



**REGULATORY COMPLIANCE TEST REPORT**  
**FCC CFR 47 15.247, RSS-247 Issue 2**

**Report No.: SONO01-U4 Rev A (BLE)**

**Company:** Sonos, Inc

**Test of:** S26



## REGULATORY COMPLIANCE TEST REPORT

**Company:** Sonos Inc.

**Test of:** S26

**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS), RSS-247 Issue 2

**Test Report Serial No.:** SONO01-U4 Rev A (BLE)

This report supersedes: NONE

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

Issue Date: 31<sup>st</sup> March 2020

**This Test Report is Issued Under the Authority of:**

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MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

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## **1. ACCREDITATION, LISTINGS & RECOGNITION**

### **1.1. TESTING ACCREDITATION**

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard ISO/IEC 17025:2017. The company is accredited by the American Association for Laboratory Accreditation (A2LA) [www.a2la.org](http://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>



## 1.2. RECOGNITION

MiCOM Labs, Inc has widely recognized wireless testing and certification capabilities. In addition to being recognized for Testing and Certification under Phase 2 agreements with Canada, Europe and Japan, our international recognition includes Conformity Assessment Body designation under Phase 1 agreements with APEC MRA countries. MiCOM Labs test reports are accepted globally.

Country	Recognition Body	Status	MRA Phase	Identification No.
USA	Federal Communications Commission (FCC)	TCB	-	US0159 Test Firm Designation#: US1084
Canada	Industry Canada (ISED)	FCB	APEC MRA 2	US0159 ISED#: 4143A
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	Japan MRA 2	RCB 210
	Japan Approvals Institute for Telecommunication Equipment (JATE)			
	VCCI			
Europe	European Commission	NB	EU MRA 2	NB 2280
Mexico	Instituto Federal de Telecomunicaciones (IFT)	CAB	Mexico MRA 1	US0159
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)			
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)			
Singapore	Infocomm Development Authority (IDA)			
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)			
Vietnam	Ministry of Communication (MIC)			

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.

MRA 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](http://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 24<sup>th</sup> day of February 2020



Vice President, Accreditation Services  
For the Accreditation Council  
Certificate Number 2381.02  
Valid to November 30, 2021



*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	27 <sup>th</sup> March 2020	
Rev A	31 <sup>st</sup> March 2020	Initial Release

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:** S26

**Telephone:** +1 925 462 0304  
**Fax:** +1 925 462 0306

**Equipment Type:** Home Audio Equipment

**S/N's:** Conducted: #1  
Radiated: 54-2A-1B-20-02-04-E

**Test Date(s):** 23<sup>rd</sup> – 27<sup>th</sup> March 2020

**Website:** [www.micomlabs.com](http://www.micomlabs.com)

#### **STANDARD(S)**

**FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
ISED RSS-247 Issue 2**

#### **TEST RESULTS**

**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:**

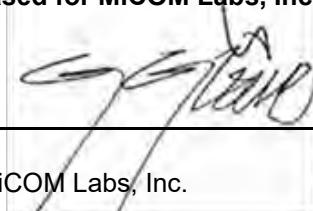
1. This document reports conditions under which testing was conducted and the results of testing performed.
2. Details of test methods used have been recorded and kept on file by the laboratory.
3. Test results apply only to the item(s) tested.

**Approved & Released for MiCOM Labs, Inc. by:**



TESTING CERT #2381.01

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 v05r02	2nd April 2019	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	October 2019	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	2020	Radio Frequency Devices; Subpart C – Intentional Radiators
IX	ICES-003	Issue 6 Jan 2016; Updated April 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	March 2019 Amendment 1	General Requirements for Compliance of Radio Apparatus
XIII	FCC 47 CFR Part 2.1033	2020	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

#### **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.

## 5. PRODUCT DETAILS AND TEST CONFIGURATIONS

### 5.1. Technical Details

Details	Description
Purpose:	Test of the Sonos, Inc S26 BLE technology 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 Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) 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:	SONO01 - S26 FCC ISED EU Japan China Mexico
Date EUT received:	20 <sup>th</sup> March 2020
Standard(s) applied:	FCC CFR 47 Part 15 Subpart C 15.247 (DTS) ISED RSS-247
Dates of test (from - to):	23 <sup>rd</sup> – 27 <sup>th</sup> March 2020
No of Units Tested:	2
Product Family Name:	N/A
Model(s):	S26
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):	-2 dBm
Rated Input Voltage and Current:	115 Vac, 60 Hz, 2A
Operating Temperature Range:	0°C - 40°C
ITU Emission Designator:	1M1G1D
Hardware Rev:	A100
Firmware Ver:	See Software Rev.
Software Rev:	52.10-64150-1-29

## 5.2. Scope Of Test Program

### Sonos, Inc S26

The scope of the test program was to test the Sonos, Inc S26 configurations in the frequency ranges 2400 - 2483.5 MHz for compliance against the following specification:

#### 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.	S26	54-2A-1B-20-02-04-E
EUT	Home Audio Equipment	SONOS Inc.	S26	Conducted #1
Support	Laptop	Lenovo	X230	SON-00002271

## 5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
integral	Sonos	n/a	f type	6.1	-	360	-	2400 - 2483.5

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

## 5.5. Cabling and I/O Ports

Port Type	Max Cable Length	# of Ports	Screened	Conn Type	Data Type	Bit Rate
Ethernet	10-30m	1	n/a	RJ45	Packet Data	10/100/1000
AC Input	< 3M	1	Y	AC Jack	Analog	n/a

## **5.6. Test Configurations**

Results for the following configurations are provided in this report:

<b>Operational Mode(s)</b>	<b>Data Rate with Highest Power</b>	<b>Channel Frequency (MHz)</b>		
		<b>Low</b>	<b>Mid</b>	<b>High</b>
<b>2400 - 2483.5 MHz</b>				
BLE (GFSK)	N/A	2,402.00	2,426.00	2,480.00

## **5.7. Equipment Modifications**

The following modifications were required to bring the equipment into compliance:

1. NONE

## **5.8. 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

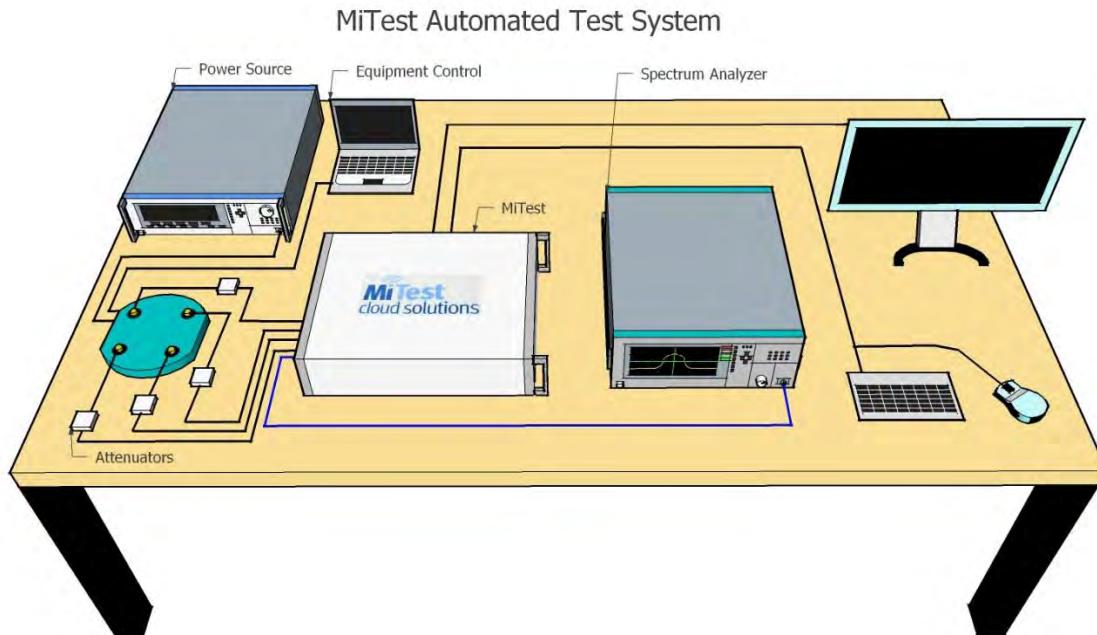
### List of Measurements

Test Header	Result	Data Link
6 dB & 99% Bandwidth	Complies	<a href="#">View Data</a>
Conducted Output Power	Complies	<a href="#">View Data</a>
Power Spectral Density	Complies	<a href="#">View Data</a>
Emissions	Complies	-
(1) Conducted Emissions	Complies	-
(i) Conducted Spurious Emissions	Complies	<a href="#">View Data</a>
(ii) Conducted Band-Edge Emissions	Complies	<a href="#">View Data</a>
(2) Radiated Emissions	Complies	-
(i) TX Spurious & Restricted Band Emissions	Complies	<a href="#">View Data</a>
(ii) Restricted Edge & Band-Edge Emissions	Complies	<a href="#">View Data</a>
(3) Digital Emissions (0.03 - 1 GHz)	Not Tested	See test report SONO01-U2
(4) AC Wireline Emissions	Not Tested	See test report SONO01-U2
Maximum Permissible Exposure	Complies	SONO01-MPE
RF Unique Connector	Complies (integral Antennas)	-

## 7. TEST EQUIPMENT CONFIGURATION(S)

### 7.1. Conducted

Conducted RF Emission Test Set-up(s) The following tests were performed using the conducted test set-up shown in the diagram below.



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

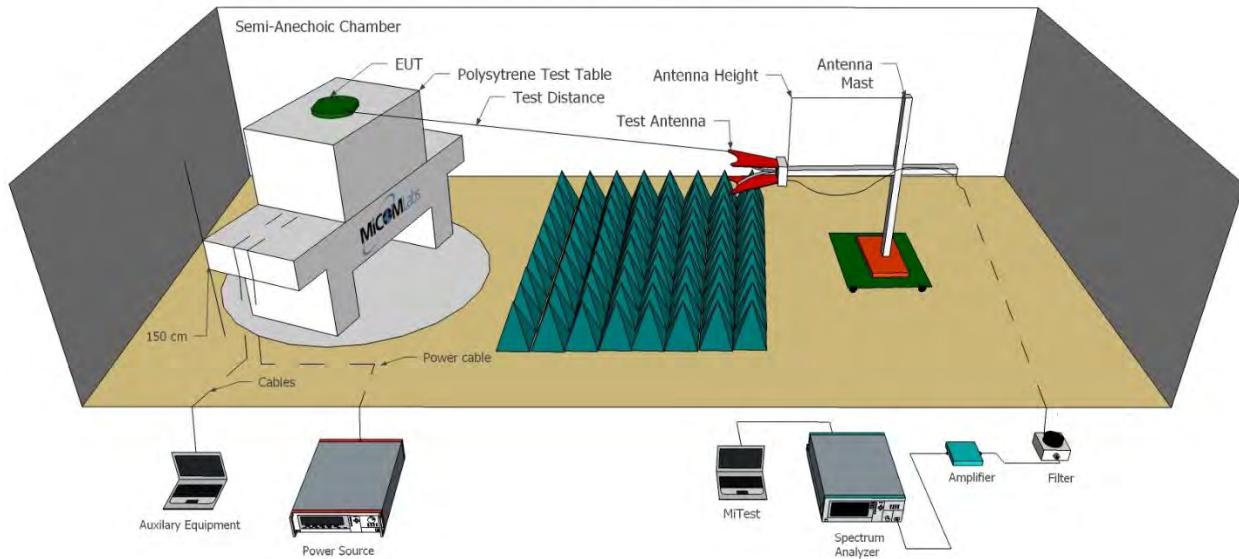
Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
127	Power Supply	HP	6674A	US36370530	Cal when used
248	Resistance Thermometer	Thermotronics	GR2105-02	9340 #1	30 Oct 2020
398	MiTest RF Conducted Test Software	MiCOM	MiTest ATS	Version 4.1	Not Required
420	USB to GPIB Interface	National Instruments	GPIB-USB HS	1346738	Not Required
461	Spectrum Analyzer	Agilent	E4440A	MY46185537	20 Sep 2020
441	USB Wideband Power Sensor	Boonton	55006	9179	19 Sep 2020
510	Barometer/Thermometer	Control Company	68000-49	170871375	20 Dec 2020
512	MiTest Cloud Solutions RF Test Box	MiCOM	2nd Gen with DFS	512	27 Sep 2020
516	USB Wideband Power Sensor	Boonton	RTP5006	10511	12 Jun 2020
517	USB Wideband Power Sensor	Boonton	RTP5006	10510	12 Jun 2020

436	USB Wideband Power Sensor	Boonton	55006	8731	19 Sep 2020
RF#2 GPIB#1	GPIB cable to Power Supply	HP	GPIB	None	Not Required
RF#2 SMA#1	EUT to Mitest box port 1	Flexco	SMA Cable port1	None	27 Sep 2020
RF#2 SMA#2	EUT to Mitest box port 2	Flexco	SMA Cable port2	None	27 Sep 2020
RF#2 SMA#3	EUT to Mitest box port 3	Flexco	SMA Cable port3	None	27 Sep 2020
RF#2 SMA#4	EUT to Mitest box port 4	Flexco	SMA Cable port4	None	27 Sep 2020
RF#2 SMA#SA	Mitest box to SA	Flexco	SMA Cable SA	None	27 Sep 2020
RF#2 USB#1	USB Cable to Mitest Box	Dynex	USB Cable	None	Not Required

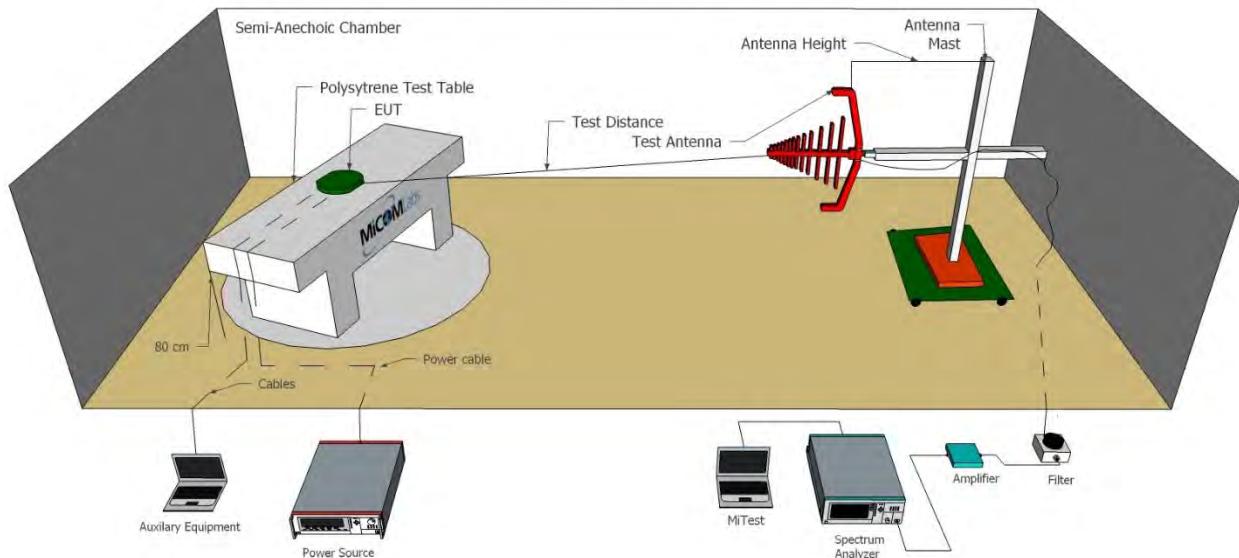
## 7.2. Radiated Emissions

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

Radiated Emissions Above 1GHz Test Setup



Radiated Emissions Below 1GHz Test Setup



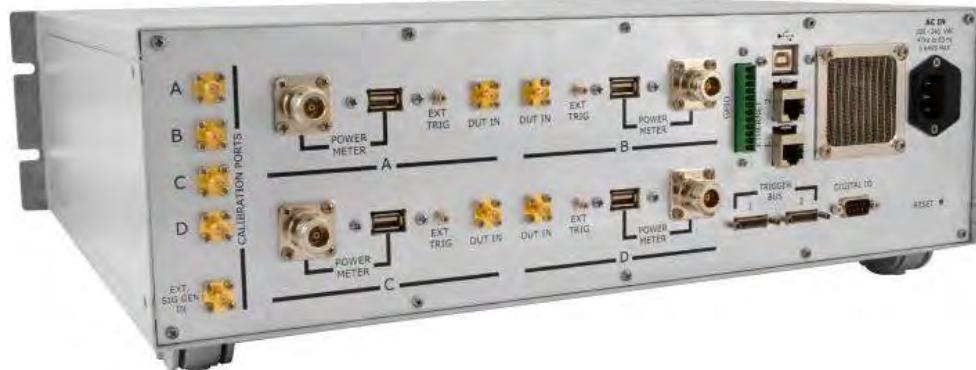
A full system calibration was performed on the test station and any resulting system losses (or gains) were taken into account in the production of all final measurement data.

## **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 MiCOM Labs "[MiTest](#)" Automated Test System" (Patent Pending)

## **9. TEST RESULTS**

### **9.1. Control of Test Item**

The EUT was controlled via the Sonos GUI. This gave access to operational channels, output power and antenna port activation. The device a single chain device was activated to operate during conducted and radiated testing. Duty cycle was fixed as reported in Section 9.2.

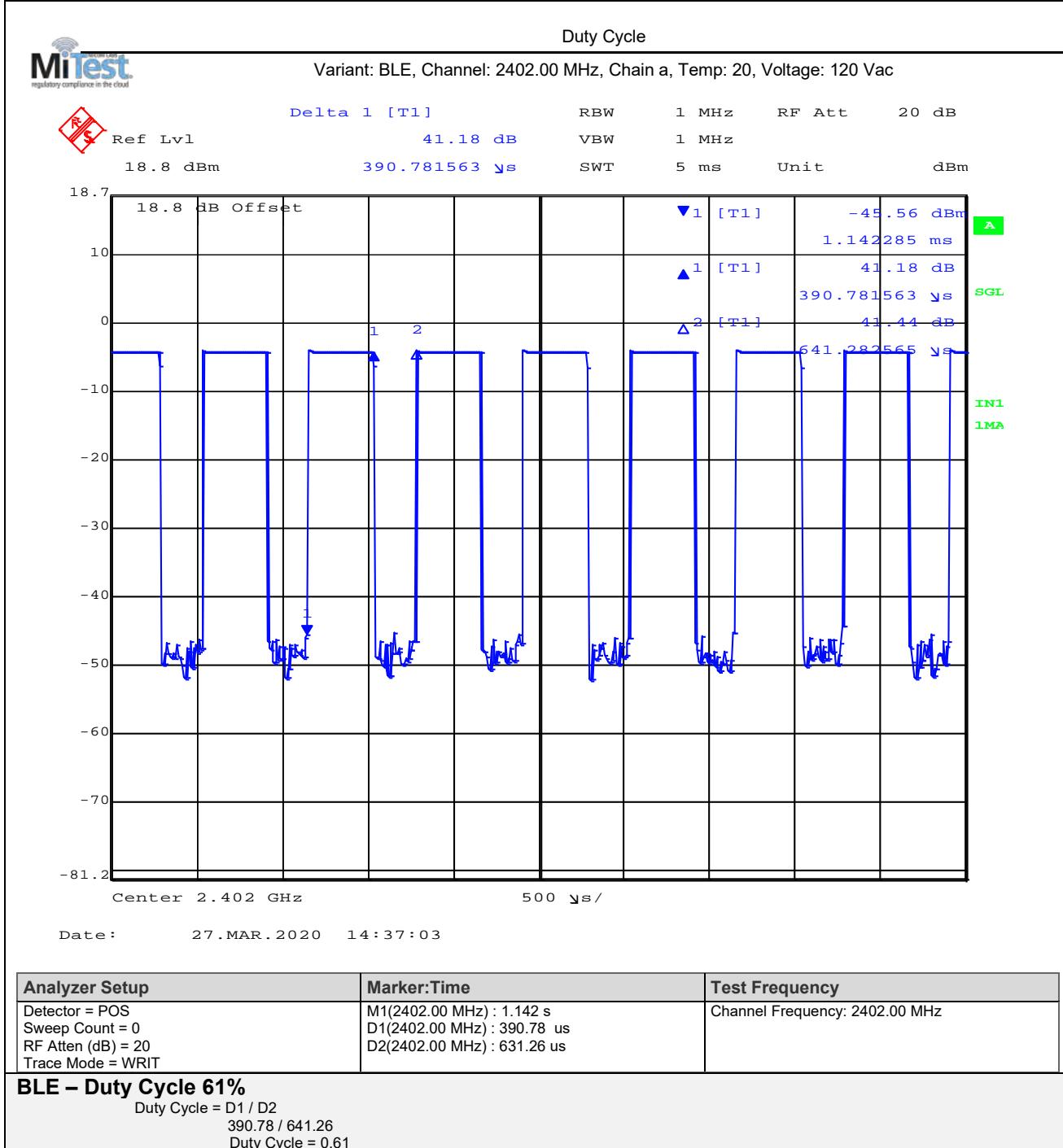
The power setting reported in Section 9.4 Conducted Output Power is the final power setting found in order to prove compliance for radiated and conducted testing for the Sonos S26.

#### **Output Power**

In the case of average power measurements an average power sensor was utilized using connected to each antenna port. Power measurements on the antenna ports were measured, the EUT was set to transmit maximum power during the test program (compliant power setting logged for each test mode). As the Duty Cycle was constant (see Section 9.2 Operational Mode Duty Cycle) the duty cycle correction factor was used to correct all power readings.

## 9.2. Operational Mode Duty Cycle(s)

Results for system Duty Cycle for the following configurations are measured and reported below:



### 9.3. 6 dB & 99% Bandwidth

Conducted Test Conditions for 6 dB and 99% Bandwidth			
<b>Standard:</b>	FCC CFR 47:15.247	<b>Ambient Temp. (°C):</b>	24.0 - 27.5
<b>Test Heading:</b>	6 dB and 99 % Bandwidth	<b>Rel. Humidity (%):</b>	32 - 45
<b>Standard Section(s):</b>	15.247 (a)(2)	<b>Pressure (mBars):</b>	999 - 1001
<b>Reference Document(s):</b>	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**

<b>Variant:</b>	GFSK	<b>Duty Cycle (%):</b>	61
<b>Data Rate:</b>	1.00 MBit/s	<b>Antenna Gain (dBi):</b>	Not Applicable
<b>Modulation:</b>	GFSK	<b>Beam Forming Gain (Y)(dB):</b>	Not Applicable
<b>TPC:</b>	Not Applicable	<b>Tested By:</b>	SB
<b>Engineering Test Notes:</b>			

**Test Measurement Results**

<b>Test Frequency</b>	<b>Measured 6 dB Bandwidth (MHz)</b>				<b>6 dB Bandwidth (MHz)</b>			
	<b>Port(s)</b>							
<b>MHz</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	<b>Highest</b>	<b>Lowest</b>		
2402.0	<a href="#">0.693</a>	--	--	--	0.693	0.693		
2426.0	<a href="#">0.697</a>	--	--	--	0.697	0.697		
2480.0	<a href="#">0.693</a>	--	--	--	0.693	0.693		

<b>Test Frequency</b>	<b>Measured 99% Bandwidth (MHz)</b>				<b>Maximum 99% Bandwidth (MHz)</b>						
	<b>Port(s)</b>										
<b>MHz</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>							
2402.0	<a href="#">1.130</a>	--	--	--	1.130						
2426.0	<a href="#">1.130</a>	--	--	--	1.130						
2480.0	<a href="#">1.134</a>	--	--	--	1.134						

**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. Conducted Output Power

Conducted Test Conditions for Fundamental Emission Output Power			
<b>Standard:</b>	FCC CFR 47:15.247	<b>Ambient Temp. (°C):</b>	24.0 - 27.5
<b>Test Heading:</b>	Output Power	<b>Rel. Humidity (%):</b>	32 - 45
<b>Standard Section(s):</b>	15.247 (b) & (c)	<b>Pressure (mBars):</b>	999 - 1001
<b>Reference Document(s):</b>	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 ( $\Sigma$ ) 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  $[10^{\log_{10} (10^{a/10} + 10^{b/10} + 10^{c/10} + 10^{d/10})}]$

$G$  = 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**

<b>Variant:</b>	GFSK	<b>Duty Cycle (%):</b>	61.0
<b>Data Rate:</b>	1.00 MBit/s	<b>Antenna Gain (dBi):</b>	6.10
<b>Modulation:</b>	GFSK	<b>Beam Forming Gain (Y)(dB):</b>	Not Applicable
<b>TPC:</b>	Not Applicable	<b>Tested By:</b>	SB
<b>Engineering Test Notes:</b>			

**Test Measurement Results**

<b>Test Frequency</b>	<b>Measured Output Power (dBm)</b>				<b>Calculated Total Power Σ Port(s)</b>	<b>Limit</b>	<b>Margin</b>	<b>EUT Power Setting</b>
	<b>Port(s)</b>							
<b>MHz</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	<b>dBm</b>	<b>dBm</b>	<b>dB</b>	
<b>2402.0</b>	-2.50	--	--	--	-2.50	29.90	-32.40	Max
<b>2426.0</b>	-2.49	--	--	--	-2.49	29.90	-32.39	Max
<b>2480.0</b>	-2.51	--	--	--	-2.51	29.90	-32.41	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.

## 9.5. Power Spectral Density

Conducted Test Conditions for Power Spectral Density			
<b>Standard:</b>	FCC CFR 47:15.247	<b>Ambient Temp. (°C):</b>	24.0 - 27.5
<b>Test Heading:</b>	Power Spectral Density	<b>Rel. Humidity (%):</b>	32 - 45
<b>Standard Section(s):</b>	15.247 (e)	<b>Pressure (mBars):</b>	999 - 1001
<b>Reference Document(s):</b>	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 (a) 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

$A = \text{Total Power Spectral Density} [10 \log_{10} (10^{a/10} + 10^{b/10} + 10^{c/10} + 10^{d/10})]$

$x = \text{Duty Cycle}$

### 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**

<b>Variant:</b>	GFSK	<b>Duty Cycle (%):</b>	61.0
<b>Data Rate:</b>	1.00 MBit/s	<b>Antenna Gain (dBi):</b>	6.10
<b>Modulation:</b>	GFSK	<b>Beam Forming Gain (Y)(dB):</b>	Not Applicable
<b>TPC:</b>	Not Applicable	<b>Tested By:</b>	SB
<b>Engineering Test Notes:</b>			

**Test Measurement Results**

Test Frequency	Measured Power Spectral Density				Amplitude Summation	Limit	Margin
	Port(s) (dBm/3KHz)						
MHz	a	b	c	d	dBm/3KHz	dBm/3KHz	dB
2402.0	<a href="#">-3.992</a>	--	--	--	-3.992	8.0	-12.0
2426.0	<a href="#">-3.800</a>	--	--	--	-3.800	8.0	-11.8
2480.0	<a href="#">-4.492</a>	--	--	--	-4.492	8.0	-12.5

**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).

## 9.6. Emissions

### 9.6.1. Conducted Emissions

#### 9.6.1.1. Conducted Spurious Emissions

Conducted Test Conditions for Transmitter Conducted Spurious and Band-Edge Emissions			
<b>Standard:</b>	FCC CFR 47:15.247	<b>Ambient Temp. (°C):</b>	24.0 - 27.5
<b>Test Heading:</b>	Max Unwanted Emission Levels	<b>Rel. Humidity (%):</b>	32 - 45
<b>Standard Section(s):</b>	15.247 (d)	<b>Pressure (mBars):</b>	999 - 1001
<b>Reference Document(s):</b>	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)).

Equipment Configuration for Conducted Spurious Emissions - Peak

<b>Variant:</b>	GFSK	<b>Duty Cycle (%):</b>	61
<b>Data Rate:</b>	1.00 MBit/s	<b>Antenna Gain (dBi):</b>	Not Applicable
<b>Modulation:</b>	GFSK	<b>Beam Forming Gain (Y):</b>	Not Applicable
<b>TPC:</b>	Not Applicable	<b>Tested By:</b>	SB
<b>Engineering Test Notes:</b>			

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
2402.0	30.0 - 26000.0	<a href="#">43.016</a>	-23.89	--	--	--	--	--	--
2426.0	30.0 - 26000.0	<a href="#">42.502</a>	-24.58	--	--	--	--	--	--
2480.0	30.0 - 26000.0	<a href="#">41.524</a>	-24.35	--	--	--	--	--	--

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).

### 9.6.1.2. Conducted Band-Edge Emissions

#### Equipment Configuration for Conducted Low Band-Edge Emissions - Peak

<b>Variant:</b>	GFSK	<b>Duty Cycle (%):</b>	61.0
<b>Data Rate:</b>	1.00 MBit/s	<b>Antenna Gain (dBi):</b>	Not Applicable
<b>Modulation:</b>	GFSK	<b>Beam Forming Gain (Y)(dB):</b>	Not Applicable
<b>TPC:</b>	Not Applicable	<b>Tested By:</b>	SB
<b>Engineering Test Notes:</b>			

#### Test Measurement Results

<b>Channel Frequency:</b>	2402.0 MHz				
<b>Band-Edge Frequency:</b>	2400.0 MHz				
<b>Test Frequency Range:</b>	2350.0 - 2405.0 MHz				
Port(s)	Band-Edge Markers and Limit			Revised Limit	
	M1 Amplitude (dBm)	Plot Limit (dBm)	M2 Frequency (MHz)	Amplitude (dBm)	M2A Frequency (MHz)
a	<u>-37.68</u>	-22.72	2401.40	--	--
					-1.400

#### Equipment Configuration for Conducted High Band-Edge Emissions - Peak

<b>Variant:</b>	GFSK				
<b>Data Rate:</b>	1.00 MBit/s				
<b>Modulation:</b>	GFSK				
Port(s)	Band-Edge Markers and Limit			Revised Limit	
	M3 Amplitude (dBm)	Plot Limit (dBm)	M2 Frequency (MHz)	Amplitude (dBm)	M2A Frequency (MHz)
a	<u>-42.11</u>	-22.33	2480.60	--	--
					-2.900

#### Test Measurement Results

<b>Channel Frequency:</b>	2480.0 MHz				
<b>Band-Edge Frequency:</b>	2483.5 MHz				
<b>Test Frequency Range:</b>	2475.0 - 2524.0 MHz				
Port(s)	Band-Edge Markers and Limit			Revised Limit	
	M3 Amplitude (dBm)	Plot Limit (dBm)	M2 Frequency (MHz)	Amplitude (dBm)	M2A Frequency (MHz)
a	<u>-42.11</u>	-22.33	2480.60	--	--
					-2.900

#### 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).

### 9.6.2. Radiated Emissions

#### 9.6.2.3. TX Spurious & Restricted Band Emissions

Radiated Test Conditions for Radiated Spurious and Band-Edge Emissions (Restricted Bands)			
<b>Standard:</b>	FCC CFR 47 Part 15 Subpart C 15.247 (DTS)	<b>Ambient Temp. (°C):</b>	20.0 - 24.5
<b>Test Heading:</b>	Radiated Spurious and Band-Edge Emissions	<b>Rel. Humidity (%):</b>	32 - 45
<b>Standard Section(s):</b>	15.205, 15.209	<b>Pressure (mBars):</b>	999 - 1001
<b>Reference Document(s):</b>	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:

$$FS = 51.5 + 8.5 + 1.3 - 26.0 + 1 = 36.3 \text{ dBmV/m}$$

Conversion between dBmV/m (or dBmV) and mV/m (or mV) are as follows:

$$\text{Level (dBmV/m)} = 20 * \log(\text{level (mV/m)})$$

$$40 \text{ dBmV/m} = 100 \text{ mV/m}$$

$$48 \text{ dBmV/m} = 250 \text{ mV/m}$$

##### 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).

**Equipment Configuration for TX Spurious & Restricted Band Emissions**

<b>Antenna:</b>	Integral	<b>Variant:</b>	BLE
<b>Antenna Gain (dBi):</b>	6.10	<b>Modulation:</b>	GFSK
<b>Beam Forming Gain (Y):</b>	Not Applicable	<b>Duty Cycle (%):</b>	61
<b>Channel Frequency (MHz):</b>	2402.00	<b>Data Rate:</b>	1.00 MBit/s
<b>Power Setting:</b>	Max	<b>Tested By:</b>	JMH

**Test Measurement Results**

1000.00 - 18000.00 MHz													
Num	Frequency MHz	Raw dB $\mu$ V	Cable Loss dB	AF dB/m	Level dB $\mu$ V/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dB $\mu$ V/m	Margin dB	Pass /Fail	
#1	4804.02	60.55	2.85	-12.42	50.98	Max Peak	Vertical	165	247	74.0	-23.0	Pass	
#2	4804.02	53.97	2.85	-12.42	46.50	Max Avg	Vertical	165	247	54.0	-7.5	Pass	

Test Notes: Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. Duty Cycle correction 2.1 dB

Radiated spurious emissions were investigated up to the 10th harmonic of the fundamental and no emissions were found



**Title:** Sonos, Inc SUB  
**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
**Serial #:** SONO01-U4 Rev A (BLE)

#### Equipment Configuration for TX Spurious & Restricted Band Emissions

<b>Antenna:</b>	Integral	<b>Variant:</b>	BLE
<b>Antenna Gain (dBi):</b>	6.10	<b>Modulation:</b>	GFSK
<b>Beam Forming Gain (Y):</b>	Not Applicable	<b>Duty Cycle (%):</b>	61
<b>Channel Frequency (MHz):</b>	2426.00	<b>Data Rate:</b>	1.00 MBit/s
<b>Power Setting:</b>	Max	<b>Tested By:</b>	JMH

#### Test Measurement Results

[Click here to view measurement data...](#)

Test Notes: Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. Duty Cycle correction 2.1 dB

Radiated spurious emissions were investigated up to the 10th harmonic of the fundamental and no emissions were found



**Title:** Sonos, Inc SUB  
**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
**Serial #:** SONO01-U4 Rev A (BLE)

#### Equipment Configuration for TX Spurious & Restricted Band Emissions

<b>Antenna:</b>	Integral	<b>Variant:</b>	BLE
<b>Antenna Gain (dBi):</b>	6.10	<b>Modulation:</b>	GFSK
<b>Beam Forming Gain (Y):</b>	Not Applicable	<b>Duty Cycle (%):</b>	61
<b>Channel Frequency (MHz):</b>	2480.00	<b>Data Rate:</b>	1.00 MBit/s
<b>Power Setting:</b>	Max	<b>Tested By:</b>	JMH

#### Test Measurement Results

[Click here to view measurement data...](#)

Test Notes: Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. Duty Cycle correction 2.1 dB

Radiated spurious emissions were investigated up to the 10th harmonic of the fundamental and no emissions were found

#### 9.6.2.4. Restricted Edge & Band-Edge Emissions

Sonos		Band-Edge Freq	Limit 74.0dB $\mu$ V/m	Limit 54.0dB $\mu$ V/m	Power Setting
Operational Mode	Operating Frequency (MHz)	MHz	dB $\mu$ V/m	dB $\mu$ V/m	
BLE	2402.00	2390.00	61.15	38.36	Max



**Title:** Sonos, Inc SUB  
**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
**Serial #:** SONO01-U4 Rev A (BLE)

Equipment Configuration for Radiated - Lower Restricted Band-Edge Emissions

<b>Antenna:</b>	Integral	<b>Variant:</b>	BLE
<b>Antenna Gain (dBi):</b>	Not Applicable	<b>Modulation:</b>	GFSK
<b>Beam Forming Gain (Y):</b>	Not Applicable	<b>Duty Cycle (%):</b>	61
<b>Channel Frequency (MHz):</b>	2402.00	<b>Data Rate:</b>	1.00 MBit/s
<b>Power Setting:</b>	Max	<b>Tested By:</b>	JMH

Test Measurement Results

2310.00 - 2422.00 MHz													
Num	Frequency MHz	Raw dB $\mu$ V	Cable Loss dB	AF dB/m	Level dB $\mu$ V/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dB $\mu$ V/m	Margin dB	Pass /Fail	
#1	2390.00	2.28	2.02	31.96	38.36	Max Avg	Vertical	113	68	54.0	-15.6	Pass	
#2	2390.00	27.17	2.02	31.96	61.15	Max Peak	Vertical	113	68	74.0	-12.9	Pass	
#3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--	

Test Notes: Eut connected to laptop outside chamber via ethernet. Duty Cycle correction 2.1 dB



**Title:** Sonos, Inc SUB  
**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
**Serial #:** SONO01-U4 Rev A (BLE)

Sonos		Band-Edge Freq	Limit 74.0dB $\mu$ V/m	Limit 54.0dB $\mu$ V/m	Power Setting
Operational Mode	Operating Frequency (MHz)	MHz	dB $\mu$ V/m	dB $\mu$ V/m	
BLE	2480.00	2483.50	71.81	40.08	Max



**Title:** Sonos, Inc SUB  
**To:** FCC CFR 47 Part 15 Subpart C 15.247 (DTS)  
**Serial #:** SONO01-U4 Rev A (BLE)

Equipment Configuration for Radiated - Upper Restricted Band-Edge Emissions

<b>Antenna:</b>	Integral	<b>Variant:</b>	BLE
<b>Antenna Gain (dBi):</b>	Not Applicable	<b>Modulation:</b>	GFSK
<b>Beam Forming Gain (Y):</b>	Not Applicable	<b>Duty Cycle (%):</b>	61
<b>Channel Frequency (MHz):</b>	2480.00	<b>Data Rate:</b>	1.00 MBit/s
<b>Power Setting:</b>	Max	<b>Tested By:</b>	JMH

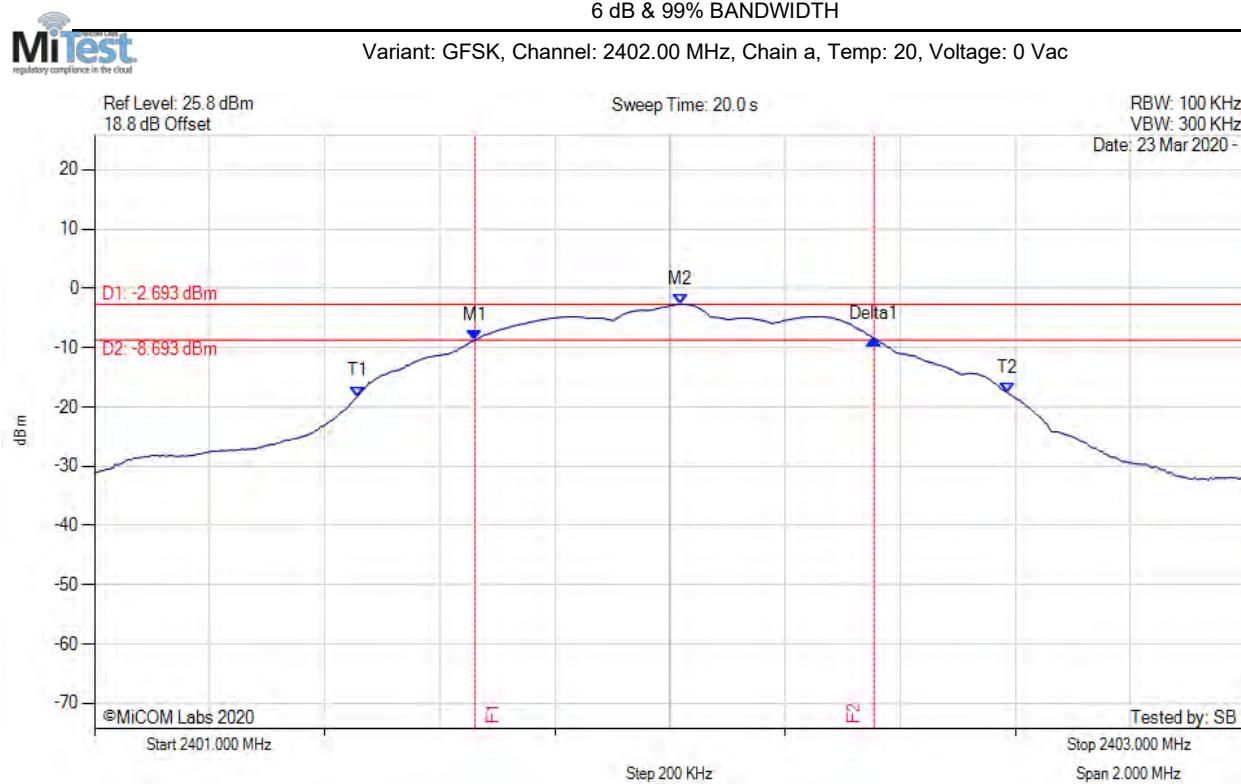
Test Measurement Results

2452.00 - 2520.00 MHz													
Num	Frequency MHz	Raw dB $\mu$ V	Cable Loss dB	AF dB/m	Level dB $\mu$ V/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dB $\mu$ V/m	Margin dB	Pass /Fail	
#1	2483.50	3.62	2.03	32.33	40.08	Max Avg	Vertical	113	68	54.0	-13.9	Pass	
#2	2483.50	37.45	2.03	32.33	71.81	Max Peak	Vertical	113	68	74.0	-2.2	Pass	
#3	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--	

Test Notes: Eut connected to laptop outside chamber via ethernet. Duty Cycle correction 2.1 dB

## **A. APPENDIX - GRAPHICAL IMAGES**

### A.1. 6 dB & 99% Bandwidth



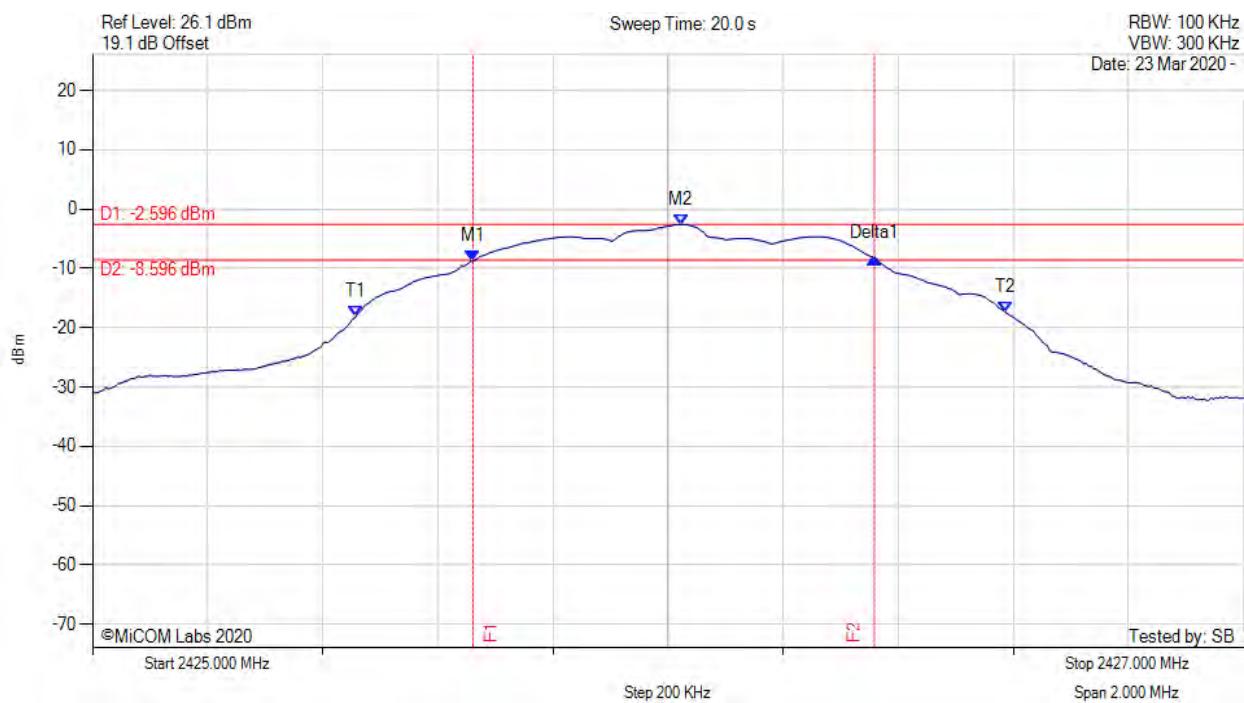
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2401.661 MHz : -8.790 dBm M2 : 2402.018 MHz : -2.693 dBm Delta1 : 693 KHz : 0.289 dB T1 : 2401.457 MHz : -18.273 dBm T2 : 2402.587 MHz : -17.623 dBm OBW : 1.130 MHz	Measured 6 dB Bandwidth: 0.693 MHz Limit: 500 kHz Margin: -0.193 MHz

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6 dB & 99% BANDWIDTH



Variant: GFSK, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



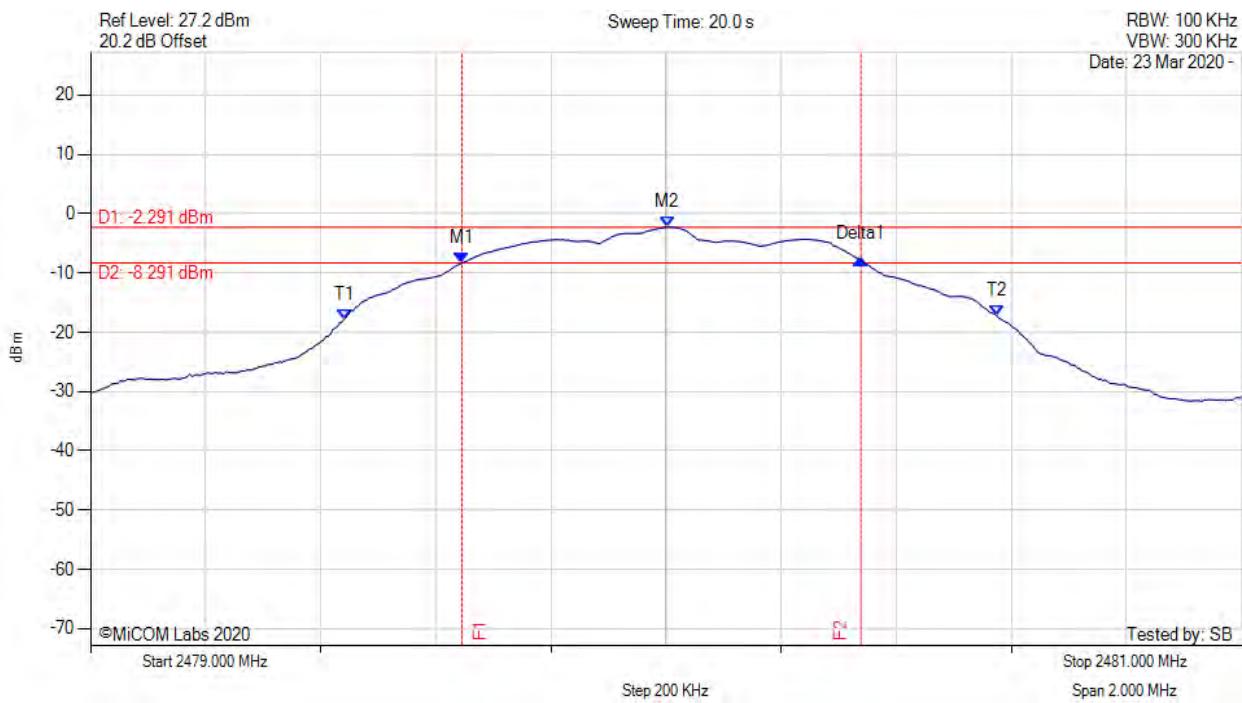
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2425.661 MHz : -8.744 dBm M2 : 2426.022 MHz : -2.596 dBm Delta1 : 697 KHz : 0.437 dB T1 : 2425.457 MHz : -18.187 dBm T2 : 2426.587 MHz : -17.451 dBm OBW : 1.130 MHz	Measured 6 dB Bandwidth: 0.697 MHz Limit: 500 kHz Margin: -0.197 MHz

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6 dB & 99% BANDWIDTH



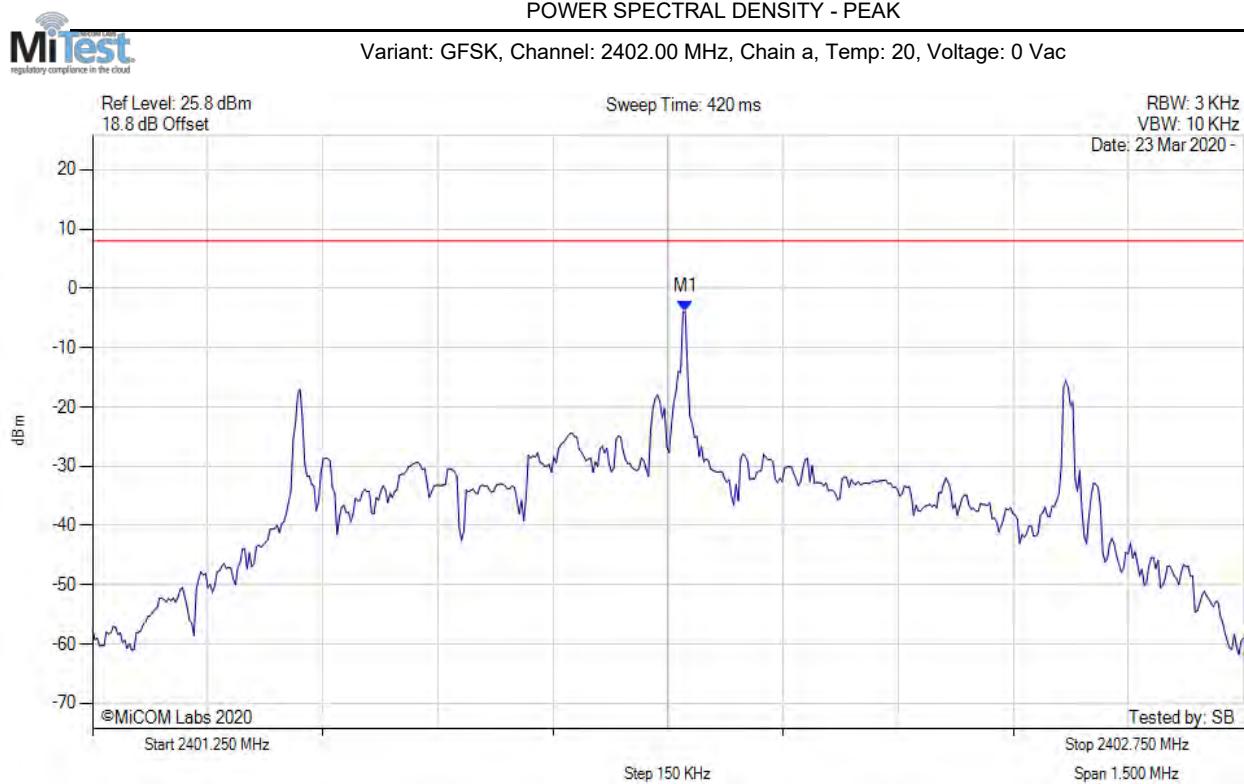
Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAX HOLD	M1 : 2479.645 MHz : -8.352 dBm M2 : 2480.002 MHz : -2.291 dBm Delta1 : 693 KHz : 0.604 dB T1 : 2479.441 MHz : -17.839 dBm T2 : 2480.575 MHz : -17.237 dBm OBW : 1.134 MHz	Measured 6 dB Bandwidth: 0.693 MHz Limit: 500 kHz Margin: -0.193 MHz

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## A.2. Power Spectral Density



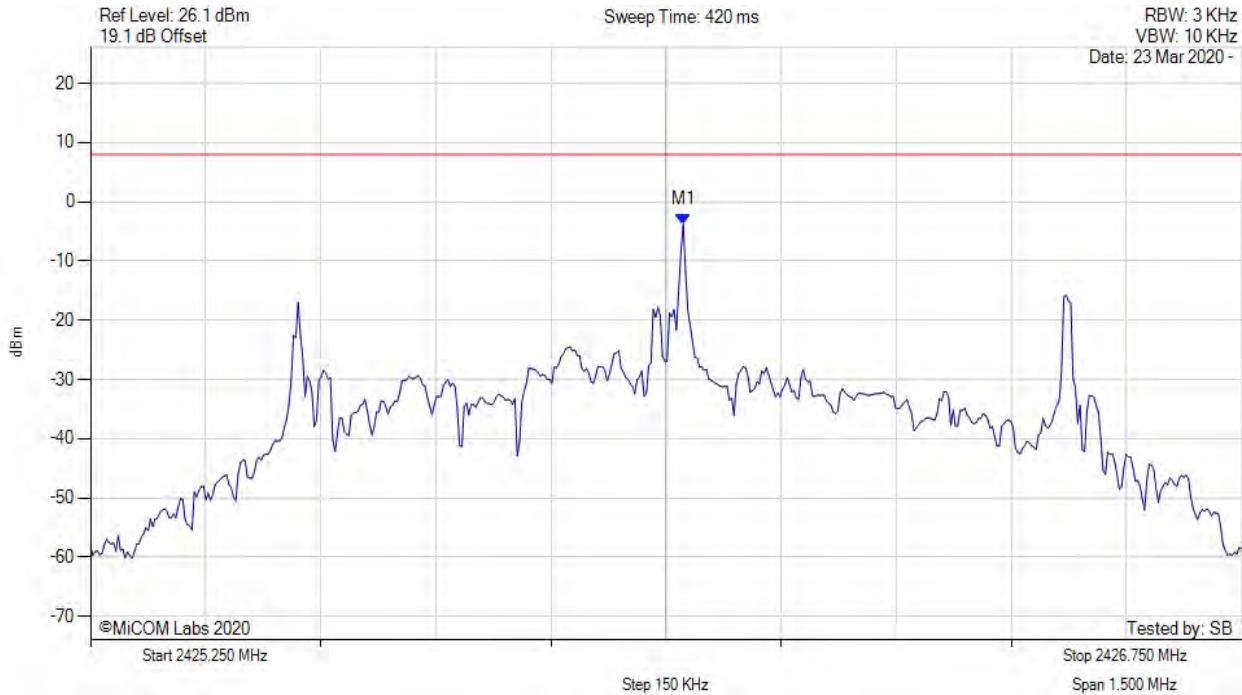
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2402.023 MHz : -3.992 dBm	Limit: ≤ 8.000 dBm Margin: 11.99 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



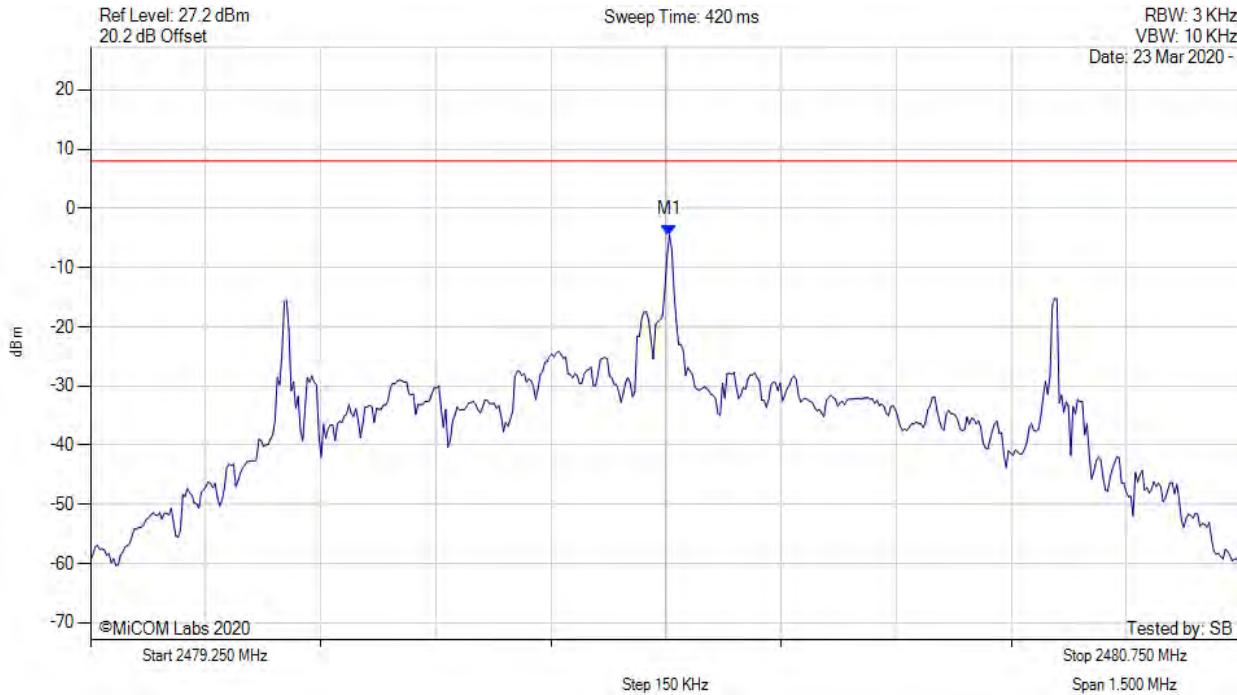
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2426.023 MHz : -3.800 dBm	Limit: ≤ 8.000 dBm Margin: 11.80 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2480.005 MHz : -4.492 dBm	Limit: ≤ 8.000 dBm Margin: 12.49 dB

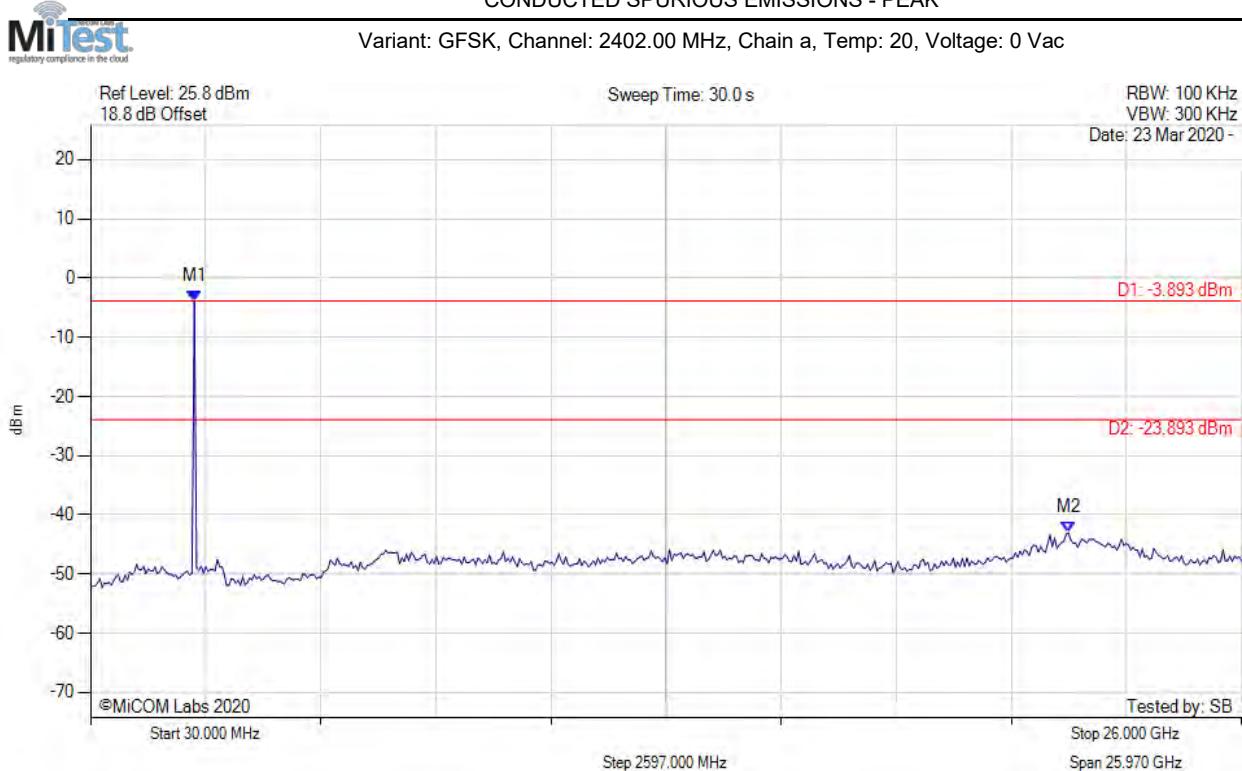
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### A.3. Emissions

#### A.3.1. Conducted Emissions

##### A.3.1.1. Conducted Spurious Emissions

###### CONDUCTED SPURIOUS EMISSIONS - PEAK



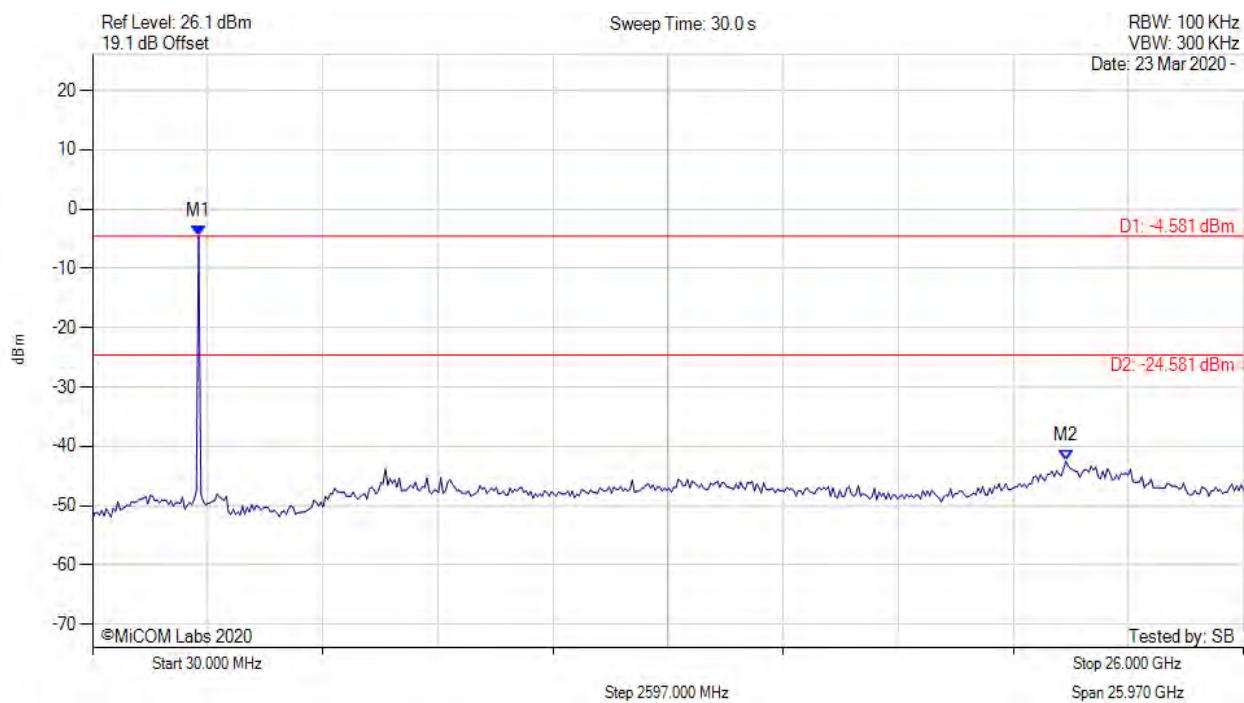
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2371.984 MHz : -3.893 dBm M2 : 22.097 GHz : -43.016 dBm	Limit: -23.89 dBm Margin: -19.13 dB

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CONDUCTED SPURIOUS EMISSIONS - PEAK



Variant: GFSK, Channel: 2426.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



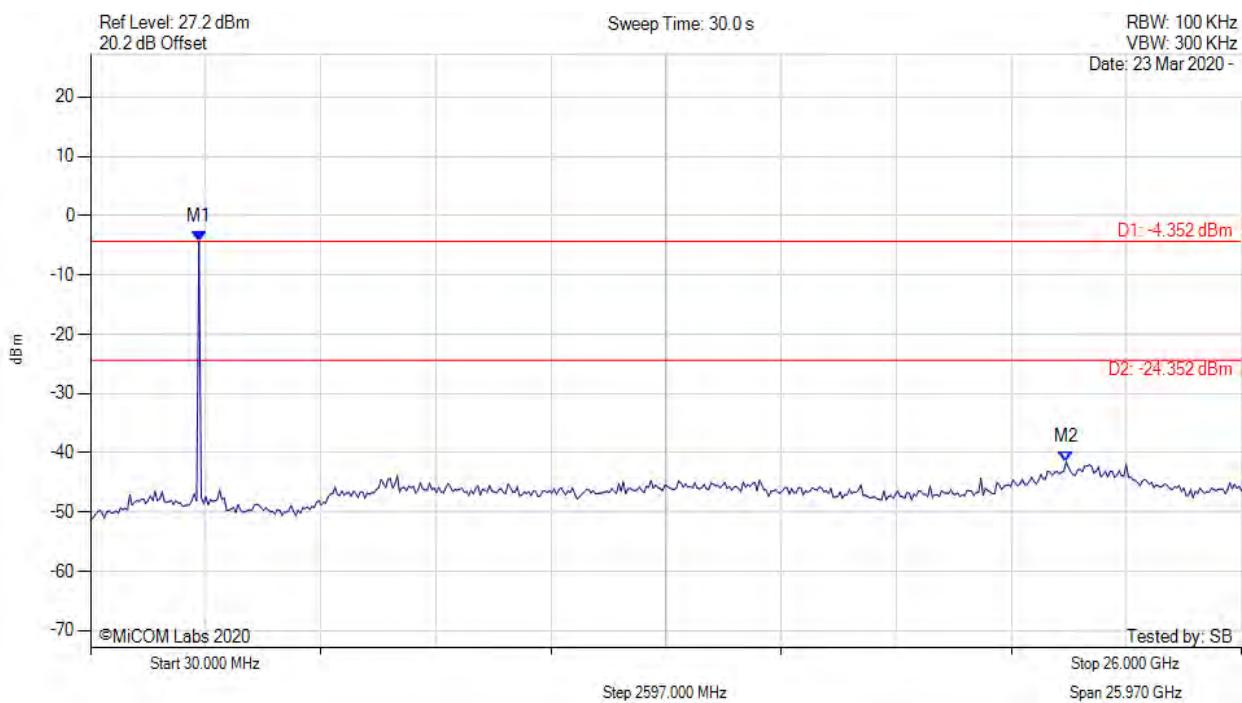
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2424.028 MHz : -4.581 dBm M2 : 21.993 GHz : -42.502 dBm	Limit: -24.58 dBm Margin: -17.92 dB

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CONDUCTED SPURIOUS EMISSIONS - PEAK



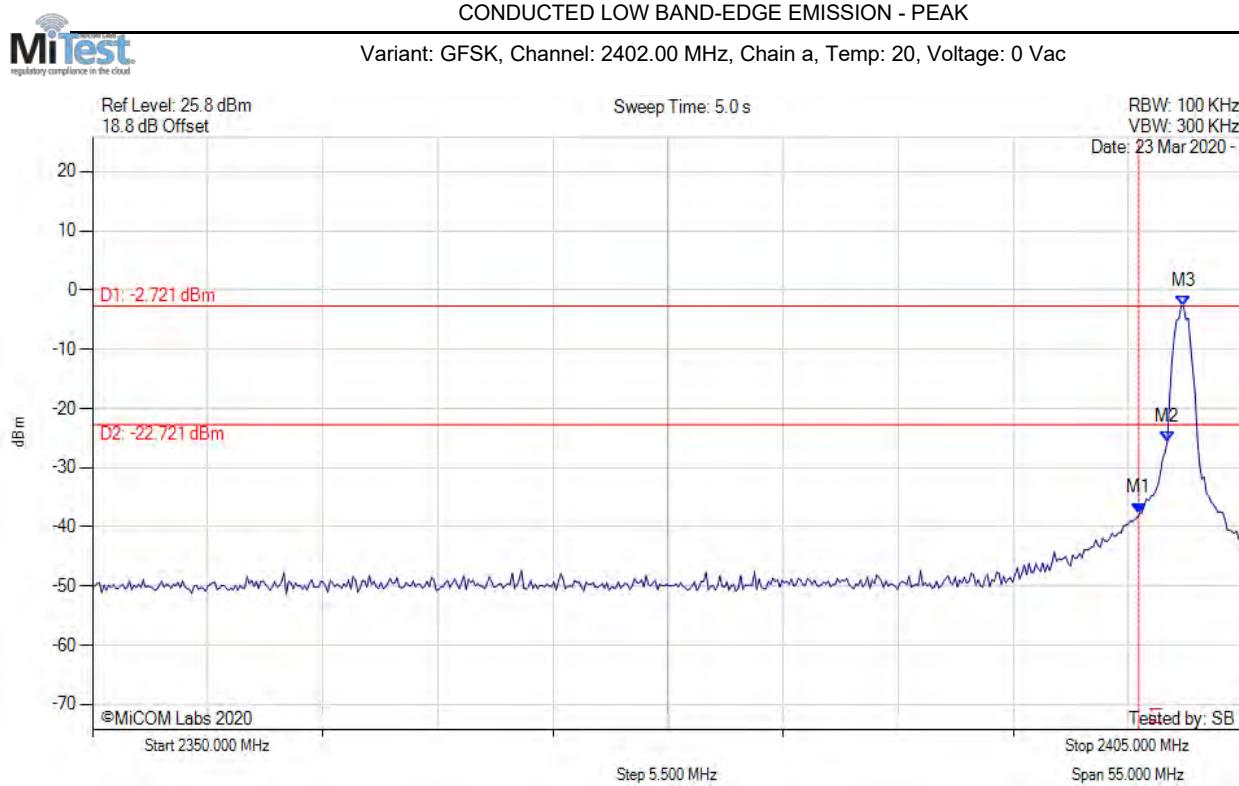
Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2476.072 MHz : -4.352 dBm M2 : 22.045 GHz : -41.524 dBm	Limit: -24.35 dBm Margin: -17.17 dB

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### A.3.1.2. Conducted Band-Edge Emissions



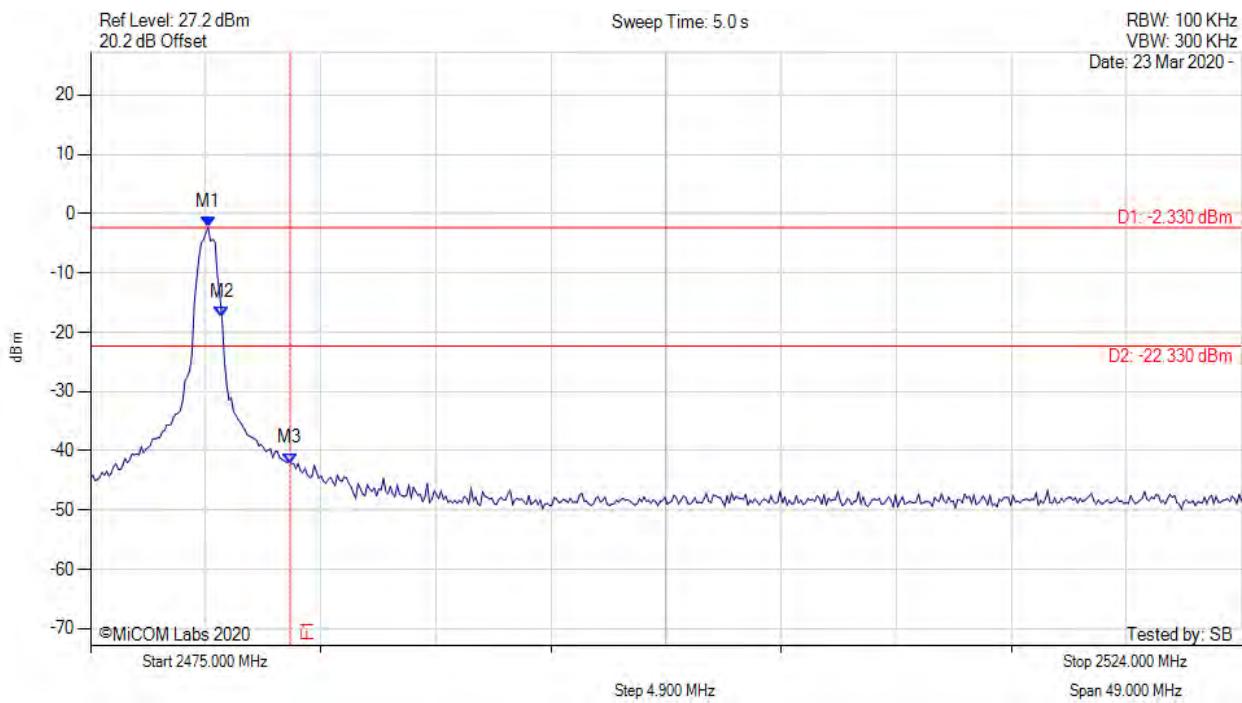
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2400.000 MHz : -37.681 dBm M2 : 2401.363 MHz : -25.599 dBm M3 : 2402.134 MHz : -2.721 dBm	Channel Frequency: 2402.00 MHz

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CONDUCTED HIGH BAND-EDGE EMISSION - PEAK



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 0 Vac



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2480.008 MHz : -2.330 dBm M2 : 2480.597 MHz : -17.496 dBm M3 : 2483.500 MHz : -42.112 dBm	Channel Frequency: 2480.00 MHz

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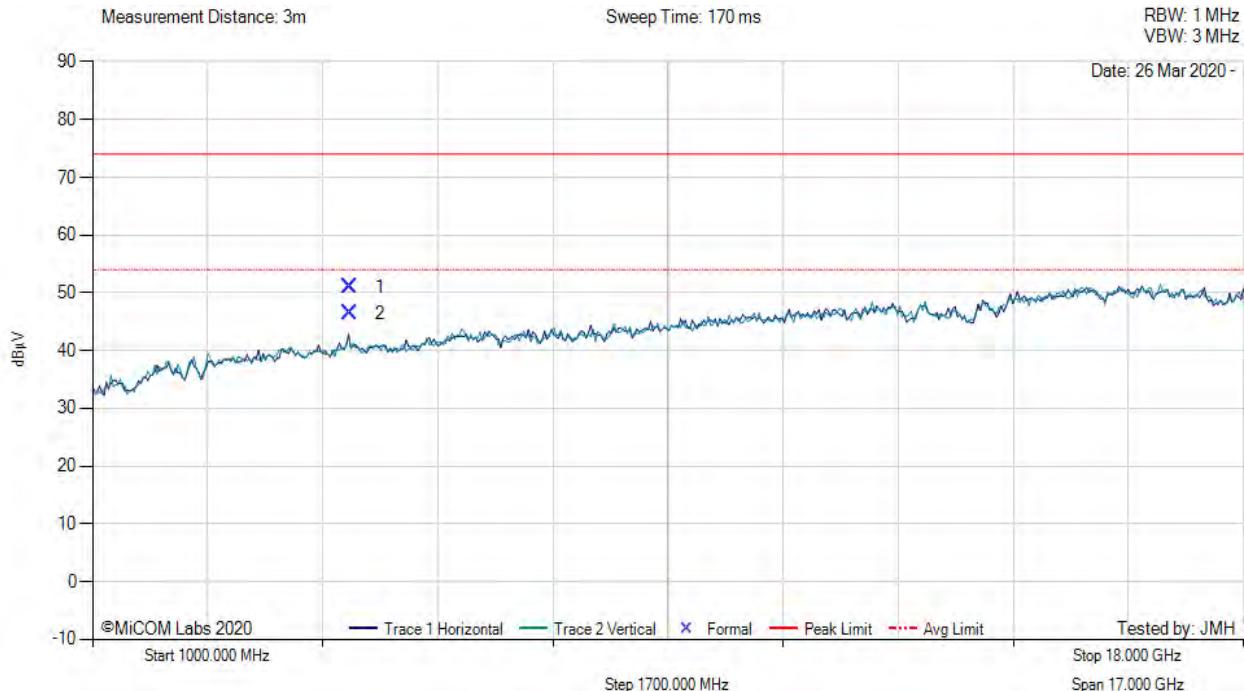
### A.3.2. Radiated Emissions

#### A.3.2.3. TX Spurious & Restricted Band Emissions



##### TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: BLE, Test Freq: 2402.00 MHz, Antenna: , Power Setting: Max, Duty Cycle (%): 61



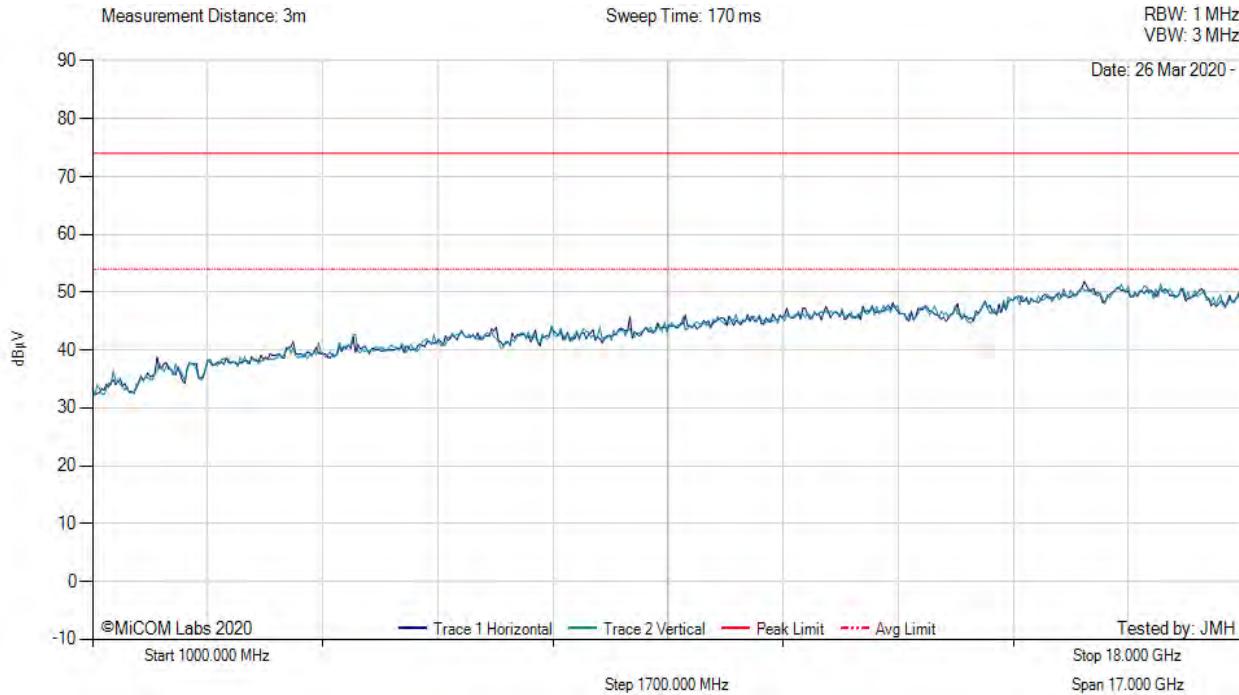
1000.00 - 18000.00 MHz													
Num	Frequency MHz	Raw dBµV	Cable Loss dB	AF dB/m	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail	
1	4804.02	60.55	2.85	-12.42	50.98	Max Peak	Vertical	165	247	74.0	-23.0	Pass	
2	4804.02	53.97	2.85	-12.42	46.50	Max Avg	Vertical	165	247	54.0	-7.5	Pass	

**Test Notes:** Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. DC correction 2.1 dB

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### TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: BLE, Test Freq: 2426.00 MHz, Antenna: , Power Setting: Max, Duty Cycle (%): 61



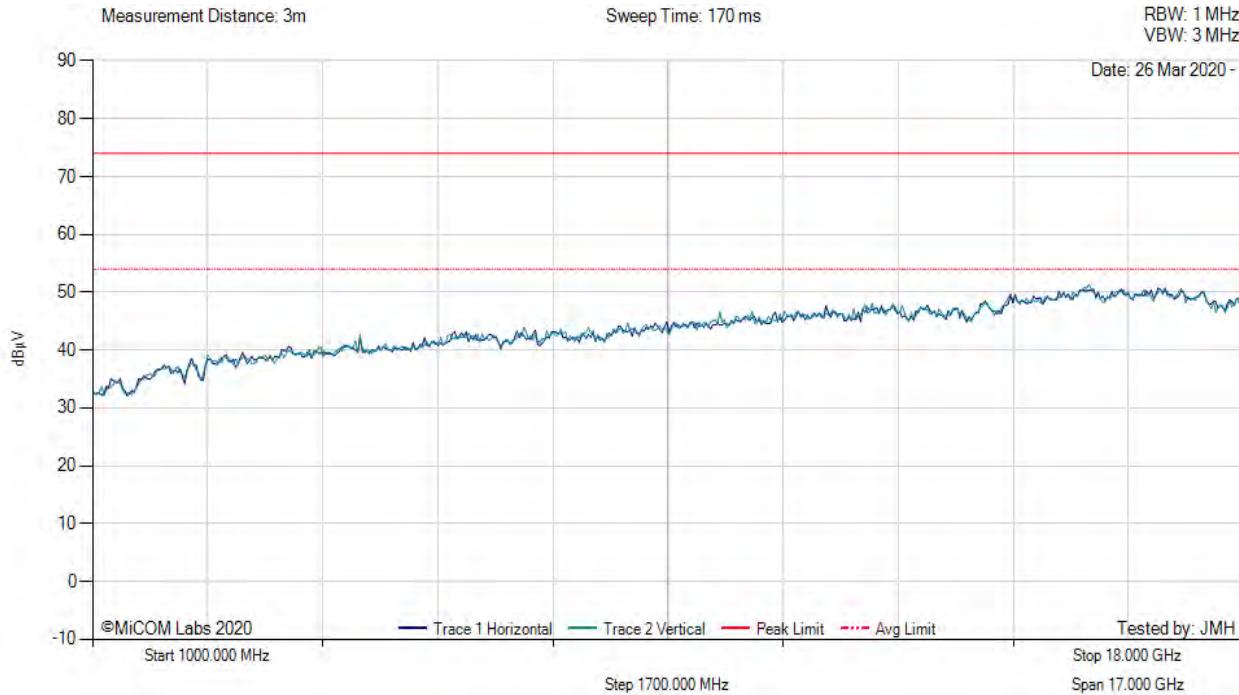
There are no emissions found within 6dB of the limit line.

**Test Notes:** Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. DC correction 2.1 dB

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### TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: , Power Setting: Max, Duty Cycle (%): 61

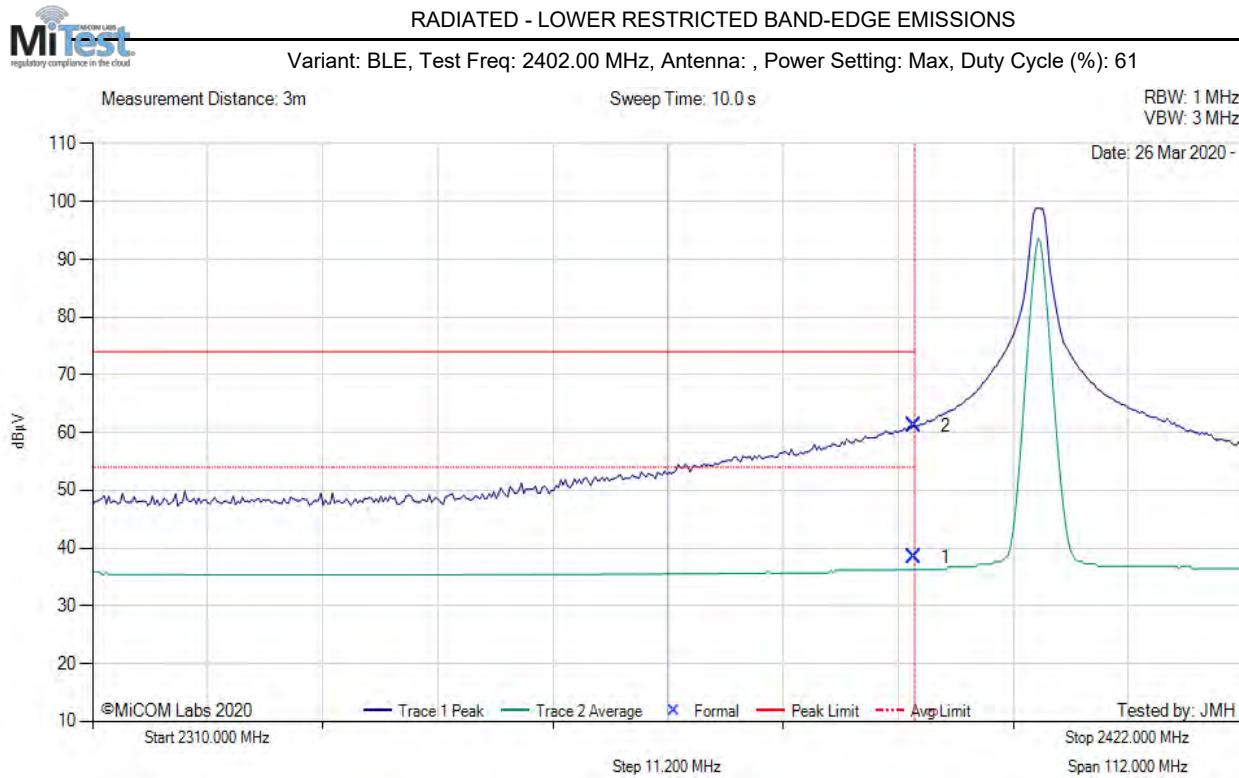


There are no emissions found within 6dB of the limit line.

**Test Notes:** Eut connected to laptop outside chamber via ethernet. 2.4G notch in front of amp to prevent overload. DC correction 2.1 dB

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### A.3.2.4. Restricted Edge & Band-Edge Emissions



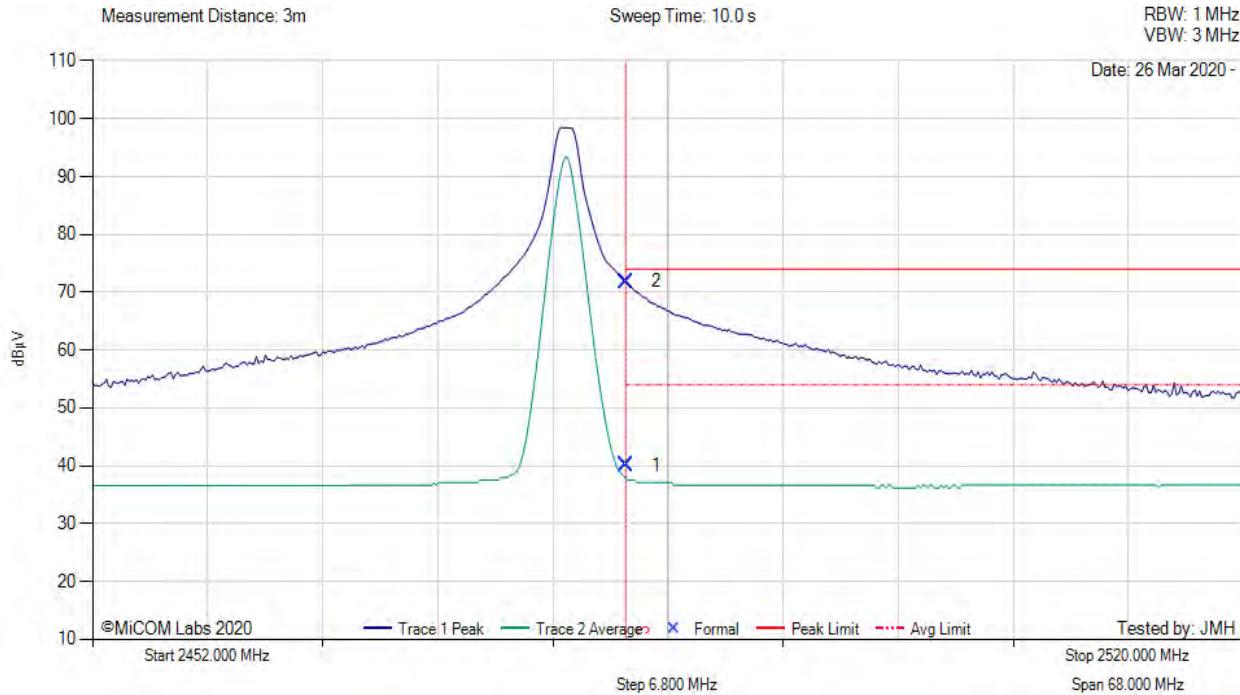
2310.00 - 2422.00 MHz													
Num	Frequency MHz	Raw dB $\mu$ V	Cable Loss dB	AF dB/m	Level dB $\mu$ V/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dB $\mu$ V/m	Margin dB	Pass /Fail	
1	2390.00	2.28	2.02	31.96	38.36	Max Avg	Vertical	113	68	54.0	-15.6	Pass	
2	2390.00	27.17	2.02	31.96	61.15	Max Peak	Vertical	113	68	74.0	-12.9	Pass	
3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--	

**Test Notes:** Eut connected to laptop outside chamber via ethernet. DC correction 2.1 dB

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### RADIATED - UPPER RESTRICTED BAND-EDGE EMISSIONS

Variant: BLE, Test Freq: 2480.00 MHz, Antenna: , Power Setting: Max, Duty Cycle (%): 61



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	3.62	2.03	32.33	40.08	Max Avg	Vertical	113	68	54.0	-13.9	Pass	
2	2483.50	37.45	2.03	32.33	71.81	Max Peak	Vertical	113	68	74.0	-2.2	Pass	
3	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--	

**Test Notes:** Eut connected to laptop outside chamber via ethernet. DC correction 2.1 dB

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