

3.5 Authorized-band Band-edge

3.5.1. Limit

FCC 47 CFR Part 15 Subpart C - §15.247 (d)

ISED RSS-247 - §5.5

In any 100kHz bandwidth outside the frequency band in which the digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on an RF conducted measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

3.5.2. Test Setup



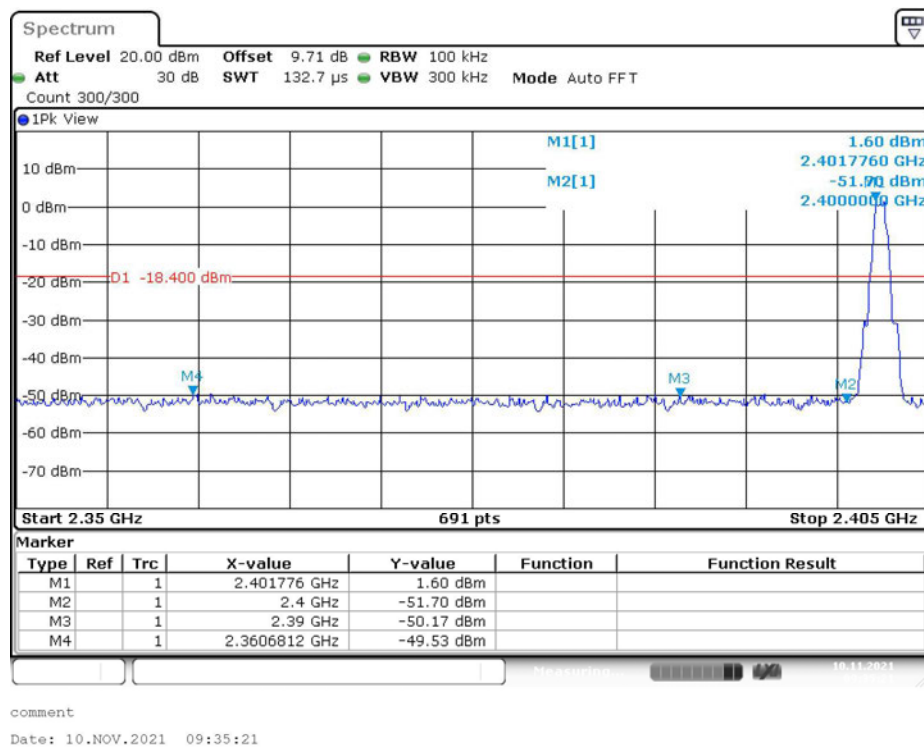
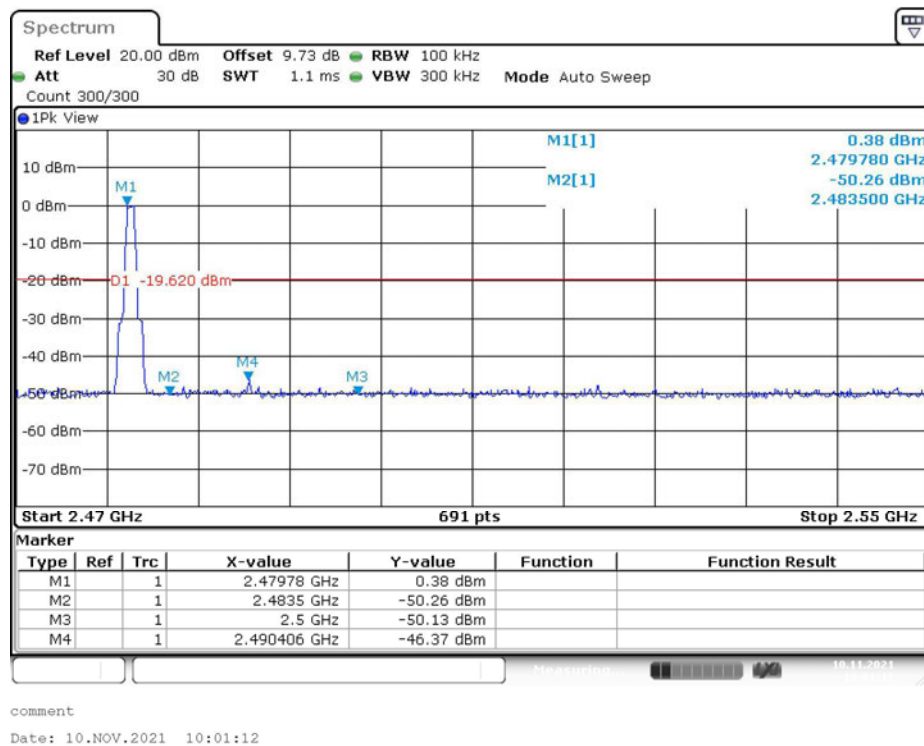
3.5.3. Test Procedures

- 1) The measurement procedure follows ANSI C63.10-2013, clause 6.10.4.
- 2) Set the EUT to operate at maximum output power and equivalent normal mode of operation.
- 3) Use the following spectrum analyzer settings:
 - a) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation;
 - b) Set RBW = 100kHz;
 - c) Set VBW $\geq 3 \times$ RBW;
 - d) Detector = Peak;
 - e) Trace Mode = Max Hold;
 - f) Sweep = Auto Couple;
 - g) Allow the trace to stabilize;
- 4) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission.

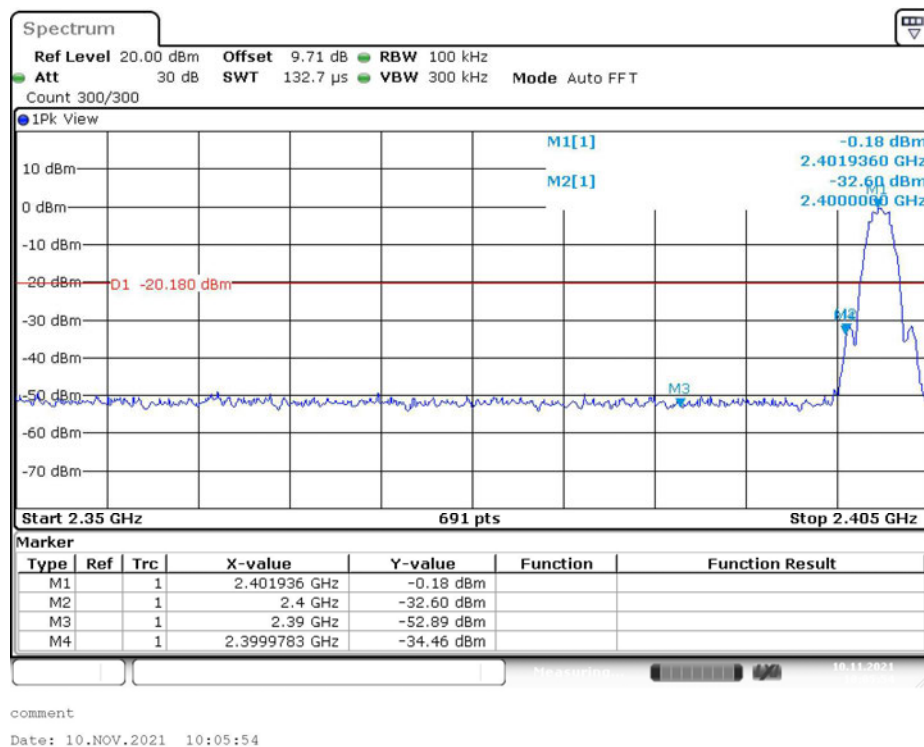
3.5.4. Test Result

Test Engineer	Xu Dongxu	Test Date	2021/11/10
Temperature	22.0°C	Relative Humidity	50.0%
Pressure	105.6kPa	Test Sample Selected	No.1

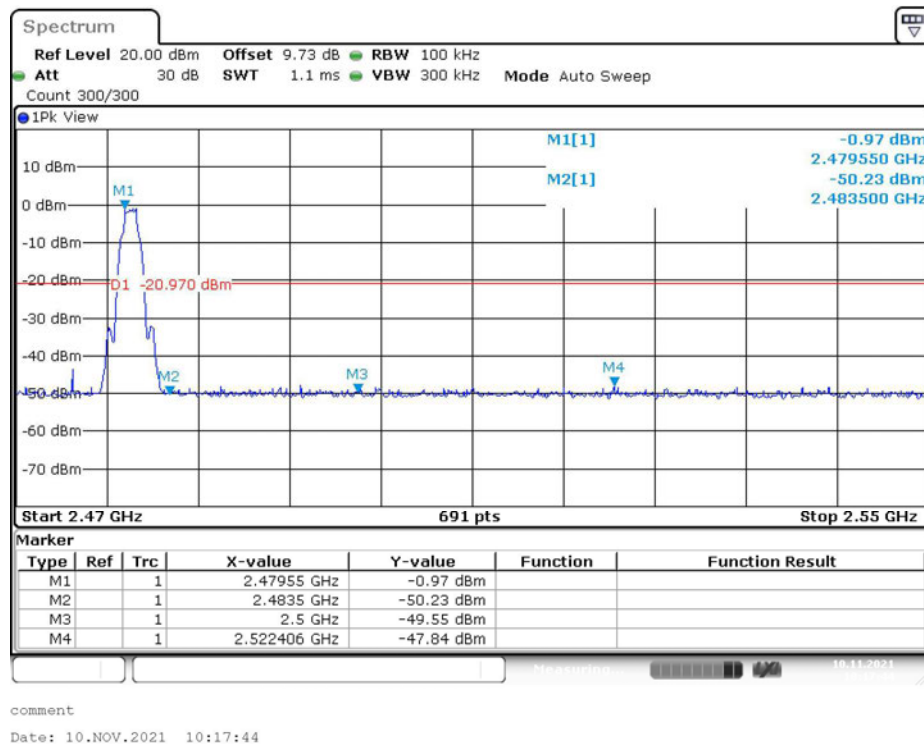
Modulation Type	Channel	Frequency (MHz)	Ref Level (dBm)	Result (dBm)	-20dBc Limit (dBm)
GFSK (BLE 1Mbps)	CH Lowest (No.0)	2402	1.60	-49.53	≤ -18.40
	CH Highest (No.39)	2480	0.38	-46.37	≤ -19.62
GFSK (BLE 2Mbps)	CH Lowest (No.0)	2402	-0.18	-34.46	≤ -20.18
	CH Highest (No.39)	2480	-0.97	-47.84	≤ -20.97

GFSK (BLE 1Mbps):

CH Lowest (No.0)

CH Highest (No.39)

GFSK (BLE 2Mbps):



CH Lowest (No.0)



CH Highest (No.39)

3.5.5. Uncertainty

$$U_{lab}=1.08\text{dB} (k=2)$$

3.6 Spurious Radiated Emissions and Restricted-band Band-edge

3.6.1. Limit

FCC 47 CFR Part 15 Subpart C - §15.205, §15.209 and §15.247 (d)

ISED RSS-247 - §5.5

ISED RSS-Gen - §8.9 and §8.10

All out of band emissions appearing in restricted band must not exceed the limits shown in below table:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

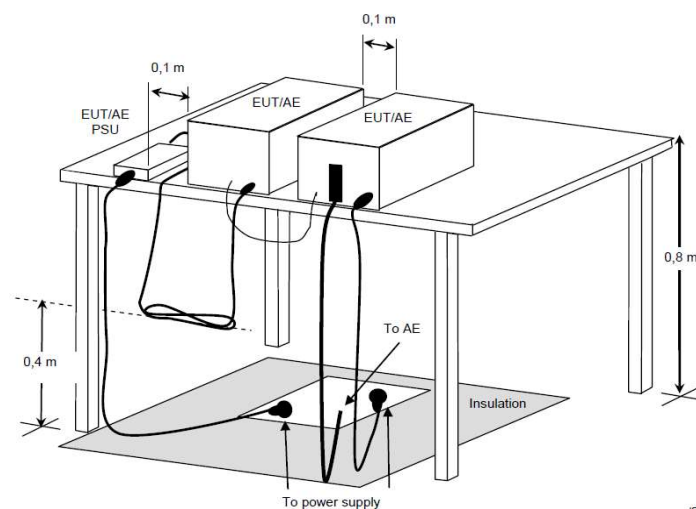
FCC 47 CFR Part 15 Subpart C - §15.35 (b)

There is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.

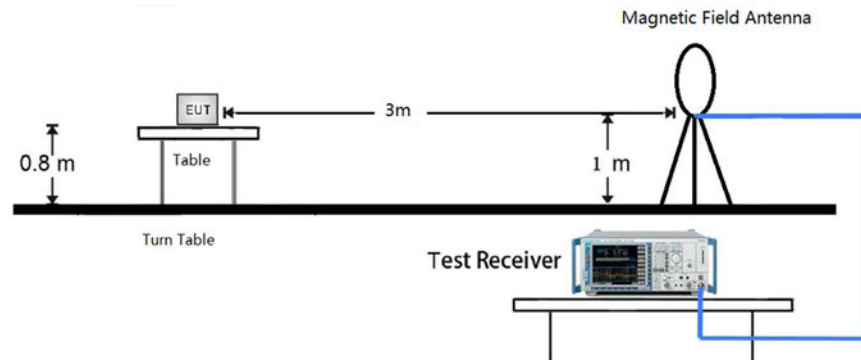
Used conversion factor: $\text{Limit (dB}\mu\text{V/m)} = 20\log (\text{Limit } (\mu\text{V/m})/1\mu\text{V/m})$

Frequency (MHz)	Detector	Unit (dBμV/m)
30-88	Quasi-Peak	40.0
88-216	Quasi-Peak	43.5
216-960	Quasi-Peak	46.0
960-1000	Quasi-Peak	54.0
1000~5th harmonic of the highest frequency or 40GHz, whichever is lower	Average	54.0
	Peak	74.0

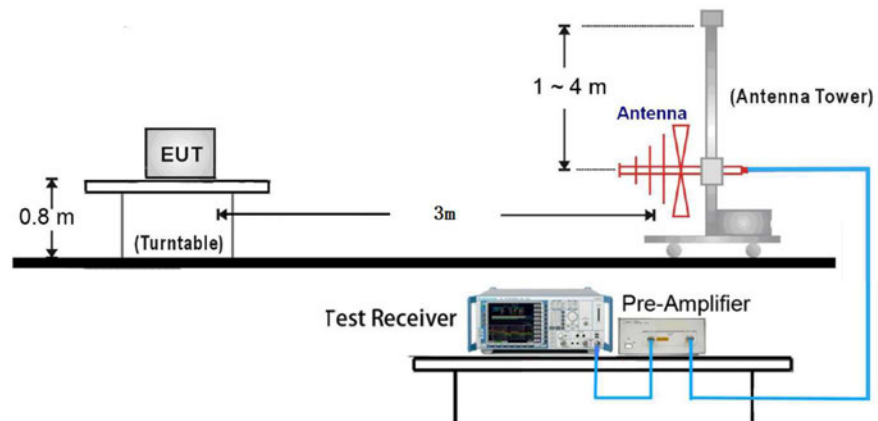
3.6.2. Test Setup



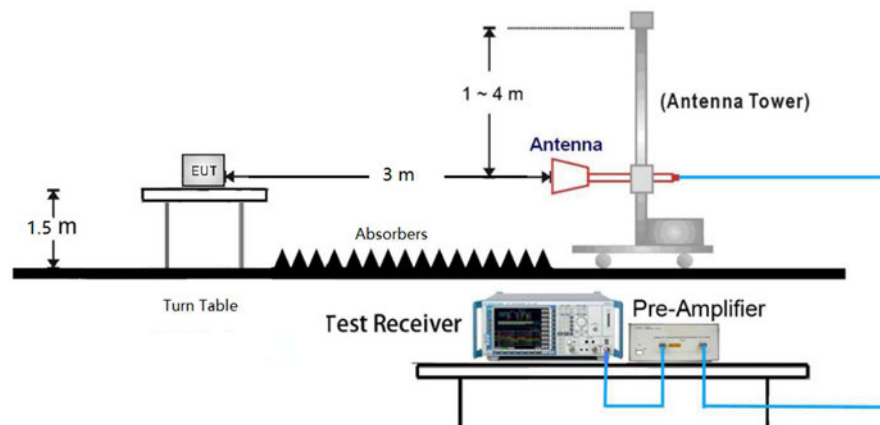
Test Connection Diagram



Below 30MHz Test Setup



30MHz-1GHz Test Setup



Above 1GHz Test Setup

3.6.3. Test Procedures

- 1) The measurement procedure follows ANSI C63.10-2013, clause 6.3, 6.5, 6.6, 6.10.5 and 6.10.6.
- 2) The data of cable loss and antenna factor has been calibrated in full testing frequency range before the testing.
- 3) EUT is placed on a non-conducting table 80cm above the ground plane for measurement below 1GHz;

- 1.5m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters.
- 4) For measurements below 30MHz, the resolution bandwidth and video bandwidth is set to 9kHz for quasi-peak detection measurements.
- For measurements from 30MHz to 1GHz, the resolution bandwidth is set to 100kHz for peak detection measurements or 120kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.
- For pre-scans above 1GHz, the resolution bandwidth is set to 1MHz; the video bandwidth is set to 30kHz for peak measurements.
- For final scans above 1GHz, the resolution bandwidth is set to 1MHz and video bandwidth is set to 30MHz for peak measurements. And 1MHz resolution bandwidth with 1/T (10Hz) video bandwidth with peak detector for average measurements.
- 5) The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and horizontal positions.
- 6) The spectrum from 1GHz to 18GHz is investigated with the EUT set to transmit at the lowest, middle and highest channels with the highest output power and worst-case modulation type (defined in section 2.6 of this report). Below 1GHz and above 18GHz emissions were performed with the EUT set to transmit at the channel and modulation type with the highest output power as worst-case scenario.

3.6.4. Test Result

Restricted-band Band-edge:

Test Engineer	Gao Shuang	Test Date	2021/11/05
Temperature	21.5°C	Relative Humidity	46.0%
Pressure	105.8kPa	Test Sample Selected	No.2

The measurement results are obtained as described below:

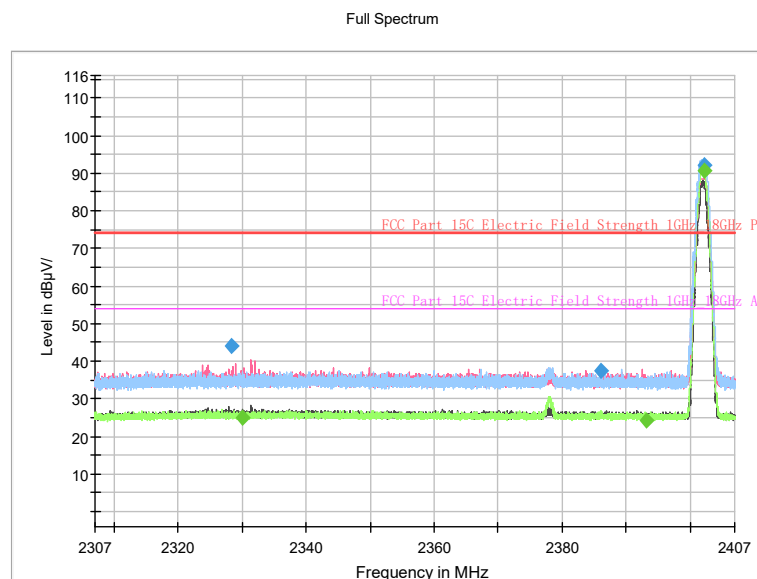
Measure Level = Reading Level + Factor;

Factor = cable loss + antenna factor + preamplifier gain;

Sample calculation: (43.95dBuV/m) = (73.05dBμV) + (-29.10dB), the corresponding frequency is 2328.34MHz.

GFSK (BLE 1Mbps):

CH Lowest (No.0)



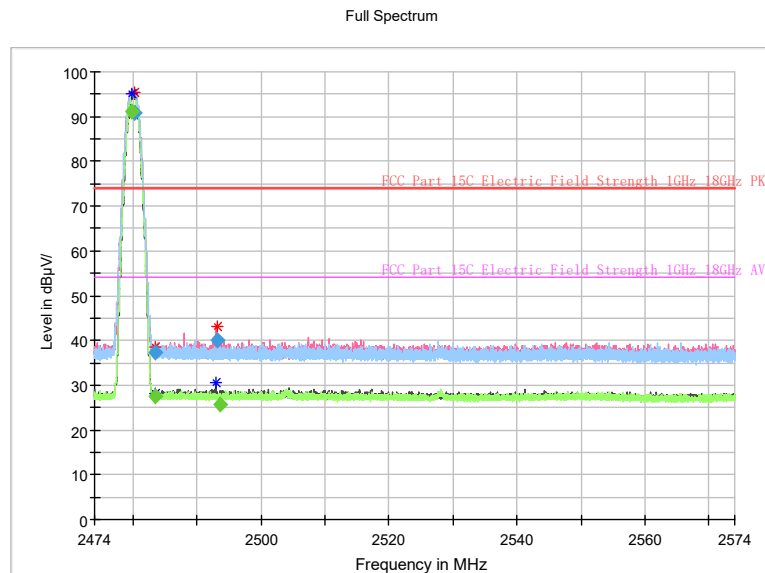
Result: PK

Frequency (MHz)	Reading MaxPeak (dBuV/m)	MaxPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2328.34	73.05	43.95	74.00	30.05	174.80	V	166.00	-29.10
2386.11	66.81	37.61	74.00	36.39	295.80	V	268.00	-29.20
2402.29	121.61	92.31	74.00	-18.31	100.90	H	15.00	-29.30

Result: AV

Frequency (MHz)	Reading Average (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2330.14	53.99	24.89	54.00	29.11	208.10	V	205.00	-29.10
2389.21	53.43	24.13	54.00	29.87	174.80	V	245.00	-29.30
2402.18	120.03	90.73	54.00	-36.73	100.60	H	15.00	-29.30

CH Highest (No.39)

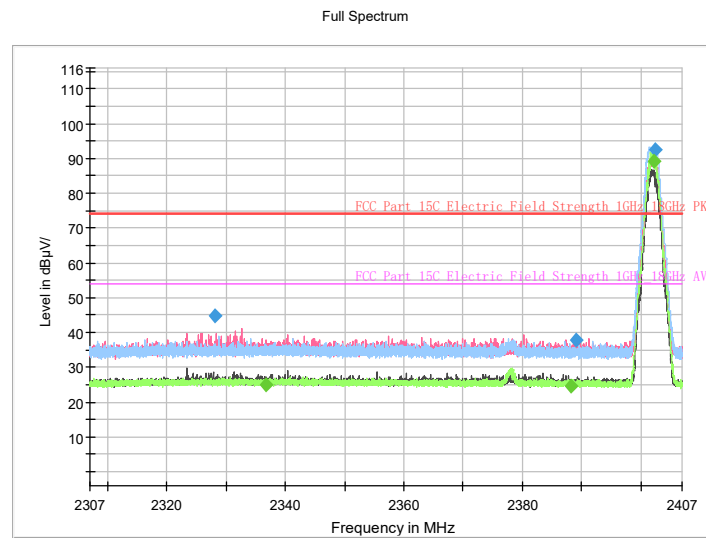


Result: PK

Frequency (MHz)	Reading MaxPeak (dBuV/m)	MaxPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2480.29	119.96	90.96	74.00	-16.96	388.80	V	13.00	-29.00
2483.58	66.17	37.17	74.00	36.83	390.00	V	273.00	-29.00
2493.17	69.21	40.21	74.00	33.79	216.50	V	82.00	-29.00

Result: AV

Frequency (MHz)	Reading Average (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2479.85	120.24	91.24	54.00	-37.24	318.50	V	135.00	-29.00
2483.50	56.51	27.51	54.00	26.49	113.80	H	355.00	-29.00
2493.53	54.65	25.65	54.00	28.35	179.10	V	82.00	-29.00

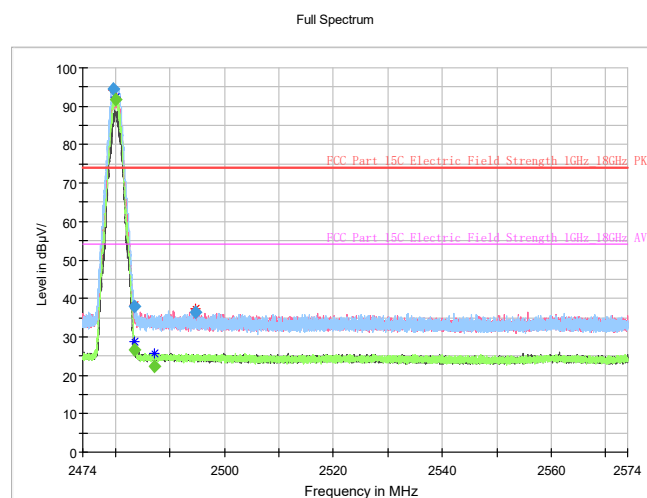
GFSK (BLE 2Mbps):
CH Lowest (No.0)


Result: PK

Frequency (MHz)	Reading MaxPeak (dBuV/m)	MaxPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2328.02	74.06	44.96	74.00	29.04	175.80	V	165.00	-29.10
2389.11	66.88	37.68	74.00	36.32	195.80	H	253.00	-29.20
2402.55	121.81	92.51	74.00	-18.51	100.90	H	15.00	-29.30

Result: AV

Frequency (MHz)	Reading Average (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2336.85	54.06	24.96	54.00	29.04	219.60	V	205.00	-29.10
2388.23	53.85	24.65	54.00	29.35	195.80	V	66.00	-29.20
2402.27	118.41	89.11	54.00	-35.11	99.80	H	14.00	-29.30

CH Highest (No.39)


Result: PK

Frequency (MHz)	Reading MaxPeak (dBuV/m)	MaxPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2479.53	123.36	94.36	74.00	-20.36	174.70	H	336.00	-29.00
2483.54	67.02	38.02	74.00	35.98	175.80	H	65.00	-29.00
2494.60	65.14	36.34	74.00	37.66	125.00	V	292.00	-28.80

Result: AV

Frequency (MHz)	Reading Average (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2480.00	120.62	91.62	54.00	-37.62	174.80	H	336.00	-29.00
2483.41	55.48	26.48	54.00	27.52	125.00	H	105.00	-29.00
2487.23	51.00	22.20	54.00	31.80	100.00	H	155.00	-28.80

Spurious Radiated Emissions:

Test Engineer	Gao Shuang	Test Date	2021/11/05
Temperature	21.5°C	Relative Humidity	46.0%
Pressure	105.8kPa	Test Sample Selected	No.2

A “reference path loss” is established and the A_{Rpl} is the attenuation of “reference path loss”, and including the gain of receive antenna, the gain of the preamplifier, the cable loss.

The measurement results are obtained as described below:

Result = $P_{mea} + A_{Rpl}$

Sample calculation: $(6.99\text{dB}\mu\text{V/m}) = (33.69\text{dB}\mu\text{V}) + (-26.70\text{dB/m})$, the corresponding frequency is 79.55MHz.

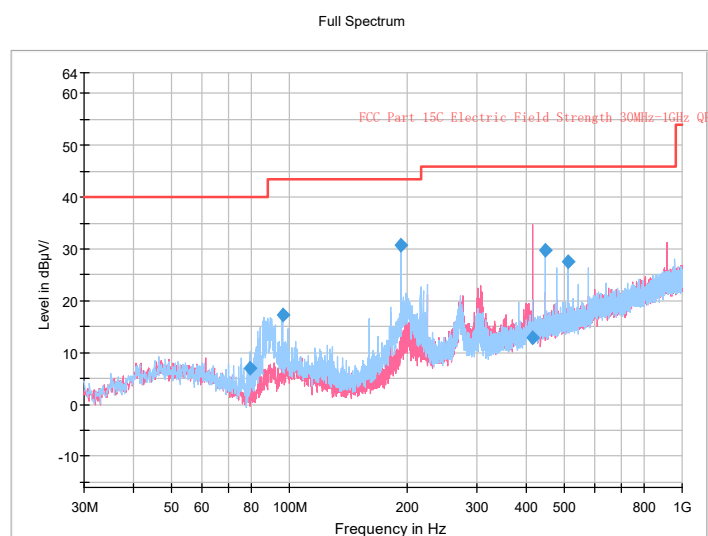
Spurious Radiated Emissions below 30MHz:

There were no emissions from 9kHz to 30MHz found within 20dB of the limit. Thus, the test result was not reported according to §15.31 (o)

Spurious Radiated Emissions from 30MHz to 1GHz:

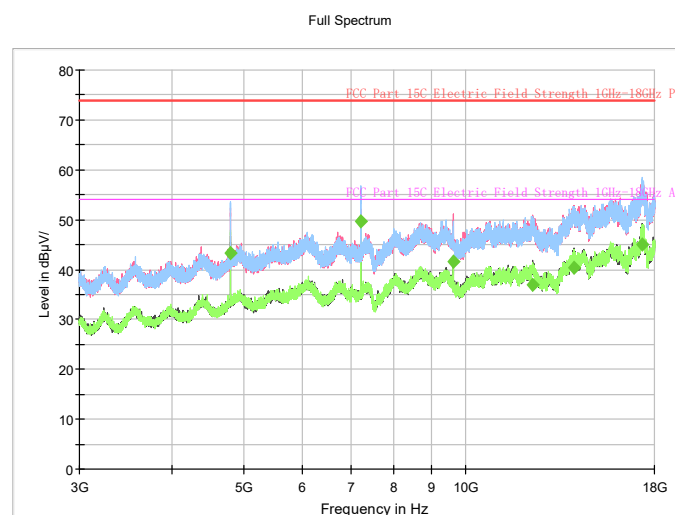
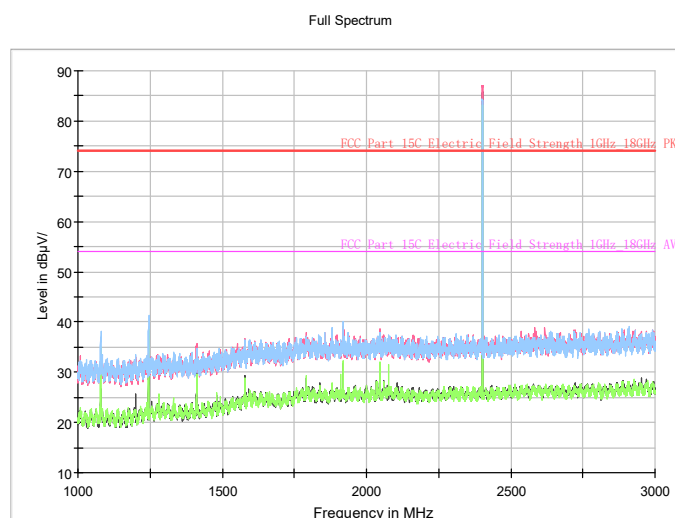
GFSK (BLE 2Mbps):

CH Middle (No.19)



Frequency (MHz)	Reading (dBuV/m)	QuasiPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
79.55	33.69	6.99	40.00	33.01	120.00	224.70	H	25.00	-26.70
96.00	39.36	17.36	43.50	26.14	120.00	197.00	H	25.00	-22.00
192.01	51.77	30.77	43.50	12.73	120.00	99.50	H	357.00	-21.00
414.75	26.58	12.78	46.00	33.22	120.00	175.70	V	205.00	-13.80
448.01	42.70	29.70	46.00	16.30	120.00	224.70	H	115.00	-13.00
512.02	38.77	27.47	46.00	18.53	120.00	174.50	H	88.00	-11.30

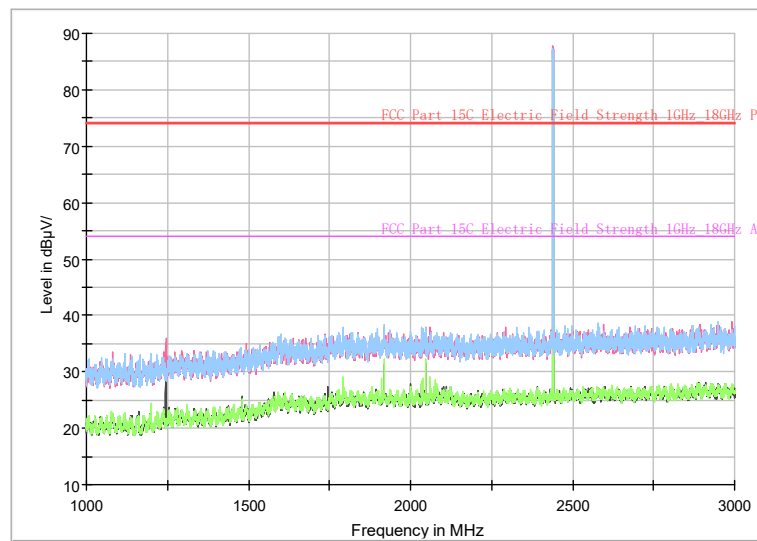
Spurious Radiated Emissions from 1GHz to 18GHz:
GFSK (BLE 1Mbps):
CH Lowest (No.0)



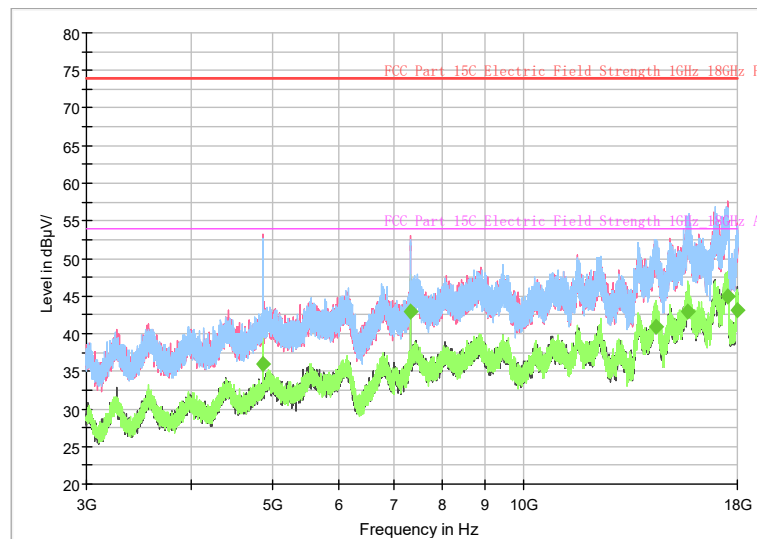
Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4803.26	---	64.38	---	43.38	54.00	10.62	190.20	H	139.00	-21.00
7207.45	---	70.91	---	49.61	54.00	4.39	224.80	H	191.00	-21.30
9606.11	---	61.31	---	41.51	54.00	12.49	224.80	V	176.00	-19.80
12329.93	---	54.04	---	36.94	54.00	17.06	100.00	V	200.00	-17.10
13999.59	---	53.99	---	40.29	54.00	13.71	99.90	V	259.00	-13.70
17332.52	---	56.46	---	44.96	54.00	9.04	174.70	V	323.00	-11.50

CH Middle (No.19)

Full Spectrum



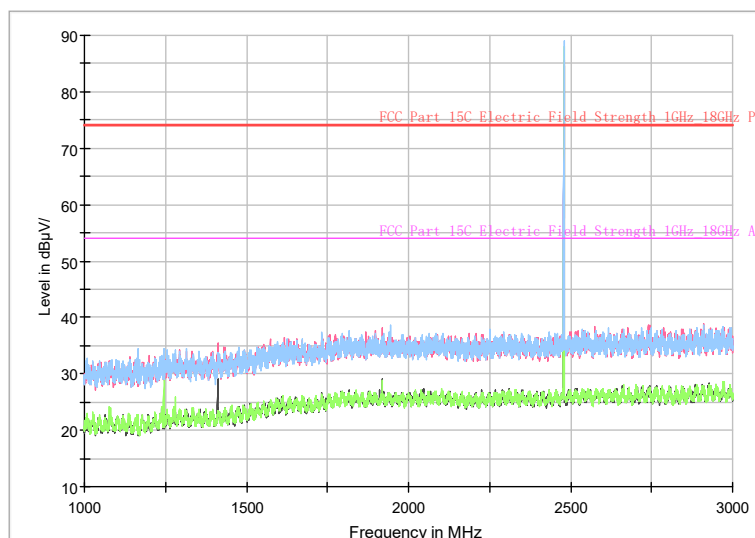
Full Spectrum



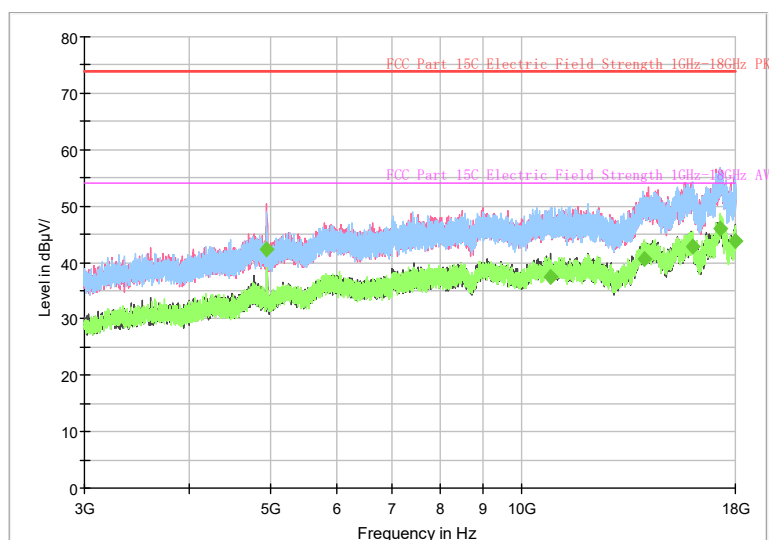
Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4880.49	---	57.65	---	36.05	54.00	17.95	225.00	H	88.00	-21.60
7319.60	---	64.11	---	42.91	54.00	11.09	225.00	H	66.00	-21.20
14373.87	---	54.40	---	41.00	54.00	13.00	125.00	H	257.00	-13.40
15717.45	---	56.60	---	42.90	54.00	11.10	276.00	H	346.00	-13.70
17534.29	---	56.28	---	44.98	54.00	9.02	225.00	H	65.00	-11.30
17997.74	---	52.49	---	43.09	54.00	10.91	274.90	V	155.00	-9.40

CH Highest (No.39)

Full Spectrum



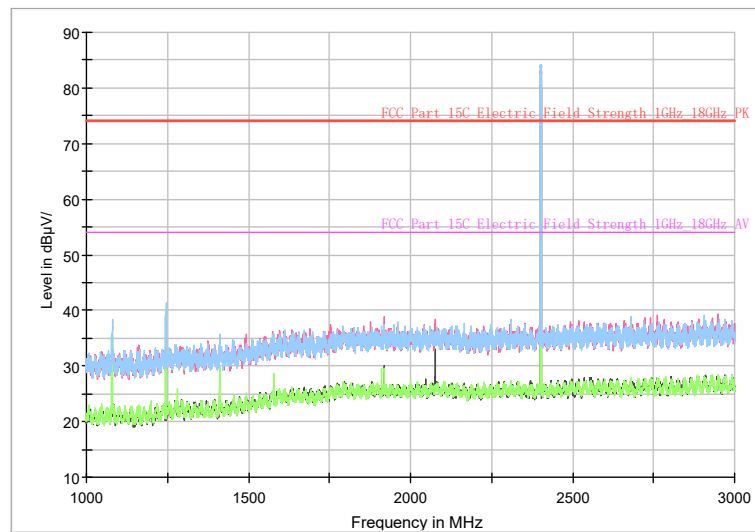
Full Spectrum



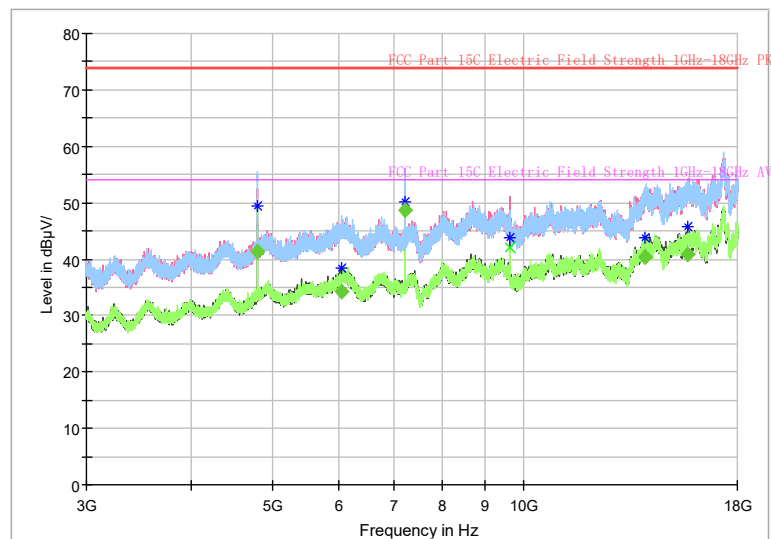
Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4959.80	---	64.62	---	42.32	54.00	11.68	325.10	V	179.00	-22.30
10807.81	---	58.66	---	37.46	54.00	16.54	274.40	V	110.00	-18.30
13989.87	---	61.12	---	40.62	54.00	13.38	325.10	H	25.00	-13.70
15977.22	---	54.32	---	42.72	54.00	11.28	274.50	H	295.00	-13.90
17270.36	---	57.62	---	46.02	54.00	7.98	100.00	H	264.00	-11.60
17975.37	---	55.18	---	43.68	54.00	10.32	319.60	V	115.00	-9.50

GFSK (BLE 2Mbps):
CH Lowest (No.0)

Full Spectrum



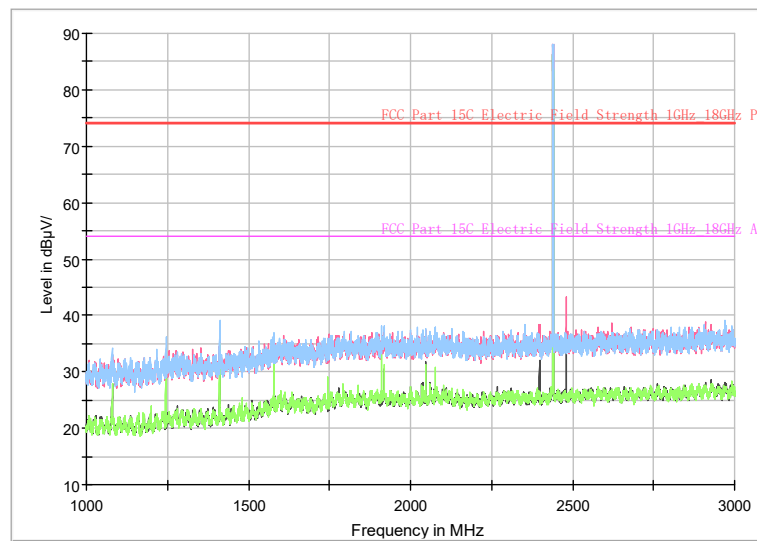
Full Spectrum



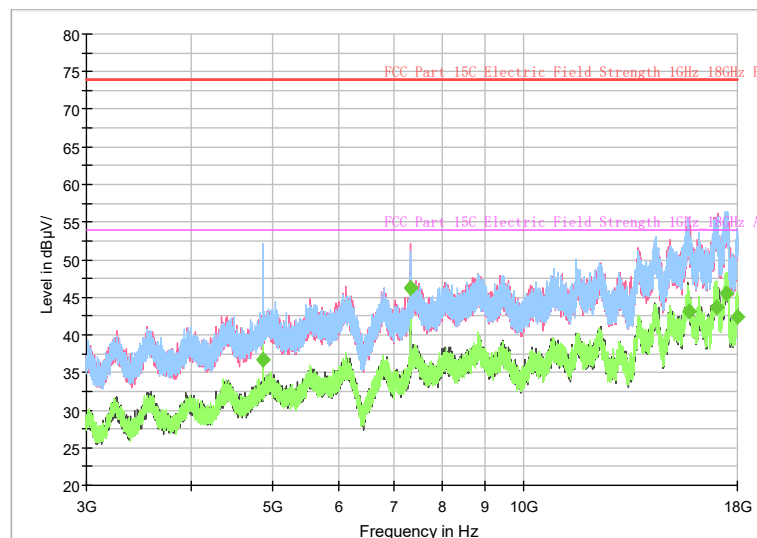
Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4805.10	---	62.30	---	41.30	54.00	12.70	125.20	H	244.00	-21.00
6048.24	---	54.53	---	34.13	54.00	19.87	274.40	V	25.00	-20.40
7204.81	---	70.01	---	48.71	54.00	5.29	297.70	H	150.00	-21.30
13968.07	---	54.00	---	40.30	54.00	13.70	325.00	H	221.00	-13.70
15687.56	---	54.43	---	40.83	54.00	13.17	180.30	V	288.00	-13.60
17142.44	---	52.86	---	41.26	54.00	12.74	190.30	V	257.00	-11.60

CH Middle (No.19)

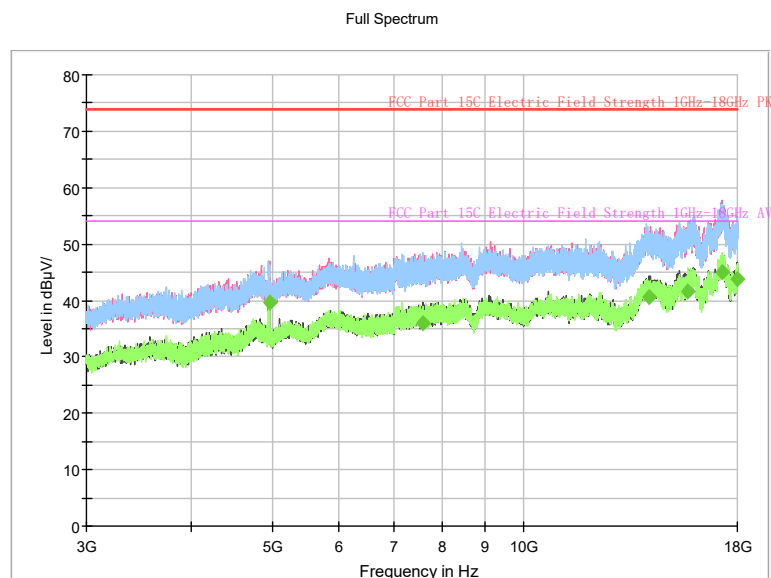
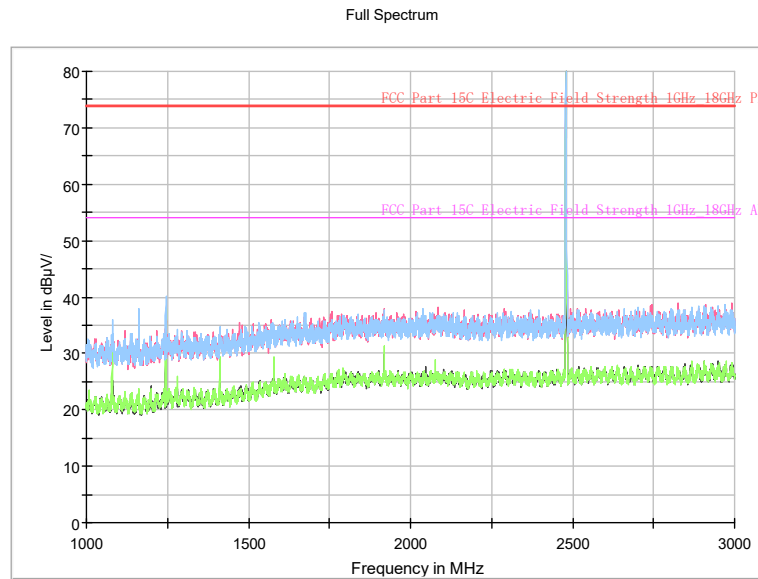
Full Spectrum



Full Spectrum



Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4879.13	---	68.50	---	46.90	54.00	7.10	207.50	H	77.00	-21.60
7318.56	---	65.80	---	44.60	54.00	9.40	186.00	H	110.00	-21.20
15732.91	---	60.63	---	46.93	54.00	7.07	319.00	V	166.00	-13.70
17026.67	---	59.08	---	47.08	54.00	6.92	124.90	H	290.00	-12.00
17475.30	---	59.65	---	48.25	54.00	5.75	101.10	H	335.00	-11.40
17987.09	---	55.06	---	45.66	54.00	8.34	112.60	H	111.00	-9.40

CH Highest (No.39)


Frequency (MHz)	MaxPeak Reading (dBuV/m)	Average Reading (dBuV/m)	MaxPeak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4961.07	---	62.04	---	39.74	54.00	14.26	280.30	H	166.00	-22.30
7564.40	---	57.18	---	36.08	54.00	17.92	298.30	V	293.00	-21.10
14137.24	---	54.27	---	40.67	54.00	13.33	174.80	V	179.00	-13.60
15712.13	---	55.36	---	41.66	54.00	12.34	224.80	H	313.00	-13.70
17238.87	---	56.53	---	44.93	54.00	9.07	100.00	H	205.00	-11.60
17970.46	---	53.31	---	43.81	54.00	10.19	224.80	V	134.00	-9.50

Spurious Radiated Emissions above 18GHz:

There were no emissions above 18GHz found within 20dB of the limit. Thus, the test result was not reported according to §15.31 (o)

3.6.5. Uncertainty

Frequency	Antenna Polarization	Distance	U_{lab}	k
30MHz-200MHz	Horizontal	3m	4.58	2
	Vertical	3m	4.73	2
200MHz-1GHz	Horizontal	3m	4.90	2
	Vertical	3m	4.93	2
1GHz-6GHz	--	3m	4.66	2
6GHz-18GHz	--	3m	5.14	2
18GHz-26GHz	--	3m	4.80	2

3.7 AC Power Line Conducted Emission

3.7.1. Limit

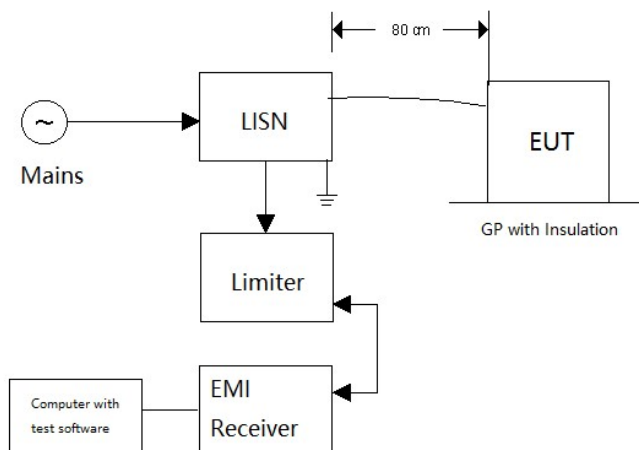
FCC 47 CFR Part 15 Subpart C - §15.207

ISED RSS-Gen - §8.8

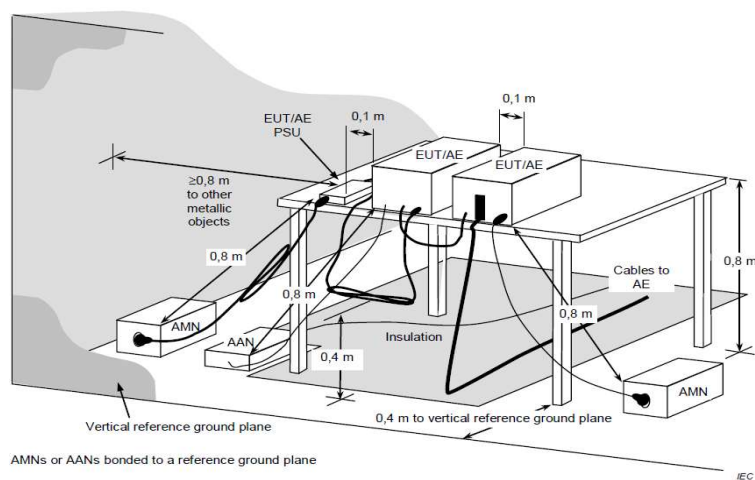
Frequency of Emission (MHz)	Conducted Limit (dBμV)	
	Quasi-peak	Average
0.15 - 0.50	66 - 56	56 - 46
0.50 - 5	56	46
5 - 30	60	50

Note: The limits decrease linearly with the logarithm of the frequency in the range of 0.15MHz to 0.5MHz

3.7.2. Test Setup



Test Connection Diagram



Typical Test Layout

3.7.3. Test Procedures

- 1) The measurement procedure follows ANSI C63.10-2013, clause 6.2;
- 2) The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50ohm/50uH of coupling impedance for the measuring instrument;
- 3) Both lines of the power mains connected to the EUT were checked for maximum conducted interference;
- 4) The frequency range from 150kHz to 30MHz was searched. Emission levels under limit -20dB were not recorded;
- 5) The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz;
- 6) The EUT shall test under the power AC120V/60Hz.

3.7.4. Test Result

N/A

Note:

This test was not performed since the EUT is only powered by the button battery.

3.7.5. Uncertainty

$U_{lab}=3.0\text{dB}$, $k=2$ ($U_{Cispr}=3.4\text{dB}$)

Determining compliance with the limits shall be based on the results of the compliance measurements, taking into account the considerations on measurement instrumentation uncertainty.

Because U_{lab} is equal to U_{CISPR} (as specified in CISPR16-4-2), then:

-compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;

-non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit;

4 Test Instruments

Description	Model Name	S/N	Manufacturer	Next Cal Date
Spectrum Analyzer	FSV40	101403	R&S	2022/01/12
USB Wideband Power Sensor	U2021XA	MY56120024	Keysight	2022/01/12
RF Control Unit	JS0806-2	1918060196	TONSCEND	2022/01/12
Hybrid Antenna	VULB9163	01266	SCHWARZBECK	2022/07/04
Double Ridged Broadband Horn Antenna	BBHA 9120D	1276	SCHWARZBECK	2022/04/07
Pre-Amplifier	SCU40	2046336	R&S	2022/04/07
Pre-Amplifier	TAP-011858	AP19L806047	TONSCEND	2022/04/07
Pre-Amplifier	PE15A1009	V00140120181115E825	Pasternack Enterprises	2022/01/12
EMI Test Receiver	ESR26	101320	R&S	2022/01/12
Active Loop Antenna	HFH2-Z2	100533	R&S	2022/01/12
Double-Ridged Waveguide Horn Antenna	HF907	100096	R&S	2022/04/07
Broad-Band Horn Antenna	BBHA9170	797	R&S	2022/04/07
Digital Display Temperature and Humidity Recorder	TM320	15082	DICKSON	2022/05/12
Digital Display Temperature and Humidity Recorder	TM320	15080	DICKSON	2022/05/12
Aneroid Barometer	DYM3	00868	Shanghai Boji	2022/05/05

--- End of Test Report ---