FCC TEST REPORT No. 13/1413	March 24, 2014
for 47 CFR Part 15 Subpart C	date of issue

Model name:	2.4 Dual FHSS BAT 60 Transmitter
Product description	2.4 GHz FHSS Transceiver
FCC ID	W3X2754-60
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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КАНЦЕЛЯРИЯ

Approved by
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1 EQUIPMENT UNDER TEST

1.1 Basic description

Equipment Category	Transceiver
Test item description	2.4 GHz FHSS Transceiver
Model name	2.4 Dual FHSS BAT 60 Transmitter
Serial numbers	6000-000144

1.2 Technical characteristics declared by manufacturer

Frequency range	2.400 to 2.4835 GHz
Transmission	Adaptive and non-adaptive frequency hopping operation with "listen before talk" function
Channel Usage	80
Number of transceivers	2 (two separate transmitters and receivers Tx1 and Tx2)
Channel Spacing used	1 MHz
Maximum output power (EIRP)	+20 dBm (100 mW)
Modulation form	FHSS
Modulation type	MSK
MSK Deviation	2.182 kHz
Symbol Rate	150 kHz
Maximal Duty Cycle:	20 %
Antenna type	2 x patch antennas (angle of radiation > 180°)
Antenna gain	2 dBi
Temperature range	from 0 °C to + 50 °C, non-condensing
Supply voltage	from 3.0 V to 4.2 V

1.3 Photos

Figure 1

Figure 2

Figure 3

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 CFR 47:2008 § 15.247 (a)(1) IC RSS-210 A 8.1(b)	Hopping channel separation	Pass
2	FCC CFR 47:2008 § 15.247 (a)(1)(iii) IC RSS-210 A 8.1(b)	Number of hopping frequencies used	Pass
3	FCC CFR 47:2008 § 15.247 (a)(1) IC RSS-210 A 8.2 (a)	Hopping channel bandwidth	Pass
4	FCC CFR 47:2008 § 15.247 (a)(1)(iii) IC RSS-210	Dwell time of each frequency	Pass
5	FCC CFR 47:2008 § 15.247 (b)(1) IC RSS-210 A 8.4 (2)	Output power	Pass
6	FCC CFR 47:2008 § 15.247 (d) IC RSS-210 A 8.5	100 kHz Bandwidth of Frequency Band Edges measurement	Pass
7	FCC CFR 47:2008 § 15.209 IC RSS-210 A 8.5	Radiated Emission	Pass
8	FCC CFR 47:2008 § 15.203	Antenna Requirement	Pass
9	FCC CFR 47:2008 §15.109 IC RSS-210 A 8.5	Radiated Emission from Receiver Part	Pass
10	FCC CFR 47:2008 § 15.247 (h)(i) IC RSS-102 (4.2)	RF exposure	Pass

Tested by:
Laboratory engineer Boris Trifonov

Laboratory engineer Sergey Melnik

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.
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 0 °C to 50 °C (non-condensing);
- relative humidity: from 20 % to 75 %

Normal power source:
Unom = 3.0 V to 4.2 V.

The frequencies for the testing

Channel, No.	Frequency, MHz
0	2401.7
40	2441.7
79	2480.7

2.4 Test equipment used

№	Name	Model	Inventory or serial No.
1.	Spectrum analyzer	FSV40	100821
2.	EMI test receiver	R&S ESU-26	100260
3.	Directional coupler	773D	100101
4.	Attenuator	Agilent 8494B	MY42141168
5.	Attenuator	PE7014-10	101692
6.	Antenna	Schwarzbeck UBAA 9114	9111-214
7.	Antenna	HP11966 model 3115	9903-5701
8.	Antenna	BBHA 9170	9170446
9.	Power supply	Б5-29	12426
10.	Psychrometer	ВИТ-2	В931

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	MULTIPLEX PS-30BH	65003
2.	2.4 Dual FHSS Dual Receiver	8 Smart	N/A

2.5 Measurement uncertainty

Parameter	Maximum uncertainty
Output power	± 1.3 dB
Frequency range	± 1×10^{-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.

2.6 Photo of test site

Figure 4 Conducted Test

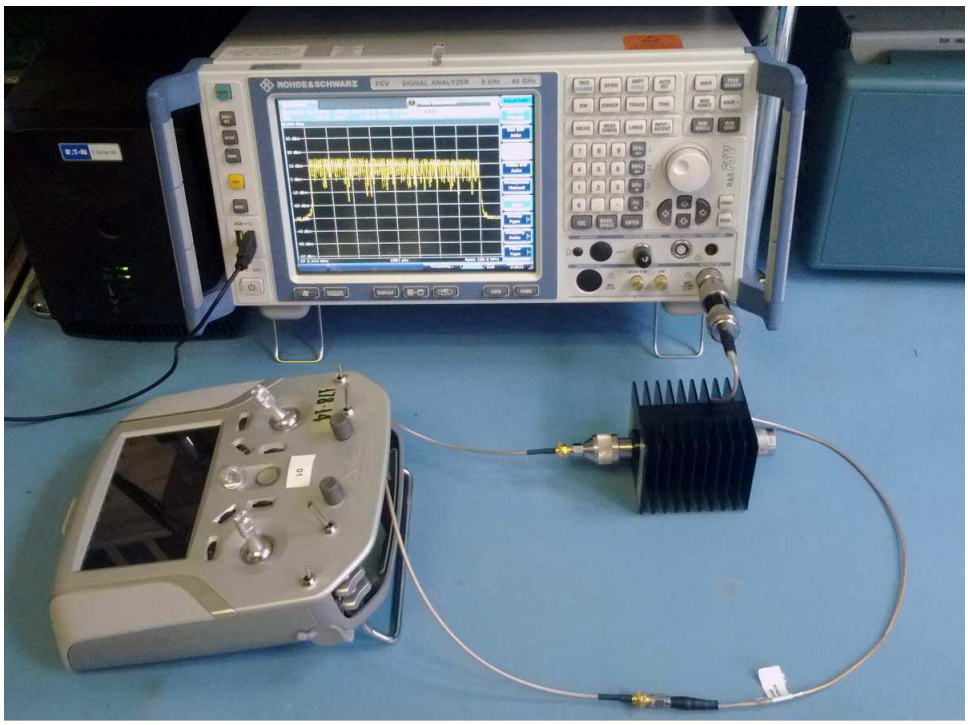


Figure 5 Radiated Emission (30 MHz to 1000 MHz)

Figure 6 Radiated Emission (1000 MHz to 18000 MHz)

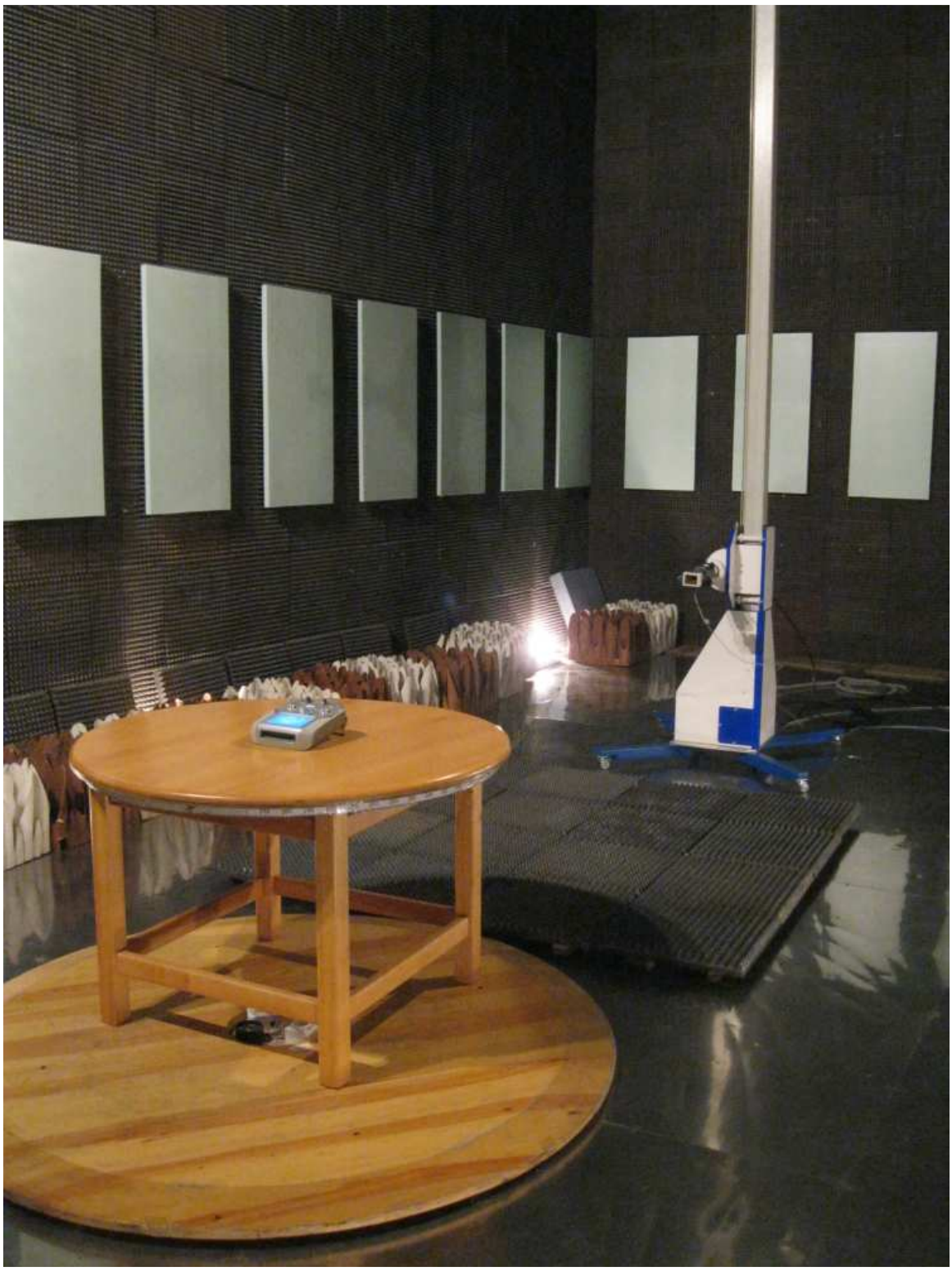


Figure 7 Radiated Emission (18000 MHz to 25000 MHz)

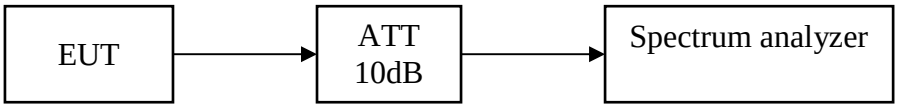
3 REPORT OF MEASUREMENTS AND EXAMINATIONS.

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



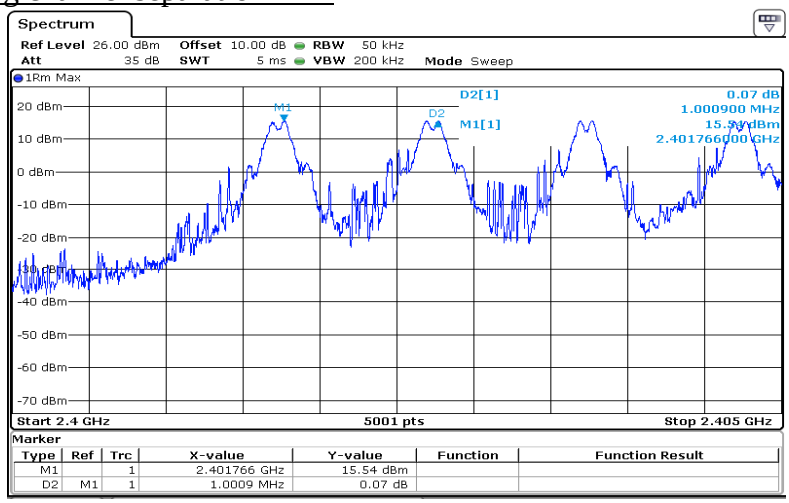
3.1.3 Test result

Temperature: + 18 ^{o}C Relative humidity: 60 %

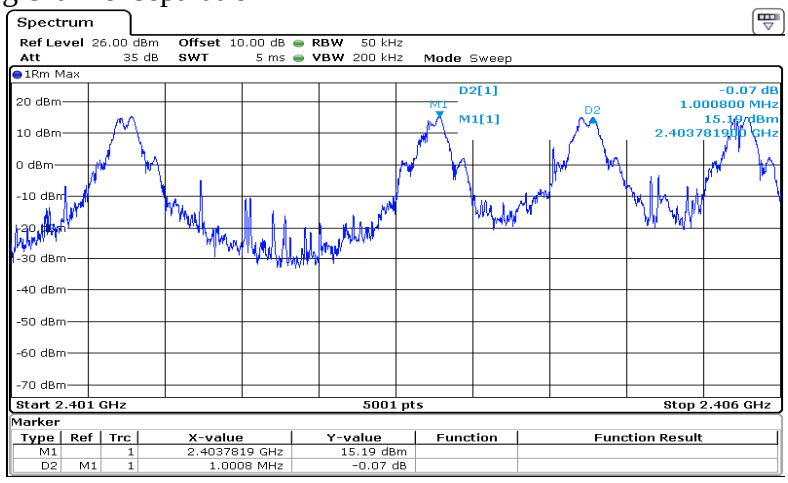
	Hopping channel separation, MHz	Limit (2/3 of 20dB Bandwidth), kHz	Test Result (Pass, Fail, N/A)
Tx 1	1.0009	374	Pass
Tx 2	1.0008	374	Pass

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



3.1.5 Plot Hopping channel separation Tx 2

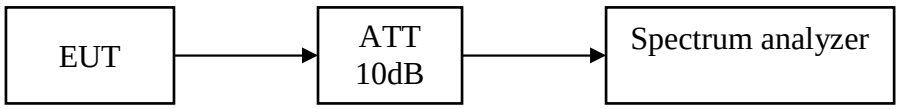


3.2 Number of hopping frequencies used

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



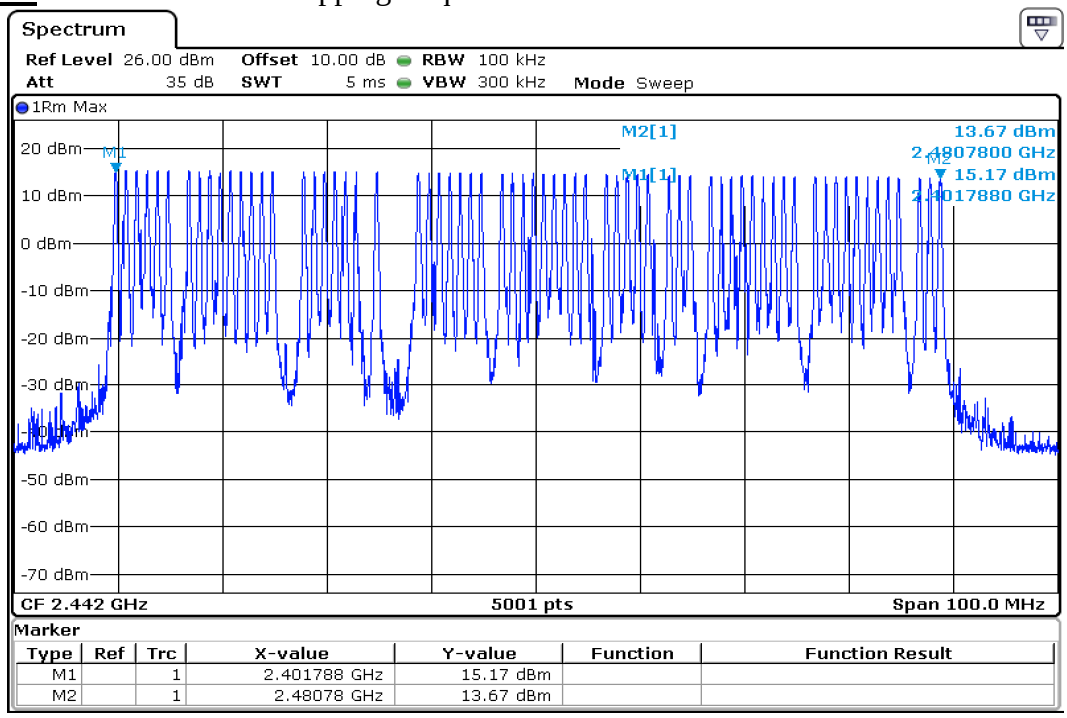
3.2.3 Test result

Temperature: +18 °C Relative humidity: 46 %

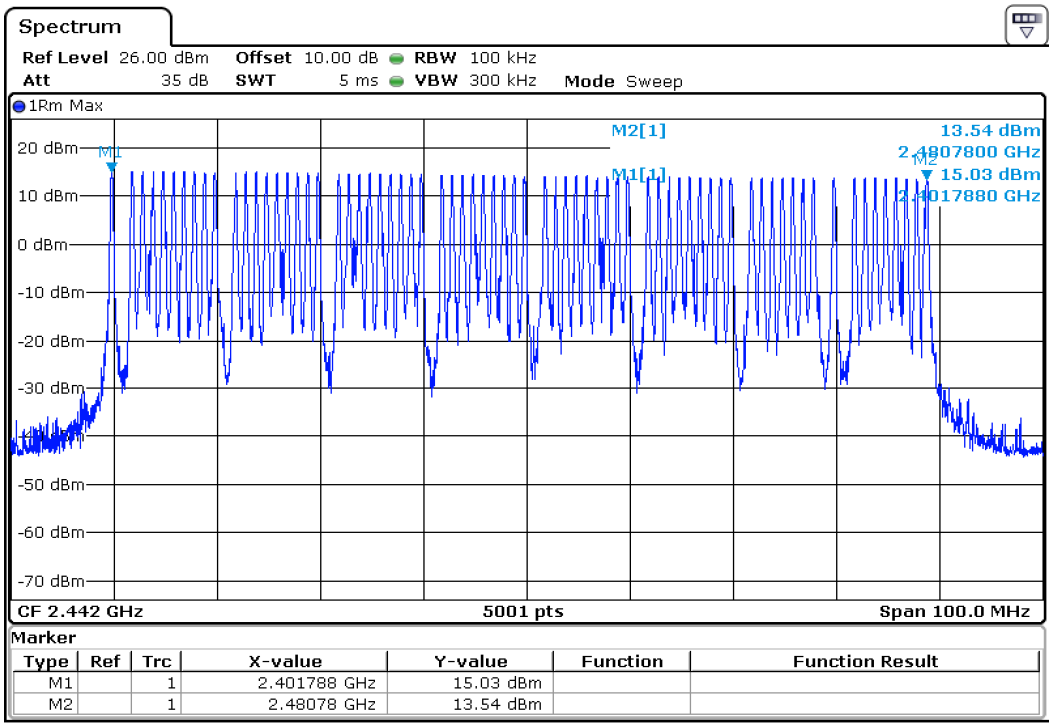
	Number of hopping frequencies	Limit	Test Result (Pass, Fail, N/A)
Tx 1	67	15	Pass
Tx 2	71	15	Pass
Tx 1 + Tx 2	80	15	Pass

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.

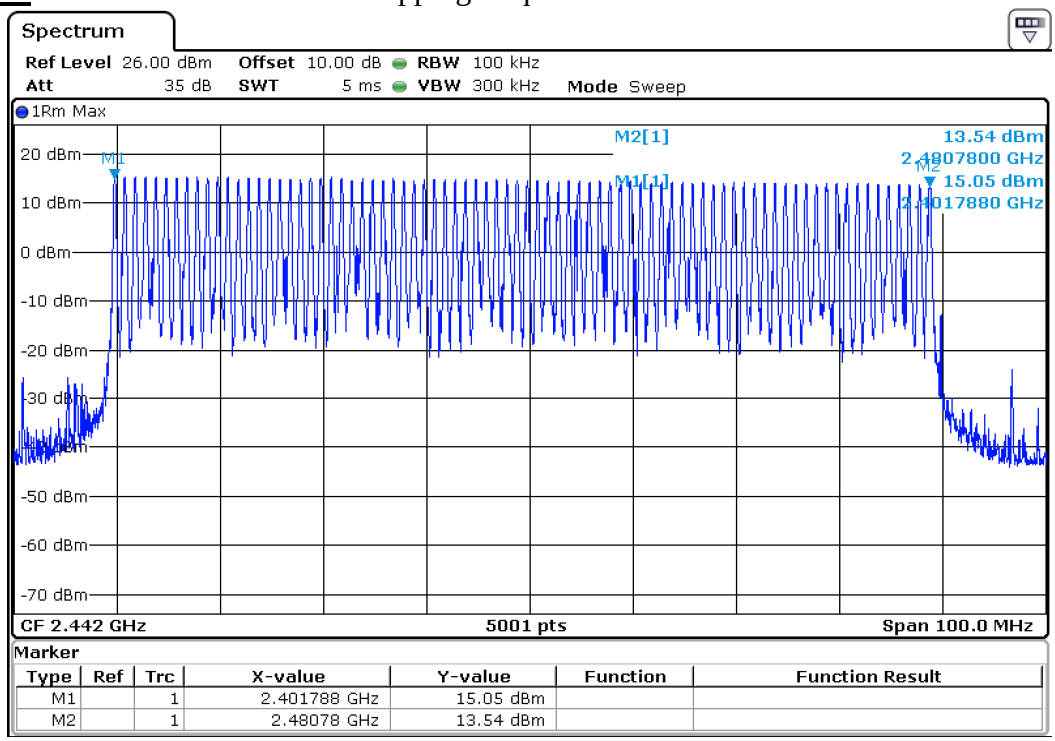
3.2.4 Plot Tx 1 - Number of hopping frequencies



3.2.5 Plot Tx 2 - Number of hopping frequencies



3.2.6 Plot Tx 1 + Tx 2 - Number of hopping frequencies

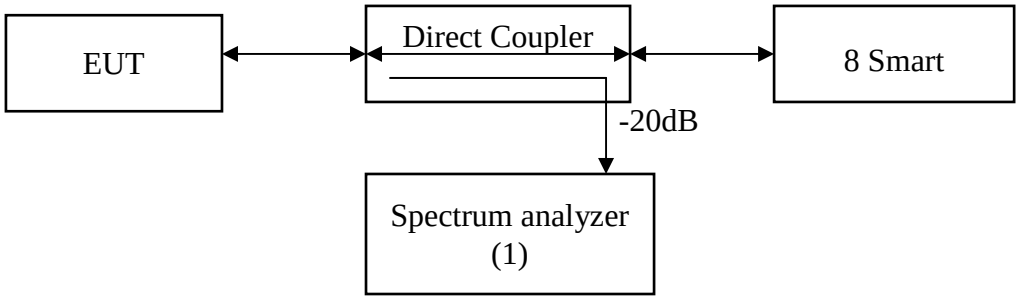


3.3 Hopping channel bandwidth

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



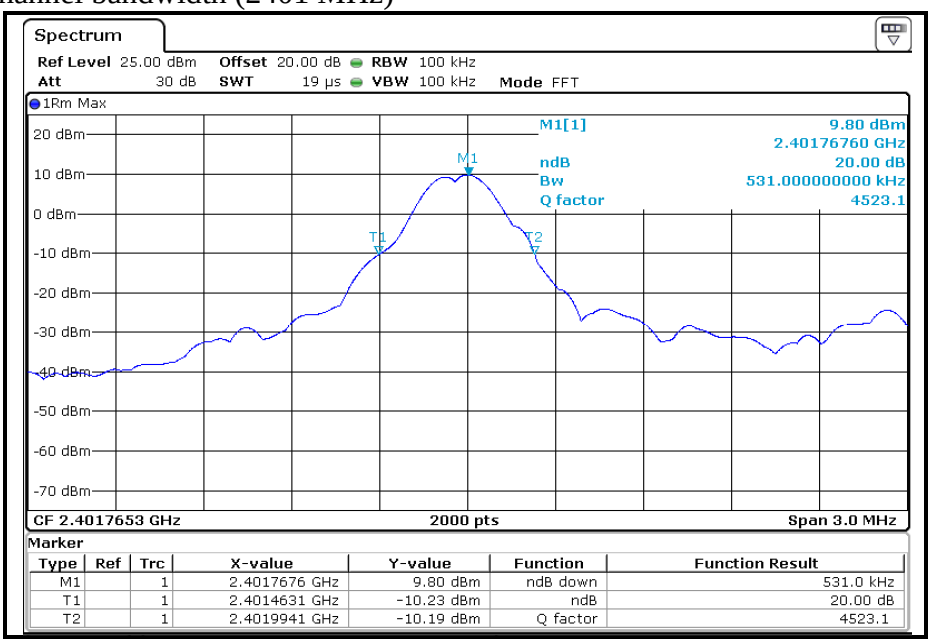
3.3.3 Test result

Temperature: +18 °C Relative humidity: 46 %

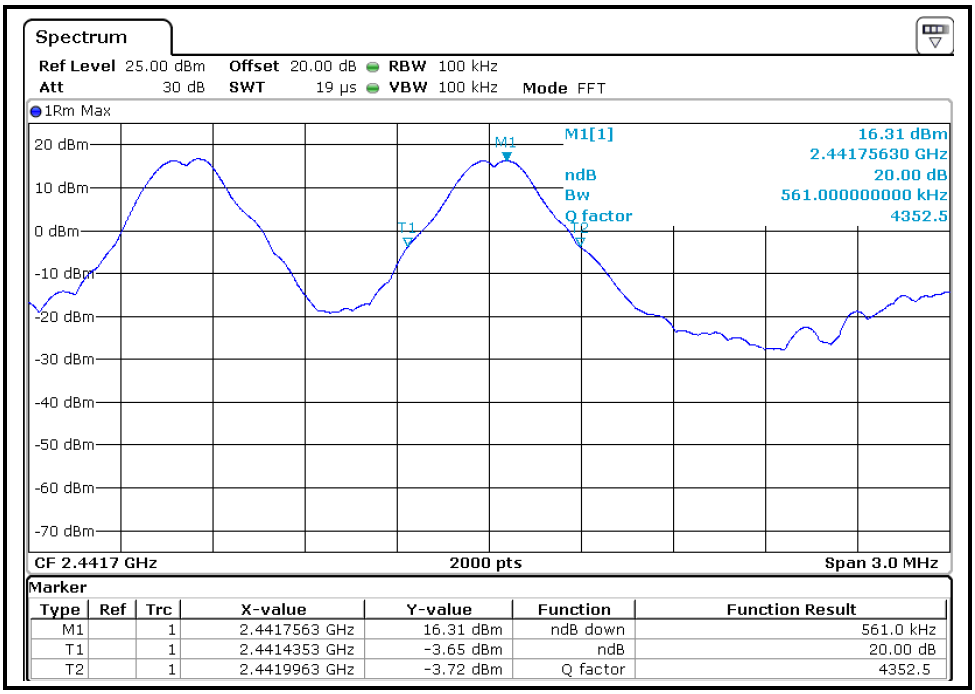
Channel	Frequency, MHz	Hopping channel bandwidth, kHz	Limit, MHz	Test Result (Pass, Fail, N/A)
0	2401.7	531.0	1.0	Pass
40	2441.7	561.0	1.0	Pass
79	2480.7	549.0	1.0	Pass

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).

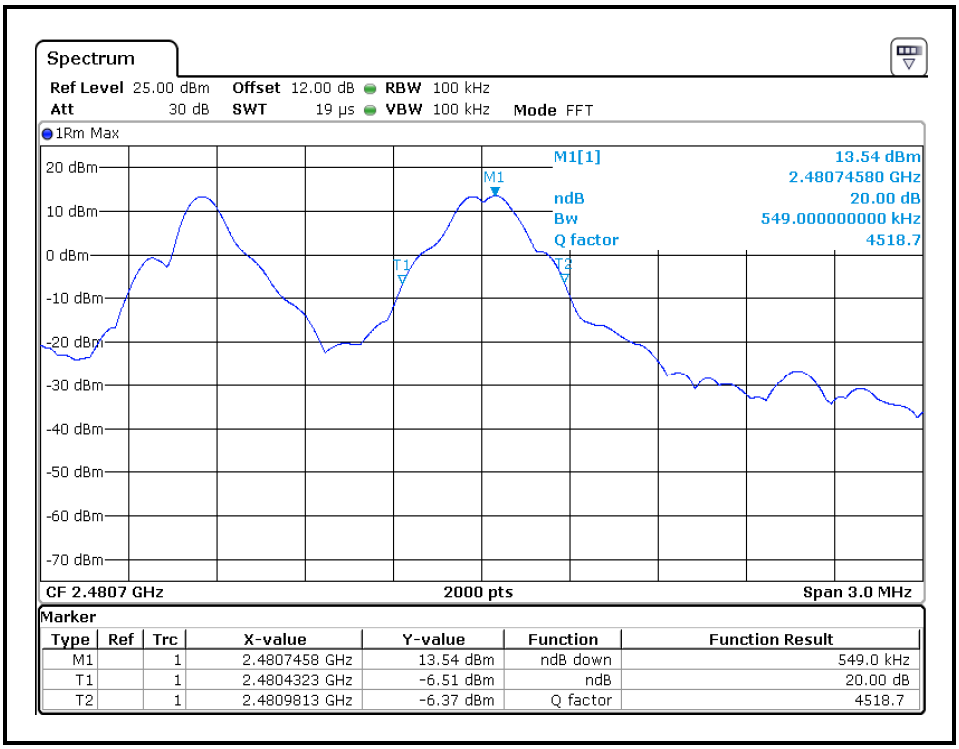
3.3.4 Plot Channel bandwidth (2401 MHz)



3.3.5 Plot Channel bandwidth (2441 MHz)



3.3.6 Plot Channel bandwidth (2481 MHz)

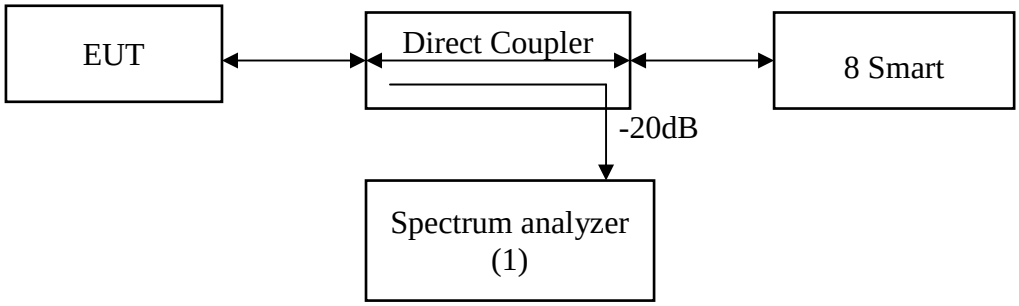


3.4 Dwell Time of Each Frequency

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

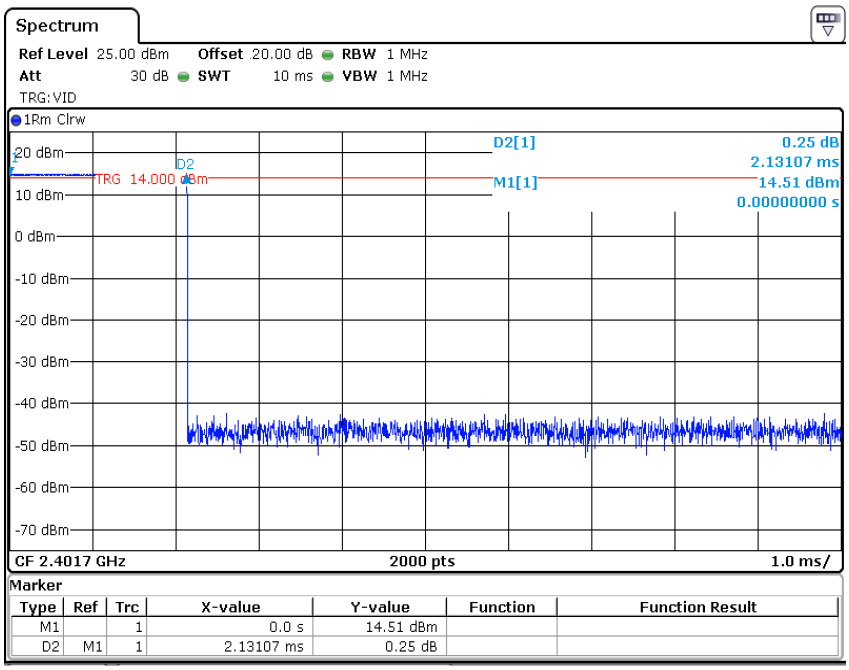
Temperature: +18 ^{o}C Relative humidity: 46 %

Channels	Pulse width (ms)	Number of 6 sec	Dwell Time, ms	Limit, s	Test Result (Pass, Fail, N/A)
0	2.13	6	12.78	0.4	Pass
79	2.13	8	17.04	0.4	Pass

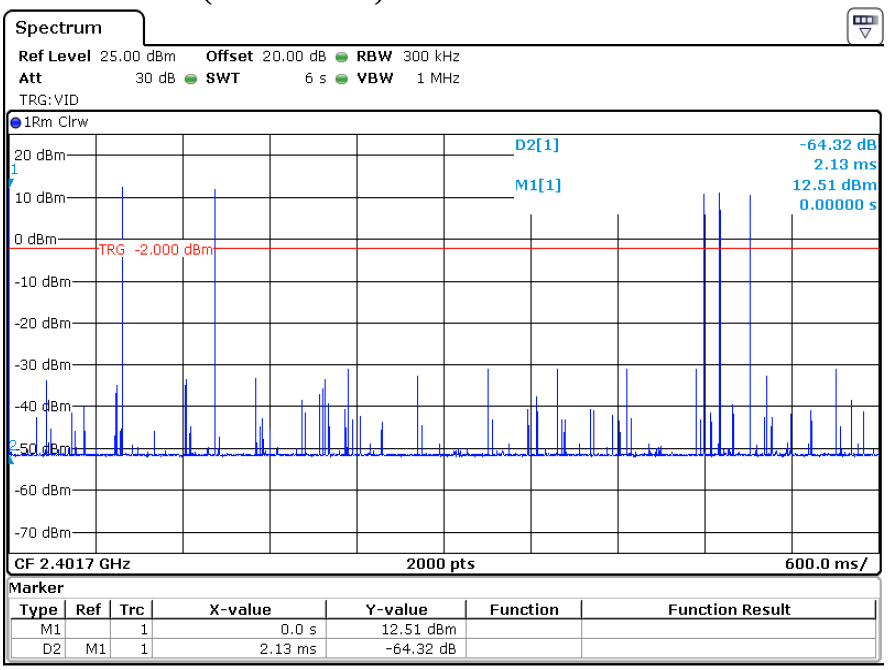
Remark:

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

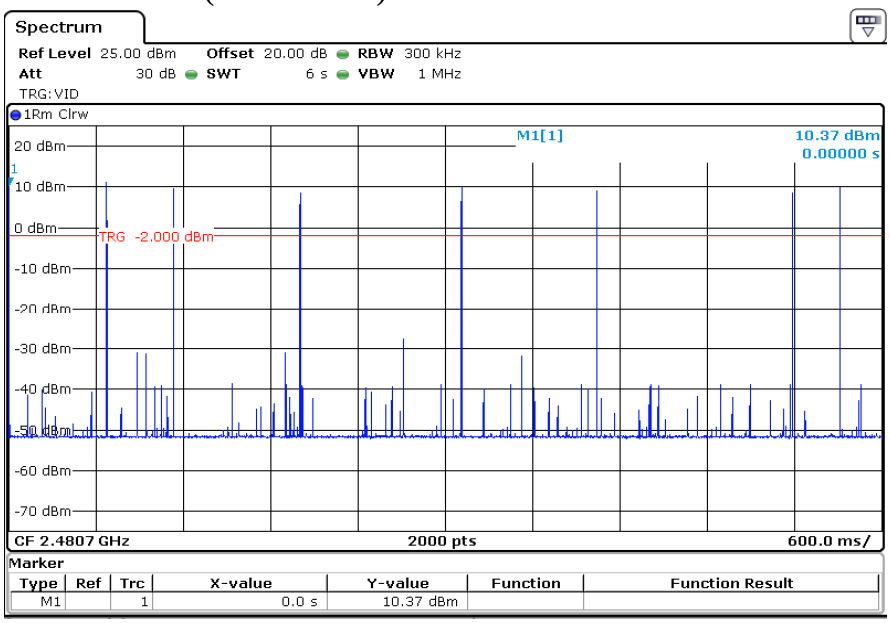
3.4.4 Plot "Pulse width"



3.4.5 Plot "Number of 6 sec" (2401.7 MHz)



3.4.6 Plot "Number of 6 sec" (2480.7 MHz)

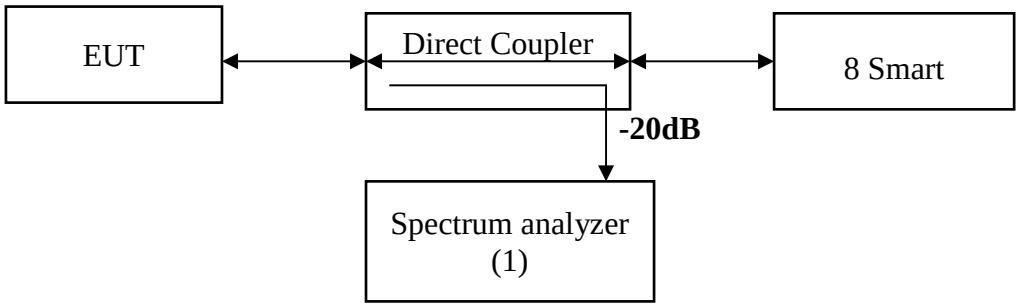


3.5 Output power

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 ^{o}C Relative humidity: 46 %

Ant. 1

Channel	Frequency, MHz	Measured output power, W	Limit, W	Test Result (Pass, Fail, N/A)
0	2401.78	0.061	0.125	Pass
40	2441.78	0.062	0.125	Pass
80	2480.78	0.050	0.125	Pass

Ant. 2

Channel	Frequency, MHz	Measured output power, W	Limit, W	Test Result (Pass, Fail, N/A)
0	2401.78	0.050	0.125	Pass
40	2441.78	0.060	0.125	Pass
80	2481.78	0.043	0.125	Pass

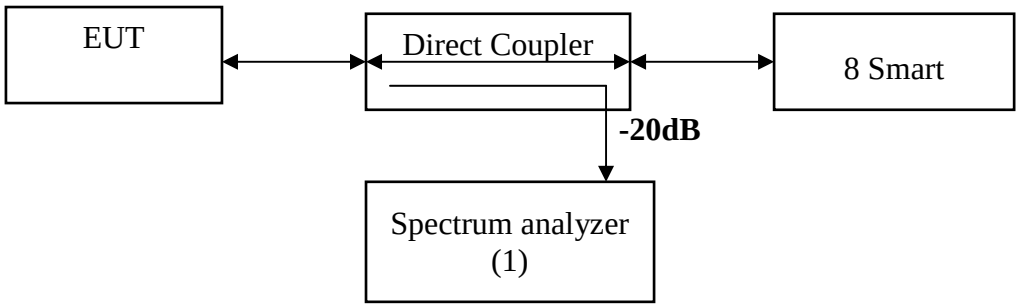
Remark: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2401-2483.5 MHz band: 0,125 watts.

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 100MHz 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



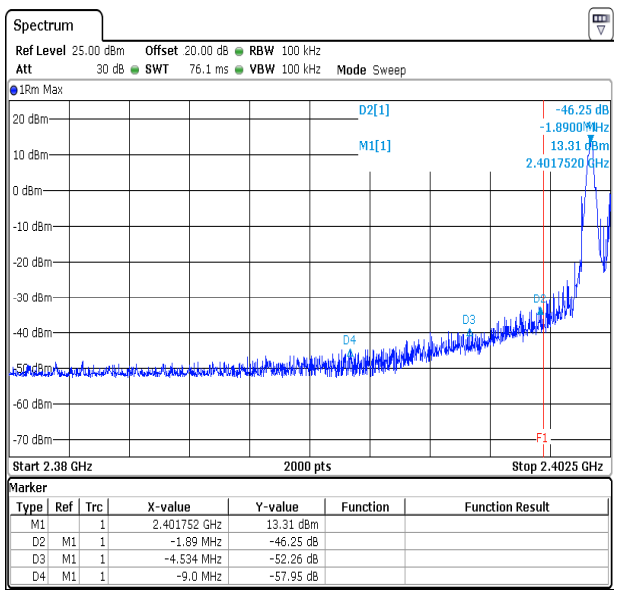
3.6.3 Test result

Temperature: +18 °C Relative humidity: 46 %

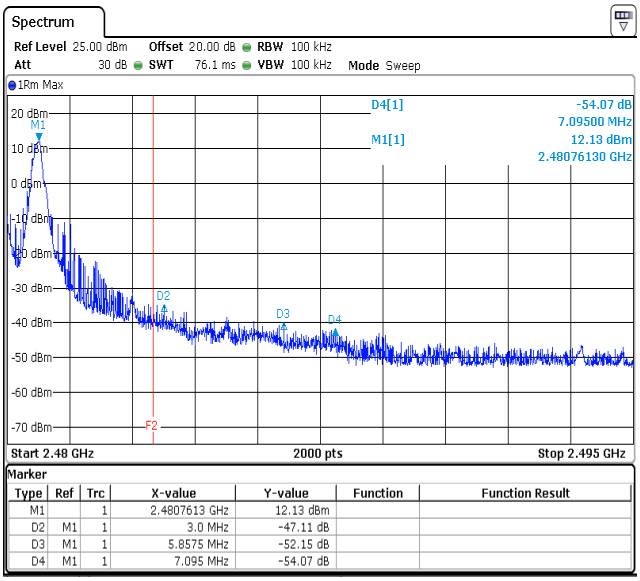
Frequency, MHz	Measured, dBm	Limit, dBc	Test Result (Pass, Fail, N/A)
2392.67	- 50.28	- 20	Pass
2397.23	- 47.05	- 20	Pass
2399.83	- 43.67	- 20	Pass
2484.55	- 55.91	- 20	Pass
2484.99	- 56.22	- 20	Pass
2485.47	- 56.09	- 20	Pass

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

3.6.4 Plots Frequency Band Edges



F1 = 2400 MHz



F2 = 2483.5 MHz

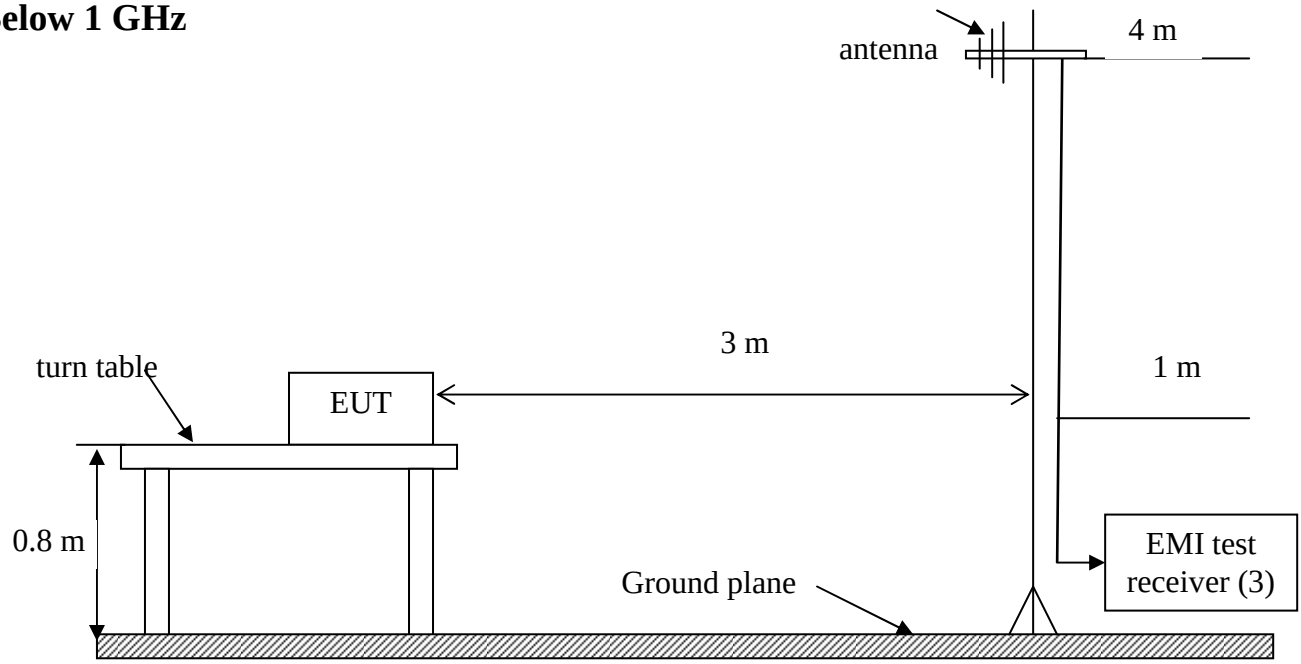
3.7 Radiated Emission

3.7.1 Test procedure

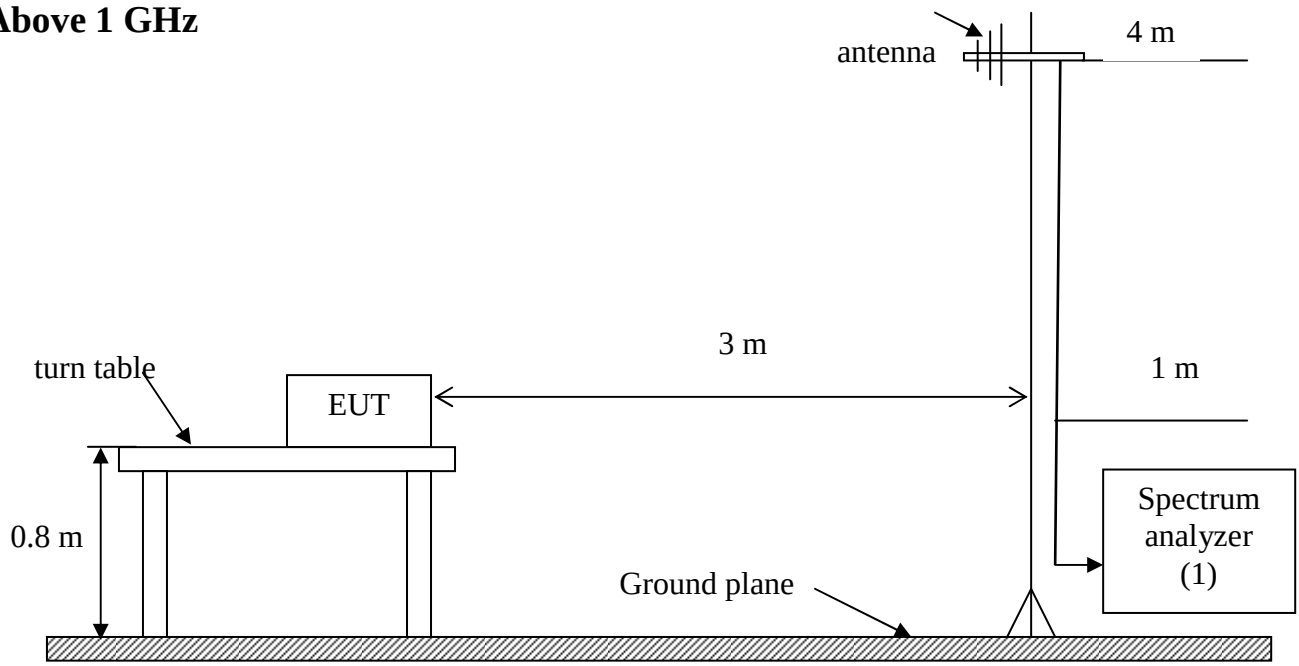
1) The EUT was placed on a turn table top 0.8 m above the floor.
2) The EUT was set 3 meters from the interference receiving antenna which was mounted on the top of a variable height antenna tower.
3) The table was rotated 360 degrees to determine the position of the highest radiation.
4) The antenna 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) The test-receiver was set to Peal or Quasi-peak detect function with specified bandwidth with maximum hold mode.
7) For testing below 1 GHz, if the emission level of EUT in peak mode was 3 dB lower than the specified limit, the testing stopped and peak values of EUT were noted, otherwise, the emissions were repeating one by one using the quasi-peak method and noted.

3.7.2 Test setup layout

Below 1 GHz



Above 1 GHz



3.7.3 Limits

Limit

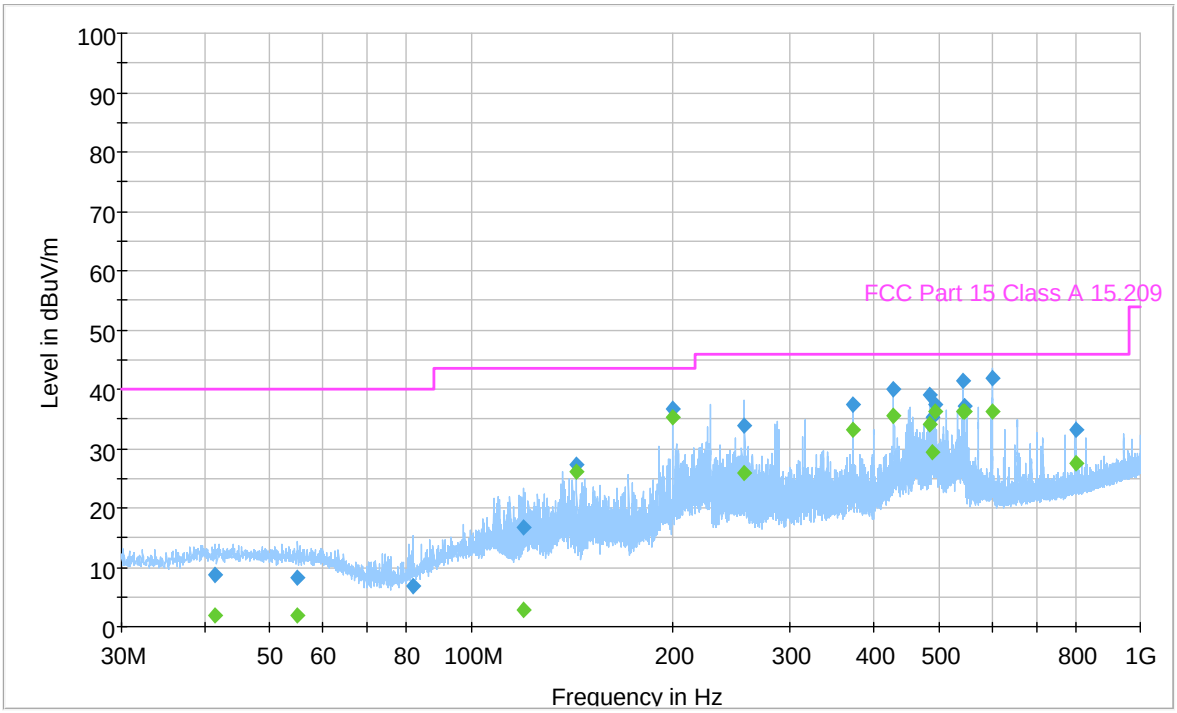
Frequency (MHz)	Field Strength (dBuV/m at 3-meter)	Field Strength (uV/m at 3-meter)
30-88	40	100
88-216	43.5	150
216-960	46	200
Above 960	54	500

3.7.4 Test result

Temperature: +18 °C Relative humidity: 60 %

Below 1 GHz

FCC CFR 47 part 15.209 30-1000 MHz



Final Result 1

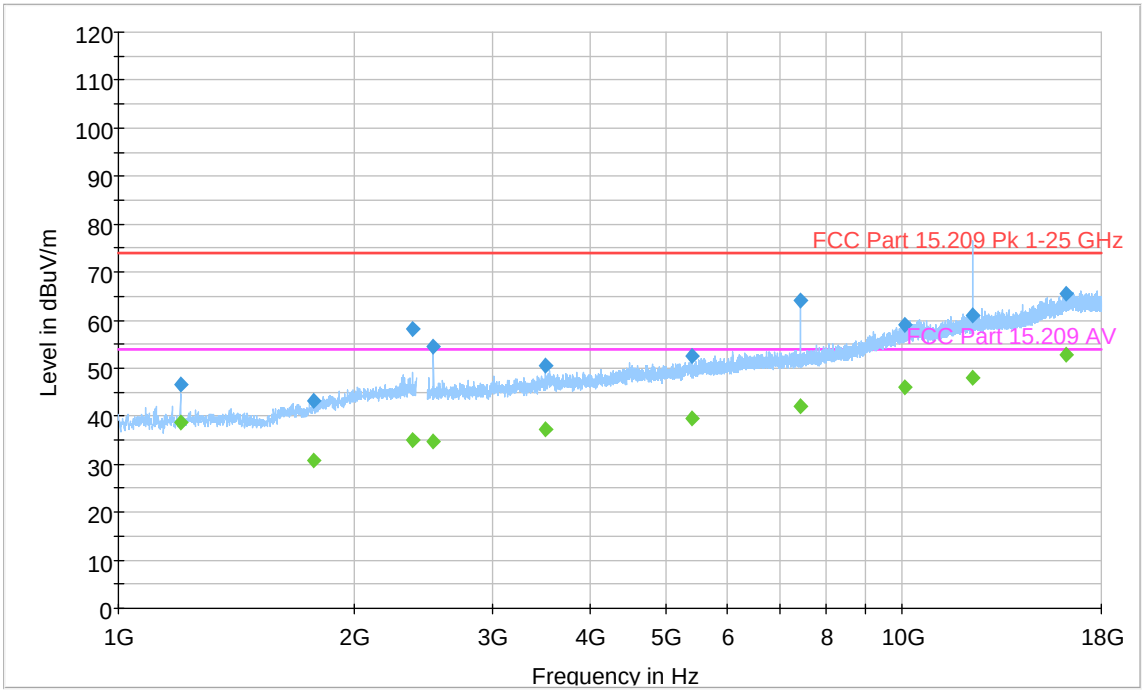
Frequency (MHz)	QuasiPeak (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
41.400000	8.7	1.0	120.000	400.0	H	-14.9	31.3	40.0	
55.080000	8.3	1.0	120.000	300.0	H	-15.4	31.7	40.0	
81.880000	6.8	1.0	120.000	200.0	V	-19.0	33.2	40.0	
119.440000	16.7	1.0	120.000	250.0	V	-17.2	26.8	43.5	
143.880000	27.2	1.0	120.000	200.0	V	-19.2	16.3	43.5	
200.000000	36.8	1.0	120.000	200.0	V	-16.2	6.7	43.5	
256.160000	33.8	1.0	120.000	200.0	V	-14.1	12.2	46.0	
371.920000	37.5	1.0	120.000	150.0	V	-11.4	8.5	46.0	
428.080000	40.0	1.0	120.000	100.0	V	-10.5	6.0	46.0	
484.240000	39.0	1.0	120.000	100.0	V	-9.8	7.0	46.0	
487.800000	35.4	1.0	120.000	100.0	H	-9.7	10.6	46.0	
494.000000	37.4	1.0	120.000	150.0	V	-9.5	8.6	46.0	
543.840000	41.3	1.0	120.000	150.0	V	-8.3	4.7	46.0	
546.000000	37.3	1.0	120.000	100.0	V	-8.2	8.7	46.0	
600.040000	41.9	1.0	120.000	100.0	V	-6.9	4.1	46.0	
800.080000	33.2	1.0	120.000	150.0	V	-4.5	12.8	46.0	

Final Result 2

Frequency (MHz)	Average (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
41.400000	1.9	1.0	120.000	400.0	H	-14.9	38.1	40.0	
55.080000	1.8	1.0	120.000	300.0	H	-15.4	38.2	40.0	
81.880000	-1.0	1.0	120.000	200.0	V	-19.0	41.0	40.0	
119.440000	2.9	1.0	120.000	250.0	V	-17.2	40.6	43.5	
143.880000	26.1	1.0	120.000	200.0	V	-19.2	17.4	43.5	
200.000000	35.4	1.0	120.000	200.0	V	-16.2	8.1	43.5	
256.160000	25.9	1.0	120.000	200.0	V	-14.1	20.1	46.0	
371.920000	33.3	1.0	120.000	150.0	V	-11.4	12.7	46.0	
428.080000	35.5	1.0	120.000	100.0	V	-10.5	10.5	46.0	
484.240000	34.1	1.0	120.000	100.0	V	-9.8	11.9	46.0	
487.800000	29.4	1.0	120.000	100.0	H	-9.7	16.6	46.0	
494.000000	36.2	1.0	120.000	150.0	V	-9.5	9.8	46.0	
543.840000	36.3	1.0	120.000	150.0	V	-8.3	9.7	46.0	
546.000000	36.3	1.0	120.000	100.0	V	-8.2	9.7	46.0	
600.040000	36.3	1.0	120.000	100.0	V	-6.9	9.7	46.0	
800.080000	27.4	1.0	120.000	150.0	V	-4.5	18.6	46.0	

Above 1 GHz

FCC CFR 47 part 15.209 1-18 GHz



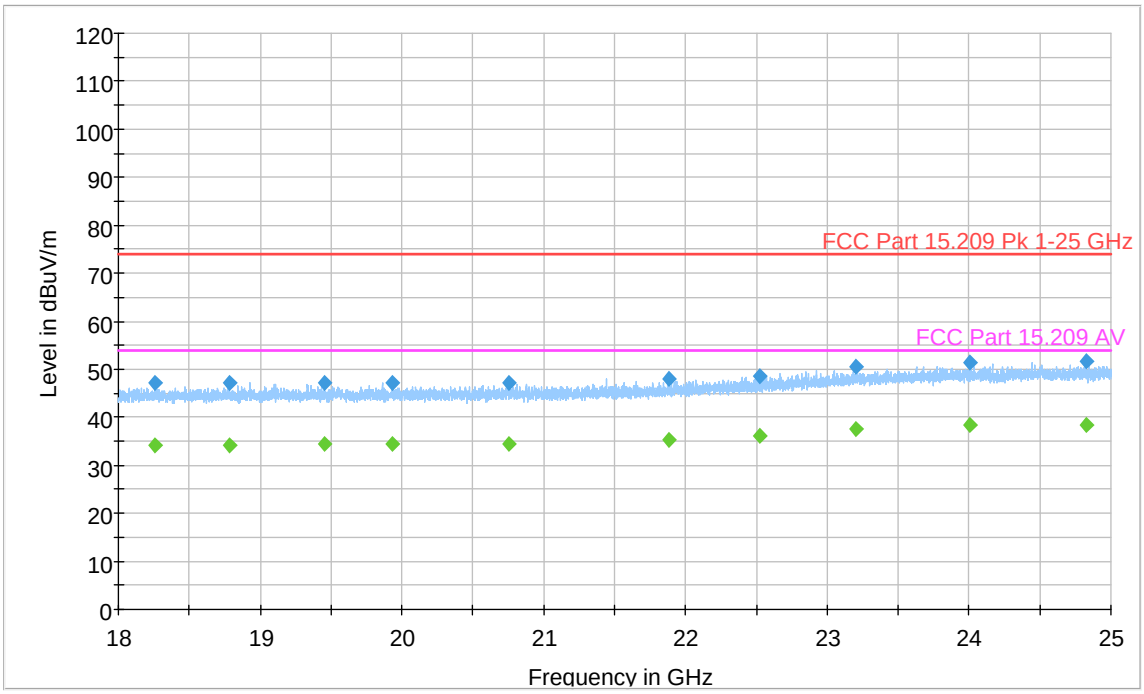
Final Result 1

Frequency (MHz)	MaxPeak (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
1200.000000	46.5	500.0	1000.000	100.0	H	7.2	27.5	74.0	
1775.000000	43.2	500.0	1000.000	100.0	H	10.1	30.8	74.0	
2375.000000	58.2	500.0	1000.000	100.0	H	13.0	15.8	74.0	
2526.500000	54.5	500.0	1000.000	100.0	V	13.5	19.5	74.0	
3512.500000	50.6	500.0	1000.000	100.0	V	15.8	23.4	74.0	
5397.500000	52.5	500.0	1000.000	100.0	V	19.8	21.5	74.0	
7424.500000	64.2	500.0	1000.000	100.0	H	23.1	9.8	74.0	
10081.500000	59.0	500.0	1000.000	100.0	H	27.1	15.0	74.0	
12309.500000	61.1	500.0	1000.000	100.0	H	30.1	12.9	74.0	
16201.500000	65.4	500.0	1000.000	100.0	H	34.2	8.6	74.0	

Final Result 2

Frequency (MHz)	Average (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
1200.000000	38.6	500.0	1000.000	100.0	H	7.2	15.4	54.0	
1775.000000	30.9	500.0	1000.000	100.0	H	10.1	23.1	54.0	
2375.000000	35.1	500.0	1000.000	100.0	H	13.0	18.9	54.0	
2526.500000	34.8	500.0	1000.000	100.0	V	13.5	19.2	54.0	
3512.500000	37.3	500.0	1000.000	100.0	V	15.8	16.7	54.0	
5397.500000	39.5	500.0	1000.000	100.0	V	19.8	14.5	54.0	
7424.500000	42.1	500.0	1000.000	100.0	H	23.1	11.9	54.0	
10081.500000	46.1	500.0	1000.000	100.0	H	27.1	7.9	54.0	
12309.500000	48.0	500.0	1000.000	100.0	H	30.1	6.0	54.0	
16201.500000	52.7	500.0	1000.000	100.0	H	34.2	1.3	54.0	

FCC CFR 47 part 15.209 18-25 GHz



Final Result 1

Frequency (MHz)	MaxPeak (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
18260.000000	47.1	500.0	1000.000	100.0	H	19.8	26.9	74.0	
18783.000000	47.0	500.0	1000.000	100.0	V	20.3	27.0	74.0	
19454.000000	47.3	500.0	1000.000	100.0	H	20.8	26.7	74.0	
19933.000000	47.2	500.0	1000.000	100.0	V	21.2	26.8	74.0	
20754.000000	47.2	500.0	1000.000	100.0	H	21.6	26.8	74.0	
21886.000000	47.9	500.0	1000.000	100.0	H	22.5	26.1	74.0	
22519.000000	48.7	500.0	1000.000	100.0	H	23.6	25.3	74.0	
23203.000000	50.4	500.0	1000.000	100.0	H	24.7	23.6	74.0	
24005.000000	51.3	500.0	1000.000	100.0	V	25.1	22.7	74.0	
24830.000000	51.6	500.0	1000.000	100.0	V	25.4	22.4	74.0	

Final Result 2

Frequency (MHz)	Average (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Corr. (dB)	Margin (dB)	Limit (dBuV/m)	Comment
18260.000000	34.2	500.0	1000.000	100.0	H	19.8	19.8	54.0	
18783.000000	34.1	500.0	1000.000	100.0	V	20.3	19.9	54.0	
19454.000000	34.4	500.0	1000.000	100.0	H	20.8	19.6	54.0	
19933.000000	34.3	500.0	1000.000	100.0	V	21.2	19.7	54.0	
20754.000000	34.4	500.0	1000.000	100.0	H	21.6	19.6	54.0	
21886.000000	35.3	500.0	1000.000	100.0	H	22.5	18.7	54.0	
22519.000000	36.2	500.0	1000.000	100.0	H	23.6	17.8	54.0	
23203.000000	37.6	500.0	1000.000	100.0	H	24.7	16.5	54.0	
24005.000000	38.5	500.0	1000.000	100.0	V	25.1	15.5	54.0	
24830.000000	38.5	500.0	1000.000	100.0	V	25.4	15.5	54.0	

3.8 Antenna Requirement

3.8.1 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.

3.8.2 Test result

The antennas of the 2.4 Dual FHSS BAT 60 Transmitter permanently attached and there are no provisions for connection to external antennas. It complies with the requirement of §15.203.

3.9 RF exposure

3.9.1 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/f2	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/cm^2)
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 20 %:

$$S = \frac{0.2\times62\times1.58}{4\times\pi\times20^2} = 0.0039\ [mW/cm^2]$$

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	18	2	20	100	0.0039	1.0	0.9961	Pass

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