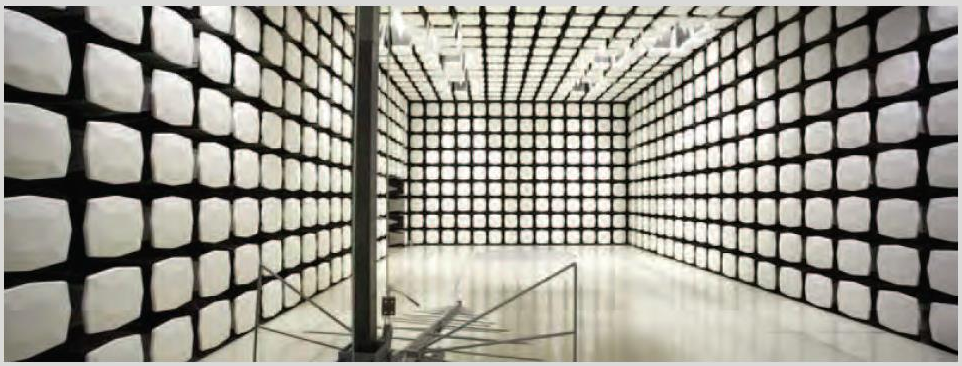
EchoNous, Inc.

Thor Radio Module AC WLAN and Bluetooth and BLE

FCC 15.247:2019

Bluetooth (FHSS) Radio

Report # ECHN0015.6



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

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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
FCC 15.247:2019	

Results

Method Clause	Test Description	Applied	Results	Comments
6.2	Powerline Conducted Emissions	Yes	Pass	
6.5, 6.6	Spurious Radiated Emissions	Yes	Pass	
7.5	Duty Cycle	Yes	N/A	
7.8.2	Carrier Frequency Separation	Yes	Pass	
7.8.3	Number of Hopping Frequencies	Yes	Pass	
7.8.4	Dwell Time	Yes	Pass	
7.8.5	Output Power	Yes	Pass	
7.8.5	Equivalent Isotropic Radiated Power	Yes	Pass	
7.8.6	Band Edge Compliance	Yes	Pass	
7.8.6	Band Edge Compliance - Hopping Mode	Yes	Pass	
7.8.7	Occupied Bandwidth	Yes	Pass	
7.8.8	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

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Hong Kong

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

Vietnam

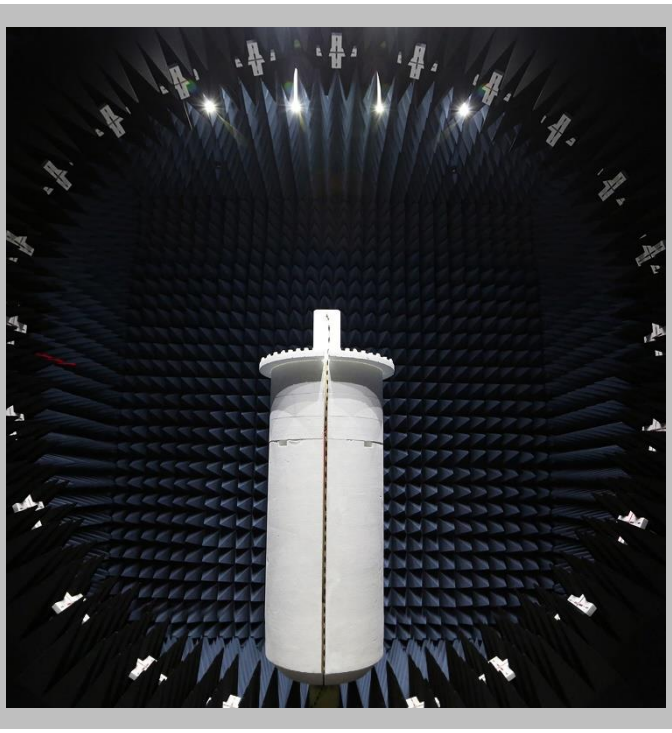
MIC – Recognized by MIC as a CAB for the acceptance of test data.

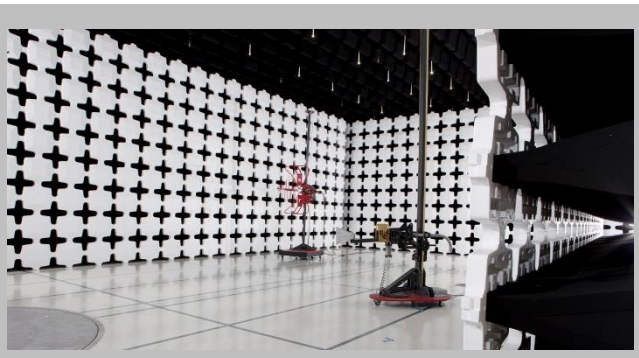
SCOPE

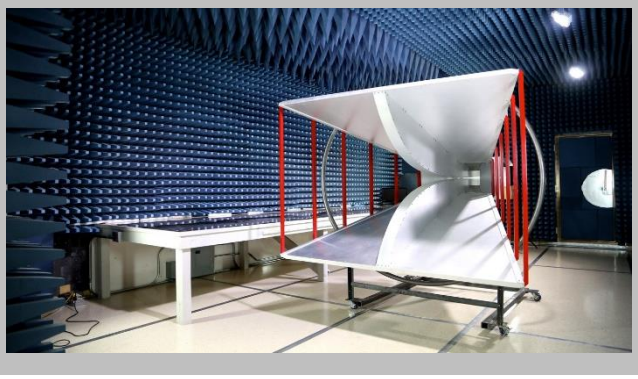
For details on the Scopes of our Accreditations, please visit:
https://www.nwemc.com/emc-testing-accreditations

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.

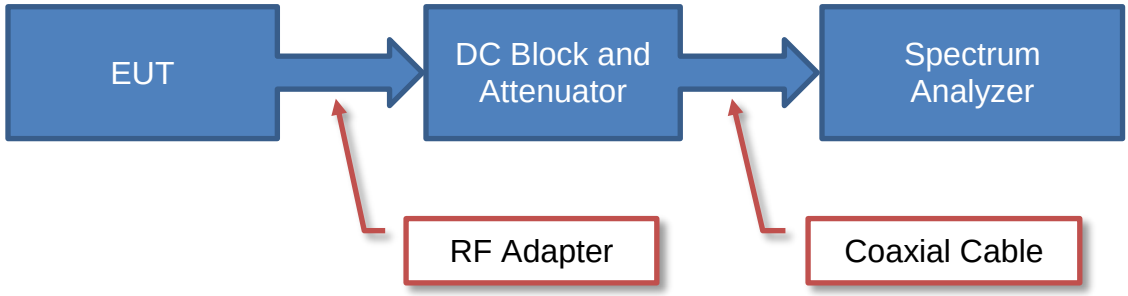
A measurement uncertainty estimation has been performed for each test per our internal quality document QM205.4.6. The estimation is used to compare the measured result with its "true" or theoretically correct value. The expanded measurement uncertainty (K=2) can be found included as part of the applicable 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.

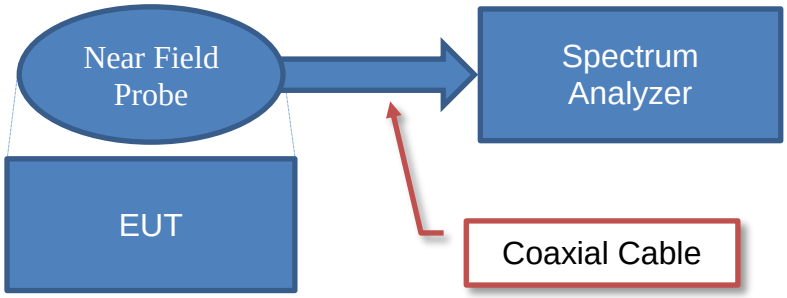
Test	+ MU	- MU
Frequency Accuracy	0.0007%	-0.0007%
Amplitude Accuracy (dB)	1.2 dB	-1.2 dB
Conducted Power (dB)	1.2 dB	-1.2 dB
Radiated Power via Substitution (dB)	0.7 dB	-0.7 dB
Temperature (degrees C)	0.7°C	-0.7°C
Humidity (% RH)	2.5% RH	-2.5% RH
Voltage (AC)	1.0%	-1.0%
Voltage (DC)	0.7%	-0.7%
Field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

Test Setup Block Diagrams

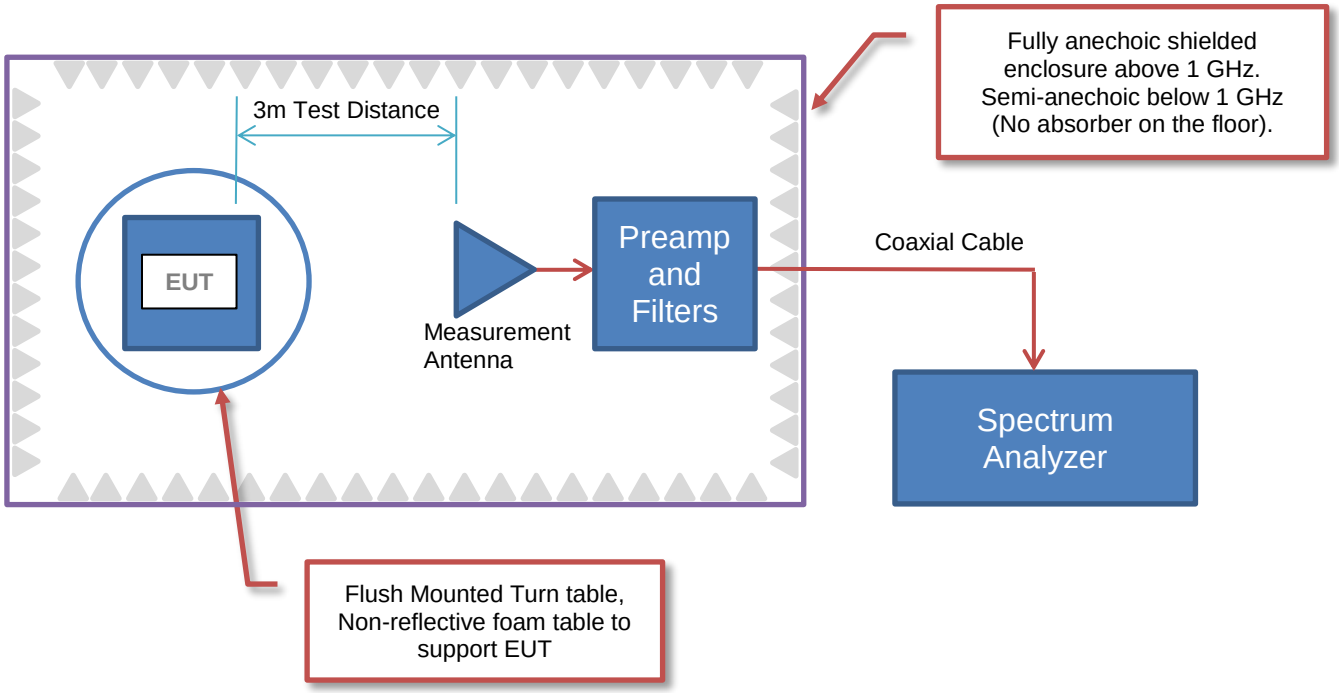
Antenna Port Conducted Measurements



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 17, 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 (FHSS) 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	2019-07-17	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.
2	2019-07-17	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.
3	2019-07-17	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.
4	2019-07-17	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.
5	2019-07-24	Number of Hopping Frequencies	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	2019-07-24	Dwell Time	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	2019-07-24	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	2019-08-01	Carrier Frequency Separation	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	2019-08-01	Band Edge Compliance - Hopping Mode	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
10	2019-08-02	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.
11	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.
12	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

The EUT was tested using the power settings provided by the manufacturer:

SETTINGS FOR ALL TESTS IN THIS REPORT

Modulation Types	Type	Channel	Position	Frequency (MHz)	Power Setting
DH5, 2DH5, 3DH5	FHSS	0 or 1	Low Channel	2402	9
		39	Mid Channel	2440 or 2441	9
		78 or 79	High Channel	2480	9

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

BT FHSS, Tx, DH5, Mid Ch. 2441 MHz

POWERLINE CONDUCTED EMISSIONS

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

COMMENTS

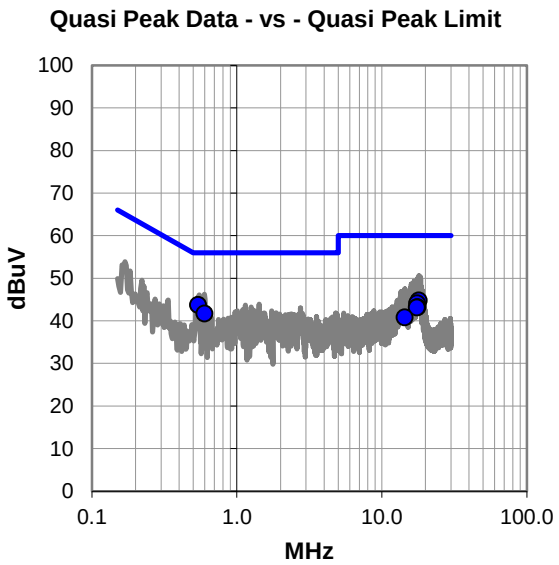
None

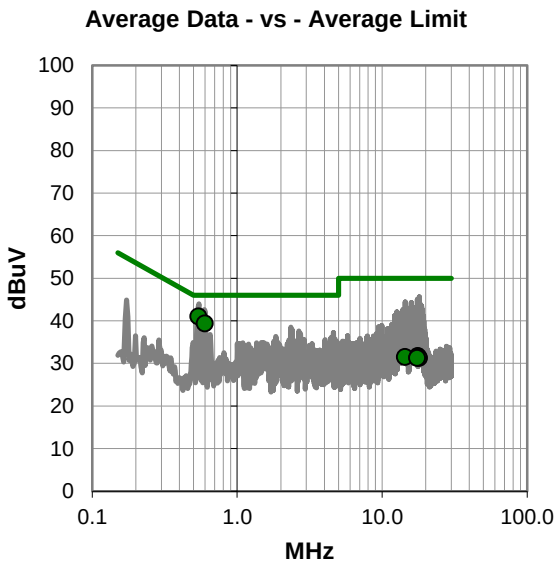
EUT OPERATING MODES

BT FHSS, Tx, DH5, Mid Ch. 2441 MHz

DEVIATIONS FROM TEST STANDARD

None





POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

RESULTS - Run #20

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.5	23.800	19.9	43.7	56.0	-12.3
0.6	21.800	19.9	41.7	56.0	-14.3
18.0	24.200	20.6	44.8	60.0	-15.2
17.5	23.500	20.6	44.1	60.0	-15.9
17.6	22.600	20.6	43.2	60.0	-16.8
17.5	22.500	20.6	43.1	60.0	-16.9
14.4	20.400	20.4	40.8	60.0	-19.2

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.5	21.100	19.9	41.0	46.0	-5.0
0.6	19.500	19.9	39.4	46.0	-6.6
17.6	11.100	20.6	31.7	50.0	-18.3
14.4	11.100	20.4	31.5	50.0	-18.5
17.5	10.800	20.6	31.4	50.0	-18.6
18.0	10.700	20.6	31.3	50.0	-18.7
17.5	10.700	20.6	31.3	50.0	-18.7

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS

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

COMMENTS

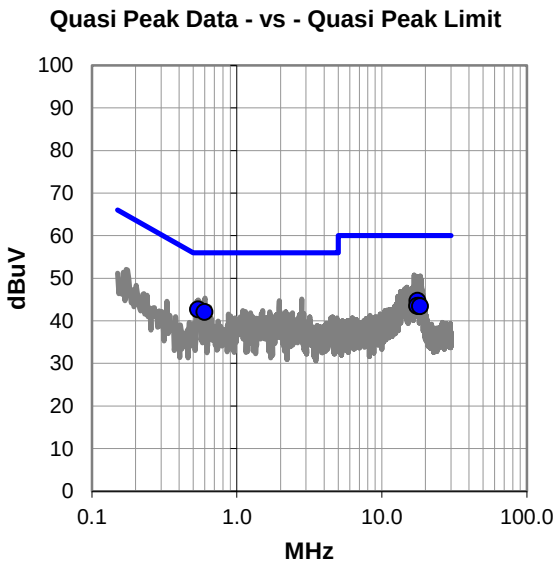
None

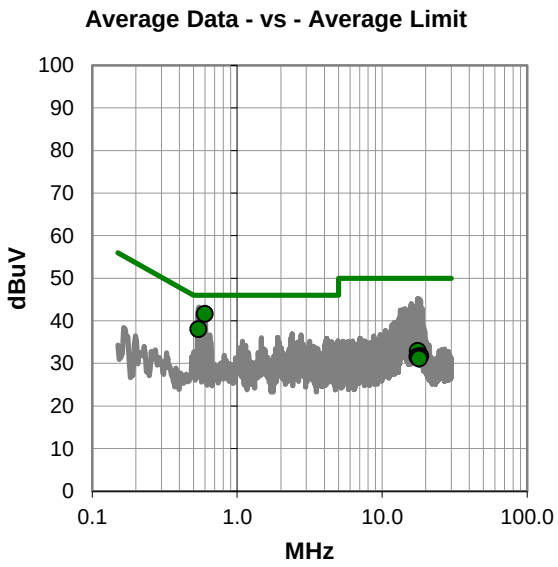
EUT OPERATING MODES

BT FHSS, Tx, DH5, Mid Ch. 2441 MHz

DEVIATIONS FROM TEST STANDARD

None





POWERLINE CONDUCTED EMISSIONS

element
WTD.2019.10.29.0

RESULTS - Run #21

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.5	22.800	19.9	42.7	56.0	-13.3
0.6	22.200	19.9	42.1	56.0	-13.9
17.6	24.100	20.6	44.7	60.0	-15.3
18.0	22.900	20.6	43.5	60.0	-16.5
18.0	22.900	20.6	43.5	60.0	-16.5
17.5	22.900	20.6	43.5	60.0	-16.5
18.4	22.700	20.7	43.4	60.0	-16.6

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.6	21.700	19.9	41.6	46.0	-4.4
0.5	18.100	19.9	38.0	46.0	-8.0
17.6	12.300	20.6	32.9	50.0	-17.1
18.4	11.000	20.7	31.7	50.0	-18.3
17.5	11.000	20.6	31.6	50.0	-18.4
18.0	10.800	20.6	31.4	50.0	-18.6
18.0	10.500	20.6	31.1	50.0	-18.9

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

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:	17-Jul-19
Customer:	EchoNous, Inc.	Temperature:	22.4 °C
Attendees:	None	Humidity:	59.2% RH
Project:	None	Barometric Pres.:	1015 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

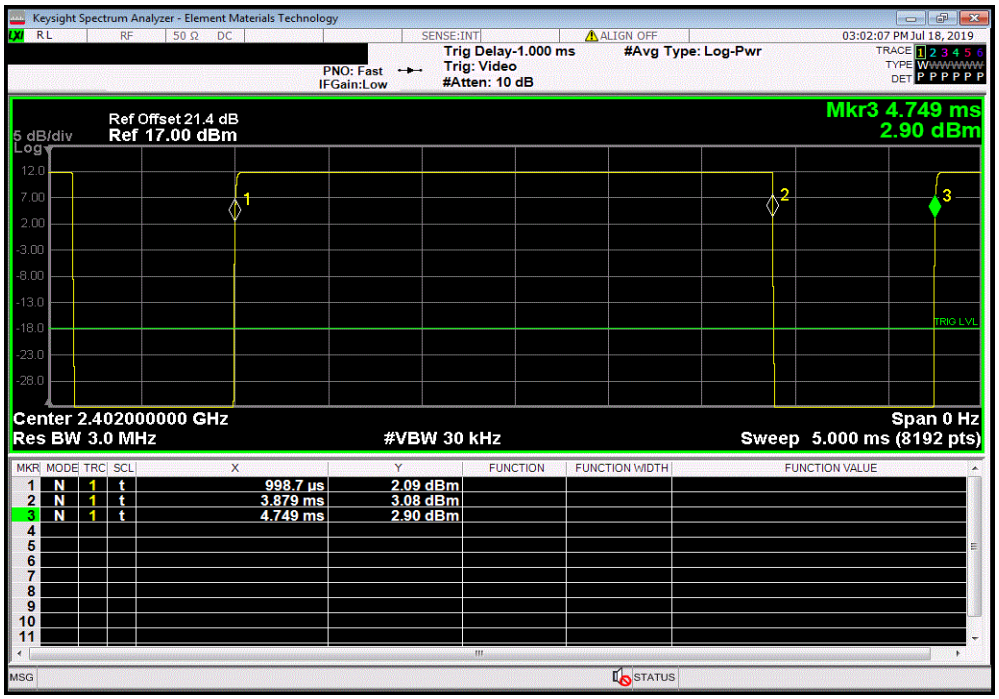
Configuration #	1	Signature

		Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
DH5, GFSK							
	Low Channel, 2402 MHz	2.88 ms	3.75 ms	1	76.8	N/A	N/A
	Low Channel, 2402 MHz	N/A	N/A	5	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.88 ms	3.75 ms	1	76.8	N/A	N/A
	Mid Channel, 2441 MHz	N/A	N/A	5	N/A	N/A	N/A
	High Channel, 2480 MHz	2.879 ms	3.75 ms	1	76.8	N/A	N/A
	High Channel, 2480 MHz	N/A	N/A	5	N/A	N/A	N/A
2DH5, pi/4-DQPSK							
	Low Channel, 2402 MHz	2.373 ms	3.75 ms	1	63.3	N/A	N/A
	Low Channel, 2402 MHz	N/A	N/A	5	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.374 ms	3.751 ms	1	63.3	N/A	N/A
	Mid Channel, 2441 MHz	N/A	N/A	5	N/A	N/A	N/A
	High Channel, 2480 MHz	2.373 ms	3.75 ms	1	63.3	N/A	N/A
	High Channel, 2480 MHz	N/A	N/A	5	N/A	N/A	N/A
3DH5, 8-DPSK							
	Low Channel, 2402 MHz	2.884 ms	3.75 ms	1	76.9	N/A	N/A
	Low Channel, 2402 MHz	N/A	N/A	5	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.884 ms	3.75 ms	1	76.9	N/A	N/A
	Mid Channel, 2441 MHz	N/A	N/A	5	N/A	N/A	N/A
	High Channel, 2480 MHz	2.883 ms	3.75 ms	1	76.9	N/A	N/A
	High Channel, 2480 MHz	N/A	N/A	5	N/A	N/A	N/A

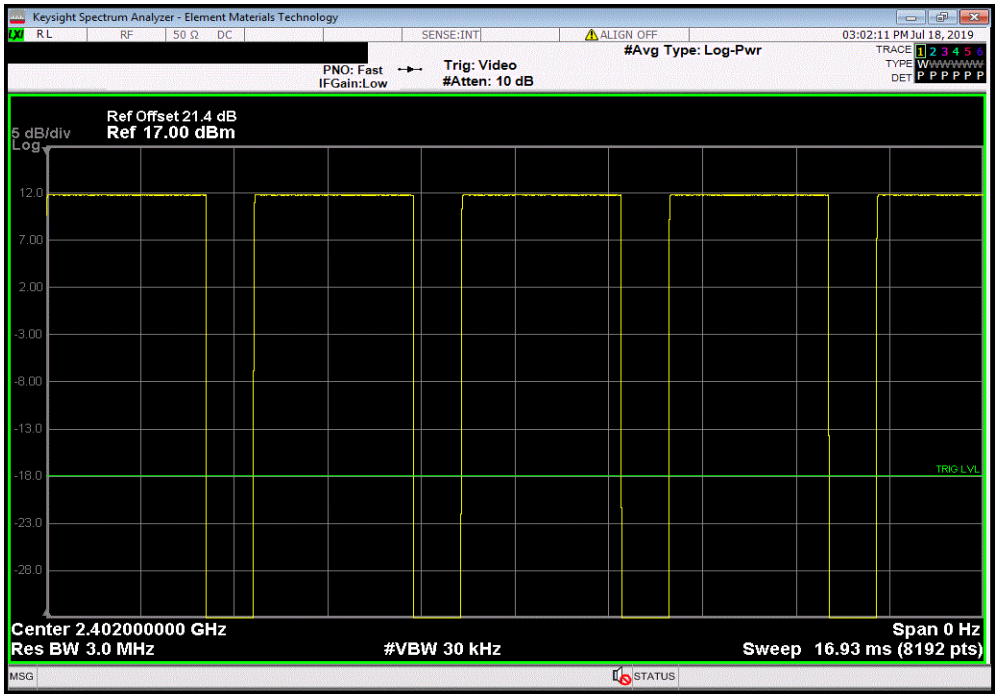
DUTY CYCLE

TbtTx 2018.09.13 XMit 2019.06.11

DH5, GFSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.88 ms	3.75 ms	1	76.8	N/A	N/A

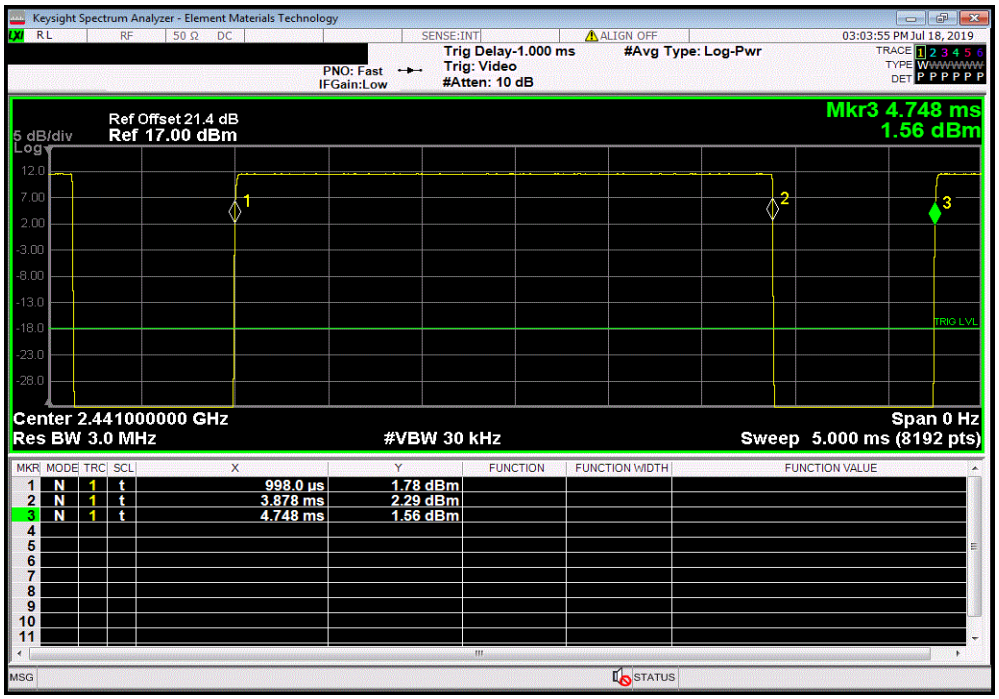


DH5, GFSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

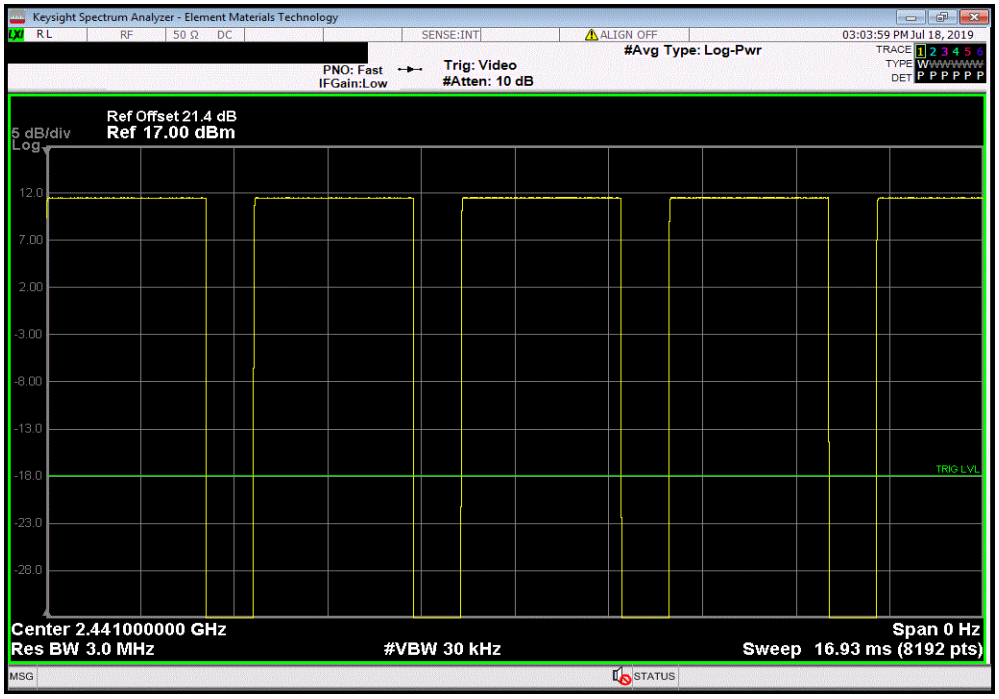


DUTY CYCLE

DH5, GFSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.88 ms	3.75 ms	1	76.8	N/A	N/A



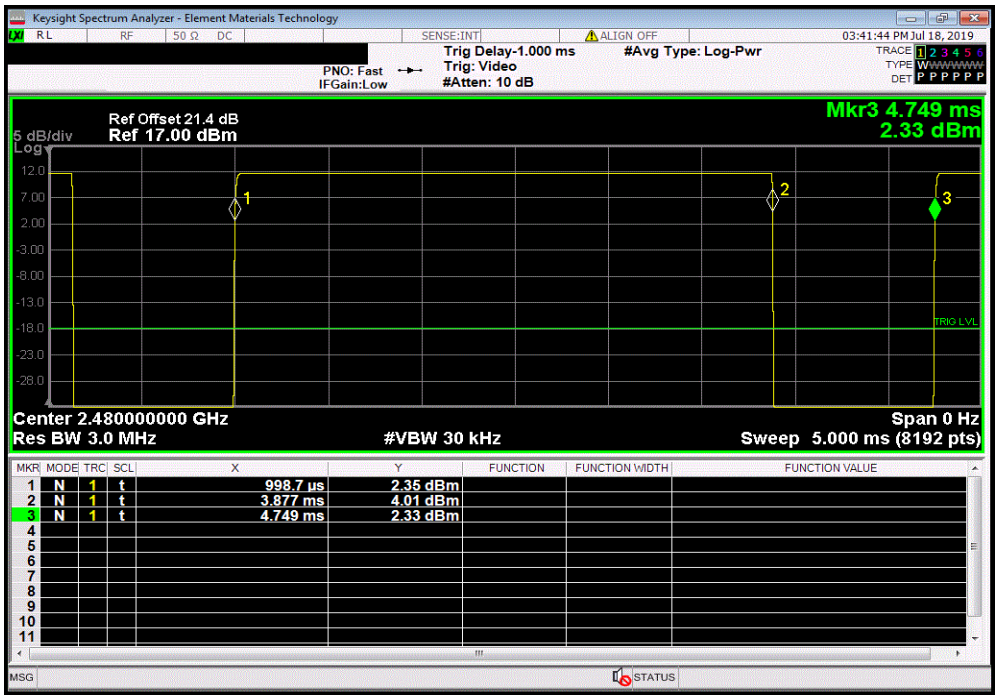
DH5, GFSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A



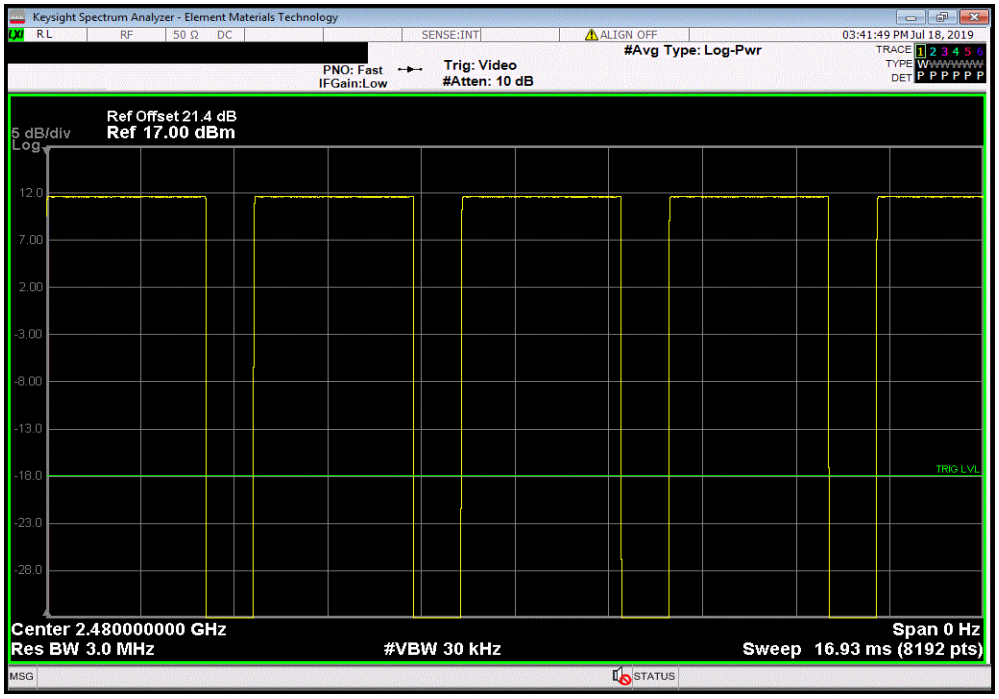
DUTY CYCLE

TbtTx 2018.09.13 XMit 2019.06.11

DH5, GFSK, High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.879 ms	3.75 ms	1	76.8	N/A	N/A



DH5, 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

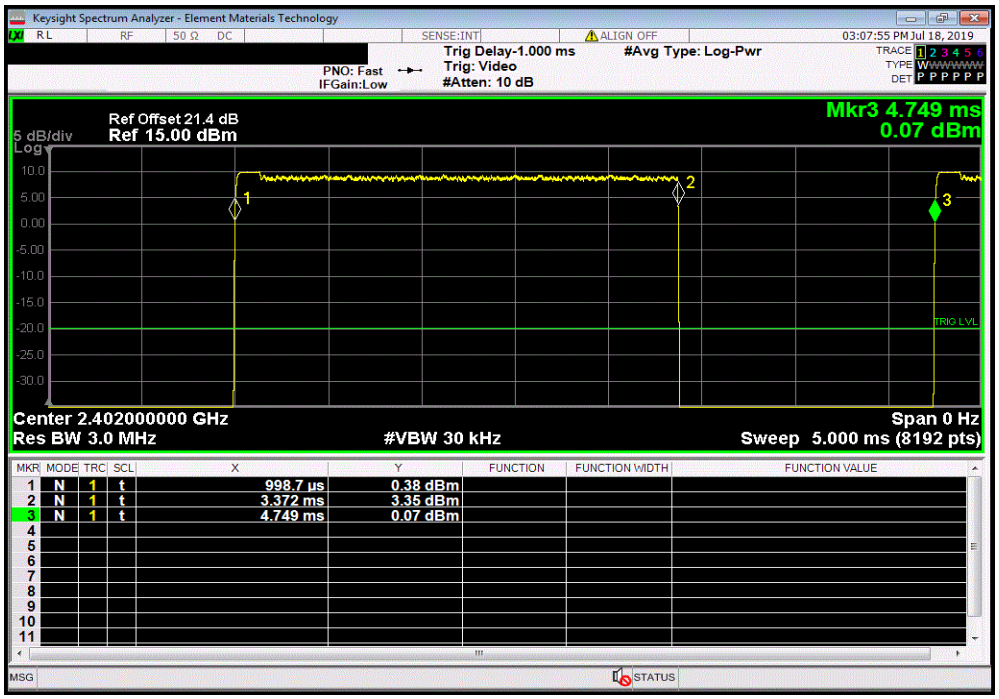


DUTY CYCLE

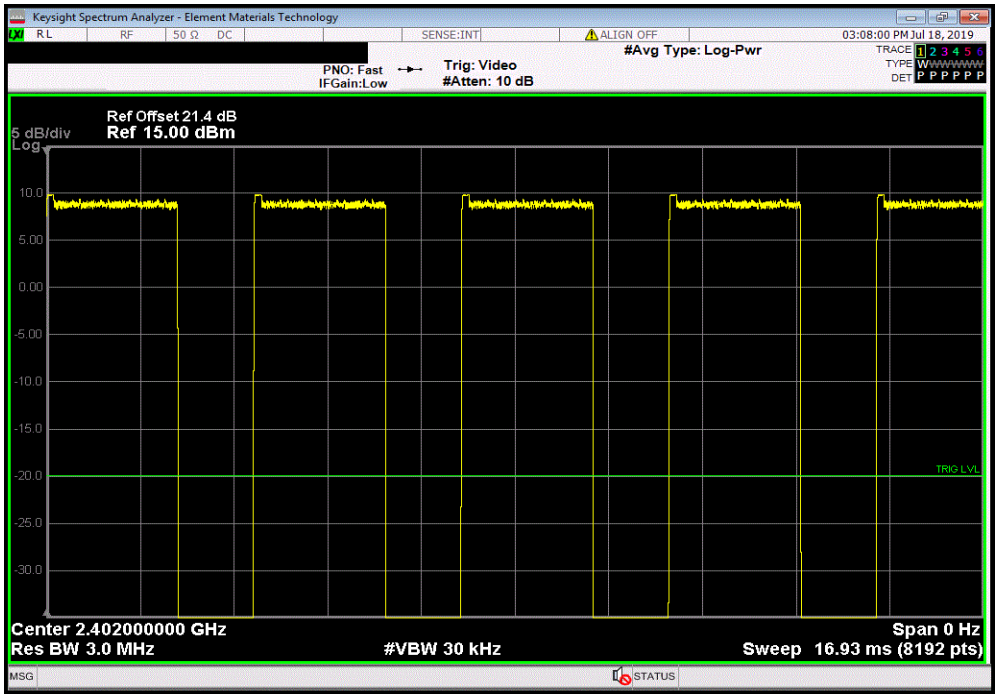
element

TbtTx 2018.09.13 XMit 2019.06.11

2DH5, pi/4-DQPSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.373 ms	3.75 ms	1	63.3	N/A	N/A



2DH5, pi/4-DQPSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

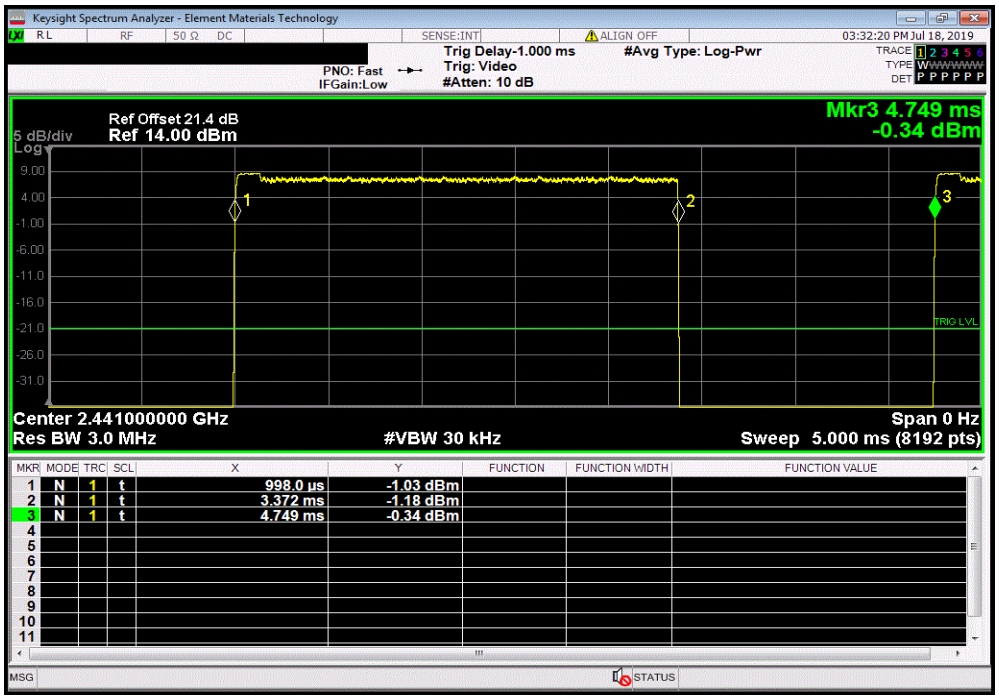


DUTY CYCLE

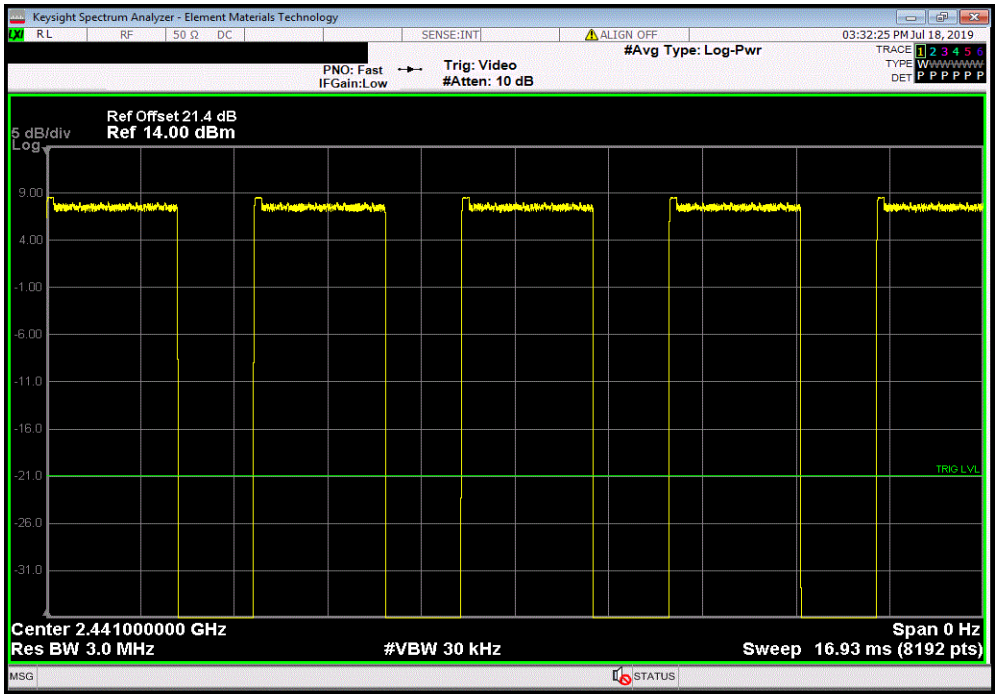
element

TbtTx 2018.09.13 XMit 2019.06.11

2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.374 ms	3.751 ms	1	63.3	N/A	N/A

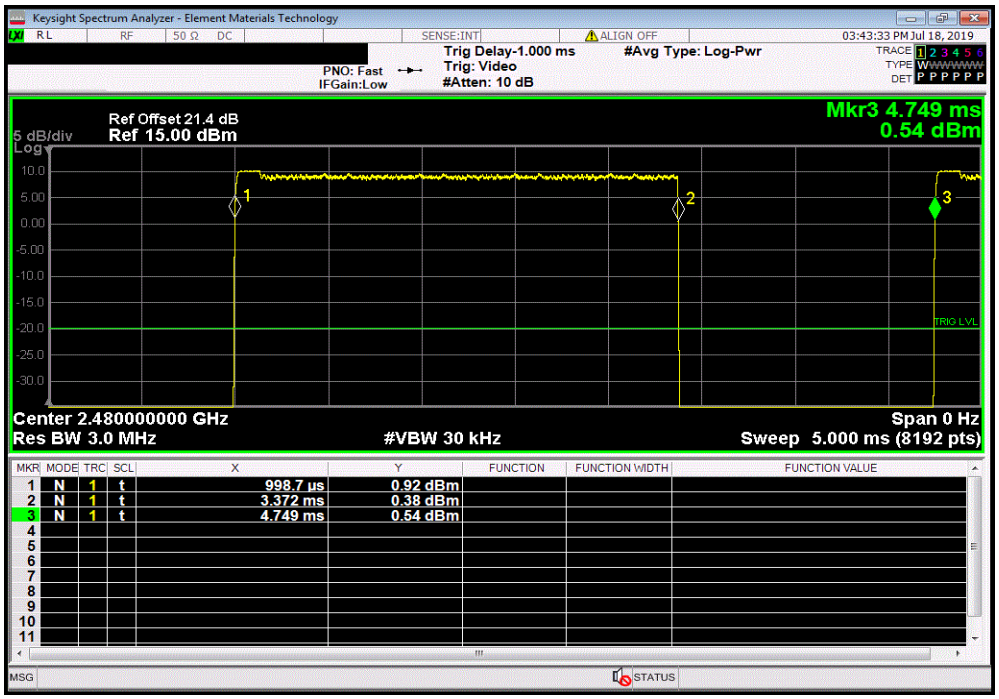


2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

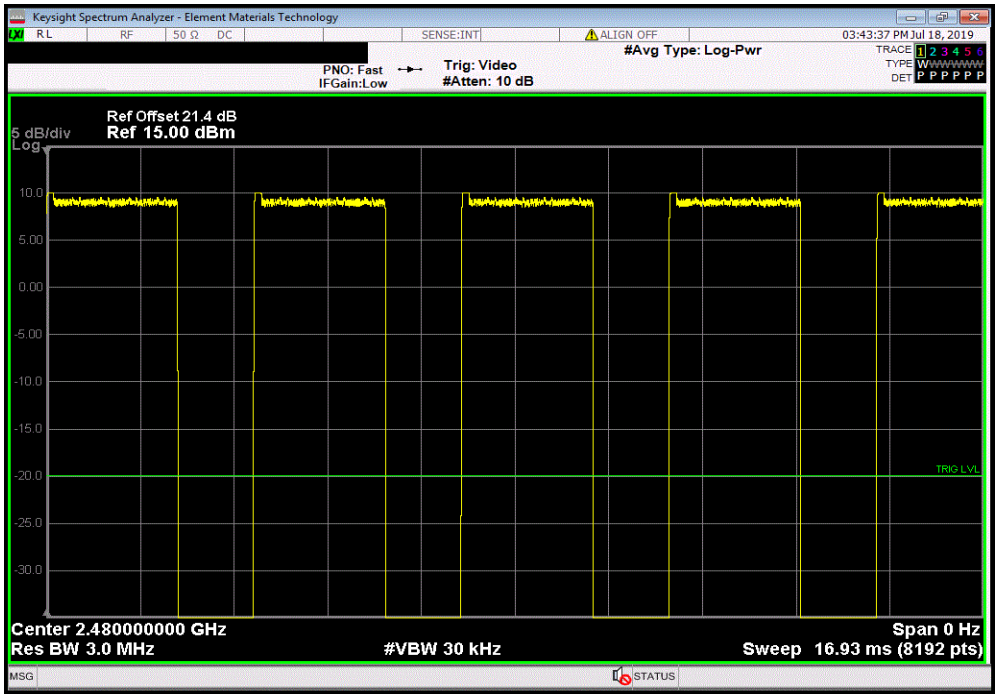


DUTY CYCLE

2DH5, pi/4-DQPSK, High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.373 ms	3.75 ms	1	63.3	N/A	N/A



2DH5, pi/4-DQPSK, High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

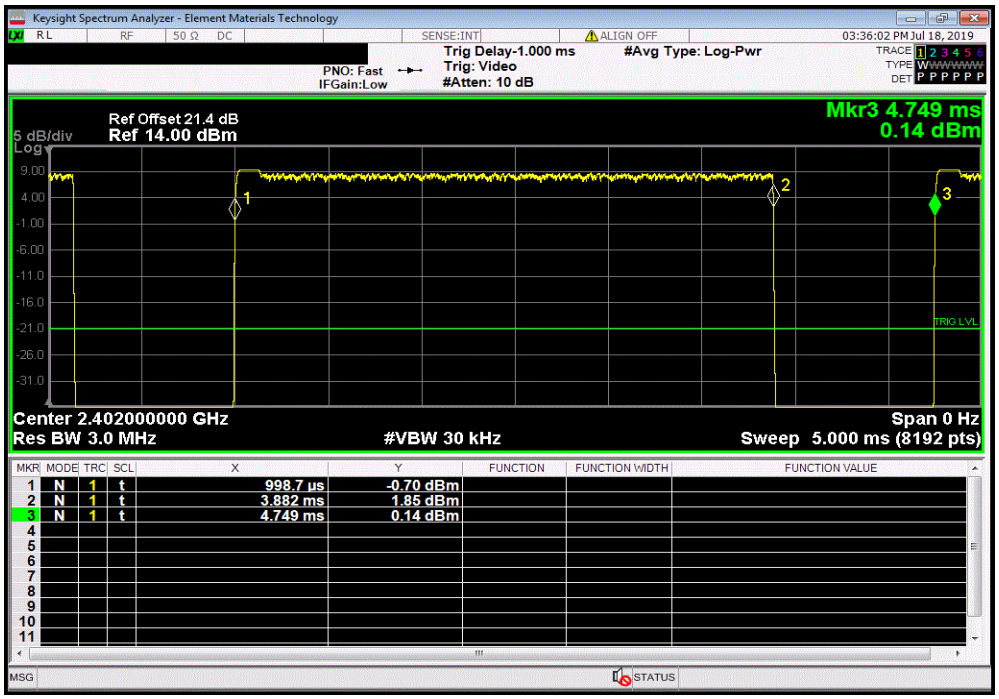


DUTY CYCLE

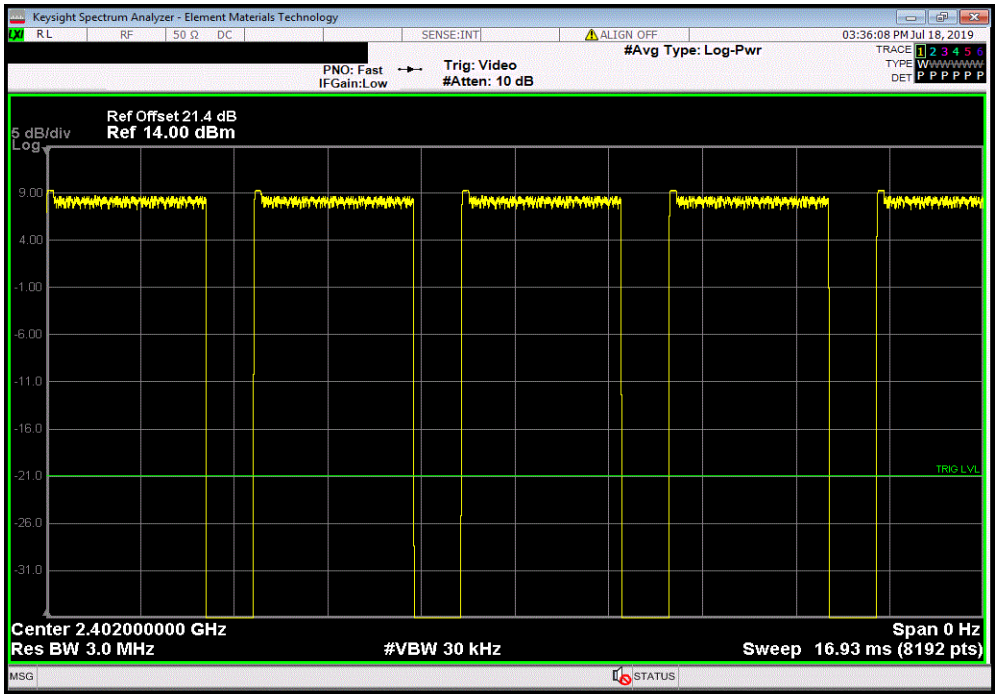
element

TbtTx 2018.09.13 XMit 2019.06.11

3DH5, 8-DPSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.884 ms	3.75 ms	1	76.9	N/A	N/A

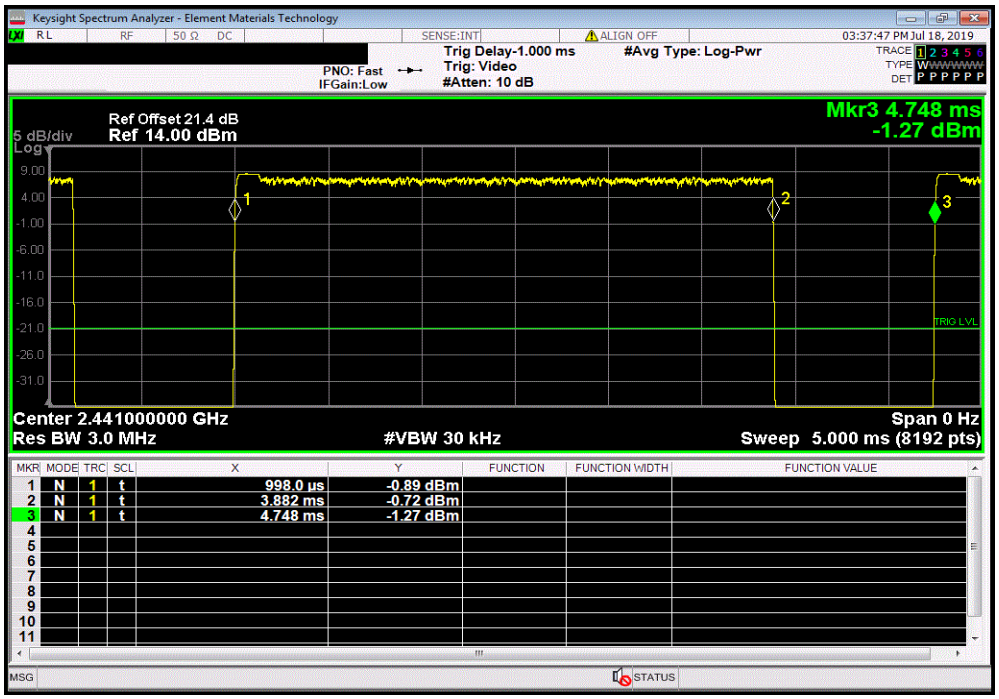


3DH5, 8-DPSK, Low Channel, 2402 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

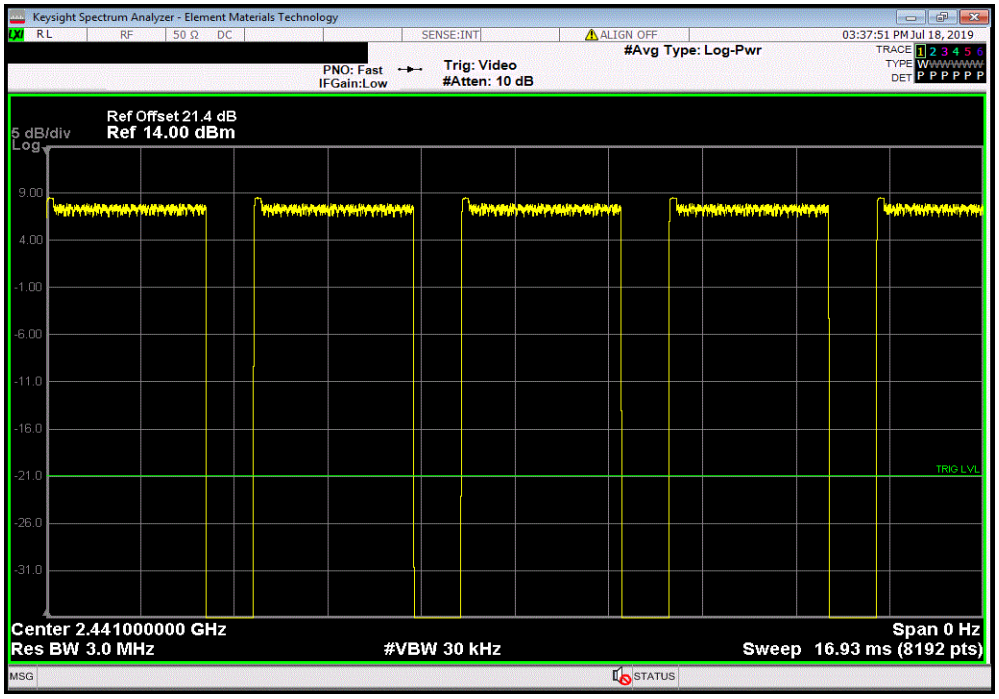


DUTY CYCLE

3DH5, 8-DPSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.884 ms	3.75 ms	1	76.9	N/A	N/A



3DH5, 8-DPSK, Mid Channel, 2441 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

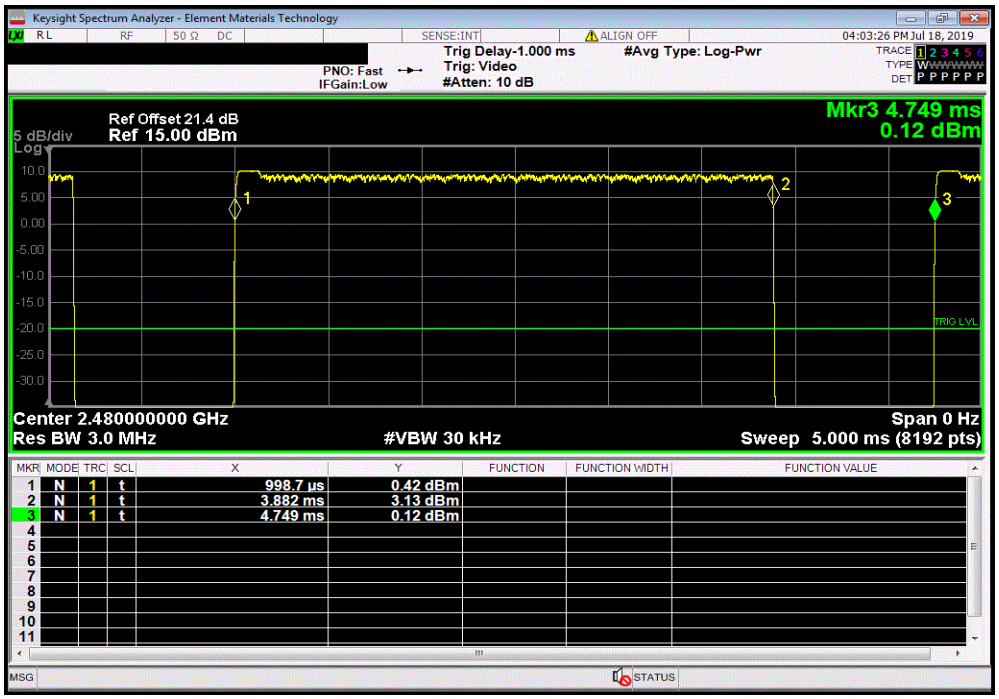


DUTY CYCLE

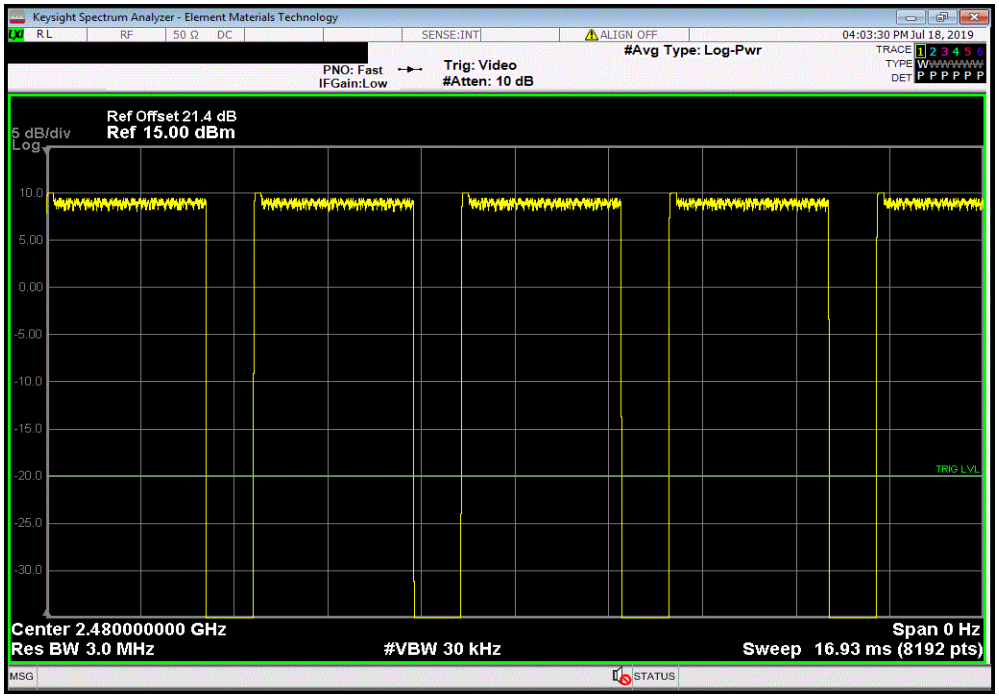
element

TbtTx 2018.09.13 XMit 2019.06.11

3DH5, 8-DPSK, High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	2.883 ms	3.75 ms	1	76.9	N/A	N/A



3DH5, 8-DPSK, High Channel, 2480 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A



CARRIER FREQUENCY SEPARATION

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 channel carrier frequencies in the 2400-2483.5MHz band must be separated by 25 kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Or, if the output power is less than 125 mW, the channel separation can be 25 kHz or 2/3 of the 20dB bandwidth. The EUT was operated in pseudorandom hopping mode. The spectrum was scanned across two adjacent peaks. The separation between the peaks of these channels was measured.

CARRIER FREQUENCY SEPARATION

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:	1-Aug-19
Customer:	EchoNous, Inc.	Temperature:	22.6 °C
Attendees:	None	Humidity:	48.7% RH
Project:	None	Barometric Pres.:	1017 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

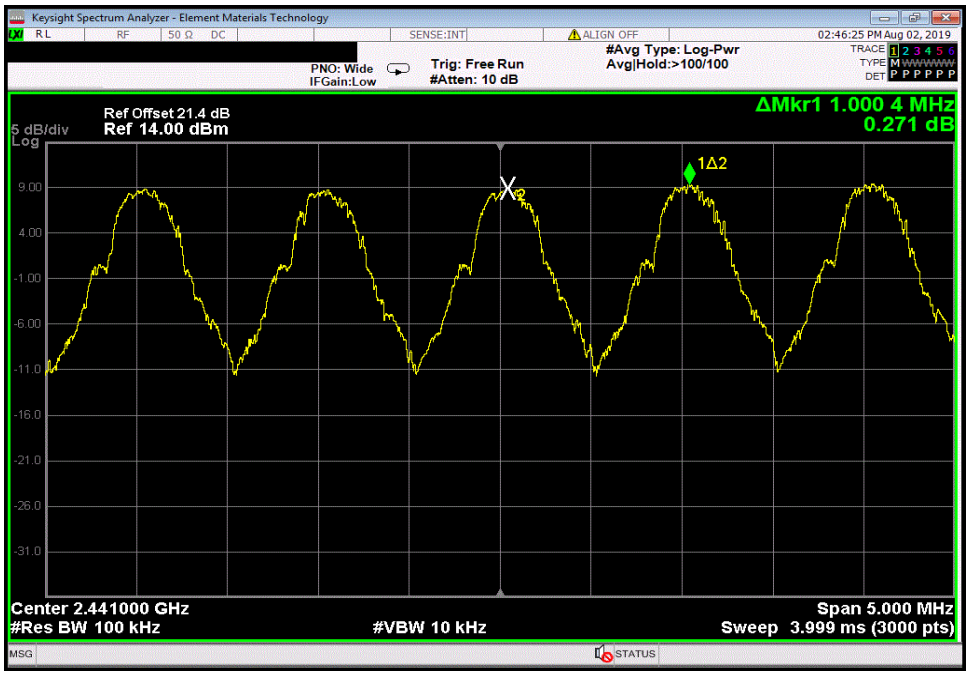
Configuration #	1	Signature

	Value	Limit (≥)	Results
DH5, GFSK, Hopping Mode			
Mid Channel, 2441 MHz	1.0 MHz	1 MHz	Pass

CARRIER FREQUENCY SEPARATION

TbtTx 2018.09.13 XMit 2019.06.11

DH5, GFSK, Hopping Mode, Mid Channel, 2441 MHz						
				Value	Limit (≥)	Results
				1.0 MHz	1 MHz	Pass



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

BT EDR, Low Ch. 0 = 2402 MHz, Mid Ch. 39 = 2441 MHz, High Ch. 78 = 2480 MHz, Software power setting = 9

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.

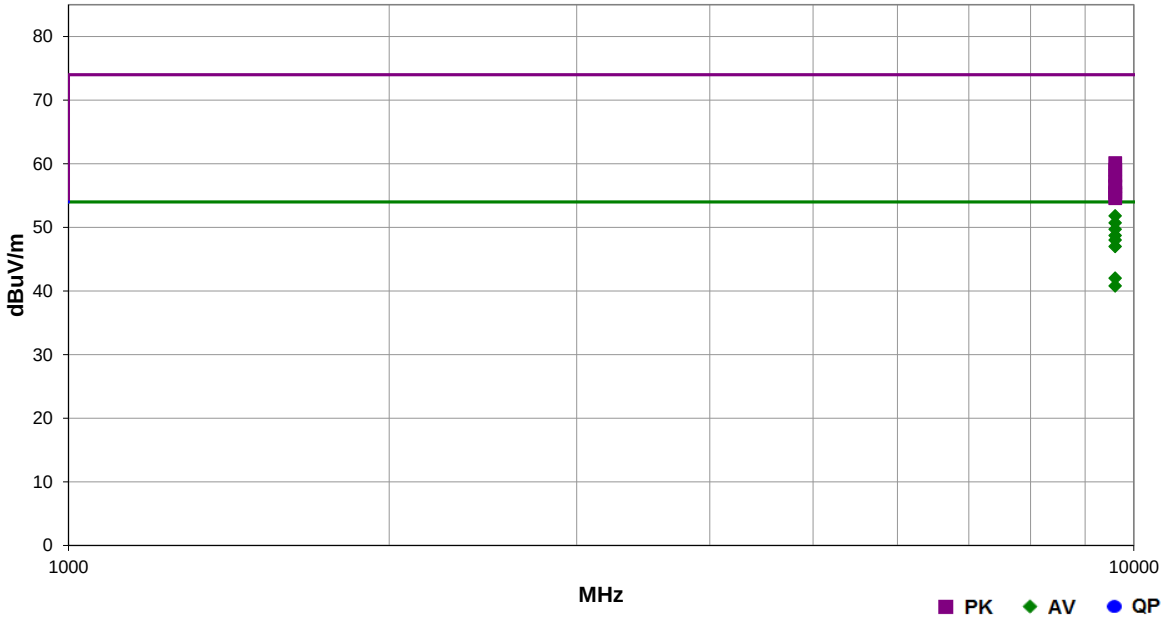
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.15.1 PSA-ESCI 2019.05.10

Work Order:	ECHN0015	**Date:**	26-Nov-2019		
Project:	None	**Temperature:**	21 °C		
Job Site:	EV01	**Humidity:**	36.8% RH		
Serial Number:	H1UR1944002-03	**Barometric Pres.:**	1000 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:	BT EDR, Low Ch. 0 = 2402 MHz, Mid Ch. 39 = 2441 MHz, High Ch. 78 = 2480 MHz, Software power setting = 9				
Deviations:	None				
Comments:	See comments below for channel, modulation type, and EUT orientation. Note: the emission below does not fall in a restricted band. This emission was the only emission noted during pre-scans, and was used to determine worst case orientation of the EUT for measurements on the subsequent data sheets.				

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

Run #	12	**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
9607.850	53.7	-1.9	2.23	286.0	3.0	0.0	Horz	AV	0.0	51.8	54.0	-2.2	Low Ch, DH5, EUT Horz
9607.867	52.6	-1.9	1.0	300.0	3.0	0.0	Vert	AV	0.0	50.7	54.0	-3.3	Low Ch, DH5, EUT Vert
9607.858	51.6	-1.9	2.51	56.0	3.0	0.0	Horz	AV	0.0	49.7	54.0	-4.3	Low Ch, DH5, EUT on Side
9607.817	50.6	-1.9	3.23	54.0	3.0	0.0	Vert	AV	0.0	48.7	54.0	-5.3	Low Ch, DH5, EUT on Side
9608.342	49.9	-1.9	2.37	61.0	3.0	0.0	Vert	AV	0.0	48.0	54.0	-6.0	Low Ch, DH5, EUT Horz
9608.317	48.9	-1.9	1.37	136.0	3.0	0.0	Horz	AV	0.0	47.0	54.0	-7.0	Low Ch, DH5, EUT Vert
9608.225	43.9	-1.9	2.26	35.0	3.0	0.0	Horz	AV	0.0	42.0	54.0	-12.0	Low Ch, 3DH5, EUT Horz
9607.717	42.7	-1.9	2.26	35.0	3.0	0.0	Horz	AV	0.0	40.8	54.0	-13.2	Low Ch, 2DH5, EUT Horz
9607.450	62.0	-1.9	2.23	286.0	3.0	0.0	Horz	PK	0.0	60.1	74.0	-13.9	Low Ch, DH5, EUT Horz
9607.717	61.0	-1.9	1.0	300.0	3.0	0.0	Vert	PK	0.0	59.1	74.0	-14.9	Low Ch, DH5, EUT Vert
9607.717	60.0	-1.9	2.51	56.0	3.0	0.0	Horz	PK	0.0	58.1	74.0	-15.9	Low Ch, DH5, EUT on Side
9608.842	59.0	-1.9	3.23	54.0	3.0	0.0	Vert	PK	0.0	57.1	74.0	-16.9	Low Ch, DH5, EUT on Side
9608.383	58.4	-1.9	2.37	61.0	3.0	0.0	Vert	PK	0.0	56.5	74.0	-17.5	Low Ch, DH5, EUT Horz
9608.683	57.4	-1.9	1.37	136.0	3.0	0.0	Horz	PK	0.0	55.5	74.0	-18.5	Low Ch, DH5, EUT Vert
9608.083	57.1	-1.9	2.26	35.0	3.0	0.0	Horz	PK	0.0	55.2	74.0	-18.8	Low Ch, 3DH5, EUT Horz
9607.550	56.5	-1.9	2.26	35.0	3.0	0.0	Horz	PK	0.0	54.6	74.0	-19.4	Low Ch, 2DH5, EUT Horz

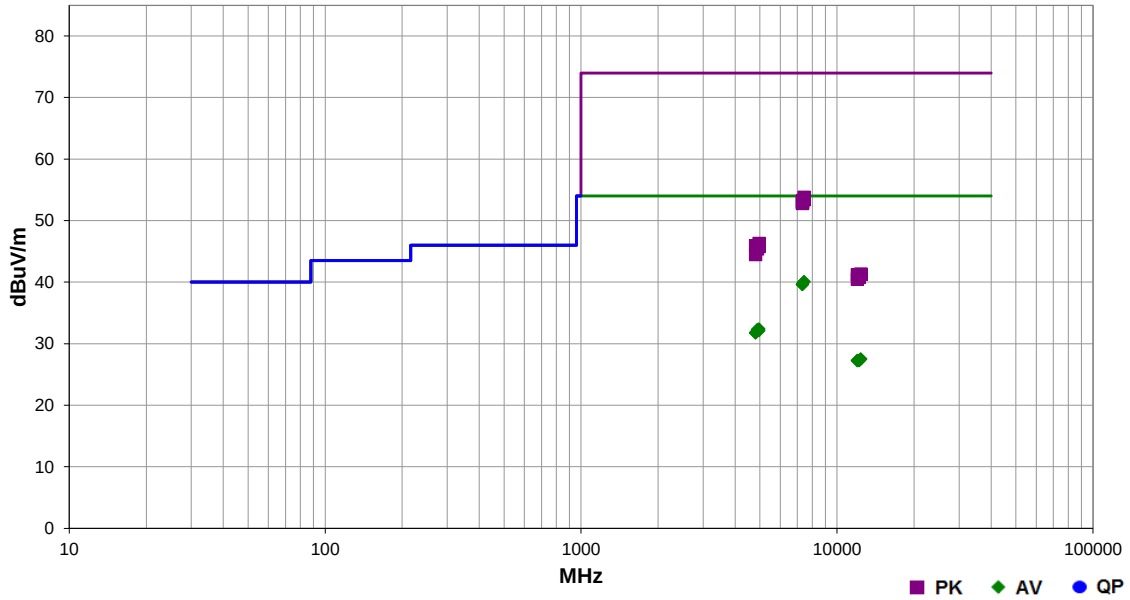
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.15.1 PSA-ESCI 2019.05.10

Work Order:	ECHN0015	**Date:**	26-Nov-2019		
Project:	None	**Temperature:**	21 °C		
Job Site:	EV01	**Humidity:**	36.8% RH		
Serial Number:	H1UR1944002-03	**Barometric Pres.:**	1000 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:	BT EDR, Low Ch. 0 = 2402 MHz, Mid Ch. 39 = 2441 MHz, High Ch. 78 = 2480 MHz, Software power setting = 9.				
Deviations:	None				
Comments:	See comments below for channel, modulation type, and EUT orientation. Note: All emissions were noise floor and do not need a Duty Cycle correction factor applied to them.				

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

Run #	13	**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
7440.475	25.5	14.6	1.5	360.0	3.0	0.0	Vert	AV	0.0	40.1	54.0	-13.9	High Ch, DH5, EUT Vert
7441.933	25.4	14.6	1.5	0.0	3.0	0.0	Horz	AV	0.0	40.0	54.0	-14.0	High Ch, DH5, EUT Horz
7321.608	25.6	14.1	1.44	360.0	3.0	0.0	Horz	AV	0.0	39.7	54.0	-14.3	Mid Ch, DH5, EUT Horz
7322.892	25.6	14.1	1.44	0.0	3.0	0.0	Vert	AV	0.0	39.7	54.0	-14.3	Mid Ch, DH5, EUT Vert
7321.217	25.5	14.1	1.5	69.0	3.0	0.0	Horz	AV	0.0	39.6	54.0	-14.4	Mid Ch, 2DH5, EUT Horz
7322.417	25.5	14.1	1.5	69.0	3.0	0.0	Horz	AV	0.0	39.6	54.0	-14.4	Mid Ch, 3DH5, EUT Horz
7440.733	39.2	14.6	1.5	0.0	3.0	0.0	Horz	PK	0.0	53.8	74.0	-20.2	High Ch, DH5, EUT Horz
7442.400	38.8	14.6	1.5	360.0	3.0	0.0	Vert	PK	0.0	53.4	74.0	-20.6	High Ch, DH5, EUT Vert
7323.450	39.1	14.1	1.5	69.0	3.0	0.0	Horz	PK	0.0	53.2	74.0	-20.8	Mid Ch, 2DH5, EUT Horz
7324.658	38.9	14.1	1.5	69.0	3.0	0.0	Horz	PK	0.0	53.0	74.0	-21.0	Mid Ch, 3DH5, EUT Horz
7324.217	38.8	14.1	1.44	0.0	3.0	0.0	Vert	PK	0.0	52.9	74.0	-21.1	Mid Ch, DH5, EUT Vert
7321.850	38.7	14.1	1.44	360.0	3.0	0.0	Horz	PK	0.0	52.8	74.0	-21.2	Mid Ch, DH5, EUT Horz
4961.908	25.9	6.5	1.5	0.0	3.0	0.0	Vert	AV	0.0	32.4	54.0	-21.6	High Ch, DH5, EUT Vert
4884.400	25.9	6.4	1.44	0.0	3.0	0.0	Horz	AV	0.0	32.3	54.0	-21.7	Mid Ch, DH5, EUT Horz
4957.658	25.6	6.5	1.5	360.0	3.0	0.0	Horz	AV	0.0	32.1	54.0	-21.9	High Ch, DH5, EUT Horz
4884.467	25.7	6.4	1.44	360.0	3.0	0.0	Vert	AV	0.0	32.1	54.0	-21.9	Mid Ch, DH5, EUT Vert
4804.242	26.3	5.5	1.44	0.0	3.0	0.0	Vert	AV	0.0	31.8	54.0	-22.2	Low Ch, DH5, EUT Vert
4806.125	26.2	5.5	1.44	360.0	3.0	0.0	Horz	AV	0.0	31.7	54.0	-22.3	Low Ch, DH5, EUT Horz
12397.500	26.4	1.1	1.5	0.0	3.0	0.0	Horz	AV	0.0	27.5	54.0	-26.5	High Ch, DH5, EUT Horz
12397.500	26.4	1.1	1.5	360.0	3.0	0.0	Vert	AV	0.0	27.5	54.0	-26.5	High Ch, DH5, EUT Vert
12009.610	26.3	1.0	1.5	347.0	3.0	0.0	Horz	AV	0.0	27.3	54.0	-26.7	Low Ch, DH5, EUT Horz
12203.440	26.5	0.8	1.5	360.0	3.0	0.0	Horz	AV	0.0	27.3	54.0	-26.7	Mid CH, DH5, EUT Horz
12007.840	26.2	1.0	1.5	324.0	3.0	0.0	Vert	AV	0.0	27.2	54.0	-26.8	Low Ch, DH5, 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
12205.320	26.4	0.8	1.5	0.0	3.0	0.0	Vert	AV	0.0	27.2	54.0	-26.8	Mid CH, DH5, EUT Vert
4961.792	39.8	6.5	1.5	0.0	3.0	0.0	Vert	PK	0.0	46.3	74.0	-27.7	High Ch, DH5, EUT Vert
4806.225	40.4	5.5	1.44	360.0	3.0	0.0	Horz	PK	0.0	45.9	74.0	-28.1	Low Ch, DH5, EUT Horz
4960.483	39.3	6.5	1.5	360.0	3.0	0.0	Horz	PK	0.0	45.8	74.0	-28.2	High Ch, DH5, EUT Horz
4880.833	39.4	6.4	1.44	0.0	3.0	0.0	Horz	PK	0.0	45.8	74.0	-28.2	Mid Ch, DH5, EUT Horz
4882.267	39.0	6.4	1.44	360.0	3.0	0.0	Vert	PK	0.0	45.4	74.0	-28.6	Mid Ch, DH5, EUT Vert
4803.367	39.1	5.4	1.44	0.0	3.0	0.0	Vert	PK	0.0	44.5	74.0	-29.5	Low Ch, DH5, EUT Vert
12398.100	40.2	1.1	1.5	0.0	3.0	0.0	Horz	PK	0.0	41.3	74.0	-32.7	High Ch, DH5, EUT Horz
12397.550	40.2	1.1	1.5	360.0	3.0	0.0	Vert	PK	0.0	41.3	74.0	-32.7	High Ch, DH5, EUT Vert
12011.680	40.2	1.0	1.5	324.0	3.0	0.0	Vert	PK	0.0	41.2	74.0	-32.8	Low Ch, DH5, EUT Vert
12206.570	40.3	0.8	1.5	0.0	3.0	0.0	Vert	PK	0.0	41.1	74.0	-32.9	Mid CH, DH5, EUT Vert
12206.580	40.0	0.8	1.5	360.0	3.0	0.0	Horz	PK	0.0	40.8	74.0	-33.2	Mid CH, DH5, EUT Horz
12012.230	39.5	1.0	1.5	347.0	3.0	0.0	Horz	PK	0.0	40.5	74.0	-33.5	Low Ch, DH5, EUT Horz

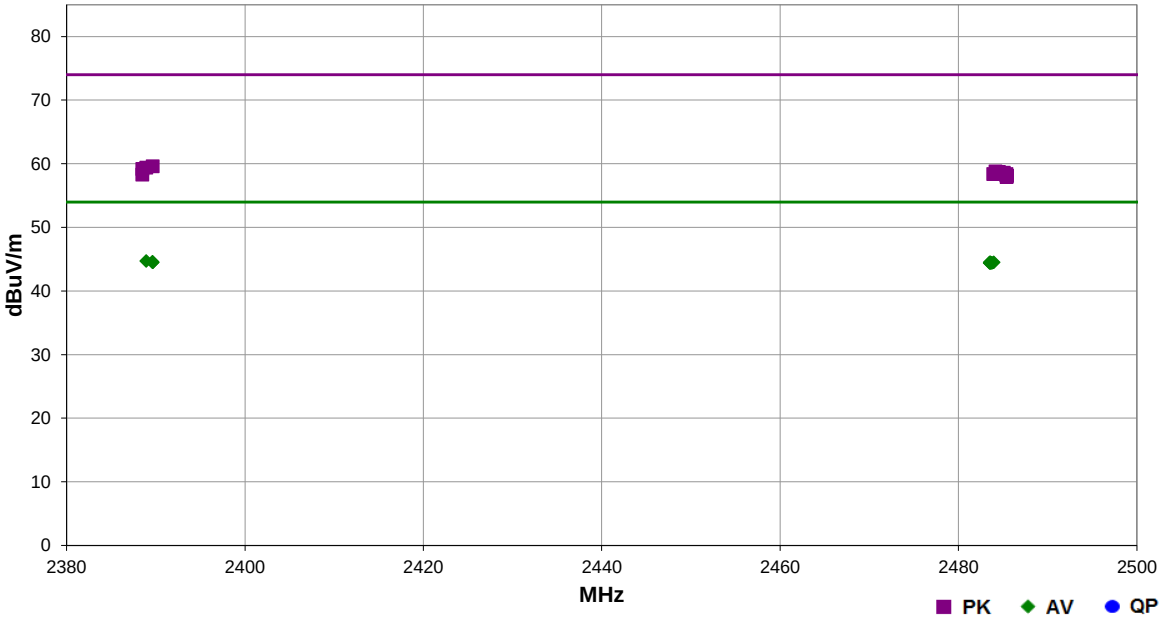
SPURIOUS RADIATED EMISSIONS

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:	BT EDR, Low Ch. 0 = 2402 MHz, Mid Ch. 39 = 2441 MHz, High Ch. 78 = 2480 MHz, Software power setting = 9				
Deviations:	None				
Comments:	See comments below for channel, modulation type, and EUT orientation. Note: All emissions were noise floor and do not need a Duty Cycle correction factor applied to them.				

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

Run #	16	**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
2388.927	28.7	-4.0	1.5	69.0	3.0	20.0	Horz	AV	0.0	44.7	54.0	-9.3	Low Ch, DH5, EUT Horz
2389.633	28.6	-4.0	1.5	69.0	3.0	20.0	Horz	AV	0.0	44.6	54.0	-9.4	Low Ch, 3DH5, EUT Horz
2483.957	28.3	-3.8	1.05	203.0	3.0	20.0	Horz	AV	0.0	44.5	54.0	-9.5	High Ch, DH5, EUT Horz
2483.597	28.3	-3.8	1.5	51.0	3.0	20.0	Vert	AV	0.0	44.5	54.0	-9.5	High Ch, DH5, EUT Horz
2483.520	28.3	-3.8	1.5	91.0	3.0	20.0	Horz	AV	0.0	44.5	54.0	-9.5	High Ch, 3DH5, EUT Horz
2389.660	28.5	-4.0	2.99	33.0	3.0	20.0	Vert	AV	0.0	44.5	54.0	-9.5	Low Ch, DH5, EUT Horz
2389.687	28.5	-4.0	1.5	69.0	3.0	20.0	Horz	AV	0.0	44.5	54.0	-9.5	Low CH, 2DH5, EUT Horz
2483.760	28.2	-3.8	1.5	279.0	3.0	20.0	Horz	AV	0.0	44.4	54.0	-9.6	High Ch, DH5, EUT Vert
2483.500	28.2	-3.8	1.54	321.0	3.0	20.0	Vert	AV	0.0	44.4	54.0	-9.6	High Ch, DH5, EUT Vert
2483.657	28.2	-3.8	1.5	89.0	3.0	20.0	Horz	AV	0.0	44.4	54.0	-9.6	High Ch, DH5, EUT on Side
2483.550	28.2	-3.8	3.32	308.0	3.0	20.0	Vert	AV	0.0	44.4	54.0	-9.6	High Ch, DH5, EUT on Side
2483.547	28.2	-3.8	1.5	91.0	3.0	20.0	Horz	AV	0.0	44.4	54.0	-9.6	High Ch, 2DH5, EUT Horz
2389.650	43.6	-4.0	1.5	69.0	3.0	20.0	Horz	PK	0.0	59.6	74.0	-14.4	Low Ch, DH5, EUT Horz
2388.930	43.4	-4.0	1.5	69.0	3.0	20.0	Horz	PK	0.0	59.4	74.0	-14.6	Low Ch, 3DH5, EUT Horz
2388.493	43.2	-4.0	1.5	69.0	3.0	20.0	Horz	PK	0.0	59.2	74.0	-14.8	Low CH, 2DH5, EUT Horz
2484.140	42.6	-3.8	1.54	321.0	3.0	20.0	Vert	PK	0.0	58.8	74.0	-15.2	High Ch, DH5, EUT Vert
2484.523	42.4	-3.7	1.5	51.0	3.0	20.0	Vert	PK	0.0	58.7	74.0	-15.3	High Ch, DH5, EUT Horz
2485.087	42.3	-3.7	1.5	91.0	3.0	20.0	Horz	PK	0.0	58.6	74.0	-15.4	High Ch, 2DH5, EUT Horz
2485.370	42.1	-3.7	1.05	203.0	3.0	20.0	Horz	PK	0.0	58.4	74.0	-15.6	High Ch, DH5, EUT Horz
2483.897	42.2	-3.8	3.32	308.0	3.0	20.0	Vert	PK	0.0	58.4	74.0	-15.6	High Ch, DH5, EUT on Side

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
2388.500	42.3	-4.0	2.99	33.0	3.0	20.0	Vert	PK	0.0	58.3	74.0	-15.7	Low Ch, DH5, EUT Horz
2485.363	41.9	-3.7	1.5	91.0	3.0	20.0	Horz	PK	0.0	58.2	74.0	-15.8	High Ch, 3DH5, EUT Horz
2485.440	41.8	-3.7	1.5	279.0	3.0	20.0	Horz	PK	0.0	58.1	74.0	-15.9	High Ch, DH5, EUT Vert
2485.393	41.6	-3.7	1.5	89.0	3.0	20.0	Horz	PK	0.0	57.9	74.0	-16.1	High Ch, DH5, EUT on Side

NUMBER OF HOPPING FREQUENCIES

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 number of hopping frequencies was measured across the authorized band. The hopping function of the EUT was enabled.

NUMBER OF HOPPING FREQUENCIES

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:	24-Jul-19
Customer:	EchoNous, Inc.	Temperature:	22.3 °C
Attendees:	None	Humidity:	52% RH
Project:	None	Barometric Pres.:	1028 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

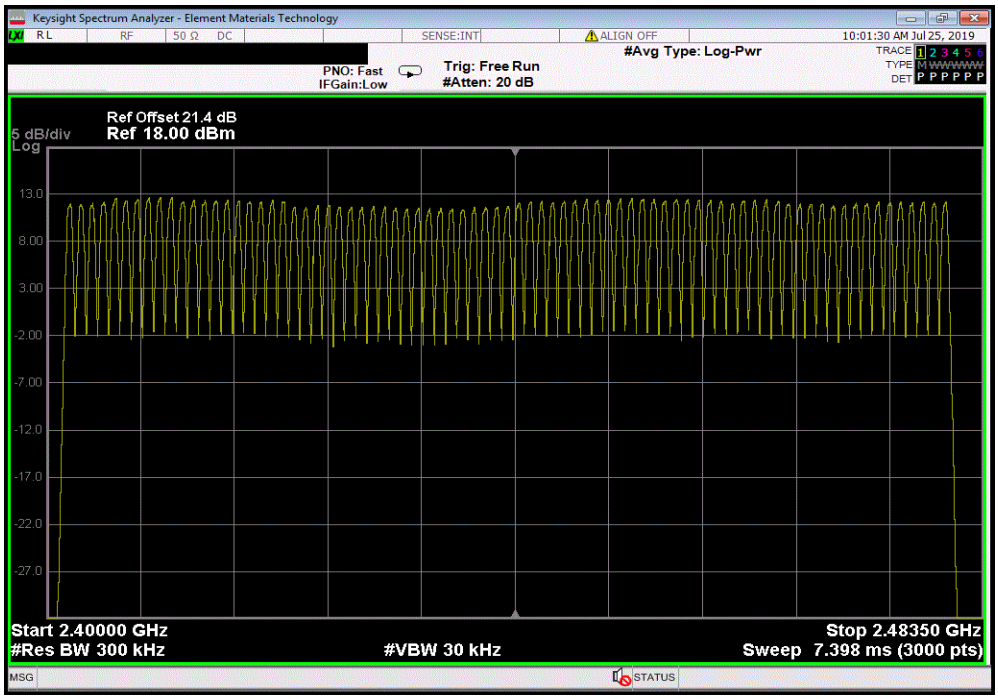
None

Configuration #	1	Signature

	Number of Channels	Limit (≥)	Results
DH5, GFSK			
Mid Channel, 2441 MHz	79	15	Pass

NUMBER OF HOPPING FREQUENCIES

DH5, GFSK, Mid Channel, 2441 MHz						
				Number of Channels	Limit (≥)	Results
				79	15	Pass



DWELL TIME

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 average dwell time per hopping channel was measured at one hopping channel in the middle of the authorized band. The hopping function of the EUT was enabled.

The dwell time limit is based on the Number of Hopping Channels * 400 mS. For Bluetooth this would be 79 Channels * 400mS = 31.6 Sec.

On Time During 31.6 Sec = Pulse Width * Average Number of Pulses * Scale Factor

- Average Number of Pulses is based on 4 samples.
- Scale Factor = 31.6 Sec / Screen Capture Sweep Time = 31.6 Sec / 6.32 Sec = 5

DWELL TIME

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:	24-Jul-19
Customer:	EchoNous, Inc.	Temperature:	22.5 °C
Attendees:	None	Humidity:	49.9% RH
Project:	None	Barometric Pres.:	1028 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

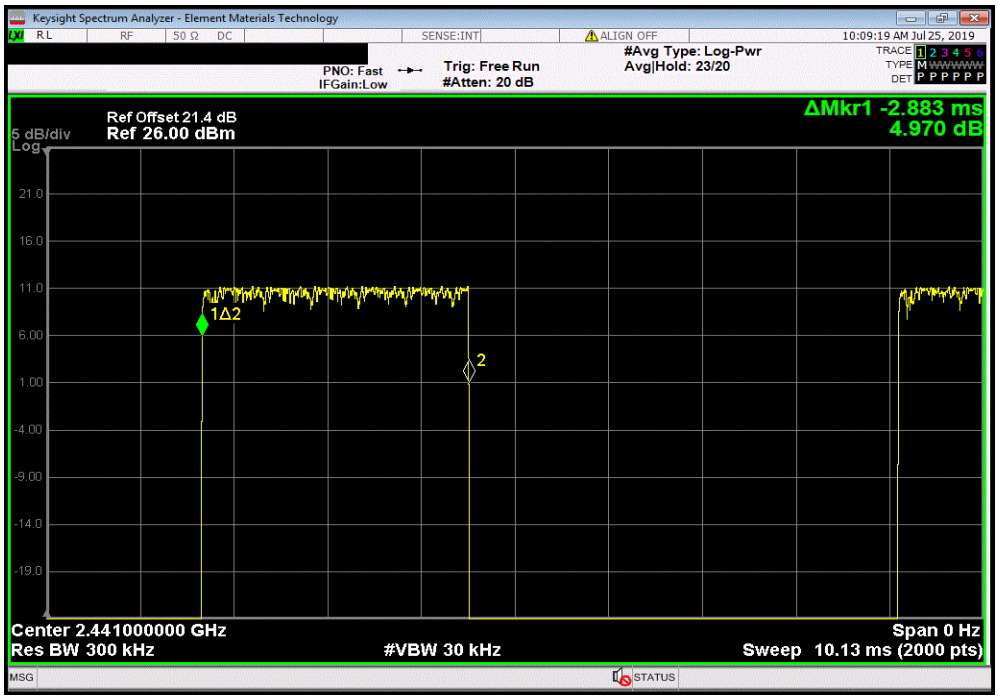
None

Configuration #	1	Signature

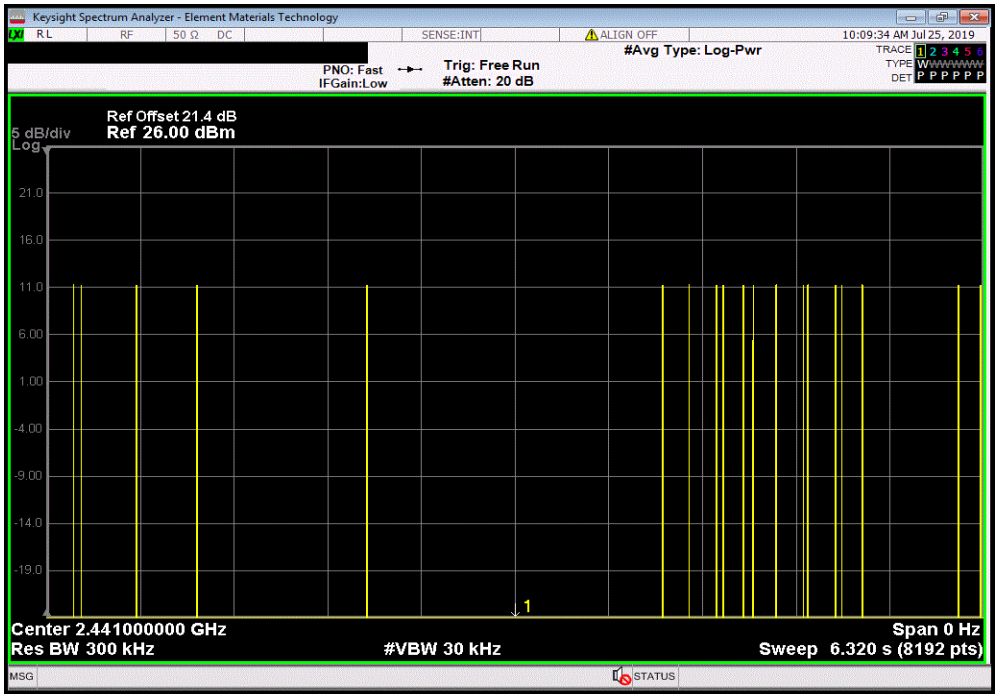
		Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
DH5, GFSK								
	Mid Channel, 2441 MHz	2.883	N/A	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	19	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	22	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	19	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	20	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.883	N/A	20	5	288.3	400	Pass
2DH5, pi/4-DQPSK								
	Mid Channel, 2441 MHz	2.381	N/A	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	14	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	25	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	22	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	20	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.381	N/A	20.25	5	241.08	400	Pass
3DH5, 8-DPSK								
	Mid Channel, 2441 MHz	2.898	N/A	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	22	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	22	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	18	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	N/A	20	N/A	N/A	N/A	N/A	N/A
	Mid Channel, 2441 MHz	2.898	N/A	20.5	5	297.05	400	Pass

DWELL TIME

DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.883	N/A	N/A	N/A	N/A	N/A	N/A

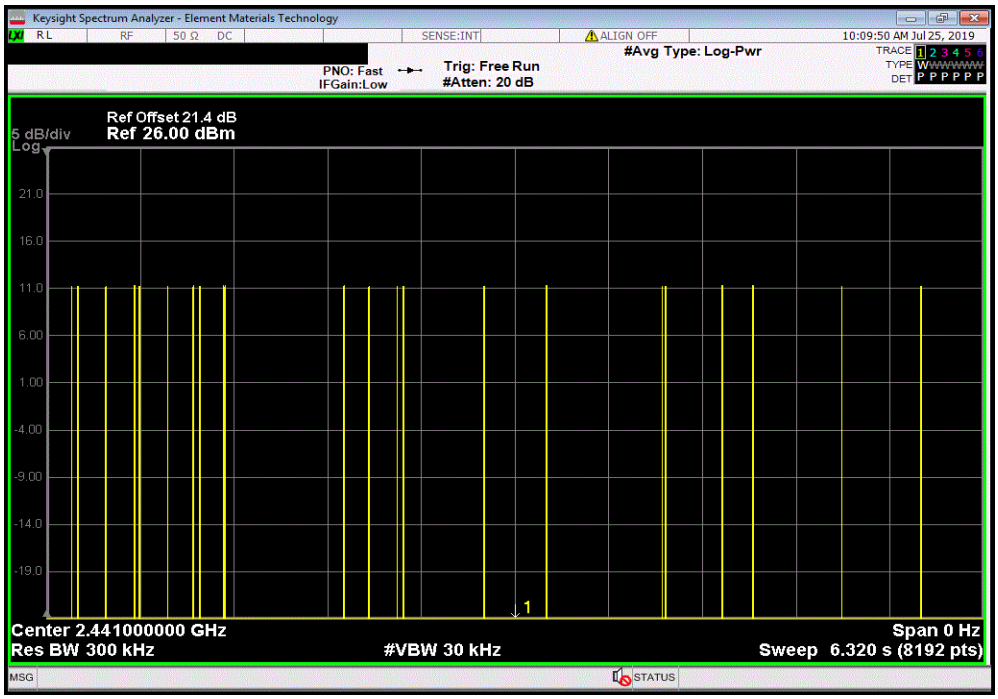


DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	19	N/A	N/A	N/A	N/A	N/A

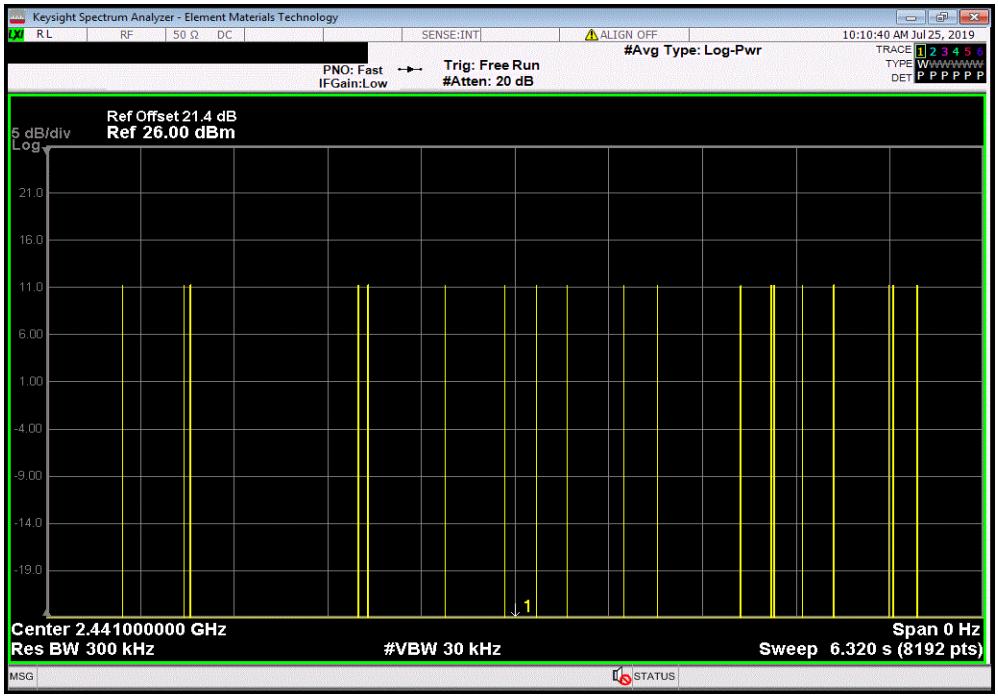


DWELL TIME

DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	22	N/A	N/A	N/A	N/A	N/A

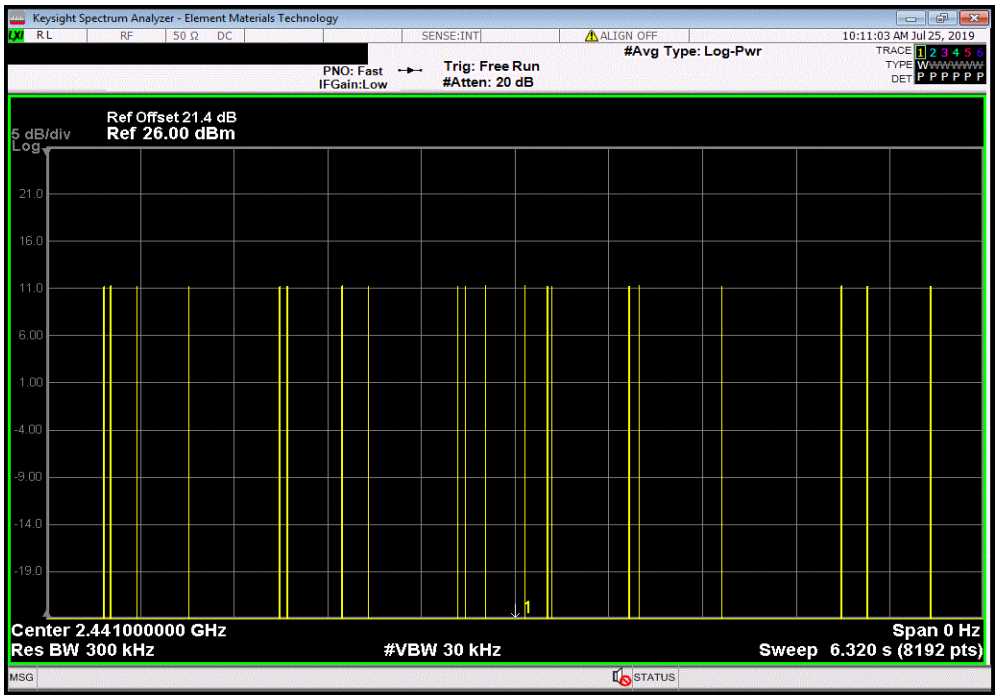


DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	19	N/A	N/A	N/A	N/A	N/A



DWELL TIME

DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	20	N/A	N/A	N/A	N/A	N/A



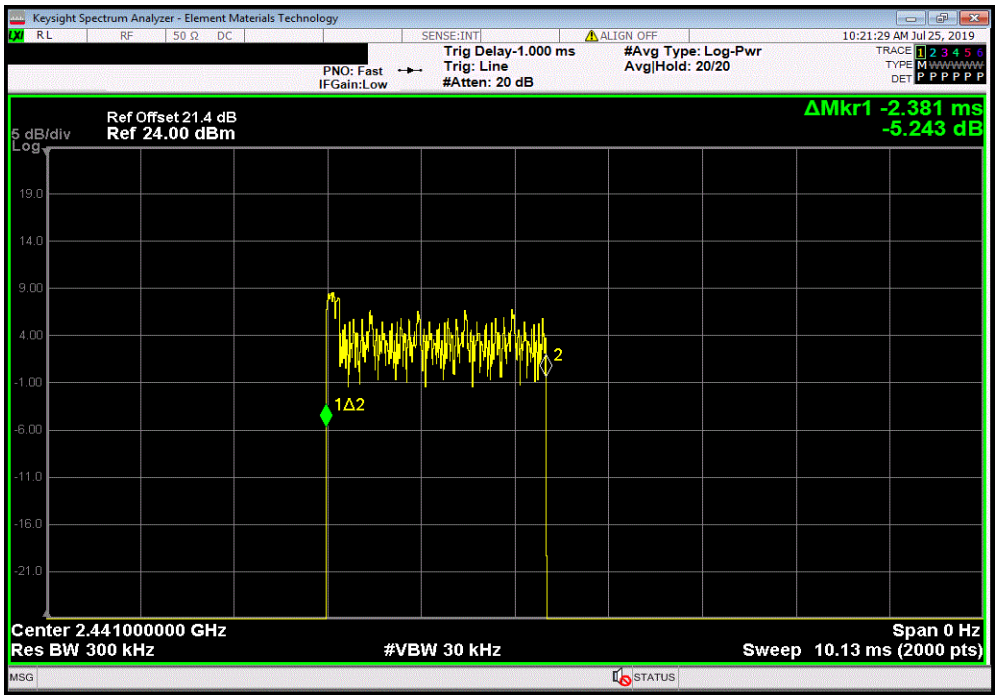
DH5, GFSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.883	N/A	20	5	288.3	400	Pass

Calculation Only

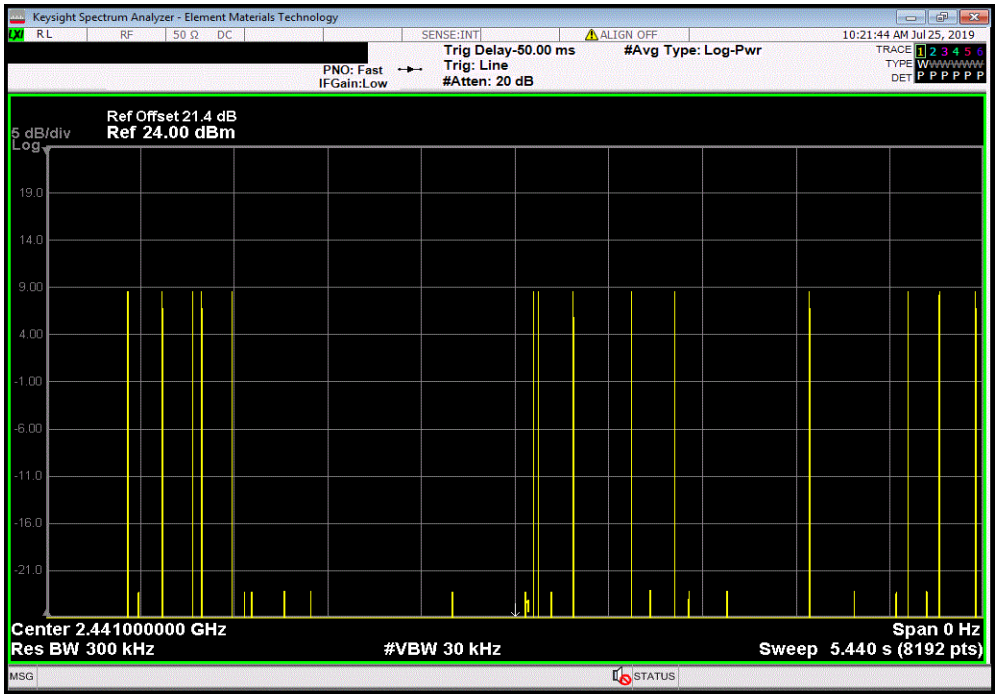
No Screen Capture Required

DWELL TIME

2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.381	N/A	N/A	N/A	N/A	N/A	N/A

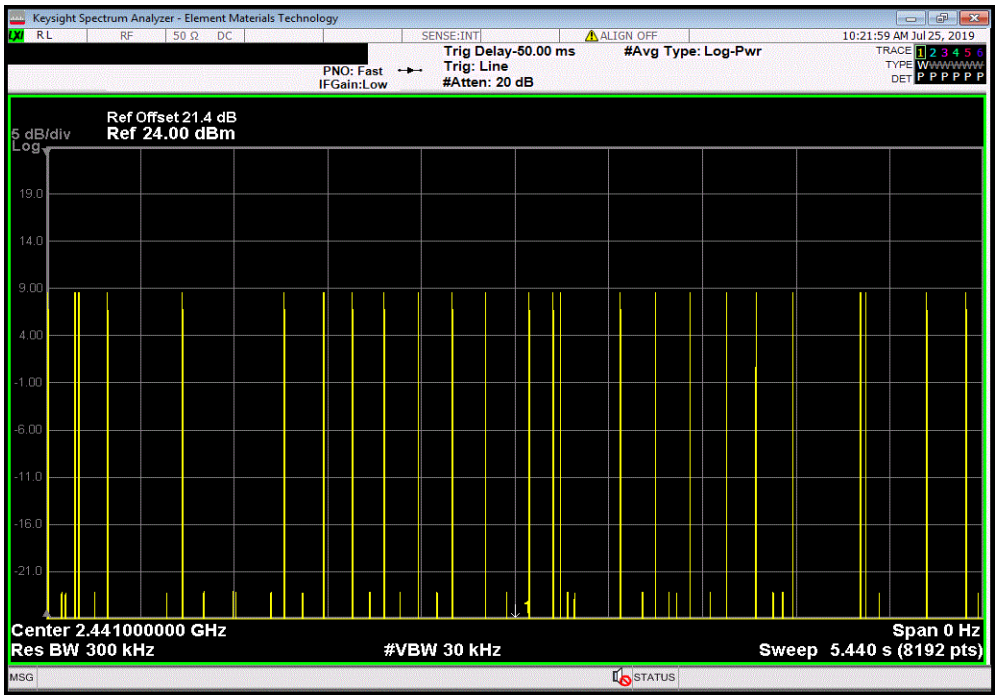


2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	14	N/A	N/A	N/A	N/A	N/A

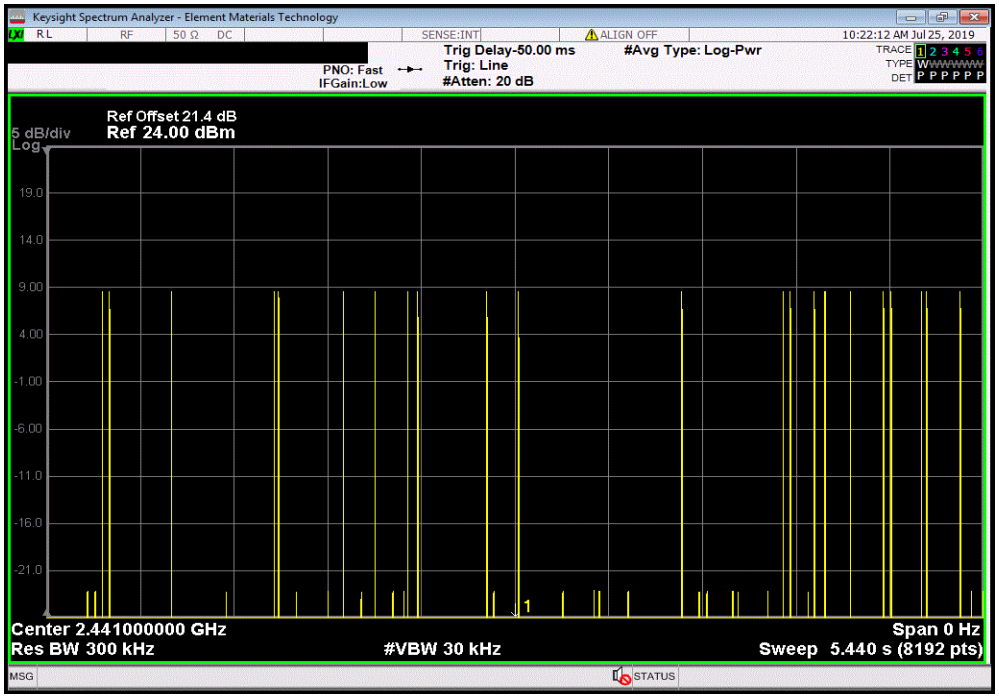


DWELL TIME

2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	25	N/A	N/A	N/A	N/A	N/A

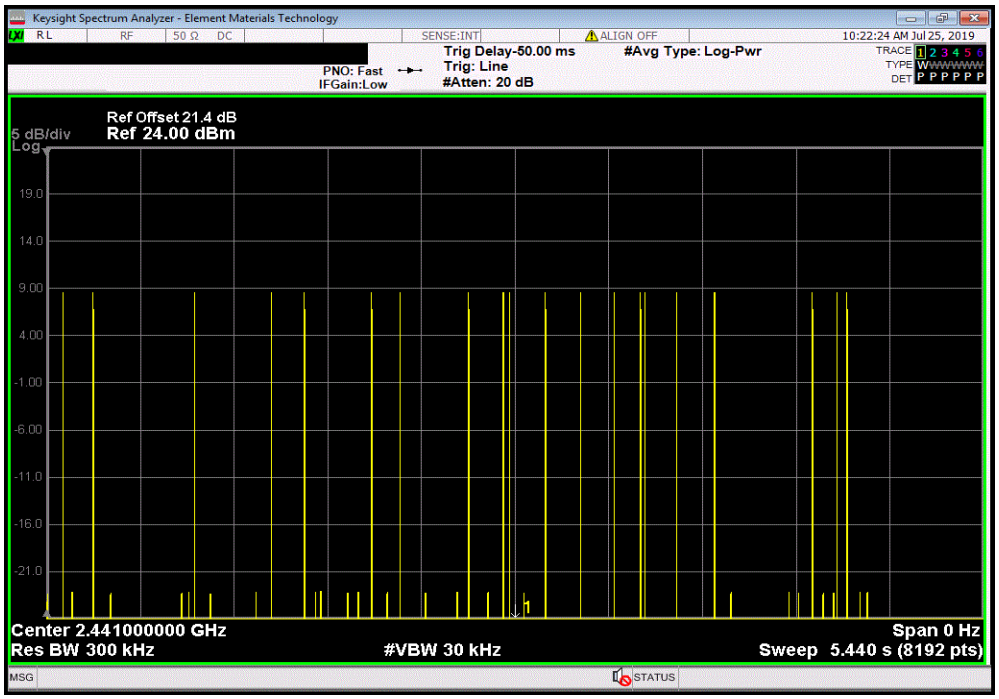


2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	22	N/A	N/A	N/A	N/A	N/A



DWELL TIME

2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	20	N/A	N/A	N/A	N/A	N/A



2DH5, pi/4-DQPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.381	N/A	20.25	5	241.08	400	Pass

Calculation Only

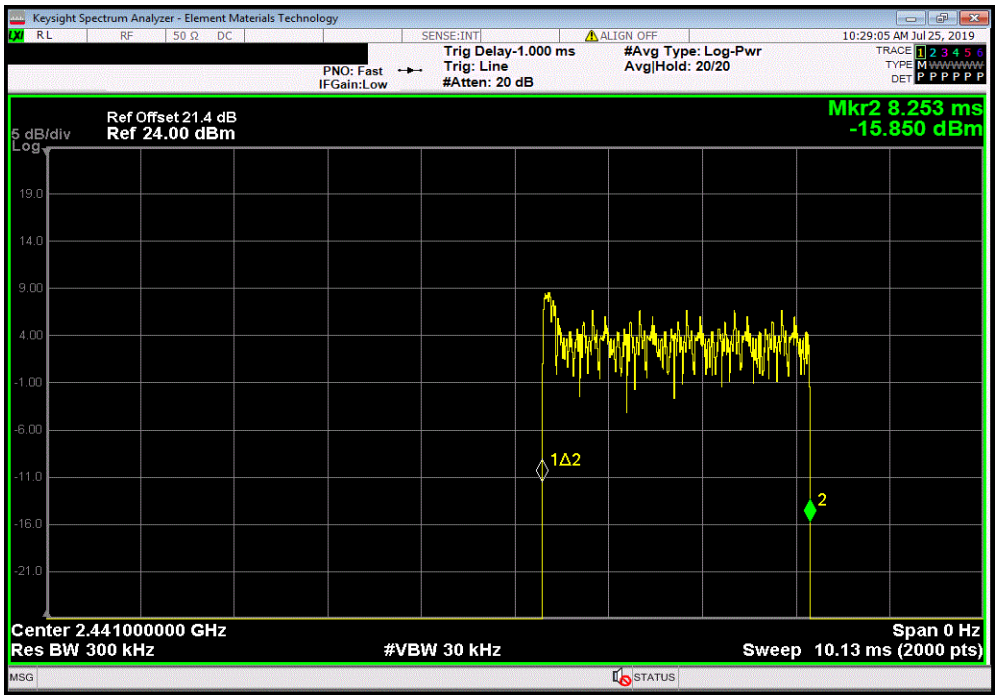
No Screen Capture Required

DWELL TIME

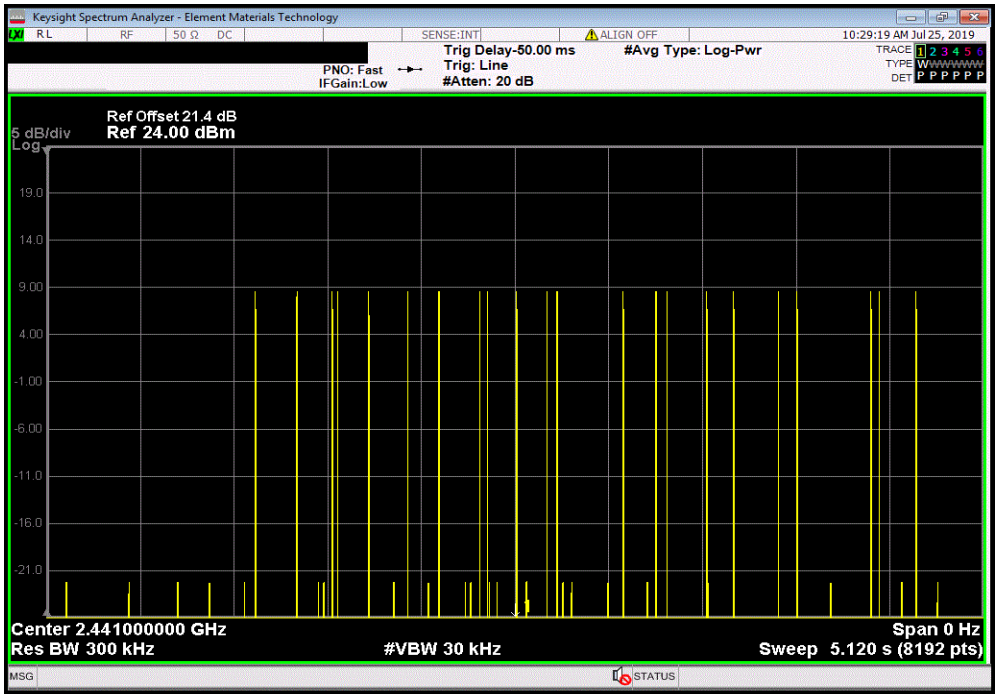
element

TbtTx 2018.09.13 XMit 2019.06.11

3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.898	N/A	N/A	N/A	N/A	N/A	N/A

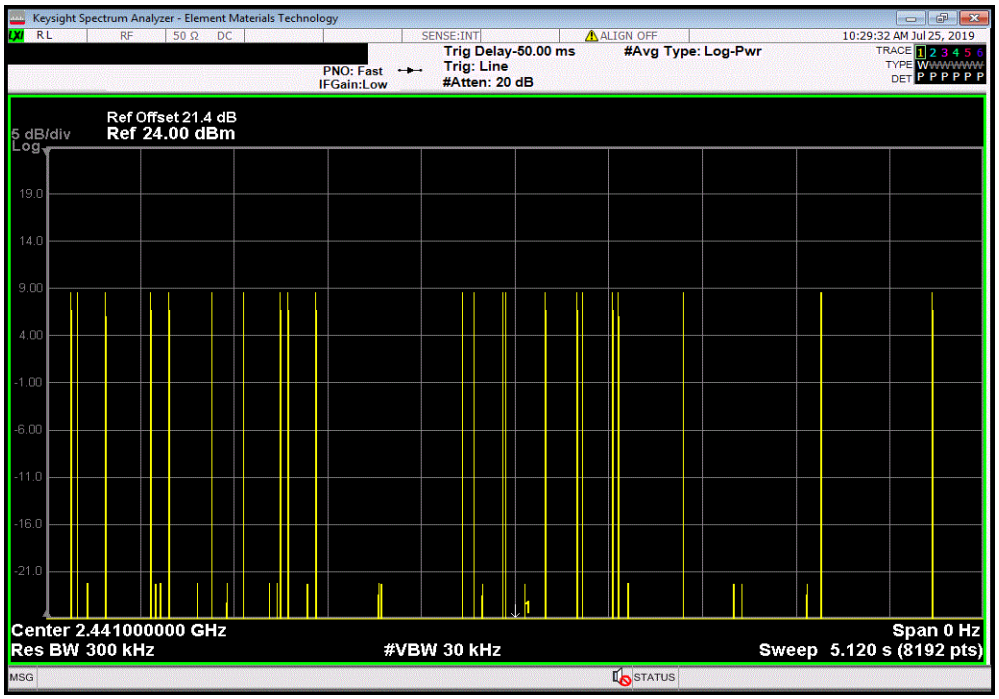


3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	22	N/A	N/A	N/A	N/A	N/A

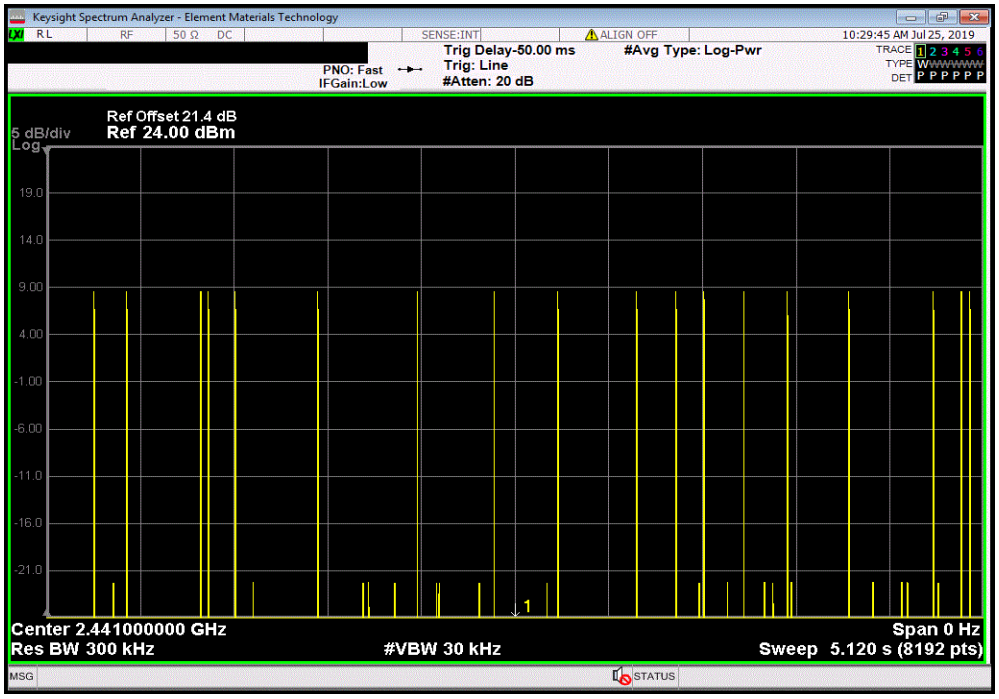


DWELL TIME

3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	22	N/A	N/A	N/A	N/A	N/A

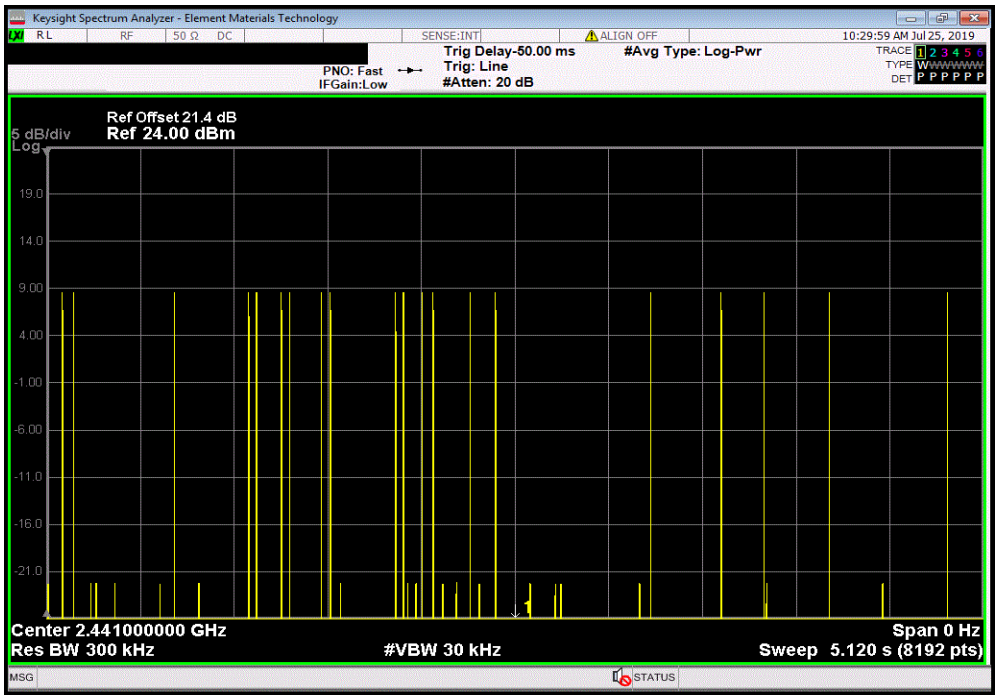


3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	18	N/A	N/A	N/A	N/A	N/A



DWELL TIME

3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
N/A	20	N/A	N/A	N/A	N/A	N/A



3DH5, 8-DPSK, Mid Channel, 2441 MHz						
Pulse Width (ms)	Number of Pulses	Average No. of Pulses	Scale Factor	On Time (ms) During 31.6 s	Limit (ms)	Results
2.898	N/A	20.5	5	297.05	400	Pass

Calculation Only

No Screen Capture Required