



REGULATORY COMPLIANCE TEST REPORT

FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Report No.: CATA08-U4 Rev A (BLE)

Company: Catapult Sports Pty Ltd

Model Name: Smart Football

REGULATORY COMPLIANCE TEST REPORT

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Model Name: Smart Football

To: FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Test Report Serial No.: CATA08-U4 Rev A (BLE)

This report supersedes: NONE

Applicant: Catapult Sports Pty Ltd
75-83 High Street
Prahran, Victoria 3197
Australia

Issue Date: 28th June 2021

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 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

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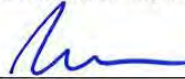
for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *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 24th day of February 2020.



Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2021

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

1.2. RECOGNITION

MiCOM Labs, Inc is widely recognized for its wireless testing and certification capabilities. In addition to being recognized for Testing and Certification under Phase 2 Mutual Recognition Agreements (MRA) with Canada, Europe, United Kingdom and Japan, our international recognition includes Conformity Assessment Body (CAB) designation status under agreements with Asia Pacific (APEC) MRA Phase 1 countries giving acceptance of MiCOM Labs test reports. 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	--	--	A-0012
Europe	European Commission	NB	EU MRA 2	NB 2280
United Kingdom	Department for Business, Energy & Industrial Strategy (BEIS)	AB	UK MRA 2	AB 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)			

TCB – Telecommunications Certification Bodies (TCB)

FCB – Foreign Certification Body

CAB – Conformity Assessment Body

NB – Notified Body

AB – Approved Body

MRA – Mutual Recognition Agreement

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 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

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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 24th 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
UK – Approved Body (AB), AB Identifier - 2280
Japan – Recognized Certification Body (RCB), RCB Identifier - 210

2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft	25 th June 2021	Initial Draft for Client Review
Rev A	28 th June 2021	Initial Release

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

3. TEST RESULT CERTIFICATE

Manufacturer: Catapult Sports Pty Ltd 75-83 High Street Pahran Victoria 3197 Australia	Tested By: MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Model: B001	Telephone: +1 925 462 0304
Type Of Equipment: Smart Football	Fax: +1 925 462 0306
S/N's: None	
Test Date(s): 11 th June 2021	Website: www.micomlabs.com

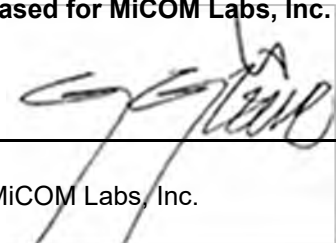
STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15 Subpart C 15.247 (DTS)	EQUIPMENT COMPLIES

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.

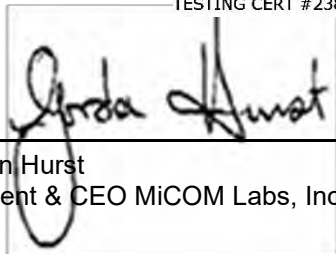
Notes:

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:



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	5th October 2020	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 7; October 15,2020	Information Technology Equipment (Including Digital Apparatus)
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	2018	General Requirements for Compliance of Radio Apparatus. With Amendments 1: March 2019 and 2: Feb 2021.
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 Catapult Sports Pty Ltd Smart Football to FCC CFR 47 Part 15 Subpart C 15.247 (DTS). Radio Frequency Devices; Subpart C – Intentional Radiators
Applicant:	Catapult Sports Pty Ltd 75-83 High Street Prahran Victoria 3197 Australia
Manufacturer:	Catapult Sports Pty Ltd
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	CATA08 - Football UWB BLE FCC
Date EUT received:	12th May 2021
Standard(s) applied:	FCC CFR 47 Part 15 Subpart C 15.247 (DTS)
Dates of test (from - to):	11 June 2021
No of Units Tested:	2
Product Family Name:	Smart Football
Model(s):	B001
Location for use:	Indoor and Outdoor
Declared Frequency Range(s):	2400 - 2483.5 MHz;
Type of Modulation:	GFSK
EUT Modes of Operation:	2400 - 2483.5 MHz: BLE;
Declared Nominal Output Power (dBm):	2400 - 2483.5 MHz: BLE: +4 dBm
Transmit/Receive Operation:	Transceiver
Rated Input Voltage and Current:	3.7 VDC 0.36 A
Operating Temperature Range:	-20 – 60 °C
ITU Emission Designator:	1M0G1D
Equipment Dimensions:	175 x 130 x 59.5 mm
Weight:	520 g
Hardware Rev:	MP
Software Rev:	1.1.0

5.2. Scope Of Test Program

Catapult Sports Pty Ltd B001

The scope of the test program was to test the Catapult Sports Pty Ltd B001, Smart Football 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

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

Type (EUT/Support)	Equipment Description	Manufacturer	Model No.	Serial No.
EUT	Smart Football	Catapult Sports Pty Ltd	B001	N/A
Support	Charging Cradle	Energous	--	--

5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
integral	Catapult	BLE	PCB	1.0	-	360	-	2400 - 2483.5

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

5.5. Cabling and I/O Ports

The EUT has no I/O Ports, it connects to the charger wirelessly.

5.6. 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 (Band 2400 - 2483.5 MHz) (MHz)		
		Low	Mid	High
BLE	1	2,402.00	2,440.00	2,480.00

5.7. Equipment Modifications

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

- NONE

5.8. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:

- NONE

6. TEST SUMMARY

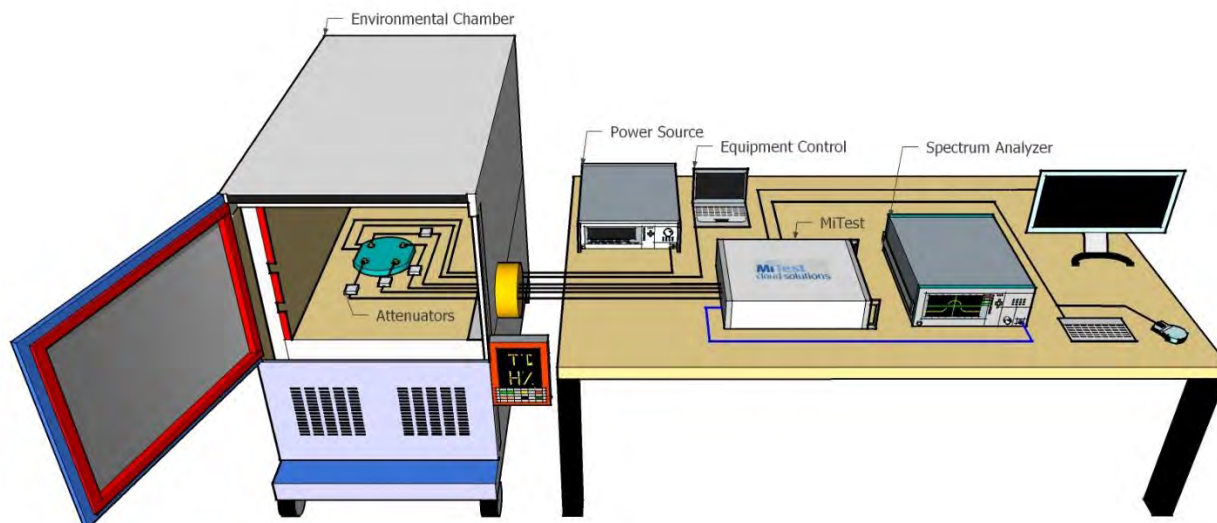
List of Measurements

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

7. TEST EQUIPMENT CONFIGURATION(S)

7.1. Conducted Test Setup

MiTest Automated Test System



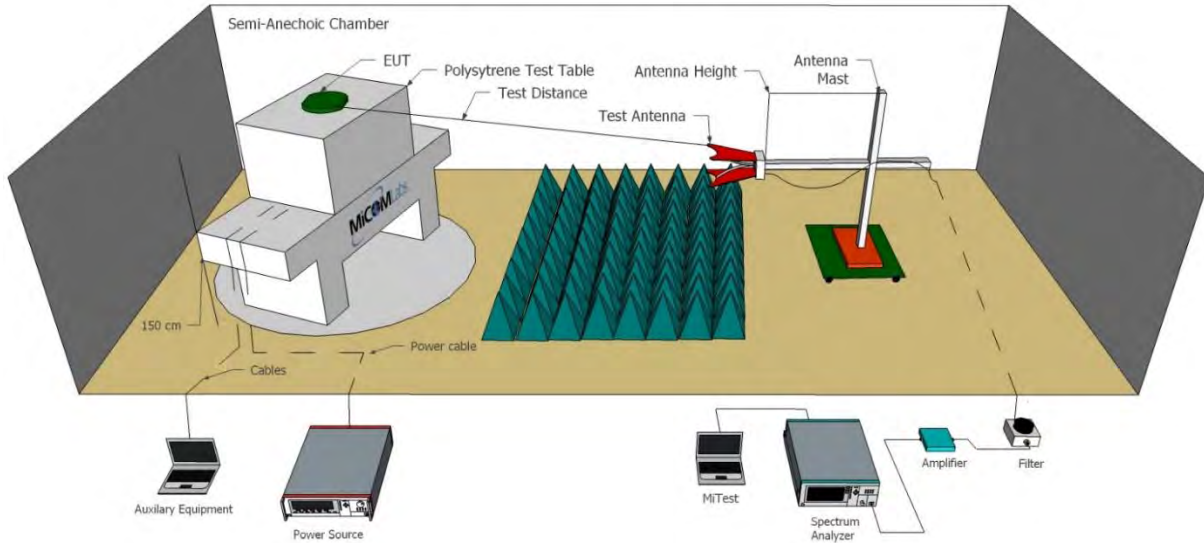
A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
249	Resistance Thermometer	Thermotronics	GR2105-02	9340 #2	30 Oct 2021
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 2021
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
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2021
75	Environmental Chamber	Thermatron	SE-300-2-2	27946	24 Feb 2022

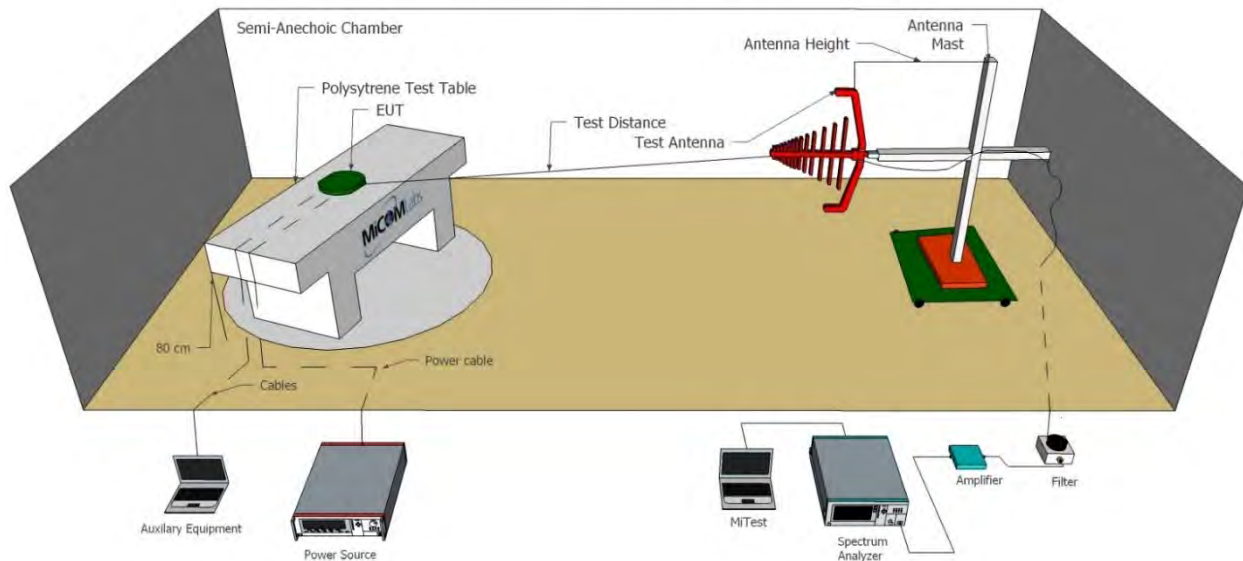
7.2. Radiated Emissions - 3m Chamber

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
107	26–40 GHz Horn Antenna	Millimeter Products	261A	None	15 Jan 2022
145	18–26 GHz Horn Antenna	Millimeter Products	261K	None	15 Jan 2022
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 2022
336	Active Loop Antenna	Emco	6502	00060498	29 Nov 2021
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	4 Apr 2022
378	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2021
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	12 Apr 2022
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 Oct 2021
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	12 Apr 2022
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
447	MiTest Rad Emissions Test Software	MiCOM	Test Software Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	9 Oct 2021
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	9 Oct 2021
464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	9 Oct 2021
465	Low Pass Filter DC-1000 MHz	Mini-Circuits	NLP-1200+	VUU01901402	9 Oct 2021
480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	24 Sep 2021
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	24 Sep 2021
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2021
518	Cable - Amp to Antenna	SRC Haverhill	157-3051574	518	24 Sep 2021

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. 6 dB & 99% Bandwidth

Conducted Test Conditions for 6 dB and 99% Bandwidth			
Standard:	FCC CFR 47:15.247	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	6 dB and 99 % Bandwidth	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (a)(2)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		
<p>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.</p> <p>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.</p> <p>Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.</p> <p>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.</p>			

Equipment Configuration for 6 dB & 99% Bandwidth

Variant:	GFSK	Duty Cycle (%):	17
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	Not Applicable
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
Engineering Test Notes:			

Test Measurement Results

Test Frequency MHz	Measured 6 dB Bandwidth (MHz)				6 dB Bandwidth (MHz)	
	Port(s)				Highest	Lowest
	a	b	c	d		
2402.0	0.693	--	--	--	0.693	0.693
2440.0	0.690	--	--	--	0.690	0.690
2480.0	0.690	--	--	--	0.690	0.690

Test Frequency MHz	Measured 99% Bandwidth (MHz)				Maximum 99% Bandwidth (MHz)
	Port(s)				
	a	b	c	d	
2402.0	1.075	--	--	--	1.075
2440.0	1.076	--	--	--	1.076
2480.0	1.074	--	--	--	1.074

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	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Output Power	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (b) & (c)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		
<p>Test Procedure for Fundamental Emission Output Power Measurement In the case of average power measurements an average power sensor was utilized.</p> <p>For peak power measurements the spectrum analyzer built-in power function was used to integrate peak power over the 20 dB bandwidth.</p> <p>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.</p> <p>Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.</p> <p>Supporting Information Calculated Power = A + G + Y + 10 log (1/x) dBm</p> <p>A = Total Power [$10 \cdot \text{Log}_{10} (10^{a/10} + 10^{b/10} + 10^{c/10} + 10^{d/10})$] G = Antenna Gain Y = Beamforming Gain x = Duty Cycle (average power measurements only)</p> <p>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:</p> <p>(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.</p> <p>(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.</p> <p>(c) Operation with directional antenna gains greater than 6 dBi.</p> <p>(1) Fixed point-to-point operation:</p> <p>(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.</p> <p>(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.</p>			

(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:	GFSK	Duty Cycle (%):	16.8
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	1.00
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
	Port(s)							
MHz	a	b	c	d	dBm	dBm	dB	
2402.0	0.825	--	--	--	0.825	30.00	-29.18	0x7F
2440.0	0.648	--	--	--	0.648	30.00	-29.35	0x7F
2480.0	1.542	--	--	--	1.542	30.00	-28.46	0x7F

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.

9.3. Power Spectral Density

Conducted Test Conditions for Power Spectral Density			
Standard:	FCC CFR 47:15.247	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Power Spectral Density	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (e)	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 (â) 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

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

$x = \text{Duty Cycle}$

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

Variant:	GFSK	Duty Cycle (%):	16.8
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	1.00
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
Engineering Test Notes:			

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	-17.167	--	--	--	-17.167	8.0	-25.2
2440.0	-17.212	--	--	--	-17.212	8.0	-25.2
2480.0	-17.300	--	--	--	-17.300	8.0	-25.3

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	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Max Unwanted Emission Levels	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (d)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		
<p>Test Procedure for Transmitter Conducted Spurious and Band-Edge Emissions Measurement</p> <p>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.</p> <p>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.</p> <p>Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.</p> <p>Limits Transmitter Conducted Spurious and Band-Edge Emissions</p> <p>(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)).</p>			

Equipment Configuration for Conducted Spurious Emissions - Peak

Variant:	GFSK	Duty Cycle (%):	17
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	Not Applicable
Modulation:	GFSK	Beam Forming Gain (Y):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
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	-45.805	-22.47	--	--	--	--	--	--
2440.0	30.0 - 26000.0	-43.794	-21.52	--	--	--	--	--	--
2480.0	30.0 - 26000.0	-44.712	-22.82	--	--	--	--	--	--

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

Equipment Configuration for Conducted Low Band-Edge Emissions - Peak			
Variant:	GFSK	Duty Cycle (%):	16.8
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	Not Applicable
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
Engineering Test Notes:			

Test Measurement Results

Channel Frequency:	2402.0 MHz					
Band-Edge Frequency:	2400.0 MHz					
Test Frequency Range:	2350.0 - 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	-43.48	-20.01	2401.30	--	--	-1.300

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).

Equipment Configuration for Conducted High Band-Edge Emissions - Peak

Variant:	GFSK	Duty Cycle (%):	16.8
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	Not Applicable
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JK
Engineering Test Notes:			

Test Measurement Results

Channel Frequency:	2480.0 MHz					
Band-Edge Frequency:	2483.5 MHz					
Test Frequency Range:	2475.0 - 2524.0 MHz					
Port(s)	Band-Edge Markers and Limit			Revised Limit		Margin (MHz)
	M3 Amplitude (dBm)	Plot Limit (dBm)	M2 Frequency (MHz)	Amplitude (dBm)	M2A Frequency (MHz)	
a	-51.71	-20.16	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).

9.4.2. 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 15.247 (DTS)	Ambient Temp. (°C):	20.0 - 24.5
Test Heading:	Radiated Spurious and Band-Edge Emissions	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.205, 15.209	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:

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

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

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

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

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

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

Antenna:	Catapult BLE	Variant:	GFSK
Antenna Gain (dBi):	1.00	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	16.5
Channel Frequency (MHz):	2402.00	Data Rate:	1.00 MBit/s
Power Setting:	0x7F	Tested By:	JK

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	7205.13	70.71	3.57	-7.92	66.36	Max Peak	Horizontal	192	4	74.0	-7.6	Pass
#2	7205.13	50.11	3.57	-7.92	45.76	Max Avg	Horizontal	192	4	54.0	-8.2	Pass
#3	7205.21	74.81	3.57	-7.92	70.46	Max Peak	Vertical	194	0	74.0	-3.5	Pass
#4	7205.21	54.24	3.57	-7.92	49.89	Max Avg	Vertical	194	0	54.0	-4.1	Pass

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

Equipment Configuration for TX Spurious & Restricted Band Emissions

Antenna:	Catapult BLE	Variant:	BLE
Antenna Gain (dBi):	1.00	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	16.5
Channel Frequency (MHz):	2440.00	Data Rate:	1.00 MBit/s
Power Setting:	0x7F	Tested By:	JK

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	7320.00	73.30	3.60	-7.80	69.10	Max Peak	Vertical	196	0	74.0	-4.9	Pass
#2	7320.00	51.81	3.60	-7.80	47.61	Max Avg	Vertical	196	0	54.0	-6.4	Pass
#3	7320.00	71.17	3.60	-7.80	66.97	Max Peak	Horizontal	190	0	74.0	-7.0	Pass
#4	7320.00	49.97	3.60	-7.80	45.77	Max Avg	Horizontal	190	0	54.0	-8.2	Pass

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

Equipment Configuration for TX Spurious & Restricted Band Emissions

Antenna:	Catapult BLE	Variant:	BLE
Antenna Gain (dBi):	1.00	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	16.5
Channel Frequency (MHz):	2480.00	Data Rate:	1.00 MBit/s
Power Setting:	0x7F	Tested By:	JK

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	7440.68	68.21	3.62	-7.72	64.11	Max Peak	Horizontal	188	0	74.0	-9.9	Pass
#2	7440.68	46.49	3.62	-7.72	42.39	Max Avg	Horizontal	188	0	54.0	-11.6	Pass
#3	7440.81	66.56	3.62	-7.72	62.46	Max Peak	Vertical	192	0	74.0	-11.5	Pass
#4	7440.81	44.74	3.62	-7.72	40.64	Max Avg	Vertical	192	0	54.0	-13.4	Pass

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

9.4.2.4. Restricted Edge & Band-Edge Emissions

Catapult BLE		Band-Edge Freq	Limit 74.0dBµV/m	Limit 54.0dBµV/m	Power Setting
Operational Mode	Operating Frequency (MHz)	MHz	dBµV/m	dBµV/m	
GFSK	2402.00	2390.00	49.64	35.92	0x7F

Equipment Configuration for Radiated - Lower Restricted Band-Edge Emissions

Antenna:	Catapult BLE	Variant:	BLE
Antenna Gain (dBi):	1.00	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	16.5
Channel Frequency (MHz):	2402.00	Data Rate:	1.00 MBit/s
Power Setting:	0x7F	Tested By:	JK

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	2310.00	2.23	1.98	31.71	35.92	Max Avg	Horizontal	190	0	54.0	-18.1	Pass
#2	2377.33	15.75	2.00	31.89	49.64	Max Peak	Horizontal	190	0	74.0	-24.4	Pass
#3	2389.97	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent. 7.82 DCCF added to avg measurement

Catapult BLE		Band-Edge Freq	Limit 74.0dBµV/m	Limit 54.0dBµV/m	Power Setting
Operational Mode	Operating Frequency (MHz)	MHz	dBµV/m	dBµV/m	
GFSK	2480.00	2483.50	54.21	36.66	0x7F

Equipment Configuration for Radiated - Upper Restricted Band-Edge Emissions

Antenna:	Catapult BLE	Variant:	BLE
Antenna Gain (dBi):	Not Applicable	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	16.5
Channel Frequency (MHz):	2480.00	Data Rate:	1.00 MBit/s
Power Setting:	0x7F	Tested By:	JK

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
#2	2483.64	19.85	2.03	32.33	54.21	Max Peak	Vertical	190	82	74.0	-19.8	Pass
#3	2492.90	2.31	2.03	32.32	36.66	Max Avg	Vertical	190	82	54.0	-17.3	Pass
#1	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent. 7.95 DCCF added to avg measurement

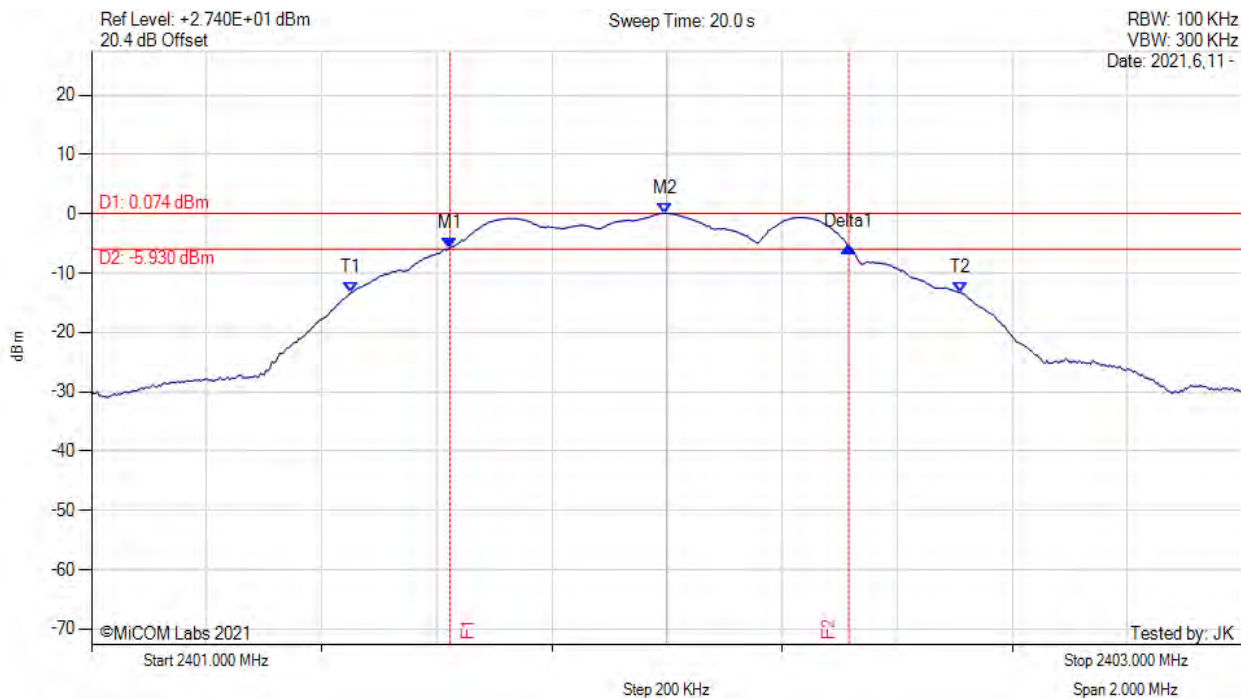
A. APPENDIX - GRAPHICAL IMAGES

A.1. 6 dB & 99% Bandwidth

6 dB & 99% BANDWIDTH



Variant: GFSK, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



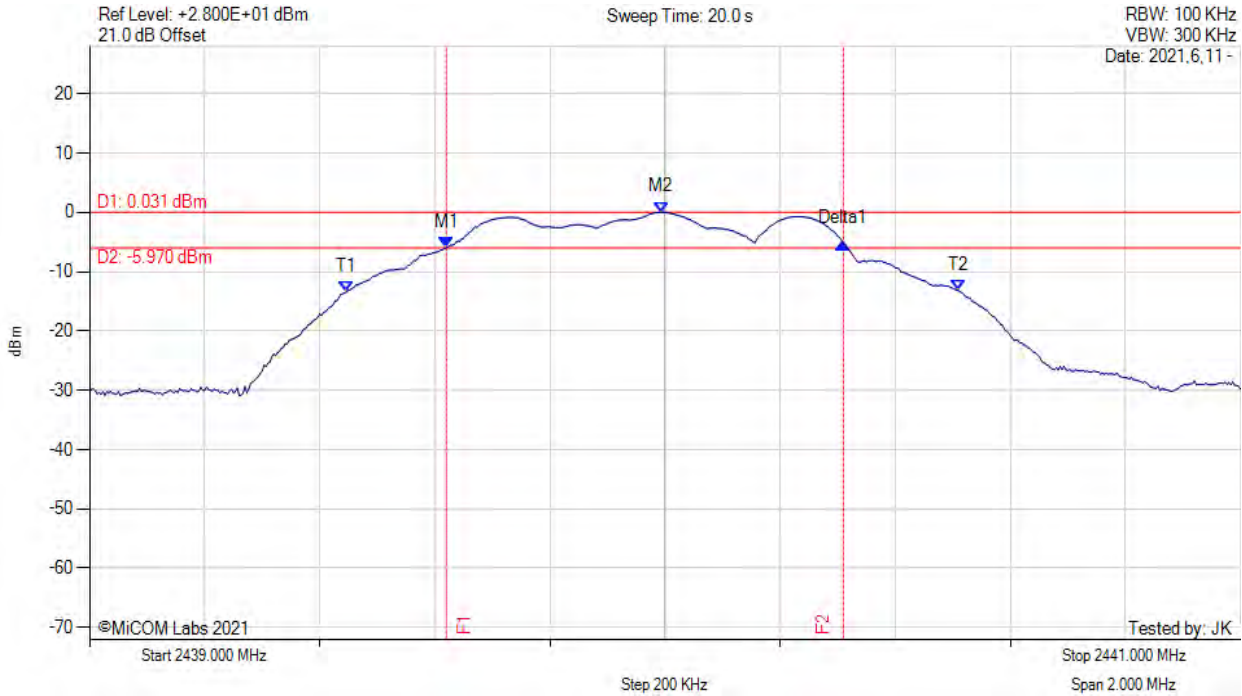
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2401.623 MHz : -5.714 dBm M2 : 2401.997 MHz : 0.074 dBm Delta1 : 693 KHz : 0.145 dB T1 : 2401.450 MHz : -13.370 dBm T2 : 2402.510 MHz : -13.313 dBm OBW : 1.075 MHz	Measured 6 dB Bandwidth: 0.693 MHz Limit: ≥500 kHz Margin: -0.11 MHz

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6 dB & 99% BANDWIDTH



Variant: GFSK, Channel: 2440.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



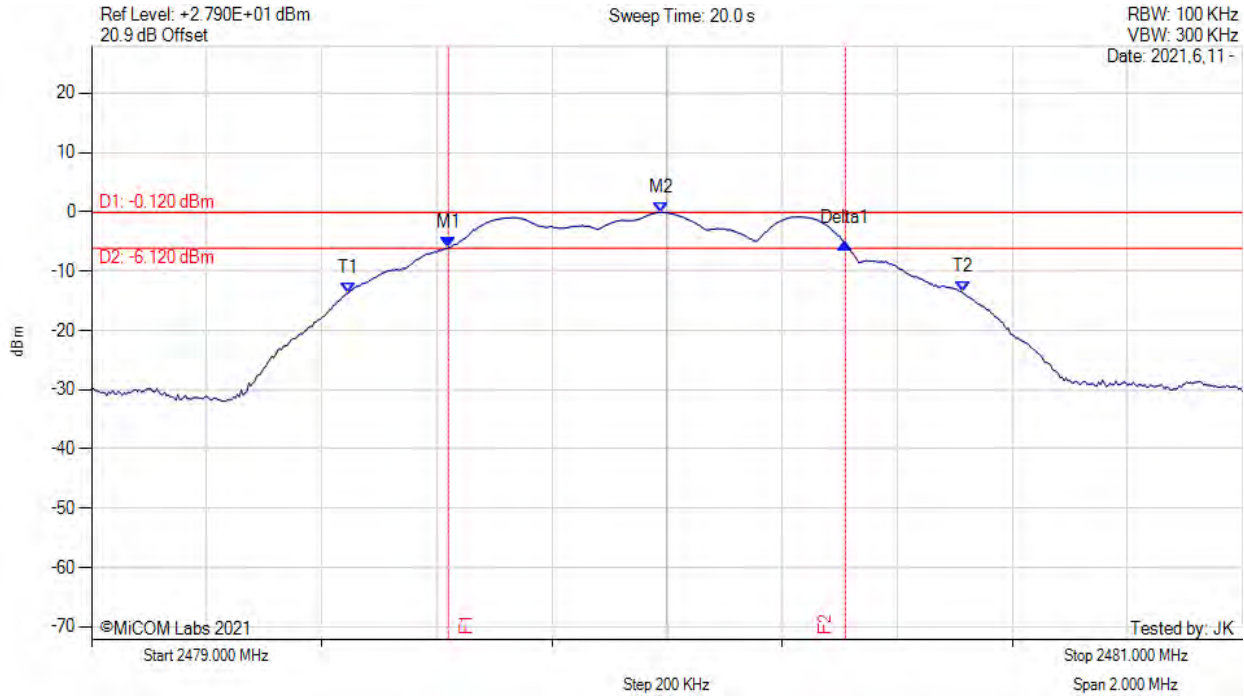
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2439.620 MHz : -5.953 dBm M2 : 2439.993 MHz : 0.031 dBm Delta1 : 690 KHz : 0.720 dB T1 : 2439.447 MHz : -13.404 dBm T2 : 2440.510 MHz : -13.190 dBm OBW : 1.076 MHz	Measured 6 dB Bandwidth: 0.690 MHz Limit: ≥500 kHz Margin:-0.11 MHz

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6 dB & 99% BANDWIDTH



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2479.620 MHz : -6.051 dBm M2 : 2479.990 MHz : -0.120 dBm Delta1 : 690 KHz : 0.777 dB T1 : 2479.447 MHz : -13.626 dBm T2 : 2480.513 MHz : -13.595 dBm OBW : 1.074 MHz	Measured 6 dB Bandwidth: 0.690 MHz Limit: ≥500 kHz Margin: -0.11 MHz

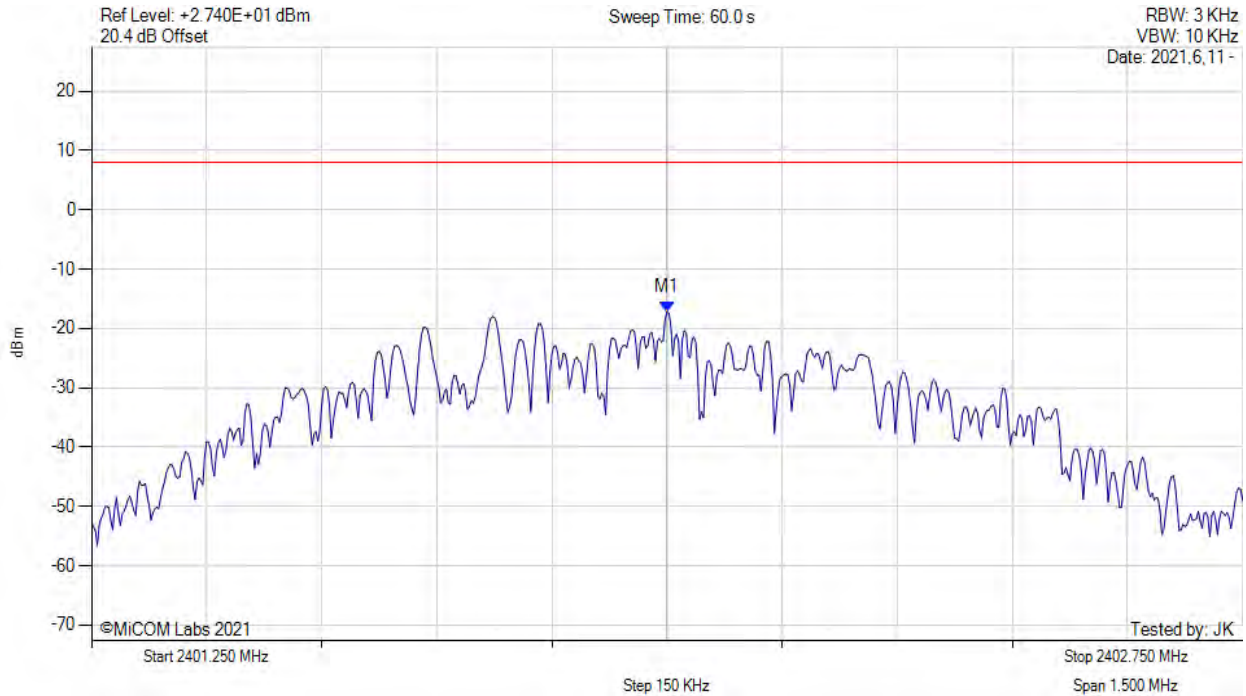
[back to matrix](#)

A.2. Power Spectral Density

POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



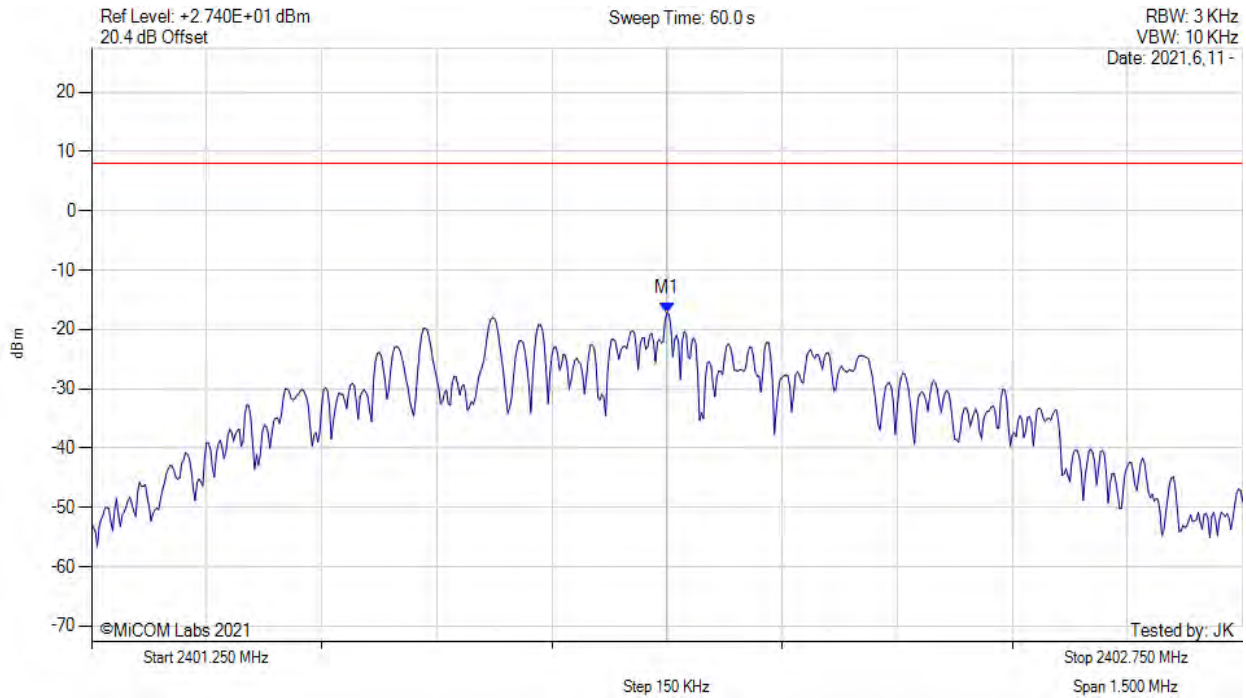
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2402.000 MHz : -17.167 dBm	Limit: ≤ 8.000 dBm Margin: 25.17 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2402.00 MHz, SUM, Temp: 20, Voltage: 3.7 Vdc



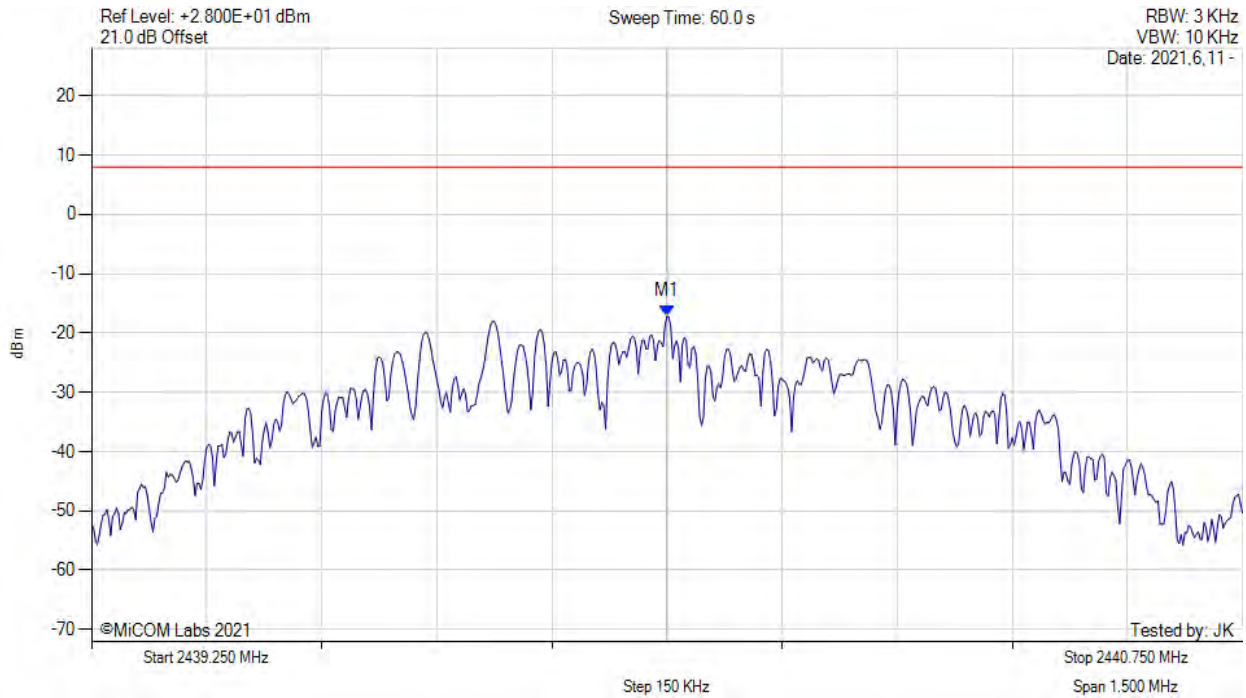
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2402.000 MHz : -17.167 dBm	Limit: ≤ 8.0 dBm Margin: -25.2 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2440.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



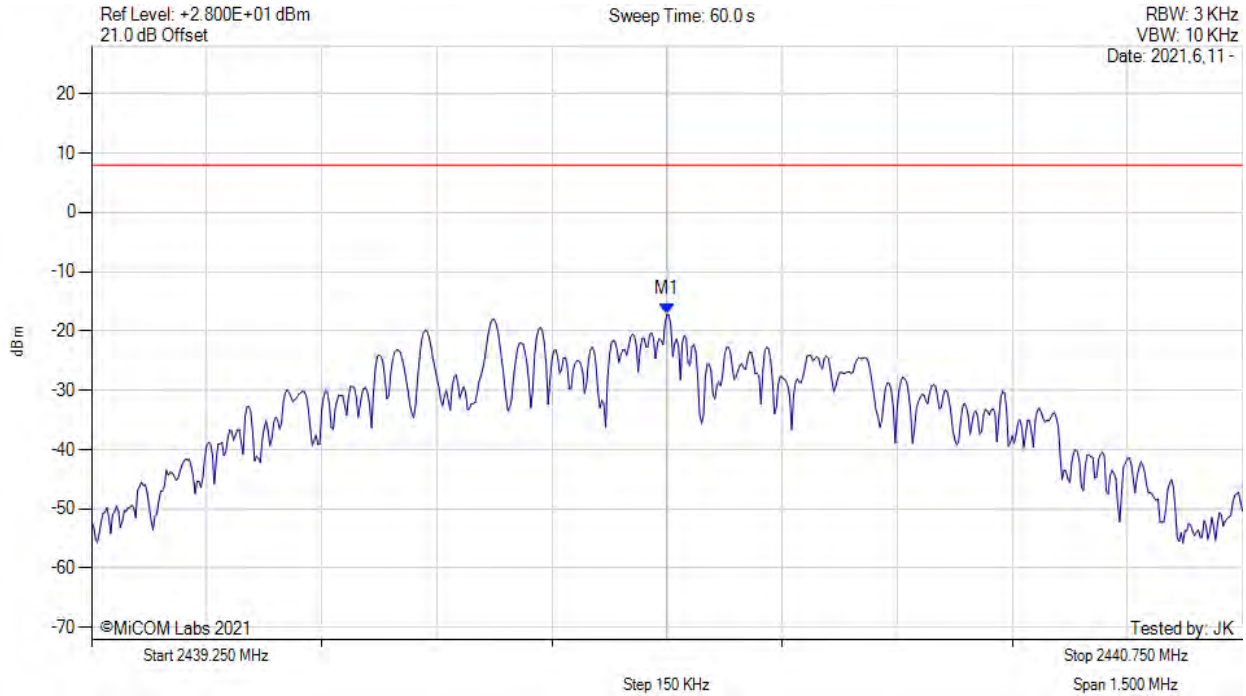
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2440.000 MHz : -17.212 dBm	Limit: ≤ 8.000 dBm Margin: 25.21 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2440.00 MHz, SUM, Temp: 20, Voltage: 3.7 Vdc



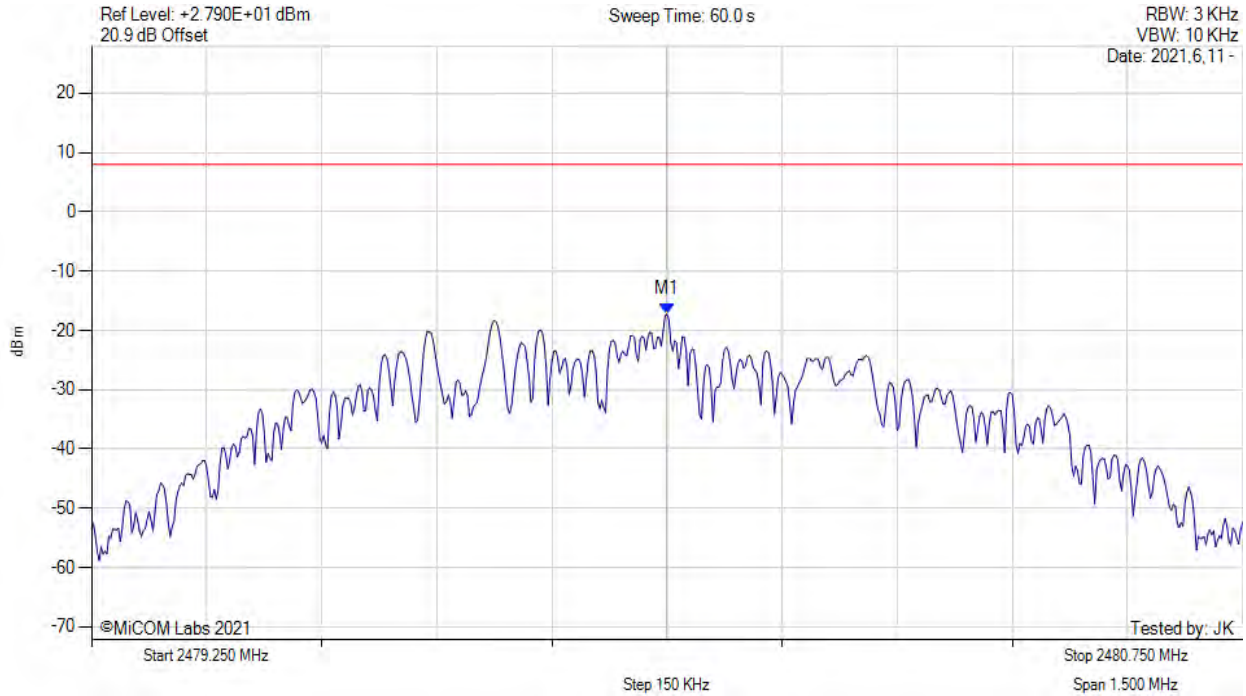
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2440.000 MHz : -17.212 dBm	Limit: ≤ 8.0 dBm Margin: -25.2 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



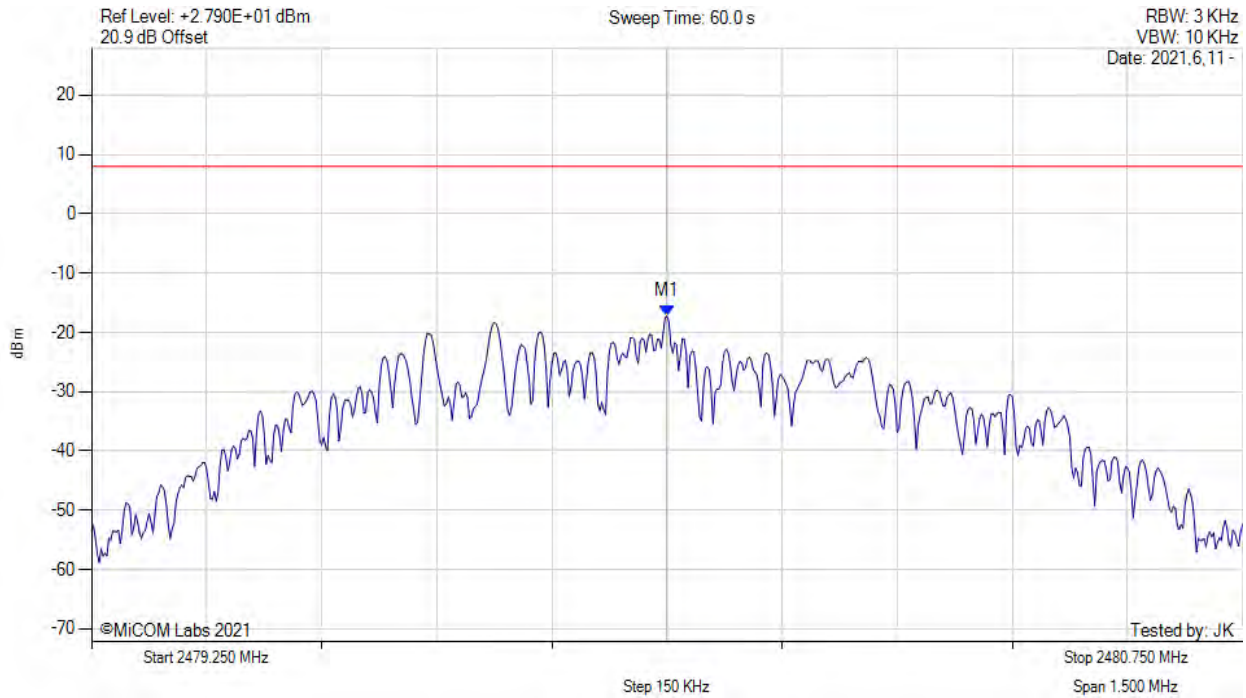
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2480.000 MHz : -17.300 dBm	Limit: ≤ 8.000 dBm Margin: 25.30 dB

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POWER SPECTRAL DENSITY - PEAK



Variant: GFSK, Channel: 2480.00 MHz, SUM, Temp: 20, Voltage: 3.7 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2480.000 MHz : -17.300 dBm	Limit: ≤ 8.0 dBm Margin: -25.3 dB

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A.3. Emissions

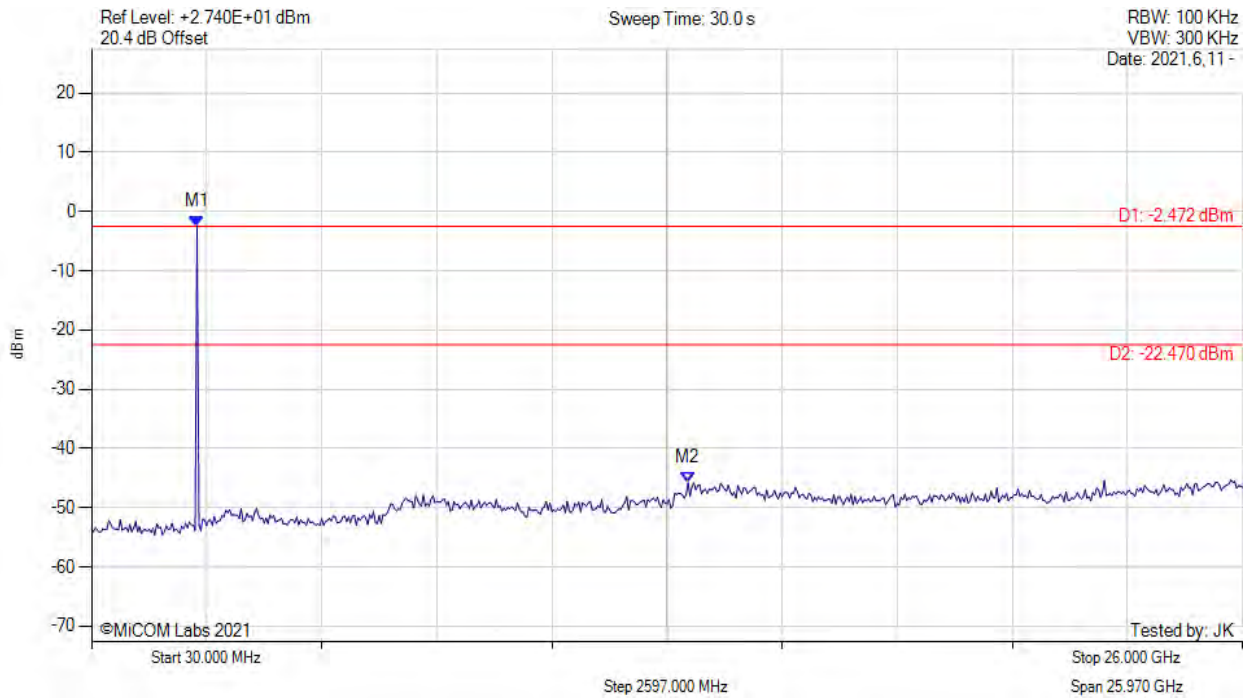
A.3.1. Conducted Emissions

A.3.1.1. Conducted Spurious Emissions

CONDUCTED SPURIOUS EMISSIONS - PEAK



Variant: GFSK, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



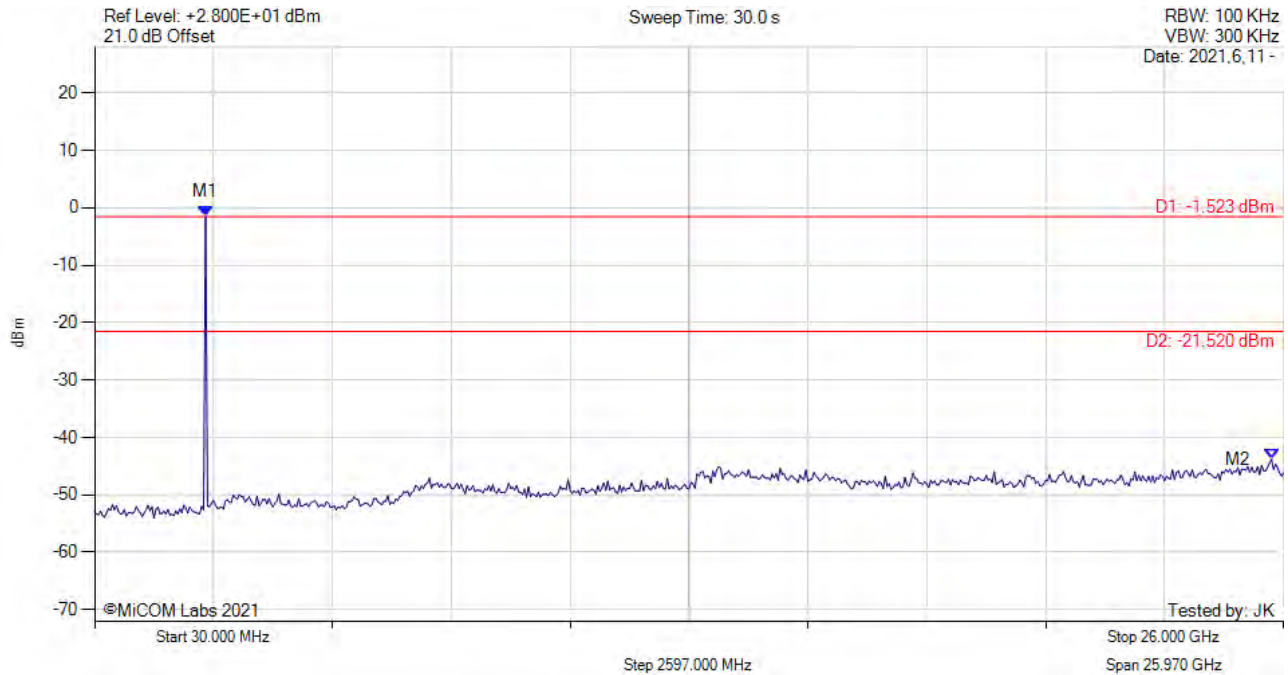
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2410.000 MHz : -2.472 dBm M2 : 13.490 GHz : -45.805 dBm	Limit: -22.47 dBm Margin: -23.34 dB

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CONDUCTED SPURIOUS EMISSIONS - PEAK



Variant: GFSK, Channel: 2440.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



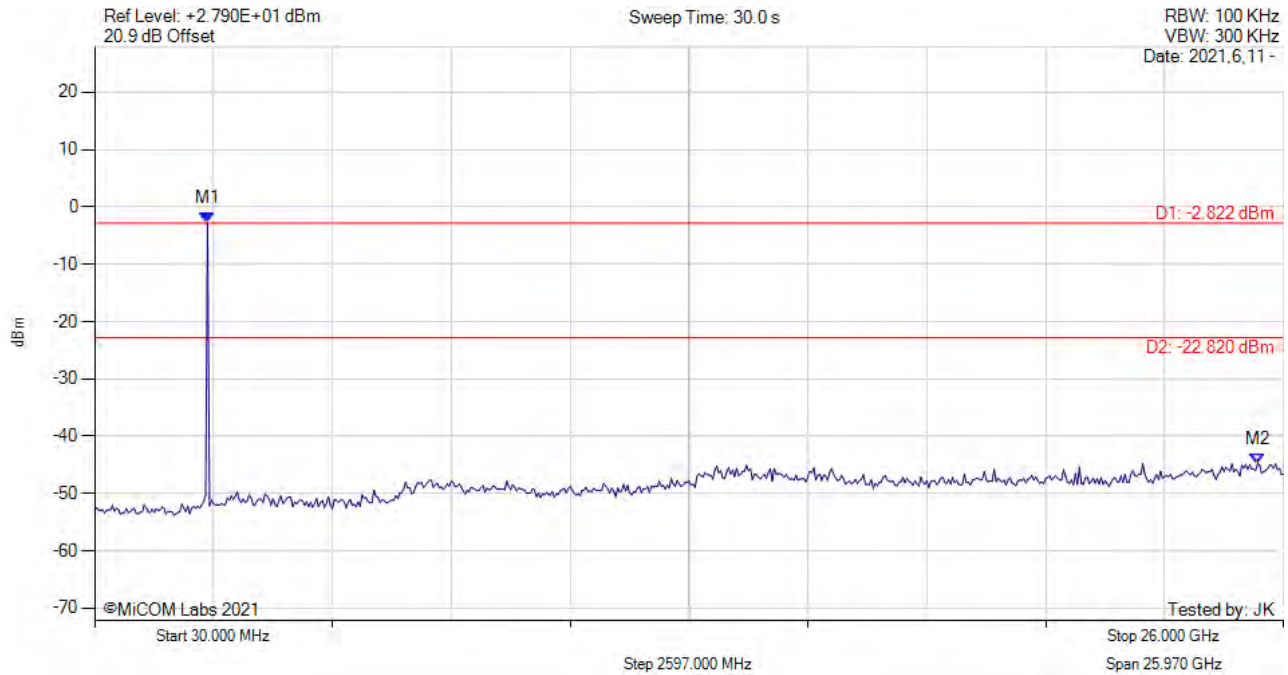
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2450.000 MHz : -1.170 dBm M2 : 25.740 GHz : -43.794 dBm	Channel Frequency: 2440.00 MHz

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CONDUCTED SPURIOUS EMISSIONS - PEAK



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2500.000 MHz : -2.822 dBm M2 : 25.437 GHz : -44.712 dBm	Limit: -22.82 dBm

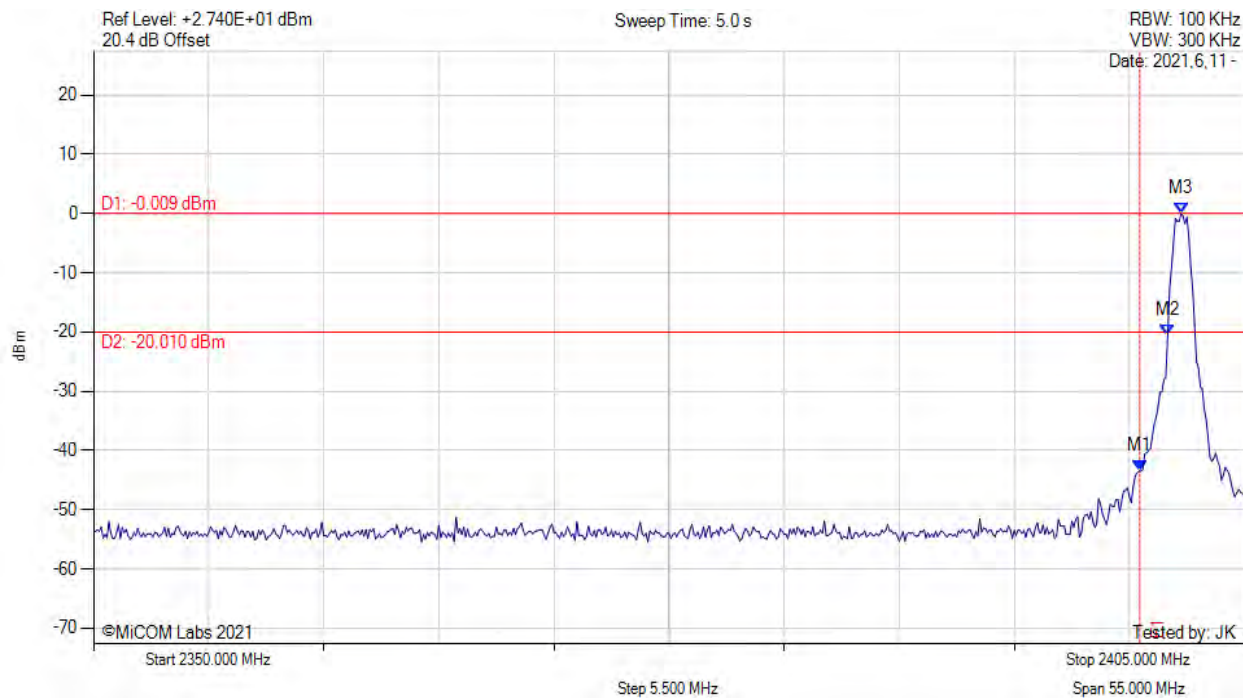
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A.3.1.2. Conducted Band-Edge Emissions



CONDUCTED LOW BAND-EDGE EMISSION - PEAK

Variation: GFSK, Channel: 2402.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



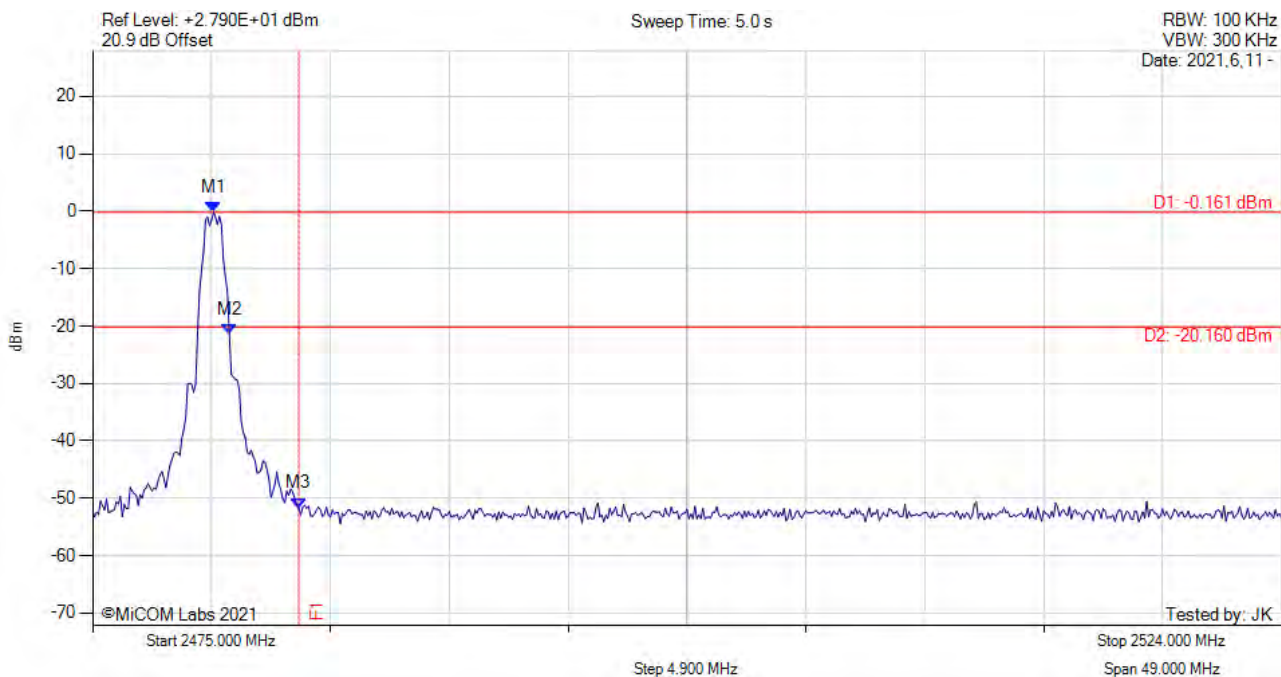
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2400.000 MHz : -43.475 dBm M2 : 2401.330 MHz : -20.508 dBm M3 : 2401.980 MHz : -0.009 dBm	Channel Frequency: 2402.00 MHz

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CONDUCTED HIGH BAND-EDGE EMISSION - PEAK



Variant: GFSK, Channel: 2480.00 MHz, Chain a, Temp: 20, Voltage: 3.7 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2479.980 MHz : -0.161 dBm M2 : 2480.635 MHz : -21.342 dBm M3 : 2483.500 MHz : -51.708 dBm	Channel Frequency: 2480.00 MHz

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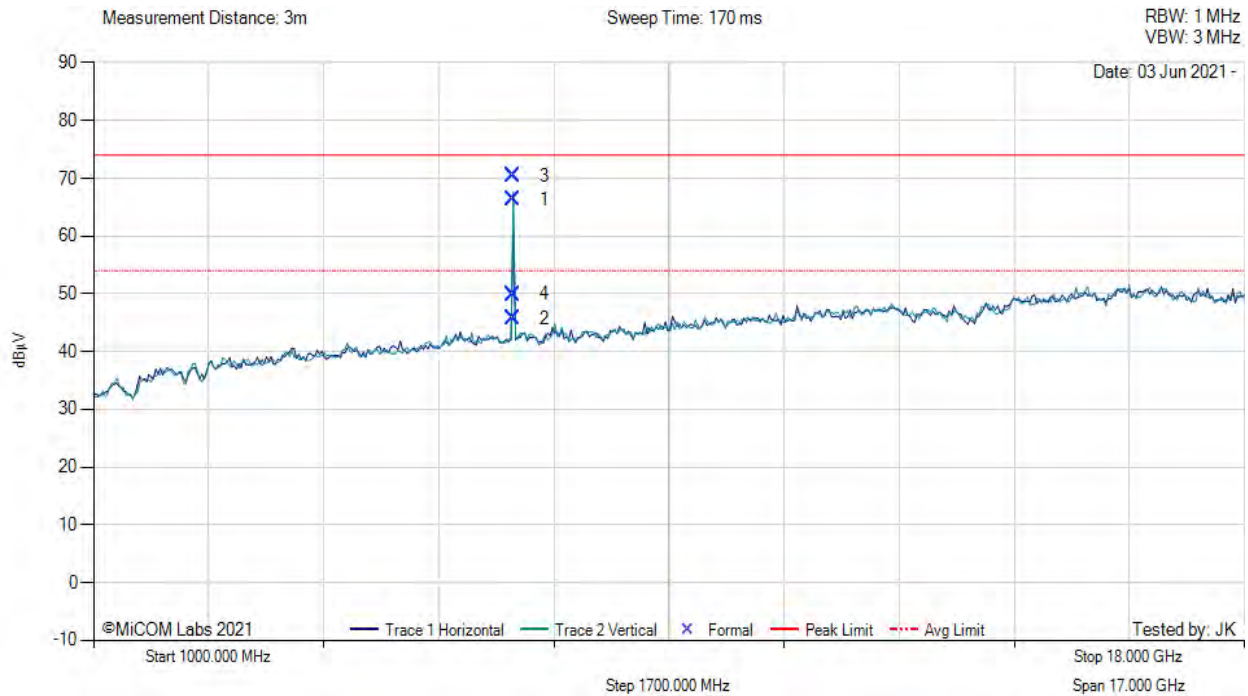
A.3.2. Radiated Emissions

A.3.2.3. TX Spurious & Restricted Band Emissions



TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2402.00 MHz, Antenna: Catapult BLE, Power Setting: 0x7F, Duty Cycle (%): 16.5



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	7205.13	70.71	3.57	-7.92	66.36	Max Peak	Horizontal	192	4	74.0	-7.6	Pass
2	7205.13	50.11	3.57	-7.92	45.76	Max Avg	Horizontal	192	4	54.0	-8.2	Pass
3	7205.21	74.81	3.57	-7.92	70.46	Max Peak	Vertical	194	0	74.0	-3.5	Pass
4	7205.21	54.24	3.57	-7.92	49.89	Max Avg	Vertical	194	0	54.0	-4.1	Pass

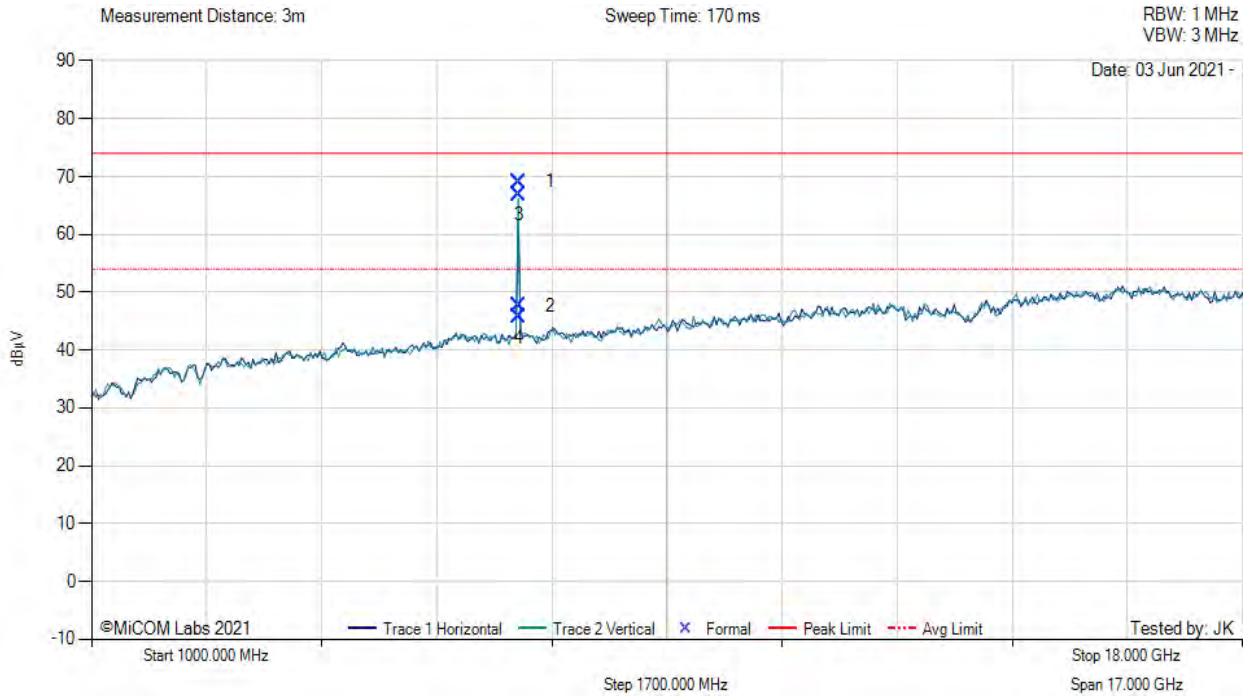
Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

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TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2440.00 MHz, Antenna: Catapult BLE, Power Setting: 0x7F, Duty Cycle (%): 16.5



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	7320.00	73.30	3.60	-7.80	69.10	Max Peak	Vertical	196	0	74.0	-4.9	Pass
2	7320.00	51.81	3.60	-7.80	47.61	Max Avg	Vertical	196	0	54.0	-6.4	Pass
3	7320.00	71.17	3.60	-7.80	66.97	Max Peak	Horizontal	190	0	74.0	-7.0	Pass
4	7320.00	49.97	3.60	-7.80	45.77	Max Avg	Horizontal	190	0	54.0	-8.2	Pass

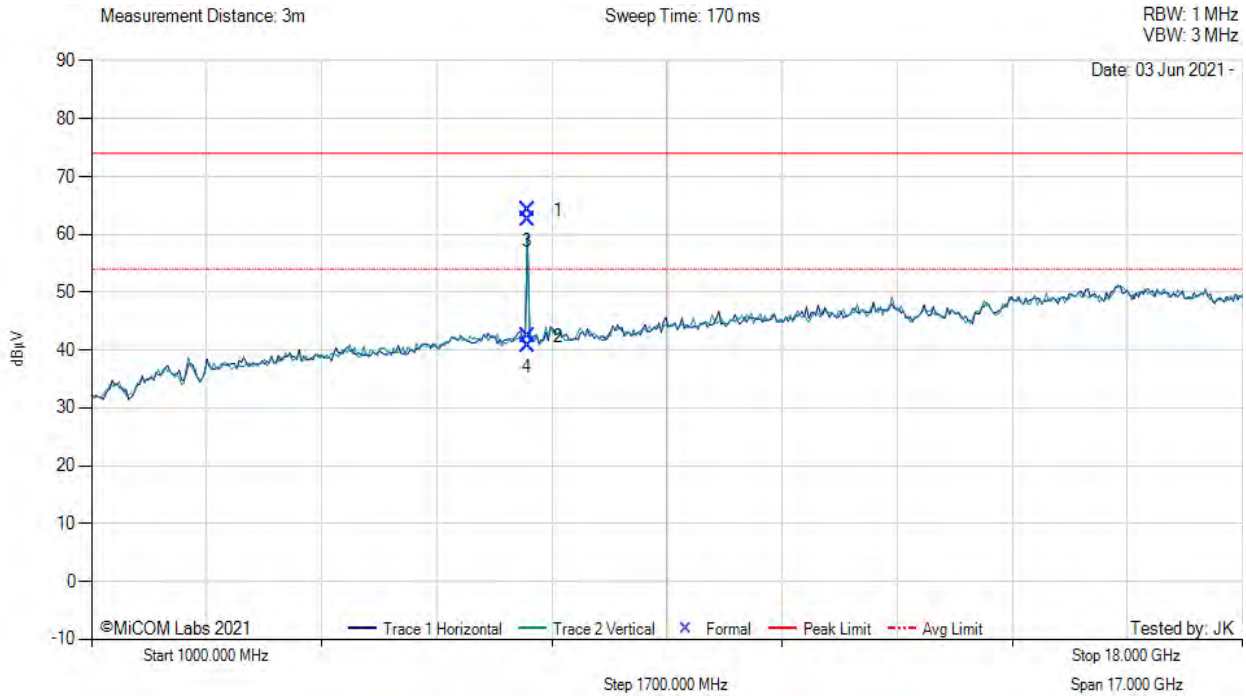
Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

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TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2480.00 MHz, Antenna: Catapult BLE, Power Setting: 0x7F, Duty Cycle (%): 16.5



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	7440.68	68.21	3.62	-7.72	64.11	Max Peak	Horizontal	188	0	74.0	-9.9	Pass
2	7440.68	46.49	3.62	-7.72	42.39	Max Avg	Horizontal	188	0	54.0	-11.6	Pass
3	7440.81	66.56	3.62	-7.72	62.46	Max Peak	Vertical	192	0	74.0	-11.5	Pass
4	7440.81	44.74	3.62	-7.72	40.64	Max Avg	Vertical	192	0	54.0	-13.4	Pass

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent.

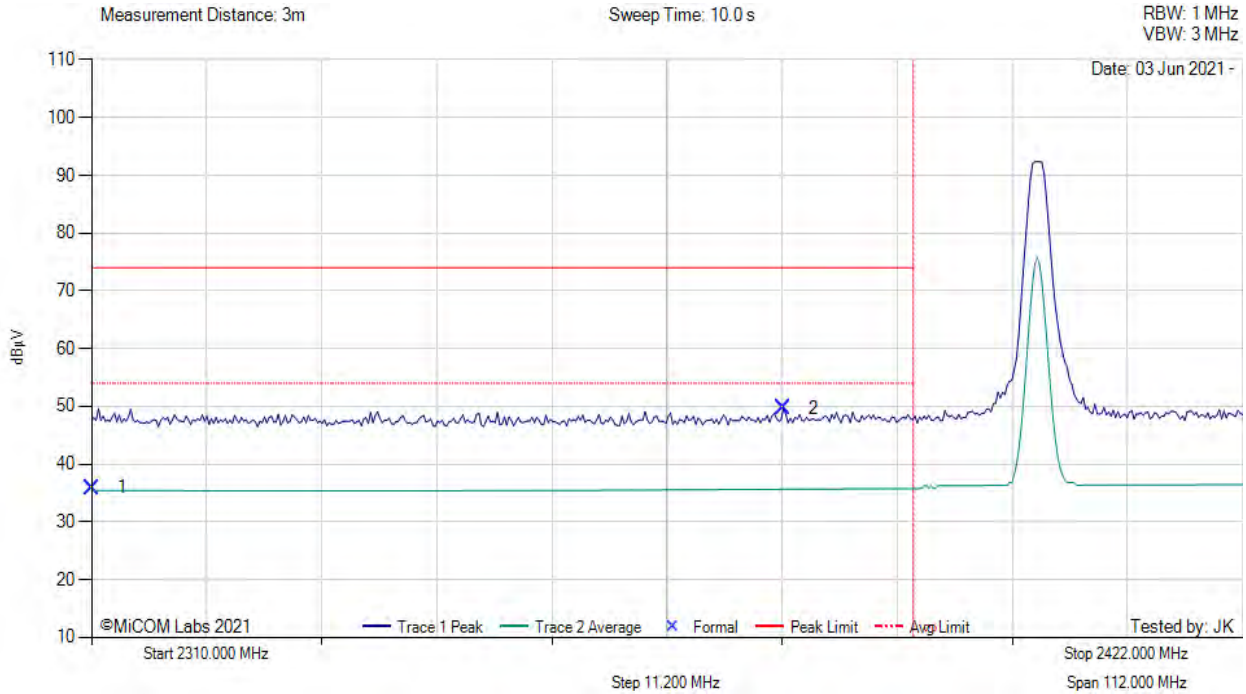
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A.3.2.4. Restricted Edge & Band-Edge Emissions



RADIATED - LOWER RESTRICTED BAND-EDGE EMISSIONS

Variant: GFSK, Test Freq: 2402.00 MHz, Antenna: Catapult BLE, Power Setting: 0x7F, Duty Cycle (%): 16.5



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	2310.00	2.23	1.98	31.71	35.92	Max Avg	Horizontal	190	0	54.0	-18.1	Pass
2	2377.33	15.75	2.00	31.89	49.64	Max Peak	Horizontal	190	0	74.0	-24.4	Pass
3	2389.97	--	--	--	--	Restricted-Band	--	--	--	--	--	--

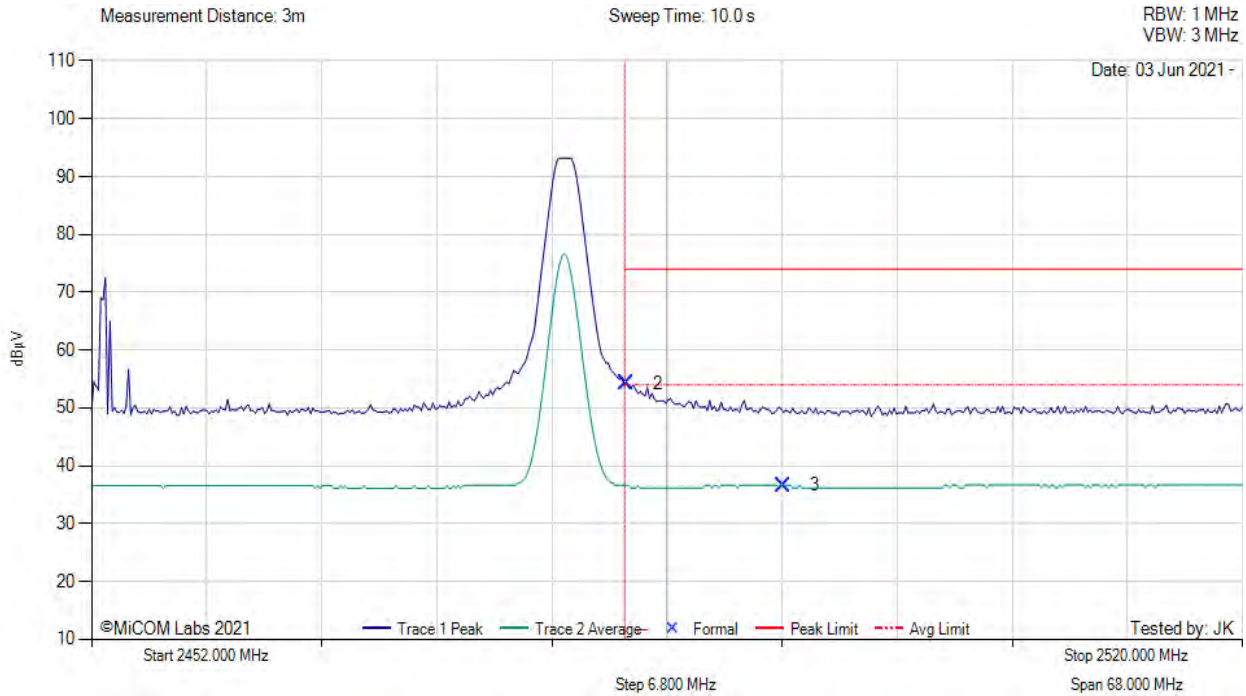
Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent. 7.82 DCCF added to avg measurement

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RADIATED - UPPER RESTRICTED BAND-EDGE EMISSIONS

Variant: GFSK, Test Freq: 2480.00 MHz, Antenna: Catapult BLE, Power Setting: 0x7F, Duty Cycle (%): 16.5



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
2	2483.64	19.85	2.03	32.33	54.21	Max Peak	Vertical	190	82	74.0	-19.8	Pass
3	2492.90	2.31	2.03	32.32	36.66	Max Avg	Vertical	190	82	54.0	-17.3	Pass
1	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BLE transmitter at max power. Battery discharging, charger not present. Battery >80 percent. 7.95 DCCF added to avg measurement

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