REGULATORY COMPLIANCE TEST REPORT

FCC CFR47 Part 15 SubPart C 15.247
ISED RSS-247 Issue 2, February 2017

Report No.: TUVR116-U2 Rev C (BLE)

Company: SONOS Inc.

Model Name: S23

REGULATORY COMPLIANCE TEST REPORT

Company: Sonos Inc.

Model Name: S23

To: FCC CFR47 Part 15 Subpart C 15.247 (DTS)
ISED RSS-247 Issue 2, February 2017

Test Report Serial No.: TUVR116-U2 Rev C (BLE)

This report supersedes: NONE

Applicant: Sonos Inc
614 Chapala St.
Santa Barbara, California 93101
USA

Issue Date: 25th July 2019

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
575 Boulder Court
Pleasanton California 94566
USA
Phone: +1 (925) 462-0304
Fax: +1 (925) 462-0306
www.micomlabs.com

ACCREDITED
TESTING CERT #2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

Table of Contents

1. ACCREDITATION, LISTINGS & RECOGNITION

1.1. TESTING ACCREDITATION

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard ISO/IEC 17025:2005. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-01.pdf

Accredited Laboratory

A2LA has accredited

MiCOM LABS

Pleasanton, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 14th day of May 2018.

President and CEO
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2019

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

1.2. RECOGNITION

MiCOM Labs, Inc has widely recognized wireless testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA countries. MiCOM Labs test reports are accepted globally.

Country	Recognition Body	Status	Phase	Identification No.
USA	Federal Communications Commission (FCC)	TCB	-	US0159 Listing #: 102167
Canada	Industry Canada (IC)	FCB	APEC MRA 2	US0159 Listing #: 4143A-2 4143A-3
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	APEC MRA 2	RCB 210
	VCCI	--	--	A-0012
Europe	European Commission	NB	EU MRA	NB 2280
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)	CAB	APEC MRA 1	
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)	CAB	APEC MRA 1	
Singapore	Infocomm Development Authority (IDA)	CAB	APEC MRA 1	
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)	CAB	APEC MRA 1	
Vietnam	Ministry of Communication (MIC)	CAB	APEC MRA 1	

EU MRA – European Union Mutual Recognition Agreement.
NB – Notified Body
APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement. Recognition agreement under which test lab is accredited to regulatory standards of the APEC member countries.

Phase I - recognition for product testing
Phase II – recognition for both product testing and certification

1.3. PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard ISO/IEC 17065:2012. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-02.pdf

Accredited Product Certification Body

A2LA has accredited

MiCOM LABS

Pleasanton, CA

This product certification body is accredited in accordance with the recognized International Standard ISO/IEC 17065:2012 *Requirements for bodies certifying products, processes and services*. This product certification body also meets the *A2LA R322 – Specific Requirements – Notified Body Accreditation Requirements* and *A2LA R308 - Specific Requirements - ISO-IEC 17065 - Telecommunication Certification Body Accreditation Program*. This accreditation demonstrates technical competence for a defined scope and the operation of a management system.

Presented this 14th day of May 2018

President and CEO
For the Accreditation Council
Certificate Number 2381.02
Valid to November 30, 2019

For the product certification schemes to which this accreditation applies, please refer to the organization's Product Certification Scope of Accreditation.

United States of America – Telecommunication Certification Body (TCB)
Industry Canada – Certification Body, CAB Identifier – US0159
Europe – Notified Body (NB), NB Identifier - 2280
Japan – Recognized Certification Body (RCB), RCB Identifier - 210

2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft	3rd May 2019	Initial Draft
Rev A	20th May 2019	Initial Release
Rev B	16th July 2019	Client required modification to Section 5.1 Technical Details
Rev C	25th July 2019	Client requested change to Section 5.6 Cabling and I/O Ports
.		
.		
.		

In the above table the latest report revision will replace all earlier versions.

3. TEST RESULT CERTIFICATE

Manufacturer:	Sonos Inc 614 Chapala St. Santa Barbara California 93101 USA	**Tested By:**	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Model:	S23	**Telephone:**	+1 925 462 0304
Type Of Equipment:	Home Audio Equipment	**Fax:**	+1 925 462 0306
S/N's:	48A6B820046C5, 48A6B820046E7		
Test Date(s):	29th April – 2nd May 2019	**Website:**	www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15 Subpart C 15.247 (DTS) ISED RSS-247 Issue 2 (BLE)	**EQUIPMENT COMPLIES**

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

Notes:

1. This document reports conditions under which testing was conducted and the results of testing performed.

2. Details of test methods used have been recorded and kept on file by the laboratory.

3. Test results apply only to the item(s) tested.

A2LA ACCREDITED
TESTING CERT #2381.01

Approved & Released for MiCOM Labs, Inc. by:

Graeme Grieve
Quality Manager MiCOM Labs, Inc.

Gordon Hurst
President & CEO MiCOM Labs, Inc.

4. REFERENCES AND MEASUREMENT UNCERTAINTY

4.1. Normative References

REF.	PUBLICATION	YEAR	TITLE
I	KDB 662911 D01 & D02	Oct 31 2013	Guidance for measurement of output emission of devices that employ single transmitter with multiple outputs or systems with multiple transmitters operating simultaneously in the same frequency band
II	KDB 558074 D01 v05	24th August 2018	Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices operating under section 15.247 of the FCC Rules.
III	A2LA	August 2018	R105 - Requirement's When Making Reference to A2LA Accreditation Status
IV	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
V	ANSI C63.4	2014	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
VI	CISPR 32	2015	Electromagnetic compatibility of multimedia equipment - Emission requirements
VII	ETSI TR 100 028	2001-12	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
VIII	FCC 47 CFR Part 15.247	2016	Radio Frequency Devices; Subpart C – Intentional Radiators
IX	ICES-003	Issue 5 March 2019	Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement.
X	M 3003	Edition 3 Nov.2012	Expression of Uncertainty and Confidence in Measurements
XI	RSS-247 Issue 2	Feb 2017	Digital Transmission Systems (DTSs), Frequency Hopping System (FHSs) and Licence-Exempt Local Area Network (LE-LEN) Devices
XII	RSS-Gen Issue 5	April 2018	General Requirements for Compliance of Radio Apparatus
XIII	FCC 47 CFR Part 2.1033	2016	FCC requirements and rules regarding photographs and test setup diagrams.
XIV	KDB 789033 D02 V02r01	14th December, 2017	Guidelines For Compliance Testing Of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
XV	15.207	28th June 2019	Conducted limits

4.2. Test and Uncertainty Procedure

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.

MiCOM Labs, 575 Boulder Court, Pleasanton, California 94566 USA, Phone: +1 (925) 462 0304, Fax: +1 (925) 462 0306, www.micomlabs.com

5. PRODUCT DETAILS AND TEST CONFIGURATIONS

5.1. Technical Details

Details	Description
Purpose:	Test of the Sonos Inc S23 to: FCC CFR 47 Part 15 Subpart C 15.247 (DTS). Radio Frequency Devices; Subpart C – Intentional Radiators ISED RSS-247 Digital Transmission Systems (DTSs), Frequency Hopping System (FHSS) and Licence-Exempt Local Area Network (LE-LEN) Devices
Applicant:	Sonos Inc 614 Chapala St. Santa Barbara California 93101 USA
Manufacturer:	Sonos Inc
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	TUVR116-U2
Date EUT received:	22nd April 2019
Standard(s) applied:	FCC CFR 47 Part 15 Subpart C 15.247 (DTS)
Dates of test (from - to):	29th April – 2nd May 2019
No of Units Tested:	2
Product Family Name:	N/A
Model(s):	S23
Location for use:	Indoors
Declared Frequency Range(s):	2400 - 2483.5 MHz;
Type of Modulation:	GFSK
EUT Modes of Operation:	BLE
Declared Nominal Output Power (dBm):	0 dBm
Transmit/Receive Operation:	Transceiver
Rated Input Voltage and Current:	12Vdc 1A
Operating Temperature Range:	0ºC - 40ºC
ITU Emission Designator:	1M2G1D
Hardware Rev:	A100
Firmware Ver:	See Software Rev.
Software Rev:	52.10-64150-1-29

5.2. Scope Of Test Program

Sonos Inc S23

The scope of the test program was to test the Sonos Inc S23 configurations in the frequency ranges 2400 - 2483.5 MHz; for compliance against the following specifications:

FCC CFR 47 Part 15 Subpart C 15.247 (DTS)
Radio Frequency Devices; Subpart C – Intentional Radiators

ISED RSS-247 Issue 2
Digital Transmission Systems (DTSs), Frequency Hopping System (FHSs) and Licence-Exempt Local Area Network (LE-LEN) Devices

5.3. Equipment Model(s) and Serial Number(s)

Type (EUT/ Support)	Equipment Description	Mfr	Model No.	Serial No.
EUT	Home Audio Equipment	SONOS Inc.	S23	48A6B820046C5
EUT	Home Audio Equipment	SONOS Inc.	S23	48A6B820046E7
EUT	Power Supply	SONOS Inc	CPS012027U	
Support	Laptop	Lenovo	X230	

5.4. External A.C/D.C. Power Adaptor

AC/DC Adaptor
Manufacturer: SONOS Model: CPS012027U I: 100 – 240 V_{AC}, 50/60 Hz 0: +12 V_{DC} 1.00 A

5.5. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
integral	Welshin	--	PIFA	3.3	N/A	360º	N/A	2400 - 2483.5

BF Gain - Beamforming Gain
Dir BW - Directional BeamWidth
X-Pol - Cross Polarization

5.6. Cabling and I/O Ports

Port Type	Max Cable Length	# of Ports	Conn Type	Data Type	Bit Rate	Environment
ENET	>10m	2	No	Conn Type	10,100,1000	
DC	1m	1				
Other Port Type*		*	*	*		

*This port(s) is fully described in the technical documentation included in the related FCC and ISED filings.

5.7. Test Configurations

Results for the following configurations are provided in this report:

Operational Mode(s) (802.11a/b/g/n/ac)	Data Rate with Highest Power MBit/s	Channel Frequency (MHz)		
		Low	Mid	High
2400 - 2483.5 MHz				
BLE	1	2,402.00	2426.00	2,480.00

5.8. Equipment Modifications

The following modifications were required to bring the equipment into compliance:
1. NONE

5.9. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:
1. NONE

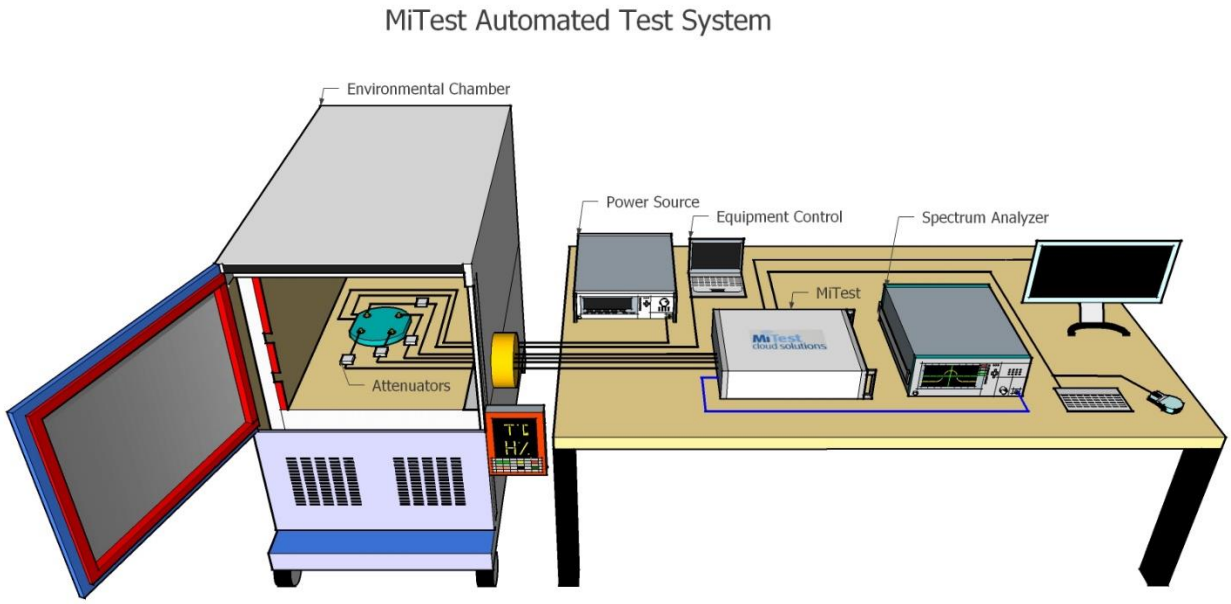
6. TEST SUMMARY

List of Measurements

Test Header	Result	Data Link
6 dB & 99% Bandwidth	Complies	View Data
Conducted Output Power	Complies	View Data
Power Spectral Density	Complies	View Data
Emissions	Complies	-
(1) Conducted Emissions	Complies	-
(i) Conducted Spurious Emissions	Complies	View Data
(ii) Conducted Band-Edge Emissions	Complies	View Data
(2) Radiated Emissions	Complies	-
(i) TX Spurious & Restricted Band Emissions	Complies	View Data
(ii) Restricted Edge & Band-Edge Emissions	Complies	View Data
(3) Digital Emissions (0.03 - 1 GHz)	Complies	View Data
(4) AC Wireline Emissions	Complies	View Data
RF Unique Connector	Complies (Integral Antennas)	-

7. TEST EQUIPMENT CONFIGURATION(S)

7.1. Conducted Test Setup



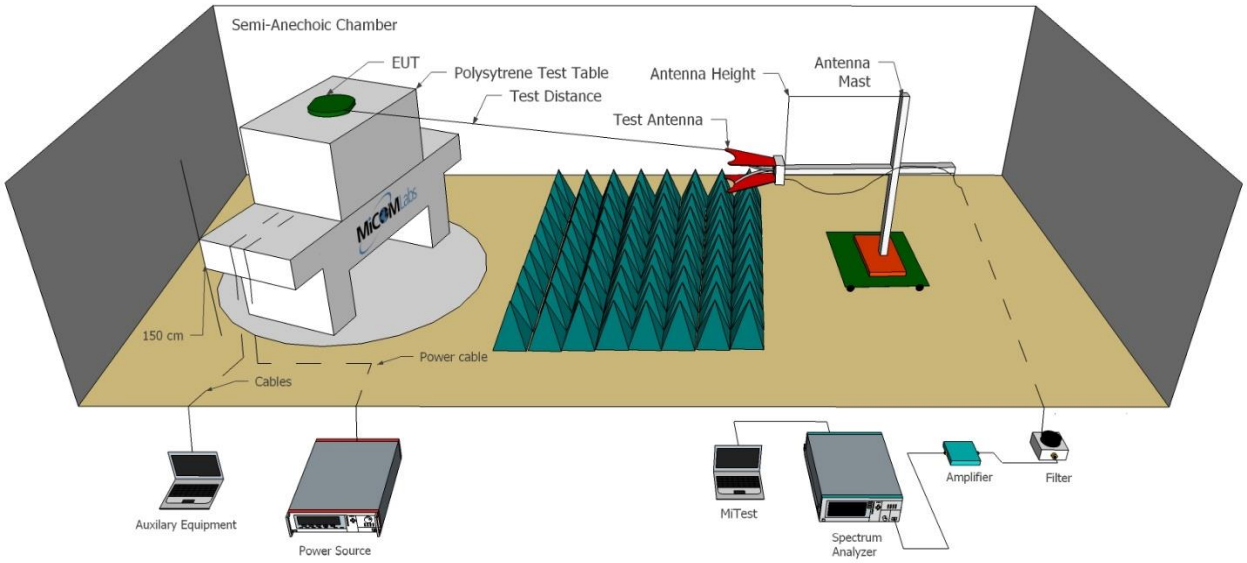
A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
249	Resistance Thermometer	Thermotronics	GR2105-02	9340 #2	30 Oct 2019
361	Desktop for RF#1, Labview Software installed	Dell	Vostro 220	WS RF#1	Not Required
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2019
405	DC Power Supply 0-60V	Agilent	6654A	MY4001826	Cal when used
408	USB to GPIB interface	National Instruments	GPIB-USB HS	14C0DE9	Not Required
445	PoE Injector	D-Link	DPE-101GL	QTAH1E2000625	Not Required
461	Spectrum Analyzer	Agilent	E4440A	MY46185537	20 Sep 2019
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019
75	Environmental Chamber	Thermatron	SE-300-2-2	27946	24 Feb 2020

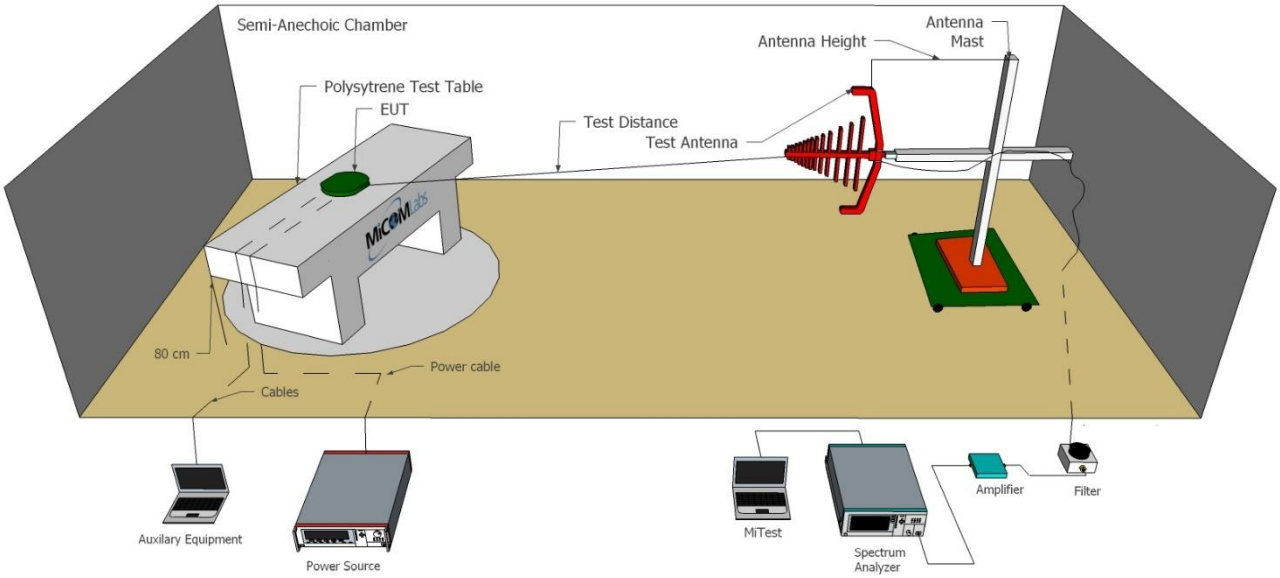
7.2. Radiated Emissions - 3m Chamber

The following tests were performed using the radiated test set-up shown in the diagram below. Radiated emissions above and below 1GHz.

Radiated Emissions Above 1GHz Test Setup



Radiated Emissions Below 1GHz Test Setup

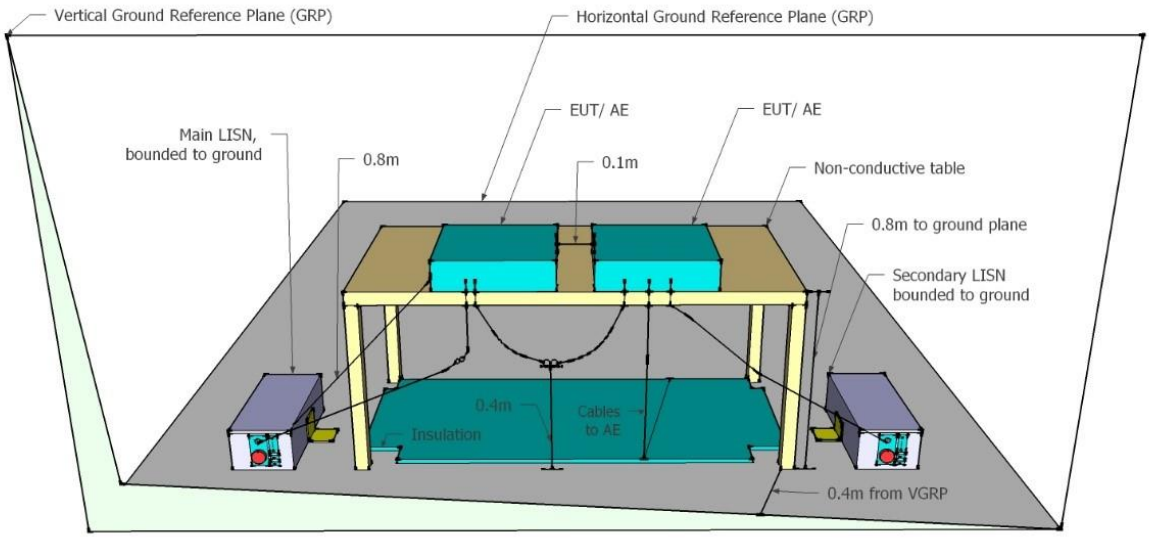


A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
170	Video System Controller for Semi Anechoic Chamber	Panasonic	WV-CU101	04R08507	Not Required
298	3M Radiated Emissions Chamber Maintenance Check	MiCOM	3M Chamber	298	21 Apr 2020
336	Active Loop Antenna	Emco	6502	00060498	29 Nov 2019
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	4 Apr 2020
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2019
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	12 Apr 2020
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 Oct 2019
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	12 Apr 2020
410	Desktop Computer	Dell	Inspiron 620	WS38	Not Required
411	Mast/Turntable Controller	Sunol Sciences	SC98V	060199-1D	Not Required
412	USB to GPIB Interface	National Instruments	GPIB-USB HS	11B8DC2	Not Required
413	Mast Controller	Sunol Science	TWR95-4	030801-3	Not Required
415	Turntable Controller	Sunol Sciences	Turntable Controller	None	Not Required
416	Gigabit ethernet filter	ETS-Lingren	Gigafoil 260366	None	Not Required
447	MiTest Rad Emissions Test Software	MiCOM	Rad Emissions Test Software Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	9 Oct 2019
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	9 Oct 2019
464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	9 Oct 2019
465	Low Pass Filter DC-1000 MHz	Mini-Circuits	NLP-1200+	VUU01901402	9 Oct 2019
480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	24 Aug 2019
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	24 Aug 2019
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019
518	Cable - Amp to Antenna	SRC Haverhill	157-3051574	518	24 Aug 2019

7.3. ac Wireline Emissions

Test Setup – Power Input / Output Port



A full system calibration was performed on the test station and any resulting system losses (or gains) were taken into account in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
184	Pulse Limiter	Rhode & Schwarz	ESH3Z2	357.8810.52	6 Oct 2019
190	LISN (two-line V-network)	Rhode & Schwarz	ESH3Z5	836679/006	18 Oct 2019
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	2 Jul 2019
295	Conducted Emissions Chamber Maintenance Check	MiCOM	Conducted Emissions Chamber	295	19 Jun 2019
307	BNC-CABLE	Megaphase	1689 1GVT4	15F50B002	11 Jun 2019
316	Dell desktop computer workstation	Dell	Desktop	WS04	Not Required
372	AC Variable PS	California Instruments	1251P	L06951	Cal when used
388	LISN (3 Phase) 9kHz - 30MHz	Rohde & Schwarz	ESH2-Z5	892107/022	20 Oct 2019
496	MiTest Conducted Emissions test software.	MiCOM	Test Software Version 1.0	496	Not Required
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019

8. MEASUREMENT AND PRESENTATION OF TEST DATA

The measurement and graphical data presented in this test report was generated automatically using state-of-the-art technology creating an easy to read report structure. Numerical measurement data is separated from supporting graphical data (plots) through hyperlinks. Numerical measurement data can be reviewed without scrolling through numerous graphical pages to arrive at the next data matrix.

Plots have been relegated into the Appendix 'Graphical Data'.

Test and report automation was performed by MiTest. MiTest is an automated test system developed by MiCOM Labs. MiTest is the first cloud based modular test system enabling end-to-end automation of regulatory compliance testing for conducted RF testing.

The Patented MiCOM Labs "MiTest" Automated Test System"

9. TEST RESULTS

9.1. 6 dB & 99% Bandwidth

Conducted Test Conditions for 6 dB and 99% Bandwidth			
Standard:	FCC CFR 47:15.247 RSS-247	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	6 dB and 99 % Bandwidth	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.247 (a)(2) RSS-247 5.2 a	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for 6 dB and 99% Bandwidth Measurement
The bandwidth at 6 dB and 99 % was measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

Testing was performed under ambient conditions at nominal voltage. Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured and reported.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Limits for 6 dB and 99% Bandwidth

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(2) Systems using digital modulation techniques may operate in the 902-928 MHz and 2400-2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

Equipment Configuration for 6 dB & 99% Bandwidth			
Variant:	BLE	**Duty Cycle (%):**	66
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured 6 dB Bandwidth (MHz) Port(s)				6 dB Bandwidth (MHz)		Limit	Lowest Margin
MHz	a	b	c	d	Highest	Lowest	KHz	MHz
2402.0	0.689	--	--	--	0.689	0.689	≥500.0	-0.19
2426.0	0.689	--	--	--	0.689	0.689	≥500.0	-0.19
2480.0	0.689	--	--	--	0.689	0.689	≥500.0	-0.19

Test Frequency	Measured 99% Bandwidth (MHz) Port(s)				Maximum 99% Bandwidth (MHz)
MHz	a	b	c	d	
2402.0	1.194	--	--	--	1.194
2426.0	1.194	--	--	--	1.194
2480.0	1.194	--	--	--	1.194

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

9.2. Conducted Output Power

Conducted Test Conditions for Fundamental Emission Output Power			
Standard:	FCC CFR 47:15.247 RSS-247	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Output Power	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.247 (b) & (c) RSS-247 5.4 (d)	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Fundamental Emission Output Power Measurement
In the case of average power measurements an average power sensor was utilized.

For peak power measurements the spectrum analyzer built-in power function was used to integrate peak power over the 20 dB bandwidth.

Testing was performed under ambient conditions at nominal voltage only. Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured, summed (Σ) and reported.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.
Supporting Information
Calculated Power = A + G + Y+ 10 log (1/x) dBm

A = Total Power [10*Log10 ($10^{a/10}$ + $10^{b/10}$ + $10^{c/10}$ + $10^{d/10}$)]
G = Antenna Gain
Y = Beamforming Gain
x = Duty Cycle (average power measurements only)

Limits for Fundamental Emission Output Power
(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following for non-frequency hopping systems:

(3) For systems using digital modulation in the 902-928 MHz and 2400-2483.5 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(c) Operation with directional antenna gains greater than 6 dBi.
(1) Fixed point-to-point operation:
(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted 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.

(iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated 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.

(2) In addition to the provisions in paragraphs (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

Equipment Configuration for Peak Output Power			
Variant:	BLE	**Duty Cycle (%):**	66.0
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	3.30
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm) Port(s)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
MHz	a	b	c	d	dBm	dBm	dB	
2402.0	-7.02	--	--	--	-7.02	30.00	-37.02	Max
2426.0	-6.97	--	--	--	-6.97	30.00	-36.97	Max
2480.0	-6.62	--	--	--	-6.62	30.00	-36.62	Max

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Measurement Uncertainty:	±1.33 dB

The above measurements are true pulse readings and therefore a Duty Cycling correction factor is not required.

2402 MHz EIRP = -3.72dBm

2426 MHz EIRP = -3.67dBm

2480 MHz EIRP = -3.32dBm

9.3. Power Spectral Density

Conducted Test Conditions for Power Spectral Density			
Standard:	FCC CFR 47:15.247 RSS-247	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Power Spectral Density	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.247 (e) RSS-247 5.2 b	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Power Spectral Density
The transmitter output was connected to a spectrum analyzer and the measured made in a 3 kHz resolution bandwidth using the analyzer auto-coupled sweep-time. A peak value was found over the full emission bandwidth and the spectrum downloaded for post processing purposes.

Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured separately. The Peak Power Spectral Density is the highest level found across the emission bandwidth. With multiple antenna port measurements the numerical analyzer data from each port is summed (å) and a link to this additional graphic is provided.

Testing was performed under ambient conditions at nominal voltage only.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Measure and sum the spectra across the outputs. With this technique, spectra are measured at each output of the device at the required resolution bandwidth. The individual spectra are then summed mathematically in linear power units. Unlike in-band power measurements, in which the sum involves a single measured value (output power) from each output, measurements for compliance with PSD limits involve summing entire spectra across corresponding frequency bins on the various outputs. Consistency is maintained for any device with multiple transmitter outputs to be certain the individual outputs are all aligned with the same span and same number of points. In this instance, the linear power spectrum value within the first spectral bin of output 0 is summed with that in the first spectral bin of output 1, and the first spectral bin of output 2, and so on up to the Nth output to obtain the true value for the first frequency bin of the summed spectrum. The summed spectrum value for each frequency bin is computed in this fashion. These summed spectral values were post processed and the resulting numerical and graphical data presented.

NOTE:
It may be observed that the spectrum in some antenna port plots break the limit line however this in itself does NOT constitute a failure. In all cases a spectrum summation plot is provided in order to prove compliance. A failure occurs only after the summation of all spectrum plots have been summed and are found to be greater than the limit line.

Supporting Information
Calculated Power = A + 10 log (1/x) dBm
A = Total Power Spectral Density [10 Log10 ($10^{a/10}$ + $10^{b/10}$ + $10^{c/10}$ + $10^{d/10}$)]
x = Duty Cycle

Limits Power Spectral Density
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than +8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Equipment Configuration for Power Spectral Density - Peak			
Variant:	BLE	**Duty Cycle (%):**	66.0
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	3.30
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Power Spectral Density Port(s) (dBm/3KHz)				Amplitude Summation	Limit	Margin
MHz	a	b	c	d	dBm/3KHz	dBm/3KHz	dB
2402.0	-8.531	--	--	--	-8.531	2.0	-10.5
2426.0	-7.271	--	--	--	-7.271	2.0	-9.3
2480.0	-6.003	--	--	--	-6.003	2.0	-8.0

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

9.4. Emissions

9.4.1. Conducted Emissions

9.4.1.1. Conducted Spurious Emissions

Conducted Test Conditions for Transmitter Conducted Spurious and Band-Edge Emissions			
Standard:	FCC CFR 47:15.247 RSS-247 Issue 2	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Max Unwanted Emission Levels	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.247 (d) RSS-247 5.5	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Transmitter Conducted Spurious and Band-Edge Emissions Measurement
Transmitter Conducted Spurious and Band-Edge emissions were measured at a limit of 30 dBc (average detector) or 20 dBc (peak detector) below the highest in-band spectral density measured with a spectrum analyzer connected to the antenna terminal. Measurements were made while EUT was operating in transmit mode of operation at the appropriate centre frequency closest to the band-edge. Emissions were maximized during the measurement and limits derived from the peak spectral power and drawn on each plot.

Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured separately. Testing was performed under ambient conditions at nominal voltage only.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Limits Transmitter Conducted Spurious and Band-Edge Emissions
(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. 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) (see §15.205(c)).

Measured Frequency Range
Conducted spurious emissions were measured from 9 kHz to 26 GHz covering the entire range specified under FCC Section 15.33. No spurious emissions were found within 6 dB of the limit.

Equipment Configuration for Conducted Spurious Emissions - Peak			
Variant:	BLE	**Duty Cycle (%):**	66
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Frequency Range	Conducted Spurious Emissions - Peak (dBm)							
		Port a		Port b		Port c		Port d	
MHz	MHz	SE	Limit	SE	Limit	SE	Limit	SE	Limit
2402.0	30.0 - 26000.0	-40.778	-25.62	--	--	--	--	--	--
2426.0	30.0 - 26000.0	-39.551	-28.91	--	--	--	--	--	--
2480.0	30.0 - 26000.0	-39.698	-25.64	--	--	--	--	--	--

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

9.4.1.2. Conducted Band-Edge Emissions

Low Channel

Equipment Configuration for Conducted Low Band-Edge Emissions - Peak

Variant:	BLE	**Duty Cycle (%):**	66.0
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Channel Frequency:	2402.0 MHz					
Band-Edge Frequency:	2400.0 MHz					
Test Frequency Range:	2200.0 - 2405.0 MHz					
Port(s)	**Band-Edge Markers and Limit**			**Revised Limit**		**Margin**
	M1 Amplitude (dBm)	**Plot Limit (dBm)**	**M2 Frequency (MHz)**	**Amplitude (dBm)**	**M2A Frequency (MHz)**	**(MHz)**
a	-39.76	-25.95	2401.30	--	--	-13.810

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

High Channel

Equipment Configuration for Conducted High Band-Edge Emissions - Peak			
Variant:	BLE	**Duty Cycle (%):**	66.0
Data Rate:	125 kBit/s	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Channel Frequency:	2480.0 MHz					
Band-Edge Frequency:	2483.5 MHz					
Test Frequency Range:	2479.0 - 2500.0 MHz					
Port(s)	**Band-Edge Markers and Limit**			**Revised Limit**		**Margin**
	M3 Amplitude (dBm)	**Plot Limit (dBm)**	**M2 Frequency (MHz)**	**Amplitude (dBm)**	**M2A Frequency (MHz)**	**(MHz)**
a	-42.724	-25.08	2483.50	--	--	-17.6443

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

9.4.2. Radiated Emissions

9.4.2.3. TX Spurious & Restricted Band Emissions

Radiated Test Conditions for Radiated Spurious and Band-Edge Emissions (Restricted Bands)			
Standard:	FCC CFR 47 Part 15 Subpart C RSS-GEN Issue 5	**Ambient Temp. (ºC):**	20.0 - 24.5
Test Heading:	Radiated Spurious and Band-Edge Emissions	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.205, 15.209 RSS-Gen 8.9	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Radiated Spurious and Band-Edge Emissions (Restricted Bands)
Radiated emissions for restricted bands above 1 GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarities. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. Depending on the frequency band spanned a notch filter and waveguide filter was used to remove the fundamental frequency. The highest emissions relative to the limit are listed for each frequency spanned. Measurements on any restricted band frequency or frequencies above 1 GHz are based on the use of measurement instrumentation employing peak and average detectors. All measurements were performed using a resolution bandwidth of 1 MHz.

Test configuration and setup for Radiated Spurious and Band-Edge Measurement were per the Radiated Test Set-up specified in this document.

Limits for Restricted Bands
Peak emission: 74 dBuV/m
Average emission: 54 dBuV/m

Field Strength Calculation
The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.
FS = R + AF + CORR - FO

where:
FS = Field Strength
R = Measured Spectrum analyzer Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain
FO = Distance Falloff Factor
NFL = Notch Filter Loss or Waveguide Loss

Example:
Given receiver input reading of 51.5 dBmV; Antenna Factor of 8.5 dB; Cable Loss of 1.3 dB; Falloff Factor of 0 dB, an Amplifier Gain of 26 dB and Notch Filter Loss of 1 dB. The Field Strength (FS) of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3 dBmV/m

Conversion between dBmV/m (or dBmV) and mV/m (or mV) are as follows:
Level (dBmV/m) = 20 * Log (level (mV/m))

40 dBmV/m = 100 mV/m
48 dBmV/m = 250 mV/m
Restricted Bands of Operation (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:

Frequency Band			
MHz	**MHz**	**MHz**	**GHz**
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
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	2690-2900	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	Above 38.6
13.36-13.41			

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

(c) Except as provided in paragraphs (d) and (e) of this section, regardless of the field strength limits specified elsewhere in this subpart, the provisions of this section apply to emissions from any intentional radiator.

(d) The following devices are exempt from the requirements of this section:

(1) Swept frequency field disturbance sensors operating between 1.705 and 37 MHz provided their emissions only sweep through the bands listed in paragraph (a) of this section, the sweep is never stopped with the fundamental emission within the bands listed in paragraph (a) of this section, and the fundamental emission is outside of the bands listed in paragraph (a) of this section more than 99% of the time the device is actively transmitting, without compensation for duty cycle.

(2) Transmitters used to detect buried electronic markers at 101.4 kHz which are employed by telephone companies.

(3) Cable locating equipment operated pursuant to §15.213.

(4) Any equipment operated under the provisions of §15.253, 15.255, and 15.256 in the frequency band 75-85 GHz, or §15.257 of this part.

(5) Biomedical telemetry devices operating under the provisions of §15.242 of this part are not subject to the restricted band 608-614 MHz but are subject to compliance within the other restricted bands.

(6) Transmitters operating under the provisions of subparts D or F of this part.

(7) Devices operated pursuant to §15.225 are exempt from complying with this section for the 13.36-13.41 MHz band only.

(8) Devices operated in the 24.075-24.175 GHz band under §15.245 are exempt from complying with the requirements of this section for the 48.15-48.35 GHz and 72.225-72.525 GHz bands only, and shall not exceed the limits specified in §15.245(b).

(9) Devices operated in the 24.0-24.25 GHz band under §15.249 are exempt from complying with the requirements of this section for the 48.0-48.5 GHz and 72.0-72.75 GHz bands only, and shall not exceed the limits specified in §15.249(a).

(e) Harmonic emissions appearing in the restricted bands above 17.7 GHz from field disturbance sensors operating under the provisions of §15.245 shall not exceed the limits specified in §15.245(b).

§15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permItted under other sections of this part, e.g., §§15.231 and 15.241.

(b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

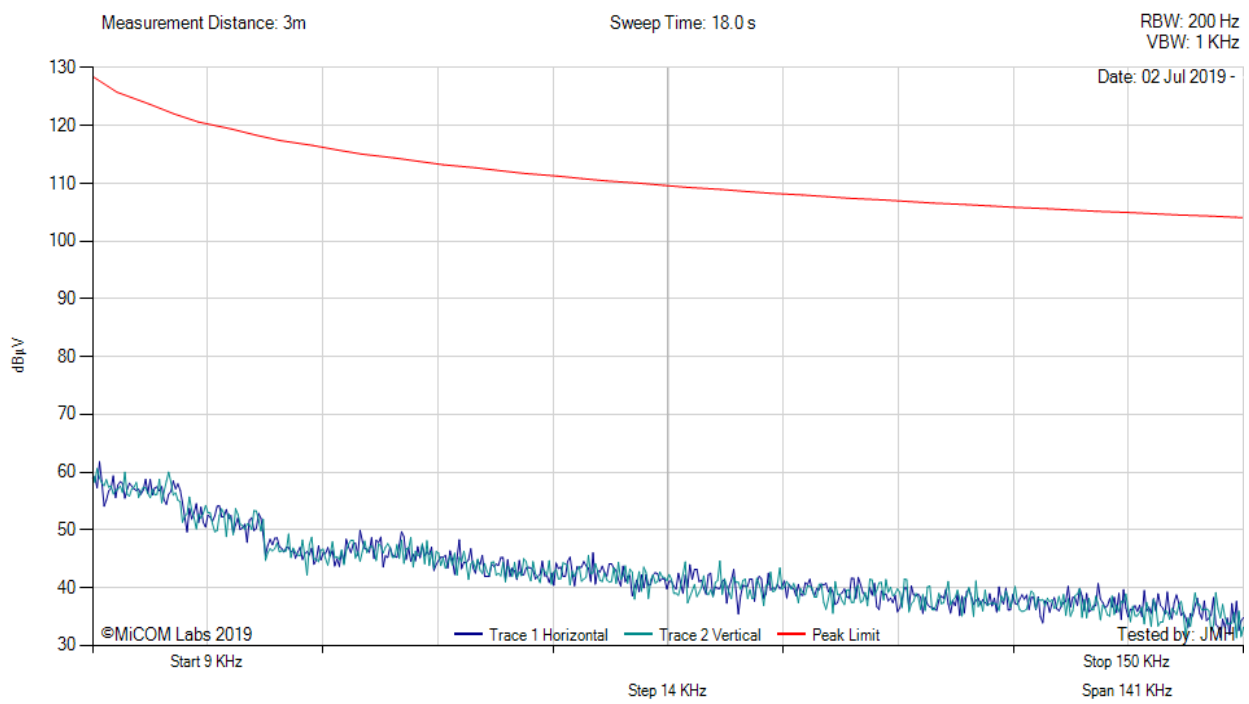
(f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device.

(g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

TX Spurious Emissions 9 KHz – 30 MHz

No Emissions found within 20 dB of Limit. Per 15.31 (o) The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

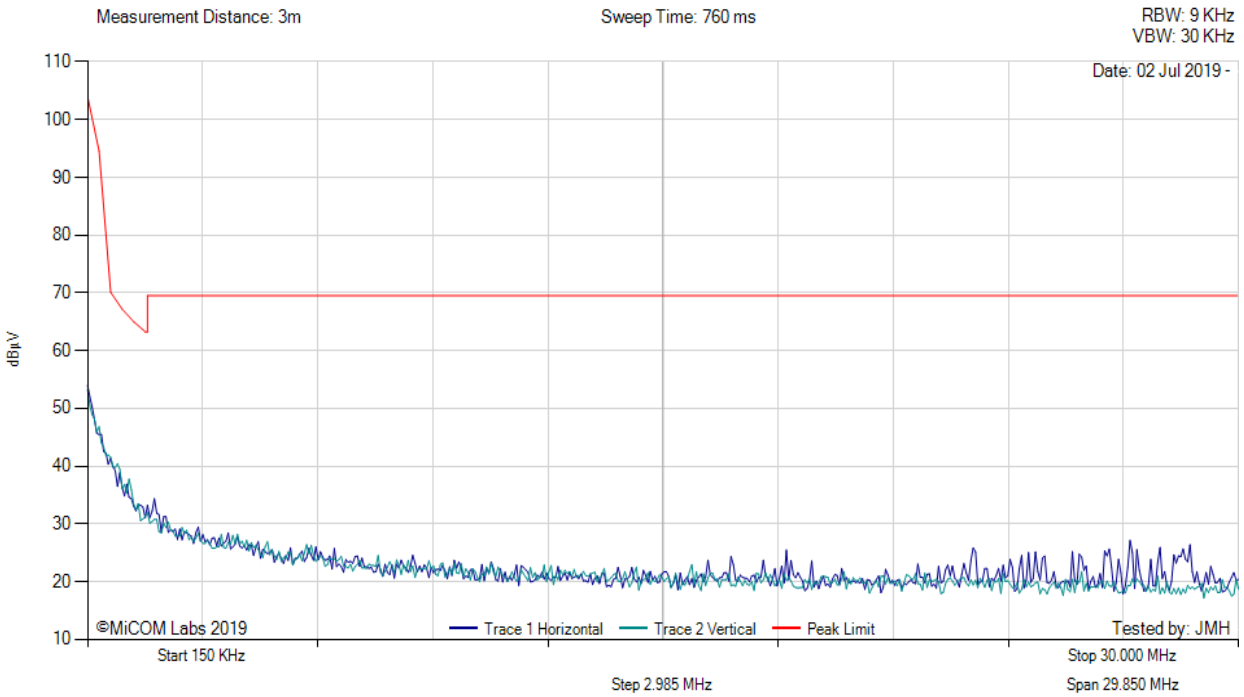
Variant: S23 , Test Freq: 2402.00 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

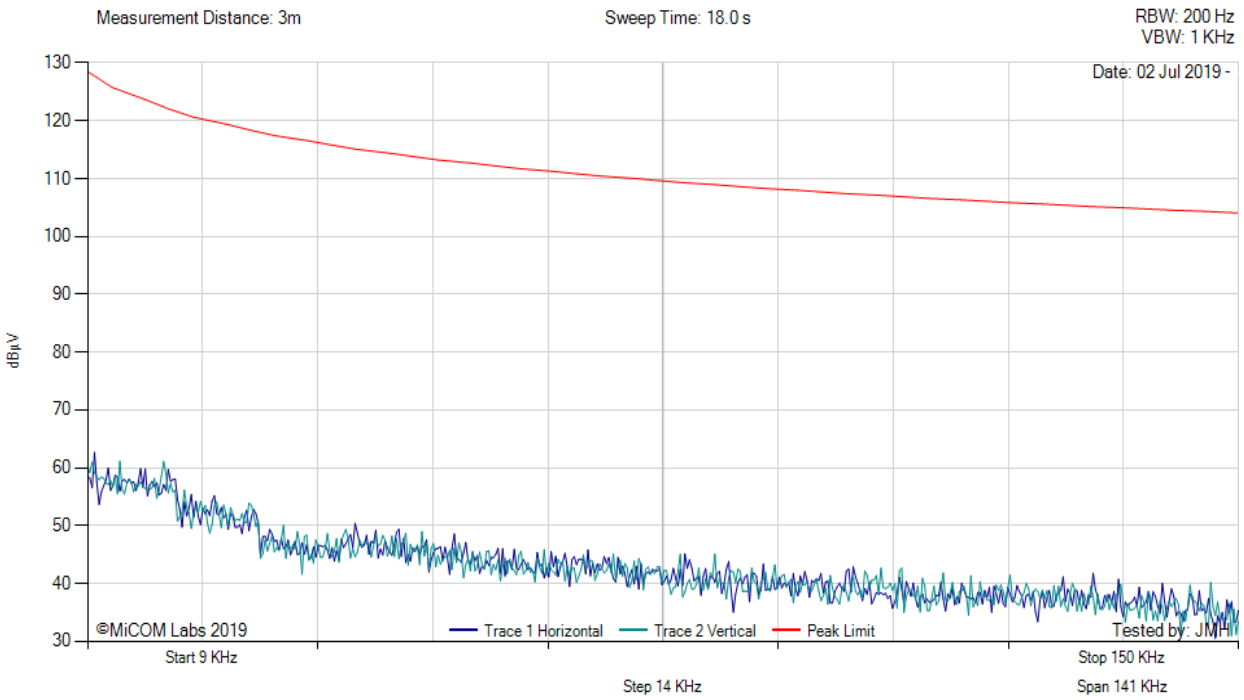
Variant: S23, Test Freq: 2402.00 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

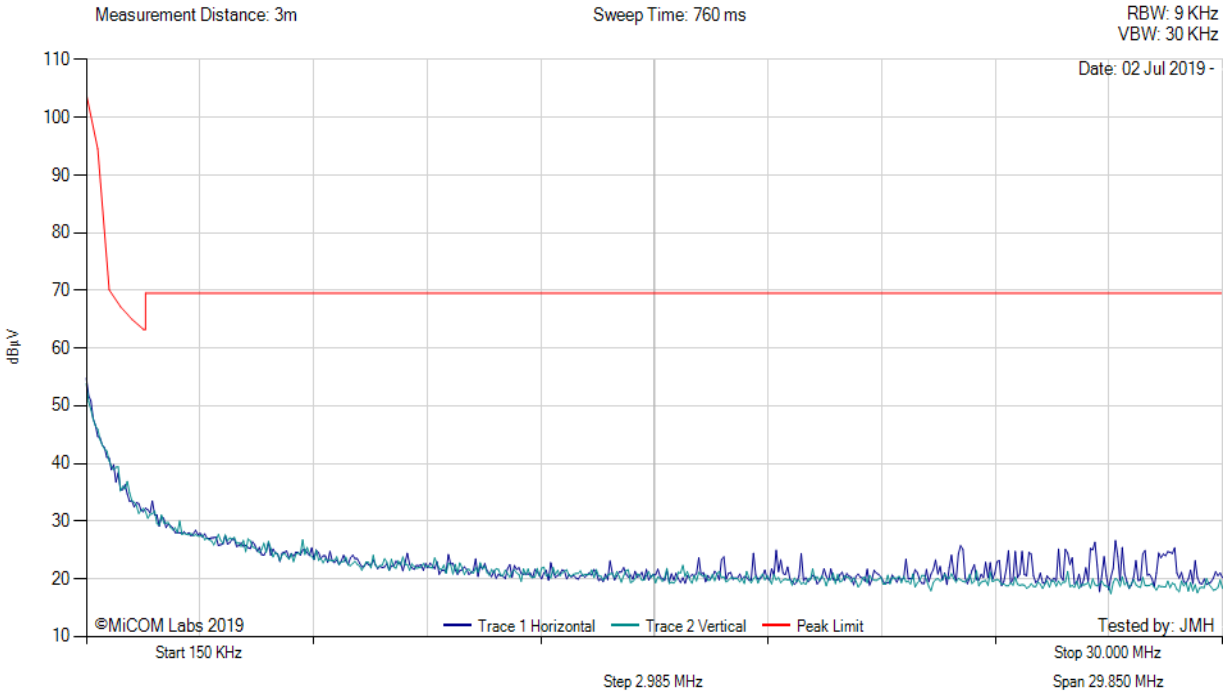
Variant S23, Test Freq: 2426.00 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

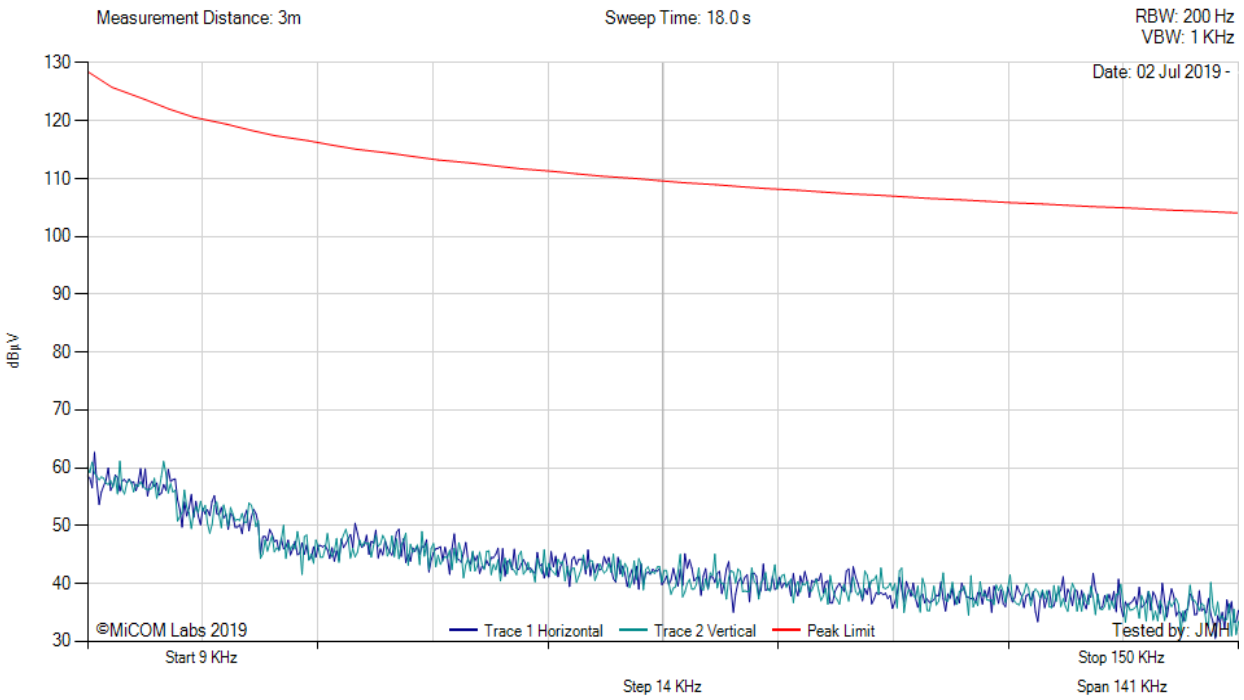
Variant: S23, Test Freq: 2426 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

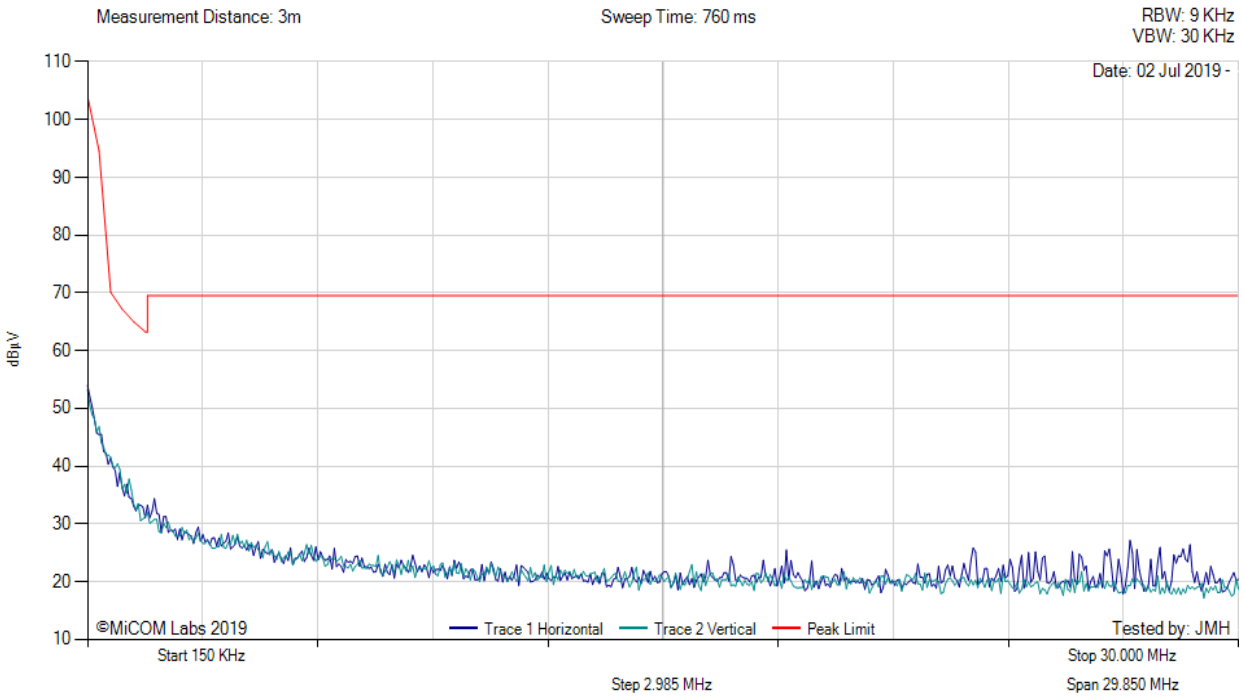
Variant: S23 , Test Freq: 2480.00 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

Variant: S23, Test Freq: 2480.00 MHz, Power Setting: max



There are no emissions found within 20dB of the limit line.

Test Notes: Eut powered by AC/DC PS. BLE. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back. EUT transmitting maximum power.

Equipment Configuration for TX Spurious & Restricted Band Emissions 1 – 18 GHz			
Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2402.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results
Click here to view measurement data...
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload. No Tx Spurious Emissions were found. EUT transmitting maximum power.

Equipment Configuration for TX Spurious & Restricted Band Emissions 1 – 18 GHz

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2426.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

1000.00 - 18000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	4852.03	65.52	-2.53	-12.40	50.59	Max Peak	Horizontal	102	4	74.0	-23.4	Pass
#2	4852.03	46.05	-2.53	-12.40	31.12	Max Avg	Horizontal	102	4	54.0	-22.9	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload.

Equipment Configuration for TX Spurious & Restricted Band Emissions 1 – 18 GHz

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2480.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

1000.00 - 18000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	4960.06	64.93	-2.55	-12.13	50.25	Max Peak	Horizontal	147	46	74.0	-23.8	Pass
#2	4960.06	49.15	-2.55	-12.13	36.27	Max Avg	Horizontal	147	46	54.0	-17.7	Pass

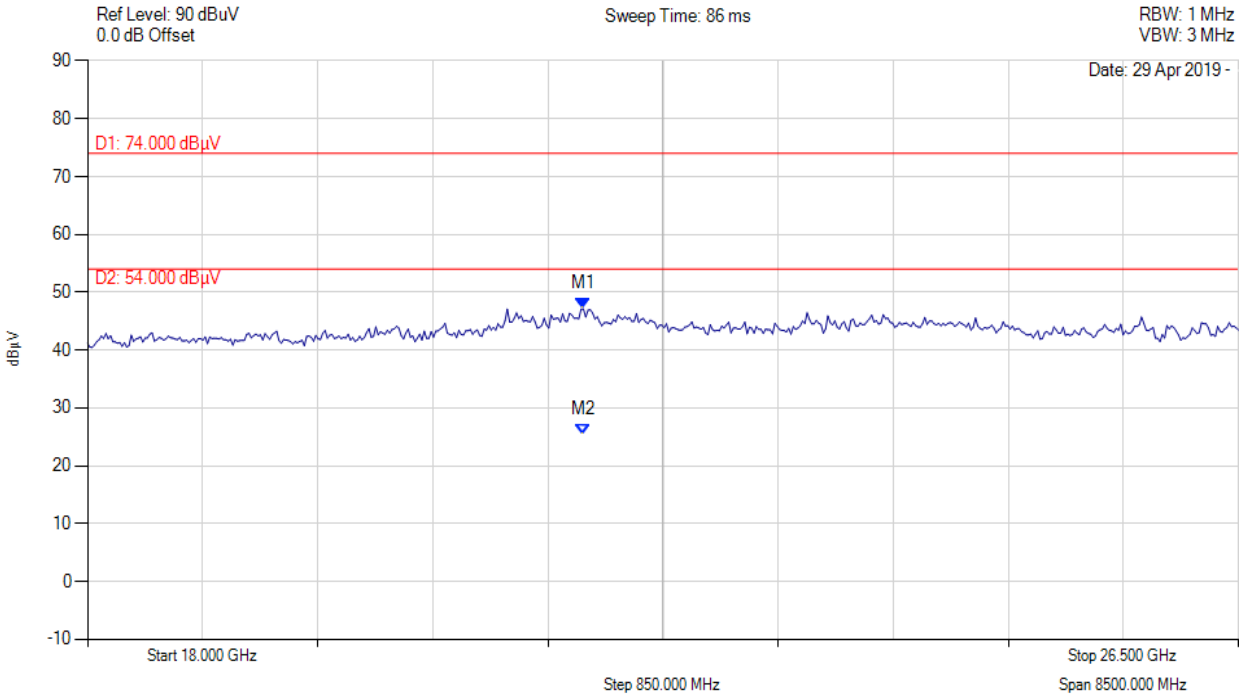
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload. DC Correction 1.8 dB.

Equipment Configuration for TX Spurious & Restricted Band Emissions 18 – 26.5 GHz			
Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2402.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload EUT transmitting maximum power.

TX SPURIOUS & RESTRICTED BAND EMISSIONS 18.0 -26.5 GHz

Variant: BLE, Test Freq: 2402.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 21.662 GHz : 47.126 dBµV M2 : 21.662 GHz : 25.426 dBµV	Channel Frequency: 2402.00 MHz

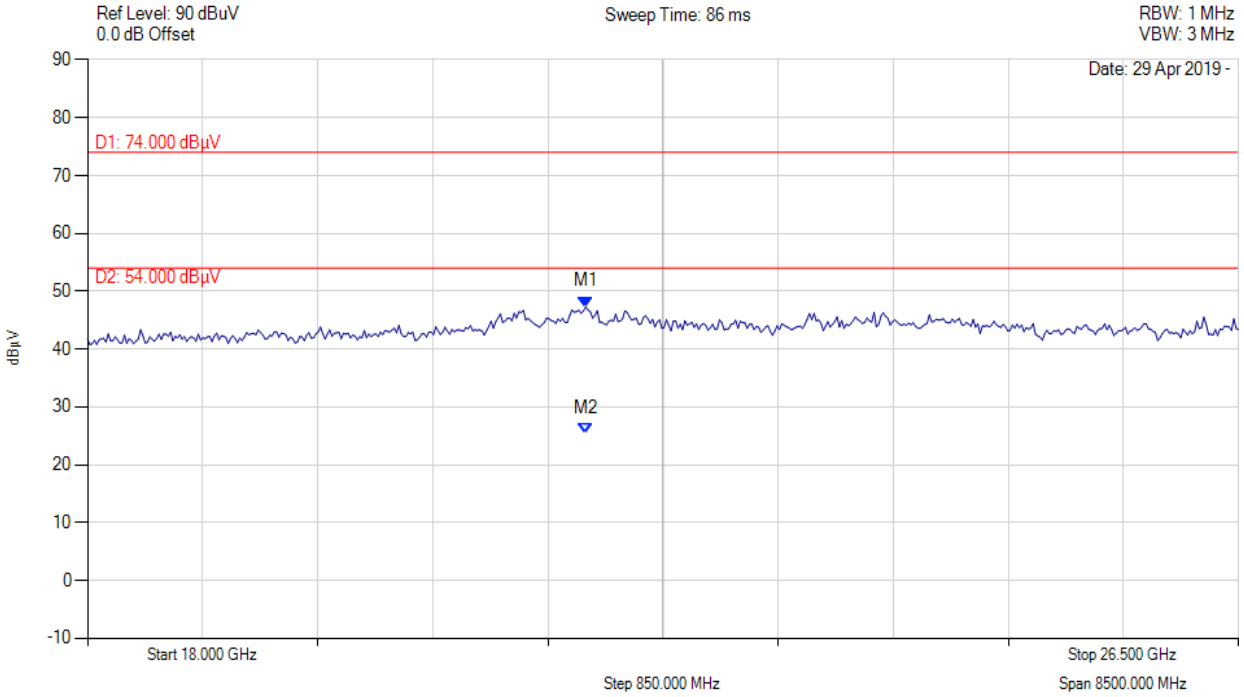
*Trace is max hold composite of vertical and horizontal orientations

Equipment Configuration for TX Spurious & Restricted Band Emissions 18 – 26.5 GHz			
Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2426.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload EUT transmitting maximum power.

TX SPURIOUS & RESTRICTED BAND EMISSIONS 18.0 -26.5 GHz

Variant: BLE, Test Freq: 2426.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



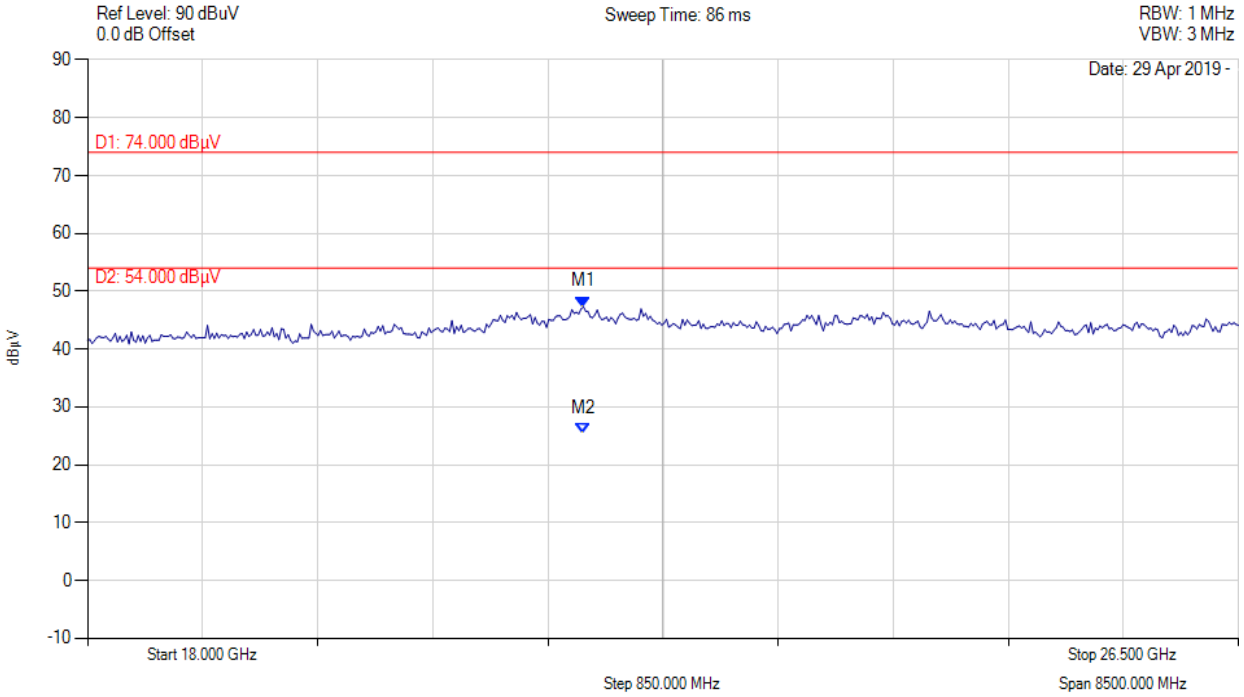
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 21.679 GHz : 47.311 dBµV M2 : 21.679 GHz : 25.308 dBµV	Channel Frequency: 2426.00 MHz

Equipment Configuration for TX Spurious & Restricted Band Emissions 18 – 26.5 GHz			
Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2480.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload EUT transmitting maximum power.

TX SPURIOUS & RESTRICTED BAND EMISSIONS 18.0 -26.5 GHz

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 21.662 GHz : 47.330 dBµV M2 : 21.662 GHz : 25.488 dBµV	Channel Frequency: 2480.00 MHz

9.4.2.4. Restricted Edge & Band-Edge Emissions

WD PCB		Band-Edge Freq	Limit 74.0dBµV/m	Limit 54.0dBµV/m	Power Setting
Operational Mode	Operating Frequency (MHz)	MHz	dBµV/m	dBµV/m	
BLE	2402.00	2390.00	57.05	37.57	Max
BLE	2480.00	2483.50	67.85	38.44	Max

Equipment Configuration for Radiated - Lower Restricted Band-Edge Emissions

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.30	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2402.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

2310.00 - 2422.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	2390.00	5.58	-1.77	31.96	37.57	Max Avg	Horizontal	148	36	54.0	-16.4	Pass
#2	2390.00	26.86	-1.77	31.96	57.05	Max Peak	Horizontal	148	36	74.0	-17.0	Pass
#3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. DC Correction 1.8 dB.												

Equipment Configuration for Radiated - Upper Restricted Band-Edge Emissions			
Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	66
Channel Frequency (MHz):	2480.00	**Data Rate:**	125 kBit/s
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

2452.00 - 2520.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	2483.50	6.09	-1.78	32.33	38.44	Max Avg	Horizontal	148	48	54.0	-15.6	Pass
#2	2483.50	37.30	-1.78	32.33	67.85	Max Peak	Horizontal	148	48	74.0	-6.2	Pass
#3	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. DC Correction 1.8 dB.												

9.4.3. Digital Emissions / Radiated Spurious Emissions (0.03 - 1 GHz)

Test Conditions for Digital Emissions			
Standard:	FCC CFR 47:15.109 ICES-003 Issue 6	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Radiated Emissions Limits	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.109 (a) ICES-003 6.2.1	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Radiated Emissions Measurement
Test Procedure
Testing 30 – 1,000 MHz was performed in an anechoic chamber using a CISPR compliant receiver. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. To further maximize emissions the receive antenna was varied between 1 and 4 meters. The emissions are recorded with receiver in peak hold mode.

Emissions nearest the limits were chosen for maximization and formal measurement using a CISPR Compliant receiver. Emissions from 30 MHz – 1000 MHz are measured utilizing a CISPR compliant quasi-peak detector with a tuned receiver, using a bandwidth of 120 kHz.. Only the highest emissions relative to the limit are listed.

15.109 Radiated limits.
((a) Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency (MHz)	Quasi-peak Limit (dBµV/m)	Measurement Distance (meters)
30 to 88	40	3
88-216	43.5	3
216-960	46	3
960-1000	54	3

(b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following:

Frequency(MHz)	Quasi-peak Limit (dBµV/m)	Measurement Distance (meters)
30 to 88	49.5	3
88-216	54	3
216-960	56.5	3
960-1000	60	3

Traceability

Laboratory Measurement Uncertainty	
Measurement uncertainty	+5.6/ -4.5 dB

Equipment Configuration for Digital Emissions

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.3	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	Not Applicable
Channel Frequency (MHz):	2402.00	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	31.96	29.79	3.53	-8.70	24.62	MaxQP	Vertical	109	339	40.0	-15.4	Pass
#2	98.17	45.63	4.00	-18.60	31.03	MaxQP	Vertical	106	8	43.0	-12.0	Pass
#3	124.18	39.12	4.12	-14.60	28.64	MaxQP	Vertical	102	76	43.0	-14.4	Pass
#4	146.84	47.08	4.23	-15.90	35.41	MaxQP	Vertical	102	174	43.0	-7.6	Pass
#5	338.68	42.47	4.98	-13.70	33.75	MaxQP	Horizontal	101	257	46.0	-12.3	Pass
#6	361.26	40.96	5.06	-12.70	33.52	MaxQP	Horizontal	102	276	46.0	-12.5	Pass
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.												

Note: click the links in the above matrix to view the graphical image (plot).

Equipment Configuration for Digital Emissions

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.3	**Modulation:**	Not Applicable
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	Not Applicable
Channel Frequency (MHz):	2426	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	31.78	28.69	3.53	-8.70	23.52	MaxQP	Vertical	122	352	40.0	-16.5	Pass
#2	98.06	46.15	4.00	-18.60	31.55	MaxQP	Vertical	101	1	43.0	-11.5	Pass
#3	124.18	39.62	4.12	-14.60	29.14	MaxQP	Vertical	100	73	43.0	-13.9	Pass
#4	146.74	46.88	4.23	-15.90	35.21	MaxQP	Vertical	99	171	43.0	-7.8	Pass
#5	338.68	41.57	4.98	-13.70	32.85	MaxQP	Horizontal	101	257	46.0	-13.2	Pass
#6	361.26	40.26	5.06	-12.70	32.62	MaxQP	Horizontal	100	270	46.0	-13.4	Pass
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.												

Note: click the links in the above matrix to view the graphical image (plot).

Equipment Configuration for Digital Emissions

Antenna:	WD PCB	**Variant:**	BLE
Antenna Gain (dBi):	3.3	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	Not Applicable
Channel Frequency (MHz):	2480.00	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	JMH

Test Measurement Results

30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
#1	31.84	28.39	3.53	-8.70	23.24	MaxQP	Vertical	119	345	40.0	-16.8	Pass
#2	98.35	45.26	4.00	-18.60	30.67	MaxQP	Vertical	106	7	43.0	-12.3	Pass
#3	124.58	38.91	4.12	-14.60	28.43	MaxQP	Vertical	101	76	43.0	-14.6	Pass
#4	146.79	47.99	4.23	-15.90	36.33	MaxQP	Vertical	100	178	43.0	-6.7	Pass
#5	338.76	41.47	4.98	-13.70	32.74	MaxQP	Horizontal	106	253	46.0	-13.3	Pass
#6	361.00	40.95	5.06	-12.70	33.31	MaxQP	Horizontal	100	275	46.0	-12.7	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.

No spurious emissions found.
Note: click the links in the above matrix to view the graphical image (plot).

9.4.4. AC Wireline Emissions

Test Conditions for AC Mains Conducted Emissions			
Standard:	FCC CFR 47:15.107 ICES-003	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	AC Mains Conducted Limits	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.207 RSS-GEN Section 8.8	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Method
The test method shall be in accordance with ANSI C63.4 and the Artificial Mains Networks (AMNs) shall be connected to the AC mains power source. The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies for measurements in the transmit mode of operation.

Test Procedure for AC Mains Conducted Emissions Measurement
The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9 kHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

15.107 Conducted limits.
(a) Except for Class A digital devices, for equipment 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 30 MHz shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms 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 band edges.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

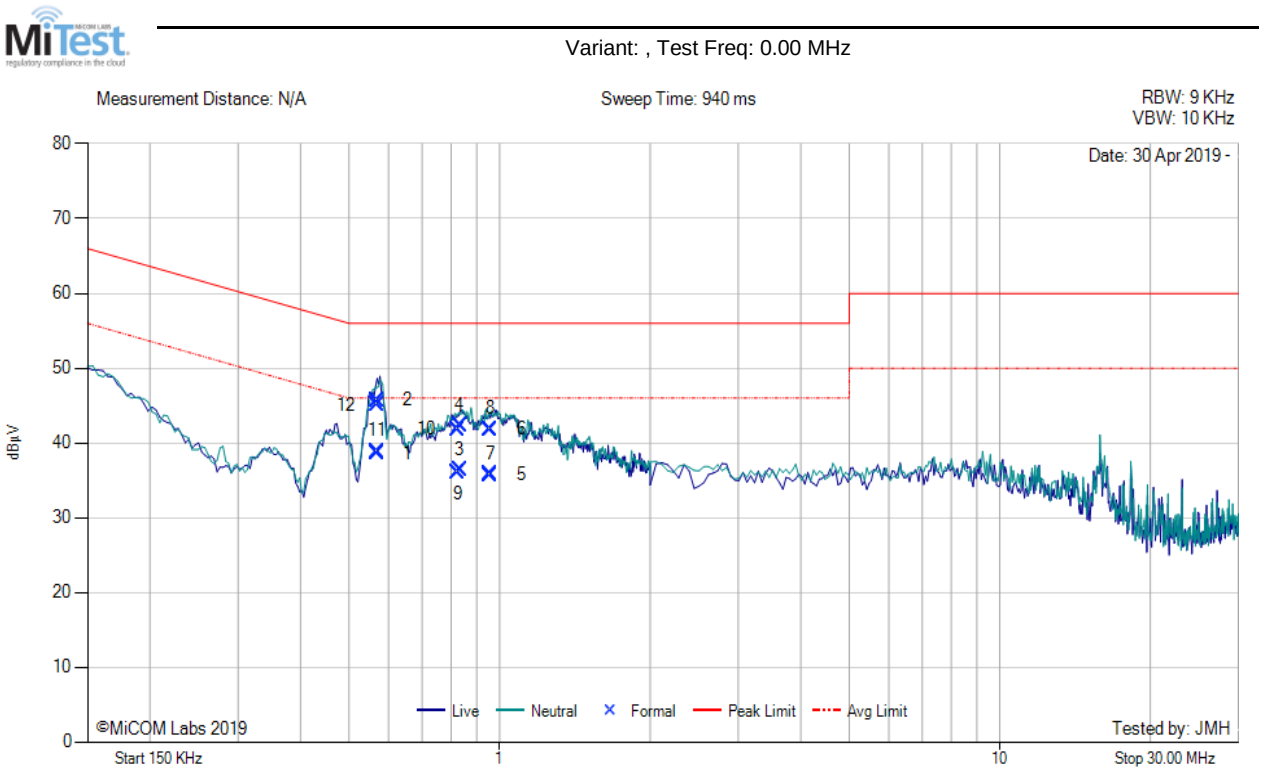
(b) For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms 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 of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	79	66
0.5-30	73	60

Traceability
All conducted emission measurements are traceable to national standards. The uncertainty of measurement at a confidence level of not less than 95 %, with a coverage factor of k=2, in the range 9 kHz – 30 MHz (Average & Quasi-peak) is ±2.64 dB.

Laboratory Measurement Uncertainty	
Measurement uncertainty	±2.64 dB

Model:	S23	Configuration tested:	AC/DC PS
Input power:	120V_{AC}/60Hz	Standard:	FCC



Num	Frequency MHz	Raw dBµV	Cable Loss dB	Factor dB	Total Correction dBµV	Corrected Value dBµV	Measurement Type	Line	Limit dBµV/m	Margin dB	Pass /Fail
1	0.570	28.56	0.10	9.92	10.02	38.58	Max Avg	Live	46.0	-7.4	Pass
2	0.570	35.69	0.10	9.92	10.02	45.71	Max Qp	Live	56.0	-10.3	Pass
3	0.833	26.28	0.10	9.94	10.04	36.32	Max Avg	Neutral	46.0	-9.7	Pass
4	0.833	32.28	0.10	9.94	10.04	42.32	Max Qp	Neutral	56.0	-13.7	Pass
5	0.960	25.79	0.08	9.93	10.01	35.80	Max Avg	Neutral	46.0	-10.2	Pass
6	0.960	31.85	0.08	9.93	10.01	41.86	Max Qp	Neutral	56.0	-14.1	Pass
7	0.959	25.73	0.08	9.93	10.01	35.74	Max Avg	Live	46.0	-10.3	Pass
8	0.959	31.83	0.08	9.93	10.01	41.84	Max Qp	Live	56.0	-14.2	Pass
9	0.825	25.96	0.10	9.94	10.04	36.00	Max Avg	Live	46.0	-10.0	Pass
10	0.825	31.77	0.10	9.94	10.04	41.81	Max Qp	Live	56.0	-14.2	Pass
11	0.569	28.86	0.10	9.92	10.02	38.88	Max Avg	Live	46.0	-7.1	Pass
12	0.569	35.05	0.10	9.92	10.02	45.07	Max Qp	Live	56.0	-10.9	Pass

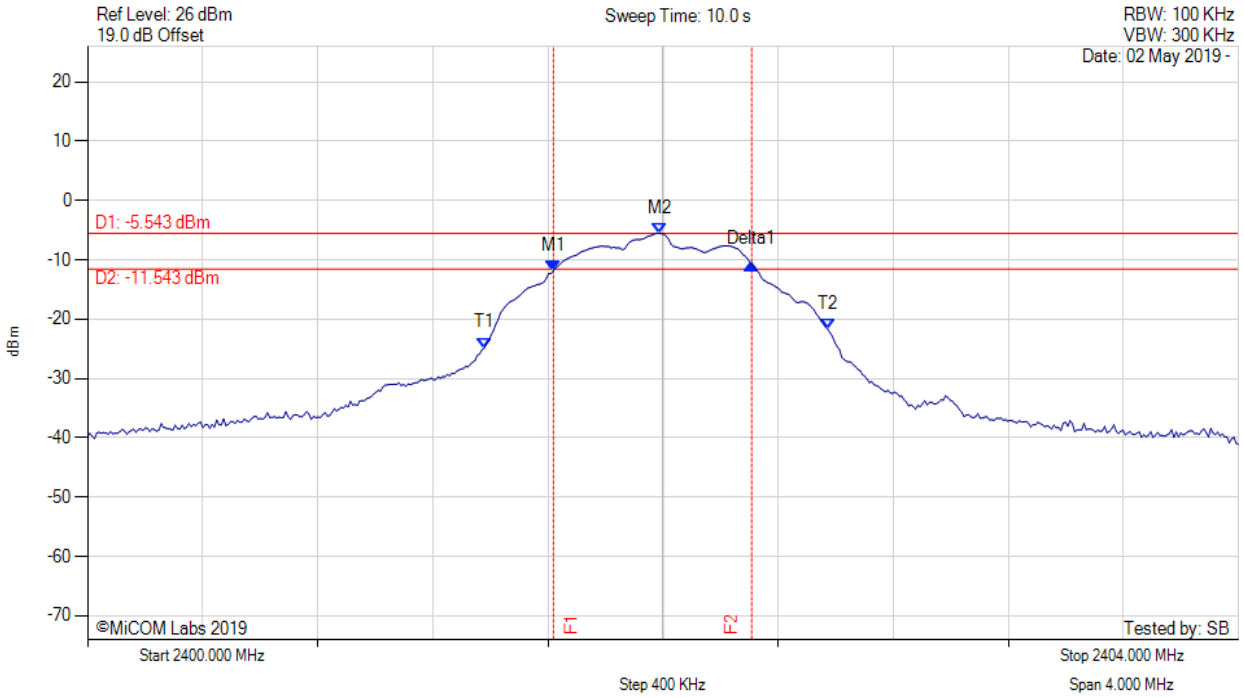
Test Notes: EUT powered by AC/DC PS 120V 60 Hz, connected to laptop via ethernet. 2nd ethernet cable connected to hub with traffic. Transmitting 2412b WiFi and BLE for maximum load. Audio ports looped back. For test purposes EUT was set to transmit maximum power

A. APPENDIX - GRAPHICAL IMAGES

A.1. 6 dB & 99% Bandwidth

6 dB & 99% BANDWIDTH

Variant: BLE, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

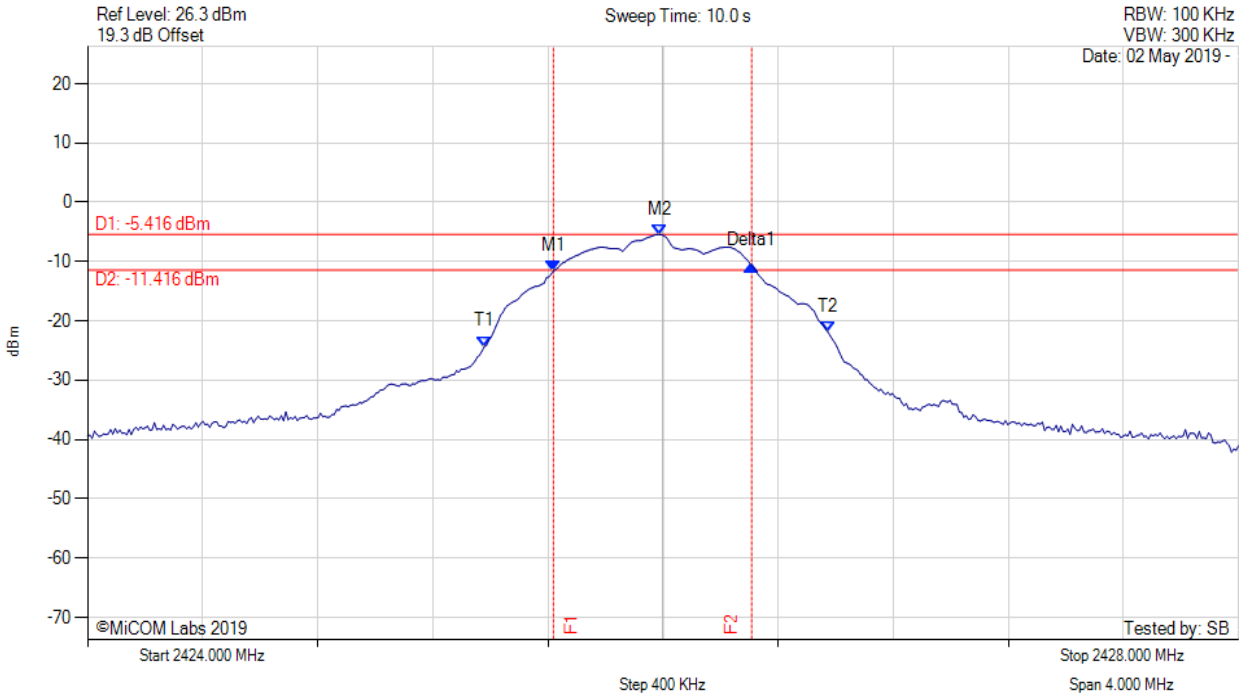


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2401.619 MHz : -11.791 dBm M2 : 2401.988 MHz : -5.543 dBm Delta1 : 689 KHz : 1.078 dB T1 : 2401.379 MHz : -24.862 dBm T2 : 2402.573 MHz : -21.748 dBm OBW : 1.194 MHz	Measured 6 dB Bandwidth: 0.689 MHz Limit: ≥500.0 kHz Margin: -0.19 MHz

back to matrix

6 dB & 99% BANDWIDTH

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

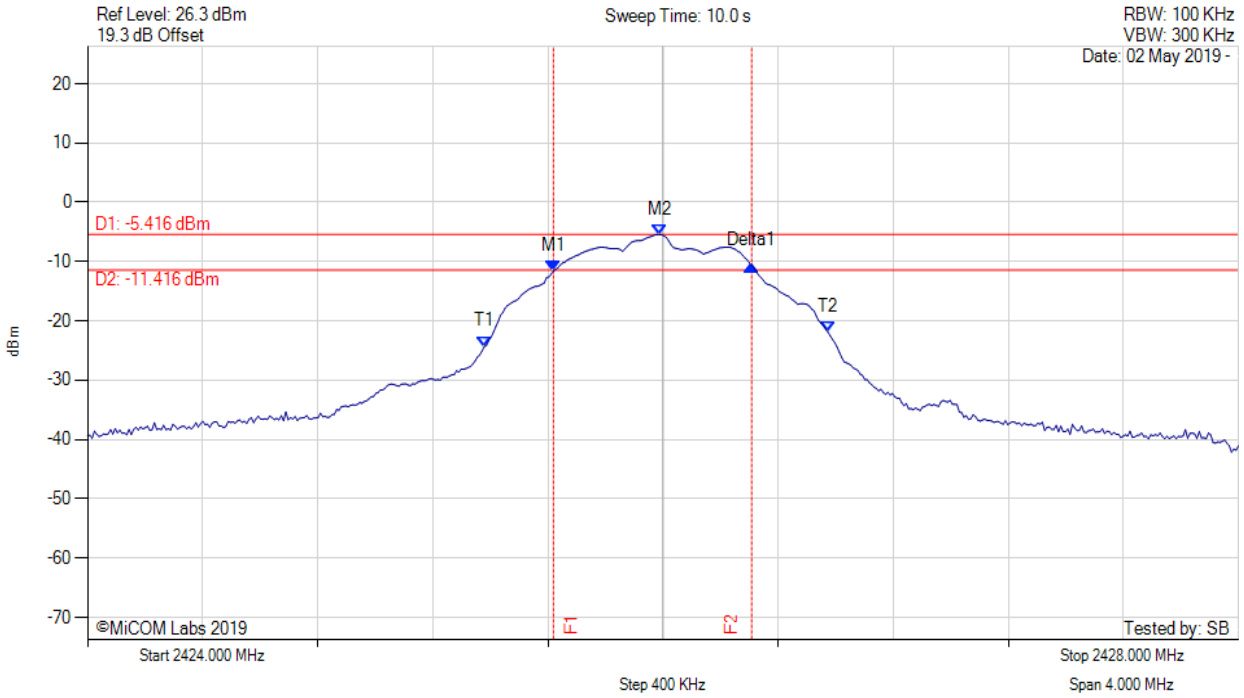


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2425.619 MHz : -11.605 dBm M2 : 2425.988 MHz : -5.416 dBm Delta1 : 689 KHz : 0.927 dB T1 : 2425.379 MHz : -24.326 dBm T2 : 2426.573 MHz : -21.875 dBm OBW : 1.194 MHz	Measured 6 dB Bandwidth: 0.689 MHz Limit: ≥500.0 kHz Margin: -0.19 MHz

back to matrix

6 dB & 99% BANDWIDTH

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

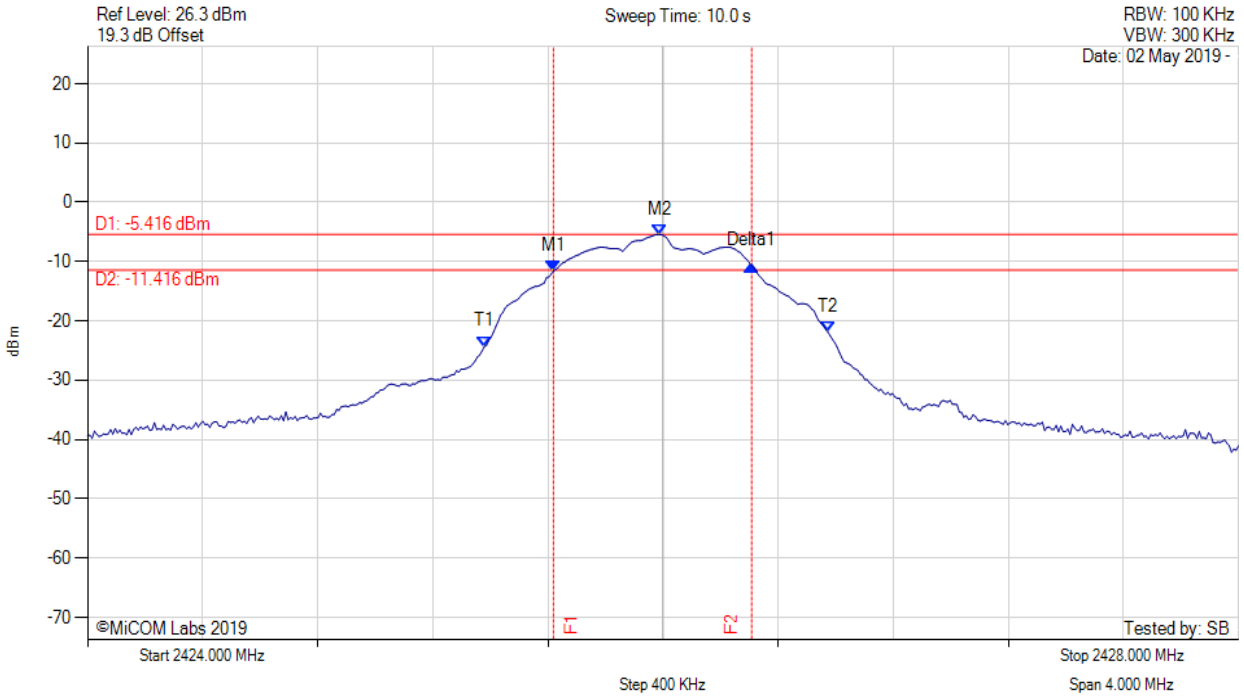


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2425.619 MHz : -11.605 dBm M2 : 2425.988 MHz : -5.416 dBm Delta1 : 689 KHz : 0.927 dB T1 : 2425.379 MHz : -24.326 dBm T2 : 2426.573 MHz : -21.875 dBm OBW : 1.194 MHz	Channel Frequency: 2426.00 MHz

back to matrix

6 dB & 99% BANDWIDTH

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

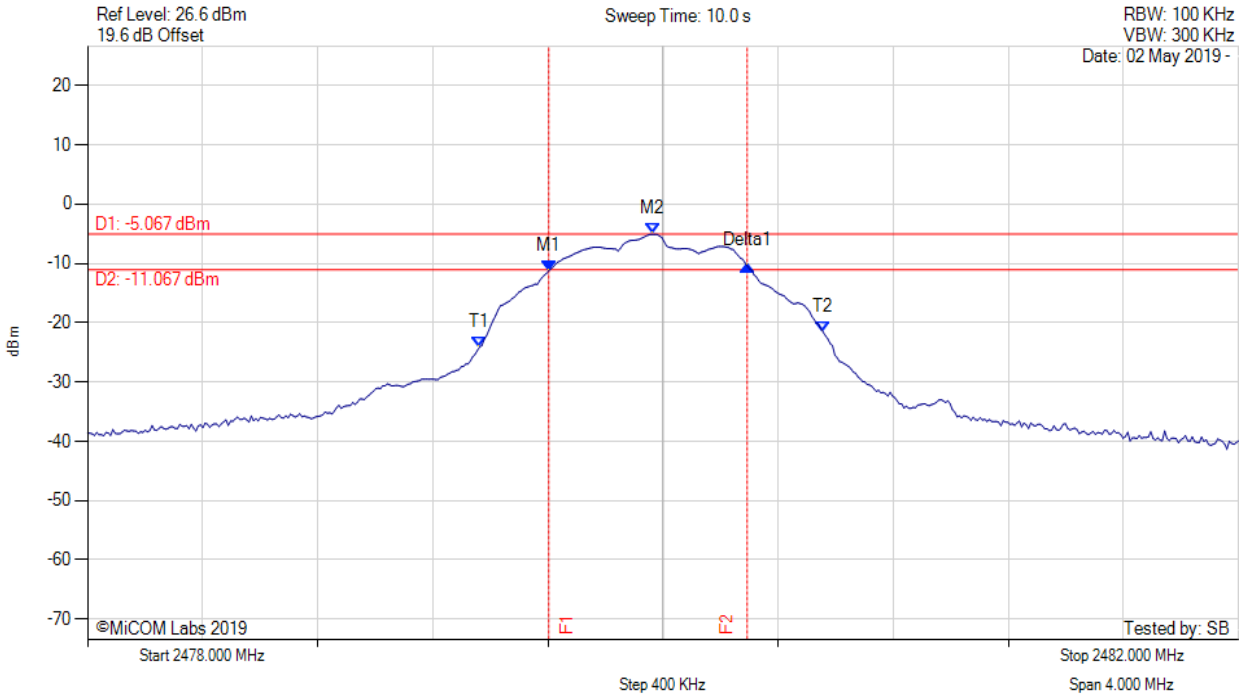


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2425.619 MHz : -11.605 dBm M2 : 2425.988 MHz : -5.416 dBm Delta1 : 689 KHz : 0.927 dB T1 : 2425.379 MHz : -24.326 dBm T2 : 2426.573 MHz : -21.875 dBm OBW : 1.194 MHz	Measured 6 dB Bandwidth: 0.689 MHz Limit: ≥500.0 kHz Margin: -0.19 MHz

back to matrix

6 dB & 99% BANDWIDTH

Variant: BLE, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc



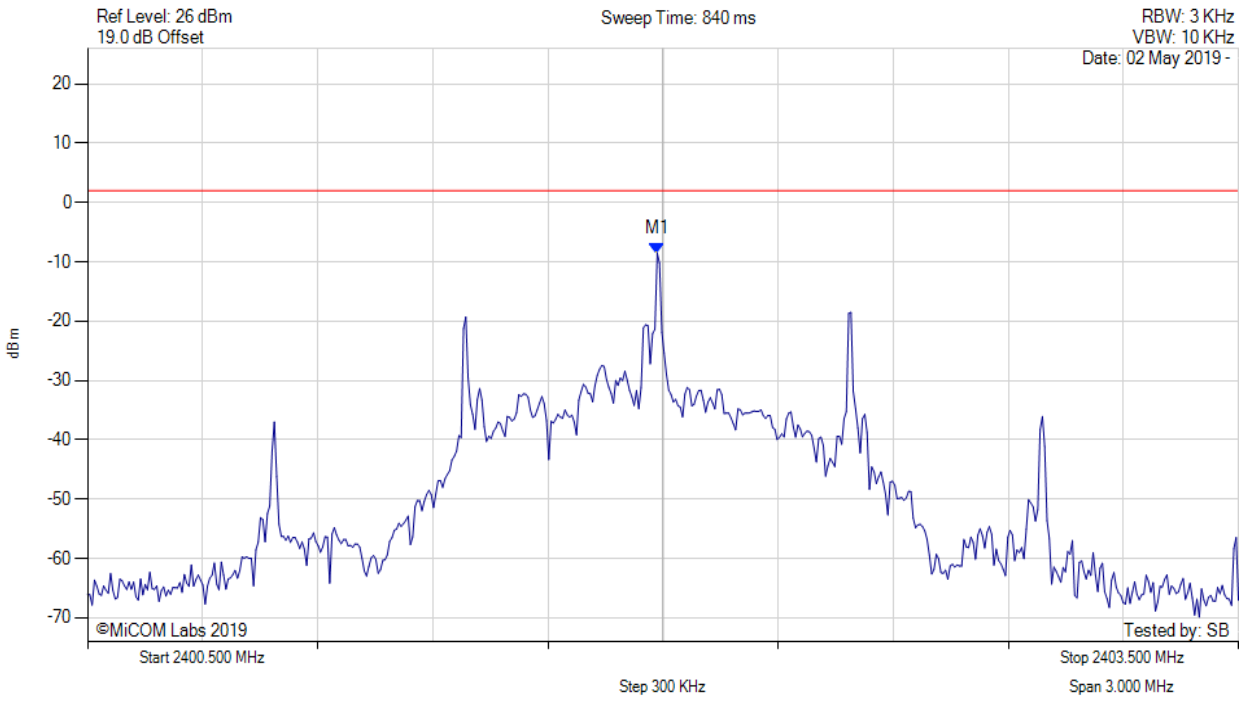
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2479.603 MHz : -11.232 dBm M2 : 2479.964 MHz : -5.067 dBm Delta1 : 689 KHz : 0.836 dB T1 : 2479.363 MHz : -24.101 dBm T2 : 2480.557 MHz : -21.620 dBm OBW : 1.194 MHz	Measured 6 dB Bandwidth: 0.689 MHz Limit: ≥500.0 kHz Margin: -0.19 MHz

back to matrix

A.2. Power Spectral Density

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

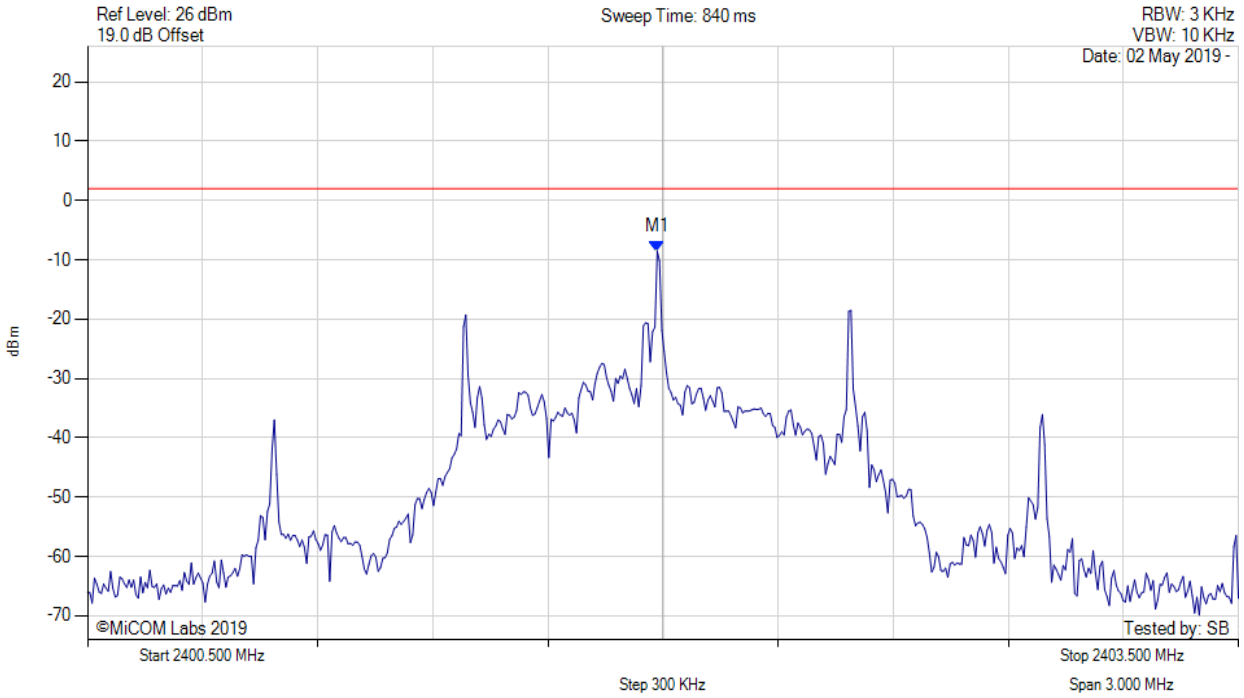


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2401.985 MHz : -8.531 dBm	Limit: ≤ 1.980 dBm Margin: 10.51 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2402.00 MHz, SUM, Temp: 20, Voltage: 12 Vdc

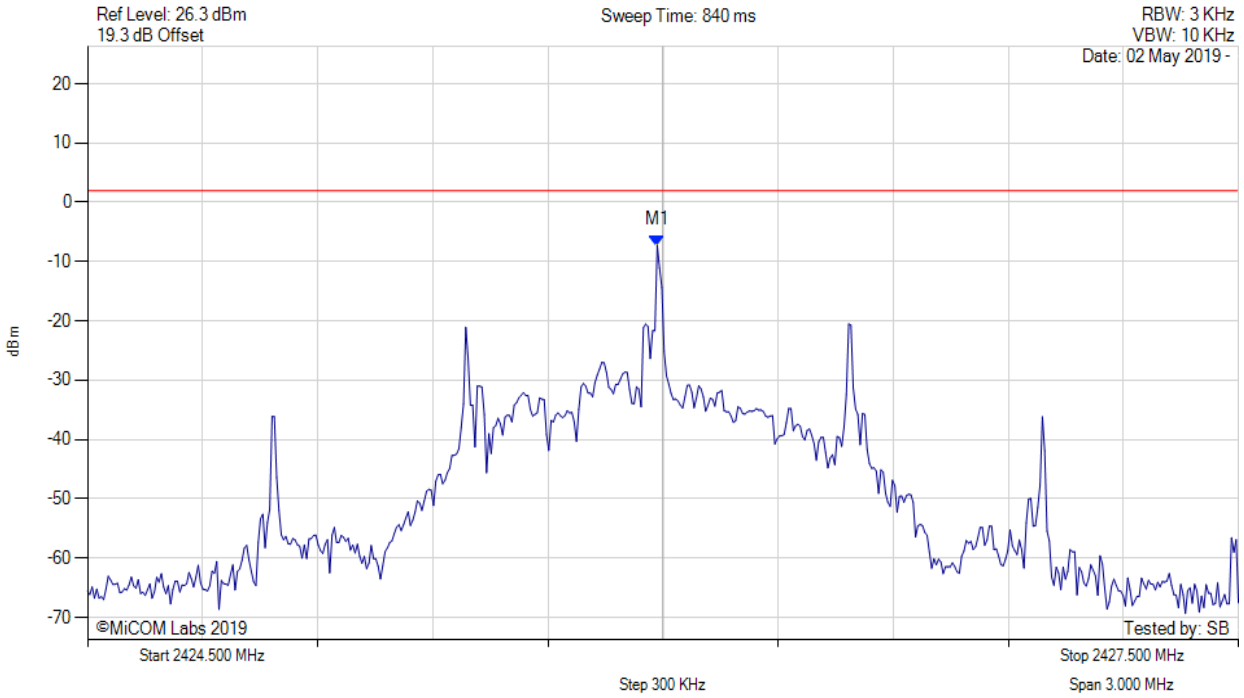


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2401.985 MHz : -8.531 dBm	Limit: ≤ 2.0 dBm Margin: -10.5 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

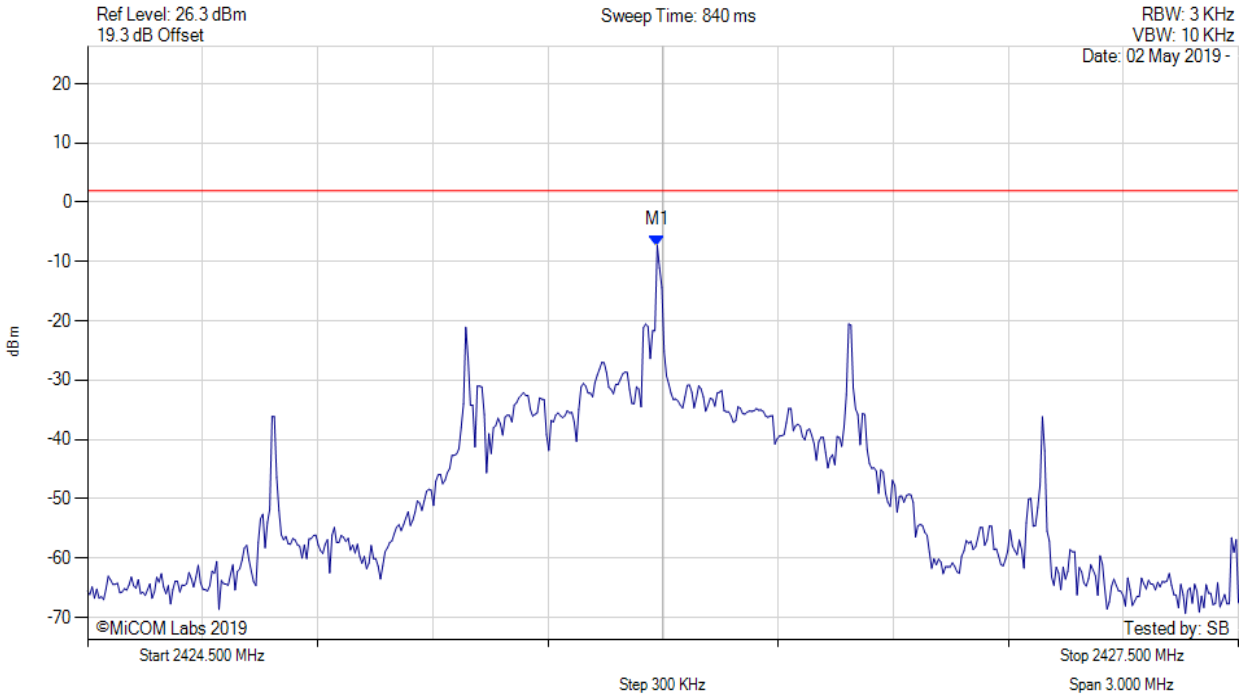


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Channel Frequency: 2426.00 MHz

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

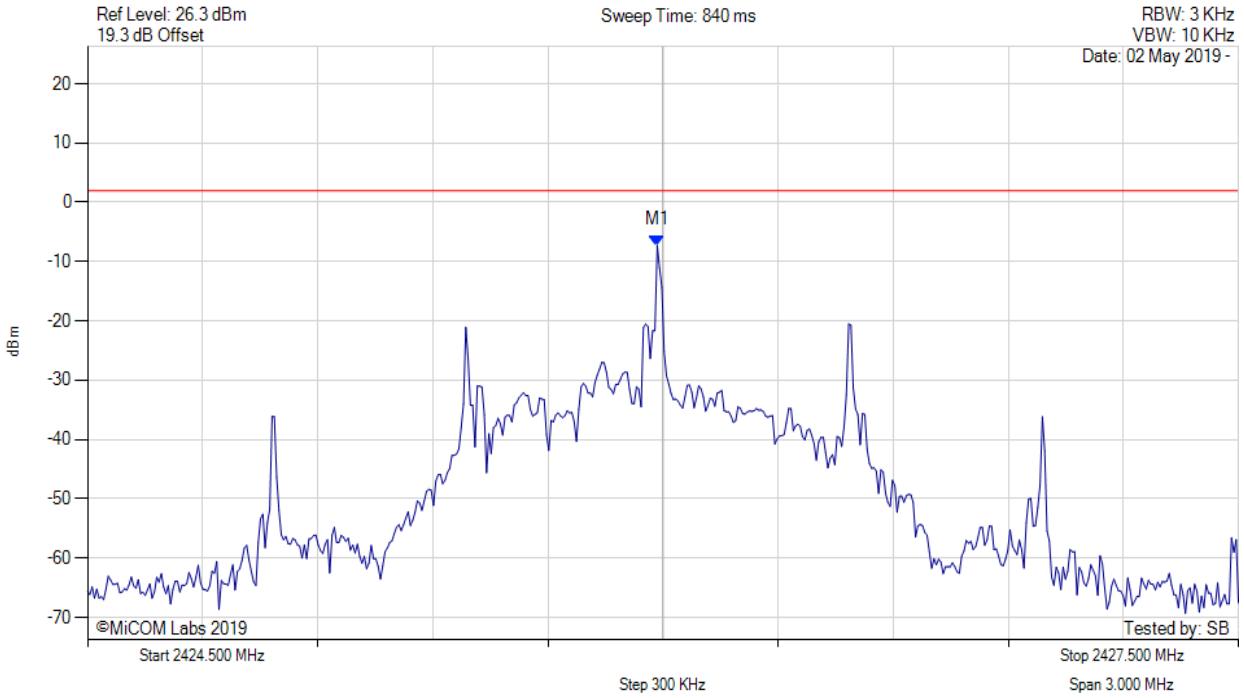


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Limit: ≤ 1.980 dBm Margin: 9.25 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

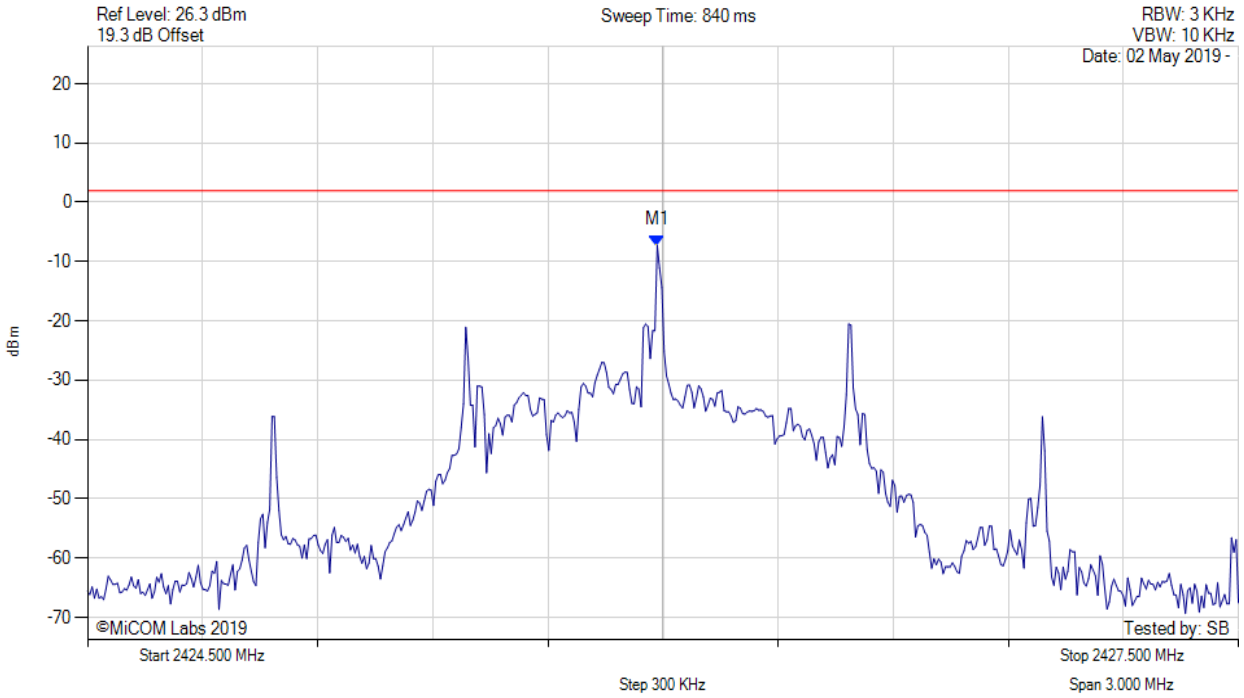


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Limit: ≤ 1.980 dBm Margin: 9.25 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, SUM, Temp: 20, Voltage: 12 Vdc

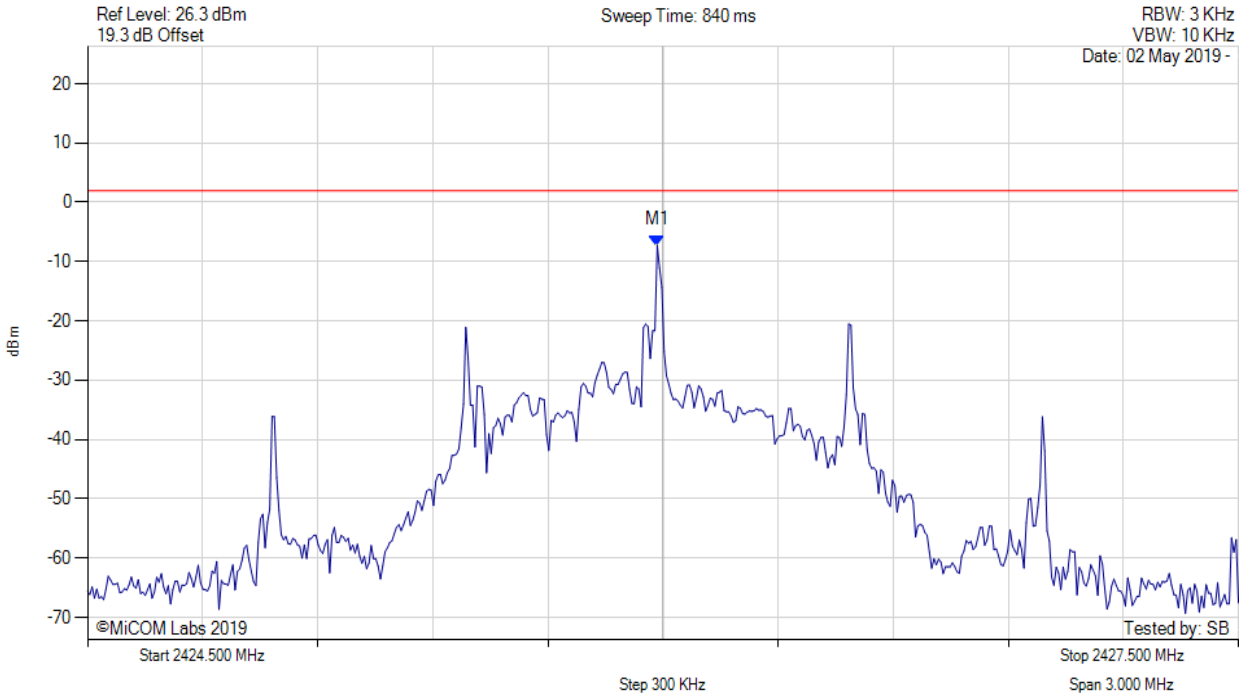


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Limit: ≤ 2.0 dBm Margin: -9.3 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, SUM, Temp: 20, Voltage: 12 Vdc

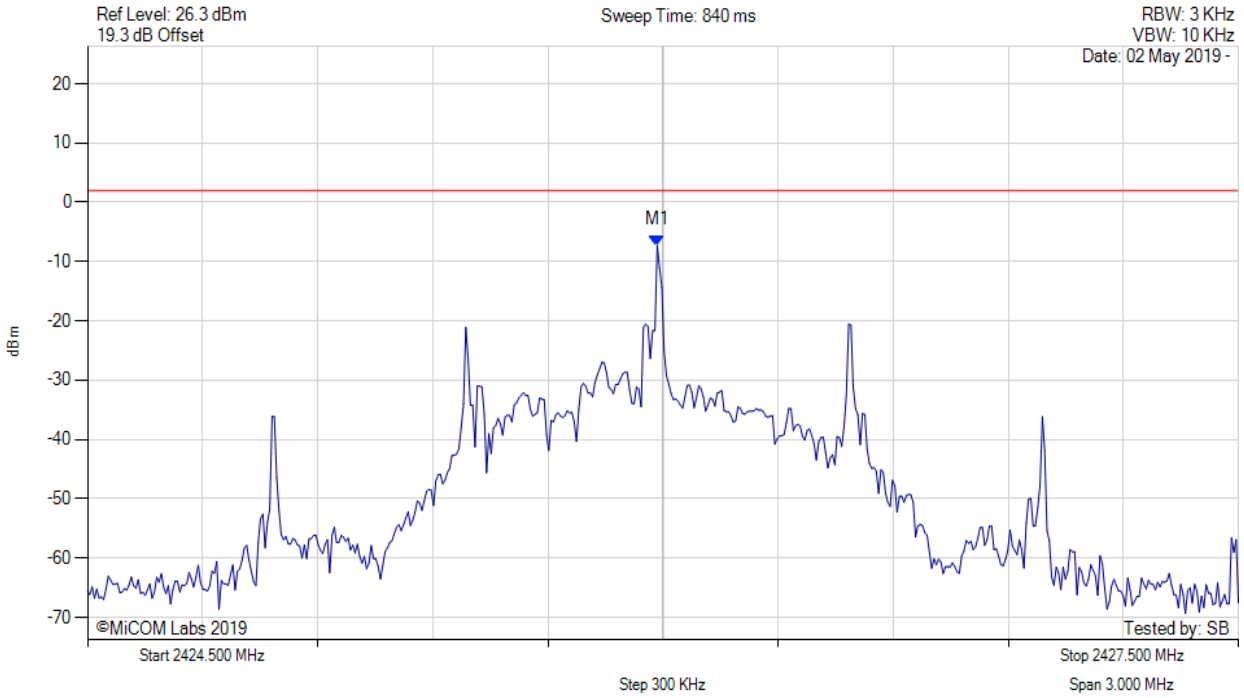


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Channel Frequency: 2426.00 MHz

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2426.00 MHz, SUM, Temp: 20, Voltage: 12 Vdc

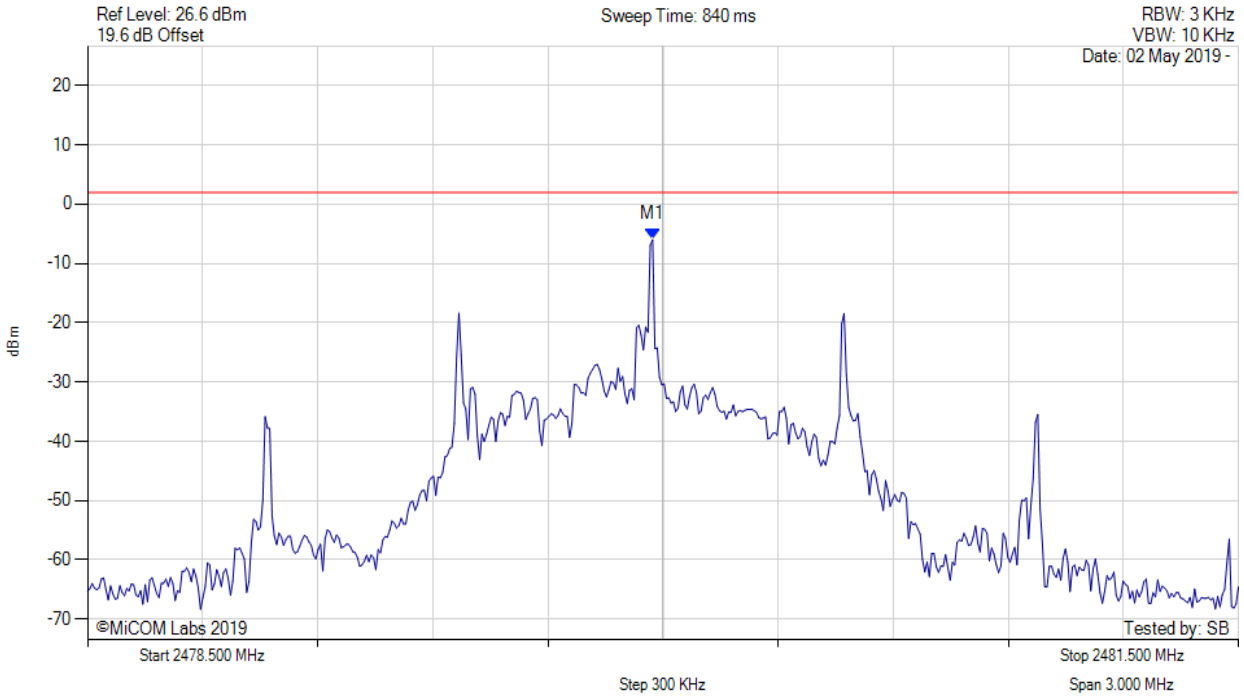


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2425.985 MHz : -7.271 dBm	Limit: ≤ 2.0 dBm Margin: -9.3 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

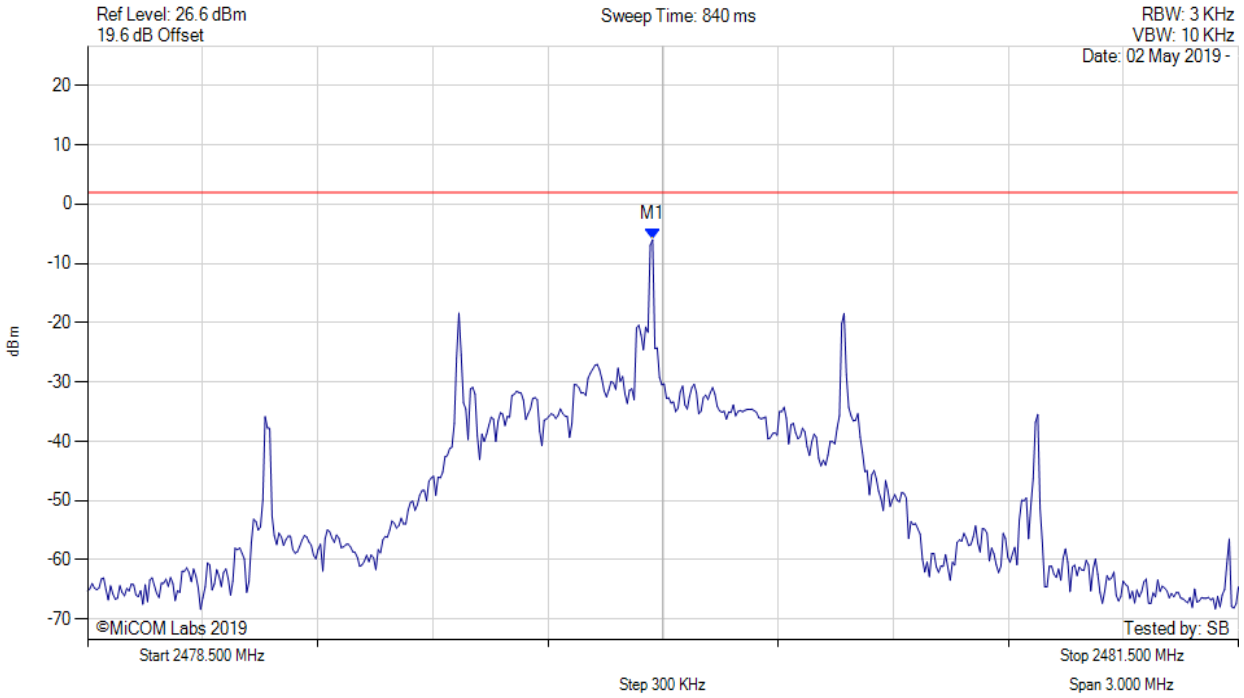


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2479.973 MHz : -6.003 dBm	Limit: ≤ 1.980 dBm Margin: 7.98 dB

back to matrix

POWER SPECTRAL DENSITY - PEAK

Variant: BLE, Channel: 2480.00 MHz, SUM, Temp: 20, Voltage: 12 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2479.973 MHz : -6.003 dBm	Limit: ≤ 2.0 dBm Margin: -8.0 dB

back to matrix

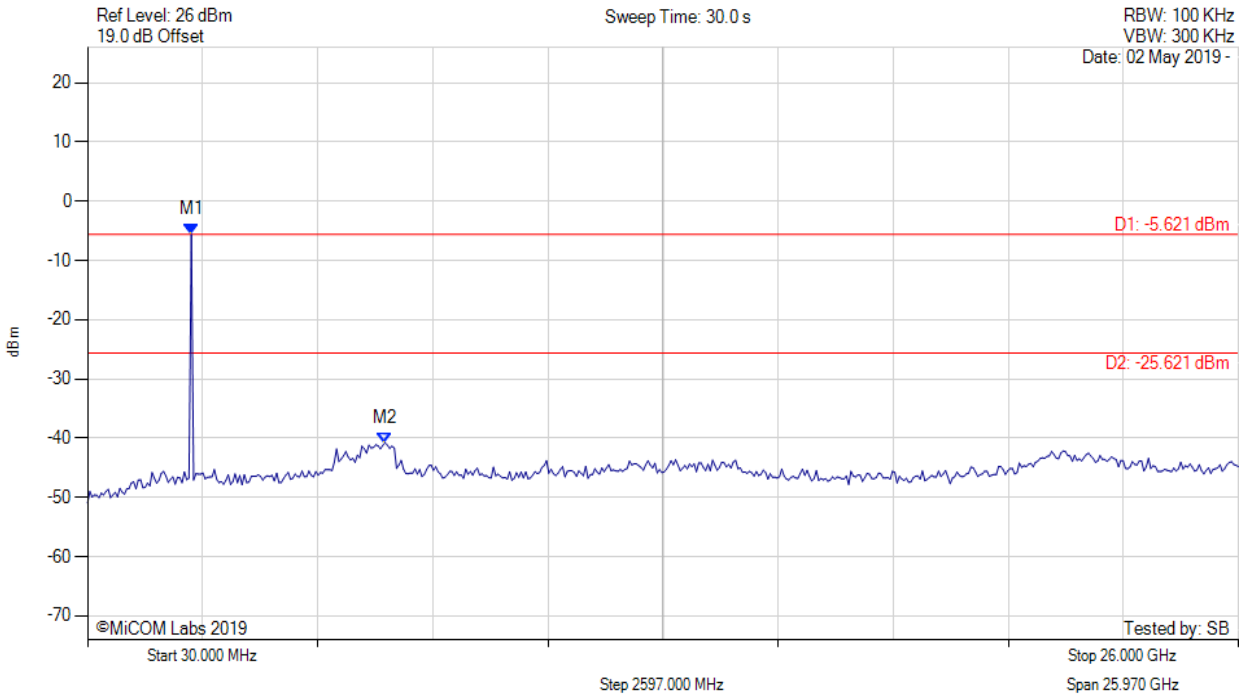
A.3. Emissions

A.3.1. Conducted Emissions

A.3.1.1. Conducted Spurious Emissions

CONDUCTED SPURIOUS EMISSIONS - PEAK

Variant: BLE, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

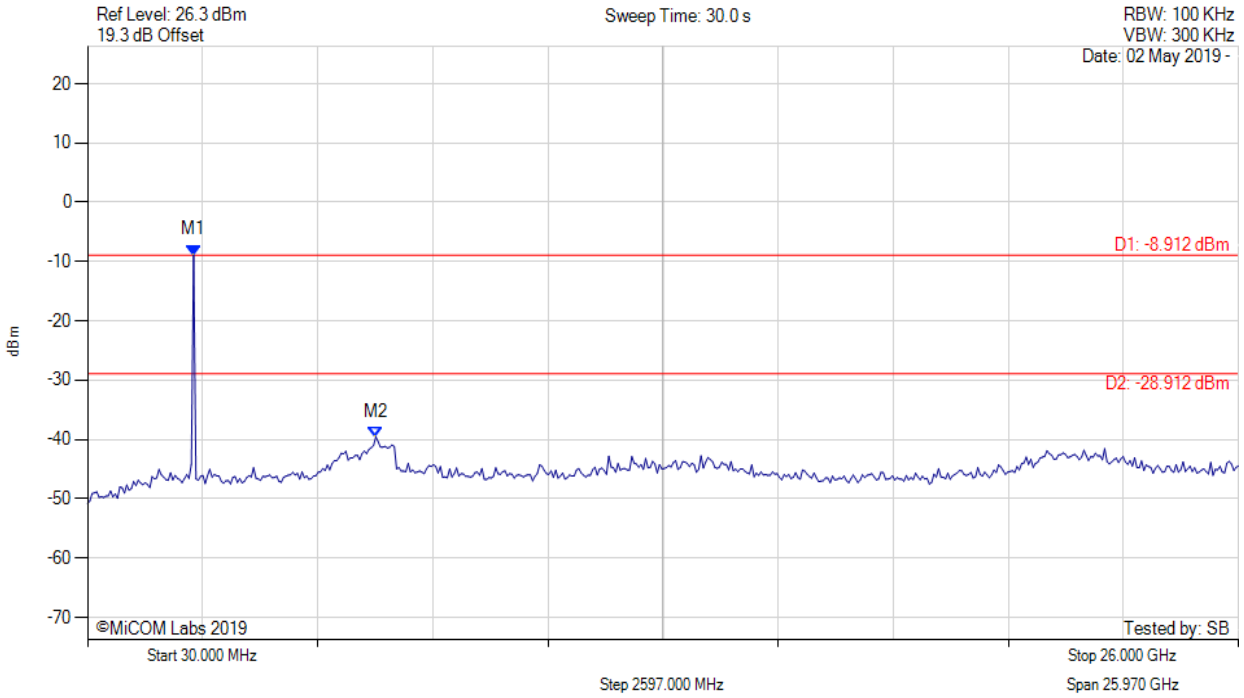


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2371.984 MHz : -5.621 dBm M2 : 6743.687 MHz : -40.778 dBm	Limit: -25.62 dBm Margin: -15.16 dB

back to matrix

CONDUCTED SPURIOUS EMISSIONS - PEAK

Variant: BLE, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

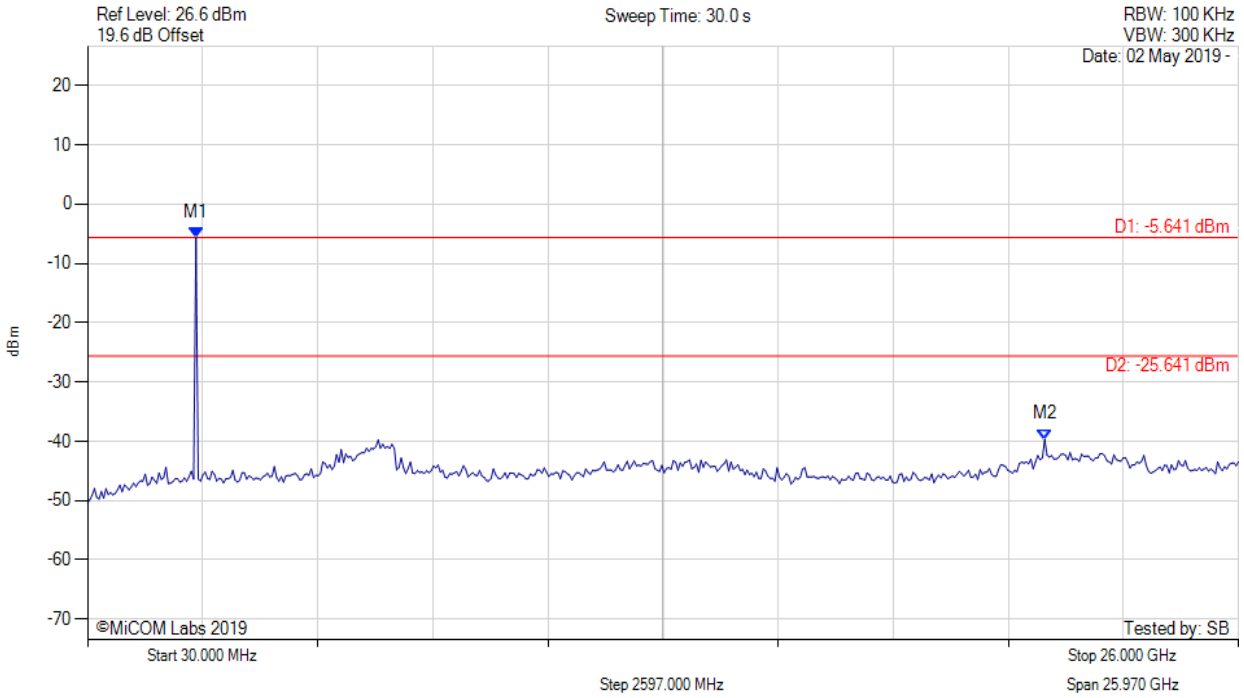


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2424.028 MHz : -8.912 dBm M2 : 6535.511 MHz : -39.551 dBm	Limit: -28.91 dBm Margin: -10.64 dB

back to matrix

CONDUCTED SPURIOUS EMISSIONS - PEAK

Variant: BLE, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc



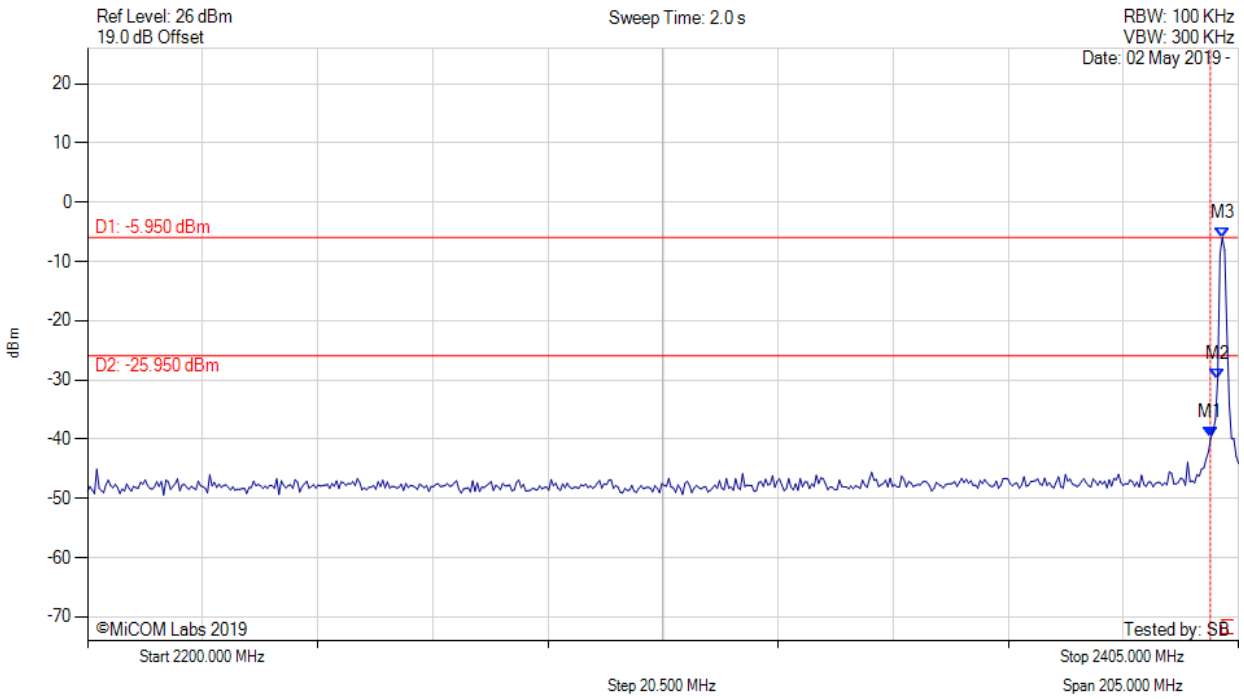
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2476.072 MHz : -5.641 dBm M2 : 21.628 GHz : -39.698 dBm	Limit: -25.64 dBm Margin: -14.06 dB

back to matrix

A.3.1.2. Conducted Band-Edge Emissions

CONDUCTED LOW BAND-EDGE EMISSION - PEAK

Variant: BLE, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

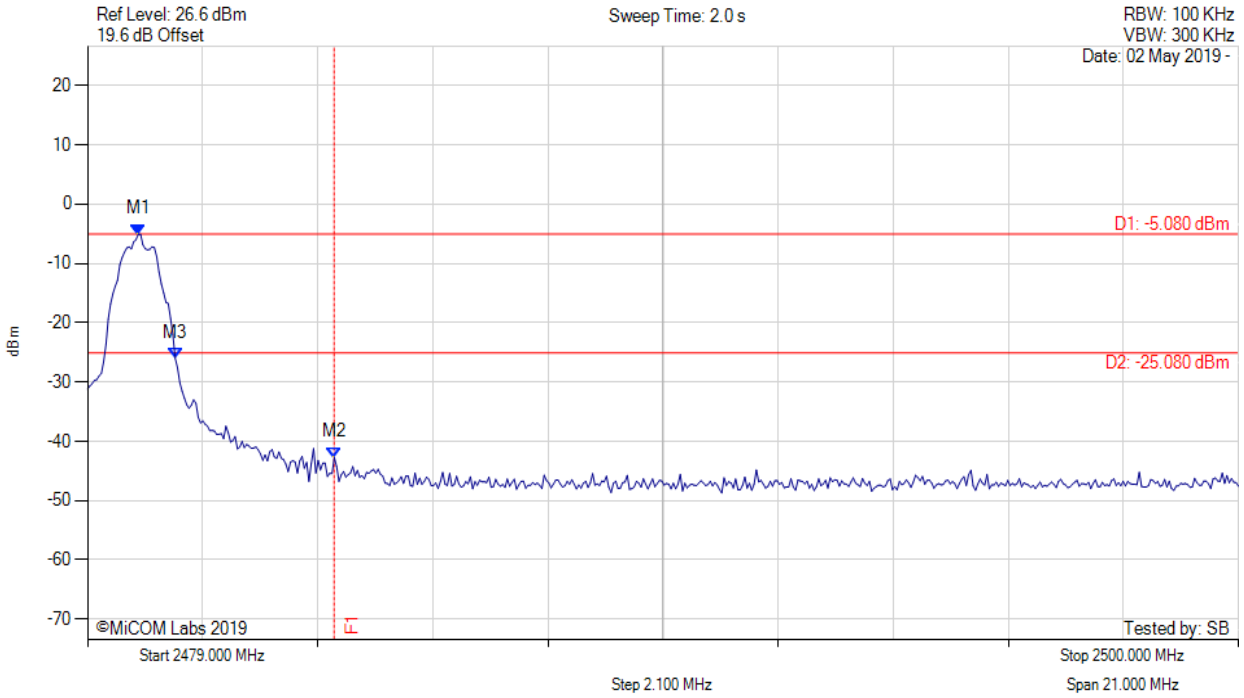


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = CLR/WRITE	M1 : 2400.000 MHz : -39.759 dBm M2 : 2401.303 MHz : -29.956 dBm M3 : 2402.124 MHz : -5.950 dBm	Channel Frequency: 2402.00 MHz

back to matrix

CONDUCTED HIGH BAND-EDGE EMISSION - PEAK

Variant: BLE, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 12 Vdc

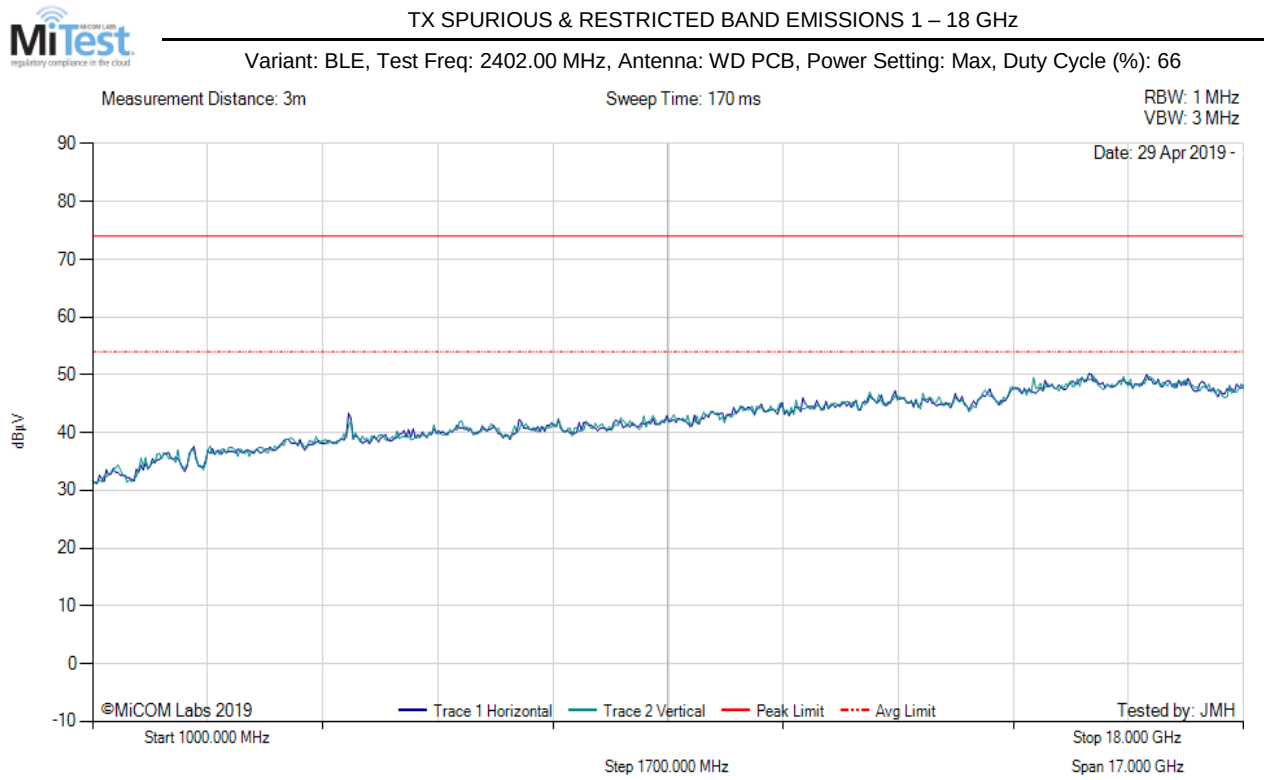


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = CLR/WRITE	M1 : 2479.926 MHz : -5.084 dBm M2 : 2483.500 MHz : -42.724 dBm M3 : 2480.599 MHz : -25.999 dBm	Channel Frequency: 2480.00 MHz

back to matrix

A.3.2. Radiated Emissions

A.3.2.3. TX Spurious & Restricted Band Emissions



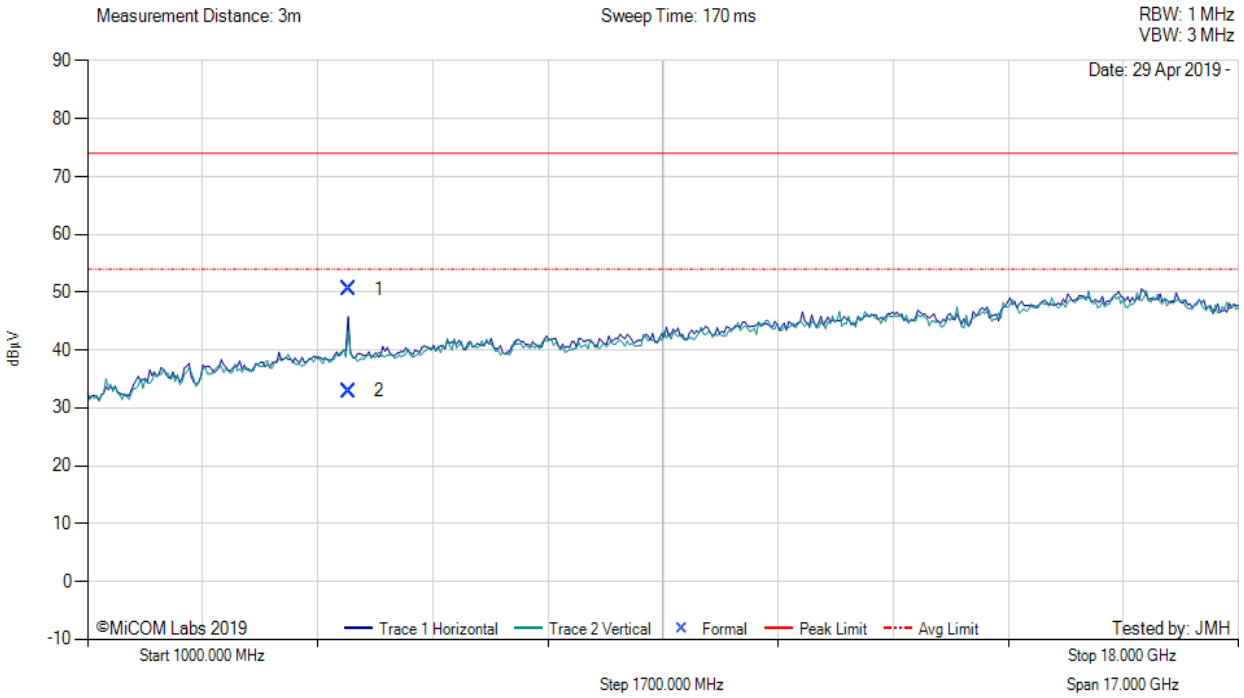
There are no emissions found within 6dB of the limit line.

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload.

back to matrix

TX SPURIOUS & RESTRICTED BAND EMISSIONS 1 – 18 GHz

Variant: BLE, Test Freq: 2426.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



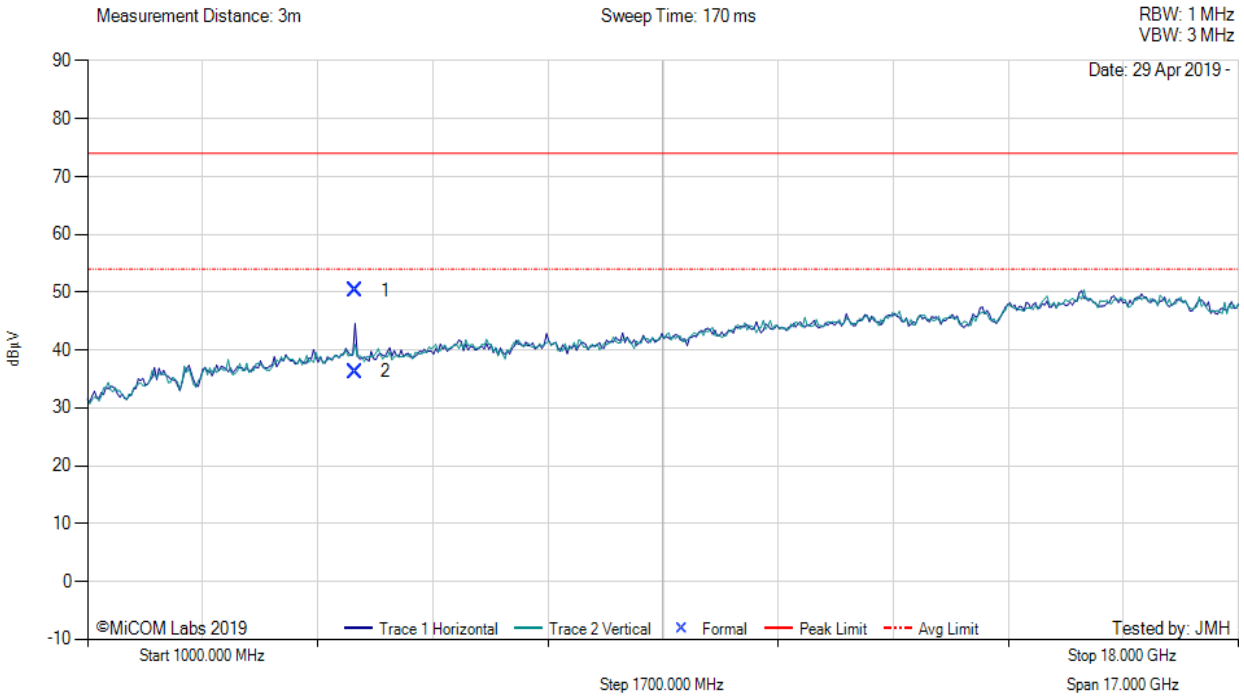
1000.00 - 18000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	4852.03	65.52	-2.53	-12.40	50.59	Max Peak	Horizontal	102	4	74.0	-23.4	Pass
2	4852.03	46.05	-2.53	-12.40	32.92	Max Avg	Horizontal	102	4	54.0	-21.1	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload. DC Correction 1.8 dB.

back to matrix

TX SPURIOUS & RESTRICTED BAND EMISSIONS 1 – 18 GHz

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



1000.00 - 18000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	4960.06	64.93	-2.55	-12.13	50.25	Max Peak	Horizontal	147	46	74.0	-23.8	Pass
2	4960.06	49.15	-2.55	-12.13	36.27	Max Avg	Horizontal	147	46	54.0	-17.7	Pass

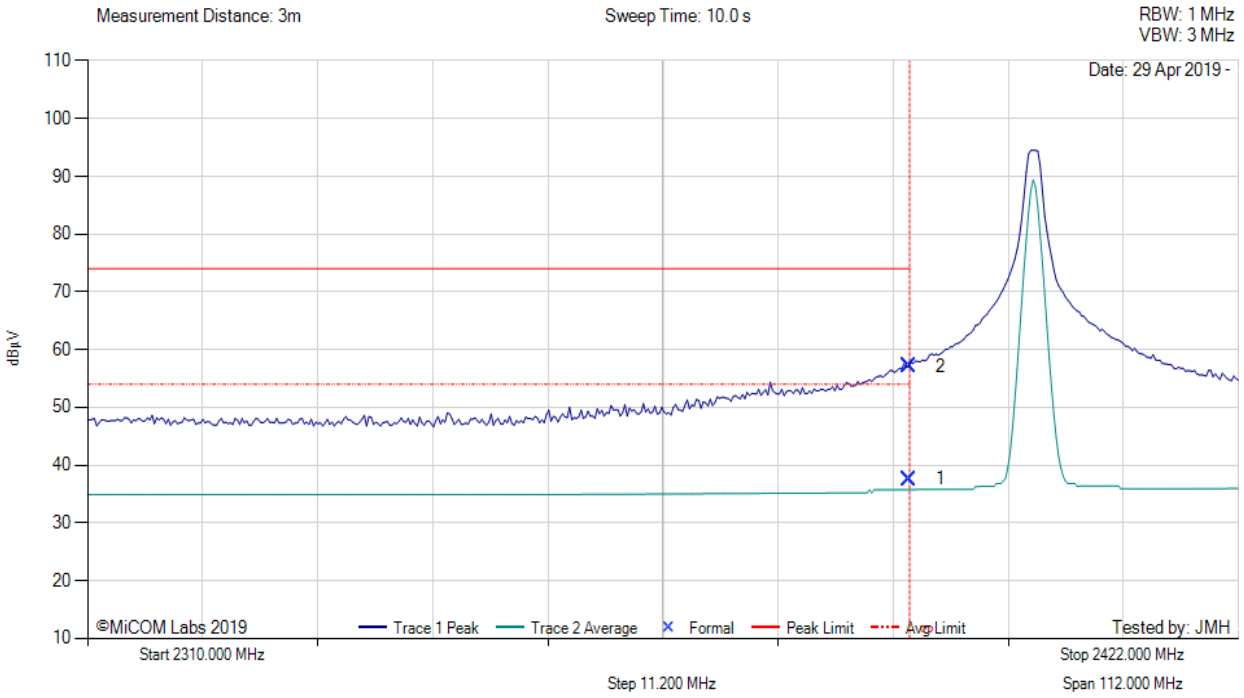
Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2.4 G Notch in front of amp to prevent overload. DC Correction 1.8 dB.

back to matrix

A.3.2.4. Restricted Edge & Band-Edge Emissions

RADIATED - LOWER RESTRICTED BAND-EDGE EMISSIONS

Variant: BLE, Test Freq: 2402.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66



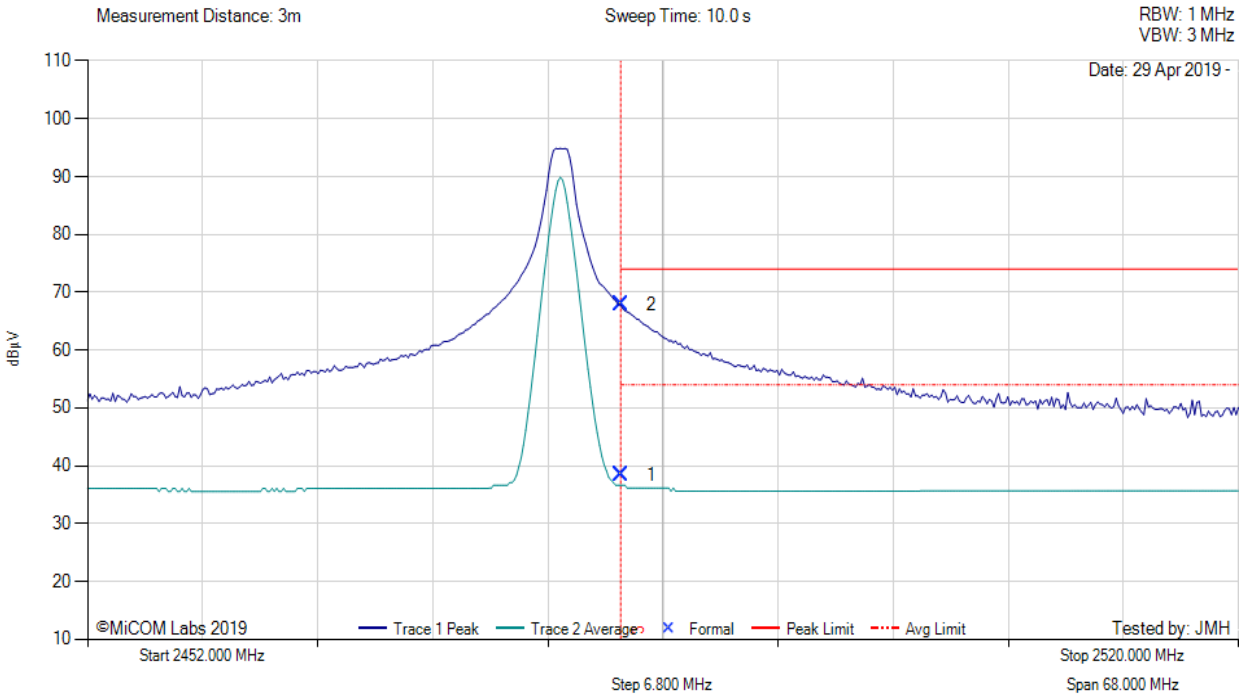
2310.00 - 2422.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	2390.00	5.58	-1.77	31.96	37.57	Max Avg	Horizontal	148	36	54.0	-16.4	Pass
2	2390.00	26.86	-1.77	31.96	57.05	Max Peak	Horizontal	148	36	74.0	-17.0	Pass
3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. DC Correction 1.8 dB.

back to matrix

RADIATED - UPPER RESTRICTED BAND-EDGE EMISSIONS

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: WD PCB, Power Setting: Max, Duty Cycle (%): 66

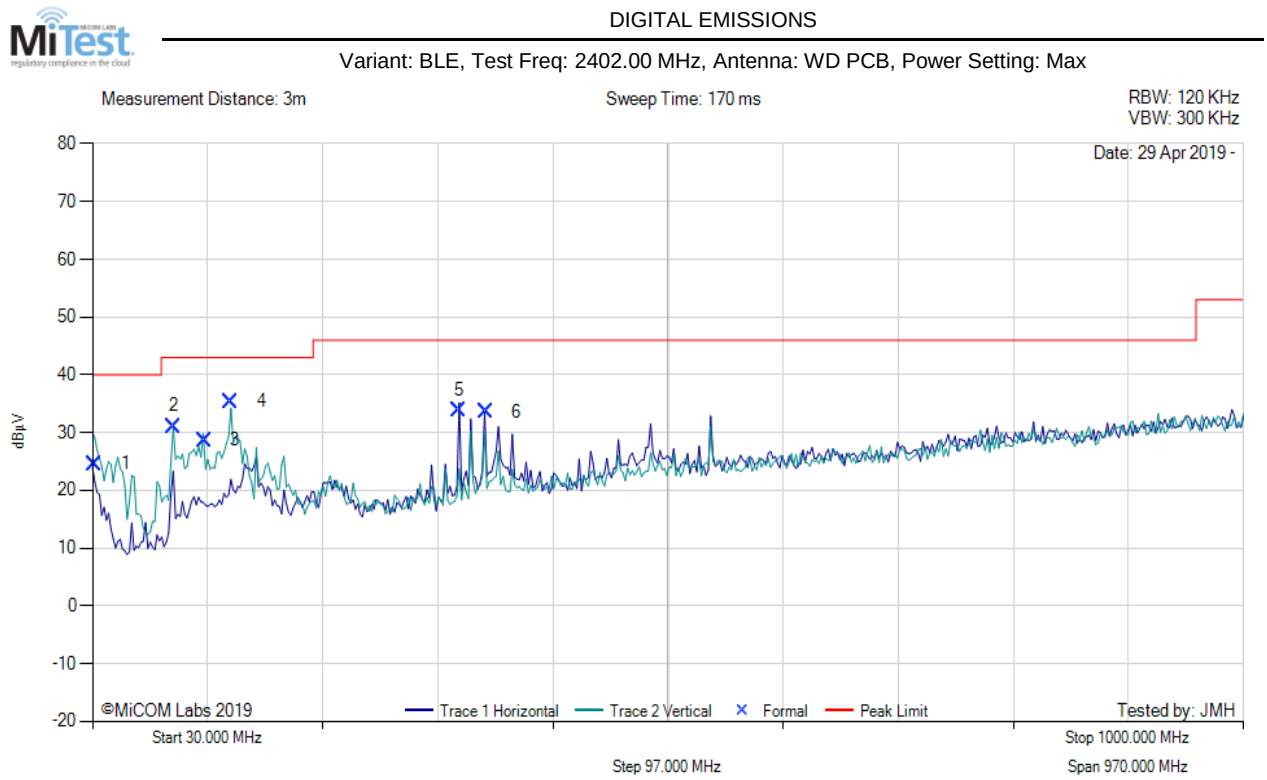


2452.00 - 2520.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	2483.50	6.09	-1.78	32.33	38.44	Max Avg	Horizontal	148	48	54.0	-15.6	Pass
2	2483.50	37.30	-1.78	32.33	67.85	Max Peak	Horizontal	148	48	74.0	-6.2	Pass
3	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. DC Correction 1.8 dB.

back to matrix

A.3.3. Digital Emissions (0.03 - 1 GHz)



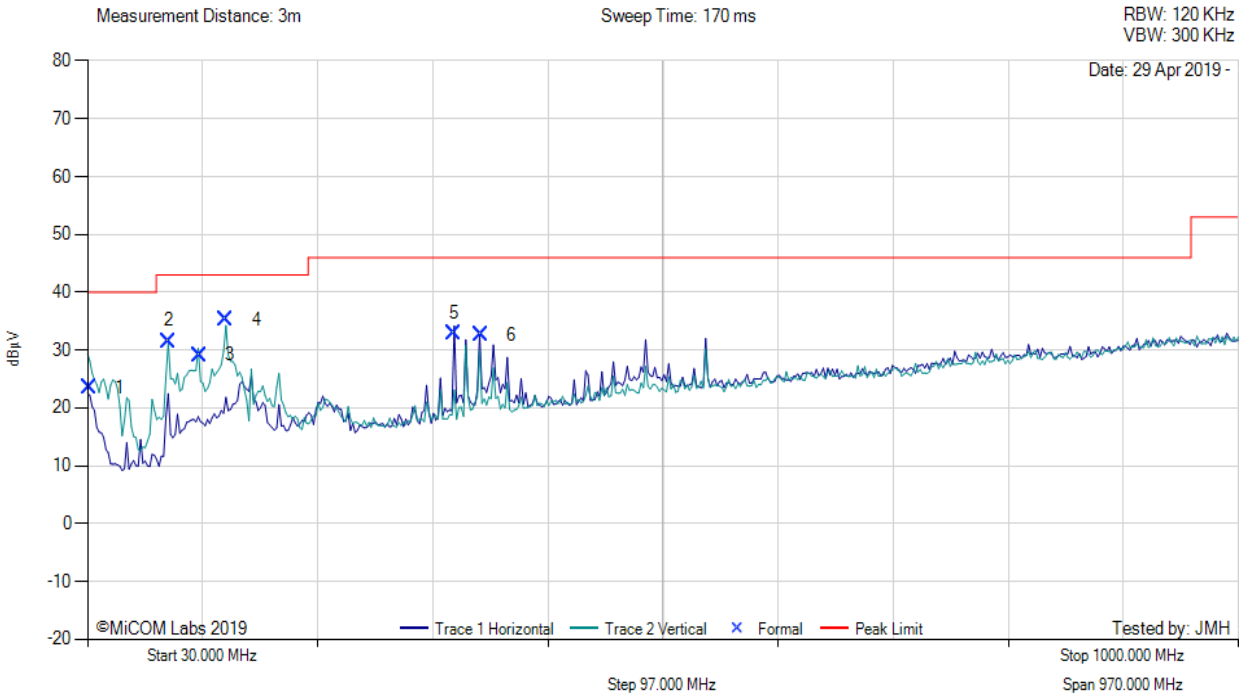
30.00 - 1000.00 MHz												
Num	Frequency MHz	Raw dBµV	Cable Loss dB	AF dB/m	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	31.96	29.79	3.53	-8.70	24.62	MaxQP	Vertical	109	339	40.0	-15.4	Pass
2	98.17	45.63	4.00	-18.60	31.03	MaxQP	Vertical	106	8	43.0	-12.0	Pass
3	124.18	39.12	4.12	-14.60	28.64	MaxQP	Vertical	102	76	43.0	-14.4	Pass
4	146.84	47.08	4.23	-15.90	35.41	MaxQP	Vertical	102	174	43.0	-7.6	Pass
5	338.68	42.47	4.98	-13.70	33.75	MaxQP	Horizontal	101	257	46.0	-12.3	Pass
6	361.26	40.96	5.06	-12.70	33.52	MaxQP	Horizontal	102	276	46.0	-12.5	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.

back to matrix

DIGITAL EMISSIONS

Variant: BLE, Test Freq: 2426.00 MHz, Antenna: AMPHENOL WD PCB, Power Setting: Max, Duty Cycle (%): 66



30.00 - 1000.00 MHz												
Num	Frequency MHz	Raw dBµV	Cable Loss dB	AF dB/m	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	31.78	28.69	3.53	-8.70	23.52	MaxQP	Vertical	122	352	40.0	-16.5	Pass
2	98.06	46.15	4.00	-18.60	31.55	MaxQP	Vertical	101	1	43.0	-11.5	Pass
3	124.18	39.62	4.12	-14.60	29.14	MaxQP	Vertical	100	73	43.0	-13.9	Pass
4	146.74	46.88	4.23	-15.90	35.21	MaxQP	Vertical	99	171	43.0	-7.8	Pass
5	338.68	41.57	4.98	-13.70	32.85	MaxQP	Horizontal	101	257	46.0	-13.2	Pass
6	361.26	40.26	5.06	-12.70	32.62	MaxQP	Horizontal	100	270	46.0	-13.4	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.

back to matrix

DIGITAL EMISSIONS

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: WD PCB, Power Setting: Max

30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	31.84	28.39	3.53	-8.70	23.24	MaxQP	Vertical	119	345	40.0	-16.8	Pass
2	98.35	45.26	4.00	-18.60	30.67	MaxQP	Vertical	106	7	43.0	-12.3	Pass
3	124.58	38.91	4.12	-14.60	28.43	MaxQP	Vertical	101	76	43.0	-14.6	Pass
4	146.79	47.99	4.23	-15.90	36.33	MaxQP	Vertical	100	178	43.0	-6.7	Pass
5	338.76	41.47	4.98	-13.70	32.74	MaxQP	Horizontal	106	253	46.0	-13.3	Pass
6	361.00	40.95	5.06	-12.70	33.31	MaxQP	Horizontal	100	275	46.0	-12.7	Pass

Test Notes: EUT powered by AC/DC PS. Connected to laptop outside chamber via ENET. 2nd ENET connected to Hub with data transferring. Audio ports looped back.

back to matrix

575 Boulder Court
Pleasanton, California 94566, USA
Tel: +1 (925) 462 0304
Fax: +1 (925) 462 0306
www.micomlabs.com