

FCC Test Report

FCC ID : Q6G-MS5AE5W
Product Name : Security Network Appliance T55-W
Model No. : MS5AE5W
Brand Name : WatchGuard
Applicant : WatchGuard Technologies, Inc.
Address : 505 5th Ave S. Suite 500, Seattle, WA 98104
USA
Standard : 47 CFR FCC Part 15.247
Received Date : Jul. 07, 2017
Tested Date : Jul. 20 ~ Aug. 09, 2017

We, International Certification Corp., would like to declare that the tested sample has been evaluated and in compliance with the requirement of the above standards. The test results contained in this report refer exclusively to the product. It may be duplicated completely for legal use with the approval of the applicant. It shall not be reproduced except in full without the written approval of our laboratory.

Reviewed by:



Along Chen / Assistant Manager

Approved by:



Gary Chang / Manager



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Release Record

Report No.	Version	Description	Issued Date
FR770703AC	Rev. 01	Initial issue	Aug. 29, 2017

Summary of Test Results

FCC Rules	Test Items	Measured	Result
15.207	Conducted Emissions	[dBuV]: 0.469MHz 43.68 (Margin -2.85dB) - AV	Pass
15.247(d) 15.209	Radiated Emissions	[dBuV/m at 3m]: 4874.00MHz 52.99 (Margin -1.01dB) – AV 2390.00MHz 52.99 (Margin -1.01dB) – AV	Pass
15.247(b)(3)	Maximum Output Power	Max Power [dBm]: 27.20	Pass
15.247(a)(2)	6dB Bandwidth	Meet the requirement of limit	Pass
15.247(e)	Power Spectral Density	Meet the requirement of limit	Pass
15.203	Antenna Requirement	Meet the requirement of limit	Pass

1 General Description

1.1 Information

1.1.1 Specification of the Equipment under Test (EUT)

RF General Information					
Frequency Range (MHz)	IEEE Std. 802.11	Ch. Freq. (MHz)	Channel Number	Transmit Chains (N _{TX})	Data Rate / MCS
2400-2483.5	b	2412-2462	1-11 [11]	3	1-11 Mbps
2400-2483.5	g	2412-2462	1-11 [11]	3	6-54 Mbps
2400-2483.5	n (HT20)	2412-2462	1-11 [11]	3	MCS 0-23
2400-2483.5	n (HT40)	2422-2452	3-9 [7]	3	MCS 0-23

Note 1: RF output power specifies that Maximum Peak Conducted Output Power.
 Note 2: 802.11b uses a combination of DSSS-DBPSK, DQPSK, CCK modulation.
 Note 3: 802.11g/n uses a combination of OFDM-BPSK, QPSK, 16QAM, 64QAM modulation.

1.1.2 Antenna Details

Ant. No.	Model	Type	Connector	Operating Frequencies (MHz) / Antenna Gain (dBi)		
				2400~2483.5	5150~5250	5725~5850
1	ANT 1	dipole	IPEX	4.22	4.21	4.21
2	ANT 2	dipole	IPEX	5.1	5.96	5.96
3	ANT 3	dipole	IPEX	4.95	4.99	4.99

Note: The antennas with highest gain of each type were selected for final testing in this test report.

1.1.3 Power Supply Type of Equipment under Test (EUT)

Power Supply Type	54Vdc from AC adapter
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1.1.4 Accessories

Accessories		
No.	Equipment	Description
1	AC adapter	Brand: Senao Model: EAA65A-54 Power Rating: I/P: 100-240Vac, 50/60Hz, 1.8A O/P: 54Vdc, 1.2A Power Line: DC 1.5m non-shielded with one core
2	RJ45 cable	1.5m non-shielded without core
3	Power cord	1.85m non-shielded without core

1.1.5 Channel List

Frequency band (MHz)		2400~2483.5	
802.11 b / g / n HT20		802.11n HT40	
Channel	Frequency(MHz)	Channel	Frequency(MHz)
1	2412	3	2422
2	2417	4	2427
3	2422	5	2432
4	2427	6	2437
5	2432	7	2442
6	2437	8	2447
7	2442	9	2452
8	2447	---	---
9	2452	---	---
10	2457	---	---
11	2462	---	---

1.1.6 Test Tool and Duty Cycle

Test Tool	QCART, Version: 3.0.187.0		
Duty Cycle and Duty Factor	Mode	Duty cycle (%)	Duty factor (dB)
	11b	100.00%	0.00
	11g	94.00%	0.27
	HT20	93.70%	0.28
	HT40	85.99%	0.66

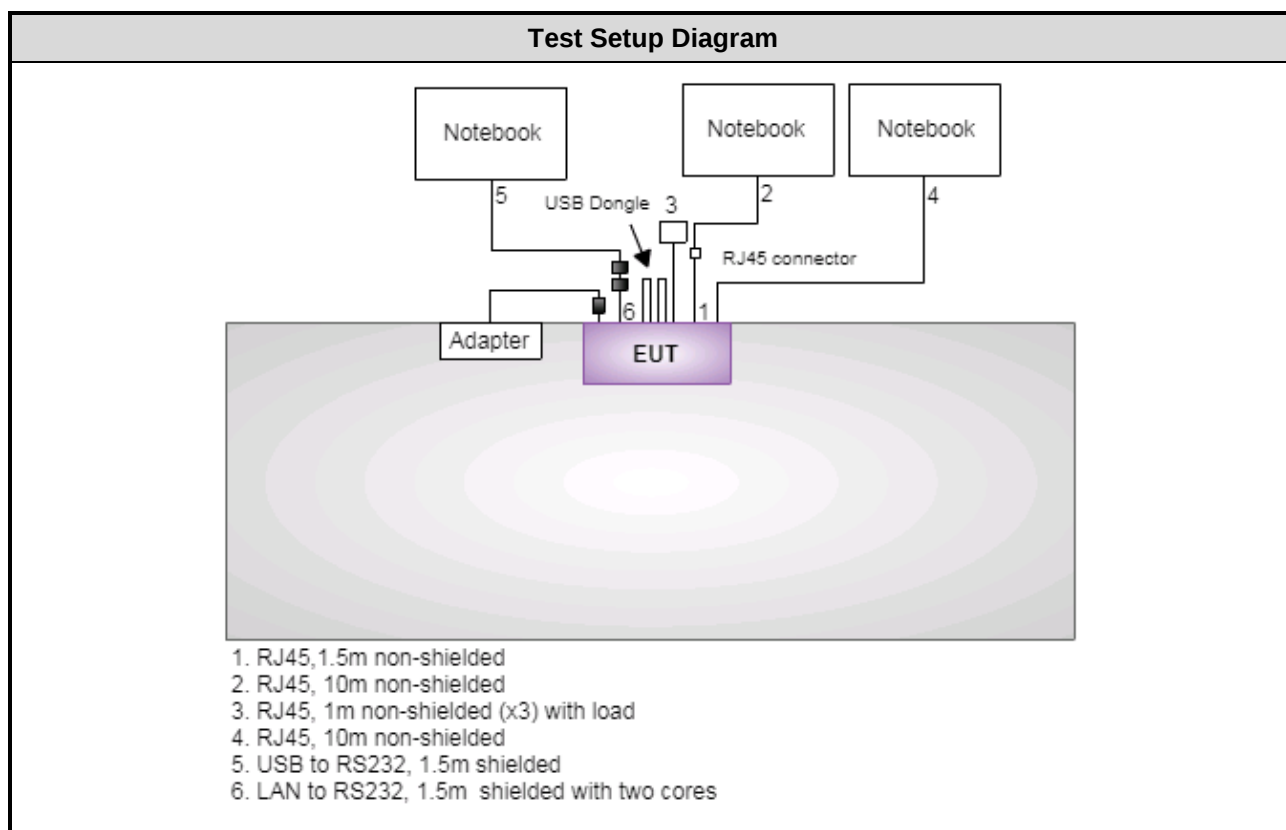
1.1.7 Power Setting

Modulation Mode	Test Frequency (MHz)	Power Set
11b	2412	15
11b	2437	15
11b	2462	14.5
11g	2412	15
11g	2437	22
11g	2462	15.5
HT20	2412	14.5
HT20	2437	22
HT20	2462	15
HT40	2422	10.5
HT40	2437	15.5
HT40	2452	10

1.2 Local Support Equipment List

Support Equipment List					
No.	Equipment	Brand	Model	FCC ID	Signal cable / Length (m)
1	Notebook	DELL	Latitude E6430	DoC	USB to RS232, 1.5m shielded
2	Notebook	DELL	Latitude E5420	DoC	RJ45, 10m non-shielded.
3	Notebook	DELL	Latitude E6430	DoC	RJ45, 10m non-shielded.
4	USB Dongle x2	Gigastone	U211	---	---

1.3 Test Setup Chart



1.4 The Equipment List

Test Item	Conducted Emission				
Test Site	Conduction room 1 / (CO01-WS)				
Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Until
Receiver	R&S	ESR3	101657	Dec. 21, 2016	Dec. 20, 2017
LISN	SCHWARZBECK	Schwarzbeck 8127	8127-667	Nov. 08, 2016	Nov. 07, 2017
RF Cable-CON	EMC	EMCCFD300-BM-BM-6000	50821	Dec. 20, 2016	Dec. 19, 2017
Measurement Software	AUDIX	e3	6.120210k	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

Test Item	Radiated Emission				
Test Site	966 chamber1 / (03CH01-WS)				
Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Until
Spectrum Analyzer	R&S	FSV40	101498	Nov. 25, 2016	Nov. 24, 2017
Receiver	R&S	ESR3	101658	Nov. 24, 2016	Nov. 23, 2017
Bilog Antenna	SCHWARZBECK	VULB9168	VULB9168-524	Oct. 13, 2016	Oct. 12, 2017
Horn Antenna 1G-18G	SCHWARZBECK	BBHA 9120 D	BBHA 9120 D 1096	Dec. 21, 2016	Dec. 20, 2017
Horn Antenna 18G-40G	SCHWARZBECK	BBHA 9170	BBHA 9170517	Oct. 25, 2016	Oct. 24, 2017
Loop Antenna	R&S	HFH2-Z2	100330	Nov. 10, 2016	Nov. 09, 2017
Loop Antenna Cable	KOAX KABEL	101354-BW	101354-BW	Dec. 09, 2016	Dec. 08, 2017
Preamplifier	EMC	EMC02325	980146	Oct. 08, 2016	Oct. 07, 2017
Preamplifier	Agilent	83017A	MY39501308	Oct. 06, 2016	Oct. 05, 2017
Preamplifier	EMC	EMC184045B	980192	Aug. 24, 2016	Aug. 23, 2017
RF Cable	HUBER+SUHNER	SUCOFLEX104	MY16014/4	Dec. 09, 2016	Dec. 08, 2017
RF Cable	HUBER+SUHNER	SUCOFLEX104	MY16019/4	Dec. 09, 2016	Dec. 08, 2017
RF Cable	HUBER+SUHNER	SUCOFLEX104	MY16139/4	Dec. 09, 2016	Dec. 08, 2017
LF cable 1M	EMC	EMCCFD400-NM-N M-1000	16052	Dec. 09, 2016	Dec. 08, 2017
LF cable 3M	Woken	CFD400NL-LW	CFD400NL-001	Dec. 09, 2016	Dec. 08, 2017
LF cable 10M	Woken	CFD400NL-LW	CFD400NL-002	Dec. 09, 2016	Dec. 08, 2017
Measurement Software	AUDIX	e3	6.120210g	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

Test Item	RF Conducted				
Test Site	(TH01-WS)				
Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Until
Spectrum Analyzer	R&S	FSV40	101063	Mar. 15, 2017	Mar. 14, 2018
Power Meter	Anritsu	ML2495A	1241002	Oct. 06, 2016	Oct. 05, 2017
Power Sensor	Anritsu	MA2411B	1207366	Oct. 06, 2016	Oct. 05, 2017
AC POWER SOURCE	APC	AFC-500W	F312060012	Oct. 28, 2016	Oct. 27, 2017
Measurement Software	Sporton	Sporton_1	1.3.30	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

1.5 Test Standards

According to the specification of EUT, the EUT must comply with following standards and KDB documents.

47 CFR FCC Part 15.247

ANSI C63.10-2013

FCC KDB 558074 D01 DTS Meas Guidance v04

FCC KDB 662911 D01 Multiple Transmitter Output v02r01

1.6 Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2))

Measurement Uncertainty	
Parameters	Uncertainty
Bandwidth	±34.134 Hz
Conducted power	±0.808 dB
Power density	±0.463 dB
Conducted emission	±2.670 dB
AC conducted emission	±2.90 dB
Radiated emission ≤ 1GHz	±3.66 dB
Radiated emission > 1GHz	±5.63dB

2 Test Configuration

2.1 Testing Condition

Test Item	Test Site	Ambient Condition	Tested By
AC Conduction	CO01-WS	24°C / 56%	Alex Tsai
Radiated Emissions	03CH01-WS	24°C / 61-62%	Aska Huang Vincent Yeh
RF Conducted	TH01-WS	21°C / 64%	Felix Sung

- FCC Designation No.: TW2732
- FCC site registration No.: 181692
- IC site registration No.: 10807A-1

2.2 The Worst Test Modes and Channel Details

Test item	Modulation Mode	Test Frequency (MHz)	Data Rate	Test Configuration
Conducted Emissions	11g	2437	6 Mbps	---
Radiated Emissions ≤1GHz	11g	2437	6 Mbps	---
Radiated Emissions >1GHz	11b	2412 / 2437 / 2462	1 Mbps	---
Maximum Output Power	11g	2412 / 2437 / 2462	6 Mbps	
6dB bandwidth	HT20	2412 / 2437 / 2462	MCS 0	
Power spectral density	HT40	2422 / 2437 / 2452	MCS 0	

3 Transmitter Test Results

3.1 Conducted Emissions

3.1.1 Limit of Conducted Emissions

Conducted Emissions Limit		
Frequency Emission (MHz)	Quasi-Peak	Average
0.15-0.5	66 - 56 *	56 - 46 *
0.5-5	56	46
5-30	60	50

Note 1: * Decreases with the logarithm of the frequency.

3.1.2 Test Procedures

1. The device is placed on a test table, raised 80 cm above the reference ground plane. The vertical conducting plane is located 40 cm to the rear of the device.
2. The device is connected to line impedance stabilization network (LISN) and other accessories are connected to other LISN. Measured levels of AC power line conducted emission are across the 50 Ω LISN port.
3. AC conducted emission measurements is made over frequency range from 150 kHz to 30 MHz.
4. This measurement was performed with AC 120V / 60Hz.

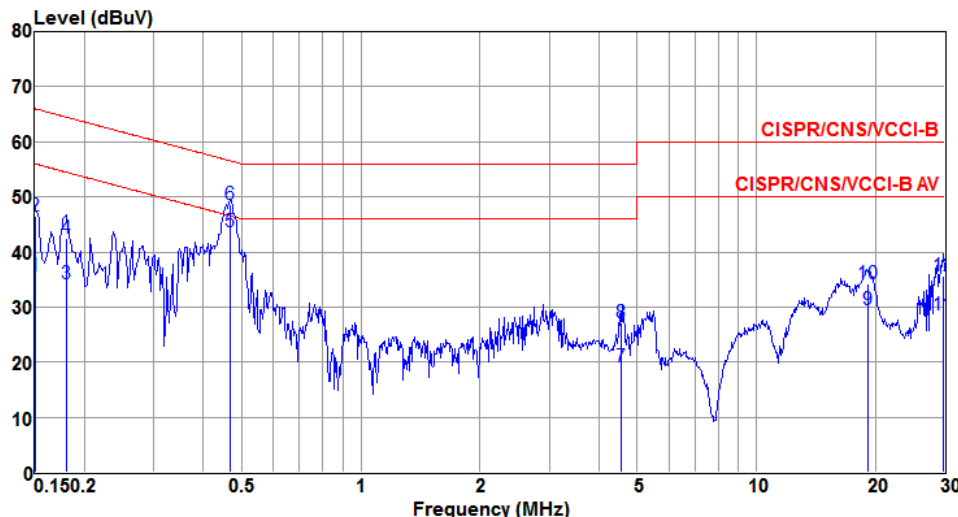
3.1.3 Test Setup



- Note: 1. Support units were connected to second LISN.
 2. Both of LISNs (AMN) are 80 cm from EUT and at least 80 cm from other units and other metal planes

3.1.4 Test Result of Conducted Emissions

Modulation	11g	Test Freq. (MHz)	2437
Power Phase	Line		



	Freq	Level	Limit	Over	Read	LISN	cable	
	MHz	dBuV	Line	Limit	Level	factor	loss	Remark
			dBuV	dB	dBuV	dB	dB	
1	0.150	35.57	56.00	-20.43	35.46	0.07	0.04	Average
2	0.150	46.56	66.00	-19.44	46.45	0.07	0.04	QP
3	0.180	34.32	54.50	-20.18	34.19	0.09	0.04	Average
4	0.180	42.43	64.50	-22.07	42.30	0.09	0.04	QP
5@	0.469	43.68	46.53	-2.85	43.58	0.06	0.04	Average
6	0.469	48.56	56.53	-7.97	48.46	0.06	0.04	QP
7	4.538	19.17	46.00	-26.83	18.83	0.17	0.17	Average
8	4.538	27.06	56.00	-28.94	26.72	0.17	0.17	QP
9	19.110	29.59	50.00	-20.41	28.95	0.39	0.25	Average
10	19.110	34.22	60.00	-25.78	33.58	0.39	0.25	QP
11	29.692	28.53	50.00	-21.47	27.73	0.45	0.35	Average
12	29.692	35.73	60.00	-24.27	34.93	0.45	0.35	QP

Note 1: Level (dBUV) = Read Level (dBUV) + LISN Factor (dB) + Cable Loss (dB).

2: Over Limit (dB) = Level (dBUV) – Limit Line (dBUV).

Modulation	11g	Test Freq. (MHz)	2437
Power Phase	Neutral		

Level (dBUV)

Frequency (MHz)

	Freq	Level	Limit	Over	Read	LISN	cable	
	MHz	dBuV	Line	Limit	Level	factor	loss	Remark
			dBuV	dB	dBuV	dB	dB	
1	0.156	36.82	55.69	-18.87	36.68	0.10	0.04	Average
2	0.156	46.23	65.69	-19.46	46.09	0.10	0.04	QP
3	0.270	31.51	51.12	-19.61	31.36	0.11	0.04	Average
4	0.270	39.86	61.12	-21.26	39.71	0.11	0.04	QP
5@	0.464	43.74	46.62	-2.88	43.58	0.12	0.04	Average
6	0.464	49.13	56.62	-7.49	48.97	0.12	0.04	QP
7	2.841	19.41	46.00	-26.59	19.16	0.15	0.10	Average
8	2.841	26.31	56.00	-29.69	26.06	0.15	0.10	QP
9	18.869	29.33	50.00	-20.67	28.68	0.40	0.25	Average
10	18.869	34.22	60.00	-25.78	33.57	0.40	0.25	QP
11	29.913	28.77	50.00	-21.23	27.93	0.49	0.35	Average
12	29.913	37.50	60.00	-22.50	36.66	0.49	0.35	QP

Note 1: Level (dBUV) = Read Level (dBUV) + LISN Factor (dB) + Cable Loss (dB).

2: Over Limit (dB) = Level (dBUV) – Limit Line (dBUV).

3.2 6dB and Occupied Bandwidth

3.2.1 Limit of 6dB Bandwidth

The minimum 6dB bandwidth shall be at least 500 kHz.

3.2.2 Test Procedures

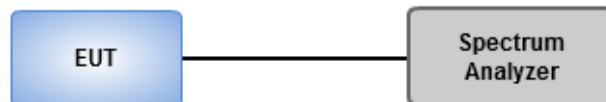
6dB Bandwidth

1. Set resolution bandwidth (RBW) = 100 kHz, Video bandwidth = 300 kHz.
2. Detector = Peak, Trace mode = max hold.
3. Sweep = auto couple, Allow the trace to stabilize.
4. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower) that are attenuated by 6dB relative to the maximum level measured in the fundamental emission.

Occupied Bandwidth

1. Set resolution bandwidth (RBW) = 1 MHz, Video bandwidth = 3 MHz.
2. Detector = Sample, Trace mode = max hold.
3. Sweep = auto couple, Allow the trace to stabilize.
4. Use the OBW measurement function of spectrum analyzer to measure the occupied bandwidth.

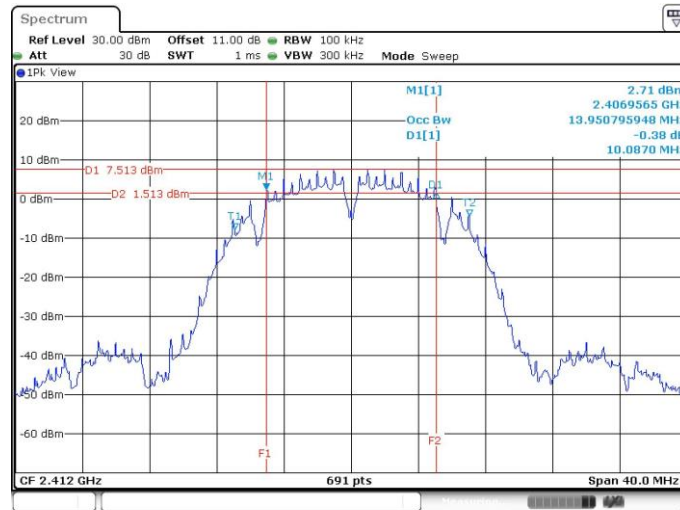
3.2.3 Test Setup



3.2.4 Test Result of 6dB and Occupied Bandwidth

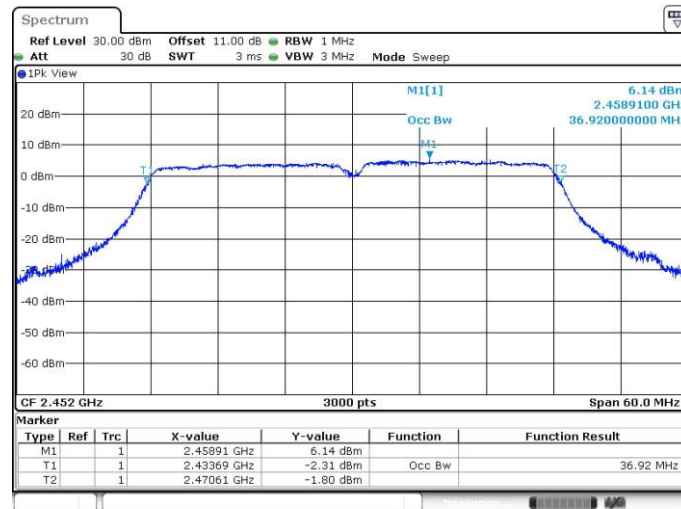
Modulation Mode	N _{TX}	Freq. (MHz)	6dB Bandwidth (MHz)				Limit (kHz)
			Chain 0	Chain 1	Chain 2	Chain 3	
11b	3	2412	10.09	10.09	10.09	---	500
11b	3	2437	10.09	10.09	10.09	---	500
11b	3	2462	10.09	10.09	10.09	---	500
11g	3	2412	16.35	15.94	15.77	---	500
11g	3	2437	15.88	15.71	15.71	---	500
11g	3	2462	15.94	16.06	16.29	---	500
HT20	3	2412	17.16	17.16	16.06	---	500
HT20	3	2437	17.57	17.22	15.71	---	500
HT20	3	2462	17.22	16.81	17.22	---	500
HT40	3	2422	35.71	35.71	35.71	---	500
HT40	3	2437	35.25	35.83	35.83	---	500
HT40	3	2452	35.83	35.71	35.25	---	500

Worst Plot



Modulation Mode	N _{TX}	Freq. (MHz)	99% Occupied Bandwidth (MHz)			
			Chain 0	Chain 1	Chain 2	Chain 3
11b	3	2412	13.88	13.87	13.88	---
11b	3	2437	13.87	13.87	13.85	---
11b	3	2462	13.89	13.87	13.84	---
11g	3	2412	16.62	16.62	16.53	---
11g	3	2437	17.88	19.09	17.54	---
11g	3	2462	16.64	16.65	16.54	---
HT20	3	2412	17.77	17.70	17.73	---
HT20	3	2437	18.49	19.09	18.37	---
HT20	3	2462	17.73	17.74	17.69	---
HT40	3	2422	36.90	36.68	36.72	---
HT40	3	2437	36.70	36.66	36.76	---
HT40	3	2452	36.92	36.64	36.76	---

Worst Plot



3.3 RF Output Power

3.3.1 Limit of RF Output Power

Conducted power shall not exceed 1Watt.

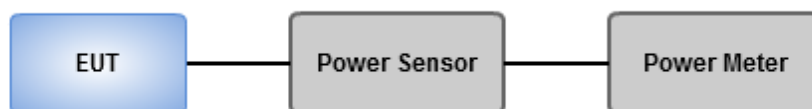
- ☒ Antenna gain $\leq 6\text{dBi}$, no any corresponding reduction is in output power limit.
- ☐ Antenna gain $> 6\text{dBi}$
 - ☐ Non Fixed, point to point operations.
The conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dB
 - ☐ Fixed, point to point operations
Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point Operations, maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725–5850 MHz band that are used exclusively for fixed, point-to-point operations ,no any corresponding reduction is in transmitter peak output power

3.3.2 Test Procedures

- ☒ Maximum Peak Conducted Output Power
 - ☐ **Spectrum analyzer**
 1. Set RBW = 1MHz, VBW = 3MHz, Detector = Peak.
 2. Sweep time = auto, Trace mode = max hold, Allow trace to fully stabilize.
 3. Use the spectrum analyzer channel power measurement function with the band limits set equal to the DTS bandwidth edges.
 - ☒ **Power meter**
 1. A broadband Peak RF power meter is used for output power measurement. The video bandwidth of power meter is greater than DTS bandwidth of EUT. If duty cycle of test signal is not 100 %, trigger and gating function of power meter will be enabled to capture transmission burst for measuring output power.
- ☒ Maximum Conducted Output Power (For reference only)
 - ☒ **Power meter**
 1. A broadband Average RF power meter is used for output power measurement. The video bandwidth of power meter is greater than DTS bandwidth of EUT. If duty cycle of test signal is not 100 %, trigger and gating function of power meter will be enabled to capture transmission burst for measuring output power.

3.3.3 Test Setup



3.3.4 Test Result of Maximum Output Power

Modulation Mode	N _{TX}	Freq. (MHz)	Conducted (Average) Output Power (dBm)				Total Power (mW)	Total Power (dBm)	Limit (dBm)
			Chain 0	Chain 1	Chain 2	Chain 3			
11b	3	2412	16.4	16.36	16.78	---	134.546	21.29	30.00
11b	3	2437	16.74	16.77	16.31	---	137.496	21.38	30.00
11b	3	2462	15.84	16.12	15.77	---	117.054	20.68	30.00
11g	3	2412	16.48	16.57	16.61	---	135.671	21.32	30.00
11g	3	2437	22.54	22.59	22.14	---	524.707	27.20	30.00
11g	3	2462	16.84	16.97	16.6	---	143.788	21.58	30.00
HT20	3	2412	15.98	15.93	15.9	---	117.707	20.71	30.00
HT20	3	2437	22.53	22.6	21.95	---	517.706	27.14	30.00
HT20	3	2462	16.02	16.46	16.13	---	125.274	20.98	30.00
HT40	3	2422	11.81	11.76	11.55	---	44.456	16.48	30.00
HT40	3	2437	16.5	16.49	16.52	---	134.109	21.27	30.00
HT40	3	2452	11.09	11.15	11.05	---	38.620	15.87	30.00

Note: Conducted average output power is for reference only.

3.4 Power Spectral Density

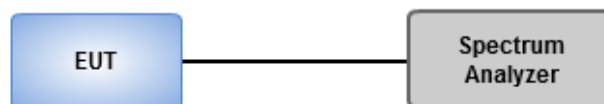
3.4.1 Limit of Power Spectral Density

Power spectral density shall not be greater than 8 dBm in any 3 kHz band.

3.4.2 Test Procedures

- ☐ Maximum peak conducted output power was used to demonstrate compliance to the fundamental output power limit.
 1. Set the RBW = 3kHz, VBW = 10kHz.
 2. Detector = Peak, Sweep time = auto couple.
 3. Trace mode = max hold, allow trace to fully stabilize.
 4. Use the peak marker function to determine the maximum amplitude level.
- ☒ Maximum (average) conducted output power was used to demonstrate compliance to the fundamental output power limit.
 1. Set the RBW = 100kHz, VBW = 300 kHz.
 2. Detector = RMS, Sweep time = auto couple.
 3. Set the sweep time to: $\geq 10 \times (\text{number of measurement points in sweep}) \times (\text{maximum data rate per stream})$.
 4. Perform the measurement over a single sweep.
 5. Use the peak marker function to determine the maximum amplitude level.

3.4.3 Test Setup

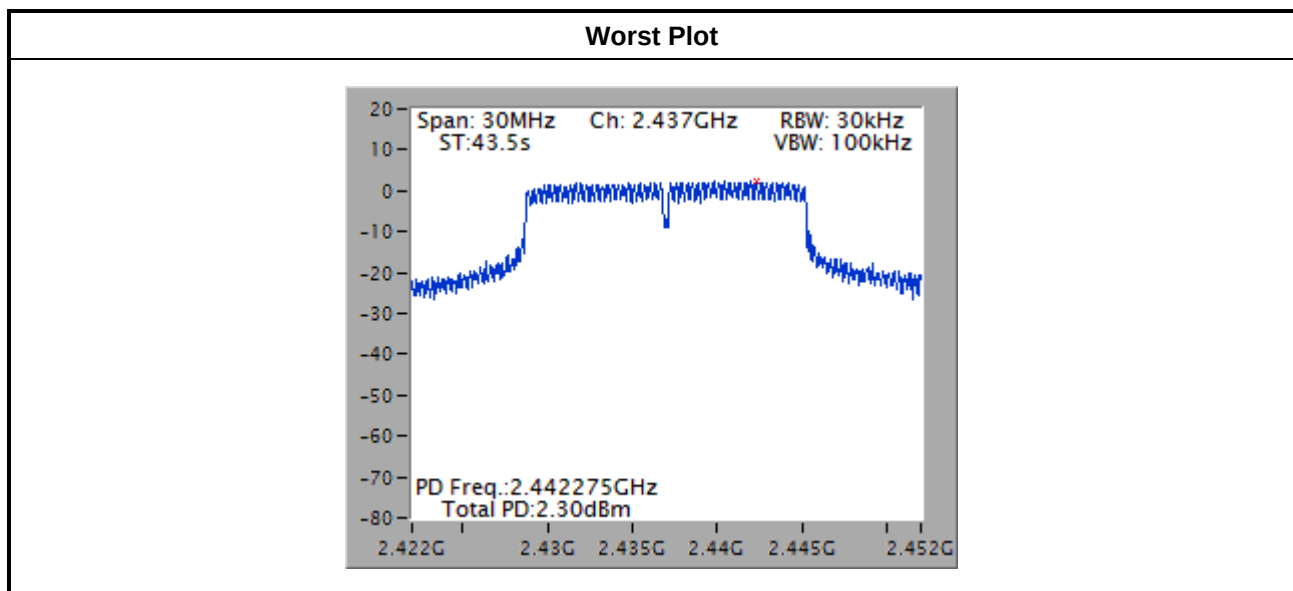


3.4.4 Test Result of Power Spectral Density

Modulation Mode	N _{TX}	Freq. (MHz)	PPSD w/o D.F (dBm/MHz)	Duty Factor (dB)	PPSD with D.F (dBm/MHz)	PPSD Limit (dBm/MHz)
11b	3	2412	-1.55	0.00	-1.55	4.46
11b	3	2437	-1.49	0.00	-1.49	4.46
11b	3	2462	-2.07	0.00	-2.07	4.46
11g	3	2412	-3.71	0.27	-3.44	4.46
11g	3	2437	2.30	0.27	2.57	4.46
11g	3	2462	-3.52	0.27	-3.25	4.46
HT20	3	2412	-4.48	0.28	-4.20	4.46
HT20	3	2437	2.11	0.28	2.39	4.46
HT20	3	2462	-4.18	0.28	-3.90	4.46
HT40	3	2422	-11.40	0.66	-10.74	4.46
HT40	3	2437	-6.79	0.66	-6.13	4.46
HT40	3	2452	-11.91	0.66	-11.25	4.46

Note:

1. D.F is duty factor.
2. Test result is bin-by-bin summing measured value of each TX port.
3. Directional gain = $10 * \log((10^{4.22/20} + 10^{5.1/20} + 10^{4.95/20})^3 / 3) = 9.54 \text{ dBi} > 6 \text{ dBi}$
Limit shall be reduced to 8 dBm – (9.53 dBi – 6 dBi) = 4.46 dBm.



Note: The plot without duty factor.

3.5 Unwanted Emissions into Restricted Frequency Bands

3.5.1 Limit of Unwanted Emissions into Restricted Frequency Bands

Restricted Band Emissions Limit			
Frequency Range (MHz)	Field Strength (uV/m)	Field Strength (dBuV/m)	Measure Distance (m)
0.009~0.490	2400/F(kHz)	48.5 - 13.8	300
0.490~1.705	24000/F(kHz)	33.8 - 23	30
1.705~30.0	30	29	30
30~88	100	40	3
88~216	150	43.5	3
216~960	200	46	3
Above 960	500	54	3

Note 1:
Quasi-Peak value is measured for frequency below 1GHz except for 9–90 kHz, 110–490 kHz frequency band. Peak and average value are measured for frequency above 1GHz. The limit on average radio frequency emission is as above table. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit

Note 2:
Measurements may be performed at a distance other than what is specified provided. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor as below, Frequency at or above 30 MHz: 20 dB/decade Frequency below 30 MHz: 40 dB/decade.

3.5.2 Test Procedures

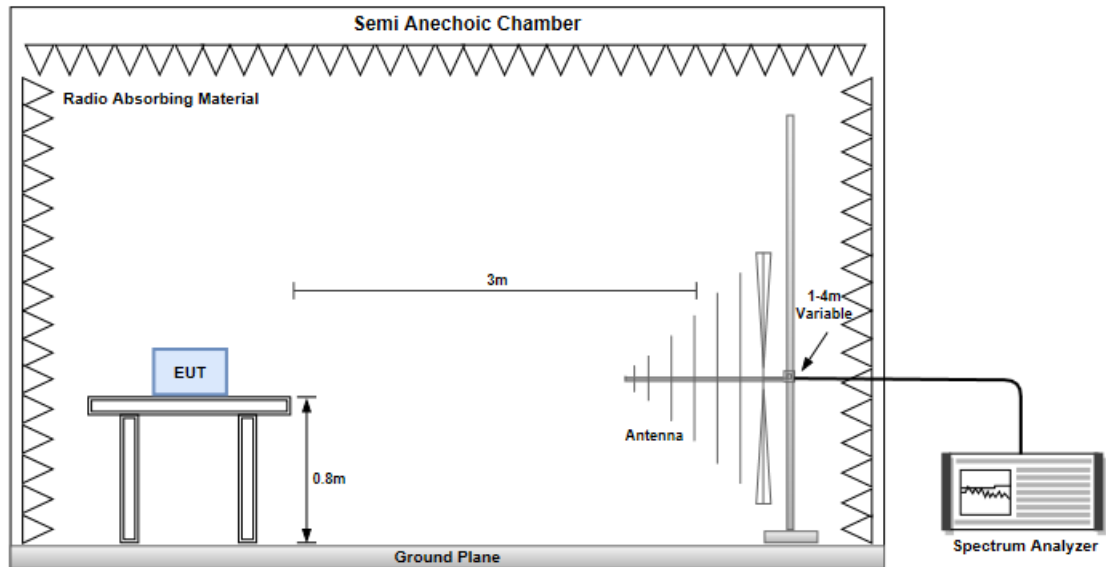
1. Measurement is made at a semi-anechoic chamber that incorporates a turntable allowing a EUT rotation of 360°. A continuously-rotating, remotely-controlled turntable is installed at the test site to support the EUT and facilitate determination of the direction of maximum radiation for each EUT emission frequency. The EUT is placed at test table. For emissions testing at or below 1 GHz, the table height is 80 cm above the reference ground plane. For emission measurements above 1 GHz, the table height is 1.5 m
2. Measurement is made with the antenna positioned in both the horizontal and vertical planes of polarization. The measurement antenna is varied in height (1m ~ 4m) above the reference ground plane to obtain the maximum signal strength. Distance between EUT and antenna is 3 m.
3. This investigation is performed with the EUT rotated 360°, the antenna height scanned between 1 m and 4 m, and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations.

Note:

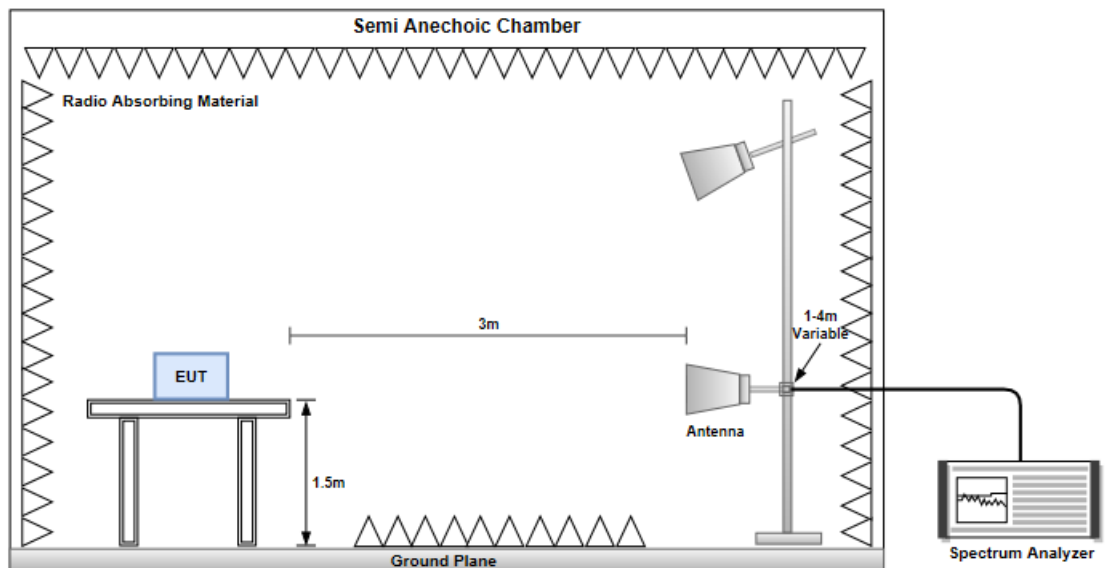
1. 120kHz measurement bandwidth of test receiver and Quasi-peak detector is for radiated emission below 1GHz.
2. RBW=1MHz, VBW=3MHz and Peak detector is for peak measured value of radiated emission above 1GHz.
3. RBW=1MHz, VBW=1/T and Peak detector is for average measured value of radiated emission above 1GHz.

3.5.3 Test Setup

Radiated Emissions below 1 GHz

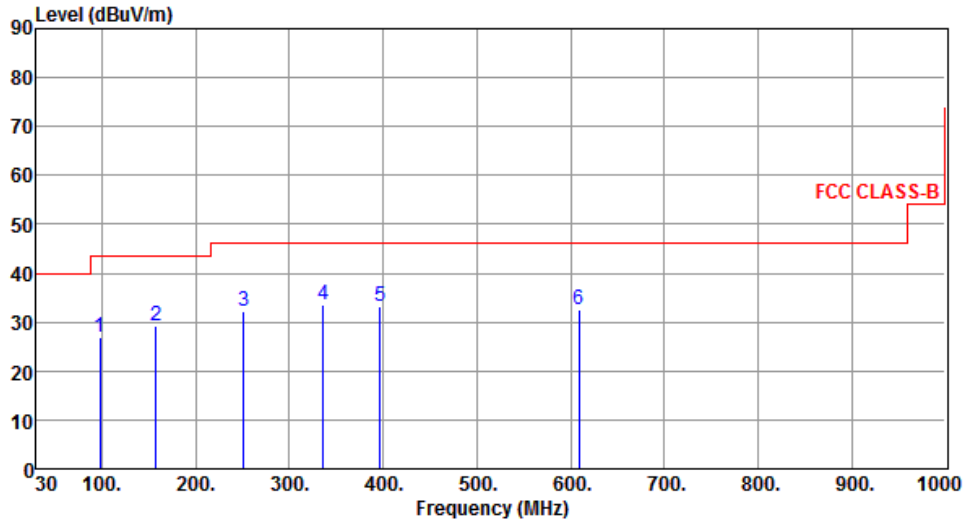


Radiated Emissions above 1 GHz



3.5.4 Transmitter Radiated Unwanted Emissions (Below 1GHz)

Modulation	11g	Test Freq. (MHz)	2437
Polarization	Horizontal		



The graph displays the radiated unwanted emissions for a transmitter operating at 2437 MHz. The y-axis represents the emission level in dBUV/m, ranging from 0 to 90. The x-axis represents the frequency in MHz, ranging from 30 to 1000. A red line indicates the FCC CLASS-B limit, which is 40 dBUV/m from 30 MHz to 100 MHz, 45 dBUV/m from 100 MHz to 1000 MHz, and 55 dBUV/m from 1000 MHz to 10000 MHz. Six emission peaks are identified and labeled 1 through 6, with their corresponding data listed in the table below.

	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	97.90	26.81	43.50	-16.69	40.08	-13.27	Peak	---	---
2	158.04	29.32	43.50	-14.18	37.56	-8.24	Peak	---	---
3	251.16	32.27	46.00	-13.73	41.61	-9.34	Peak	---	---
4	336.52	33.38	46.00	-12.62	40.13	-6.75	Peak	---	---
5	396.66	33.15	46.00	-12.85	38.20	-5.05	Peak	---	---
6	609.09	32.40	46.00	-13.60	33.02	-0.62	Peak	---	---

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)
*Factor includes antenna factor , cable loss and amplifier gain
Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).
Note 3: All spurious emissions below 30MHz are more than 20 dB below the limit.

Modulation	11g	Test Freq. (MHz)	2437
Polarization	Vertical		
Level (dBuV/m) </			

3.5.5 Transmitter Radiated Unwanted Emissions (Above 1GHz) for 11b

Modulation	11b	Test Freq. (MHz)	2412
Polarization	Horizontal		

	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	41.38	54.00	-12.62	44.56	-3.18	Average	390	6
2	2390.00	55.37	74.00	-18.63	58.55	-3.18	Peak	390	6
3	4824.00	52.55	54.00	-1.45	48.77	3.78	Average	234	333
4	4824.00	54.69	74.00	-19.31	50.91	3.78	Peak	234	333
5	12060.00	41.96	54.00	-12.04	28.38	13.58	Average	100	315
6	12060.00	54.54	74.00	-19.46	40.96	13.58	Peak	100	315

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)
*Factor includes antenna factor , cable loss and amplifier gain
Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

Modulation	11b	Test Freq. (MHz)	2412
Polarization	Vertical		
Level (dBUV/m) <			

Modulation	11b	Test Freq. (MHz)	2437
Polarization	Horizontal		
Level (dBuV/m)			

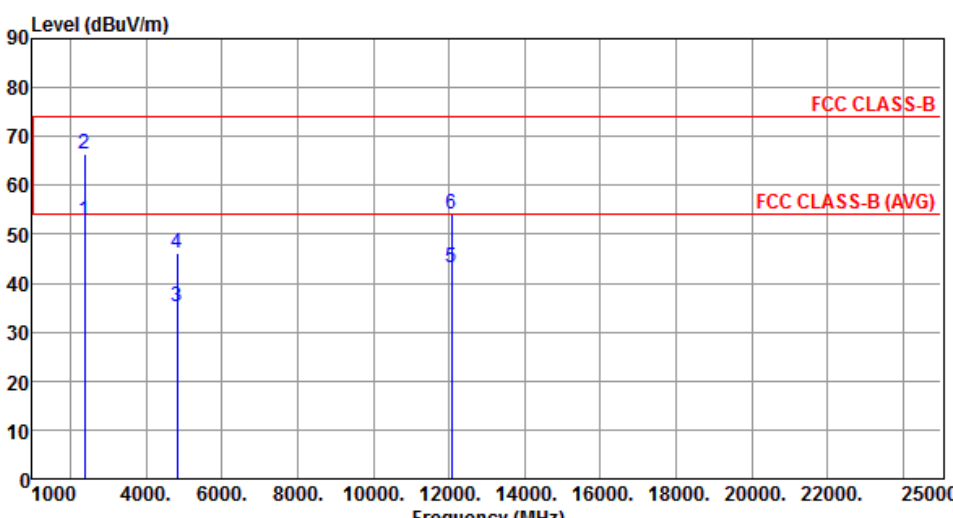
Modulation	11b	Test Freq. (MHz)	2437
Polarization	Vertical		
Level (dBUV/m)			

Modulation	11b	Test Freq. (MHz)	2462
Polarization	Horizontal		
Level (dBUV/m) </			

Modulation	11b	Test Freq. (MHz)	2462
Polarization	Vertical		
Level (dBuV/m)			

3.5.6 Transmitter Radiated Unwanted Emissions (Above 1GHz) for 11g

Modulation	11g	Test Freq. (MHz)	2412
Polarization	Horizontal		

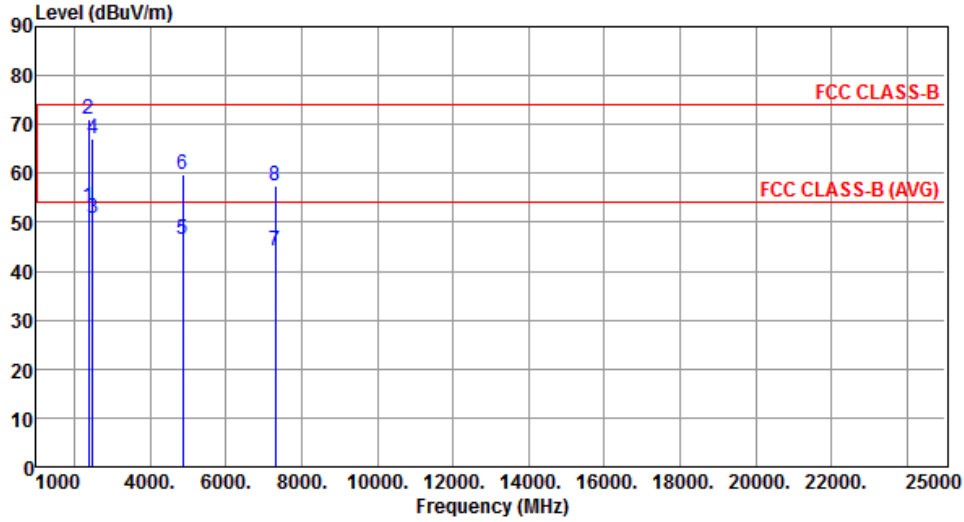


	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	52.80	54.00	-1.20	55.98	-3.18	Average	388	258
2	2390.00	66.37	74.00	-7.63	69.55	-3.18	Peak	388	258
3	4824.00	35.15	54.00	-18.85	31.37	3.78	Average	100	23
4	4824.00	46.07	74.00	-27.93	42.29	3.78	Peak	100	23
5	12060.00	43.33	54.00	-10.67	29.75	13.58	Average	100	142
6	12060.00	53.98	74.00	-20.02	40.40	13.58	Peak	100	142

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)
*Factor includes antenna factor , cable loss and amplifier gain
Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

Modulation	11g	Test Freq. (MHz)	2412
Polarization	Vertical		
Level (dBUV/m)			

Modulation	11g	Test Freq. (MHz)	2437
Polarization	Horizontal		



	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	52.99	54.00	-1.01	56.17	-3.18	Average	345	110
2	2390.00	71.22	74.00	-2.78	74.40	-3.18	Peak	345	110
3	2483.50	50.68	54.00	-3.32	53.48	-2.80	Average	345	110
4	2483.50	67.02	74.00	-6.98	69.82	-2.80	Peak	345	110
5	4874.00	46.65	54.00	-7.35	42.71	3.94	Average	120	9
6	4874.00	59.69	74.00	-14.31	55.75	3.94	Peak	120	9
7	7311.00	44.27	54.00	-9.73	35.86	8.41	Average	100	314
8	7311.00	57.53	74.00	-16.47	49.12	8.41	Peak	100	314

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)
 *Factor includes antenna factor , cable loss and amplifier gain
 Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

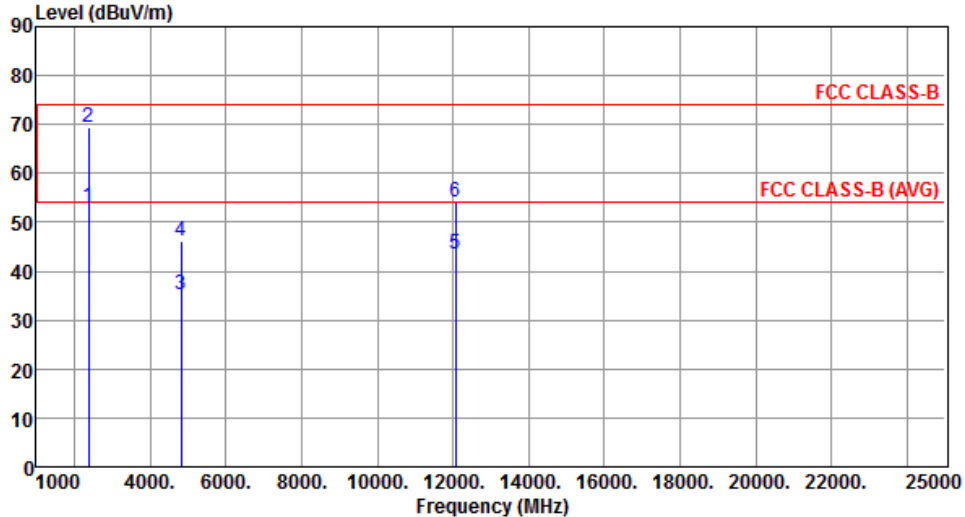
Modulation	11g	Test Freq. (MHz)	2437
Polarization	Vertical		
Level (dBuV/m) </			

Modulation	11g	Test Freq. (MHz)	2462
Polarization	Horizontal		
Level (dBUV/m) </			

Modulation	11g	Test Freq. (MHz)	2462
Polarization	Vertical		
Level (dBUV/m)			

3.5.7 Transmitter Radiated Unwanted Emissions (Above 1GHz) for HT20

Modulation	HT20	Test Freq. (MHz)	2412
Polarization	Horizontal		



	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	52.98	54.00	-1.02	56.16	-3.18	Average	367	112
2	2390.00	69.52	74.00	-4.48	72.70	-3.18	Peak	367	112
3	4824.00	35.08	54.00	-18.92	31.30	3.78	Average	100	36
4	4824.00	46.16	74.00	-27.84	42.38	3.78	Peak	100	36
5	12060.00	43.41	54.00	-10.59	29.83	13.58	Average	100	155
6	12060.00	54.21	74.00	-19.79	40.63	13.58	Peak	100	155

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)
 *Factor includes antenna factor , cable loss and amplifier gain
 Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

Modulation	HT20	Test Freq. (MHz)	2412
Polarization	Vertical		
Level (dBUV/m)			

Modulation	HT20		Test Freq. (MHz)		2437	
Polarization	Horizontal					
Level (dBUV/m) </						

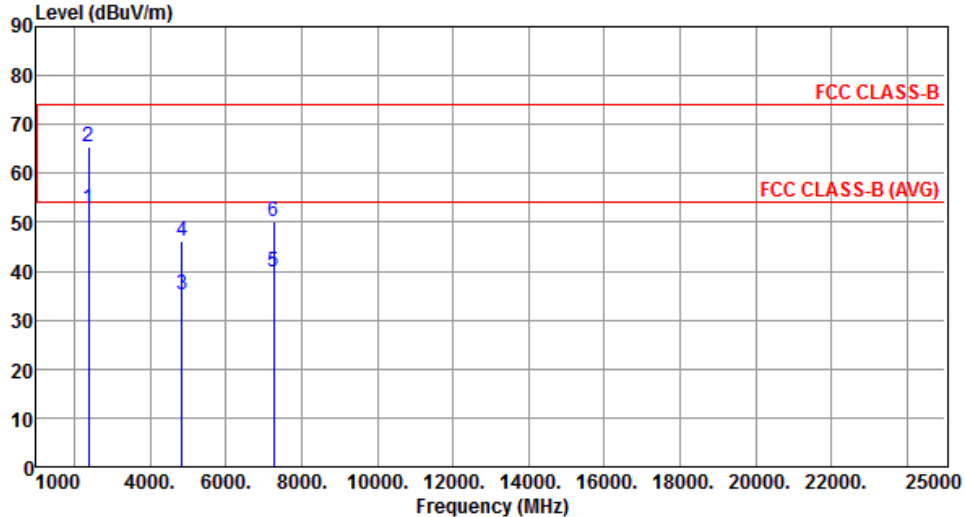
Modulation	HT20	Test Freq. (MHz)	2437
Polarization	Vertical		
Level (dBUV/m) <			

Modulation	HT20	Test Freq. (MHz)	2462
Polarization	Horizontal		
Level (dBUV/m) </			

Modulation	HT20	Test Freq. (MHz)	2462
Polarization	Vertical		
Level (dBUV/m)			

3.5.8 Transmitter Radiated Unwanted Emissions (Above 1GHz) for HT40

Modulation	HT40	Test Freq. (MHz)	2422
Polarization	Horizontal		

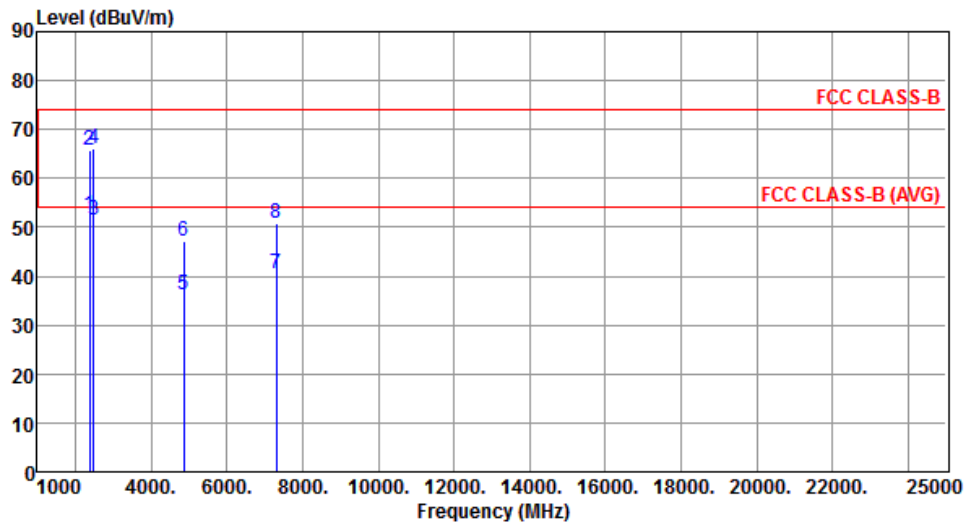


	Freq. MHz	Emission level dBuV/m	Limit dBuV/m	Margin dB	SA reading dBuV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	52.72	54.00	-1.28	55.90	-3.18	Average	321	100
2	2390.00	65.52	74.00	-8.48	68.70	-3.18	Peak	321	100
3	4844.00	35.13	54.00	-18.87	31.28	3.85	Average	100	49
4	4844.00	46.25	74.00	-27.75	42.40	3.85	Peak	100	49
5	7266.00	39.92	54.00	-14.08	31.53	8.39	Average	100	294
6	7266.00	50.01	74.00	-23.99	41.62	8.39	Peak	100	294

Note 1: Emission Level (dBuV/m) = SA Reading (dBuV/m) + Factor* (dB)
*Factor includes antenna factor , cable loss and amplifier gain
Note 2: Margin (dB) = Emission level (dBuV/m) – Limit (dBuV/m).

Modulation	HT40	Test Freq. (MHz)	2422
Polarization	Vertical		
Level (dBuV/m) </			

Modulation	HT40	Test Freq. (MHz)	2437
Polarization	Horizontal		



	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2390.00	52.53	54.00	-1.47	55.71	-3.18	Average	301	126
2	2390.00	65.63	74.00	-8.37	68.81	-3.18	Peak	301	126
3	2483.50	51.55	54.00	-2.45	54.35	-2.80	Average	301	68
4	2483.50	66.00	74.00	-8.00	68.80	-2.80	Peak	301	68
5	4874.00	36.24	54.00	-17.76	32.30	3.94	Average	100	45
6	4874.00	47.23	74.00	-26.77	43.29	3.94	Peak	100	45
7	7311.00	40.68	54.00	-13.32	32.27	8.41	Average	100	303
8	7311.00	50.85	74.00	-23.15	42.44	8.41	Peak	100	303

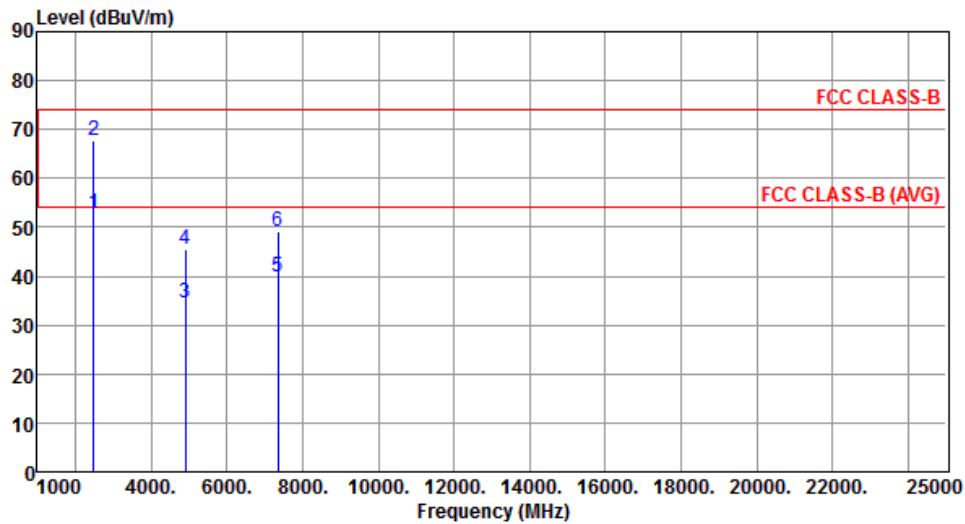
Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)

*Factor includes antenna factor , cable loss and amplifier gain

Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

Modulation	HT40	Test Freq. (MHz)	2437
Polarization	Vertical		
Level (dBuV/m) </			

Modulation	HT40	Test Freq. (MHz)	2452
Polarization	Horizontal		



	Freq. MHz	Emission level dBUV/m	Limit dBUV/m	Margin dB	SA reading dBUV	Factor dB	Remark	ANT High cm	Turn Table deg
1	2483.50	52.80	54.00	-1.20	55.60	-2.80	Average	366	127
2	2483.50	67.90	74.00	-6.10	70.70	-2.80	Peak	366	127
3	4904.00	34.50	54.00	-19.50	30.45	4.05	Average	100	58
4	4904.00	45.42	74.00	-28.58	41.37	4.05	Peak	100	58
5	7356.00	39.72	54.00	-14.28	31.29	8.43	Average	100	304
6	7356.00	49.22	74.00	-24.78	40.79	8.43	Peak	100	304

Note 1: Emission Level (dBUV/m) = SA Reading (dBUV/m) + Factor* (dB)

*Factor includes antenna factor , cable loss and amplifier gain

Note 2: Margin (dB) = Emission level (dBUV/m) – Limit (dBUV/m).

Modulation	HT40	Test Freq. (MHz)	2452
Polarization	Vertical		
Level (dBuV/m) </			

3.6 Emissions in Non-Restricted Frequency Bands

3.6.1 Emissions in Non-Restricted Frequency Bands Limit

Peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz

3.6.2 Test Procedures

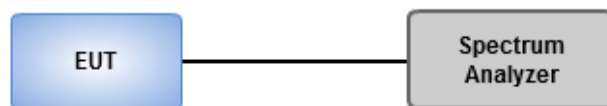
Reference level measurement

1. Set RBW=100kHz, VBW = 300kHz , Detector = Peak, Sweep time = Auto
2. Trace = max hold , Allow Trace to fully stabilize
3. Use the peak marker function to determine the maximum PSD level

Emission level measurement

1. Set RBW=100kHz, VBW = 300kHz , Detector = Peak, Sweep time = Auto
2. Trace = max hold , Allow Trace to fully stabilize
3. Scan Frequency range is up to 25GHz
4. Use the peak marker function to determine the maximum amplitude level

3.6.3 Test Setup

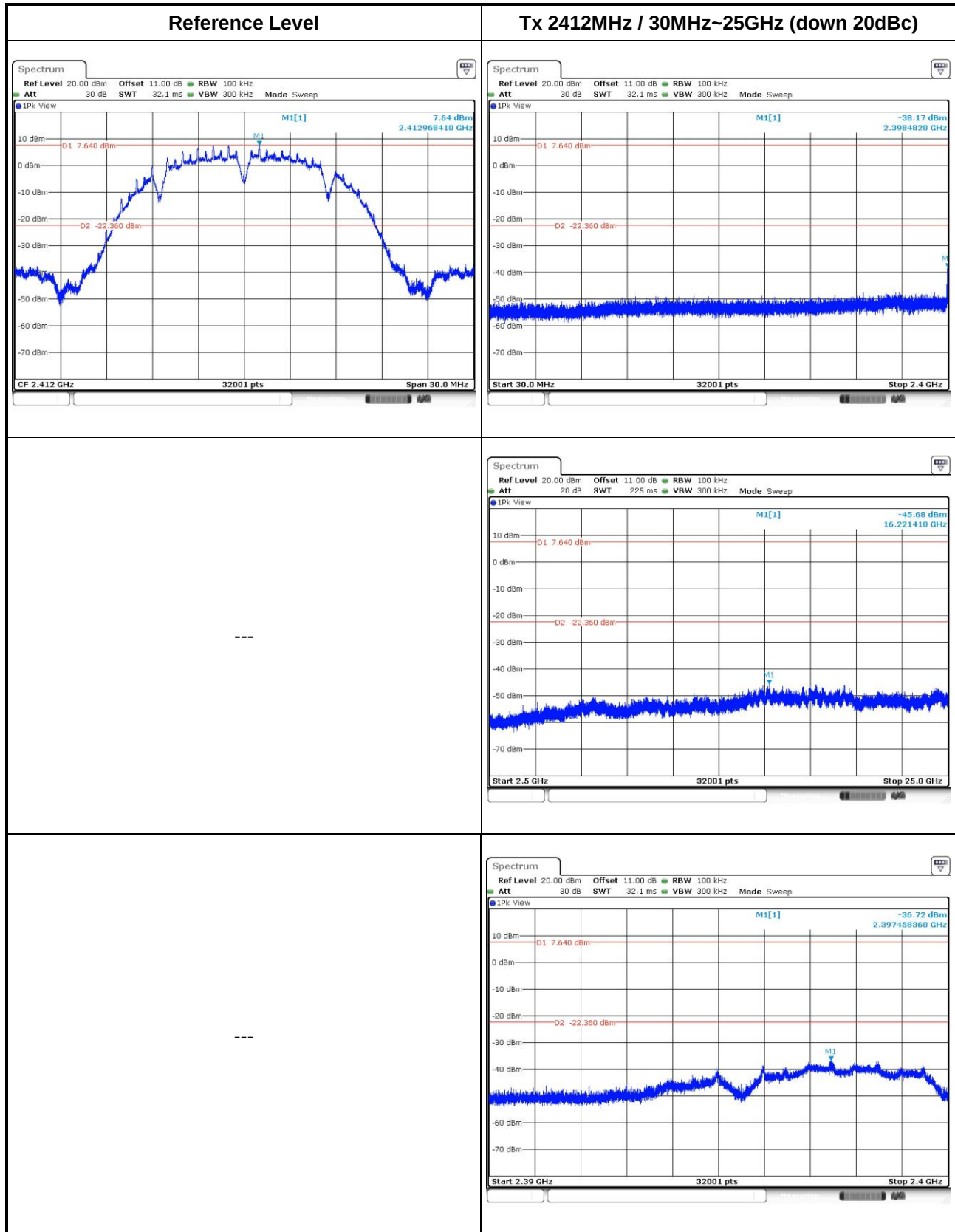


3.6.4 Test Result of Emissions in non-restricted frequency bands

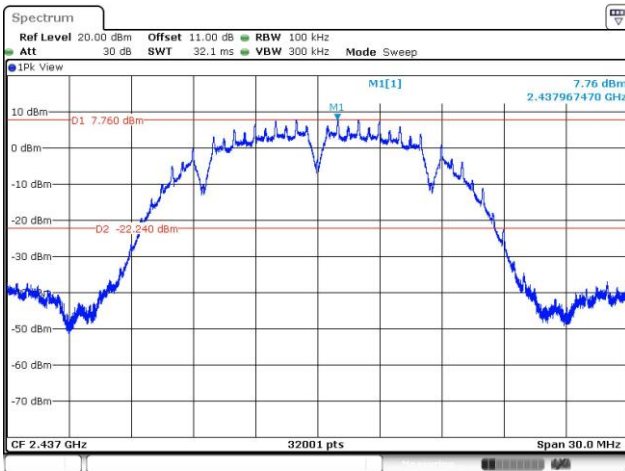
This test item is performed on each TX output individually without summing or adding $10 \log(N_{ANT})$ since measurements are made relative to the in-band emissions on the individual outputs. Only worst test result of each operating mode is presented.

3.6.5 Unwanted Emissions into Non-Restricted Frequency Bands

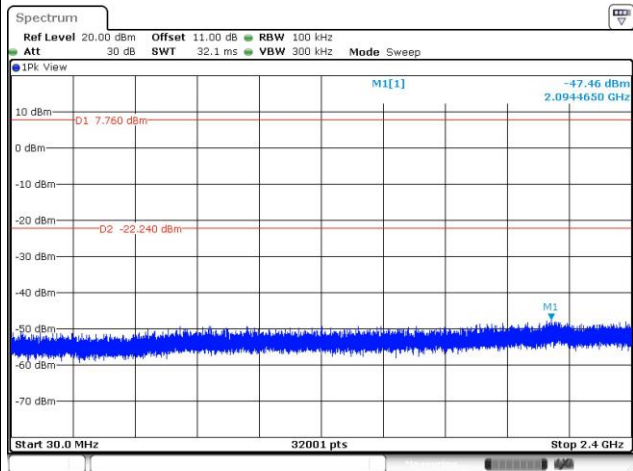
802.11b

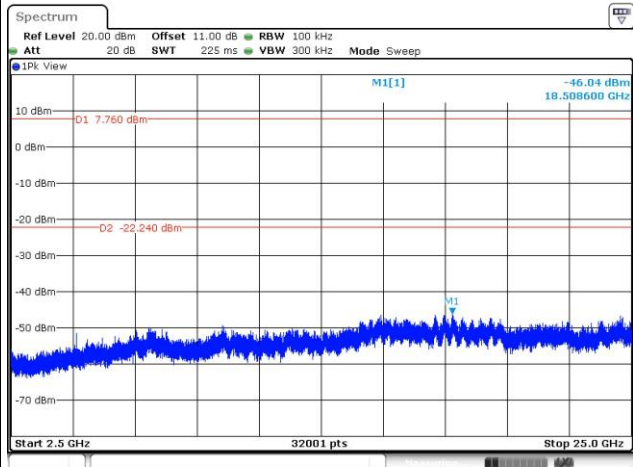


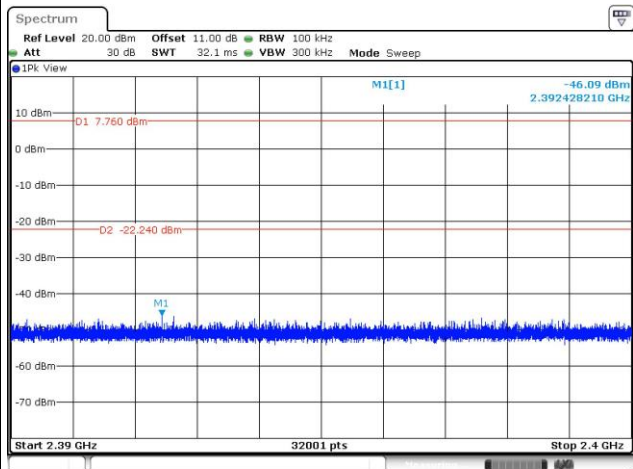
Reference Level



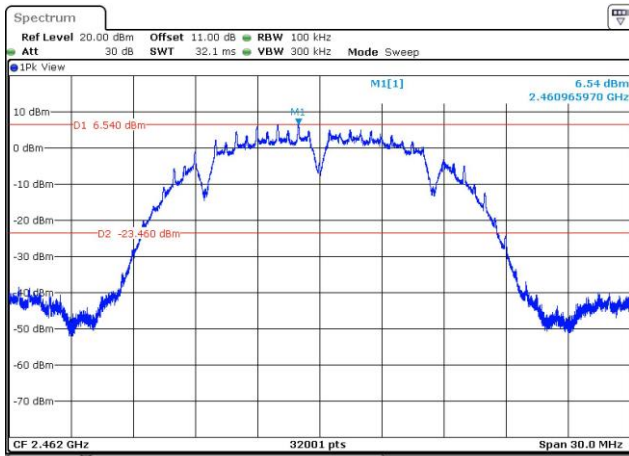
Tx 2437MHz / 30MHz~25GHz (down 20dBc)



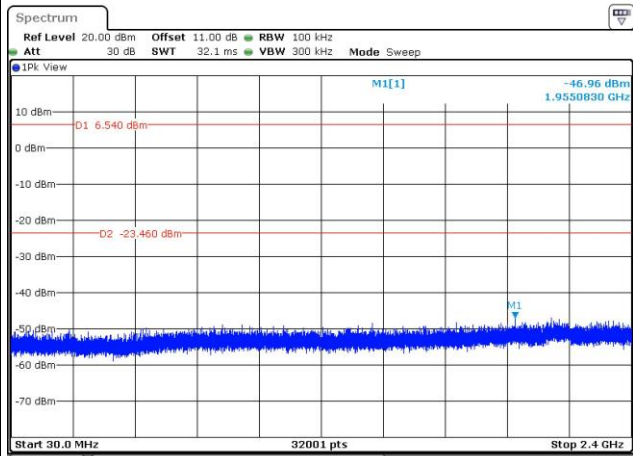


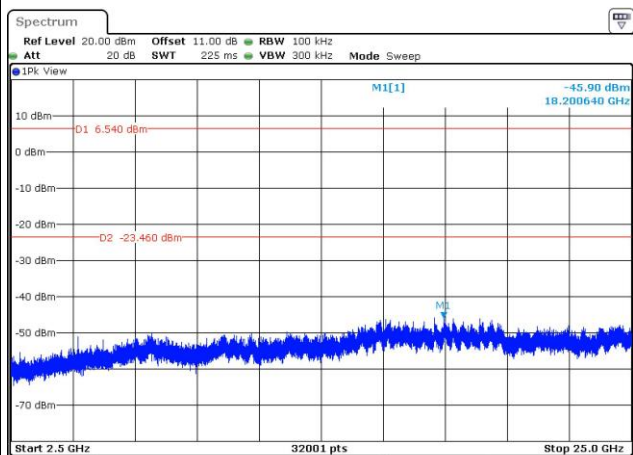


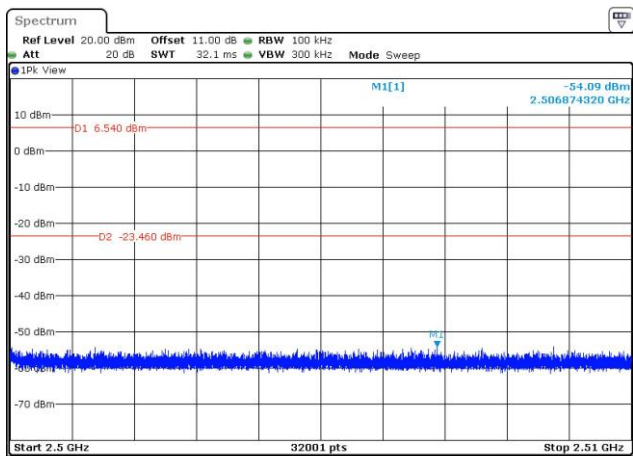
Reference Level



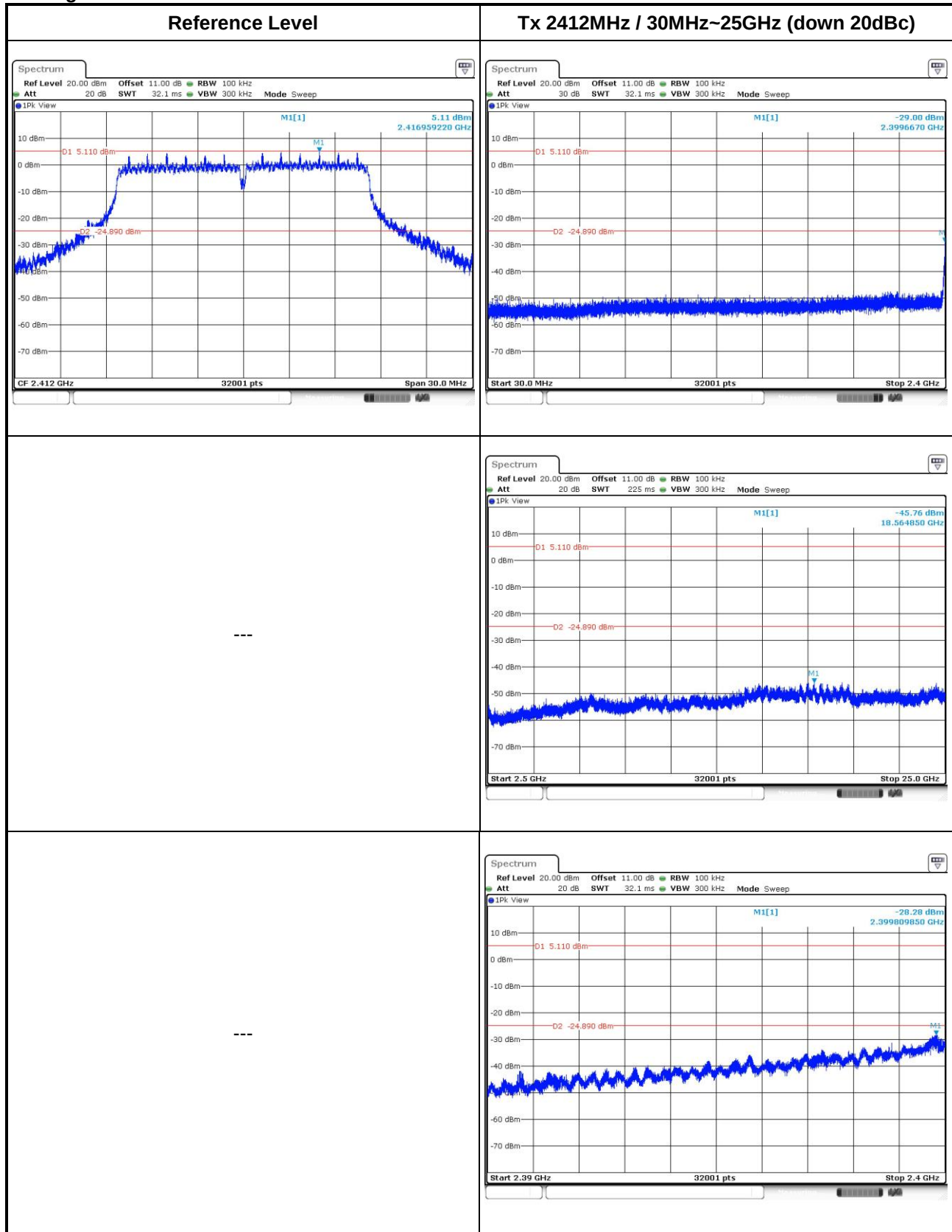
Tx 2462MHz / 30MHz~25GHz (down 20dBc)



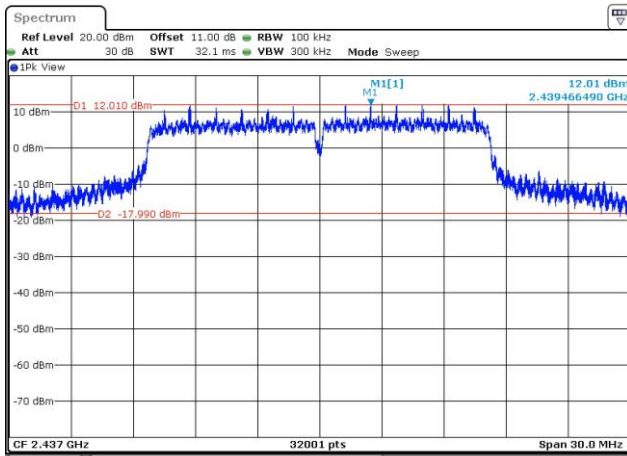




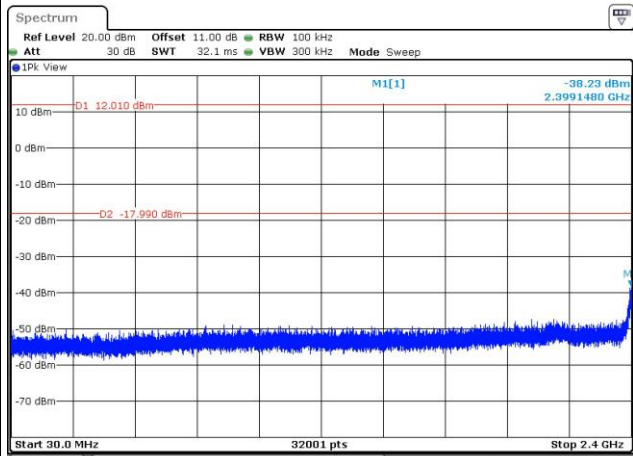
802.11g

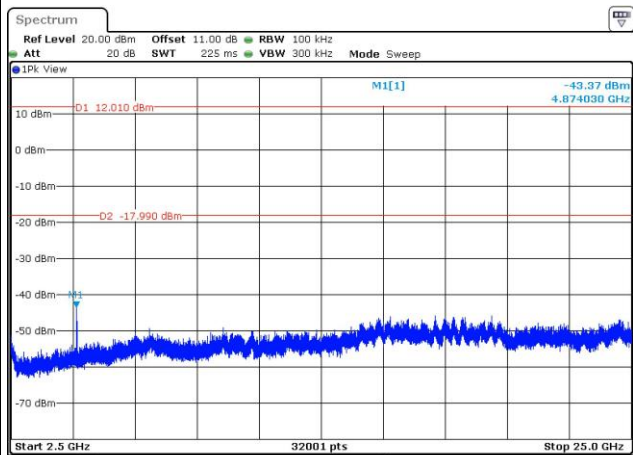


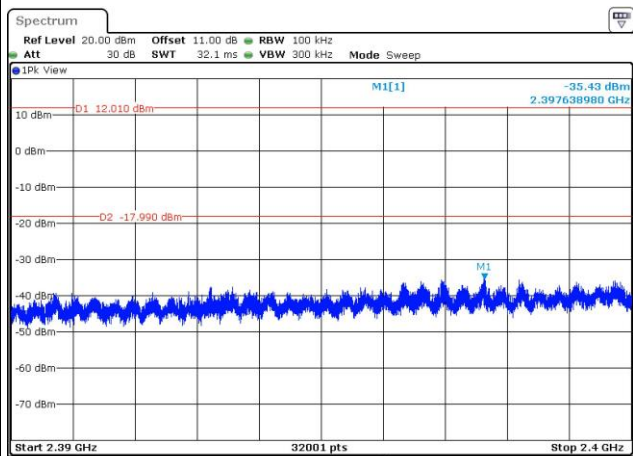
Reference Level

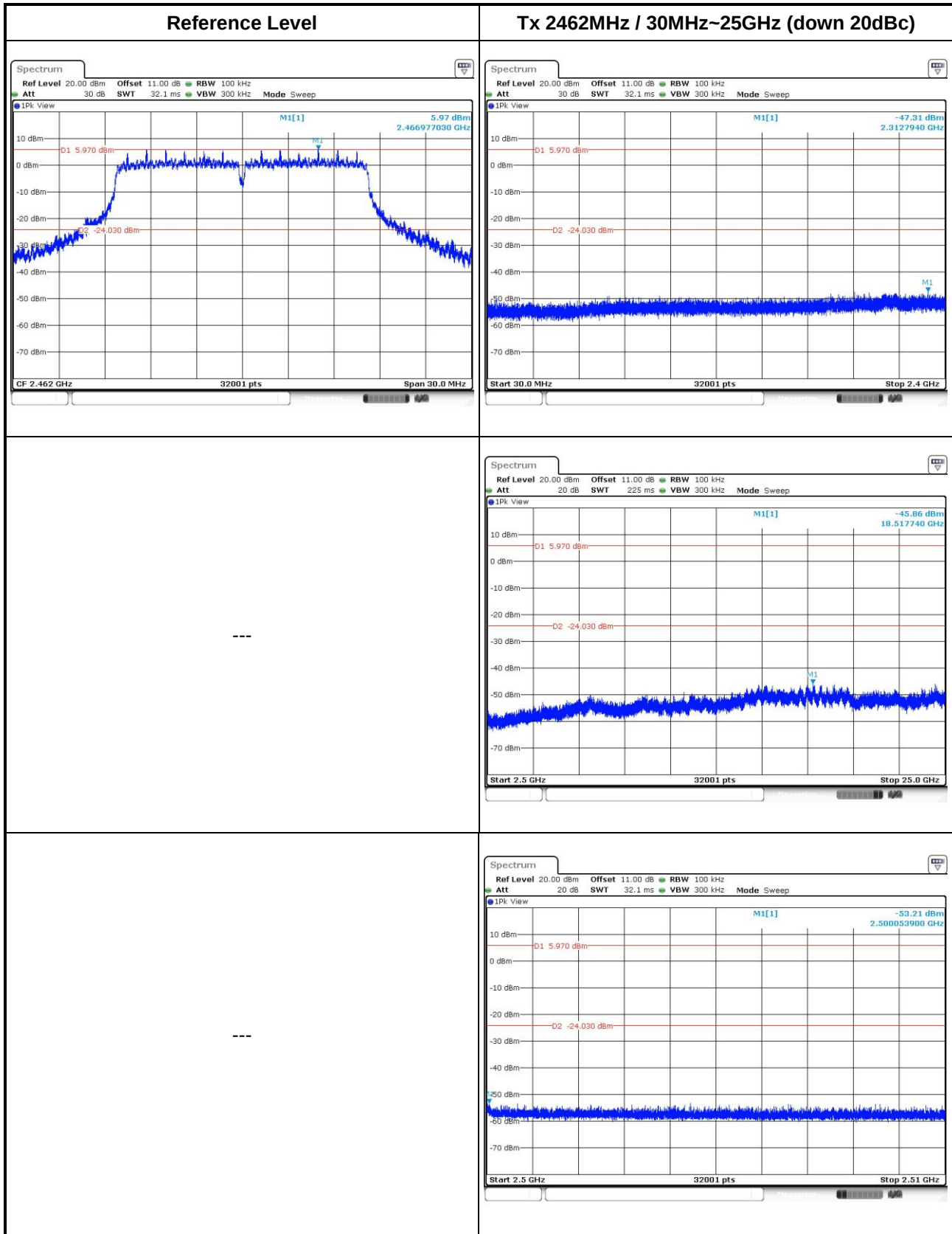


Tx 2437MHz / 30MHz~25GHz (down 20dBc)

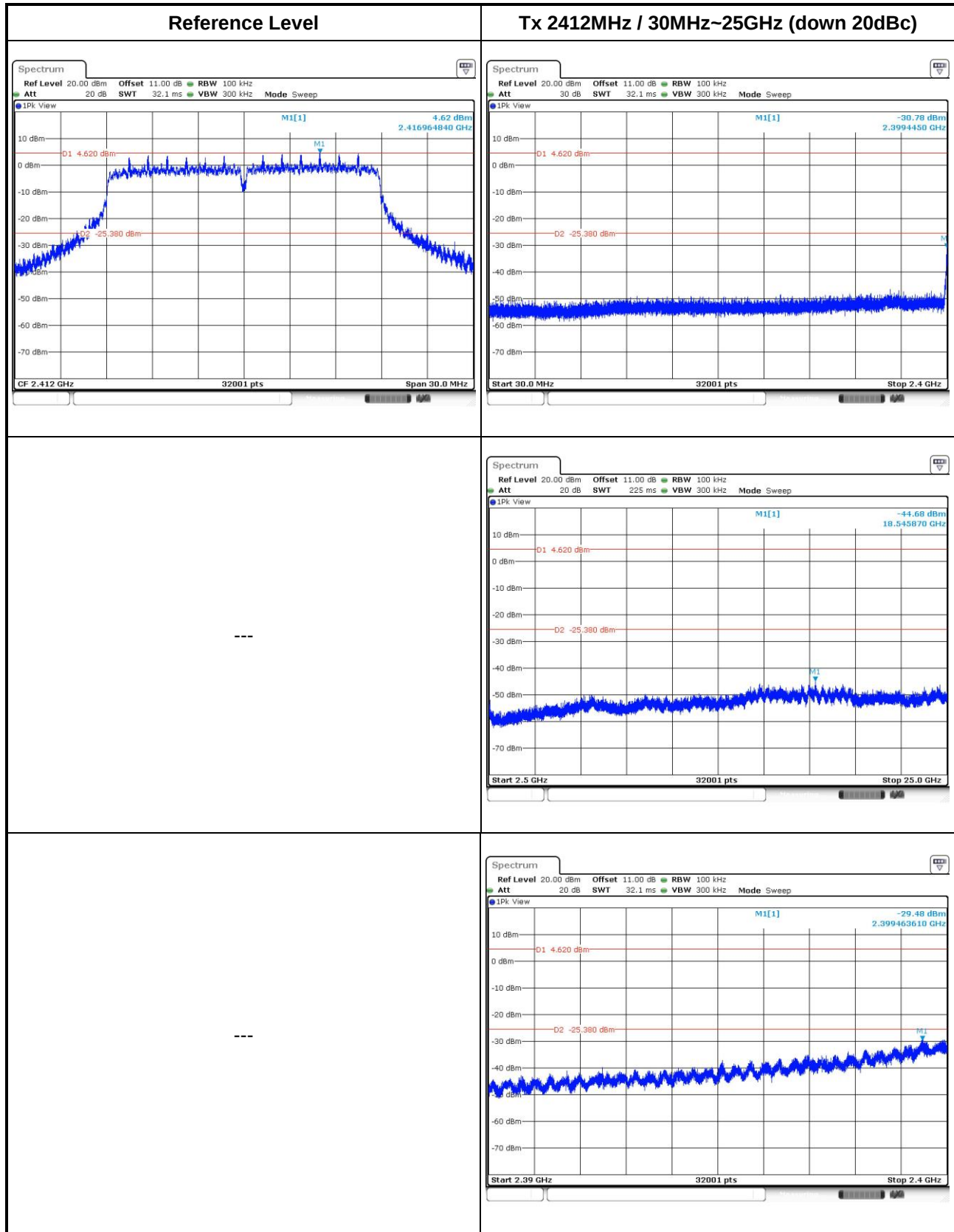


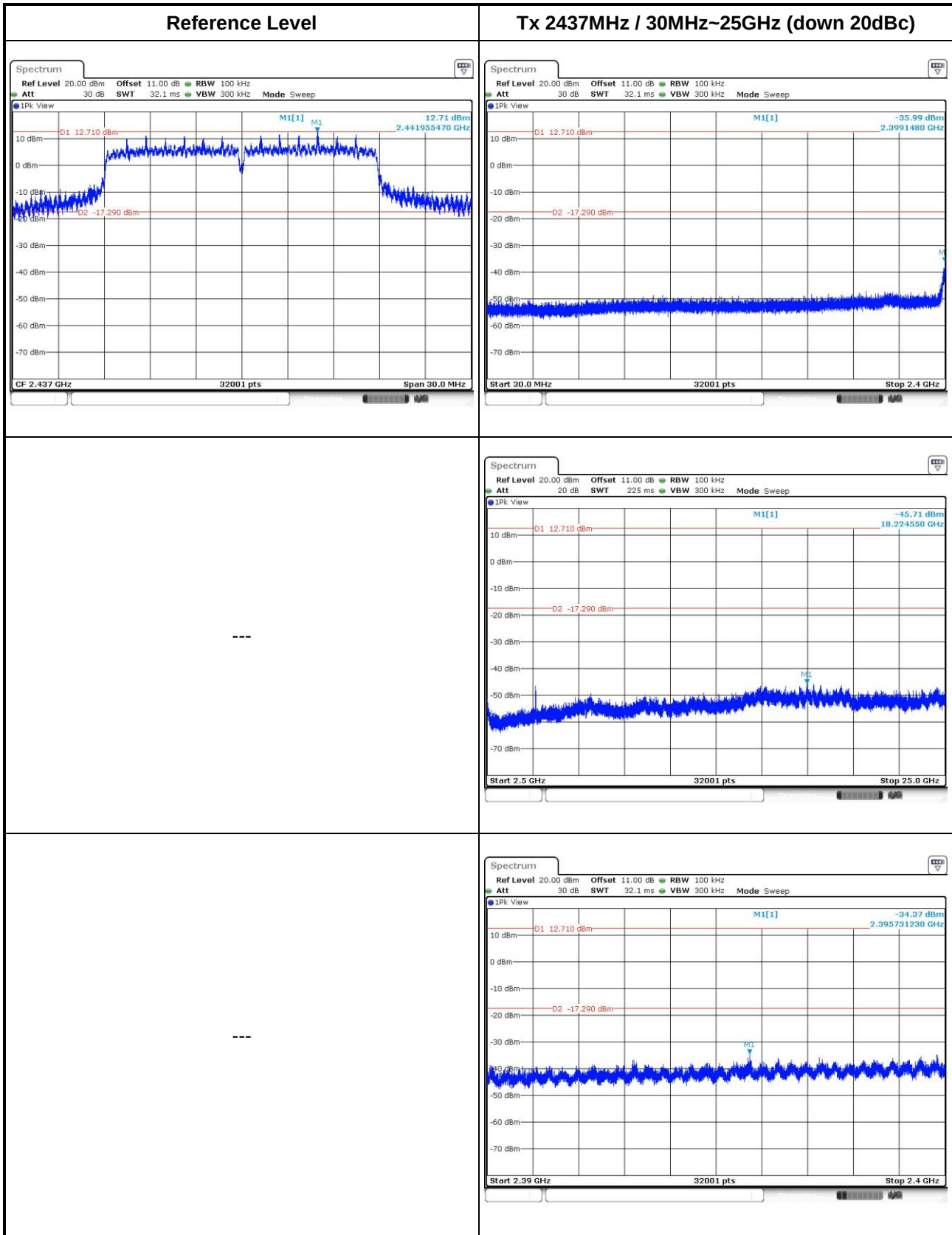




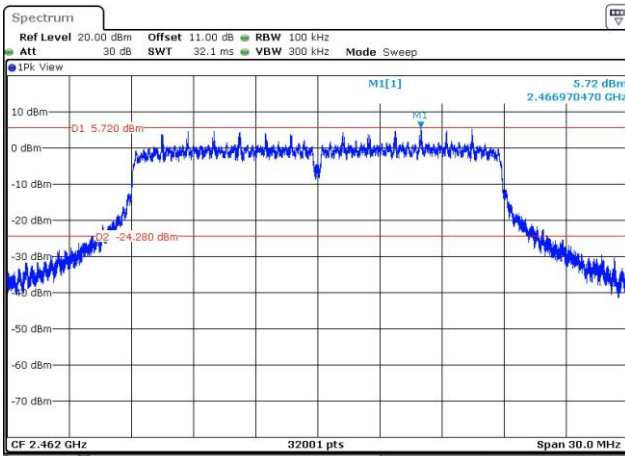


802.11n HT20

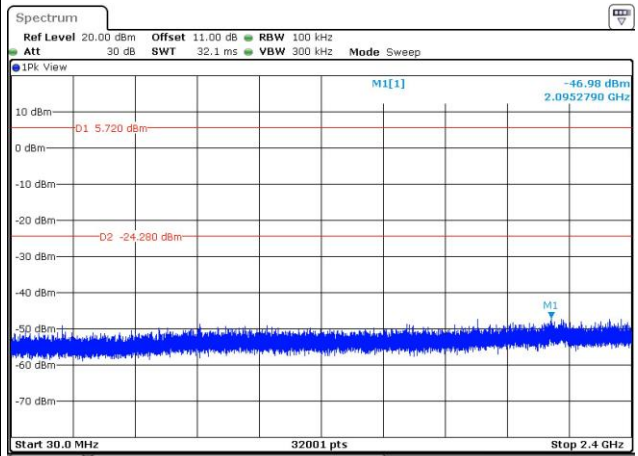


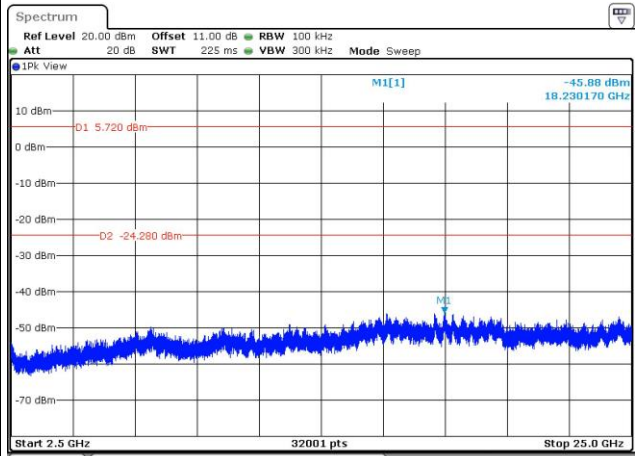


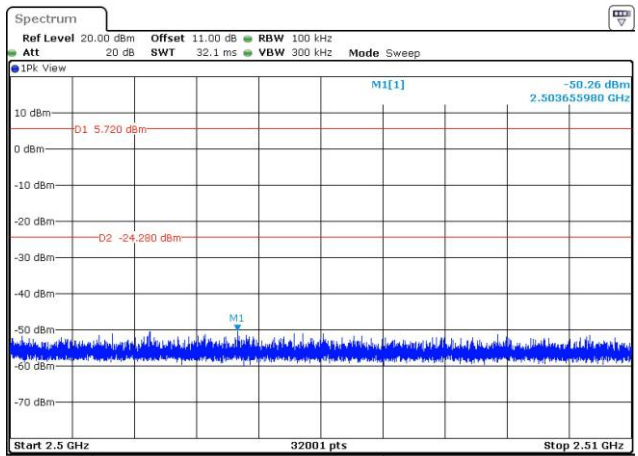
Reference Level



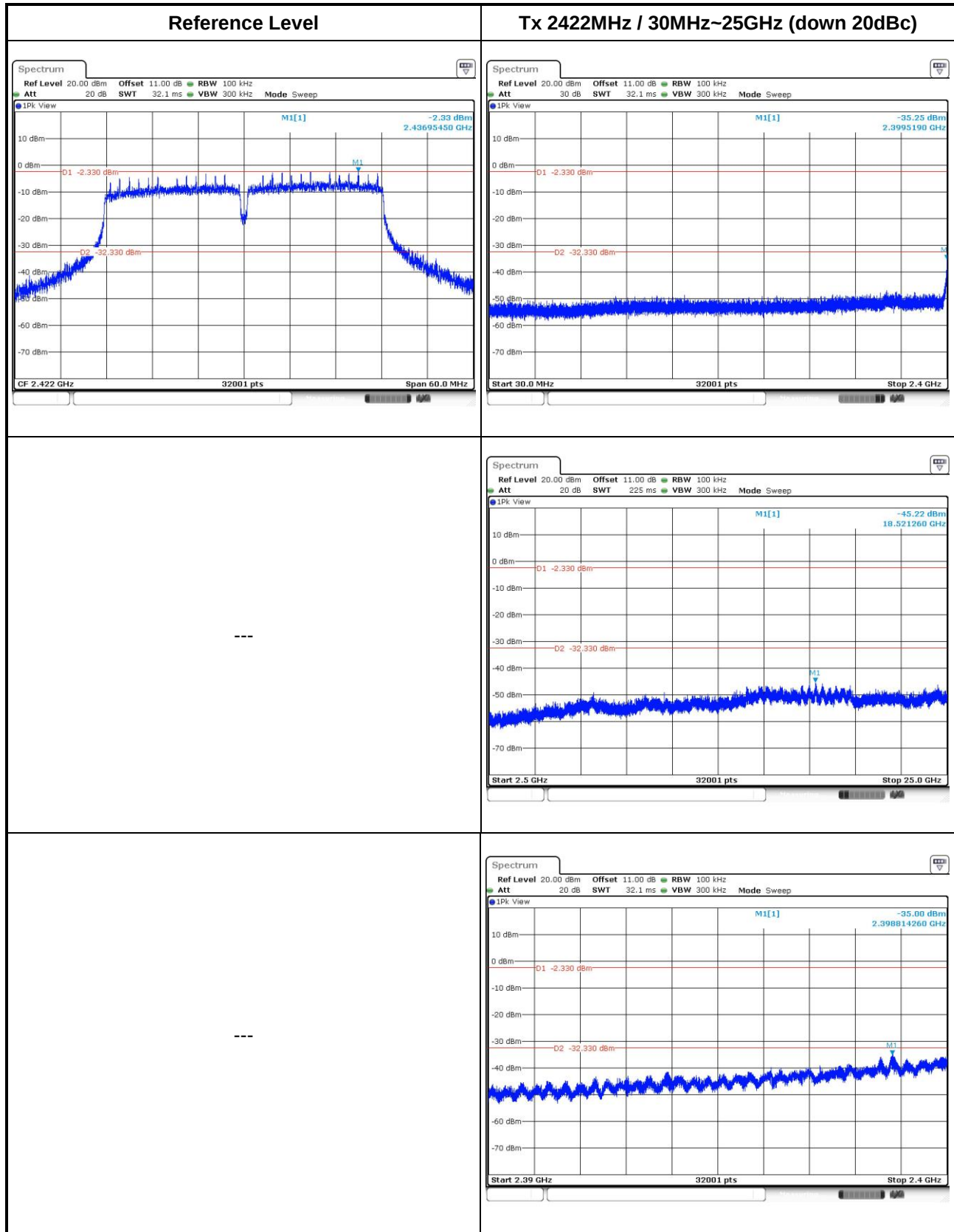
Tx 2462MHz / 30MHz~25GHz (down 20dBc)

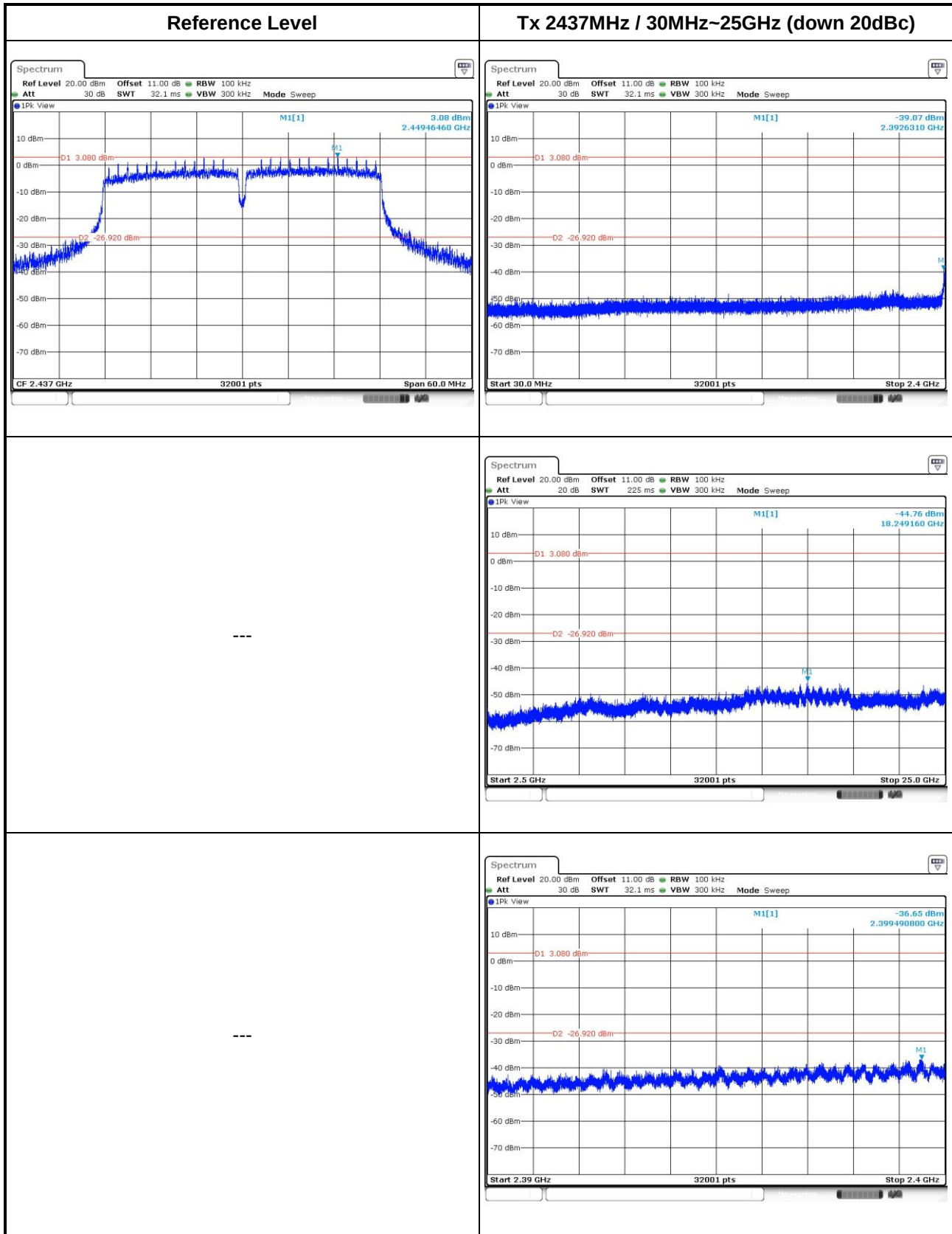




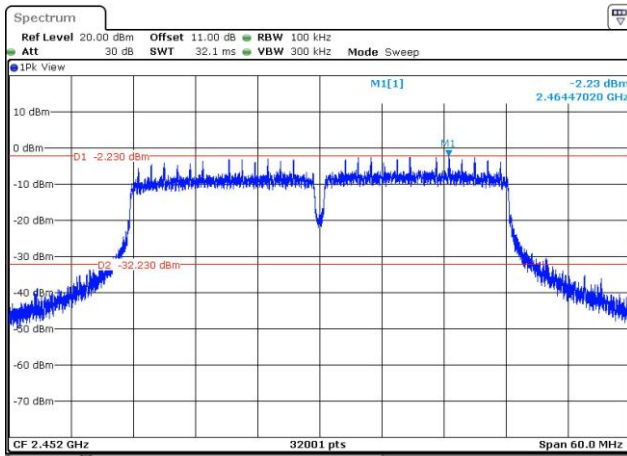


802.11n HT40

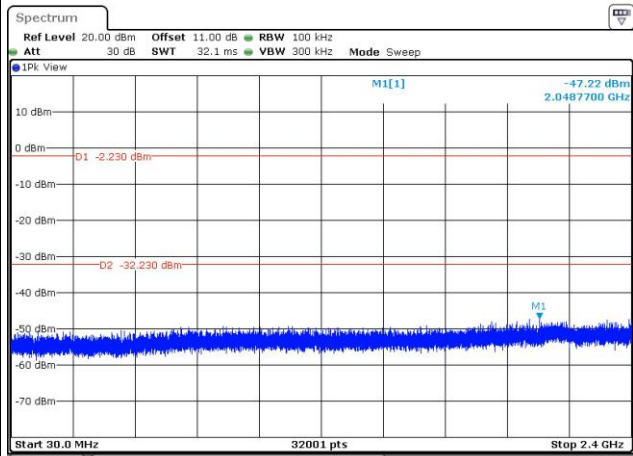


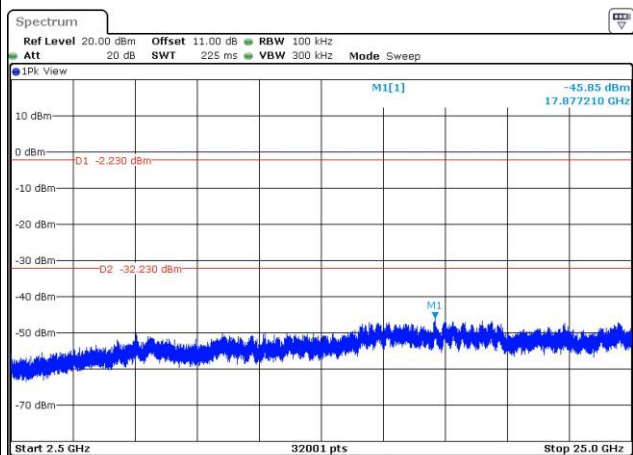


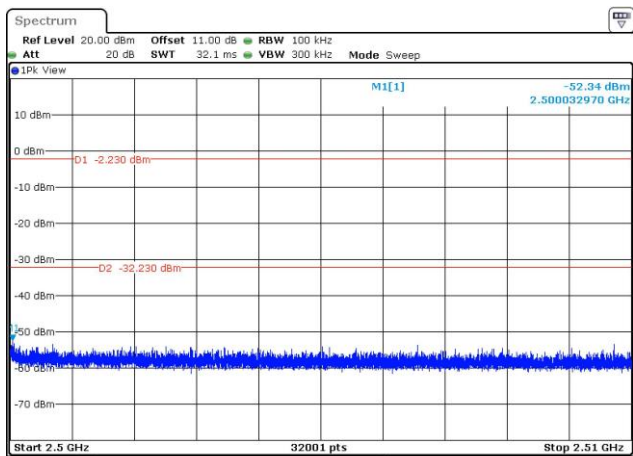
Reference Level



Tx 2452MHz / 30MHz~25GHz (down 20dBc)







4 Test laboratory information

Established in 2012, ICC provides foremost EMC & RF Testing and advisory consultation services by our skilled engineers and technicians. Our services employ a wide variety of advanced edge test equipment and one of the widest certification extents in the business.

International Certification Corp (EMC and Wireless Communication Laboratory), it is our definitive objective is to institute long term, trust-based associations with our clients. The expectation we set up with our clients is based on outstanding service, practical expertise and devotion to a certified value structure. Our passion is to grant our clients with best EMC / RF services by oriented knowledgeable and accommodating staff.

Our Test sites are located at Linkou District and Kwei Shan District. Location map can be found on our website <http://www.icertifi.com.tw>.

Linkou

Tel: 886-2-2601-1640

No. 30-2, Ding Fwu Tsuen, Lin
Kou District, New Taipei City,
Taiwan, R.O.C.

Kwei Shan

Tel: 886-3-271-8666

No. 3-1, Lane 6, Wen San 3rd St.,
Kwei Shan District, Tao Yuan City
333, Taiwan, R.O.C.

Kwei Shan Site II

Tel: 886-3-271-8640

No. 14-1, Lane 19, Wen San 3rd
St., Kwei Shan District, Tao Yuan
City 333, Taiwan, R.O.C.

If you have any suggestion, please feel free to contact us as below information.

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