ENGINEERING TEST REPORT

VHF AM Transceiver
Model: TDAM-1000
FCC ID: IMA-TDAM1000

Applicant:

Technisonic Industries Limited
240 Traders Blvd. E.
Mississauga, Ontario
Canada L4Z 1W7

Tested in Accordance With

Federal Communications Commission (FCC)
47 CFR, Parts 2 and 87 (Subpart D) – Aviation Services

UltraTech's File No.: 18TIL127_FCC87

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: October 31, 2018	
Report Prepared by: Dan Huynh Issued Date: October 31, 2018	Tested by: Nimisha Desai Test Dates: April 27 & 30, 2018 May 2 - 11, 2018 September 14, 24, 25, 26 & 27, 2018

- *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 any agency of the US Government.*
- *This test report shall not be reproduced, except in full, without a written approval from UltraTech*

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 87
Title:	Code of Federal Regulations (CFR), Title 47 Telecommunication – Parts 2 & 87
Purpose of Test:	To gain FCC Equipment Authorization Certification for Radio operating in Part 87.
Test Procedures:	• ANSI/TIA-603-E • ANSI C63.26-2015

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

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2018	Code of Federal Regulations, Title 47 – Telecommunication
ANSI C63.4	2014	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
ANSI/TIA-603-E	2016	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
ANSI C63.26	2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Technisonic Industries Ltd.
Address:	240 Traders Blvd. E. Mississauga, Ontario Canada L4Z 1W7
Contact Person:	Mr. Steve M^{c}Intosh Phone #: 905-890-2113 ext 205 Fax #: 905-890-5338 Email Address: stevem@til.ca

Manufacturer	
Name:	Technisonic Industries Ltd.
Address:	240 Traders Blvd. E. Mississauga, Ontario Canada L4Z 1W7
Contact Person:	Mr. Steve M^{c}Intosh Phone #: 905-890-2113 ext 205 Fax #: 905-890-5338 Email Address: stevem@til.ca

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

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

Brand Name:	Technisonic Industries Limited
Product Name:	VHF AM Transceiver
Model Name or Number:	TDAM-1000
Serial Number:	ENG-C01
Type of Equipment:	Licensed Non-Broadcast Station Transmitter
Power Supply Requirement:	+13.8 to +28 VDC
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Communication between air traffic control and ground mobile vehicles

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	+13.8 VDC to +28 VDC (+24 VDC nominal)
RF Output Power Rating:	1 or 10 watts; LO – 1 watt, HI – 10 watts
Operating Frequency Range:	117.975 - 137 MHz
RF Output Impedance:	50 Ω
Channel Spacing:	25 kHz & 8.33 kHz
Modulation Employed:	Amplitude Modulation
Emission Designation:	6K00A3E & 5K60A3E
Antenna Connector Type:	BNC

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

Calculation of Necessary Bandwidth for Telephony (Commercial Quality)

Telephony, double-sideband (single channel):

Bn = 2M

Where: Bn = Necessary bandwidth in hertz
M = Maximum modulation frequency in hertz

M = 3000 Hz
Bn =2(3000) = 6000 Hz = 6.00 kHz

2.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	MIC	1	RJ-45	shielded
2	HEADSET	1	¼"	shielded
3	USB*	1	USB	not applicable
4	ANTENNA	1	BNC	shielded
5	EXT SPKR	1	3.5 mm	non-shielded
6	P1 – ACCESSORIES	1	15-PIN "D"	non-shielded
7	J1 - POWER	1	2-PIN "D"	non-shielded

*Used for programming data

2.5. ANCILLARY EQUIPMENT

Ancillary Equipment # 1	
Description:	Test Jig (TEST BOX)
Brand name:	Technisonic Industries Limited
Model Name or Number:	N/A
Connected to EUT's Port:	ACCESSORIES (15-PIN "D") and POWER (2-PIN "D")

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	+13.8 VDC to +28 VDC (+24 VDC nominal)

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

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

Transmitter Test Signals	
Frequency Band(s):	117.975 – 137 MHz
Test Frequency(ies):	118.005 MHz, 127.505 MHz, 136.980 MHz 118.000 MHz, 127.500 MHz, 136.975 MHz
Transmitter Wanted Output Test Signals:	
• Transmitter Power (measured maximum output power):	10.67 W
• Normal Test Modulation:	AM or 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50 percent modulation
• Modulating signal source:	External

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

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

Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
2.1046 & 87.131	RF Power Output	Yes
2.1047(a) & 87.141(f)	Modulation Characteristics - Audio Frequency Response	Yes
2.1047(b) & 87.141	Modulation Characteristics - Modulation Limiting	Yes
2.1049, 87.135, 87.137 & 87.139	Occupied Bandwidth and Emission Limitations	Yes
2.1051, 2.1057 & 87.139,	Spurious Emissions at Antenna Terminals	Yes
2.1053, 2.1057 & 87.139	Field Strength of Spurious Radiation	Yes
2.1055 & 87.133	Frequency Stability	Yes
1.1307, 1.1310 & 2.1091	Radiofrequency Radiation Exposure Evaluation	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None.

EXHIBIT 5. TEST DATA

5.1. RF POWER OUTPUT [§§ 2.1046 & 87.131]

5.1.1. Limits

The following table lists authorized emissions and maximum power. Power must be determined by direct measurement.

Class of station	Frequency band/ frequency	Authorized emission(s) [2]	Maximum power [1]
Aeronautical advisory	VHF	A3E	10 watts[3]
Aeronautical multicom	VHF	A3E	10 watts
Aeronautical search and rescue	VHF	A3E	10 watts
Aviation support	VHF	A3E	50 watts
Airport control tower	VHF	A3E	50 watts
Aeronautical utility mobile	VHF	A3E	10 watts
Aircraft	VHF	A3E	55 watts

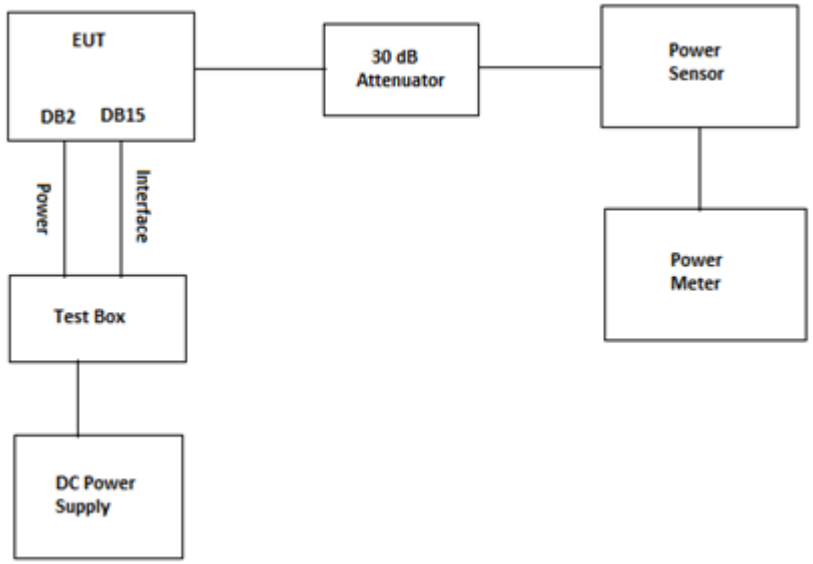
Notes:

(1) The power is measured at the transmitter output terminals and the type of power is determined according to the emission designator as follows:
 (i) Mean power (pY) for amplitude modulated emissions and transmitting both sidebands using unmodulated full carrier.
 (ii) Peak envelope power (pX) for all emission designators other than those referred to in paragraph (i) of this note.
(2) Excludes automatic link establishment.
(3) Power is limited to 0.5 watt, but may not exceed 2 watts when station is used in an automatic unattended mode.

5.1.2. Method of Measurements

TIA-603-E / ANSI C63.26

5.1.3. Test Arrangement



5.1.4. Test Data

Supply Voltage (VDC)	Channel Spacing (kHz)	Channel	Frequency MHz	Power Rating		Measured Power	
				W	dBm	dBm	W
13.8	8.33	1	118.005	10.00	40.00	40.22	10.52
	8.33	2	127.505	10.00	40.00	40.24	10.57
	8.33	3	136.980	10.00	40.00	40.23	10.54
	25	4	118.000	10.00	40.00	40.18	10.42
	25	5	127.500	10.00	40.00	40.24	10.57
	25	6	136.975	10.00	40.00	40.18	10.42
	8.33	1	118.005	1.00	30.00	30.12	1.03
	8.33	2	127.505	1.00	30.00	30.12	1.03
	8.33	3	136.980	1.00	30.00	30.17	1.04
	25	4	118.000	1.00	30.00	30.11	1.03
	25	5	127.500	1.00	30.00	30.12	1.03
	25	6	136.975	1.00	30.00	30.17	1.04

Supply Voltage (VDC)	Channel Spacing (kHz)	Channel	Frequency (MHz)	Power Rating		Measured Power	
				W	dBm	dBm	W
28	8.33	1	118.005	10.00	40.00	40.26	10.62
	8.33	2	127.505	10.00	40.00	40.23	10.54
	8.33	3	136.980	10.00	40.00	40.20	10.47
	25	4	118.000	10.00	40.00	40.22	10.52
	25	5	127.500	10.00	40.00	40.23	10.54
	25	6	136.975	10.00	40.00	40.20	10.47
	8.33	1	118.005	1.00	30.00	30.11	1.03
	8.33	2	127.505	1.00	30.00	30.12	1.03
	8.33	3	136.980	1.00	30.00	30.17	1.04
	25	4	118.000	1.00	30.00	30.11	1.03
	25	5	127.500	1.00	30.00	30.13	1.03
	25	6	136.975	1.00	30.00	30.18	1.04

Supply Voltage (VDC)	Channel Spacing (kHz)	Channel	Frequency (MHz)	Power Rating		Measured Power	
				W	dBm	dBm	W
24	8.33	1	118.005	10.00	40.00	40.28	10.67
	8.33	2	127.505	10.00	40.00	40.24	10.57
	8.33	3	136.980	10.00	40.00	40.23	10.54
	25	4	118.000	10.00	40.00	40.21	10.50
	25	5	127.500	10.00	40.00	40.23	10.54
	25	6	136.975	10.00	40.00	40.20	10.47
	8.33	1	118.005	1.00	30.00	30.08	1.02
	8.33	2	127.505	1.00	30.00	30.09	1.02
	8.33	3	136.980	1.00	30.00	30.16	1.04
	25	4	118.000	1.00	30.00	30.08	1.02
	25	5	127.500	1.00	30.00	30.09	1.02
	25	6	136.975	1.00	30.00	30.16	1.04

5.2. MODULATION CHARACTERISTICS – AUDIO FREQUENCY RESPONSE [§§ 2.1047(a) & 87.141(f)]

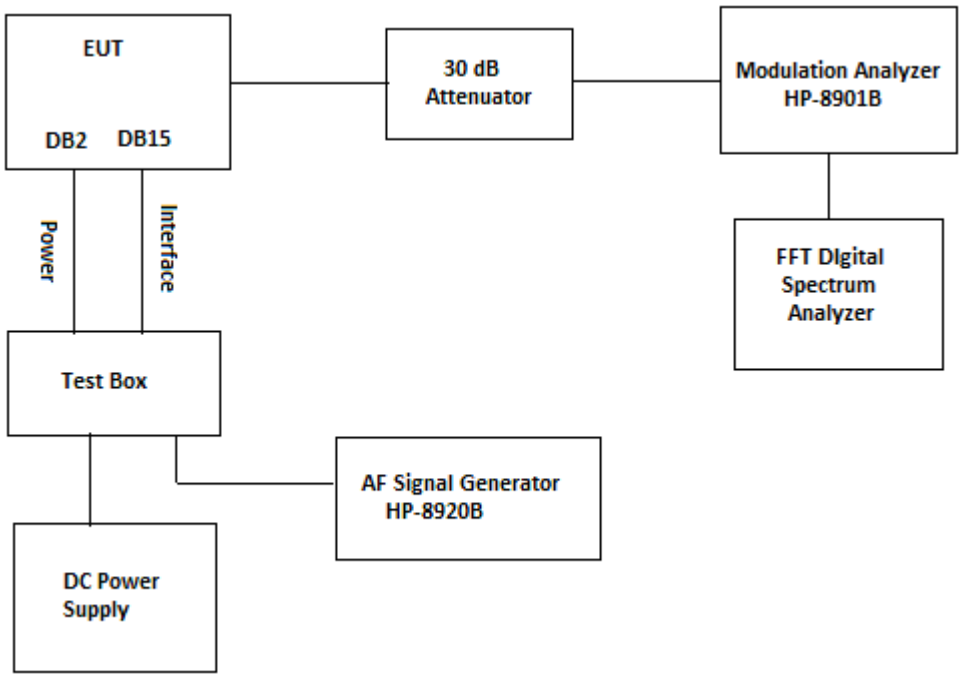
5.2.1. Limits

§ 87.141(f) Each frequency modulated transmitter equipped with a modulation limiter must have a low pass filter between the modulation limiter and the modulated stage. At audio frequencies between 3 kHz and 15 kHz, the filter must have an attenuation greater than the attenuation at 1 kHz by at least 40 $\log_{10}$ (f/3) db where "f" is the frequency in kilohertz. Above 15 kHz, the attenuation must be at least 28 db greater than the attenuation at 1 kHz.

5.2.2. Method of Measurements

The rated audio input signal was applied to the input of the audio lowpass filter (or of all modulation stages) using an audio oscillator, this input signal level and its corresponding output signal were then measured and recorded using the FFT (Audio) spectrum analyzer. Tests were repeated at different audio signal frequencies from 0 to 50 kHz.

5.2.3. Test Arrangement

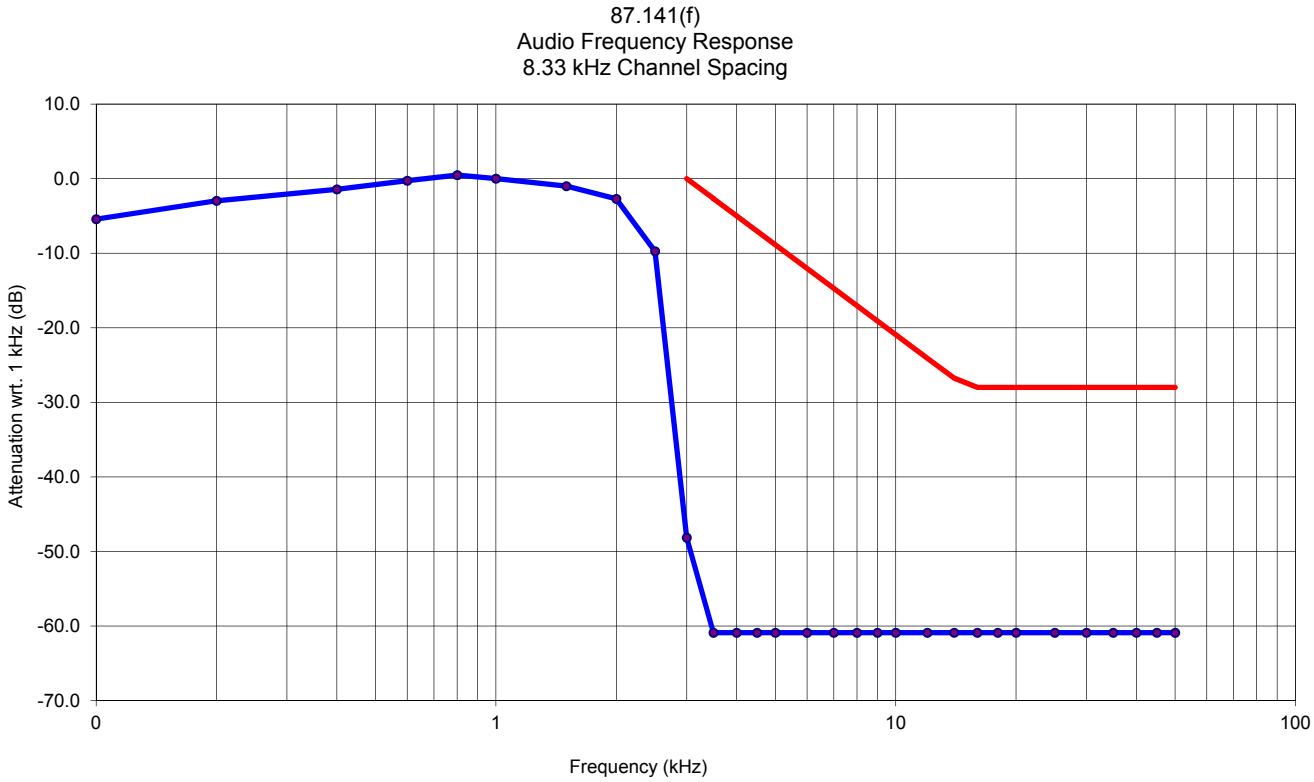


5.2.4. Test Data

Remark: Due to the difficulty of measuring the Frequency Response of the internal low-pass filter, the frequency response of all modulation states was performed to show the roll-off at 3 kHz in comparison with FCC Limit for audio low-pass filter.

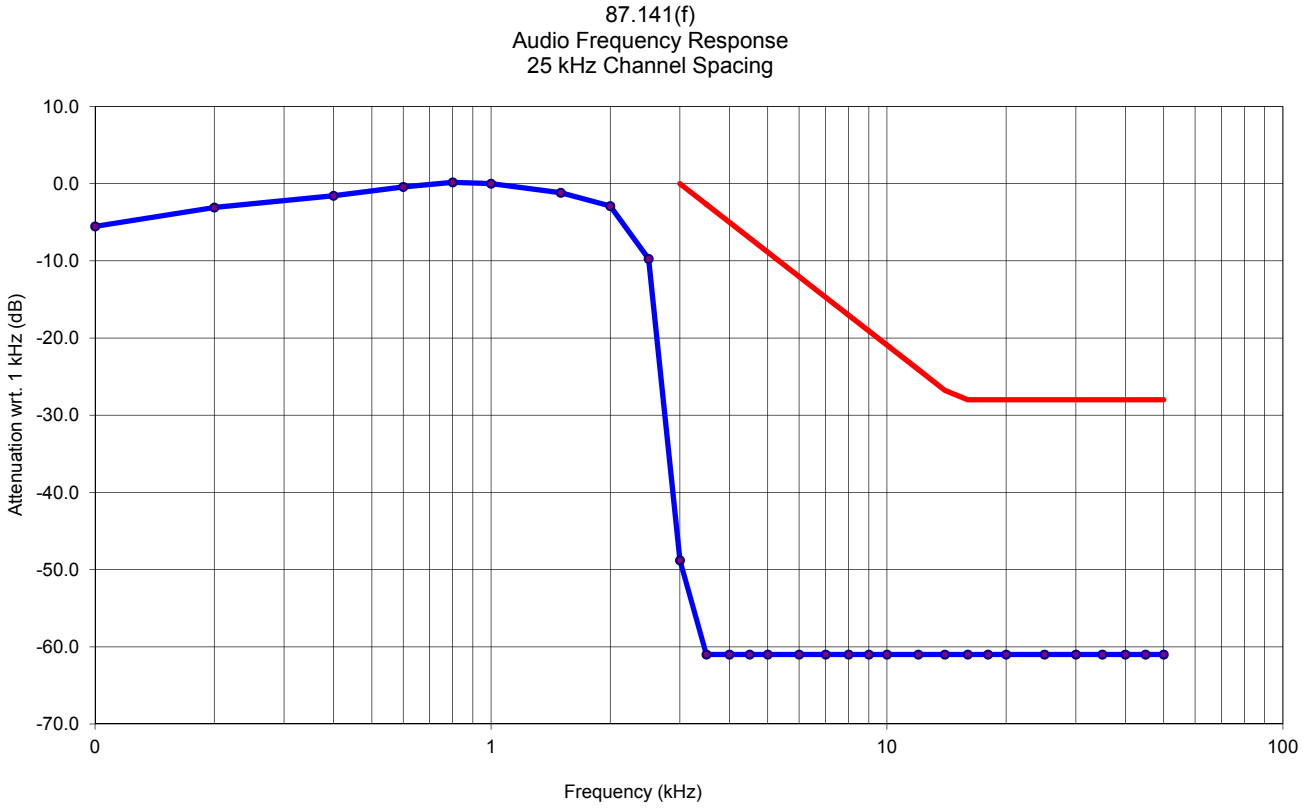
5.2.4.1. Audio Frequency Response of All Modulation States for 8.33 kHz Channel Spacing

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 1 kHz (dB)	§ 87.141(f) Limit (dB)
0.1	-29.24	-14.54	14.7	-5.4	--
0.2	-29.24	-12.08	17.2	-3.0	--
0.4	-29.24	-10.54	18.7	-1.4	--
0.6	-29.24	-9.38	19.9	-0.3	--
0.8	-29.24	-8.63	20.6	0.5	--
1.0	-29.24	-9.10	20.1	0.0	--
1.5	-29.24	-10.11	19.1	-1.0	--
2.0	-29.24	-11.82	17.4	-2.7	--
2.5	-29.24	-18.84	10.4	-9.7	--
3.0	-29.24	-57.25	-28.0	-48.2	0
3.5	-29.24	-70.00	-40.8	-60.9	-3
4.0	-29.24	-70.00	-40.8	-60.9	-5
4.5	-29.24	-70.00	-40.8	-60.9	-7
5.0	-29.24	-70.00	-40.8	-60.9	-9
6.0	-29.24	-70.00	-40.8	-60.9	-12
7.0	-29.24	-70.00	-40.8	-60.9	-15
8.0	-29.24	-70.00	-40.8	-60.9	-17
9.0	-29.24	-70.00	-40.8	-60.9	-19
10.0	-29.24	-70.00	-40.8	-60.9	-21
12.0	-29.24	-70.00	-40.8	-60.9	-24
14.0	-29.24	-70.00	-40.8	-60.9	-27
16.0	-29.24	-70.00	-40.8	-60.9	-28
18.0	-29.24	-70.00	-40.8	-60.9	-28
20.0	-29.24	-70.00	-40.8	-60.9	-28
25.0	-29.24	-70.00	-40.8	-60.9	-28
30.0	-29.24	-70.00	-40.8	-60.9	-28
35.0	-29.24	-70.00	-40.8	-60.9	-28
40.0	-29.24	-70.00	-40.8	-60.9	-28
45.0	-29.24	-70.00	-40.8	-60.9	-28
50.0	-29.24	-70.00	-40.8	-60.9	-28


87.141(f)
Audio Frequency Response
8.33 kHz Channel Spacing
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
Attenuation wrt. 1 kHz (dB)
0
1
10
100
Frequency (kHz)

5.2.4.2. Audio Frequency Response of All Modulation States for 25 kHz Channel Spacing

Frequency (kHz)	Audio IN (dBV)	Audio OUT (dBV)	Attenuation (OUT - IN) (dB)	Attenuation wrt. 1 kHz (dB)	§ 87.141(f) Limit (dB)
0.1	-29.24	-14.54	14.7	-5.5	--
0.2	-29.24	-12.09	17.2	-3.1	--
0.4	-29.24	-10.57	18.7	-1.6	--
0.6	-29.24	-9.42	19.8	-0.4	--
0.8	-29.24	-8.83	20.4	0.2	--
1.0	-29.24	-9.00	20.2	0.0	--
1.5	-29.24	-10.18	19.1	-1.2	--
2.0	-29.24	-11.90	17.3	-2.9	--
2.5	-29.24	-18.74	10.5	-9.7	--
3.0	-29.24	-57.80	-28.6	-48.8	0
3.5	-29.24	-70.00	-40.8	-61.0	-3
4.0	-29.24	-70.00	-40.8	-61.0	-5
4.5	-29.24	-70.00	-40.8	-61.0	-7
5.0	-29.24	-70.00	-40.8	-61.0	-9
6.0	-29.24	-70.00	-40.8	-61.0	-12
7.0	-29.24	-70.00	-40.8	-61.0	-15
8.0	-29.24	-70.00	-40.8	-61.0	-17
9.0	-29.24	-70.00	-40.8	-61.0	-19
10.0	-29.24	-70.00	-40.8	-61.0	-21
12.0	-29.24	-70.00	-40.8	-61.0	-24
14.0	-29.24	-70.00	-40.8	-61.0	-27
16.0	-29.24	-70.00	-40.8	-61.0	-28
18.0	-29.24	-70.00	-40.8	-61.0	-28
20.0	-29.24	-70.00	-40.8	-61.0	-28
25.0	-29.24	-70.00	-40.8	-61.0	-28
30.0	-29.24	-70.00	-40.8	-61.0	-28
35.0	-29.24	-70.00	-40.8	-61.0	-28
40.0	-29.24	-70.00	-40.8	-61.0	-28
45.0	-29.24	-70.00	-40.8	-61.0	-28
50.0	-29.24	-70.00	-40.8	-61.0	-28


87.141(f)
Audio Frequency Response
25 kHz Channel Spacing
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
Attenuation wrt. 1 kHz (dB)
0
1
10
100
Frequency (kHz)

5.3. MODULATION CHARACTERISTICS – MODULATION LIMITING [§§ 2.1047(a) & 87.141(a) & (c)]

5.3.1. Limits

§ 87.141

(a) When A3E emission is used, the modulation percentage must not exceed 100 percent. This requirement does not apply to emergency locator transmitters or survival craft transmitters.

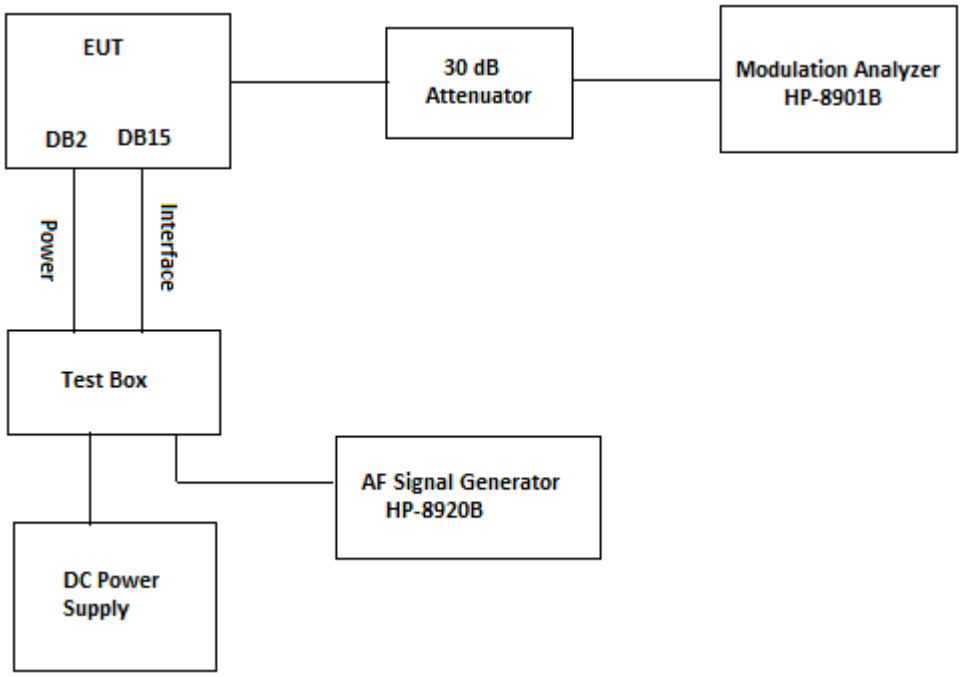
(c) If any licensed radiotelephone transmitter causes harmful interference to any authorized radio service because of excessive modulation, the Commission will require the use of the transmitter to be discontinued until it is rendered capable of automatically preventing modulation in excess of 100 percent.

5.3.2. 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.

5.3.3. Test Arrangement



5.3.4. Test Data

5.3.4.1. Modulation Limiting at 8.33 kHz Channel Spacing

Modulating Signal Level	Peak Modulation depth %					Maximum Limit
(mVrms)	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	%
2	0.22	0.21	0.44	0.39	0.49	100
5	0.27	7.88	7.73	0.39	0.42	100
10	0.28	15.42	15.56	0.44	0.28	100
15	11.99	22.00	22.52	0.43	0.39	100
20	15.95	29.65	30.23	0.30	0.24	100
25	19.73	36.20	37.45	0.34	0.39	100
30	23.51	49.60	44.70	0.86	0.28	100
35	27.82	50.10	50.80	0.73	0.22	100
40	31.60	55.80	57.10	0.84	0.33	100
45	35.65	61.40	63.10	0.87	0.38	100
50	39.22	66.90	68.40	1.12	0.23	100
60	47.20	76.30	78.50	1.08	0.41	100
70	54.30	76.80	77.50	1.42	0.45	100
80	62.20	77.50	77.80	1.58	0.39	100
90	66.30	78.30	79.20	1.31	0.39	100
100	69.40	76.60	78.10	1.41	0.32	100
150	66.60	75.40	77.40	2.06	0.39	100
200	67.70	76.30	76.20	2.22	0.32	100
250	69.50	76.20	76.30	2.78	0.39	100
300	68.30	76.20	76.30	3.39	0.24	100
400	68.40	76.30	76.30	4.19	0.24	100
500	68.40	76.30	76.30	5.12	0.24	100

Remarks

Standard Modulation Level: 34.50 mV = 30.76 dB (mVrms)
Voice Signal Input Level: Standard Modulation Level + 16 dB = 30.76 dB (mVrms) + 16 = 46.76 (mVrms) = 217.68 mVrms

Modulation Frequency (kHz	Peak Depth (%)	Maximum Limit (%)
0.1	68.90	100
0.2	76.90	100
0.4	76.40	100
0.6	78.00	100
0.8	77.00	100
1.0	75.80	100
1.2	74.90	100
1.4	73.90	100
1.6	75.90	100
1.8	76.30	100
2.0	70.80	100
2.5	35.30	100
3.0	2.66	100
3.5	0.65	100
4.0	0.19	100
4.5	0.18	100
5.0	0.21	100
6.0	0.24	100
7.0	0.23	100
8.0	0.23	100
9.0	0.23	100
10.0	0.25	100

5.3.4.2. Modulation Limiting at 25 kHz Channel Spacing

Modulating Signal Level	Peak Modulation depth %					Maximum Limit
(mVrms)	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	%
2	0.33	0.26	0.32	0.42	0.34	100
5	0.47	7.96	8.04	0.25	0.22	100
10	0.23	15.04	15.47	0.34	0.25	100
15	11.95	21.73	22.77	0.33	0.23	100
20	15.96	29.18	30.27	0.20	0.24	100
25	19.73	35.78	37.32	0.36	0.39	100
30	23.82	42.30	44.30	0.83	0.28	100
35	27.42	48.90	51.00	0.76	0.26	100
40	31.77	55.30	57.30	0.90	0.33	100
45	35.48	61.90	63.00	0.74	0.23	100
50	39.16	66.80	68.80	1.06	0.22	100
60	46.90	76.40	78.40	1.06	0.22	100
70	54.30	77.80	77.40	1.09	0.23	100
80	61.80	78.40	78.30	1.18	0.23	100
90	66.20	79.80	79.30	1.59	0.25	100
100	69.40	78.10	78.80	1.55	0.22	100
150	66.40	76.20	76.40	2.31	0.23	100
200	69.30	76.60	76.50	2.56	0.24	100
250	69.50	76.50	76.50	2.91	0.23	100
300	68.90	76.60	76.70	3.43	0.23	100
350	68.80	76.80	76.70	3.48	0.23	100
400	68.70	76.50	76.70	3.80	0.22	100
450	68.50	76.30	77.30	4.32	0.22	100
500	68.50	76.20	77.30	5.30	0.22	100

Remarks

Standard Modulation Level: 34.50 mV = 30.76 dB (mVrms)
Voice Signal Input Level: Standard Modulation Level + 16 dB = 30.76 dB (mVrms) + 16 = 46.76 (mVrms) = 217.68 mVrms

Modulation Frequency (kHz	Peak Depth (%)	Maximum Limit (%)
0.1	67.30	100
0.2	73.00	100
0.4	76.80	100
0.6	77.40	100
0.8	76.60	100
1.0	75.10	100
1.2	74.30	100
1.4	73.80	100
1.6	76.00	100
1.8	75.90	100
2.0	70.90	100
2.5	35.40	100
3.0	2.83	100
3.5	0.60	100
4.0	0.26	100
4.5	0.20	100
5.0	0.18	100
6.0	0.19	100
7.0	0.17	100
8.0	0.20	100
9.0	0.20	100
10.0	0.20	100

5.4. OCCUPIED BANDWIDTH AND EMISSION LIMITATIONS [§§ 2.1049, 87.135, 87.137 & 87.139]

5.4.1. Limits

§ 87.135 Bandwidth of emission

(a) Occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5 percent of the total mean power of a given emission.

(b) The authorized bandwidth is the maximum occupied bandwidth authorized to be used by a station.

(c) The necessary bandwidth for a given class of emission is the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

§87.137 Types of emission

(a) The assignable emissions, corresponding emission designators and authorized bandwidths are as follows:

Class of emission	Emission designator	Authorized bandwidth (kilohertz)		
		Below 50 MHz	Above 50 MHz	Frequency deviation
A3E[1]	6K00A3E		50[2]	
A3E	5K60A3E		8.33 kHz[3]	

[1]For use with an authorized bandwidth of 8.0 kilohertz at radiobeacon stations. A3E will not be authorized:
(i) At existing radiobeacon stations that are not authorized to use A3 and at new radiobeacon stations unless specifically recommended by the FAA for safety purposes.
(ii) At existing radiobeacon stations currently authorized to use A3, subsequent to January 1, 1990, unless specifically recommended by the FAA for safety purposes.

[2]In the band 117.975-136 MHz, the authorized bandwidth is 25 kHz for transmitters approved after January 1, 1974.

[3]In the band 117.975-137 MHz, the Commission will not authorize any 8.33 kHz channel spaced transmissions or the use of their associated emission designator within the U.S. National Airspace System, except, on an optional basis, by Aeronautical Enroute Stations and Flight Test Stations, or by avionics equipment manufacturers which are required to perform installation and checkout of such radio systems prior to delivery to their customers. For transmitters certificated to tune to 8.33 kHz channel spacing as well as 25 kHz channel spacing, the authorized bandwidth is 8.33 kHz when tuned to an 8.33 kHz channel.

§87.139 Emission limitations

(a) Except for ELTs and when using single sideband (R3E, H3E, J3E), or frequency modulation (F9) or digital modulation (F9Y) for telemetry or telecommand in the 1435-1525 MHz, 2345-2395 MHz, or 5091-5150 MHz band or digital modulation (G7D) for differential GPS, the mean power of any emissions must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB;

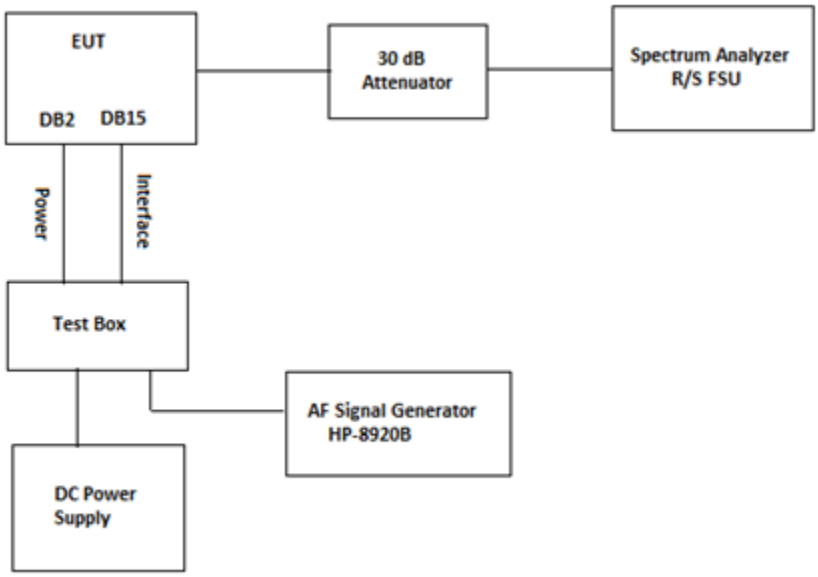
(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 + 10 $\log_{10}$ pY dB.

5.4.2. Method of Measurements

47 CFR 2.1049, ANSI C63.26 and TIA-603-E

5.4.3. Test Arrangement



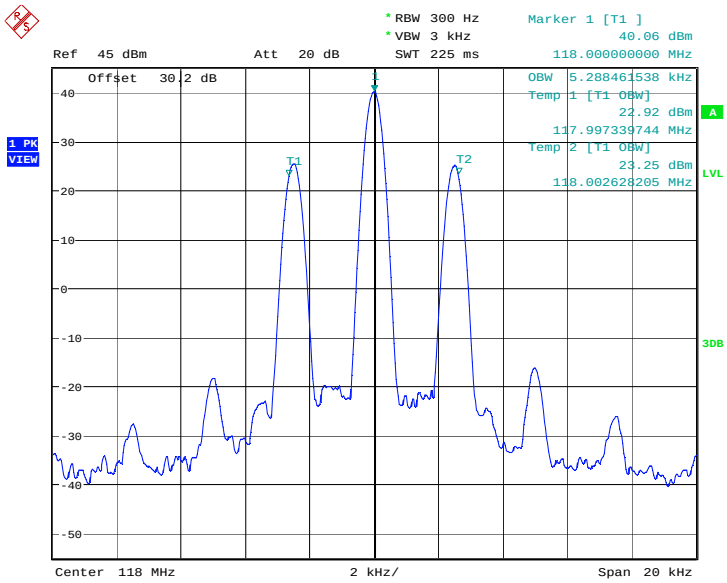
5.4.4. Test Data

5.4.4.1. 99% Occupied Bandwidth

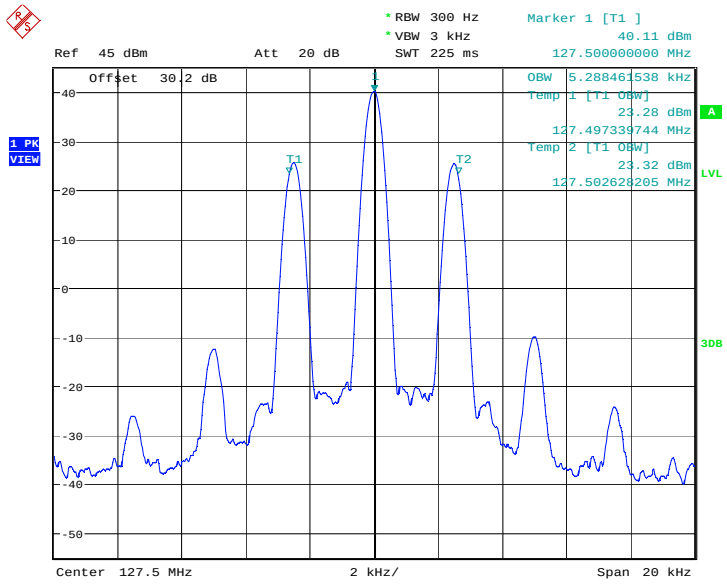
Channel Spacing (kHz)	Frequency (MHz)	*Measured 99% Occupied Bandwidth (kHz)	Authorized Bandwidth (kHz)
8.33	118.005	5.29	8.33
	127.505	5.29	8.33
	136.980	5.29	8.33
25	118.000	5.29	25
	127.500	5.29	25
	136.975	5.29	25

* See the following plots for details of measurements

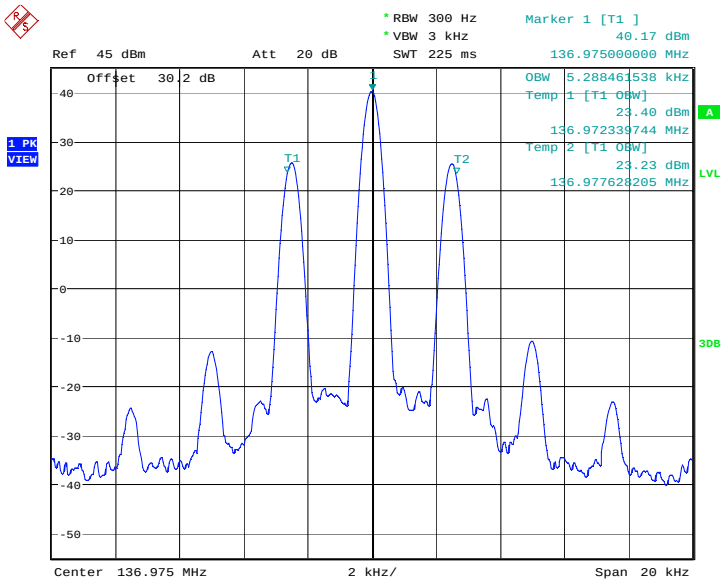
Plot 5.4.4.1.1. 99% Occupied Bandwidth, 8.33 kHz Channel Spacing, 118.005 MHz



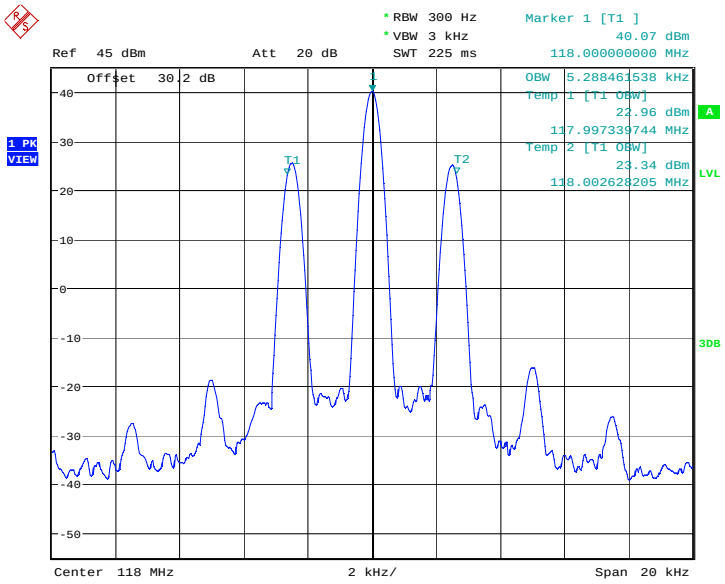
Plot 5.4.4.1.2. 99% Occupied Bandwidth, 8.33 kHz Channel Spacing, 127.505 MHz



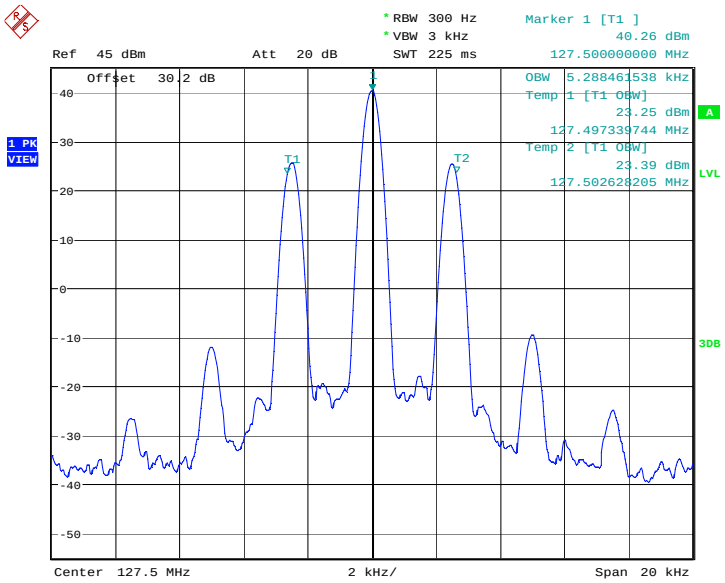
Plot 5.4.4.1.3. 99% Occupied Bandwidth, 8.33 kHz Channel Spacing, 136.980 MHz



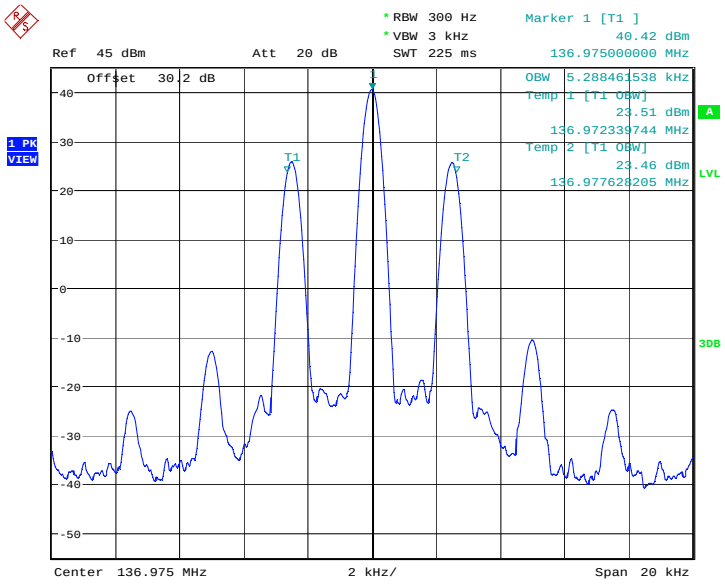
Plot 5.4.4.1.4. 99% Occupied Bandwidth, 25 kHz Channel Spacing, 118.000 MHz



Plot 5.4.4.1.5. 99% Occupied Bandwidth, 25 kHz Channel Spacing, 127.500 MHz

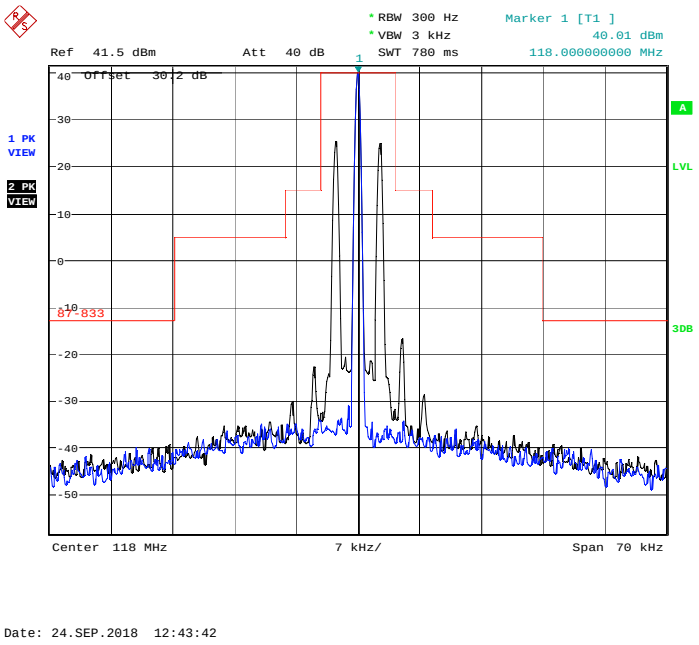


Plot 5.4.4.1.6. 99% Occupied Bandwidth, 25 kHz Channel Spacing, 136.975 MHz

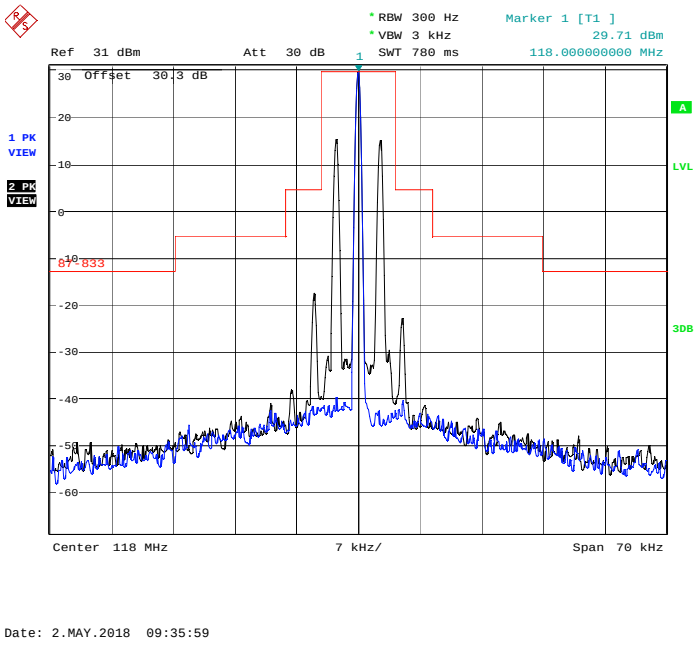


5.4.4.2. Emission Limitations

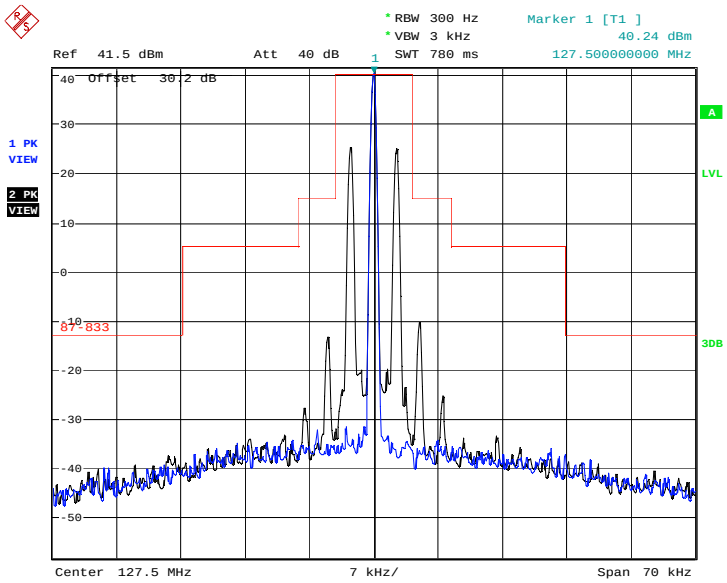
Plot 5.4.4.2.1. Emissions Limitation, 8.33 kHz Channel Spacing, 118.005 MHz, High Power (10 W)



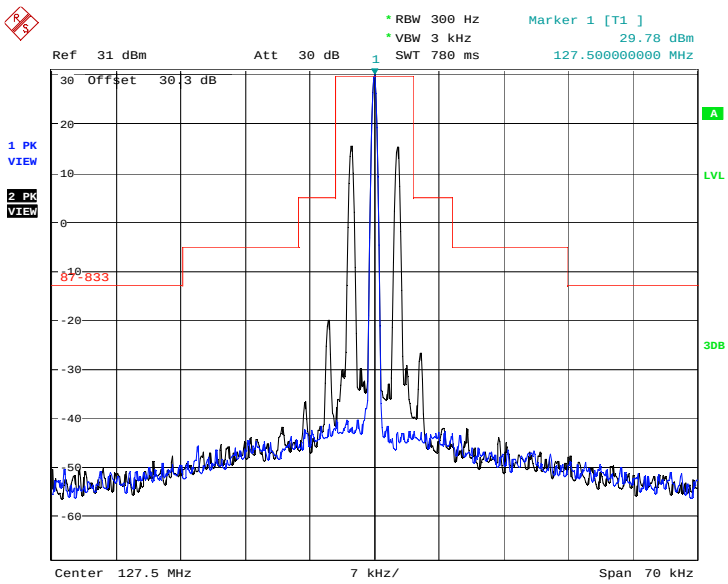
Plot 5.4.4.2.2. Emissions Limitation, 8.33 kHz Channel Spacing, 118.005 MHz, Low Power (1 W)



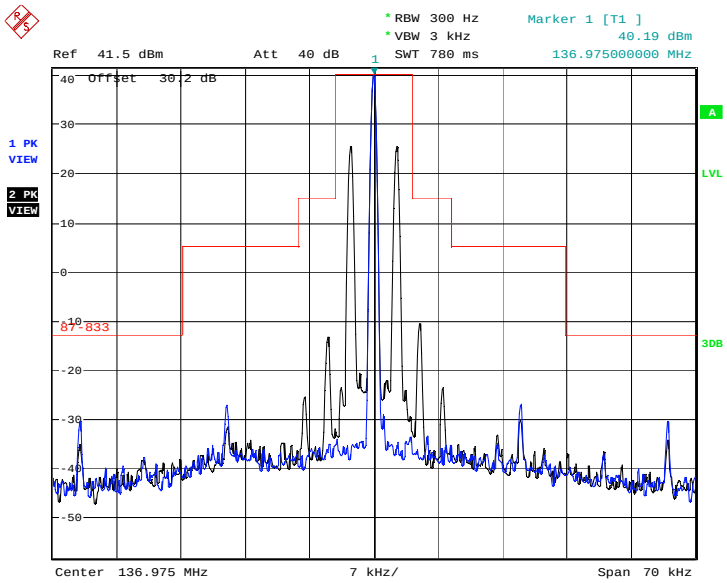
Plot 5.4.4.2.3. Emissions Limitation, 8.33 kHz Channel Spacing, 127.505 MHz, High Power (10 W)



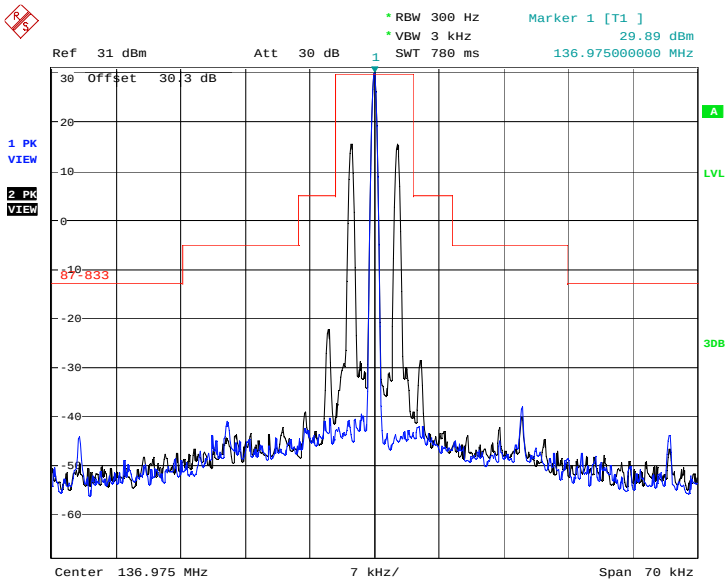
Plot 5.4.4.2.4. Emissions Limitation, 8.33 kHz Channel Spacing, 127.505 MHz, Low Power (1 W)



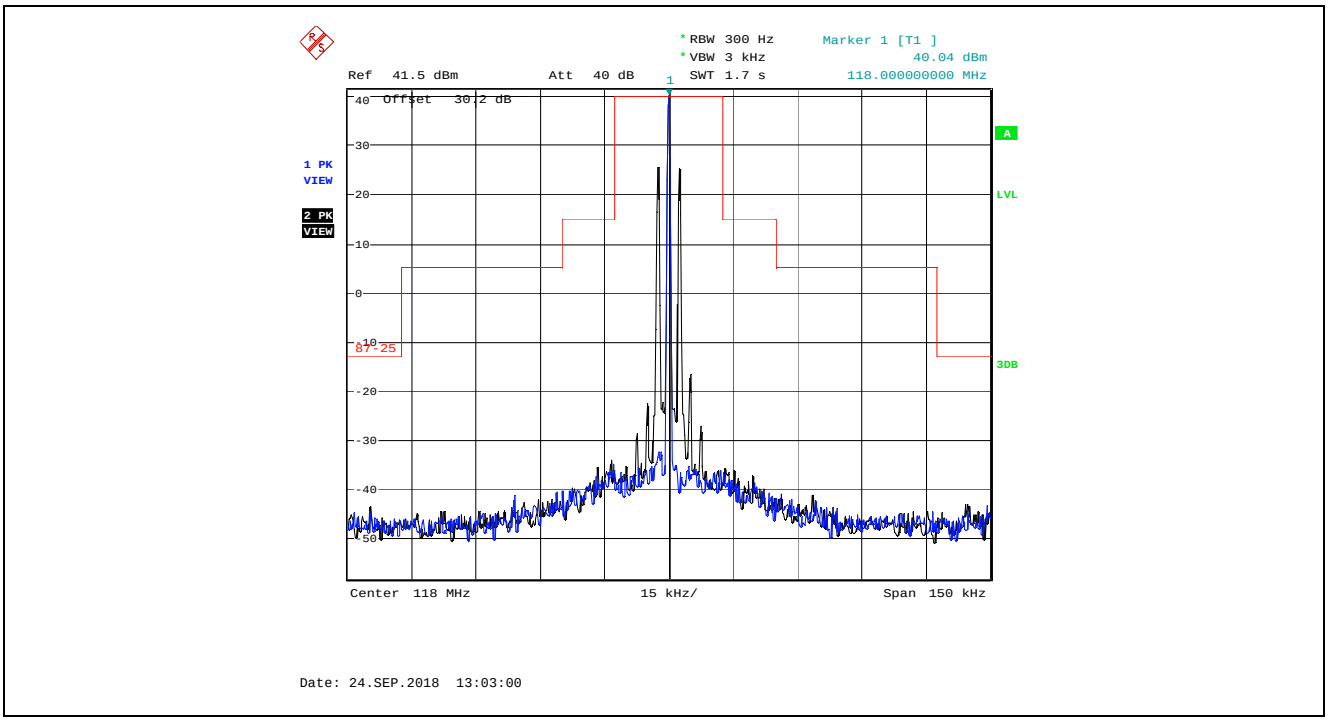
Plot 5.4.4.2.5. Emissions Limitation, 8.33 kHz Channel Spacing, 136.980 MHz, High Power (10 W)



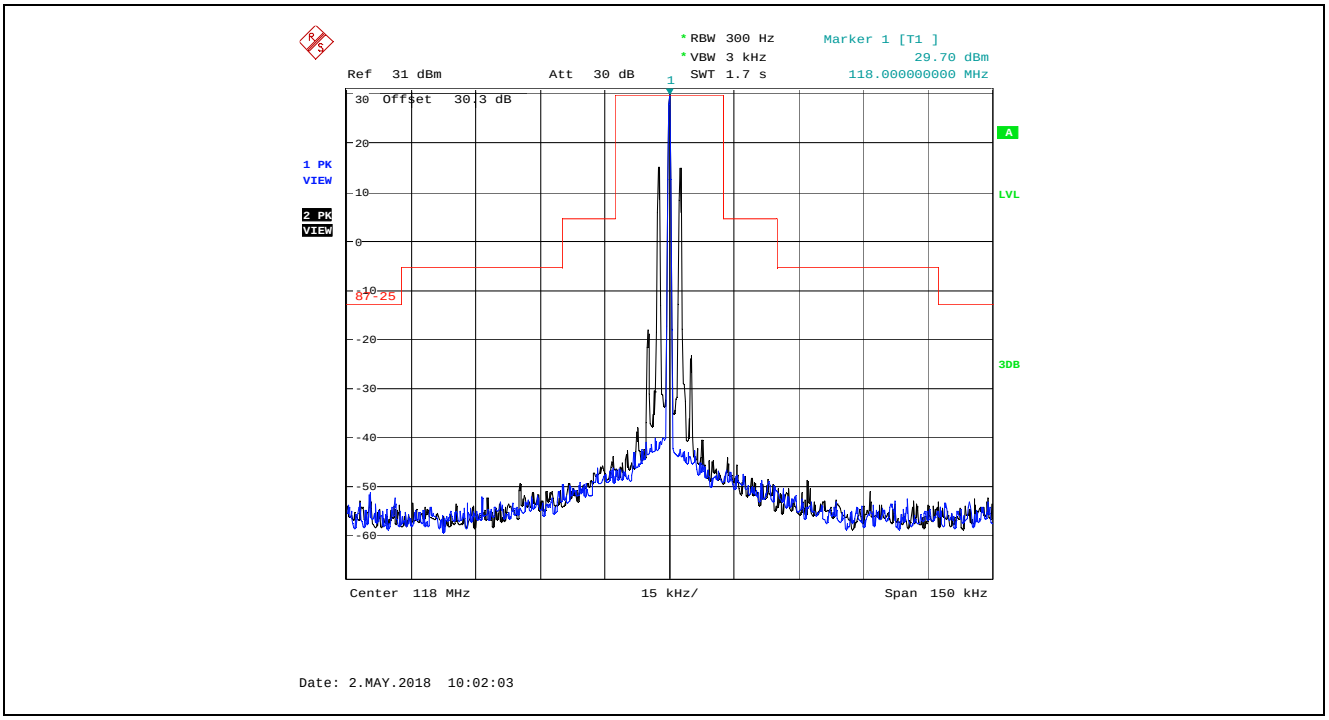
Plot 5.4.4.2.6. Emissions Limitation, 8.33 kHz Channel Spacing, 136.980MHz, Low Power (1 W)



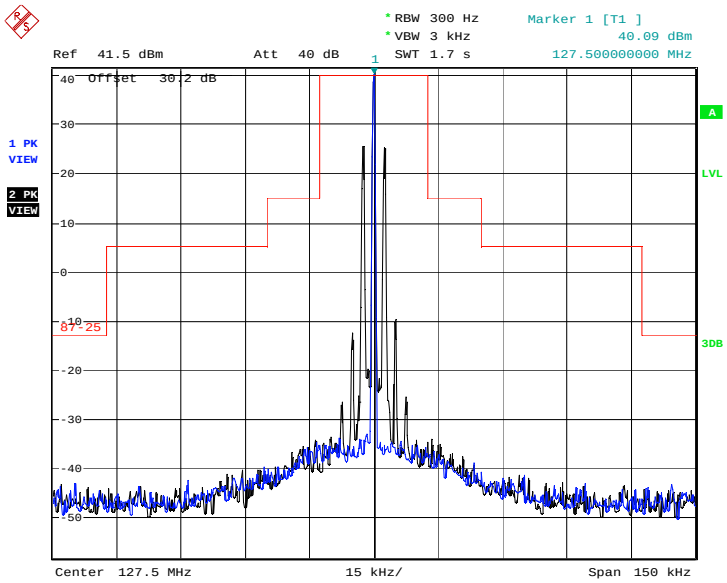
Plot 5.4.4.2.7. Emissions Limitation, 25 kHz Channel Spacing, 118.000 MHz, High Power (10 W)



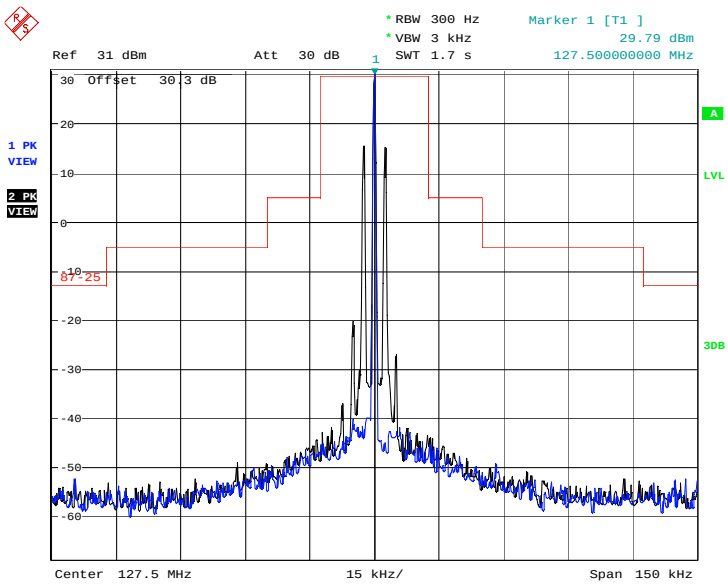
Plot 5.4.4.2.8. Emissions Limitation, 25 kHz Channel Spacing, 118.000 MHz, Low Power (1 W)



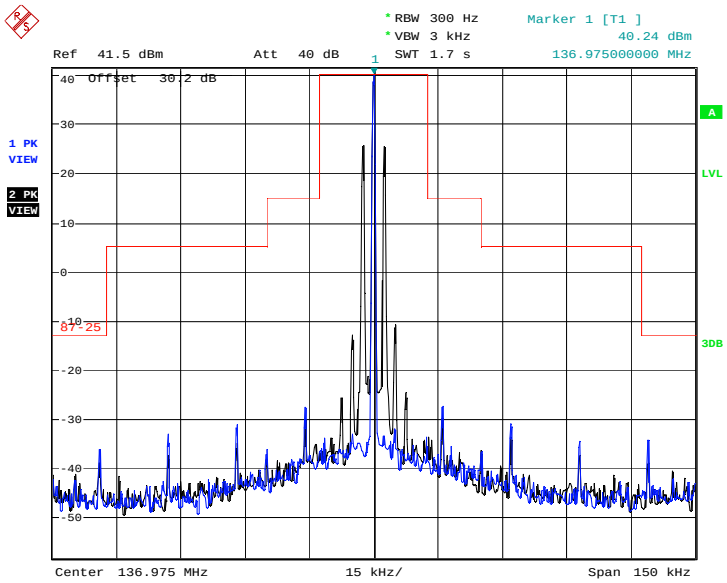
Plot 5.4.4.2.9. Emissions Limitation, 25 kHz Channel Spacing, 127.500 MHz, High Power (10 W)



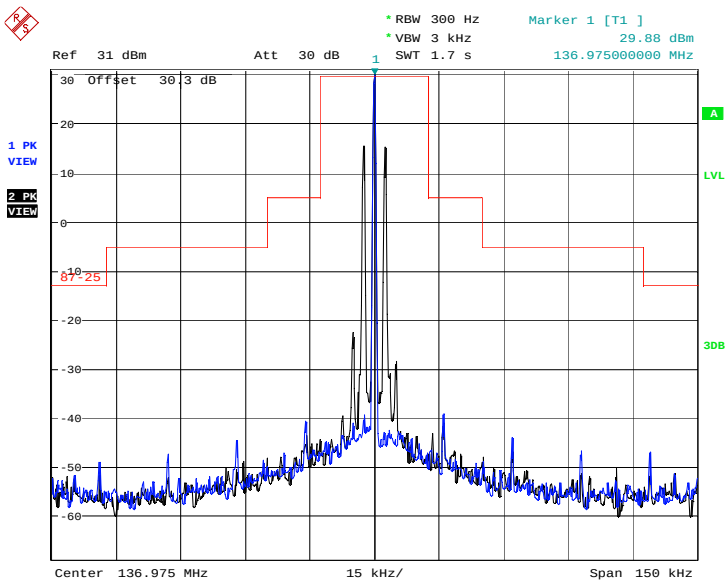
Plot 5.4.4.2.10. Emissions Limitation, 25 kHz Channel Spacing, 127.500 MHz, Low Power (1 W)



Plot 5.4.4.2.11. Emissions Limitation, 25 kHz Channel Spacing, 136.975 MHz, High Power (10 W)



Plot 5.4.4.2.12. Emissions Limitation, 25 kHz Channel Spacing, 136.975MHz, Low Power (1 W)



5.5. TRANSMITTER SPURIOUS EMISSIONS AT ANTENNA TERMINALS [§§ 2.1053 & 87.139]

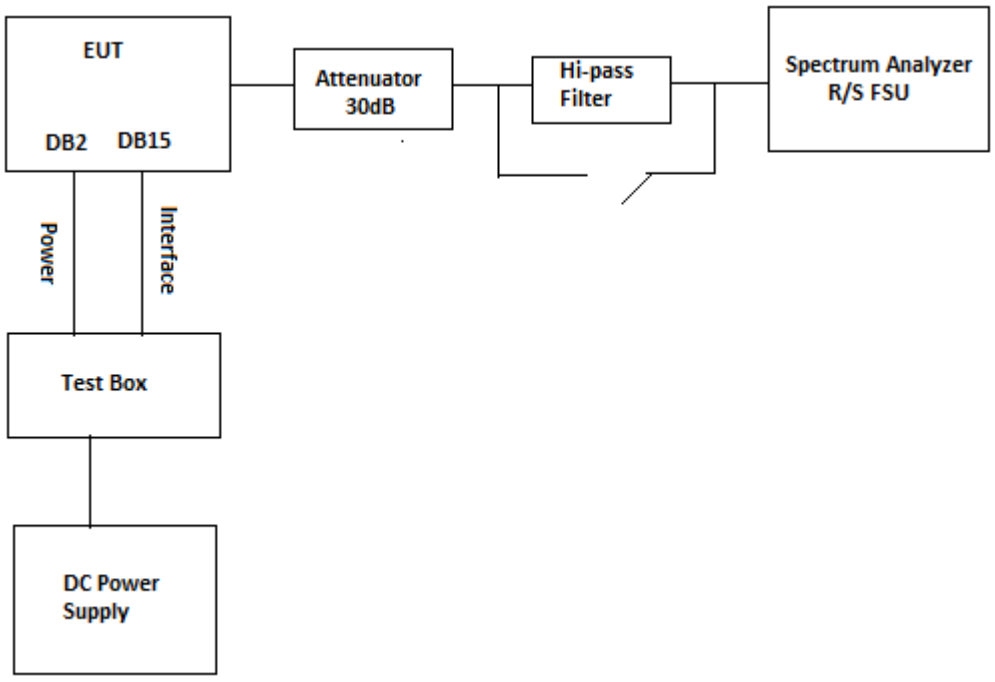
5.5.1. Limits

§ 87.139(a)(3): When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 + 10 $\log_{10}$ pY dB.

5.5.2. Method of Measurements

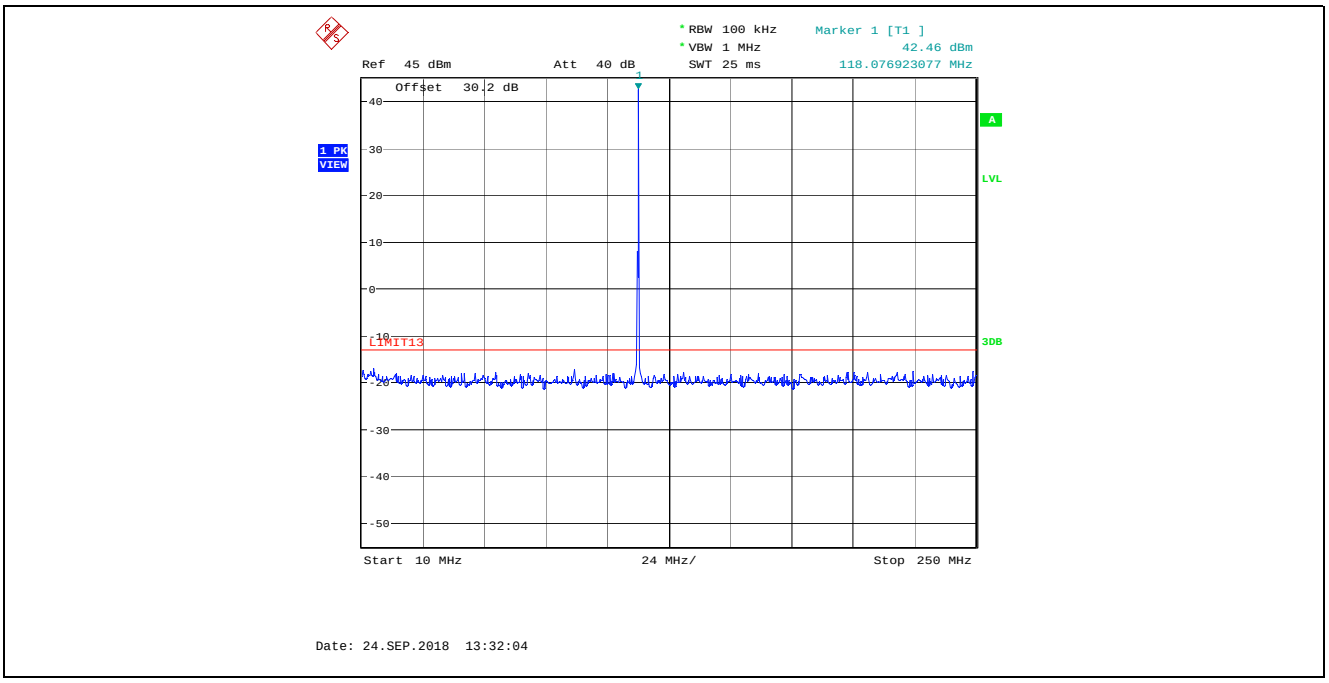
TIA-603-E / ANSI C63.26

5.5.3. Test Arrangement

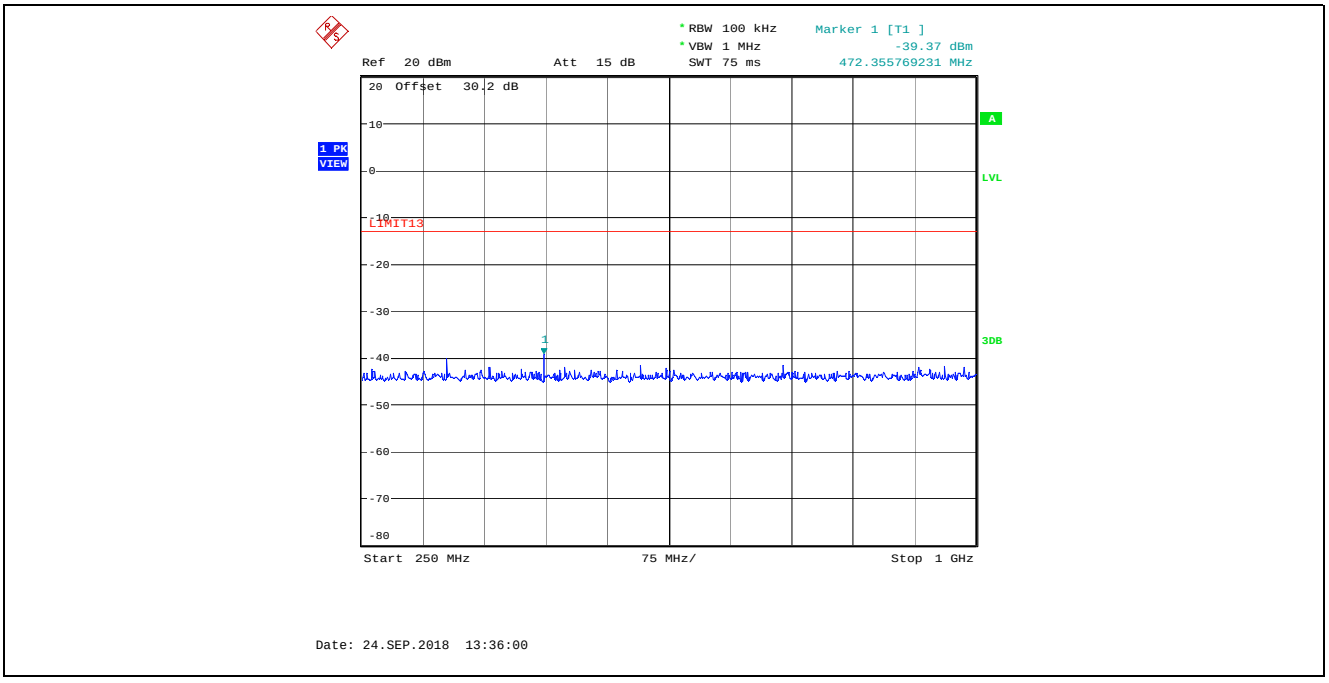


5.5.4. Test Data

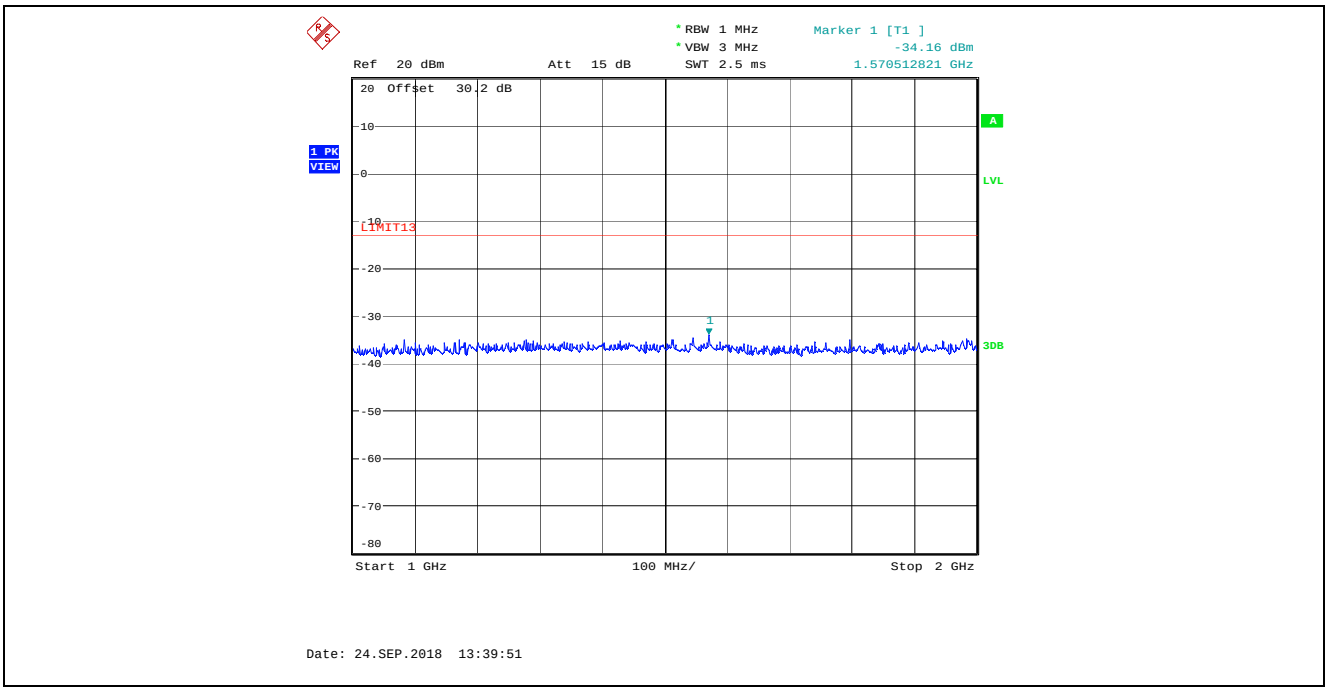
Plot 5.5.4.1. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
118.000 MHz, 10 MHz – 250 MHz



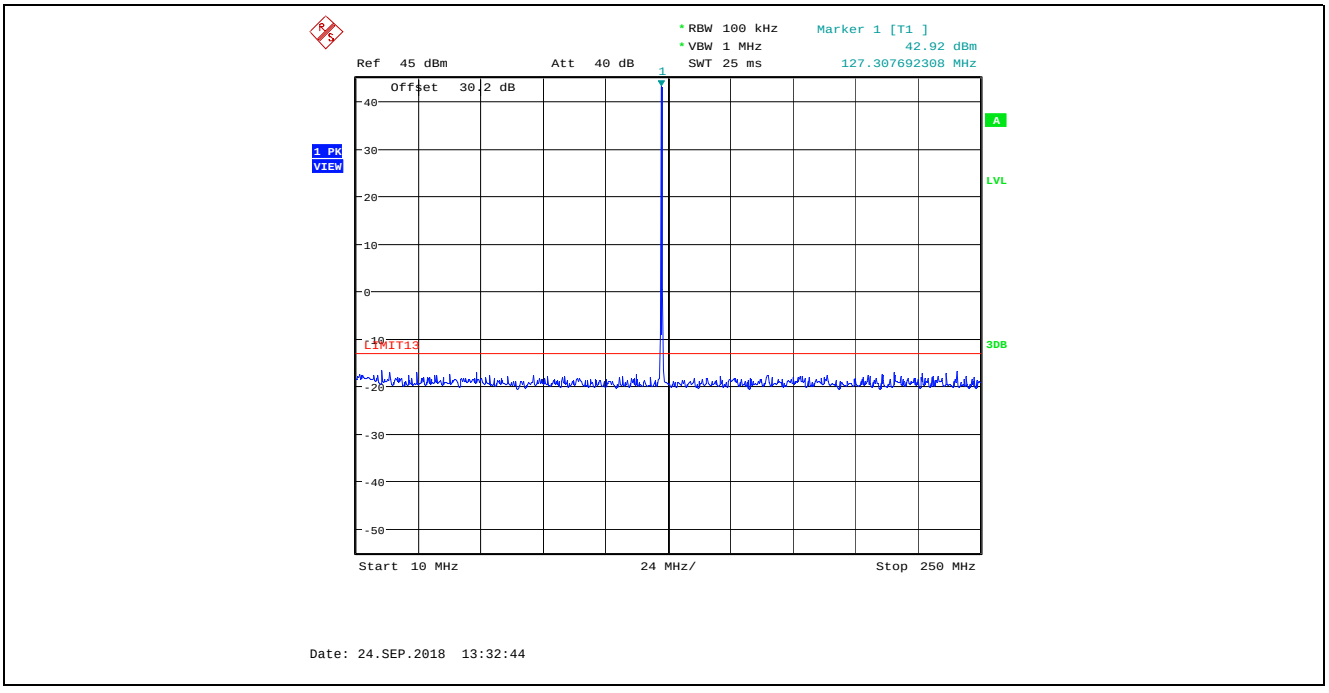
Plot 5.5.4.2. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
118.000 MHz, 250 MHz – 1 GHz



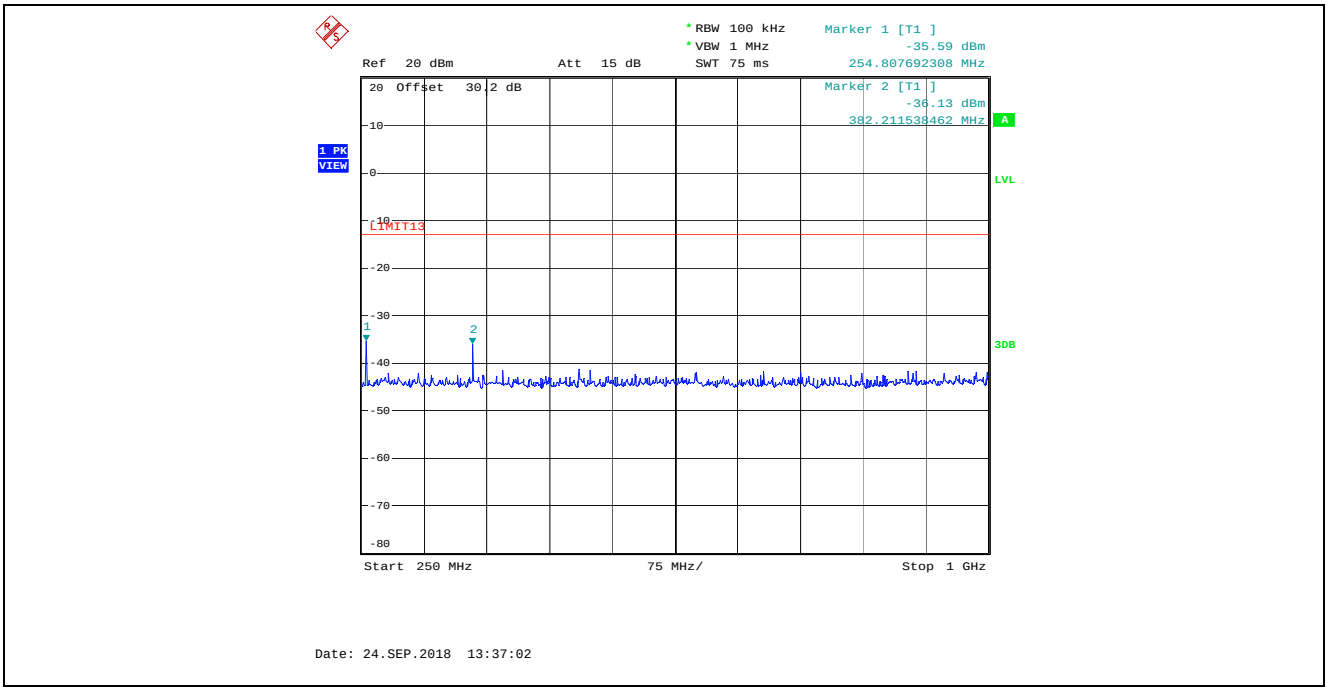
Plot 5.5.4.3. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
118.000 MHz, 1 GHz - 2 GHz



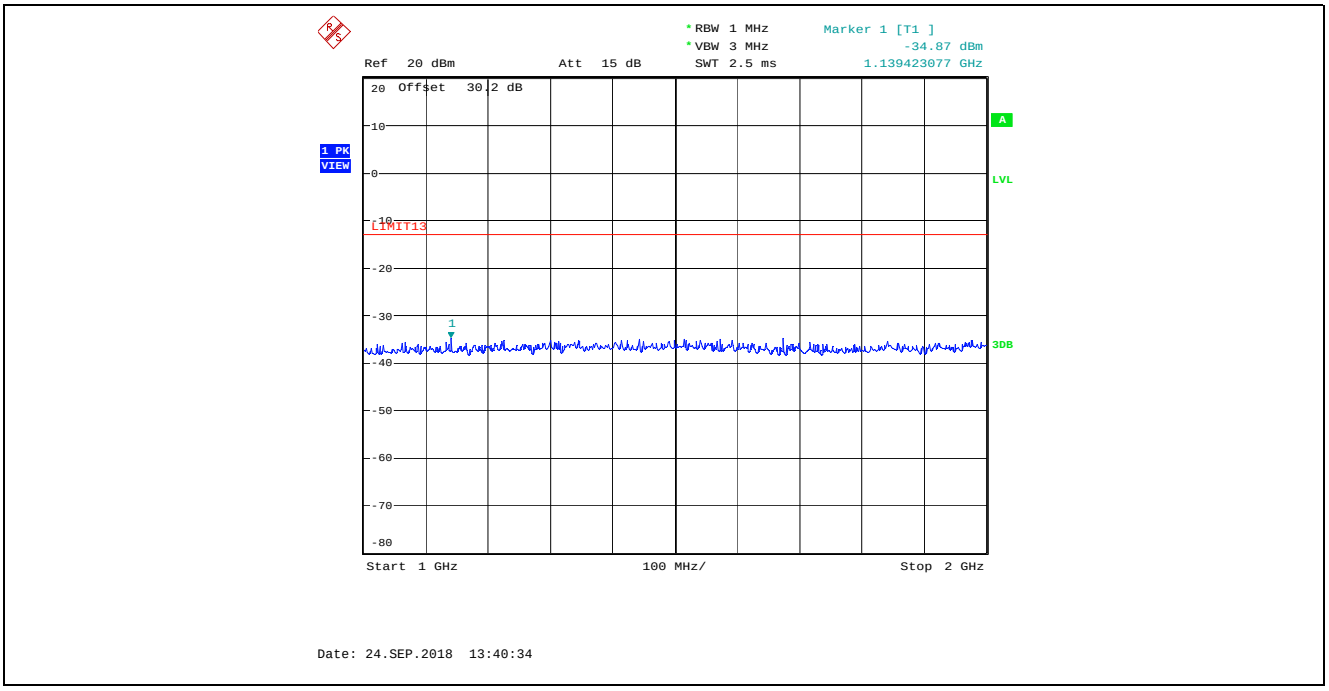
Plot 5.5.4.4. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
127.500 MHz, 10 MHz – 250 MHz



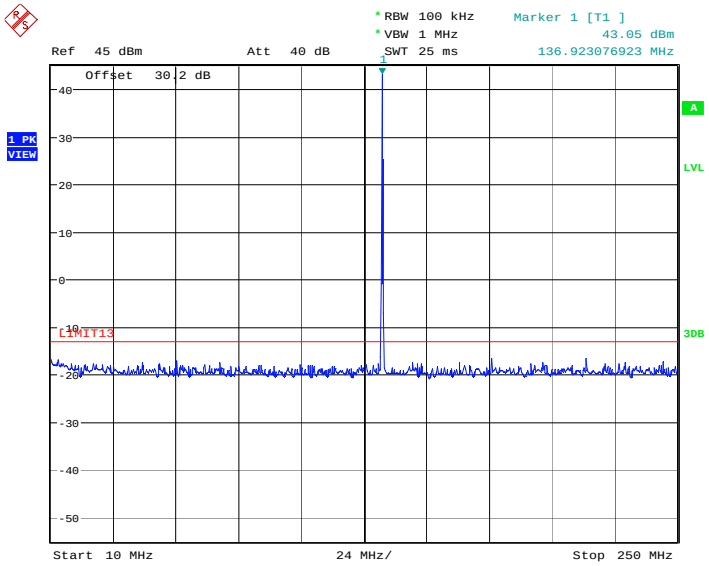
Plot 5.5.4.5. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
127.500 MHz, 250 MHz – 1 GHz



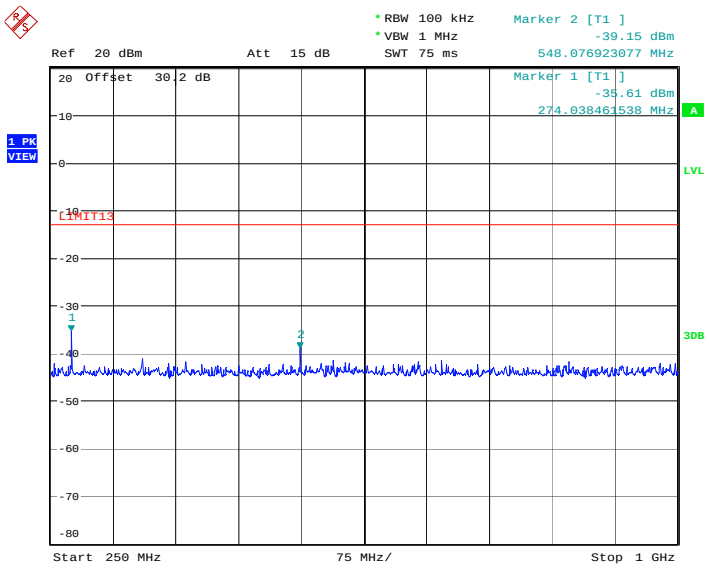
Plot 5.5.4.6. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
127.500 MHz, 1 GHz - 2 GHz



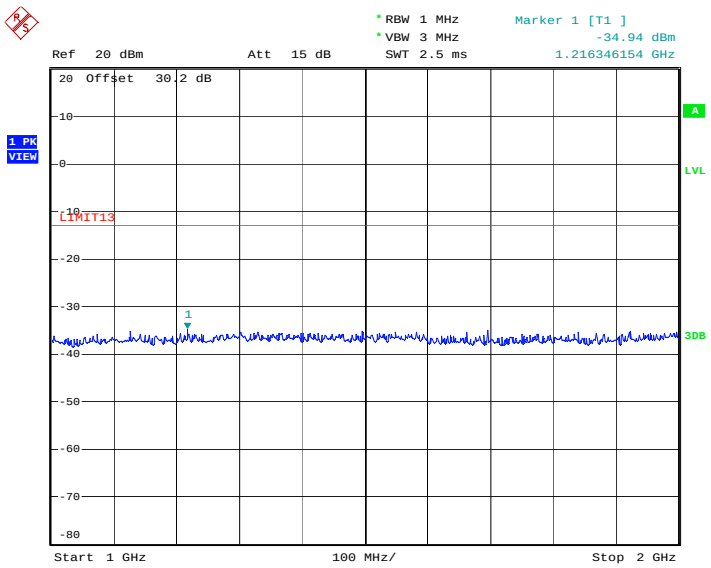
Plot 5.5.4.7. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
136.975 MHz, 10 MHz – 250 MHz



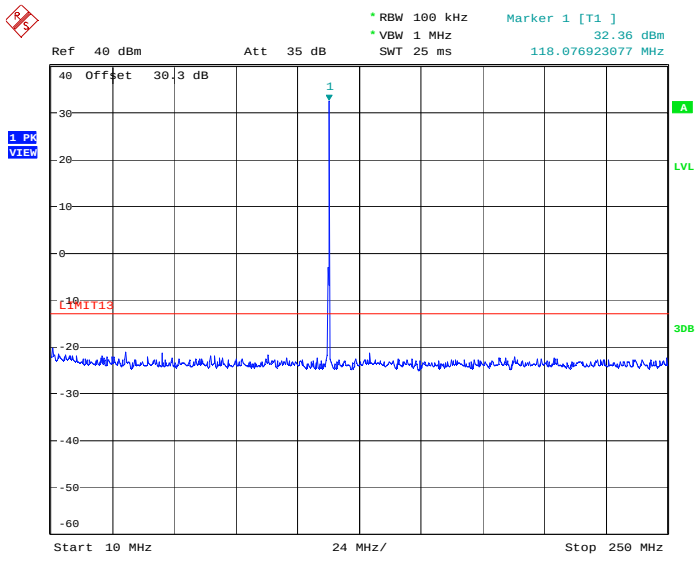
Plot 5.5.4.8. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
136.975 MHz, 250 MHz – 1 GHz



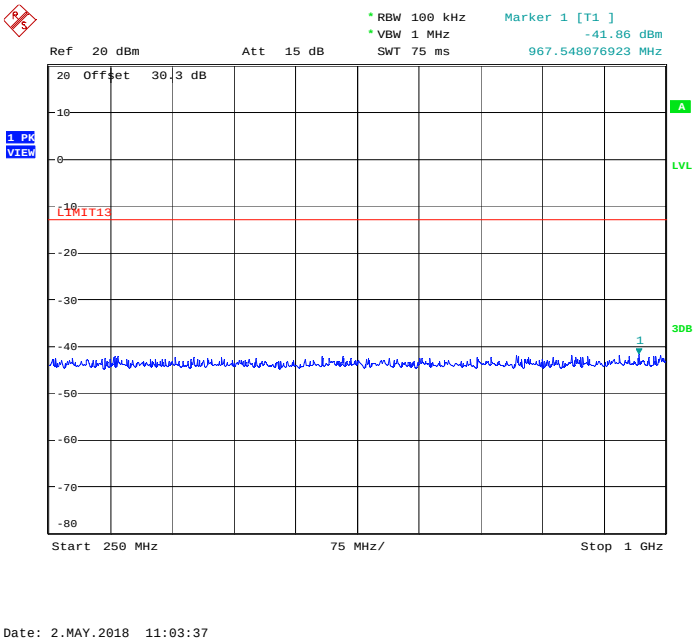
Plot 5.5.4.9. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, High Power (10 W)
136.975 MHz, 1 GHz - 2 GHz



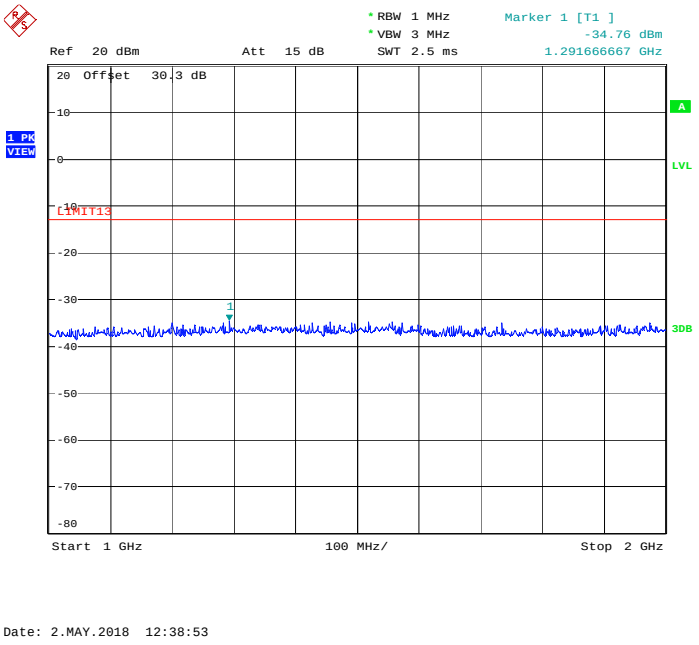
Plot 5.5.4.10. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
118.000 MHz, 10 MHz – 250 MHz



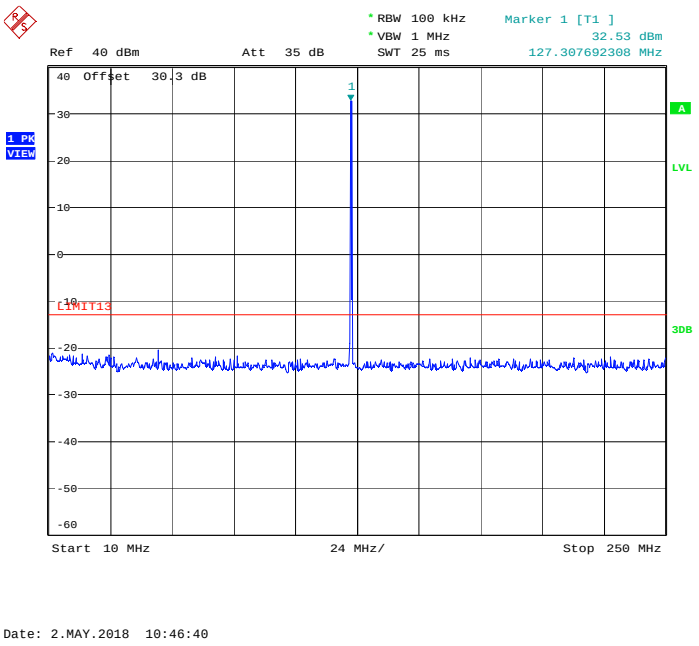
Plot 5.5.4.11. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
118.000 MHz, 250 MHz – 1 GHz



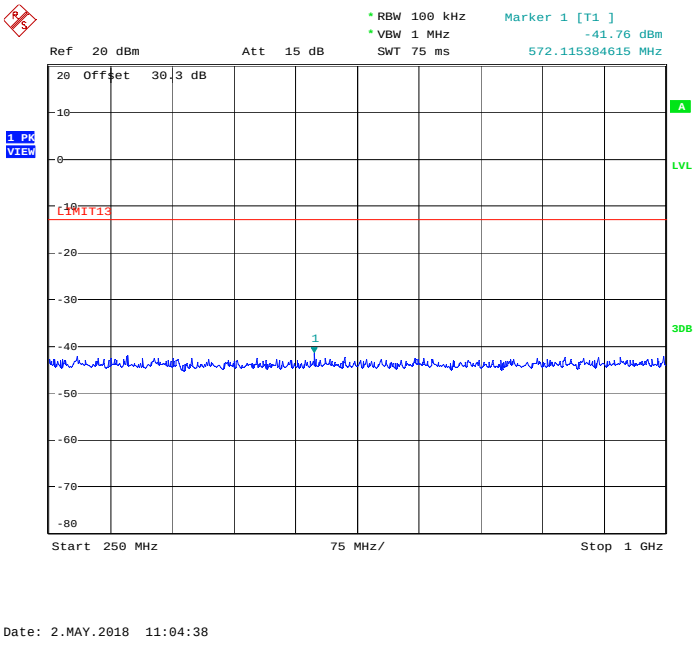
Plot 5.5.4.12. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
118.000 MHz, 1 GHz - 2 GHz



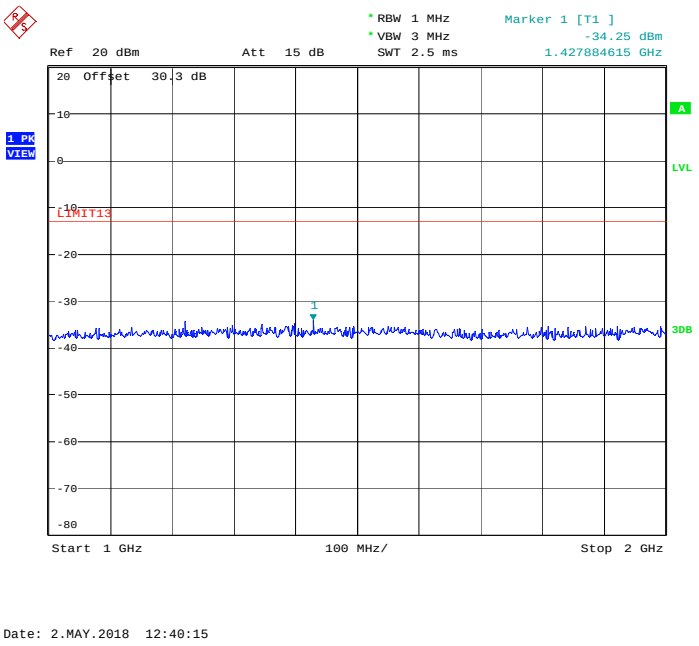
Plot 5.5.4.13. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
127.500 MHz, 10 MHz – 250 MHz



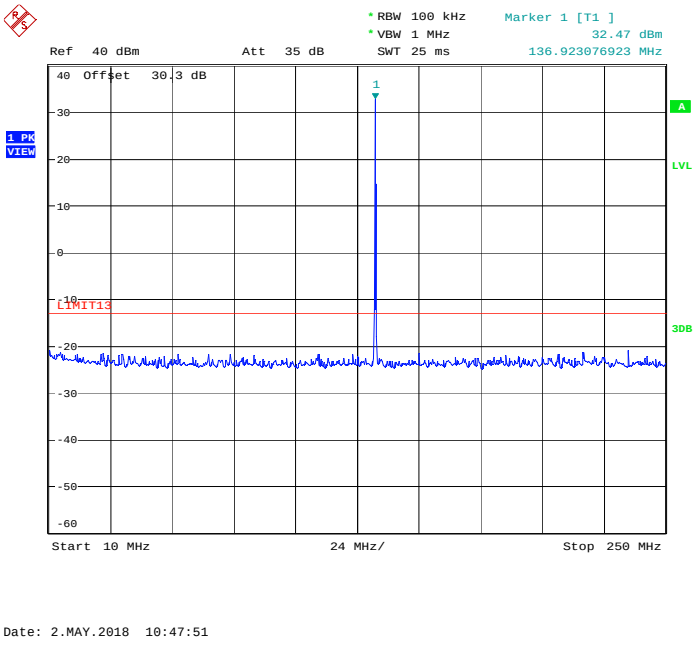
Plot 5.5.4.14. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
127.500 MHz, 250 MHz – 1 GHz



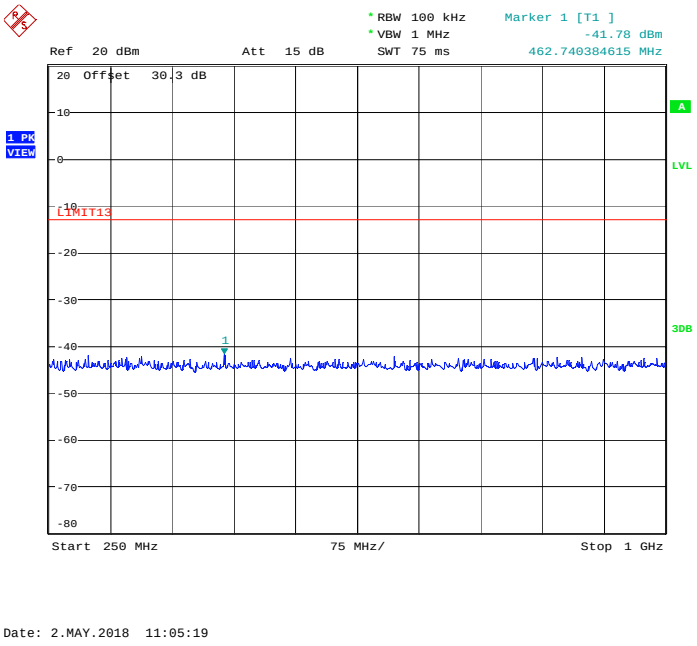
Plot 5.5.4.15. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
127.500 MHz, 1 GHz - 2 GHz



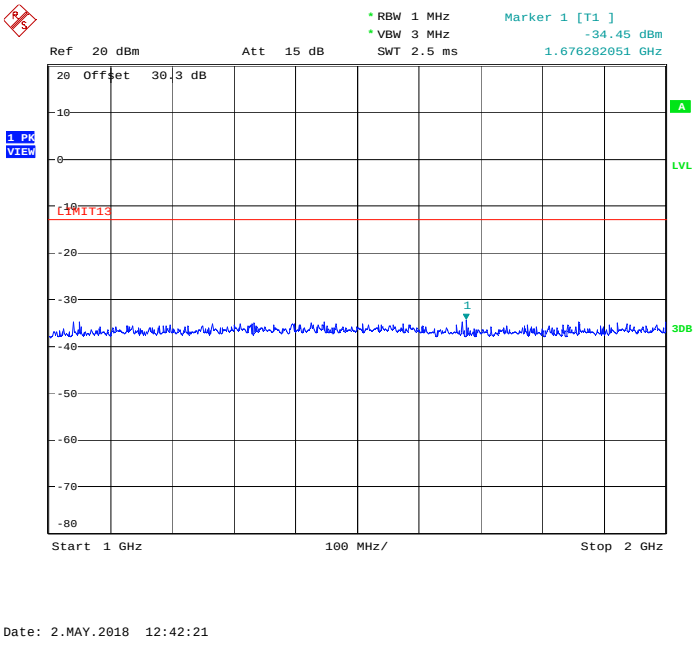
Plot 5.5.4.16. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
136.975 MHz, 10 MHz – 250 MHz



Plot 5.5.4.17. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
136.975 MHz, 250 MHz – 1 GHz



Plot 5.5.4.18. Transmitter Spurious Emissions at Antenna Terminal, 25 kHz Channel Spacing, Low Power (1 W)
136.975 MHz, 1 GHz - 2 GHz



5.6. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§§ 2.1053 & 87.139]

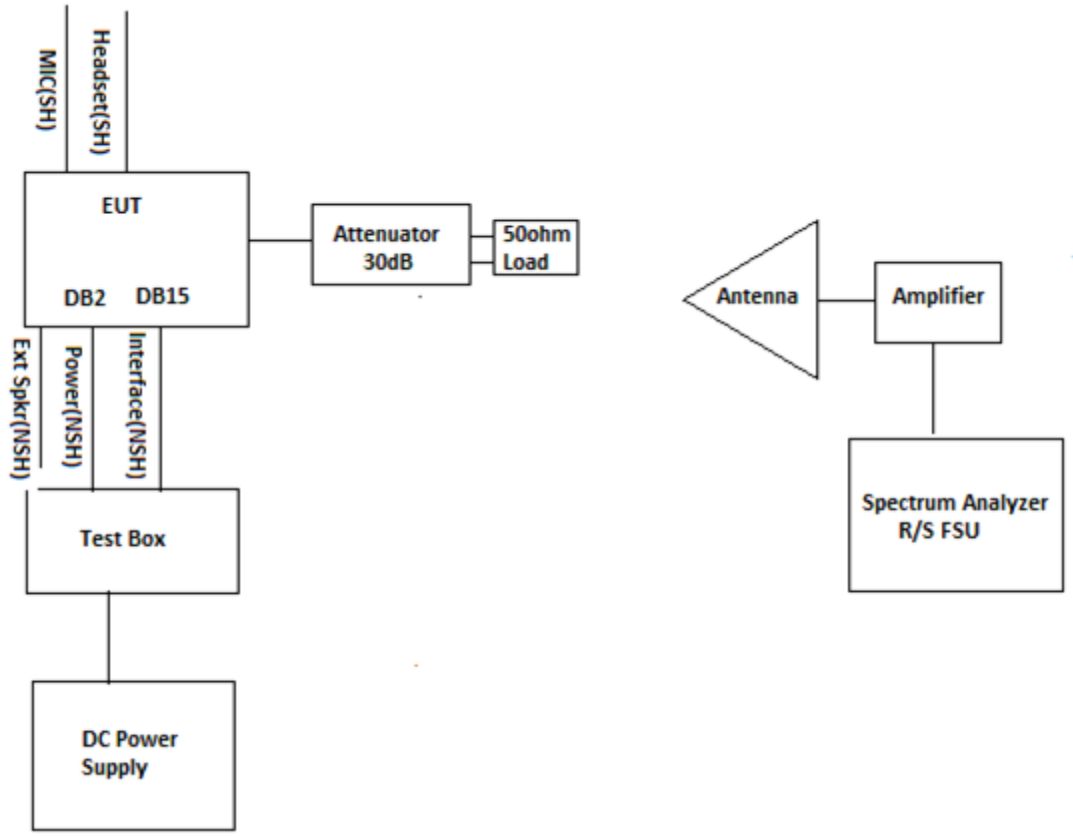
5.6.1. Limits

§ 87.139(a)(3): When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43 + 10 $\log_{10}$ pY dB.

5.6.2. Method of Measurements

TIA-603-E / ANSI C63.26

5.6.3. Test Arrangement



5.6.4. Test Data

Remark(s):

- Test conducted at 25 kHz channel spacing.
- The emissions were scanned from 30 MHz to 6 GHz; all spurious emissions that are in excess of 20dB below the specified limit shall be recorded.

Carrier Frequency:	118.000 MHz
Power:	10.50 W
Limit:	-13 dBm

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
30 - 6000	*	Peak	H/V	*	-13	*

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

Carrier Frequency:	127.500 MHz
Power:	10.54 W
Limit:	-13 dBm

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
30 - 6000	*	Peak	H/V	*	-13	*

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

Carrier Frequency:	136.975 MHz
Power:	10.47 W
Limit:	-13 dBm

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
30 - 6000	*	Peak	H/V	*	-13	*

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

5.7. FREQUECNY STABILITY [§§ 2.1055 & 87.133]

5.7.1. Limits

§ 87.133 The carrier frequency of each station must be maintained within the tolerance in the following table:

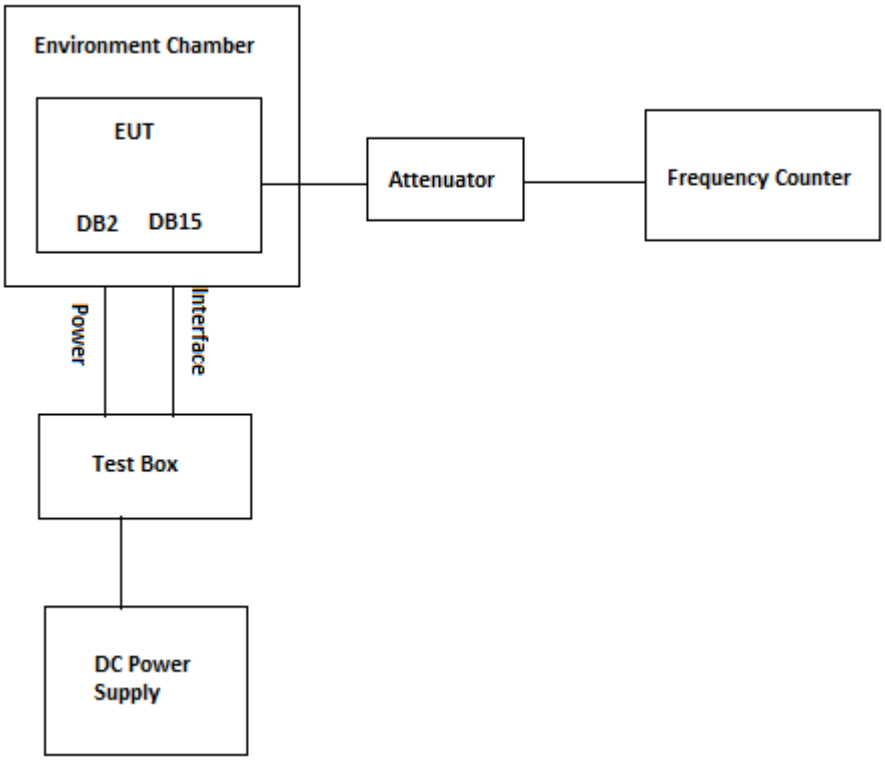
Frequency band (lower limit exclusive, upper limit inclusive), and categories of station	Tolerance (ppm)
(5) Band - 108 to 137 MHz: Aircraft and other mobile stations in the Aviation Services.	*30

* For emissions G1D and G7D, the tolerance is 5 parts per 10^6.

5.7.2. Method of Measurements

47 CFR 2.1049, ANSI C63.26 and TIA-603-E

5.7.3. Test Arrangement



5.7.4. Test Data

Center Frequency:	118.000 MHz
Full Power Level:	10.5 W
Frequency Tolerance Limit (Worst Case):	30 ppm or 3540 Hz (Manufacturer's rating: ± 1 ppm)
Max. Frequency Tolerance Measured:	0.14 ppm or -17 Hz
Input Voltage Rating:	13.8 to 28 VDC (24 VDC Nominal)

Ambient Temperature (°C)	**Frequency Drift (Hz)**		
	Supply Voltage (Nominal) 24 VDC	**Supply Voltage (85% of 13.8 VDC) 11.73 VDC**	**Supply Voltage (115% of 28 VDC) 32.2 VDC**
-30	+9	--	--
-20	-12	--	--
-10	-15	--	--
0	-16	--	--
+10	-15	--	--
+20	-17	-15	-15
+30	-17	--	--
+40	-13	--	--
+50	-8	--	--
+60	+7	--	--

5.8. EXPOSURE OF HUMANS TO RF FIELD [[§§ 1.1310 & 2.1091]

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

Limits for Maximum Permissible Exposure (MPE)

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

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.8.1. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2} \quad \text{or} \quad r = \sqrt{\frac{P \cdot G}{4 \cdot \pi \cdot S}} = \sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}}$$

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

5.8.2. RF Evaluation

Frequency (MHz)	Max. Conducted Power (dBm)	Max. Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	MPE Limit (mW/cm2)
118.000	40.28	3	43.28	21281.39	115	0.128	0.2

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Power Meter	HP	436A	2016A07747	100 kHz-sensor dependent	04 May 2019
Power Sensor	HP	8482A	MY41172054	0.1 MHz - 4.2 GHz	26 Oct 2019
Attenuator(30dB)	Aeroflex\Weinschel	46-30-34	BR9127	DC – 18 GHz	Cal on use
50Ω Termination	Mini Circuits	KARN-50+	00834	DC – 8000 MHz	Cal on use
Power Supply	Tenma	72-7295	490300297	1-40 V, DC 5A	Cal on use
Modulation Analyzer	HP	HP-8901B	3226A04606	150 kHz – 1300 MHz	23 Mar 2020
AF Signal Generator	HP	HP-8920B	US39064699	30 MHz – 1 GHz	20 Mar 2020
Digital Voltmeter	HP	3456A	2015A04523		19 Dec 2019
FFT Digital Spectrum Analyzer	Advantest	R9211E	8202336	10 mHz – 100 kHz	12 Sep 2020
Signal Generator	Marconi	2024	112255/164	9 kHz - 2.4 GHz	29 Aug 2019
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20 Hz - 26.5 GHz	06 Oct 2019
Hi-pass filter	Mini-Circuit	SHP-250	--	Cut off 230 MHz	Cal on use
Combiner	Weinschel 93458	1515	PS119	DC – 18 GHz	Cal on use
Bicon Antenna	ETS-Lindgren	3110B	3379	30 – 200 MHz	06 Feb 2020
Log Periodic Antenna	ETS-Lindgren	3148	00023845	200 - 2000 MHz	02 Aug 2020
Horn Antenna	ETS-Lindgren	3117	00119425	1 – 18 GHz	29 Jun 2019
Horn Antenna	ETS-Lindgren	3160-09	00118385	18 - 26.5 GHz	11 Oct 2018
Preamplifier	Com-Power	PAM-118A	551016	500 MHz – 18 GHz	09 Mar 2019
Preamplifier	Com-Power	PA-103	161040	1 – 1000 MHz	16 May 2019
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177° C	16 Jun 2019
Frequency Counter	EIP	545A	2683	10 MHz – 1 GHz	07 Aug 2020
Attenuator	Aeroflex\Weinschel	46-10-34	BS4336	DC – 18 GHz	Cal on use
Attenuator	Weinschel	WA 35-20-33	A164	DC - 8.5 GHz	Cal on use
Multimeter	Tenma	72-6202	02080027	---	14 Dec 2019
EMI Receiver	Rohde & Schwarz	ESU40	100037	20 Hz – 40 GHz	09 May 2018*
Biconilog Antenna	EMCO	3142	9601-1005	26 – 2000 MHz	12 May 2018*
Preamplifier	Com-Power	PAM-0118A	551052	500 MHz – 18 GHz	17 July 2018*
Horn Antenna	EMCO	3115	6570	1 – 18 GHz	13 Oct 2018*

* Equipment used before cal. due date.

EXHIBIT 7. MEASUREMENT UNCERTAINTY

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

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.79**	**± 5.2**

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

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