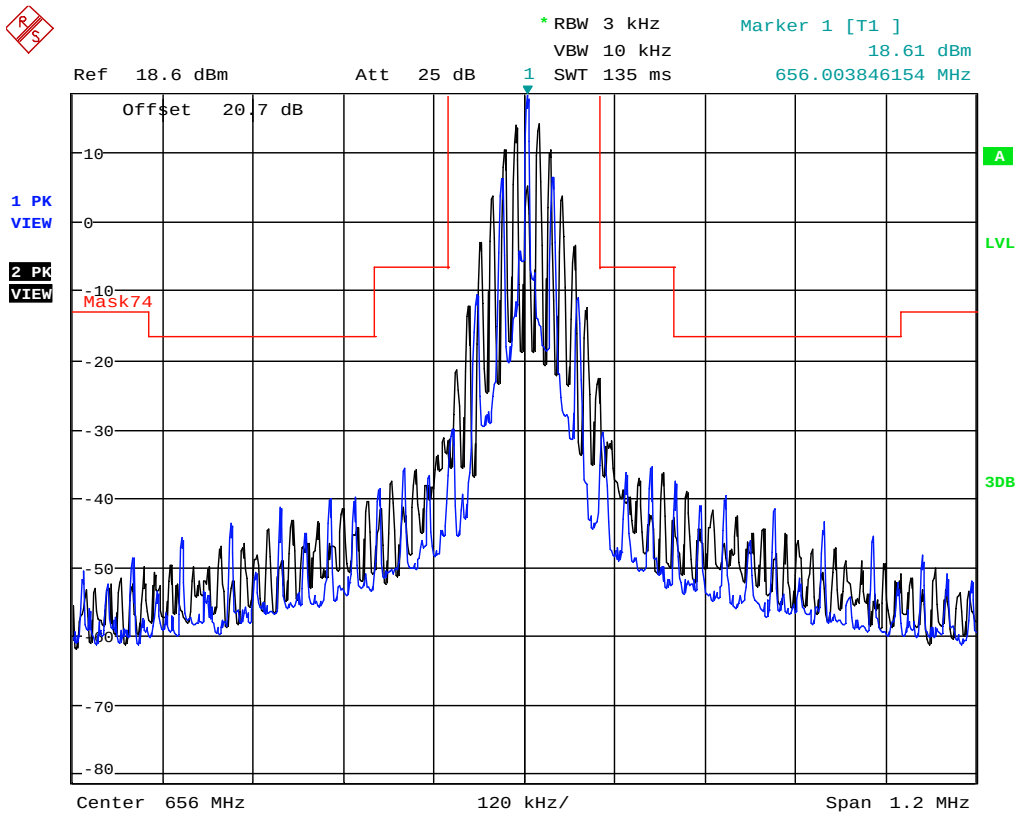
Plot # 4: Emission Mask - Low Channel, 614.225 MHz, FM Modulation with 15kHz Sine Wave signal



Date: 18.SEP.2015 15:54:54

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

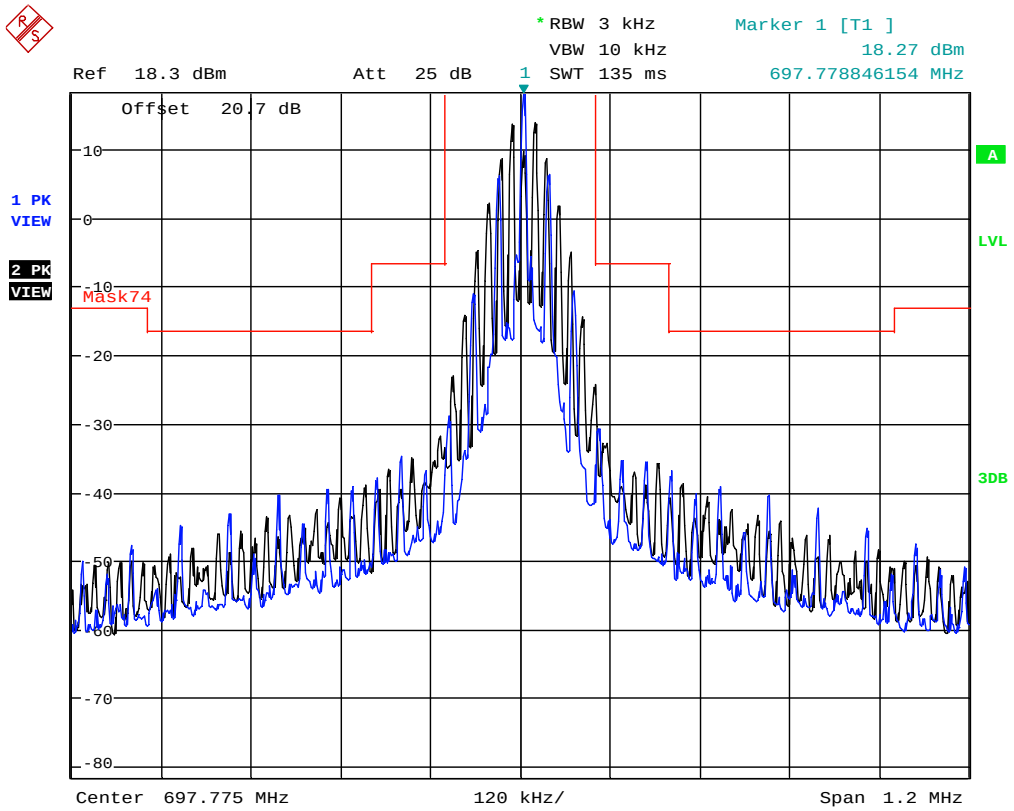
Plot # 5: Emission Mask - Mid Channel, 656.0 MHz, FM Modulation with 15kHz Sine Wave Signal



Date: 17.SEP.2015 17:33:41

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

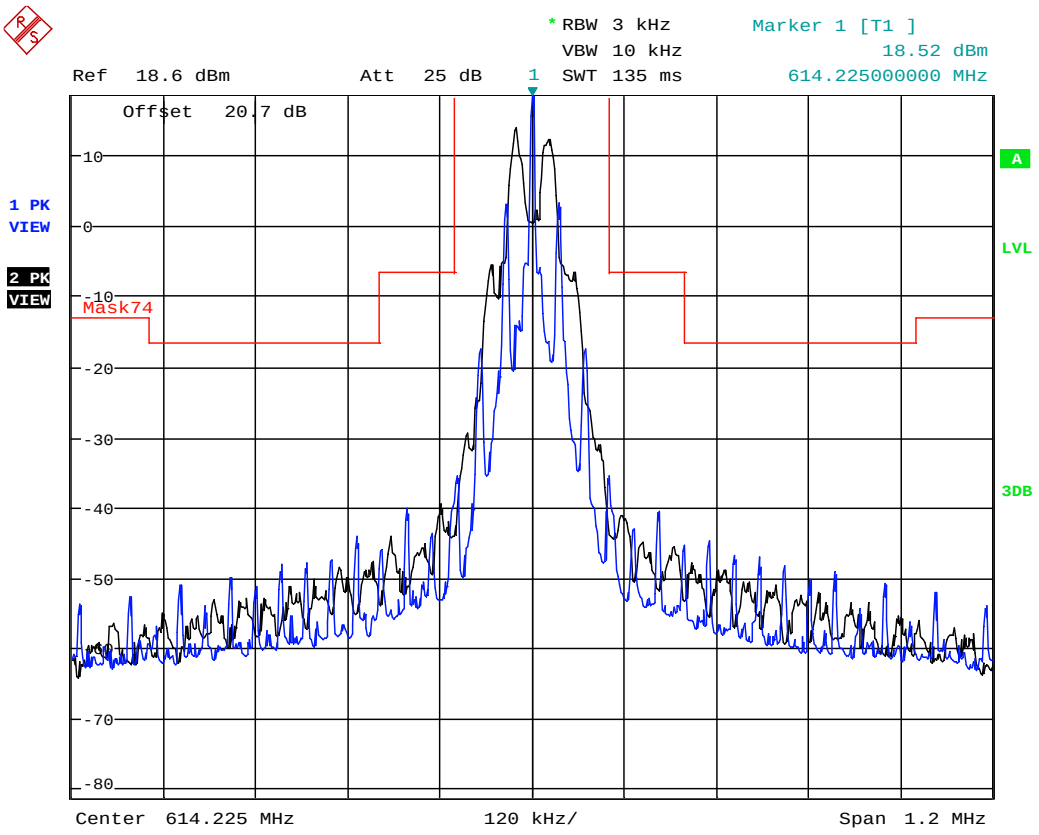
Plot # 6: Emission Mask - High Channel, 697.775 MHz, FM Modulation with 15kHz Sine Wave Signal



Date: 18.SEP.2015 15:43:59

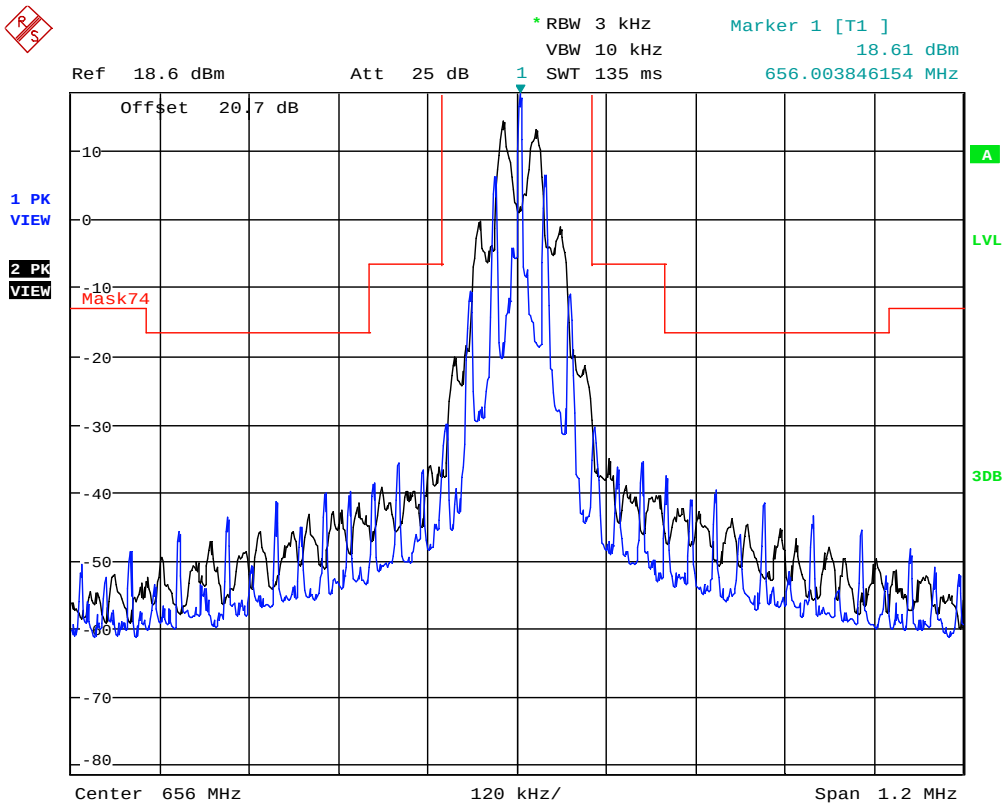
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 7: Emission Mask - Low Channel, 614.225 MHz, FM Modulation with 2.5kHz Sine Wave signal



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

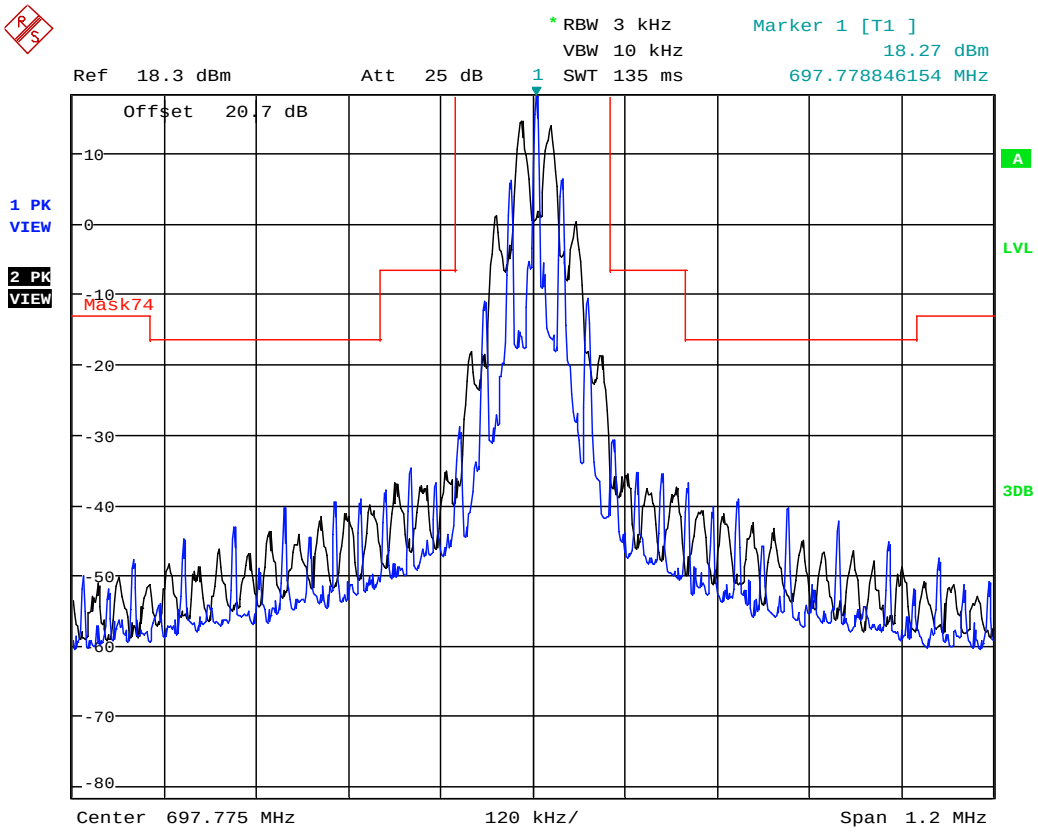
Plot # 8: Emission Mask - Mid Channel, 656.0 MHz, FM Modulation with 2.5kHz Sine Wave Signal



Date: 17.SEP.2015 17:35:09

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 9: Emission Mask - High Channel, 697.775 MHz, FM Modulation with 2.5kHz Sine Wave Signal



Date: 18.SEP.2015 15:42:09

5.12. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS @ FCC 74.861(E)(6)

5.12.1. Limits

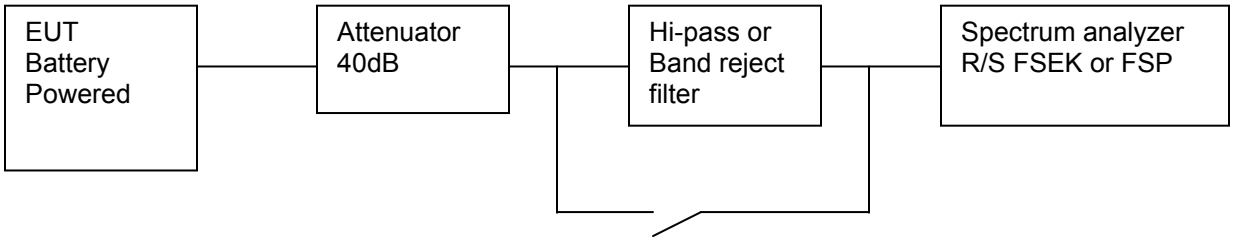
FCC 74.861(e)(6) - Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
74.861(e)(6)	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P)

5.12.2. Method of Measurements

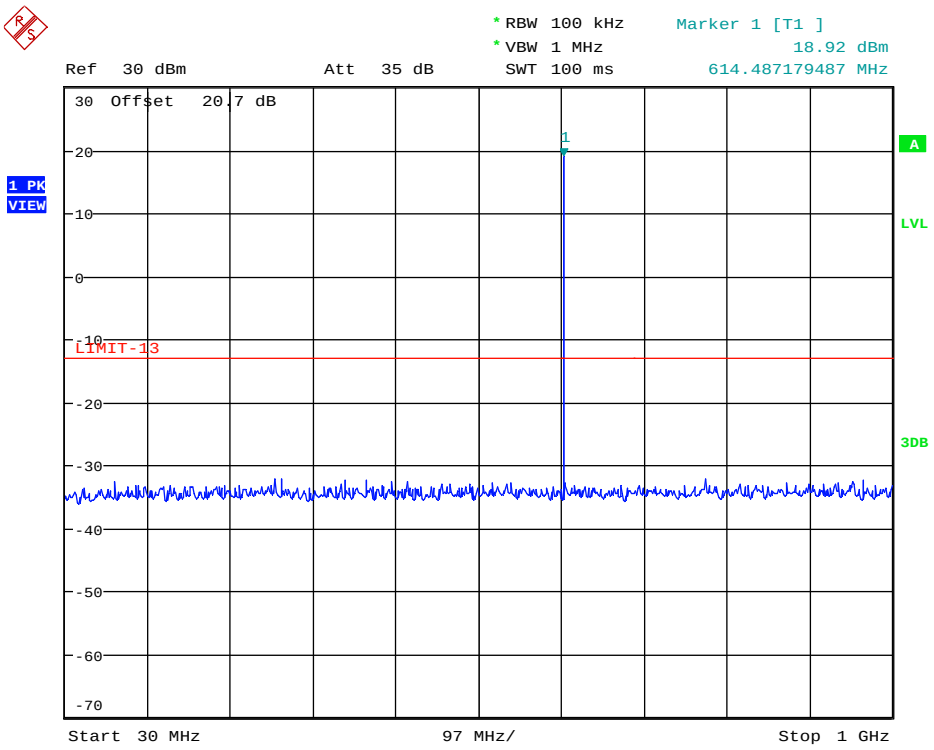
Refer to Exhibit 8 § 8.5 of this report for measurement details

5.12.3. Test Arrangement



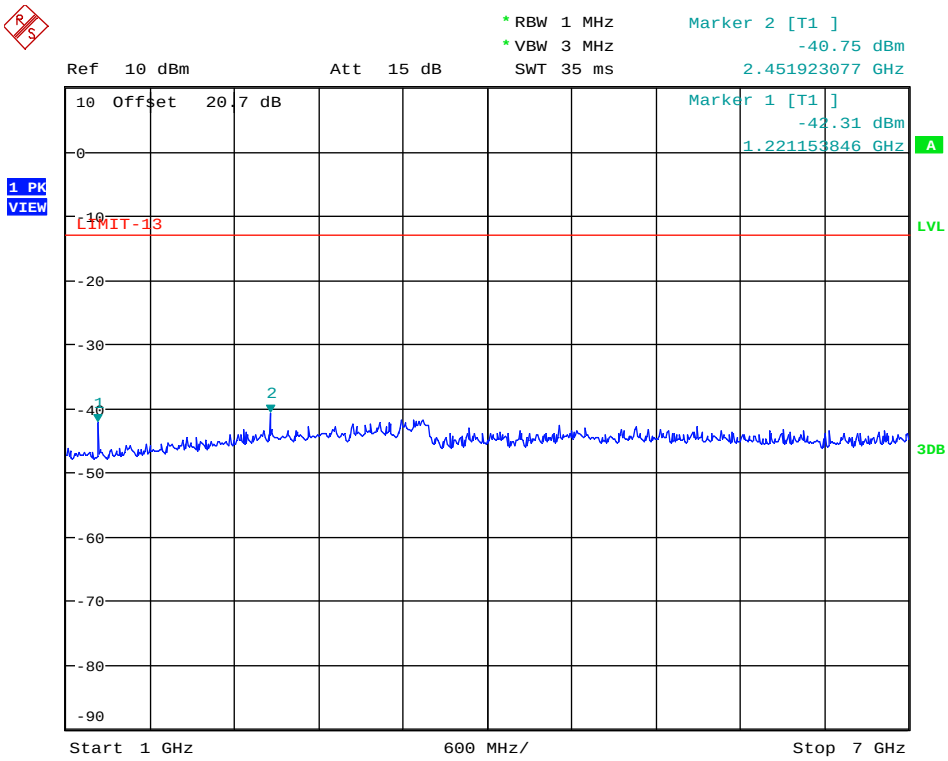
5.12.4. Test Data

Plot # 10: Transmitter Antenna Power Conducted Emissions - Low Channel, 614.225 MHz FM Modulation with 15kHz Sine Wave signal, 30 MHz – 1 GHz



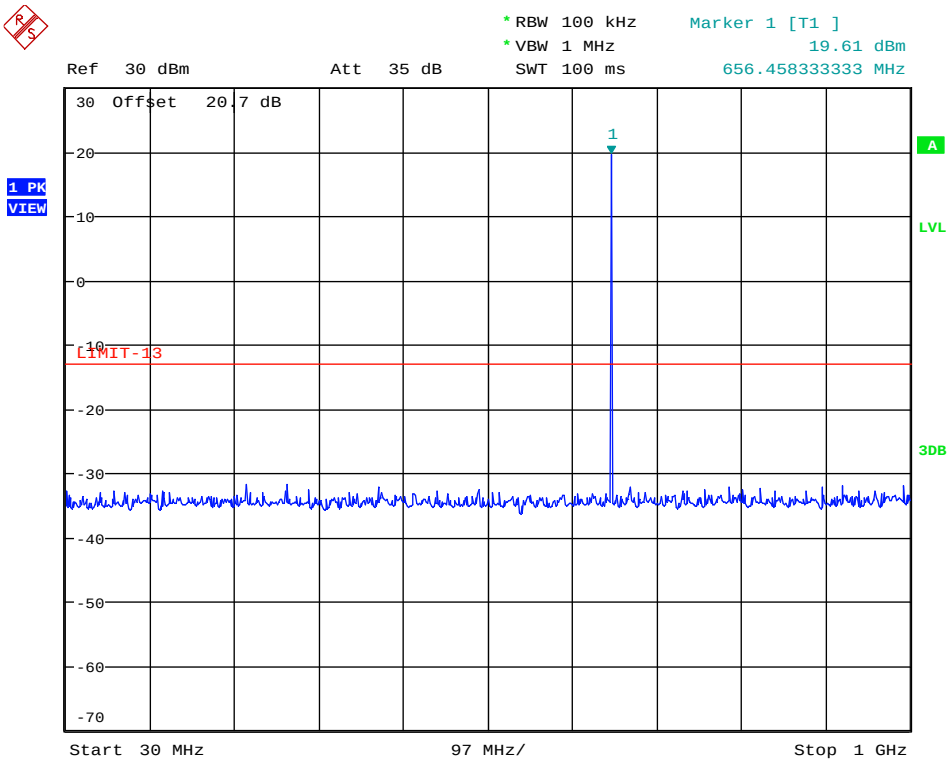
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 11: Transmitter Antenna Power Conducted Emissions - Low Channel, 614.225 MHz FM Modulation with 15kHz Sine Wave signal, 1 – 7 GHz



Date: 18.SEP.2015 10:40:21

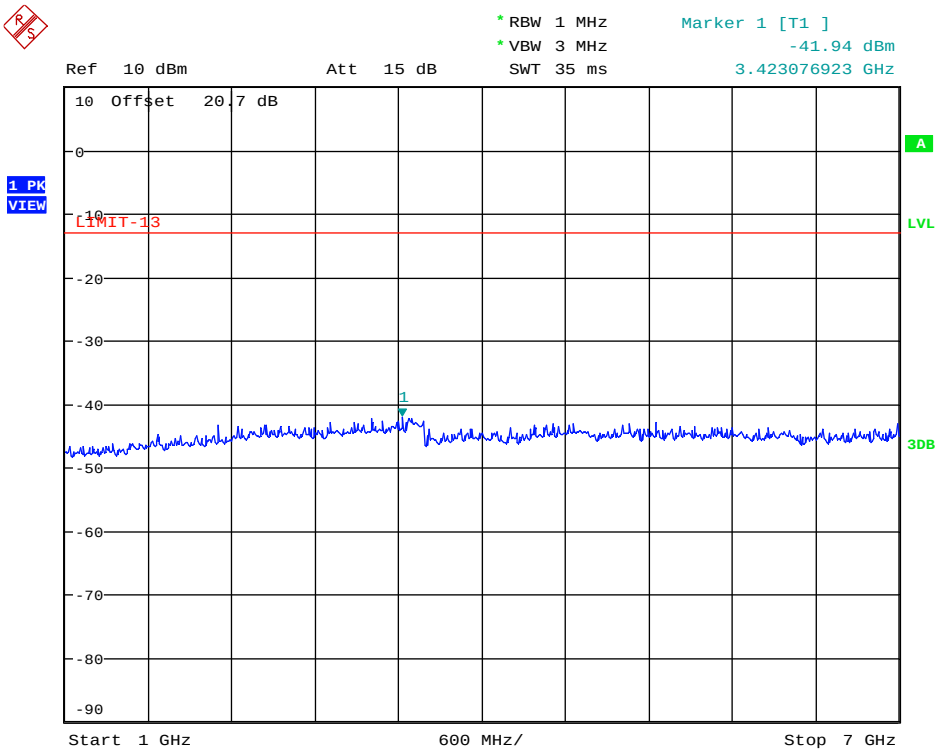
Plot # 12: Transmitter Antenna Power Conducted Emissions - Mid Channel, 656.0 MHz FM Modulation with 15kHz Sine Wave signal, 30 MHz – 1 GHz



Date: 18.SEP.2015 10:04:35

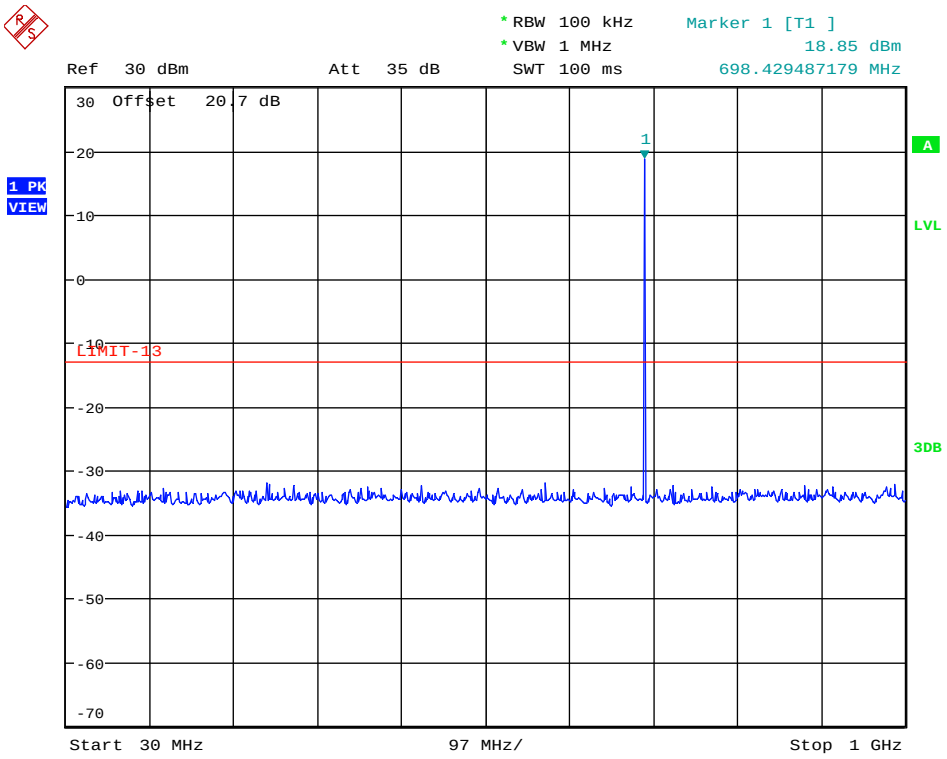
- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 13: Transmitter Antenna Power Conducted Emissions - Mid Channel, 656.0 MHz FM Modulation with 15kHz Sine Wave signal, 1 – 7 GHz



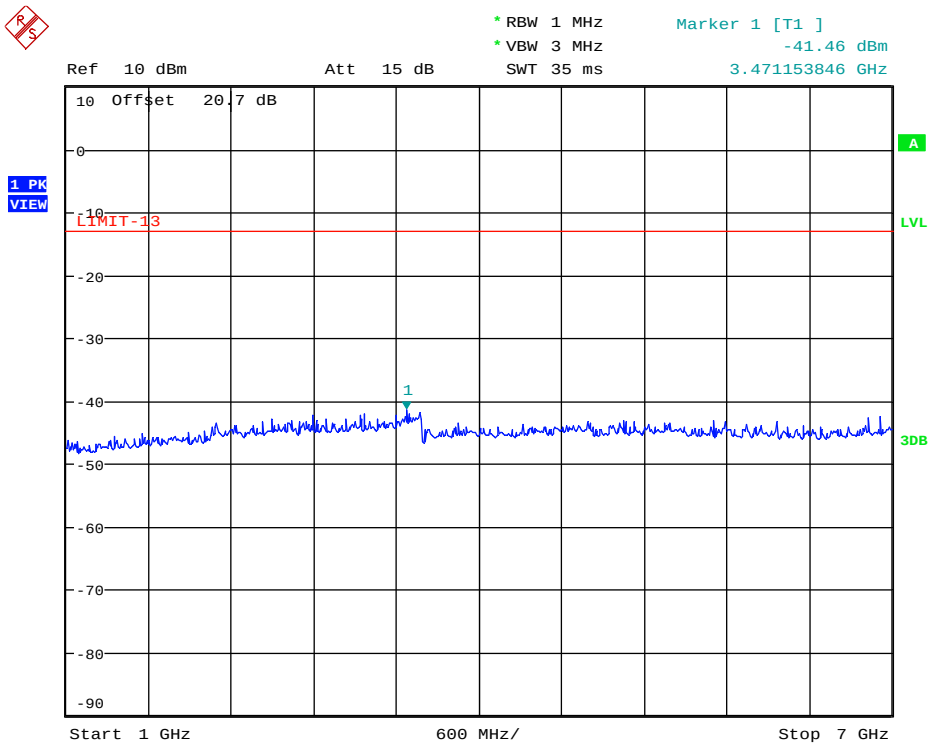
Date: 18.SEP.2015 10:34:22

Plot # 14: Transmitter Antenna Power Conducted Emissions - High Channel, 697.775 MHz FM Modulation with 15kHz Sine Wave signal, 30 MHz – 1 GHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

Plot # 15: Transmitter Antenna Power Conducted Emissions - High Channel, 697.775 MHz FM Modulation with 15kHz Sine Wave signal, 1 – 7 GHz



Date: 18.SEP.2015 10:36:49

5.13. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 74.861(E)(6)

5.13.1. Limits

FCC 74.861(e)(6) - Emissions shall be attenuated below the mean output power of the transmitter as follows:

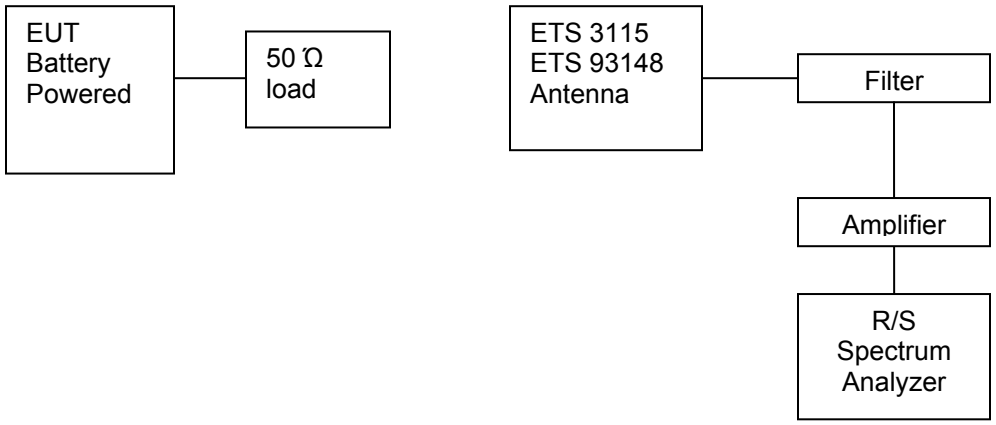
FCC Rules	Frequency Range	Attenuation Limit (dBc)
74.861(e)(6)	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P)

5.13.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in **Error! Reference source not found.** of this report and its value in dBc is calculated as follows:

(1) If the transmitter's antenna is an integral part of the EUT, the ERP is measured using substitution method.
(2) If the transmitter's antenna is non-integral and diverse, the lowest ERP of the carrier with 0 dBi antenna gain is used for calculation of the spurious/harmonic emissions in dBc:
Lowest ERP of the carrier = EIRP – 2.15 dB = Pc + G - 2.15 dB = Pc dBm (conducted) + 0 dBi – 2.15 dB

5.13.3. Test Arrangement



5.13.4. Test Data

Remarks:

- The radiated emissions were performed with high power at 3 m distance to represents the worst-case test configuration.
- The emissions were scanned from 30 MHz to 7 GHz; all spurious emissions that are in excess of 20dB below the specified limit shall be recorded.

5.13.4.1. Near Lowest Frequency (614.225 MHz)

Test Frequency (MHz):		614.225				
Power $_{conducted}$ (dBm):		19.05				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All spurious emissions found are more than 20dB below the specified limit.						

5.13.4.2. Near Middle Frequency (656.0 MHz)

Test Frequency (MHz):		656.0				
Power $_{conducted}$ (dBm):		19.09				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All spurious emissions found are more than 20dB below the specified limit.						

5.13.4.3. Near Highest Frequency (697.775 MHz)

Test Frequency (MHz):		697.775				
Power $_{conducted}$ (dBm):		19.01				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All other spurious emissions are more than 20dB below the specified limit.						

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	R/S	FSU	100398/026	20 Hz – 26.5 GHz	14-Sep-17
Attenuator (30dB)	Aeroflex/Weinschel	53-40-34	MN917	DC-1 GHz	Cal. on use
High Pass Filter	Mini Circuit	SHP 250	--	Cut off 230 MHz	Cal. on use
Power Meter	Hewlett Packard	436A	2016A07747	100K--50G sensor dependent	08-Mar-16
Power Sensor	Hewlett Packard	8481A	2237A33409	0.1 - 18 GHz	05-Mar-16
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150KHz-1300MHz	29-Jan-16
Combiner	Mini Circuit	ZFSC-3-4	15542	1MHz - 1GHz	Cal. on use
RF Detector	Pasternack	PE8000-50	--	10M--1G Hz	Cal. on use
Infinium Digital Oscilloscope	Hewlett-Packard	54801A	US38380192	DC--500M Hz 1G sampling	16-July-16
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177 degree C	02-Jun-16
RF Synthesized signal Generator	HP	8648C	3343U00391	100K-3200M Hz AM/ FM/ PM	02-Feb-17
Power supply	Tenma	72-7295	490300297	1-40V DC 5A	Cal. on use
FFT Digital Spectrum Analyzer	Advantest	R9211E	8202336	10mHz - 100KHz	27-Jan-16
RF Communication Test Set	Hewlett Packard	8920B	US39064699	30MHz – 1 GHz	30-Jan-17
Horn antenna	ETS-LINDGREN	3117	119425	1 – 18 GHz	17-Jun-17
Preamplifier	Hewlett Packard	8449B	3008A00769	1 - 26.5 GHz	06-Aug-16
High Pass Filter	Mini Circuit	SHP 600	--	Cut off 600 MHz	Cal. on use
Power Supply	XANTREX	XKW 60-50	26509	0-60V 0-50A DC	Cal. on use
High Pass Filter	Mini Circuit	SHP 800	--	Cut off 750 MHz	Cal. on use
Attenuator	Aeroflex/Weinschel	23-20-34	BH7876	DC-18 GHz	Cal. on use
Antenna	ETS	93148	1101	200-2000 MHz	14-Jul-16
Attenuator	Aeroflex/Weinschel	24-20-34	BJ2364	DC-18 GHz	Cal. on use
Frequency counter	EIP	545A	2683	10Hz-18 GHz	24-Apr-16
Biconical Antenna	ETS	3110B	3379	20-200MHz	11-Sep-16
Preamplifier	Com-power	PA-118A	551016	500MHz-18GHz	06-Jan-16
Tunable Band-reject Filter	K & L	3TFNF-30/76-N-N	36	28-300MHz	Cal. on use

Note: *Environmental Chamber temperature verified with a calibrated sensor throughout testing.

- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (150 kHz – 30 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 1.57**	**± 1.8**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.14**	**± 3.6**

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.15**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.30**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.78**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal & Vertical (1 – 18 GHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 1.87**	**Under consideration**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.75**	**Under consideration**

EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- I f the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements if the transmitter's transmission is transient

- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, x = Tx on / (Tx on + Tx off) with 0<x<1, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

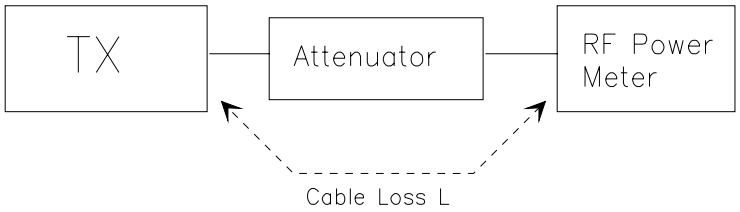
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average power meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- The e.i.r.p. shall be calculated from the above measured power output "A", the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

EIRP = A + G + 10log(1/x)

{ X = 1 for continuous transmission => 10log(1/x) = 0 dB }

Figure 1.



8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. Maximizing RF Emission Level (E-Field)

(a) The measurements was performed with full rf output power and modulation.
(b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
(c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
(d) The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
(e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(f) Set the EMI Receiver and #2 as follows:

Center Frequency:	test frequency
Resolution BW:	100 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
(h) The transmitter was rotated through 360^{o} about a vertical axis until a higher maximum signal was received.
(i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
(j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
(k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
(l) Repeat for all different test signal frequencies

8.2.2. Measuring the EIRP of Spurious/Harmonic Emissions using Substitution Method

(a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency:	equal to the signal source
Resolution BW:	10 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

P = P1 - L1 = (P2 + L2) – L1 = P3 + A + L2 - L1
EIRP = P + G1 = P3 + L2 - L1 + A + G1
ERP = EIRP – 2.15 dB
Total Correction factor in EMI Receiver # 2 = L2 – L1 + G1

Where: P: Actual RF Power fed into the substitution antenna port after corrected.
P1: Power output from the signal generator
P2: Power measured at attenuator A input
P3: Power reading on the Average Power Meter
EIRP: EIRP after correction
ERP: ERP after correction

(o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.

(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.:

Figure 2

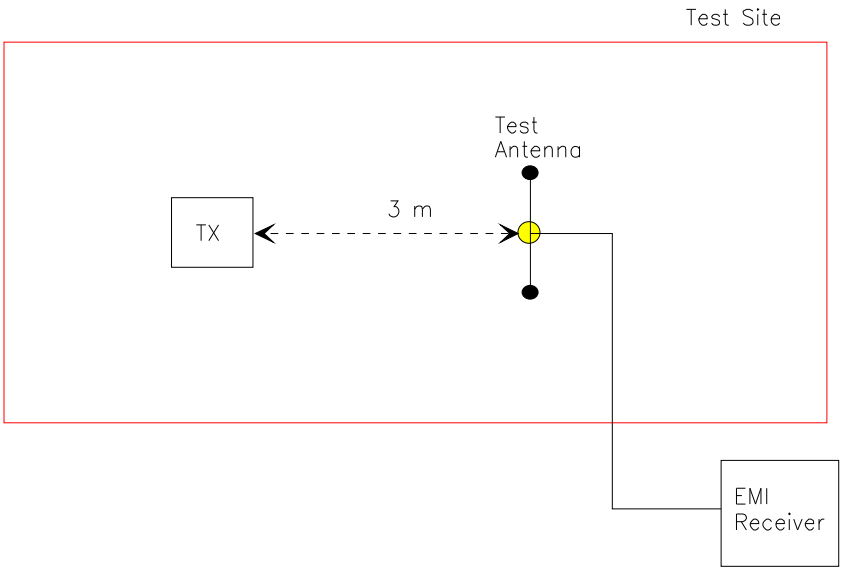
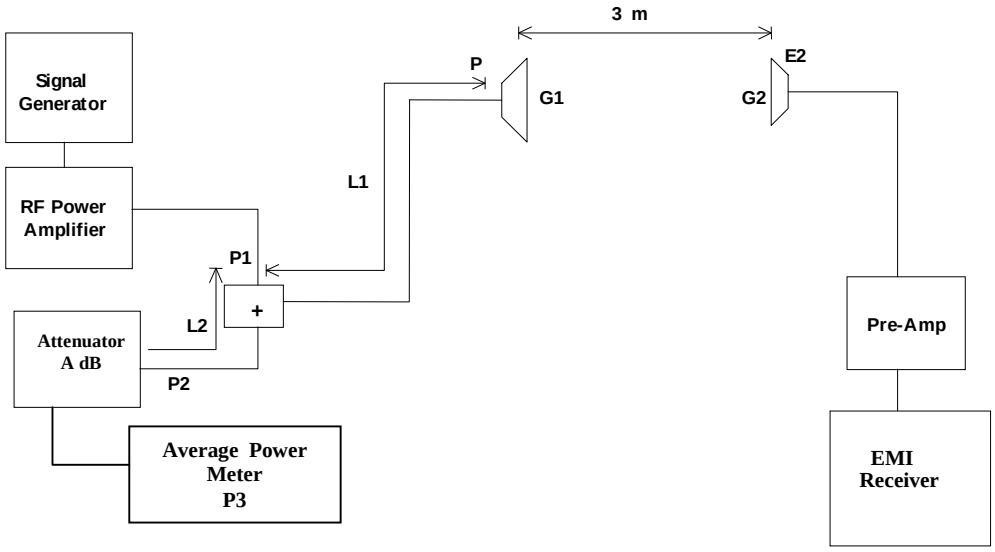


Figure 3



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

(a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.

(b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.

(d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

8.4. EMISSION LIMITATION

Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i):- The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ±2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

Digital Modulation Through a Data Input Port @ 2.1049(h):- Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Limitations shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

The following EMI Receiver bandwidth shall be used for measurement of Emission Limitation/Out-of-Band Emission Measurements:

(1) For 25 kHz Channel Spacing: RBW = 300 Hz
(2) For 12.5 kHz or 6.25 kHz Channel Spacings: RBW = 100 Hz

The all cases the Video Bandwidth shall be equal or greater than the measuring bandwidth.

8.5. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 kHz minimum , VBW ≥ RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC CFR 47, Para. 2.1057 - Frequency spectrum to be investigated:- The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10^{th} harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.1051 - Spurious Emissions at Antenna Terminal:- The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.