ENGINEERING TEST REPORT

VHF Marine Transceiver
Model No.: IC-M90
FCC ID: AFJ279501

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) & Part 90 (146-174 MHz)

UltraTech's File No.: ICOM-090F80-90

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: September 20, 2004	
Report Prepared by: Dan Huynh Issued Date: September 20, 2004	Tested by: Wayne Wu, EMC/RFI Technician Test Dates: September 4 – 12, 2004

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. SUBMITTAL CHECK LIST

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
--	Test Report	▪ Exhibit 1: Submittal Check Lists ▪ Exhibit 2: Introduction ▪ Exhibit 3: Performance Assessment ▪ Exhibit 4: EUT Operation and Configuration During Tests ▪ Exhibit 5: Summary of test Results ▪ Exhibit 6: Measurement Data ▪ Exhibit 7: Measurement Uncertainty ▪ Exhibit 8: Measurement Methods	OK
1	Test Setup Photos	Radiated Emissions Setup Photos	OK
2	External Photos of EUT	External Photos	OK
3	Internal Photos of EUT	Internal Photos	OK
4	Cover Letters	▪ Letter from Ultratech for Certification Request ▪ Letter from the Applicant to Appoint Ultratech to Act as an Agent ▪ Letter from the Applicant to Request for Confidentiality Filing	OK
5	Attestation Statements	▪ Manufacturer's Declaration ▪ Part 80	OK
6	ID Label/Location Info	▪ ID Label ▪ Location of ID Label	OK
7	Block Diagrams	Block Diagram	OK
8	Schematic Diagrams	Schematic Diagrams	OK
9	Parts List/Tune Up Info	▪ Parts List ▪ Tune Up/Adjustment Procedures	OK
10	Operational Description	Operational Description	OK
11	RF Exposure Info	See SAR Test Report	OK
12	Users Manual	Instruction Manual	OK

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Parts 2, 80 and 90
Title:	Telecommunication - Code of Federal Regulations, 47CFR, Parts 2, 80 and 90
Purpose of Test:	To gain FCC Equipment Authorization for Radio operating in the frequency bands, 156-.025-157.425 MHz (Marine) and 146-174 MHz (General)
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.
Categories of Station:	▪ Coast Station in 156.025-157.425 MHz ▪ Ship Station in 156.025-157.425 MHz ▪ General Station: 146-174 MHz

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

None.

2.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2003	Code of Federal Regulations – Telecommunication
ANSI C63.4	2003	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 22 & EN 55022	2003 2003	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1	2003	Specification for Radio Disturbance and Immunity measuring apparatus and methods
TIA-603-B	2002	Land Mobile FM or Pm Communications Equipment, Measurement and Performance Standards.

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT	
Name:	Icom Incorporated
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Contact Person:	Mr. Takashi Aoki Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

MANUFACTURER	
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Contact Person:	Mr. Takashi Aoki Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

3.2. 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-M90
Serial Number:	Test Sample
Type of Equipment:	Non-broadcast Radio Communication Equipment
Power Supply Requirement:	▪ 7.5 V DC ▪ 6 X AA(R6) size Alkaline cells (BP-223) ▪ 7.2 V/750 mAh Ni-Cd battery pack (BP-224) ▪ 7.2 V1100 mAh Ni-Cd battery pack (BP225)
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Voice wireless communication for Marine in 156.025-157.425 MHz band and Land Mobile Radio (LMR) in 146-174 MHz band.

3.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Portable
Intended Operating Environment:	▪ Marine ▪ Commercial & industrial
Power Supply Requirement:	▪ 7.5 V DC ▪ 6 X AA(R6) size Alkaline cells (BP-223) ▪ 7.2 V/750 mAh Ni-Cd battery pack (BP-224) ▪ 7.2 V1100 mAh Ni-Cd battery pack (BP225)
RF Output Power Rating:	5 Watts (High), 3 Watts (Mid) and 1 Watt (Low)
Operating Frequency Range:	▪ 156.025-157.425 MHz (Marine) ▪ 146-174 MHz (LMR)
RF Output Impedance:	50 Ohms
Channel Spacing:	▪ 25 kHz (Marine & LMR) ▪ 12.5 kHz (LMR)
Occupied Bandwidth (99%):	▪ 7.24 kHz (12.5 kHz channel spacing) ▪ 11.97 kHz (25 kHz channel spacing)
Emission Designation*:	▪ Marine: 16K0G3E ▪ LMR: 16K0F3E and 11K0F3E
Antenna Connector Type:	SMA

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

For FM Voice Modulation:

* Channel Spacing = 12.5 KHz, D = 2.5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3)/2 + 2(2.5)(1) = **11 KHz**
emission designation: 11K0F3E

* 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: 16K0F3E

Receiver	
Power Supply Requirement:	7.5 Vdc
Operating Frequency Range:	▪ 156.0250-163.275 MHz (Marine) ▪ 146-174 MHz (LMR)
RF Input Impedance:	50 Ohms
Channel Spacing:	▪ 25 kHz (Marine & LMR) ▪ 12.5 kHz (LMR)
IF Frequencies	31.05 MHz (1st IF),), 450 kHz (2nd IF)
Audio Output Power	0.35 W typical at 10% distortion with an 8 Ω load

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF Port	1	Female SMA	None
2	SP MIC	1	4 pin Microphone Connector	Shielded

3.5. ANCILLARY EQUIPMENT

None.

EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	7.5 Vdc

4.2. 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 (Marine) ▪ 146-174 MHz (General VHF)
Test Frequency(ies): (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	▪ 156.025 and 157.425 MHz ▪ 146.050, 160.050 and 173.950 MHz
Transmitter Wanted Output Test Signals:	
• Transmitter Power (measured maximum output power):	5 Watts High & 1 Watts Low
• Normal Test Modulation:	FM with and without scrambler
• Modulating signal source:	External

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

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. 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 Powerline Conducted Emissions were performed in UltraTech's shielded room, 16'(L) by 12'(W) by 12'(H).
- Radiated Emissions were performed at the Ultratech's 3 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario.

  The above sites have 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 Open Field Test Site has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada File No.: IC2049). Last Date of Site Calibration: February 17, 2004

5.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
80.215, 90.205(d) & 2.1046	RF Power Output	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
80.209, 90.213 & 2.1055	Frequency Stability	Yes
80.213(e), 90.242(b)(8) & 2.1047(a)	Audio Frequency Response	Yes
2.1047(b)	Modulation Limiting	Yes
80.211(f), 90.210 & 2.1049	Emission Limitation / Emission Mask	Yes
80.211(f)(3), 90.210, 2.1051 & 2.1057	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
80.211(f)(3), 90.210, 2.1053 & 2.1057	Emission Limits - Field Strength of Spurious Emissions	Yes
90.214	Transient Frequency Behavior	Yes
80.217	Suppression of Interference aboard ships	Yes
VHF Marine Transceiver, **Model No.: IC-M90**, 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.		

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

5.4. DEVIATION OF STANDARD TEST PROCEDURES

None.

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

6.1. TEST PROCEDURES

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

6.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 7 for Measurement Uncertainties.

6.3. 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.

6.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER

The essential function of the EUT is to correctly communicate data to and from radios over RF link.

6.5. RF POWER OUTPUT [§§ 2.1046, 80.215 & 90.205(d)]

6.5.1. Limits

§ 80.215 - For 156-162 MHz Band:

- Coast Stations: 50W (Maximum authorized power at the input terminals of the station antenna)
- Marine utility stations: 10W
- Ship stations: 25W (Reducible to 1 watt or less, except for transmitters limited to public correspondence channels and used in an automated system.)
- Marine utility stations and hand-held portable transmitters: 10W

§ 90.205(d) - Please refer to § 90.205(d) for Power and antenna height limits

6.5.2. Method of Measurements

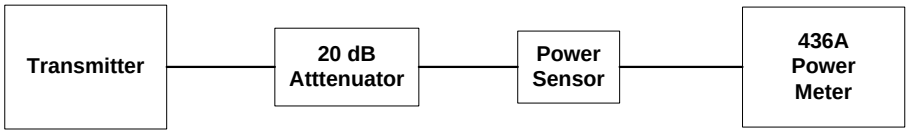
Refer to Section 8.1 (Conducted) and Section 8.2 (Radiated) in this test report for test procedures and test setup.

6.5.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Attenuator	Weinschel Corp	23-20-34	BH7876	DC – 18 GHz
Power Meter	Hewlett Packard	436A	1725A02249	10 kHz – 50 GHz, sensor dependent
Power Sensor	Hewlett Packard	8481A	2702A68983	10 MHz – 18 GHz

6.5.4. Test Arrangement

Power at RF Power Output Terminals



6.5.5. Test Data

Remark: Test is performed in the General Operating Frequency Band 146-174 MHz and the results shall also represent the Marine band 156.025-157.425 MHz since the marine operating frequency band lies within the general band and RF output power is constant throughout the band.

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Conducted Power (Watts)	Power Rating (Watts)
Power Setting: High			
Lowest	146.050	5.05	5.0
Middle	160.050	5.18	5.0
Highest	173.950	5.06	5.0
Power Setting: Medium			
Lowest	146.050	3.19	3.0
Middle	160.050	3.30	3.0
Highest	173.950	3.19	3.0
Power Setting: Low			
Lowest	146.050	0.80	1.0
Middle	160.050	0.87	1.0
Highest	173.950	0.84	1.0

6.6. FREQUECNY STABILITY [§§ 2.1055, 80.209 & 90.213]

6.6.1. Limits

Refer to § 80.209 for specification details.

Operating Frequency Band (MHz)	Coast Stations		Ship Stations
	Below 3 W	3 to 100 W	
156–162	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 25 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.

Refer to § 90.213 for specification details.

Frequency range (MHz)	Fixed and base stations	Mobile stations	
		Over 2 watts output power	2 watts or less output power
150–174	[2,4] 5	[3] 5	[1,3] 50

1 Stations operating in the 154.45 to 154.49 MHz or the 173.2 to 173.4 MHz bands must have a frequency stability of 5 ppm.

2 In the 150–174 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

3 In the 150–174 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth or designed to operate on a frequency specifically designated for itinerant use or designed for low-power operation of two watts or less, must have a frequency stability of 5.0 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 2.0 ppm.

4 Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150–174 MHz band and 2.5 ppm in the 421–512 MHz band.

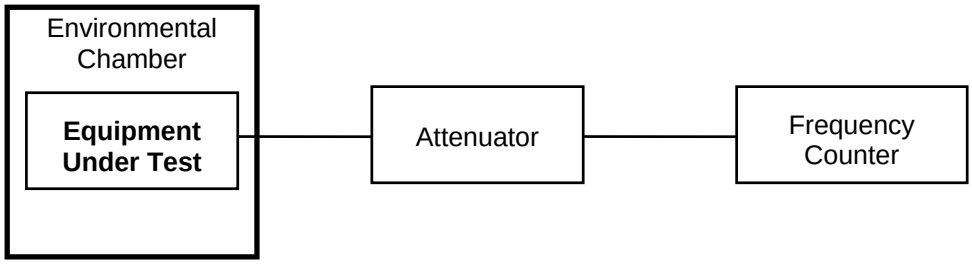
6.6.2. Method of Measurements

Refer to Section 8.3 of this report for measurement details

6.6.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Frequency Counter	EIP	545A	2683	10Hz-18GHz
Attenuator	Weinschel	23-20-34	BH7876	DC-18 GHz
Temperature & Humidity Chamber	Tenney	T5	9723B	-40^{o} to $+60^{o}$ C range

6.6.4. Test Arrangement



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

6.6.5. Test Data

Remark: The worst limits of § 80.209 and 90.213 are applied for compliance for Parts 80 & 90.

6.6.5.1. Frequency Tolerance versus Ambient Temperature

Product Name: **Model No.:**	**VHF Marine Transceiver** **IC-M90**
Center Frequency:	146.050 MHz
Full Power Level:	5 Watts
Frequency Tolerance Limit (Worst Case):	±5 ppm or 730.25 Hz
Max. Frequency Tolerance Measured:	-95 Hz or 0.7 ppm
Input Voltage Rating:	7.5 Vdc

CENTER FREQUENCY & RF POWER OUTPUT VARIATION			
Ambient Temperature (°C)	**Supply Voltage (Nominal) 7.2 Volts**	**Supply Voltage (Minimum before switch-off)) 5.6 Volts**	**Supply Voltage (115% of Nominal) 8.28 Volts**
	Hz	**Hz**	**Hz**
-30	-95	N/A	N/A
-20	-37	N/A	N/A
-10	-49	N/A	N/A
0	-39	N/A	N/A
+10	-15	N/A	N/A
+20	-10	-7	+18
+30	+30	N/A	N/A
+40	+45	N/A	N/A
+50	+64	N/A	N/A
+60	+62	N/A	N/A

6.6.5.2. RF Output Power Versus Input Voltage at Room Temperature

Ambient Temperature (^{o}C)	Supply Voltage (Vdc)	Current (A)	RF Output Power (Watts)
20	8.4	1.562	5.07
20	8.2	1.564	5.05
20	8.0	1.565	5.02
20	7.8	1.571	5.02
20	7.6	1.580	5.02
20	7.4	1.600	5.02
20	7.2	1.614	4.97
20	7.0	1.610	4.85
20	6.8	1.608	4.76
20	6.6	1.611	4.62
20	6.4	1.569	4.32
20	6.2	1.538	4.11
20	6.0	1.498	3.85
20	5.8	1.460	3.61
20	5.6	1.428	3.40
20	5.5	0.655	0.71
20	5.4	0.646	0.68
20	5.3	*	*

* Stop transmitting.

6.7. AUDIO FREQUENCY RESPONSE [§§ 2.1047(a), 80.213(e) & 90.242(b)(8)]

6.7.1. Limits

The coast station transmitter operated in 156.025-157.425 MHz must be equipped with a lowpass filter. The filter must be installed between the modulation limiter and the modulated radio frequency stages. The audio lowpass filter shall meet the following characteristics:

RF Band	Audio band	Minimum Attenuation Rel. to 1 kHz Attenuation
156.025-157.425 MHz / 146-174 MHz	3 –20 kHz above 20 kHz	60 $\log_{10}$(f/3) dB where f is in kHz 50dB

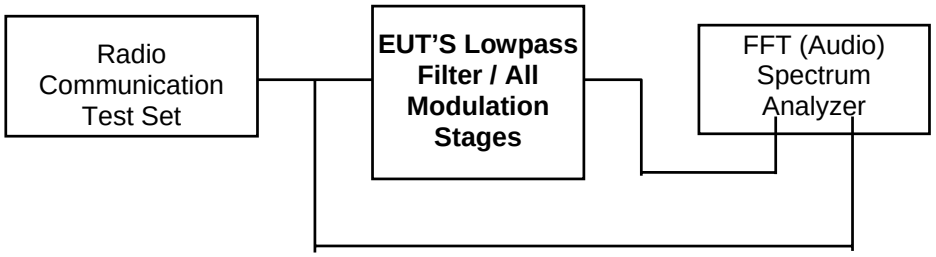
6.7.2. Method of Measurements

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.

6.7.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
FFT (audio) Spectrum Analyzer	Advantest	R9211E	…	10 mHz – 100 kHz, 1 MHz Input Impedance
Radio Communication Test Set	Marconi Instruments	2955	132037/226	AF SG 20Hz--20KHz

6.7.4. Test Arrangement



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

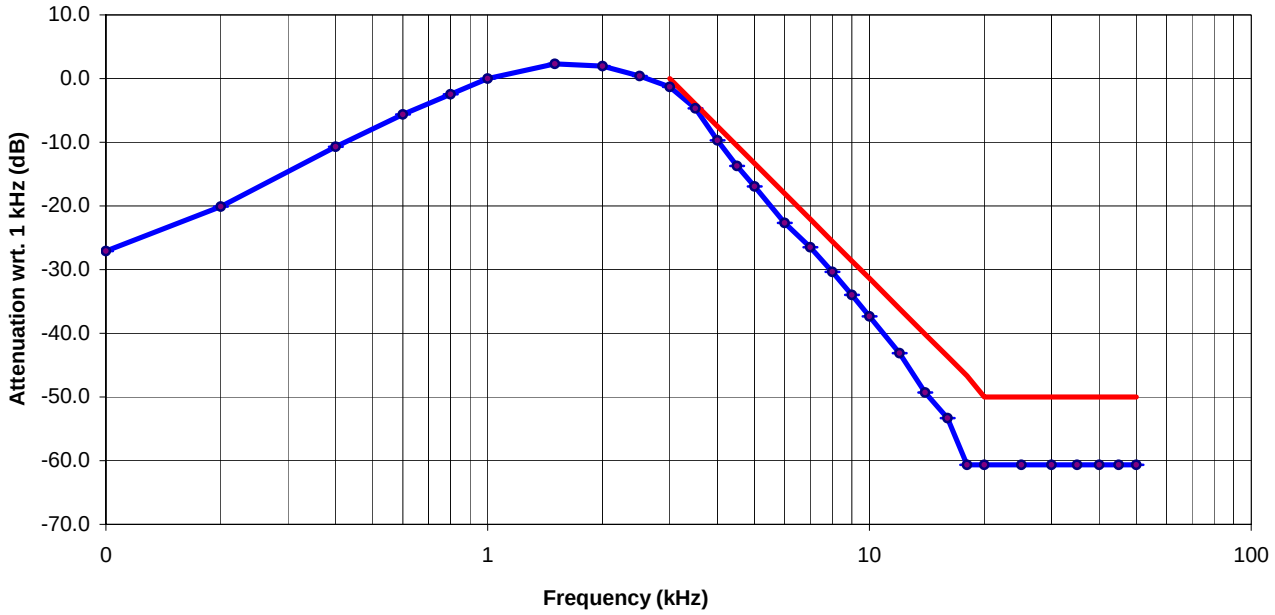
6.7.5. Test Data

6.7.5.1. 12.5 kHz Channel Spacing, Frequency of All Modulation States*

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 FCC Limit for audio lowpass filter.

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 1 kHz (dB)	Recommended FCC Limit (dB)
0.1	-51.06	-26.48	24.6	-27.1	--
0.2	-51.06	-19.45	31.6	-20.1	--
0.4	-51.06	-10.07	41.0	-10.7	--
0.6	-51.06	-5.02	46.0	-5.7	--
0.8	-51.06	-1.83	49.2	-2.5	--
1.0	-51.06	0.63	51.7	0.0	--
1.5	-51.06	2.92	54.0	2.3	--
2.0	-51.06	2.59	53.7	2.0	--
2.5	-51.06	1.02	52.1	0.4	--
3.0	-51.06	-0.69	50.4	-1.3	0
3.5	-51.06	-4.03	47.0	-4.7	-4
4.0	-51.06	-9.08	42.0	-9.7	-7
4.5	-51.06	-13.11	38.0	-13.7	-11
5.0	-51.06	-16.29	34.8	-16.9	-13
6.0	-51.06	-22.01	29.1	-22.6	-18
7.0	-51.06	-25.84	25.2	-26.5	-22
8.0	-51.06	-29.73	21.3	-30.4	-26
9.0	-51.06	-33.35	17.7	-34.0	-29
10.0	-51.06	-36.72	14.3	-37.4	-31
12.0	-51.06	-42.50	8.6	-43.1	-36
14.0	-51.06	-48.65	2.4	-49.3	-40
16.0	-51.06	-52.67	-1.6	-53.3	-44
18.0	-51.06	<-60.00	<-8.9	<-60.6	<-47
20.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
25.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
30.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
35.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
40.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
45.0	-51.06	<-60.00	<-8.9	<-60.6	<-50
50.0	-51.06	<-60.00	<-8.9	<-60.6	<-50

Audio Frequency Response
12.5 kHz Channel Spacing

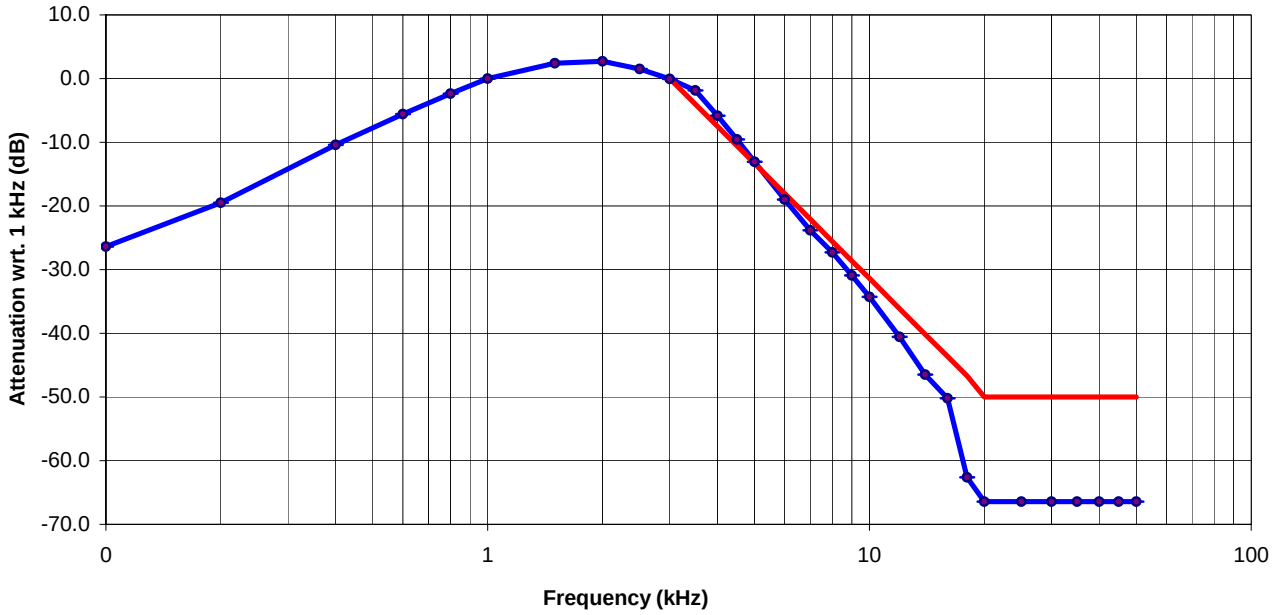


6.7.5.2. 25 kHz Channel Spacing, Frequency of All Modulation States*

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 FCC Limit for audio lowpass filter.

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 1 kHz (dB)	Recommended FCC Limit (dB)
0.1	-51.37	-19.91	31.5	-26.4	--
0.2	-51.37	-13.06	38.3	-19.5	--
0.4	-51.37	-3.96	47.4	-10.4	--
0.6	-51.37	0.88	52.3	-5.6	--
0.8	-51.37	4.11	55.5	-2.3	--
1.0	-51.37	6.45	57.8	0.0	--
1.5	-51.37	8.88	60.3	2.4	--
2.0	-51.37	9.15	60.5	2.7	--
2.5	-51.37	7.97	59.3	1.5	--
3.0	-51.37	6.39	57.8	-0.1	0
3.5	-51.37	4.57	55.9	-1.9	-4
4.0	-51.37	0.61	52.0	-5.8	-7
4.5	-51.37	-3.12	48.3	-9.6	-11
5.0	-51.37	-6.60	44.8	-13.1	-13
6.0	-51.37	-12.53	38.8	-19.0	-18
7.0	-51.37	-17.39	34.0	-23.8	-22
8.0	-51.37	-20.82	30.6	-27.3	-26
9.0	-51.37	-24.46	26.9	-30.9	-29
10.0	-51.37	-27.82	23.6	-34.3	-31
12.0	-51.37	-34.12	17.3	-40.6	-36
14.0	-51.37	-40.01	11.4	-46.5	-40
16.0	-51.37	-43.75	7.6	-50.2	-44
18.0	-51.37	-56.16	-4.8	-62.6	-47
20.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
25.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
30.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
35.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
40.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
45.0	-51.37	<-60.00	<-8.6	<-66.5	<-50
50.0	-51.37	<-60.00	<-8.6	<-66.5	<-50

Audio Frequency Response
25 kHz Channel Spacing



6.8. MODULATION LIMITING [§ 2.1047(b)]

6.8.1. Limits

Recommended frequency deviation characteristics are given below:

Frequency Range (MHz)	Maximum Authorized BW (KHz)	Channel Spacing (KHz)	Recommended Frequency Deviation (KHz)
156.025-157.425 MHz (Marine) 150-174 MHz (General)	20.0	25.0	5.0
150-174 MHz (General)	11.25	12.5	2.5

6.8.2. Method of Measurements

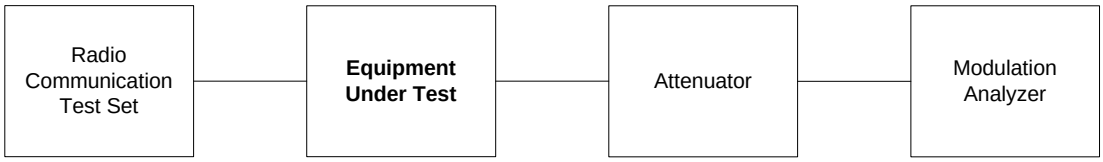
For Audio Transmitter:- The carrier frequency deviation was measured with the tone input signal level varied from 0 Vp to audio input rating level plus 16 dB at frequencies 0.1, 0.5, 1.0, 3.0 and 5.0 kHz. The maximum deviation was recorded at each test condition.

For Data Transmitter with Maximum Frequency Deviation set by Factory:- The EUT was set at maximum frequency deviation, and its peak frequency deviation was then measured using EUT's internal random data source.

6.8.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Radio Communication Test Set	Marconi Instruments	2955	132037/226	20 Hz - 20 kHz
Modulation Analyzer	Hewlett-Packard	8901B	3226A04606	150kHz - 1300 MHz
Attenuator	Weinschel	23-20-34	BH7876	DC-18 GHz

6.8.4. Test Arrangement



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

6.8.5. Test Data

Remark: Test is performed in the General Operating Frequency Band 146-174 MHz and the results shall also represent the Marine band 156.025-157.425 MHz since the marine operating frequency band lies within the general band RF output power is constant throughout the band.

6.8.5.1. Voice Modulation Limiting for 12.5 kHz Channel Spacing Operation:

MODULATING SIGNAL LEVEL	PEAK FREQUENCY DEVIATION (kHz) at the following modulating frequency:					MAXIMUM LIMIT
(mVrms)	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	(kHz)
1	0.05	0.22	0.55	1.13	0.24	2.5
2	0.06	0.45	1.12	1.29	0.23	2.5
4	0.11	0.84	1.89	1.29	0.23	2.5
6	0.16	1.23	2.01	1.29	0.22	2.5
8	0.21	1.67	2.04	1.29	0.22	2.5
10	0.25	1.71	2.06	1.29	0.22	2.5
20	0.50	1.93	2.02	1.30	0.22	2.5
30	0.72	2.01	2.02	1.30	0.22	2.5
40	0.96	2.04	2.03	1.30	0.22	2.5
50	1.22	2.05	2.04	1.30	0.22	2.5
60	1.45	2.06	2.11	1.32	0.22	2.5

Voice Signal Input Level = STD MOD Level + 16 dB = 8.94 dB(mVrms) + 16 = 24.94 dB(mVrms) or 17.67 mVrms

MODULATING FREQUENCY (KHz)	PEAK FREQUENCY DEVIATION (KHz)	MAXIMUM LIMIT (KHz)
0.1	0.44	2.5
0.2	0.98	2.5
0.4	1.76	2.5
0.6	1.99	2.5
0.8	2.04	2.5
1.0	2.01	2.5
1.2	1.99	2.5
1.4	1.99	2.5
1.6	2.07	2.5
1.8	2.01	2.5
2.0	1.90	2.5
2.5	1.60	2.5
3.0	1.30	2.5
3.5	0.83	2.5
4.0	0.50	2.5
4.5	0.33	2.5
5.0	0.22	2.5
6.0	0.13	2.5
7.0	0.09	2.5
8.0	0.06	2.5
9.0	0.05	2.5
10.0	0.04	2.5

6.8.5.2. Voice Modulation Limiting for 25 kHz Channel Spacing Operation:

MODULATING SIGNAL LEVEL	PEAK FREQUENCY DEVIATION (kHz) at the following modulating frequency:					MAXIMUM LIMIT
(mVrms)	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	(kHz)
1	0.08	0.47	1.13	2.74	0.63	5.0
2	0.12	0.91	2.50	2.87	0.66	5.0
4	0.22	1.80	3.74	2.88	0.66	5.0
6	0.33	2.65	4.03	2.88	0.66	5.0
8	0.43	3.54	4.10	2.88	0.66	5.0
10	0.53	3.63	4.12	2.88	0.66	5.0
20	1.06	3.81	4.15	2.91	0.64	5.0
30	1.56	4.12	4.17	2.92	0.65	5.0
40	2.07	4.18	4.19	2.92	0.63	5.0
50	2.57	4.24	4.20	2.94	0.63	5.0
60	3.14	4.22	4.31	2.95	0.63	5.0

Voice Signal Input Level = STD MOD Level + 16 dB = 8.63 dB(mVrms) + 16 = 24.63 dB(mVrms) or 17.04 mVrms

MODULATING FREQUENCY (KHz)	PEAK FREQUENCY DEVIATION (KHz)	MAXIMUM LIMIT (KHz)
0.1	0.93	5.0
0.2	2.04	5.0
0.4	3.78	5.0
0.6	4.07	5.0
0.8	4.10	5.0
1.0	4.13	5.0
1.2	4.10	5.0
1.4	4.07	5.0
1.6	4.07	5.0
1.8	4.09	5.0
2.0	3.99	5.0
2.5	3.46	5.0
3.0	2.90	5.0
3.5	2.36	5.0
4.0	1.47	5.0
4.5	0.94	5.0
5.0	0.64	5.0
6.0	0.34	5.0
7.0	0.21	5.0
8.0	0.14	5.0
9.0	0.10	5.0
10.0	0.07	5.0

6.9. EMISSION MASK [§§ 2.1049, 80.211, 90.209 & 90.210]

6.9.1. Limits

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

§ 80.211 (Marine):

Frequency Range (MHz)	Maximum Authorized BW (KHz)	Channel Spacing (KHz)	Recommended Frequency Deviation (KHz)	FCC Applicable Mask
156.025-157.425	20.0	25.0	5.0	See § 80.211(f)

§ FCC 90.210 (General):

Frequency Range (MHz)	Maximum Authorized BW (KHz)	Channel Spacing (KHz)	Recommended Frequency Deviation (KHz)	FCC Applicable Mask
150-174	20.0	25.0	5.0	90.210(b): Mask B – Voice
150-174	11.25	12.5	2.5	90.210(d): Mask D – Voice & Data

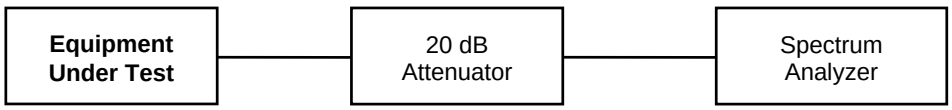
6.9.2. Method of Measurements

Refer to Section 8.4 of this report for measurement details

6.9.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Advantest	R3271	15050203	100 Hz - 26.5 GHz
Radio Communication Test Set	Marconi Instruments	2955	132037/226	20 Hz - 20 kHz
Attenuator	Weinschel	23-20-34	BH7876	DC-18 GHz

6.9.4. Test Arrangement



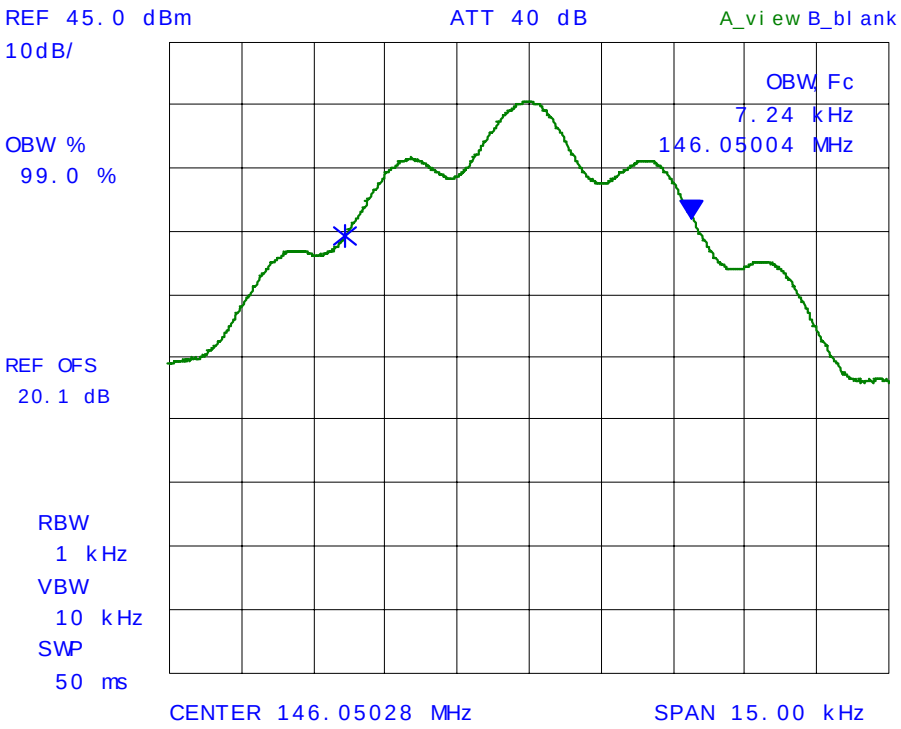
6.9.5. Test Data

6.9.5.1. 99% Occupied Bandwidth

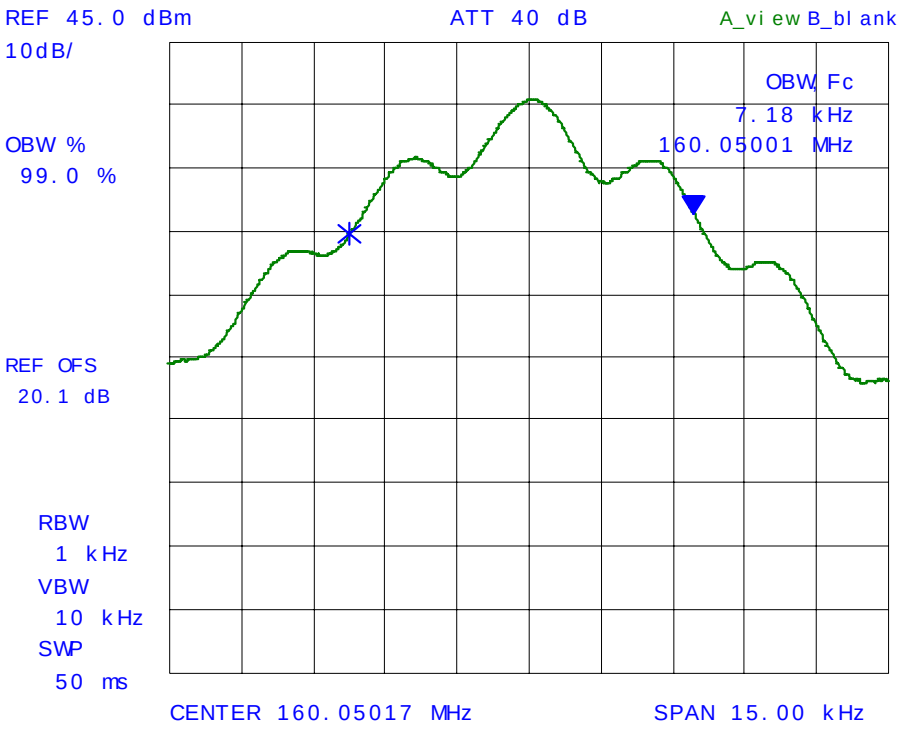
Frequency (MHz)	Channel Spacing (kHz)	Measured 99% OBW (kHz)	Authorized Bandwidth (kHz)
Scrambler not Active			
146.050	12.5	7.24	11.0
160.050	12.5	7.18	11.0
173.950	12.5	7.11	11.0
146.050	25.0	11.97	16.0
160.050	25.0	11.97	16.0
173.950	25.0	11.97	16.0
Scrambler Active			
146.050	12.5	7.09	11.0
160.050	12.5	7.03	11.0
173.950	12.5	6.99	11.0
146.050	25.0	11.54	16.0
160.050	25.0	11.49	16.0
173.950	25.0	11.69	16.0

See the following plots (1 – 12) for details of measurements.

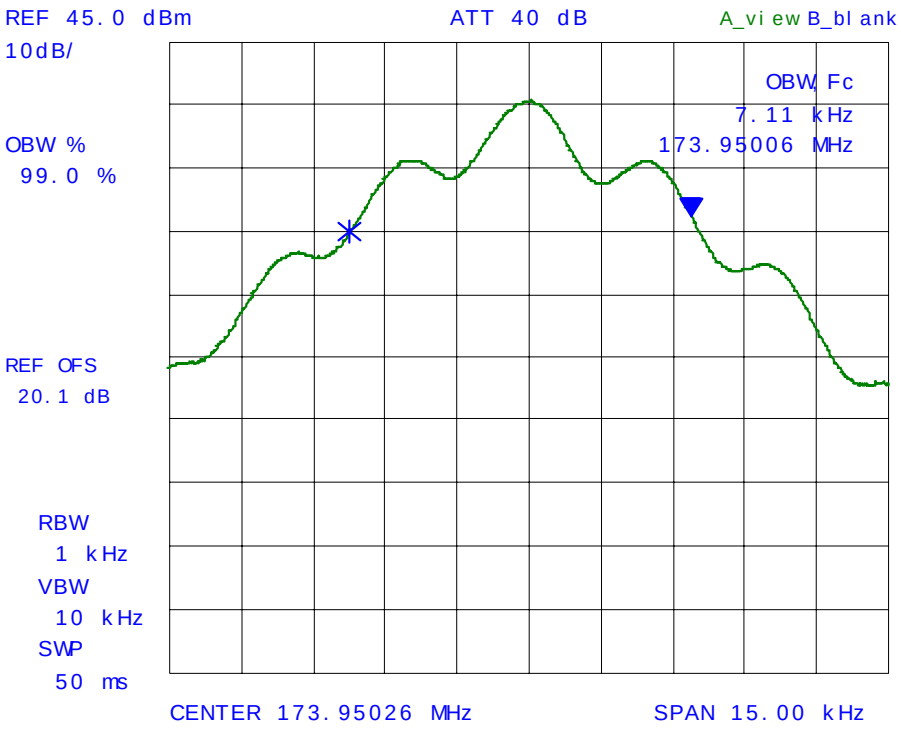
Plot # 1:
Occupied Bandwidth
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



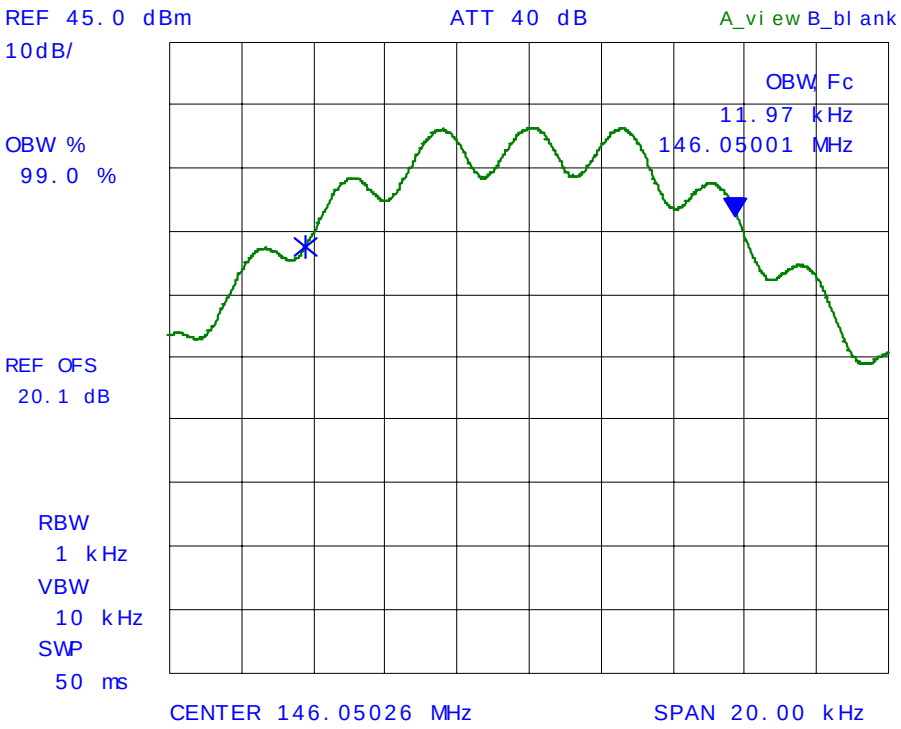
Plot # 2:
Occupied Bandwidth
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



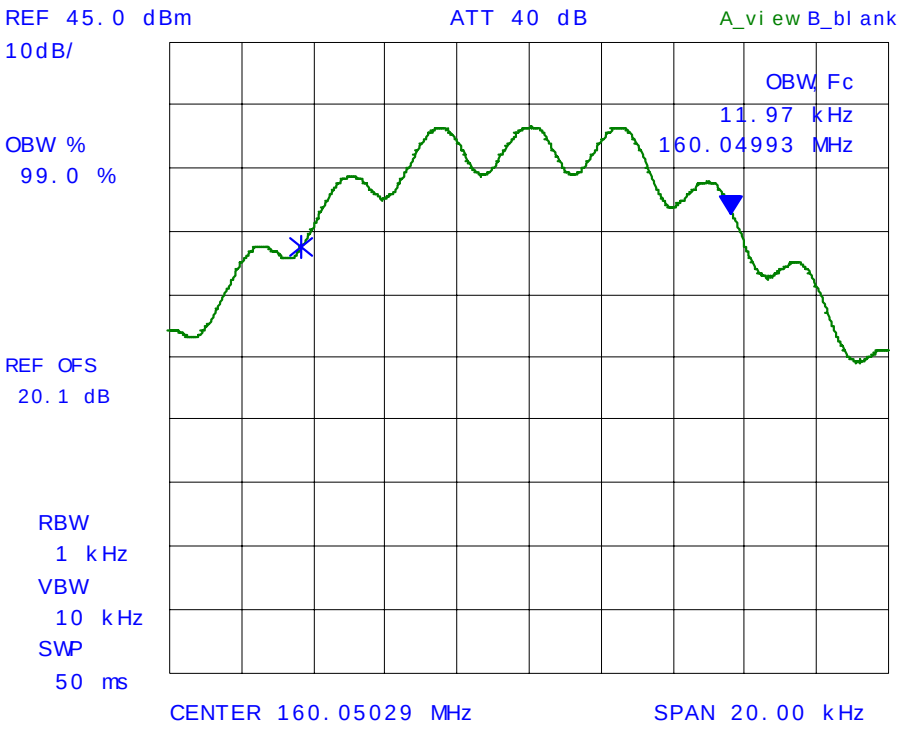
Plot # 3:
Occupied Bandwidth
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



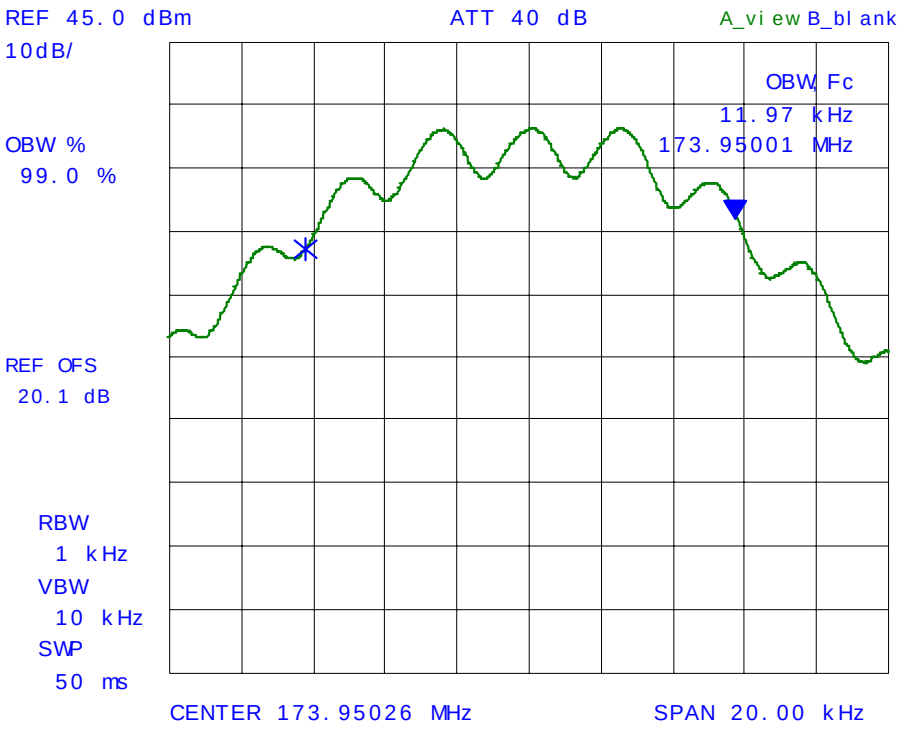
Plot # 4:
Occupied Bandwidth
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



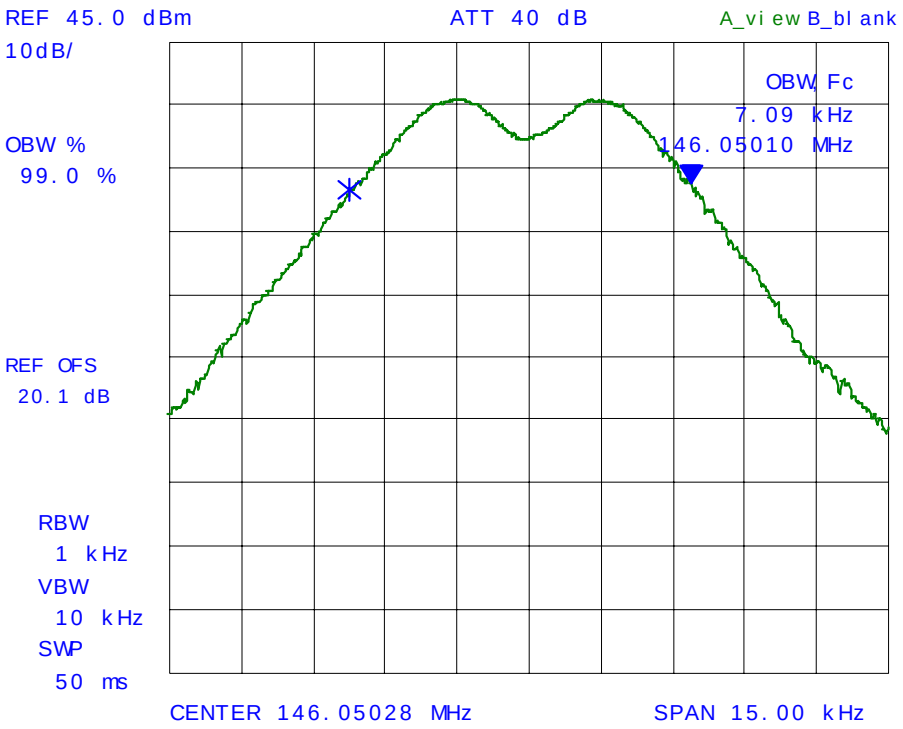
Plot # 5:
Occupied Bandwidth
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



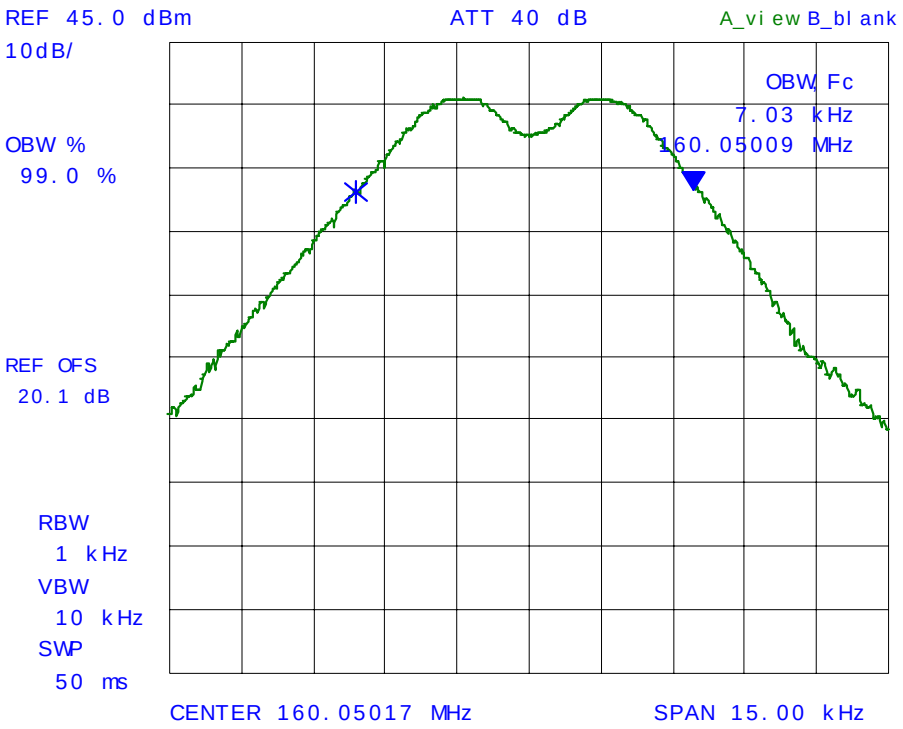
Plot # 6:
Occupied Bandwidth
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



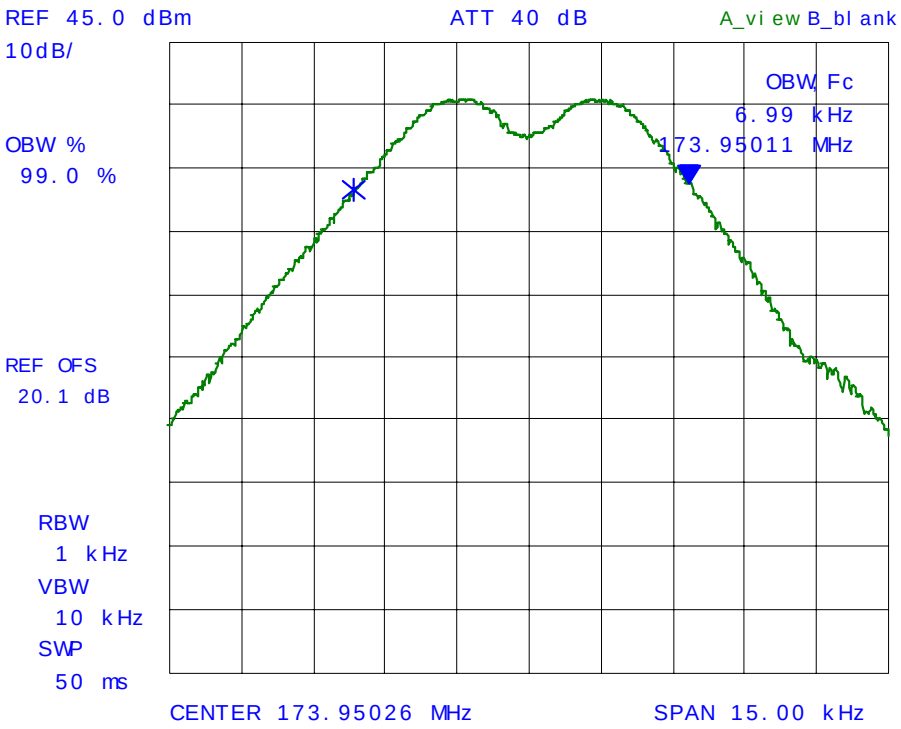
Plot # 7:
Occupied Bandwidth
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



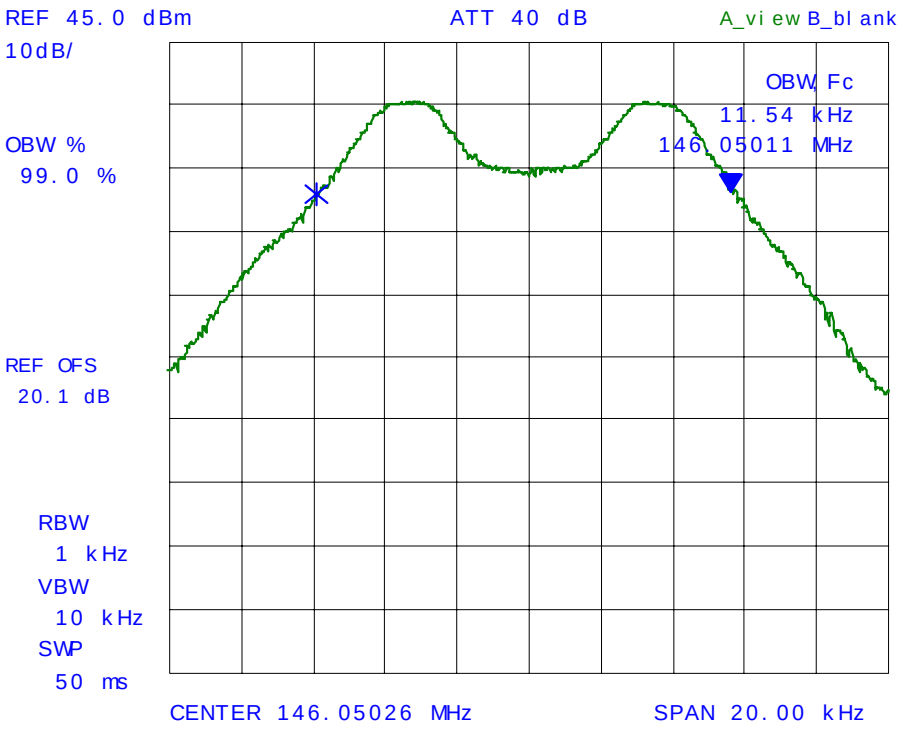
Plot # 8:
Occupied Bandwidth
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



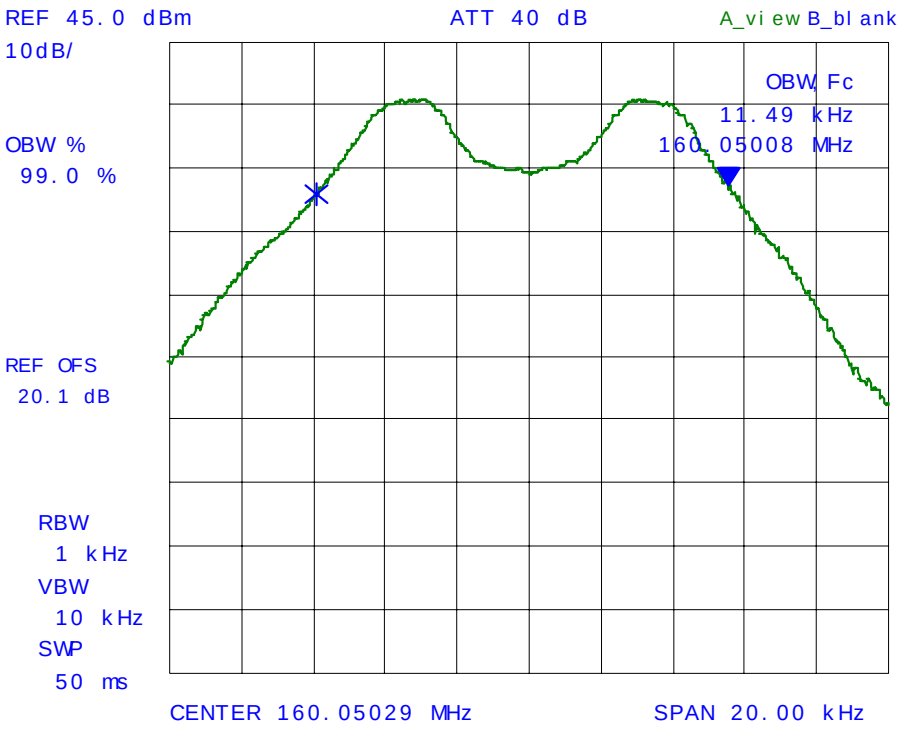
Plot # 9:
Occupied Bandwidth
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



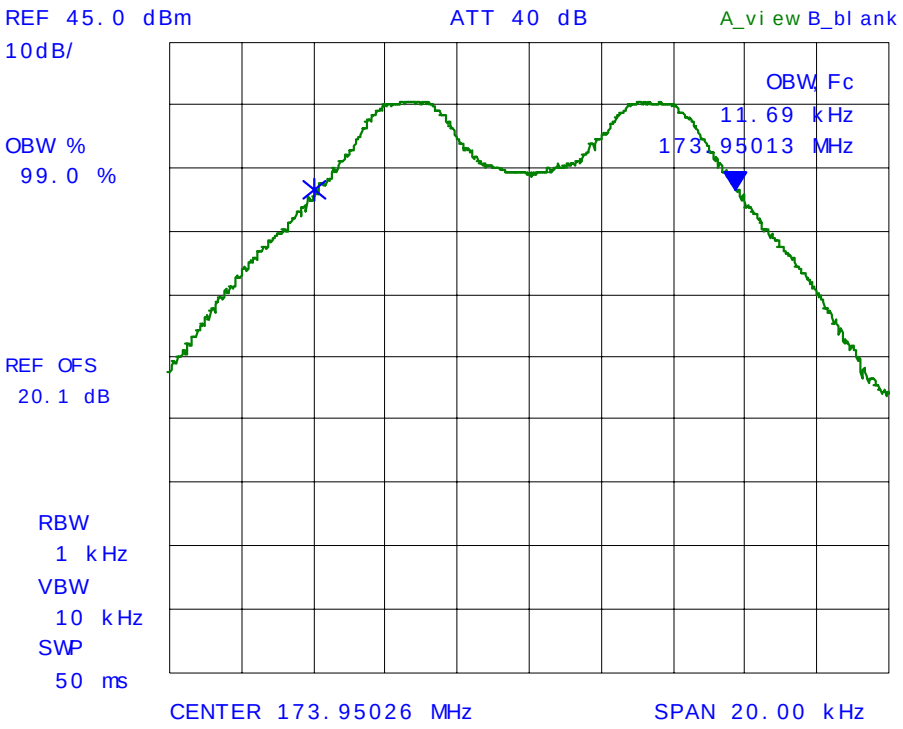
Plot # 10:
Occupied Bandwidth
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



Plot # 11:
Occupied Bandwidth
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



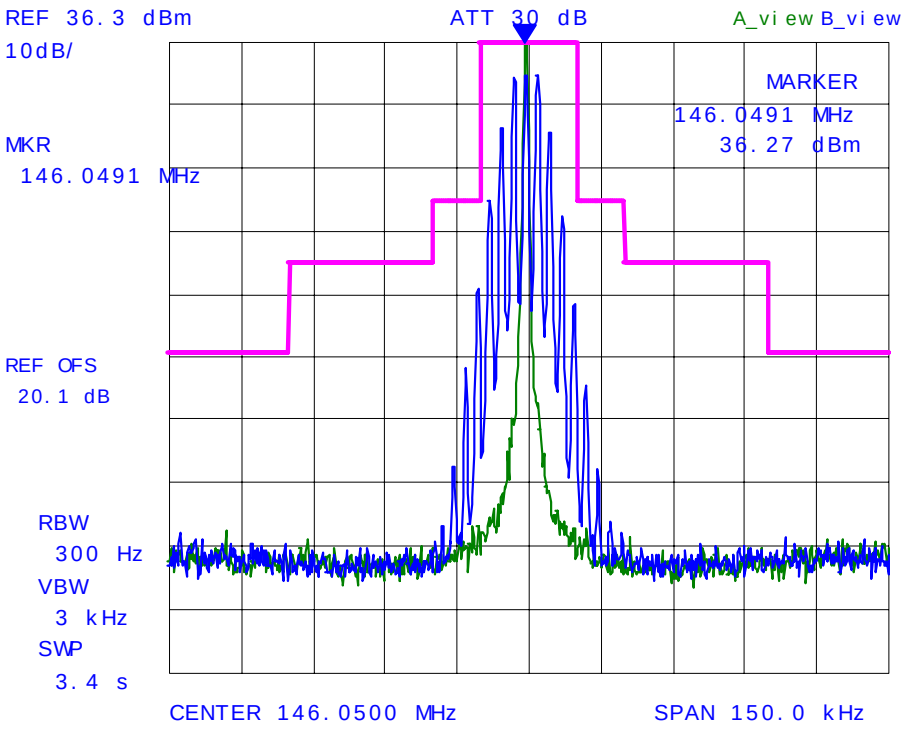
Plot # 12:
Occupied Bandwidth
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5 kHz sine wave signal and scrambler



6.9.5.2. Emission Masks

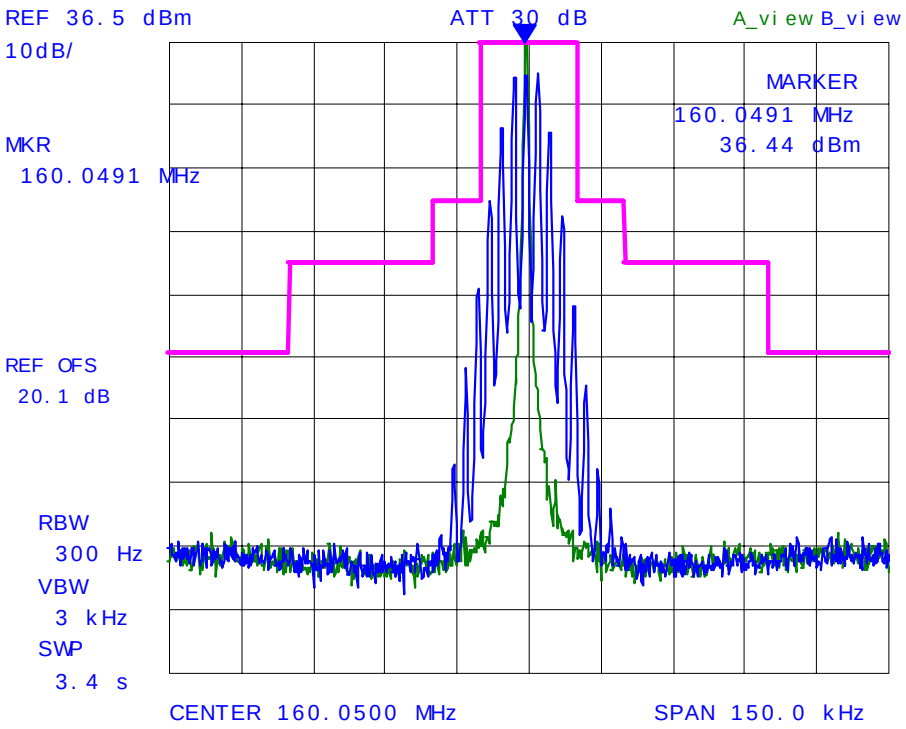
Conform. See the following test data plots (13 through 44) for details.

Plot # 13:
Emission Mask B (LMR)
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave

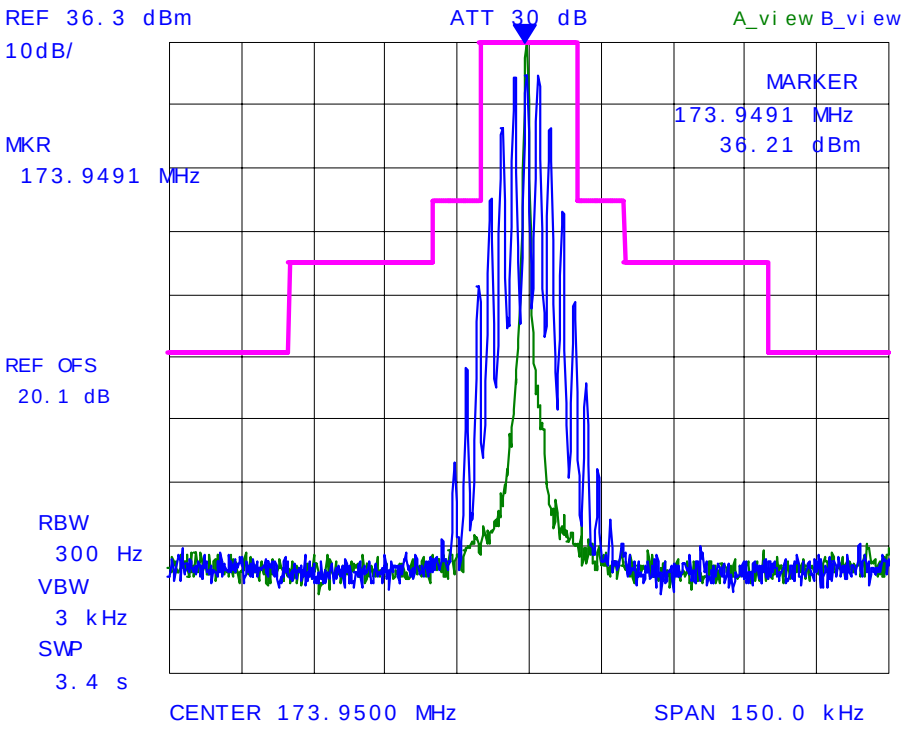


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

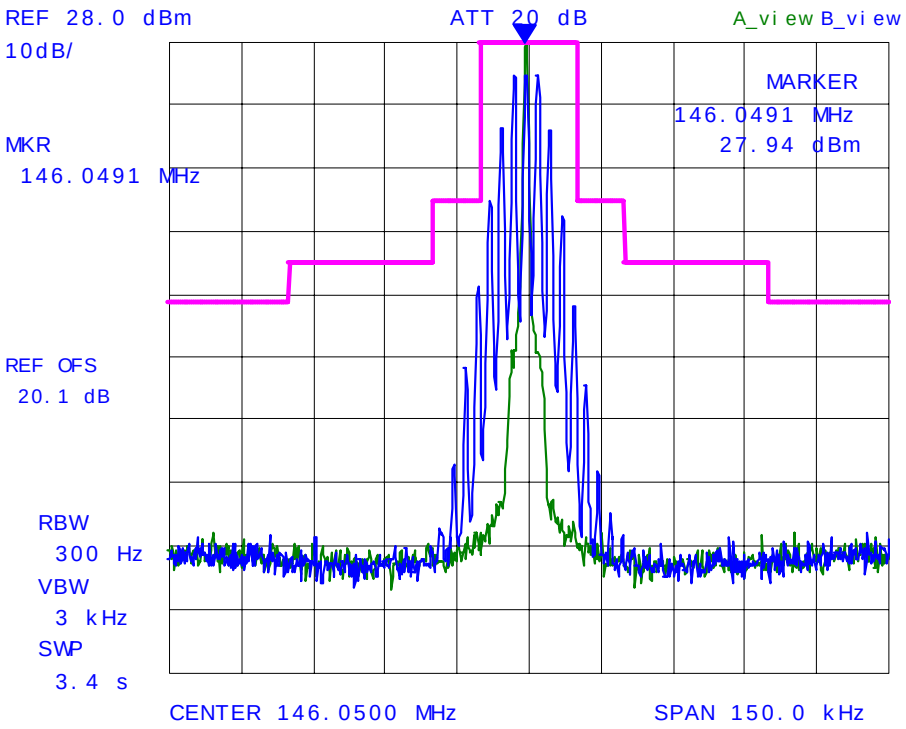
Plot # 14:
Emission Mask B (LMR)
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



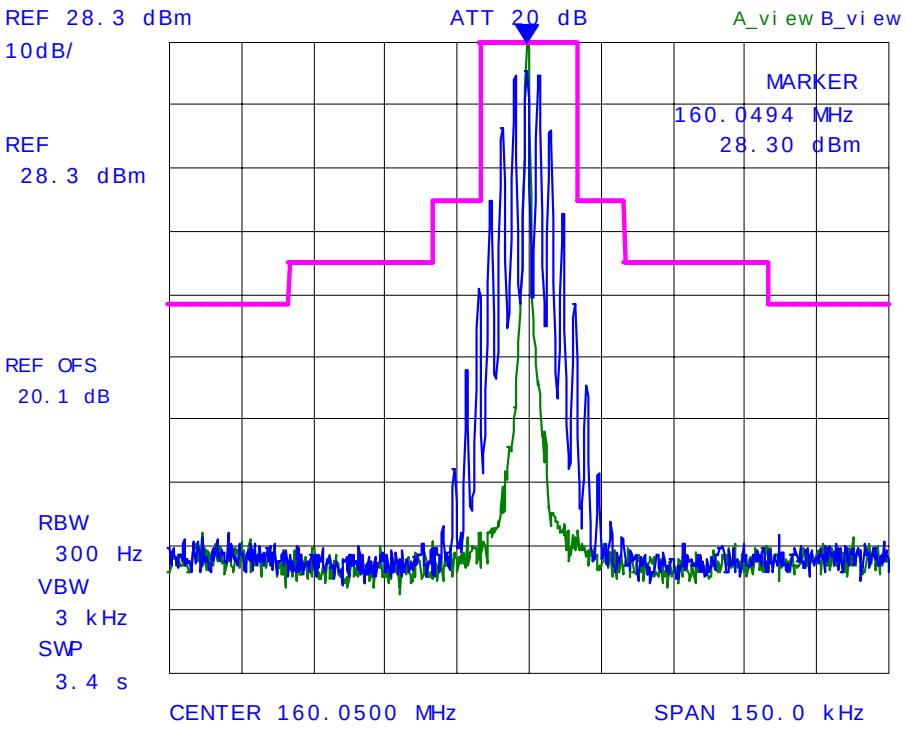
Plot # 15:
Emission Mask B (LMR)
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



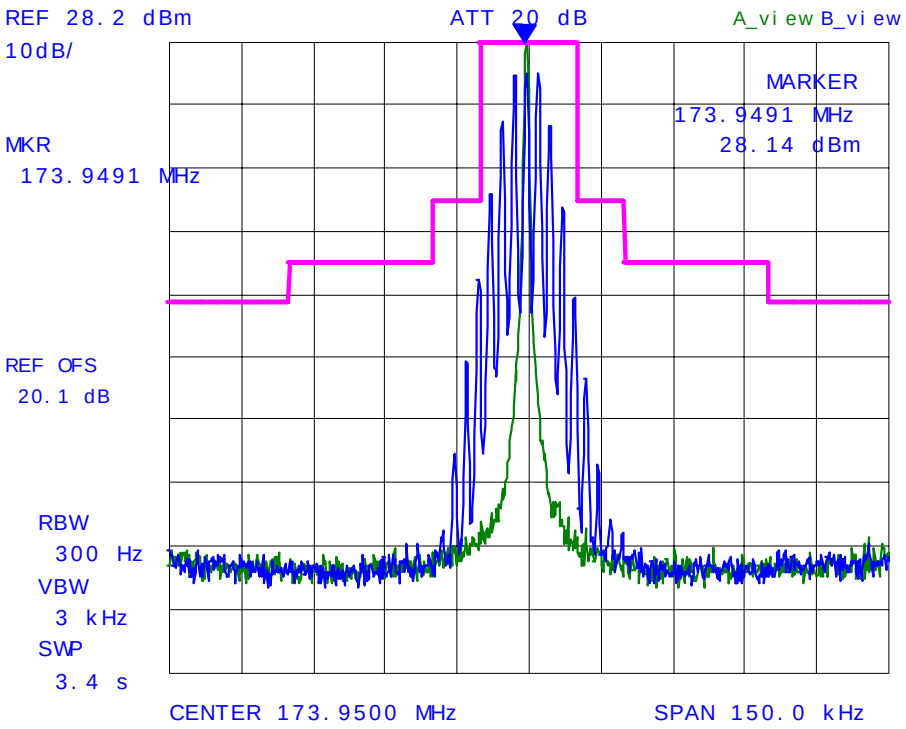
Plot # 16:
Emission Mask B (LMR)
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



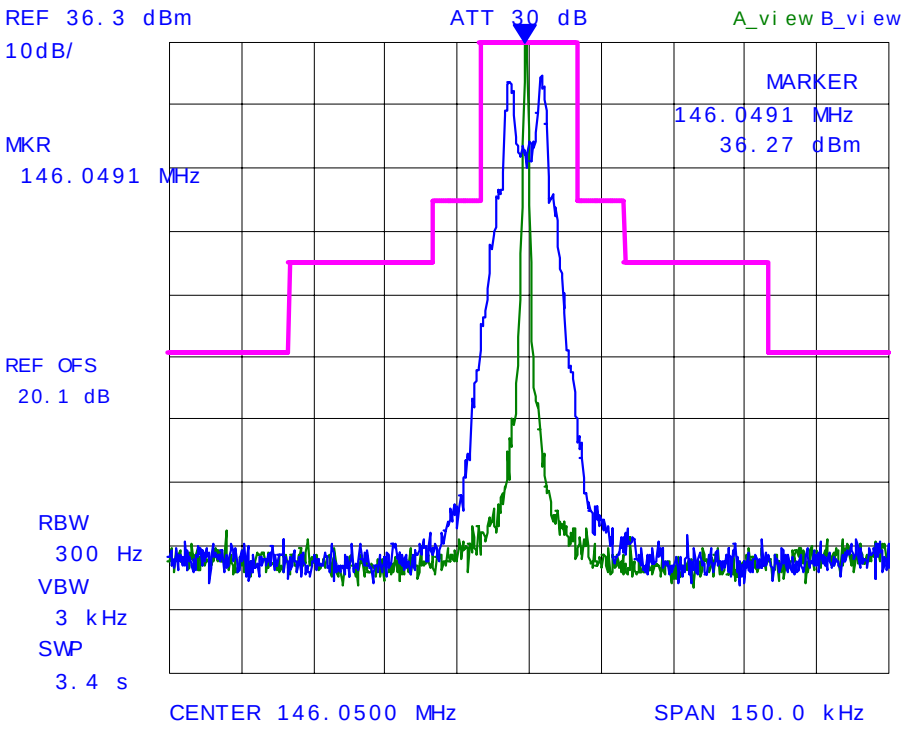
Plot # 17:
Emission Mask B (LMR)
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave



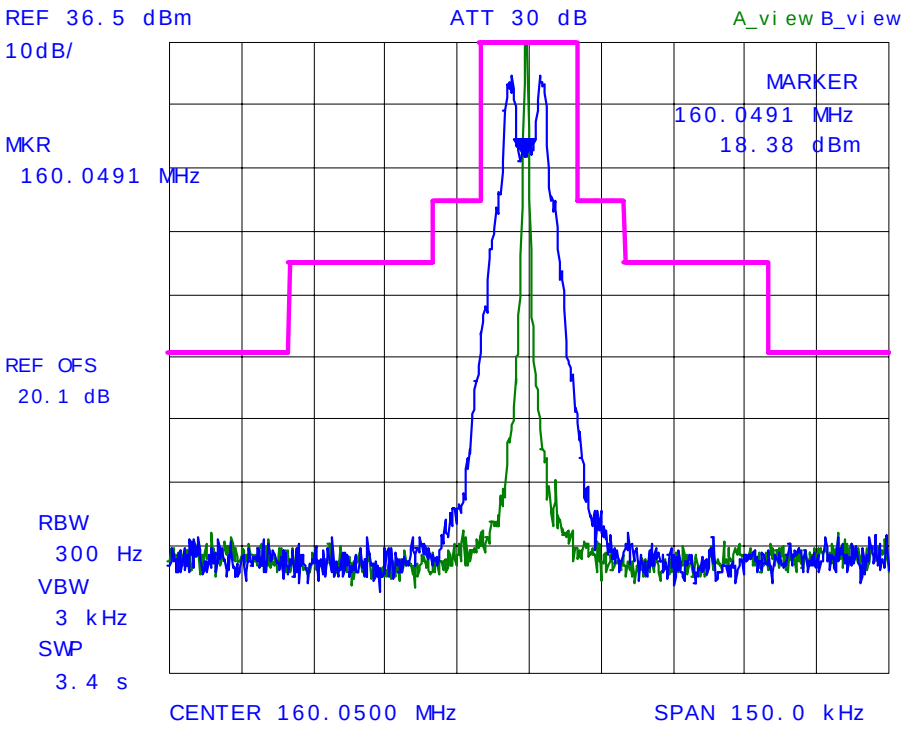
Plot # 18:
Emission Mask B (LMR)
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave



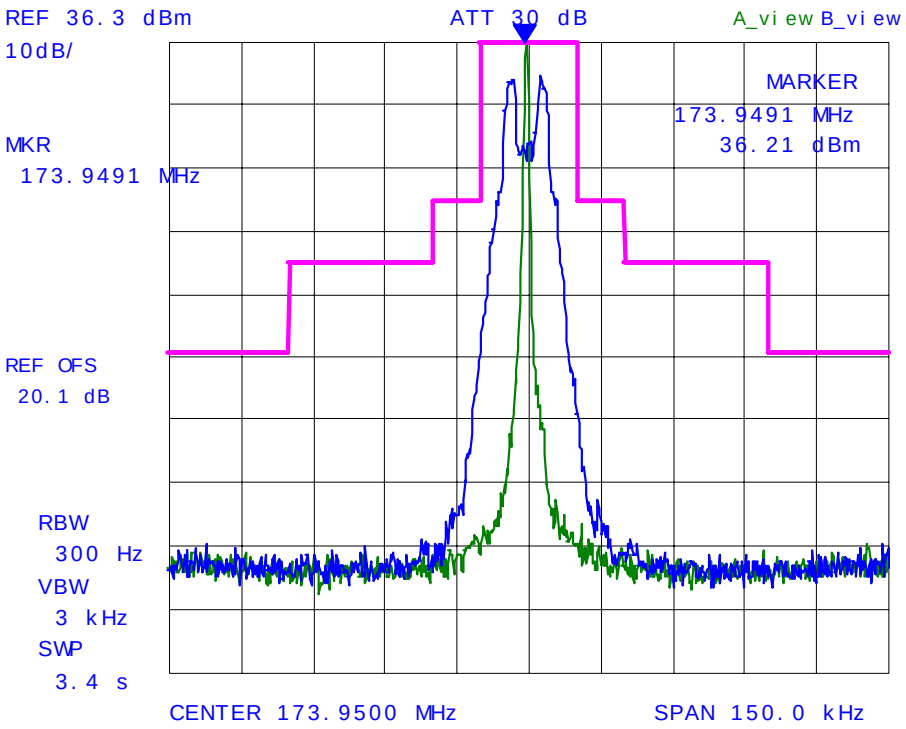
Plot # 19:
Emission Mask B (LMR)
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



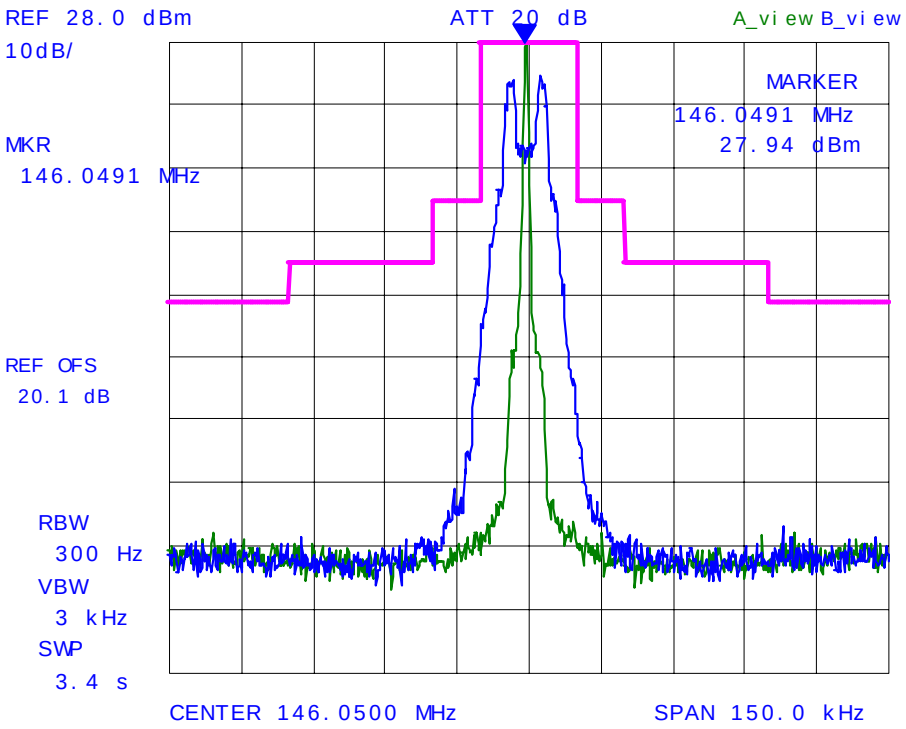
Plot # 20:
Emission Mask B (LMR)
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



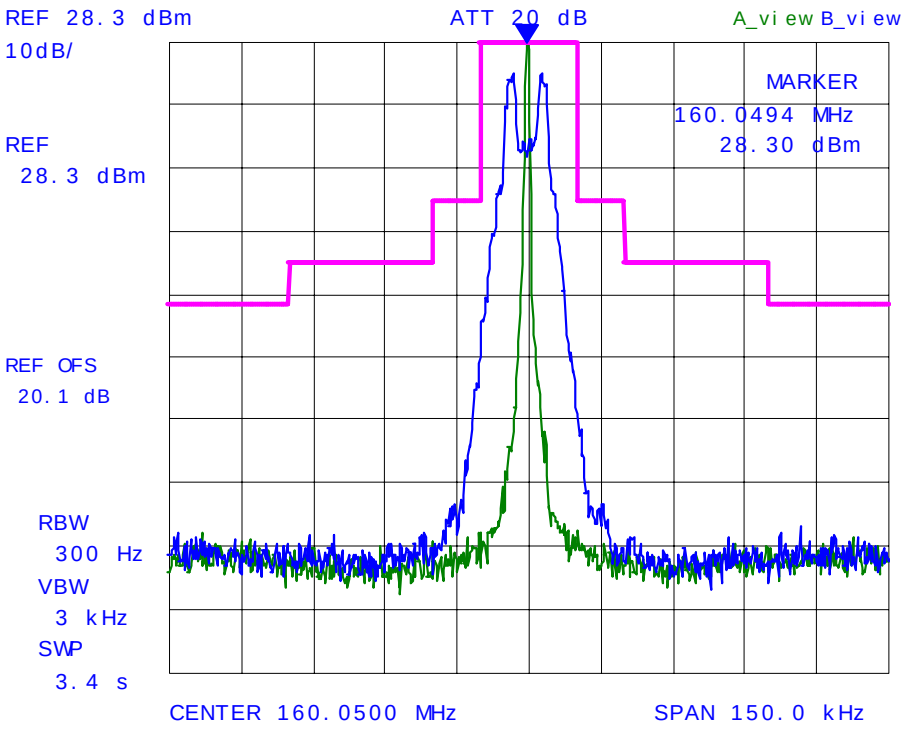
Plot # 21:
Emission Mask B (LMR)
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



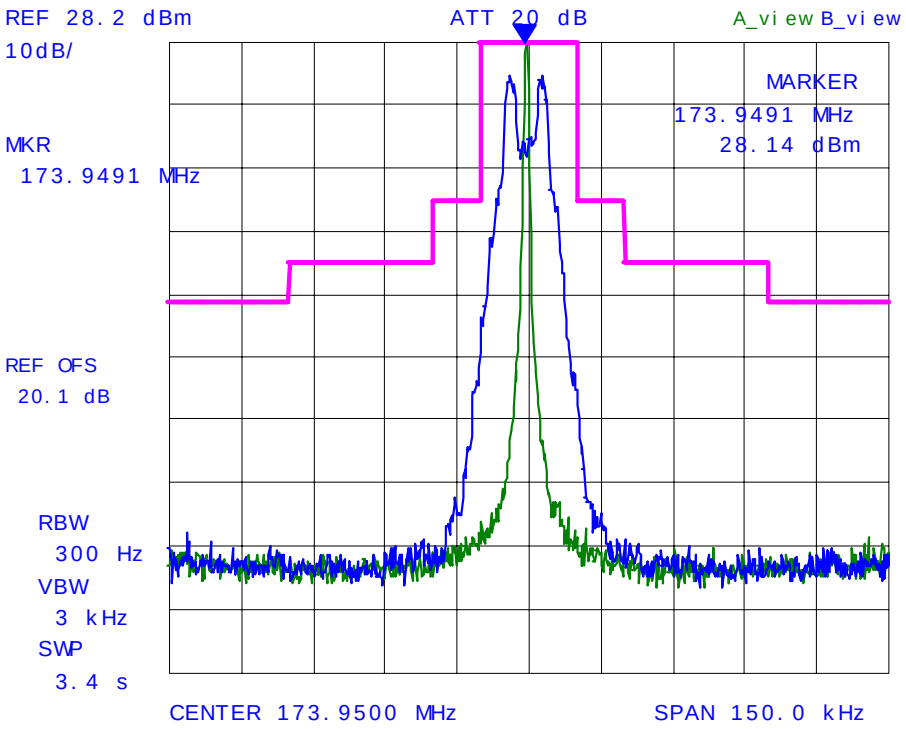
Plot # 22:
Emission Mask B (LMR)
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave and scrambler



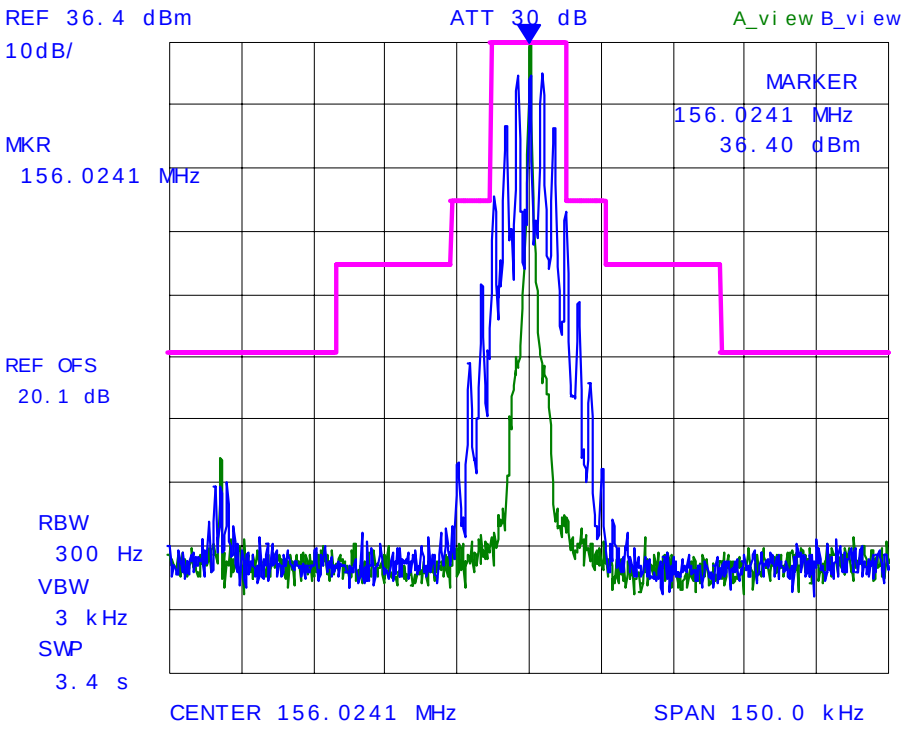
Plot # 23:
Emission Mask B (LMR)
Carrier Frequency: 160.050 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave and scrambler



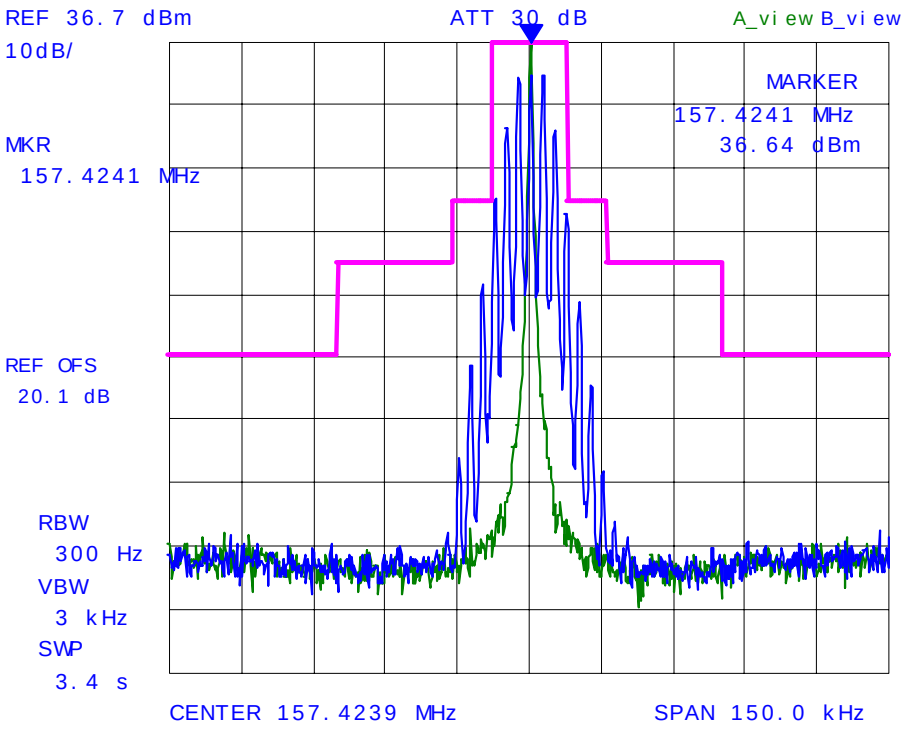
Plot # 24:
Emission Mask B (LMR)
Carrier Frequency: 173.950 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave and scrambler



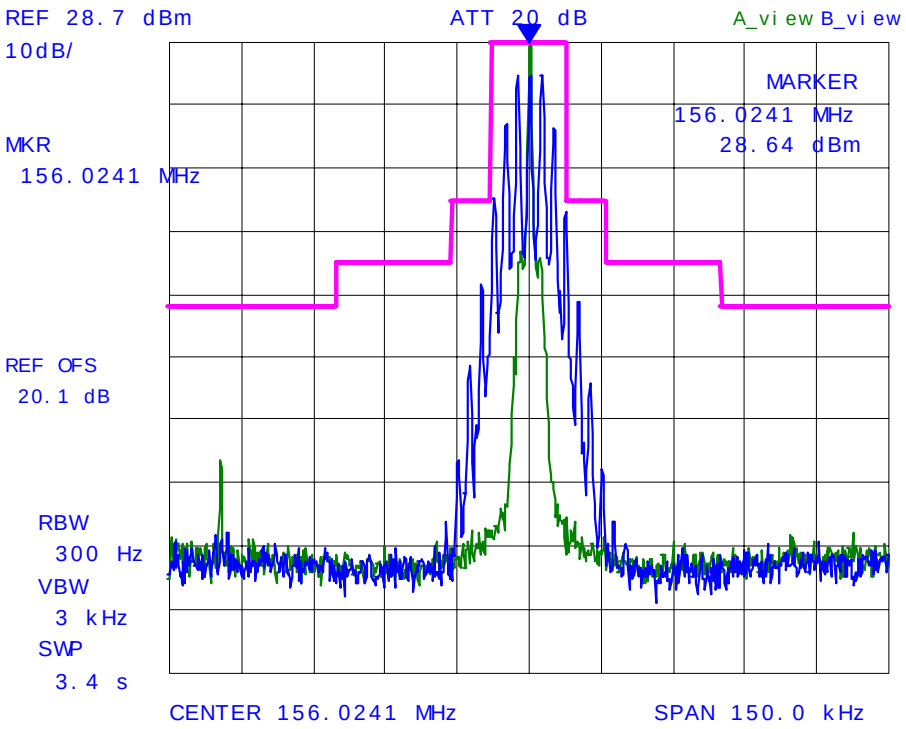
Plot # 25:
Emission Mask B (Marine)
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



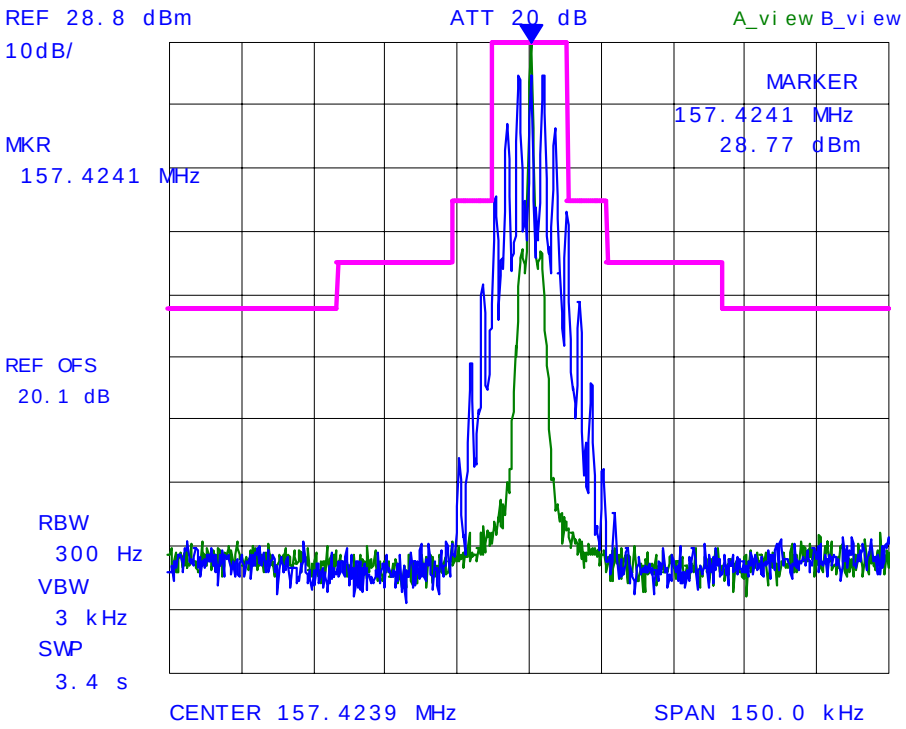
Plot # 26:
Emission Mask B (Marine)
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



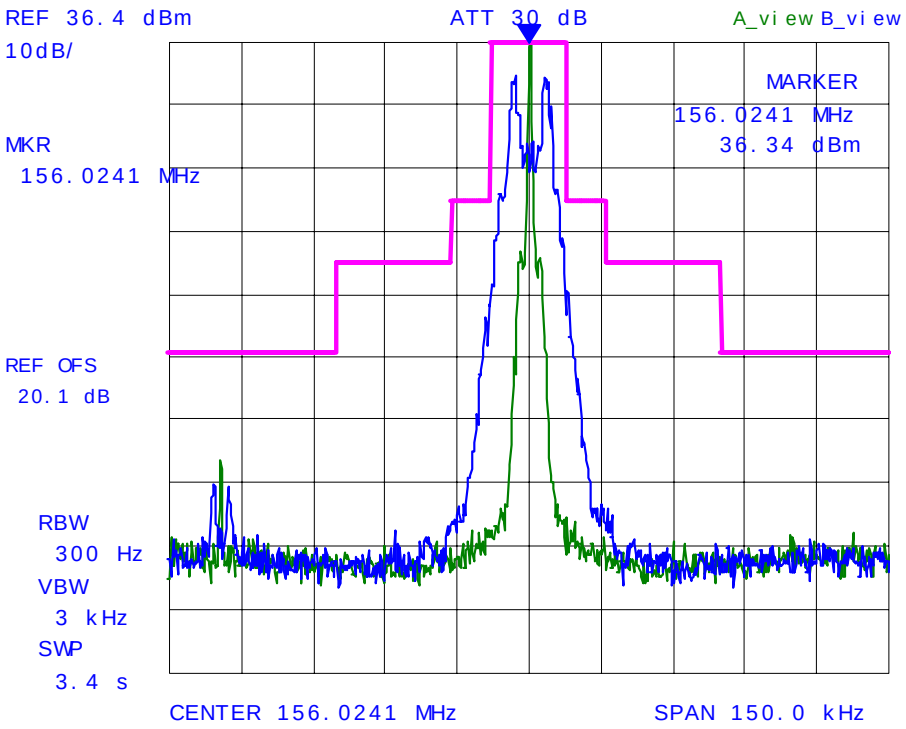
Plot # 27:
Emission Mask B (Marine)
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



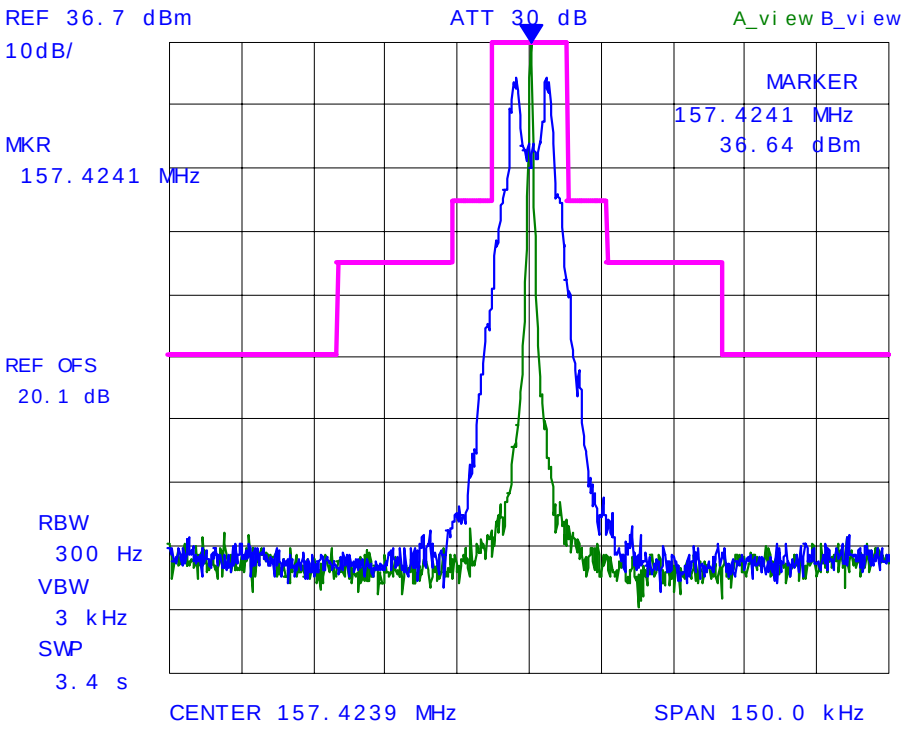
Plot # 28:
Emission Mask B (Marine)
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave



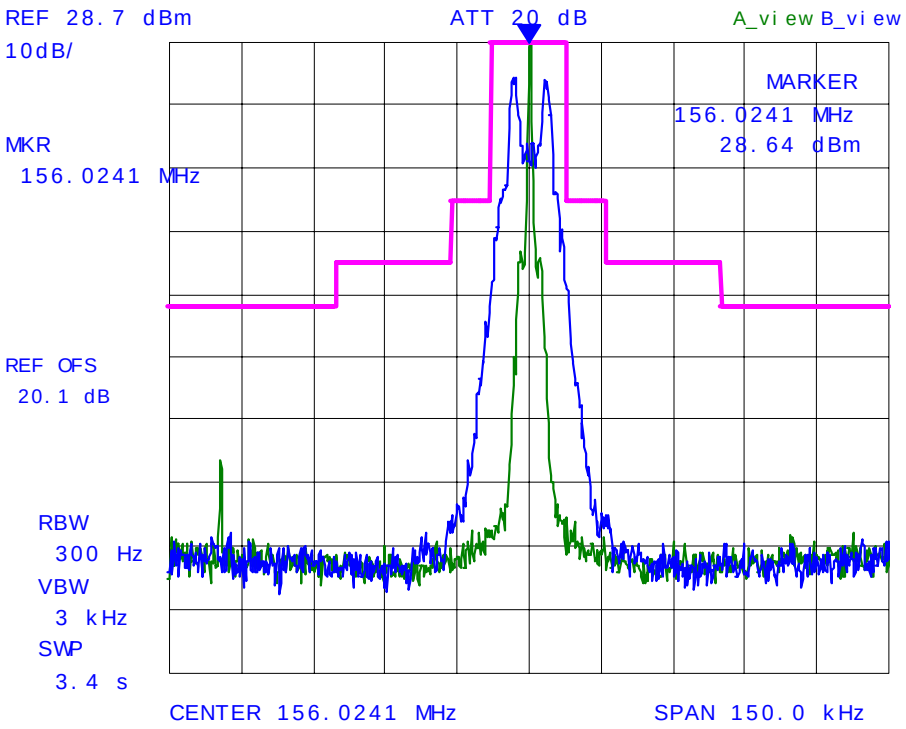
Plot # 29:
Emission Mask B (Marine)
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



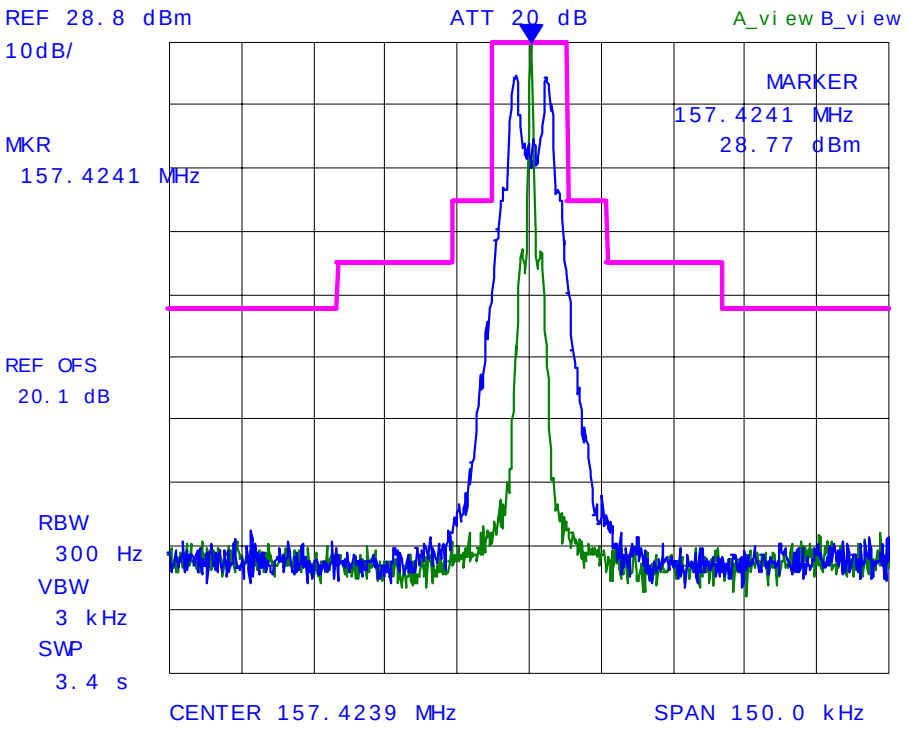
Plot # 30:
Emission Mask B (Marine)
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



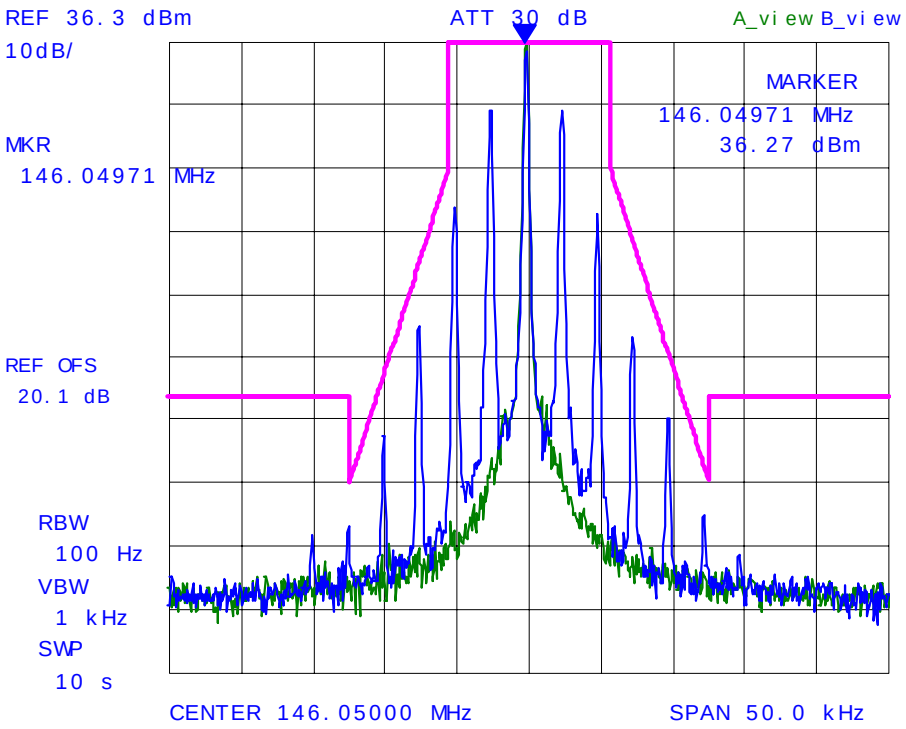
Plot # 31:
Emission Mask B (Marine)
Carrier Frequency: 156.025 MHz
Channel Spacing: 25 kHz
Power: 1W
Modulation: FM with 2.5kHz sine wave and scrambler



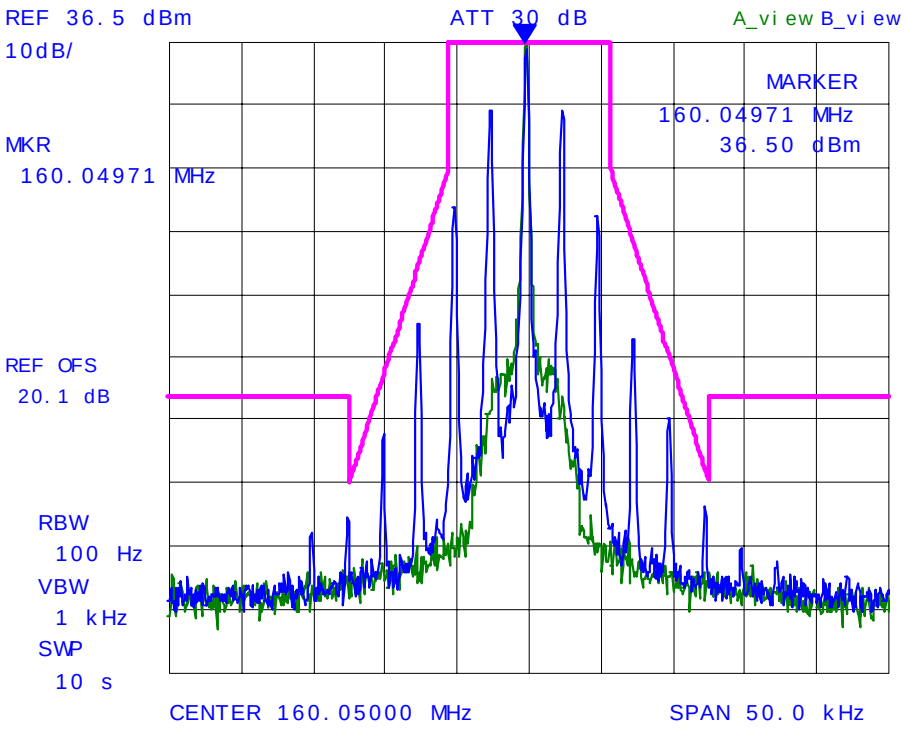
Plot # 32:
Emission Mask B (Marine)
Carrier Frequency: 157.425 MHz
Channel Spacing: 25 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave and scrambler



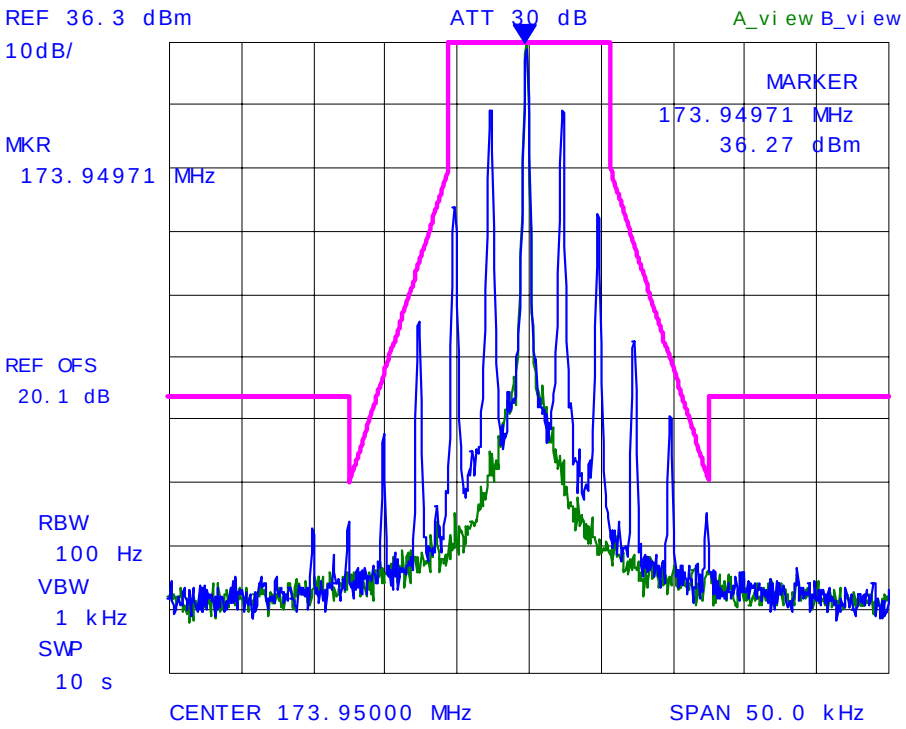
Plot # 33:
Emission Mask D
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



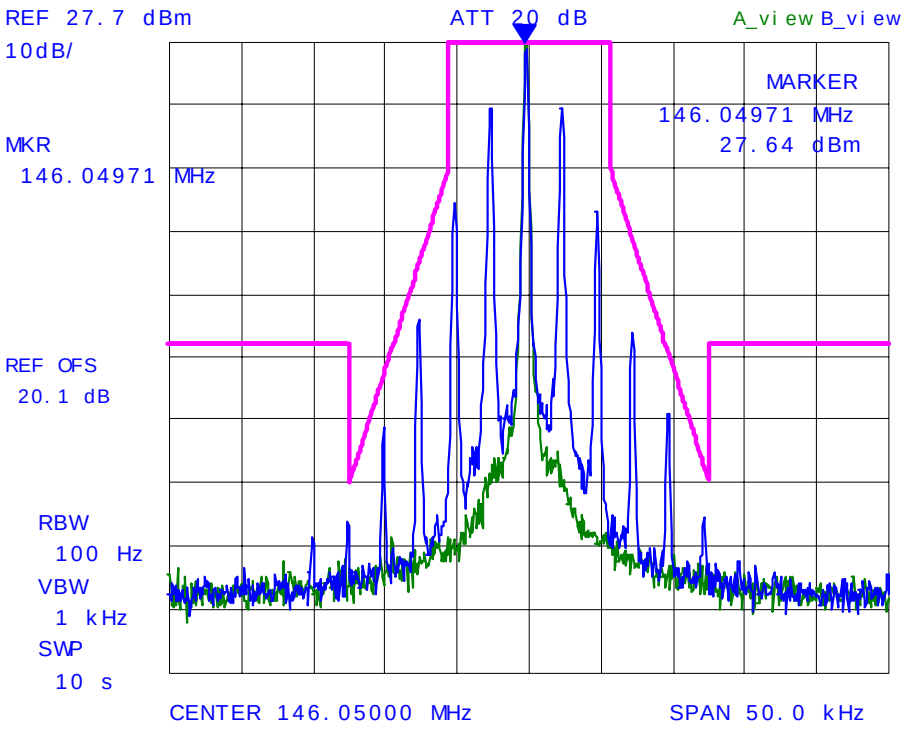
Plot # 34:
Emission Mask D
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



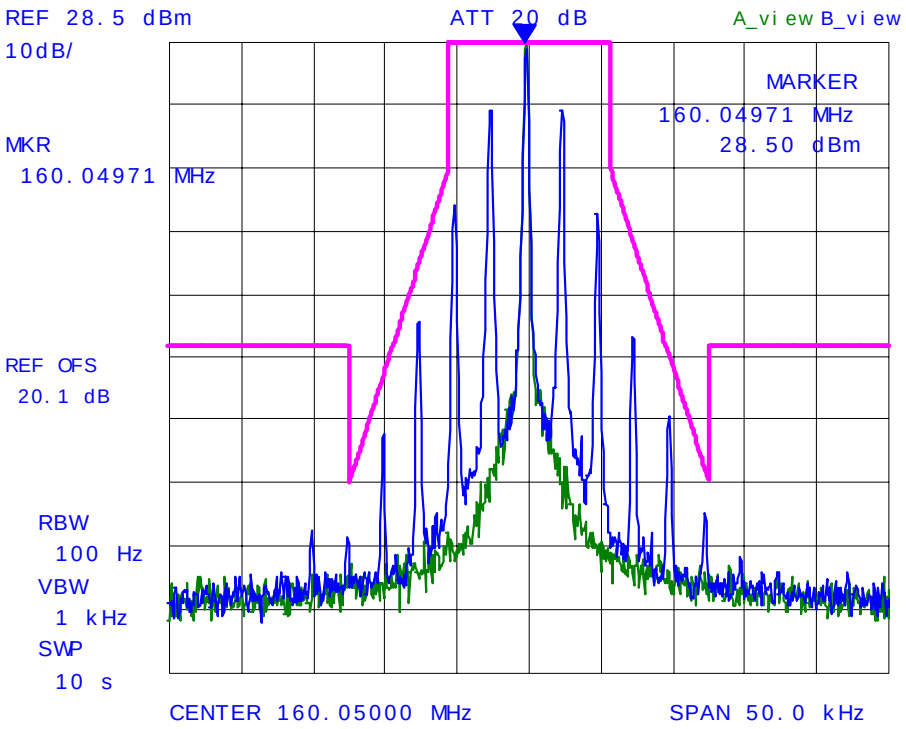
Plot # 35:
Emission Mask D
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



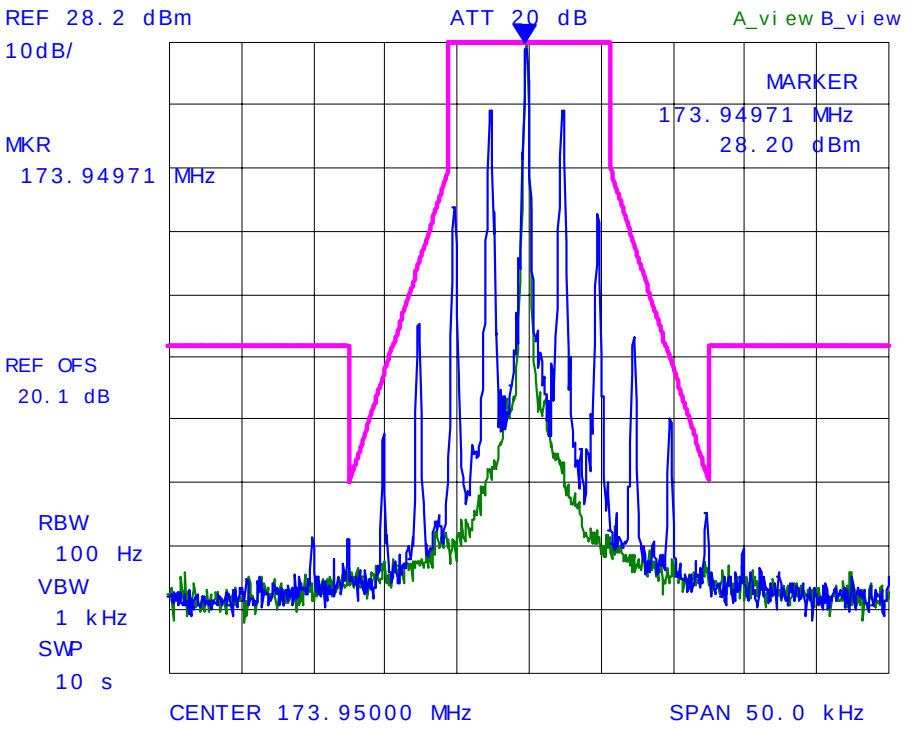
Plot # 36:
Emission Mask D
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



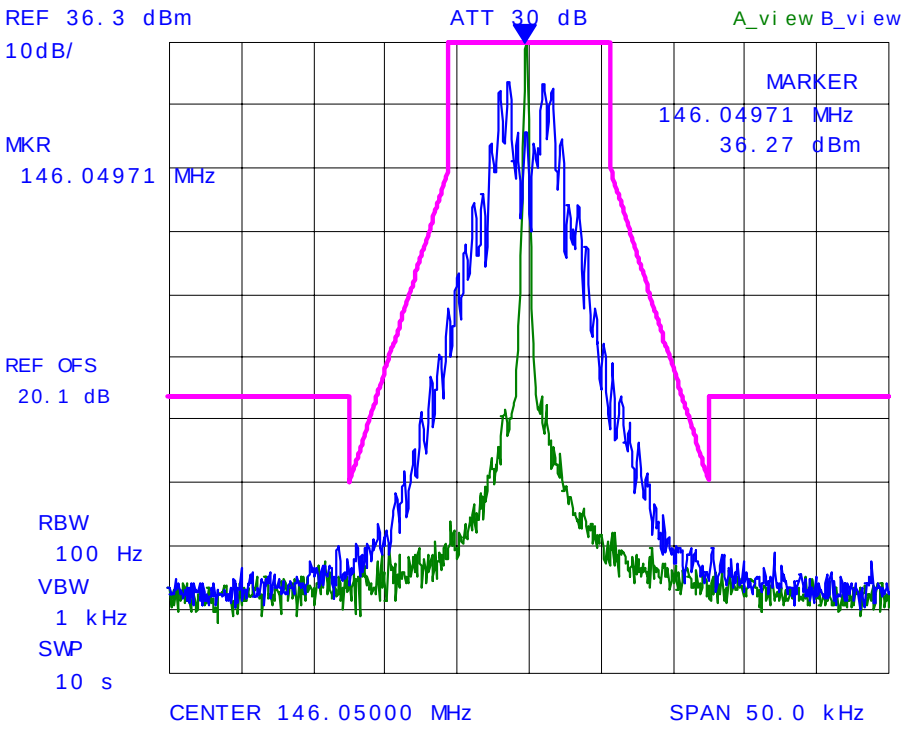
Plot # 37:
Emission Mask D
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



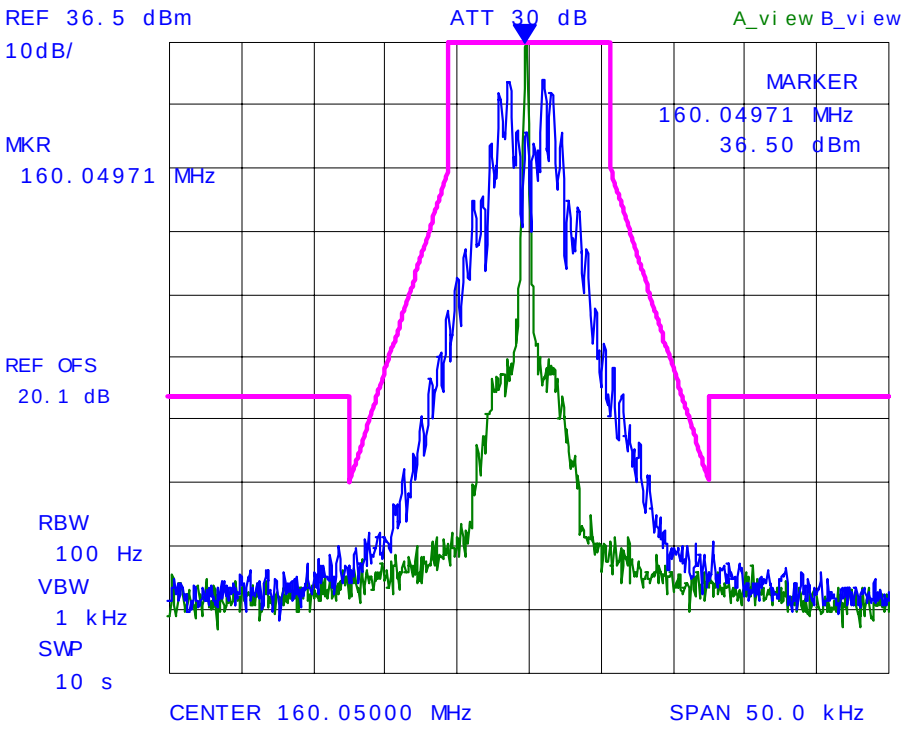
Plot # 38:
Emission Mask D
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



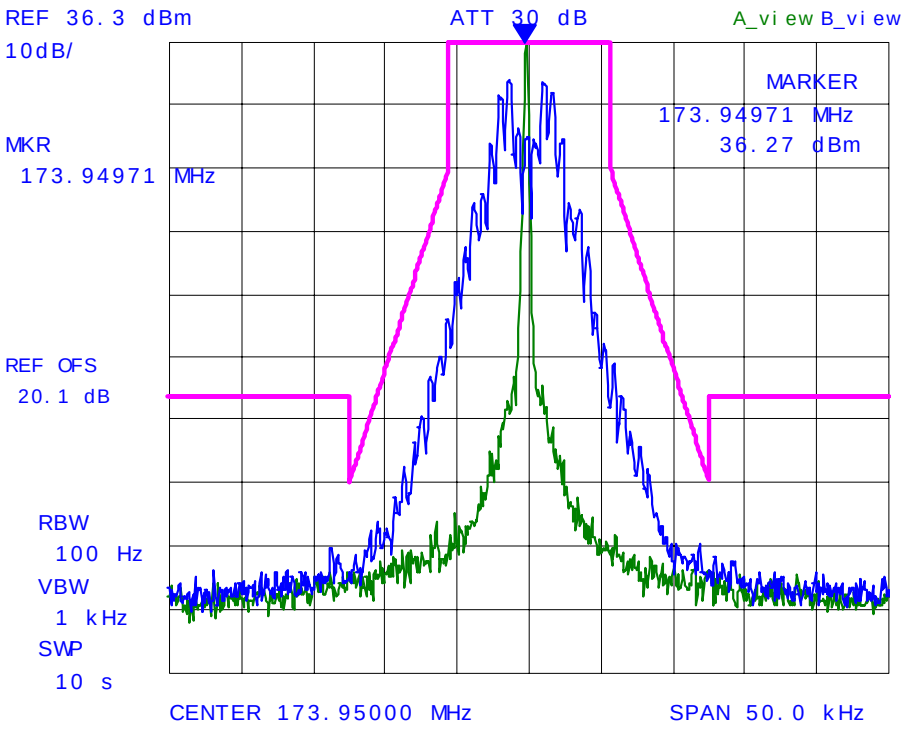
Plot # 39:
Emission Mask D
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



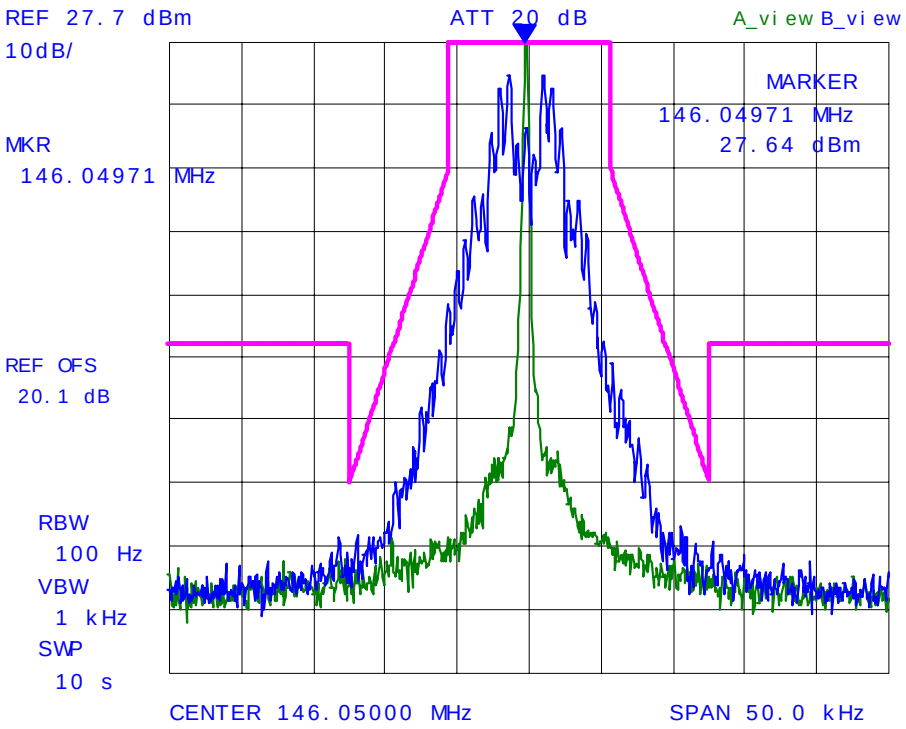
Plot # 40:
Emission Mask D
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



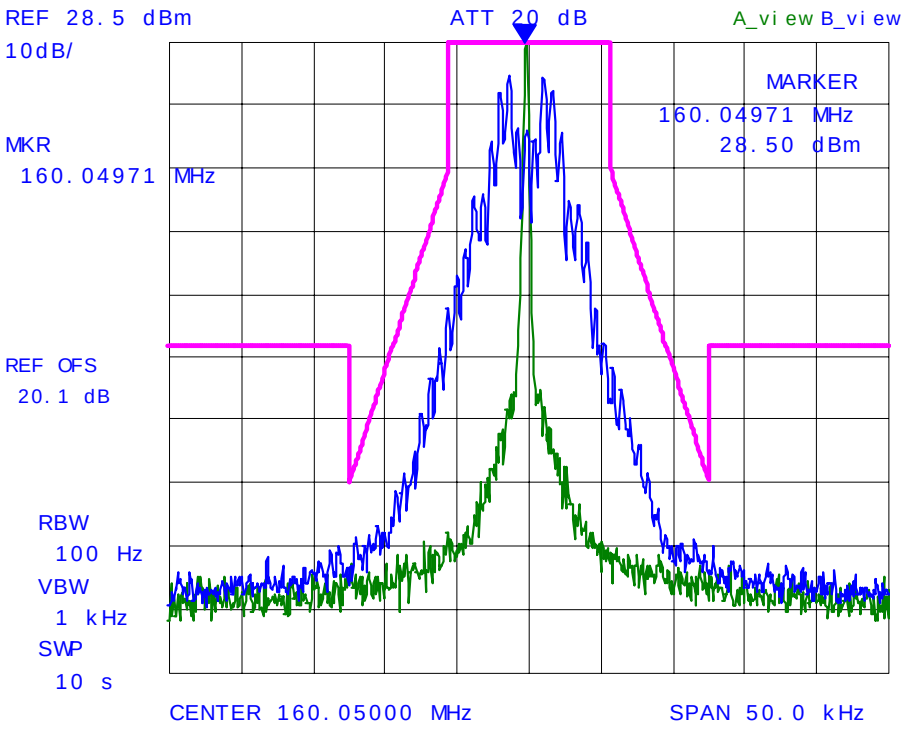
Plot # 41:
Emission Mask D
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave and scrambler



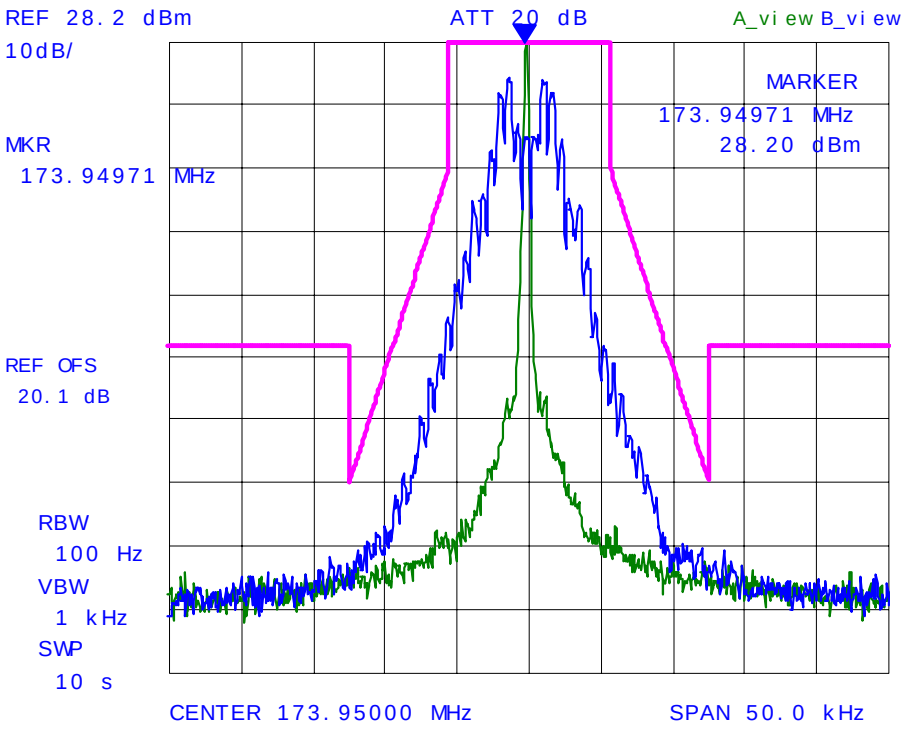
Plot # 42:
Emission Mask D
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave and scrambler



Plot # 43:
Emission Mask D
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave and scrambler



Plot # 44:
Emission Mask D
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave and scrambler



6.10. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [§§ 80.211(f)(3) & 90.210]

6.10.1. Limits

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

FCC Rules	Frequency Range	Attenuation Limit (dBc)
80.211(f)(3) - Marine 90.210(b)&(c) – Voice & data	10 MHz or Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P)
90.210(d) – Voice & data	10 MHz or Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	50+10*log(P) or -20 dBm or 70 dBc whichever is less

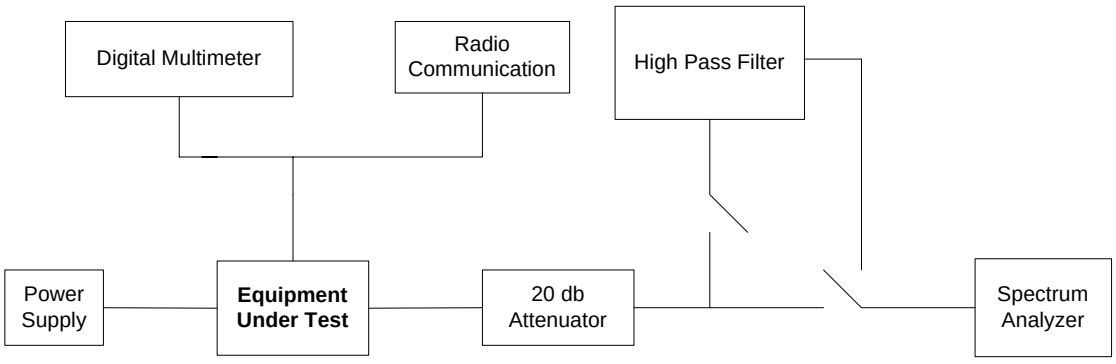
6.10.2. Method of Measurements

Refer to Section 8.5 of this report for measurement details

6.10.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
EMI Receiver/ Spectrum Analyzer	Advantest	R3271	15050203	100 Hz – 26.5 GHz
Attenuator(s)	Weinschel Corp	23-20-34	BH7876	DC – 18 GHz
Radio Communication	Marconi	2955	132037/226	20Hz – 20kHz
High Pass Filter	Mini-Circuits	SHP-250	--	Cut-off Frequency at 225 MHz
Power Supply	Tenna	72-6153	--	--
Digital Multimeter	Rohde & Schwarz	UDS5	8729841067	DC-100 kHz

6.10.4. Test Arrangement



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

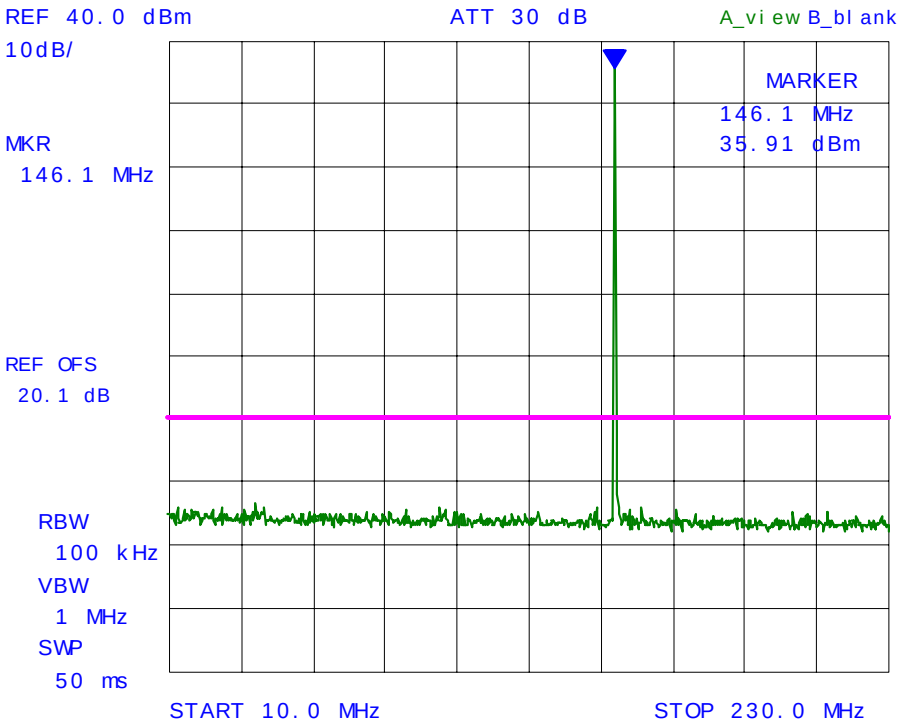
6.10.5. Test Data

Remarks:

- Since, the marine operating frequency band lies within the general band and RF output power is constant throughout the band. Tests are performed in the General Operating Frequency Bands 146-174 MHz and the results also represent the Marine band 156.025-157.425 MHz.
- Tests are performed with 12.5 kHz Channel Spacing where the lowest limit of 50+10log(P) is applied as the worst case.

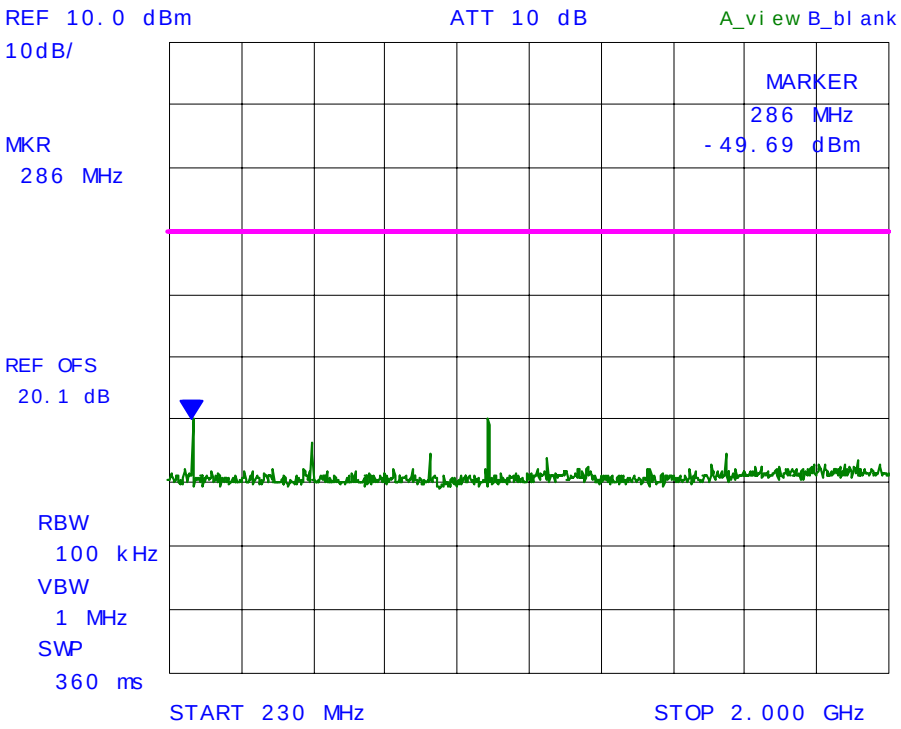
6.10.5.1. Near Lowest Frequency (146.050 MHz)

Plot # 45:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave

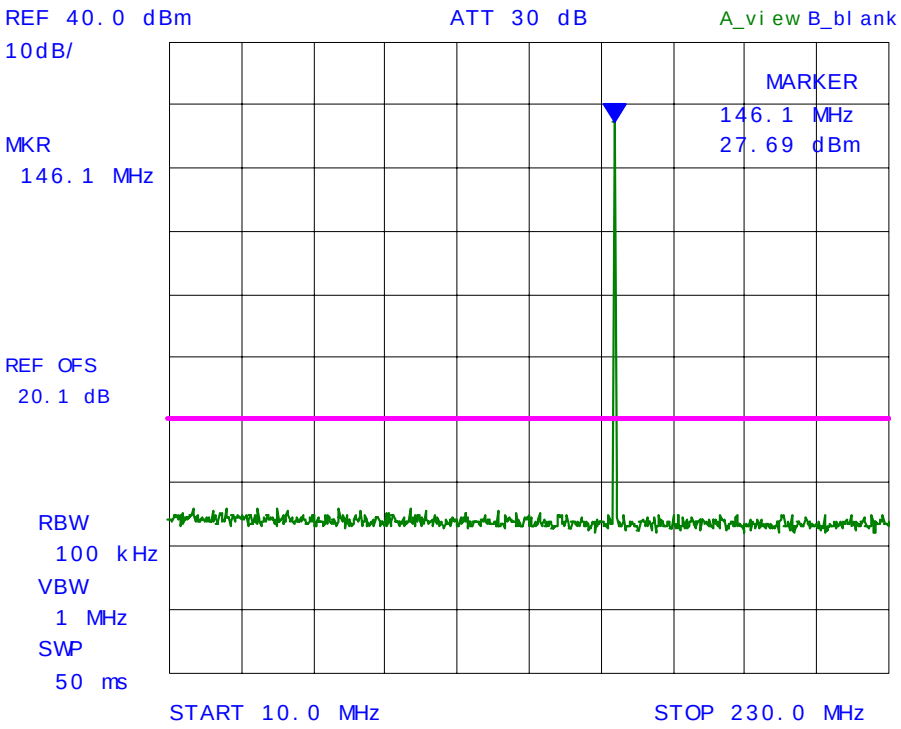


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

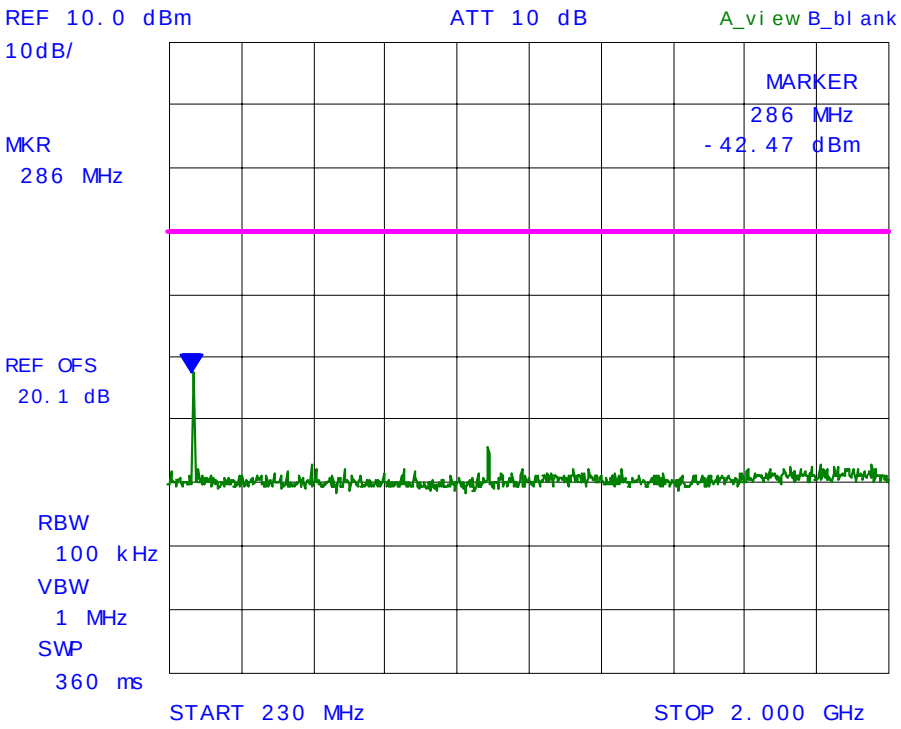
Plot # 46:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



Plot # 47:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave

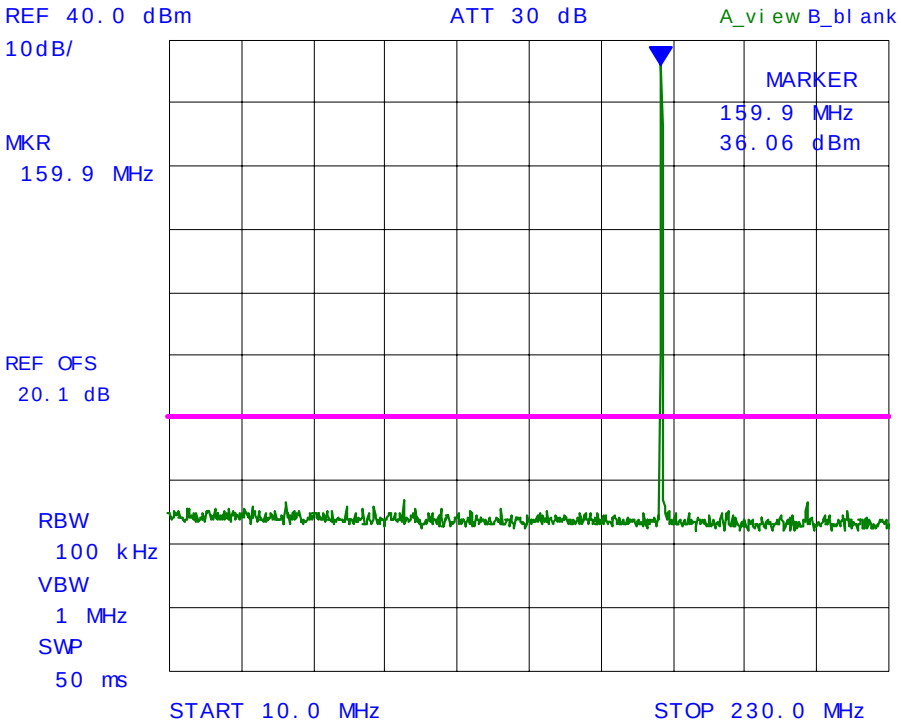


Plot # 48:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



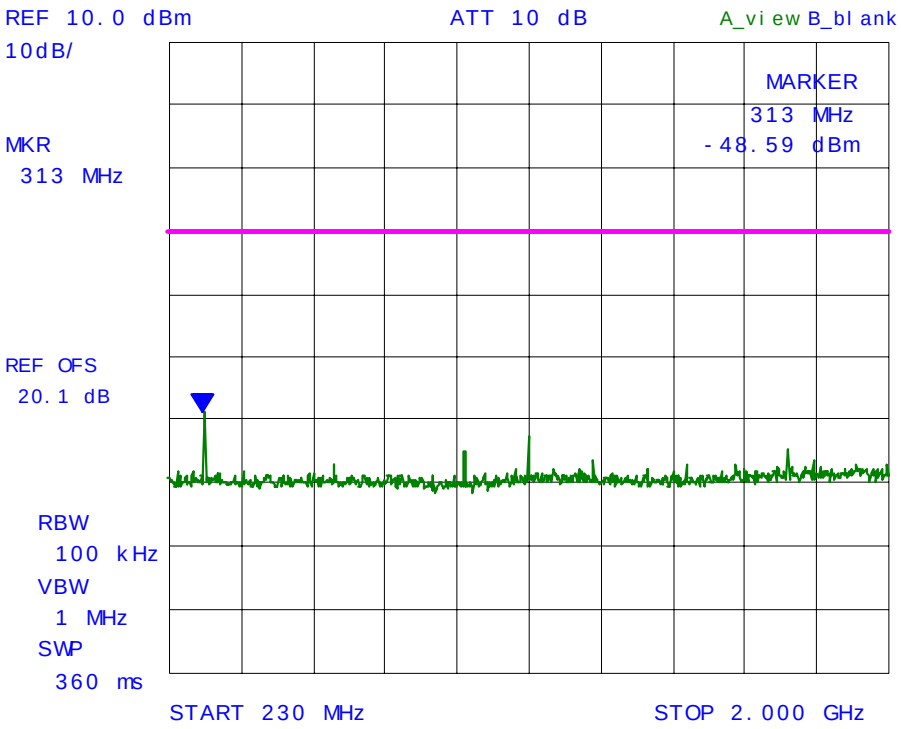
6.10.5.2. Near Middle Frequency (160.050 MHz)

Plot # 49:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave

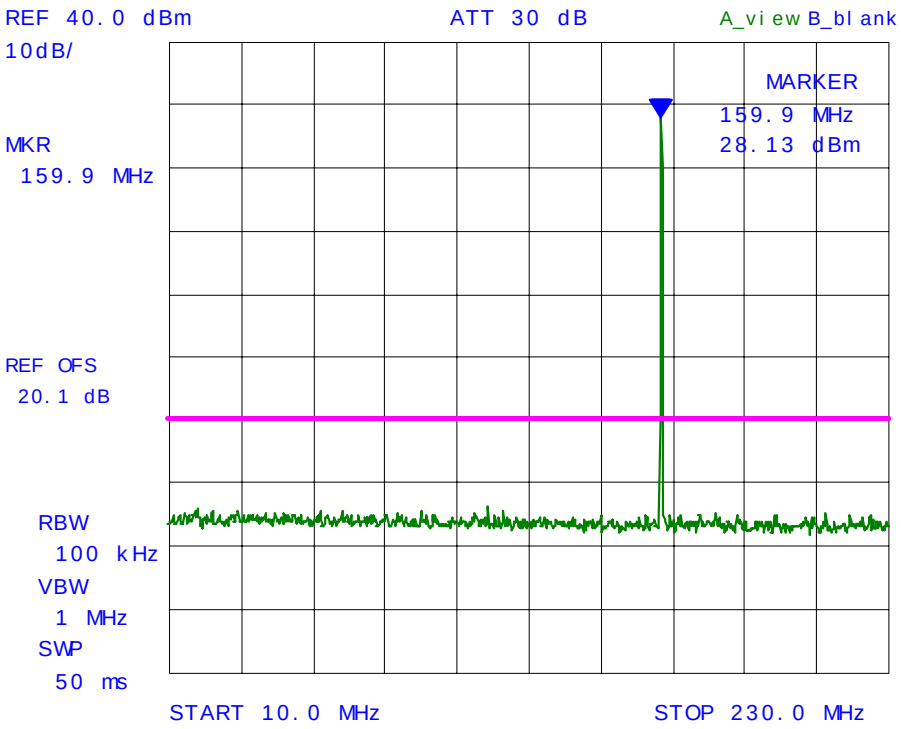


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

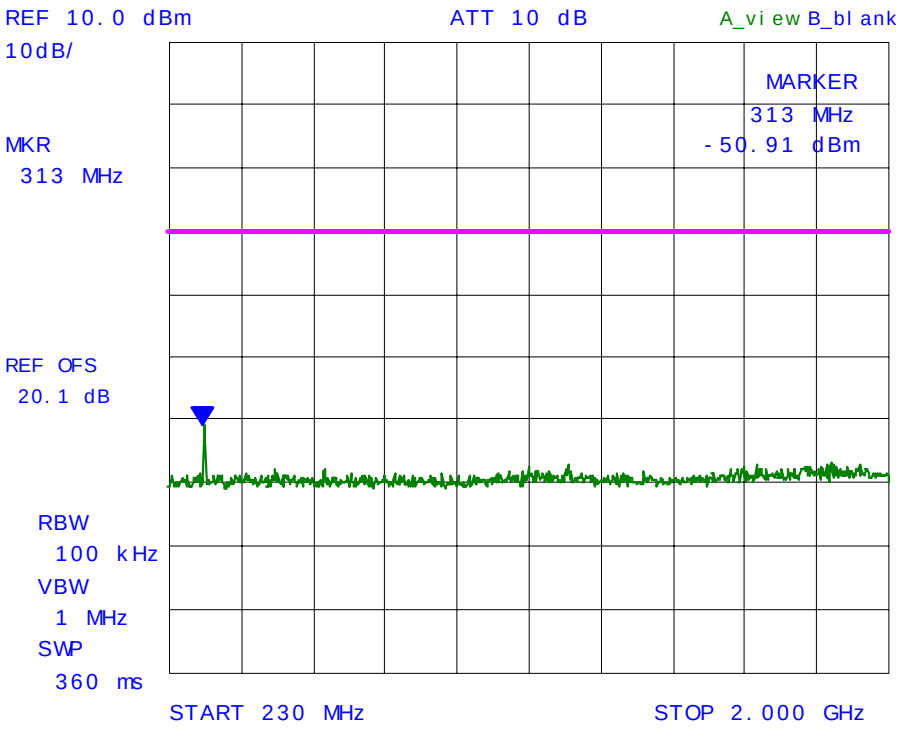
Plot # 50:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



Plot #51:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave

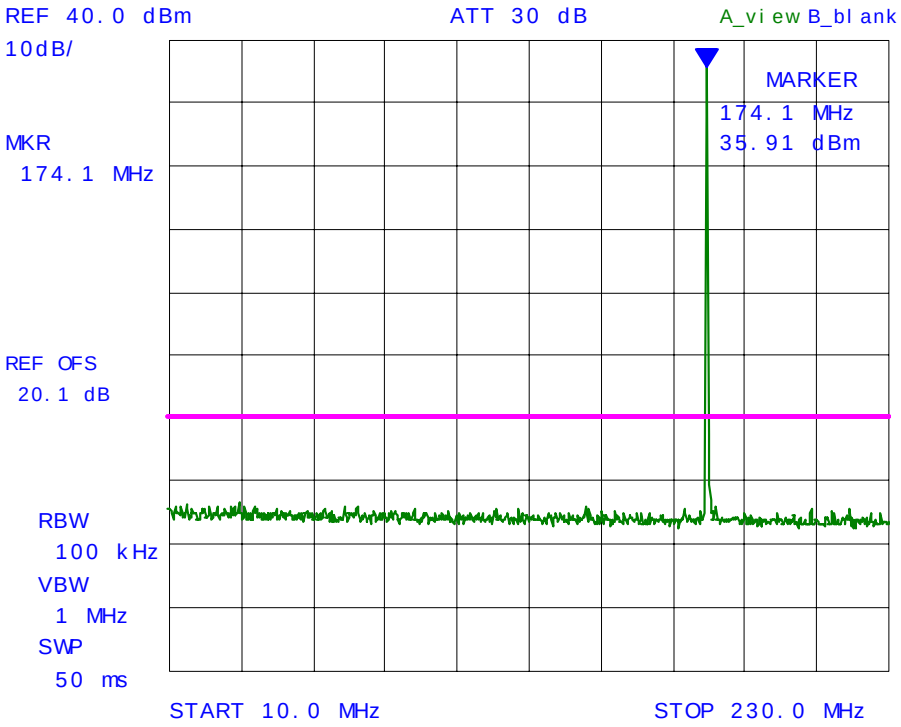


Plot # 52:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 160.050 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



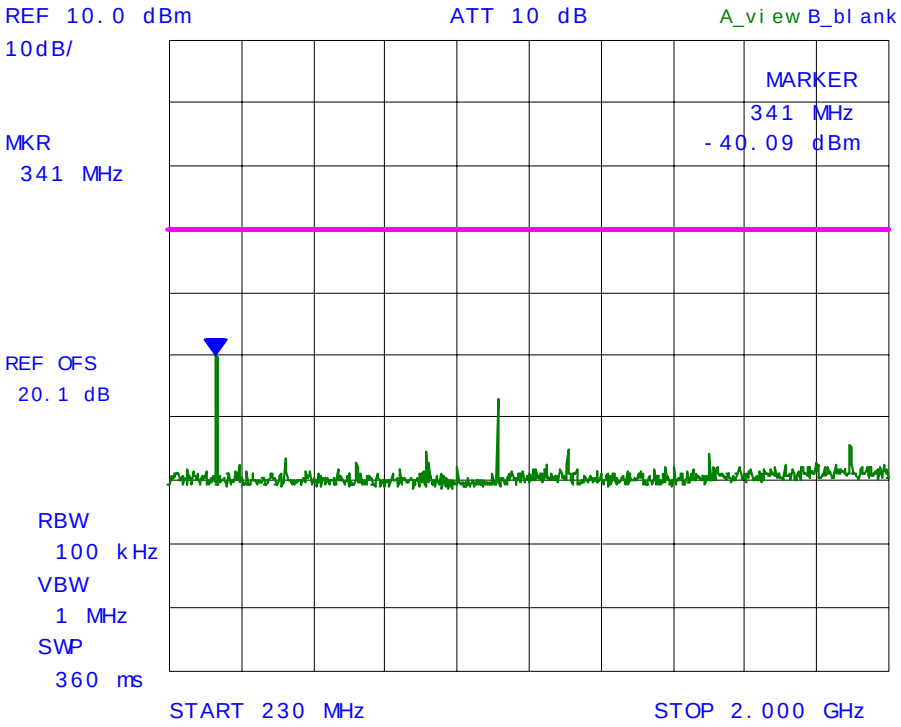
6.10.5.3. Near Highest Frequency (173.950 MHz)

Plot # 53:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave

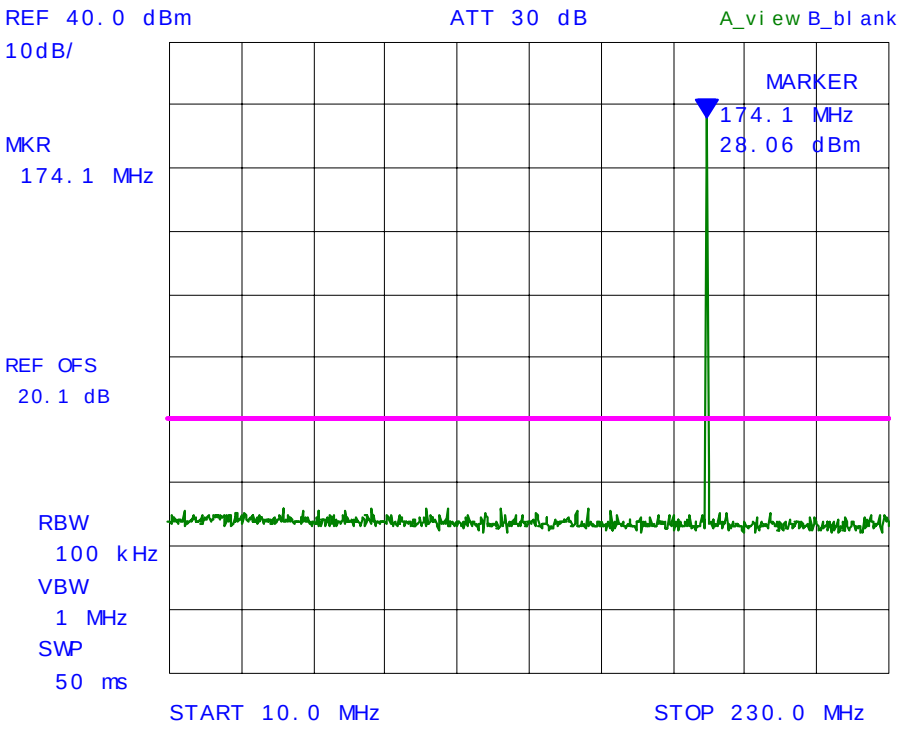


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

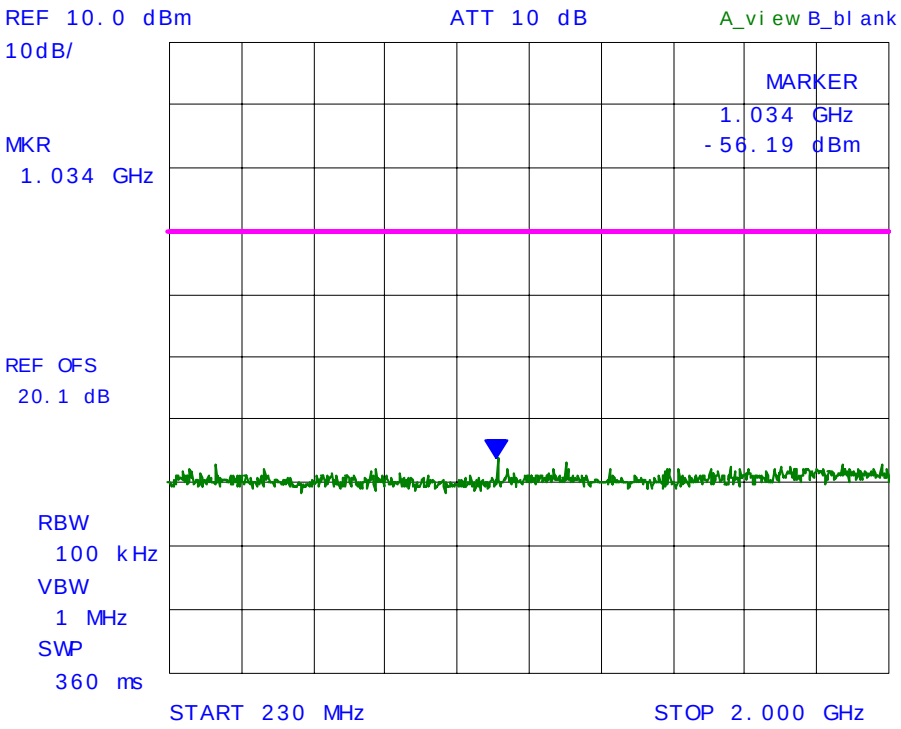
Plot # 54:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: FM with 2.5kHz sine wave



Plot #55:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



Plot # 56:
Spurious Emissions at Antenna Terminals
Carrier Frequency: 173.950 MHz
Channel Spacing: 12.5 kHz
Power: 1 W
Modulation: FM with 2.5kHz sine wave



6.11. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§§ 80.211(f)(3) & 90.210]

6.11.1. Limits

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

FCC Rules	Frequency Range	Attenuation Limit (dBc)
80.211(f)(3) - Marine 90.210(b)&(c) – Voice & data	10 MHz or Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P)
90.210(d) – Voice & data	10 MHz or Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	50+10*log(P) or -20 dBm or 70 dBc whichever is less

6.11.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Exhibit 8, § 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
(3) Spurious /harmonic emissions levels expressed in dBc (dB below carrier) are as follows:

ERP of spurious/harmonic (dBc) = ERP of carrier (dBm) – ERP of spurious/harmonic emission (dBm)

6.11.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8546A	…	9 kHz to 5.6 GHz with built-in 30 dB Gain Pre-selector, QP, Average & Peak Detectors.
RF Amplifier	Com-Power	PA-102		1 MHz to 1 GHz, 30 dB gain nomimal
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz, 30 dB nominal
Biconilog Antenna	EMCO	3142	10005	30 MHz to 2 GHz
Dipole Antenna	EMCO	3121C	8907-434	30 GHz – 1 GHz
Dipole Antenna	EMCO	3121C	8907-440	30 GHz – 1 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz
Horn Antenna	EMCO	3155	9911-5955	1 GHz – 18 GHz
RF Signal Generator	Hewlett Packard	HP 83752B	3610A00457	0.01 – 20 GHz

6.11.4. Test Data

Remarks:

- Since, the marine operating frequency band lies within the general band and RF output power is constant throughout the band. Tests are performed in the General Operating Frequency Bands 146-174 MHz and the results also represent the Marine band 156.025-157.425 MHz.
- Tests are performed with 12.5 kHz Channel Spacing where the lowest limit of 50+10*log(P) is applied as the worst case.
- The radiated emissions are performed with high power setting (5 Watts) at 3 meters distance to represents the worst-case test configuration.

6.11.4.1. Near Lowest Frequency (146.050 MHz)

Fundamental Frequency:	146.050 MHz
RF Output Power:	5 Watts
Modulation:	FM modulation with 2.5 kHz sine wave signal
Frequency Test Range:	10 MHz – 2 GHz

All spurious emissions and harmonics are more than 20 dB below the limit.

6.11.4.2. Near Middle Frequency (160.050 MHz)

Fundamental Frequency:	160.050 MHz
RF Output Power:	5 Watts
Modulation:	FM modulation with 2.5 kHz sine wave signal
Frequency Test Range:	10 MHz – 2 GHz

All spurious emissions and harmonics are more than 20 dB below the limit.

6.11.4.3. Near Highest Frequency (173.950 MHz)

Fundamental Frequency:	173.950 MHz
RF Output Power:	5 Watts
Modulation:	FM modulation with 2.5 kHz sine wave signal
Frequency Test Range:	10 MHz – 2 GHz

All spurious emissions and harmonics are more than 20 dB below the limit.

6.12. TRANSIENT FREQUENCY BEHAVIOR [§ 90.214]

6.12.1. Limits

Transient frequencies must be within the maximum frequency difference limits during the time intervals indicated:

Time intervals [1, 2]	Maximum frequency difference [3]	All equipment	
		150 to 174 MHz	421 to 512MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels			
t_1 [4] ……..	± 25.0 kHz	5.0 ms	10.0 ms
t_2 ……..	± 12.5 kHz	20.0 ms	25.0 ms
t_3 [4] ……..	± 25.0 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels			
t_1 [4] ……..	± 12.5 kHz	5.0 ms	10.0 ms
t_2 ……..	± 6.25 kHz	20.0 ms	25.0 ms
t_3 [4] ……..	± 12.5 kHz	5.0 ms	10.0 ms

1. t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.
   t_1 is the time period immediately following t_{on}.
   t_2 is the time period immediately following t_1.
   t_3 is the time period from the instant when the transmitter is turned off until t_{off}.
   t_{off} is the instant when the 1 kHz test signal starts to rise.
2. During the time from the end of t_2 to the beginning of t_3, the frequency difference must not exceed the limits specified in § 90.213.
3. Difference between the actual transmitter frequency and the assigned transmitter frequency.
4. If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

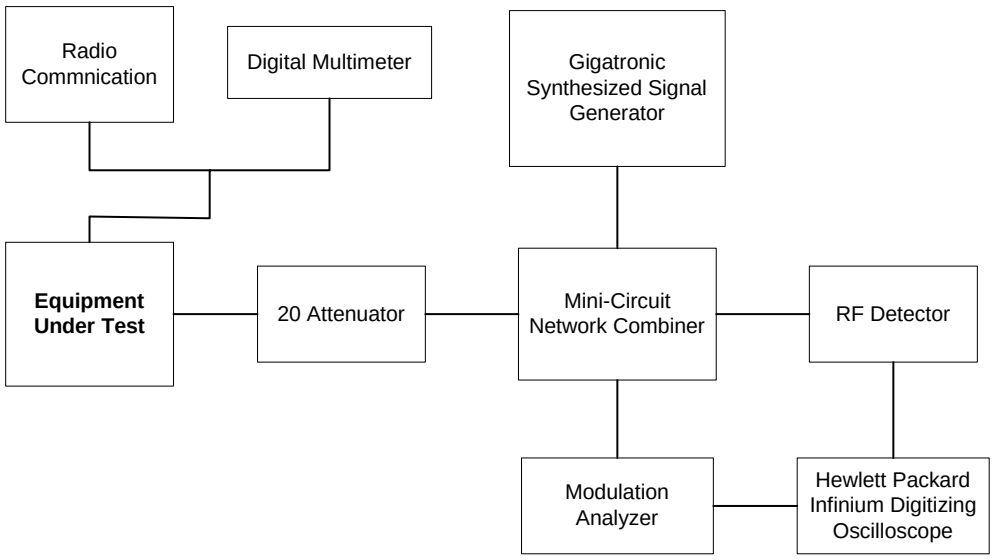
6.12.2. Method of Measurements

Refer to Section 8.6 of this test report and ANSI/TIA-603-B.

6.12.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Radio Communication	Marconi	2955	132037/226	20Hz – 20kHz
RF Synthesized Signal Generator	Gigatronic	6061A	5130408	10kHz – 1050 MHz
Network Combiner	Mini-Circuit	ZFSC-3-4	15542	1 – 1000 MHz
Infinium Digitizing Oscilloscope	Hewlett Packard	54810A	US38380192	DC - 500 MHz, 1 Gsa/s
RF Detector	Narda	503A-03	105	10 MHz - GHz
Attenuator	Weinschel	23-20-34	BH7876	DC - 18GHz
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150 kHz – 1300 MHz
Digital Multimeter	Rohde & Schwartz	UDS5	872984/067	DC-100kHz

6.12.4. Test Arrangement

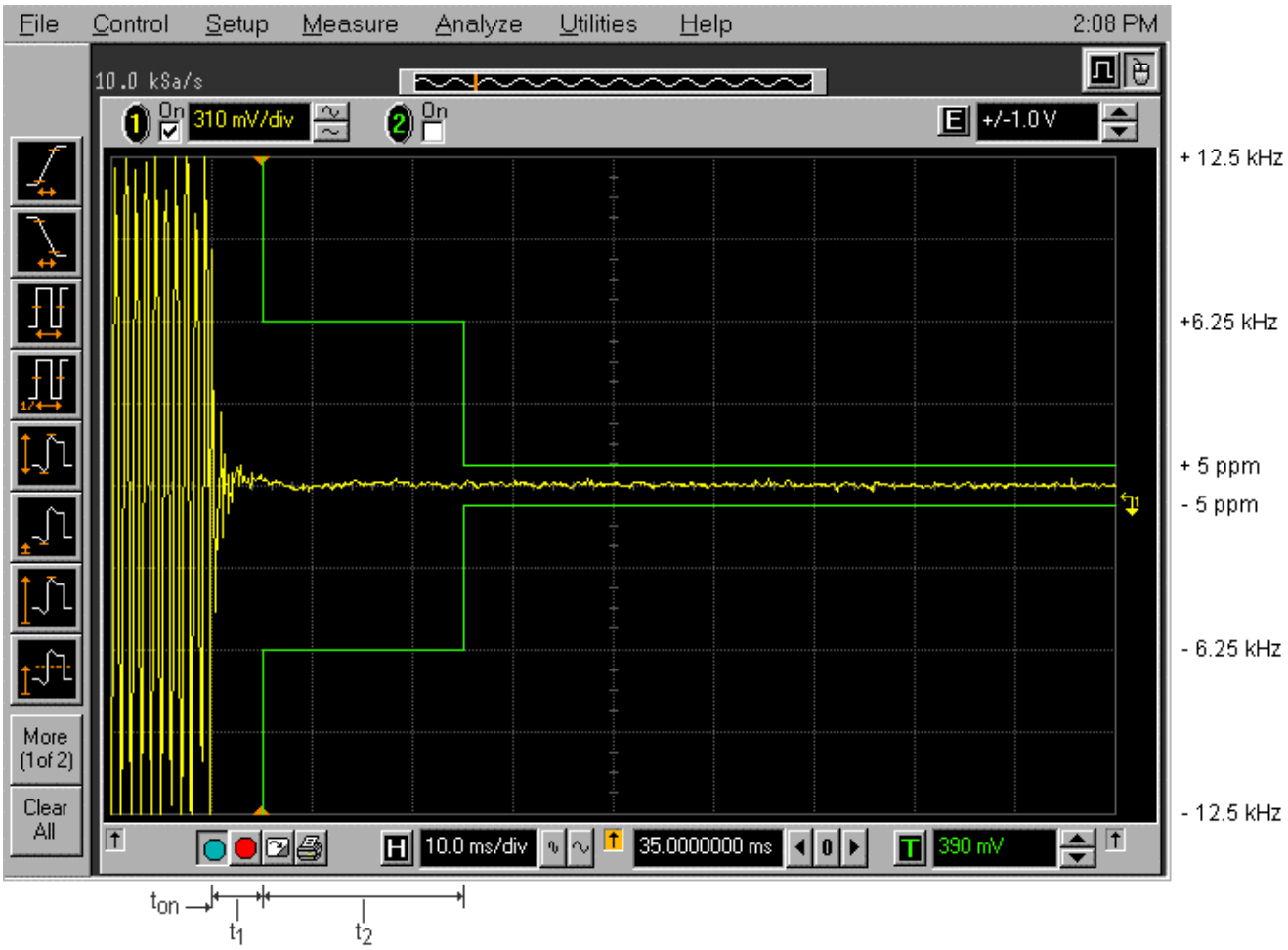


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

6.12.5. Test Data

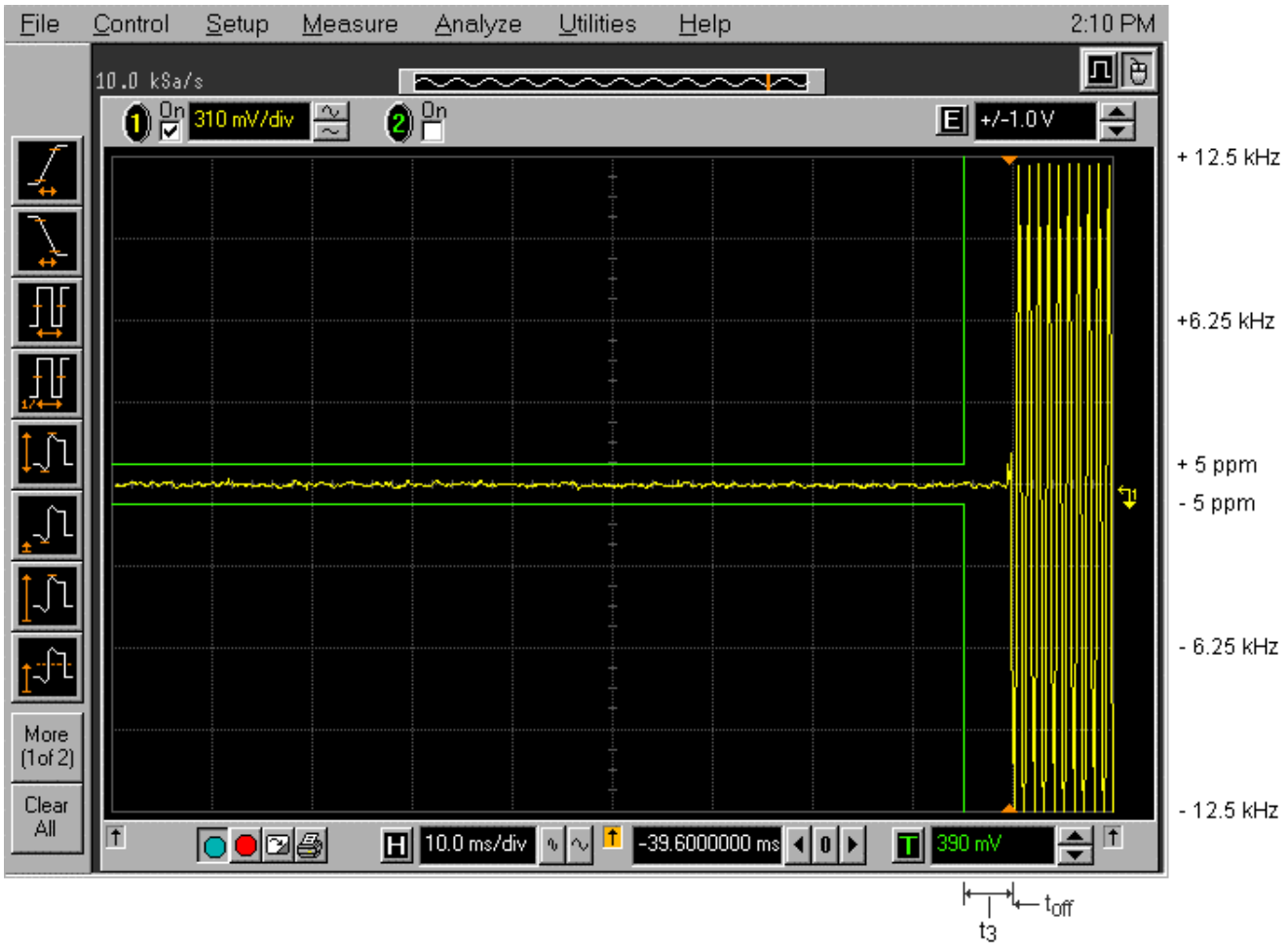
6.12.5.1. 12.5 kHz Channel Spacing Operation

Plot # 57:
Transient Frequency Behavior
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: Unmodulated
Description: Switch on condition t_{on}, t_1, and t_2



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

Plot # 58:
Transient Frequency Behavior
Carrier Frequency: 146.050 MHz
Channel Spacing: 12.5 kHz
Power: 5 W
Modulation: Unmodulated
Description: Switch off condition t_3, t_{off}



6.12.5.2. 25 kHz Channel Spacing Operation

Plot # 59:
Transient Frequency Behavior
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: Unmodulated
Description: Switch on condition t_{on}, t_1, and t_2

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

Plot # 60:
Transient Frequency Behavior
Carrier Frequency: 146.050 MHz
Channel Spacing: 25 kHz
Power: 5 W
Modulation: Unmodulated
Description: Switch off condition t_3, t_{off}

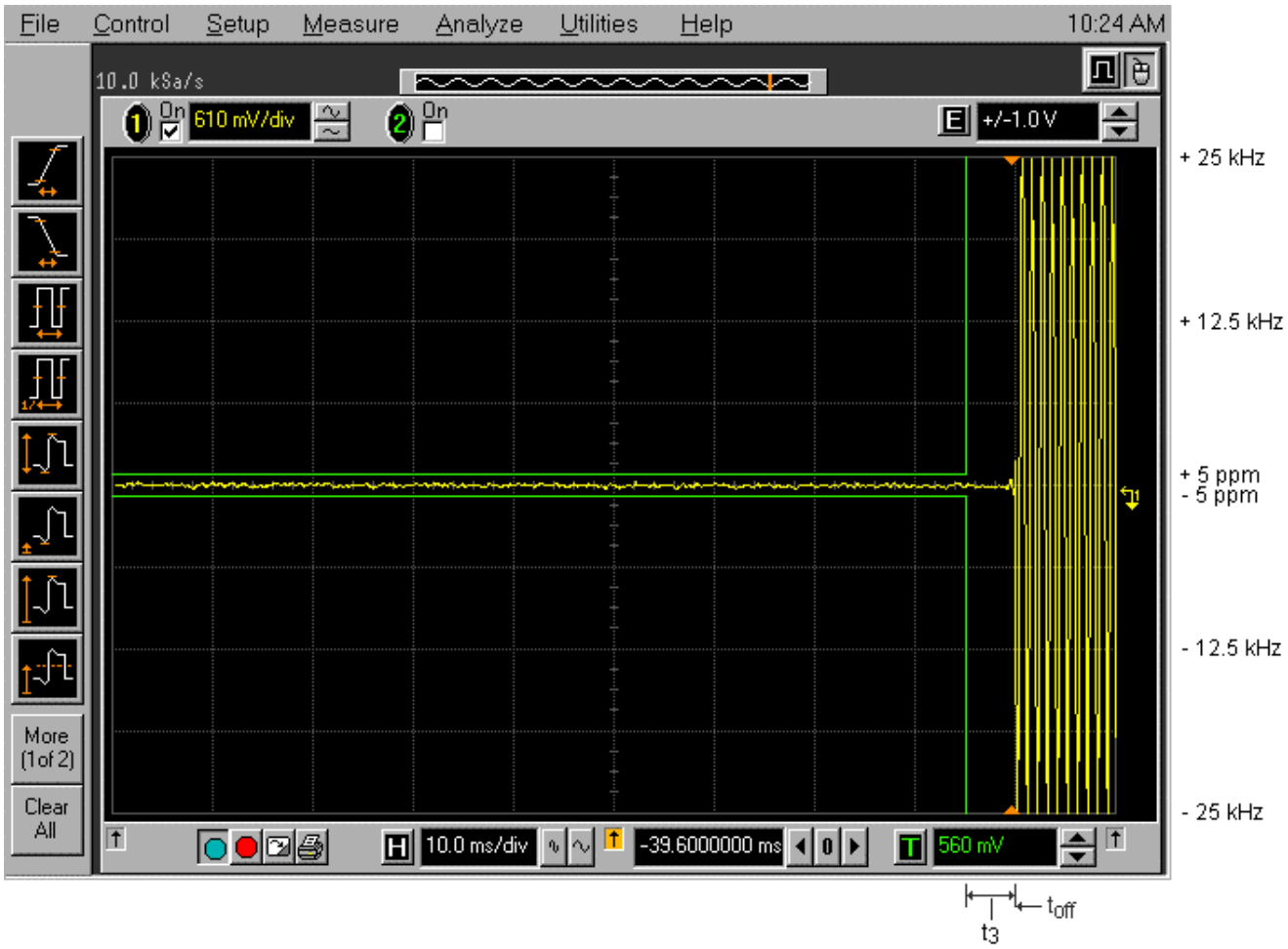


EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	±1.0	±1.0
Cable Loss Calibration	Normal (k=2)	±0.3	±0.5
EMI Receiver specification	Rectangular	±1.5	±1.5
Antenna Directivit	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center variation	Rectangular	0.0	±0.2
Antenna factor frequency interpolation	Rectangular	±0.25	±0.25
Measurement distance variation	Rectangular	±0.6	±0.4
Site imperfections	Rectangular	±2.0	±2.0
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67$(Bi) 0.3 (Lp) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k = 2 is used:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB

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

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.

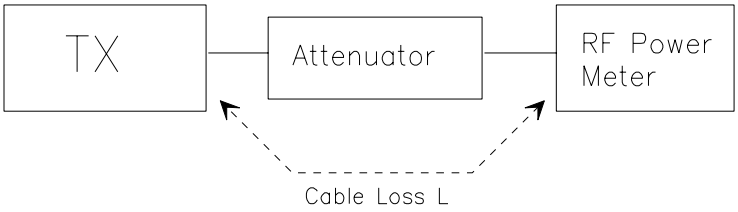
Step 2: Calculation of Average EIRP. See Figure 1

- 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.



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

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:	10 kHz
Video BW:	same
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

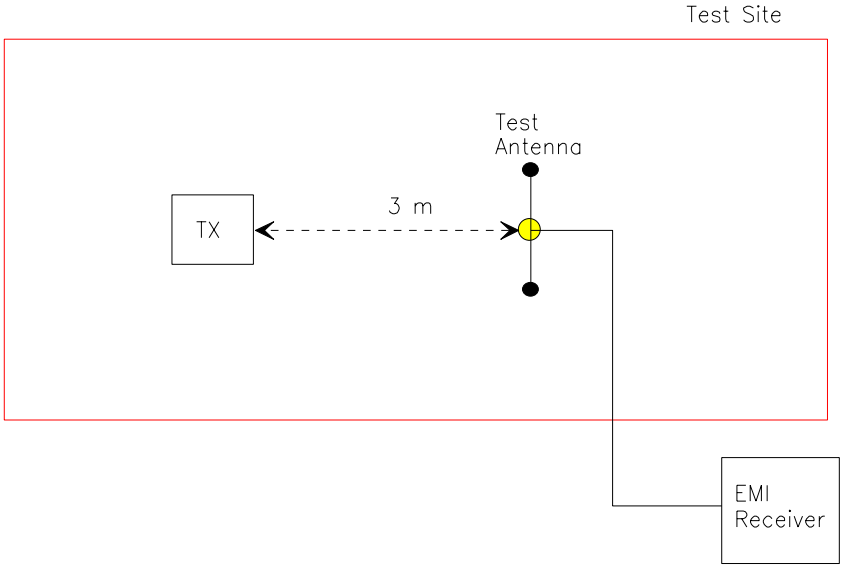
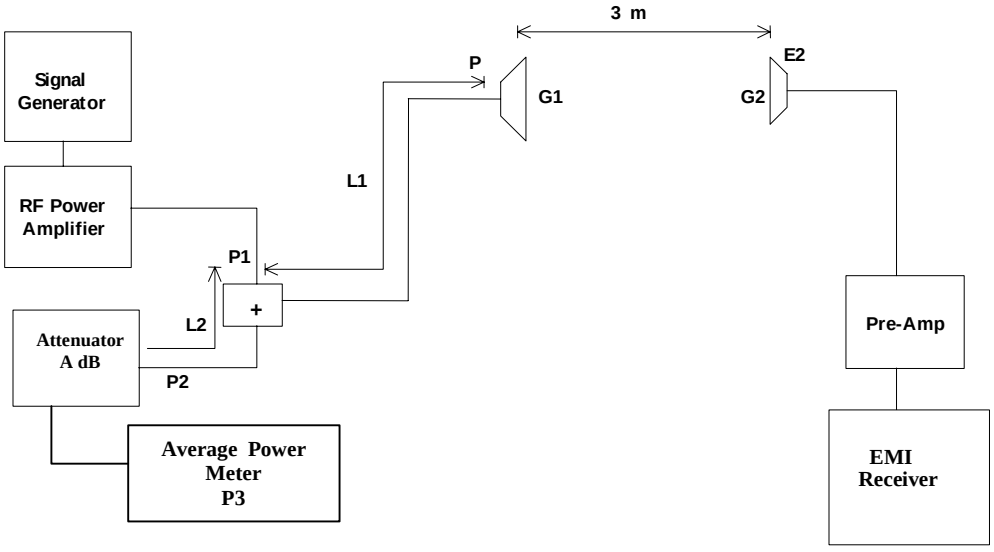


Figure 3



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 § 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.: $\pm$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 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.

8.6. TRANSIENT FREQUENCY BEHAVIOR

- Connect the transmitter under tests as shown in the above block diagram
- Set the signal generator to the assigned frequency and modulate with a 1 kHz tone at ±12.5 kHz deviation and its output level to be 50 dB below the transmitter rf output at the test receiver end.
- Set the horizontal sweep rate on the storage scope to 10 milliseconds per division and adjust the display to continuously view the 1000 Hz tone from the Demodulator Output Port (DOP) of the Test Receiver. Adjust the vertical scale amplitude control of the scope to display the 1000 Hz at ±4 divisions vertical Center at the display.
- Adjust the scope so it will trigger on an increasing magnitude from the RF trigger signal of the transmitter under test when the transmitter was turned on. Set the controls to store the display.
- The output at the DOP, due to the change in the ratio of the power between the signal generator input power and transmitter output power will, because of the capture effect of the test receiver, produce a change in display: For the first part of the sweep it will show the 1 kHz test signal. Then once the receiver's demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. The instant when the 1 kHz test signal is completely suppressed (including any capture time due to phasing) is considered to be t_{on}. The trace should be maintained within the allowed divisions during the period t_1 and t_2.
- During the time from the end of t_2 to the beginning of t_3 the frequency difference should not exceed the limits set by the FCC in Part 90.214 and the outlined in the Carrier Frequency Stability sections. The allowed limit is equal to FCC frequency tolerance limits specified in FCC 90.213.
- Repeat the above steps when the transmitter was turned off for measuring t_3.