Radio Test Report

Test Report No: QT-MAYEMC_FCC.49088_TR Rev.3
Issued on: October 11, 2023

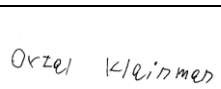
Product Name
WAVE140 POWER SUPPLY
FCC ID: WCHWAVEBTFSK
IC: 29982-WAVEBTFSK

Tested According to
FCC 47CFR part 15 subpart C §15.247
RSS-247 Issue 2:2017, RSS-Gen Issue 5

Tests Performed for
Maytronics Ltd.
Kibbutz Yizre'el 1935000 Israel
Tel.: +972-4-6598111

QualiTech EMC Laboratory
43 Hasivim Street, POB 7500
Petah-Tikva, 4951169, Israel
Tel: +972-4-6268494

Test Personnel

Testing performed by	**Izak Shtier**	
	Ortal Kleinman	
Test report prepared by	**Bina Talkar**	
Test report reviewed by	**Michael Gudovsky**	
Test report approved by	**Michael Nikishin** **Group Manager**	

Test Report details:

Test commencement date: 18.01.2023

Test completion date: 27.06.2023

Applicant's representative: Eugene Plotnichenko

Issued on: 11.10.2023

Revision details:

Version	Date	Details/Reasons
Rev. 1	02.07.2023	-
Rev.2	19.07.2023	Added on the first page of the test report, updated EUT name, FCC ID and IC.
Rev.3	11.10.2023	Updated test setup on page 9.

Assessment information:

This report contains an assessment of the EUT against Electromagnetic Compatibility based upon tests carried out on the samples submitted. The results contained in this report relate only to the items tested. Manufactured products will not necessarily give identical results due to production and measurement tolerances. QualiTech, EMC Lab does not assume responsibility for any conclusion and generalization drawn from the test results with regards to other specimens or samples of type of the equipment represented by test item.
The EUT was setup and exercised using the configuration, modes of operation and arrangements defined in this report only.

Modifications:

Modifications made to the EUT

None

Modifications made to the Test Standard

None

Summary of Compliance Status

The EUT was tested according to the following test methods.
Test results are given in full in section 3-8.

Test Case	Verdict
Minimum 6 dB bandwidth	Pass
Field strength of spurious emissions	Pass
Peak output power	Pass
Band edge radiated emissions	Pass
Peak spectral power density	Pass
Conducted emissions	Pass

Table of Contents

1. General

1.1. Referenced documents:

FCC Part 15	Code of Federal Regulations (Washington, DC: Federal Communications Commission), Title 47, Part 15, Subpart C
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-247 Issue 2:2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen Issue 5	General Requirements for Compliance of Radio Apparatus

1.2. EUT description:

Following data in this clause is provided by the customer and represents his sole responsibility.

1.2.1. General Description:

TRX1 – FSK transceiver operating on single channel 2433 MHz, less than 0dBm transmitted power, OCB ~600 kHz.
TRX2 – BLE transceiver operating overall 2.4 GHz band, estimated EIRP less than 2dBm, OCB ~600 kHz.

Power supply: 30VDC

Test configuration: Standalone

1.3. Transmitter characteristics

Type of equipment								
	Stand-alone (Equipment with or without its own control provisions)							
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)							
V	Plug-in card (Equipment intended for a variety of host systems)							
Assigned frequency range	2400 -2483.5 MHz							
Operating frequencies	2402-2480 MHz							
Maximum rated output power	Peak output power 0 dBm							
Is transmitter output power variable?	**V**	No						
		Yes		continuous variable				
				stepped variable with stepsize	dB			
			minimum RF power	dBm				
			maximum RF power	dBm				
Antenna connection								
	unique coupling		standard connector	**V**	Integral		with temporary RF connector	
						V	without temporary RF connector	
Antenna/s technical characteristics								
Type	Manufacturer	Model number	Gain					
Integral	Maytronics	Printed	3.3dBi					
Transmitter aggregate data rate/s	1 Mbps							
Type of modulation	GFSK							
Modulating test signal (baseband)								
Transmitter power source								
	Battery	**Nominal rated voltage**		Battery type				
V	DC	**Nominal rated voltage**	30 VDC					
	AC mains	**Nominal rated voltage**		Frequency	Hz			

2. Test Facility & Uncertainty of Measurement

2.1. Accreditation/ Registration reference:

- *A2LA Certificate Number: 1633.01*
- *FCC Registration Number: 102724*

2.2. Test Facility description

The tests were performed at the EMC Laboratory, QualiTech

Address: 43, Hasivim Street, Petah Tikva, Israel.
Tel: +972-4-6268494

Semi Anechoic Configuration:

Measurement distance	3m
Chamber dimensions	9.5m x 6.5m x 5.2m
Antenna height	1 - 4m
Shielding Effectiveness	Magnetic field ≥80dB at 15 kHz ≥90dB at 100 kHz Electric field >120dB from 1 MHz to 1 GHz >110dB from 1 GHz to 10 GHz
Absorbing material	Ferrite tiles on the walls and ceiling Emerson and Cuming absorbing material in selected positions on the walls
Normalized Site Attenuation measured at 5 positions	±3.9dB, 30 MHz to 200 MHz ±3dB, 200 MHz to 1000 MHz
Transmission Loss measured at 5 positions, at 1.5m height	±3dB, 1 GHz to 18 GHz

2.3. The measurement software used:

Software Name	Software Version
Test Software “TILE”	Ver.7.1.4.10 & Ver.7.4.2.5

3. Minimum 6 dB bandwidth

Date of Test: 18.01.2023
Relative Humidity: 48%
Ambient Temperature: 21°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Izak Shtir

Test Method: ANSI C63.10 section 11.9.2.2.4

Compliance status: Pass

3.1. General

This test was performed to measure 6 dB bandwidth of the EUT carrier frequency. Specification test limits are given in Table 3.1.

Table 3.1 6 dB bandwidth limits

Assigned frequency, MHz	Modulation envelope reference points*, dBc	Minimum bandwidth, kHz
2400.0 – 2483.5	6.0	500.0

* - Modulation envelope reference points provided in terms of attenuation below the peak of modulated carrier.

Table 3.2 The 99% bandwidth limits

Assigned frequency, MHz	Modulation envelope reference points	Limit, kHz
2400.0 – 2483.5	99%	NA

3.2. Test procedure

The EUT was set up as shown in
Figure 3.2, energized and its proper operation was checked.
The EUT was set to transmit modulated carrier.
The transmitter minimum 6 dB bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 3.3 and associated plot.

Figure 3.2 6 dB bandwidth test setup

Table 3.3 6 dB and 99% bandwidth test results

ASSIGNED FREQUENCY BAND:	2400.0 – 2483.5 MHz
DETECTOR USED:	Peak Maxhold
SWEEP TIME:	Auto
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	300 kHz
MODULATION:	GFSK
BIT RATE:	1 Mbps

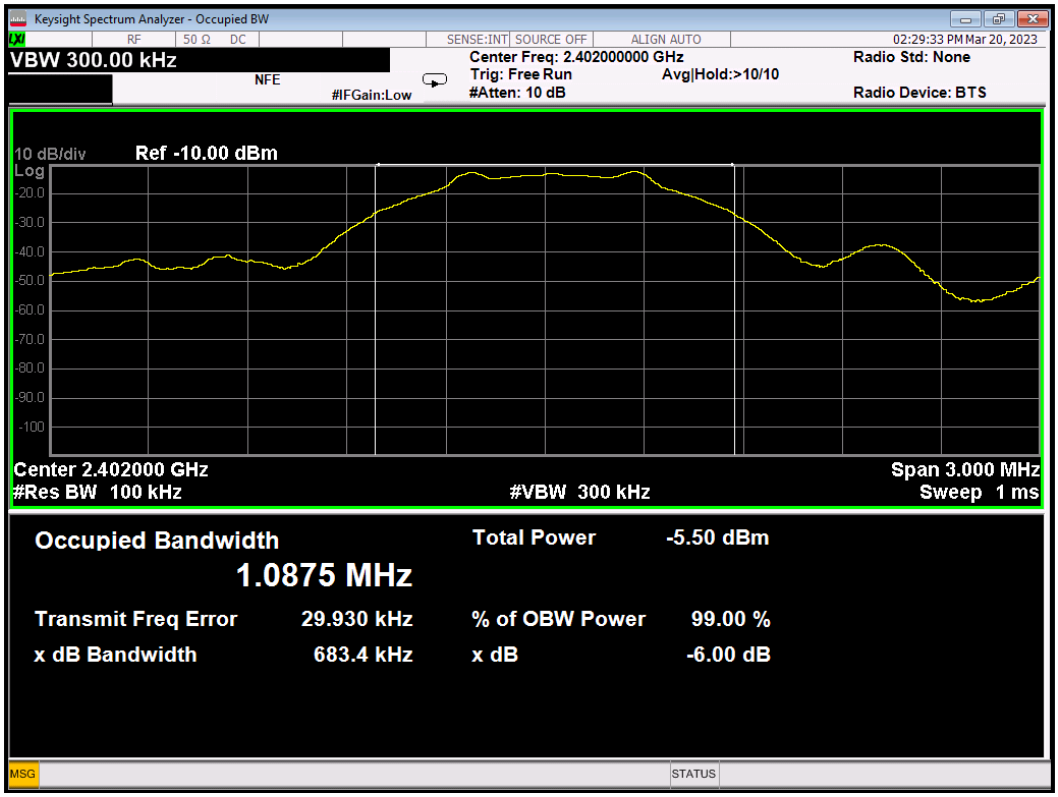
Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency				
2402.0	683.4	500.0	183.4	Pass
Mid frequency				
2442.0	682.2	500.0	182.2	Pass
High frequency				
2480.0	682.4	500.0	182.4	Pass

Table 3.4 99% bandwidth test results

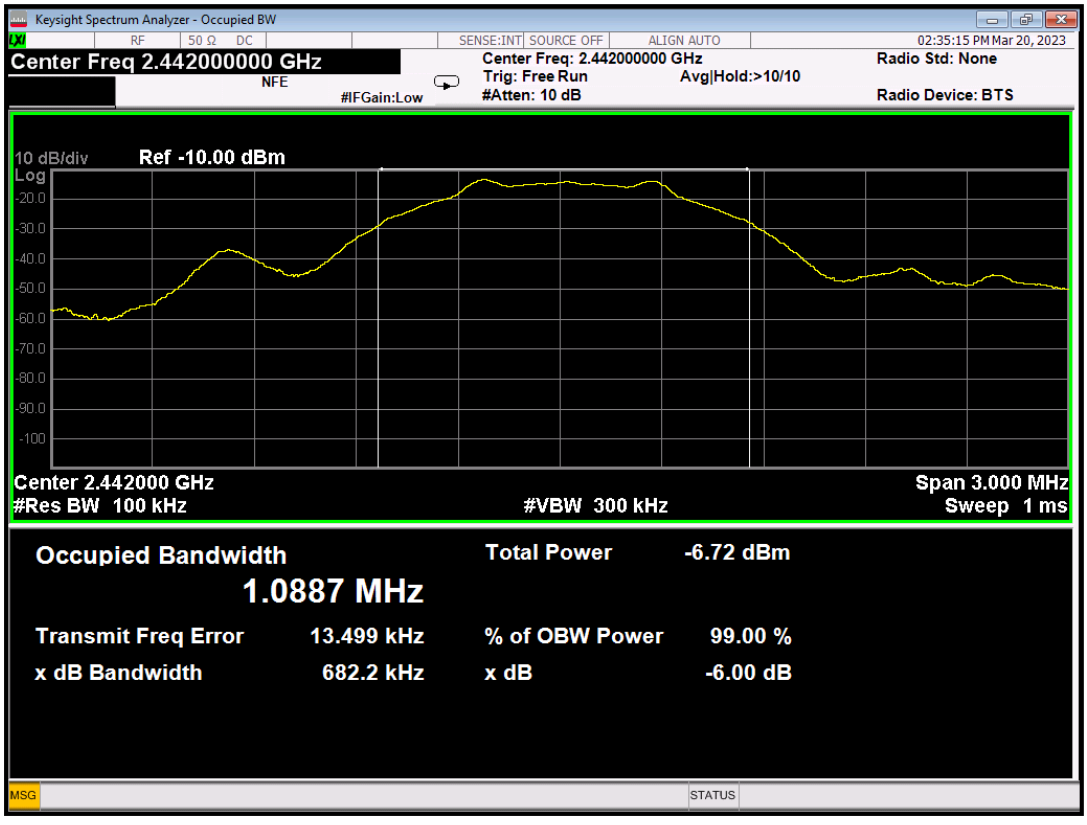
ASSIGNED FREQUENCY BAND:	2400.0 – 2483.5 MHz
DETECTOR USED:	Peak Maxhold
SWEEP TIME:	Auto
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	300 kHz
MODULATION:	GFSK
BIT RATE:	1 Mbps

Carrier frequency, MHz	99% bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency				
2402.0	1087.8	NA	NA	Pass
Mid frequency				
2442.0	1088.7	NA	NA	Pass
High frequency				
2480.0	1087.9	NA	NA	Pass

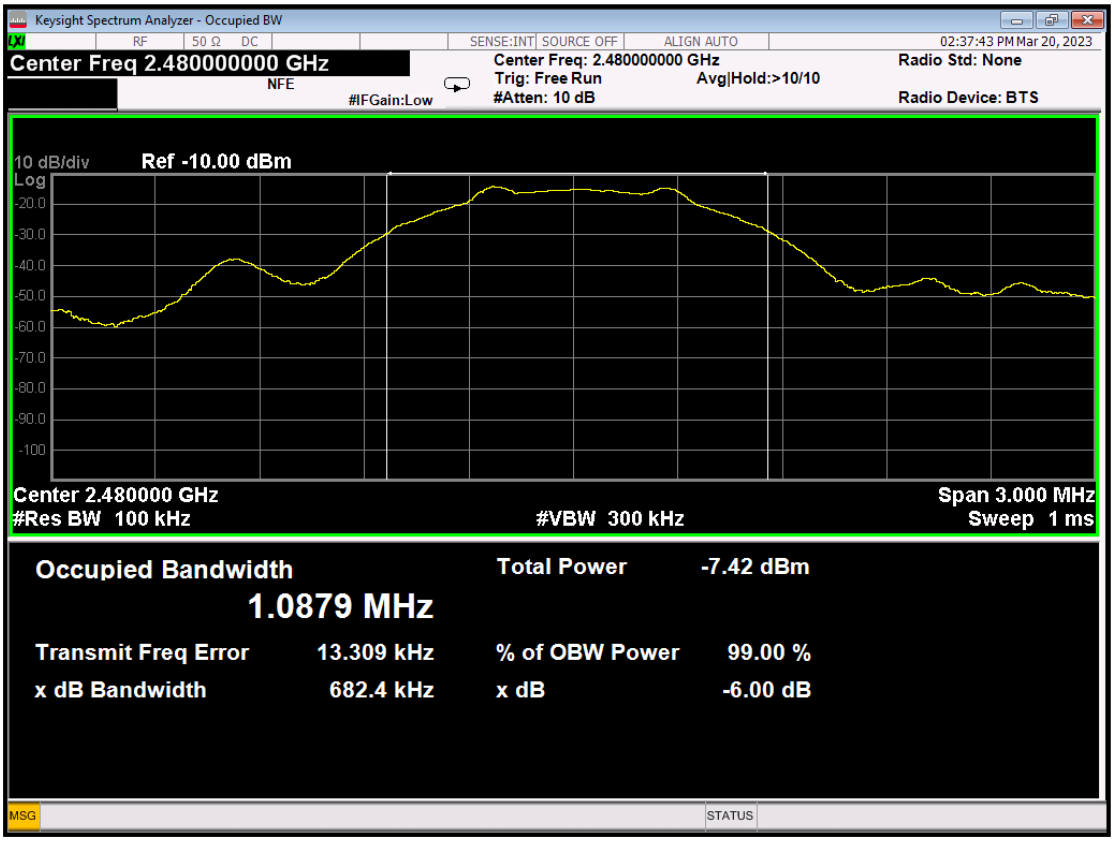
Plot 3.1: 6 dB and 99% bandwidth test result at low frequency band



Plot 3.2 6 dB and 99% bandwidth test result at mid frequency band



Plot 3.3 6 dB and 99% bandwidth test result at high frequency band



4. Field strength of spurious emissions

Date of Test: 25.02.2022
Relative Humidity: 48%
Ambient Temperature: 21°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Izak Shtir

Test Method: ANSI C63.10 section 6.5, 6.5

Compliance status: Pass

4.1. General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in 4.1

Table 4.1: Radiated spurious emissions limits

Frequency, MHz	Field strength at 3 m within restricted bands, dB(µV/m)***			Attenuation of field strength of spurious versus carrier outside restricted bands, dBc***
	Peak	Quasi Peak	Average	
0.009 – 0.090	148.5 – 128.5	NA	128.5 – 108.5**	20.0
0.090 – 0.110	NA	108.5 – 106.8**	NA	
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**	
0.490 – 1.705	NA	73.8 – 63.0**	NA	
1.705 – 30.0*		69.5		
30 – 88		40.0		
88 – 216		43.5		
216 – 960		46.0		
960 - 1000		54.0		
1000 – 10th harmonic	74.0	NA	54.0	

*- The limit for 3 m test distance was calculated using the inverse square distance extrapolation factor as follows:
$Lim_{S2} = Lim_{S1} + 40 \log (S_1/S_2)$, where S_1 and S_2 – standard defined and test distance respectively in meters.
**- The limit decreases linearly with the logarithm of frequency.
*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

4.2. Test procedure for spurious emission field strength measurements in 9 kHz to 30 MHz band

The EUT was set up as shown in Figure 4.1, energized and the performance check was conducted.

The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna was rotated around its vertical axis.

The worst test results (the lowest margins) were recorded and shown in the associated plots.

4.3. Test procedure for spurious emission field strength measurements above 30 MHz

The EUT was set up as shown in Figure 4.3, energized and the performance check was conducted.

The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 3600, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

The worst test results (the lowest margins) were recorded and shown in the associated plots.

Figure 4.1 Setup for spurious emission field strength measurements below 30 MHz

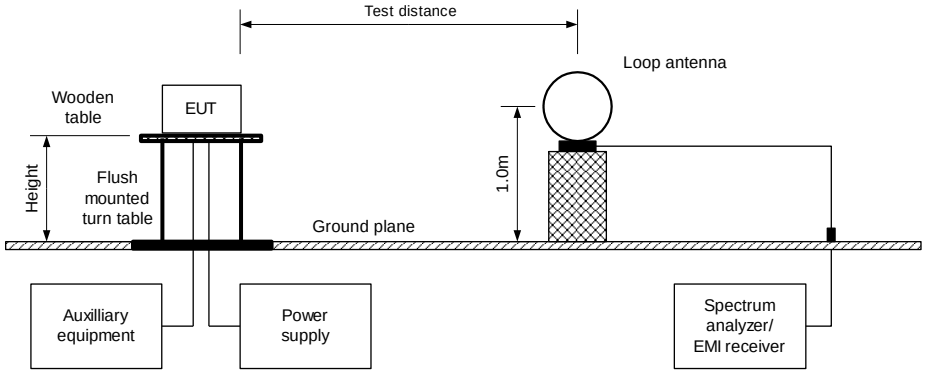


Figure 4.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

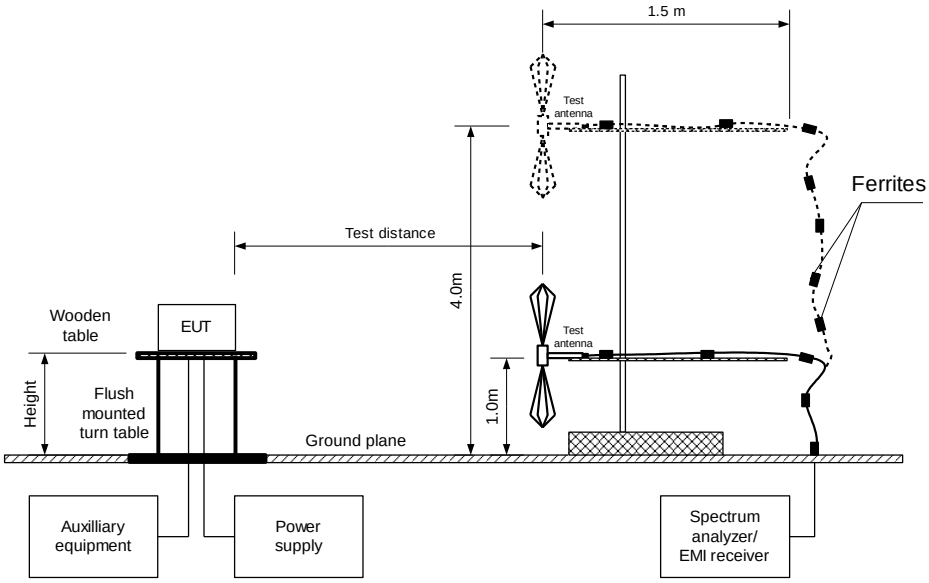
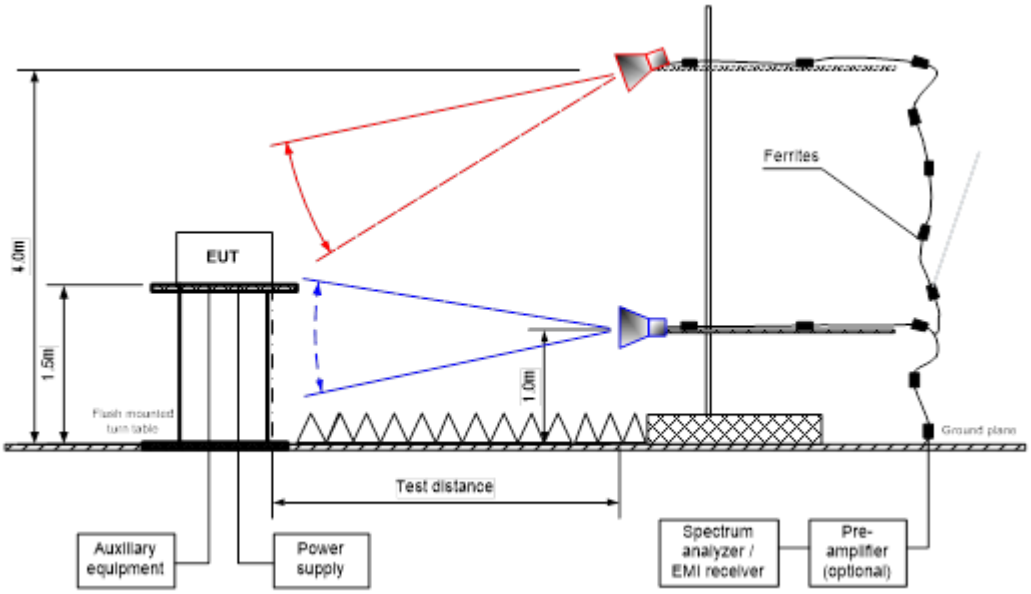


Figure 4.3 Setup for spurious emission field strength measurements above1000 MHz



List of Test Equipment:

Refer to appendix A for complete list of equipment used and respective calibration dates.

Test results:

Table 4.1 Field strength of emissions within restricted bands

Assigned frequency:				2400.0 – 2483.5 MHz			
Investigated frequency range:				0.009 - 25000 MHz			
Test distance:				3 m			
Modulation:				GFSK			
Bit rate:				1 Mbps			
Duty cycle:				100 %			
Transmitter output power settings:				Maximum			
Detector used:				Peak			
Resolution bandwidth:				100 kHz			
Video bandwidth:				300 kHz			
Test antenna type:				Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz) Double ridged guide (above 1000 MHz)			
9 kHz – 30 MHz							
Frequency (MHz)	Measured Peak (dBuV/m)	Measured QP (dBuV/m)	Margin QP (dB)	Polarization	Ant Height (cm)	TT Azimuth (Deg)	Verdict
Low carrier frequency							
All emissions were greater than 20 dB below the limit							Pass
Mid carrier frequency							
All emissions were greater than 20 dB below the limit							Pass
High carrier frequency							
All emissions were greater than 20 dB below the limit							Pass

Table 4.1 Field strength of emissions within restricted bands continued..

30 MHz – 1000 MHz							
Low carrier frequency							
Frequency (MHz)	Measured QP (dBuV/m)	Limit (dBuV/m)	Margin QP (dB)	Polarization	Ant Height (cm)	TT Azimuth (Deg)	Verdict
31.849	31.01	40.0	-8.99	H	302	359	Pass
108.133	32.01	43.5	-11.49	H	240	267	Pass
116.478	20.74	43.5	-22.76	H	257	360	Pass
213.050	33.32	43.5	-10.18	H	104	0	Pass
560.551	31.11	46.0	-14.89	H	330	0	Pass
951.418	37.24	46.0	-8.76	H	248	250	Pass
32.231	30.795	40.0	-9.20	V	342	0	Pass
48.006	35.069	40.0	-4.93	V	110	262	Pass
58.587	31.067	40.0	-8.93	V	101	360	Pass
95.975	30.888	43.5	-12.61	V	101	186	Pass
112.607	33.201	43.5	-10.30	V	130	360	Pass
937.856	36.663	46.0	-9.34	V	151	51	Pass
Mid carrier frequency							
31.749	31.03	40.0	-8.97	H	314	73	Pass
105.390	34.53	43.5	-8.97	H	249	295	Pass
111.545	34.94	43.5	-8.56	H	257	91	Pass
117.532	31.81	43.5	-11.69	H	400	277	Pass
213.062	33.67	43.5	-9.83	H	134	360	Pass
953.050	37.29	46.0	-8.71	H	183	185	Pass
32.400	30.642	40.0	-9.36	V	399	269	Pass
47.976	34.223	40.0	-5.78	V	102	360	Pass
58.600	33.465	40.0	-6.53	V	100	294	Pass
112.624	33.707	43.5	-9.79	V	122	37	Pass
767.482	33.988	46.0	-12.01	V	338	0	Pass
938.099	36.687	46.0	-9.31	V	143	131	Pass
High carrier frequency							
31.423	31.12	40.0	-8.88	H	163	360	Pass
103.679	33.12	43.5	-10.38	H	239	266	Pass
112.607	34.48	43.5	-9.02	H	229	84	Pass
208.010	32.97	43.5	-10.53	H	130	8	Pass
211.989	34.00	43.5	-9.50	H	122	9	Pass
958.361	37.21	46.0	-8.79	H	175	277	Pass
30.436	31.614	40.0	-8.39	V	134	13	Pass
48.011	35.761	40.0	-4.24	V	102	248	Pass
58.609	33.724	40.0	-6.28	V	101	247	Pass
111.525	32.303	43.5	-11.20	V	100	360	Pass
791.996	33.745	46.0	-12.25	V	330	360	Pass
947.882	37.130	46.0	-8.87	V	134	308	Pass

Table 4.1 Field strength of emissions within restricted bands continued..

1000 MHz – 4000 MHz										
Frequency (MHz)	Measured Peak (dBuV/m)	Limit Peak (dBuV/m)	Margin Peak (dB)	Measured AVG (dBuV/m)	Limit AVG (dBuV/m)	Margin AVG (dB)	Polarization	Height (cm)	Azimuth (Deg)	Verdict
Low carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
Mid carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
High carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
4000 MHz – 18000 MHz										
Frequency (MHz)	Measured Peak (dBuV/m)	Limit Peak (dBuV/m)	Margin Peak (dB)	Measured AVG (dBuV/m)	Limit AVG (dBuV/m)	Margin AVG (dB)	Polarization	Height (cm)	Azimuth (Deg)	Verdict
Low carrier frequency										
4804.177	47.44	74.00	-26.56	43.76	54.00	-10.24	H	104	66	Pass
4865.270	43.55	74.00	-30.45	37.42	54.00	-16.58	H	180	3	Pass
7209.907	45.37	74.00	-28.63	38.88	54.00	-15.12	H	233	0	Pass
4803.856	47.11	74.00	-26.89	42.53	54.00	-11.47	V	187	8	Pass
4854.146	39.76	74.00	-34.24	26.46	54.00	-27.54	V	216	27	Pass
Mid carrier frequency										
4882.035	43.08	74.00	-30.92	31.39	54.00	-22.61	H	100	90	Pass
4883.881	45.16	74.00	-28.84	40.37	54.00	-13.63	V	228	13	Pass
17692.278	46.97	74.00	-27.03	33.60	54.00	-20.40	V	277	53	Pass
High carrier frequency										
4865.599	44.76	74.00	-29.24	38.97	54.00	-15.03	H	253	0	Pass
4958.030	46.93	74.00	-27.07	44.31	54.00	-9.69	H	154	7	Pass
4860.382	35.15	74.00	-38.85	36.70	54.00	-17.30	V	110	87	Pass
4959.921	45.23	74.00	-28.77	41.18	54.00	-12.82	V	216	0	Pass
17906.707	47.38	74.00	-26.62	33.93	54.00	-20.07	V	371	0	Pass
18000 MHz – 25000 MHz										
Frequency (MHz)	Measured Peak (dBuV/m)	Limit Peak (dBuV/m)	Margin Peak (dB)	Measured AVG (dBuV/m)	Limit AVG (dBuV/m)	Margin AVG (dB)	Polarization	Height (cm)	Azimuth (Deg)	Verdict
Low carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
Mid carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
High carrier frequency										
All emissions were greater than 20 dB below the limit										Pass

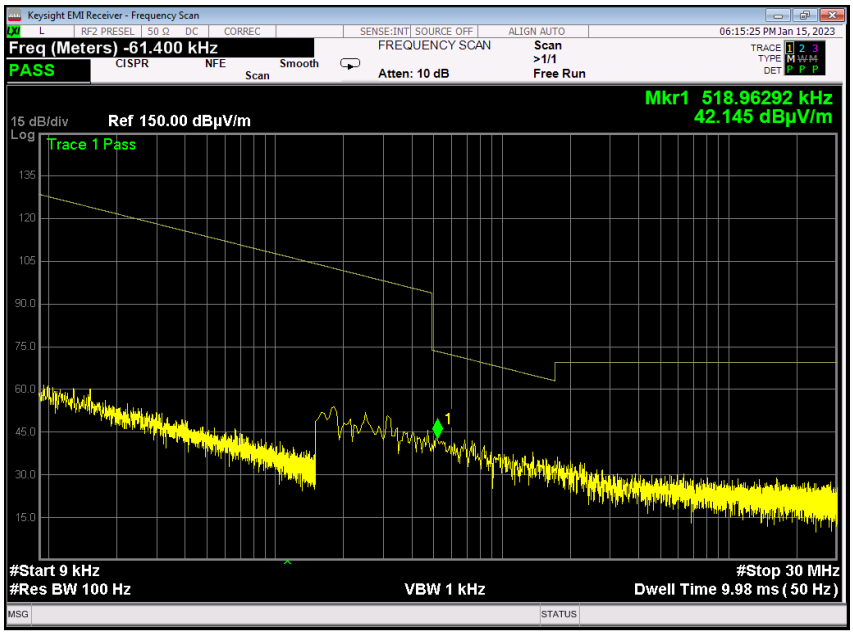
Table 4.2 Field strength of spurious emissions above 1 GHz within restricted bands

Assigned frequency:					2400.0 – 2483.5 MHz					
Investigated frequency range:					1000 - 25000 MHz					
Test distance:					3 m					
Modulation:					GFSK					
Bit rate:					1 Mbps					
Duty cycle:					100 %					
Transmitter output power settings:					Maximum					
Detector used:					Peak					
Resolution bandwidth:					100 kHz					
Video bandwidth:					300 kHz					
Test antenna type:					Double ridged guide					
Frequency (MHz)	Measured Peak (dBuV/m)	Limit Peak (dBuV/m)	Margin Peak (dB)	Measured AVG (dBuV/m)	Limit AVG (dBuV/m)	Margin AVG (dB)	Polarization	Height (cm)	Azimuth (Deg)	Verdict
Low carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
Mid carrier frequency										
All emissions were greater than 20 dB below the limit										Pass
High carrier frequency										
All emissions were greater than 20 dB below the limit										Pass

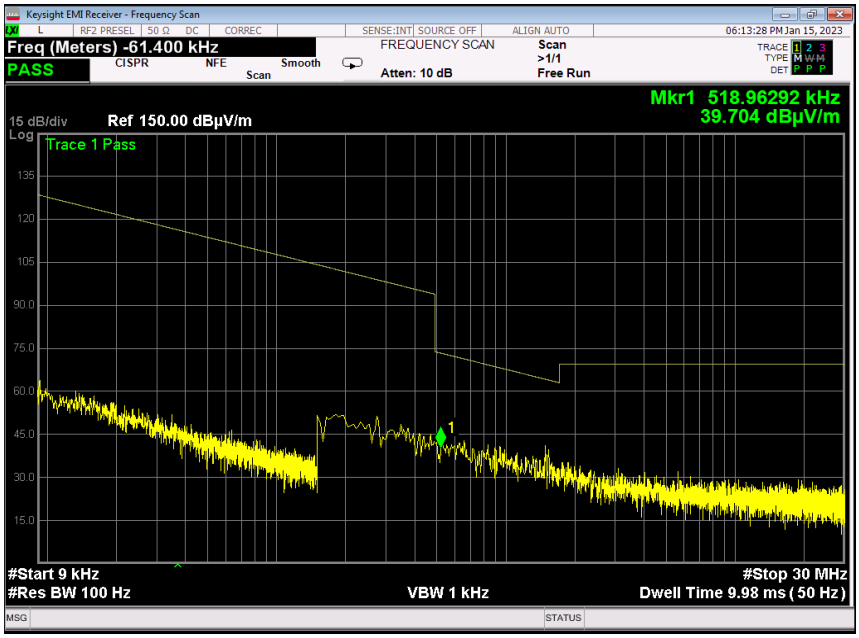
Plot 4.1: Radiated emission measurements from 9 kHz to 30 MHz at the low carrier frequency

Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical

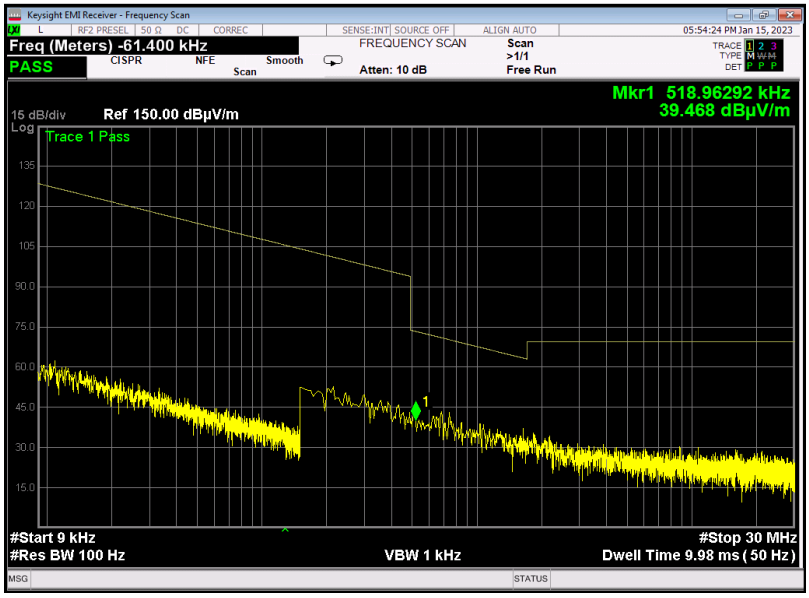
Parallel



Perpendicular



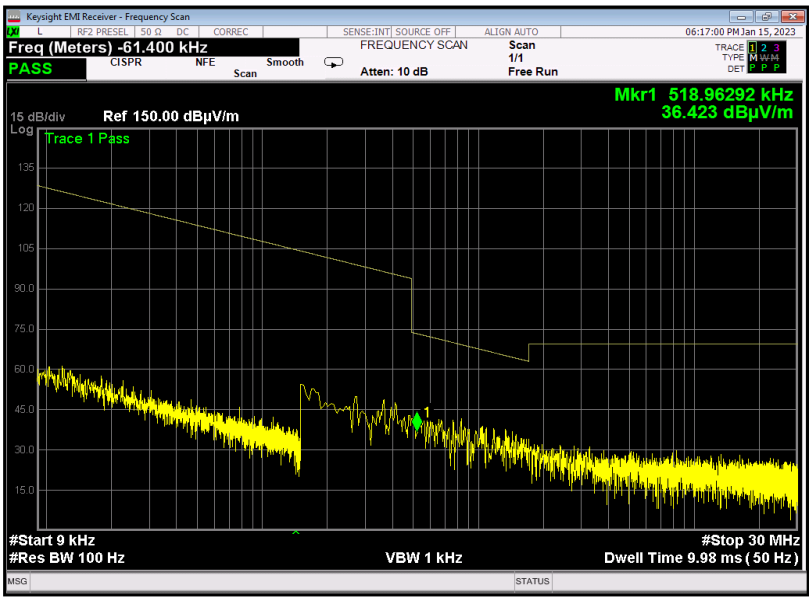
Horizontal



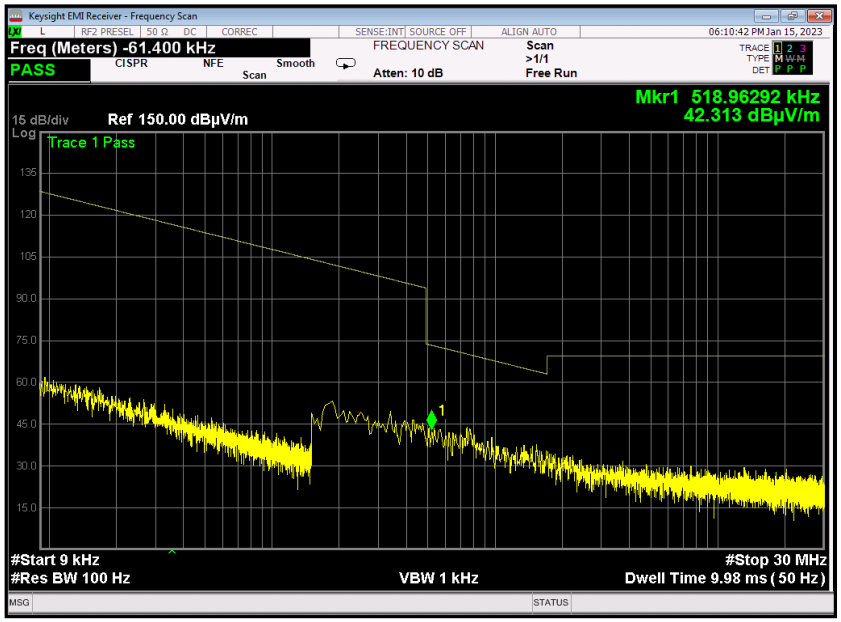
Plot 4.2: Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical

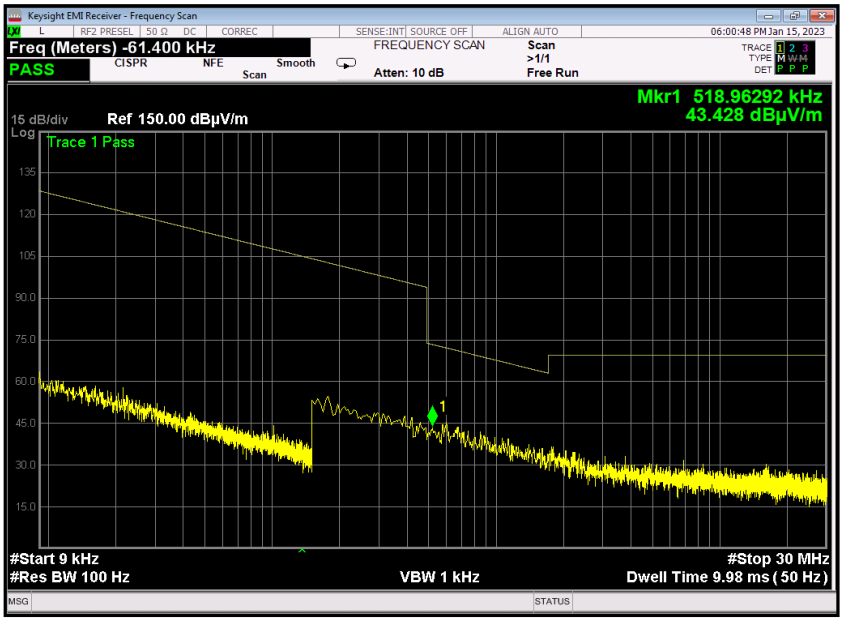
Parallel



Perpendicular



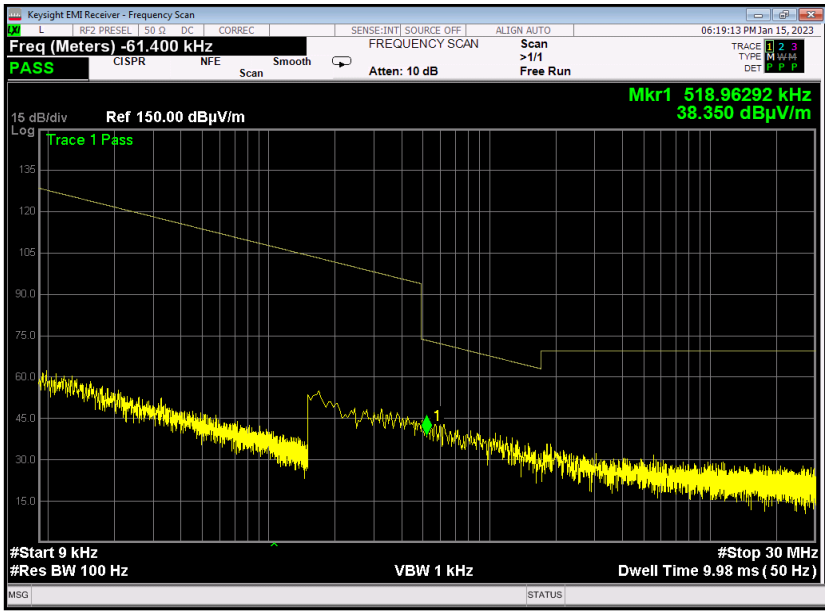
Horizontal



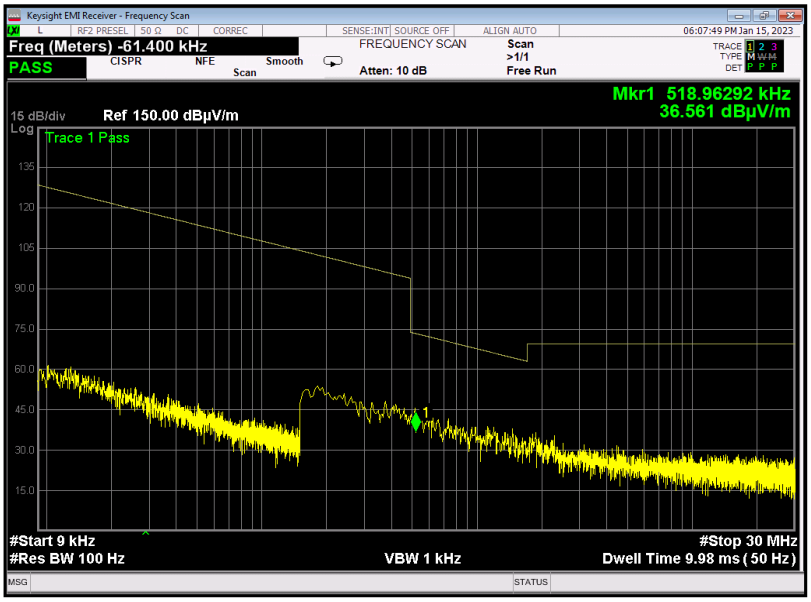
Plot 4.3: Radiated emission measurements from 9 kHz to 30 MHz at the high carrier frequency

Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical

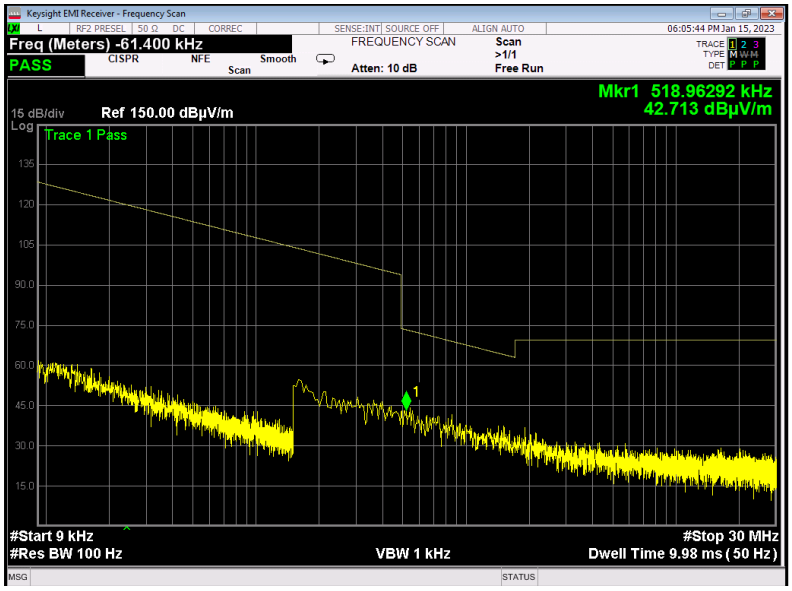
Parallel



Perpendicular

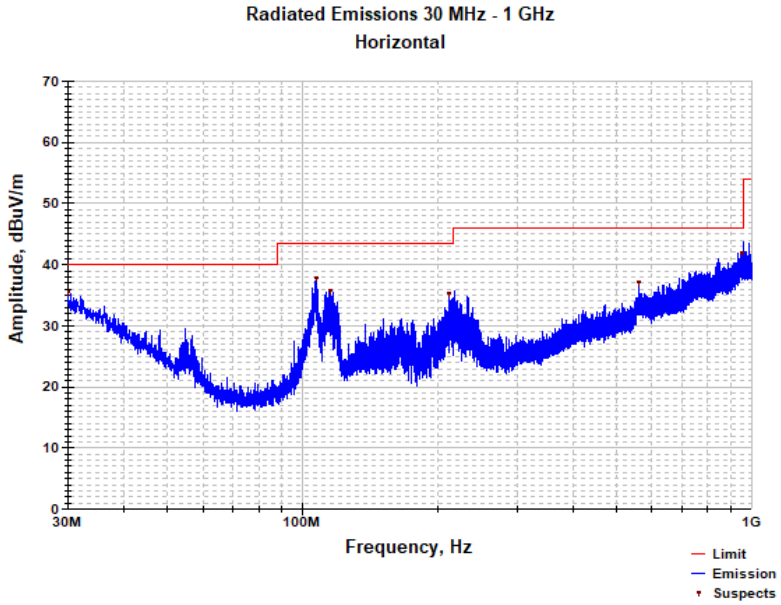


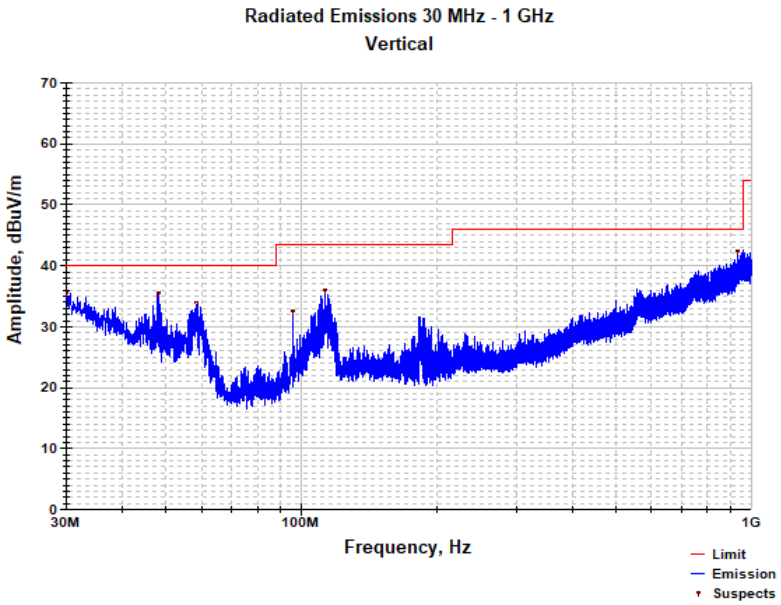
Horizontal


Keysight EMI Receiver - Frequency Scan
Freq (Meters) -61.400 kHz
PASS
CISPR
NFE
Smooth
Scan
FREQUENCY SCAN
Atten: 10 dB
Scan
>1/1
Free Run
06:05:44 PM Jan 15, 2023
Mkr1 518.96292 kHz
42.713 dBµV/m
15 dB/div
Log
Ref 150.00 dBµV/m
Trace 1 Pass
#Start 9 kHz
#Res BW 100 Hz
VBW 1 kHz
#Stop 30 MHz
Dwell Time 9.98 ms (50 Hz)
MSG
STATUS

Plot 4.4: Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

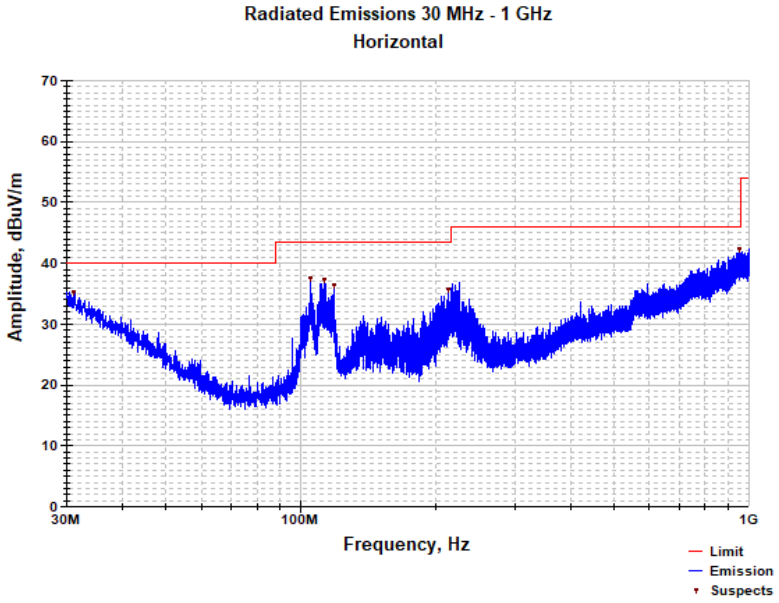
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and horizontal

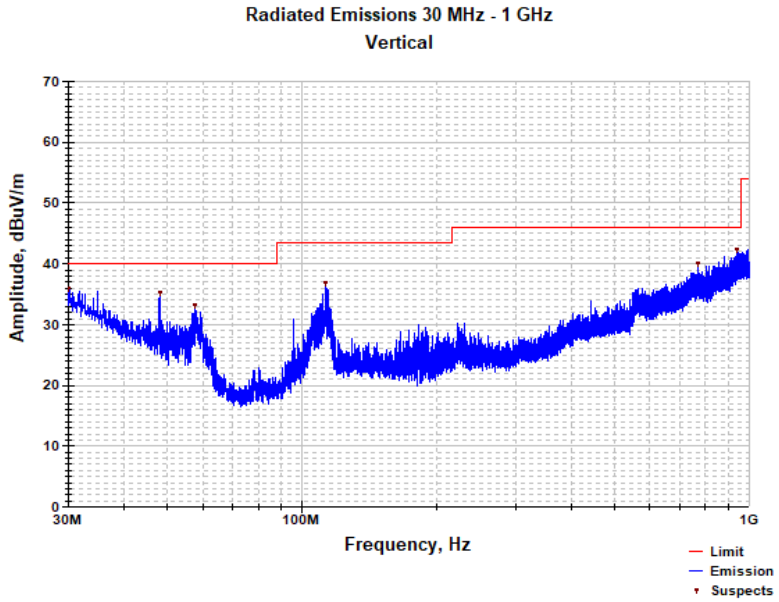




Plot 4.5: Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

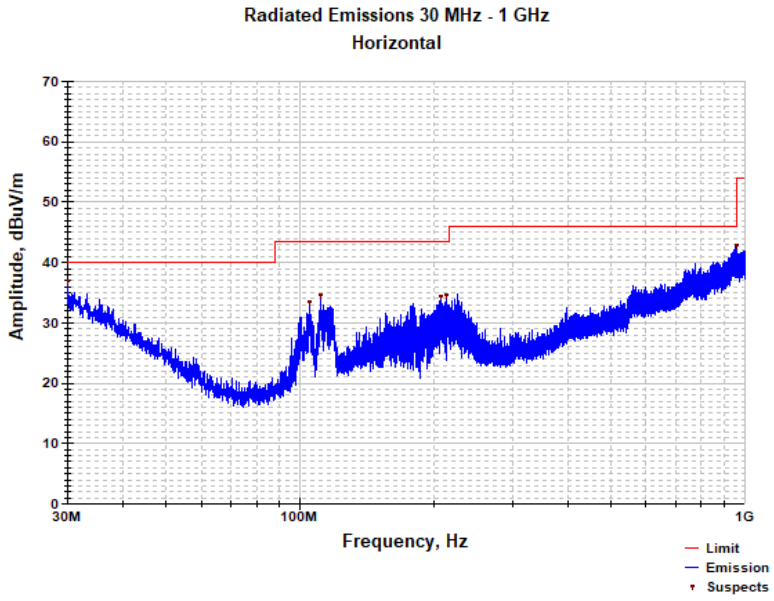
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal

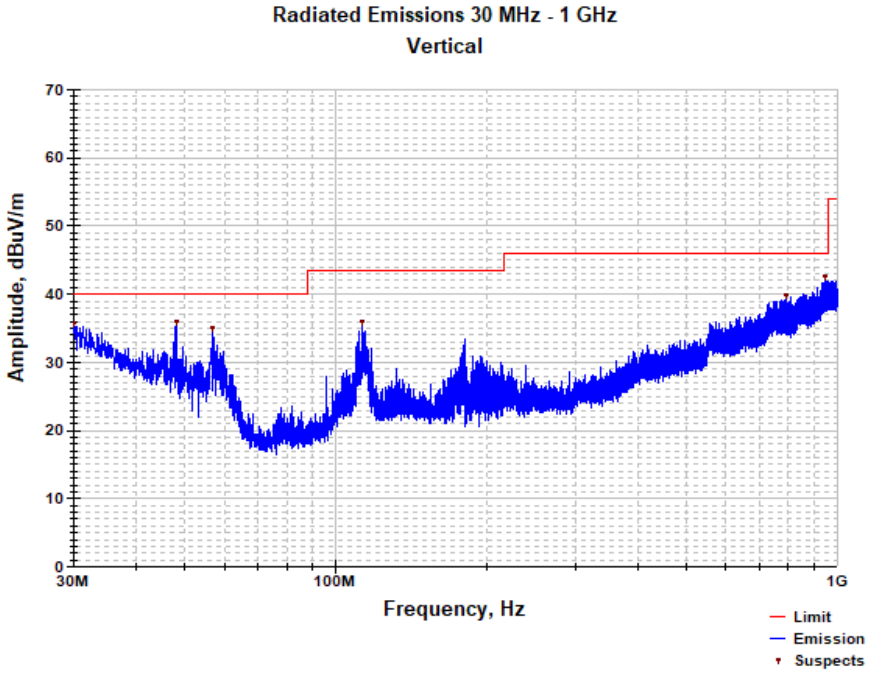




Plot 4.6: Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

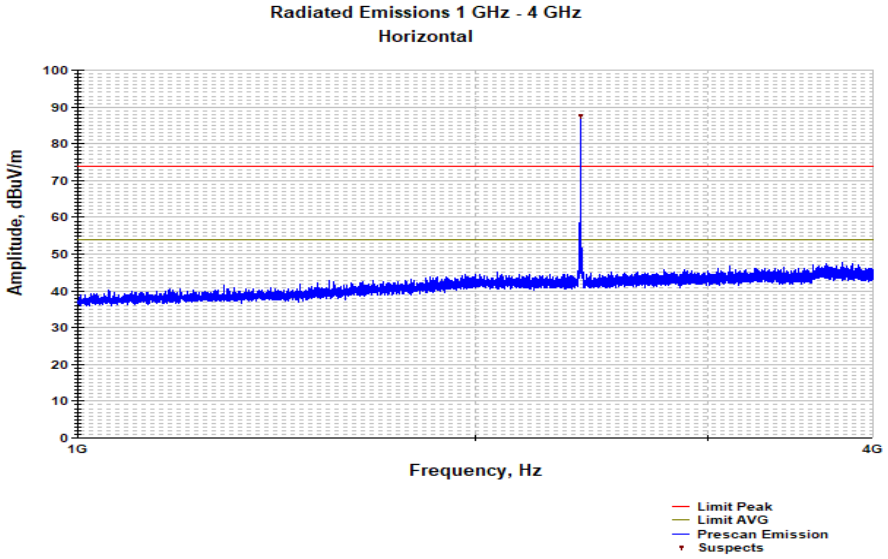
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal

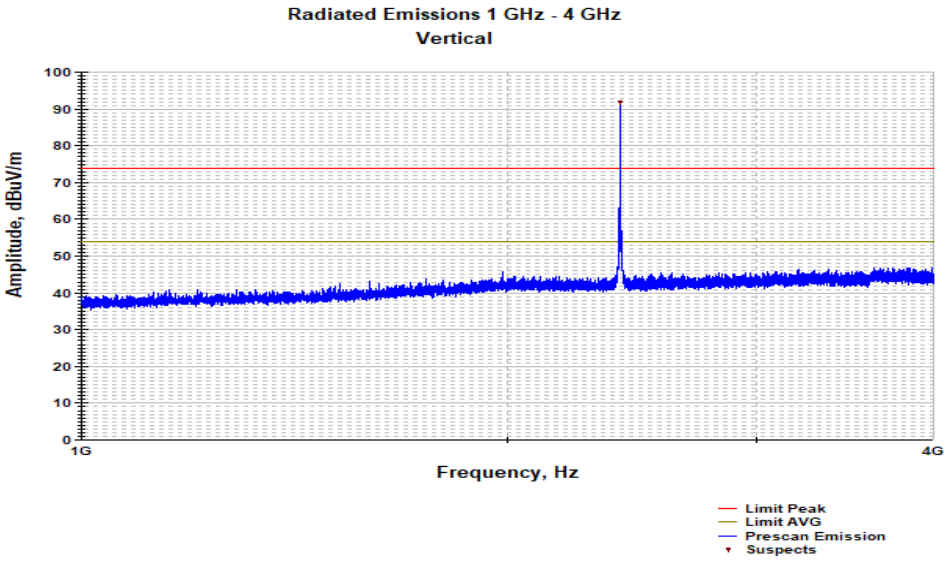




Plot 4.7: Radiated emission measurements from 1000 to 4000 MHz at the low carrier frequency

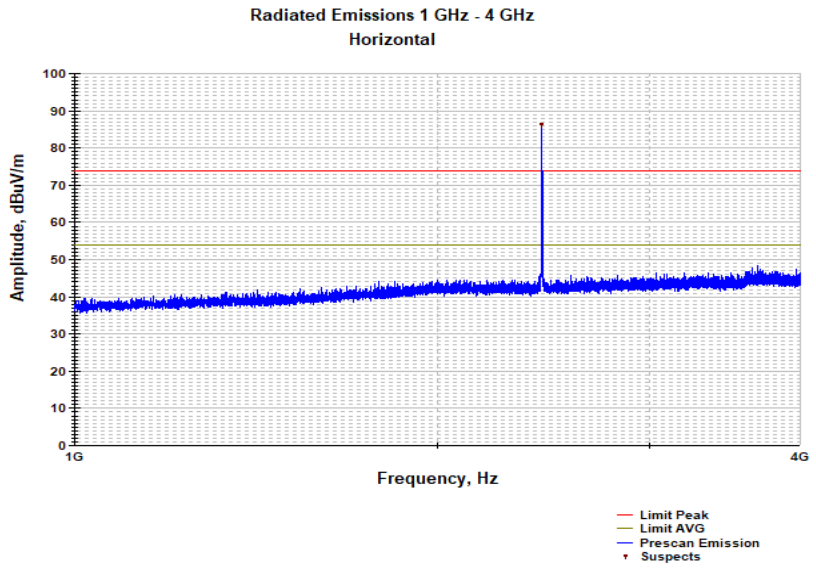
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
Attenuator 10dB in use	

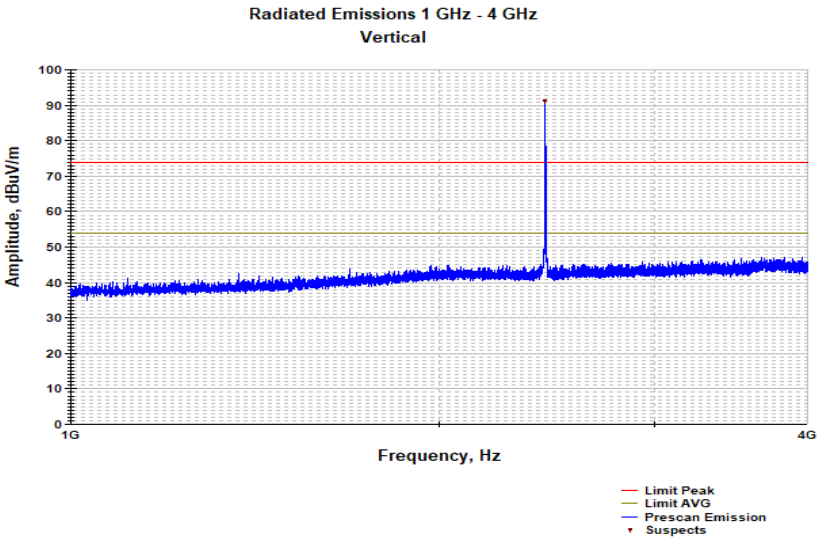




Plot 4.8: Radiated emission measurements from 1000 to 4000 MHz at the mid carrier frequency

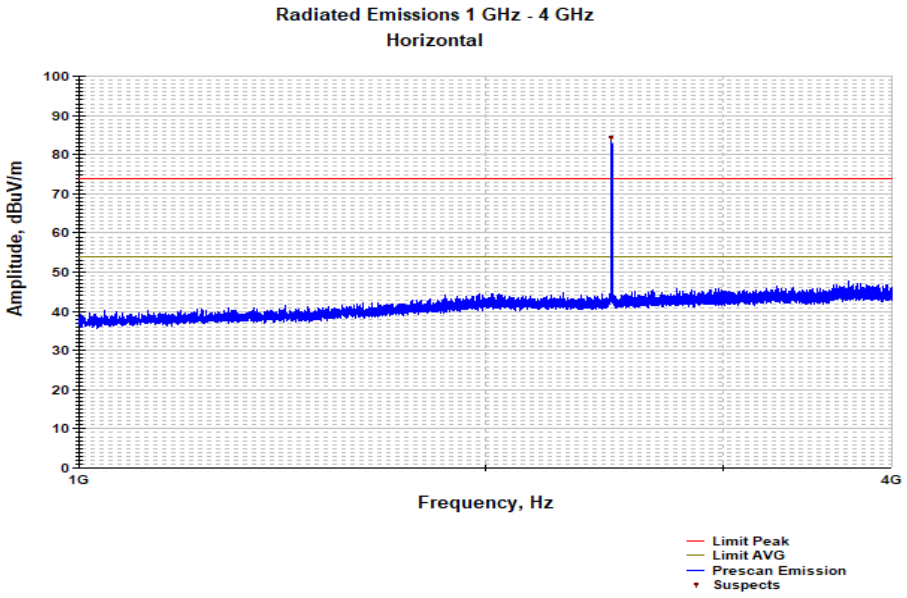
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
Attenuator 10dB in use	

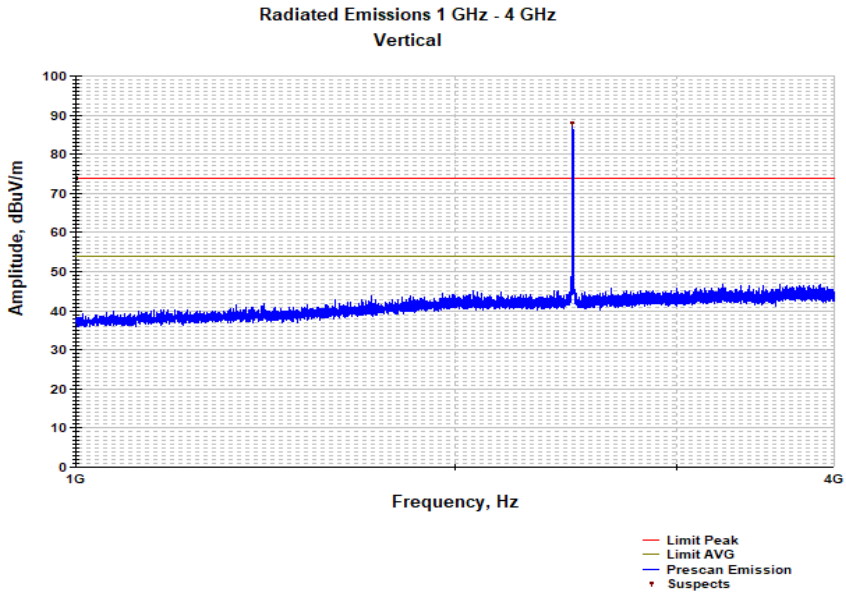




Plot 4.9: Radiated emission measurements from 1000 to 4000 MHz at the high carrier frequency

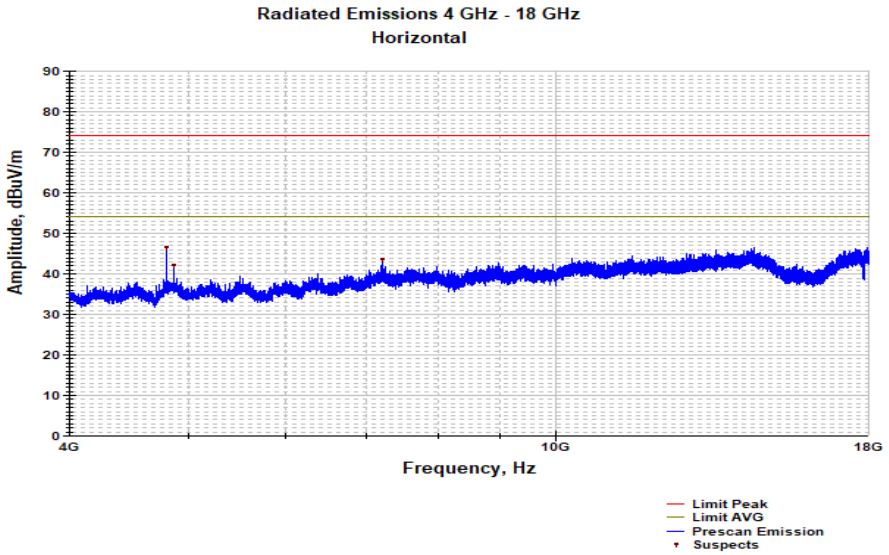
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
Attenuator 10dB in use	

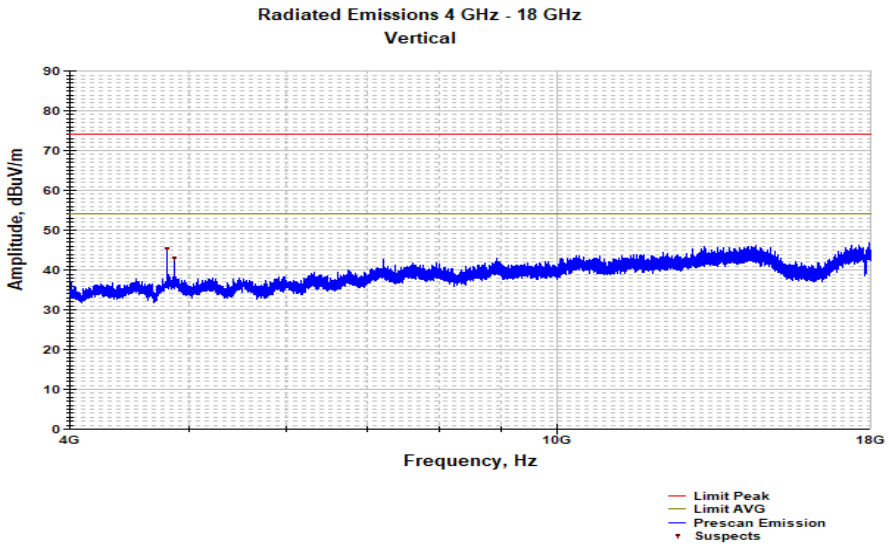




Plot 4.10: Radiated emission measurements from 4000 to 18000 MHz at the low carrier frequency

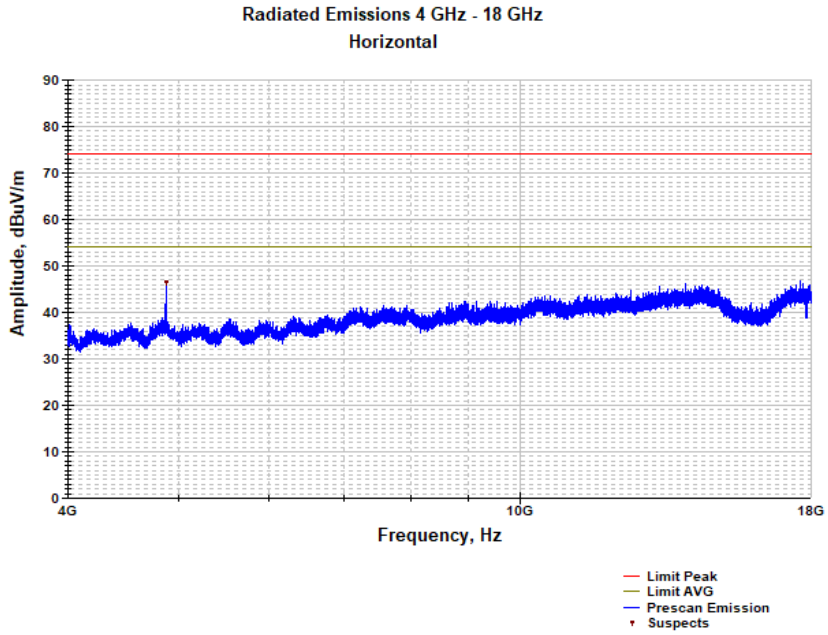
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
With HPF 2.8 GHz	

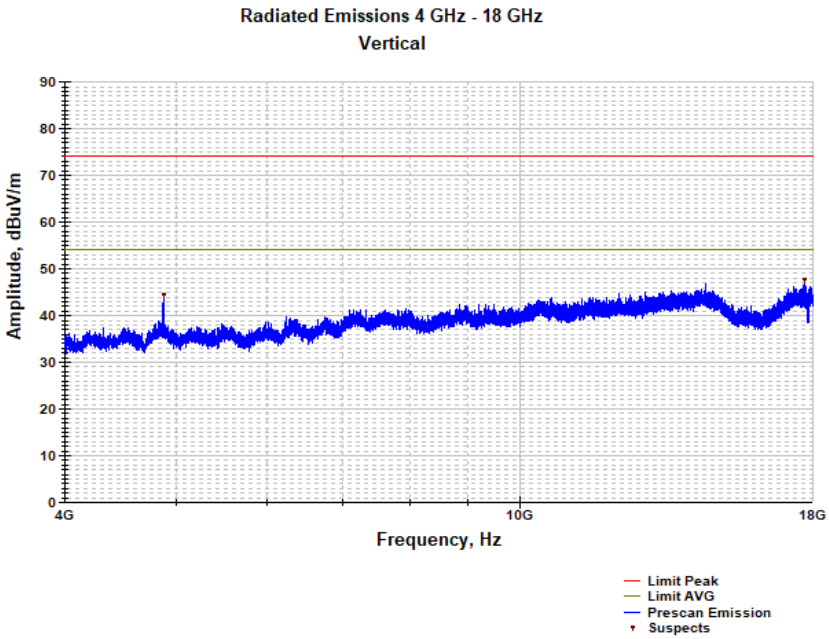




Plot 4.11: Radiated emission measurements from 4000 to 18000 MHz at the mid carrier frequency

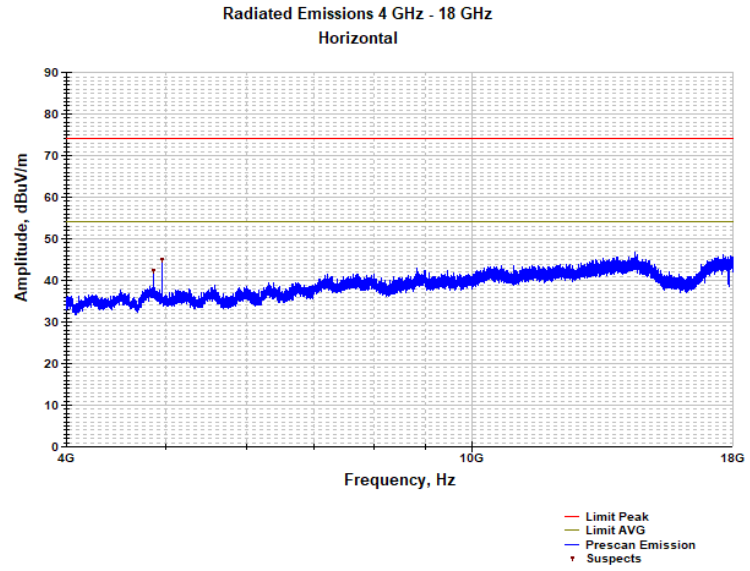
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
With HPF 2.8 GHz	

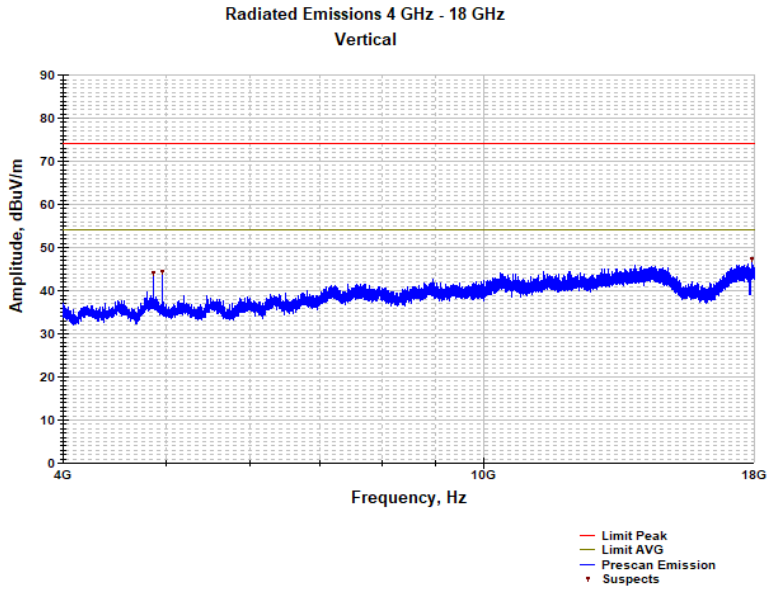




Plot 4.12: Radiated emission measurements from 4000 to 18000 MHz at the high carrier frequency

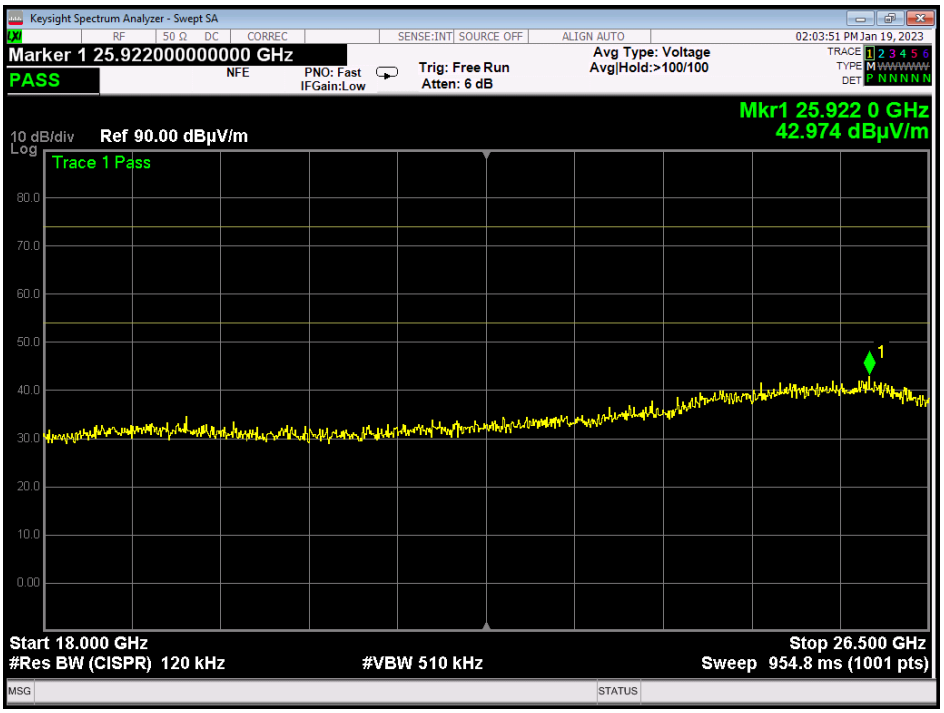
Test site:	Semi anechoic chamber
Test distance:	3 m
Antenna polarization:	Vertical and Horizontal
With HPF 2.8 GHz	



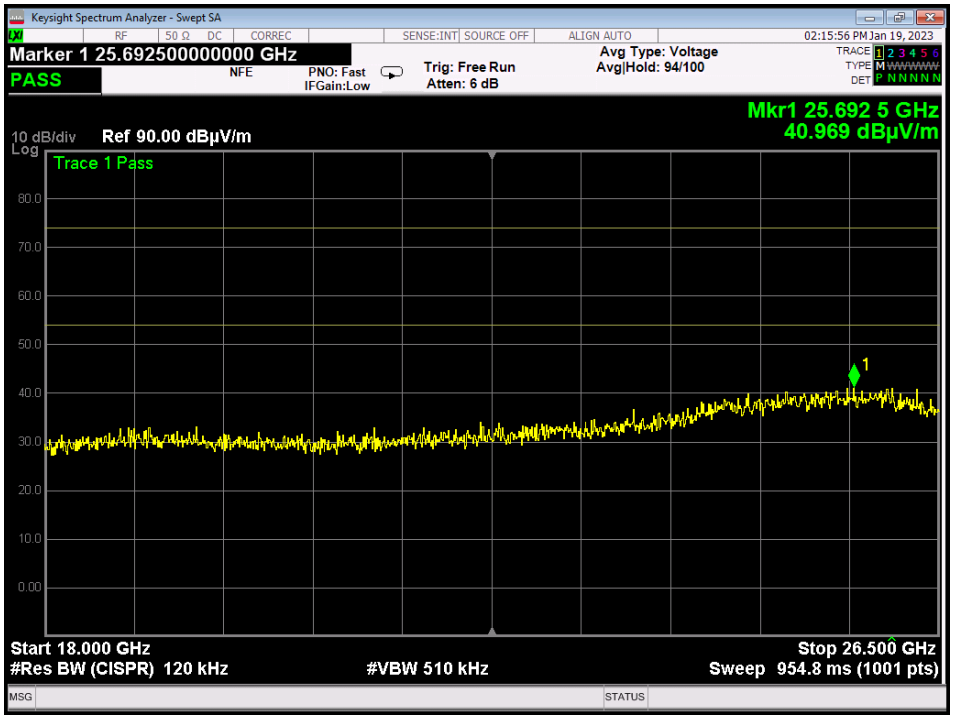


Plot 4.13: Radiated emission measurements from 18000 to 25000 MHz at the Low carrier frequency

Horizontal

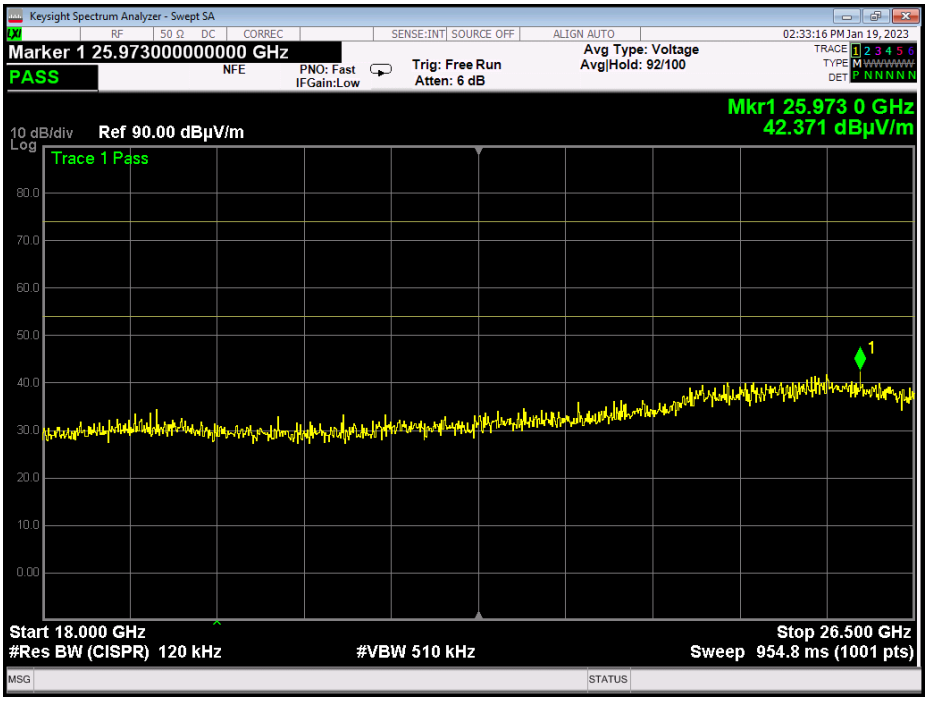


Vertical

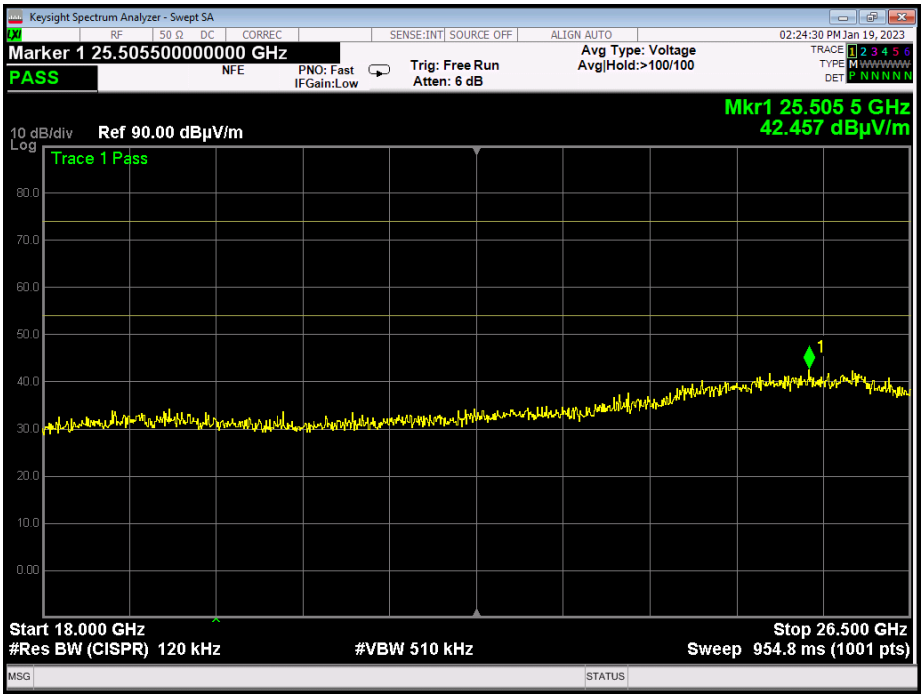


Plot 4.14: Radiated emission measurements from 18000 to 25000 MHz at the Mid carrier frequency

Horizontal

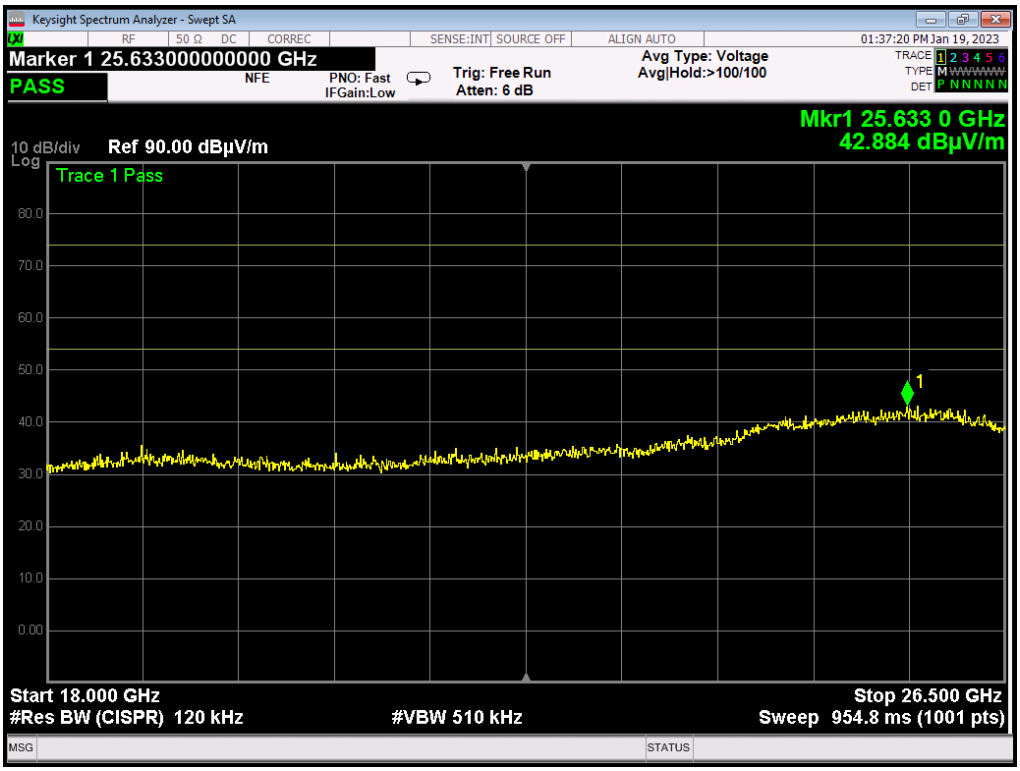


Vertical

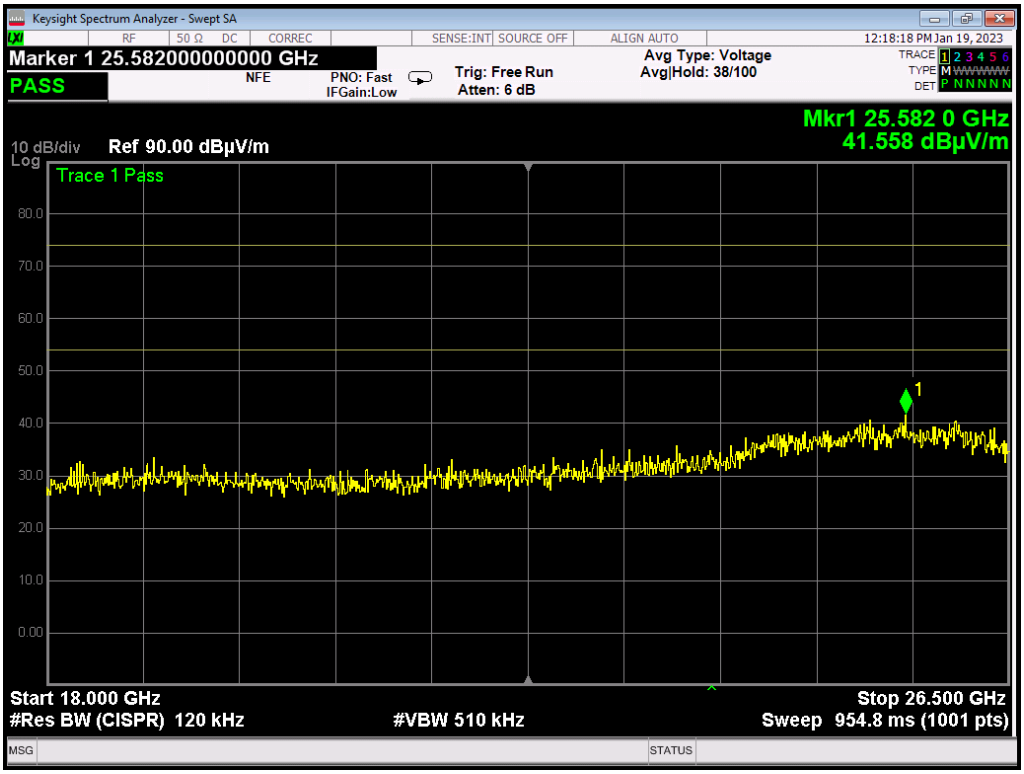


Plot 4.15: Radiated emission measurements from 18000 to 25000 MHz at the High carrier frequency

Horizontal



Vertical



5. Peak output power

Date of Test: 18.01.2023
Relative Humidity: 48%
Ambient Temperature: 21°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Izak Shtir

Test Method: ANSI C63.10 sections 11.9.2.2.4

Compliance status: Pass

5.1. General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 5.1.

Table 5.1 Peak output power limits

Assigned frequency range, MHz	Maximum antenna gain, dBi	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)**
		W	dBm	
2400.0 – 2483.5	6.0	1.0	30.0	131.2

*- The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:
by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.
**- Equivalent field strength limit was calculated from the peak output power as follows: E=sqrt(30×P×G)/r, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

5.2. Test procedure

The EUT was set up as shown in Figure , energized and its proper operation was checked.
The EUT was adjusted to produce maximum available to end user RF output power.
The resolution bandwidth of spectrum analyzer was set wider than 6 dB bandwidth of the EUT and the field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 3600 and the measuring antenna height was swept in both vertical and horizontal polarizations.
The maximum field strength of the EUT carrier frequency was measured as provided in Table and associated plots.
The maximum peak output power was calculated from the field strength of carrier as follows:

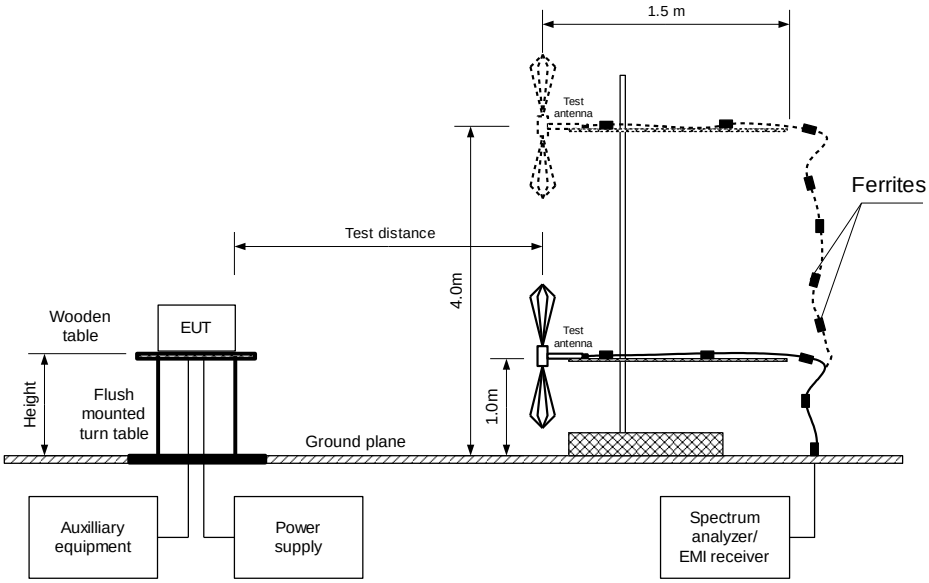
$$P = (E \times d)2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB

The worst test results (the lowest margins) were recorded in Table .

Figure 5.2 Setup for carrier field strength measurements



List of Test Equipment:

Refer to appendix A for complete list of equipment used and respective calibration dates.

Test results:

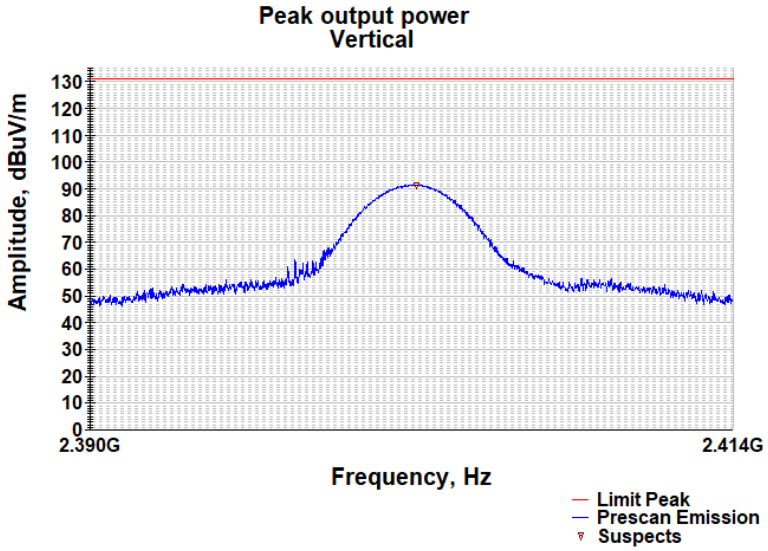
Table 5.2 Peak output power test results

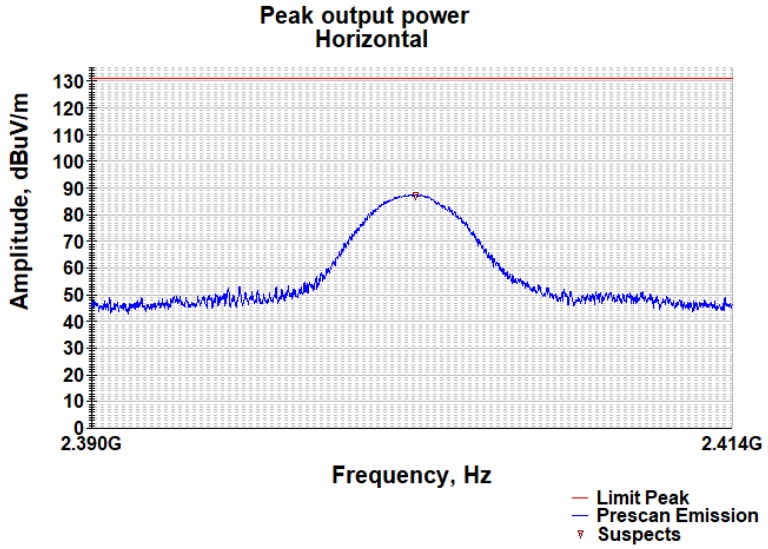
Assigned frequency:	2400.0 – 2483.5 MHz
Test distance:	3 m
Test site:	Semi anechoic chamber
EUT height:	1.5 m
Detector used:	Peak
Test antenna type:	Double ridged guide (above 1000 MHz)
Transmitter output power settings:	Maximum
Detector used:	Peak
Resolution bandwidth:	3 MHz
Video bandwidth:	50 MHz
Modulation:	GFSK
Bitrate:	1 Mbps

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, cm	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2402.32	87.89	H	122	127	3.3	-10.61	30	-40.61	Pass
2402.135	93.65	V	126	187	3.3	-4.85	30	-34.85	Pass
2441.976	86.40	H	102	125	3.3	-12.10	30	-42.10	Pass
2441.893	91.90	V	102	183	3.3	-6.60	30	-36.6	Pass
2479.976	84.96	H	110	125	3.3	-13.54	30	-43.54	Pass
2479.93	89.04	V	228	189	3.3	-9.46	30	-39.46	Pass

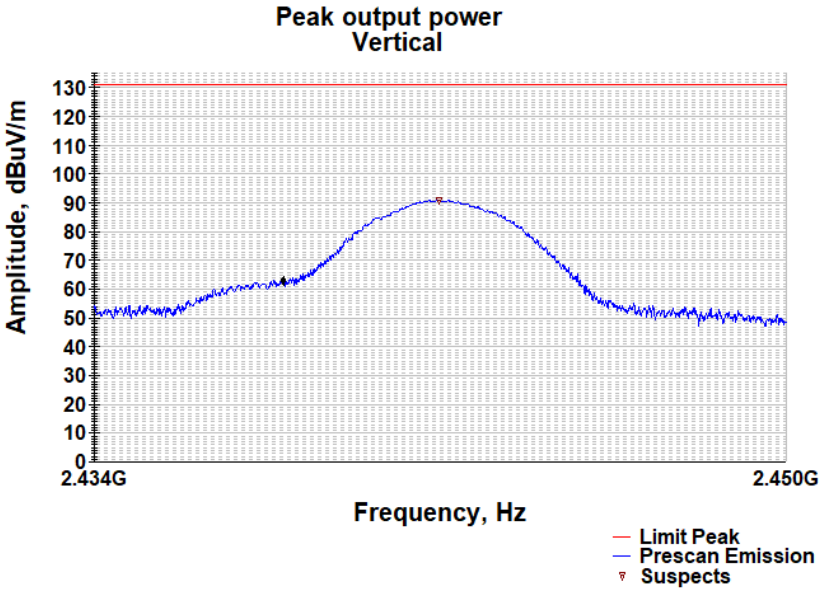
*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance:
Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi – 95.2 dB
***- Margin = Peak output power – specification limit.
Note: Maximum peak output power was obtained at U_{nom} (115%U_{nom}, 85%U_{nom}) input power voltage.

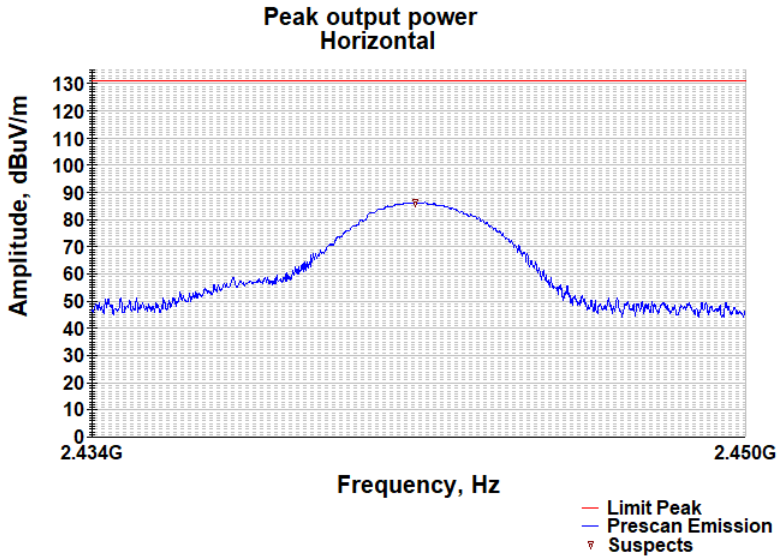
Plot 5.1: Field strength of carrier at low frequency



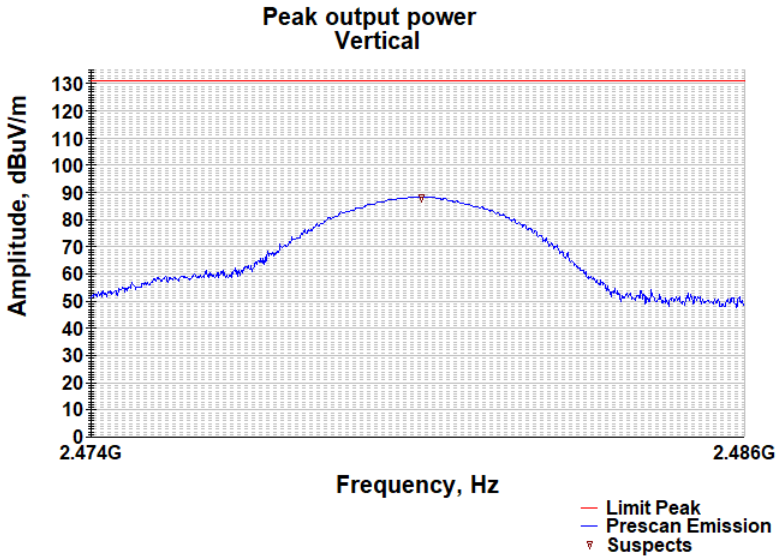


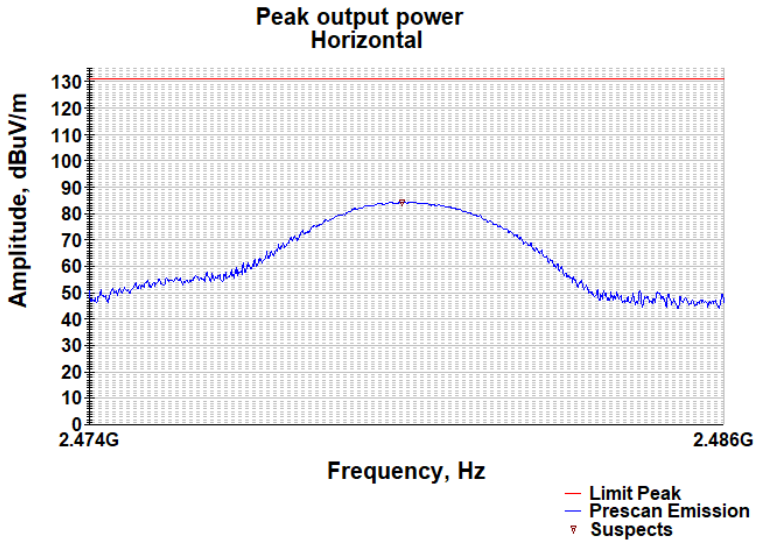
Plot 5.2: Field strength of carrier at mid frequency





Plot 5.3: Field strength of carrier at high frequency





6. Band edge radiated emissions

Date of Test: 10.01.2023
Relative Humidity: 48%
Ambient Temperature: 21°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Izak Shtir

Test Method: ANSI C63.10 section 11.12.1

Compliance status: Pass

6.1. General

This test was performed to measure emissions, radiated from the EUT at the assigned frequency band edges. Specification test limits are given in Table 6.1.

Table 6.1 Band edge emission limits

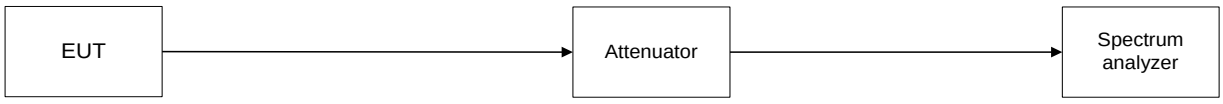
Output power	Assigned frequency, MHz	Attenuation below carrier*, dBc	Field strength at 3 m within restricted bands, dB(µV/m)	
			Peak	Average
Peak	2400.0 – 2483.5	20.0	74.0	54.0

* - Band edge emission limit is provided in terms of attenuation below the peak of modulated carrier measured with the same resolution bandwidth.

6.2. Test procedure

The EUT was set up as shown in Figure 6.1, energized normally modulated at the maximum data rate and its proper operation was checked.
The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.
The spectrum analyzer span was set to capture the carrier frequency and associated modulation products.
The resolution bandwidth was set wider than 1 % of the frequency span.
The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.
The maximum band edge emission and modulation product outside of the band were measured as provided in Table 6.2 and associated plots and referenced to the highest emission level measured within the authorized band.
The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.
The above procedure was repeated with the frequency hopping function enabled.

Figure 6.1 Band edge emission test setup



List of Test Equipment:

Refer to appendix A for complete list of equipment used and respective calibration dates.

Test results:

Table 6.2 Band edge emission outside restricted bands test results

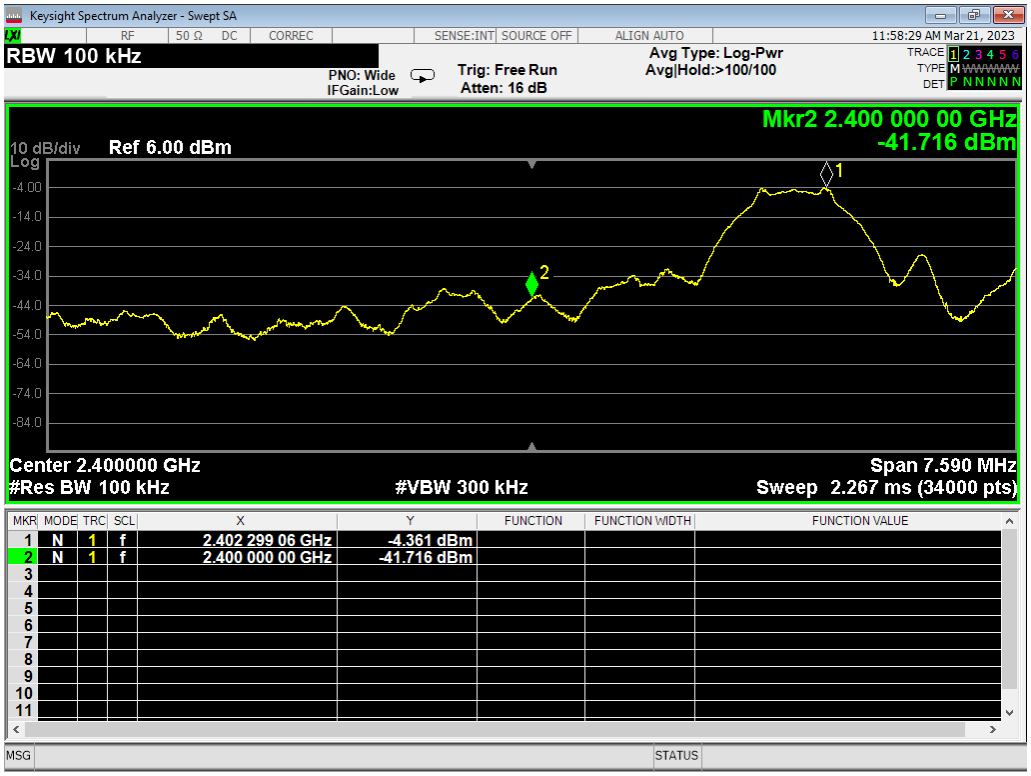
Assigned frequency range:			2400.0 – 2483.5 MHz			
Detector used:			Peak			
Transmitter output power settings:			Maximum			
Resolution bandwidth:			100 kHz			
Video bandwidth:			≥ RBW			
Modulation/bitrate:			GFSK / 1 Mbps			
Frequency, MHz	**Band edge emission, dBm**	**Emission at carrier, dBm**	**Attenuation below carrier, dBc**	**Limit, dBc**	**Margin, dB***	**Verdict**
Low carrier frequency						
2402	-41.716	-4.361	37.355	20	17.355	Pass
High carrier frequency						
2480	-49.884	-5.698	44.186	20	24.186	Pass

***-** Margin = Attenuation below carrier – specification limit.

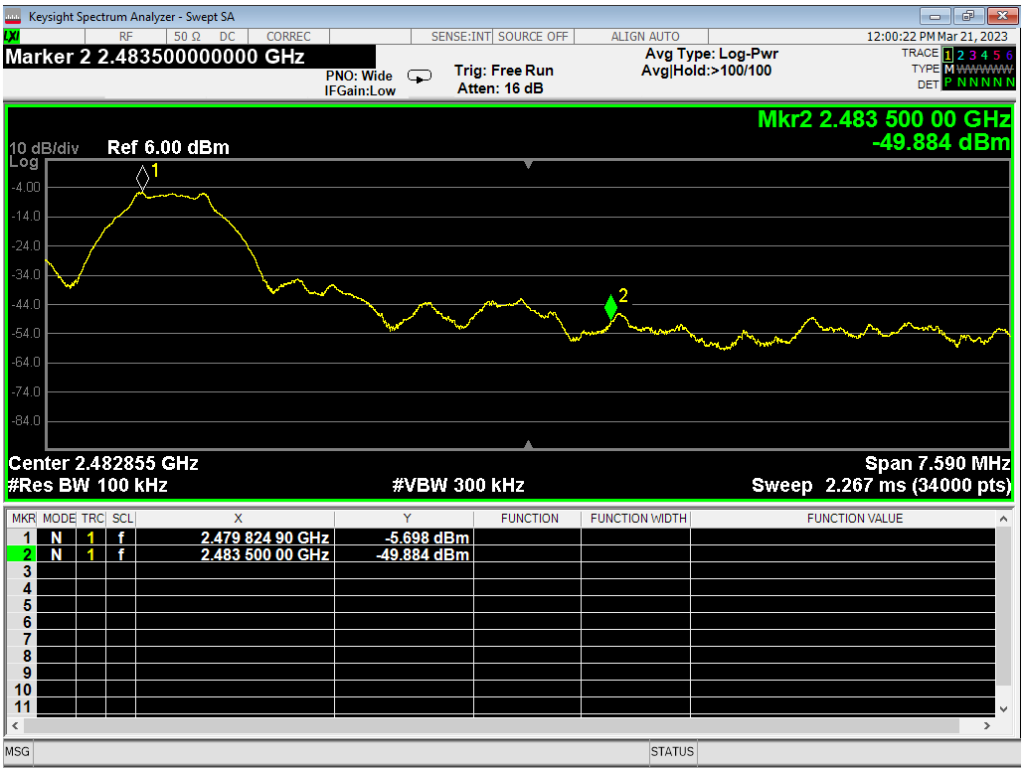
Table 6.3 Band edge emission inside restricted bands test results

Assigned frequency range:			2400.0 – 2483.5 MHz				
Detector used:			Peak				
Transmitter output power settings:			Maximum				
Video bandwidth:			≥ RBW				
Modulation/bitrate:			GFSK / 1 Mbps				
Frequency, MHz	**Peak field strength (VBW=3 MHz)**			**Average field strength (VBW=1 kHz)**			**Verdict**
	Measured, dB(µV/m)	**Limit, dB(µV/m)**	**Margin, dB****	**Measured, dB(µV/m)**	**Limit, dB(µV/m)**	**Margin, dB****	
2396.690	46.627	74.0	-27.373	NA	54.0	NA	Pass
2485.670	44.353	74.0	-29.647	NA	54.0	NA	Pass

Plot 6.1: Band edge radiated emissions Low frequency band



Plot 6.2: Band edge radiated emissions High frequency band



7. Peak spectral power density

Date of Test: 15.01.2023
Relative Humidity: 48%
Ambient Temperature: 21°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Izak Shtir

Test Method: ANSI C63.10 section 11.10.2

Compliance status: Pass

7.1. General

This test was performed to measure the peak spectral power density radiated by the transmitter RF antenna. Specification test limits are given in 7.1.

Table 7.1 Peak spectral power density limits

Assigned frequency range, MHz	Measurement bandwidth, kHz	Peak spectral power density, dBm	Equivalent Peak spectral power density limit @ 3m, dB(µV/m)*
2400.0 – 2483.5	3.0	8.0	103.2

* - Equivalent Peak spectral power density limit was calculated from the peak spectral power density as follows: E=sqrt(30×P)/r, where P is peak spectral power density and r is antenna to EUT distance in meters.

Test procedure

The EUT was set up as shown in Figure 7.1, energized and its proper operation was checked.

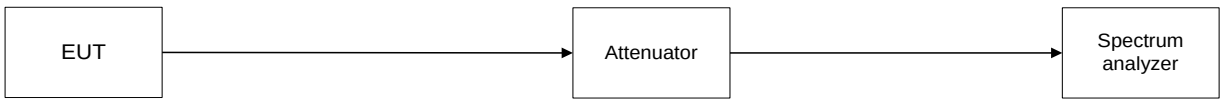
The EUT was adjusted to produce maximum available to end user RF output power.

The Peak spectral power density of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna height was swept in both vertical and horizontal polarizations.

The frequency span of spectrum analyzer was set to capture the entire 6 dB band of the transmitter, in peak hold mode with resolution bandwidth set to 3.0 kHz, video bandwidth wider than resolution bandwidth, auto sweep time and sufficient number of sweeps was allowed for trace stabilization. The spectrum lines spacing was verified to be wider than 3 kHz. Otherwise the resolution bandwidth was reduced until individual spectrum lines were resolved and the power of individual spectrum lines was integrated over 3 kHz band.

The peak of emission was zoomed with span set just wide enough to capture the emission peak area and sweep time was set equal to span width divided by resolution bandwidth. Spectrum analyzer was set in peak hold mode, sufficient number of sweeps was allowed for trace stabilization and peak spectral power density was measured as provided in table 7.2 and associated plots.

Figure 7.1 Setup for carrier Peak spectral power density measurements



List of Test Equipment:

Refer to appendix A for complete list of equipment used and respective calibration dates.

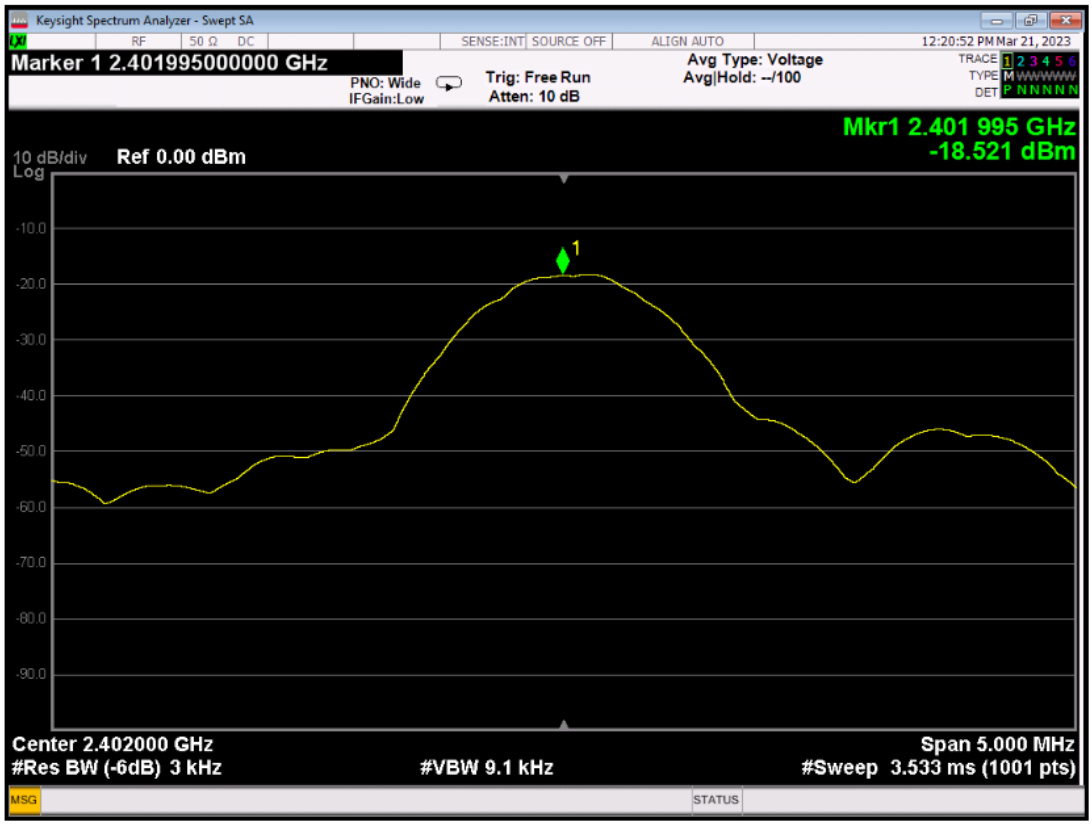
Test results:

Table 7.2 Peak spectral power density measurement

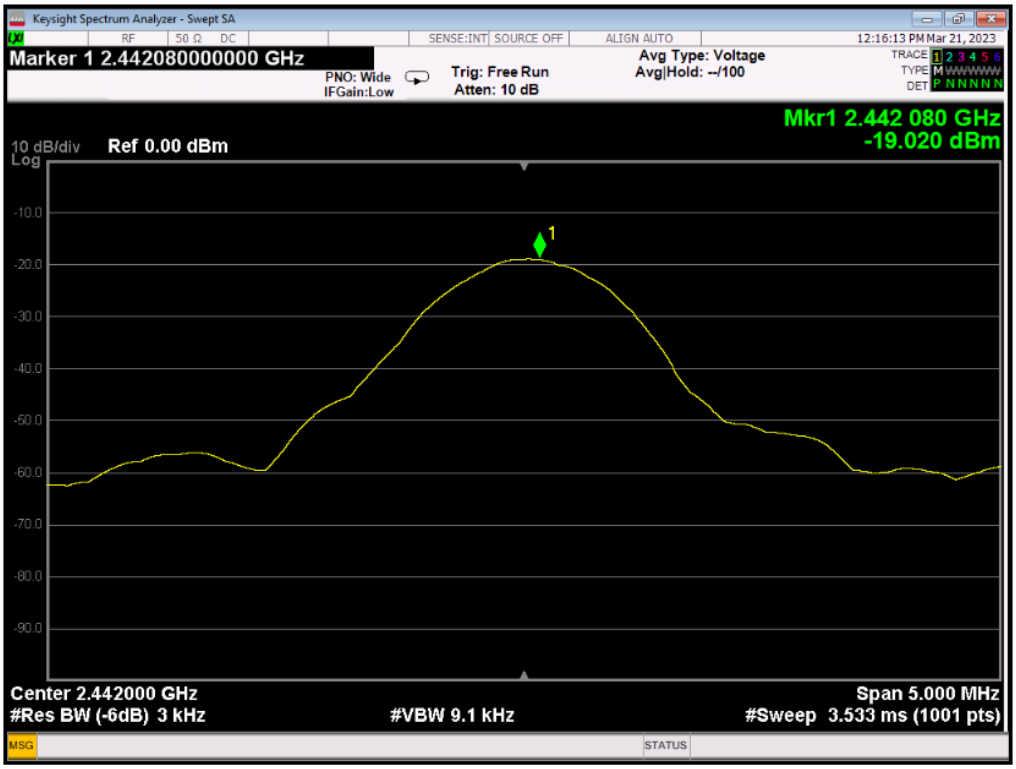
Assigned frequency:	2400.0 – 2483.5 MHz
Test site:	Semi anechoic chamber
Eut height:	1.5 m
Detector used:	Peak
Resolution bandwidth:	3 kHz
Video bandwidth:	9.1 kHz
Test antenna type:	Double ridged guide (above 1000 MHz)
Transmitter output power settings:	Maximum
Modulation/bitrate:	GFSK / 1 Mbps

Frequency, MHz	Peak spectral power density, dBm	Limit, dBm	Margin, dB*	Verdict
2402	-18.521	8	-26.521	Pass
2442	-19.020	8	-27.020	Pass
2480	-20.253	8	-28.253	Pass

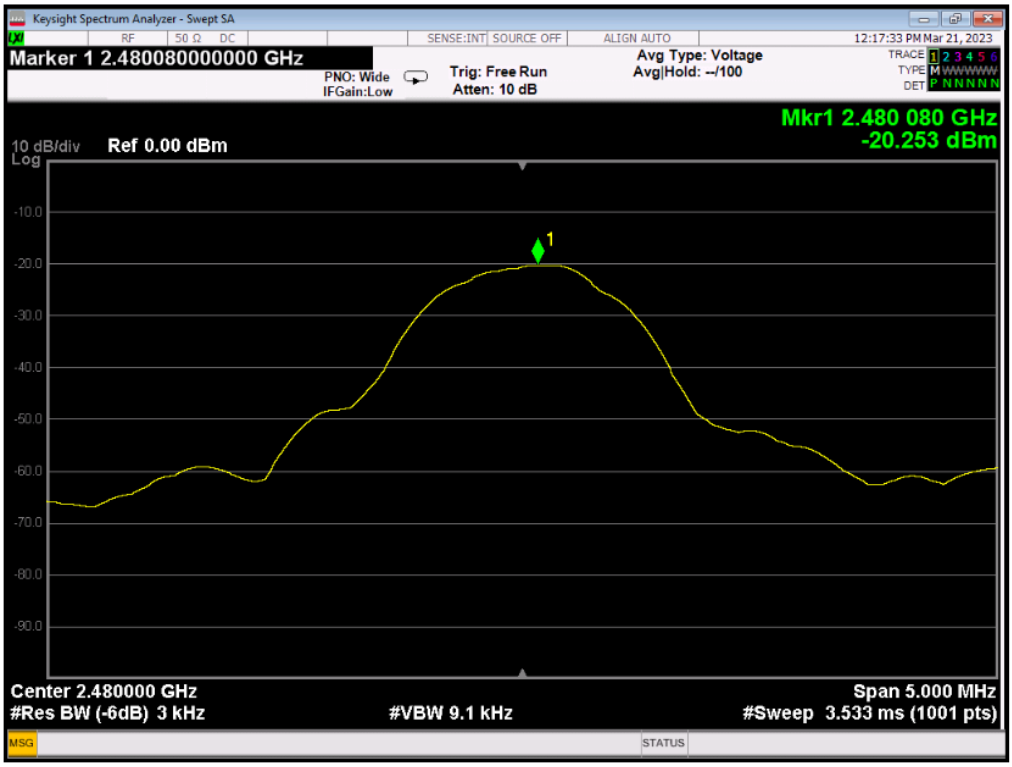
Plot 7.1: Peak PSD @ 2.402 GHz



Plot 7.2: Peak PSD @ 2.442 GHz



Plot 7.3: Peak PSD @ 2.480 GHz



8. Conducted Emissions

Date of Test: 27.06.2023
Relative Humidity: 50%
Ambient Temperature: 23.8°C
Atmospheric Pressure: 1011.4 hPa
Test performed by: Ortal Klainman

Test Method: **ANSI C63.4**

Compliance status: Pass

General

This test was performed to measure common mode conducted emissions at the mains power port.
Specification test limits are given in **Error! Reference source not found.**.

Limits:

Power Supply Port:

Frequency, [MHz]	Limit [dBµV] [Class A]		Limit [dBµV] [Class B]	
	QP	Average	QP	Average
0.15 - 0.5	79	66	66 - 56	56 - 46
0.5 - 5	73	60	56	46
5 - 30	73	60	60	50

Test procedure

The EUT was set up as shown in Figure 8 and associated photographs, energized and the performance check was conducted.
The measurements were performed at power terminals with the LISN, connected to a spectrum analyzer in the frequency range referred to in Table 8. Unused coaxial connector of the LISN was terminated with 50 Ohm. Quasi-peak and average detectors were used throughout the testing.
The position of the device cables was varied to determine maximum emission level.
The worst test results (the lowest margins) were recorded in Table 8 and shown in the associated plots.

List of Test Equipment:

Refer to appendix A for complete list of equipment used and respective calibration dates.

Test results:

Table 8.1: Power supply port: Transmitter BLE 2.44 GHz

"L1" Lead

Frequency [MHz]	Measured Peak [dBµV]	Measured QP [dBµV]	QP limit [dBµV]	QP margin [dBµV]	Measured AVG [dBµV]	AVG limit [dBµV]	AVG margin [dBµV]
0.196	52.3	49.2	64.7	-15.5	41.8	54.7	-12.8
0.639	42.2	40.7	56.0	-15.3	40.0	46.0	-6.0
0.664	42.4	39.8	56.0	-16.2	38.9	46.0	-7.1
0.688	45.4	44.0	56.0	-12.0	41.1	46.0	-4.9
0.712	41.6	40.2	56.0	-15.8	39.4	46.0	-6.6
0.737	41.8	40.3	56.0	-15.7	39.2	46.0	-6.8
1.180	43.3	40.8	56.0	-15.2	34.1	46.0	-11.9
1.474	41.5	39.2	56.0	-16.8	30.0	46.0	-16.0

"L2" Lead

Frequency [MHz]	Measured Peak [dBµV]	Measured QP [dBµV]	QP limit [dBµV]	QP margin [dBµV]	Measured AVG [dBµV]	AVG limit [dBµV]	AVG margin [dBµV]
0.196	50.1	47.7	64.7	-17.0	39.8	54.7	-14.8
0.639	42.9	41.8	56.0	-14.2	41.2	46.0	-4.8
0.688	46.4	44.8	56.0	-11.2	42.5	46.0	-3.5
0.712	41.9	41.0	56.0	-15.0	40.3	46.0	-5.7
0.738	42.9	41.3	56.0	-14.7	40.3	46.0	-5.7
0.982	42.7	40.7	56.0	-15.3	34.7	46.0	-11.3
1.180	44.0	41.9	56.0	-14.1	35.9	46.0	-10.1
2.063	45.7	42.6	56.0	-13.4	36.0	46.0	-10.0

Table 8.2: Power supply port: Receiver BLE 2.44 GHz

"L1" Lead

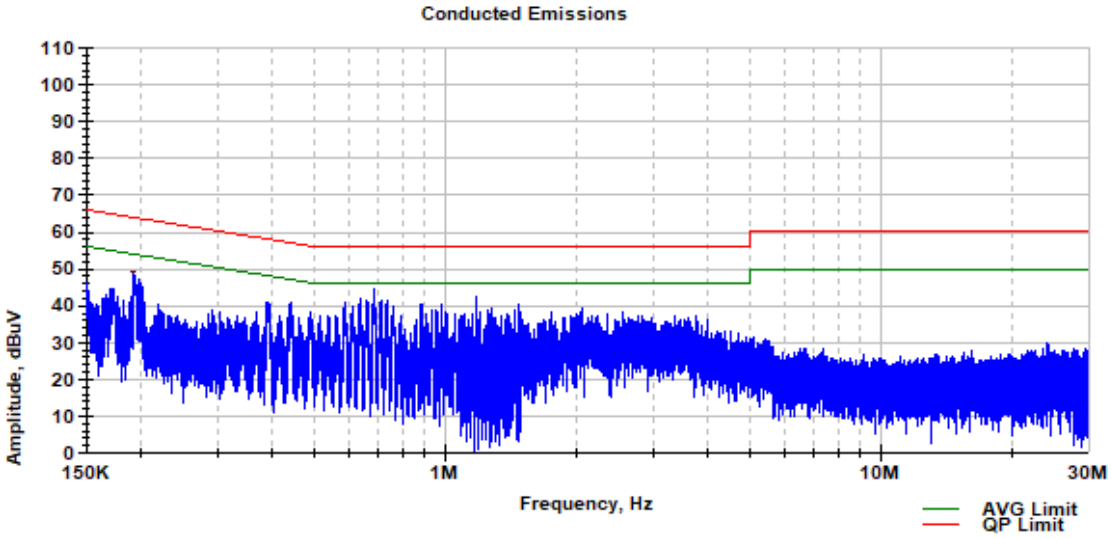
Frequency [MHz]	Measured Peak [dBµV]	Measured QP [dBµV]	QP limit [dBµV]	QP margin [dBµV]	Measured AVG [dBµV]	AVG limit [dBµV]	AVG margin [dBµV]
0.198	51.4	49.0	64.6	-15.7	41.6	54.6	-13.0
0.198	52.3	48.8	64.6	-15.8	41.4	54.6	-13.2
0.589	42.5	40.6	56.0	-15.4	37.8	46.0	-8.2
0.639	42.4	40.6	56.0	-15.4	39.9	46.0	-6.1
0.688	45.3	43.7	56.0	-12.3	40.8	46.0	-5.2
0.885	41.5	39.6	56.0	-16.4	34.3	46.0	-11.7
1.474	41.7	39.3	56.0	-16.7	30.2	46.0	-15.8
1.769	43.0	41.1	56.0	-14.9	33.9	46.0	-12.1

"L2" Lead

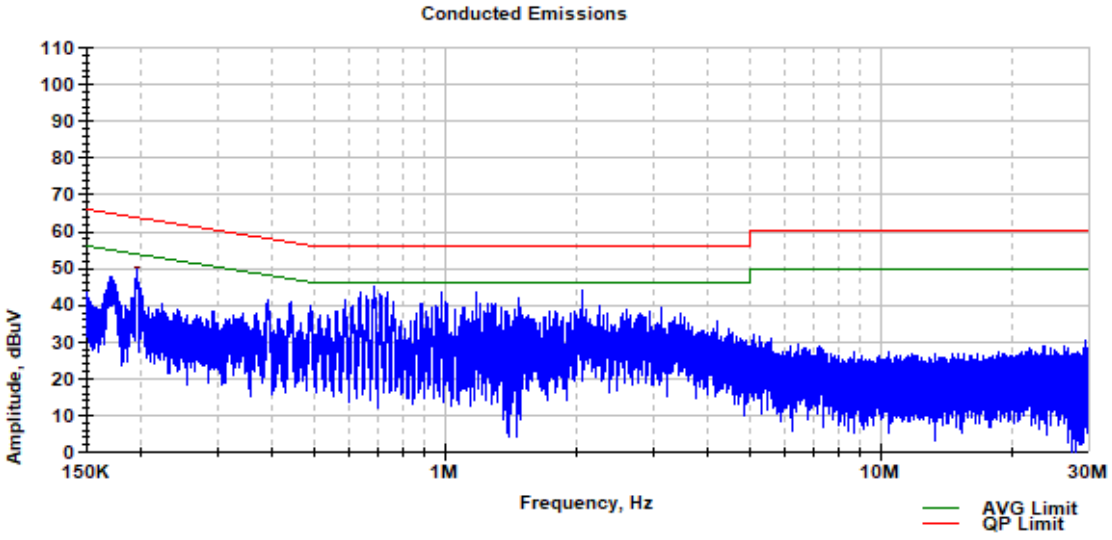
Frequency [MHz]	Measured Peak [dBµV]	Measured QP [dBµV]	QP limit [dBµV]	QP margin [dBµV]	Measured AVG [dBµV]	AVG limit [dBµV]	AVG margin [dBµV]
0.198	50.6	47.6	64.6	-17.1	39.6	54.6	-15.0
0.639	42.8	41.6	56.0	-14.4	41.1	46.0	-4.9
0.688	45.6	44.3	56.0	-11.7	41.9	46.0	-4.1
0.762	42.6	41.3	56.0	-14.7	40.7	46.0	-5.3
0.886	42.9	40.1	56.0	-15.9	35.5	46.0	-10.5
0.982	42.6	40.2	56.0	-15.8	34.0	46.0	-12.0
1.178	43.9	41.5	56.0	-14.5	35.6	46.0	-10.4
2.064	44.1	41.8	56.0	-14.2	35.1	46.0	-10.9

Transmitter BLE 2.44 GHz

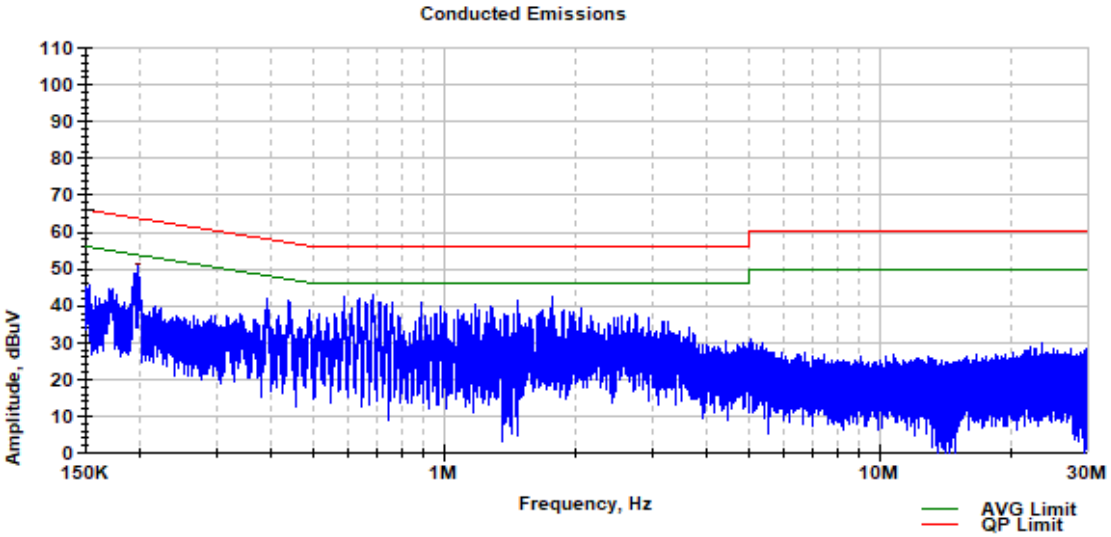
Plot 8.1: Power Supply Ports, 150 kHz – 30 MHz, Lead L1



Plot 8.2: Power Supply Ports, 150 kHz – 30 MHz, Lead L2



Receiver BLE 2.44 GHz
Plot 8.3: Power Supply Ports, 150 kHz – 30 MHz, Lead L1



Plot 8.4: Power Supply Ports, 150 kHz – 30 MHz, Lead L2

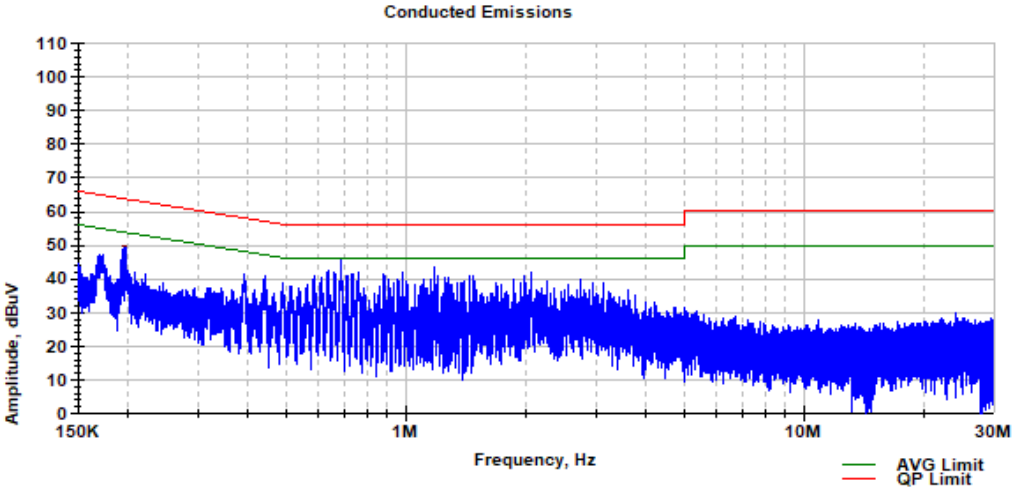
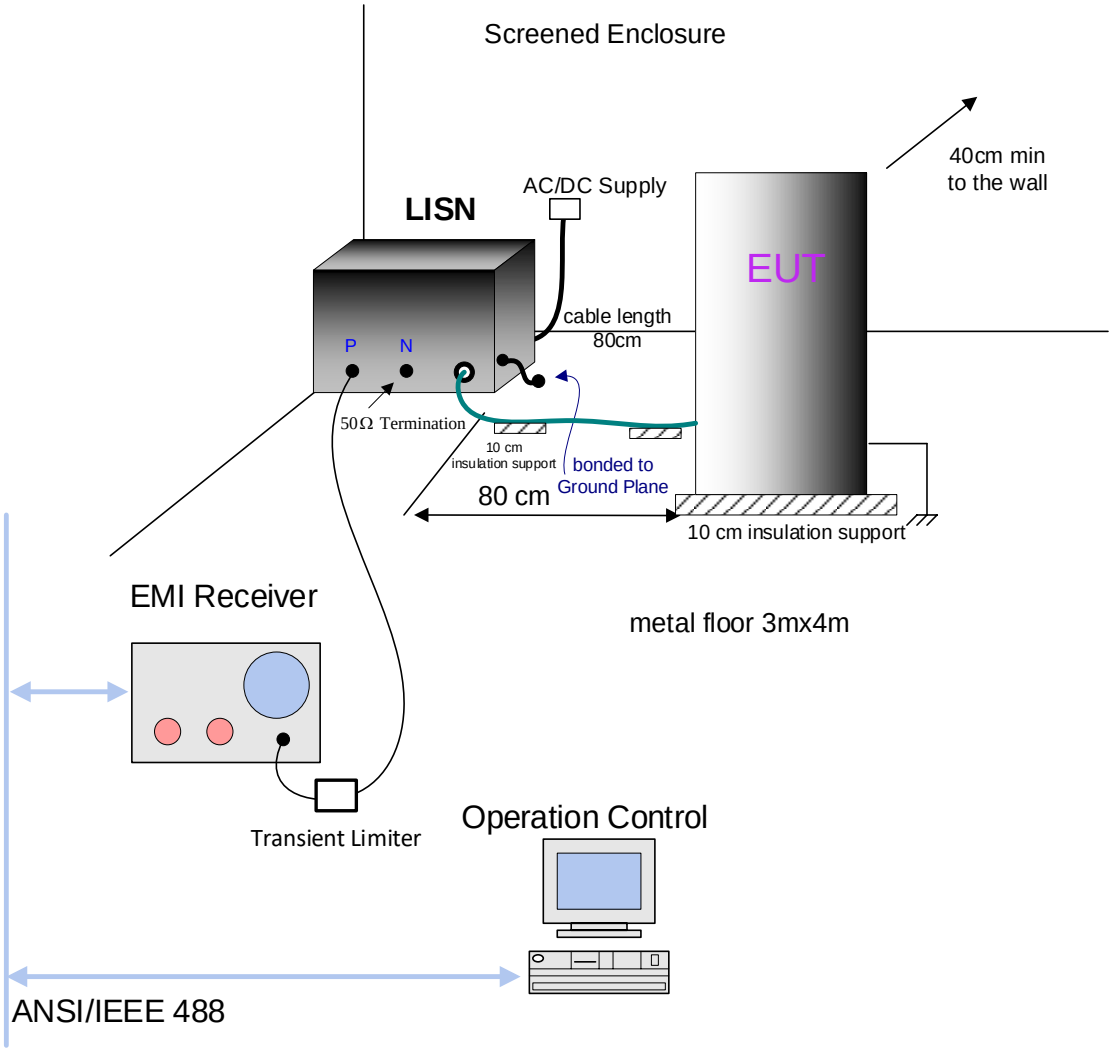


Figure 8: Setup for conducted emission measurements



Photograph 8.1: Setup for conducted emission measurements, Transmitter BLE 2.44 GHz

Photograph 8.2: Setup for conducted emission measurements, Receiver BLE 2.44GHz

9. Appendices

9.1. Appendix A: List of Measuring Equipment used:

Equipment description	Last Cal	Cal Due
Semi Anechoic Chamber, 9.5m [L] x 6.5m [W] x 5.2m [H]	19 05 2022	19 05 2024
Teseq CBL 6141B, Bilog Antenna	01 06 2022	01 06 2025
1 GHz to 18 GHz, Double ridge horn antenna, 24.2 by 13.6 cm opening ARA DRG-118/A	03 10 2022	03 10 2023
LNA 1-18GHz (New), Spacek Labs, SL1018-56-5, 17J29	20 09 2022	20 09 2023
Keysight MXE EMI Receiver N9038A	11 05 2022	11 05 2023
Spectrum Keysight E4446A	05 09 2022	05 09 2023
Schwarzbeck BBHA 9170 SHF-EHF horn	21 03 2021	21 03 2024
Low-Noise Amplifier 26.5GHz - 40GHz, Spacek Labs, SLKa-35-4	27 02 2023	27 02 2024
Screened Enclosure 4m x 3m x 3m	CNR	
Keysight EMI Receiver N9038A-MXE, MY55420200	12.06.2023	12.06.2024
Agilent 11947A Transient Limiter	23 03 2023	23 03 2024
Schwarzbeck NNBL 8226-2 V-LISN	CNR	
Variable Transformer	CNR	

9.2. Appendix B: Abbreviations/ Glossary used in the test report

AC	Alternating Current
AVR	Average (Detector)
A/m	Ampere per meter
AE	Auxiliary equipment
AM	Amplitude modulation
cm	Centimeter
CE	Conducted Emission
CI	Conducted Immunity
CNR	Calibration not required
dB	Decibel
dBm	Decibel referred to one Mill watt
dB(µV)	Decibel referred to one micro volt
dB(µV/*m*)	Decibel referred to one micro volt per meter
DC	Direct Current
ESD	Electrostatic Discharge
EFT	Electrical Fast Transients
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Immunity
EN	European Standard
EUT	Equipment under test
F/O	Fiber optic
GHz	Gigahertz
Hz	Hertz
HCP	Horizontal Coupling Plane
kHz	Kilohertz
kV	Kilovolt

ISN	Impedance stabilization network
LISN	Line Impedance Stabilization Network
m	Meter
MHz	Megahertz
NA	Not Applicable
NP	Normal performance
QP	Quasi-Peak (Detector)
Ω	Ohm
PM	Pulse modulation
PC	Personal Computer
RF	Radio Frequency
RE	Radiated Emission
RI	Radiated Immunity
rms	Root-mean-square
sec	Second
SA	Spectrum analyzer
Transceiver	Transmitter -receiver
V	Volt
VCP	Vertical coupling plane
W	Watt

9.3. Appendix C: Accreditation Certificate

Accredited Laboratory

A2LA has accredited

QUALITECH

Petah-Tikva, Israel

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 29th day of August 2022.

Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1633.01
Valid to June 30, 2024

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

End of the Test Report