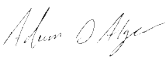
Test Report TR3696A

Equipment Under Test:	AEQ-001JKNF
Requirement(s):	FCC: 15.247 ISED: RSS-247
Test Date(s):	6/26/2023 – 6/28/2023, 7/11/2023, 12/27/2023 – 1/4/2024, 4/15/2024
Prepared for:	Chicago Faucets, Inc Attn: Larry Himelblau 2100 South Clearwater Drive Des Plaines, IL 60018

Report Issued by: Dylan Rosenfeldt, EMC Engineer

Signature:  Date: 4/25/2024

Report Reviewed by: Adam Alger, Laboratory Manager

Signature:  Date: 4/23/2024

Report Constructed by: Dylan Rosenfeldt, EMC Engineer

Signature:  Date: 1/8/2024

CONTENTS

Ezurio Test Services in Review

The Ezurio laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted

---

Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

1 TEST REPORT SUMMARY

During **6/26/2023 – 6/28/2023, 7/11/2023, 12/27/2023 – 1/4/2024, 4/15/2024,** the Equipment Under Test, **AEQ-001JKNF**, as provided by **Chicago Faucets, Inc.** was tested to the following requirements:

FCC 15.247 / RSS-247, DTS

Requirement	Description	Specification	Method	Result
FCC: 15.247 (a)(2) IC: RSS-247 5.2 (a)	Digital Modulation System 6 dB bandwidth	500 kHz	ANSI C63.10	Pass
FCC: 2.1049 IC: RSS-GEN 6.7	Occupied Bandwidth	Reported	ANSI C63.10	Pass
FCC: 15.247 (b)(3) IC: RSS-247 5.4 (d)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Pass
FCC: 15.247 (e) IC: RSS-247 5.2 (b)	Digital Modulation System Power Spectral Density	8 dBm / 3 kHz	ANSI C63.10	Pass
FCC: 15.247 (d) IC: RSS-247 5.5	RF Spurious Emissions at the Transmitter Antenna Terminal	20 dBc	ANSI C63.10	Pass
FCC: 15.247 (d) IC: RSS-GEN 8.10	Spurious Radiated Emissions in Restricted Bands	FCC 15.209 RSS-GEN 8.9	ANSI C63.10	Pass
FCC: 2.1055 (d) IC: RSS-GEN 6.11	Frequency Stability	Reported	ANSI C63.10	Pass
FCC: 15.207 IC: RSS-GEN 8.8	AC Power Line Conducted Emissions	0.150-30 MHz	ANSI C63.10	Pass

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	1 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Chicago Faucets, Inc
Contact Person	Larry Himelblau
Address	2100 South Clearwater Drive Des Plaines, IL 60018

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	AEQ-001JKNF
Model Number	AEQ-001JKNF
Serial Number	Engineering Samples 1 & 2
FCC ID **IC ID**	2APTX-CFC05 31327-CFC05

2.2 Product Description

BLE module

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

Powered by 6VDC from 120VAC adapter. Device is programmed via FTDI-USB cable. Programmed using STM32CubeMonitor-RF version 2.11.0. Channels used low, mid, high (2402 MHz, 2440 MHz, 2480 MHz) with a data rate of 1Mbps and 2Mbps using a pseudo-random bit sequence 9 modulation. The transmit power setting used was 'PA level 31 (+6dBm)'. FTDI leads and header added to program module for both units. Unit 2 – Resistor removed in line to chip antenna and u.fl connector added for conducted RF testing.

3 REFERENCES

Publication	Edition	Date	AMD 1	AMD 2
FCC eCFR	-	2023	-	-
RSS-247	3	2023	-	-
RSS-GEN	5	2018	2019	2021
ANSI C63.10	-	2020	-	-

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References
CISPR 16-4-1
CISPR 16-4-2
CISPR 32
ANSI C63.23
A2LA P103
A2LA P103c
ETSI TR 100-028

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

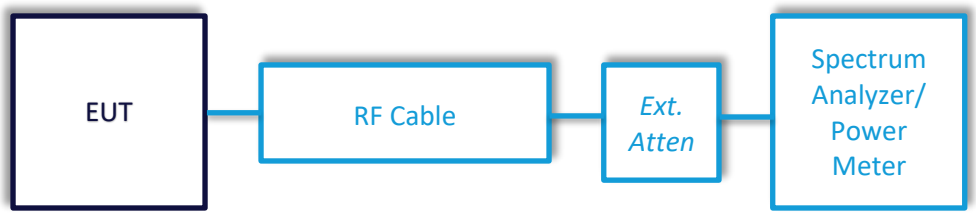
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 DTS Bandwidth

Operator	Dylan Rosenfeldt	**QA**	Anthony Smith
Temperature	21.3°C	**R.H. %**	46.9%
Test Date	6/6/2023	**Location**	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	**Method**	ANSI C63.10

Limits: Greater than 500kHz

Test Parameters

Frequency	2402, 2440, 2480 MHz	**Setup**	Conducted
RBW	100 kHz	**VBW**	300 kHz
Detector(s)	Max Peak Hold		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

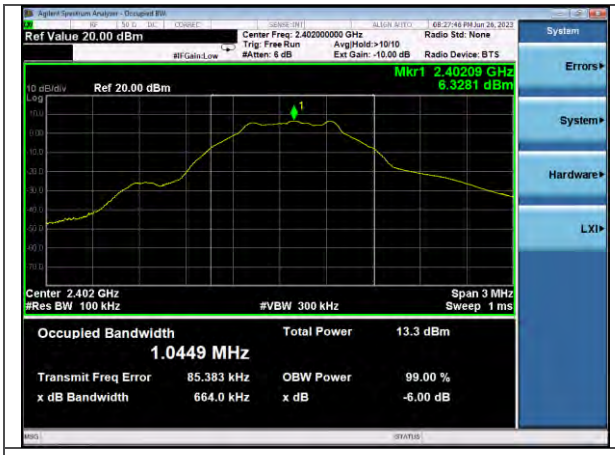
EUT Parameters

Input Power	6VDC via AC adapter	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

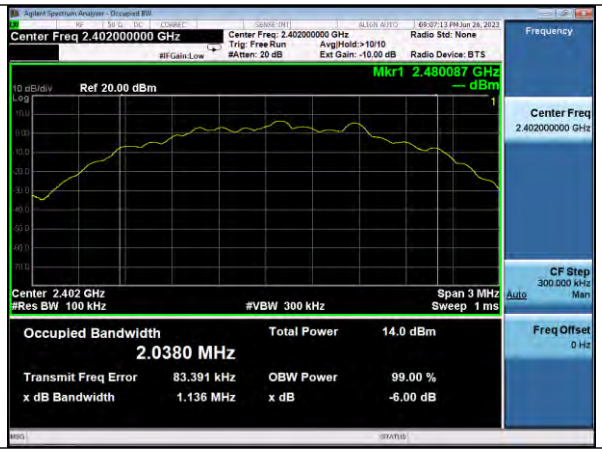
Data Table

Channel	Data Rate	DTS BW (kHz)	Limit (kHz)	Margin (kHz)
37	BLE 1Mbps	664.0	500	164.0
37	BLE 2Mbps	1136.0	500	636.0
17	BLE 1Mbps	661.6	500	161.6
17	BLE 2Mbps	1135.0	500	635.0
39	BLE 1Mbps	662.0	500	162.0
39	BLE 2Mbps	1134.0	500	134.0

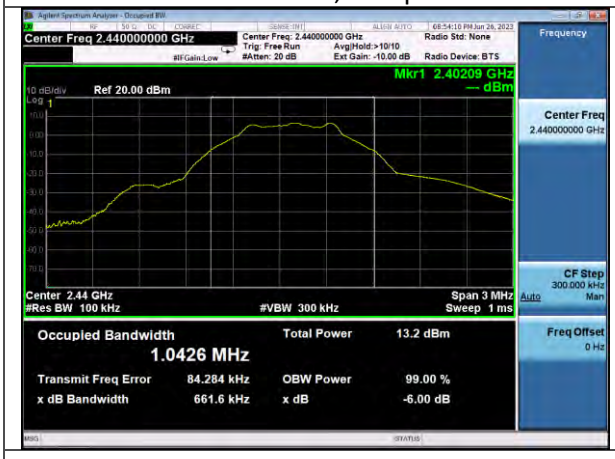
Plots



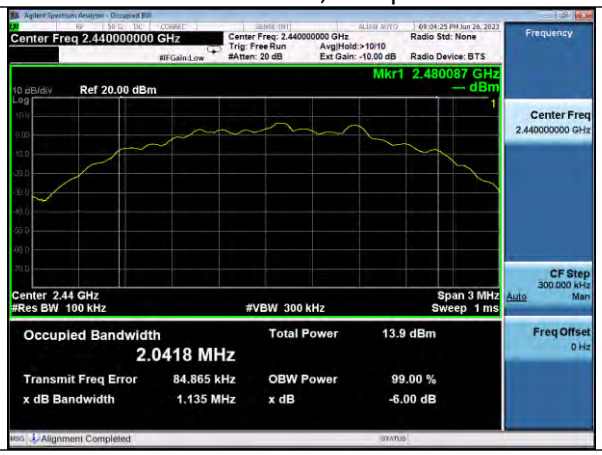
Channel 37, 1Mbps



Channel 37, 2Mbps

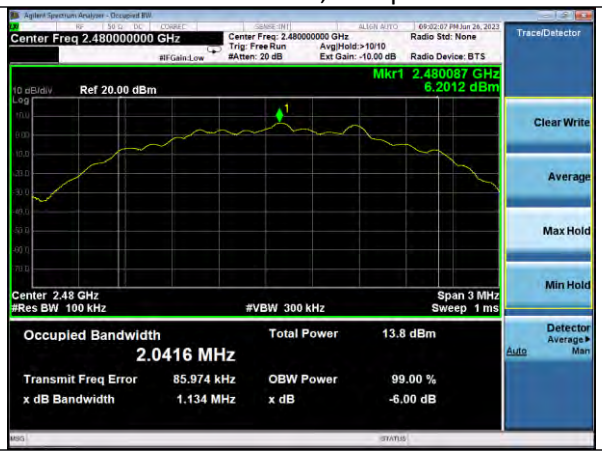


Channel 17, 1Mbps



Channel 17, 2Mbps

Channel 39, 1Mbps



Channel 39, 2Mbps

5.1.2 99% Occupied Bandwidth

Operator	Dylan Rosenfeldt	**QA**	Anthony Smith
Temperature	21.3°C	**R.H. %**	46.9%
Test Date	6/6/2023	**Location**	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	**Method**	ANSI C63.10

Limits: Reported

Test Parameters

Frequency	2402, 2440, 2480 MHz	**Setup**	Conducted
RBW	30, 62 kHz	**VBW**	100, 300 kHz
Detector(s)	Max Peak Hold		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

EUT Parameters

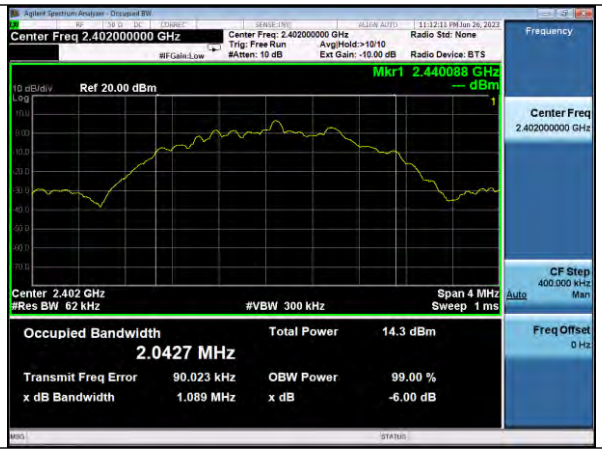
Input Power	6VDC via AC adapter	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

Data Table

Channel	Data Rate	99% OBW (MHz)
37	BLE 1Mbps	1.01
37	BLE 2Mbps	2.04
17	BLE 1Mbps	1.01
17	BLE 2Mbps	2.05
39	BLE 1Mbps	1.01
39	BLE 2Mbps	2.05

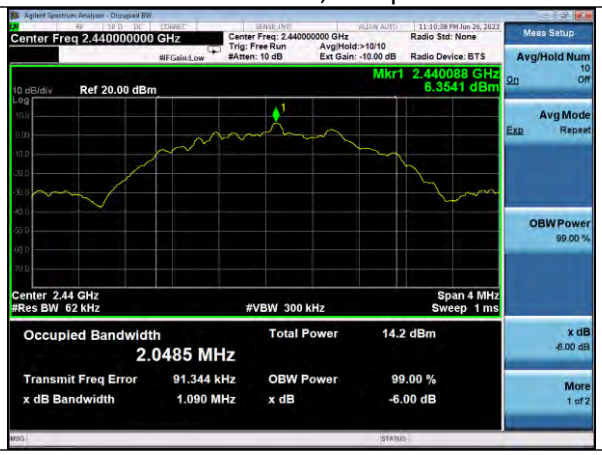
Plots

Channel 37, 1Mbps

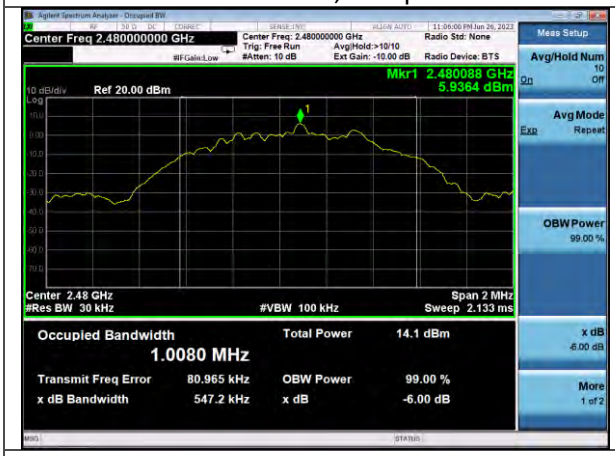


Channel 37, 2Mbps

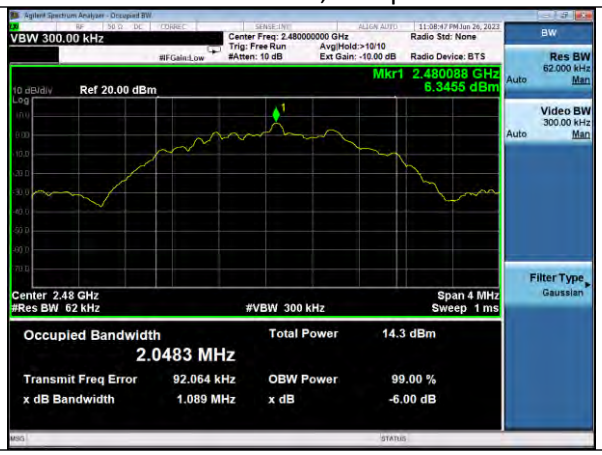
Channel 17, 1Mbps



Channel 17, 2Mbps



Channel 39, 1Mbps



Channel 39, 1Mbps

5.1.3 Peak Output Power

Operator	Dylan Rosenfeldt	QA	Anthony Smith
Temperature	21.3°C	R.H. %	46.9%
Test Date	6/6/2023	Location	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	Method	ANSI C63.10

Limits: 30dBm

Test Parameters

Frequency	2402, 2440, 2480 MHz	Setup	Conducted
RBW	1, 2 MHz	VBW	3, 6 MHz
Detector(s)	Max Peak Hold		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

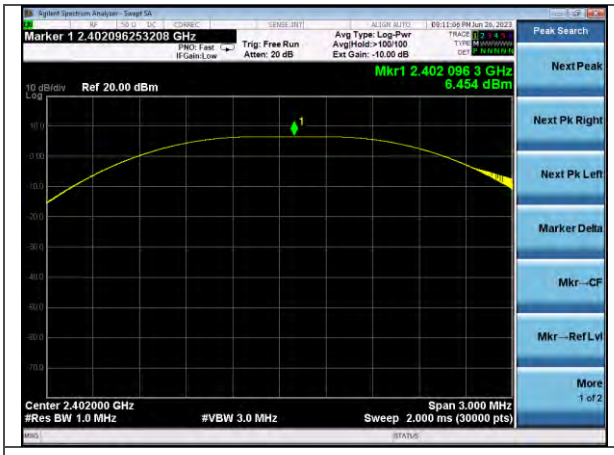
EUT Parameters

Input Power	6VDC via AC adapter	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

Data Table

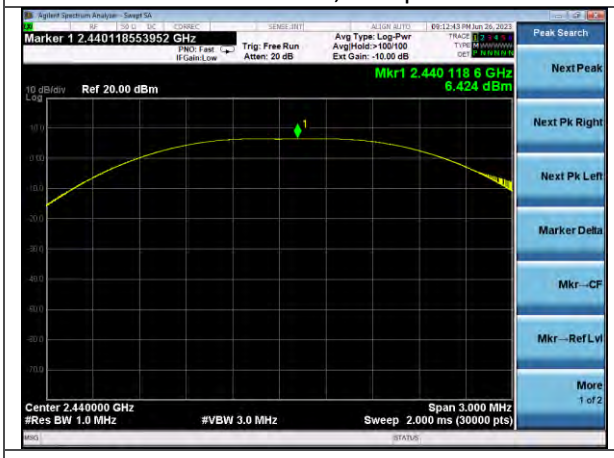
Channel	Data Rate	Transmit Power Setting	Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
37	BLE 1Mbps	31	6.5	30	23.5
37	BLE 2Mbps	31	6.4	30	23.6
17	BLE 1Mbps	31	6.4	30	23.6
17	BLE 2Mbps	31	6.4	30	23.6
39	BLE 1Mbps	31	6.3	30	23.7
39	BLE 2Mbps	31	6.3	30	23.7

Plots



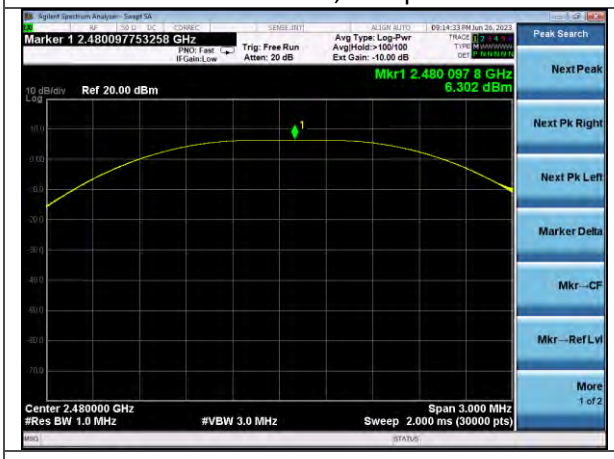
Channel 37, 1Mbps

Channel 37, 2Mbps

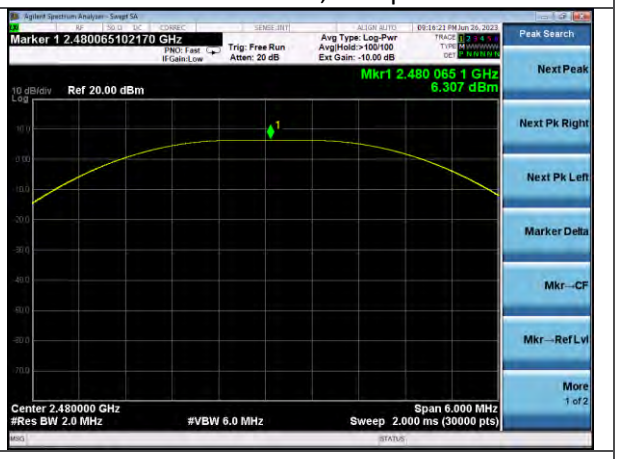


Channel 17, 1Mbps

Channel 17, 2Mbps



Channel 39, 1Mbps



Channel 39, 1Mbps

5.1.4 Peak Power Spectral Density

Operator	Dylan Rosenfeldt	**QA**	Anthony Smith
Temperature	21.3°C	**R.H. %**	46.9%
Test Date	6/6/2023	**Location**	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	**Method**	ANSI C63.10

Limits: 8dBm / 3kHz

Test Parameters

Frequency	2402, 2440, 2480 MHz	**Setup**	Conducted
RBW	100 kHz	**VBW**	300 kHz
Detector(s)	Max Peak Hold		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

EUT Parameters

Input Power	6VDC via AC adapter	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

Data Table

Channel	Data Rate	Transmit Power Setting	PSD Reading (dBm/100kHz)	Limit (dBm/3 kHz)	Margin (dB)
37	BLE 1Mbps	31	6.4	8.0	1.6
37	BLE 2Mbps	31	6.4	8.0	1.6
17	BLE 1Mbps	31	6.4	8.0	1.6
17	BLE 2Mbps	31	6.4	8.0	1.6
39	BLE 1Mbps	31	6.3	8.0	1.7
39	BLE 2Mbps	31	6.3	8.0	1.7

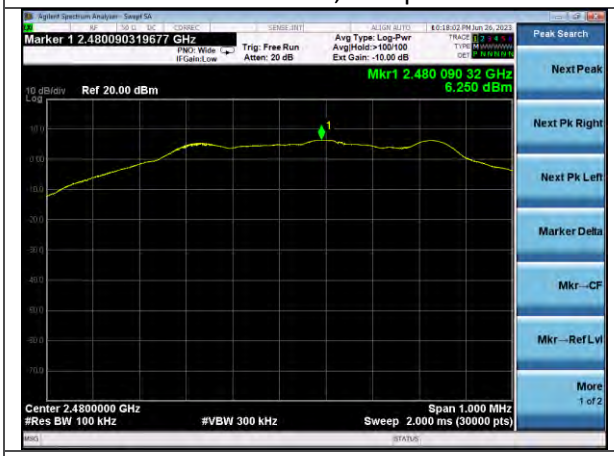
Plots

Channel 37, 1Mbps

Channel 37, 2Mbps

Channel 17, 1Mbps

Channel 17, 2Mbps



Channel 39, 1Mbps

Channel 39, 1Mbps

5.1.5 Conducted Spurious Emissions

Operator	Dylan Rosenfeldt	**QA**	Anthony Smith
Temperature	21.3°C	**R.H. %**	46.9%
Test Date	6/6/2023	**Location**	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	**Method**	ANSI C63.10

Limits: 20 dBc

Reference level = 6.4 dBm

Limit = -13.6 dBm

Test Parameters

Frequency	2402, 2440, 2480 MHz	**Setup**	Conducted
RBW	100 kHz	**VBW**	300 kHz
Detector(s)	Max Peak Hold	**Limit Calculation**	Reference Level (dBm) – 20 dB = Limit (dBm)

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

Reference Level Plot

EUT Parameters

Input Power	6VDC via AC adapter	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

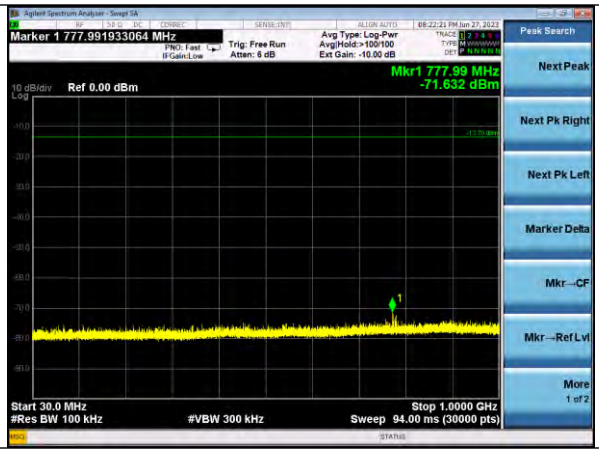
Data Table

Frequency (MHz)	Emission Measurement (dBm)	Limit (dBm)	Margin (dB)	Channel	Data Rate
876.1	-72.6	-13.6	59.0	37	1 Mbps
2400.0	-34.9	-13.6	21.3	37	1 Mbps
12011.3	-54.7	-13.6	41.1	37	1 Mbps
9609.5	-57.0	-13.6	43.4	37	1 Mbps
869.6	-72.6	-13.6	59.0	17	1 Mbps
2328.0	-61.0	-13.6	47.4	17	1 Mbps
23570.2	-53.5	-13.6	39.9	17	1 Mbps
885.7	-73.5	-13.6	59.9	39	1 Mbps
2372.4	-61.2	-13.6	47.6	39	1 Mbps
2483.5	-43.7	-13.6	30.1	39	1 Mbps
778.0	-71.6	-13.6	58.0	37	2 Mbps
2400.0	-16.7	-13.6	3.1	37	2 Mbps
12012.8	-53.9	-13.6	40.3	37	2 Mbps
438.1	-73.5	-13.6	59.9	17	2 Mbps
2290.0	-61.7	-13.6	48.1	17	2 Mbps
23980.7	-55.2	-13.6	41.6	17	2 Mbps
836.6	-69.3	-13.6	55.7	39	2 Mbps
2360.5	-57.9	-13.6	44.3	39	2 Mbps
2483.6	-41.8	-13.6	28.2	39	2 Mbps

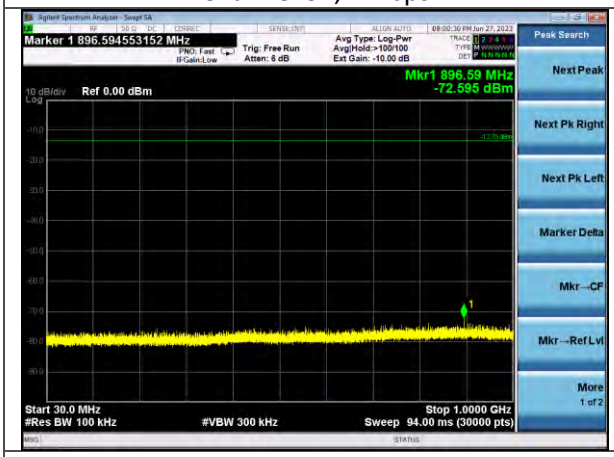
Plots

30 – 1000 MHz

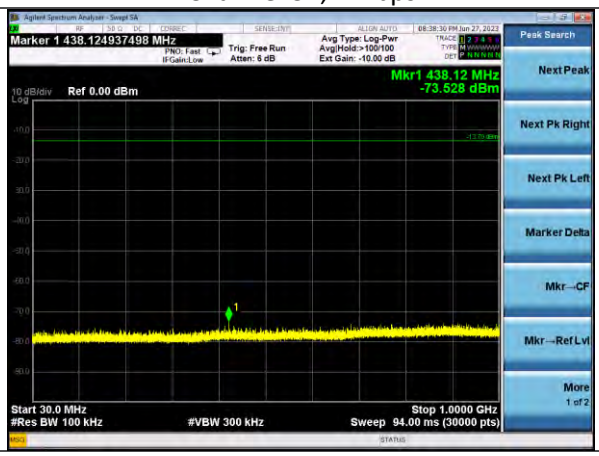
Channel 37, 1Mbps



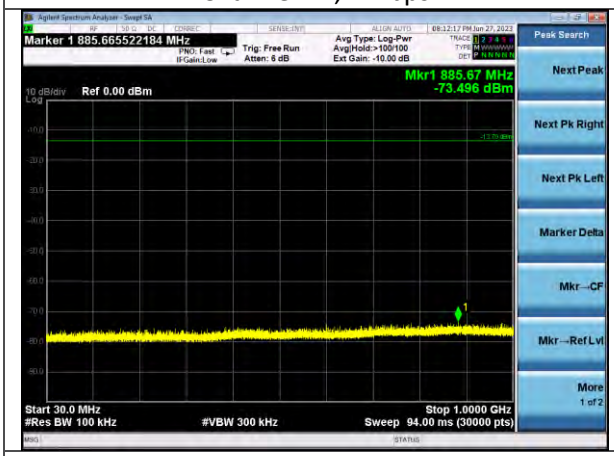
Channel 37, 2Mbps



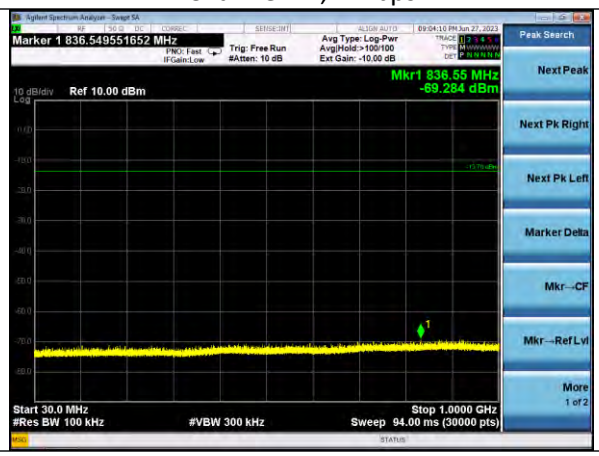
Channel 17, 1Mbps



Channel 17, 2Mbps



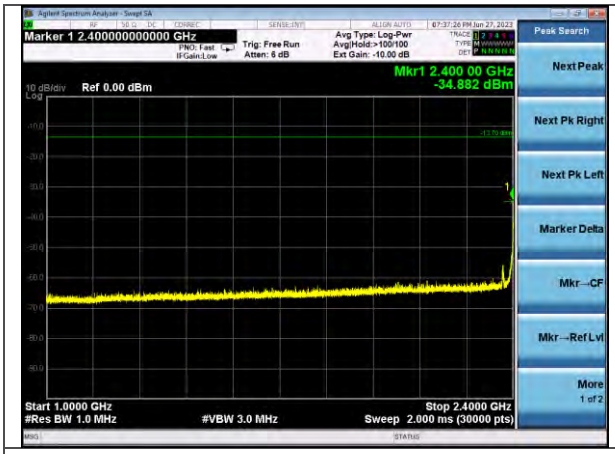
Channel 39, 1Mbps



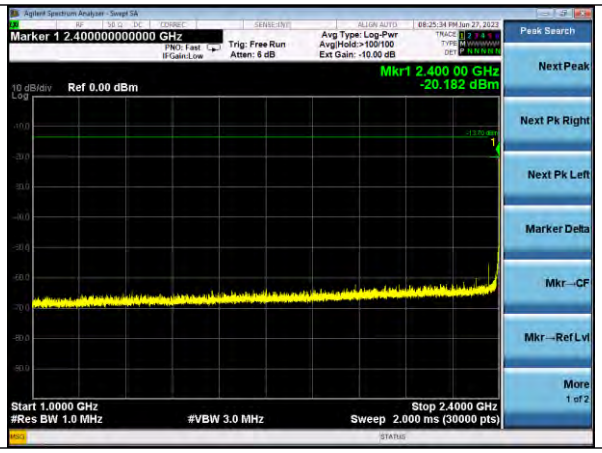
Channel 39, 1Mbps

Plots

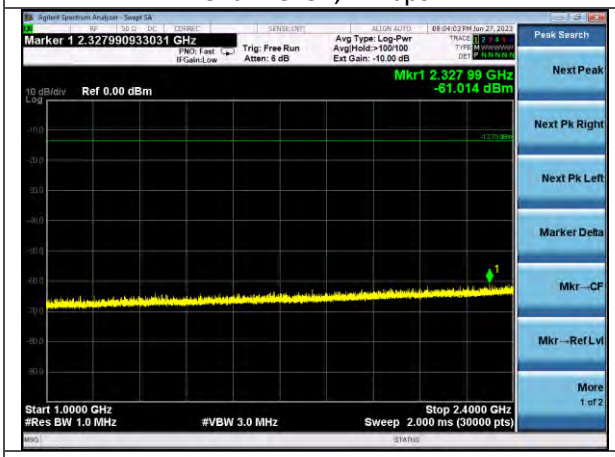
1000 – 2400 MHz



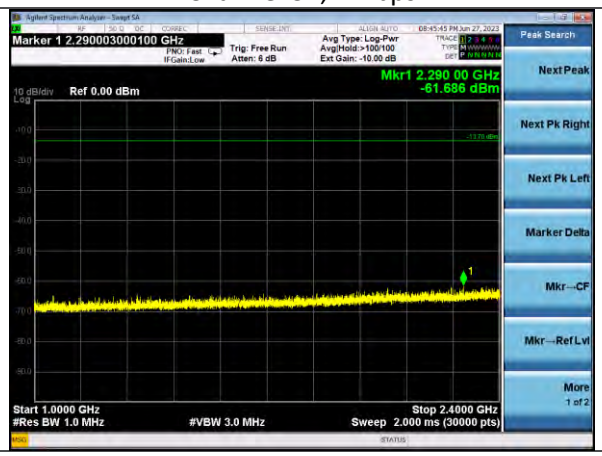
Channel 37, 1Mbps



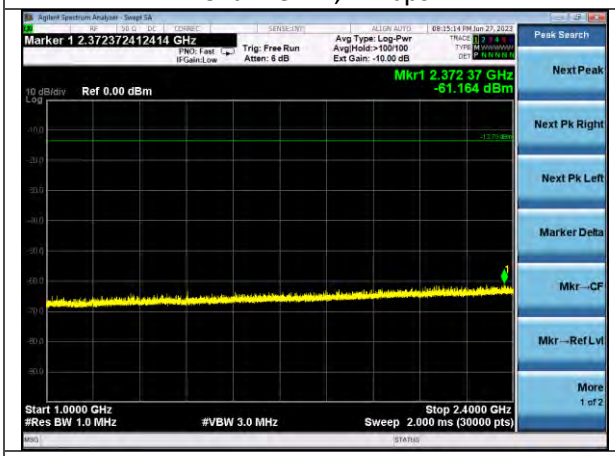
Channel 37, 2Mbps



Channel 17, 1Mbps



Channel 17, 2Mbps

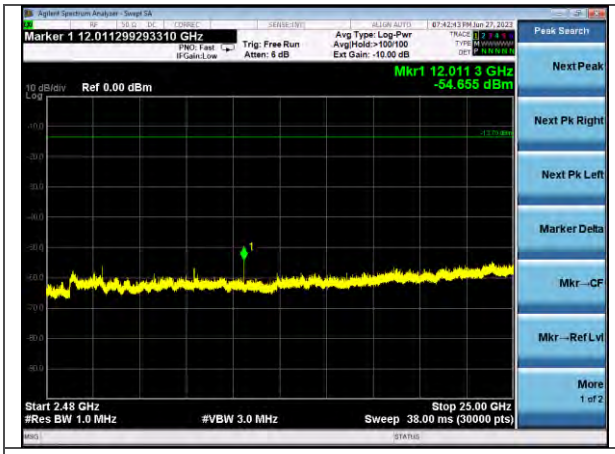


Channel 39, 1Mbps

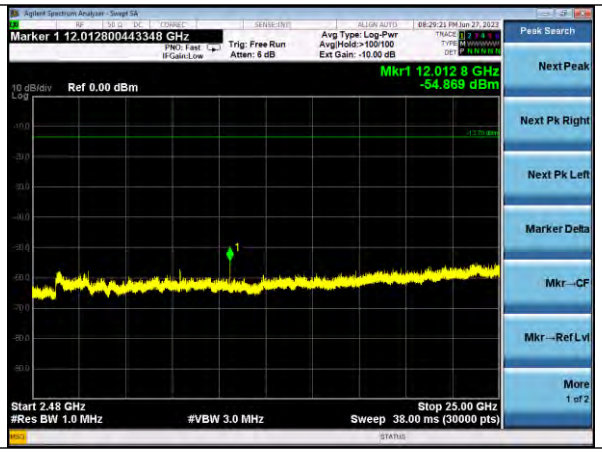
Channel 39, 1Mbps

Plots

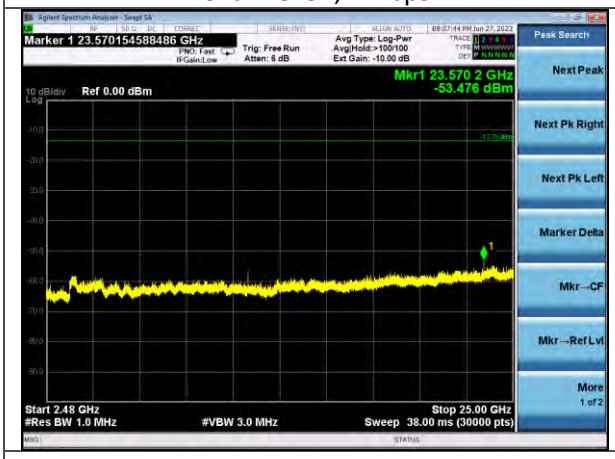
2483.5 – 25000 MHz



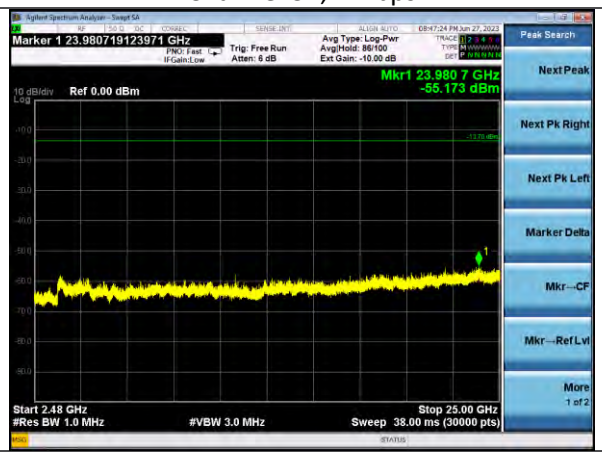
Channel 37, 1Mbps



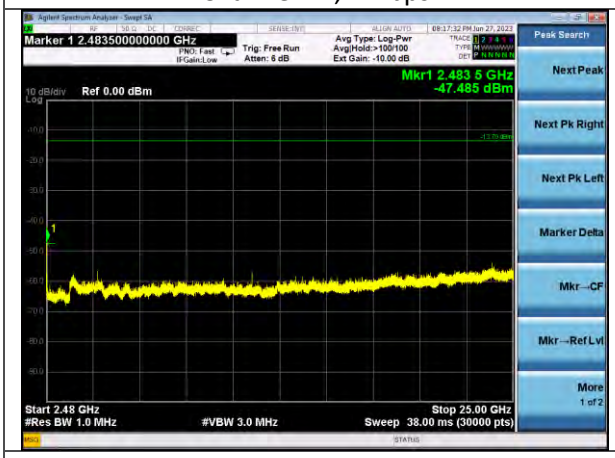
Channel 37, 2Mbps



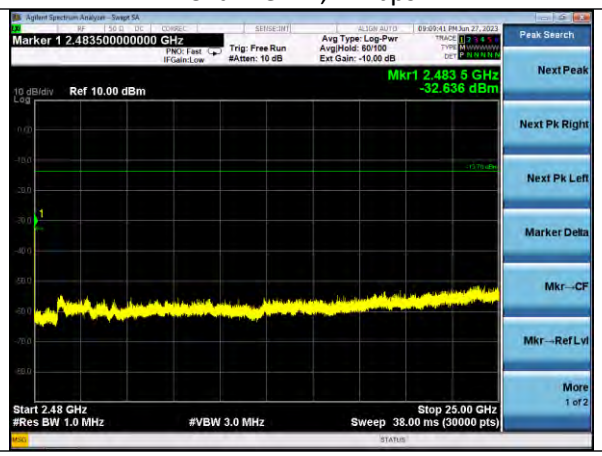
Channel 17, 1Mbps



Channel 17, 2Mbps



Channel 39, 1Mbps



Channel 39, 1Mbps

5.1.6 Frequency Stability

Operator	Dylan Rosenfeldt	QA	Anthony Smith
Temperature	21.3°C	R.H. %	46.9%
Test Date	6/6/2023	Location	Conducted RF Bench
Requirement	FCC: 15.247 ISED: RSS-247	Method	ANSI C63.10

Limits: Reported

Test Parameters

Frequency	2402, 2440, 2480 MHz	Setup	Conducted
RBW	1 kHz	VBW	3 kHz
Detector(s)	Max Peak Hold		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification

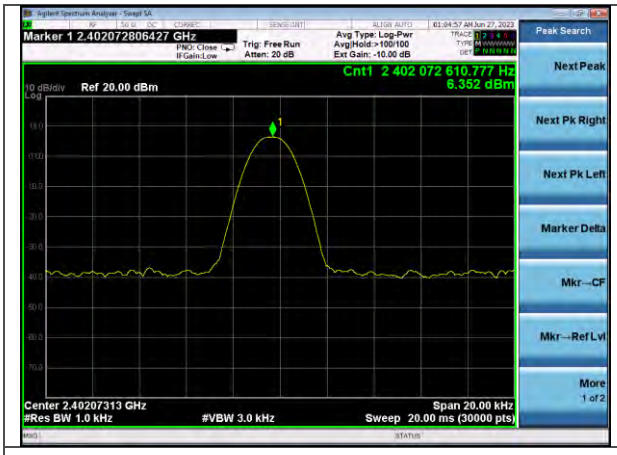
EUT Parameters

Input Power	6VDC, 5.1VDC, 6.9VDC via Bench Power supply	**Mode**	BLE TX
Frequency	2402, 2440, 2480 MHz	**Channel**	37, 17, 39
Serial	Unit 2	**Data Rate / Modulation**	1 & 2 Mbps, PRBS9

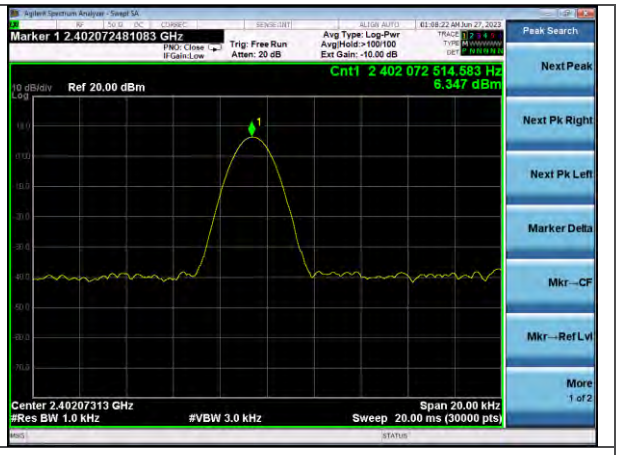
Data Table

Channel	Voltage	Frequency (Hz)	Frequency Deviation (Hz)
37	6.0	2402072611	0
37	5.1	2402072515	96
37	6.9	2402072340	271
17	6.0	2440073132	0
17	5.1	2440073235	103
17	6.9	2440073195	63
39	6.0	2480074699	0
39	5.1	2480074639	60
39	6.9	2480074503	196

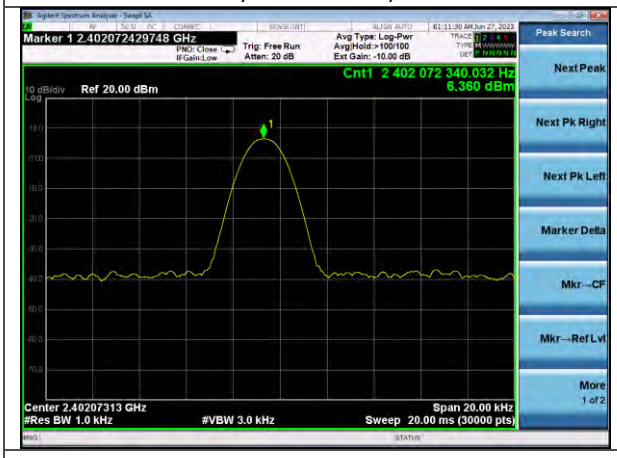
Plots



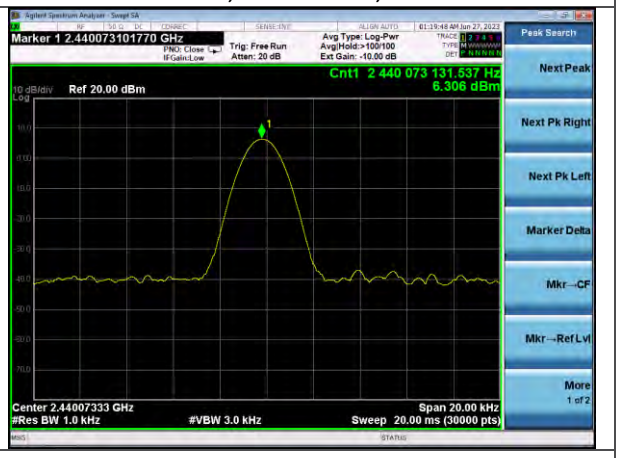
6.0V, Channel 37, CW



5.1V, Channel 37, CW



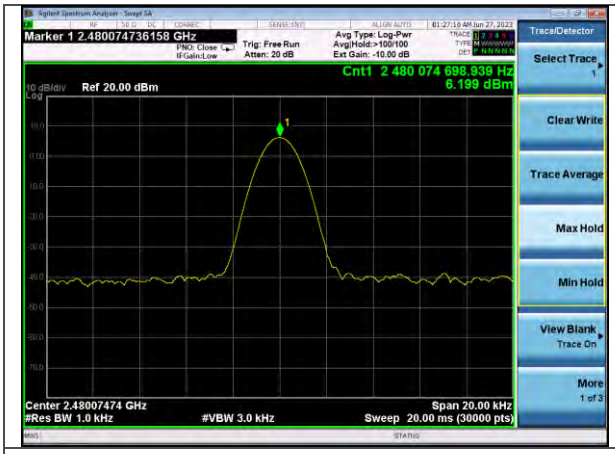
6.9V, Channel 37, CW



6.0V, Channel 17, CW

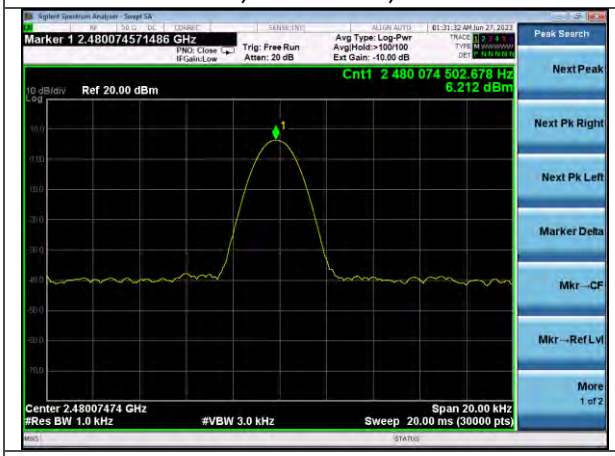
5.1V, Channel 17, CW

6.9V, Channel 17, CW



6.0V, Channel 39, CW

5.1V, Channel 39, CW

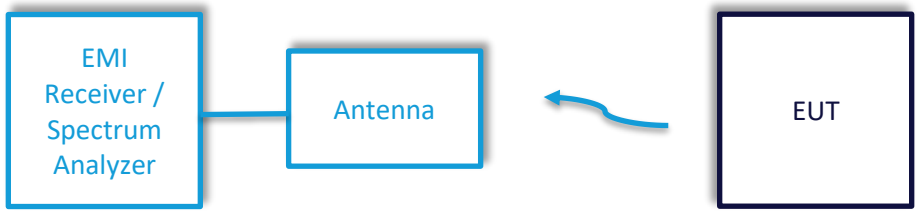


6.9V, Channel 39, CW

5.2 Radiated Emissions

Description of Measurement	The frequency spectrum is investigated for intentional and / or unintentional signals emanating from the EUT by use of a standardized test site and measurement antenna. The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed allowing the data to be gathered and reported as corrected values. The maximum emissions from the EUT are determined by turn-table azimuth rotation (360°) and scanning of the measurement antenna. Maximized levels are noted at degree values of azimuth, measurement antenna height, and measurement antenna polarity.
Example Calculations	Measurement (dBµV) + Cable factor (dB) + Other (dB) + Antenna Factor (dB/m) = Corrected Reading (dBµV/m) Margin (dB) = Limit (dBµV/m) - Corrected Reading (dBµV/m) Example at 4000 MHz: Reading = 40 dBµV + 3.4 dB + 0.9 dB + 6.5 dB/m = 50.8 dBµV/m Average Limit = 20 log (500) = 54 dBµV/m Margin = 54 dBµV/m - 50.8 dBµV/m = 3.2 dB

Block Diagram



5.2.1 Radiated Emissions

Operator	Dylan Rosenfeldt	**QA**	Jon Dilley
Temperature	21.8°C – 23.9°C	**R.H. %**	24.8% – 32.3%
Test Date	12/27/2023 – 12/29/2023, 1/2/2024, 4/15/2024	**Location**	Chamber 3
Requirement	FCC: 15.247/15.209 ISED: RSS-247	**Method**	ANSI C63.10

FCC 15.209 Limits:

Frequency (MHz)	Quasi Peak Limit (dBuV/m)	Average Limit (dBuV/m)	Peak Limit (dBuV/m)
0.009 – 0.490	20log(2400/F(kHz))	20log(2400/F(kHz))	-
0.490 – 1.705	20log(24000/F(kHz))	-	-
1.705 - 30	49.5	-	-
30 – 88	40.0	-	-
88 – 216	43.5	-	-
216 – 960	46.0	-	-
960 – 1000	54.0	-	-
1000 – 25000	-	54.0	74.0

Test Parameters

Frequency	0.009 – 25000 MHz	**Distance**	3m
Detector(s)	Peak – Trace/Final Quasi-Peak – Final	**Table height**	80cm (<1GHz), 150cm (>1GHz)
RBW	120 kHz (<1GHz), 1 MHz (>1GHz)	**VBW**	1.2 MHz (<1GHz), 3 MHz (>1GHz)
Notes	A Reduced VBW of 470 Hz was used for average measurements of the 1Mbps data rate, and 910Hz for average measurements of the 2Mbps data rate.		
Example Calculations	VBW = 1 / on-time = 1 / 2.160ms = 463 Hz		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	4/11/2023	4/11/2024	Active Calibration
AA 960158	Antenna - Double Ridge Horn	ETS Lindgren	3117	109300	1/30/2023	1/30/2024	Active Calibration
AA 960220	Cable	A.H. Systems, Inc.	SAC-26G-6	552	2/16/2023	2/16/2024	Active Verification
AA 960211	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	977711030	1/30/2023	1/30/2024	Active Calibration
LSC-216	Cable	A.H. Systems, Inc.	2533-8.5	1534	4/25/2023	4/25/2024	Active Verification
AA 960163	Antenna - Log Periodic	A.H. Systems, Inc.	SAS-512-2	500	8/10/2023	8/10/2024	Active Calibration
AA 960218	Antenna - Biconical	A.H. Systems, Inc.	SAS-540	853	7/17/2023	7/17/2024	Active Calibration
AA 960174	Antenna - Small Horn	ETS Lindgren	3116C-PA	00206880	8/30/2023	8/30/2024	Active Calibration
AA 960154	Filter - High Pass 2.4 GHz	KWM	HPF-L-14186	7272-02	4/11/2023	4/11/2024	Active Calibration
AA 960206	Antenna - Loop	A.H. Systems, Inc.	SAS-565-H	2758	8/31/2023	8/31/2025	Active Calibration

EUT Parameters

Input Power	6VDC from 120VAC adapter	**Mode**	BLE TX
Channels	37 (2402 MHz) 17 (2440 MHz) 39 (2480 MHz)	**Data Rate(s)**	1 Mbps, 2 Mbps

Band Edge Data Table (Average)

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Average Reading (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)	Data Rate	Channel
2386.0	Horizontal	Flat	150	210	42.7	54.0	11.3	1Mbps	37
2387.2	Vertical	Vertical	141	312	42.6	54.0	11.4	1Mbps	37
2367.9	Vertical	Horizontal	160	69	42.7	54.0	11.3	1Mbps	37
2386.4	Vertical	Horizontal	160	70	43.1	54.0	10.9	2Mbps	37
2335.7	Vertical	Vertical	141	308	43.0	54.0	11.0	2Mbps	37
2389.5	Horizontal	Flat	150	223	43.0	54.0	11.0	2Mbps	37
2494.7	Vertical	Vertical	150	292	43.1	54.0	10.9	1Mbps	39
2489.6	Vertical	Vertical	150	292	43.6	54.0	10.4	2Mbps	39
2494.5	Horizontal	Horizontal	120	189	43.0	54.0	11.0	1Mbps	39
2486.6	Horizontal	Horizontal	120	189	43.5	54.0	10.5	2Mbps	39
2494.3	Horizontal	Flat	150	198	43.1	54.0	10.9	1Mbps	39
2483.9	Horizontal	Flat	150	198	43.4	54.0	10.6	2Mbps	39

Band Edge Data Table (Peak)

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Data Rate	Channel
2386.0	Horizontal	Flat	150	210	54.4	74.0	19.6	1Mbps	37
2387.2	Vertical	Vertical	141	312	54.2	74.0	19.8	1Mbps	37
2367.9	Vertical	Horizontal	160	69	54.0	74.0	20.0	1Mbps	37
2386.4	Vertical	Horizontal	160	70	54.1	74.0	19.9	2Mbps	37
2335.7	Vertical	Vertical	141	308	53.9	74.0	20.1	2Mbps	37
2389.5	Horizontal	Flat	150	223	54.3	74.0	19.7	2Mbps	37
2494.7	Vertical	Vertical	150	292	54.4	74.0	19.6	1Mbps	39
2489.6	Vertical	Vertical	150	292	54.4	74.0	19.6	2Mbps	39
2494.5	Horizontal	Horizontal	120	189	54.4	74.0	19.6	1Mbps	39
2486.6	Horizontal	Horizontal	120	189	54.5	74.0	19.5	2Mbps	39
2494.3	Horizontal	Flat	150	198	54.5	74.0	19.5	1Mbps	39
2483.9	Horizontal	Flat	150	198	54.5	74.0	19.5	2Mbps	39

Spurious Emissions Data Table (Average)

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Average Reading (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)	Data Rate	Channel
12202.6	Horizontal	Vertical	150	53	49.0	54.0	5.0	2 Mbps	17
12202.6	Vertical	Vertical	183	331	44.5	54.0	9.5	2 Mbps	17
12202.6	Vertical	Horizontal	149	328	47.4	54.0	6.6	2 Mbps	17
12008.2	Horizontal	Horizontal	221	325	52.5	54.0	1.5	2 Mbps	17
12202.6	Horizontal	Horizontal	142	40	44.2	54.0	9.8	2 Mbps	17
12008.2	Vertical	Flat	255	146	51.9	54.0	2.1	2 Mbps	37
12402.6	Vertical	Flat	293	172	42.9	54.0	11.1	2 Mbps	39
7320.8	Vertical	Flat	270	300	48.0	54.0	6.0	2 Mbps	17
7320.8	Horizontal	Flat	100	208	46.8	54.0	7.2	2 Mbps	17
7321.4	Horizontal	Vertical	202	344	44.5	54.0	9.5	2 Mbps	17
7321.5	Vertical	Vertical	100	0	48.0	54.0	6.0	2 Mbps	17
7321.5	Vertical	Horizontal	220	356	45.0	54.0	9.0	2 Mbps	17
7321.5	Horizontal	Horizontal	186	321	49.8	54.0	4.2	2 Mbps	17
7439.0	Horizontal	Horizontal	182	329	47.1	54.0	6.9	2 Mbps	39
7320.8	Horizontal	Flat	400	227	46.2	54.0	7.8	1 Mbps	17
7440.7	Horizontal	Flat	400	227	43.4	54.0	10.6	1 Mbps	39
12201.4	Horizontal	Flat	291	303	43.9	54.0	10.1	1 Mbps	37
12201.5	Vertical	Flat	259	260	47.4	54.0	6.6	1 Mbps	17
7320.8	Vertical	Flat	100	307	47.2	54.0	6.8	1 Mbps	17
7440.8	Vertical	Flat	100	302	45.1	54.0	8.9	1 Mbps	39
12401.5	Vertical	Flat	260	259	45.9	54.0	8.1	1 Mbps	39
12011.4	Vertical	Flat	160	156	52.6	54.0	1.4	1 Mbps	37
12011.4	Horizontal	Flat	291	295	46.8	54.0	7.2	1 Mbps	37
12401.4	Horizontal	Flat	288	305	41.1	54.0	12.9	1 Mbps	39
7320.8	Vertical	Vertical	180	0	48.1	54.0	5.9	1 Mbps	17
7440.7	Vertical	Vertical	186	0	45.0	54.0	9.0	1 Mbps	39
4960.2	Vertical	Vertical	205	0	41.3	54.0	12.7	1 Mbps	39
4880.2	Vertical	Vertical	191	12	37.6	54.0	16.4	1 Mbps	17
4804.2	Vertical	Vertical	193	8	37.9	54.0	16.1	1 Mbps	37
14413.8	Vertical	Vertical	155	8	43.2	54.0	10.8	1 Mbps	37
12011.4	Horizontal	Vertical	291	300	47.5	54.0	6.5	1 Mbps	37
12201.5	Horizontal	Vertical	160	5	47.7	54.0	6.3	1 Mbps	17
12401.4	Horizontal	Vertical	166	53	47.9	54.0	6.1	1 Mbps	39
12401.4	Vertical	Horizontal	150	330	46.3	54.0	7.7	1 Mbps	39
12201.4	Vertical	Horizontal	154	336	48.4	54.0	5.6	1 Mbps	17
12011.5	Vertical	Horizontal	152	339	49.3	54.0	4.7	1 Mbps	37
4804.1	Horizontal	Horizontal	210	325	40.6	54.0	13.4	1 Mbps	37
12009.3	Horizontal	Horizontal	253	209	51.2	54.0	2.8	1 Mbps	37
4880.1	Horizontal	Horizontal	218	316	39.9	54.0	14.1	1 Mbps	17
12201.4	Horizontal	Horizontal	246	221	50.8	54.0	3.2	1 Mbps	17
4960.1	Horizontal	Horizontal	237	317	43.3	54.0	10.7	1 Mbps	39
14413.8	Horizontal	Horizontal	150	353	43.6	54.0	10.4	1 Mbps	37
7440.7	Horizontal	Horizontal	175	330	48.3	54.0	5.7	1 Mbps	39
7320.8	Horizontal	Horizontal	187	321	50.3	54.0	3.7	1 Mbps	17
19522.3	Horizontal	Horizontal	174	65	47.5	54.0	6.5	1 Mbps	17

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Average Reading (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)	Data Rate	Channel
19218.4	Horizontal	Horizontal	171	61	47.9	54.0	6.1	1 Mbps	37
19842.4	Horizontal	Horizontal	174	63	46.3	54.0	7.7	1 Mbps	39
22322.8	Horizontal	Horizontal	125	19	45.8	54.0	8.2	1 Mbps	39
19524.4	Horizontal	Horizontal	150	44	46.4	54.0	7.6	2 Mbps	17
19220.4	Horizontal	Horizontal	150	58	46.5	54.0	7.5	2 Mbps	37
19836.9	Horizontal	Horizontal	150	34	44.8	54.0	9.2	2 Mbps	39
22324.9	Horizontal	Horizontal	136	18	45.7	54.0	8.3	2 Mbps	39
19844.3	Vertical	Vertical	150	9	44.8	54.0	9.2	2 Mbps	39
22324.9	Vertical	Vertical	154	20	44.3	54.0	9.7	2 Mbps	39
19516.7	Vertical	Vertical	135	0	45.6	54.0	8.4	2 Mbps	17
19220.5	Vertical	Vertical	132	0	45.1	54.0	8.9	2 Mbps	37
19842.3	Vertical	Vertical	140	0	45.4	54.0	8.6	1 Mbps	39
22322.8	Vertical	Vertical	140	7	44.5	54.0	9.5	1 Mbps	39
19522.3	Vertical	Vertical	143	6	46.4	54.0	7.6	1 Mbps	17
19218.4	Vertical	Vertical	141	0	46.8	54.0	7.2	1 Mbps	37
22322.7	Vertical	Flat	282	348	42.8	54.0	11.2	1 Mbps	39
19838.9	Vertical	Flat	286	353	43.6	54.0	10.4	1 Mbps	39
19522.4	Vertical	Flat	280	0	45.2	54.0	8.8	1 Mbps	17
19218.4	Vertical	Flat	285	0	45.3	54.0	8.7	1 Mbps	37
22316.6	Vertical	Flat	280	341	43.3	54.0	10.7	2 Mbps	39
19836.8	Vertical	Flat	285	341	43.5	54.0	10.5	2 Mbps	39
19516.7	Vertical	Flat	307	0	44.9	54.0	9.1	2 Mbps	17
19220.4	Vertical	Flat	302	0	44.4	54.0	9.6	2 Mbps	37

Spurious Emissions Data Table (Peak)

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Data Rate	Channel
12202.6	Horizontal	Vertical	150	53	57.0	74.0	17.0	2 Mbps	17
12202.6	Vertical	Vertical	183	331	53.2	74.0	20.8	2 Mbps	17
12202.6	Vertical	Horizontal	149	328	55.8	74.0	18.2	2 Mbps	17
12008.2	Horizontal	Horizontal	221	325	59.7	74.0	14.3	2 Mbps	37
12202.6	Horizontal	Horizontal	142	40	52.3	74.0	21.7	2 Mbps	17
12008.2	Vertical	Flat	255	146	59.4	74.0	14.6	2 Mbps	37
12402.6	Vertical	Flat	293	172	51.5	74.0	22.5	2 Mbps	39
7320.8	Vertical	Flat	270	300	54.5	74.0	19.5	2 Mbps	17
7320.8	Horizontal	Flat	100	208	53.5	74.0	20.5	2 Mbps	17
7321.4	Horizontal	Vertical	202	344	52.3	74.0	21.7	2 Mbps	17
7321.5	Vertical	Vertical	100	0	55.1	74.0	18.9	2 Mbps	17
7321.5	Vertical	Horizontal	220	356	52.4	74.0	21.6	2 Mbps	17
7321.5	Horizontal	Horizontal	186	321	56.8	74.0	17.2	2 Mbps	17
7439.0	Horizontal	Horizontal	182	329	54.5	74.0	19.5	2 Mbps	39
7320.8	Horizontal	Flat	400	227	52.7	74.0	21.3	1 Mbps	17
7440.7	Horizontal	Flat	400	227	50.6	74.0	23.4	1 Mbps	39
12201.4	Horizontal	Flat	291	303	52.8	74.0	21.2	1 Mbps	37
12201.5	Vertical	Flat	259	260	55.3	74.0	18.7	1 Mbps	17
7320.8	Vertical	Flat	100	307	53.8	74.0	20.2	1 Mbps	17
7440.8	Vertical	Flat	100	302	52.1	74.0	21.9	1 Mbps	39
12401.5	Vertical	Flat	260	259	54.3	74.0	19.7	1 Mbps	39
12011.4	Vertical	Flat	160	156	59.6	74.0	14.4	1 Mbps	37
12011.4	Horizontal	Flat	291	295	54.5	74.0	19.5	1 Mbps	37
12401.4	Horizontal	Flat	288	305	50.2	74.0	23.8	1 Mbps	39
7320.8	Vertical	Vertical	180	0	54.6	74.0	19.4	1 Mbps	17
7440.7	Vertical	Vertical	186	0	51.9	74.0	22.1	1 Mbps	39
4960.2	Vertical	Vertical	205	0	47.3	74.0	26.7	1 Mbps	39
4880.2	Vertical	Vertical	191	12	45.3	74.0	28.7	1 Mbps	17
4804.2	Vertical	Vertical	193	8	46.0	74.0	28.0	1 Mbps	37
14413.8	Vertical	Vertical	155	8	51.7	74.0	22.3	1 Mbps	37
12011.4	Horizontal	Vertical	291	300	54.5	74.0	19.5	1 Mbps	37
12201.5	Horizontal	Vertical	160	5	55.3	74.0	18.7	1 Mbps	17
12401.4	Horizontal	Vertical	166	53	55.6	74.0	18.4	1 Mbps	39
12401.4	Vertical	Horizontal	150	330	54.0	74.0	20.0	1 Mbps	39
12201.4	Vertical	Horizontal	154	336	56.4	74.0	17.6	1 Mbps	17
12011.5	Vertical	Horizontal	152	339	56.5	74.0	17.5	1 Mbps	37
4804.1	Horizontal	Horizontal	210	325	46.8	74.0	27.2	1 Mbps	37
12009.3	Horizontal	Horizontal	253	209	58.4	74.0	15.6	1 Mbps	37
4880.1	Horizontal	Horizontal	218	316	46.6	74.0	27.4	1 Mbps	17
4960.1	Horizontal	Horizontal	237	317	47.9	74.0	26.1	1 Mbps	39
12201.4	Horizontal	Horizontal	246	221	58.0	74.0	16.0	1 Mbps	17
14413.8	Horizontal	Horizontal	150	353	52.4	74.0	21.6	1 Mbps	37
7440.7	Horizontal	Horizontal	175	330	54.7	74.0	19.3	1 Mbps	39
7320.8	Horizontal	Horizontal	187	321	56.5	74.0	17.5	1 Mbps	17
19522.3	Horizontal	Horizontal	174	65	56.9	74.0	17.1	1 Mbps	17

Frequency (MHz)	Antenna Polarity	EUT Orientation	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Data Rate	Channel
19218.4	Horizontal	Horizontal	171	61	56.7	74.0	17.3	1 Mbps	37
19842.4	Horizontal	Horizontal	174	63	56.1	74.0	17.9	1 Mbps	39
22322.8	Horizontal	Horizontal	125	19	55.5	74.0	18.5	1 Mbps	39
19524.4	Horizontal	Horizontal	150	44	56.0	74.0	18.0	2 Mbps	17
19220.4	Horizontal	Horizontal	150	58	55.2	74.0	18.8	2 Mbps	37
19836.9	Horizontal	Horizontal	150	34	53.8	74.0	20.2	2 Mbps	39
22324.9	Horizontal	Horizontal	136	18	54.9	74.0	19.1	2 Mbps	39
19844.3	Vertical	Vertical	150	9	54.4	74.0	19.6	2 Mbps	39
22324.9	Vertical	Vertical	154	20	54.0	74.0	20.0	2 Mbps	39
19516.7	Vertical	Vertical	135	0	54.4	74.0	19.6	2 Mbps	17
19220.5	Vertical	Vertical	132	0	54.3	74.0	19.7	2 Mbps	37
19842.3	Vertical	Vertical	140	0	54.8	74.0	19.2	1 Mbps	39
22322.8	Vertical	Vertical	140	7	54.6	74.0	19.4	1 Mbps	39
19522.3	Vertical	Vertical	143	6	56.0	74.0	18.0	1 Mbps	17
19218.4	Vertical	Vertical	141	0	55.2	74.0	18.8	1 Mbps	37
22322.7	Vertical	Flat	282	348	53.0	74.0	21.0	1 Mbps	39
19838.9	Vertical	Flat	286	353	53.5	74.0	20.5	1 Mbps	39
19522.4	Vertical	Flat	280	0	54.3	74.0	19.7	1 Mbps	17
19218.4	Vertical	Flat	285	0	54.1	74.0	19.9	1 Mbps	37
22316.6	Vertical	Flat	280	341	52.2	74.0	21.8	2 Mbps	39
19836.8	Vertical	Flat	285	341	53.1	74.0	20.9	2 Mbps	39
19516.7	Vertical	Flat	307	0	54.6	74.0	19.4	2 Mbps	17
19220.4	Vertical	Flat	302	0	54.1	74.0	19.9	2 Mbps	37

Plots

0.009 – 0.150 MHz, Parallel Polarity
EUT Vertical, 1Mbps

0.009 – 0.150 MHz, Perpendicular Polarity
EUT Vertical, 1Mbps

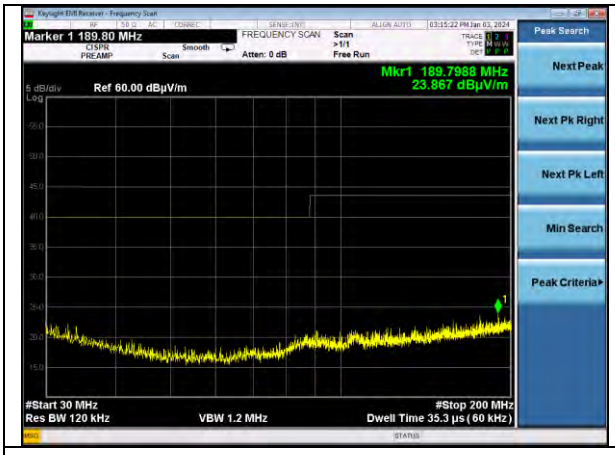
0.009 – 0.150 MHz, Skew Polarity
EUT Vertical, 1Mbps

0.150 - 30 MHz, Parallel Polarity
EUT Horizontal, 1Mbps

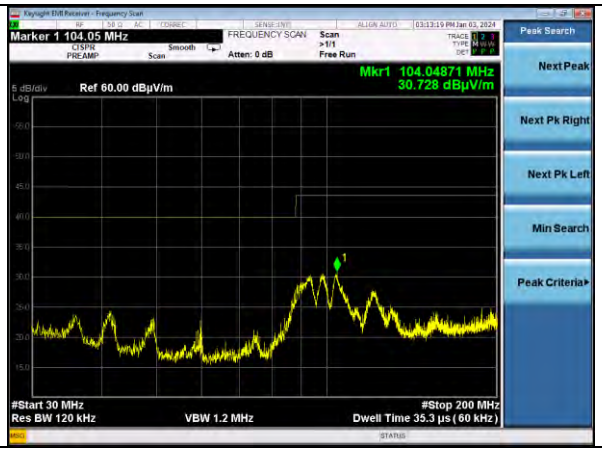
0.150 - 30 MHz, Perpendicular Polarity
EUT Horizontal, 1Mbps

0.150 - 30 MHz, Skew Polarity
EUT Horizontal, 1Mbps

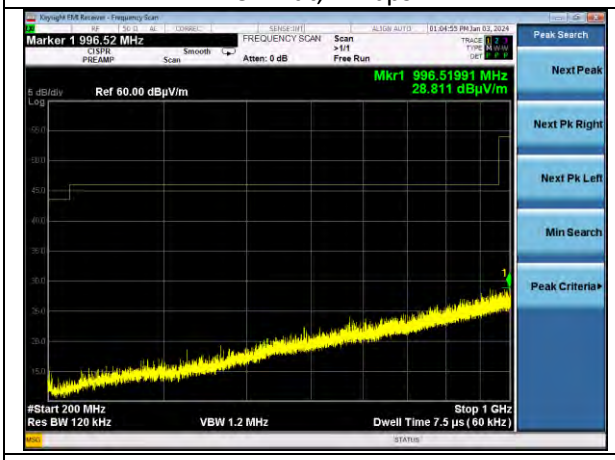
All Measurements in 9kHz to 30MHz range had greater than 30dB of margin



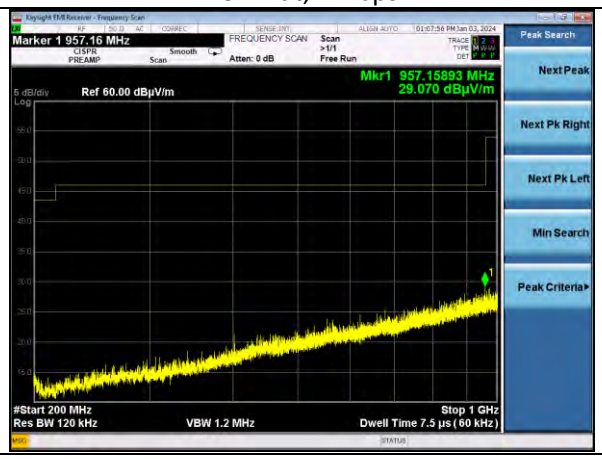
30 – 200 MHz, Horizontal Polarity
EUT Flat, 1Mbps



30 – 200 MHz, Vertical Polarity
EUT Flat, 1Mbps



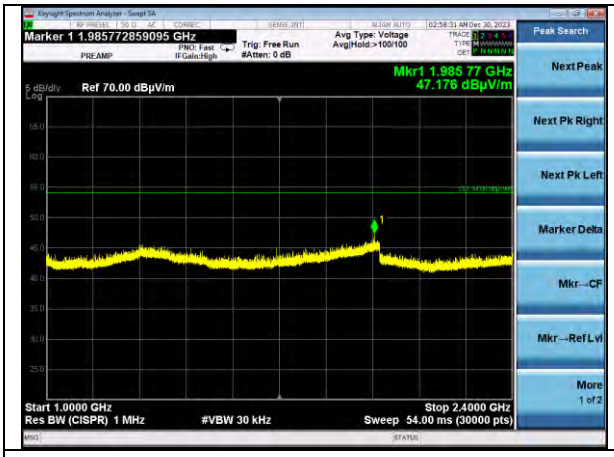
200 – 1000 MHz, Horizontal Polarity
EUT Flat, 1Mbps



200 – 1000 MHz, Vertical Polarity
EUT Flat, 1Mbps

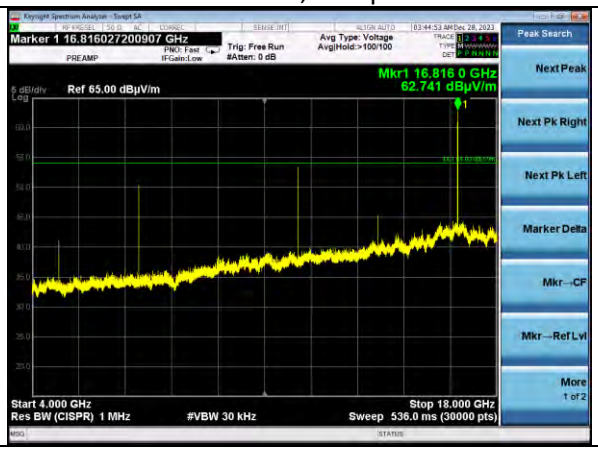
1000 – 2400 MHz, Horizontal Polarity
EUT Flat, 1Mbps

1000 – 2400 MHz, Vertical Polarity
EUT Flat, 1Mbps

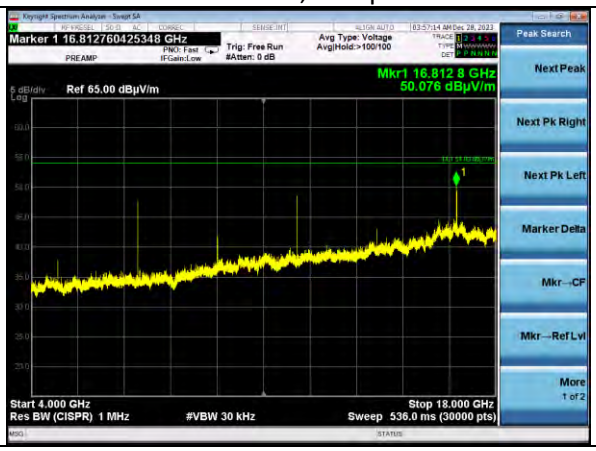


2500 – 4000 MHz, Horizontal Polarity
EUT Flat, 1Mbps

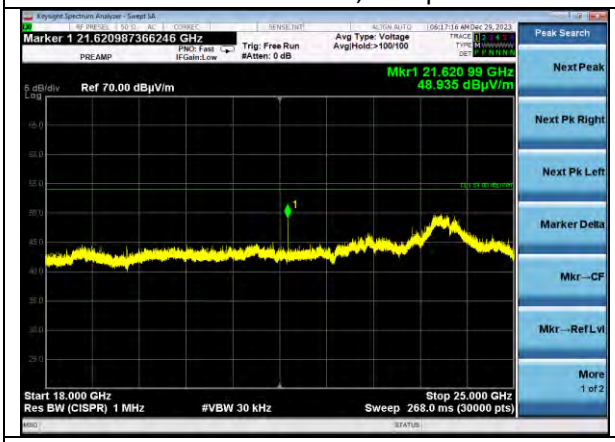
2500 – 4000 MHz, Vertical Polarity
EUT Flat, 1Mbps



4000 – 18000 MHz, Horizontal Polarity
EUT Horizontal, 1Mbps



4000 – 18000 MHz, Vertical Polarity
EUT Horizontal, 1Mbps



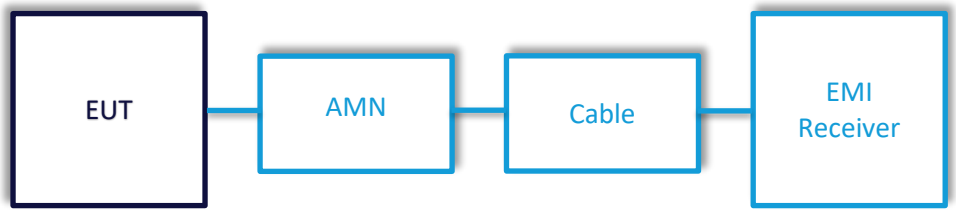
18000 – 25000 MHz, Horizontal Polarity
EUT Horizontal, 1Mbps

18000 – 25000 MHz, Vertical Polarity
EUT Horizontal, 1Mbps

5.3 AC Mains Conducted Emissions

	A line impedance stabilization network (LISN) or artificial mains network (AMN) allows the emissions of the power supply conductors to be measured while isolating the EUT from the supply mains.
Description of Measurement	The AMN, cable, and other necessary measurement system correction factors are loaded onto the EMI receiver when the measurements are performed. The data is gathered and reported as the corrected values. Maximum emissions are determined with a peak max hold trace then measurements at a selection of the highest points are made with quasi-peak and average detectors. Results are recorded and compared to limit for each line. (e.g. line and neutral)
Example Calculations	Measurement (dBµV) + Cable factor (dB) + Other (dB) = Corrected Reading (dBµV) Margin (dB) = Limit (dBµV) - Corrected Reading (dBµV)

Block Diagram



5.3.1 AC Mains Conducted Emissions

Operator	Dylan Rosenfeldt	**QA**	Adam Hauke
Temperature	21.3C	**R.H. %**	36.1%
Test Date	1/4/2024	**Location**	Conducted Bench
Requirement	FCC 15.207	**Method**	ANSI C63.10

FCC 15.207 Limits:

Frequency (MHz)	Quasi-Peak (dBµV)	Average (dBµV)
0.15 – 0.5	66 to 56	56 to 46
0.5 – 5	56	46
5 – 30	60	50

Test Parameters

Frequency	0.150 – 30 MHz	**Distance**	40cm from VCP, 80cm from LISN, 80cm from RGP
Detector(s)	Peak – Trace Quasi-Peak – Final Average – Final	**Table height**	80cm
RBW	9kHz	**VBW**	62kHz

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2023	4/10/2024	Active Calibration
LSC-214	Cable	Micro-Coax	UFB311A-0-1440-70U70U	64639 224071-006	4/25/203	4/25/2024	Active Verification
EE 960162	LISN	COM-POWER	LI-215A	191969	4/10/2023	4/10/2024	Active Calibration
EE 960110	Meter - Milliohm	Extech Instruments	380560	H.292953	4/13/2023	4/13/2024	Active Calibration

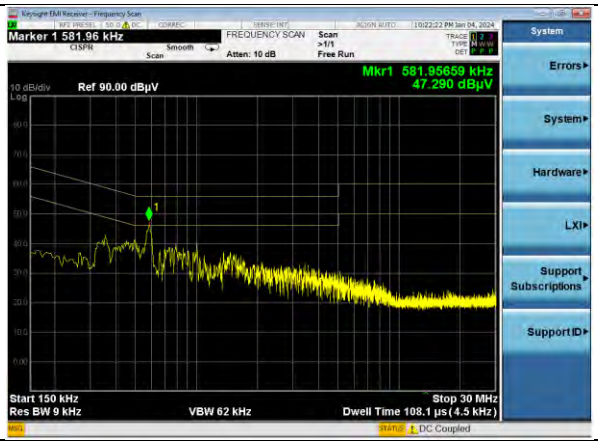
EUT Parameters

Input Power	6VDC via 120VAC adapter	Mode	BLE TX
Notes	Plots shown are with device transmitting on channel 17 at 1Mbps, there is no significant difference between different channels or datarates		

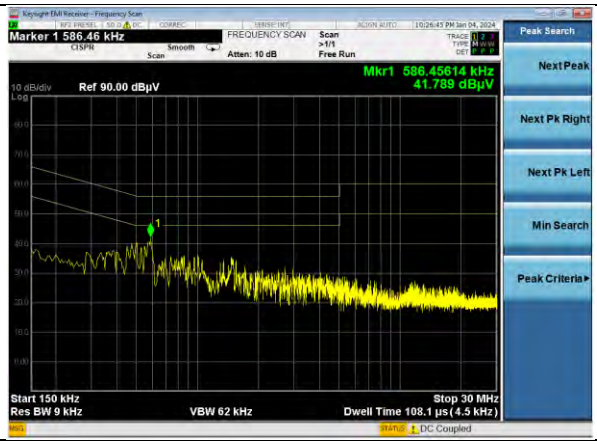
Conducted Emissions Data Table

Line	Frequency (MHz)	Peak Reading (dBµV)	Quasi-Peak Reading (dBµV)	Average Reading (dBµV)	Quasi-Peak Limit (dBµV)	Average Limit (dBµV)	Quasi-Peak Margin (dB)	Average Margin (dB)
1	0.16	40.2	35.4	28.3	65.7	55.7	30.3	27.4
1	0.58	45.4	40.8	27.0	56.0	46.0	15.2	19.0
1	1.5	34.5	28.7	16.7	56.0	46.0	27.3	29.3
2	0.19	40.0	34.4	26.7	64.2	54.2	29.8	27.5
2	0.6	47.2	42.8	27.8	56.0	46.0	13.2	18.2
2	1.4	36.9	31.3	18.0	56.0	46.0	24.7	28.0

Plots



Line 1



Line 2

6 REVISION HISTORY

Version	Date	Notes	Person
0	8/21/2023	Initial Draft	Dylan Rosenfeldt
1	1/4/2024	Revised Radiated and AC Mains Emissions	Dylan Rosenfeldt
2	1/8/2024	Final Draft	Dylan Rosenfeldt
3	2/27/2024	Updated References	Dylan Rosenfeldt
4	3/22/2024	Updated to Ezurio	Adam Alger
5	4/22/2024	Added Radiated Emissions plots below 30MHz	Dylan Rosenfeldt
6	4/25/2024	Statement added to 9kHz to 30MHz plots	Dylan Rosenfeldt

END OF REPORT