ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT

Applicant:	Murata Manufacturing Co., Ltd. 10-1, Higashikotari 1-chome, Nagaokakyo-shi, Kyoto 617-8555 Japan
Product Name:	Communication Module
Brand Name:	muRata
Model No.:	LBEQ6ZZ1BN
Model Difference:	N/A
Report Number:	ER/2019/A0013
FCC ID:	VPYLB1BN
IC:	772C-LB1BN
FCC Rule Part:	§15.247, Cat: DTS
IC RSS:	RSS-247 issue 2 Feb 2017
Issue Date:	Oct. 24, 2019
Date of Test:	Oct. 02, 2019 ~ Oct. 23, 2019
Date of EUT Received:	Oct. 02, 2019

We hereby certify that:
The above equipment was tested by SGS Taiwan Ltd. Electronics & Communication Laboratory The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10:2013 and the energy emitted by the sample EUT tested as described in this report is in compliance with conducted and radiated emission limits.
The test results of this report relate only to the tested sample identified in this report.

Approved By: CHUN-CHIEH, CHEN

CHUN CHIEH CHEN /
Asst. Supervisor

Testing Laboratory
0513

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Revision History

Revision	Description	Issue Date	Remark
Rev.00	Original.	Oct. 24, 2019	Revised By: Yuri Tsai

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1 GENERAL INFORMATION

1.1 Product Description

Product Name:	Communication Module
Brand Name:	muRata
Model No.:	LBEQ6ZZ1BN
Model Difference:	N/A
Hardware Version:	1.0
Software Version:	1.0
Power Supply:	Typ. 3.3V, Min 3.0V, Max 3.6V from DC power supply

Radio Technology:	Bluetooth LE Single mode
Frequency Range:	2402 – 2480MHz
Channel number:	40 channels
Modulation type:	GFSK
Transmit Power:	9.23 dBm
Antenna Designation:	Dipole Antenna, Gain: 2.37dBi Model No: GW.59.3153; Supplier: Taoglas

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1.2Test Methodology of Applied Standards

FCC Part 15, Subpart C §15.247
FCC KDB 558074 D01 DTS Meas. Guidance v05r01
RSS-247 issue 2 Feb. 2017
RSS-Gen. issue 5 Mar. 2019
ANSI C63.10:2013

1.3Test Facility

SGS Taiwan Ltd. Electronics & Communication Laboratory (TAF code 0513)
No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803

FCC Designation number: TW0001

Canada Registration Number: 4620A-4

1.4Special Accessories

There are no special accessories used while test was conducted.

1.5Equipment Modifications

There was no modification incorporated into the EUT.

1.6Radiated Emission Test Sites For Measurements From 9 kHz To 30 MHz

Radiated emission below 30MHz is measured in a 9m*9m*6m semi-anechoic chamber, the measurements correspond to those obtained at an open-field test site.
There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

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2 SYSTEM TEST CONFIGURATION

2.1EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

2.2EUT Exercise

An engineering test mode (software/firmware) that applicant provided was utilized to manipulate the EUT into transmit, selection of the test channel, and modulation scheme.

2.3Test Procedure

2.3.1Conducted Emissions

The EUT is a placed on a table which is 0.8 m above ground plane. Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz. The CISPR Quasi-Peak and Average detector mode is employed. The two LISNs provide 50uH/50 ohm of coupling impedance for the measuring instrument. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

2.3.2Conducted Test (RF)

The active antenna port of the unlicensed wireless device is connected to the spectrum analyzer with attenuator to protect the instrumentation. If a second antenna port is available, it is tested at one operating frequency, with other port(s) appropriately terminated, to verify it has similar output characteristics as the fully tested port.

2.3.3Radiated Emissions

The EUT is a placed on a turn table. For emissions testing at or below 1 GHz, the table height shall be 0.8 m above the reference ground plane. For emission measurements above 1 GHz, the table height shall be 1.5 m. The turn table shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this transmitter (EUT) was rotated through three orthogonal axes and measurement procedures for electric field radiated emissions above 1 GHz the EUT measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” is still within the 3dB illumination BW of the measurement antenna.

2.4Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuation factor between EUT conducted port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly EUT RF output level.

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2.5Configuration of Tested System

Fig. 2-1 Conducted (Antenna Port) Emission Configuration

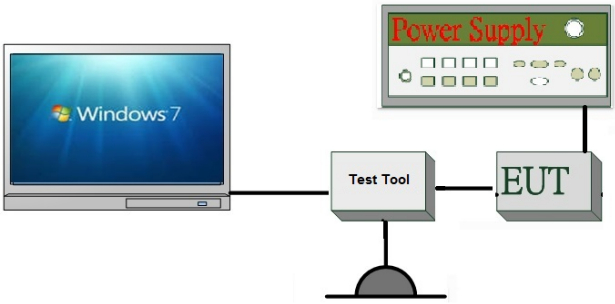

Fig 2-3 Conduction (AC Power Line) Radiated Emission

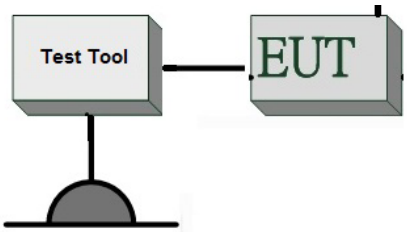

Fig 2-2 Radiated Emission

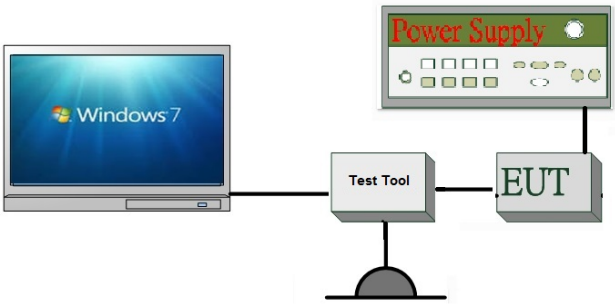

Table 2-1 Equipment Used in Tested System

Item	Equipment	Mfr/Brand	Model/Type No.	Series No.	Data Cable	Power Cord
1	Bluetooth Test Software	N/A	N/A	N/A	N/A	N/A
2	Notebook	Lenovo	L430	R9-XFG0X	Shielded	Unshielded
3	DC power supply	Agilent	E3640A	MY52410006	N/A	Unshielded
4	Test tool kit	N/A	N/A	N/A	N/A	N/A

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3 SUMMARY OF TEST RESULTS

FCC Rules	ISED Rules	Description Of Test	Result
§15.207(a)	RSS-Gen §8.8	AC Power Line Conducted Emission	Compliant
§15.247(b) (3)	RSS-247 §5.4(4)	Peak Output Power	Compliant
§15.247(a)(2)	RSS-247 §5.2 (1) RSS-Gen §6.7	6dB & 99% Bandwidth	Compliant
§15.205 §15.209 §15.247(d)	RSS-247 §5.5	Conducted Band Edge and Spurious Emission	Compliant
§15.205 §15.209 §15.247(d)	RSS-247 §5.5	Radiated Band Edge and Spurious Emission	Compliant
§15.247(e)	RSS-247 §5.2(2)	Peak Power Density	Compliant
§15.203 §15.247(b)	N/A	Antenna Requirement	Compliant

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4 DESCRIPTION OF TEST MODES

4.1Operated in 2400 ~ 2483.5MHz Band

40 channels are provided for Bluetooth LE

ITEM	FREQUENCY	ITEM	FREQUENCY	ITEM	FREQUENCY
1	2402 MHz	15	2430 MHz	29	2458 MHz
2	2404 MHz	16	2432 MHz	30	2460 MHz
3	2406 MHz	17	2434 MHz	31	2462 MHz
4	2408 MHz	18	2436 MHz	32	2464 MHz
5	2410 MHz	19	2438 MHz	33	2466 MHz
6	2412 MHz	20	2440 MHz	34	2468 MHz
7	2414 MHz	21	2442 MHz	35	2470 MHz
8	2416MHz	22	2444 MHz	36	2472 MHz
9	2418 MHz	23	2446 MHz	37	2474 MHz
10	2420 MHz	24	2448 MHz	38	2476 MHz
11	2422 MHz	25	2450 MHz	39	2478 MHz
12	2424 MHz	26	2452 MHz	40	2480 MHz
13	2426 MHz	27	2454 MHz		
14	2428 MHz	28	2456 MHz		

4.2The Worst Test Modes and Channel Details

1. The EUT has been tested under operating condition.
2. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.
3. Investigation has been done on all the possible configurations for searching the worst case.

MODE	AVAILABLE FREQUENCY (MHz)	TESTED FREQUENCY (MHz)	MODULATION	DATA RATE (Mbps)
RADIATED EMISSION TEST (BELOW 1 GHz)				
Bluetooth LE	2402 to 2480	2402, 2440, 2480	GFSK	1
RADIATED EMISSION TEST (ABOVE 1 GHz)				
Bluetooth LE	2402 to 2480	2402, 2440, 2480	GFSK	1

Note: The field strength of radiation emission was measured as EUT stand-up position (H mode) and lie down position (E1, E2 mode) for Bluetooth LE Transmitter for channel Low, Mid and High, the worst case H position was reported.

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ANTENNA PORT CONDUCTED MEASUREMENT				
MODE	AVAILABLE FREQUENCY (MHz)	TESTED FREQUENCY (MHz)	MODULATION	DATA RATE (Mbps)
Bluetooth LE	2402 to 2480	2402, 2440, 2480	GFSK	1

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5 MEASUREMENT UNCERTAINTY

Test Items	Uncertainty
AC Power Line Conducted Emission	+/- 2.586 dB
Peak Output Power	+/- 0.84 dB
6dB Bandwidth	+/- 51.33 Hz
100 KHz Bandwidth Of Frequency Band Edges	+/- 0.84 dB
Peak Power Density	+/- 1.3 dB
Temperature	+/- 0.65 °C
Humidity	+/- 4.6 %
DC / AC Power Source	DC= +/- 0.13%, AC= +/- 0.2%

Radiated Spurious Emission Measurement Uncertainty	
Polarization: Vertical	9kHz~30MHz: +-2.3dB
	30MHz - 180MHz: +/- 3.37dB
	180MHz -417MHz: +/- 3.19dB
	0.417GHz-1GHz: +/- 3.19dB
	1GHz - 18GHz: +/- 4.04dB
	18GHz - 40GHz: +/- 4.04dB
Polarization: Horizontal	9kHz~30MHz: +-2.3dB
	30MHz - 167MHz: +/- 4.22dB
	167MHz -500MHz: +/- 3.44dB
	0.5GHz-1GHz: +/- 3.39dB
	1GHz - 18GHz: +/- 4.08dB
	18GHz - 40GHz: +/- 4.08dB

Note:

1. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.
2. The conformity assessment statement in this report is based solely on the test results, measurement uncertainty is excluded.

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6 CONDUCTED EMISSION TEST

6.1Standard Applicable:

Frequency range within 150kHz to 30MHz shall not exceed the Limit table as below.

Frequency range MHz	Limits dB(μV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

Note
1.The lower limit shall apply at the transition frequencies
2.The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.

6.2Measurement Equipment Used:

Conducted Emission Test Site					
EQUIPMENT TYPE	**MFR**	**MODEL NUMBER**	**SERIAL NUMBER**	**LAST CAL.**	**CAL DUE.**
EMI Test Receiver	R&S	ESCI 3	100335	02/12/2019	02/11/2020
Coaxial Cables	N/A	WK CE Cable	N/A	11/26/2018	11/25/2019
LISN	SCHWARZ BECK	NSLK 8127	8127-649	04/02/2019	04/01/2020
LISN	FCC	FCC-LISN-50/250-25-2-01	4034	04/09/2019	04/08/2020
Test Software	Farad	EZ-EMC	Ver. SGS-03A2	N.C.R	N.C.R

6.3EUT Setup:

1. The conducted emission tests were performed in the test site, using the setup in accordance with the ANSI C63.10:2013.
2. The AC/DC Power adaptor of EUT was plug-in LISN. The EUT was placed flushed with the rear of the table.
3. The LISN was connected with 120Vac/60Hz power source.

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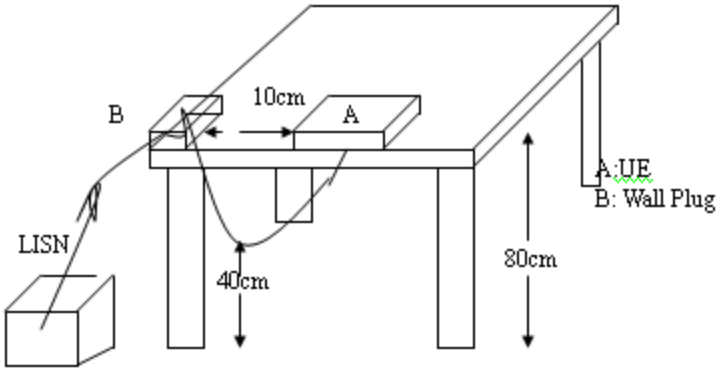
6.4Test SET-UP (Block Diagram of Configuration)



6.5Measurement Procedure:

1. The EUT was placed on a table which is 0.8m above ground plan.
2. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
3. Repeat above procedures until all phases of power being supplied by given UE are completed

6.6Measurement Result:

Note: Refer to next page for measurement data and plots.

Note2: The * reveals the worst-case results that closet to the limit.

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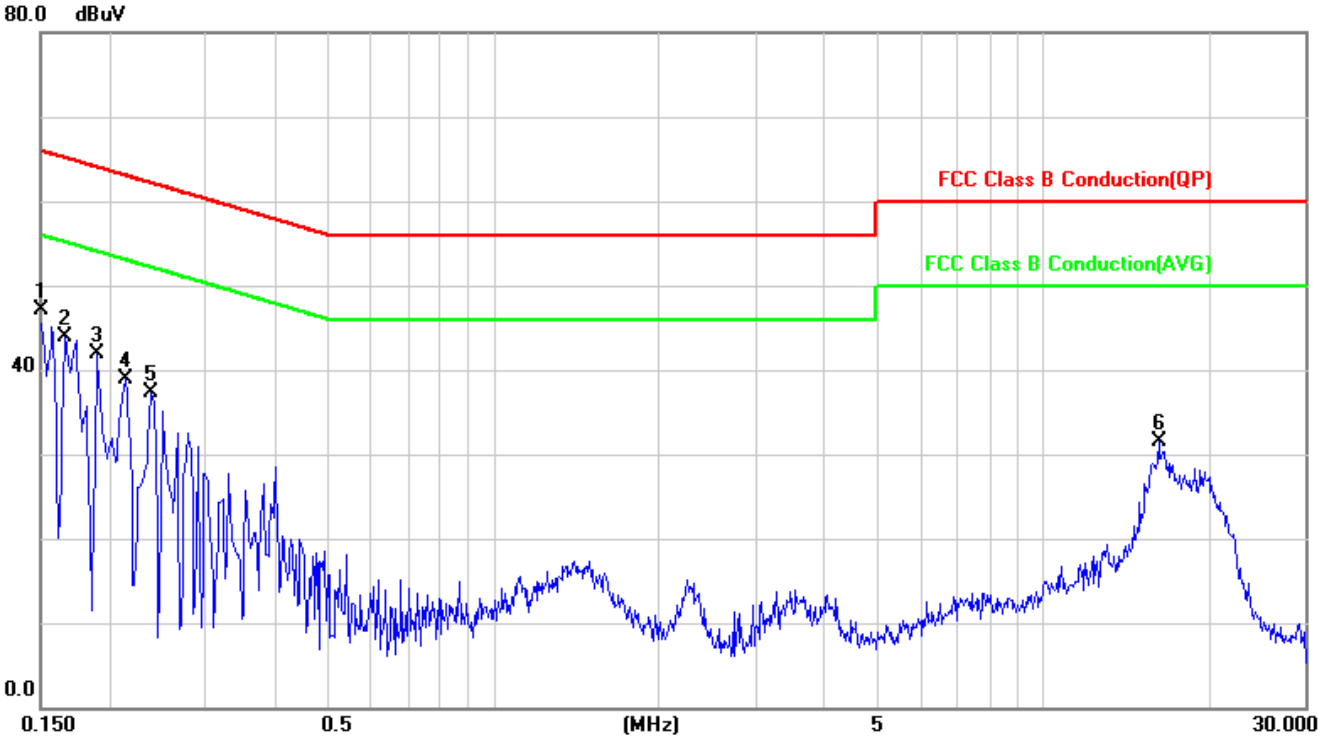
AC POWER LINE CONDUCTED EMISSION TEST DATA

Description:	Operation	Date:	2019/10/23
Line:	L1	Temp.(℃)/Hum.(%):	24(℃)/71%
Test Voltage:	AC 120V/60Hz	Test By:	Nick



No.	Mk.	Freq.	Reading	Factor	Measurement	Limit	Over	Detector
		(MHz)	dBuV	(dB)	(dBuV)	(dBuV)	(dB)	
1	*	0.1500	47.14	0.00	47.14	66.00	-18.86	peak
2		0.1660	43.96	0.00	43.96	65.16	-21.20	peak
3		0.1900	41.92	0.01	41.93	64.04	-22.11	peak
4		0.2140	38.81	0.01	38.82	63.05	-24.23	peak
5		0.2380	37.24	0.01	37.25	62.17	-24.92	peak
6		16.2940	31.16	0.35	31.51	60.00	-28.49	peak

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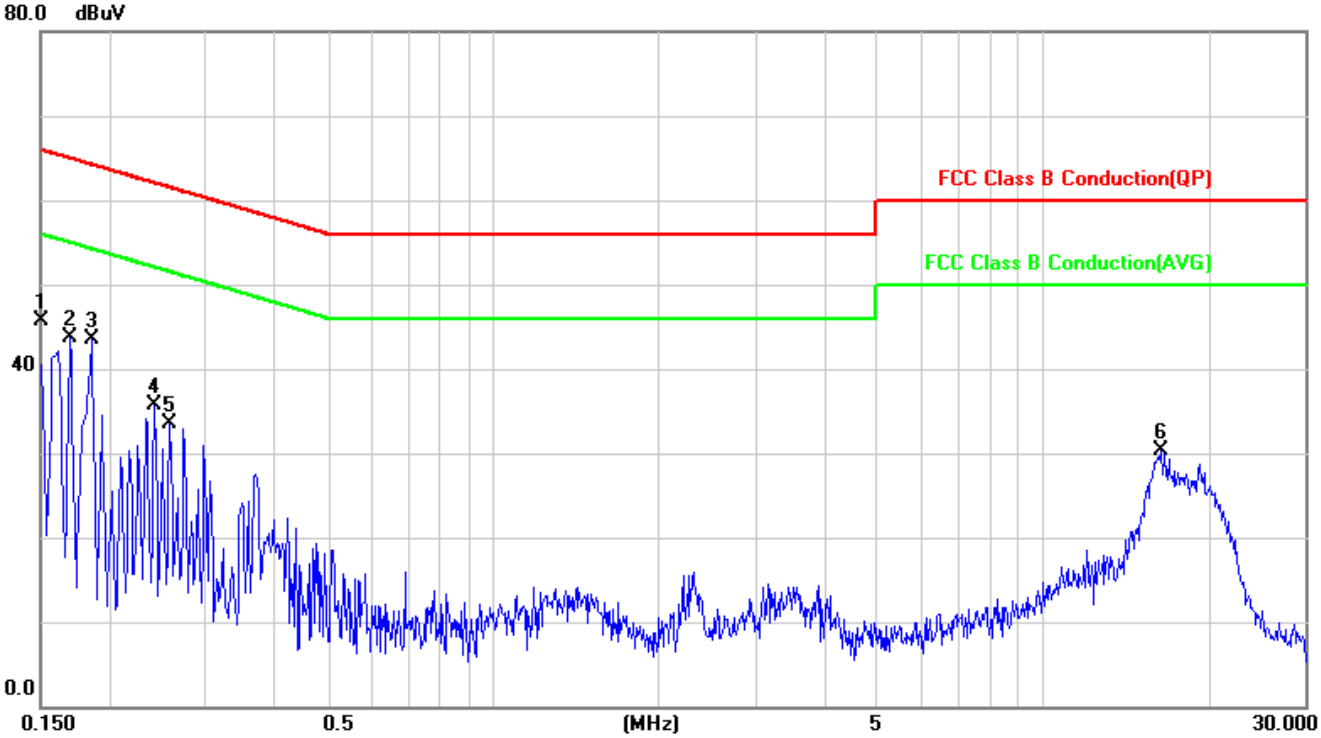
Description:	Operation	Date:	2019/10/23
Line:	N	Temp.(℃)/Hum.(%):	24(℃)/71%
Test Voltage:	AC 120V/60Hz	Test By:	Nick



No.	Mk.	Freq.	Reading	Factor	Measurement	Limit	Over	Detector
		(MHz)	dBuV	(dB)	(dBuV)	(dBuV)	(dB)	
1	*	0.1500	45.61	0.03	45.64	66.00	-20.36	peak
2		0.1700	43.65	0.03	43.68	64.96	-21.28	peak
3		0.1860	43.42	0.03	43.45	64.21	-20.76	peak
4		0.2420	35.76	0.03	35.79	62.03	-26.24	peak
5		0.2580	33.38	0.03	33.41	61.50	-28.09	peak
6		16.4540	29.90	0.37	30.27	60.00	-29.73	peak

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7 PEAK OUTPUT POWER MEASUREMENT

7.1Standard Applicable:

For systems using digital modulation in the 2400-2483.5 MHz bands, the limit for peak output power is 1Watt and the e.i.r.p. shall not exceed 4 W.

If the transmitting antenna of directional gain greater than 6dBi are used the peak output power form the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the Antenna exceeds 6dBi.

In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of Antenna exceeds 6dBi.

7.2Measurement Equipment Used:

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Power Meter	Anritsu	ML2496A	1804001	02/13/2019	02/12/2020
Power Sensor	Anritsu	MA2411B	1726104	02/13/2019	02/12/2020
Power Sensor	Anritsu	MA2411B	1726107	02/13/2019	02/12/2020
DC Power Supply	Agilent	E3640A	MY52410006	12/04/2018	12/03/2019

7.3Test Set-up:

7.4Measurement Procedure:

1.Place the EUT on the table and set it in transmitting mode.

2.The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.

3.Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the power meter.

4.Record the max. Reading as observed from Power Meter.

5.Repeat above procedures until all test default channel measured was complete.

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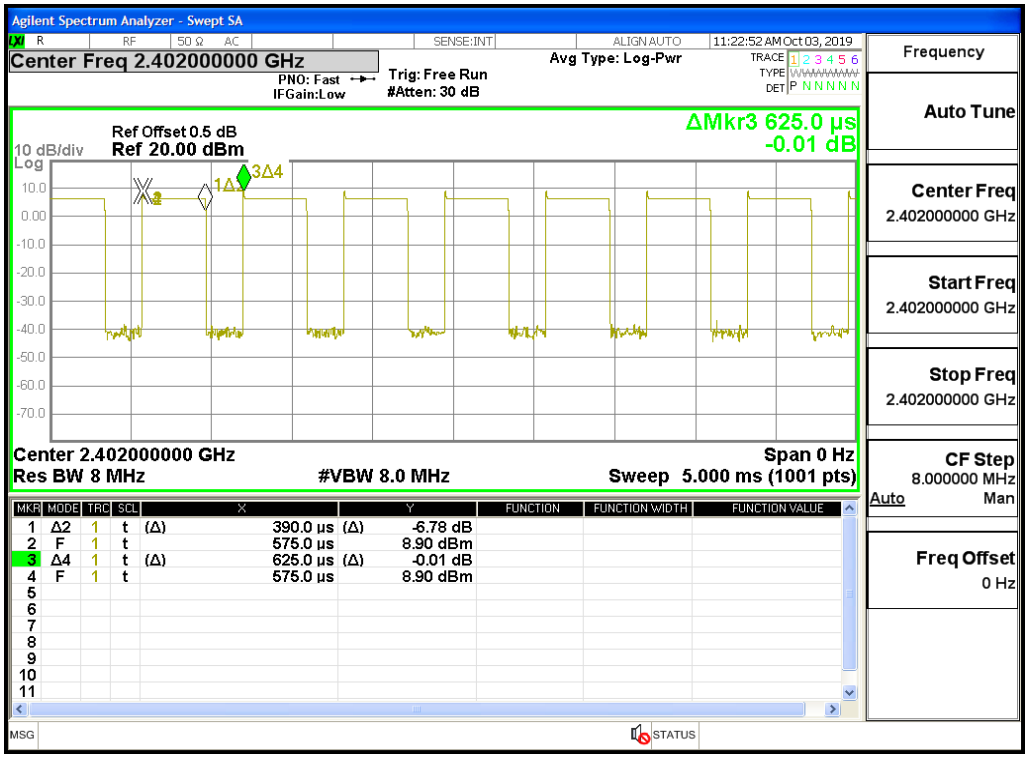
7.5Duty Factor:

	Duty Cycle (%)	Duty Factor (dB)	1/T (kHz)	VBW setting (kHz)
BLE	62.00	2.08	2.56	3.00

Duty Cycle_BLE_1M_LowCH00-2402



Duty Cycle Factor:10*log(1/(62/100))=2.08

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7.6Output Power:

7.6.1 Peak & Avg

BLE mode:

CH	Frequency (MHz)	Peak Power Output (dBm)	Required Limit
Low	2402	**9.23**	1 Watt = 30 dBm
Mid	2440	8.87	1 Watt = 30 dBm
High	2480	8.54	1 Watt = 30 dBm
BLE mode:			
CH	**Frequency (MHz)**	**Max. Avg. Output include tune up tolerance Power (dBm)**	**Required Limit**
Low	2402	6.43	1 Watt = 30 dBm
Mid	2440	6.06	1 Watt = 30 dBm
High	2480	6.47	1 Watt = 30 dBm

**Note: Measured by power meter, cable loss as 0.5 dB that offsets on the power meter in Peak*
Note: Measured by power meter,* ***as cable loss+ Duty cycle factor that offsets on the power meter*
**Note: Max. Output include tune up tolerance Power is average power*

7.6.2 EIRP

EIRP

CH	Frequency (MHz)	Max. Avg. Output include tune up tolerance Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Limit		
Low	2402	6.43	1.87	8.30	4W=	36	dBm
Mid	2440	6.06	1.87	7.93	4W=	36	dBm
High	2480	6.47	1.87	8.34	4W=	36	dBm

**** Note:*** EIRP = Average Power + Gain

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8 6DB & 99% BANDWIDTH MEASUREMENT

8.1Standard Applicable

The minimum 6 dB bandwidth shall be at least 500 kHz .

8.2Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
EXA Spectrum Analyzer	Agilent	N9010A	MY50420195	05/02/2019	05/01/2020
DC Power Supply	Agilent	E3640A	MY52410006	12/04/2018	12/03/2019
DC Block	Mini-Circuits	BLK-18-S+	1	01/02/2019	01/01/2020

8.3Test Set-up:

8.4Measurement Procedure:

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. For 6dB Bandwidth:
   Set the spectrum analyzer as RBW=100 kHz, VBW= 3*RBW, Span = 5MHz, Detector=Peak, Sweep=auto.
5. Mark the peak frequency and –6dB (upper and lower) frequency.
6. For 99% Bandwidth:
   Set the spectrum analyzer as RBW=1%, VBW=3*RBW, Span = 2MHz, Detector=Sample, Sweep=auto.
7. Turn on the 99% bandwidth function, max reading.
8. Repeat above procedures until all test default channel is completed

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8.5Measurement Result:

BLE mode

Frequency (MHz)	6dB BW (MHz)	BW (MHz)	Result
2402	0.6779	> 0.5	PASS
2440	0.6859	> 0.5	PASS
2480	0.6815	> 0.5	PASS

BLE mode

Frequency (MHz)	99%Bandwidth (MHz)
2402	1.0202
2440	1.0196
2480	1.0215

Note: Refer to next page for plots.

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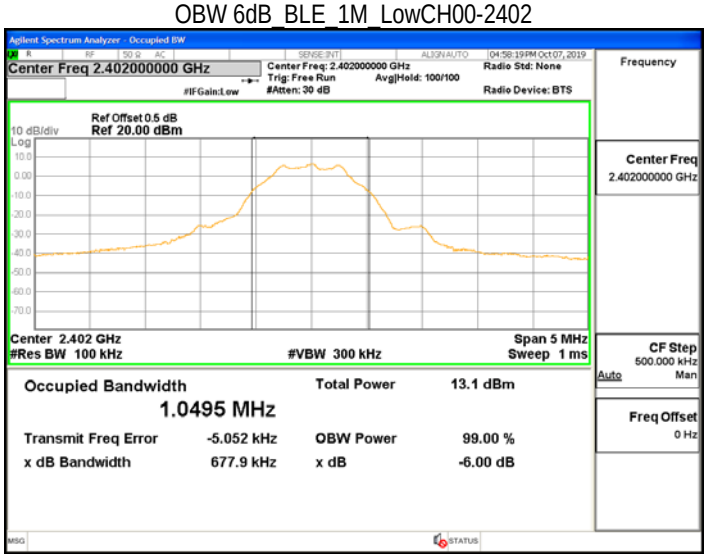
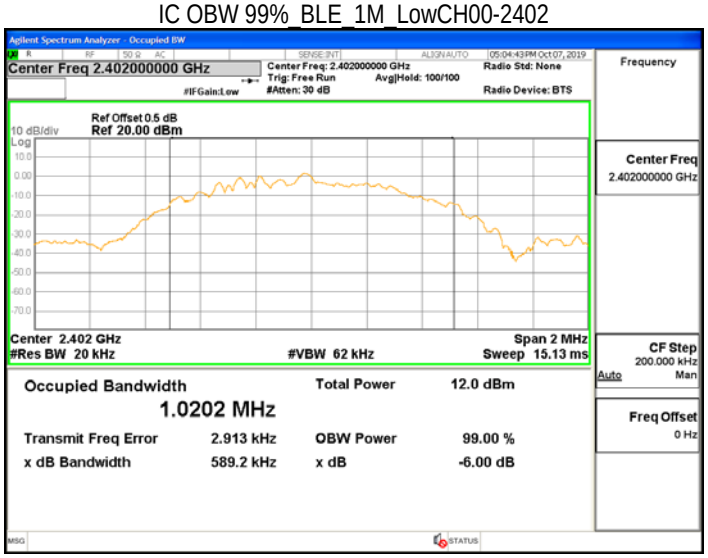
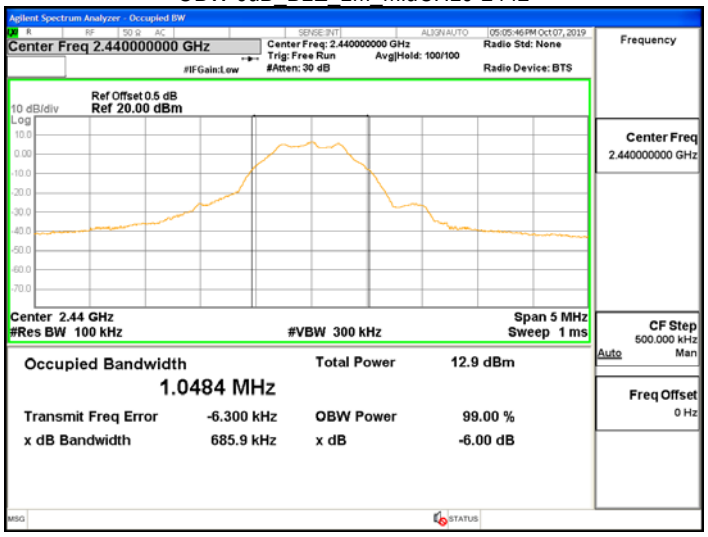
OBW 6dB_BLE_1M_LowCH00-2402



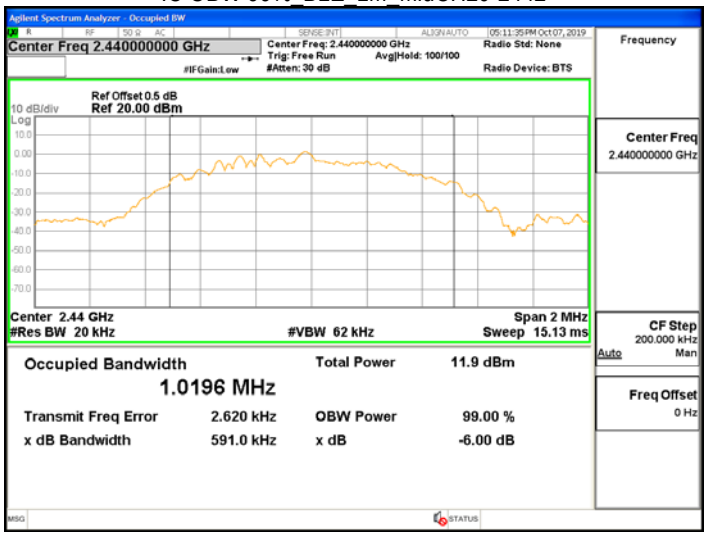
IC OBW 99%_BLE_1M_LowCH00-2402



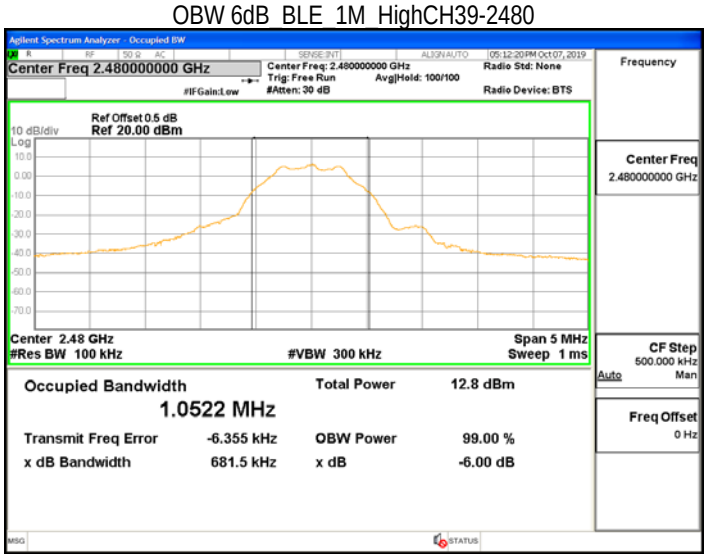
OBW 6dB_BLE_1M_MidCH19-2442



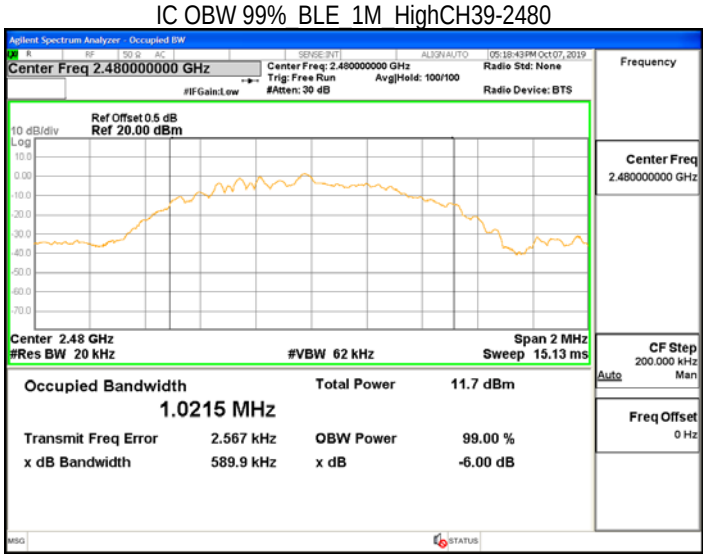
IC OBW 99%_BLE_1M_MidCH20-2442



OBW 6dB_BLE_1M_HighCH39-2480



IC OBW 99%_BLE_1M_HighCH39-2480



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9 CONDUCTED BAND EDGES AND SPURIOUS EMISSION MEASUREMENT

9.1Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a) & RSS-Gen §8.10, must also comply with the radiated emission limits specified in §15.209(a) & RSS-Gen §8.9.

9.2Measurement Equipment Used:

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
EXA Spectrum Analyzer	Agilent	N9010A	MY50420195	05/02/2019	05/01/2020
DC Power Supply	Agilent	E3640A	MY52410006	12/04/2018	12/03/2019
DC Block	Mini-Circuits	BLK-18-S+	1	01/02/2019	01/01/2020

9.3Test SET-UP:

9.4Measurement Procedure

9.4.1 Reference Level of Emission Limit:

1. Set analyzer center frequency to DTS channel center frequency.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
3. Set the span to 1.5 times the DTS channel bandwidth.
4. Set the RBW = 100kHz & VBW = 300 kHz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.

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8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level.

9.4.2 Conducted Band Edge:

1. To connect Antenna Port of EUT to Spectrum.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set start to edge frequency, and stop frequency of spectrum analyzer so as to encompass the spectrum to be examined.
5. Set the spectrum analyzer as RBW=100 kHz, VBW=300 kHz, Detector = Peak, Sweep = auto
6. Mark the highest reading of the emission as the reference level measurement.
7. Marker on frequency, 2.3999GHz and 2.4836GHz, and examine shall 100 kHz immediately outside the authorized (2400~2483.5MHz) be attenuated by 20dB at least relative to the maximum emission of power.
8. Repeat above procedures until all default test channel (low, middle, and high) was complete.

9.4.3 Conducted Spurious Emission:

1. To connect Antenna Port of EUT to Spectrum.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
3. Set RBW = 100 kHz & VBW=300 kHz, Detector =Peak, Sweep = Auto
4. Allow trace to fully stabilize.
5. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.
6. Repeat above procedures until all default test channel measured were complete.

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9.5Measurement Result

Reference Level of Limit

Frequency (MHz)	RF Power Density (dBm)	Reference Level of Limit = PSD - 20dB (dBm)
2402	6.36	-13.64
2440	6.23	-13.77
2480	6.12	-13.88

NOTE: cable loss as 0.5dB that offsets in the spectrum

NOTE: Refer to next page for plots.

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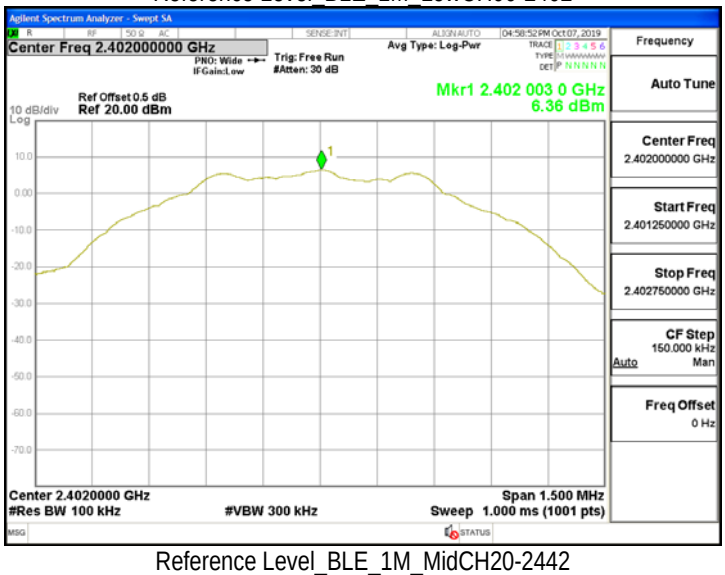
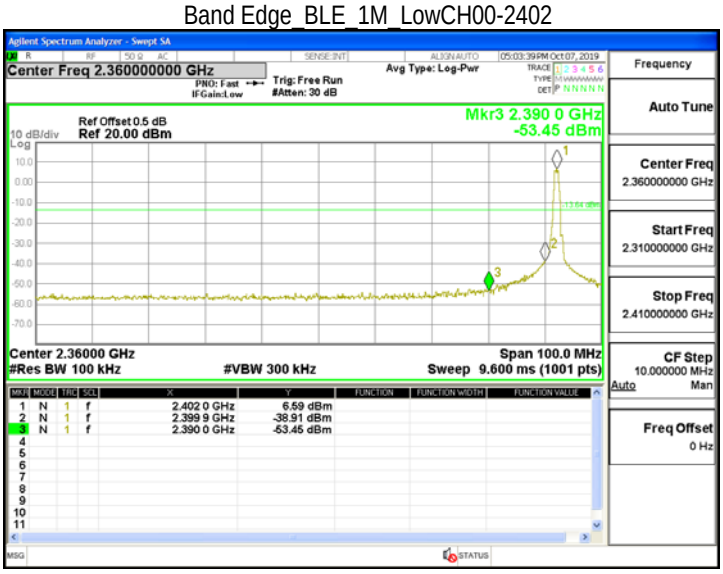
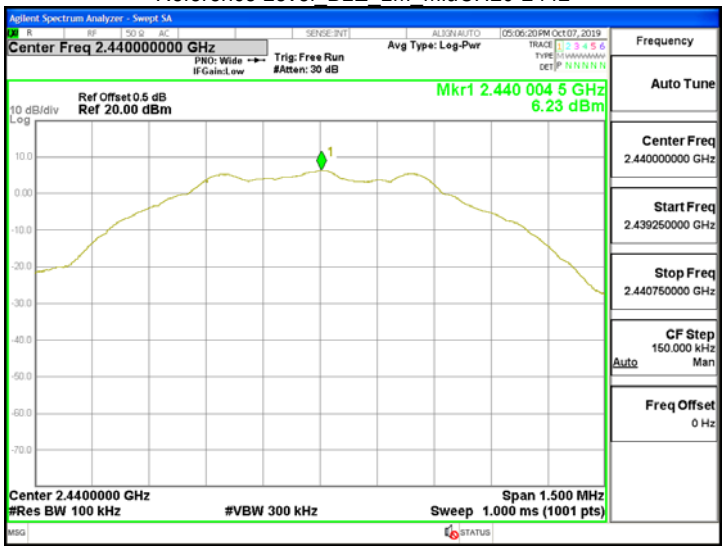
Reference Level_BLE_1M_LowCH00-2402



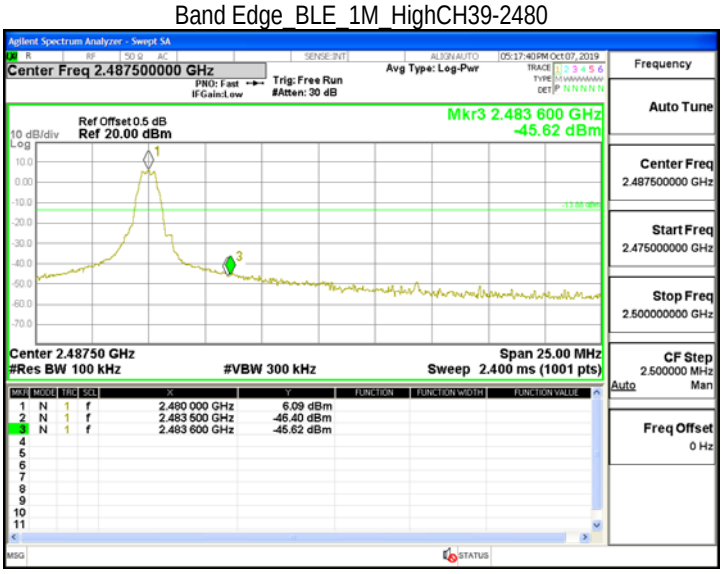
Band Edge_BLE_1M_LowCH00-2402



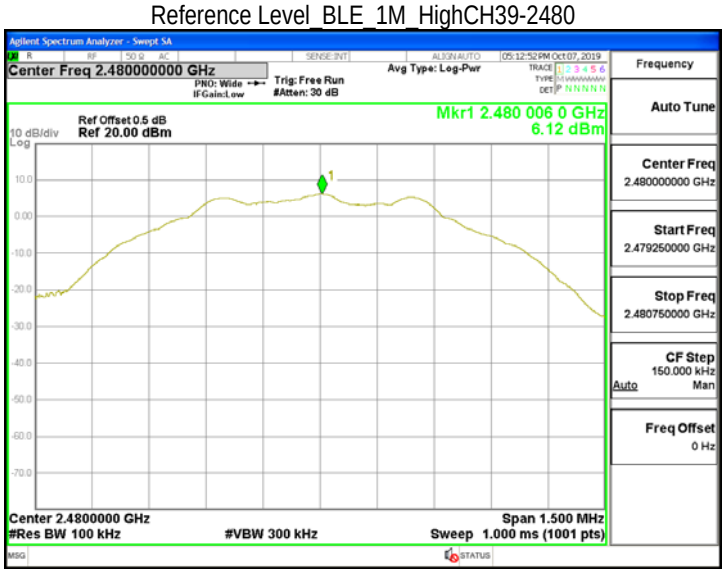
Reference Level_BLE_1M_MidCH20-2442



Band Edge_BLE_1M_HighCH39-2480



Reference Level_BLE_1M_HighCH39-2480



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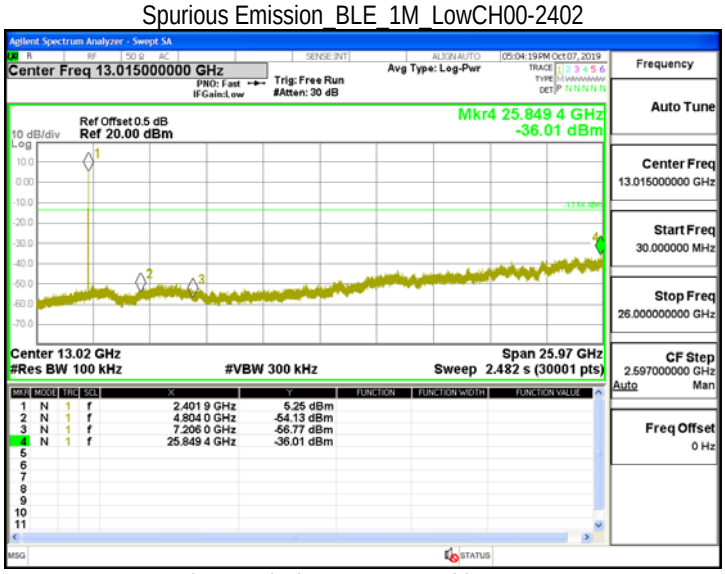
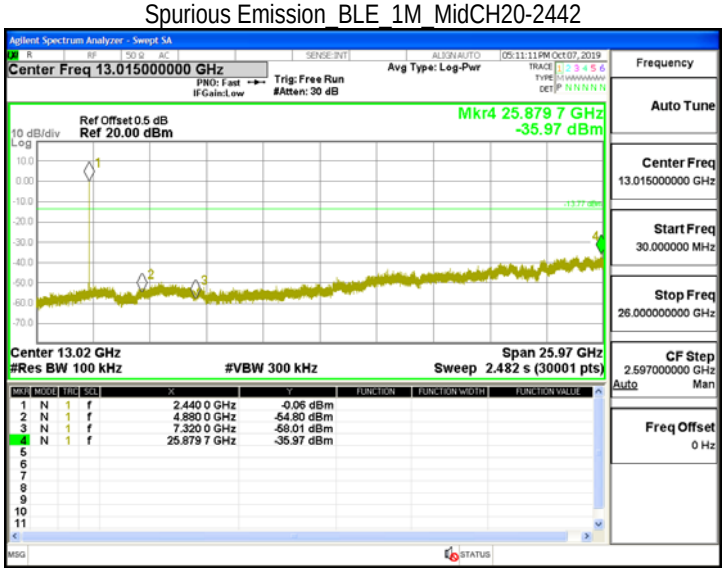
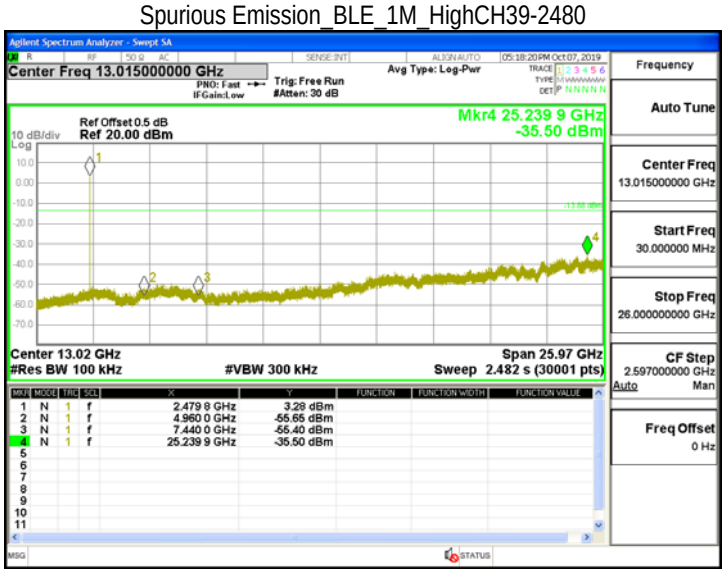
Spurious Emission_BLE_1M_LowCH00-2402



Spurious Emission_BLE_1M_MidCH20-2442



Spurious Emission_BLE_1M_HighCH39-2480



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10 RADIATED BANDEDGE AND SPURIOUS EMISSION MEASUREMENT

10.1 Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. In addition, radiated emissions which fall in the restricted bands must also comply with the §15.209 and RSS-Gen §8.9 Table 5 and 6 limit as below.

And according to §15.33(a) (1) & RSS-Gen §6.13.2.a for an intentional radiator operates below 10GHz, the frequency range of measurements: to the tenth harmonic of the highest fundamental frequency or to 40GHz, whichever is lower.

Frequency (MHz)	Field strength (microvolts/meter)	Distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

1. The lower limit shall apply at the transition frequencies.

2.Emission level (dBμV/m) = 20 log Emission level (dBμV/m)

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10.2 Measurement Equipment Used

966 Chamber					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Bi-log Antenna	TESEO	CBL 6112D	35242 & AT-N0555	01/10/2019	01/09/2020
Horn Antenna	Schwarzbeck	BBHA9170	07/02/1900	12/27/2018	12/26/2019
Horn Antenna	Schwarzbeck	BBHA9120D	D803	12/24/2018	12/23/2019
Loop Antenna	ETS.LINDGREN	6502	148045	10/08/2018	10/07/2019
PXA Spectrum Analyzer	Agilent	N9030A	MY53120760	04/22/2019	04/21/2020
EMI Test Receiver	R&S	ESCI 3	100335	02/12/2019	02/11/2020
Pre-Amplifier	EMC Instruments	EMC184045B	980135	01/02/2019	01/01/2020
Pre-Amplifier	EMC Instruments	EMC051825	980152	01/02/2019	01/01/2020
Pre-Amplifier	HP	8447D	2944A09469	01/02/2019	01/01/2020
Filter 2400-2483.5 MHz	EWT	EWT-14-0166	M1	01/02/2019	01/01/2020
High Pass Filter	WI	WHKX4.0/18G-10SS	22	01/02/2019	01/01/2020
Coaxial Cable	Huber Suhner	succoflex 102	MY2622/2	01/02/2019	01/01/2020
Coaxial Cable	Huber Suhner	succoflex 104A	800086/4a	01/02/2019	01/01/2020
Coaxial Cable	Huber Suhner	EMC 104-SM-SM-2000	160123	01/02/2019	01/01/2020
Software	e3 V6.11-20180413				

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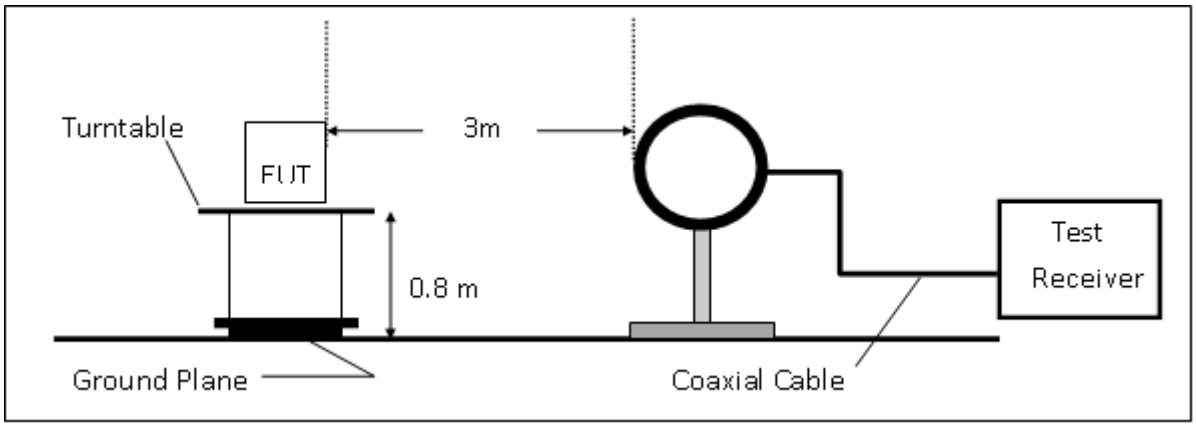
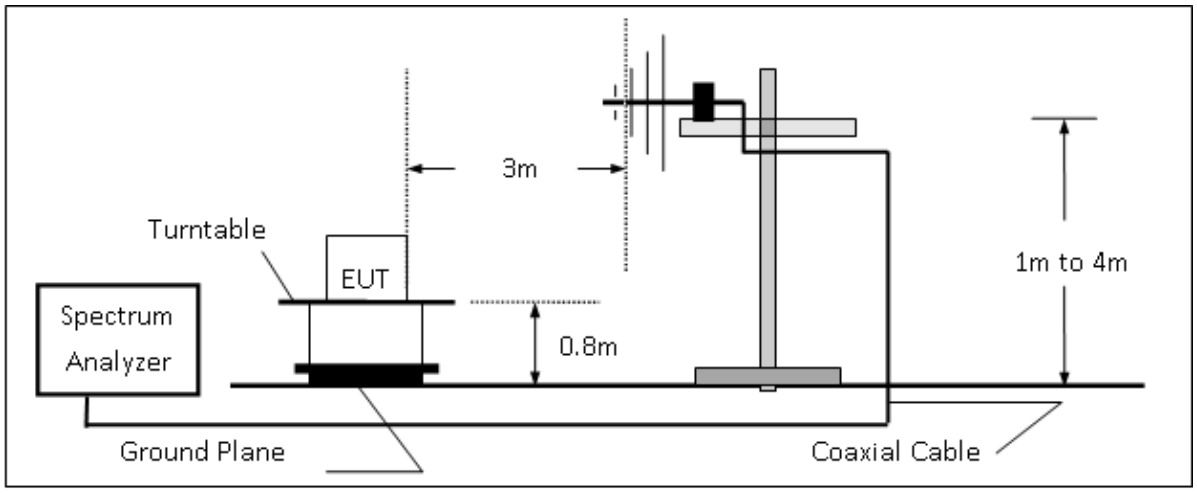
10.3 Test SET-UP

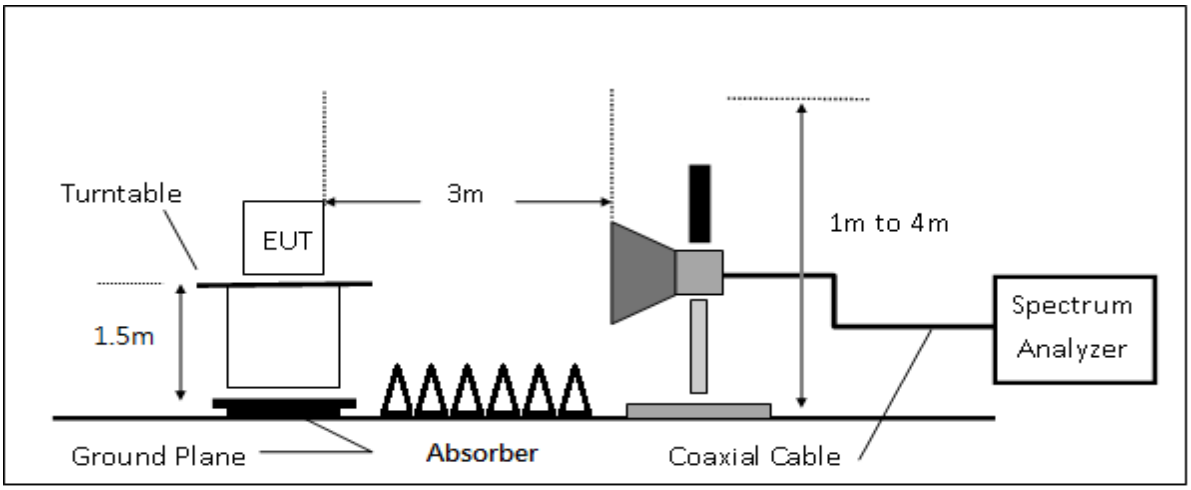
(A) Radiated Emission Test Set-UP Frequency Below 30MHz.



(B) Radiated Emission Test Set-Up, Frequency form 30MHz to 1000MHz



(C) Radiated Emission Test Set-UP Frequency Over 1 GHz



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10.4 Measurement Procedure

1. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
2. The EUT was placed on a turn table with 0.8m for frequency< 1GHz and 1.5m for frequency> 1GHz above ground plan.
3. The turn table shall rotate 360 degrees to determine the position of maximum emission level.
4. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emissions.
5. Set the spectrum analyzer as RBW=120 kHz and VBW=300 kHz for Peak Detector (PK) and Quasi-peak (QP) at frequency below 1 GHz.
6. Set the spectrum analyzer as RBW=1 MHz, VBW=3 MHz for Peak Detector at frequency above 1 GHz.
7. Set the spectrum analyzer as RBW=1 MHz, VBW=10 Hz (Duty cycle > 98%) or VBW ≥ 1/T (Duty cycle < 98%) for Average Detector at frequency above 1 GHz.
8. When measurement procedures for electric field radiated emissions above 1 GHz the EUT measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” is still within the 3dB illumination BW of the measurement antenna.
9. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
10. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. On spectrum, change spectrum mode in linear display mode, and reduce VBW = 10Hz if average reading is measured.
11. Repeat above procedures until all default test channel measured were complete.

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10.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CL - AG$$

Where *FS = Field Strength*
RA = Reading Amplitude
AF = Antenna Factor
CL = Cable Attenuation Factor (Cable Loss)
AG = Amplifier Gain

*The limit of the emission level is expressed in dBuV/m, which converts 20*log(uV/m)*

Actual FS(dBµV/m) = SPA. Reading level(dBµV) + Factor(dB)

Factor(dB) = Antenna Factor(dBµV/m) + Cable Loss(dB) – Pre_Amplifier Gain(dB)

10.6 Test Results of Radiated Spurious Emissions form 9 kHz to 30 MHz

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit per 15.31(o) was not reported.

10.7 Measurement Result:

Note: Refer to next page spectrum analyzer data chart and tabular data sheets.

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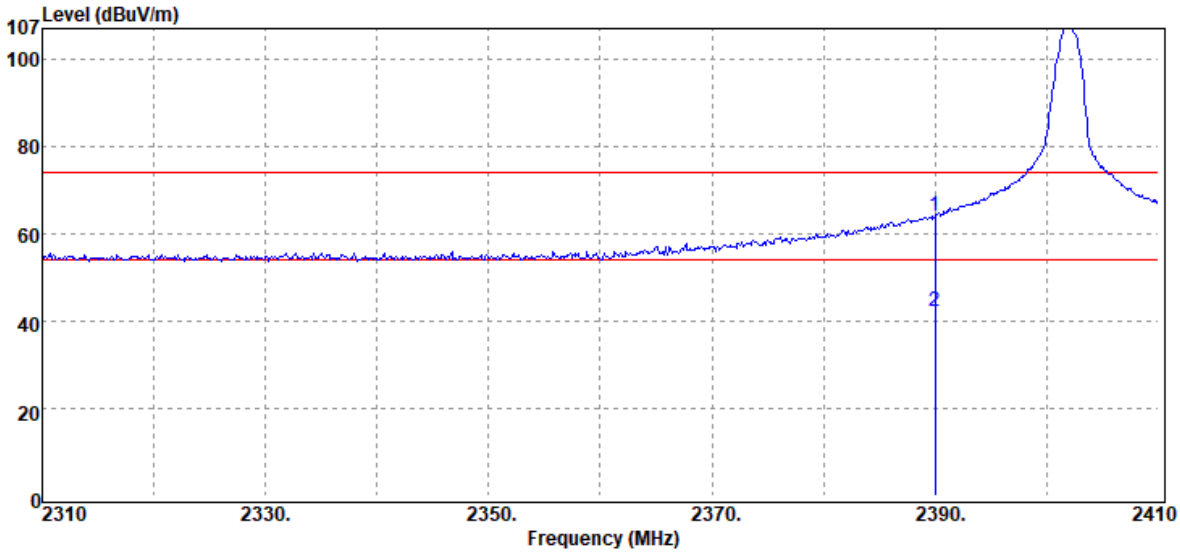
10.7.1 Radiated Band Edge Measurement Result

Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:26.3/69
Test Channel	:2402 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Bandedge CH Low	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2390.00	Peak	56.64	7.57	64.21	74.00	-9.79
2390.00	Average	34.82	7.57	42.39	54.00	-11.61

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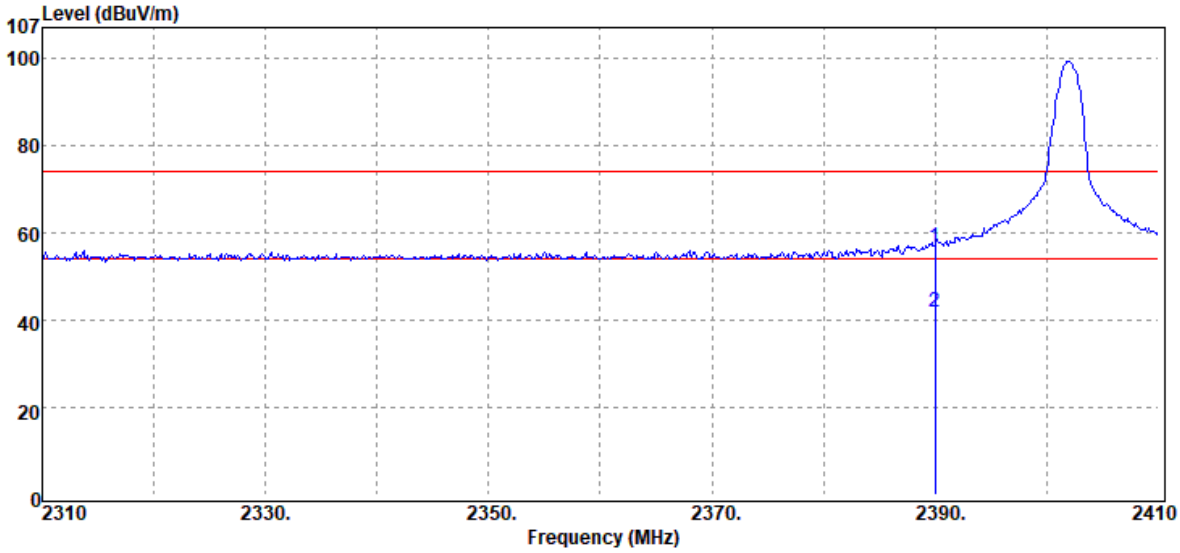
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:26.3/69
Test Channel	:2402 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Bandedge CH Low	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2390.00	Peak	48.95	7.57	56.52	74.00	-17.48
2390.00	Average	34.13	7.57	41.70	54.00	-12.30

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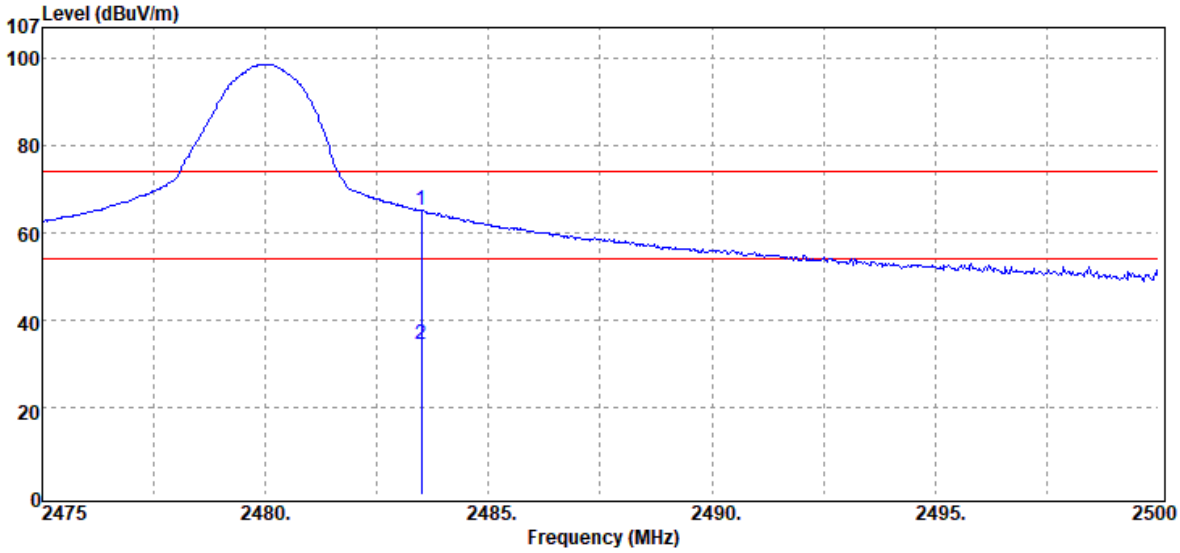
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2480 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Bandedge CH High	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Peak	58.05	6.94	64.99	74.00	-9.01
2483.50	Average	27.67	6.94	34.61	54.00	-19.39

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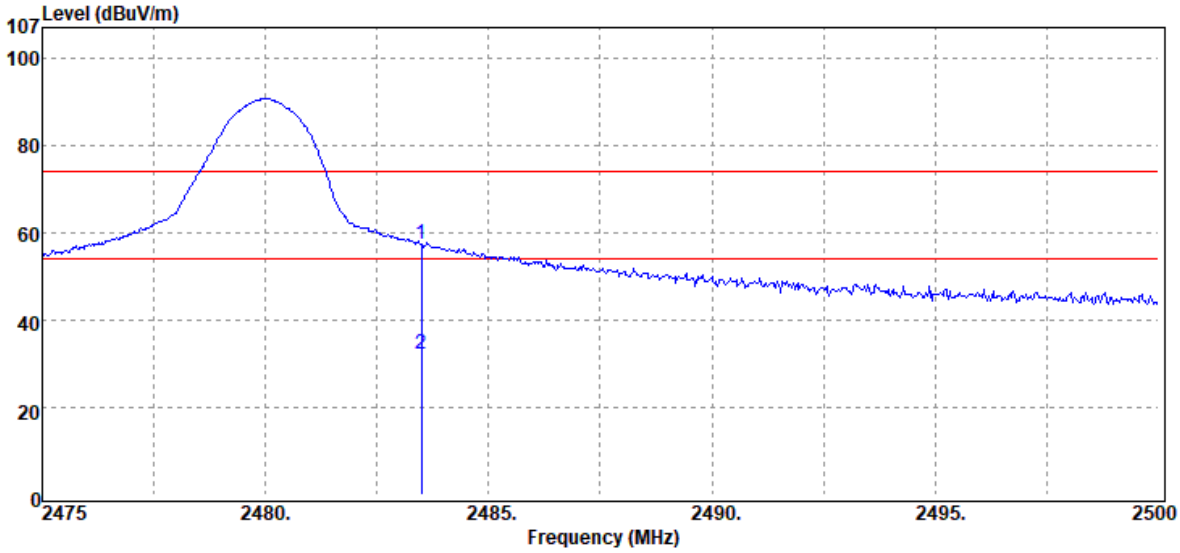
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2480 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Bandedge CH High	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Peak	50.42	6.94	57.36	74.00	-16.64
2483.50	Average	25.34	6.94	32.28	54.00	-21.72

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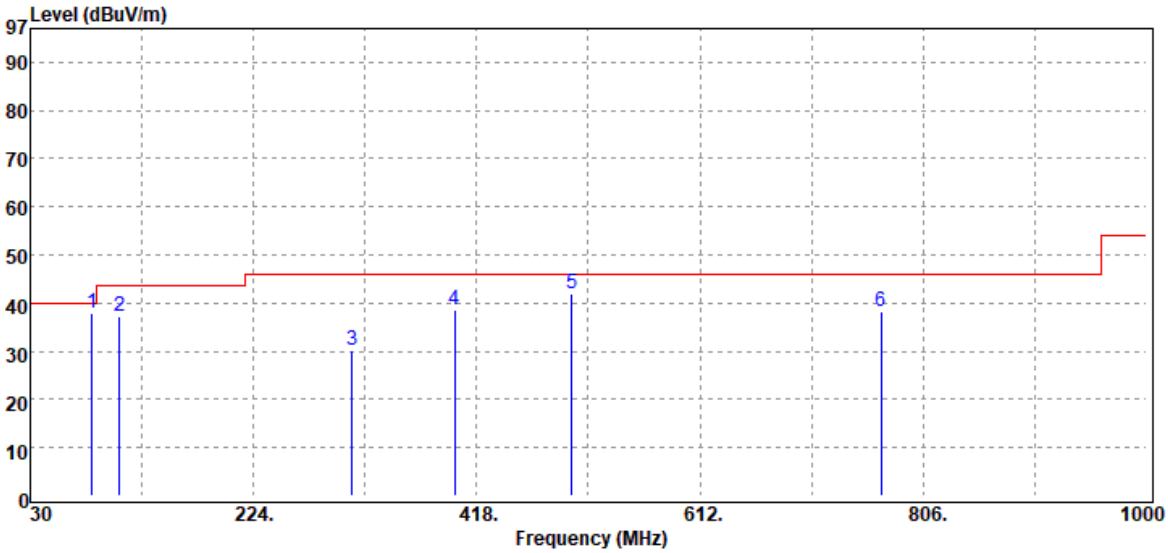
10.7.2 Radiated Spurious Emission from 30MHz to 1000MHz

Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2440 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Tx CH Mid	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
83.35	Peak	53.90	-16.13	37.77	40.00	-2.23
107.60	Peak	49.05	-11.77	37.28	43.50	-6.22
309.36	Peak	38.46	-8.22	30.24	46.00	-15.76
398.60	Peak	44.79	-6.14	38.65	46.00	-7.35
500.45	Peak	46.43	-4.31	42.12	46.00	-3.88
769.14	Peak	39.56	-1.41	38.15	46.00	-7.85

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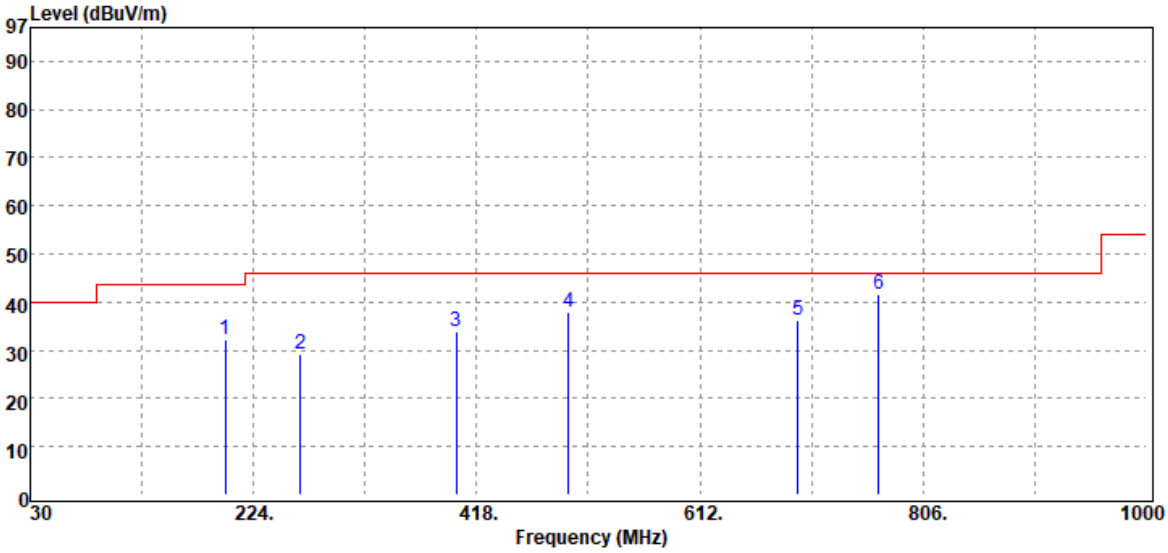
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2440 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Tx CH Mid	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
199.75	Peak	44.58	-12.38	32.20	43.50	-11.30
264.74	Peak	37.71	-8.47	29.24	46.00	-16.76
400.54	Peak	40.05	-6.07	33.98	46.00	-12.02
497.54	Peak	42.57	-4.55	38.02	46.00	-7.98
697.36	Peak	38.63	-2.29	36.34	46.00	-9.66
767.20	Peak	43.08	-1.38	41.70	46.00	-4.30

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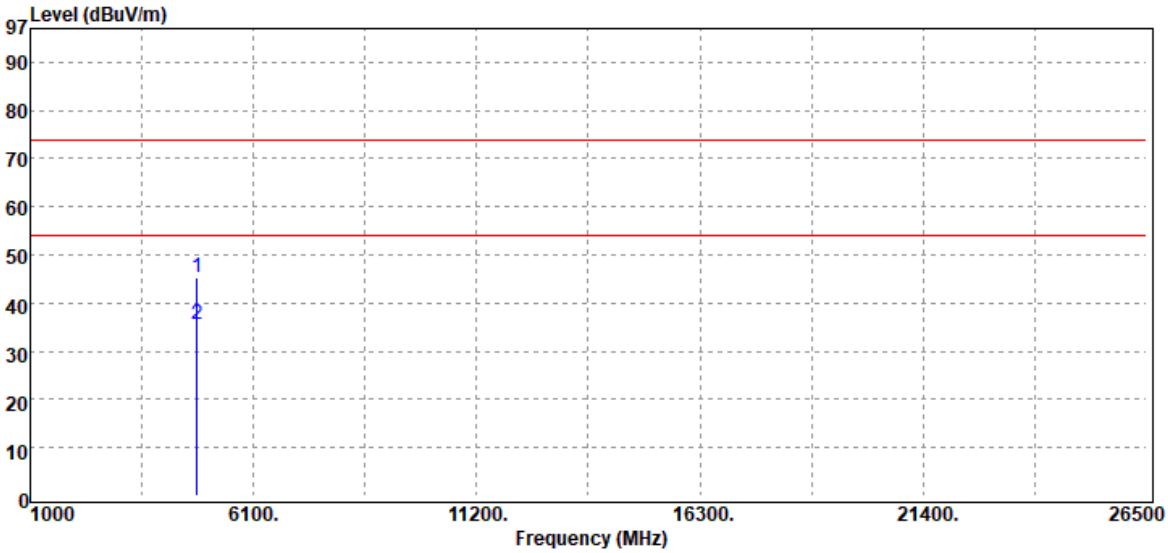
10.7.3 Radiated Spurious Emission above 1GHz

Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2402 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Tx CH Low	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4804.00	Peak	30.80	14.57	45.37	74.00	-28.63
4804.00	Average	20.99	14.57	35.56	54.00	-18.44

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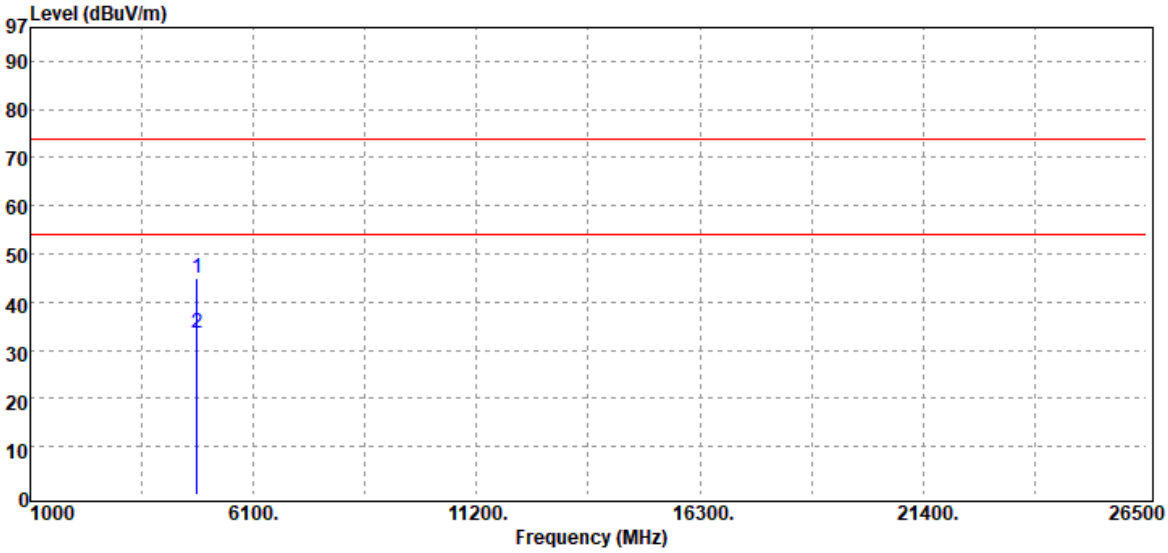
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2402 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Tx CH Low	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4804.00	Peak	30.33	14.57	44.90	74.00	-29.10
4804.00	Average	19.10	14.57	33.67	54.00	-20.33

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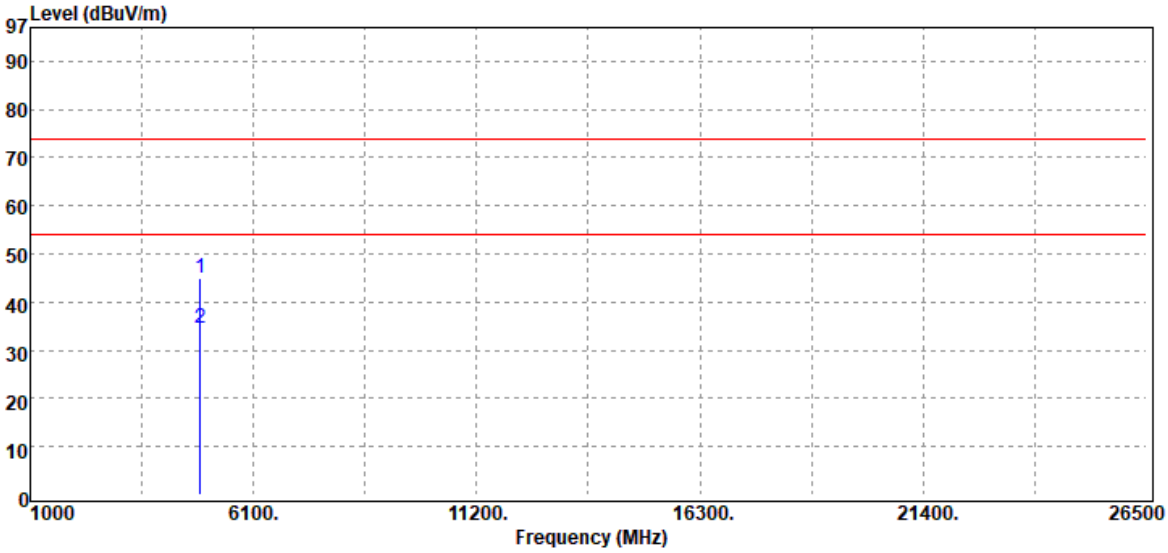
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2440 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Tx CH Mid	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4880.00	Peak	29.81	15.06	44.87	74.00	-29.13
4880.00	Average	19.64	15.06	34.70	54.00	-19.30

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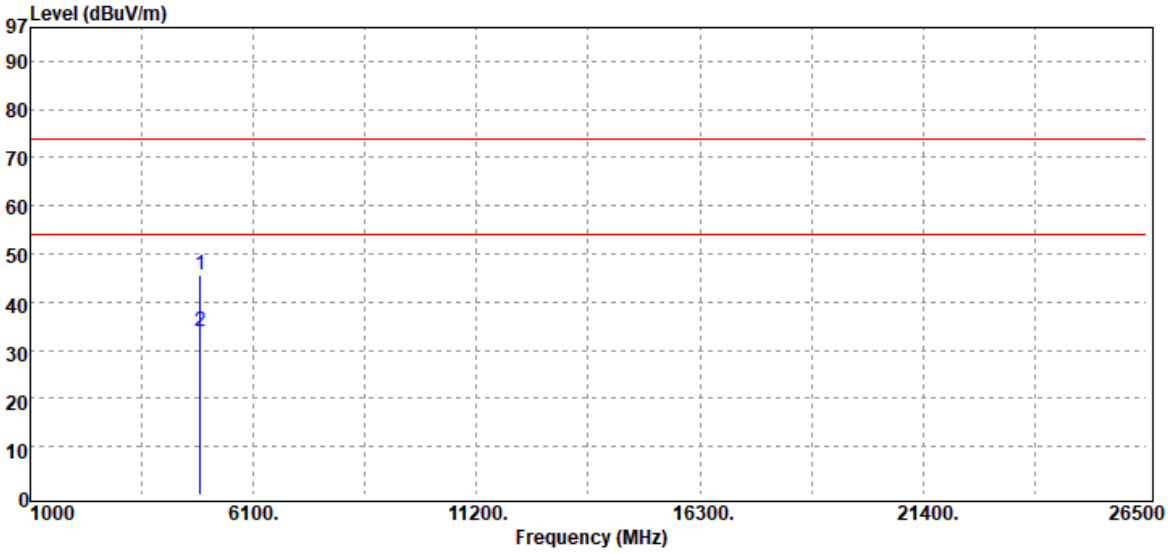
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2440 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Tx CH Mid	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4880.00	Peak	30.60	15.06	45.66	74.00	-28.34
4880.00	Average	18.90	15.06	33.96	54.00	-20.04

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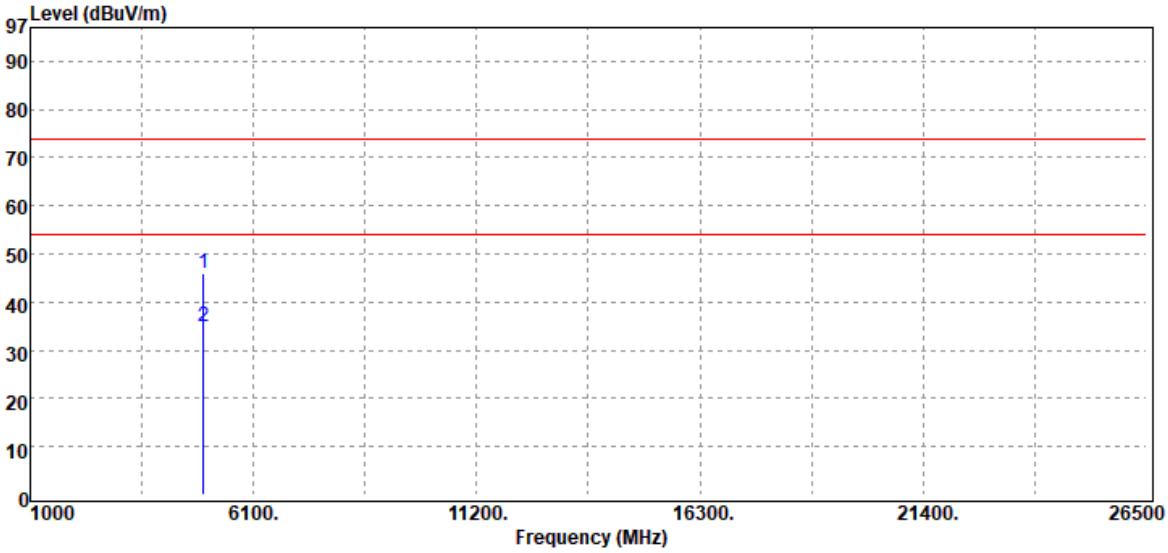
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2480 MHz	Antenna Pol.	:VERTICAL
Test Mode	:Tx CH High	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4960.00	Peak	30.83	15.13	45.96	74.00	-28.04
4960.00	Average	19.79	15.13	34.92	54.00	-19.08

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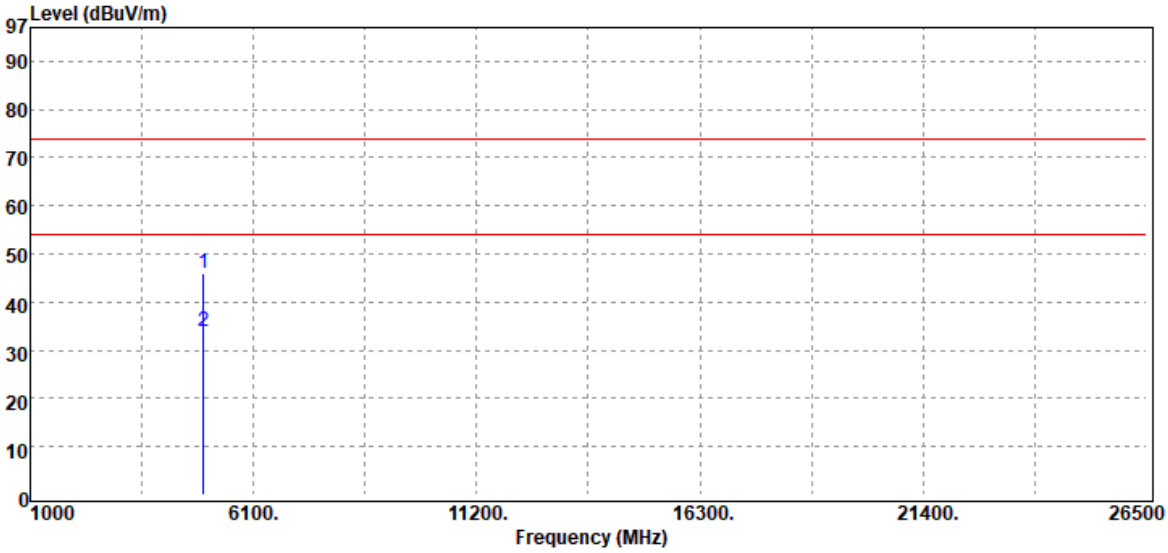
Report Number	:ER-2019-A0013	Test Date	:2019-10-05
Operation Mode	:BLE 1M	Temp./Humi.	:23.1/66
Test Channel	:2480 MHz	Antenna Pol.	:HORIZONTAL
Test Mode	:Tx CH High	Engineer	:Nick
EUT Pol	:H Plane		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4960.00	Peak	30.78	15.13	45.91	74.00	-28.09
4960.00	Average	18.89	15.13	34.02	54.00	-19.98

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11 POWER SPECTRAL DENSITY

11.1 Standard Applicable:

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

11.2 Measurement Equipment Used:

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
EXA Spectrum Analyzer	Agilent	N9010A	MY50420195	05/02/2019	05/01/2020
DC Power Supply	Agilent	E3640A	MY52410006	12/04/2018	12/03/2019
DC Block	Mini-Circuits	BLK-18-S+	1	01/02/2019	01/01/2020

11.3 Test Set-up:

11.4 Measurement Procedure:

1. Set analyzer center frequency to DTS channel center frequency.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance.
3. Set the span to 1.5 times the DTS channel bandwidth.
4. Set the RBW = 3 kHz. & the VBW = 10 kHz
5. For defining Restricted Band Edge Limit:
   Set the RBW = 100kHz & VBW = 300 kHz.
6. Detector = peak.
7. Sweep time = auto couple.
8. Trace mode = max hold.
9. Allow trace to fully stabilize.
10. Use the peak marker function to determine the maximum amplitude level.

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11.5 Measurement Result:

BLE mode

Frequency (MHz)	RF Power Density (dBm)	Offset	Maximum Limit (dBm)	Result
2402	-7.80	0.50	8	PASS
2440	-8.07	0.50	8	PASS
2480	-8.14	0.50	8	PASS

NOTE: cable loss as 0.5dB that offsets in the spectrum

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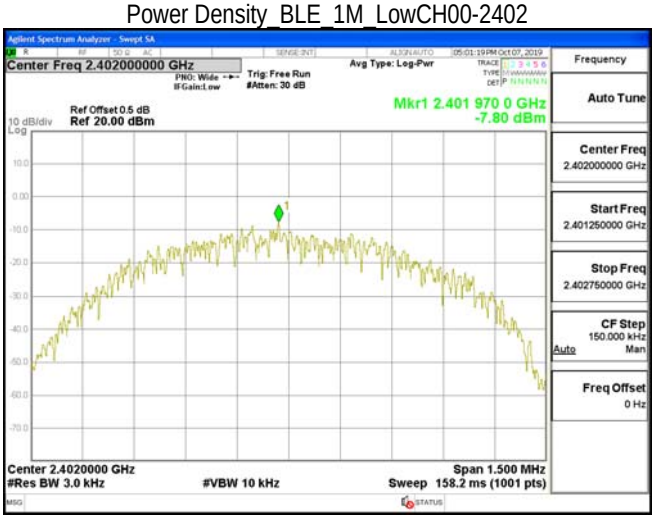
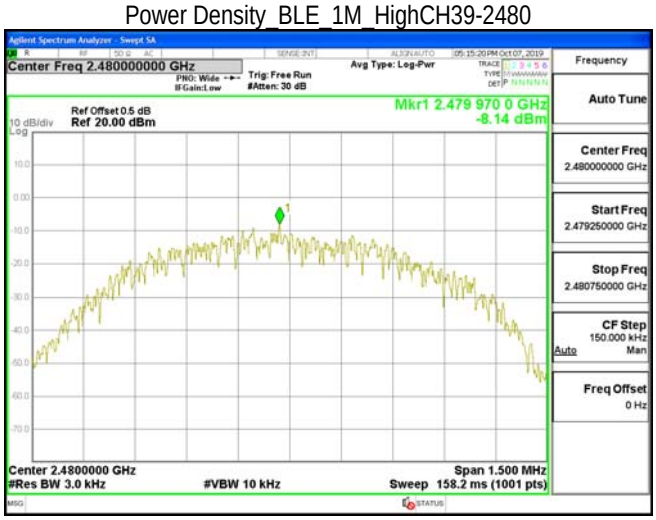
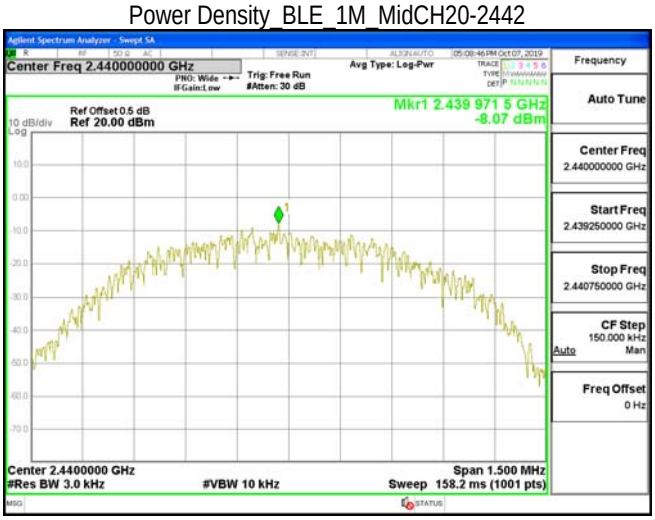
Power Density_BLE_1M_LowCH00-2402



Power Density_BLE_1M_HighCH39-2480



Power Density_BLE_1M_MidCH20-2442



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12 ANTENNA REQUIREMENT

12.1 Standard Applicable:

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by the responsible party shall be used with the device.

If the transmitting antenna is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi.

In case of point-to-point operation, the power shall be reduced by the one dB for every 3 dB that the directional gain of antenna exceeds 6dBi.

12.2 Antenna Connected Construction:

The antenna is designed with unique RF connector and no consideration of replacement. Please see EUT photo for details.

~ End of Report ~

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