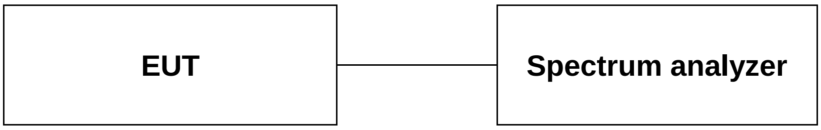
7. power spectral density

7.1. Test setup



7.2. Test Overview and Limit

Frequency Band	Limit
5150-5250MHz	The power spectral density less than 11dBm/1MHz
5250-5350MHz	The power spectral density less than 11dBm/1MHz
5470-5725MHz	The power spectral density less than 11dBm/1MHz
5725-5850MHz	The power spectral density less than 30dBm/500kHz

7.3. Test procedure (KDB 789033)

1. Create an average power spectrum for the EUT operating mode being tested by following the instructions in section II.E.2. for measuring maximum conducted output power using a spectrum analyzer or EMI receiver: select the appropriate test method (SA-1, SA-2, SA-3, or alternatives to each) and apply it up to, but not including, the step labeled, “Compute power….” (This procedure is required even if the maximum conducted output power measurement was performed using a power meter, method PM.)

2. Use the peak search function on the instrument to find the peak of the spectrum and record its value.

3. Make the following adjustments to the peak value of the spectrum, if applicable:
a) If Method SA-2 or SA-2 Alternative was used, add 10 log (1/x), where x is the duty cycle, to the peak of the spectrum.

b) If Method SA-3 Alternative was used and the linear mode was used in step II.E.2.g)(viii), add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.
4. The result is the Maximum PSD over 1 MHz reference bandwidth.

5. For devices operating in the bands 5.15-5.25 GHz, 5.25-5.35 GHz, and 5.47-5.725 GHz, the above procedures make use of 1 MHz RBW to satisfy directly the 1 MHz reference bandwidth specified in § 15.407(a)(5). For devices operating in the band 5.725-5.85 GHz, the rules specify a measurement bandwidth of 500 kHz. Many spectrum analyzers do not have 500 kHz RBW, thus a narrower RBW may need to be used. The rules permit the use of a RBWs less than 1 MHz, or 500 kHz, “provided that the measured power is integrated over the full reference bandwidth” to show the total power over the specified measurement bandwidth (i.e., 1 MHz, or 500 kHz). If measurements are performed using a reduced resolution bandwidth (< 1 MHz, or < 500 kHz) and integrated over 1 MHz, or 500 kHz bandwidth, the following adjustments to the procedures apply:
a) Set RBW ≥ 1/T, where T is defined in section II.B.l.a).

b) Set VBW ≥ 3 RBW.

c) If measurement bandwidth of Maximum PSD is specified in 500 kHz, add 10 log (500 kHz/RBW) to the measured result, whereas RBW (<500 kHz) is the reduced resolution bandwidth of the spectrum analyzer set during measurement.

d) If measurement bandwidth of Maximum PSD is specified in 1 MHz, add 10 log (1MHz/RBW) to the measured result, whereas RBW (< 1 MHz) is the reduced resolution bandwidth of spectrum analyzer set during measurement.

e) Care must be taken to ensure that the measurements are performed during a period of continuous transmission or are corrected upward for duty cycle.
Note: As a practical matter, it is recommended to use reduced RBW of 100 kHz for the sections 5.c) and 5.d) above, since RBW=100 KHZ is available on nearly all spectrum analyzers.

7.4. Test results

Ambient temperature: 22℃
Relative humidity: 45% R.H.

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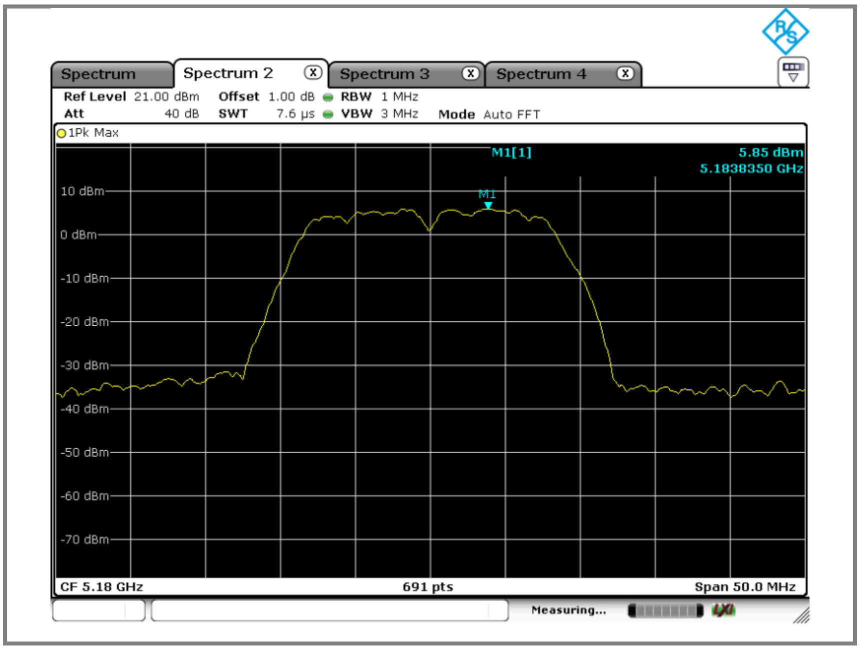
Mode	Frequency (㎒)	Power Spectral Density (dB m /1 ㎒)	Limit (dB m /1 ㎒)
U-NII-1(802.11a)	5 180	5.85	11dBm
	5 220	6.07	
	5 240	5.85	
U-NII-1(n_HT20)	5 180	5.15	
	5 220	5.03	
	5 240	5.82	
U-NII-1(n_HT40)	5 190	0.95	
	5 230	1.38	
U-NII-1(VHT80)	5 210	-2.19	
U-NII-2A(802.11a)	5 180	6.64	11dBm
	5 220	6.01	
	5 240	7.23	
U-NII-2A(n_HT20)	5 180	5.58	
	5 220	5.65	
	5 240	5.71	
U-NII-2A(n_HT40)	5 270	1.60	
	5 310	2.43	
U-NII-2A(VHT80)	5 290	-2.73	
U-NII-2C(802.11a)	5 500	6.45	11dBm
	5 560	5.33	
	5 620	5.12	
U-NII-2C(n_HT20)	5 500	5.54	
	5 560	5.44	
	5 620	4.90	
U-NII-2C(n_HT40)	5 510	1.29	
	5 550	0.73	
	5 590	0.87	
U-NII-2C(VHT80)	5 530	-3.34	
	5 610	-3.02	

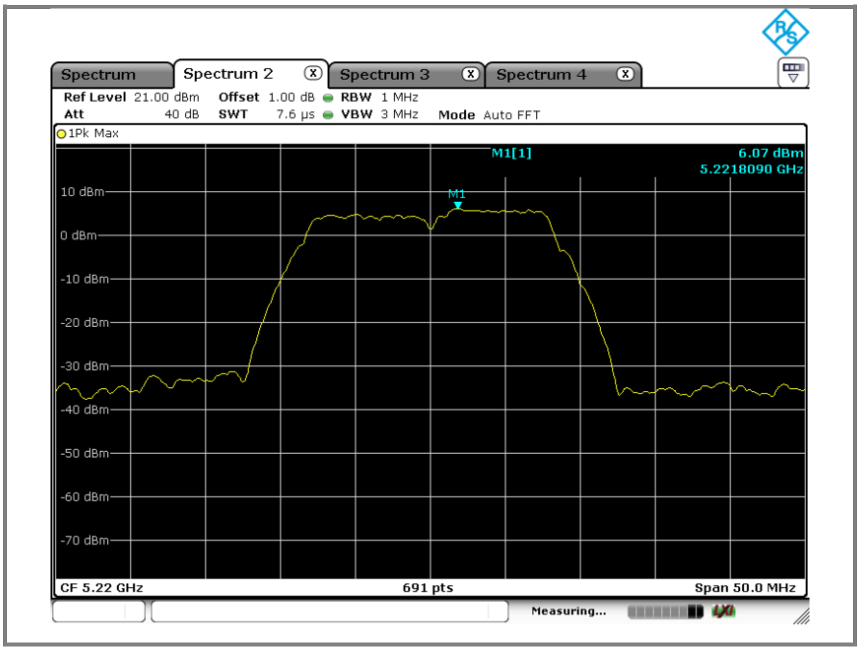
Mode	Frequency (㎒)	Power Spectral Density (dB m /500kHz)	Limit (dB m /500kHz)
U-NII-3(802.11a)	5 745	3.73	30
	5 785	3.30	
	5 805	3.25	
U-NII-3(n_HT20)	5 745	3.21	
	5 785	2.66	
	5 805	2.49	
U-NII-3(n_HT40)	5 755	-0.58	
	5 795	1.57	
U-NII-3(VHT80)	5 775	-4.37	

Operation mode: U-NII-1(802.11a)

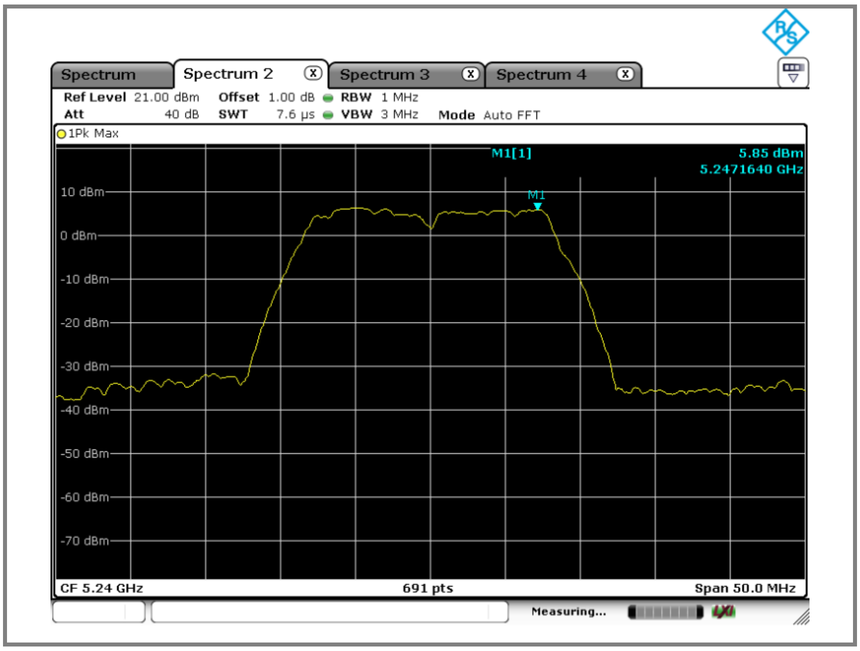
A. Low channel(5180 ㎒)



B. Middle channel(5220 ㎒)

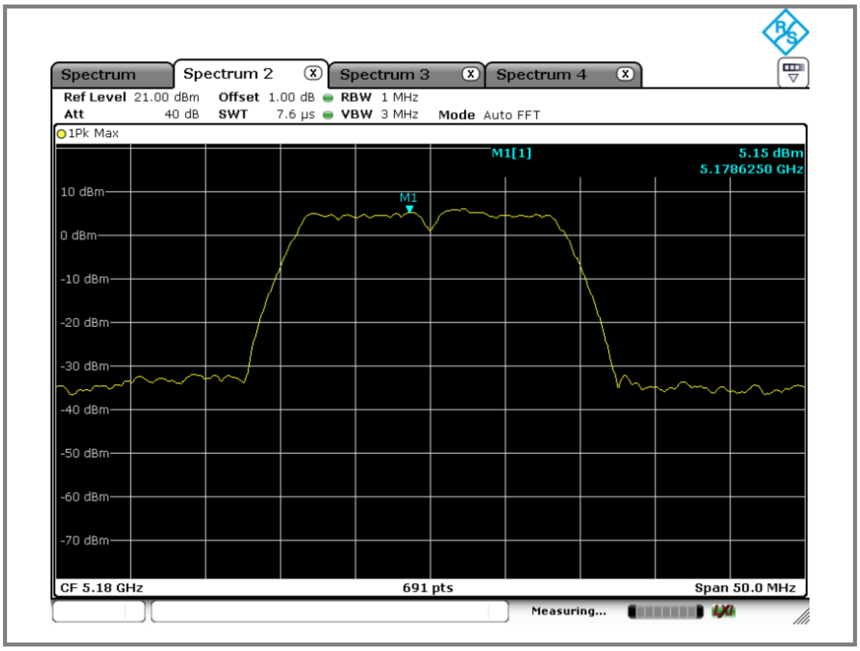


C. High channel(5240 ㎒)

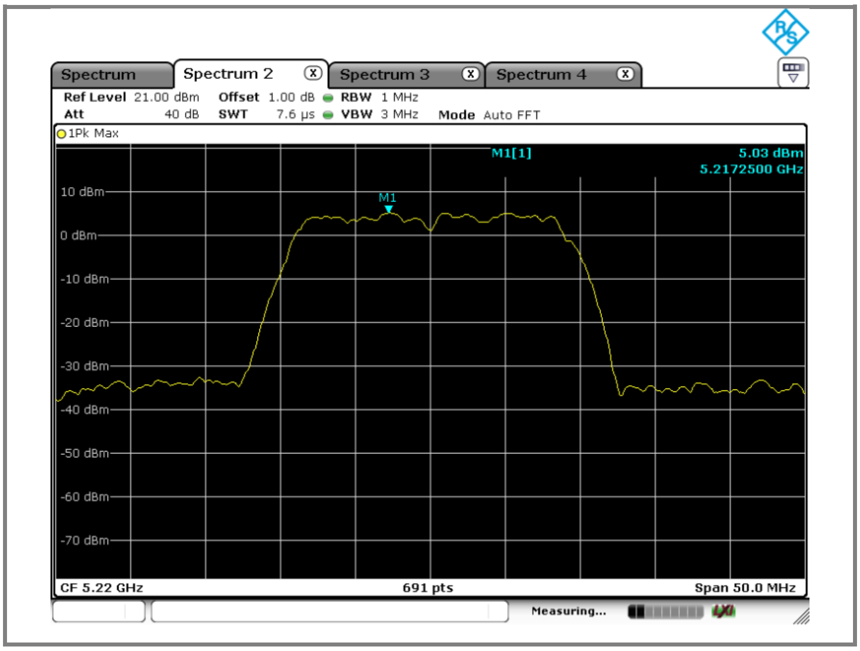


Operation mode: U-NII-1(n_HT20)

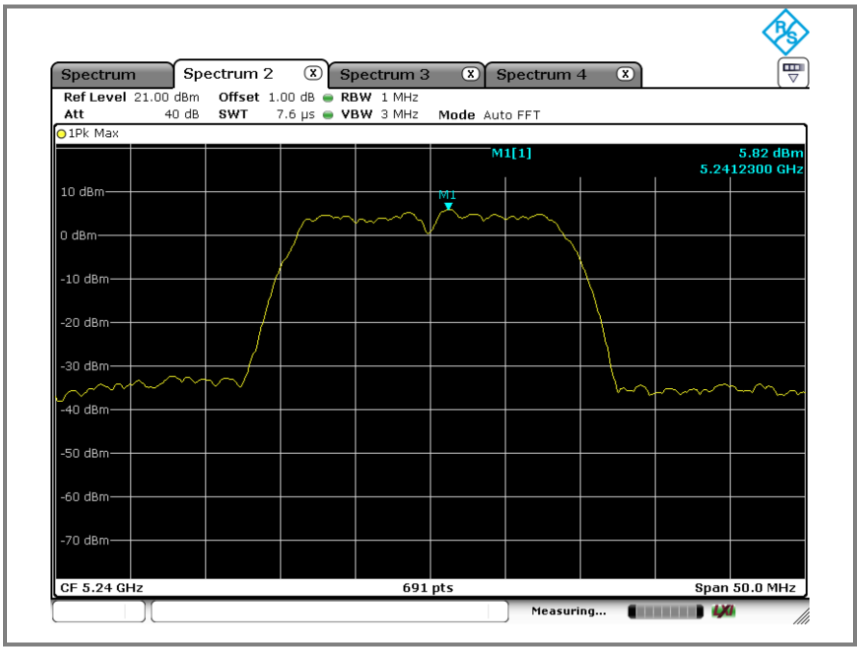
A. Low channel(5180 ㎒)



B. Middle channel(5220 ㎒)

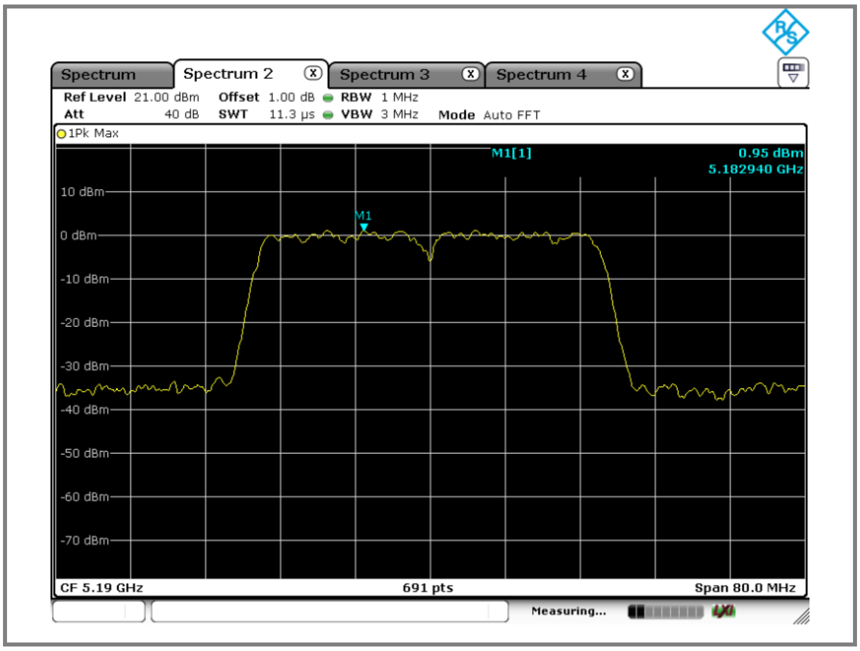


C. High channel(5240 ㎒)

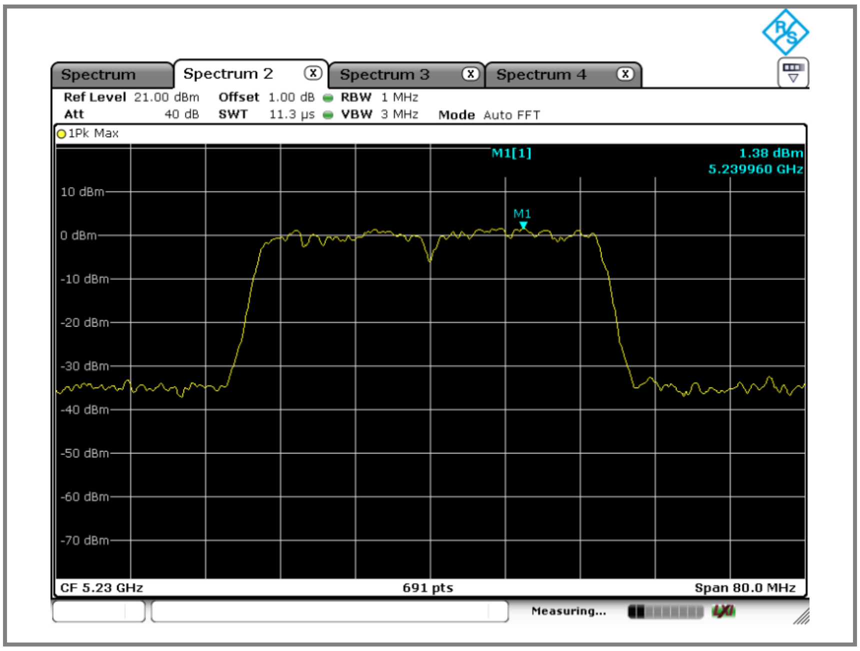


Operation mode: U-NII-1(n_HT40)

A. Low channel(5190 ㎒)

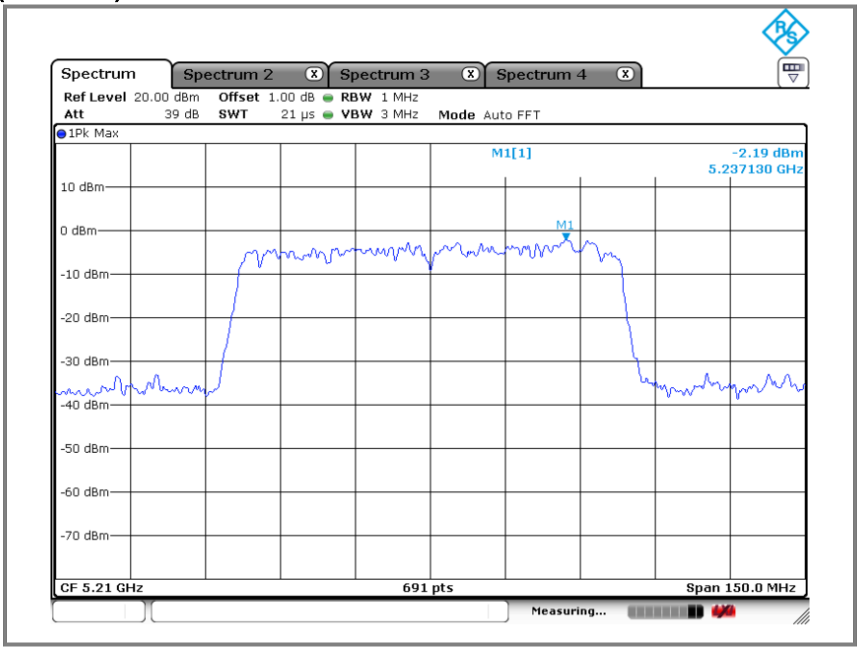


B. High channel(5230 ㎒)



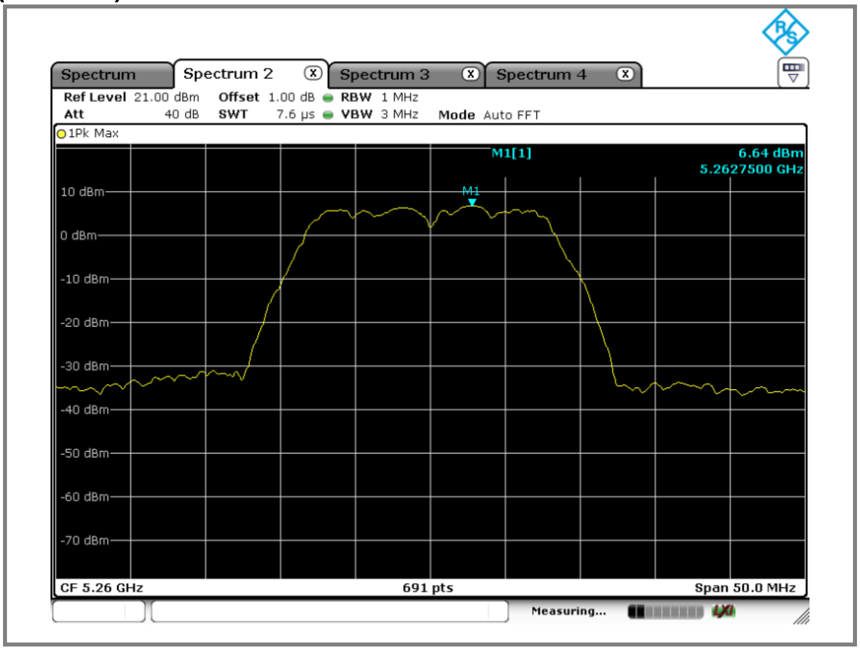
Operation mode: U-NII-1(VHT80)

A. Low channel(5210 ㎒)

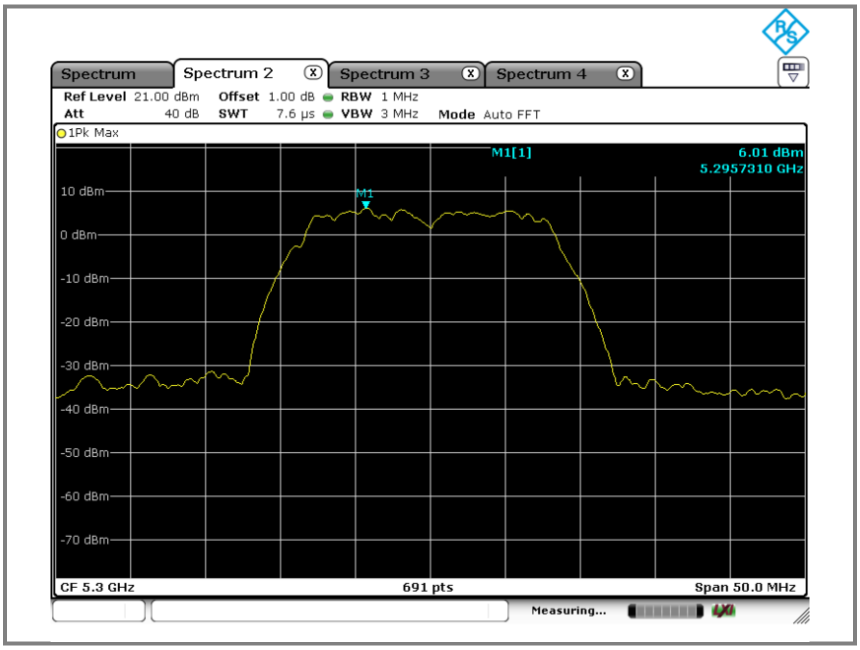


Operation mode: U-NII-2A(802.11a)

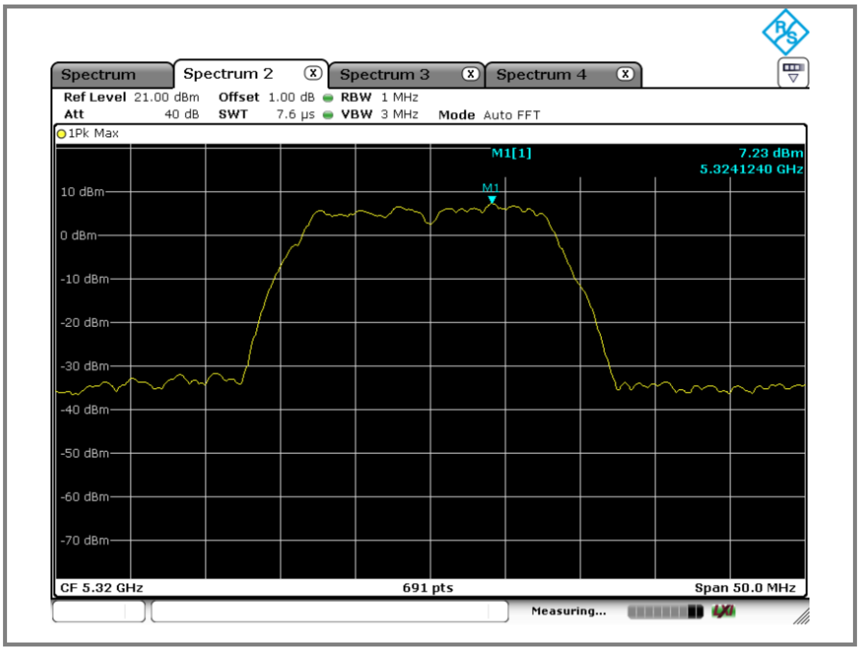
A. Low channel(5260 ㎒)



B. Middle channel(5300 ㎒)

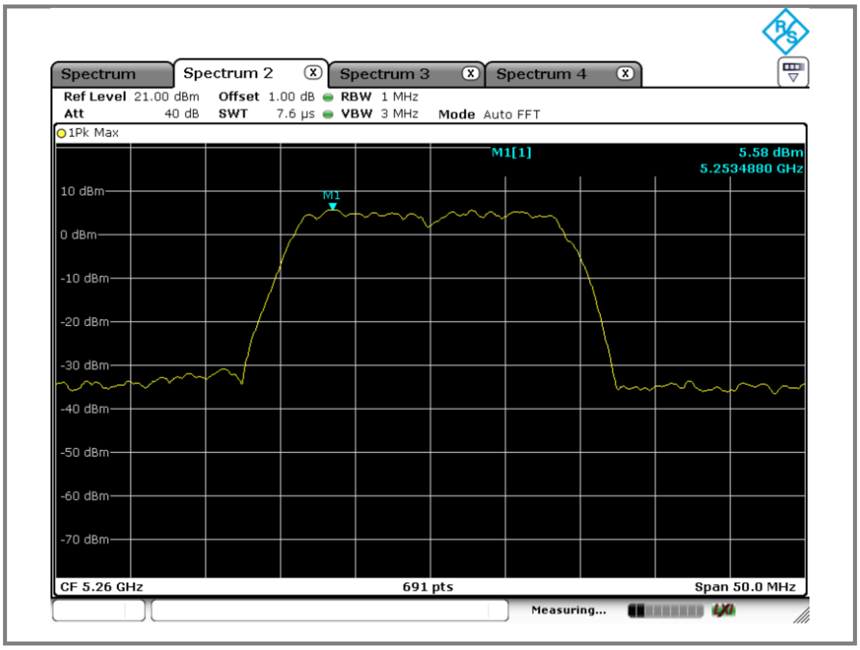


C. High channel(5320 ㎒)

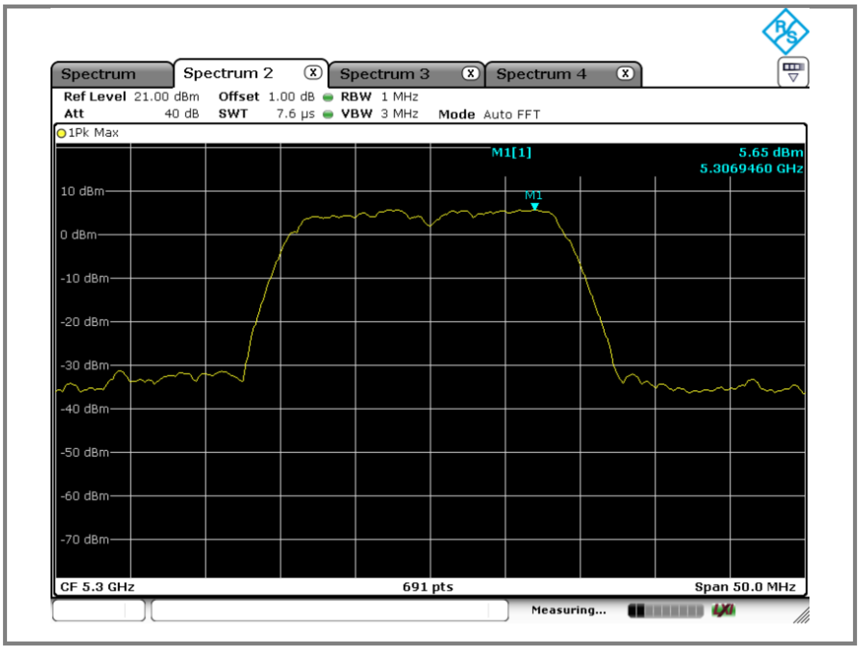


Operation mode: U-NII-2A(n_HT20)

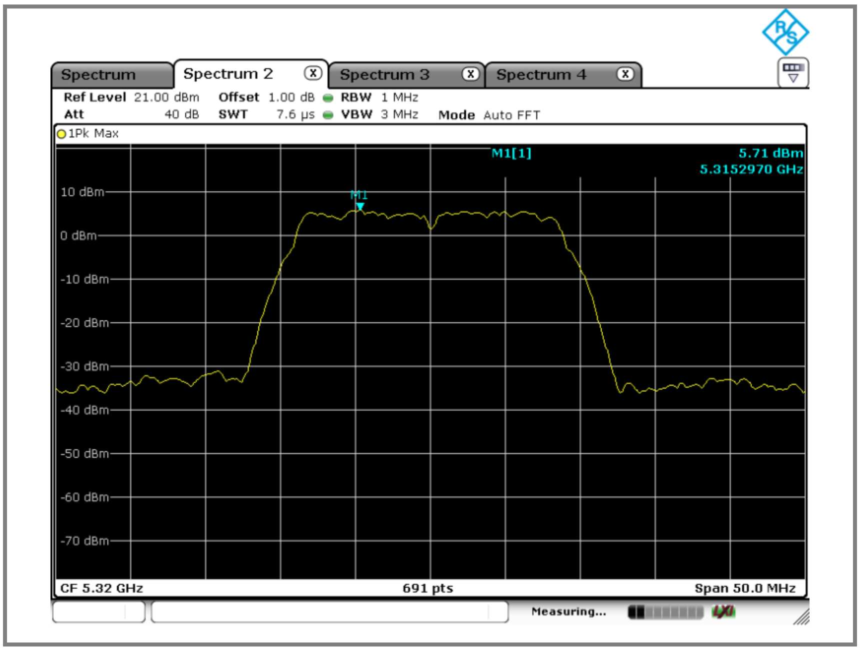
A. Low channel(5260 ㎒)



B. Middle channel(5300 ㎒)

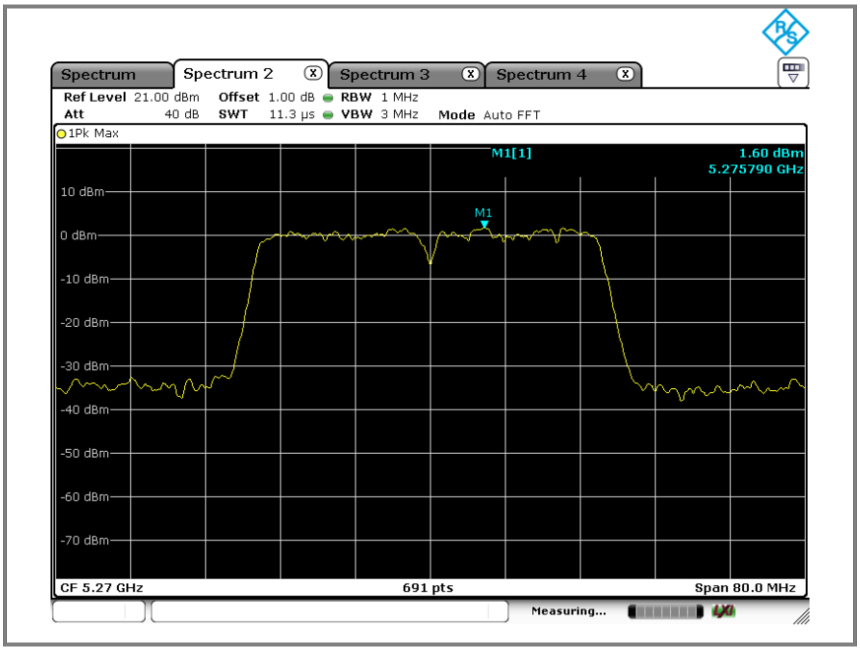


C. High channel(5320 ㎒)

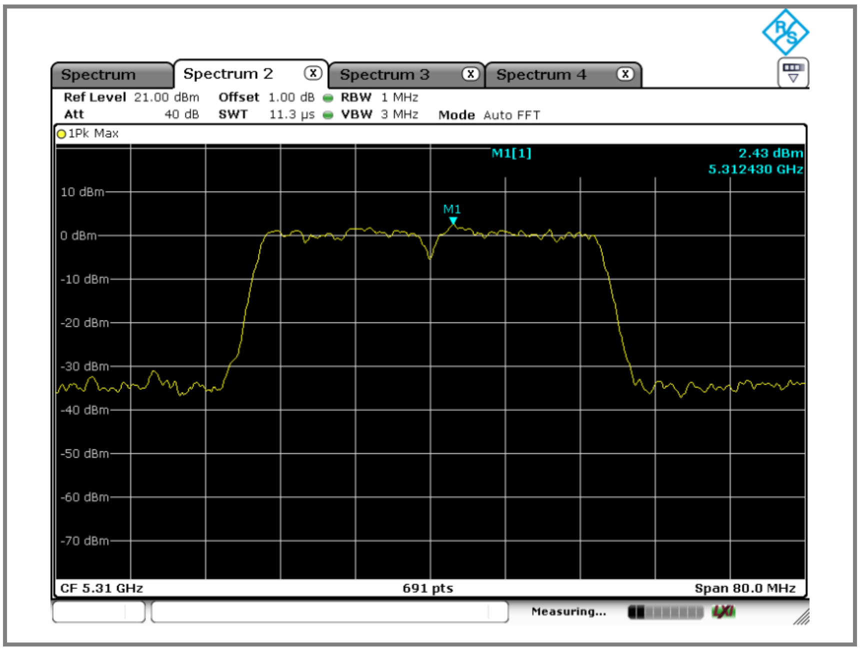


Operation mode: U-NII-2A(n_HT40)

A. Low channel(5270 ㎒)

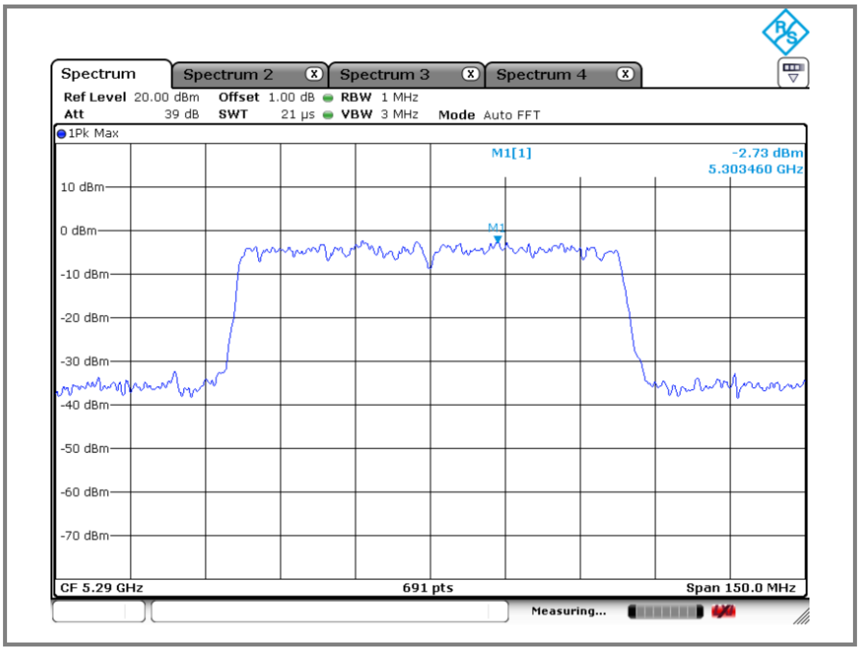


B. High channel(5310 ㎒)



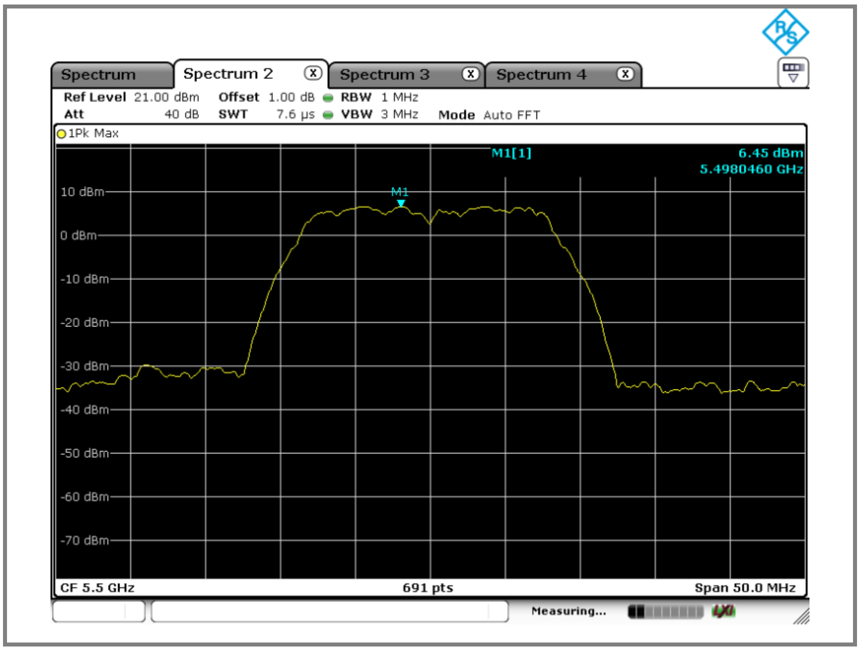
Operation mode: U-NII-2A(VHT80)

A. Low channel(5290 ㎒)

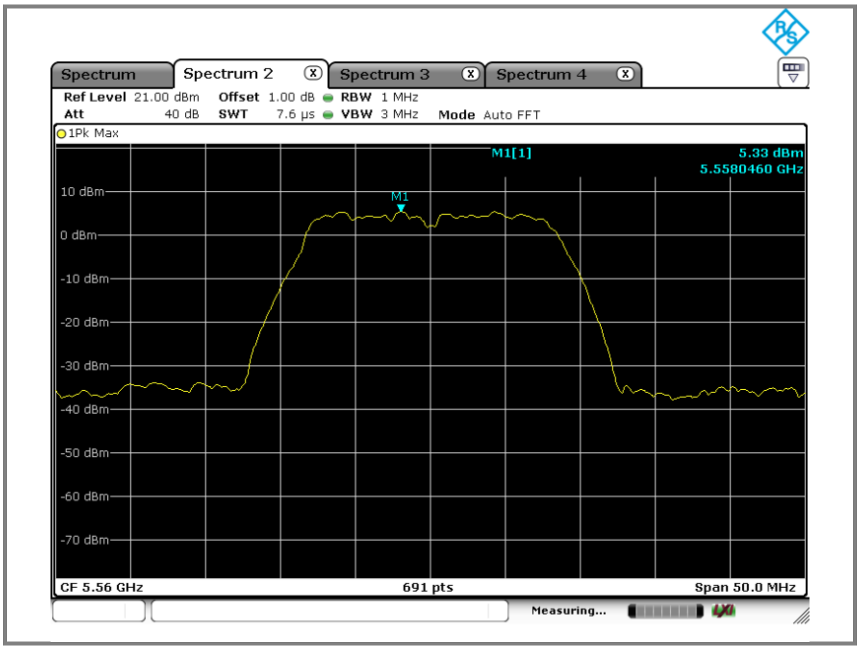


Operation mode: U-NII-2C(802.11a)

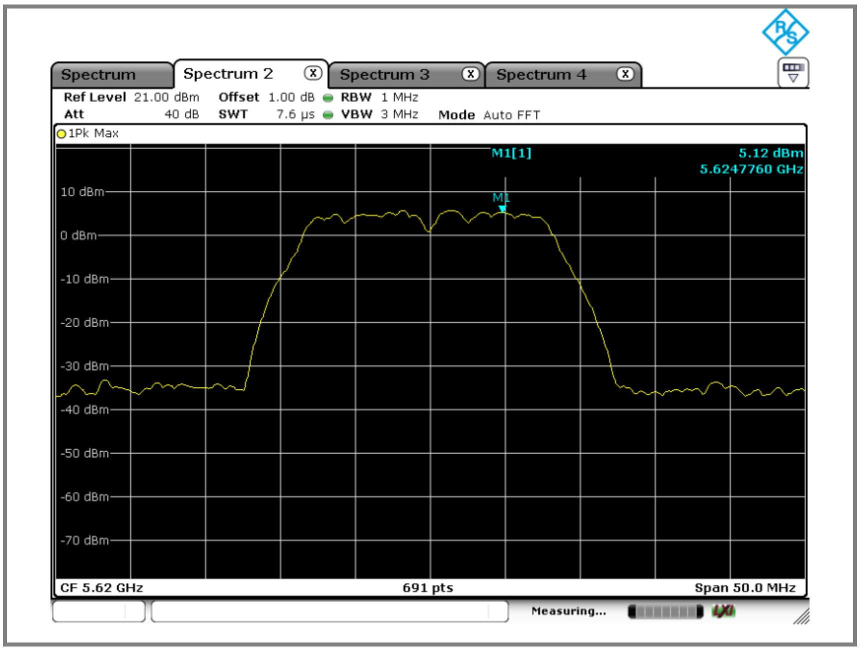
A. Low channel(5500 ㎒)



B. Middle channel(5560 ㎒)

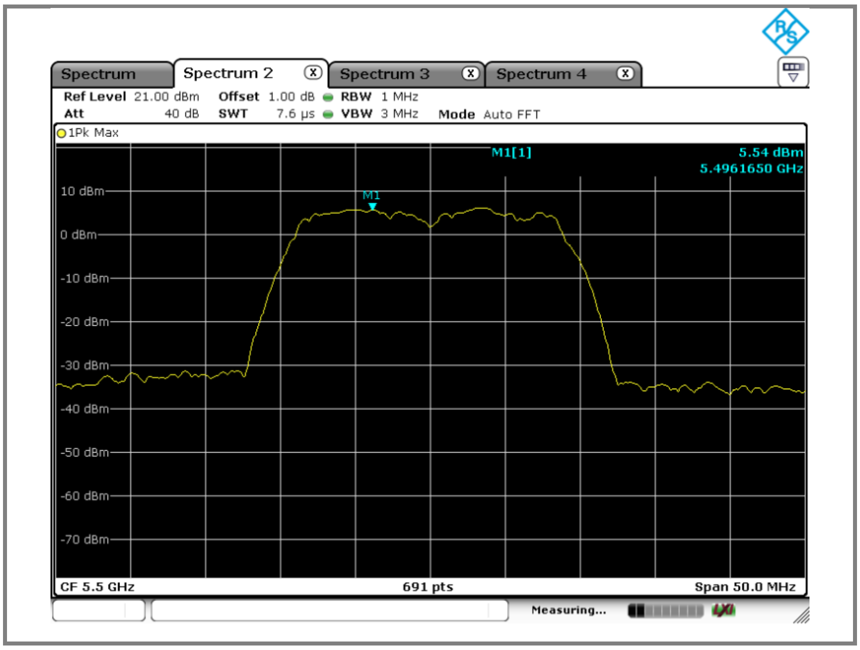


C. High channel(5620 ㎒)

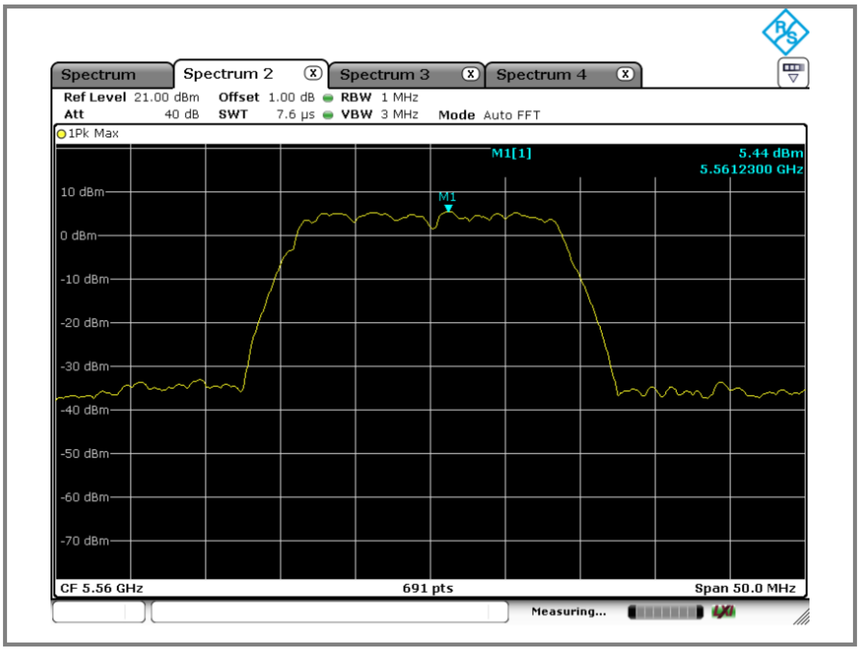


Operation mode: U-NII-2C(n_HT20)

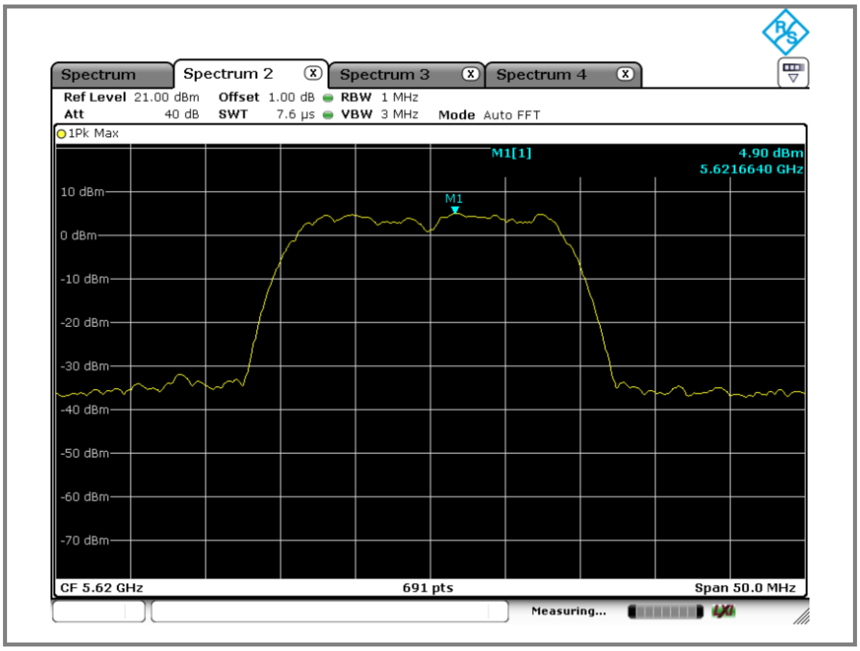
A. Low channel(5500 ㎒)



B. Middle channel(5560 ㎒)

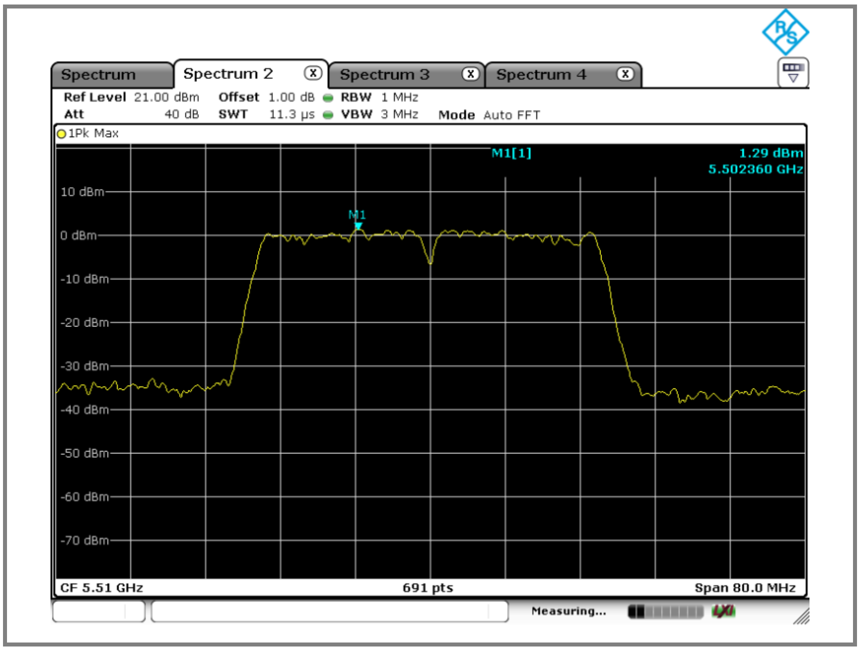


C. High channel(5620 ㎒)

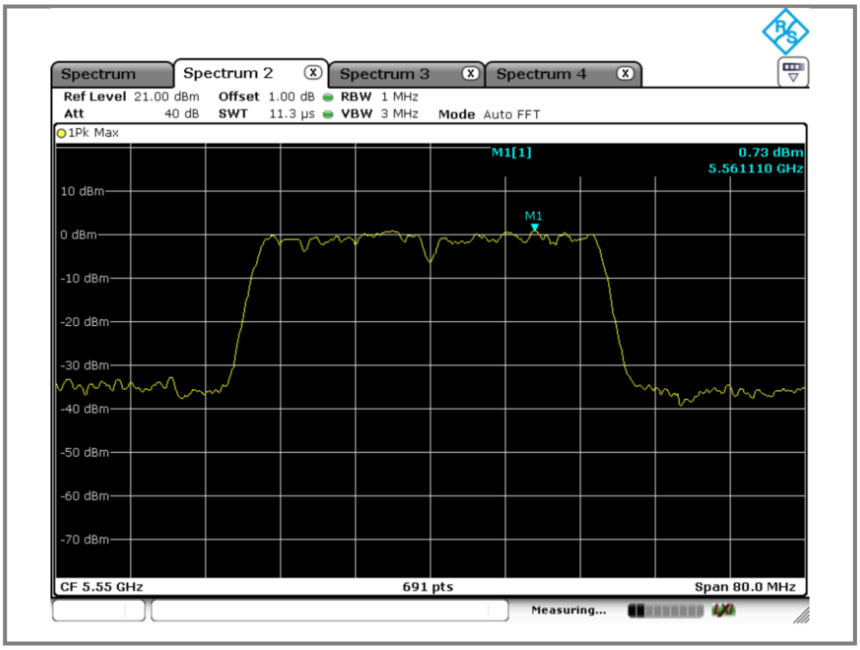


Operation mode: U-NII-2C(n_HT40)

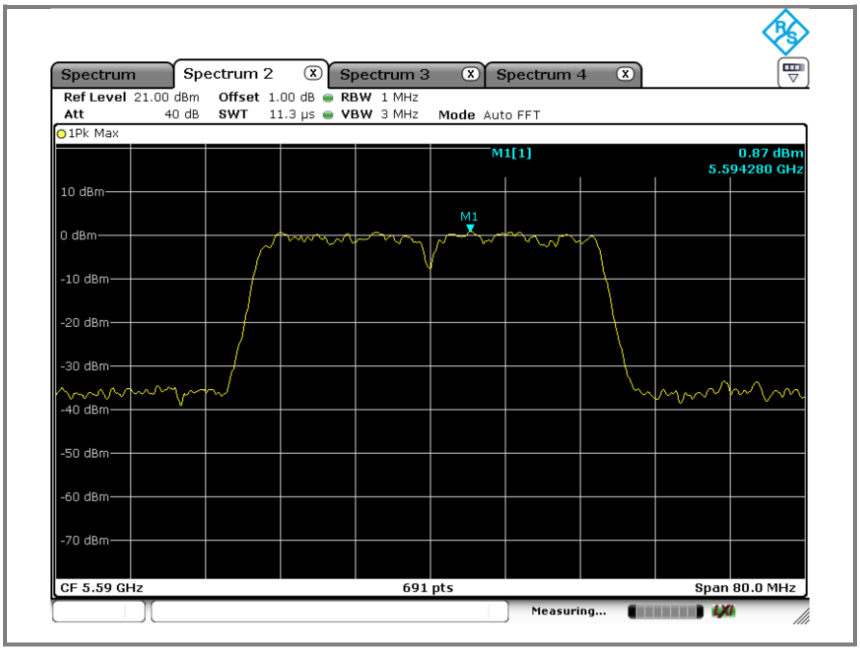
A. Low channel(5510 ㎒)



B. Middle channel(5550 ㎒)

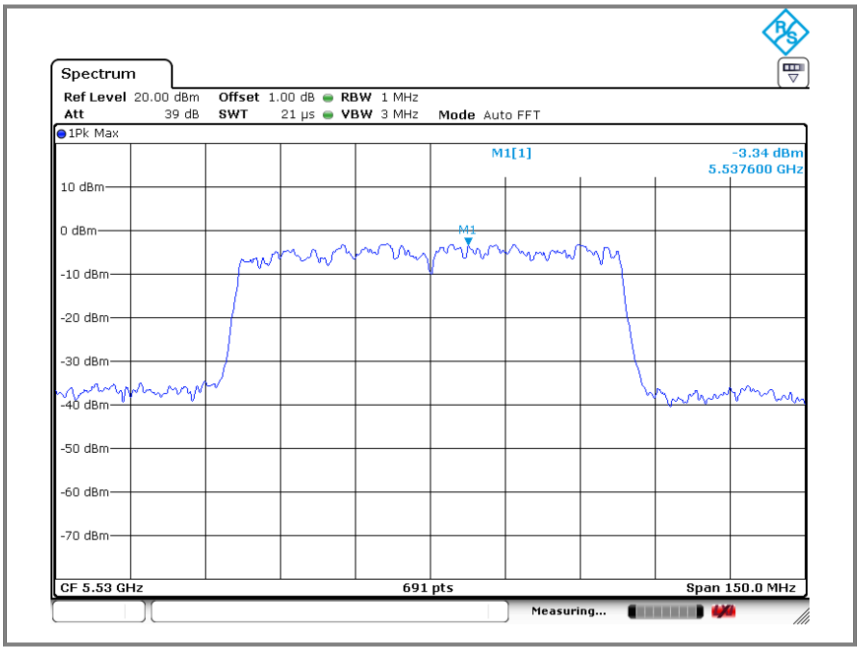


C. High channel(5590 ㎒)

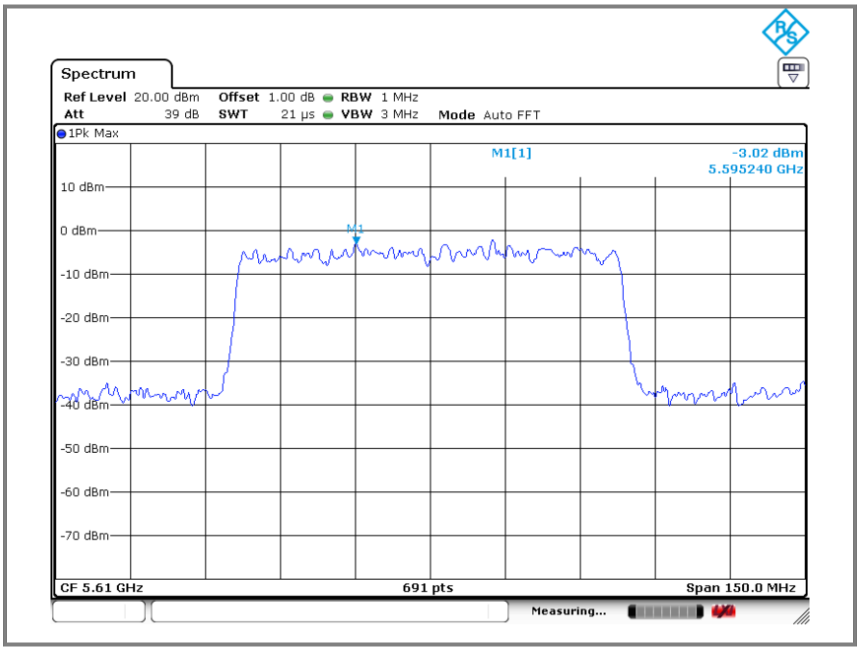


Operation mode: U-NII-2C(VHT80)

A. Low channel(5530 ㎒)

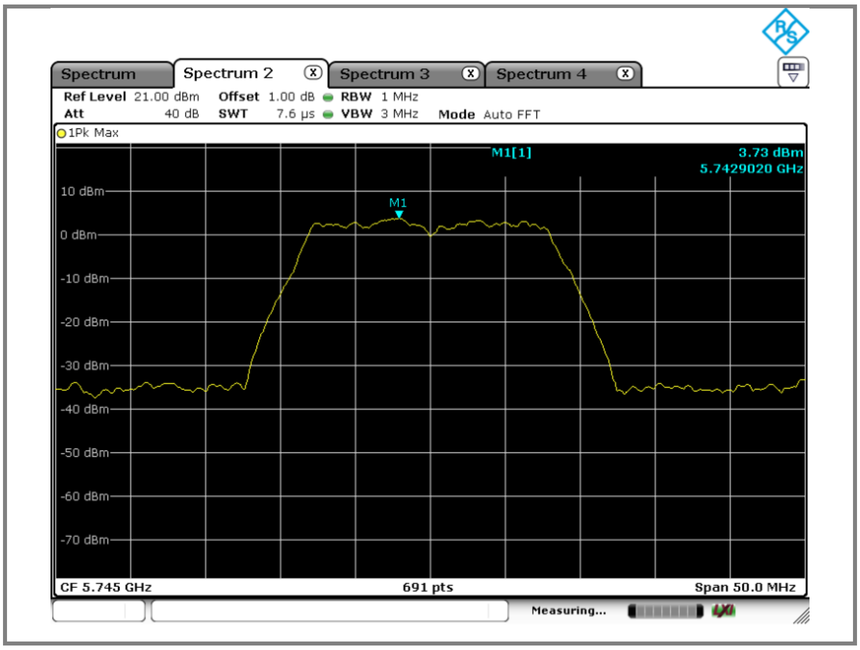


A. High channel(5610 ㎒)

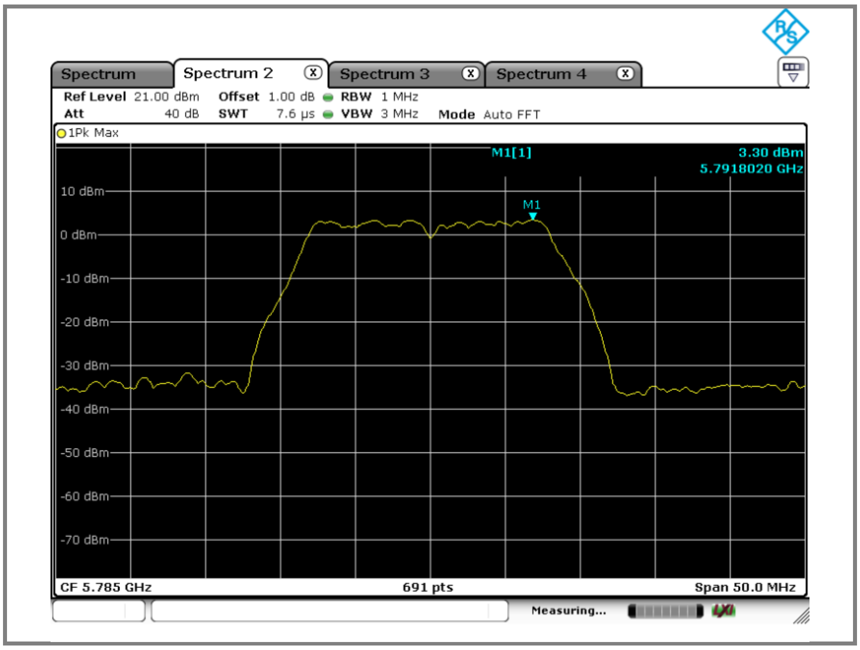


Operation mode: U-NII-3(802.11a)

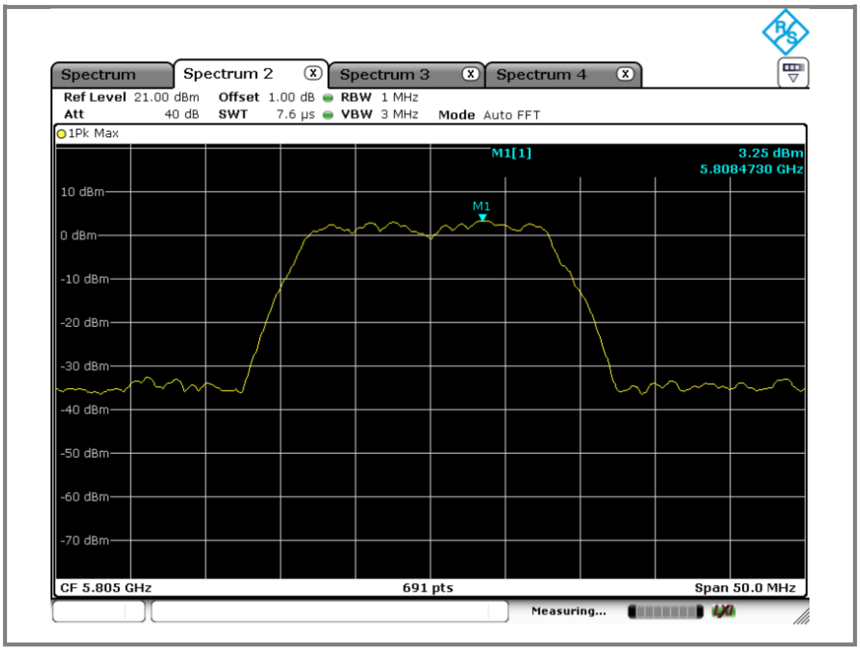
A. Low channel(5745 ㎒)



B. Middle channel(5785 ㎒)

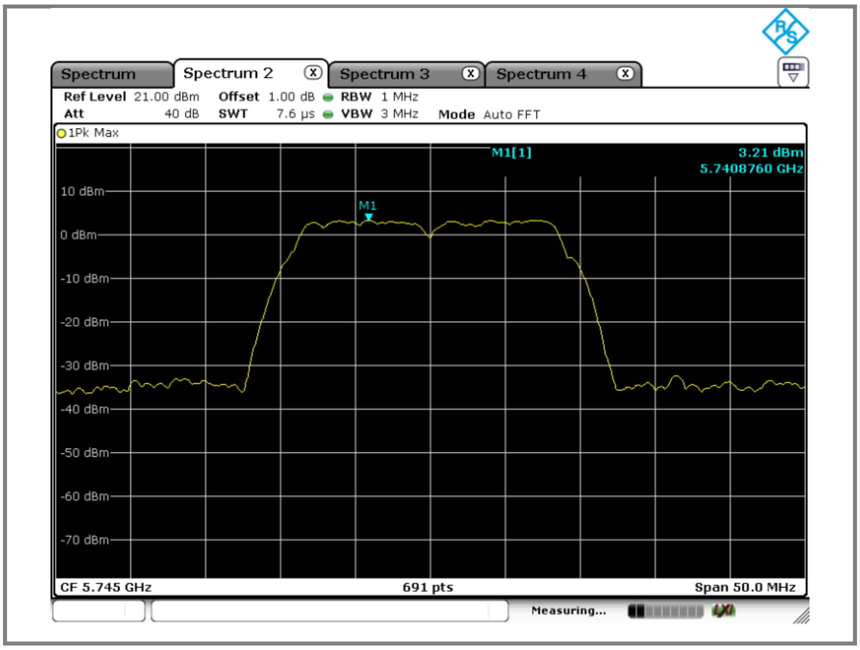


C. High channel(5805 ㎒)

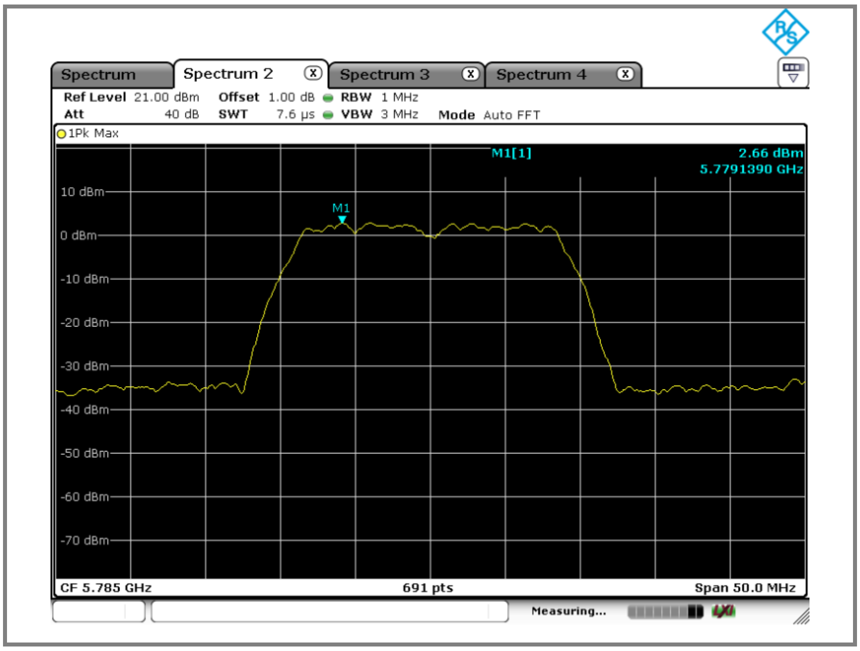


Operation mode: U-NII-3(n_HT20)

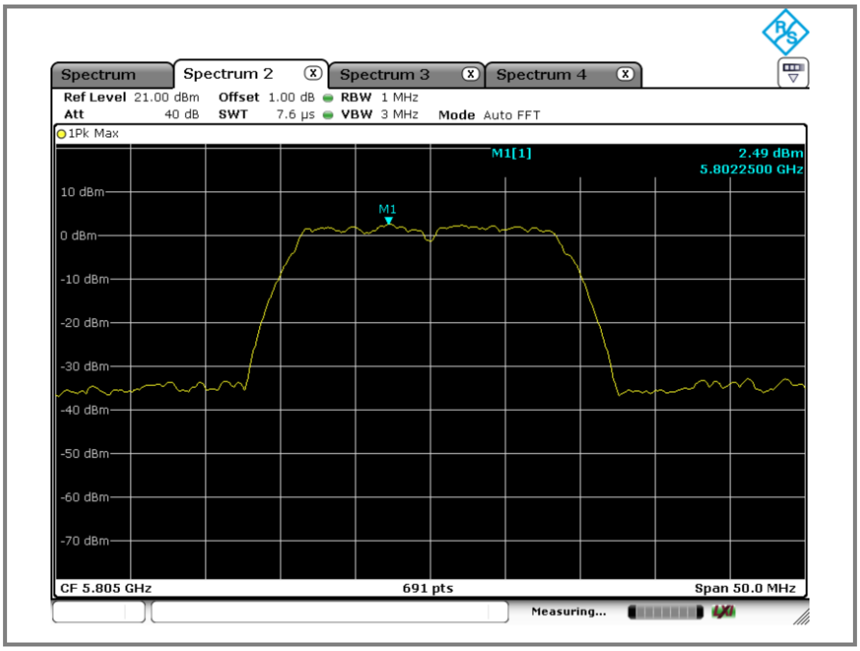
A. Low channel(5745 ㎒)



B. Middle channel(5785 ㎒)

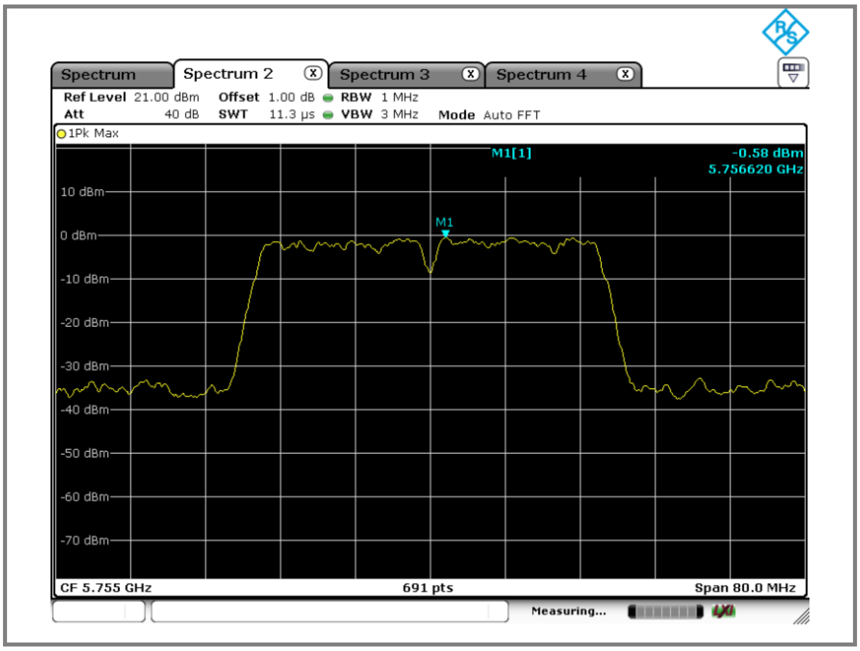


C. High channel(5805 ㎒)

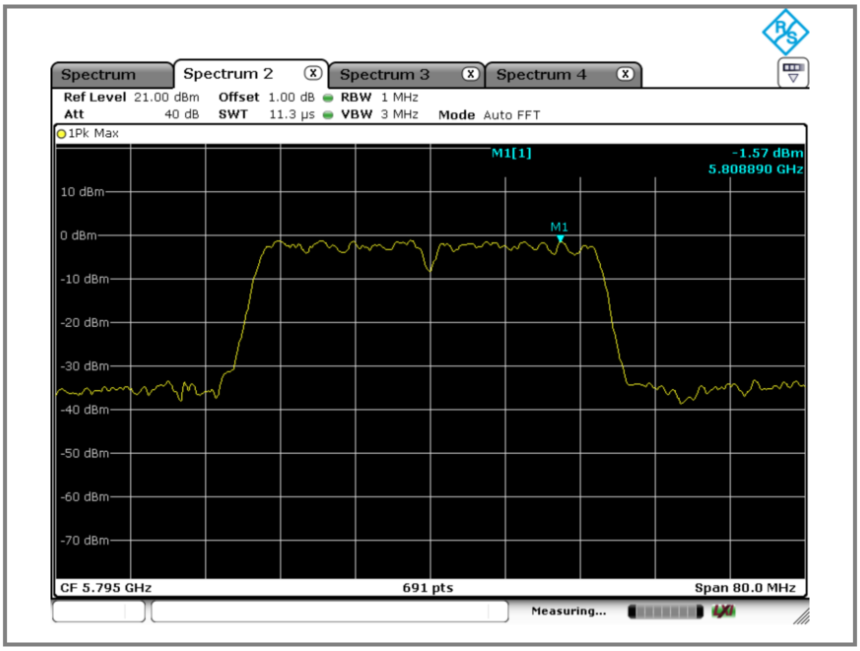


Operation mode: U-NII-3(n_HT40)

A. Low channel(5755 ㎒)

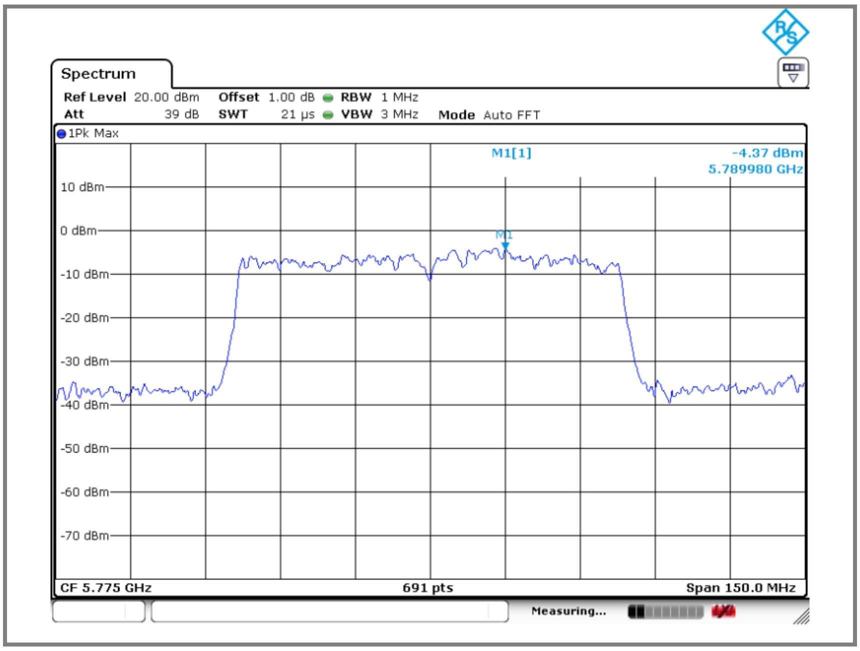


B. High channel(5795 ㎒)



Operation mode: U-NII-3(VHT80)

A. Low channel(5775 ㎒)



8. 6 ㏈ Bandwidth

8.1. Test setup

EUT		Spectrum analyzer

8.2. Limit

Within the 5.725-5.85 ㎓ band, the minimum 6 ㏈ bandwidth of U-NII devices shall be at least 500 ㎑.

8.3. Test procedure

Test procedure
KDB 789033 D02 v01r03– Section C.2, KDB 644545 D03 v01
1. Set RBW = 100 ㎑
2. Set the video bandwidth (VBW) ≥ 3 × RBW.
3. Detector = peak.
4. Sweep = auto couple.
5. Allow the trace to stabilize
6. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 ㏈ relative to the maximum level measured in the fundamental emission.
7. In case of band crossing channels 138, 142 and 144, the measurement is complied with section D of KDB 644545_D03 v01.

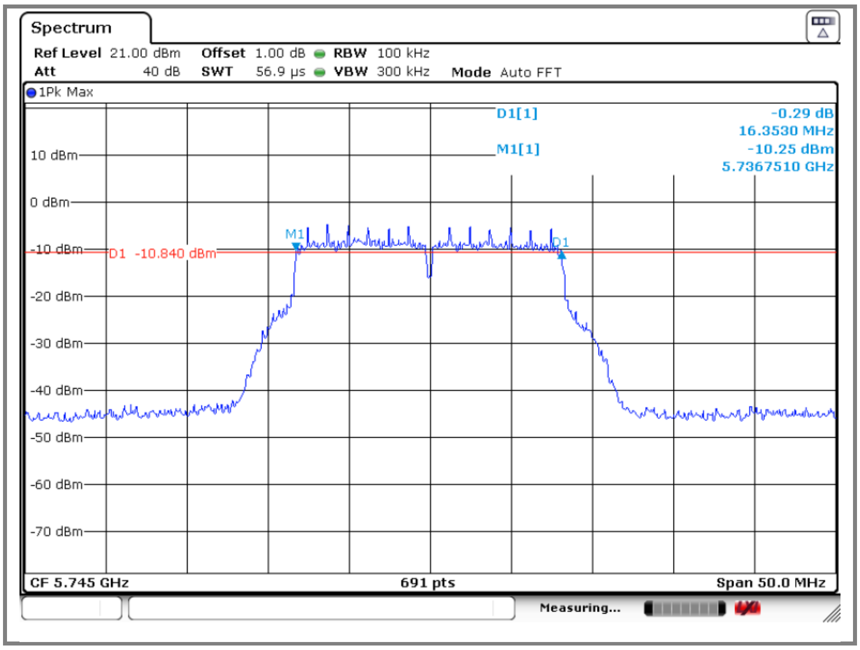
8.4. Test results

Ambient temperature: 22℃
Relative humidity: 45 % R.H.

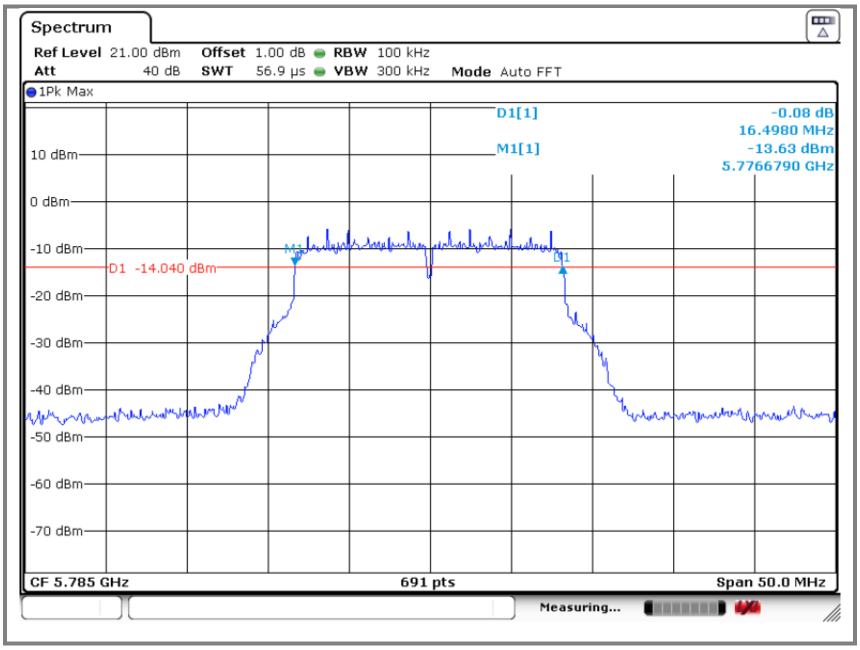
Mode	Frequency (㎒)	6 ㏈ bandwidth (㎒)
U-NII-3(802.11a)	5 745	16.35
	5 785	16.50
	5 805	16.57
U-NII-3(n_HT20)	5 745	17.73
	5 785	17.58
	5 805	17.66
U-NII-3(n_HT40)	5 755	36.47
	5 795	36.47
U-NII-3(VHT80)	5 775	75.98

Operation mode: U-NII-3(802.11a)

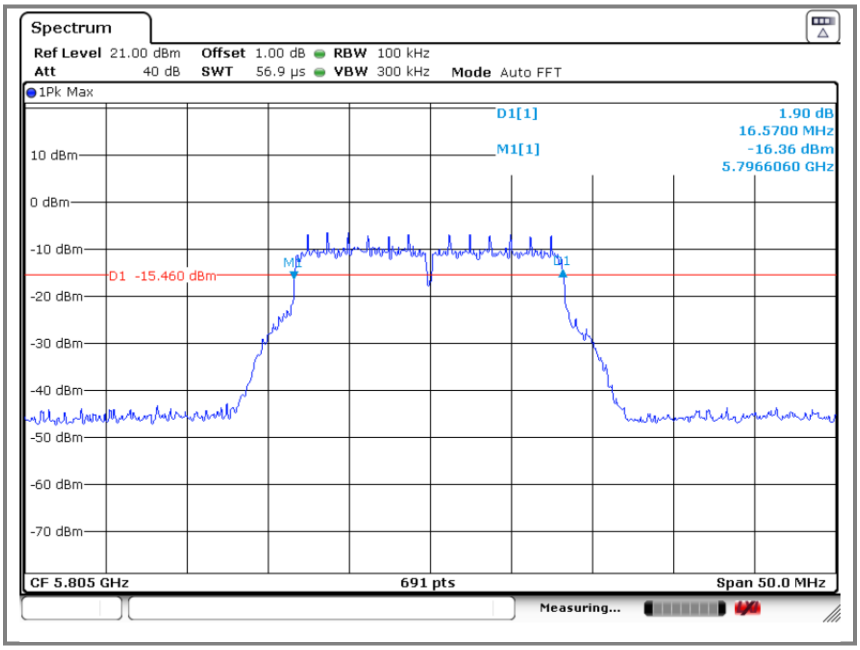
A. Low channel(5745 ㎒)



B. Middle channel(5785 ㎒)

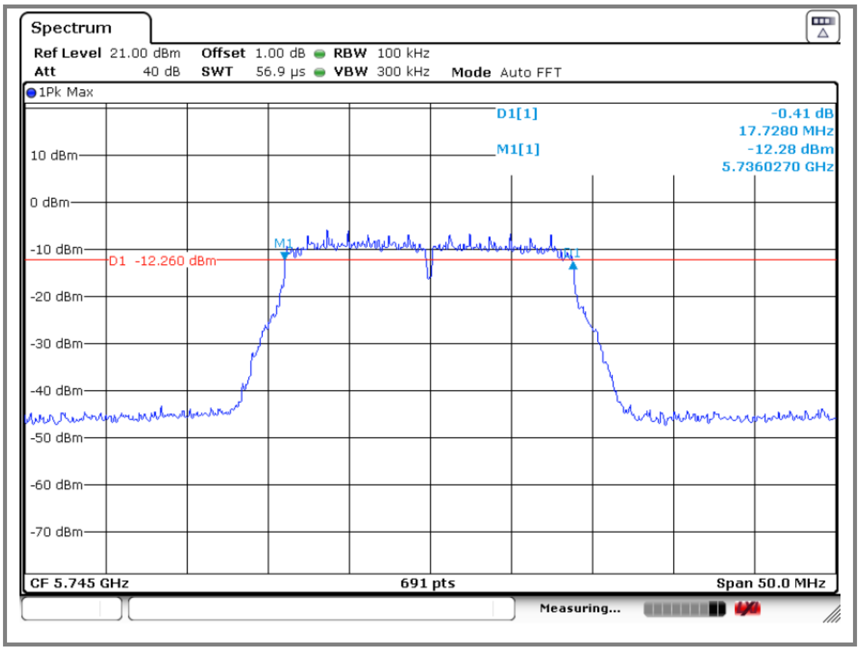


C. High channel(5805 ㎒)

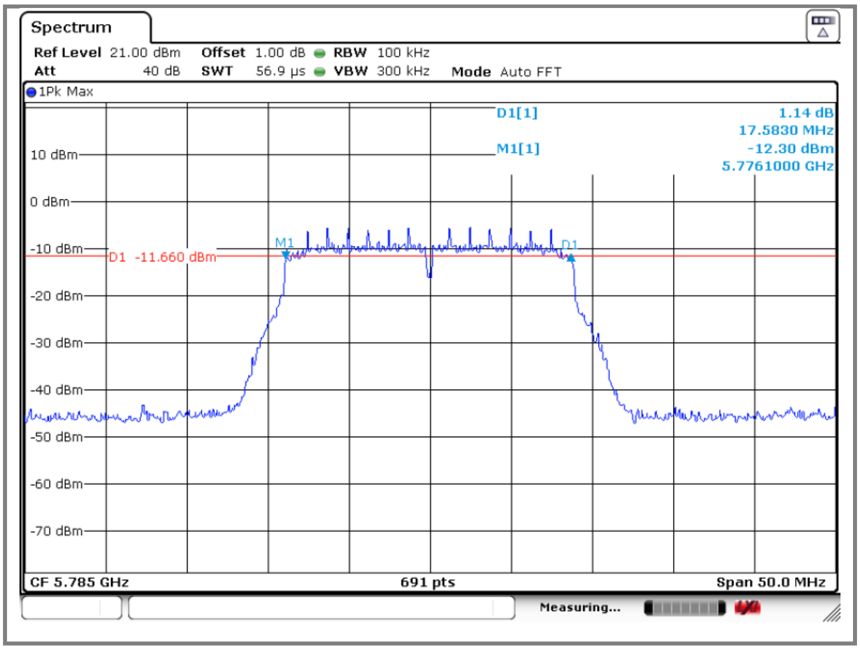


Operation mode: U-NII-3(n_HT20)

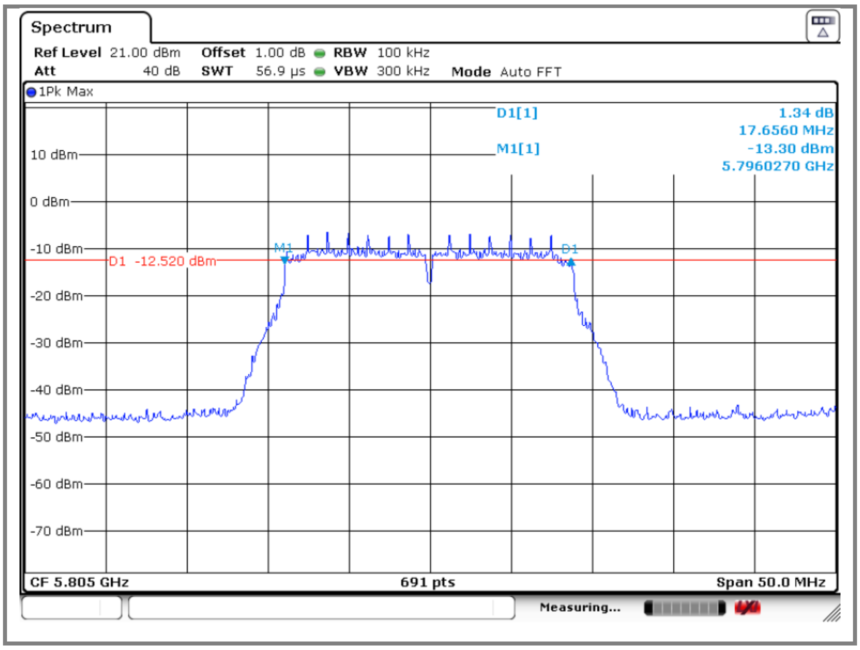
A. Low channel(5745 ㎒)



B. Middle channel(5785 ㎒)

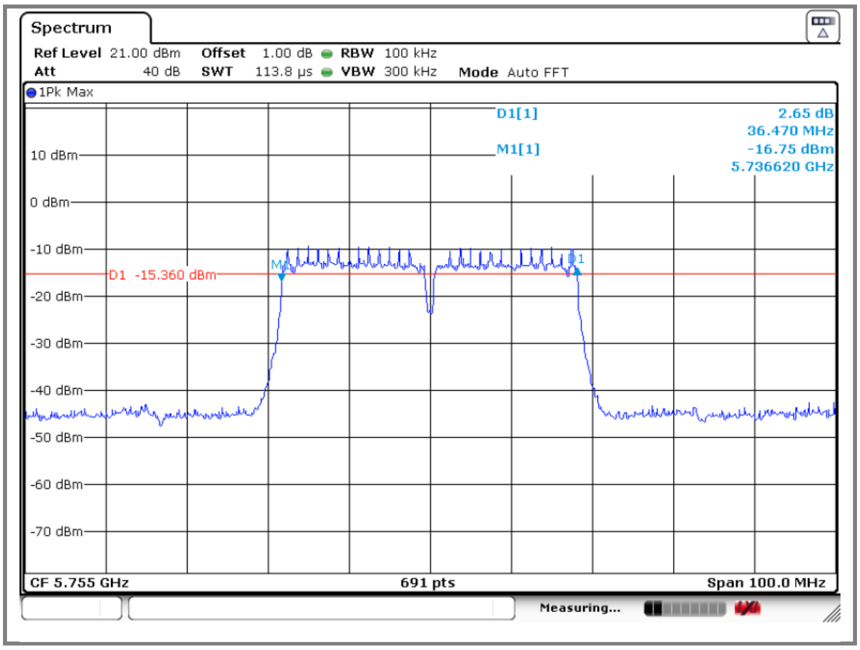


C. High channel(5805 ㎒)

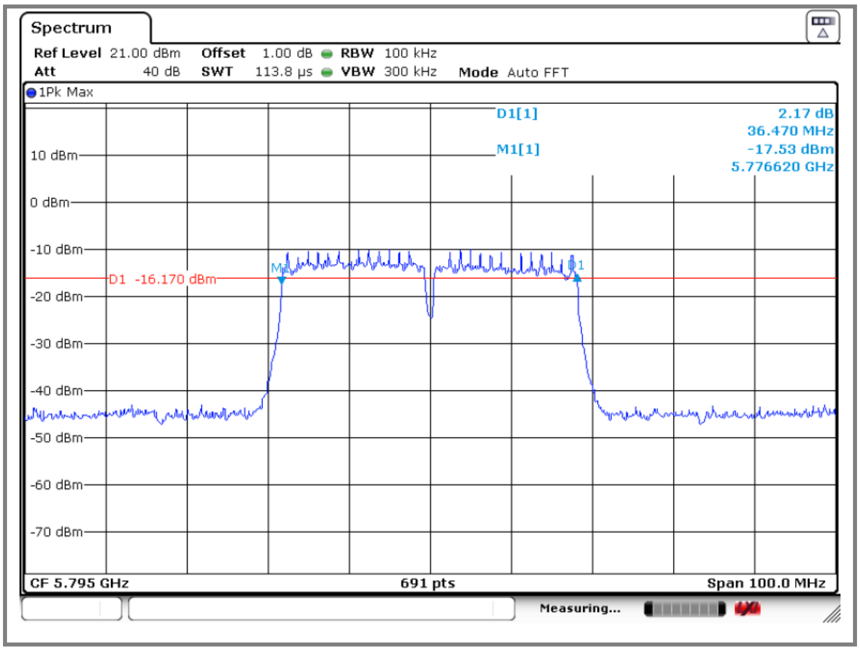


Operation mode: U-NII-3(n_HT40)

A. Low channel(5755 ㎒)

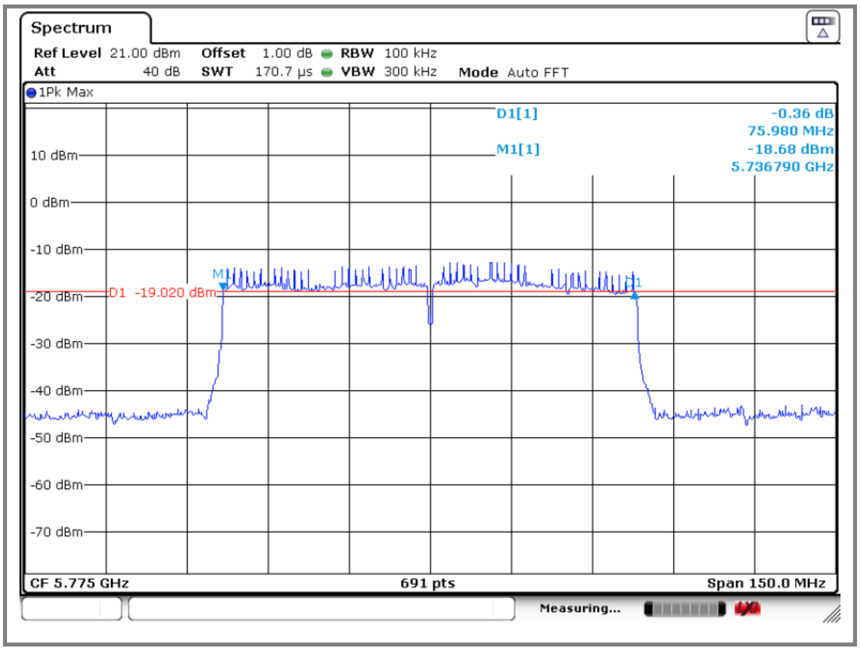


B. High channel(5795 ㎒)



Operation mode: U-NII-3(VHT80)

A. Low channel(5775 ㎒)



9. Frequency stability

9.1. Test setup

EUT	—	Spectrum analyzer

9.2. Limit

Not applicable

9.3. Test procedure

a. The EUT was placed inside the environmental test chamber and powered by nominal AC/DC voltage.
b. Turn the EUT on and couple its output to a spectrum analyzer.
c. Turn the EUT off and set the chamber to the highest temperature specified.
d. Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize.
e. Repeat step 2 and 3 with the temperature chamber set to the lowest temperature.
f. The test chamber was allowed to stabilize at +20 degree C for a minimum of 30 minutes. The supply voltage was then adjusted on the EUT from 85% to 115% and the frequency record.

9.4. Test results

Operation mode: Normal mode

Operation Frequency :5 180 ㎒ (Worst case)

VOLTAGE (%)	POWER (VDC)	TEMP (dB)	FREQ (Hz)	Deviation (%)
100%	13.5	+20(Ref)	5179 986 415	0.000 262
100%		-20	5179 975 479	0.000 473
100%		-10	5179 993 057	0.000 134
100%		0	5179 971 473	0.000 551
100%		+10	5179 987 173	0.000 248
100%		+20	5179 993 528	0.000 125
100%		+25	5179 981 580	0.000 356
100%		+30	5179 984 428	0.000 301
100%		+40	5179 998 263	0.000 034
100%		+50	5179 984 175	0.000 306
100%		+60	5179 974 115	0.000 500
85%	11.48	+20	5179 994 283	0.000 110
115%	15.53	+20	5179 988 871	0.000 215

Operation Frequency :5 260 ㎒ (Worst case)

VOLTAGE (%)	POWER (VDC)	TEMP (dB)	FREQ (Hz)	Deviation (%)
100%	13.5	+20(Ref)	5259 984 155	0.000 301
100%		-20	5259 985 263	0.000 280
100%		-10	5259 966 377	0.000 639
100%		0	5259 983 645	0.000 311
100%		+10	5259 976 911	0.000 439
100%		+20	5259 989 760	0.000 195
100%		+25	5259 994 435	0.000 106
100%		+30	5259 985 546	0.000 275
100%		+40	5259 982 673	0.000 329
100%		+50	5259 996 969	0.000 058
100%		+60	5259 989 664	0.000 197
85%	11.48	+20	5259 974 395	0.000 487
115%	15.53	+20	5259 971 513	0.000 542

Operation Frequency :5 500 ㎒ (Worst case)

VOLTAGE (%)	POWER (VDC)	TEMP (dB)	FREQ (Hz)	Deviation (%)
100%	13.5	+20(Ref)	5 499 985 252	0.000 268
100%		-20	5 499 986 635	0.000 243
100%		-10	5 499 989 896	0.000 184
100%		0	5 499 978 558	0.000 390
100%		+10	5 499 984 704	0.000 278
100%		+20	5 499 982 141	0.000 325
100%		+25	5 499 986 322	0.000 249
100%		+30	5 499 995 993	0.000 073
100%		+40	5 499 982 566	0.000 317
100%		+50	5 499 983 359	0.000 303
100%		+60	5 499 986 638	0.000 243
85%	11.48	+20	5 499 978 464	0.000 392
115%	15.53	+20	5 499 984 222	0.000 287

Operation Frequency :5 745 ㎒ (Worst case)

VOLTAGE (%)	POWER (VDC)	TEMP (dB)	FREQ (Hz)	Deviation (%)
100%	13.5	+20(Ref)	5 744 985 602	0.000 251
100%		-20	5 744 963 353	0.000 638
100%		-10	5 744 986 836	0.000 229
100%		0	5 744 986 569	0.000 234
100%		+10	5 744 984 948	0.000 262
100%		+20	5 744 970 164	0.000 519
100%		+25	5 744 975 342	0.000 429
100%		+30	5 744 983 625	0.000 285
100%		+40	5 744 976 466	0.000 410
100%		+50	5 744 989 893	0.000 176
100%		+60	5 744 977 687	0.000 388
85%	11.48	+20	5 744 982 747	0.000 300
115%	15.53	+20	5 744 973 922	0.000 454

10. RF exposure evaluation

10.1 Environmental evaluation and exposure limit according to FCC CFR 47 part 1, 1.1307(b), 1.1310

According to §15.247(e)(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines. According to KDB 447498 (2)(a)(i)

Limits for maximum permissible exposure (MPE)

Frequency range (㎒)	Electric field strength(V/m)	Magnetic field strength (A/m)	Power density (㎽/㎠)	Average time
(A) Limits for Occupational / Control exposures				
300 – 1 500	--	--	F/300	6
1 500 – 100 000	--	--	5	6
(B) Limits for General Population / Uncontrol Exposures				
300 – 1 500	--	--	F/1 500	6
1 500 – 100 000	--	--	1	30

10.2. Friis transmission formula : Pd=(Pout*G)\(4*pi*R2)

Where
Pd= Power density in ㎽/㎠
Pout=output power to antenna in ㎽
G= Numeric gain of the antenna relative to isotropic antenna
Pi=3.1416
R= distance between observation point and center of the radiator in cm
Pd the limit of MPE, 1 ㎽/㎠. If we know the maximum gain of the antenna and total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

10.3. Test result of RF exposure evaluation

Test Item : RF Exposure evaluation data
Test Mode : Normal operation

10.4. Output power into antenna & RF exposure evaluation distance

Mode	Frequency (㎒)	Output Peak power to antenna (dBm)	Antenna gain(dBi)	Antenna Gain (dBi) Numeric	Powerdensity at 20 ㎝ (㎽/㎠)	Power density Limits (㎽/㎠)
U-NII-1(802.11a)	5 180	14.70	3.36	2.17	0.012 7	1
	5 220	14.74			0.012 9	
	5 240	15.03			0.013 8	
U-NII-1(n_HT20)	5 180	14.68			0.012 7	
	5 220	14.66			0.012 6	
	5 240	14.76			0.012 9	
U-NII-1(n_HT40)	5 190	13.41			0.009 5	
	5 230	13.23			0.009 1	
U-NII-1(VHT80)	5 210	11.97			0.006 8	
U-NII-2A(802.11a)	5 260	15.36	3.36	2.17	0.014 8	
	5 300	15.33			0.014 7	
	5 320	15.15			0.014 1	
U-NII-2A(n_HT20)	5 260	15.12			0.014 0	
	5 300	14.95			0.013 5	
	5 320	15.26			0.014 5	
U-NII-2A(n_HT40)	5 270	13.84			0.010 5	
	5 310	14.05			0.011 0	
U-NII-2A(VHT80)	5 290	11.75			0.006 5	
U-NII-2C(802.11a)	5 500	15.40	3.36	2.17	0.015 0	
	5 560	14.66			0.012 6	
	5 620	14.43			0.012 0	
U-NII-2C(n_HT20)	5 500	15.19			0.014 3	
	5 560	14.77			0.013 0	
	5 620	14.43			0.012 0	
U-NII-2C(n_HT40)	5 510	13.13			0.008 9	
	5 550	12.72			0.008 1	
	5 590	12.83			0.008 3	
U-NII-2C(VHT80)	5 530	11.18			0.005 7	
	5 610	10.93			0.0054	
U-NII-3(802.11a)	5 745	12.81	3.36	2.17	0.0082	
	5 785	12.60			0.0079	
	5 805	11.95			0.0068	
U-NII-3(n_HT20)	5 745	12.47			0.0076	
	5 785	12.81			0.0082	
	5 805	11.81			0.0066	
U-NII-3(n_HT40)	5 755	11.15			0.0056	
	5 795	10.74			0.0051	
U-NII-3(VHT40)	5 775	9.54			0.0039	

※ Remark

The power density P_d (5th column) at a distance of 20 ㎝ calculated from the friis transmission formula is far below the limit of 1 ㎽/㎠ .

11. Antenna requirement

11.1 Standard Applicable:

According to §15.203, Antenna requirement.

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 manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sec- tions 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field dis- turbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

11.2 Antenna Connected Construction:

The directional gins of antenna used for transmitting is below table, and the antenna connector is designed with fixed type RF connector and no consideration of replacement. Please see EUT photo and antenna spec. for details.

	P/N	Type	Gain
Ant	ODBWPTR5020	Chip Antenna	3.36dBi