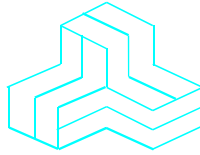


ENGINEERING TEST REPORT



VHF Marine Transceiver
Model No.: IC-M324
FCC ID: AFJ349300

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 156.050-157.425 MHz)

UltraTech's File No.: ICOM-3865Q_FCC80

This Test report is Issued under the Authority of
Tri M. Luu
Vice President of Engineering
UltraTech Group of Labs

Date: October 30, 2014

Report Prepared by: Dharmajit Solanki

Tested by: Wei Wu, RF Technician

Issued Date: October 30, 2014

Test Dates: October 23-24, 2014

*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.*

UltraTech

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91038



1309



46390-2049



NVLAP LAB
CODE 200093-0



SL2-IN-E-
1119R



CA2049



TL363_B



TPTDP
DA1300

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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 Equipment Authorization for Radio operating in the frequency bands, 156.050-157.425 MHz (Marine)
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with TIA/EIA Standard TIA/EIA-603 D (2010) – Land Mobile FM or PM Communications Equipment Measurement and performance Standards.
Categories of Station:	Ship station transceiver operating in 156.050-157.425 MHz band

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

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2013	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, Edition 6.0 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

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October 30, 2014

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EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Osaka Japan, 547-0003
Contact Person:	Mr. Hideji Fujishima Phone #: +81-66-793-8424 Fax #: +81-66-793-3336 Email Address: world_support@icom.co.jp

Manufacturer	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Osaka Japan, 547-0003
Contact Person:	Mr. Hideji Fujishima Phone #: +81-66-793-8424 Fax #: +81-66-793-3336 Email Address: world_support@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 Incorporated
Product Name:	VHF Marine Transceiver
Model Name or Number:	IC-M324
Serial Number:	00000111
Type of Equipment:	Licensed Non-Broadcast Station Transceiver
Power Supply Requirement:	13.8 V DC
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	VHF Marine Transceiver for Ship Station

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2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile or Fixed Station
Intended Operating Environment:	Marine
Power Supply Requirement:	13.8 V DC
RF Output Power Rating:	25 Watts (High) and 1 Watt (Low)
Operating Frequency Range:	156.050-157.425 MHz (Marine)
RF Output Impedance:	50 Ohm
Channel Spacing:	25 kHz
Modulation Employed:	Variable reactance Frequency Modulation
Occupied Bandwidth (99%):	14.97 kHz (FM) & 12.62 kHz (DSC)
Emission Designation*:	16K0G3E (FM), 16K0G2B (DSC)
Antenna Connector Type:	UHF Type

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

Channel Spacing = 25 KHz, D = 5 KHz max, K = 1, M = 3 KHz

$B_n = 2M + 2DK = 2(3) + 2(5)(1) = 16 \text{ kHz}$

Emission designation: 16K0G3E

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	Antenna	1	UHF Female	Shielded
2	Ground Terminal	1	Screw hole	Shielded
3	NMEA 0183 In/Out Leads	1	4-Wire	Non Shielded
4	AF Out Leads	1	3-Wire	Non Shielded
5	DC Power	1	2 Wire	Non Shielded

2.5. ANCILLARY EQUIPMENT

Ancillary Equipment # 1	
Description:	Speaker Microphone
Brand Name:	Icom Inc.
Model Name or Number:	HM-200B
Serial Number:	N/A

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 to 23°C
Humidity:	30 to 55%
Pressure:	102 kPa
Power input source:	13.8 V DC

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 Ohm RF Load.

Transmitter Test Signals	
Frequency Band(s):	156.050 - 157.425 MHz
Test Frequency(ies):	156.050 and 157.425 MHz
Transmitter Wanted Output Test Signals: • Transmitter Power (measured maximum output power): • Normal Test Modulation: • Modulating signal source:	25 Watts High, 1 Watt Low Variable reactance Frequency Modulation External

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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: 2017-04-02.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
2.1046 & 80.215	RF Power Output	Yes
2.1047(a) & 80.213(e)	Modulation Characteristics - Audio Frequency Response	Yes
2.1047(b) & 80.213	Modulation Characteristics - Modulation Limiting	Yes
2.1049, 80.205 & 80.211(f)	Occupied Bandwidth and Emission Limitations	Yes
2.1051, 2.1057 & 80.211(f)(3)	Spurious Emissions at Antenna Terminal	Yes
2.1053, 2.1057 & 80.211(f)(3)	Field Strength of Spurious Emissions	Yes
2.1055 & 80.209	Frequency Stability	Yes
80.217	Suppression of Interference aboard ships	Yes ¹
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes

¹ Complies with FCC Part 15, Subpart B.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None

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EXHIBIT 5. TEST DATA

5.1. RF POWER OUTPUT [§§ 2.1046 & 80.215]

5.1.1. Limits

§ 80.215(e)(1) Ship stations 156–162 MHz - 25W^{1,2}

Marine utility stations and hand-held portable transmitters: 156–162 MHz -10W

¹ Reducible to 1 watt or less, except for transmitters limited to public correspondence channels and used in an automated system.

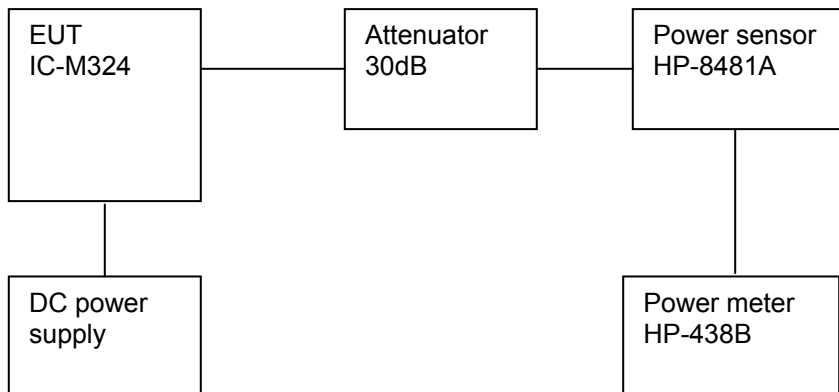
² The frequencies 156.775 and 156.825 MHz are available for navigation-related port operations or ship movement only, and all precautions must be taken to avoid harmful interference to channel 16. Transmitter output power is limited to 1 watt for ship stations, and 10 watts for coast stations.

5.1.2. Method of Measurements

Refer to Section 8.1 of this report for measurement details.

5.1.3. Test Arrangement

Conducted Power.



5.1.4. Test Data

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Conducted Power (W)	Power Rating (W)
Power Setting: High			
Lowest	156.050	23.12	25.0
Highest	157.050	23.17	25.0
Power Setting: Low			
Lowest	156.050	0.82	1.0
Highest	157.425	0.85	1.0

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5.2. RF EXPOSURE REQUIREMENTS @ 1.1310 & 2.1091

5.2.1. Limits

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).

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density ()	Average Time (minutes)
(A) Limits for Occupational/Control Exposures				
30-300	61.4	0.163	1.0	6
(B) Limits for General Population/Uncontrolled Exposure				
30-300	27.5	0.073	0.2	30

5.2.2. Method of Measurements

Calculation Method of RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where,
P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm²
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

$$r = \sqrt{\frac{PG}{4\pi \cdot S}} = \sqrt{\frac{EIRP}{4\pi \cdot S}}$$

FCC radio frequency exposure limits may be exceeded at distances closer than r cm from the antenna of this device.

5.2.3. Evaluation of RF Exposure Compliance Requirements

MPE Limit for Occupational/Controlled Exposure, $S_{\text{controlled}}[\text{mW}/\text{cm}^2] = 1.0$

MPE Limit for General Population/Uncontrolled Exposure, $S_{\text{uncontrolled}}[\text{mW}/\text{cm}^2] = 0.2$

Maximum RF Power conducted, $P_{\text{conducted}}[\text{dBm}] = 43.98$

Maximum Antenna Gain, $G[\text{dBi}] = 9$

Maximum EIRP, $P_{\text{EIRP}} = 52.98 \text{ dBm}$ or 198582 mwatts

User-based time-average for PTT = 50%

Calculated RF Safety Distance for Occupational/Controlled Exposure, $r_{\text{safety_controlled}}[\text{cm}] = 89 \text{ cm}$

Calculated RF Safety Distance for General Population/Uncontrolled Exposure, $r_{\text{safety_uncontrolled}}[\text{cm}] = 199 \text{ cm}$

5.3. MODULATION CHARACTERISTICS & AUDIO FREQUENCY RESPONSE [§§ 2.1047(a) & 80.213(e)]

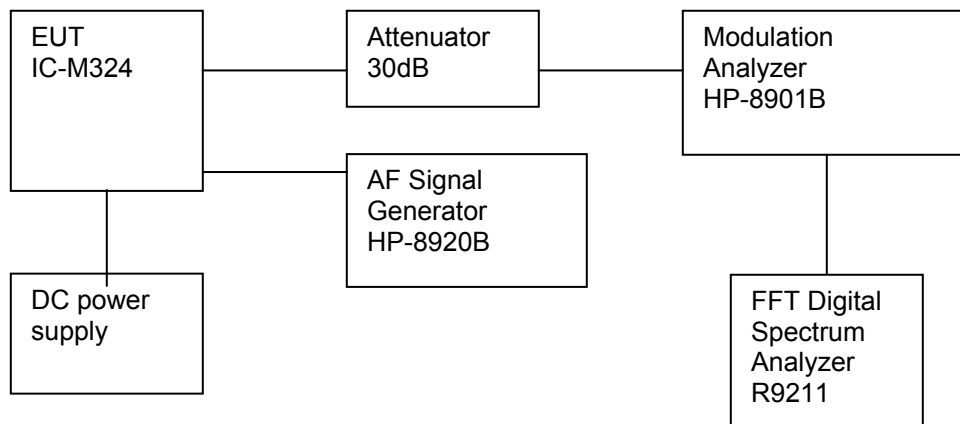
5.3.1. Limits

(e) Coast station transmitters operated in the 156–162 MHz band must be equipped with an audio low-pass filter. The filter must be installed between the modulation limiter and the modulated radio frequency stage. At frequencies between 3 kHz and 20 kHz it must have an attenuation greater than at 1 kHz by at least $60\log_{10}(f/3)$ dB where “f” is the audio frequency in kilohertz. At frequencies above 20 kHz the attenuation must be at least 50 dB greater than at 1 kHz

5.3.2. Method of Measurements

The rated audio input signal was applied to the input of the audio lowpass 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 50 kHz.

5.3.3. Test Arrangement



5.3.4. Test Data

Note: Due to the difficulty of measuring the Frequency Response of the internal lowpass 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 (25 kHz channel spacing)**

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 1 kHz (dB)	Recommended FCC Limit (dB)
0.1	-33.98	-42.38	-8.4	-48.8	--
0.2	-33.98	-18.03	16.0	-24.5	--
0.4	-33.98	-2.09	31.9	-8.6	--
0.6	-33.98	1.64	35.6	-4.8	--
0.8	-33.98	4.36	38.3	-2.1	--
1.0	-33.98	6.46	40.4	0.0	--
1.5	-33.98	9.75	43.7	3.3	--
2.0	-33.98	9.95	43.9	3.5	--
2.5	-33.98	9.61	43.6	3.2	--
3.0	-33.98	8.35	42.3	1.9	0
3.5	-33.98	5.98	40.0	-0.5	-4
4.0	-33.98	2.71	36.7	-3.8	-7
4.5	-33.98	-0.79	33.2	-7.3	-11
5.0	-33.98	-4.01	30.0	-10.5	-13
6.0	-33.98	-10.05	23.9	-16.5	-18
7.0	-33.98	-15.44	18.5	-21.9	-22
8.0	-33.98	-19.95	14.0	-26.4	-26
9.0	-33.98	-23.86	10.1	-30.3	-29
10.0	-33.98	-27.59	6.4	-34.1	-31
12.0	-33.98	-34.40	-0.4	-40.9	-36
14.0	-33.98	-41.05	-7.1	-47.5	-40
16.0	-33.98	-48.17	-14.2	-54.6	-44
18.0	-33.98	-56.11	-22.1	-62.6	-47
20.0	-33.98	-60.00	-26.0	-66.5	-49
22.0	-33.98	-60.00	-26.0	-66.5	-50
25.0	-33.98	-60.00	-26.0	-66.5	-50
30.0	-33.98	-60.00	-26.0	-66.5	-50
35.0	-33.98	-60.00	-26.0	-66.5	-50
40.0	-33.98	-60.00	-26.0	-66.5	-50
45.0	-33.98	-60.00	-26.0	-66.5	-50
50.0	-33.98	-60.00	-26.0	-66.5	-50

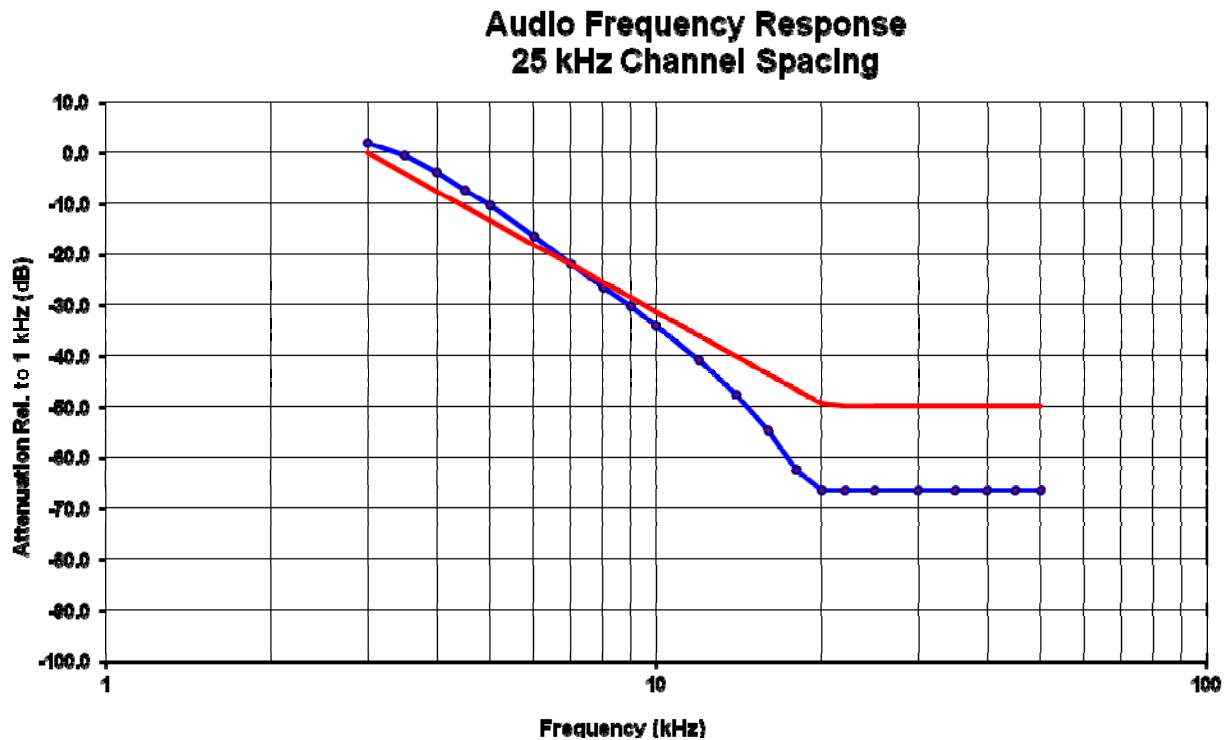
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5.4. MODULATION LIMITING [§ 80.213 & § 2.1047(b)]

5.4.1. Limits

§ 80.213 (a)(2) When phase or frequency modulation is used in the 156-162 MHz band the peak modulation must be maintained between 75 and 100 percent. A frequency deviation of ± 5 kHz is defined as 100 percent peak modulation; and

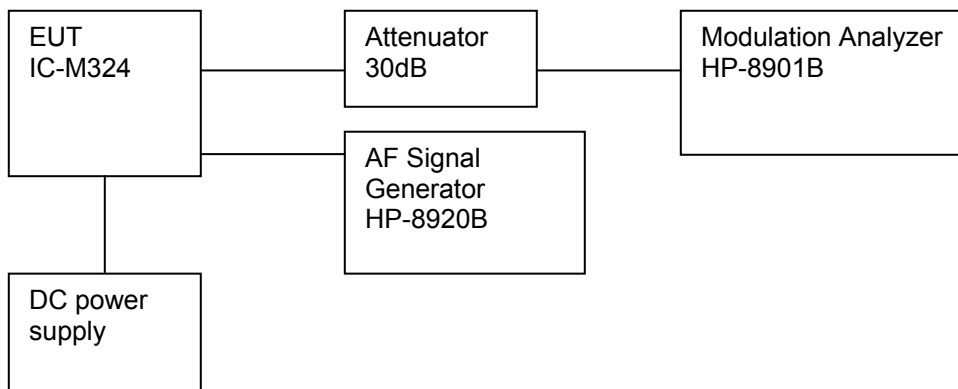
§ 80.213 (b) Radiotelephone transmitters using A3E, F3E and G3E emission must have a modulation limiter to prevent any modulation over 100 percent. This requirement does not apply to survival craft transmitters, to transmitters that do not require a license or to transmitters whose output power does not exceed 3 watts.

§ 80.213 (d) Ship and coast station transmitters operating in the 156-162 MHz and 216-220 bands must be capable of proper operation with a frequency deviation that does not exceed ± 5 kHz when using any emission authorized by Sec. 80.207.

5.4.2. 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.

5.4.3. Test Arrangement



5.4.4. Test Data

5.4.4.1. Voice Modulation Limiting

MODULATING SIGNAL LEVEL (mVrms)	PEAK FREQUENCY DEVIATION (kHz) at the following modulating frequency:					MAXIMUM LIMIT (kHz)
	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	
2	0.04	0.16	0.33	0.87	0.42	5.0
4	0.04	0.30	0.62	1.69	0.80	5.0
6	0.04	0.45	0.92	2.51	0.88	5.0
8	0.04	0.59	1.24	3.42	0.88	5.0
10	0.04	0.73	1.50	3.68	0.88	5.0
15	0.04	1.08	2.23	3.74	0.91	5.0
20	0.04	1.45	3.00	3.75	0.91	5.0
25	0.04	1.78	3.61	3.76	0.91	5.0
30	0.04	2.13	3.65	3.77	0.91	5.0
35	0.04	2.49	4.22	3.77	0.91	5.0
40	0.04	2.83	4.32	3.78	0.91	5.0
45	0.05	3.18	4.34	3.78	0.91	5.0
50	0.09	3.52	4.36	3.79	0.91	5.0
60	0.05	3.78	4.38	3.80	0.91	5.0
70	0.06	3.87	4.40	3.80	0.91	5.0
80	0.06	4.01	4.40	3.80	0.91	5.0
90	0.06	4.33	4.40	3.80	0.91	5.0
100	0.07	4.40	4.41	3.81	0.91	5.0
200	0.18	4.48	4.41	3.81	0.91	5.0
300	0.18	4.48	4.41	3.81	0.91	5.0

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October 30, 2014

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Voice Signal Input Level = STD MOD Level + 16 dB = 42.02 dB(mVrms) = 126.19 mVrms		
Modulation Frequency (KHz)	Peak Deviation (KHz)	Maximum Limit (KHz)
0.1	0.08	5.0
0.2	1.08	5.0
0.4	4.37	5.0
0.6	4.37	5.0
0.8	4.36	5.0
1.0	4.41	5.0
1.2	4.36	5.0
1.4	4.32	5.0
1.6	4.30	5.0
1.8	4.32	5.0
2.0	4.35	5.0
2.5	4.30	5.0
3.0	3.81	5.0
3.5	2.89	5.0
4.0	1.98	5.0
4.5	1.33	5.0
5.0	0.91	5.0
6.0	0.46	5.0
7.0	0.26	5.0
8.0	0.16	5.0
9.0	0.11	5.0
10.0	0.07	5.0

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

5.5.1. Limits

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

Emission designator	Maximum Authorized BW (kHz)	Channel Spacing (kHz)	Recommended Frequency Deviation (kHz)	Applicable Mask
16K0G3E	20	25	5	See § 80.211 (f)

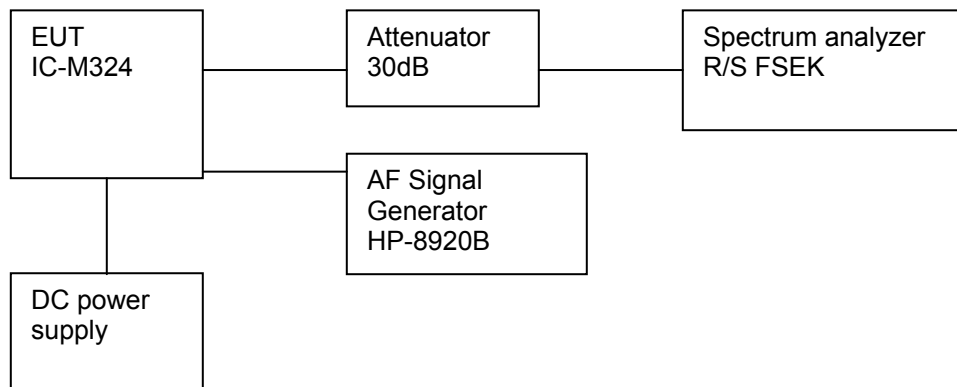
§ 80.211 (f) Emission Limitations:

- (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;
- (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
- (3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB.

5.5.2. Method of Measurements

Refer to Section 8.4 of this report for measurement details

5.5.3. Test Arrangement



5.5.4. Test Data

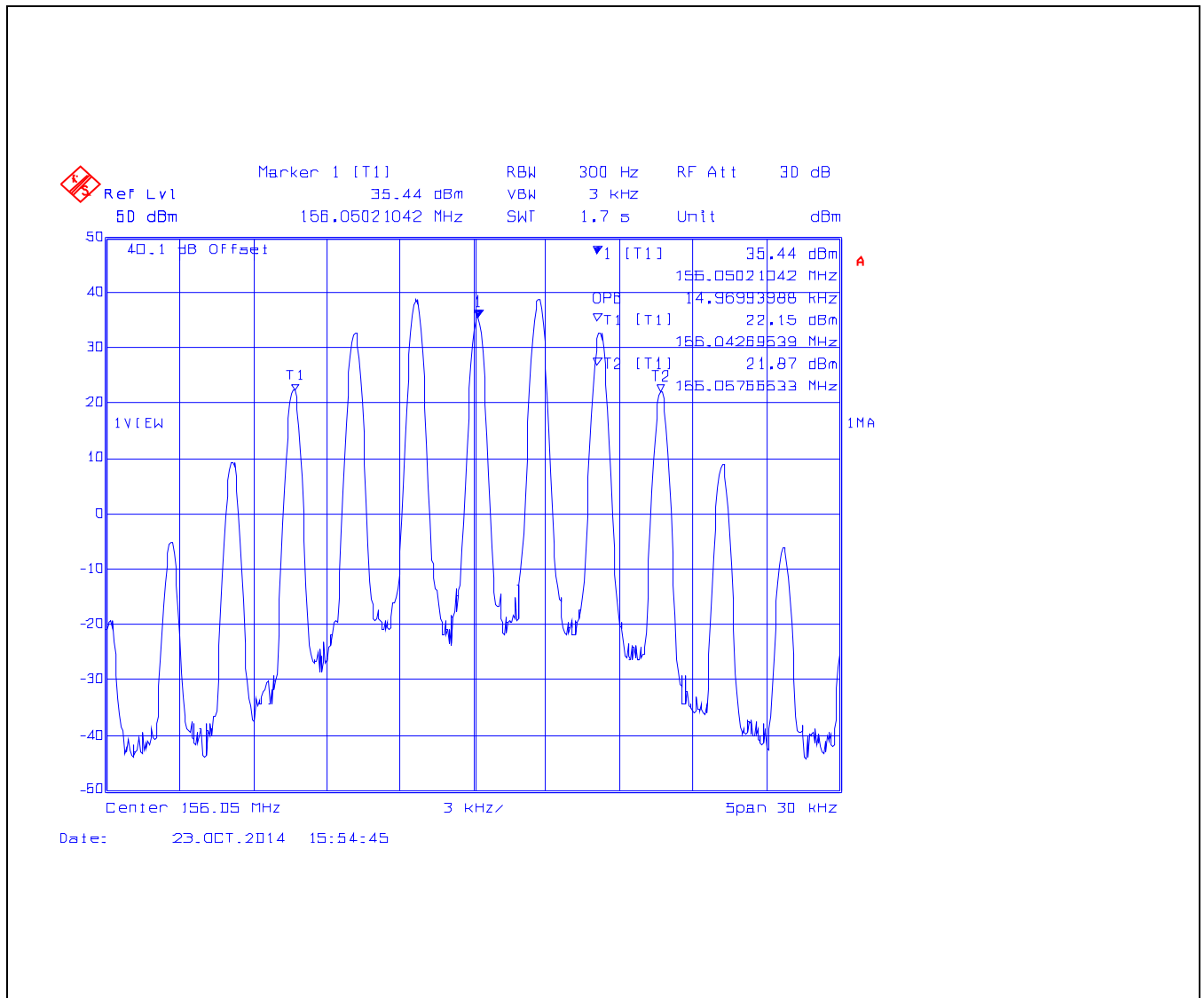
5.5.4.1. 99% Occupied Bandwidth

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

Frequency (MHz)	Channel Spacing (kHz)	Measured 99% OBW (kHz)	Authorized Bandwidth (kHz)
156.050	25	14.97	20
157.425	25	14.97	20
156.525 (DSC)	25	12.62	20

See the following plots for details of measurements.

Plot 5.5.4.1.1. Occupied Bandwidth for 156.050 MHz, 25 kHz Channel Spacing, High Power (25 W), G3E



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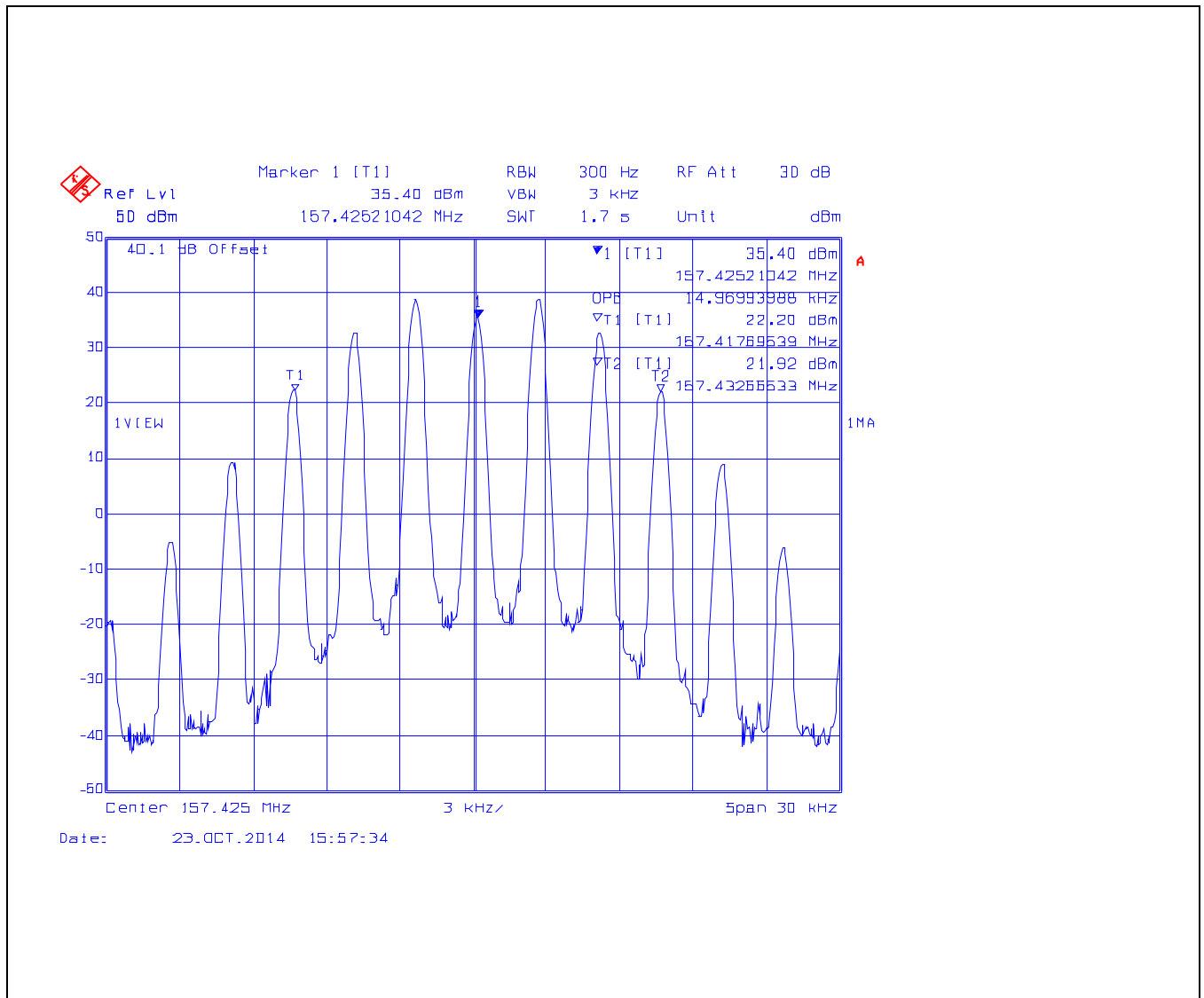
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
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Plot 5.5.4.1.2. Occupied Bandwidth for 157.425 MHz, 25 kHz Channel Spacing, High Power (25 W), G3E



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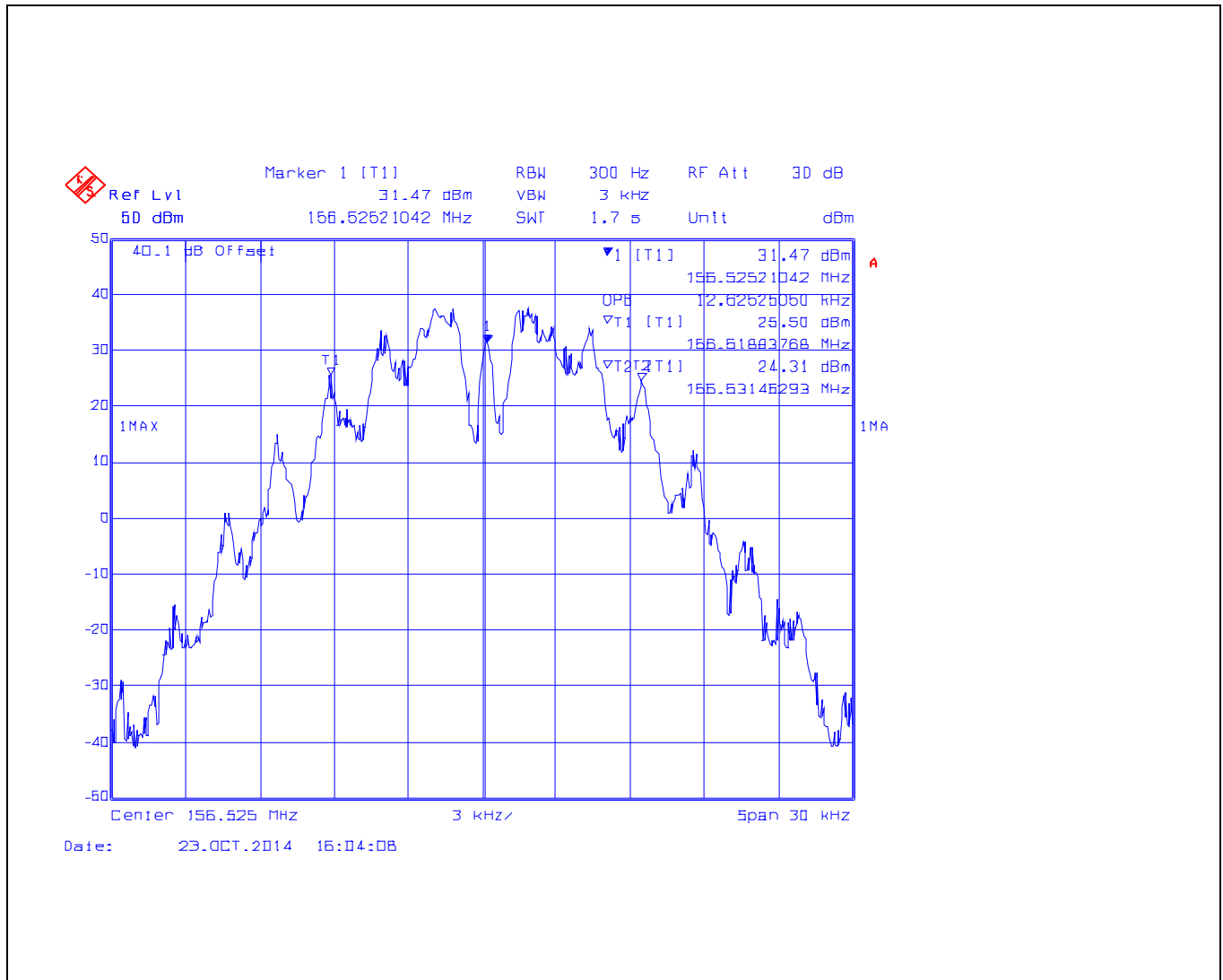
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.5.4.1.3. Occupied Bandwidth for 156.525 MHz, 25 kHz Channel Spacing, High Power (25 W),
DSC-G2B



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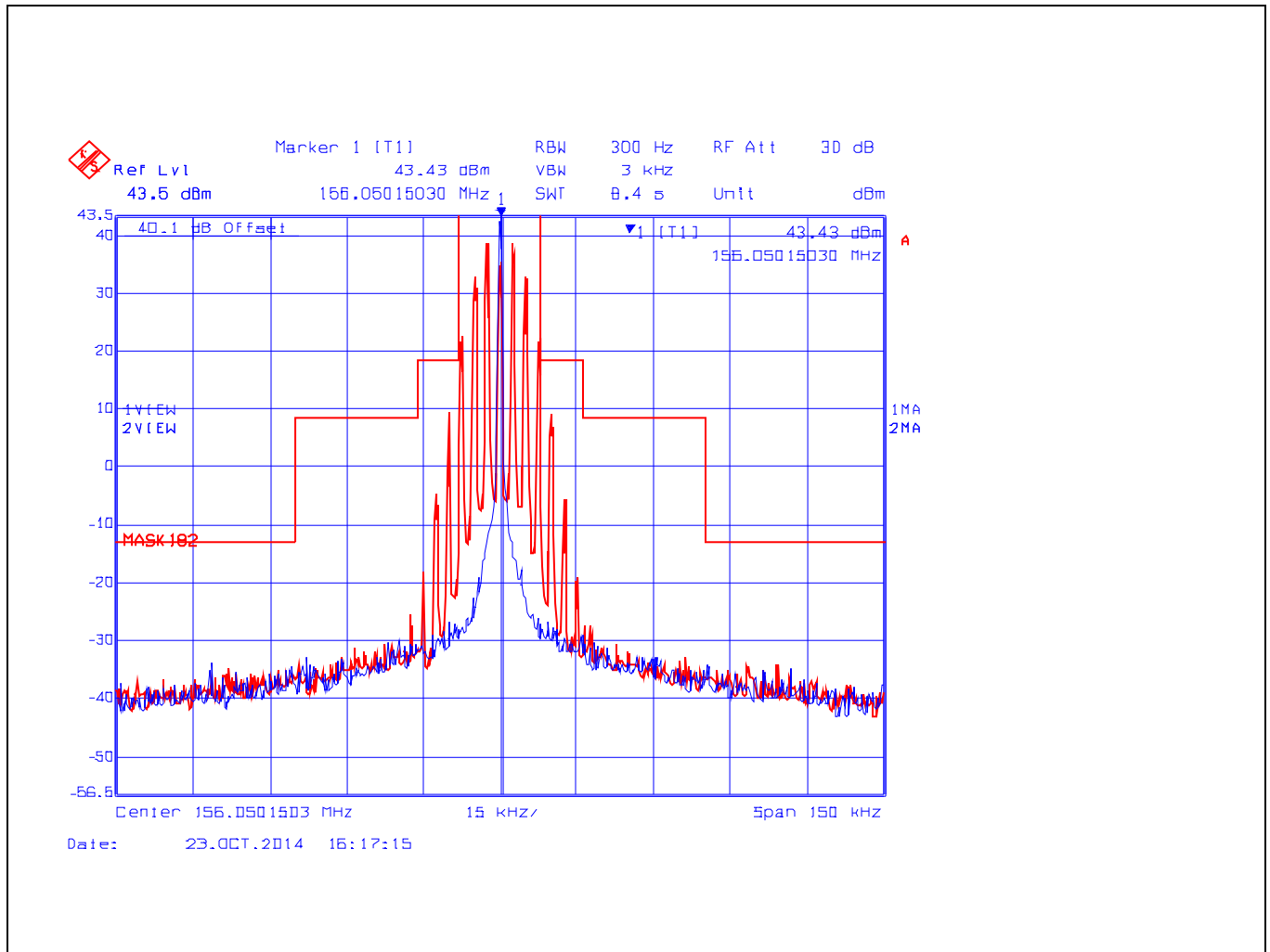
File #: ICOM-386Q_FCC80

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5.5.4.2. Emission Limitation

Plot 5.5.4.2.1. Emission Limitation for 156.050 MHz, 25 kHz Channel Spacing, High Power (25 W), G3E, 150 kHz Span



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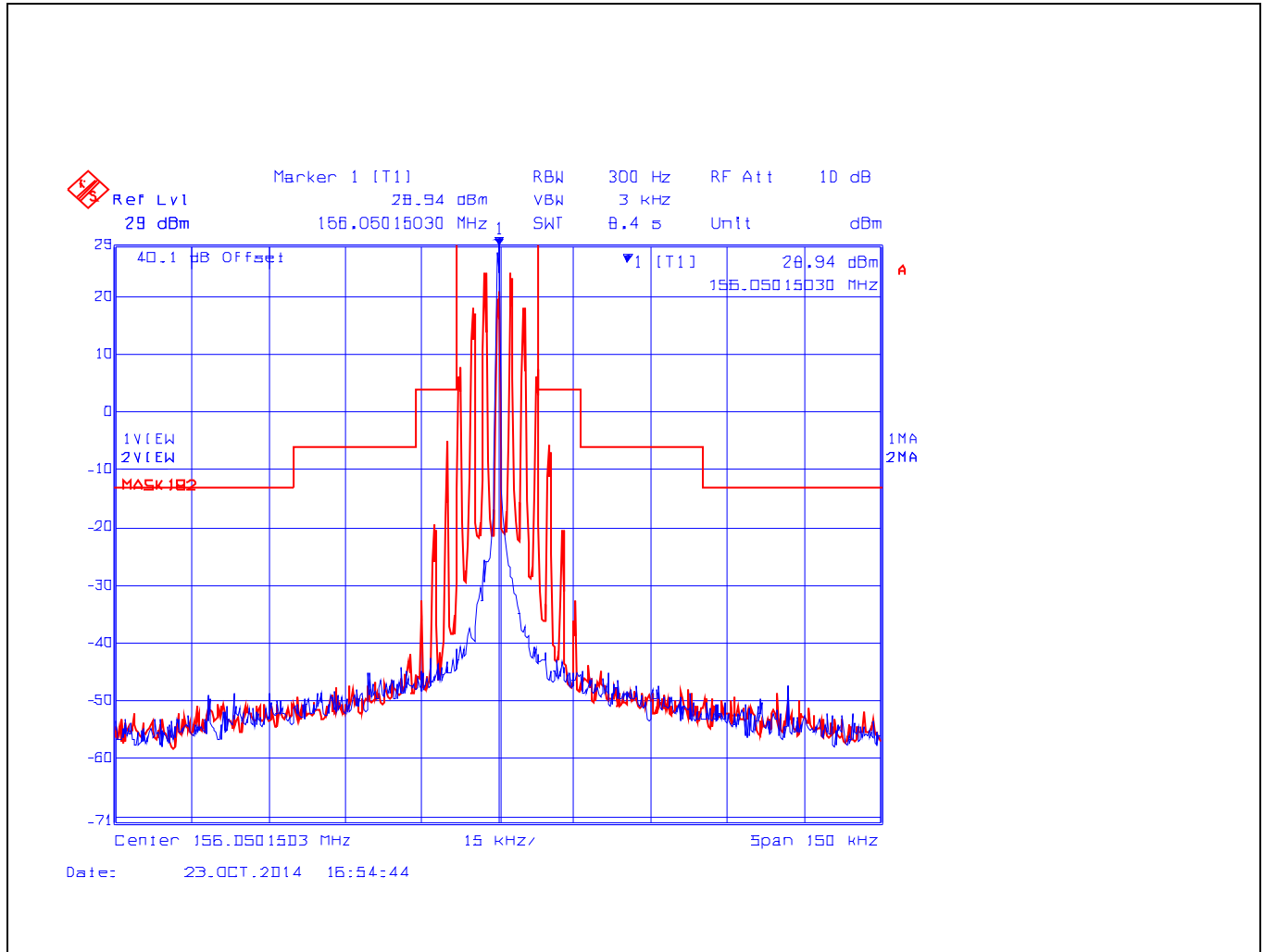
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.5.4.2.2. Emission Limitation for 156.050 MHz, 25 kHz Channel Spacing, Low Power (1 W), G3E, 150 kHz Span



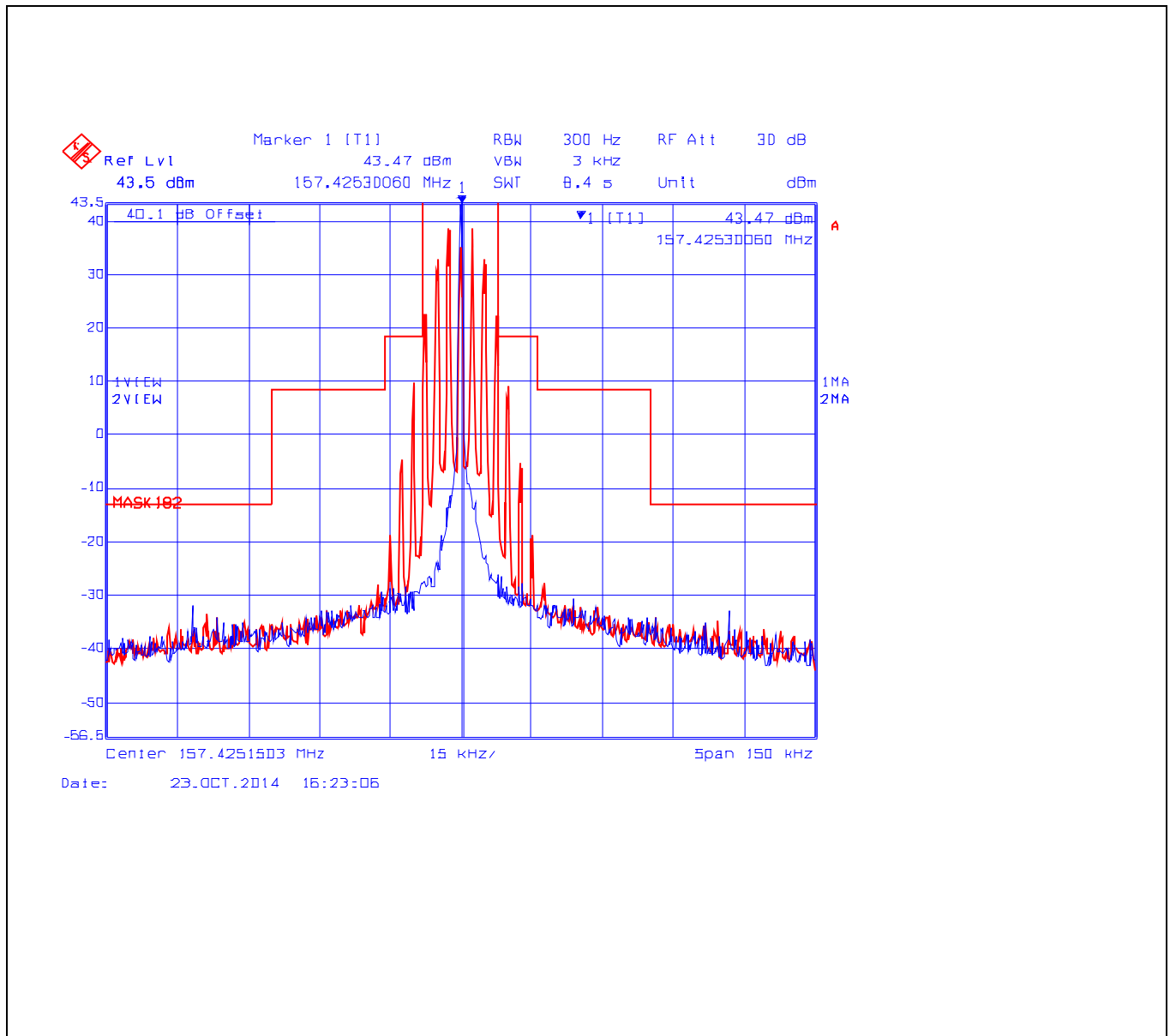
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Plot 5.5.4.2.3. Emission Limitation for 157.425 MHz, 25 kHz Channel Spacing, High Power (25 W), G3E, 150 kHz Span



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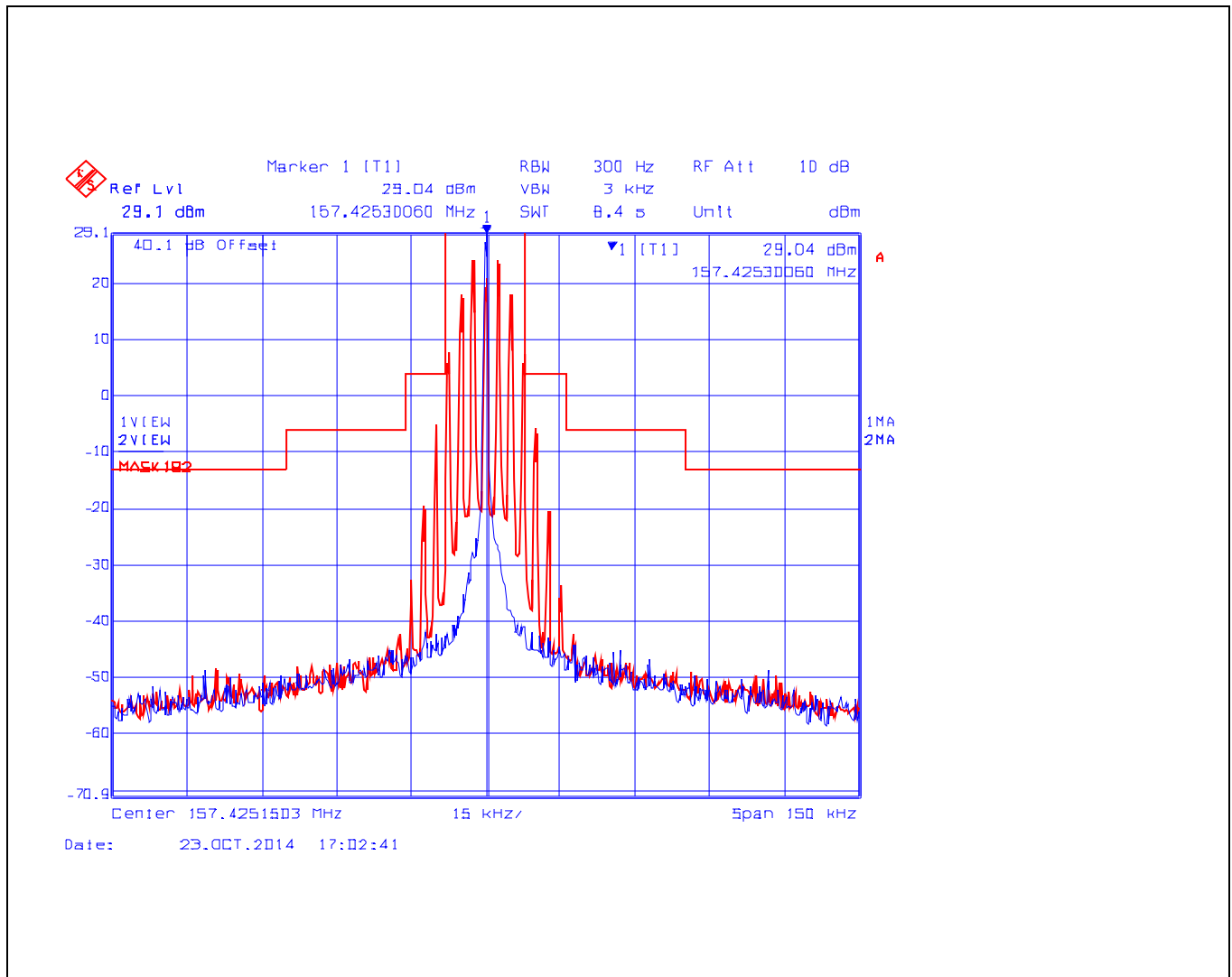
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.5.4.2.4. Emission Limitation for 157.425 MHz, 25 kHz Channel Spacing, Low Power (1 W), G3E, 150 kHz Span



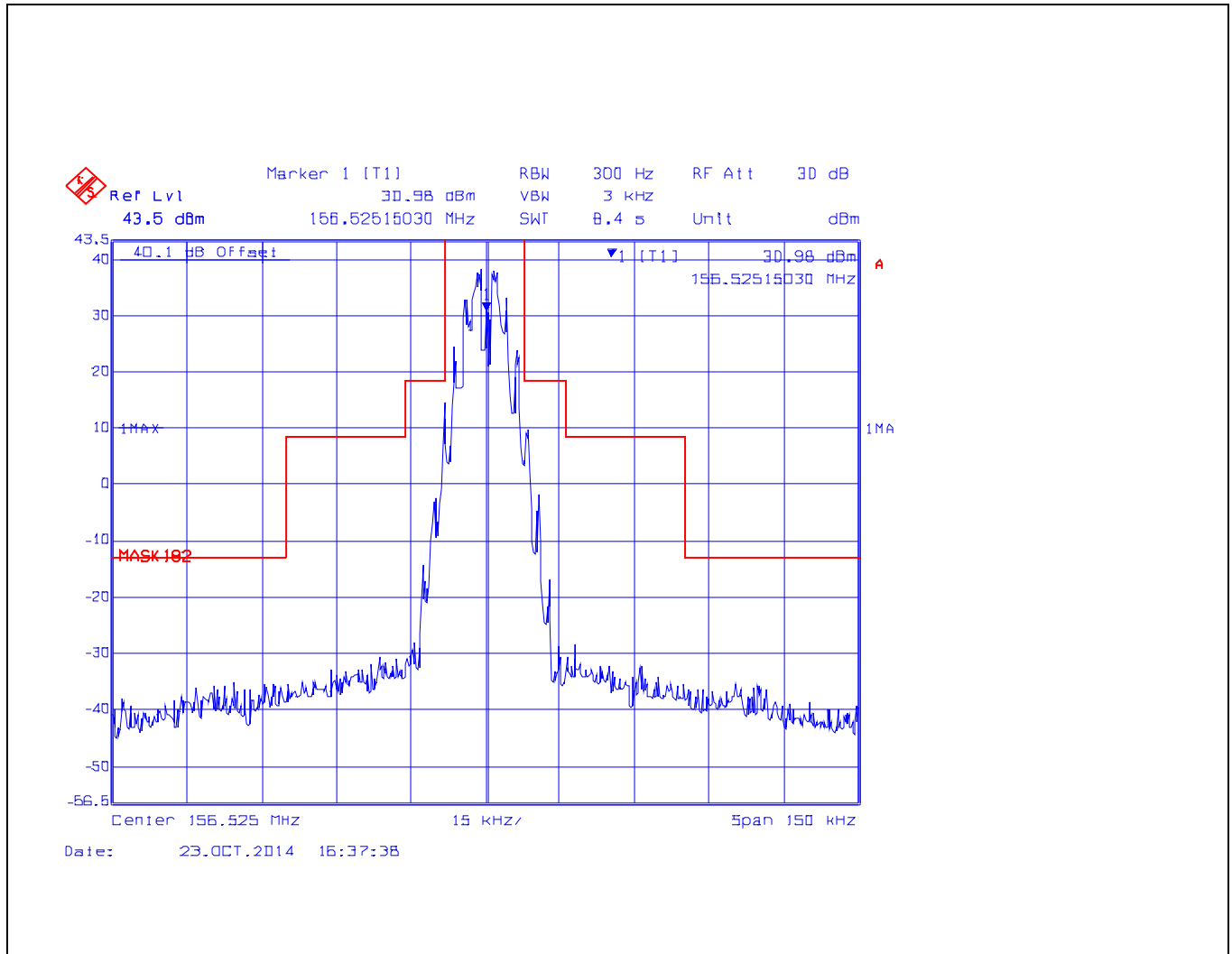
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Plot 5.5.4.2.5. Emission Limitation for 156.525 MHz, 25 kHz Channel Spacing, High Power (25 W), DSC-G2B



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

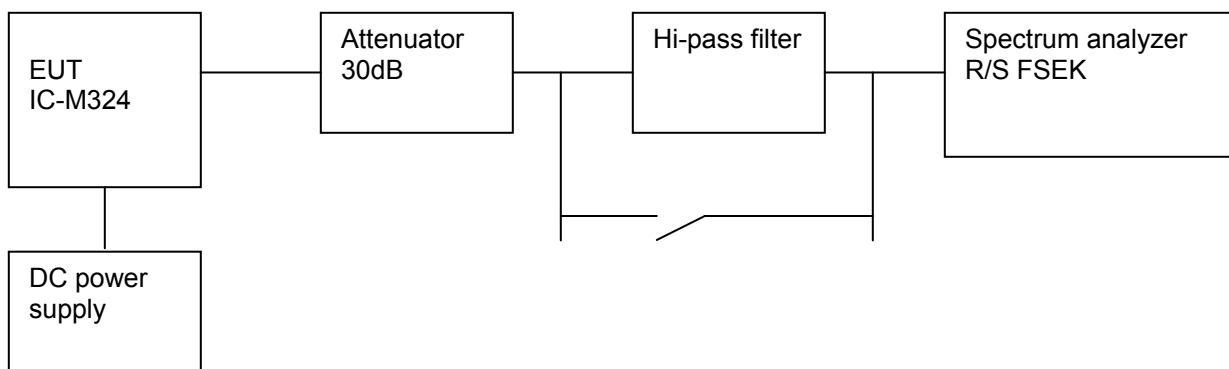
5.6.1. Limits

§ 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 $10\log_{10}$ (mean power in watts) dB.

5.6.2. Method of Measurements

Refer to Section 8.5 of this report for measurement details

5.6.3. Test Arrangement



5.6.4. Test Data

Plot 5.6.4.1. Spurious Emissions at Antenna Terminals, 156.050 MHz, 25 kHz Channel Spacing, 25 W, 30 MHz - 250 MHz



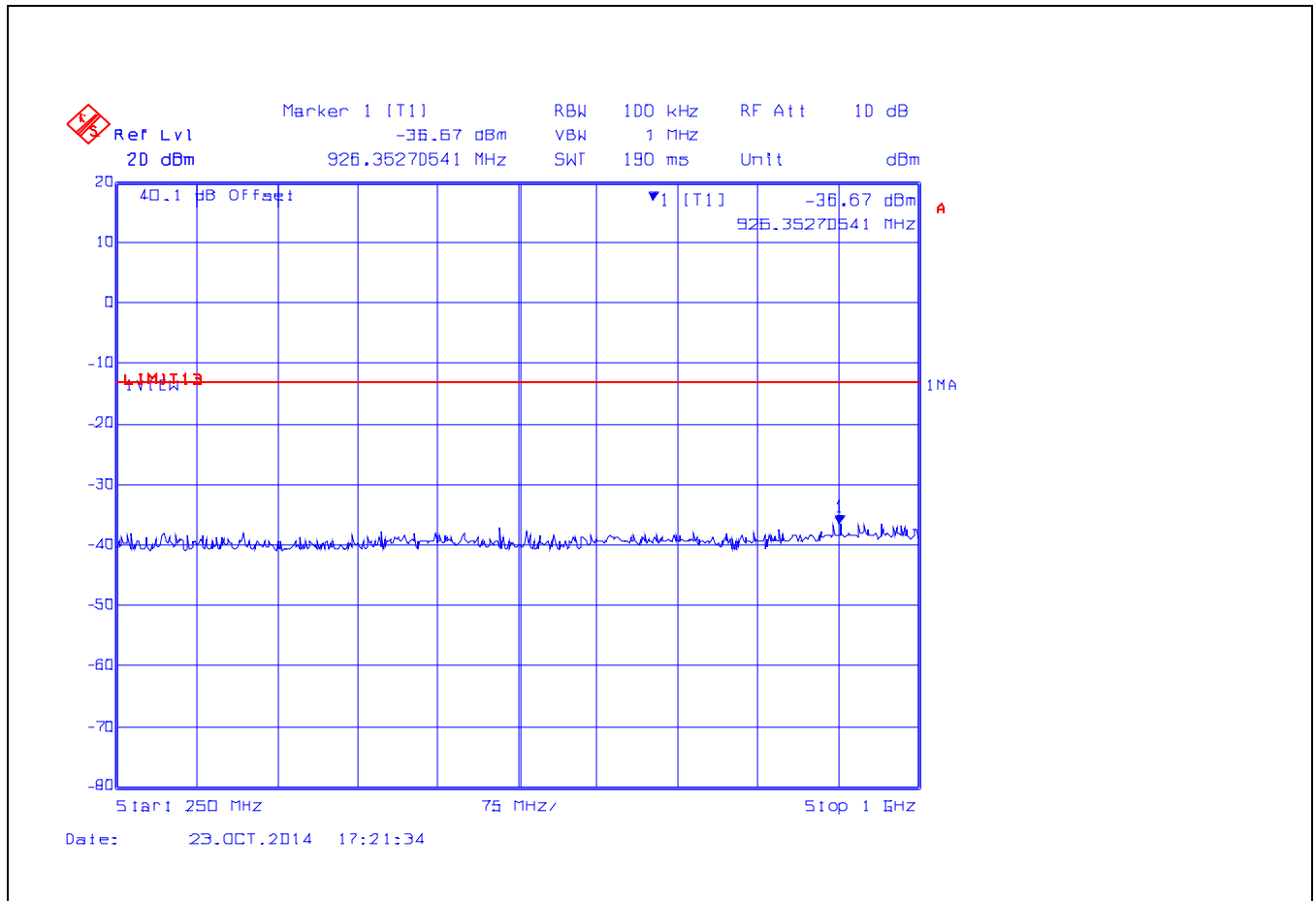
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Plot 5.6.4.2. Spurious Emissions at Antenna Terminals, 156.050 MHz, 25 kHz Channel Spacing, 25 W, 250 MHz - 2 GHz



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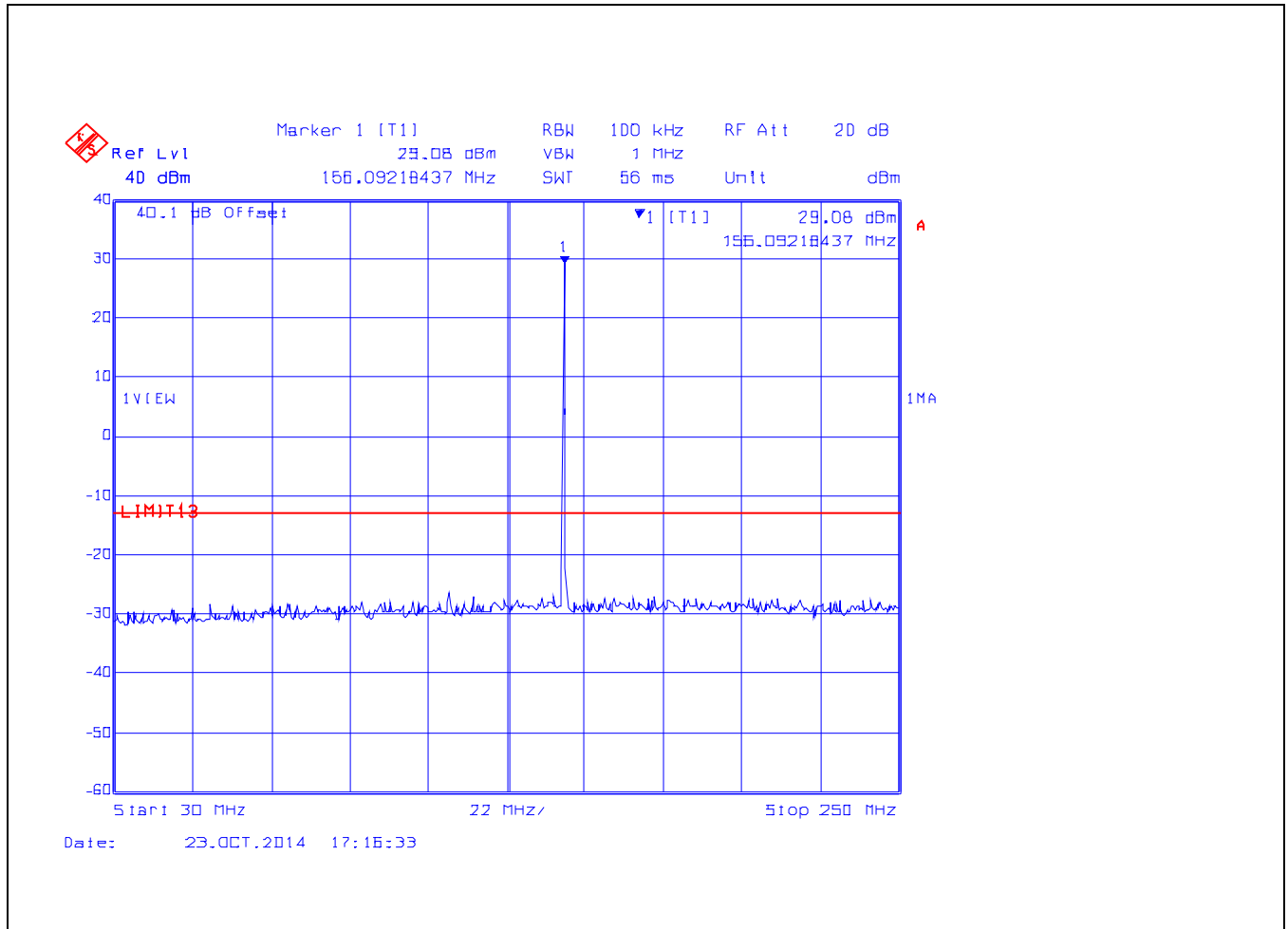
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.6.4.3. Spurious Emissions at Antenna Terminals, 156.050 MHz, 25 kHz Channel Spacing, 1 W, 30 MHz - 250 MHz



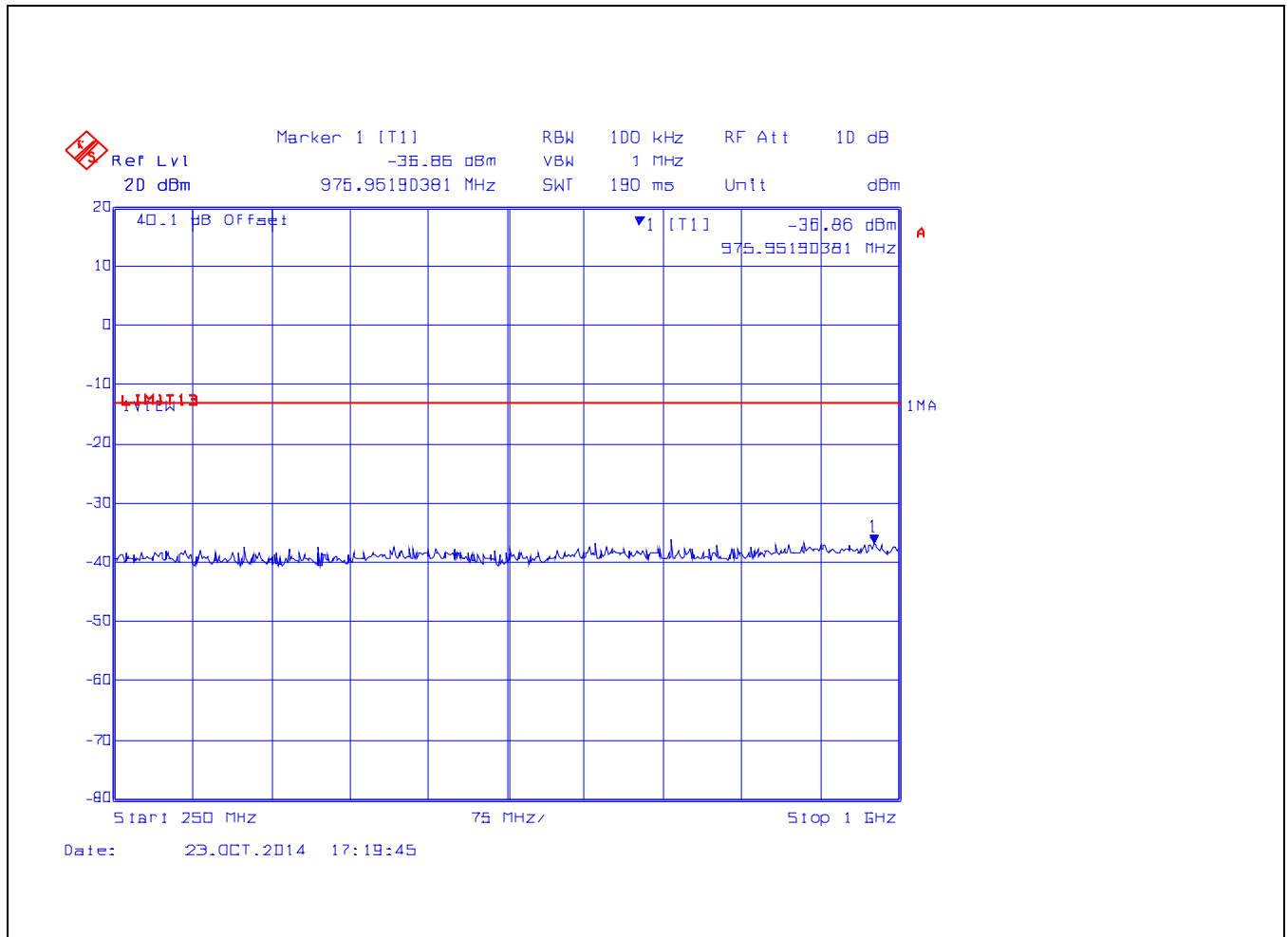
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Plot 5.6.4.4. Spurious Emissions at Antenna Terminals, 156.050 MHz, 25 kHz Channel Spacing, 1 W, 250 MHz - 2 GHz



ULTRATECH GROUP OF LABS

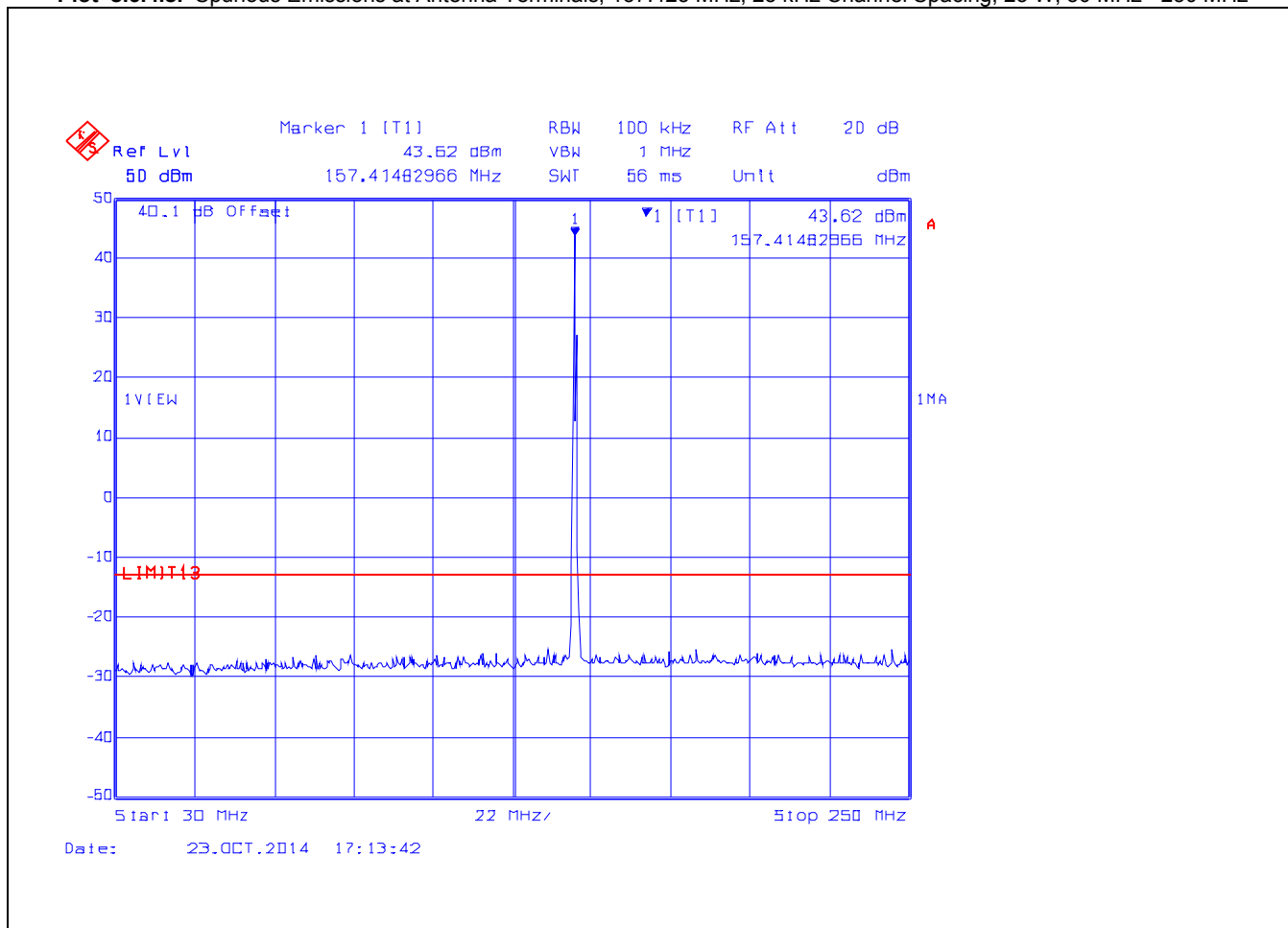
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.6.4.5. Spurious Emissions at Antenna Terminals, 157.425 MHz, 25 kHz Channel Spacing, 25 W, 30 MHz - 250 MHz



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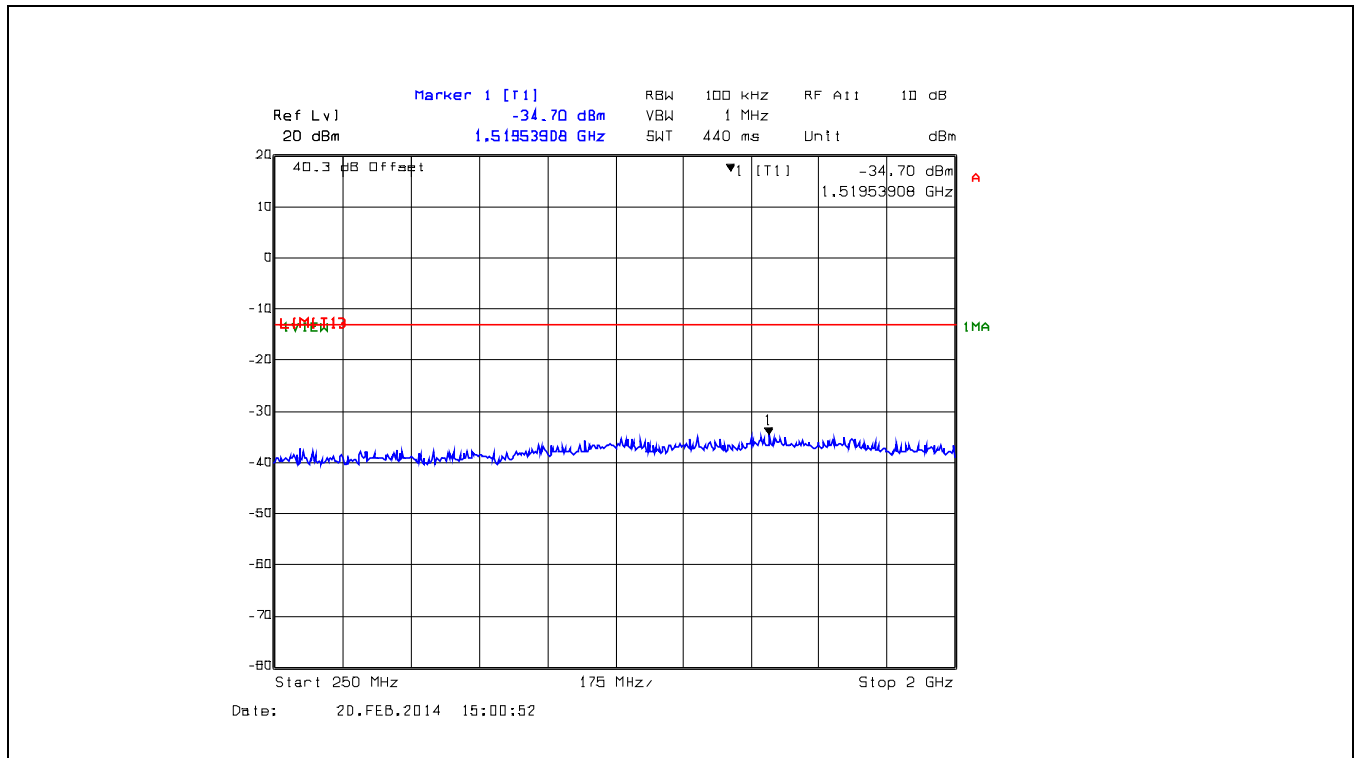
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.6.4.6. Spurious Emissions at Antenna Terminals, 157.425 MHz, 25 kHz Channel Spacing, 25 W, 250 MHz - 2 GHz



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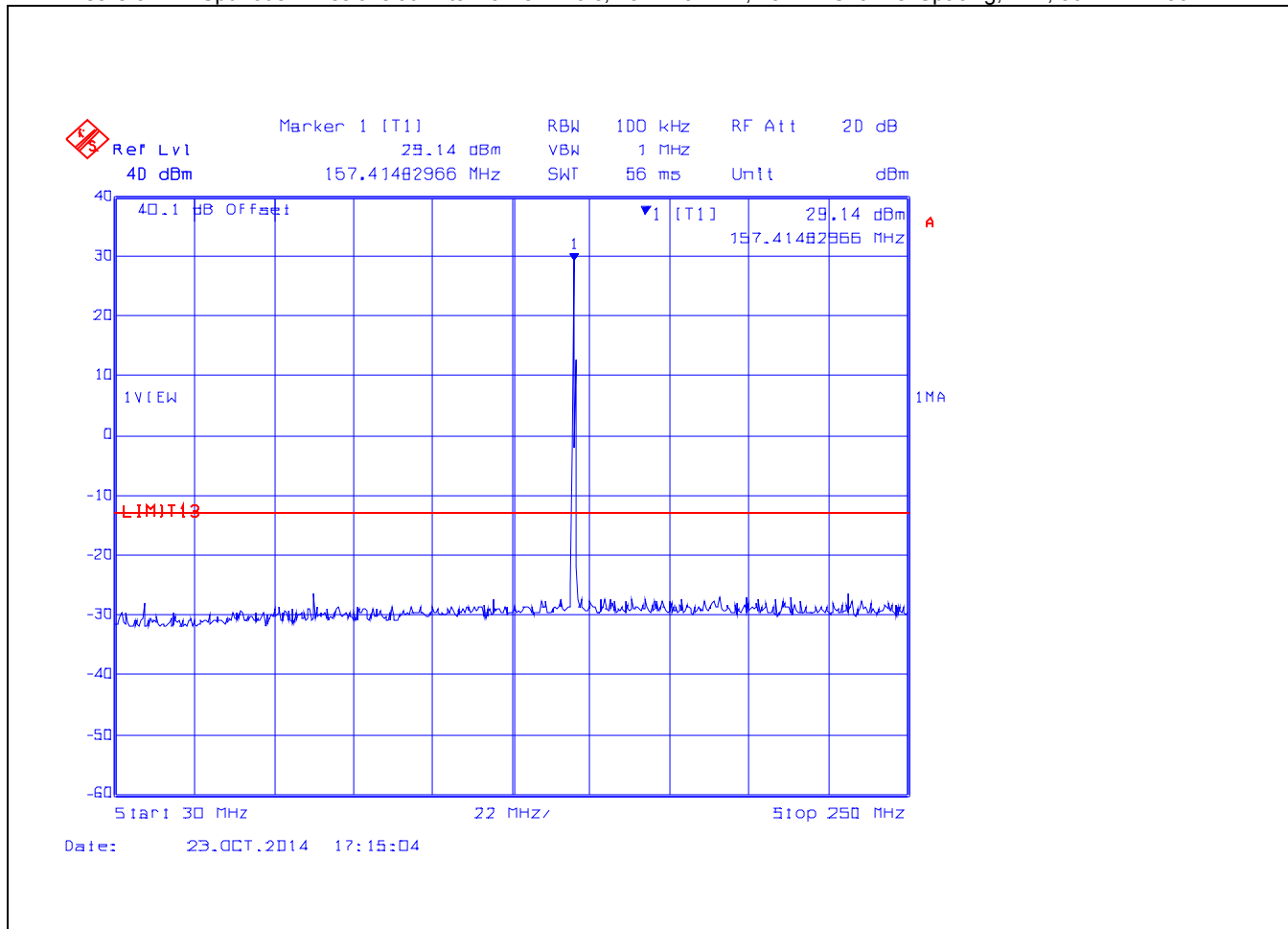
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.6.4.7. Spurious Emissions at Antenna Terminals, 157.425 MHz, 25 kHz Channel Spacing, 1 W, 30 MHz - 250 MHz



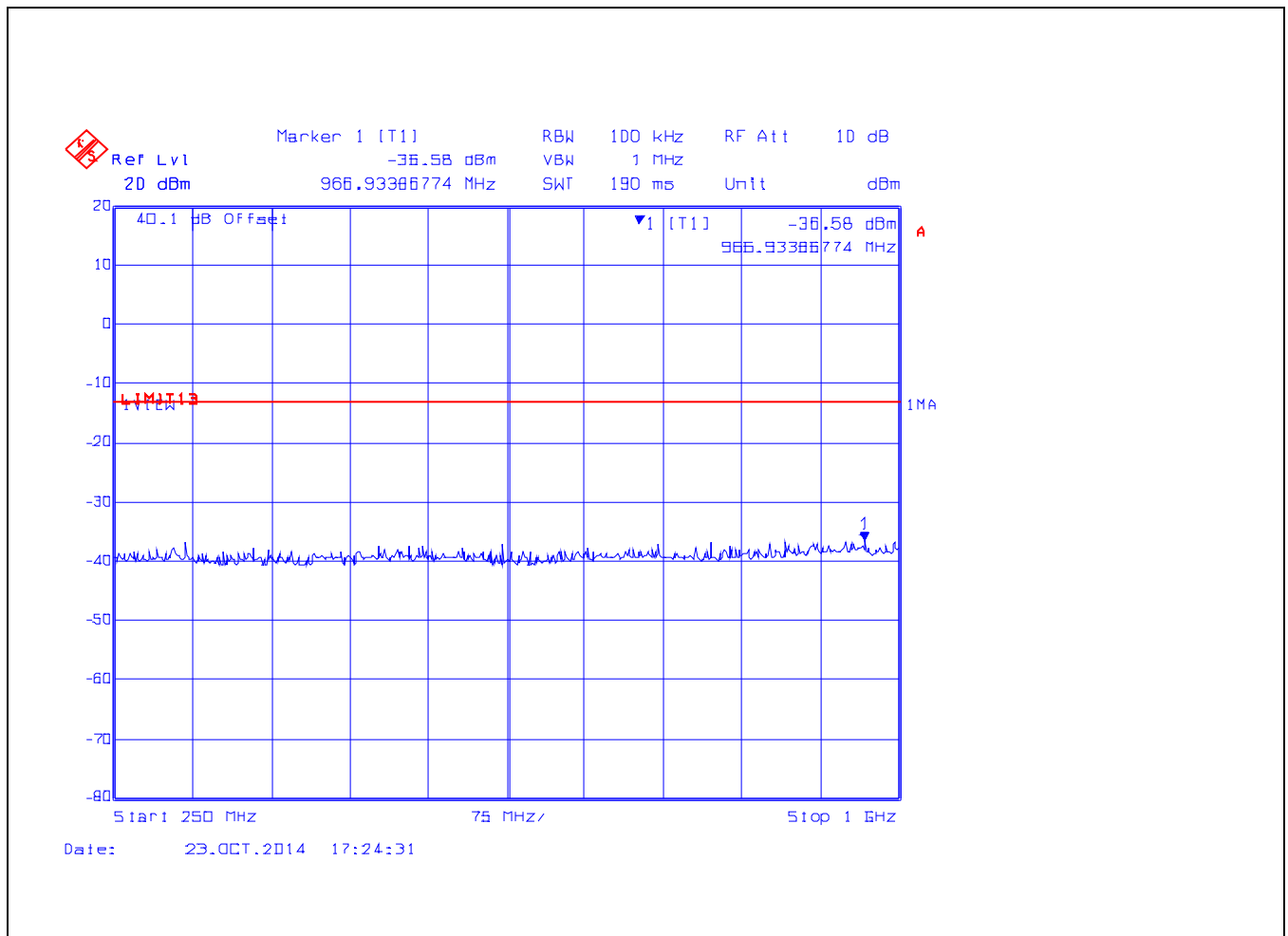
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Plot 5.6.4.8. Spurious Emissions at Antenna Terminals, 157.425 MHz, 25 kHz Channel Spacing, 1 W, 250 MHz - 2 GHz



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

5.7.1. Limits

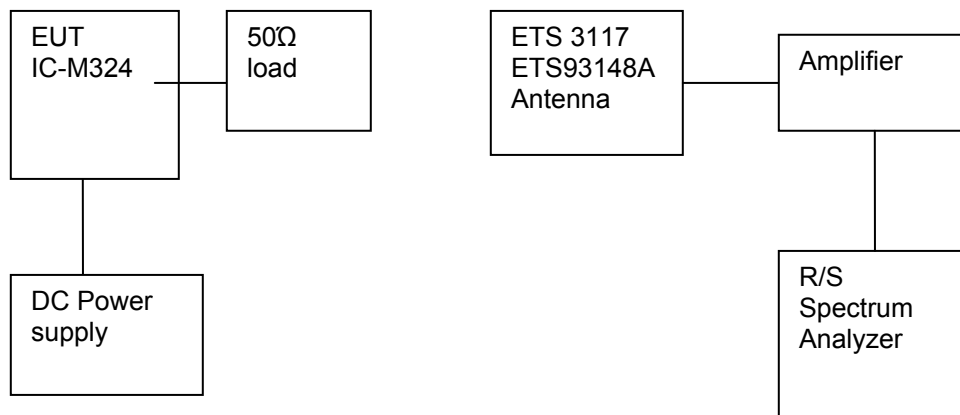
§ 80.211 (f)(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB.

5.7.2. 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 = $EIRP - 2.15 \text{ dB} = P_c + G - 2.15 \text{ dB} = P_c \text{ dBm (conducted)} + 0 \text{ dBi} - 2.15 \text{ dB}$

5.7.3. Test Arrangement



5.7.4. Test Data

Remarks:

- The radiated emissions were performed with high power setting (25 W) and 25 kHz channel spacing at 3 m distance to represents the worst-case test configuration.
- The emissions were scanned from 30 MHz to 2 GHz; all significant emissions were recorded.

Carrier Frequency:		156.050 MHz				
Power:		43.64 dBm				
Limit:		-13.0 dBm				
Frequency (MHz)	E-Field (dBμV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
312.10	49.6	Peak	V	-47.8	-13.0	-34.8
312.10	56.5	Peak	H	-40.8	-13.0	-27.8
468.15	44.1	Peak	V	-53.3	-13.0	-40.3
468.15	42.6	Peak	H	-54.7	-13.0	-41.7
624.20	49.8	Peak	V	-47.6	-13.0	-34.6
624.20	48.7	Peak	H	-48.7	-13.0	-35.7
780.25	51.5	Peak	V	-45.8	-13.0	-32.8
780.25	48.4	Peak	H	-49.0	-13.0	-36.0
936.30	56.1	Peak	V	-41.2	-13.0	-28.2
936.30	56.3	Peak	H	-41.1	-13.0	-28.1
1092.35	53.9	Peak	V	-43.4	-13.0	-30.4
1092.35	46.2	Peak	H	-51.2	-13.0	-38.2
1248.40	47.0	Peak	V	-50.3	-13.0	-37.3
1248.40	43.3	Peak	H	-54.1	-13.0	-41.1

* All other harmonics and spurious emissions are more than 27.8 dB below the specified attenuation limit.

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Carrier Frequency:		157.425 MHz				
Power:		43.65 dBm				
Limit:		-13.0 dBm				
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
314.85	51.5	Peak	V	-45.8	-13.0	-32.8
314.85	55.1	Peak	H	-42.2	-13.0	-29.2
472.28	42.4	Peak	H	-55.0	-13.0	-42.0
472.28	44.0	Peak	V	-53.4	-13.0	-40.4
629.70	50.9	Peak	V	-46.4	-13.0	-33.4
629.70	52.0	Peak	H	-45.4	-13.0	-32.4
787.13	53.3	Peak	H	-44.1	-13.0	-31.1
787.13	49.5	Peak	V	-47.9	-13.0	-34.9
944.55	56.8	Peak	V	-40.5	-13.0	-27.5
944.55	56.4	Peak	H	-41.0	-13.0	-28.0
1101.98	55.9	Peak	H	-41.4	-13.0	-28.4
1101.98	45.3	Peak	V	-52.1	-13.0	-39.1
1259.40	47.7	Peak	V	-49.6	-13.0	-36.6
1259.40	45.8	Peak	V	-51.6	-13.0	-38.6

* All other harmonics and spurious emissions are more than 28.0 dB below the specified attenuation limit.

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5.8. FREQUENCY STABILITY [§§ 2.1055 & 80.209]

5.8.1. Limits

Frequency Band	Coast Stations		Ship Stations
	Below 3 W	3 to 100 W	
156–162 MHz	10 ppm	¹ 5 ppm	² 10 ppm

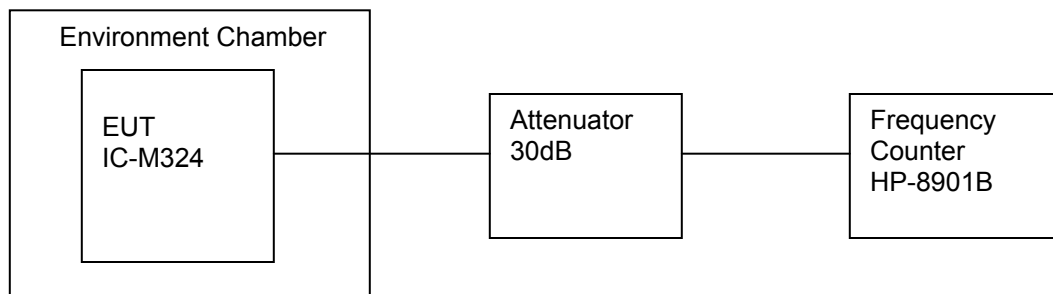
¹ For transmitters operated at private coast stations with antenna heights less than 6 meters (20 feet) above ground and output power of 225 Watts or less the frequency tolerance is 10 parts in 10^6 .

² For transmitters in the radiolocation and associated telecommand service operating on 154.585 MHz, 159.480 MHz, 160.725 MHz and 160.785 MHz the frequency tolerance is 15 parts in 10^6 .

5.8.2. Method of Measurements

Refer to Section 8.3 of this report for measurement details

5.8.3. Test Arrangement



5.8.4. Test Data

Center Frequency:		156.050 MHz	
Full Power Level:		43.64 dBm	
Frequency Tolerance Limit (Worst Case):		±10 ppm or 1560.25 Hz	
Max. Frequency Tolerance Measured:		1415 Hz or 9.07 ppm	
Input Voltage Rating:		13.8 VDC	
Ambient Temperature (°C)	Frequency Drift (Hz)		
	Supply Voltage (Nominal) 13.8 Volts	Supply Voltage (85% of Nominal) 11.7 Volts	Supply Voltage (115% of Nominal) 15.9 Volts
-20	-1415	--	--
-10	350	--	--
0	288	--	--
10	183	--	--
20	-315	-279	-376
30	-408	--	--
40	-506	--	--
50	-493	--	--
60	-327	--	--

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EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Operating Range	Calibration Due Date
Spectrum Analyzer	R/S	FSEK	834157/005	9 KHz – 40 GHz	3-Jan-15
Attenuator (40dB)	Aeroflex/Weinschel	53-40-34	MN917	DC-1 GHz	Note 1
High Pass Filter	Mini Circuit	SHP 250		Cut off 230 MHz	Note 1
Power Meter	Hewlett Packard	436A	2016A07747	100K--50G sensor depondent	12-Feb-15
Power Sensor	Hewlett Packard	8481A	2237A33409	100KHz-18GHZ	12-Feb-15
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150KHz-1300MHz	29-Jan-15
Combiner	Mini Circuit	ZFSC-3-4	15542	1MHz - 1GHz	Note 1
RF Detector	Pasternack	PE8000-50		10M--1G Hz	Note 1
Infinium Digital Oscilloscope	Hewlett-Packard	54801A	US38380192	DC--500M Hz 1G sampling	16-Jun-15
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177 degree C	1-May-15
RF Synthesized signal Generator	HP	8648C	3343U00391	100K-3200M Hz AM/ FM/ PM	3-Jan-15
Power supply	Tenma	72-7295	490300297	1-40V DC 5A	Note 1
FFT Digital Spectrum Analyzer	Advantest	R9211E	8202336	10mHz--100KHz	3-Feb-15
RF Communication Test Set	Hewlett Packard	8920B	US39064699	30MHz-1GHz	17-Jan-15
Horn antenna	EMCO	3117	119425	1-18GHz	2-May-15
Preamplifier	Com-power	PAM-118A	551016	0.5-18GHz 40dB Gain	20-Nov-14
High Pass Filter	Mini Circuit	SHP 600		Cut off 560 MHz	Note 1
Power supply	XANTREX	XKW 60-50	26509	0-60V 0-50A DC	Note 1
High Pass Filter	Mini Circuit	SHP 800		Cut off 750 MHz	Note 1
Attenuator	Aeroflex/Weinschel	23-20-34	BH7876	DC-18 GHz	Note 1
Antenna	ETS	3148	23845	200-2000 MHz	14-Apr-15
Attenuator	Aeroflex/Weinschel	24-20-34	BJ2364	DC-18 GHz	Note 1
Frequency counter	EIP	545A	2683	10Hz-18 GHz	7-Apr-15
Tunable Bandreject Filter	K & L	3TFNF-30/76-N-N	36	28-300MHz	Note 1
Attenuator	Aeroflex/Weinschel	24-10-34	BK8612	DC-8.5GHz	Note 1
Tunable Bandreject Filter	K & L	3TFNF-250/500-N-N	21	250-500 MHz	Note 1
Preamplifier	Com-power	PA-103A	161243	10-1000MHz	10-Jun-15

Note 1: Calibration by test lab is conducted at every tests.

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File #: ICOM-386Q_FCC80
October 30, 2014

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 @ 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).

- If 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, $x = \text{Tx on} / (\text{Tx on} + \text{Tx off})$ 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.

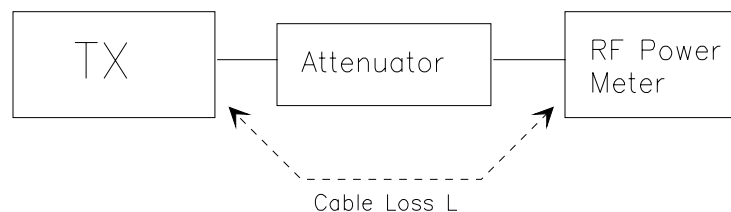
Step 2: Calculation of Average EIRP. See Figure 1

- 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:

$$\text{EIRP} = A + G + 10\log(1/x)$$

{ $X = 1$ for continuous transmission $\Rightarrow 10\log(1/x) = 0 \text{ dB}$ }

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
 $E \text{ (dBuV/m)} = \text{Reading (dBuV)} + \text{Total Correction Factor (dB/m)}$

- (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° 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: 100 kHz
Video BW: VBW > RBW
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
 $E \text{ (dBuV/m)} = \text{Reading (dBuV)} + \text{Total Correction Factor (dB/m)}$

- (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:

$$P = P1 - L1 = (P2 + L2) - L1 = P3 + A + L2 - L1$$

$$\text{EIRP} = P + G1 = P3 + L2 - L1 + A + G1$$

$$\text{ERP} = \text{EIRP} - 2.15 \text{ dB}$$

$$\text{Total Correction factor in EMI Receiver \# 2} = L2 - L1 + G1$$

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

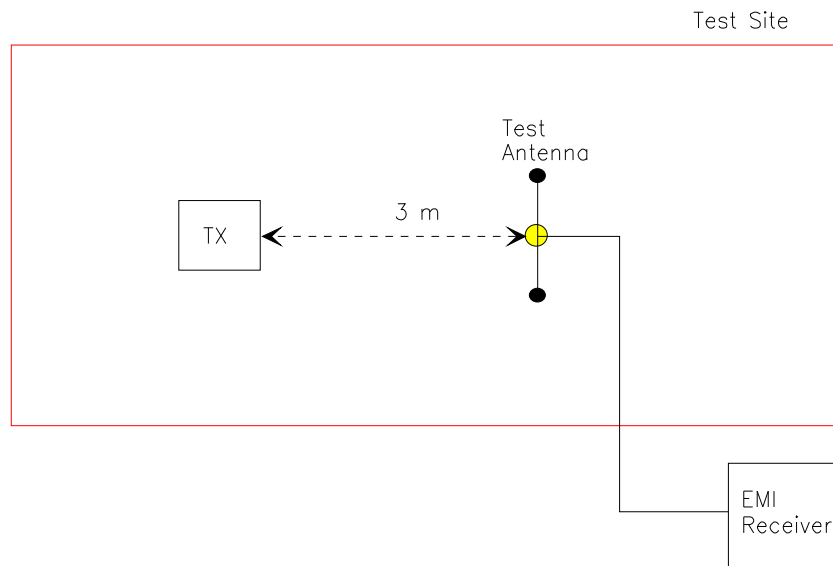
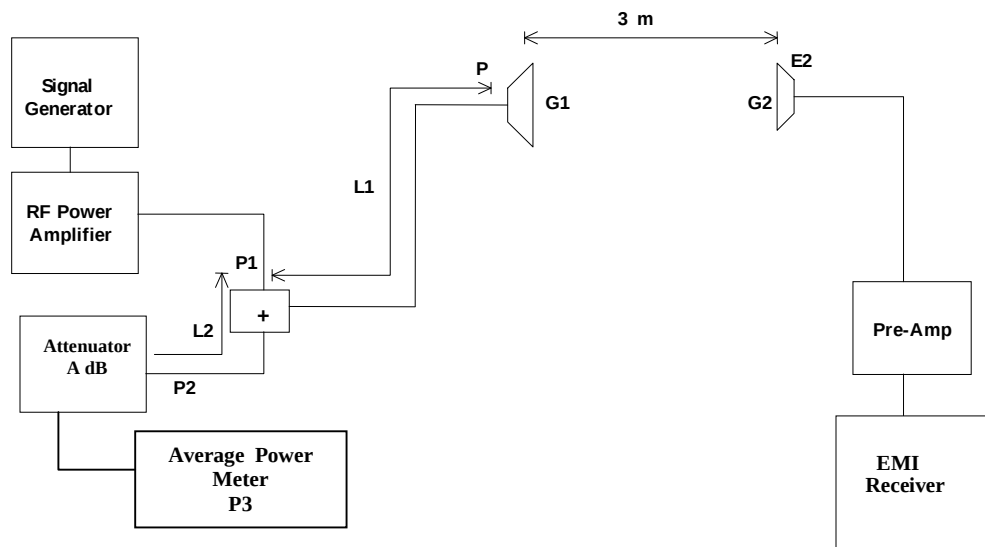


Figure 3



8.3. FREQUENCY STABILITY

Refer to § 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 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.

8.5. 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 $\geq$ 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 10th 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.