



RF Test Report

Standard(s): FCC Part 15 Subpart 15.247,
RSS-247 Issue 3:2023
Unlicensed Intentional Radiators

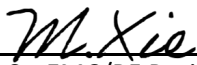
Issued To: Ecobee Inc
207 Queens Quay Suite 600
Toronto, ON M5J 1A7
Canada

Product Name: Smart Thermostat Lite & Smart Thermostat Essential
Model: ECB701
FCC ID: WR9202428847PR
IC: 7981A-202428847PR

Report No. ML301244A-RF01 (DTS – BLE)
Date of Issue: August 9, 2024

Report Prepared By:

Reviewed By:


Min Xie, Sr. EMC/RF Project Engineer


Amir Emami, Project Engineer

Megalab Group Inc. – 150 Addison Hall Circle, Aurora, Ontario, L4G 3X8, Canada

www.megalabinc.com – (905) 752-1925

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Table of Contents

1.	Revision History	3
2.	Summary of Test Results.....	4
2.1	Test Verdict	4
2.2	Test Standards.....	5
2.3	Test Facility	6
3.	General Information	9
3.1	Client Information.....	9
3.2	Device Under Test (DUT).....	9
3.3	Test Setup of DUT	10
3.4	Modifications for Compliance.....	10
4.	Test Results	11
4.1	Emission Bandwidth.....	11
4.2	Peak Conducted Output Power	17
4.3	Spurious Out of Band Emissions (-20dBc).....	29
4.4	Transmitter Spurious Radiated Emissions	36
4.5	Lower and Upper Band Edges	46
4.6	Power Spectral Density	23
4.7	Power Line Conducted Emissions	60

1. Revision History

Project No. & Revision	Report Date	Initials	Description
ML301244A-RF00 (DTS – BLE)	July 26, 2024	MX	Initial Release
ML301244A-RF01 (DTS – BLE)	August 9, 2024	MX	Updated Product name and added duty cycle to section 3.3.

NOTE:

- Latest reports marked as a revision replace any previous report and/or report revision issued under the same project number.

2. Summary of Test Results

2.1 Test Verdict

Unless otherwise stated, the test data and results in this test report relate only to the sample(s) tested.

Requirement		Test Type	Result	Remark
FCC	ISED			
15.203 15.247(b)(4)	RSS-247 5.4(d)	Antenna Gain and Requirement	Pass	PCB Trace Antenna 2.5 dBi
15.247(a)(2)	RSS-247 5.2(a)	Emission Bandwidth	Pass	6dB Bandwidth > 500kHz
15.247(b)(3)	RSS-247 5.4(d)	Peak Conducted Output Power	Pass	< 1 Watt
15.247(d)	RSS-247 5.5	Spurious Out of Band Emissions	Pass	< 20dBc
15.247(d) 15.209	RSS-GEN 8.9 (Table 5 & 6)	Transmitter Spurious Radiated Emissions	Pass	---
15.205 15.209	RSS-GEN 8.10 (Table 7)	Lower and Upper Band Edges	Pass	Transmitter spurious radiated emissions which fall in the restricted bands
15.247(e)	RSS-247 5.2(b)	Power Spectral Density	Pass	< 8 dBm in 3kHz BW
15.207	RSS-GEN (Table 4)	Power Line Conducted Emissions	Pass	--

2.1.1 Test Verdict Notes and Justifications

The DUT was mounted as in normal usage. See the Test Setup Photos for details.

Antenna details obtained from Manufacturer's Datasheet.

2.2 Test Standards

Standard	Description
47 CFR FCC Part 15 Subpart C	Code of Federal Regulations – Radio Frequency Devices, Intentional Radiators
FCC KDB 558074:2019	Digital Transmission Systems, measurements and procedures
RSS-247 Issue 3:2023	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN Issue 5:2021	General Requirements for Compliance of Radio Apparatus
ANSI C63.4:2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ISO 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories

2.3 Test Facility

All tests were performed at Megalab Group Inc., located at 150 Addison Hall Circle, Aurora, ON, L4G 3X8, Canada.

The 10-meter semi-anechoic chamber for radiated emission and radiated immunity is designed to handle weights of up to 10,000lb and has power capability of over 100A. The turntable is capable of supporting test devices or systems either floor standing or table top of up to 4 meters wide and 3m tall. Conducted emissions, unless otherwise specified, are performed on a 2.44m x 2.48m ground plane and using a 2.44m x 2.48m vertical ground plane if applicable.

2.3.1 Accreditations

This report does not indicate any product endorsement by any government, accreditation agency, or Megalab Group Inc. Megalab Group Inc. shall have no liability for any deductions, interpretations or generalizations drawn by the client or others from the issued reports. If any opinions or interpretations are expressed in this report, they are outside Megalab Group Inc.'s scope of accreditation and do not necessarily reflect the opinions of Megalab Group Inc., unless otherwise specified.



A2LA (Certificate #5179.02)

Megalab Group Inc. is accredited to ISO/IEC 17025:2017 by the American Association for Laboratory Accreditation (A2LA) with Testing Certificate #5179.02. The laboratories current scope of accreditation can be found as listed on A2LA's website.



Innovation, Science and
Economic Development Canada

ISED

Megalab Group Inc. is registered with and recognized by Innovation, Science and Economic Development Canada (ISED) as an accredited testing laboratory.
Company Number: 28697



FCC

Megalab Group Inc. is registered with and recognized by the Federal Communications Commission (FCC) as an accredited testing laboratory.
Registration No. 200040



VCCI

The Semi-anechoic chamber of Megalab Group Inc. is registered with the Regulations for Voluntary Control Council for Interference (VCCI). Registration No.: R-20173, G-20174, C-20132, T-20133.

2.3.2 Measurement Uncertainty

As per ISO/IEC 17025 requirements, an evaluation of the measurement uncertainties associated with the emission test results should be included in the test report.

Where relevant, the following measurement uncertainty levels have been estimated for the tests performed on the DUT as specified in CISPR 16-4-2. The measurement uncertainties given below are based on a coverage factor $k = 2$ which yields approximately a 95% level of confidence for the near-normal distribution typical of most measurement results.

Measurement	Frequency Range	Uncertainty
Conducted Emissions at AC Mains Power Port	150kHz to 30MHz	2.27 dB
Radiated Emissions	30MHz to 1GHz	5.22 dB
	1GHz to 18GHz	4.76 dB

2.3.3 Sample Calculations

Conducted Emissions

$$\begin{aligned}
 \text{Emission Level (dB}\mu\text{V)} &= \text{Read Level (dB}\mu\text{V)} + \text{LISN Factor (dB)} + \text{Attenuation Factor (dB)} + \text{Cable Loss (dB)} \\
 &= 34.8 + 0.1 + 10.0 + 0.2 \\
 &= 45.1
 \end{aligned}$$

$$\begin{aligned}
 \text{Margin (dB)} &= \text{Limit (dB}\mu\text{V)} - \text{Emission Level (dB}\mu\text{V)} \\
 &= 60.0 - 45.1 \\
 &= 14.9
 \end{aligned}$$

Radiated Emissions

$$\begin{aligned}
 \text{Emission Level (dB}\mu\text{V/m)} &= \text{Read Level (dB}\mu\text{V)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Pre-Amp Gain (dB)} \\
 &= 52.4 + 9.4 + 1.3 - 29.2 \\
 &= 33.9
 \end{aligned}$$

$$\begin{aligned}
 \text{Margin (dB)} &= \text{Limit (dB}\mu\text{V/m)} - \text{Emission Level (dB}\mu\text{V/m)} \\
 &= 50.0 - 33.9 \\
 &= 16.1
 \end{aligned}$$

2.3.4 Terms, Definitions and Abbreviations

AE	Auxiliary Equipment
DUT	Device Under Test
DTS	Digital Transmission System
EMC	Electro-Magnetic Compatibility
FHSS	Frequency Hopping Spread Spectrum
ISM	Industrial, Scientific and Medical
LISN	Line Impedance Stabilization Network
N/A	Not Applicable
NCR	No Calibration Required
RF	Radio Frequency
RBW	Resolution Bandwidth
VBW	Video Bandwidth

Auxiliary Equipment/Support Equipment

Equipment needed to exercise and/or monitor the operation of the DUT.

Artificial Mains Network

Network that provides a defined impedance to the DUT at radio frequencies, couples the disturbance voltage to the measuring receiver and decouples the test circuit from the supply mains.

Class A Equipment

Equipment suitable for use in all locations other than those allocated in residential environments and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class B Equipment

Equipment suitable for use in all locations, including in residential environments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Device Under Test

Device or system being evaluated for compliance with the requirements of the Test Standards listed in this report.

Electro-Magnetic Compatibility

Ability of equipment or system to function satisfactorily in its EM environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Electromagnetic Disturbance

Any electromagnetic phenomenon which may degrade the performance of a device, equipment or system.

3. General Information

3.1 Client Information

Company	Ecobee Inc
Address	207 Queens Quay Suite 600 Toronto, ON M5J 1A7 Canada
Contact	John Russomanno
Email	john@ecobee.com

3.2 Device Under Test (DUT)

3.2.1 DUT Information

DUT Name	Smart Thermostat Lite & Smart Thermostat Essential
DUT Model(s)	ECB701
Serial Number	Production samples
Power Source (AC / DC / Battery)	AC
Input Voltage (V) or Range	24Vac
Frequency (Hz) or Range	60Hz
Mode(s) of Operation	Continuous transmission
Connectors Available on DUT	Standard thermostat connections
Transmitter Information	
FCC ID	WR9202428847PR
IC	7981A-202428847PR
Technology Used	BLE
Operating Frequency	2402 MHz to 2480 MHz
Modulation Type	GFSK
Number of Channels	40
Antenna Manufacturer	Custom – PCB trace
Antenna Model	N/A
Antenna Type	Monopole
Antenna Gain	2.5 dBi

Note: Above antenna information is provided by the client. The characteristics and gain are obtained from the Antenna Manufacturer's Data Sheet.

3.2.2 DUT Description

EUT is a smart thermostat; it contains 2400 – 2483.5 MHz DTS (802.11 b/g/n and BLE) transmitters on one chip, and a 920 – 928 MHz FHSS/Hybrid transmitter on second chip.

This report documents the compliance of the BLE transmitter.

3.3 Test Setup of DUT

3.3.1 Configuration

The DUT was configured in a direct test mode with the following parameters

- For all the tests, the DUT was set to transmit continuously with maximum duty cycle; 61.8% for 1 MBPS (0.772 ms ON time with a period of 1.25 ms) and 31.5% for 2 MBPS (0.394 ms ON time with a period of 1.25 ms)
- Output Power: +20 dBm
- Channels:
 - o low, 2402MHz
 - o Mid, 2440MHz
 - o High, 2480MHz

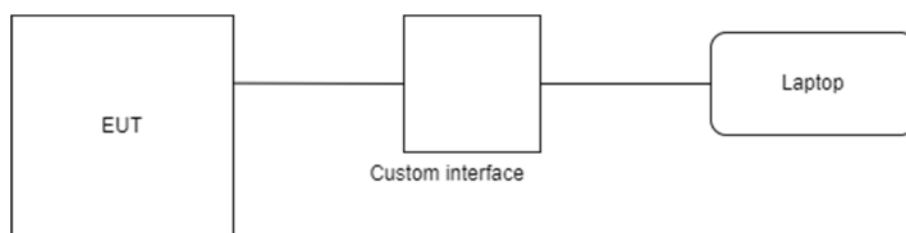


Figure 1 – Configuration Block Diagram

Description of I/O Cables			
Cable Function	Length of Cable (m)	Shielded (Y/N)	Outdoor Use (Y/N)
Thermostat control	>3	N	N

3.3.2 Support Equipment

Device	Manufacturer	Model	S/N
Custom USB Interface	Ecobee	--	---

3.4 Modifications for Compliance

No modifications were made to the device under test to comply with the testing requirements.

4. Test Results

4.1 Emission Bandwidth

Test Date: May 14, 2024
Temperature (°C) 21.8
Relative Humidity (%) 53.6
Barometric Pressure (kPa) 101.0

Initials: MX

4.1.1 Limits

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

4.1.2 Test Procedure

Tested according to ANSI C63.10 Section 11.8 and 6.9.3.

For the 6dB (DTS) Bandwidth:

- Set RBW = 100kHz and VBW $\geq [3 \times \text{RBW}]$.
- Detector = Peak and Trace Mode = Max Hold.
- Sweep = Auto Couple.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6dB relative to the maximum level measured in the fundamental emission.

For the 99% Bandwidth:

- Set RBW in the range of 1% to 5% of the actual occupied bandwidth.
- Set VBW $\geq [3 \times \text{RBW}]$.
- Span set to 1.5 to 5 times the occupied bandwidth.
- Use the 99% power bandwidth function of the instrument to measure bandwidth.

4.1.3 Test Results

EUT meets minimum of 500 kHz 6dB bandwidth.

1 MBPS				
6dB (DTS) & 99% Bandwidth				
Frequency (MHz)	6dB DTS Bandwidth (MHz)	99% Occupied Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	Test Result
2402	0.663	1.03	> 0.50	Pass
2440	0.669	1.03	> 0.50	Pass
2480	0.666	1.03	> 0.50	Pass

2 MBPS				
6dB (DTS) & 99% Bandwidth				
Frequency (MHz)	6dB DTS Bandwidth (MHz)	99% Occupied Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	Test Result
2402	1.12	2.07	> 0.50	Pass
2440	1.14	2.06	> 0.50	Pass
2480	1.14	2.07	> 0.50	Pass

4.1.3.1. 1 MBPS Plots

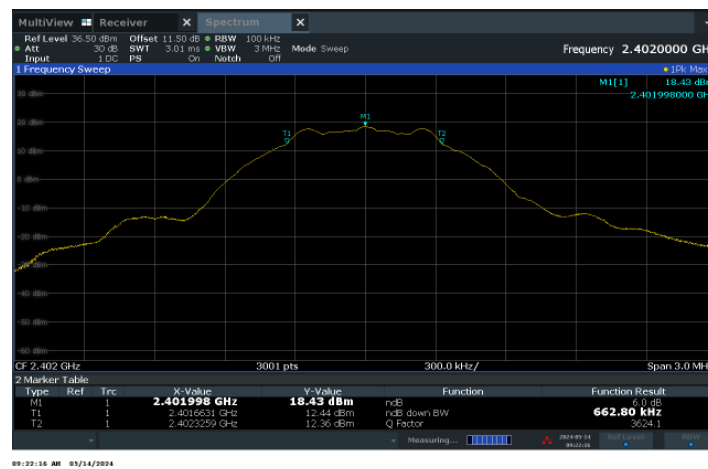


Figure 2 – 6dB Bandwidth – 2402 MHz

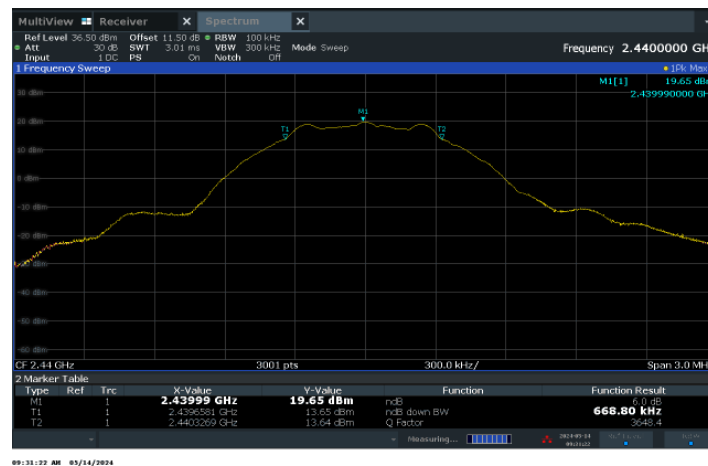


Figure 3 – 6dB Bandwidth – 2440 MHz

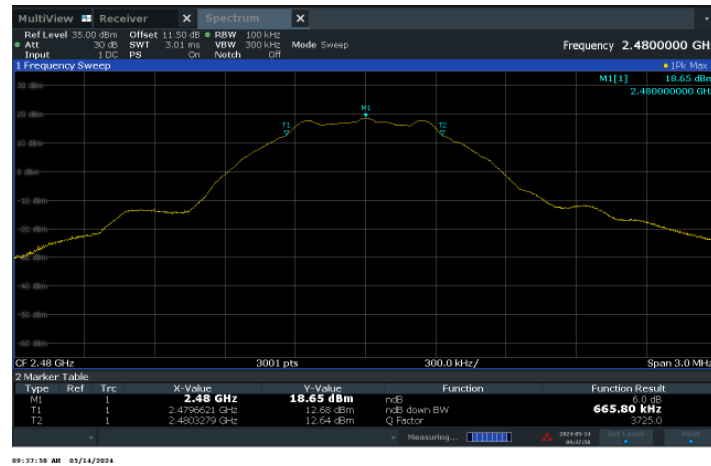


Figure 4 – 6dB Bandwidth – 2480 MHz



Figure 5 – 99% Bandwidth – 2402 MHz



Figure 6 – 99% Bandwidth – 2440 MHz



Figure 7 – 99% Bandwidth – 2480 MHz

4.1.3.2. 2 MBPS Plots

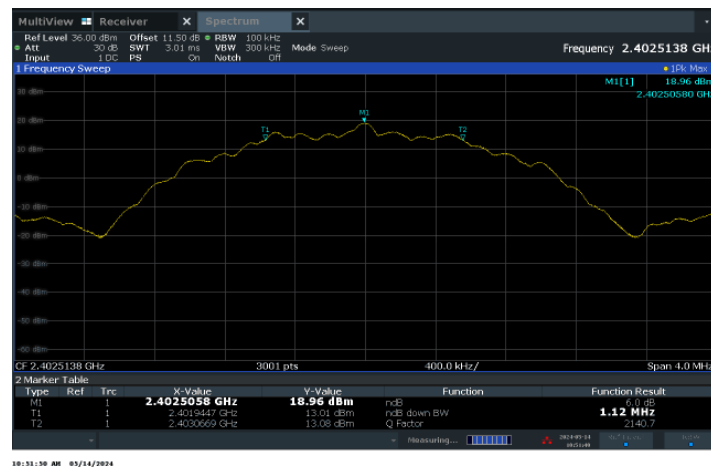


Figure 8 – 6dB Bandwidth – 2402 MHz

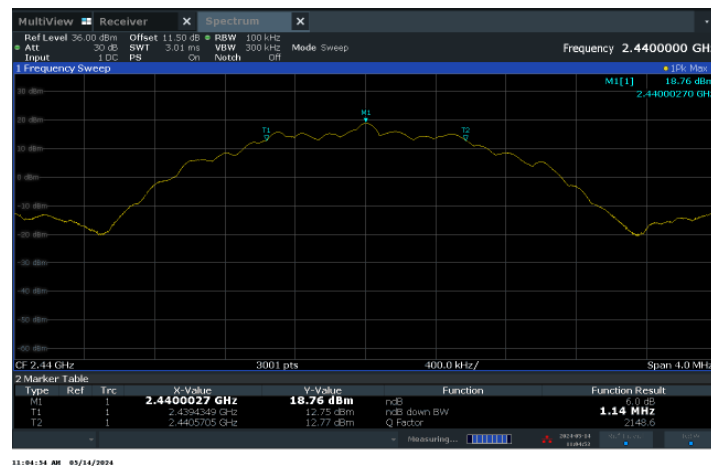


Figure 9 – 6dB Bandwidth – 2440 MHz



Figure 10 – 6dB Bandwidth – 2480 MHz

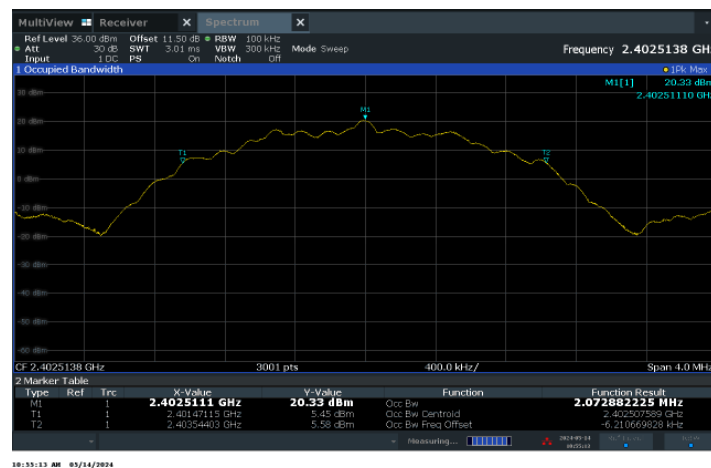


Figure 11 – 99% Bandwidth – 2402 MHz

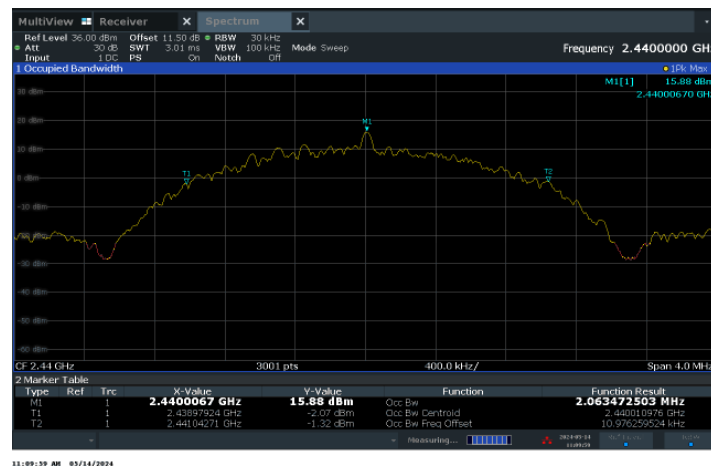


Figure 12 – 99% Bandwidth – 2440 MHz



Figure 13 – 99% Bandwidth – 2480 MHz

4.1.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.2 Peak Conducted Output Power

Test Date: May 14, 2024
Temperature (°C) 21.8
Relative Humidity (%) 53.6
Barometric Pressure (kPa) 101.0

Initials: MX

4.2.1 Limits

The maximum peak conducted output power of the intentional radiator shall not exceed 1 Watt (+30dBm) for systems using digital modulation in the 902–928MHz, 2400–2483.5MHz, and 5725–5850MHz bands. The maximum conducted output power is the highest total transmit power occurring in any mode.

4.2.2 Test Procedure

Tested according to ANSI C63.10 Section 11.9.1.

The test was performed using a spectrum analyzer with a resolution bandwidth greater than the DTS bandwidth.

- Set RBW $\geq$ DTS Bandwidth and VBW $\geq$ $[3 \times \text{RBW}]$.
- Set Span to 1.5 times the DTS Bandwidth.
- Detector = Peak and Trace Mode = Max Hold.
- Sweep = Auto Couple.
- Use the peak marker function to determine the maximum level.

The RF output of the DUT was connected to the spectrum analyzer with sufficient attenuation in front and the total path loss was set as reference offset to correct the final reading.

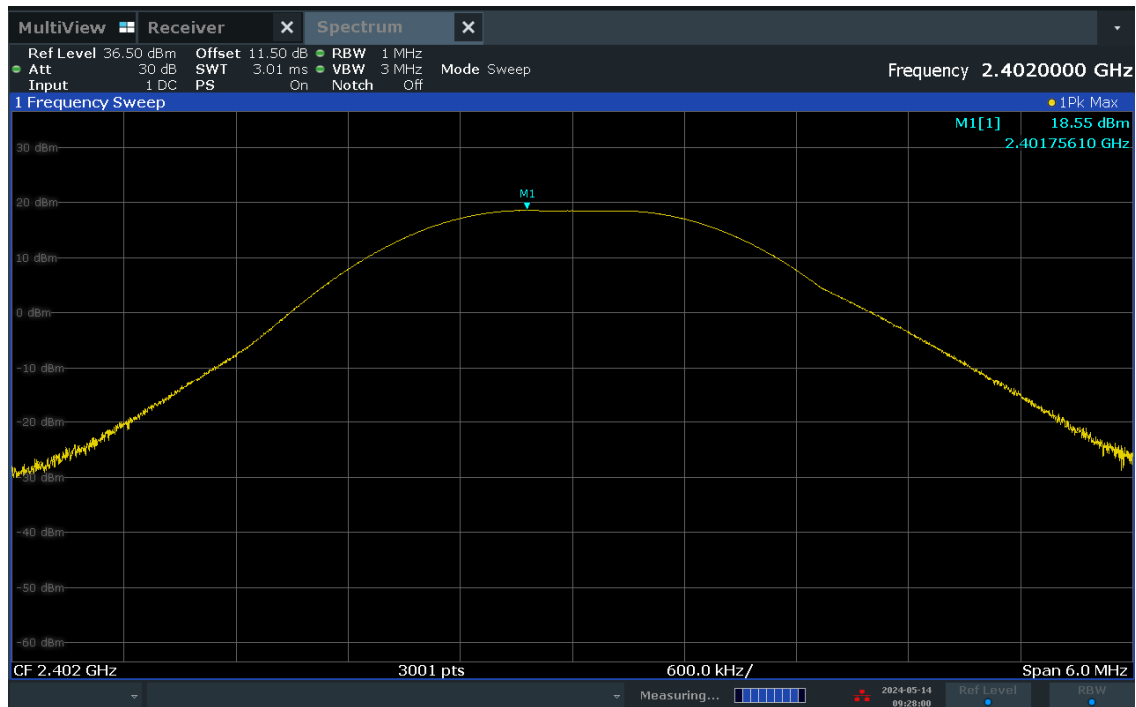
4.2.3 Test Results

The EUT peak power is below 30 dBm (1 W).

1 MBPS					
Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)	Limit (dBm)	Test Result
Low	2402	18.55	71.61	30	Pass
Mid	2440	19.62	91.62	30	Pass
High	2480	20.11	102.57	30	Pass

2 MBPS					
Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)	Limit (dBm)	Test Result
Low	2402	18.79	75.68	30	Pass
Mid	2440	18.84	76.56	30	Pass
High	2480	18.69	73.96	30	Pass

4.2.3.1. 1 MBPS Plots



09:28:00 AM 05/14/2024

Figure 14 – Peak Power - Low Channel

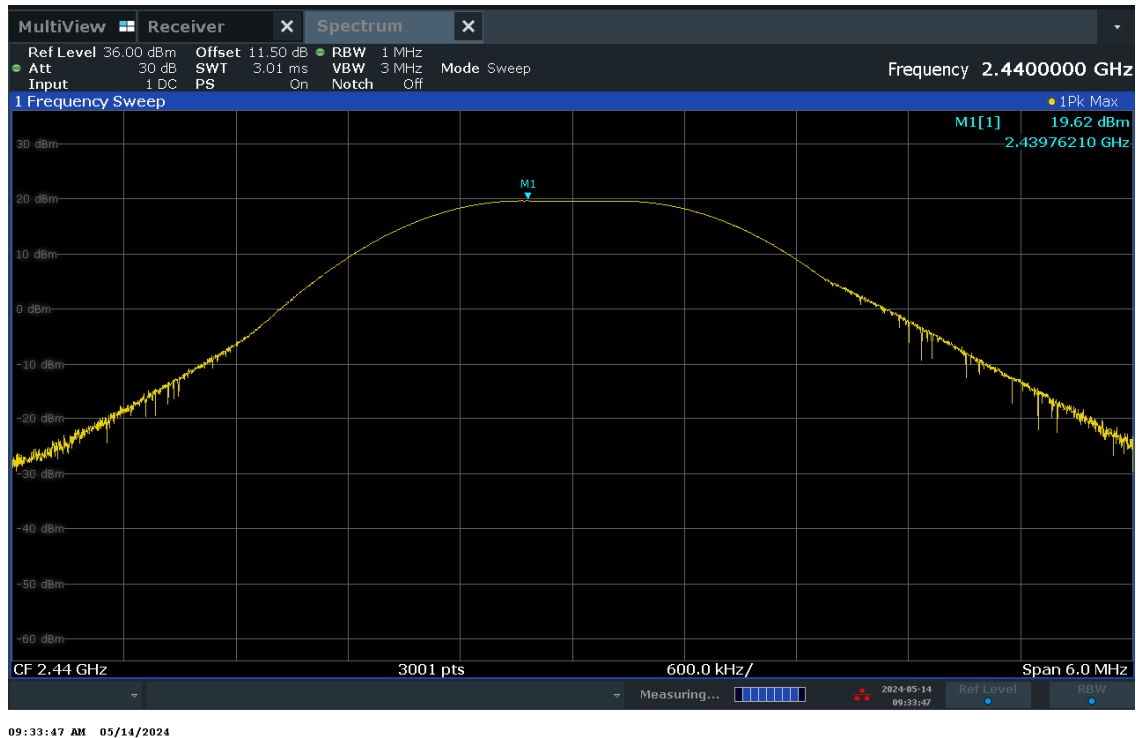


Figure 15 – Peak Power - Mid Channel

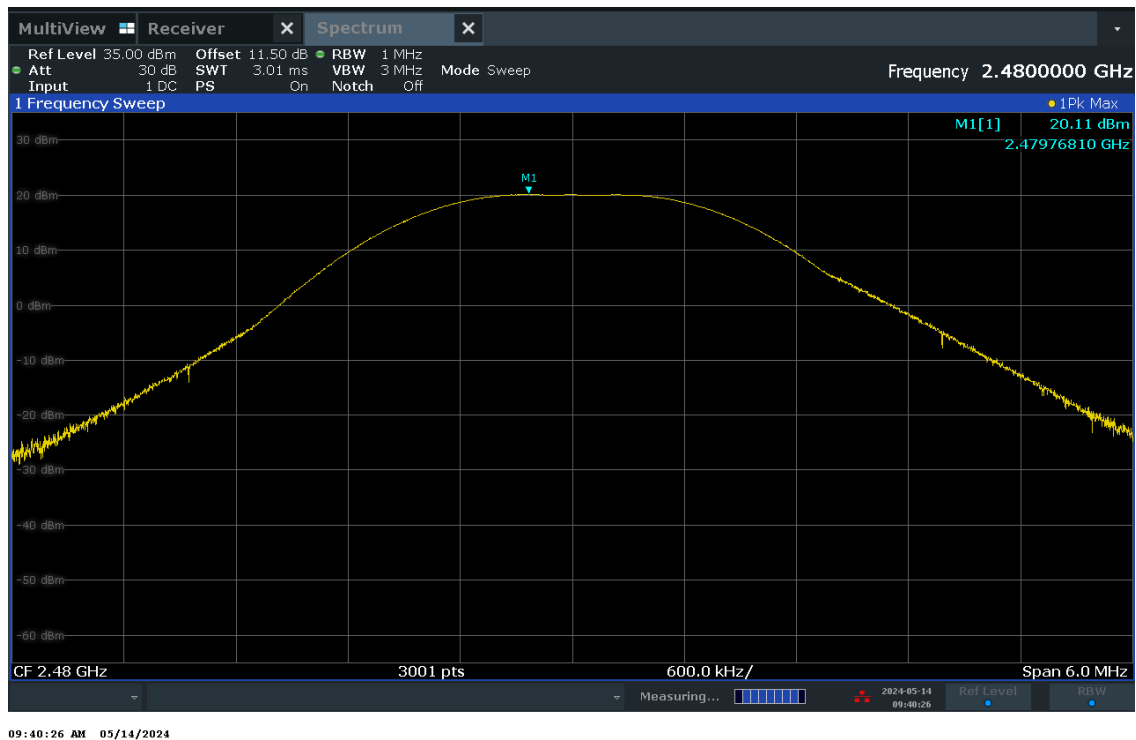


Figure 16 – Peak Power - High Channel

4.2.3.2. 2 MBPS Plots

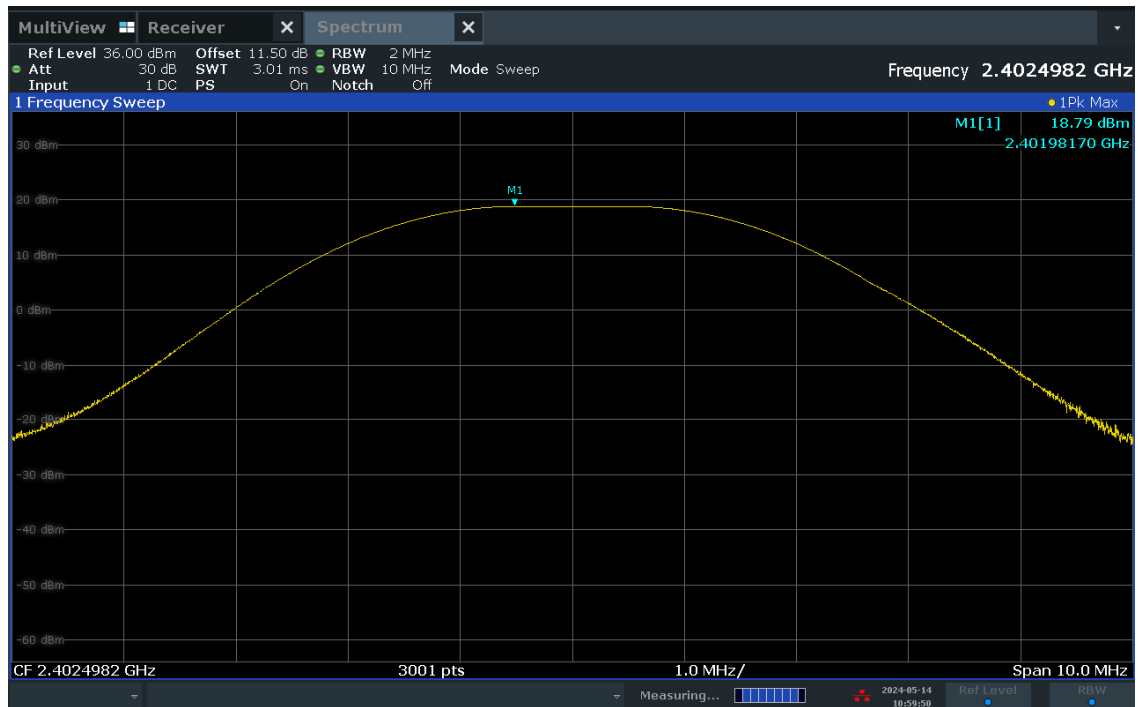


Figure 17 – Peak Power - Low Channel

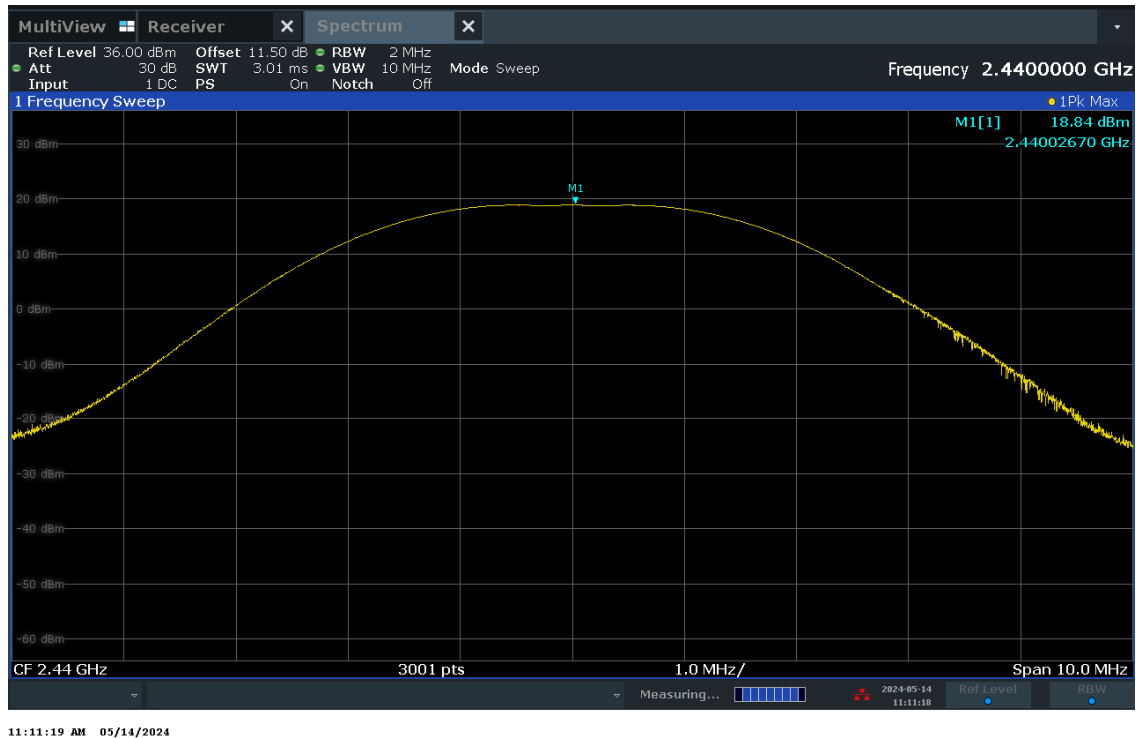


Figure 18 – Peak Power - Mid Channel

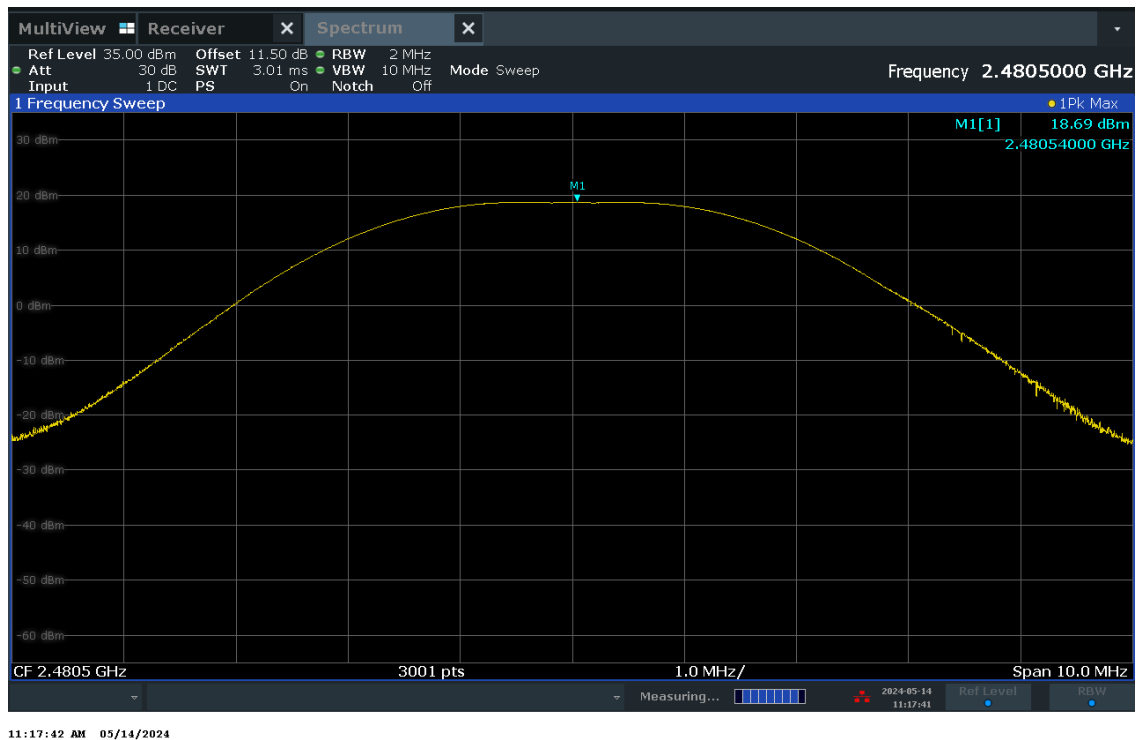


Figure 19 – Peak Power - High Channel

4.2.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.3 Power Spectral Density

Test Date: May 14, 2024
Temperature (°C) 21.8
Relative Humidity (%) 53.6
Barometric Pressure (kPa) 101.0

Initials: MX

4.3.1 Limits

For digitally modulated systems, the power spectral density (PSD) conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.3.2 Test Procedure

Tested according to ANSI C63.10 Section 11.10

- f) Set RBW = 3kHz and VBW $\geq [3 \times \text{RBW}]$.
- g) Set Span to 1.5 times the DTS Bandwidth.
- h) Detector = Peak and Trace Mode = Max Hold.
- i) Sweep = Auto Couple.
- j) Use the peak marker function to determine the maximum level.

The RF output of the DUT was connected to the spectrum analyzer with sufficient attenuation in front and the total path loss was set as reference offset to correct the final reading.

4.3.3 Test Results

The DUT meet the 8 dBm/3kHz power spectral density limit.

1 MBPS				
Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Test Result
Low	2402	5.07	8	Pass
Mid	2440	3.62	8	Pass
High	2480	4.93	8	Pass

2 MBPS				
Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Test Result
Low	2402	0.71	8	Pass
Mid	2440	0.82	8	Pass
High	2480	0.73	8	Pass

4.3.3.1. 1 MBPS

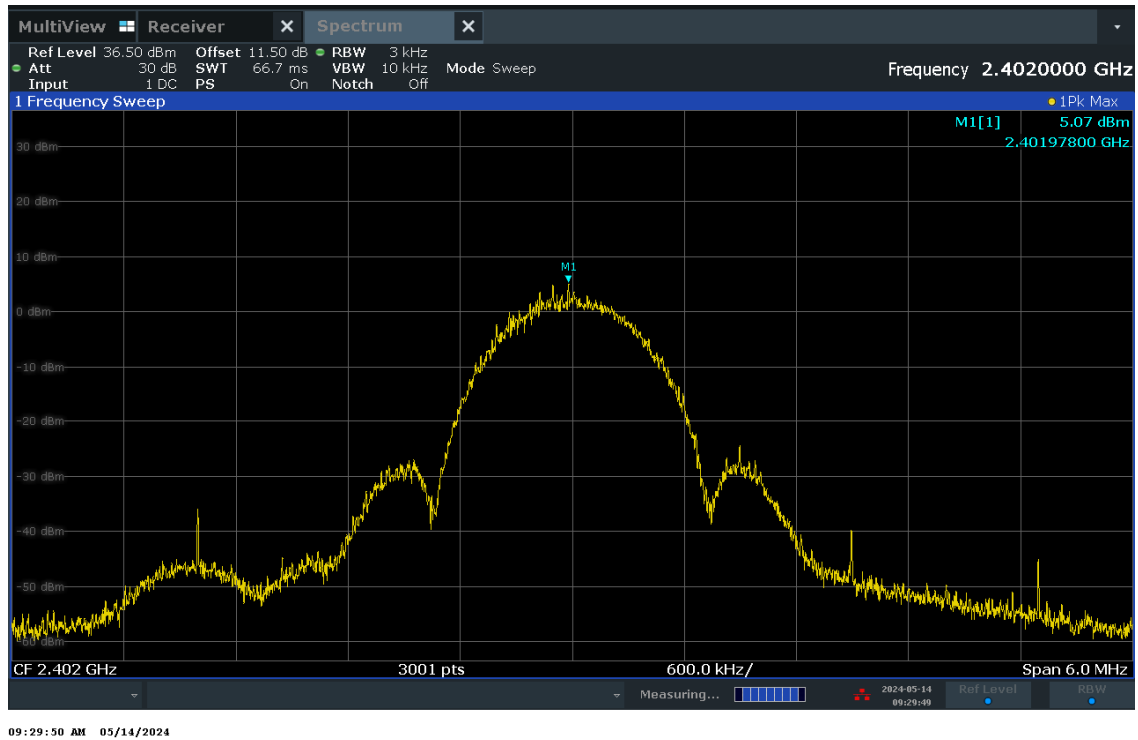


Figure 20 – PSD - Low Channel

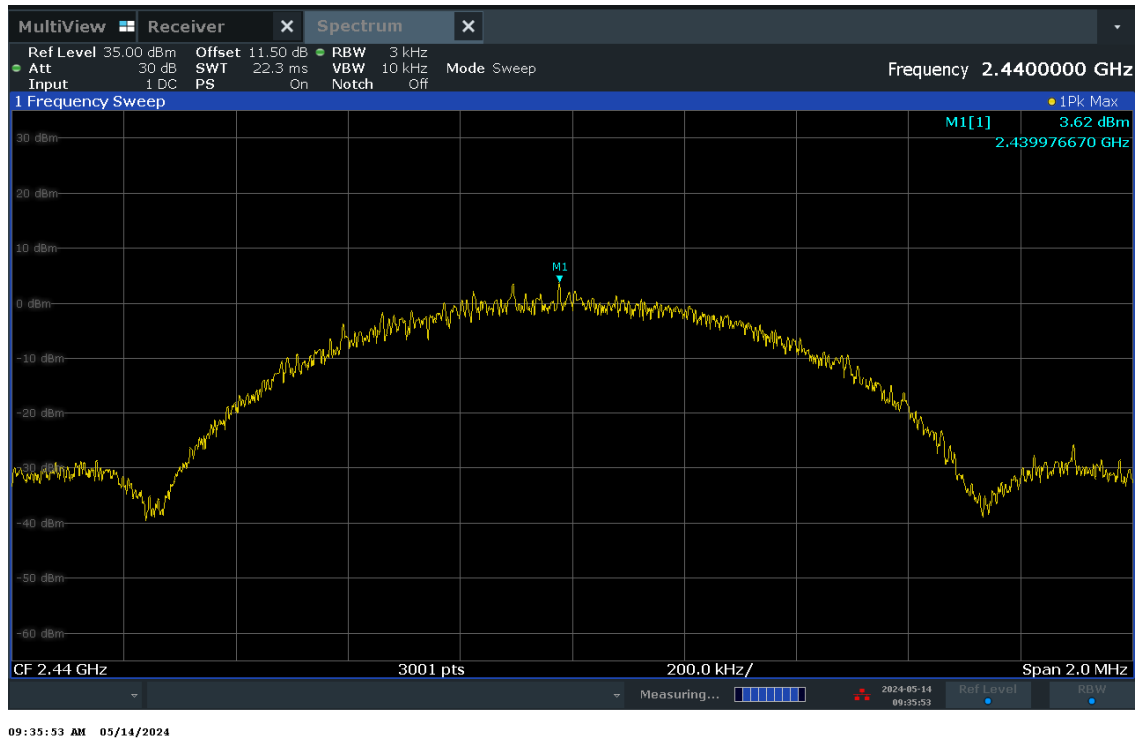


Figure 21 – PSD - Mid Channel

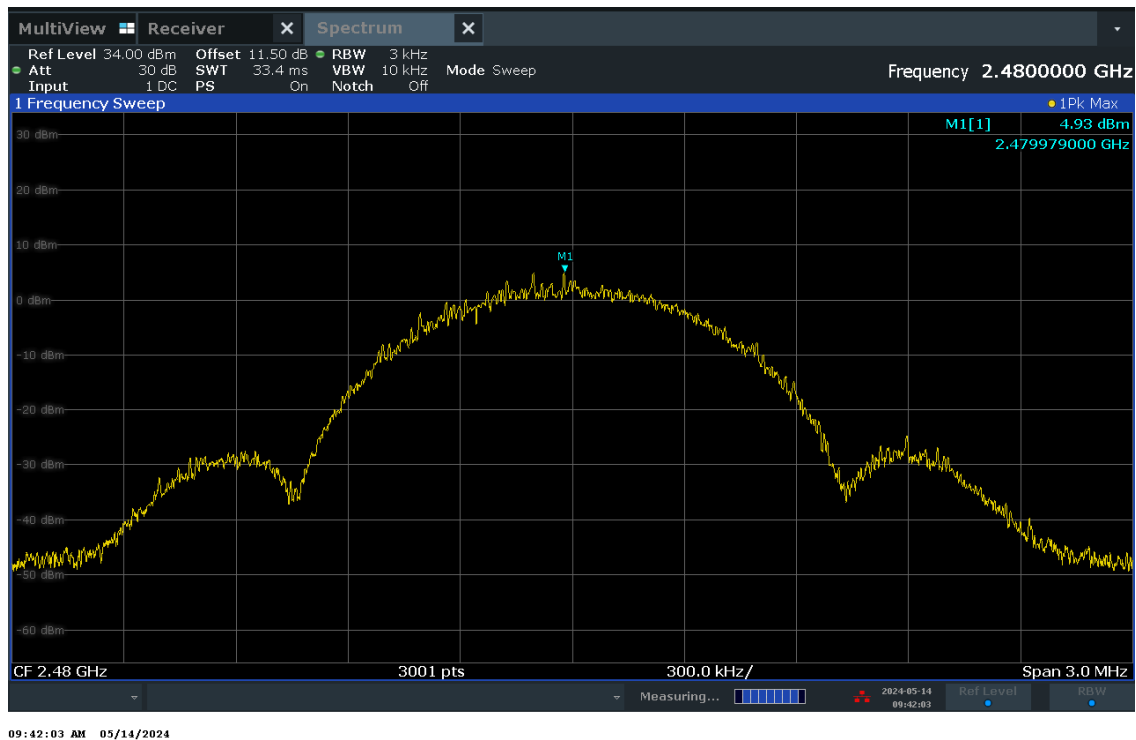


Figure 22 – PSD - High Channel

4.3.3.2. 2 MBPS

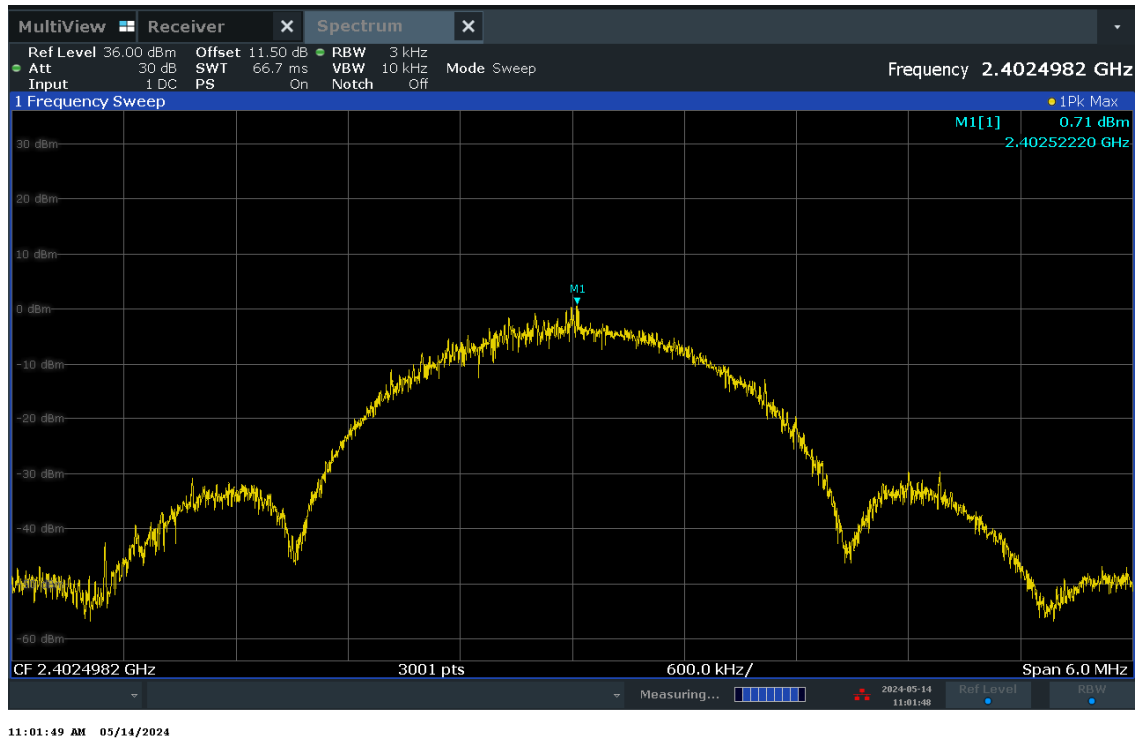


Figure 23 – PSD - Low Channel

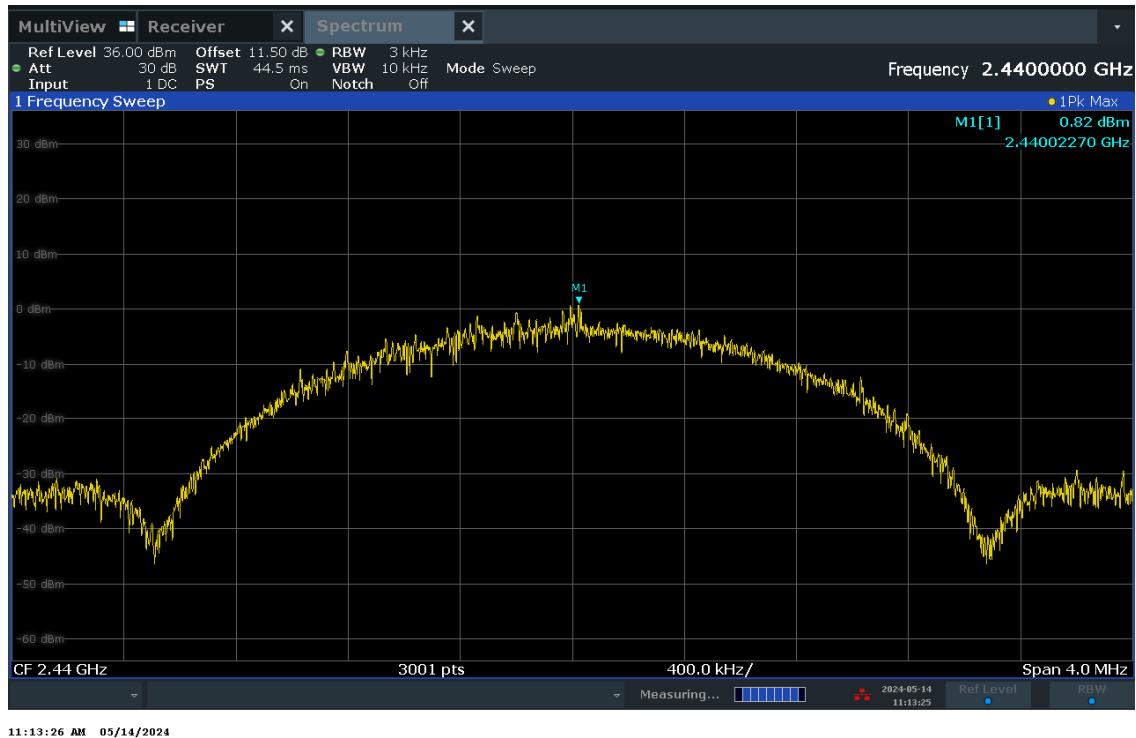


Figure 24 – PSD - Mid Channel

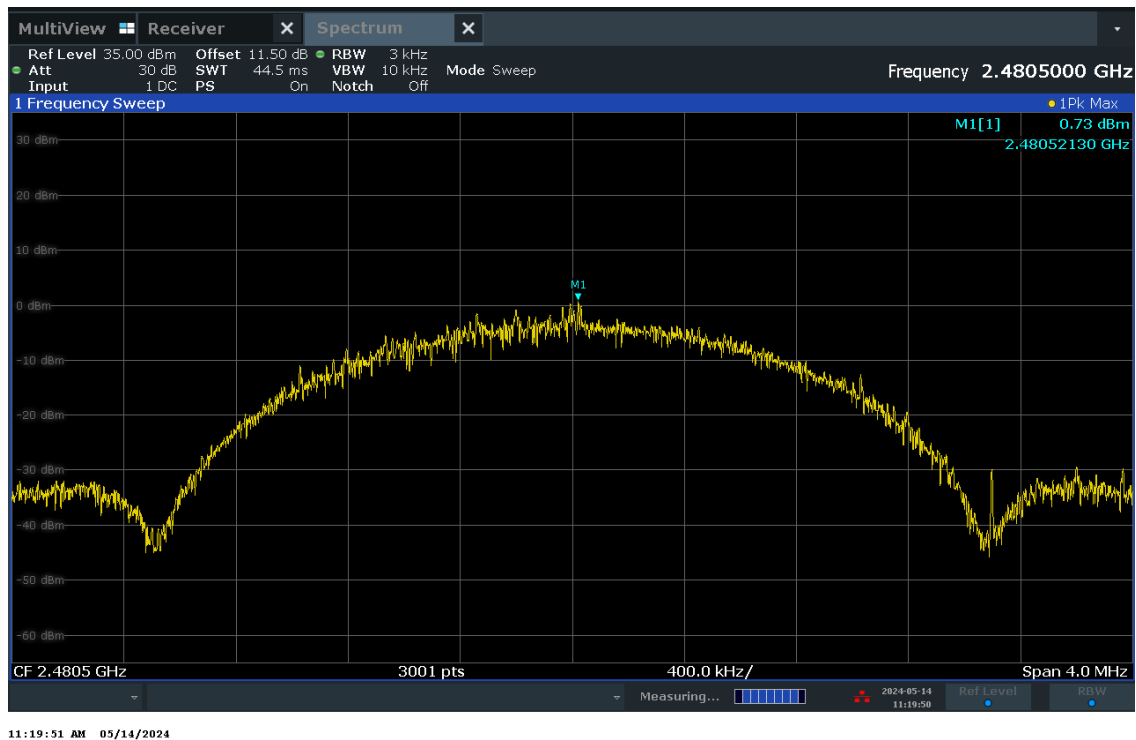


Figure 25 – PSD - High Channel

4.3.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.4 Spurious Out of Band Emissions (-20dBc)

Test Date:	May 14, 2024
Temperature (°C)	21.8
Relative Humidity (%)	53.6
Barometric Pressure (kPa)	101.0

Initials: MX

4.4.1 Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required shall be 30dB instead of 20dB.

4.4.2 Test Procedure

Tested according to ANSI C63.10 Section 11.11

For the reference level measurement:

- Set RBW = 100kHz and VBW $\geq [3 \times \text{RBW}]$.
- Detector = Peak and Trace Mode = Max Hold.
- Sweep = Auto Couple.
- Span set to ≥ 1.5 DTS bandwidth.
- Use the peak marker function to determine the maximum level.

For the out of band emission measurement

- Set the start and stop frequency to encompass the frequency range to be measured.
- Set RBW = 100kHz and VBW $\geq [3 \times \text{RBW}]$.
- Detector = Peak and Trace Mode = Max Hold.
- Sweep = Auto Couple.
- Use the peak marker function to determine the maximum level.

The RF output of the DUT was connected to the spectrum analyzer with sufficient attenuation in front and the total path loss was set as reference offset to correct the final reading.

4.4.3 Test Results

The DUT met the 20dB below carrier requirement for out of band emissions.

4.4.3.1. 1 MBPS

1 MBPS			
Channel	Frequency (MHz)	Peak PSD w/ RBW=100 kHz (dBm)	20 dBc Limit (dBm)
Low	2402	18.49	-1.51
Mid	2440	19.14	-0.86
High	2480	19.52	-0.48

The highest peak power in 100 kHz is 19.52 dBm; therefore, the 20 dBc limit is -0.48 dBm.

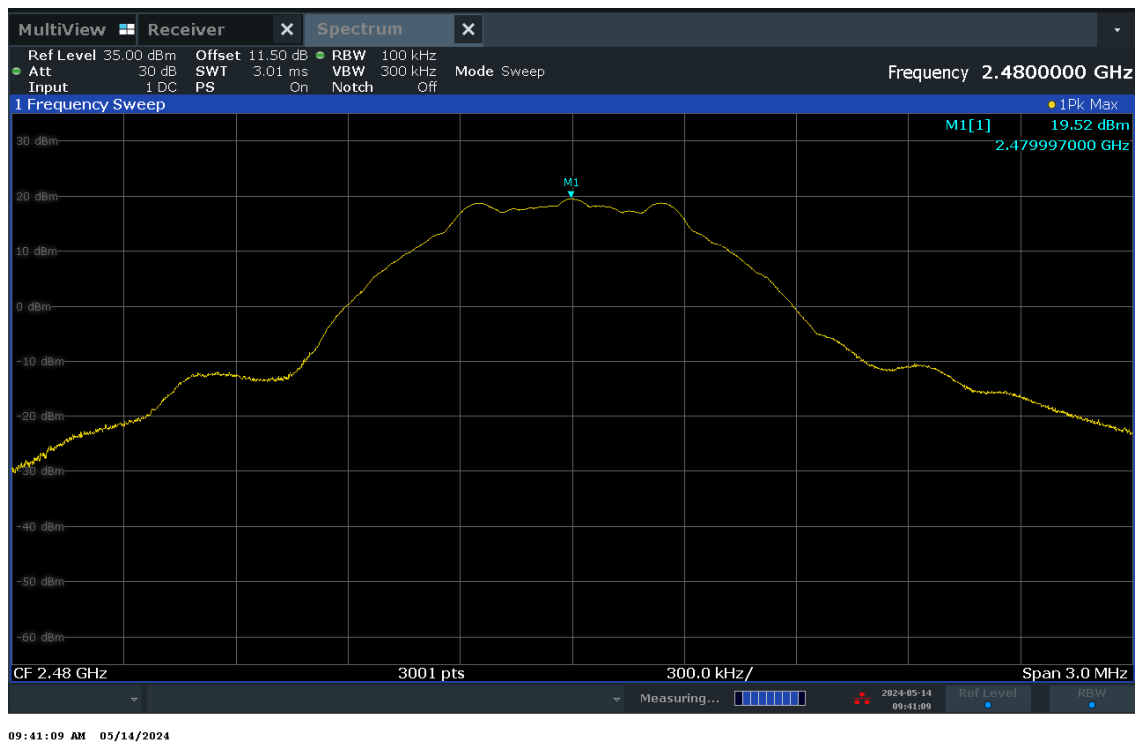


Figure 26 – -20dBc Reference Level - High Channel

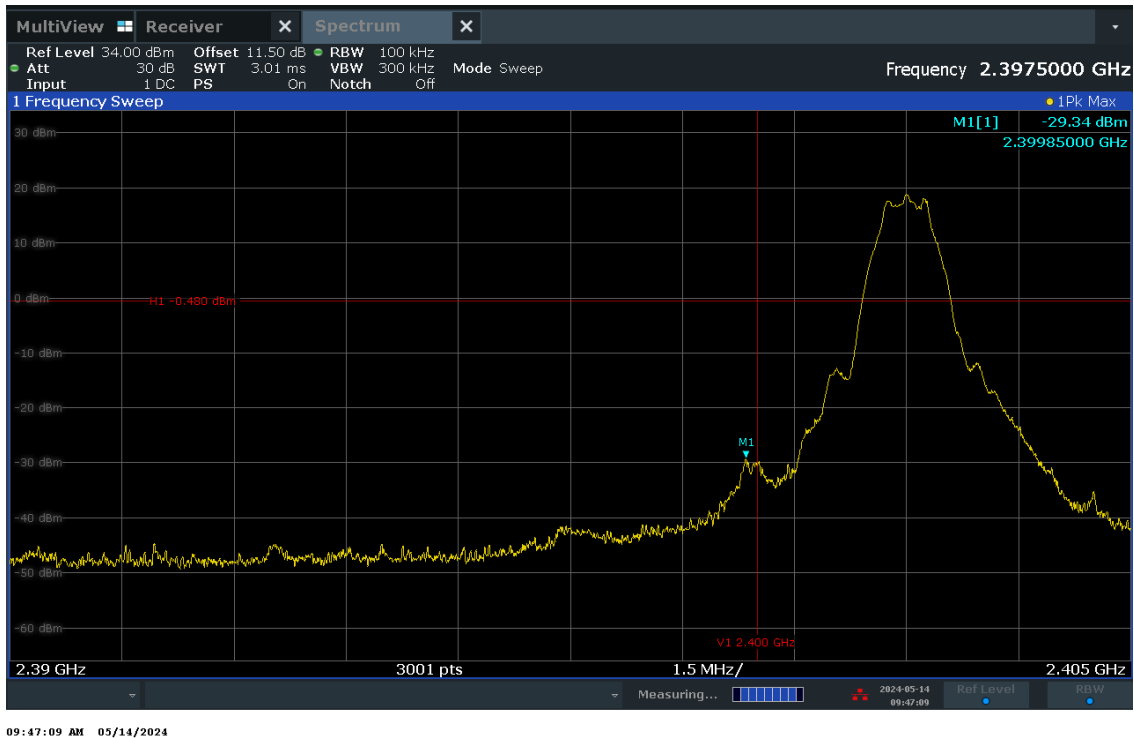


Figure 27 – -20dBc Band Edge - Low Channel

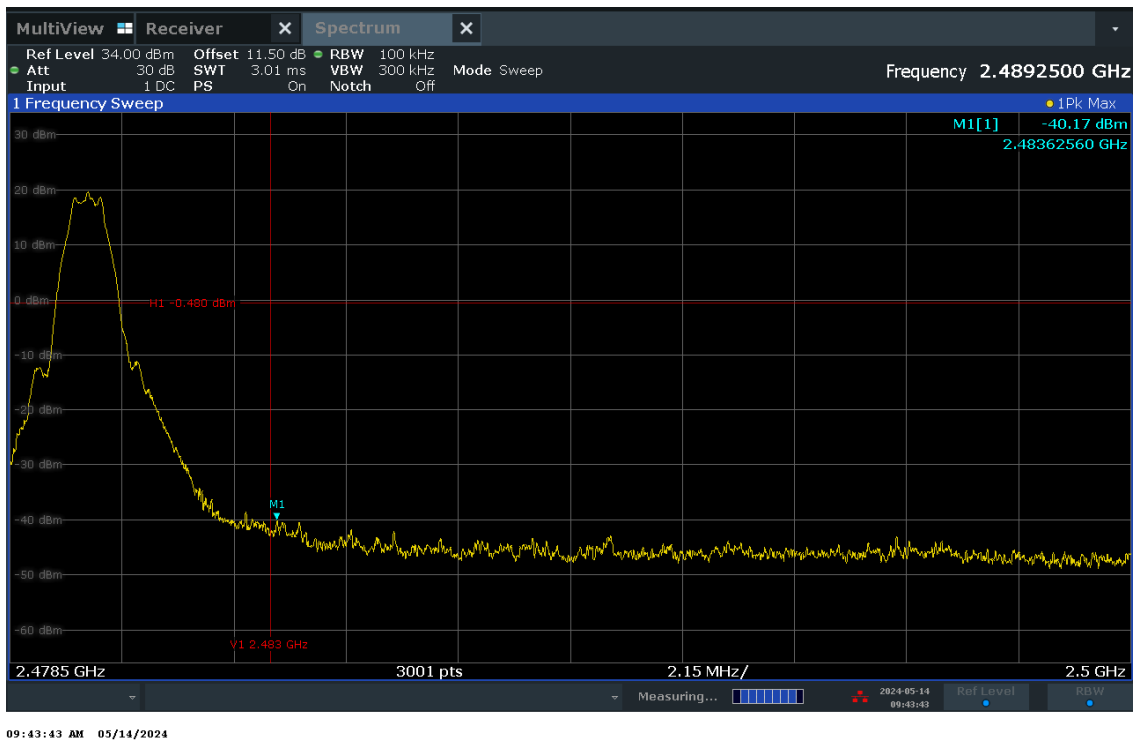
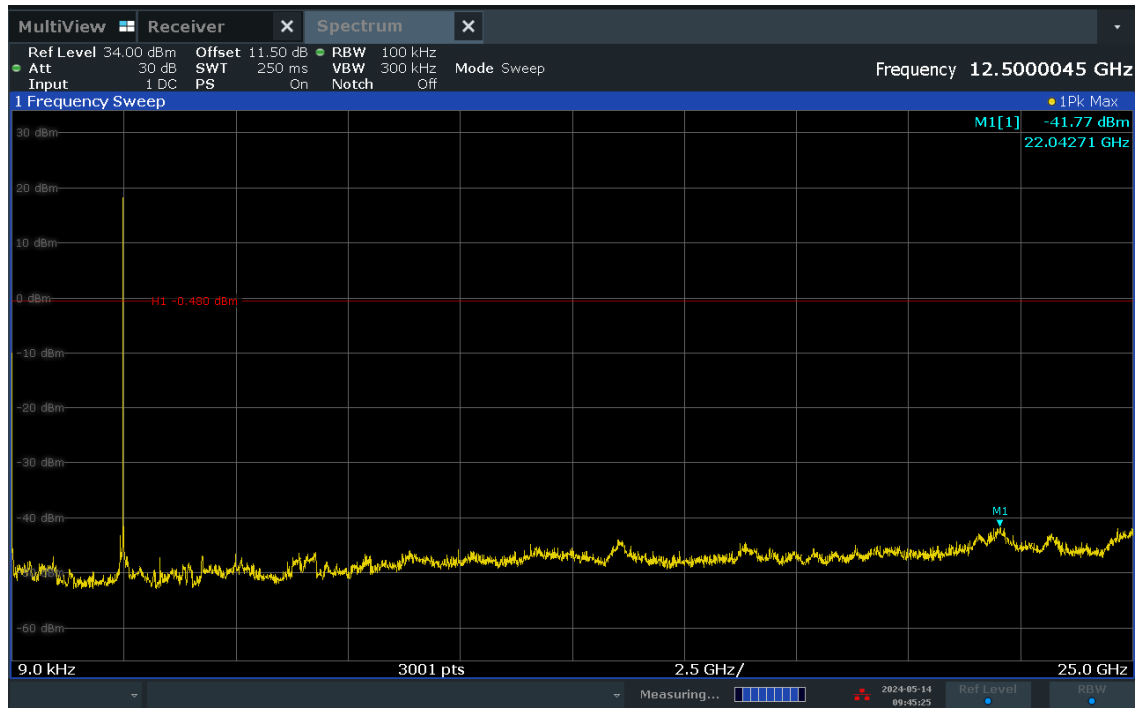


Figure 28 – -20dBc Band Edge - Low Channel



09:45:25 AM 05/14/2024

Figure 29 – -20dBc Low Channel 9kHz – 25 GHz

4.4.3.2. 2 MBPS

2 MBPS			
Channel	Frequency (MHz)	Peak PSD w/ RBW=100 kHz (dBm)	20 dBc Limit (dBm)
Low	2402	18.67	-1.33
Mid	2440	18.87	-1.13
High	2480	18.86	-1.14

The highest peak power in 100 kHz is 18.86 dBm; therefore, the 20 dBc limit is -1.14 dBm.

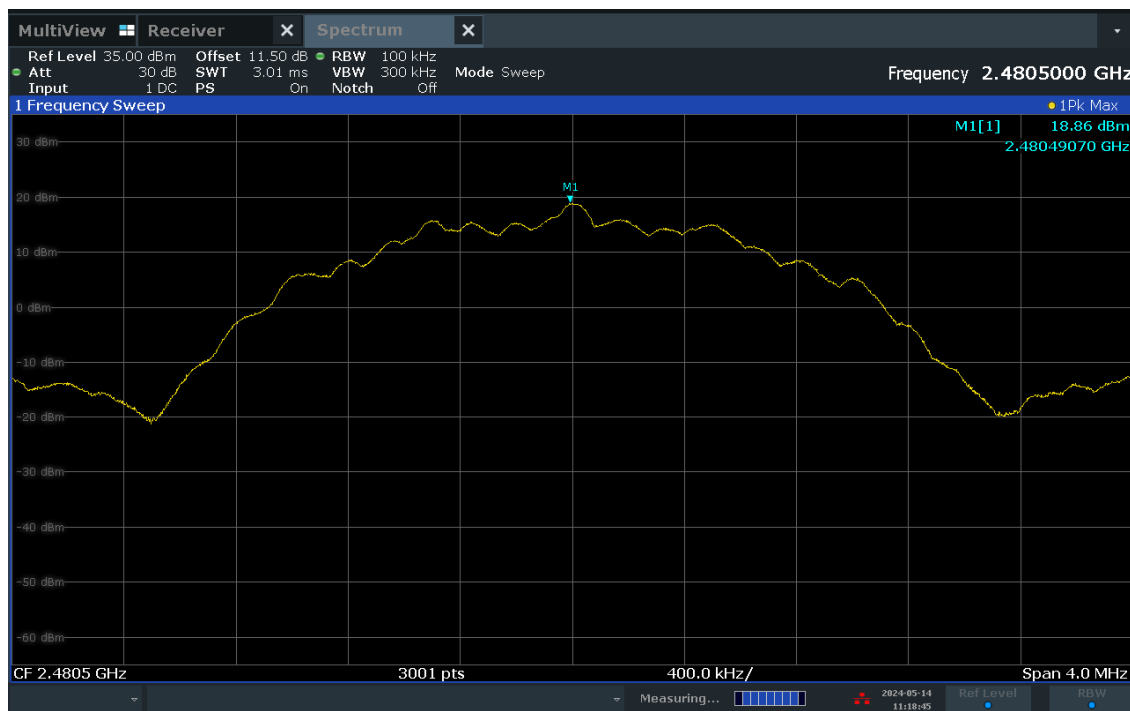


Figure 30 – -20dBc Reference Level - High Channel

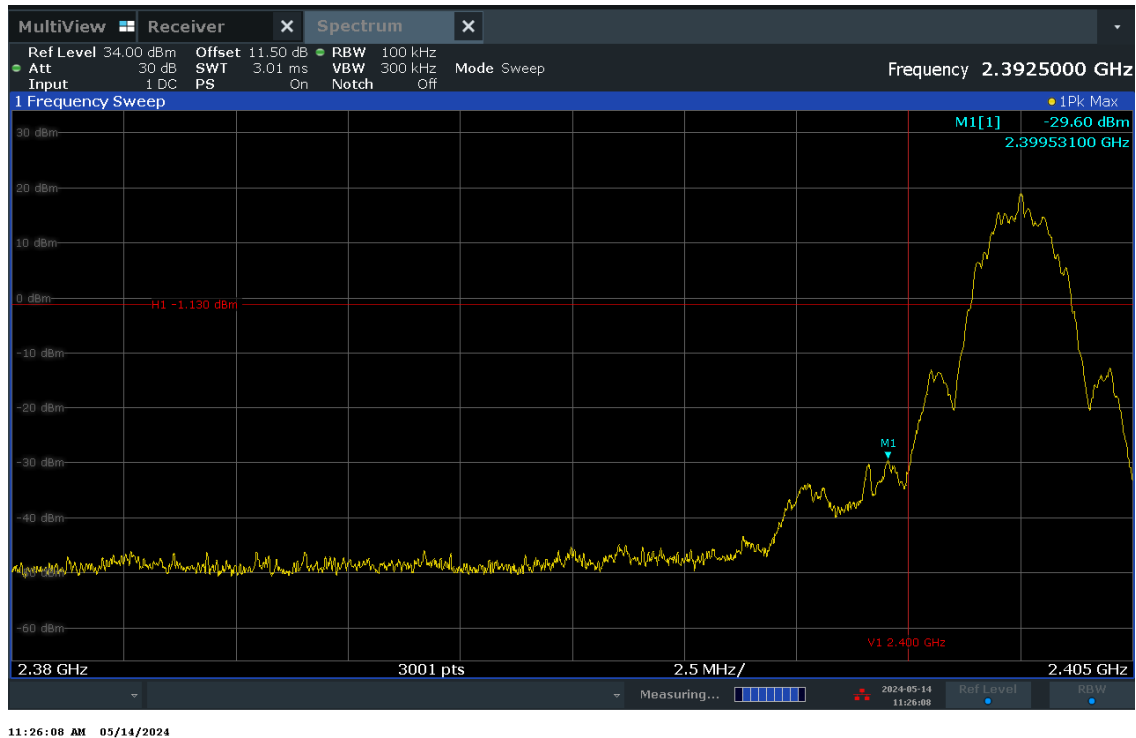


Figure 31 – -20dBc Band Edge - Low Channel

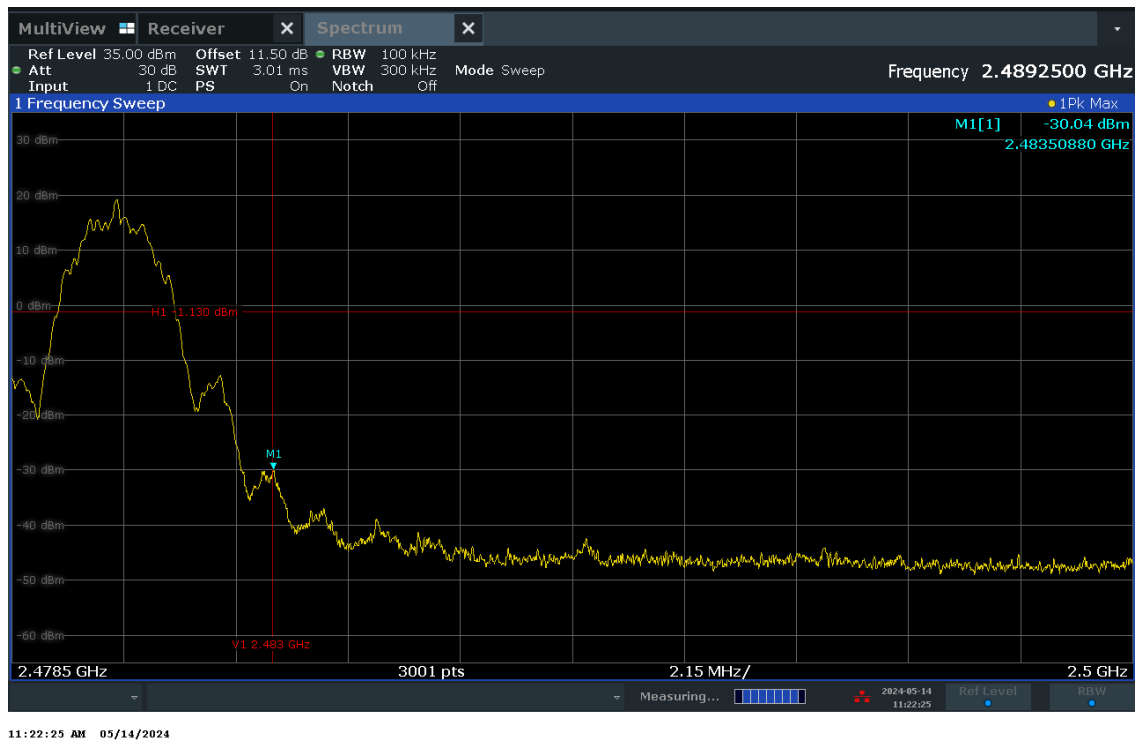


Figure 32 – -20dBc Band Edge - Low Channel

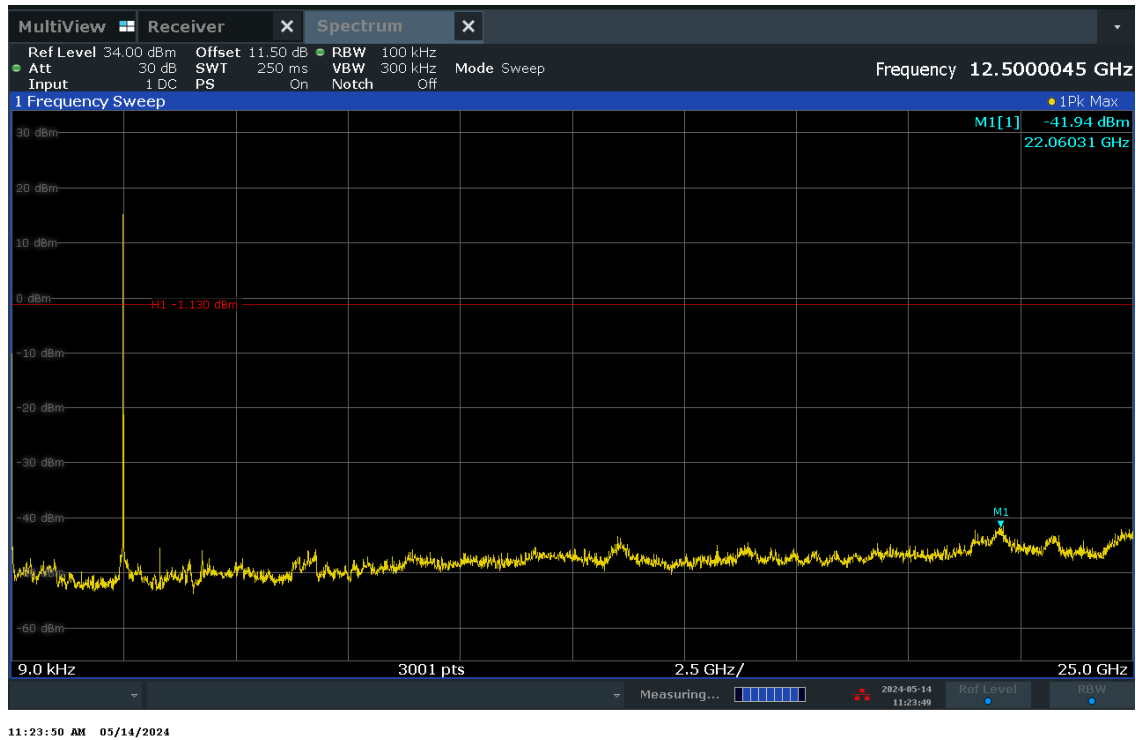


Figure 33 – -20dBc Low Channel 9kHz – 25 GHz

4.4.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.5 Transmitter Spurious Radiated Emissions

Test Date: May 6 – 13, 2024
Temperature (°C) 20.8 - 21.7
Relative Humidity (%) 42.8 - 54.7
Barometric Pressure (kPa) 100.4 - 54.7

Initials: MX

4.5.1 Limits

Any radiated emissions which fall in the restricted bands, as defined in FCC 15.205(a), must comply with the general radiated emission limits specified in FCC 15.209(a). Other emissions shall be at least 20dB below the highest level of the intentional transmitter.

Base Standard(s): FCC Subpart C 15.209 and RSS-Gen Section 8.9.

Frequency Range (MHz)	Field Strength Limit		Field Strength at 3m (dBμV/m)	Detector Type / Measurement Bandwidth
	μV/m	Distance		
0.009 – 0.150	2400/F(kHz)	300	128.5 – 104.1	Quasi-Peak‡ / 200Hz
0.150 – 0.490	2400/F(kHz)	300	104.1 – 93.8	Quasi-Peak‡ / 9kHz
0.490 – 1.705	24000/F(kHz)	30	73.8 – 63.0	Quasi-Peak / 9kHz
1.705 – 30	30	30	69.5	Quasi-Peak / 9kHz
30 – 88	100	3	40.0	Quasi-Peak / 120kHz
88 – 216	150	3	43.5	Quasi-Peak / 120kHz
216 – 960	200	3	46.0	Quasi-Peak / 120kHz
960 – 1000	500	3	54.0	Quasi-Peak / 120kHz
Above 1000	500	3	54.0	Average / 1MHz
Above 1000	5000	3	74.0	Peak / 1MHz

‡The emission limits below 1GHz shown in the above table are based on measurements employing a CISPR Quasi-Peak detector except for the frequency bands 9-90 kHz and 110-490 kHz. Radiated emission limits in these two bands are based on measurements employing an average detector.

As per ANSI C63.10 Section 4.1, if the Peak detector measurements do not exceed the Quasi-Peak limits, or Average limits where defined, then the DUT is considered to have passed the requirements.

4.5.2 Test Procedure

Tested according to ANSI C63.10 Section 6.3.

The device under test was setup inside a semi-anechoic chamber with remotely controlled turntable and antenna positioner at a 3m test distance. The DUT was placed on top of a 0.8m high non-conductive table above the reference ground plane for frequencies below 1GHz and 1.5m high for frequencies above 1GHz.

To determine the emission characteristics of the DUT, exploratory radiated emission scans were made while rotating the turntable 0° to 360° and using a Peak detector. The results were recorded in graphical form.

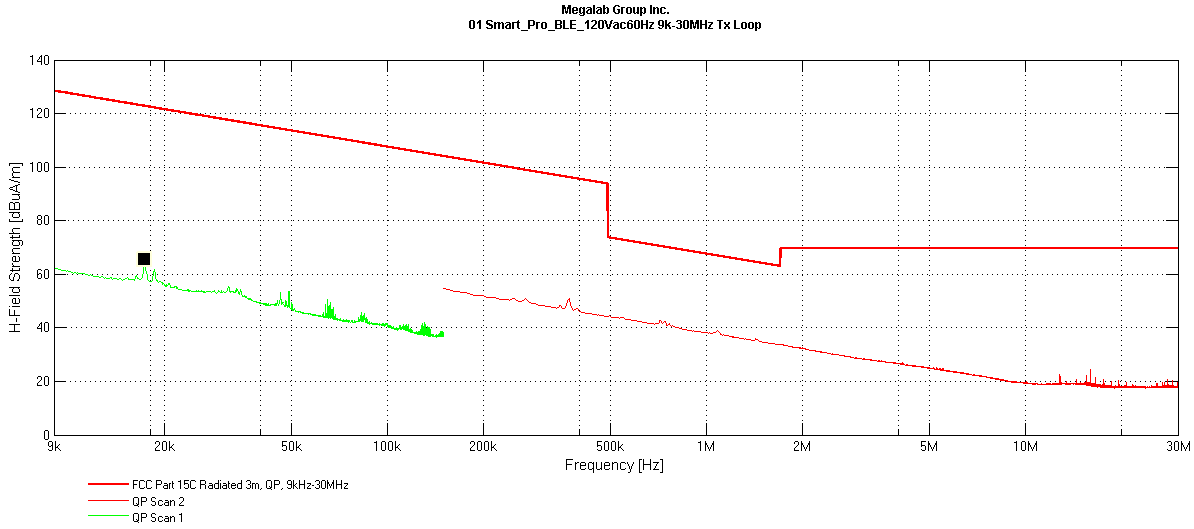
For each suspected emission, final measurements of the DUT radiated emissions with the Quasi-Peak, Average or Peak detector, as defined in the limit tables above, were made with the turntable azimuth rotated 0° to 360° and antenna height varied from 1m to 4m. The antenna was positioned to receive emissions in the vertical and horizontal polarizations such that the maximum radiated emission levels were detected.

As per FCC Part 15.33(a), the DUT was scanned to the 10th harmonic of the highest fundamental frequency.

Testing for 9 kHz – 30 MHz was performed with 3 orthogonal antenna polarities. The worst case results were present in this report.

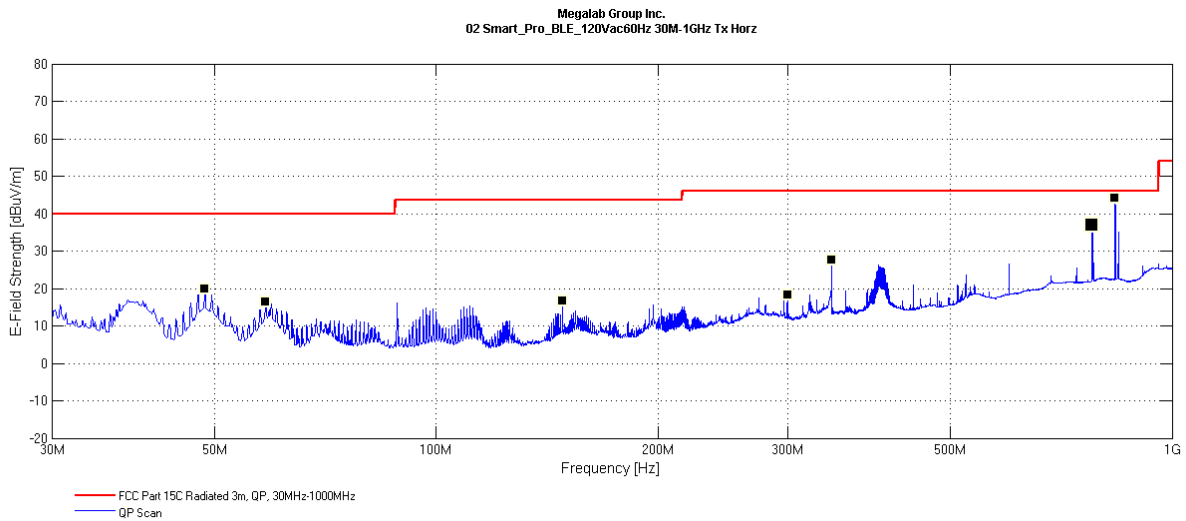
4.5.3 Test Results

Range:	9kHz to 30 MHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	XZ-Plane



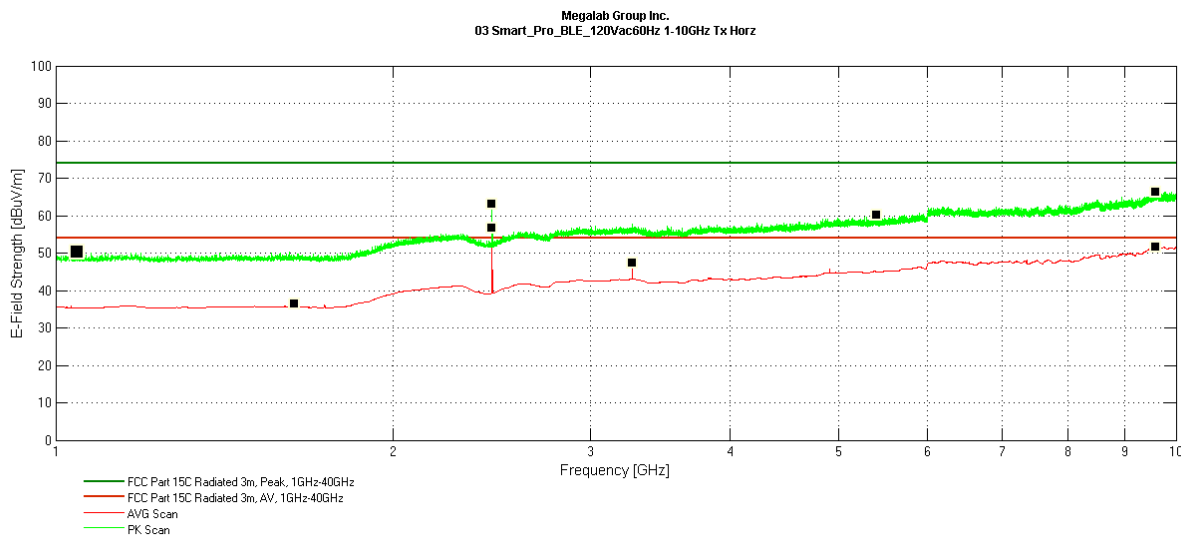
Remark: Quasi-Peak Emission Plot

Range:	30MHz to 1GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Horizontal



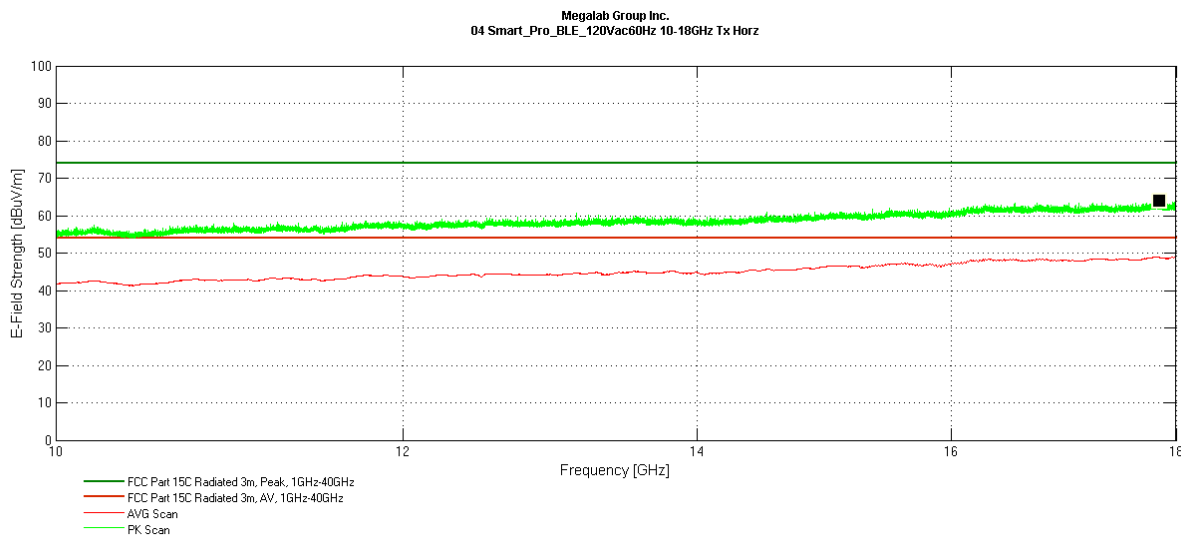
Remark: - Quasi-Peak Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	1GHz to 10GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Horizontal



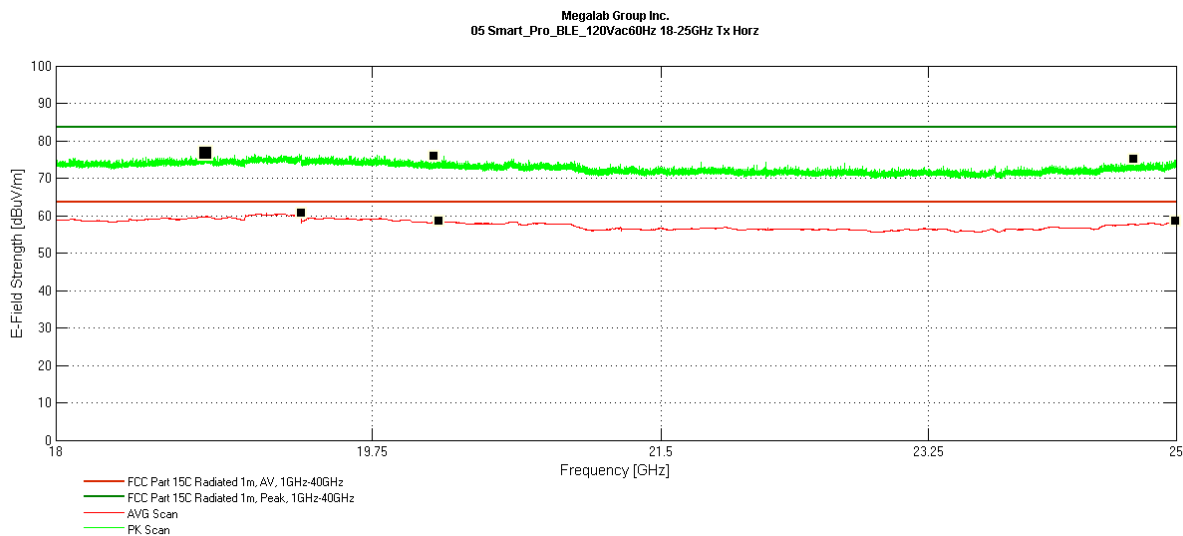
Remark: - **Peak** and **Average** Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	10GHz to 18GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Horizontal



Remark: - **Peak** and **Average** Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	18GHz to 25GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Horizontal

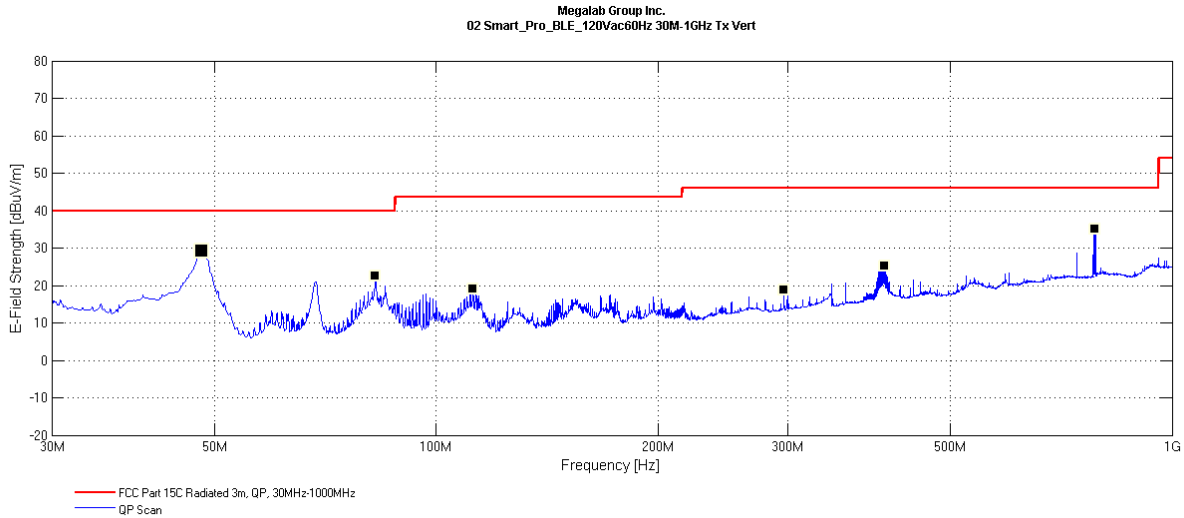


Remark: - **Peak** and **Average** Emission Plot

Horizontal Antenna Polarization							
Frequency (MHz)	Detector	Reading (dBμV)	Correction Factor (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
836.20	QP	41.6	2.4	44.1	46.0	2.0	Pass
778.00	QP	35.2	1.8	37.0	9.0	9.0	Pass
344.25	QP	34.2	-6.6	27.6	46.0	18.4	Pass
48.50	QP	35.7	-15.8	20.0	40.0	20.0	Pass
58.60	QP	32.2	-15.9	16.3	40.0	23.7	Pass
148.50	QP	30.0	-13.2	16.8	43.5	26.7	Pass

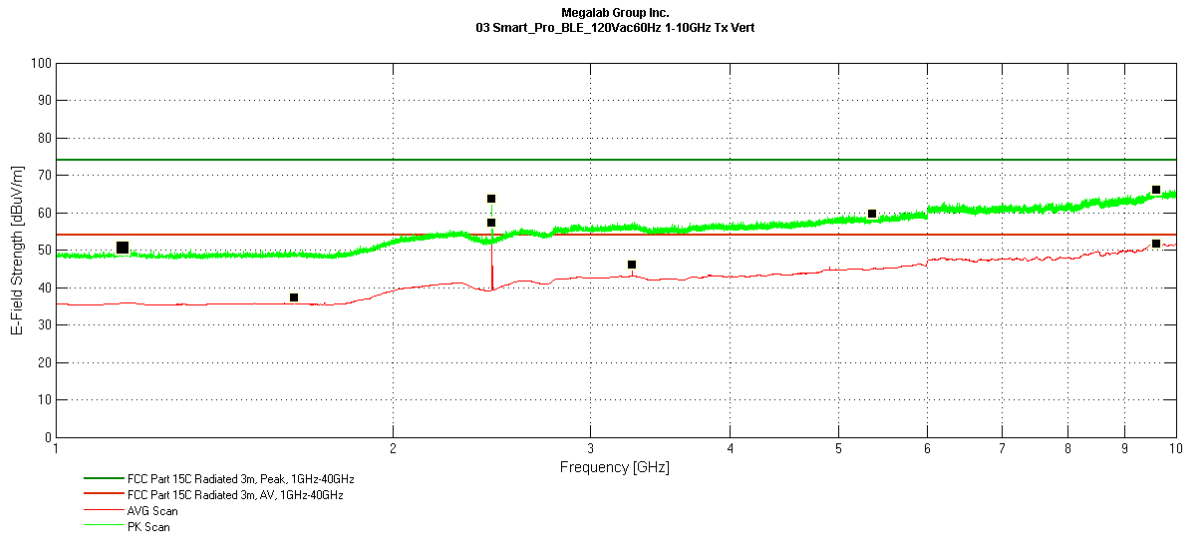
Horizontal Antenna Polarization – Harmonic Emissions							
Frequency (MHz)	Detector	Reading (dBμV)	Correction Factor (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
Low Channel							
4804	PEAK	49.9	0.8	50.7	74.0	23.3	Pass
4804	AVG	42.2	0.8	43.0	54.0	11.0	Pass
7206	PEAK	47.4	4.0	51.4	74.0	22.6	Pass
7206	AVG	36.3	4.0	40.3	54.0	13.7	Pass
Mid Channel							
4880	PEAK	49.8	1.1	50.9	74.0	23.1	Pass
4880	AVG	42.1	1.1	43.2	54.0	10.8	Pass
7320	PEAK	47.6	4.2	51.9	74.0	22.1	Pass
7320	AVG	36.3	4.2	40.5	54.0	13.5	Pass
High Channel							
4960	PEAK	48.9	1.4	50.3	74.0	23.7	Pass
4960	AVG	36.4	1.4	37.8	54.0	16.2	Pass
7440	PEAK	48.6	4.5	53.0	74.0	21.0	Pass
7440	AVG	36.7	4.5	41.2	54.0	12.8	Pass

Range:	30MHz to 1GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Vertical



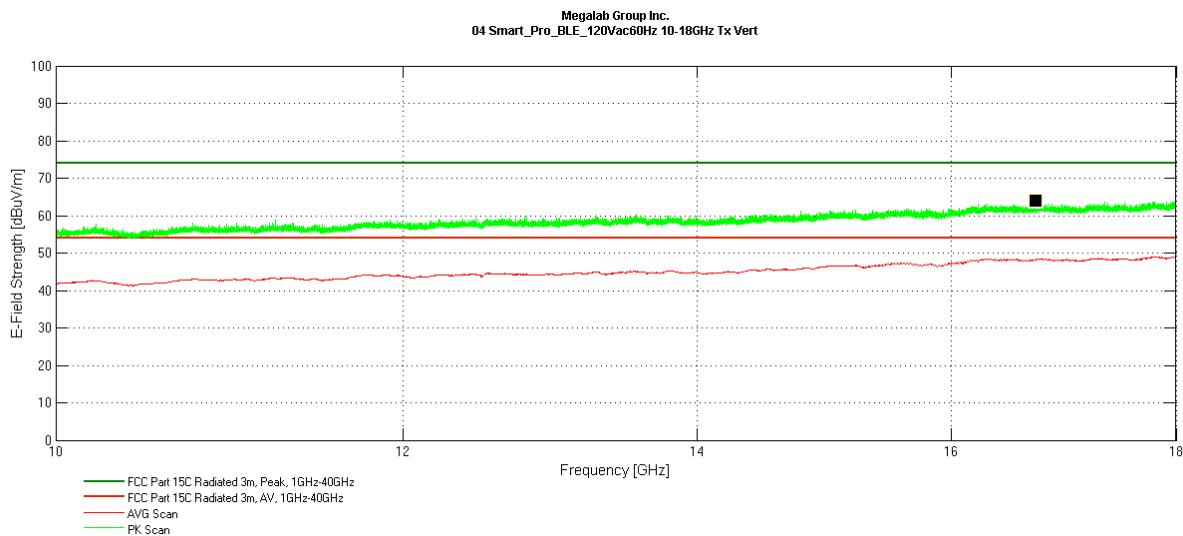
Remark: - Quasi-Peak Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	1GHz to 10GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Vertical



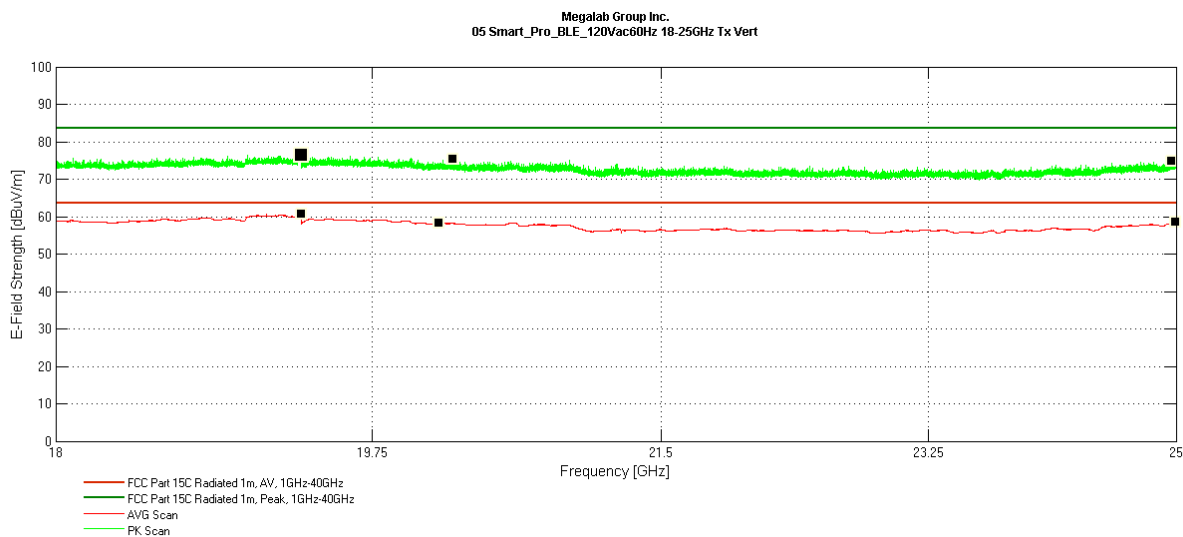
Remark: - **Peak** and **Average** Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	10GHz to 18GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Vertical



Remark: - **Peak** and **Average** Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	18GHz to 25GHz	Tx Frequency	2480 MHz
Test Voltage:	24Vac 60Hz	Antenna Polarization	Vertical



Remark: **Peak** and **Average** Emission Plot

Vertical Antenna Polarization							
Frequency (MHz)	Detector	Reading (dBμV)	Correction Factor (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
48.00	QP	44.7	-15.6	29.1	40.0	10.9	Pass
786.30	QP	33.0	2.0	35.0	46.0	11.0	Pass
82.65	QP	38.0	-15.5	22.4	40.0	17.6	Pass
406.10	QP	28.9	-3.7	25.2	46.0	20.8	Pass

Vertical Antenna Polarization – Harmonic Emissions							
Frequency (MHz)	Detector	Reading (dBμV)	Correction Factor (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
Low Channel							
4804	PEAK	49.7	0.8	50.5	74.0	23.5	Pass
4804	AVG	41.8	0.8	42.5	54.0	11.5	Pass
7206	PEAK	47.8	4.0	51.8	74.0	22.2	Pass
7206	AVG	36.1	4.0	40.1	54.0	13.9	Pass
Mid Channel							
4880	PEAK	50.0	1.1	51.1	74.0	22.9	Pass
4880	AVG	41.5	1.1	42.6	54.0	11.4	Pass
7320	PEAK	47.2	4.2	51.4	74.0	22.6	Pass
7320	AVG	35.3	4.2	39.5	54.0	14.5	Pass
High Channel							
4960	PEAK	48.3	1.4	49.7	74.0	24.3	Pass
4960	AVG	37.3	1.4	38.7	54.0	15.3	Pass
7440	PEAK	48.8	4.5	53.3	74.0	20.7	Pass
7440	AVG	36.8	4.5	41.2	54.0	12.8	Pass

4.5.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_132	EMI Test Receiver (v6.91.2)	Gauss Instruments	TDEMI X40	Nov 29, 2023	Nov 29, 2025
EQ_EMC_48	Loop Antenna	Com-Power	AL-130R	Apr 9, 2024	Apr 9, 2026
EQ_EMC_59	BiLog Antenna	ETS Lindgren	3142E	Apr 19, 2024	Apr 19, 2026
EQ_EMC_60	Horn Antenna	ETS Lindgren	3117	Apr 9, 2024	Apr 9, 2026
EQ_EMC_56	DRG Horn Antenna 18GHz-40GHz	A.H Systems	SAS-574	Apr 8, 2024	Apr 8, 2026
EQ_EMC_68	6dB Attenuator	Fairview Microwave	SA3NS-06	Apr 19, 2024	Apr 19, 2026
EQ_EMC_85	RF Cable <1GHz	Times Microwave	LMR-400	NCR	NCR
EQ_EMC_75	RF Cable >1GHz	MegaPhase	EMC2	NCR	NCR
EQ_EMC_123	Preamplifier 30MHz-9GHz	RF Bay	EPA-250T	Jan 23, 2024	Jan 23, 2026
EQ_EMC_42	Preamplifier 1GHz-18GHz	Com-Power	PAM-118A	Jan 17, 2024	Jan 17, 2026
EQ_EMC_43	Preamplifier 18GHz-40GHz	Com-Power	PAM-840A	Jan 31, 2024	Jan 31, 2026
EQ_EMC_108	2400 - 2500MHz Notch Filter	Micro-Tronics	BRM50702	NCR	NCR
EQ_EMC_149	Emission Software RE/CE	Gauss Instruments	EMI64k v6.31.2	NCR	NCR

4.6 Lower and Upper Band Edges

Test Date:	January 18/30, 2024
Temperature (°C)	20.7/ 20.4
Relative Humidity (%)	9.1 / 20.9
Barometric Pressure (kPa)	97.5 / 98.1

Initials: MX

4.6.1 Limits

Any radiated emissions which fall in the restricted bands, as defined in FCC 15.205(a), must comply with the general radiated emission limits specified in FCC 15.209(a).

4.6.2 Test Procedure

Tested according to ANSI C63.10 Section 11.12

The device under test was setup inside a semi-anechoic chamber with remotely controlled turntable and antenna positioner at a 3m test distance. The DUT was placed on top of a 0.8m high non-conductive table above the reference ground plane for frequencies below 1GHz and 1.5m high for frequencies above 1GHz.

For both the lower and upper radiated band edges, the radiated emission was first maximized on the center frequency of the low and high channels with the turntable azimuth rotated 0° to 360° and antenna height varied from 1m to 4m. Once maximized, the start and stop frequency were adjusted to capture that channel's lower and upper band edges inside the restricted bands.

The antenna was positioned to receive emissions in the vertical and horizontal polarizations such that the maximum radiated emission levels were detected.

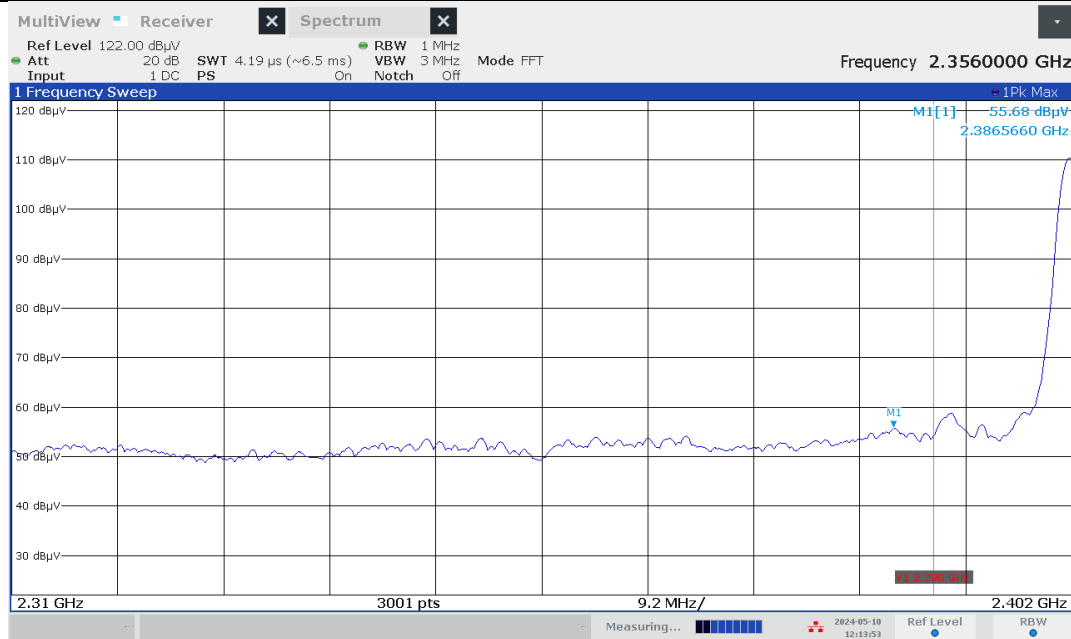
The radiated band edge measurements were made with the DUT in normal operation position.

4.6.3 Test Results – 1 MBPS

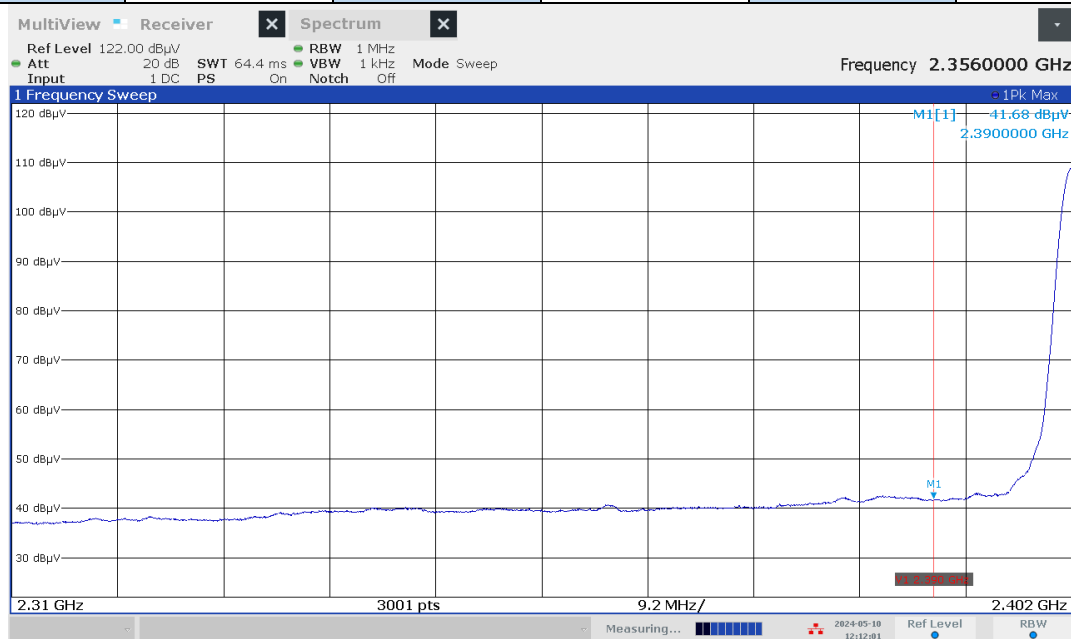
The DUT met the band edge requirements. Peak output power for low, mid and high channels were measured and the Plots Section below contains the maximum radiated emission levels captured on the spectrum analyzer at the band edges. The Final Measurements Section contains the final results with the correction factors added in.

4.6.3.1. Plots

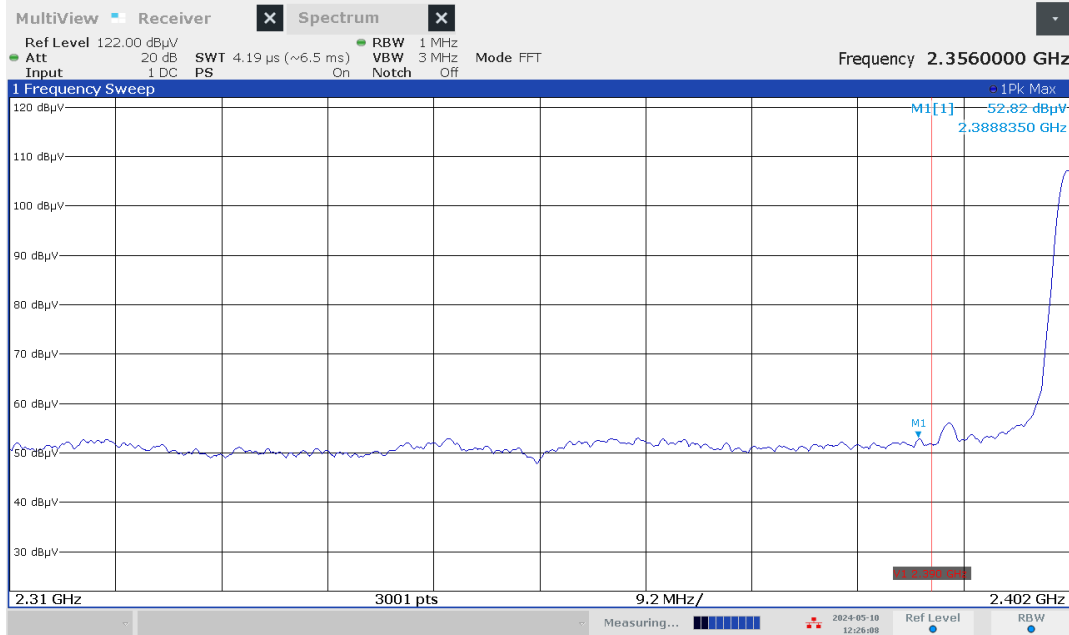
Tx Frequency	Low Channel	Antenna Polarization	Horizontal	Emission	Peak
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Tx Frequency	Low Channel	Antenna Polarization	Horizontal	Emission	Average
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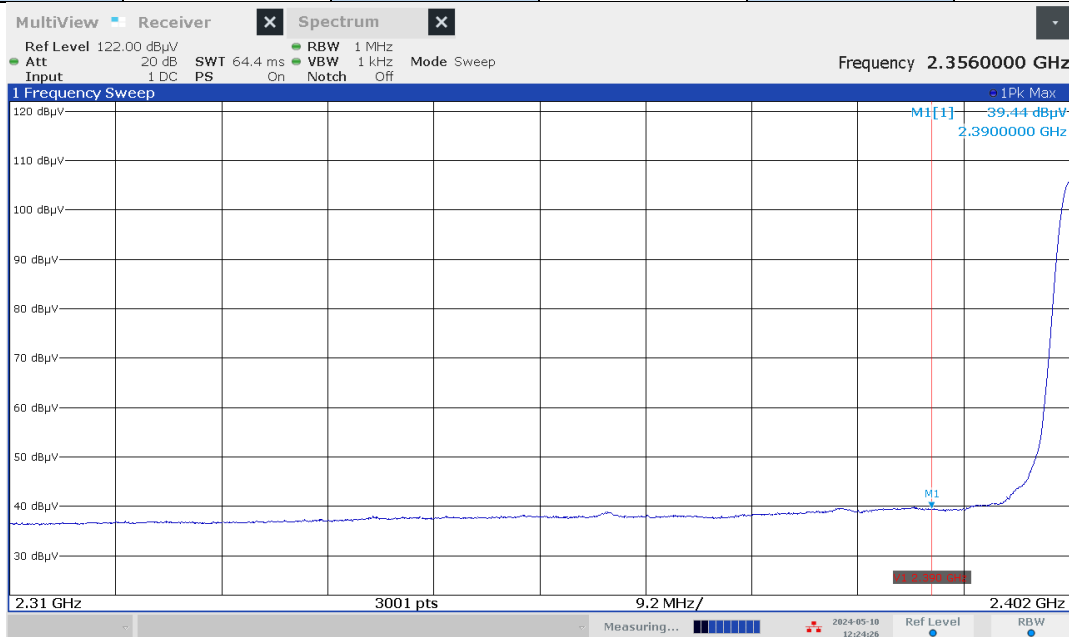


Tx Frequency	Low Channel	Antenna Polarization	Vertical	Emission	Peak
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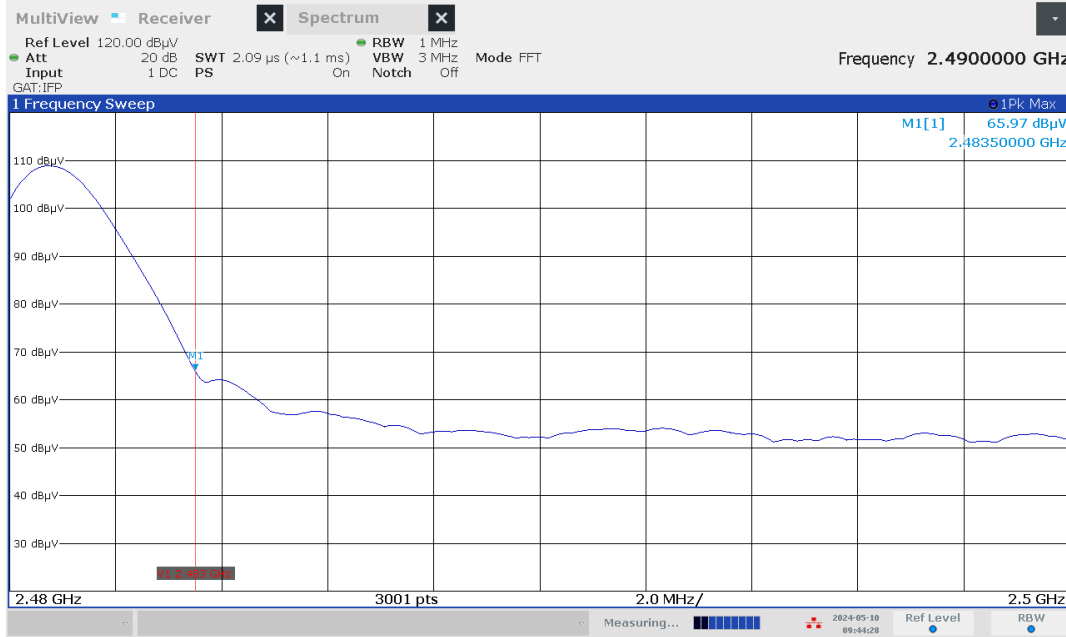
12:26:08 PM 05/10/2024

Tx Frequency	Low Channel	Antenna Polarization	Vertical	Emission	Average
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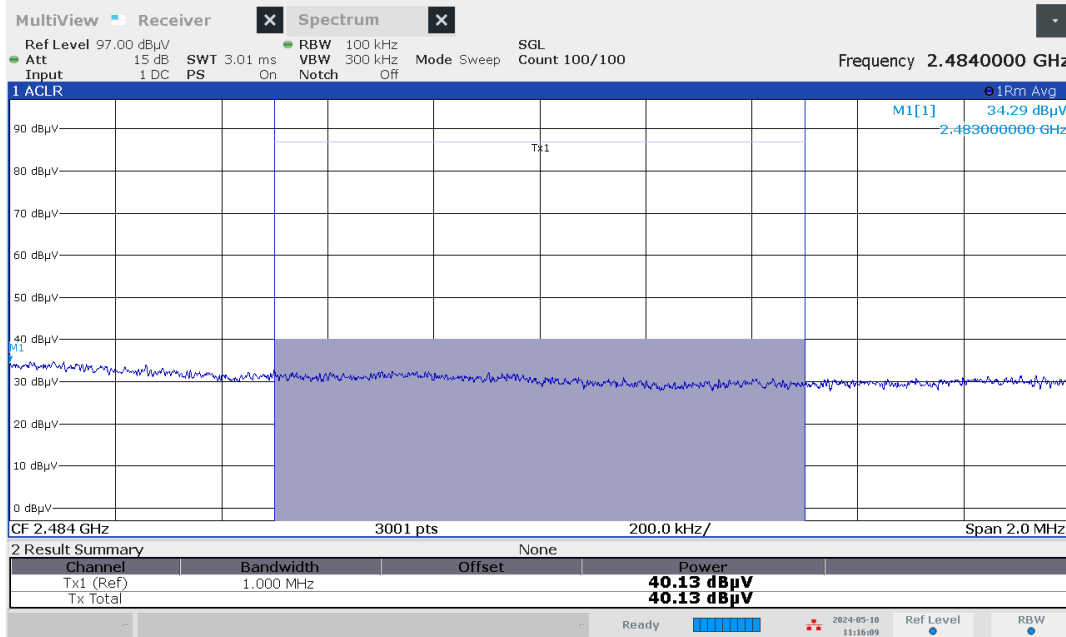


12:24:26 PM 05/10/2024

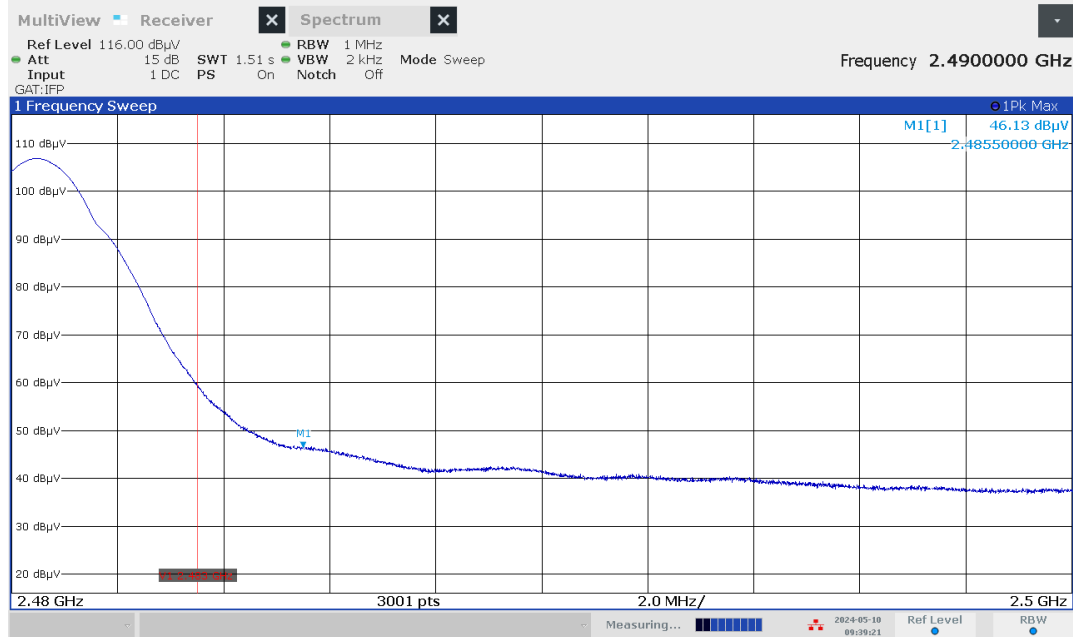
Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Peak
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Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Average (Integration Method)
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Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Average
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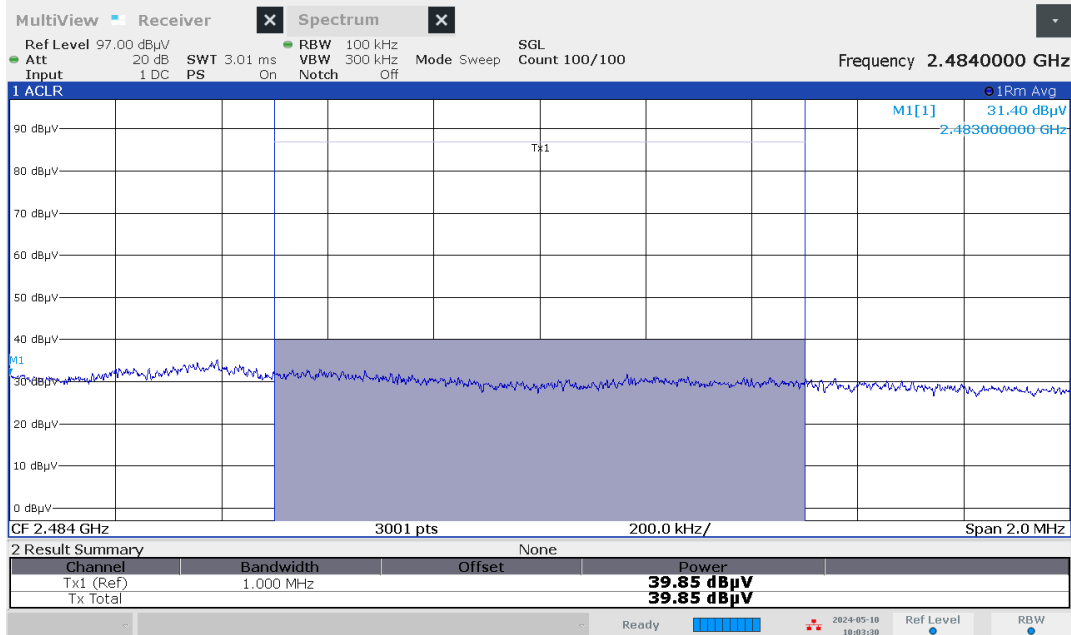
09:39:22 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Peak
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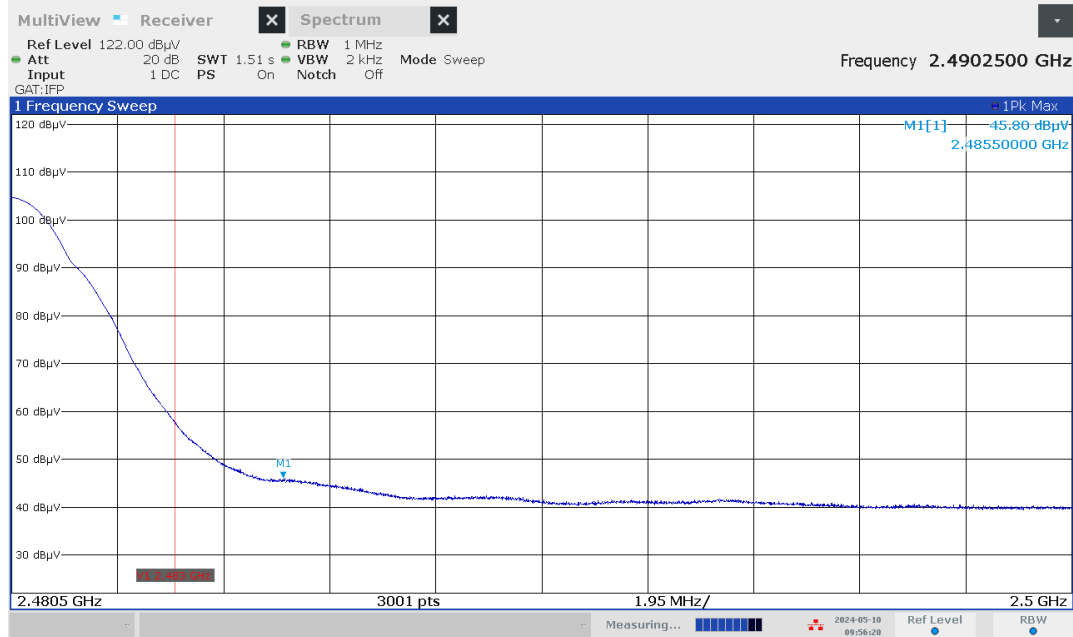
09:57:40 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Average (Integration Method)
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10:03:31 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Average
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09:56:21 AM 05/10/2024

4.6.3.2. Final Measurements

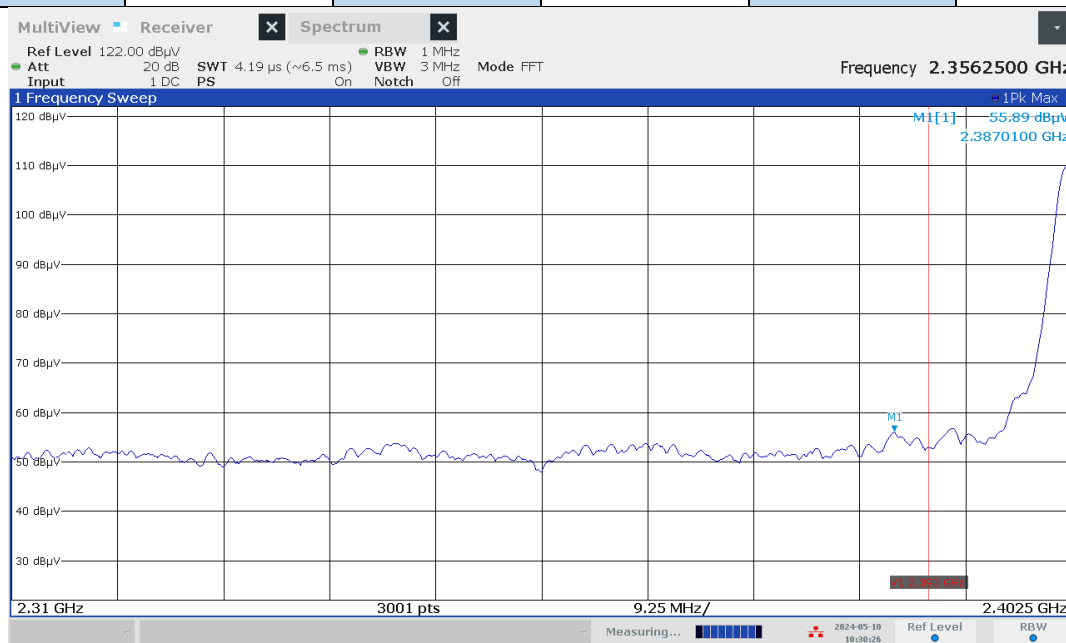
Frequency (MHz)	Detector	Antenna Polarity	Reading (dBμV)	Antenna Factor (dB/m)	Cable Factor (dB)	Attenuator (dB)	Pre-Amp Gain (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
Low Channel											
BLE - 1 MBPS											
2402	PEAK	Horz	110.2	32.5	6.8	10.0	-41.6	117.9			Pass
2402	AVG	Horz	109.0	32.5	6.8	10.0	-41.6	116.7			Pass
2402	PEAK	Vert	107.0	32.5	6.8	10.0	-41.6	114.6			Pass
2402	AVG	Vert	105.8	32.5	6.8	10.0	-41.6	113.4			Pass
2390	PEAK	Horz	55.7	32.4	6.8	10.0	-41.6	63.3	74.0	10.7	Pass
2390	AVG	Horz	41.6	32.4	6.8	10.0	-41.6	49.3	54.0	4.7	Pass
2390	PEAK	Vert	52.8	32.4	6.8	10.0	-41.6	60.5	74.0	13.5	Pass
2390	AVG	Vert	39.4	32.4	6.8	10.0	-41.6	47.1	54.0	6.9	Pass
High Channel											
BLE - 1 MBPS											
2480	PEAK	Horz	109.0	32.6	6.9	10.0	-41.7	116.7			Pass
2480	AVG	Horz	106.8	32.6	6.9	10.0	-41.7	114.5			Pass
2480	PEAK	Vert	106.8	32.6	6.9	10.0	-41.7	114.6			Pass
2480	AVG	Vert	104.7	32.6	6.9	10.0	-41.7	112.4			Pass
2483.6	PEAK	Horz	66.0	32.6	6.9	10.0	-41.7	73.7	74.0	0.3	Pass
2483.5	AVG	Horz	40.1	32.6	6.9	10.0	-41.7	47.9	54.0	6.1	Pass
2483.6	PEAK	Vert	63.8	32.6	6.9	10.0	-41.7	71.5	74.0	2.5	Pass
2483.5	AVG	Vert	39.9	32.6	6.9	10.0	-41.7	47.6	54.0	6.4	Pass
2485.5	AVG	Horz	46.1	32.6	6.9	10.0	-41.7	53.9	54.0	0.1	Pass
2485.5	AVG	Vert	45.8	32.6	6.9	10.0	-41.7	53.5	54.0	0.5	Pass

4.6.4 Test Results – 2 MBPS

The DUT met the band edge requirements. Peak output power for low, mid and high channels were measured and the Plots Section below contains the maximum radiated emission levels captured on the spectrum analyzer at the band edges. The Final Measurements Section contains the final results with the correction factors added in.

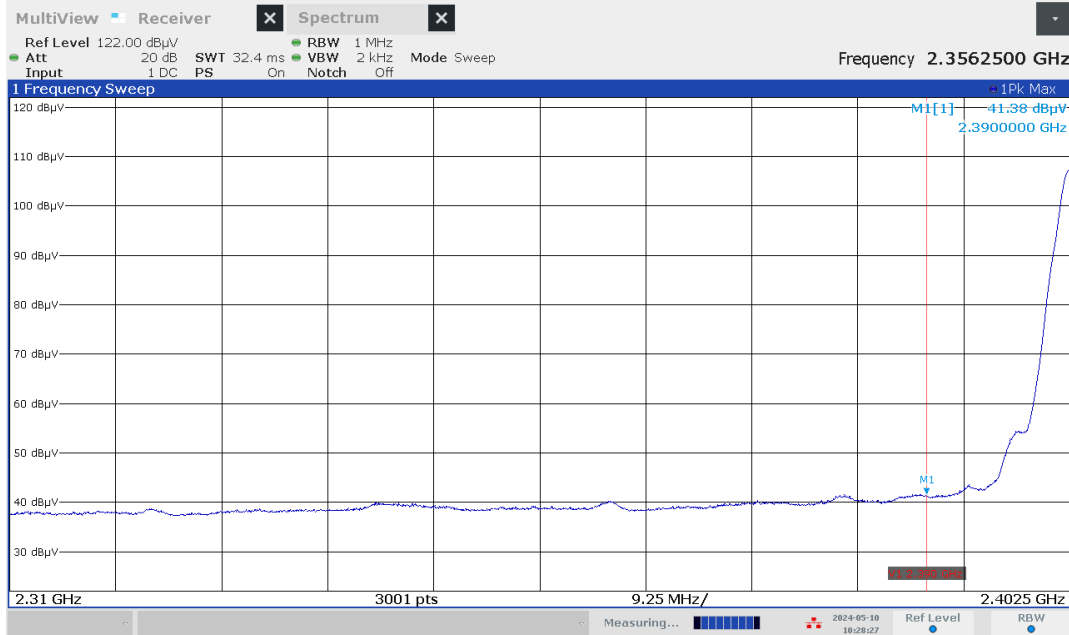
4.6.4.1. Plots

Tx Frequency	Low Channel	Antenna Polarization	Horizontal	Emission	Peak
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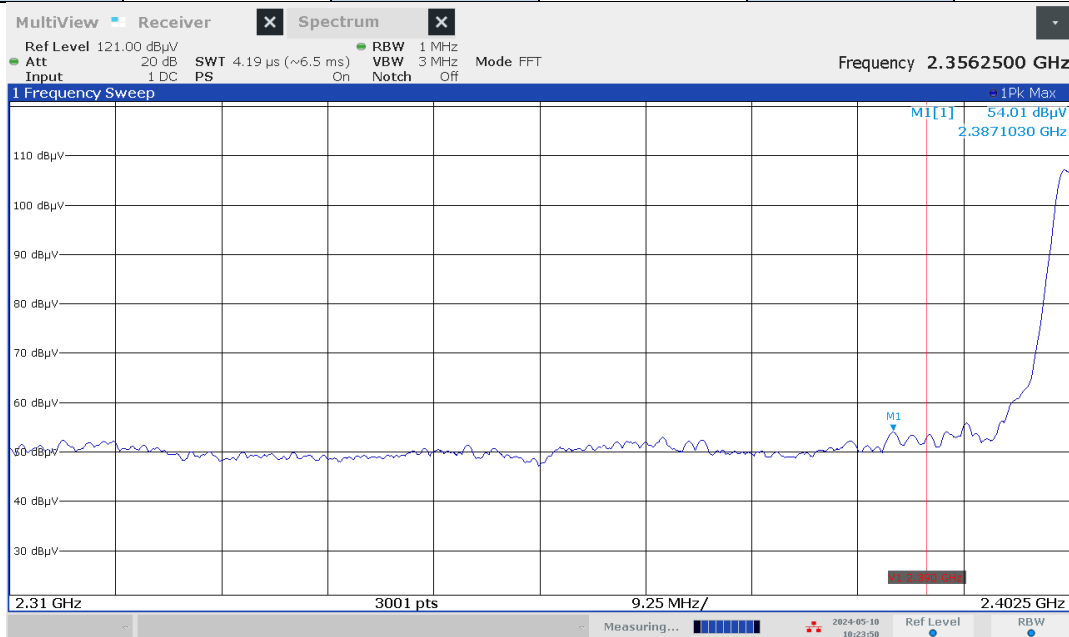
10:30:26 AM 05/10/2024

Tx Frequency	Low Channel	Antenna Polarization	Horizontal	Emission	Average
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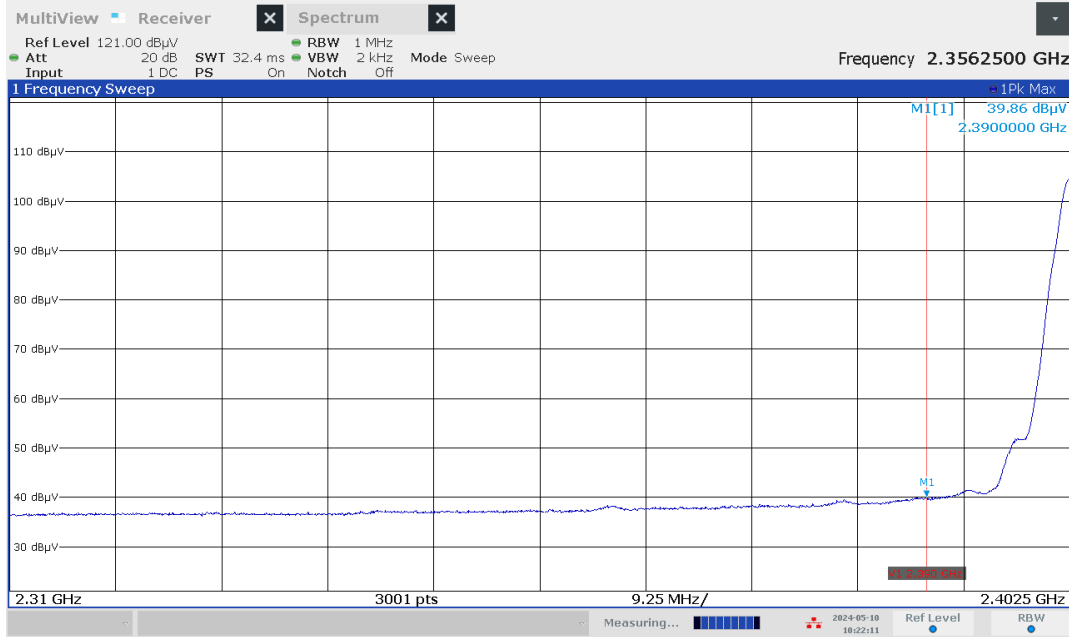
10:28:28 AM 05/10/2024

Tx Frequency	Low Channel	Antenna Polarization	Vertical	Emission	Peak
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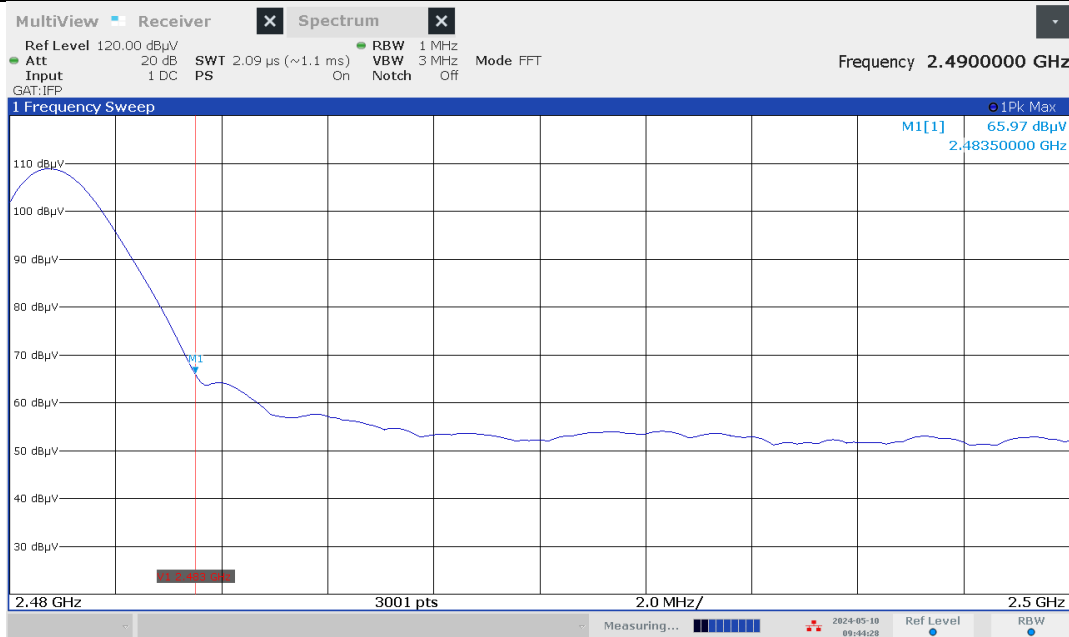
10:23:51 AM 05/10/2024

Tx Frequency	Low Channel	Antenna Polarization	Vertical	Emission	Average
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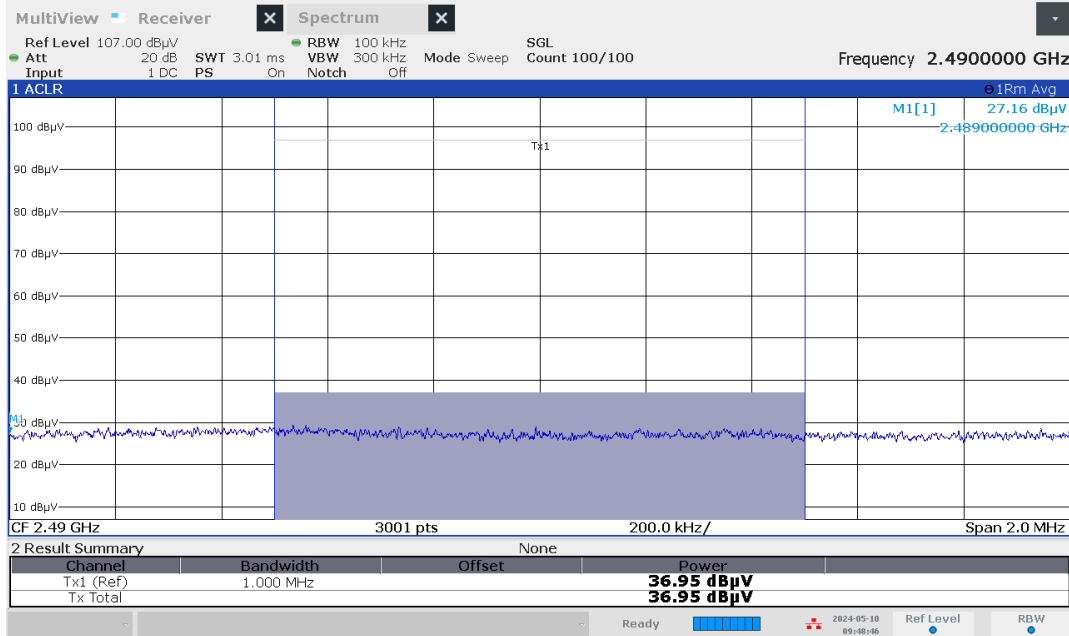
10:22:11 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Peak
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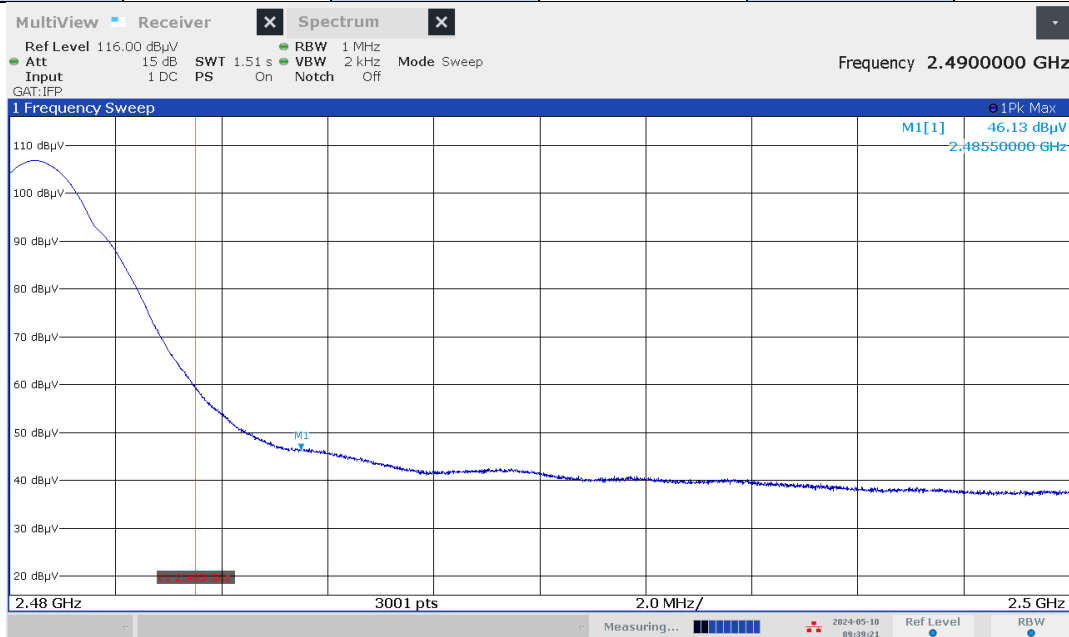
09:44:28 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Average (Integration Method)
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09:48:47 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Horizontal	Emission	Average
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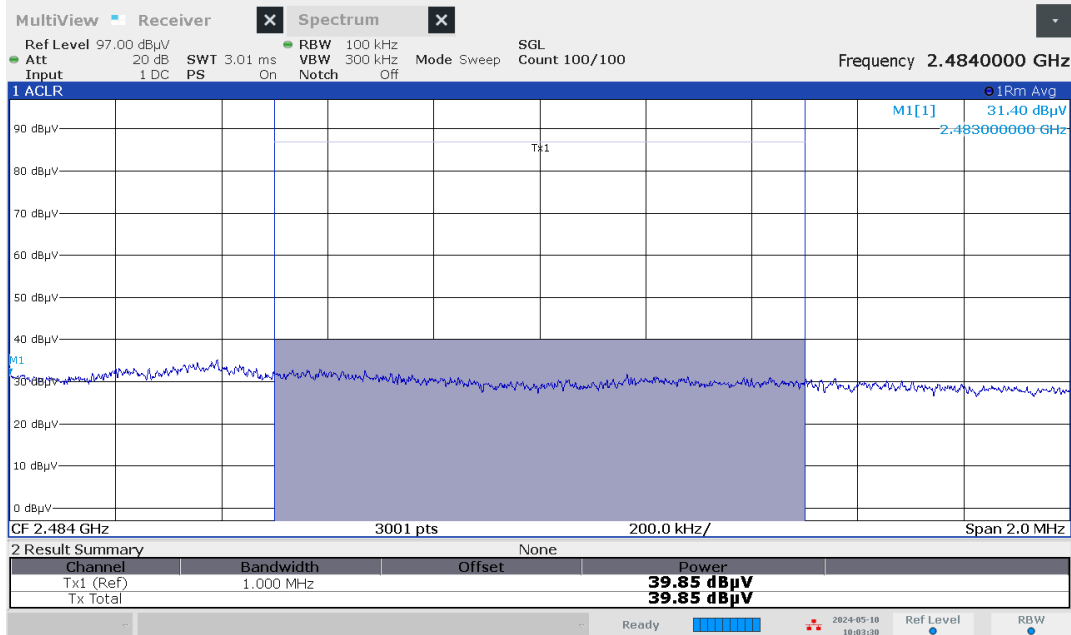
09:39:22 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Peak
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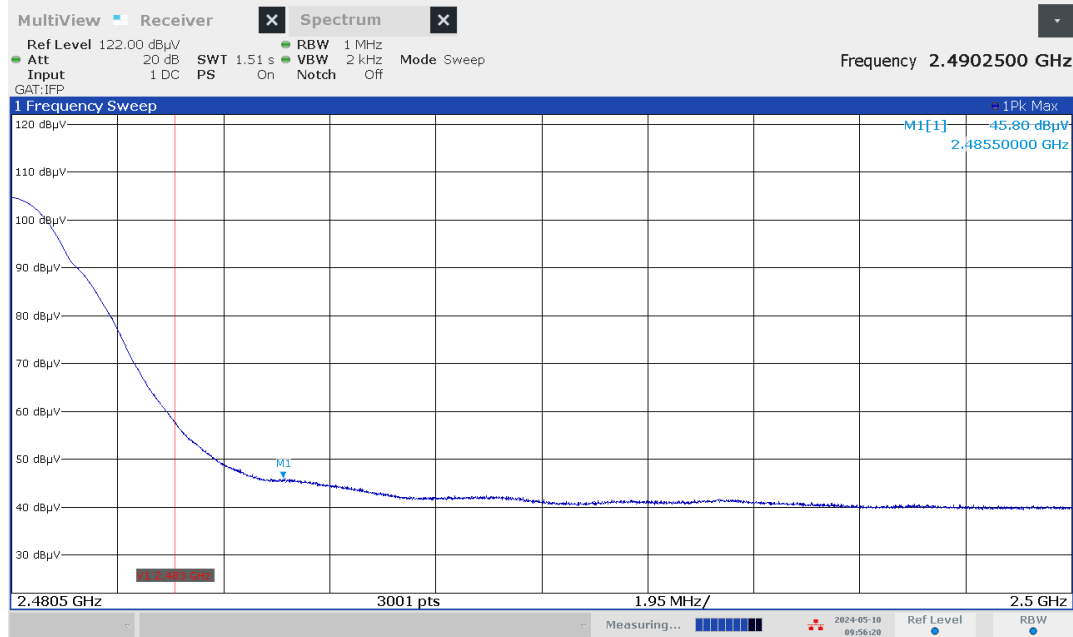
09:57:40 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Average (Integration Method)
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10:03:31 AM 05/10/2024

Tx Frequency	High Channel	Antenna Polarization	Vertical	Emission	Average
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09:56:21 AM 05/10/2024

4.6.4.2. Final Measurements

Frequency (MHz)	Detector	Antenna Polarity	Reading (dBμV)	Antenna Factor (dB/m)	Cable Factor (dB)	Attenuator (dB)	Pre-Amp Gain (dB)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Test Result
Low Channel											
BLE- 2 MBPS											
2402	PEAK	Horz	109.9	32.5	6.8	10.0	-41.6	117.5			Pass
2402	AVG	Horz	107.5	32.5	6.8	10.0	-41.6	115.2			Pass
2402	PEAK	Vert	107.1	32.5	6.8	10.0	-41.6	114.7			Pass
2402	AVG	Vert	104.7	32.5	6.8	10.0	-41.6	112.3			Pass
2387	PEAK	Horz	55.9	32.4	6.8	10.0	-41.6	63.5	74.0	10.5	Pass
2390	AVG	Horz	41.4	32.4	6.8	10.0	-41.6	49.0	54.0	5.0	Pass
2387	PEAK	Vert	54.0	32.4	6.8	10.0	-41.6	61.7	74.0	12.3	Pass
2390	AVG	Vert	39.9	32.4	6.8	10.0	-41.6	47.5	54.0	6.5	Pass
High Channel											
BLE 2 MBPS											
2480	PEAK	Horz	109.6	32.6	6.9	10.0	-41.7	117.4			Pass
2480	AVG	Horz	108.3	32.6	6.9	10.0	-41.7	116.1			Pass
2480	PEAK	Vert	108.3	32.6	6.9	10.0	-41.7	116.0			Pass
2480	AVG	Vert	107.1	32.6	6.9	10.0	-41.7	114.8			Pass
2483.5	PEAK	Horz	66.0	32.6	6.9	10.0	-41.7	73.7	74.0	0.3	Pass
2484	AVG	Horz	37.0	32.6	6.9	10.0	-41.7	44.7	54.0	9.3	Pass
2483.5	PEAK	Vert	63.8	32.6	6.9	10.0	-41.7	71.5	74.0	2.5	Pass
2484	AVG	Vert	39.9	32.6	6.9	10.0	-41.7	47.6	54.0	6.4	Pass
2485.5	AVG	Horz	46.1	32.6	6.9	10.0	-41.7	53.9	54.0	0.1	Pass
2485.5	AVG	Vert	45.8	32.6	6.9	10.0	-41.7	53.5	54.0	0.5	Pass

4.6.5 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Mar 1, 2024	Mar 1, 2026
EQ_EMC_60	Horn Antenna	ETS Lindgren	3117	Apr 9, 2024	Apr 9, 2026
EQ_EMC_75	RF Cable >1GHz	MegaPhase	EMC2	NCR	NCR
EQ_EMC_115	10 dB Attenuator SMA	Fairview Microwave	SA18E-10	NCR	NCR
EQ_EMC_42	Preamplifier 1GHz-18GHz	Com-Power	PAM-118A	Jan 17, 2024	Jan 17, 2026

4.7 Power Line Conducted Emissions

Test Date: May 13, 2024
Temperature (°C) 21.1
Relative Humidity (%) 54.7
Barometric Pressure (kPa) 100.8

Initials: MX

The conducted emission test is to measure radio-frequency (RF) signals and noise emitted from electrical and electronic devices in the frequency range of 150kHz to 30MHz.

4.7.1 Limits

Base Standard(s): FCC Subpart B 15.207 and RSS-GEN Section 8.8.

Frequency Range (MHz)	Coupling Device	Detector Type / Bandwidth	Limit (dBμV)
0.15 to 0.50	LISN	Quasi-Peak / 9kHz	66 to 56*
0.50 to 5			56
5 to 30			60
0.15 to 0.50	LISN	Average / 9kHz	56 to 46*
0.50 to 5			46
5 to 30			50

* Decreases linearly with the logarithm of the frequency

As per ANSI C63.4 Section 4.2, if the Peak or Quasi-Peak detector measurements do not exceed the Average limits, then the DUT is considered to have passed the requirements.

4.7.2 Test Procedure

Tested according to ANSI C63.10 Section 6.2.

Conducted emissions were measured on the DUT's power port via an Artificial Mains Network (AMN), also known as Line Impedance Stabilization Network (LISN), and maximum conducted emissions are checked on all the DUT's AC lines in the frequency range of 150kHz to 30MHz. All other support equipment were powered via another LISN. The LISNs provide 50Ω/50μH of coupling impedance for the measuring receiver.

To determine the emission characteristics of the DUT, the conducted emission scans were made using a Peak detector and the results were recorded in graphical form.

For each suspected emission, final measurements of the DUT conducted emissions were made with the Quasi-Peak or Average detector as defined in the limits table above.

For Table-Top Equipment, the device under test is configured on a 0.8m high non-conductive table above the reference ground plane and 0.4m away from the vertical reference ground plane.

4.7.3 Setup Diagram

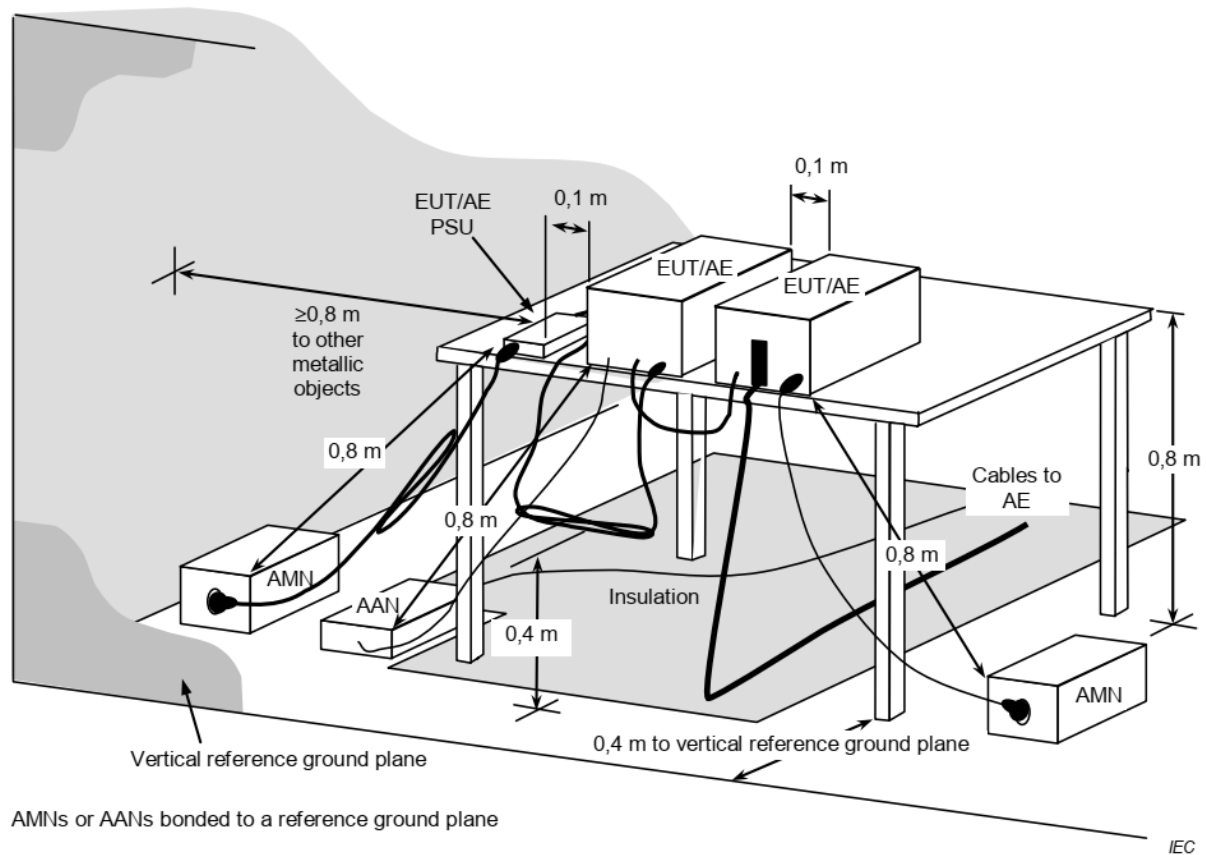
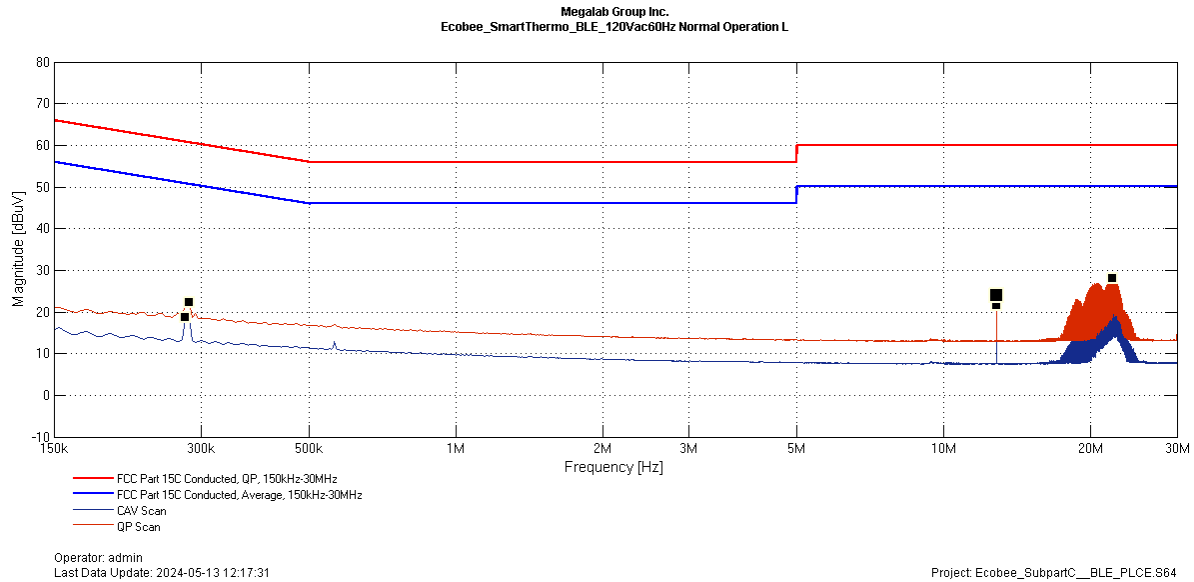


Figure 34 – Sample Measurement Arrangement for DUT

4.7.4 Test Results

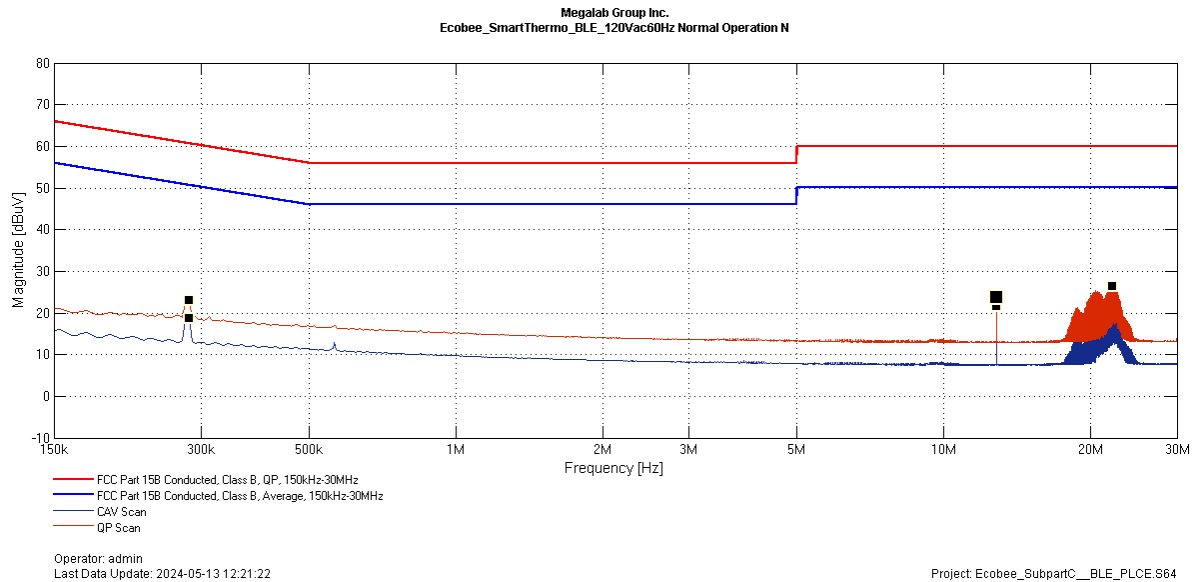
Range:	150kHz to 30MHz	DUT	ECB701/BLE
Test Voltage:	120Vac 60Hz	Phase	Line



Remark: Quasi-Peak and Average Emission Plot

Line										
Freq (MHz)	QP Reading (dBμV)	AVG Reading (dBμV)	Corr Factor (dB)	QP Emission Level (dBμV)	AVG Emission Level (dBμV)	QP Limit (dBμV)	QP Margin (dB)	AVG Limit (dBμV)	AVG Margin (dB)	Test Result
0.284	13.1	8.8	9.9	23.0	18.7	60.7	37.8	50.7	32.0	Pass
22.132	16.2	--	10.3	26.4	--	60.0	33.6	--	--	Pass
12.799	13.6	11.5	10.1	23.7	21.6	60.0	36.3	50.0	28.4	Pass

Range:	150kHz to 30MHz	DUT	ECB701/BLE
Test Voltage:	120Vac 60Hz	Phase	Neutral



Remark: Peak Emission Plot

Neutral										
Freq (MHz)	QP Reading (dBμV)	AVG Reading (dBμV)	Corr Factor (dB)	QP Emission Level (dBμV)	AVG Emission Level (dBμV)	QP Limit (dBμV)	QP Margin (dB)	AVG Limit (dBμV)	AVG Margin (dB)	Test Result
0.284	13.1	8.8	9.9	23.0	18.7	60.7	37.8	50.7	32.0	Pass
22.132	16.2	--	10.3	26.4	--	60.0	33.6	--	--	Pass
12.799	13.6	11.5	10.1	23.7	21.6	60.0	36.3	50.0	28.4	Pass

4.7.5 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_132	EMI Test Receiver (v6.91.2)	Gauss Instruments	TDEMI X40	Nov 29, 2023	Nov 29, 2025
EQ_EMC_61	LISN	FCC	50/250-16-2-01	Jan 16, 2024	Jan 16, 2026
EQ_EMC_44	Transient Limiter (10dB)	Com-Power	LIT-930A	NCR	NCR
EQ_EMC_84	RF Cable	Times Microwave	LMR-400	NCR	NCR
EQ_EMC_149	Emission Software RE/CE	Gauss Instruments	EMI64k v6.31.2	NCR	NCR

----- End of Test Report -----