

FCC C2PC Test Report

FCC ID : SQGBL652
Equipment : Bluetooth 4.2 module (BLE only)
Model No. : BL652-SA, BL652-SC
(Refer to item 1.1.1 for more details)
Brand Name : Laird
Applicant : Laird Technologies
Address : W66N220 Commerce Court, Cedarburg,
Wisconsin 53012, USA
Standard : 47 CFR FCC Part 15.247
Received Date : May 14, 2018
Tested Date : May 28, 2018

We, International Certification Corp., would like to declare that the tested sample has been evaluated and in compliance with the requirement of the above standards. The test results contained in this report refer exclusively to the product. It may be duplicated completely for legal use with the approval of the applicant. It shall not be reproduced except in full without the written approval of our laboratory.

Reviewed by:



Along Chen / Assistant Manager

Approved by:



Gary Chang / Manager



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Release Record

Report No.	Version	Description	Issued Date
FR662202-06AE	Rev. 01	Initial issue	Jul. 27, 2018

Summary of Test Results

FCC Rules	Test Items	Measured	Result
15.207	AC Power Line Conducted Emissions	[dBuV]: 0.389MHz 37.50 (Margin -10.58dB) - AV	Pass
15.247(d) 15.209	Antenna-port conducted measurement	Meet the requirement of limit	Pass
15.247(b)(3)	Maximum Output Power	Power [dBm]: 4.56	Pass
15.203	Antenna Requirement	Meet the requirement of limit	Pass

1 General Description

1.1 Information

This report is issued as a FCC Class II Permissive Change.

This report is issued as a supplementary report to original ICC report no. FR662202AE. The modification is concerned with adding 4 antennas.

1.1.1 Product Details

The following models are provided to this EUT.

Brand Name	Model Name	Product Name	Description
Laird	BL652-SA	Bluetooth 4.2 module (BLE only)	with chip antenna
	BL652-SC		with MHF4 & IPEX connector type antenna
† The above models, model BL652-SC was selected as a representative one for the final test and only its data was recorded in this report.			

1.1.2 Specification of the Equipment under Test (EUT)

RF General Information				
Frequency Range (MHz)	Bluetooth Mode	Ch. Freq. (MHz)	Channel Number	Data Rate
2400-2483.5	V4.2 LE	2402-2480	0-39 [40]	1 Mbps
Note 1: Bluetooth LE (Low energy) uses GFSK modulation.				

1.1.3 Antenna Details (The additional antennas are marked in boldface)

Ant. No.	Brand	Model	Type	Connector	Gain (dBi)	Remarks
1	ACX	AT3216-B2R7HAA	Chip	N/A	0.5	For BL652-SA
2	LSR	FlexPIFA 001-0022	FlexPIFA	MHF4	2	For BL652-SC
3	LSR	FlexNotch 001-0023	Flexible Notch	MHF4	2	
4	MAG. LAYERS	EDA-8709-2G4C1-B27	Dipole	MHF4	2	
5	Walsin	RFDPA870910EMAB302	Dipole	MHF4	2	
6	Walsin	RFDPA870900SBAB8G1	Dipole	MHF4	2	
7	YAMAMOTO METAL	YAN-02-C-MHF4P-050	Chip	MHF4	-1.76	
8	Laird	PCA-4606-2G4C1-A33-CY Laird # 0600-00056	PCB Dipole	IPEX	2.21	
9	Laird	EFA2400A3S-10MH4L	mFlexPIFA	MHF4	2	

Note: The antenna with highest gain was selected for final testing in this test report

1.1.4 Power Supply Type of Equipment under Test (EUT)

Power Supply Type	3.3Vdc from host
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1.1.5 Accessories

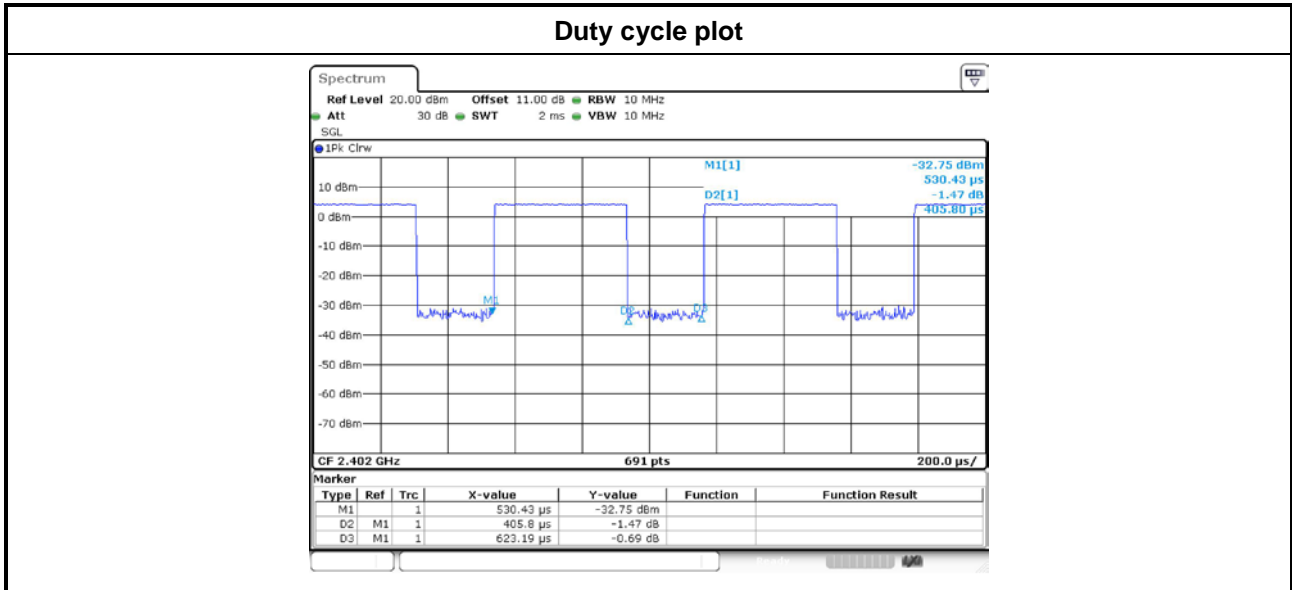
N/A

1.1.6 Channel List

Frequency band (MHz)				2400~2483.5			
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
37	2402	9	2422	18	2442	28	2462
0	2404	10	2424	19	2444	29	2464
1	2406	38	2426	20	2446	30	2466
2	2408	11	2428	21	2448	31	2468
3	2410	12	2430	22	2450	32	2470
4	2412	13	2432	23	2452	33	2472
5	2414	14	2434	24	2454	34	2474
6	2416	15	2436	25	2456	35	2476
7	2418	16	2438	26	2458	36	2478
8	2420	17	2440	27	2460	39	2480

1.1.7 Test Tool and Duty Cycle

Test tool	nrfgostudio, Version:1.16.1
Duty cycle of test signal (%)	65.12%
Duty Factor (dB)	1.86



1.1.8 Power Setting

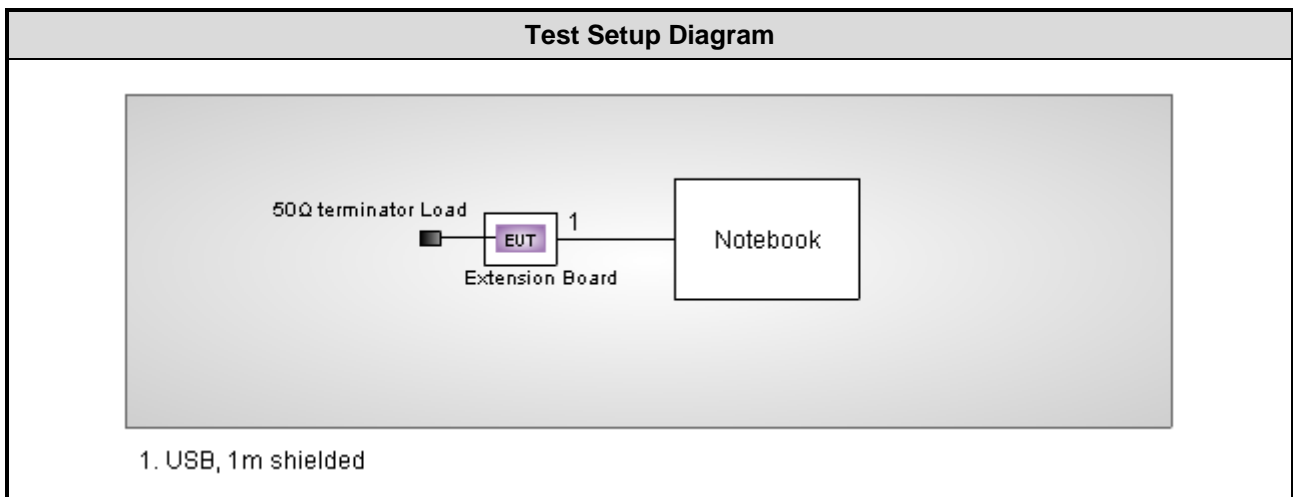
Modulation Mode	Test Frequency (MHz)		
	2402	2440	2480
GFSK/1Mbps	Default	Default	Default

1.2 Local Support Equipment List

Support Equipment List					
No.	Equipment	Brand	Model	FCC ID	Signal cable / Length (m)
1	Notebook	DELL	Latitude E6440	DoC	---
2	Extension Board	Laird	DVK-BL652-A1	---	USB, 1m shielded without core

Note: Extension Board and USB cable were supplied by applicant.

1.3 Test Setup Chart



1.4 Test Equipment List and Calibration Data

Test Item	Conducted Emission				
Test Site	Conduction room 1 / (CO01-WS)				
Tested Date	May 28, 2018				
Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Until
Receiver	R&S	ESR3	101657	Jan. 05, 2018	Jan. 04, 2019
LISN	SCHWARZBECK	Schwarzbeck 8127	8127-667	Nov. 13, 2017	Nov. 12, 2018
RF Cable-CON	EMC	EMCCFD300-BM-BM-6000	50821	Dec. 18, 2017	Dec. 17, 2018
Measurement Software	AUDIX	e3	6.120210k	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

1.5 Test Standards

According to the specification of EUT, the EUT must comply with following standards and KDB documents.

47 CFR FCC Part 15.247

ANSI C63.10-2013

FCC KDB 558074 D01 DTS Meas Guidance v04

1.6 Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor ($k=2$))

Measurement Uncertainty	
Parameters	Uncertainty
Bandwidth	± 34.134 Hz
Conducted power	± 0.808 dB
Power density	± 0.463 dB
Conducted emission	± 2.670 dB
AC conducted emission	± 2.90 dB
Radiated emission ≤ 1 GHz	± 3.66 dB
Radiated emission > 1 GHz	± 5.37 dB

2 Test Configuration

2.1 Testing Condition

Test Item	Test Site	Ambient Condition	Tested By
AC Conduction	CO01-WS	22°C / 58%	Alex Tsai

- FCC Desingation No. TW0009
- FCC site registration No.: 207696
- IC site registration No.: 10807C-1

2.2 The Worst Test Modes and Channel Details

Test item	Mode	Test Frequency (MHz)	Data Rate	Test Configuration
AC Power Line Conducted Emissions	BT LE	2440	1Mbps	---
Antenna-port Conducted Emission	BT LE	2402, 2440, 2480	1Mbps	---
Maximum Output Power	BT LE	2402, 2440, 2480	1Mbps	---

NOTE:

1. Radiated emission is not performed since alternative method to radiated measurement is used in original test report as below:
 "50Ω terminator is connected to antenna port of EUT for radiated emission measurement and Antenna-port conducted emission"
 Thus, radiated emission with antenna is not performed.
2. Antenna-port conducted emission and maximum output power test values refer to original test report. The test results need to be re-calculated since highest antenna gain of additional antenna is higher than original antenna.

3 Transmitter Test Results

3.1 Conducted Emissions

3.1.1 Limit of Conducted Emissions

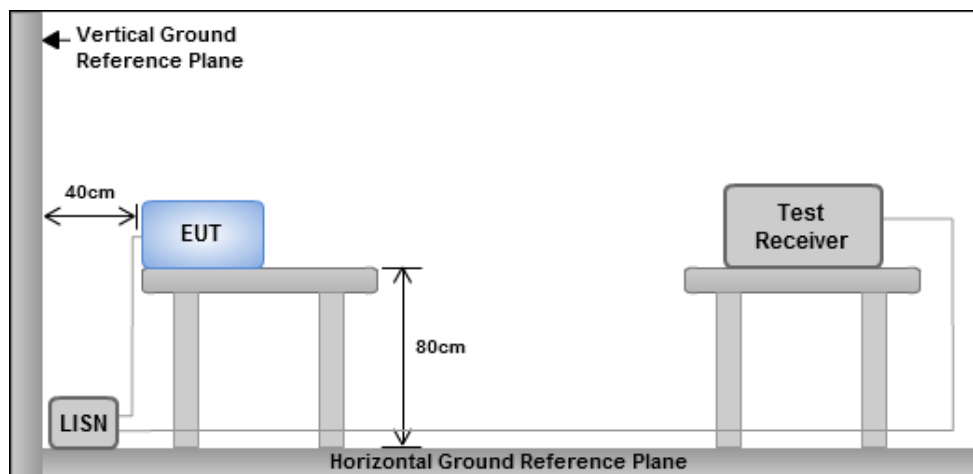
Conducted Emissions Limit		
Frequency Emission (MHz)	Quasi-Peak	Average
0.15-0.5	66 - 56 *	56 - 46 *
0.5-5	56	46
5-30	60	50

Note 1: * Decreases with the logarithm of the frequency.

3.1.2 Test Procedures

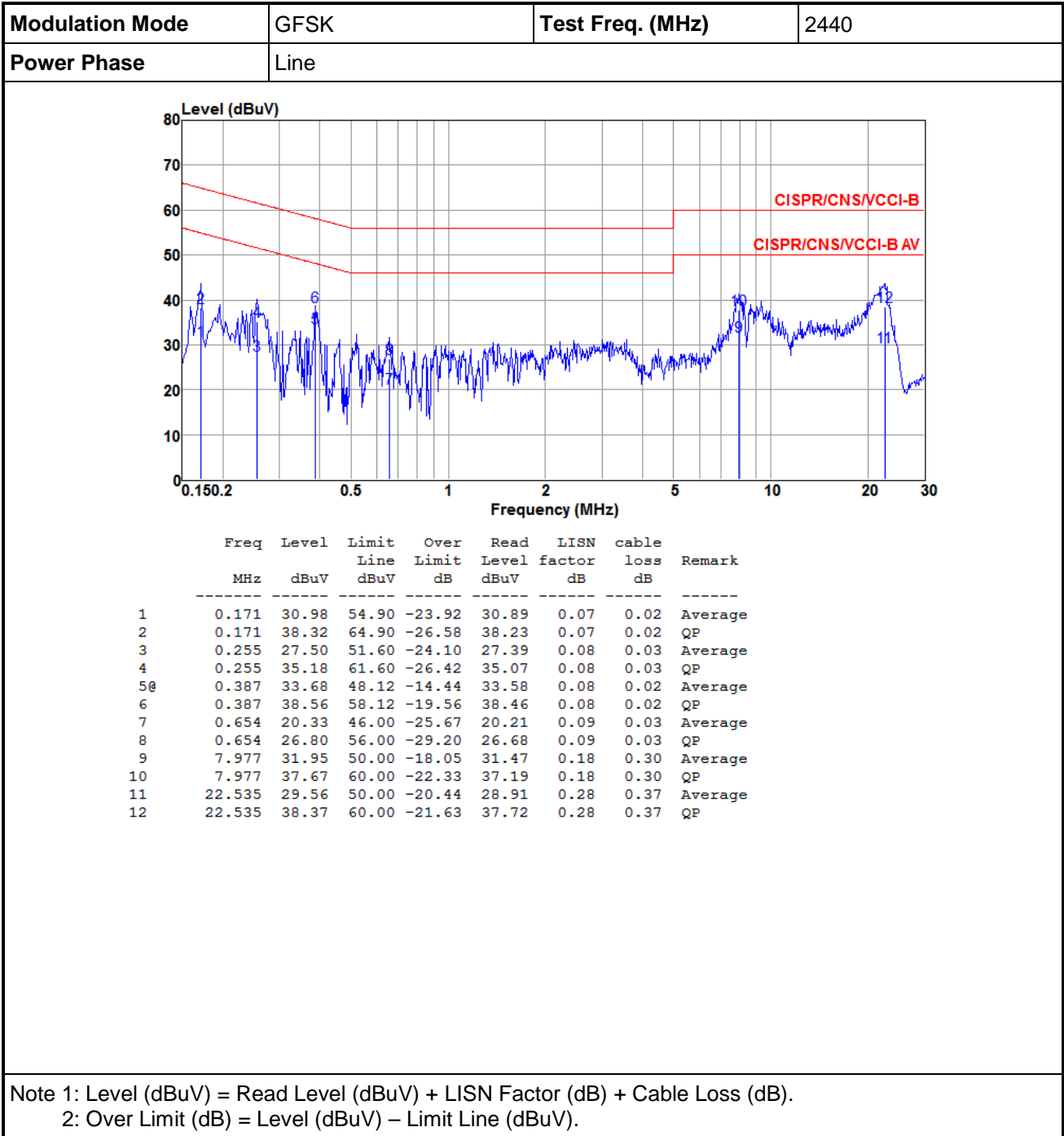
1. The device is placed on a test table, raised 80 cm above the reference ground plane. The vertical conducting plane is located 40 cm to the rear of the device.
2. The device is connected to line impedance stabilization network (LISN) and other accessories are connected to other LISN. Measured levels of AC power line conducted emission are across the 50 Ω LISN port.
3. AC conducted emission measurements is made over frequency range from 150 kHz to 30 MHz.
4. This measurement was performed with AC 120V/60Hz

3.1.3 Test Setup



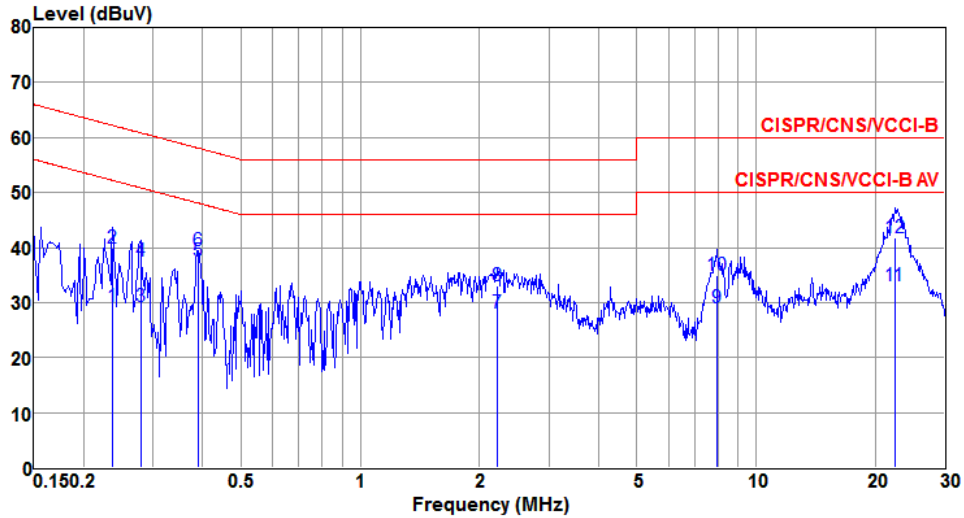
- Note: 1. Support units were connected to second LISN.
 2. Both of LISNs (AMN) are 80 cm from EUT and at least 80 cm from other units and other metal planes

3.1.4 Test Result of Conducted Emissions



Modulation Mode	GFSK	Test Freq. (MHz)	2440
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Power Phase	Neutral
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	Freq MHz	Level dBUV	Limit Line dBUV	Over Limit dB	Read Level dBUV	LISN factor dB	cable loss dB	Remark
1	0.237	29.17	52.22	-23.05	29.10	0.04	0.03	Average
2	0.237	39.82	62.22	-22.40	39.75	0.04	0.03	QP
3	0.279	29.36	50.85	-21.49	29.29	0.04	0.03	Average
4	0.279	37.51	60.85	-23.34	37.44	0.04	0.03	QP
5e	0.389	37.50	48.08	-10.58	37.44	0.04	0.02	Average
6	0.389	39.45	58.08	-18.63	39.39	0.04	0.02	QP
7	2.225	27.99	46.00	-18.01	27.80	0.07	0.12	Average
8	2.225	33.14	56.00	-22.86	32.95	0.07	0.12	QP
9	7.977	29.08	50.00	-20.92	28.63	0.15	0.30	Average
10	7.977	34.92	60.00	-25.08	34.47	0.15	0.30	QP
11	22.416	33.15	50.00	-16.85	32.50	0.28	0.37	Average
12	22.416	41.81	60.00	-18.19	41.16	0.28	0.37	QP

Note 1: Level (dBUV) = Read Level (dBUV) + LISN Factor (dB) + Cable Loss (dB).
 2: Over Limit (dB) = Level (dBUV) – Limit Line (dBUV).

3.2 RF Output Power

3.2.1 Limit of RF Output Power

Conducted power shall not exceed 1Watt.

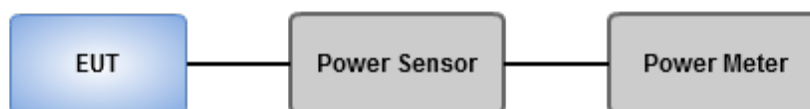
- Antenna gain \leq 6dBi, no any corresponding reduction is in output power limit.
- Antenna gain $>$ 6dBi
 - Non Fixed, point to point operations.
The conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dB
 - Fixed, point to point operations
Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point Operations, maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725–5850 MHz band that are used exclusively for fixed, point-to-point operations ,no any corresponding reduction is in transmitter peak output power

3.2.2 Test Procedures

- Maximum Peak Conducted Output Power
 - Spectrum analyzer**
 1. Set RBW = 1MHz, VBW = 3MHz, Detector = Peak.
 2. Sweep time = auto, Trace mode = max hold, Allow trace to fully stabilize.
 3. Use the spectrum analyzer channel power measurement function with the band limits set equal to the DTS bandwidth edges.
 - Power meter**
 1. A broadband Peak RF power meter is used for output power measurement. The video bandwidth of power meter is greater than DTS bandwidth of EUT. If duty cycle of test signal is not 100 %, trigger and gating function of power meter will be enabled to capture transmission burst for measuring output power.
- Maximum Conducted Average Output Power (For reference only)
 - Power meter**
 1. A broadband Average RF power meter is used for output power measurement. The video bandwidth of power meter is greater than DTS bandwidth of EUT. If duty cycle of test signal is not 100 %, trigger and gating function of power meter will be enabled to capture transmission burst for measuring output power.

3.2.3 Test Setup



3.2.4 Test Result of Maximum Output Power

Mode	Freq. (MHz)	Peak Power			Antenna gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)
		Power (mW)	Power (dBm)	Limit (dBm)			
BT LE	2402	2.825	4.51	30	2.21	6.72	36
BT LE	2440	2.858	4.56	30	2.21	6.77	36
BT LE	2480	2.799	4.47	30	2.21	6.68	36

Mode	Freq. (MHz)	AV Power (mW)	AV Power (dBm)	Limit (dBm)
BT LE	2402	2.805	4.48	---
BT LE	2440	2.838	4.53	---
BT LE	2480	2.780	4.44	---

Note: Average power is for reference only

3.3 Emissions in Restricted Frequency Bands

3.3.1 Limit of Emissions in Restricted Frequency Bands

Restricted Band Emissions Limit			
Frequency Range (MHz)	Field Strength (uV/m)	Field Strength (dBuV/m)	Measure Distance (m)
0.009~0.490	2400/F(kHz)	48.5 - 13.8	300
0.490~1.705	24000/F(kHz)	33.8 - 23	30
1.705~30.0	30	29	30
30~88	100	40	3
88~216	150	43.5	3
216~960	200	46	3
Above 960	500	54	3

Note 1:
Quasi-Peak value is measured for frequency below 1GHz except for 9–90 kHz, 110–490 kHz frequency band. Peak and average value are measured for frequency above 1GHz. The limit on average radio frequency emission is as above table. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit

Note 2:
Measurements may be performed at a distance other than what is specified provided. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor as below, Frequency at or above 30 MHz: 20 dB/decade Frequency below 30 MHz: 40 dB/decade.

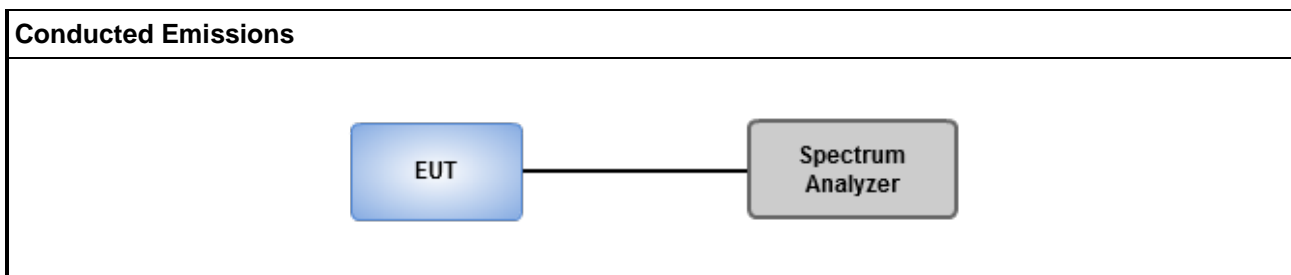
3.3.2 Test Procedures

1. Set EUT to transmit at low / middle / high channel
2. Follow below setting to measure emission level
3. Record the measured value and add antenna gain to calculate EIRP

Note:

1. 120kHz measurement bandwidth of test receiver and Quasi-peak detector is for radiated emission below 1GHz.
2. RBW=1MHz, VBW=3MHz and Peak detector is for peak measured value of radiated emission above 1GHz.
3. RBW=1MHz, VBW=3kHz(1/T) and Peak detector is for average measured value of radiated emission above 1GHz.

3.3.3 Test Setup

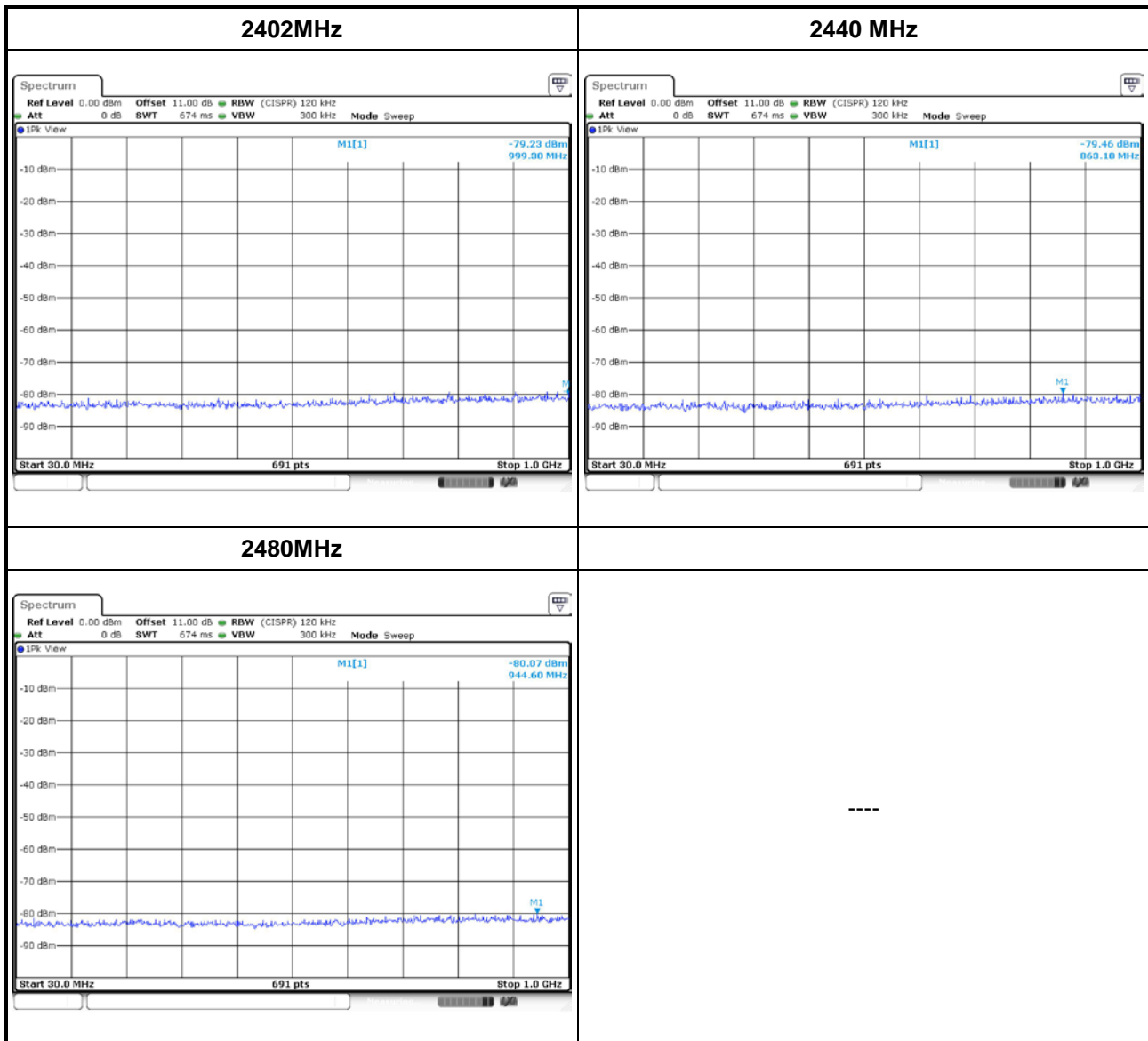


3.3.4 Transmitter Conducted Unwanted Emissions (Below 1 GHz)

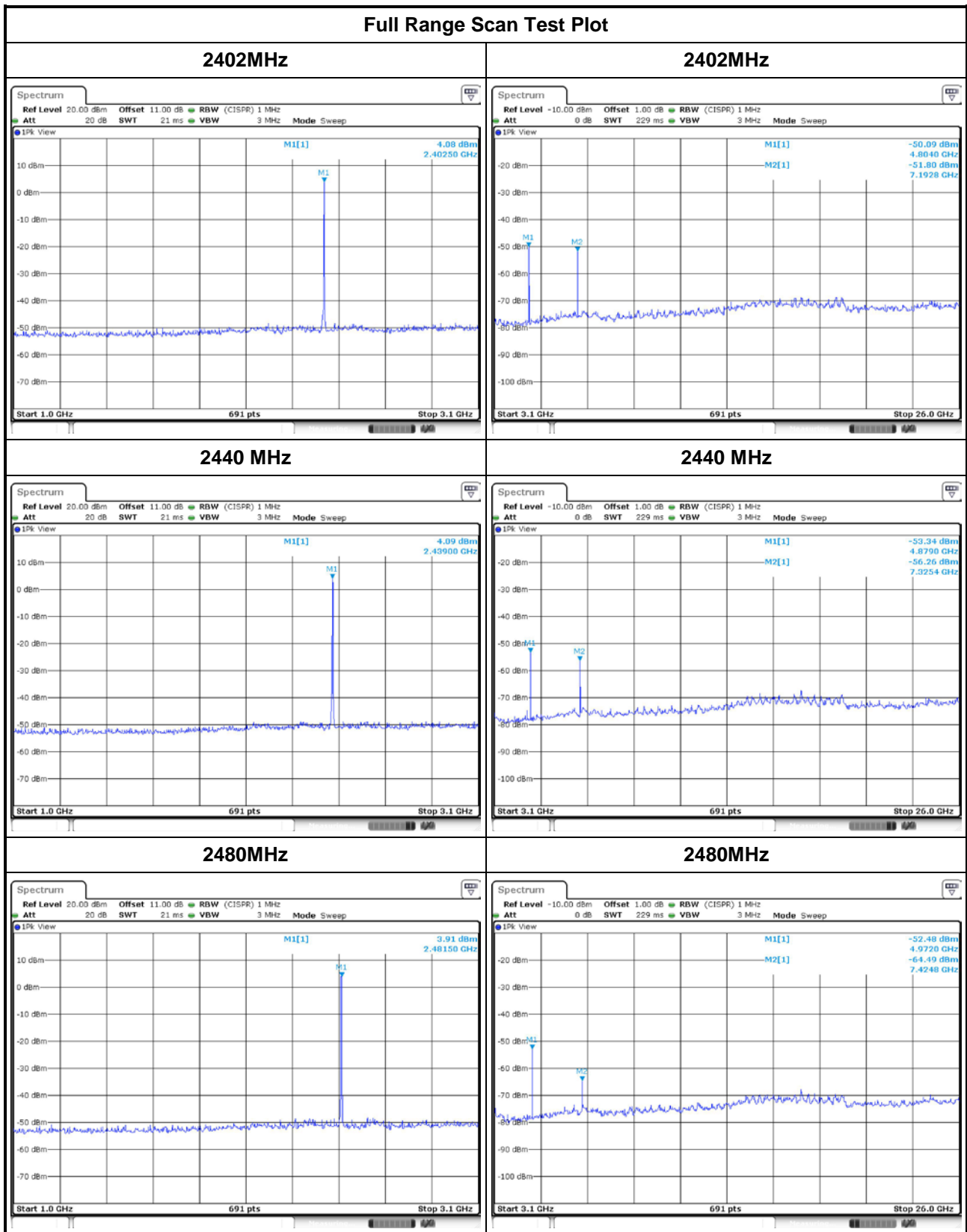
Transmitter Conducted Unwanted Emissions Results in Restrict bands							
Modulation	BT-BLE				NTx	1	
Test ch. Freq. (MHz)	Range (MHz)	Max Value (dBm)	Gain (dBi)	GRF (dB)	EIRP (dBm)	Limit* (dBm)	Margin (dB)
2402	30-1000	-79.23	2.21	4.7	-72.32	-55.2	-17.12
2440	30-1000	-79.46	2.21	4.7	-72.55	-55.2	-17.35
2480	30-1000	-80.07	2.21	4.7	-73.16	-55.2	-17.96

Note:

1. GRF = Ground Reflection Factor.
2. DG = Directional Gain.
3. Worst case of emission limit below 1GHz is selected to be limit.



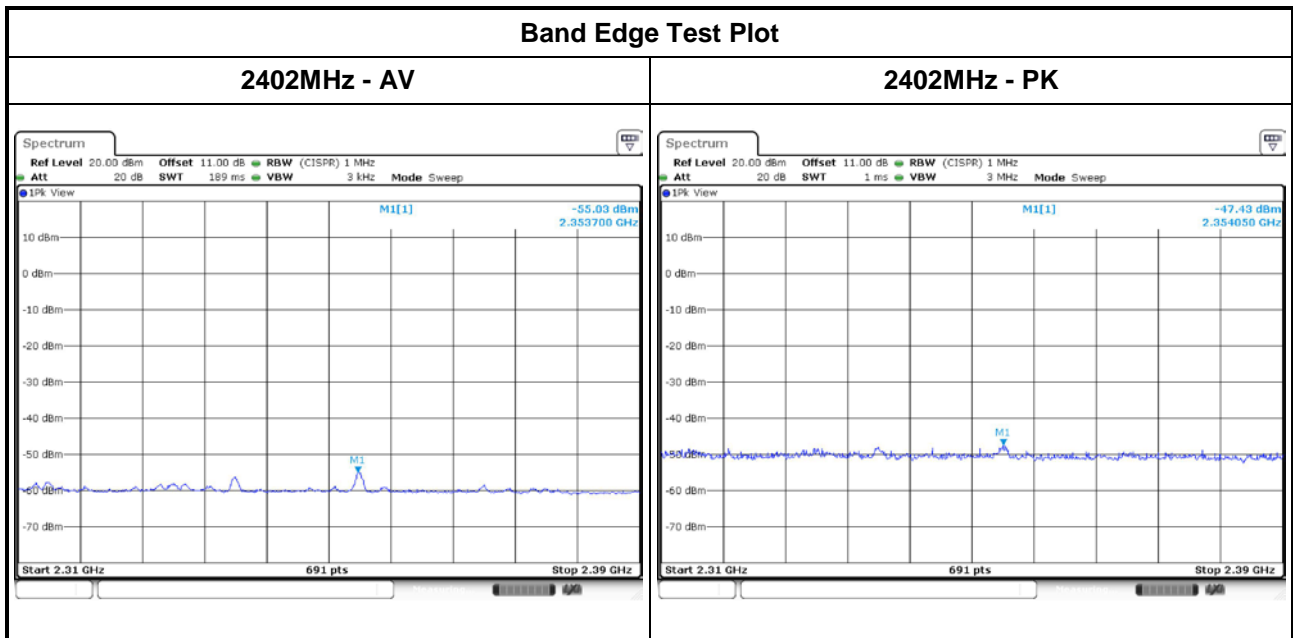
3.3.5 Transmitter Conducted Unwanted Emissions (Above 1GHz)



Transmitter Conducted Unwanted Emissions Results in Band Edge

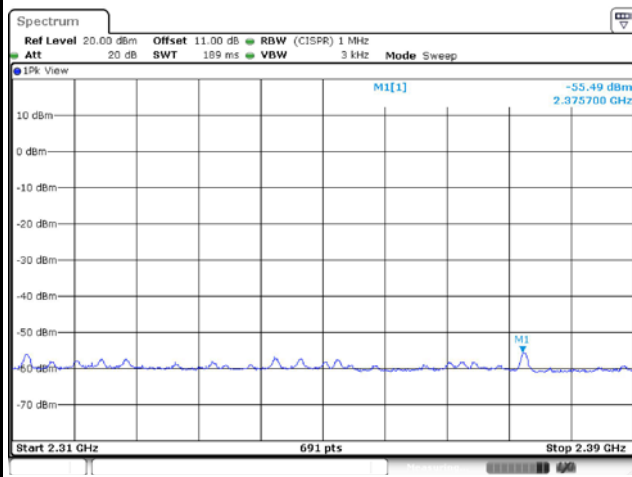
Modulation		BT-BLE		NTx		1	
Test ch. Freq. (MHz)	Freq (MHz)	Measured Value (dBm)	Gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)	Remark
2402	2353.70	-55.03	2.21	-52.82	-41.20	-11.62	AV
	2354.05	-47.43	2.21	-45.22	-21.20	-24.02	PK
2440	2375.70	-55.49	2.21	-53.28	-41.20	-12.08	AV
	2325.22	-47.30	2.21	-45.09	-21.20	-23.89	PK
	2487.88	-54.77	2.21	-52.56	-41.20	-11.36	AV
	2488.24	-47.52	2.21	-45.31	-21.20	-24.11	PK
2480	2483.51	-55.00	2.21	-52.79	-41.20	-11.59	AV
	2483.51	-34.89	2.21	-32.68	-21.20	-11.48	PK

Band Edge Test Plot

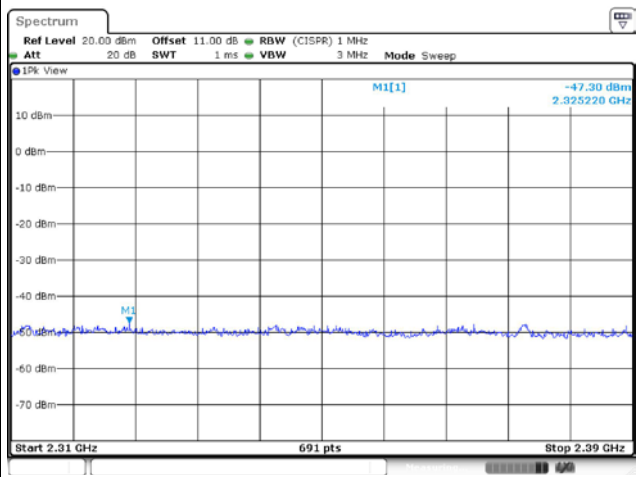


Band Edge Test Plot

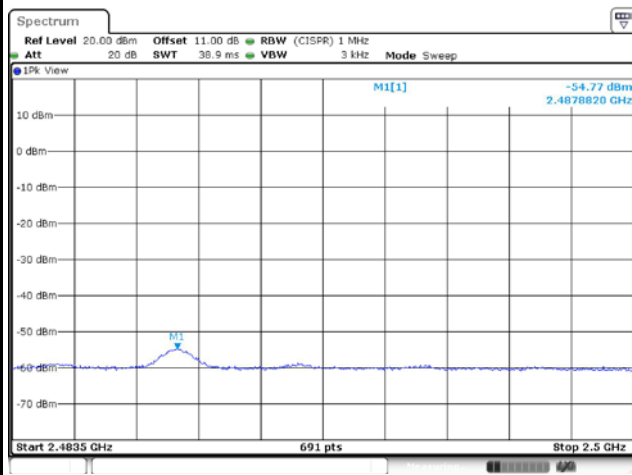
2440MHz - AV



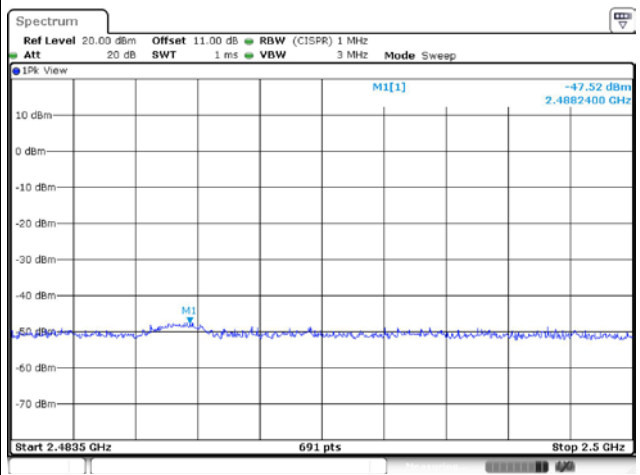
2440MHz - PK



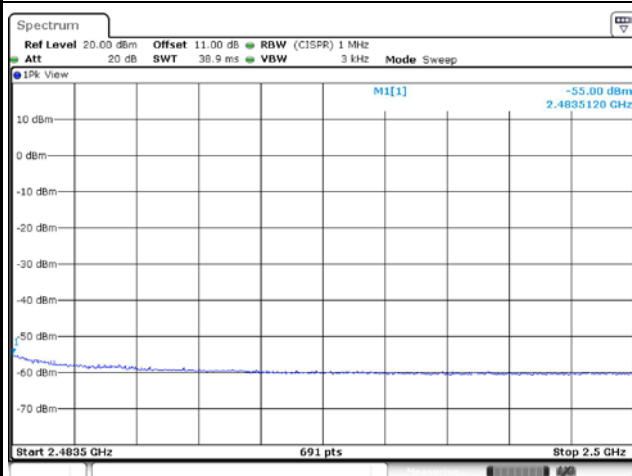
2440MHz - AV



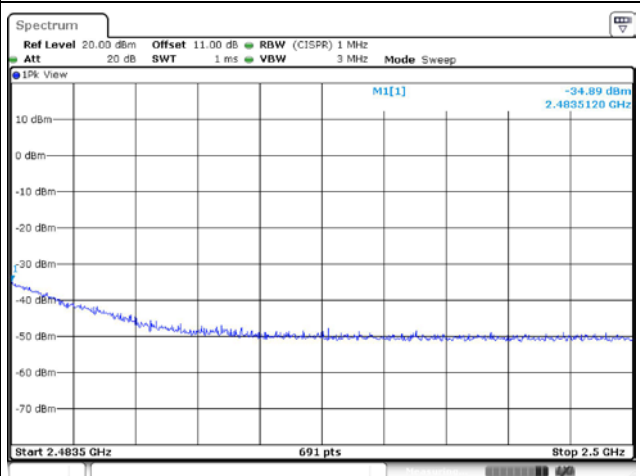
2440MHz - PK



2480MHz - AV



2480MHz - PK

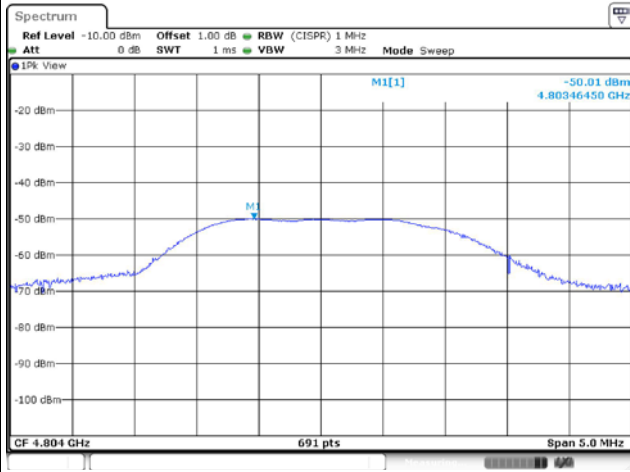


Transmitter Conducted Unwanted Emissions Results in Restricted Frequency Band							
Modulation	BT-BLE			NTx	1		
Test ch. Freq. (MHz)	Freq (MHz)	Measured Value (dBm)	Gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)	Remark
2402	-	-	2.21	-	-41.20	-	AV
	4804.00	-50.01	2.21	-47.80	-21.20	-26.60	PK
2440	-	-	2.21	-	-41.20	-	AV
	4880.00	-53.11	2.21	-50.90	-21.20	-29.70	PK
	-	-	2.21	-	-41.20	-	AV
	7320.00	-55.67	2.21	-53.46	-21.20	-32.26	PK
2480	-	-	2.21	-	-41.20	-	AV
	4960.00	-52.37	2.21	-50.16	-21.20	-28.96	PK
	-	-	2.21	-	-41.20	-	AV
	7440.00	-62.45	2.21	-60.24	-21.20	-39.04	PK

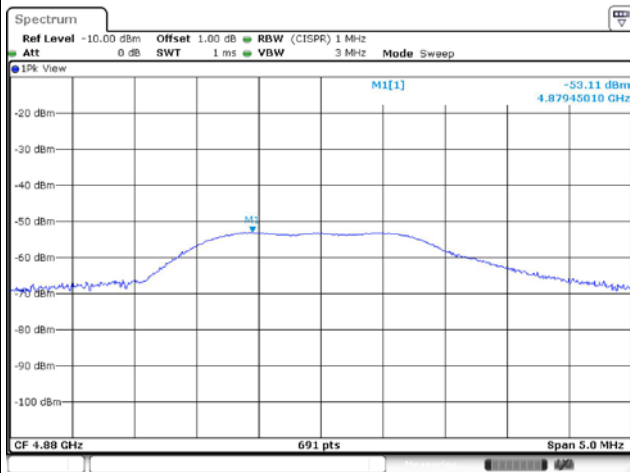
Note: Average value measurement is not performed if the Peak value below the average limit

Harmonic Emissions Test Plots

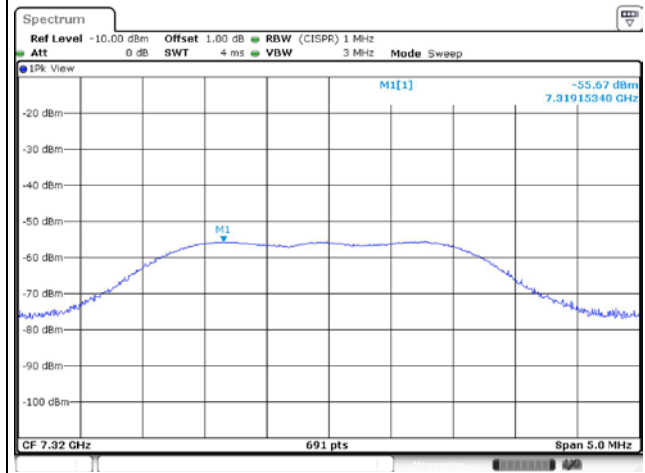
2402MHz - PK



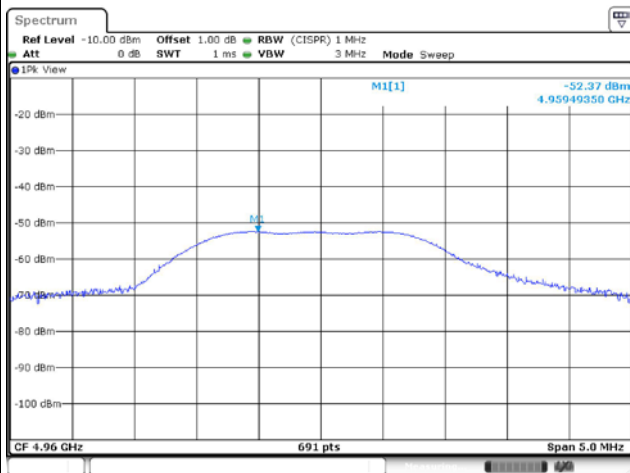
2440MHz - PK



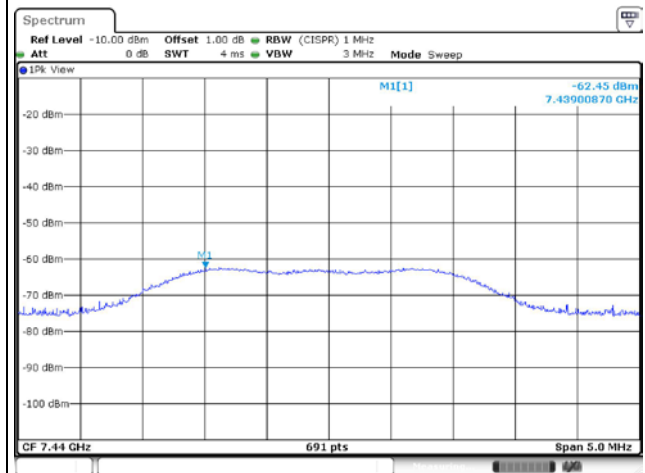
2440MHz - PK



2480MHz - PK



2480MHz - PK



4 Test laboratory information

Established in 2012, ICC provides foremost EMC & RF Testing and advisory consultation services by our skilled engineers and technicians. Our services employ a wide variety of advanced edge test equipment and one of the widest certification extents in the business.

International Certification Corp (EMC and Wireless Communication Laboratory), it is our definitive objective is to institute long term, trust-based associations with our clients. The expectation we set up with our clients is based on outstanding service, practical expertise and devotion to a certified value structure. Our passion is to grant our clients with best EMC / RF services by oriented knowledgeable and accommodating staff.

Our Test sites are located at Linkou District and Kwei Shan District. Location map can be found on our website <http://www.icertifi.com.tw>.

Linkou

Tel: 886-2-2601-1640

No. 30-2, Ding Fwu Tsuen, Lin
Kou District, New Taipei City,
Taiwan, R.O.C.

Kwei Shan

Tel: 886-3-271-8666

No. 3-1, Lane 6, Wen San 3rd St.,
Kwei Shan District, Tao Yuan City
333, Taiwan, R.O.C.

Kwei Shan Site II

Tel: 886-3-271-8640

No. 14-1, Lane 19, Wen San 3rd
St., Kwei Shan District, Tao Yuan
City 333, Taiwan, R.O.C.

If you have any suggestion, please feel free to contact us as below information.

Tel: 886-3-271-8666

Fax: 886-3-318-0155

Email: ICC_Service@icertifi.com.tw

==END==