FCC and ISED Canada Radio Testing of the

Barrett Communication Pty. Ltd.
Barrett 4050 HF SDR
4050ip

In accordance with FCC 47 CFR Part 87 Subpart D and 90 Subpart I

America

Add value.
Inspire trust.

Prepared for: Barrett Communication Pty. Ltd.
47 Discovery Drive Bibra Lake
Western Australia 6163, Australia

FCC ID: OW4-4050IP
IC: 6468A-4050IP

COMMERCIAL-IN-CONFIDENCE

Document Number: TP72191371.102 | Version Number: 03

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Peter Walsh	2023 -September-01	
Testing	Thierry Jean-Charles	2023-September-01	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

FCC Accreditation Designation Number US1063 Tampa, FL Test Laboratory	Innovation, Science, and Economic Development Canada Accreditation Site Number 2087A-2 Tampa, FL Test Laboratory

EXECUTIVE SUMMARY
Samples of this product were tested and found to be in compliance with FCC Part 87 Subpart D and 90 Subpart I.

A2LA Cert. No. 2955.15

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	2023-August-22
2	Corrected some typographical errors	2023-August-23
3	Corrected the Model Number	2023-September-01

1.2 Introduction

The purpose of this report is to demonstrate compliance with the FCC's Code of Federal Regulations Part 87 Subpart D and 90 Subpart I for the tests documented herein.

Applicant	Barrett Communication Pty. Ltd.
Manufacturer	Barrett Communication Pty. Ltd.
Applicant's Email Address	dave.archer@motorolasolutions.com
Model Number(s)	4050ip and 4050se
Serial Number(s)	405013698 (RF Conducted Emissions) 405013734 (Radiated Spurious Emissions) 405013615 (Frequency Stability)
FCC ID	OW4-4050IP
ISED Certification Number	6468A-4050IP
Hardware Version(s)	Micro – A9, PA – A11, Rear Interface – A11, Control Head – A15
Software Version(s)	1.9.5
Number of Samples Tested	3
Test Specification/Issue/Date	US Code of Federal Regulations (CFR): Title 47, Part 87, Subpart D: Equipment Authorization Procedures - 2023 US Code of Federal Regulations (CFR): Title 47, Part 90, Subpart I: Equipment Authorization Procedures - 2023
Test Plan/Issue/Date	2023-June-16
Order Number	72191371
Date	2023-June-28
Date of Receipt of EUT	2023-June-30
Start of Test	2023-July-07
Finish of Test	2023-August-17
Name of Engineer(s)	Thierry Jean-Charles
Related Document(s)	US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures - 2023 ANSI C63.26: 2015: American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services. ANSI/TIA-603-E (2016): Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 87 Subpart D and 90 Subpart I is shown below.

Table 1.3-1 – Test Result Summary

Test Parameter	Test Plan (Yes/No)	Test Results	FCC 47 CFR Rule Part	Test Report Page No.
RF Power Output	Yes	Pass	2.1046; 87.131; 90.205	13
Occupied Bandwidth	Yes	Pass	2.1049; 87.135; 90.209	19
Modulation Characteristics	Yes	Pass	2.1047; 87.141	25
Out of Band Unwanted EmissionsOut of Band Unwanted Emissions	Yes	Pass	2.1051; 87.139; 90.210	39
Spurious Emissions at Antenna Terminals	Yes	Pass	2.1051; 87.139; 90.210	48
Field Strength of Spurious Radiation	Yes	Pass	2.1053; 87.139; 90.210	58
Frequency Stability	Yes	Pass	2.1055; 87.133; 90.213	70

1.4 Product Information

1.4.1 Technical Description

The equipment under test was the 4050 HF SDR Transceiver. The device is an SDR based HF SSB transceiver with a frequency range of 1.5 MHz to 30 MHz in transmit and 250 kHz to 30 MHz in receive. It is designed to operate in the most arduous environments, as encountered in portable, off-road vehicles, vessels, and aircraft environments. The device comes as an Ethernet (4050ip) or a no-Ethernet (4050se) variant. Testing was performed on the 4050ip model to demonstrate compliance of both variants.

Technical Details

Mode of Operation	HF SSB Transceiver
Frequency Range:	1.5 MHz - 30 MHz
Antenna Type/Gain:	Automatic Tuned and Whip, 0 dBi
	Magnetic Loop, 1.5 dBi
	Multi-Wire Broadband, 5 dBi
	Log Periodic, 13 dBi
Input Power:	12V-24V

The Barrett 4050 HF SDR transmitters produce 2 distinct modulation formats. The emissions designators for the modulation types used by the Barrett 4050 HF SDR transmitters are as follows:

EMISSIONS DESIGNATORS:

J3E, H3E

A full description and detailed product specification details are available from the manufacturer.

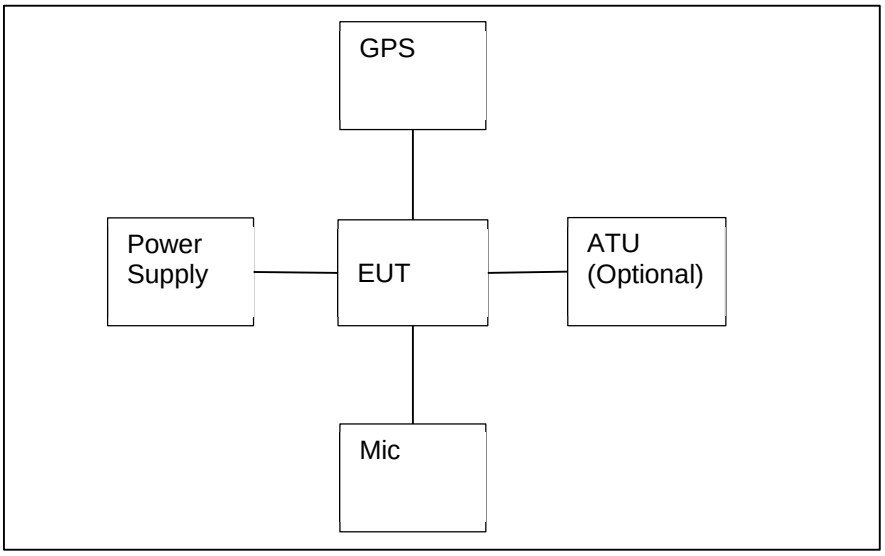


Figure 1.4.1-1 – Equipment Under Test Diagram

Table 1.4.1-1 – Cable Descriptions

Cable/Port	Description
Power Cable	0.5 m, P/N: SA-42020, EUT to Power Supply
Audio Cable	0.5 m, P/N: SA-45010, EUT to Power Supply
GPS Cable	5 m, GPS Antenna to EUT
Coaxial/Control Cable	6 m, P/N: BCA201904, ATU to EUT
Control Cable	6 m, EUT to Control Head
Power Cord	1.8 m, Power Supply to AC Mains
Mic Cable	1.8 m, Microphone to EUT
Ethernet	10 m, EUT to Ethernet Switch

Table 1.4.1-2 – Support Equipment Descriptions

Make/Model	Description
Barrett / 4022	24V Power Supply / S/N: 402411965
Barrett / BCA40010	Hand microphone and clip with channel up/down buttons
Garmin / GPS18x LVC	GPS receiver, S/N: 19S295850
Barrett / 4045	Automatic HF Antenna Tuner, S/N:
Barrett / BCS40005	Control Head, S/N: 406900446
Barrett / 4090-01-11	12 VDC Fan

Declaration of Build Status

Declaration of Build Status

EQUIPMENT DESCRIPTION	
Model Name/Number	Barrett 4050 HF SDR/ 4050ip and 4050se
Part Number	BC405000IP
Hardware Version	Micro – A9, PA – A11, Rear Interface – A11, Control Head – A15
Software Version	1.9.5
FCC ID (if applicable)	OW4-4050IP
ISED ID (if applicable)	6468A-4050IP
Technical Description (Please provide a brief description of the intended use of the equipment)	The 4050 HF SDR Transceiver is an SDR based HF SSB transceiver with a frequency range of 1.5 MHz to 30 MHz in transmit and 250 kHz to 30 MHz in receive. Designed to operate in the most arduous environments, as encountered in portable, off-road vehicles, vessels, and aircraft environments.

UN-INTENTIONAL RADIATOR	
Highest frequency generated or used in the device or on which the device operates or tunes	**Internal - 196.976 MHz**
Lowest frequency generated or used in the device or on which the device operates or tunes	**Internal – 32 kHz**
Class A Digital Device (Use in commercial, industrial or business environment) ☒ Class B Digital Device (Use in residential environment only) ☐	

Power Source			
AC	Single Phase	Three Phase	Nominal Voltage
	☐	☐	
External DC	Nominal Voltage		Maximum Current
	+13.8VDC, Negative Ground		25 A
Battery	Nominal Voltage		Battery Operating End Point Voltage

EXTREME CONDITIONS					
Maximum temperature	+70	°C	Minimum temperature	-30	°C

Ancillaries
Please list all ancillaries which will be used with the device.
Hand microphone and clip with channel up/down buttons (Barrett PN: BCA40010) Loudspeaker (Barrett PN: BCA40015) 4022 Mains power supply 24V for 4050 (Barrett PN: BC402201)

4049 Automatic tuning mobile HF antenna (Barrett PN: BC404901)
4045 Automatic HF antenna tuner (Barrett PN: BC404501)
GPS/ESU receiver (Barrett PN: BCA40009)
4050 Control Head (Barrett PN: BCS40005)
4050 Control Handset (Barrett PN: BCA40500)
Desktop Mic (Barrett PN: BCA40011)
Headphones (Barrett PN: BCA40013)
Headset (Barrett PN: BCA40040)
Ethernet adapter (Barrett PN: BCA40505)

I hereby declare that the information supplied is correct and complete.

Name: Dragan Plesa/ Updated by Deanna Zakharia (Regulatory Compliance Mgr)

Position held: R&D Manager Date: 18th August 2023/ updated 8/31/2023

1.4.2 Modes of Operation

The tested mode of operation was for the EUT configured as a base station with the 24 VDC power supply. The EUT was pre-configured to transmit at 150W maximum power. The evaluation was performed for both H3E and J3E types of emissions.

In all tests, the input level of the modulating signal was such as to develop rated peak envelope power or carrier power, as appropriate, for the transmitter as described below.

(1) Single sideband transmitters in the A3A or A3J emission modes—by two tones at frequencies of 400 Hz and 1800 Hz (for 3.0 kHz authorized bandwidth), applied simultaneously, the input levels of the tones so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude.

(2) Single sideband transmitters in the A3H emission mode—by one tone at a frequency of 1500 Hz (for 3.0 kHz authorized bandwidth), the level of which is adjusted to produce a radio frequency signal component equal in magnitude to the magnitude of the carrier in this mode.

Therefore, for the H3E mode of operation, the EUT carrier signal was modulated using a 1500 MHz tone. The J3E transmission was generated using a two-tone signal of 400 Hz and 1800 Hz, respectively. During the evaluation, the RF port was terminated via a 50 ohm matching load.

1.4.3 Monitoring of Performance

The following performance attributes were monitored:

1. RF Output Power
2. Occupied Bandwidth
3. Modulation Characteristics
4. Out-of-Band Unwanted Emissions
5. Unwanted Emissions at the Antenna Terminal
6. Radiated Spurious Emissions
7. Frequency Stability

For the frequency stability evaluation, the results are reported for both 24 VDC and 13.8 VDC input voltages.

The EUT is designed to operate in multiple bands under the requirements of FCC CFR 47 Parts 87 and 90.
Based on the requirements set forth in accordance 47 CFR 2.1046-2.1057 as stated above, the methodology in selecting the places to test in the available bands of operation is outlined in the following table to cover the entire range of evaluation of the product.

CFR Title 47 Rule Part	Frequency Band of Operation (MHz)	Location in the Range of Operation	Approx. Test Frequency (MHz)
87 / 90	1.5 - 30	Low	1.6
		Middle	15.8
		High	29.8

1.4.4 Performance Criteria

The parameters evaluated are summarized below.

Table 1.4.4-1 - Performance Criteria

Parameter	Requirement
RF Output Power	FCC 47 CFR Rule Part 2.1046; 87.131; 90.205
Occupied Bandwidth	FCC 47 CFR Rule Part 2.1049; 87.135; 90.209
Modulation Characteristics	FCC 47 CFR Rule Part 2.1047; 87.141
Out-of-Band Unwanted Emissions	FCC 47 CFR Rule Part 2.1051; 87.139; 90.210
Unwanted Emissions at the Antenna Terminal	FCC 47 CFR Rule Part 2.1051; 87.139; 90.210
Radiated Spurious Emissions	FCC 47 CFR Rule Part 2.1053; 87.139; 90.210
Frequency Stability	FCC 47 CFR Rule Part 2.1055; 87.133; 90.213

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
1	Replace GPS reverse protection diode with inductor	Barrett	7/12/2023
2	1. Replace GPS reverse protection diode with inductor. 2. Increase bias resistors and improve bias pot resolution. 3. Short final amplifier input stage attenuator 4. Lower the lowest filter cut-off frequency. 5. Bias amplifier at 50 °C	Barrett	8/1/2023

1.7 Test Location

TÜV SÜD Product Service conducted the following tests at our Tampa FL Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
DC Powered Operating		
RF Power Output	Thierry Jean-Charles	A2LA
Out of Band Emissions	Thierry Jean-Charles	A2LA
Occupied Bandwidth	Thierry Jean-Charles	A2LA
Modulation Characteristics	Thierry Jean-Charles	A2LA
Spurious Emissions at the Antenna Terminal	Thierry Jean-Charles	A2LA
Field Strength of Spurious Radiation	Thierry Jean-Charles	A2LA
Frequency Stability	Thierry Jean-Charles	A2LA

Office Address:

TÜV SÜD America, Inc.
5610 W. Sligh Ave, Suite 100
Tampa, FL 33634
USA

2 Test Details

2.1 RF Power Output

2.1.1 Specification Reference

FCC 47 CFR Part 2.1046; 87.131; 90.205

2.1.2 Equipment Under Test and Modification State

S/N: 405013698

2.1.3 Date of Test

2023-August-05 to 2023-August-09

2.1.4 Test Method

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through 50 dB of passive attenuation. The resolution and video bandwidths of the spectrum analyzer were set at sufficient levels, >> signal bandwidth.

2.1.5 Environmental Conditions

Ambient Temperature	25.4 °C
Relative Humidity	39.9 %
Atmospheric Pressure	1013.4 mbar

2.1.6 Test Results

FCC 47 CFR Part 87.131

Table 2.1.6-1 – FCC Part 87.131 Limits

Class of station	Frequency band/frequency	Authorized emission(s)	Maximum power
Aeronautical enroute and aeronautical fixed	HF	R3E, H3E, J3E, J7B, H2B, J2D	6 kw.
Aeronautical Frequencies			
Aircraft (Communication)	HF	R3E, H3E, J3E, J7B, H2B, J7D, J9W	400 watts.
Marine Frequencies			
	HF	R3E, H3E, J3E, J2B, F1B, A3E	1000 watts. 250 watts.

FCC 47 CFR Part 90.205

Table 2.1.6-2 – FCC Part 90.205 Limits

Class of station	Frequency band/frequency	Maximum power
single sideband operations (J3E emission)	Below 25 MHz	1000 watts.
	25 – 50 MHz	300 watts.

Table 2.1.6-3 - RF Output Power – H3E

Frequency MHz	Power (dBm)	Power (Watt)
1.6	52.35	171.79
15.8	51.74	149.28
29.8	51.5	141.25

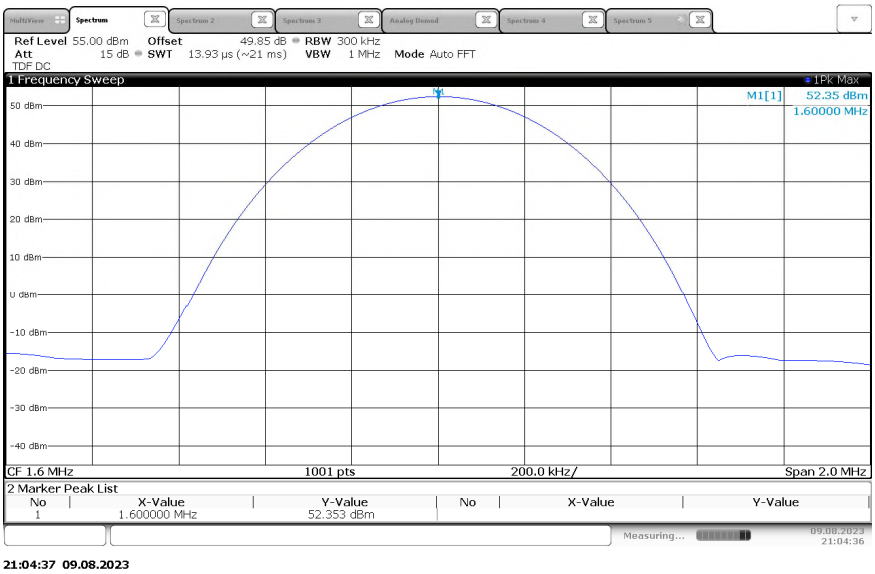


Figure 2.1.6-1 - RF Output Power – 1.6 MHz – H3E

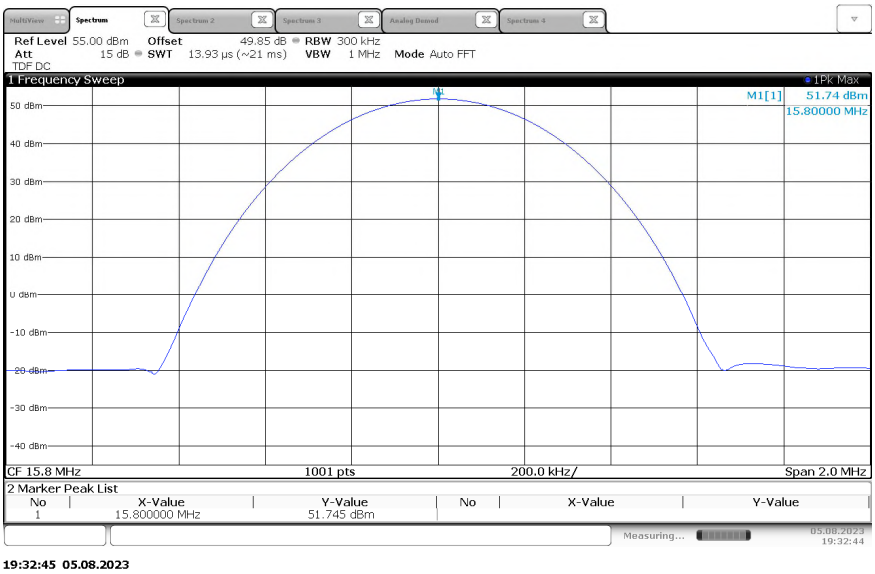


Figure 2.1.6-2 - RF Output Power – 15.8 MHz – H3E

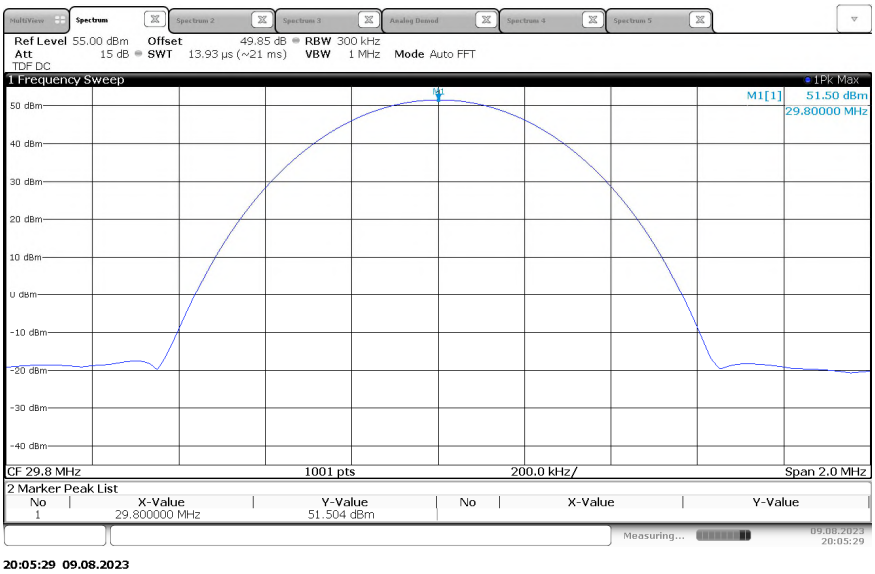


Figure 2.1.6-3 - RF Output Power – 29.8 MHz – H3E

Table 2.1.6-4 - RF Output Power – J3E

Frequency MHz	Power (dBm)	Power (Watt)
1.6	52.35	171.79
15.8	51.77	150.31
29.8	51.4	138.04

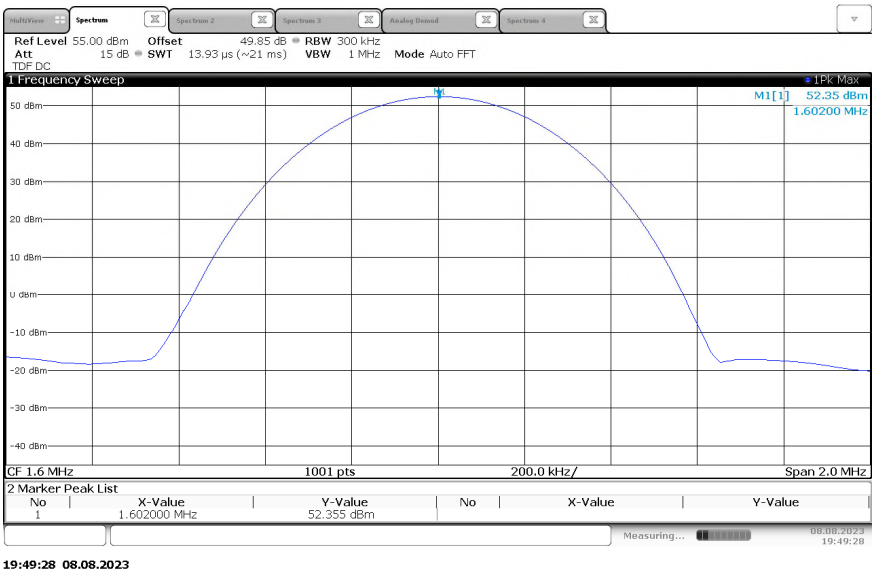


Figure 2.1.6-4 - RF Output Power – 1.6 MHz – J3E

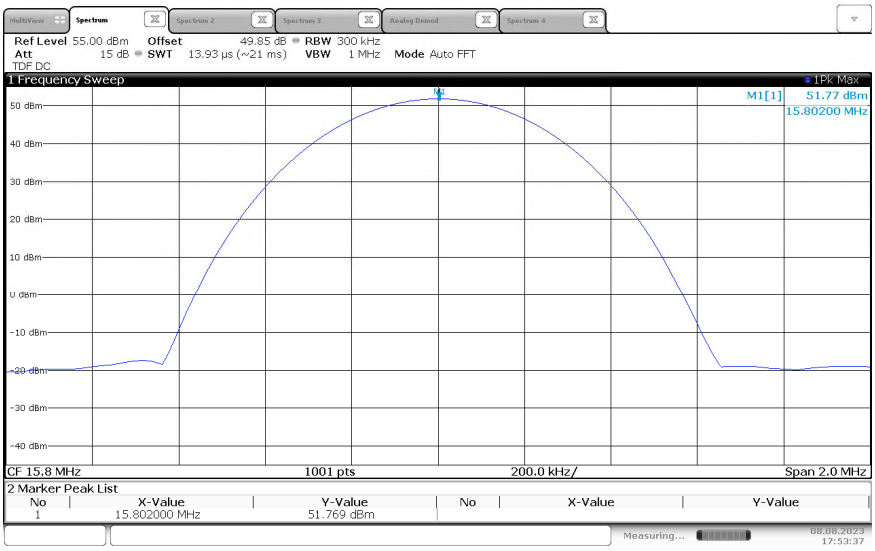


Figure 2.1.6-5 - RF Output Power – 15.8 MHz – J3E

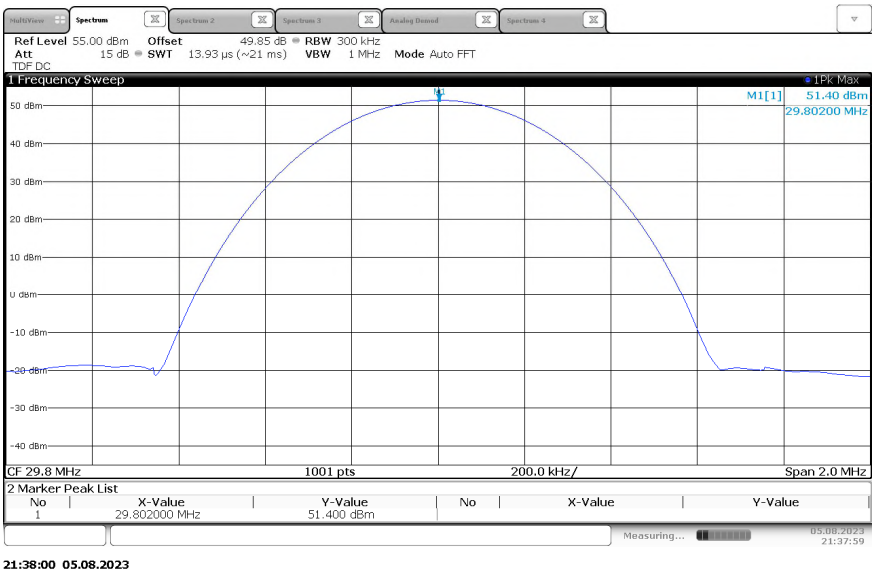


Figure 2.1.6-6 - RF Output Power – 29.8 MHz – J3E

2.1.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR, OP/MON
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.2 Occupied Bandwidth

2.2.1 Specification Reference

FCC Section 2.1049; 87.135(c); 90.209 (b)(2)(3)

2.2.2 Equipment Under Test and Modification State

S/N: 405013698

2.2.3 Date of Test

2023-August-03 to 2023-August-09

2.2.4 Test Method

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through suitable of passive attenuation. The internal correction factors of the spectrum analyzer were employed to correct for any cable and attenuator losses.

The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be set wide enough to capture all modulation products including the emission skirts. The nominal IF filter 3 dB bandwidth (RBW) is in the range of 1% to 5% of the OBW, and the VBW was set ≥ 3 × RBW. The reference level was set to prevent the signal amplitude from exceeding the maximum spectrum analyzer input mixer level for linear operation. The measurements were made using the spectrum analyzer's 99% BW function.

2.2.5 Environmental Conditions

Ambient Temperature	24.4 °C
Relative Humidity	42.5 %
Atmospheric Pressure	1013.6 mbar

2.2.6 Test Results

FCC 87.135(c)
(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.

FCC 90.209(b)
(2) For operations below 25 MHz utilizing J3E emission, the bandwidth occupied by the emission shall not exceed 3000 Hz. The assigned frequency will be specified in the authorization. The authorized carrier frequency will be 1400 Hz lower in frequency than the assigned frequency. Only upper sideband emission may be used. In the case of regularly available double sideband radiotelephone channels, an assigned frequency for J3E emissions is available either 1600 Hz below or 1400 Hz above the double sideband radiotelephone assigned frequency.
(3) For all other types of emissions, the maximum authorized bandwidth shall not be more than that normally authorized for voice operations.

Table 2.2.6-1 - 99% Bandwidth – H3E

Frequency (MHz)	99% Bandwidth (kHz)
1.6	1.6455
15.8	1.6452
29.8	1.6443

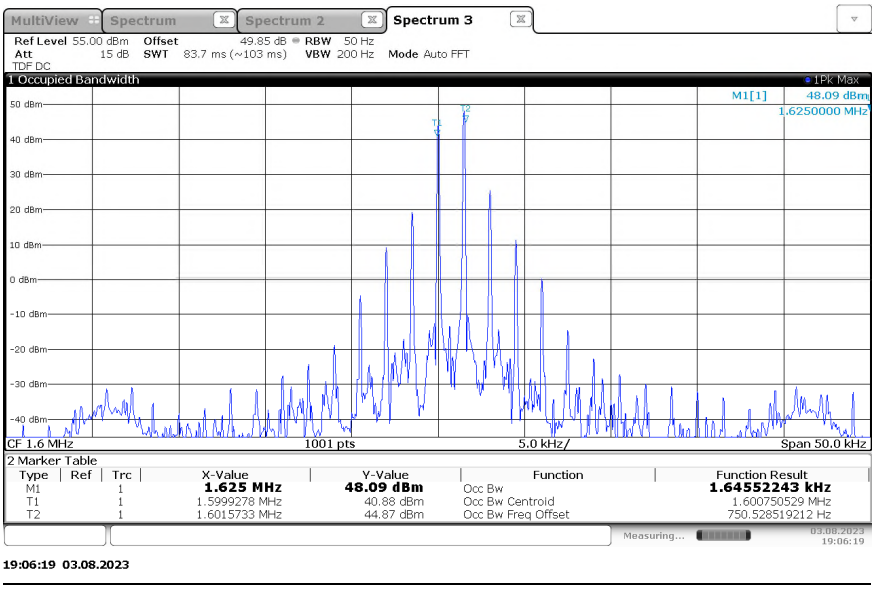


Figure 2.2.6-1 - 99% Bandwidth – 1.6 MHz – H3E

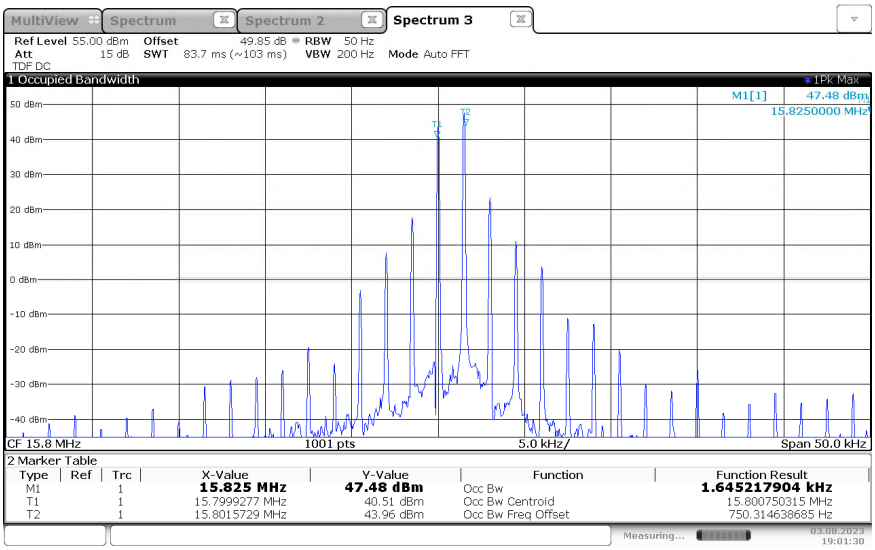


Figure 2.2.6-2 - 99% Bandwidth – 15.8 MHz – H3E

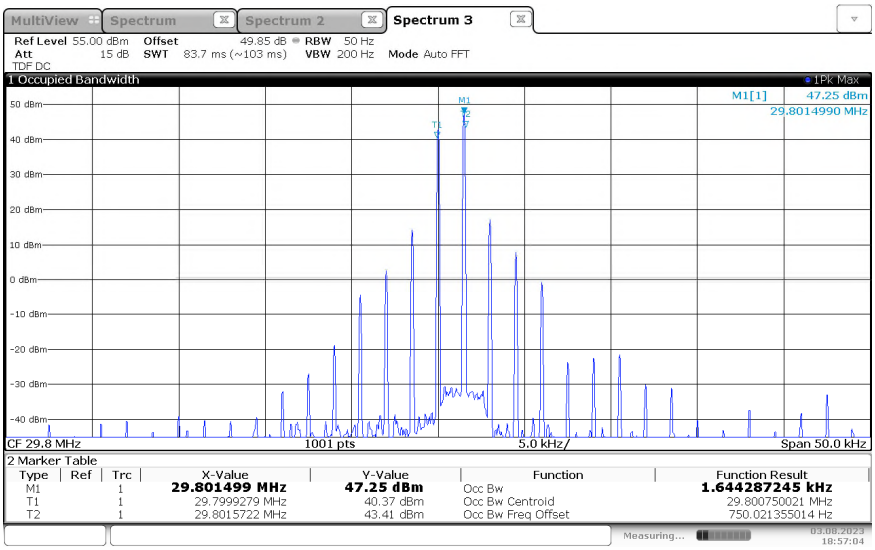


Figure 2.2.6-3 - 99% Bandwidth – 29.8 MHz – H3E

Table 2.2.6-2 - 99% Bandwidth – J3E

Frequency (MHz)	99% Bandwidth (kHz)
1.6	1.5476
15.8	1.5455
29.8	1.5449

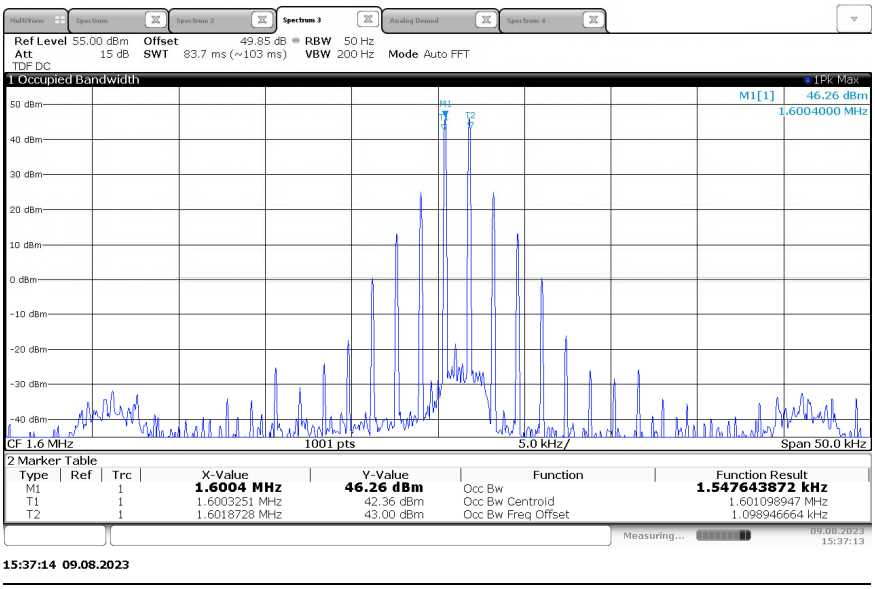


Figure 2.2.6-4 - 99% Bandwidth – 1.6 MHz – J3E

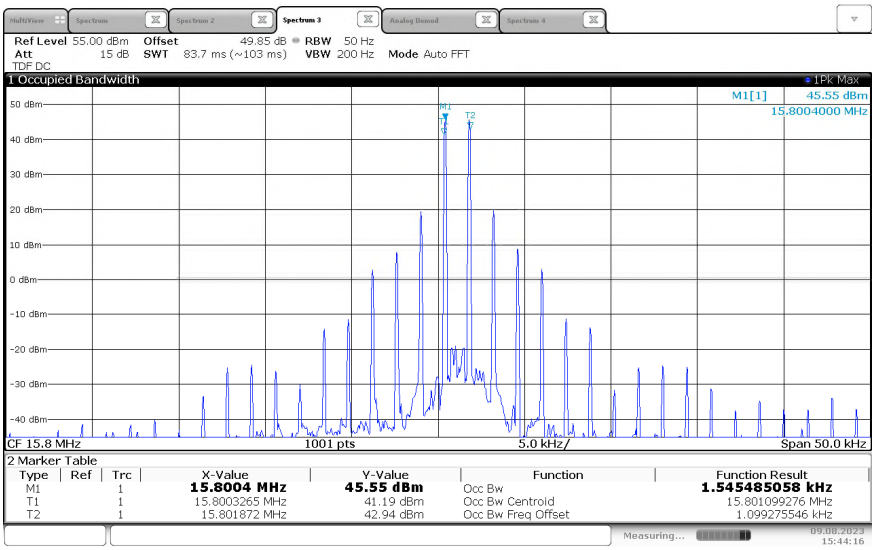


Figure 2.2.6-5 - 99% Bandwidth – 15.8 MHz – J3E

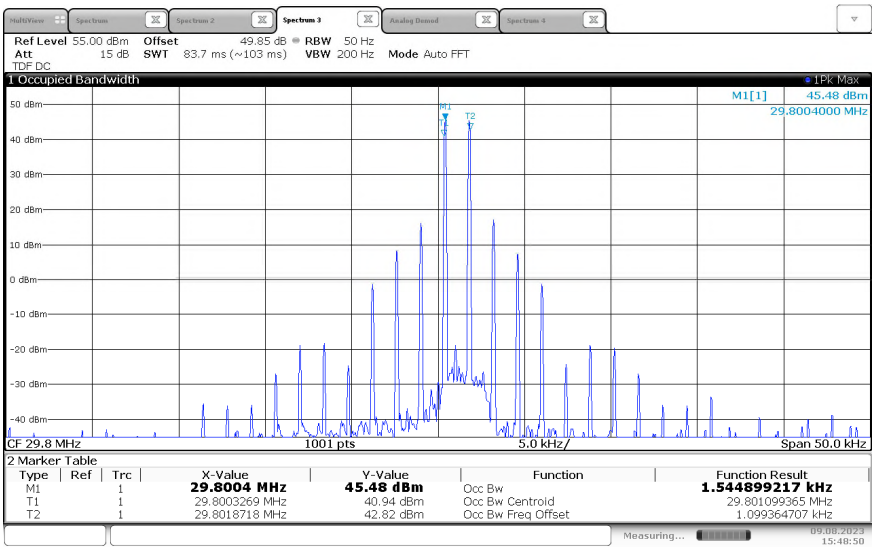


Figure 2.2.6-6 - 99% Bandwidth – 29.8 MHz – J3E

2.2.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR, O/P MON
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.3 Modulation Characteristics

2.3.1 Specification Reference

FCC Section 2.1047, 87.141

2.3.2 Equipment Under Test and Modification State

S/N: 405013698

2.3.3 Date of Test

2023-August-03 to 2023-August-17

2.3.4 Test Method

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through suitable of passive attenuation. The internal correction factors of the spectrum analyzer were employed to correct for any cable and attenuator losses.

2.3.5 Environmental Conditions

Ambient Temperature	24.6 °C
Relative Humidity	52 %
Atmospheric Pressure	1014.2 mbar

2.3.6 Test Results

FCC 47 CFR Part 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.

(c) Single sideband and independent sideband radiotelephone transmitters which employ a device or circuit to limit peak envelope power. A curve showing the peak envelope power output versus the modulation input voltage shall be supplied. The modulating signals shall be the same in frequency as specified in paragraph (c) of § 2.1049 for the occupied bandwidth tests.

FCC 47 CFR Part 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.

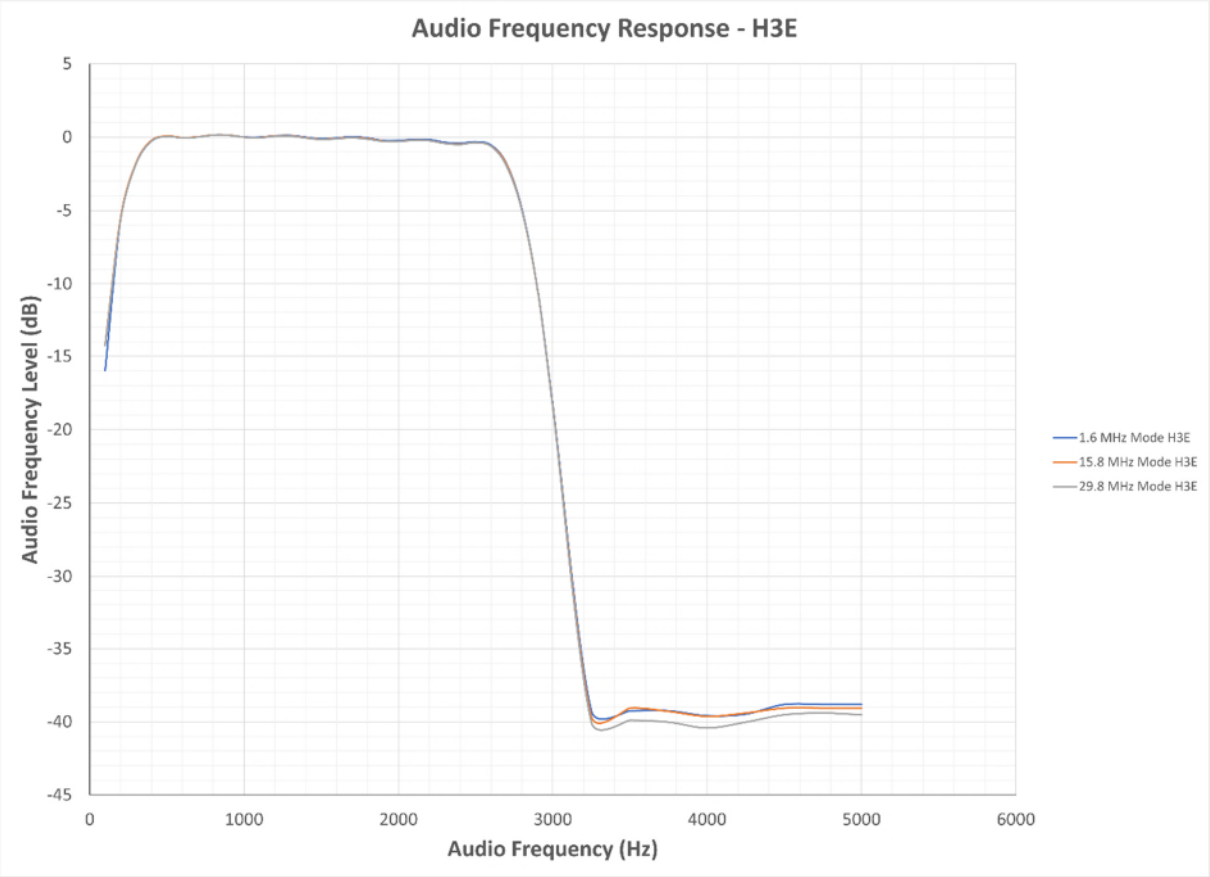


Figure 2.3.6-1 – Modulation Characteristics – Audio Frequency Response – H3E

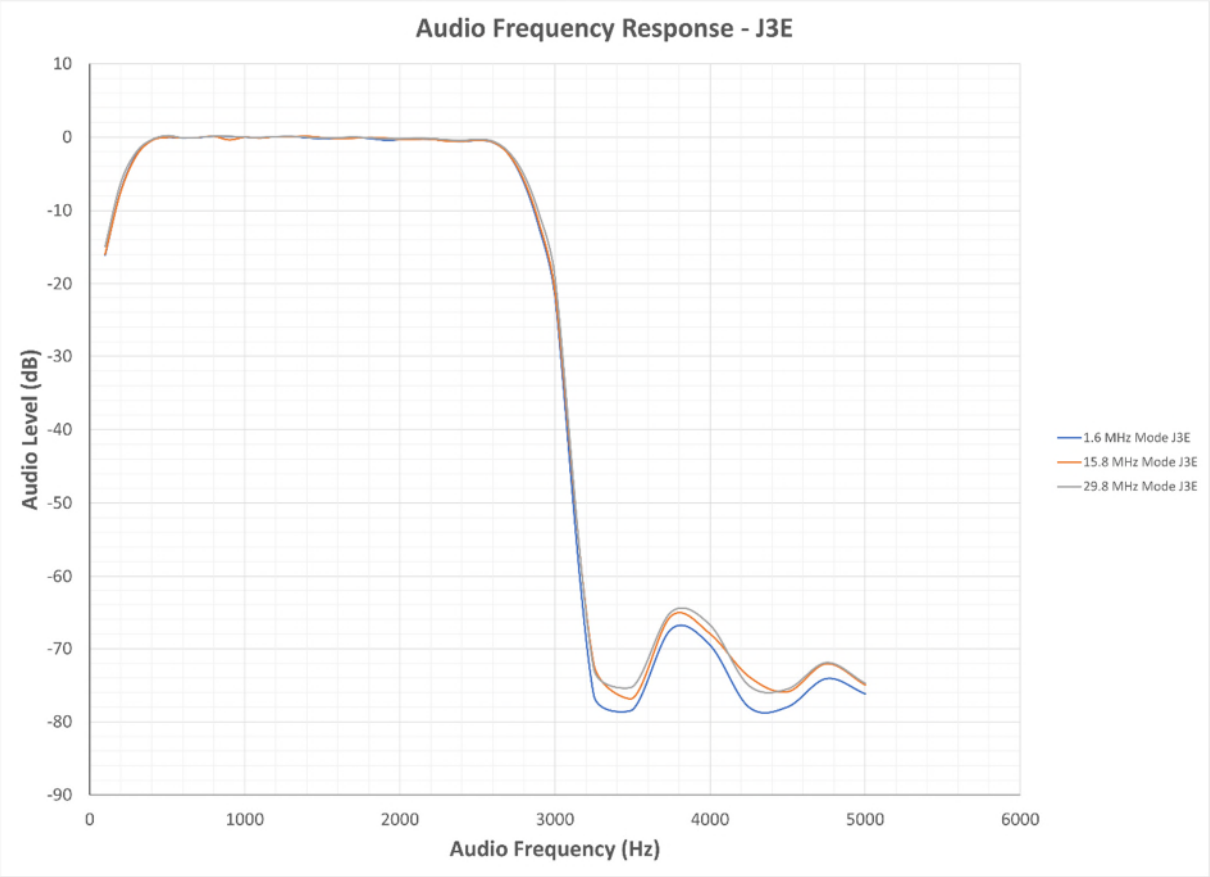


Figure 2.3.6-2 – Modulation Characteristics – Audio Frequency Response – J3E

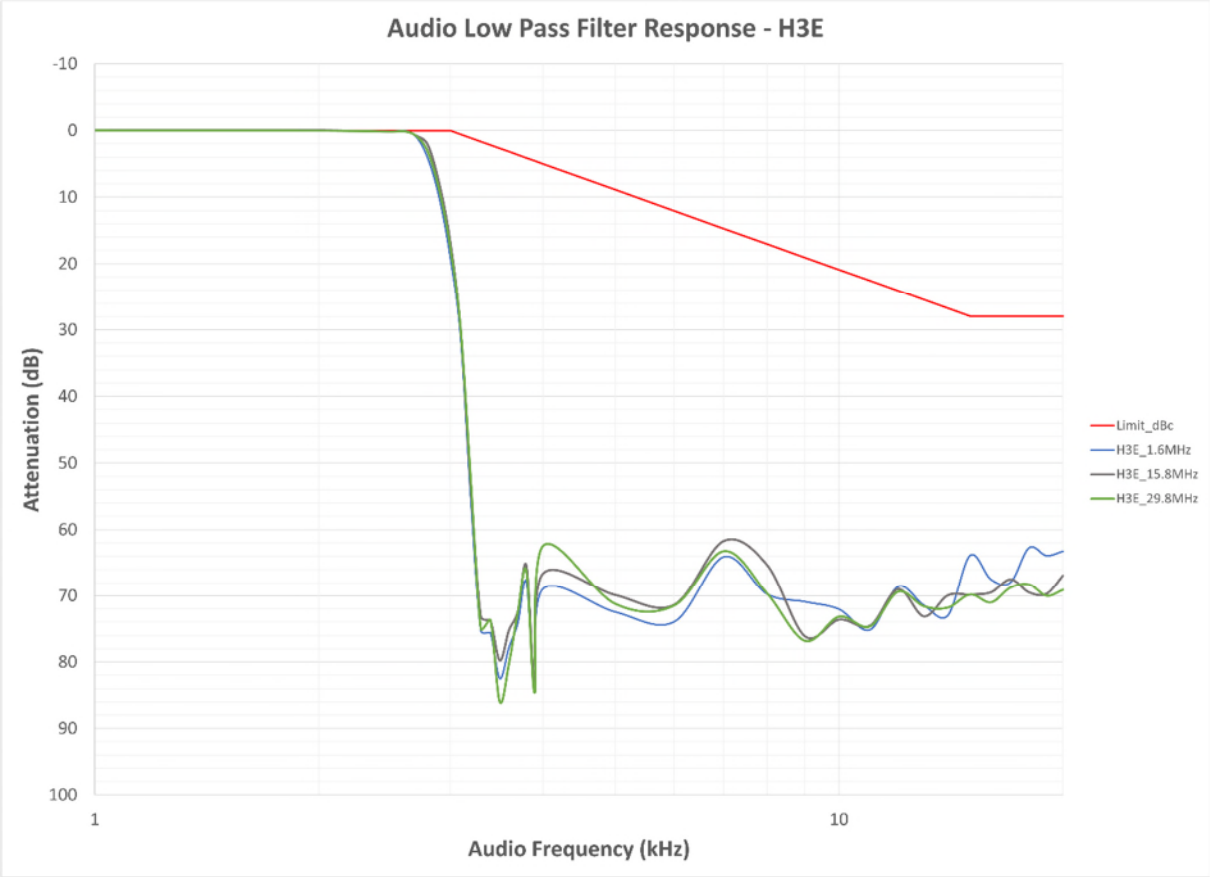


Figure 2.3.6-3 – Modulation Characteristics – Audio Low Pass Filter Response – H3E

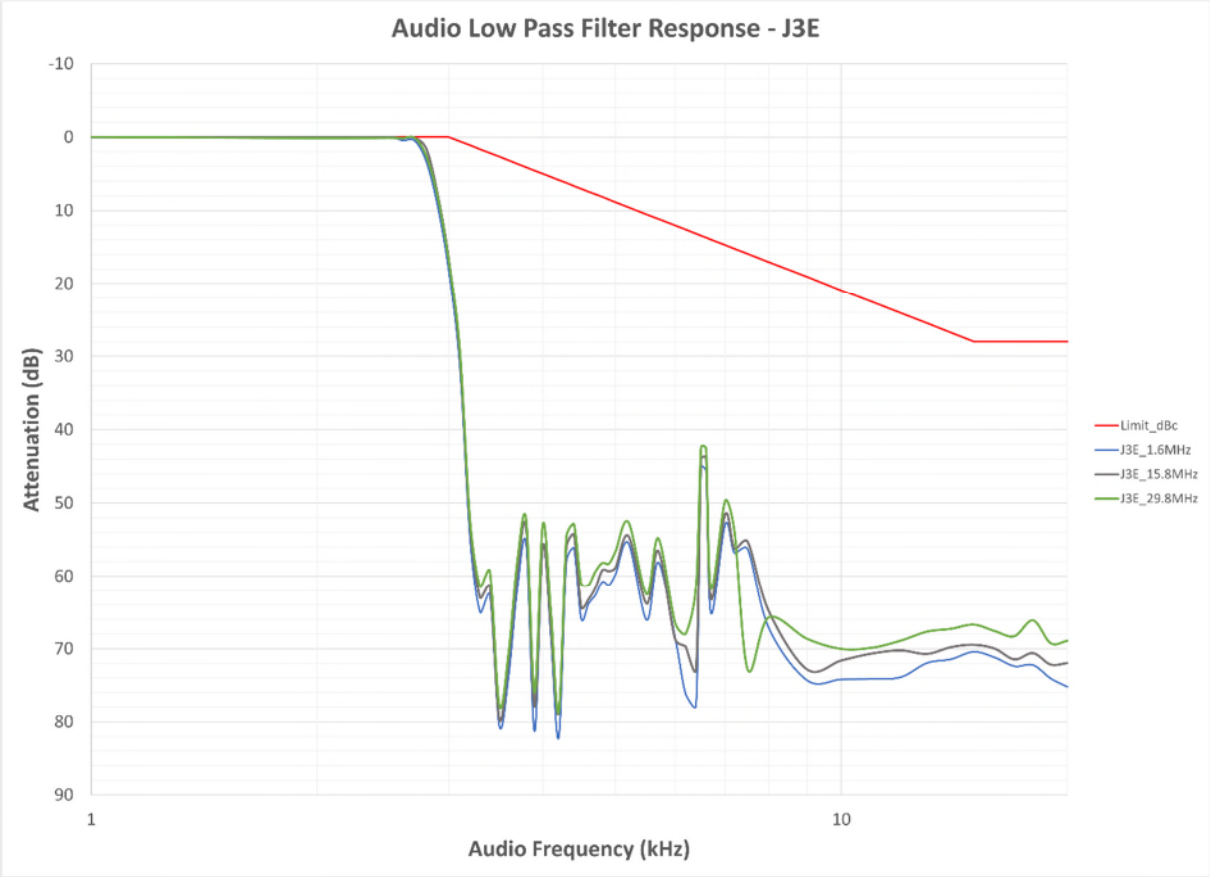


Figure 2.3.6-4 – Modulation Characteristics – Audio Low Pass Filter Response – J3E

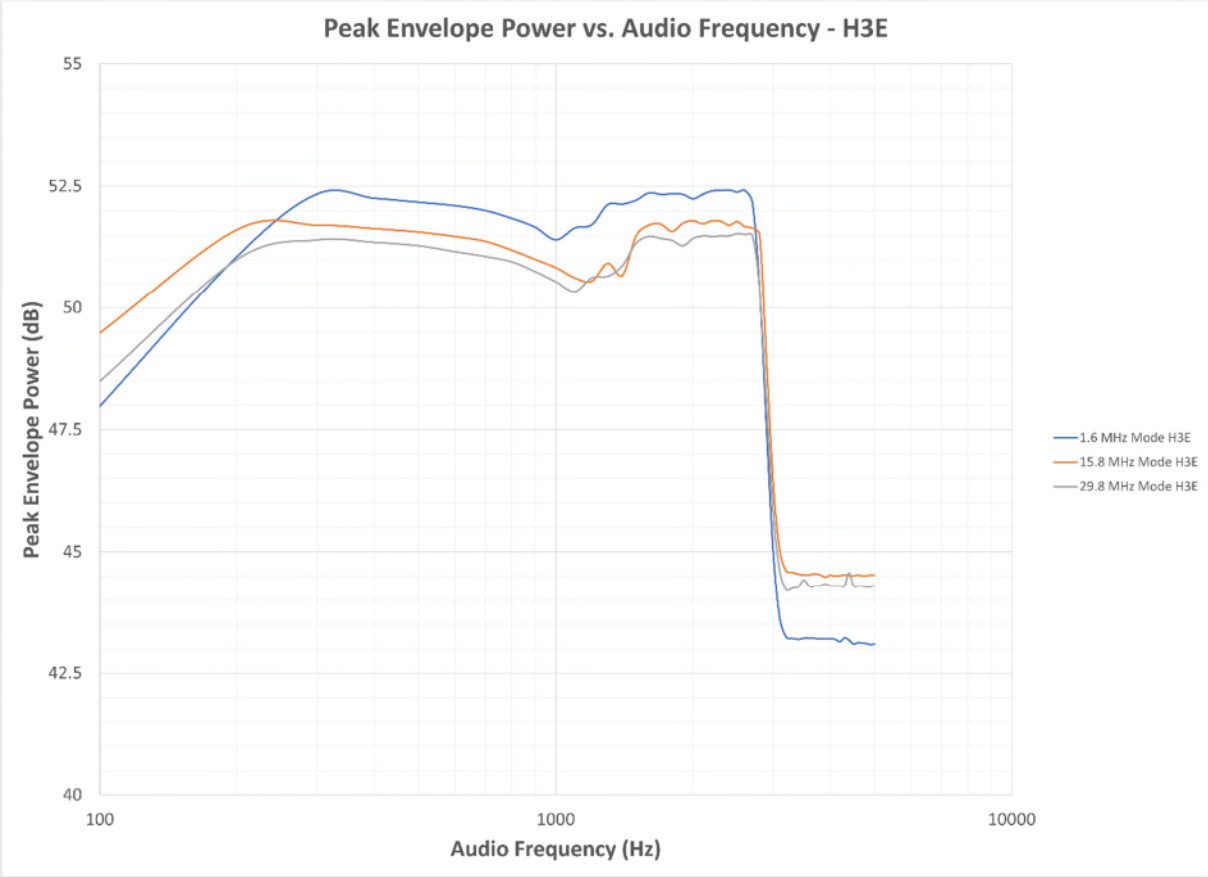


Figure 2.3.6-5 – Modulation Characteristics – Peak Envelope vs Audio Frequency – H3E

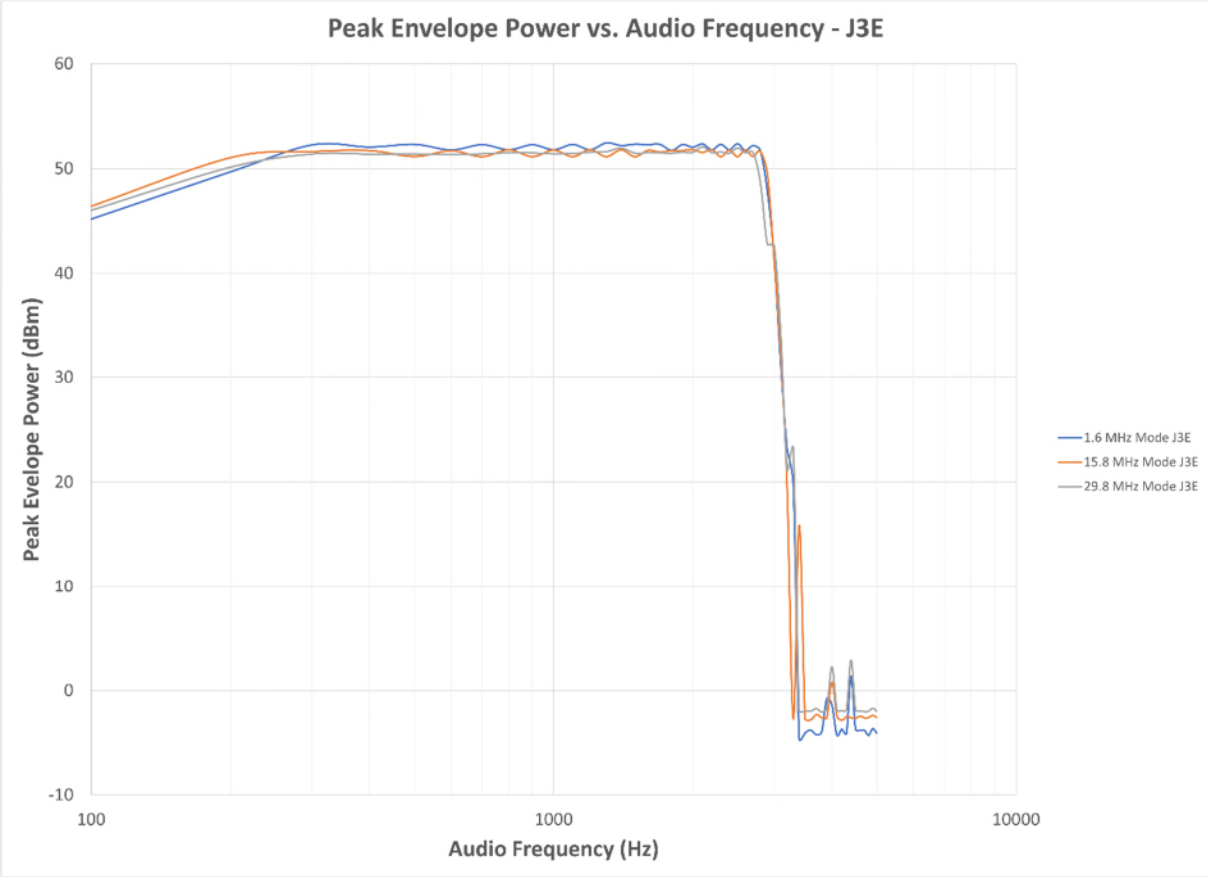


Figure 2.3.6-6 – Modulation Characteristics – Peak Envelope vs Audio Frequency – J3E

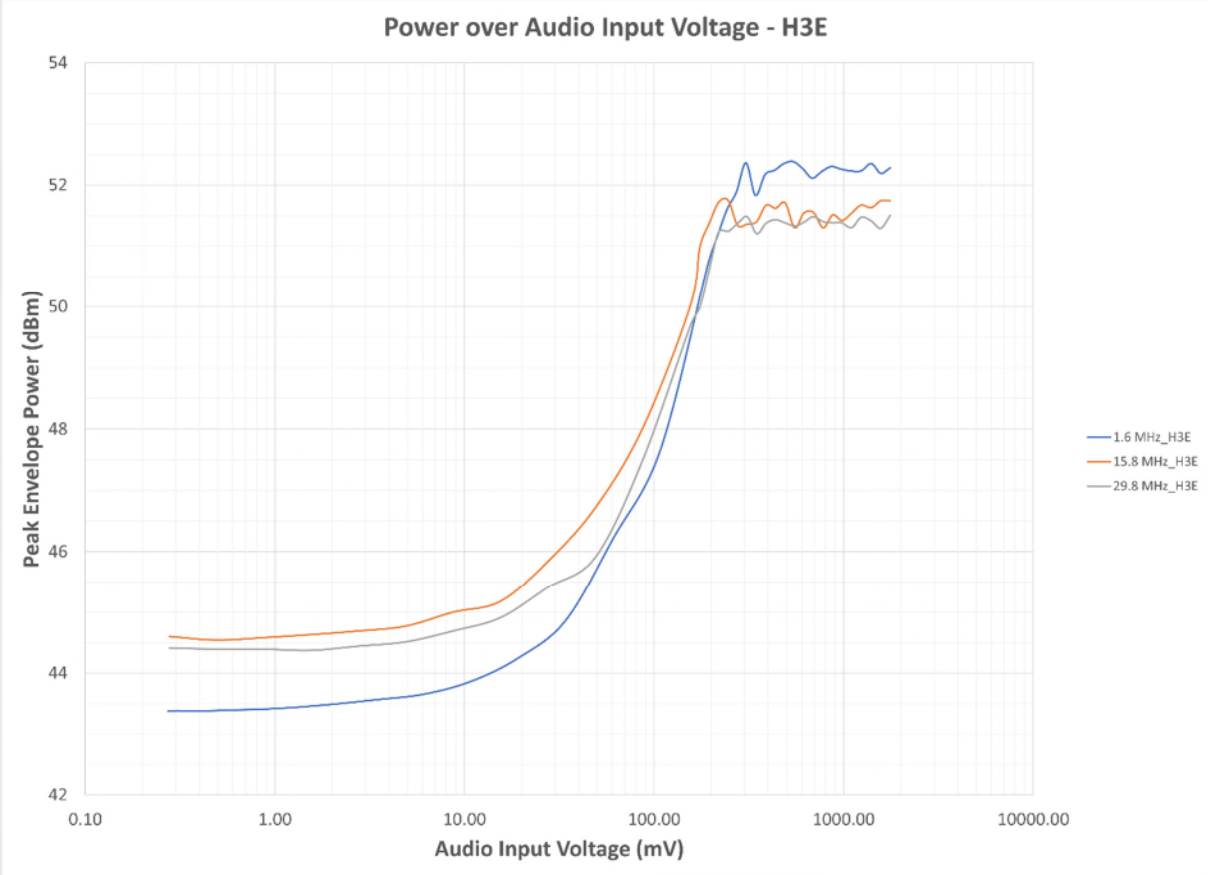


Figure 2.3.6-7 – Modulation Characteristics – Peak Envelope vs Audio Amplitude – H3E

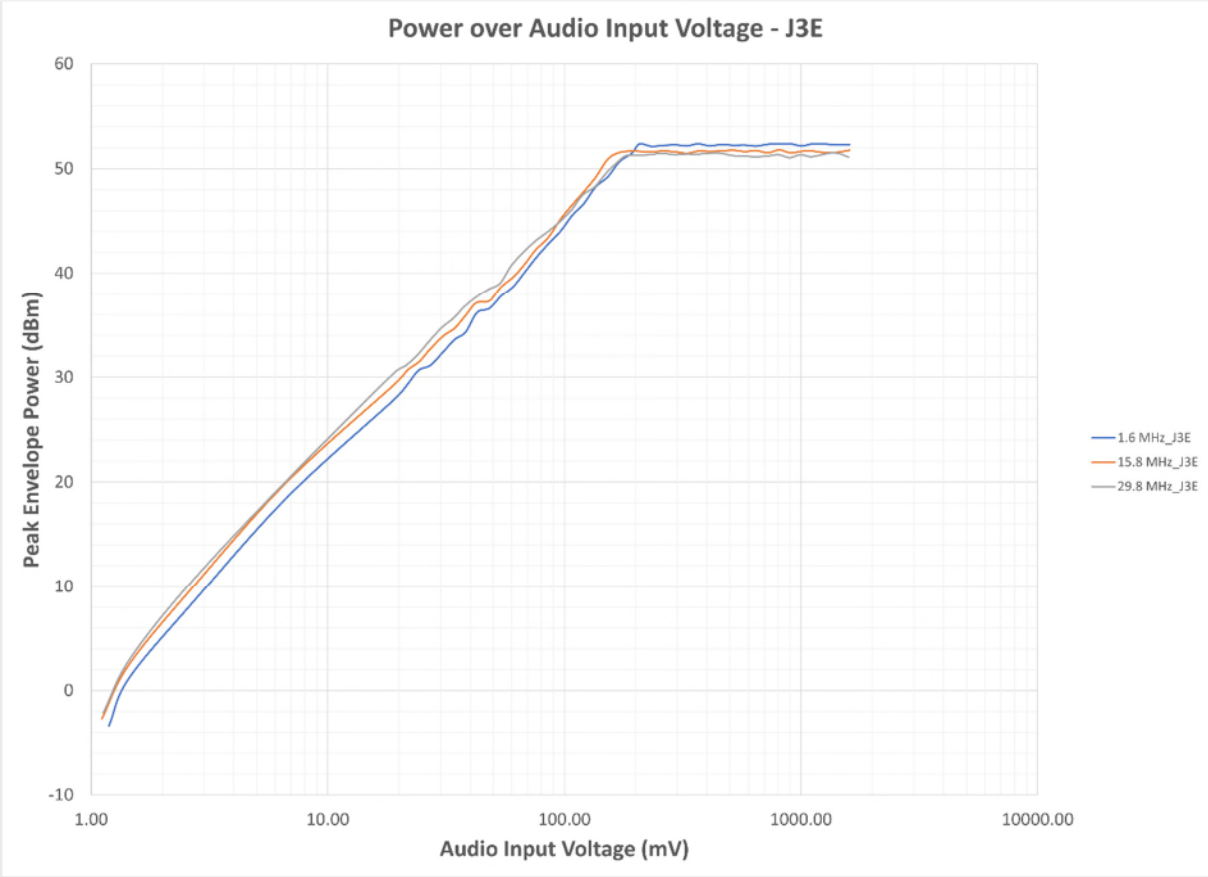


Figure 2.3.6-8 – Modulation Characteristics – Peak Envelope vs Audio Amplitude – J3E

FCC 47 CFR Part 87.141(d)

Carrier mode	Level N(dB) of the carrier with respect to peak envelope power
Full carrier (H3E)	O>N>−6.
Suppressed carrier (J3E)	Aircraft stations N<−26;
	Aeronautical stations N<−40.

Table 2.3.6-1 – Carrier Attenuation – H3E

Frequency (MHz)	Attenuation (dB)	Limit (dB)	Margin
1.6	4.23	6	1.77
15.8	4.34	6	1.66
29.8	4.4	6	1.6

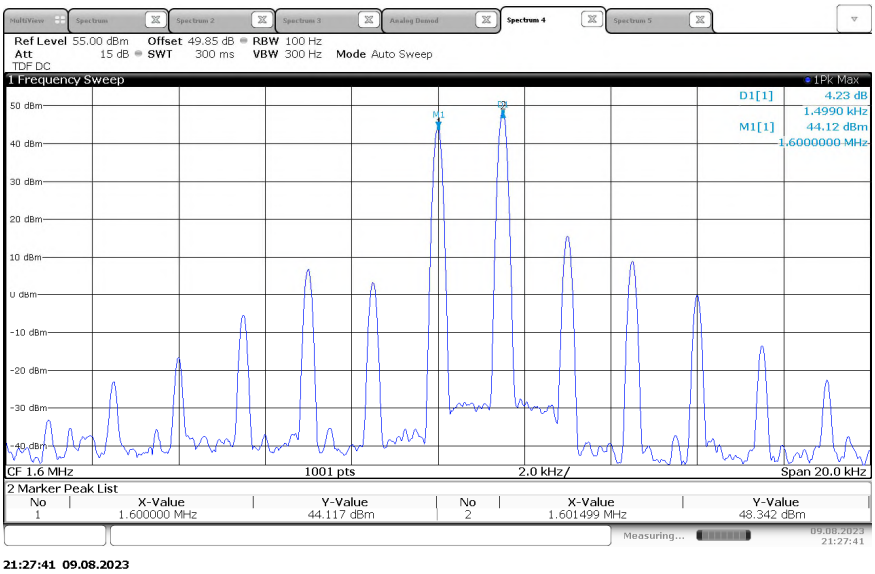


Figure 2.3.6-9 – Modulation Characteristics – Carrier Attenuation – H3E – 1.6 MHz

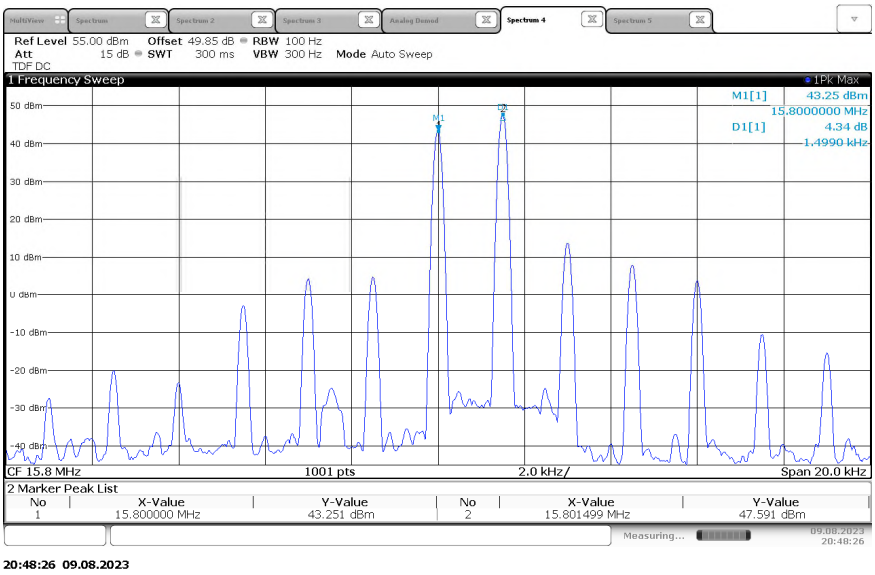


Figure 2.3.6-10 – Modulation Characteristics – Carrier Attenuation – H3E – 15.8 MHz

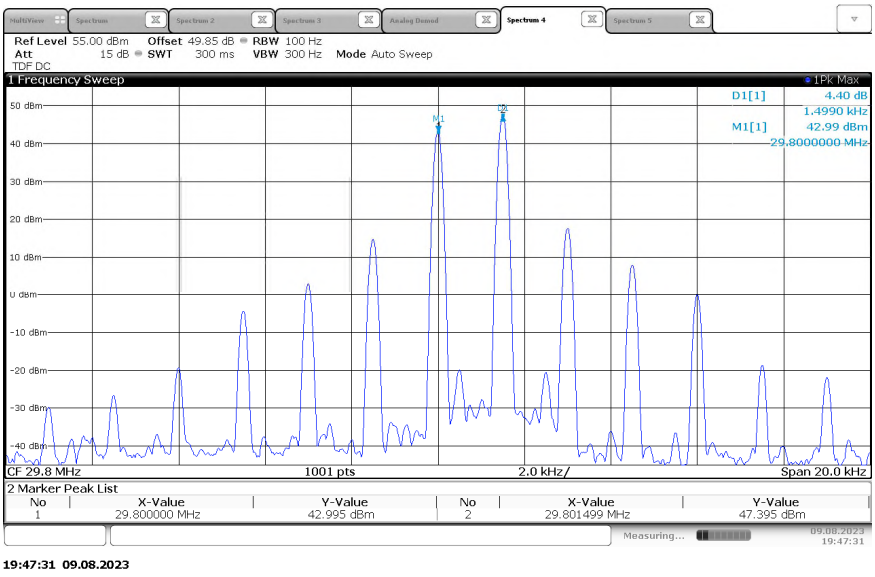


Figure 2.3.6-11 – Modulation Characteristics – Carrier Attenuation – H3E – 29.8 MHz

Table 2.3.6-2 – Carrier Attenuation – J3E

Frequency (MHz)	Attenuation (dB)	Limit (dB)	Margin
1.6	73.97	40	33.97
15.8	72.92	40	32.92
29.8	72.95	40	32.95

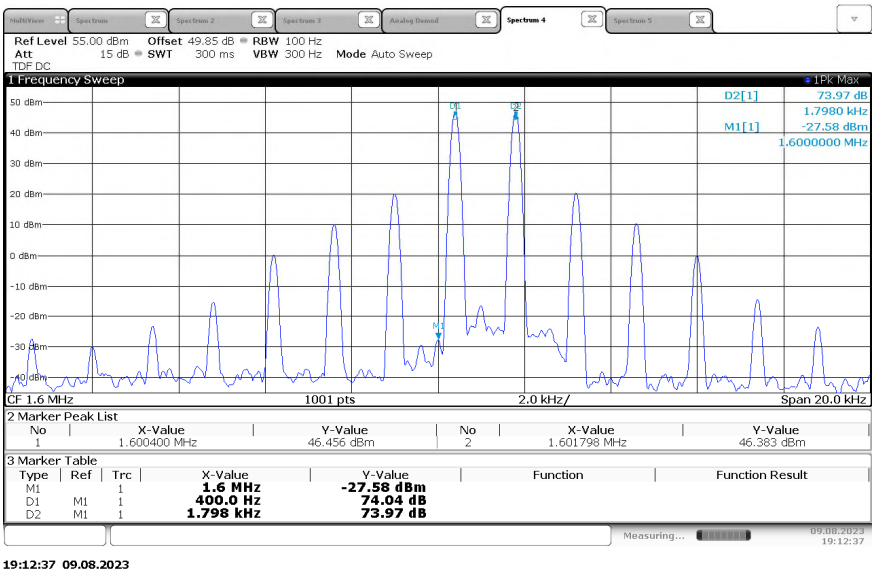


Figure 2.3.6-12 – Modulation Characteristics – Carrier Attenuation – J3E – 1.6 MHz

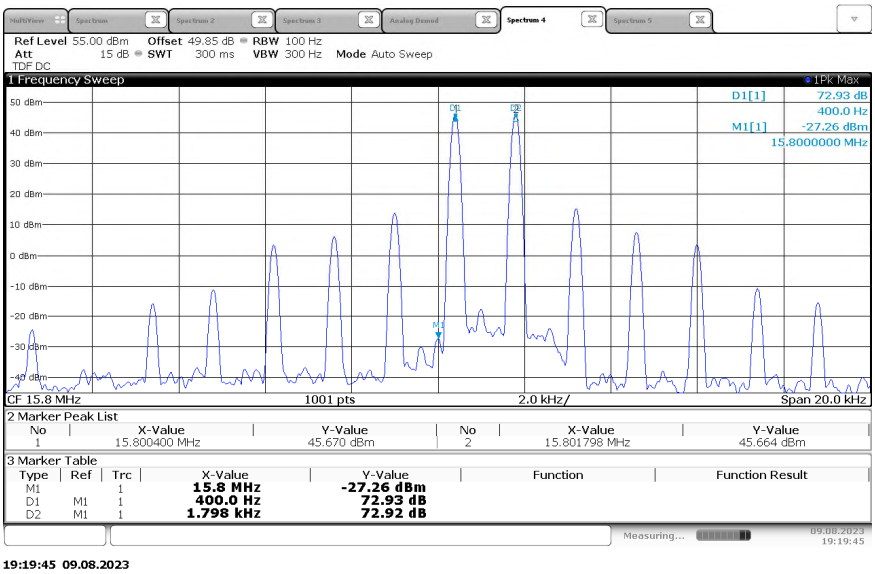


Figure 2.3.6-13 – Modulation Characteristics – Carrier Attenuation – J3E – 15.8 MHz

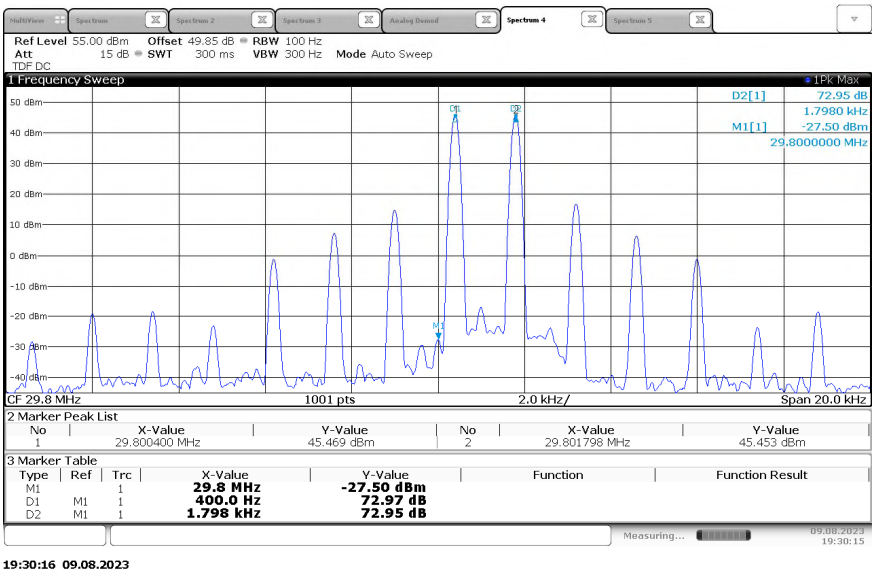


Figure 2.3.6-14 – Modulation Characteristics – Carrier Attenuation – J3E – 29.8 MHz

2.3.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.4 Out of Band Unwanted Emissions

2.4.1 Specification Reference

FCC 47 CFR Parts: 2.1051; 87.139; 90.210

2.4.2 Equipment Under Test and Modification State

S/N: 405013698

2.4.3 Date of Test

2023-August-09

2.4.4 Test Method

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through a 50 dB passive attenuator. The spectrum analyzer resolution and video bandwidths were set to 100 Hz and 1000 Hz, respectively. The internal correction factors of the spectrum analyzer were employed to correct for any cable or attenuator losses. Results of the test are shown below for all modes of operation.

2.4.5 Environmental Conditions

Ambient Temperature	25.1 °C
Relative Humidity	40.2 %
Atmospheric Pressure	1013.4 mbar

2.4.6 Test Results

DC Powered Operating

FCC 47 CFR Parts: 2.1053; 87.139(c)
(c) For aircraft station transmitters first installed after February 1, 1983, and for aeronautical station transmitters in use after February 1, 1983, and using H2B, H3E, J3E, J7B or J9W, the peak envelope power of any emissions must be attenuated below the peak envelope power of the transmitter (pX) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 150 percent of the authorized bandwidth of 3.0 kHz, the attenuation must be at least 30 dB.
(2) When the frequency is removed from the assigned frequency by more than 150 percent up to and including 250 percent of the authorized bandwidth of 3.0 kHz, the attenuation must be at least 38 dB.
(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth of 3.0 kHz for aircraft transmitters the attenuation must be at least 43 dB. For aeronautical station transmitters with transmitter power up to and including 50 watts the attenuation must be at least 43 + 10 log10 pX dB and with transmitter power more than 50 watts the attenuation must be at least 60 dB.

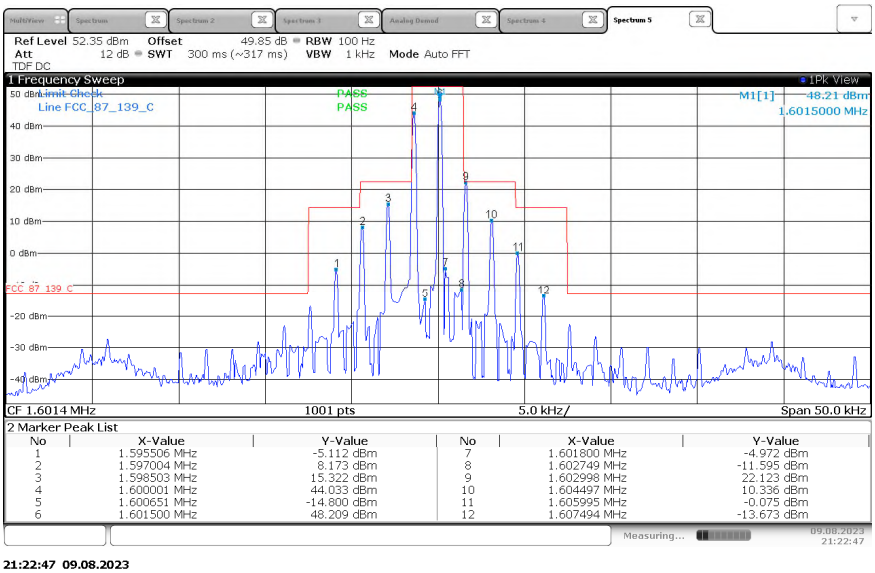


Figure 2.4.6-1 - Emissions Mask – 1.6 MHz – H3E

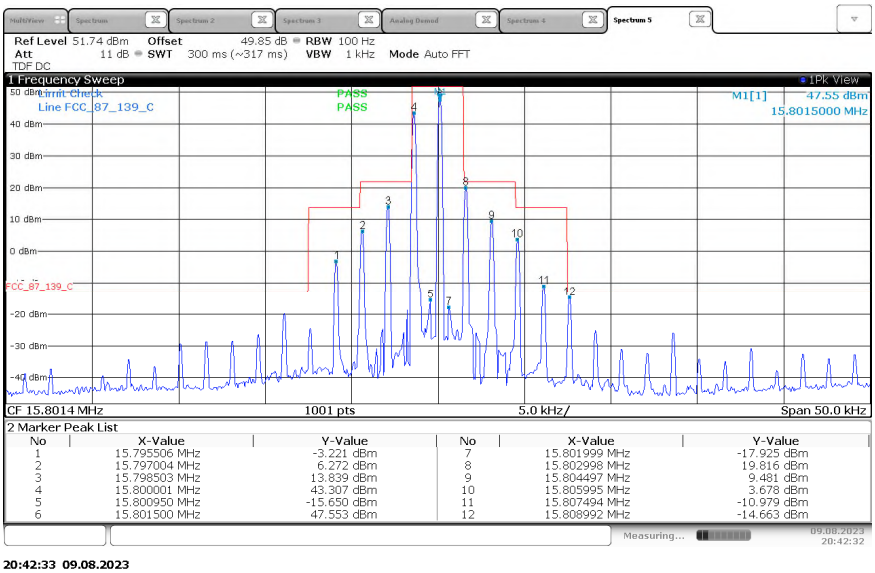
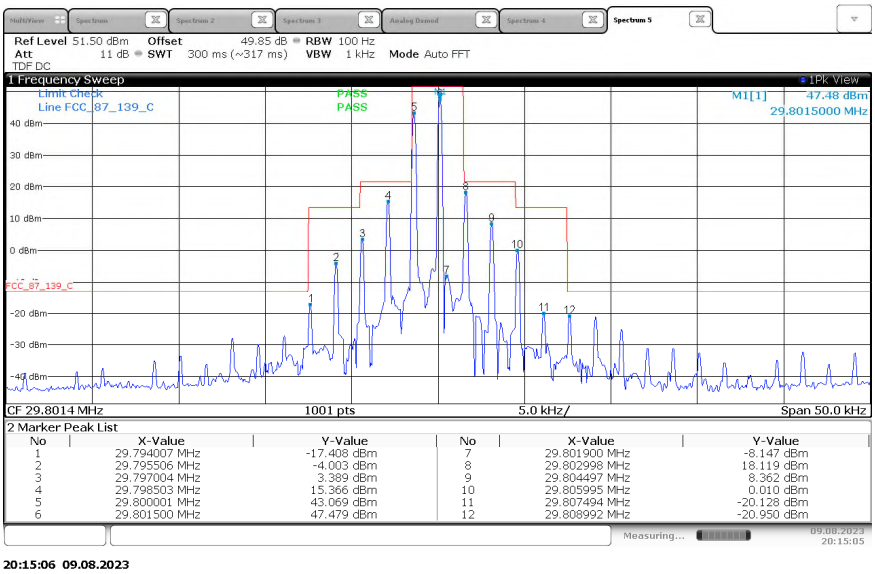
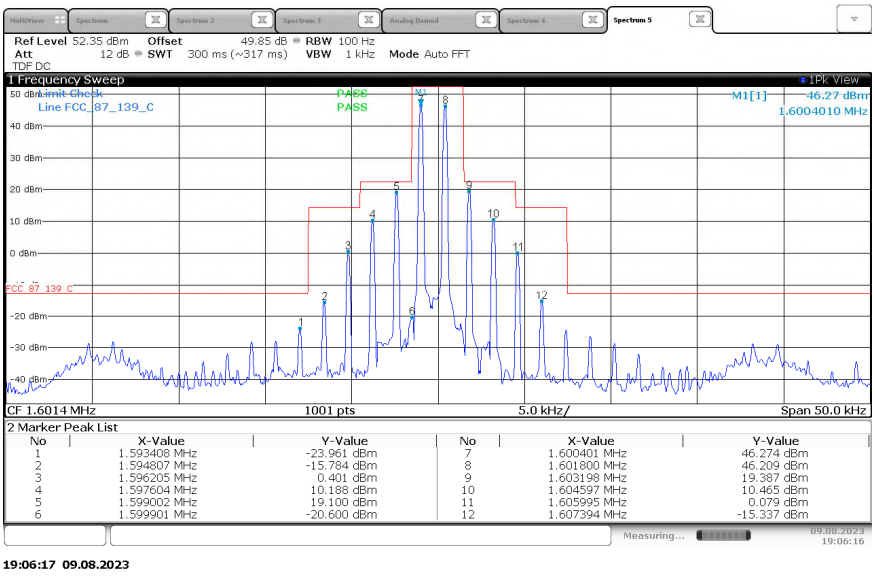


Figure 2.4.6-2 - Emissions Mask – 15.8 MHz – H3E



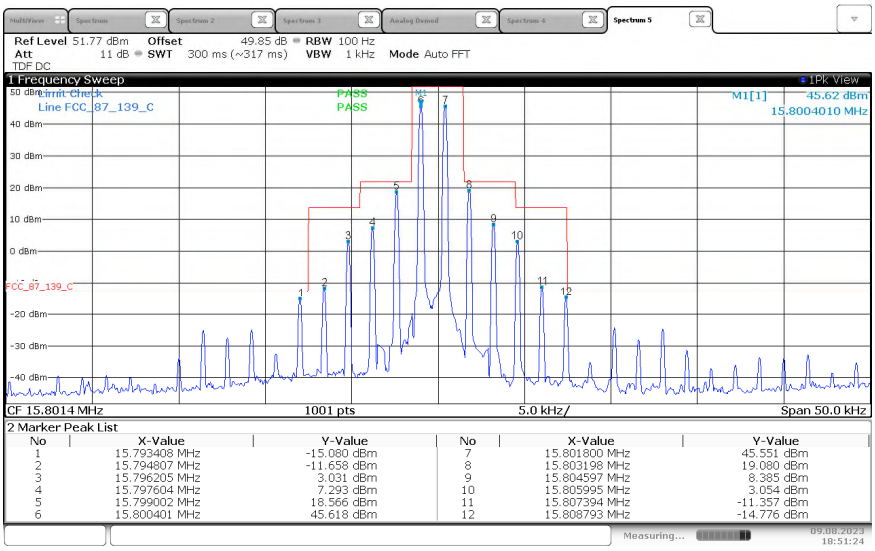
20:15:06 09.08.2023

Figure 2.4.6-3 - Emissions Mask – 29.8 MHz – H3E



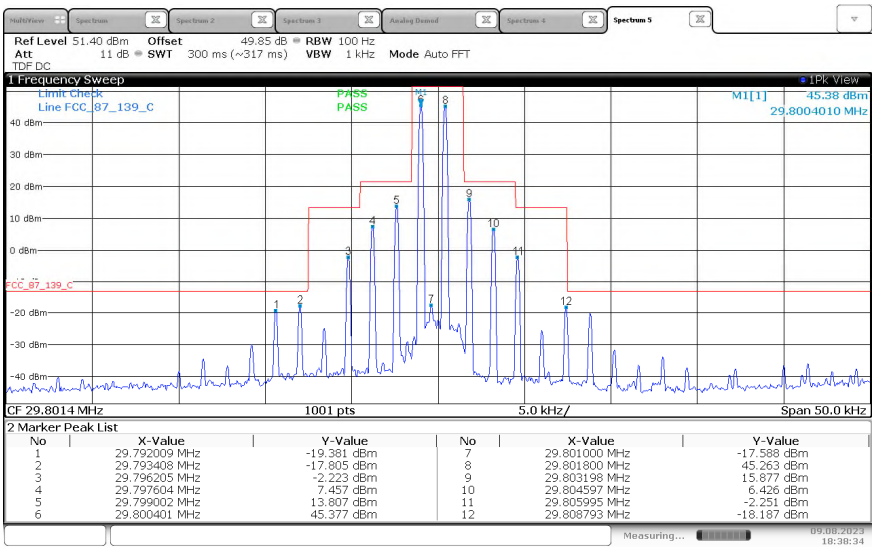
19:06:17 09.08.2023

Figure 2.4.6-4 - Emissions Mask – 1.6 MHz – J3E



18:51:25 09.08.2023

Figure 2.4.6-5 - Emissions Mask – 15.8 MHz – J3E



18:38:35 09.08.2023

Figure 2.4.6-6 - Emissions Mask – 29.8 MHz – J3E

FCC 47 CFR Parts: 2.1053; 90.210(a)(b)

(a) *Emission Mask A.* For transmitters utilizing J3E emission, the carrier must be at least 40 dB below the peak envelope power and the power of emissions must be reduced below the output power (P in watts) of the transmitter as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 150 percent of the authorized bandwidth: At least 25 dB.

(2) On any frequency removed from the assigned frequency by more than 150 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log P dB

(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.

(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

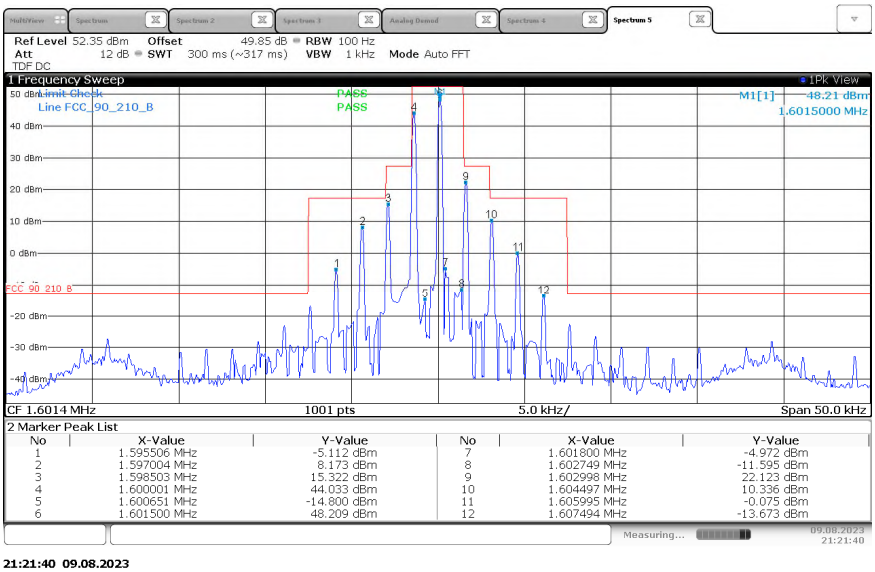


Figure 2.4.6-7 - Emissions Mask – 1.6 MHz – H3E

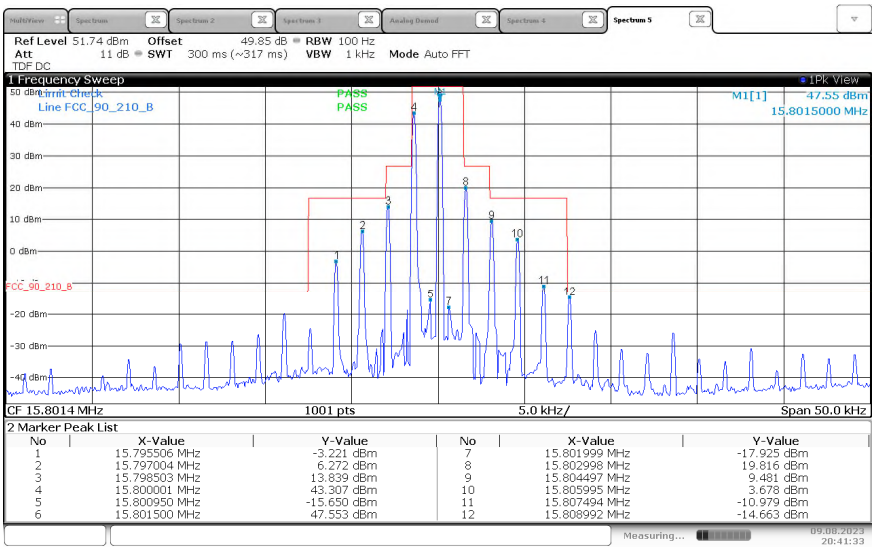


Figure 2.4.6-8 - Emissions Mask – 15.8 MHz – H3E

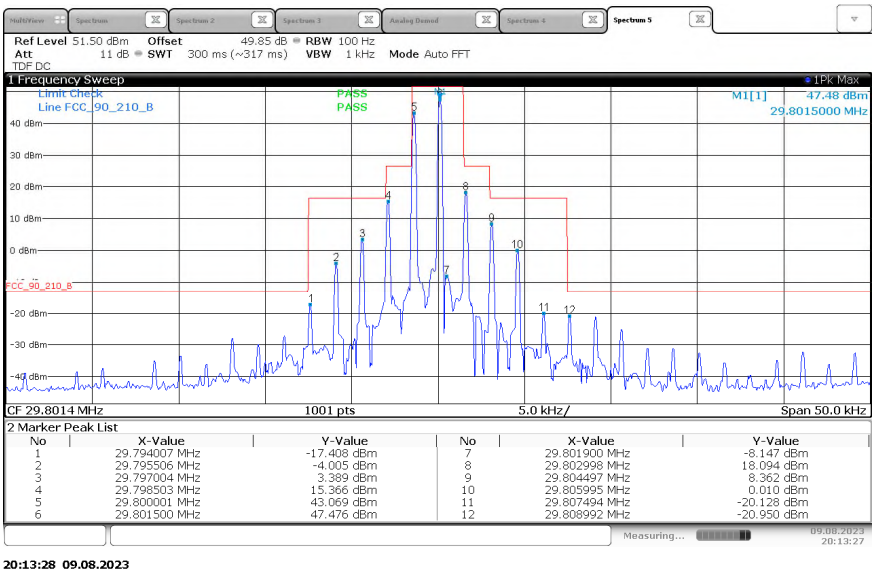
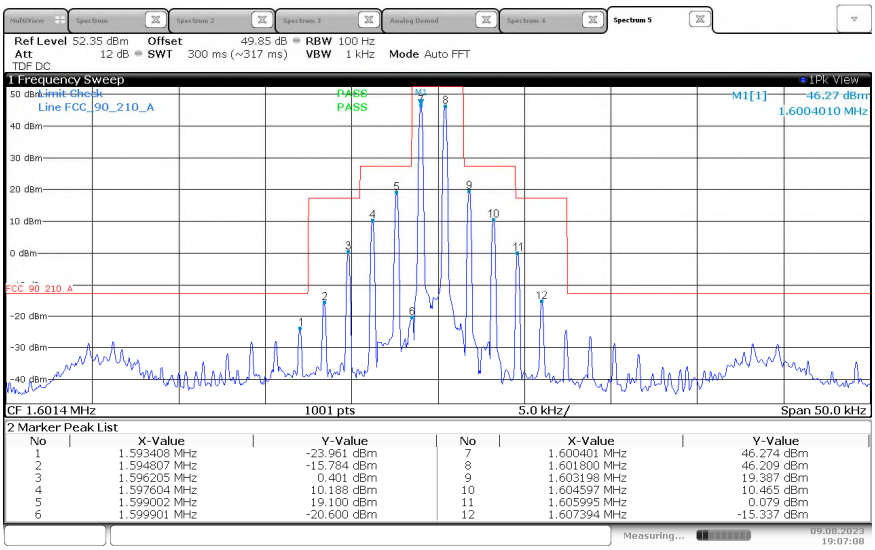
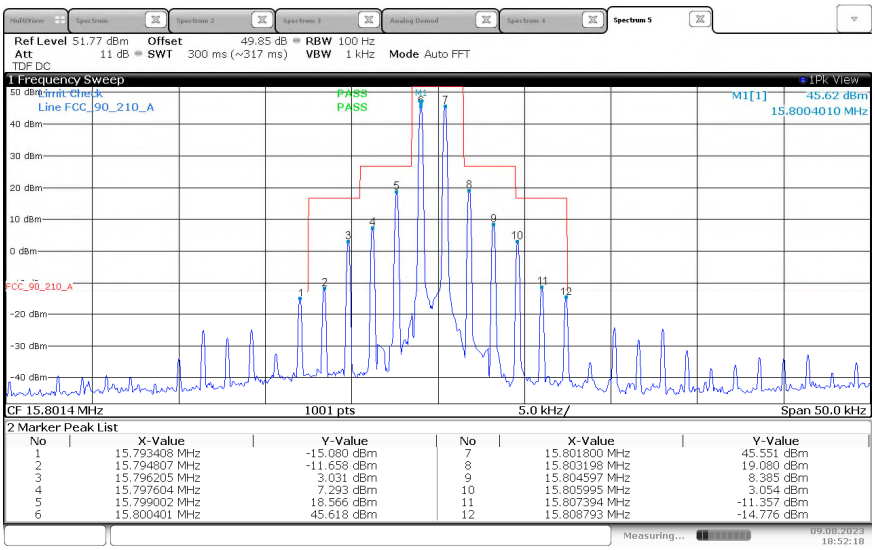


Figure 2.4.6-9 - Emissions Mask – 29.8 MHz – H3E



19:07:09 09.08.2023

Figure 2.4.6-10 - Emissions Mask – 1.6 MHz – J3E



18:52:18 09.08.2023

Figure 2.4.6-11 - Emissions Mask – 15.8 MHz – J3E

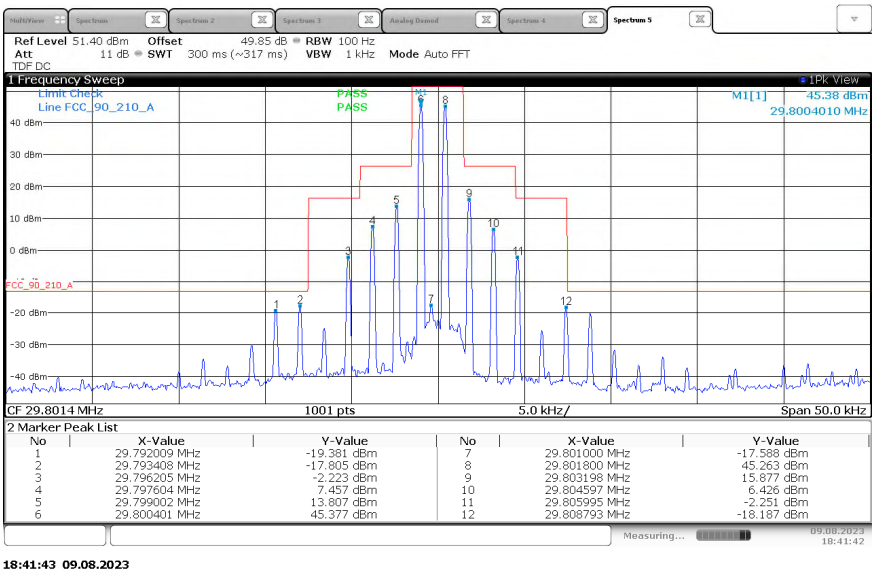


Figure 2.4.6-12 - Emissions Mask – 29.8 MHz – J3E

2.4.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.5 Spurious Emissions at Antenna Terminals

2.5.1 Specification Reference

FCC 47 CFR Parts: 2.1051; 87.139; 90.210

2.5.2 Equipment Under Test and Modification State

S/N: 405013698

2.5.3 Date of Test

2023-August-03 to 2023-August-17

2.5.4 Test Method

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through a 50 dB passive attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz below 1000 MHz and 1 MHz above 1000 MHz. The internal correction factors of the spectrum analyzer were employed to correct for any cable or attenuator. The spectrum was investigated in accordance with CFR 47 Part 2.1057.

2.5.5 Environmental Conditions

Ambient Temperature	24.9 °C
Relative Humidity	48.8 %
Atmospheric Pressure	1015.3 mbar

2.5.6 Test Results

DC Powered Operating

FCC 47 CFR Parts: 2.1053; 87.139(c)(3); 90.210(a)(3),(b)(3)

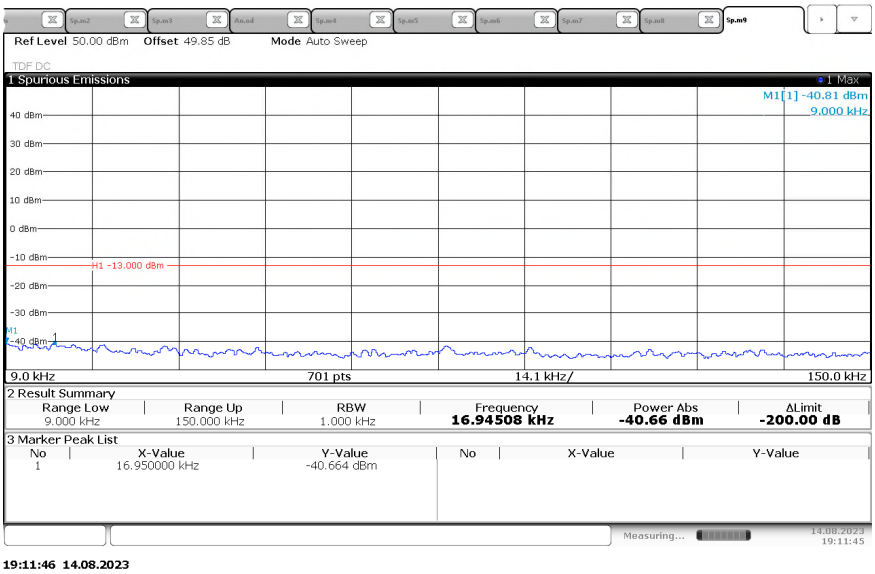


Figure 2.5.6-1 - Transmitter Conducted Spurious Emissions – 1.6 MHz – H3E

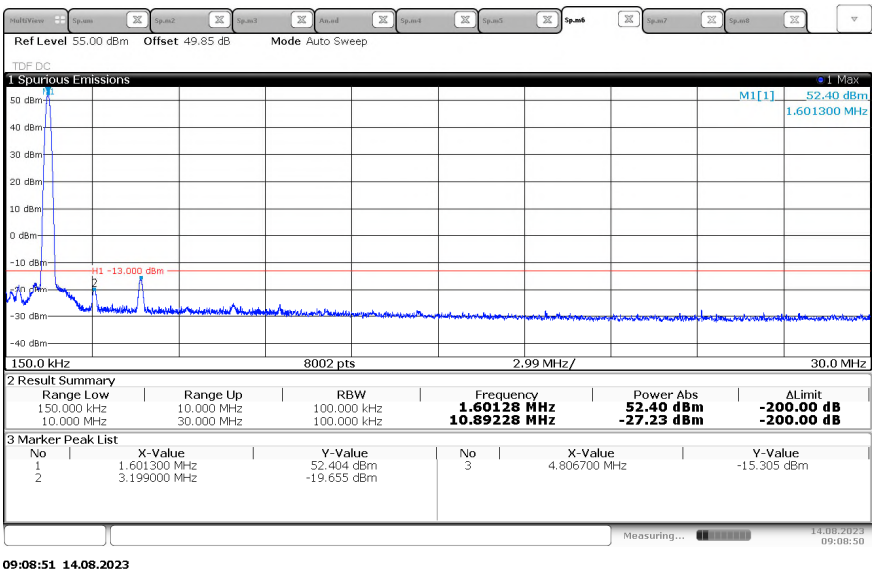


Figure 2.5.6-2 - Transmitter Conducted Spurious Emissions – 1.6 MHz – H3E

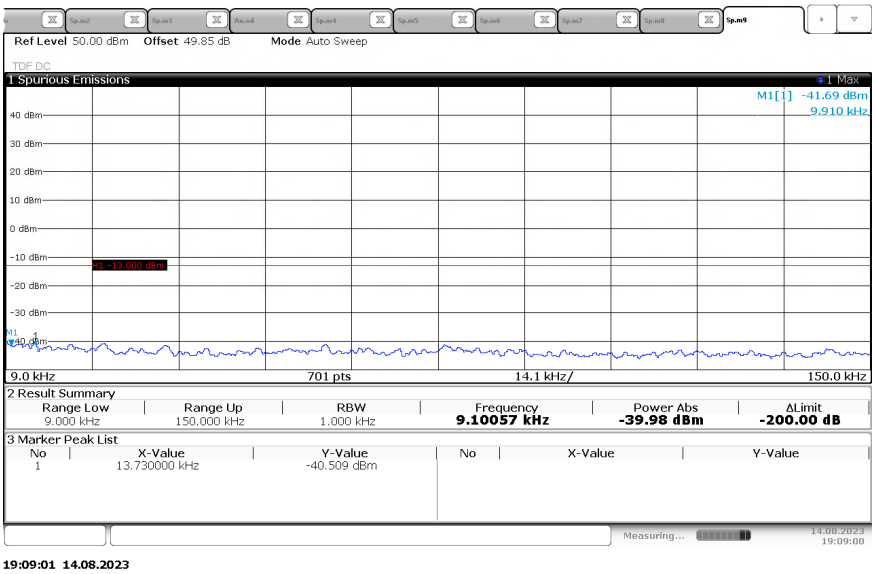


Figure 2.5.6-3 - Transmitter Conducted Spurious Emissions – 15.8 MHz – H3E

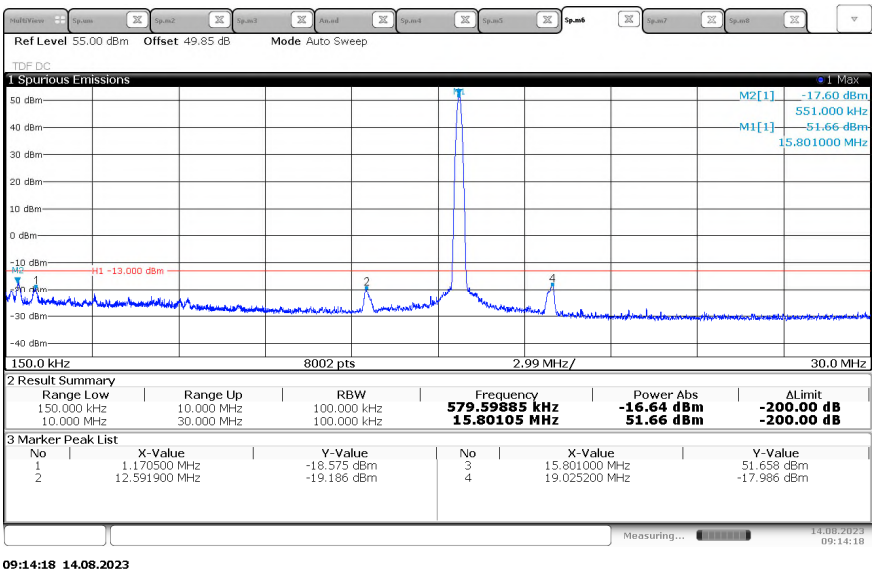


Figure 2.5.6-4 - Transmitter Conducted Spurious Emissions – 15.8 MHz – H3E

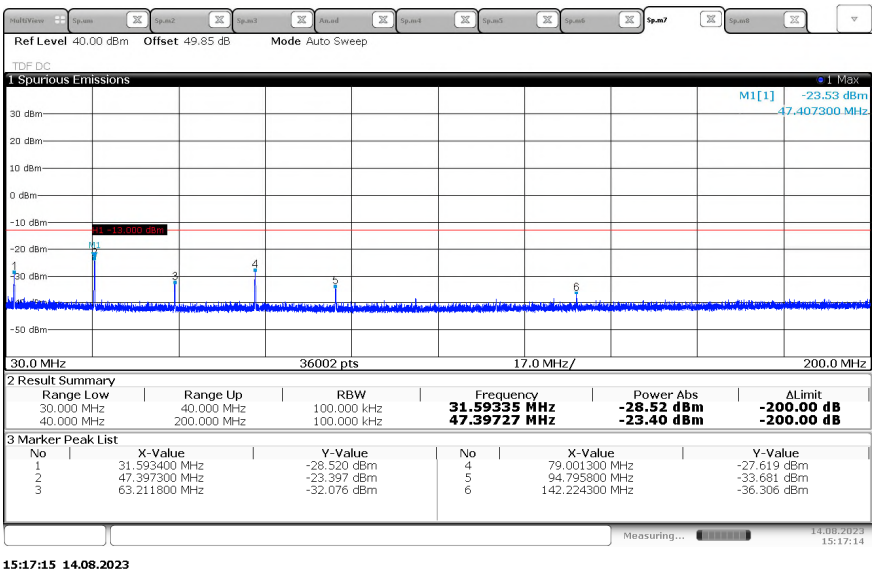


Figure 2.5.6-5 - Transmitter Conducted Spurious Emissions – 15.8 MHz – H3E

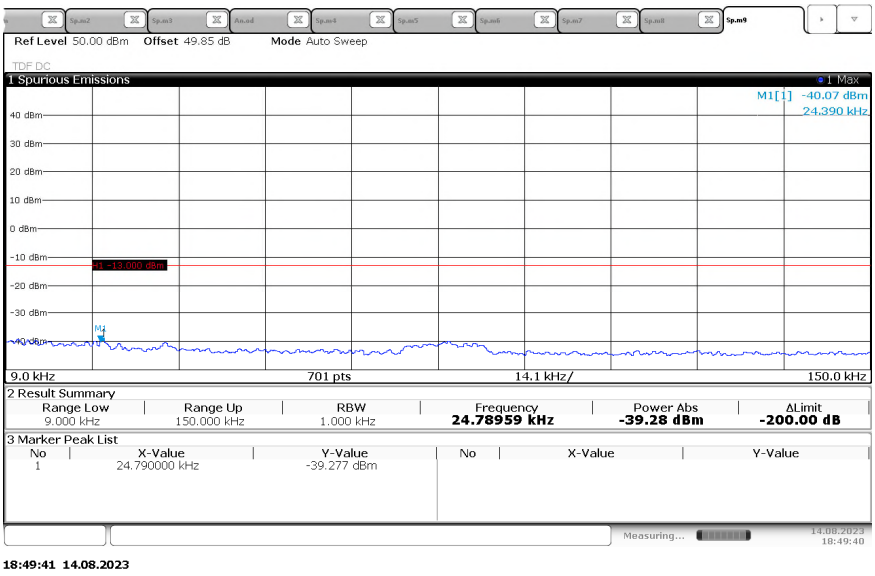


Figure 2.5.6-6 - Transmitter Conducted Spurious Emissions – 29.8 MHz – H3E

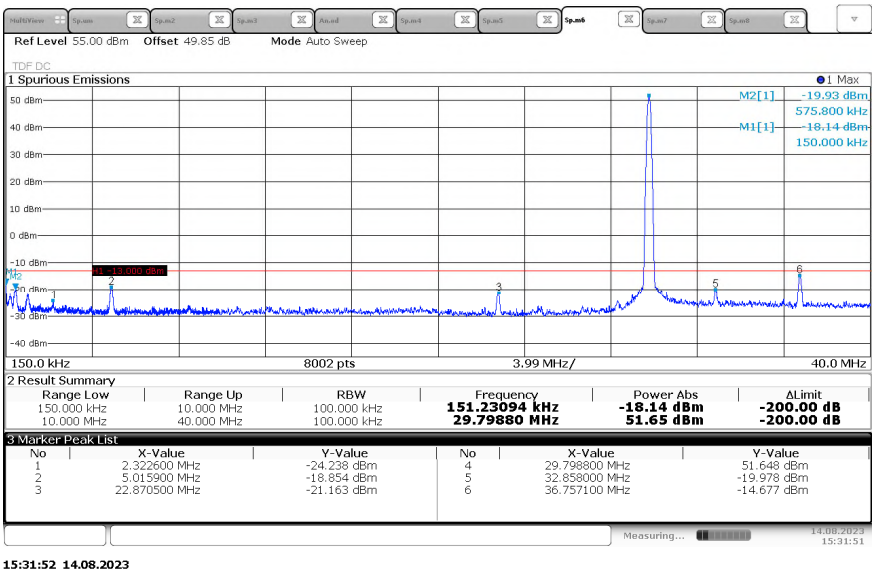


Figure 2.5.6-7 - Transmitter Conducted Spurious Emissions – 29.8 MHz – H3E

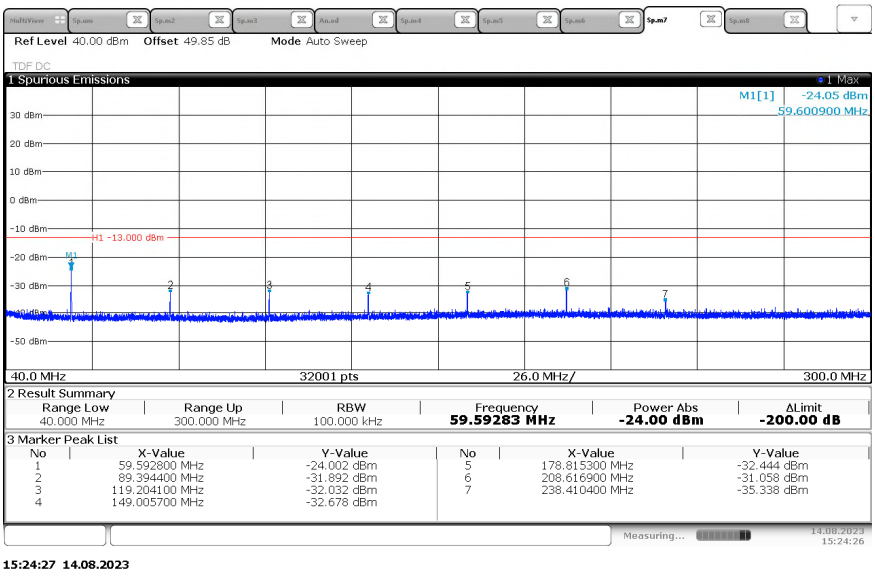


Figure 2.5.6-8 - Transmitter Conducted Spurious Emissions – 29.8 MHz – H3E

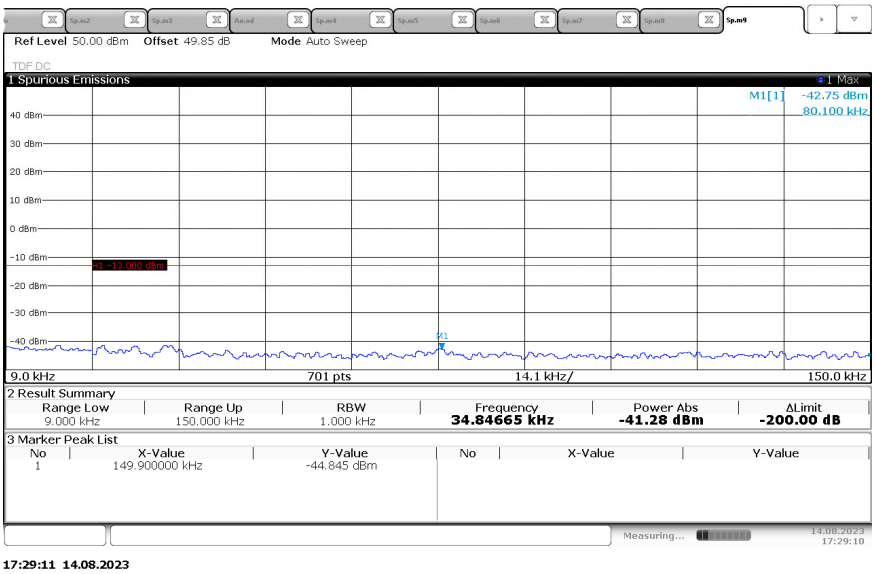


Figure 2.5.6-9 - Transmitter Conducted Spurious Emissions – 1.6 MHz – J3E

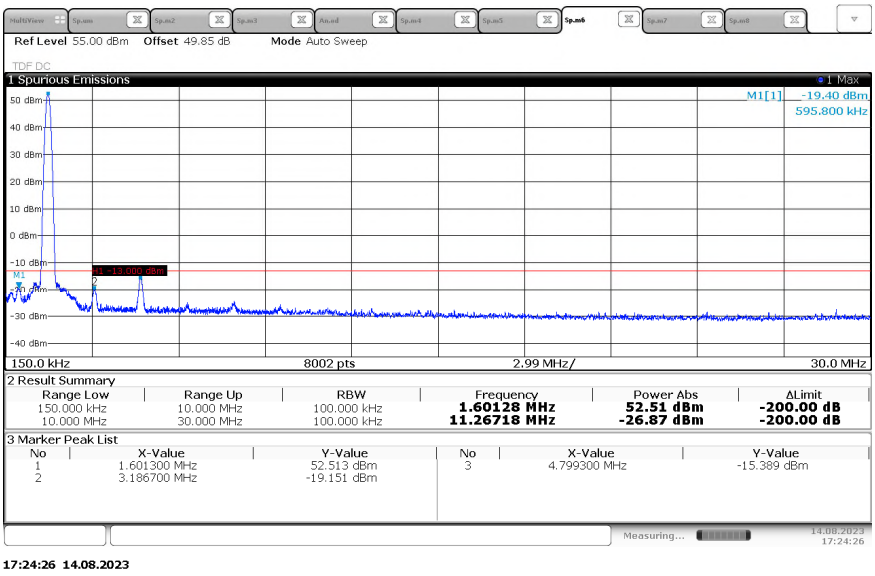


Figure 2.5.6-10 - Transmitter Conducted Spurious Emissions – 1.6 MHz – J3E

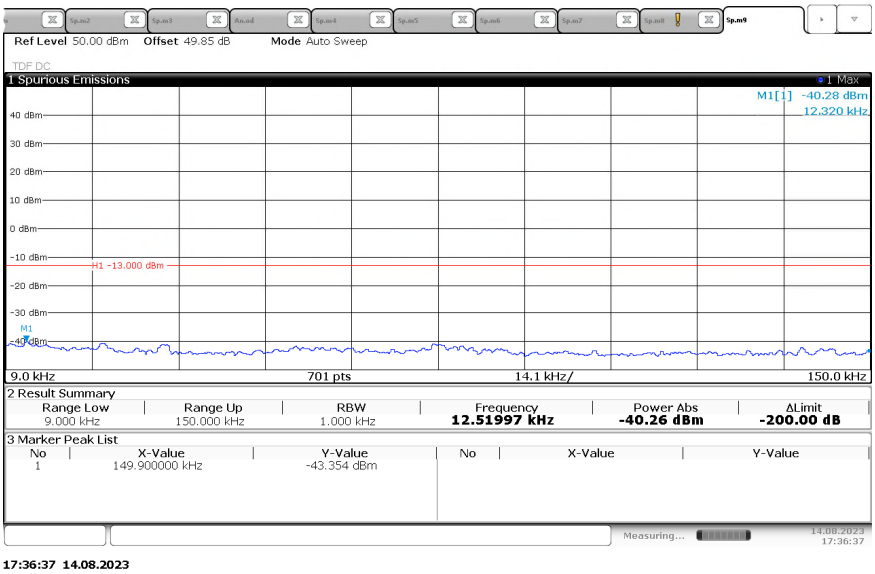


Figure 2.5.6-11 - Transmitter Conducted Spurious Emissions – 15.8 MHz – J3E

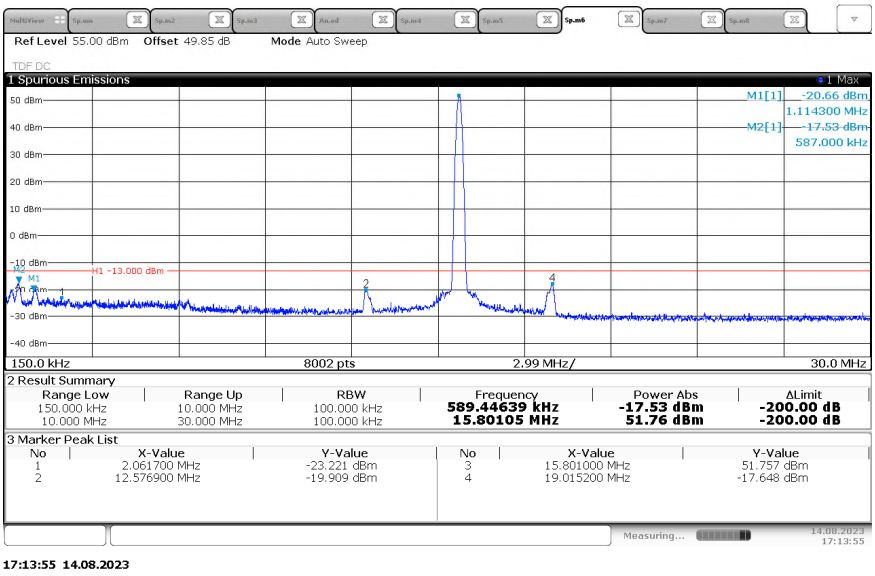


Figure 2.5.6-12 - Transmitter Conducted Spurious Emissions – 15.8 MHz – J3E

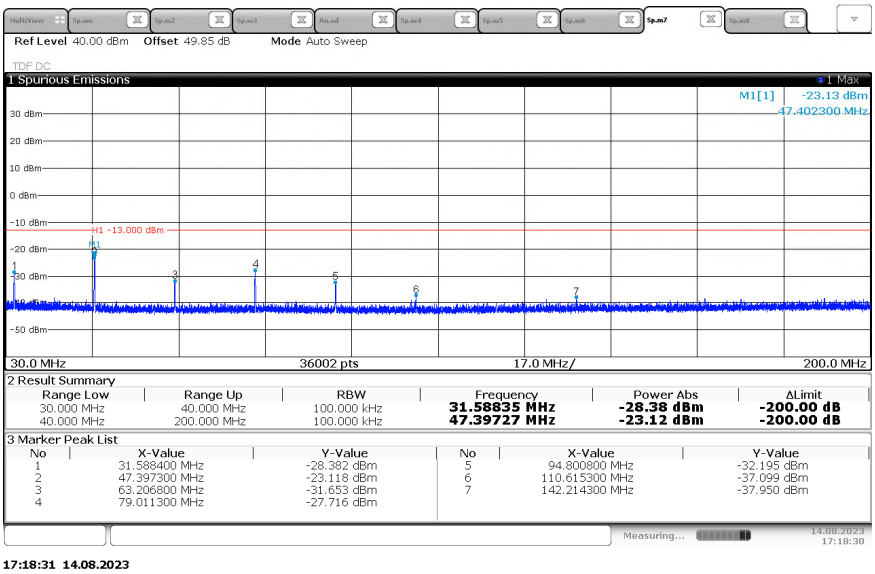


Figure 2.5.6-13 - Transmitter Conducted Spurious Emissions – 15.8 MHz – J3E

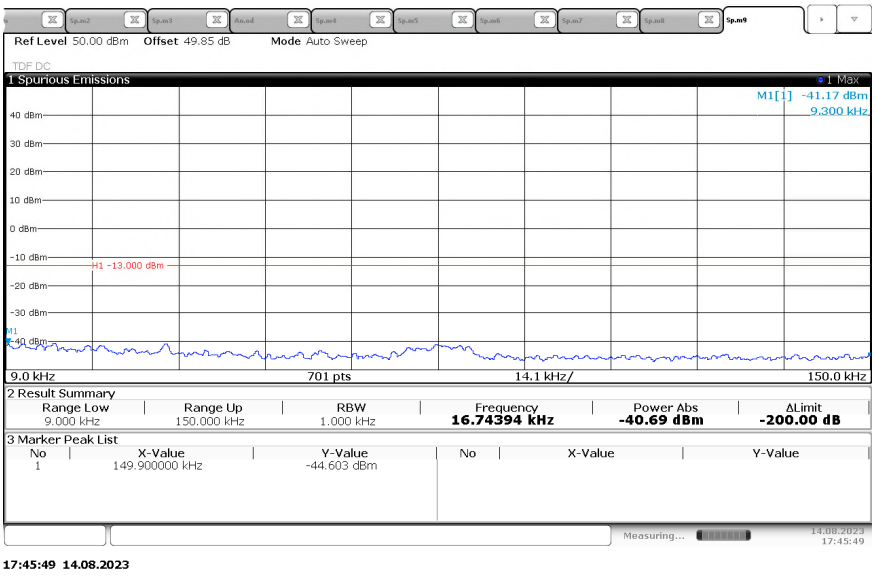


Figure 2.5.6-14 - Transmitter Conducted Spurious Emissions – 29.8 MHz – J3E

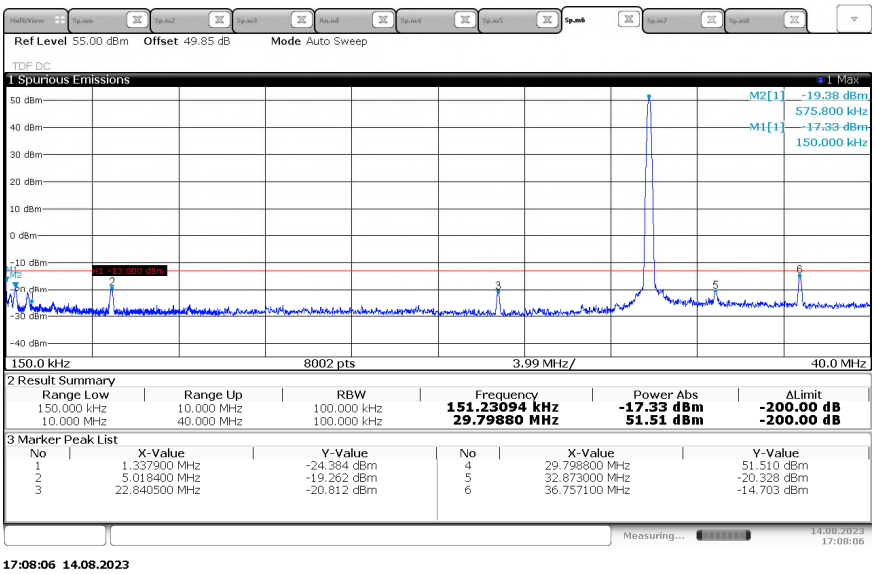


Figure 2.5.6-15 - Transmitter Conducted Spurious Emissions – 29.8 MHz – J3E

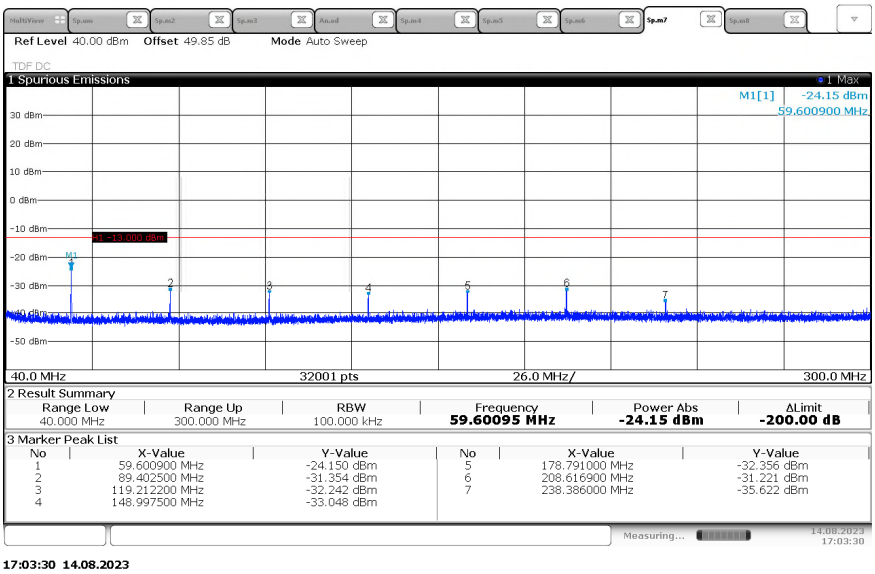


Figure 2.5.6-16 - Transmitter Conducted Spurious Emissions – 29.8 MHz – J3E

2.5.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
High Pass Filter	Mini-Circuits	SHP-25+	TEMC00263	N/A	12	17-Mar-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024
High Pass Filter 41-800 MHz	Mini Circuits	BHP-50+	TEMC00287	N/A	12	14-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.6 Field Strength of Spurious Radiation

2.6.1 Specification Reference

FCC 47 CFR Parts: 2.1053; 87.139; 90.210

2.6.2 Equipment Under Test and Modification State

S/N: 405013734

2.6.3 Date of Test

2023-July-13 to 2023-August-16

2.6.4 Test Method

For measurements below 30 MHz, the EUT was evaluated in accordance with C63.26:2015 Section 4.4.3 Substitution Antennas. The electric field strength was converted to radiated power using the equation d) from Section 5.2.7. The receive antenna height was set to 1 m and the EUT was rotated through 360 degrees. Preliminary measurements were performed for multiple orientations of the receive loop antenna. The results are provided for the worst-case receive antenna configuration.

For emisions above 30 MHz, the EUT was evaluated in accordance with ANSI C63.26:2015 Section 5.5.3 Measurement of Spurious Emissions using Substitution Method.

Radiated emissions tests were made over the frequency range of 30 MHz to 10 times the highest fundamental frequency. The equipment under test is placed in the Semi-Anechoic Chamber on a RF transparent table at the turntable center. For each spurious emission, the antenna mast is raised and lowered from one (1) to four (4) meters and the turntable is rotated 360º and the maximum reading on the spectrum analyzer is recorded. This was repeated for both horizontal and vertical polarizations of the receive antenna.

The equipment under test is then replaced with a substitution antenna fed by a signal generator. The signal generator's frequency is set to that of the spurious emission recorded from the equipment under test. The antenna mast is raised and lowered from one (1) to four (4) meters to obtain a maximum reading on the spectrum analyzer. The output of the signal generator is then adjusted until the reading on the spectrum analyzer matches that obtained from the equipment under test. The signal generator level is recorded. The power in dBm of each spurious emission is calculated by correcting the signal generator level for the cable loss and gain of the substitution antenna referenced to a dipole. The spectrum was investigated in accordance to FCC CFR 47 Part 2.1057.

The magnitude of all spurious emissions not reported were attenuated below the noise floor of the measurement system and therefore not specified in this report. Results are shown below.

2.6.5 Environmental Conditions

Ambient Temperature	23.4 °C
Relative Humidity	44.6 %
Atmospheric Pressure	1013.2 mbar

2.6.6 Test Results

DC Powered Operating

FCC 47 CFR Parts: 2.1053; 87.139(c)(3); 90.210(a)(3),(b)(3)

Table 2.6.6-1 - Transmitter Radiated Spurious Emissions – 1.6 MHz – H3E

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.59	V	14.59	66.18	-31.23	-13.0	18.23
0.58	47.95	V	14.78	62.73	-34.68	-13.0	21.68

Table 2.6.6-2 - Transmitter Radiated Spurious Emissions – 15.8 MHz – H3E – Below 30 MHz

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.54	V	14.59	66.13	-31.28	-13.0	18.28
0.58	47.56	V	14.78	62.34	-35.07	-13.0	22.07

Table 2.6.6-3 - Transmitter Radiated Spurious Emissions – 15.8 MHz – H3E – Above 30 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBuV)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
47.4	25.77	H	-52.12	-13.00	39.12
63.2	27.77	H	-58.99	-13.00	45.99
79	34.73	H	-50.05	-13.00	37.05
94.8	23.12	H	-58.98	-13.00	45.98
126.4	19.40	H	-64.55	-13.00	51.55
142.2	38.78	H	-43.44	-13.00	30.44
158	24.43	H	-59.69	-13.00	46.69
205.4	35.87	H	-48.85	-13.00	35.85
47.4	33.10	V	-50.93	-13.00	37.93
63.2	28.11	V	-61.27	-13.00	48.27
79	27.85	V	-56.15	-13.00	43.15
94.8	23.37	V	-61.22	-13.00	48.22
126.4	17.01	V	-63.32	-13.00	50.32
142.2	34.83	V	-46.95	-13.00	33.95
158	18.46	V	-65.29	-13.00	52.29
205.4	30.26	V	-49.46	-13.00	36.46

Table 2.6.6-4 - Transmitter Radiated Spurious Emissions – 29.8 MHz – H3E – Below 30 MHz

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.60	V	14.59	66.19	-31.22	-13.0	18.22
0.58	48.01	V	14.78	62.79	-34.62	-13.0	21.62

Table 2.6.6-5 - Transmitter Radiated Spurious Emissions – 29.8 MHz – H3E – Above 30 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBuV)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
59.6	29.72	H	-56.83	-13.00	43.83
89.4	38.35	H	-44.18	-13.00	31.18
119.2	24.70	H	-57.78	-13.00	44.78
149	39.92	H	-42.64	-13.00	29.64
178.8	30.88	H	-54.85	-13.00	41.85
208.6	44.79	H	-39.62	-13.00	26.62
238.4	29.32	H	-53.99	-13.00	40.99
268.2	41.44	H	-40.79	-13.00	27.79
298	25.01	H	-57.00	-13.00	44.00
59.6	33.10	V	-55.18	-13.00	42.18
89.4	40.12	V	-44.29	-13.00	31.29
119.2	21.95	V	-55.59	-13.00	42.59
149	39.17	V	-42.99	-13.00	29.99
178.8	25.91	V	-56.35	-13.00	43.35
208.6	38.82	V	-40.04	-13.00	27.04
238.4	25.45	V	-52.13	-13.00	39.13
268.2	32.68	V	-45.40	-13.00	32.40
298	20.42	V	-58.11	-13.00	45.11

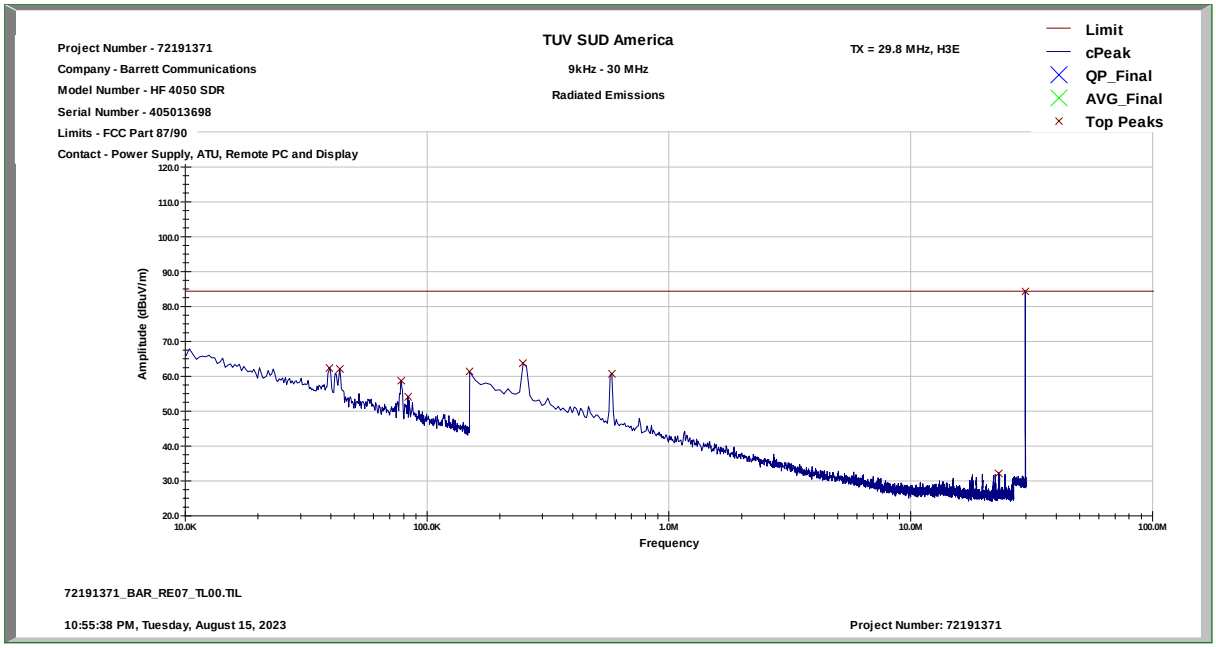


Figure 2.6.6-1 - Transmitter Radiated Spurious Emissions Representative Scan Plot – 29.8 MHz - H3E – below 30 MHz

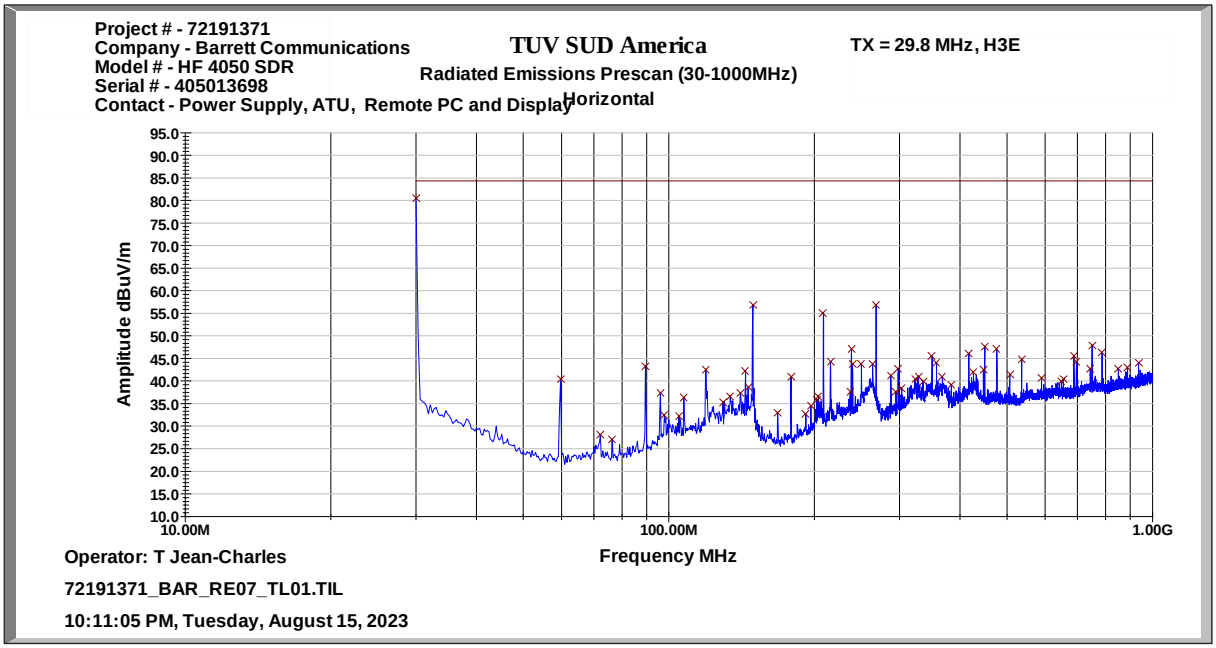


Figure 2.6.6-2 - Transmitter Radiated Spurious Emissions Representative Scan Plot – 29.8 MHz - H3E – 30 MHz – 1 GHz – Horizontal Polarization

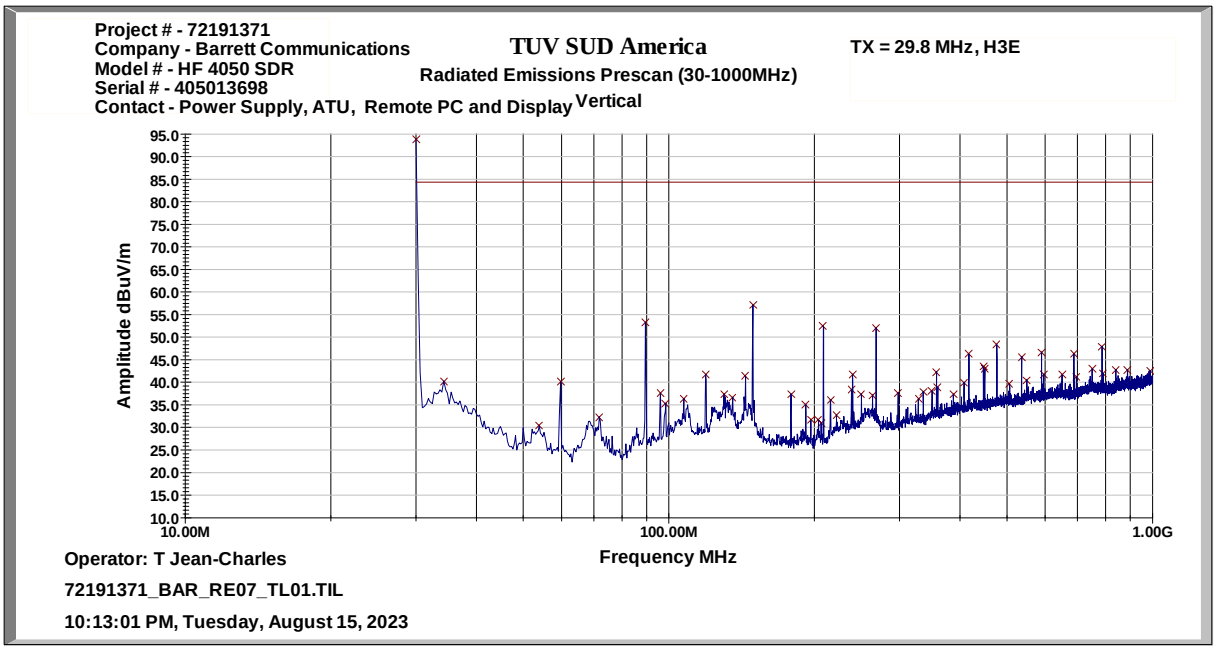


Figure 2.6.6-3 - Transmitter Radiated Spurious Emissions Representative Scan Plot – 29.8 MHz - H3E – 30 MHz – 1 GHz – Vertical Polarization

Table 2.6.6-6 - Transmitter Radiated Spurious Emissions – 1.6 MHz – J3E

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.55	V	14.59	66.14	-31.27	-13.0	18.27
0.58	47.22	V	14.78	62.00	-35.41	-13.0	22.41

Table 2.6.6-7 - Transmitter Radiated Spurious Emissions – 15.8 MHz – J3E – Below 30 MHz

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.55	V	14.59	66.14	-31.26	-13.0	18.26
0.58	47.68	V	14.78	62.46	-34.94	-13.0	21.94

Table 2.6.6-8 - Transmitter Radiated Spurious Emissions – 15.8 MHz – J3E – Above 30 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBuV)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
47.4	26.35	H	-51.55	-13.00	38.55
63.2	27.54	H	-59.22	-13.00	46.22
79	34.75	H	-50.03	-13.00	37.03
94.8	22.97	H	-59.13	-13.00	46.13
126.4	20.04	H	-63.91	-13.00	50.91
142.2	38.36	H	-43.86	-13.00	30.86
158	24.55	H	-59.57	-13.00	46.57
205.4	36.51	H	-48.21	-13.00	35.21
47.4	31.74	V	-52.37	-13.00	39.37
63.2	27.26	V	-62.46	-13.00	49.46
79	25.26	V	-59.16	-13.00	46.16
94.8	18.00	V	-67.05	-13.00	54.05
126.4	16.53	V	-63.80	-13.00	50.80
142.2	34.77	V	-47.01	-13.00	34.01
158	17.54	V	-66.59	-13.00	53.59
205.4	30.39	V	-49.33	-13.00	36.33

Table 2.6.6-9 - Transmitter Radiated Spurious Emissions – 29.8 MHz – J3E – Below 30 MHz

Frequency MHz	Level dBuV	Antenna Polarity (H/V)	Correction Factors (dB)	rrected Le (dBuV/m) pk	ERP dBm	Limit dBm	Margin dB
0.252	51.58	V	14.59	66.17	-31.23	-13.0	18.23
0.58	48.08	V	14.78	62.86	-34.54	-13.0	21.54

Table 2.6.6-10 - Transmitter Radiated Spurious Emissions – 29.8 MHz – J3E – Above 30 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBuV)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
59.6	29.21	H	-56.73	-13.00	43.73
89.4	38.36	H	-44.17	-13.00	31.17
119.2	25.31	H	-57.05	-13.00	44.05
149	40.37	H	-42.19	-13.00	29.19
178.8	31.35	H	-54.38	-13.00	41.38
208.6	44.86	H	-39.55	-13.00	26.55
238.4	30.51	H	-52.66	-13.00	39.66
268.2	41.49	H	-40.74	-13.00	27.74
298	26.28	H	-55.24	-13.00	42.24
59.6	33.12	V	-55.16	-13.00	42.16
89.4	40.36	V	-43.96	-13.00	30.96
119.2	21.49	V	-56.05	-13.00	43.05
149	38.75	V	-43.48	-13.00	30.48
178.8	25.36	V	-56.90	-13.00	43.90
208.6	39.00	V	-39.86	-13.00	26.86
238.4	25.36	V	-52.22	-13.00	39.22
268.2	32.31	V	-45.77	-13.00	32.77
298	20.96	V	-57.57	-13.00	44.57

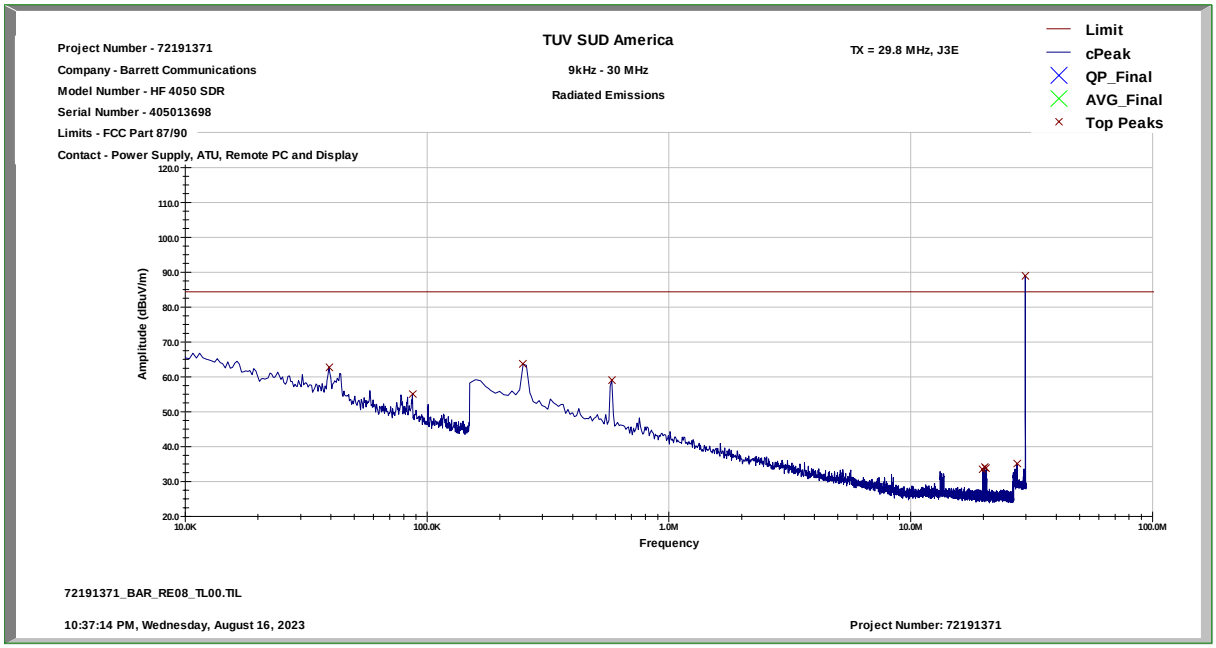


Figure 2.6.6-4 - Transmitter Radiated Spurious Emissions Representative Scan Plot – 29.8 MHz - J3E – below 30 MHz

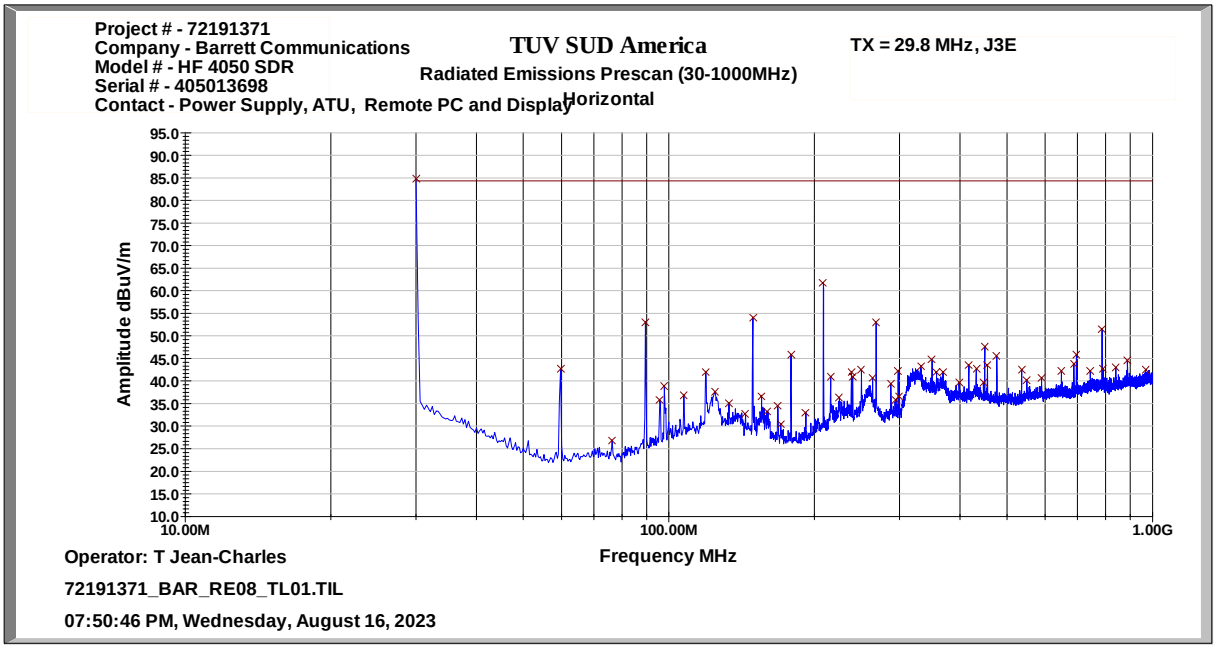


Figure 2.6.6-5 - Transmitter Radiated Spurious Emissions Representative Scan Plot – 29.8 MHz - J3E – 30 MHz – 1 GHz – Horizontal Polarization

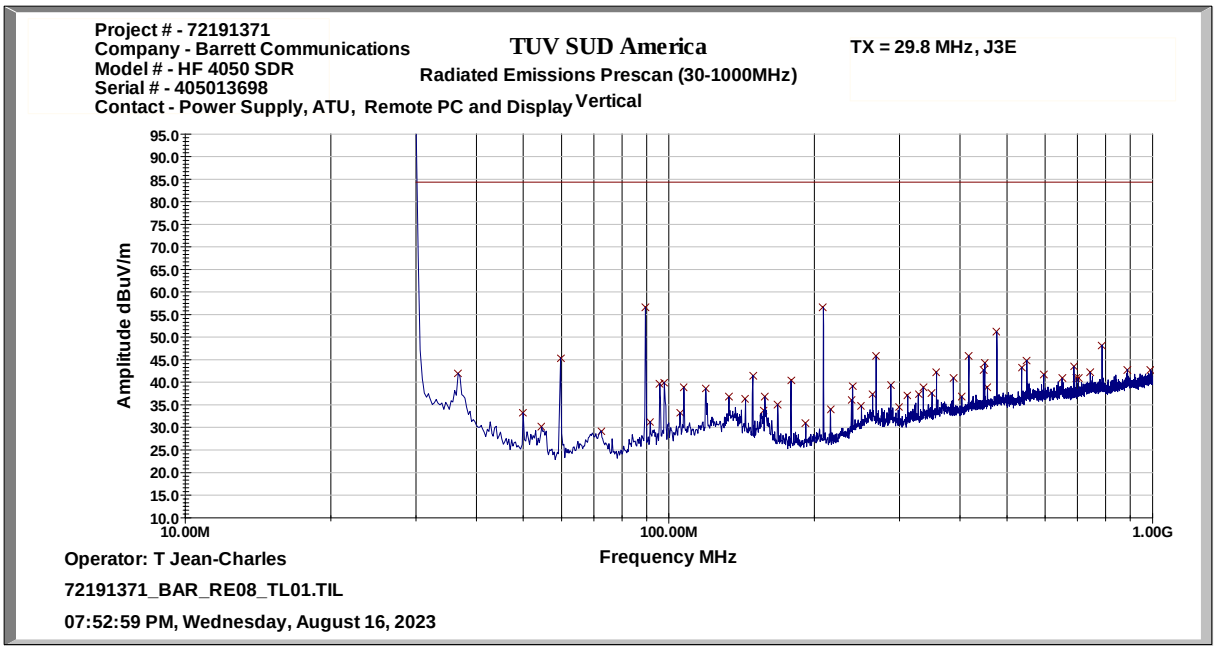


Figure 2.6.6-6 - Transmitter Radiated Spurious Emissions – 29.8 MHz - J3E – 30 MHz – 1 GHz – Vertical Polarization

2.6.7 Sample Calculations

Calculations below 30 MHz

$R_C = R_U + CF_T$

Where:
CF_T = Total Correction Factor (AF+CA+AG)
R_U = Uncorrected Reading
R_C = Corrected Level
AF = Antenna Factor
CA = Cable Attenuation
AG = Amplifier Gain

EIRP = Rc (dBuV/m) +20log(D) – 104.8 where D is the measurement Distance (3m)
EIRP = Rc (dBuV/m) – 95.26 dB
ERP = EIRP – 2.15 dB
ERP = Rc (dBuV/m) – 97.41 dB

Example Calculation: Peak
Field Strength: 51.55 + 14.59 = 66.14 dBµV/m
Corrected Level: 66.14 + (-97.41) = -31.27 dBm
Margin: -13 dBm – (-31.27) dBm = 18.27 dB

Calculations above 30 MHz

ERP = Pgen – Cables Loss + Substitution Antenna Gain [dBd]

Where:
ERP is the EUT radiated Power in dBm
Pgen is the signal generator setting [dBm]
Cable Loss is the Transmit cable loss [dB]
Substitution Antenna Gain [dBd] = 10 Log (antenna numeric gain) – 2.15.

Example Calculation: ERP
Radiated Power: -42 – 0.71 + -9.65 = -52.36 dBm
Margin: -13 dBm – (-52.36) dBm = 39.36 dB

2.6.8 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
100Hz-26.5GHz EMC analyzer/HYZ	Hewlett Packard	E7405A	BEMC00523	A.14.06	12	24-Jan-2024
30 MHz to 200 MHz Biconical Antenna	EMCO	3108	BEMC02002	N/A	24	06-Dec-2024
Tile Automation Software	ETS Lindgren	TILE4! - Version 4.2.A	BEMC02095	4.2A	N/A	NCR
Synthesized Signal Generator 0.05 - 26 GHz	Hewlett Packard	8673D	BEMC02126	N/A	24	07-Jun-2024
PE-P160 40 GHz Cable	Pasternack	PE360-396	BEMC02147	N/A	12	30-May-2024
BI LOG PERIODIC, ANTENNA	Schaffner	CBL6112B	TEMC00005	N/A	24	01-Nov-2023
Loop Antenna	Com Power	AL-130	TEMC00025	N/A	24	14-Oct-2023
EMC Chamber	Panashield	N/A	TEMC00031	N/A	36	28-Jan-2024
Log-Periodic Antenna	EMCO	3148	TEMC00060	N/A	36	06-Aug-2024
A81-0303 18 GHz Cable Set	Teledyne Storm Products	A81-0303-360/96	TEMC00201	N/A	12	18-Feb-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR – No Calibration Required

2.7 Frequency Stability

2.7.1 Specification Reference

FCC Section 2.1055; FCC Section 87.133; FCC Section 90.213

2.7.2 Equipment Under Test and Modification State

S/N: 405013615

2.7.3 Date of Test

2023-July-11 to 2023-July-13

2.7.4 Test Method

The equipment under test is placed inside an environmental chamber. The RF output is directly coupled to the input of the measurement equipment and a power supply is attached to the primary supply voltage.

Frequency measurements were made at the extremes of the of temperature range -30º C to +50º C and at intervals of 10º C at normal supply voltage. Sufficient time to stabilize all components of the equipment was allowed at each frequency measurement. At a temperature 20º C the supply voltage was varied by 15%. The maximum variation of frequency was recorded.

2.7.5 Environmental Conditions

Ambient Temperature	24.5 °C
Relative Humidity	45.6 %
Atmospheric Pressure	1015.6 mbar

2.7.6 Test Results

FCC 47 CFR Part 87.133

Table 2.7.6-1 – Frequency Stability Limits – FCC 47 CFR Part 87.133

Frequency band (lower limit exclusive, upper limit inclusive), and categories of stations	Tolerance
(2) Band-1605 to 4000 kHz:	
Aeronautical fixed stations:	
Power 200 W or less	100
Power above 200 W	50
Aeronautical stations:	
Power 200 W or less	100
Power above 200 W	50
Aircraft stations	100
Survival craft stations on 2182 kHz	20 Hz
(3) Band-4 to 29.7 MHz:	
Single-sideband and Independent-sideband emission:	
Power 500 W or less	50 Hz
Power above 500 W	20 Hz
Class F1B emissions	10 Hz
Other classes of emission:	
Power 500 W or less	20
Power above 500 W	10
Aeronautical stations:	
Power 500 W or less	100
Power above 500 W	50
Aircraft stations	100
Survival craft stations on 8364 kHz	50 Hz
(4) Band-29.7 to 100 MHz:	
Aeronautical fixed stations:	
Power 50 W or less	30
Power above 50 W	20
Radionavigation stations	50

FCC 47 CFR Part 90.213

Table 2.7.6-2 – Frequency Stability Limits – FCC 47 CFR Part 90.213

Frequency range (MHz)	Fixed and base stations	Mobile stations	
		Over 2 watts output power	2 watts or less output power
Below 25	100	100	200
25–50	20	20	50
For single sideband operations below 25 MHz, the carrier frequency must be maintained within 50 Hz of the authorized carrier frequency.			

Frequency Stability

Frequency (MHz): 1.6
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 13.8

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**1.600000**	**0.300**	100%	13.80
-20 C	**1.600000**	**-0.100**	100%	13.80
-10 C	**1.600000**	**0.100**	100%	13.80
0 C	**1.600000**	**0.100**	100%	13.80
10 C	**1.600000**	**0.100**	100%	13.80
20 C	**1.600000**	**0.000**	100%	13.80
30 C	**1.600000**	**-0.100**	100%	13.80
40 C	**1.600000**	**-0.100**	100%	13.80
50 C	**1.600000**	**-0.100**	100%	13.80
20 C	**1.600000**	**0.000**	85%	11.73
20 C	**1.600000**	**0.000**	115%	15.87

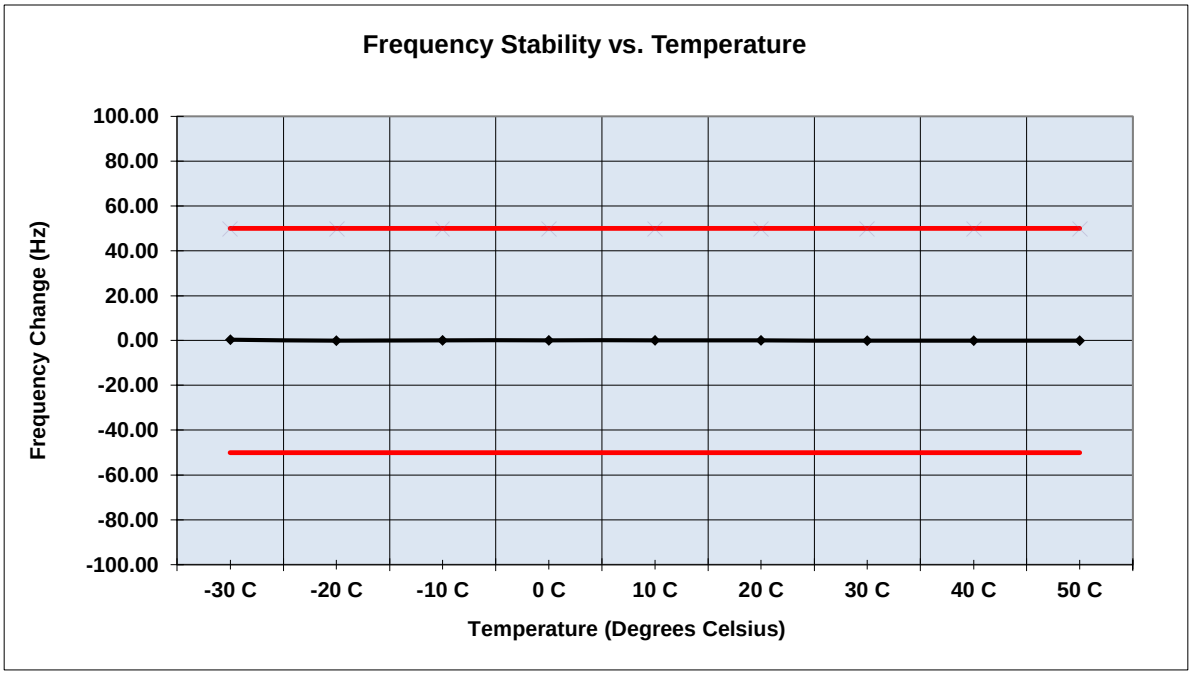


Figure 2.7.6-1 - Frequency Stability – 1.6 MHz – 13.8 VDC

Frequency Stability

Frequency (MHz): 15.8
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 13.8

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**15.800004**	**3.300**	100%	13.80
-20 C	**15.800000**	**-0.200**	100%	13.80
-10 C	**15.800002**	**1.100**	100%	13.80
0 C	**15.800002**	**1.600**	100%	13.80
10 C	**15.800002**	**1.200**	100%	13.80
20 C	**15.800001**	**0.000**	100%	13.80
30 C	**15.800000**	**-0.300**	100%	13.80
40 C	**15.800000**	**-0.800**	100%	13.80
50 C	**15.800000**	**-0.400**	100%	13.80
20 C	**15.800001**	**0.200**	85%	11.73
20 C	**15.800001**	**0.200**	115%	15.87

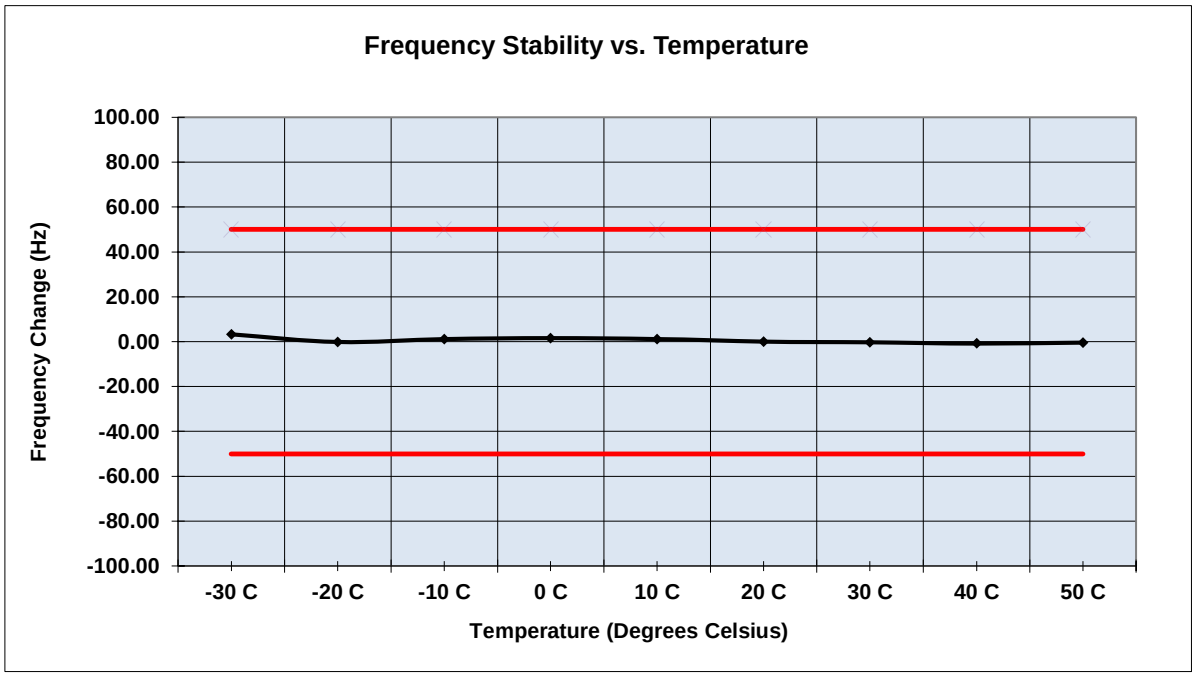


Figure 2.7.6-2 - Frequency Stability – 15.8 MHz – 13.8 VDC

Frequency Stability

Frequency (MHz): 29.8
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 13.8

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**29.800006**	**5.000**	100%	13.80
-20 C	**29.800000**	**-0.900**	100%	13.80
-10 C	**29.800005**	**3.500**	100%	13.80
0 C	**29.800004**	**3.000**	100%	13.80
10 C	**29.800003**	**2.000**	100%	13.80
20 C	**29.800001**	**0.000**	100%	13.80
30 C	**29.800001**	**-0.500**	100%	13.80
40 C	**29.799999**	**-1.700**	100%	13.80
50 C	**29.800000**	**-1.200**	100%	13.80
20 C	**29.800002**	**0.700**	85%	11.73
20 C	**29.800002**	**0.600**	115%	15.87

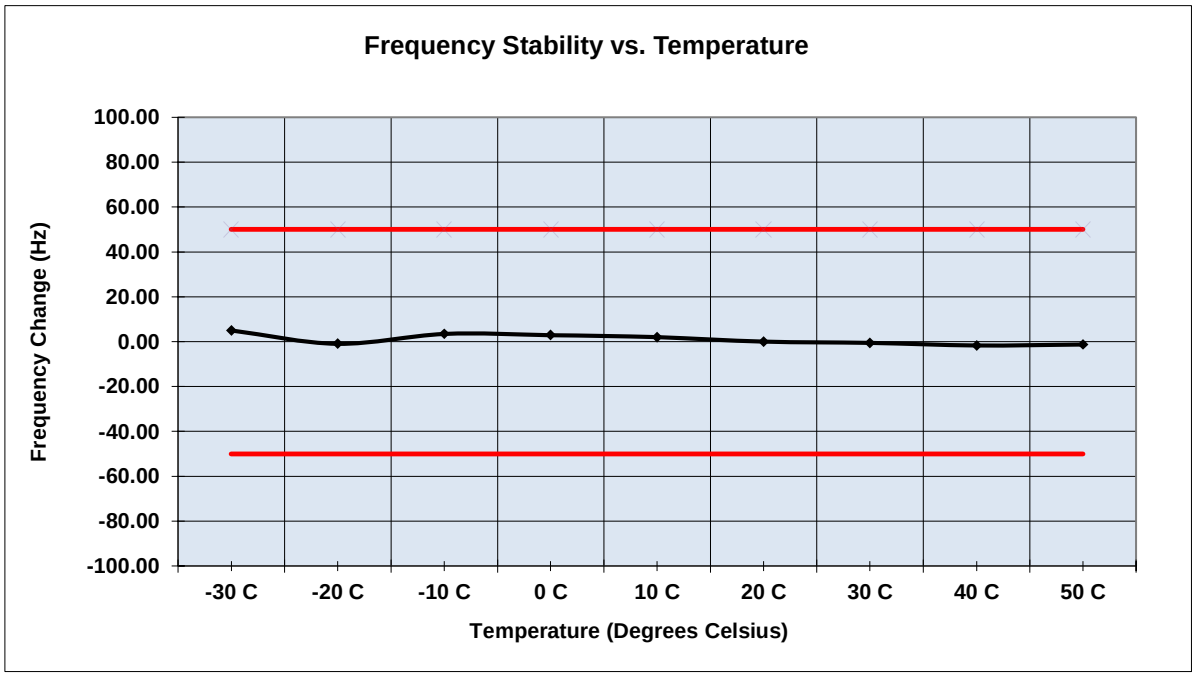


Figure 2.7.6-3 - Frequency Stability – 29.8 MHz – 13.8 VDC

Frequency Stability

Frequency (MHz): 1.6
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 24

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**1.600000**	**0.200**	100%	24.00
-20 C	**1.600000**	**-0.100**	100%	24.00
-10 C	**1.600000**	**0.000**	100%	24.00
0 C	**1.600000**	**0.100**	100%	24.00
10 C	**1.600000**	**0.100**	100%	24.00
20 C	**1.600000**	**0.000**	100%	24.00
30 C	**1.600000**	**-0.100**	100%	24.00
40 C	**1.600000**	**-0.100**	100%	24.00
50 C	**1.600000**	**-0.100**	100%	24.00
20 C	**1.600000**	**0.000**	85%	20.40
20 C	**1.600000**	**0.000**	115%	27.60

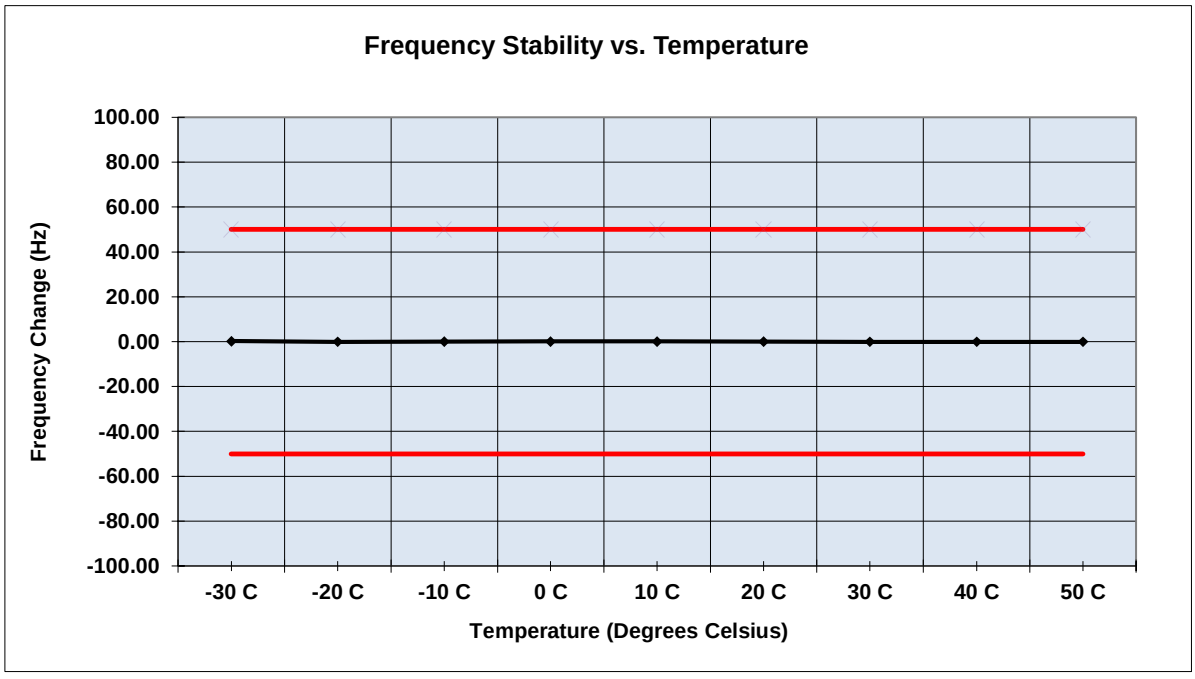


Figure 2.7.6-4 - Frequency Stability – 1.6 MHz – 24 VDC

Frequency Stability

Frequency (MHz): 15.8
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 24

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**15.800004**	**2.800**	100%	24.00
-20 C	**15.800000**	**-0.500**	100%	24.00
-10 C	**15.800002**	**1.500**	100%	24.00
0 C	**15.800002**	**1.500**	100%	24.00
10 C	**15.800002**	**0.900**	100%	24.00
20 C	**15.800001**	**0.000**	100%	24.00
30 C	**15.800000**	**-0.500**	100%	24.00
40 C	**15.800000**	**-1.100**	100%	24.00
50 C	**15.800000**	**-0.700**	100%	24.00
20 C	**15.800001**	**0.000**	85%	20.40
20 C	**15.800001**	**0.000**	115%	27.60

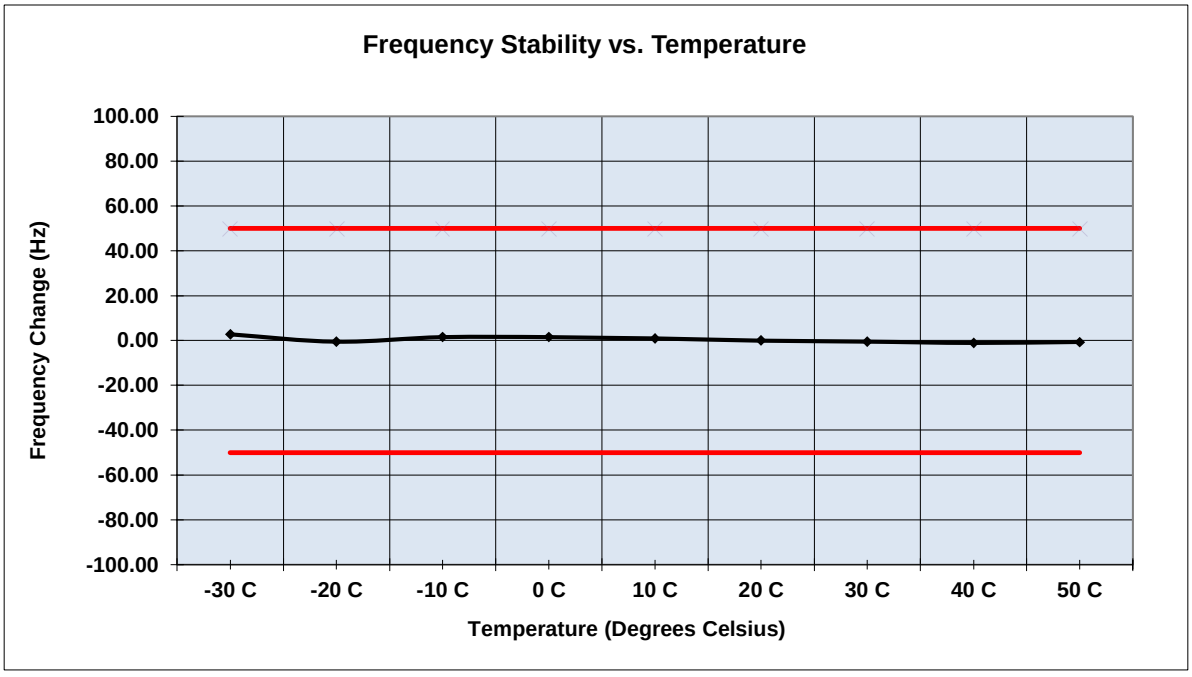


Figure 2.7.6-5 - Frequency Stability – 15.8 MHz – 24 VDC

Frequency Stability

Frequency (MHz): 29.8
Deviation Limit (Hz): 50
Nominal Voltage (VDC): 24

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(Hz)	(%)	(VDC)
-30 C	**29.800006**	**3.700**	100%	24.00
-20 C	**29.800000**	**-2.200**	100%	24.00
-10 C	**29.800004**	**2.000**	100%	24.00
0 C	**29.800004**	**1.800**	100%	24.00
10 C	**29.800003**	**0.700**	100%	24.00
20 C	**29.800002**	**0.000**	100%	24.00
30 C	**29.800001**	**-1.700**	100%	24.00
40 C	**29.799999**	**-3.000**	100%	24.00
50 C	**29.800000**	**-2.200**	100%	24.00
20 C	**29.800002**	**-0.500**	85%	20.40
20 C	**29.800002**	**-0.500**	115%	27.60

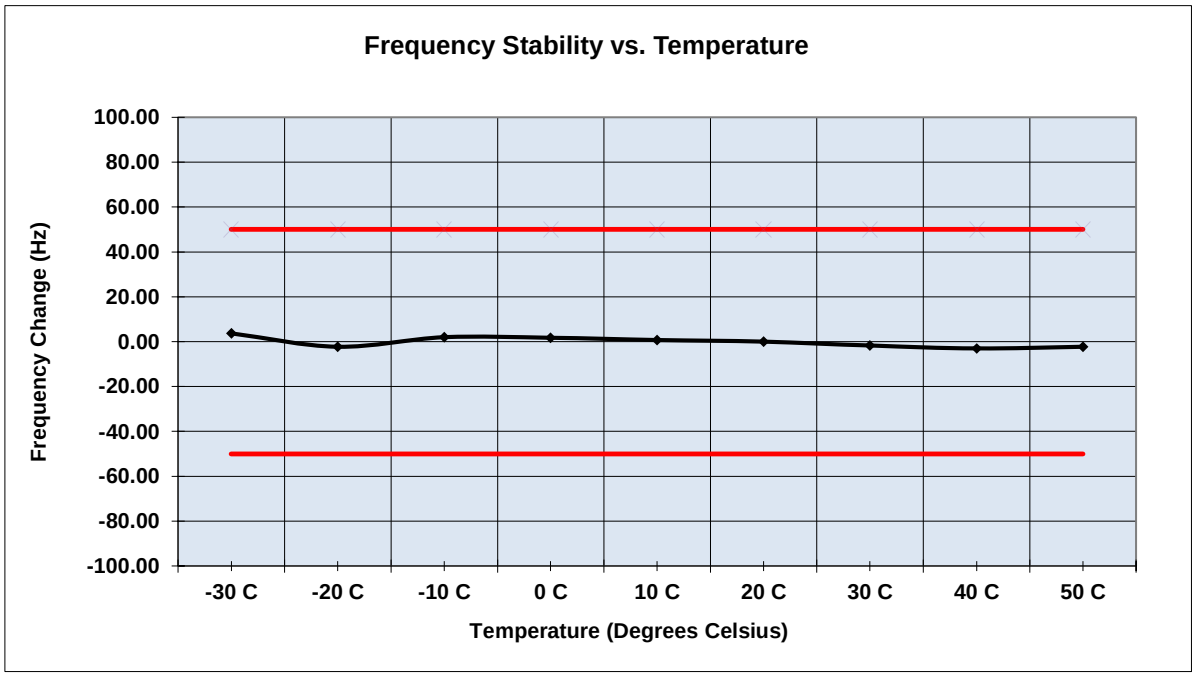


Figure 2.7.6-6 - Frequency Stability – 29.8 MHz – 24 VDC

2.7.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Digital Thermometer	Omega Engineering, Inc.	MDSS41-TC	BEMC00002	N/A	24	21-Sep-2023
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
DC Power Supply 0-60V/0-35A	Hewlett Packard	6674A	DEMC780	N/A	N/A	NCR
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
Temperature Test Chamber	Sun Electronic Systems, Inc.	EC127	TEMC00242	5.10	N/A	NCR
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR - No Calibration Required

3 Test Equipment Information

3.1 General Test Equipment Used

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Digital Thermometer	Omega Engineering, Inc.	MDSS41-TC	BEMC00002	N/A	24	21-Sep-2023
100Hz-26.5GHz EMC analyzer/HYZ	Hewlett Packard	E7405A	BEMC00523	A.14.06	12	24-Jan-2024
Audio Analyzer	Hewlett-Packard	8903B	BEMC00776	N/A	24	07-Jun-2024
30 MHz to 200 MHz Biconical Antenna	EMCO	3108	BEMC02002	N/A	24	06-Dec-2024
11 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8494B	BEMC02074	N/A	N/A	NCR
70 dB, Freq Range DC-18GHz; Max RF Power 1W CW	Hewlett Packard	8495B	BEMC02075	N/A	12	18-Apr-2024
Tile Automation Software	ETS Lindgren	TILE4! - Version 4.2.A	BEMC02095	4.2A	N/A	NCR
Digital Phosphor Oscilloscope, 1.5 GHz, 20GS/S	Tektronix, Inc.	TDS7154B	BEMC02103	3.0.2	24	07-Jun-2024
Digital MultiMeter	Fluke	115	BEMC02108	N/A	12	25-Jan-2024
Synthesized Signal Generator 0.05 - 26 GHz	Hewlett Packard	8673D	BEMC02126	N/A	24	07-Jun-2024
PE-P160 40 GHz Cable	Pasternack	PE360-396	BEMC02147	N/A	12	30-May-2024
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	DEMC3085	2.90 SP1	12	08-Jun-2024
DC Power Supply 0-60V/0-35A	Hewlett Packard	6674A	DEMC780	N/A	N/A	NCR
BI LOG PERIODIC, ANTENNA	Schaffner	CBL6112B	TEMC00005	N/A	24	01-Nov-2023
Loop Antenna	Com Power	AL-130	TEMC00025	N/A	24	14-Oct-2023
EMC Chamber	Panashield	N/A	TEMC00031	N/A	36	28-Jan-2024
Log-Periodic Antenna	EMCO	3148	TEMC00060	N/A	36	06-Aug-2024
Arbitrary Function Generator	Tektronix	AFG 3021	TEMC00079	3.2.3	12	26-Jan-2024
High Power Directional Coupler	Werlatone, Inc.	C3653	TEMC00191	N/A	12	12-Apr-2024
A81-0303 18 GHz Cable Set	Teledyne Storm Products	A81-0303-360/96	TEMC00201	N/A	12	18-Feb-2024
Temperature Test Chamber	Sun Electronic Systems, Inc.	EC127	TEMC00242	5.10	N/A	NCR

High Pass Filter	Mini-Circuits	SHP-25+	TEMC00263	N/A	12	17-Mar-2024
Flexible Test Cable	Mini-Circuits	ULC-8FT-SMSM+	TEMC00268	N/A	12	21-Mar-2024
Splitter DC-18 GHz	Mini Circuits	ZX10R-2-183-S+	TEMC00269	N/A	12	17-Apr-2024
SMA Fixed Attenuator Kit	Mini Circuits	K2-BW2+	TEMC00272	N/A	12	15-Apr-2024
High Pass Filter 41-800 MHz	Mini Circuits	BHP-50+	TEMC00287	N/A	12	14-Apr-2024

TU - Traceability Unscheduled
O/P MON - Output Monitored with Calibrated Equipment
N/A - Not Applicable
NCR - No Calibration Required

4 Diagram of Test Set-ups

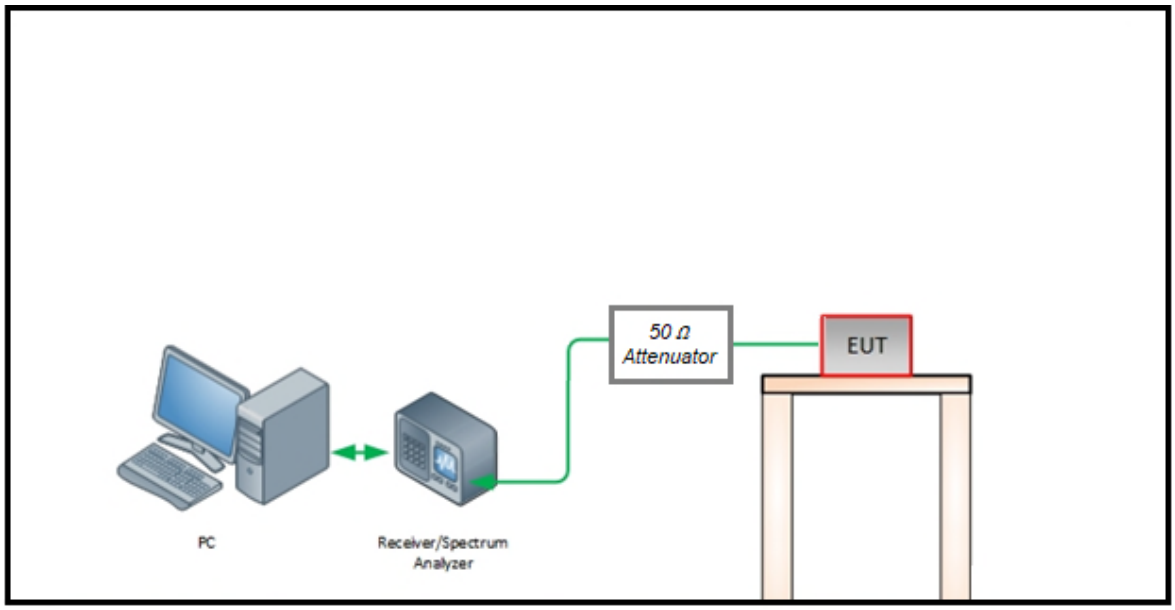


Figure 4-1 – RF Conducted Emissions Test Setup up, General Measurements

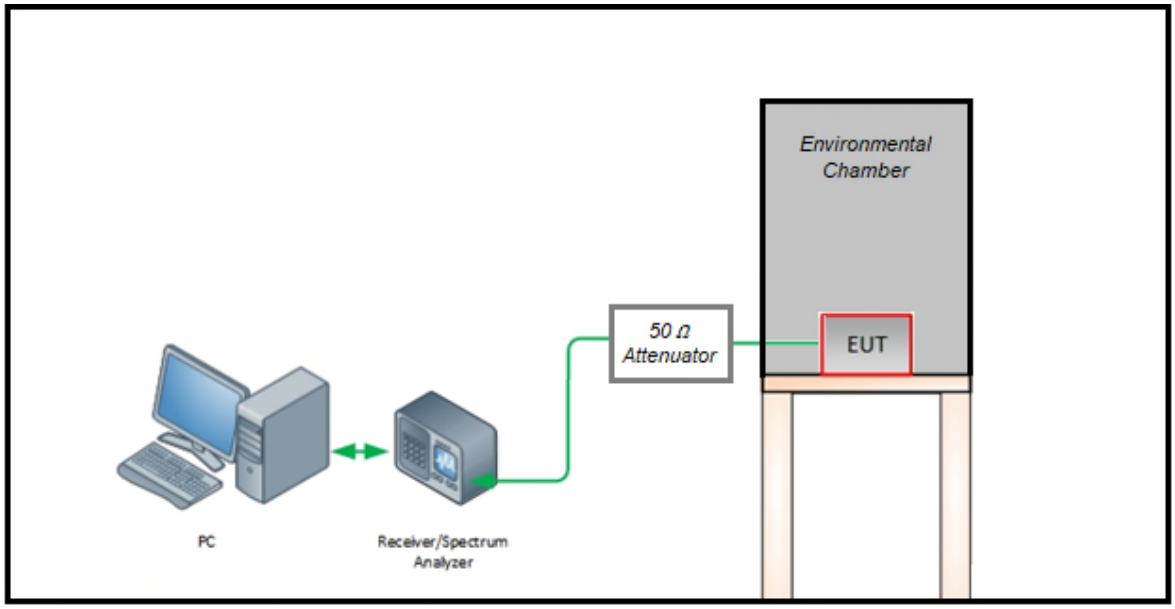


Figure 4-2 – RF Conducted Emissions Test Setup up, Extreme Conditions

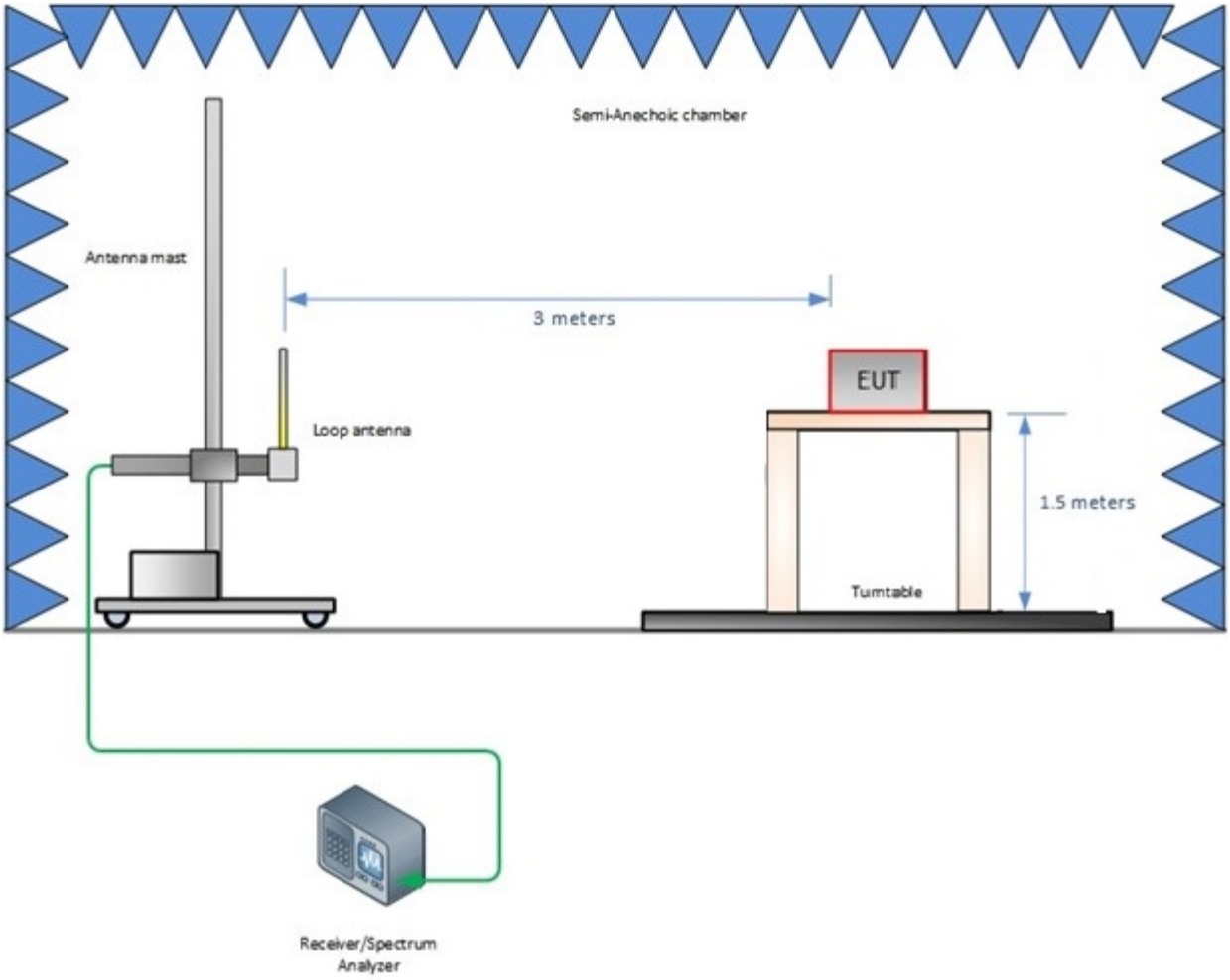


Figure 4-3 – Radiated Emissions Test Setup up to 30 MHz

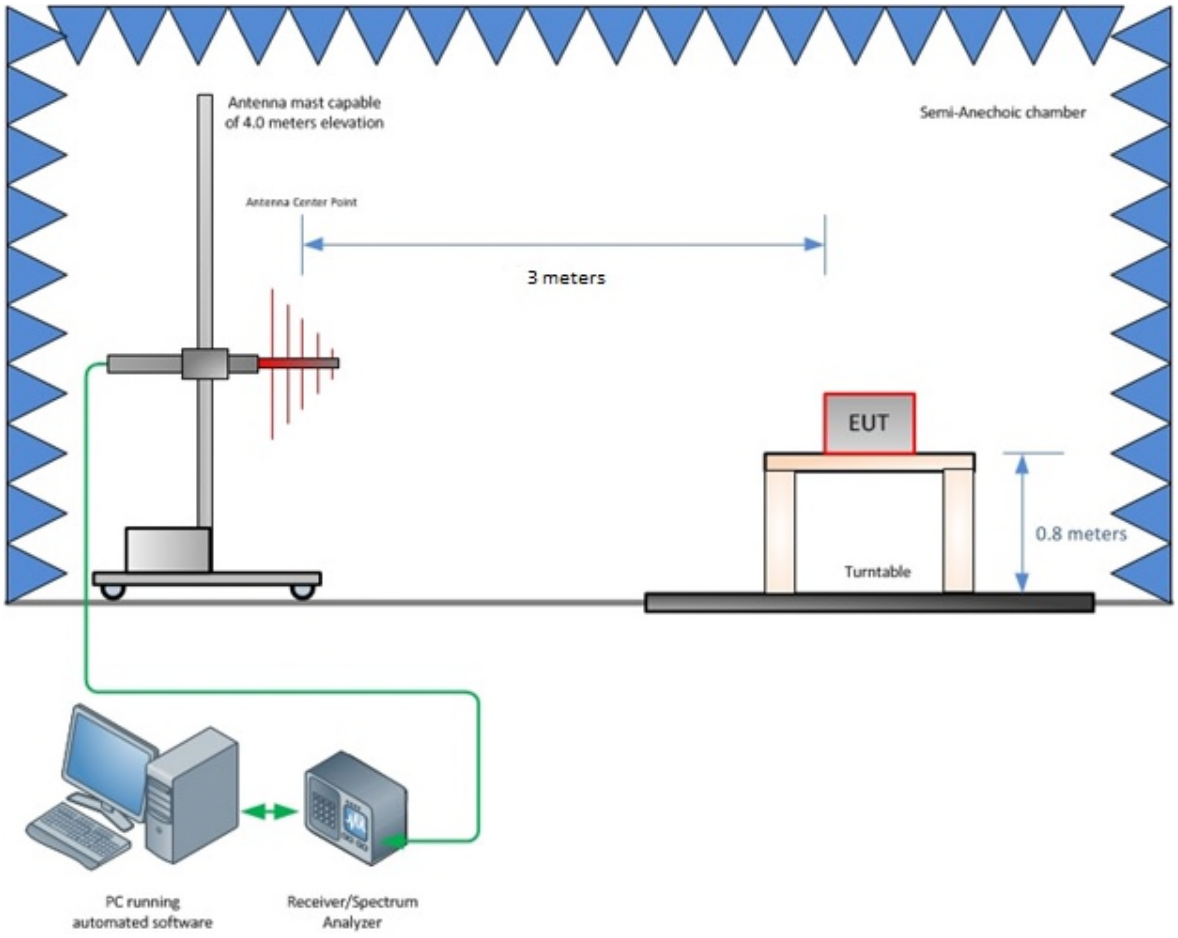


Figure 4-4 – Radiated Emissions Test Setup up to 1 GHz

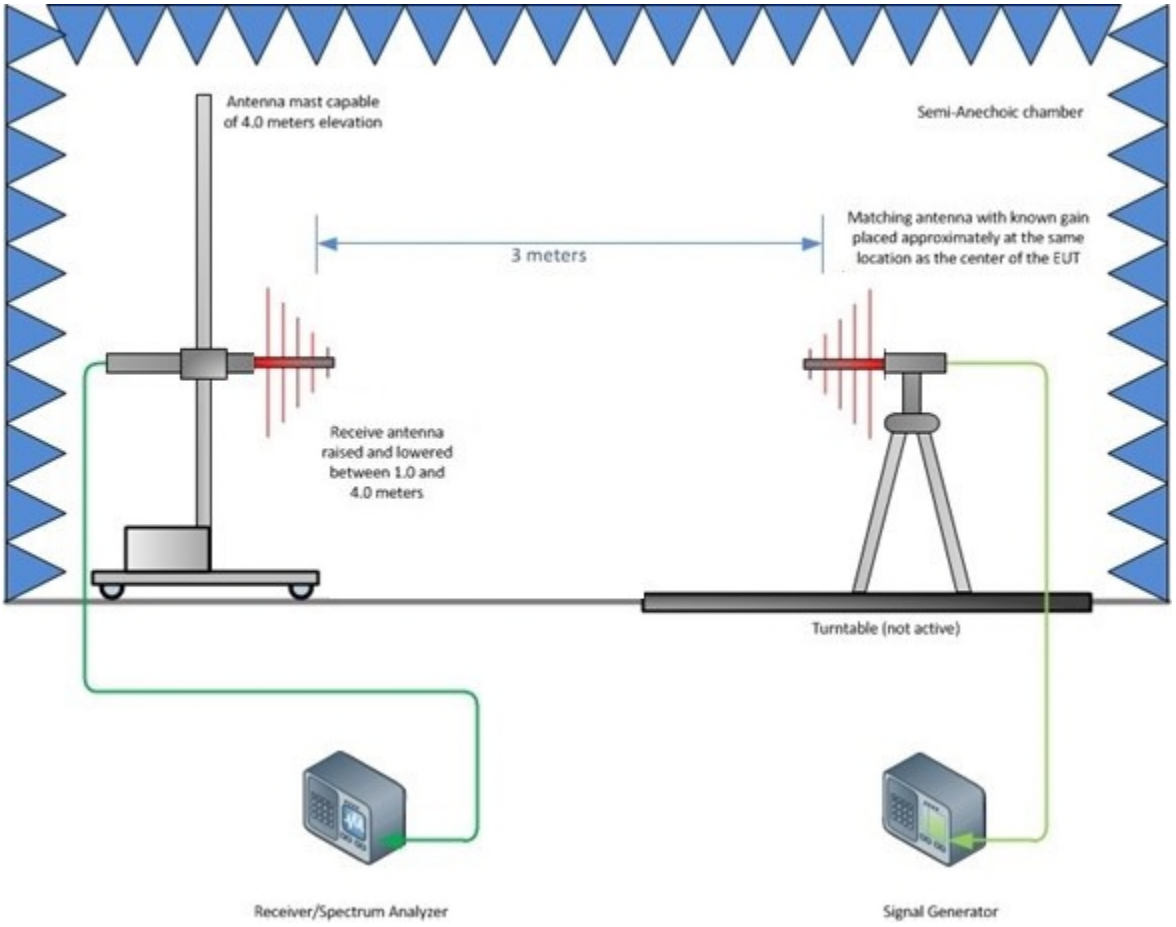


Figure 4-5 – Substitution Test Setup below 1 GHz

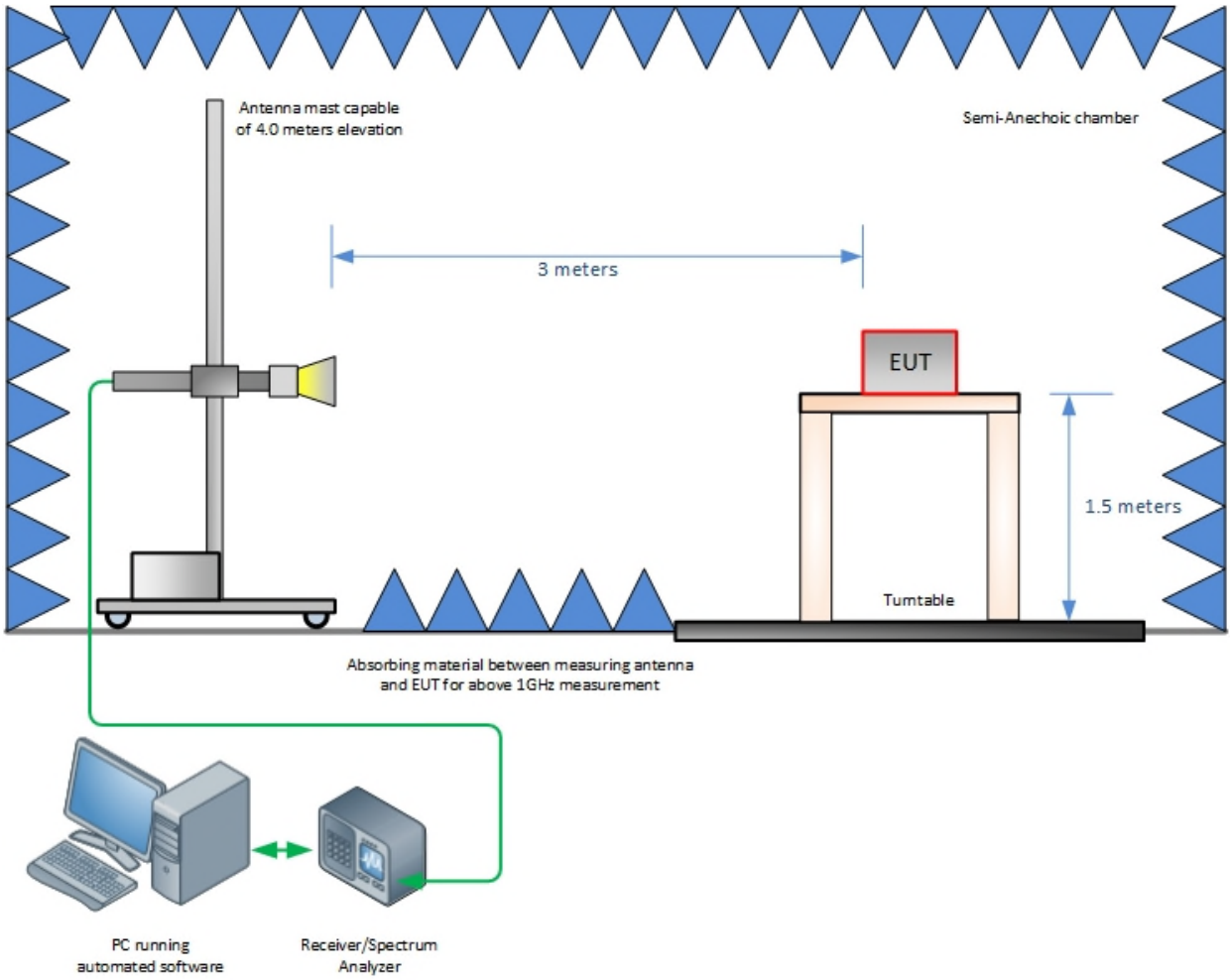


Figure 4-6 – Radiated Emissions Test Setup above 1 GHz

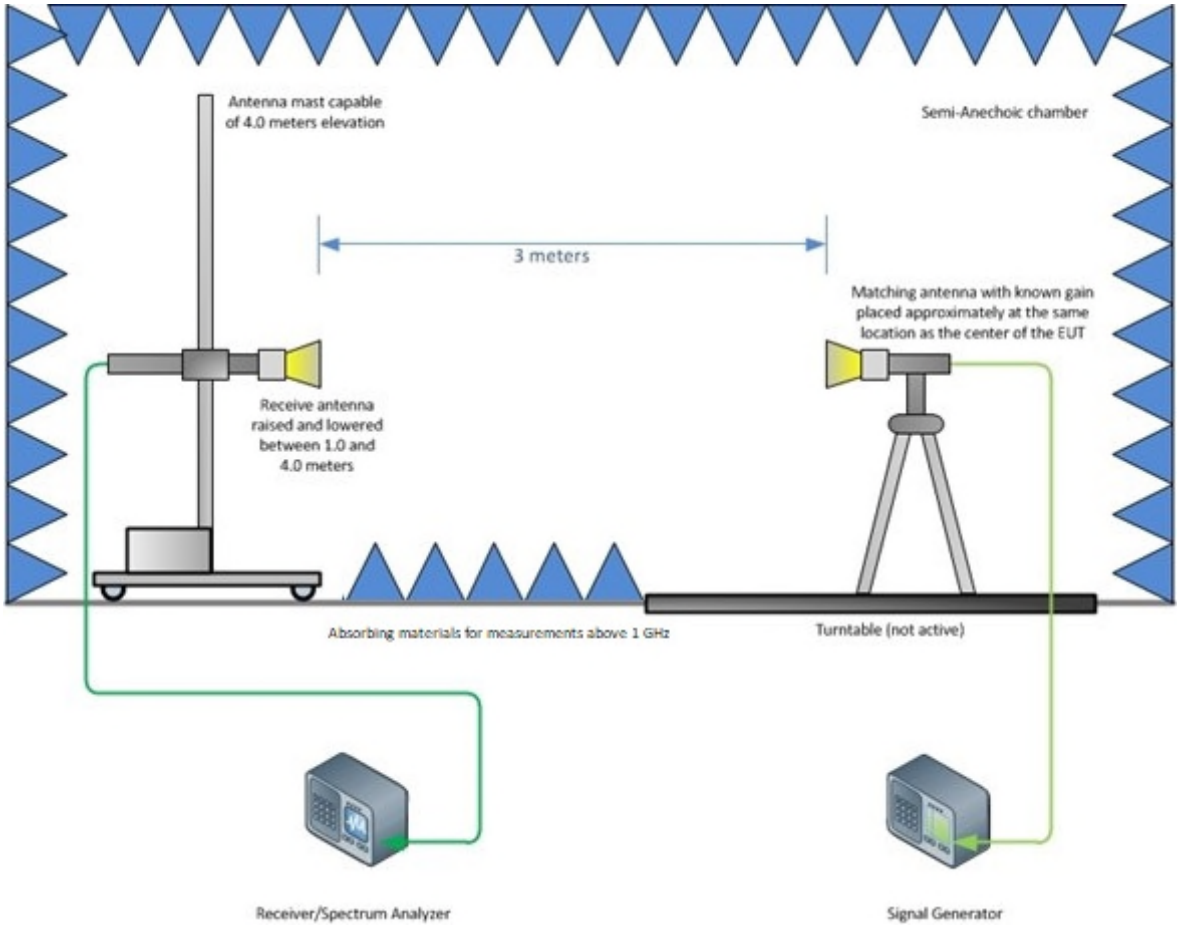


Figure 4-7 – Substitution Test Setup above 1 GHz

5 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Table 5-1 - Values of U_{cispr} and U_{Lab}

Measurement	U_{cispr}	U_{Lab}
Conducted disturbance (mains port) (9 kHz – 150 kHz) (150 kHz – 30 MHz)	 3.8 dB 3.4 dB	 3.71 dB 3.31 dB
Conducted disturbance (telecom port) (150 kHz – 30 MHz 55 dB LCL) (150 kHz – 30 MHz 65 dB LCL) (150 kHz – 30 MHz 75 dB LCL)	 5.0 dB 5.0 dB 5.0 dB	 4.11 dB 4.50 dB 4.94 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1 000 MHz) (1 – 6 GHz) (6-18 GHz)	 6.3 dB 5.2 dB 5.5 dB	 5.85 dB 4.48 dB 4.48 dB

Notes:

U_{cispr} resembles a value of measurement uncertainty for a specific test, which was determined by considering uncertainties associated with the quantities listed in CISPR 16-4-2:2011.

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