
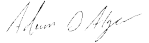



TR3818-BLE

Equipment Under Test:	SONA TI351
Requirement(s):	eCFR 47 Part 15.247 RSS-247
Test Date(s):	06/19/2024-10/19/2024
Prepared for:	Ezurio Attn: Brian Petted W66 N220 Commerce Ct. Cedarburg, WI 53012

Report Issued by: Dylan Rosenfeldt, EMC Engineer	
Signature: 	Date: 10/22/2024
Report Reviewed by: Adam Alger, Manager EMC Laboratory	
Signature: 	Date: 10/22/2024
Report Constructed by: Dylan Rosenfeldt, EMC Engineer	
Signature: 	Date: 10/22/2024

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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

Company: Ezurio	Page 3 of 42	Name: SONA TI351
Report: TR3818-BLE		Model: SONA TI351
Job: C-3818		Serial: 00013 00008

1 TEST REPORT SUMMARY

During **06/19/2024-10/01/2024** the Equipment Under Test (EUT), **SONA TI351**, as provided by Ezurio was tested to the following requirements:

FCC 15.247 | RSS-247 – DTS Bluetooth Low Energy

Requirements	Description	Method	Compliant
15.247(d) 15.209 RSS-247 Clause 5.5 RSS-GEN Clause 8.10	Spurious Radiated Emissions in Restricted Bands 30-25000 MHz	ANSI C63.10	Yes
15.247(a)(2) RSS-247 Clause 5.2 (a)	6dB and 99% Occupied Bandwidth	ANSI C63.10	Yes
15.247(b)(3) RSS-247 Clause 5.4 (d)	RF Output Power	ANSI C63.10	Yes
15.247(d) RSS-247 Clause 5.5 RSS-GEN A1 Clause 8.9	Out-of-band Emissions	ANSI C63.10	Yes
15.247(e) RSS-247 Clause 5.2 (b)	Power Spectral Density	ANSI C63.10	Yes
2.1055(d) RSS-GEN 6.11	Frequency Stability	ANSI C63.10	Reported
15.207 RSS-GEN 8.8	AC Conducted Emissions	ANSI C63.10	Yes

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	Ezurio
Contact Person	Brian Petted
Address	W66 N220 Commerce Ct. Cedarburg, WI 53012

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	SONA TI351
Model Number	SONA TI351
Serial Number	00013 00008
FCC ID	SQG-SONATI351
IC ID	3147A-SONATI351

2.2 Product Description

The TI351 is based upon TI CC3351 Wi-Fi 6 chipset. Feature-set includes 802.11 a/b/g/n/ac/ax Wi-Fi 6 and Bluetooth Low Energy v5.4.

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 EUT Information

Power Supply – INPUT:100-240VAC 50/60 Hz 0.3A

OUTPUT: 5VDC 2A

Firmware - image-imx8mp-evk-rdvk 1.0.0.5

2.6 Ancillary Equipment

Equipment used for EUT programming (not part of the EUT)

Development Kit, NXP 8MPLUS-BB

Power Supply: INPUT: 100-240 VAC 50/60Hz

OUTPUT: USB Type C 45W, 5V/3A; 9V/3A; 15V/3 A; 20V/2.25 A

HP Elitebook 840G1

TeraTerm Version: 5.1

2.7 Antenna Information

Manufacturer	Model	Part Number	Dimension	Type	Peak Gain (dBi)	
					2400-2500 MHz	4900-5925 MHz
Ezurio	FlexPIFA 6E	EFB2471A3S-10MH4L	16mm X 36mm X 2.5mm	PIFA	2.2	3.9
Ezurio	Mini NanoBlade Flex 6E	EMF2471A3S-10MH4L	36mm X 12mm X 0.3mm	PCB Dipole	2.4	4.4
Ezurio	FlexPIFA	001-0021	38.5mm X 12.7mm X 2.5mm	PIFA	2.5	3.0
Joymax Electronics	N/A	TWX-100BRS3B	137mm X 13mm	Dipole	2.0	4.0
Ezurio	FlexPIFA	EFB2455A3S-15MH4L	2.5mm X 38.6mm X 12.7mm	PIFA	2.5	3.0
Ezurio	Mini NanoBlade Flex	EMF2449A1-10MH4L	36mm x 12mm x 0.1mm	PIFA	2.8	3.4
Ezurio	NanoBlade	ENB2449A1-10MH4L	50.8mm x 16.5mm	PCB Dipole	3.2	4.1

2.8 Test Channels

Channel	Frequency (MHz)	Data Rates
0	2402	125k, 500k, 1M and 2M
19	2440	
39	2480	

2.9 Power Table and Reduced Video Bandwidth for Average Measurements

Data Rate	Minimum Average VBW (Hz)	Power Setting
125 kbps	62	10
500 kbps	220	10
1 Mbps	470	10
2 Mbps	1000	10

3 WORST CASE TEST RESULTS SUMMARY

Requirement	Channel and Data Rate	Frequency (MHz)	Measurement	Limit	Margin
15.247 (a)(2) RSS-247 Clause 5.2(a)	0 125kbps	2402	605 kHz	500 kHz	105kHz
15.247 (b)(3) RSS-247 Clause 5.4 (d)	19 2Mbps	2440	5.6 dBm	30 dBm	24.4 dB
15.247 (e) RSS-247 Clause 5.2 (b)	39 125kbps	2480	5.0 dBm	8dBm/3kHz	3.0 dB
15.247 (d) RSS-247 Clause 5.5 Conducted	0 1Mbps	2399.8	-49.7 dBm	-15.0 dBm	34.7 dB
	0 500kbps	4804.0	47.5 dBuV/m	54.0 dBuV/m	6.5 dB
15.247(d) RSS-247 Clause 5.5 RSS-GEN Clause 8.9 Radiated	0 1Mbps	17716.3	46.7 dBuV/m	54.0 dBuV/m	7.3 dB
15.207	19 1Mbps	0.541	25.0 dBuV	46.0 dBuV	21.0 dB

4 REFERENCES

Publication	Edition	Date	AMD 1	AMD 2
FCC eCFR 47 Part 15	-	2023	-	-
ANSI C63.10	-	2020	-	-
RSS-247	3	2023	-	-
RSS-GEN	5	2018	2019	2021
KDB 558074 D01	-	2019	-	-

5 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 \pm
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

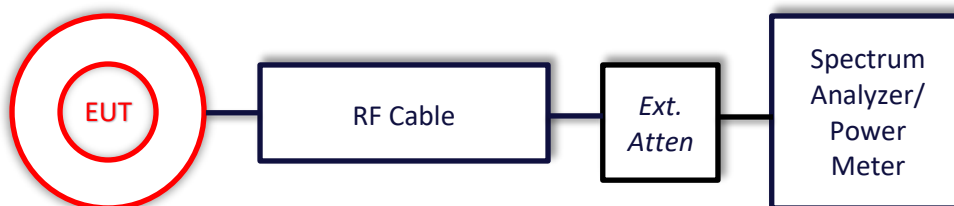
Parameter	ETSI U.C. \pm	U.C. \pm
Radio Frequency, from F0	1×10^{-7}	0.55×10^{-7}
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

6 TEST DATA

6.1 Antenna Port Conducted Emissions

Description of Measurement	<p>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.</p> <p>The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.</p>
Example Calculations	<p>Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm)</p> <p>Margin (dB) = Limit (dBm) – Corrected Reading (dBm)</p>

Block Diagram



6.1.1 6dB and 99% Occupied Bandwidth

Operator	Dylan Rosenfeldt	QA	Anthony Smith
Temperature	22.1°C	R.H. %	51.0%
Test Date	06/19/2024	Location	Conducted RF Bench
Requirement	15.247 (a)(2) RSS-247 Clause 5.2 (a)	Method	ANSI C63.10 6.9

Limits: The minimum 6 dB bandwidth shall be at least 500 kHz

Test Parameters

Frequency	2400-2483.5 MHz	Setup	Antenna Port
RBW	99% OBW - 30 kHz 6dB DTS - 100 kHz	VBW	300 kHz
Detector(s)	Peak	Settings	Max Hold

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2024	6/12/2025	Active Verification
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration

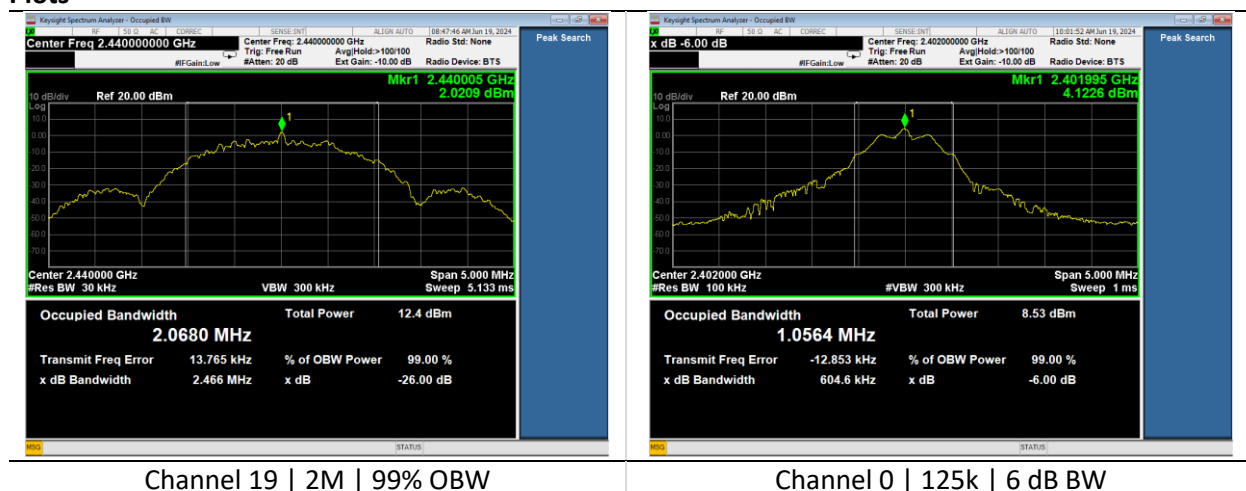
EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
Frequency	2400-2483.5 MHz	Channel	See 2.10

Table

Data Rate	Channel	6 dB BW (kHz)	99% BW (kHz)
1M	0	679	1023
	19	678	1024
	39	681	1024
2M	0	1161	2064
	19	1156	2068
	39	1159	2068
125k	0	605	1053
	19	611	1053
	39	609	1054
500k	0	674	1023
	19	676	1024
	39	676	1023

Plots



6.1.2 RF Output Power

Operator	Dylan Rosenfeldt	QA	Adam Alger
Temperature	22.1°C	R.H. %	52.4%
Test Date	06/19/2024	Location	Conducted RF Bench
Requirement	15.247 (b)(3) RSS-247 Clause 5.4 (d)	Method	ANSI C63.10 11.9.1

Limit: The maximum peak conducted output power of the intentional radiator shall not exceed 1 Watt.

Test Parameters

Frequency	2400-2483.5 MHz	Setup	Antenna Port
RBW	3 MHz	VBW	50 MHz
Detector(s)	Peak	Settings	Max Hold Span: 10 MHz

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2024	6/12/2025	Active Verification
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration

EUT Parameters

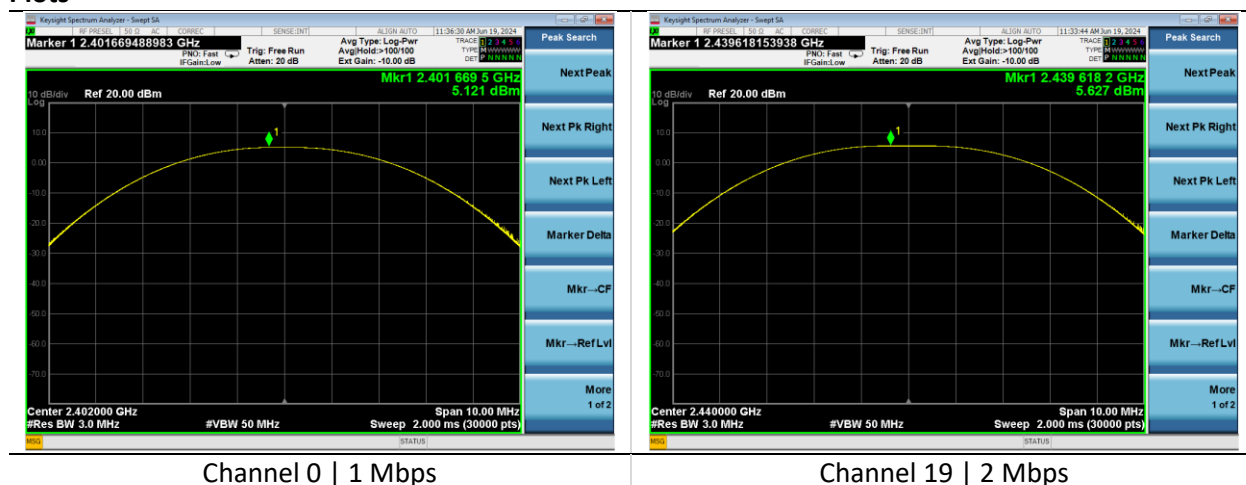
Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
Frequency	2400-2483.5 MHz	Channel	See 2.10

Tables

Company: Ezurio	Page 14 of 42	Name: SONA TI351
Report: TR3818-BLE		Model: SONA TI351
Job: C-3818		Serial: 00013 00008

Rate	Channel	Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
1 Mbps	0	5.1	30	24.9
	19	5.4	30	24.6
	39	5.1	30	24.9
2 Mbps	0	5.1	30	24.9
	19	5.6	30	24.4
	39	5.4	30	24.6
500 kbps	0	4.9	30	25.1
	19	5.3	30	24.7
	39	5.0	30	25.0
125 kbps	0	4.9	30	25.1
	19	5.3	30	24.7
	39	4.9	30	25.1

Plots



6.1.3 Power Spectral Density

Operator	Dylan Rosenfeldt	QA	Adam Alger
Temperature	22.1°C	R.H. %	52.4%
Test Date	06/19/2024	Location	Conducted RF Bench
Requirement	15.247 (e) RSS-247 Clause 5.2 (b)	Method	ANSI C63.10 11.10.2

Limits: Power spectral density shall not be greater than 8 dBm in any 3 kHz band.

Test Parameters

Frequency	2400-2483.5 MHz	Detector(s)	Peak
RBW	100 kHz	VBW	300 kHz
Notes	The same method of determining the conducted output power shall be used to determine the power spectral density		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2024	6/12/2025	Active Verification
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration

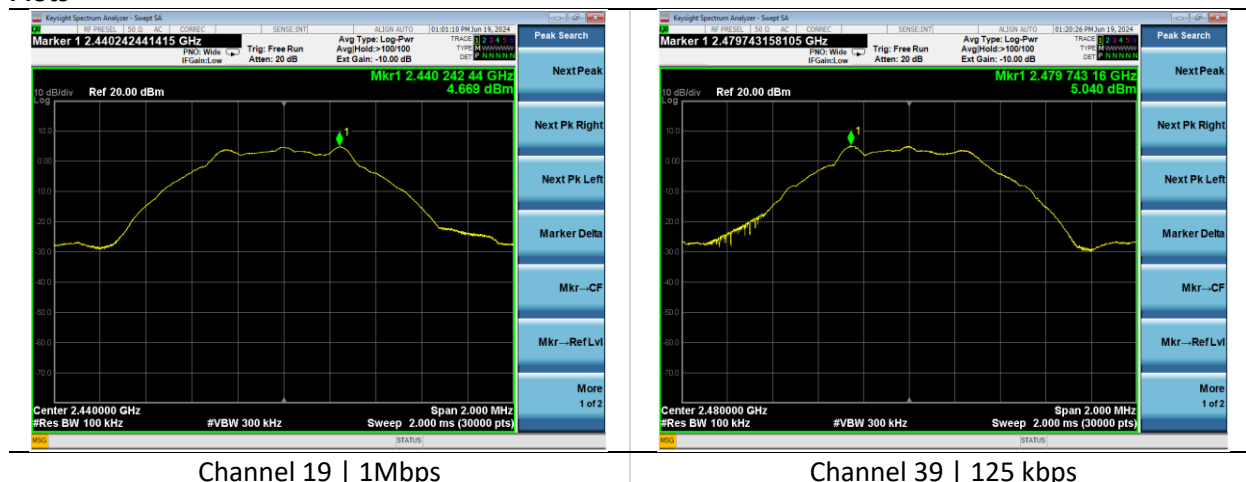
EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
Frequency	2400-2483.5 MHz	Channel	See 2.10

Table

Rate	Channel	Peak PSD (dBm/100 kHz)	Limit (dBm/3 kHz)	Margin (dB)
1 Mbps	0	4.6	8	3.4
	19	4.7	8	3.3
	39	4.4	8	3.6
2 Mbps	0	4.4	8	3.6
	19	4.8	8	3.2
	39	4.5	8	3.5
500 kbps	0	4.0	8	4.0
	19	4.6	8	3.4
	39	4.6	8	3.4
125 kbps	0	4.2	8	3.8
	19	4.8	8	3.2
	39	5.0	8	3.0

Plots



6.1.4 Emissions in Non-Restricted Frequency Bands

Operator	Dylan Rosenfeldt	QA	Adam Alger, Anthony Smith
Temperature	22.3C, 22.8C, 22.6C	R.H. %	52.2%, 43.8%, 50.6%
Test Date	6/19/2024, 7/17/2024, 8/29/2024	Location	RF conducted bench
Requirement	15.247(d) RSS-247 Clause 5.5	Method	ANSI C63.10 11.12.2.5.2

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

Reference Level (Worst Case PSD)

Channel 39 – 125 kbps – 5.0 dBm/100 kHz

5.0 dBm-20 dB = -15.0 dBm Limit

Test Parameters

Frequency	30-25000 MHz	Setup	Antenna Port
RBW	100 kHz	VBW	300 kHz
Detector(s)	Peak		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960085	Analyzer – Spectrum	Agilent	N9010A	MY53400296	04/11/2024	04/11/2025	Active Calibration
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2024	6/12/2025	Active Verification
AA 960153	Filter - High Pass 2.4 GHz	KWM	HPF-L-14186	7272-04	4/11/2024	4/11/2025	Active Calibration

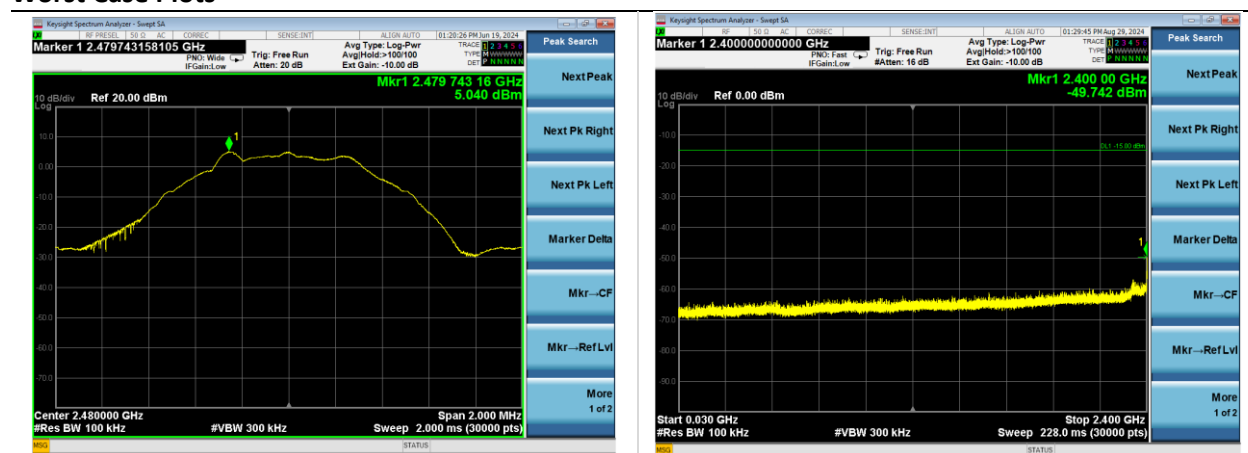
Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
Company: Ezurio	Page 18 of 42	Name: SONA TI351	
Report: TR3818-BLE		Model: SONA TI351	
Job: C-3818		Serial: 00013 00008	

Frequency	2400-2483.5 MHz	Channel	See 2.8
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Measurements

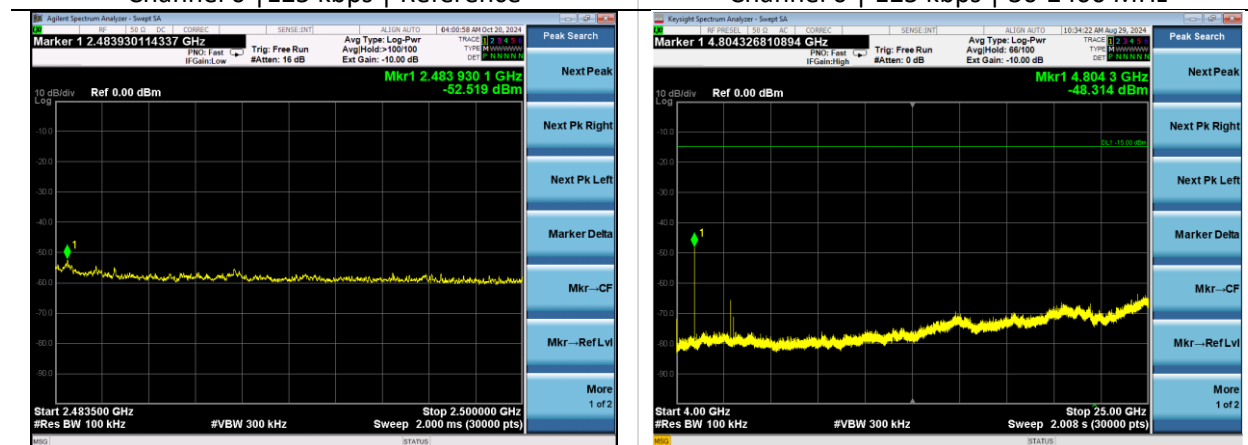
Rate	Channel	Frequency (MHz)	Measurement (dBm)	Limit (dBm)	Margin (dB)
1 Mbps	0	6404.4	-65.7	-15.0	50.7
	0	2399.8	-49.7	-15.0	34.7
	39	2500.4	-58.5	-15.0	43.5
2 Mbps	1	2400.0	-52.0	-15.0	37.0
500 kbps	0	2400.0	-49.9	-15.0	34.9
	39	2505.9	-58.2	-15.0	43.2
125 kbps	0	2400.0	-49.7	-15.0	34.7

Worst Case Plots



Channel 0 | 125 kbps | Reference

Channel 0 | 125 kbps | 30-2400 MHz



Channel 39 | 1 Mbps | 2483.5-2500 MHz

Channel 0 | 1 Mbps | 2500-25000 MHz

Company: Ezurio	Page 19 of 42	Name: SONA TI351
Report: TR3818-BLE		Model: SONA TI351
Job: C-3818		Serial: 00013 00008

6.1.5 Spurious Emissions in Restricted Bands

Operator	Dylan Rosenfeldt	QA	Adam Alger, Anthony Smith
Temperature	22.3C, 22.8C, 22.6C	R.H. %	52.2%, 43.8%, 50.6%
Test Date	6/19/2024, 7/17/2024, 8/29/2024	Location	RF Conducted Bench
Requirement	15.247(d) RSS-247 Clause 5.5	Method	ANSI C63.10 6.8.2

15.209 Limits:

Frequency (MHz)	Quasi-Peak Limit (dBμV/m)	Average Limit (dBμV/m)	Peak Limit (dBμV/m)
30-88	40.0	-	-
88-216	43.5	-	-
216-960	46.0	-	-
960-1000	54.0	-	-
1000-40000	-	54.0	74.0

Test Parameters

Frequency	30-25000 MHz	Setup	Antenna Port
RBW	1 MHz	VBW	3 MHz See 2.9
Detector(s)	Peak	Method	RF Conducted
Notes	Declared antenna gain 3.2 dBi		
Example Calculations	EIRP = Measurement + Antenna Gain + Correction Factor E-Field = EIRP – 20log3 + 104.8		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960172	Cable	A.H. Systems, Inc.	SAC-26G-1	387	06/13/2024	06/12/2025	Active Verification
EE 960085	Analyzer – Spectrum	Agilent	N9010A	MY53400296	04/11/2024	04/11/2025	Active Calibration
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2024	4/11/2025	Active Calibration
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2024	6/12/2025	Active Verification

EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
Frequency	2402 MHz 2480 MHz 2404 MHz 2478 MHz	Channel	0 39; 125kbps, 500kbps, 1Mbps 1 38; 2Mbps

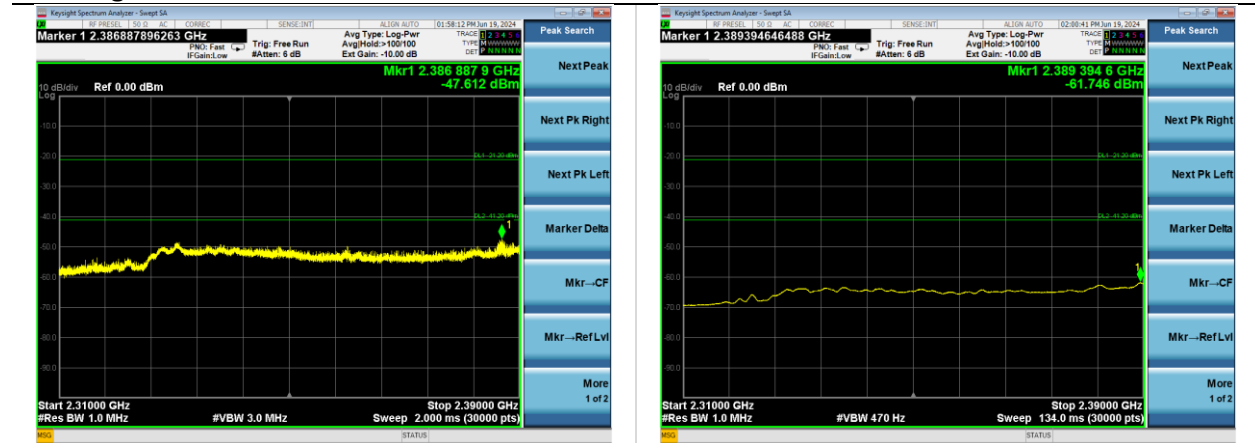
Measurements – Lower Band Edge

Rate	Channel	Measurement Type	Frequency (MHz)	Measurement (dBm)	EIRP (dBm)	E-Field (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1	0	Peak	2386.9	-47.6	-44.4	50.9	74.0	23.1
Mbps	0	Average	2389.4	-61.7	-58.5	36.8	54.0	17.2
2	1	Peak	2388.5	-46.3	-43.1	52.2	74.0	21.8
Mbps	1	Average	2363.3	-62.4	-59.2	36.1	54.0	17.9
500	0	Peak	2387.2	-47.7	-44.5	50.8	74.0	23.2
kbps	0	Average	2387.7	-62.8	-59.6	35.7	54.0	18.3
125	0	Peak	2386.5	-49.0	-45.8	49.5	74.0	24.5
kbps	0	Average	2387.9	-62.8	-59.6	35.7	54.0	18.3

Measurements – Upper Band Edge

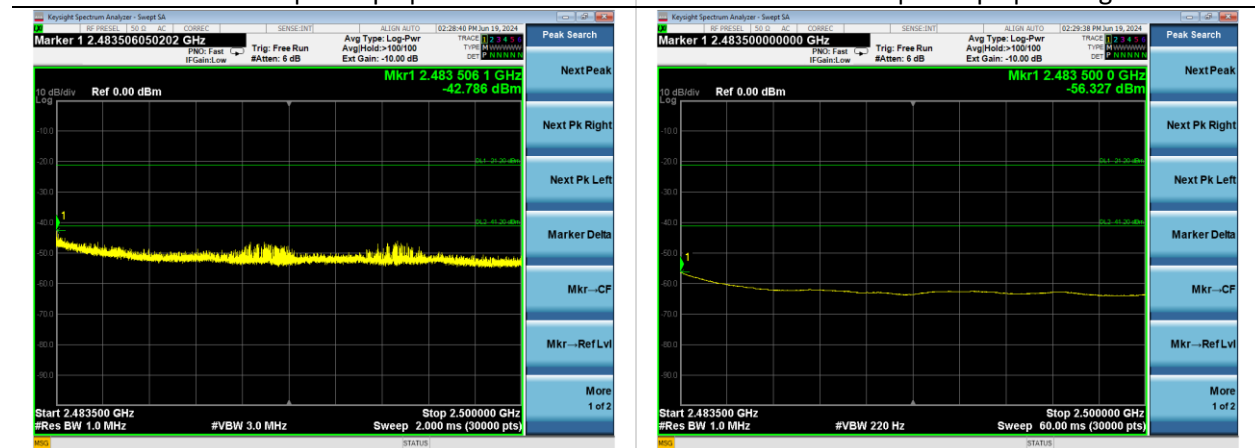
Rate	Channel	Measurement Type	Frequency (MHz)	Measurement (dBm)	EIRP (dBm)	E-Field (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1	39	Peak	2483.6	-45.0	-41.8	53.5	74.0	20.5
Mbps	39	Average	2483.5	-57.3	-54.1	41.2	54.0	12.8
2	38	Peak	2483.7	-43.9	-40.7	54.6	74.0	19.4
Mbps	38	Average	2483.6	-57.4	-54.2	41.1	54.0	12.9
500	39	Peak	2483.5	-42.8	-39.6	55.7	74.0	18.3
kbps	39	Average	2483.5	-56.3	-53.1	42.2	54.0	11.8
125	39	Peak	2483.5	-45.8	-42.6	52.7	74.0	21.3
kbps	39	Average	2483.5	-57.7	-54.5	40.8	54.0	13.2

Band Edge Worst Case Plots



Channel 0 | 1 Mbps | Peak

Channel 0 | 1 Mbps | Average



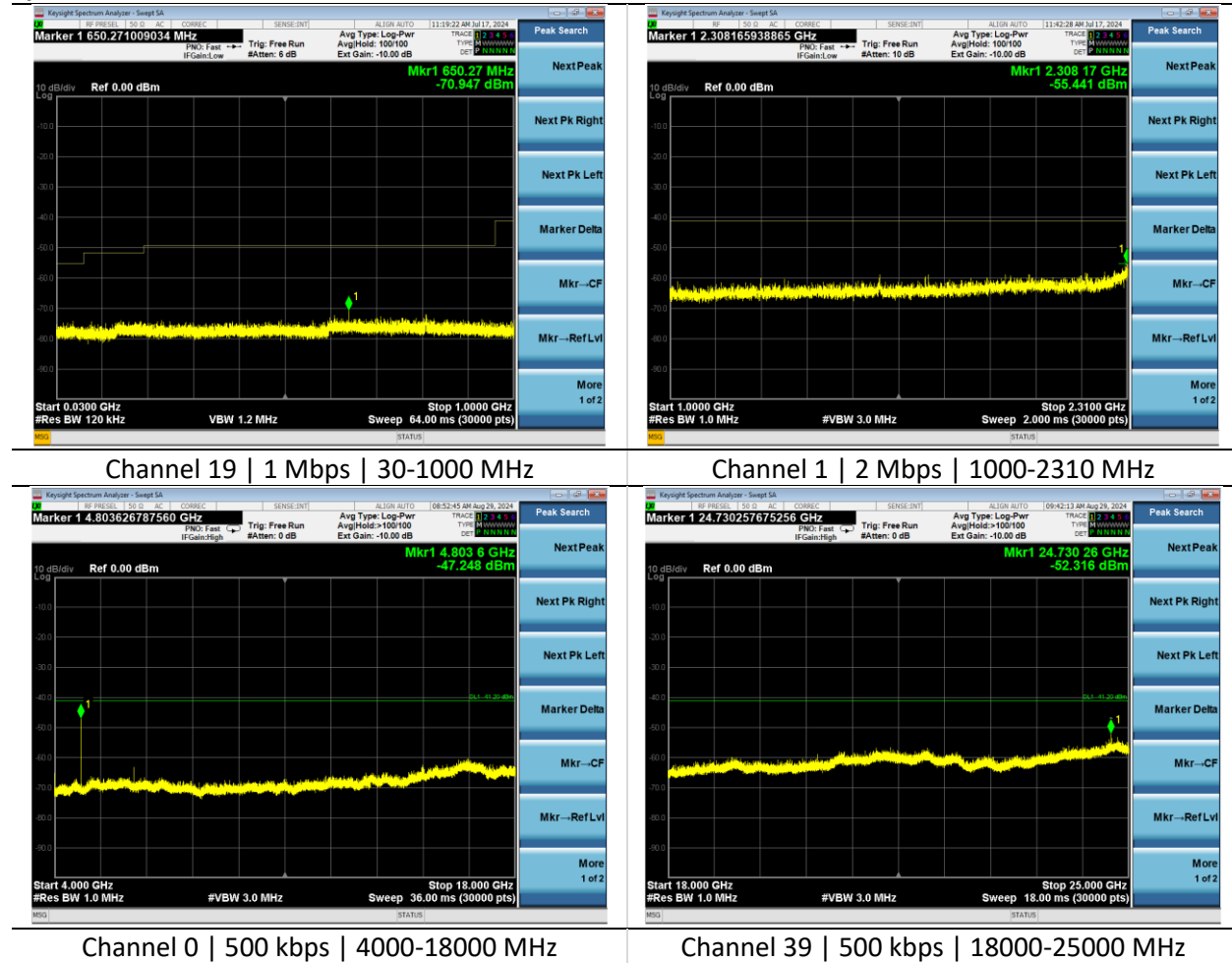
Channel 39 | 500 kbps | Peak

Channel 39 | 500 kbps | Average

Spurious Table

Rate	Channel	Measurement Type	Frequency (MHz)	Measurement (dBm)	EIRP (dBm)	E-Field (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 Mbps	0	Peak	4803.4	-48.7	-46.2	49.1	74.0	24.9
	0	Average	4804.1	-50.9	-48.4	46.9	54.0	7.1
	19	Peak	4879.7	-48.8	-46.3	49.0	74.0	25.0
	19	Average	4880.1	-51.2	-48.7	46.6	54.0	7.4
	39	Peak	4959.5	-50.5	-48.0	47.3	74.0	26.7
	39	Average	4960.1	-53.2	-50.7	44.6	54.0	9.4
2 Mbps	1	Peak	4807.1	-47.0	-44.5	50.8	74.0	23.2
	1	Average	4808.1	-53.4	-50.9	44.4	54.0	9.6
	19	Peak	4880.9	-47.3	-44.8	50.5	74.0	23.5
	19	Average	4880.1	-53.7	-51.2	44.1	54.0	9.9
	38	Peak	4954.9	-48.9	-46.4	48.9	74.0	25.1
	38	Average	4956.1	-55.3	-52.8	42.5	54.0	11.5
500 kbps	0	Peak	4803.5	-47.7	-45.2	50.1	74.0	23.9
	0	Average	4804.0	-50.3	-47.8	47.5	54.0	6.5
	19	Peak	4879.4	-47.8	-45.3	50.0	74.0	24.0
	19	Average	4880.0	-50.5	-48.0	47.3	54.0	6.7
	39	Peak	4959.4	-49.4	-46.9	48.4	74.0	25.6
	39	Average	4960.0	-52.3	-49.8	45.5	54.0	8.5
125 kbps	0	Peak	4803.5	-47.8	-45.3	50.0	74.0	24.0
	0	Average	4804.0	-50.6	-48.1	47.2	54.0	6.8
	19	Peak	4879.5	-47.7	-45.2	50.1	74.0	23.9
	19	Average	4880.0	-50.8	-48.3	47.0	54.0	7.0
	39	Peak	4959.5	-49.4	-46.9	48.4	74.0	25.6
	39	Average	4960.0	-52.4	-49.9	45.4	54.0	8.6

Spurious Worst Case Plots



6.1.6 Frequency Stability

Operator	Dylan Rosenfeldt	QA	Anthony Smith
Temperature	22.8°C	R.H. %	46.40%
Test Date	8/28/2024	Location	RF Conducted Bench
Requirement	2.1055(d) RSS-GEN Clause 6.11	Method	ANSI C63.10 6.8

Test Parameters

Frequency	2402-2480 MHz	Voltage	4.3 VDC, 5 VDC, and 5.8 VDC
Detector(s)	Peak	Settings	Max Hold

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	387	06/13/2024	06/12/2025	Active Verification
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration

Table

Channel	Voltage (VDC)	Center Frequency (Hz)
0	5	2402249719
	4.3	2402245045
	5.8	2402244347
19	5	2440242867
	4.3	2440243449
	5.8	2440245420
39	5	2480397108
	4.3	2480397589
	5.8	2480396960

6.2 Radiated Emissions

Description of Measurement	<p>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.</p> <p>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.</p> <p>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.</p>
Example Calculations	<p>Measurement (dBμV) + Cable factor (dB) + Other (dB) + Antenna Factor (dB/m) = Corrected Reading (dBμV/m)</p> <p>Margin (dB) = Limit (dBμV/m) - Corrected Reading (dBμV/m)</p> <p>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</p>

Block Diagram



6.2.1 Spurious Radiated Emissions in the Restricted Bands – Cabinet Radiation

Operator	Mitchell Freund Nicole Sedmak Jon Dilley	QA	Adam Alger Zach Brown Dylan Rosenfeldt Adam Hauke
Temperature	19.8°C-25.6°C	R.H. %	40.9%-50.0%
Test Date	06/19/2024-07/02/2024	Location	Chamber 3 Chamber 5
Requirement	15.247 (d) 15.209 RSS-247 Clause 5.5 RSS-GEN Clause 8.9	Method	ANSI C63.10

15.209 Limits:

Frequency (MHz)	Quasi-Peak Limit (dBμV/m)	Average Limit (dBμV/m)	Peak Limit (dBμV/m)
30-88	40.0	-	-
88-216	43.5	-	-
216-960	46.0	-	-
960-1000	54.0	-	-
1000-40000	-	54.0	74.0

Test Parameters

Frequency	30-40000 MHz	Distance	3 m
Detector(s)	Peak Trace Peak and Average Final	Table height	<1000 MHz – 80 cm >1000MHz – 150 cm
RBW	<1000 MHz – 120 kHz >1000 MHz – 1 MHz	VBW	<1000 MHz – 1.2 MHz >1000 MHz – 3 MHz See 2.9

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960007	Antenna - Double Ridge Horn	EMCO	3115	9311-4138	8/10/2024	8/10/2025	Active Calibration
AA 960174	Antenna - Small Horn	ETS Lindgren	3116C-PA	00206880	8/30/2024	8/30/2025	Active Calibration
AA 960153	Filter - High Pass 2.4 GHz	KWM	HPF-L-14186	7272-04	4/11/2024	4/11/2025	Active Calibration
AA 960163	Antenna - Log Periodic	A.H. Systems, Inc.	SAS-512-2	500	8/10/2024	8/10/2025	Active Calibration
AA 960217	Antenna - Biconical	A.H. Systems, Inc.	SAS-540	852	7/17/2024	7/17/2025	Active Calibration
AA 960220	Cable	A.H. Systems, Inc.	SAC-26G-6	552	2/16/2024	2/16/2025	Active Verification
EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	4/11/2024	4/11/2025	Active Calibration
LSC-300	Cable	Chamber 3 Emissions	-	-	1/5/2024	1/5/2025	Active Verification

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LSC-500	Cable	Chamber 5 Emissions	-	-	1/8/2024	1/8/2025	Active Verification
AA 960209	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	037101808	8/10/2024	8/10/2025	Active Calibration

EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
EUT	X, Y, Z Plane Orientations Antenna ports terminated with 50 Ω SMA terminators	AE	HP Elitebook 840G1 Development Kit, NXP 8MPLUS-BB
Notes	<1000 MHz Emissions from auxiliary equipment. Not a function of the EUT. Emission at 4GHz is not a function of the transmitter.		

Radiated Spurious – 30-1000 MHz

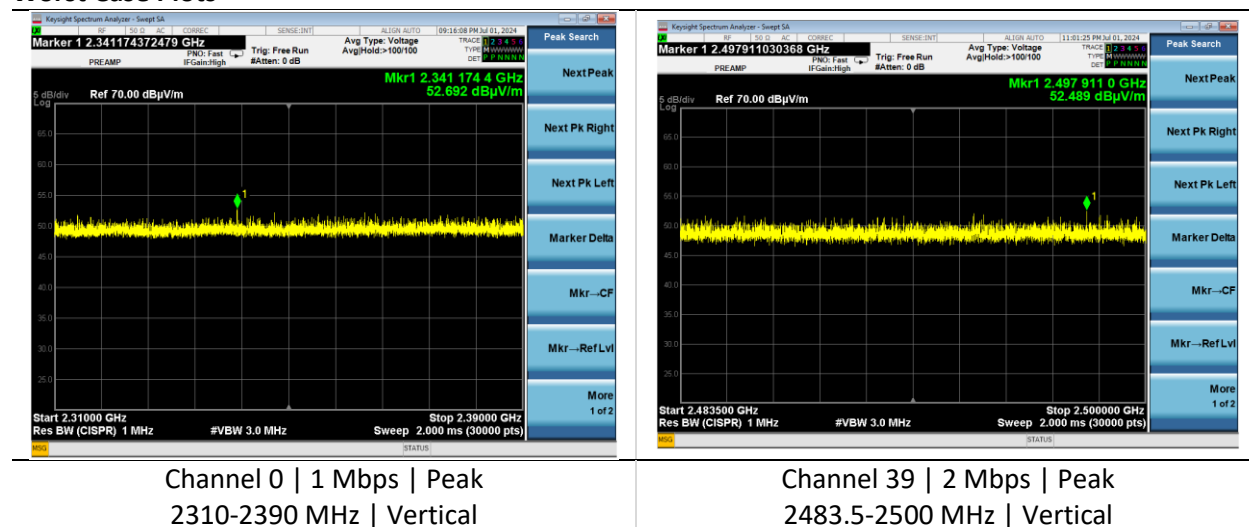
No Emissions in restricted frequency bands

1000-40000 MHz

Band Edge

Channel	EUT Orientation	Data Rate	Measurement Type	Frequency (MHz)	Antenna Polarity	Measurement (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
0	Y Plane	125 kbps	Peak	2325.4	V	51.3	74.0	22.7
			Average	2325.4	V	39.2	54.0	14.8
		500 kbps	Peak	2324.7	V	51.6	74.0	22.4
			Average	2324.7	V	39.2	54.0	14.8
		1 Mbps	Peak	2341.2	V	52.7	74.0	21.3
			Average	2341.2	V	39.4	54.0	14.6
		2 Mbps	Peak	2377.2	V	51.6	74.0	22.4
			Average	2377.2	V	39.6	54.0	14.4
39	X Plane	125 kbps	Peak	2486.4	V	51.8	74.0	22.2
			Average	2486.4	V	39.8	54.0	14.2
		500 kbps	Peak	2491.0	V	51.4	74.0	22.6
			Average	2491.0	V	39.9	54.0	14.1
		1 Mbps	Peak	2489.0	V	51.5	74.0	22.5
			Average	2489.0	V	39.9	54.0	14.1
		2 Mbps	Peak	2497.9	V	52.5	74.0	21.5
			Average	2497.9	V	39.9	54.0	14.1

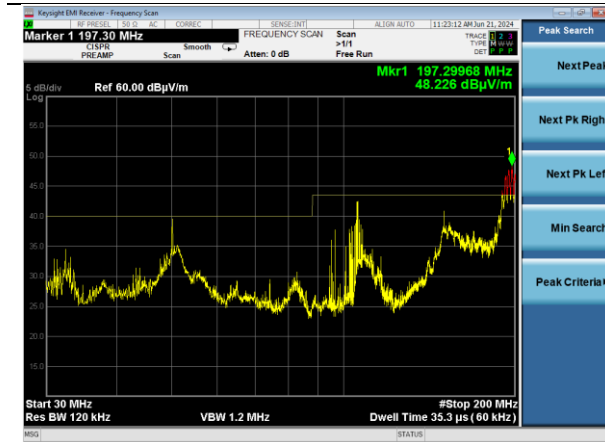
Worst Case Plots



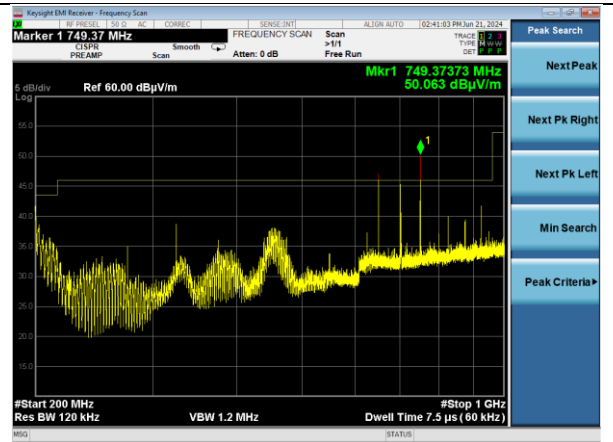
Spurious

EUT Orientation	Data Rate	Channel	Measurement Type	Frequency (MHz)	Antenna Polarity	Measurement (dBμV/m)	Limit (dBμV/m)	Margin (dB)
X Plane	1 Mbps	0	Peak	23914.1	V	53.4	74.0	20.6
			Average	23914.1	V	45.4	54.0	8.6
		39	Peak	23988.5	V	56.5	74.0	17.5
			Average	23988.5	V	45.6	54.0	8.4
Z Plane	1 Mbps	0	Peak	17716.3	V	55.8	74.0	18.2
			Average	17716.3	V	46.7	54.0	7.3
		39	Peak	17896.4	H	56.1	74.0	17.9
			Average	17896.4	H	45.3	54.0	8.7

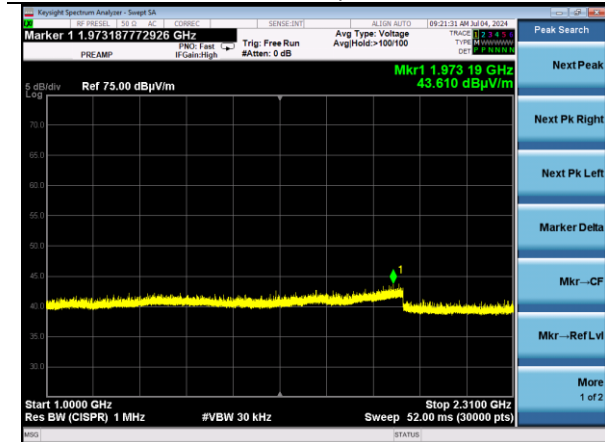
Worst Case Plots



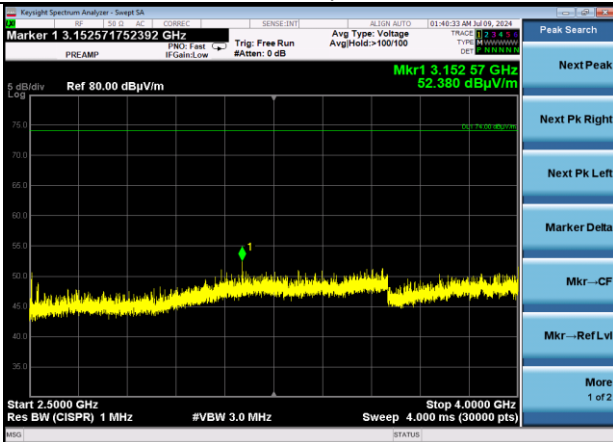
Channel 19 | 1 Mbps
30-200 MHz | Vertical



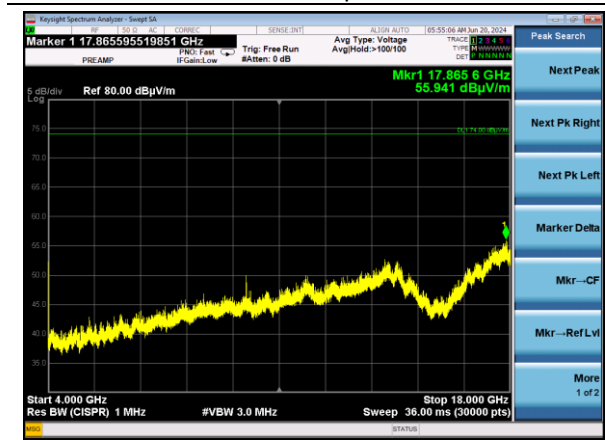
Channel 19 | 1 Mbps
200-1000 MHz | Horizontal



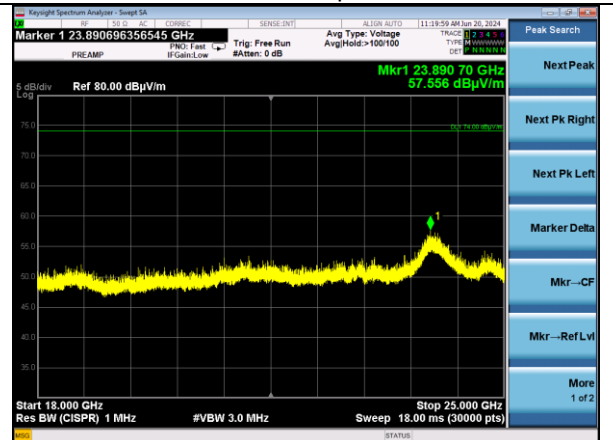
Channel 0 | 2 Mbps
1000-2310 MHz | Horizontal



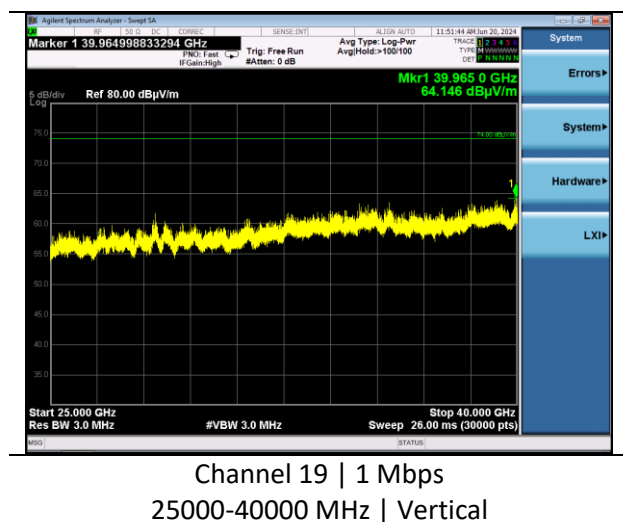
Channel 39 | 125 kbps
2500-4000 MHz | Horizontal



Channel 0 | 1 Mbps
4000-18000 MHz | Vertical



Channel 19 | 1 Mbps
18000-25000 MHz | Horizontal



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6.2.2 Spurious Radiated Emissions in the Restricted Bands – Chip Antenna

Operator	Mitchell Freund Nicole Sedmak Jon Dilley Zachary Brown	QA	Anthony Smith Adam Alger Adam Hauke Dylan Rosenfeldt
Temperature	19.2°C-24.7°C	R.H. %	47.1%-63.2%
Test Date	07/08/2024-07/24/2024, 10/19/2024	Location	Chamber 3 Chamber 5
Requirement	15.247 (d) 15.209 RSS-247 Clause 5.5 RSS-GEN Clause 8.10	Method	ANSI C63.10

15.209 Limits:

Frequency (MHz)	Quasi-Peak Limit (dBμV/m)	Average Limit (dBμV/m)	Peak Limit (dBμV/m)
30-88	40.0	-	-
88-216	43.5	-	-
216-960	46.0	-	-
960-1000	54.0	-	-
1000-40000	-	54.0	74.0

Test Parameters

Frequency	30-40000 MHz	Distance	3 m
Detector(s)	Peak Trace Peak and Average Final	Table height	150 cm
RBW	<1000 MHz – 120 kHz >1000 MHz – 1 MHz	VBW	<1000 – 1.2 MHz >1000 MHz – 3MHz See 2.9

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960007	Antenna - Double Ridge Horn	EMCO	3115	9311-4138	8/10/2024	8/10/2025	Active Calibration
AA 960174	Antenna - Small Horn	ETS Lindgren	3116C-PA	00206880	8/30/2024	8/30/2025	Active Calibration
AA 960153	Filter - High Pass 2.4 GHz	KWM	HPF-L-14186	7272-04	4/11/2024	4/11/2025	Active Calibration
AA 960163	Antenna - Log Periodic	A.H. Systems, Inc.	SAS-512-2	500	8/10/2024	8/10/2025	Active Calibration
AA 960217	Antenna - Biconical	A.H. Systems, Inc.	SAS-540	852	7/17/2024	7/17/2025	Active Calibration
AA 960220	Cable	A.H. Systems, Inc.	SAC-26G-6	552	2/16/2024	2/16/2025	Active Verification
EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	4/11/2024	4/11/2025	Active Calibration
LSC-300	Cable	Chamber 3 Emissions	-	-	1/5/2024	1/5/2025	Active Verification

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LSC-500	Cable	Chamber 5 Emissions	-	-	1/8/2024	1/8/2025	Active Verification
AA 960209	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	037101808	8/10/2024	8/10/2025	AA 960209

EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx
EUT	X, Y, Z Plane Orientations	AE	HP Elitebook 840G1 Development Kit, NXP 8MPLUS-BB
Notes	<1000 MHz Emissions from auxiliary equipment. Not a function of the EUT. Emission at 4GHz is not a function of the transmitter. No Spurious Emissions observed		

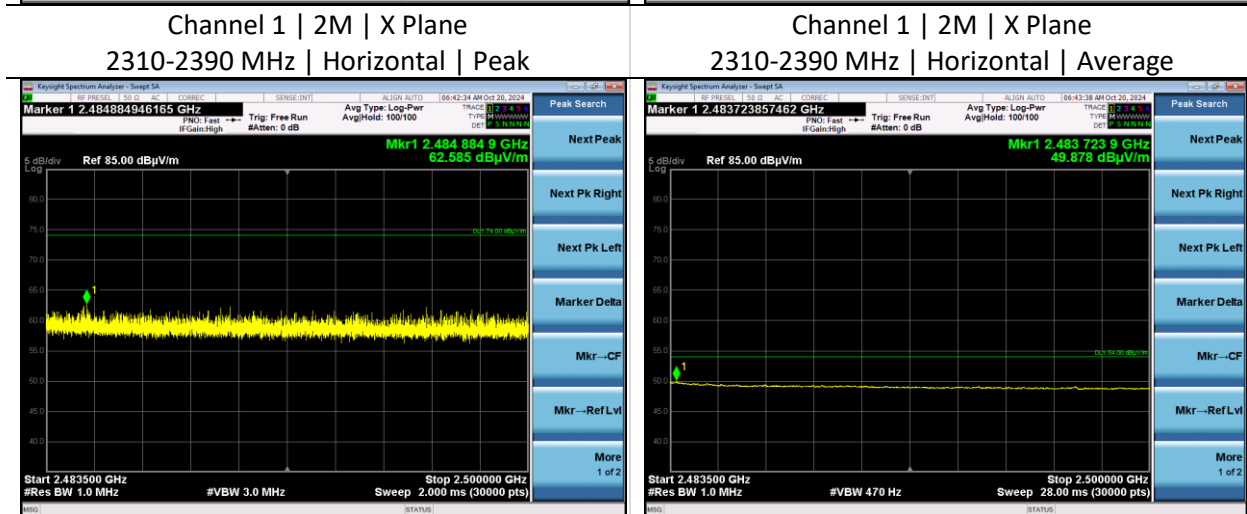
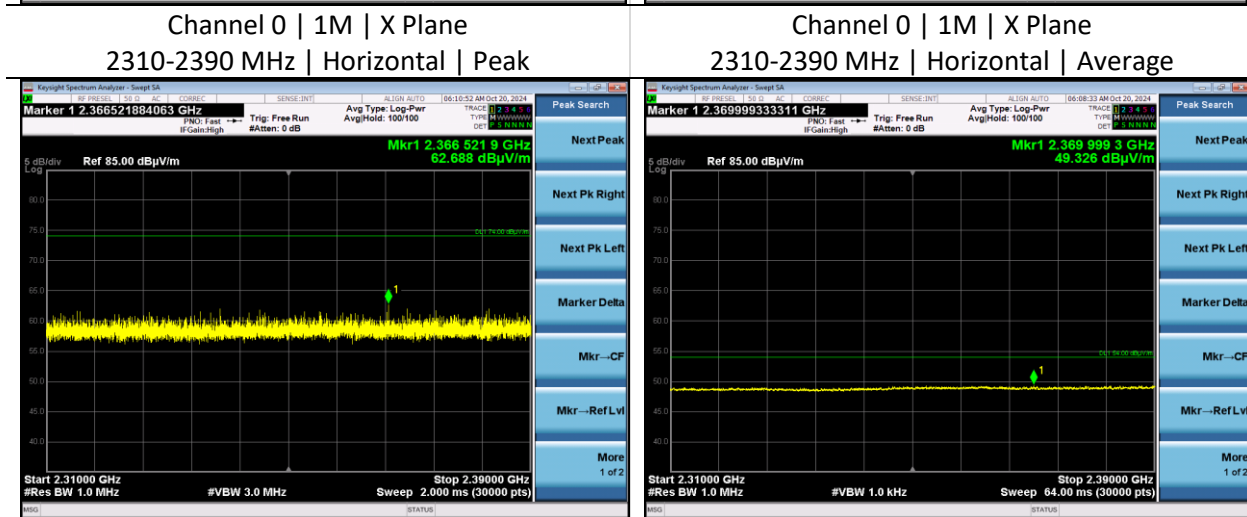
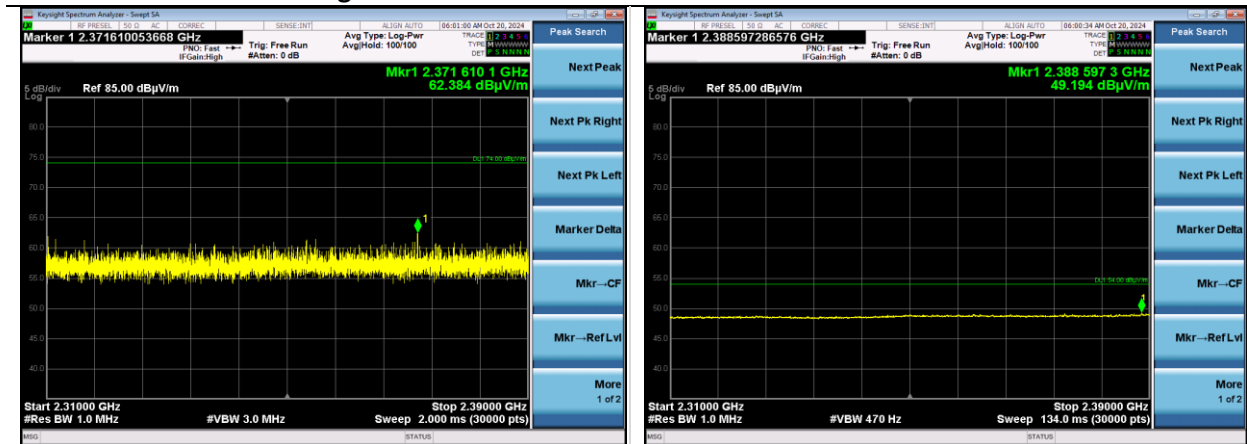
Radiated Spurious – 30-1000 MHz – All Modes

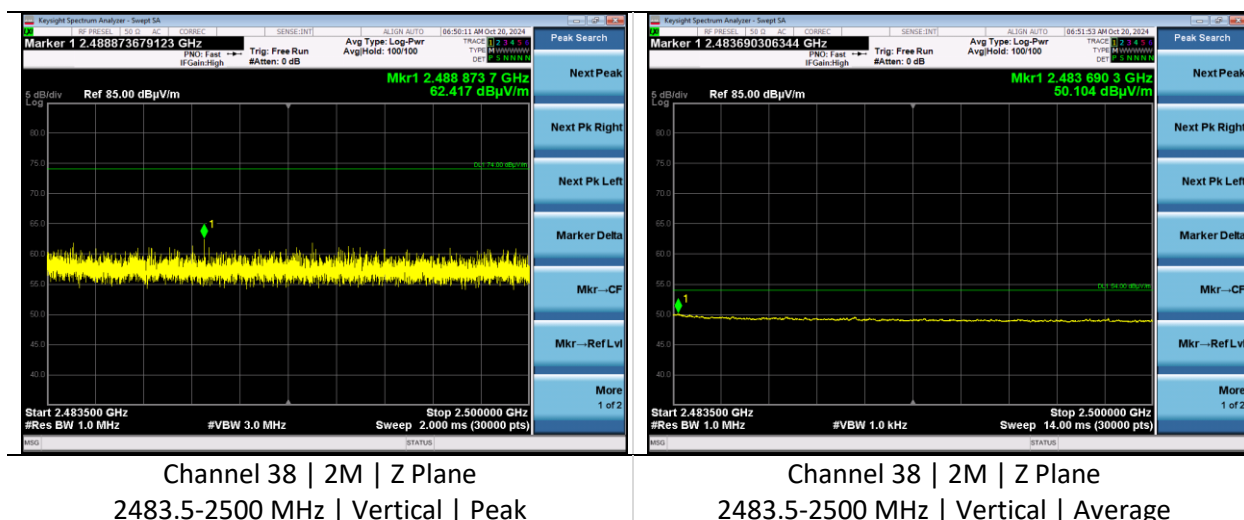
No Emissions in Restricted Frequency Bands

Measurements – Band Edge

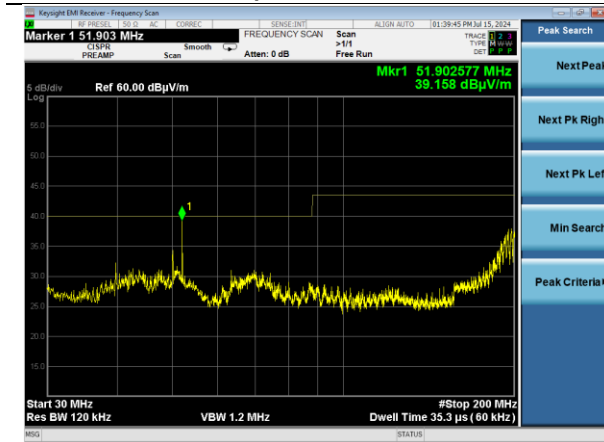
EUT Orientation	Channel	Data Rate	Measurement Type	Frequency (MHz)	Antenna Polarity	Measurement (dBμV/m)	Limit (dBμV/m)	Margin (dB)
X Plane	0	125 kbps	Peak	2363.3	H	61.8	74.0	12.2
			Average	2389.9	H	48.8	54.0	5.2
	0	500 kbps	Peak	2348.4	H	62.4	74.0	11.6
			Average	2390.0	H	48.9	54.0	5.1
	0	1 Mbps	Peak	2371.6	H	62.4	74.0	11.6
			Average	2388.6	H	49.2	54.0	4.8
	1	2 Mbps	Peak	2366.5	H	62.7	74.0	11.3
			Average	2370.0	H	49.3	54.0	4.7
Z Plane	39	125 kbps	Peak	2483.8	V	62.4	74.0	11.6
			Average	2483.5	V	49.6	54.0	4.4
	39	500 kbps	Peak	2487.6	V	62.5	74.0	11.5
			Average	2483.5	V	50.0	54.0	4.0
	39	1 Mbps	Peak	2484.9	V	62.6	74.0	11.4
			Average	2483.7	V	49.9	54.0	4.1
	38	2 Mbps	Peak	2488.9	V	62.4	74.0	11.6
			Average	2483.7	V	50.1	54.0	3.9

Worst Case Plots – Band Edge

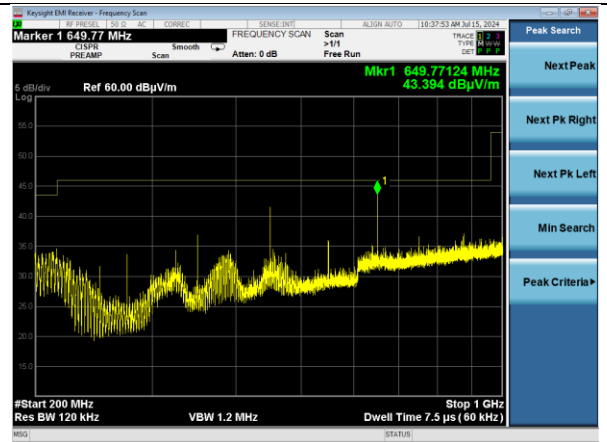




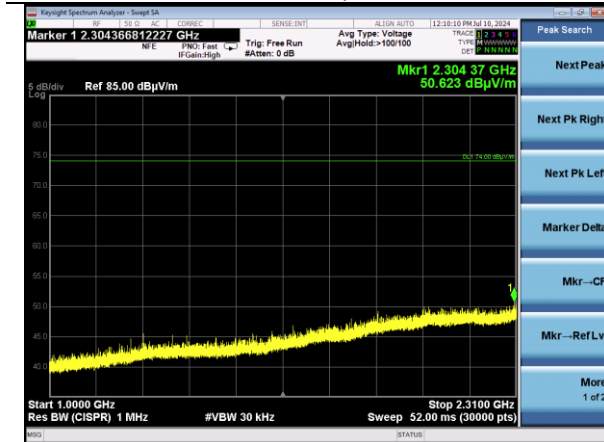
Worst Case Plots – Spurious Emissions



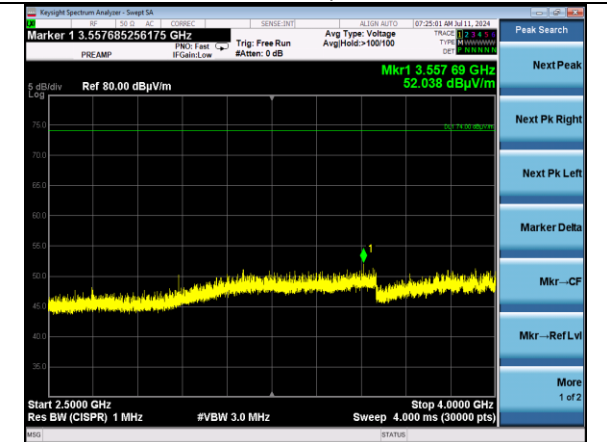
Channel 1 | 2 Mbps | X Plane
30-200 MHz | Vertical



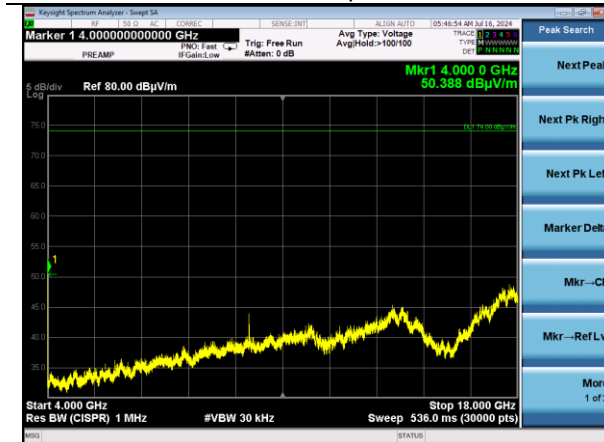
Channel 1 | 2 Mbps | X Plane
200-1000 MHz | Horizontal



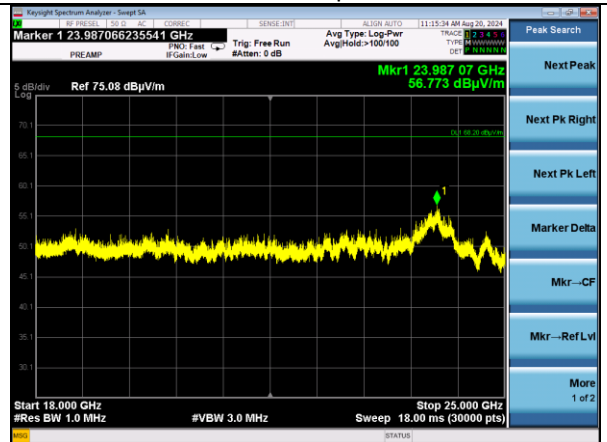
Channel 0 | 125 kbps | X Plane
1000-2390 MHz | Horizontal



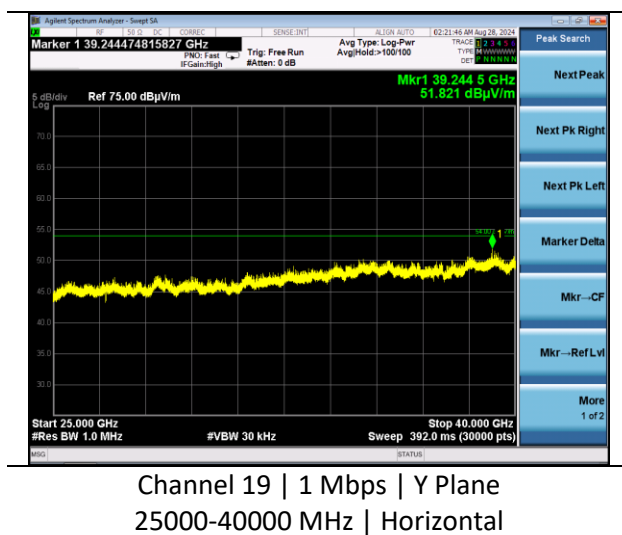
Channel 19 | 2 Mbps | Y Plane
2500-4000 MHz | Horizontal



Channel 19 | 1 Mbps | X Plane
4000-18000 MHz | Vertical



Channel 19 | 1 Mbps | Y Plane
18000-25000 MHz | Vertical



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6.3 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.

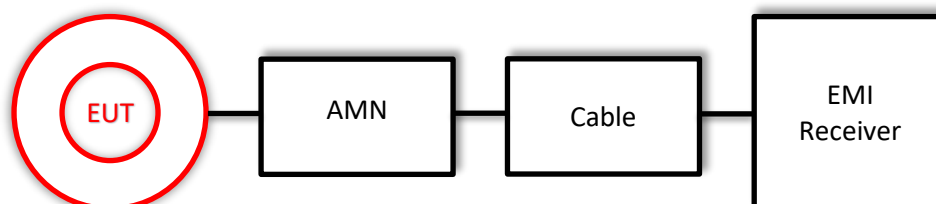
Maximum emissions are determined with a peak max hold trace then measurements at a selection of the highest points are made with quasi-peak and average detectors. Results are recorded and compared to limit for each line. (e.g. line and neutral)

Example Calculations

Measurement (dBμV) + Cable factor (dB) + Other (dB) = Corrected Reading (dBμV)

Margin (dB) = Limit (dBμV) - Corrected Reading (dBμV)

Block Diagram



6.3.1 AC Mains Conducted Emissions

Operator	Dylan Rosenfeldt	QA	Adam Alger, Jon Dilley
Temperature	22.8C	R.H. %	41.8%
Test Date	10/1/2021	Location	Conducted Emissions Bench
Requirement	15.207	Method	C63.10

Limits:

Frequency (MHz)	Quasi-Peak Limit (dBμV)	Average Limit (dBμV)
0.15-0.5	66.0-56.0*	56.0-46.0*
0.5-5	56.0	46.0
5-30	60.0	50.0

*Decreases with the logarithm of the frequency.

Test Parameters

Frequency	0.15-30 MHz	Distance	40 cm from wall 80 cm from LISN
Detector(s)	Peak Trace Quasi-Peak, Average Final	Table height	80 cm
RBW	9 kHz	VBW	62 kHz
Notes	Channel has no effect on emission		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/10/2024	4/10/2025	Active Calibration
EE 960089	LISN	COM-POWER	LI-215A	191943	4/10/2024	4/10/2025	Active Calibration
EE 960162	LISN	COM-POWER	LI-215A	191969	4/10/2024	4/10/2025	Active Calibration
LSC-203	Cable	Micro-Coax	UFB311A-0-1440-70U70U	64639 224071-005	1/8/2024	1/8/2025	Active Verification

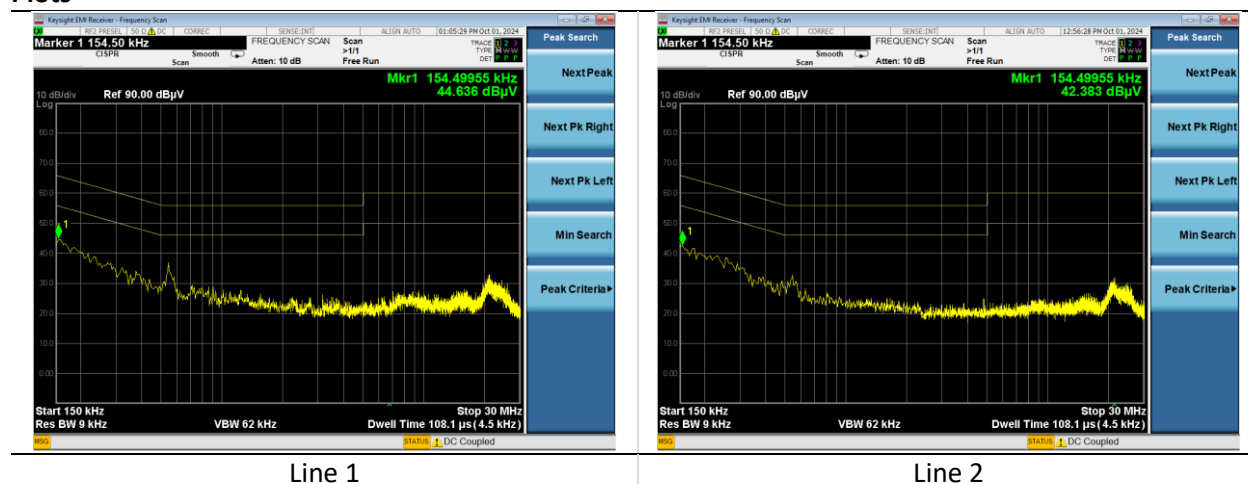
EUT Parameters

Input Power	120 VAC @ 60 Hz	Mode	BLE Tx Channel 19 1 Mbps
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Measurements

Line	Frequency (MHz)	Quasi Peak Reading (dBμV)	Quasi-Peak Limit (dBμV)	Quasi Peak Margin (dB)	Average Reading (dBμV)	Average Limit (dBμV)	Average Margin (dB)
1	0.154	43.6	65.8	22.2	31.8	55.8	24.0
1	0.541	34.6	56.0	21.4	24.9	46.0	21.1
1	21.365	27.5	60.0	32.5	17.7	50.0	32.3
2	0.154	42.6	65.8	23.2	31.7	55.8	24.1
2	0.541	32.0	56.0	24.0	25.0	46.0	21.0
2	21.181	26.4	60.0	33.6	18.2	50.0	31.8

Plots



7 REVISION HISTORY

Version	Date	Notes	Person
0	10/04/2024	Initial Draft	Dylan Rosenfeldt
1	10/22/2024	Final Draft	Dylan Rosenfeldt

END OF REPORT