

FCC Part 15 EMI TEST REPORT

Part II – Bluetooth BLE

of

E.U.T. : FM STEREO/AM/AUX-IN/BLUETOOTH
RECEIVER
Model No. : WR-12BT
Serial Model : ---
FCC ID : BYG-WR12BT

for

APPLICANT : SANGEAN ELECTRONICS INC.
ADDRESS : NO.18, LANE 7, LI-DE STREET, CHUNG
HO DISTRICT, NEW TAIPEI CITY,
23584, TAIWAN, R.O.C.

Test Performed by

ELECTRONICS TESTING CENTER, TAIWAN

NO. 34. LIN 5. DINGFU VIL., LINKOU DIST.,
NEW TAIPEI CITY, TAIWAN, 24442, R.O.C.

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Report Number : 18-04-RBF-008-02

TEST REPORT CERTIFICATION

Applicant : SANGEAN ELECTRONICS INC.
NO.18, LANE 7, LI-DE STREET, CHUNG HO DISTRICT, NEW
TAIPEI CITY, 23584, TAIWAN, R.O.C.
SANGEAN ELECTRONICS INC.
Manufacturer : NO.18, LANE 7, LI-DE STREET, CHUNG HO DISTRICT, NEW
TAIPEI CITY, 23584, TAIWAN, R.O.C.

Description of EUT

a) Type of EUT : FM STEREO/AM/AUX-IN/BLEETOOTH RECEIVER
b) Trade Name : SANGEAN
c) Model No. : WR-12BT
d) Serial Model : --
e) Power Supply : AC 120V/60Hz /50W(max) (US version)
f) Frequency Range : Bluetooth : 2402MHz ~ 2480MHz
FM 87.50 - 108 MHz ; AM 520 - 1710 kHz

Regulation Applied : FCC Rules and Regulations Part 15 Subpart C

I HEREBY CERTIFY THAT: The data shown in this report were made in accordance with the procedures given in ANSI C63.10-2013, and the energy emitted by the device was founded to be within the limits applicable. I assume full responsibility for accuracy and completeness of these data.

Note: 1. The result of the testing report relate only to the item tested.
2. The testing report shall not be reproduced expect in full, without the written approval of ETC

Summary of Tests

Test	Results
Radiated Emission	Pass
Conducted Emission	N/A
Emission Bandwidth	Pass
Output Power	Pass
100 kHz Bandwidth of Band Edges	Pass
Power Density	Pass
Out-of-Band Conducted Emission	Pass
Duty Cycle	N/A

Date Test Item Received : Apr. 17, 2018
Date Test Campaign Completed : May 05, 2018
Date of Issue : May 18, 2018

Test Engineer : Brian Huang
(Brian Huang , Engineer)



Approve & Authorized Signer : Vincent Chang
Vincent Chang, Section Manager
EMC Dept. II of ELECTRONICS
TESTING CENTER, TAIWAN

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1 GENERAL INFORMATION

1.1 Product Description

- a) Type of EUT : FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER
- b) Trade Name : SANGEAN
- c) Model No. : WR-12BT
- d) Serial Model : --
- e) Power Supply : AC 120V/60Hz /50W(max) (US version)
AC 230V/50 HZ/50W(max) (European version)

1.2 Characteristics of Device

The product is a FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER

1.3 Test Methodology

Both conducted and radiated emissions were performed according to the procedures illustrated in ANSI C63.10-2013. Other required measurements were illustrated in separate sections of this test report for details. For RF test the measurement procedure was referred to FCC KDB 558074 D01 DTS Meas Guidance v04.

Measurement Software

Software	Version	Note
e3	Version 6.100618f	Radiated Emission Test
e3	Version 6.100421	Conducted Emission Test

1.4 Test Facility

Location of the Test site: No.34, Lin 5, Dingfu Vil., Linkou Dist., New Taipei City, Taiwan 24442, R.O.C.

Designation Number: TW2628.

2 PROVISIONS APPLICABLE

2.1 Definition

Unintentional radiator:

A device that intentionally generates and radio frequency energy for use within the device, or that sends radio frequency signals by conduction to associated equipment via connecting wiring, but which is not intended to emit RF energy by radiation or induction.

Class A Digital Device:

A digital device which is marketed for use in commercial or business environment; exclusive of a device which is market for use by the general public, or which is intended to be used in the home.

Class B Digital Device :

A digital device which is marketed for use in a residential environment notwithstanding use in a commercial, business of industrial environment. Example of such devices that are marketed for the general public.

Note : A manufacturer may also qualify a device intended to be marketed in a commercial, business, or industrial environment as a Class B digital device, and in fact is encouraged to do so, provided the device complies with the technical specifications for a Class B Digital Device. In the event that a particular type of device has been found to repeatedly cause harmful interference to radio communications, the Commission may classify such a digital device as a Class B Digital Device, Regardless of its intended use.

Intentional radiator:

A device that intentionally generates and emits radio frequency energy by radiation or induction.

2.2 Requirement for Compliance

(1) Conducted Emission Requirement

Except for Class A digital devices, for equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150kHz to 30MHz shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the band edges.

Frequency MHz	Quasi Peak dB μ V	Average dB μ V
0.15 - 0.5	66-56*	56-46*
0.5 - 5.0	56	46
5.0 - 30.0	60	50

* Decreases with the logarithm of the frequency

(2) Radiated Emission Requirement

For unintentional device, according to §15.109(a), except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency MHz	Distance Meters	Radiated dB μ V/m	Radiated μ V/m
30 - 88	3	40.0	100
88 - 216	3	43.5	150
216 - 960	3	46.0	200
Above 960	3	54.0	500

For intentional device, according to §15.209(a), the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the above table.

(3) Antenna Requirement

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

(4) Bandwidth Requirement

For direct sequence system, according to 15.247(a)(2), the minimum 6dB bandwidth shall be at least 500 kHz.

(5) Output Power Requirement

For direct sequence system, according to 15.247(b), the maximum peak output power of the transmitter shall not exceed 1 Watt. If transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(6) 100 kHz Bandwidth of Frequency Band Edges Requirement

According to 15.247(c), if any 100 kHz bandwidth outside these frequency bands, the radio frequency power that is produced by the modulation products of the spreading sequence, the information sequence and the carrier frequency shall be either at least 20 dB below that in any 100 kHz bandwidth within the band that contains the highest level of the desired power or shall not exceed the general levels specified in §15.209(a), whichever results in the lesser attenuation.

(7) Power Density Requirement

According to 15.247(d), for direct sequence systems, the transmitted power density averaged over any 1 second interval shall not be greater than 8 dBm in any 3 kHz bandwidth within these bands.

2.3 Restricted Bands of Operation

Only spurious emissions are permitted in any of the frequency bands listed below :

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42-16.423	399.9-410	4.5-5.15
0.495 - 0.505 **	16.69475 - 16.69525	608-614	5.35-5.46
2.1735 - 2.1905	16.80425 - 16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475 - 156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2655-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3360-4400	Above 38.6
13.36-13.41			

** : Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz

2.4 Labeling Requirement

The device shall bear the following statement in a conspicuous location on the device :

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions : (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

2.5 User Information

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual.

The Federal Communications Commission Radio Frequency Interference Statement includes the following paragraph.

This equipment has been tested and found to comply with the limits for a Class B Digital Device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio / TV technician for help.

3. SYSTEM TEST CONFIGURATION

3.1 Justification

For both radiated and conducted emissions, the system was configured for testing in a typical fashion as a customer would normally use it. The peripherals other than EUT were connected in normally standing by situation.

All measurement were intentional to maximum the emissions from EUT by varying the connection cables(if applicable), therefore, the test result is sure to meet the applicable requirement.

For portable device, the EUT was pretested in three orthogonal plans: put on table horizontally, stands vertically and side up vertically. The worst case was chosen for final test.

3.2 Devices for Tested System

Device	Manufacture	Model / FCC ID.	Description
FM STEREO/AM/AUX -IN/BLEETOOTH RECEIVER*	SANGEAN ELECTRONICS INC.	WR-12BT	1.6m Unshielded AC Power Cord 1.6m Unshielded Audio Line 1.8m Unshielded Headphone Line
iPod	Apple	A1285	1.6m Unshielded Audio Line
Earphone	OPPO	---	1.8m Unshielded Audio Line

Remark “*” means equipment under test.

4 RADIATED EMISSION MEASUREMENT

4.1 Applicable Standard

For unintentional radiator, the radiated emission shall comply with §15.109(a).

For intentional radiators, according to §15.247 (a), operation under this provision is limited to frequency hopping and direct sequence spread spectrum, and the out band emission shall be comply with §15.247 (d)

4.2 Measurement Procedure

A. Preliminary Measurement For Portable Devices

For portable devices, the following procedure was performed to determine the maximum emission axis of EUT:

1. With the receiving antenna is H polarization, rotate the EUT in turns with three orthogonal axes to determine the axis of maximum emission.
2. With the receiving antenna is V polarization, rotate the EUT in turns with three orthogonal axes to determine the axis of maximum emission.
3. Compare the results derived from above two steps. So, the axis of maximum emission from EUT was determined and the configuration was used to perform the final measurement.

B. Final Measurement

1. Setup the configuration per figure 1(a), 1(b) and 2 for frequencies measured below and above 1 GHz respectively. Turn on EUT and make sure that it is in normal function.
2. For emission frequencies measured below 1 GHz, a pre-scan is performed in a shielded chamber to determine the accurate frequencies of higher emissions will be checked on a open test site. As the same purpose, for emission frequencies measured above 1 GHz, a pre-scan also be performed with a 1 meter measuring distance before final test.
3. For emission frequencies measured below and above 1 GHz, set the spectrum analyzer on a 100 kHz and 1 MHz resolution bandwidth respectively for each frequency measured in step 2.
4. The search antenna is to be raised and lowered over a range from 1 to 4 meters in horizontally polarized orientation. Position the highness when the highest value is indicated on spectrum analyzer, then change the orientation of EUT on test table over a range from 0 ° to 360 ° with a speed as slow as possible, and keep the azimuth that highest emission is indicated on the spectrum analyzer. Vary the antenna position again and record the highest value as a final reading. A RF test receiver is also used to confirm emissions measured.

5. Repeat step 4 until all frequencies need to be measured were complete.
6. Repeat step 5 with search antenna in vertical polarized orientations.
7. Check the three frequencies of highest emission with varying the placement of cables (if any) associated with EUT to obtain the worse case and record the result.

Figure 1 : Frequencies measured below 1 GHz configuration

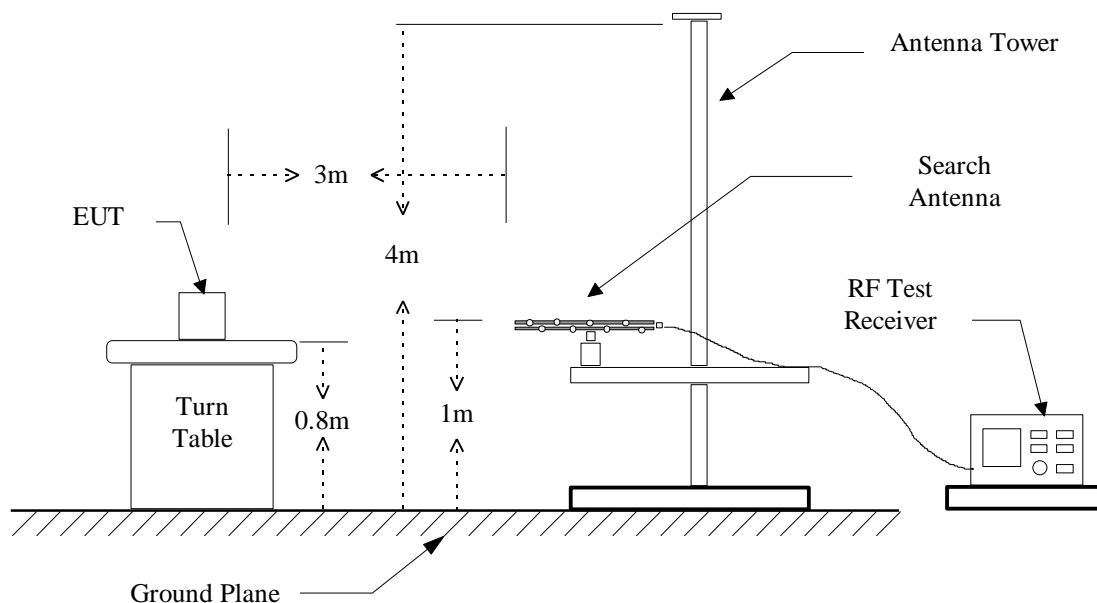
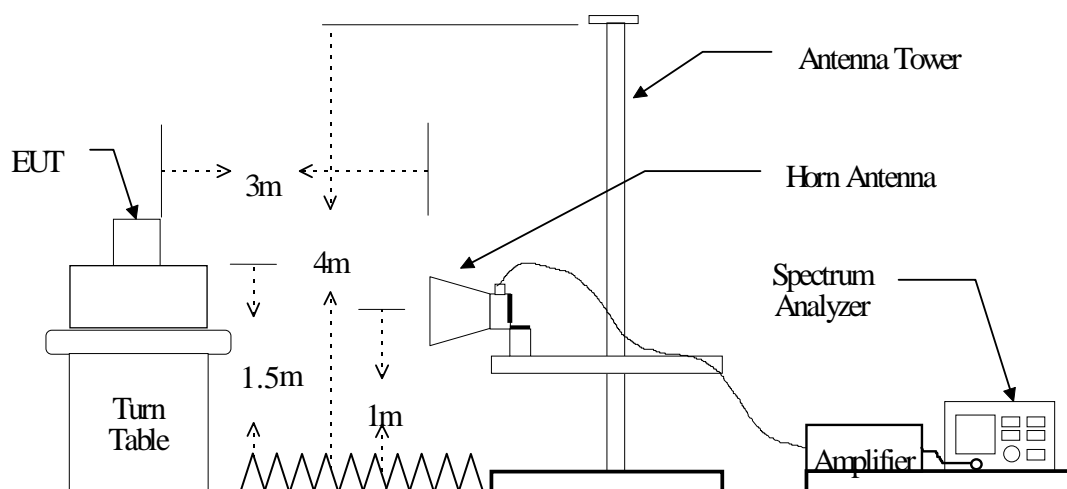


Figure 2 : Frequencies measured above 1 GHz configuration



4.3 Measuring Instrument

The following instrument are used for radiated emissions measurement:

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2017/11/15	2018/11/14
Bi-Log Antenna	ETC	MCTD 2786	2017/07/12	2018/07/11
Horn Antenna	EMCO	3115	2017/10/11	2018/10/10
Horn Antenna	EMCO	3116	2017/11/15	2018/11/14
Amplifier	HP	8447D	2017/10/05	2018/10/04
Amplifier	HP	83051A	2017/08/25	2018/08/24
LOOP Antenna	EMCO	6512	2017/10/13	2018/10/12

Measuring instrument setup in measured frequency band when specified detector function is used :

Frequency Band (MHz)	Instrument	Function	Resolution bandwidth	Video Bandwidth
30 to 1000	RF Test Receiver	Quasi-Peak	120 kHz	N/A
	Spectrum Analyzer	Peak	100 kHz	100 kHz
Above 1000	Spectrum Analyzer	Peak	1 MHz	1 MHz
	Spectrum Analyzer	Average	1 MHz	10 Hz or $\geq 1/T$ (Note 1)

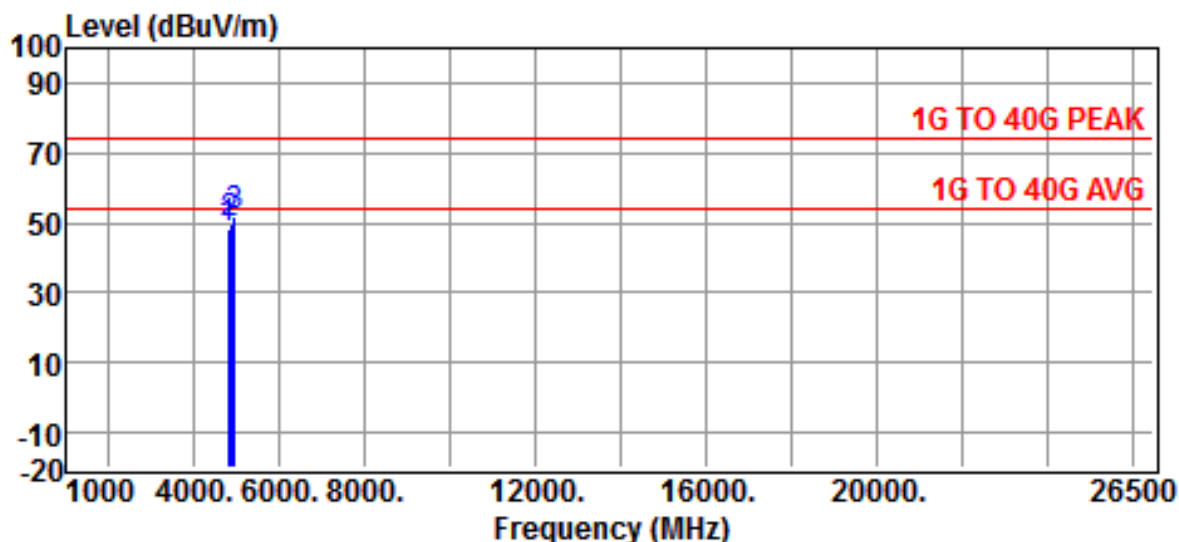
Note 1:

VBW = 10 Hz, when the duty cycle is no less than 98%.

VBW $\geq 1/T$, when duty cycle is less than 98% where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

4.4 Radiated Emission Data

4.4.1 RF Portion

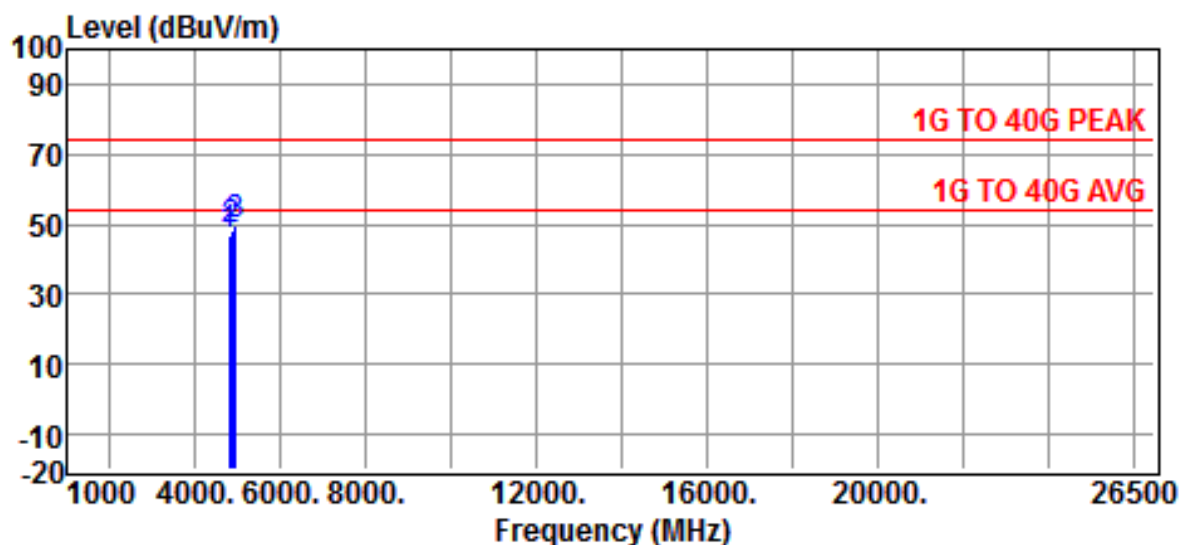


Site	:Chamber #2	Date	:2018-05-10
Limit	:1G TO 40G PEAK	Ant. Pol.	:HORIZONTAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac60Hz	Temp.	:26 °C
Engineer	: Brian Huang	Humi.	:52 %
Test Mode	:BLE Mode		

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
4804.0000	47.04	1.47	48.51	74.00	-25.49	Peak
4880.0000	48.35	1.70	50.05	74.00	-23.95	Peak
4960.0000	49.73	1.98	51.71	74.00	-22.29	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.



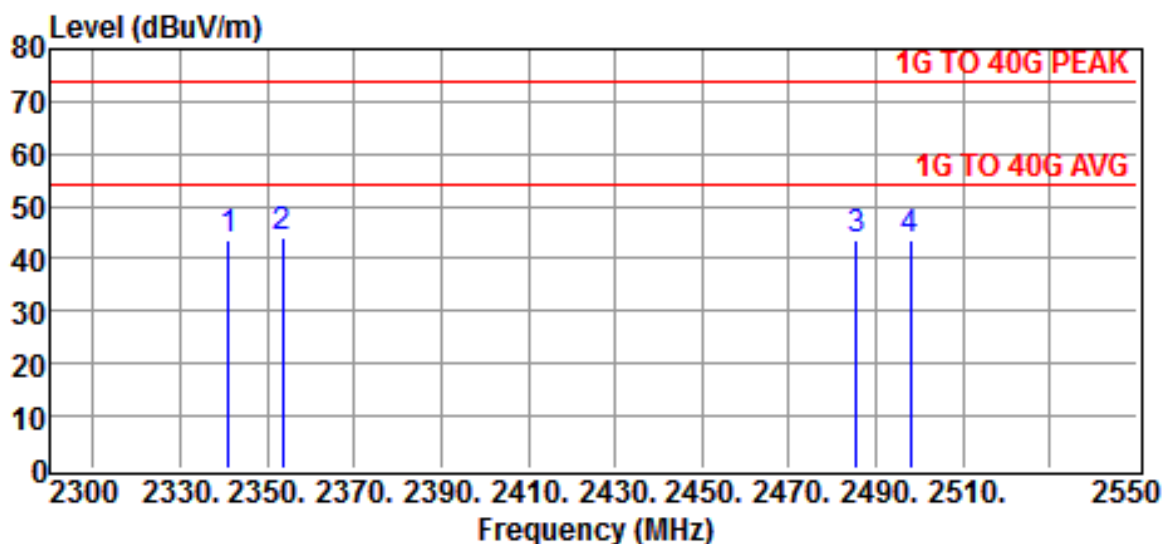
Site	:Chamber #2	Date	:2018-05-10
Limit	:1G TO 40G PEAK	Ant. Pol.	:VERTICAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac60Hz	Temp.	:26 °C
Engineer	: Brian Huang	Humi.	:52 %
Test Mode	:BLE Mode		

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
4804.0000	45.65	1.47	47.12	74.00	-26.88	Peak
4880.0000	46.92	1.70	48.62	74.00	-25.38	Peak
4960.0000	47.63	1.98	49.61	74.00	-24.39	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.

4.4.2 Radiated Emission of Restricted bands

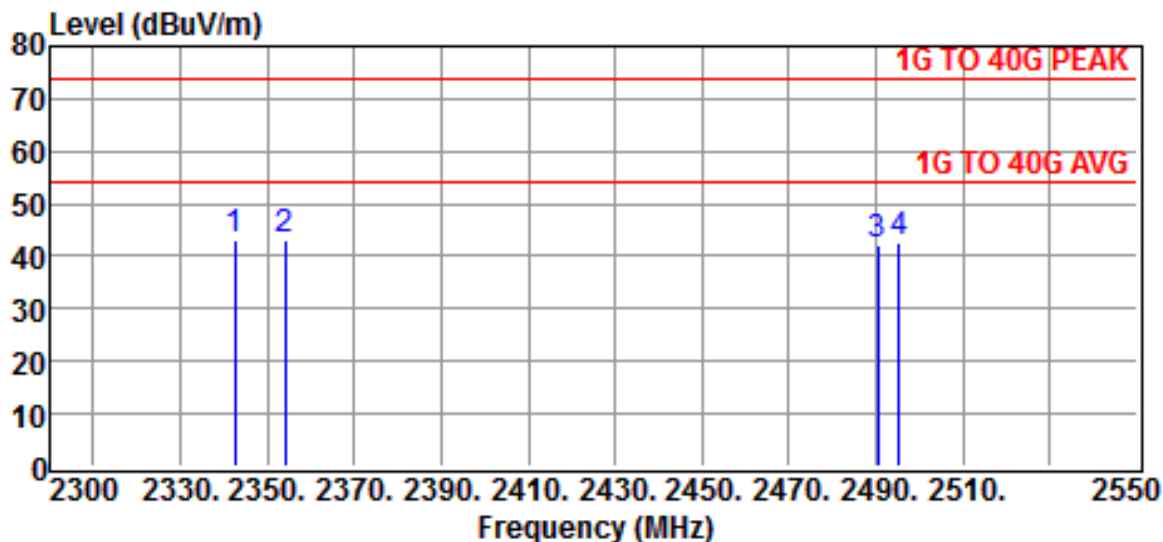


Site	:Chamber #2	Date	:2018-05-10
Limit	:1G TO 40G PEAK	Ant. Pol.	:HORIZONTAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac 60Hz	Temp.	:22 °C
Engineer	: Brian Huang	Humi.	:53 %
Test Mode	:BLE Mode		

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
2341.0000	49.22	-5.60	43.62	74.00	-30.38	Peak
2353.5000	49.59	-5.56	44.03	74.00	-29.97	Peak
2485.5000	48.94	-5.27	43.67	74.00	-30.33	Peak
2497.7500	48.85	-5.23	43.62	74.00	-30.38	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.



Site	:Chamber #2	Date	:2018-05-10
Limit	:1G TO 40G PEAK	Ant. Pol.	:VERTICAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac 60Hz	Temp.	:22 °C
Engineer	: Brian Huang	Humi.	:53 %
Test Mode	:BLE Mode		

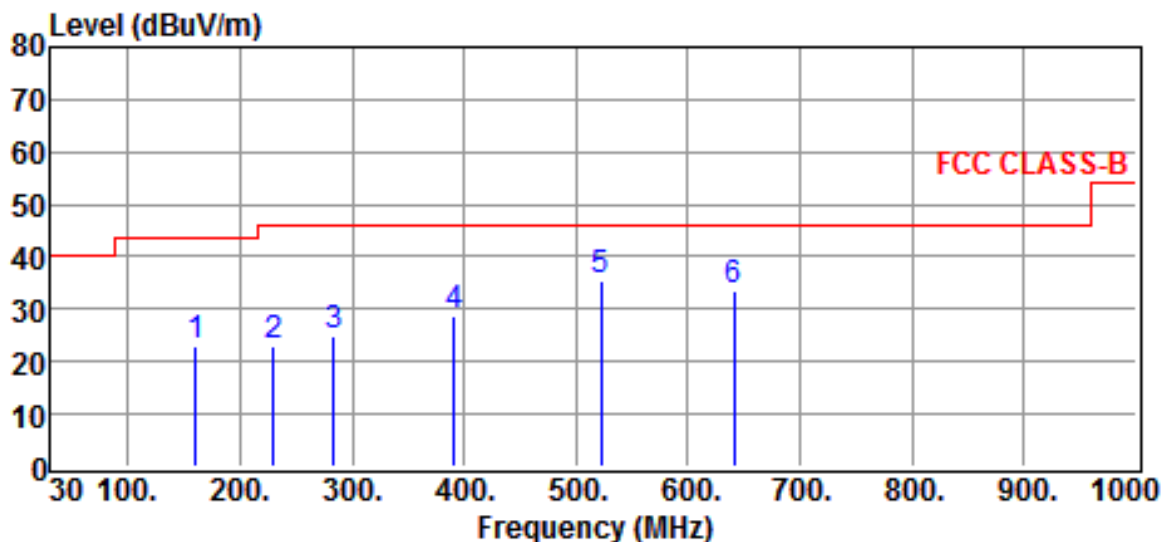
Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
2342.5000	48.63	-5.60	43.03	74.00	-30.97	Peak
2354.0000	48.88	-5.56	43.32	74.00	-30.68	Peak
2490.5000	47.27	-5.24	42.03	74.00	-31.97	Peak
2495.2500	47.93	-5.23	42.70	74.00	-31.30	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.

4.4.3 Other Emission

a) Emission frequencies below 1 GHz

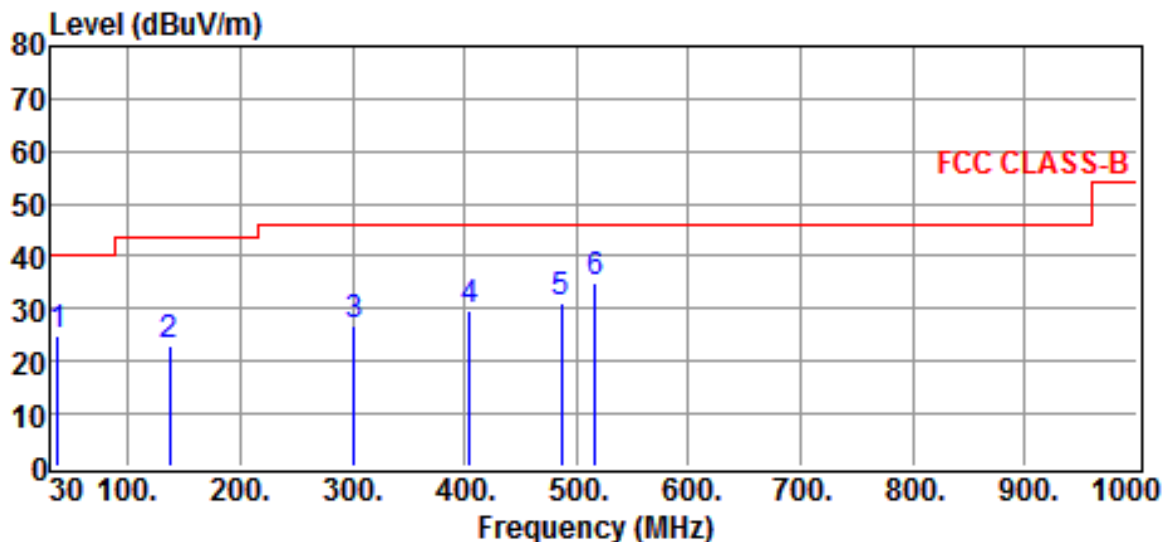


Site	:Chamber #2	Date	:2018-05-16
Limit	:FCC CLASS-B	Ant. Pol.	:HORIZONTAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac60Hz	Temp.	:28 °C
Engineer	: Brian Huang	Humi.	:53 %
Test Mode	:BT Mode		

Freq MHz	Reading dBUV	Correction Factor dB	Result dBUV/m	Limits dBUV/m	Over limit dB	Detector
159.9800	32.14	-9.19	22.95	43.50	-20.55	QP
229.8200	31.28	-8.30	22.98	46.00	-23.02	QP
283.1700	30.13	-5.17	24.96	46.00	-21.04	QP
390.8400	30.79	-2.21	28.58	46.00	-17.42	QP
522.7600	36.02	-0.48	35.54	46.00	-10.46	QP
641.1000	31.56	1.91	33.47	46.00	-12.53	QP

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.



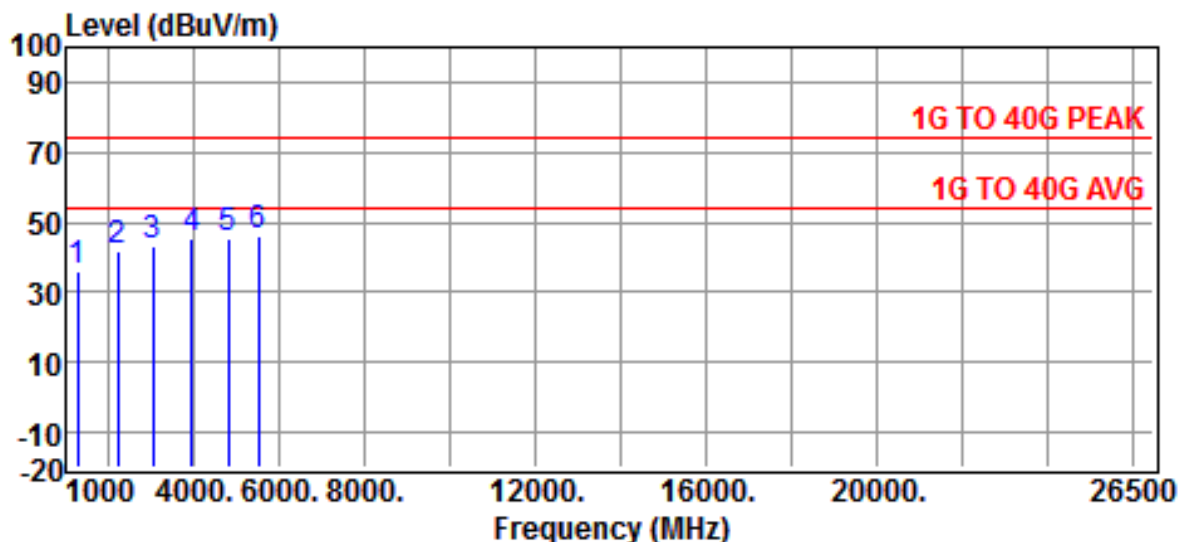
Site :Chamber #2 Date :2018-05-16
 Limit :FCC CLASS-B Ant. Pol. :VERTICAL
 EUT :FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER
 Model :WR-12BT
 Power Rating :120Vac60Hz Temp. :28°C
 Engineer : Brian Huang Humi. :53 %
 Test Mode :BT Mode

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
37.7600	31.47	-6.50	24.97	40.00	-15.03	QP
136.7000	31.86	-8.72	23.14	43.50	-20.36	QP
301.6000	30.99	-4.14	26.85	46.00	-19.15	QP
404.4200	31.50	-1.88	29.62	46.00	-16.38	QP
485.9000	32.09	-0.95	31.14	46.00	-14.86	QP
516.9400	35.43	-0.57	34.86	46.00	-11.14	QP

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.

b) Emission frequencies above 1 GHz

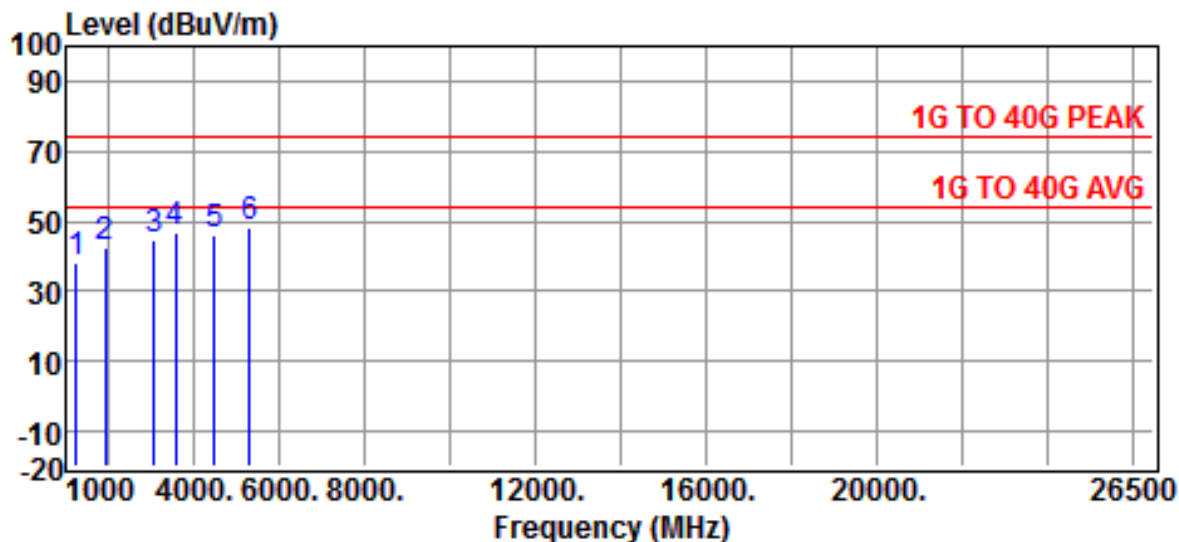


Site	:Chamber #2	Date	:2018-05-16
Limit	:1G TO 40G PEAK	Ant. Pol.	:HORIZONTAL
EUT	:FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER		
Model	:WR-12BT		
Power Rating	:120Vac60Hz	Temp.	:28 °C
Engineer	: Brian Huang	Humi.	:52 %
Test Mode	:BT Mode		

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
1270.0000	46.82	-10.44	36.38	74.00	-37.62	Peak
2235.0000	47.43	-5.83	41.60	74.00	-32.40	Peak
3045.0000	46.58	-3.12	43.46	74.00	-30.54	Peak
3970.0000	45.45	0.14	45.59	74.00	-28.41	Peak
4825.0000	44.01	1.54	45.55	74.00	-28.45	Peak
5520.0000	42.72	3.16	45.88	74.00	-28.12	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.



Site :Chamber #2 Date :2018-05-16
 Limit :1G TO 40G PEAK Ant. Pol. :VERTICAL
 EUT :FM STEREO/AM/AUX-IN/BLUETOOTH RECEIVER
 Model :WR-12BT
 Power Rating :120Vac60Hz Temp. :28°C
 Engineer : Brian Huang Humi. :52 %
 Test Mode :BT Mode

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
1245.0000	48.47	-10.51	37.96	74.00	-36.04	Peak
1920.0000	49.17	-6.95	42.22	74.00	-31.78	Peak
3090.0000	47.67	-2.96	44.71	74.00	-29.29	Peak
3585.0000	47.93	-1.34	46.59	74.00	-27.41	Peak
4485.0000	45.63	0.46	46.09	74.00	-27.91	Peak
5315.0000	45.26	2.75	48.01	74.00	-25.99	Peak

Note :

1. Result = Reading + Corrected Factor
2. Average Result = Peak Result + Duty Factor ()
3. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
4. The margin value=Limit - Result
5. Above 1Ghz : Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.

c) Emission frequencies below 30MHz (9kHz - 30MHz)

According to exploratory test no any obvious emissions were detected from 9 kHz to 30MHz. All emissions were greater than 20 dB below the limit. Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

4.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor, High Pass Filter Loss(if used) and Cable Loss, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation calculation is as follows:

$$\textbf{Result} = \textbf{Reading} + \textbf{Corrected Factor}$$

where

$$\text{Corrected Factor} = \text{Antenna FACTOR} + \text{Cable Loss} + \text{High Pass Filter Loss} - \text{Amplifier Gain}$$

5 CONDUCTED EMISSION MEASUREMENT

5.1 Description

This EUT is excused from investigation of conducted emission, for it is powered by DC battery only. According to §15.207 (d), measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines.

6 ANTENNA REQUIREMENT

6.1 Standard Applicable

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

And according to §15.247 (b)(4), if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

6.2 Antenna Construction and Directional Gain

The antenna is connected to the main PCB and installed inside the housing, no consideration of replacement.

Please refer to the construction Photo for details.

7 EMISSION BANDWIDTH MEASUREMENT

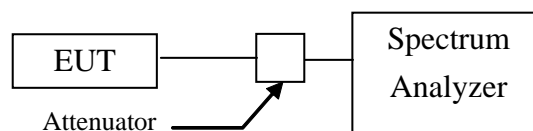
7.1 Standard Applicable

According to 15.247(a)(2), for direct sequence system, the minimum 6dB bandwidth shall be at least 500 kHz.

7.2 Measurement Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in figure 4 without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value. The settings of spectrum analyzer is as followings.
 - 1) Set RBW = 100 kHz.
 - 2) Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
 - 3) Detector = Peak.
 - 4) Trace mode = max hold.
 - 5) Sweep = auto couple.
 - 6) Allow the trace to stabilize.
 - 7) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.
3. Repeat above procedures until all frequencies measured were complete.

Figure 4: Measurement configuration.



7.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP40	2017/11/02	2018/11/01
Attenuator	MINI-CIRCUITS	BW-S10W2+	2017/10/06	2018/10/05

7.4 Measurement Data

Test Date : May 04, 2018 Temperature : 25 °C Humidity : 55 %

Mode: Bluetooth BLE

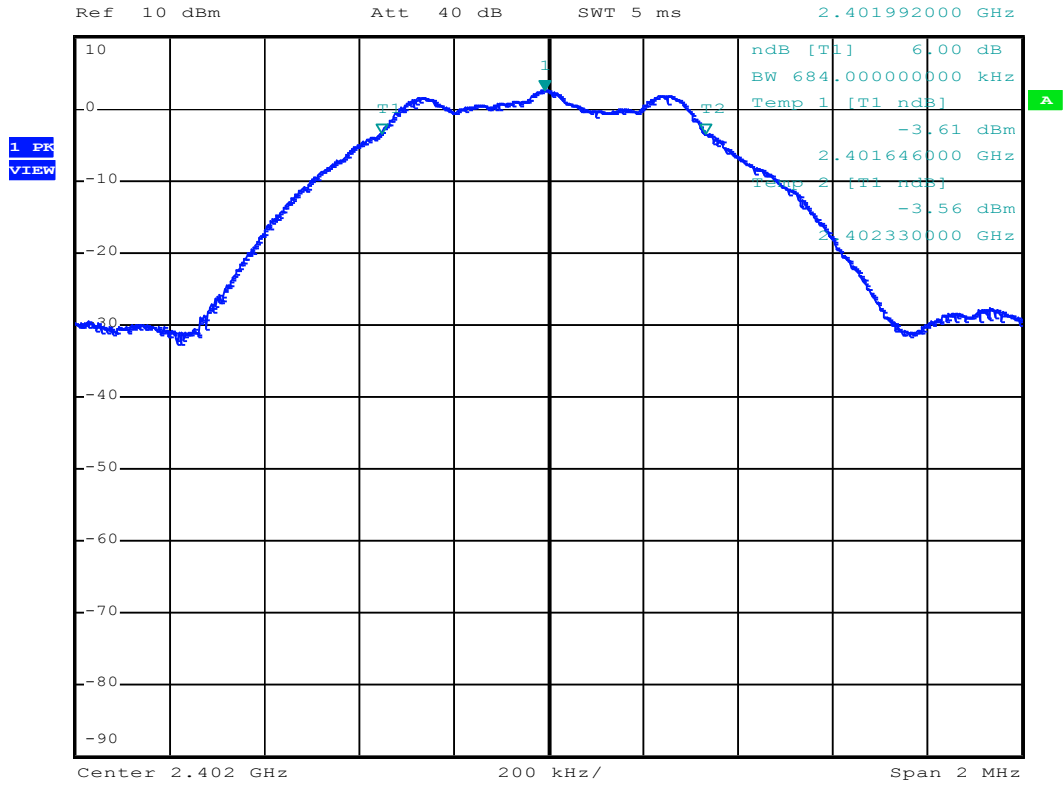
- a) Channel Low: 6 dB Emission Bandwidth is 0.684 MHz
- b) Channel Mid: 6 dB Emission Bandwidth is 0.686 MHz
- c) Channel High: 6 dB Emission Bandwidth is 0.688 MHz

Note : The expanded uncertainty: frequency $\times 1.65 \times 10^{-6}$ ($1 \text{ GHz} < f \leq 18 \text{ GHz}$).

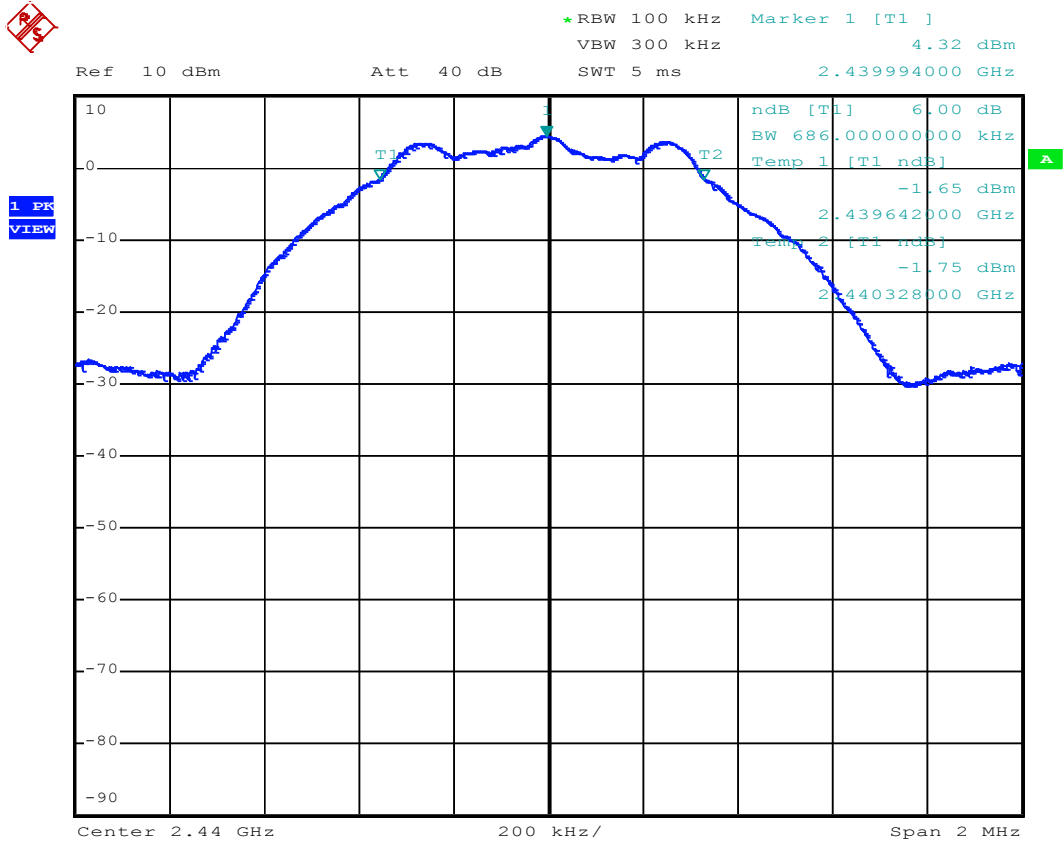
Mode: Bluetooth BLE / Channel Low



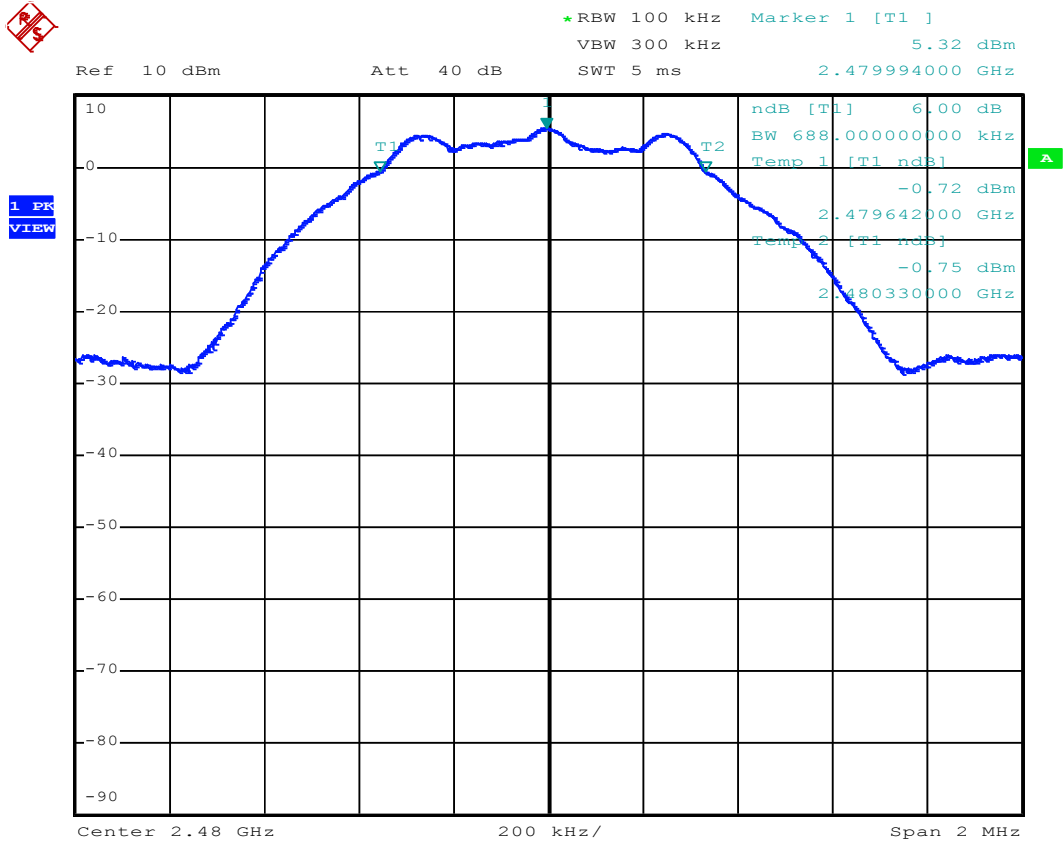
*RBW 100 kHz Marker 1 [T1]
VBW 300 kHz 2.45 dBm
SWT 5 ms 2.401992000 GHz



Mode: Bluetooth BLE / Channel Mid



Mode: Bluetooth BLE / Channel High



8 OUTPUT POWER MEASUREMENT

8.1 Standard Applicable

For direct sequence system, according to 15.247(b), the maximum peak output power of the transmitter shall not exceed 1 Watt. If transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

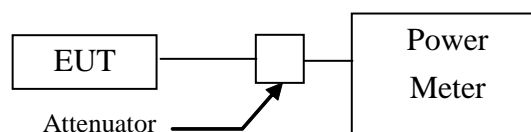
8.2 Measurement Procedure

Measurement Procedure:

9.1.2 PKPM1 Peak power meter method

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in figure 5 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable.
3. Record the readings on the instrument and add a compensat factor of the attenuator.
4. Repeat above procedures until all frequencies measured were complete.

Figure 5: Output power and measurement configuration.



8.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
POWER METER +SENSOR	ANRITSU	ML2487A +MA2491A	2017/05/18	2018/05/17
Attenuator	MINI-CIRCUITS	BW-S10W2+	2017/10/06	2018/10/05

8.4 Measurement Data

Test Date : May 04, 2018 Temperature : 25 °C Humidity : 55 %

Measurement Procedure:

9.1.2 PKPM1 Peak power meter method

Output Peak Power		dBm	mW
Bluetooth BLE	Channel Low:2402MHz	2.57	1.807
	Channel Mid:2440MHz	4.36	2.729
	Channel High:2480MHz	5.39	3.459

Note : The expanded uncertainty: 2dB.

9 100 kHz BANDWIDTH OF BAND EDGES MEASUREMENT

9.1 Standard Applicable

According to 15.247(c), if any 100 kHz bandwidth outside these frequency bands, the radio frequency power that is produced by the modulation products of the spreading sequence, the information sequence and the carrier frequency shall be either at least 20 dB below that in any 100 kHz bandwidth within the band that contains the highest level of the desired power or shall not exceed the general levels specified in §15.209(a), whichever results in the lesser attenuation.

9.2 Measurement Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in figure 4 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Set both RBW of spectrum analyzer to 100kHz and VBW to 1 MHz with a convenient frequency span including 100kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

9.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP40	2016/10/03	2017/10/02
Attenuator	MINI-CIRCUITS	BW-S10W2+	2016/09/30	2017/09/29

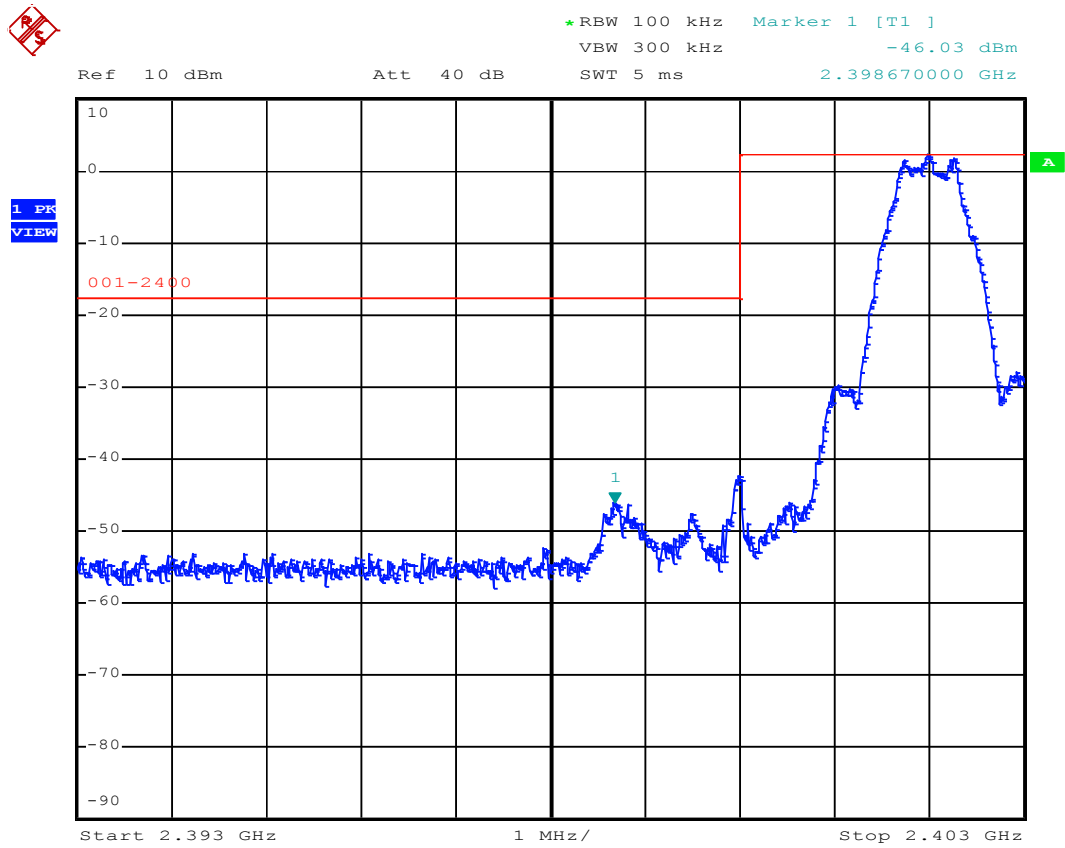
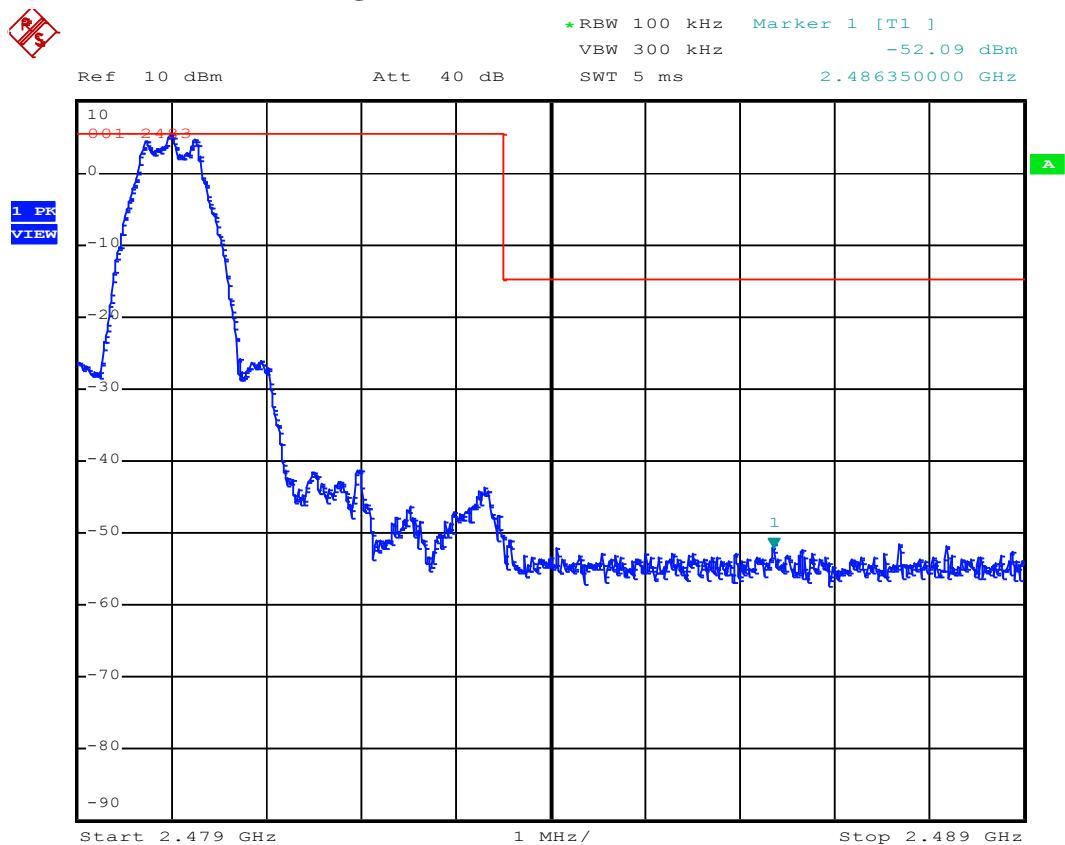
9.4 Measurement Data

Test Date : May 04, 2018 Temperature : 25 °C Humidity : 55 %

Mode: Bluetooth BLE

- a) Lower Band Edge : All emissions in this 100kHz bandwidth are attenuated more than 20dB from the carrier.
- b) Upper Band Edge : All emissions in this 100kHz bandwidth are attenuated more than 20dB from the carrier.

Note : The expanded uncertainty: 2dB.

Bluetooth BLE / Channel Low**Bluetooth BLE / Channel High**

10 POWER DENSITY MEASUREMENT

10.1 Standard Applicable

According to 15.247(d), for direct sequence systems, the transmitted power density averaged over any 1 second interval shall not be greater than 8 dBm in any 3 kHz bandwidth within these bands.

10.2 Measurement Procedure

Measurement Method: PKPSD

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in figure 5 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set EUT to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Set analyzer center frequency to DTS channel center frequency.
4. Set the span to 1.5 times the DTS bandwidth.
5. Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
6. Set the VBW $\geq 3 \times \text{RBW}$.
7. Detector = peak.
8. Sweep time = auto couple.
9. Trace mode = max hold.
10. Allow trace to fully stabilize.
11. Use the peak marker function to determine the maximum amplitude level within the RBW.
12. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.
13. Repeat above procedures until all measured frequencies were complete.

10.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP40	2017/11/02	2018/11/01
Attenuator	MINI-CIRCUITS	BW-S10W2+	2017/10/06	2018/10/05

10.4 Measurement Data

Test Date : May 05, 2018 Temperature : 25 °C Humidity : 55 %

Mode: Bluetooth BLE

- a) Channel Low: Maximun PSD is -13.25 dBm
- b) Channel Mid: Maximun PSD is -11.35 dBm
- c) Channel High: Maximun PSD is -10.18 dBm

Note : The expanded uncertainty: 2dB.

Bluetooth BLE / Channel Low



*RBW 3 kHz Marker 1 [T1]
 VBW 10 kHz -13.25 dBm
 SWT 170 ms 2.401986500 GHz

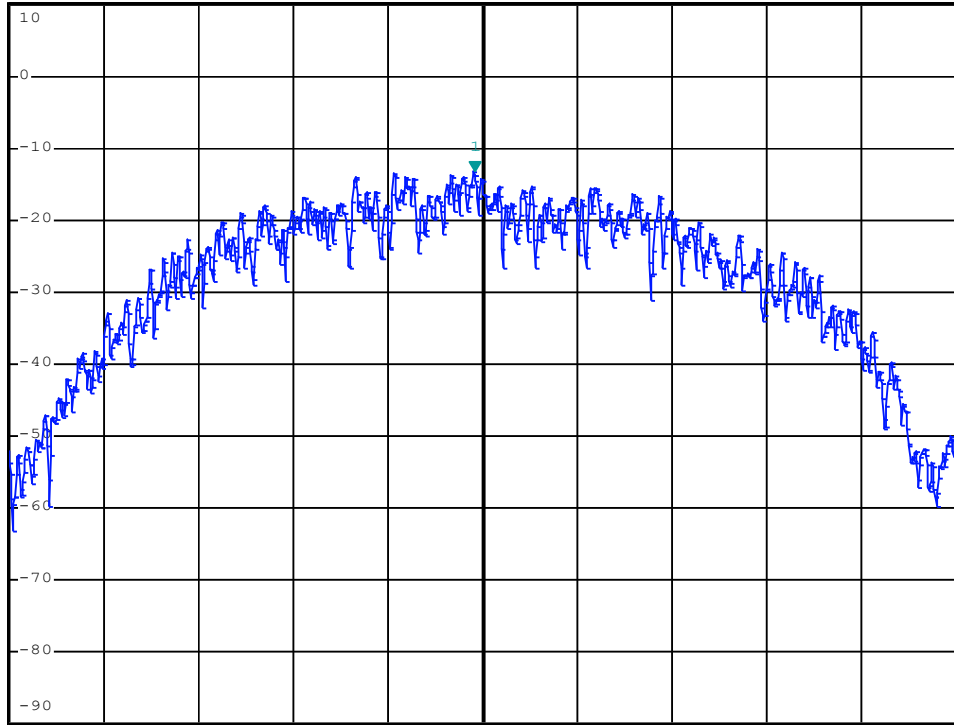
Ref 10 dBm

Att 40 dB

SWT 170 ms

2.401986500 GHz

1 PK
VIEW

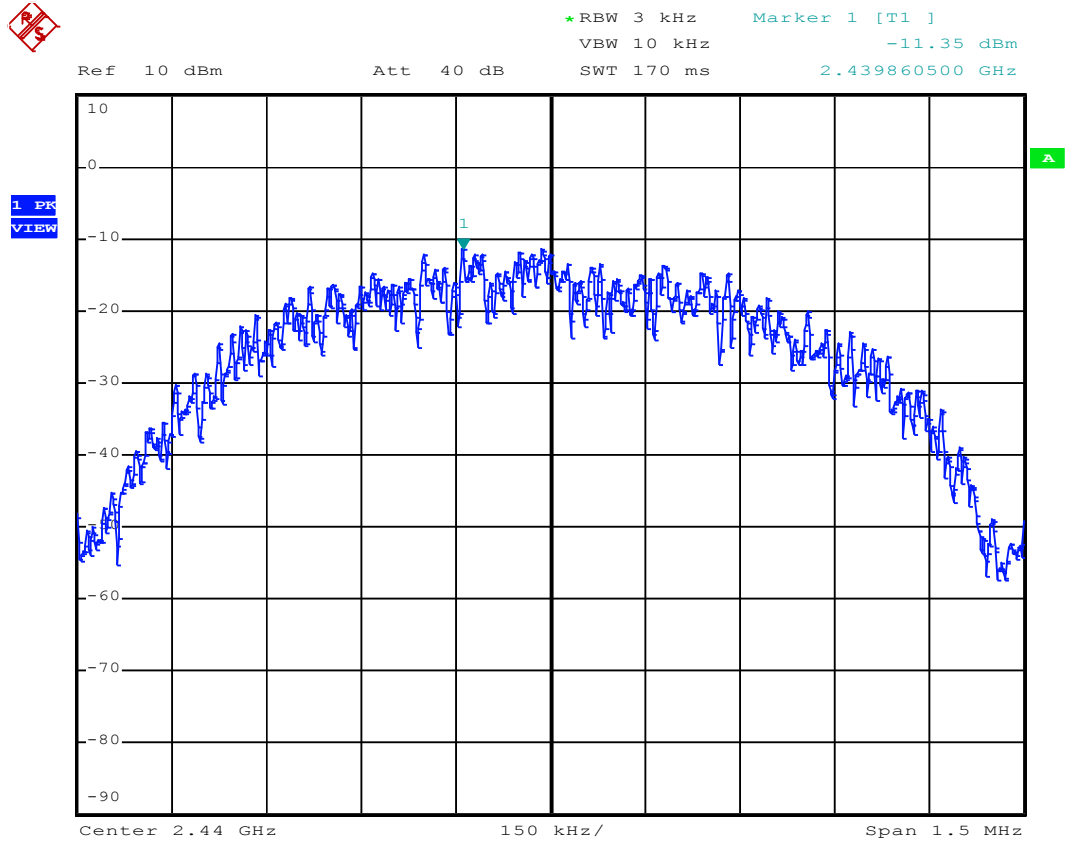


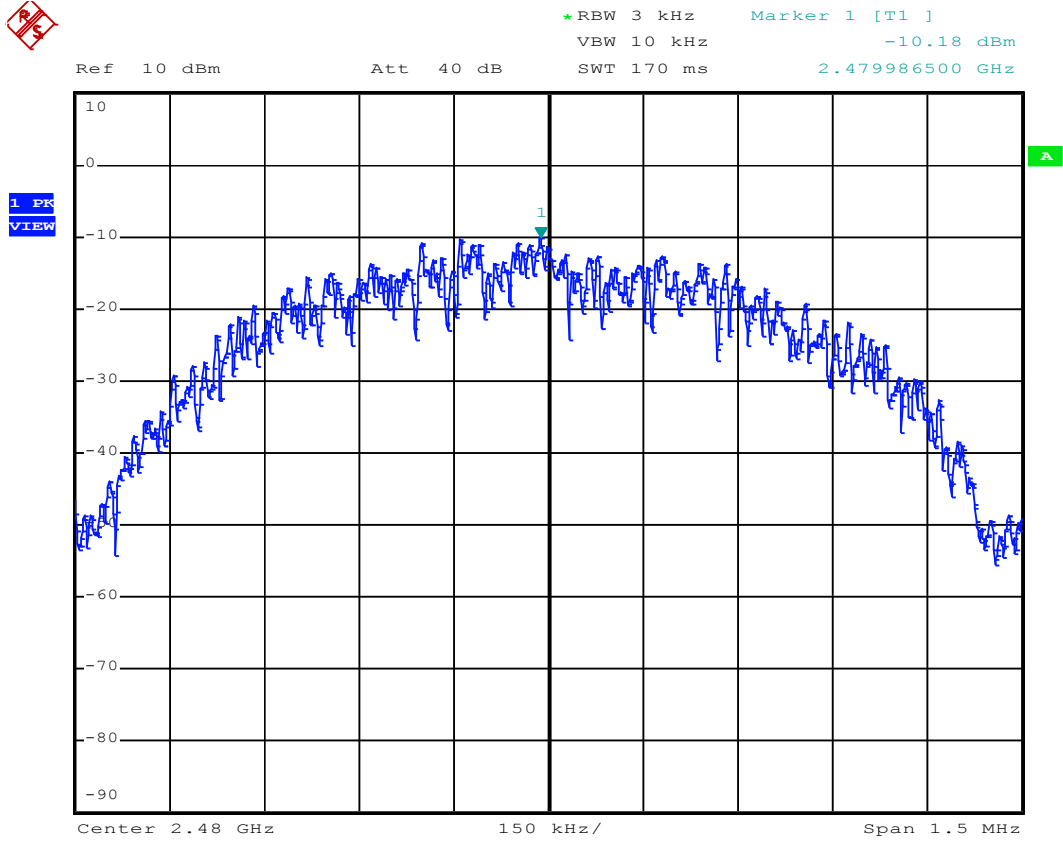
Center 2.402 GHz

150 kHz/

Span 1.5 MHz

Bluetooth BLE / Channel Mid



Bluetooth BLE / Channel High

11. OUT-OF-BAND CONDUCTED EMISSION MEASUREMENT

11.1 Standard Applicable

According to 15.247(c), 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. Attenuation below the general limits specified in Section 15.209(a) is not required.

11.2 Measurement Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in figure 4 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Use the following spectrum analyzer settings:
 Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
 RBW = 100 kHz
 VBW \geq RBW
 Sweep = auto
 Detector function = peak
 Trace = max hold.
4. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all measured frequencies were complete.

11.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP40	2017/11/02	2018/11/01
Attenuator	MINI-CIRCUITS	BW-S10W2+	2017/10/06	2018/10/05

11.4 Measurement Data

Test Date : May 04, 2018 Temperature : 25 °C Humidity : 55 %

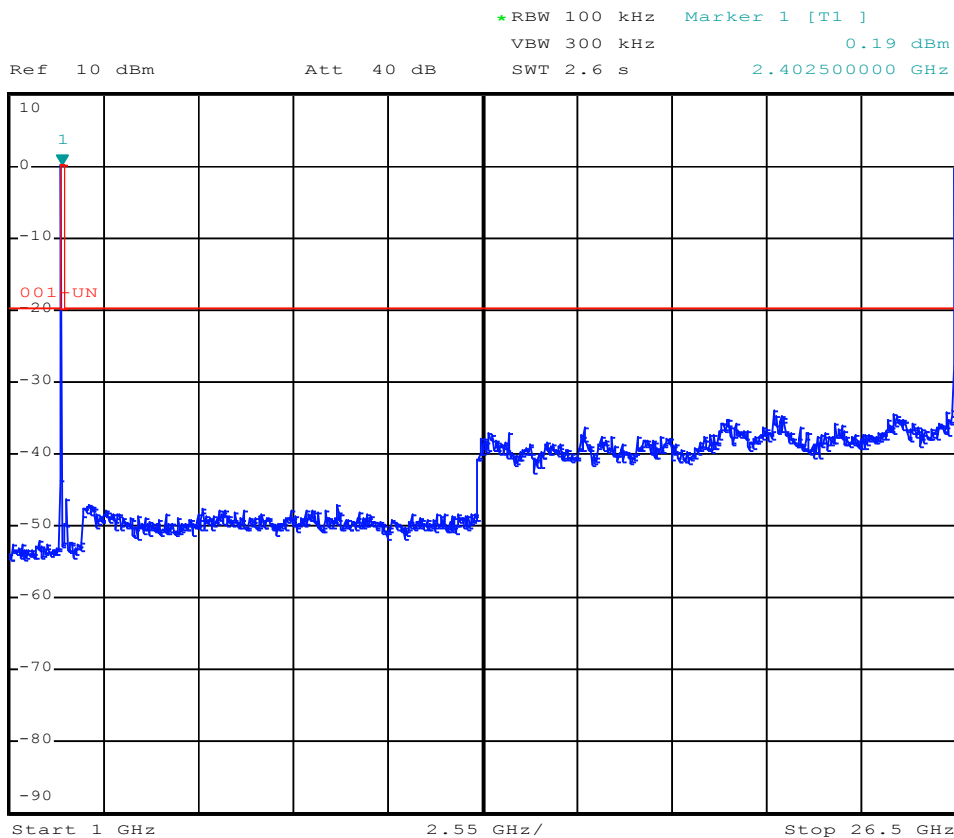
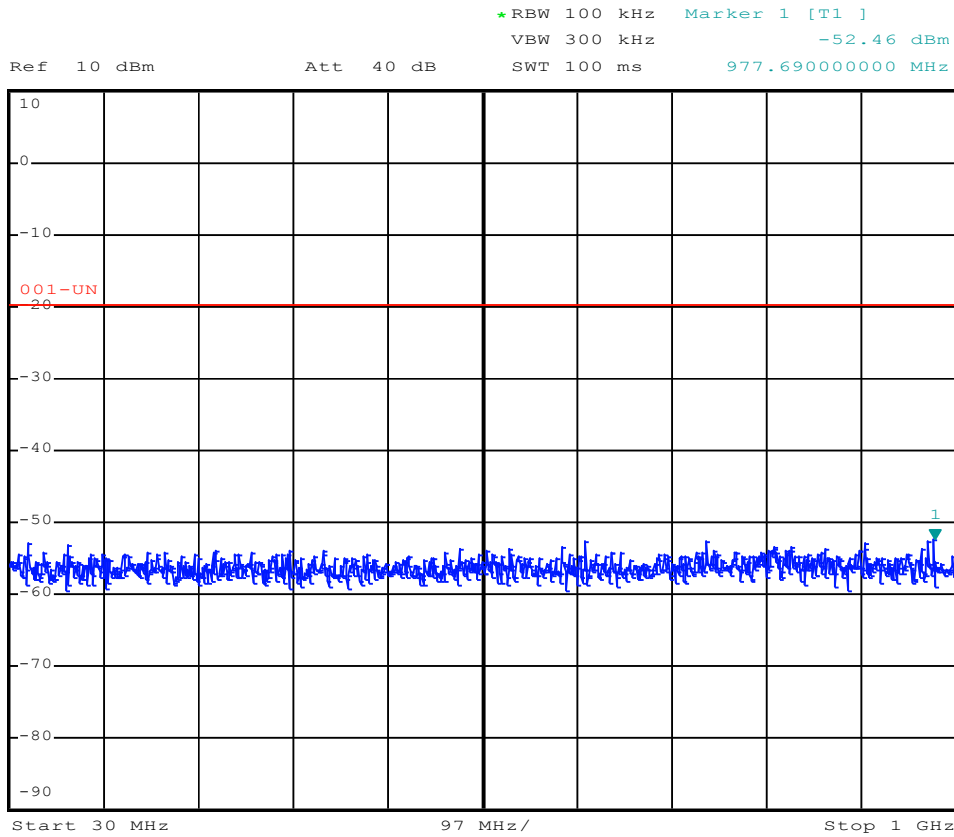
A. Bluetooth BLE

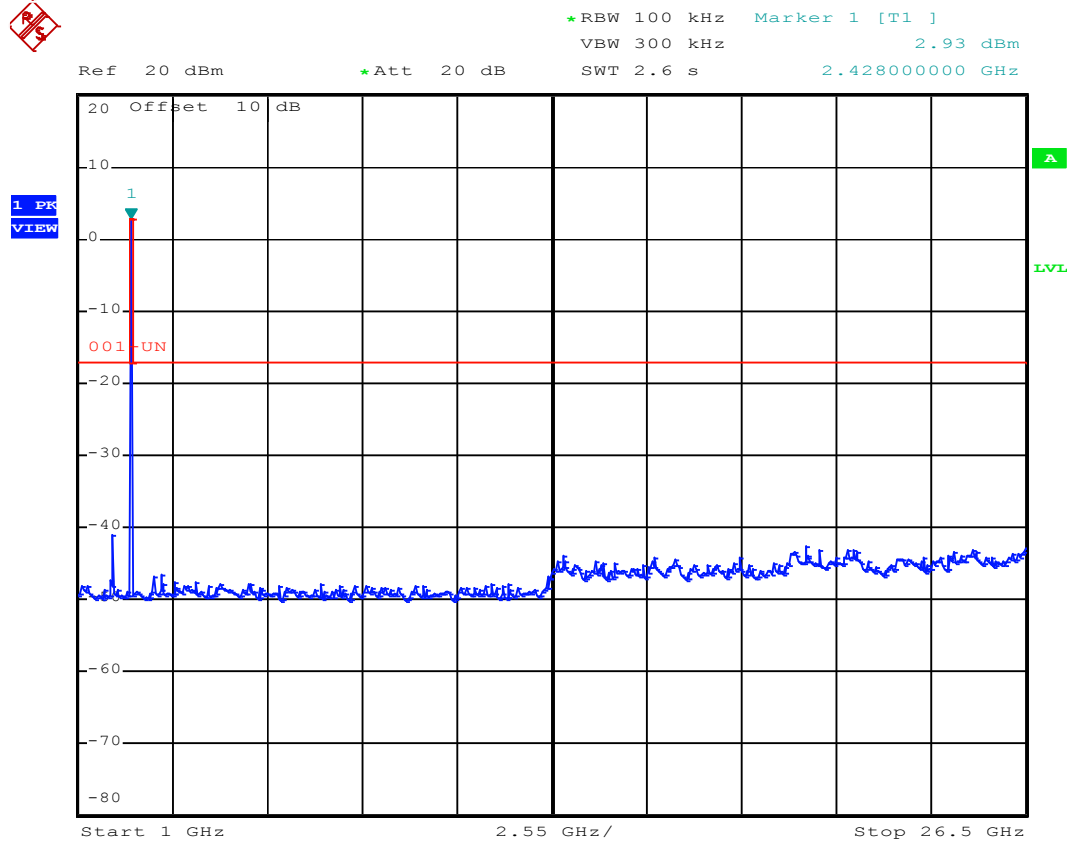
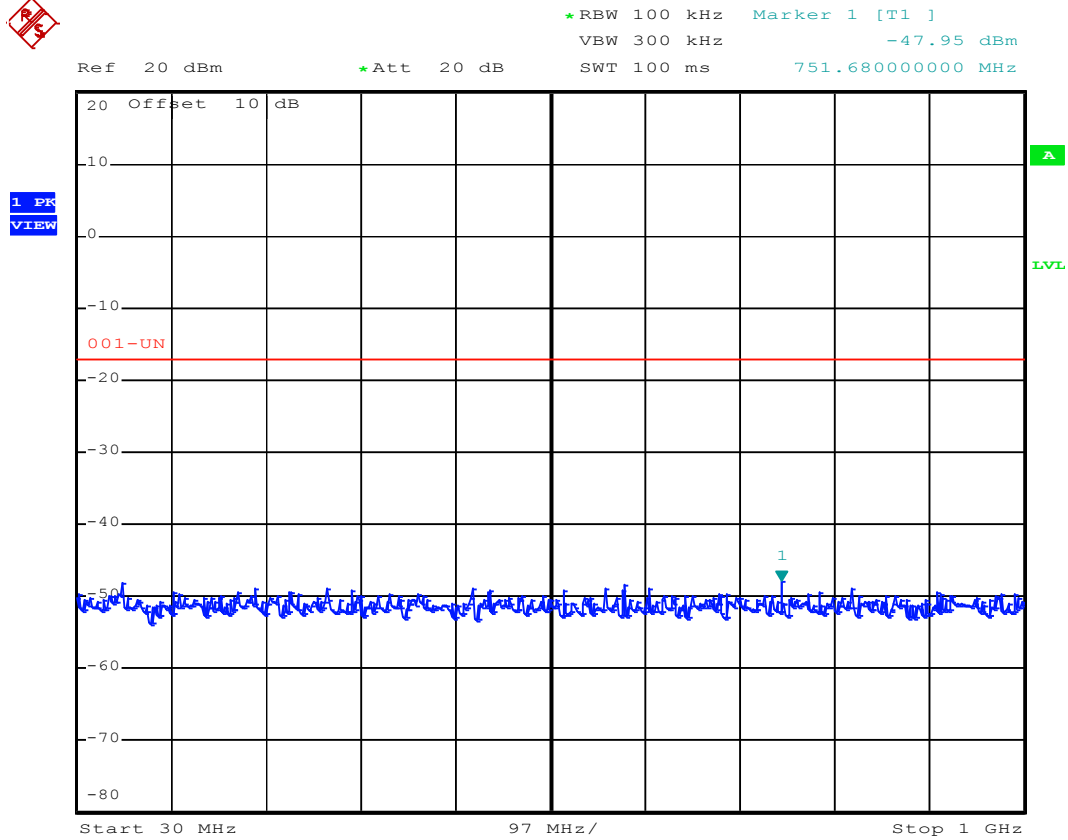
Mode: Channel Low, Mid, High

(a) 30 MHz to 1 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.

(b) 1 GHz to 26.5 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.

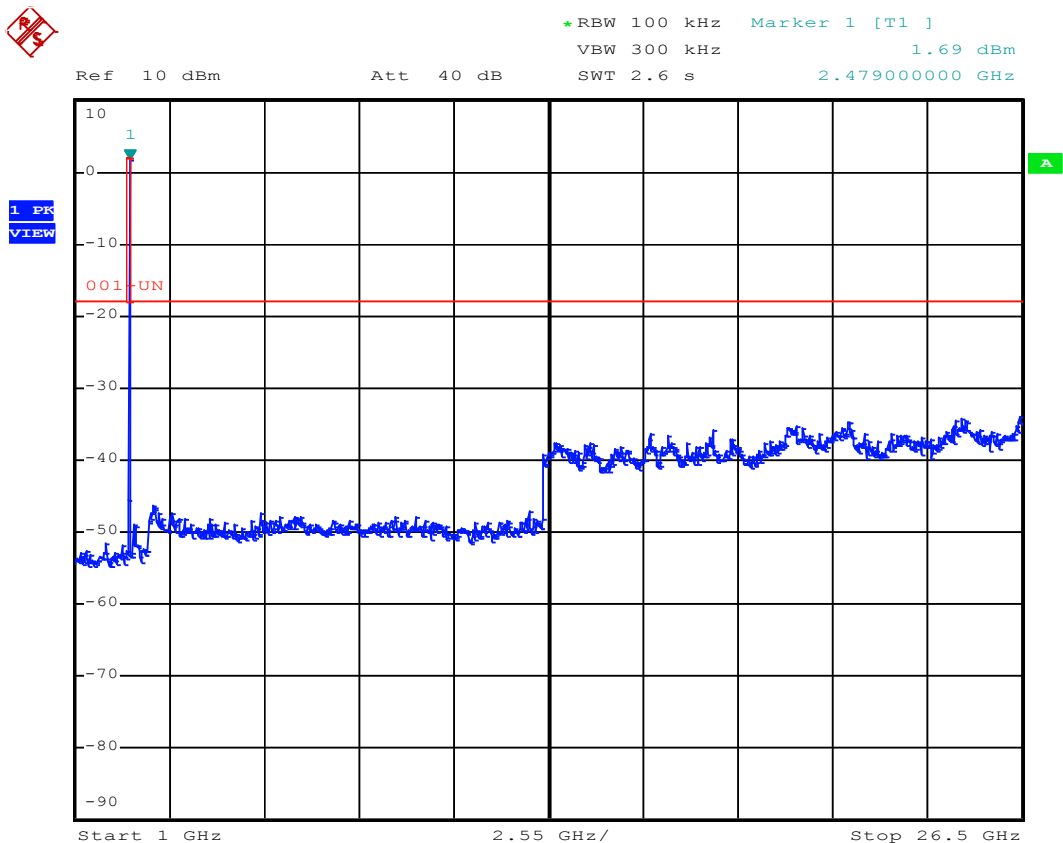
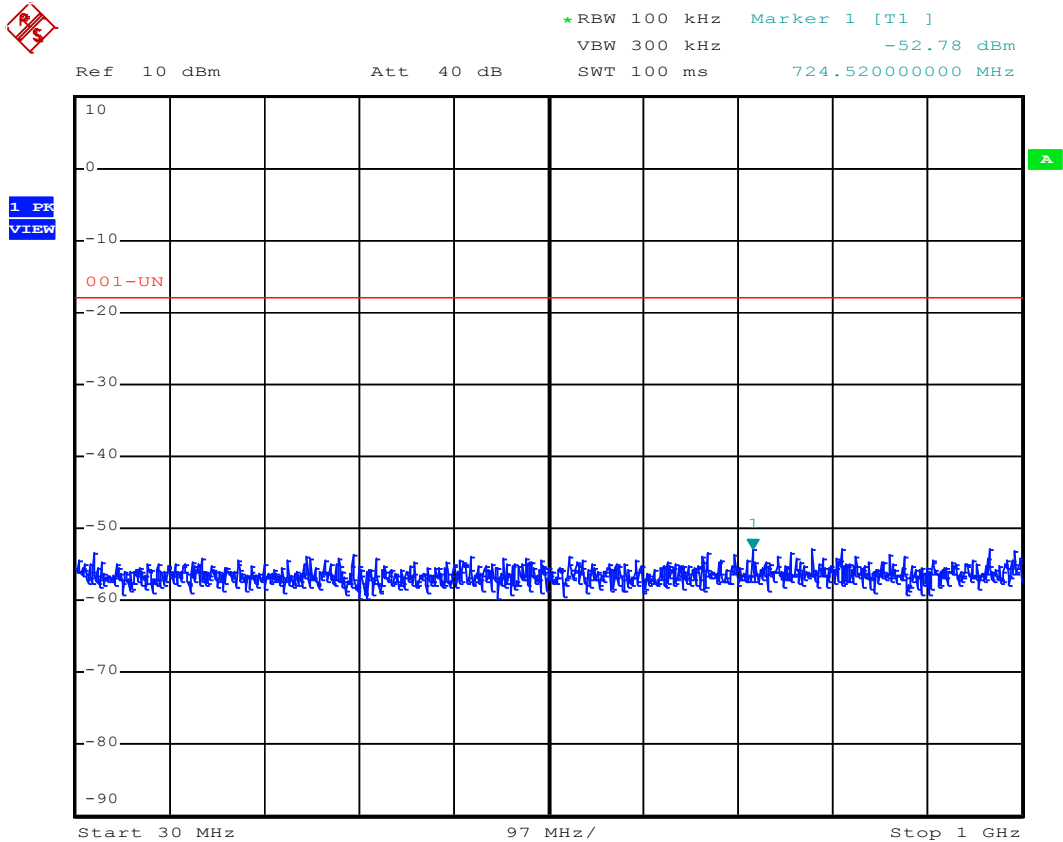
Note : The expanded uncertainty: 2dB.

Bluetooth BLE
Channel Low

Bluetooth BLE
Channel Mid

Bluetooth BLE

Channel High



12. DUTY CYCLE

12.1 Standard Applicable

None. Referency only.

12.2 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP40	2017/11/02	2018/11/01
Attenuator	MINI-CIRCUITS	BW-S10W2+	2017/10/06	2018/10/05

12.3 Measurement Data

Test Date : May 04, 2018 Temperature : 25 °C Humidity : 55 %

Duty Cycle Calculation

Mode	Period (ms)	Transmission duration (T) (ms)	Duty Cycle (%)	1/T (kHz)	VBW setting (kHz)
BLE	0.66	0.46	69.70	2.174	3

Note:

1. When the duty cycle is less than 98%, for the average measurement of the radiated emission test, the VBW setting is $>1/T$ where the T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

Refer to the following page for data plots.

Bluetooth BLE

