

FCC TEST REPORT No. 12/1178	05 November 2012
for 47 CFR Part 15 Subpart C	date of issue

Model name:	Typ-D V4
Product description	Transmitter Module 2.4 Dual FHSS 12-16 channels
FCC ID	W3X2754-11
Applicant	weatronic GmbH, Schmiedestr. 2A, D- 15745 Wildau, Germany
Manufacturer	weatronic GmbH, Schmiedestr. 2A, D- 15745 Wildau, Germany

*The results in this report apply only to the samples tested.
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1 EQUIPMENT UNDER TEST

1.1 Basic description

Equipment Category	Transceiver
Test item description	Transmitter Module 2.4 Dual FHSS 12-16 channels
Model name	Typ-D V4
Serial numbers	30120900002

1.2 Technical characteristics declared by manufacturer

Frequency range	2,400 GHz - 2,4835 GHz
Number of transceivers	2 (two separate transmitters and receivers Tx1 and Tx2)
Number of channels (hopping frequencies)	15 (Tx1) 66 (Tx2)
Carrier frequency of each channel	2401 + n×1 MHz, n= 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70 (Tx1) 2401 + n×1 MHz, n=1...80 except n= 5, 10, 15, 20, 25, 30, 35, 40, 45, 50. 55, 60, 65, 70 (Tx2)
Channel spacing	5 MHz (Tx1)
Channel spacing	1 MHz (Tx2)
Maximum output power	20 dBm (100 mW)
Modulation form	FHSS
Modulation type	QPSK
Data rate	1 Mbps
Duty cycle (max.)	40 %
Antenna type	2xRHCP patch
Antenna gain	2 dBi
Temperature range	from minus 20 °C to +55 °C
Supply voltage	6 – 10 V DC

1.3 Photos



Figure 1 – Model Typ-D V4. Front view.



Figure 2 – Model Typ-D V4. Back view.

2 GENERAL INFORMATION ABOUT TESTS

2.1 Test program and results of the tests

Number of test	FCC rule	Description of test	Result (Pass, Fail, N/A)
1	FCC § 15.247 (a)(1) IC RSS-210 A 8.1(b)	Hopping channel separation	Pass
2	FCC § 15.247 (a)(1)(iii) IC RSS-210 A 8.1(b)	Number of hopping frequencies used	Pass
3	FCC § 15.247 (a)(1) IC RSS-210 A 8.2 (a)	Hopping channel bandwidth	Pass
4	FCC § 15.247 (a)(1)(iii) IC RSS-210	Dwell time of each frequency	Pass
5	FCC § 15.247 (b)(1) IC RSS-210 A 8.4 (2)	Output power	Pass
6	FCC § 15.247 (d) IC RSS-210 A 8.5	100 kHz Bandwidth of Frequency Band Edges measurement	Pass
7	FCC § 15.209 IC RSS-210 A 8.5	Radiated Emission from Transmitter Part	Pass
8	FCC § 15.203	Antenna Requirement	Pass
9	FCC § 15.209 IC RSS-210 A 8.5	Radiated Emission from Receiver Part	Pass
10	FCC § 15.247 (h)(i) IC RSS-102 (4.2)	RF exposure	Pass

Tested by:

Laboratory engineer



Boris Trifonov

Laboratory engineer



Maxim Kozub

Checked by:

Leading engineer



Fjodor Shubin

2.2 Test manner

The EUT consists from two identical transmitter chains with two transmitters and two antennas. For organization of connection was used ancillary transceiver Typ-K V2. The test distance of radiated emission from antenna to EUT is 3 m. Methods of measurement - according to ANSI C63.4-2003.

2.3 Test conditions and test modes

Normal temperature and humidity:

- temperature: from +15 °C to +35 °C;
- relative humidity: from 20 % to 75 %

Normal power source:

Unom = 6 VDC.

The frequencies for the testing

Tx, No.	Channel, No.	Frequency, MHz
1	0	2401
2	1	2402
1	35	2436
2	39	2440
1	70	2471
2	80	2481

2.4 Test equipment used

№	Name	Model	Inventory or serial No.
1.	Spectrum analyzer	FSV40	100821
2.	Spectrum analyzer	R&S FSH8	105763
3.	EMI test receiver	R&S ESU-26	100260
4.	Directional coupler	773D	100101
5.	Attenuator	Agilent 8494B	MY42141168
6.	Attenuator	PE7014-10	101692
7.	Antenna	Schwarzbeck UBAA 9114	9111-214
8.	Antenna	HP11966 model 3115	9903-5701
9.	Antenna	VULB9163	9163244
10.	Antenna	ETS-Lindgren 3117	110306
11.	Preamplifier	U3-40	03792
12.	Preamplifier	Agilent 87405C	MY47010400
13.	Preamplifier	BBV 9719	100218
14.	Antenna	BBHA 9170	9170446
15.	Power supply	B5-29	12426
16.	Psychrometer	BHT-2	B931

All listed above test equipment is calibrated and certified in accordance with established procedure. The equipment has certificates currently in force.

Ancillary equipment

№	Name	Model	Serial Number
1.	Servo - mechanism	XT Mini Blue 07 4220	-
2.	Dual Receiver 2.4 Dual FHSS	Typ-K V2	370120720021

2.5 Measurement uncertainty

Parameter	Maximum uncertainty
Output power	± 1.3 dB
Frequency range	$\pm 1 \times 10^{-5}$
Spurious emissions	± 2.7 dB
Radiated Emission	± 4.8 dB
Time	± 3 %
Temperature	± 1 °C
Humidity	± 5 %
DC voltage	± 2 %

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level using a coverage factor of $k=2$.

Measurement uncertainty complies with the requirements of the normative documents and is guaranteed by the test procedures and test equipment.

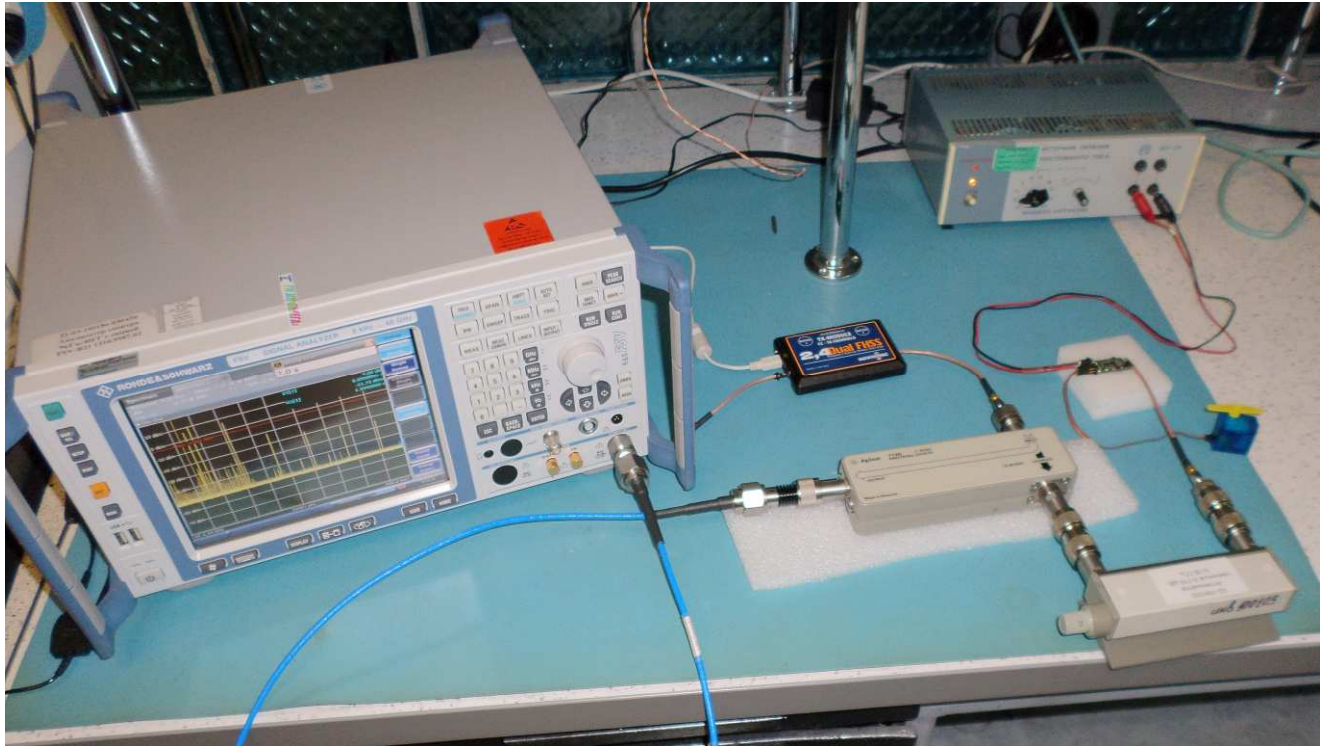


Figure 3 Conducted Test Tx1

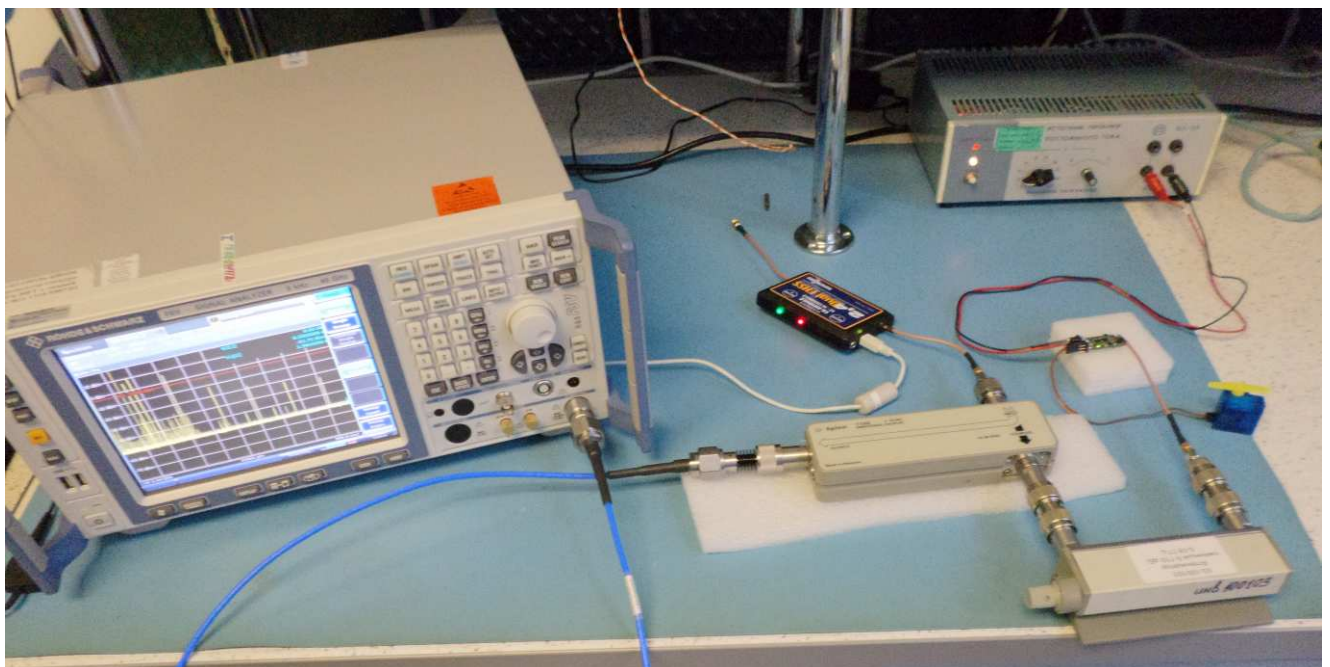


Figure 4 Conducted Test Tx2



Figure 5 Radiated Emission Test

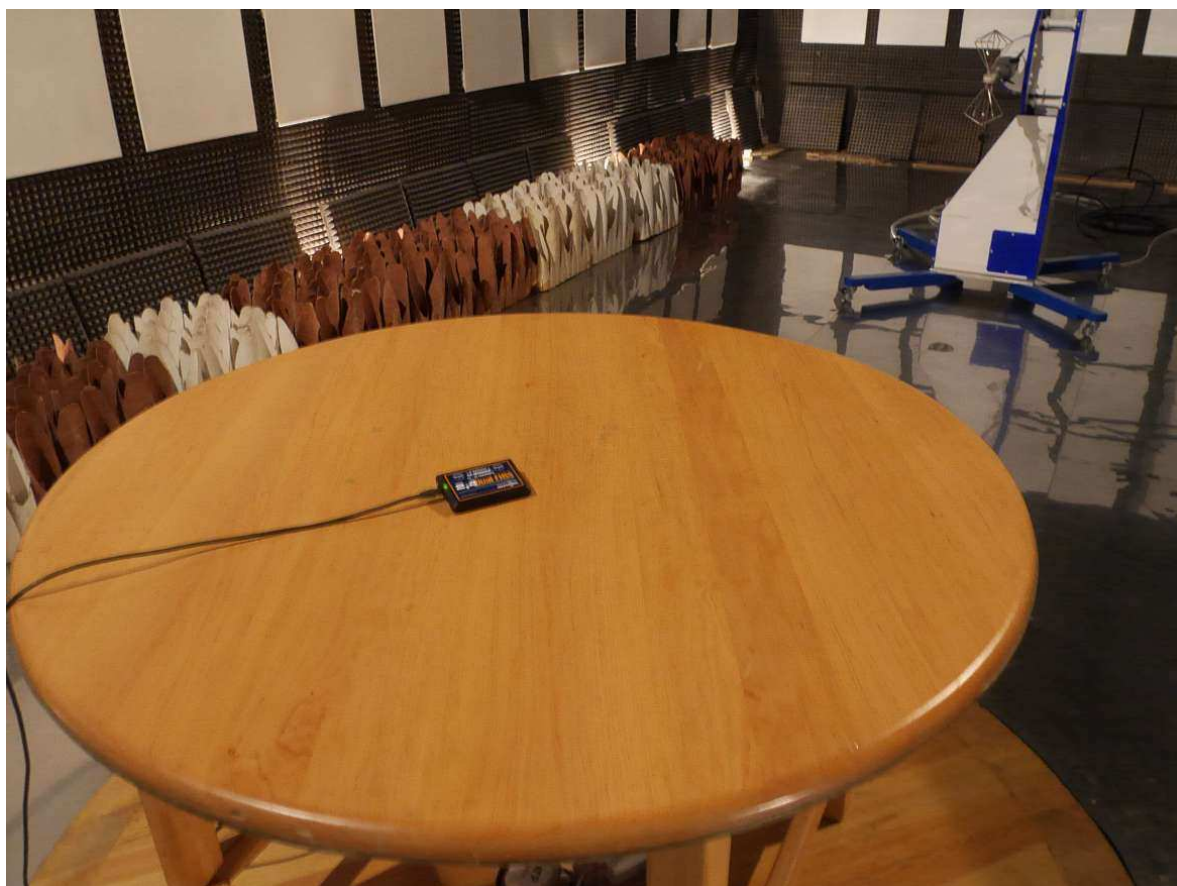


Figure 6 Radiated Emission

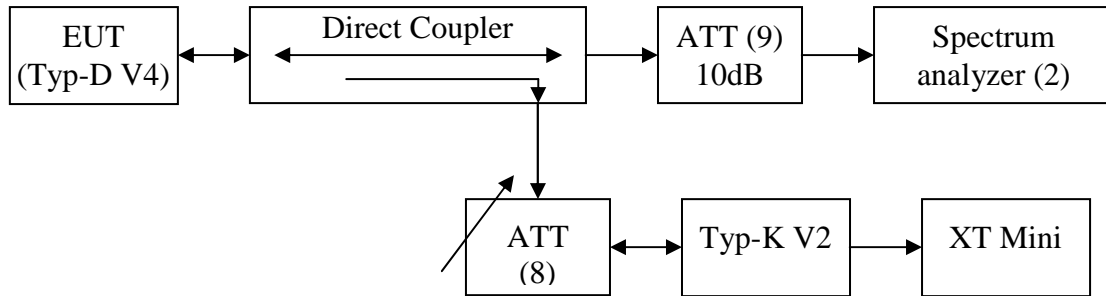
3 REPORT OF MEASUREMENTS AND EXAMINATIONS.

3.1 Hopping channel separation

3.1.1 Test procedure

- 1) The EUT output was connected to the spectrum analyzer according to test setup layout (3.1.2).
- 2) Set RBW of spectrum analyzer to 100 kHz and VBW to 100 kHz.
- 3) The Hopping channel separation is defined as the channel is separated with the next channel.

3.1.2 Test setup layout



3.1.3 Test result

Temperature: +18 °C

Relative humidity: 60 %

Transmitter	Hopping channel separation, MHz	Limit (2/3 of 20dB Bandwidth), kHz	Test Result (Pass, Fail, N/A)
Tx 1	5.003	332	Pass
Tx 2	1.007	332	Pass

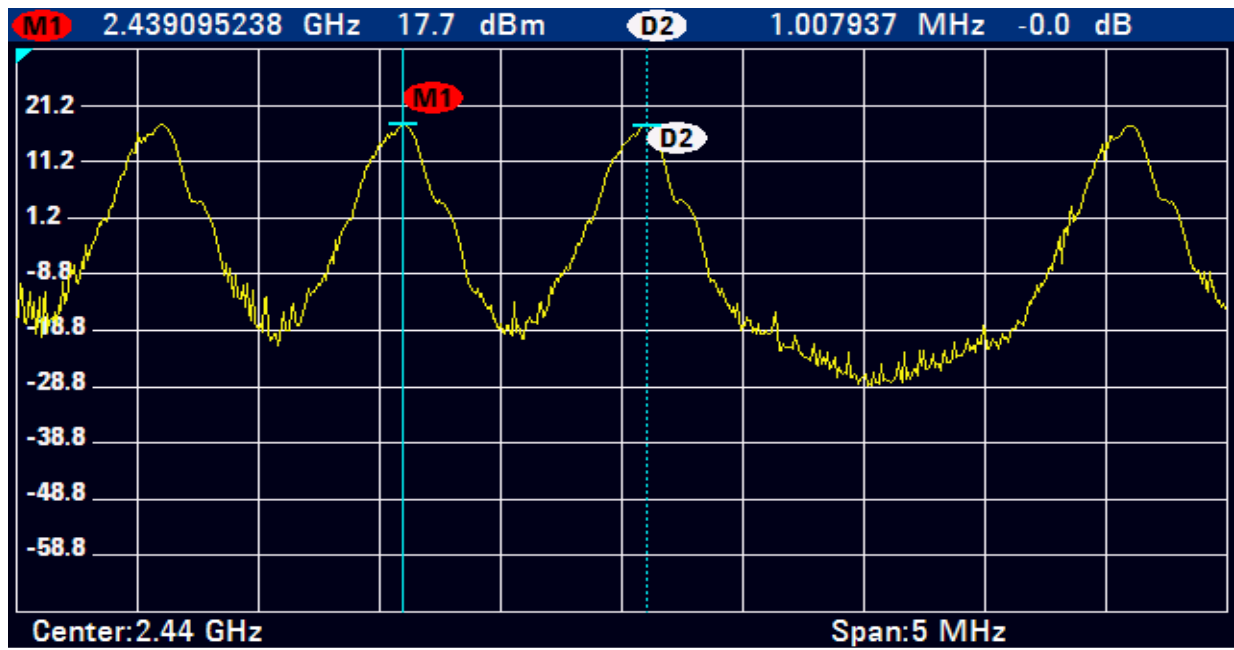
Remark: frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or **two-thirds** of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

3.1.4 Plot Hopping channel separation

Tx 1



Tx 2

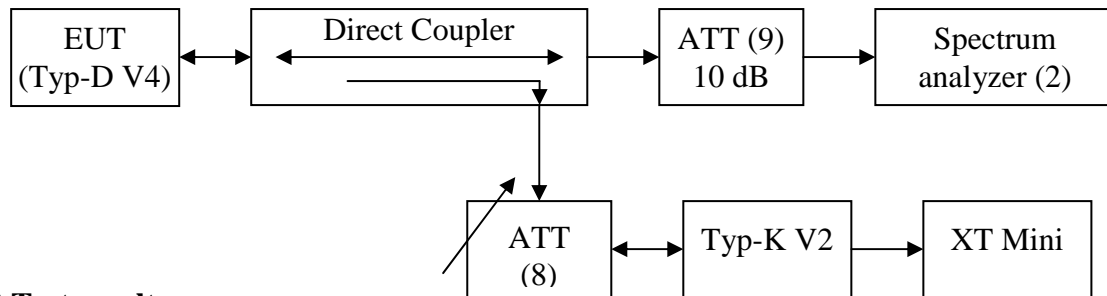


3.2 Number of hopping frequencies used

3.2.1 Test procedure

- 1) The EUT output was connected to the spectrum analyzer according to test setup layout (3.2.2).
- 2) Set RBW of spectrum analyzer to 300 kHz and VBW to 300 kHz.
- 3) The Number of hopping frequencies used is defined as the device has numbers of total channel.

3.2.2 Test setup layout



3.2.3 Test result

Temperature: +18 °C

Relative humidity: 60 %

Tx 1

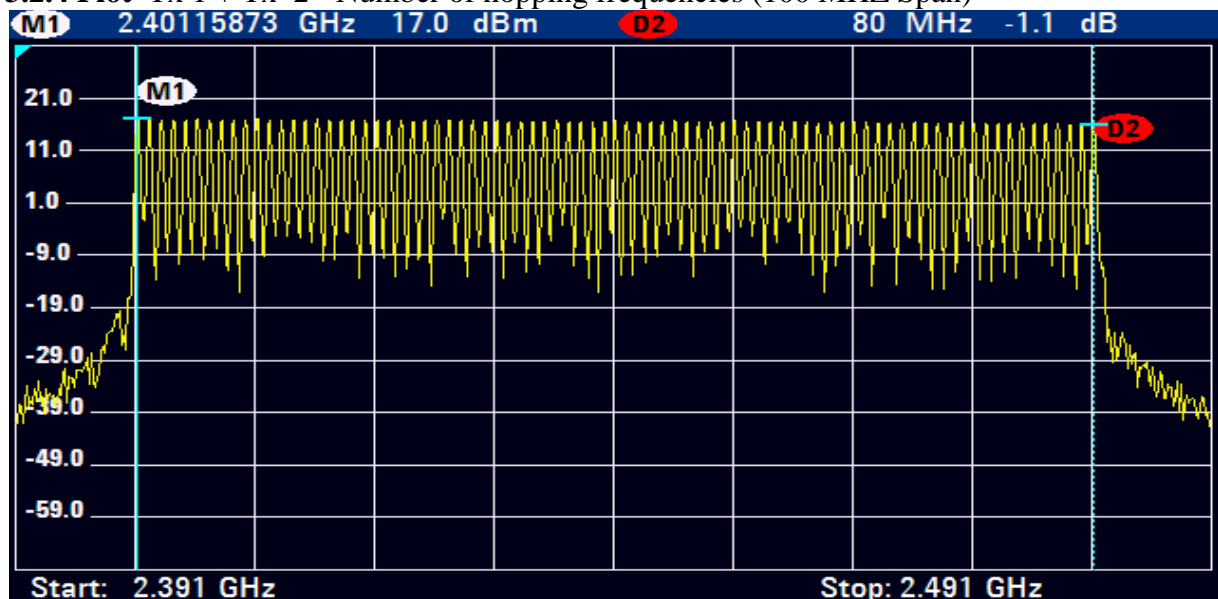
Number of hopping frequencies	Limit	Test Result (Pass, Fail, N/A)
15	15	Pass

Tx 2

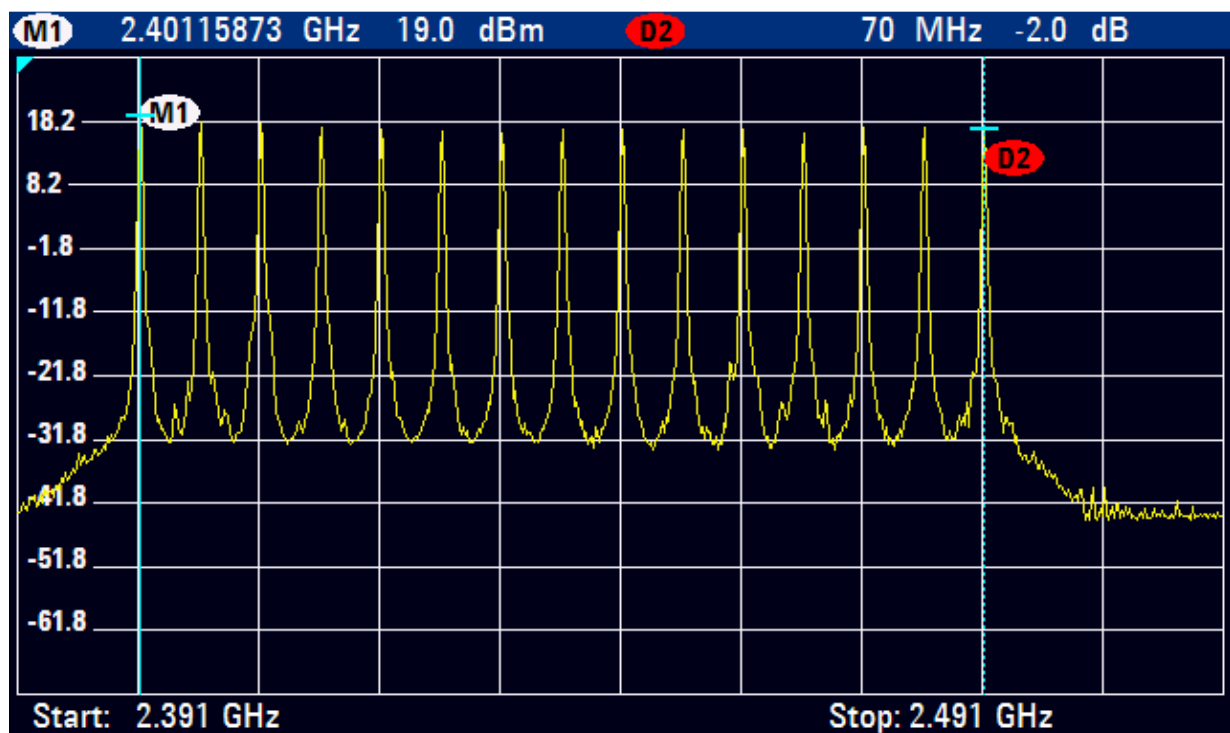
Number of hopping frequencies	Limit	Test Result (Pass, Fail, N/A)
66	15	Pass

Remark: The hopping sequence of a FHSS system is the sequence of the hopping channels used by the equipment. Non-adaptive Frequency Hopping systems shall make use of a hopping sequence(s) that contains at least 15 hopping channels. Adaptive Frequency Hopping systems shall make use of a hopping sequence(s) that is capable of operating over a minimum of 90 % of the band specified in table, from which at any given time a minimum of 20 hopping channels shall be used. Each hopping channel of the hopping sequence shall be occupied at least once during a period not exceeding four times the product of the dwell time per hop and the number of channels.

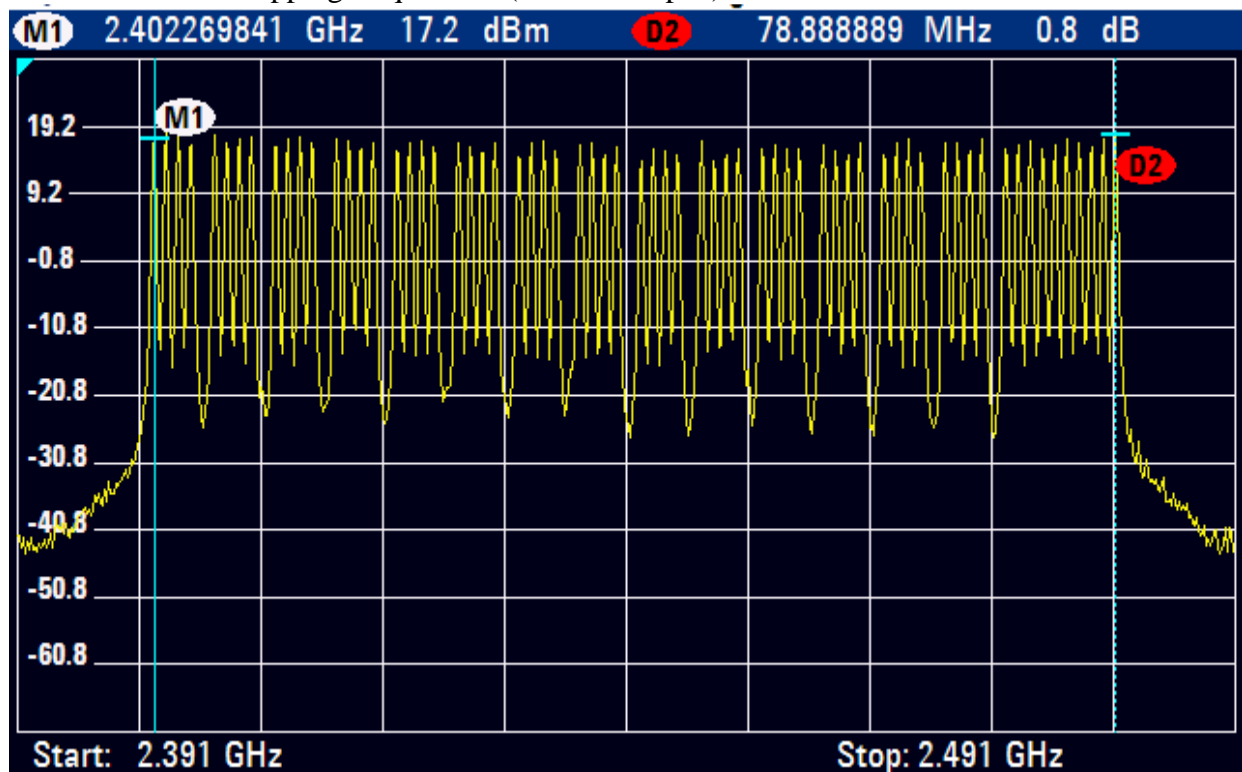
3.2.4 Plot Tx 1 + Tx 2 - Number of hopping frequencies (100 MHz Span)



Tx 1 - Number of hopping frequencies (100 MHz Span)



Tx 2 - Number of hopping frequencies (100 MHz Span)

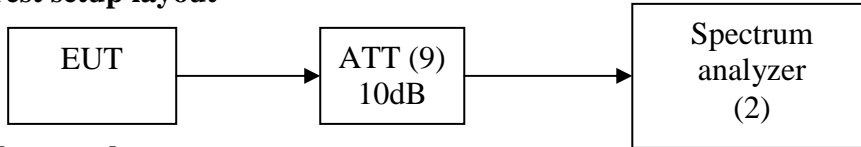


3.3 Hopping channel bandwidth

3.3.1 Test procedure

- 1) The ETU output was connected to the spectrum analyzer via attenuator.
- 2) Set RBW of spectrum analyzer to 100 kHz and VBW to 100 kHz.
- 3) The Hopping channel bandwidth is defined as the frequency range where the power is higher than peak power minus 20 dB.

3.3.2 Test setup layout



3.3.3 Test result

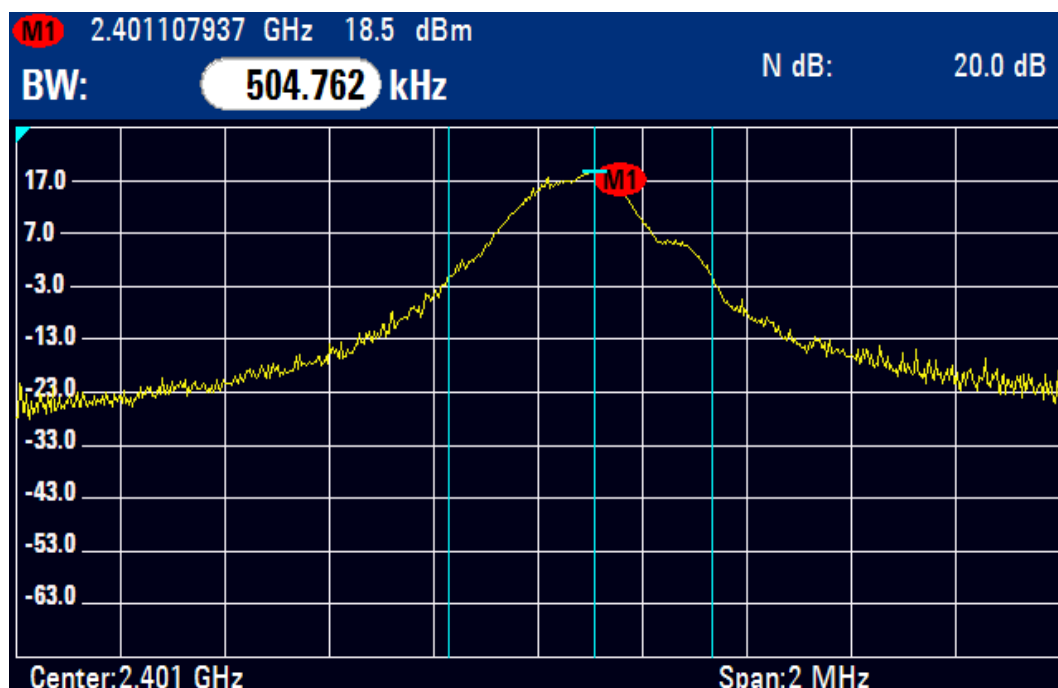
Temperature: +18 °C

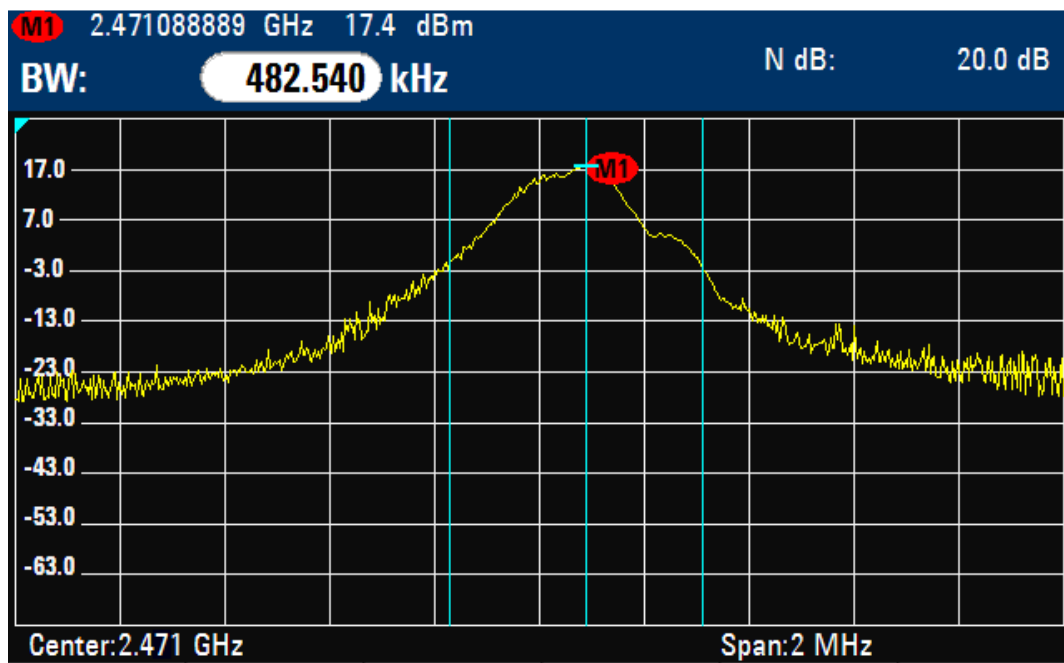
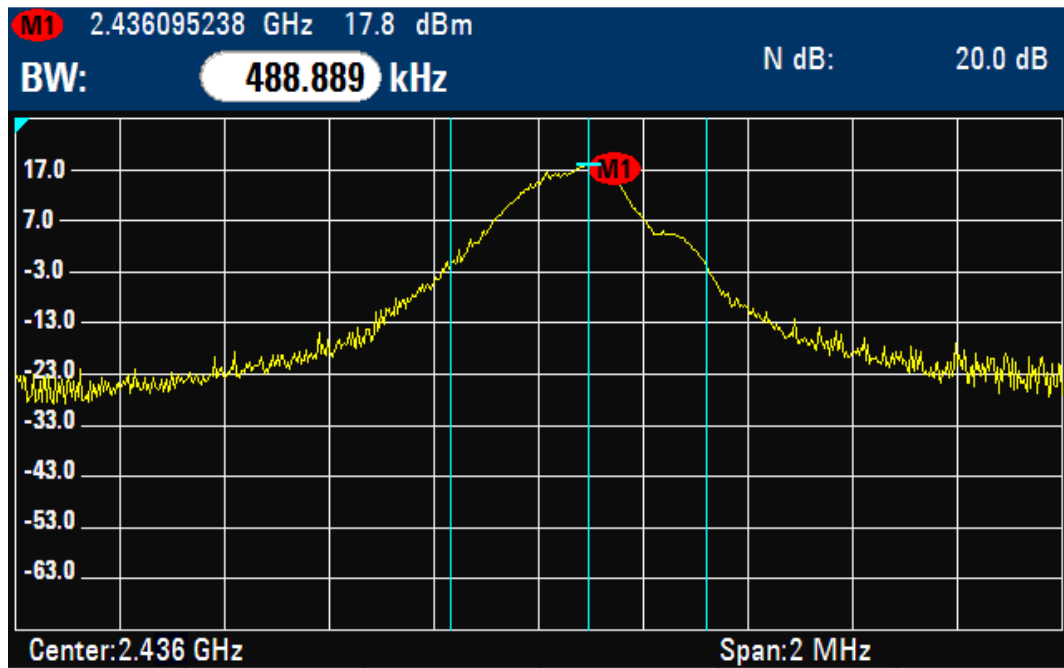
Relative humidity: 60 %

Channel	Frequency, MHz	Hopping channel bandwidth, MHz		Limit, MHz	Test Result (Pass, Fail, N/A)
		Tx 1	Tx 2		
0	2401	0.505	-	1.0	Pass
1	2402	-	0.483	1.0	Pass
35	2436	0.489	-	1.0	Pass
39	2440	-	0.498	1.0	Pass
70	2471	0.483	-	1.0	Pass
80	2481	-	0.495	1.0	Pass

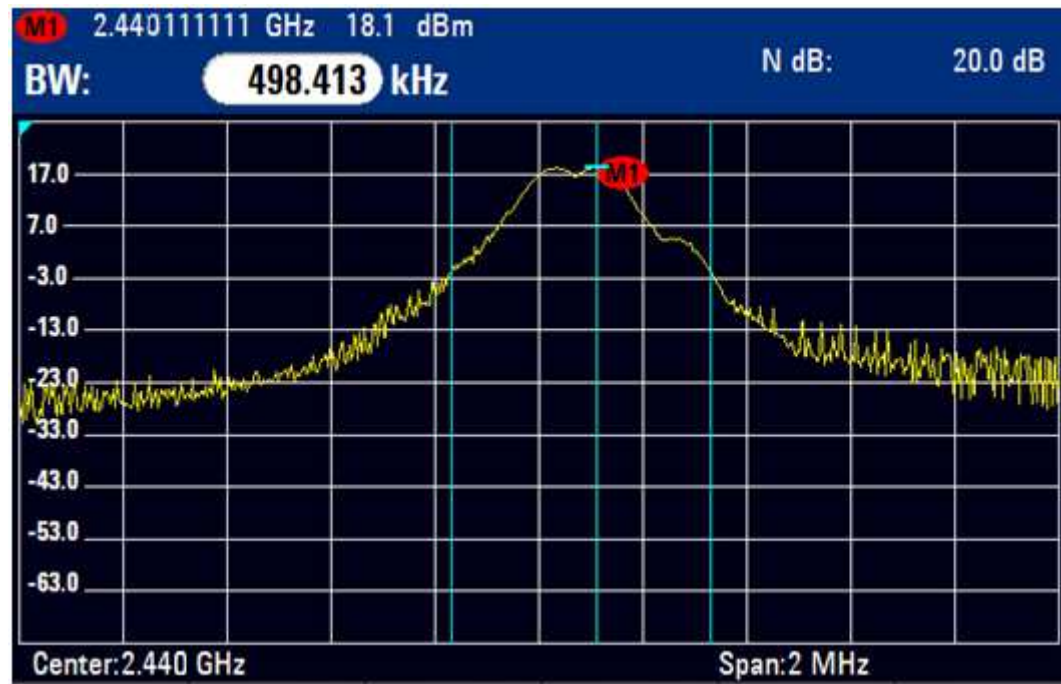
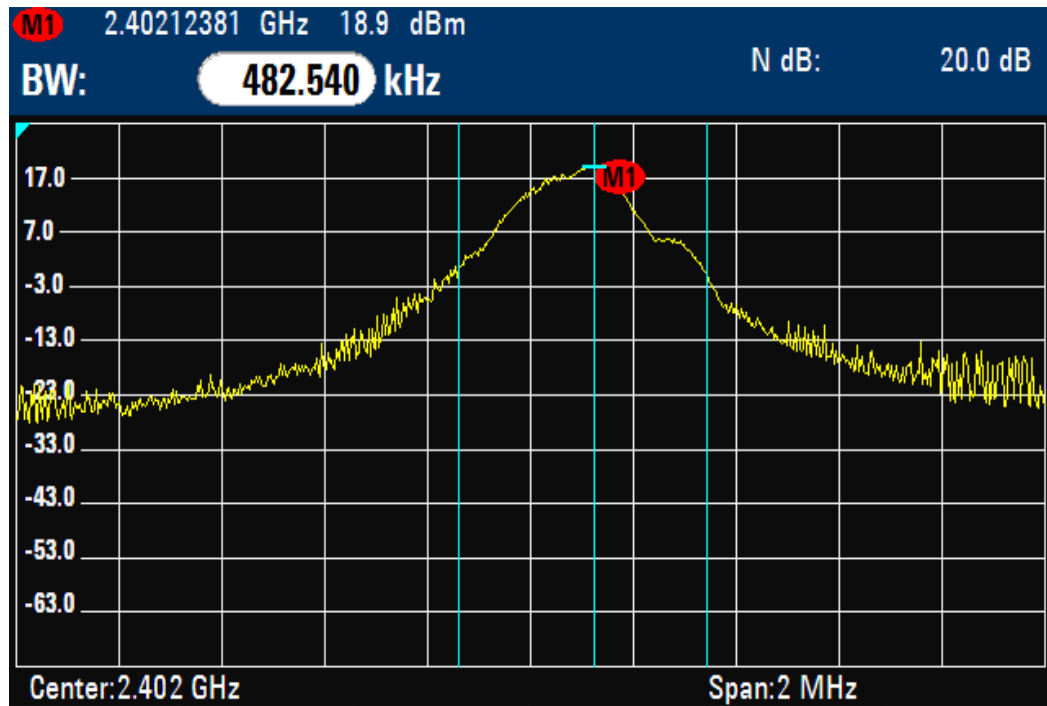
Remark: Non-adaptive Frequency Hopping systems shall make use of non-overlapping hopping channels separated by the channel bandwidth as measured at 20 dB below peak power.
The hopping channels defined within a hopping sequence shall be at least 1 MHz apart (channel separation).

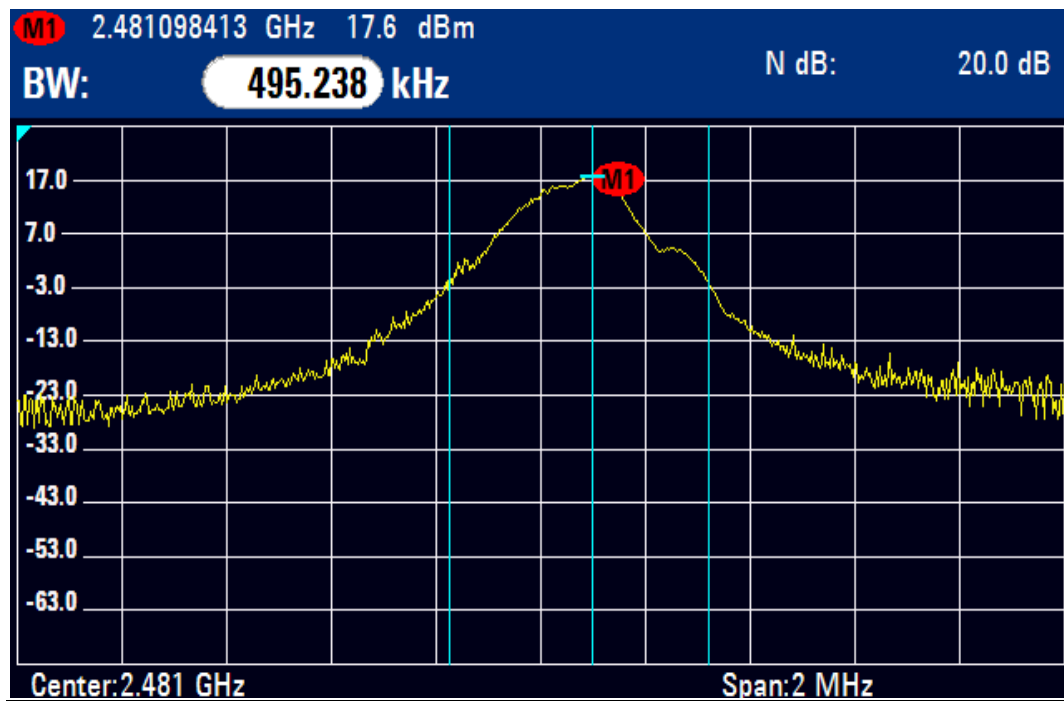
3.3.4 Plot Tx 1 Channel bandwidth





3.3.5 Plot Tx 2 Channel bandwidth



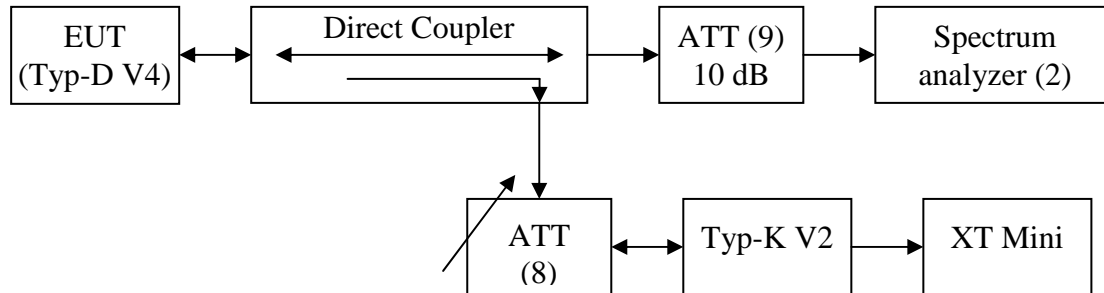


3.4 Dwell Time of Each Frequency

3.4.1 Test procedure

- 1) The EUT output was connected to the spectrum analyzer according to test setup layout (3.4.2).
- 2) Set RBW of spectrum analyzer to 1 MHz and VBW to 1 MHz.
- 3) Set the center frequency on any frequency would be measured and set the frequency span to zero span.

3.4.2 Test setup layout



3.4.3 Test result

Temperature: +18°C

Relative humidity: 60 %

Tx 1

Channels	Pulse width (ms)	Number of 6 sec	Dwell Time, ms	Limit, s	Test Result (Pass, Fail, N/A)
0	2.4444	20	48.888	0.4	Pass
70	2.5079	20	50.158	0.4	Pass

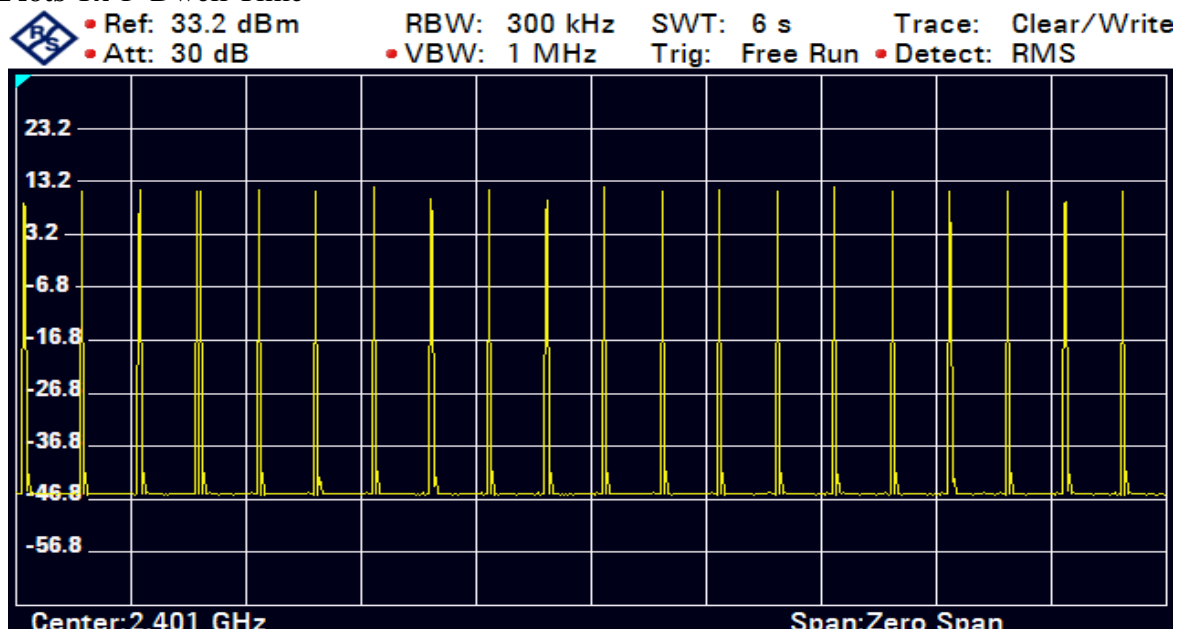
Tx 2

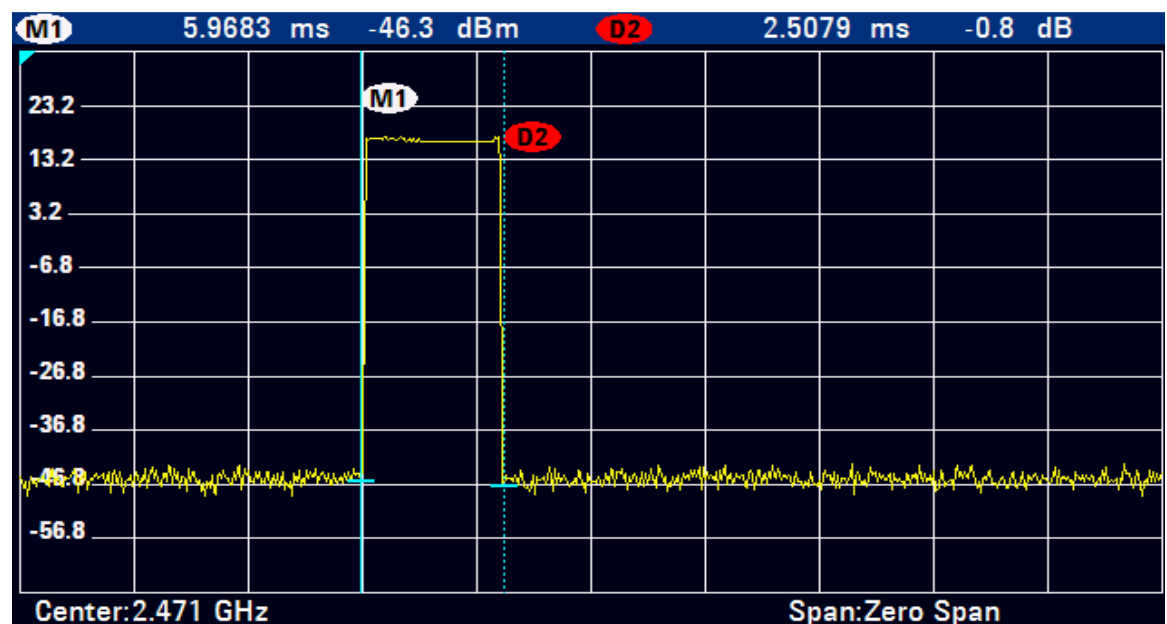
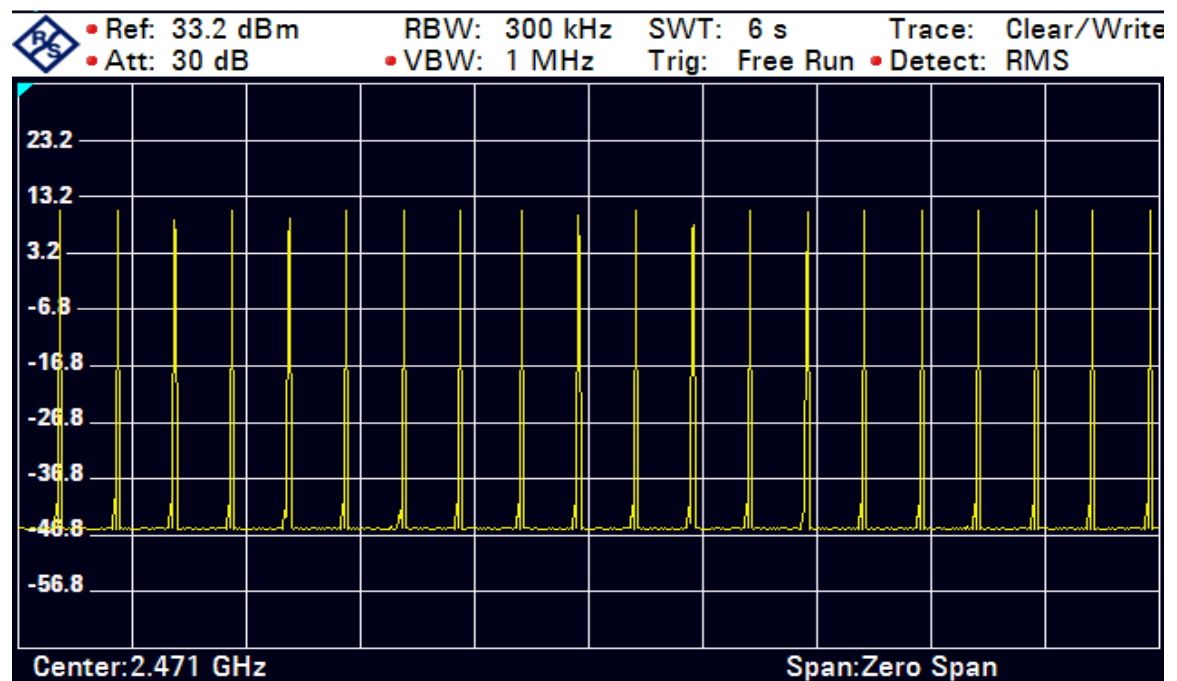
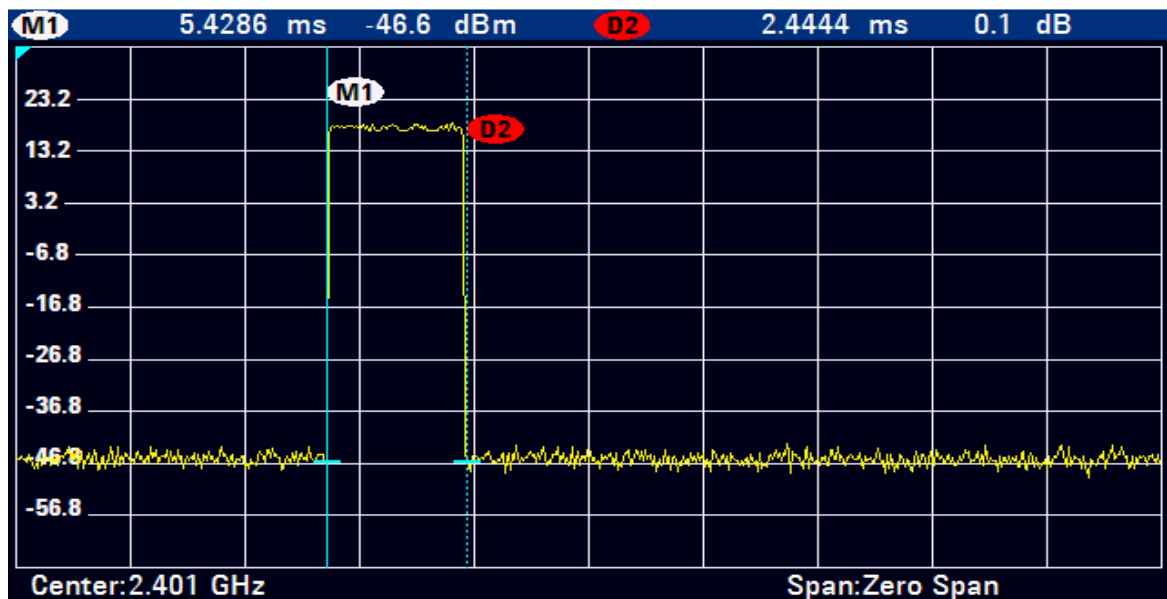
Channels	Pulse width (ms)	Number of 6 sec	Dwell Time, ms	Limit, s	Test Result (Pass, Fail, N/A)
1	2.4762	2	4.952	0.4	Pass
80	2.4762	5	12.381	0.4	Pass

Remark:

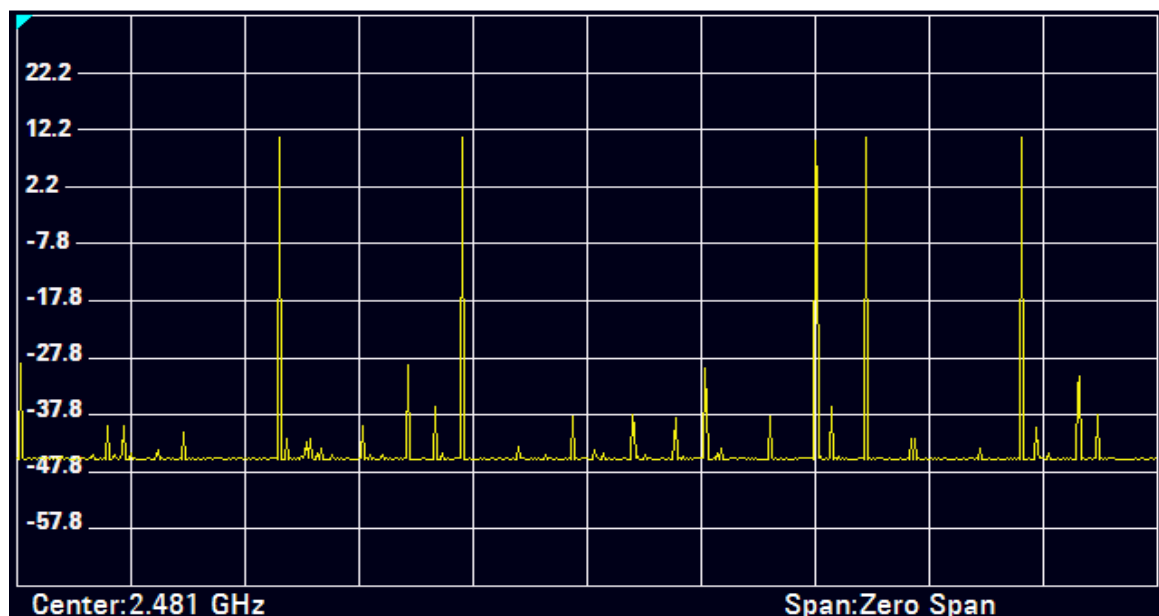
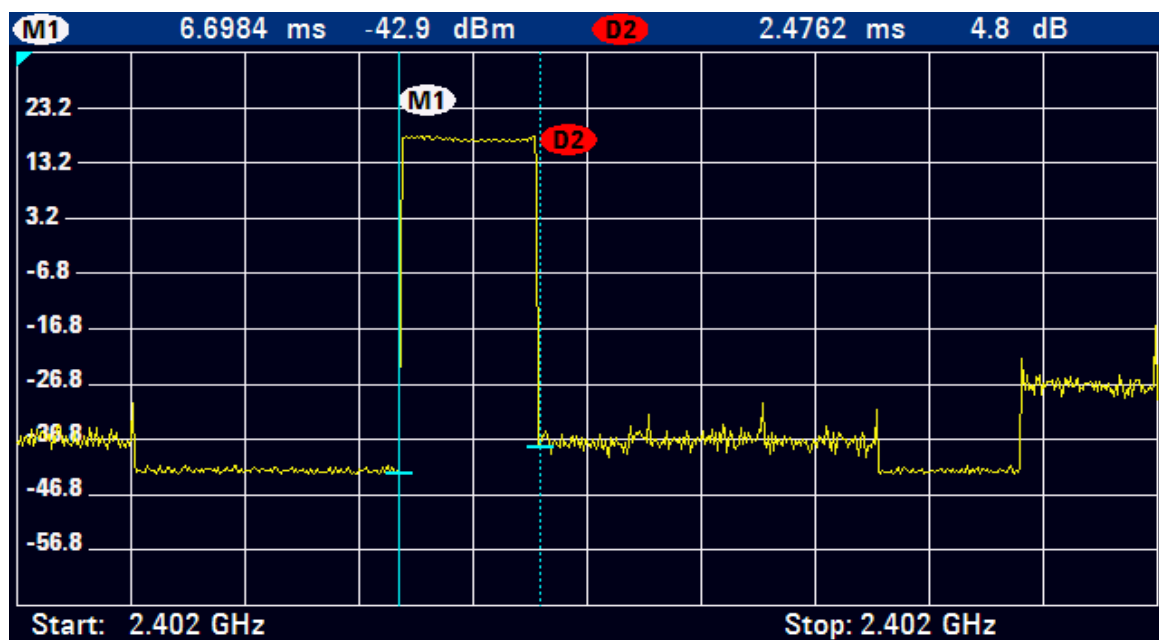
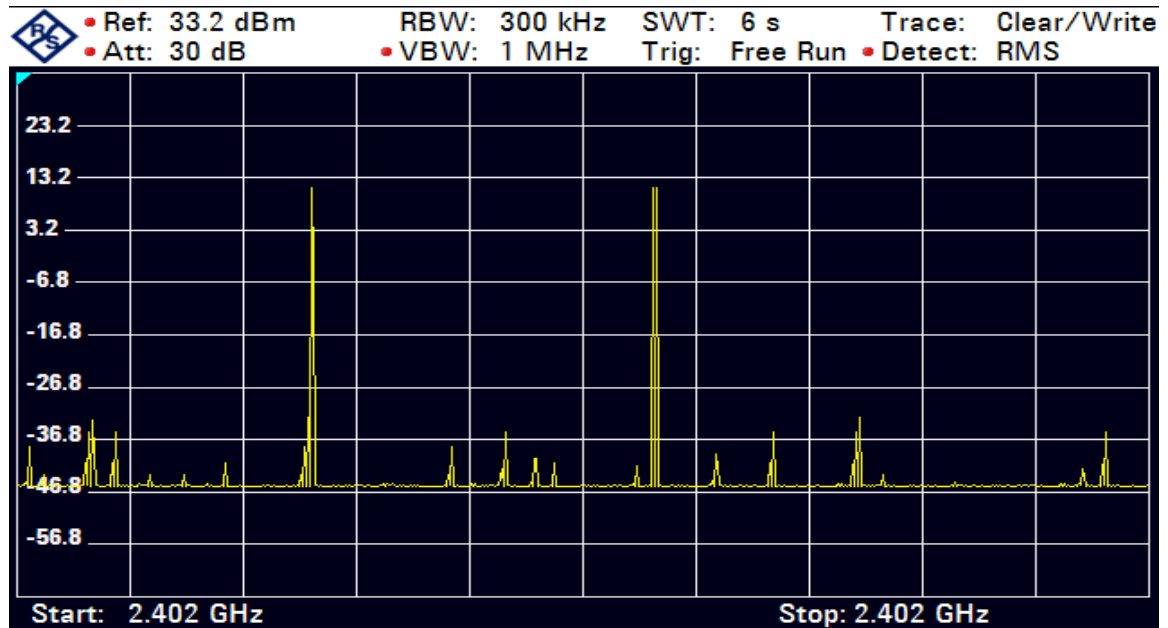
1. Dwell time = pulse width * Number of 6 sec.
2. 6 sec = 0.4 sec * 15 times (Dwell Time * Minimum number of hopping frequencies)

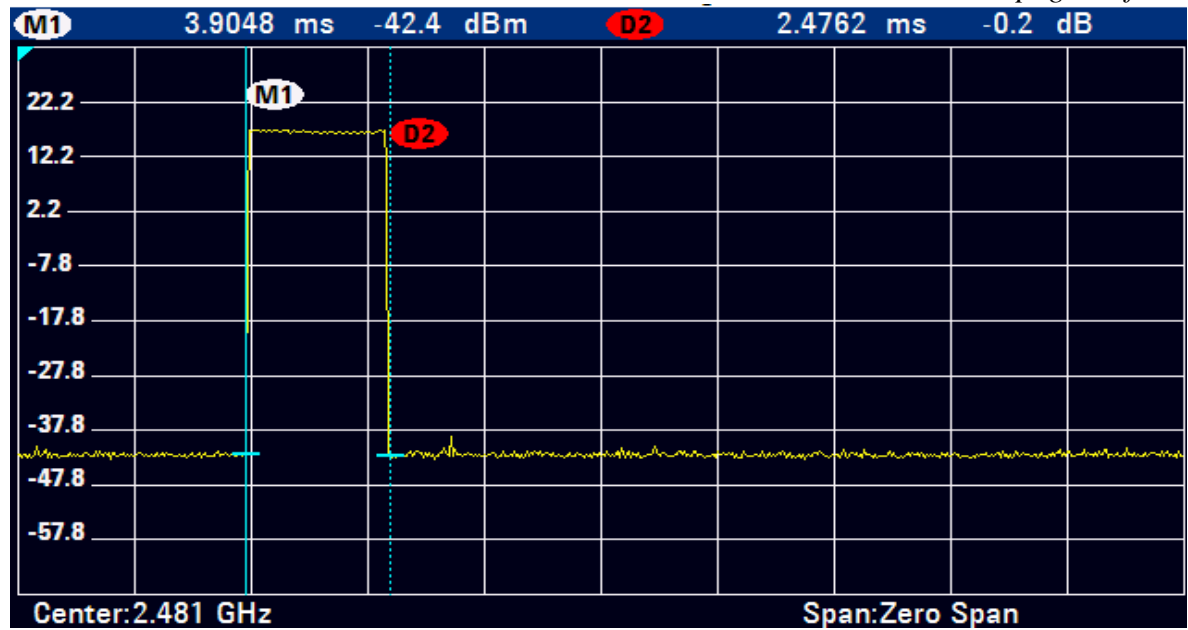
3.4.4 Plots Tx 1 Dwell Time





3.4.5 Plots Tx 2 Dwell Time



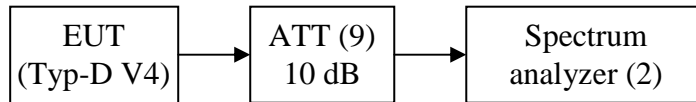


3.5 Output power

3.5.1 Test procedure

- 1) The EUT output was connected to the spectrum analyzer according to test setup layout (3.5.2).
- 2) The center frequency of the spectrum analyzer was set to the fundamental frequency and set RBW to 1 MHz and VBW to 1 MHz.

3.5.2 Test setup layout



3.5.3 Test result

Temperature: +18 °C

Relative humidity: 60 %

Tx 1

Channel	Frequency, MHz	Measured output power, W	Limit, W	Test Result (Pass, Fail, N/A)
0	2401	0.0832	0.125	Pass
35	2436	0.0692	0.125	Pass
70	2471	0.0603	0.125	Pass

Tx 2

Channel	Frequency, MHz	Measured output power, W	Limit, W	Test Result (Pass, Fail, N/A)
1	2401	0.0759	0.125	Pass
39	2440	0.0661	0.125	Pass
80	2481	0.0562	0.125	Pass

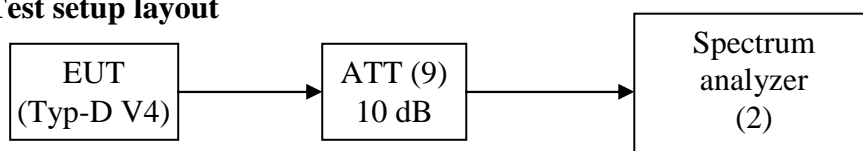
Remark: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2401-2483.5 MHz band: 0,125 watts.

3.6 100 kHz Bandwidth of Frequency Band Edges measurement

3.6.1 Test procedure

The transmitter output was connected to the spectrum analyzer via attenuator. Set both RBW and VBW of spectrum analyzer to 100 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded. The spectrum plots (Peak RBW=VBW=100 kHz) are attached on the following pages.

3.6.2 Test setup layout



3.6.3 Test result

Temperature: +18°C

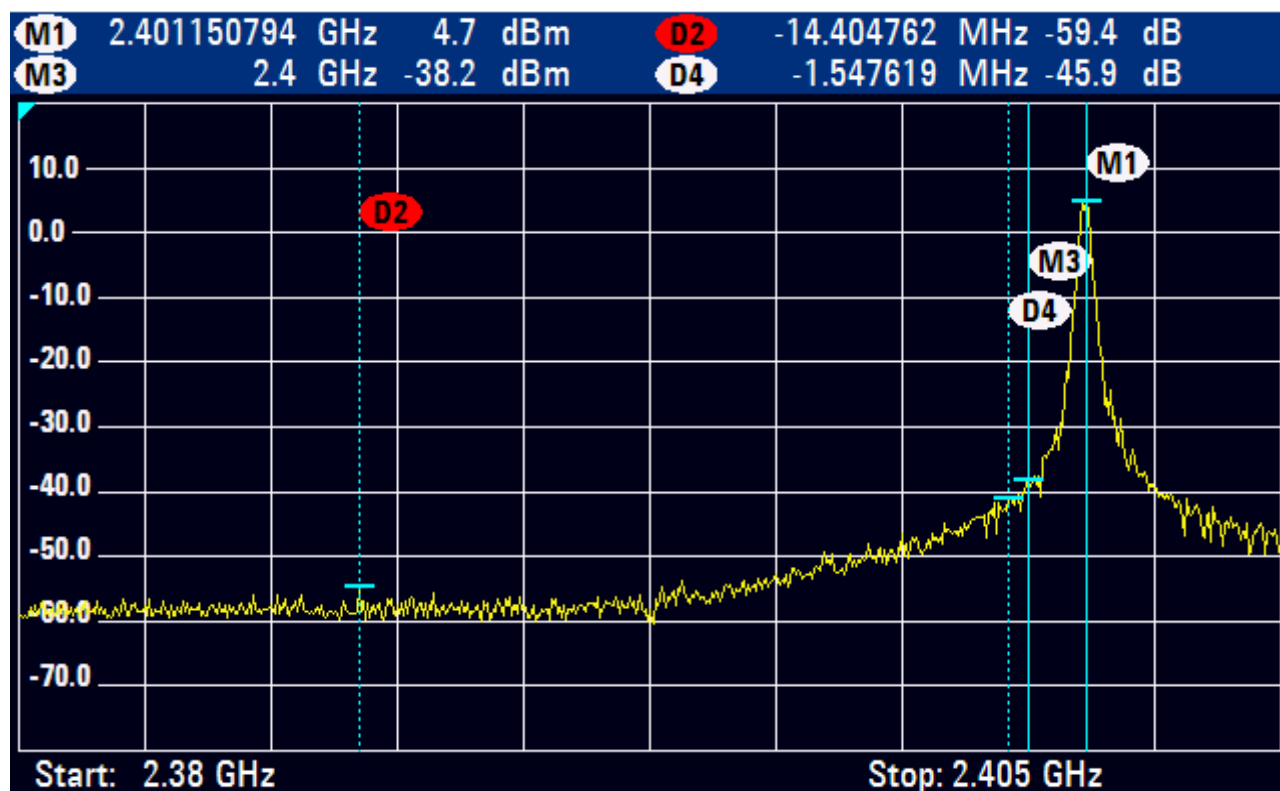
Relative humidity: 60

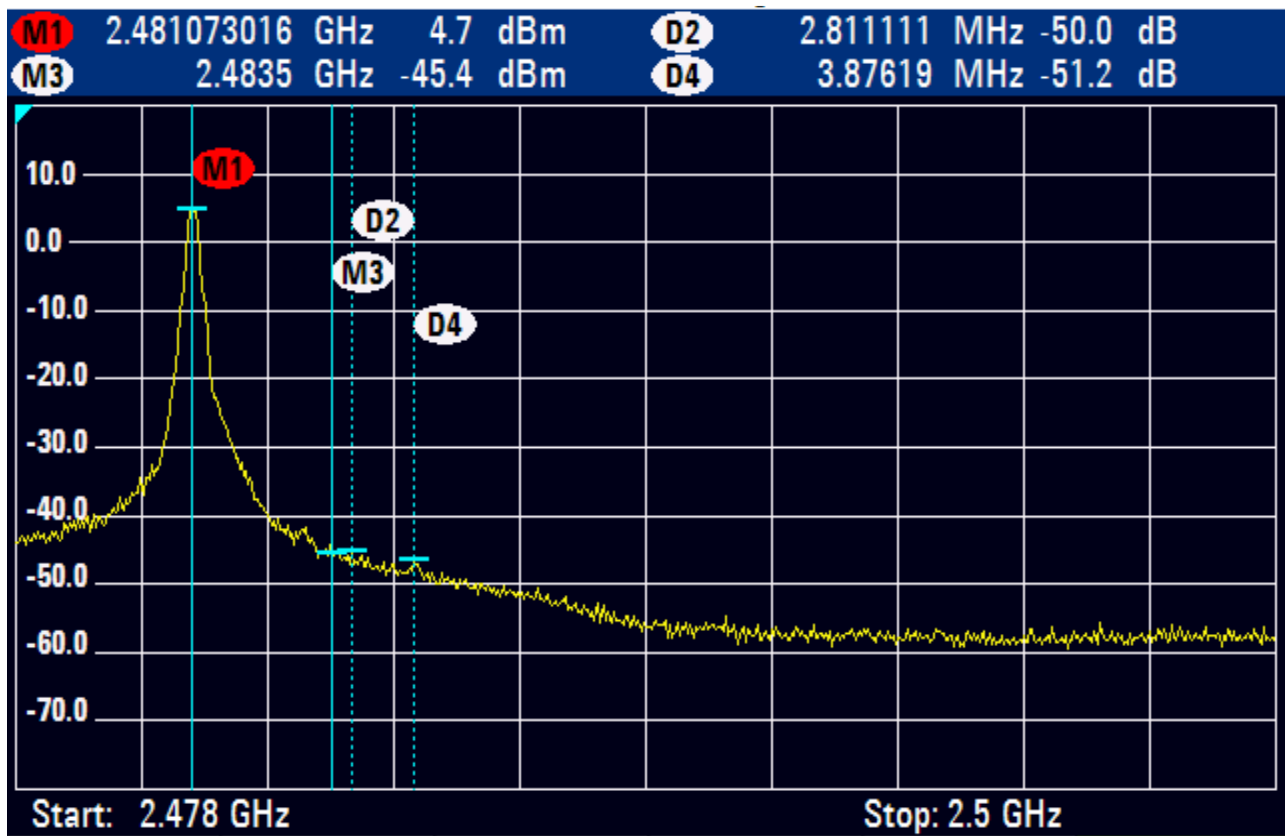
Frequency, MHz	Measured, dBm	Limit, dBm	Test Result (Pass, Fail, N/A)
2386,75	- 59.4	- 20	Pass
2399,60	- 45.9	- 20	Pass
2483,88	- 50.0	- 20	Pass
2484,95	- 51.2	- 20	Pass

Remark:

Below -20 dB of the highest emission level of operating band (in 100 kHz Resolution Bandwidth)

3.6.4 Plots Frequency Band Edges





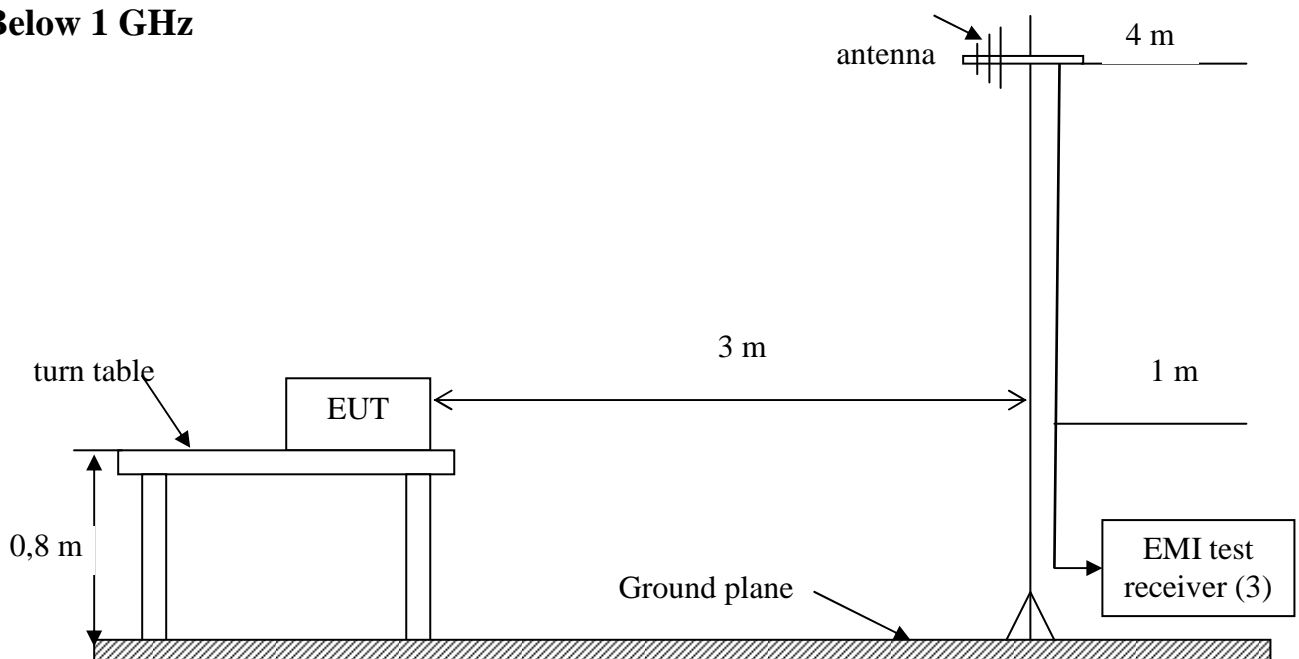
3.7 Radiated Emission from Transmitter Part

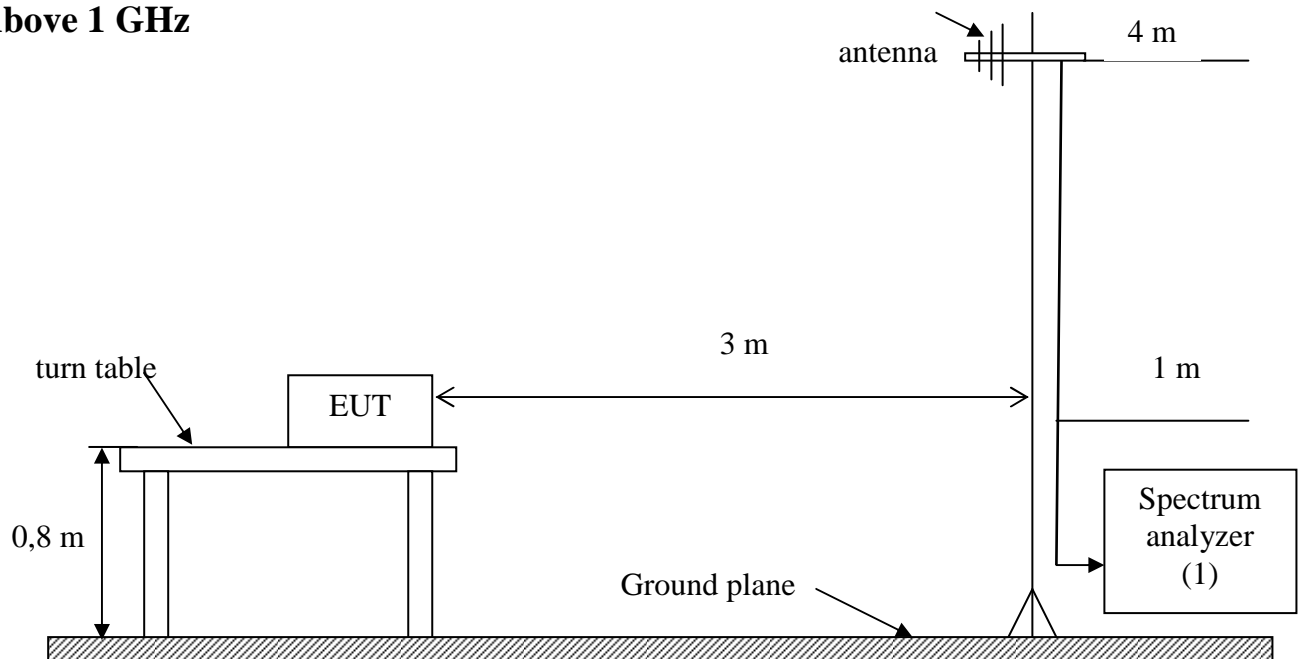
3.7.1 Test procedure

- 1) The EUT was placed on a turn table top 0.8 m above the floor.
- 2) The EUT was set 3 meters from the interference receiving antenna which was mounted on the top of a variable height antenna tower.
- 3) The table was rotated 360 degrees to determine the position of the highest radiation.
- 4) The antenna is a broadband antenna and its height is varied between 1 meter and 4 meters above the floor to find the maximum value of the shield strength for both horizontal polarization and vertical polarization of the antenna.
- 5) For each suspected emission, the EUT was arranged to its worst case.
- 6) On any frequency or frequencies below or equal to 1000 MHz the test-receiver was set to Quasi-peak detector function with specified bandwidth with maximum hold mode.
- 7) On any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function and peak detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to EUT. Measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

3.7.2 Test setup layout

Below 1 GHz





Limits

Frequency (MHz)	Field Strength (dBuV/m at 3-meter)	Field Strength (uV/m at 3-meter)
30-88	40	100
88-216	43.5	150
216-960	46	200
Above 960	54	500

3.7.3 Test result radiated emission from transmitter part

Temperature: +18 °C

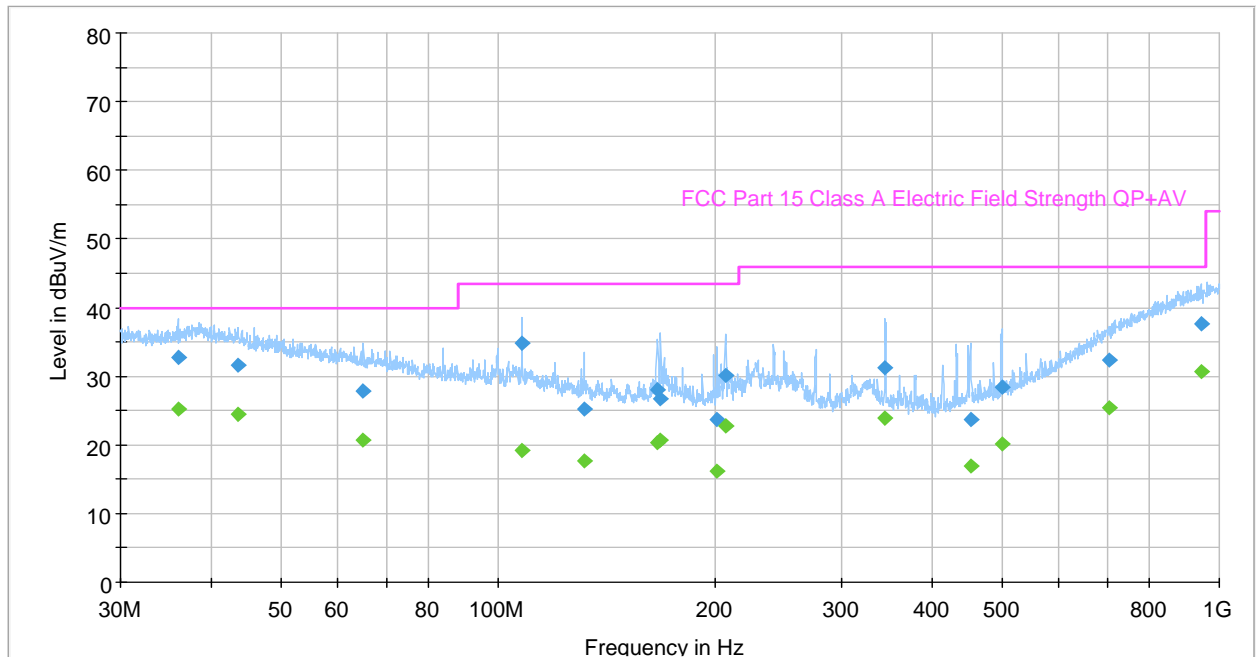
Relative humidity: 60 %

Mode:

Transmitter on

Below 1 GHz**Frequency 2401**

FCC_30_1000

**Final Result 1**

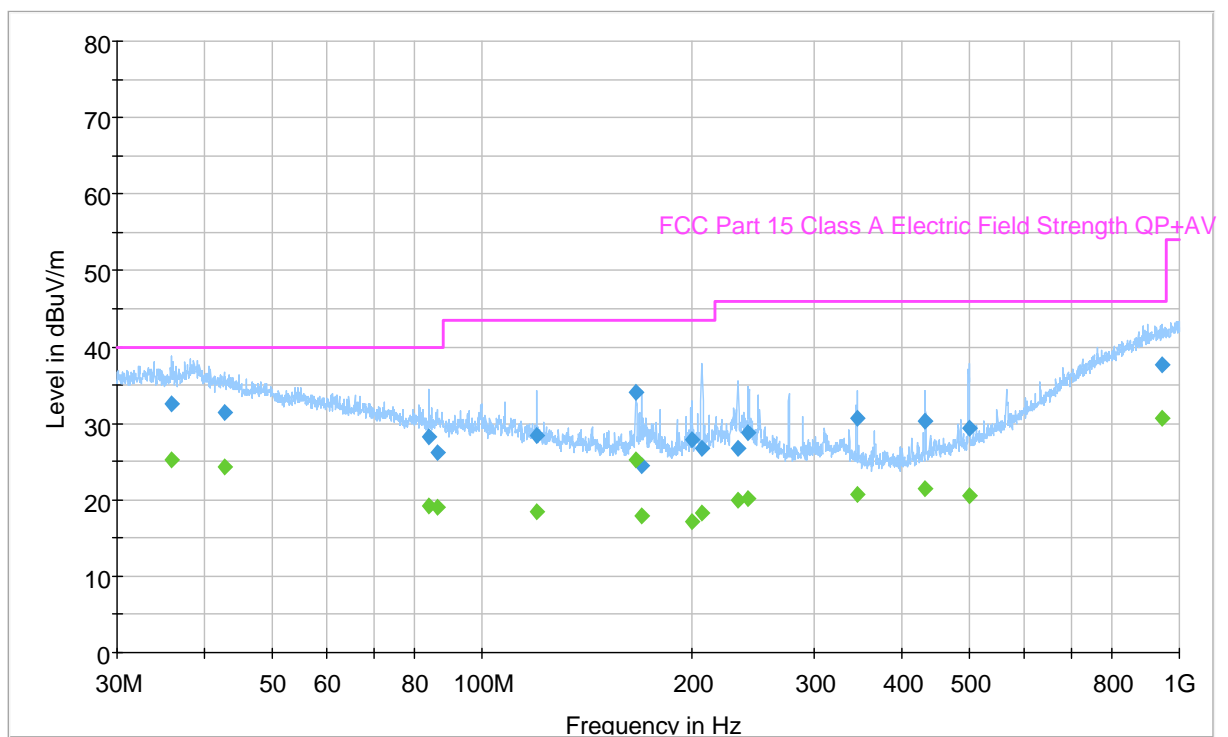
Frequency (MHz)	QuasiPeak (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
36.021138	32.7	100.0	V	35.9	7.3	40.0
43.641564	31.6	100.0	V	35.2	8.4	40.0
65.157645	27.8	200.0	V	32.0	12.2	40.0
108.045973	34.9	400.0	H	28.5	8.6	43.5
131.954462	25.3	100.0	V	27.1	18.2	43.5
166.724034	28.0	100.0	V	26.1	15.5	43.5
168.230566	26.7	100.0	V	26.1	16.8	43.5
200.988263	23.6	100.0	V	25.9	19.9	43.5
206.486085	30.2	100.0	V	25.8	13.3	43.5
344.115616	31.3	100.0	V	24.0	14.7	46.0
452.071922	23.8	100.0	V	25.2	22.2	46.0
500.091369	28.4	100.0	V	26.4	17.6	46.0
702.482811	32.4	100.0	V	35.2	13.6	46.0
942.441672	37.7	100.0	V	40.6	8.3	46.0

Final Result 2

Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
36.021138	25.2	100.0	V	35.9	14.8	40.0
43.641564	24.6	100.0	V	35.2	15.4	40.0
65.157645	20.8	200.0	V	32.0	19.2	40.0
108.045973	19.2	400.0	H	28.5	24.3	43.5
131.954462	17.6	100.0	V	27.1	25.9	43.5
166.724034	20.4	100.0	V	26.1	23.1	43.5
168.230566	20.7	100.0	V	26.1	22.8	43.5
200.988263	16.2	100.0	V	25.9	27.3	43.5
206.486085	22.8	100.0	V	25.8	20.7	43.5
344.115616	24.0	100.0	V	24.0	22.0	46.0
452.071922	16.9	100.0	V	25.2	29.1	46.0
500.091369	20.2	100.0	V	26.4	25.8	46.0
702.482811	25.4	100.0	V	35.2	20.6	46.0
942.441672	30.7	100.0	V	40.6	15.3	46.0

Frequency 2441

FCC_30_1000

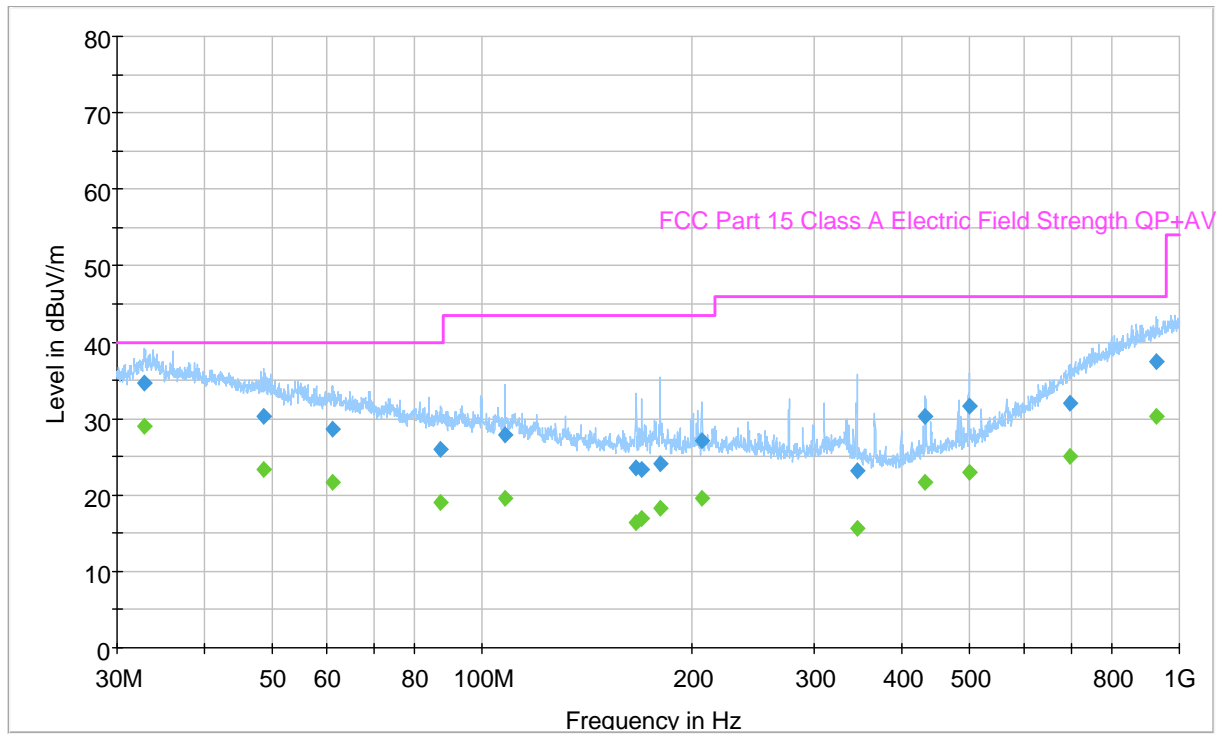


Frequency (MHz)	QuasiPeak (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
35.949204	32.5	100.0	V	35.9	7.5	40.0
42.735096	31.4	400.0	V	35.3	8.6	40.0
83.988739	28.3	300.0	H	30.0	11.7	40.0
86.545279	26.1	100.0	V	29.8	13.9	40.0
120.001512	28.4	100.0	H	27.7	15.1	43.5
166.557476	34.0	100.0	V	26.1	9.5	43.5
169.750712	24.5	100.0	V	26.1	19.0	43.5
200.386503	27.8	100.0	V	25.9	15.7	43.5
207.313269	26.7	100.0	V	25.8	16.8	43.5
233.497546	26.6	100.0	V	25.3	19.4	46.0
240.845603	28.8	100.0	V	25.2	17.2	46.0
345.148996	30.6	200.0	V	24.0	15.4	46.0
431.757579	30.2	100.0	V	24.7	15.8	46.0
500.091369	29.3	200.0	V	26.4	16.7	46.0
945.271825	37.7	400.0	H	40.6	8.3	46.0

Final Result 2

Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
35.949204	25.1	100.0	V	35.9	14.9	40.0
42.735096	24.3	400.0	V	35.3	15.7	40.0
83.988739	19.3	300.0	H	30.0	20.7	40.0
86.545279	19.1	100.0	V	29.8	20.9	40.0
120.001512	18.4	100.0	H	27.7	25.1	43.5
166.557476	25.3	100.0	V	26.1	18.2	43.5
169.750712	17.8	100.0	V	26.1	25.7	43.5
200.386503	17.2	100.0	V	25.9	26.3	43.5
207.313269	18.3	100.0	V	25.8	25.2	43.5
233.497546	19.9	100.0	V	25.3	26.1	46.0
240.845603	20.1	100.0	V	25.2	25.9	46.0
345.148996	20.7	200.0	V	24.0	25.3	46.0
431.757579	21.4	100.0	V	24.7	24.6	46.0
500.091369	20.4	200.0	V	26.4	25.6	46.0
945.271825	30.7	400.0	H	40.6	15.3	46.0

FCC_30_1000



Final Result 1

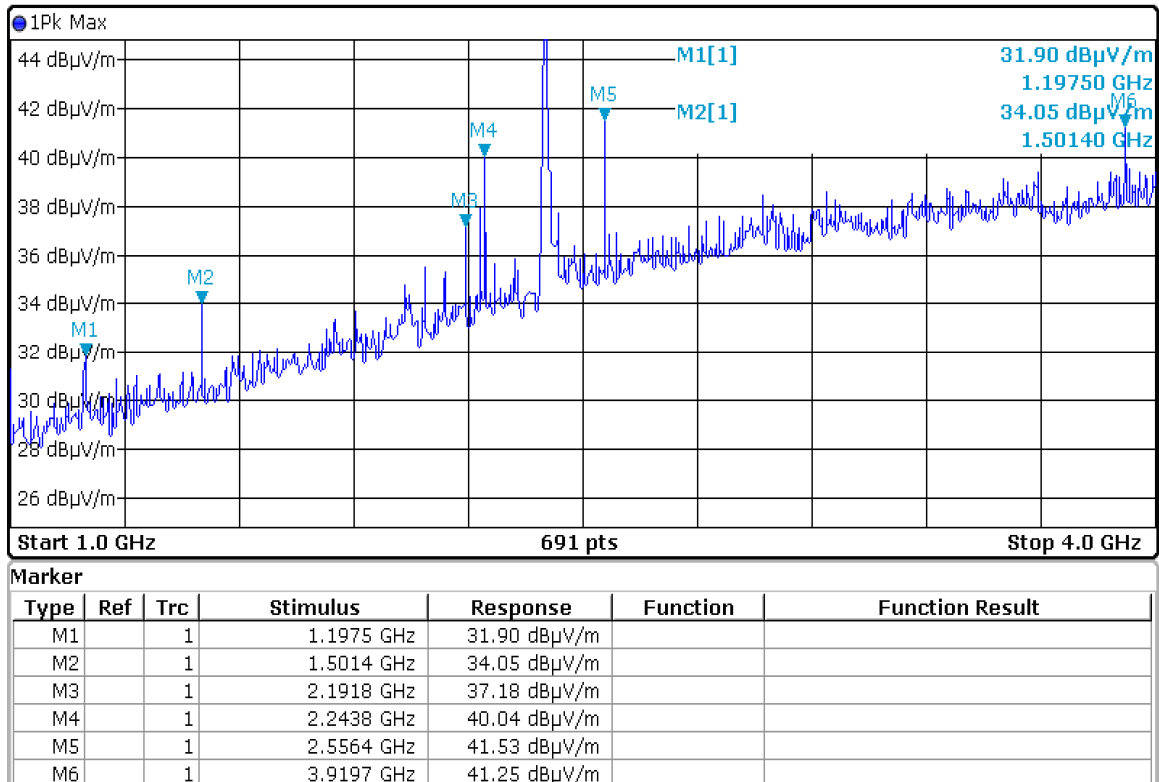
Frequency (MHz)	QuasiPeak (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
32.823752	34.6	100.0	V	36.1	5.4	40.0
48.616163	30.3	100.0	H	34.4	9.7	40.0
61.181271	28.6	300.0	H	32.5	11.4	40.0
87.414637	26.0	400.0	V	29.8	14.0	40.0
107.93803	27.8	200.0	H	28.5	15.7	43.5
166.72403	23.4	100.0	V	26.1	20.1	43.5
169.75071	23.3	100.0	V	26.1	20.2	43.5
180.24210	24.1	200.0	H	26.0	19.4	43.5
206.48608	27.1	100.0	V	25.8	16.4	43.5
345.49414	23.1	100.0	V	24.0	22.9	46.0
431.75757	30.4	100.0	V	24.7	15.6	46.0
499.59177	31.6	100.0	V	26.4	14.4	46.0
697.58504	32.0	100.0	V	35.1	14.0	46.0
926.56344	37.4	100.0	H	40.3	8.6	46.0

Final Result 2

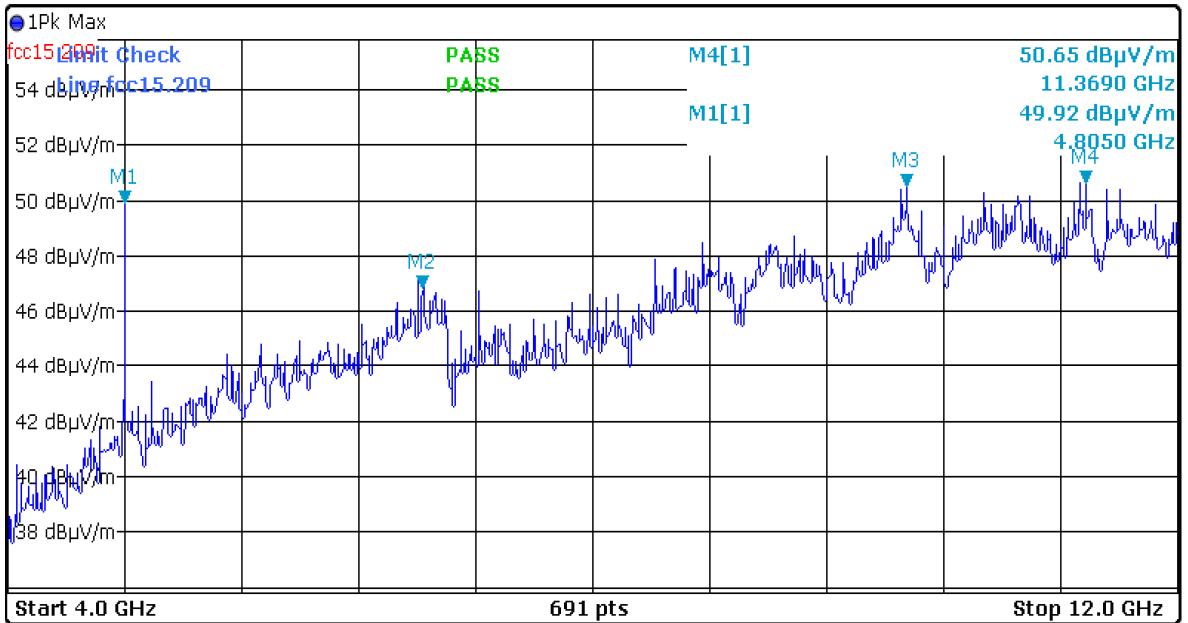
Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
32.823752	29.0	100.0	V	36.1	11.0	40.0
48.616163	23.3	100.0	H	34.4	16.7	40.0
61.181271	21.6	300.0	H	32.5	18.4	40.0
87.414637	19.0	400.0	V	29.8	21.0	40.0
107.938035	19.5	200.0	H	28.5	24.0	43.5
166.724034	16.5	100.0	V	26.1	27.0	43.5
169.750712	16.9	100.0	V	26.1	26.6	43.5
180.242106	18.3	200.0	H	26.0	25.2	43.5
206.486085	19.5	100.0	V	25.8	24.0	43.5
345.494145	15.7	100.0	V	24.0	30.3	46.0
431.757579	21.6	100.0	V	24.7	24.4	46.0
499.591777	22.9	100.0	V	26.4	23.1	46.0
697.585042	25.0	100.0	V	35.1	21.0	46.0
926.563448	30.4	100.0	H	40.3	15.6	46.0

Above 1 GHzFrequency 2401Polarity Ver.

Ref Level 44.80 dBuV/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 30 ms VBW 1 MHz Mode Auto Sweep
TDF



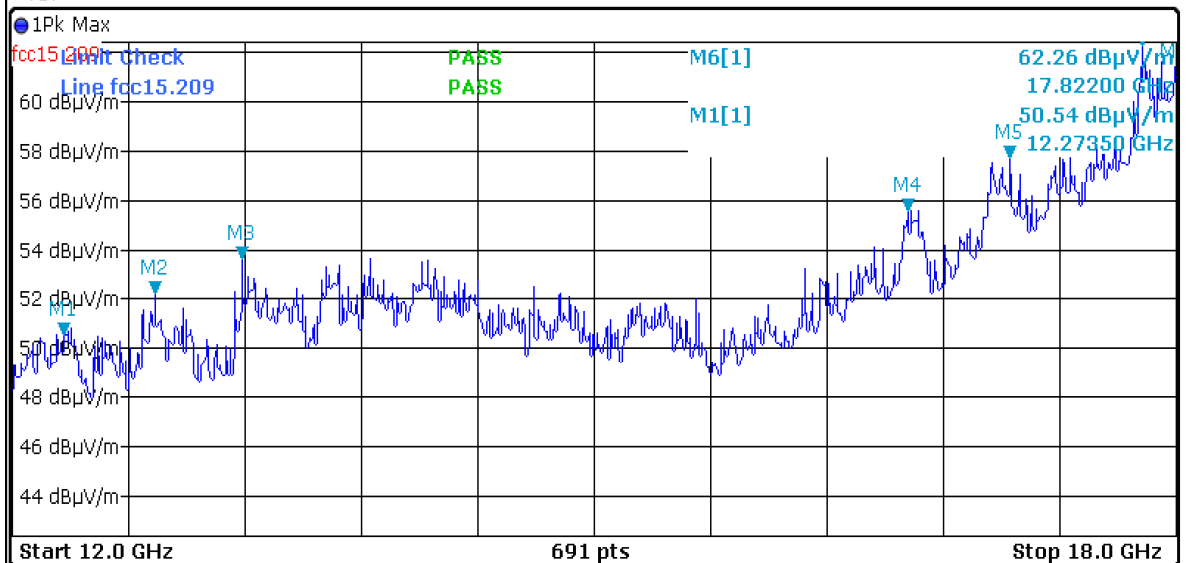
Ref Level 55.80 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 80 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	4.805 GHz	49.92 dB μ V/m		
M2		1	6.842 GHz	46.85 dB μ V/m		
M3		1	10.142 GHz	50.50 dB μ V/m		
M4		1	11.369 GHz	50.65 dB μ V/m		

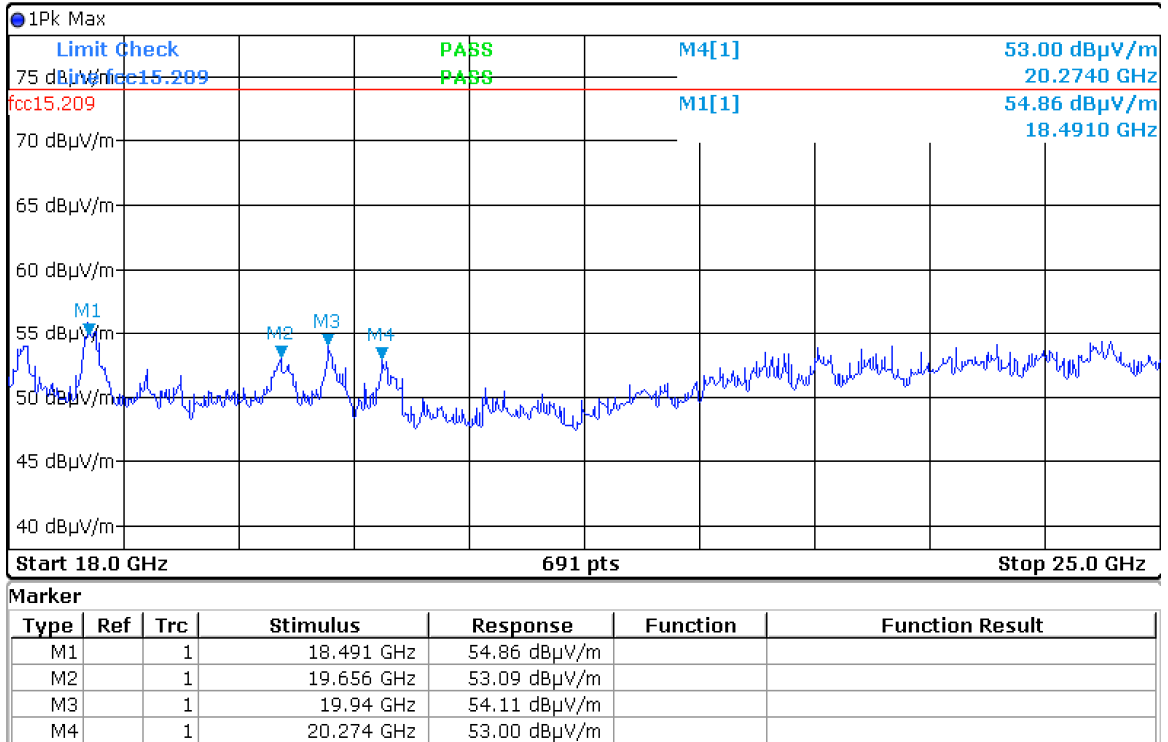
Ref Level 62.40 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 60 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

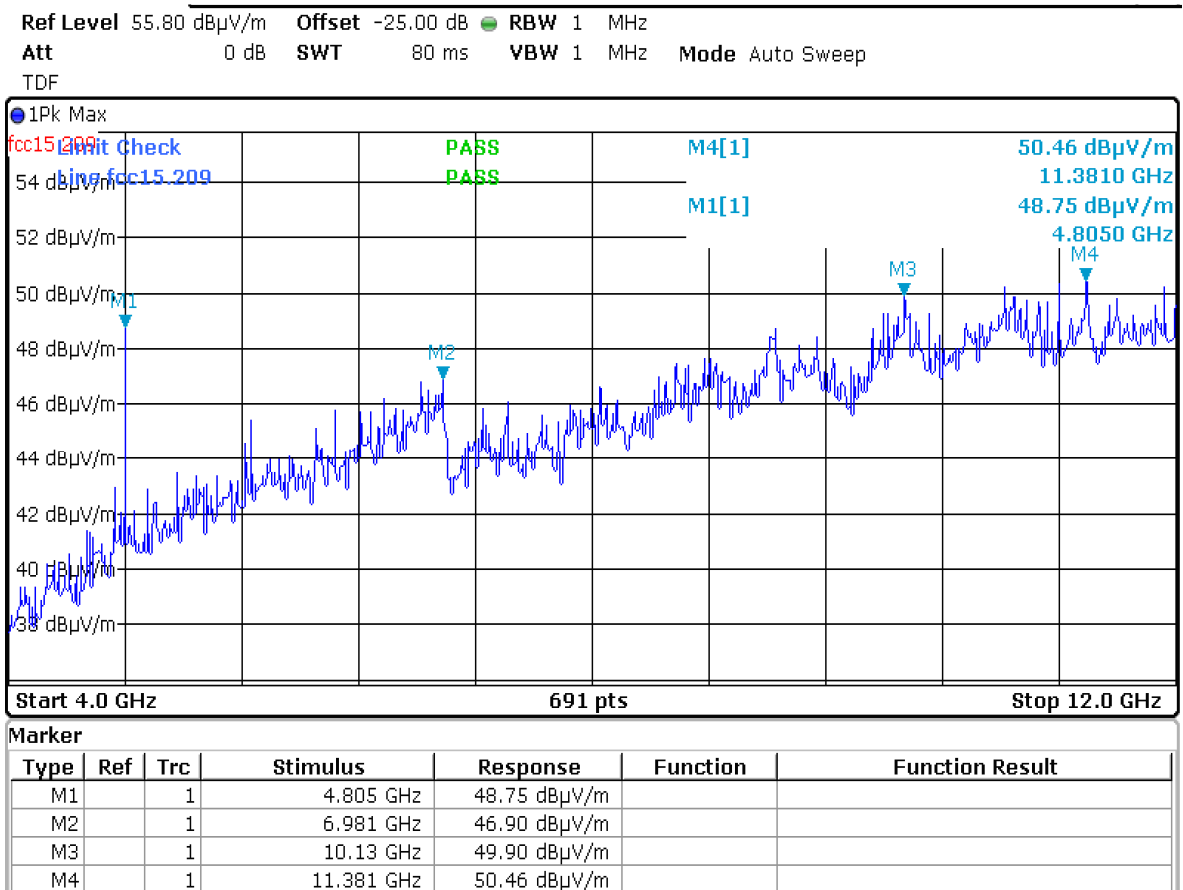
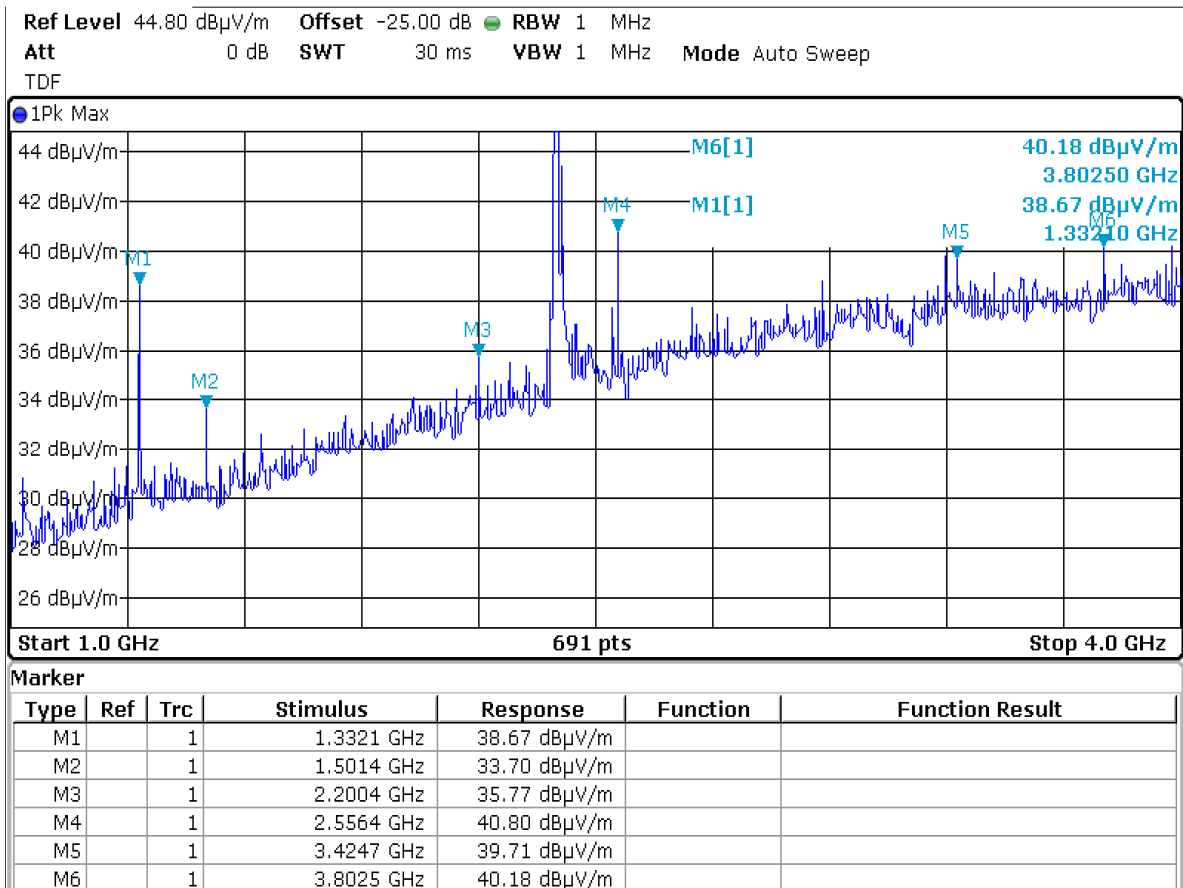
Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	12.2735 GHz	50.54 dB μ V/m		
M2		1	12.7424 GHz	52.21 dB μ V/m		
M3		1	13.1852 GHz	53.63 dB μ V/m		
M4		1	16.6151 GHz	55.58 dB μ V/m		
M5		1	17.136 GHz	57.72 dB μ V/m		
M6		1	17.822 GHz	62.26 dB μ V/m		

Ref Level 78.20 dBμV/m RBW 1 MHz
 Att 0 dB SWT 28 ms VBW 1 MHz Mode Auto Sweep
 TDF

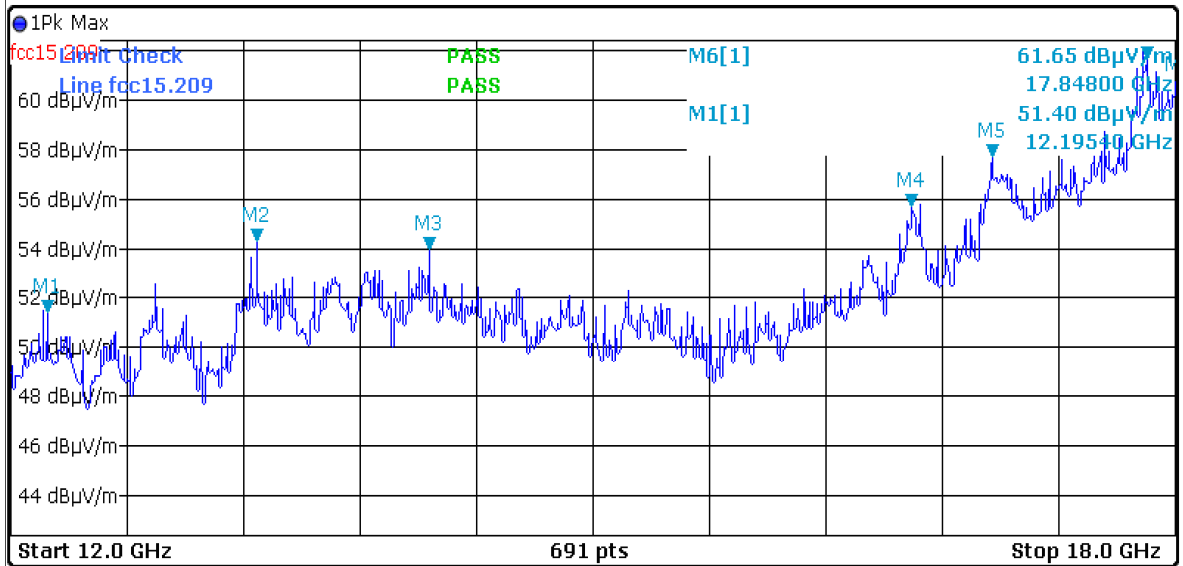


Polarity Ver.

Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1197.5	24.8	22.31	31.90	74	54
1501.4	24.9	25.67	34.05	74	54
2191.8	27.6	28.14	37.18	74	54
2243.8	27.8	31.21	40.04	74	54
2556.4	28.8	31.45	41.53	74	54
3919.7	32.0	32.16	41.25	74	54
4805.0	33.9	38.58	49.92	74	54
6842.0	35.9	39.44	46.85	74	54
10142.0	38.2	40.55	50.50	74	54
11369.0	39.2	41.21	50.65	74	54
12273.5	39.1	40.89	50.54	74	54
12742.4	39.4	43.46	52.21	74	54
13185.2	40.1	44.78	53.63	74	54
16615.1	39.7	46.15	55.58	74	54
17136.0	41.5	47.51	57.72	74	54
17822.0	43.7	52.56	62.26	74	54
18491.0	37.9	46.78	54.86	74	54
19656.0	38.0	41.12	53.04	74	54
19940.0	38.0	42.32	54.11	74	54
20274.0	38.0	44.85	53.00	74	54

Polarity Hor.

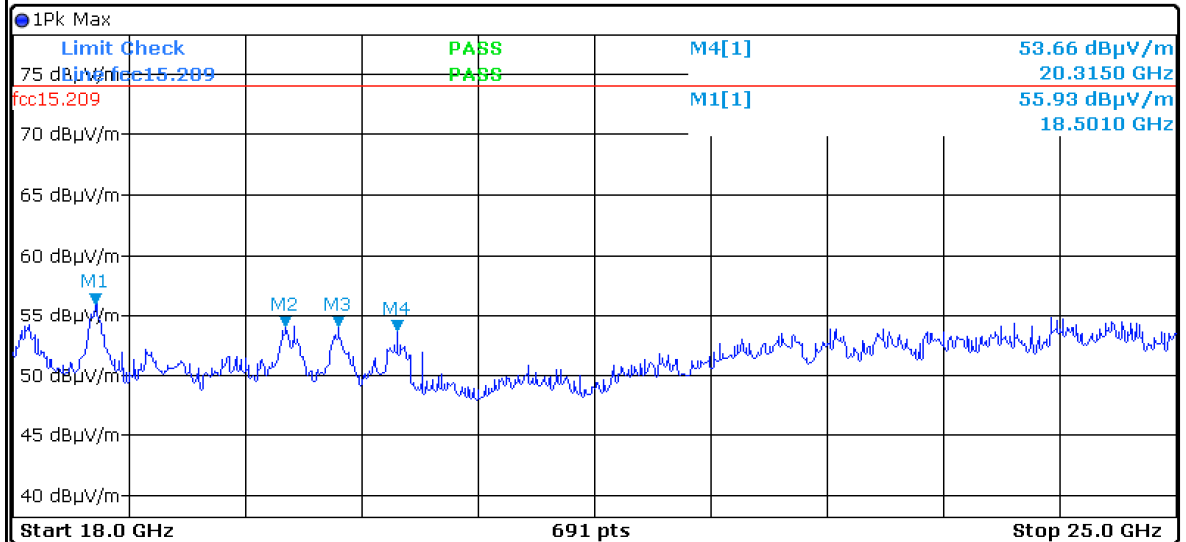
Ref Level 62.40 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 60 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	12.1954 GHz	51.40 dB μ V/m		
M2		1	13.2721 GHz	54.32 dB μ V/m		
M3		1	14.1577 GHz	53.96 dB μ V/m		
M4		1	16.6411 GHz	55.69 dB μ V/m		
M5		1	17.0579 GHz	57.69 dB μ V/m		
M6		1	17.848 GHz	61.65 dB μ V/m		

Ref Level 78.20 dB μ V/m RBW 1 MHz
Att 0 dB SWT 28 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

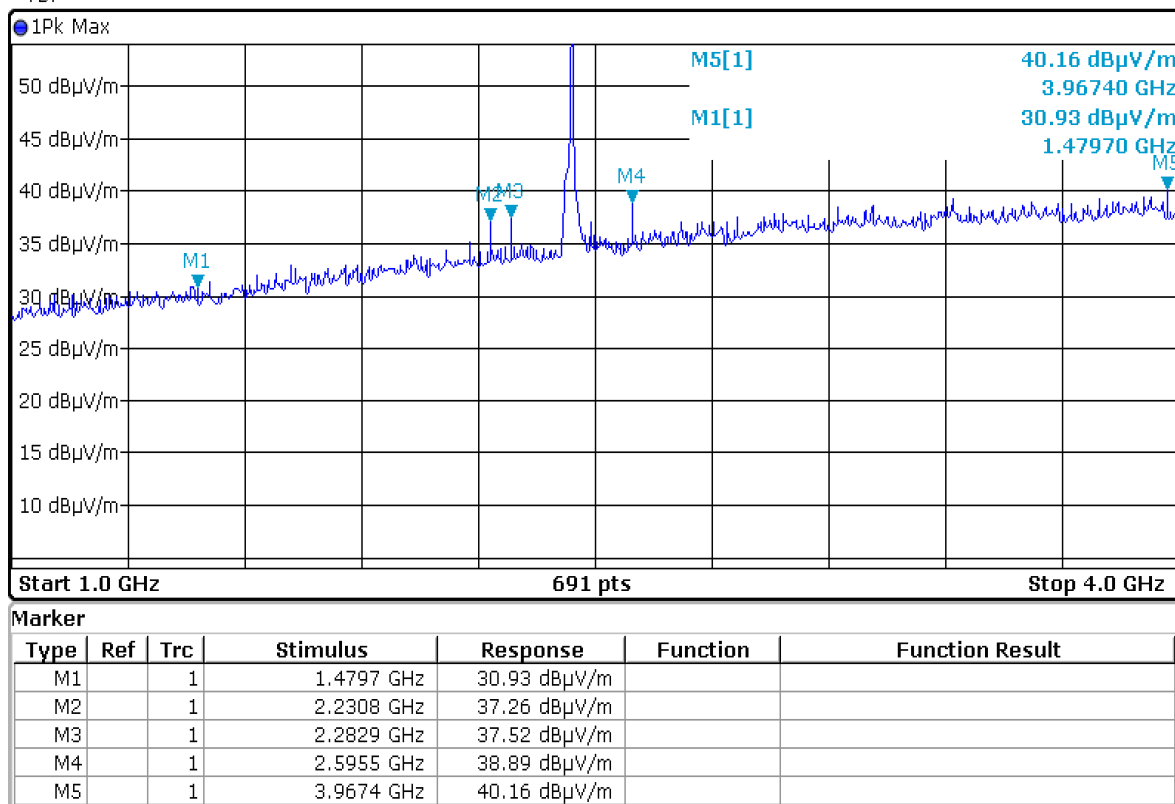
Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	18.501 GHz	55.93 dB μ V/m		
M2		1	19.646 GHz	54.09 dB μ V/m		
M3		1	19.96 GHz	54.10 dB μ V/m		
M4		1	20.315 GHz	53.66 dB μ V/m		

Polarity Hor.

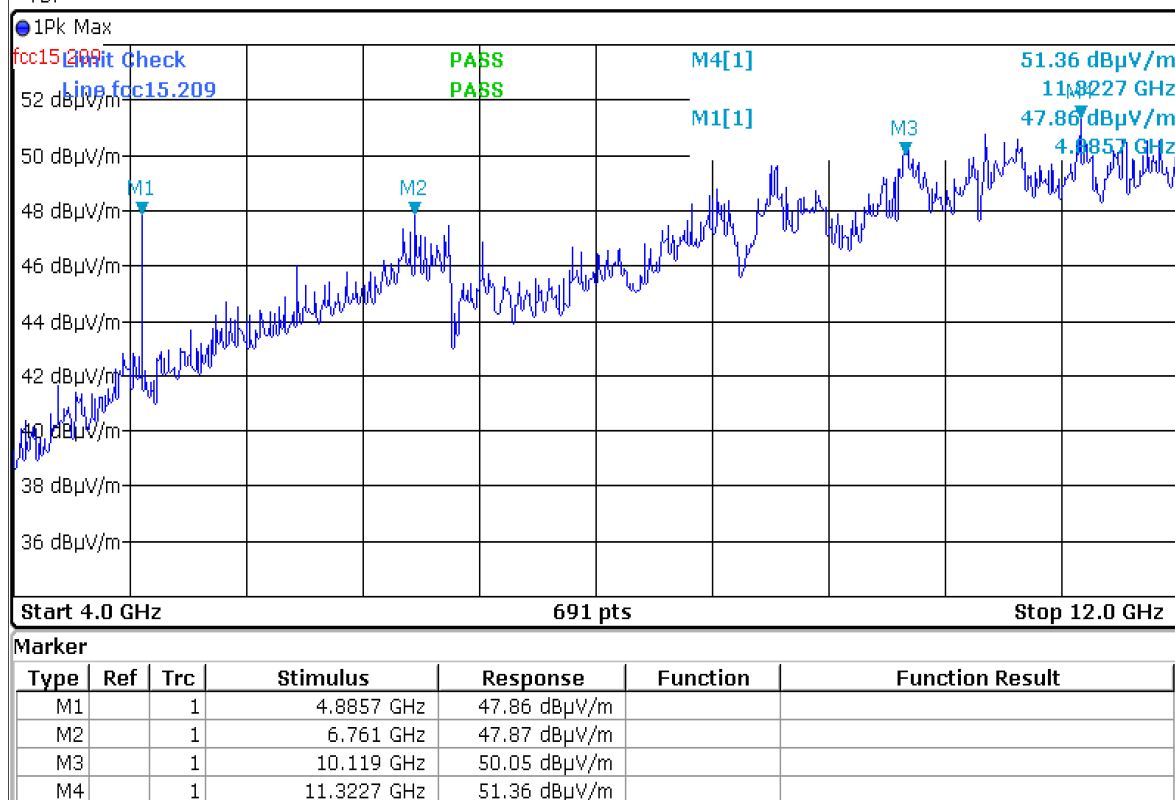
Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1332.1	24.8	28.87	38.67	74	54
1501.4	24.9	24.59	33.70	74	54
2200.4	28.1	26.65	35.77	74	54
2556.4	28.8	29.99	40.80	74	54
3424.7	32.6	28.41	39.71	74	54
3802.5	32.4	30.87	40.18	74	54
4805.0	33.4	38.50	48.75	74	54
6981.0	36.0	36.75	46.90	74	54
10130.0	38.2	38.95	49.90	74	54
11381.0	39.1	40.90	50.46	74	54
12195.4	39.2	41.35	51.40	74	54
13272.1	40.4	43.98	54.32	74	54
14157.7	41.8	43.45	53.96	74	54
16641.1	39.9	46.15	55.69	74	54
17057.9	41.6	47.55	57.69	74	54
17848.0	43.7	50.78	61.65	74	54
18501.0	37.9	46.44	55.93	74	54
19960.0	38.0	42.91	54.10	74	54
20315.0	38.0	43.77	53.66	74	54

Polarity Ver.

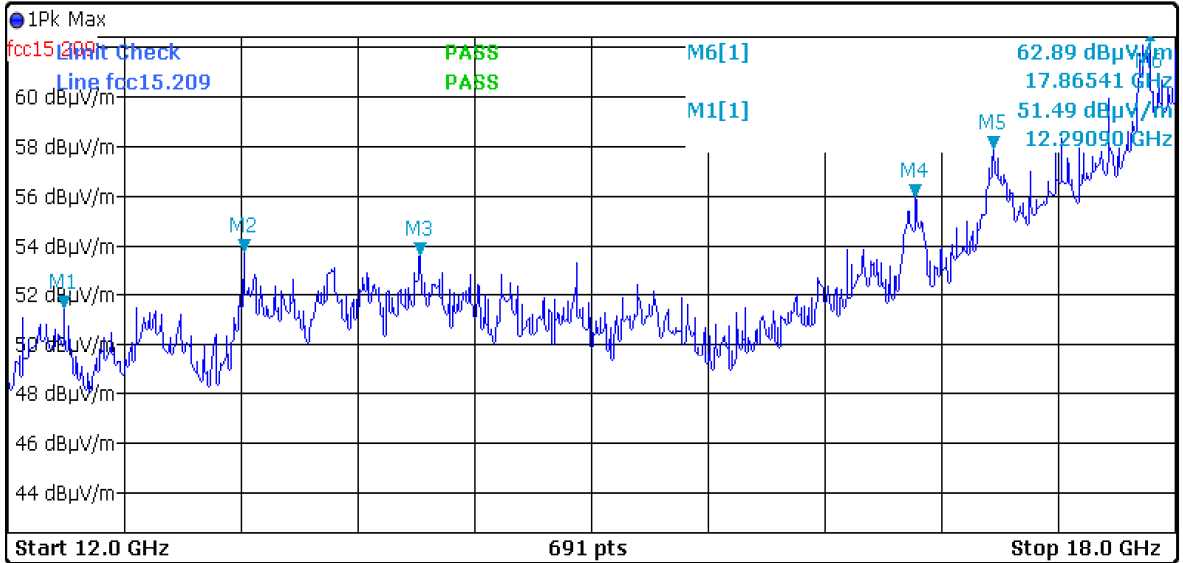
Ref Level 54.00 dBμV/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 30 ms VBW 1 MHz Mode Auto Sweep
TDF



Ref Level 54.00 dBμV/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 80 ms VBW 1 MHz Mode Auto Sweep
TDF



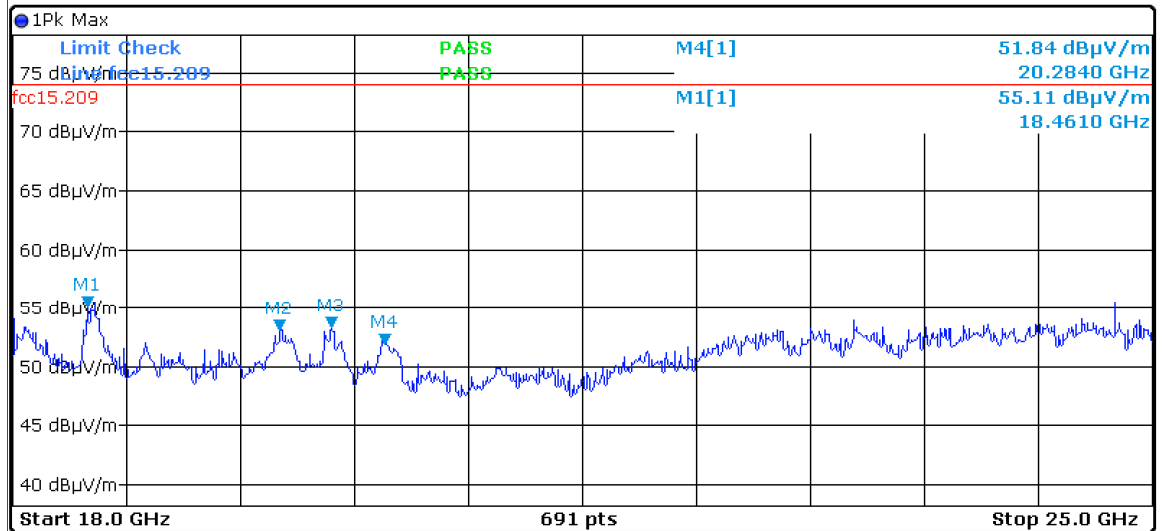
Ref Level 62.40 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 60 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	12.2909 GHz	51.49 dB μ V/m		
M2		1	13.22 GHz	53.75 dB μ V/m		
M3		1	14.123 GHz	53.65 dB μ V/m		
M4		1	16.6585 GHz	55.95 dB μ V/m		
M5		1	17.0666 GHz	57.90 dB μ V/m		
M6		1	17.86541 GHz	62.89 dB μ V/m		

Ref Level 78.20 dB μ V/m RBW 1 MHz
Att 0 dB SWT 28 ms VBW 1 MHz Mode Auto Sweep
TDF

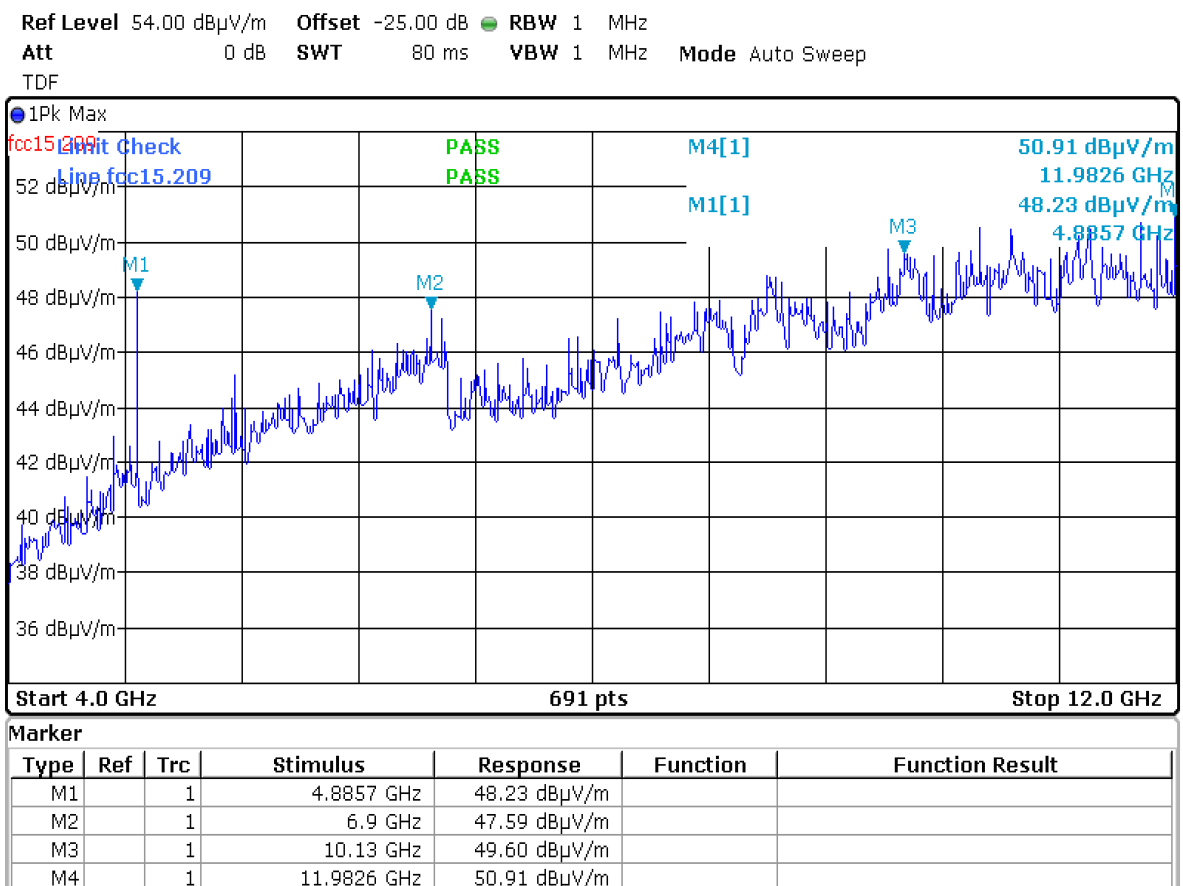
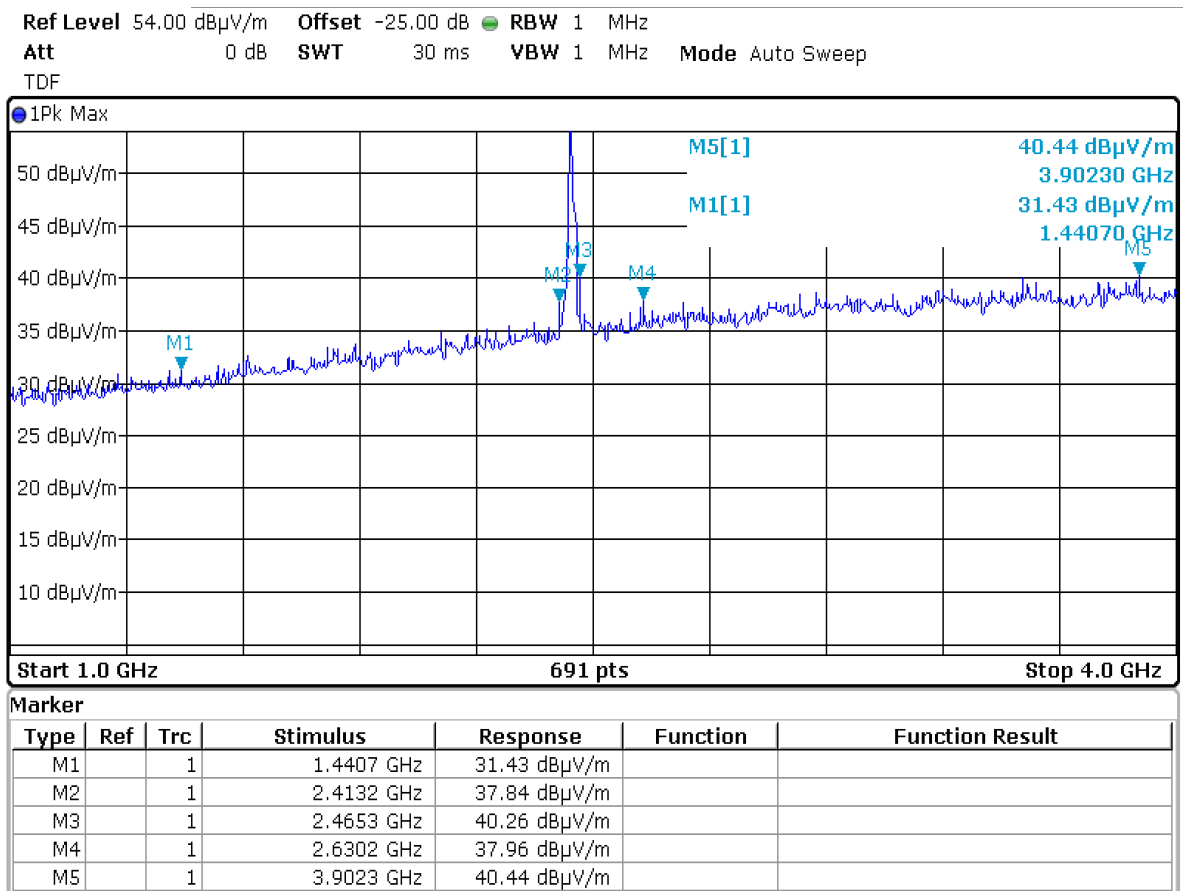


Marker

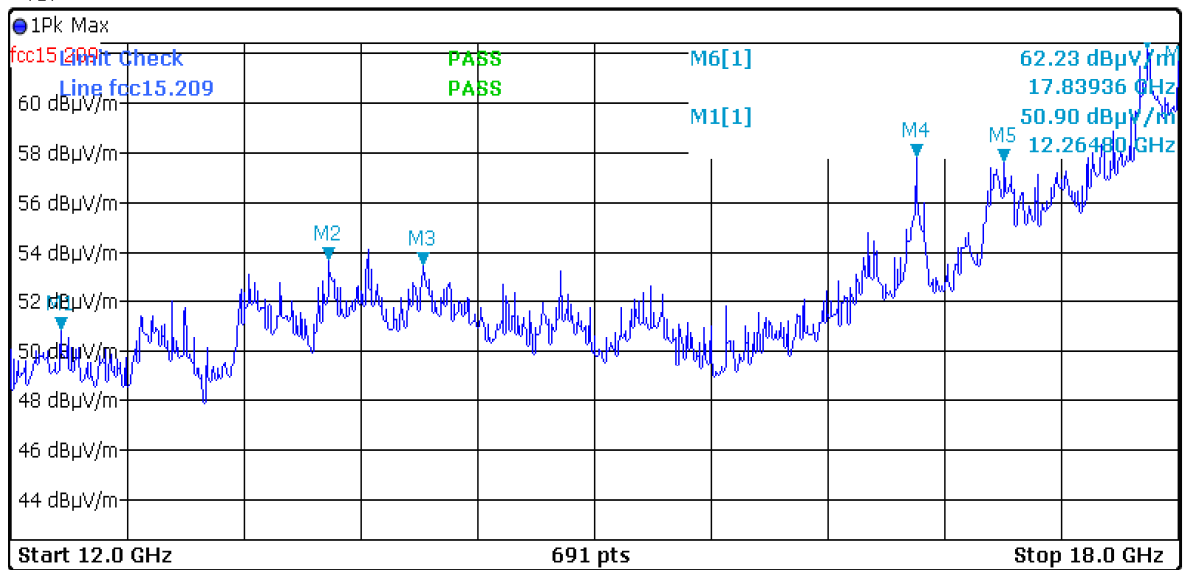
Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	18.461 GHz	55.11 dB μ V/m		
M2		1	19.646 GHz	53.08 dB μ V/m		
M3		1	19.96 GHz	53.38 dB μ V/m		
M4		1	20.284 GHz	51.84 dB μ V/m		

Polarity Ver.

Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1497.7	24.9	29.80	30.93	74	54
2230.8	28.1	25.98	37.26	74	54
2282.9	28.2	27.55	37.82	74	54
2595.5	28.8	36.67	38.89	74	54
3967.4	32.0	29.98	40.16	74	54
4885.7	34.0	37.53	47.86	74	54
6761.0	35.6	37.11	46.87	74	54
10119.0	38.4	39.88	50.05	74	54
11322.7	39.1	41.17	51.36	74	54
12290.9	39.1	40.87	51.49	74	54
14123.0	41.7	43.13	53.65	74	54
16658.5	39.7	46.45	55.95	74	54
17066.6	41.6	46.13	57.90	74	54
17865.4	47.2	53.18	62.89	74	54
18461.0	37.9	45.67	55.11	74	54
19646.0	38.0	42.77	53.08	74	54
19960.0	38.0	44.12	53.38	74	54
20284.0	38.0	40.66	51.84	74	54

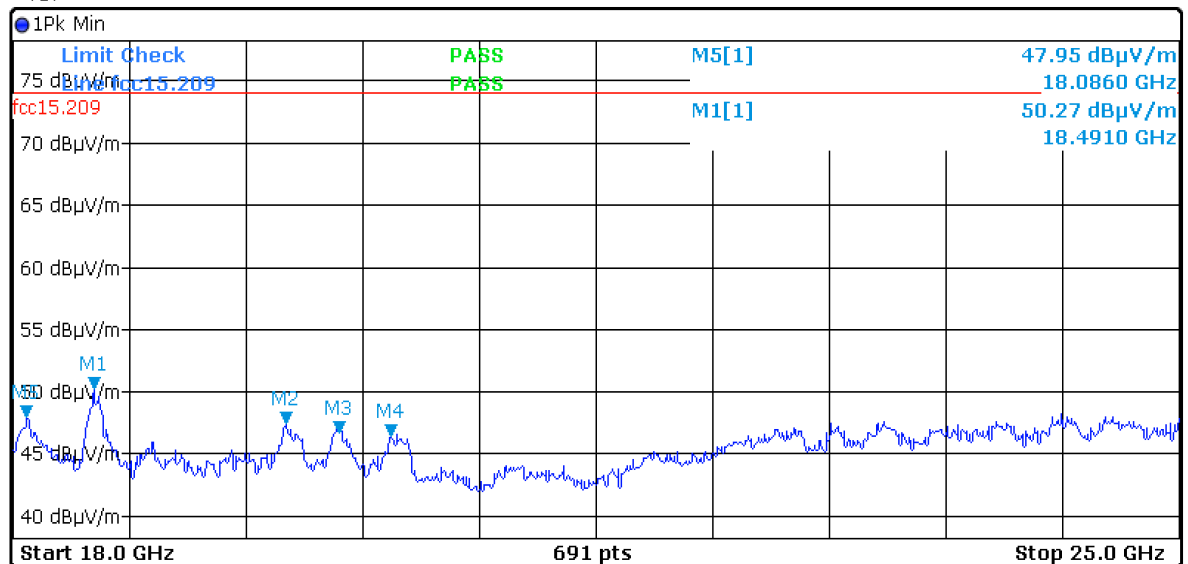
Polarity Hor.

Ref Level 62.40 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 60 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker						
Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	12.2648 GHz	50.90 dB μ V/m		
M2		1	13.6368 GHz	53.67 dB μ V/m		
M3		1	14.123 GHz	53.49 dB μ V/m		
M4		1	16.6498 GHz	57.87 dB μ V/m		
M5		1	17.1013 GHz	57.65 dB μ V/m		
M6		1	17.83936 GHz	62.23 dB μ V/m		

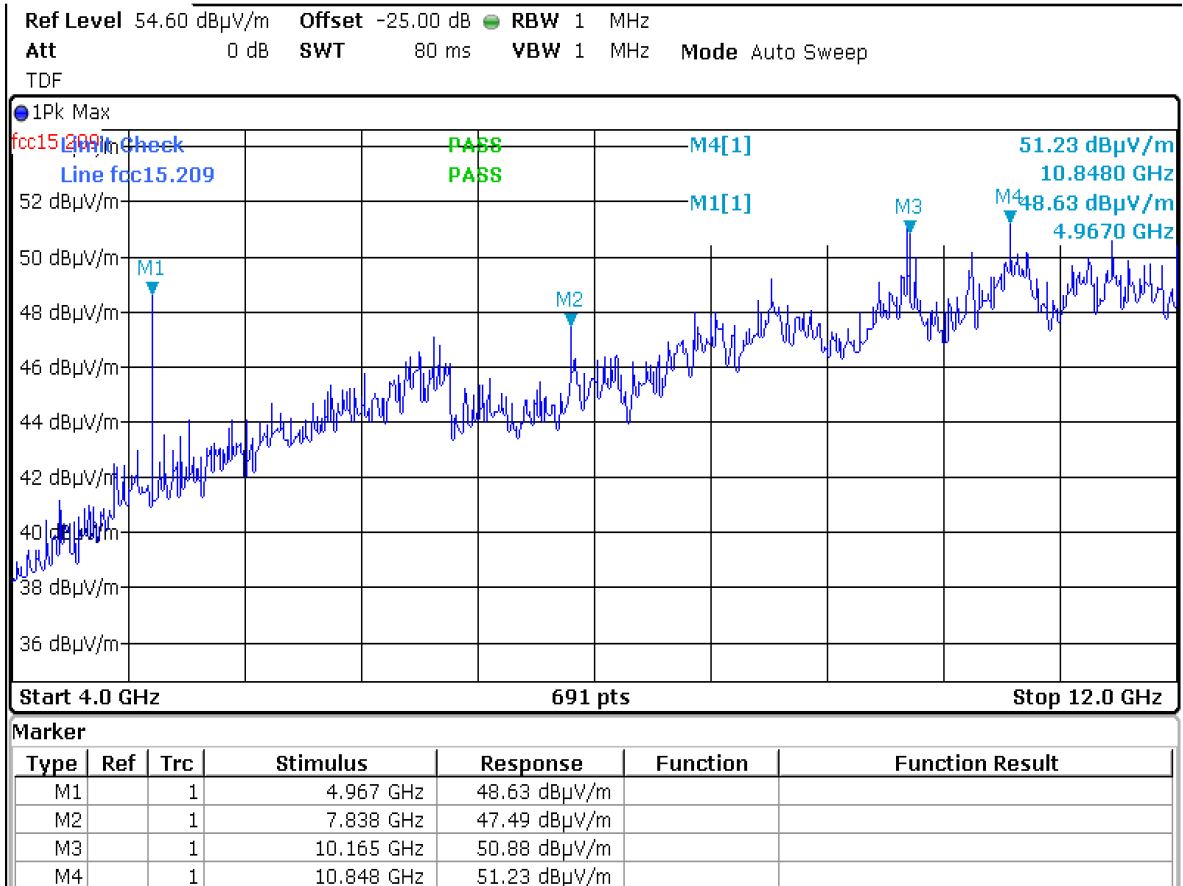
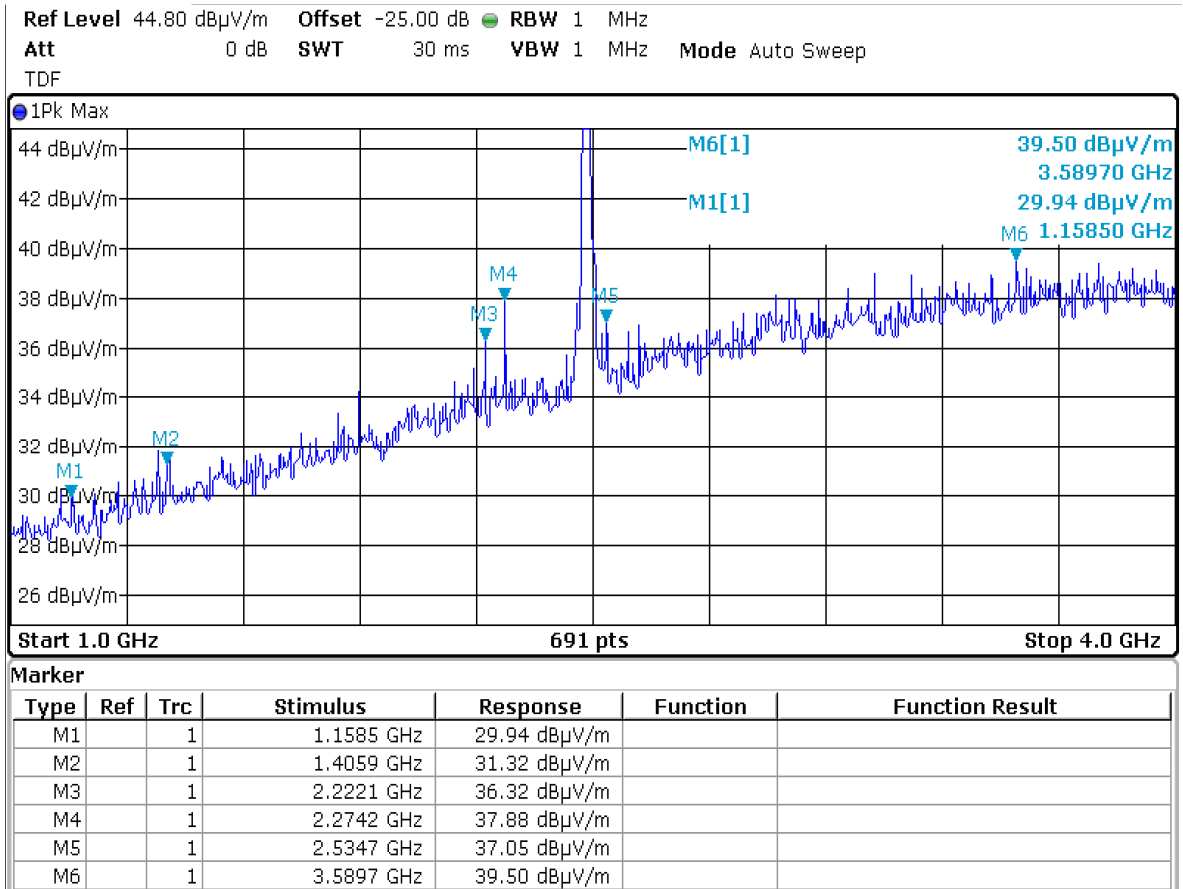
Ref Level 78.20 dB μ V/m RBW 1 MHz
Att 0 dB SWT 28 ms VBW 1 MHz Mode Auto Sweep
TDF

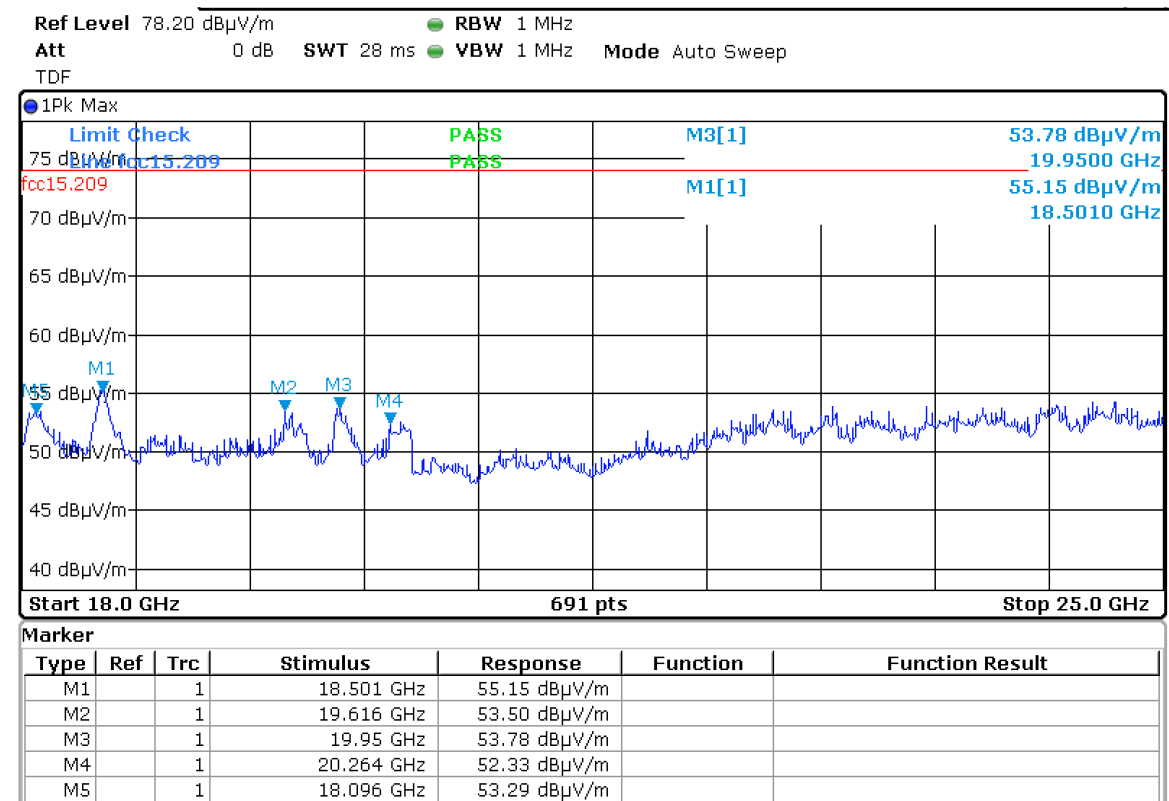
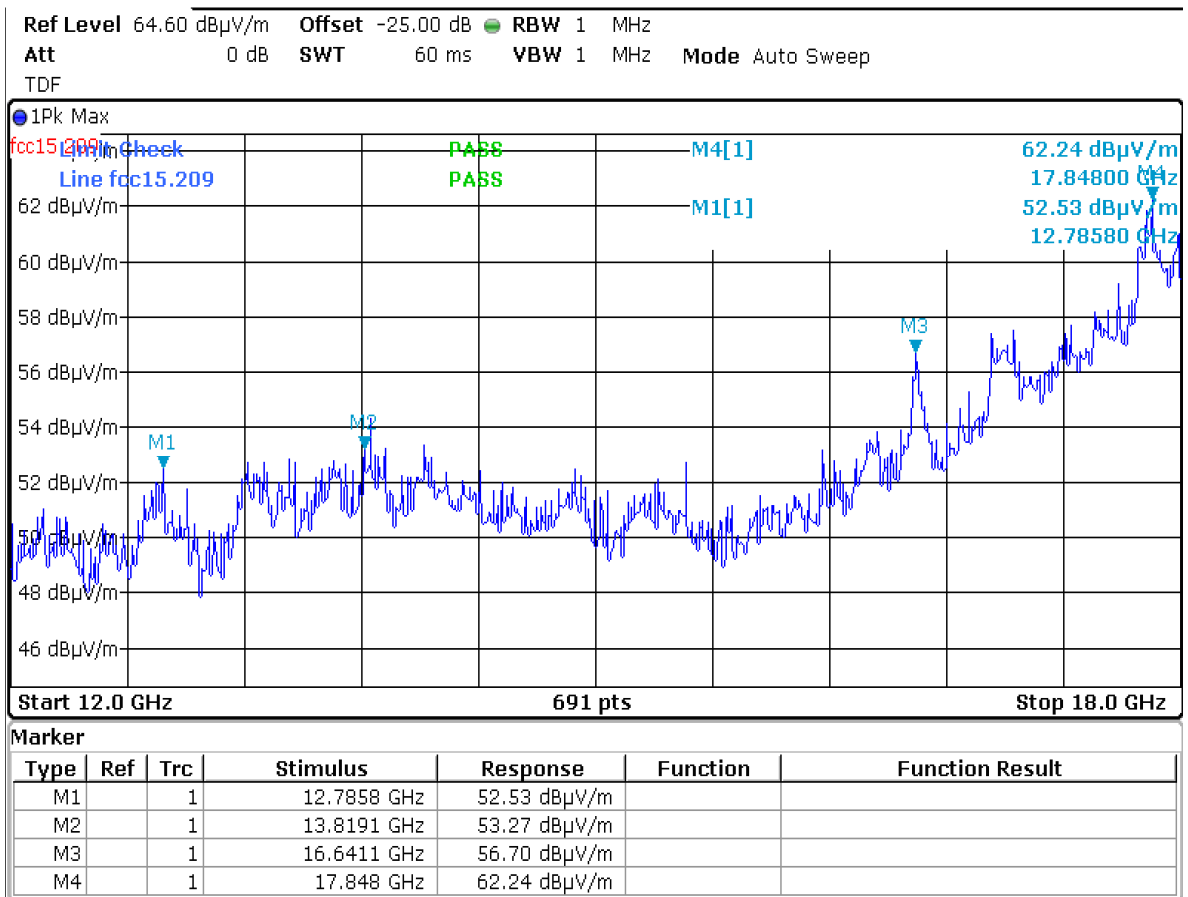


Marker						
Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	18.491 GHz	50.27 dB μ V/m		
M2		1	19.646 GHz	47.49 dB μ V/m		
M3		1	19.96 GHz	46.66 dB μ V/m		
M4		1	20.274 GHz	46.41 dB μ V/m		
M5		1	18.086 GHz	47.95 dB μ V/m		

Polarity Hor.

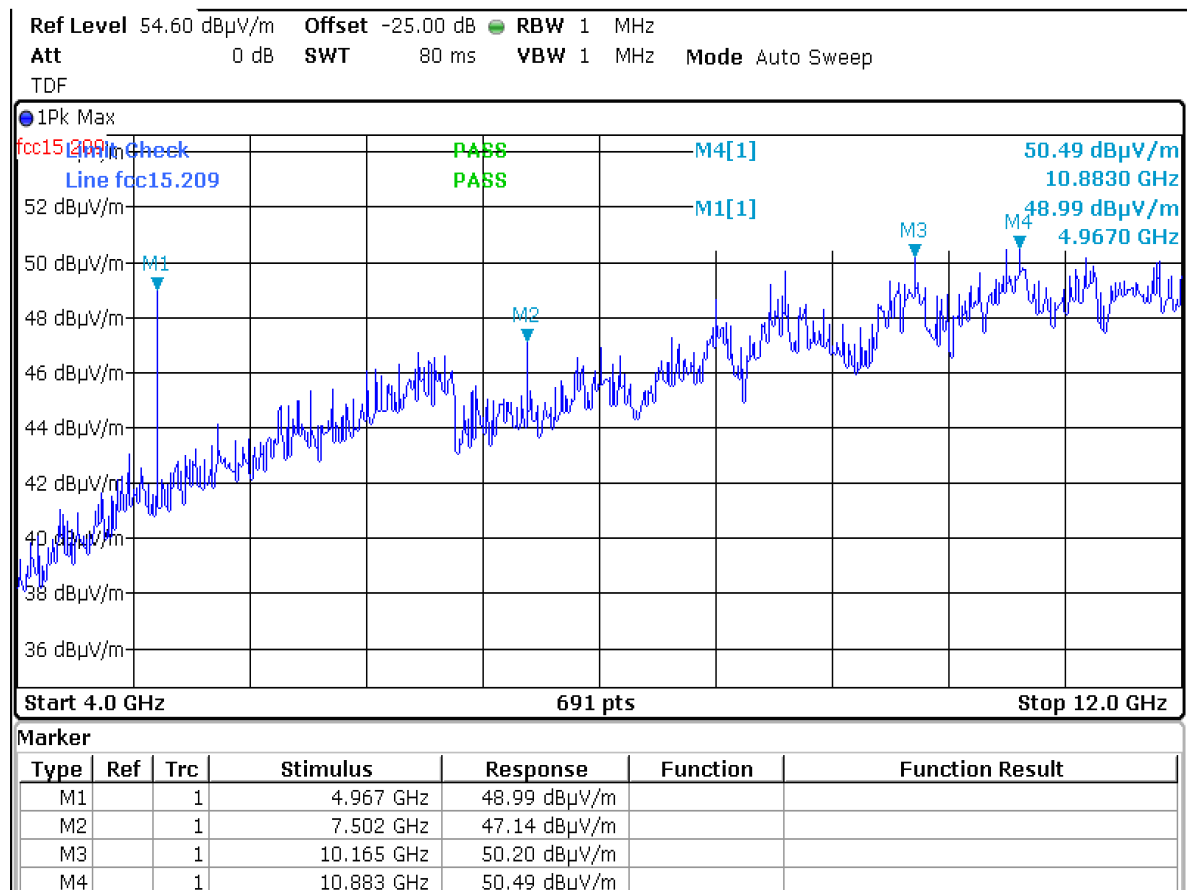
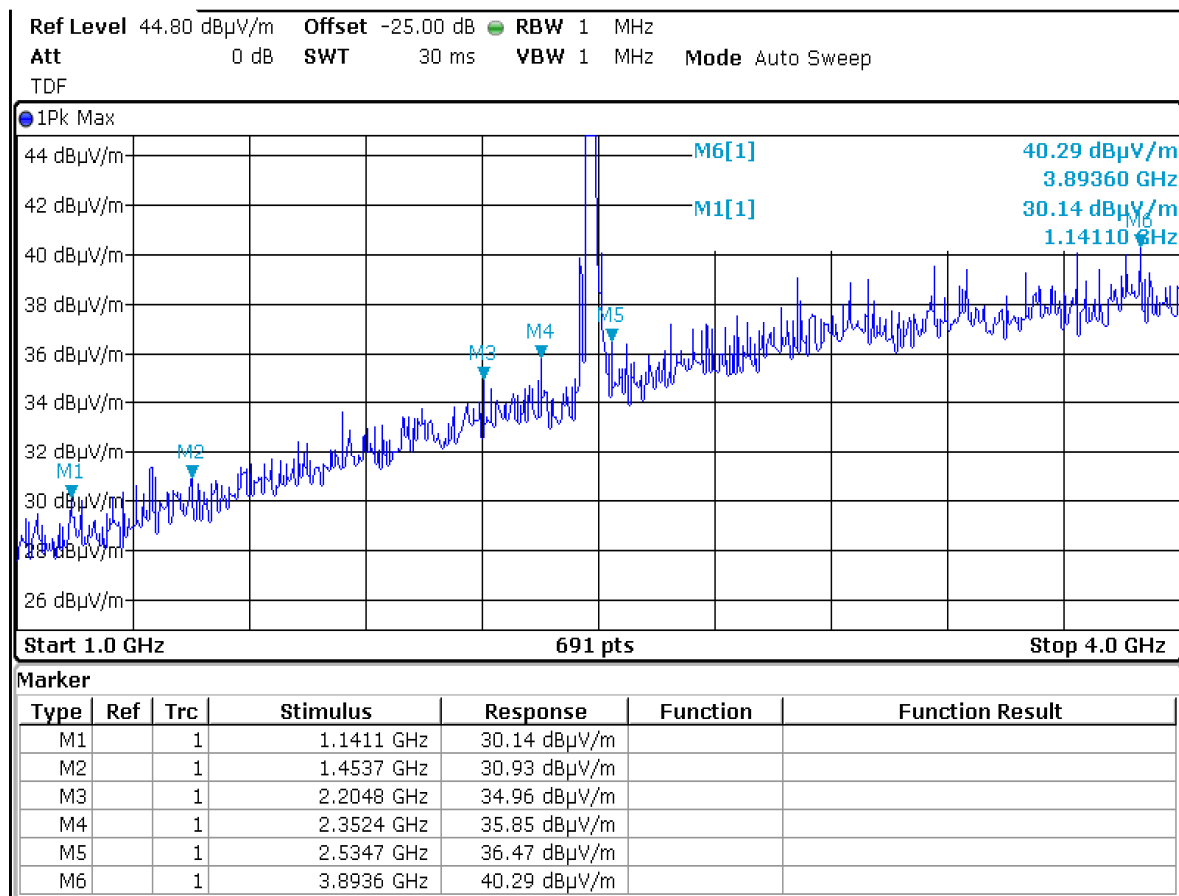
Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1440.7	24.9	20.99	31.43	74	54
2413.2	28.1	27.55	37.84	74	54
2465.3	28.2	31.03	40.26	74	54
2630.2	28.8	28.11	37.96	74	54
3902.3	32.0	30.13	40.44	74	54
4885.7	34.0	37.77	48.23	74	54
6900.0	35.6	38.50	47.59	74	54
10130.0	38.4	40.15	49.60	74	54
11982.6	39.1	40.66	50.91	74	54
12264.8	39.1	40.88	50.90	74	54
13636.8	41.7	42.56	53.67	74	54
16649.8	39.7	46.79	57.87	74	54
17101.3	41.6	46.22	57.65	74	54
17865.4	47.2	51.90	62.89	74	54
19646.0	37.9	36.44	47.49	74	54
19960.0	38.0	36.12	46.66	74	54
20274.0	38.0	35.88	46.41	74	54

Frequency 2481**Polarity Ver.**

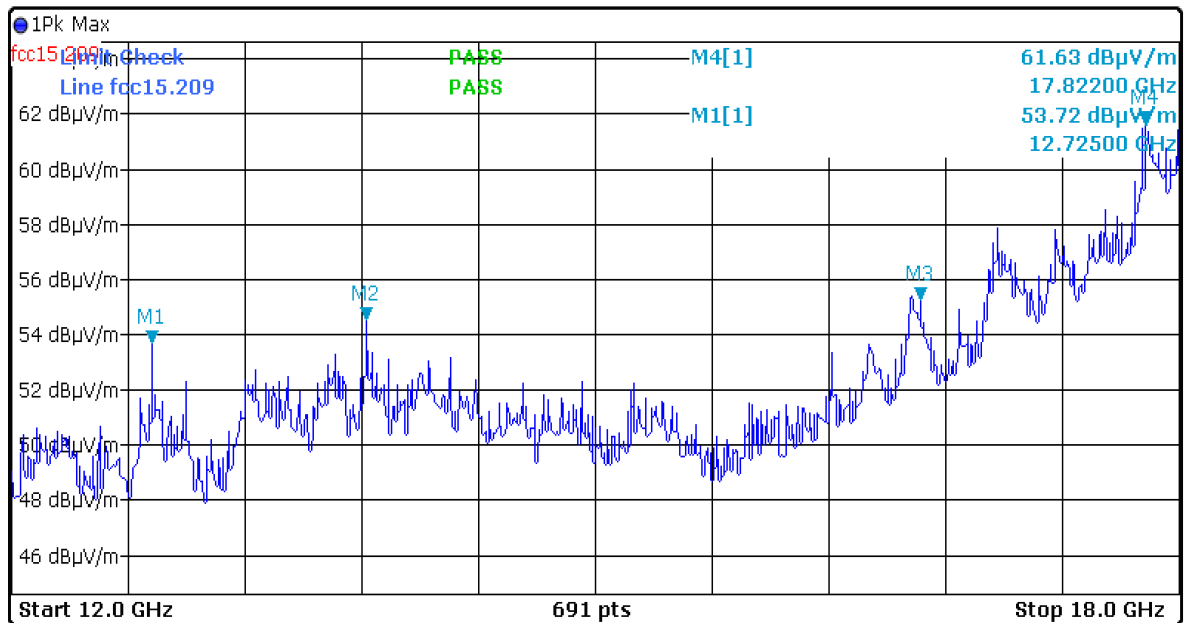


Polarity Ver.

Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1158.5	24.8	20.11	29.94	74	54
1405.9	24.9	21.55	31.32	74	54
2222.1	28.2	25.98	36.32	74	54
2274.2	28.3	27.66	37.88	74	54
3589.7	32.6	29.83	39.50	74	54
4967.0	34.1	37.77	48.63	74	54
7838.0	37.0	37.65	47.49	74	54
10165.0	38.2	40.55	50.88	74	54
10848.0	38.8	40.79	51.23	74	54
12785.8	39.9	42.23	52.53	74	54
13819.1	41.7	43.45	53.27	74	54
16641.1	39.7	46.15	56.70	74	54
17848.0	47.4	51.90	62.24	74	54
18501.0	37.9	44.84	55.15	74	54
19616.0	38.0	42.70	53.50	74	54
19955.0	38.0	43.55	53.78	74	54
20264.0	38.0	41.63	52.33	74	54

Polarity Hor.

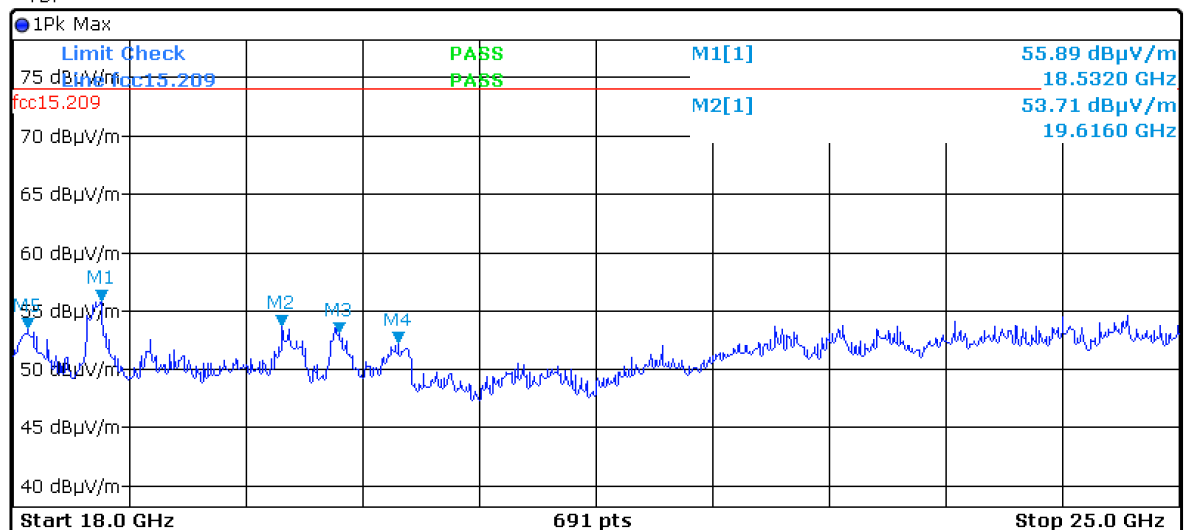
Ref Level 64.60 dB μ V/m Offset -25.00 dB RBW 1 MHz
Att 0 dB SWT 60 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	12.725 GHz	53.72 dB μ V/m		
M2		1	13.8278 GHz	54.60 dB μ V/m		
M3		1	16.6671 GHz	55.31 dB μ V/m		
M4		1	17.822 GHz	61.63 dB μ V/m		

Ref Level 78.20 dB μ V/m RBW 1 MHz
Att 0 dB SWT 28 ms VBW 1 MHz Mode Auto Sweep
TDF



Marker

Type	Ref	Trc	Stimulus	Response	Function	Function Result
M1		1	18.532 GHz	55.89 dB μ V/m		
M2		1	19.616 GHz	53.71 dB μ V/m		
M3		1	19.96 GHz	53.11 dB μ V/m		
M4		1	20.315 GHz	52.28 dB μ V/m		
M5		1	18.096 GHz	53.51 dB μ V/m		

Polarity Ver.

Frequency (MHz)	Antenna factor, dB	Value Average (dBuV/m)	Value Peak (dBuV/m)	Limit peak (dBuV/m)	Limit average (dBuV/m)
1141.1	24.8	19.78	30.14	74	54
1453.7	24.9	20.54	30.93	74	54
2204.8	28.2	25.15	34.96	74	54
2532.4	28.8	26.14	36.47	74	54
3893.6	32.0	30.77	40.29	74	54
4967.0	34.1	39.44	48.99	74	54
7502.0	36.8	37.88	47.14	74	54
10165.0	38.2	39.73	50.20	74	54
10883.0	38.8	40.50	50.49	74	54
12725.0	39.0	42.62	53.72	74	54
13827.8	41.7	44.77	54.60	74	54
16671.1	39.7	44.92	55.31	74	54
17822.0	47.4	50.55	61.63	74	54
18532.0	37.9	46.12	55.89	74	54
19616.0	38.0	42.86	53.71	74	54
19960.0	38.0	42.45	53.11	74	54
20315.0	38.0	41.57	52.28	74	54

3.8 Radiated Emission from Receiver Part

3.8.1 Test procedure

- 1) The EUT was placed on a turn table top 0.8 m above the floor.
- 2) The EUT was set 3 meters from the interference receiving antenna which was mounted on the top of a variable height antenna tower.
- 3) The table was rotated 360 degrees to determine the position of the highest radiation.
- 4) The antenna is a broadband antenna and its height is varied between 1 meter and 4 meters above the floor to find the maximum value of the shield strength for both horizontal polarization and vertical polarization of the antenna.
- 5) For each suspected emission, the EUT was arranged to its worst case.
- 6) On any frequency or frequencies below or equal to 1000 MHz the test-receiver was set to Quasi-peak detector function with specified bandwidth with maximum hold mode.
- 7) On any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function and peak detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to EUT. Measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

3.8.2 Test result radiated emission from receiver part

Temperature: +18 °C

Relative humidity: 69 %

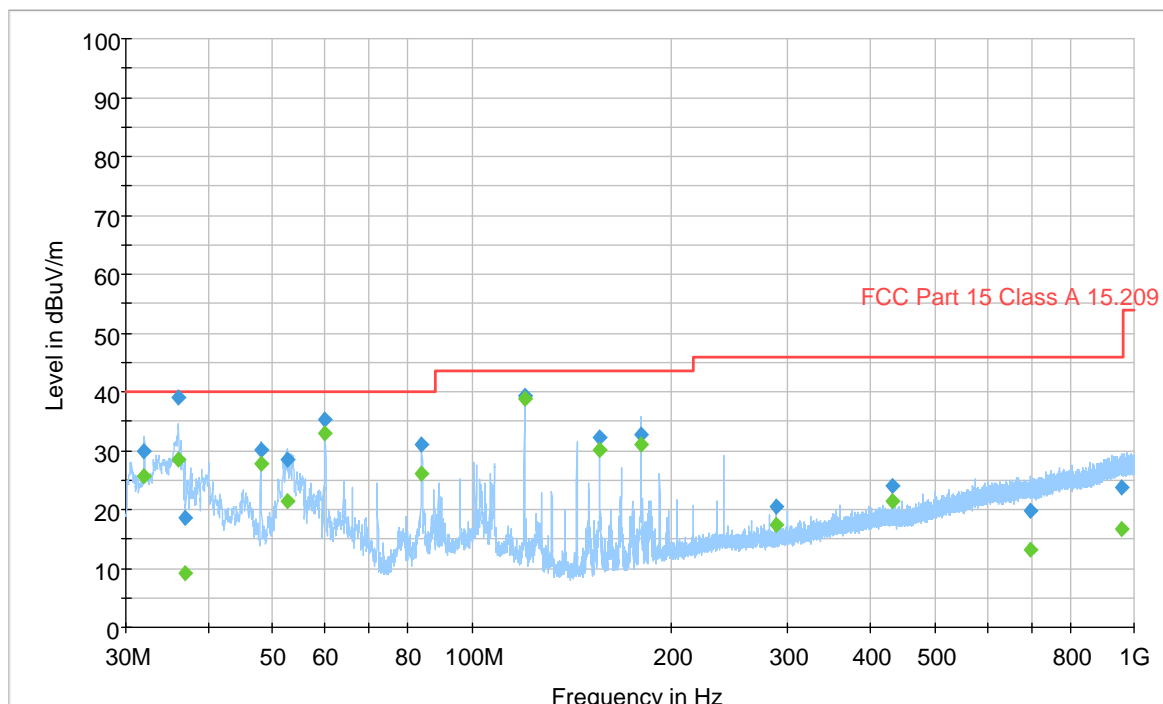
Mode:

Receiver on

Frequency 2481 (worst case)

Below 1 GHz

FCC CFR 47 part 15.209 30-1000 MHz

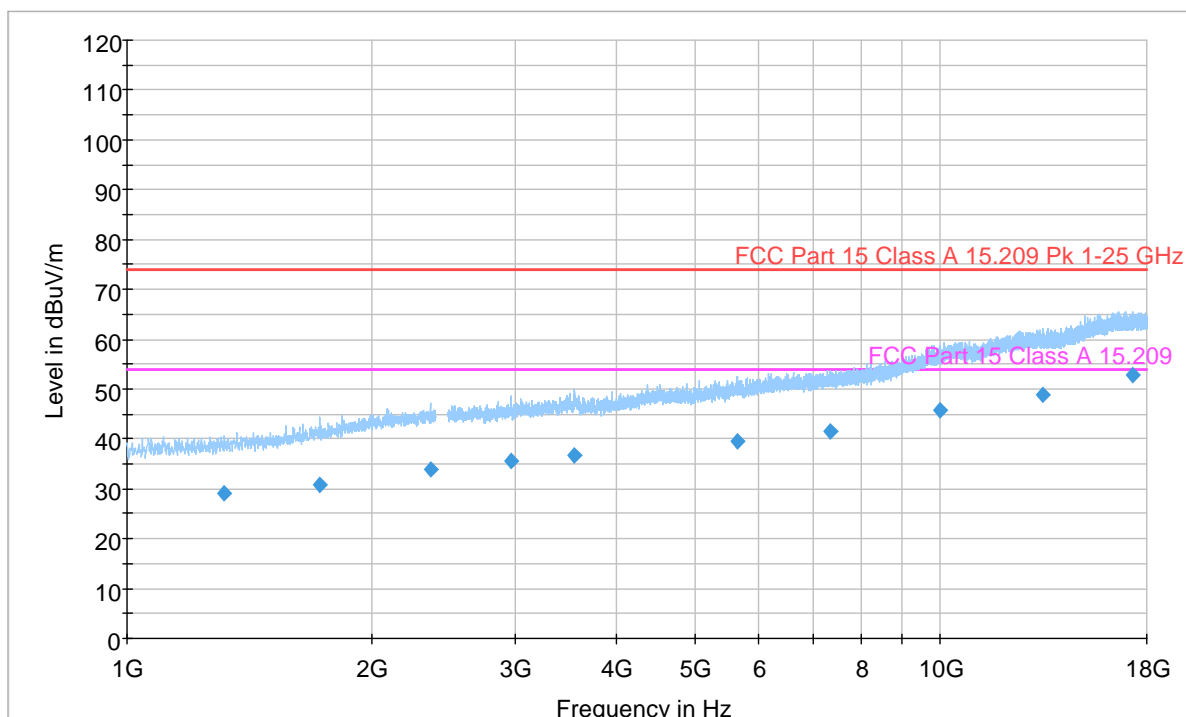


Frequency (MHz)	QuasiPeak (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
32.000000	29.8	100.0	V	-13.3	10.2	40.0
36.000000	39.1	100.0	V	-13.0	0.9	40.0
36.800000	18.7	100.0	V	-12.8	21.3	40.0
48.000000	30.1	150.0	V	-12.1	9.9	40.0
52.520000	28.4	100.0	V	-12.3	11.6	40.0
60.000000	35.2	100.0	V	-12.7	4.8	40.0
84.000000	31.0	100.0	V	-15.3	9.0	40.0
120.000000	39.3	100.0	V	-14.8	4.2	43.5
156.040000	32.2	100.0	V	-16.6	11.3	43.5
180.040000	32.6	150.0	V	-15.2	10.9	43.5
288.000000	20.5	150.0	V	-11.3	25.5	46.0
432.000000	24.0	100.0	V	-8.0	22.0	46.0
696.680000	19.8	300.0	H	-3.8	26.2	46.0
956.480000	23.8	250.0	H	-0.3	22.2	46.0

Final Result 2

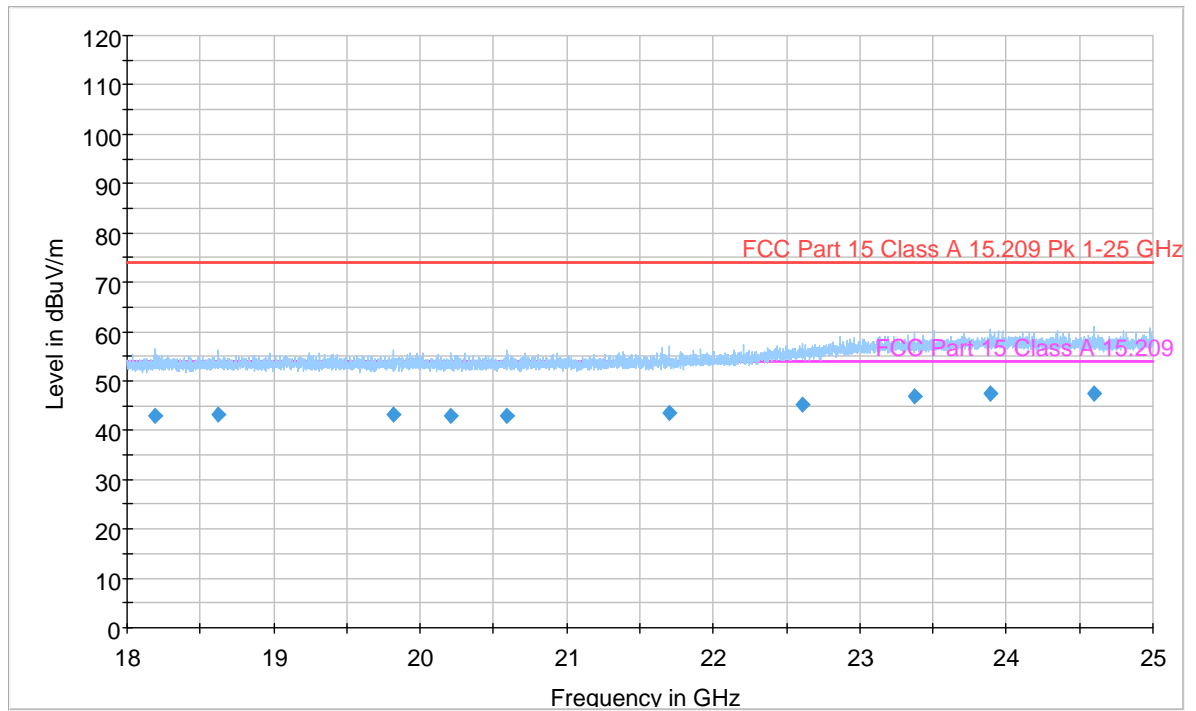
Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
32.000000	25.7	100.0	V	-13.3	14.3	40.0
36.000000	28.5	100.0	V	-13.0	11.5	40.0
36.800000	29.2	100.0	V	-12.8	10.8	40.0
48.000000	27.8	150.0	V	-12.1	12.2	40.0
52.520000	21.5	100.0	V	-12.3	18.5	40.0
60.000000	32.9	100.0	V	-12.7	7.1	40.0
84.000000	26.0	100.0	V	-15.3	14	40.0
120.000000	38.9	100.0	V	-14.8	4.6	43.5
156.040000	30.1	100.0	V	-16.6	13.4	43.5
180.040000	31.0	150.0	V	-15.2	12.5	43.5
288.000000	17.4	150.0	V	-11.3	28.6	46.0
432.000000	21.3	100.0	V	-8.0	24.7	46.0
696.680000	13.1	300.0	H	-3.8	32.9	46.0
956.480000	16.8	250.0	H	-0.3	29.2	46.0

FCC CFR 47 part 15.209 1-18 GHz



Final Result 3

Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
1319.00	29.2	100.0	V	7.5	24.8	54.0
1725.00	30.7	100.0	H	9.7	23.3	54.0
2362.00	33.8	100.0	H	13.0	20.2	54.0
2971.00	35.5	100.0	H	14.3	18.5	54.0
3560.00	36.8	100.0	V	15.9	17.2	54.0
5651.00	39.5	100.0	V	20.3	14.5	54.0
7337.00	41.4	100.0	H	23.0	12.6	54.0
10017.00	45.7	100.0	V	27.0	8.3	54.0
13401.00	48.8	100.0	V	30.8	5.2	54.0
17271.00	52.9	100.0	H	35.3	1.1	54.0



Final Result 4

Frequency (MHz)	Average (dBuV/m)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)
18192.00000	43.0	100.0	V	19.7	11.0	54.0
18620.00000	43.1	100.0	H	20.1	10.9	54.0
19819.00000	43.1	100.0	V	21.1	10.9	54.0
20212.00000	42.9	100.0	V	21.3	11.1	54.0
20593.00000	43.0	100.0	H	21.5	11.0	54.0
21700.00000	43.5	100.0	H	22.3	10.5	54.0
22609.00000	45.2	100.0	H	23.8	8.8	54.0
23377.00000	47.0	100.0	V	24.8	7.0	54.0
23886.00000	47.4	100.0	V	25.1	6.6	54.0
24599.00000	47.4	100.0	V	25.3	6.6	54.0

3.9 Antenna Requirement

3.9.1 Test procedure

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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The antenna of the Transmitter Module 2.4 Dual FHSS 12 – 16 channels Typ-D permanently attached and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

3.10 RF exposure

3.10.1 General

This test was performed to determine the minimum safe distance between the transmitter antenna and human to avoid public exposure in excess of limits for general population (uncontrolled exposure). Specification test limits are given in Table 3.10.1.

Table 3.10.1 — Limits For Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f ²	6
30-300	61.4	0.163	1.0	6
300-1,500	-	-	f/300	6
1,500-100,000	-	-	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f ²	30
30-300	27.5	0.073	0.2	30
300-1,500	-	-	f/1500	30
1,500-100,000	-	-	1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

3.10.2 Test procedure: 47 CRF, §1.1307(b)(1).

3.10.3 Power density calculation for mobile transmitter

The power density at the specified distance was calculated from the following equation:

$$S = \frac{PG}{4\pi R^2},$$

where

S = power density (mW/cm²)

P = average power input to the antenna over averaging time (mW)

G = power gain of the antenna in the direction of interest relative to an isotropic radiator (numeric)

R = distance to the center of radiation of the antenna (cm)

Power density calculation for duty cycle 40 %:

$$S = \frac{0.4 \times 100 \times 1.58}{4 \times \pi \times 20^2} = 0.0126 \text{ [mW/cm}^2\text{]}$$

Frequency range, MHz	Maximum output power, dBm	Antenna gain, dBi	EIRP		Power density, mW/m ²	Limit, mW/cm ²	Margin, mW/cm ²	Verdict
			dBm	mW				
2.400 - 2.4835	20	2	20	100	0.0126	1.0	0.9874	Pass

The equipment is intended for use at a distance of more than 20 cm from humans.