RF Test Report

Standard(s):	FCC Part 15 Subpart 15.247, RSS-247 Issue 3:2023 Unlicensed Intentional Radiators
Issued To:	Gelo Technologies Inc 281 Vellore Ave Woodbridge ON L4H 3J1
Product Name:	Thermostat
Model:	GTT-010
FCC ID:	2BEIZ-GTT010
IC:	31904-GTT010
Report No.	ML300945A-RF00 Thermostat
Date of Issue:	May 15, 2024

Report Prepared By:

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1. Revision History

Project No. & Revision	Report Date	Initials	Description
ML300945-RF00	April 17, 2024	MX	Initial Release
ML300945A-RF00 Thermostat	May 15, 2024	MX	Updated report number. Delete data not related to Thermostat from this report.

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	1.5 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 Antenna 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.

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

Emission Level (dBµV) =	Read Level (dBµV)	+	LISN Factor (dB)	+	Attenuation Factor (dB)	+	Cable Loss (dB)	
=	34.8	+	0.1	+	10.0	+	0.2	
=	45.1							

Margin (dB) =	Limit (dBµV)	-	Emission Level (dBµV)
=	60.0	-	45.1
=	14.9		

Radiated Emissions

Emission Level (dBµV/m) =	Read Level (dBµV)	+	Antenna Factor (dB/m)	+	Cable Loss (dB)	-	Pre-Amp Gain (dB)	
=	52.4	+	9.4	+	1.3	-	29.2	
=	33.9							

Margin (dB) =	Limit (dBµV/m)	-	Emission Level (dBµV/m)
=	50.0	-	33.9
=	16.1		

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	Gelo Technologies Inc
Address	281 Vellore Ave Woodbridge ON L4H 3J1
Contact	Oleg Bukin
Email	obukin@gelo.ca

3.2 Device Under Test (DUT)

3.2.1 DUT Information

DUT Name	Thermostat
DUT Model(s)	GTT-010
Serial Number	Engineering samples
Power Source (AC / DC / Battery)	AC
Input Voltage (V) or Range	24Vac
Frequency (Hz) or Range	60Hz
Mode(s) of Operation	Continuous transmission, > 98% Duty Cycle
Connectors Available on DUT	standard thermostat field connections
Transmitter Information	
FCC ID	2BEIZ-GTT010
IC	31904-GTT010
Technology Used	OPENTHREAD
Operating Frequency	2405 MHz to 2475 MHz
Modulation Type	O-QPSK
Number of Channels	14
Antenna Manufacturer	Johanson Technology
Antenna Model	2450AT45A100E-AEC
Antenna Type	SMD Chip
Antenna Gain	1.5 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

The EUT is a close environment control system where it has a wireless network of thermostats and an Open Thread border router as an access point to this wireless network. The system uses Open Thread wireless protocol.

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 >98% duty cycle
- Output Power: +20 dBm
- Channels:
  - low, 2405MHz),
  - Mid, 2440MHz),
  - High, 2475MHz)
- Device is limited to 30% duty cycle under normal operation. Maximum output power was measured with the device configured for 100% duty cycle with the following parameters:

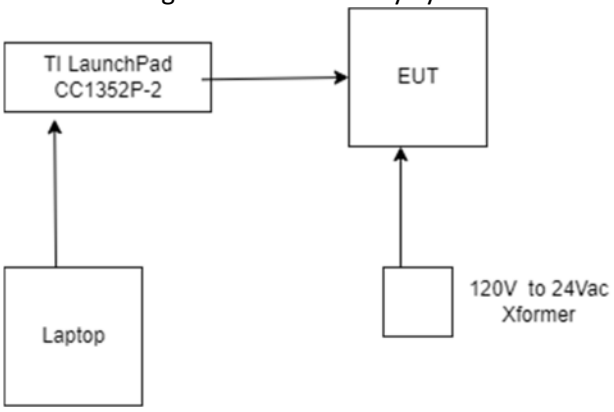


Figure 1 – Configuration Block Diagram

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
LaunchPad	TI	CC1352P-2	---

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:	January 31, 2024	Initials:	MX
Temperature (°C)	20.2		
Relative Humidity (%)	24.3		
Barometric Pressure (kPa)	97.7		

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:

a) Set RBW = 100kHz and VBW ≥ [3 × RBW].
b) Detector = Peak and Trace Mode = Max Hold.
c) Sweep = Auto Couple.
d) 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:

a) Set RBW in the range of 1% to 5% of the actual occupied bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Span set to 1.5 to 5 times the occupied bandwidth.
d) Use the 99% power bandwidth function of the instrument to measure bandwidth.

4.1.3 Test Results

6dB (DTS) Bandwidth				
Channel	**Frequency (MHz)**	**6dB Bandwidth (MHz)**	**Limit (MHz)**	**Test Result**
Low	2405.4	1.57	> 0.50	Pass
Mid	2440.4	1.58	> 0.50	Pass
High	2475.4	1.59	> 0.50	Pass

99% Bandwidth					
Channel	**Frequency (MHz)**	**F_{LOW} (MHz)**	**F_{HIGH} (MHz)**	**Occupied Bandwidth (MHz)**	**Test Result**
Low	2405.4	2404.103	2406.708	2.61	Pass
Mid	2440.4	2439.148	2441.678	2.53	Pass
High	2475.4	2474.142	2476.694	2.55	Pass

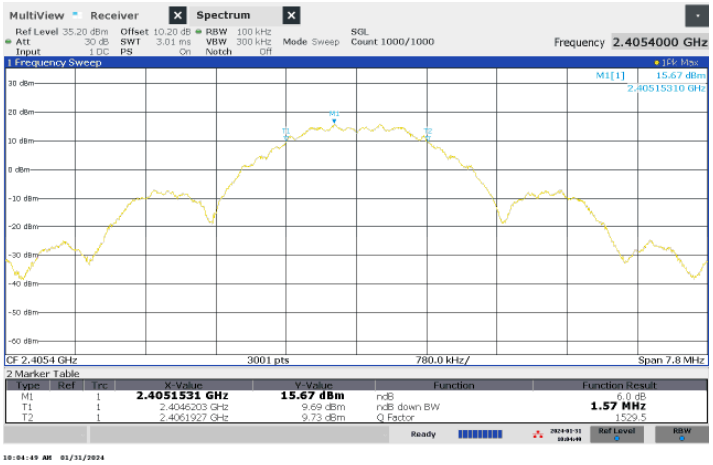


Figure 2 – 6dB Bandwidth - Low Channel

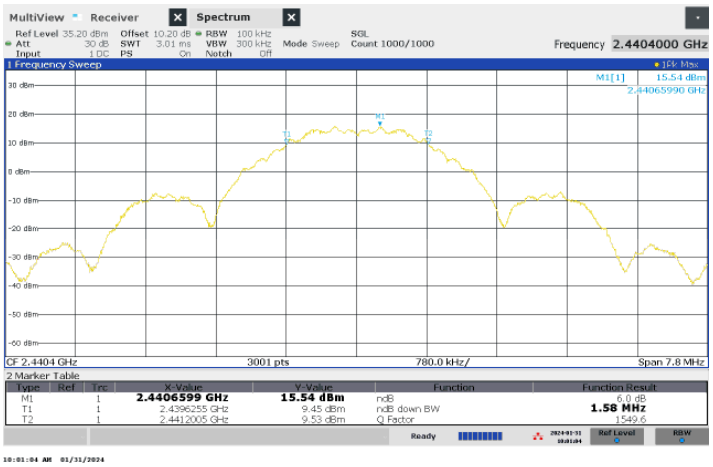


Figure 3 – 6dB Bandwidth - Mid Channel

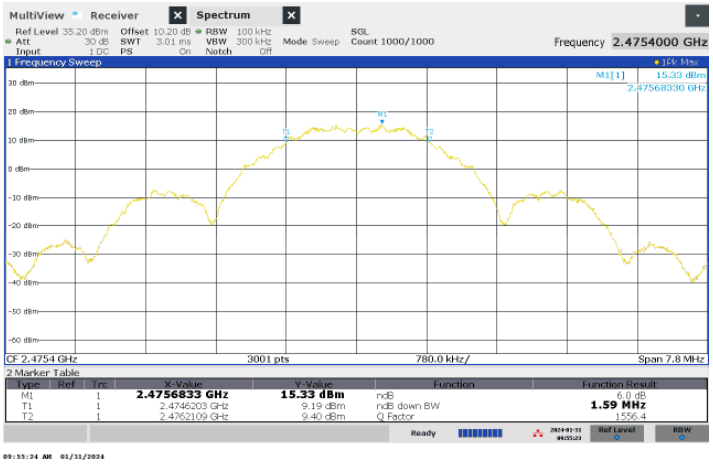


Figure 4 – 6dB Bandwidth - High Channel

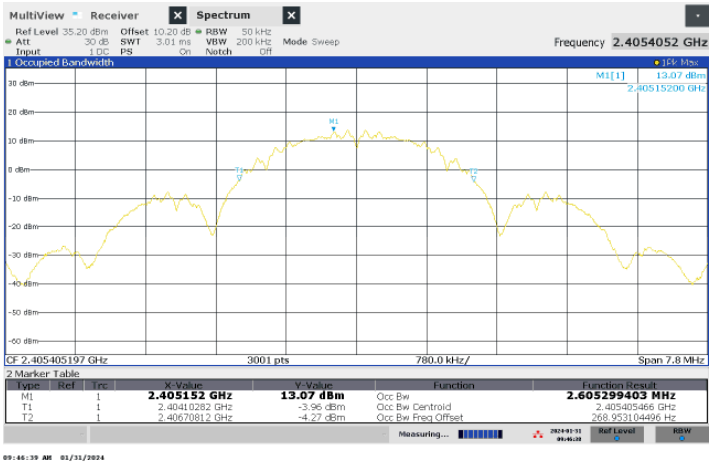


Figure 5 – 99% Bandwidth - Low Channel

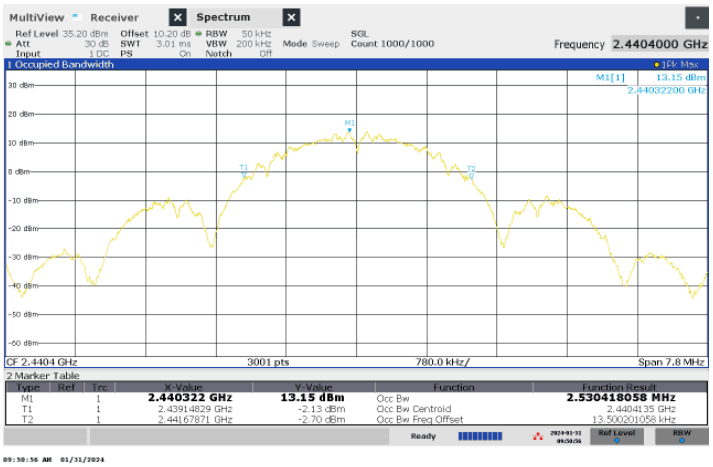


Figure 6 – 99% Bandwidth - Mid Channel

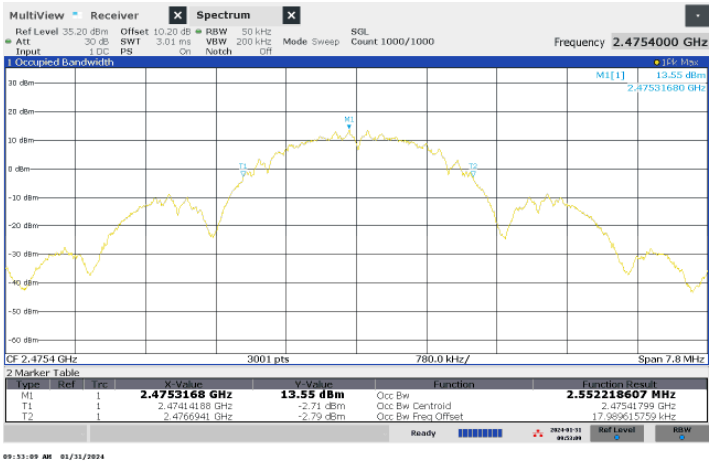


Figure 7 – 99% Bandwidth - High Channel

4.1.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.2 Peak Conducted Output Power

Test Date:	January 31, 2024	Initials:	MX
Temperature (°C)	20.2		
Relative Humidity (%)	24.3		
Barometric Pressure (kPa)	97.7		

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.

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

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)	Limit (dBm)	Test Result
Low	2405.4	18.68	73.79	30	Pass
Mid	2440.4	18.53	71.29	30	Pass
High	2475.4	18.44	69.82	30	Pass

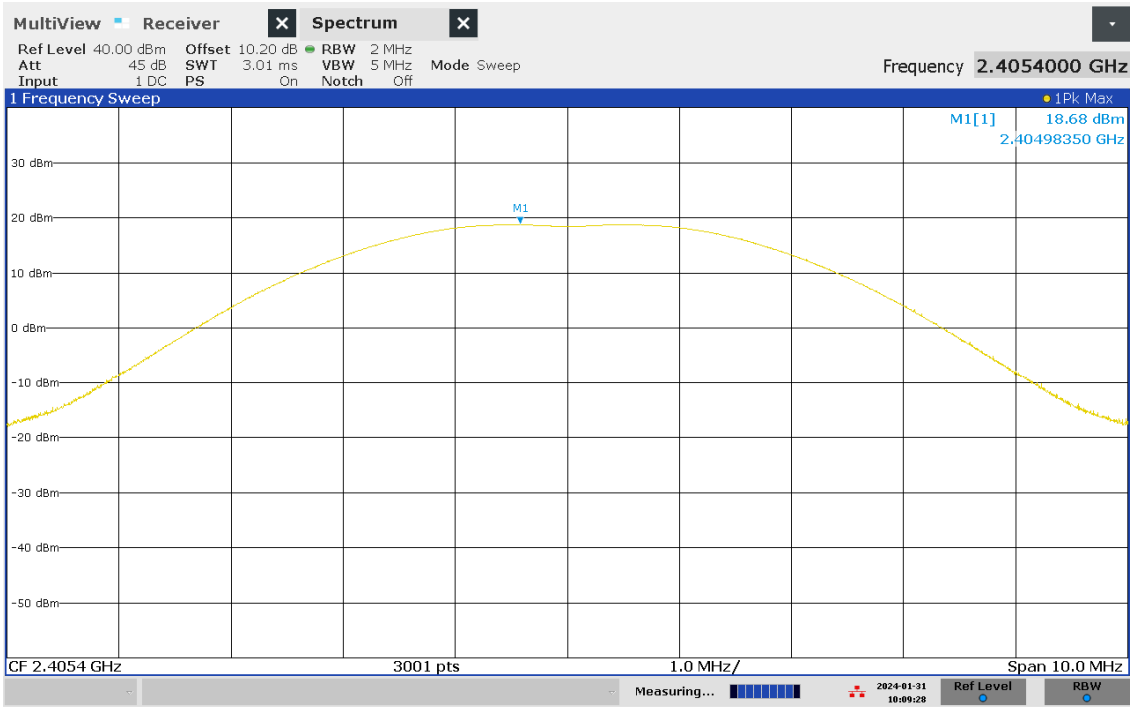


Figure 8 – Peak Power - Low Channel

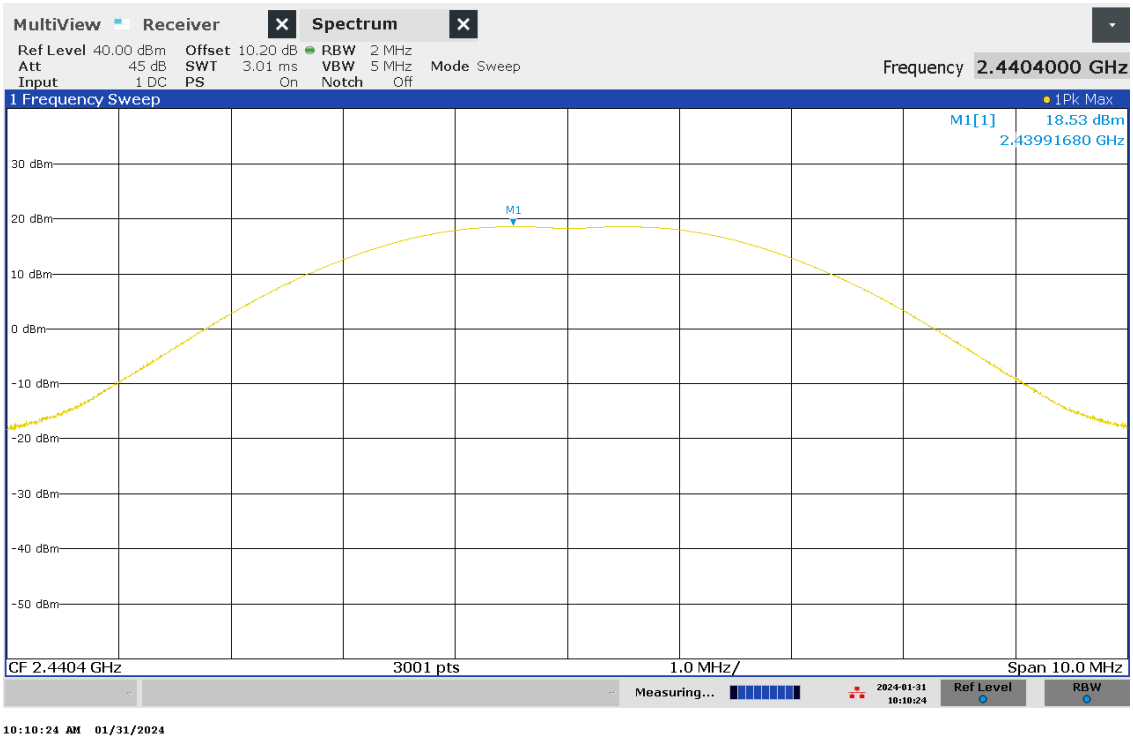


Figure 9 – Peak Power - Mid Channel

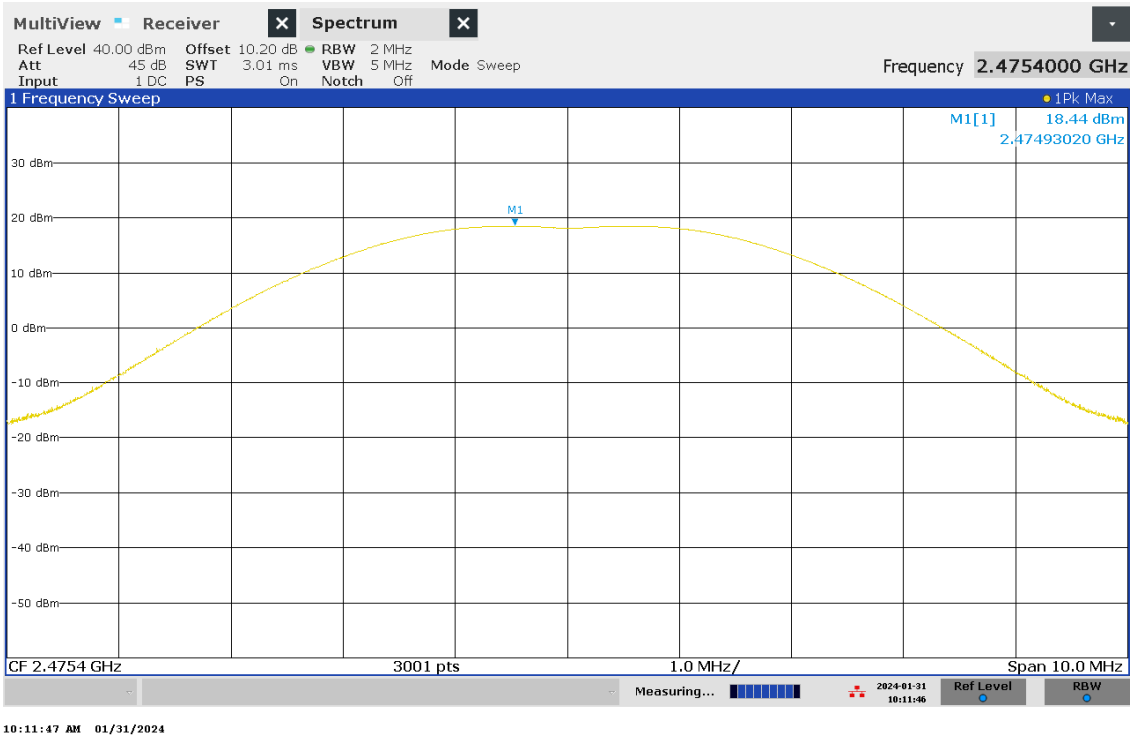


Figure 10 – Peak Power - High Channel

4.2.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.3 Spurious Out of Band Emissions (-20dBc)

Test Date:	January 31, 2024	Initials:	MX
Temperature (°C)	20.2		
Relative Humidity (%)	24.3		
Barometric Pressure (kPa)	97.7		

4.3.1 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.

4.3.2 Test Procedure

Tested according to ANSI C63.10 Section 11.11

For the reference level measurement:

a) Set RBW = 100kHz and VBW ≥ [3 × RBW].
b) Detector = Peak and Trace Mode = Max Hold.
c) Sweep = Auto Couple.
d) Span set to ≥1.5 DTS bandwidth.
e) Use the peak marker function to determine the maximum level.

For the out of band emission measurement

a) Set the start and stop frequency to encompass the frequency range to be measured.
b) Set RBW = 100kHz and VBW ≥ [3 × RBW].
c) Detector = Peak and Trace Mode = Max Hold.
d) Sweep = Auto Couple.
e) 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 met the 20dB below carrier requirement for out of band emissions.

Channel	Frequency (MHz)	Peak PSD w/ RBW=100 kHz (dBm)	20 dBc Limit (dBm)
Low	2405.4	15.67	-4.33
Mid	2440.4	15.54	-4.46
High	2475.4	15.33	-4.67

The highest peak power in 100 kHz is 15.67 dBm; therefore, the 20 dBc limit is -4.33 dBm

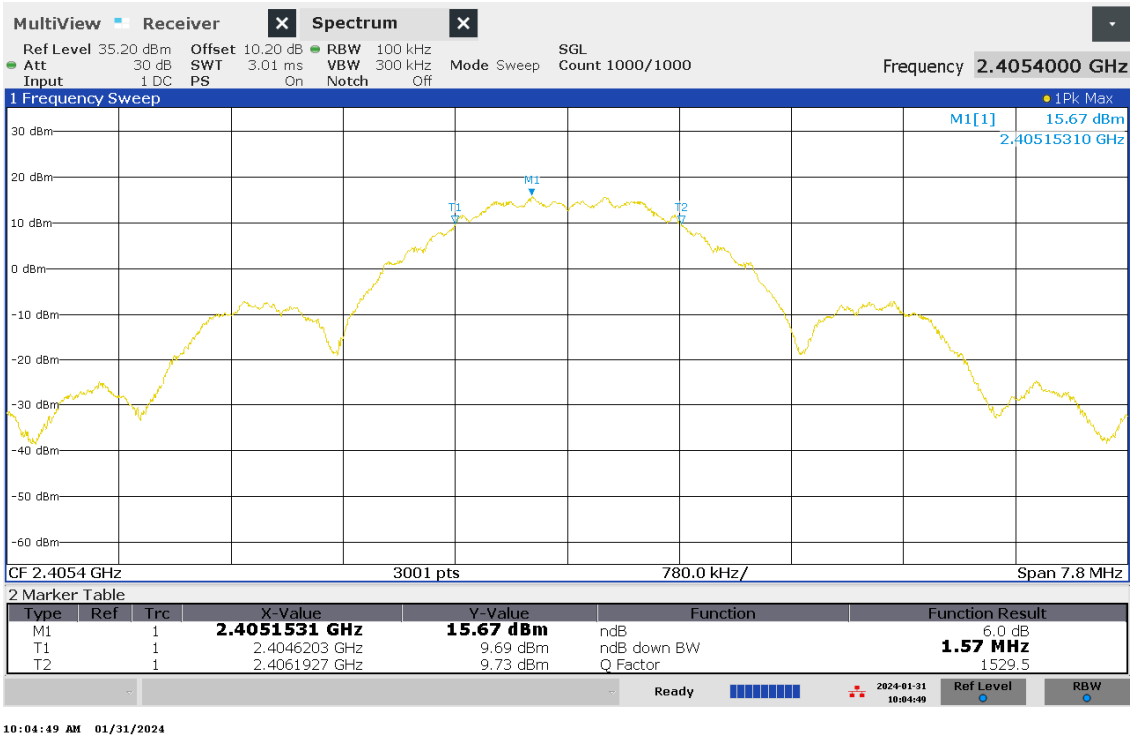


Figure 11 – -20dBc Reference Level - Low Channel

Figure 12 – -20dBc Band Edge - Low Channel

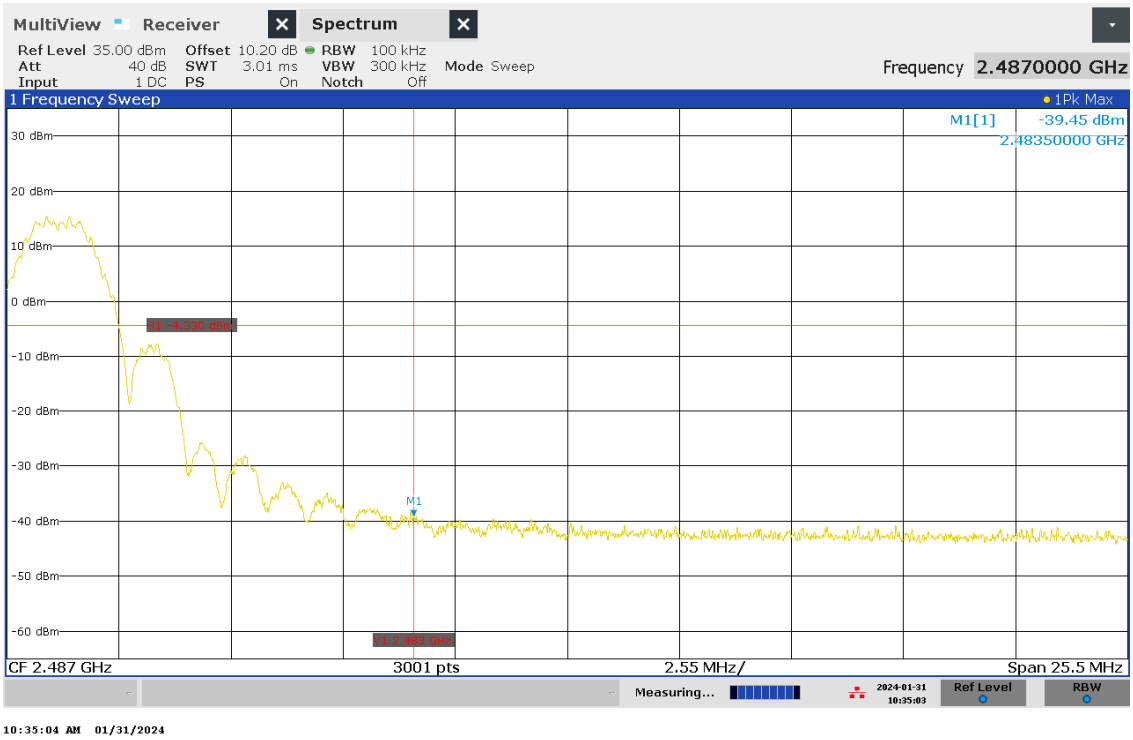


Figure 13 – -20dBc Band Edge - Low Channel

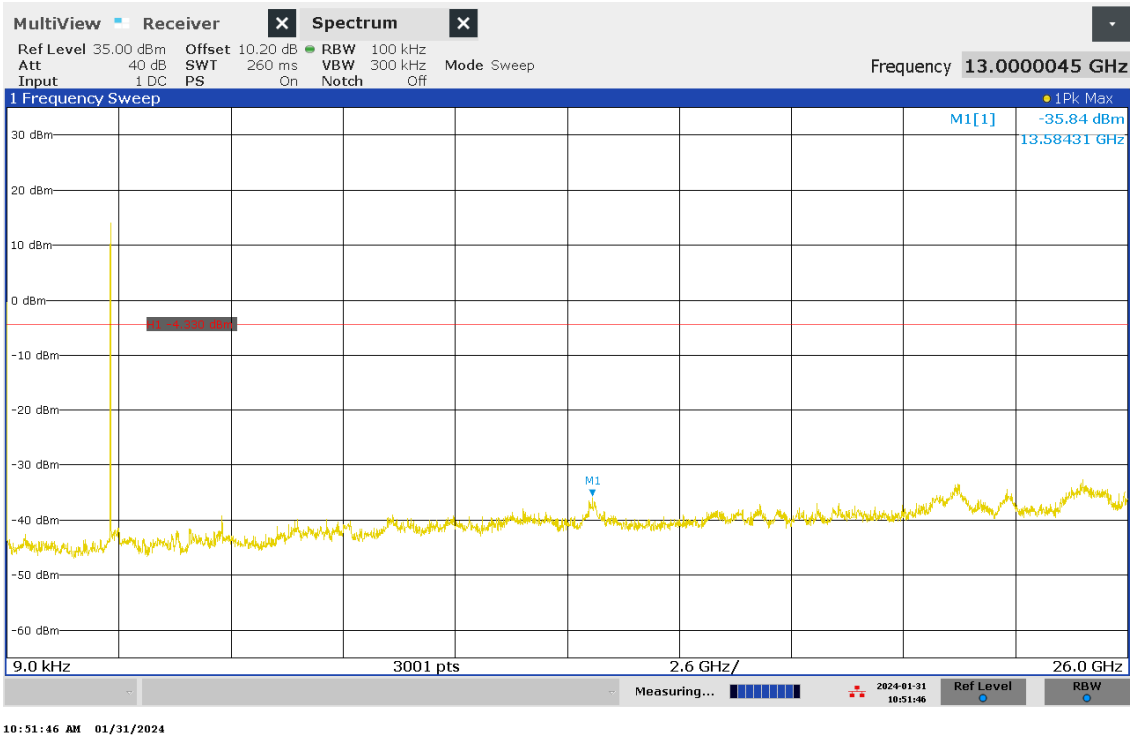


Figure 14 – -20dBc Low Channel 9kHz – 26 GHz

4.3.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.4 Transmitter Spurious Radiated Emissions

Test Date:	January 17 – 30, 2024	Initials:	MX
Temperature (°C)	19.6 – 21.0		
Relative Humidity (%)	5.2 – 29.7		
Barometric Pressure (kPa)	97.1 – 99.1		

4.4.1 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.

4.4.2 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.

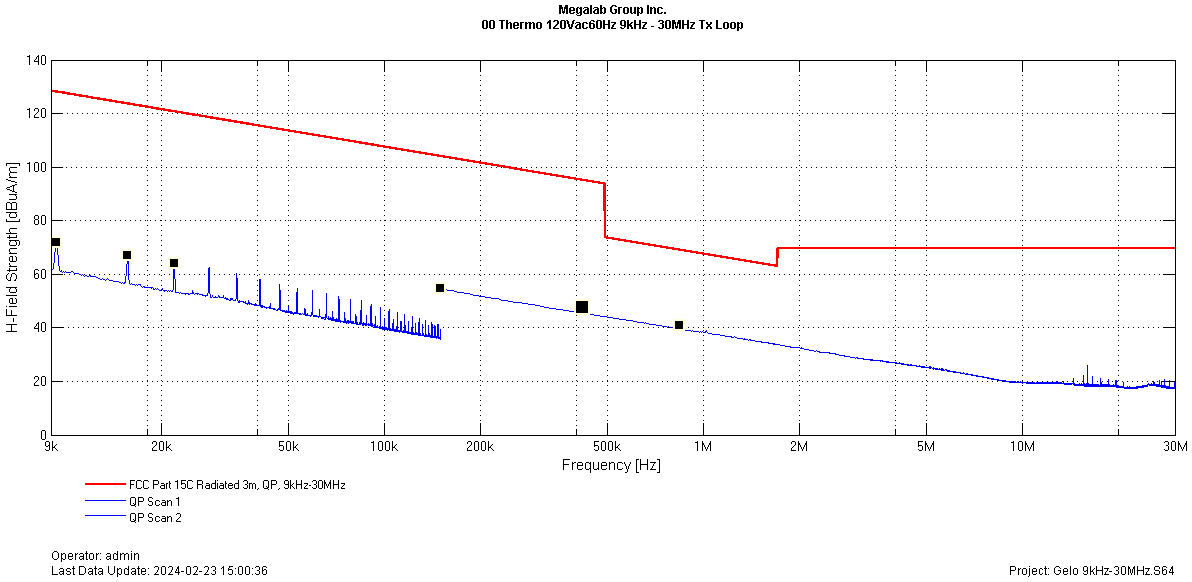
As per FCC Part 15.33(a), the DUT was scanned to the 10th harmonic of the highest fundamental frequency.

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

Duty Cycle Correction Factor (DCCF) of the Thermostat was provided by client. Under certain operation configuration the worst case operational duty cycle is 29.97% which results in a DCCF of -10.5 dB. See Operation Description for additional details.

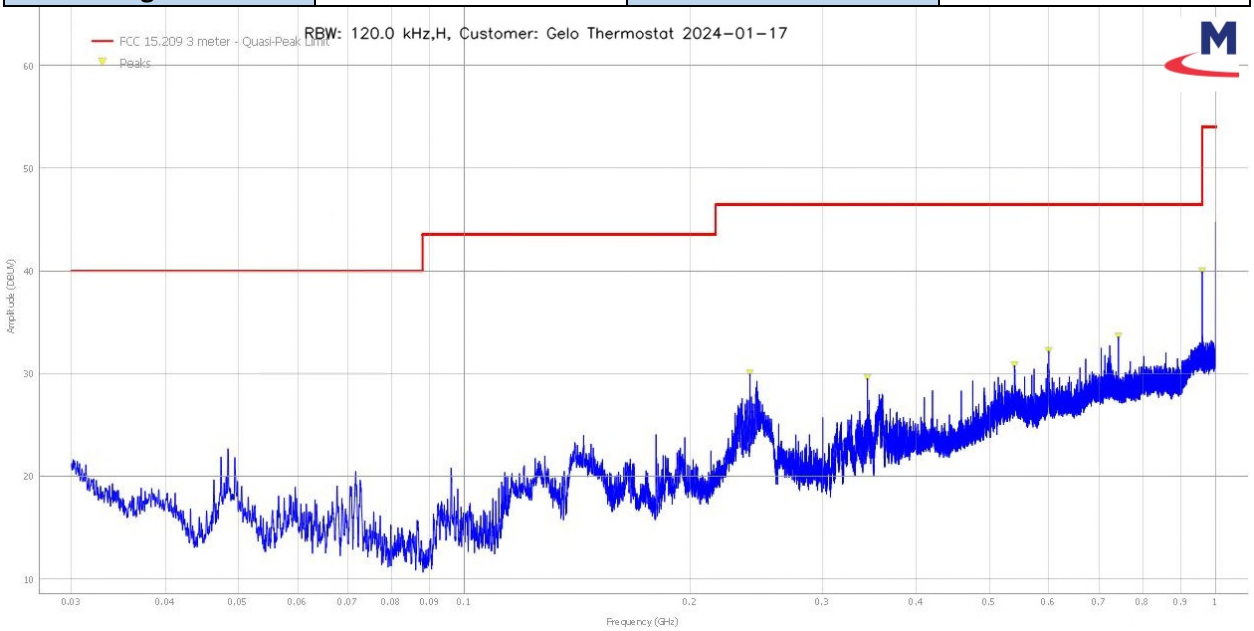
4.4.3 Test Results - Thermostat

Range:	9kHz to 150kHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	N/A



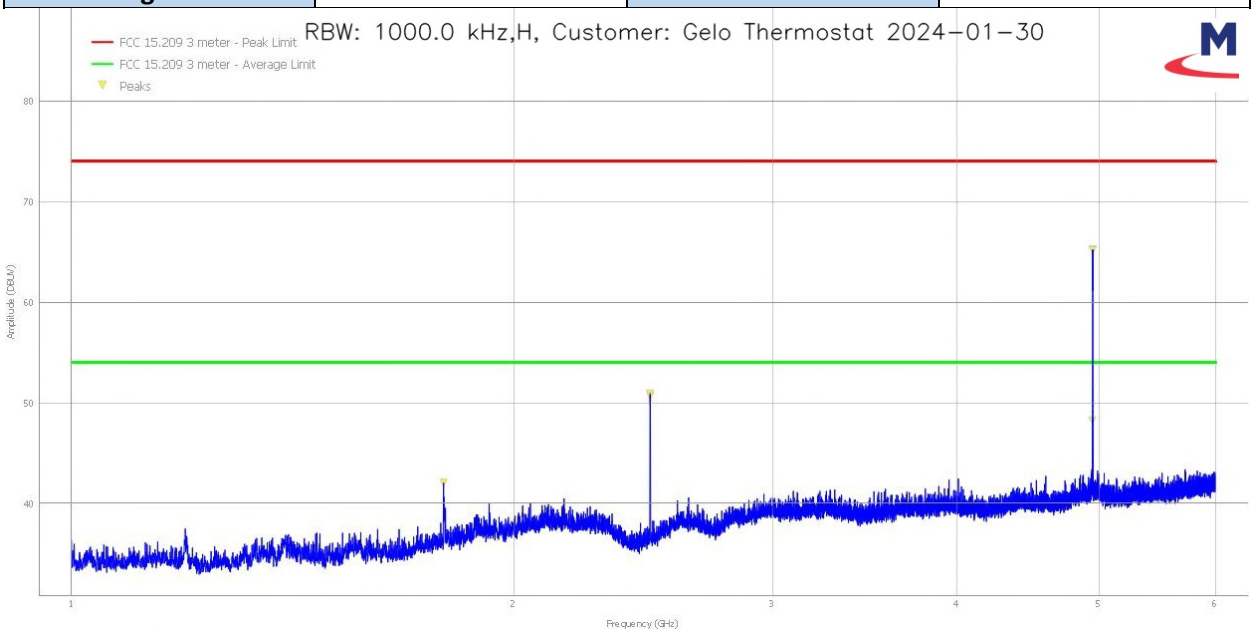
Remark: Quasi-Peak Emission Plot.

Range:	30MHz to 1GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Horizontal



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

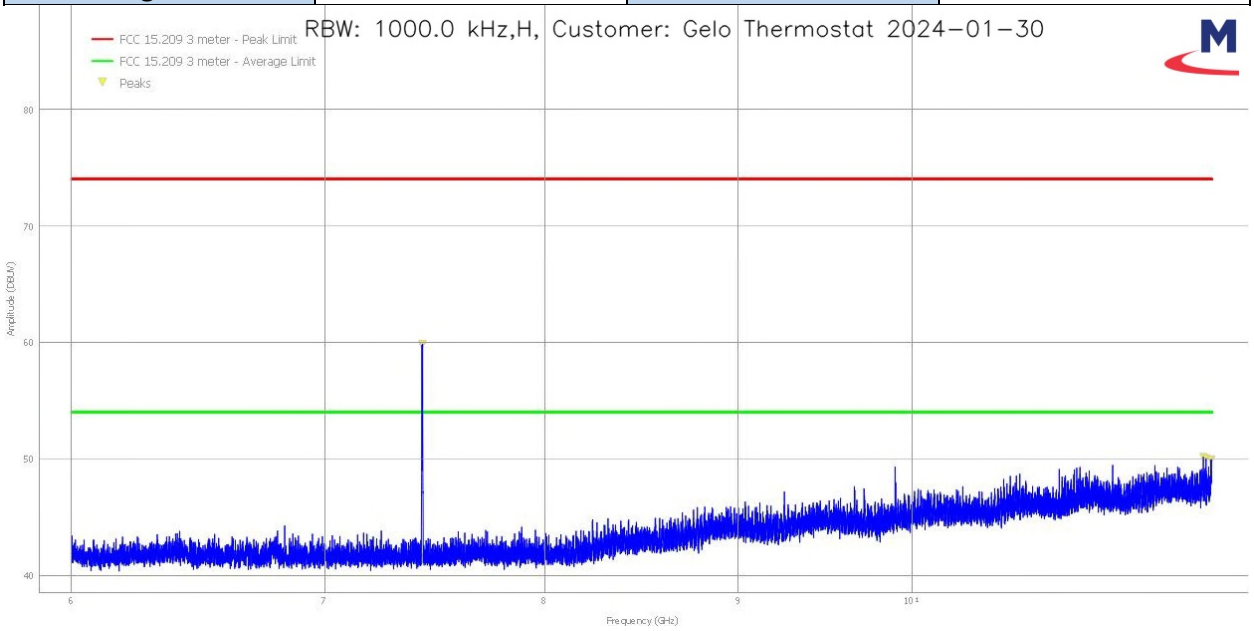
Range:	1GHz to 6GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Horizontal



Remark: - Peak Emission Plot

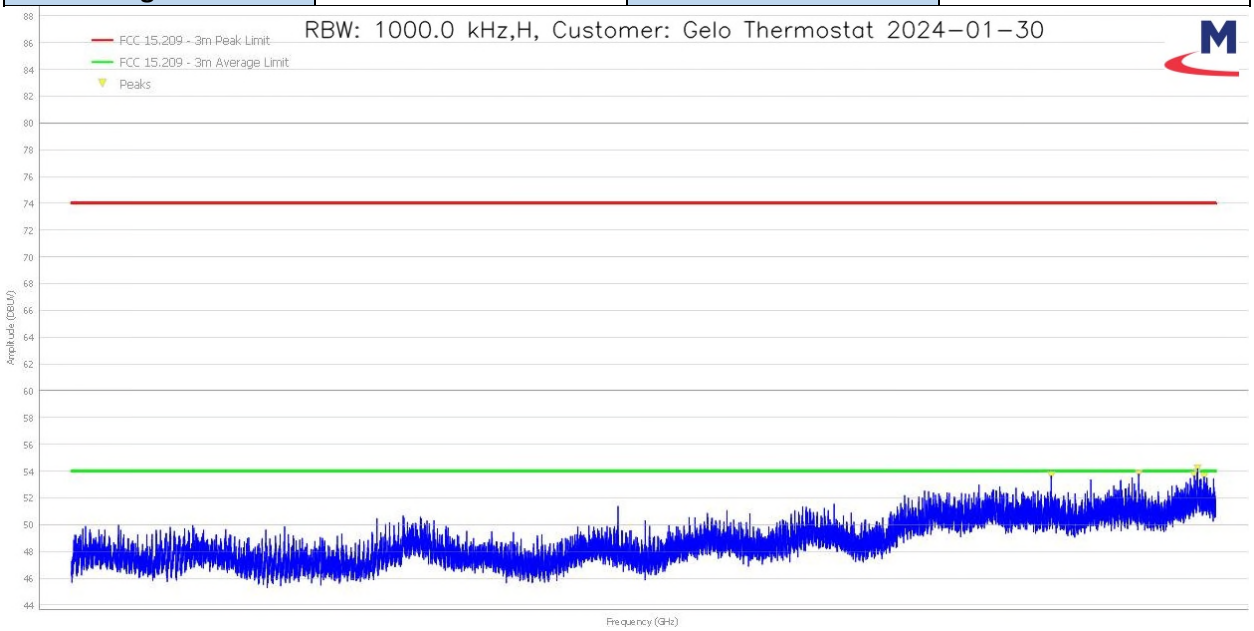
- A Notch filter was used to filter out the fundamental

Range:	6GHz to 12GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Horizontal



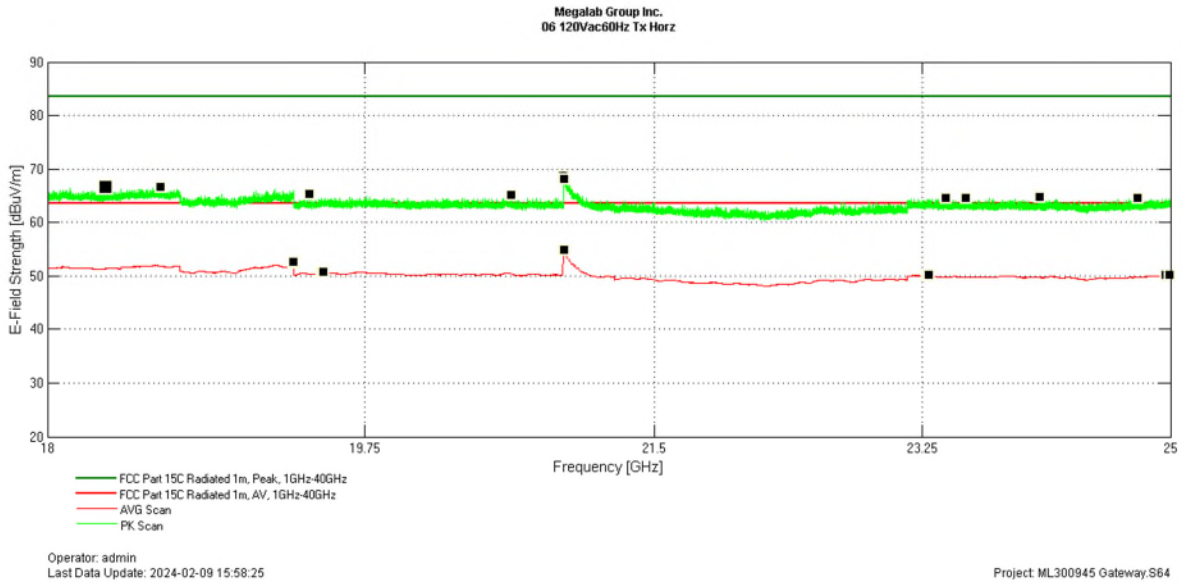
Remark: Peak Emission Plot

Range:	12GHz to 18GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Horizontal



Remark: Peak Emission Plot

Range:	18GHz to 25GHz	**Tx Frequency**	2405 MHz
Test Voltage:		**Antenna Polarization**	Horizontal



Remark: Peak Emission Plot

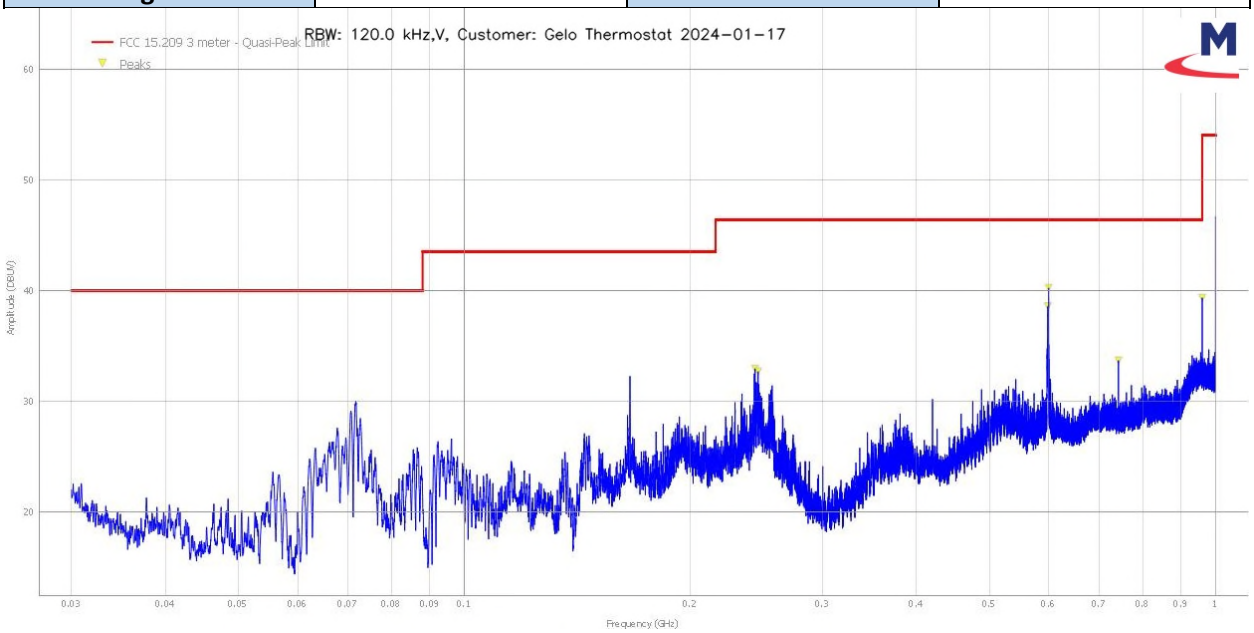
Horizontal Antenna Polarization							
Frequency (MHz)	Detector	Reading (dBµV)	Correction Factor (dB)	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Test Result
960.03	QP	35.6	4.8	40.4	46.4	6.0	Pass
17886.50	AVG	27.1	12.3	39.4	54.0	14.6	Pass
17884.25	AVG	27.1	12.3	39.3	54.0	14.7	Pass
17517.00	AVG	28.7	11.8	40.4	54.0	13.6	Pass
17866.00	AVG	27.1	12.2	39.3	54.0	14.7	Pass
16982.00	AVG	28.3	11.6	39.9	54.0	14.1	Pass
17928.25	AVG	27.0	12.3	39.4	54.0	14.6	Pass
17886.50	AVG	27.1	12.3	39.4	54.0	14.6	Pass

Worst case position: Angle: 226 Deg
Height: 138 cm

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							
4810.8	PEAK	68.7	-3.1	65.6	74.0	8.4	Pass
4810.8	AVG	61.0	-3.1	47.4	54.0	6.6	Pass*
7216.2	PEAK	60.0	-0.7	59.3	74.0	14.7	Pass
7216.2	AVG	51.0	-0.7	39.8	54.0	14.2	Pass*
9621.6	PEAK	48.4	2.2	50.6	74.0	23.4	Pass
9621.6	AVG	37.3	2.2	39.5	54.0	14.5	Pass
Mid Channel							
4880	PEAK	67.3	-2.9	64.3	74.0	9.7	Pass
4880	AVG	59.4	-2.9	45.9	54.0	8.1	Pass*
7320	PEAK	60.9	-0.6	60.2	74.0	13.8	Pass
7320	AVG	52.0	-0.6	40.9	54.0	13.1	Pass*
9760	PEAK	48.2	2.5	50.7	74.0	23.3	Pass
9760	AVG	36.2	2.5	38.7	54.0	15.3	Pass
High Channel							
4950.86	PEAK	68.2	-2.7	65.5	74.0	8.5	Pass
4950.86	AVG	60.8	-2.7	47.5	54.0	6.5	Pass*
7426.29	PEAK	62.9	-0.6	62.3	74.0	11.7	Pass
7426.29	AVG	53.9	-0.6	42.8	54.0	11.2	Pass*
9901.72	PEAK	48.6	2.8	51.3	74.0	22.7	Pass
9901.72	AVG	36.8	2.8	39.5	54.0	14.5	Pass
12377.15	PEAK	45.5	6.9	52.4	74.0	21.6	Pass
12377.15	AVG	33.3	6.9	29.6	54.0	24.4	Pass

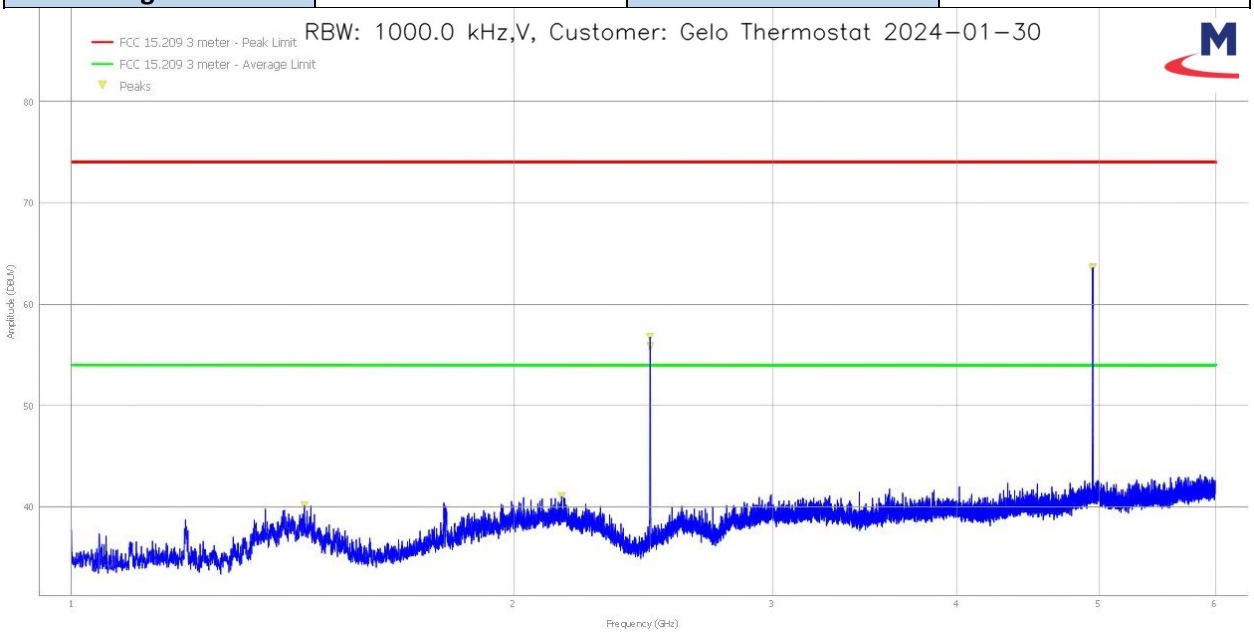
*Note: A Duty Cycle Correction Factor of -10.5 dB was applied to Average Emissions of 2nd and 3rd harmonics. See Section 2.1.1 for additional details.

Range:	30MHz to 1GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Vertical



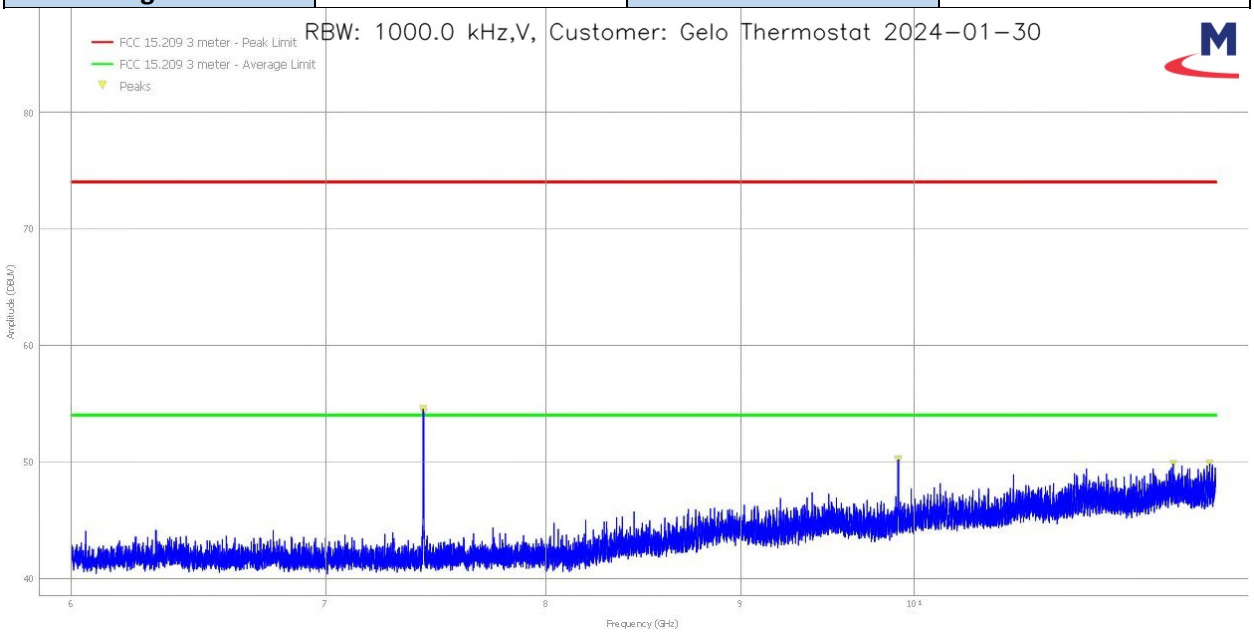
Remark: - Peak Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	1GHz to 6GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Vertical



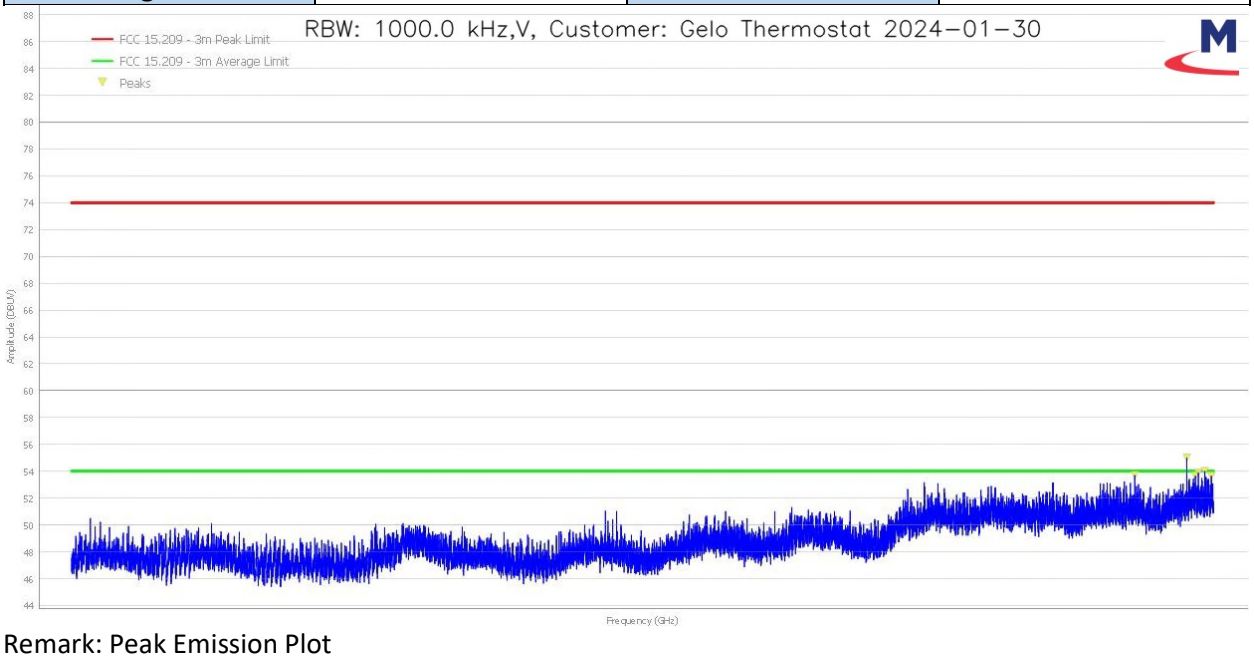
Remark: - Peak Emission Plot
- A Notch filter was used to filter out the fundamental

Range:	6GHz to 12GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Vertical



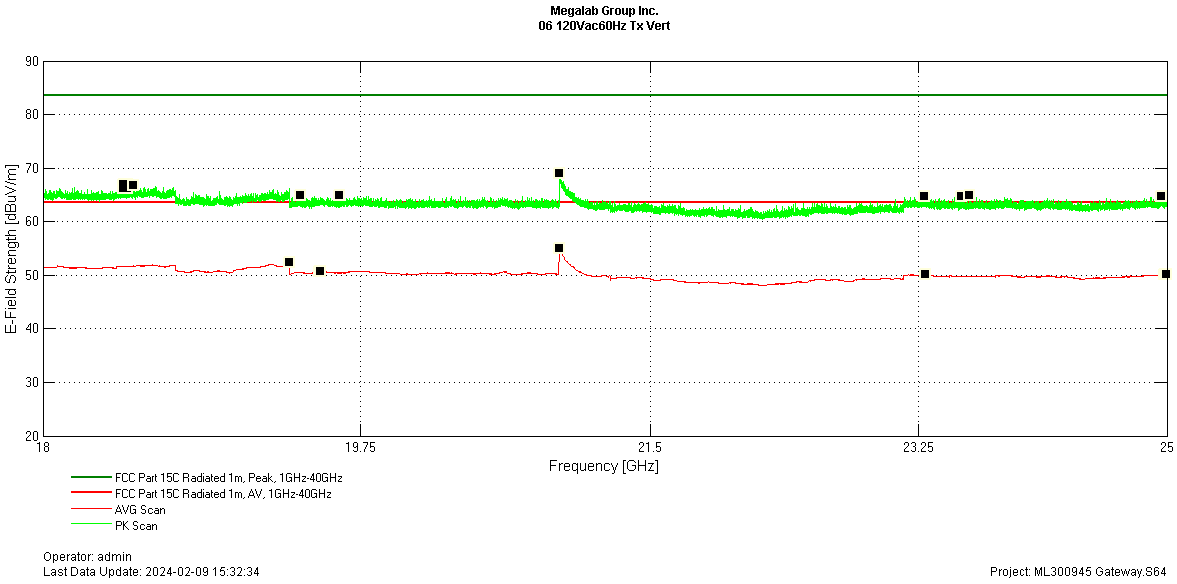
Remark: Peak Emission Plot

Range:	12GHz to 18GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Vertical



Remark: Peak Emission Plot

Range:	18GHz to 25GHz	**Tx Frequency**	2405 MHz
Test Voltage:	24Vac 60Hz	**Antenna Polarization**	Vertical



Remark: Peak Emission Plot

Vertical Antenna Polarization							
Frequency (MHz)	**Detector**	**Reading (dBµV)**	**Correction Factor (dB)**	**Emission Level (dBµV/m)**	**Limit (dBµV/m)**	**Margin (dB)**	**Test Result**
599.49	QP	30.8	-0.7	30.1	46.4	16.3	Pass
960.03	QP	34.9	4.8	39.7	46.4	6.7	Pass
17830.75	AVG	28.1	12.2	40.2	54.0	13.8	Pass
17945.00	AVG	27.1	12.4	39.5	54.0	14.5	Pass
17904.00	AVG	28.2	12.3	40.5	54.0	13.5	Pass
17504.50	AVG	27.6	11.7	39.4	54.0	14.6	Pass
17885.00	AVG	27.7	12.3	39.9	54.0	14.1	Pass
17986.75	AVG	27.0	12.4	39.4	54.0	14.6	Pass

Worst case position: Angle: 224 Deg
Height: 151 cm

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							
4810.8	PEAK	68.2	-3.1	65.0	74.0	9.0	Pass
4810.8	AVG	60.3	-3.1	46.6	54.0	7.4	Pass*
7216.2	PEAK	59.7	-0.7	59.1	74.0	14.9	Pass
7216.2	AVG	50.9	-0.7	39.8	54.0	14.2	Pass*
9621.6	PEAK	49.9	2.2	52.2	74.0	21.8	Pass
9621.6	AVG	39.8	2.2	42.0	54.0	12.0	Pass
Mid Channel							
4880	PEAK	67.7	-2.9	64.7	74.0	9.3	Pass
4880	AVG	60.3	-2.9	46.9	54.0	7.1	Pass*
7320	PEAK	60.2	-0.6	59.5	74.0	14.5	Pass
7320	AVG	51.0	-0.6	39.9	54.0	14.1	Pass*
9760	PEAK	46.7	2.5	49.2	74.0	24.8	Pass
9760	AVG	35.2	2.5	37.7	54.0	16.3	Pass
High Channel							
4950.86	PEAK	70.3	-2.7	67.6	74.0	6.4	Pass
4950.86	AVG	62.7	-2.7	49.5	54.0	4.5	Pass*
7426.29	PEAK	59.5	-0.6	58.9	74.0	15.1	Pass
7426.29	AVG	50.4	-0.6	39.3	54.0	14.7	Pass*
9901.72	PEAK	49.0	2.8	51.7	74.0	22.3	Pass
9901.72	AVG	37.2	2.8	39.9	54.0	14.1	Pass
12377.15	PEAK	45.6	6.9	52.5	74.0	21.5	Pass
12377.15	AVG	32.8	6.9	39.6	54.0	14.4	Pass

*Note: A Duty Cycle Correction Factor of -10.5 dB was applied to Average Emissions of 2nd and 3rd harmonics. See Section 2.1.1 for additional details.

4.4.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
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	May 4, 2022	May 4, 2024
EQ_EMC_59	BiLog Antenna	ETS Lindgren	3142E	Feb 27, 2022	Feb 27, 2024
EQ_EMC_60	Horn Antenna	ETS Lindgren	3117	Mar 11, 2022	Mar 11, 2024
EQ_EMC_56	DRG Horn Antenna 18GHz-40GHz	A.H Systems	SAS-574	Apr 1, 2022	Apr 1, 2024
EQ_EMC_68	6dB Attenuator	Fairview Microwave	SA3NS-06	NCR	NCR
EQ_EMC_85	RF Cable <1GHz	Times Microwave	LMR-400	NCR	NCR
EQ_EMC_75	RF Cable >1GHz	MegaPhase	EMC2	NCR	NCR
EQ_EMC_89	Preamplifier 9kHz-1GHz	Teseq	LNA 6901	May 12, 2022	May 12, 2024
EQ_EMC_42	Preamplifier 1GHz-18GHz	Com-Power	PAM-118A	Mar 24, 2022	Mar 24, 2024
EQ_EMC_43	Preamplifier 18GHz-40GHz	Com-Power	PAM-840A	Mar 24, 2022	Mar 24, 2024
EQ_EMC_108	2400 - 2500MHz Notch Filter	Micro-Tronics	BRM50702	NCR	NCR
EQ_EMC_96	Emissions Software	Megalab Group	EMI V1.0	NCR	NCR
EQ_EMC_149	Emission Software RE/CE	Gauss Instruments	EMI64k v6.31.2	NCR	NCR

4.5 Lower and Upper Band Edges

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

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).

4.5.2 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.

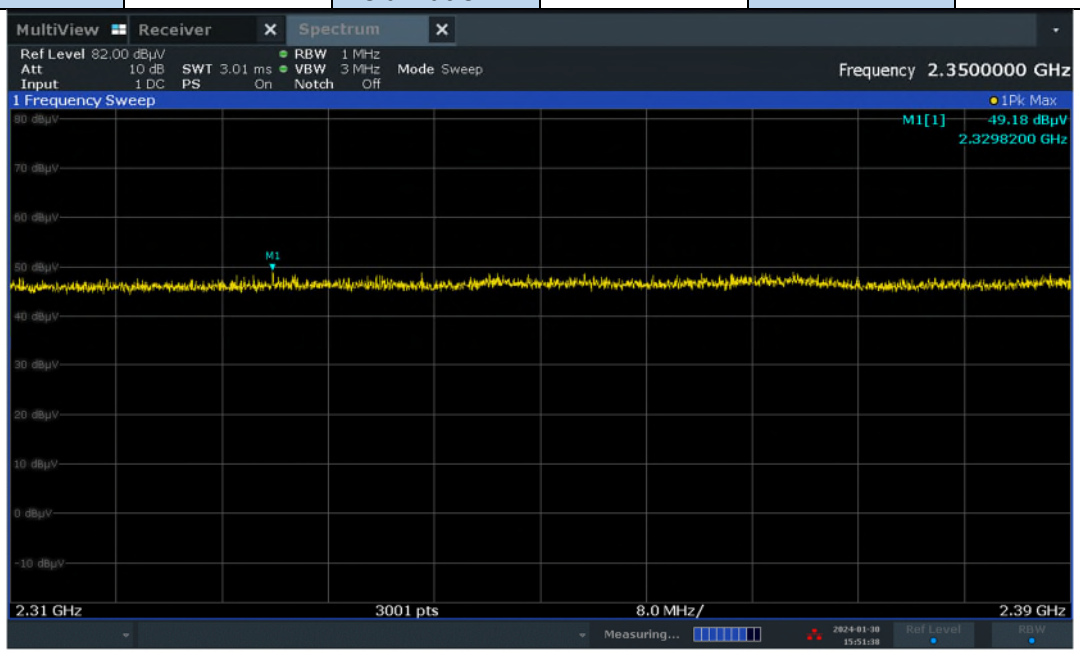
The radiated band edge measurements were made with the DUT in normal operation position.

4.5.3 Test Results - Thermostat

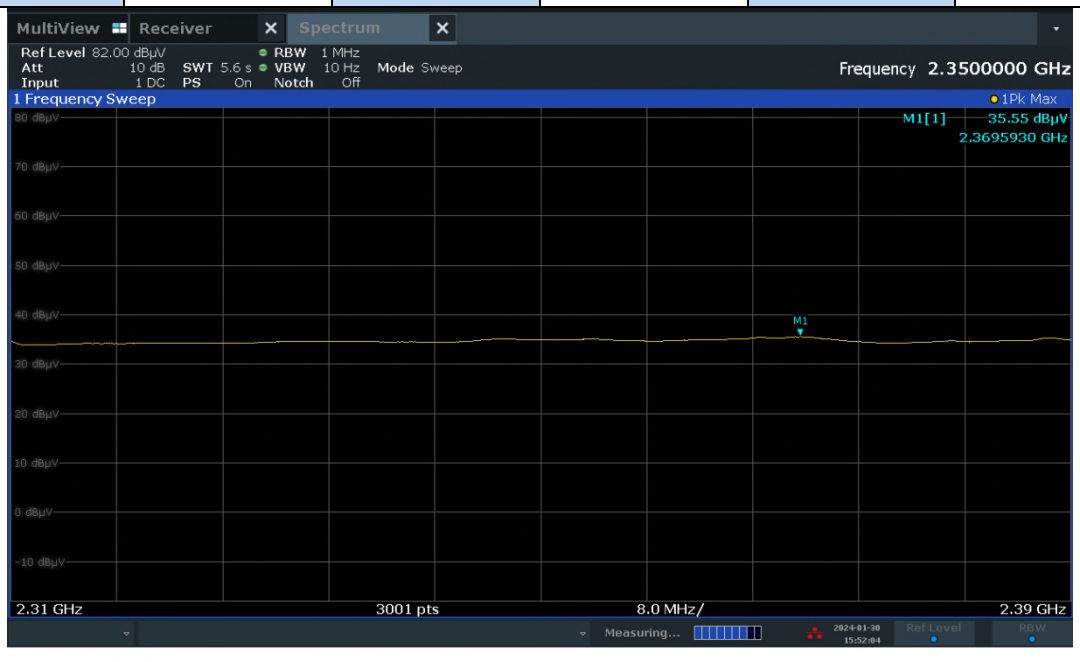
The DUT met the band edge requirements. Peak output power for low, mid and high channels were measured and the Plots Section below contains the maximum radiated emission levels captured on the spectrum analyzer at the band edges. The Final Measurements Section contains the final results with the correction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

4.5.3.1. Plots

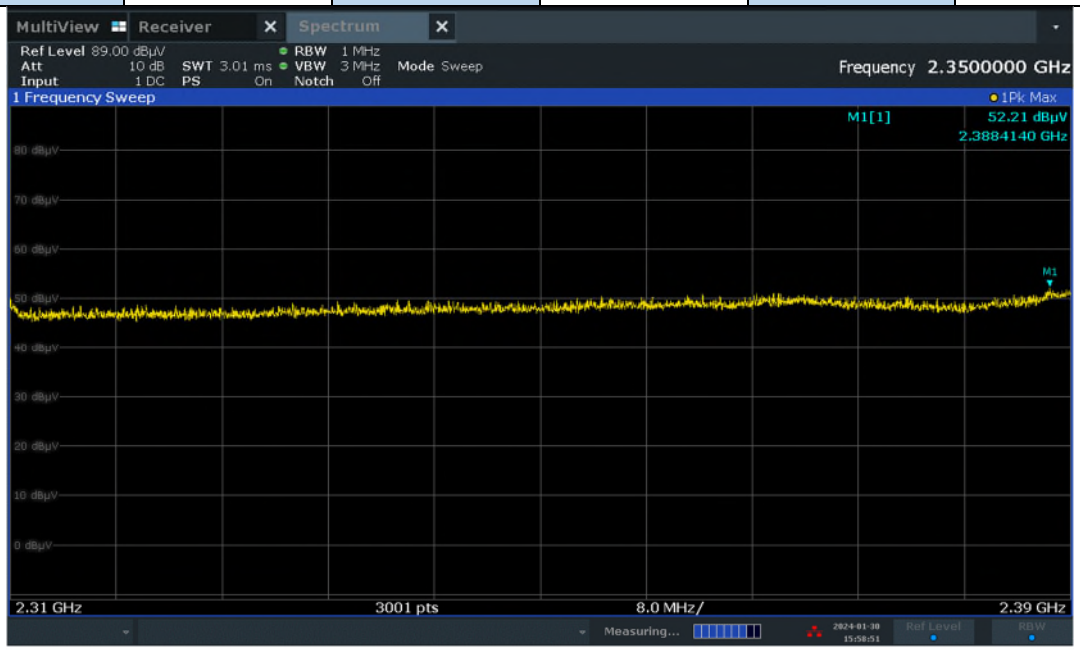
Tx Frequency	Low Channel	**Antenna Polarization**	Horizontal	**Emission**	Peak



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

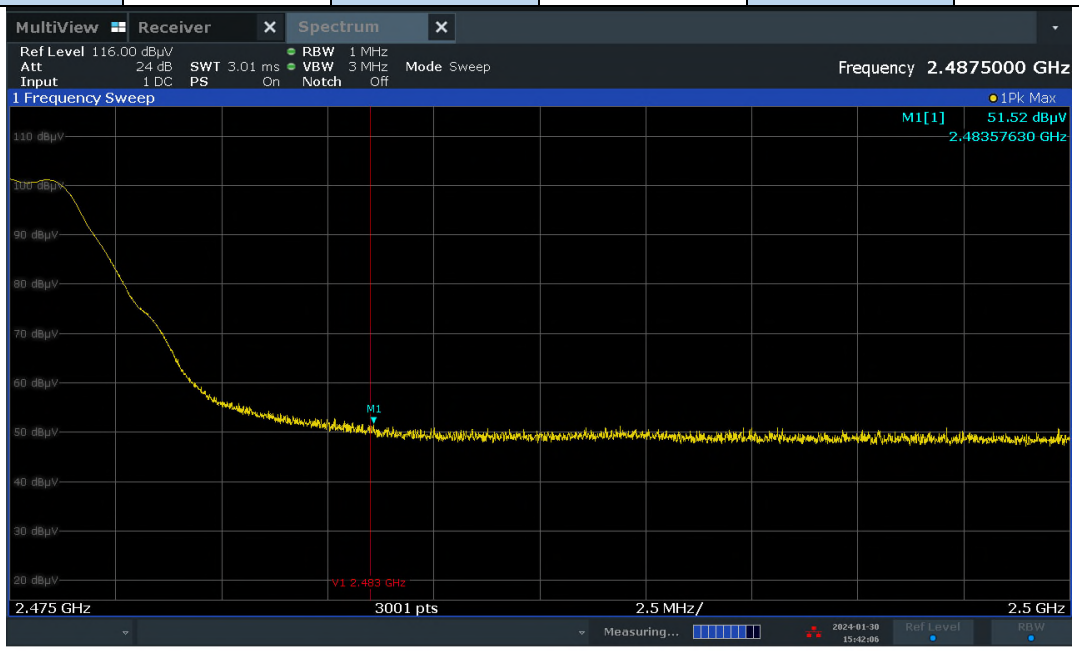


Tx Frequency	Low Channel	**Antenna Polarization**	Vertical	**Emission**	Peak



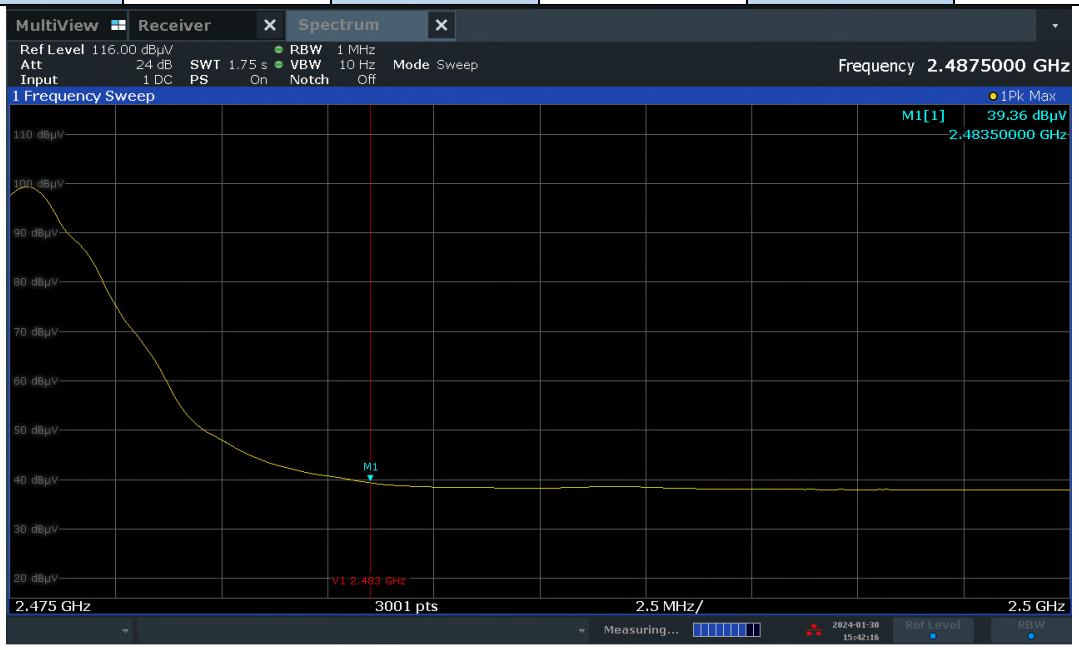
Tx Frequency	Low Channel	**Antenna Polarization**	Vertical	**Emission**	Average

Tx Frequency	High Channel	**Antenna Polarization**	Horizontal	**Emission**	Peak



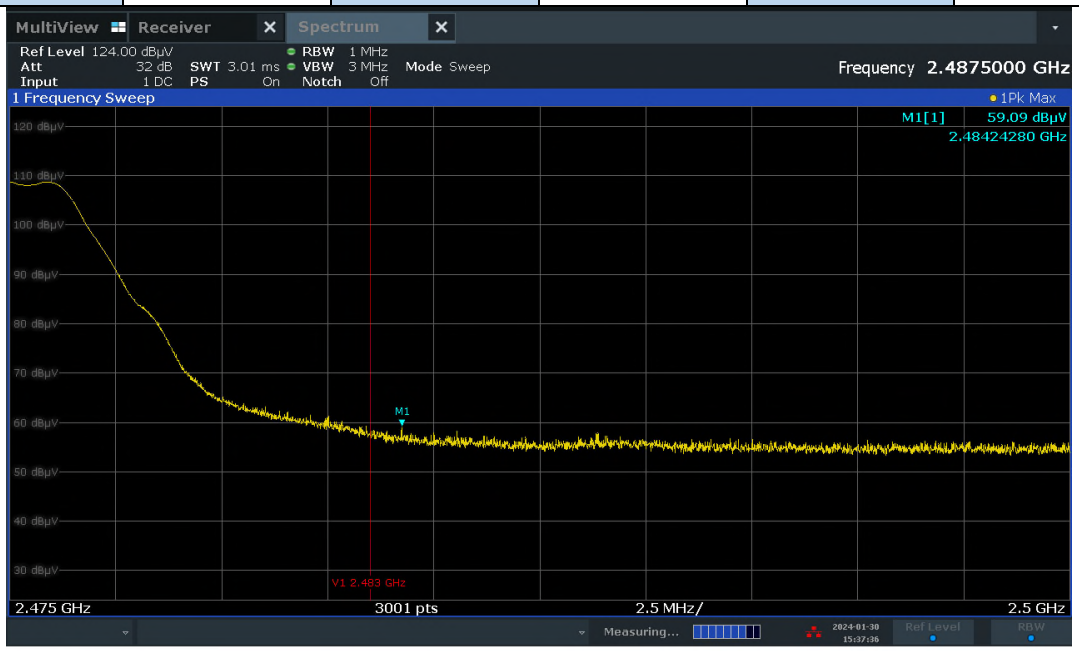
03:42:07 PM 01/30/2024

Tx Frequency	High Channel	**Antenna Polarization**	Horizontal	**Emission**	Average



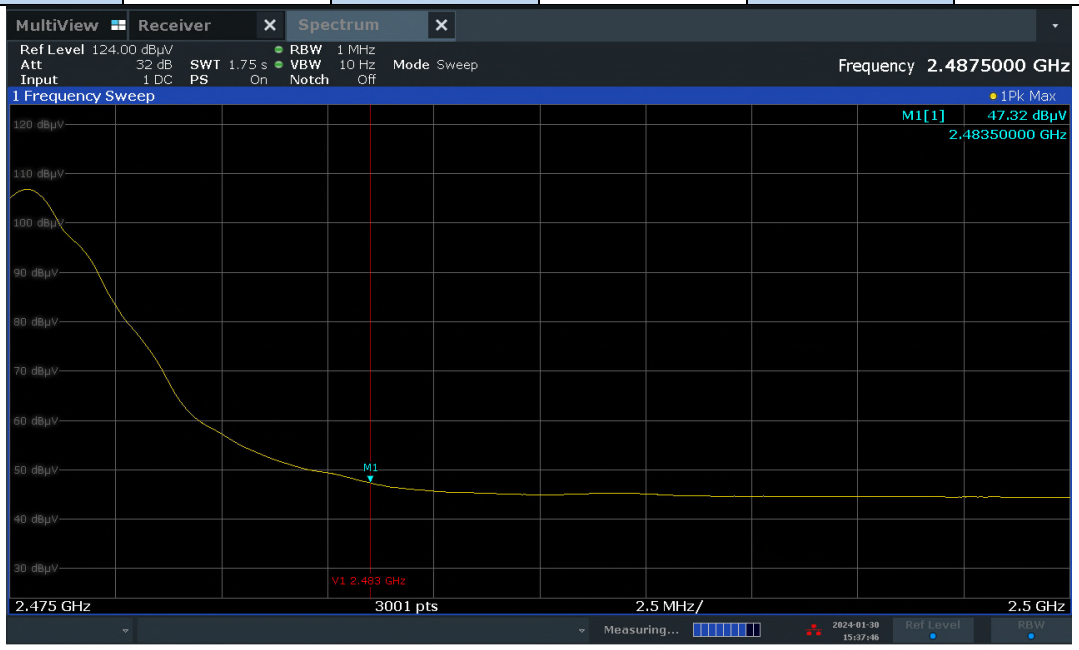
03:42:17 PM 01/30/2024

Tx Frequency	High Channel	**Antenna Polarization**	Vertical	**Emission**	Peak



03:37:37 PM 01/30/2024

Tx Frequency	High Channel	**Antenna Polarization**	Vertical	**Emission**	Average



03:37:47 PM 01/30/2024

4.5.3.2. Final Measurements

Test Frequency (MHz)	Detection Mode	Antenna Polarity (Horz/Vert)	Received Signal (dBµV)	Antenna Factor (dB/m)	Cable Factor (dB)	Attenuator (dB)	Pre-Amp Gain (dB)	Level (dBµV/m)	Emission Limit (dBµV/m)	Margin (dB)	Result
Low Channel											
2405.4	Peak	Horz	101.8	32.5	2.7	10.0	-41.6	105.4			PASS
2405.4	Avg	Horz	99.3	32.5	2.7	10.0	-41.6	103.0			PASS
2405.4	Peak	Vert	109.0	32.5	2.7	10.0	-41.6	112.6			PASS
2405.4	Avg	Vert	106.8	32.5	2.7	10.0	-41.6	110.4			PASS
2329.8	Peak	Horz	49.2	32.3	2.7	10.0	-41.5	52.7	74.0	21.3	PASS
2369.6	Avg	Horz	35.5	32.4	2.7	10.0	-41.6	39.1	54.0	14.9	PASS
2388.4	Peak	Vert	52.2	32.4	2.7	10.0	-41.6	55.8	74.0	18.2	PASS
2390	Avg	Vert	39.3	32.4	2.7	10.0	-41.6	42.9	54.0	11.1	PASS
High Channel											
2475.43	Peak	Horz	101.4	32.6	2.8	10.0	-41.7	105.1			PASS
2475.43	Avg	Horz	99.3	32.6	2.8	10.0	-41.7	102.9			PASS
2475.43	Peak	Vert	108.8	32.6	2.8	10.0	-41.7	112.5			PASS
2475.43	Avg	Vert	106.8	32.6	2.8	10.0	-41.7	110.4			PASS
2483.6	Peak	Horz	51.5	32.6	2.8	10.0	-41.7	55.2	74.0	18.8	PASS
2483.5	Avg	Horz	39.4	32.6	2.8	10.0	-41.7	43.0	54.0	11.0	PASS
2484.2	Peak	Vert	59.1	32.6	2.8	10.0	-41.7	62.7	74.0	11.3	PASS
2483.5	Avg	Vert	47.3	32.6	2.8	10.0	-41.7	51.0	54.0	3.0	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	Feb 03, 2022	Feb 03, 2024
EQ_EMC_60	Horn Antenna	ETS Lindgren	3117	Mar 11, 2022	Mar 11, 2024
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	Mar 24, 2022	Mar 24, 2024

4.6 Power Spectral Density

Test Date:	January 31, 2024	Initials:	MX
Temperature (°C)	20.2		
Relative Humidity (%)	24.3		
Barometric Pressure (kPa)	97.7		

4.6.1 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.

4.6.2 Test Procedure

Tested according to ANSI C63.10 Section 11.10

a) Set RBW = 3kHz and VBW ≥ [3 × RBW].
b) Set Span to 1.5 times the DTS Bandwidth.
c) Detector = Peak and Trace Mode = Max Hold.
d) Sweep = Auto Couple.
e) 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.

4.6.3 Test Results

Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Test Result
Low	2405.4	5.10	8	Pass
Mid	2440.4	5.02	8	Pass
High	2475.4	5.98	8	Pass

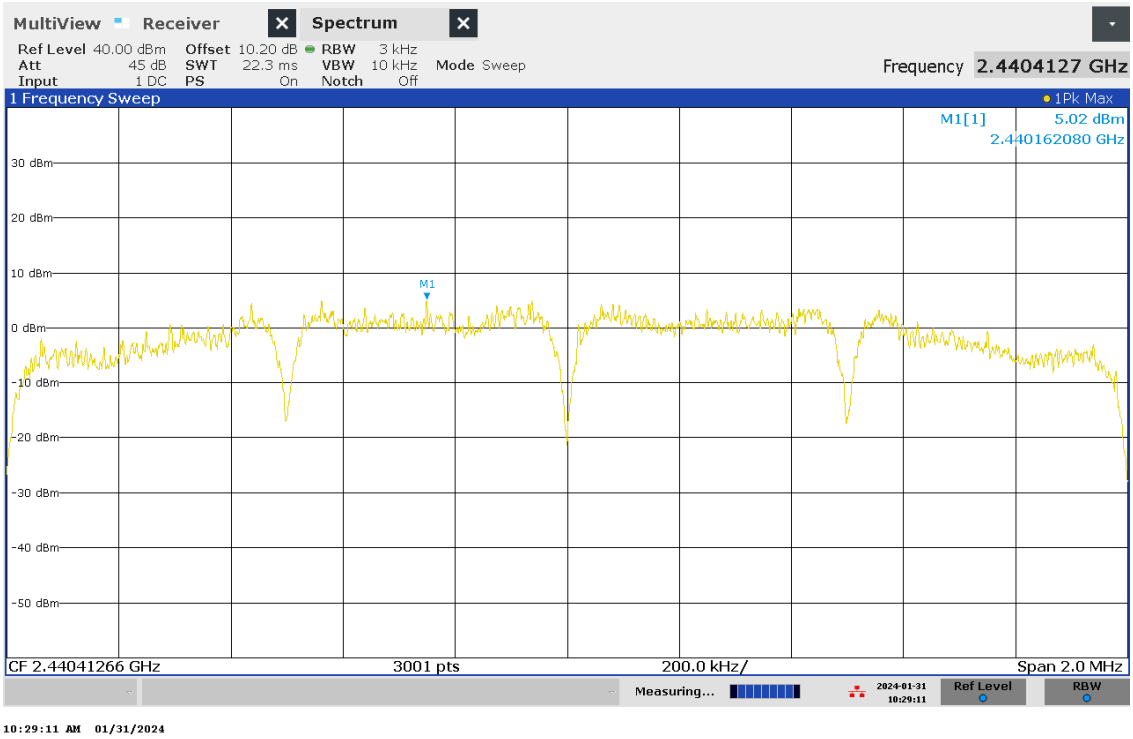


Figure 15 – PSD - Low Channel

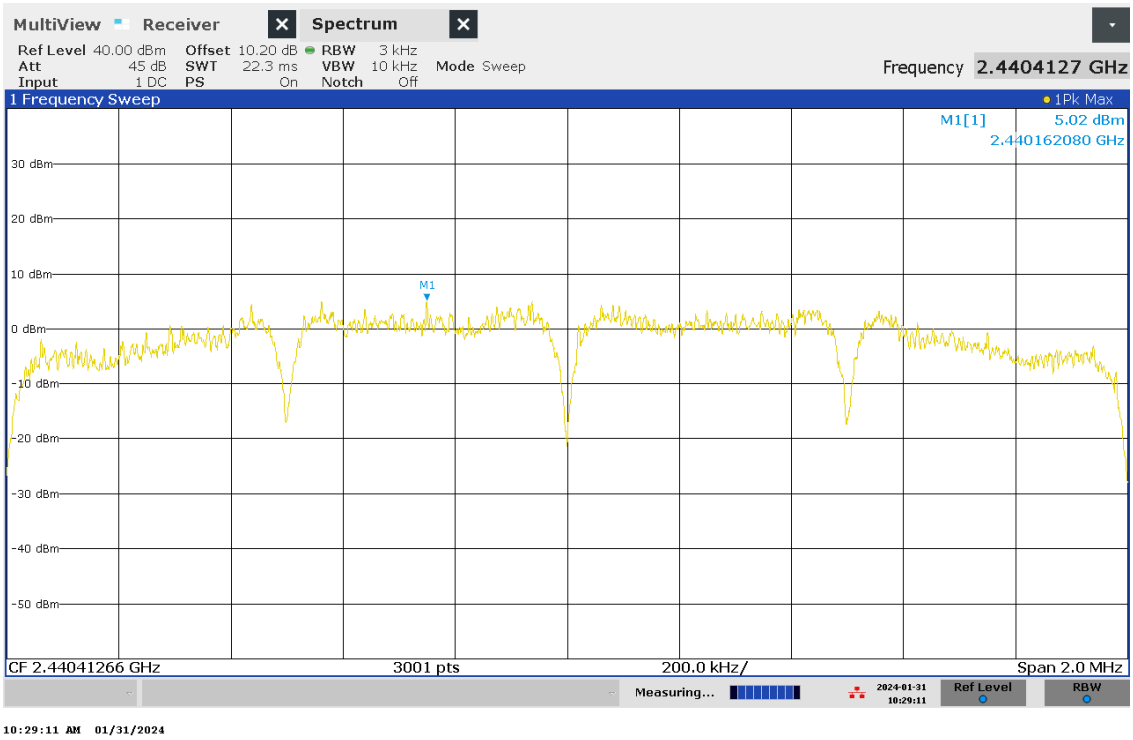


Figure 16 – PSD - Mid Channel

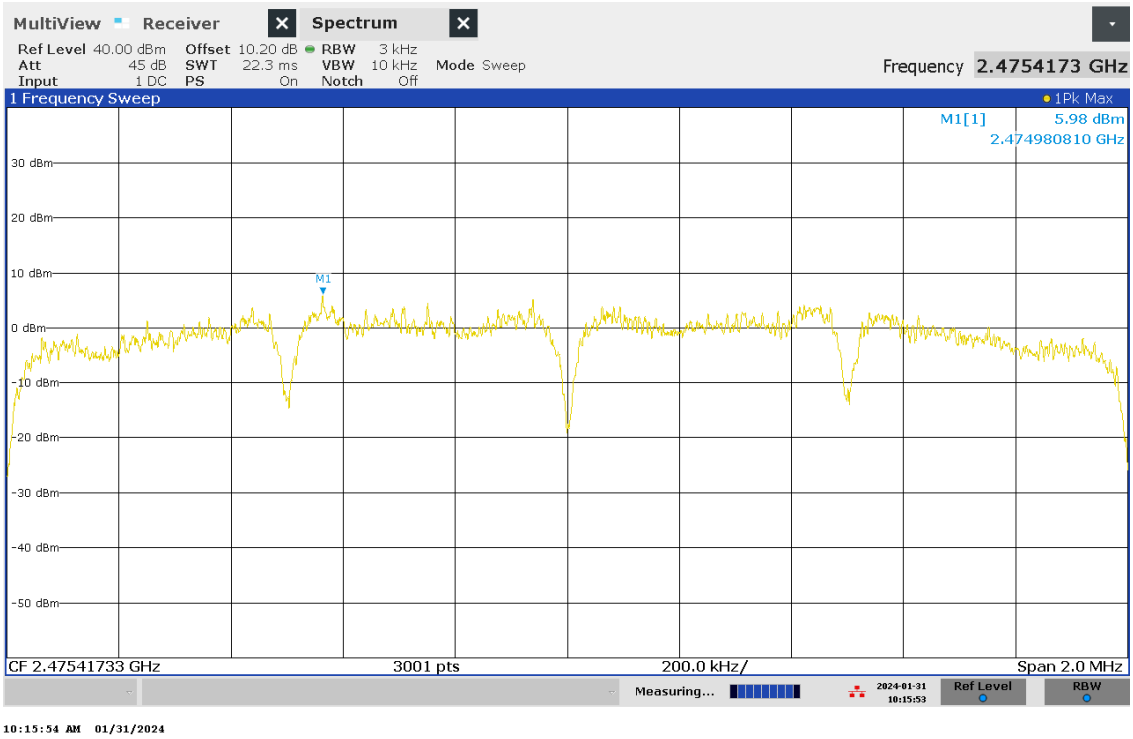


Figure 17 – PSD - High Channel

4.6.4 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
EQ_EMC_115	10dB Attenuator	Fairview Microwave	SA18E-10	NCR	NCR

4.7 Power Line Conducted Emissions

Test Date:	January 31, 2024	April 15, 2024	Initials:	MX
Temperature (°C)	20.2	20.8		
Relative Humidity (%)	24.3	36.7		
Barometric Pressure (kPa)	97.7	101.2		

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

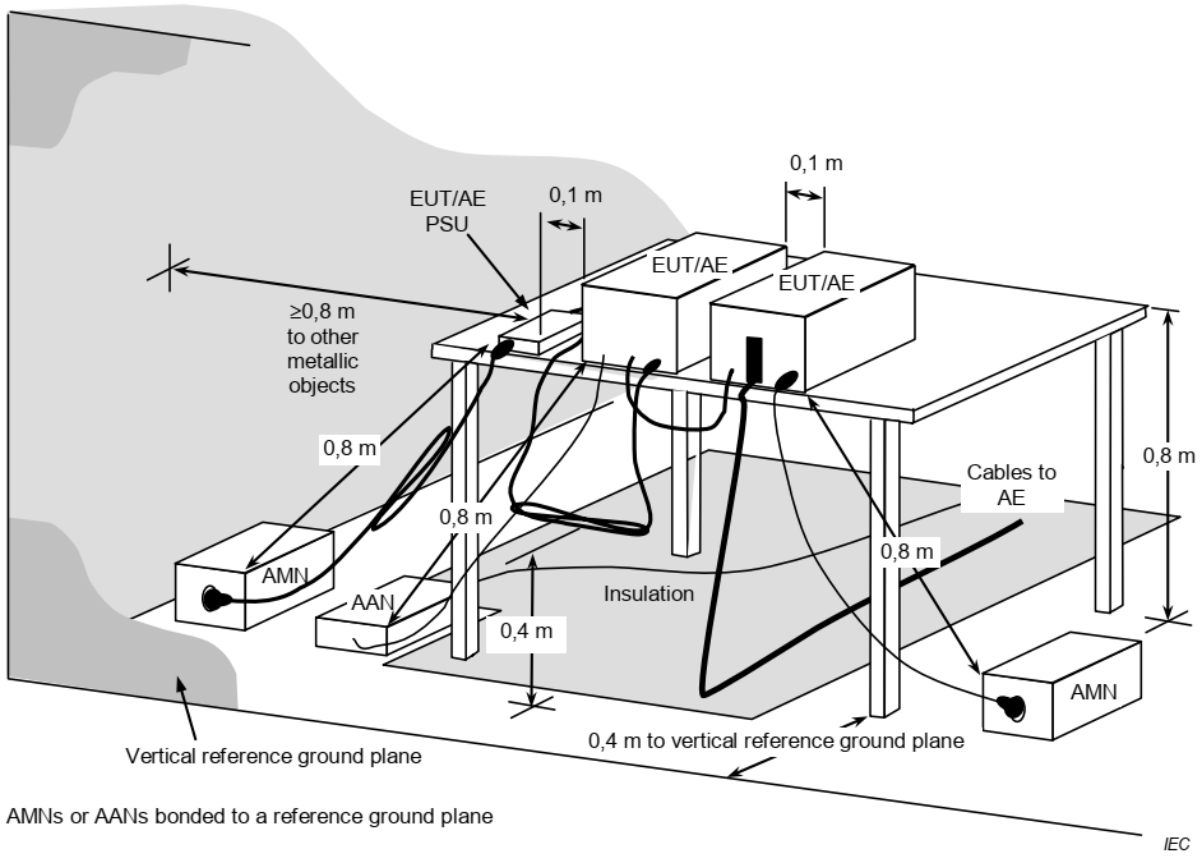
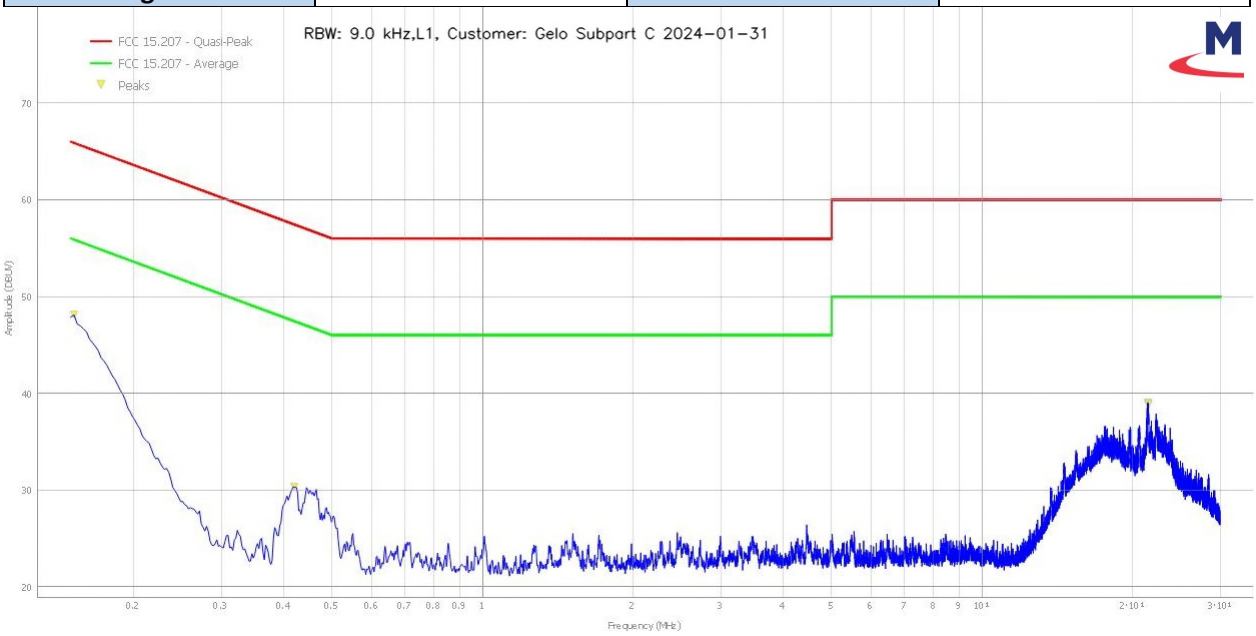


Figure 18 – Sample Measurement Arrangement for DUT

4.7.4 Test Results - Thermostat

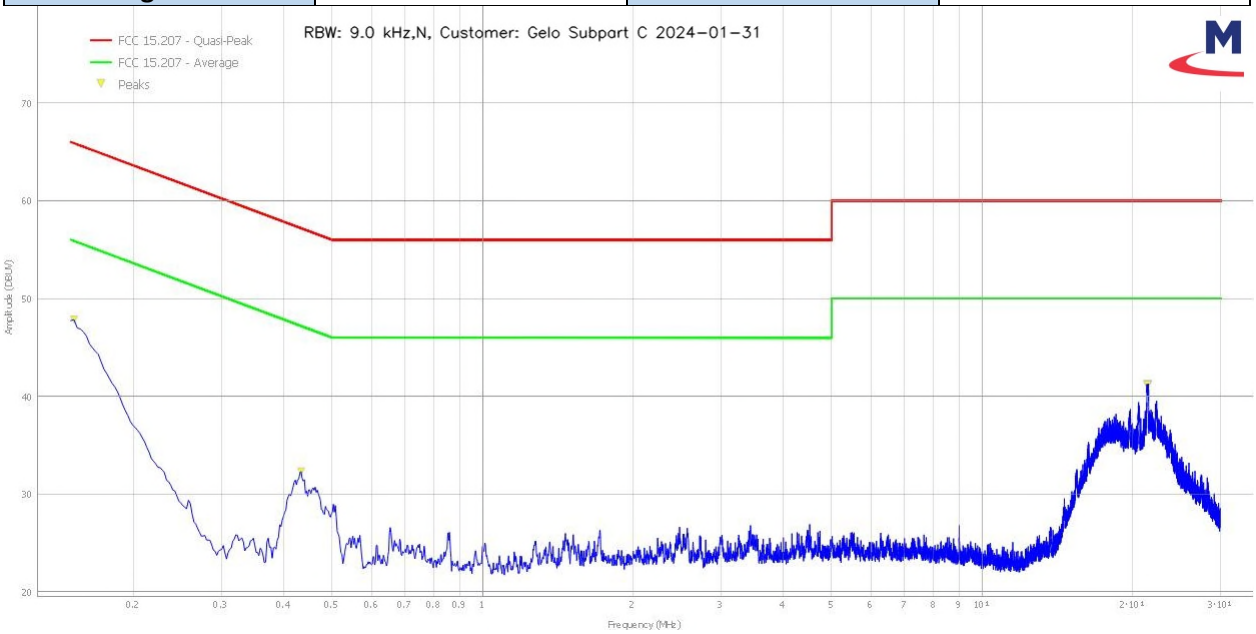
Range:	150kHz to 30MHz	**DUT**	Thermostat
Test Voltage:	120Vac 60Hz	**Phase**	Line



Remark: Peak Emission Plot

Line									
Frequency (MHz)	**Detector**	**Reading (dBµV)**	**Correction Factor (dB)**	**Emission Level (dBµV)**	**AVG Limit (dBµV)**	**AVG Margin (dB)**	**QP Limit (dBµV)**	**QP Margin (dB)**	**Test Result**
0.152	PEAK	38.0	10.1	48.1	55.9	7.8	65.9	17.8	Pass
21.498	PEAK	28.8	10.2	39.0	50.0	11.0	60.0	21.0	Pass
21.451	PEAK	28.8	10.2	39.0	50.0	11.0	60.0	21.0	Pass
21.541	PEAK	28.6	10.2	38.9	50.0	11.1	60.0	21.1	Pass
21.534	PEAK	28.6	10.2	38.8	50.0	11.2	60.0	21.2	Pass
0.420	PEAK	20.3	10.0	30.3	47.5	17.1	57.5	27.1	Pass

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



Remark: Peak Emission Plot

Neutral									
Frequency (MHz)	**Detector**	**Reading (dBµV)**	**Correction Factor (dB)**	**Emission Level (dBµV)**	**AVG Limit (dBµV)**	**AVG Margin (dB)**	**QP Limit (dBµV)**	**QP Margin (dB)**	**Test Result**
0.152	PEAK	37.8	10.1	47.8	55.9	8.0	65.9	18.0	Pass
21.530	PEAK	31.1	10.2	41.3	50.0	8.7	60.0	18.7	Pass
21.390	PEAK	31.1	10.2	41.3	50.0	8.7	60.0	18.7	Pass
21.516	PEAK	31.0	10.2	41.2	50.0	8.8	60.0	18.8	Pass
21.413	PEAK	31.0	10.2	41.2	50.0	8.8	60.0	18.8	Pass
0.434	PEAK	22.3	10.0	32.3	47.2	14.9	57.2	24.9	Pass

4.7.5 Test Equipment List

Equipment ID	Description	Manufacturer	Model	Calibration Date	Calibration Due
EQ_EMC_58	EMI Receiver	Rohde & Schwarz	ESW 44	Feb 03, 2022	Feb 03, 2024
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_96	Emissions Software	Megalab Group	EMI V2.0	NCR	NCR
EQ_EMC_149	Emission Software RE/CE	Gauss Instruments	EMI64k v6.31.2	NCR	NCR

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