

ROGERS LABS, INC.

4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

Application For Grant of Certification

FCC CFR47 Part 87
Model: GMN-02002

118-136.975 MHz
Aviation Communications Transceiver
FCC ID: IPH-03309

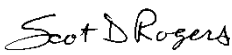
For

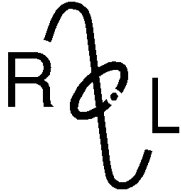
Garmin International, Inc.

1200 East 151st Street
Olathe, KS 66062

FCC Designation: US5305
ISED Registration: 3041A-1
Test Report Number: 190715

Test Date: July 15, 2019

Authorized Signatory: 
Scot D. Rogers



ROGERS LABS, INC.

4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

Engineering Test Report Application for Grant of Certification

For

Aviation Communications Transceiver Model: GMN-02002

Garmin International, Inc.

1200 East 151st Street
Olathe, KS 66062

FCC ID: IPH-03309
Frequency Range: 118-136.975 MHz

Test Date: July 15, 2019

Certifying Engineer: *Scot D. Rogers*

Scot D. Rogers
Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053
Telephone/Facsimile: (913) 837-3214

This report shall not be reproduced except in full, without the written approval of the laboratory. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053
Phone/Fax: (913) 837-3214
Revision 1

Garmin International, Inc.
Model: GMN-02002
Test: 190715
Test to: FCC Parts 2, 15, 87
File: GMN02002 FCC VHF Com TstRpt 190715 r1 Page 2 of 43

SN : 5FR000206
FCC ID: IPH-03309

Date: December 3, 2019

Table of Contents

TABLE OF CONTENTS.....	3
REVISION HISTORY	4
FORWARD	5
OPINION / INTERPRETATION OF RESULTS	5
APPLICABLE STANDARDS & TEST PROCEDURES	5
APPLICATION FOR CERTIFICATION.....	6
SYSTEM DESCRIPTION	9
Equipment Configuration.....	10
UNITS OF MEASUREMENTS	11
TEST SITE LOCATIONS	11
ENVIRONMENTAL CONDITIONS.....	11
LIST OF TEST EQUIPMENT	12
TRANSMITTER POWER OUTPUT	13
Measurements Required	13
Test Arrangement.....	13
Table 1 Transmitter Power Results.....	14
Figure 1 Power Output Across Frequency Band 118-136.750 MHz (25 kHz mode, 10 Watt)	15
Figure 2 Power Output Across Frequency Band 118-136.750 MHz (25 kHz mode, 16 Watt)	16
Figure 3 Power Output 136.992 MHz (8.33 kHz mode)	17
MODULATION CHARACTERISTICS.....	18
Measurements Required	18
Test Arrangement.....	18
Modulation Characteristic Results.....	19
Figure 4 Modulation Characteristics	19
Figure 5 Audio Frequency Response / Modulation Characteristics	20
OCCUPIED BANDWIDTH	21
Measurements Required	21
Test Arrangement.....	21
Table 2 Occupied Bandwidth Results	22

Figure 6 Occupied Band Width (25 kHz channels 118.000-136.975 MHz)	23
Figure 7 Occupied Band Width (8.33 kHz channels 118.000-136.992 MHz)	24
SPURIOUS EMISSIONS AT ANTENNA TERMINALS.....	25
Measurements Required	25
Test Arrangement	25
Table 3 Spurious Emissions at Antenna Terminal Results (10 Watt)	26
Table 4 Spurious Emissions at Antenna Terminal Results (16 Watt)	27
Figure 8 Spurious Emissions at Antenna Terminal (10 Watt).....	28
Figure 9 Spurious Emissions at Antenna Terminal (16 Watt).....	29
Figure 10 Spectral Emission Mask at Antenna Terminal (10 Watt)	30
Figure 11 Spectral Emission Mask at Antenna Terminal (16 Watt)	31
FIELD STRENGTH OF SPURIOUS RADIATION (UNWANTED EMISSIONS).....	32
Measurements Required	32
Test Arrangement	32
Table 5 General Spurious Radiated Emission Results (Worst-case).....	34
Table 6 Spurious Radiated Emission Results for 118.000 MHz Operation	34
Table 7 Spurious Radiated Emission Results for 127.500 MHz Operation	35
Table 8 Spurious Radiated Emission Results for 136.975 MHz Operation	35
Table 9 Spurious Radiated Emission Results for 136.992 MHz Operation	36
FREQUENCY STABILITY	37
Measurements Required	37
Test Arrangement	37
Table 10 Frequency Stability vs. Temperature Results.....	38
Table 11 Frequency Stability vs. Input Power Supply Voltage Results	38
ANNEX.....	39
Annex A Measurement Uncertainty Calculations	40
Annex B Additional Test Equipment List.....	41
Annex C Rogers Qualifications.....	42
Annex D Laboratory Certificate of Accreditation	43

Revision History

Revision 1 Issued December 3, 2019

Forward

In accordance with the Federal Communications, Code of Federal Regulations dated July 15, 2019, Part 2 Subpart J, Paragraphs 2.907, 2.911, 2.913, 2.915, 2.925, 2.926, 2.1031 through 2.1057, and Part 87, Subchapter D, Paragraphs 87.131 through 87.147 the following information is submitted for consideration on obtaining Grant of Certification.

Opinion / Interpretation of Results

Tests Performed	Results
Emissions Tests	
Requirements per CFR47 paragraphs 2.1031-2.1057	Complies
Requirements per CFR47 paragraphs 87.131	Complies
Requirements per CFR47 paragraphs 87.133	Complies
Requirements per CFR47 paragraphs 87.135	Complies
Requirements per CFR47 paragraphs 87.139	Complies
Requirements per CFR47 paragraphs 87.141	Complies

Applicable Standards & Test Procedures

In accordance with the Federal Communications Code of Federal Regulations Part 2, Subpart J, Paragraphs 2.907, 2.911, 2.913, 2.925, 2.926, 2.1031 through 2.1057, and applicable paragraphs of Part 87 the following is submitted for consideration in obtaining Grant of Certification. Test procedures used are the established Methods of Measurement of Radio-Noise Emissions as described in ANSI C63.4-2014 and ANSI C63.26-2015.

Application for Certification

- (1) The full name and mailing address of the manufacturer of the device and the applicant for certification.

Garmin International, Inc. 1200 East 151st Street Olathe, KS 66062

- (2) FCC identifier. FCC ID: IPH-03309

- (3) A copy of the installation and operating instructions to be furnished the user. A draft copy of the instructions may be submitted if the actual document is not available. The actual document shall be furnished to the FCC when it becomes available.

Refer to exhibit for Draft Instruction Manual.

- (4) Type or types of emission. 6K00A3E (25 kHz), (5K60A3E for 8.33 kHz operation)

- (5) Frequency range. 118-136.975 MHz (25 kHz channel operation), (118-136.992, 8.33 kHz channels)

- (6) Range of operating power values or specific operating power levels, and description of any means provided for variation of operating power.

Nominal 10 W or 16 W minimum, 40 or 42 dBm

- (7) Maximum power rating as defined in the applicable part(s) of the rules.

Maximum allowable power output of 55 Watts as defined per CFR47 paragraph 87.131.

- (8) The dc voltages applied to and dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Power delivered into final amplifier

16W Operation 9.95 Volts @ 3.11 Amps (30.94 Watts)

10W Operation 8.19 Volts @ 2.57 Amps (21.05 Watts)

- (9) Tune-up procedure over the power range, or at specific operating power levels.

Refer to Exhibit for Transceiver Alignment Procedure.

- (10) A schematic diagram and a description of all circuitry and devices provided for determining and stabilizing frequency, for suppression of spurious radiation, for limiting modulation, and for limiting power.

Refer to Exhibit for Circuit information and theory of operation.

- (11) A photograph or drawing of the equipment identification plate or label showing the information to be placed thereon.

Refer to Exhibit for Photograph or Drawing.

- (12) Photographs (8" × 10") of the equipment of sufficient clarity to reveal equipment construction and layout, including meters, if any, and labels for controls and meters and sufficient views of the internal construction to define component placement and chassis assembly. Insofar as these requirements are met by photographs or drawings contained in instruction manuals supplied with the certification request, additional photographs are necessary only to complete the required showing.

Refer to Exhibit for Drawings of Components Layout and Chassis Drawings.

- (13) For equipment employing digital modulation techniques, a detailed description of the modulation system to be used, including the response characteristics (frequency, phase and amplitude) of any filters provided, and a description of the modulating wave train, shall be submitted for the maximum rated conditions under which the equipment will be operated.

Not applicable

- (14) The data required by §§2.1046 through 2.1057, inclusive, measured in accordance with the procedures set out in §2.1041.

Data is contained in this application

- (15) The application for certification of an external radio frequency power amplifier under part 97 of this chapter need not be accompanied by the data required by paragraph (b)(14) of this section. In lieu thereof, measurements shall be submitted to show compliance with the technical specifications in subpart C of part 97 of this chapter and such information as required by §2.1060 of this part.

Does not apply to this device or application.

- (16) An application for certification of an AM broadcast stereophonic exciter-generator intended for interfacing with existing certified, or formerly type accepted or notified transmitters must include measurements made on a complete stereophonic transmitter. The instruction book must include complete specifications and circuit requirements for interconnecting with existing transmitters. The instruction book must also provide a full description of the equipment and measurement procedures to monitor modulation and to verify that the combination of stereo exciter-generator and transmitter meet the emission limitations of §73.44.

Does not apply to this device or application.

- (17) Applications for certification required by §25.129 of this chapter shall include any additional equipment test data required by that section.

Does not apply to this device or application.

- (18) An application for certification of a software defined radio must include the information required by §2.944.

Does not apply to this device or application.

- (19) Applications for certification of equipment operating under part 27 of this chapter, that a manufacturer is seeking to certify for operation in the:

- (i) 1755-1780 MHz, 2155-2180 MHz, or both bands shall include a statement indicating compliance with the pairing of 1710-1780 and 2110-2180 MHz specified in §§27.5(h) and 27.75 of this chapter.
- (ii) 1695-1710 MHz, 1755-1780 MHz, or both bands shall include a statement indicating compliance with §27.77 of this chapter.
- (iii) 600 MHz band shall include a statement indicating compliance with §27.75 of this chapter.

Does not apply to this device or application.

- (20) Before equipment operating under part 90 of this chapter and capable of operating on the 700 MHz interoperability channels (See §90.531(b)(1) of this chapter) may be marketed or sold, the manufacturer thereof shall have a Compliance Assessment Program Supplier's Declaration of Conformity and Summary Test Report or, alternatively, a document detailing how the manufacturer determined that its equipment complies with §90.548 of this chapter and that the equipment is interoperable across vendors. Submission of a 700 MHz narrowband radio for certification will constitute a representation by the manufacturer that the radio will be shown, by testing, to be interoperable across vendors before it is marketed or sold.

Does not apply to this device or application.

- (21) Contain at least one drawing or photograph showing the test set-up for each of the required types of tests applicable to the device for which certification is requested. These drawings or photographs must show enough detail to confirm other information contained in the test report. Any photographs used must be focused originals without glare or dark spots and must clearly show the test configuration used.

Data is contained in this application or application exhibits.

System Description

The GMN-02002 is an aeronautical communications transceiver. The authorized transmitter operational frequency band is 118.000 to 136.975 MHz (25 kHz mode). The device is marketed as Aircraft Panel Mounted Navigation Display Unit. The design provides communication capability in the Aviation VHF Band with channel operational capability for 25 kHz or 8.33 kHz Channel Spacing. In addition to the authorized frequency band the design provides for VHF operation in 8.33 kHz channel spacing for international frequency band services and compatibility. This report documents operation for this application and authorization only as provided in 47CFR 87.173.

Equipment Configuration

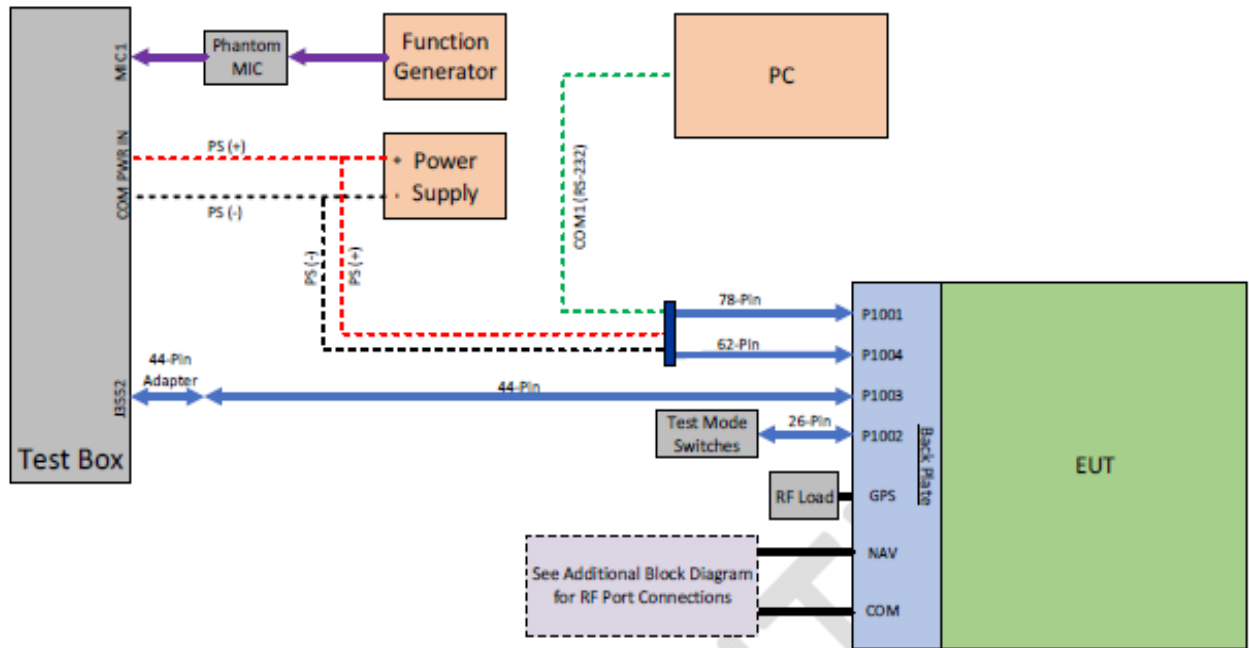


Figure 2 – General Test Block Diagram

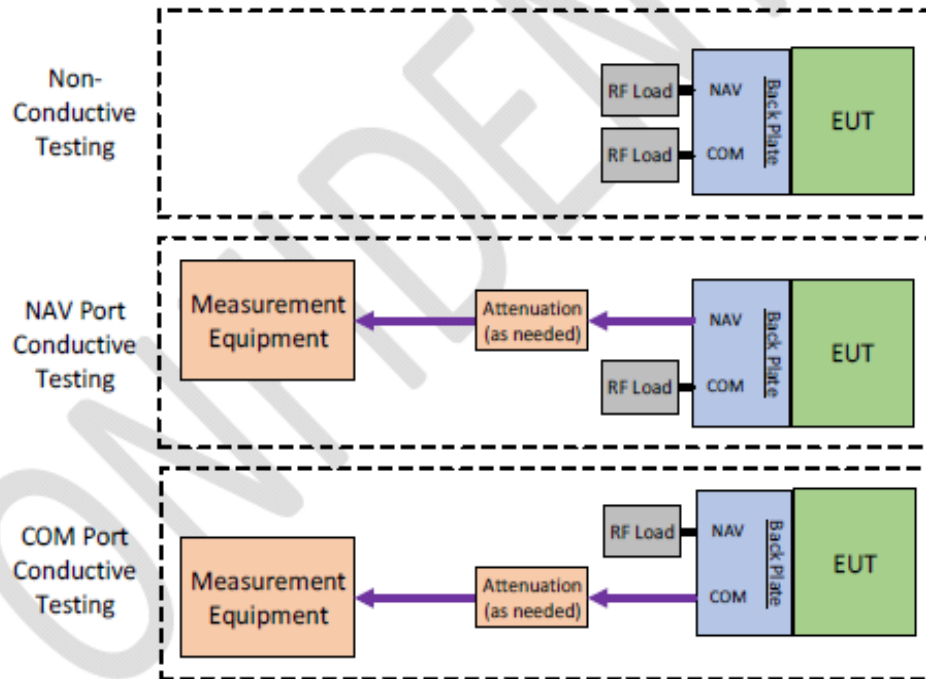


Figure 3- COM and NAV RF Port Test Block Diagram

Units of Measurements

AC Line Conducted EMI Data is in dB μ V; dB referenced to one microvolt.

Radiated EMI Data is in dB μ V/m; dB/m referenced to one microvolt per meter

Antenna Conducted Data is in dBm, dB referenced to one milliwatt

Test Site Locations

Conducted EMI Antenna Port conducted emissions testing was performed in a shielded screen room located at Rogers Labs, Inc., 4405 W. 259th Terrace, Louisburg, KS.

Radiated EMI The radiated emissions testing performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., 4405 W. 259th Terrace, Louisburg, KS.

Registered Site information: FCC Site: US5305 and ISED: 3041A, CAB Identifier: US0096

NVLAP Accreditation Lab code 200087-0

Environmental Conditions

Ambient Temperature 23.4° C

Relative Humidity 37%

Atmospheric Pressure 1017.3 mb

List of Test Equipment

<u>Equipment</u>	<u>Manufacturer</u>	<u>Model (SN)</u>	<u>Band</u>	<u>Cal Date(m/d/y)</u>	<u>Due</u>
<input type="checkbox"/> LISN	FCC	FCC-LISN-50-25-10(1PA) (160611)	.15-30MHz	4/18/2019	4/18/2020
<input type="checkbox"/> LISN	Compliance Design	FCC-LISN-2.Mod.cd,(126)	.15-30MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(303073)	9kHz-40 GHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303069)	9kHz-40 GHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303071)	9kHz-40 GHz	10/16/2018	10/16/2019
<input type="checkbox"/> Cable	Belden	RG-58 (L1-CAT3-11509)	9kHz-30 MHz	10/16/2018	10/16/2019
<input type="checkbox"/> Cable	Belden	RG-58 (L2-CAT3-11509)	9kHz-30 MHz	10/16/2018	10/16/2019
<input type="checkbox"/> Antenna	ARA	BCD-235-B (169)	20-350MHz	10/16/2018	10/16/2019
<input type="checkbox"/> Antenna	EMCO	3147 (40582)	200-1000MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Antenna	ETS-Lindgren	3117 (200389)	1-18 GHz	5/2/2018	5/2/2020
<input type="checkbox"/> Antenna	Com Power	AH-118 (10110)	1-18 GHz	10/16/2018	10/24/2019
<input type="checkbox"/> Antenna	Com Power	AH-840 (101046)	18-40 GHz	4/18/2019	4/18/2021
<input checked="" type="checkbox"/> Antenna	Com Power	AL-130 (121055)	.001-30 MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Antenna	Sunol	JB-6 (A100709)	30-1000 MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Analyzer	Rohde & Schwarz	ESU40 (100108)	20Hz-40GHz	4/18/2019	4/18/2020
<input checked="" type="checkbox"/> Analyzer	Rohde & Schwarz	ESW44 (101534)	20Hz-44GHz	1/31/2019	1/31/2020
<input type="checkbox"/> Analyzer	Rohde & Schwarz	FS-Z60, 90, 140, and 220	40GHz-220GHz	12/22/2017	12/22/2019
<input checked="" type="checkbox"/> Amplifier	Com-Power	PA-010 (171003)	100Hz-30MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Amplifier	Com-Power	CPPA-102 (01254)	1-1000 MHz	10/16/2018	10/16/2019
<input checked="" type="checkbox"/> Amplifier	Com-Power	PAM-118A (551014)	0.5-18 GHz	10/16/2018	10/16/2019
<input type="checkbox"/> Amplifier	Com-Power	PAM-840A (461328)	18-40 GHz	10/16/2018	10/16/2019
<input type="checkbox"/> Power Meter	Agilent	N1911A with N1921A	0.05-40 GHz	4/18/2019	4/18/2020
<input checked="" type="checkbox"/> Generator	Rohde & Schwarz	SMB100A6 (100150)	20Hz-6 GHz	4/18/2019	4/18/2020
<input type="checkbox"/> Generator	Rohde & Schwarz	SMBV100A6 (260771)	20Hz-6 GHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	BRC50722 (009).9G notch	30-1800 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	HPM50114 (017)1.5G HPF	30-18000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	HPM50117 (063) 3G HPF	30-18000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	HPM50105 (059) 6G HPF	30-18000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	BRM50702 (172) 2G notch	30-1800 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	BRC50703 (G102) 5G notch	30-1800 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> RF Filter	Micro-Tronics	BRC50705 (024) 5G notch	30-1800 MHz	4/18/2019	4/18/2020
<input checked="" type="checkbox"/> Attenuator	Fairview	SA6NFNF100W-14 (1625)	30-1800 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> Attenuator	Mini-Circuits	VAT-3W2+ (1436)	30-6000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> Attenuator	Mini-Circuits	VAT-3W2+ (1445)	30-6000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> Attenuator	Mini-Circuits	VAT-6W2+ (1438)	30-6000 MHz	4/18/2019	4/18/2020
<input type="checkbox"/> Attenuator	Mini-Circuits	VAT-6W2+ (1736)	30-6000 MHz	4/18/2019	4/18/2020
<input checked="" type="checkbox"/> Weather station	Davis	6312 (A81120N075)		10/26/2018	10/26/2019

Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053
Phone/Fax: (913) 837-3214
Revision 1

Garmin International, Inc.
Model: GMN-02002
Test: 190715
Test to: FCC Parts 2, 15, 87
File: GMN02002 FCC VHF Com TstRpt 190715 r1 Page 12 of 43

SN : 5FR000206
FCC ID: IPH-03309

Date: December 3, 2019

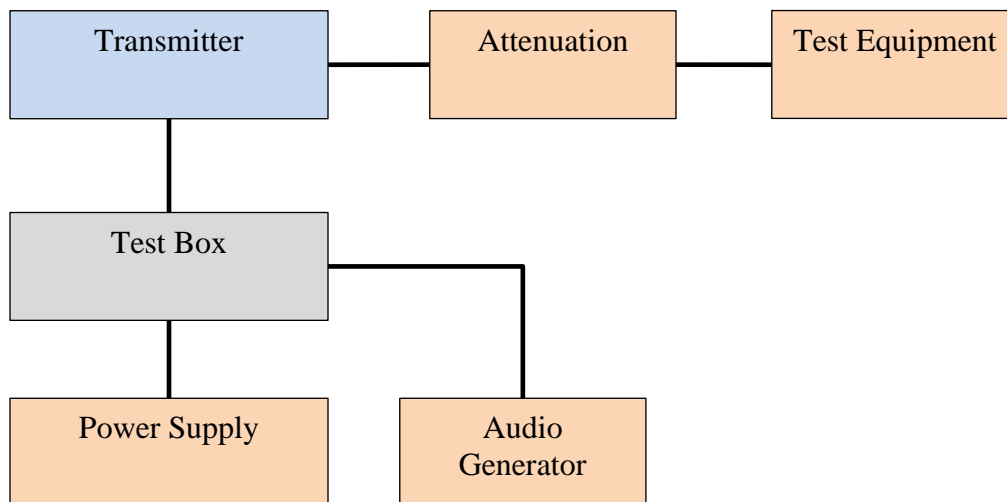
Transmitter Power Output

Measurements Required

Measurements shall be made to establish the radio frequency power delivered by the transmitter into the standard output termination. The power output shall be monitored and recorded, and no adjustment shall be made to the transmitter after the test has begun, except as noted below:

If the power output is adjustable, measurements shall be made for the highest and lowest power levels. Output transmitter power is not user selectable.

Test Arrangement



The radio frequency power output was measured at the antenna terminal by placing appropriate attenuation in the antenna line and observing the emission with the spectrum analyzer. The spectrum analyzer and attenuation offered an impedance of 50Ω to match the impedance of the standard antenna. A Rohde & Schwarz ESU40 Spectrum Analyzer was used to measure the radio frequency power at the antenna port. Data was taken in dBm and converted to watts as shown in the following Table. Refer to Figures one through three showing plots of output power of the transmitter across the frequency band. Data was taken per CFR47 Paragraph 2.1046(a) and applicable paragraphs of Part 87.

P_{dBm} = power in dB above 1 milliwatt
 Milliwatts = $10^{(P_{dBm}/10)}$
 Watts = (Milliwatts)(0.001)(W/mW)
 Milliwatts = $10^{(40.79/10)}$
 = 11,995 mW
 = 12.0 Watts Peak power

Table 1 Transmitter Power Results

Frequency	Input Voltage	P_{dBm}	P_{mw}	P_w
VHF Communications (25 kHz Channel)				
118.000	14	40.79	11,995.0	12.0
127.000	14	40.80	12,022.6	12.0
136.975	14	41.13	12,971.8	13.0
VHF Communications (25 kHz Channel)				
118.000	28	42.41	17,418.1	17.4
127.000	28	42.50	17,782.8	17.8
136.975	28	42.79	19,010.8	19.0
VHF Communications (8.33 kHz Channel)				
118.000	14	40.79	11,995.0	12.0
127.000	14	40.80	12,022.6	12.0
136.992	14	41.13	12,971.8	13.0
VHF Communications (8.33 kHz Channel)				
118.000	28	42.41	17,418.1	17.4
127.000	28	42.50	17,782.8	17.8
136.992	28	42.79	19,010.8	19.0

The EUT demonstrated compliance with specifications of CFR47 Paragraph 2.1046(a) and applicable Parts of 2 and 87.131. There are no deviations to the specifications.

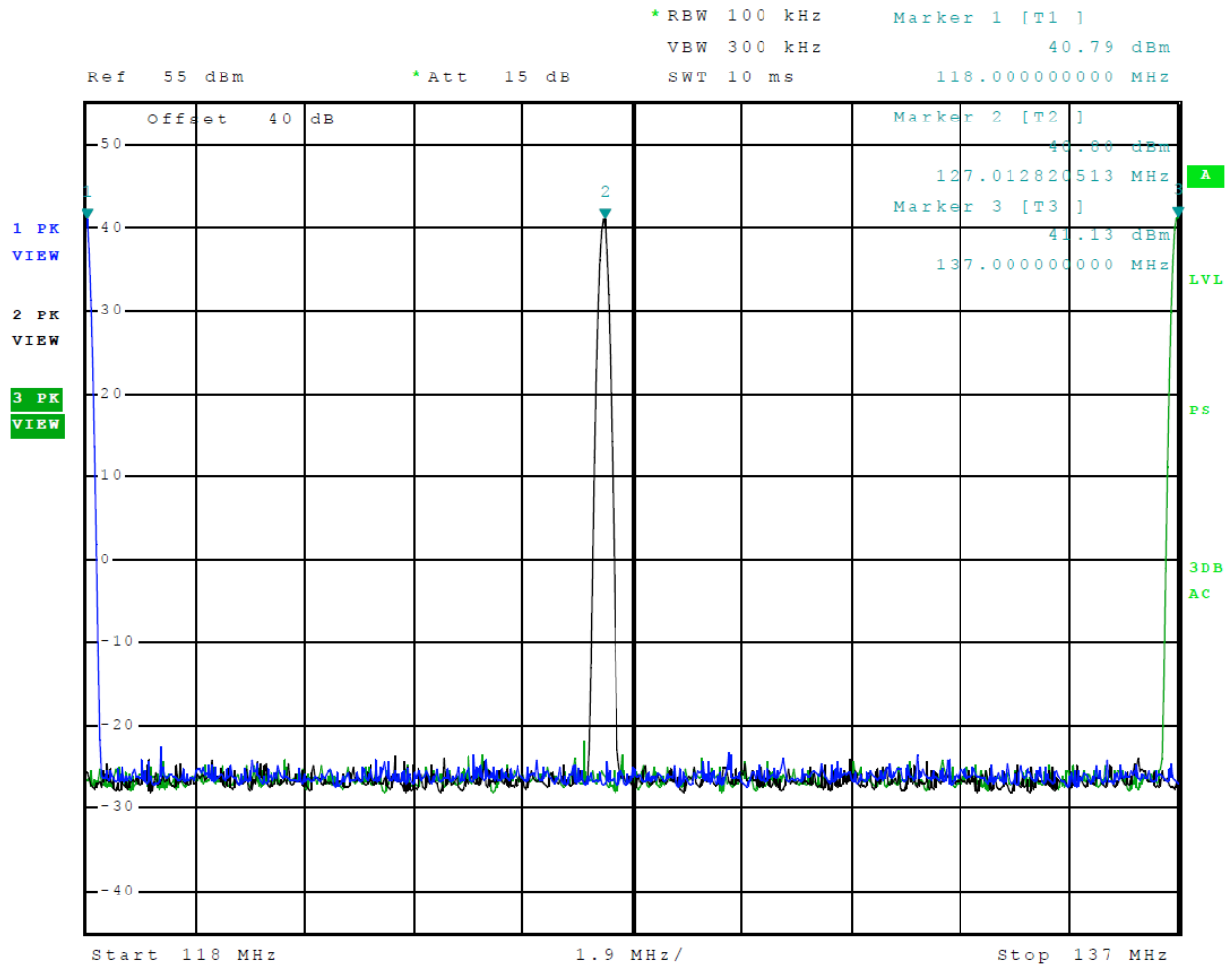


Figure 1 Power Output Across Frequency Band 118-136.750 MHz (25 kHz mode, 10 Watt)

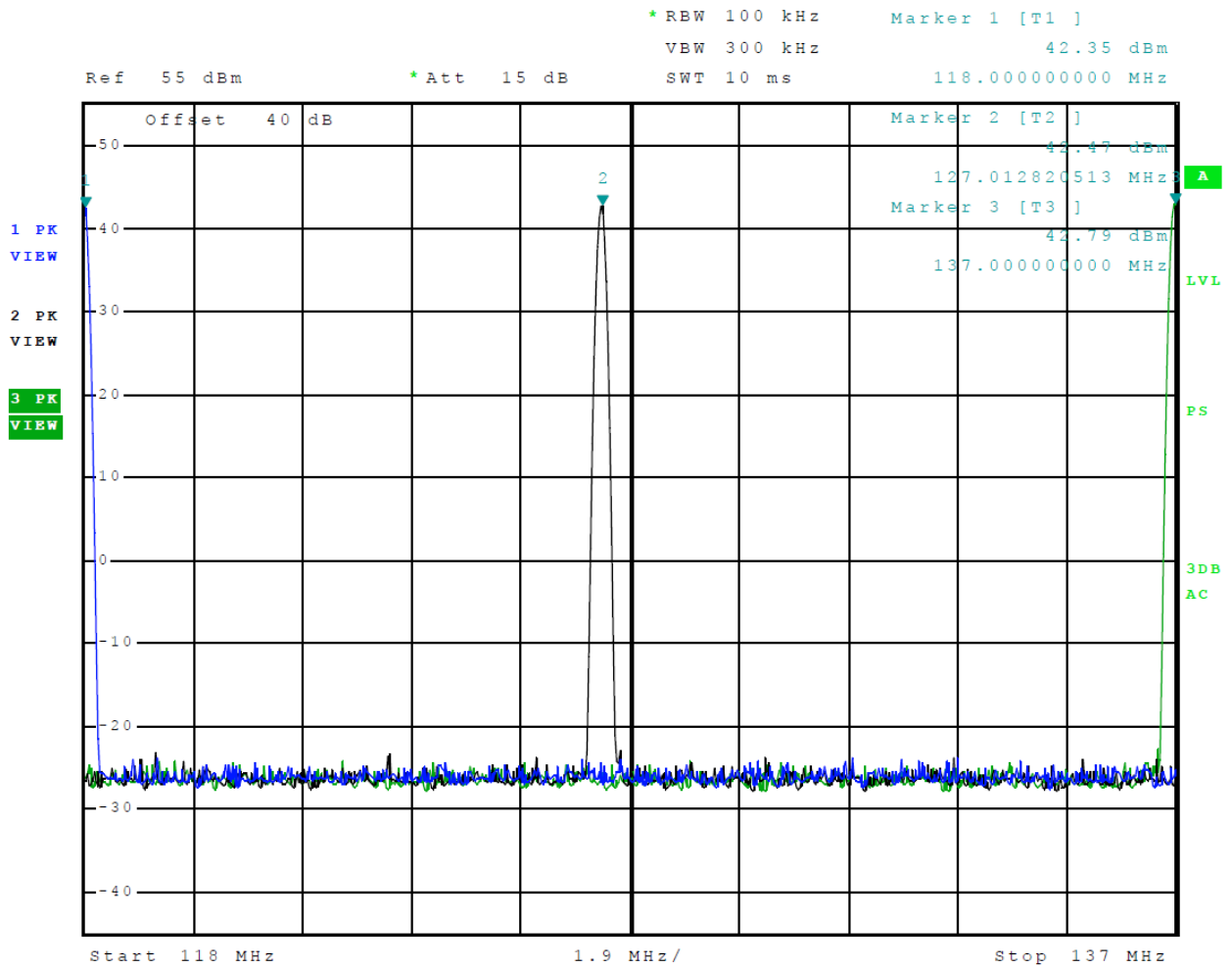


Figure 2 Power Output Across Frequency Band 118-136.750 MHz (25 kHz mode, 16 Watt)

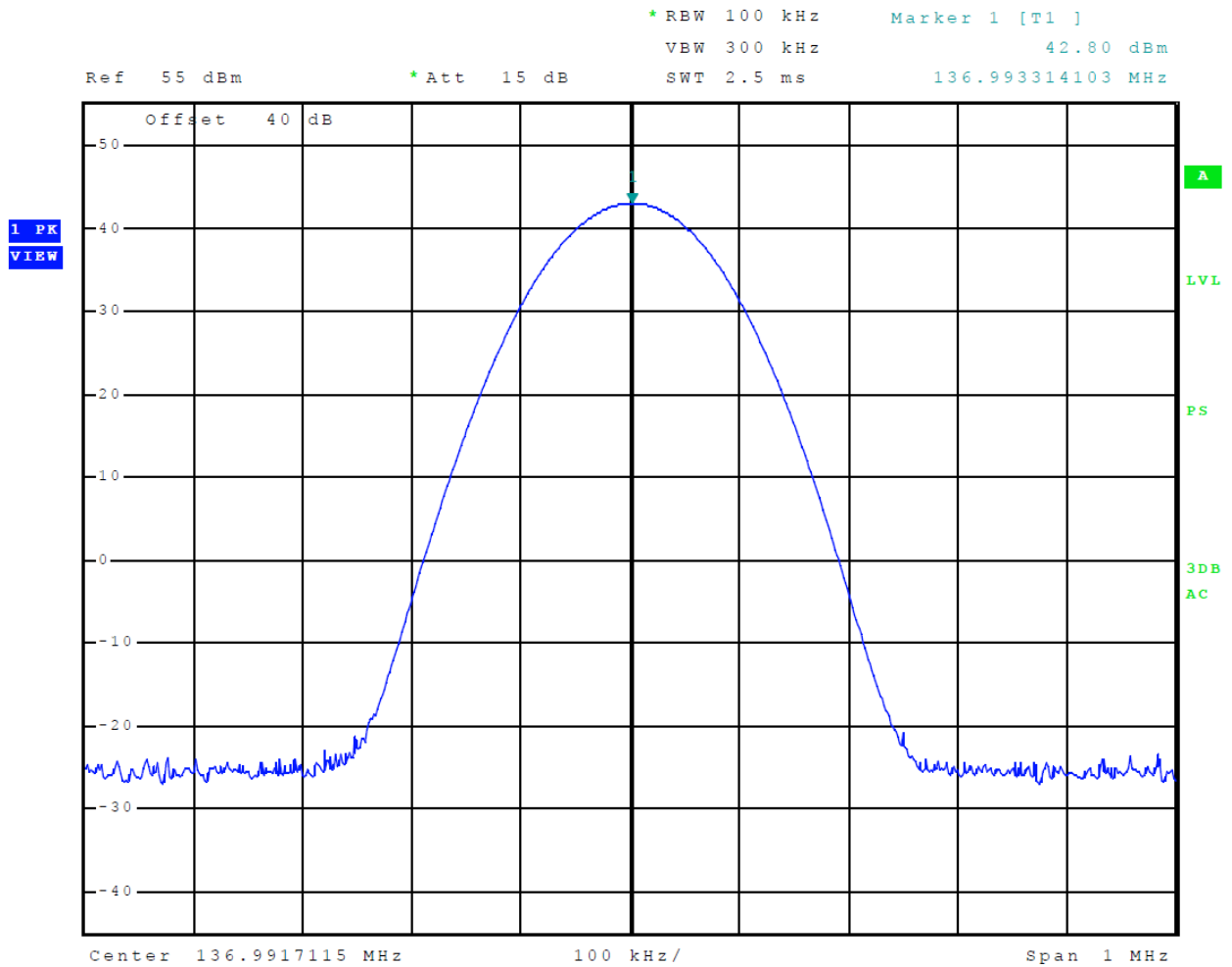


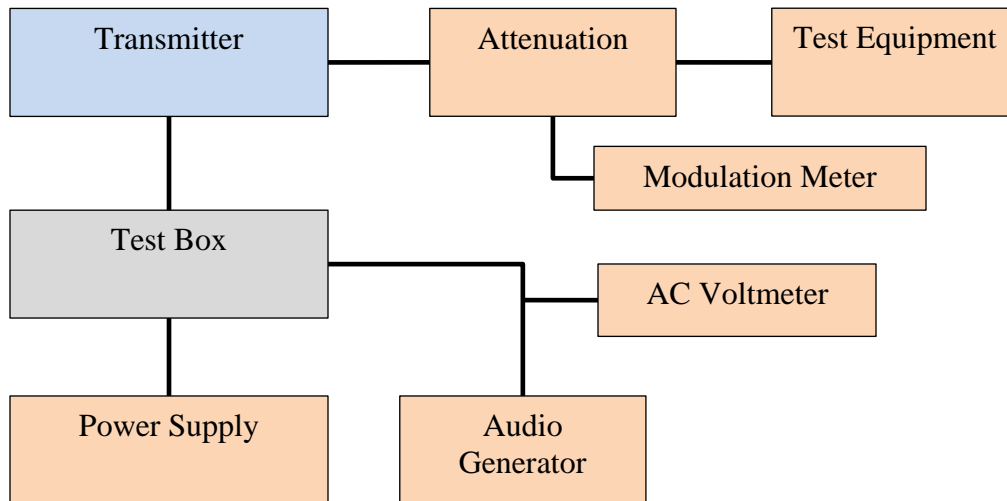
Figure 3 Power Output 136.992 MHz (8.33 kHz mode)

Modulation Characteristics

Measurements Required

A curve or equivalent data, which shows that the equipment will meet the modulation requirements of the rules, under which the equipment is licensed, shall be submitted. The radio frequency output was coupled to a Spectrum Analyzer and a modulation meter. The spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operating in its various modes. The modulation meter was used to measure the percent modulation.

Test Arrangement



Modulation Characteristic Results

Figure 4 shows the modulation characteristics of six frequencies while the input voltage was varied. The frequency was held constant and the percent modulation read from the modulation meter.

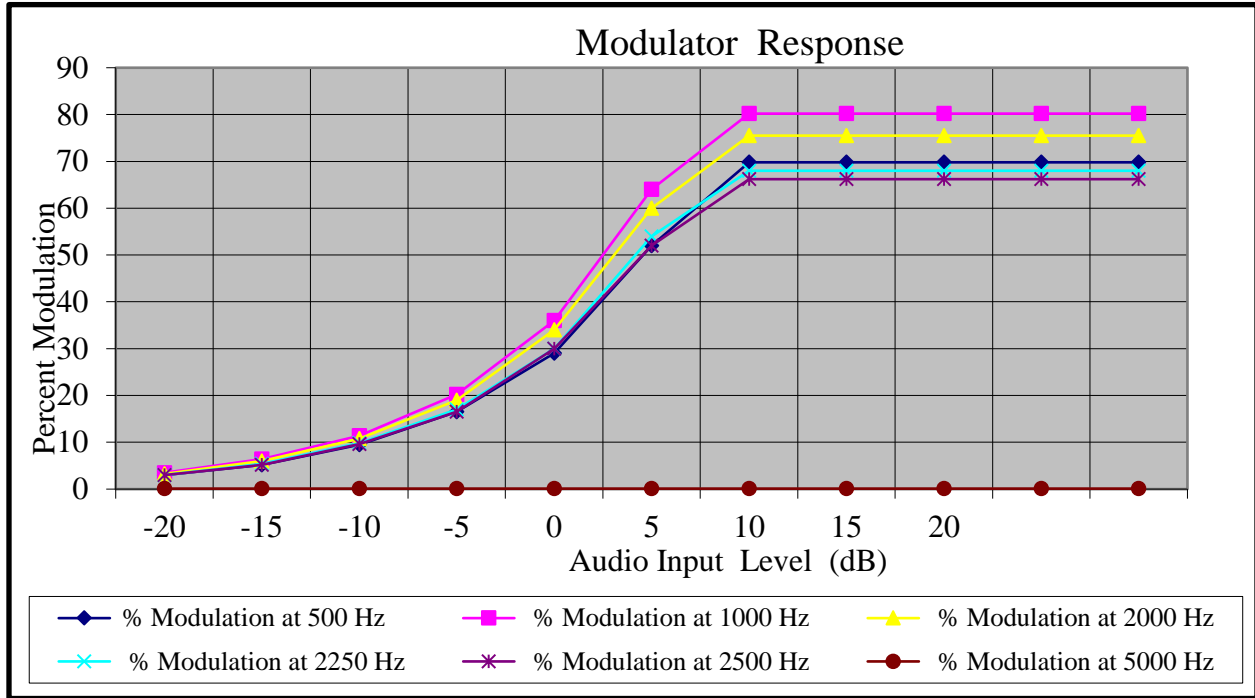


Figure 4 Modulation Characteristics

Figure 5 displays the graph made showing the audio frequency response of the modulator and low pass filter. The frequency generator was set to 1 kHz frequency and injected into the audio input port of the EUT. The input voltage amplitude was adjusted to obtain 50% modulation at 1000 Hz. This level was then taken as the 0-dB reference. The frequency of the generator was then varied, and the output voltage level was adjusted to maintain the 50% modulation. The output level required for 50% modulation then recorded. This level was normalized to the level required for 50% modulation at 1000 Hz.

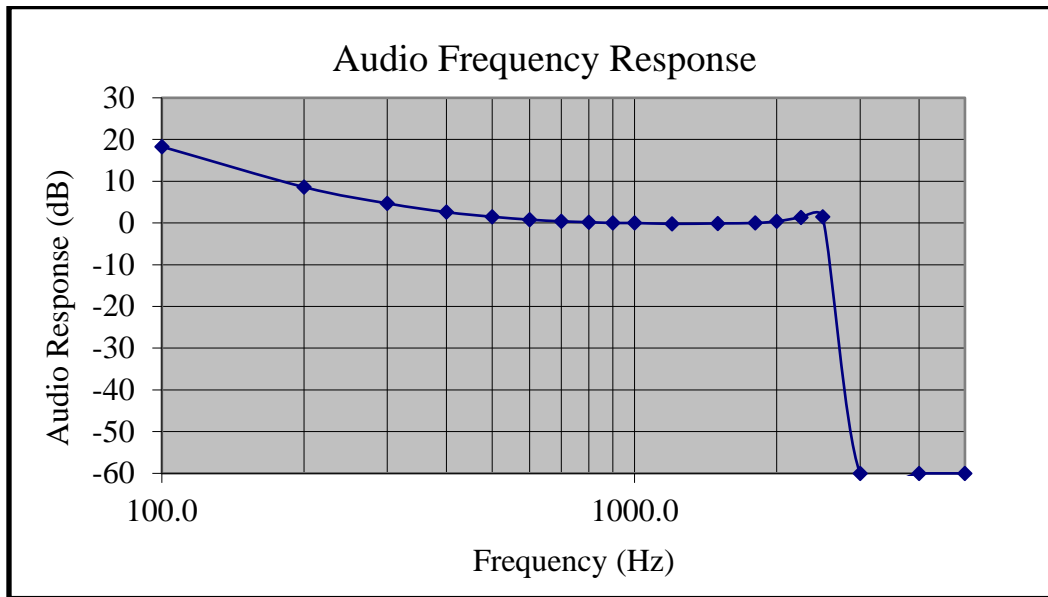


Figure 5 Audio Frequency Response / Modulation Characteristics

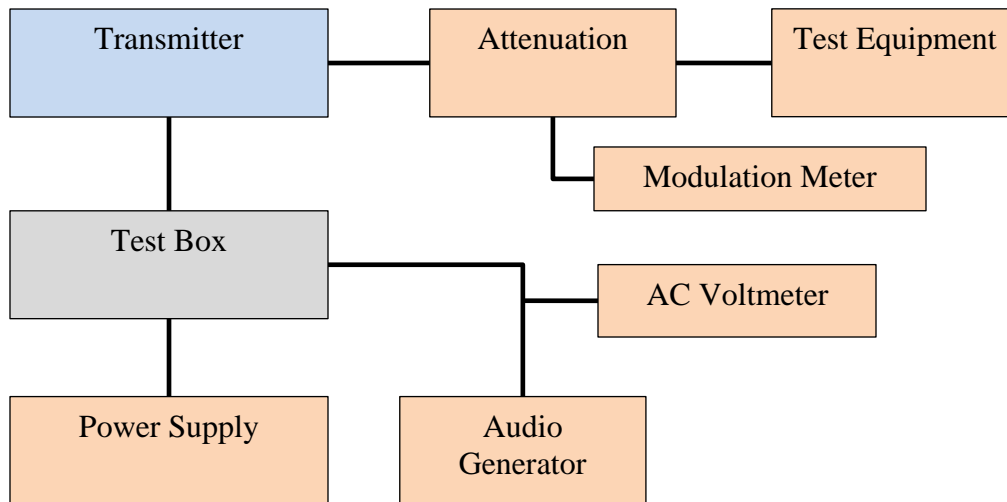
The EUT demonstrated compliance with specifications of CFR47 Paragraph 2.1047 and applicable Parts of 2 and 87. There are no deviations to the specifications.

Occupied Bandwidth

Measurements Required

The occupied bandwidth, that is the frequency bandwidth such that below its lower and above its upper frequency limits, the mean powers radiated are equal to 0.5 percent of the total mean power radiated by a given emission.

Test Arrangement



A Rohde & Schwarz ESU 40 spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operating in normal modes. Characteristics for audio communications were obtained with the EUT modulated by a frequency of 2500 Hz at a level 16 dB above 50% modulation. Other modulation schemes were measured using appropriate input signals as defined by other standards. The power ratio in dB representing 99% of the total mean power was recorded from the spectrum analyzer measurements. Refer to figures 6 and 7 displaying plots of 99% power occupied bandwidth measurements.

Table 2 Occupied Bandwidth Results

Frequency (MHz)	Occupied bandwidth (kHz)
118.000 (25 kHz mode)	5.353
127.500 (25 kHz mode)	5.321
136.975 (25 kHz mode)	5.353
118.000 (8.33 kHz mode)	5.321
127.500 (8.33 kHz mode)	5.321
136.992 (8.33 kHz mode)	5.321

The EUT demonstrated compliance with specifications of CFR47 Paragraph 2.1049 and applicable Parts of 2 and 87.135. There are no deviations to the specifications.

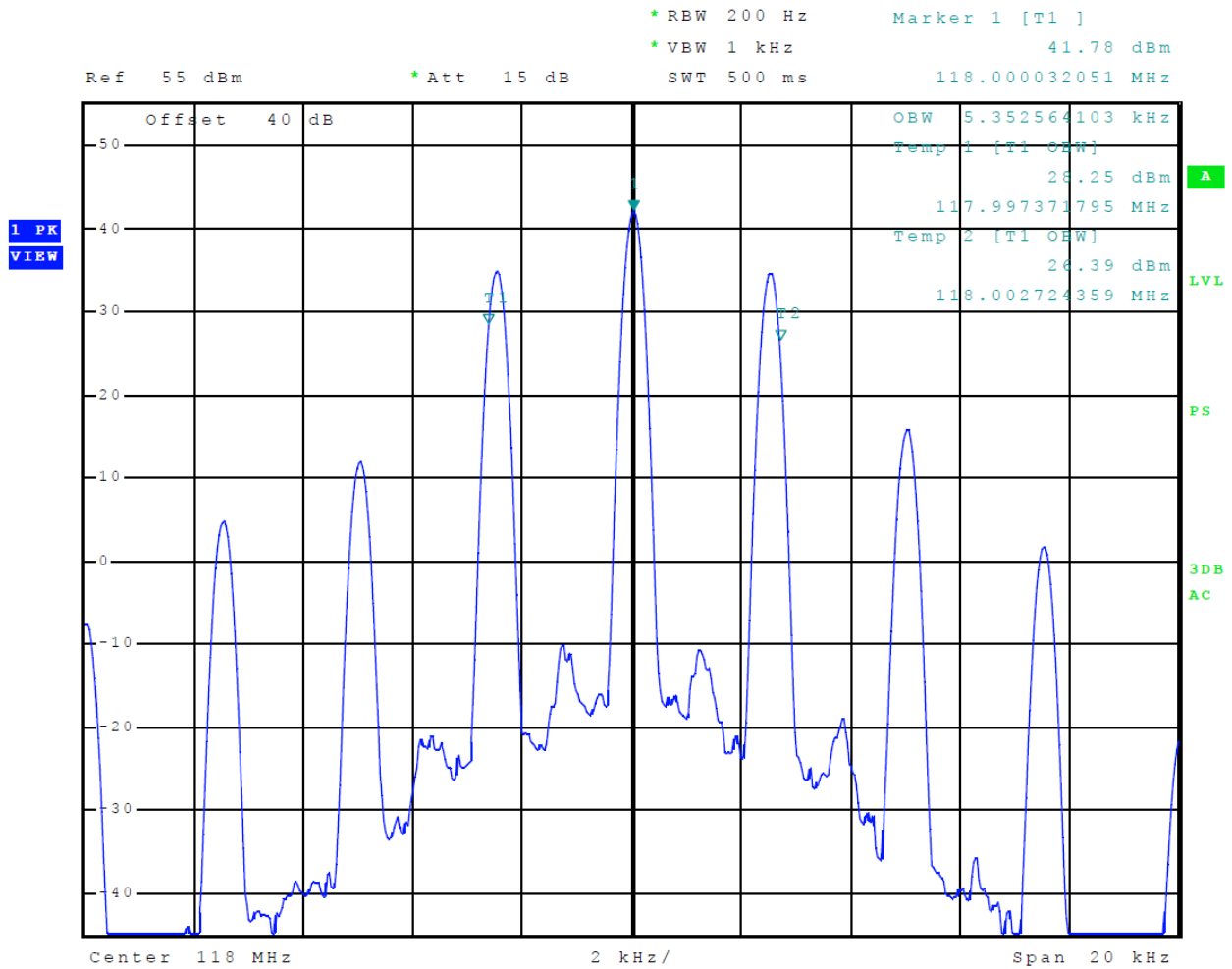


Figure 6 Occupied Band Width (25 kHz channels 118.000-136.975 MHz)

Spurious Emissions at Antenna Terminals

Measurements Required

The radio frequency voltage or power 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. All spurious emissions must be attenuated at least $43 + 10 \log (P_o)$ below the fundamental emission power level. The following equations represent the calculated attenuation offset level for the equipment operating with rated output power of 13.0 or 19.0 Watts.

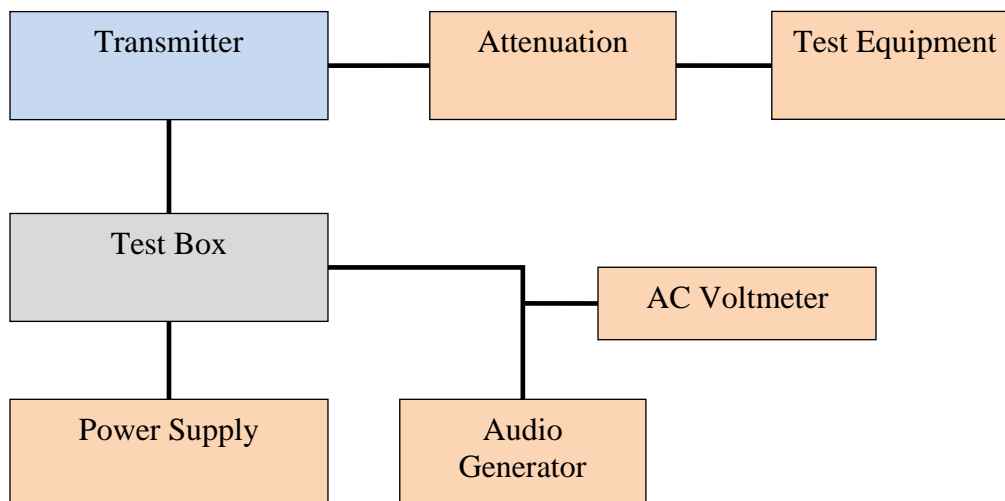
Limit for 10-Watt transmitter (13W)

$$\begin{aligned} \text{Limit (dBc)} &= 43 + 10 \text{ Log } (P_o) \\ &= 43 + 10 \text{ Log } (13.0) \\ &= 54.1 \text{ dBc} \end{aligned}$$

Limit for 16-Watt transmitter (19.0W)

$$\begin{aligned} &= 43 + 10 \text{ Log } (P_o) \\ &= 43 + 10 \text{ Log } (19.0) \\ &= 55.8 \text{ dBc} \end{aligned}$$

Test Arrangement



The radio frequency output was coupled to a Rohde & Schwarz ESU40 Spectrum Analyzer during antenna port conducted emissions measurements. The spectrum analyzer was used to observe the radio frequency spectrum with the transmitter modulated per section 2.1049 and operated in all normal modes. The frequency spectrum from 30 MHz to 1,500 MHz was observed and plot produced of the frequency spectrum displayed on the test equipment. Refer to figures eight through eleven demonstrating compliance with antenna spurious emissions and Spectral Emission Mask. Data was taken per CFR47 2.1051, 2.1057, and applicable paragraphs of Part 87.139. There are no deviations to the specifications.

Table 3 Spurious Emissions at Antenna Terminal Results (10 Watt)

Channel MHz	Spurious Freq. (MHz)	Measured Level (dBm)	Level Below Carrier (dBc)
118.000	236.0	-24.4	-65.2
	354.0	-36.1	-76.9
	472.0	-52.9	-93.7
	590.0	-55.2	-96.0
	708.0	-57.4	-98.2
127.000	826.0	-57.3	-98.1
	254.0	-28.4	-69.2
	381.0	-35.1	-75.9
	508.0	-54.2	-95.0
	635.0	-57.4	-98.2
136.975	762.0	-58.1	-98.9
	889.0	-57.0	-97.8
	274.0	-36.3	-77.4
	410.9	-36.2	-77.3
	547.9	-56.8	-97.9
	684.9	-55.8	-96.9
	821.9	-58.7	-99.8
	958.8	-56.7	-97.8

Table 4 Spurious Emissions at Antenna Terminal Results (16 Watt)

Channel MHz	Spurious Freq. (MHz)	Measured Level (dBm)	Level Below Carrier (dBc)
118.000	236.0	-24.5	-66.9
	354.0	-30.6	-73.0
	472.0	-52.5	-94.9
	590.0	-51.7	-94.1
	708.0	-58.4	-100.8
	826.0	-55.6	-98.0
127.000	254.0	-27.8	-70.3
	381.0	-30.2	-72.7
	508.0	-52.9	-95.4
	635.0	-58.1	-100.6
	762.0	-57.0	-99.5
	889.0	-58.4	-100.9
136.975	274.0	-34.1	-73.3
	410.9	-30.5	-95.1
	547.9	-52.3	-96.3
	684.9	-53.5	-100.4
	821.9	-57.6	-100.2
	958.8	-57.4	-73.3

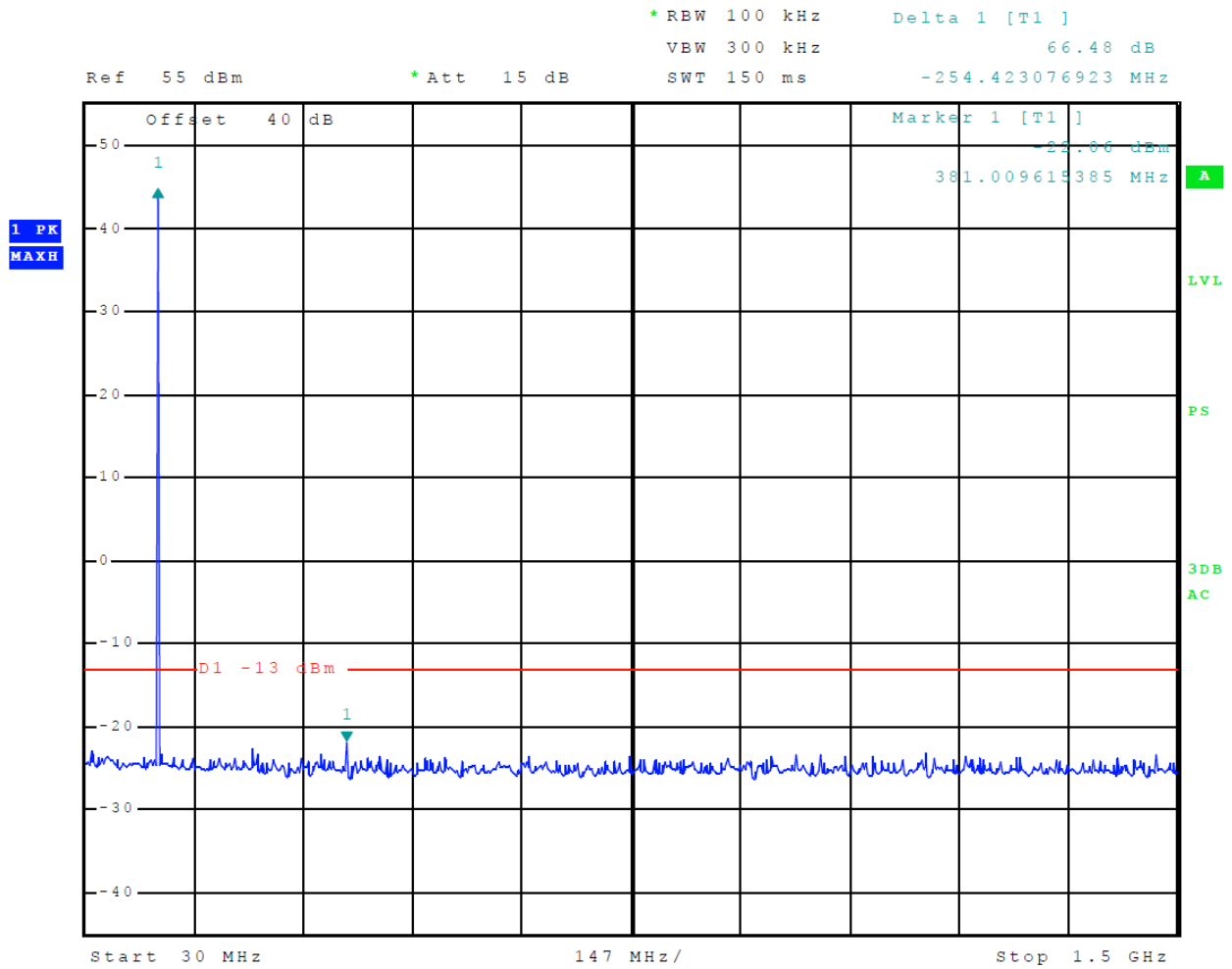


Figure 8 Spurious Emissions at Antenna Terminal (10 Watt)

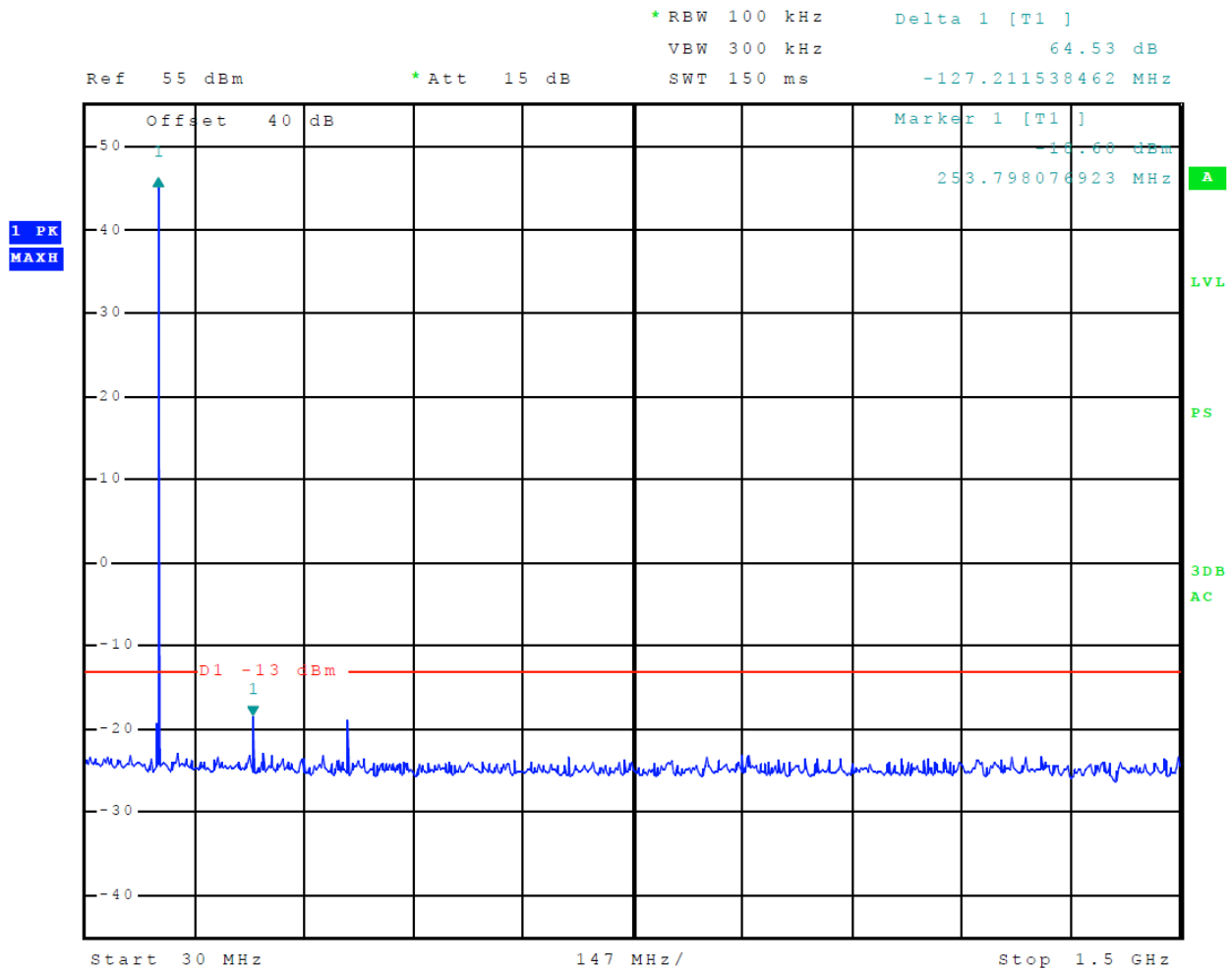


Figure 9 Spurious Emissions at Antenna Terminal (16 Watt)

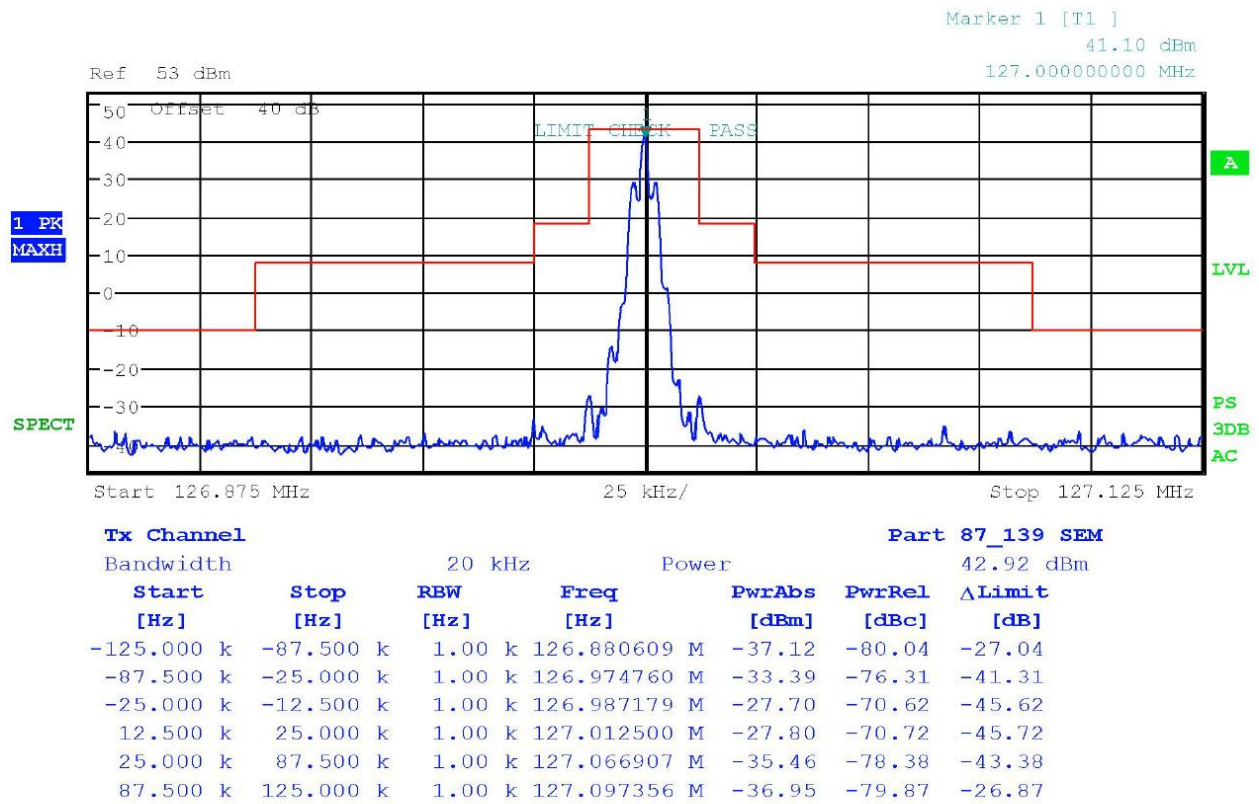


Figure 10 Spectral Emission Mask at Antenna Terminal (10 Watt)

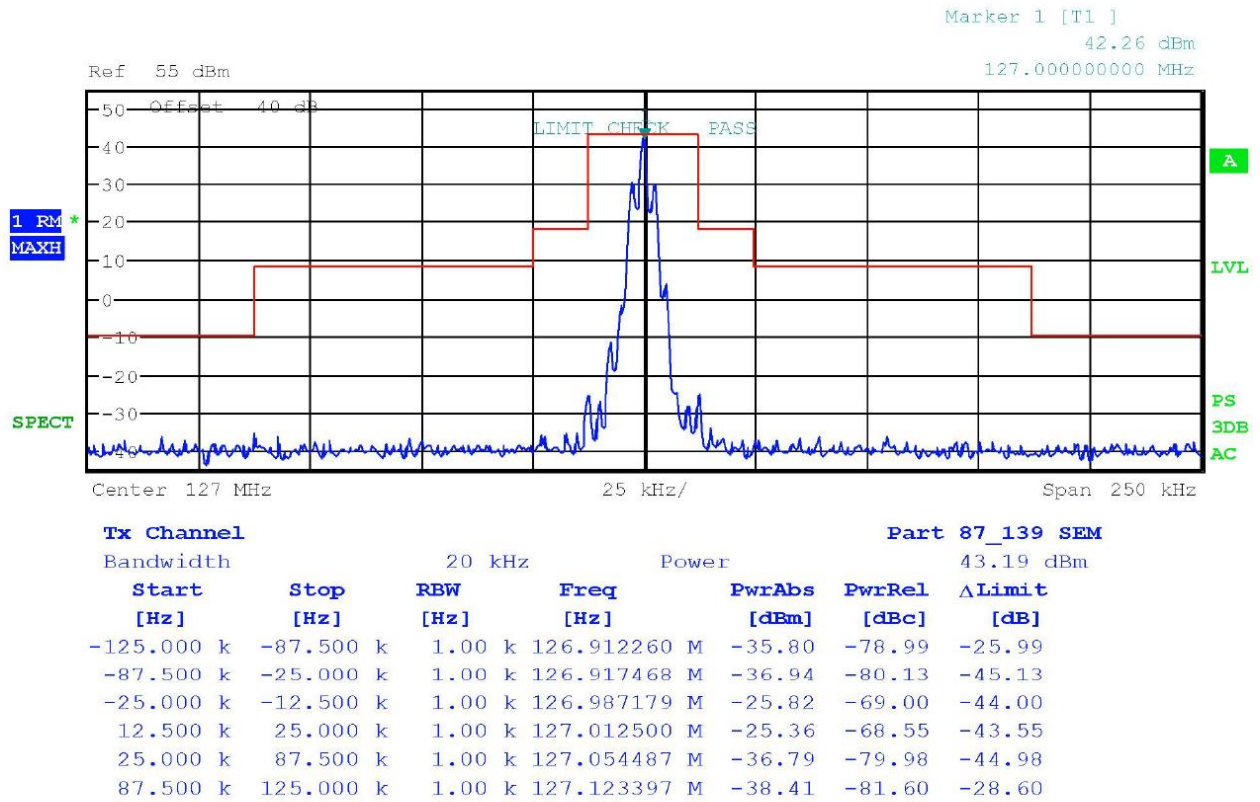


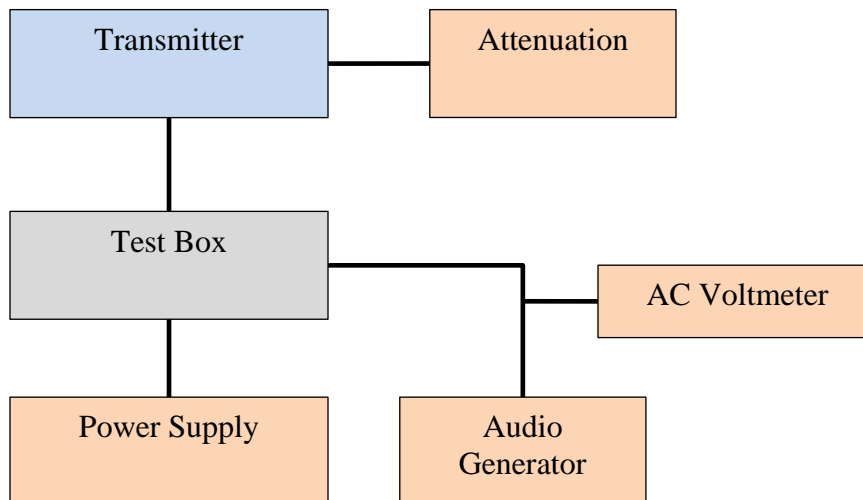
Figure 11 Spectral Emission Mask at Antenna Terminal (16 Watt)

Field Strength of Spurious Radiation (Unwanted Emissions)

Measurements Required

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. This equipment is typically remote mounted with interface cabling connecting the display control unit to the cabinet. The test sample offered for testing required interfacing with additional test control panels offering operation and communications with all functions of transmitter.

Test Arrangement



The test setup was assembled in a screen room for preliminary screening. The transmitter was placed on a supporting platform 0.8 meters above the ground plane and at a distance of 1 meter from the receive antenna, plots were taken of the general radiated emissions. A final radiated emission testing was performed with the transmitter placed on a supporting turntable platform 0.8 meters above the ground plane and at a distance of 3 meters from the Field Strength Measuring (FSM) antenna. The EUT was operational and radiating into a 50Ω load. The receiving antenna was raised and lowered from 1m to 4m in height to obtain the maximum reading of spurious radiation from the EUT, cabinet, and interface cabling. The turntable was rotated though 360 degrees to locate the position registering the highest amplitude of emission.

The frequency spectrum was then searched for spurious emissions generated from the transmitter, interface cabling, and test setup. The amplitude of each spurious emission was maximized by raising and lowering the FSM antenna, and rotating the turntable before final data was recorded. The frequency spectrum from 30 MHz to 1,500 MHz was investigated during radiated emissions testing. A Biconilog antenna was used for frequency measurements of 30 to 1000 MHz. A double-ridge horn antenna was used for frequencies of 1000 MHz to 1,500 MHz. Emission levels were measured and recorded from the spectrum analyzer in dBμV. Data was taken at the Rogers Labs, Inc. 3 meters open area test site (OATS). The transmitter was then removed and replaced with a substitution antenna, amplification as required, and signal generator. The signal from the generator was then adjusted such that the amplitude received was the same as that previously recorded for each frequency. This step was repeated for both horizontal and vertical polarizations. The power in dBm required to produce the desired signal level was then recorded from the signal generator. The power in dBm was then calculated by reducing the previous readings by the gain in the substitution antenna.

All spurious emissions must be attenuated at least $43 + 10\log(P_o)$ below the fundamental emission power level. The following equations represent the calculated attenuation levels for the equipment.

Limit for 10-Watt transmitter (13W)	Limit for 16-Watt transmitter (19.0W)
Limit (dBc) = $43 + 10 \text{ Log } (P_o)$	= $43 + 10 \text{ Log } (P_o)$
= $43 + 10 \text{ Log } (13.0)$	= $43 + 10 \text{ Log } (19.0)$
= 54.1 dBc	= 55.8 dBc

Requirement 54.1 dBc below the fundamental of 41.1 dBm equates to an absolute level of -13 dBm.

Table 5 General Spurious Radiated Emission Results (Worst-case)

Frequency	Amplitude of Emission (dB μ V)		Signal Level to dipole required to Reproduce(dBm)		Emission level below carrier (dBc)		Limit (dBm)
	MHz	Horizontal	Vertical	Horizontal	Vertical	Horizontal	
72.0	30.8	30.9	-64.4	-64.3	-105.7	-105.6	-13
120.0	25.4	30.9	-69.8	-64.3	-111.1	-105.6	-13
132.0	21.1	26.4	-74.1	-68.8	-115.4	-110.1	-13
144.0	30.7	30.5	-64.5	-64.7	-105.8	-106.0	-13
180.0	22.8	27.4	-72.4	-67.8	-113.7	-109.1	-13
204.0	24.6	25.3	-70.6	-69.9	-111.9	-111.2	-13
216.0	28.5	24.3	-66.7	-70.9	-108.0	-112.2	-13
240.0	35.6	32.9	-59.6	-62.3	-100.9	-103.6	-13

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequencies below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequencies above 1000 MHz.

Table 6 Spurious Radiated Emission Results for 118.000 MHz Operation

Frequency	Amplitude of Emission (dB μ V)		Signal Level to dipole required to Reproduce(dBm)		Emission level below carrier (dBc)		Limit (dBm)
	MHz	Horizontal	Vertical	Horizontal	Vertical	Horizontal	
236.00	26.3	19.3	-68.93	-75.93	-111.7	-118.7	-13
354.00	22.4	17.1	-72.83	-78.13	-115.6	-120.9	-13
472.00	17.9	14.2	-77.33	-81.03	-120.1	-123.8	-13
590.00	24.7	25.5	-70.53	-69.73	-113.3	-112.5	-13
708.00	20.1	21.9	-75.13	-73.33	-117.9	-116.1	-13
826.00	18.5	18.5	-76.73	-76.73	-119.5	-119.5	-13

Table 7 Spurious Radiated Emission Results for 127.500 MHz Operation

Frequency MHz	Amplitude of Emission (dB μ V)		Signal Level to dipole required to Reproduce(dBm)		Emission level below carrier (dBc)		Limit (dBm)
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
254.00	21.2	18.4	-74.03	-76.83	-116.8	-119.6	-13
381.00	19.8	20.7	-75.43	-74.53	-118.2	-117.3	-13
508.00	17.0	19.8	-78.23	-75.43	-121.0	-118.2	-13
635.00	25.8	25.1	-69.43	-70.13	-112.2	-112.9	-13
762.00	18.2	17.9	-77.03	-77.33	-119.8	-120.1	-13
889.00	38.3	37.1	-56.93	-58.13	-99.7	-100.9	-13

Table 8 Spurious Radiated Emission Results for 136.975 MHz Operation

Frequency MHz	Amplitude of Emission (dB μ V)		Signal Level to dipole required to Reproduce(dBm)		Emission level below carrier (dBc)		Limit (dBm)
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
273.95	30.8	22.6	-64.43	-72.63	-107.2	-115.4	-13
410.93	31.7	24.4	-63.53	-70.83	-106.3	-113.6	-13
547.90	22.6	21.8	-72.63	-73.43	-115.4	-116.2	-13
684.88	21.9	22.4	-73.33	-72.83	-116.1	-115.6	-13
821.85	18.3	18.4	-76.93	-76.83	-119.7	-119.6	-13
958.83	19.4	19.2	-75.83	-76.03	-118.6	-118.8	-13

Table 9 Spurious Radiated Emission Results for 136.992 MHz Operation

Frequency MHz	Amplitude of Emission (dBµV)		Signal Level to dipole required to Reproduce(dBm)		Emission level below carrier (dBc)		Limit (dBm)
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
273.98	47.0	37.2	-48.23	-58.03	-91.0	-100.8	-13
410.98	29.8	26.3	-65.43	-68.93	-108.2	-111.7	-13
547.97	22.5	25.7	-72.73	-69.53	-115.5	-112.3	-13
684.96	24.7	23.2	-70.53	-72.03	-113.3	-114.8	-13
821.95	22.7	25.6	-72.53	-69.63	-115.3	-112.4	-13
958.94	23.2	24.8	-72.03	-70.43	-114.8	-113.2	-13

The EUT demonstrated compliance with specifications of CFR47 Paragraph 2.1053 and applicable Parts of 2 and 87.139. There are no deviations to the specifications. There are no deviations or exceptions to the specifications.

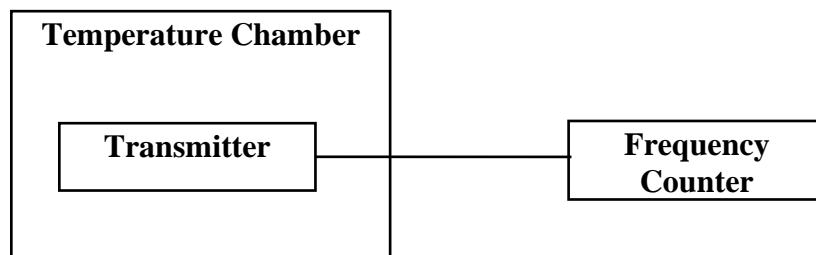
Frequency Stability

Measurements Required

The frequency stability shall be measured with variations of ambient temperature from -30° to +50° centigrade. Measurements shall be made at the extremes of the temperature range and at intervals of not more than 10° centigrade through the range. A period sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. In addition to temperature stability, the frequency stability 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.
- (2) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided.

Test Arrangement



The measurement procedure outlined below shall be followed.

Step 1: The transmitter shall be installed in an environmental test chamber whose temperature is controllable. Provision shall be made to measure the frequency of the transmitter.

Step 2: With the transmitter inoperative (power switched “OFF”), the temperature of the test chamber shall be adjusted to +25°C. After a temperature stabilization period of one hour at +25°C, the transmitter shall be switched “ON” with standard test voltage applied.

Step 3: The carrier shall be keyed “ON”, and the transmitter shall be operated at full radio frequency power output at the duty cycle, for which it is rated, for duration of at least 5 minutes. The radio frequency carrier frequency shall be monitored, and measurements shall be recorded.

Step 4: The test procedures outlined in Steps 2 and 3, shall be repeated after stabilizing the transmitter at the environmental temperatures specified, -30°C to +50°C in 10-degree increments.

The frequency stability was measured with variations in the power supply voltage from 85 to 115 percent of the nominal value. The frequency was measured and the variation in parts per million calculated. Data was taken per CFR47 Paragraphs 2.1055 and applicable paragraphs of part 87.133.

Table 10 Frequency Stability vs. Temperature Results

Frequency 127.000 MHz)	Frequency Stability Vs. Temperature Ambient Frequency (127.0000)								
	Temperature °C	-30	-20	-10	0	+10	+20	+30	+40
Change (Hz)	-60	-68	-30	-20	-13	4	-81	-71	-41
PPM	-0.472	-0.535	-0.236	-0.157	-0.102	0.031	-0.638	-0.559	-0.323
%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Limit (PPM)	5	5	5	5	5	5	5	5	5

Table 11 Frequency Stability vs. Input Power Supply Voltage Results

Frequency (127.000 MHz)	Frequency Stability Vs. Voltage Variation 14-28 volts nominal; Results in Hz change		
	Voltage V _{dc}	9.8	28.0
Change (Hz)	0	0	0
PPM	0	0	0
%	0	0	0
Limit (PPM)	5	5	5

The EUT demonstrated compliance with specifications of CFR47 Paragraph 2.1055 and applicable Parts of 87.133(a). There are no deviations or exceptions to the specifications.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Additional Test Equipment List
- Annex C Rogers Qualifications
- Annex D Laboratory Certificate of Accreditation

Annex A Measurement Uncertainty Calculations

The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16-4. Result of measurement uncertainty calculations are recorded below. Component and process variability of production devices similar to those tested may result in additional deviations. The manufacturer has the sole responsibility of continued compliance.

Measurement	Expanded Measurement Uncertainty $U_{(lab)}$
3 Meter Horizontal 0.009-1000 MHz Measurements	4.16
3 Meter Vertical 0.009-1000 MHz Measurements	4.33
3 Meter Measurements 1-18 GHz	5.14
3 Meter Measurements 18-40 GHz	5.16
10 Meter Horizontal Measurements 0.009-1000 MHz	4.15
10 Meter Vertical Measurements 0.009-1000 MHz	4.32
AC Line Conducted	1.75
Antenna Port Conducted power	1.17
Frequency Stability	1.00E-11
Temperature	1.6°C
Humidity	3%

Annex B Additional Test Equipment List

List of Test Equipment	Calibration	Date (m/d/y)	Due
Antenna: Schwarzbeck Model: BBA 9106/VHBB 9124 (9124-627)		4/18/2019	4/18/2020
Antenna: Schwarzbeck Model: VULP 9118 A (VULP 9118 A-534)		4/18/2019	4/18/2020
Antenna: EMCO 6509		10/16/2018	10/16/2020
Antenna: EMCO 3143 (9607-1277) 20-1200 MHz		4/18/2019	4/18/2020
Antenna: EMCO Dipole Set 3121C		2/22/2019	2/22/2020
Antenna: C.D. B-101		2/22/2019	2/22/2020
Antenna: Solar 9229-1 & 9230-1		2/22/2019	2/22/2020
Cable: Belden 8268 (L3)		10/16/2018	10/16/2019
Cable: Time Microwave: 4M-750HF290-750		10/16/2018	10/16/2019
Frequency Counter: Leader LDC-825 (8060153)		4/18/2019	4/18/2020
Oscilloscope Scope: Tektronix 2230		2/22/2019	2/22/2020
Wattmeter: Bird 43 with Load Bird 8085		2/22/2019	2/22/2020
R.F. Generators: HP 606A, HP 8614A, HP 8640B		2/22/2019	2/22/2020
R.F. Power Amp 65W Model: 470-A-1010		2/22/2019	2/22/2020
R.F. Power Amp 50W M185- 10-501		2/22/2019	2/22/2020
R.F. Power Amp A.R. Model: 10W 1010M7		2/22/2019	2/22/2020
R.F. Power Amp EIN Model: A301		2/22/2019	2/22/2020
LISN: Compliance Eng. Model 240/20		4/18/2019	4/18/2020
LISN: Fischer Custom Communications Model: FCC-LISN-50-16-2-08		4/18/2019	4/18/2020
Audio Oscillator: H.P. 201CD		2/22/2019	2/22/2020
ESD Test Set 2010i		2/22/2019	2/22/2020
Oscilloscope Scope: Tektronix MDO 4104		2/22/2019	2/22/2020
EMC Transient Generator HVT TR 3000		2/22/2019	2/22/2020
AC Power Source (Ametech, California Instruments)		2/22/2019	2/22/2020
Fast Transient Burst Generator Model: EFT/B-101		2/22/2019	2/22/2020
Field Intensity Meter: EFM-018		2/22/2019	2/22/2020
KEYTEK Ecat Surge Generator		2/22/2019	2/22/2020
ESD Simulator: MZ-15		2/22/2019	2/22/2020
Shielded Room not required			

Annex C Rogers Qualifications

Scot D. Rogers, Engineer

Rogers Labs, Inc.

Mr. Rogers has approximately 31 years' experience in the field of electronics. Work experience includes six years working in the automated controls industry and remaining years working with the design, development and testing of radio communications and electronic equipment.

Positions Held:

Systems Engineer: A/C Controls Mfg. Co., Inc. 6 Years

Electrical Engineer: Rogers Consulting Labs, Inc. 5 Years

Electrical Engineer: Rogers Labs, Inc. Current

Educational Background:

- 1) Bachelor of Science Degree in Electrical Engineering from Kansas State University
- 2) Bachelor of Science Degree in Business Administration Kansas State University
- 3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.

Annex D Laboratory Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology



Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 200087-0

Rogers Labs, Inc.
Louisburg, KS

*is accredited by the National Voluntary Laboratory Accreditation Program for specific services,
listed on the Scope of Accreditation, for:*

Electromagnetic Compatibility & Telecommunications

*This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005.
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality
management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).*

2019-03-27 through 2020-03-31
Effective Dates



For the National Voluntary Laboratory Accreditation Program