ENGINEERING TEST REPORT

VHF Marine Transceiver
Model No.: IC-M504
FCC ID: AFJ291400

Applicant:

ICOM Incorporated
1-1-32, Kamiminami,
Hirano-ku, Osaka
Japan, 547-0003

Tested in Accordance With

Federal Communications Commission (FCC)
47 CFR, Part 2, Part 80 (Marine in 156.025-157.425 MHz)

UltraTech's File No.: ICOM-275_FCC80

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: August 15, 2011	
Report Prepared by: Dharmajit Solanki Issued Date: August 15, 2011	Tested by: Wayne Wu, RF Technician Test Dates: July 13 to 19, 2011

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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FCC	VCCI	Industry Canada / Industrie Canada Approved Test Facility	NVLAP	BSMI	Korea KCC-RRL
91038	1309	46390-2049	NVLAP Lab Code 200093-0	SL2-IN-E-1119R	CA2049

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 80
Title:	Telecommunication - Code of Federal Regulations, 47CFR, Parts 2 and 80
Purpose of Test:	To gain FCC Class II Permissive Change Authorization for Radio operating in the frequency bands, 156.025-157.425 MHz (Marine)
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with TIA/EIA Standard TIA/EIA-603C – Land Mobile FM or PM Communications Equipment Measurement and performance Standards.
Categories of Station:	Ship station transceiver operating in 156.025-157.425 MHz band

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

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2009	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
CISPR 16-1	2003	Specification for Radio Disturbance and Immunity measuring apparatus and methods
TIA-603-C	2004	Land Mobile FM or PM Communications Equipment, Measurement and Performance Standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Oaska Japan, 547-0003
Contact Person:	Mr. Takayuki Watanabe Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

MANUFACTURER	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Oaska Japan, 547-0003
Contact Person:	Mr. Takayuki Watanabe Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

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:	ICOM Canada
Product Name:	VHF Marine Transceiver
Model Name or Number:	IC-M504
Serial Number:	0000001
Type of Equipment:	Maritime Radio Transmitters and Receivers in the Band 156-162.5 MHz
Power Supply Requirement:	13.8 VDC
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Wireless Voice Communication for Marine Ship Station.

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	Mobile
Intended Operating Environment:	Marine Ship Station
Power Supply Requirement:	13.8 VDC
RF Output Power Rating:	25 Watts (High) and 1 Watt (Low)
Tx. Operating Frequency Range:	156.025-157.425 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	25 kHz
Emission Designation*:	16K0G3E(FM), 16K0G2B(DSC)
Antenna Connector Type:	N Type Connector
RECEIVER	
Operating Frequency Range:	156.050-163.275 MHz
RF Input Impedance:	50 Ohms
Channel Spacing:	25 kHz
IF Frequencies:	21.7MHz, 21.25MHz, 450 kHz
Audio Output Power:	4.5 W (typical) at 10% distortion with a 4Ω load

* For an average case of commercial telephony, the Necessary Bandwidth is calculated as follows:

For FM Voice Modulation:

Channel Spacing = 25 KHz, D = 5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(5)(1) = **16 KHz**
Emission Designation: 16K0G3E and 16K0G2B

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	DC Power Connector	1	Wireleads	Non-shielded
2	External Microphone Jack	1	8-Pin CPC	Non-shielded
3	Antenna Connector	1	PL-259	Shielded
4	Ground Terminal	1	GND Pin	Non-shielded
5	Hailer/Foghorn	1	2 Wire	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:	13.8 VDC Power Supply

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):	▪ 156.025 - 157.425 MHz
Test Frequency(ies): (Near lowest & near highest frequencies in the frequency range of operation.)	▪ 156.025 and 157.425 MHz
Transmitter Wanted Output Test Signals:	
• Transmitter Power (measured maximum output power):	25 Watts High & 1 Watt Low
• Normal Test Modulation:	FM, DSC
• Modulating signal source:	External

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.

- 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: 2014-04-14.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
80.215 & 2.1046	RF Power Output	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes*
80.209 & 2.1055	Frequency Stability	Yes*
80.213(e) & 2.1047(a)	Audio Frequency Response	Yes*
80.213 & 2.1047(b)	Modulation Limiting	Yes*
80.205, 80.211(f) & 2.1049	Emission Limitation / Emission Mask	Yes
80.211(f)(3), 2.1051 & 2.1057	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
80.211(f)(3), 2.1053 & 2.1057	Emission Limits - Field Strength of Spurious Emissions	Yes
80.217	Suppression of Interference aboard ships	Yes* (complies with FCC Part 15, Subpart B)
VHF Marine Transceiver, **Model No.: IC-M504**, by **ICOM Incorporated** 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 it is available upon FCC request.		

* Note: Please refer to the original filing for details.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None.

EXHIBIT 5. TEST DATA

5.1. RF POWER OUTPUT [§ 2.1046 & 80.215]

5.1.1. Limits

FCC § 80.215:

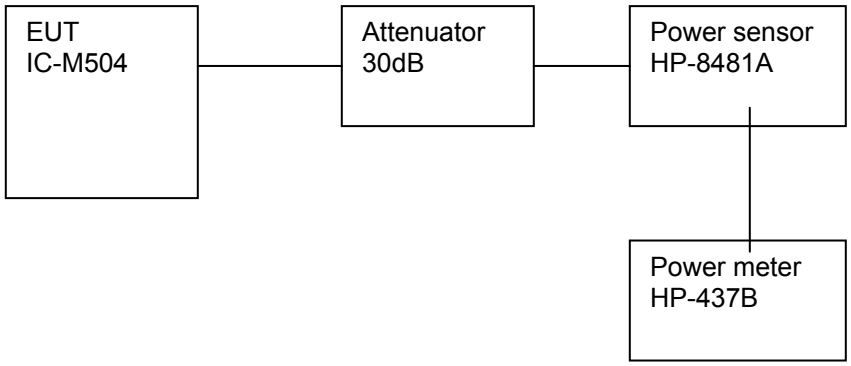
- **Coast Stations in 156.025-157.425 MHz**: 50 Watts (at the input terminal of the station antenna). The frequencies 156.375 and 156.65 are primarily intership frequencies. When authorized for coast station on secondary basis, the normal output power must not exceed 1 Watt and the maximum output power must not exceed 10 Watts.
- **Marine Utility Stations & Handheld Portable in 156.025-157.425 MHz**: 10 Watts (at the input terminal of the station antenna)
- **Ship Stations in 156.025-157.425 MHz**: 25 Watts (at the input terminal of the station antenna)

5.1.2. Method of Measurements

Refer to 8.1 (Conducted) and 8.2 (Radiated) in this test report for test procedures and test setup.

5.1.3. Test Arrangement

Power at RF Power Output Terminals



5.1.4. Test Data

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Conducted Power (Watts)	Power Rating (Watts)
Power Setting: High			
Lowest	156.025	24.15	25.0
Highest	157.425	23.82	25.0
Power Setting: Low			
Lowest	156.025	0.82	1.0
Highest	157.425	0.82	1.0

5.2. EXPOSURE OF HUMANS TO RADIO FREQUENCY FIELDS [§ 2.1091]

The following criteria shall be used to evaluate the environmental impact of human exposure to RF radiation:

FCC 1.1310:- The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	$*(900/f^2)$	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	$*(180/f^2)$	30
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density
NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Calculation Method of RF Safety Distance:

$$S = PG/4\Pi r^2 = EIRP/4\Pi r^2 \implies r = \sqrt{PG/4\Pi S} = \sqrt{EIRP/4\Pi S}$$

Where: P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to center of radiation in cm

MPE Evaluation

Antenna Gain Limit specified by Manufacturer: 9 dBi

Frequency (MHz)	Measured RF Conducted (Watts)	Calculated EIRP (Watts)	Laboratory's Recommended Minimum RF Safety Distance r (meters)	Manufacturer's Minimum RF Safety Distance (meters)
156.050	24.15	191.8	2.8	3
157.425	23.8	189.1	2.8	3

Note 1: RF EXPOSURE DISTANCE LIMITS: $r = (PG/4\Pi S)^{1/2} = (EIRP/4\Pi S)^{1/2}$
$S = 0.2$ mW/cm^2 (specified limits for general population/uncontrolled exposure)

$$r = \sqrt{EIRP / 4\Pi S} = \sqrt{191830 / (4\Pi(0.2))} = 276.3\text{cm} \approx 2.8\text{ m}$$

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
Minimum calculated separation distance between antenna and persons required: 2.8 meters	Manufacturer's instruction for separation distance between antenna and persons required: 3 meters.

5.3. EMISSION MASK [§ 80.205, § 80.211 & § 2.1049]

5.3.1. Limits

Emissions shall be attenuated below the mean output power of the transmitter as follows:

§ 80.205 (a)

Emission designator	Maximum Authorized BW (KHz)	Channel Spacing (KHz)	Recommended Frequency Deviation (KHz)	FCC Applicable Mask
16K0G3E	20.0	25.0	5.0	See **§ 80.211** (f)

§ 80.211 (f)(1) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 dB;

§ 80.211 (f)(2) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 dB; and

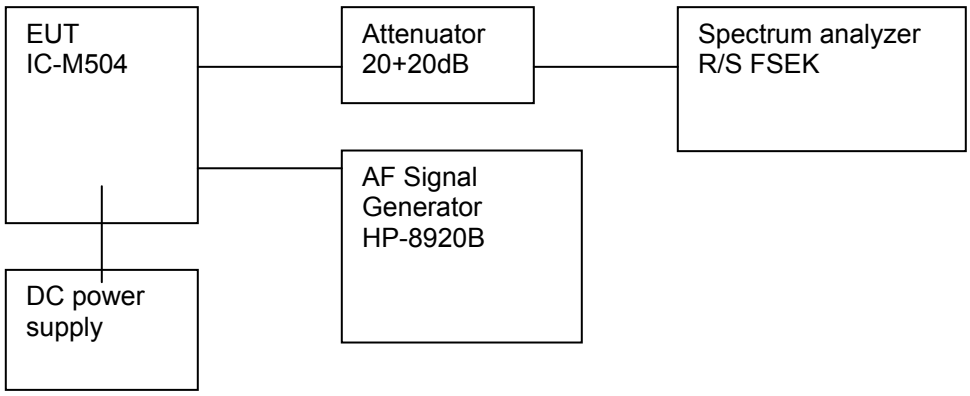
§ 80.211 (f)(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus 10log10 (mean power in watts) dB.

Remark: More stringent IC/RSS-182 maximum authorization bandwidth of 16 kHz for voice is applied instead of 20 kHz specified in Sec. 80.205 to verify and confirm compliance with both FCC and IC using single set of test data.

5.3.2. Method of Measurements

Refer to 8.3 of this report for measurement details

5.3.3. Test Arrangement



5.3.4. Test Data

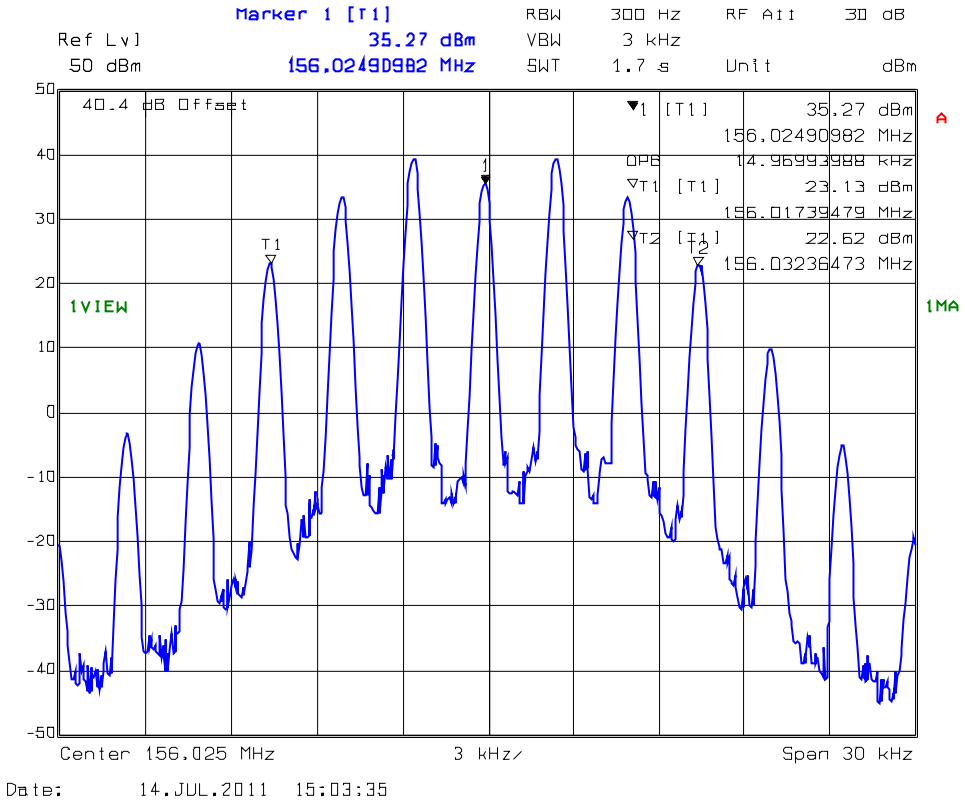
5.3.4.1. 99% Occupied Bandwidth

Frequency (MHz)	Channel Spacing (kHz)	Measured 99% OBW (kHz)	Authorized Bandwidth (kHz)
156.025	25.0	14.97	16
157.425	25.0	14.97	16

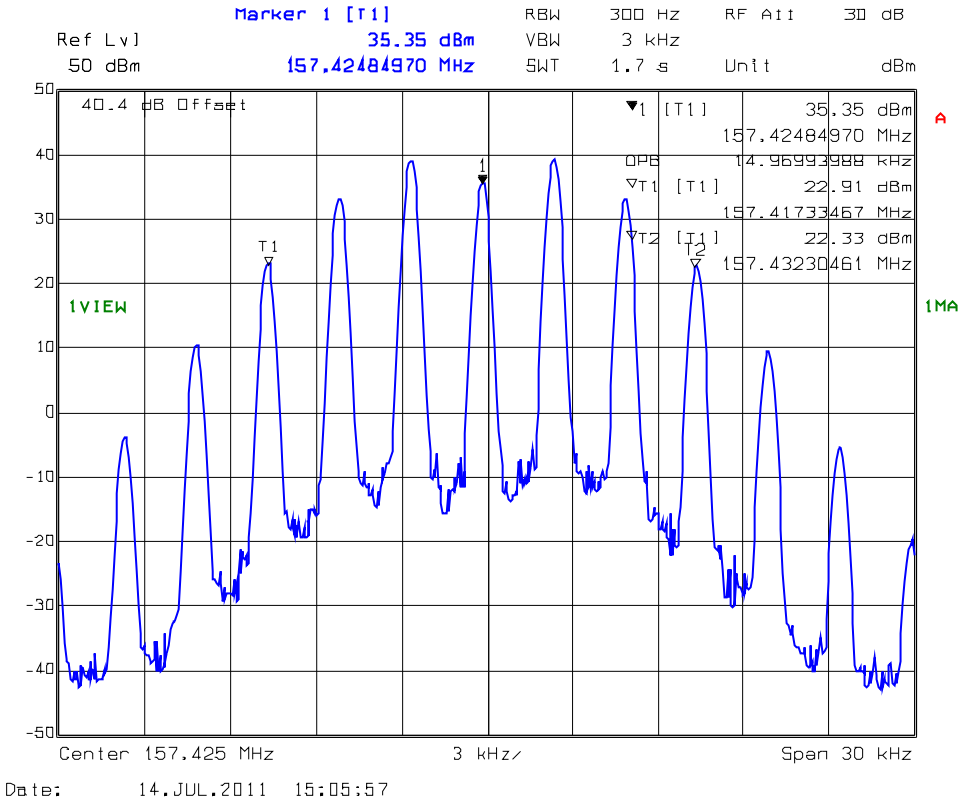
Remark: 99% Occupied Bandwidth measurements were done using the built-in auto function of the analyzer.

See the following plots (1 & 2) for details of measurements.

Plot # 1.:
Occupied Bandwidth
Carrier Frequency: 156.025 MHz
Channel Spacing: 25.0 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



Plot # 2.:
Occupied Bandwidth
Carrier Frequency: 157.425 MHz
Channel Spacing: 25.0 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave

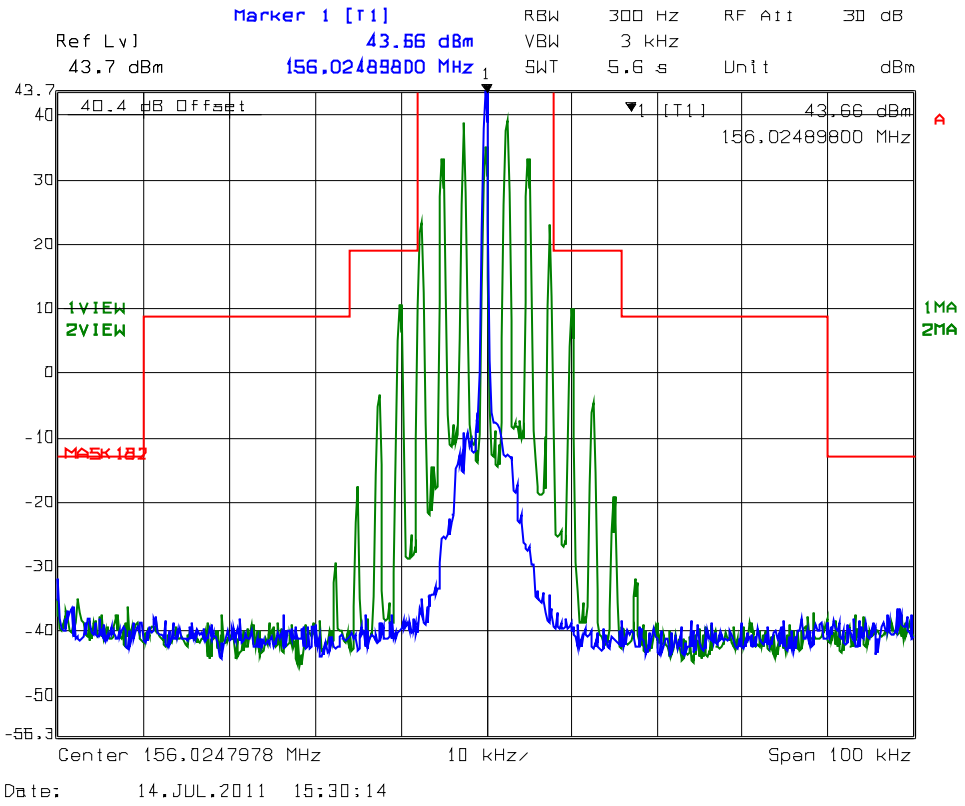


5.3.4.2. Emission Masks

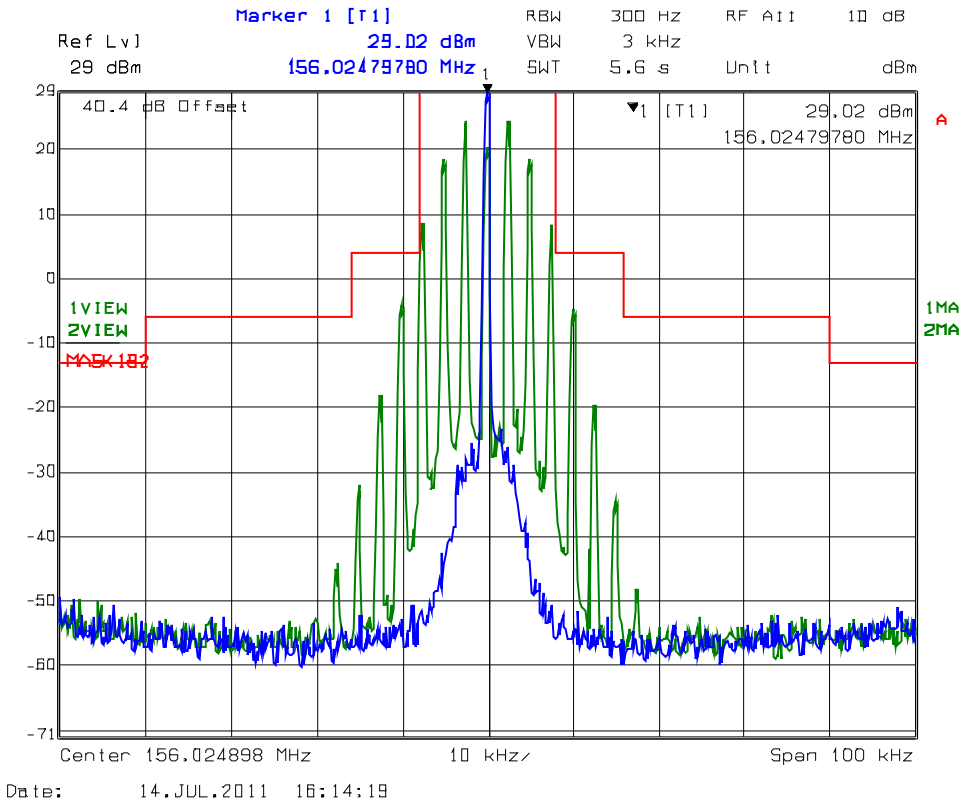
Remark: More stringent IC/RSS-182 maximum authorization bandwidth of 16 kHz for voice is applied instead of 20 kHz specified in Sec. 80.205 to verify and confirm compliance with both FCC and IC using single set of test data.

Conform. See the following test data plots (3 through 6) for details.

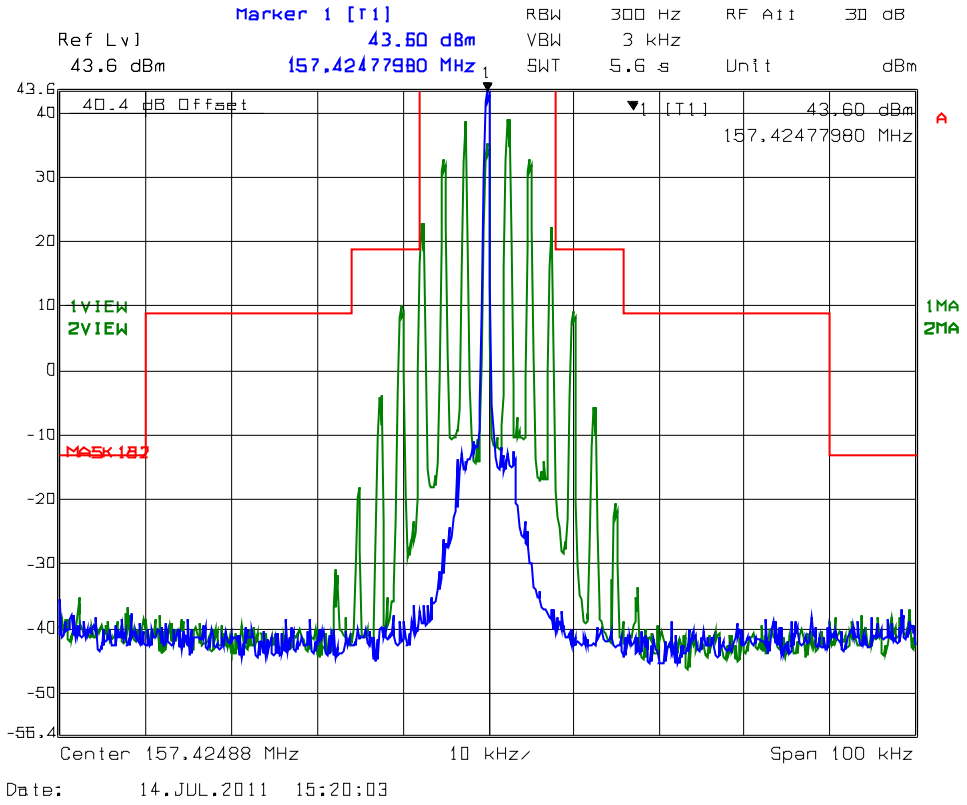
Plot # 3.:
Emission Mask B
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



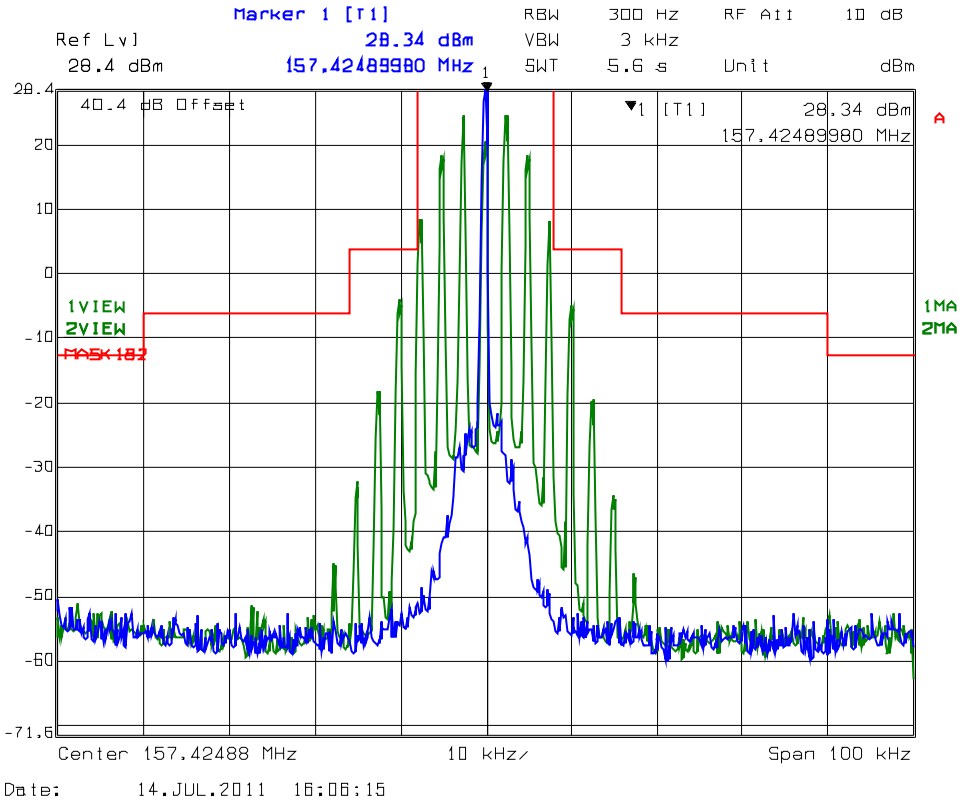
Plot # 4.:
Emission Mask B
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



Plot # 5.:
Emission Mask B
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



Plot # 6.:
Emission Mask B
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



5.4. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [§ 80.211(f)(3)]

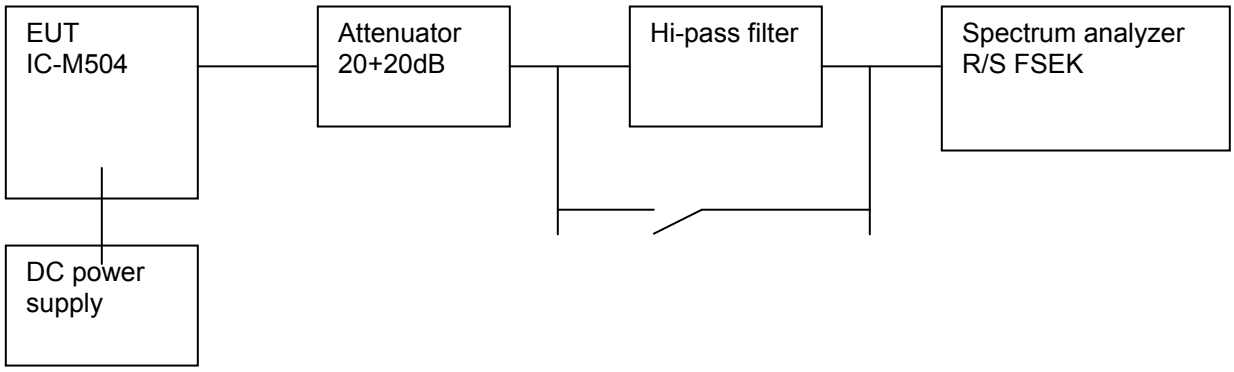
5.4.1. Limits

§ 80.211 (f)(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus 10log10 (mean power in watts) dB.

5.4.2. Method of Measurements

Refer to 8.4 of this report for measurement details

5.4.3. Test Arrangement



5.4.4. Test Data

5.4.4.1. Near Lowest Frequency (156.025 MHz)

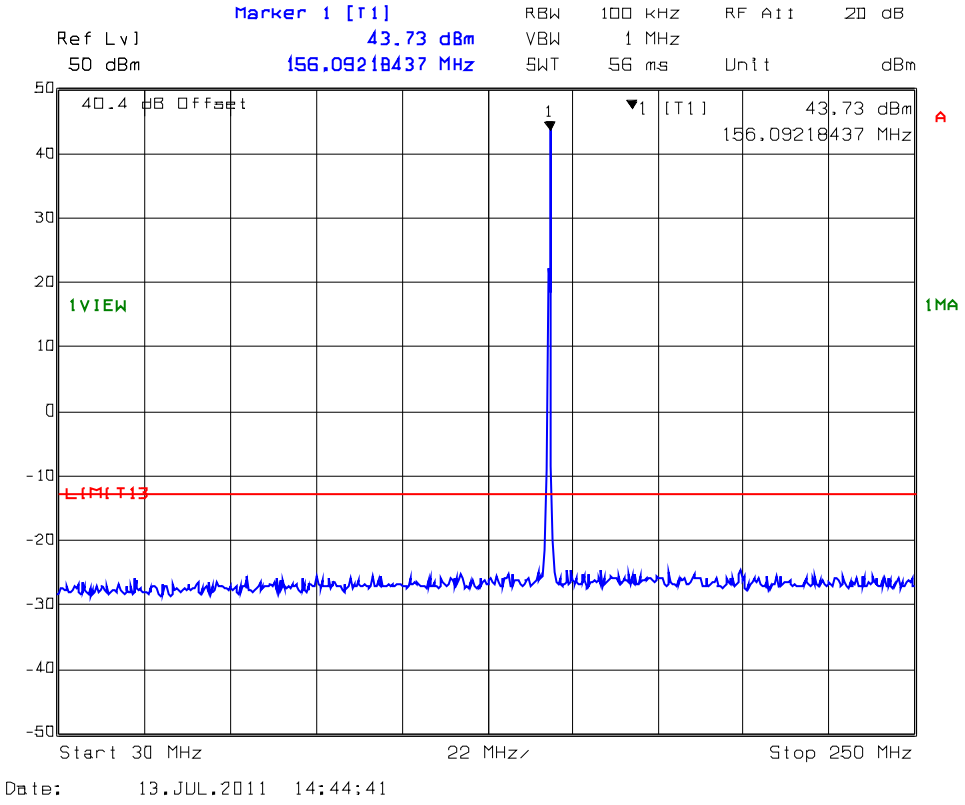
Carrier Frequency (MHz): 156.025

Power (dBm): 43.83

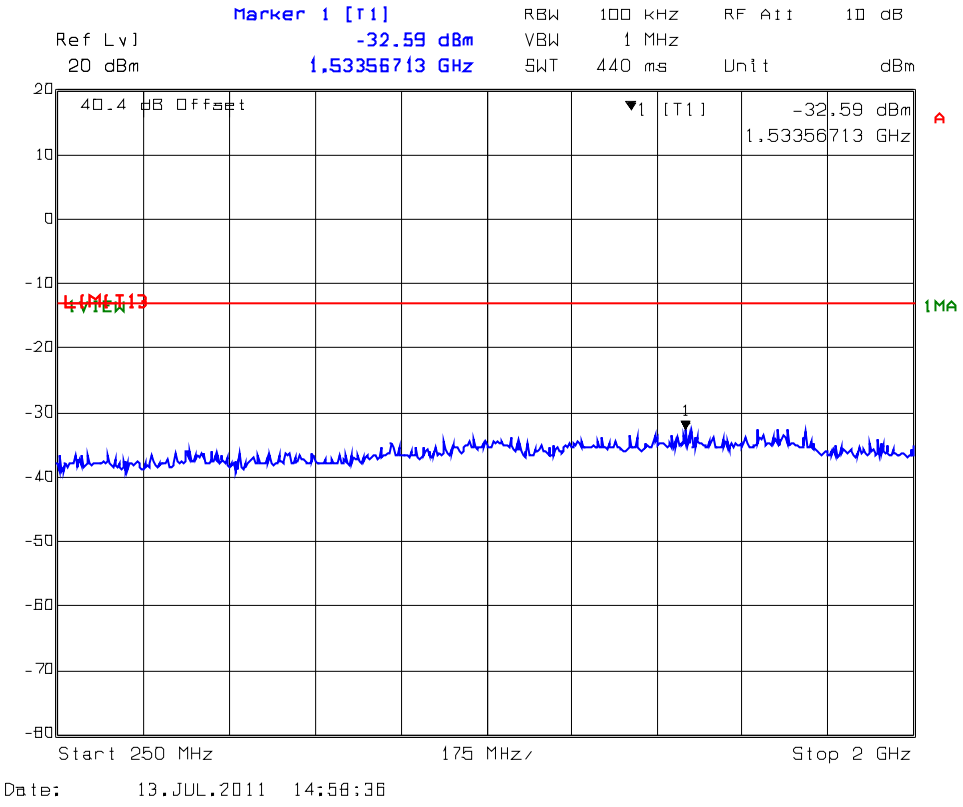
Limit (dBm): -13

All emissions found were more than 20 dB below the permissible limits.

Plot # 7.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 156.025 MHz
Channel Spacing: 25.0kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



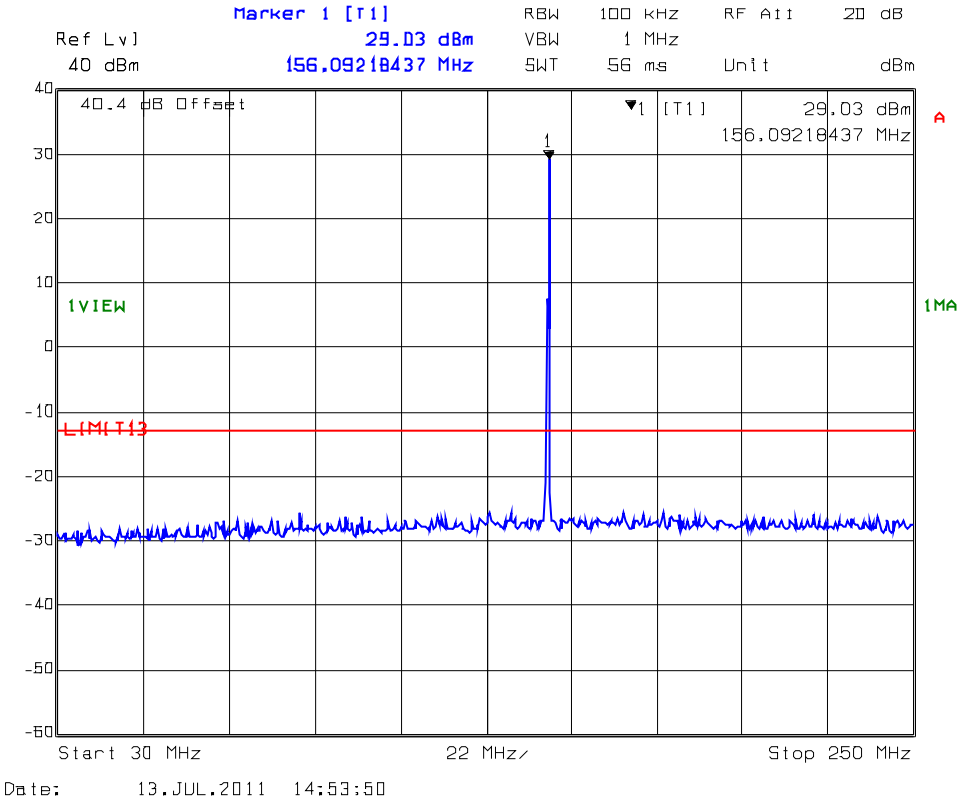
Plot # 8.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 156.025 MHz
Channel Spacing: 25.0 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



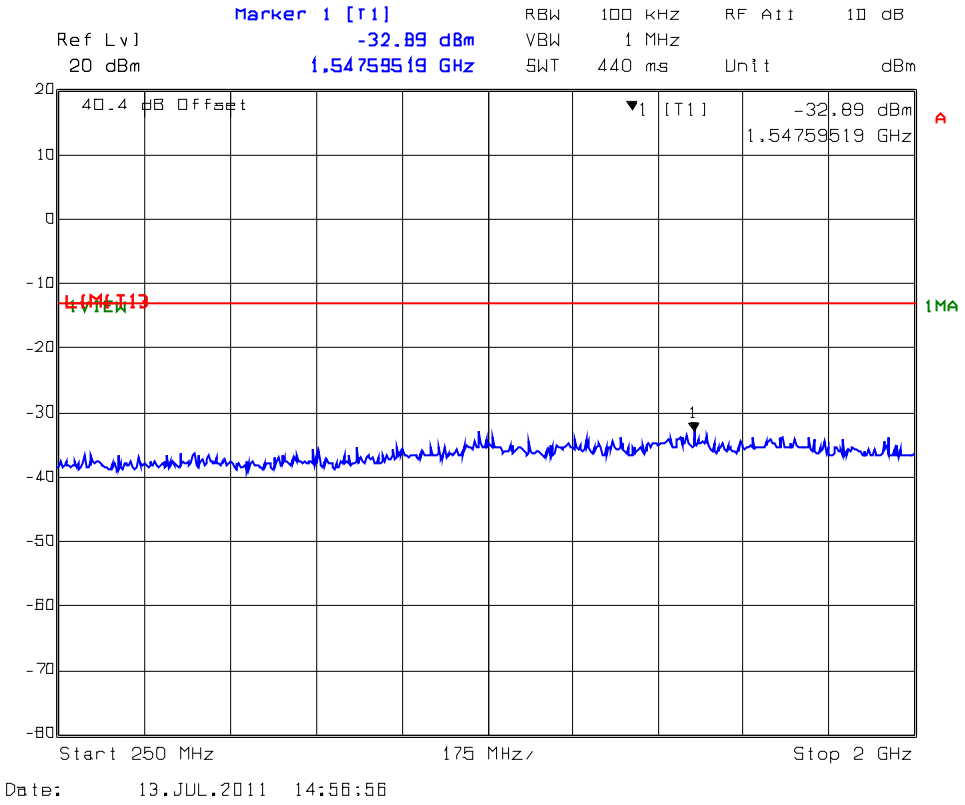
Carrier Frequency (MHz):	156.025
Power (dBm):	29.19
Limit (dBm):	-13

All emissions found were more than 20 dB below the permissible limits.

Plot # 9.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 156.025 MHz
Channel Spacing: 25.0 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



Plot # 10.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 156.025 MHz
Channel Spacing: 25.0 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



5.4.4.2. Near Highest Frequency (157.425 MHz)

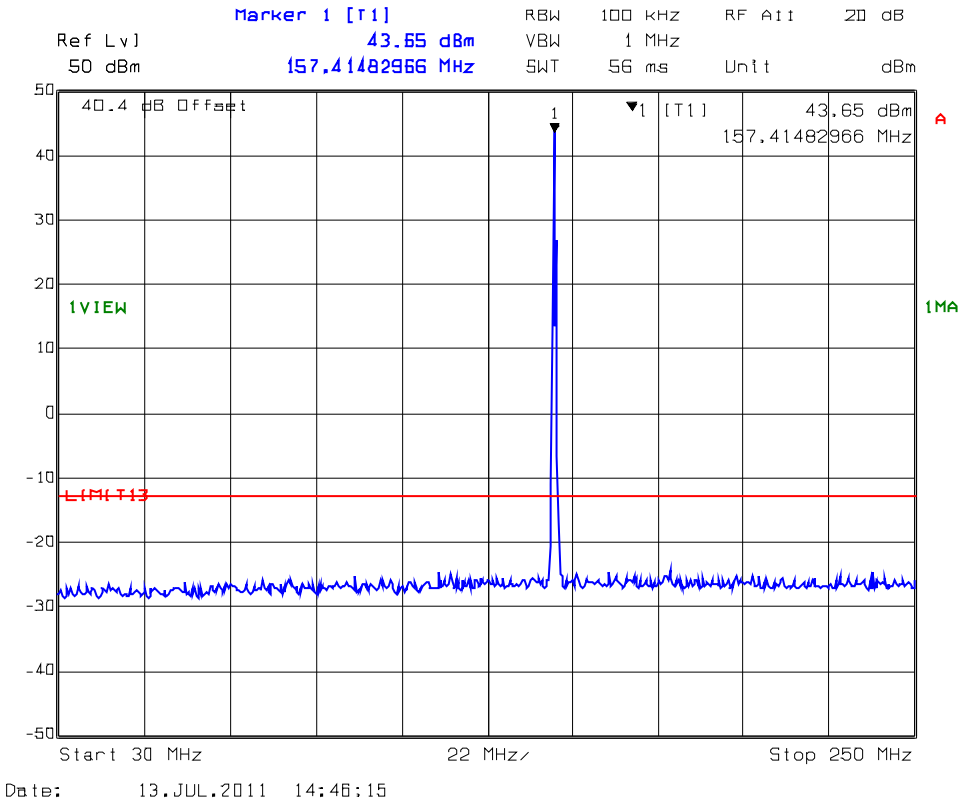
Carrier Frequency (MHz): 157.425

Power (dBm): 43.77

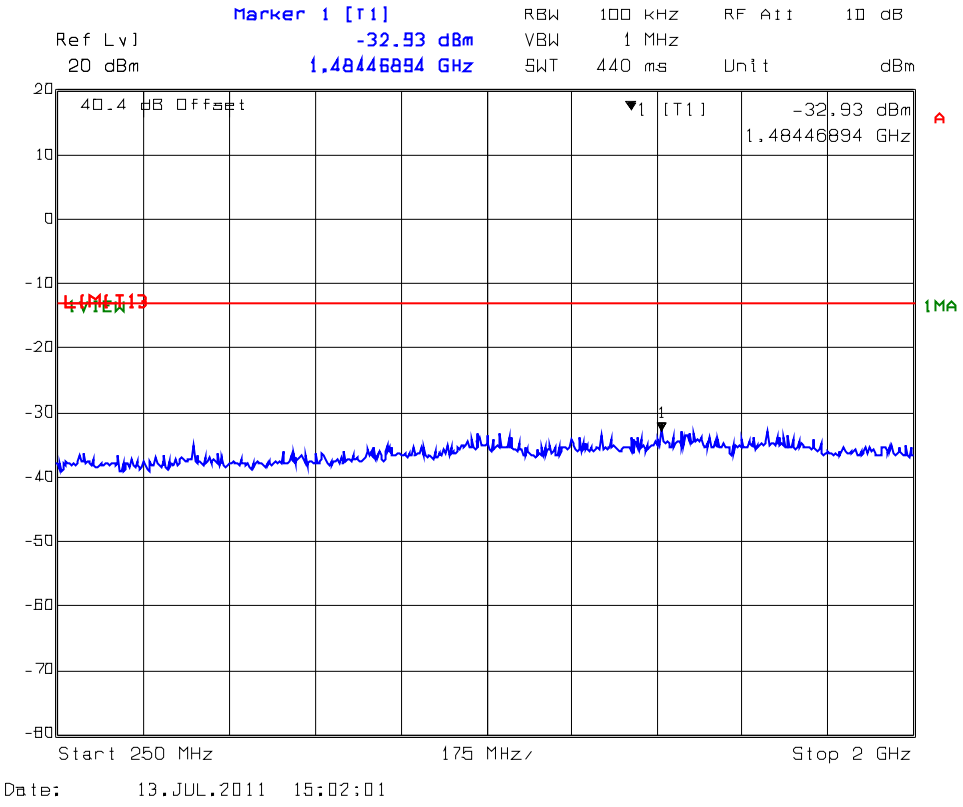
Limit (dBm): -13

All emissions found were more than 20 dB below the permissible limits.

Plot # 11.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 157.425 MHz
Channel Spacing: 25.0 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



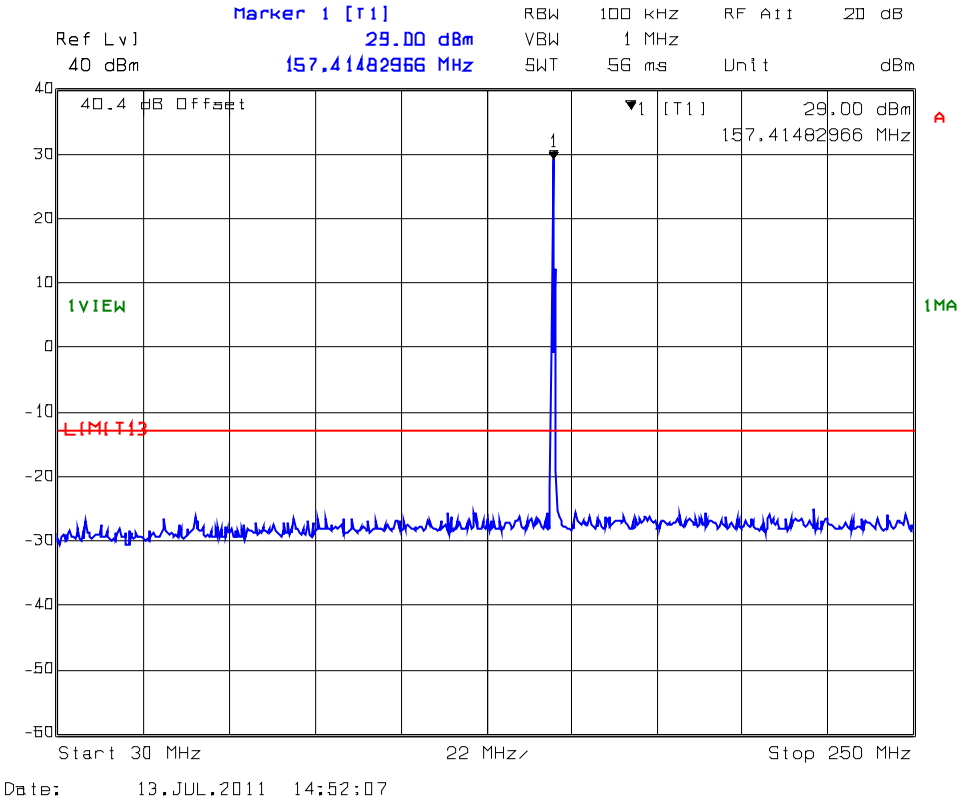
Plot # 12.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 157.425 MHz
Channel Spacing: 25.0 kHz
Power: 25 W
Modulation: G3E, 2.5 kHz sine wave



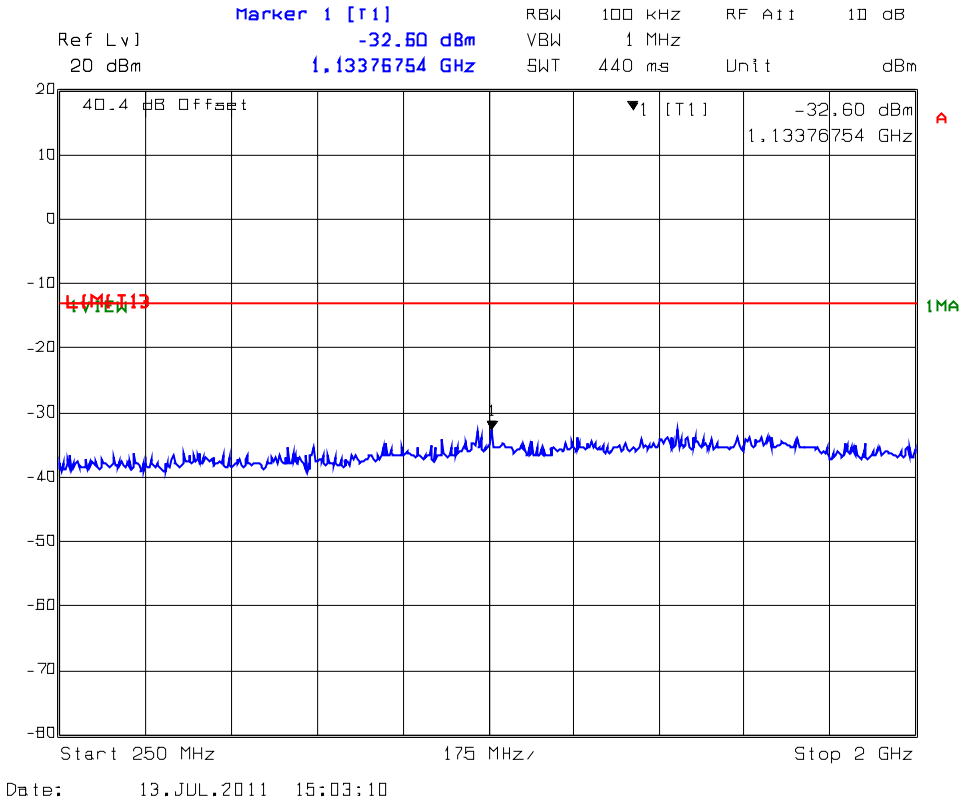
Carrier Frequency (MHz):	157.425
Power (dBm):	29.18
Limit (dBm):	-13

All emissions found were more than 20 dB below the permissible limits.

Plot # 13.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 157.425 MHz
Channel Spacing: 25.0 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



Plot # 14.:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 157.425 MHz
Channel Spacing: 25.0 kHz
Power: 1 W
Modulation: G3E, 2.5 kHz sine wave



5.5. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§ 80.211(f)(3)]

5.5.1. Limits

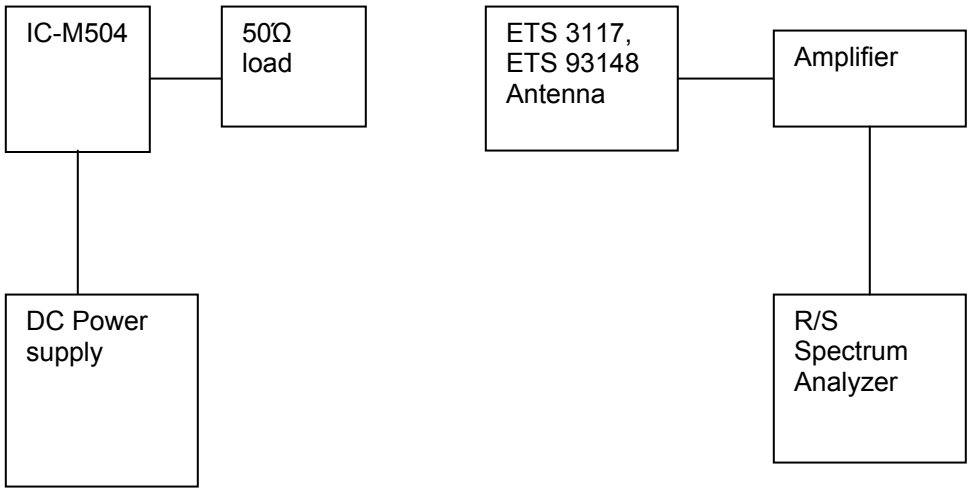
§ 80.211 (f)(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus 10log10 (mean power in watts) dB.

5.5.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in 8.2 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

5.5.3. Test Arrangement



5.5.4. Test Data

Remarks: The radiated emissions are scanned from 30 MHz to 2 GHz with high power setting (25 Watts) at 3 meters distance to represents the worst-case test configuration.

5.5.4.1. Near Lowest Frequency (156.025 MHz)

Carrier Frequency (MHz):	156.025
Power (dBm):	43.83
Limit (dBm):	-13

All emissions found were more than 20 dB below the permissible limits.

5.5.4.2. Near Highest Frequency (157.425 MHz)

Carrier Frequency (MHz):	157.425
Power (dBm):	43.77
Limit (dBm):	-13

All emissions found were more than 20 dB below the permissible limits.

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Rhode & Schwarz	FSEK	834157/005	9 KHz – 40 GHz	26 Jul 2011
Attenuator (30dB)	Aeroflex/Weinschel	46-30-34	BR9127	DC-18 GHz	Cal. on use
Power Meter	Hewlett Packard	437B	3125U06665	100K--50G sensor dependent	20 Aug 2011
Log Periodic Antenna	ETS-LINDGREN	93148	1101	200-2000 MHz	04 Jan 2012
Bi-conical Antenna	ETS-LINDGREN	3110B	3379	30-300MHz	20 Nov 2011
Horn Antenna	ETS-LINDGREN	3117	119425	1-18GHz	15 Feb 2012
Power Sensor	Hewlett Packard	8481A	2237A33409	0.1 - 18 GHz	27 Aug 2011
RF Communication Test Set	Hewlett Packard	8920B	US39064699	30MHz-1GHz	27 Oct 2012
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150KHz-1300MHz	17 Dec 2011
FFT Spectrum Analyzer	Advantest	R9211E	8202336	10mHz--100KHz	12 Nov 2011
High Pass Filter	Mini Circuit	SHP 250	--	Cut off 230 MHz	Cal. on use
Combiner	Mini Circuit	ZFSC-3-4	15542	1MHz - 1GHz	Cal. on use
Power supply	Tenma	72-7295	490300297	1-40V DC 5A	Cal. on use

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. 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 @ 3 m, 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:

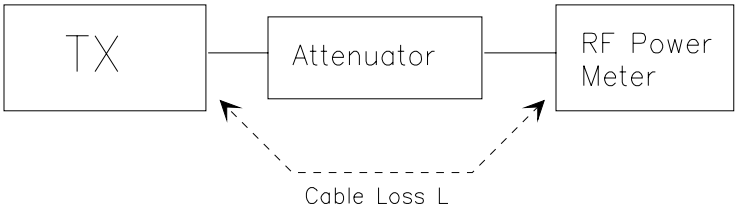
Step 1: Duty Cycle measurements if the transmitter's transmission is transient
- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, 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)

- The measurements was performed with full rf output power and modulation.
- Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
- The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
- The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
- 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)

- Set the EMI Receiver #1 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

- The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
- The transmitter was rotated through 360^{o} about a vertical axis until a higher maximum signal was received.
- The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
- The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
- 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.
- Repeat for all different test signal frequencies

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

- 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:	100 kHz
Video BW:	VBW > RBW
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

- 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)

- Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
- 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 }.
- Mount the transmitting antenna at 1.5 meter high from the ground plane.
- 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 }.
- If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
- Adjust both transmitting and receiving antenna in a VERTICAL polarization.
- Tune the EMI Receivers to the test frequency.
- Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
- The transmitter was rotated through 360^{o} about a vertical axis until a higher maximum signal was received.
- Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
- 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.
- 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

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

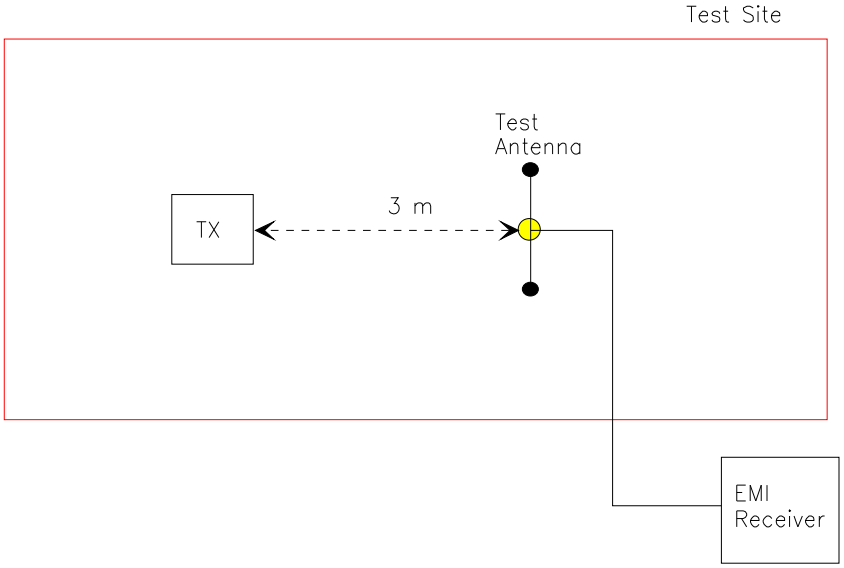
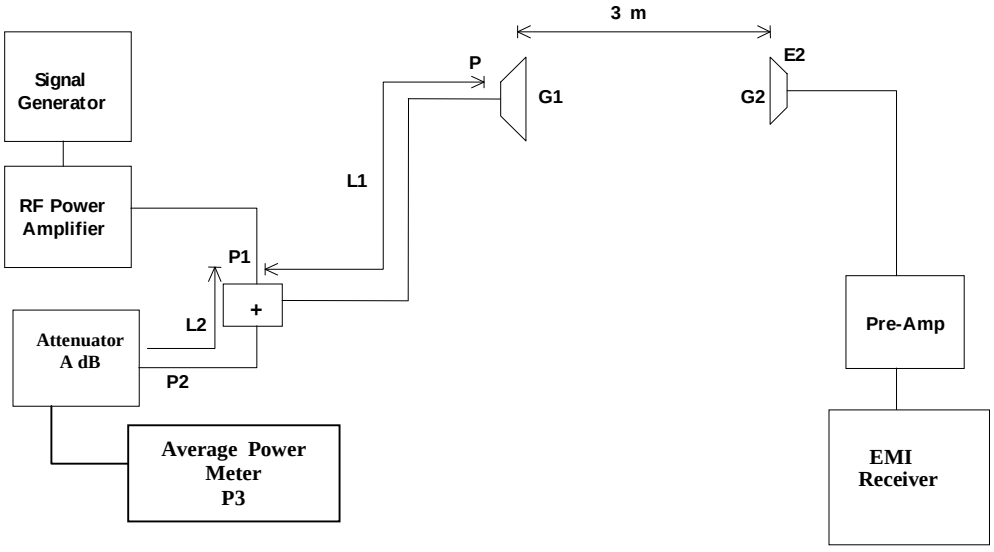


Figure 3



8.3. EMISSION MASK

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 Masks 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 Mask/Out-of-Band Emission Measurements:

For 25 kHz Channel Spacing: RBW = 300 Hz
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.

8.4. 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 47 CFR 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 47 CFR 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.