

Sept 17, 2020

CalAmp
2200 Faraday Ave, Suite 220
Carlsbad, CA 92008
USA

Dear Imad Rizk,

Enclosed is the EMC Wireless test report for compliance testing of the CalAmp, TTU2830MB as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins E&E North America. If you have any questions regarding these results or if we can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS E&E NORTH AMERICA

A handwritten signature in black ink, appearing to read "Arsalan Hasan".

Arsalan Hasan
Wireless Laboratory

Reference: (\CalAmp\WIRS109402-FCC247 BLE Rev 1)



Certificates and reports shall not be reproduced except in full, without the written permission of Eurofins E&E North America. This letter of transmittal is not a part of the attached report.

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

Electromagnetic Compatibility Criteria Test Report

for the

**CalAmp
TTU2830MB**

Tested under
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

Report: WIRS109402-FCC247 BLE Rev 1

September 17, 2020

Prepared For:

**CalAmp
2200 Faraday Ave, Suite 220
Carlsbad, CA 92008
USA**

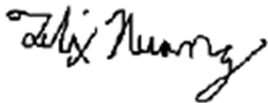
Prepared By:
Eurofins E&E North America
3162 Belick Street
Santa Clara, CA 95054

Electromagnetic Compatibility Criteria Test Report

for the

**CalAmp
TTU2830MB**

Tested under
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

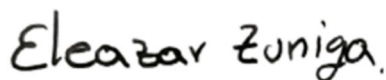


Felix Huang
Engineer, Wireless Laboratory



Arsalan Hasan
Manager, Wireless Laboratory

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.



Eleazar Zuniga, PhD.
Director, Wireless Technologies

Report Status Sheet

Revision	Report Date	Reason for Revision
0	September 10, 2020	Initial Issue.
1	September 17, 2020	TCB Updates

Table of Contents

I.	Executive Summary	1
	A. Purpose of Test.....	2
	B. Executive Summary	2
II.	Equipment Configuration.....	3
	A. Overview.....	4
	B. References.....	5
	C. Test Site.....	5
	D. Description of Test Sample	6
	E. Equipment Configuration.....	6
	F. Support Equipment.....	6
	G. Ports and Cabling Information	6
	H. Mode of Operation	7
	I. Method of Monitoring EUT Operation	8
	J. Modifications	8
	a) Modifications to EUT	8
	b) Modifications to Test Standard.....	8
	K. Disposition of EUT	8
	L. Measurement Uncertainty	8
III.	Electromagnetic Compatibility Criteria for Intentional Radiators	9
	§ 15.203 Antenna Requirement	10
	§ 15.207(a) Conducted Emissions Limits	11
	§ 15.247(a)(a) 6 dB and 99% Bandwidth	12
	§ 15.247(b) Peak Power Output.....	14
	§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge.....	17
	§ 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge.....	34
	§ 15.247(e) Peak Power Spectral Density	39
IV.	Test Equipment	41

List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB_μA	Decibels above one microamp
dB_μV	Decibels above one microvolt
dB_μA/m	Decibels above one microamp per meter
dB_μV/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μH	microhenry
μ	microfarad
μs	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane

I. Executive Summary

A. Purpose of Test

An EMC Wireless evaluation was performed to determine compliance of the CalAmp, TTU2830MB, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the TTU2830MB. CalAmp should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the TTU2830MB, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with CalAmp, purchase order number 401701. All tests were conducted using measurement procedure ANSI C63.4-2014.

FCC Reference 47 CFR Part 15.247:2005	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	N/A
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RF Conducted Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RF Conducted Band Edge	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	Maximum Permissible Exposure (MPE)	Compliant

Table 1: Executive Summary of EMC Part 15.247 Compliance Testing

II. Equipment Configuration

A. Overview

Eurofins MET Laboratories, Inc. was contracted by CalAmp to perform testing on the TTU2830MB, under CalAmp's purchase order number 401701.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the CalAmp's, TTU2830MB.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	TTU2830MB	
Model(s) Covered:	TTU2830MB	
EUT Specifications:	Primary Power: 12 VDC	
	FCC ID: APV-2830MB	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	3.389 dBm
	EUT Frequency Ranges:	2402 – 2480 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Arsalan Hasan	
Report Date(s):	September 17, 2020	

Table 2: EUT Summary Table

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

Table 3: References

C. Test Site

All testing was performed at Eurofins MET Labs, 3162 Belick St., Santa Clara, CA 95054. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Eurofins MET Labs is a ISO/IEC 17025 accredited site by A2LA, California #0591.02.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 4. Measurement Uncertainty

E. Description of Test Sample

The CalAmp TTU2830MB is a vehicle tracking device using LTE connectivity and GPS for fleet management.

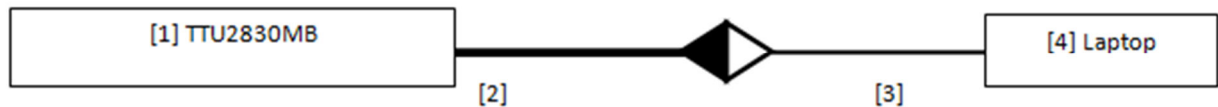


Figure 1: Block Diagram of Test Configuration

F. Equipment Configuration

Ref. ID	Slot #	Name / Description	Model Number	Part Number	Serial Number	Revision
1		Asset Tracker	TTU2830MB	TTU2830MB	4672001045	1

Table 5: Equipment Configuration

G. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
3	Serial Adaptor	CalAmp	134364-SER	NA
4	Laptop	Dell	Latitude	NA

Table 6: Support Equipment

H. Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
2	Power/Data Port	12 wire BUS	1	1m	1m	n	na

Table 7: Ports and Cabling Information

I. Mode of Operation During Testing

Open the device and insert SIM card.

Connect the serial into the laptop or computer, two different setup.

One way is to connect is to the cables where the serial port on the cable harness itself.

Second way where serial isn't on the cable harness, where you can attached 4 pins on the board itself.

Connect Serial/USB adapter on the computer and check the device manager to know what Com Port is being used.

Connect the device's harness into power supply (12/24VDC) (RED/Black)

Connect Serial adapter into the computer or laptop.

Turn the device on, connect TeraTerm (or any Terminal tool)

Set Tera Term settings as follow: (on This machine the assigned Com port was COM3)

Make sure to select the appropriate one on your machine.

Tera Term should start scrolling debug messaging

To start Transmit test: use the following commands:

EUT Software (internal to EUT): Custom Rev 8.4

Support Software (used by support PC to exercise EUT): Tera term

```

at
OK
app[3:58:21:78] PIO: Batt Chrg Off - St: NONE
app[3:58:22:35] ADM2: Send Cmd: AT+QCSQ
app[3:58:22:35] ADM2: Rcv Resp: +QCSQ: "CAT-M1",-91,-131,51,-20
app[3:58:22:36] ADM2: Rcv Resp: OK
app[3:58:22:36] ADM2: Send Cmd: AT+COPS?
app[3:58:22:36] ADM2: Rcv Resp: +COPS: 0
app[3:58:22:36] ADM2: Rcv Resp: OK
app[3:58:22:36] ADM2: Send Cmd: AT+CREG?
app[3:58:22:37] ADM2: Rcv Resp: +CREG: 1,2
app[3:58:22:37] ADM2: Rcv Resp: OK
app[3:58:22:37] ADM2: Send Cmd: AT+QENG="servingcell"
app[3:58:22:39] ADM2: Rcv Resp: +QENG: "servingcell","LMSRV","CAT-M","FDD",313,100,A142310,298,5110,12,3,3,8B35,-131,-20,-90,2,8
app[3:58:22:39] ADM2: Rcv Resp: OK
app[3:58:22:39] ADM2: Send Cmd: AT+CHGL="ALL"
app[3:58:22:39] ADM2: Rcv Resp: OK
AT#BLEHCI 011E2003002502
app[3:58:28:22] BT: st: 20 -> 20
#BLEHCI: OK
OK
app[3:58:29:72] BT: LE PTH response:
04 0E 04 01 1E 20 00

```

Mode	Channel	Frequency	Test Software Setting
BLE	Low	2402	0x00
	Mid	2442	0x00
	High	2480	0x00

Table 8. Power setting used for BLE in the customer provided test software.

J. Method of Monitoring EUT Operation

The signal will be displayed on a spectrum analyzer.

K. Modifications**a) Modifications to EUT**

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

L. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to CalAmp upon completion of testing.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

- a.) Antenna must be permanently attached to the unit.
- b.) Antenna must use a unique type of connector to attach to the EUT.
- c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT **completed testing** to the criteria of §15.203.

Test Engineer: Arsalan Hasan

Test Date: September 5, 2020

EUT Model/Mode	Gain	Type	Manufacturer
TTU2830MB	1.88 dBi	Ceramic Antenna	(Ethertronics - Part # 1001312)

Table 9: Antenna Requirement, Antenna List

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207(a) Conducted Emissions Limits

Test Requirement(s): **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Σ line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dB μ V)	
	Quasi-Peak	Average
* 0.15- 0.45	66 - 56	56 - 46
0.45 - 0.5	56	46
0.5 - 30	60	50

Table 10: Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Procedure: The EUT was placed on a 0.8 m-high wooden table inside a screen room. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω /50 μ H Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.4-2014 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz"*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω /50 μ H LISN as the input transducer to an EMC/field intensity meter. For the purpose of this testing, the transmitter was turned on. Scans were performed with the transmitter on.

Test Results: This test case was not applicable for this EUT.

Test Engineer: Arsalan Hasan

Test Date: September 5, 2020

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

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

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using an RBW approximately 1% of the total emission bandwidth, VBW > RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

Test Results The EUT **completed testing** to the requirements of § 15.247 (a)(2). No anomalies noted.

The 6 dB Bandwidth was determined from the plots on the following pages.

Test Engineer: Arsalan Hasan

Test Date: September 5, 2020

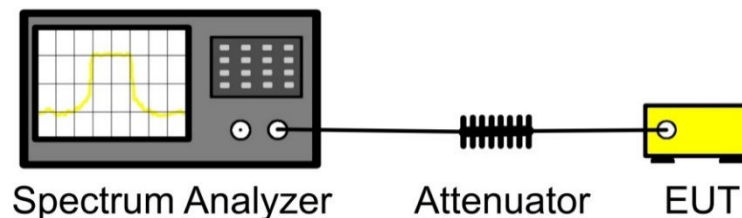
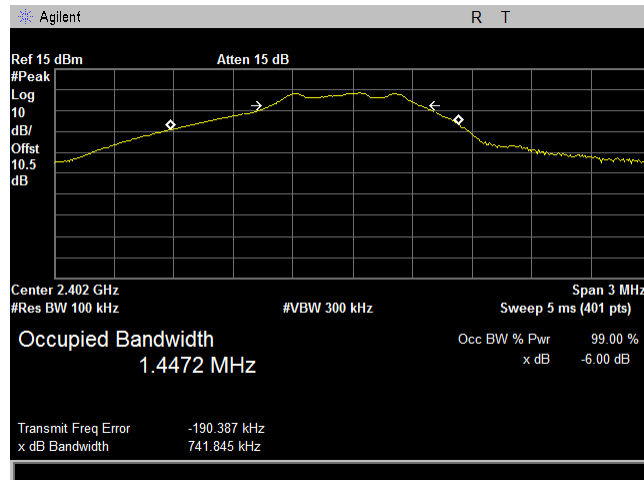


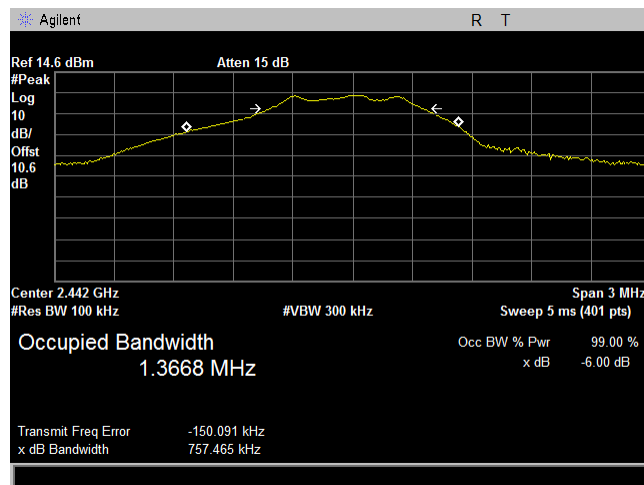
Figure 2: Block Diagram, Occupied Bandwidth Test Setup

Occupied Bandwidth			
Carrier Channel	Frequency (MHz)	Measured 6 dB Bandwidth (KHz)	Limit (KHz)
Low	2402	741.845	≥500
Mid	2442	747.465	≥500
High	2480	750.195	≥500

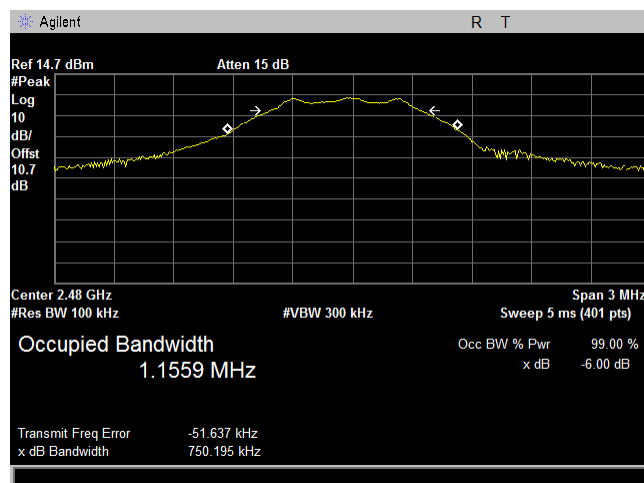
Table 11: 6 dB Bandwidth, Test Data



Plot 1: 6 dB Bandwidth, 2402MHz Low Channel



Plot 2: 6 dB Bandwidth, 2442MHz Mid Channel



Plot 3: 6 dB Bandwidth, 2480MHz High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: §15.247(b): The maximum peak output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit (Watts)
902-928	1.000
2400-2483.5	1.000
5725- 5850	1.000

Table 12: Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the Figure 21, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400 – 2483.5 MHz band and using a point to point application may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Fixed, point-to-point operation excludes the use of point-to-multipoint systems, Omni-directional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

Test Procedure: The transmitter was connected to a calibrated spectrum analyzer. The EUT was measured at the low, mid and high channels of each band at the maximum power level.

Test Results: The EUT **completed testing** to the requirements of §15.247(b). No anomalies noted.

Test Engineer: Arsalan Hasan

Test Date: September 5, 2020

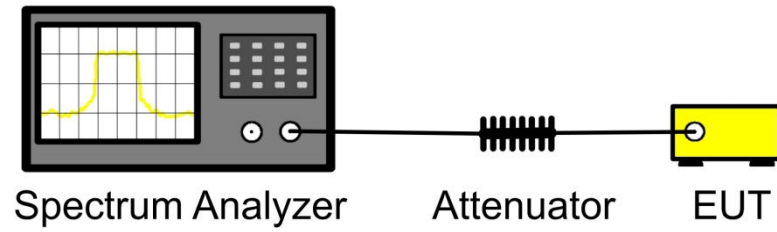
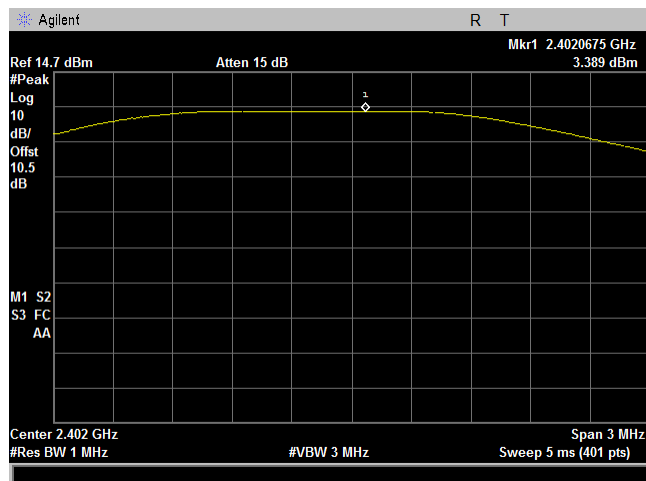


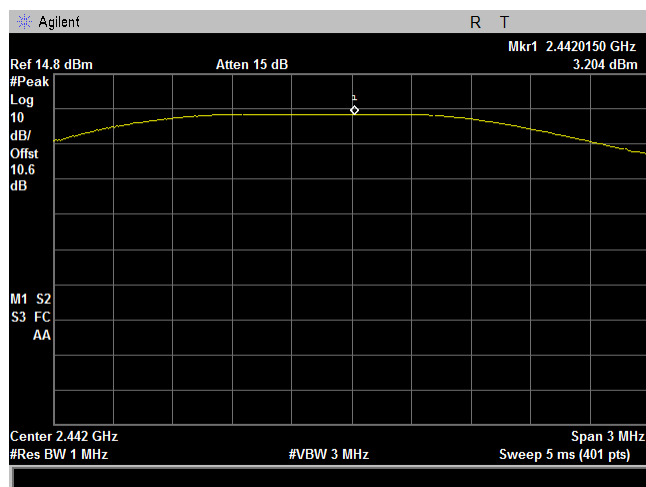
Figure 3: Peak Power Output Test Setup

Output Power			
Carrier Channel	Frequency (MHz)	Measured Conducted Power (dBm)	Limit (dBm)
Low	2402	3.389	≤ 30
Mid	2442	3.204	≤ 30
High	2480	3.108	≤ 30

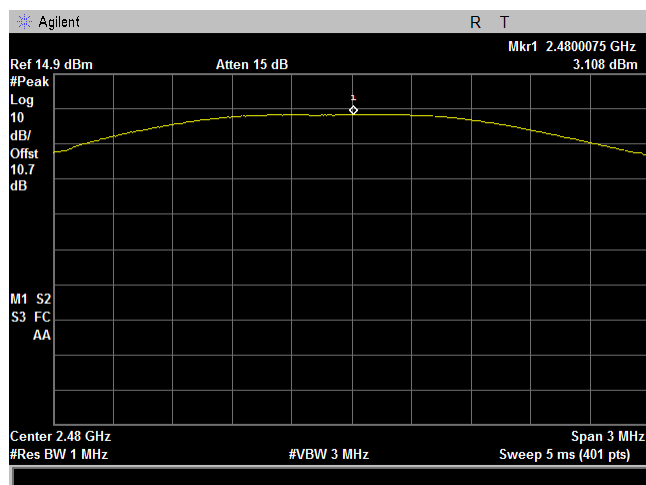
Table 13: Peak Power Output, Test Data



Plot 4: Peak Power Output, 2402MHz Low Channel



Plot 5: Peak Power Output, 2442MHz Mid Channel



Plot 6: Peak Power Output, 2480MHz High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge

Test Requirements: §15.247(d); §15.205: Emissions outside the frequency band.

§15.247(d): 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. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110-----	16.42–16.423	399.9–410	4.5–5.15
¹ 0.495–0.505-----	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905-----	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128-----	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775-----	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775-----	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218-----	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825-----	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225-----	123–138	2200–2300	14.47–14.5
8.291–8.294-----	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366-----	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675-----	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475-----	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293-----	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025-----	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725-----	322–335.4	3600–4400	(²)

Table 14: Restricted Bands of Operation

¹ Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

² Above 38.6

Test Requirement(s): § 15.209 (a): Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 15:

Frequency (MHz)	§ 15.209(a), Radiated Emission Limits (dBμV) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 15: Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line. Only noise floor was measured below 30 MHz and above 18 GHz.

Test Results: The EUT **completed testing** to the requirements of § 15.247(d). No anomalies noted.

Test Engineer: Arsalan Hasan

Test Date: September 6, 2020

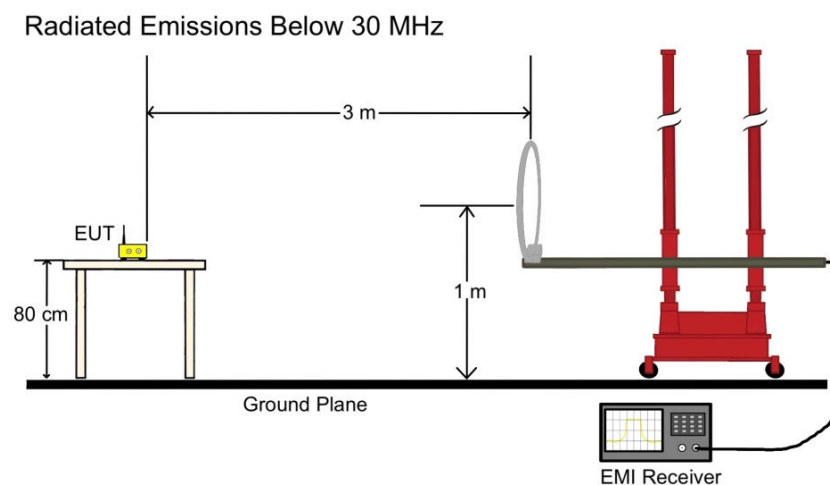


Figure 4: Radiated Emissions, Below 30MHz, Test Setup

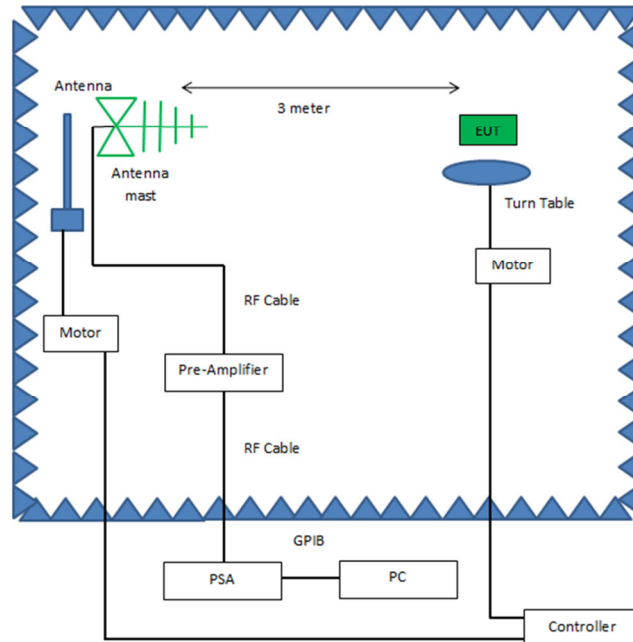


Figure 5: Radiated Emissions, Below 1GHz, Test Setup

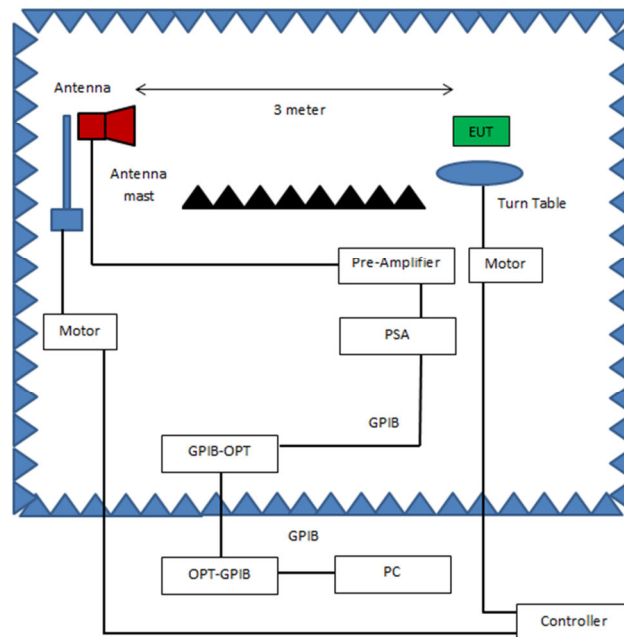


Figure 6: Radiated Emissions, Above 1GHz, Test Setup

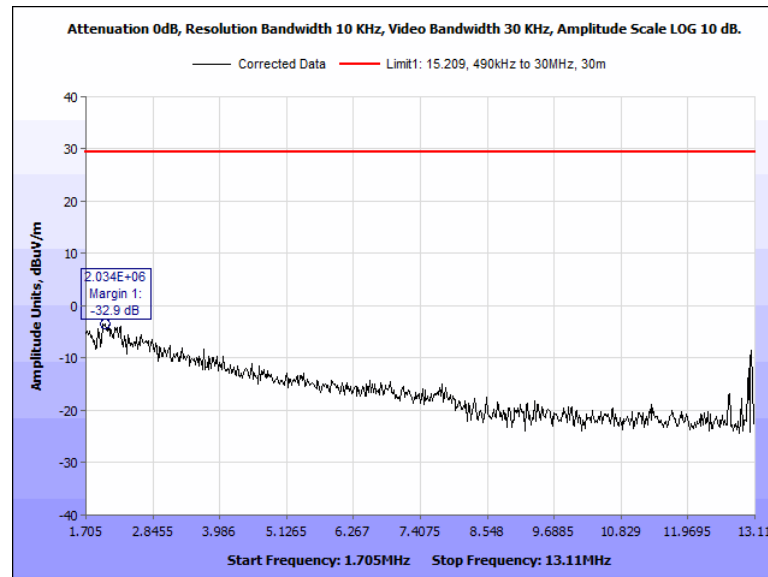


Figure 7: Radiated Spurious Emissions, Below 30MHz, Spot check for 12MHz Clock

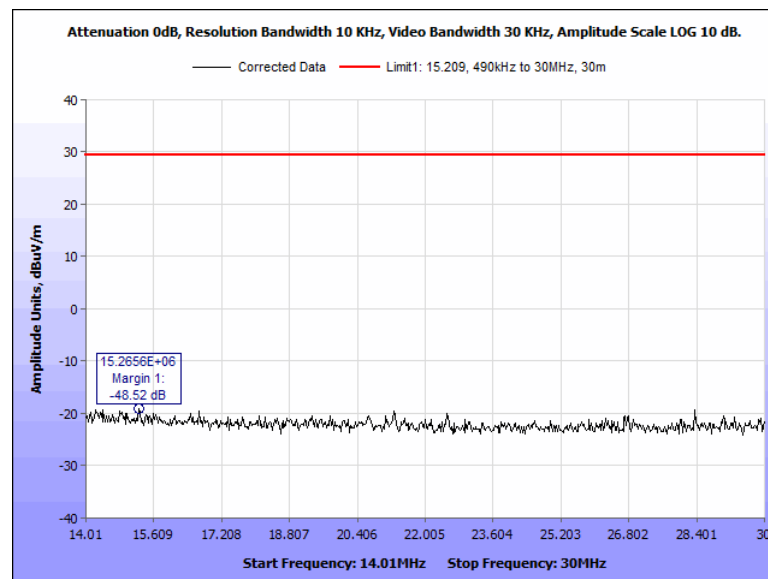
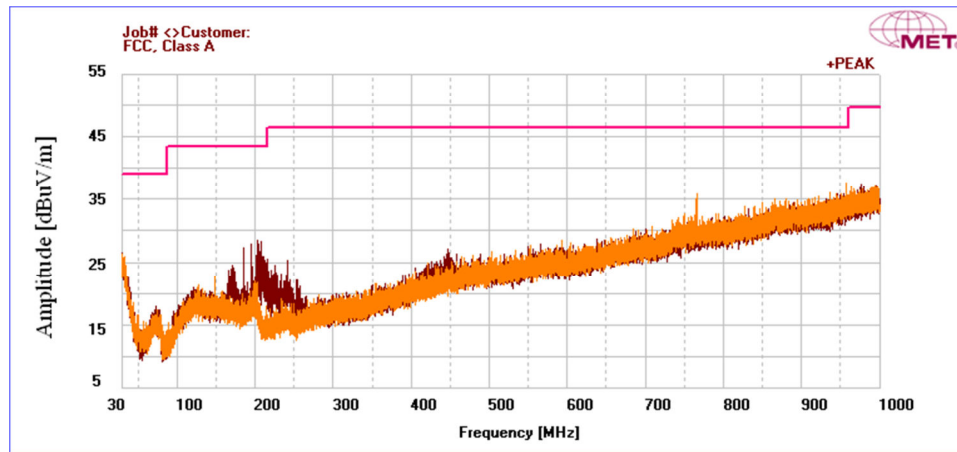


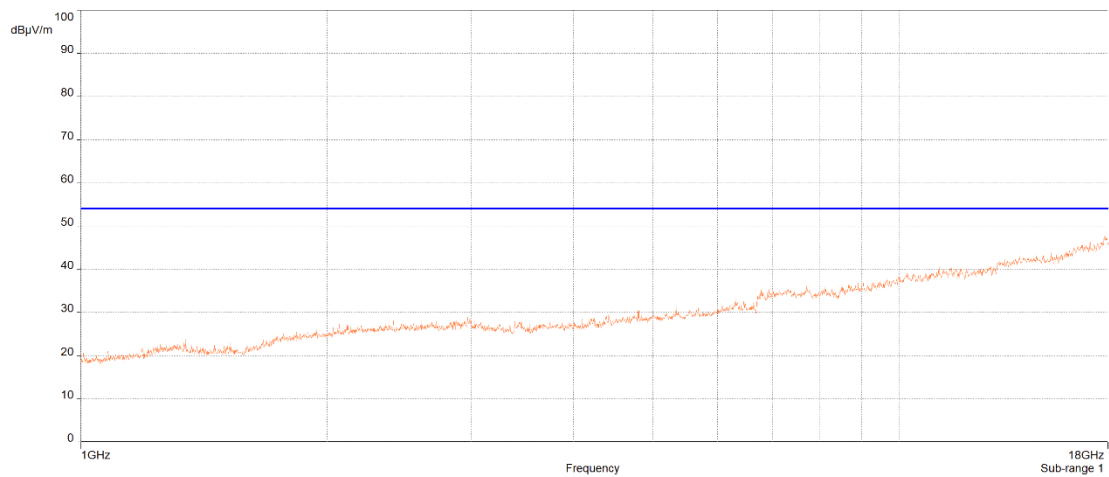
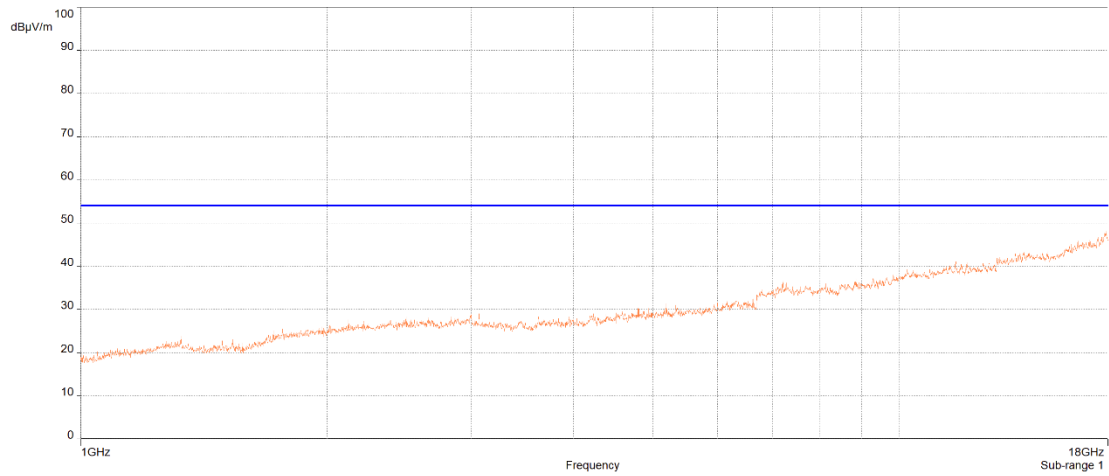
Figure 8: Radiated Spurious Emissions, Below 30MHz, Spot check for 24MHz Clock

Frequency (MHz)	EUT Azimuth (Degrees)	Antenna Polarity (H/V)	Antenna HEIGHT (m)	Uncorrected EMI Meter Reading (dBuV)	Antenna Correction Factor (dB/m) (+)	Cable Loss (dB) (+)	Distance Correction Factor (dB) (-)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
62.36	157	V	1.2	19.67	7.83	1.40	0.00	28.90	40.00	-11.10
79.43	132	H	1.6	18.37	8.03	1.56	0.00	27.96	40.00	-12.04
421.78	186	V	1.1	8.56	15.68	2.37	0.00	26.61	46.00	-19.39
721	241	V	1.8	9.23	16.25	2.96	0.00	28.44	46.00	-17.56
892	147	H	1	10.38	17.15	3.28	0.00	30.81	46.00	-15.19
930	295	V	1	11.38	17.94	3.86	0.00	33.18	46.00	-12.82

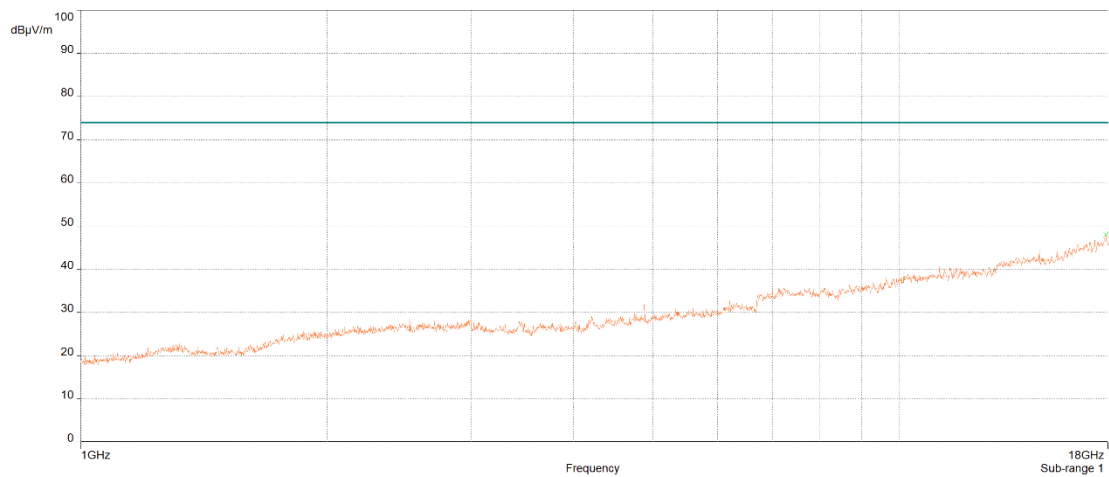
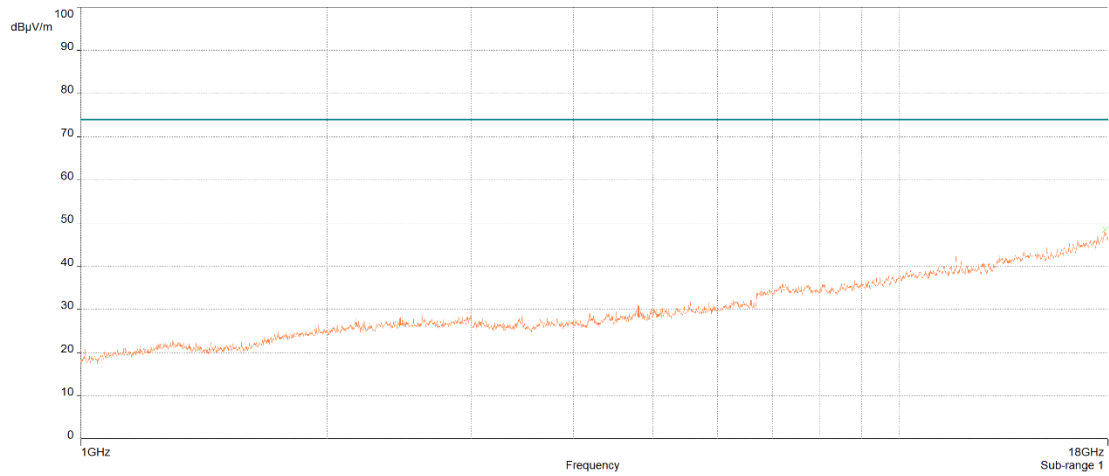
Table 16. Radiated Emissions Data 30MHz – 1GHz



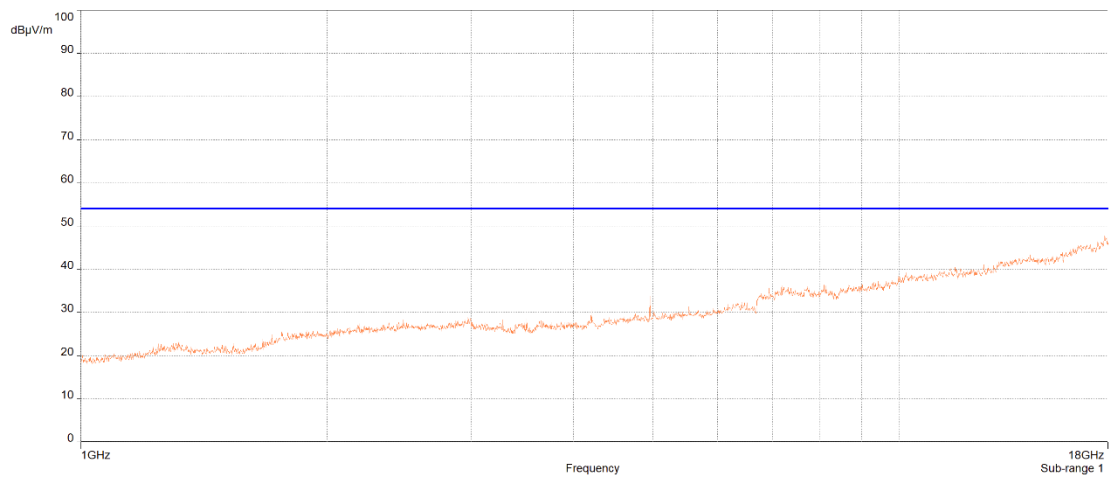
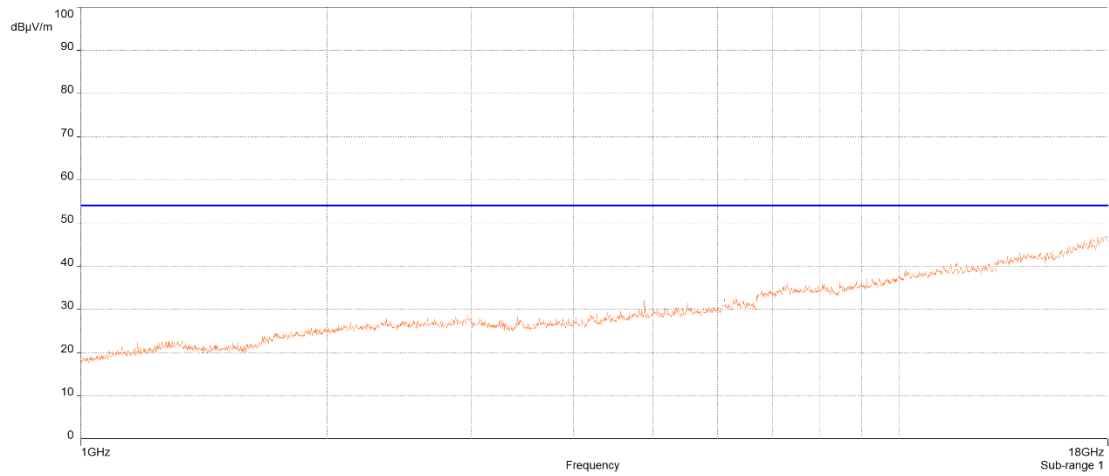
Plot 9: Radiated Emissions, BLE, 30 MHz - 1 GHz, (worst case)



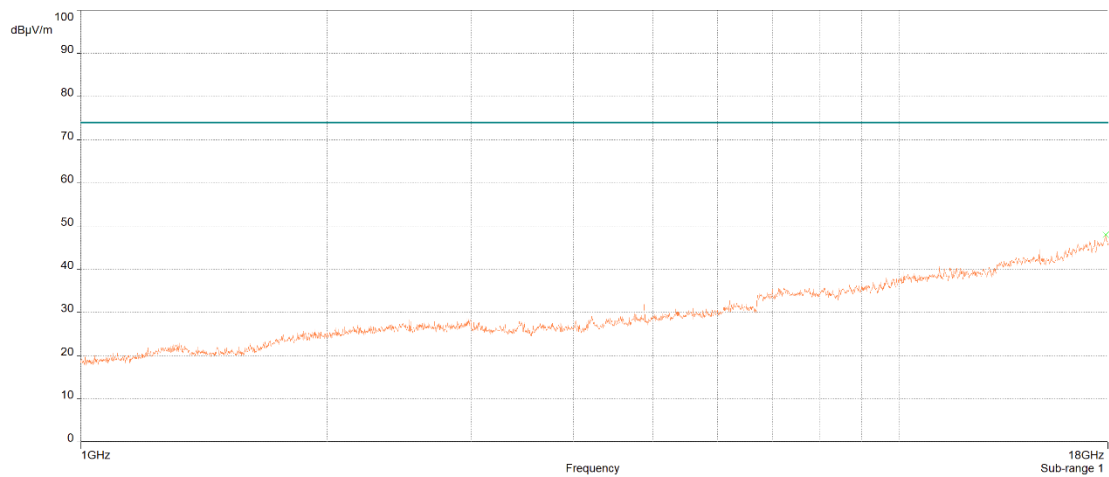
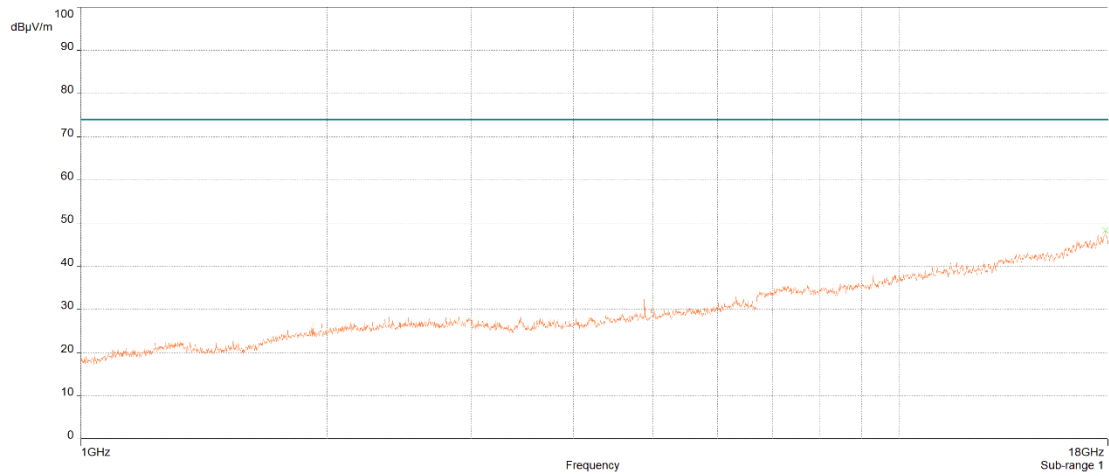
Plot 10: Radiated Spurious Emissions Requirements, Low Channel 2402MHz, Average



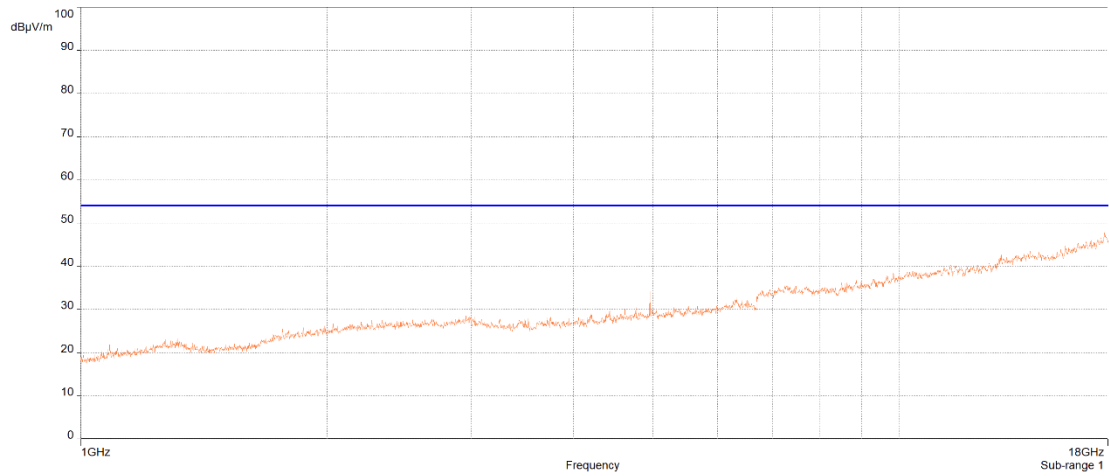
Plot 11: Radiated Spurious Emissions Requirements, Low Channel 2402MHz, Peak



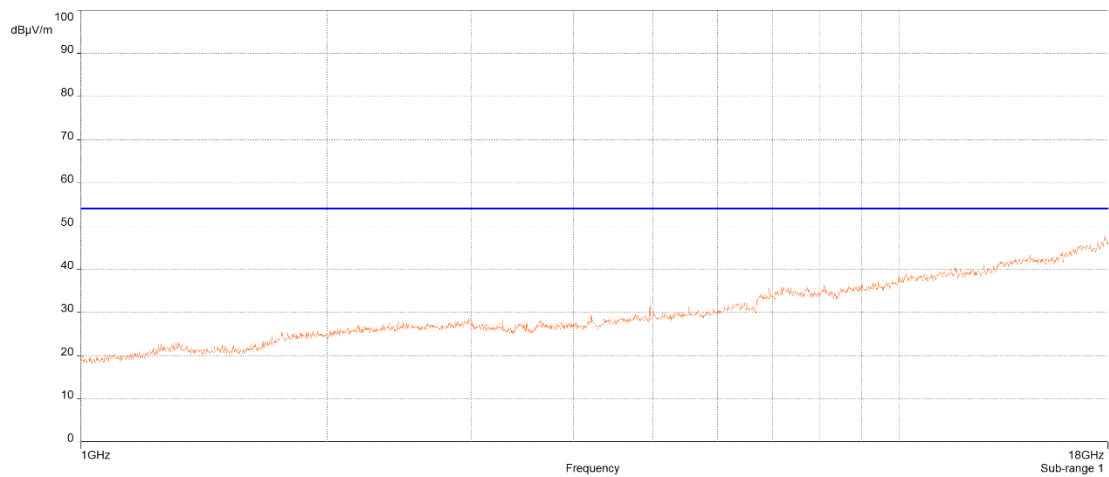
Plot 12: Radiated Spurious Emissions Requirements, Mid Channel 2442MHz, Average



Plot 13: Radiated Spurious Emissions Requirements, Mid Channel 2442MHz, Peak

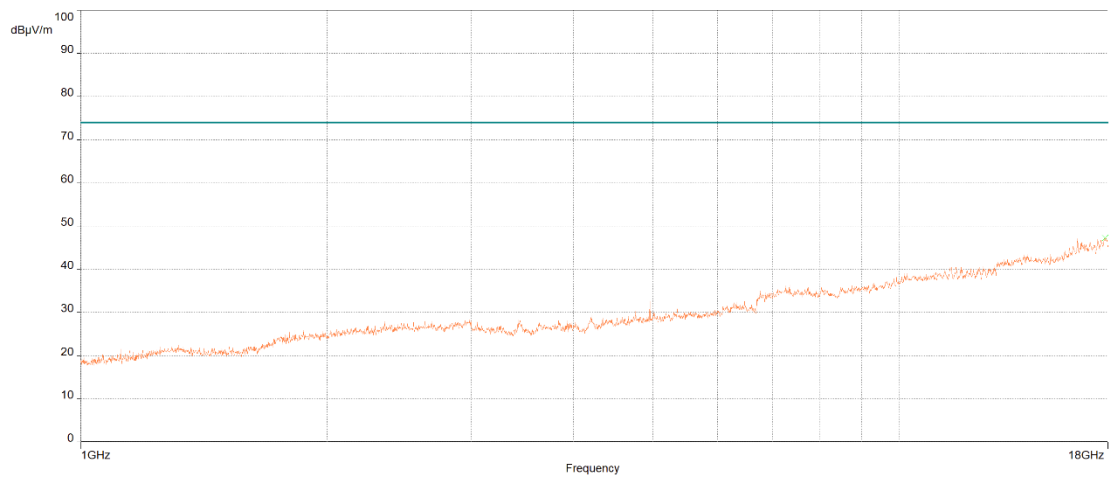
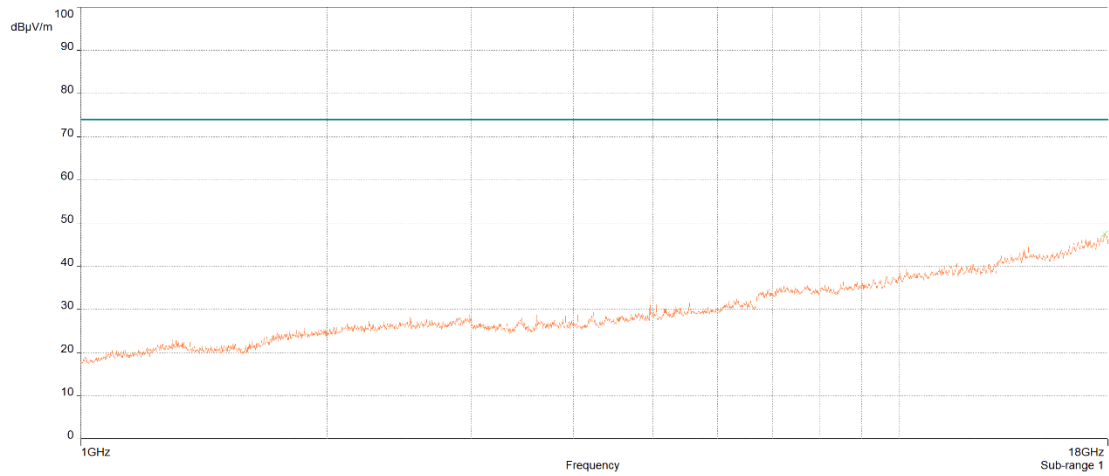


Vertical



Horizontal

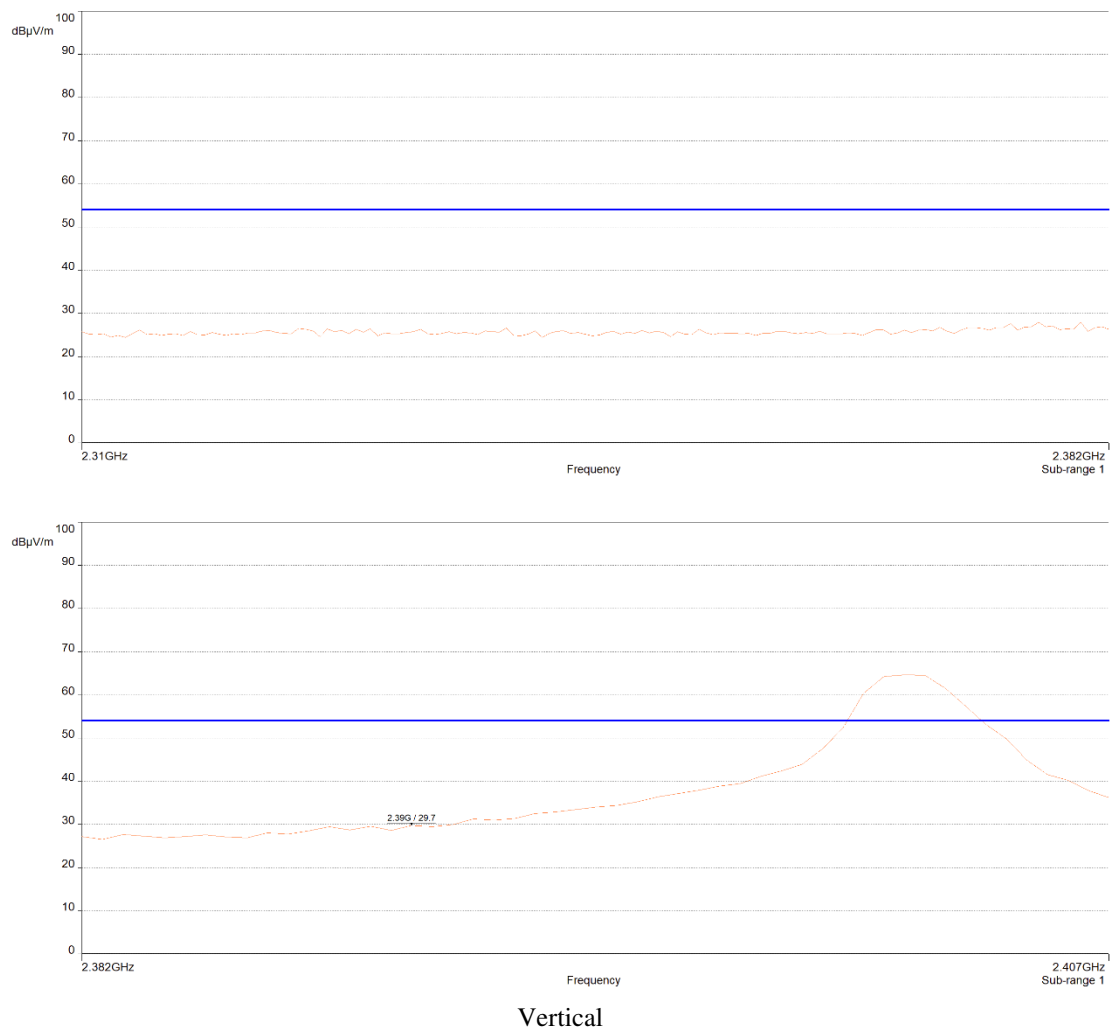
Plot 14: Radiated Spurious Emissions Requirements, High Channel 2480MHz, Average



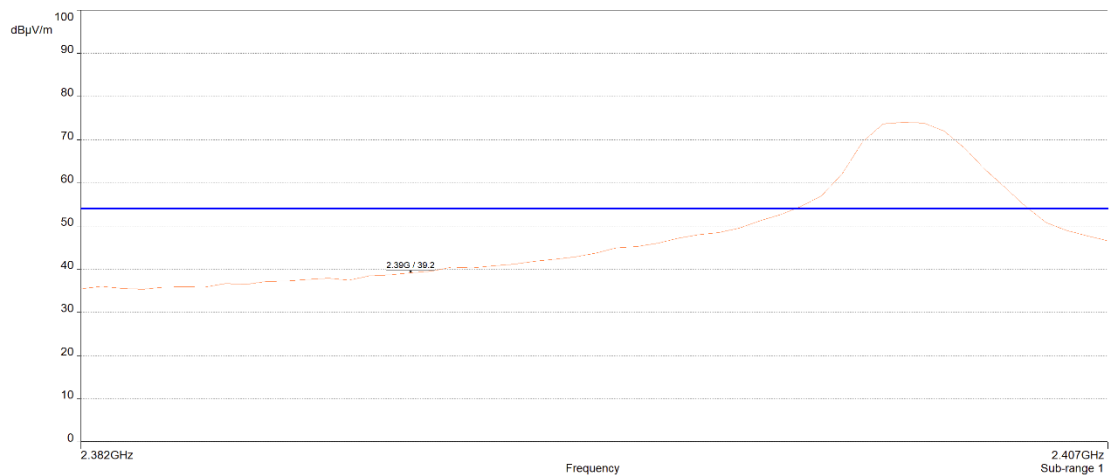
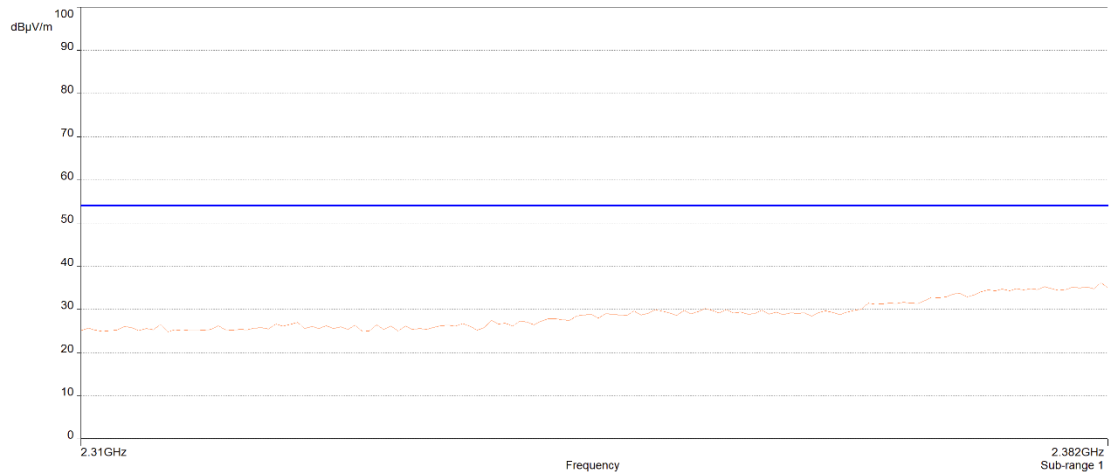
Plot 15: Radiated Spurious Emissions Requirements, High Channel 2480MHz, Peak

Radiated Band Edge Measurements

Test Procedures: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

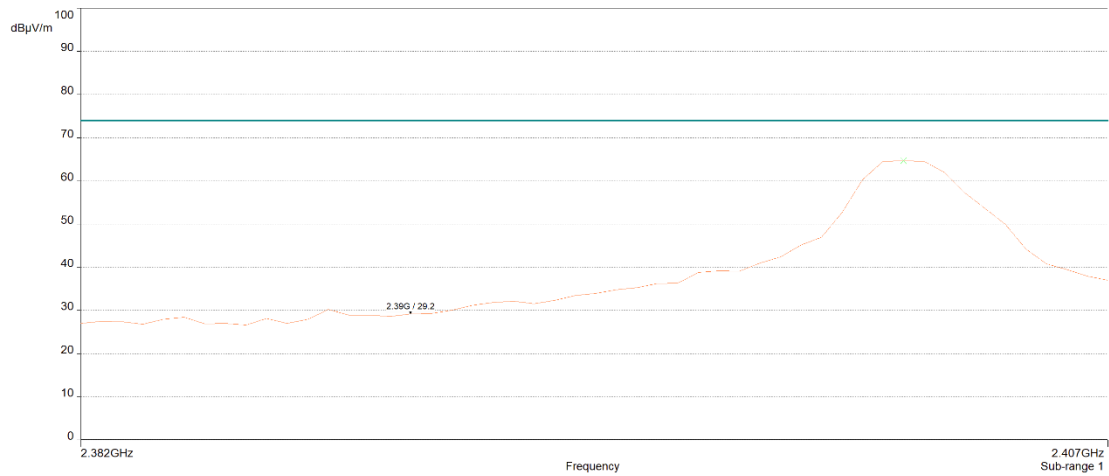
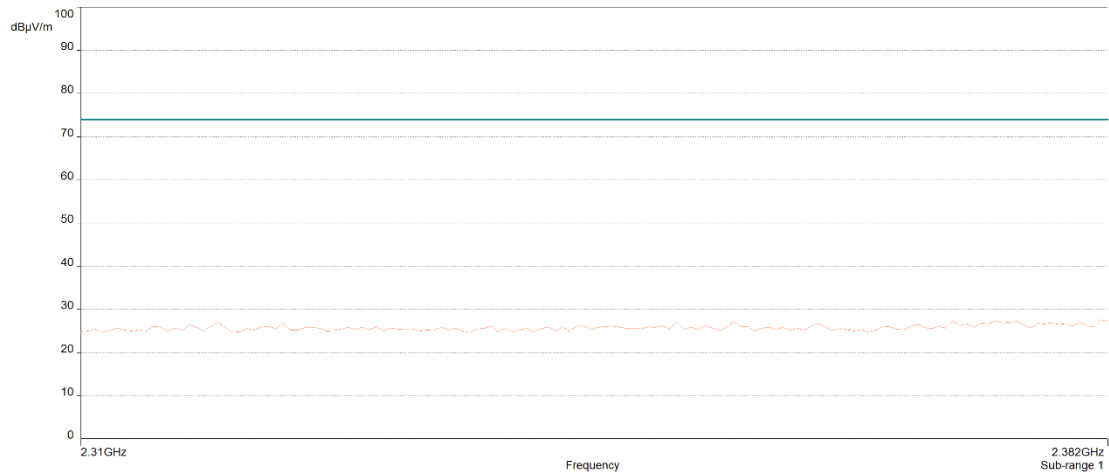


Plot 16: Radiated Band Edge, Low Channel 2402MHz, Average



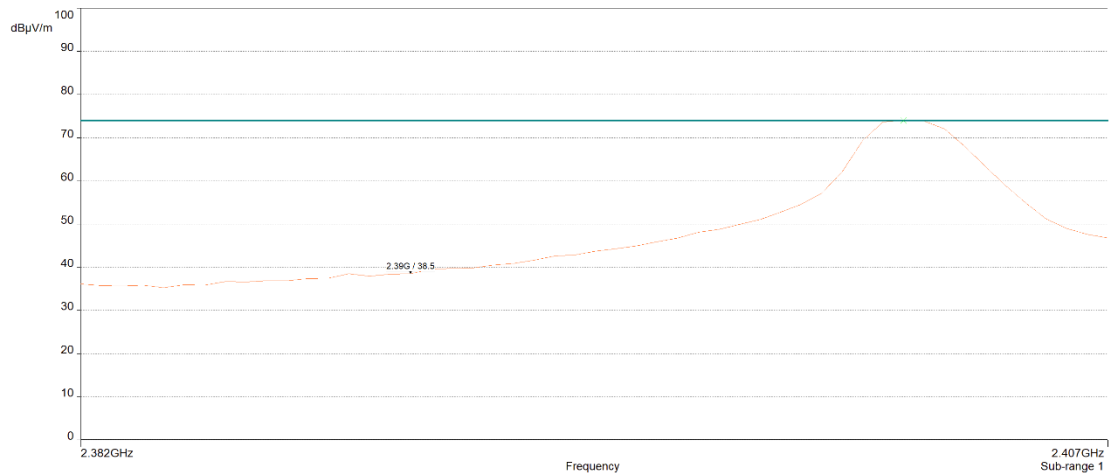
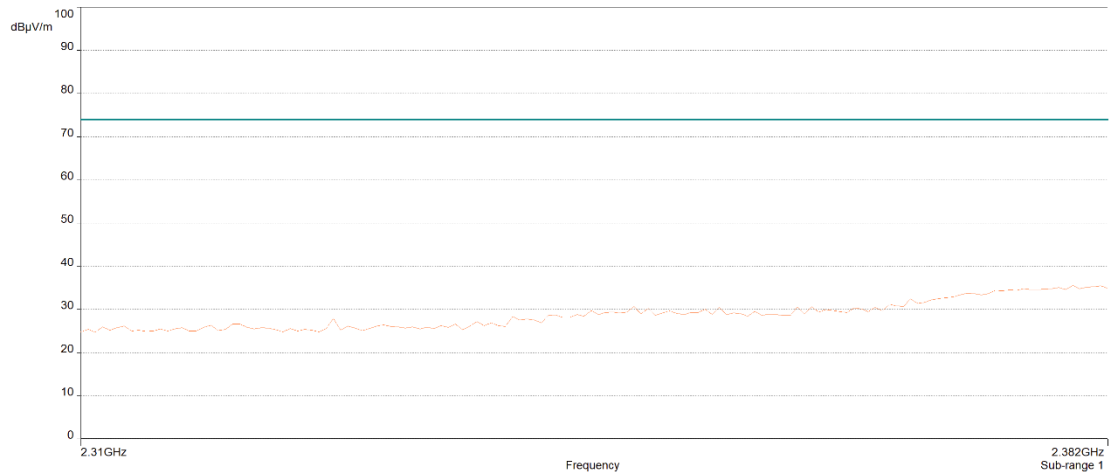
Horizontal

Plot 17: Radiated Band Edge, Low Channel 2402MHz, Average



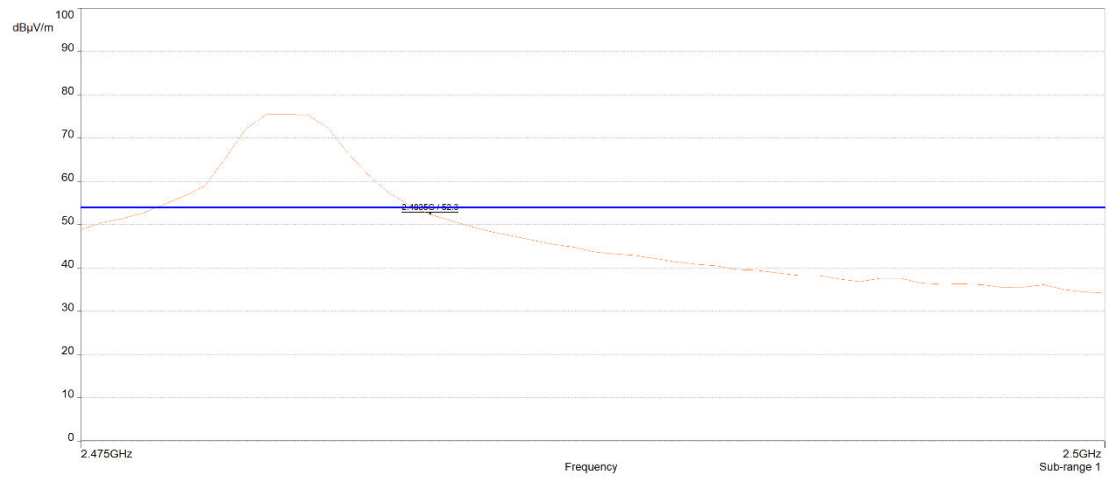
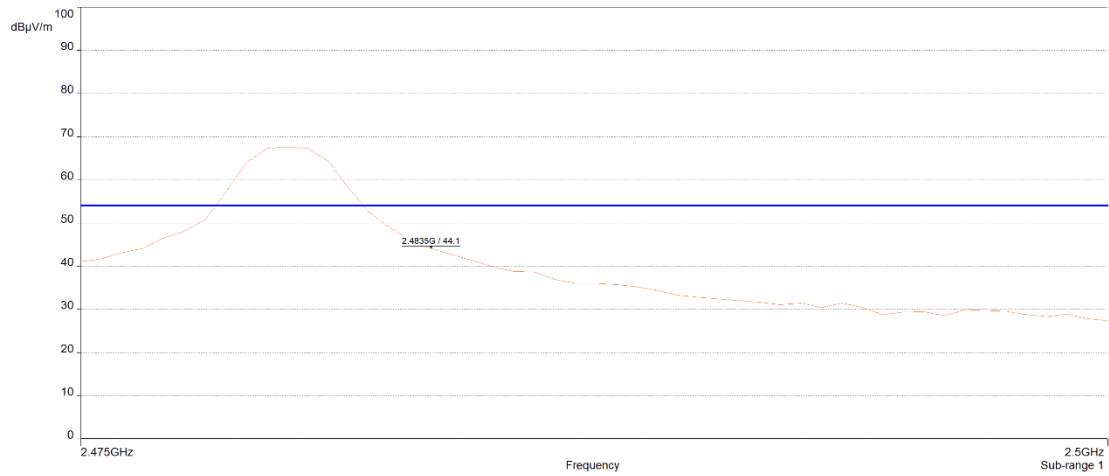
Vertical

Plot 18: Radiated Band Edge, Low Channel 2402MHz, Peak

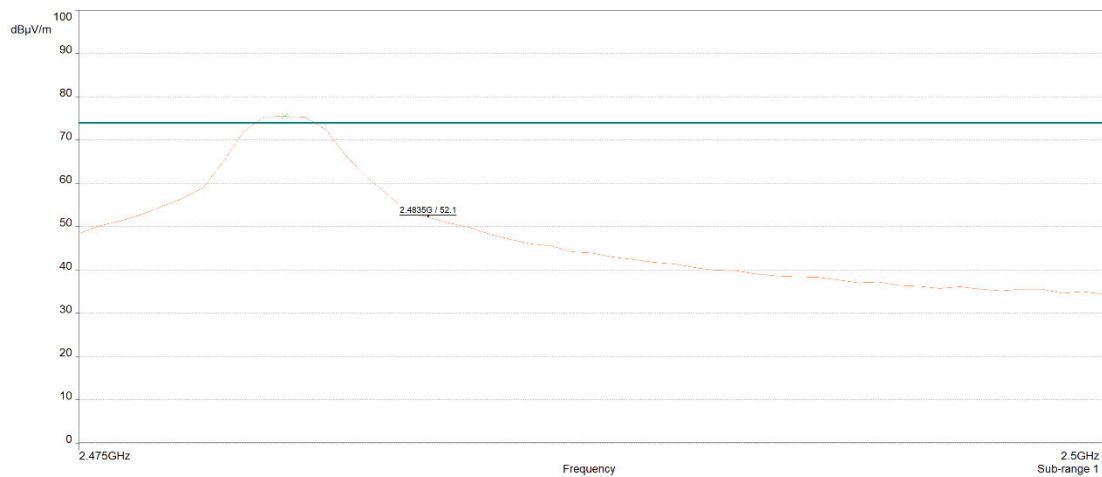
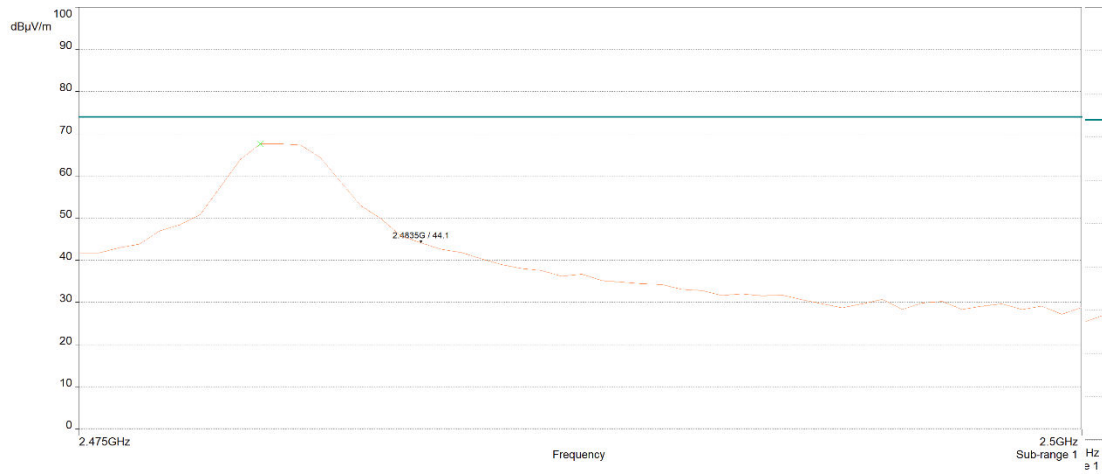


Horizontal

Plot 19: Radiated Band Edge, Low Channel 2402MHz, Peak



Plot 20: Radiated Band Edge, High Channel 2480MHz, Average



Plot 21: Radiated Band Edge, High Channel 2480MHz, Peak

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge

Test Requirement: **15.247(d)** 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. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

Since the EUT had an integral antenna, conducted measurements could not be performed. Measurements needed to be taken radiated. An antenna was located 3 m away from the EUT and plots were taken. The EUT was rotated through all three orthogonal axes. The plots were corrected for both antenna correction factor and cable loss.

See following pages for detailed test results with RF Conducted Spurious Emissions.

Test Results: The EUT **completed testing** to the requirements of **§15.247(d)**. No anomalies noted.

Test Engineer: Arsalan Hasan

Test Date: September 6, 2020

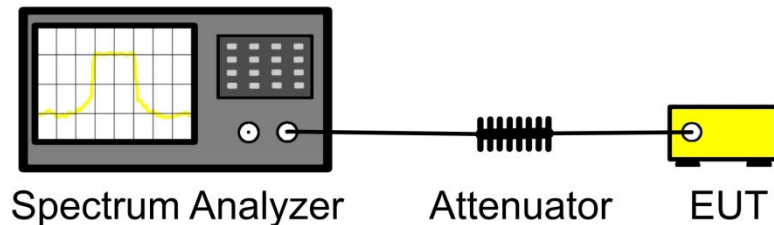
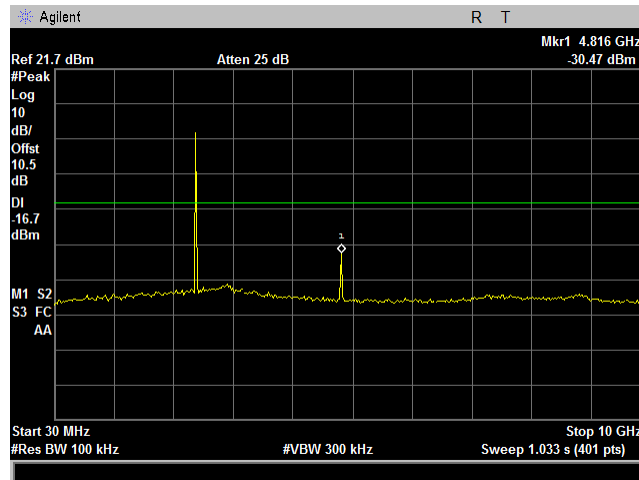
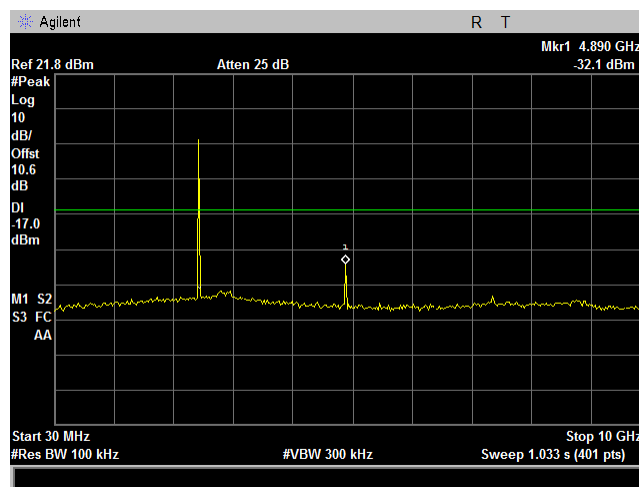


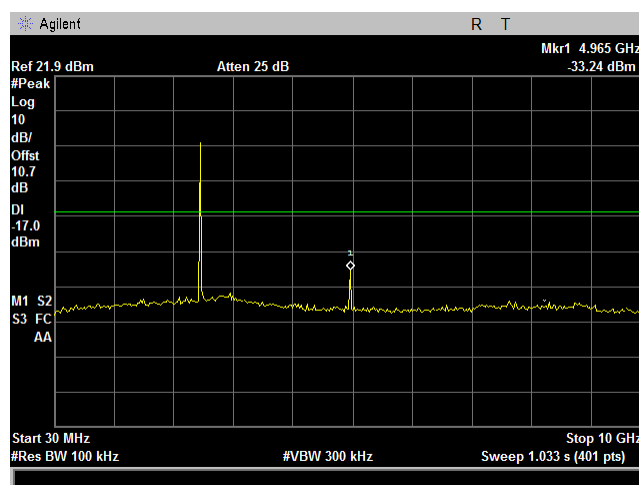
Figure 7: Block Diagram, Conducted Spurious Emissions Test Setup



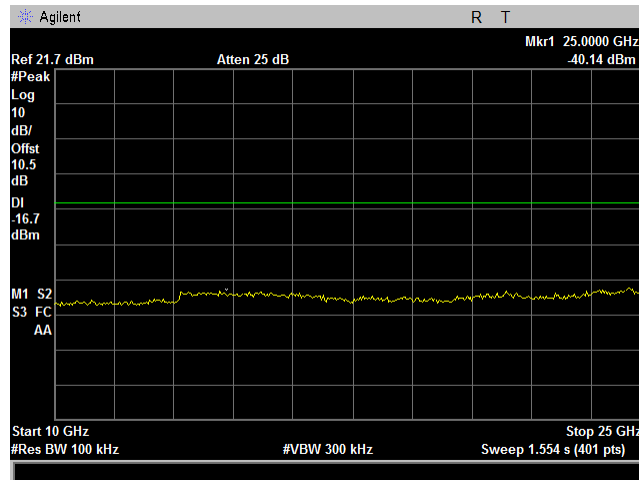
Plot 22: RF Conducted Spurious Emissions Requirements, 30MHz-10GHz 2402MHz Low Channel



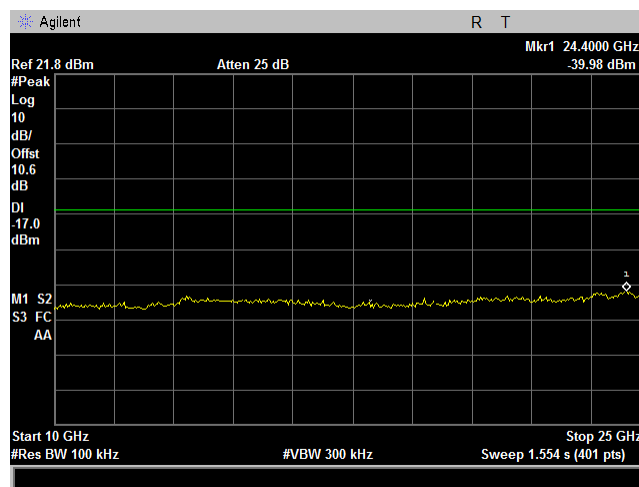
Plot 23: RF Conducted Spurious Emissions Requirements, 30MHz-10GHz 2442MHz Mid Channel



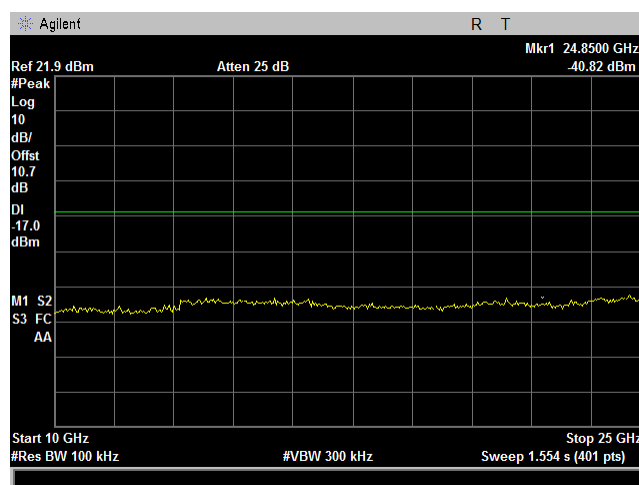
Plot 24: RF Conducted Spurious Emissions Requirements, 30MHz-10GHz 2480MHz High Channel



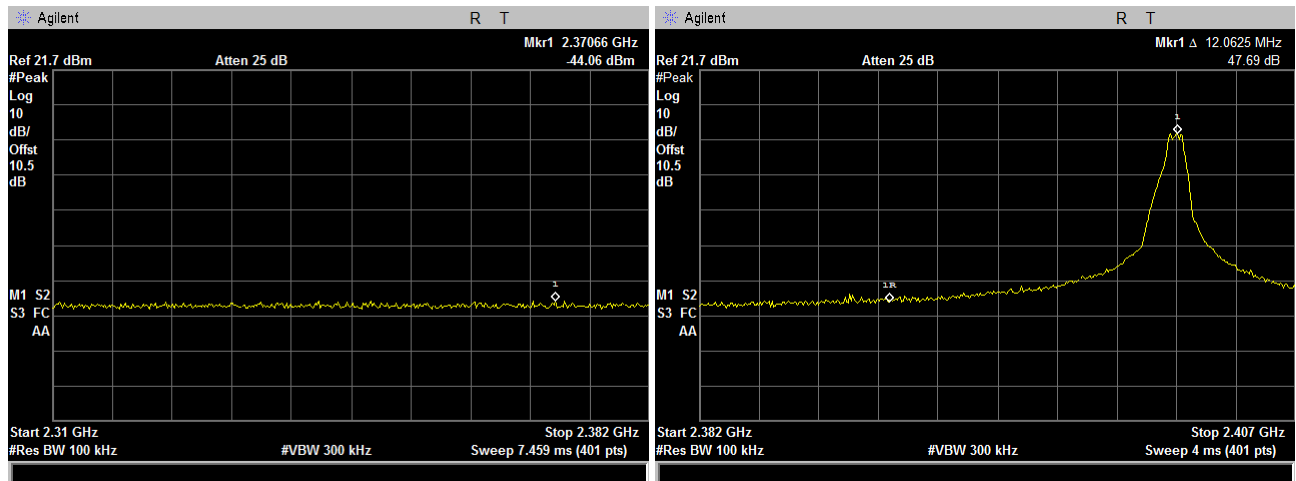
Plot 25: RF Conducted Spurious Emissions Requirements, 10GHz-25GHz 2402MHz Low Channel



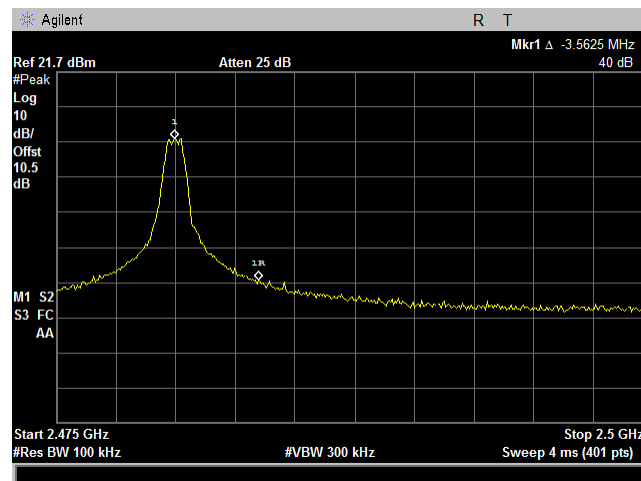
Plot 26: RF Conducted Spurious Emissions Requirements, 10GHz-25GHz 2442MHz Mid Channel



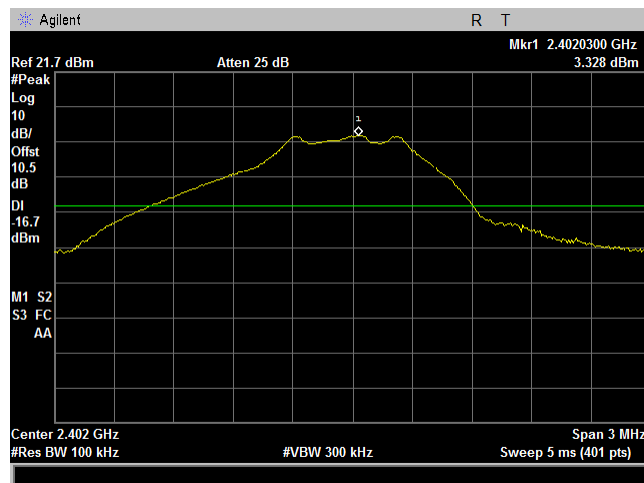
Plot 27: RF Conducted Spurious Emissions Requirements, 10GHz-25GHz 2480MHz High Channel



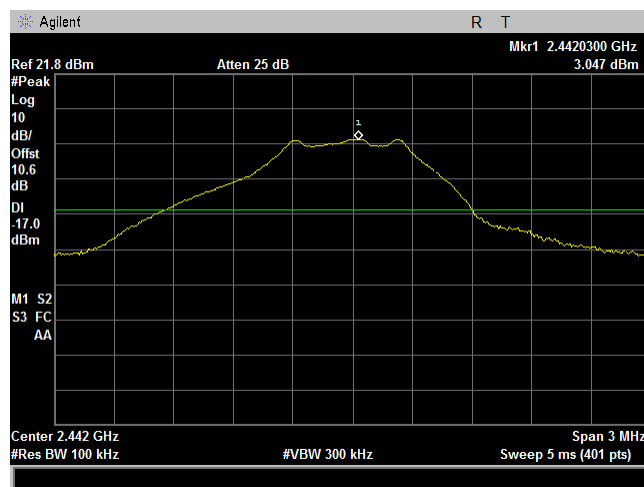
Plot 28: RF Conducted Band Edge, 2402MHz Low Channel



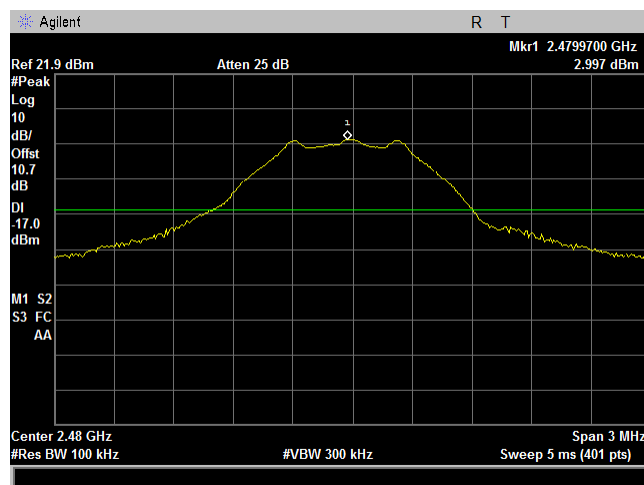
Plot 29: RF Conducted Band Edge, 2480MHz High Channel



Plot 30: RF Conducted Band Edge, Reference Level 2402MHz Low Channel



Plot 31: RF Conducted Band Edge, Reference Level 2442MHz Mid Channel



Plot 32: RF Conducted Band Edge, Reference Level 2480MHz High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

Test Requirements: §15.247(e): For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level throughout each of the 100 sweeps of power averaging. The RBW was set to 3 kHz and a VBW set to 9 kHz or greater. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels.

Test Results: The EUT **completed testing** to the requirements of § 15.247 (e). No anomalies noted.

The peak power spectral density was determined from plots on the following page(s).

Test Engineer: Arsalan Hasan

Test Date: September 6, 2020

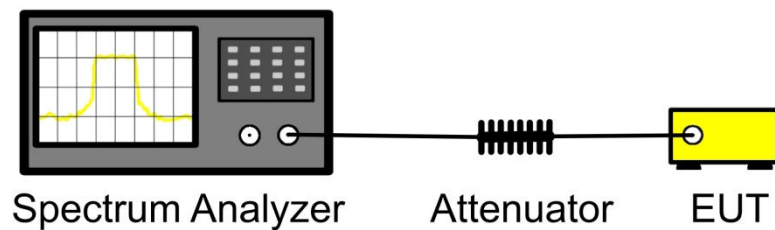
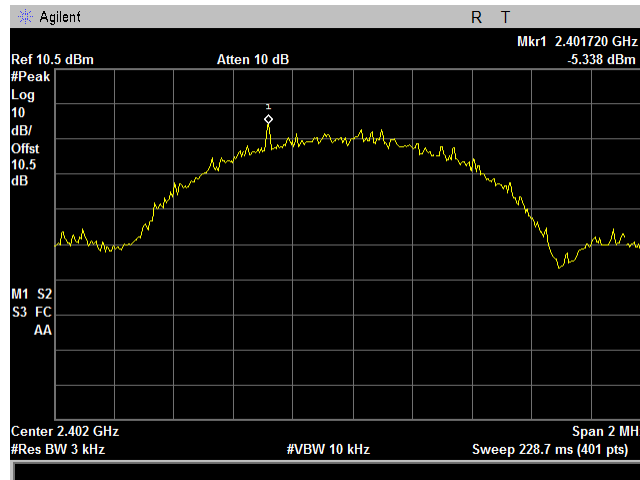


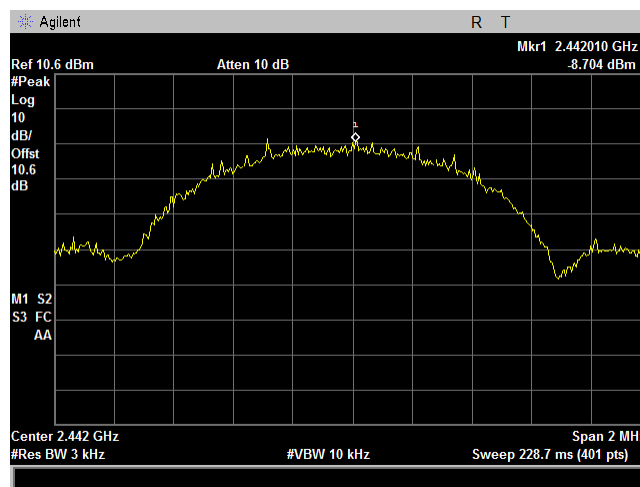
Figure 8: Block Diagram, Peak Power Spectral Density Test Setup

Power Spectral Density			
Carrier Channel	Frequency (MHz)	Measured Conducted Power (dBm)	Limit (dBm)
Low	2402	-5.338	8
Mid	2442	-8.704	8
High	2480	-7.486	8

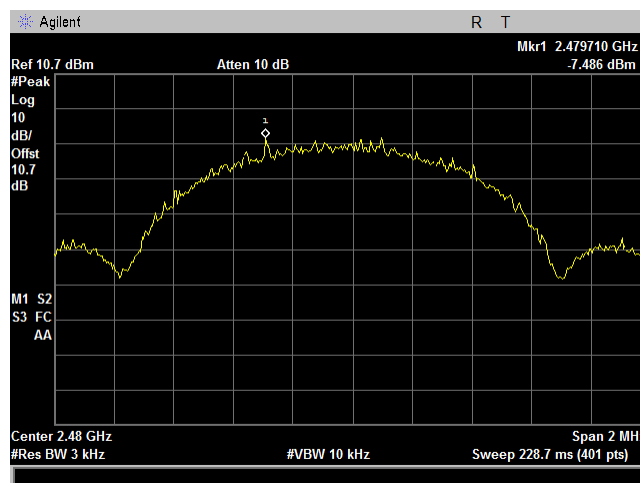
Table 17: Peak Power Output, Test Data



Plot 33: Peak Power Spectral Density, 2402MHz Low Channel



Plot 34: Peak Power Spectral Density, 2442MHz Mid Channel



Plot 35: Peak Power Spectral Density, 2480MHz High Channel

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

ASSET #	NOMENCLATURE	MANUFACTURER	MODEL	LAST CAL	CAL DUE
1S2399	TURNTABLE CONTROLLER	SUNOL SCIENCE	SC99V	FUNCTIONAL VERIFY	
1S3928	EMI TESTER RECEIVER	ROHDE & SCHWARZ	ESR26	03/04/2020	03/04/2021
1S2600	BILOG ANTENNA	TESEQ	CBL6112D	03/19/2019	03/19/2021
1S2486	5 METER CHAMBER CONTROL ROOM	PANASHIELD	5 METER CONTROL ROOM	FUNCTIONAL VERIFY	
1S3926	1MHZ STEP, 1GHZ COMBO GENERATOR	COM-POWER CORP	CGO-501	FUNCTIONAL VERIFY	
1S4067	DIGITAL BAROMETER	CONTROL CO	6530	06/22/2018	06/22/2020
1S2481	10 METER CHAMBER	ETS-LINGREN	DKE-8X8 DBL	FUNCTIONAL VERIFY	
1S406	DIGITAL BAROMETER	CONTROL CO	6530	6/22/2018	06/22/2020
1S380	EMI RECEIVER	NARDA SAFETY TEST SOLUTIONS	PMM 9010F	8/23/2019	8/23/2020
1S2678	LISN, DUAL LINE V-NETWORK	TESEQ	NNB 51	8/16/2019	8/16/2020
1S245	COMB GENERATOR (RADIATED)	COM-POWER	GG510	FUNCTIONAL VERIFY	
1S2599	LASER PROBE INTERFACE	AMPLIFIER RESEARCH	F1700	FUNCTIONAL VERIFY	
1S2603	DOUBLE RIDGED WAVEGUIDE HORN	ETS-LINDGREN	3117	09/18/2018	09/18/2020
1S2000	SPECTRUM ANALYZER	AGILENT	E4448A	11/06/2019	11/06/2020
1S3818	DRG HORN ANTENNA	A.H. SYSTEMS, INC	SAS-574	09/24/2018	09/24/2020

Table 18: Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

End of Report