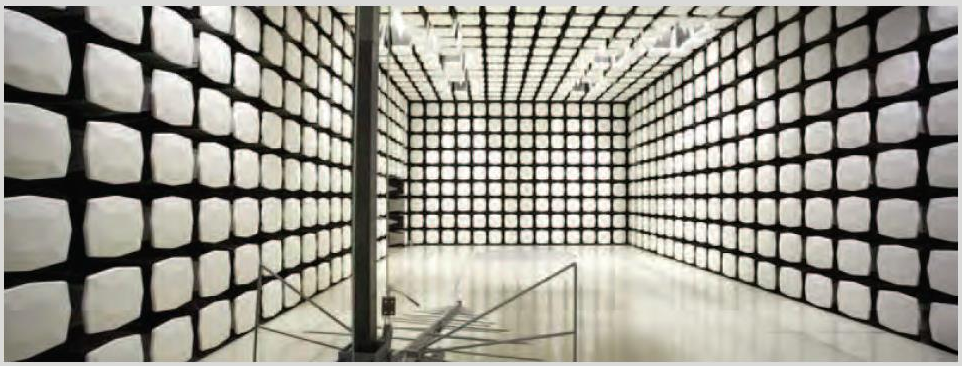
EchoNous, Inc.

Thor Radio Module AC WLAN and Bluetooth and BLE

FCC 15.247:2019

Bluetooth (DTS) Radio

Report # ECHN0015.7



NVLAP LAB CODE: 200630-0
NVLAP LAB CODE: 200629-0

CERTIFICATE OF TEST

Last Date of Test: December 27, 2019
EchoNous, Inc.
EUT: Thor Radio Module AC WLAN and Bluetooth and BLE

Radio Equipment Testing

Standards

Specification	Method
FCC 15.207:2019	ANSI C63.10:2013, KDB 558074
FCC 15.247:2019	

Results

Method Clause	Test Description	Applied	Results	Comments
6.2	Powerline Conducted Emissions	Yes	Pass	
11.12.1, 11.13.2, 6.5, 6.6	Spurious Radiated Emissions	Yes	Pass	
11.6	Duty Cycle	Yes	N/A	
11.8.2	Occupied Bandwidth	Yes	Pass	
11.9.1.1	Output Power	Yes	Pass	
11.9.1.1	Equivalent Isotropic Radiated Power	Yes	Pass	
11.10.2	Power Spectral Density	Yes	Pass	
11.11	Band Edge Compliance	Yes	Pass	
11.11	Spurious Conducted Emissions	Yes	Pass	

Deviations From Test Standards

None

Approved By:

Rod Munro, Operations Manager

Product compliance is the responsibility of the client; therefore, the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test. This report reflects only those tests from the referenced standards shown in the certificate of test. It does not include inspection or verification of labels, identification, marking or user information. As indicated in the Statement of Work sent with the quotation, Element's standard process is to always use the latest published version of the test methods even when earlier versions are cited in the test specification. Issuance of a purchase order was de facto acceptance of this approach. Otherwise, the client would have advised Element in writing of the specific version of the test methods they wanted applied to the subject testing.

REVISION HISTORY

Revision Number	Description	Date (yyyy-mm-dd)	Page Number
00	None		

ACCREDITATIONS AND AUTHORIZATIONS

United States

FCC - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

A2LA - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Element to certify transmitters to FCC and IC specifications.

NVLAP - Each laboratory is accredited by NVLAP to ISO 17025

Canada

ISED - Recognized by Innovation, Science and Economic Development Canada as a Certification Body (CB) and as a CAB for the acceptance of test data.

European Union

European Commission – Within Element, we have a EU Notified Body validated for the EMCD and RED Directives.

Australia/New Zealand

ACMA - Recognized by ACMA as a CAB for the acceptance of test data.

Korea

MSIT / RRA - Recognized by KCC's RRA as a CAB for the acceptance of test data.

Japan

VCCI - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

Taiwan

BSMI – Recognized by BSMI as a CAB for the acceptance of test data.

NCC - Recognized by NCC as a CAB for the acceptance of test data.

Singapore

IDA – Recognized by IDA as a CAB for the acceptance of test data.

Israel

MOC – Recognized by MOC as a CAB for the acceptance of test data.

Hong Kong

OFCA – Recognized by OFCA as a CAB for the acceptance of test data.

Vietnam

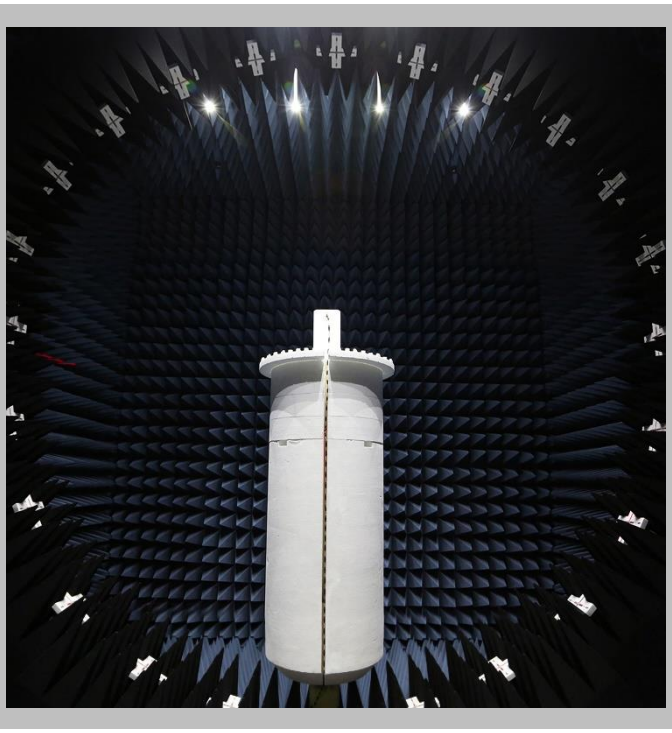
MIC – Recognized by MIC as a CAB for the acceptance of test data.

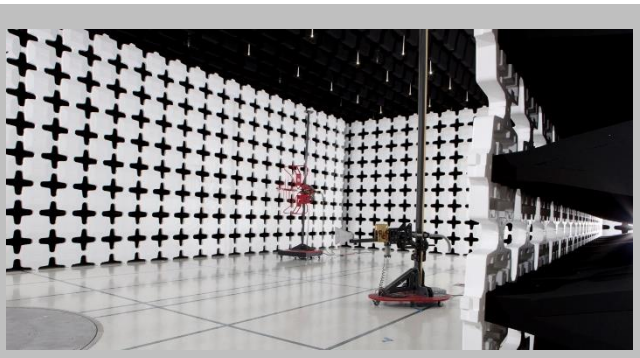
SCOPE

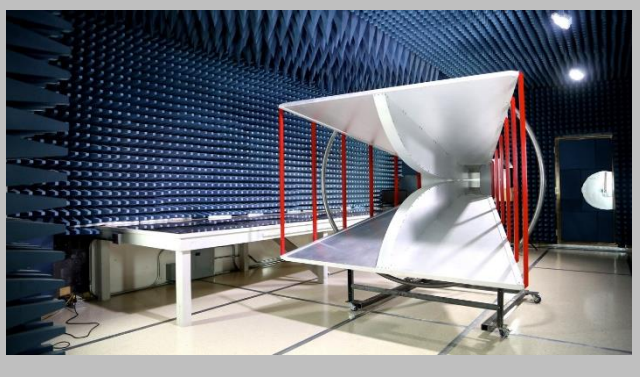
For details on the Scopes of our Accreditations, please visit:
https://www.nwemc.com/emc-testing-accreditations

FACILITIES

California	Minnesota	Oregon	Texas	Washington
Labs OC01-17 41 Tesla Irvine, CA 92618 (949) 861-8918	Labs MN01-10 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Labs EV01-12 6775 NE Evergreen Pkwy #400 Hillsboro, OR 97124 (503) 844-4066	Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Labs NC01-05 19201 120th Ave NE Bothell, WA 98011 (425)984-6600
NVLAP				
NVLAP Lab Code: 200676-0	NVLAP Lab Code: 200881-0	NVLAP Lab Code: 200630-0	NVLAP Lab Code:201049-0	NVLAP Lab Code: 200629-0
Innovation, Science and Economic Development Canada				
2834B-1, 2834B-3	2834E-1, 2834E-3	2834D-1	2834G-1	2834F-1
BSMI				
SL2-IN-E-1154R	SL2-IN-E-1152R	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI				
A-0029	A-0109	A-0108	A-0201	A-0110
Recognized Phase I CAB for ISED, ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA				
US0158	US0175	US0017	US0191	US0157







MEASUREMENT UNCERTAINTY

element
TMU.2015.07.10

Measurement Uncertainty

When a measurement is made, the result will be different from the true or theoretically correct value. The difference is the result of tolerances in the measurement system that cannot be completely eliminated. To the extent that technology allows us, it has been our aim to minimize this error. Measurement uncertainty is a statistical expression of measurement error qualified by a probability distribution.

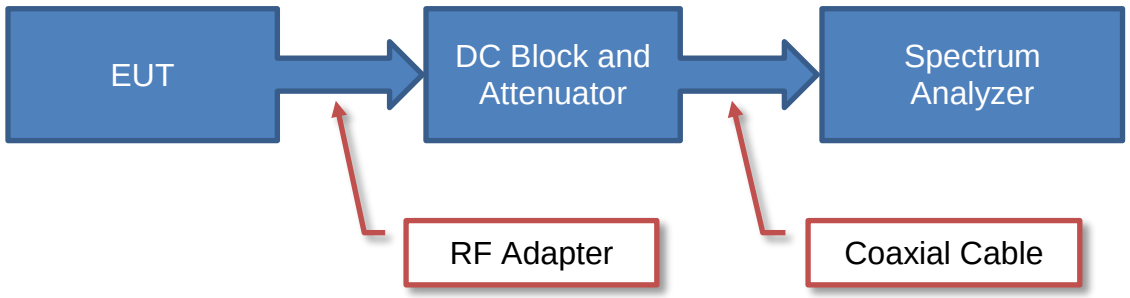
A measurement uncertainty estimation has been performed for each test per our internal quality document QM205.4.6. The estimation is used to compare the measured result with its "true" or theoretically correct value. The expanded measurement uncertainty (K=2) can be found included as part of the applicable test description page. Our measurement data meets or exceeds the measurement uncertainty requirements of the applicable specification; therefore, the test data can be compared directly to the specification limit to determine compliance. The calculations for estimating measurement uncertainty are based upon ETSI TR 100 028 (or CISPR 16-4-2 as applicable), and are available upon request.

The following table represents the Measurement Uncertainty (MU) budgets for each of the tests that may be contained in this report.

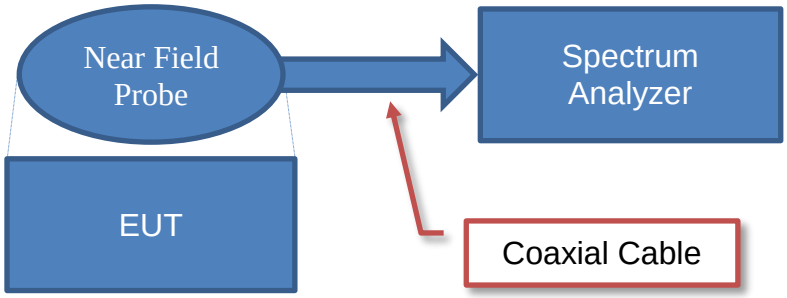
Test	+ MU	- MU
Frequency Accuracy	0.0007%	-0.0007%
Amplitude Accuracy (dB)	1.2 dB	-1.2 dB
Conducted Power (dB)	1.2 dB	-1.2 dB
Radiated Power via Substitution (dB)	0.7 dB	-0.7 dB
Temperature (degrees C)	0.7°C	-0.7°C
Humidity (% RH)	2.5% RH	-2.5% RH
Voltage (AC)	1.0%	-1.0%
Voltage (DC)	0.7%	-0.7%
Field Strength (dB)	5.2 dB	-5.2 dB
AC Powerline Conducted Emissions (dB)	2.4 dB	-2.4 dB

Test Setup Block Diagrams

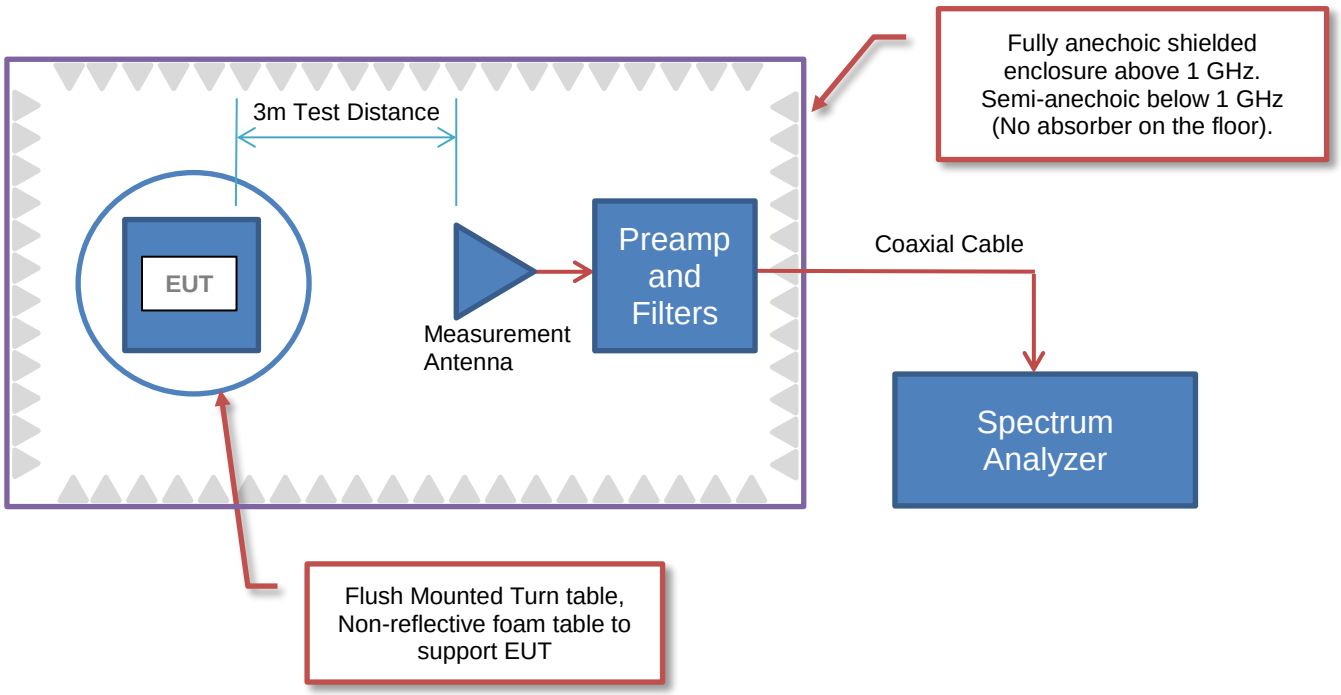
Antenna Port Conducted Measurements



Near Field Test Fixture Measurements



Spurious Radiated Emissions



PRODUCT DESCRIPTION

Client and Equipment Under Test (EUT) Information

Company Name:	EchoNous, Inc.
Address:	8310 154th Ave NE, Bldg. B, Ste. 200
City, State, Zip:	Redmond, WA 98052
Test Requested By:	Sanchit Chirania
EUT:	Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE
First Date of Test:	July 23, 2019
Last Date of Test:	December 27, 2019
Receipt Date of Samples:	July 16, 2019
Equipment Design Stage:	Production
Equipment Condition:	No Damage
Purchase Authorization:	Verified

Information Provided by the Party Requesting the Test

Functional Description of the EUT:
Qualcomm Snapdragon 835 WLAN with Bluetooth 5.0 and BLE for QCA6174 based NFA324 Foxconn Module, 2x2 802.11ac with MU-MIMO

Testing Objective:
To demonstrate compliance of the Bluetooth (DTS) radio to FCC 15.247 requirements.

CONFIGURATIONS

Configuration ECHN0015- 1

Software/Firmware Running during test	
Description	**Version**
Qualcomm Radio Control Tool	4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE	Qualcomm	Thor 1.0	Pre-production #1

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Laptop #1	Lenovo	E590	PF-1KP4WR

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
USB-C Cable	No	1.2m	No	USB-C Connector (Laptop)	USB-C Connector (Thor Radio Module)

CONFIGURATIONS

Configuration ECHN0015- 4

Software/Firmware Running during test	
Description	**Version**
Qualcomm Radio Control Tool	4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE	EchoNous, Inc.	Thor 1.0	H1UR1944002-03

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Laptop #1	Lenovo	E590	PF-1KP4WR

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
USB-C Cable	No	1.2m	No	USB-C Connector (Laptop)	USB-C Connector (Thor Radio Module)
USB-C Cable	No	2.0m	No	Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE	Unterminated

CONFIGURATIONS

Configuration ECHN0015- 10

Software/Firmware Running during test	
Description	**Version**
Qualcomm Radio Control Tool	4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE	EchoNous, Inc.	Thor 1.0	30

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Laptop #1	Lenovo	E590	PF-1KP4WR
USB-C Hub	Monprice	15249	None

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
USB-C Cable	No	2.0m	No	Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE	Unterminated
USB-C	Yes	0.1m	No	Laptop	USB-C Hub
USB-C	Yes	1.4m	No	AC/DC Adapter	USB-C Hub
USB-C	Yes	2.0m	No	USB-C Hub	Thor Radio Module AC WLAN and Bluetooth 5.0 and BLE

MODIFICATIONS

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2019-07-23	Duty Cycle	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
2	2019-07-23	Occupied Bandwidth	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
3	2019-07-23	Output Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
4	2019-07-23	Equivalent Isotropic Radiated Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
5	2019-07-23	Power Spectral Density	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
6	2019-07-23	Band Edge Compliance	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
7	2019-07-23	Spurious Conducted Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
8	2019-11-26	Spurious Radiated Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
9	2019-12-27	Powerline Conducted Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

POWER SETTINGS

No adjustable power settings were provided. The EUT was tested using power settings pre-defined by the manufacturer.

POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

TEST DESCRIPTION

Using the mode of operation and configuration noted within this report, conducted emissions tests were performed. The frequency range investigated (scanned), is also noted in this report. Conducted power line measurements are made, unless otherwise specified, over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from the EUT power-input terminals that are directly (or indirectly via separate transformer or power supplies) connected to a public power network. Per the standard, an insulating material was also added to ground plane between the EUT's power and remote I/O cables. Equipment is tested with power cords that are normally used or that have electrical or shielding characteristics that are the same as those cords normally used. Typically those measurements are made using a LISN (Line Impedance Stabilization Network), the 50ohm measuring port is terminated by a 50ohm EMI meter or a 50ohm resistive load. All 50ohm measuring ports of the LISN are terminated by 50ohm. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Receiver	Rohde & Schwarz	ESCI	ARH	2019-05-02	2020-05-02
LISN	Solar Electronics	9252-50-R-24-BNC	LIP	2019-08-28	2020-08-28
Cable - Conducted Cable Assembly	Northwest EMC	EVG, HHD, RKT	EVGA	2019-01-07	2020-01-07

MEASUREMENT UNCERTAINTY

Description		
Expanded k=2	2.4 dB	-2.4 dB

CONFIGURATIONS INVESTIGATED

ECHN0015-10

MODES INVESTIGATED

On, Continuous Tx BLE Mid Ch. 2442 MHz

POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE	Work Order:	ECHN0015
Serial Number:	30	Date:	2019-12-27
Customer:	EchoNous, Inc.	Temperature:	20.3°C
Attendees:	None	Relative Humidity:	36.9%
Customer Project:	None	Bar. Pressure:	1026 mb
Tested By:	Cole Ghizzone	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	ECHN0015-10

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	22	Line:	High Line	Add. Ext. Attenuation (dB):	0

COMMENTS

None

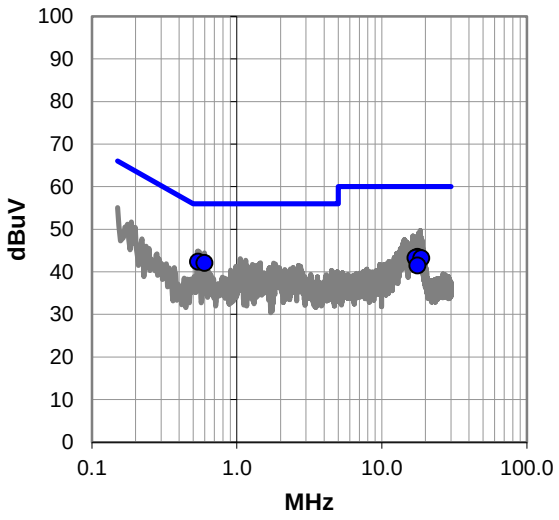
EUT OPERATING MODES

On, Continuous Tx BLE Mid Ch. 2442 MHz

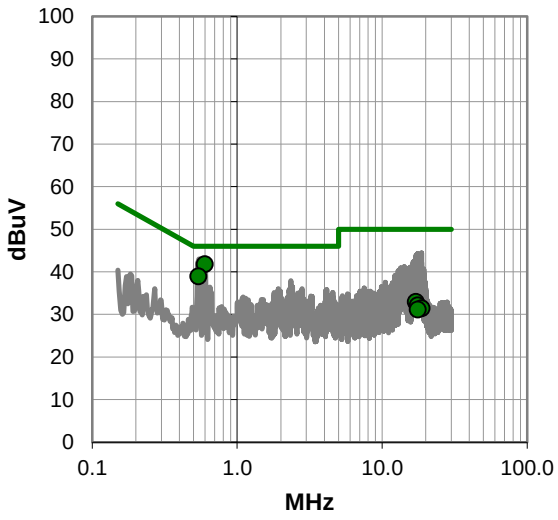
DEVIATIONS FROM TEST STANDARD

None

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

RESULTS - Run #22

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.5	22.500	19.9	42.4	56.0	-13.6
0.6	22.200	19.9	42.1	56.0	-13.9
17.6	22.900	20.6	43.5	60.0	-16.5
17.1	22.700	20.6	43.3	60.0	-16.7
18.7	22.400	20.8	43.2	60.0	-16.8
17.7	20.900	20.6	41.5	60.0	-18.5

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.6	21.900	19.9	41.8	46.0	-4.2
0.5	19.000	19.9	38.9	46.0	-7.1
17.1	12.300	20.6	32.9	50.0	-17.1
17.6	11.500	20.6	32.1	50.0	-17.9
18.7	10.600	20.8	31.4	50.0	-18.6
17.7	10.500	20.6	31.1	50.0	-18.9

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE	Work Order:	ECHN0015
Serial Number:	30	Date:	2019-12-27
Customer:	EchoNous, Inc.	Temperature:	20.3°C
Attendees:	None	Relative Humidity:	36.9%
Customer Project:	None	Bar. Pressure:	1026 mb
Tested By:	Cole Ghizzone	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	ECHN0015-10

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	23	Line:	Neutral	Add. Ext. Attenuation (dB):	0

COMMENTS

None

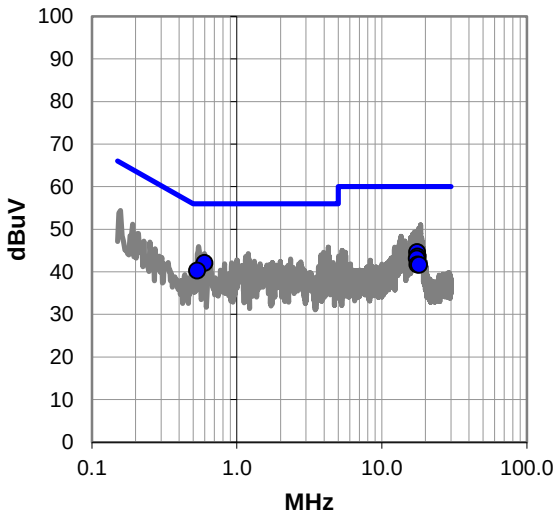
EUT OPERATING MODES

On, Continuous Tx BLE Mid Ch. 2442 MHz

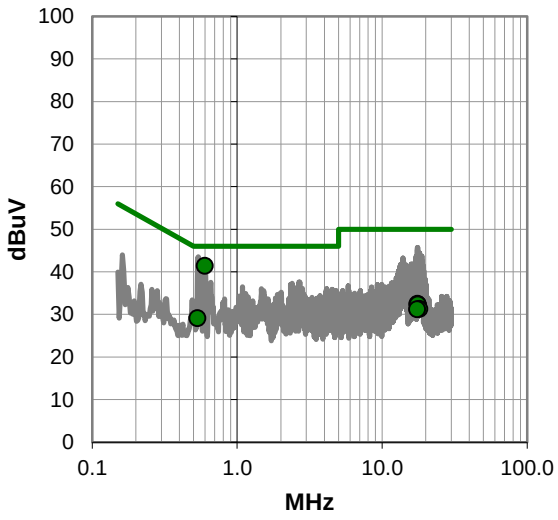
DEVIATIONS FROM TEST STANDARD

None

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

RESULTS - Run #23

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.6	22.200	19.9	42.1	56.0	-13.9
17.5	24.000	20.6	44.6	60.0	-15.4
0.5	20.400	19.9	40.3	56.0	-15.7
17.6	23.000	20.6	43.6	60.0	-16.4
17.5	22.500	20.6	43.1	60.0	-16.9
17.7	21.100	20.6	41.7	60.0	-18.3
18.1	21.000	20.6	41.6	60.0	-18.4

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.6	21.500	19.9	41.4	46.0	-4.6
0.5	9.200	19.9	29.1	46.0	-16.9
17.5	11.900	20.6	32.5	50.0	-17.5
17.6	11.700	20.6	32.3	50.0	-17.7
17.7	11.700	20.6	32.3	50.0	-17.7
18.1	10.700	20.6	31.3	50.0	-18.7
17.5	10.600	20.6	31.2	50.0	-18.8

CONCLUSION

Pass

Tested By

DUTY CYCLE

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The Duty Cycle (x) of the single channel operation of the radio as controlled by the provided test software was measured for each of the EUT operating modes.

There is no compliance requirement to be met by this test, so therefore no Pass / Fail criteria.

The measurements were made using a zero span on the spectrum analyzer to see the pulses in the time domain. The transmit power was set to its default maximum.

The duty cycle was calculated by dividing the transmission pulse duration (T) by the total period of a single on and total off time.

If the transmit duty cycle < 98 percent, burst gating may have been used during some of the other tests in this report to only take the measurement during the burst duration.

DUTY CYCLE

element

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.4 °C
Attendees:	None			**Humidity:**	51.5% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

DEVIATIONS FROM TEST STANDARD

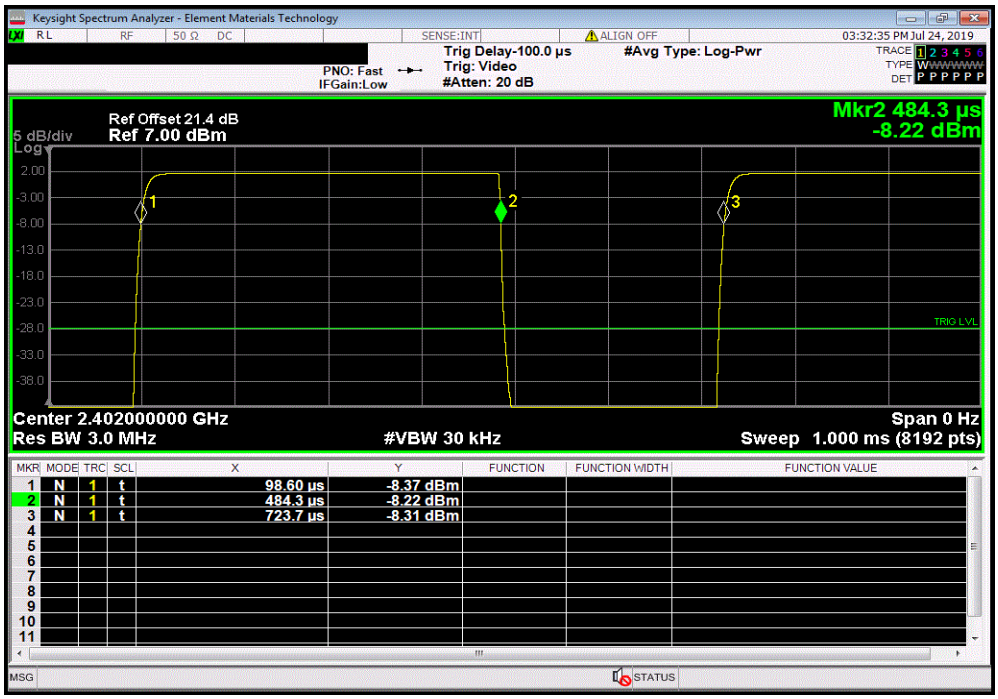
None

Configuration #	1	*Signature*

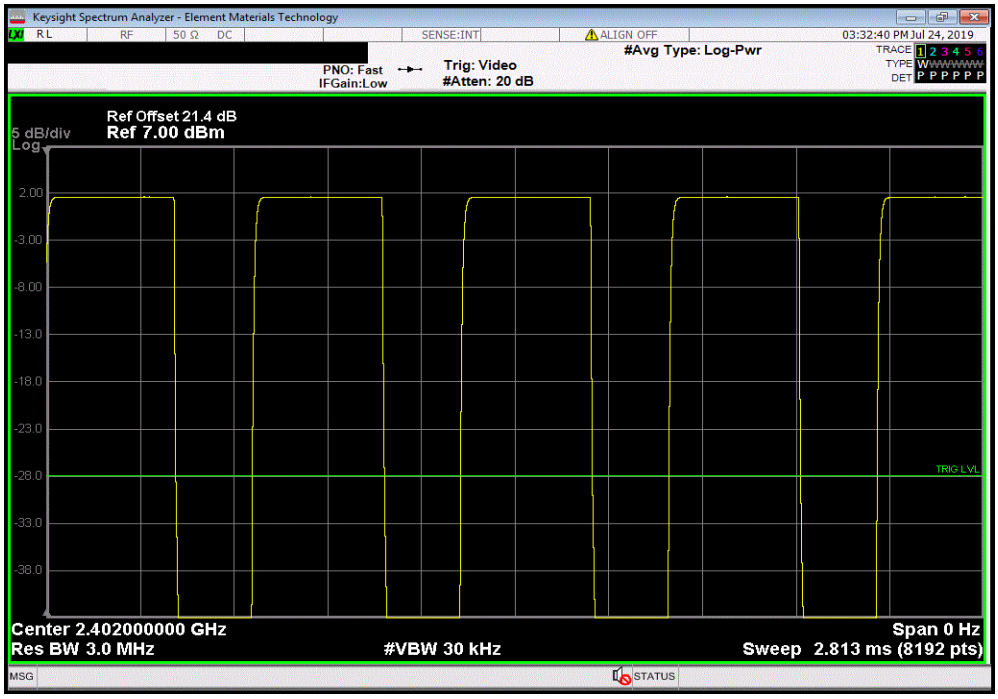
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
Mode: - LE1M						
BLE/GFSK Low Channel, 2402 MHz	385.71 us	625.1 us	1	61.7	N/A	N/A
BLE/GFSK Low Channel, 2402 MHz	N/A	N/A	5	N/A	N/A	N/A
BLE/GFSK Mid Channel, 2442 MHz	385.488 us	625.2 us	1	61.7	N/A	N/A
BLE/GFSK Mid Channel, 2442 MHz	N/A	N/A	5	N/A	N/A	N/A
BLE/GFSK High Channel, 2480 MHz	385.411 us	625.3 us	1	61.6	N/A	N/A
BLE/GFSK High Channel, 2480 MHz	N/A	N/A	5	N/A	N/A	N/A
Mode: - LE2M						
BLE/GFSK Low Channel, 2402 MHz	200.779 us	625.2 us	1	32.1	N/A	N/A
BLE/GFSK Low Channel, 2402 MHz	N/A	N/A	5	N/A	N/A	N/A
BLE/GFSK Mid Channel, 2442 MHz	200.801 us	625.4 us	1	32.1	N/A	N/A
BLE/GFSK Mid Channel, 2442 MHz	N/A	N/A	5	N/A	N/A	N/A
BLE/GFSK High Channel, 2480 MHz	200.423 us	625.1 us	1	32.1	N/A	N/A
BLE/GFSK High Channel, 2480 MHz	N/A	N/A	5	N/A	N/A	N/A

DUTY CYCLE

Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	385.71 us	625.1 us	1	61.7	N/A	N/A

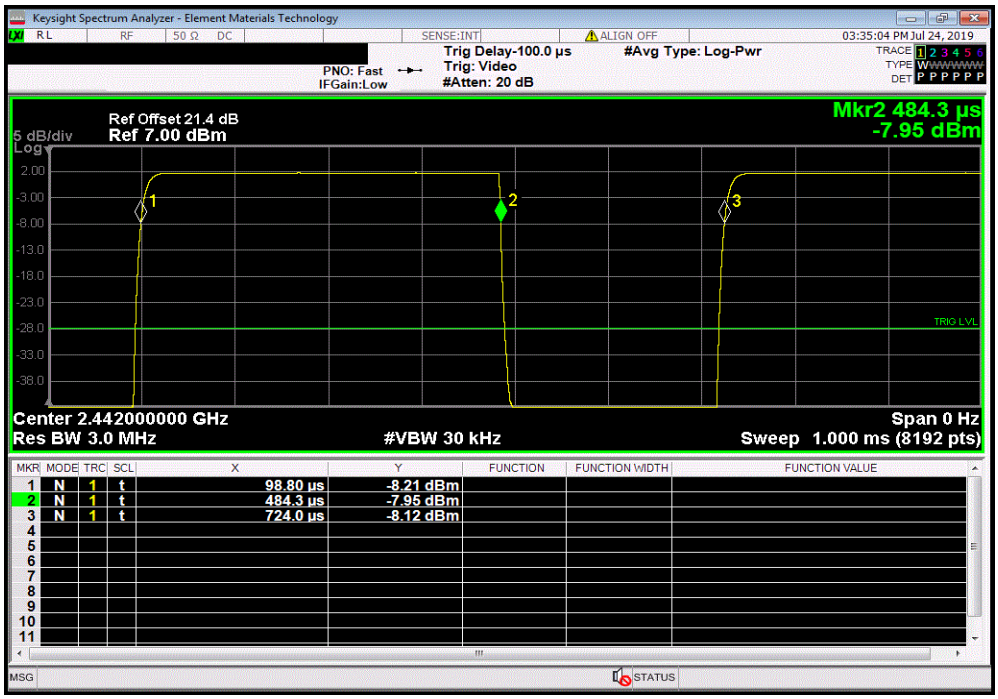


Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

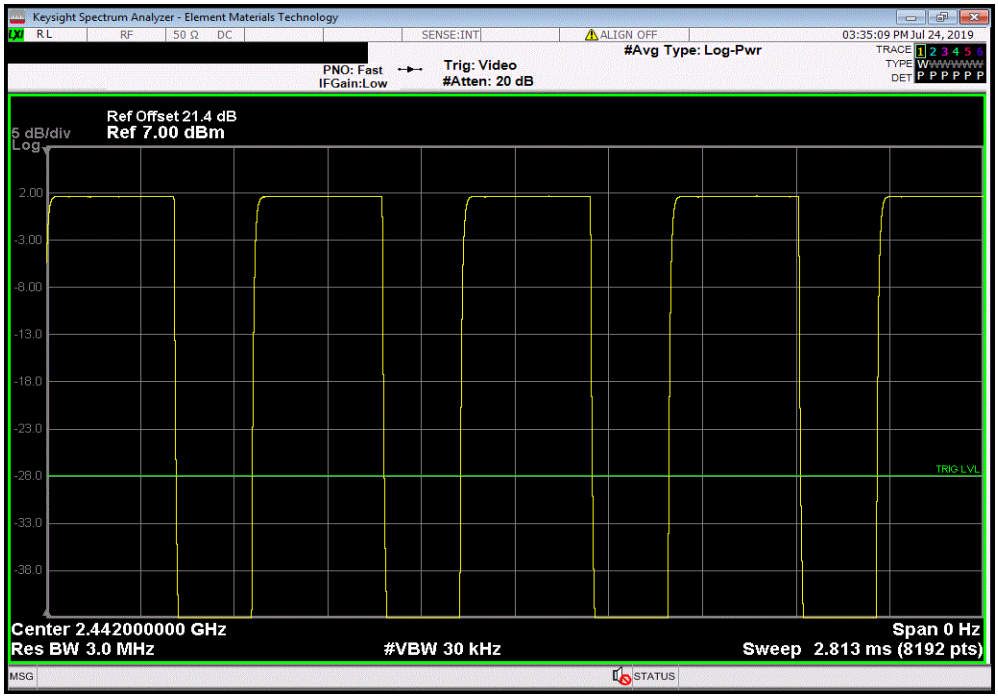


DUTY CYCLE

Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	385.488 us	625.2 us	1	61.7	N/A	N/A

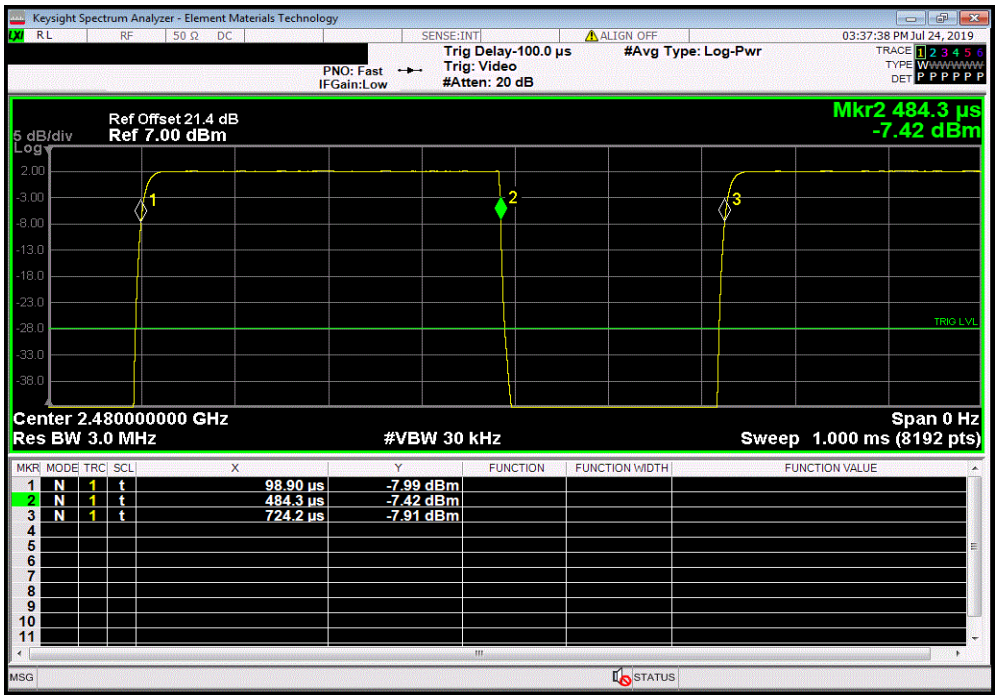


Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

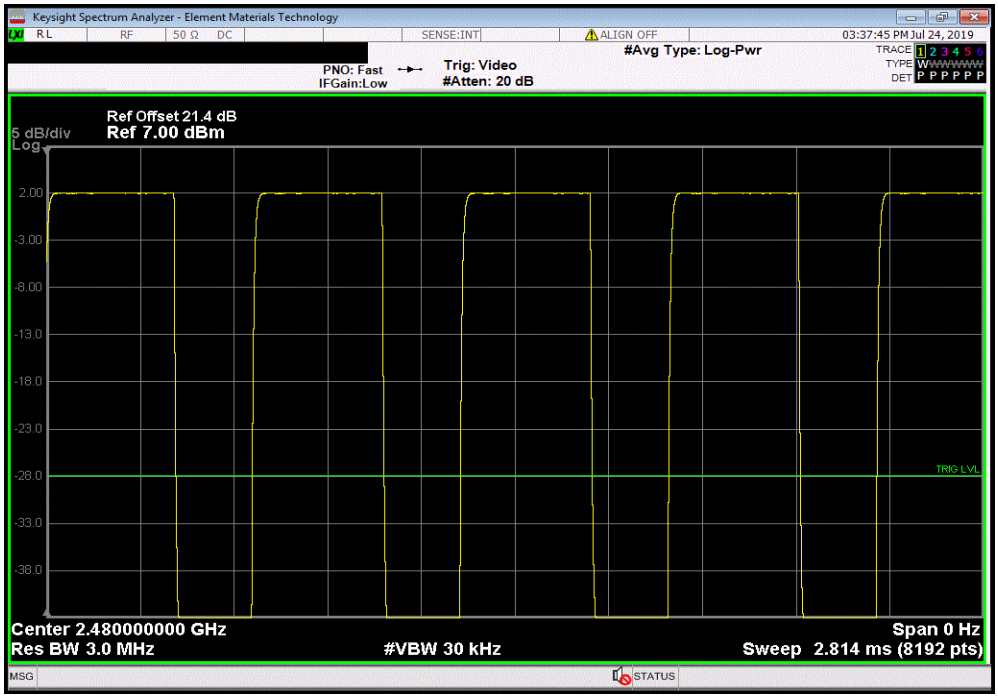


DUTY CYCLE

Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	385.411 us	625.3 us	1	61.6	N/A	N/A

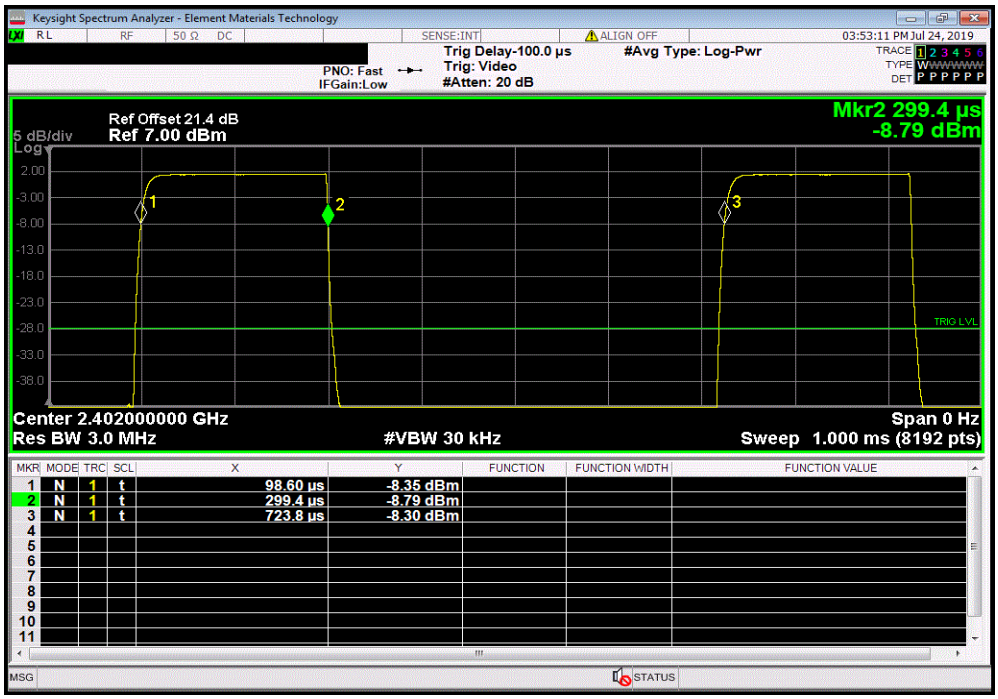


Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

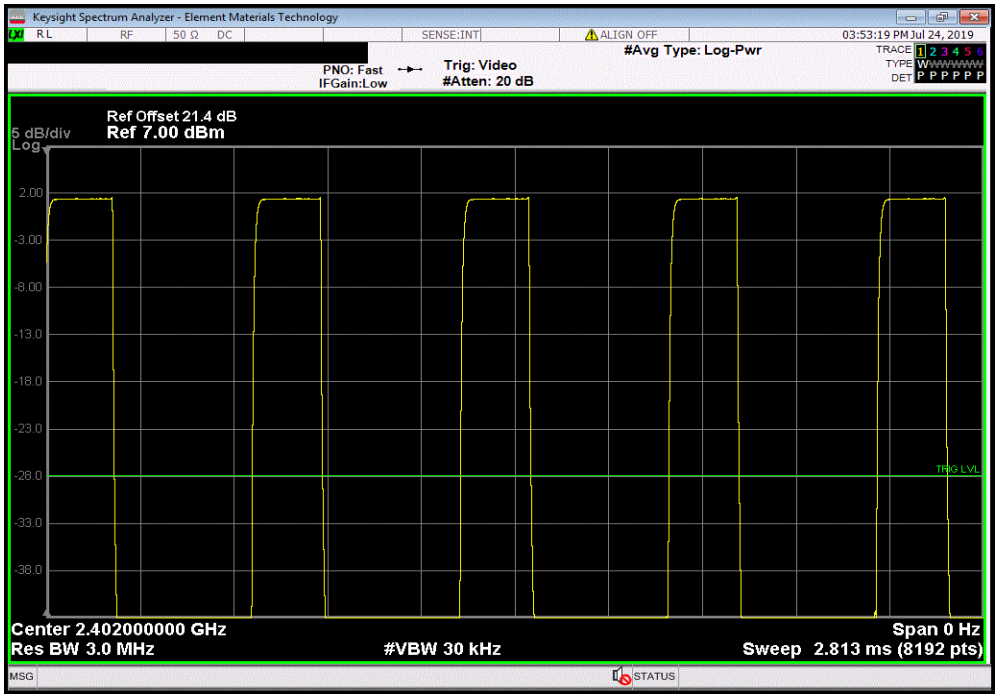


DUTY CYCLE

Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	200.779 us	625.2 us	1	32.1	N/A	N/A

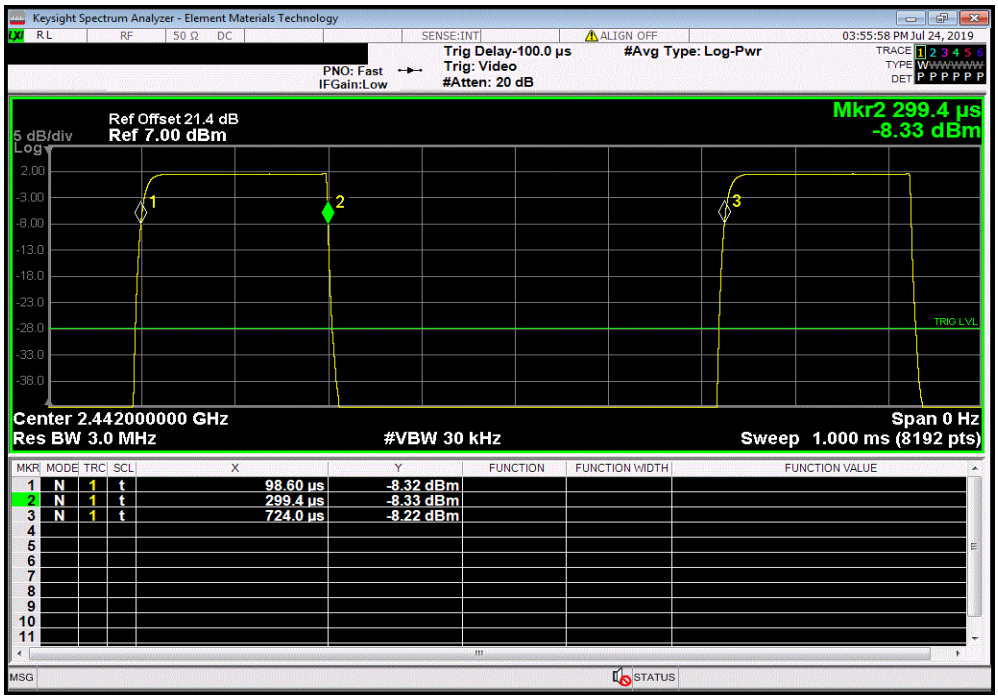


Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

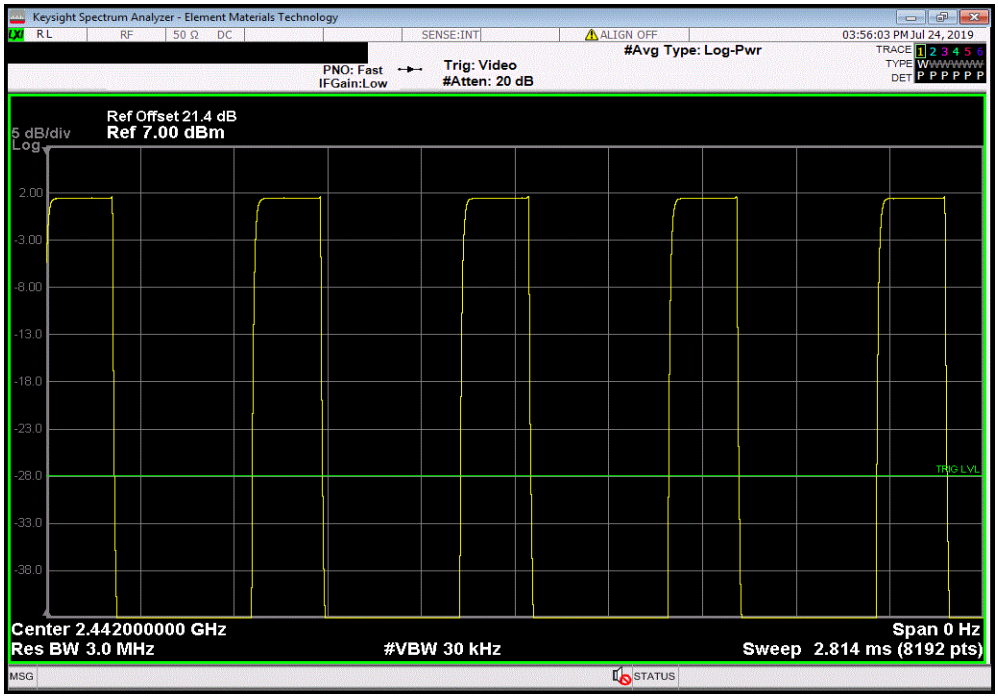


DUTY CYCLE

Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	200.801 us	625.4 us	1	32.1	N/A	N/A

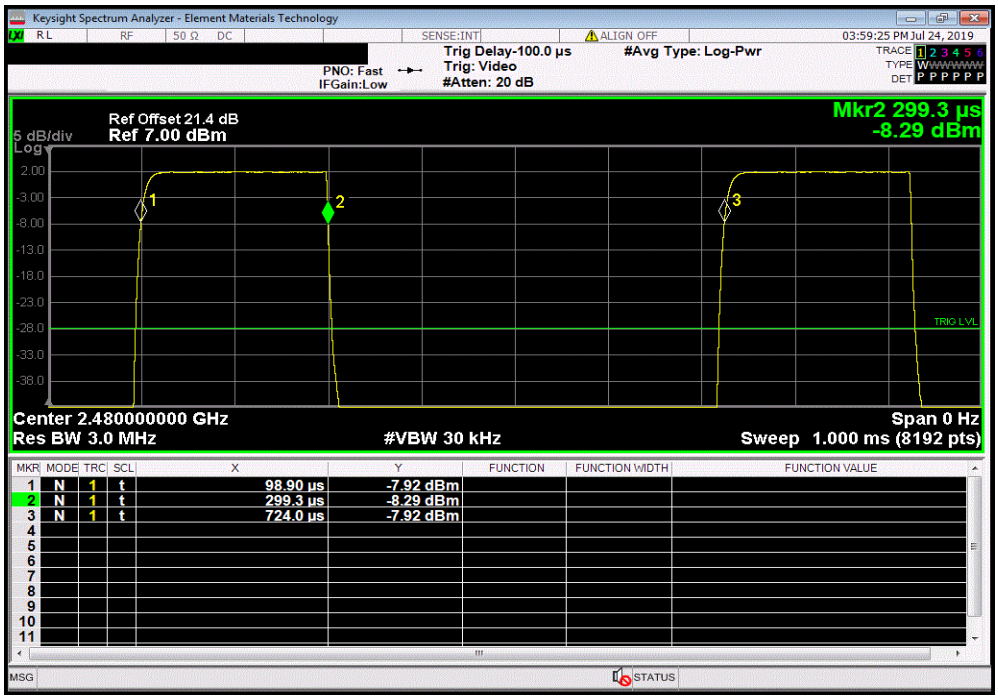


Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

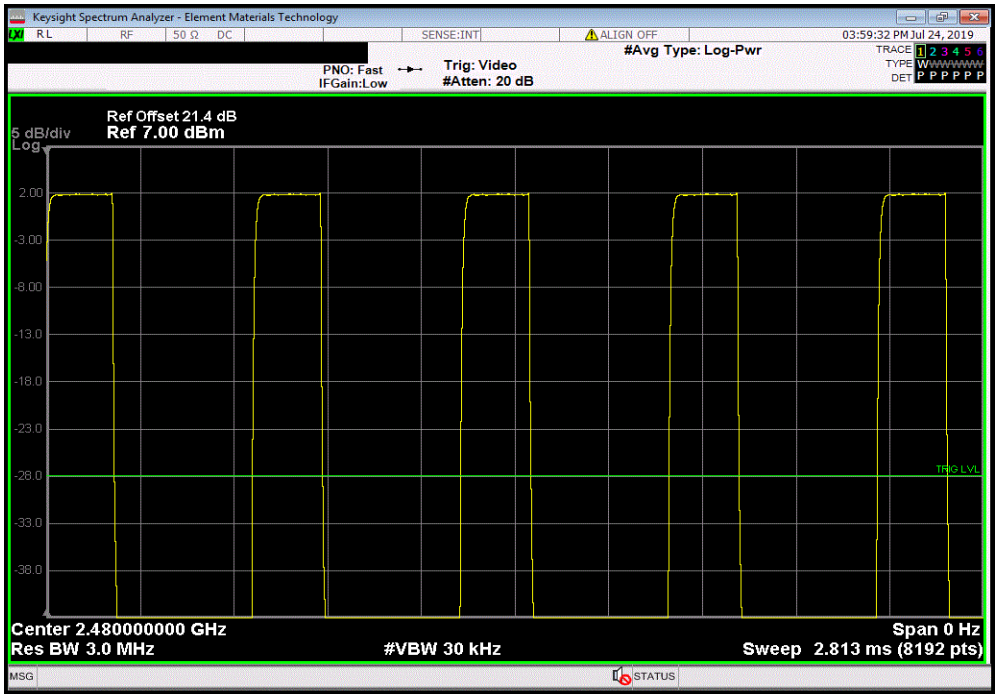


DUTY CYCLE

Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	200.423 us	625.1 us	1	32.1	N/A	N/A



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A



SPURIOUS RADIATED EMISSIONS

PSA-ESCI 2019.05.10

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

MODES OF OPERATION

BTLE 5.0, Low Ch = 2402 MHz, Mid Ch = 2442 MHz, High Ch 2480 MHz

POWER SETTINGS INVESTIGATED

3.7 VDC

CONFIGURATIONS INVESTIGATED

ECHN0015 - 4

FREQUENCY RANGE INVESTIGATED

Start Frequency	30 MHz	Stop Frequency	26.5 GHz

SAMPLE CALCULATIONS

Radiated Emissions: Field Strength = Measured Level + Antenna Factor + Cable Factor - Amplifier Gain + Distance Adjustment Factor + External Attenuation

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Filter - High Pass	Micro-Tronics	HPM50111	HFO	11-Dec-2018	12 mo
Filter - Low Pass	Micro-Tronics	LPM50004	LFD	15-Feb-2019	12 mo
Attenuator	Coaxicom	3910-20	AXZ	15-Feb-2019	12 mo
Cable	ESM Cable Corp.	TTBJ141-KMKM-72	EVY	31-Jul-2019	12 mo
Cable	None	Standard Gain Horns Cable	EVF	18-Nov-2019	12 mo
Cable	N/A	Double Ridge Horn Cables	EVB	18-Nov-2019	12 mo
Cable	N/A	Bilog Cables	EVA	18-Nov-2019	12 mo
Amplifier - Pre-Amplifier	Miteq	AMF-6F-18002650-25-10P	AVU	31-Jul-2019	12 mo
Amplifier - Pre-Amplifier	Miteq	AMF-6F-12001800-30-10P	AVD	18-Nov-2019	12 mo
Amplifier - Pre-Amplifier	L-3 Narda-MITEQ	AMF-6F-08001200-30-10P	PAO	18-Nov-2019	12 mo
Amplifier - Pre-Amplifier	Miteq	AMF-3D-00100800-32-13P	PAG	18-Nov-2019	12 mo
Amplifier - Pre-Amplifier	Miteq	AM-1616-1000	AOL	18-Nov-2019	12 mo
Antenna - Standard Gain	ETS Lindgren	3160-09	AIV	NCR	0 mo
Antenna - Standard Gain	ETS Lindgren	3160-08	AHV	NCR	0 mo
Antenna - Standard Gain	ETS Lindgren	3160-07	AHU	NCR	0 mo
Antenna - Double Ridge	ETS Lindgren	3115	AIZ	7-Feb-2018	24 mo
Antenna - Biconilog	Teseq	CBL 6141B	AXR	2-Oct-2018	24 mo
Analyzer - Spectrum Analyzer	Agilent	E4446A	AAQ	24-Mar-2019	12 mo

TEST DESCRIPTION

The highest gain antenna of each type to be used with the EUT was tested. The EUT was configured for the required transmit frequencies and the modes as showed in the data sheets.

For each configuration, the spectrum was scanned throughout the specified range as part of the exploratory investigation of the emissions. These “pre-scans” are not included in the report. Final measurements on individual emissions were then made and included in this test report.

The individual emissions from the EUT were maximized by rotating the EUT on a turntable, adjusting the position of the EUT and EUT antenna in three orthogonal axis if required, and adjusting the measurement antenna height and polarization (per ANSI C63.10). A preamp and high pass filter (and notch filter) were used for this test in order to provide sufficient measurement sensitivity.

Measurements were made with the required detectors and annotated on the data for each individual point using the following annotation:

QP = Quasi-Peak Detector
PK = Peak Detector
AV = RMS Detector

Measurements were made to satisfy the specific requirements of the test specification for out of band emissions as well as the restricted band requirements.

If there are no detectable emissions above the noise floor, the data included may show noise floor measurements for reference only.

Measurements at the edges of the allowable band may be presented in an alternative method as provided for in the ANSI C63.10 Marker-Delta method. This method involves performing an in-band fundamental measurement followed by a screen capture of the fundamental and out-of-band emission using reduced measurement instrumentation bandwidths. The amplitude delta measured on this screen capture is applied to the fundamental emission value to show the out-of-band emission level as applied to the limit.

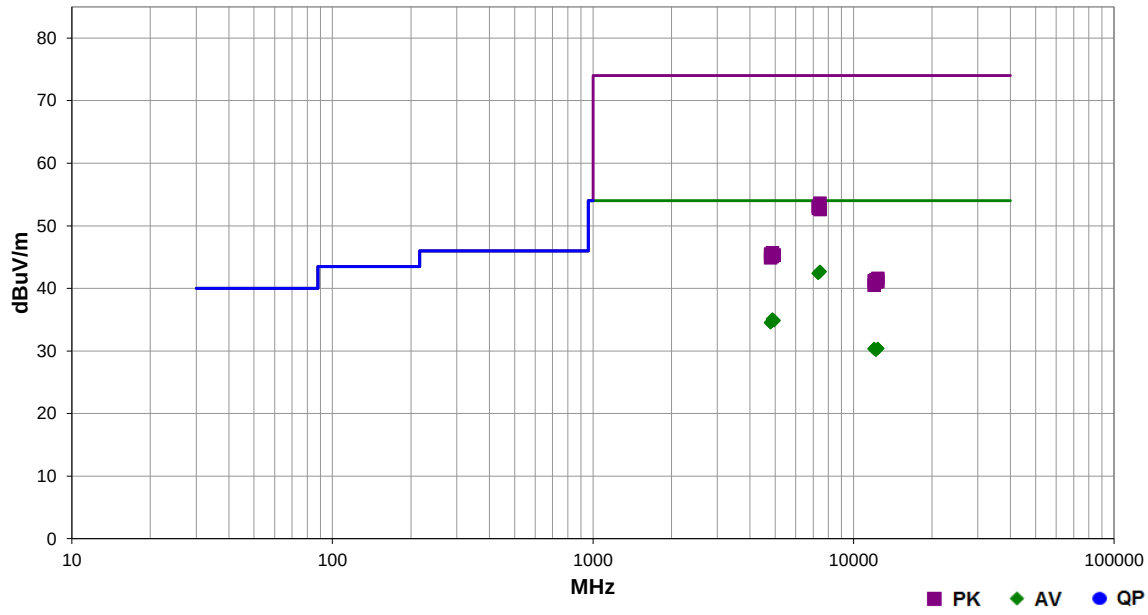
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.15.1 PSA-ESCI 2019.05.10

Work Order:	ECHN0015	**Date:**	26-Nov-2019		
Project:	None	**Temperature:**	19.2 °C		
Job Site:	EV01	**Humidity:**	34.2% RH		
Serial Number:	H1UR1944002-03	**Barometric Pres.:**	997 mbar	**Tested by:**	Jeff Alcoke
EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE				
Configuration:	4				
Customer:	EchoNous, Inc.				
Attendees:	None				
EUT Power:	3.7 VDC				
Operating Mode:	BTLE 5.0, Low Ch = 2402 MHz, Mid Ch = 2442 MHz, High Ch 2480 MHz				
Deviations:	None				
Comments:	Measurements using worst case orientations determined from BT Classic/EDR testing. See comments below for Channel, Data rate, and EUT orientation. Note: All emissions were noise floor, no Duty Cycle correction factor needs to be applied.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	19	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7437.917	28.1	14.6	1.76	228.0	3.0	0.0	Horz	AV	0.0	42.7	54.0	-11.3	High Ch, 1 Mbps BW, EUT Horz
7442.450	28.1	14.6	1.5	252.0	3.0	0.0	Vert	AV	0.0	42.7	54.0	-11.3	High Ch, 1 Mbps BW, EUT Vert
7440.710	28.0	14.6	1.5	26.0	3.0	0.0	Horz	AV	0.0	42.6	54.0	-11.4	High Ch, 2 Mbps BW. EUT Horz
7323.667	28.3	14.1	3.56	146.0	3.0	0.0	Vert	AV	0.0	42.4	54.0	-11.6	Mid Ch, 1 Mbps BW, EUT Vert
7323.808	28.3	14.1	1.5	341.0	3.0	0.0	Horz	AV	0.0	42.4	54.0	-11.6	Mid Ch, 1 Mbps BW, EUT Horz
4885.108	28.7	6.4	1.5	112.0	3.0	0.0	Vert	AV	0.0	35.1	54.0	-18.9	Mid Ch, 1 Mbps BW, EUT Vert
4962.150	28.4	6.5	1.5	214.0	3.0	0.0	Horz	AV	0.0	34.9	54.0	-19.1	High Ch, 1 Mbps BW, EUT Horz
4883.317	28.4	6.4	3.29	45.0	3.0	0.0	Horz	AV	0.0	34.8	54.0	-19.2	Mid Ch, 1 Mbps BW, EUT Horz
4958.275	28.3	6.5	1.5	352.0	3.0	0.0	Vert	AV	0.0	34.8	54.0	-19.2	High Ch, 1 Mbps BW, EUT Vert
4805.308	29.0	5.5	2.26	360.0	3.0	0.0	Horz	AV	0.0	34.5	54.0	-19.5	Low Ch, 1 Mbps BW, EUT Horz
4805.733	29.0	5.5	2.26	0.0	3.0	0.0	Vert	AV	0.0	34.5	54.0	-19.5	Low Ch, 1 Mbps BW, EUT Vert
7439.783	39.0	14.6	1.5	26.0	3.0	0.0	Horz	PK	0.0	53.6	74.0	-20.4	High Ch, 2 Mbps BW. EUT Horz
7323.967	39.0	14.1	3.56	146.0	3.0	0.0	Vert	PK	0.0	53.1	74.0	-20.9	Mid Ch, 1 Mbps BW, EUT Vert
7437.825	38.5	14.6	1.76	228.0	3.0	0.0	Horz	PK	0.0	53.1	74.0	-20.9	High Ch, 1 Mbps BW, EUT Horz
7324.342	38.7	14.1	1.5	341.0	3.0	0.0	Horz	PK	0.0	52.8	74.0	-21.2	Mid Ch, 1 Mbps BW, EUT Horz
7442.392	38.0	14.6	1.5	252.0	3.0	0.0	Vert	PK	0.0	52.6	74.0	-21.4	High Ch, 1 Mbps BW, EUT Vert
12010.030	29.4	1.0	2.26	360.0	3.0	0.0	Vert	AV	0.0	30.4	54.0	-23.6	Low Ch, 1 Mbps BW, EUT Vert
12398.590	29.3	1.1	3.08	149.0	3.0	0.0	Vert	AV	0.0	30.4	54.0	-23.6	High Ch, 1 Mbps BW, EUT Vert
12397.770	29.3	1.1	1.2	215.0	3.0	0.0	Horz	AV	0.0	30.4	54.0	-23.6	High Ch, 1 Mbps BW, EUT Horz
12007.610	29.3	1.0	2.26	0.0	3.0	0.0	Horz	AV	0.0	30.3	54.0	-23.7	Low Ch, 1 Mbps BW, EUT Horz
12209.770	29.4	0.8	2.26	360.0	3.0	0.0	Horz	AV	0.0	30.2	54.0	-23.8	Mid Ch, 1 Mbps BW, EUT Horz
12209.330	29.3	0.8	2.26	0.0	3.0	0.0	Vert	AV	0.0	30.1	54.0	-23.9	Mid Ch, 1 Mbps BW, EUT Vert

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
4885.108	39.3	6.4	1.5	112.0	3.0	0.0	Vert	PK	0.0	45.7	74.0	-28.3	Mid Ch, 1 Mbps BW, EUT Vert
4803.892	40.1	5.4	2.26	0.0	3.0	0.0	Vert	PK	0.0	45.5	74.0	-28.5	Low Ch, 1 Mbps BW, EUT Vert
4959.533	38.8	6.5	1.5	214.0	3.0	0.0	Horz	PK	0.0	45.3	74.0	-28.7	High Ch, 1 Mbps BW, EUT Horz
4958.100	38.8	6.5	1.5	352.0	3.0	0.0	Vert	PK	0.0	45.3	74.0	-28.7	High Ch, 1 Mbps BW, EUT Vert
4882.025	38.7	6.4	3.29	45.0	3.0	0.0	Horz	PK	0.0	45.1	74.0	-28.9	Mid Ch, 1 Mbps BW, EUT Horz
4803.325	39.5	5.4	2.26	360.0	3.0	0.0	Horz	PK	0.0	44.9	74.0	-29.1	Low Ch, 1 Mbps BW, EUT Horz
12398.960	40.5	1.1	3.08	149.0	3.0	0.0	Vert	PK	0.0	41.6	74.0	-32.4	High Ch, 1 Mbps BW, EUT Vert
12212.390	40.6	0.8	2.26	0.0	3.0	0.0	Vert	PK	0.0	41.4	74.0	-32.6	Mid Ch, 1 Mbps BW, EUT Vert
12010.340	40.2	1.0	2.26	0.0	3.0	0.0	Horz	PK	0.0	41.2	74.0	-32.8	Low Ch, 1 Mbps BW, EUT Horz
12398.510	40.0	1.1	1.2	215.0	3.0	0.0	Horz	PK	0.0	41.1	74.0	-32.9	High Ch, 1 Mbps BW, EUT Horz
12211.710	40.2	0.8	2.26	360.0	3.0	0.0	Horz	PK	0.0	41.0	74.0	-33.0	Mid Ch, 1 Mbps BW, EUT Horz
12008.050	39.5	1.0	2.26	360.0	3.0	0.0	Vert	PK	0.0	40.5	74.0	-33.5	Low Ch, 1 Mbps BW, EUT Vert

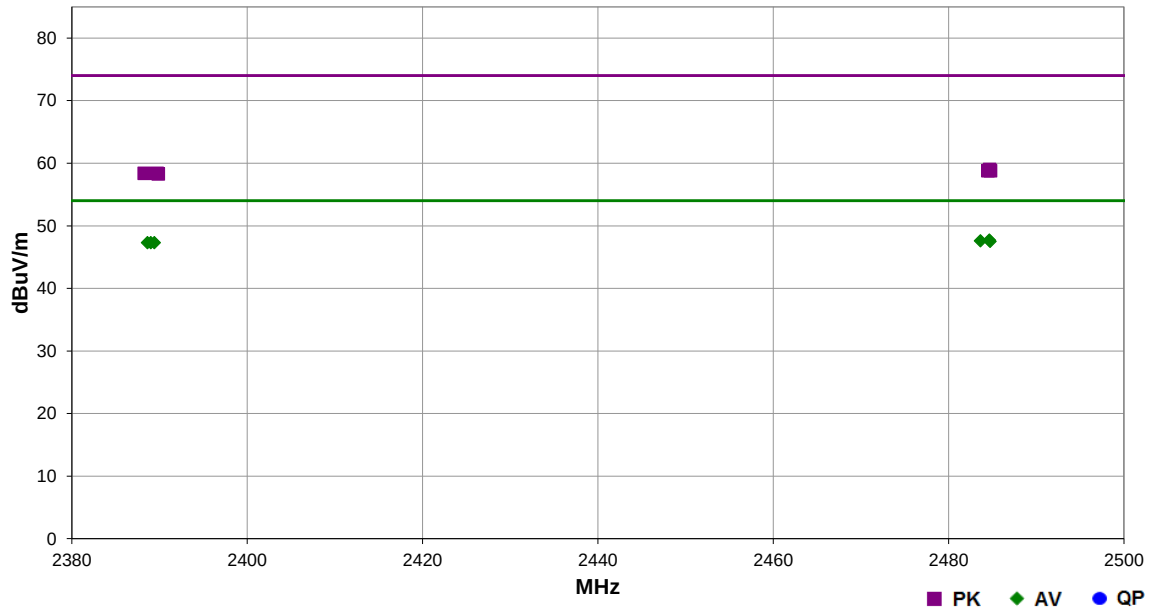
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.15.1 PSA-ESCI 2019.05.10

Work Order:	ECHN0015	**Date:**	26-Nov-2019		
Project:	None	**Temperature:**	19.2 °C		
Job Site:	EV01	**Humidity:**	34.2% RH		
Serial Number:	H1UR1944002-03	**Barometric Pres.:**	997 mbar	**Tested by:**	Jeff Alcoke
EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE				
Configuration:	4				
Customer:	EchoNous, Inc.				
Attendees:	None				
EUT Power:	3.7 VDC				
Operating Mode:	BTLE 5.0, Low Ch = 2402 MHz, Mid Ch = 2442 MHz, High Ch 2480 MHz				
Deviations:	None				
Comments:	Measurements using worst case orientations determined from BT Classic/EDR testing. See comments below for Channel, Data rate, and EUT orientation. Note: All emissions were noise floor, no Duty Cycle correction factor needs to be applied.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	23	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
2484.650	31.4	-3.7	2.29	217.0	3.0	20.0	Vert	AV	0.0	47.7	54.0	-6.3	High Ch, 1 Mbps BW, EUT Horz
2483.653	31.4	-3.8	1.5	257.0	3.0	20.0	Horz	AV	0.0	47.6	54.0	-6.4	High Ch, 1 Mbps BW, EUT Horz
2484.747	31.2	-3.7	1.01	345.0	3.0	20.0	Horz	AV	0.0	47.5	54.0	-6.5	High Ch, 2 Mbps BW, EUT Horz
2389.003	31.3	-4.0	1.5	293.0	3.0	20.0	Horz	AV	0.0	47.3	54.0	-6.7	Low Ch, 2 Mbps BW, EUT Horz
2389.410	31.3	-4.0	1.5	104.0	3.0	20.0	Horz	AV	0.0	47.3	54.0	-6.7	Low Ch, 1 Mbps BW, EUT Horz
2388.623	31.3	-4.0	3.31	100.0	3.0	20.0	Vert	AV	0.0	47.3	54.0	-6.7	Low Ch, 1 Mbps BW, EUT Horz
2484.680	42.7	-3.7	1.5	257.0	3.0	20.0	Horz	PK	0.0	59.0	74.0	-15.0	High Ch, 1 Mbps BW, EUT Horz
2484.483	42.5	-3.7	2.29	217.0	3.0	20.0	Vert	PK	0.0	58.8	74.0	-15.2	High Ch, 1 Mbps BW, EUT Horz
2484.777	42.5	-3.7	1.01	345.0	3.0	20.0	Horz	PK	0.0	58.8	74.0	-15.2	High Ch, 2 Mbps BW, EUT Horz
2389.730	42.4	-4.0	1.5	293.0	3.0	20.0	Horz	PK	0.0	58.4	74.0	-15.6	Low Ch, 2 Mbps BW, EUT Horz
2388.233	42.4	-4.0	3.31	100.0	3.0	20.0	Vert	PK	0.0	58.4	74.0	-15.6	Low Ch, 1 Mbps BW, EUT Horz
2389.840	42.3	-4.0	1.5	104.0	3.0	20.0	Horz	PK	0.0	58.3	74.0	-15.7	Low Ch, 1 Mbps BW, EUT Horz

OCCUPIED BANDWIDTH

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The EUT was set to the channels and modes listed in the datasheet.

The 6dB occupied bandwidth was measured using 100 kHz resolution bandwidth and 300 kHz video bandwidth. The 99.0% occupied bandwidth was also measured at the same time which can be needed during Output Power depending on the applicable method.

OCCUPIED BANDWIDTH

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.3 °C
Attendees:	None			**Humidity:**	60.1% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	Test Method
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

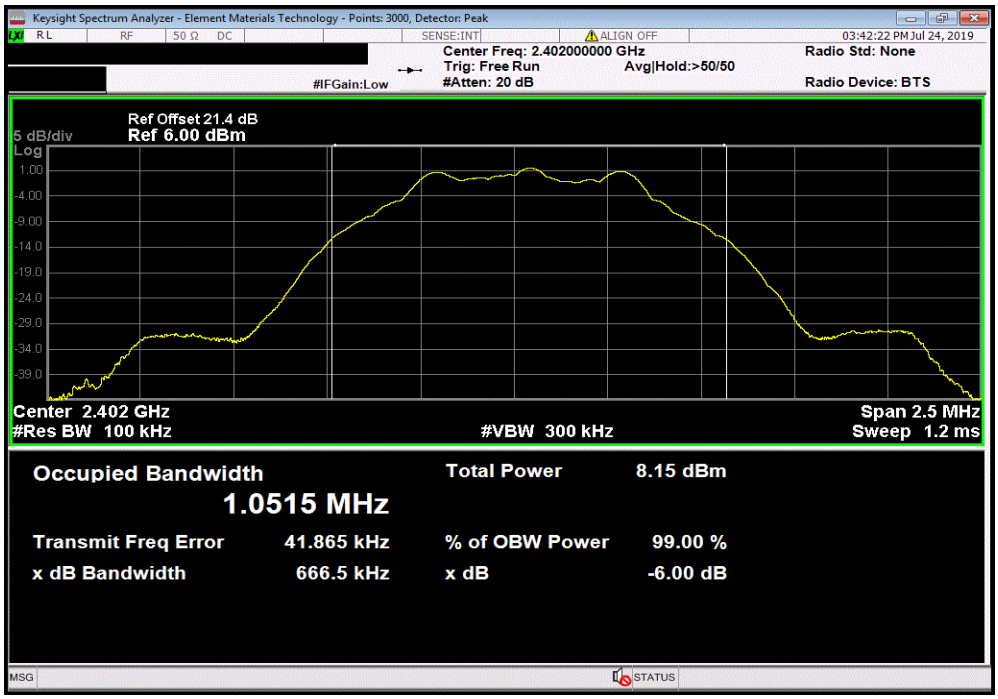
DEVIATIONS FROM TEST STANDARD

None

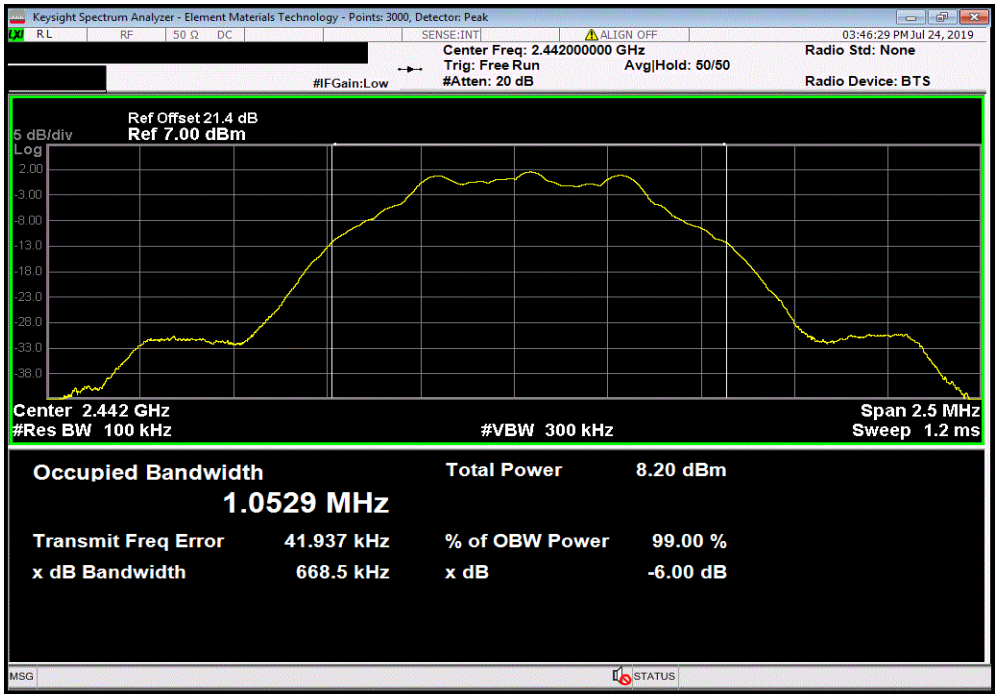
Configuration #	1	Signature

		Value	Limit (≥)	Result
Mode: - LE1M				
	BLE/GFSK Low Channel, 2402 MHz	666.513 kHz	500 kHz	Pass
	BLE/GFSK Mid Channel, 2442 MHz	668.538 kHz	500 kHz	Pass
	BLE/GFSK High Channel, 2480 MHz	666.59 kHz	500 kHz	Pass
Mode: - LE2M				
	BLE/GFSK Low Channel, 2402 MHz	1.144 MHz	500 kHz	Pass
	BLE/GFSK Mid Channel, 2442 MHz	1.15 MHz	500 kHz	Pass
	BLE/GFSK High Channel, 2480 MHz	1.152 MHz	500 kHz	Pass

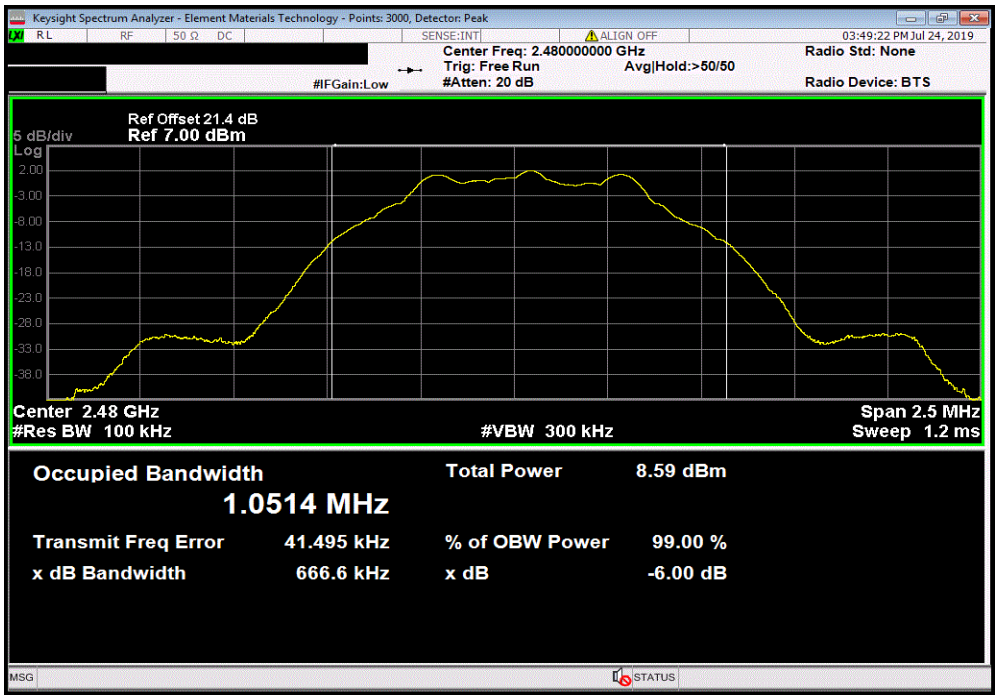
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
				Value	Limit (≥)	Result
				666.513 kHz	500 kHz	Pass



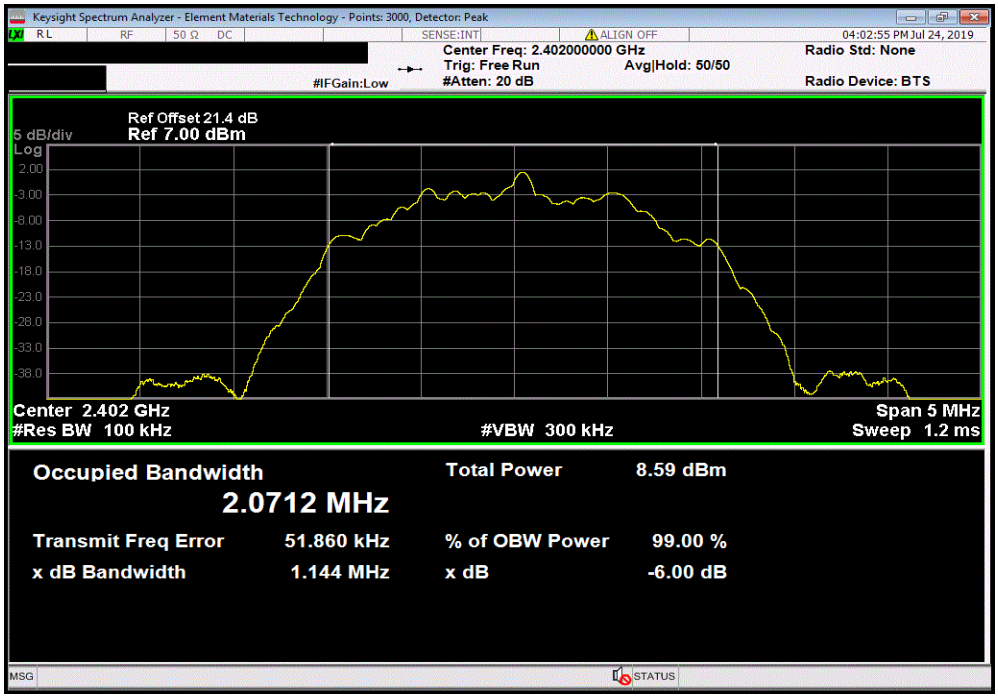
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
				Value	Limit (≥)	Result
				668.538 kHz	500 kHz	Pass



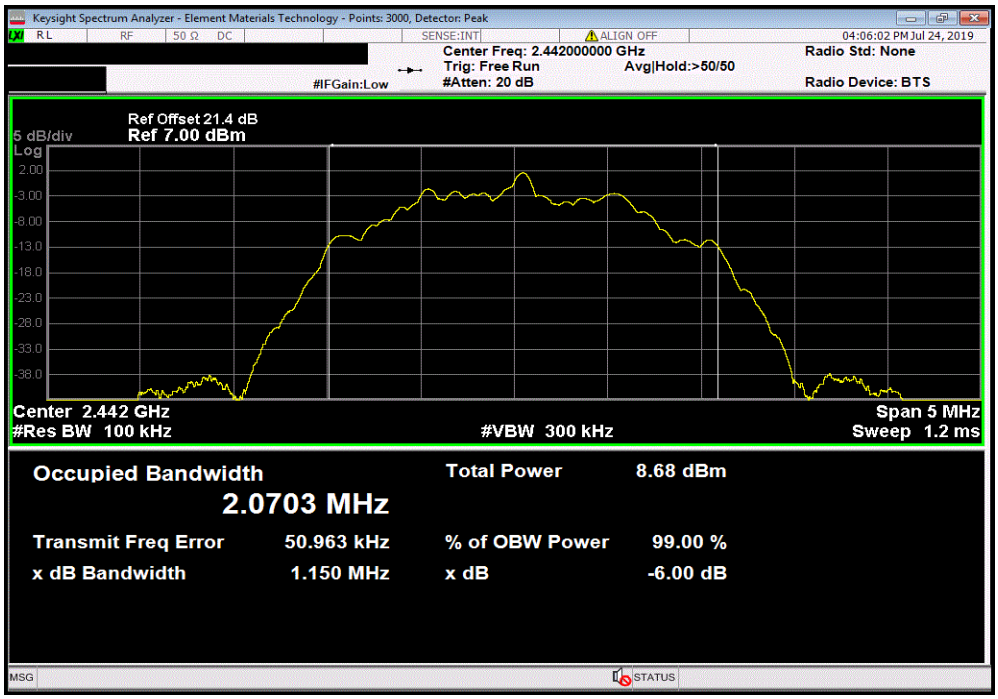
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
				Value	Limit (≥)	Result
				666.59 kHz	500 kHz	Pass



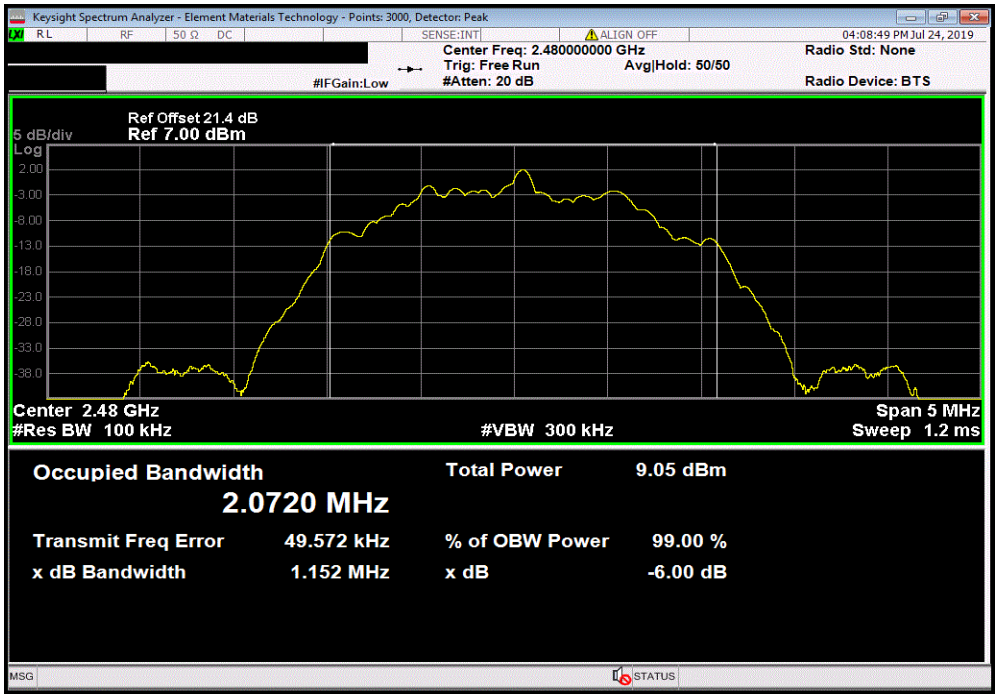
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
				Value	Limit (≥)	Result
				1.144 MHz	500 kHz	Pass



Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
				Value	Limit (≥)	Result
				1.15 MHz	500 kHz	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
				Value	Limit (≥)	Result
				1.152 MHz	500 kHz	Pass



OUTPUT POWER

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The transmit frequency was set to the required channels in each band. The transmit power was set to its default maximum.

Prior to measuring peak transmit power the DTS bandwidth (B) was measured.

The method found in ANSI C63.10:2013 Section 11.9.1.1 was used because the RBW on the analyzer was greater than the DTS Bandwidth of the radio.

OUTPUT POWER

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.4 °C
Attendees:	None			**Humidity:**	52.7% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	Test Method
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

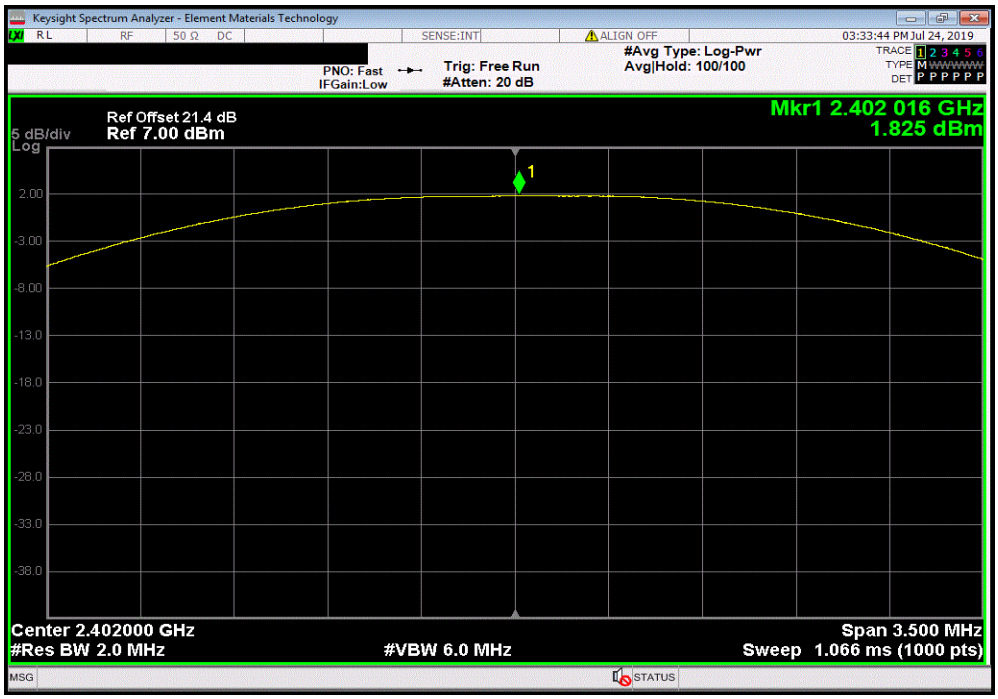
DEVIATIONS FROM TEST STANDARD

None

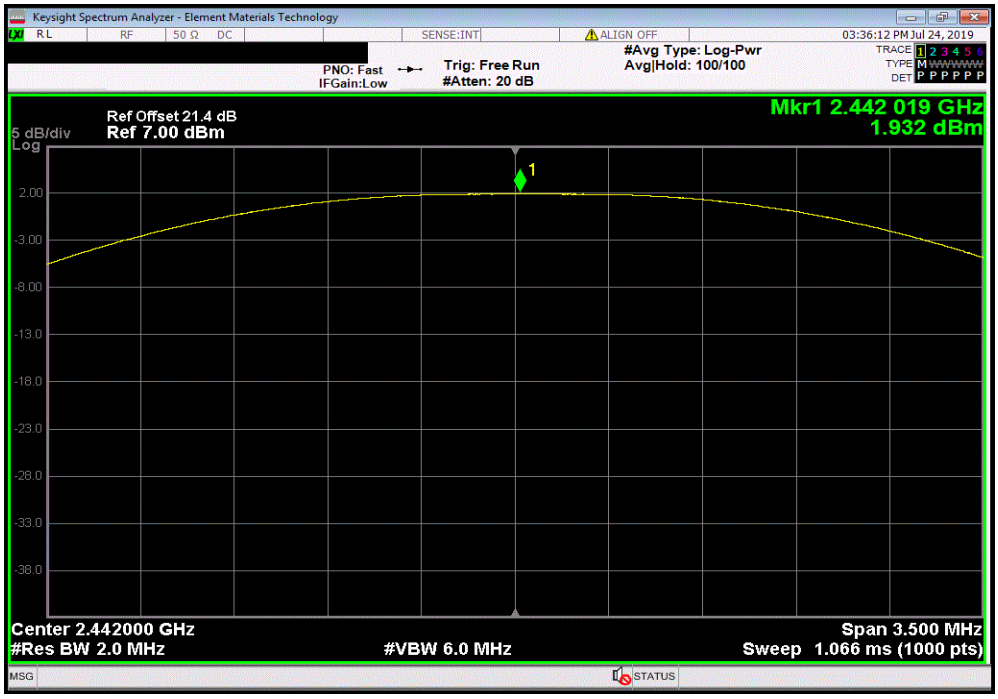
Configuration #	1	Signature

		Out Pwr (dBm)	Limit (dBm)	Result
Mode: - LE1M				
	BLE/GFSK Low Channel, 2402 MHz	1.825	30	Pass
	BLE/GFSK Mid Channel, 2442 MHz	1.932	30	Pass
	BLE/GFSK High Channel, 2480 MHz	2.238	30	Pass
Mode: - LE2M				
	BLE/GFSK Low Channel, 2402 MHz	2.071	30	Pass
	BLE/GFSK Mid Channel, 2442 MHz	2.217	30	Pass
	BLE/GFSK High Channel, 2480 MHz	2.429	30	Pass

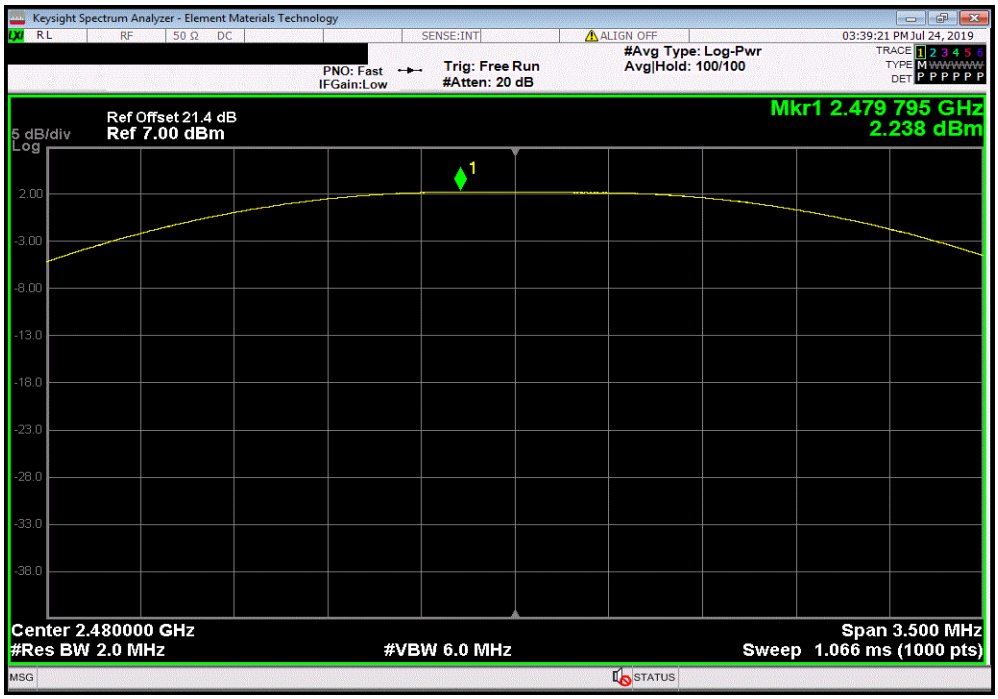
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				1.825	30	Pass



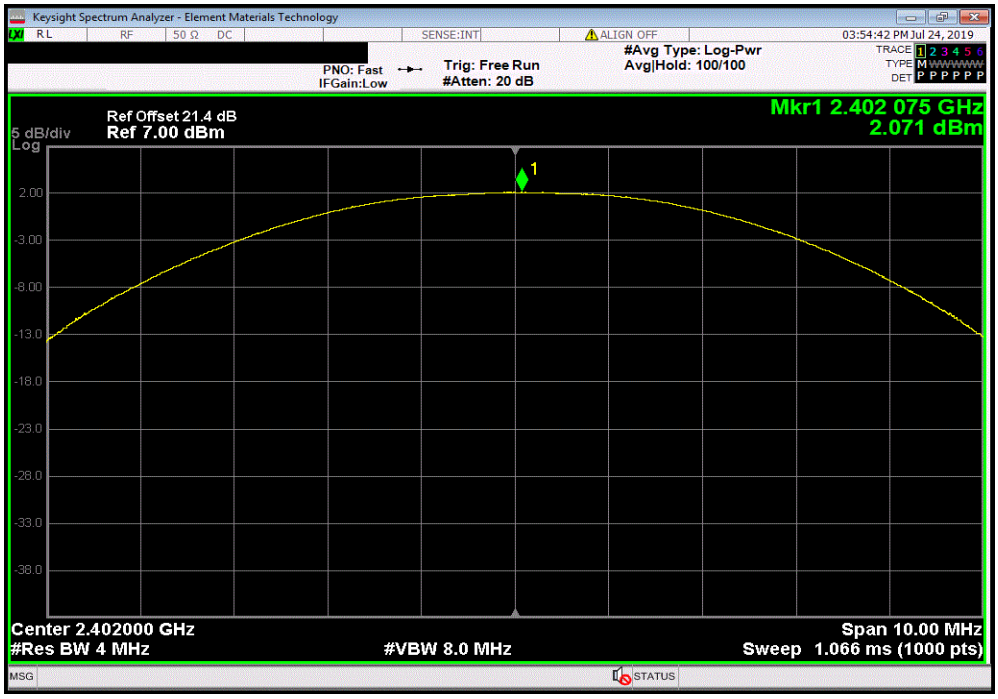
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				1.932	30	Pass



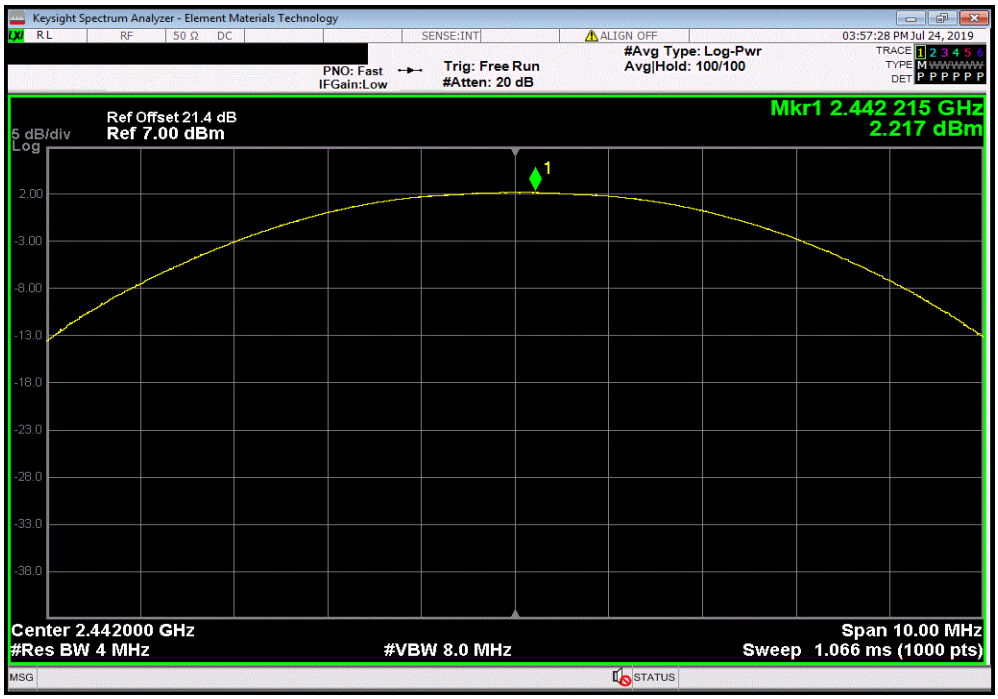
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				2.238	30	Pass



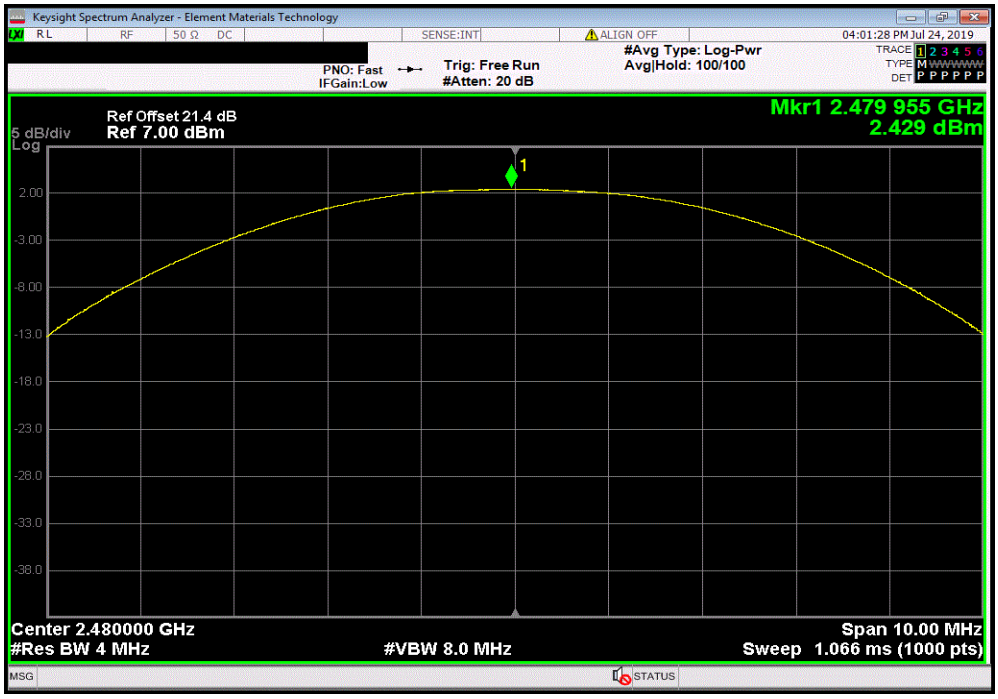
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				2.071	30	Pass



Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				2.217	30	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
				Out Pwr (dBm)	Limit (dBm)	Result
				2.429	30	Pass



EQUIVALENT ISOTROPIC RADIATED POWER (EIRP)

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The transmit frequency was set to the required channels in each band. The transmit power was set to its default maximum.

Prior to measuring peak transmit power the DTS bandwidth (B) was measured.

The method found in ANSI C63.10:2013 Section 11.9.1.1 was used because the RBW on the analyzer was greater than the DTS Bandwidth of the radio.

EQUIVALENT ISOTROPIC RADIATED POWER (EIRP)

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.2 °C
Attendees:	None			**Humidity:**	56.9% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	Test Method
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

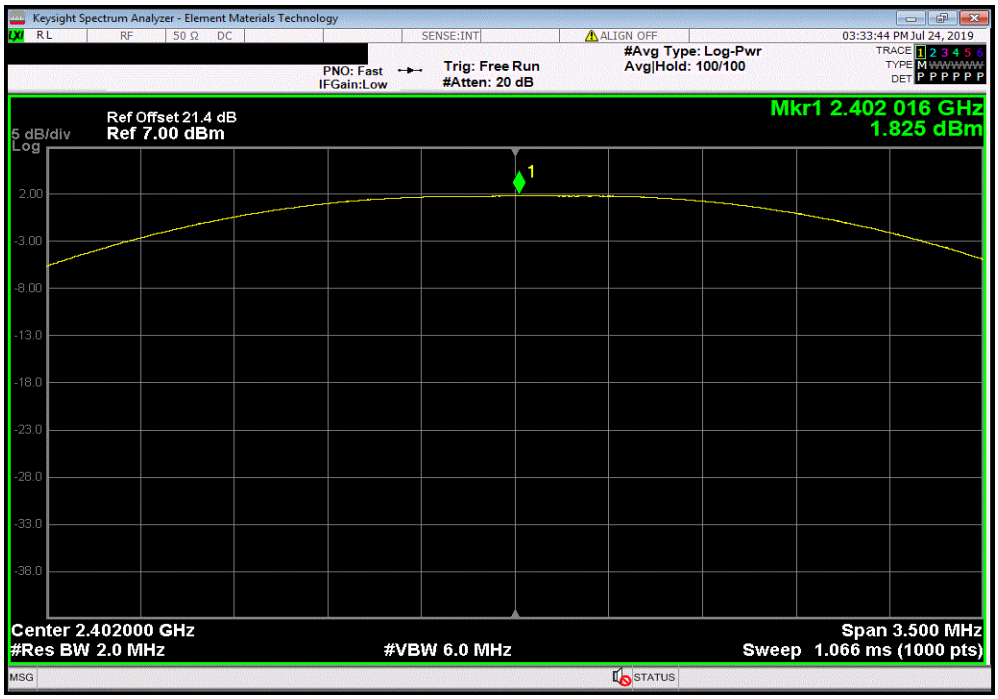
DEVIATIONS FROM TEST STANDARD

None

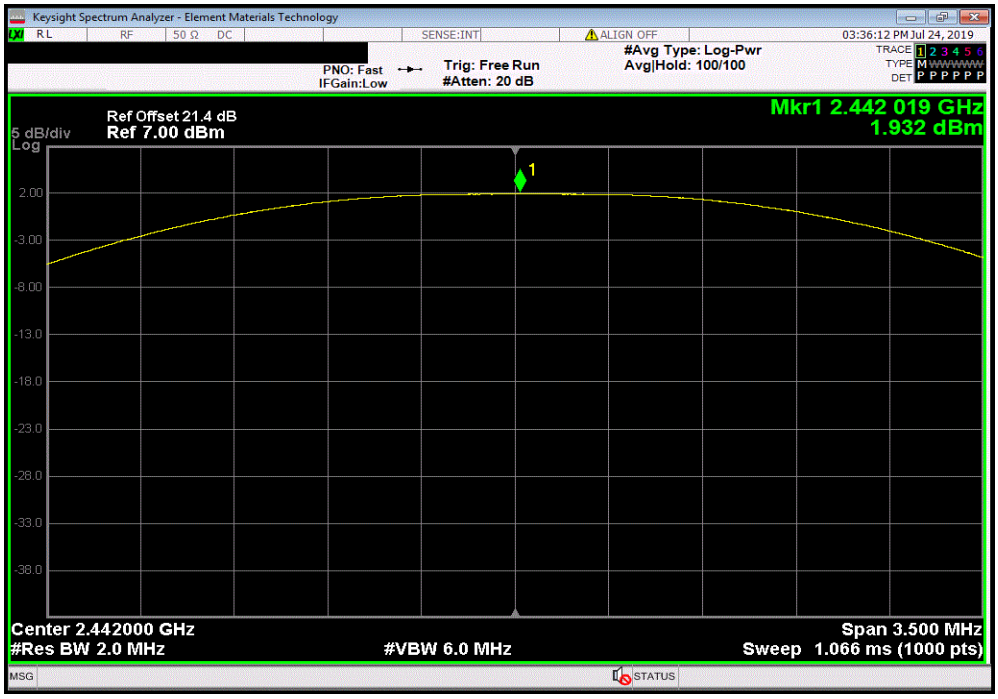
Configuration #	1	Signature

		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
Mode: - LE1M						
	BLE/GFSK Low Channel, 2402 MHz	1.825	-1.29	0.535	36	Pass
	BLE/GFSK Mid Channel, 2442 MHz	1.932	-1.29	0.642	36	Pass
	BLE/GFSK High Channel, 2480 MHz	2.238	-1.29	0.948	36	Pass
Mode: - LE2M						
	BLE/GFSK Low Channel, 2402 MHz	2.071	-1.29	0.781	36	Pass
	BLE/GFSK Mid Channel, 2442 MHz	2.217	-1.29	0.927	36	Pass
	BLE/GFSK High Channel, 2480 MHz	2.429	-1.29	1.139	36	Pass

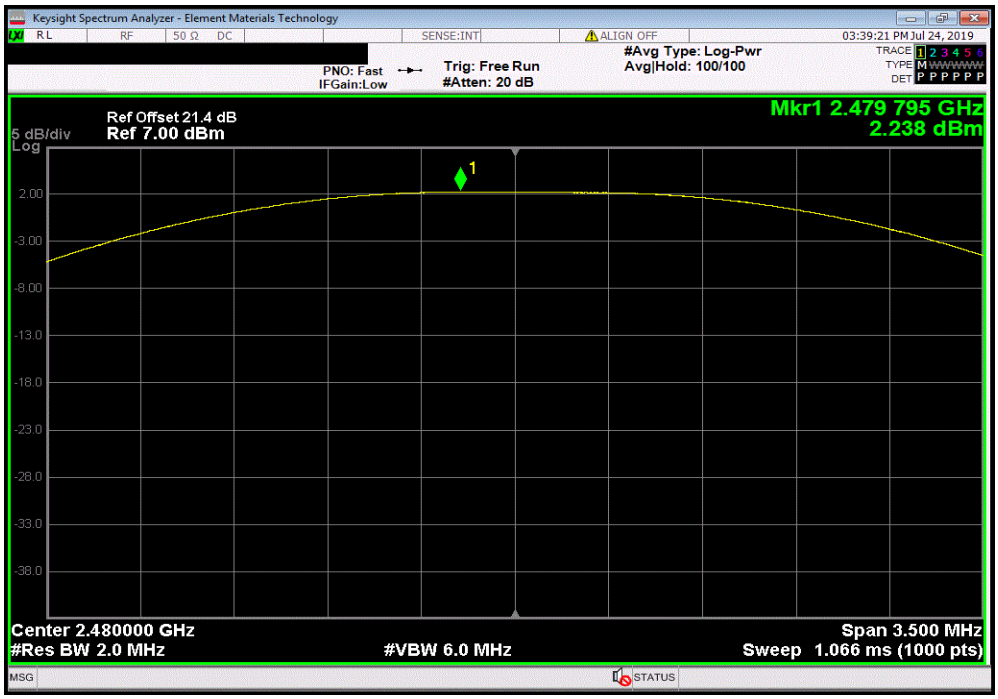
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		1.825	-1.29	0.535	36	Pass



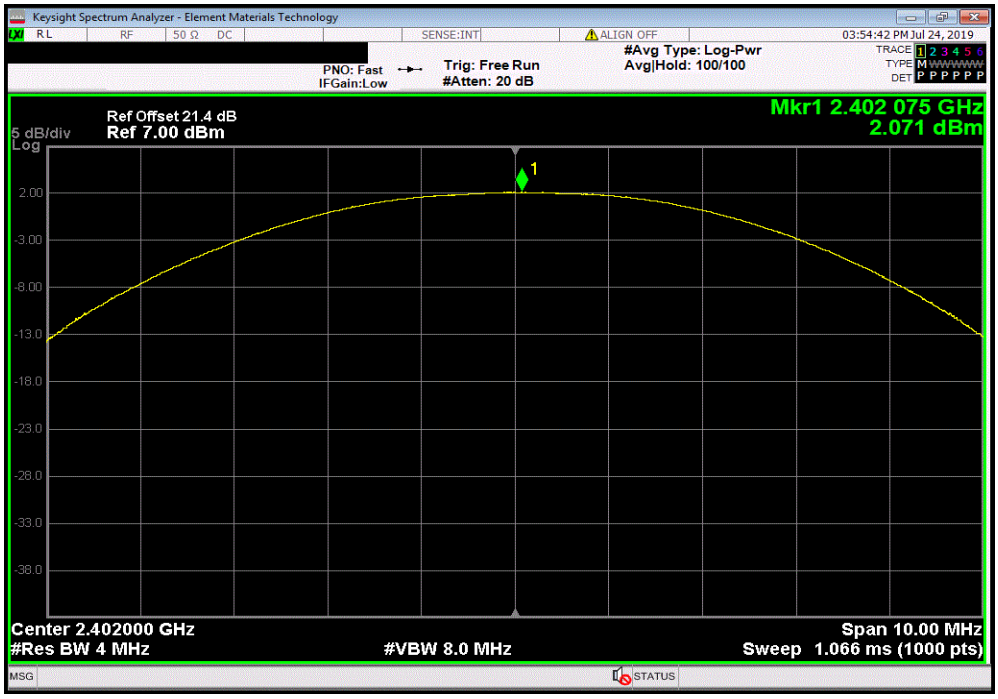
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		1.932	-1.29	0.642	36	Pass



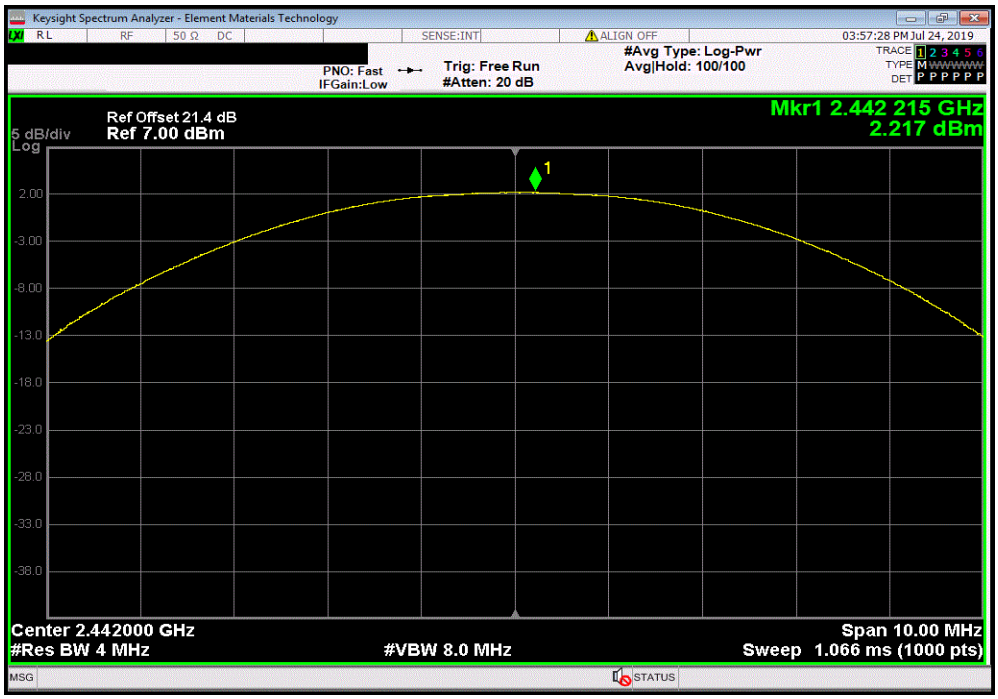
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		2.238	-1.29	0.948	36	Pass



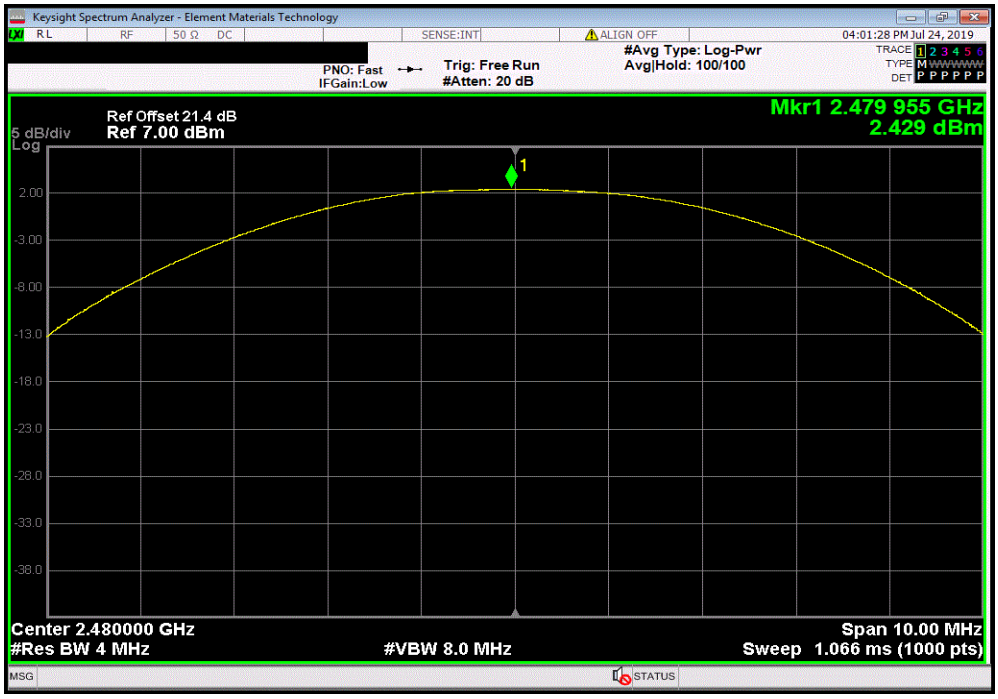
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		2.071	-1.29	0.781	36	Pass



Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		2.217	-1.29	0.927	36	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
		Out Pwr (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
		2.429	-1.29	1.139	36	Pass



BAND EDGE COMPLIANCE

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The spurious RF conducted emissions at the edges of the authorized bands were measured with the EUT set to low and high transmit frequencies in each available band. The channels closest to the band edges were selected. The EUT was transmitting at the data rate(s) listed in the datasheet.

The spectrum was scanned below the lower band edge and above the higher band edge.

BAND EDGE COMPLIANCE

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.3 °C
Attendees:	None			**Humidity:**	51.7% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	Test Method
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

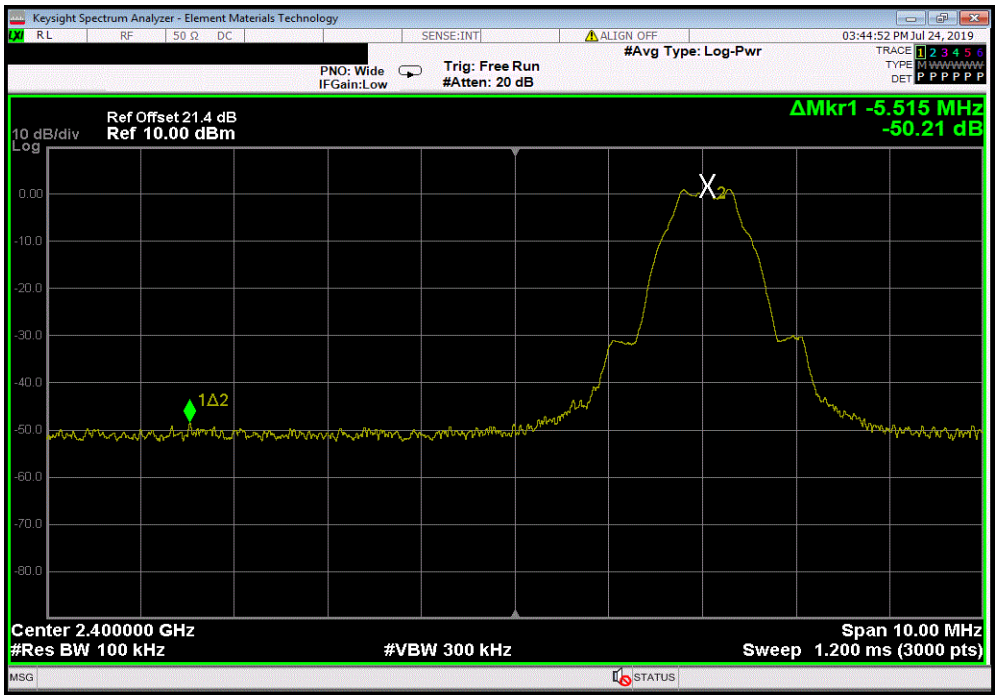
DEVIATIONS FROM TEST STANDARD

None

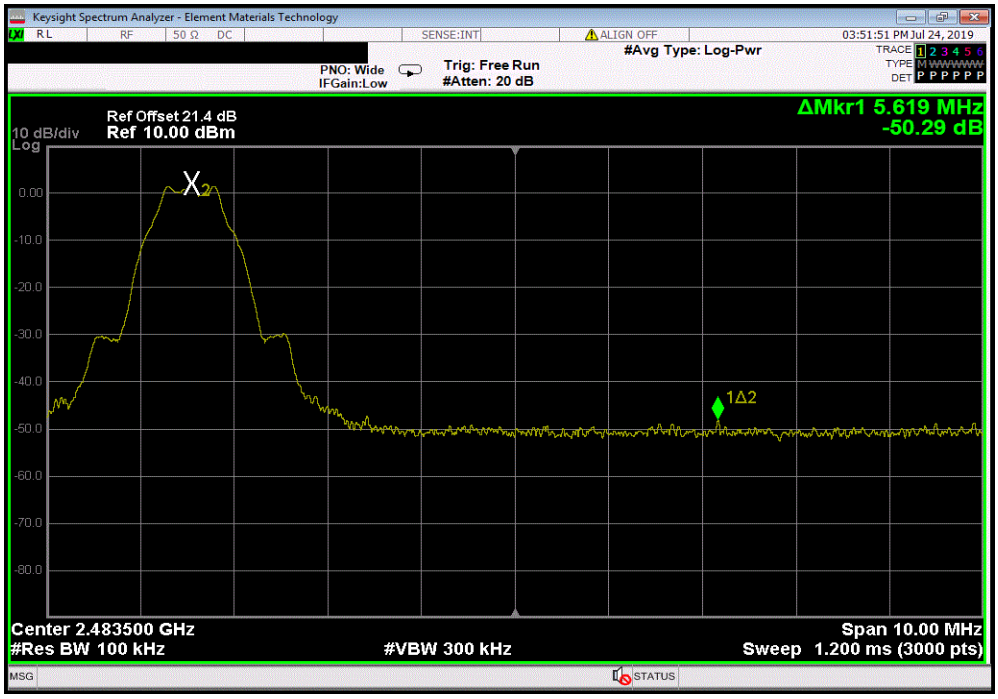
Configuration #	1	Signature

	Value (dBc)	Limit ≤ (dBc)	Result
Mode: - LE1M			
BLE/GFSK Low Channel, 2402 MHz	-50.21	-20	Pass
BLE/GFSK High Channel, 2480 MHz	-50.29	-20	Pass
Mode: - LE2M			
BLE/GFSK Low Channel, 2402 MHz	-41.98	-20	Pass
BLE/GFSK High Channel, 2480 MHz	-50.67	-20	Pass

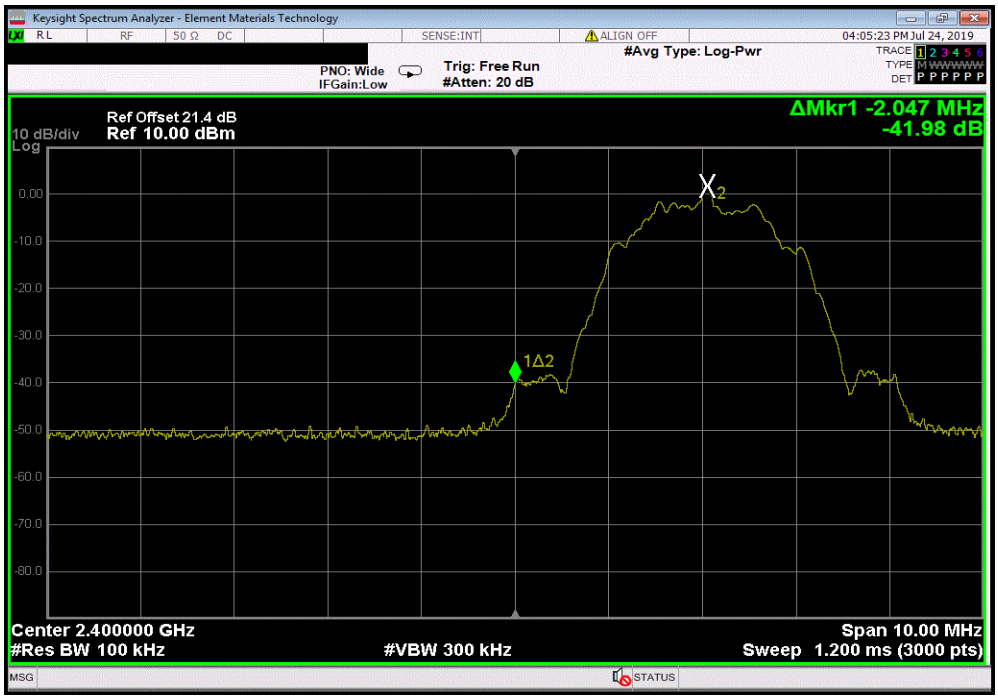
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-50.21	-20	Pass



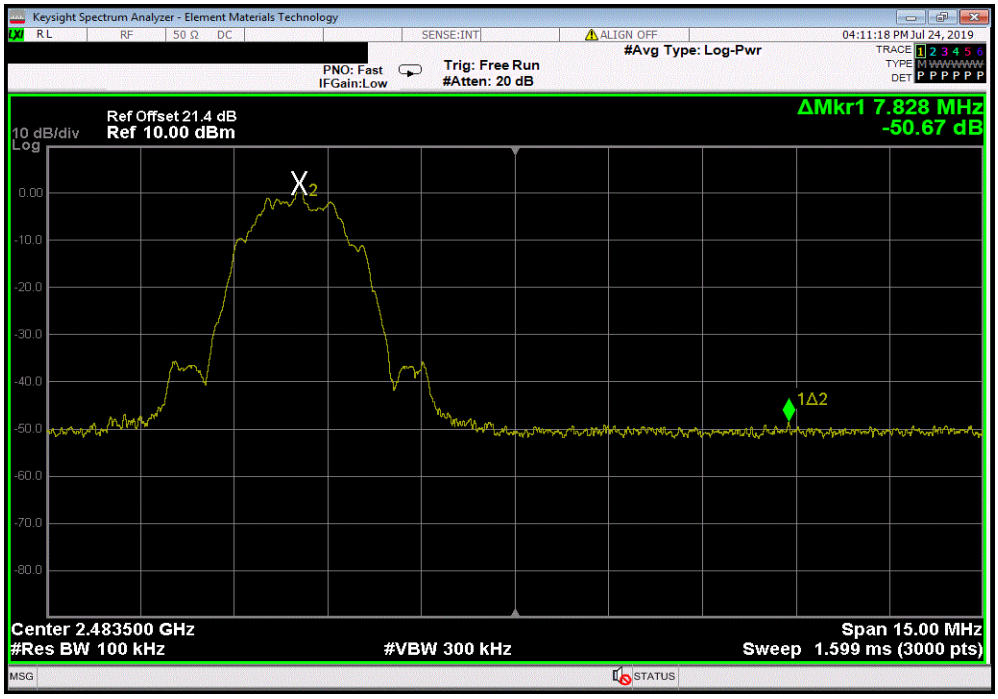
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-50.29	-20	Pass



Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-41.98	-20	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-50.67	-20	Pass



POWER SPECTRAL DENSITY

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The maximum power spectral density measurements was measured using the channels and modes as called out on the following data sheets.

Per the procedure outlined in ANSI C63.10 the peak power spectral density was measured in a 3 kHz RBW.

POWER SPECTRAL DENSITY

element

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.4 °C
Attendees:	None			**Humidity:**	51.2% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	Test Method
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

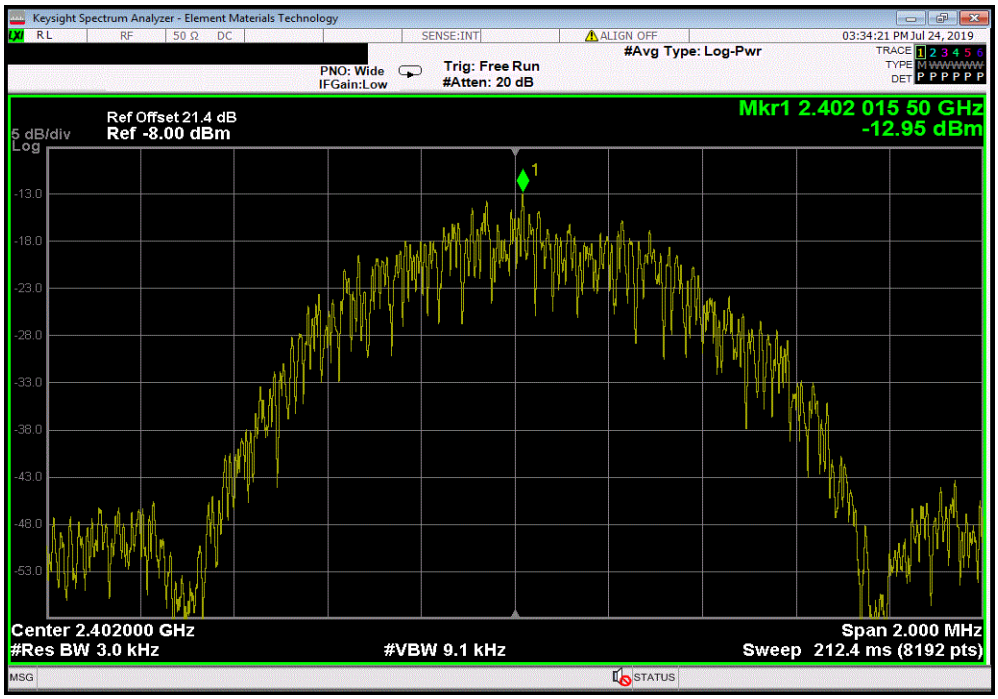
DEVIATIONS FROM TEST STANDARD

None

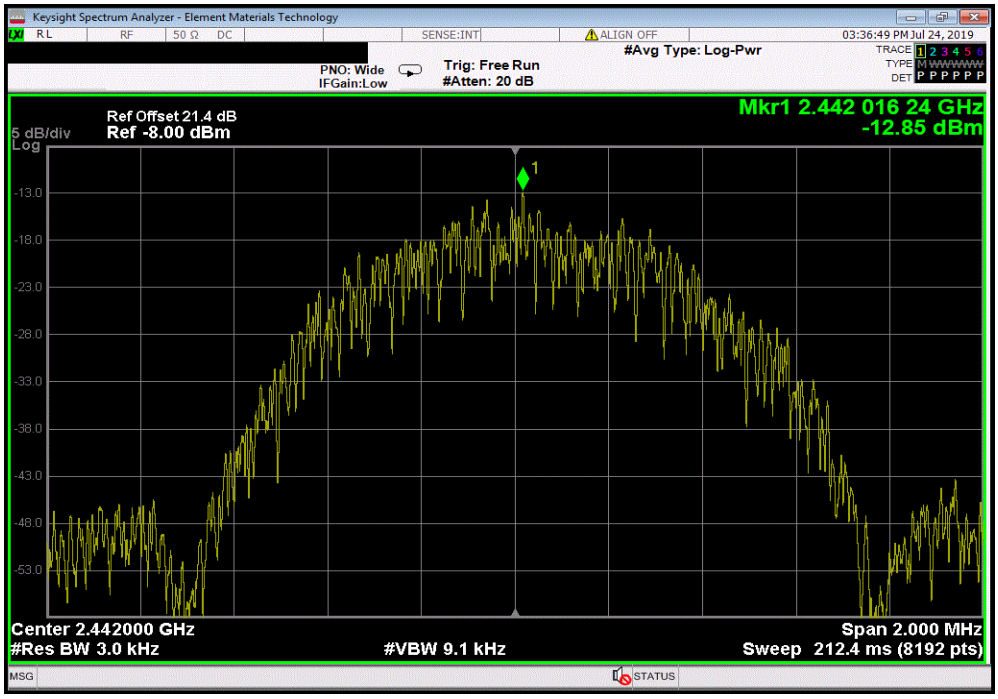
Configuration #	1	Signature

		Value dBm/3kHz	Limit < dBm/3kHz	Results
Mode: - LE1M				
	BLE/GFSK Low Channel, 2402 MHz	-12.946	8	Pass
	BLE/GFSK Mid Channel, 2442 MHz	-12.854	8	Pass
	BLE/GFSK High Channel, 2480 MHz	-12.485	8	Pass
Mode: - LE2M				
	BLE/GFSK Low Channel, 2402 MHz	-16.448	8	Pass
	BLE/GFSK Mid Channel, 2442 MHz	-16.407	8	Pass
	BLE/GFSK High Channel, 2480 MHz	-16.009	8	Pass

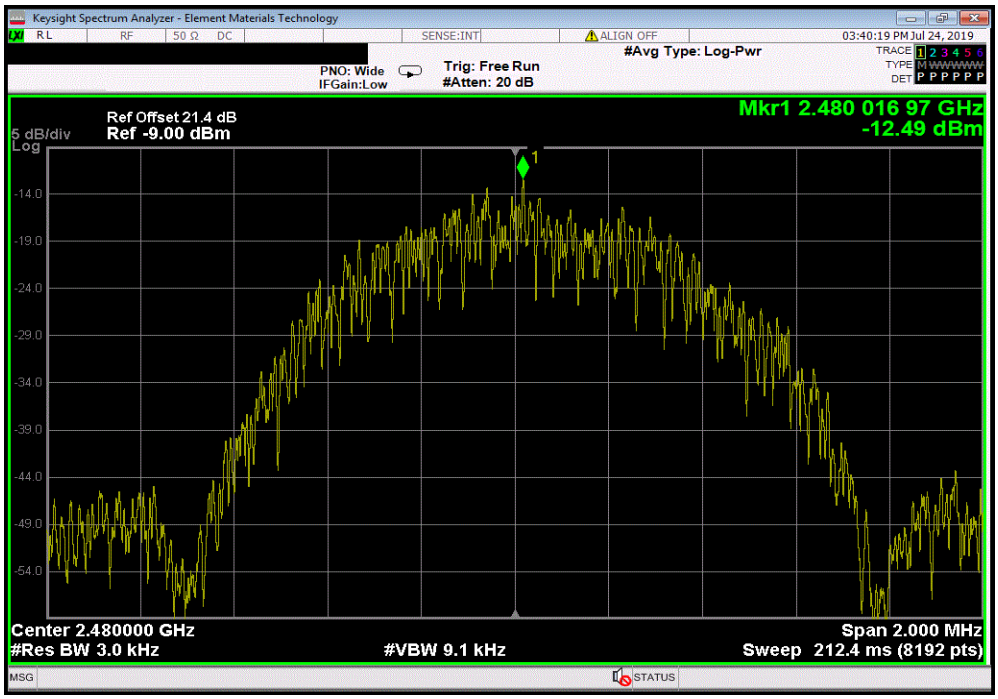
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-12.946	8	Pass



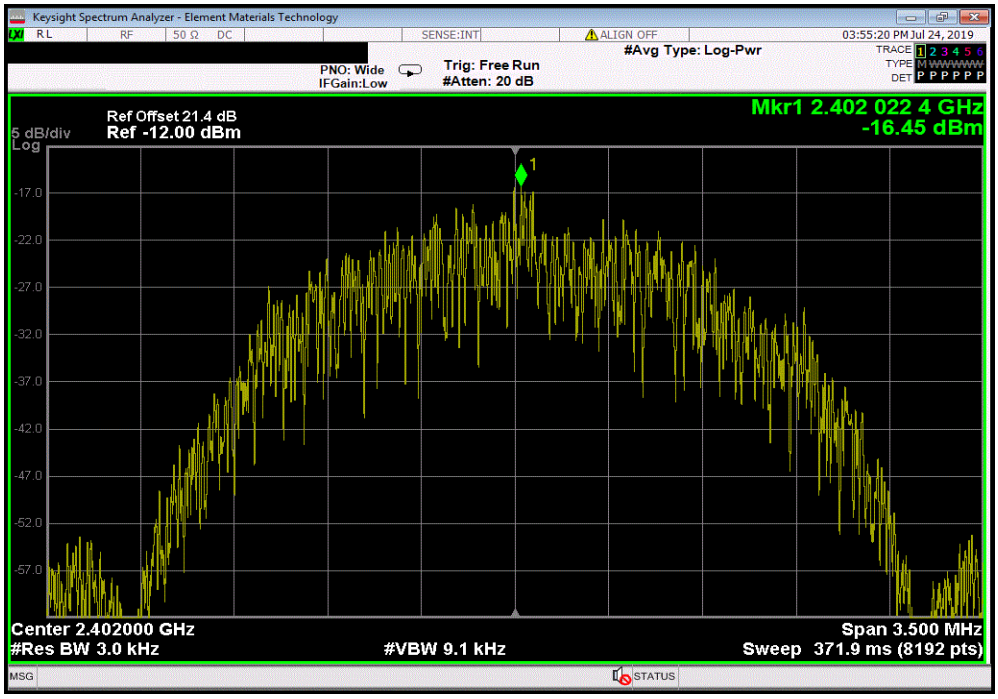
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-12.854	8	Pass



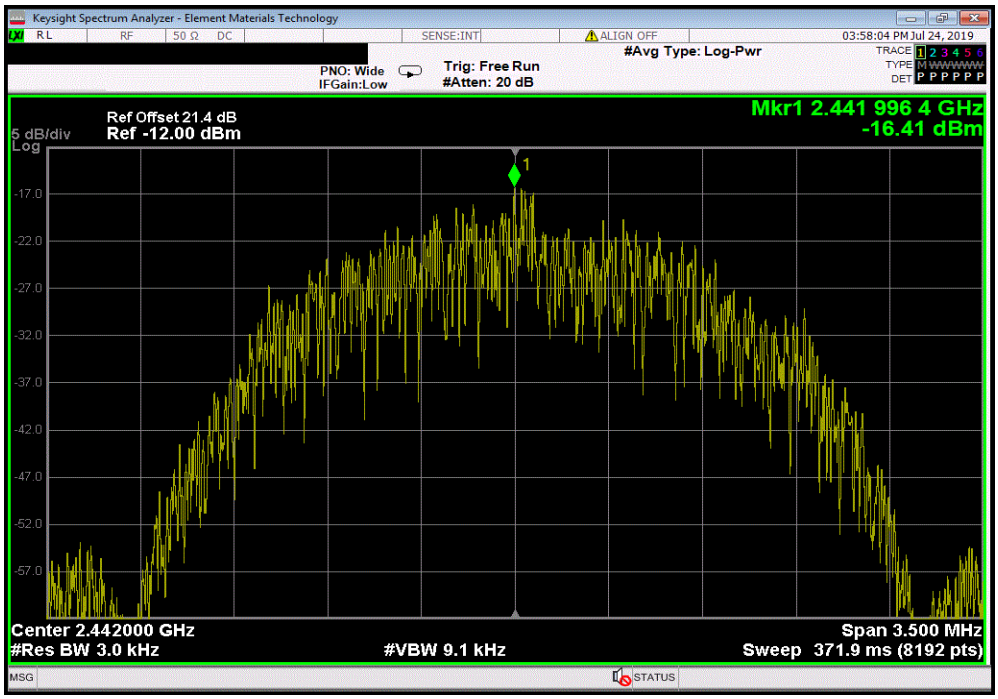
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-12.485	8	Pass



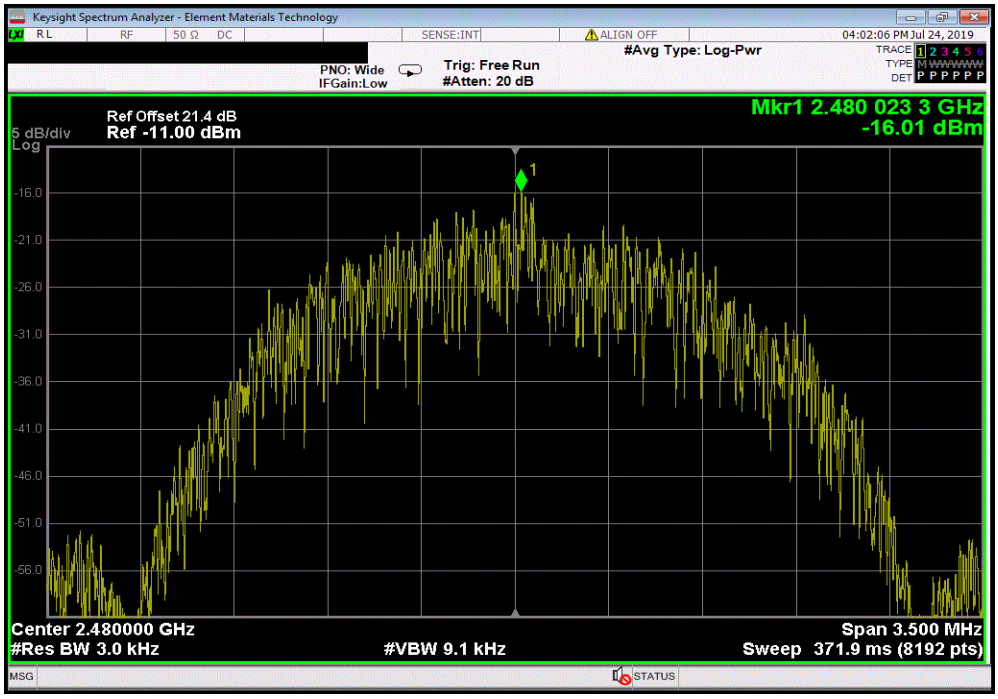
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-16.448	8	Pass



Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-16.407	8	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz						
				Value dBm/3kHz	Limit < dBm/3kHz	Results
				-16.009	8	Pass



SPURIOUS CONDUCTED EMISSIONS

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Agilent	N5183A	TIA	25-Apr-18	25-Apr-20
Cable	Micro-Coax	UFD150A-1-0720-200200	EVK	29-Mar-19	29-Mar-20
Attenuator	Fairview Microwave	SA4014-20	TKV	18-Jan-19	18-Jan-20
Block - DC	Fairview Microwave	SD3379	AMU	18-Jan-19	18-Jan-20
Analyzer - Spectrum Analyzer	Keysight	N9010A	AFO	5-May-19	5-May-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The spurious RF conducted emissions were measured with the EUT set to low, medium and high transmit frequencies. The EUT was transmitting at the data rate(s) listed in the datasheet. For each transmit frequency, the spectrum was scanned throughout the specified frequency range.

SPURIOUS CONDUCTED EMISSIONS

TbtTx 2018.09.13 XMit 2019.06.11

EUT:	Thor Radio Module AC WLAN and Bluetooth and BLE			**Work Order:**	ECHN0015
Serial Number:	Pre-production #1			**Date:**	23-Jul-19
Customer:	EchoNous, Inc.			**Temperature:**	22.5 °C
Attendees:	None			**Humidity:**	52.6% RH
Project:	None			**Barometric Pres.:**	1021 mbar
Tested by:	Brian Fahey and Jeff Alcoke	**Power:**	3.7 VDC	**Job Site:**	NC0A

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset: RF measurement cable, 20 dB attenuator, and DC Block = 21.4 dBm.

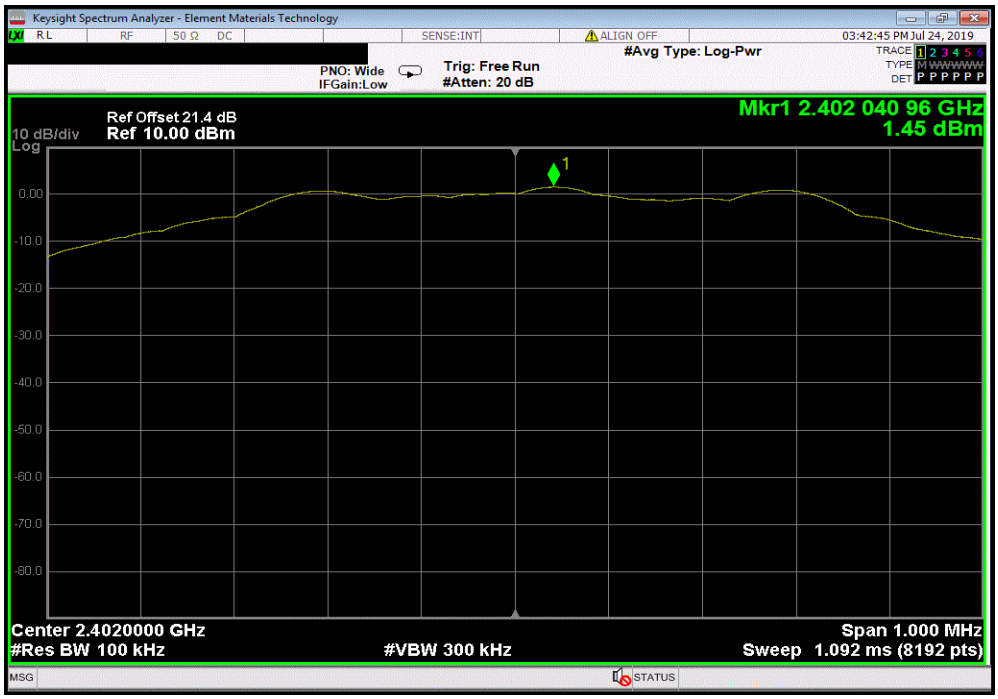
DEVIATIONS FROM TEST STANDARD

None

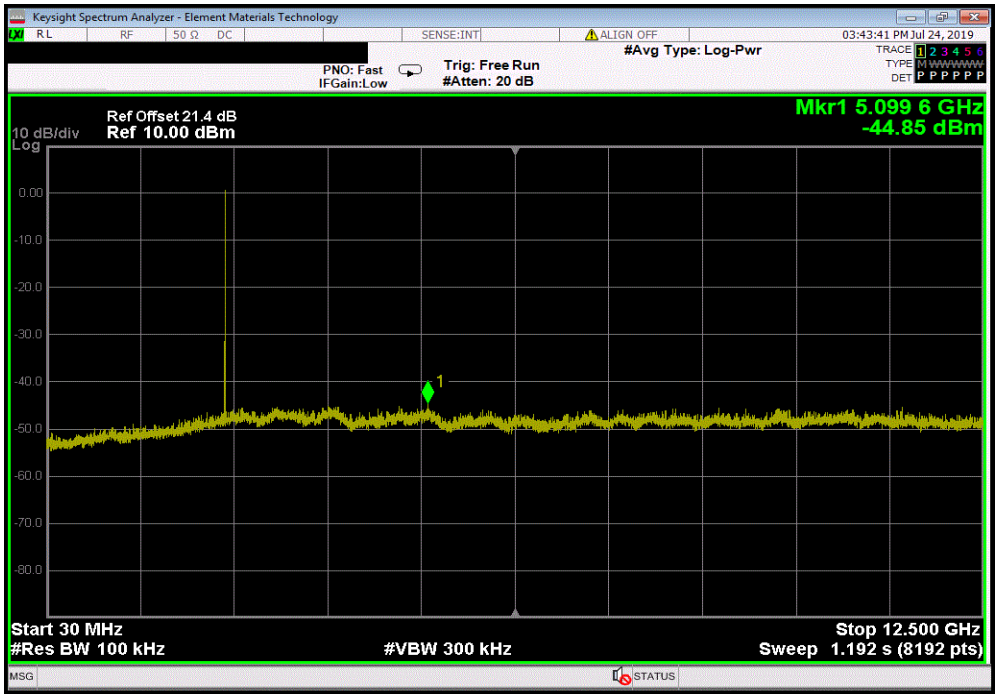
Configuration #	1	*Signature*

		Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
Mode: - LE1M						
	BLE/GFSK Low Channel, 2402 MHz	Fundamental	2402.04	N/A	N/A	N/A
	BLE/GFSK Low Channel, 2402 MHz	30 MHz - 12.5 GHz	5099.6	-46.31	-20	Pass
	BLE/GFSK Low Channel, 2402 MHz	12.5 GHz - 25 GHz	23695.21	-43.44	-20	Pass
	BLE/GFSK Mid Channel, 2442 MHz	Fundamental	2442.04	N/A	N/A	N/A
	BLE/GFSK Mid Channel, 2442 MHz	30 MHz - 12.5 GHz	5006.73	-46.17	-20	Pass
	BLE/GFSK Mid Channel, 2442 MHz	12.5 GHz - 25 GHz	23727.26	-43.29	-20	Pass
	BLE/GFSK High Channel, 2480 MHz	Fundamental	2480.04	N/A	N/A	N/A
	BLE/GFSK High Channel, 2480 MHz	30 MHz - 12.5 GHz	3158.54	-46.41	-20	Pass
	BLE/GFSK High Channel, 2480 MHz	12.5 GHz - 25 GHz	23650.96	-43.57	-20	Pass
Mode: - LE2M						
	BLE/GFSK Low Channel, 2402 MHz	Fundamental	2402.05	N/A	N/A	N/A
	BLE/GFSK Low Channel, 2402 MHz	30 MHz - 12.5 GHz	3242.27	-45.44	-20	Pass
	BLE/GFSK Low Channel, 2402 MHz	12.5 GHz - 25 GHz	23776.1	-43.37	-20	Pass
	BLE/GFSK Mid Channel, 2442 MHz	Fundamental	2442.05	N/A	N/A	N/A
	BLE/GFSK Mid Channel, 2442 MHz	30 MHz - 12.5 GHz	3750.75	-45.96	-20	Pass
	BLE/GFSK Mid Channel, 2442 MHz	12.5 GHz - 25 GHz	24665.79	-43.27	-20	Pass
	BLE/GFSK High Channel, 2480 MHz	Fundamental	2480.05	N/A	N/A	N/A
	BLE/GFSK High Channel, 2480 MHz	30 MHz - 12.5 GHz	3893.86	-46.71	-20	Pass
	BLE/GFSK High Channel, 2480 MHz	12.5 GHz - 25 GHz	24122.51	-44.01	-20	Pass

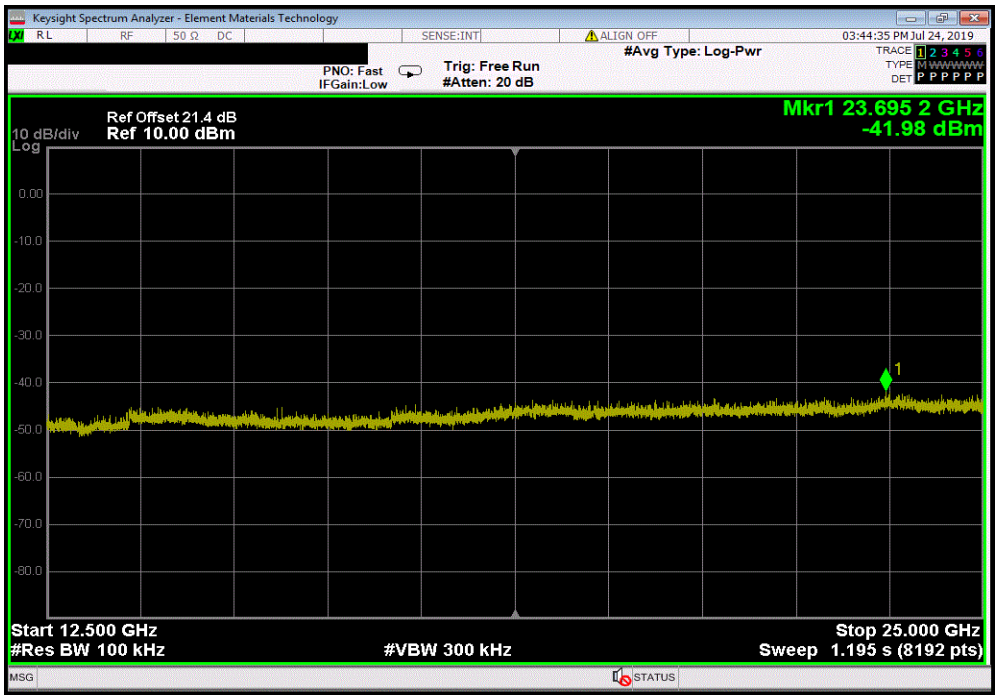
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	2402.04	N/A	N/A	N/A



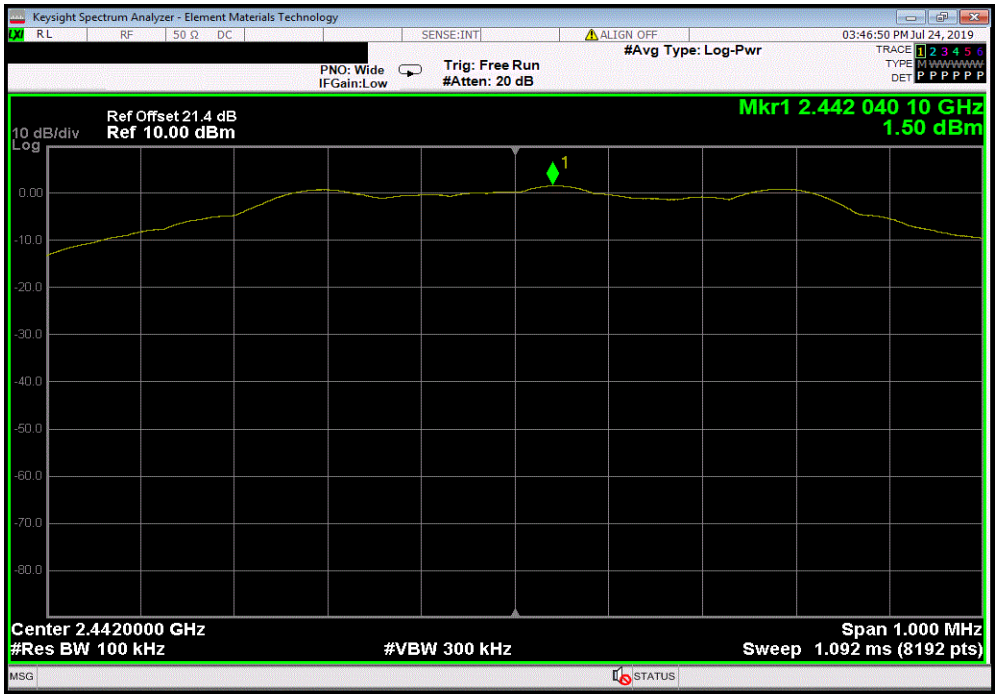
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	5099.6	-46.31	-20	Pass



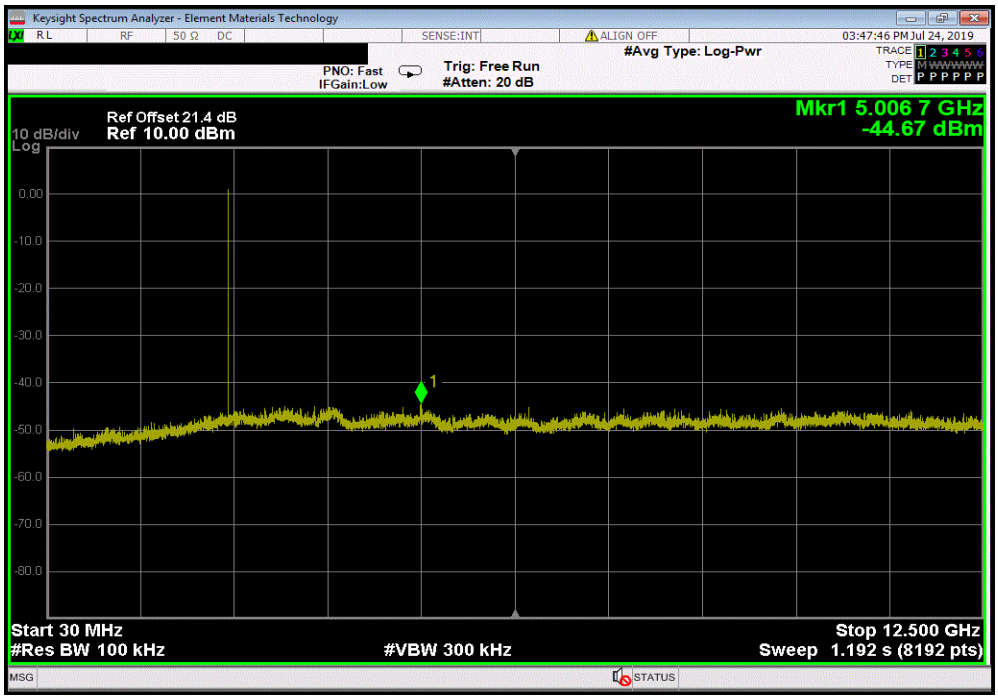
Mode: - LE1M, BLE/GFSK Low Channel, 2402 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	23695.21	-43.44	-20	Pass



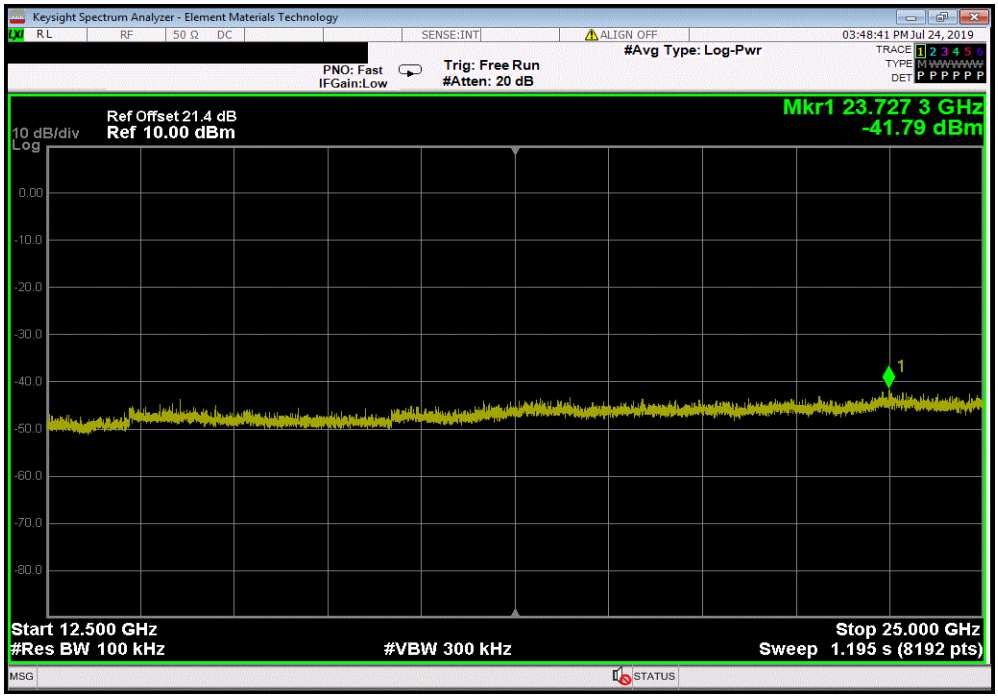
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
Fundamental	2442.04	N/A	N/A	N/A



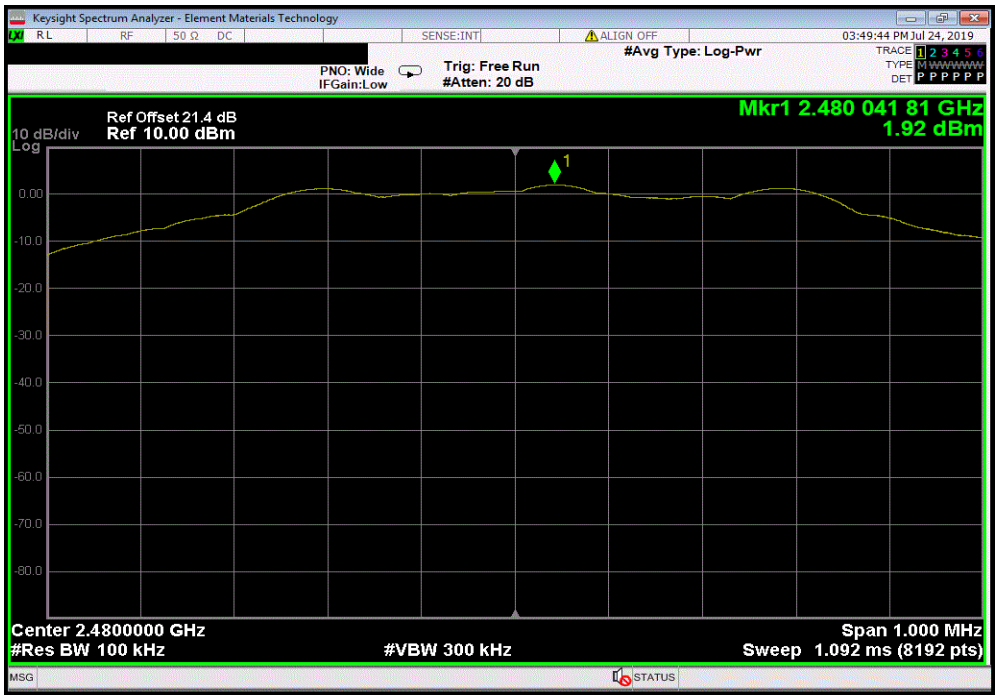
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	5006.73	-46.17	-20	Pass



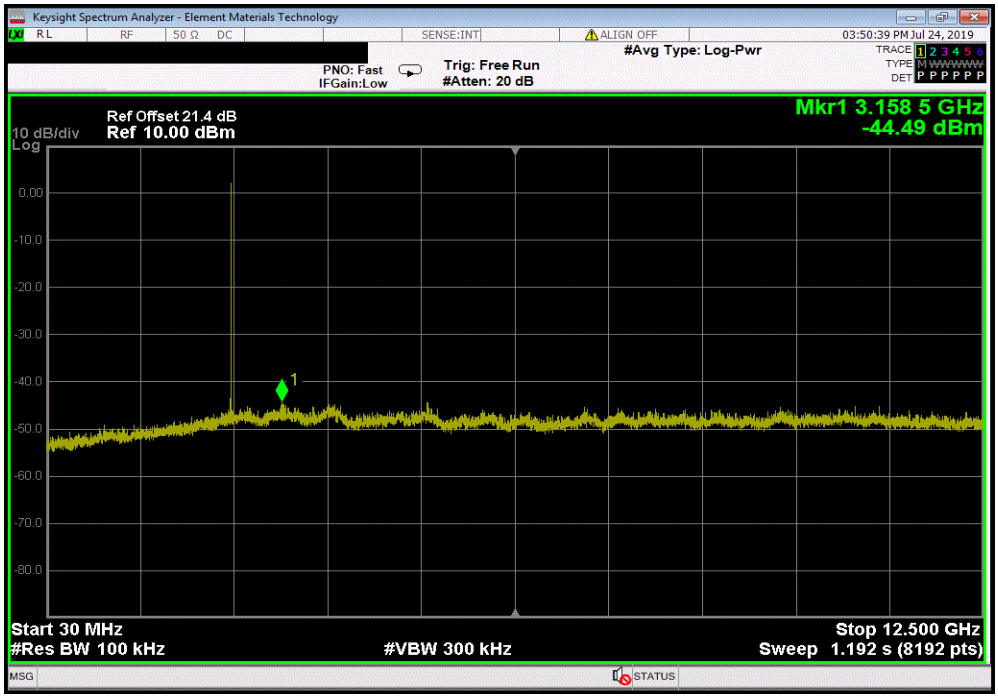
Mode: - LE1M, BLE/GFSK Mid Channel, 2442 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	23727.26	-43.29	-20	Pass



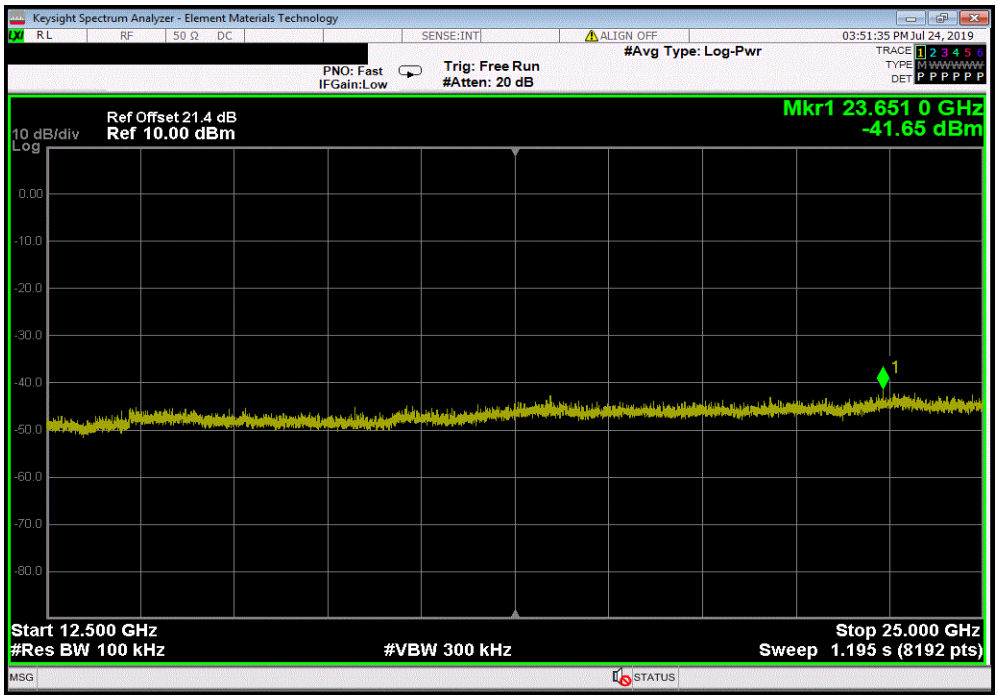
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	2480.04	N/A	N/A	N/A



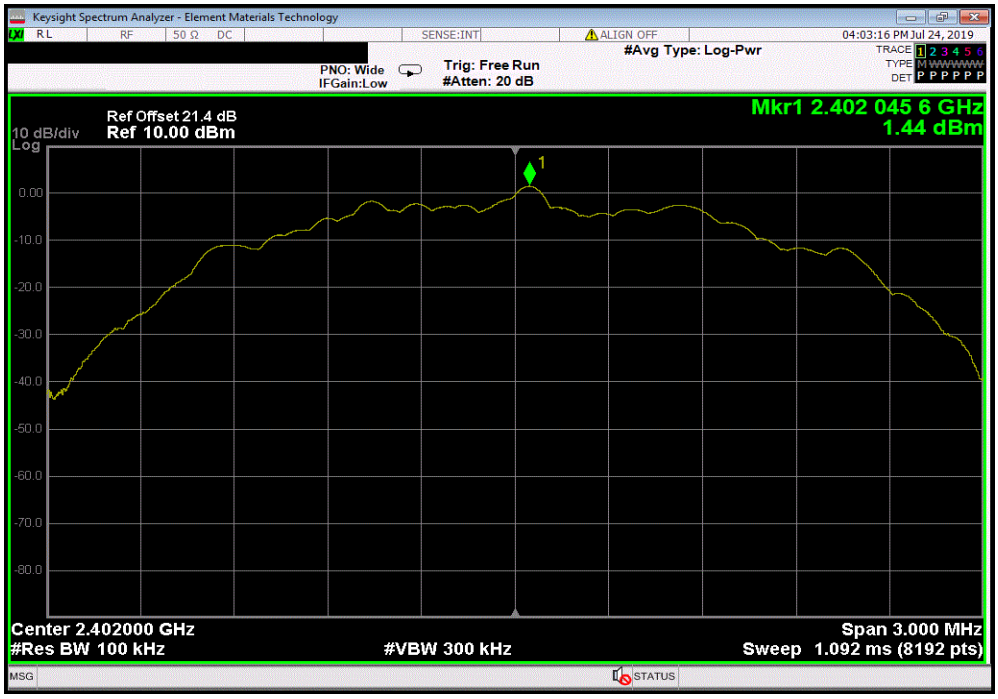
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	3158.54	-46.41	-20	Pass



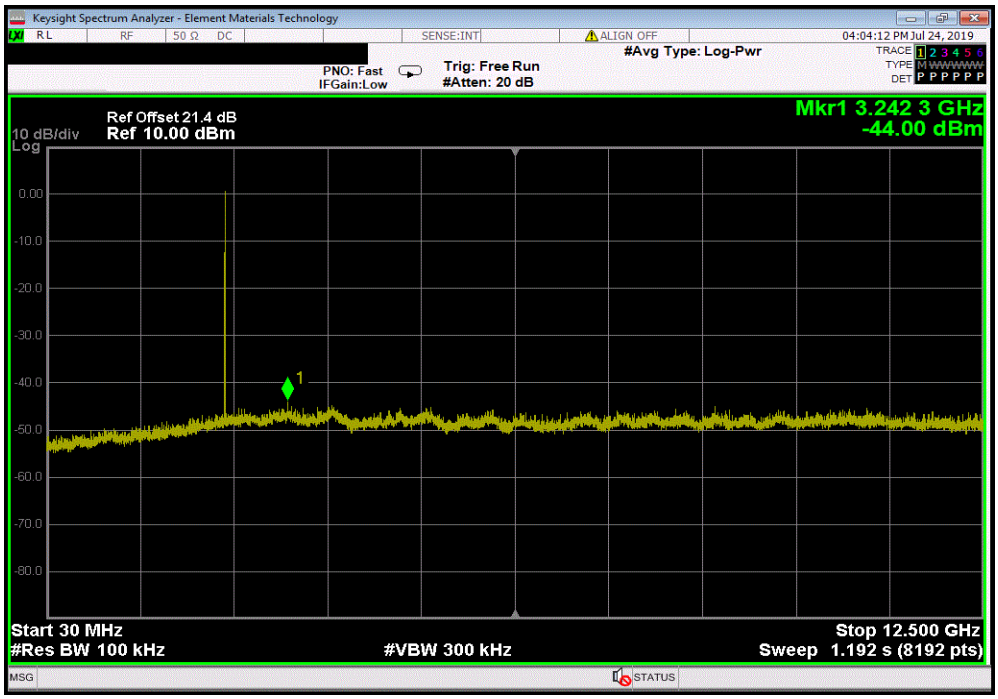
Mode: - LE1M, BLE/GFSK High Channel, 2480 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	23650.96	-43.57	-20	Pass



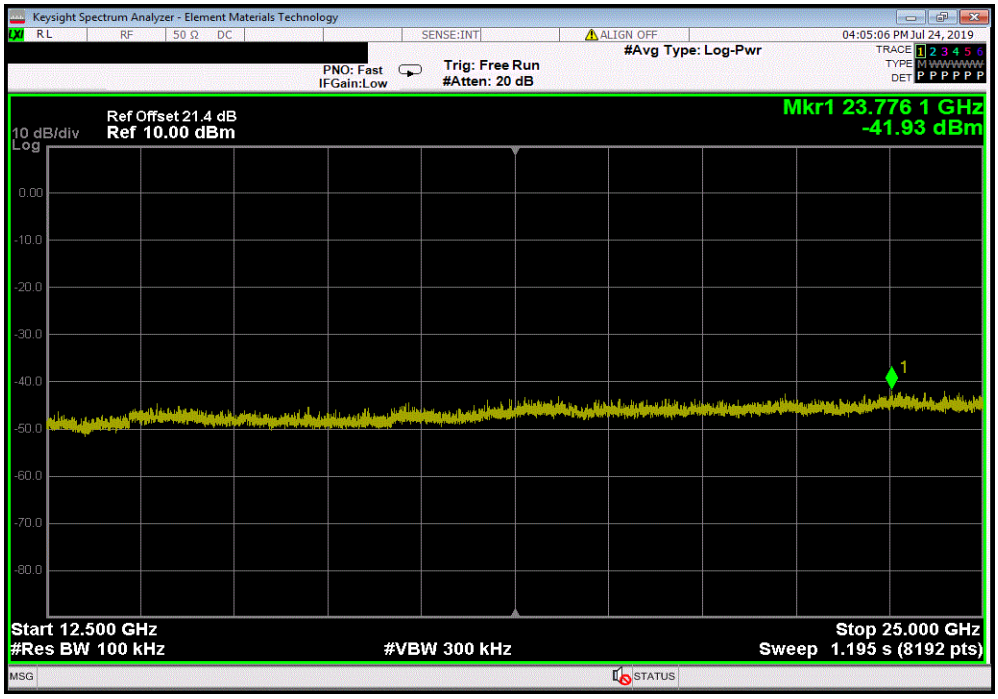
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
Fundamental	2402.05	N/A	N/A	N/A



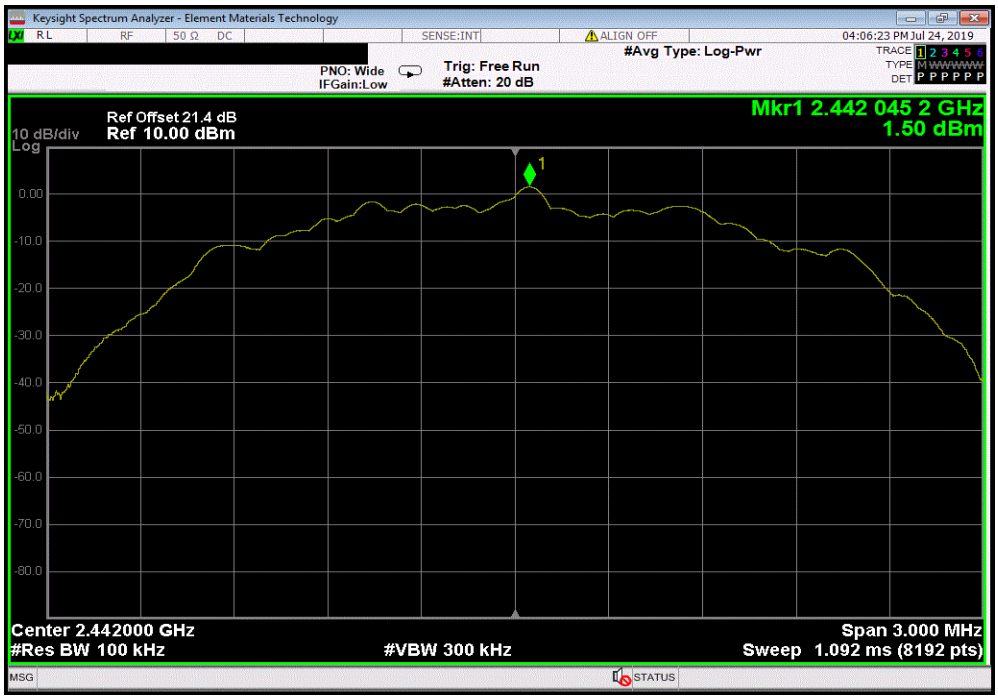
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	3242.27	-45.44	-20	Pass



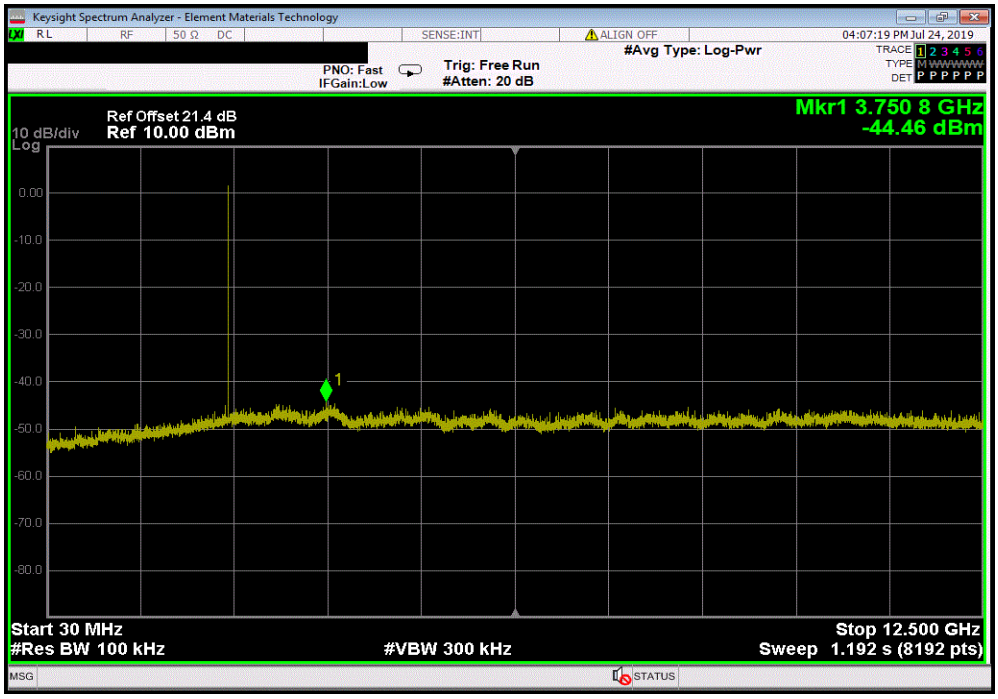
Mode: - LE2M, BLE/GFSK Low Channel, 2402 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	23776.1	-43.37	-20	Pass



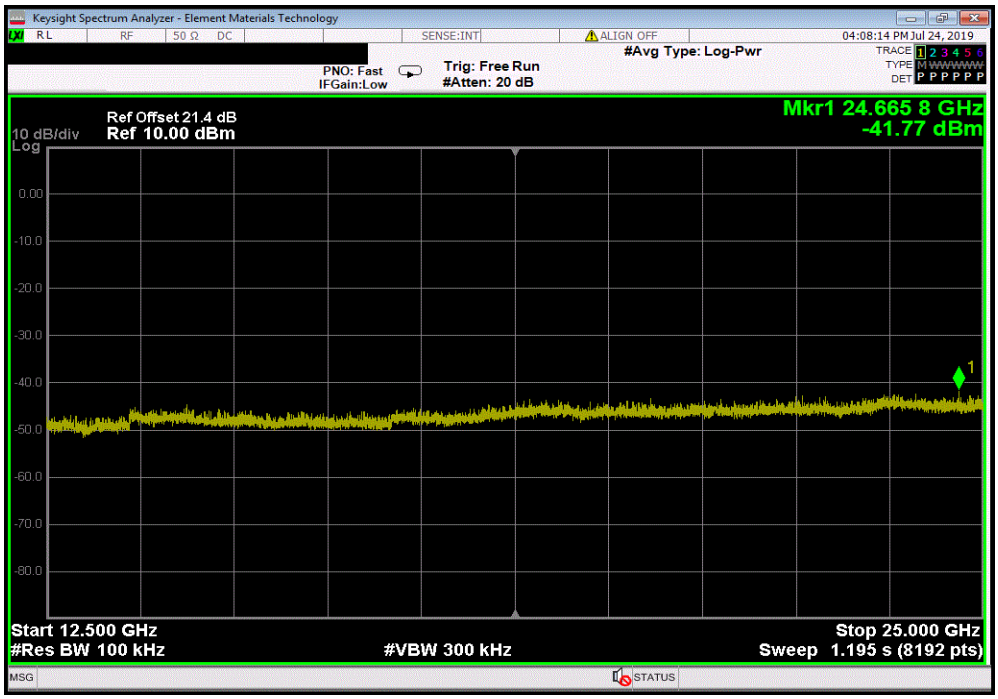
Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	2442.05	N/A	N/A	N/A



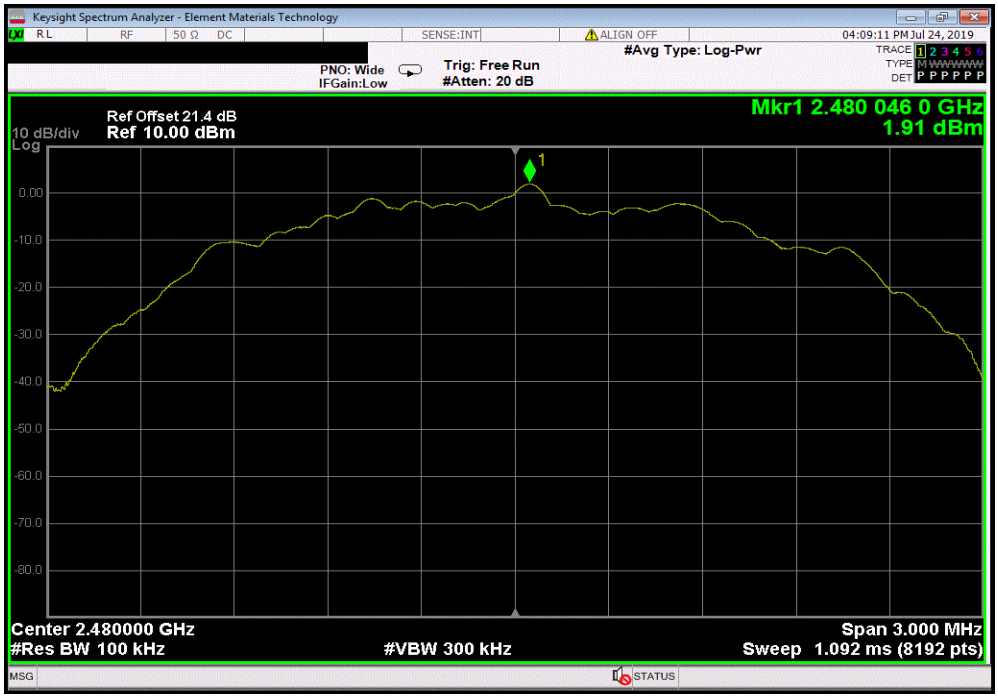
Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	3750.75	-45.96	-20	Pass



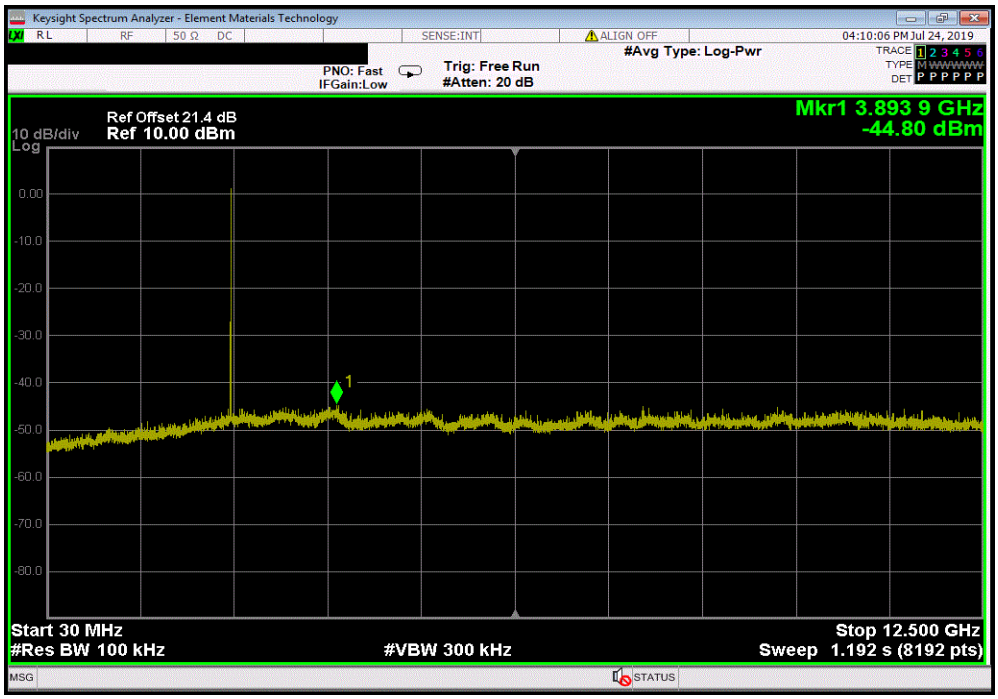
Mode: - LE2M, BLE/GFSK Mid Channel, 2442 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	24665.79	-43.27	-20	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
Fundamental	2480.05	N/A	N/A	N/A



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12.5 GHz	3893.86	-46.71	-20	Pass



Mode: - LE2M, BLE/GFSK High Channel, 2480 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
12.5 GHz - 25 GHz	24122.51	-44.01	-20	Pass