TEST REPORT

Report Number: R15670843-E3

Applicant	:	Milwaukee Electric Tool Corporation 13135 W. Lisbon Road Brookfield, WI 53005, USA
Model	:	14209440
FCC ID	:	P36-CDCBA1
IC	:	25187-CDCBA1
EUT Description	:	ST Module
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C: 2025 ISED RSS-247 ISSUE 3: 2023 ISED RSS-GEN ISSUE 5 + A1 + A2: 2021

Date Of Issue:
2025-04-07

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CERT #0751.06

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2025-04-07	Initial Issue	Chandler Stanley

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TABLE OF CONTENTS

REPORT REVISION HISTORY **2**

TABLE OF CONTENTS **3**

1. ATTESTATION OF TEST RESULTS **5**

2. TEST RESULTS SUMMARY **6**

3. TEST METHODOLOGY **6**

4. FACILITIES AND ACCREDITATION **6**

5. DECISION RULES AND MEASUREMENT UNCERTAINTY **7**

5.1. METROLOGICAL TRACEABILITY *7*

5.2. DECISION RULES *7*

5.3. MEASUREMENT UNCERTAINTY *7*

5.4. SAMPLE CALCULATION *7*

6. EQUIPMENT UNDER TEST **8**

6.1. EUT DESCRIPTION *8*

6.2. MAXIMUM OUTPUT POWER *8*

6.3. DESCRIPTION OF AVAILABLE ANTENNAS *8*

6.4. SOFTWARE AND FIRMWARE *8*

6.5. WORST-CASE CONFIGURATION AND MODE *8*

6.6. DESCRIPTION OF TEST SETUP *9*

7. MEASUREMENT METHOD **10**

8. TEST AND MEASUREMENT EQUIPMENT **11**

9. ANTENNA PORT TEST RESULTS **14**

9.1. ON TIME AND DUTY CYCLE *14*

9.2. 99% BANDWIDTH *17*

9.2.1. BLE (1Mbps) 17
9.2.2. BLE (2Mbps) 18
9.2.3. BLE (125Kbps) 19
9.2.4. BLE (500Kbps) 20

9.3. 6 dB BANDWIDTH *21*

9.3.1. BLE (1Mbps) 21
9.3.2. BLE (2Mbps) 22
9.3.3. BLE (125Kbps) 23
9.3.4. BLE (500Kbps) 24

9.4. OUTPUT POWER *25*

9.4.1. BLE (1Mbps) 25

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9.4.2. BLE (2Mbps) 25
9.4.3. BLE (125Kbps) 26
9.4.4. BLE (500Kbps) 26

9.5. AVERAGE POWER 27
9.5.1. BLE (1Mbps) 27
9.5.2. BLE (2Mbps) 27
9.5.3. BLE (125Kbps) 28
9.5.4. BLE (500Kbps) 28

9.6. POWER SPECTRAL DENSITY 29
9.6.1. BLE (1Mbps) 29
9.6.2. BLE (2Mbps) 30
9.6.3. BLE (125Kbps) 31
9.6.4. BLE (500Kbps) 32

9.7. CONDUCTED SPURIOUS EMISSIONS 33
9.7.1. BLE (1Mbps) 34
9.7.2. BLE (2Mbps) 35
9.7.3. BLE (125Kbps) 36
9.7.4. BLE (500Kbps) 37

10. RADIATED TEST RESULTS 38

10.1. LIMITS AND PROCEDURE 38

10.2. TRANSMITTER ABOVE 1 GHz 40
10.2.1. BLE (2Mbps) 40
10.2.2. BLE (125Kbps) 44

10.3. WORST CASE BELOW 30MHZ 50

10.4. WORST CASE BELOW 1 GHZ 52

10.5. WORST CASE 18-26 GHZ 54

11. SETUP PHOTOS 56

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Milwaukee Electric Tool Corporation
13135 W. Lisbon Road
Brookfield, WI 53005, USA

EUT DESCRIPTION: ST Module

MODEL: 14209440

SERIAL NUMBER: 92495-03458, 92496-122939

SAMPLE RECEIPT DATE: 2024-06-06, 2024-06-25, 2024-06-26, 2025-03-24

DATE TESTED: 2024-06-06 TO 2024-06-25, 2025-03-26 TO 2025-03-31

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C: 2025	See Section 2
ISED RSS-247 Issue 3: 2023	See Section 2
ISED RSS-GEN Issue 5 + A1 + A2: 2021	See Section 2

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document.

Approved & Released
For UL LLC By:

Brian Kiewra
Project Engineer
Consumer, Medical and IT Segment
UL LLC

Prepared By:

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Lead Project Engineer
Consumer, Medical and IT Segment
UL LLC

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2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.
Below is a list of the data provided by the customer:

1. Antenna gain and type (see section 6.3)
2. Supported data rates (see section 6.5)

FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	ANSI C63.10 Section 11.6.
-	RSS-GEN 6.7	99% OBW	Reporting purposes only	ANSI C63.10 Section 6.9.3.
15.247 (a) (2)	RSS-247 5.2 (a)	6dB BW	Complies	None.
15.247 (b) (3)	RSS-247 5.4 (d)	Output Power		
See Comment		Average power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (e)	RSS-247 5.2 (b)	PSD	Complies	None.
15.247 (d)	RSS-247 5.5	Conducted Spurious Emissions		
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions		
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	N/A	The EUT is a radio module, and it cannot connect directly to AC mains. It receives power through an intermediary device.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2020 + Cor.1-2023 + C63.10a-2024, KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 414788 D01 Radiated Test Site v01r01, RSS-GEN Issue 5 + A1 + A2, and RSS-247 Issue 3.

4. FACILITIES AND ACCREDITATION

UL LLC is accredited by A2LA, certification # 0751.06, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
☐	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	825374
☒	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A		27265	

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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{Lab}
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	1.22%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	1.94 dB
All emissions, radiated	6.01 dB
Conducted Emissions (0.150-30MHz) - LISN	3.40 dB
Temperature	0.57°C
Humidity	3.39%
DC Supply voltages	1.70%

Uncertainty figures are valid to a confidence level of 95%.

5.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:
Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

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6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The Chip Down Carrier Board is a next-gen DTS solution to be used internally within Milwaukee Tool. It presents a fully certified and tuned off-the-shelf solution for future implementation within tools and contains a BLE radio. This report covers the full emissions testing of the BLE radio.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2402 - 2480	BLE - 125Kbps	6.15	4.12
2402 - 2480	BLE - 500Kbps	6.15	4.12
2402 - 2480	BLE - 1Mbps	6.16	4.13
2402 - 2480	BLE - 2Mbps	6.14	4.11

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

The radio utilizes a passive antenna, with a maximum gain of 1.5 dBi.

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was ABLE 1.0.2.

6.5. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz and above 18GHz were performed with the EUT set to transmit at the channel with highest power spectral density as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at power setting 6 on low, and high channels, as well as middle channel for radiated spurious emissions. Radiated spurious emissions were performed on the worst-case power and PSD mode (125Kbps). Band edge testing was performed on the mode with the widest bandwidth (2Mbps) since average power for all modes was relatively the same.

The fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that Z orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Z orientation.

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6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
DC Power Supply	Keysight	E3633A	MY58426145	NA
DC Power Supply	BK Precision	1687B	347K16126	NA
Support Laptop	Lenovo	T14 Gen3	PF4FKY5C	NA

I/O CABLES

I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	DC Power Leads	2	Banana	N/A	<3m	Connects the EUT to the DC Power Supply for Power

TEST SETUP

The EUT is connected to a DC Power supply. Prior to testing, a support laptop is used to configure the EUT radio module. For final testing, the EUT was disconnected from the support laptop.

SETUP DIAGRAMS

Please refer to R15670843-EP1 for setup diagrams

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7. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

6 dB BW: ANSI C63.10 Subclause -11.8.1

Occupied BW (99%): ANSI C63.10-2020 Section 6.9.3

Output Power: ANSI C63.10 Subclause -11.9.1.2 Method PKPM1 Peak-reading power meter
ANSI C63.10 Subclause -11.9.2.3.2 Method AVGPM-G (Measurement using a gated RF average-reading power meter)

PSD: ANSI C63.10 Subclause -11.10.2 Method PKPSD (peak PSD)

Conducted emissions non-restricted frequency bands: ANSI C63.10 Subclause -11.11 and 6.10.4

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1 and 6.10.5

General radiated emissions: ANSI C63.10 Subclause - 6.3-6.6

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8. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
Common Equipment					
Conducted Room 1					
90416	Spectrum Analyzer	Keysight Technologies	N9030A	2023-06-09	2024-06-30
211056	Real-Time Peak Power Sensor 50MHz to 8GHz	Boonton	RTP5000	2023-08-01	2024-08-01
86441	EMPower USB RF Power Sensor, 10MHz to 6GHz (USB ID: 1.47.238.189.27.0.0.80)	ETS Lindgren	7002-006	2023-11-13	2024-11-13
91219	True RMS Multimeter	Agilent	U1232A	2023-08-03	2024-08-03
-	DC Power Supply	Keysight Technologies	E3633A	-	-
207726	Temp/Humid Chamber	Thermotron	SM-32-8200	2024-01-12	2025-01-12
179892	Environmental Meter	Fisher Scientific	15-077-963	2023-07-26	2024-07-31
SOFTEMI	Antenna Port Software	UL	Version 2024.2.24	NA	NA
ETSI Power Software	EMPower ETSI Burst Measurement System	ETS-Lindgren	Version 1.0.3.18	NA	NA
Power Software	Boonton Power Analyzer	Boonton	Version 3.0.13.0	NA	NA
Conducted Room 2					
90410	Spectrum Analyzer	Keysight Technologies	N9030A	2024-06-14	2025-06-14
211057	Real-Time Peak Power Sensor 50MHz to 8GHz	Boonton	RTP5000	2023-08-01	2024-08-01
157590	EMPower USB RF Power Sensor, 10MHz to 6GHz (USB ID: 1.132.133.24.23.0.0.6)	ETS Lindgren	7002-006	2023-11-13	2024-11-13
91219	True RMS Multimeter	Agilent	U1232A	2023-08-03	2024-08-03
-	DC Power Supply	Keysight Technologies	E3633A	-	-
76023	Temp/Humid Chamber	Cincinnati Sub-Zero	ZPH-8-3.5-SCT/AC	2024-01-12	2025-01-12
248881	Environmental Meter	Control Company	06-662-4	2024-04-10	2026-04-10
SOFTEMI	Antenna Port Software	UL	Version 2024.2.24	NA	NA
ETSI Power Software	EMPower ETSI Burst Measurement System	ETS-Lindgren	Version 1.0.3.18	NA	NA
Power Software	Boonton Power Analyzer	Boonton	Version 3.0.13.0	NA	NA

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Test Equipment Used - Wireless Conducted Attenuators, Cables, and Couplers

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
Attenuators					
226559	SMA Coaxial 10dB Attenuator 25MHz-18GHz	CentricRF	C18S2-10	2024-02-29	2025-02-28
226563	SMA Coaxial 10dB Attenuator 25MHz-18GHz	CentricRF	C18S2-10	2024-02-29	2025-02-28
Cables					
188125 (CBL098)	Micro-Coax UTiFLEX Cable Assembly, Low Loss,40Ghz, 39.3", Connectors 2	Carlisle Interconnect Technologies	UFA147A-0-0180-200200	2024-06-26	2025-06-26
CBL105	Micro-Coax UTiFLEX Cable Assembly, Low Loss	Carlisle Interconnect Technologies	UFB-197C-0-0160-300300	2024-03-01	2025-03-01

**NOTE: All conducted testing occurred in June 2024.

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 4)

Equip. ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
	1-18 GHz				
89509	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-05-23	2025-05-23
	Gain-Loss Chains				
207640	Gain-loss string: 1-18GHz	Various	Various	2024-05-22	2025-05-22
	Receiver & Software				
197955	Spectrum Analyzer	Rohde & Schwarz	ESW44	2024-04-16	2025-04-16
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
	Additional Equipment used				
241204	Environmental Meter	Fisher Scientific	15-077-963	2023-09-05	2025-09-05

**NOTE: All radiated testing occurred in March 2025.

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Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 2)

Equip. ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
	0.009-30MHz				
135144	Active Loop Antenna	ETS-Lindgren	6502	2024-10-02	2025-10-02
	30-1000 MHz				
159203	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2024-03-05	2026-03-05
	1-18 GHz				
86408	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-06-19	2025-06-19
	18-40 GHz				
204704	Horn Antenna, 18-26.5GHz	Com-Power	AH-826	2023-07-20	2025-07-20
	Gain-Loss Chains				
91975	Gain-loss string: 0.009-30MHz	Various	Various	2024-05-10	2025-05-10
91978	Gain-loss string: 25-1000MHz	Various	Various	2024-05-10	2025-05-10
91977	Gain-loss string: 1-18GHz	Various	Various	2024-07-17	2025-07-17
136042	Gain-loss string: 18-40GHz	Various	Various	2024-05-10	2025-05-10
	Receiver & Software				
197954	Spectrum Analyzer	Rohde & Schwarz	ESW44	2024-03-05	2025-03-31
81018	Spectrum Analyzer	Agilent	E4446A	2024-07-31	2025-07-31
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
	Additional Equipment used				
200540	Environmental Meter	Fisher Scientific	15-077-963	2023-07-19	2025-07-19

**NOTE: All radiated testing occurred in March 2025.

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9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

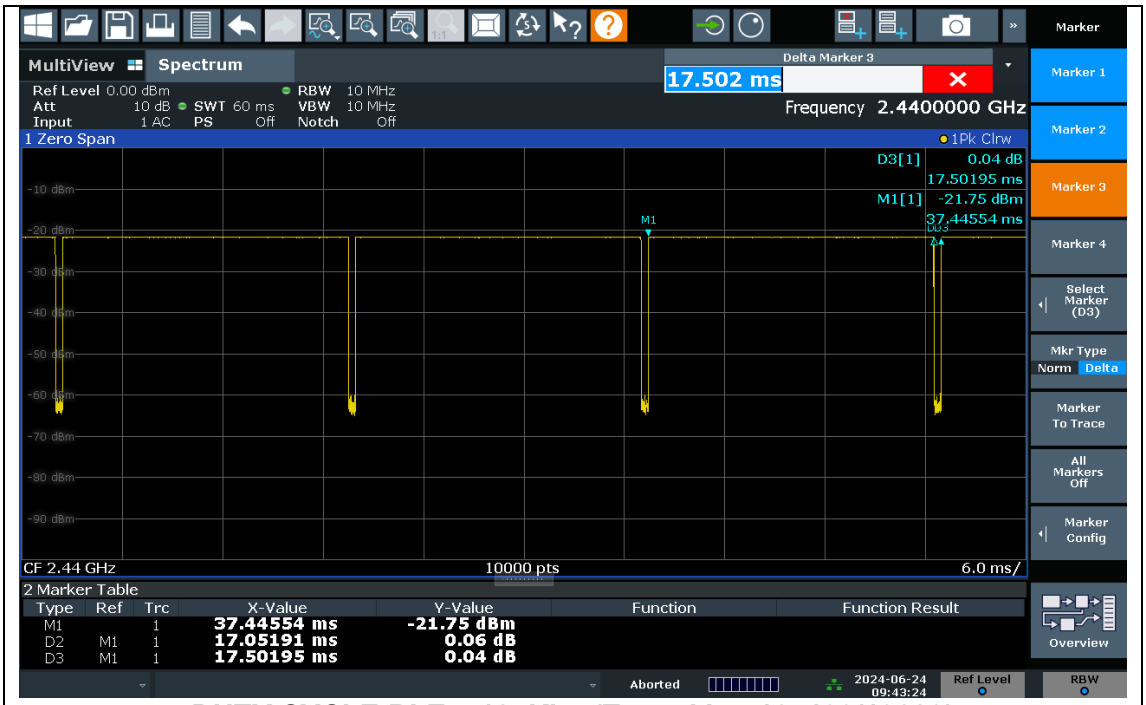
PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
BLE - 125Kbps	17.052	17.502	0.974	97.43	0.23	0.059
BLE - 500Kbps	4.560	5.000	0.912	91.20	0.80	0.219
BLE - 1Mbps	2.147	2.501	0.858	85.85	1.33	0.466
BLE - 2Mbps	1.078	1.875	0.575	57.47	4.81	0.928

DUTY CYCLE PLOTS



DUTY CYCLE BLE – 125Kbp (Tested by: 105193/19289)

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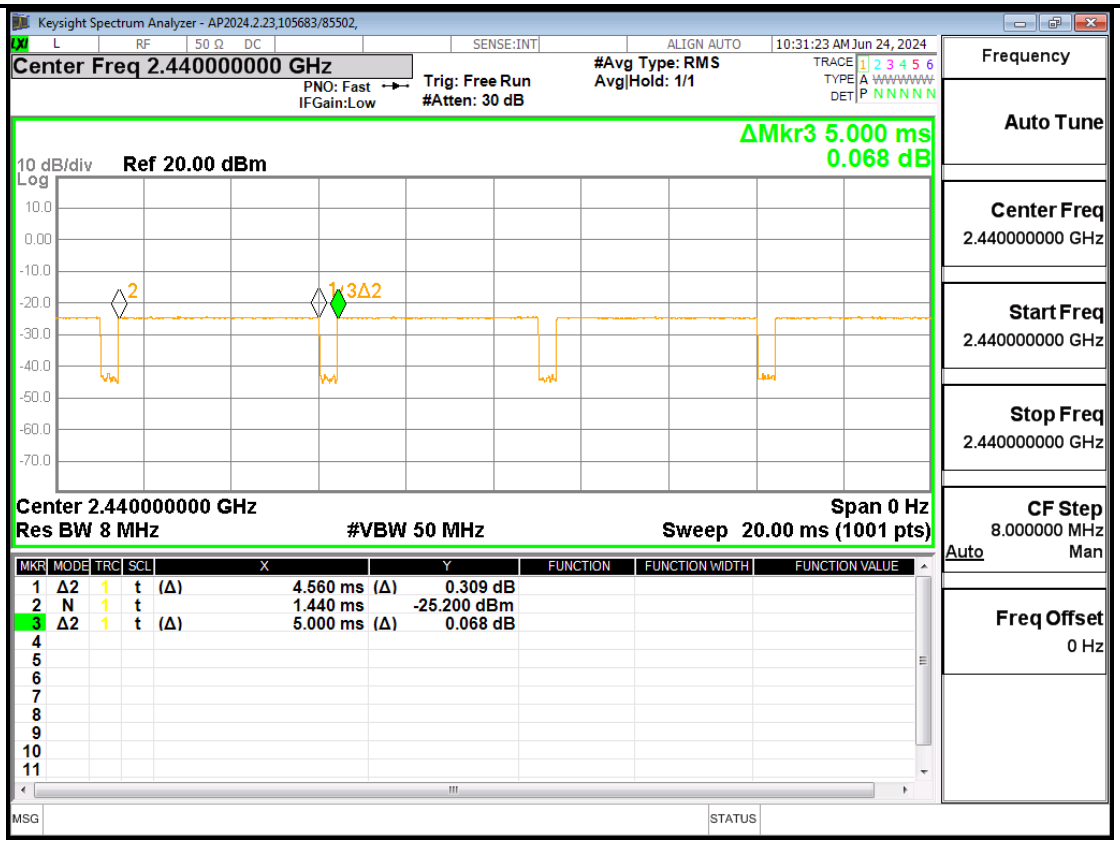
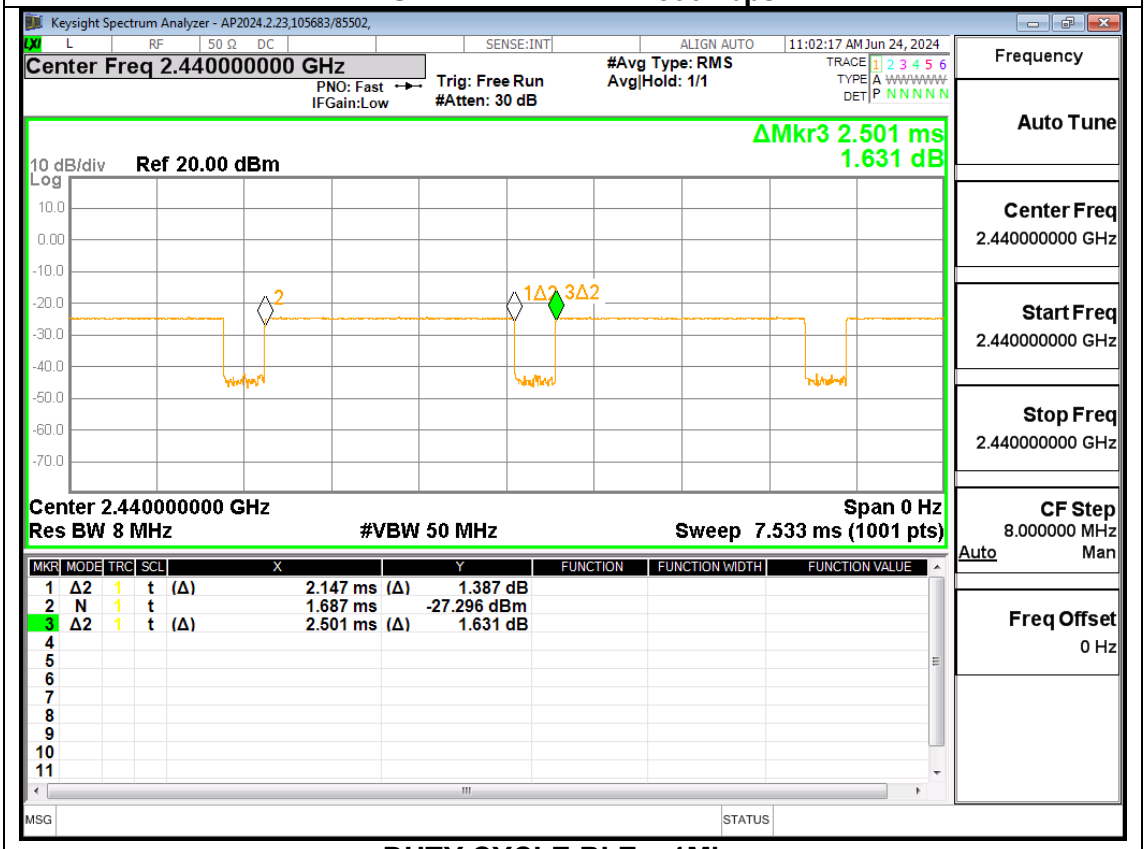


DUTY CYCLE BLE – 500Kbps



DUTY CYCLE BLE – 1Mbps

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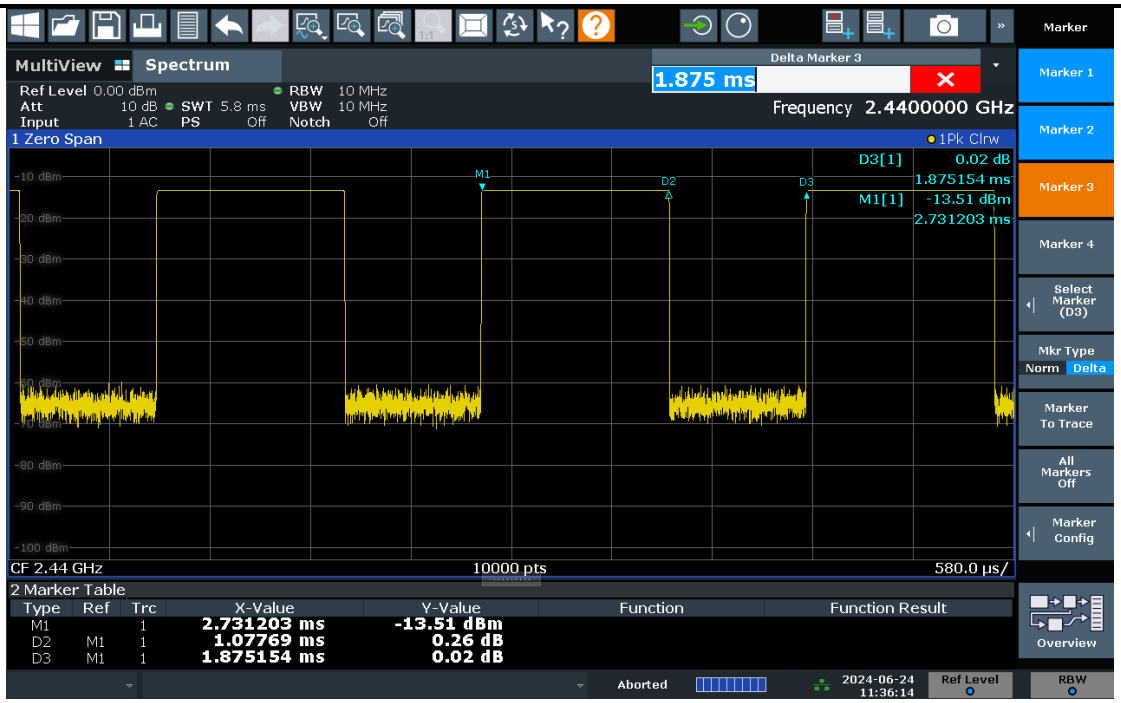

DUTY CYCLE BLE – 2Mbps (Tested by: 105193/19289)

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9.2. 99% BANDWIDTH

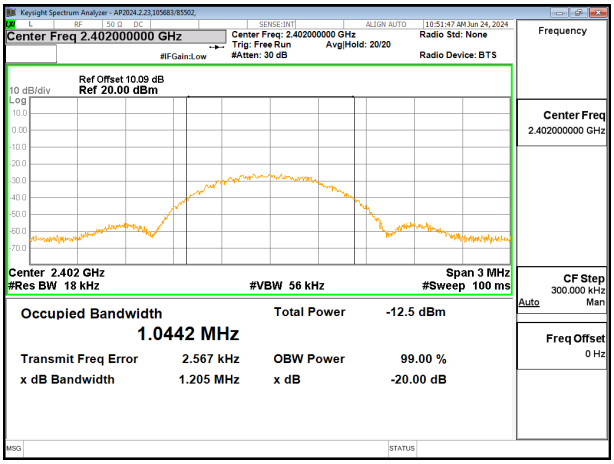
LIMITS

None; for reporting purposes only.

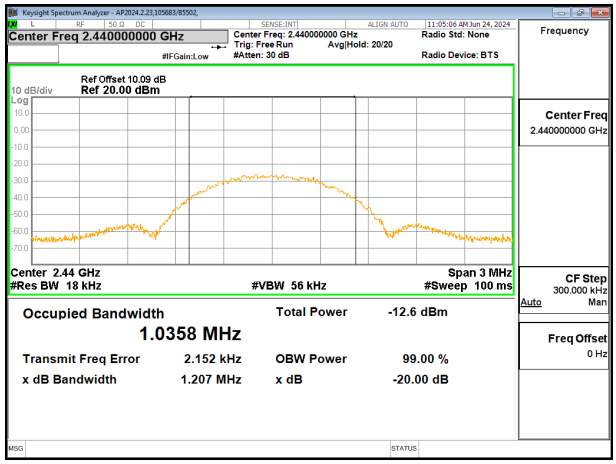
RESULTS

9.2.1. BLE (1Mbps)

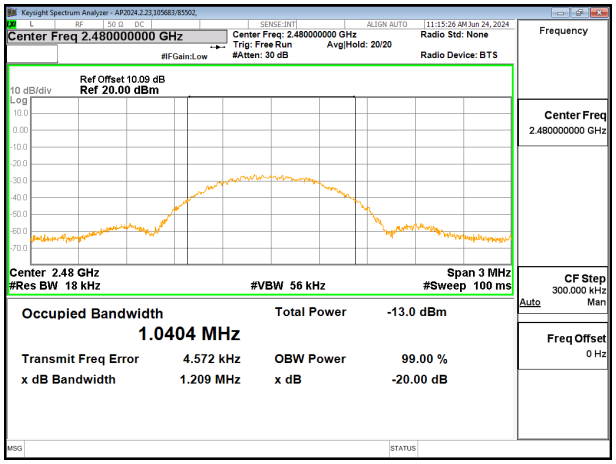
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0442
Middle	2440	1.0358
High	2480	1.0404



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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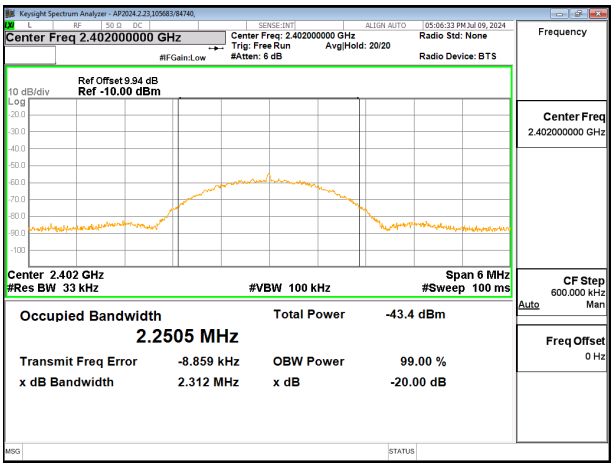
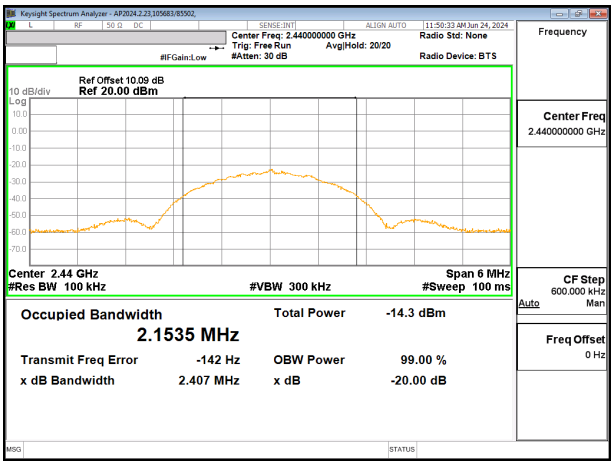
9.2.2. BLE (2Mbps)

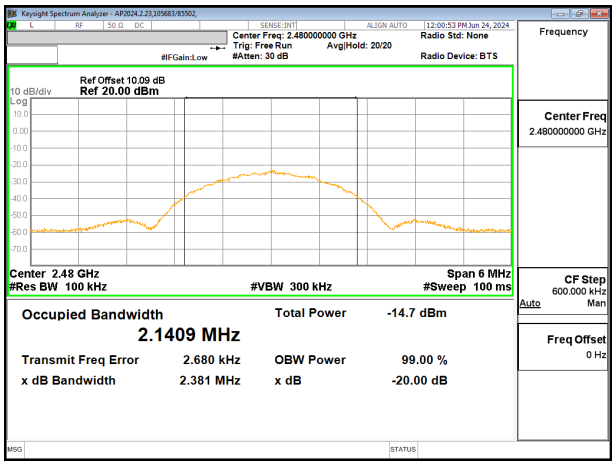
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	2.2505
Middle	2440	2.1535
High	2480	2.1409



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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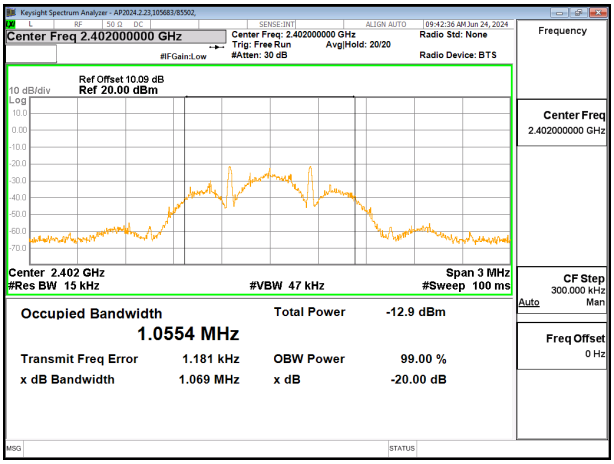
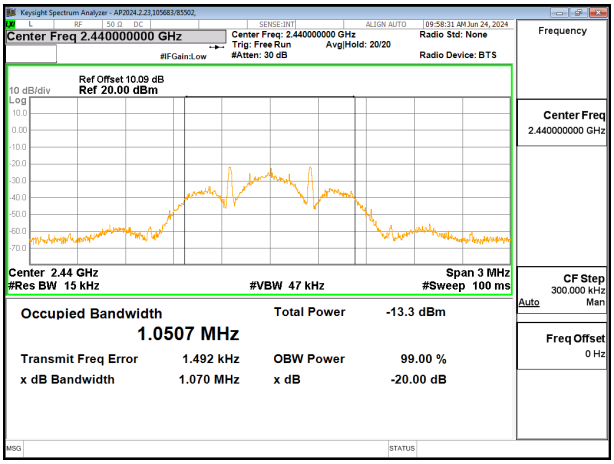
9.2.3. BLE (125Kbps)

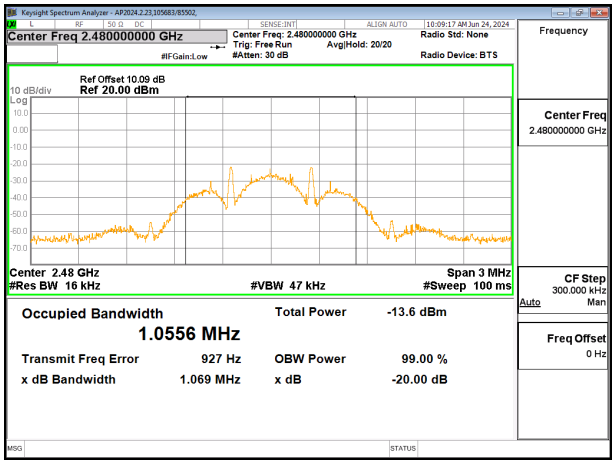
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0554
Middle	2440	1.0507
High	2480	1.0556



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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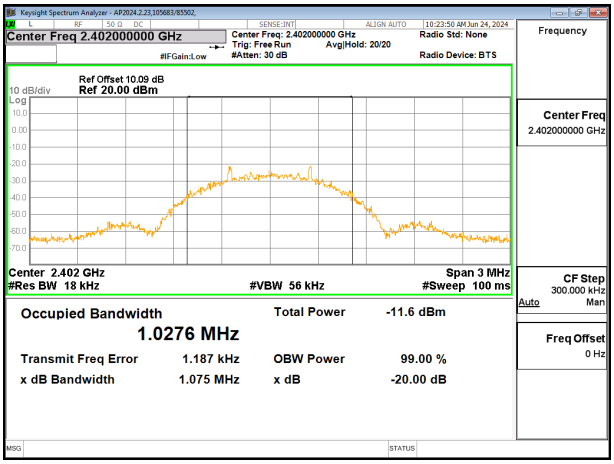
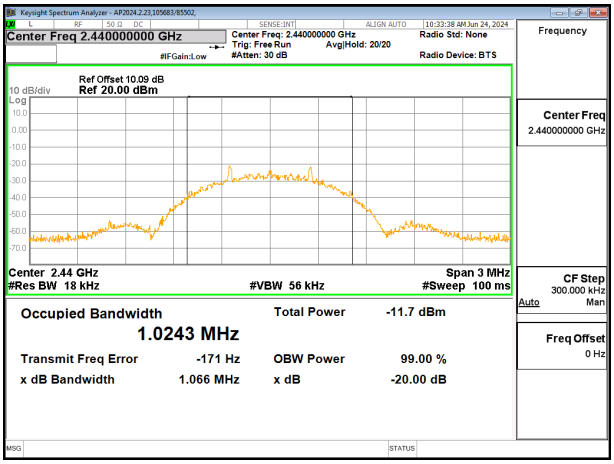
9.2.4. BLE (500Kbps)

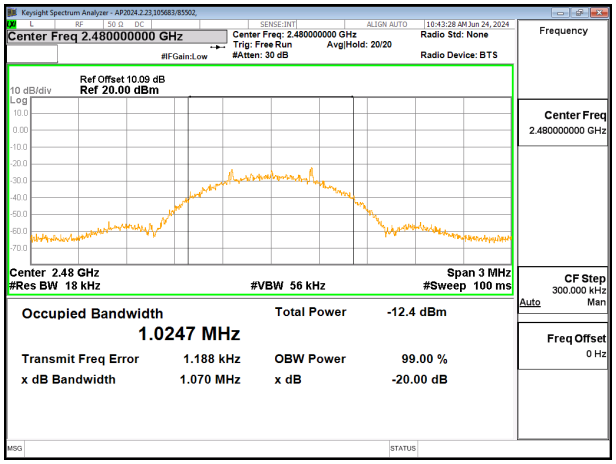
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.0276
Middle	2440	1.0243
High	2480	1.0247



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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9.3. 6 dB BANDWIDTH

LIMITS

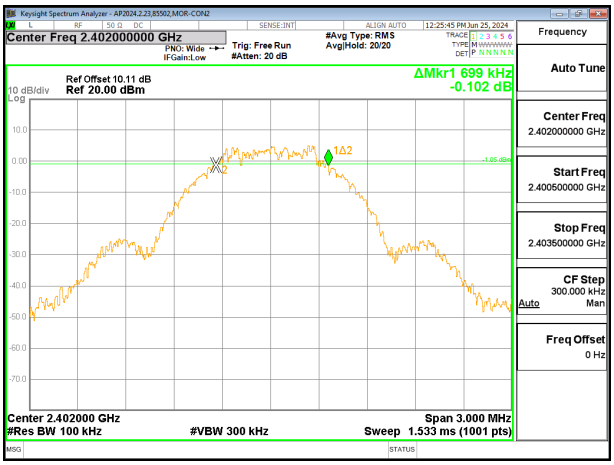
FCC §15.247 (a) (2)
RSS-247 5.2 (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

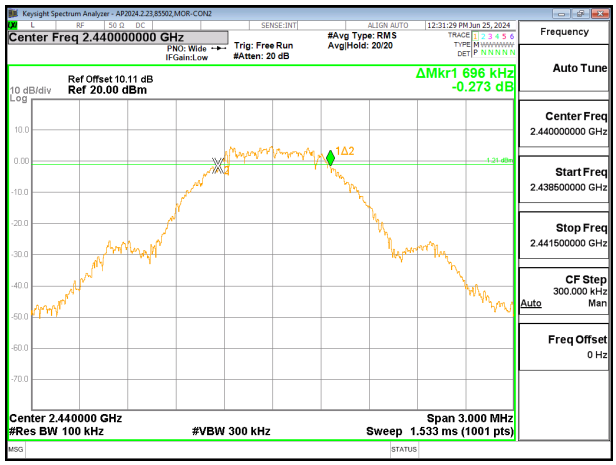
RESULTS

9.3.1. BLE (1Mbps)

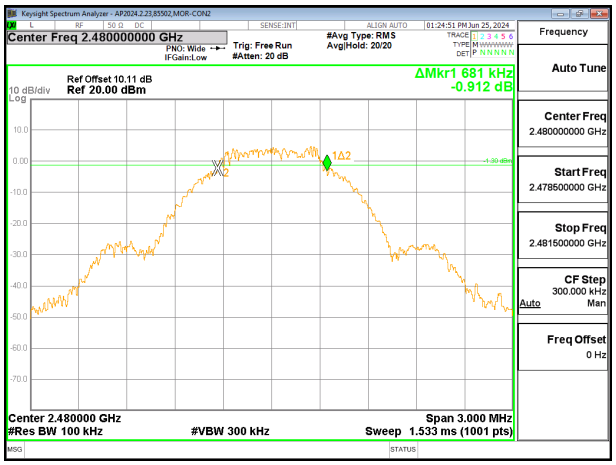
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6990	0.5
Middle	2440	0.6960	0.5
High	2480	0.6810	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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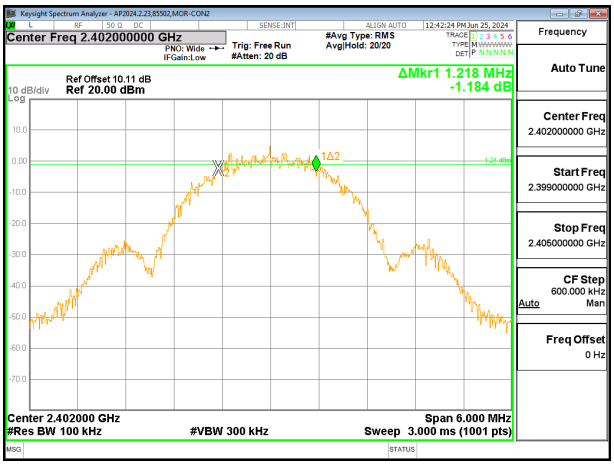
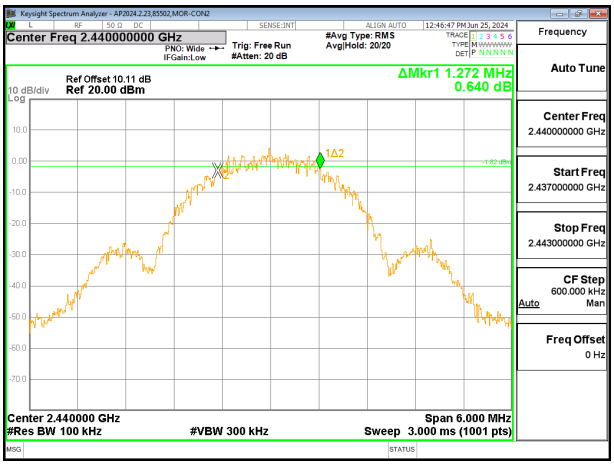
9.3.2. BLE (2Mbps)

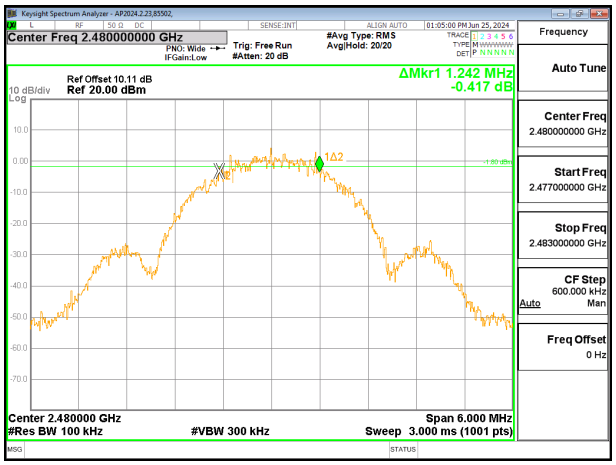
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	1.2180	0.5
Middle	2440	1.2720	0.5
High	2480	1.2420	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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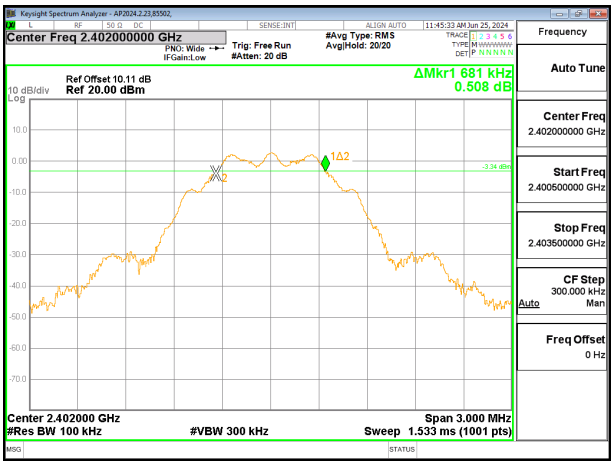
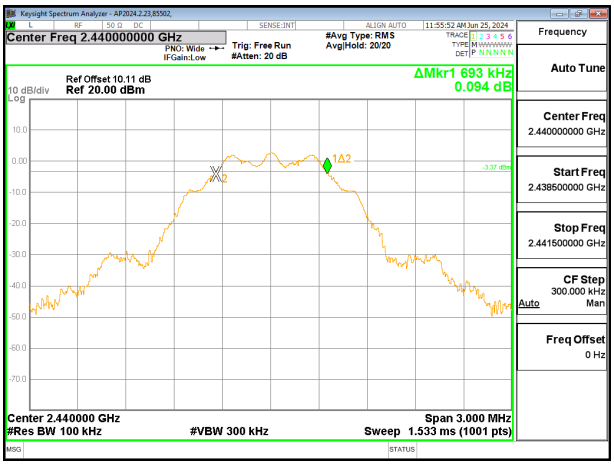
9.3.3. BLE (125Kbps)

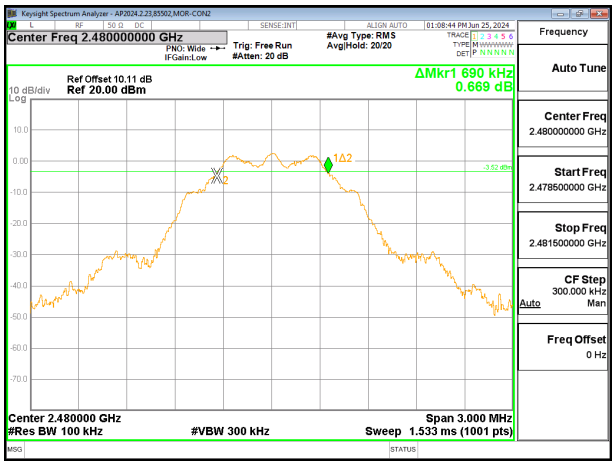
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6810	0.5
Middle	2440	0.6930	0.5
High	2480	0.6900	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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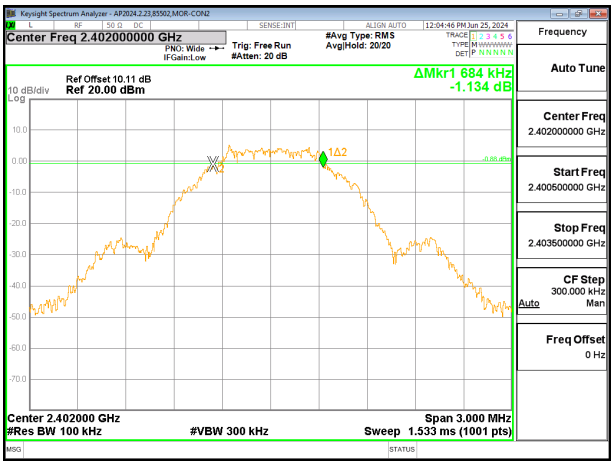
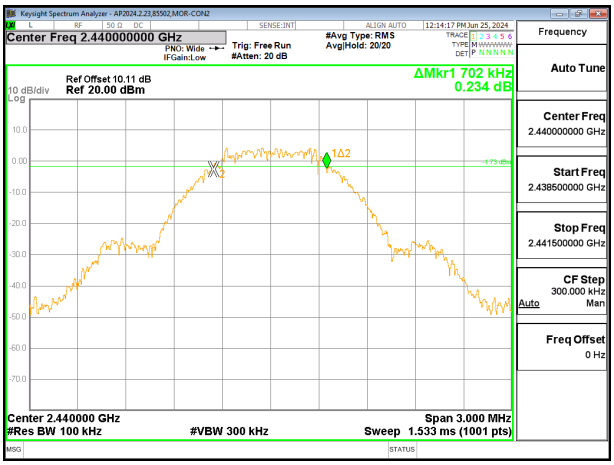
9.3.4. BLE (500Kbps)

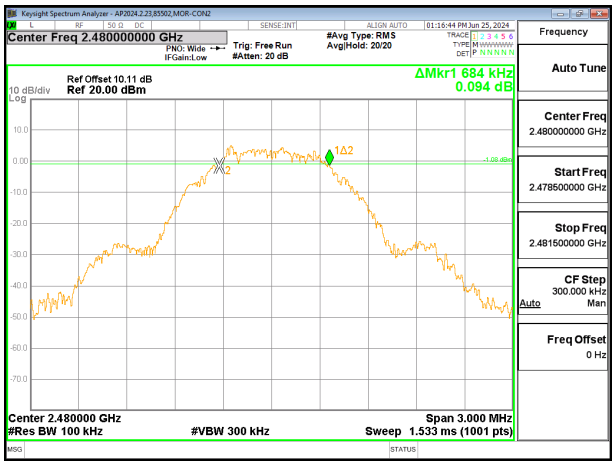
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2402	0.6840	0.5
Middle	2440	0.7020	0.5
High	2480	0.6840	0.5



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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9.4. OUTPUT POWER

LIMITS

FCC §15.247 (b) (3)
RSS-247 5.4 (d)

The maximum antenna gain is less than or equal to 6 dBi, therefore the limit is 30 dBm.

TEST PROCEDURE
The transmitter output is connected to a power meter.

The cable assembly insertion loss of .61 dB (including .21 dB EUT cable and 0.4 dB test cable) was entered as an offset in the power meter.

The power output was measured on the EUT antenna port using SMA cable with connected to a power meter via wideband power sensor. Peak output power was read directly from power meter.

RESULTS

9.4.1. BLE (1Mbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	6.160	30	-23.840
Middle	2440	5.940	30	-24.060
High	2480	5.730	30	-24.270

9.4.2. BLE (2Mbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	6.140	30	-23.860
Middle	2440	5.930	30	-24.070
High	2480	5.730	30	-24.270

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9.4.3. BLE (125Kbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	6.150	30	-23.850
Middle	2440	5.950	30	-24.050
High	2480	5.730	30	-24.270

9.4.4. BLE (500Kbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	Peak Power Reading (dBm)	Limit (dBm)	Margin (dB)
Low	2402	6.150	30	-23.850
Middle	2440	5.960	30	-24.040
High	2480	5.750	30	-24.250

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9.5. AVERAGE POWER

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to an average gated power meter.

The cable assembly insertion loss of .61 dB (including .21 dB EUT cable and 0.4 dB test cable) was entered as an offset in the average gated power meter.

The power output was measured on the EUT antenna port using SMA cable connected to a power meter via wideband average power sensor. Gated average output power was read directly from power meter.

RESULTS

9.5.1. BLE (1Mbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	5.9
Middle	2440	5.71
High	2480	5.5

9.5.2. BLE (2Mbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	5.9
Middle	2440	5.71
High	2480	5.5

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9.5.3. BLE (125Kbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	5.91
Middle	2440	5.72
High	2480	5.51

9.5.4. BLE (500Kbps)

Tested By:	104412/21193
Date:	2024-06-06

Channel	Frequency (MHz)	AV power (dBm)
Low	2402	5.91
Middle	2440	5.72
High	2480	5.51

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9.6. POWER SPECTRAL DENSITY

LIMITS

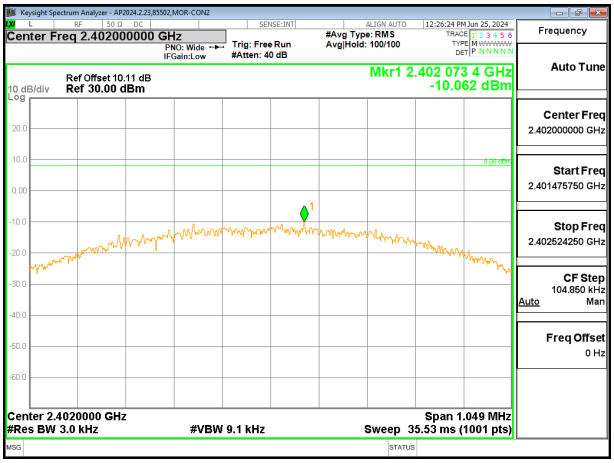
FCC §15.247 (e)
RSS-247 (5.2) (b)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

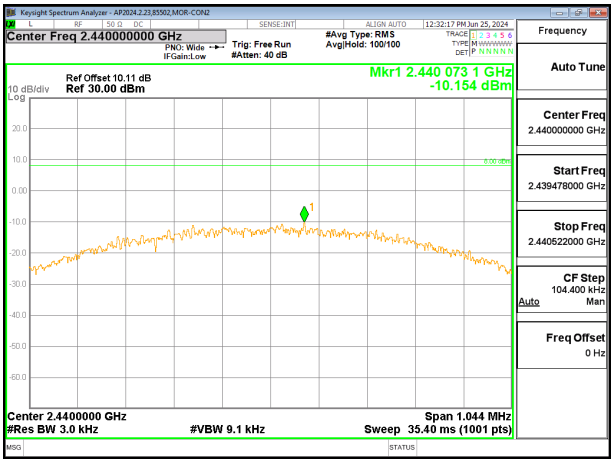
RESULTS

9.6.1. BLE (1Mbps)

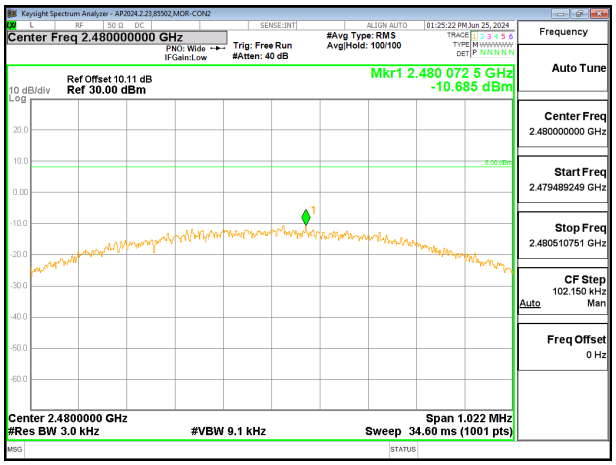
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-10.06	8	-18.06
Middle	2440	-10.15	8	-18.15
High	2480	-10.69	8	-18.69



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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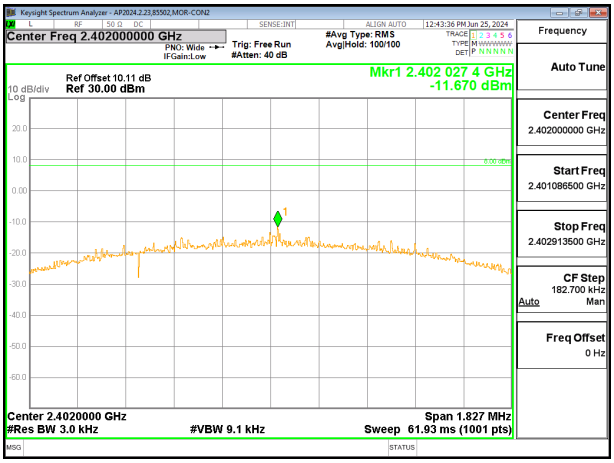
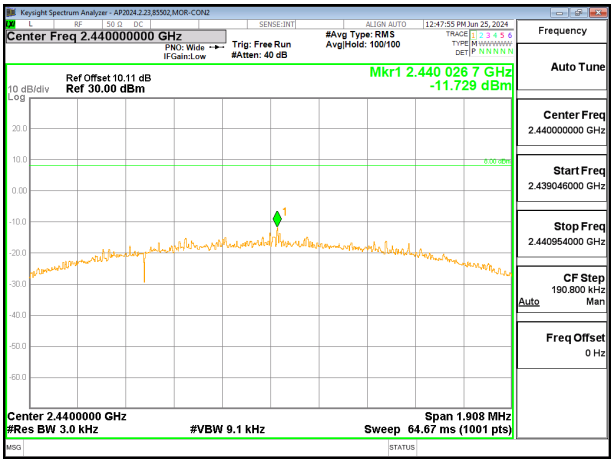
9.6.2. BLE (2Mbps)

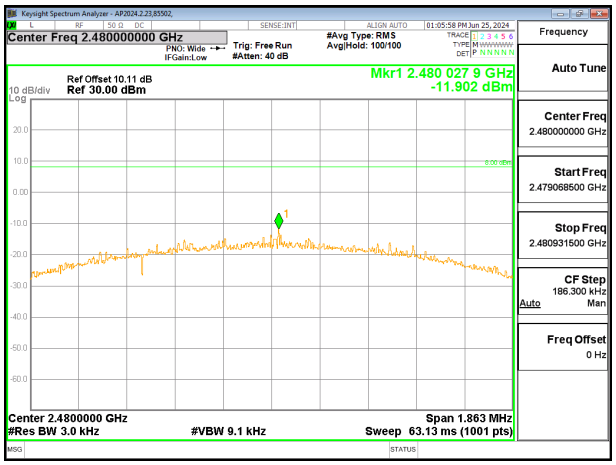
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-11.67	8	-19.67
Middle	2440	-11.73	8	-19.73
High	2480	-11.90	8	-19.90



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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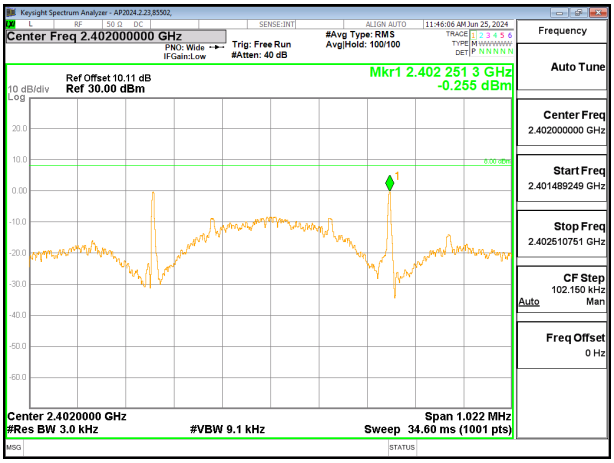
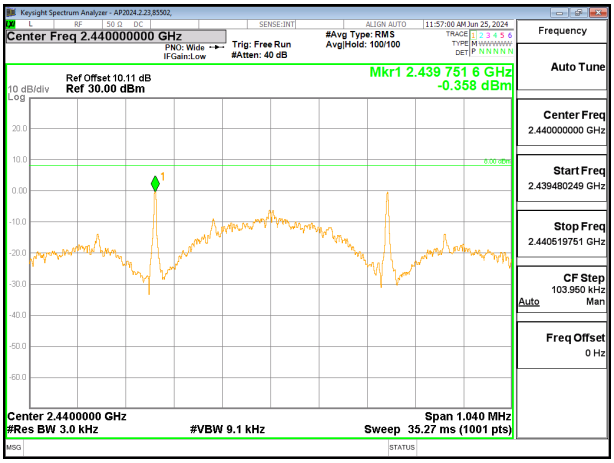
9.6.3. BLE (125Kbps)

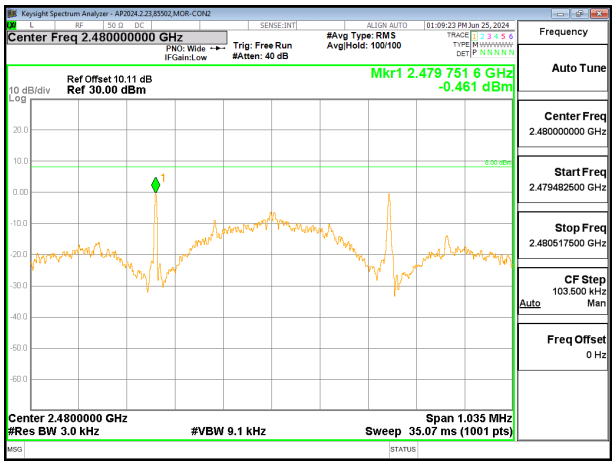
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-0.26	8	-8.26
Middle	2440	-0.36	8	-8.36
High	2480	-0.46	8	-8.46



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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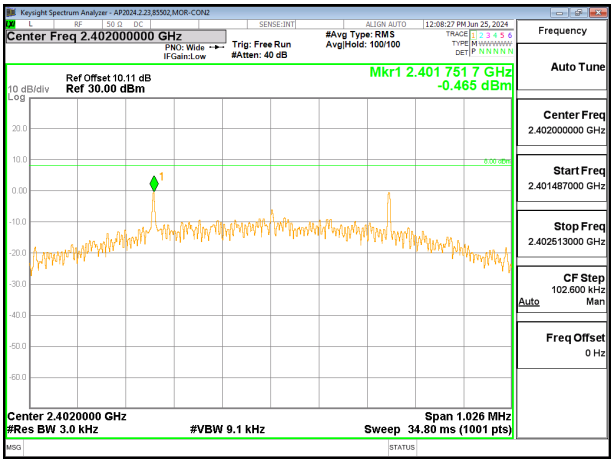
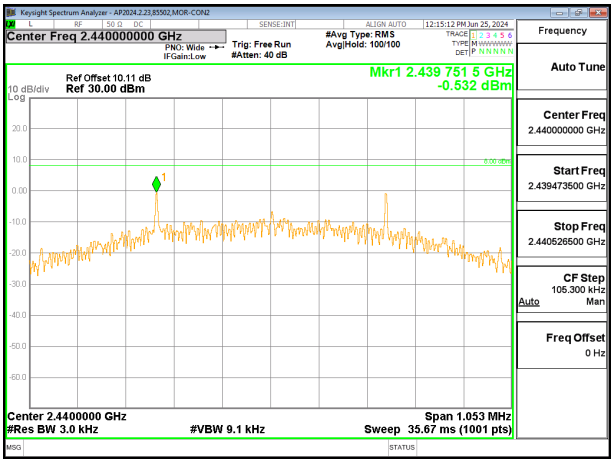
9.6.4. BLE (500Kbps)

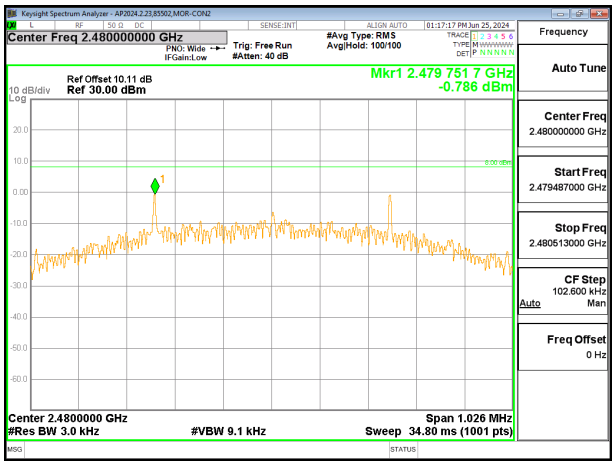
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
Low	2402	-0.47	8	-8.47
Middle	2440	-0.53	8	-8.53
High	2480	-0.79	8	-8.79



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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9.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)
RSS-247 5.5

Output power was measured based on the use of a peak measurement, therefore the required attenuation is -20 dBc.

RESULTS

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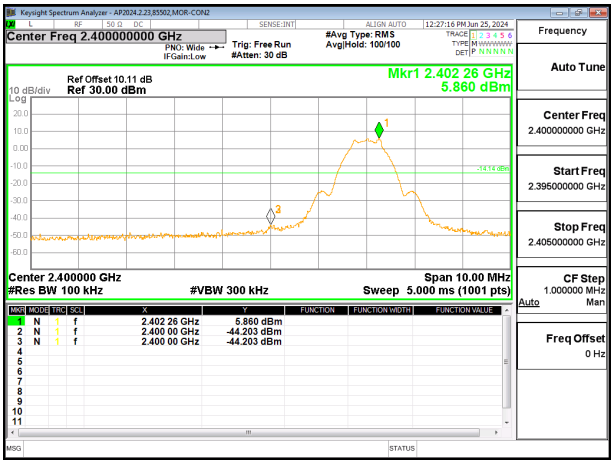
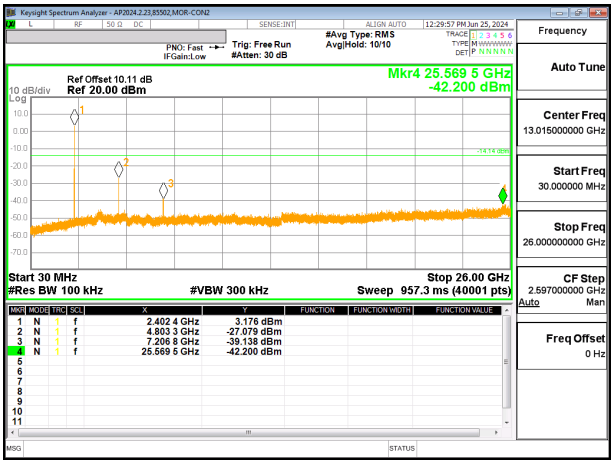
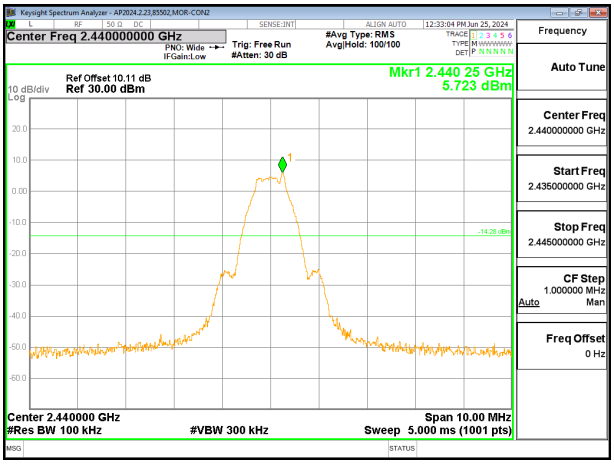
9.7.1. BLE (1Mbps)



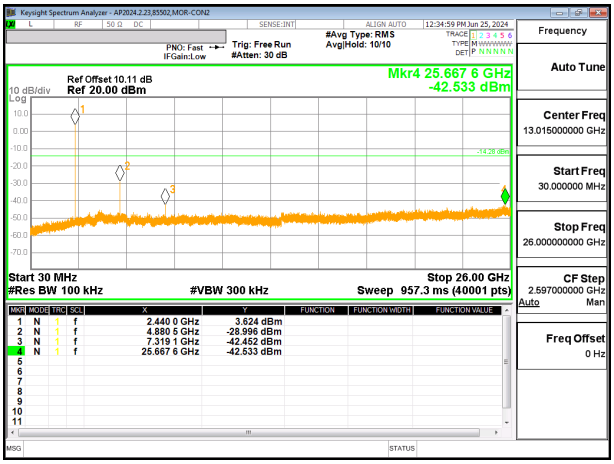
LOW CHANNEL BANDEDGE



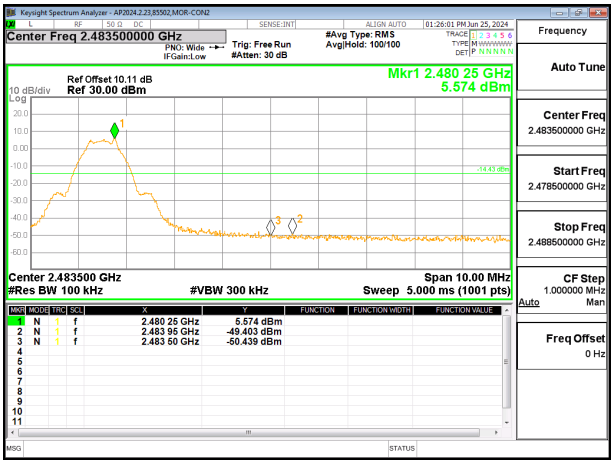
OUT-OF-BAND LOW CHANNEL



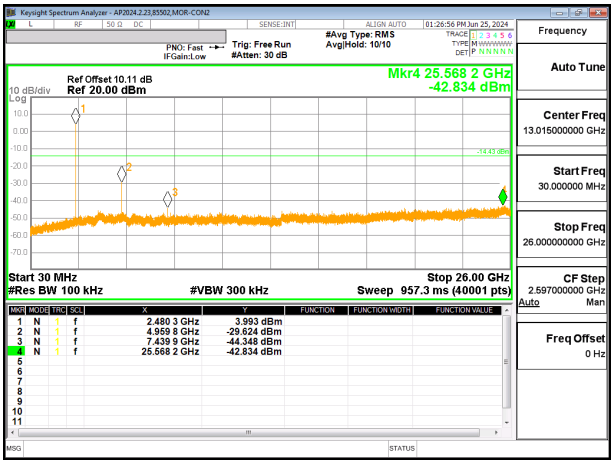
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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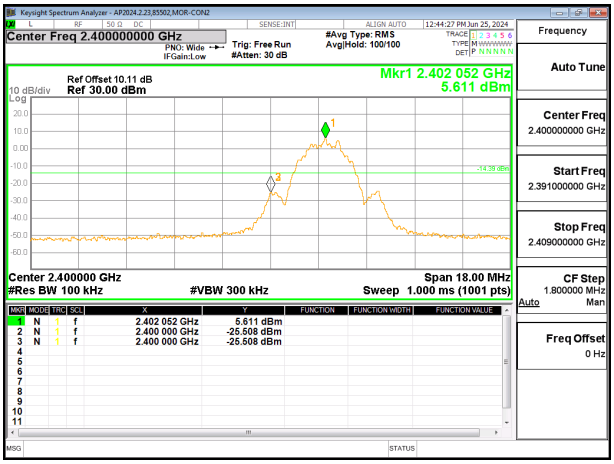
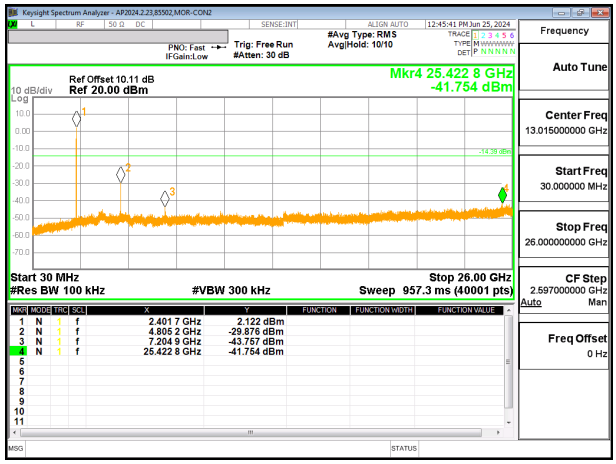
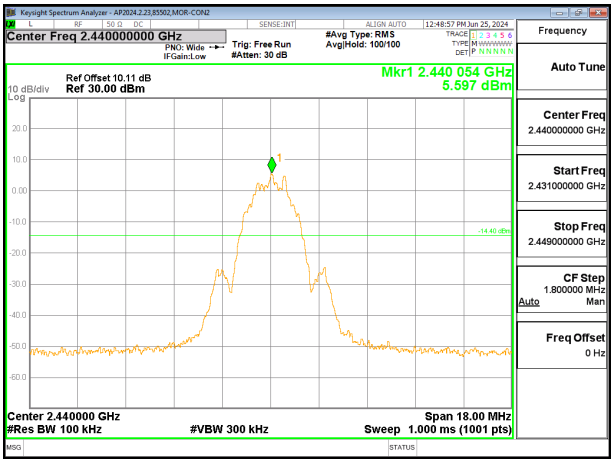
9.7.2. BLE (2Mbps)



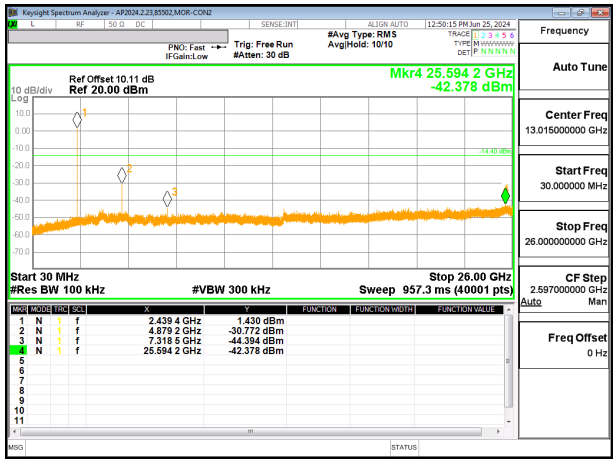
LOW CHANNEL BANDEDGE



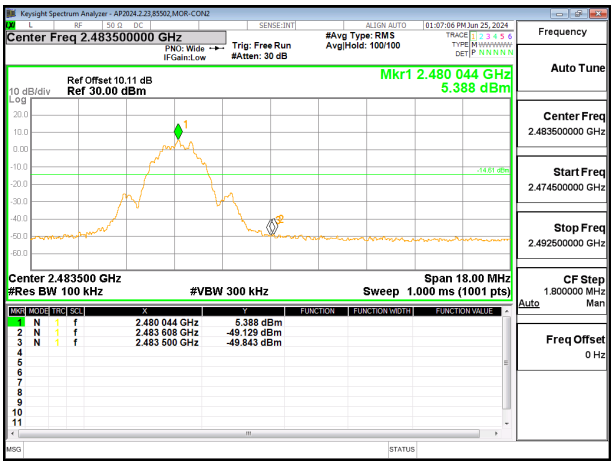
OUT-OF-BAND LOW CHANNEL



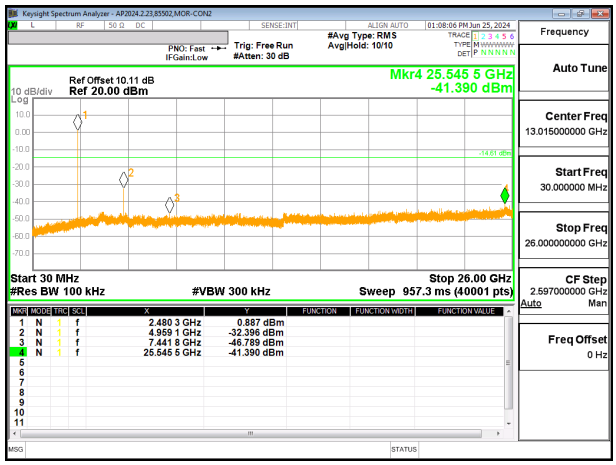
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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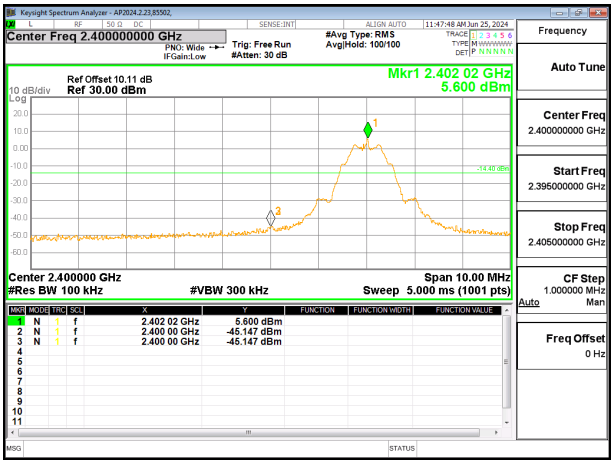
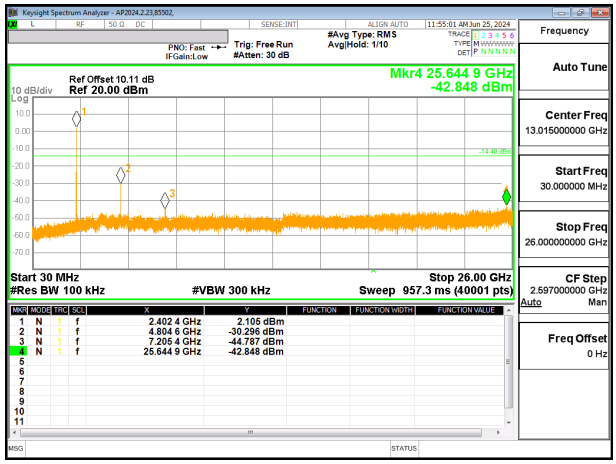
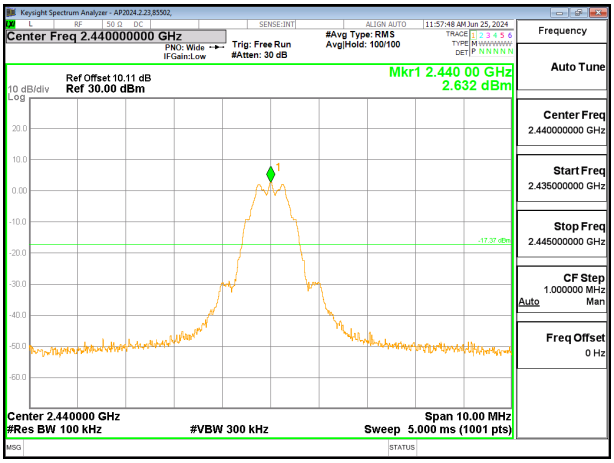
9.7.3. BLE (125Kbps)



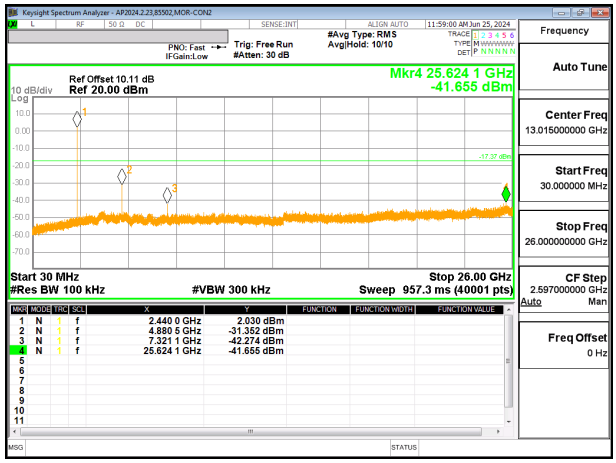
LOW CHANNEL BANDEDGE



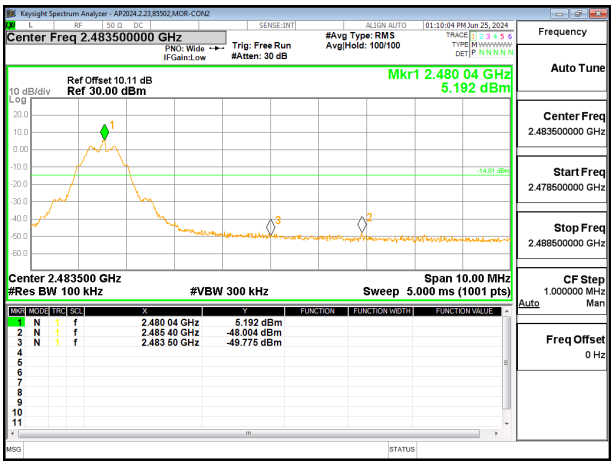
OUT-OF-BAND LOW CHANNEL



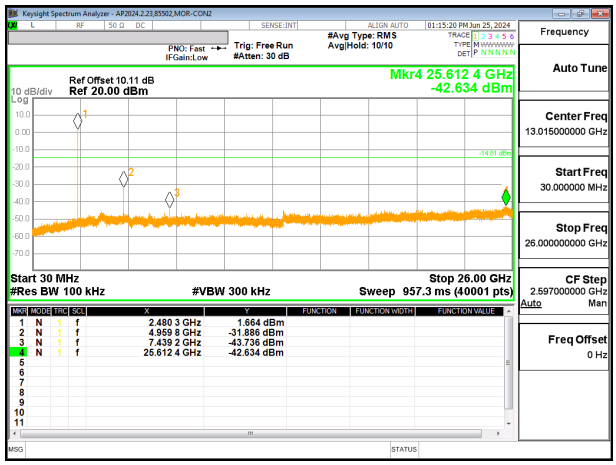
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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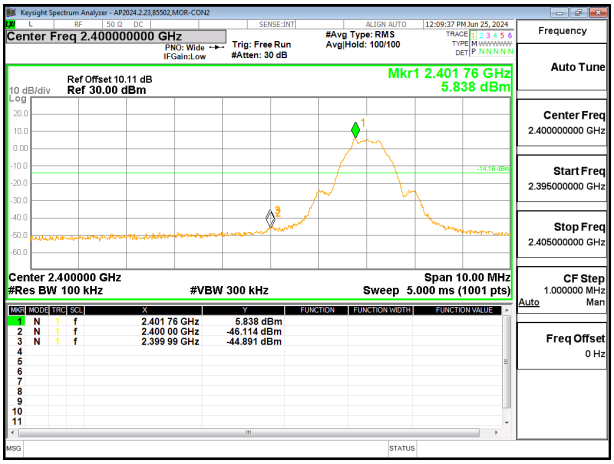
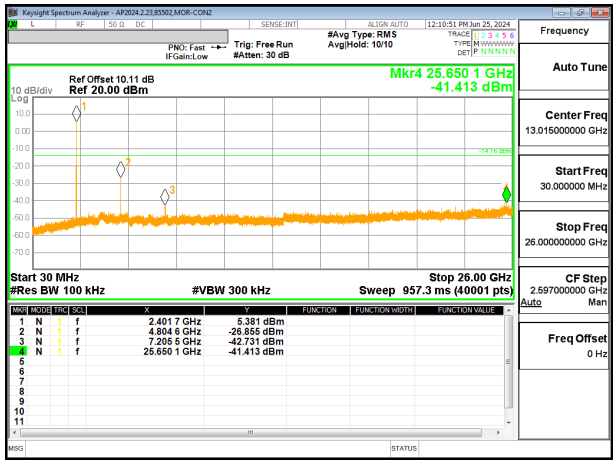
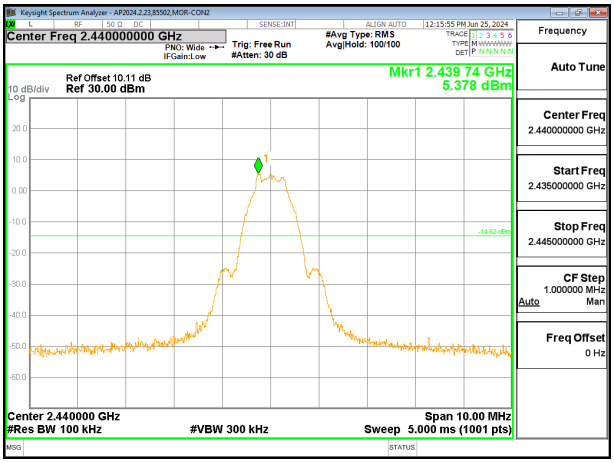
9.7.4. BLE (500Kbps)



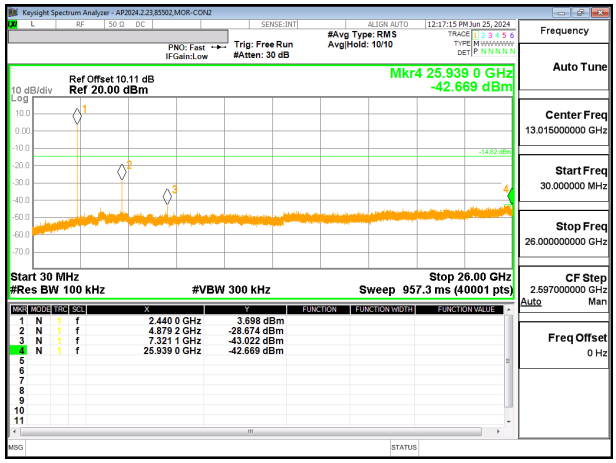
LOW CHANNEL BANDEDGE



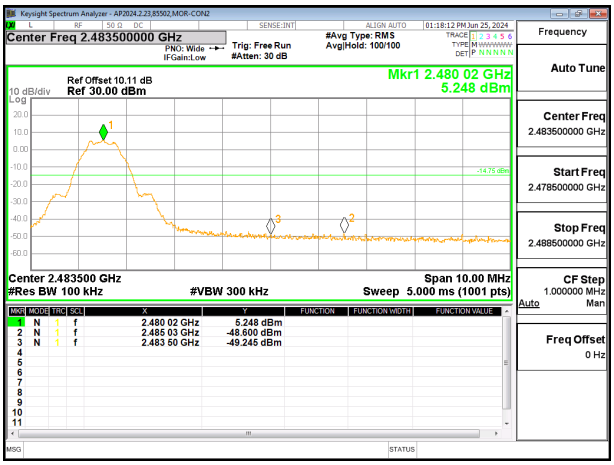
OUT-OF-BAND LOW CHANNEL



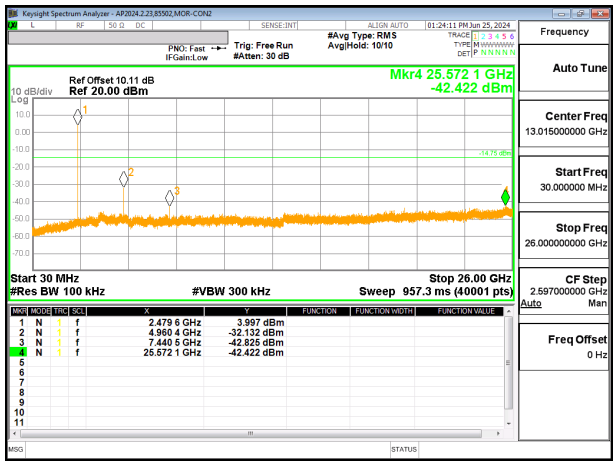
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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10. RADIATED TEST RESULTS

10.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209
RSS-GEN, Section 8.9 and 8.10.

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
0.009-0.490	2400/F(kHz) @ 300 m	-
0.490-1.705	24000/F(kHz) @ 30 m	-
1.705 - 30	30 @ 30m	-
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

RSS-GEN, Section 8.9 and 8.10.

Frequency Range (MHz)	Field Strength Limit (uA/m) at 3 m	Field Strength Limit (dBuA/m) at 3 m
0.009-0.490	6.37/F(kHz) @ 300 m	-
0.490-1.705	63.7/F(kHz) @ 30 m	-
1.705 - 30	0.08 @ 30m	-
Frequency Range (MHz)	**Field Strength Limit (uV/m) at 3 m**	**Field Strength Limit (dBuV/m) at 3 m**
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9 to 150kHz range. Peak detection is used unless otherwise noted as quasi-peak or average (9-90kHz and 110-490kHz).

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements.

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For final measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements and as applicable for average measurements. Voltage Averaging was used.

The spectrum from 1 GHz to 18 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band. Below 1GHz and above 18GHz emissions, the channel with the highest power spectral density was tested.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

3D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel).

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

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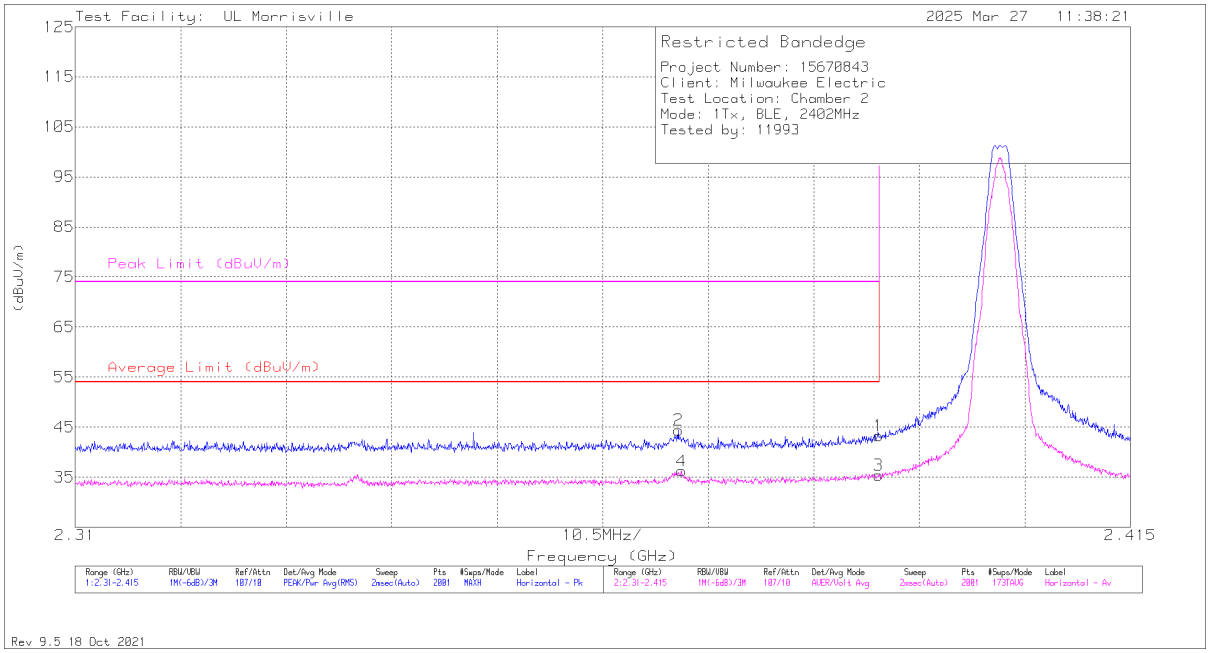
10.2. TRANSMITTER ABOVE 1 GHz

10.2.1. BLE (2Mbps)

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	34.52	Pk	32.3	-23.6	0	43.22	-	-	74	-30.78	332	101	H
2	* ** 2.37001	35.82	Pk	32.2	-23.6	0	44.42	-	-	74	-29.58	332	101	H
3	* ** 2.38996	21.86	ADV	32.3	-23.6	4.81	35.37	54	-18.63	-	-	332	101	H
4	* ** 2.37032	22.81	ADV	32.2	-23.6	4.81	36.22	54	-17.78	-	-	332	101	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
ADV - Linear Voltage Average

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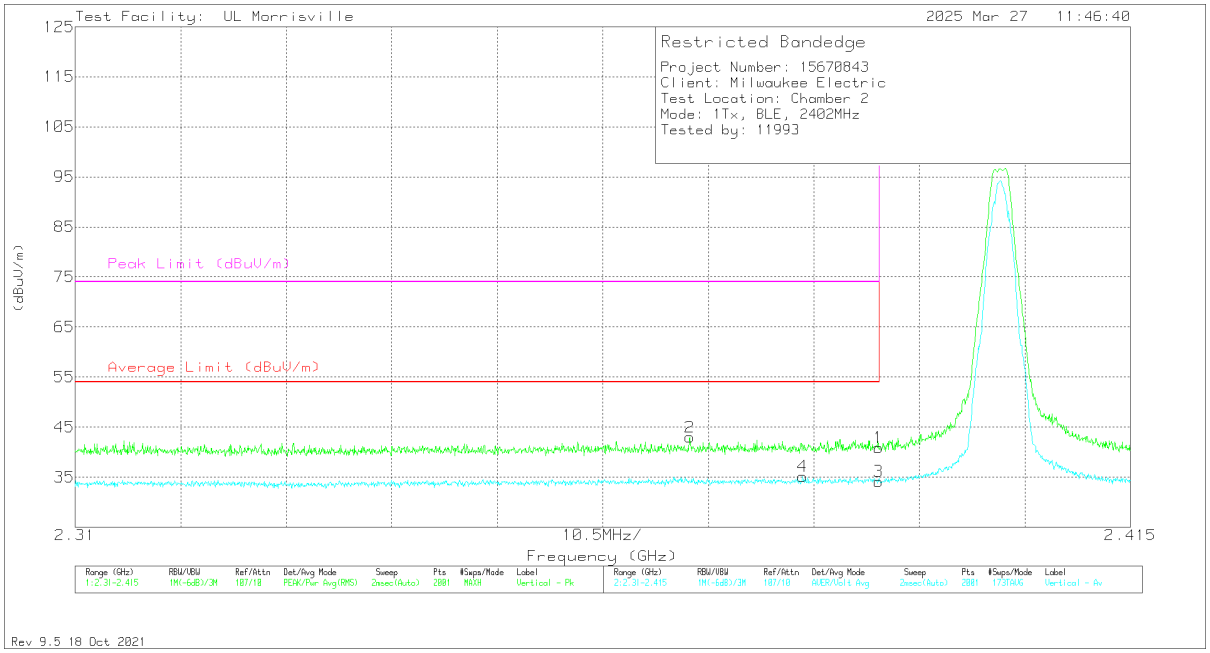
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	32.17	Pk	32.3	-23.6	0	40.87	-	-	74	-33.13	126	386	V
2	* ** 2.37116	34.36	Pk	32.2	-23.6	0	42.96	-	-	74	-31.04	126	386	V
3	* ** 2.38996	20.65	ADV	32.3	-23.6	4.81	34.16	54	-19.84	-	-	126	386	V
4	* ** 2.3824	21.61	ADV	32.2	-23.5	4.81	35.12	54	-18.88	-	-	126	386	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
ADV - Linear Voltage Average

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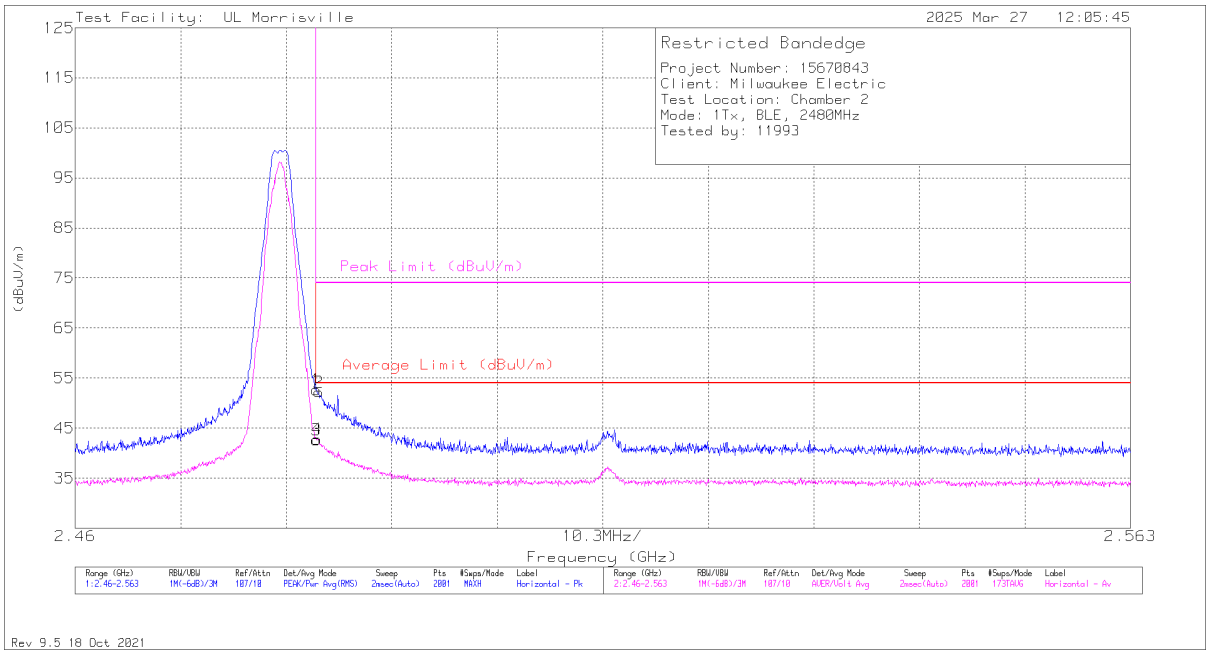
BANDEDGE (HIGH CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	44.3	Pk	32.5	-24.1	0	52.7	-	-	74	-21.3	354	155	H
2	* ** 2.48379	43.81	Pk	32.5	-24.1	0	52.21	-	-	74	-21.79	354	155	H
3	* ** 2.48354	29.43	ADV	32.5	-24.1	4.81	42.64	54	-11.36	-	-	354	154	H
4	* ** 2.48359	29.53	ADV	32.5	-24.1	4.81	42.74	54	-11.26	-	-	354	154	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
ADV - Linear Voltage Average

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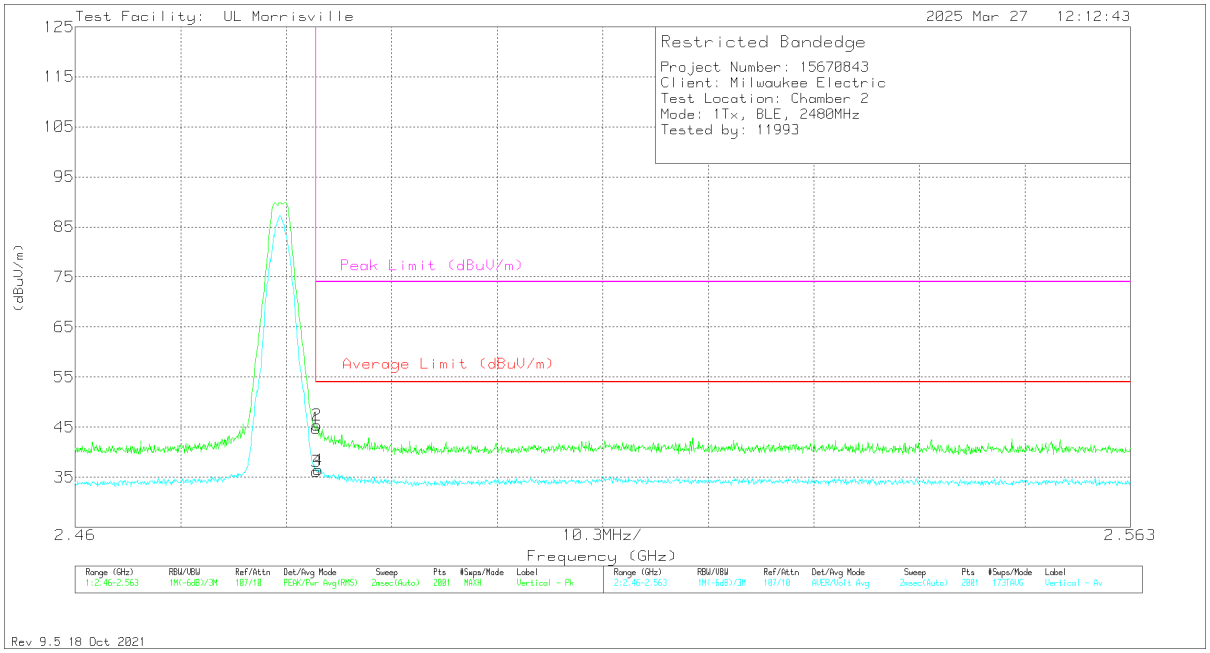
VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	36.38	Pk	32.5	-24.1	0	44.78	-	-	74	-29.22	22	145	V
2	* ** 2.48359	37	Pk	32.5	-24.1	0	45.4	-	-	74	-28.6	22	145	V
3	* ** 2.48354	22.94	ADV	32.5	-24.1	4.81	36.15	54	-17.85	-	-	22	145	V
4	* ** 2.48374	23.26	ADV	32.5	-24.1	4.81	36.47	54	-17.53	-	-	22	145	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
ADV - Linear Voltage Average

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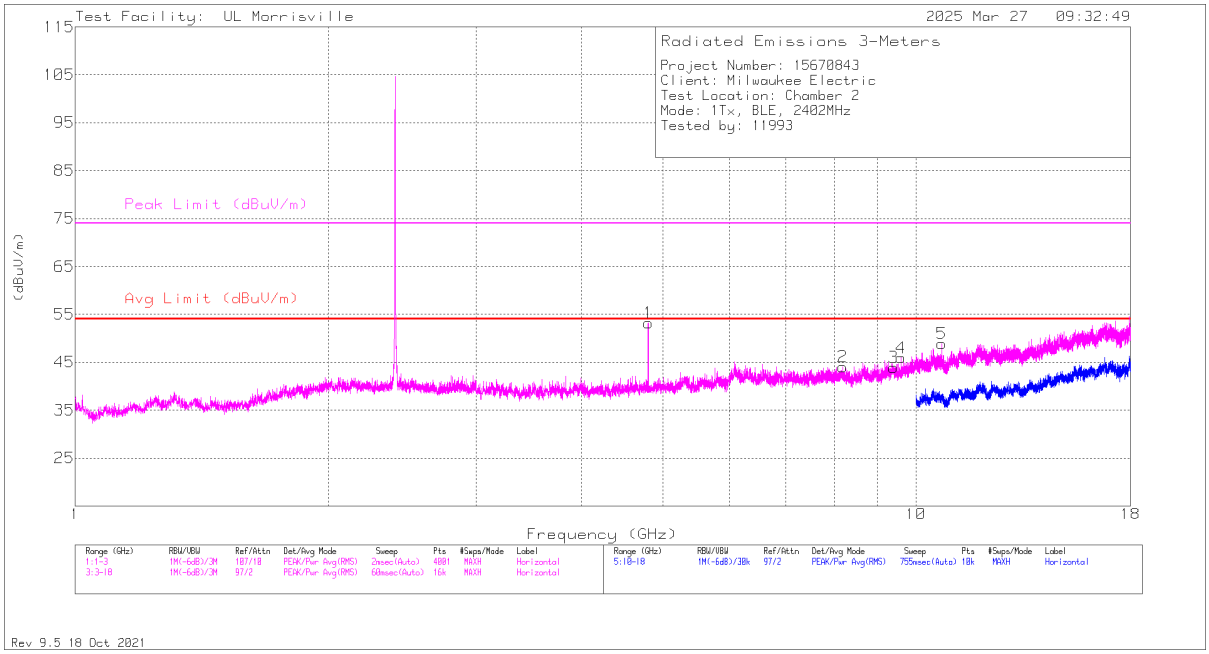
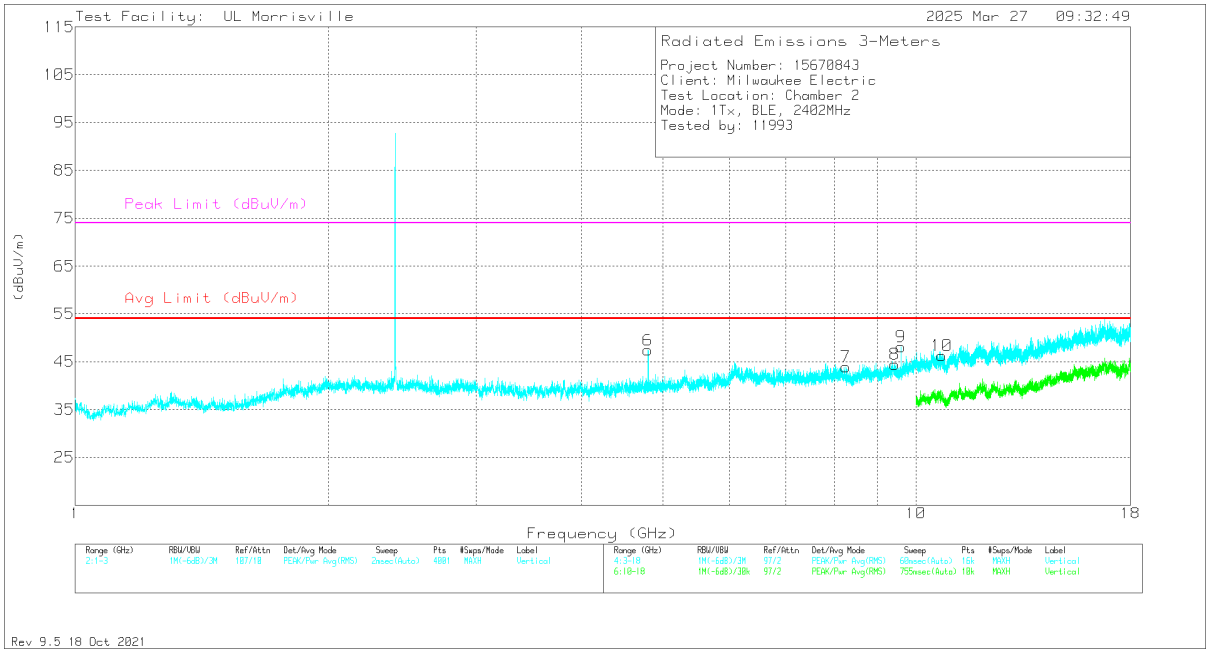
10.2.2. BLE (125Kbps)

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.80346	64.8	PK2	34.2	-43.9	0	55.1	-	-	74	-18.9	257	107	H
	* ** 4.80365	59.35	ADV	34.2	-43.9	.23	49.88	54	-4.12	-	-	257	107	H
2	* ** 8.18063	48.64	Pk	35.8	-40.4	0	44.04	54	-9.96	74	-29.96	0-360	199	H
3	* ** 9.41344	47.84	Pk	36.2	-40.1	0	43.94	54	-10.06	74	-30.06	0-360	101	H
5	* ** 10.74194	50.62	PK2	37.6	-39.8	0	48.42	-	-	74	-25.58	10	292	H
	* ** 10.73836	38.03	ADV	37.6	-39.9	.23	35.96	54	-18.04	-	-	10	292	H
6	* ** 4.80281	57.1	Pk	34.2	-43.9	0	47.4	54	-6.6	74	-26.6	0-360	200	V
7	* ** 8.25188	48.52	Pk	35.8	-40.4	0	43.92	54	-10.08	74	-30.08	0-360	200	V
8	* ** 9.4425	48.6	Pk	36.3	-40.4	0	44.5	54	-9.5	74	-29.5	0-360	200	V
10	* ** 10.73906	48.43	Pk	37.6	-39.8	0	46.23	54	-7.77	74	-27.77	0-360	101	V
9	9.60844	51.37	Pk	36.5	-39.8	0	48.07	-	-	-	-	0-360	101	V
4	9.60938	49.35	Pk	36.5	-39.9	0	45.95	-	-	-	-	0-360	199	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
PK2 - Maximum Peak
ADV - Linear Voltage Average

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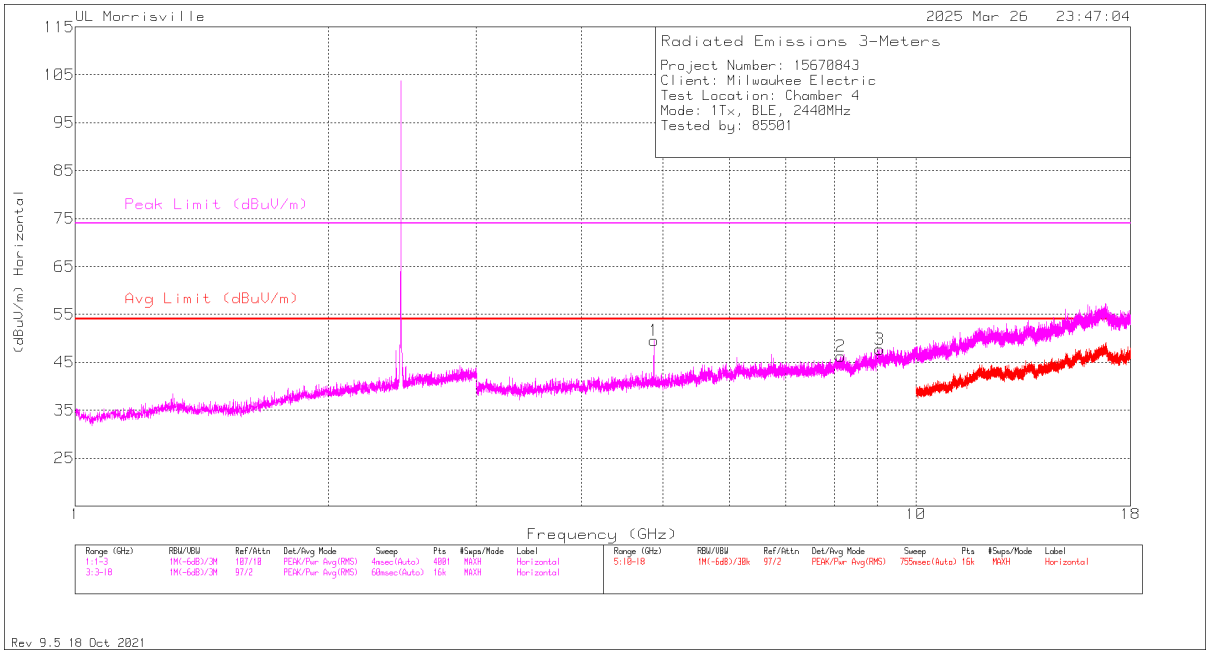
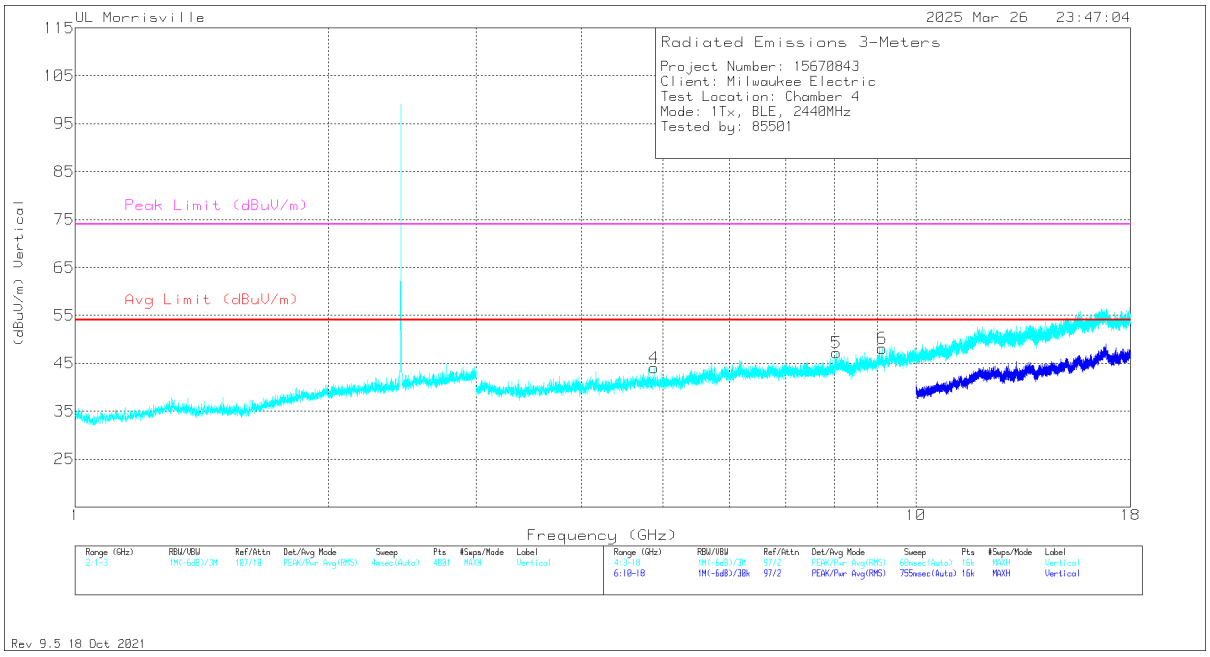
MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.87952	50.55	PK2	34	-31	0	53.55	-	-	74	-20.45	333	131	H
	* ** 4.88028	44.25	ADV	34	-31	.23	47.48	54	-6.52	-	-	333	131	H
2	* ** 8.14125	37.46	Pk	35.8	-27	0	46.26	54	-7.74	74	-27.74	0-360	100	H
3	* ** 9.05531	35.61	Pk	36.2	-24.1	0	47.71	54	-6.29	74	-26.29	0-360	100	H
4	* ** 4.87969	41.01	Pk	34	-31	0	44.01	54	-9.99	74	-29.99	0-360	200	V
5	* ** 8.04844	38.55	Pk	35.8	-27.1	0	47.25	54	-6.75	74	-26.75	0-360	200	V
6	* ** 9.11602	36.7	PK2	36.3	-24.6	0	48.4	-	-	74	-25.6	244	232	V
	* ** 9.11686	24.29	ADV	36.3	-24.7	.23	36.12	54	-17.88	-	-	244	232	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
PK2 - Maximum Peak
ADV - Linear Voltage Average

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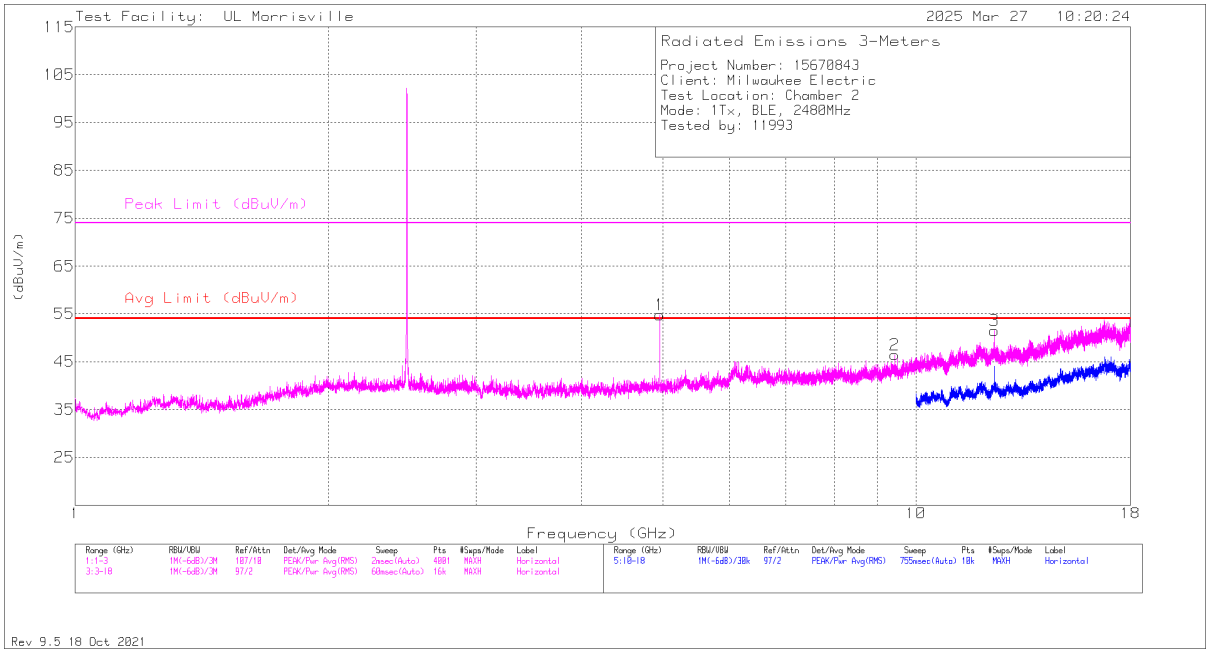
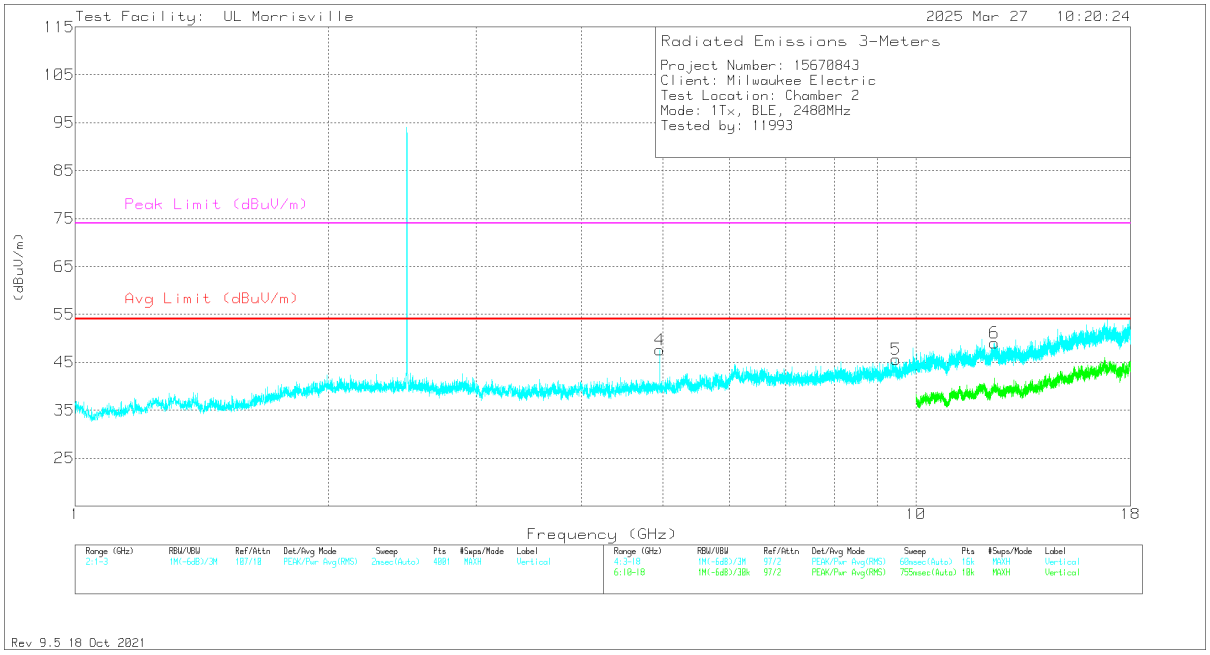
HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

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RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	86408 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.95947	66.01	PK2	34	-43.8	0	56.21	-	-	74	-17.79	244	115	H
	* ** 4.96033	60.69	ADV	34	-43.8	0.23	51.12	54	-2.88	-	-	244	115	H
2	* ** 9.44344	50.57	Pk	36.3	-40.4	0	46.47	54	-7.53	74	-27.53	0-360	101	H
3	* ** 12.39881	51.32	PK2	38.8	-38.2	0	51.92	-	-	74	-22.08	38	104	H
	* ** 12.39889	40.79	ADV	38.8	-38.2	0.23	41.62	54	-12.38	-	-	38	104	H
4	* ** 4.95938	57.38	Pk	34	-43.8	0	47.58	54	-6.42	74	-26.42	0-360	199	V
5	* ** 9.465	49.45	Pk	36.3	-40.1	0	45.65	54	-8.35	74	-28.35	0-360	199	V
6	* ** 12.39902	50.98	PK2	38.8	-38.2	0	51.58	-	-	74	-22.42	225	209	V
	* ** 12.39877	39.93	ADV	38.8	-38.2	0.23	40.76	54	-13.24	-	-	225	209	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector
PK2 - Maximum Peak
ADV - Linear Voltage Average

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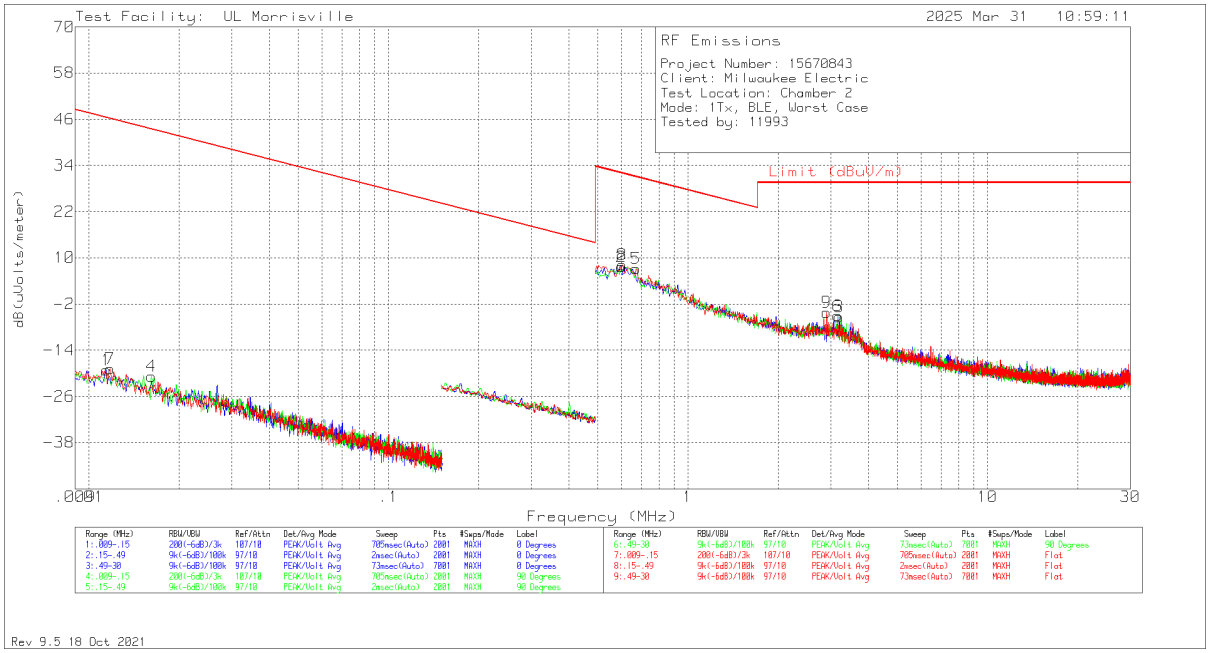
10.3. WORST CASE BELOW 30MHZ

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).



ANTENNA- THREE ORIENTATIONS – E FIELD

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dB/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	QP/AV Limit (dBuV/m)	PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Loop Angle
1	.01141	43.17	Pk	17.6	.1	-80	-19.13	46.46	66.46	-65.59	0-360	0 degs
7	.01177	43.69	Pk	17.4	.1	-80	-18.81	46.19	66.19	-65	0-360	Flat
4	.01617	43.7	Pk	15.5	.1	-80	-20.7	43.43	63.43	-64.13	0-360	90 degs
2	.59962	36.53	Pk	11	.1	-40	7.63	32.05	-	-24.42	0-360	0 degs
8	.60383	37.12	Pk	11	.1	-40	8.22	31.99	-	-23.77	0-360	Flat
5	.67129	36.12	Pk	11	.1	-40	7.22	31.07	-	-23.85	0-360	90 degs
9	2.90577	24.57	Pk	11.1	.2	-40	-4.13	29.54	-	-33.67	0-360	Flat
6	3.15873	23.54	Pk	11.1	.3	-40	-5.06	29.54	-	-34.6	0-360	90 degs
3	3.19667	23.31	Pk	11.1	.3	-40	-5.29	29.54	-	-34.83	0-360	0 degs

Pk - Peak detector

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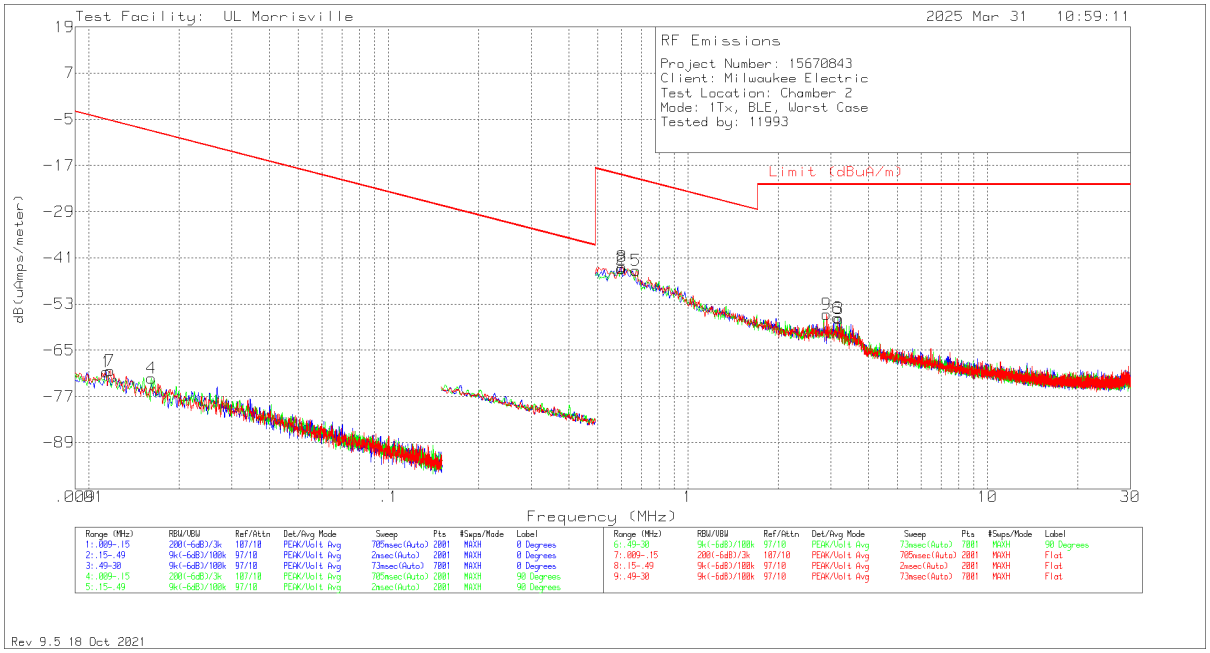

ANTENNA- THREE ORIENTATIONS – H FIELD

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dB/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uAmps/meter)	QP/AV Limit (dBuA/m)	PK Limit (dBuA/m)	Margin (dB)	Azimuth (Degs)	Loop Angle
1	.01141	43.17	Pk	-33.9	.1	-80	-70.63	-5.04	14.96	-65.59	0-360	0 degs
2	.59962	36.53	Pk	-40.5	.1	-40	-43.87	-19.45	-	-24.42	0-360	0 degs
3	3.19667	23.31	Pk	-40.4	.3	-40	-56.79	-21.96	-	-34.83	0-360	0 degs
4	.01617	43.7	Pk	-36	.1	-80	-72.2	-8.07	11.93	-64.13	0-360	90 degs
5	.67129	36.12	Pk	-40.5	.1	-40	-44.28	-20.43	-	-23.85	0-360	90 degs
6	3.15873	23.54	Pk	-40.4	.3	-40	-56.56	-21.96	-	-34.6	0-360	90 degs
7	.01177	43.69	Pk	-34.1	.1	-80	-70.31	-5.31	14.69	-65	0-360	Flat
8	.60383	37.12	Pk	-40.5	.1	-40	-43.28	-19.51	-	-23.77	0-360	Flat
9	2.90577	24.57	Pk	-40.4	.2	-40	-55.63	-21.96	-	-33.67	0-360	Flat

Pk - Peak detector

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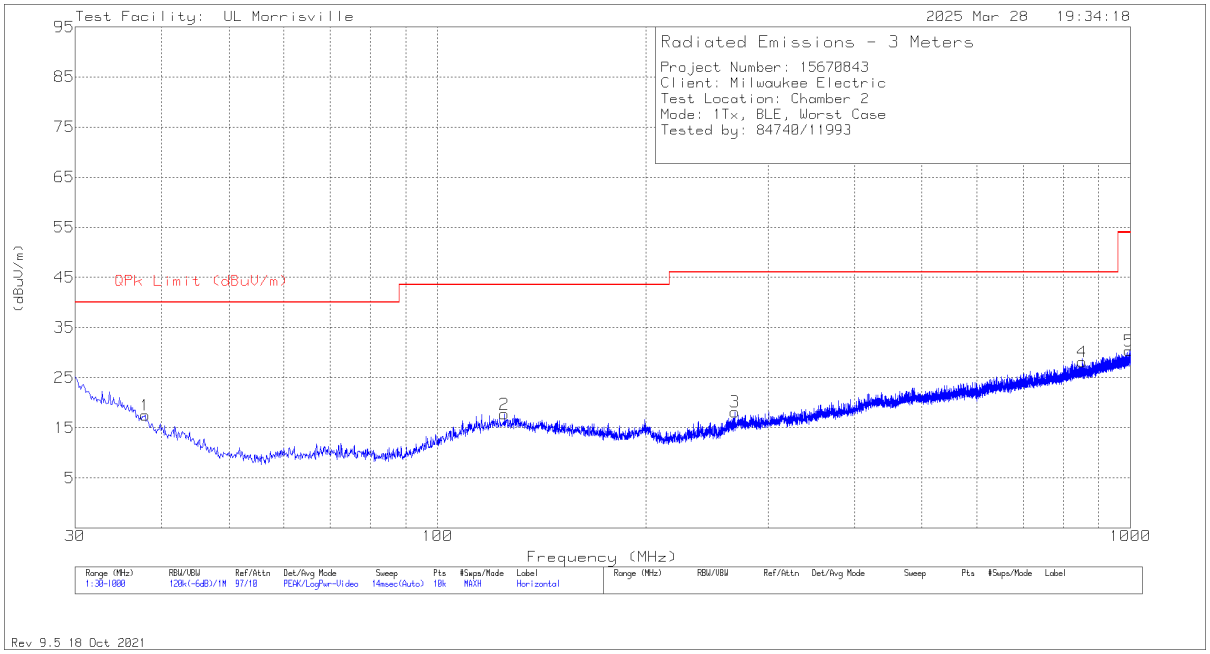
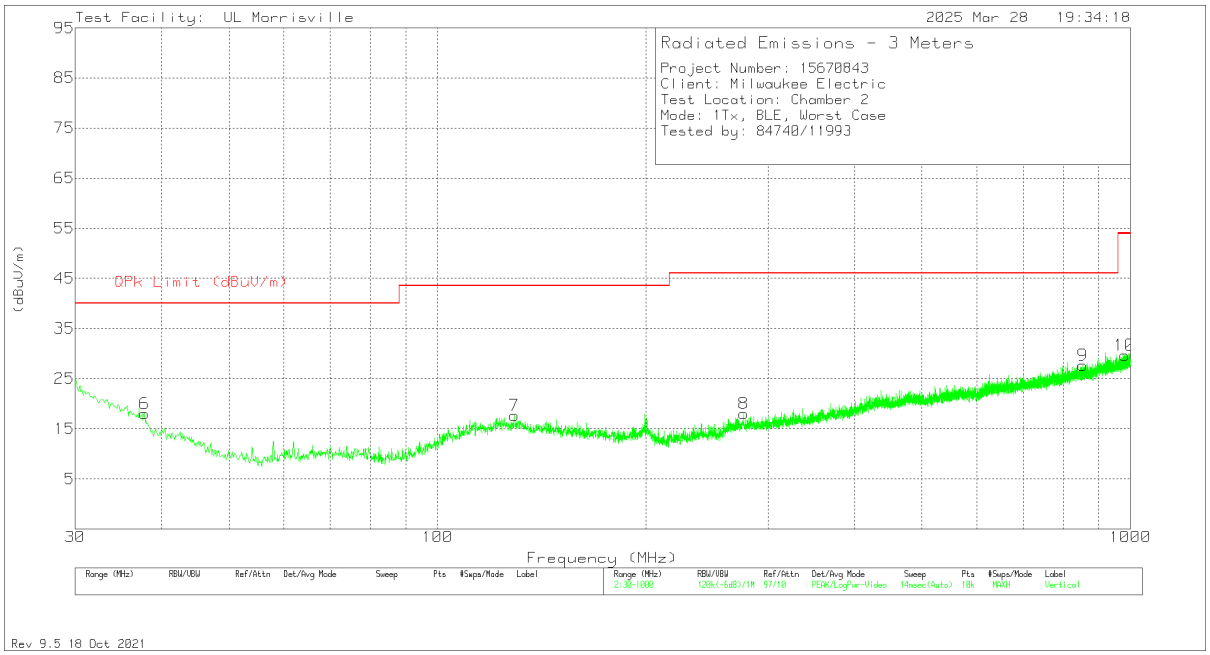
10.4. WORST CASE BELOW 1 GHZ

SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION)



HORIZONTAL



VERTICAL

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Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	159203 (dB/m)	Gain/Loss (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 37.857	27.17	Pk	21.9	-31.6	17.47	40	-22.53	0-360	299	H
2	* ** 124.866	27.91	Pk	20.4	-30.6	17.71	43.52	-25.81	0-360	199	H
3	* ** 268.814	27.94	Pk	19.7	-29.5	18.14	46.02	-27.88	0-360	199	H
4	** 851.784	26.41	Pk	28.4	-26.7	28.11	46.02	-17.91	0-360	399	H
5	* ** 996.217	25.35	Pk	30	-25	30.35	53.97	-23.62	0-360	399	H
6	* ** 37.76	27.6	Pk	22	-31.6	18	40	-22	0-360	199	V
7	* ** 129.134	28.03	Pk	20.2	-30.6	17.63	43.52	-25.89	0-360	299	V
8	* ** 276.477	27.58	Pk	19.8	-29.4	17.98	46.02	-28.04	0-360	101	V
9	** 854.112	25.82	Pk	28.5	-26.7	27.62	46.02	-18.4	0-360	101	V
10	* ** 981.958	24.94	Pk	29.8	-25.1	29.64	53.97	-24.33	0-360	199	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector

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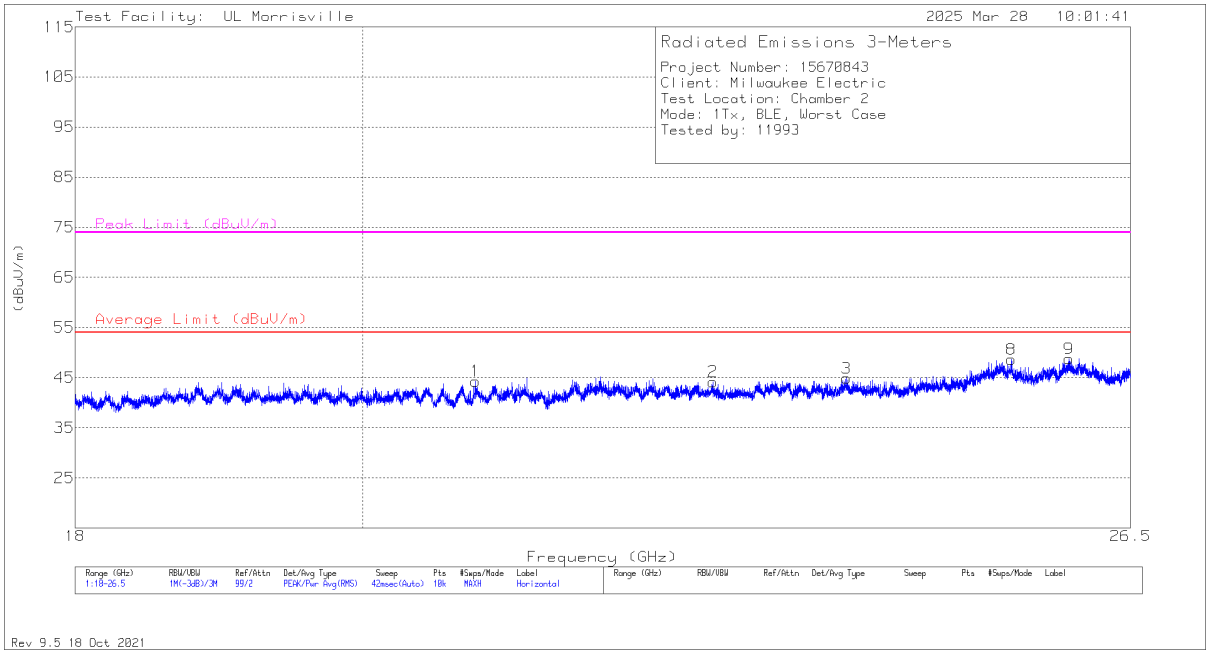
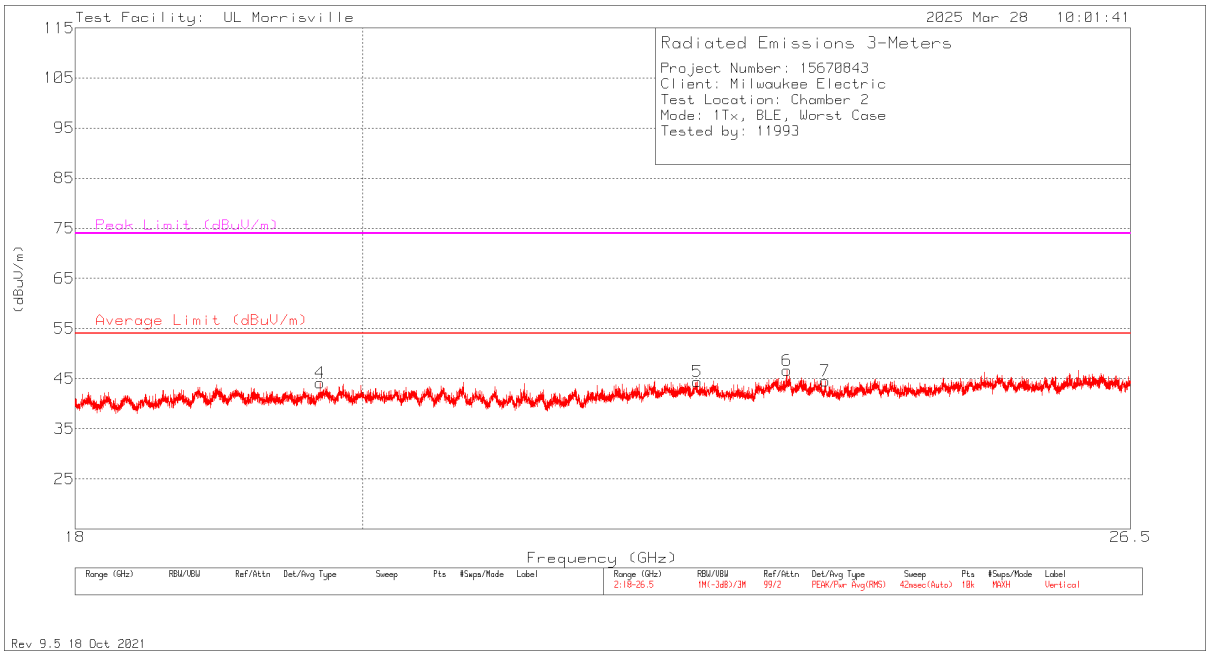
10.5. WORST CASE 18-26 GHZ

SPURIOUS EMISSIONS 18-26 GHz (WORST-CASE CONFIGURATION)



HORIZONTAL



VERTICAL

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18 – 26GHz Data

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	204704 (dB/m)	Gain/Loss (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 20.84637	48.58	Pk	33.4	-37.7	44.28	54	-9.72	74	-29.72	0-360	101	H
2	* ** 22.73828	47.53	Pk	34.1	-37.5	44.13	54	-9.87	74	-29.87	0-360	249	H
3	* ** 23.88311	47.25	Pk	34.4	-36.8	44.85	54	-9.15	74	-29.15	0-360	101	H
4	* ** 19.68963	48.97	Pk	33.2	-38	44.17	54	-9.83	74	-29.83	0-360	250	V
5	* ** 22.61079	47.77	Pk	34.3	-37.7	44.37	54	-9.63	74	-29.63	0-360	101	V
7	* ** 23.69273	47.25	Pk	34.5	-37.2	44.55	54	-9.45	74	-29.45	0-360	101	V
6	23.36296	49.51	Pk	34.5	-37.4	46.61	-	-	-	-	0-360	200	V
8	25.36961	48.51	Pk	35.6	-35.5	48.61	-	-	-	-	0-360	101	H
9	25.91016	49.23	Pk	35.3	-35.8	48.73	-	-	-	-	0-360	101	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
** - indicates frequency in Taiwan NCC LP0002 Restricted Band
Pk - Peak detector

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11. SETUP PHOTOS

Please refer to R15670843-EP1 for setup photos

END OF TEST REPORT

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