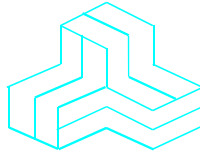


ENGINEERING TEST REPORT



P25 Vehicular Radio Extender
Model: VRX1000 700/800 MHz
FCC ID: LO6-VRX1000700800

Applicant:

Futurecom Systems Group, ULC
3277 Langstaff Road
Concord, ON
Canada L4K 5P8

Tested in Accordance With

Federal Communications Commission (FCC)
47 CFR, Parts 2 and 90

UltraTech's File No.: 22FSG198_FCC90

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

Date: February 9, 2022

Report Prepared by: Dan Huynh

Tested by: Nimisha Desai

Issued Date: February 9, 2022

Test Dates: November 18, 2021

- 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.
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UltraTech

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APEC TEL CA0001



1309



CA0001-2049



AT-1945



SL2-IN-E-1119R



Korea KCC-RRR

CA0001

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 90
Title:	Code of Federal Regulations (CFR), Title 47 –Telecommunication, Part 90 Private Land Mobile Radio (PLMR) services
Purpose of Test:	Class II Permissive Change Certification Authorization to add NPSPAC operating mode.
Test Procedures:	• ANSI C63.26-2015 • ANSI C63.4

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

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2021	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

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EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Futurecom Systems Group ULC.
Address:	3277 Langstaff Road Concord, ON Canada L4K 5P8
Contact Person:	Mr. Tony Bombera Phone #: 905 532 1114 Fax #: 905 660 6858 Email Address: tony.bombera@futurecom.com

Manufacturer	
Name:	Futurecom Systems Group ULC.
Address:	3277 Langstaff Road Concord, ON Canada L4K 5P8
Contact Person:	Mr. Tony Bombera Phone #: 905 532 1114 Fax #: 905 660 6858 Email Address: tony.bombera@futurecom.com

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:	Futurecom Systems Group, ULC
Product Name:	P25 Vehicular Radio Extender
Model Name or Number:	VRX1000 700/800 MHz
Serial Number:	18105572
Type of Equipment:	Licensed Non-Broadcast Station Transmitter
Power Supply Requirement:	13.8V DC Nominal
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Radio coverage extender for portable radios

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2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Fixed Base & Mobile Stations
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	13.8V DC 3A Nominal
RF Output Power Rating:	Programmable 0.5W – 3.0W
Operating Frequency Range:	764-776 MHz and 851-869 MHz
RF Output Impedance:	50 Ω
Channel Spacing:	25 kHz & 12.5 kHz
Modulation Employed:	Analog FM, P25 C4FM
Data Rate:	9600 bps
Emission Designation*:	16K0F3E, 11K0F3E, 8K10F1E and 8K10F1D
Oscillator Frequency(ies):	14.4MHz, 107.85MHz, 109.65MHz
Antenna Connector Type:	Mini UHF

*Necessary bandwidth determined using the Carson's formula: $B_n = 2M + 2DK$

where: B_n = Necessary bandwidth in hertz

M = Maximum modulation frequency in hertz

D = Peak frequency deviation

K = An overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion.

Standard Audio Modulation (12.5 kHz Channelization, Analog Voice):

M = 3 kHz; D = 2.5 kHz; K = 1

$B_n = 2M + 2DK = 2(3 \text{ kHz}) + 2(2.5 \text{ kHz})(1) = 11 \text{ kHz}$

Emission Designator: 11K0F3E.

Standard Audio Modulation (25 kHz Channelization, Analog Voice):

M = 3 kHz; D = 5 kHz

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

Emission Designator: 16K0F3E

For Digital Modulation the measured 99% occupied bandwidth was used instead of Carson's rule.

Digital (12.5 kHz Channelization, Digital Voice):

Emission Designator: 8K10F1E

Digital (12.5 kHz Channelization, Digital Data):

Emission Designator: 8K10F1D

2.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	DC Power Input	1	M12	1m, unshielded
2	Programming Connector	1	Mini USB	0.6m, Shielded
3	RF Connector	1	Mini UHF	0.6m, Shielded
4	Auxiliary/Options/Mobile Connector	1	DB-25	0.9m, Shielded

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21° C to 24° C
Humidity:	45% to 58%
Pressure:	102 kPa
Power input source:	13.8V DC 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:	N/A
Transmitter Test Antenna:	The EUT is tested with the transmitter antenna port terminated to a 50 Ω Load.

Transmitter Test Signals	
Frequency Band(s):	851-854 MHz
Test Frequency(ies): (in NPSPAC band, 851-854 MHz)	851.025 MHz and 853.975
Transmitter Wanted Output Test Signals: - Transmitter Power (measured maximum output power): - Normal Test Modulation: - Modulating signal source:	NPSPAC band (851-854 MHz) : 35.01 dBm (3.17 W) Analog Voice External for analog mode/Internal for digital mode

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EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

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

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- 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 & 90.205	RF Power Output	Yes
2.1047(a)	Modulation Characteristics - Audio Frequency Response	Yes
2.1047(b)	Modulation Characteristics - Modulation Limiting	Yes
2.1049, 90.209 & 90.210	Occupied Bandwidth and Emission Limitations/Masks	Yes
2.1051, 2.1057, 90.210 & 90.543(b)	Spurious Emissions at Antenna Terminal	N/A
2.1053, 2.1057, 90.210 & 90.543(b)	Field Strength of Spurious Emissions	N/A
2.1055, 90.213 & 90.539	Frequency Stability	N/A
90.214	Transient Frequency Behavior	N/A
90.543(a)	Adjacent Channel Power	N/A
1.1307, 1.1310 & 2.1091	RF Exposure Limit	N/A
15.207	AC Power Line Conducted Emissions	N/A

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None

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EXHIBIT 5. TEST DATA

5.1. RF POWER OUTPUT [§§ 2.1046 & 90.205]

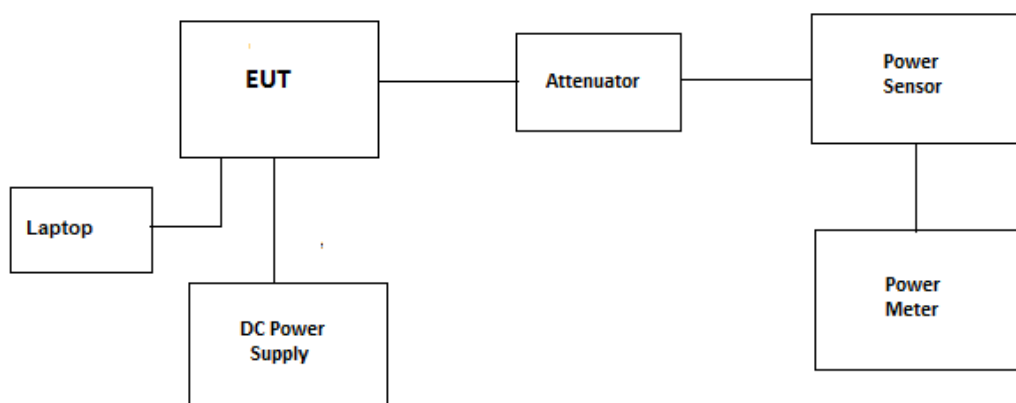
5.1.1. Limits

Please refer to FCC 47 CFR § 90.205 for specification details.

5.1.2. Method of Measurements

ANSI C63.26 Section 5.2.

5.1.3. Test Arrangement



5.1.4. Test Data

Operating Band (MHz)	Power Setting	Frequency (MHz)	Measured Conducted Power Output		Power Output Rating	
			(dBm)	(W)	(dBm)	(W)
851 - 854	High	851.025	35.01	3.17	34.77	3
		853.975	34.97	3.14	34.77	3
	Low	851.025	27.62	0.58	26.99	0.5
		853.975	27.51	0.56	26.99	0.5

5.2. MODULATION CHARACTERISTICS - AUDIO FREQUENCY RESPONSE [§ 2.1047(a)]

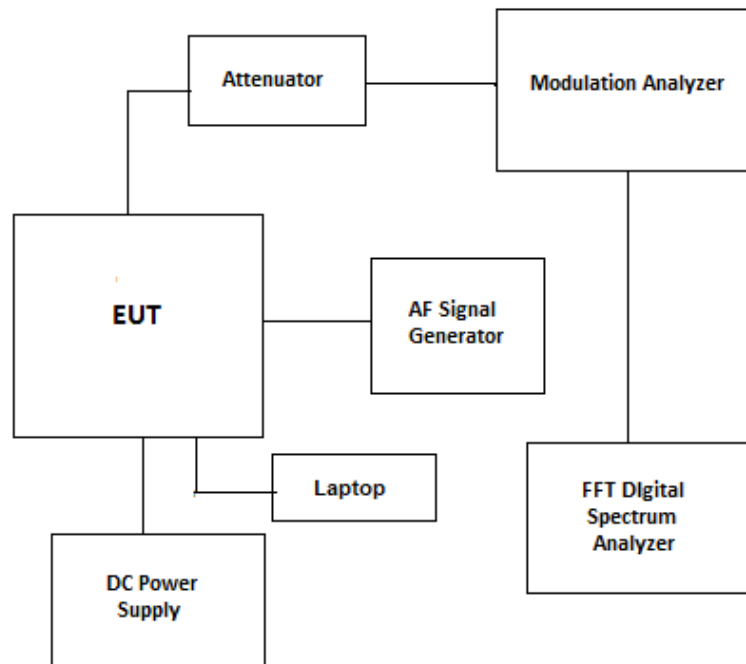
5.2.1. Limits

§ 2.1047(a): Voice modulated communication equipment. A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz shall be submitted. For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter or of all circuitry installed between the modulation limiter and the modulated stage shall be submitted.

5.2.2. Method of Measurements

The rated audio input signal was applied to the input of the audio low-pass 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 Digital 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**5.2.4.1. 20 kHz Channel Spacing, Frequency of All Modulation States**

Remark: Due to the difficulty of measuring the Frequency Response of the internal low-pass filter, the Frequency Response of All Modulation States is performed to show the roll-off at 3 kHz in comparison with the recommended audio filter attenuation.					
Frequency (kHz)	Audio In (dBV)	Audio Out (dBV)	Attenuation (Out - In) (dB)	Attenuation Rel. to 1 KHz (dB)	Recommended Attenuation (dB)
0.1	-10.90	-54.55	-43.6	-58.9	--
0.3	-10.90	-11.49	-0.6	-15.8	--
0.4	-10.90	-3.46	7.4	-7.8	--
0.6	-10.90	-0.23	10.7	-4.5	--
0.8	-10.90	2.38	13.3	-1.9	--
1.0	-10.90	4.30	15.2	0.0	--
1.5	-10.90	7.55	18.5	3.3	--
2.0	-10.90	8.02	18.9	3.7	--
2.5	-10.90	8.06	19.0	3.8	--
3.0	-10.90	7.20	18.1	2.9	0
3.5	-10.90	6.03	16.9	1.7	-4
4.0	-10.90	-6.57	4.3	-10.9	-7
4.5	-10.90	-60.00	-49.1	-64.3	-11
5.0	-10.90	-65.00	-54.1	-69.3	-13
6.0	-10.90	-70.00	-59.1	-74.3	-18
7.0	-10.90	-70.00	-59.1	-74.3	-22
8.0	-10.90	-70.00	-59.1	-74.3	-26
9.0	-10.90	-70.00	-59.1	-74.3	-29
10.0	-10.90	-70.00	-59.1	-74.3	-31
12.0	-10.90	-70.00	-59.1	-74.3	-36
14.0	-10.90	-70.00	-59.1	-74.3	-40
16.0	-10.90	-70.00	-59.1	-74.3	-44
18.0	-10.90	-70.00	-59.1	-74.3	-47
20.0	-10.90	-70.00	-59.1	-74.3	-50
25.0	-10.90	-70.00	-59.1	-74.3	-50
30.0	-10.90	-70.00	-59.1	-74.3	-50
35.0	-10.90	-70.00	-59.1	-74.3	-50
40.0	-10.90	-70.00	-59.1	-74.3	-50
45.0	-10.90	-70.00	-59.1	-74.3	-50
50.0	-10.90	-70.00	-59.1	-74.3	-50

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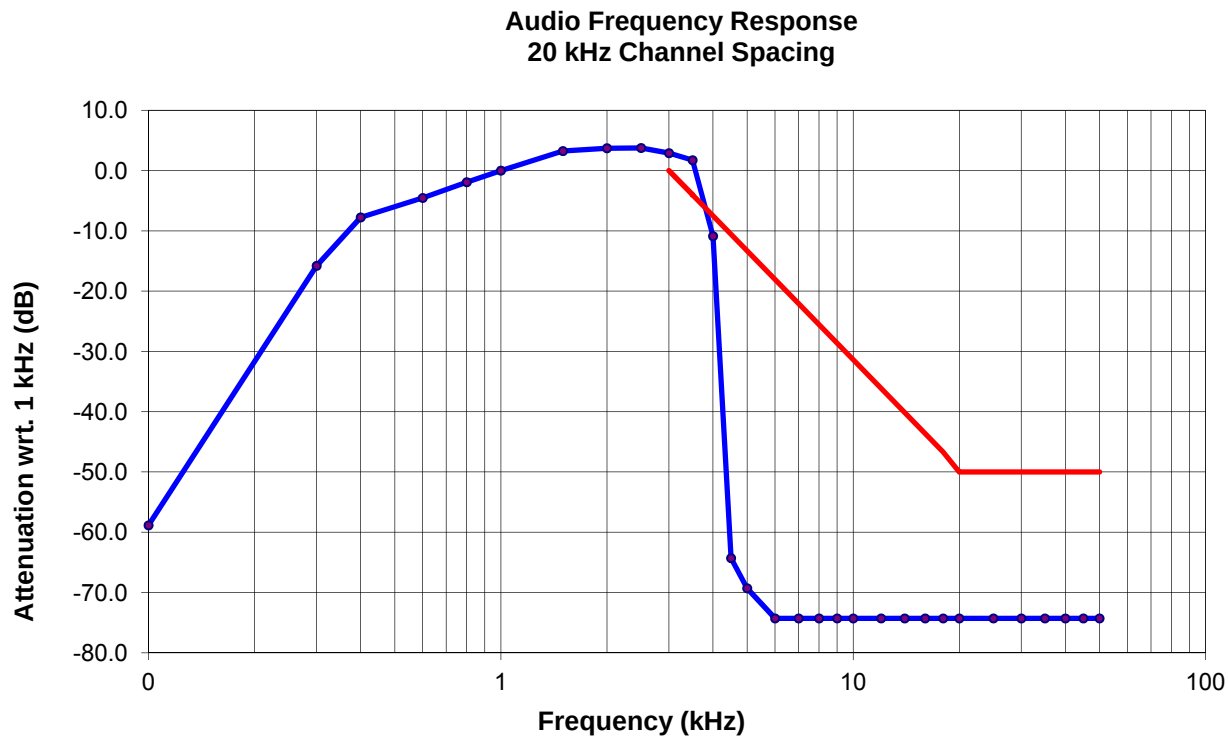
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5.3. MODULATION CHARACTERISTICS - MODULATION LIMITING [§ 2.1047 (b)]

5.3.1. Limits

§ 2.1047(b): Equipment which employs modulation limiting. A curve or family of curves showing the percentage of modulation versus the modulation input voltage shall be supplied. The information submitted shall be sufficient to show modulation limiting capability throughout the range of modulating frequencies and input modulating signal levels employed.

Recommended frequency deviation characteristics are given below:

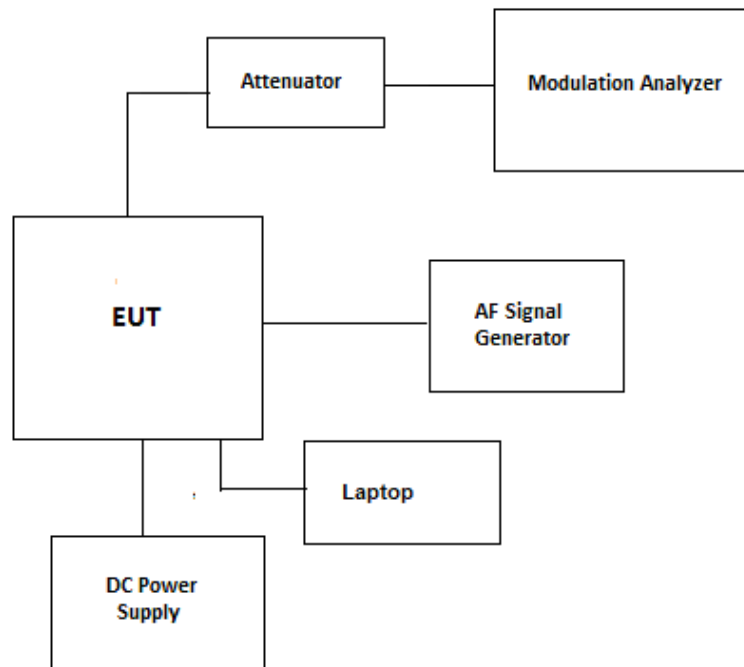
- 4.0 kHz for 20 kHz Channel Spacing System

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. Voice Modulation Limiting for 20 kHz Channel Spacing Operation

Modulating Signal Level (mVrms)	Peak Frequency Deviation (kHz) at the following modulating frequency:					Maximum Limit (kHz)
	0.1 kHz	0.5 kHz	1.0 kHz	3.0 kHz	5.0 kHz	
50	0.09	0.29	0.49	1.20	0.11	4.0
75	0.10	0.39	0.68	1.76	0.11	4.0
100	0.10	0.48	0.89	2.33	0.11	4.0
125	0.11	0.59	1.10	2.90	0.11	4.0
150	0.11	0.69	1.29	3.46	0.11	4.0
200	0.11	0.90	1.72	3.74	0.11	4.0
225	0.11	0.99	1.93	3.76	0.11	4.0
250	0.11	1.10	2.13	3.77	0.11	4.0
275	0.11	1.19	2.33	3.75	0.11	4.0
300	0.11	1.29	2.54	3.78	0.11	4.0
325	0.11	1.40	2.73	3.77	0.11	4.0
350	0.11	1.49	2.93	3.80	0.11	4.0
375	0.11	1.59	3.15	3.84	0.11	4.0
400	0.11	1.69	3.34	3.84	0.11	4.0
500	0.11	2.09	3.51	3.91	0.11	4.0
600	0.11	2.50	3.51	3.93	0.11	4.0
700	0.11	2.90	3.52	3.98	0.11	4.0
800	0.11	3.35	3.52	3.98	0.11	4.0
900	0.11	3.43	3.56	3.98	0.11	4.0
1000	0.11	3.44	3.60	3.98	0.11	4.0
2000	0.78	3.51	3.60	3.98	0.11	4.0
2500	1.29	3.62	3.60	3.98	0.11	4.0

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Voice Signal Input Level = STD MOD Level + 16 dB = 49.10 dB(mVrms) + 16 dB = 65.10 dB(mVrms) = 1798.23 mVrms		
Modulation Frequency (kHz)	Peak Deviation (kHz)	Maximum Limit (kHz)
0.1	0.57	4.0
0.2	1.46	4.0
0.3	3.51	4.0
0.4	3.49	4.0
0.6	3.51	4.0
0.8	3.51	4.0
1.0	3.65	4.0
1.2	3.73	4.0
1.4	3.59	4.0
1.6	3.66	4.0
1.8	3.71	4.0
2.0	3.73	4.0
2.5	3.82	4.0
3.0	3.98	4.0
3.5	3.68	4.0
4.0	2.55	4.0
4.5	1.26	4.0
5.0	0.13	4.0
6.0	0.31	4.0
7.0	0.49	4.0
8.0	0.85	4.0
9.0	0.37	4.0
10.0	0.10	4.0

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5.3.4.2. OCCUPIED BANDWIDTH & EMISSION MASK [§§ 2.1049, 90.209 & 90.210]

5.3.5. Limits

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

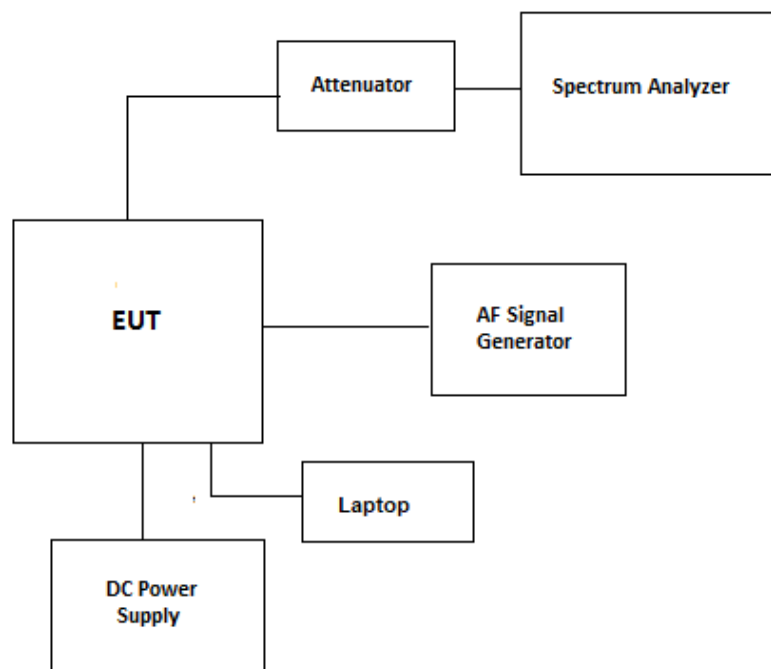
Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)	Applicable Emission Masks	
			Mask for equipment with Audio low pass filter	Mask for equipment without audio low pass filter
806-809/ 851-854	12.5	20	B	H
809-824/ 854-869 ¹	25	20	B	G

¹ Equipment used in this licensed to EA or non-EA systems shall comply with the emission mask provisions of § 90.691.

5.3.6. Method of Measurements

47 CFR 2.1049 and ANSI C63.26 Sections 5.4 and 5.7.

5.3.7. Test Arrangement



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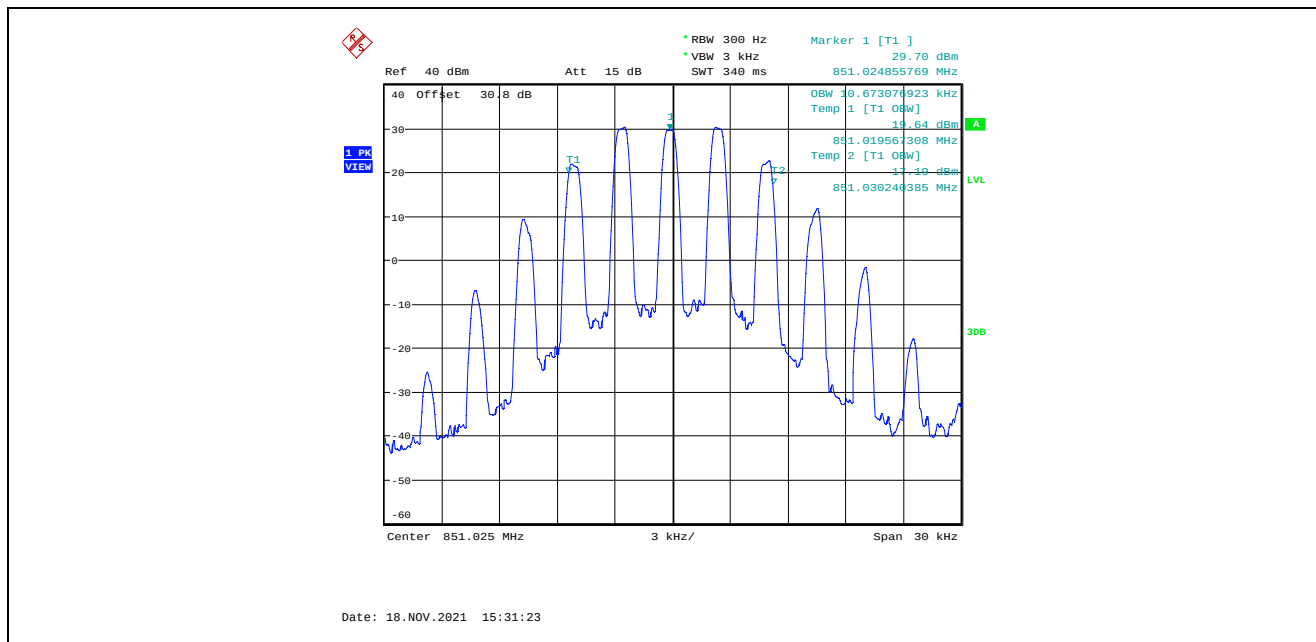
File #: 22FSG198_FCC90
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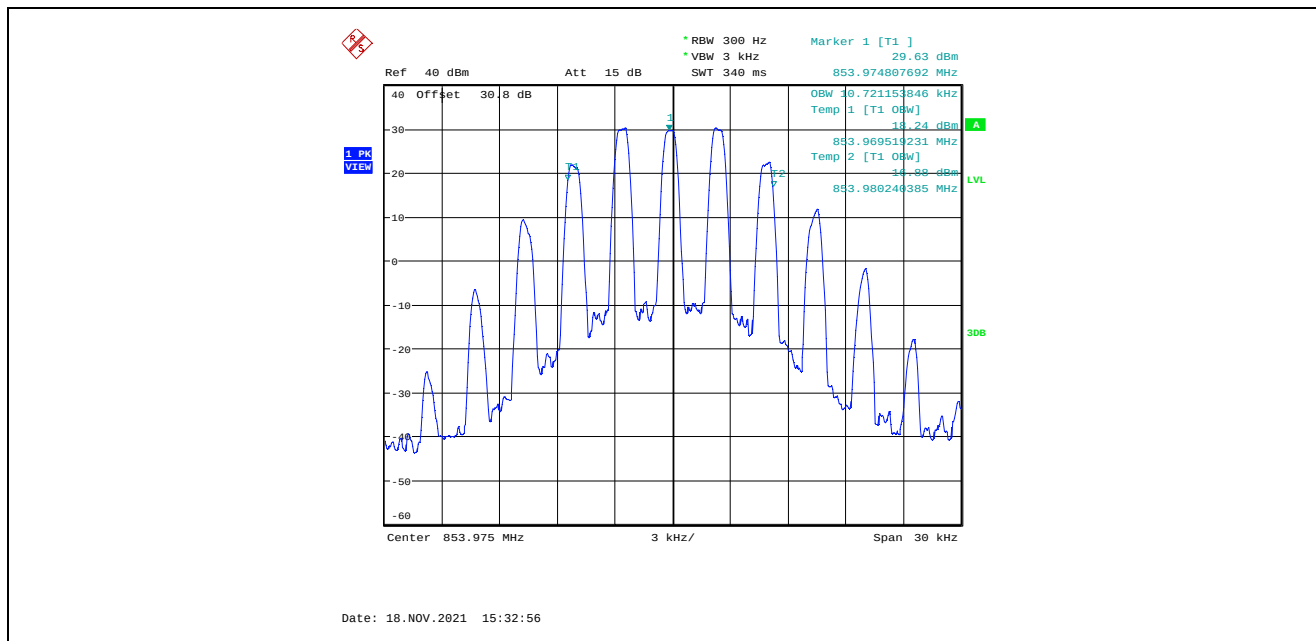
5.3.8. Test Data

5.3.8.1. 99% Occupied Bandwidth

Plot 5.3.8.1.1. 99% Occupied Bandwidth, High Power
20 kHz Channel Spacing with 4 kHz Deviation, Analog, 851.025 MHz

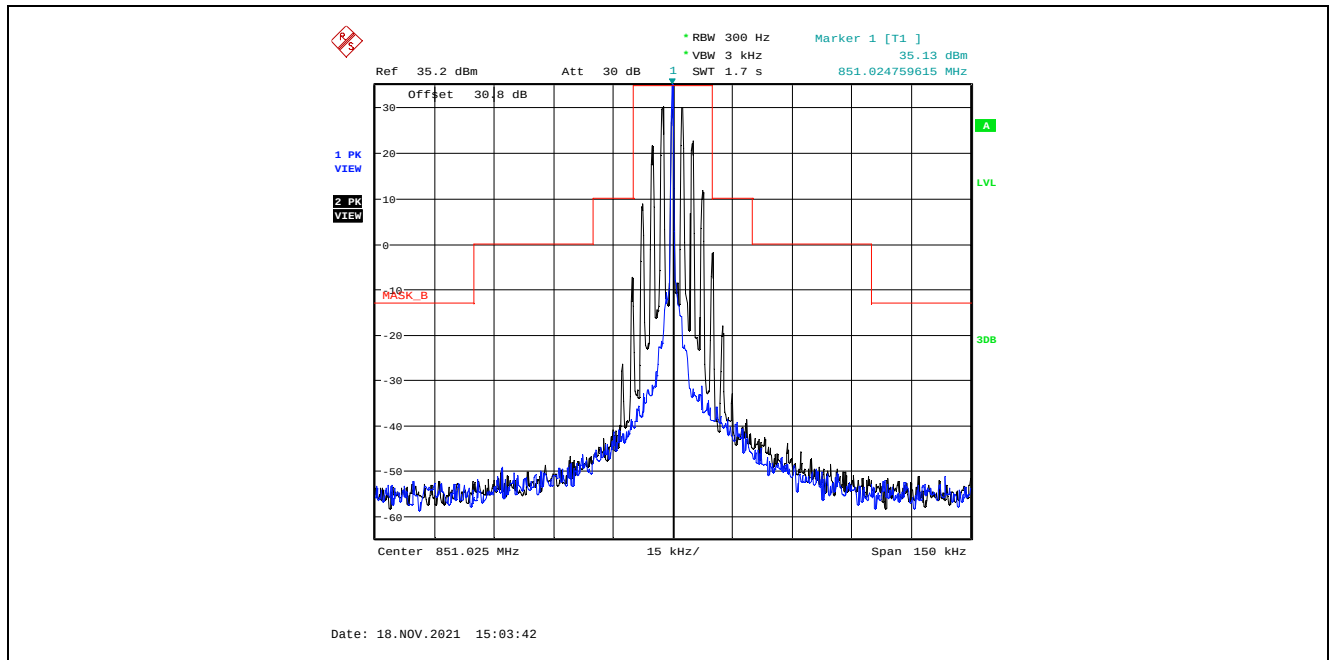


Plot 5.3.8.1.2. 99% Occupied Bandwidth, High Power
20 kHz Channel Spacing with 4 kHz Deviation, Analog, 853.975 MHz

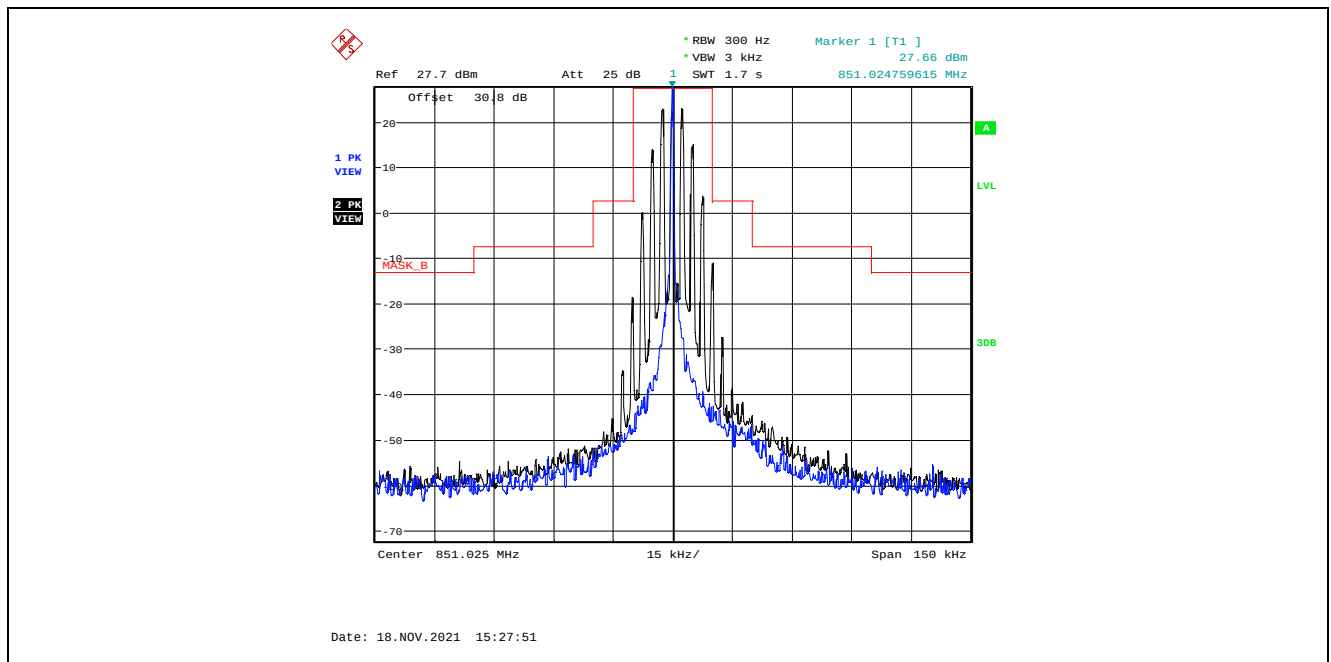


5.3.8.2. Emission Mask B

Plot 5.3.8.2.1. Emission Mask B, High Power
851.025 MHz, 12.5 kHz Channel Spacing with 4 kHz Deviation



Plot 5.3.8.2.2. Emission Mask B, Low Power
851.025 MHz, 12.5 kHz Channel Spacing with 4 kHz Deviation



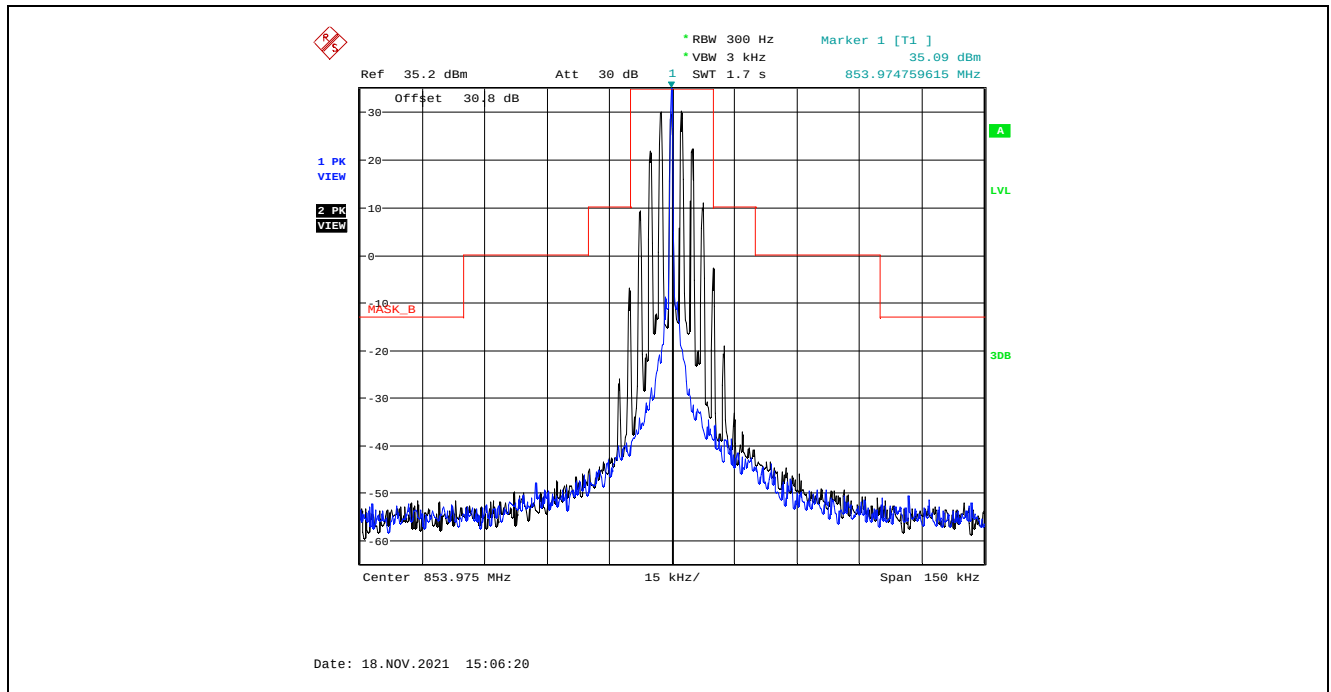
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February 9, 2022

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Plot 5.3.8.2.3. Emission Mask B, High Power
853.975 MHz, 12.5 kHz Channel Spacing with 4 kHz Deviation



Plot 5.3.8.2.4. Emission Mask B, Low Power
853.975 MHz, 12.5 kHz Channel Spacing with 4 kHz Deviation

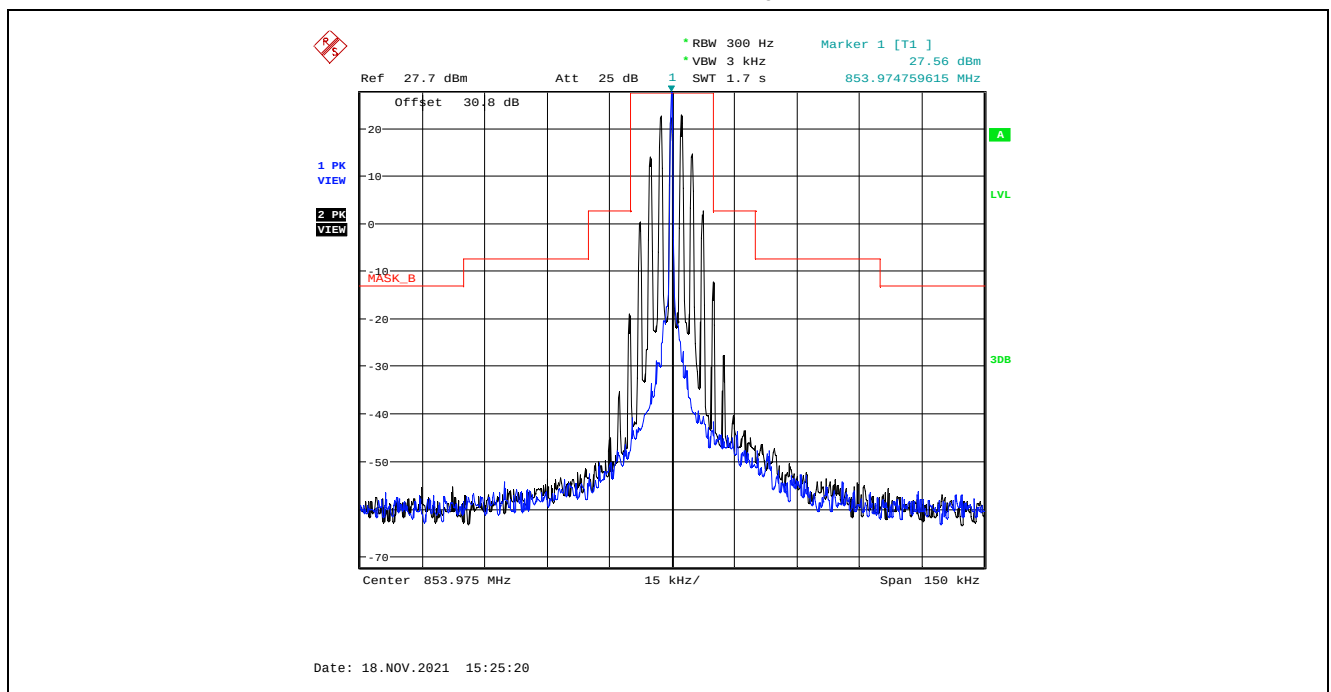


EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Range	Cal. Due Date
Power Meter	HP	436A	2709A27515	100kHz-sensor dependant	17 Jul 2022
Power Sensor	HP	8482A	2652A14099	0.1MHz-4.2GHz	11 Mar 2022
Attenuator	Aeroflex\Weinschel	46-20-34	BM1347	DC-18GHz	See Note 1
Attenuator	MACOM	3082-6193-10	--	DC-18GHz	See Note 1
Power Supply	Tenma	72-6153	-	1-18V, DC 10A	See Note 1
Multimeter	Fluke	8842A	4142055	---	03 Aug 2023
Modulation Analyzer	HP	HP-8901B	3226A04606	150kHz-1300MHz	17 Mar 2022
AF Signal Generator	HP	HP-8920B	US39064699	30MHz-1GHz	17 Mar 2022
Digital Voltmeter	HP	3456A	2015A04523	--	21 Jan 2022
FFT Digital Spectrum Analyzer	Advantest	R9211E	8202336	10mHz-100kHz	02 Nov 2022
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20Hz-26.5GHz	20 Sep 2023
Note 1: Internal Verification/Calibration check					

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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.

Test description		Uncertainty
Conducted RF Power Output		+/- 0.62 dB
Occupied Bandwidth		+/-0.2Hz
Emission Mask / Limitation	Amplitude	+/- 0.63 dB
	Frequency	+/-0.2Hz
Modulation Limiting		$\pm 1.2\%$
Audio Frequency Response	Amplitude	$\pm 0.2\text{dB}$
	Frequency	$\pm 0.2\text{Hz}$

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

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