



REGULATORY COMPLIANCE TEST REPORT

FCC CFR 47 Part 15.247 & ISSED RSS-247

Report No.: LYFT06-U5 Rev A

Company: Lyft, Inc

Model Name: BIT040B

REGULATORY COMPLIANCE TEST REPORT

Company Name: Lyft, Inc

Model Name: BIT040B

To: FCC CFR 47 Part 15.247 & ISED RSS-247

Test Report Serial No.: LYFT06-U5 Rev A

This report supersedes: NONE

Applicant: Lyft, Inc
185 Berry St #5000
San Francisco,
California 94107
USA

Issue Date: 20th April 2021

This Test Report is Issued Under the Authority of:

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



MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

Table of Contents

1. ACCREDITATION, LISTINGS & RECOGNITION	4
1.1. TESTING ACCREDITATION	4
1.2. RECOGNITION	5
1.3. PRODUCT CERTIFICATION	6
2. DOCUMENT HISTORY	7
3. TEST RESULT CERTIFICATE	8
4. REFERENCES AND MEASUREMENT UNCERTAINTY	9
4.1. Normative References	9
4.2. Test and Uncertainty Procedure	10
5. PRODUCT DETAILS AND TEST CONFIGURATIONS	11
5.1. Technical Details	11
5.2. Scope Of Test Program	12
5.3. Equipment Model(s) and Serial Number(s)	13
5.4. External A.C/D.C. Power Adaptor	13
5.5. Antenna Details	13
5.6. Cabling and I/O Ports	13
5.7. Test Configurations	14
5.8. Equipment Modifications	14
5.9. Deviations from the Test Standard	14
6. TEST SUMMARY	15
7. TEST EQUIPMENT CONFIGURATION(S)	16
7.1. Conducted Test Setup	16
7.2. Radiated Emissions - 3m Chamber	18
8. MEASUREMENT AND PRESENTATION OF TEST DATA	21
9. TEST RESULTS	22
9.1. 6 dB & 99% Bandwidth	22
9.2. Conducted Output Power	24
9.3. Power Spectral Density	27
9.4. Emissions	29
9.4.1. <i>Conducted Emissions</i>	29
9.4.1.1. Conducted Spurious Emissions	29
9.4.1.2. Conducted Band-Edge Emissions	31
9.4.2. <i>Radiated Emissions</i>	33
9.4.2.3. TX Spurious & Restricted Band Emissions	33
9.4.2.4. Restricted Edge & Band-Edge Emissions	39
9.4.3. <i>Digital Emissions (0.03 - 1 GHz)</i>	43
A. APPENDIX - GRAPHICAL IMAGES	44
A.1. 6 dB & 99% Bandwidth	45
A.2. Power Spectral Density	48
A.3. Emissions	54
A.3.1.1. Conducted Spurious Emissions	54
A.3.1.2. Conducted Band-Edge Emissions	57
A.3.1.3. TX Spurious & Restricted Band Emissions	59
A.3.1.4. Restricted Edge & Band-Edge Emissions	62

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

A2LA has accredited

MICOM LABS

Pleasanton, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 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

MRA 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>



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	16th April 2021	Draft report for client for review
Rev A	20 th April 2021	Initial release.
.		
.		
.		

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

3. TEST RESULT CERTIFICATE

Manufacturer: Lyft, Inc 185 Berry St #5000 San Francisco California 94107 USA	Tested By: MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Model: BIT040B	Telephone: +1 925 462 0304
Type Of Equipment: E-Bike Location and Control Unit	Fax: +1 925 462 0306
S/N's: Conducted: 65-0000015-7 Radiated: LY2112CVCU2FC0001	
Test Date(s): 30 th March 2021	Website: www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15.247 & ISSED RSS-247	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	FCC 47 CFR Part 15.247	2020	Radio Frequency Devices; Subpart C – Intentional Radiators
II	RSS-247 Issue 2	Feb 2017	Digital Transmission Systems (DTSS), Frequency Hopping System (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices
III	RSS-Gen Issue 5	2018	General Requirements for Compliance of Radio Apparatus With Amendments 1: March 2019 and 2: Feb 2021.
IV	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
V	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.
VI	A2LA	5th October 2020	R105 - Requirement's When Making Reference to A2LA Accreditation Status
VII	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
VIII	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
IX	CISPR 32	2015	Electromagnetic compatibility of multimedia equipment - Emission requirements
X	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
XI	ICES-003	Issue 7 ; October 15, 2020	Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement.
XII	M 3003	Edition 3 Nov.2012	Expression of Uncertainty and Confidence in Measurements
XIII	FCC 47 CFR Part 2.1033	2020	FCC requirements and rules regarding photographs and test setup diagrams.

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 Lyft, Inc BIT040B to FCC CFR 47 Part 15 Subpart C 15.247 (DTS) & ISED RSS-247
Applicant:	Lyft, Inc 185 Berry St #5000 San Francisco, California 94107 USA
Manufacturer:	Lyft, Inc
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	LYFT06-U5 Rev A
Date EUT received:	30 th March 2021
Standard(s) applied:	FCC CFR 47 Part 15.247 (DTS) & ISED RSS-247
Dates of test (from - to):	30 th March 2021
No of Units Tested:	2
Type Of Equipment:	E-Bike Location and Control Unit
Model(s):	BIT040B
Location for use:	Indoor / 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):	8
Transmit/Receive Operation:	Transceiver
Rated Input Voltage and Current:	48VDC / 1A Battery
Operating Temperature Range:	-20°C to +50°C
ITU Emission Designator:	1M07F7W
Equipment Dimensions:	15.75cm x 8.8cm x 5.5cm
Weight:	360 grams
Hardware Rev:	5
Software Rev:	9686a2fa0817

5.2. Scope Of Test Program

Lyft, Inc BIT040B

The scope of the test program was to test the Lyft, Inc BIT040B Bluetooth BLE configuration in the frequency ranges 2400 - 2483.5 MHz; for compliance against the following specifications;-

FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Radio Frequency Devices; Subpart C – Intentional Radiators

ISSED RSS-247

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

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

Type (EUT/Support)	Equipment Description (Including Brand Name)	Mfr.	Model No.	Serial No.
EUT	E-Bike Location and Control Unit	Lyft Inc	BIT040B	Conducted: 65-0000015-7 Radiated LY2112CVCU2FC0001
Support	Laptop	Lenovo	N/A	N/A

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

The BIT040B is powered via 48V Battery, no external ac/dc adaptor is used.

5.5. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
integral	Taoglas	WLA.01	Chip	2.5	-	360	-	2400 - 2483.5

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

5.6. Cabling and I/O Ports

Port Type	Max Cable Length	Conn Type	Environment
Discrete I/O	<3m	Higo L810 CG	End-User
Analog	<3m	Higo L309 CM	End-User
Analog	<3m	Higo L609 CM	End-User
CAN+DC IN	<3m	Higo L409 CG	End-User
Power + Digital I/O	<3m	Higo L509 CM	End-User

5.7. Test Configurations

Results for the following configurations are provided in this report:

Operational Mode	Data Rate with Highest Power MBit/s	Channel Frequency (MHz)		
		Low	Mid	High
2400 - 2483.5 MHz				
BLE	1	2,402.00	2,440.00	2,480.00

5.8. Equipment Modifications

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

1. NONE

5.9. Deviations from the Test Standard

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

1. NONE

6. TEST SUMMARY

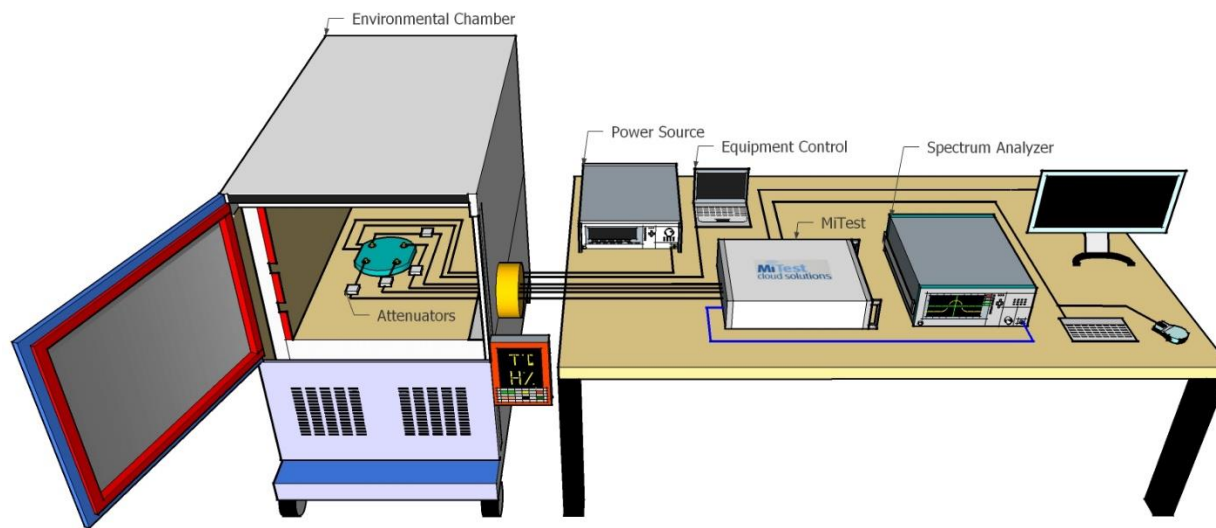
List of Measurements

Test Header	Result	Data Link
6 dB & 99% Bandwidth	Complies	View Data
Conducted Output Power	Complies	View Data
Power Spectral Density	Complies	View Data
Emissions	Complies	-
(1) Conducted Emissions	Complies	-
(i) Conducted Spurious Emissions	Complies	View Data
(ii) Conducted Band-Edge Emissions	Complies	View Data
(2) Radiated Emissions	Complies	-
(i) TX Spurious & Restricted Band Emissions	Complies	View Data
(ii) Restricted Edge & Band-Edge Emissions	Complies	View Data
(3) Digital Emissions (0.03 - 1 GHz)	Complies	View Data
(4) AC Wireline Emissions	No requirement modules are Vdc	

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.

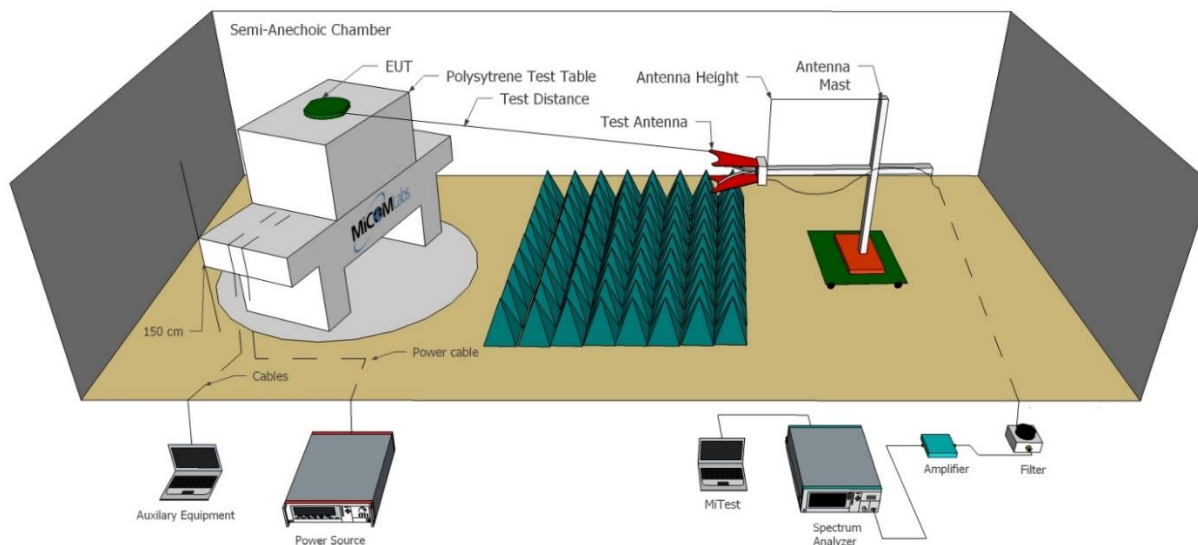
Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
#3 SA	MiTest Box to SA	Fairview Microwave	SCA1814-0101-72	#3 SA	4 Jun 2021
#3P1	EUT to MiTest box port 1	Fairview Microwave	SCA1814-0101-72	#3P1	4 Jun 2021
#3P2	EUT to MiTest box port 2	Fairview Microwave	SCA1814-0101-72	#3P2	4 Jun 2021
#3P3	EUT to MiTest box port 3	Fairview Microwave	SCA1814-0101-72	#3P3	4 Jun 2021
#3P4	EUT to MiTest box port 4	Fairview Microwave	SCA1812-0101-72	#3P4	4 Jun 2021
249	Thermocouple; Resistance Thermometer	Thermotronics	GR2105-02	9340 #2	30 Oct 2021
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	8 Oct 2021
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Jun 2021
398	MiTest RF Conducted Test Software	MiCOM	MiTest ATS	Version 4.2.3.0	Not Required
405	DC Power Supply 0-60V	Agilent	6654A	MY4001826	Cal when used
408	USB to GPIB interface	National	GPIB-USB HS	14C0DE9	Not Required

		Instruments			
440	USB Wideband Power Sensor	Boonton	55006	9178	22 Jun 2021
441	USB Wideband Power Sensor	Boonton	55006	9179	20 Jun 2021
442	USB Wideband Power Sensor	Boonton	55006	9181	19 Jun 2021
445	PoE Injector	D-Link	DPE-101GL	QTAH1E 2000625	Not Required
461	Spectrum Analyzer	Agilent	E4440A	MY46185 537	20 Jun 2021
510	Barometer/Thermometer	Control Company	68000-49	1708713 75	20 Dec 2021
515	MiTest Cloud Solutions RF Test Box	MiCOM	2nd Gen with DFS	515	4 Jun 2021
534	Power Sensor 50 GHz - 70dBm to +20dBm	R&S	NRP50SN	1419.009 3K02- 100888- SB	26 Feb 2022
75	Environmental Chamber	Thermatron	SE-300-2-2	27946	20 Feb 2022

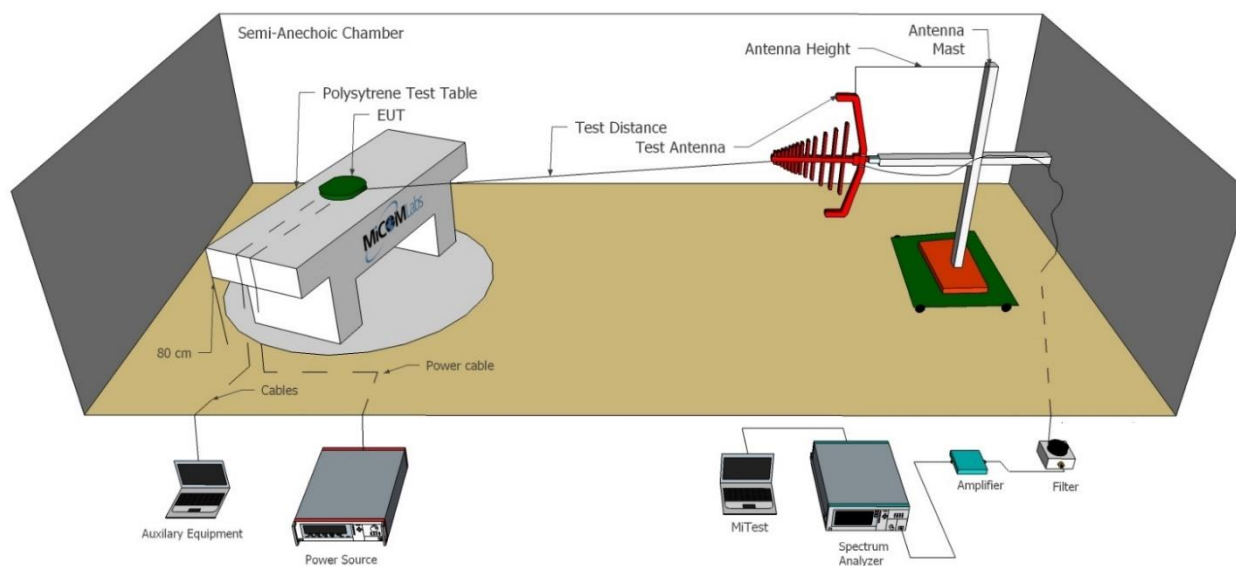
7.2. Radiated Emissions - 3m Chamber

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
170	Video System Controller for Semi Anechoic Chamber	Panasonic	WV-CU101	04R08507	Not Required
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	8 Oct 2021
330	Variac 0-280 Vac	Staco Energy Co	3PN1020B	0546	Cal when used
336	Active loop Ant 10kHz to 30 MHz	EMCO	EMCO 6502	00060498	29 Nov 2021
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	4 Oct 2021
342	2.4 GHz Notch Filter	EWT	EWT-14-0203	H1	4 May 2021
373	26III RMS Multimeter	Fluke	Fluke 26 series III	76080720	21 Jun 2021
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Jun 2021
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	9 May 2021
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 May 2021
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	9 May 2021
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
414	DC Power Supply 0-60V	HP	6274	1029A01285	Cal when used
415	Turntable Controller	Sunol Sciences	Turntable Controller	None	Not Required
416	Gigabit ethernet filter	ETS-Lingren	Gigafoil 260366	None	Not Required
447	MiTest Rad Emissions Test Software	MiCOM	Rad Emissions Test Software Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	4 May 2021
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	4 May 2021
464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	4 May 2021
466	Low Pass Filter DC-1500 MHz	Mini-Circuits	NLP-1750+	VUU10401438	4 May 2021

480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	4 May 2021
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	4 May 2021
510	Barometer/Thermometer	Control Company	68000-49	170871375	20 Dec 2021
518	Cable - Amp to Antenna	SRC Haverhill	157-3051574	518	4 May 2021
87	Uninterruptible Power Supply	Falcon Electric	ED2000-1/2LC	F3471 02/01	Cal when used

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 ISED RSS-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) RSS-247 5.2(a)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for 6 dB and 99% Bandwidth Measurement

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

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

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

Limits for 6 dB and 99% Bandwidth

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

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

Equipment Configuration for 6 dB & 99% Bandwidth

Variant:	BLE	Duty Cycle (%):	99
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:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured 6 dB Bandwidth (MHz)				6 dB Bandwidth (MHz)		Limit	Lowest Margin
	Port(s)				Highest	Lowest		
MHz	a	b	c	d			KHz	MHz
2402.0	0.567				0.567	0.567		
2440.0	0.593				0.593	0.593		
2480.0	0.630				0.630	0.630		

Test Frequency	Measured 99% Bandwidth (MHz)				Maximum 99% Bandwidth (MHz)		
	Port(s)						
MHz	a	b	c	d			
2402.0	1.064				1.064		
2440.0	1.014				1.014		
2480.0	1.067				1.067		

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 ISED RSS-247	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Output Power	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (b) & (c) RSS-247 5.4 (a)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		

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

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

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

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

Supporting Information
Calculated Power = $A + G + Y + 10 \log (1/x)$ dBm

A = Total Power [$10 \cdot \log_{10} (10^{a/10} + 10^{b/10} + 10^{c/10} + 10^{d/10})$]
 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 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 Average Output Power

Variant:	BLE	Duty Cycle (%):	99.0
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	2.50
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
	Port(s)							
MHz	a	b	c	d	dBm	dBm	dB	
2402.0	6.87				6.87	30.00	-23.13	
2440.0	6.62				6.62	30.00	-23.38	
2480.0	6.71				6.71	30.00	-23.29	

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 ISED RSS-247	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Power Spectral Density	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (e) RSS-247 5.2(b)	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Power Spectral Density

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

Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured separately. The Peak Power Spectral Density is the highest level found across the emission bandwidth. With multiple antenna port measurements the numerical analyzer data from each port is summed (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 = Total Power Spectral Density $[10 \log_{10} (10^{a/10} + 10^{b/10} + 10^{c/10} + 10^{d/10})]$

x = Duty Cycle

Limits Power Spectral Density

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

Equipment Configuration for Power Spectral Density - Average

Variant:	BLE	Duty Cycle (%):	99.0
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	2.50
Modulation:	GFSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Power Spectral Density				Amplitude Summation + DCCF (+0.04 dB)	Limit	Margin
	Port(s) (dBm/3KHz)						
MHz	a	b	c	d	dBm/3KHz	dBm/3KHz	dB
2402.0	-14.752				-14.708	8.0	-22.7
2440.0	-14.063				-14.019	8.0	-22.0
2480.0	-15.366				-15.322	8.0	-23.3

Traceability to Industry Recognized Test Methodologies

Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

DCCF - Duty Cycle Correction Factor

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 ISED RSS-247	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Max Unwanted Emission Levels	Rel. Humidity (%):	32 - 45
Standard Section(s):	15.247 (d) RSS-247 5.5	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Transmitter Conducted Spurious and Band-Edge Emissions Measurement

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

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

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

Limits Transmitter Conducted Spurious and Band-Edge Emissions

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Equipment Configuration for Conducted Spurious Emissions - Average

Variant:	BLE	Duty Cycle (%):	99
Data Rate:	1.00 MBit/s	Antenna Gain (dBi):	Not Applicable
Modulation:	GFSK	Beam Forming Gain (Y):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Frequency Range	Conducted Spurious Emissions - Average (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	-58.335	-52.01						
2440.0	30.0 - 26000.0	-58.335	-52.16						
2480.0	30.0 - 26000.0	-58.335	-53.12						

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 - Average						
Variant:	BLE			Duty Cycle (%):	99.0	
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:	SB	
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	-55.96	-32.73	2401.10			-1.100
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 - Average

Variant:	BLE	Duty Cycle (%):	99.0
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:	SB
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
	M3 Amplitude (dBm)	Plot Limit (dBm)	M2 Frequency (MHz)	Amplitude (dBm)	M2A Frequency (MHz)	(MHz)
a	-61.90	-33.63	2481.00			-2.500

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 15.247 (DTS) RSS-247 Issue 2	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 RSS-247 5.5. RSS-Gen 6.13, 8.9, 8.10	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:	Taoglas WLA.01	Variant:	GFSK
Antenna Gain (dBi):	2.50	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	50
Channel Frequency (MHz):	2402.00	Data Rate:	1.00 MBit/s
Power Setting:	Max	Tested By:	JMH

Test Measurement Results

1000.00 - 18000.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
#1	4804.51	63.38	2.85	-12.42	53.81	Max Peak	Horizontal	106	27	74.0	-20.2	Pass
#2	4804.51	53.91	2.85	-12.42	44.34	Max Avg	Horizontal	106	27	54.0	-9.7	Pass

Test Notes: BIT040B powered by 48 V DC. 2.4G Notch in front of amp to prevent overload. 3 dB DCCF added to average measurement.

Equipment Configuration for TX Spurious & Restricted Band Emissions

Antenna:	Taoglas WLA.01	Variant:	GFSK
Antenna Gain (dBi):	2.50	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	50
Channel Frequency (MHz):	2440.00	Data Rate:	1.00 MBit/s
Power Setting:	Max	Tested By:	JMH

Test Measurement Results

1000.00 - 18000.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
#1	4879.67	62.40	2.88	-12.54	52.74	Max Peak	Horizontal	98	29	74.0	-21.3	Pass
#2	4879.67	53.30	2.88	-12.54	43.64	Max Avg	Horizontal	98	29	54.0	-10.4	Pass
#3	7319.38	56.89	3.60	-7.80	52.69	Max Peak	Horizontal	182	117	74.0	-21.3	Pass
#4	7319.38	46.71	3.60	-7.80	42.51	Max Avg	Horizontal	182	117	54.0	-11.5	Pass

Test Notes: BIT040B powered by 48 V DC. 2.4G Notch in front of amp to prevent overload. 3 dB DCCF added to average measurement.

Equipment Configuration for TX Spurious & Restricted Band Emissions

Antenna:	Taoglas WLA.01	Variant:	GFSK
Antenna Gain (dBi):	2.50	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	50
Channel Frequency (MHz):	2480.00	Data Rate:	1.00 MBit/s
Power Setting:	Max	Tested By:	JMH

Test Measurement Results

1000.00 - 18000.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
#1	4960.51	61.63	2.91	-12.51	52.03	Max Peak	Horizontal	194	114	74.0	-22.0	Pass
#2	4960.51	51.80	2.91	-12.51	42.20	Max Avg	Horizontal	194	114	54.0	-11.8	Pass
#3	7439.53	56.03	3.62	-7.73	51.92	Max Peak	Horizontal	191	145	74.0	-22.1	Pass
#4	7439.53	46.36	3.62	-7.73	42.25	Max Avg	Horizontal	191	145	54.0	-11.8	Pass

Test Notes: BIT040B powered by 48 V DC. 2.4G NOtch in front of amp to prevent overload. 3dB DCCF added to average measurements.

9.4.2.4. Restricted Edge & Band-Edge Emissions

Results Summary for Radiated ; Lower Band Edge Emissions

Taoglas WLA.01		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	48.54	39.73	Max

Click on the links to view the data.

Equipment Configuration for Radiated - Lower Restricted Band-Edge Emissions

Antenna:	Taoglas WLA.01	Variant:	GFSK
Antenna Gain (dBi):	2.50	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	50
Channel Frequency (MHz):	2402.00	Data Rate:	1.00 MBit/s
Power Setting:		Tested By:	

Test Measurement Results

2310.00 - 2422.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
#1	2390.00	5.75	2.02	31.96	39.73	Max Avg	Horizontal	143	37	54.0	-14.3	Pass
#2	2390.00	14.56	2.02	31.96	48.54	Max Peak	Horizontal	143	37	74.0	-25.5	Pass
#3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BIT040B powered by 48 V DC DCCF of 3 dB added to average measurement

Results Summary for Radiated ; Upper Band Edge Emissions

Taoglas WLA.01		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	50.66	40.11	Max

Equipment Configuration for Radiated - Upper Restricted Band-Edge Emissions

Antenna:	Taoglas WLA.01	Variant:	GFSK
Antenna Gain (dBi):	Not Applicable	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	50
Channel Frequency (MHz):	2480.00	Data Rate:	1.00 MBit/s
Power Setting:		Tested By:	JMH

Test Measurement Results

2452.00 - 2520.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
#1	2483.50	5.75	2.03	32.33	40.11	Max Avg	Horizontal	143	37	54.0	-13.9	Pass
#3	2502.15	16.30	2.05	32.31	50.66	Max Peak	Horizontal	143	37	74.0	-23.3	Pass
#2	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BIT040B powered by 48 V DC. 3dB DCCF added to average measurement.

9.4.3. Digital Emissions (0.03 - 1 GHz)

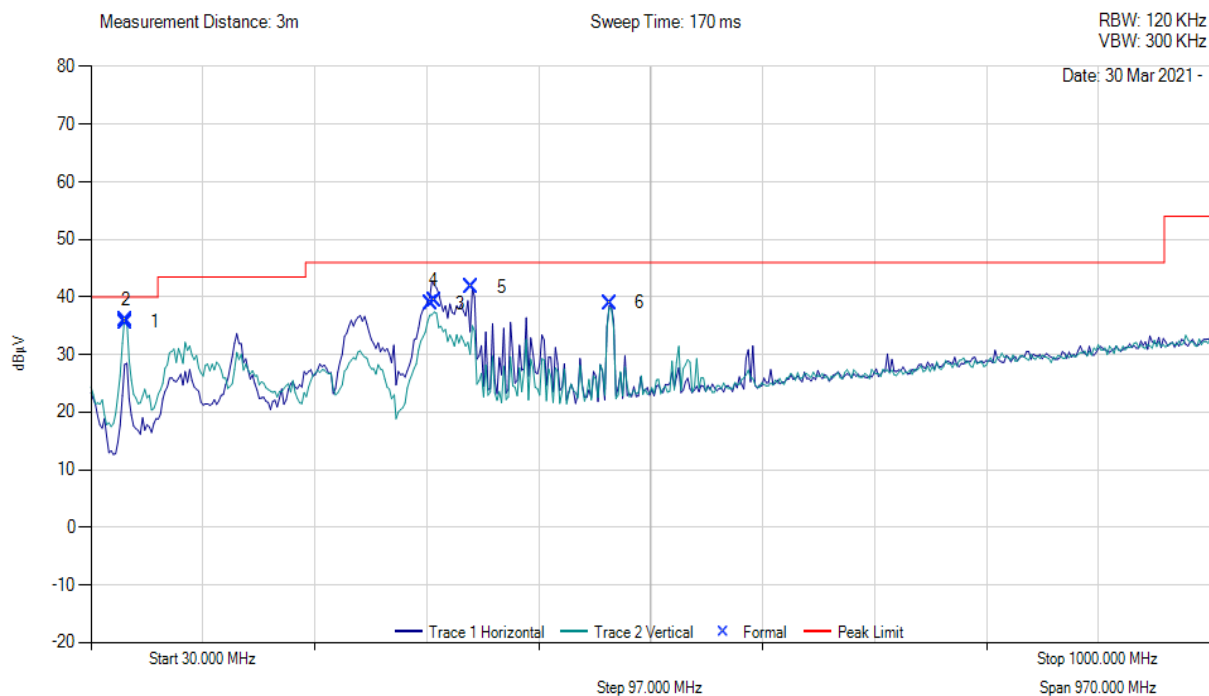
Equipment Configuration for Radiated Digital Emissions (Class B)

Antenna:	Integral	Variant:	NFC, BLE, OFDM, LTE
Antenna Gain (dBi):	Not Applicable	Modulation:	GFSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99
Channel Frequency (MHz):	13.56, 2402.	Data Rate:	1
Power Setting:	Max	Tested By:	JMH

Test Measurement Results



Variant: , Test Freq: 13.56 MHz



30.00 - 1000.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	59.85	52.80	3.80	-20.97	35.63	MaxQP	Vertical	108	356	40.0	-4.4	Pass
2	60.46	53.21	3.80	-21.08	35.93	MaxQP	Vertical	101	340	40.0	-4.1	Pass
3	324.42	47.55	5.00	-13.65	38.90	MaxQP	Horizontal	102	99	46.0	-7.1	Pass
4	327.34	47.95	5.01	-13.62	39.34	MaxQP	Horizontal	101	114	46.0	-6.7	Pass
5	360.01	49.25	5.12	-12.70	41.67	MaxQP	Horizontal	101	263	46.0	-4.3	Pass
6	480.02	43.37	5.53	-9.97	38.93	MaxQP	Horizontal	182	234	46.0	-7.1	Pass

Test Notes: BIT040B powered by 48 V DC Battery. NFC, BLE, WiFi and LTE Band 5 transmitting

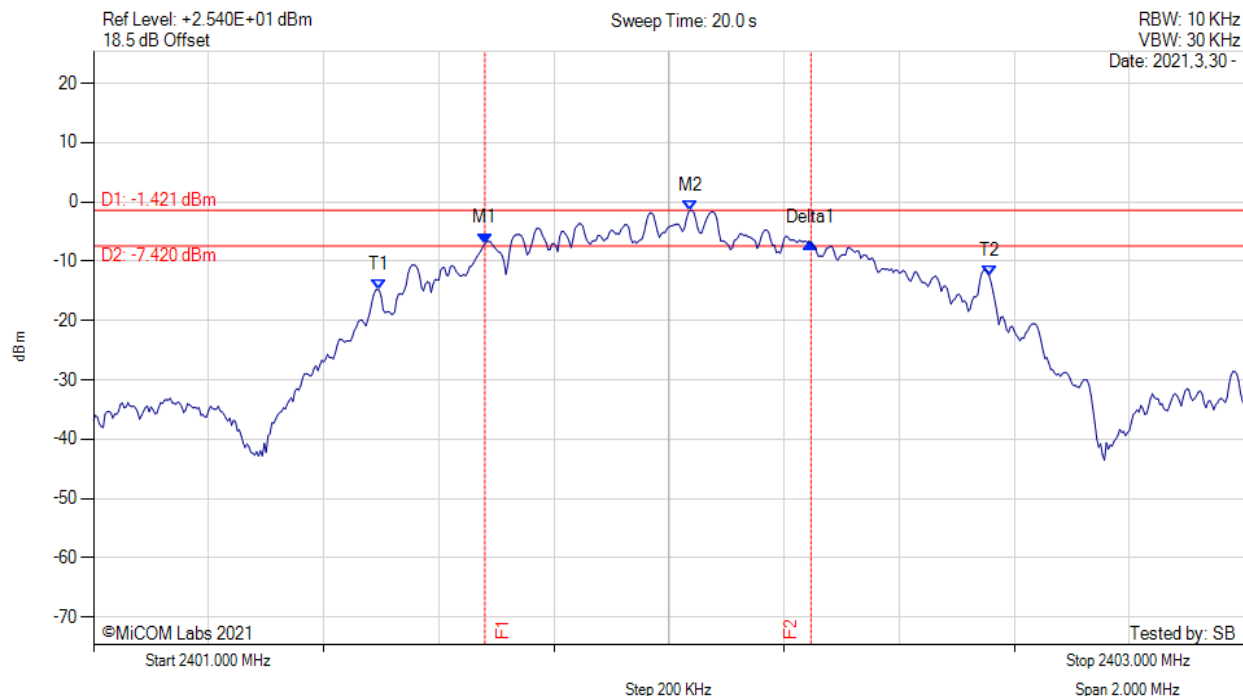
A. APPENDIX - GRAPHICAL IMAGES

A.1. 6 dB & 99% Bandwidth



6 dB & 99% BANDWIDTH

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



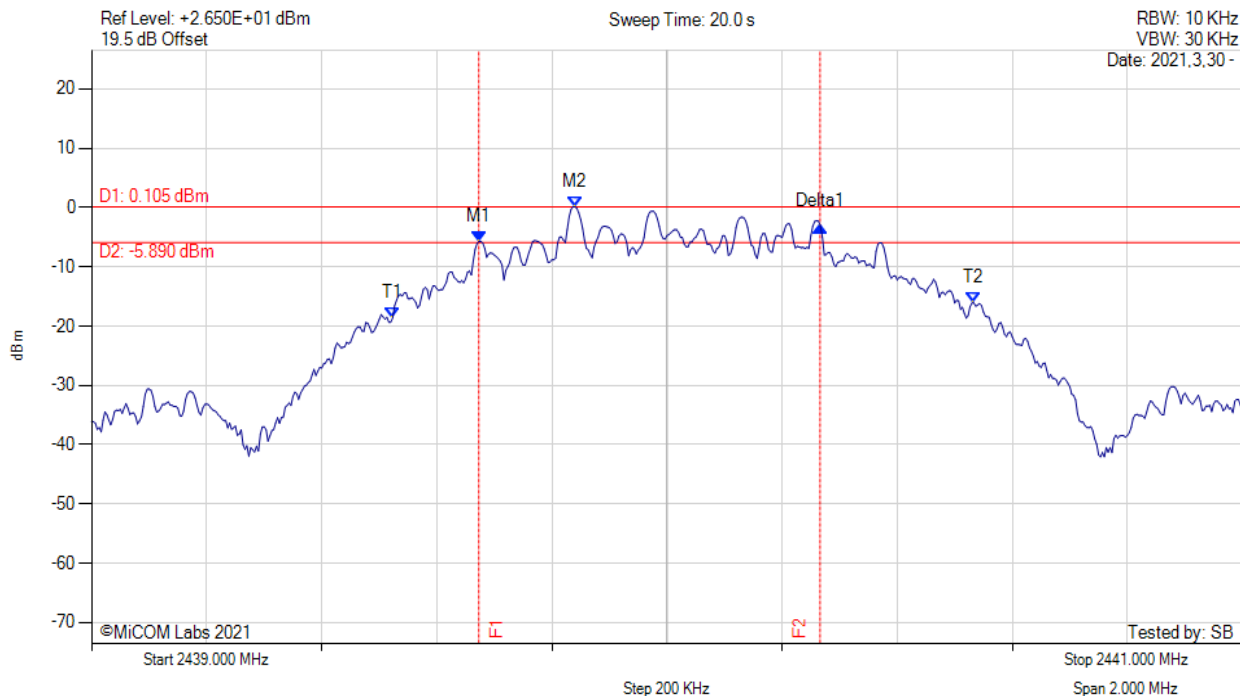
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2401.680 MHz : -7.002 dBm M2 : 2402.037 MHz : -1.421 dBm Delta1 : 567 KHz : 0.118 dB T1 : 2401.497 MHz : -14.910 dBm T2 : 2402.557 MHz : -12.505 dBm OBW : 1.064 MHz	Measured 6 dB Bandwidth: 0.567 MHz Limit: kHz Margin: #VALUE! MHz

[back to matrix](#)

6 dB & 99% BANDWIDTH



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



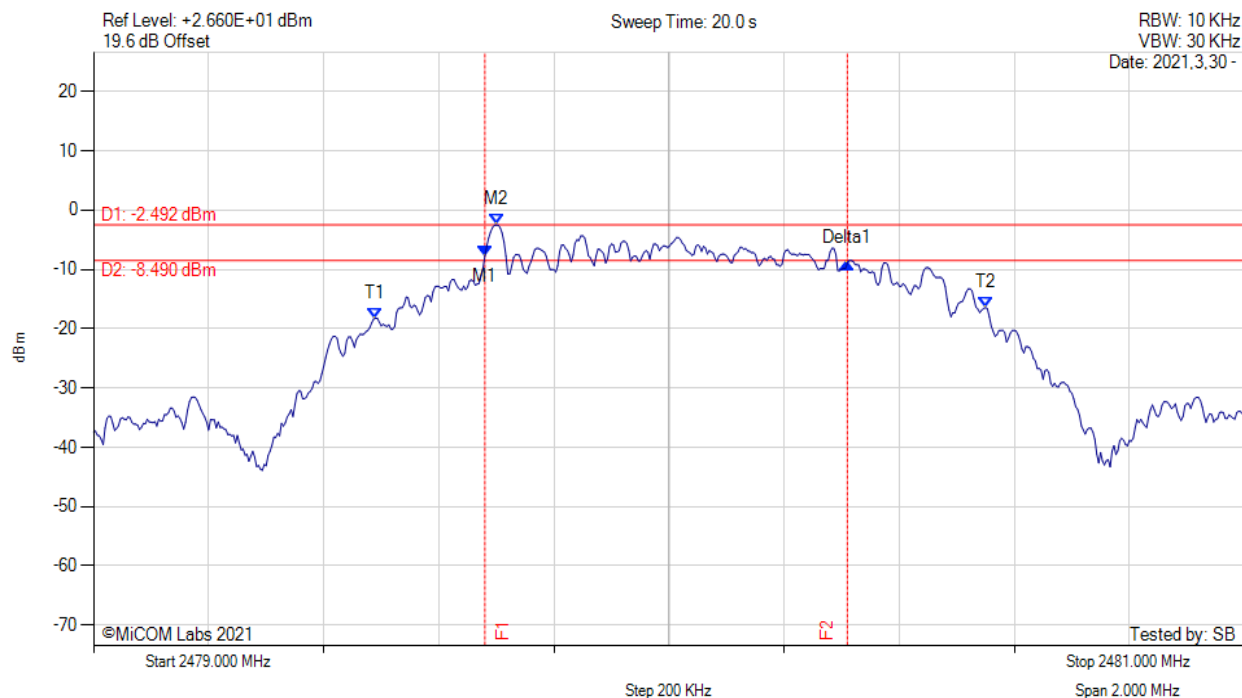
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2439.673 MHz : -5.716 dBm M2 : 2439.840 MHz : 0.105 dBm Delta1 : 593 KHz : 2.570 dB T1 : 2439.523 MHz : -18.598 dBm T2 : 2440.533 MHz : -16.101 dBm OBW : 1.014 MHz	Measured 6 dB Bandwidth: 0.593 MHz Limit: kHz Margin: #VALUE! MHz

[back to matrix](#)



6 dB & 99% BANDWIDTH

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



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = POS Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = MAXH	M1 : 2479.680 MHz : -7.733 dBm M2 : 2479.700 MHz : -2.492 dBm Delta1 : 630 KHz : -1.238 dB T1 : 2479.490 MHz : -18.217 dBm T2 : 2480.550 MHz : -16.447 dBm OBW : 1.067 MHz	Measured 6 dB Bandwidth: 0.630 MHz Limit: kHz Margin: #VALUE! MHz

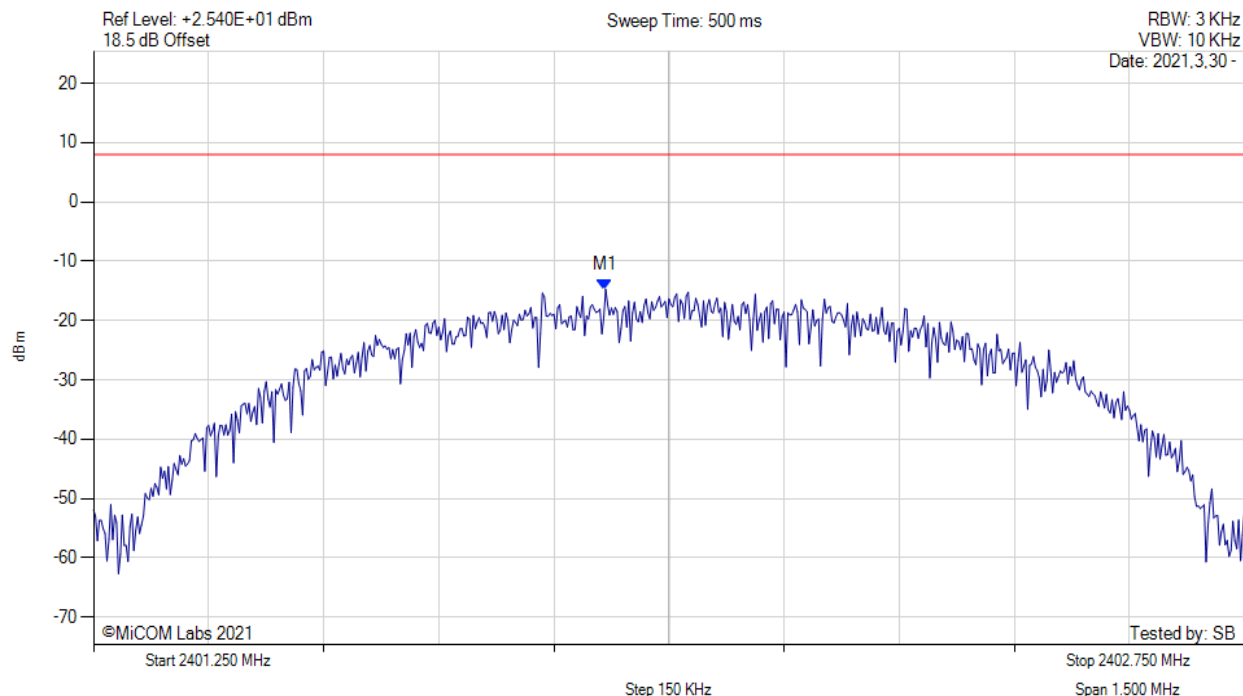
[back to matrix](#)

A.2. Power Spectral Density



POWER SPECTRAL DENSITY - AVERAGE

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



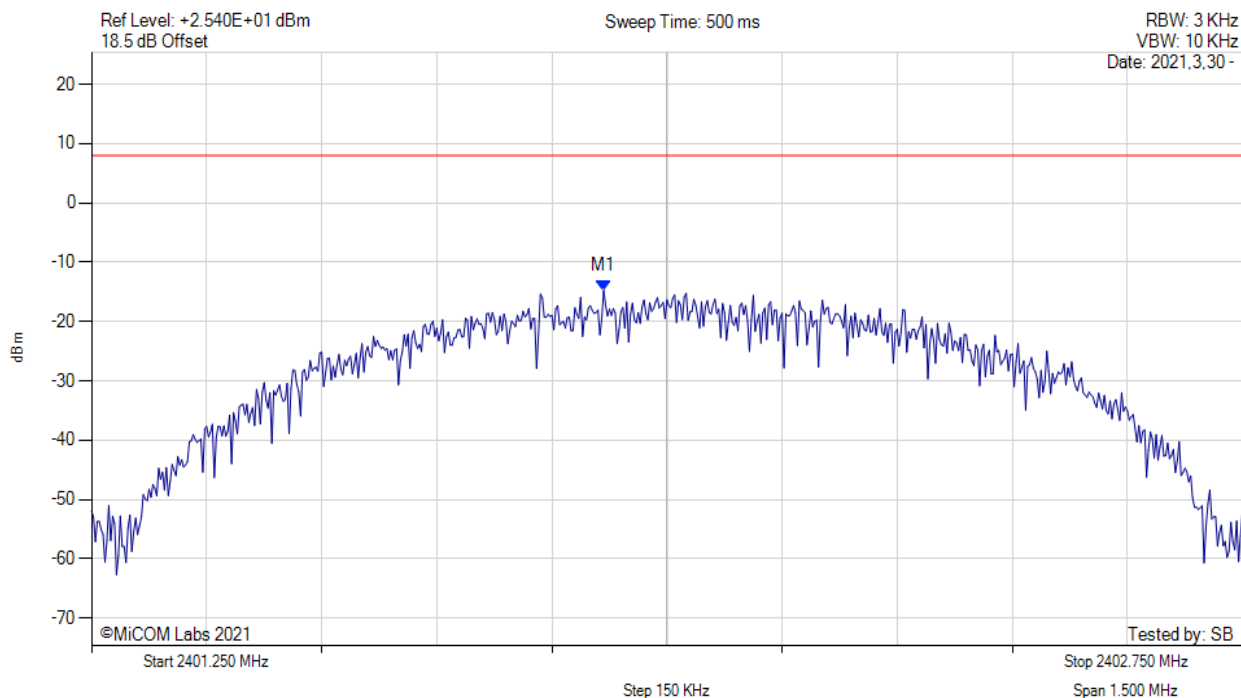
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2401.916 MHz : -14.752 dBm	Limit: ≤ 8.000 dBm

[back to matrix](#)

POWER SPECTRAL DENSITY - AVERAGE



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



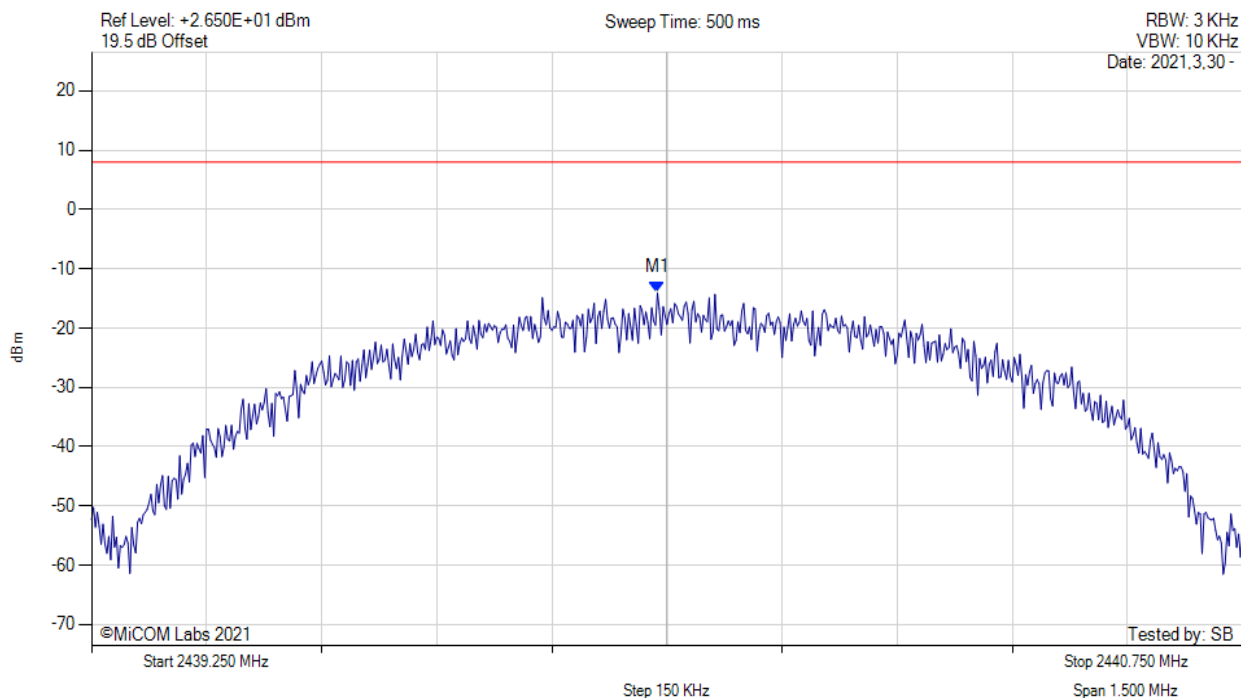
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2401.900 MHz : -14.752 dBm M1 + DCCF : 2401.900 MHz : -14.708 dBm Duty Cycle Correction Factor : +0.04 dB	Limit: ≤ 8.0 dBm Margin: -22.7 dB

[back to matrix](#)

POWER SPECTRAL DENSITY - AVERAGE



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



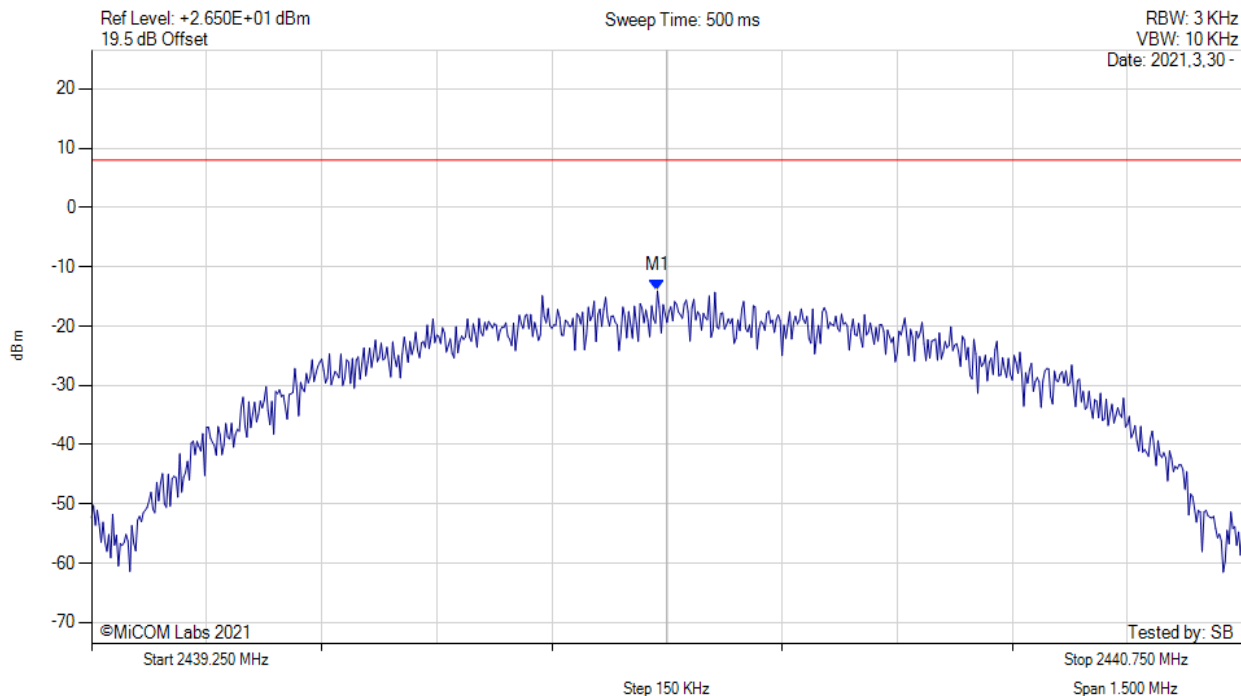
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2439.987 MHz : -14.063 dBm	Limit: ≤ 8.000 dBm

[back to matrix](#)

POWER SPECTRAL DENSITY - AVERAGE



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



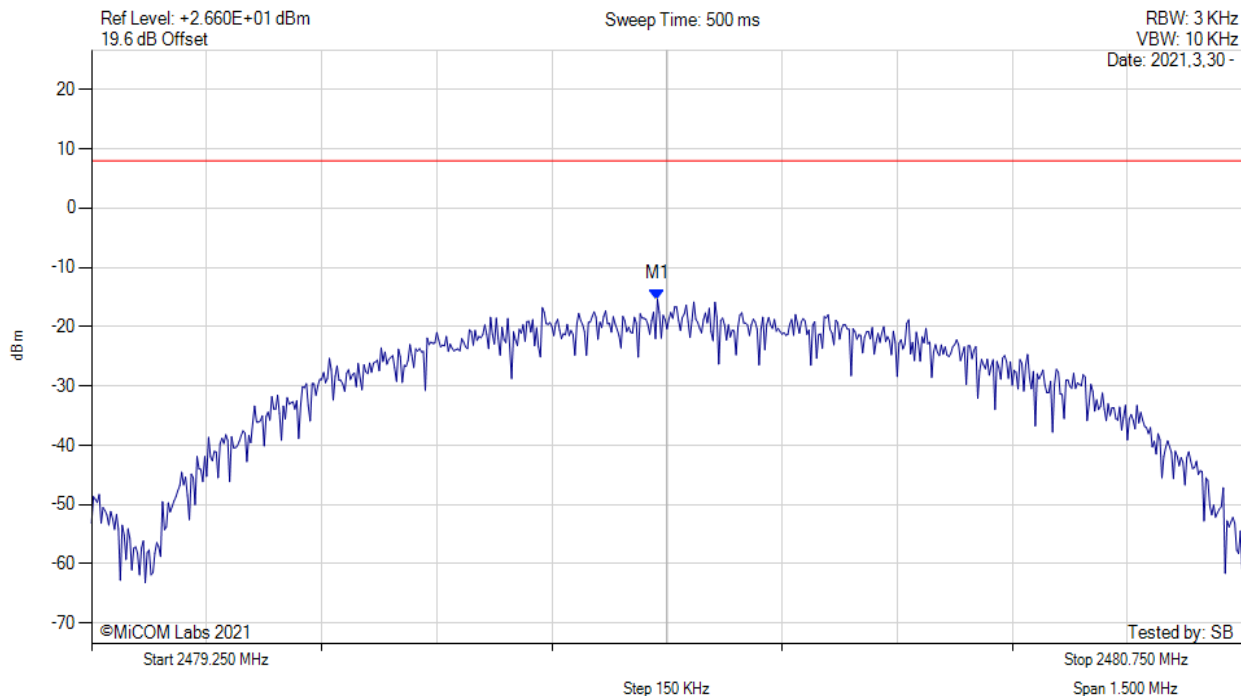
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2440.000 MHz : -14.063 dBm M1 + DCCF : 2440.000 MHz : -14.019 dBm Duty Cycle Correction Factor : +0.04 dB	Limit: ≤ 8.0 dBm Margin: -22.0 dB

[back to matrix](#)

POWER SPECTRAL DENSITY - AVERAGE



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



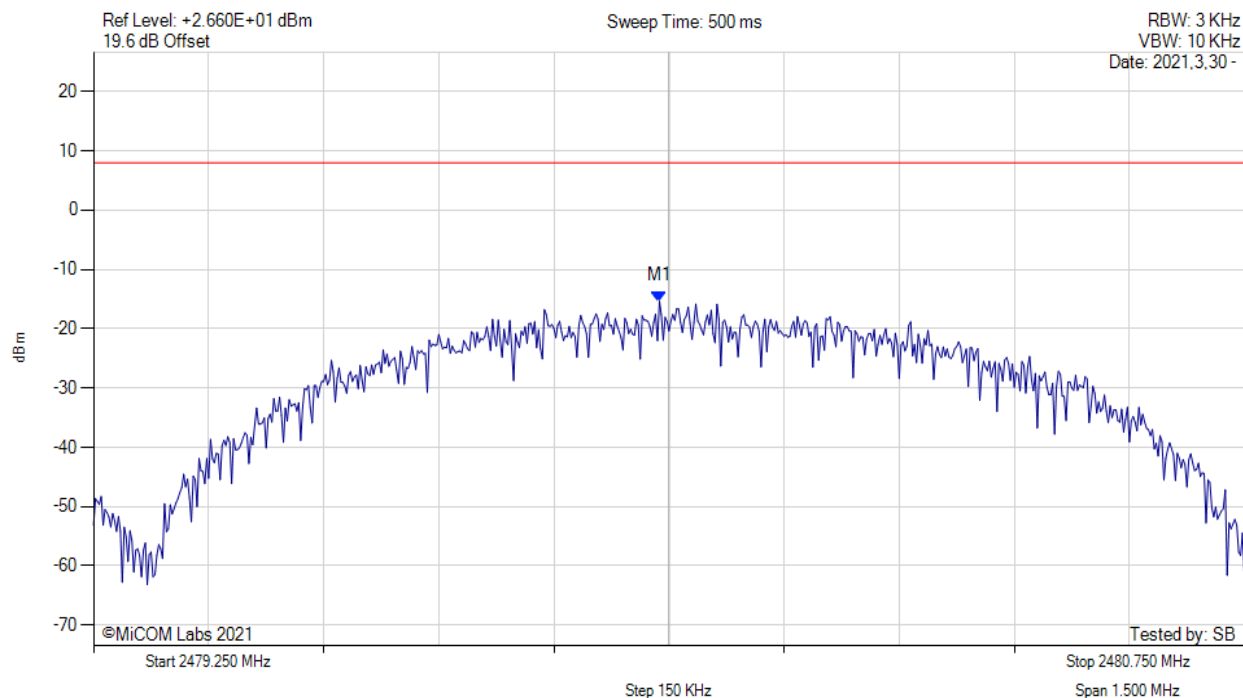
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2479.987 MHz : -15.366 dBm	Limit: ≤ 8.000 dBm

[back to matrix](#)

POWER SPECTRAL DENSITY - AVERAGE



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



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2480.000 MHz : -15.366 dBm M1 + DCCF : 2480.000 MHz : -15.322 dBm Duty Cycle Correction Factor : +0.04 dB	Limit: ≤ 8.0 dBm Margin: -23.3 dB

[back to matrix](#)

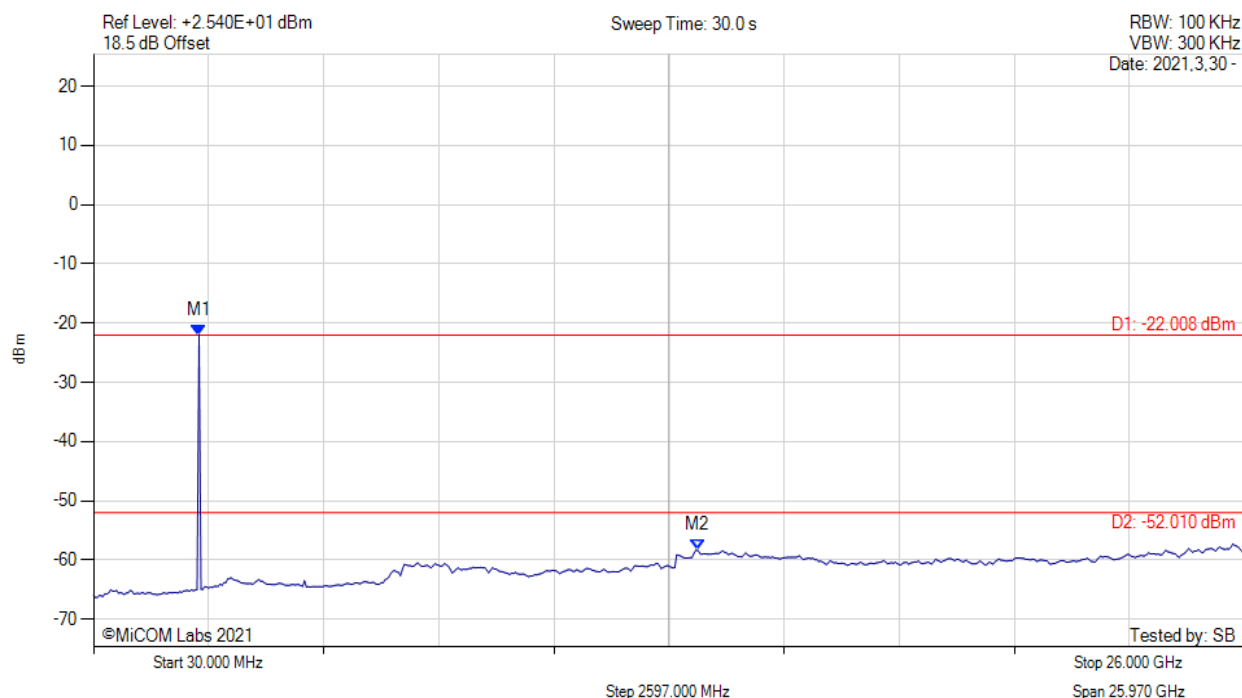
A.3. Emissions

A.3.1.1. Conducted Spurious Emissions



CONDUCTED SPURIOUS EMISSIONS - AVERAGE

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



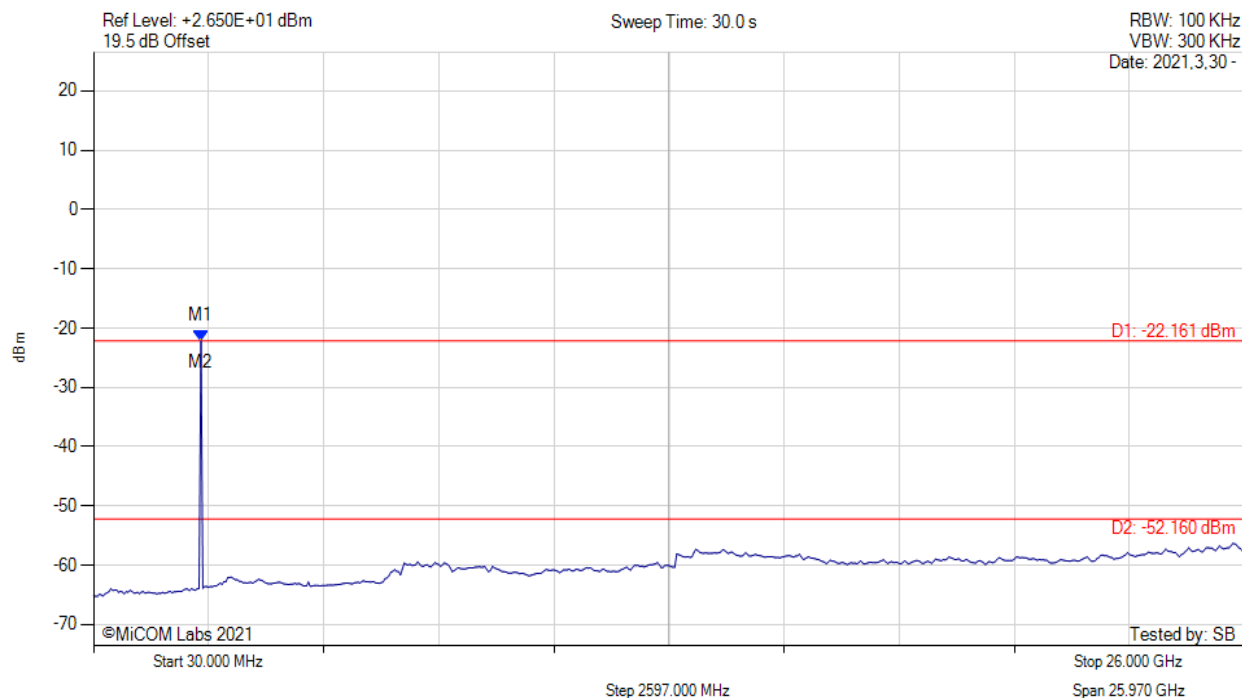
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2410.000 MHz : -22.008 dBm M2 : 13.660 GHz : -58.335 dBm	Limit: -52.01 dBm Margin: -6.33 dB

[back to matrix](#)

CONDUCTED SPURIOUS EMISSIONS - AVERAGE



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



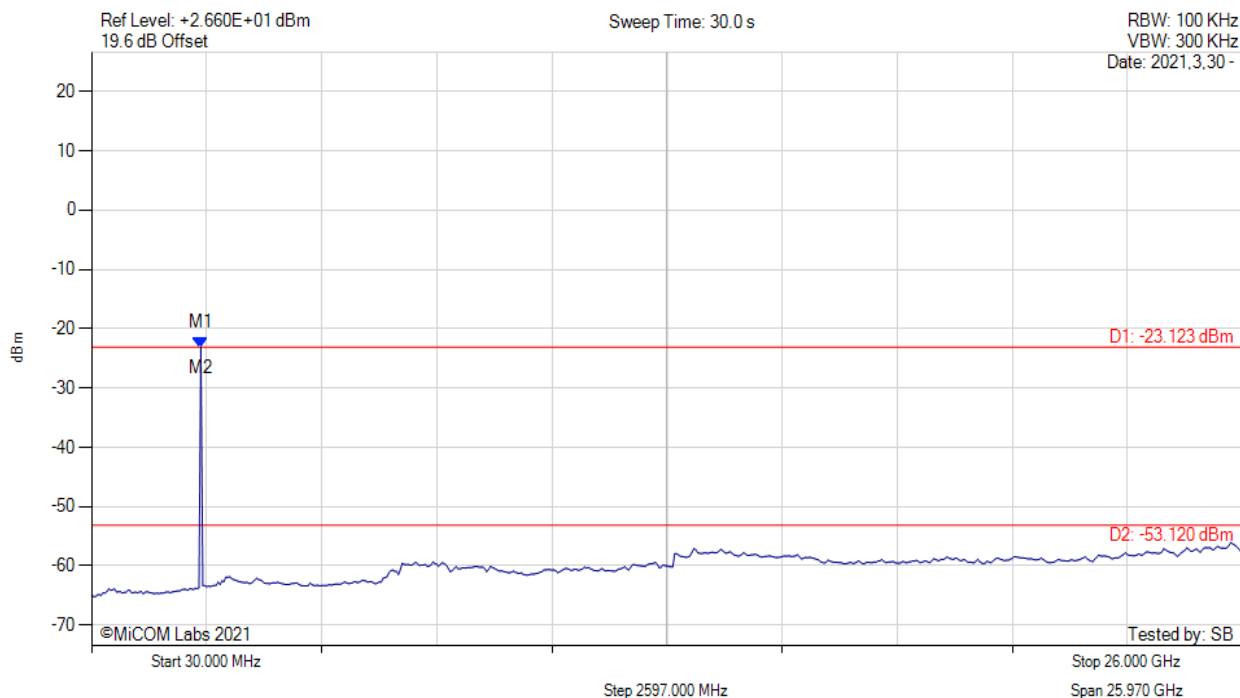
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2450.000 MHz : -22.161 dBm M2 : 2450.000 MHz : -22.161 dBm	Limit: -52.16 dBm Margin: 30.00 dB

[back to matrix](#)

CONDUCTED SPURIOUS EMISSIONS - AVERAGE



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



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2500.000 MHz : -23.123 dBm M2 : 2500.000 MHz : -23.123 dBm	Limit: -53.12 dBm Margin: 30.00 dB

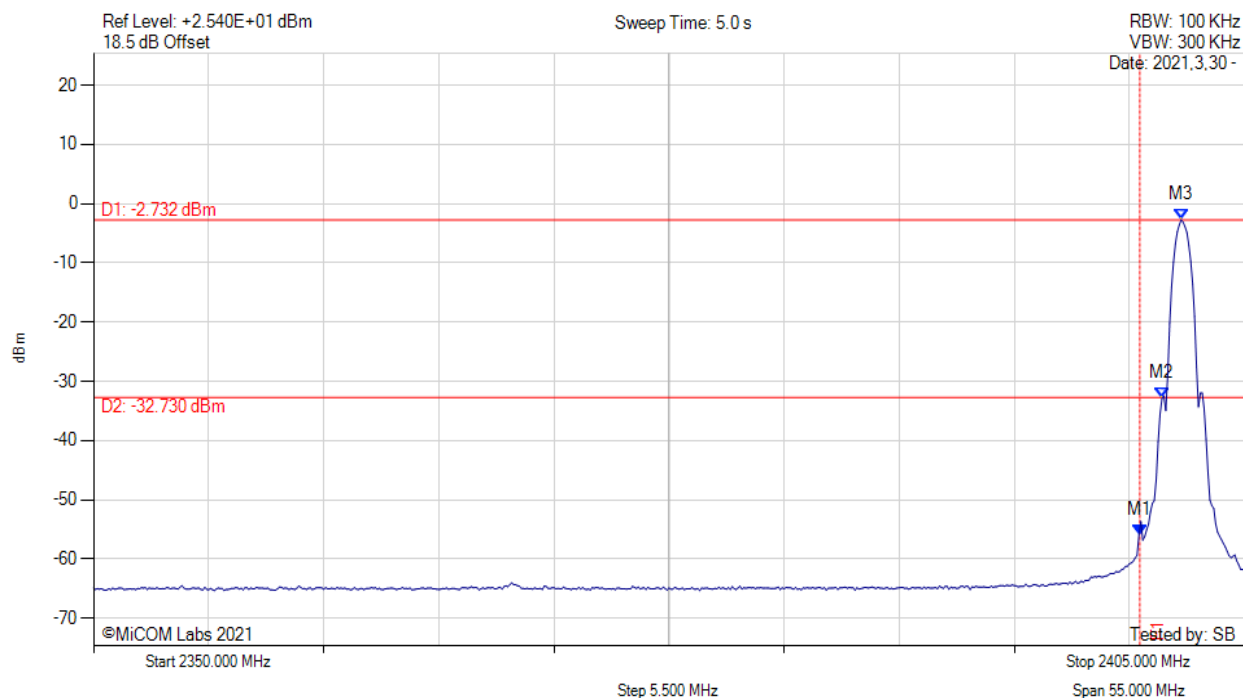
[back to matrix](#)

A.3.1.2. Conducted Band-Edge Emissions



CONDUCTED LOW BAND-EDGE EMISSIONS - AVERAGE

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



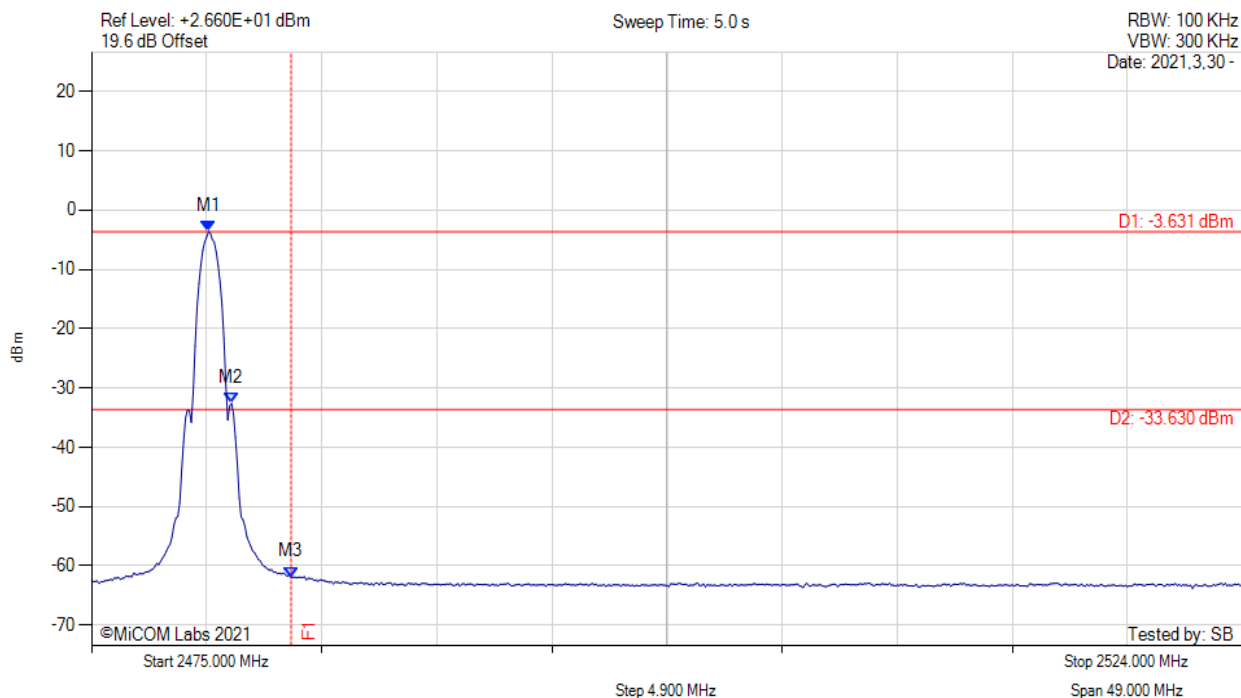
Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2400.000 MHz : -55.962 dBm M2 : 2401.060 MHz : -32.895 dBm M3 : 2401.980 MHz : -2.732 dBm	Channel Frequency: 2402.00 MHz

[back to matrix](#)

CONDUCTED HIGH BAND-EDGE EMISSIONS - AVERAGE



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



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = AVER Sweep Count = 0 RF Atten (dB) = 20 Trace Mode = VIEW	M1 : 2479.980 MHz : -3.631 dBm M2 : 2480.960 MHz : -32.588 dBm M3 : 2483.500 MHz : -61.897 dBm	Channel Frequency: 2480.00 MHz

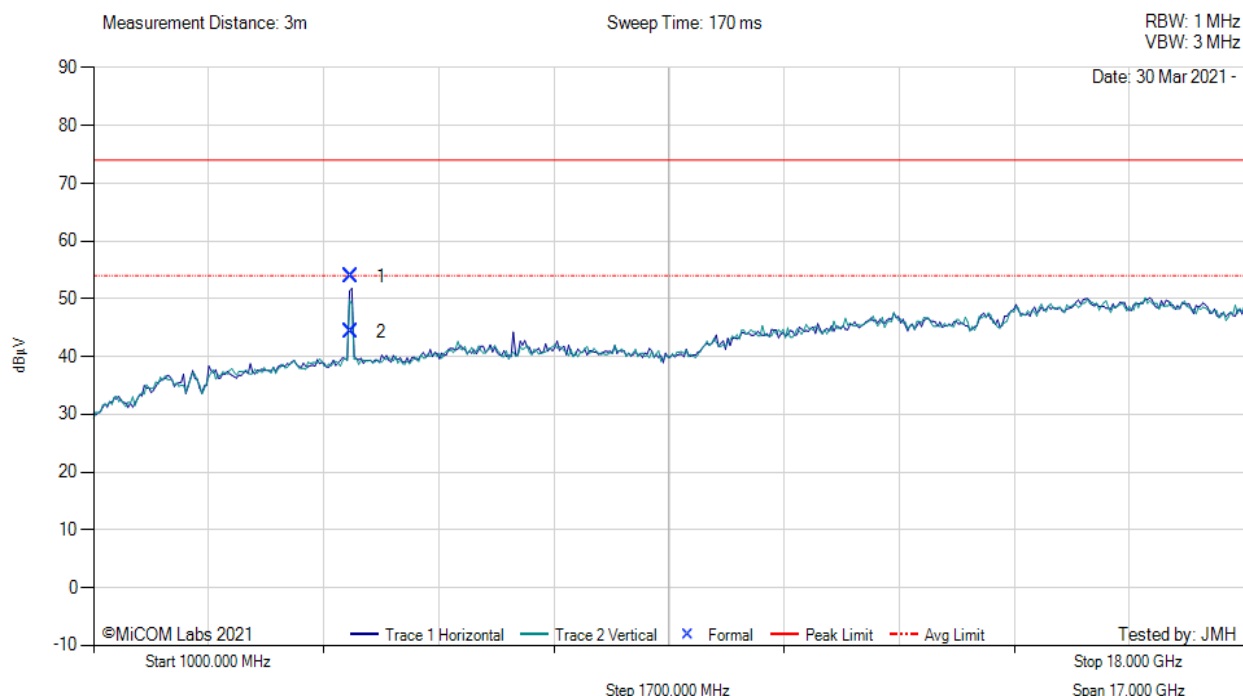
[back to matrix](#)

A.3.1.3. TX Spurious & Restricted Band Emissions



TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2402.00 MHz, Antenna: Taoglas WLA.01, Power Setting: Max, Duty Cycle (%): 50



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	4804.51	63.38	2.85	-12.42	53.81	Max Peak	Horizontal	106	27	74.0	-20.2	Pass
2	4804.51	53.91	2.85	-12.42	44.34	Max Avg	Horizontal	106	27	54.0	-9.7	Pass

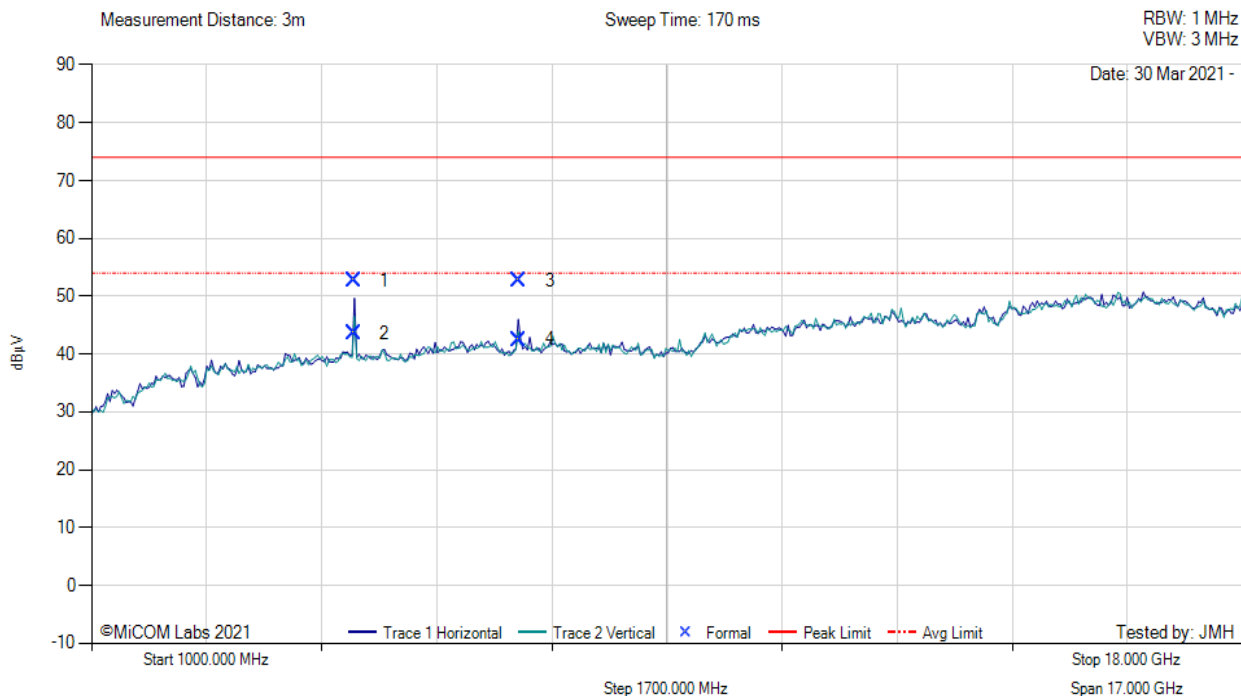
Test Notes: BIT040B powered by 48 V DC. 2.4G Notch in front of amp to prevent overload. 3 dB DCCF added to average measurement.

[back to matrix](#)



TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2440.00 MHz, Antenna: Taoglas WLA.01, Power Setting: Max, Duty Cycle (%): 50



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	4879.67	62.40	2.88	-12.54	52.74	Max Peak	Horizontal	98	29	74.0	-21.3	Pass
2	4879.67	53.30	2.88	-12.54	43.64	Max Avg	Horizontal	98	29	54.0	-10.4	Pass
3	7319.38	56.89	3.60	-7.80	52.69	Max Peak	Horizontal	182	117	74.0	-21.3	Pass
4	7319.38	46.71	3.60	-7.80	42.51	Max Avg	Horizontal	182	117	54.0	-11.5	Pass

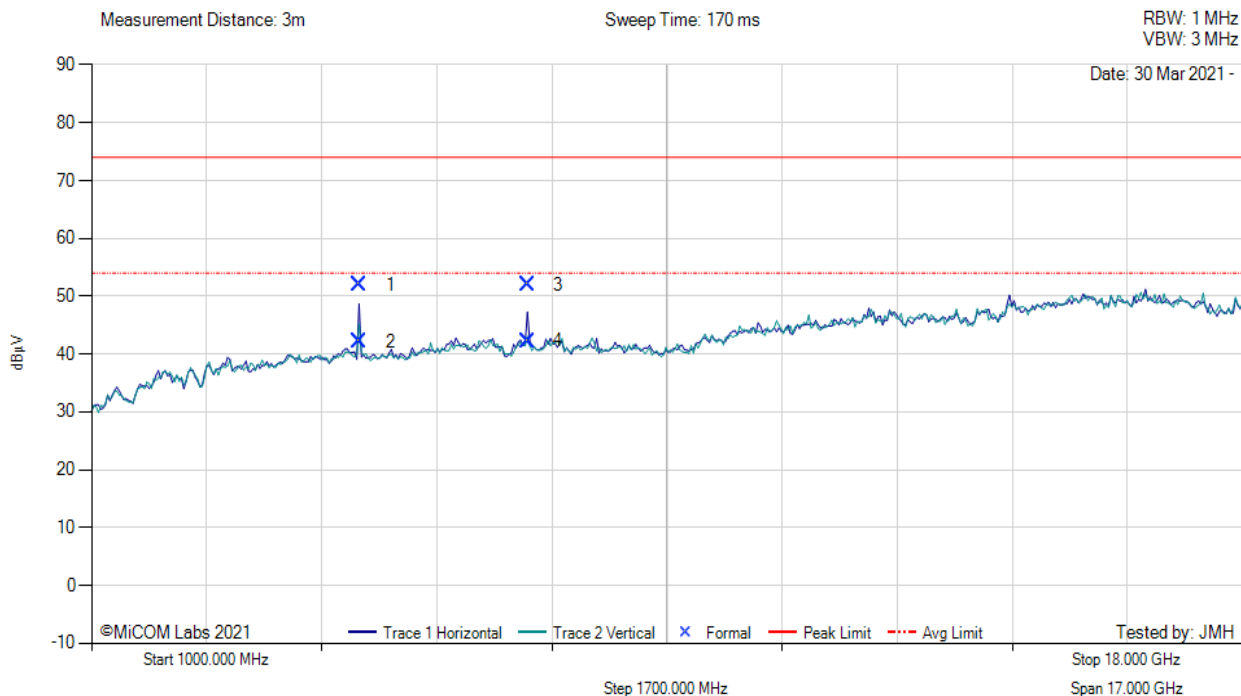
Test Notes: BIT040B powered by 48 V DC. 2.4G Notch in front of amp to prevent overload. 3 dB DCCF added to average measurement.

[back to matrix](#)



TX SPURIOUS & RESTRICTED BAND EMISSIONS

Variant: GFSK, Test Freq: 2480.00 MHz, Antenna: Taoglas WLA.01, Power Setting: Max, Duty Cycle (%): 50



1000.00 - 18000.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	4960.51	61.63	2.91	-12.51	52.03	Max Peak	Horizontal	194	114	74.0	-22.0	Pass
2	4960.51	51.80	2.91	-12.51	42.20	Max Avg	Horizontal	194	114	54.0	-11.8	Pass
3	7439.53	56.03	3.62	-7.73	51.92	Max Peak	Horizontal	191	145	74.0	-22.1	Pass
4	7439.53	46.36	3.62	-7.73	42.25	Max Avg	Horizontal	191	145	54.0	-11.8	Pass

Test Notes: BIT040B powered by 48 V DC. 2.4G NOTch in front of amp to prevent overload. 3dB DCCF added to average measurements.

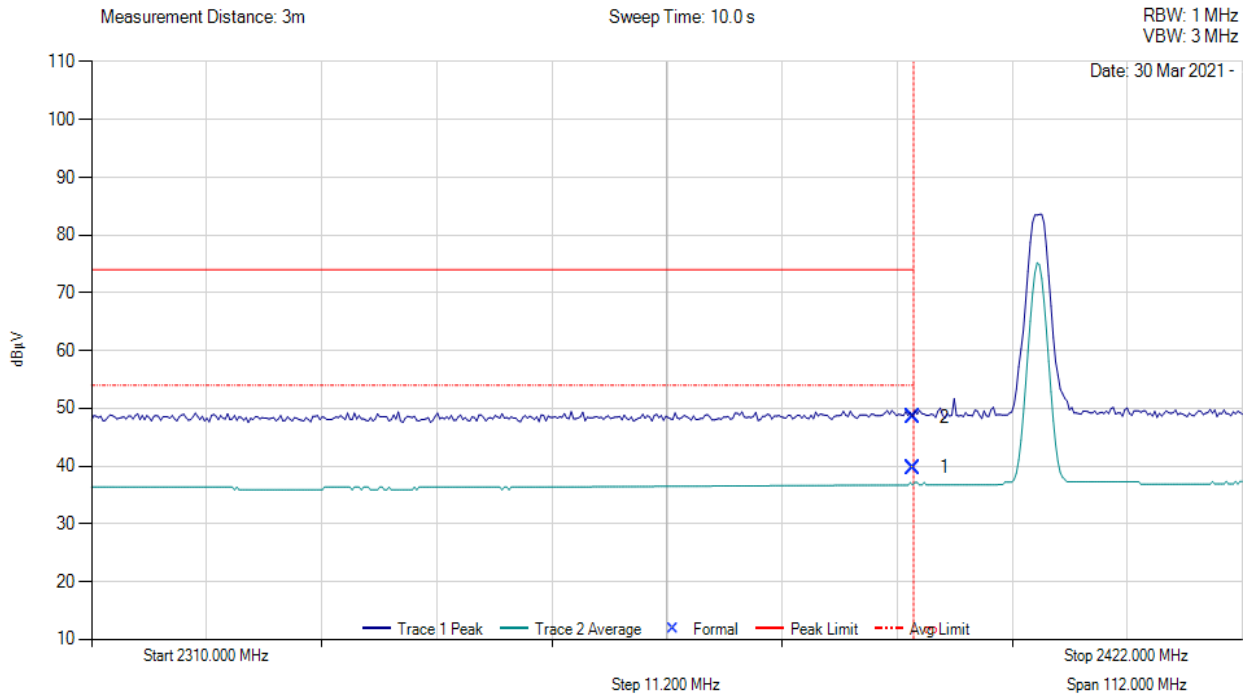
[back to matrix](#)

A.3.1.4. Restricted Edge & Band-Edge Emissions



RADIATED - LOWER RESTRICTED BAND-EDGE EMISSIONS

Variant: GFSK, Test Freq: 2402.00 MHz, Antenna: Taoglas WLA.01, Duty Cycle (%): 50



2310.00 - 2422.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB/m	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	2390.00	5.75	2.02	31.96	39.73	Max Avg	Horizontal	143	37	54.0	-14.3	Pass
2	2390.00	14.56	2.02	31.96	48.54	Max Peak	Horizontal	143	37	74.0	-25.5	Pass
3	2390.00	--	--	--	--	Restricted-Band	--	--	--	--	--	--

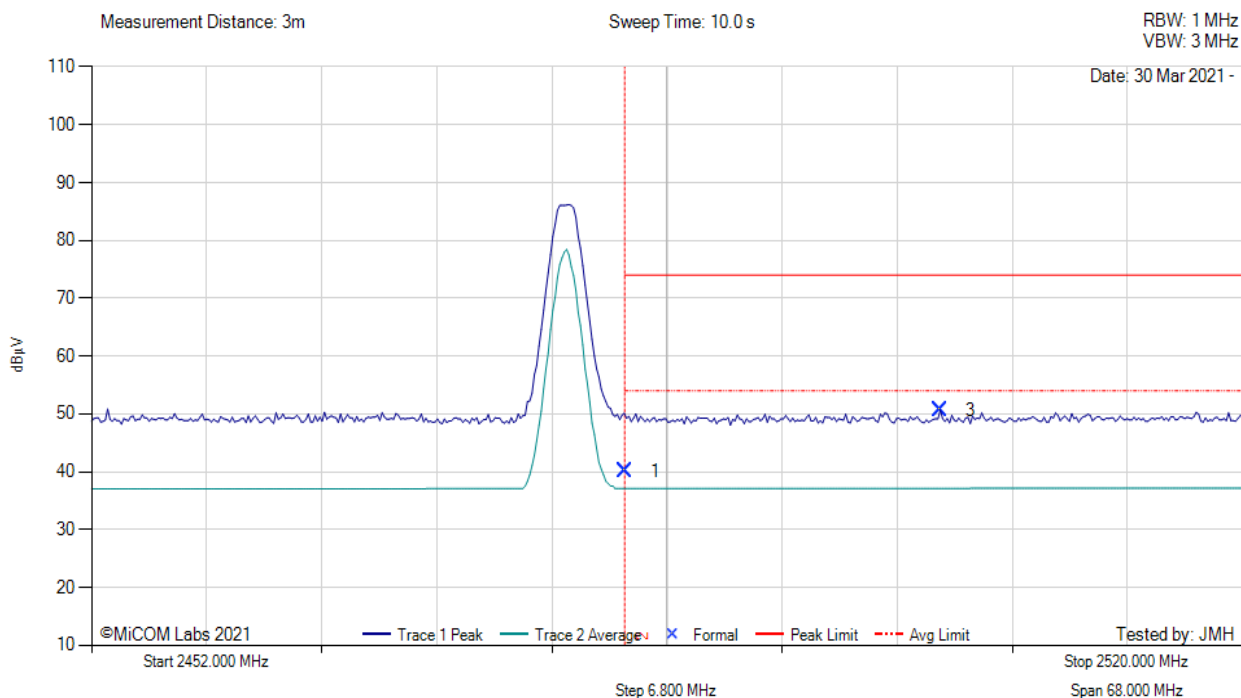
Test Notes: BIT040B powered by 48 V DC DCCF of 3 dB added to average measurement

[back to matrix](#)



RADIATED - UPPER RESTRICTED BAND-EDGE EMISSIONS

Variant: GFSK, Test Freq: 2480.00 MHz, Antenna: Taoglas WLA.01, Duty Cycle (%): 50



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	5.75	2.03	32.33	40.11	Max Avg	Horizontal	143	37	54.0	-13.9	Pass
3	2502.15	16.30	2.05	32.31	50.66	Max Peak	Horizontal	143	37	74.0	-23.3	Pass
2	2483.50	--	--	--	--	Restricted-Band	--	--	--	--	--	--

Test Notes: BIT040B powered by 48 V DC. 3dB DCCF added to average measurement.

[back to matrix](#)



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