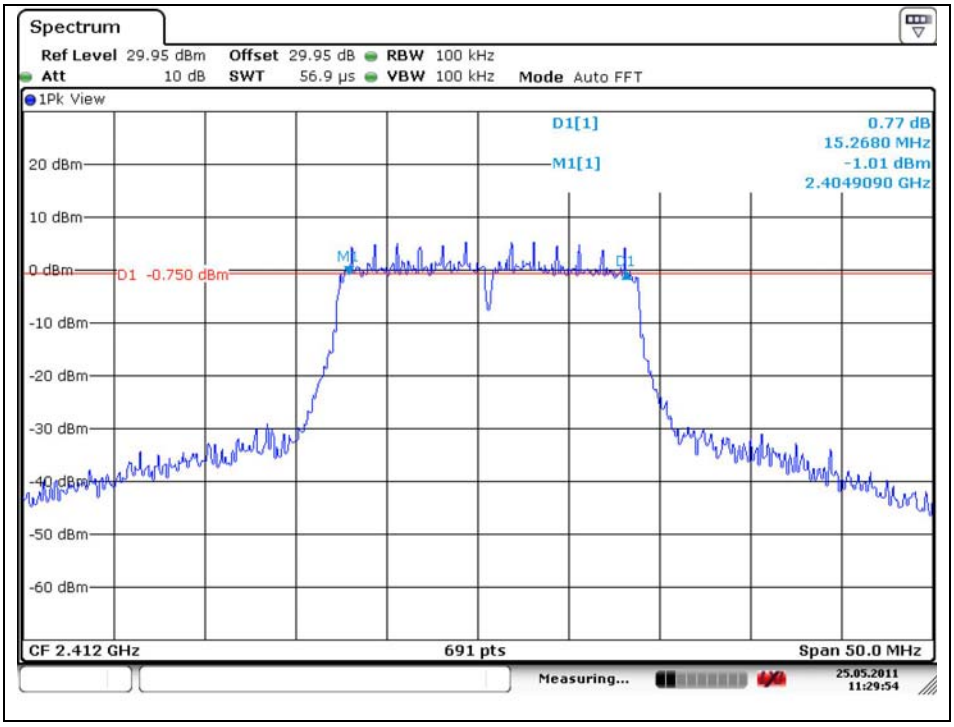
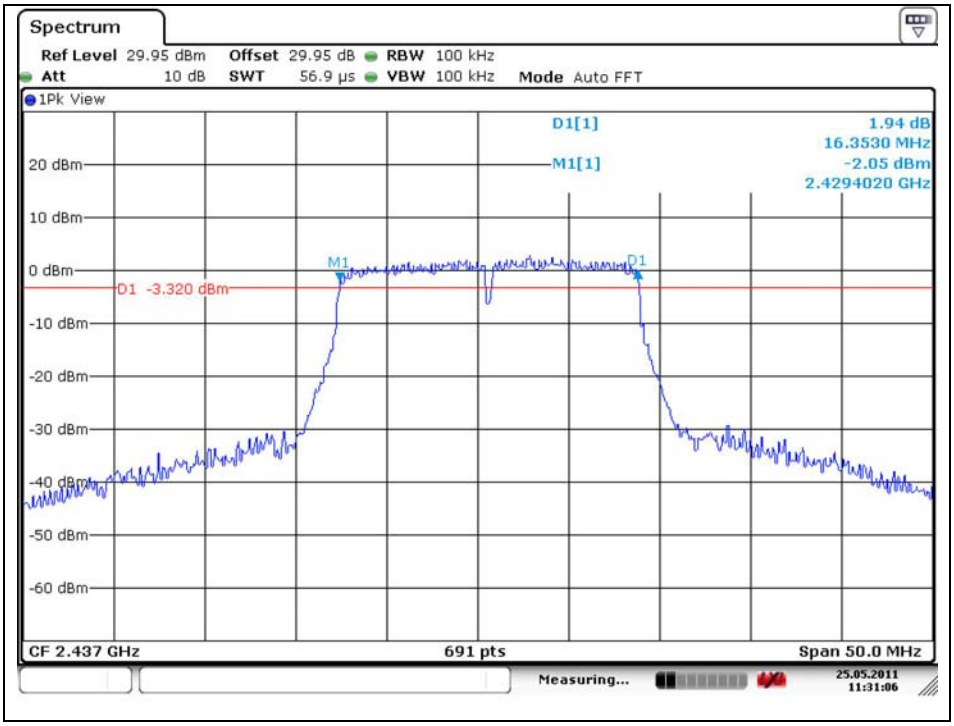
6 dB Bandwidth OFDM : 802.11g ANT1

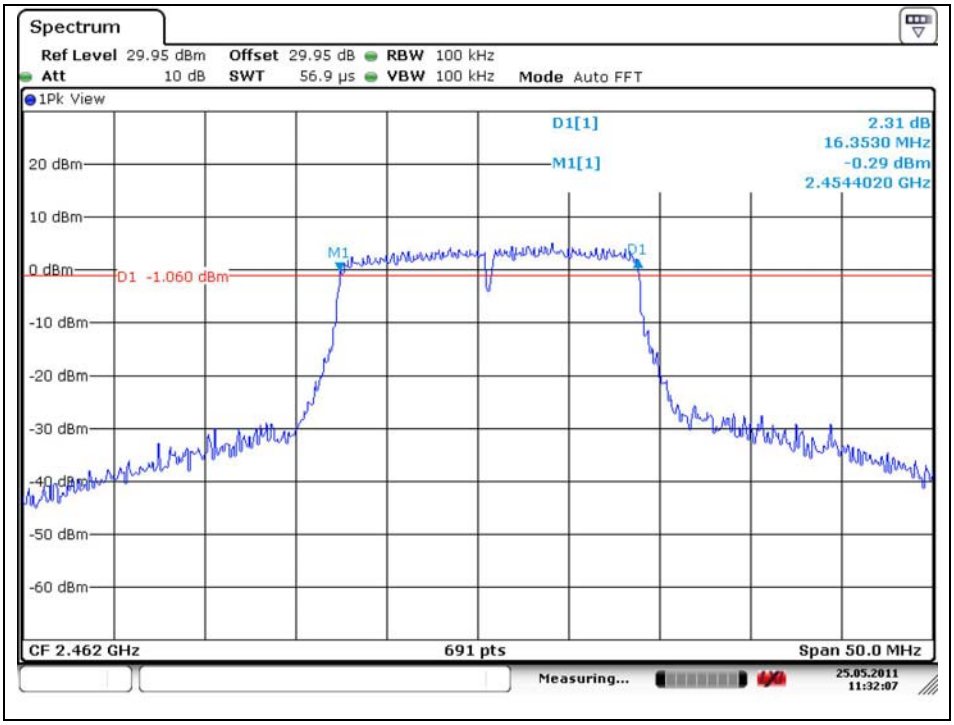
Low Channel



Middle Channel

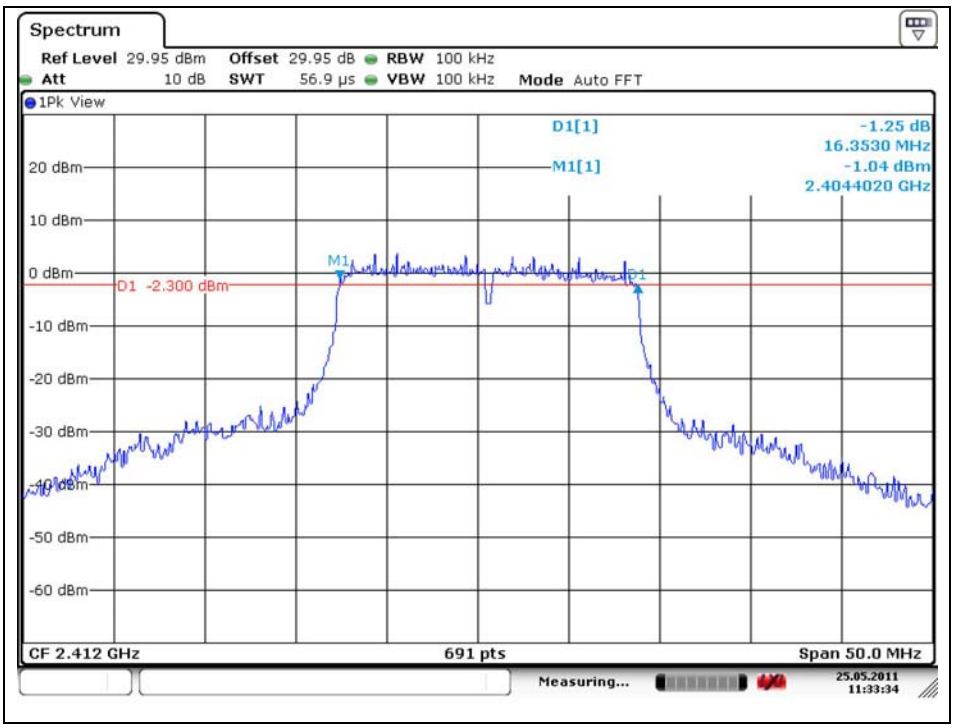


High Channel

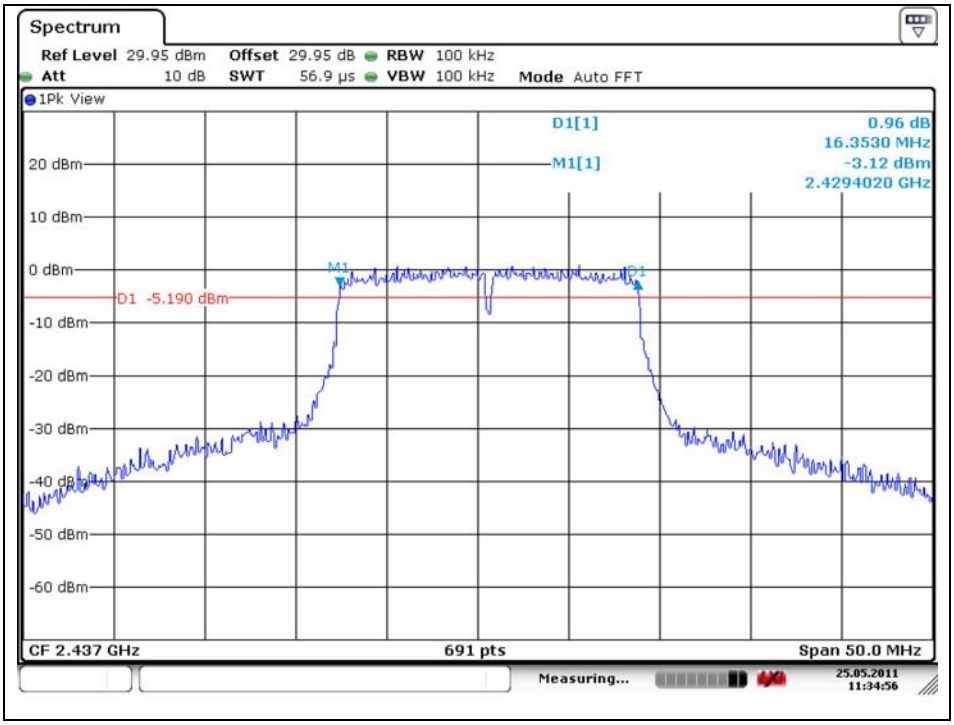


6 dB Bandwidth OFDM : 802.11g ANT2

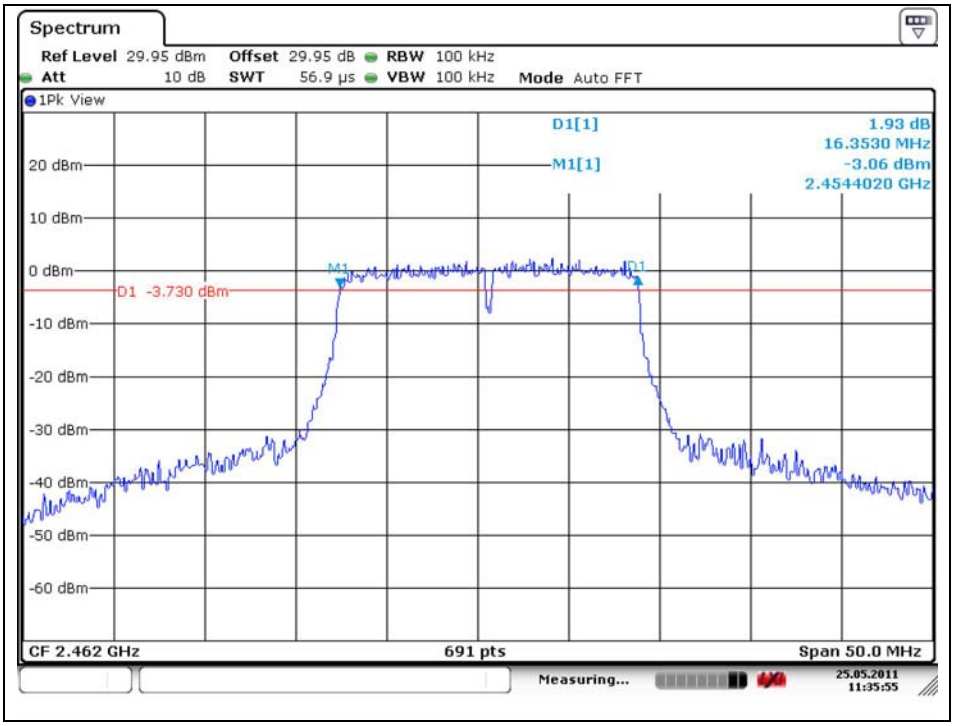
Low Channel



Middle Channel

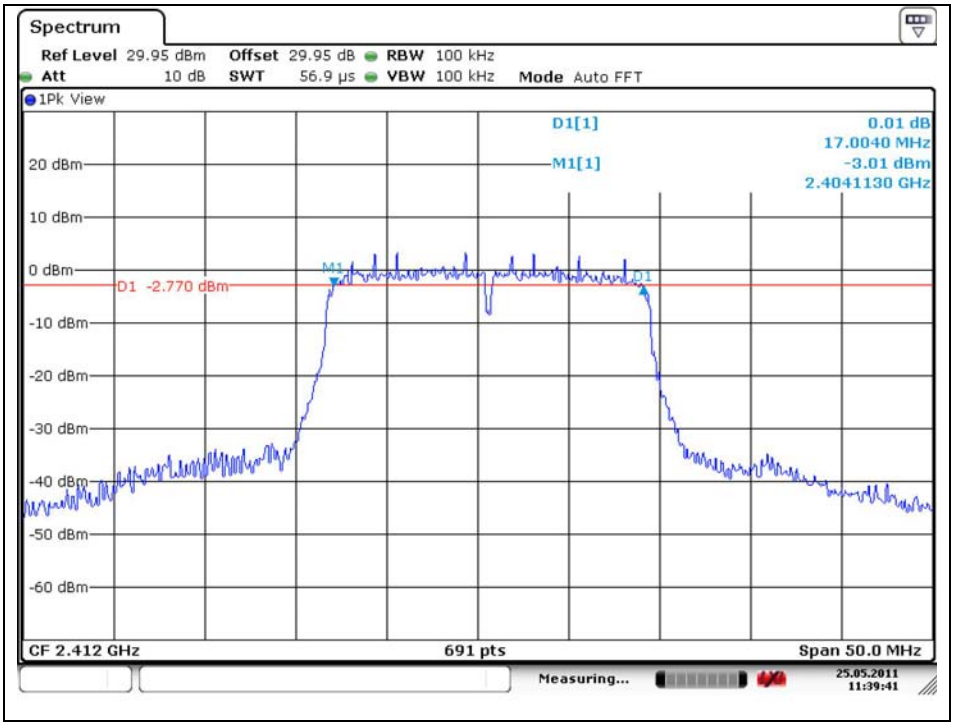


High Channel

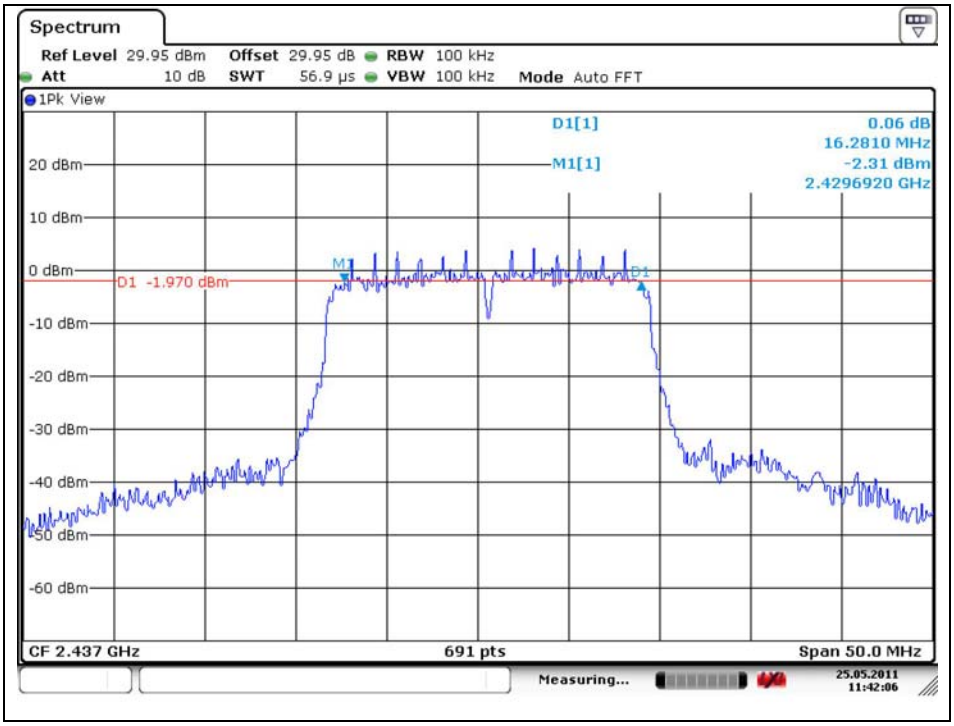


6 dB Bandwidth OFDM : 802.11n HT20 ANT1

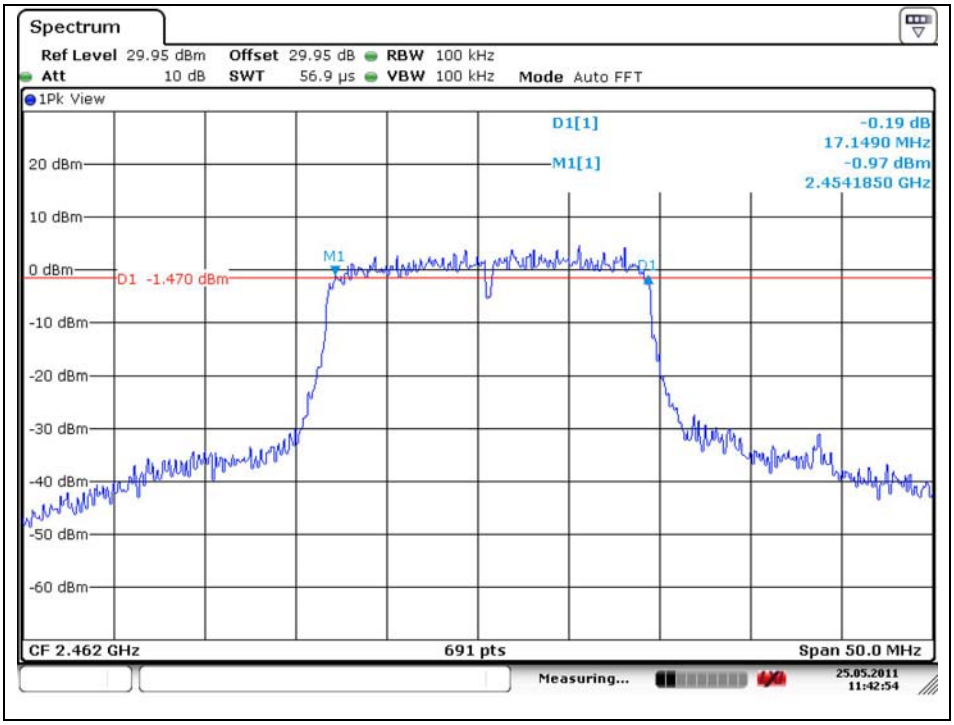
Low Channel



Middle Channel

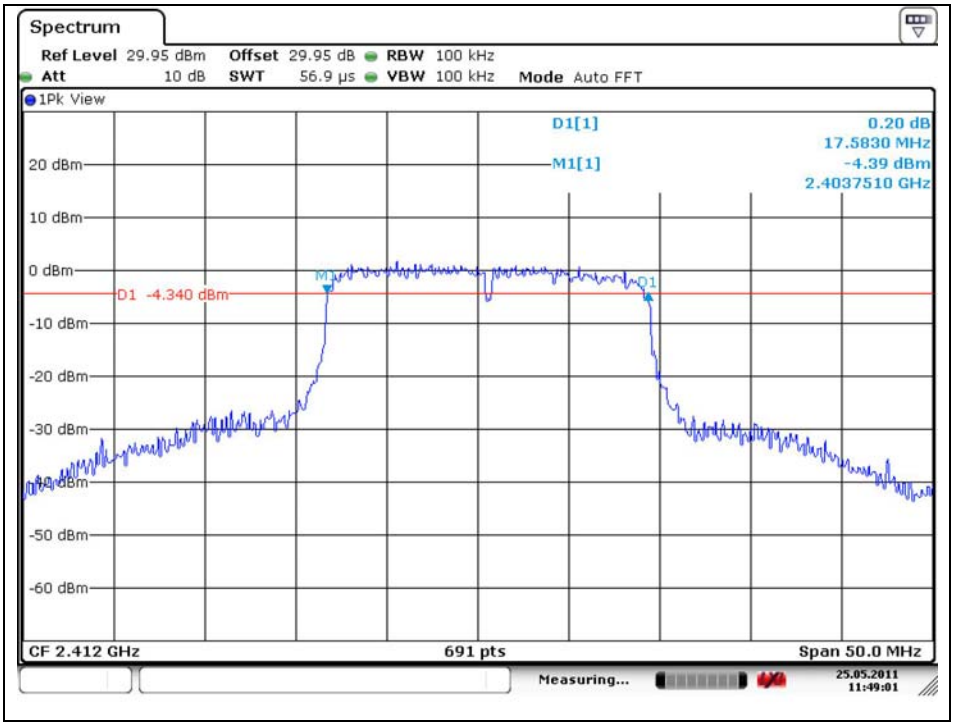


High Channel

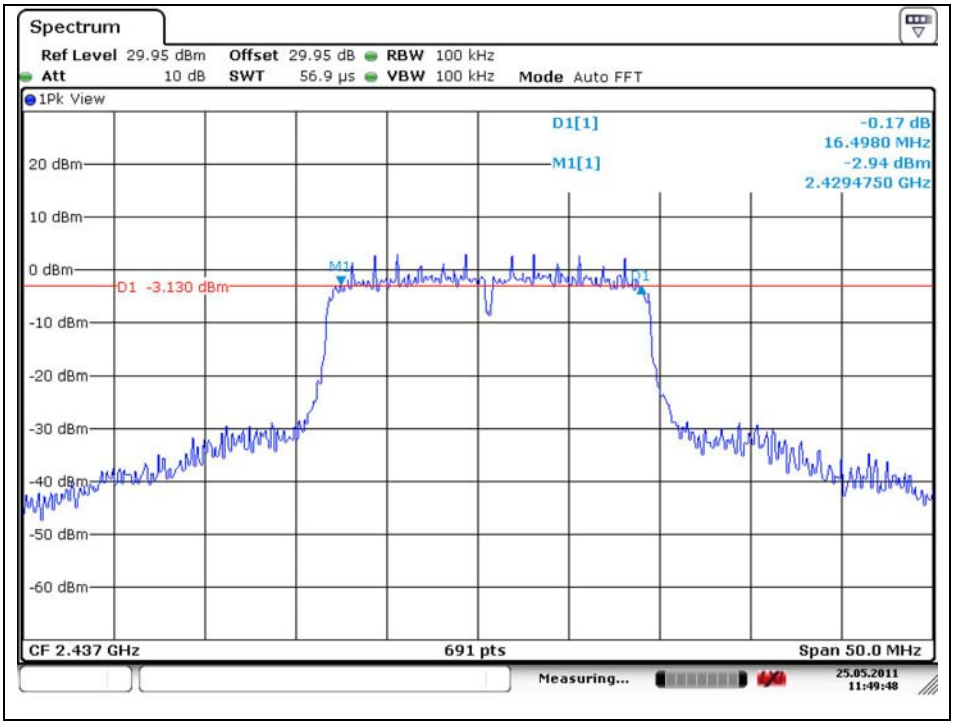


6 dB Bandwidth OFDM : 802.11n HT20 ANT2

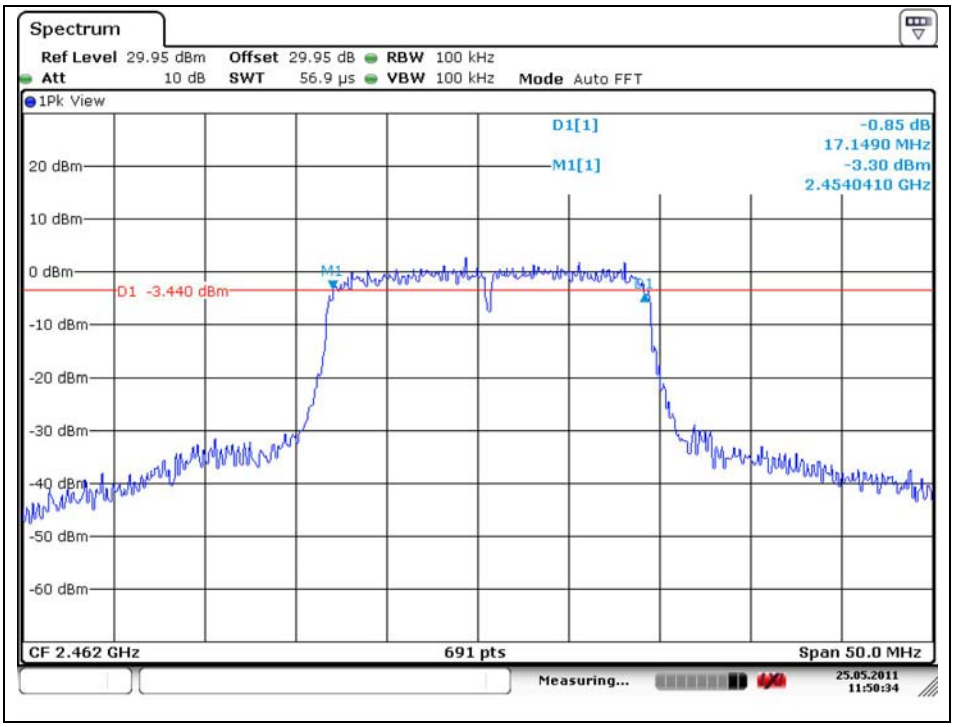
Low Channel



Middle Channel

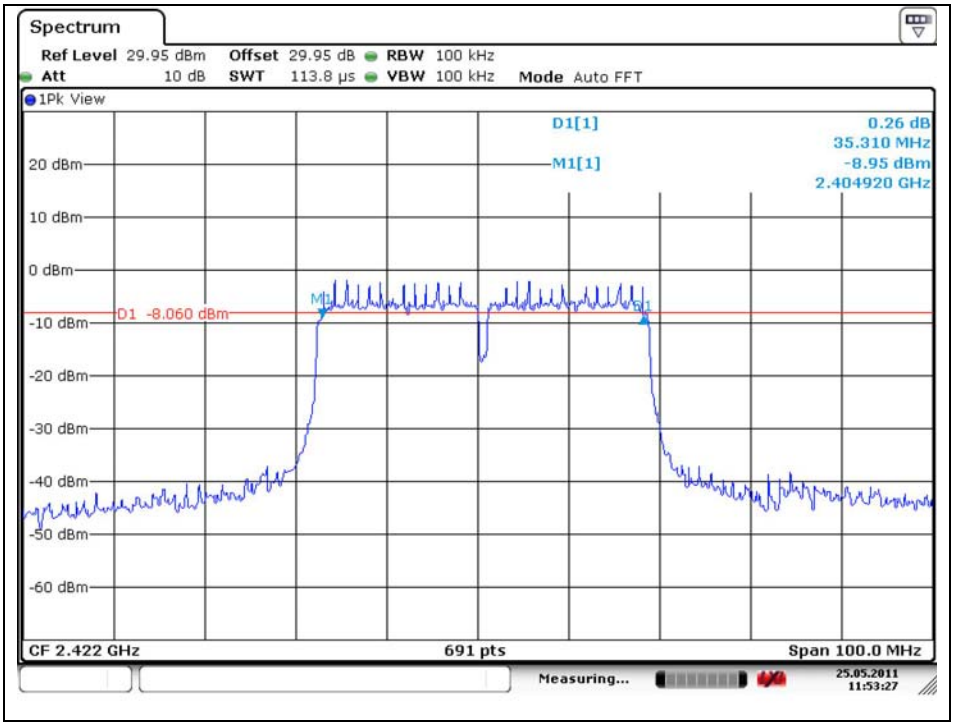


High Channel

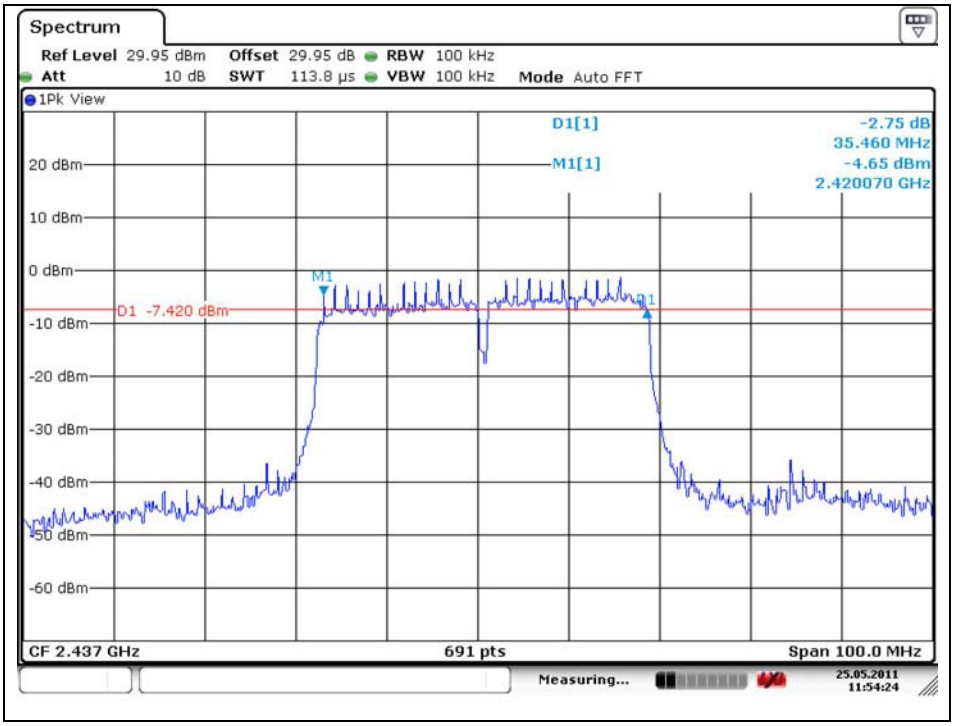


6 dB Bandwidth OFDM : 802.11n HT40 ANT1

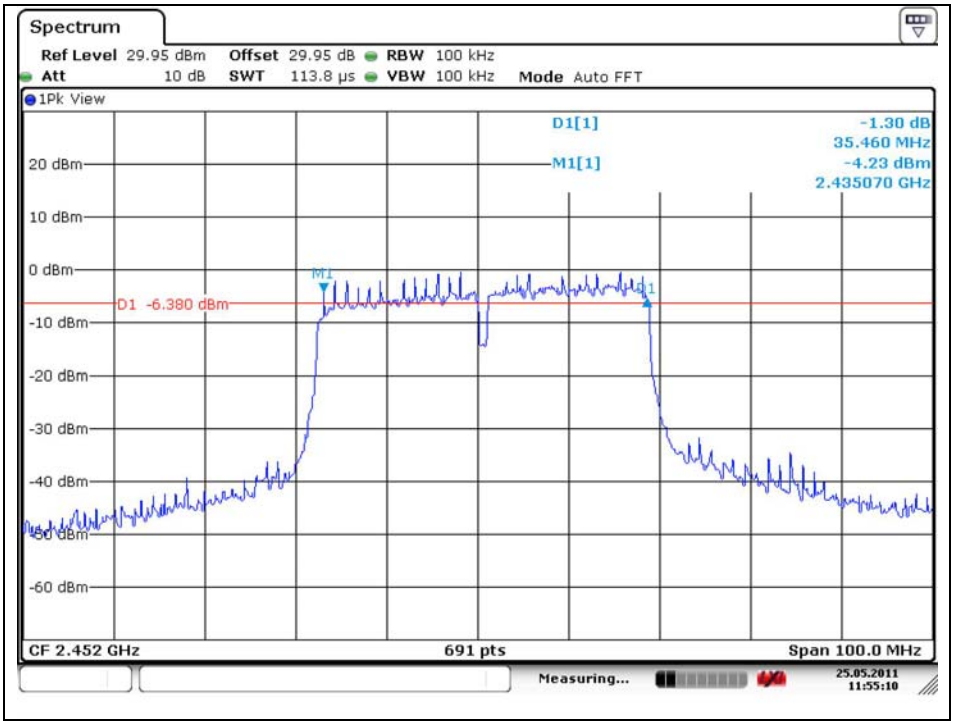
Low Channel



Middle Channel

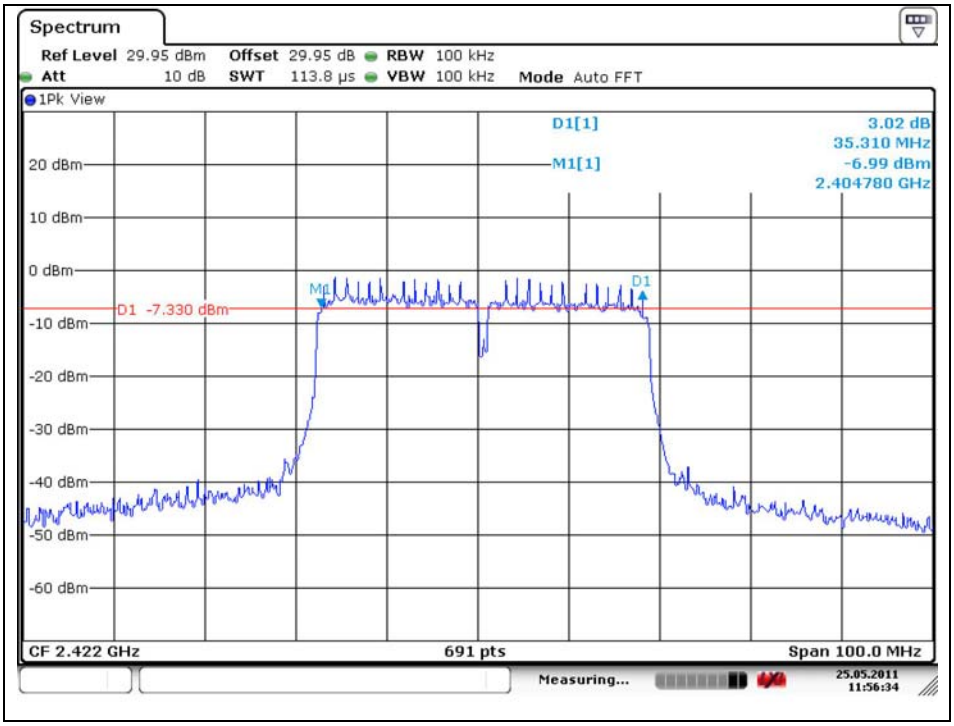


High Channel

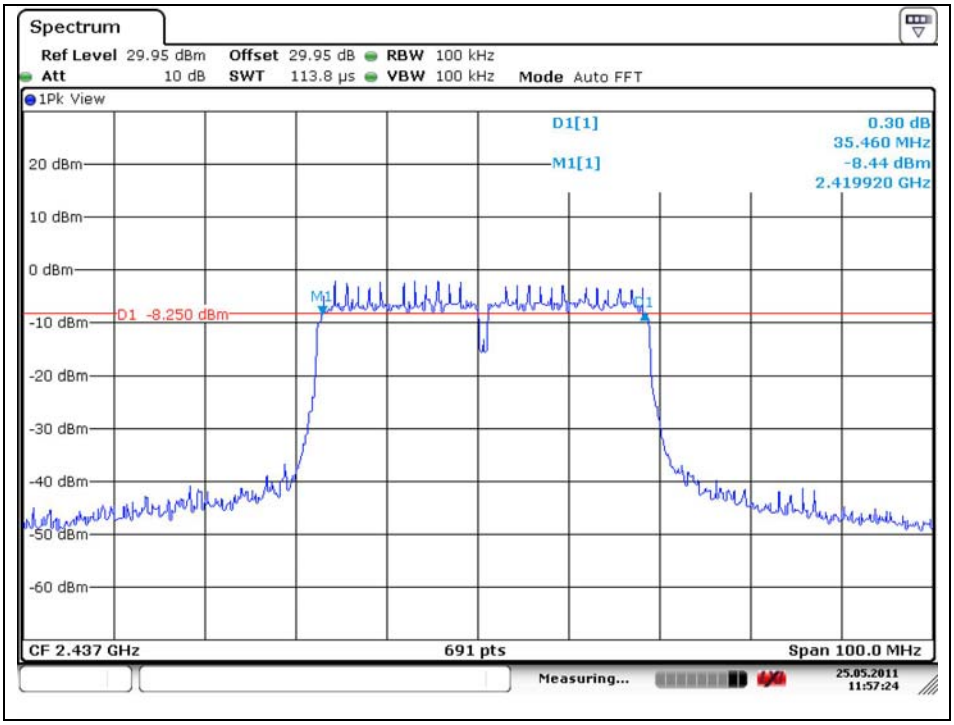


6 dB Bandwidth OFDM : 802.11n HT40 ANT2

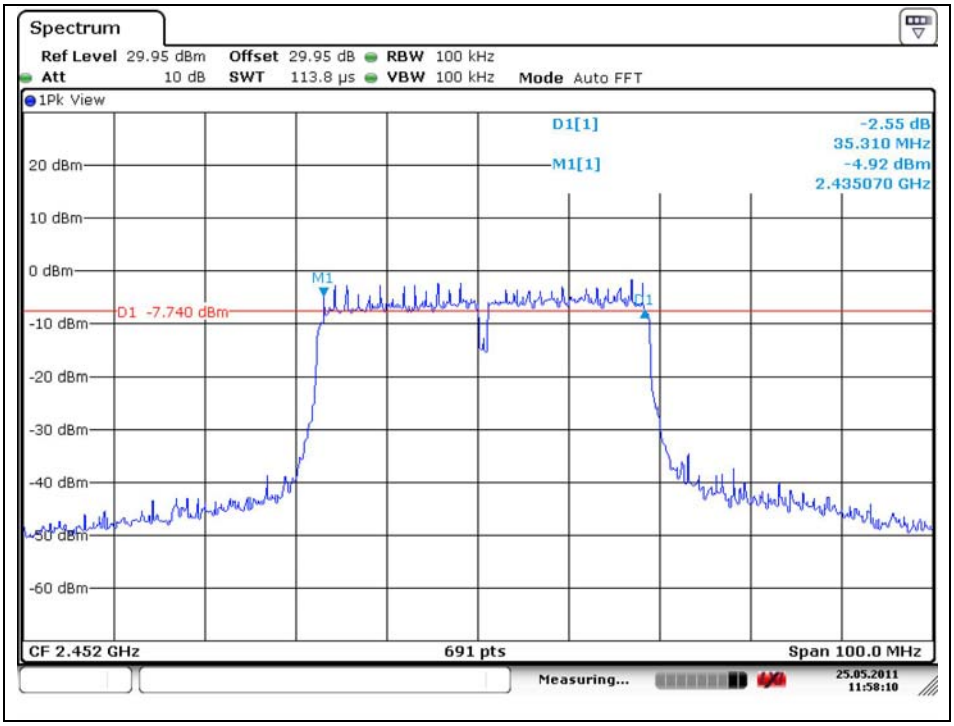
Low Channel



Middle Channel

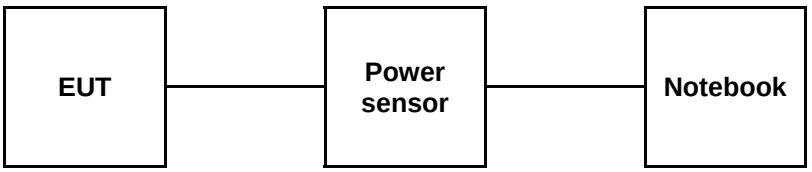


High Channel



4. Maximum Peak Output Power Measurement

4.1. Test Setup



4.2. Limit

According to §15.247(b)(3), for systems using digital modulation in the 902 ~ 928 ㎒, 2 400 ~2 483.5 ㎒, and 5 725 ~ 5 850 ㎒ band: 1 Watt. As an alternative to a peak power measurement, compliance with the one watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted output Power is defi ned a s the total tran smit power d elivered to all ant ennas an d a ntenna el ements ave raged across all symbol s in the signaling alphabet when the transmitter is operat ing at its maximum powe r control level. Power must be su mmed acro ss all antenna e lements. The average mu st not includ e any intervals during which the tran smitter is off or i s transmitting at a reduced power level. If multiple modes of op eration are po ssible (e.g., alternat ive modulatio n methods), the maximum condu cted output powe r is the highest total transmit power occurring in any mode.
According to §15.247 (b)(4), the con ducted o utput powe r limit specified in paragraph(b) of this section is based on th e use of an tenna with d irectional gai ns that do not excee d 6 ㏈i. Except as sho wn in paragraph(c) of this se ction, if transm itting antenn a of dire ctional gain greater than 6 ㏈i a re us ed, the conducted output power from the in tentional radiator shall be redu ced below the stated values in paragra ph (b)(1), (b)(2), and (b)(3) of this se ction , as appropriate, by the amount in ㏈ that the directio nal gain of the antenna exceeds 6㏈i.

4.3. Test Procedure

1. Place the EUT on the table and set it in the transmitting mode.
2. Remove the antenn a from the EUT and then co nnect a low lo ss RF cabl e from the antenna po rt to the power sensor.
3. Set the power sensor as peak mode.

4.4. Test Results

Ambient temperature : (24 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Channel	Channel Frequency (㎒)	Attenuator + Cable offset (dB)	Peak Power Output (dB m)	Peak Power Limit (dB m)
DSSS (802.11b) Ant 1	Low 2	412	30.41	23.47	28.994 dB m (= 30 dB m -1.006 dB i)
	Middle 2	437	30.41	23.90	
	High 2	462	30.41	26.15	
DSSS (802.11b) Ant 2	Low 2	412	30.41	20.94	
	Middle 2	437	30.41	19.65	
	High 2	462	30.41	20.82	
OFDM (802. 11g) Ant 1	Low 2	412	30.41	24.42	
	Middle 2	437	30.41	24.73	
	High 2	462	30.41	26.97	
OFDM (802. 11g) Ant 2	Low 2	412	30.41	23.53	
	Middle 2	437	30.41	22.44	
	High 2	462	30.41	24.41	
OFDM (802.11n HT20) Ant1	Low 2	412	30.41	21.67	
	Middle 2	437	30.41	21.75	
	High 2	462	30.41	24.07	
OFDM (802.11n HT20) Ant2	Low 2	412	30.41	21.85	
	Middle 2	437	30.41	20.73	
	High 2	462	30.41	22.32	
OFDM (802.11n HT40) Ant1	Low 2	422	30.41	22.88	
	Middle 2	437	30.41	23.36	
	High 2	452	30.41	24.61	
OFDM (802.11n HT40) Ant2	Low 2	422	30.41	22.02	
	Middle 2	437	30.41	21.81	
	High 2	452	30.41	22.70	

Operation Mode	Channel	Channel Frequency (㎒)	Peak Power Output(㏈m)			Peak Power Limit (㏈m)
			ANT 1	ANT2	Combined (Ant1+Ant 2)	
OFDM (802.11n HT20) Ant1+Ant2	Low 2	412	21.67	21.85	24.77	28.994 ㏈m (= 30 ㏈m -1.006 ㏈i)
	Middle 2	437	21.75	20.73	24.28	
	High 2	462	24.07	22.32	26.29	
OFDM (802.11n HT40) Ant1+Ant2	Low 2	422	22.88	22.02	25.48	
	Middle 2	437	23.36	21.81	25.66	
	High 2	452	24.61	22.70	26.77	

* (㏈m /Chain1)/10^Log) + (㏈m /Chain2)/10^Log) = Combined peak output power in ㎽.

5. POWER SPECTRAL DENSITY MEASUREMENT

5.1. Test Setup

5.2. Limit

§15.247(e) For digitally modulated system, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 ㎑ band any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.3. Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
3. By using the Max Hold function record the separation of adjacent channels.
4. Repeat above procedures until all frequencies measured were complete.
5. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using ; RBW = 3 ㎑, VBW = 10 ㎑, Span = 300 ㎑ and Sweep = 100 s.

5.4. Test Results

Ambient temperature : (24 ± 2) ℃
Relative humidity : 47 % R.H.

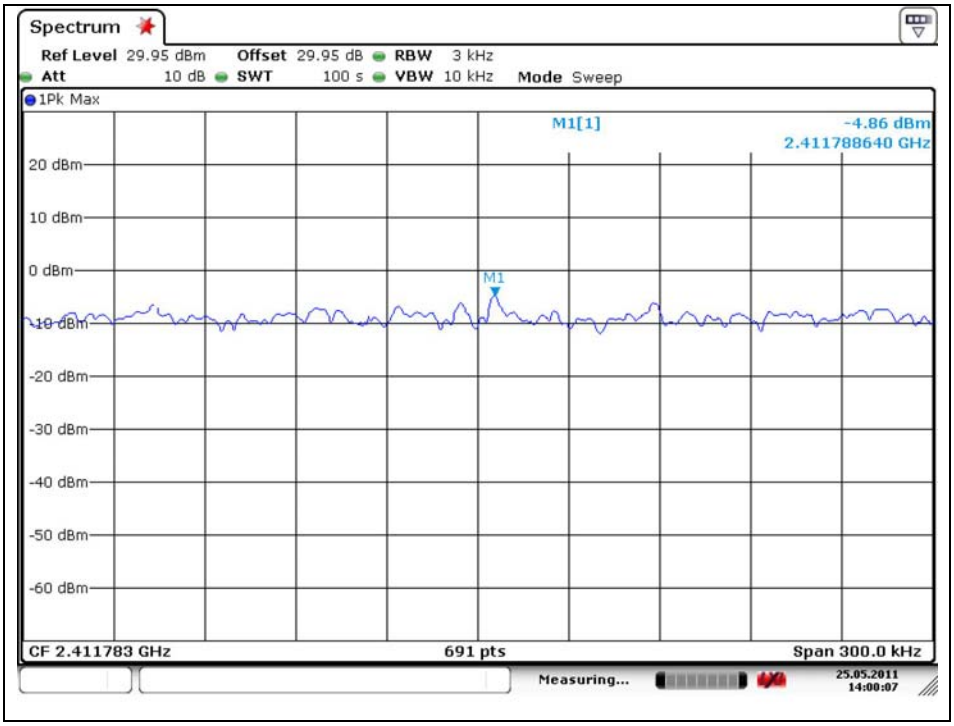
Operation Mode	Channel	Channel Frequency (㎒)	Final RF Power Level in 3 ㎑ BW (dB m)	Maximum Limit (dB m)
DSSS (802.11b) Ant 1	Low 2	412	-4.86	8 dB m
	Middle 2	437	-5.60	
	High 2	462	-3.69	
DSSS (802.11b) Ant 2	Low 2	412	-9.28	
	Middle 2	437	-10.24	
	High 2	462	-10.00	
OFDM (802. 11g) Ant 1	Low 2	412	-12.25	
	Middle 2	437	-10.88	
	High 2	462	-7.57	
OFDM (802. 11g) Ant 2	Low 2	412	-11.03	
	Middle 2	437	-12.20	
	High 2	462	-11.72	
OFDM (802.11n HT20) Ant1	Low 2	412	-8.96	
	Middle 2	437	-8.33	
	High 2	462	-9.54	
OFDM (802.11n HT20) Ant2	Low 2	412	-16.86	
	Middle 2	437	-16.84	
	High 2	462	-15.31	
OFDM (802.11n HT40) Ant1	Low 2	422	-17.46	
	Middle 2	437	-16.01	
	High 2	452	-15.37	
OFDM (802.11n HT40) Ant2	Low 2	422	-15.03	
	Middle 2	437	-16.42	
	High 2	452	-14.52	

Operation Mode	Channel	Channel Frequency (㎒)	Final RF Power Level in 3 ㎑ BW (dB m)			Maximum Limit (dB m)
			ANT 1	ANT2	Combined (Ant1+Ant 2)	
OFDM (802.11n HT20) Ant1+Ant2	Low 2	412	-8.96	-16.86	-8.30	8 dB m
	Middle 2	437	-8.33	-16.84	-7.75	
	High 2	462	-9.54	-15.31	-8.51	
OFDM (802.11n HT40) Ant1+Ant2	Low 2	422	-17.46	-15.03	-13.10	
	Middle 2	437	-16.01	-16.42	-13.19	
	High 2	452	-15.37	-14.52	-11.94	

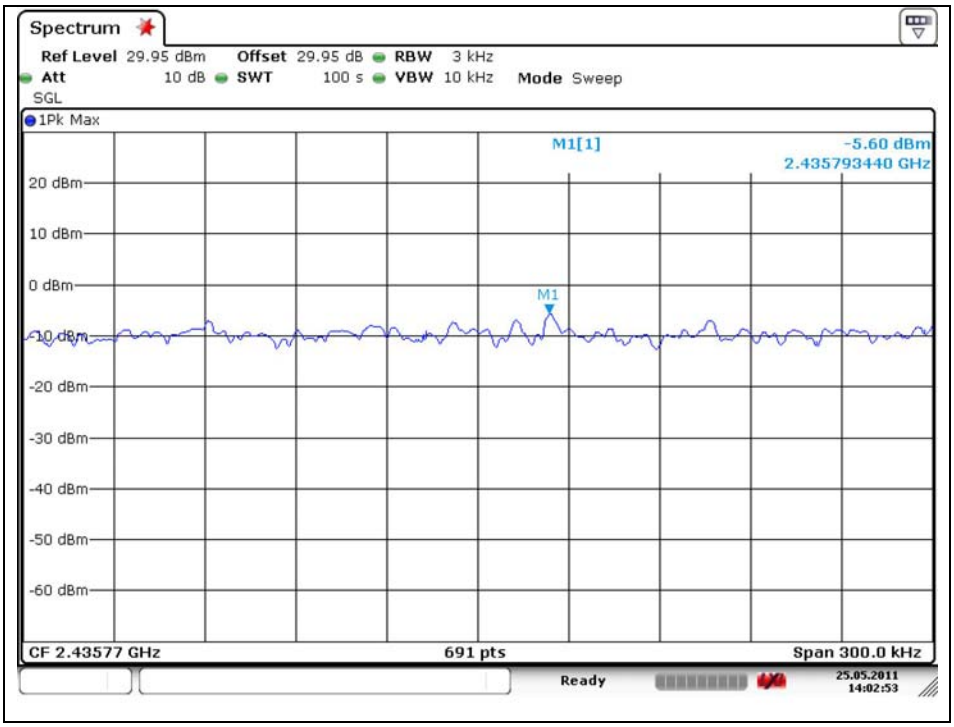
* (dB m /Chain1)/10^Log) + (dB m /Chain2)/10^Log) = Combined peak output power in ㎽.

DSSS : 802.11b_Ant 1

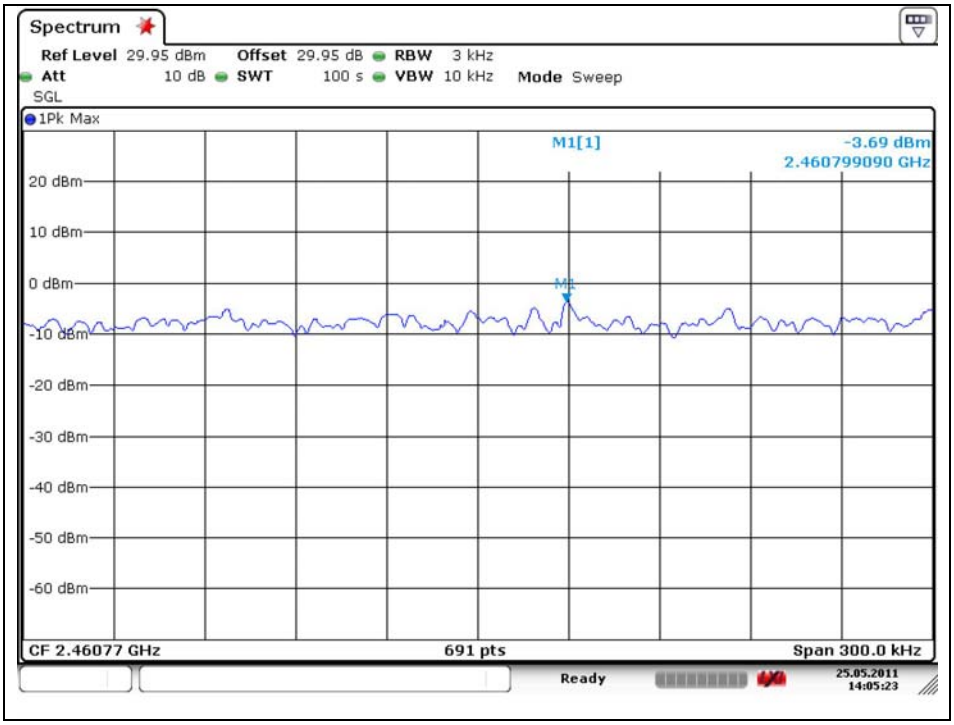
Low Channel



Middle Channel

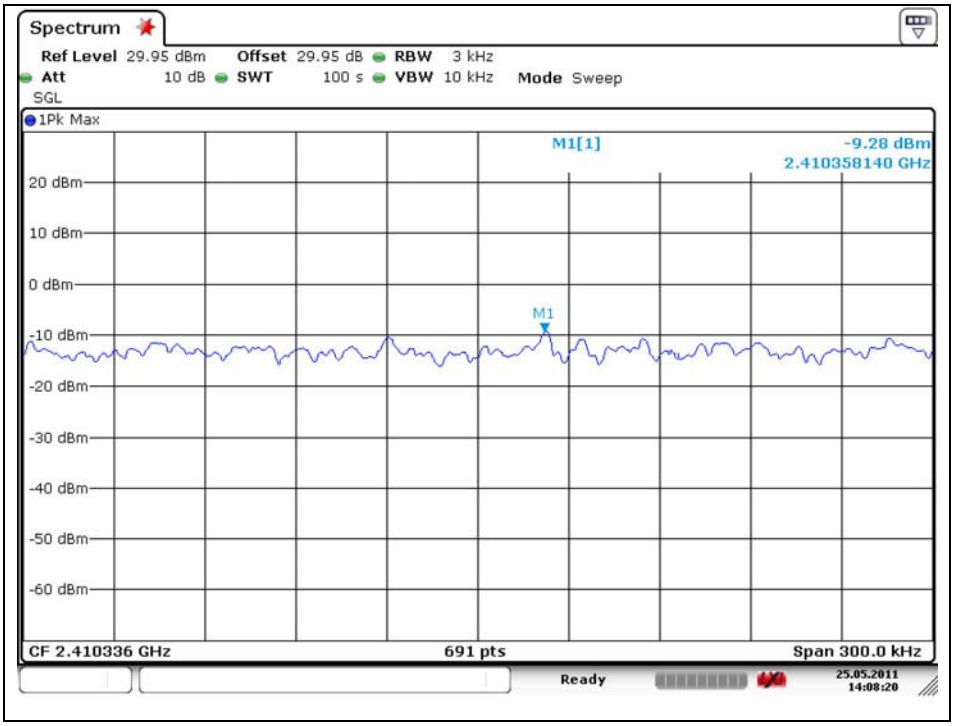


High Channel

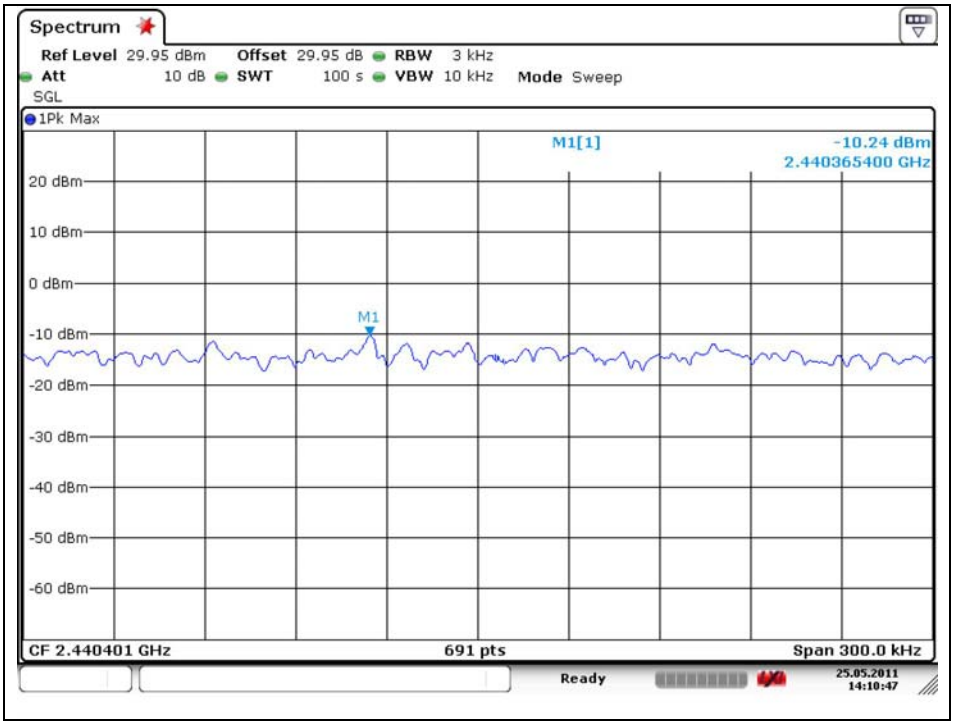


DSSS : 802.11b_Ant 2

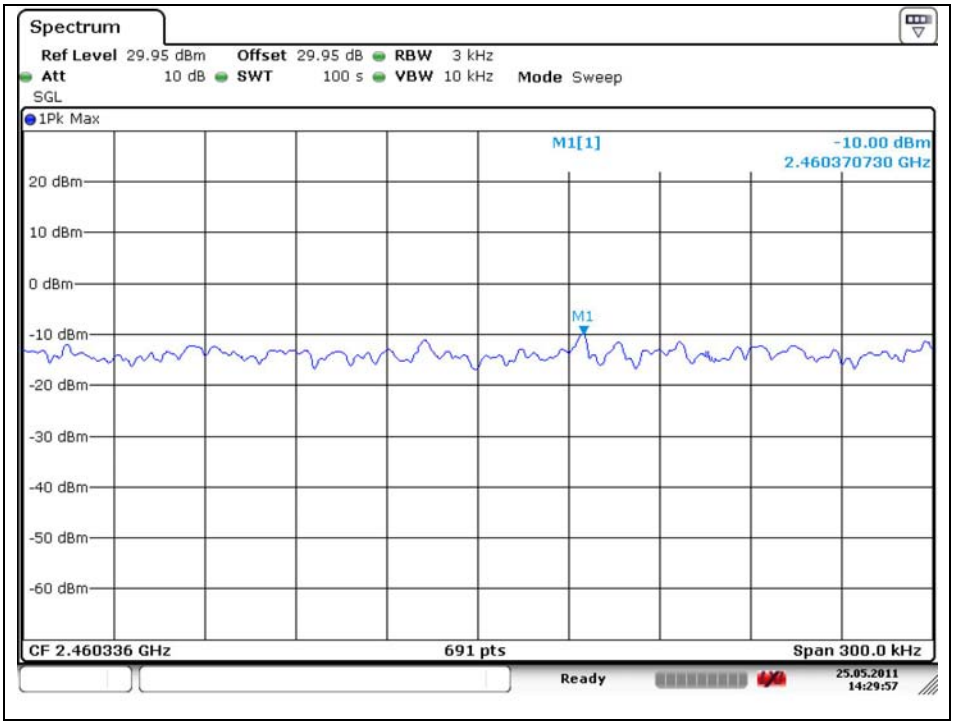
Low Channel



Middle Channel

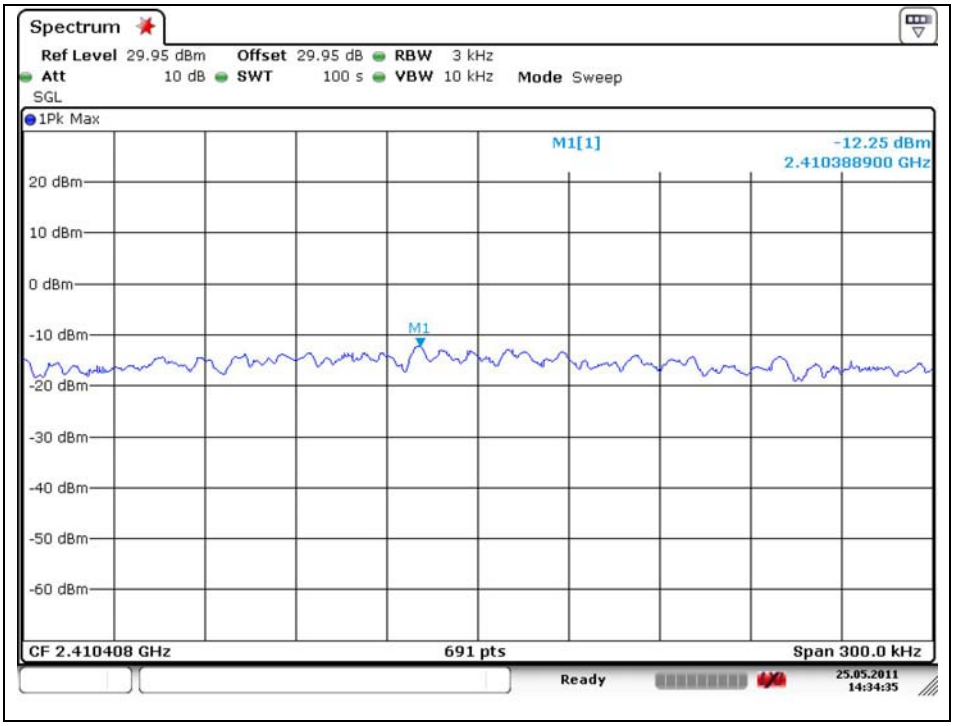


High Channel

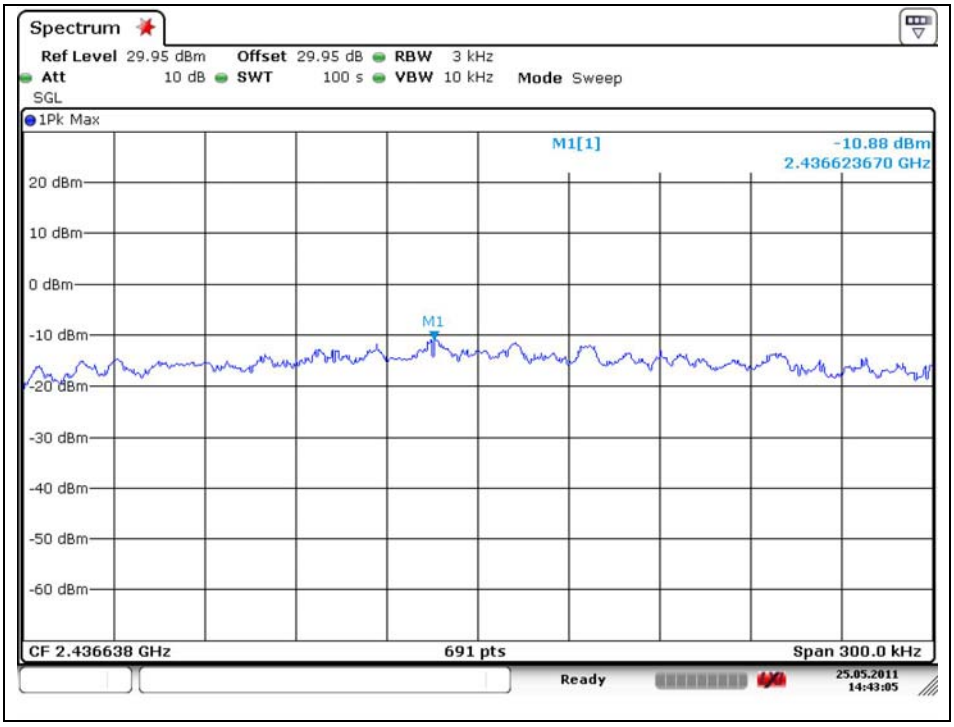


OFDM : 802.11g _ Ant 1

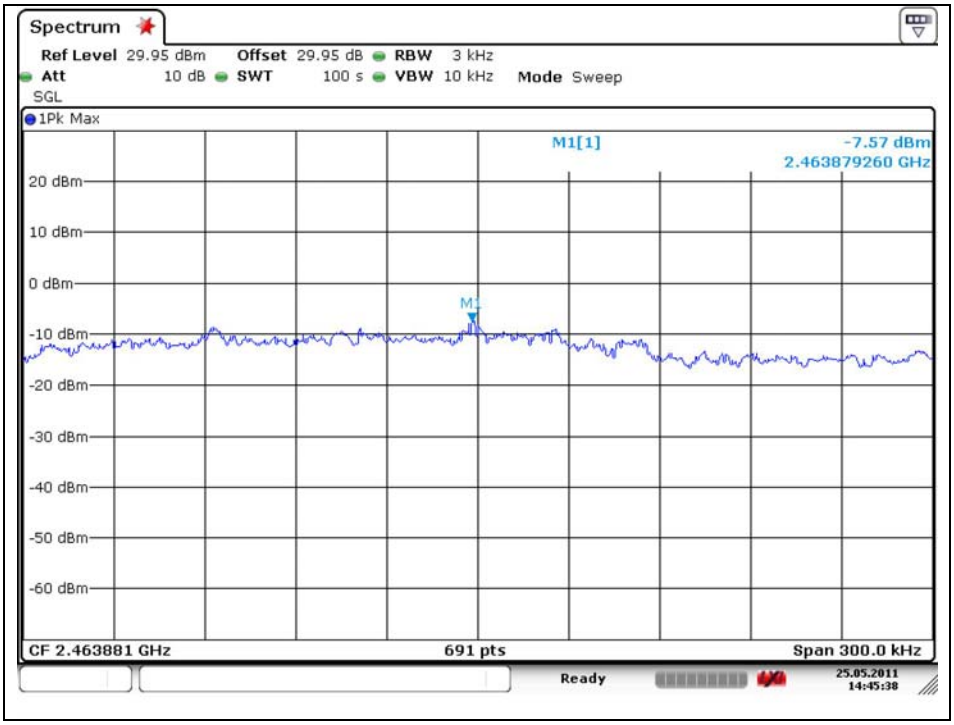
Low Channel



Middle Channel

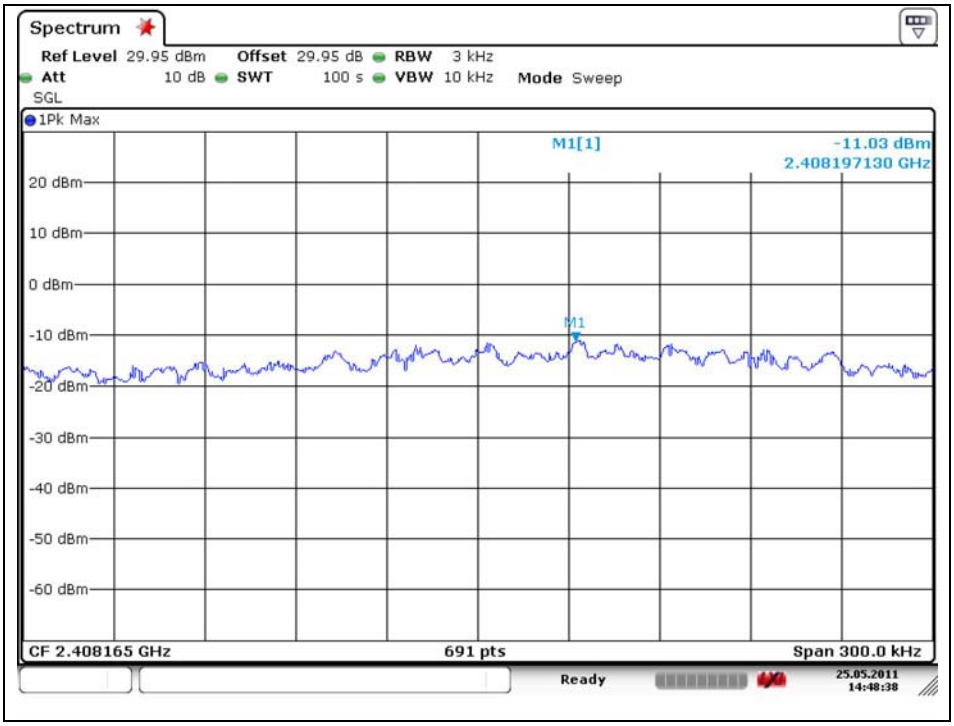


High Channel

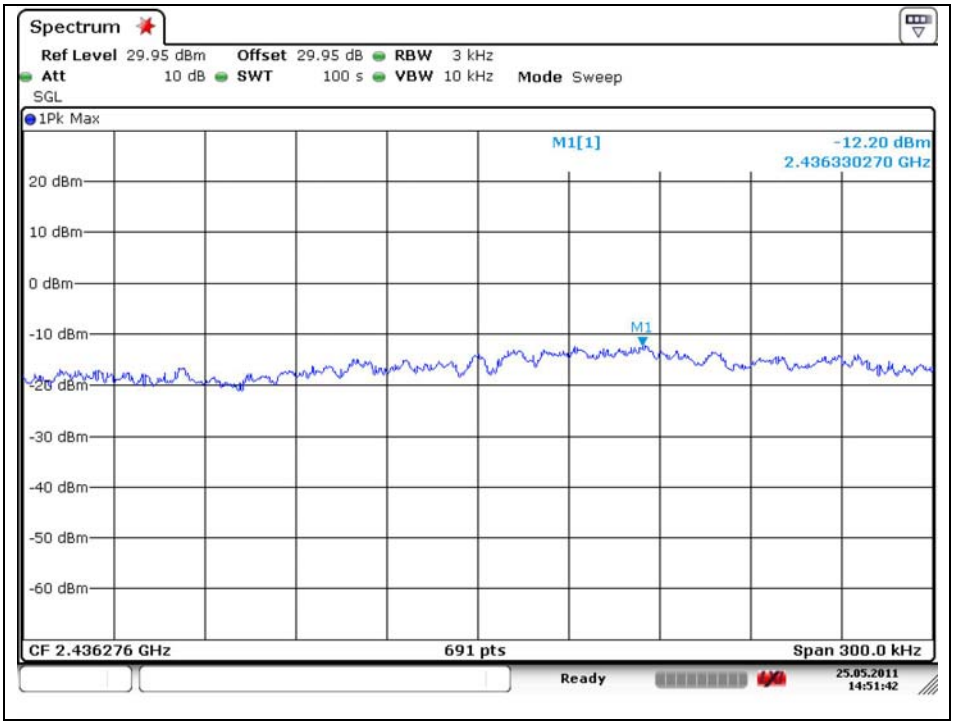


OFDM : 802.11g _ Ant 2

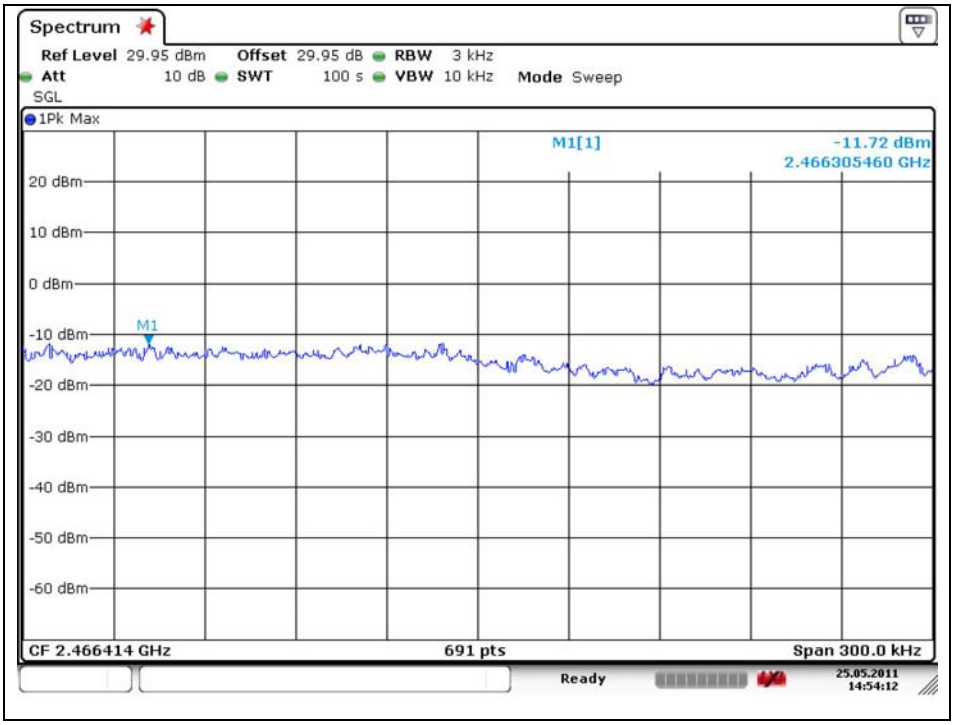
Low Channel



Middle Channel

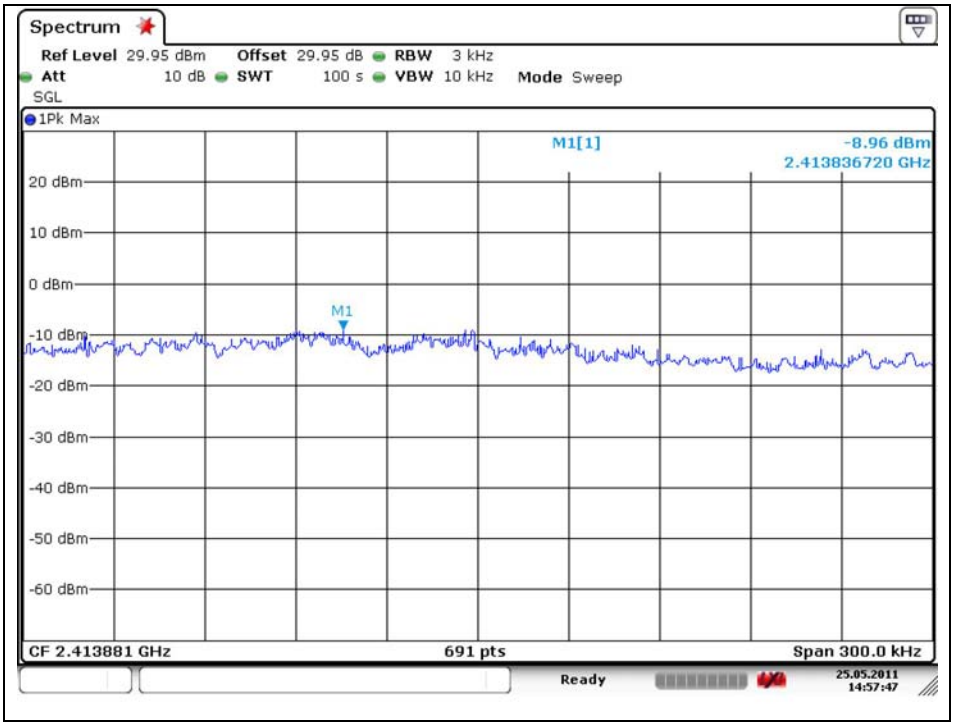


High Channel

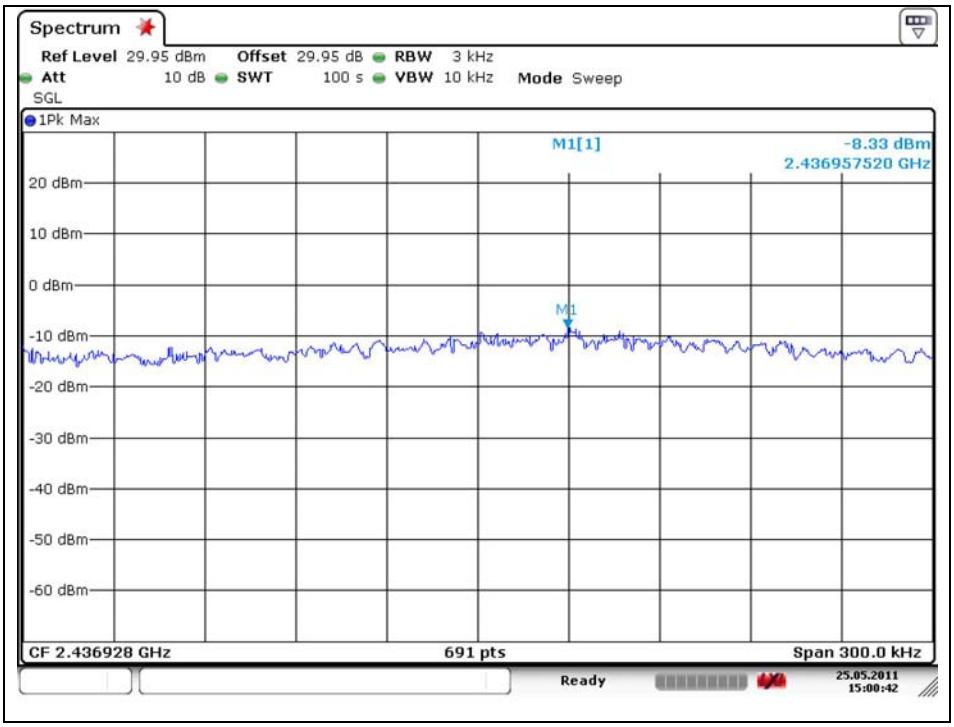


OFDM : 802.11n HT20 ANT 1

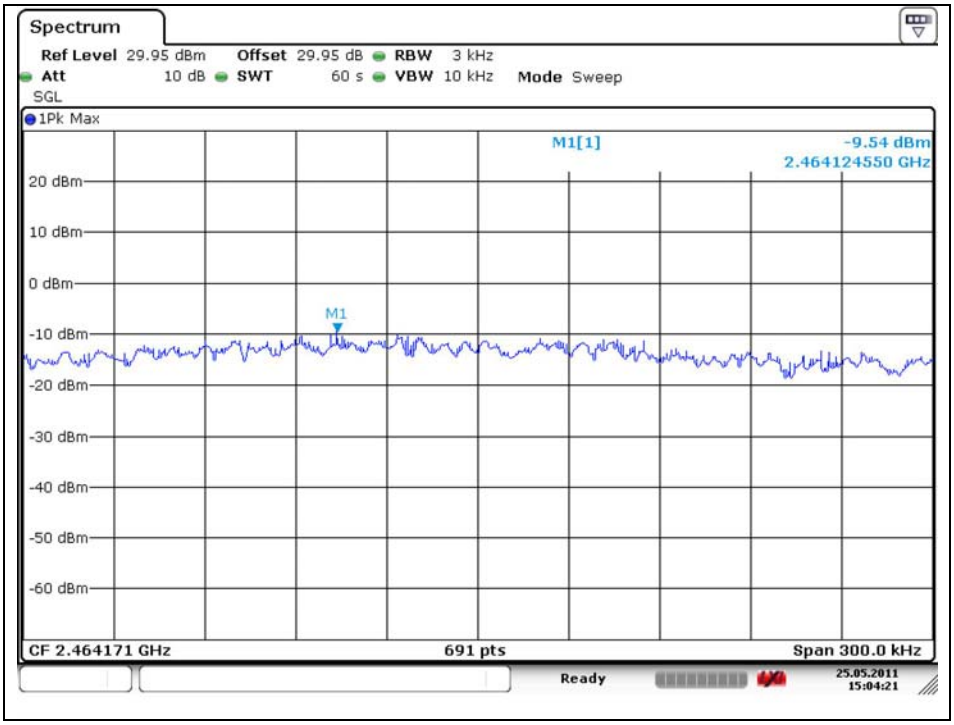
Low Channel



Middle Channel

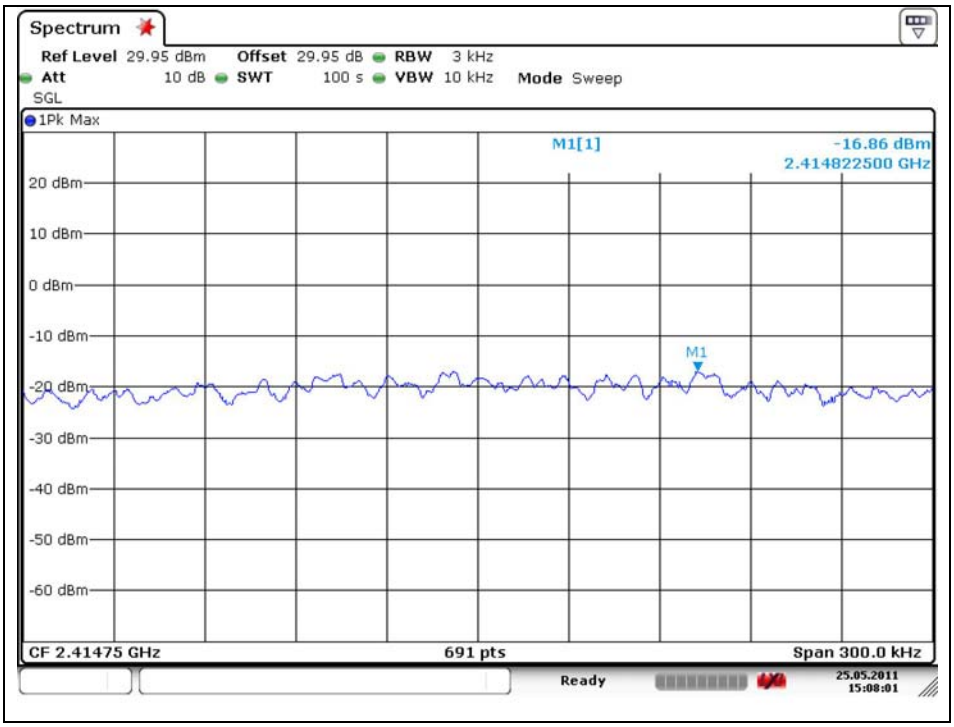


High Channel

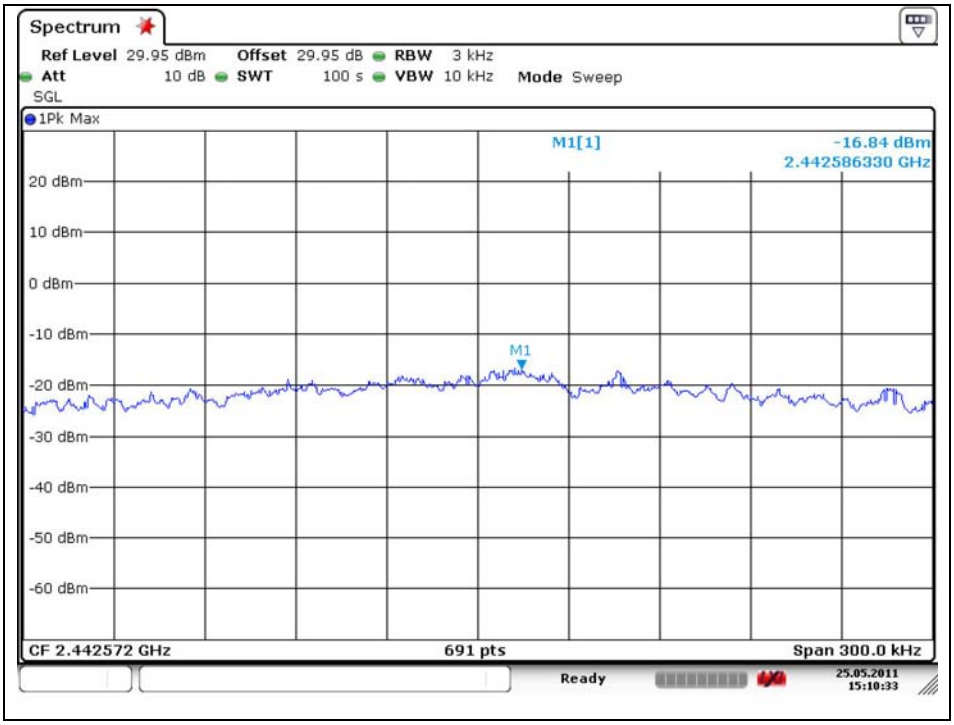


OFDM : 802.11n HT20 ANT 2

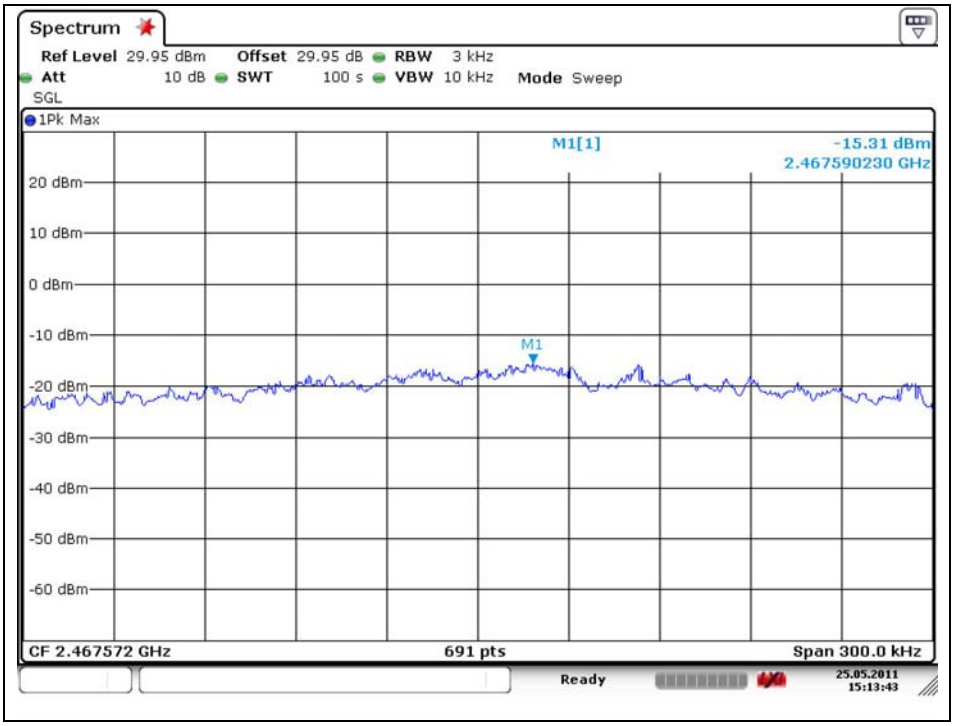
Low Channel



Middle Channel

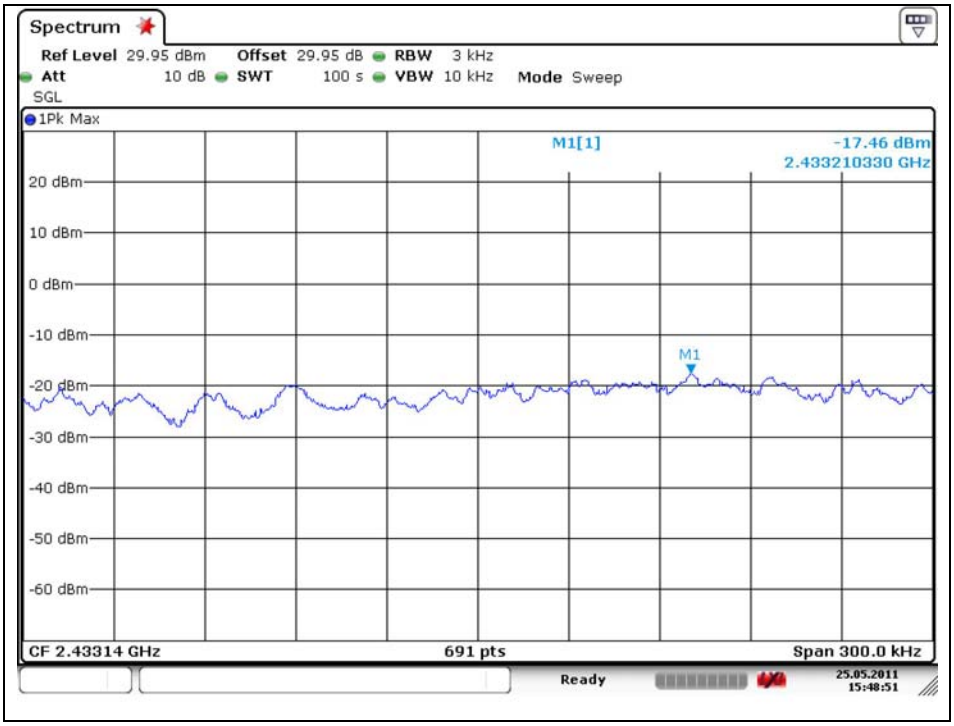


High Channel

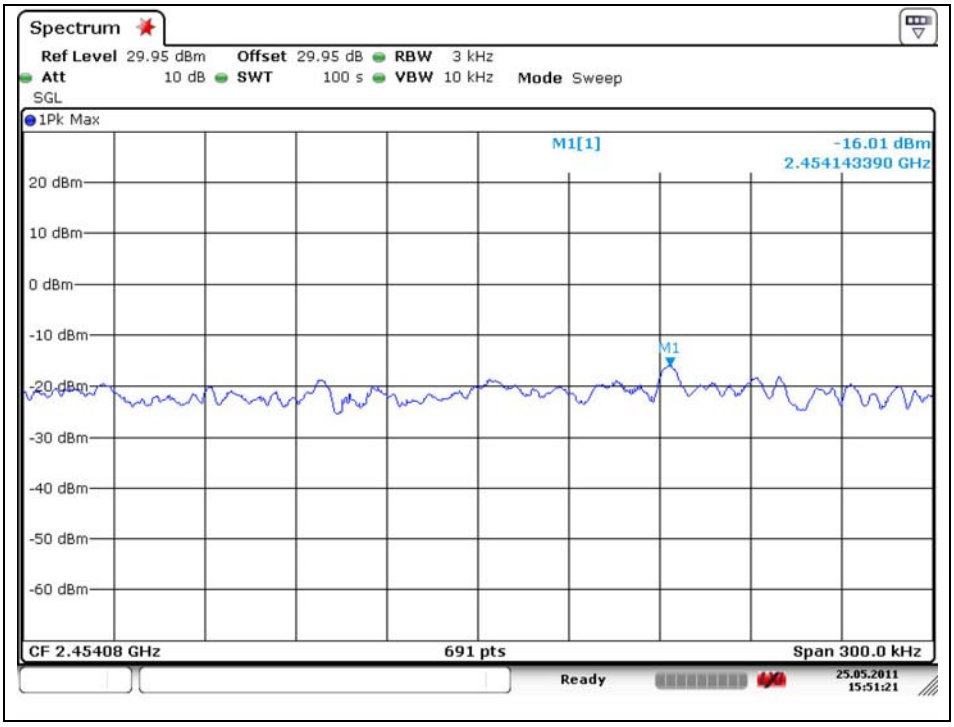


OFDM : 802.11n HT40 ANT 1

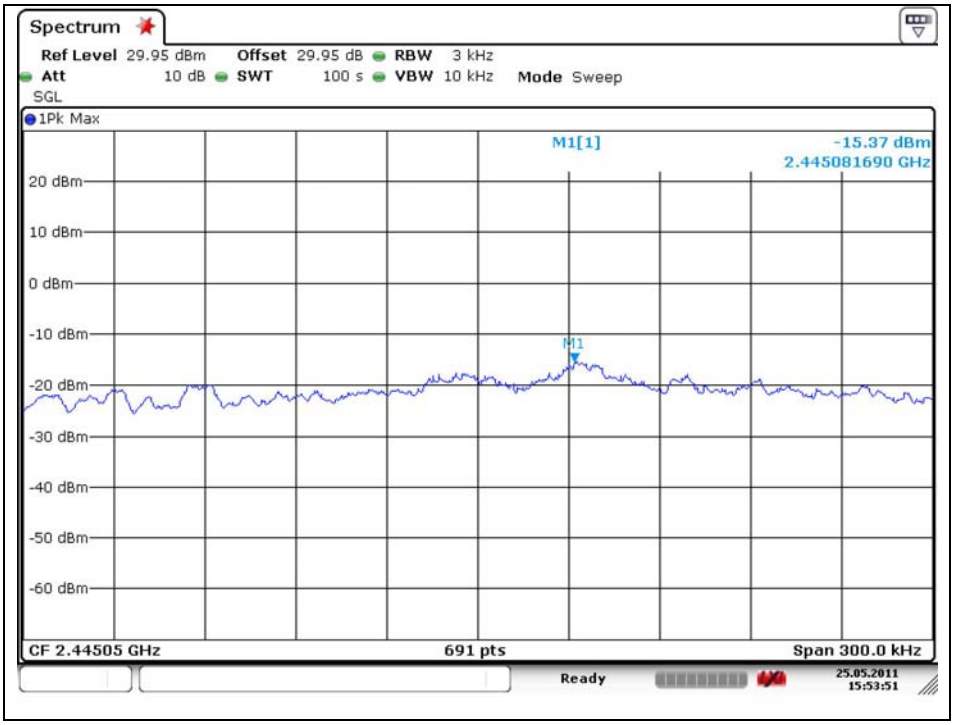
Low Channel



Middle Channel

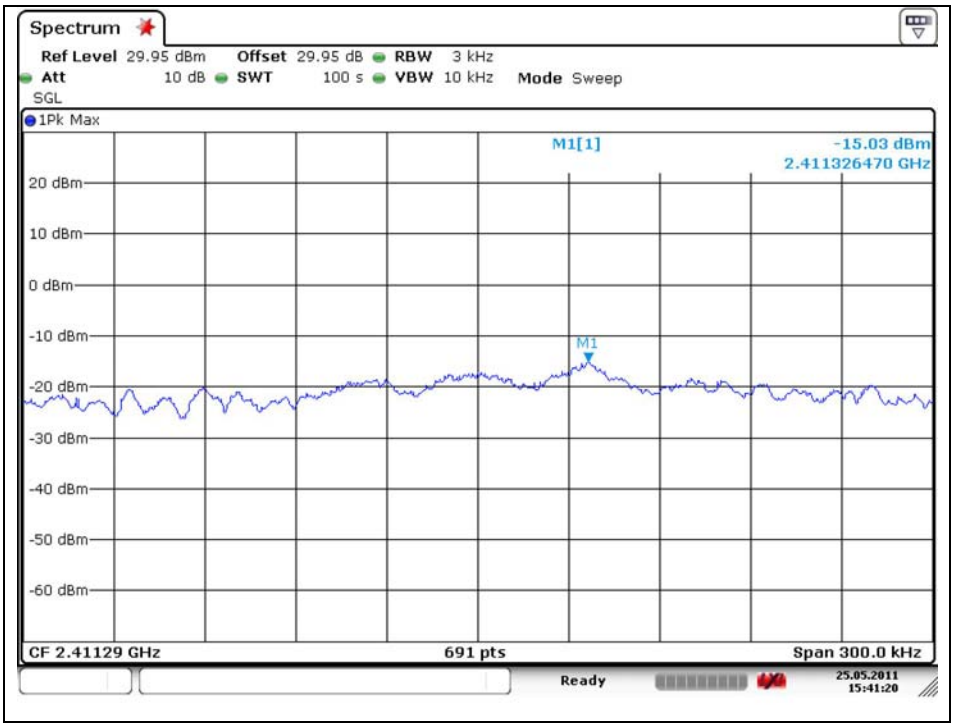


High Channel

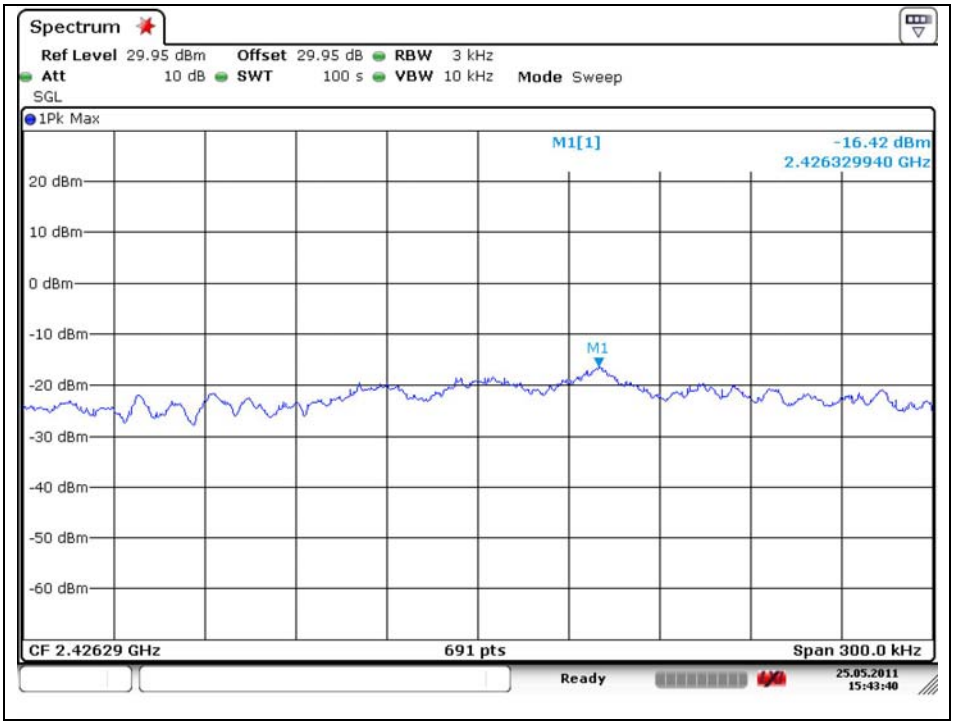


OFDM : 802.11n HT40 ANT 2

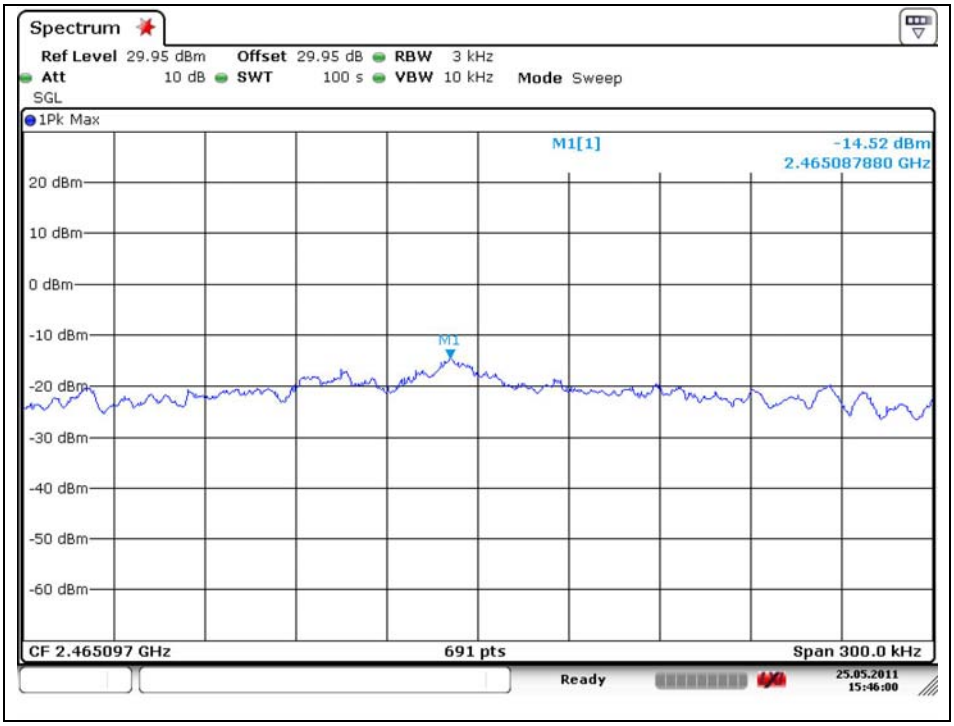
Low Channel



Middle Channel

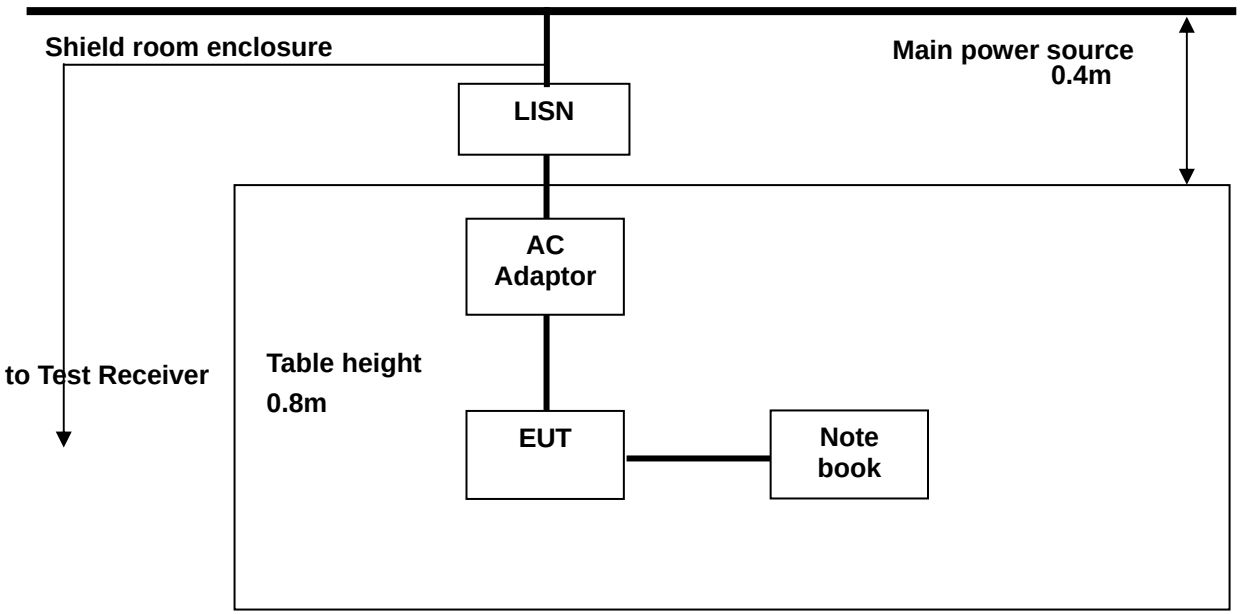


High Channel



6. Transmitter AC Power Line Conducted Emission

6.1. Test Setup



6.2. Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network(LISN).
Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency of Emission (㎒)	Conducted limit (dB㎶)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

* Decreases with the logarithm of the frequency.

6.3. Test Procedures

Radiated emissions from the EUT were measured according to the dictates of ANSI C63.4:2003

1. The test procedure is performed in a 6.5m × 3.6m× 3.6m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m(W)× 1.5 m(L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

6.4. Test Results (Worst case configuration_11n_HT40 mode)

The following table shows the highest levels of conducted emissions on both phase of Hot and Neutral line.

Ambient temperature : (24 ± 2) ℃
Relative humidity : 47 % R.H.

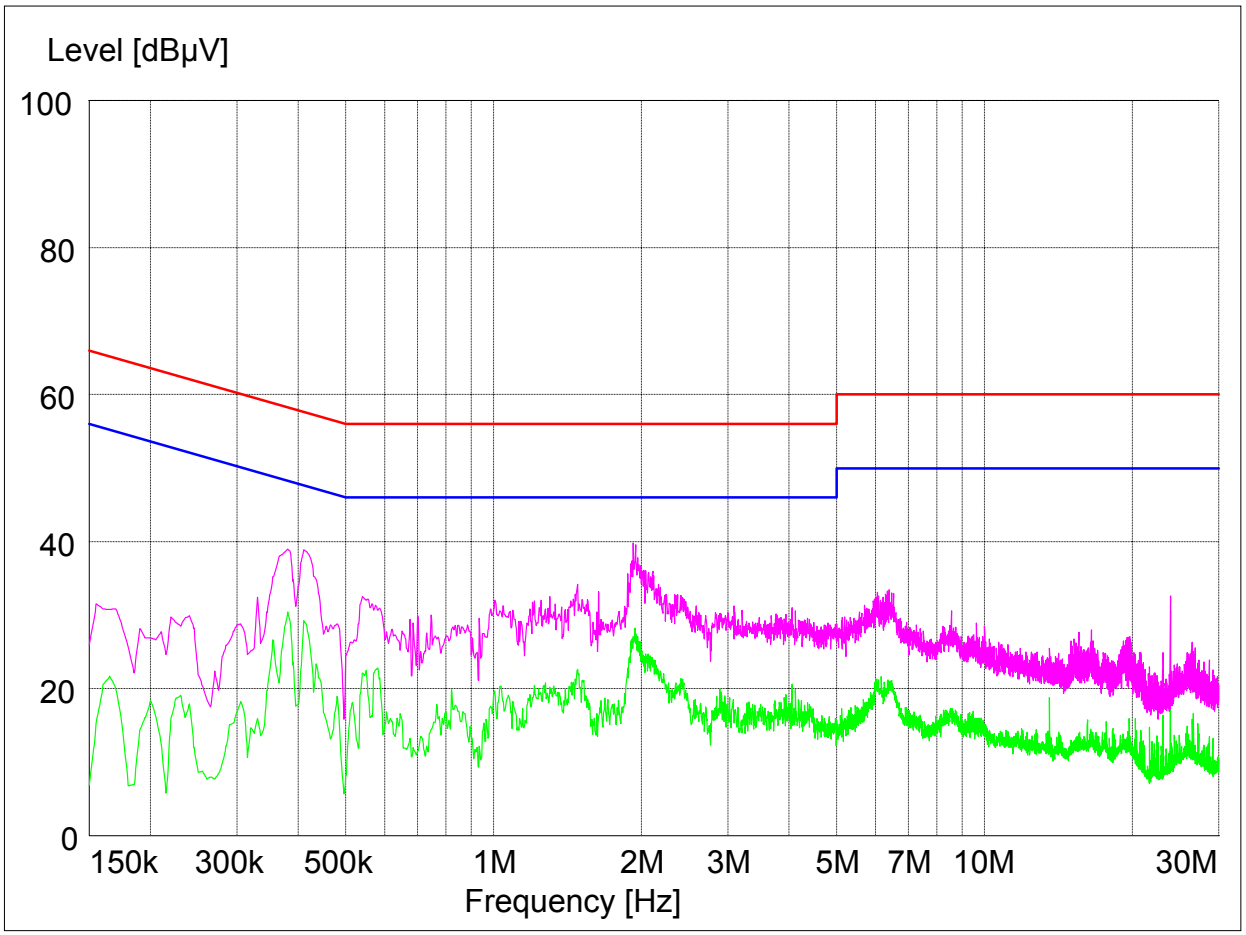
Frequency range : 0.15 ㎒ – 30 ㎒
Measured Bandwidth : 9 ㎑

FREQ.	LEVEL(dB㎶)		LINE	LIMIT(dB㎶)		MARGIN(dB)	
(㎒)	Q-Peak	Average		Q-Peak	Average	Q-Peak	Average
0.38	37.40	31.70	H	58.28	48.28	20.88	16.58
0.41	36.40	29.80	H	57.65	47.65	21.25	17.85
0.54	31.00	24.00	H	56.00	46.00	25.00	22.00
1.01	28.90	22.00	H	56.00	46.00	27.10	24.00
1.95	32.30	26.80	H	56.00	46.00	23.70	19.20
23.96	30.80	30.40	H	60.00	50.00	29.20	19.60
0.31	34.40	27.60	N	59.97	49.97	25.57	22.37
0.39	38.60	35.30	N	58.17	48.17	19.57	12.87
1.25	30.50	25.50	N	56.00	46.00	25.50	20.50
1.94	34.00	28.10	N	56.00	46.00	22.00	17.90
6.02	27.70	22.40	N	60.00	50.00	32.30	27.60
23.95	32.30	31.80	N	60.00	50.00	27.70	18.20

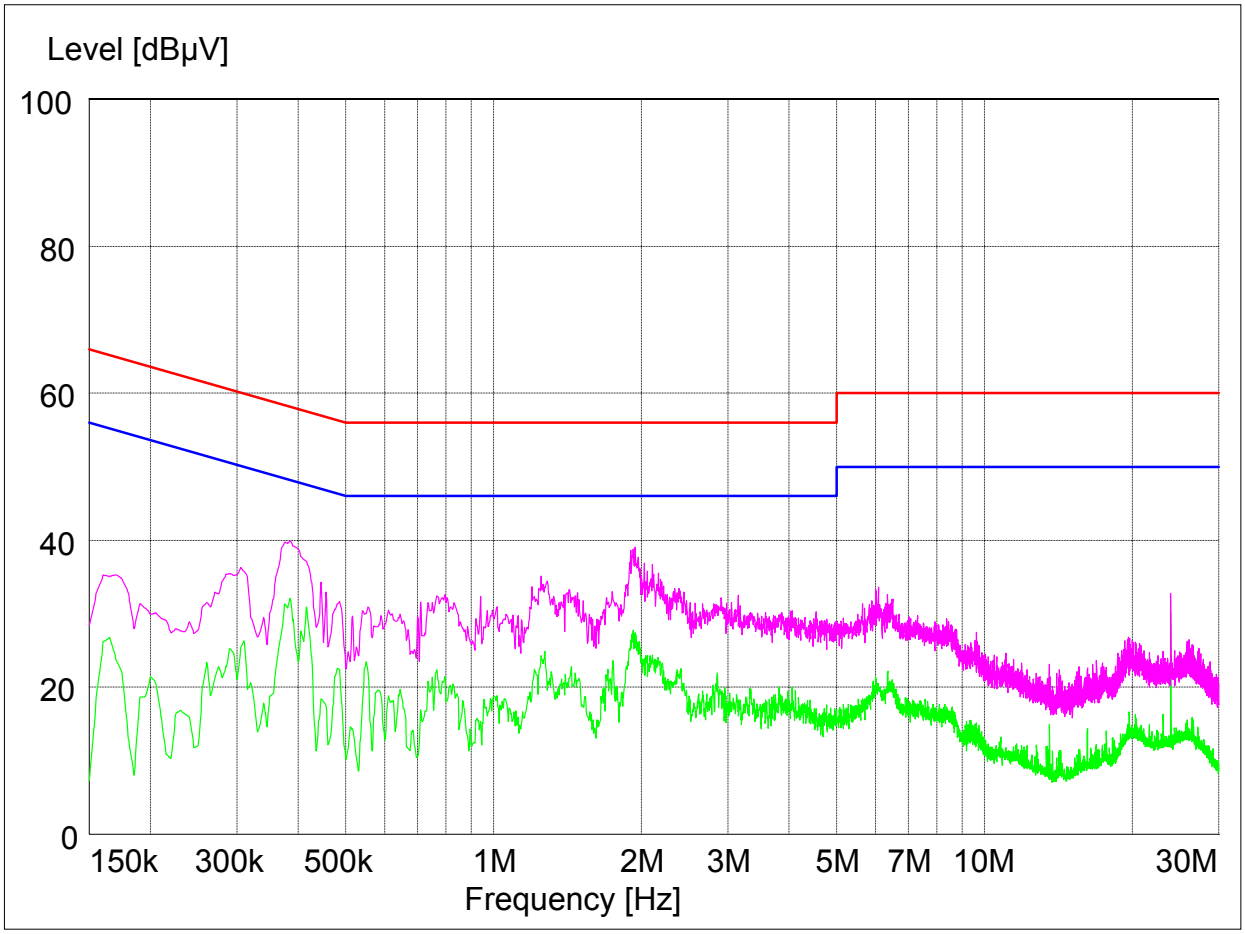
Note ;
Line (H) : Hot
Line (N) : Neutral

Plot of Conducted Power line

Test mode : (Hot)



Test mode : (Neutral)



7. Antenna Requirement

7.1. Standard Applicable

For intentional device, according to FCC 47 CFR Se ction §15.203, 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. And according to FCC 47 CFR Section §15.247 (b) if transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the gain of the antenna exceeds 6 dBi.

7.2. Antenna Connected Construction

Antennas used in this product is Integral type (Main : PCB antenna, Aux : Wire antenna) combined gain of 7.006 dBi. The power is reduced by the amount in 1.001 dBi

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ANT1 gain	4.887 dBi
ANT2 gain	2.873 dBi
Combined gain (ANT 1 +ANT 2)	7.006 dBi = 10 log ($10^{4.887/10}$+$10^{2.873/10}$)

8. RF Exposure Evaluation

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

According to FCC 1.1310 : The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in §1.1307(b)

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 – 1500	--	--	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**

8.1.1. Friis transmission formula: Pd = (Pout*G)/(4*pi*R^2)

Where Pd = power density in ㎽/㎠

Pout = output power to antenna in ㎽

G = gain of antenna in linear scale

Pi = 3.1416

R = distance between observation point and center of the radiator in ㎝

Pd the limit of MPE, 1 ㎽/㎠. If we know the maximum gain of the antenna and the total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

8.1.2. Test Result of RF Exposure Evaluation

Test Item : RF Exposure Evaluation Data
Test Mode : No rmal Operation

8.1.3. Output Power into Antenna & RF Exposure Evaluation Distance

DSSS : 802.11b Ant 1

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 412	21.44	4.887	0.085 39	1
Middle	2 437	21.55	4.887	0.087 59	1
High	2 462	23.85	4.887	0.148 74	1

DSSS : 802.11b Ant 2

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 412	18.13	2.873	0.025 06	1
Middle	2 437	16.61	2.873	0.017 66	1
High	2 462	17.72	2.873	0.022 81	1

OFDM : 802.11g Ant 1

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 412	16.27	4.887	0.025 97	1
Middle	2 437	16.34	4.887	0.026 39	1
High	2 462	18.67	4.887	0.045 13	1

OFDM : 802.11g Ant 2

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 412	16.00	2.873	0.015 35	1
Middle	2 437	14.61	2.873	0.011 14	1
High	2 462	15.79	2.873	0.014 62	1

OFDM : 802.11n_HT20_ANT 1+Ant 2

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m) Combined (ANT1 +ANT2)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 412	15.01	7.006	0.031 65	1
Middle	2 437	16.04	7.006	0.040 12	1
High	2 462	15.20	7.006	0.033 06	1

OFDM : 802.11n_HT40_ANT 1+Ant 2

Channel	Channel Frequency (㎒)	Output Average Power to Antenna (dB m) Combined (ANT1 +ANT2)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
Low	2 422	17.71	7.006	0.058 93	1
Middle	2 437	18.01	7.006	0.063 14	1
High	2 452	17.83	7.006	0.060 58	1

Simultaneous Multiple band RF Exposure results

Band	Mode	Output Average Power to Antenna (dB m)	Antenna Gain (dB i)	Power Density at 20cm (㎽/㎠)	LIMITS (㎽/㎠)
2.4 GHz	WLAN	23.85	4.887	0.148 74	1
2.4 GHz	Zigbee module 1	4.25	0.477	0.000 59	1
2.4 GHz	Zigbee module 2	2.32	0.447	0.000 38	1
Combined				0.149 71	1

Note :
1. The power density Pd (5th column) at a distance of 20cm calculated from the friis transmission formula is far below the limit of 1 mW/cm^2 .