

Radio Test Report

According to

FCC part 15C,
RSS-247, RSS-Gen

DUT Name: ABLOY CLIQ CONNECT KEY
Model No.: TQB406
Customer: ABLOY OY
Address: Walhforssinkatu 20, 80100 Joensuu, FINLAND
Summary IN COMPLIANCE
Date of Reception: 28.11.2024
Date(s) of Test(s): 05.12.2024 – 13.12.2024

Tested by Test Engineer


Pekka Pulkkinen

Approved by Technical Manager


Jukka Rauma

The test report shall not be reproduced except in full, without the written approval of the laboratory. This report is only for the equipment which is described in page 4.

CONTENTS

1. General Information	3
2. Test Samples	4
3. Configuration and Operation Modes	6
4. Test equipment.....	6
5. Uncertainties	7
6. Sample emission level calculation	8
7. Test conditions	9
8. Summary.....	12
9. Occupied bandwidth	13
10. 6 dB bandwidth	15
11. Peak conducted output power	17
12. Peak Power Spectral Density	20
13. Band edge emissions compliance (transmitter)	22
14. Tx spurious emissions, conducted.....	25
15. Emissions in restricted frequency bands.....	28
16. Tx spurious emissions, radiated	32
17. Receiver spurious emissions, radiated	45

Document Version History	Date of issue	Comments	Approved by
v0.1	19.12.2024	Initial draft	
v1.0	24.1.2025	Appoved version with signatures	Jukka Rauma
v2.0	28.5.2025	Added additional models and changed brand name/trade mark to ABLOY CLIQ CONNECT KEY. Amendment1 = A1.	Jukka Rauma

1. General Information

Test Engineers: Arto Kuosmanen, Pekka Pulkkinen

Location:

Test Firm Name	Eurofins Electric & Electronics Finland Oy (EEEF)
Test Site	Yrttipellontie, Peltola
Address of Test Site	Yrttipellontie 6, 90230 Oulu, Finland
FCC Designation number	FI0008
FCC site registration number	771880
ISED number	29576
CAB Identifier	T290

Customer:

ABLOY OY

Walhforssinkatu 20, 80100 Joensuu, FINLAND

Mikko Noropirtti

tel: +358 50 465 6813

e-mail: mikko.noropirtti@abloy.com

Climate Conditions: Temperature: 15 - 35 °C

Air pressure: 860 - 1060 hPa

Humidity: 30-60 rH%

These limits were not exceeded during testing.

2. Test Samples

General description: Double-secured locking and access control. PROTEC² CLIQ dynamic key CONNECT is intended for cases when access rights often change as it is easy to program changed access rights directly to user keys. Authorised cylinder and/or cylinder groups needs to be programmed to dynamic keys via customer software (locally or remotely). CLIQ Connect keys can be updated through Bluetooth with a smartphone application. Patented PROTEC² (T) key system.

Test sample (Conducted):

Sample number	Serial number	Manufacturer	DUT Type	Model	HW version	SW version
2400244601	-	ABLOY OY	Electromechanical key. BLE 1M	TQB406	922688 Revision 3	ASIC FW 16.3.8, BLE FW 2.5.1
2400244605	-	ABLOY OY		Key		
2400244607		ABLOY OY	Electromechanical key	TQB406	922688 Revision 3	ASIC FW 16.3.8, BLE FW 2.5.1

Test sample (Radiated):

Sample number	Serial number	Manufacturer	DUT Type	Model	HW version	SW version	Comment
2400244607	N/A	ABLOY OY	Electromechanical key	TQB406	922688 Revision 3	ASIC FW 16.3.8, BLE FW 2.5.1	"RADIO"

Auxiliary equipment:

Sample number	Serial number	Manufacturer	DUT Type	Model	Comment
2400244604	N/A	ABLOY OY	Programming device		CLIQ PD
2400244609	N/A	DELL Ltd	Laptop with AC adapter	Precision 3570	With Win10 OS, RF test tool

Description	Information	
Additional model(s)	TQB403, TQB403EX, TQGB403, TGB403EX, TQB406EX, TQC406, TQC406EX, TQGB406, TGB406EX, TQGC406, TGC406EX, TQB407, TQB407EX, TQC407, TQC407EX, TQGB407, TGB407EX, TQGC407, TGC407EX	
Brand Names(s)	ABLOY CLIQ CONNECT KEY	
PMN	CLIQ Connect key, CLIQ Connect Online Key	
HVIN	CLIQ CONNECT KEY	
FVIN	BLE 4.1	
HMN	N/A	
FCC ID	2AI5J-CONNECT2	
IC ID	21724-CONNECT2	
Equipment type	End product	
Radio type	Transceiver	
- operating frequency range:	2400.0 MHz – 2483.5 MHz	
- Nominal Channel Bandwidth:	2 MHz	
Radio technology / type of equipment	Bluetooth LE 4.1	
Modulation:	GFSK	
Number of antennas	1	
Bluetooth Specification	LE 1Mbps PHY	Yes
	LE 2Mbps PHY	No
	LE Coded PHY S=2 (500 kbit)	No
	LE Coded PHY S=8 (125 kbit)	No
	Stable Modulation Index - Transmitter	No
	Stable Modulation Index - Reer	No
Antenna	Type	Chip
	Model	Ultra-Miniature 2.4GHz Chip antenna 0.37mm max Thickness
	Manufacturer	Johanson Technology
	Gain	1 dBi
Supply voltage	Battery operated, $V_{Nom} = 3\text{ V}$ Li-Ion battery	
Type of Power source	Battery operated	
Operating Temperature	TNom = +25°C TMin = -25°C TMax = +65°C	
Manufacturer	ABLOY OY Walhforssinkatu 20, 80100 Joensuu, FINLAND	

3. Configuration and Operation Modes

Conducted and radiated emission test:

Test modes / description
Conducted RF: EUT battery powered, continuous modulated carrier at 2402 MHz, 2442 MHz and 2480 MHz, power level setting 0 dBm, data rate 1 Mbps
Radiated Emissions: EUT battery powered, continuous modulated carrier at 2402 MHz, 2442 MHz and 2480 MHz, power level setting 0 dBm, data rate 1 Mbps
Radiated Emissions: EUT battery powered, continuous reception at 2442 MHz, power level setting 0 dBm, data rate 1 Mbps

4. Test equipment

Conducted RF tests

R&S TS8997 Test System equipment list:

New ID	Manufacturer	Equipment type	Description	Serial	Calibration information	Next calibration
G4C462	Rohde & Schwarz	SMW200A	Vector signal generator	110578	27.6.2023	27.6.2026
G4C463	Rohde & Schwarz	SMB100A	Signal Generator	183205	27.6.2023	27.6.2026
G4C464	Rohde & Schwarz	OSP150	Open switch and control unit	101135	13.8.2024	13.8.2025
G4C465	Rohde & Schwarz	OSP220	Open switch and control unit	102440	14.8.2024	14.8.2025
G4C466	Rohde & Schwarz	ESW44	EMI test receiver	103103	29.7.2024	29.7.2025
G4C467	Rohde & Schwarz	CMW500	Wideband radio communication tester	171062	29.6.2023	29.6.2025

Radiated emission

New ID	Manufacturer	Equipment type	Description	Serial	Calibration information	Next calibration
G4C265	Rohde & Schwarz	ESW26	EMI test receiver	101324	26.7.2024	26.7.2025
G4C273	Frankonia	ALX-4000E	Broadband Antenna, 25MHz-4GHz with 6dB (50-A-MFN-06) att.	00816+1531	22.1.2024	22.1.2027
G4C298	Rohde & Schwarz	CMW500	Wideband radio communication tester	170980	29.6.2023	29.6.2025
G4C469	Rohde & Schwarz	TS_PRE2	RF Preamplifier	101541	12.8.2024	12.8.2026
G4C294	Rohde & Schwarz	Antenna	Horn Antenna -> 40GHz	101057	4.11.2022	4.11.2025
G4C572	Schaffner	CBL 6143	Bilog Antenna 30MHz-3GHz	5071	7.9.2022	7.9.2025
G4C576	Rohde & Schwarz	HF907	Double-Ridged Waveguide Horn Antenna 800MHz-18GHz	100163	9.8.2022	9.8.2025

Test software

Description	Manufacturer	Name	Version
EMC Software	Rohde & Schwarz	EMC32	10.60.20
RF Software	Rohde & Schwarz	WMS32	11.60.00

5. Uncertainties

Description	Expanded Uncertainty (k=2)
RF Output Power	0,99
Peak Power	0,80
Power Spectral Density	0,99
Accumulated Transmit Time	0,01%
Minimum Frequency Occupation Time	0,01%
Hopping Frequency Separation	0,60%
Occupied Channel Bandwidth	2,08 %
Out-of-band emissions	0,89
Transmitter unwanted emissions in the spurious domain	1,76
AC conducted emission	2,24
Radiated emission ≤ 1 GHz	4,62
Radiated emission > 1 GHz	5,72

6. Sample emission level calculation

The following is a description of term and a sample calculation, as appears in the radiated emissions data table. The numbers used in the calculation are for example only. There is no direct correlation to the specific data taken for the product described in this document:

Reading:

This is the reading obtained on the spectrum analyzer in dBuV.

A.F.:

This is the antenna factor for the receiving antenna. It is a conversion factor, which converts electric fields strength to voltages, which can be measured directly on the spectrum analyzer. It is treated as a loss in dB. RF path losses, including RF cables and preamplifiers, have been included with the A.F to simplify the calculations. The antenna factor is used in calculations as follows:

$$\text{Reading on Analyzer (dBuV)} + \text{A.F. (dB/m)} = \text{Net field strength (dBuV/m)}$$

Net:

This is the net field strength measurement (as shown above).

Limit:

This is the FCC Class B radiated emission limit (in units of dBuV/m). The FCC limits are given in units of uV/m. The following formula is used to convert the units of uV/m to dbuV/m:

$$\text{Limit (dBuV/m)} = 20 * \log(\text{uV/m})$$

Margin :

This is the margin of compliance below the FCC limit. The units are given in dB. A negative margin indicates the emission was below the limit. A positive margin indicates that the emission exceeds the limit.

Example only:

Reading + AF	= Net Reading :	Net reading – FCC limit	= Margin
+ 21.5 dBuV + 26 dB/m	= 47.5 dBuV/m :	47.5 dBuV/m – 57.0 dBuV/m	= -9.5 dB

7. Test conditions

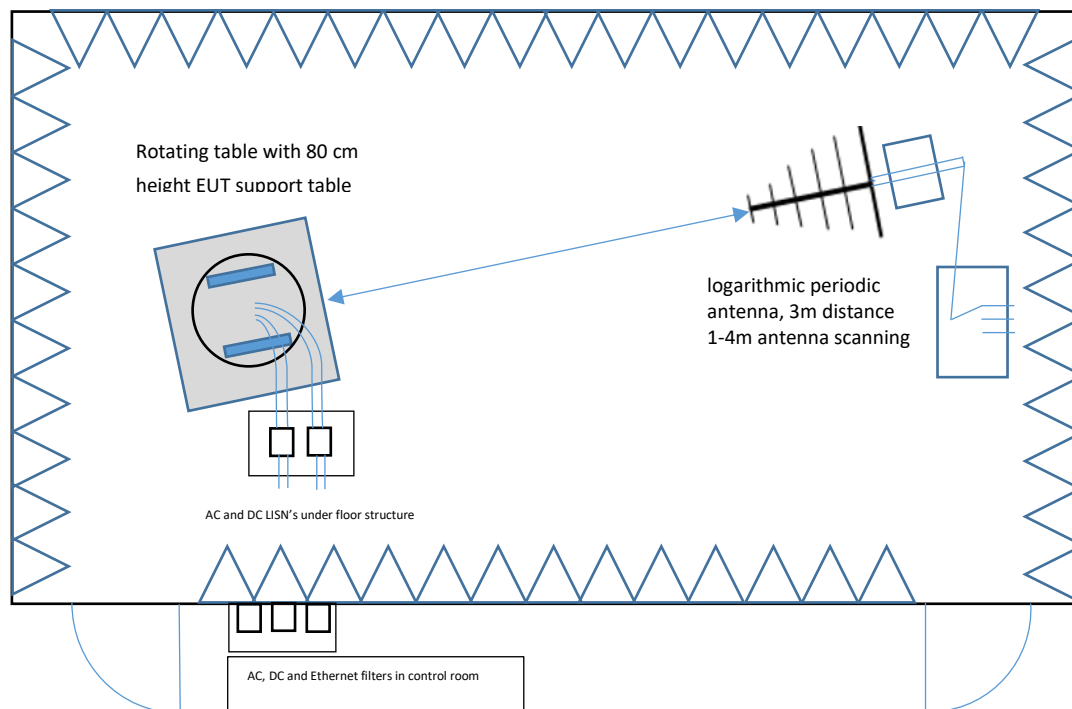
All radiated tests were performed in a semi-anechoic chamber, where the measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz, 1 GHz-18 GHz Double-ridged horn antenna and 18 GHz-40 GHz horn antenna) is located at a distance of 3 m.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (all antennas) was varied from 1 to 4 meters to find the maximum radiated emission.

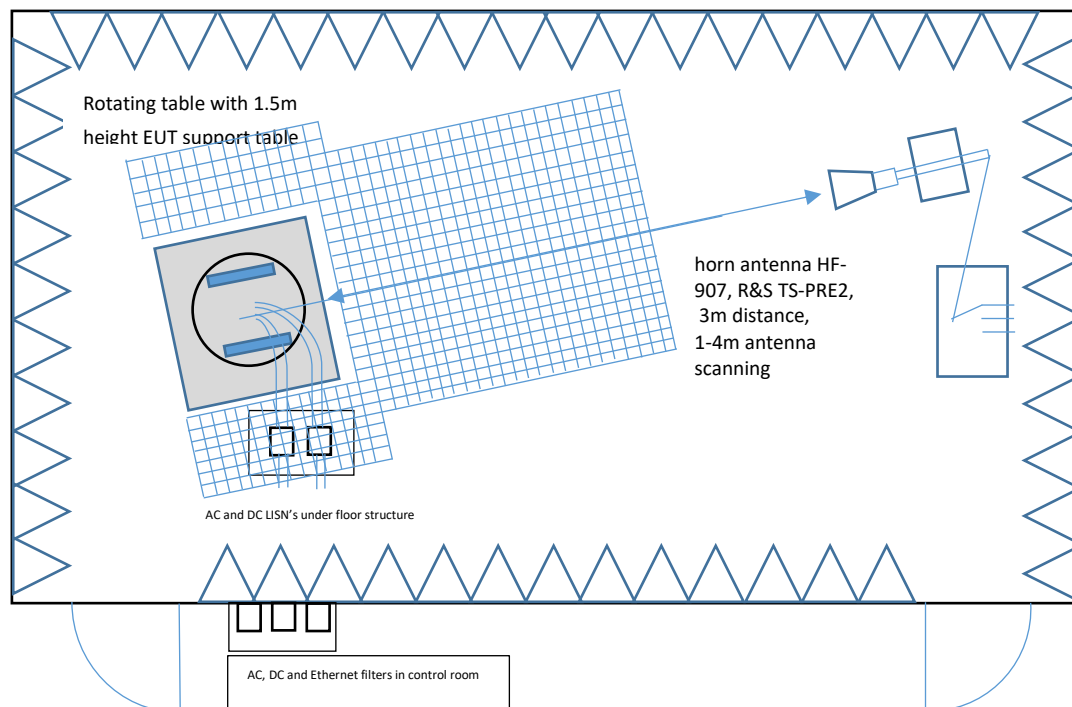
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

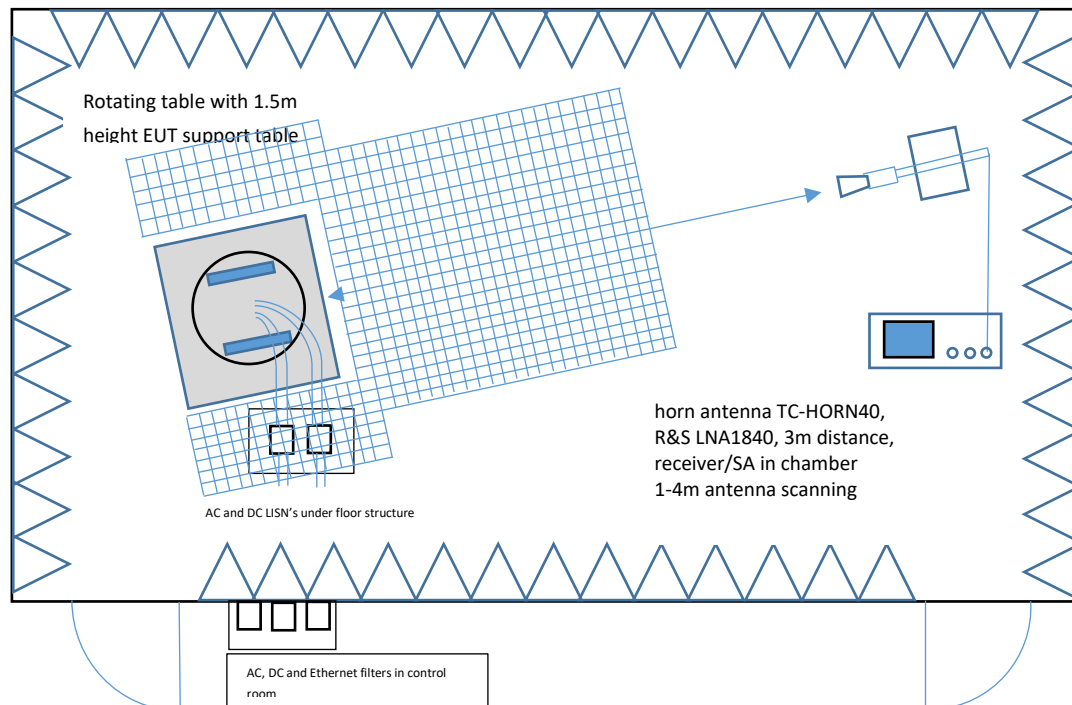
Radiated measurements setup from 30 MHz to 1 GHz:



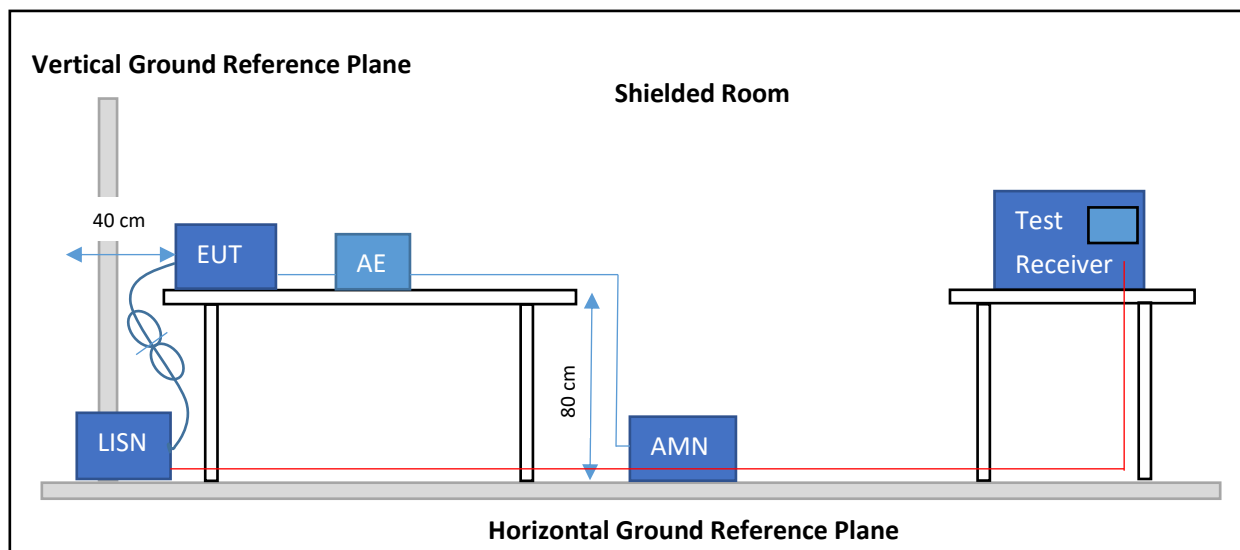
Radiated measurements setup from 1 GHz to 18 GHz:



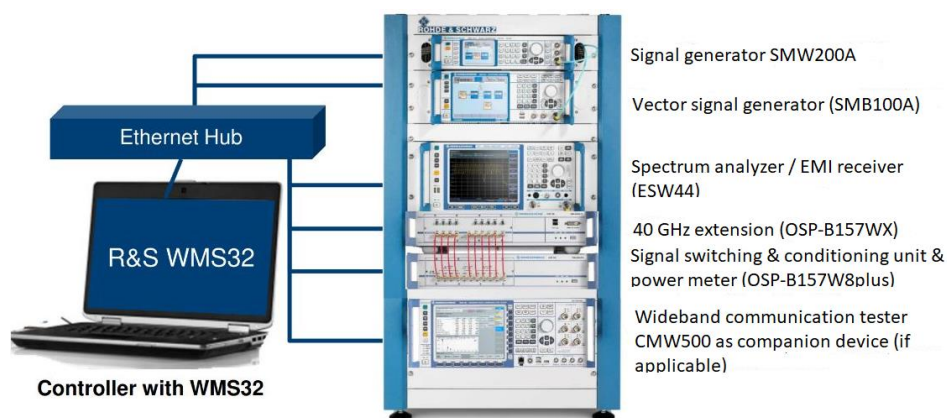
Radiated measurements setup from 18 GHz to 26 / 40 GHz:



Conducted emission setup



Conducted RF measurement system:



8. Summary

Bluetooth LE

FCC/ISED Requirement (15.247 / RSS-247)		Reference method	Result	Remark
Occupied Bandwidth	ISED RSS-Gen, Issue 5 A2 (section 6.7)	ANSI C63.10-2013	PASS	
6 dB Bandwidth	FCC § 15.247(a)(2) / RSS-247, Issue 3 (section 5.2 (a))	ANSI C63.10-2013	PASS	
Maximum peak conducted power	FCC § 15.247(b) / RSS-247, Issue 3 (section 5.4 (d))	ANSI C63.10-2013	PASS	
Power spectral density	FCC § 15.247(e) / RSS-247, Issue 3 (section 5.2)	ANSI C63.10-2013	PASS	
AC power line conducted emissions	FCC § 15.207 / RSS-247, Issue 3 (section 3.1)	ANSI C63.10-2013	N/A	
Band edge compliance	FCC § 15.247(d) / RSS-247, Issue 3 (section 5.5)	ANSI C63.10-2013	PASS	
Conducted spurious emissions	FCC § 15.247(d) / RSS-247, Issue 3 (section 5.5)	ANSI C63.10-2013	PASS	
Transmitter radiated spurious emissions	FCC § 15.247(d), FCC § 15.209 / RSS-Gen, Issue 5 A2 (section 6.13)	ANSI C63.10-2013	PASS	
Receiver radiated spurious emissions	ISED RSS-247, Issue 3 (section 3.1)	ANSI C63.4-2014	PASS	
Possible test case verdicts: PASS = Tested device meets the requirements FAIL = Tested device does not meet the requirements N/A = Test requirement not applicable for tested device N/T = Test requirement applicable for tested device, but not tested				
Applicable FCC KDB(s): KDB 558074 DO1: DTS measurement guidance v 0502 (Apr 2, 2019)				

9. Occupied bandwidth

Reference: ISED RSS-Gen, Issue 5 A2 (section 6.7)

Test method: ANSI C63.10 (6.9.3)

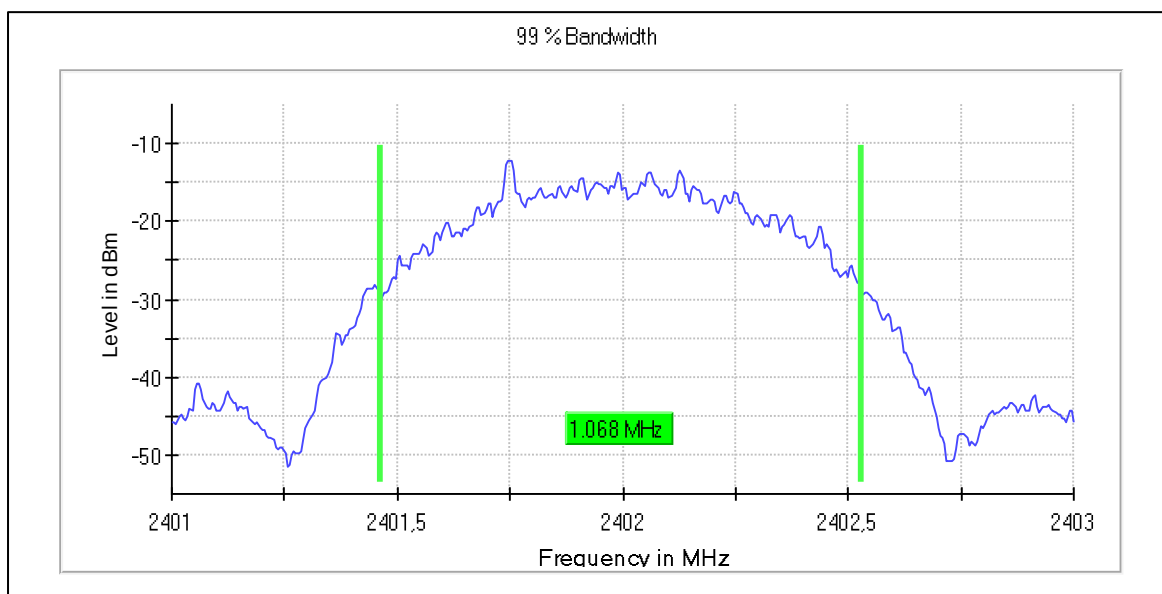
Limits
None (Informational only)

Procedure
1. EUT transmitter is activated in test mode under normal conditions 2. Spectrum analyzer is set to peak detection and maximum hold with a span twice the emission spectrum 3. The resolution bandwidth is set to the range of 1% to 5% of the occupied bandwidth 4. The occupied bandwidth is measured with the build-in analyzer function

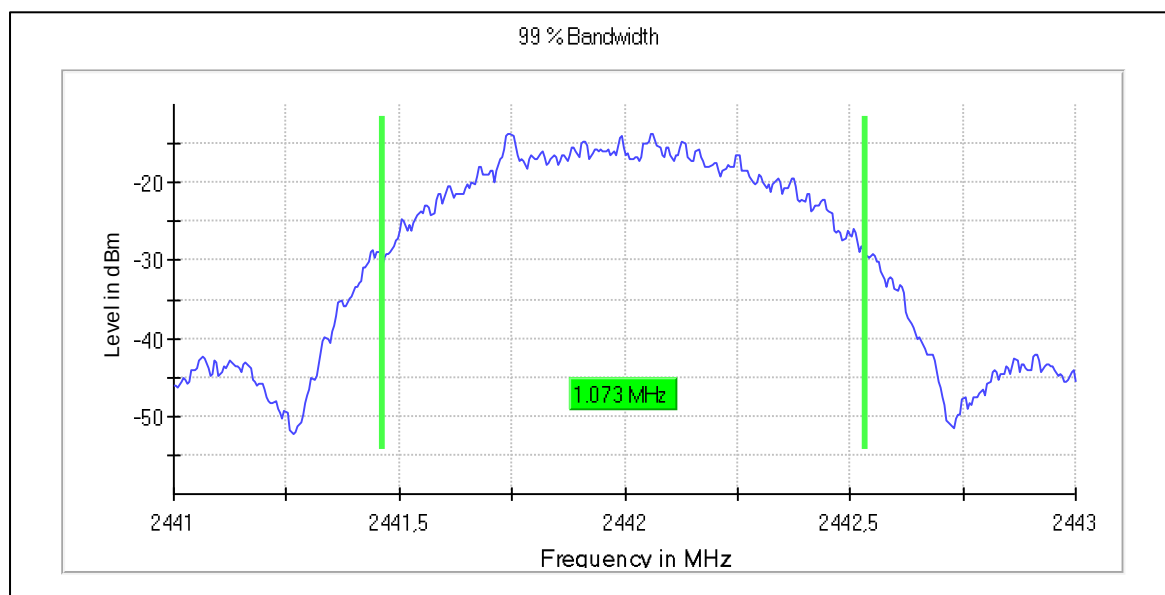
Summary:

Summary		
Mode / modulation	Frequency (MHz)	Bandwidth (MHz)
Bluetooth LE, 1 Mbps	2402	1.067669
Bluetooth LE, 1 Mbps	2442	1.072682
Bluetooth LE, 1 Mbps	2480	1.062657

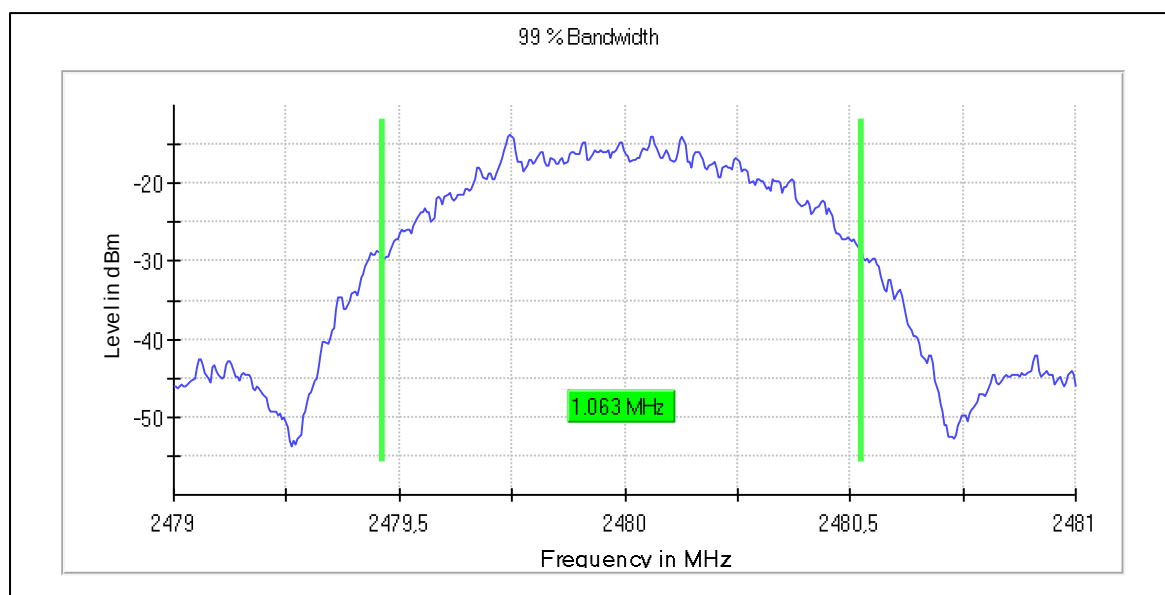
Occupied bandwidth, low channel



Occupied bandwidth, middle channel



Occupied bandwidth, high channel



10. 6 dB bandwidth

Reference: FCC title 47 part 15 §15.247(a), ISSED RSS-247, Issue 3 (section 5.2)

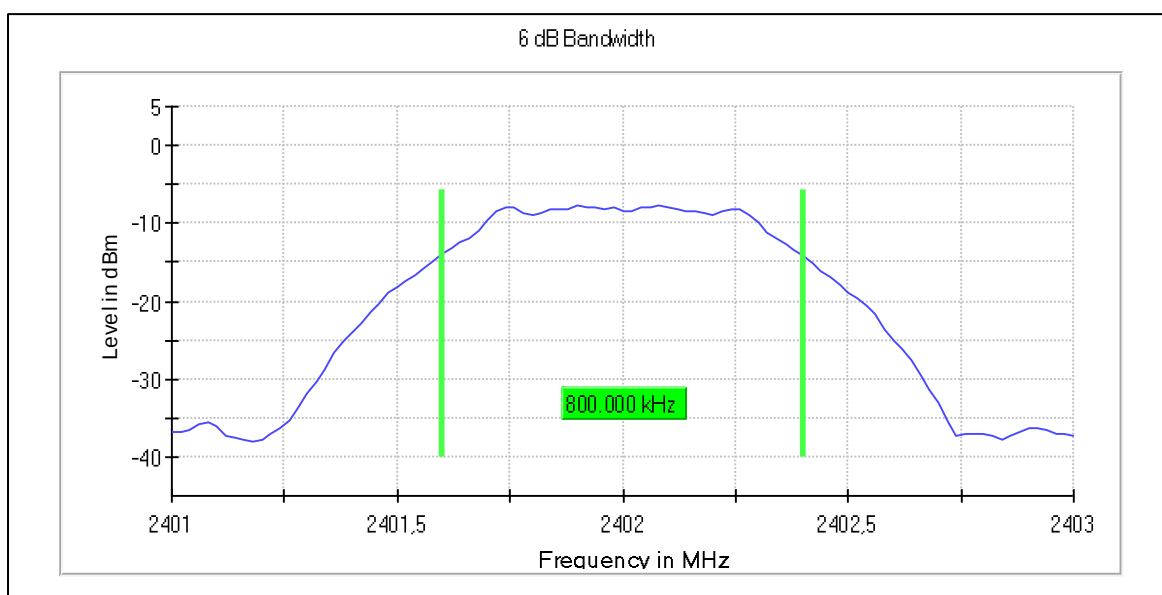
Test method: KDB 558074 D01 DTS Meas Guidance v05r02 and ANSI C63.10-2013 (11.8.1)

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

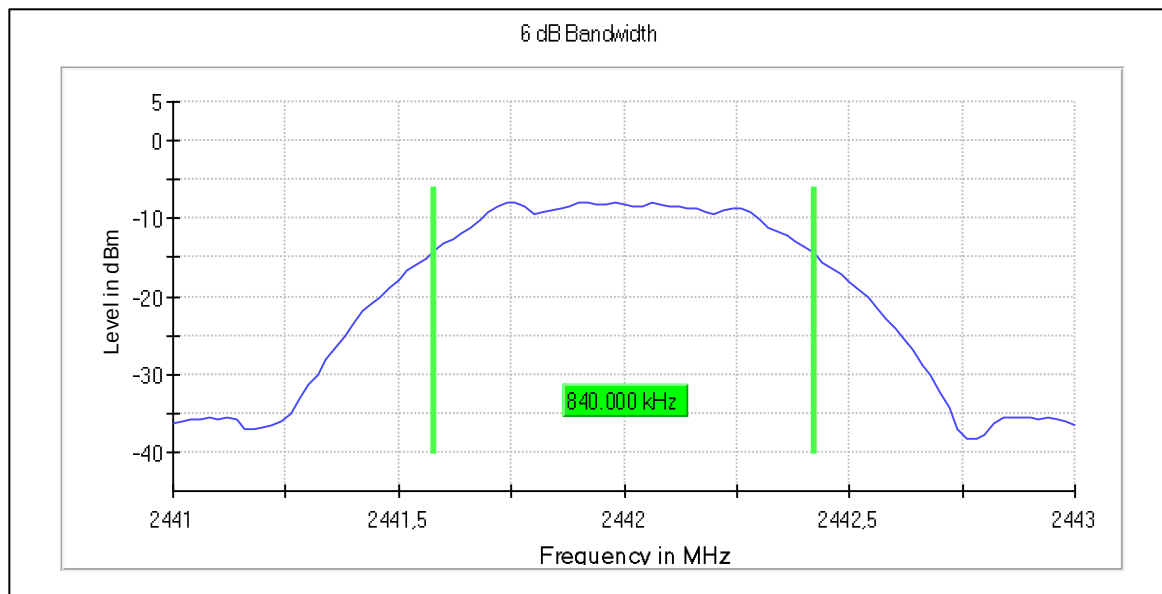
Test procedure
1. EUT set to test mode 2. Span set to at least twice the emission spectrum 3. Detector set to peak and max hold and BW is set to 100 kHz 4. Envelope peak value of emission spectrum is selected 5. Marker on envelope of spectrum is set to level of -6 dB to the left of the peak 6. Marker on envelope of spectrum is set to level of -6 dB to the right of the peak 7. 6 dB bandwidth is determined by marker frequency separation

Mode / modulation	DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)	Max Level (dBm)	Result
Bluetooth LE, 1 Mbps	2402.000000	0.800000	0.500000	---	2401.600000	2402.400000	-7.7	PASS
Bluetooth LE, 1 Mbps	2442.000000	0.840000	0.500000	---	2441.580000	2442.420000	-7.8	PASS
Bluetooth LE, 1 Mbps	2480.000000	0.840000	0.500000	---	2479.580000	2480.420000	-6.7	PASS

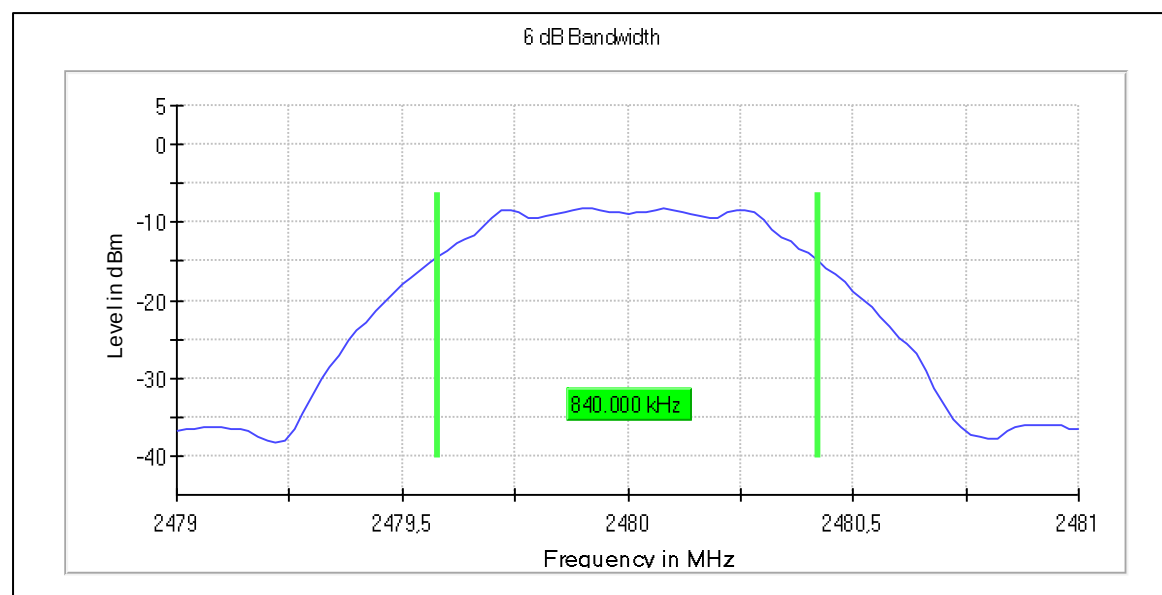
6 dB Bandwidth, low channel:



6 dB Bandwidth, middle channel:



6 dB Bandwidth, high channel:



11. Peak conducted output power

Reference: FCC part 15 §15.247(b), ISED RSS-247, Issue 3 (section 5.4)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 and ANSI C63.10-2013 (11.9.1.1)

Limits
For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm). The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).
The conducted output power limit specified above is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in the table, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

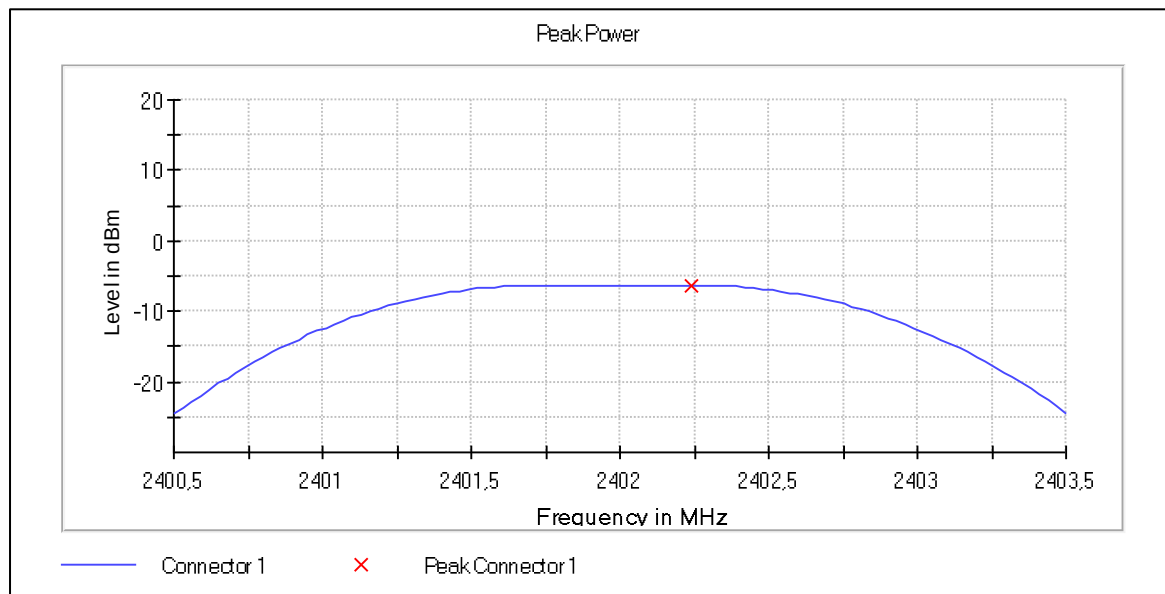
Test procedure
1. EUT set to test mode (communication tested is used if needed) 2. Analyzer resolution bandwidth is set $\geq$ DTS bandwidth 3. Detector set to peak and max hold 4. Sweep time is set to auto 5. After trace has stabilized a marker is set to peak envelope

The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power.

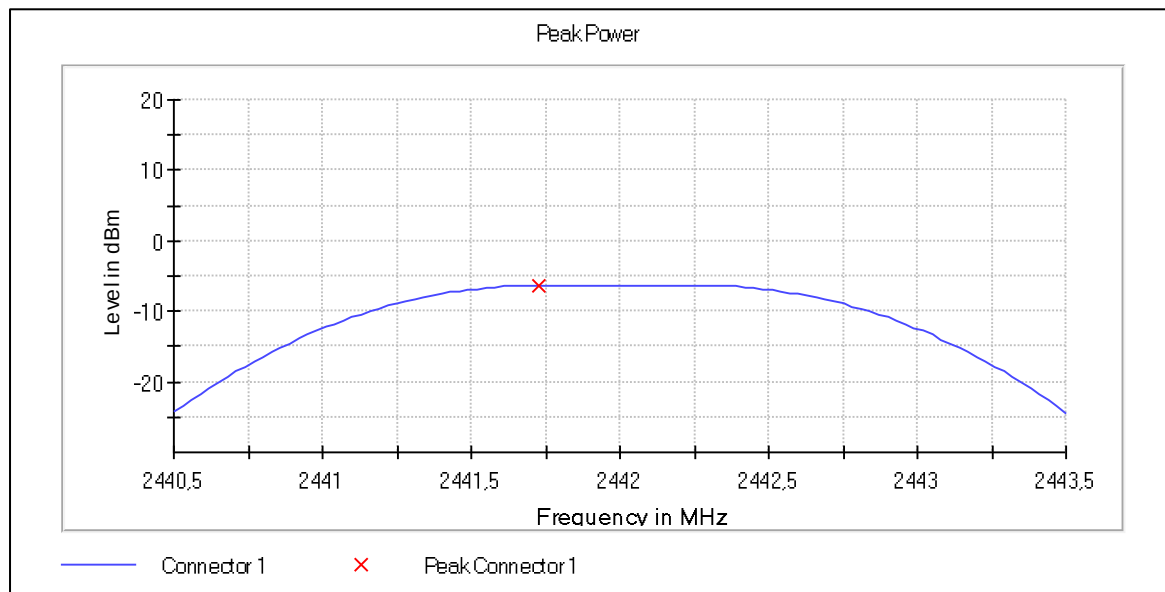
Maximum Declared Antenna Gain: 1.0 dBi

Mode / modulation	DUT Frequency (MHz)	Peak Power (dBm)	EIRP Power (dBm)	Result
Bluetooth LE, 1 Mbps	2402.000000	-6.3	30.0	PASS
Bluetooth LE, 1 Mbps	2442.000000	-6.3	30.0	PASS
Bluetooth LE, 1 Mbps	2480.000000	-6.5	30.0	PASS

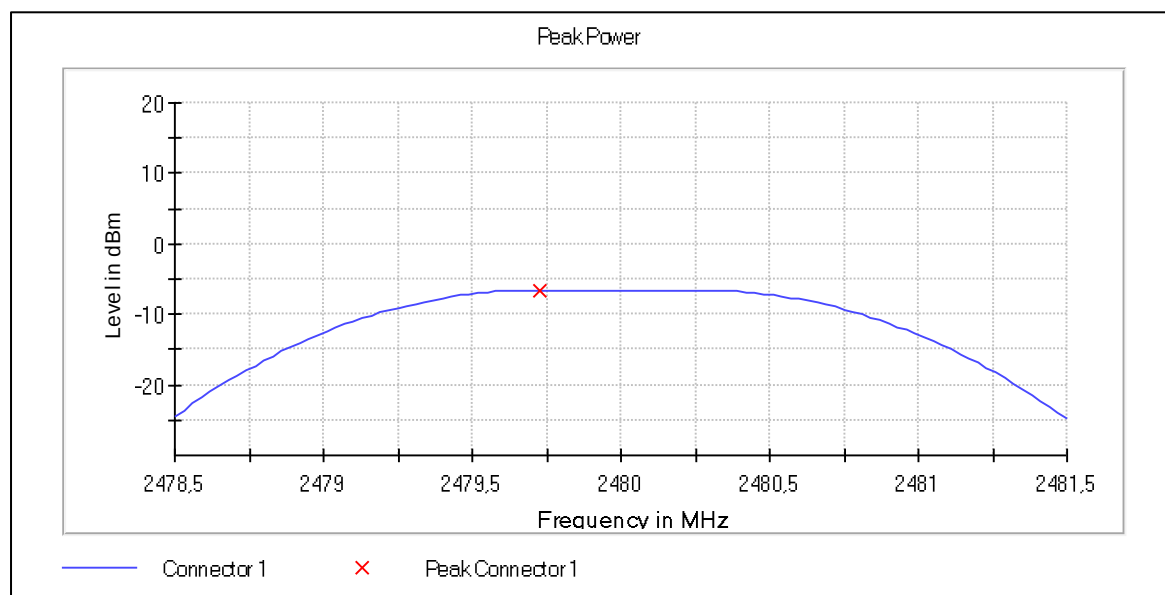
Peak power, low channel



Peak power, middle channel



Peak power, high channel



12. Peak Power Spectral Density

Reference: FCC §15.247(a),(e), ISED RSS-247, Issue 3 (section 5.2)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 and ANSI C63.10-2013 (11.10.2, 14.3.2)

Specification: For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

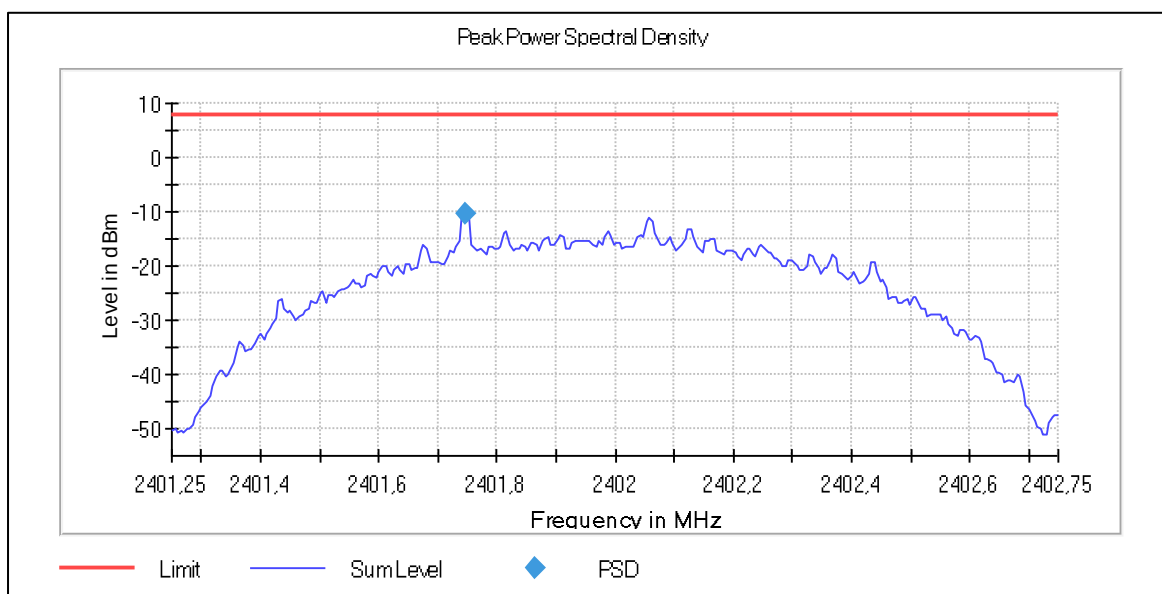
Limits
≤ 8 dBm / 3 kHz

Test procedure
1. EUT set to test mode 2. The analyser is set to DTS channel center frequency with a span of 1.5 times the DTS bandwidth 3. The analyzer is set to 100 kHz with VBW ≥ RBW and the detector is set to peak with max hold 4. After trace has stabilized a marker is set to the envelope maximum 5. If the power spectral density is above the limit the RBW is reduces (not lower than 3 kHz) and the measurement is repeated 6. If the EUT has more than one transmit chain the procedure is repeated for each chain

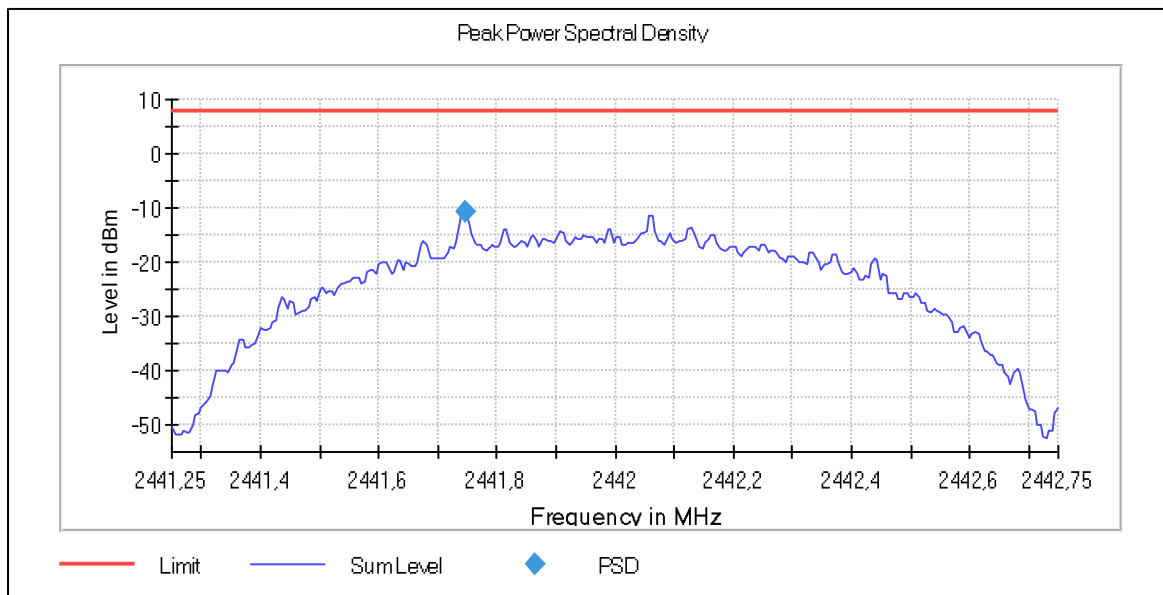
Summary

Mode / modulation	DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
Bluetooth LE, 1 Mbps	2402.000000	2401.746656	-10.536	8.0	PASS
Bluetooth LE, 1 Mbps	2442.000000	2441.746656	-10.651	8.0	PASS
Bluetooth LE, 1 Mbps	2480.000000	2479.741639	-10.779	8.0	PASS

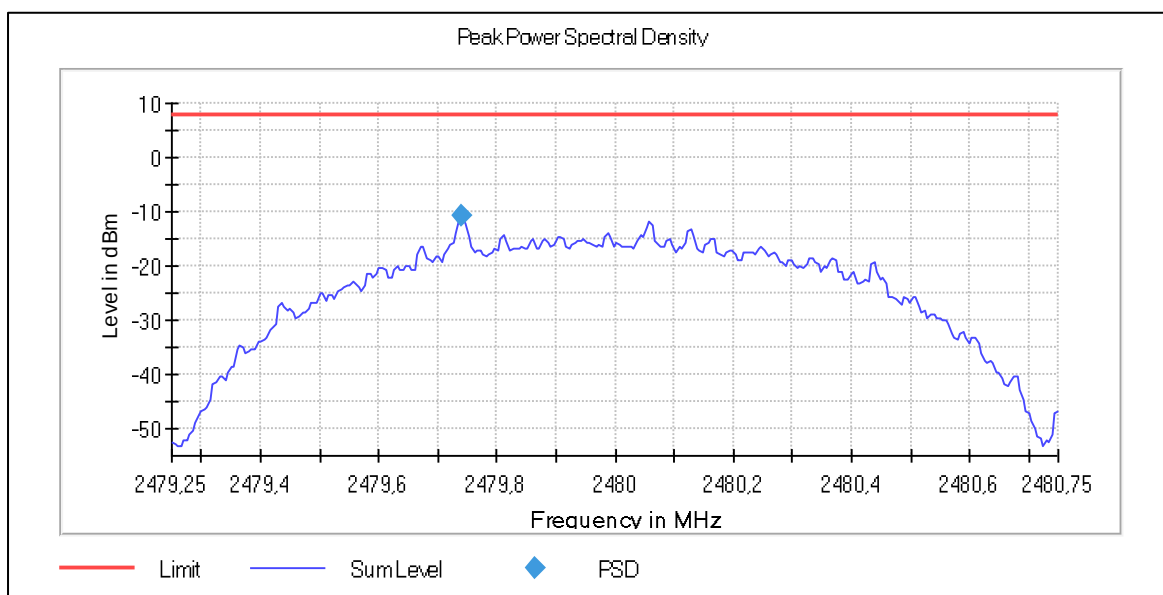
Peak power spectral density, low channel



Peak power spectral density, middle channel



Peak power spectral density, high channel:



13. Band edge emissions compliance (transmitter)

Reference: FCC §15.247(d), ISED RSS-247, Issue 3 (section 5.5)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 8.7 and ANSI C63.10-2013 (11.13)

Specification: In any 100 kHz bandwidths outside the frequency band in which the 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. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Limits	
Power measurement	Out-of-band attenuation (dB)
Peak	20
RMS	30

Limits
1. EUT set to test mode (communication tester is used if needed)
2. Span set around lower band edge and detector is set to peak and max hold
3. Resolution bandwidth is set to 100 kHz
4. Peak emission level(s) within frequency band and outside frequency band is measured
5. Band edge attenuation is determined from level difference

Summary

Mode / modulation	DUT Frequency (MHz)	Result
Bluetooth LE, 1 Mbps	2402.000000	PASS
Bluetooth LE, 1 Mbps	2480.000000	PASS

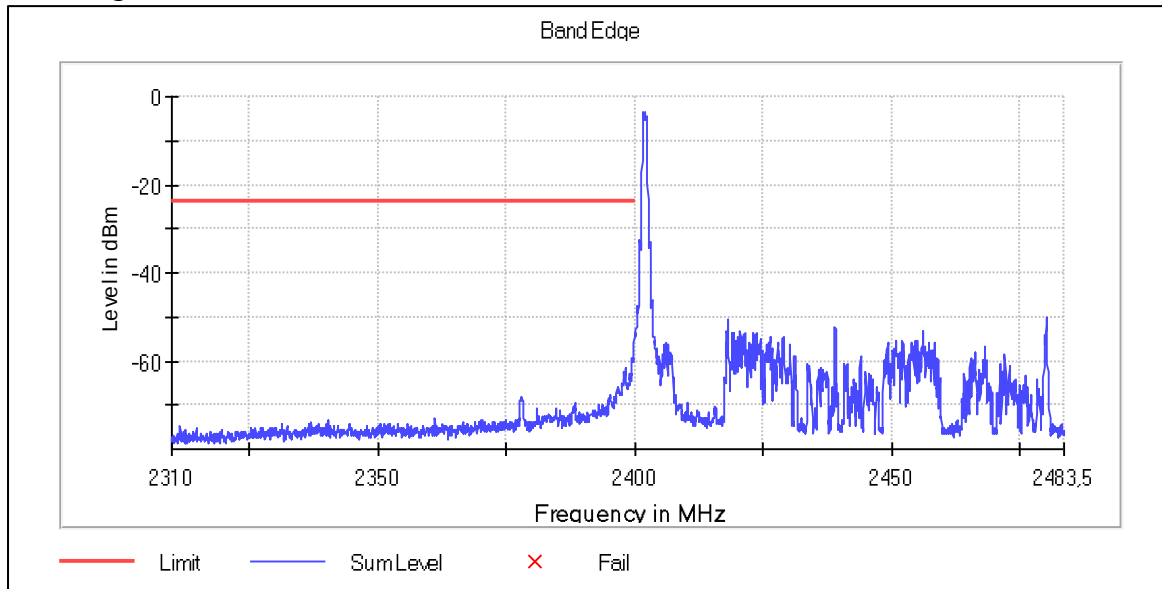
Measurements, band edge low

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2399.949972	-54.0	30.4	-23.6	PASS
2399.899944	-55.8	32.3	-23.6	PASS
2399.849917	-57.4	33.9	-23.6	PASS
2399.799889	-59.1	35.6	-23.6	PASS
2399.749861	-59.3	35.8	-23.6	PASS
2399.549750	-59.4	35.8	-23.6	PASS
2399.699833	-59.4	35.9	-23.6	PASS
2399.599778	-59.5	36.0	-23.6	PASS
2399.499722	-59.8	36.2	-23.6	PASS
2399.649805	-60.2	36.6	-23.6	PASS
2398.249027	-61.5	38.0	-23.6	PASS
2398.299055	-62.1	38.6	-23.6	PASS
2399.449694	-62.2	38.7	-23.6	PASS
2397.948860	-62.3	38.8	-23.6	PASS
2397.998888	-62.4	38.9	-23.6	PASS

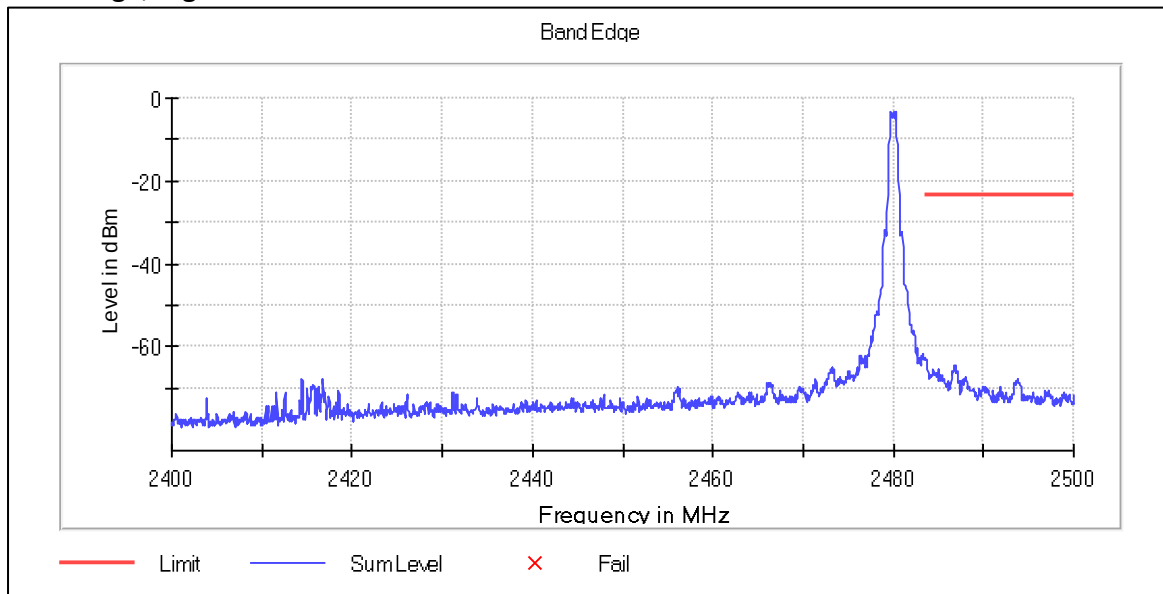
Measurements, band edge high

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2483.550152	-62.7	39.5	-23.2	PASS
2483.700608	-63.1	39.9	-23.2	PASS
2483.650456	-63.1	39.9	-23.2	PASS
2483.600304	-63.1	40.0	-23.2	PASS
2483.750760	-64.2	41.1	-23.2	PASS
2486.810030	-64.4	41.2	-23.2	PASS
2486.860182	-64.5	41.3	-23.2	PASS
2486.759878	-65.3	42.1	-23.2	PASS
2484.402736	-65.4	42.2	-23.2	PASS
2485.004559	-65.4	42.2	-23.2	PASS
2484.954407	-65.5	42.3	-23.2	PASS
2484.452888	-65.6	42.4	-23.2	PASS
2483.800912	-65.6	42.4	-23.2	PASS
2486.709726	-65.6	42.5	-23.2	PASS
2486.559271	-65.7	42.5	-23.2	PASS

Band edge, low channel



Band edge, high channel



14. Tx spurious emissions, conducted

Reference: FCC §15.247(d), ISSED RSS-247, Issue 3 (section 5.5)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 8.5 and ANSI C63.10-2013 (11.11.2 & 11.11.3)

Limits	
Power measurement	Out-of-band attenuation (dB)
Peak	20
RMS	30

Test procedure
1. EUT set to test mode (communication tester is used if needed) 2. Span set around lower band edge and detector is set to peak and max hold 3. Resolution bandwidth is set to 100 kHz 4. Markers are set to peak emission levels outside frequency band

Mode / modulation	DUT Frequency (MHz)	Result
Bluetooth LE, 1 Mbps	2402.000000	PASS
Bluetooth LE, 1 Mbps	2440.000000	PASS
Bluetooth LE, 1 Mbps	2480.000000	PASS

Pre Measurements, low channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
4803.154762	-41.9	17.4	-24.5
7202.797619	-44.4	19.9	-24.5
14411.724702	-52.1	27.5	-24.5
300.000000	-57.9	33.3	-24.5
16821.366071	-59.5	34.9	-24.5
16811.367560	-61.1	36.6	-24.5
150.000000	-63.0	38.4	-24.5
12012.081845	-65.4	40.9	-24.5
220.000000	-66.6	42.1	-24.5
190.000000	-66.7	42.2	-24.5
240.000000	-67.1	42.6	-24.5
19740.931548	-67.9	43.3	-24.5
600.000000	-68.1	43.5	-24.5
9602.440476	-68.2	43.7	-24.5
19710.936012	-68.4	43.9	-24.5

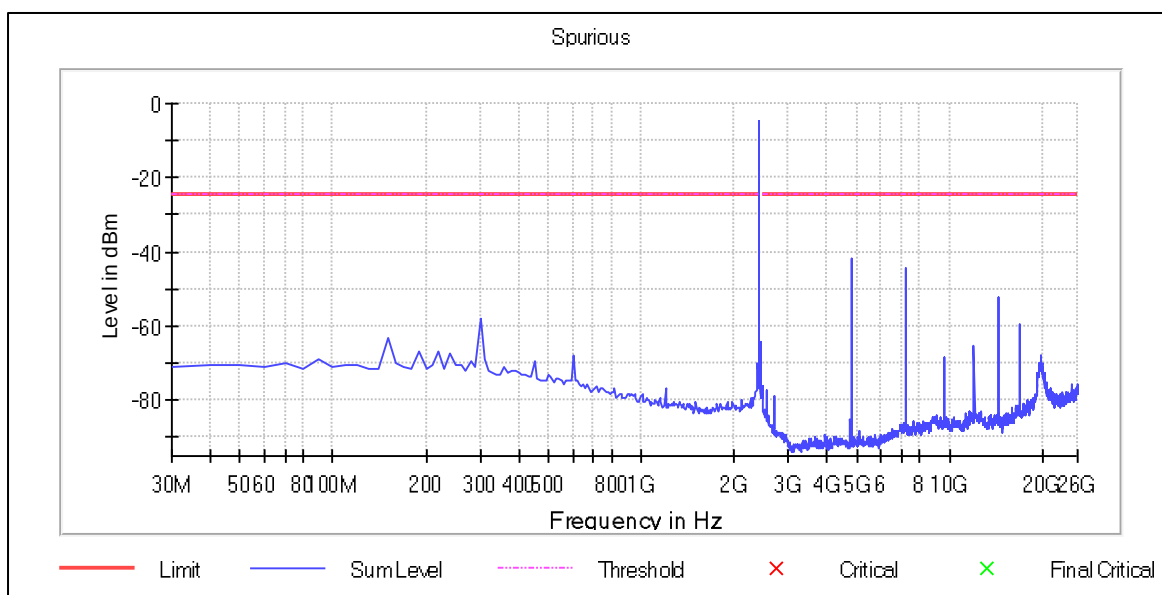
Pre Measurements, middle channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
7322.779762	-42.8	19.1	-23.8
4883.142857	-43.1	19.3	-23.8
12212.052083	-50.9	27.1	-23.8
300.000000	-58.4	34.6	-23.8
14651.688988	-58.9	35.1	-23.8
150.000000	-62.0	38.2	-23.8
17101.324405	-63.1	39.3	-23.8
17091.325893	-63.4	39.6	-23.8
9762.416667	-64.7	40.9	-23.8
190.000000	-66.1	42.3	-23.8
240.000000	-67.5	43.7	-23.8
220.000000	-67.5	43.7	-23.8
610.000000	-67.8	44.1	-23.8
19720.934524	-68.2	44.4	-23.8
19780.925595	-68.3	44.5	-23.8

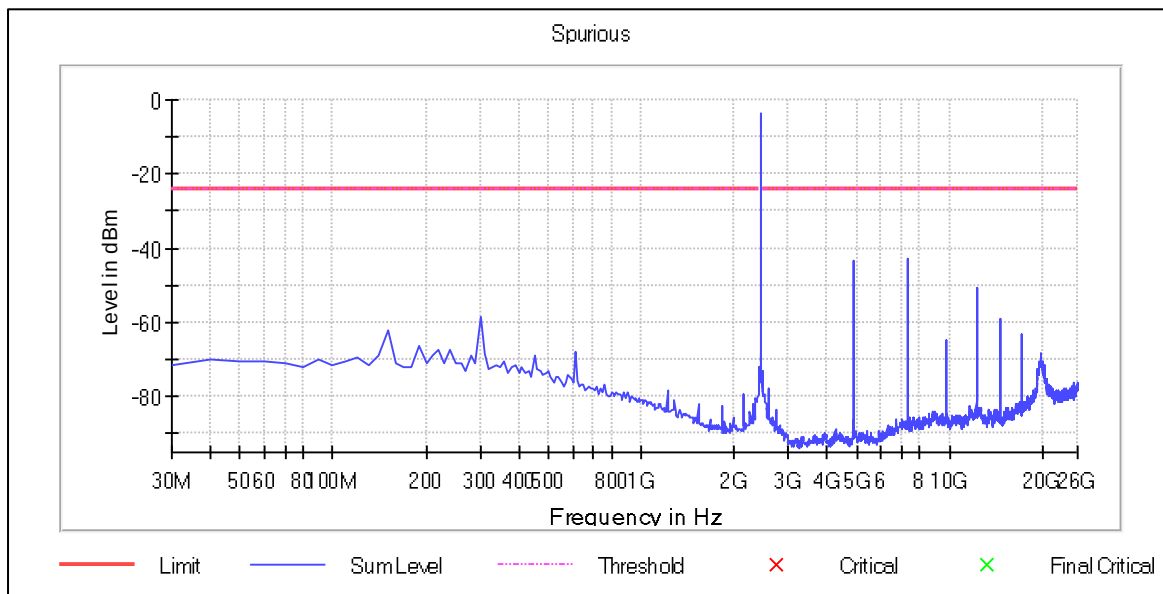
Pre Measurements, top channel

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
4953.132440	-45.4	20.5	-24.8
12402.023810	-47.3	22.4	-24.8
7432.763393	-48.3	23.4	-24.8
7442.761905	-48.6	23.7	-24.8
19720.934524	-57.5	32.7	-24.8
310.000000	-57.7	32.9	-24.8
19710.936012	-58.1	33.2	-24.8
19740.931548	-58.1	33.2	-24.8
19690.938988	-58.3	33.4	-24.8
19680.940476	-58.4	33.6	-24.8
19810.921131	-58.8	33.9	-24.8
19640.946429	-58.9	34.0	-24.8
19790.924107	-58.9	34.0	-24.8
19750.930060	-59.0	34.2	-24.8
19830.918155	-59.1	34.3	-24.8

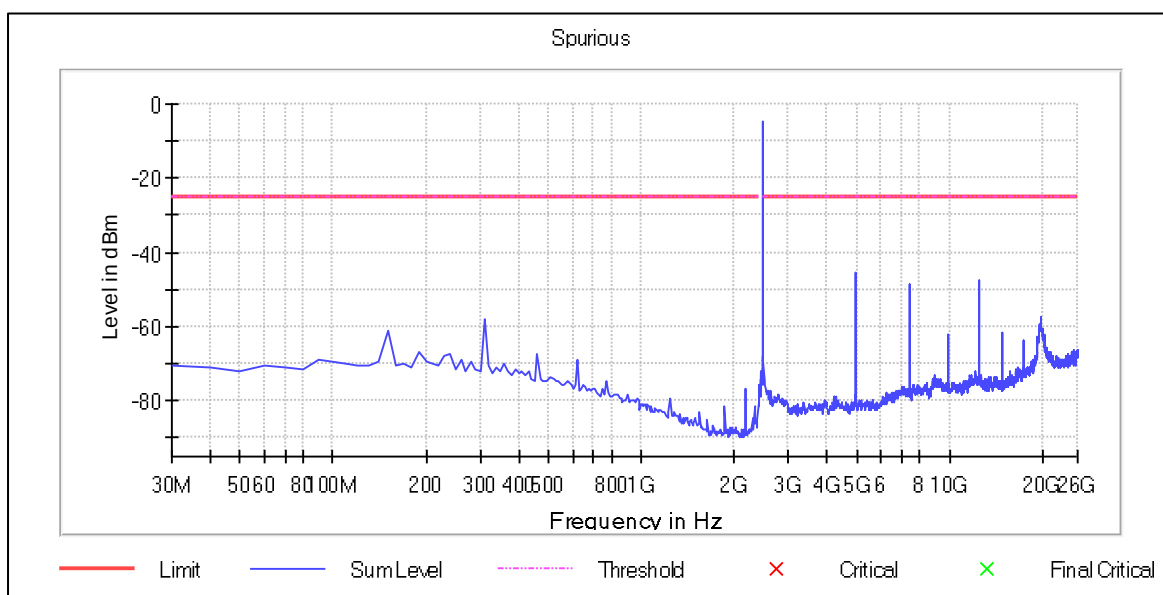
Low channel



Middle channel



High channel



15. Emissions in restricted frequency bands

Reference: FCC §15.247(d), ISED RSS-247, Issue 3 (section 6.2)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 8.6 and ANSI C63.10-2013 (11.12)

Limits	
Power measurement	Out-of-band attenuation (dB)
Peak	according to FCC §15.209 and FCC §15.205

Test procedure
1. EUT set to test mode (communication tester is used if needed)
2. Span set around lower band edge and detector is set to peak and max hold
3. Resolution bandwidth is set to 300 Hz
4. Markers are set to peak emission levels outside frequency band

Summary		
Mode / modulation	Frequency (MHz)	Bandwidth (MHz)
Bluetooth LE, 1 Mbps	2402.000000	PASS
Bluetooth LE, 1 Mbps	2440.000000	PASS
Bluetooth LE, 1 Mbps	2480.000000	PASS

Pre Measurements, bottom channel 1 Mbps

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
4804.585861	-39.5	18.3	-21.2
4803.585824	-39.5	18.3	-21.2
4804.085843	-39.5	18.3	-21.2
4803.085806	-39.6	18.4	-21.2
4805.085880	-42.1	20.9	-21.2
4802.585787	-42.3	21.1	-21.2
4805.585898	-50.5	29.3	-21.2
4802.085769	-51.6	30.4	-21.2
75.052322	-71.5	31.6	-39.9
75.102325	-72.4	32.5	-39.9
74.252281	-72.9	33.0	-39.9
74.302284	-72.9	33.0	-39.9
114.804371	-69.6	33.2	-36.4
110.104129	-69.6	33.2	-36.4
75.002320	-73.3	33.4	-39.9
4804.585861	-39.5	18.3	-21.2

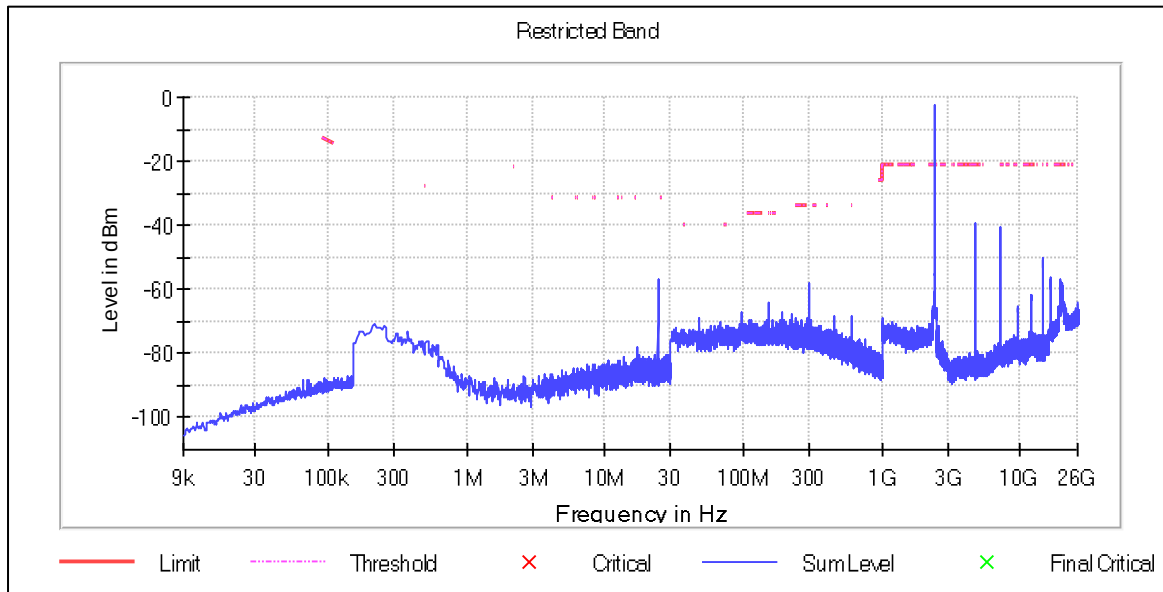
Pre Measurements, middle channel 1 Mbps

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
4884.588821	-42.0	20.8	-21.2
4884.088802	-42.0	20.8	-21.2
4883.588784	-42.1	20.9	-21.2
4883.088765	-42.1	20.9	-21.2
7325.179103	-42.3	21.1	-21.2
7326.679158	-42.3	21.1	-21.2
7326.179140	-42.6	21.4	-21.2
7327.179177	-42.6	21.4	-21.2
7325.679121	-42.6	21.4	-21.2
7324.679084	-43.4	22.2	-21.2
4885.088839	-44.1	22.9	-21.2
4882.588747	-45.8	24.6	-21.2
7327.679195	-47.2	26.0	-21.2
12208.859759	-48.9	27.7	-21.2
12211.359851	-49.1	27.9	-21.2

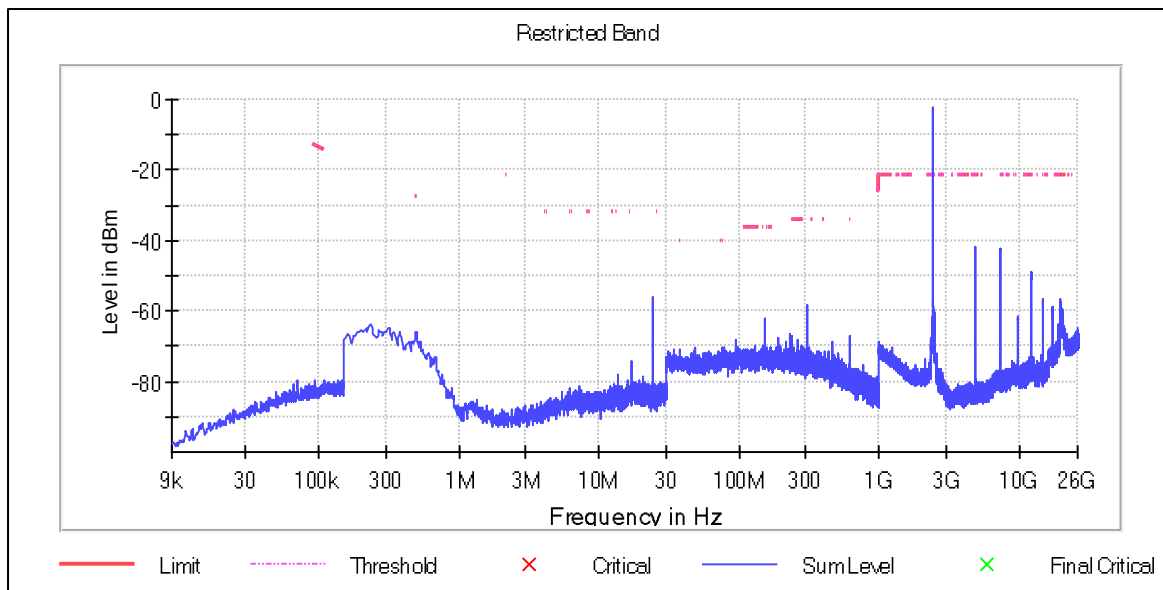
Pre Measurements, top channel 1 Mbps

Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)
4959.591595	-43.6	22.4	-21.2
4959.091577	-43.7	22.5	-21.2
4960.591632	-43.8	22.6	-21.2
4960.091614	-43.9	22.7	-21.2
12401.366880	-44.9	23.7	-21.2
12398.866788	-45.0	23.8	-21.2
7439.183320	-45.0	23.8	-21.2
7440.683375	-45.2	24.0	-21.2
12401.866898	-45.3	24.1	-21.2
12399.366806	-45.3	24.1	-21.2
12400.866861	-45.3	24.1	-21.2
7439.683338	-45.5	24.3	-21.2
7440.183357	-45.5	24.3	-21.2
7441.183394	-45.6	24.4	-21.2
12398.366769	-45.6	24.4	-21.2

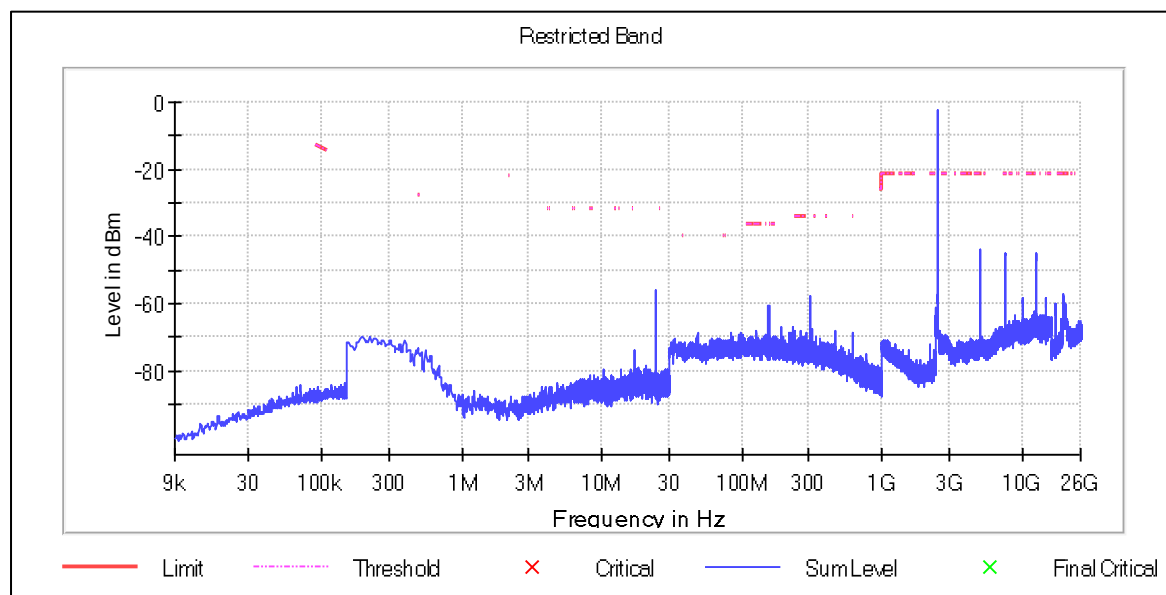
Pre Measurements, bottom channel 1 Mbps



Pre Measurements, middle channel 1 Mbps



Pre Measurements, top channel 1 Mbps



16. Tx spurious emissions, radiated

Reference: FCC §15.247(d), FCC §15.209, ISSED RSS-Gen Issue 5 A2 (section 6.13)

Test method: KDB 558074 D01 DTS Meas Guidance v05r02 8.5 and ANSI C63.10-2013 (6.4, 6.5, 6.6 & 11.12)

Specification: Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)/RSS-Gen):

Limits				
Frequency range (MHz)	Detector	Field strength (uV/m)	Field strength (dBuV/m)	Measurement distance (m)
0.009 – 0.09	Average	2400/F(kHz)	-	300
0.09 – 0.110	Quasi-Peak	2400/F(kHz)	-	300
0.110 – 0.490	Average	2400/F(kHz)	-	300
0.490 – 1.705	Quasi-Peak	24000/F(kHz)	-	30
1.705 – 30.0	Quasi-Peak	30	-	30
30 - 88	Quasi-Peak	100	40	3
88 – 216	Quasi-Peak	150	43.5	3
216 – 960	Quasi-Peak	200	46	3
960 - 1000	Quasi-Peak	500	54	3
>1000	Average	500	54	3

Test procedure 30 MHz -1 GHz	
1.	EUT is placed on a non conducting support at the center of a turn table 0.8m above the ground
2.	EUT set to test mode
3.	The receiver is set to peak detection with max hold
4.	The EUT is rotated through 360 degrees (orientation varied), measurements were made in both horizontal and vertical planes of polarization
5.	Found peak values were further maximized by adjusting turntable position $\pm 22,5$ degrees around detected value and scanning the antenna height 1 to 4m
6.	For maximized values, final measurement was done with the corresponding final detector.

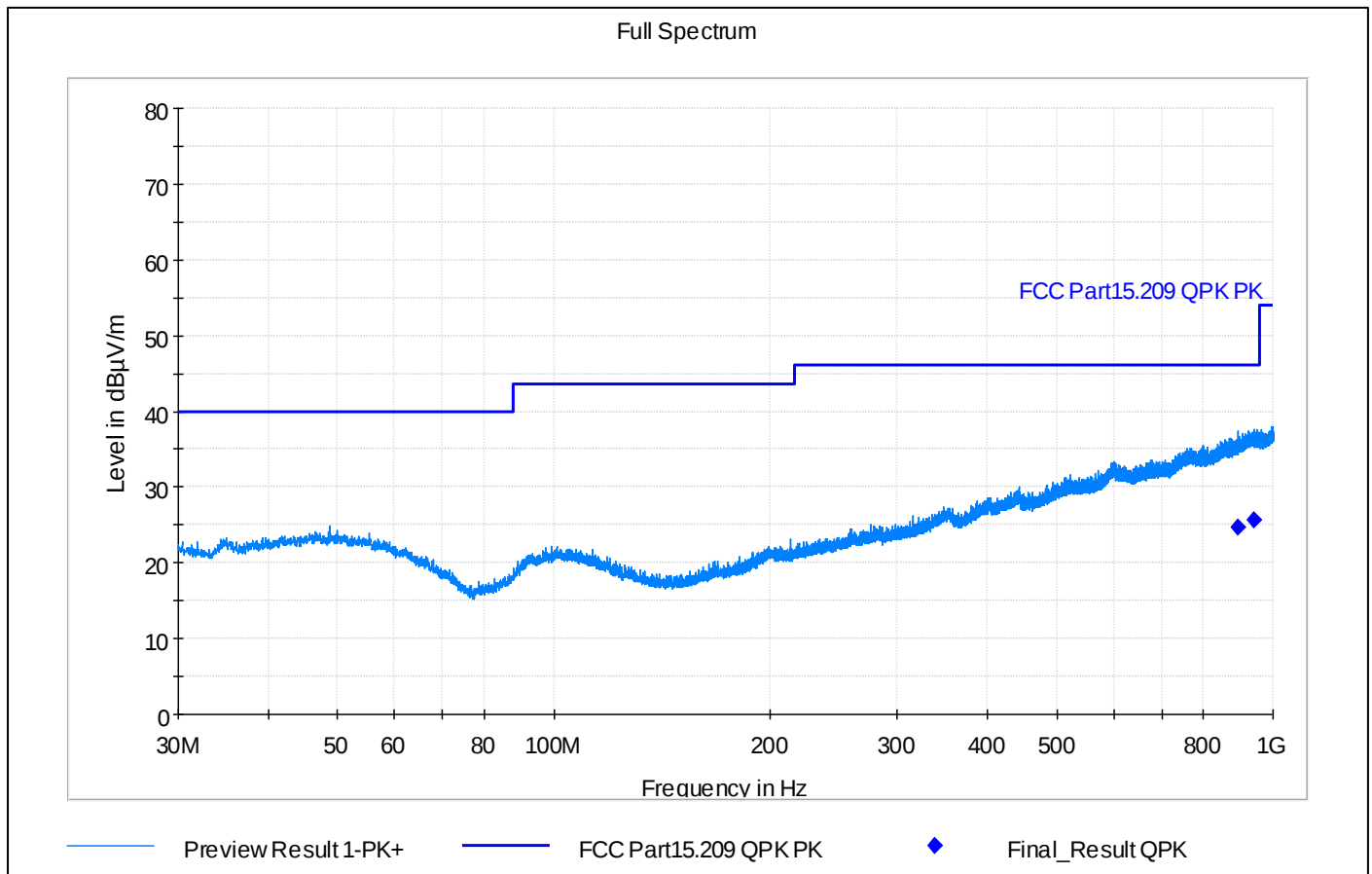
Test procedure > 1 GHz	
1.	EUT is placed on a non conducting support at the center of a turn table 1.5m above the ground
2.	EUT set to test mode
3.	The receiver is set to peak detection with max hold
4.	The EUT is rotated through 360 degrees (orientation varied), measurements were made in both horizontal and vertical planes of polarization.
5.	Found peak values were further maximized by adjusting turntable position $\pm 22,5$ degrees around detected value and scanning the antenna height 1 to 4m
6.	For maximized values, final measurement was done with the corresponding final detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function. RSS-247: Attenuation below the general field strength limits specified in RSS-Gen is not required.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Operation mode(s)	Configuration	Test Verdict
Bluetooth LE TX, 1 Mbps	Low channel, 2402 MHz	PASS
Bluetooth LE TX, 1 Mbps	Mid channel, 2442 MHz	PASS
Bluetooth LE TX, 1 Mbps	High channel, 2480 MHz	PASS

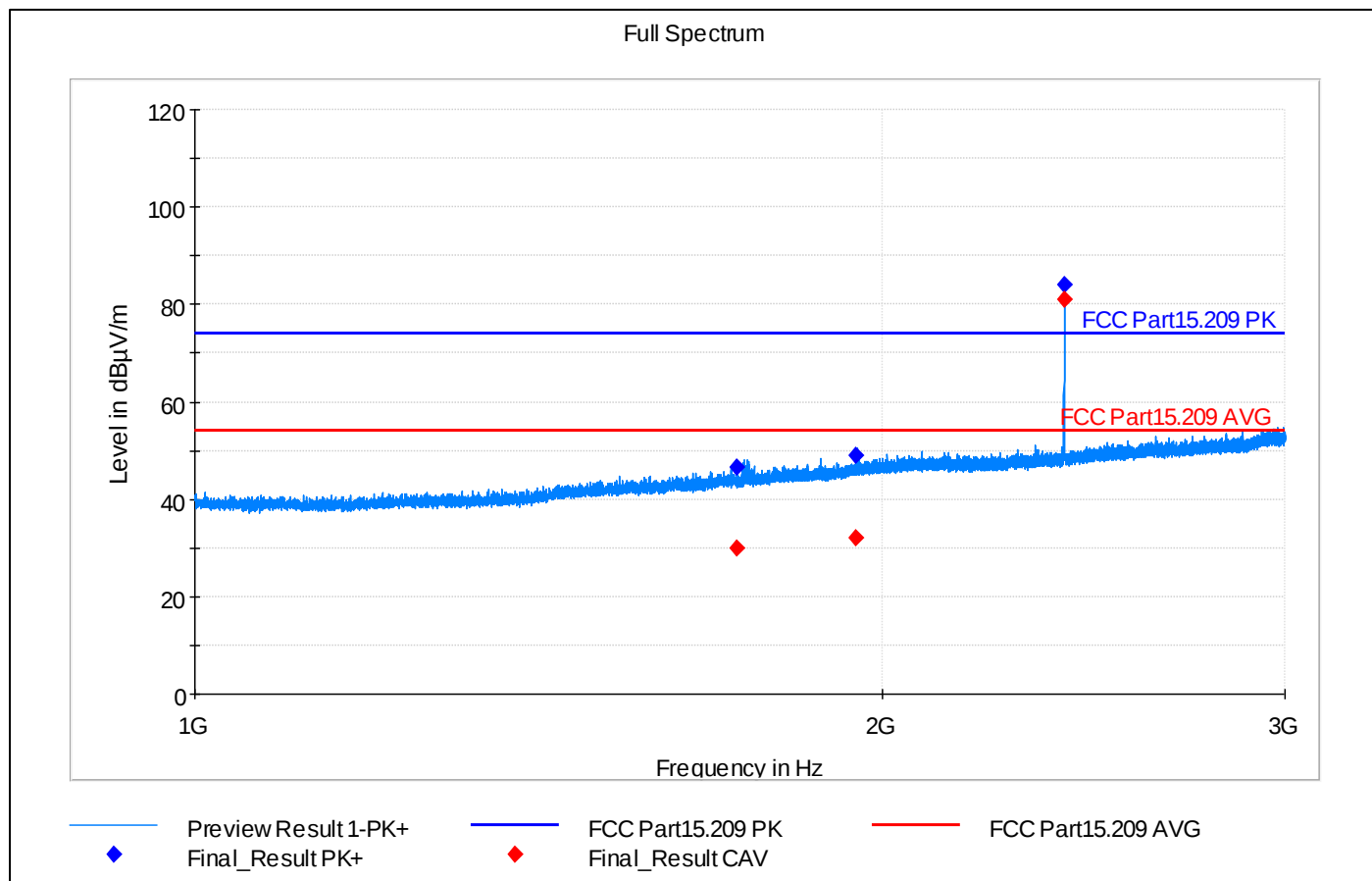
Low channel, 30 MHz – 1 GHz



Final_Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
892.980000	24.74	46.00	21.26	15000.0	120.000	228.0	H	-21.0	90.0	33.6	PASS
941.220000	25.62	46.00	20.38	15000.0	120.000	170.0	V	248.0	0.0	34.1	PASS

Low channel, 1 – 3 GHz

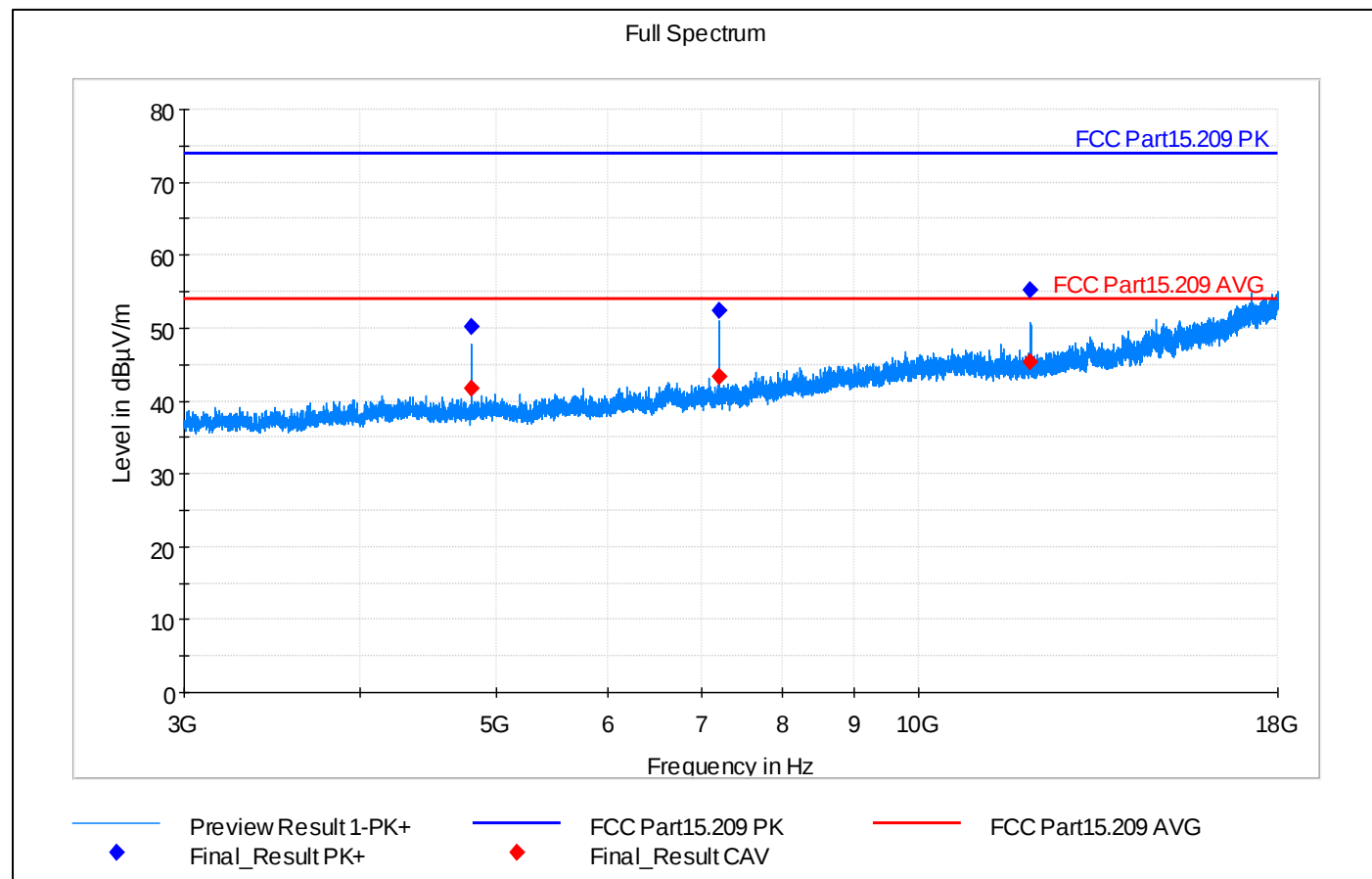


Note: Frequency 2402,300 MHz is excluded from spurious domain measurements and ignored. See table below.

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
1728.200000	46.65	---	74.00	27.35	15000.0	1000.000	153.0	V	72.0	90.0	34.9	PASS
1728.200000	---	29.78	54.00	24.22	15000.0	1000.000	153.0	V	72.0	90.0	34.9	PASS
1948.100000	---	32.03	54.00	21.97	15000.0	1000.000	275.0	V	34.0	90.0	36.7	PASS
1948.100000	49.02	---	74.00	24.98	15000.0	1000.000	275.0	V	34.0	90.0	36.7	PASS
2402.300000	84.01	---	74.00	-10.01	15000.0	1000.000	277.0	H	211.0	0.0	38.6	Fundamental TX signal, IGNORED
2402.300000	---	81.12	54.00	-27.12	15000.0	1000.000	277.0	H	211.0	0.0	38.6	Fundamental TX signal, IGNORED

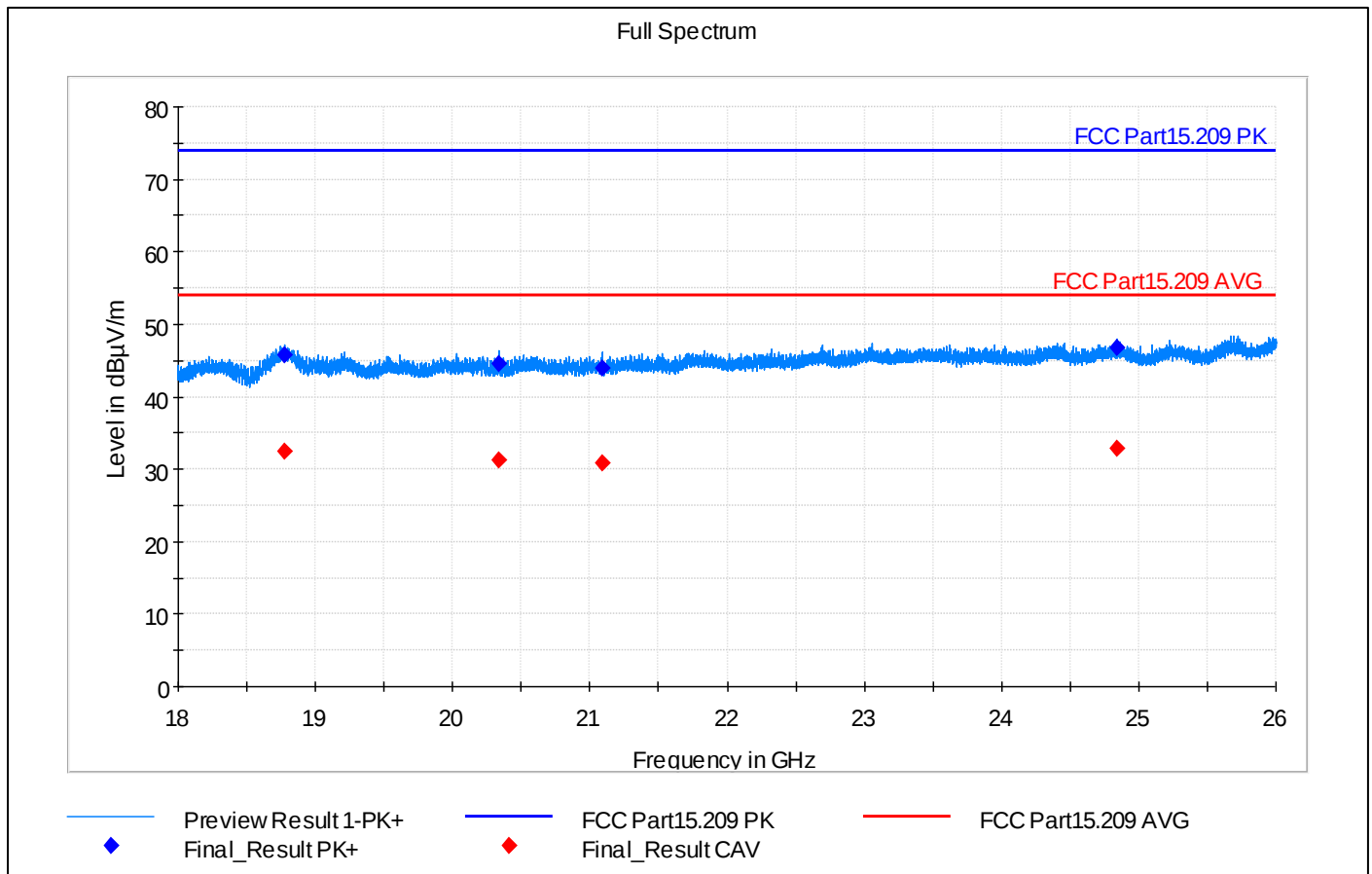
Low channel, 3 – 18 GHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Comment
4803.500000	---	41.70	54.00	12.30	15000.0	1000.000	198.0	V	183.0	90.0	9.4	PASS
4803.500000	50.13	---	74.00	23.87	15000.0	1000.000	198.0	V	183.0	90.0	9.4	PASS
7205.250000	52.35	---	74.00	21.65	15000.0	1000.000	211.0	V	180.0	0.0	14.9	PASS
7205.250000	---	43.42	54.00	10.58	15000.0	1000.000	211.0	V	180.0	0.0	14.9	PASS
12008.750000	55.29	---	74.00	18.71	15000.0	1000.000	182.0	H	131.0	90.0	23.4	PASS
12008.750000	---	45.37	54.00	8.63	15000.0	1000.000	182.0	H	131.0	90.0	23.4	PASS

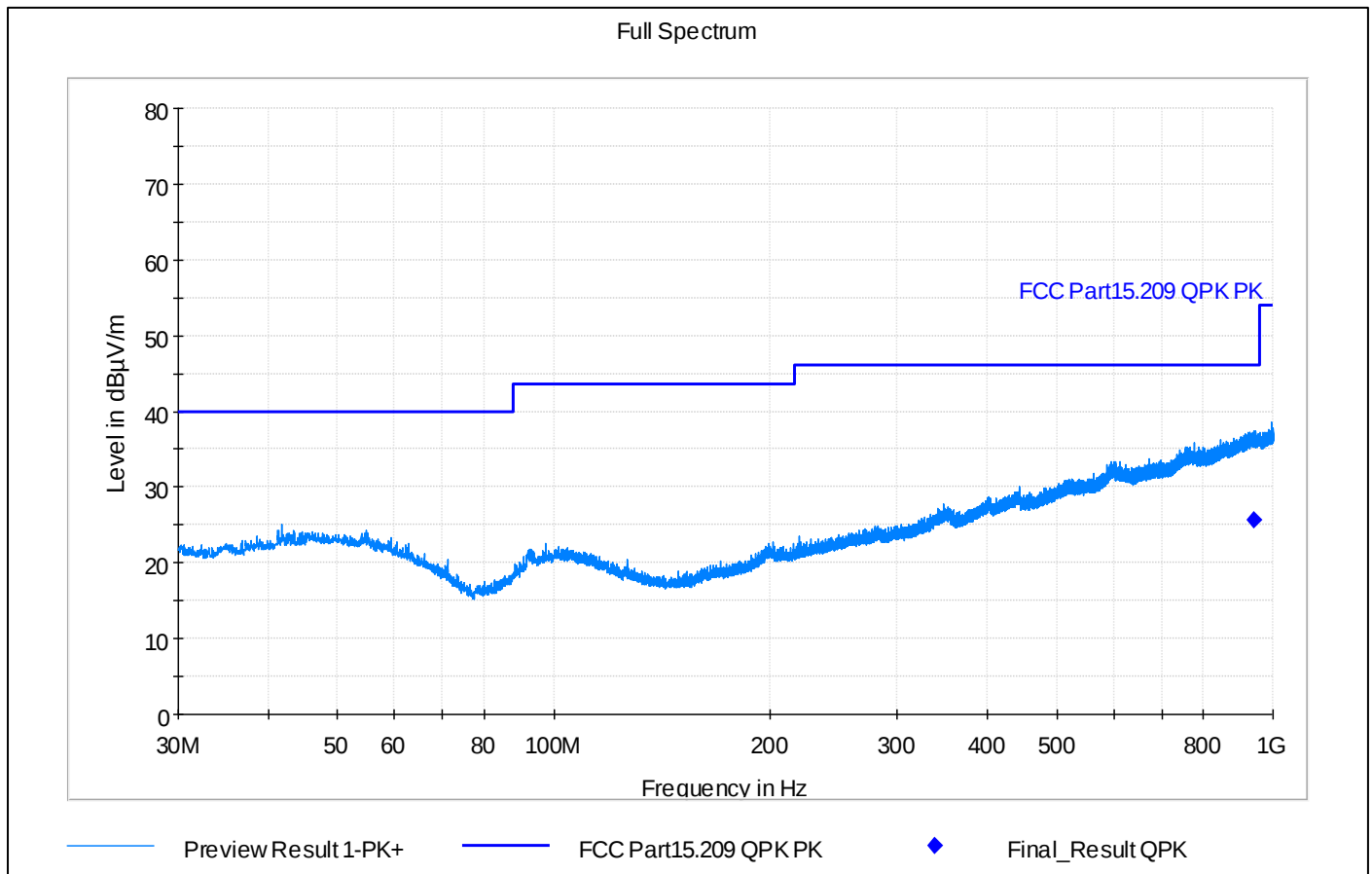
Low channel, 18 – 26 GHz



Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
18773.500000	---	32.51	54.00	21.49	3000.0	1000.000	355.0	V	299.0	90.0	23.5	PASS
18773.500000	45.83	---	74.00	28.17	3000.0	1000.000	355.0	V	299.0	90.0	23.5	PASS
20340.500000	44.51	---	74.00	29.49	3000.0	1000.000	312.0	H	196.0	90.0	24.1	PASS
20340.500000	---	31.14	54.00	22.86	3000.0	1000.000	312.0	H	196.0	90.0	24.1	PASS
21088.250000	---	30.89	54.00	23.11	3000.0	1000.000	286.0	H	19.0	90.0	24.6	PASS
21088.250000	44.00	---	74.00	30.00	3000.0	1000.000	286.0	H	19.0	90.0	24.6	PASS
24842.500000	46.68	---	74.00	27.32	3000.0	1000.000	186.0	H	2.0	90.0	26.5	PASS
24842.500000	---	32.91	54.00	21.09	3000.0	1000.000	186.0	H	2.0	90.0	26.5	PASS

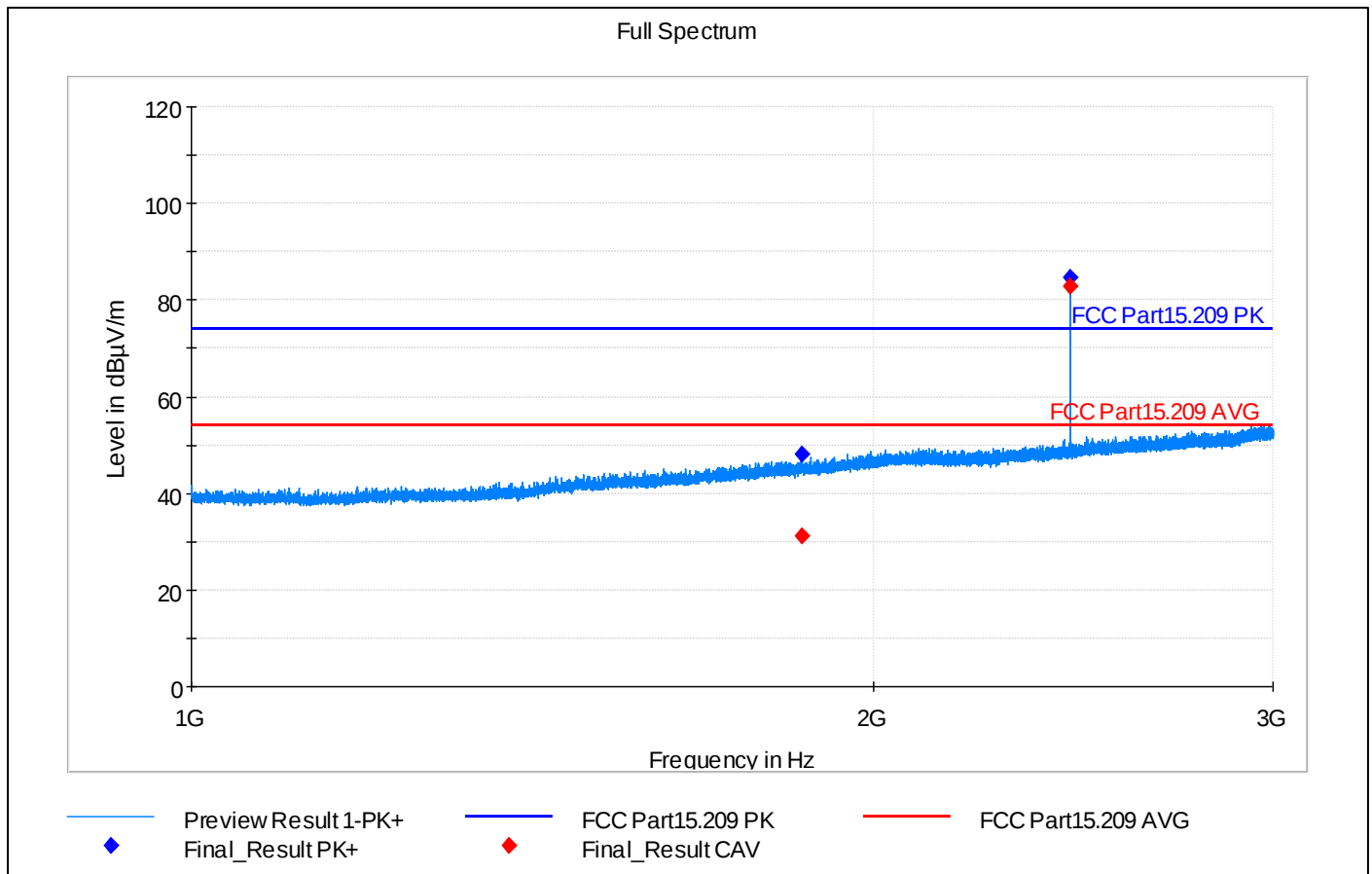
Mid channel, 30 MHz – 1 GHz



Final_Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
939.720000	25.68	46.00	20.32	15000.0	120.000	209.0	H	67.0	90.0	34.1	PASS

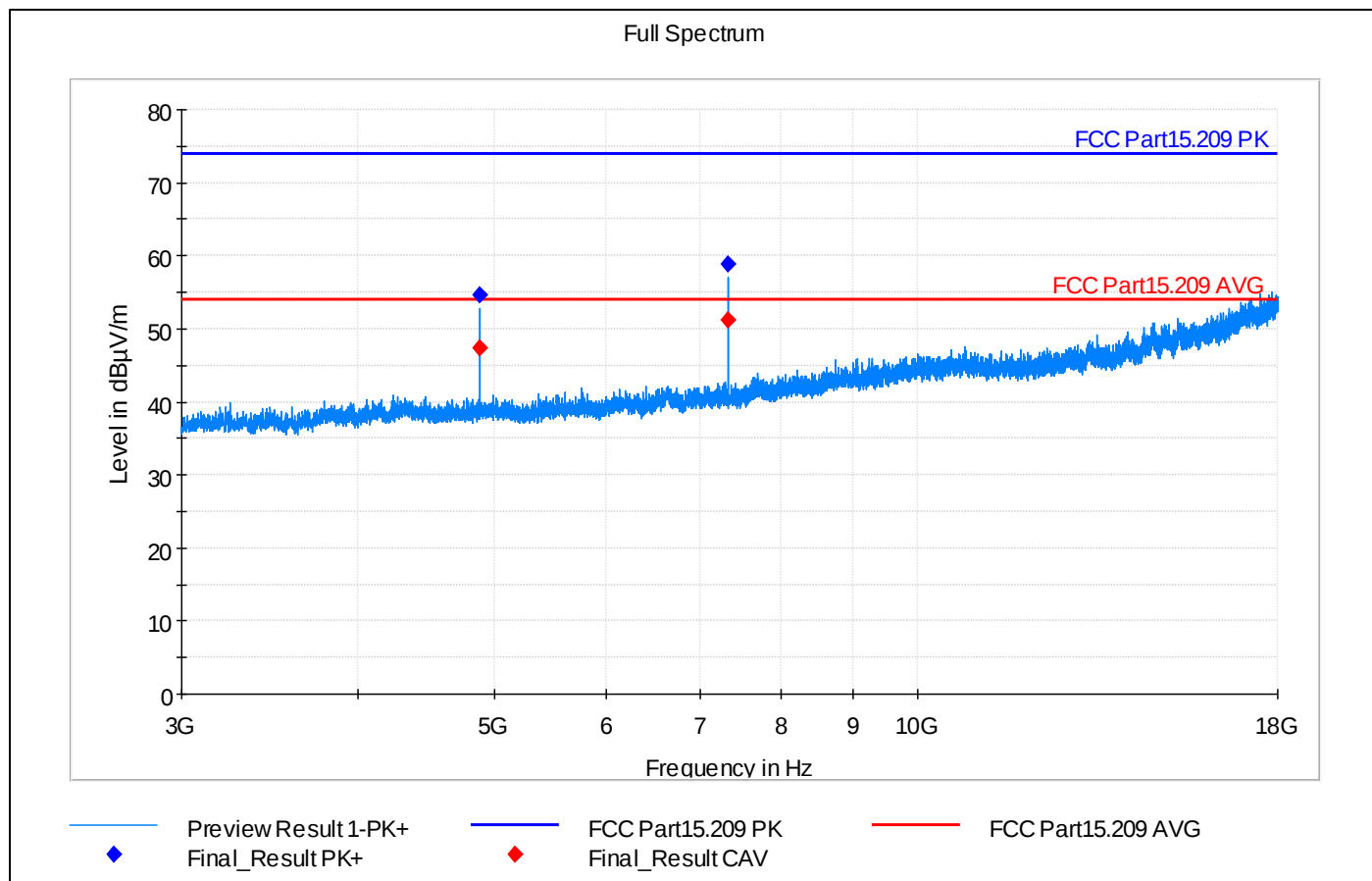
Mid channel, 1-3 GHz



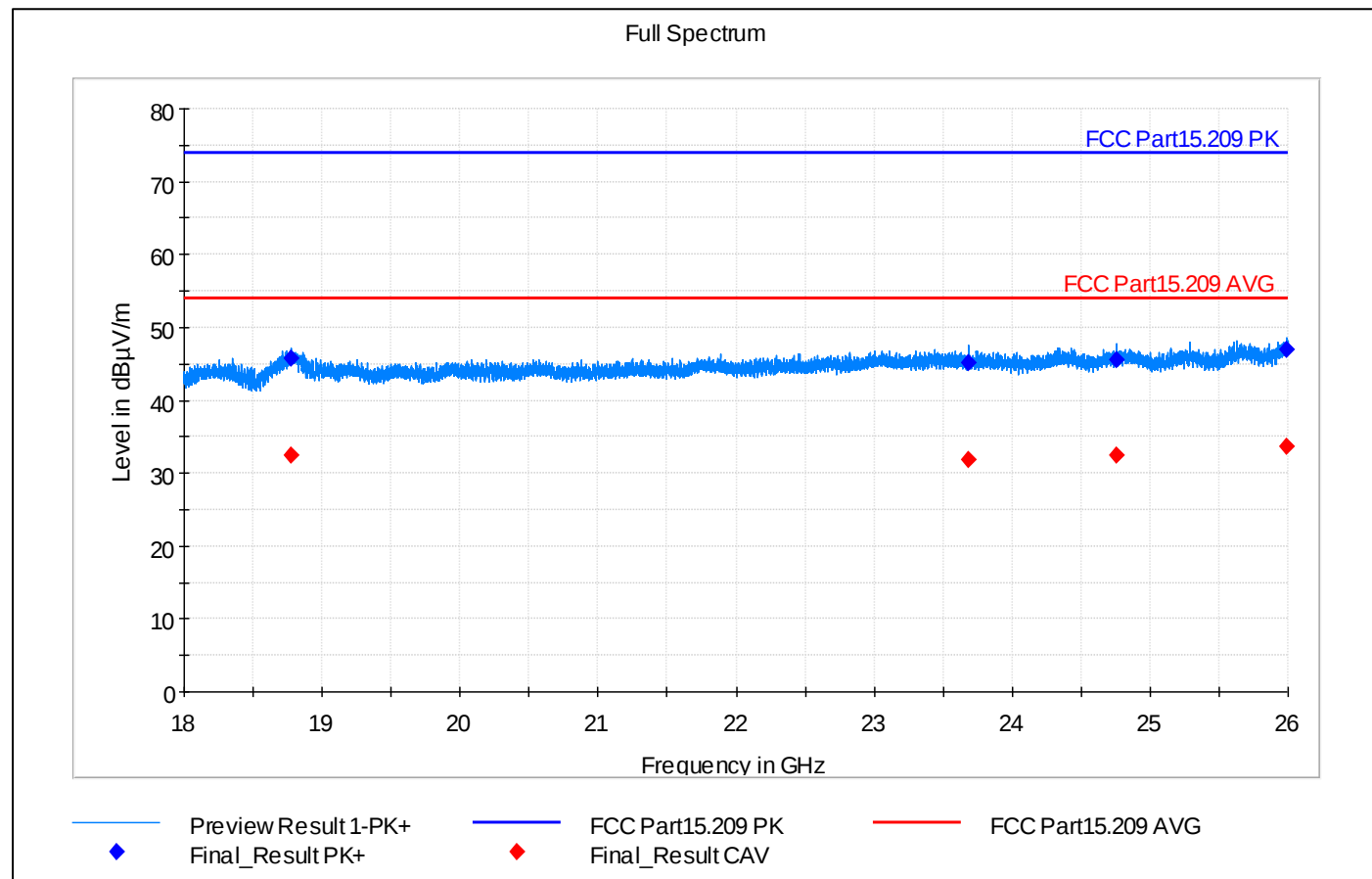
Note: Frequency 2441,800 MHz is excluded from spurious domain measurements and ignored. See table below.

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
1860.800000	47.97	---	74.00	26.03	15000.0	1000.000	149.0	V	321.0	0.0	35.6	PASS
1860.800000	---	31.06	54.00	22.94	15000.0	1000.000	149.0	V	321.0	0.0	35.6	PASS
2441.800000	84.68	---	74.00	-10.68	15000.0	1000.000	267.0	H	221.0	0.0	38.9	Fundamental TX signal, IGNORED
2441.800000	---	82.81	54.00	-28.81	15000.0	1000.000	267.0	H	221.0	0.0	38.9	Fundamental TX signal, IGNORED

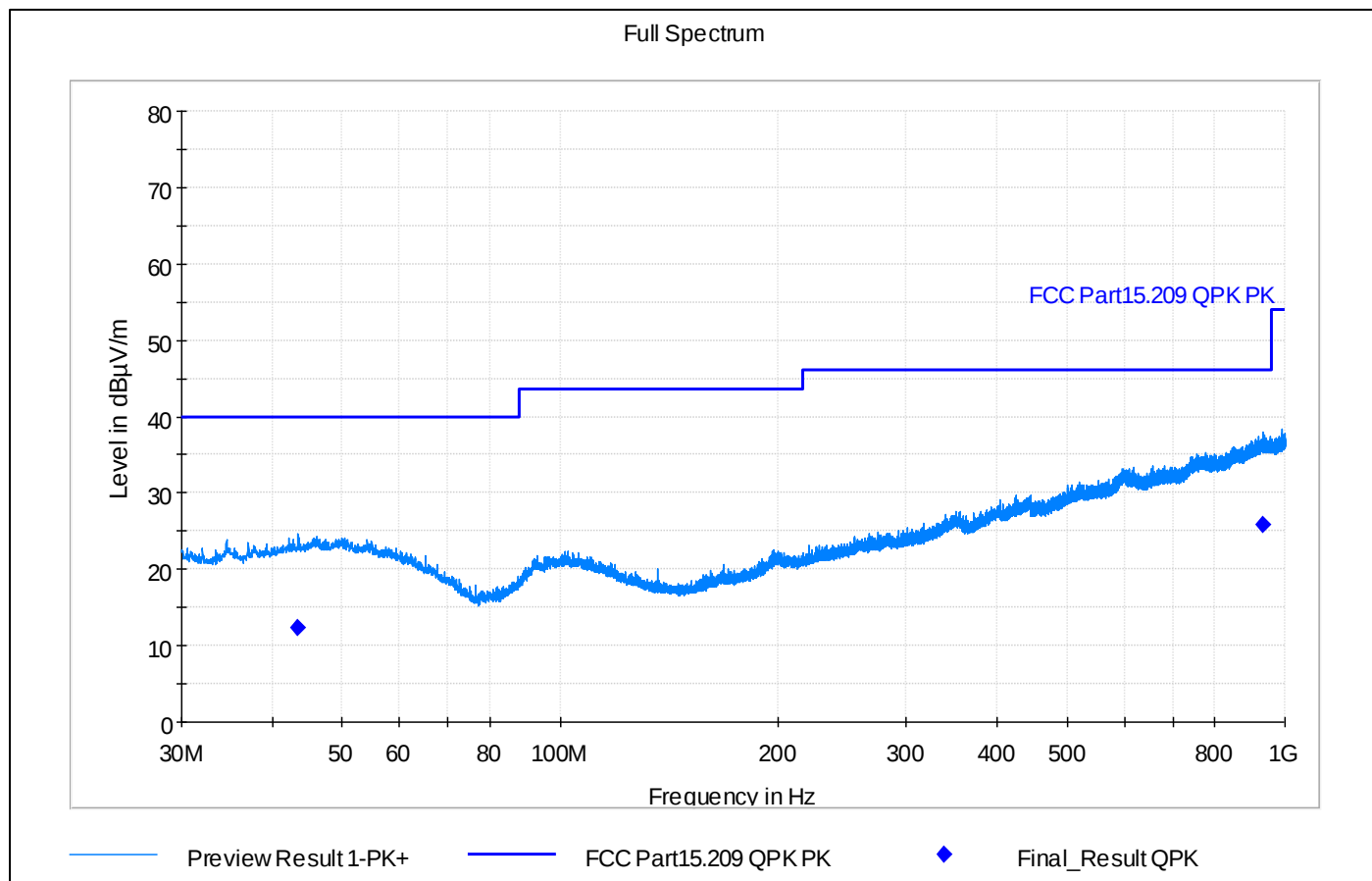
Mid channel, 3–18 GHz

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Comment
4884.500000	54.64	---	74.00	19.36	15000.0	1000.000	162.0	V	177.0	90.0	9.8	PASS
4884.500000	---	47.30	54.00	6.70	15000.0	1000.000	162.0	V	177.0	90.0	9.8	PASS
7326.750000	58.77	---	74.00	15.23	15000.0	1000.000	213.0	V	180.0	0.0	15.4	PASS
7326.750000	---	51.23	54.00	2.77	15000.0	1000.000	213.0	V	180.0	0.0	15.4	PASS

Mid channel, 18–26 GHz

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
18775.000000	45.68	---	74.00	28.32	3000.0	1000.000	317.0	V	127.0	90.0	23.5	PASS
18775.000000	---	32.44	54.00	21.56	3000.0	1000.000	317.0	V	127.0	90.0	23.5	PASS
23685.500000	---	31.74	54.00	22.26	3000.0	1000.000	198.0	V	294.0	0.0	25.8	PASS
23685.500000	45.10	---	74.00	28.90	3000.0	1000.000	198.0	V	294.0	0.0	25.8	PASS
24757.500000	---	32.47	54.00	21.53	3000.0	1000.000	327.0	V	22.0	90.0	26.5	PASS
24757.500000	45.54	---	74.00	28.46	3000.0	1000.000	327.0	V	22.0	90.0	26.5	PASS
25992.750000	46.97	---	74.00	27.03	3000.0	1000.000	191.0	H	76.0	0.0	27.1	PASS
25992.750000	---	33.67	54.00	20.33	3000.0	1000.000	191.0	H	76.0	0.0	27.1	PASS

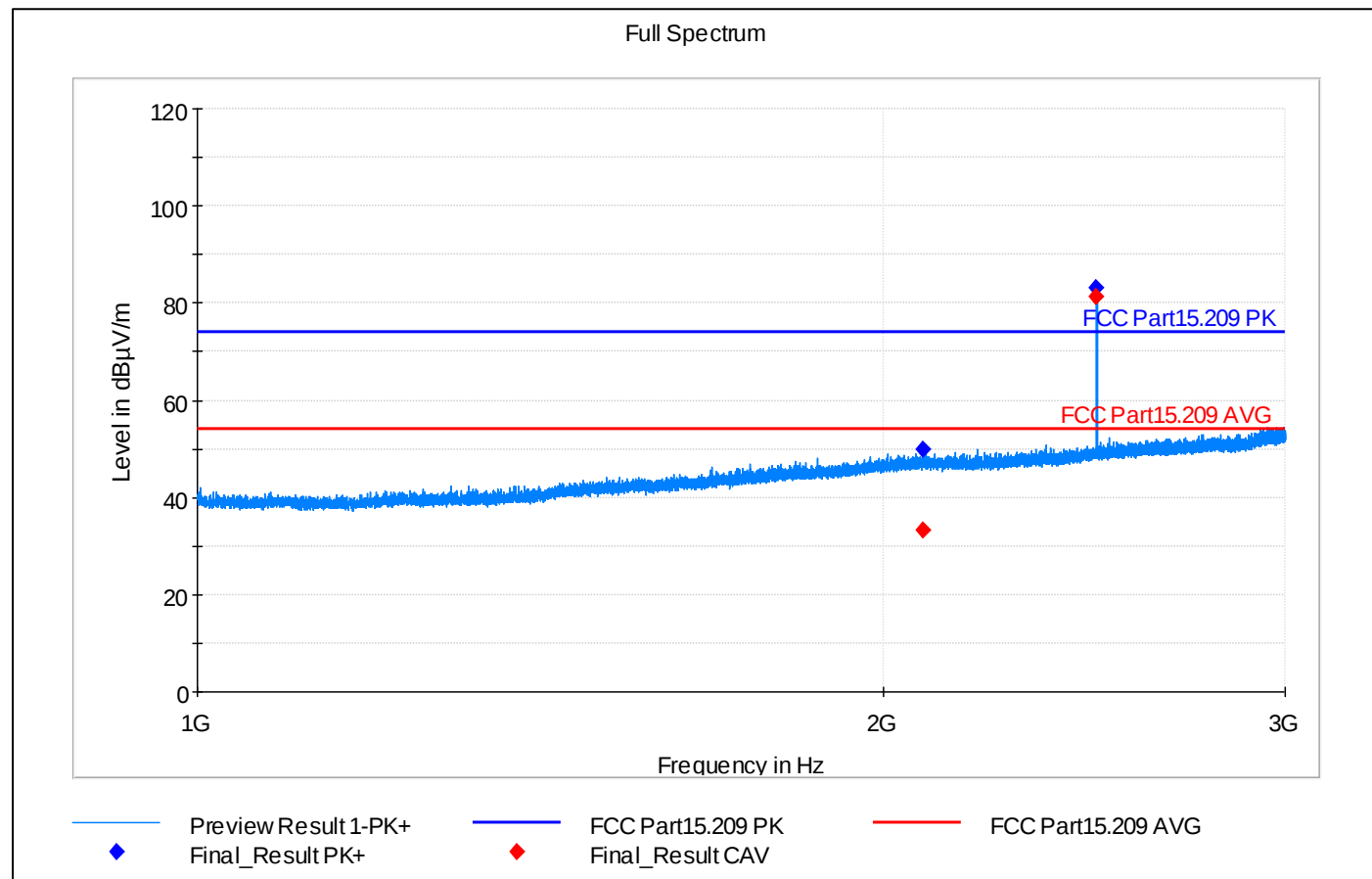
High channel, 30 MHz – 1 GHz



Final_Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
43.470000	12.31	40.00	27.69	15000.0	120.000	308.0	H	181.0	0.0	20.5	PASS
933.450000	25.75	46.00	20.25	15000.0	120.000	197.0	H	292.0	0.0	34.1	PASS

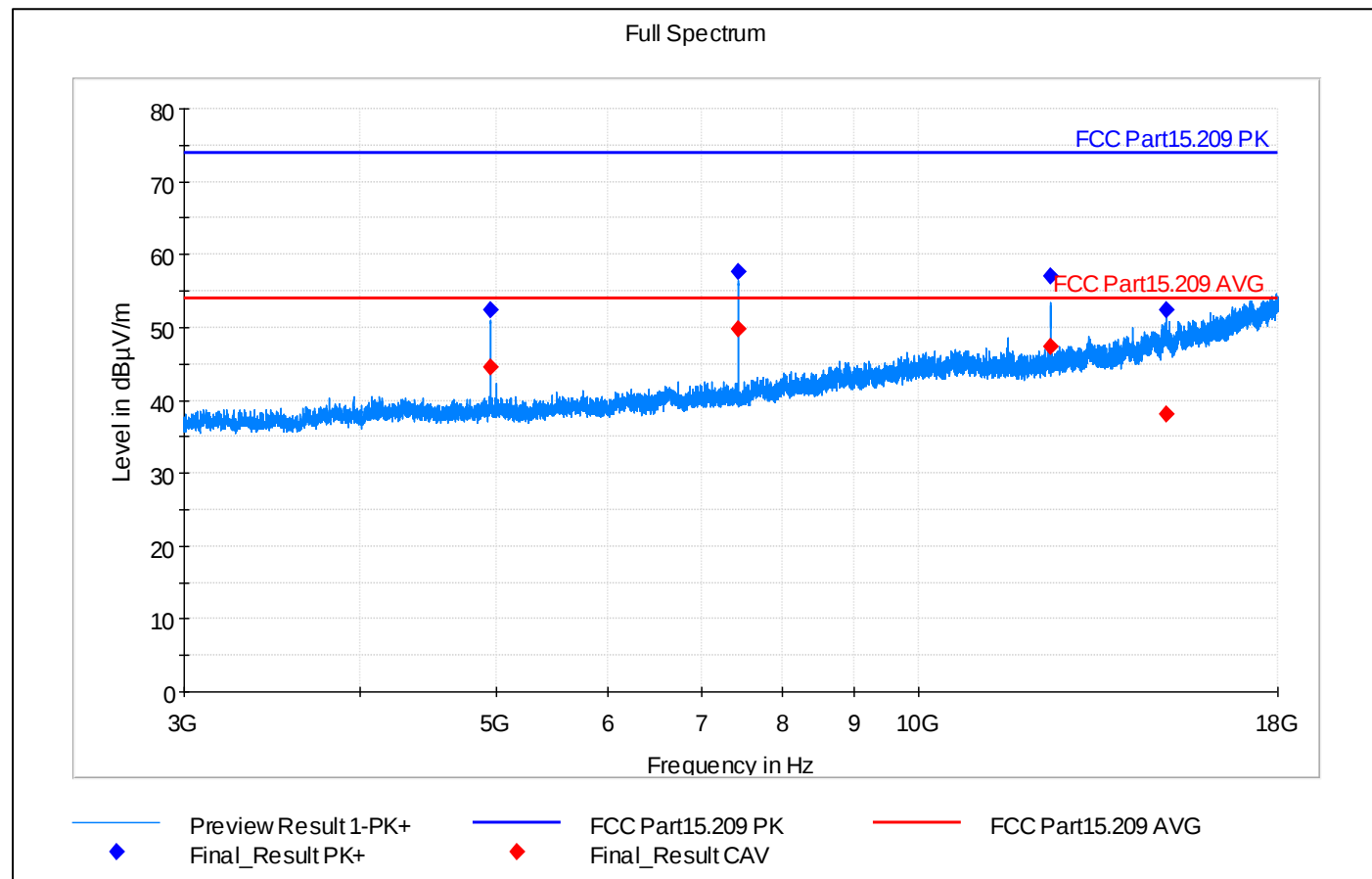
High channel, 1 – 3 GHz



Note: Frequency 2479,800 MHz is excluded from spurious domain measurements and ignored. See table below.

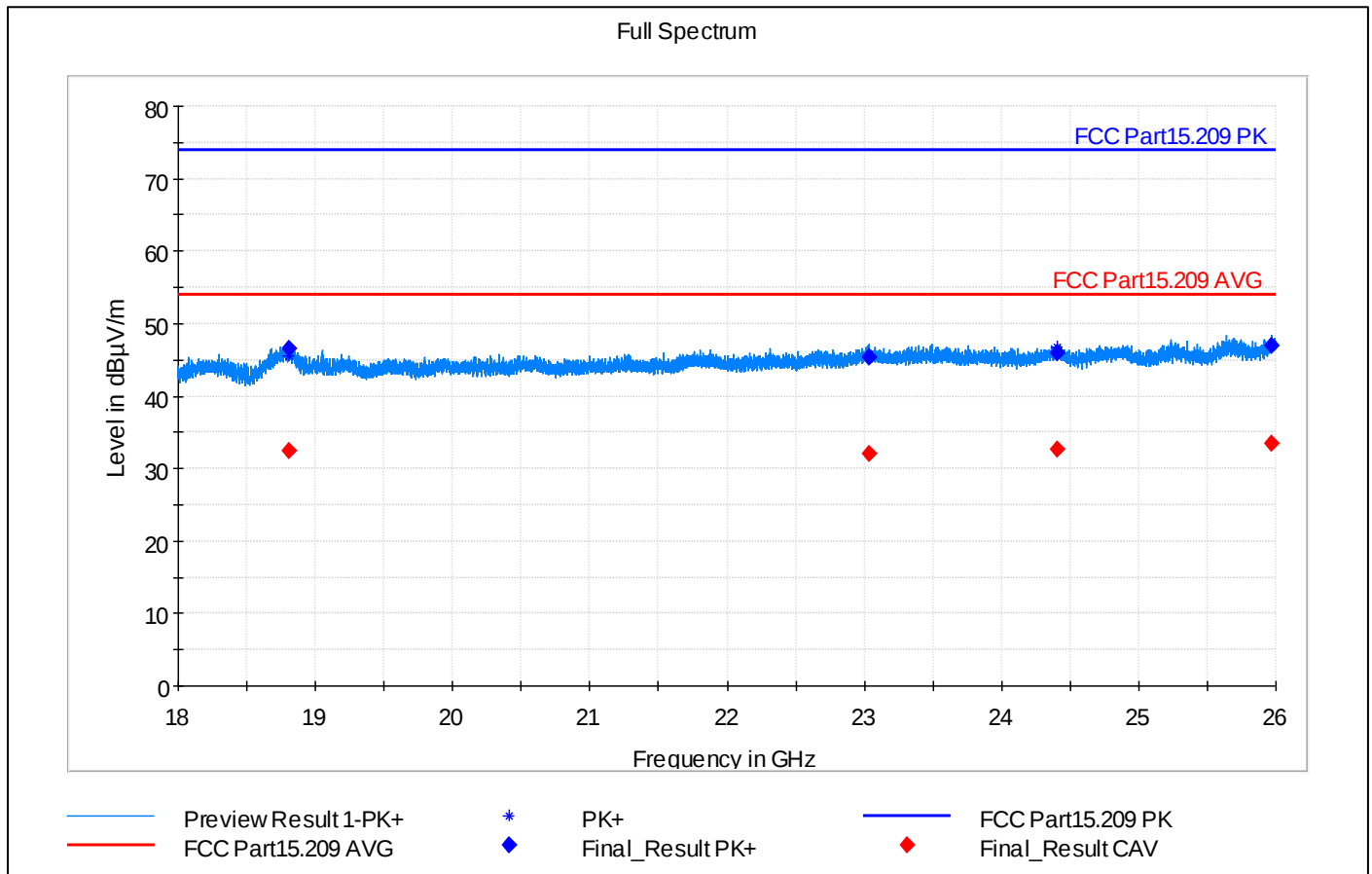
Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
2082.300000	49.77	---	74.00	24.23	15000.0	1000.000	216.0	V	111.0	0.0	37.7	PASS
2082.300000	---	33.20	54.00	20.80	15000.0	1000.000	216.0	V	111.0	0.0	37.7	PASS
2479.800000	83.21	---	74.00	-9.21	15000.0	1000.000	262.0	H	218.0	0.0	39.3	Fundamental TX signal, IGNORED
2479.800000	---	81.26	54.00	-27.26	15000.0	1000.000	262.0	H	218.0	0.0	39.3	Fundamental TX signal, IGNORED

High channel, 3 – 18 GHz

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Comment
4959.500000	52.33	---	74.00	21.67	15000.0	1000.000	229.0	H	179.0	0.0	9.9	PASS
4959.500000	---	44.52	54.00	9.48	15000.0	1000.000	229.0	H	179.0	0.0	9.9	PASS
7439.250000	57.61	---	74.00	16.39	15000.0	1000.000	215.0	V	176.0	0.0	15.1	PASS
7439.250000	---	49.86	54.00	4.14	15000.0	1000.000	215.0	V	176.0	0.0	15.1	PASS
12398.750000	56.99	---	74.00	17.01	15000.0	1000.000	197.0	H	131.0	90.0	23.7	PASS
12398.750000	---	47.37	54.00	6.63	15000.0	1000.000	197.0	H	131.0	90.0	23.7	PASS
15005.750000	52.34	---	74.00	21.66	15000.0	1000.000	261.0	H	42.0	0.0	30.5	PASS
15005.750000	---	38.18	54.00	15.82	15000.0	1000.000	261.0	H	42.0	0.0	30.5	PASS

High channel, 18 – 26 GHz



Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
18806.250000	46.52	---	74.00	27.48	3000.0	1000.000	99.0	V	31.0	90.0	23.5	PASS
18806.250000	---	32.44	54.00	21.56	3000.0	1000.000	99.0	V	31.0	90.0	23.5	PASS
23037.000000	---	32.06	54.00	21.94	3000.0	1000.000	260.0	H	205.0	90.0	25.5	PASS
23037.000000	45.27	---	74.00	28.73	3000.0	1000.000	260.0	H	205.0	90.0	25.5	PASS
24404.250000	---	32.65	54.00	21.35	3000.0	1000.000	116.0	H	269.0	90.0	26.1	PASS
24404.250000	46.02	---	74.00	27.98	3000.0	1000.000	116.0	H	269.0	90.0	26.1	PASS
25967.000000	46.99	---	74.00	27.01	3000.0	1000.000	316.0	V	-1.0	0.0	27.1	PASS
25967.000000	---	33.54	54.00	20.46	3000.0	1000.000	316.0	V	-1.0	0.0	27.1	PASS

17. Receiver spurious emissions, radiated

Reference: ISED RSS-247, Issue 3 (section 3.1)

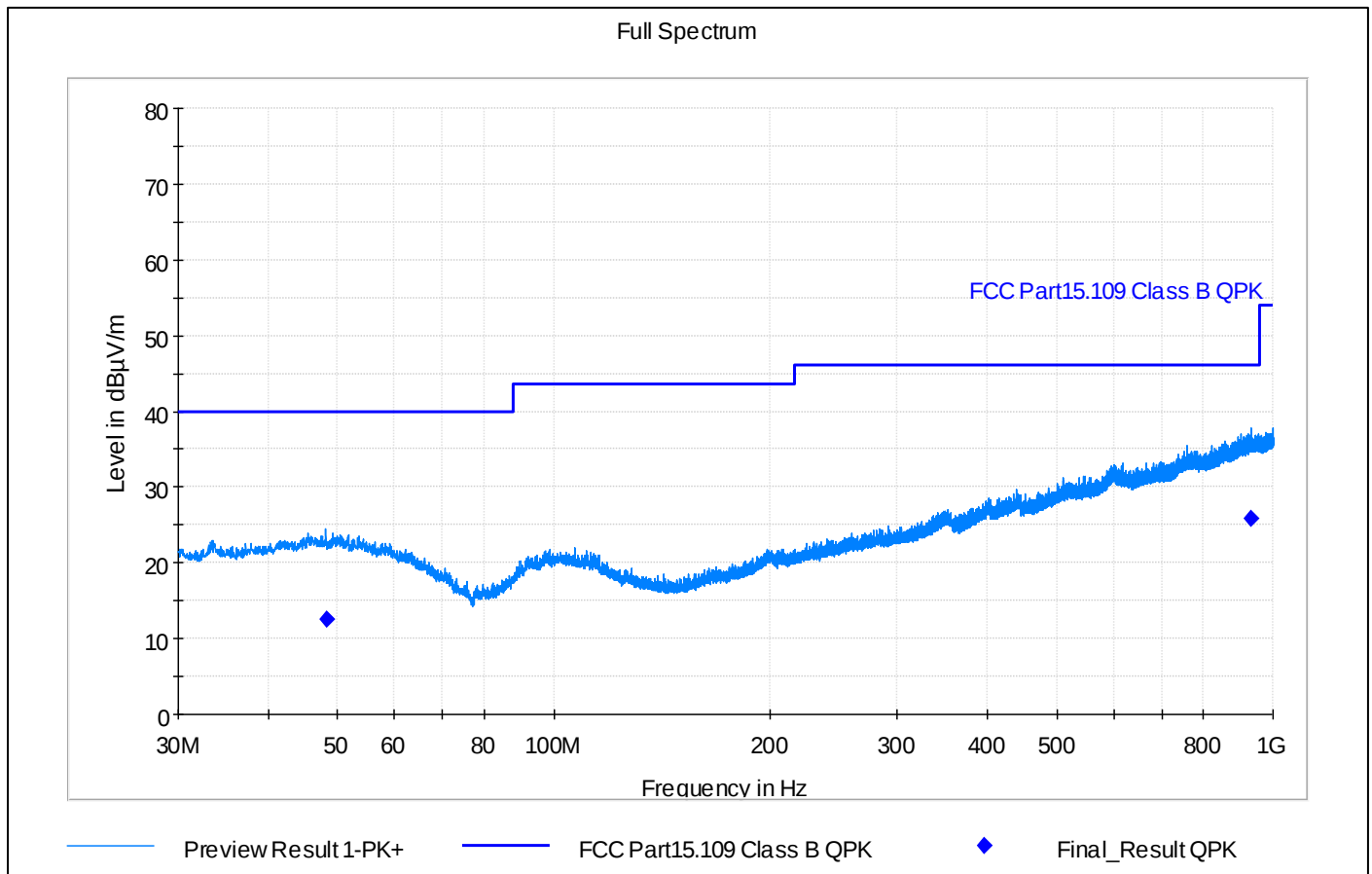
Test method: ANSI C63.4-2014 (8.1 – 8.3)

Limits			
Frequency (MHz)	Detector	Field strength (uV/m)	Measurement distance (m)
30 – 88	Quasi-Peak	100	3
88 - 216	Quasi-Peak	150	3
216 - 960	Quasi-Peak	200	3
960 - 1000	Quasi-Peak	500	3
> 1000	Average	500	3

Test procedure
1. EUT is placed on a non conducting support at the center of a turn table 0.8m above the ground 2. EUT set to test mode 3. The receiver is set to peak detection with max hold 4. The EUT is rotated through 360 degrees (orientation varied), measurements were made in both horizontal and vertical planes of polarization 5. Found peak values were further maximized by adjusting turntable position $\pm 22,5$ degrees around detected value and scanning the antenna height 1 to 4m 6. For maximized values, final measurement was done with the corresponding final detector.

Operation mode(s)	Configuration	Test Verdict
Bluetooth LE RX	Mid channel, 2442 MHz	PASS

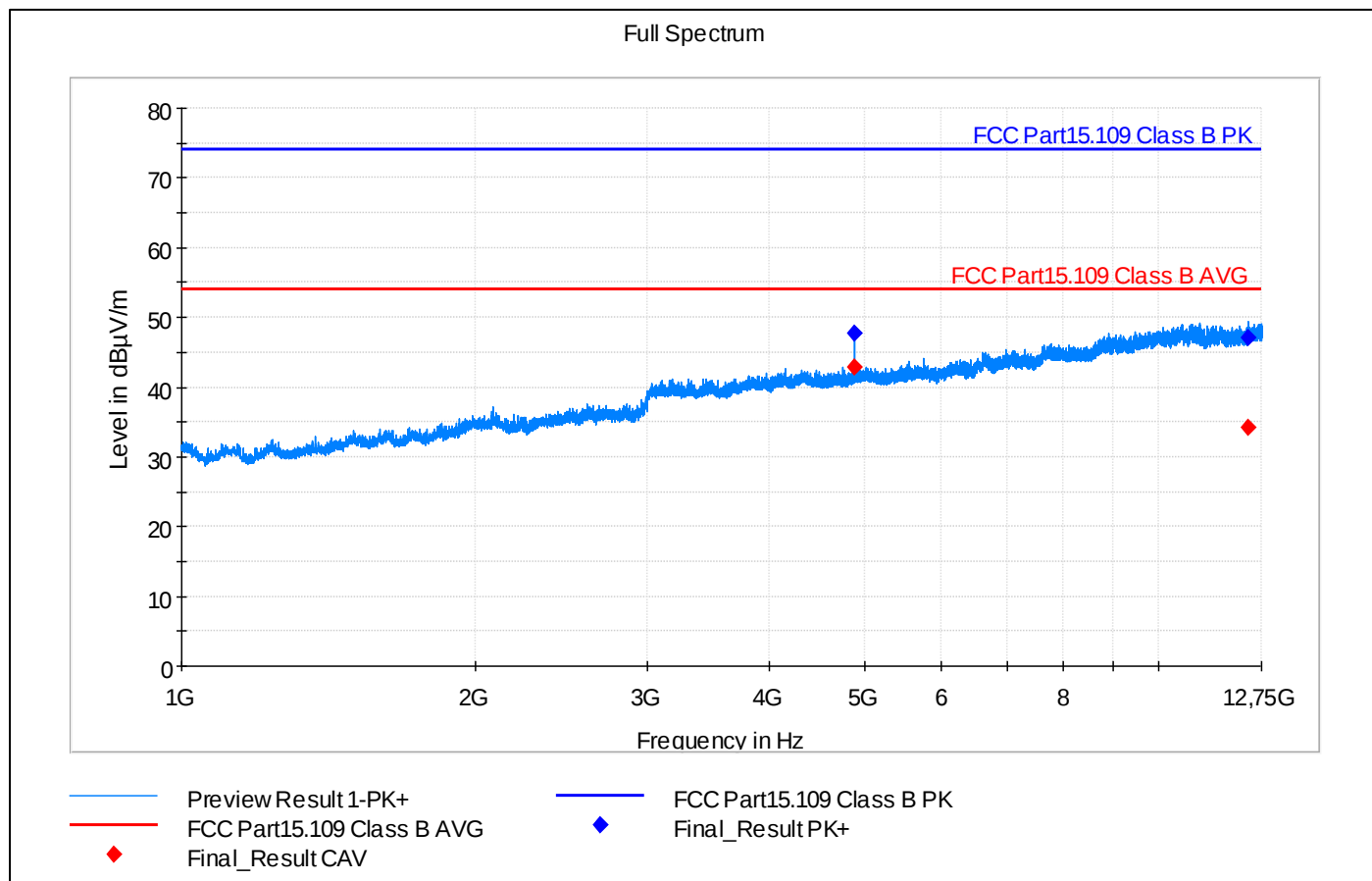
Mid channel, 30 MHz – 1 GHz



Final_Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
48.270000	12.48	40.00	27.52	15000.0	120.000	382.0	V	95.0	0.0	21.1	PASS
933.840000	25.79	46.00	20.21	15000.0	120.000	394.0	V	292.0	0.0	34.1	PASS

Mid channel, 1 GHz – 12,75 GHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
4882.000000	47.65	---	74.00	26.35	500.0	1000.000	104.0	H	273.0	9.8	PASS
4882.000000	---	42.93	54.00	11.07	500.0	1000.000	104.0	H	273.0	9.8	PASS
12344.000000	46.97	---	74.00	27.03	500.0	1000.000	152.0	H	6.0	23.4	PASS
12344.000000	---	34.28	54.00	19.72	500.0	1000.000	152.0	H	6.0	23.4	PASS