CERTIFICATION TEST REPORT

Report Number. : 11696948-E1V4

Applicant	:	APPLE, INC. 1 INFINITE LOOP CUPERTINO, CA 95014, U.S.A.
Model	:	A1864, A1899
FCC ID	:	BCG-E3160A
IC	:	579C-E3160A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C INDUSTRY CANADA RSS – 247 ISSUE 2

Date Of Issue:
August 23, 2017

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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	7/14/2017	Initial Review	Francisco Guarnero
V2	7/21/2017	Address TCB's Questions	Chin Pang
V3	8/02/2017	Address TCB's Questions	Chin Pang
V4	8/21/2017	Address TCB's Questions	Tri Pham

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.
1 INFINITE LOOP
CUPERTINO, CA 95014, U.S.A.

EUT DESCRIPTION: SMARTPHONE

MODEL: A1864, A1899

SERIAL NUMBER: C39TQ00FJ6KP

DATE TESTED: MARCH 08, 2017 – JULY 11, 2017

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Pass
INDUSTRY CANADA RSS-247 Issue 2	Pass
INDUSTRY CANADA RSS-GEN Issue 4	Pass

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

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Prepared By:

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, RSS-GEN Issue 4, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☐ Chamber A (IC:2324B-1)	☐ Chamber D (IC:22541-1)
☐ Chamber B (IC:2324B-2)	☐ Chamber E (IC:22541-2)
☐ Chamber C (IC:2324B-3)	☒ Chamber F (IC:22541-3)
	☒ Chamber G (IC:22541-4)
	☒ Chamber H (IC:22541-5)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://ts.nist.gov/standards/scopes/2000650.htm.

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4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.24 dB
Occupied Channel Bandwidth	±0.39 %
Time	±0.02 %

Uncertainty figures are valid to a confidence level of 95%.

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5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The equipment under test is a mobile phone with GSM, GPRS, EGPRS, UMTS, LTE and TD-SCDMA technologies. It also supports IEEE 802.11a/b/g/n/ac, Bluetooth®, GPS and NFC. The device has a built-in inductive charging receiver which is not user accessible. The rechargeable battery is not user accessible.

5.2. DIFFERENCE IN MODEL NUMBER

Model A1864 and A1899 are exactly the same. Two models numbers are allocated for marketing and logistic purpose only

5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

Antenna	Config	Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
UAT1	Pmax	2402 - 2480	Basic GFSK	20.21	104.95
		2402 - 2480	DQPSK	20.36	108.64
		2402 - 2480	Enhanced 8PSK	20.42	110.15
LAT3	Pmax	2402 - 2480	Basic GFSK	20.18	104.23
		2402 - 2480	DQPSK	19.96	99.08
		2402 - 2480	Enhanced 8PSK	20.21	104.95
UAT1	Plow	2402 - 2480	Basic GFSK	10.28	10.67
		2402 - 2480	DQPSK	10.31	10.74
		2402 - 2480	Enhanced 8PSK	10.51	11.25
LAT3	Plow	2402 - 2480	Basic GFSK	10.21	10.50
		2402 - 2480	DQPSK	10.12	10.28
		2402 - 2480	Enhanced 8PSK	10.20	10.47

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Band (GHz)	UAT 1 (dBi) Primary	LAT 3 (dBi) Diversity
2.4	1.01	-2.24

5.5. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was version15.1.40.176.

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5.6. WORST-CASE CONFIGURATION AND MODE

Radiated band edge, harmonic, and spurious emissions from 1GHz to 18GHz were performed with the EUT set to transmit at highest power on Low/Middle/High channels.

Radiated emissions below 30MHz, below 1GHz, above 18GHz and power line conducted emissions were performed with the EUT transmits at the channel with the highest output power as worst-case scenario.

The fundamental of the EUT was investigated in three orthogonal orientations, X (Flatbed), Y (Landscape), and Z (Portrait), on both primary and diversity antennas. In addition, the EUT was also investigated with and without AC/DC charger, headphones & laptop. It was determined that Y (Landscape) orientation was the worst-case orientation for both antennas. Therefore, all final radiated testing was performed with the EUT in Y orientation.

The EUT was tested as a standalone from 1 - 18GHz and 18 – 26GHz. EUT was tested with AC/DC charger for 30MHz – 1000MHz testing.

Worst-case data rates were:

GFSK mode: DH5
8PSK mode: 3-DH5

DQPSK mode has been verified to have the lowest power.

For simultaneous transmission of multiple channels from the same antenna LAT 3 in the 2.4GHz BTand 5GHz bands, tests were conducted for various configurations having the highest power. No noticeable new emission was found.

There are two vendors of the WiFi/Bluetooth radio modules: variant 1 and variant 2. The Wi-Fi/Bluetooth radio modules have the same mechanical outline (e.g., the same package dimension and pin-out layout), use the same on-board antenna matching circuit, have an identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances.

Baseline testing was performed on the two variants to determine the worst case on all conducted power and radiated emissions.

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5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	NA
Laptop	Apple	MackBook Air 4	NA	NA

I/O CABLES (CONDUCTED TEST)

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	Antenna	1	SMA	Un-Shielded	0.2	To spectrum Analyzer
2	USB	1	USB	Shielded	1	N/A
3	AC	1	AC	Un-shielded	3	N/A

I/O CABLES (RADIATED ABOVE 1 GHZ)

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
NA						

I/O CABLES (AC POWER CONDUCTED TEST AND BELOW 1 GHZ)

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	3	N/A

I/O CABLES (AC LINE CONDUCTED: LAPTOP CONFIGUARTION)

I/O Cable List						
Cable No	Port	# of identical	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	3	N/A
2	USB	1	USB	Shielded	1	N/A

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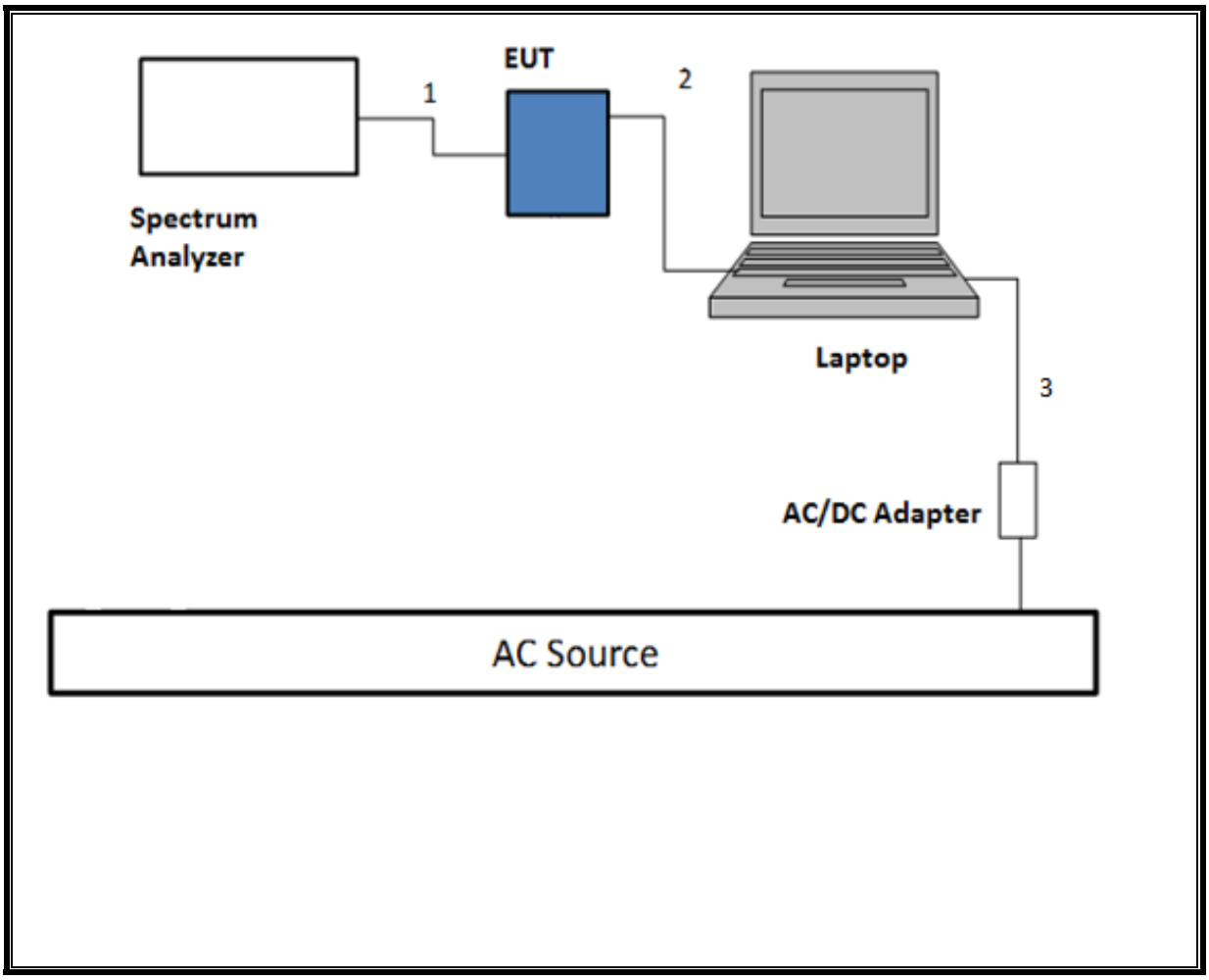
TEST SETUP

The EUT was tested connected to a host Laptop via USB cable adapter and spectrum analyzer to antenna port. Test software exercised the EUT.

SETUP DIAGRAM



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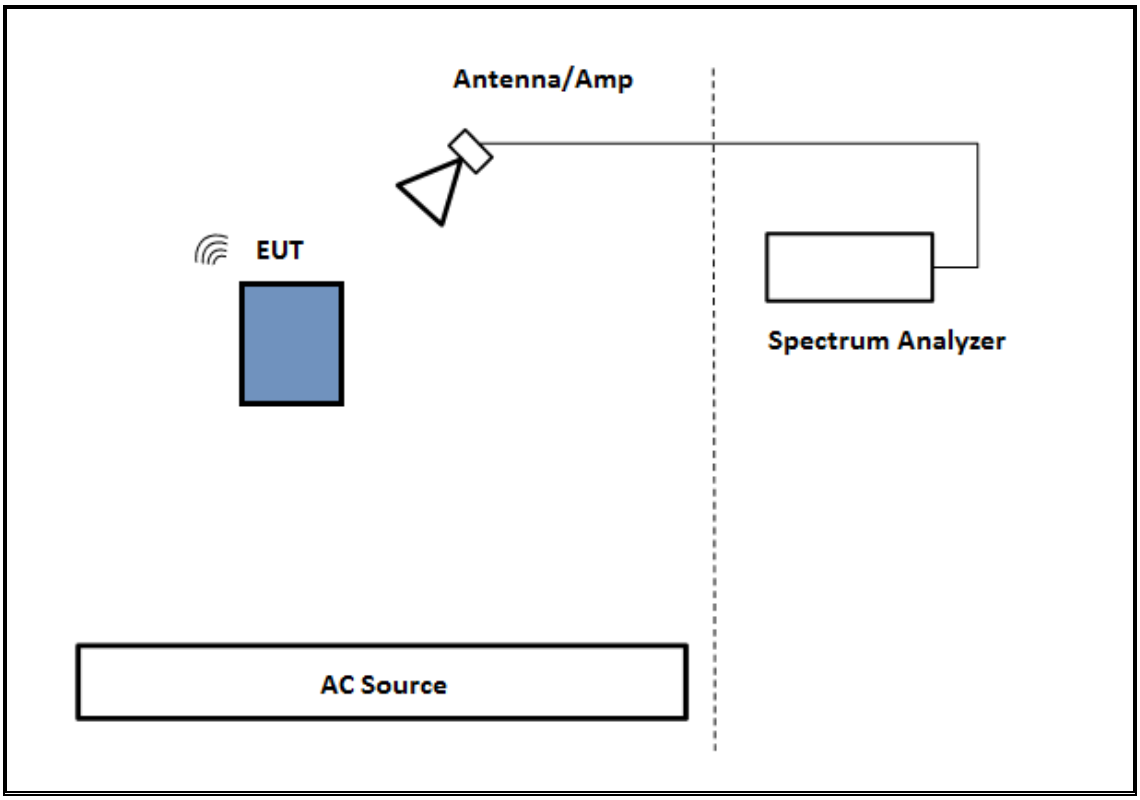
TEST SETUP- RADIATED-ABOVE 1 GHZ

The EUT was powered by battery. Test software exercised the EUT.

SETUP DIAGRAM



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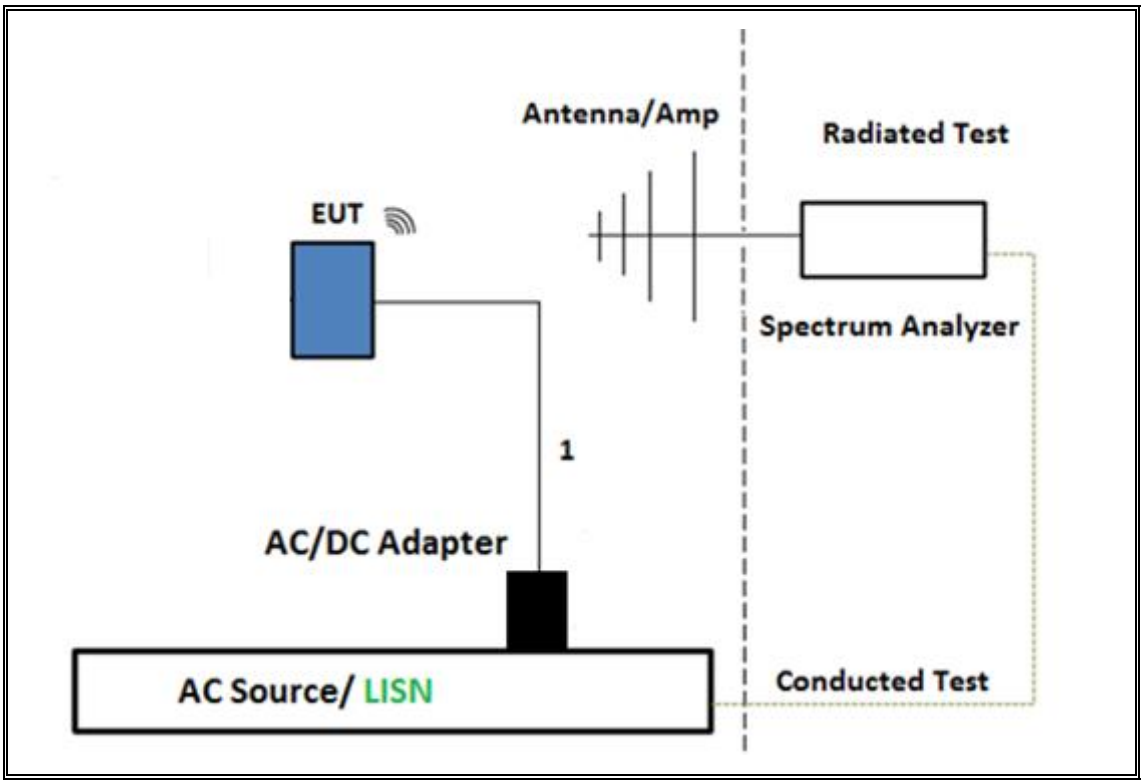
TEST SETUP- BELOW 1GHZ & AC LINE CONDUCTED TESTS

The EUT was powered by AC/DC adapter. Test software exercised the EUT.

SETUP DIAGRAM



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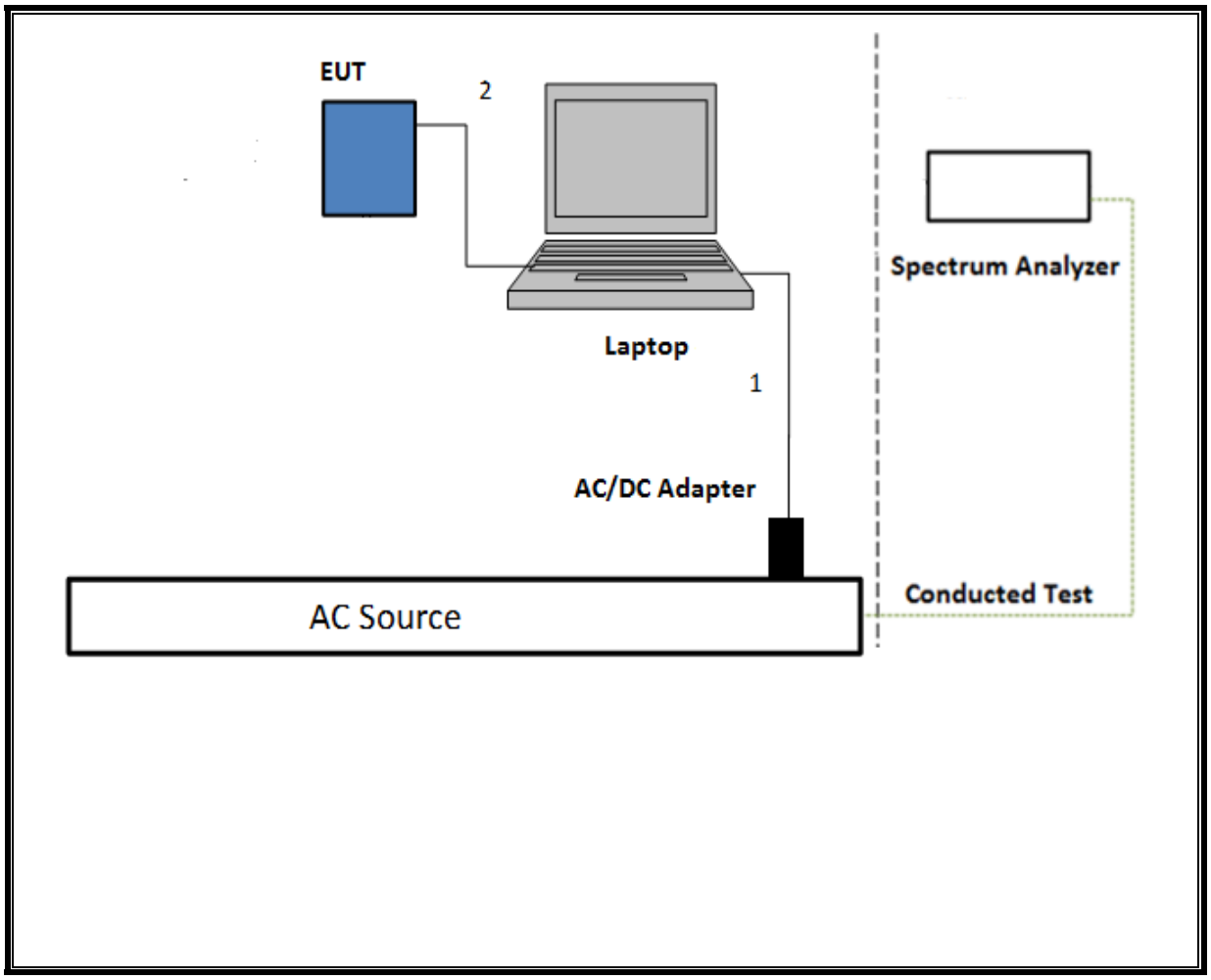
TEST SETUP- AC LINE CONDUCTED TEST (LAPTOP CONFIGURATION)

The EUT was tested connected to a host Laptop via USB cable adapter and spectrum analyzer to antenna port. Test software exercised the EUT.

SETUP DIAGRAM



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6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Asset**	**Cal Due**
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T863	4/26/2017
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB1	T122	1/31/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T742	11/29/2017
*Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T173	6/17/2017
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1113	12/20/2017
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T119	3/28/2018
*Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	5/31/2017
*Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T834	6/17/2017
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A-544	T341	10/25/2017
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T344	4/07/2017
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB1	T185	3/30/2018
Amplifier, 1 to 18GHz, 35dB	Amplical	AMP1G18-35	T1569	9/15/2017
*Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T835	6/18/2017
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1613	12/2/2017
Power Sensor	Keysight	N1921A	T750	10/1/2017
Power Meter, P-series single channel	Keysight	N1912A	T1245	1/05/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T340	12/14/2017
*Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	6/16/2017
Spectrum Analyzer, 40GHz	Agilent	8564E	T106	9/7/2017
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	7/5/2017
AC Line Conducted				
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	01/06/2018
*LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/08/2017
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/16/2018
Power Cable, Line Conducted Emissions	UL	PG1	T861	9/1/2017
UL AUTOMATION SOFTWARE				
Radiated Software	UL	UL EMC	Ver 9.5, April 26, 2016	
Conducted Software	UL	UL EMC	Ver 5.4, October 13, 2016	
AC Line Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015	

NOTE: *testing is completed before equipment calibration expiration date.

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7. MEASUREMENT METHODS

On Time and Duty Cycle: ANSI C63.10-2013 Section 11.6

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Carrier Frequency Separation: ANSI C63.10-2013 Section 7.8.2

Number of Hopping Frequencies: ANSI C63.10-2013 Section 7.8.3

Time of Occupancy (Dwell Time): ANSI C63.10-2013 Section 7.8.4

Peak Output Power: ANSI C63.10-2013 Section 7.8.5

Conducted Spurious Emissions: ANSI C63.10-2013 Section 7.8.8

Conducted Band-Edge: ANSI C63.10-2013 Section 6.10.4

Radiated Spurious Emissions 30-1000MHz: ANSI C63.10-2013 Section 6.3 and 6.5

Radiated Spurious Emissions above 1GHz: ANSI C63.10-2013 Section 6.3 and 6.6

Radiated Band-edge: ANSI C63.10-2013 Section 6.10.5

AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

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8. ANTENNA PORT TEST RESULTS

ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (khz)
GFSK	128	128	1.00	100%	0.00	0.010
8FSK	128	128	1.00	100%	0.00	0.010

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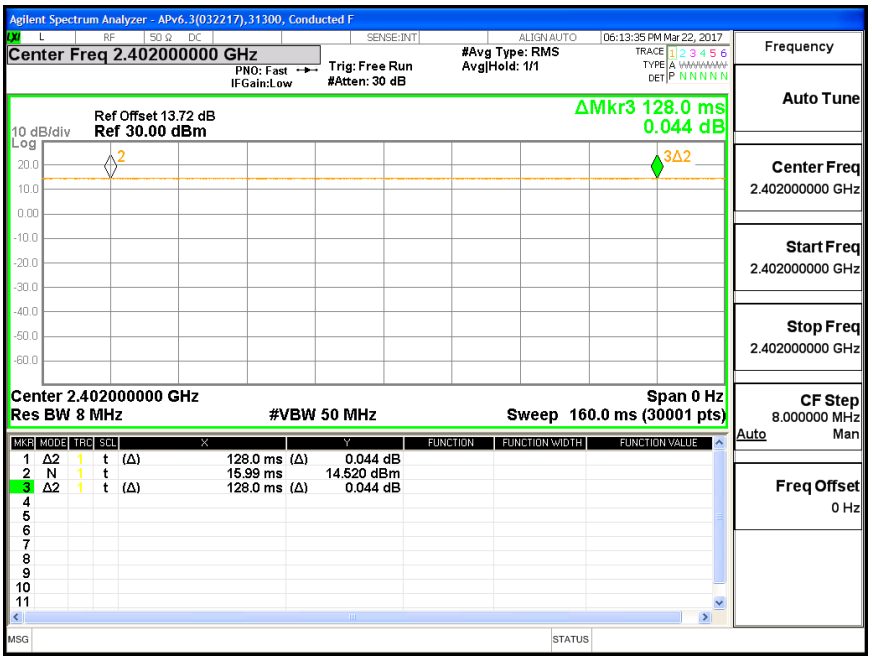
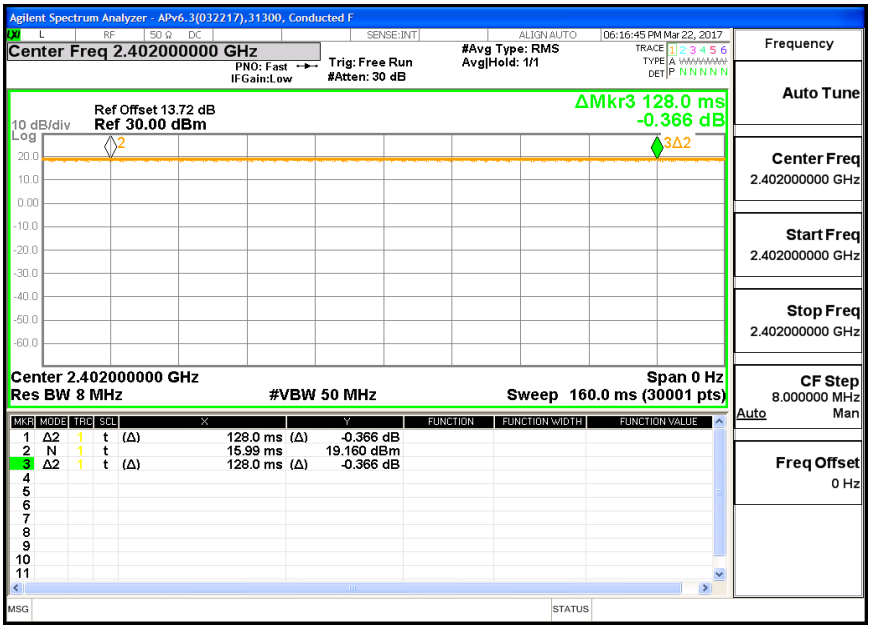
DUTY CYCLE PLOTS

HOPPING OFF

DUTY CYCLE GFSK MODE



DUTY CYCLE 8PSK MODE



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8.1. UAT 1, PMAX BASIC DATA RATE GFSK MODULATION

8.1.1. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

Channel	Frequency (MHz)	20 dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	2402	825.7	854.55
Middle	2441	868.2	856.46
High	2480	916.7	912.74

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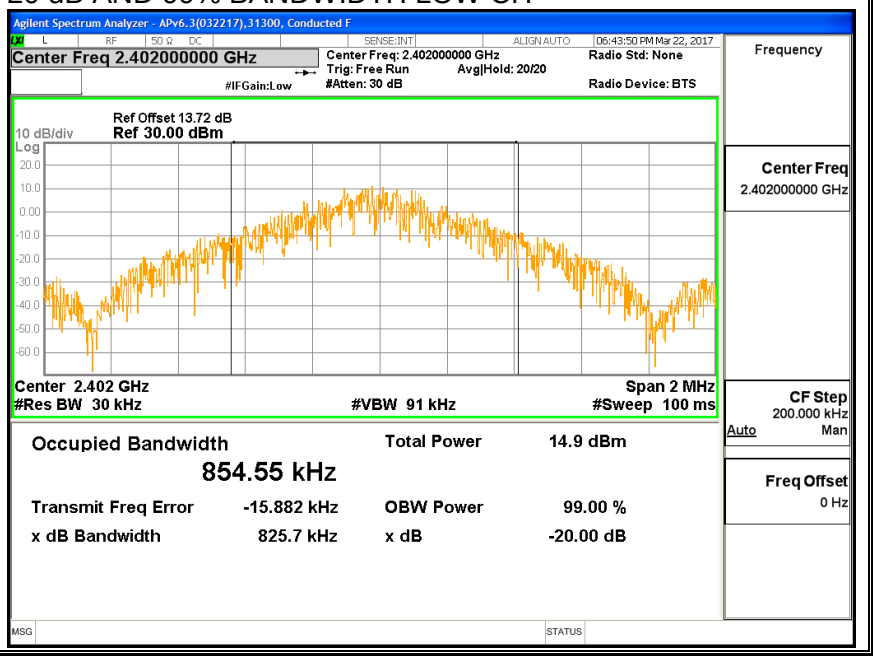
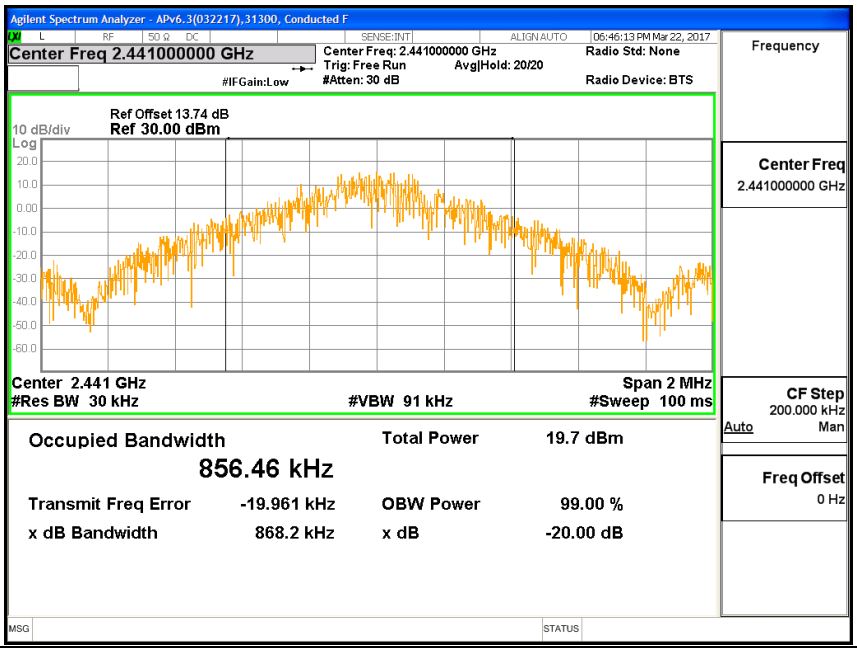
20 dB AND 99% BANDWIDTH LOW CH



20 dB AND 99% BANDWIDTH MID CH



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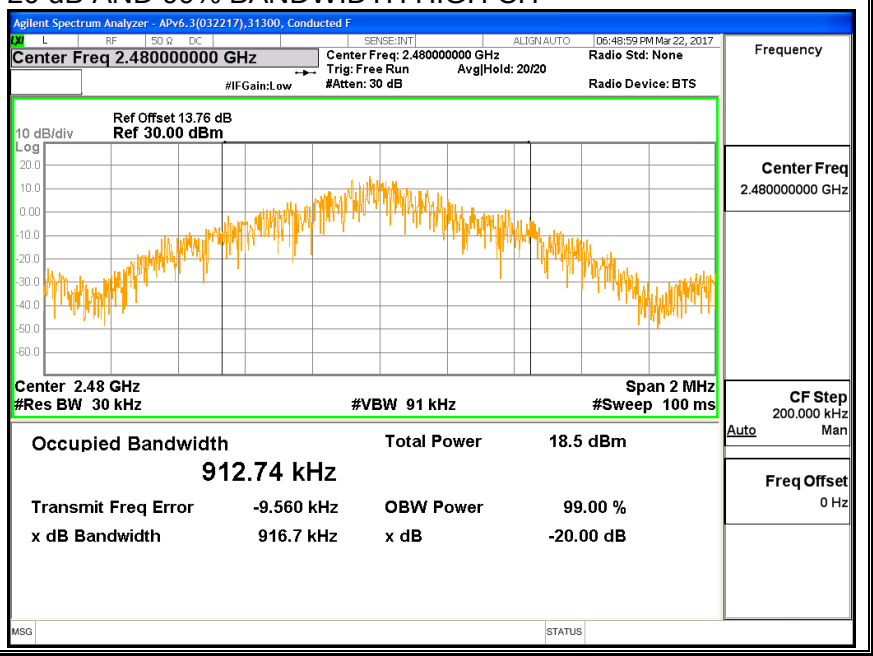
20 dB AND 99% BANDWIDTH HIGH CH



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8.1.2. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (b)

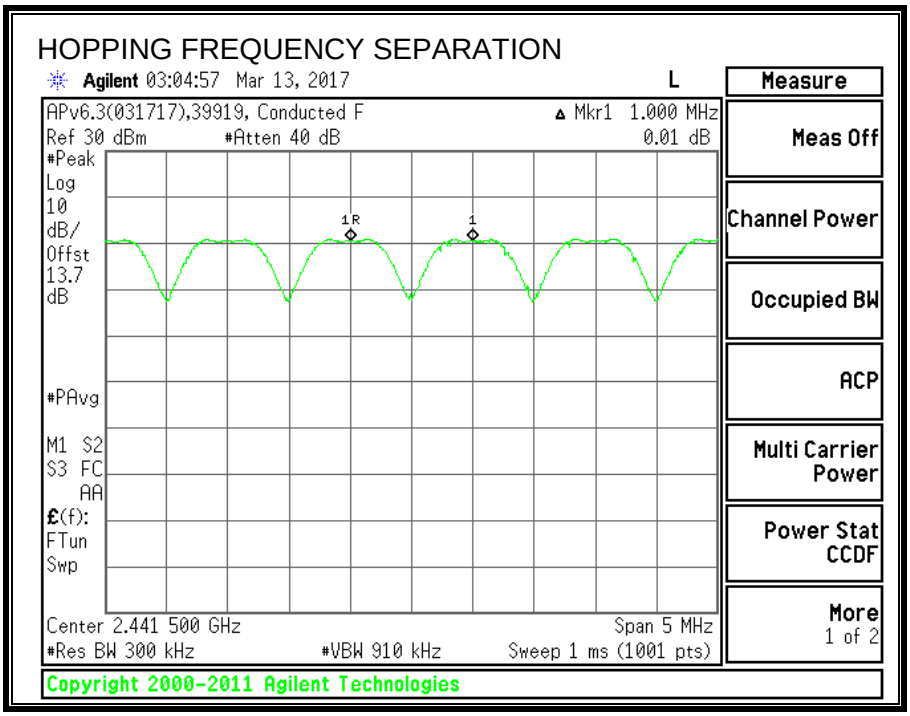
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

Alternatively, 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS



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8.1.3. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

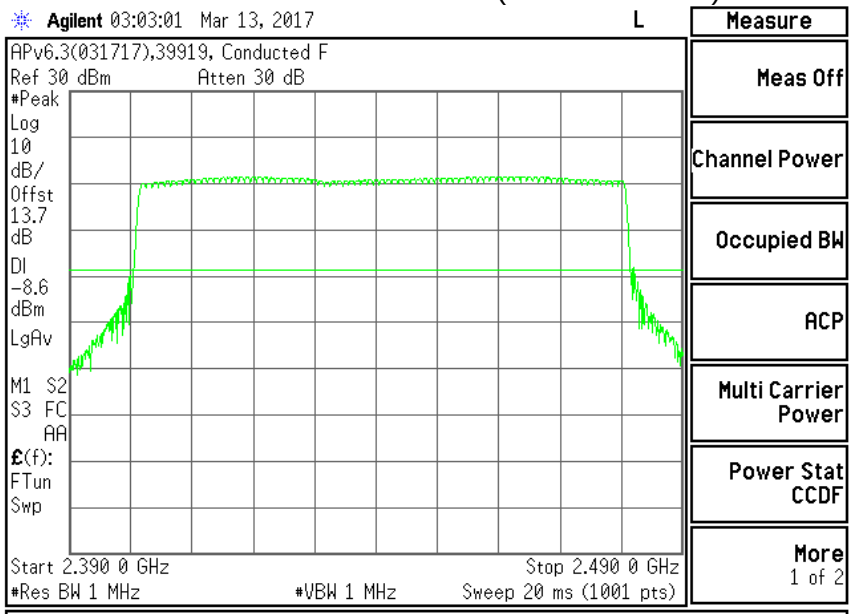
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 79 Channels observed.

NUMBER OF HOPPING CHANNELS (100 MHz SPAN)



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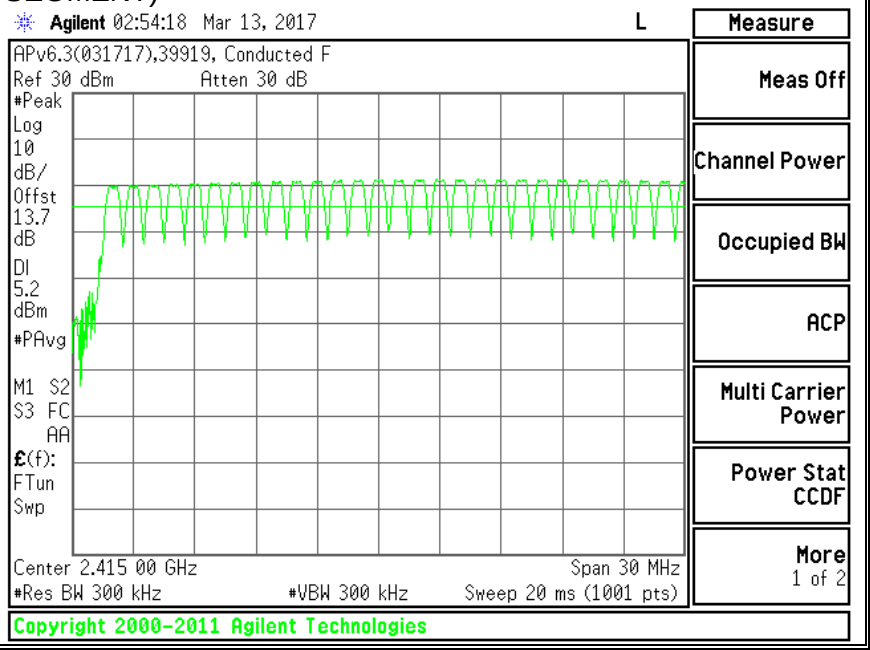
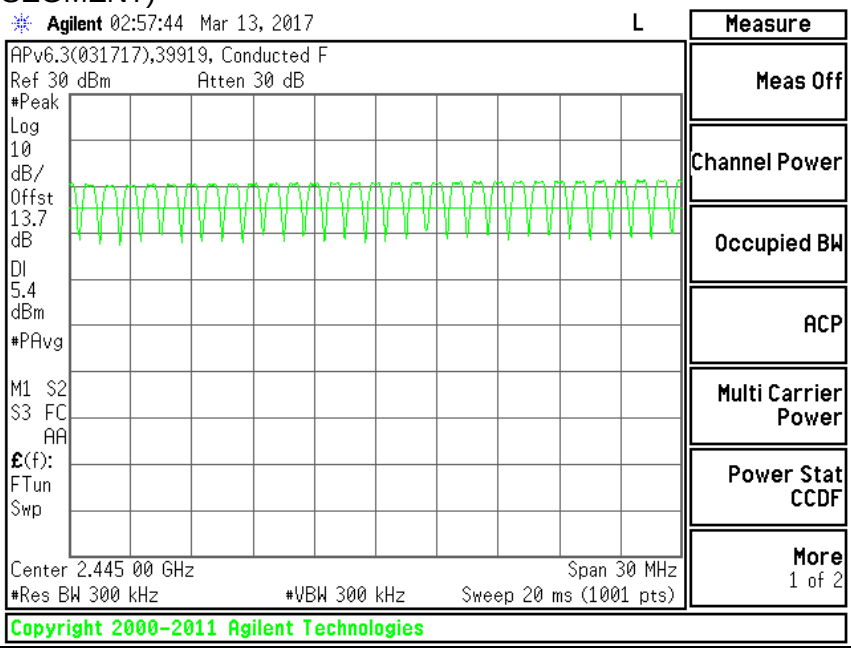
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, FIRST SEGMENT)



NUMBER OF HOPPING CHANNELS (30 MHz SPAN, SECOND SEGMENT)



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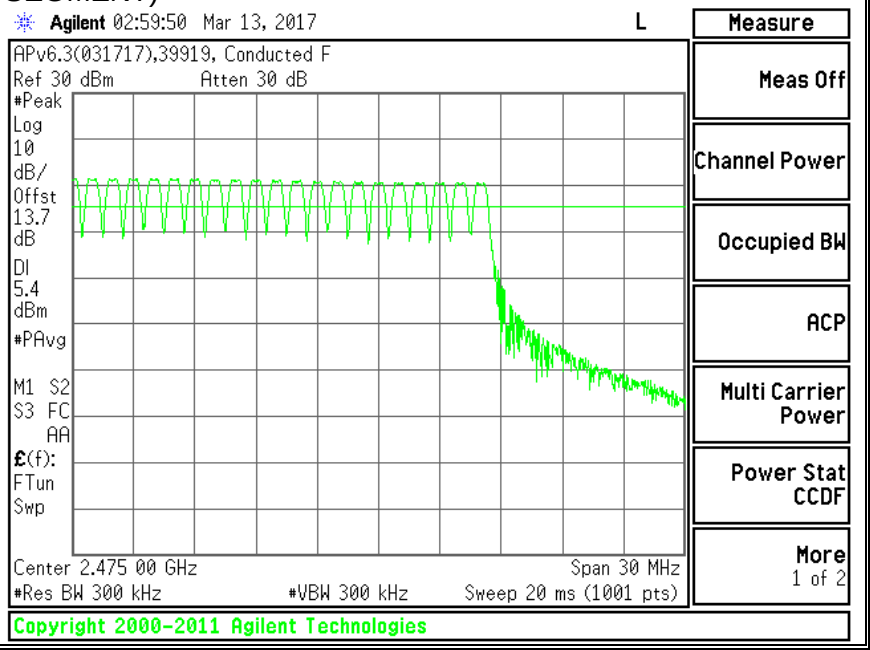
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, THIRD SEGMENT)



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8.1.4. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to 10 * (# of pulses in 0.8 s) * pulse width.

RESULTS

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.388	32	0.124	0.4	-0.276
DH3	1.644	17	0.279	0.4	-0.121
DH5	2.892	10	0.289	0.4	-0.111
DH Packet	**Pulse Width (msec)**	**Number of Pulses in 0.8 seconds**	**Average Time of Occupancy (sec)**	**Limit (sec)**	**Margin (sec)**
GFSK AFH Mode					
DH1	0.388	8	0.031	0.4	-0.369
DH3	1.644	5	0.263	0.4	-0.137
DH5	2.892	3	0.347	0.4	-0.053

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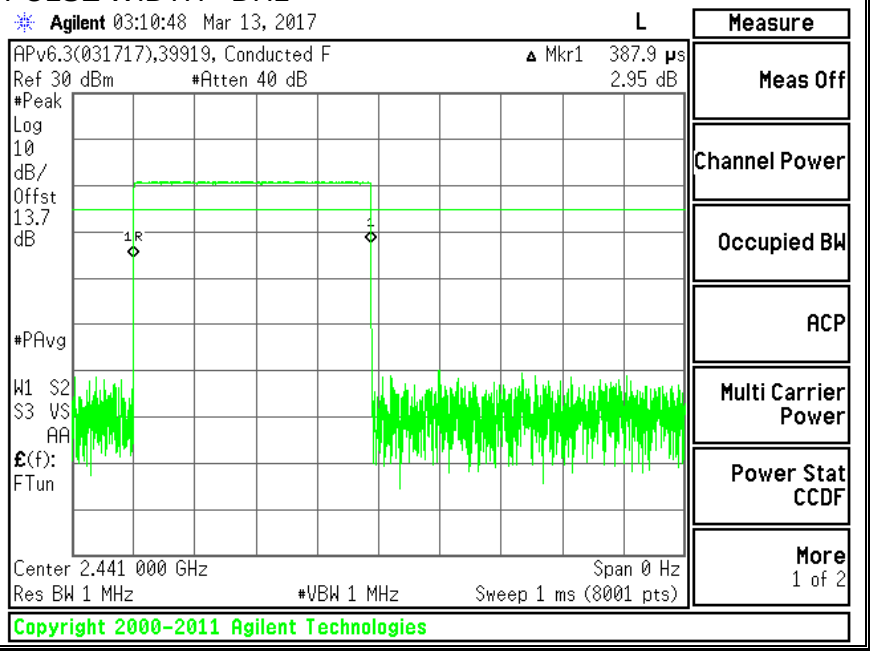
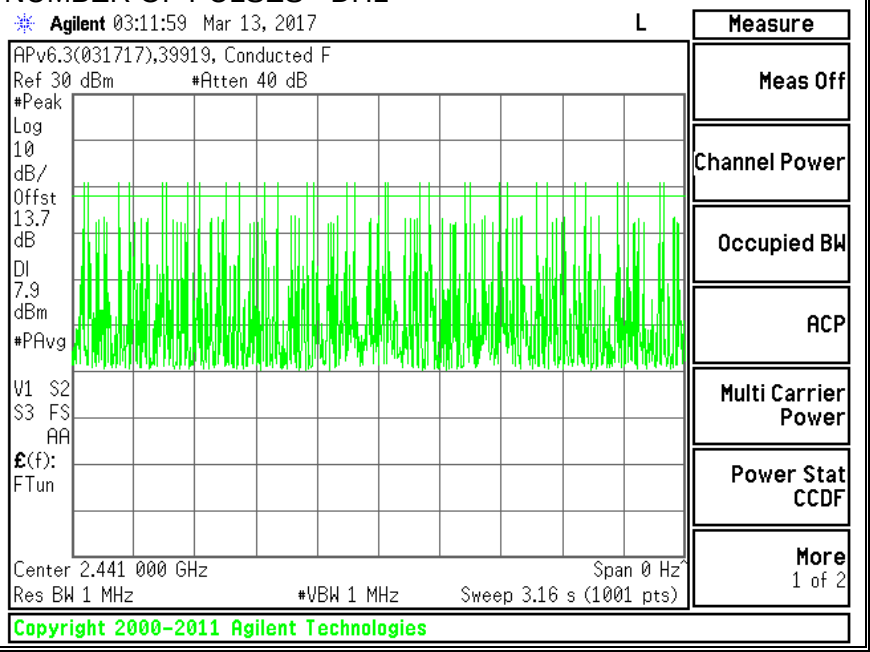
PULSE WIDTH - DH1



NUMBER OF PULSES - DH1



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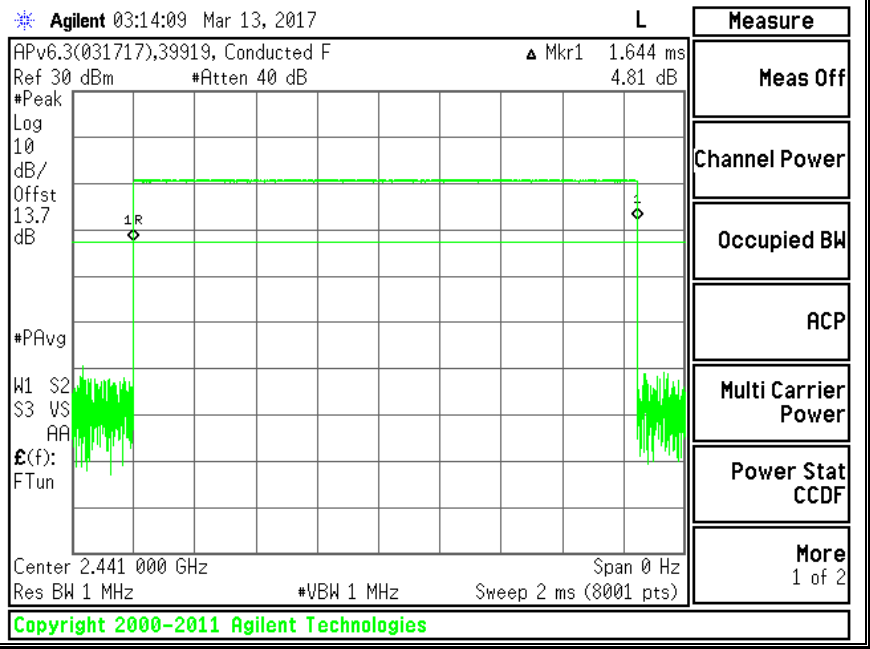
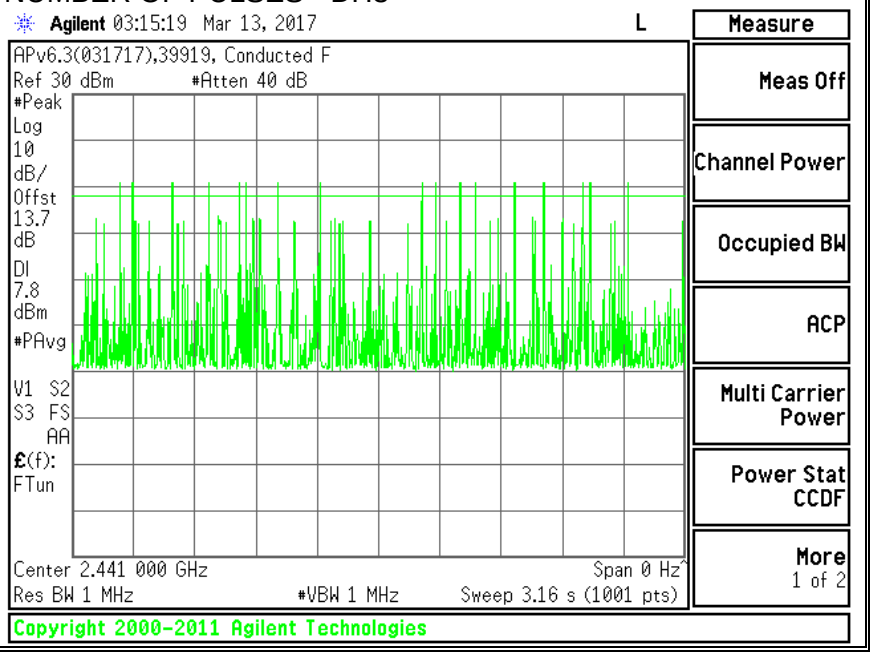
PULSE WIDTH - DH3



NUMBER OF PULSES - DH3



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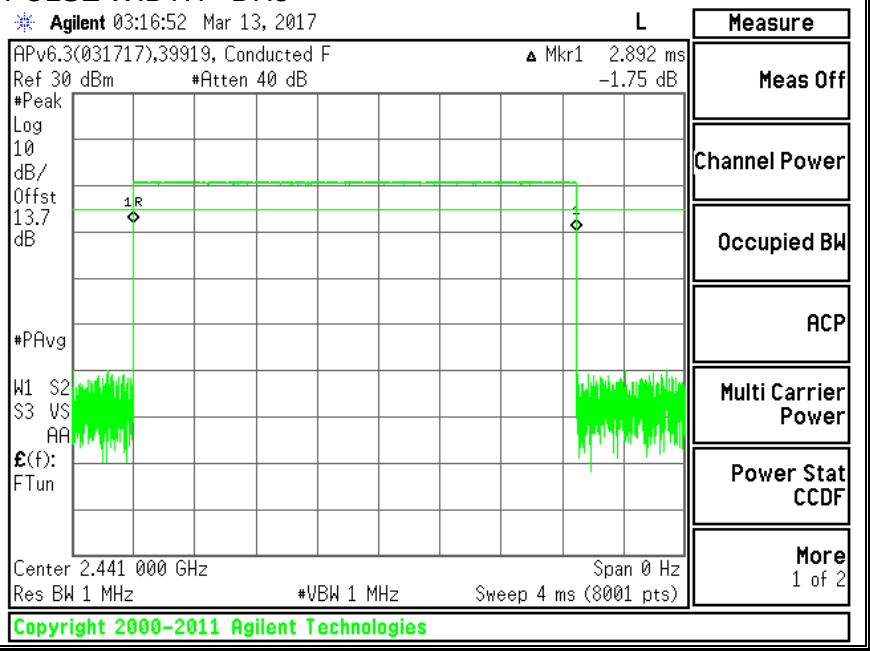
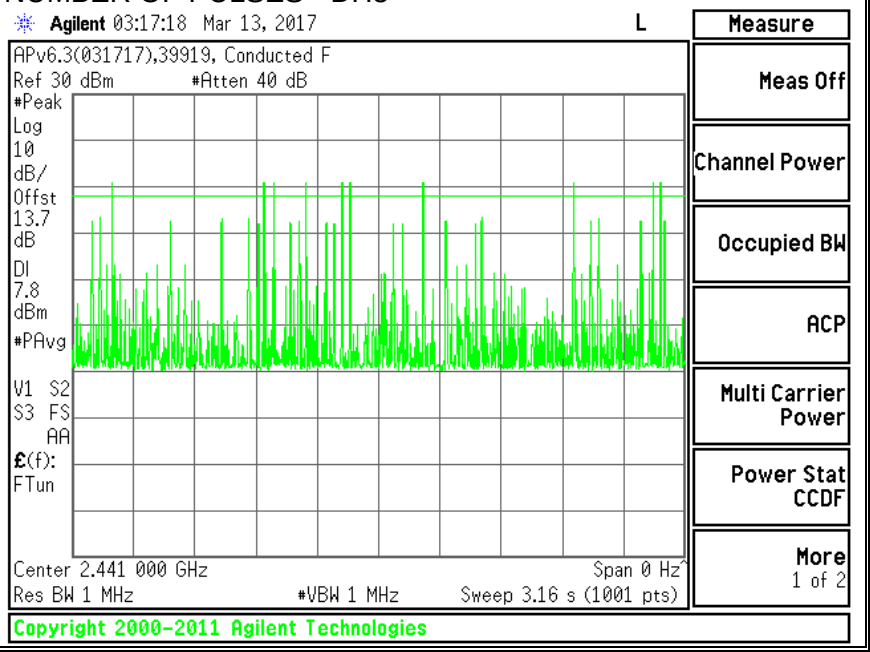
PULSE WIDTH - DH5



NUMBER OF PULSES - DH5



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8.1.5. OUTPUT POWER

ID:	30554	Date:	6/11/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.07	30	-9.93
Middle	2441	20.21	30	-9.79
High	2480	20.02	30	-9.98

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8.1.6. AVERAGE POWER

ID:	30554	Date:	6/11/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.72
Middle	2441	19.89
High	2480	19.68

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8.1.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-247 (5.5)

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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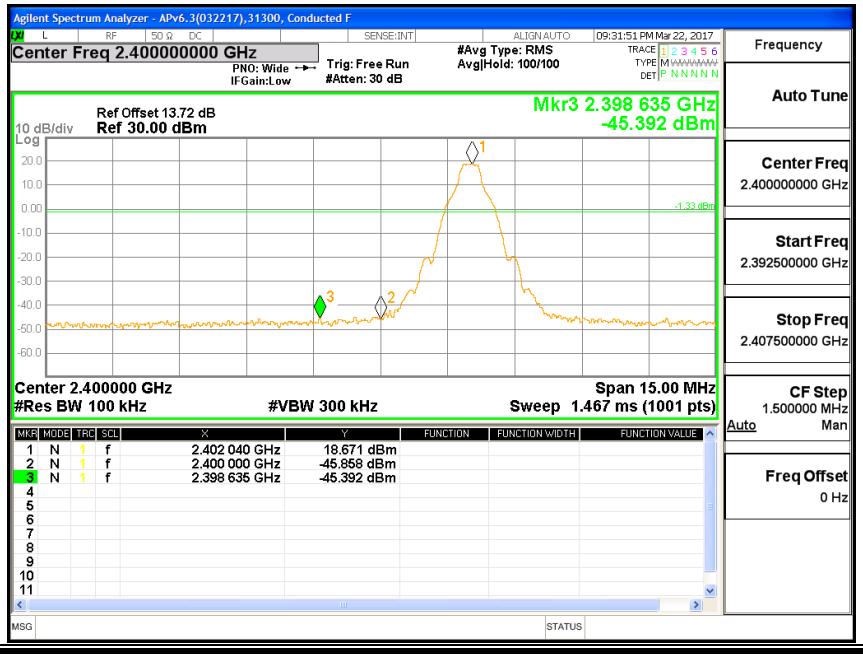
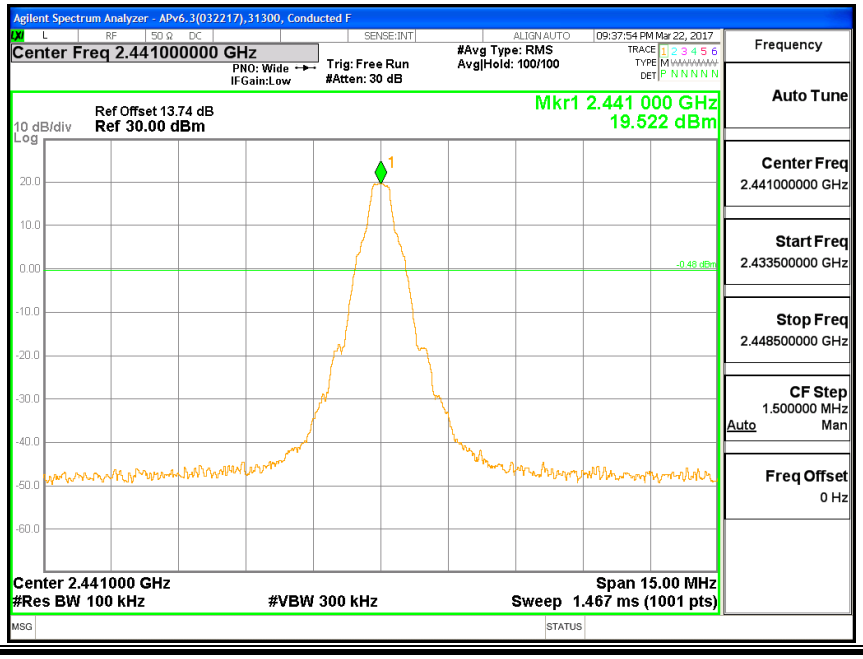
CONDUCTED BANDEDGE AND SPURIOUS EMISSIONS

CONDUCTED BANDEDGE LOW CH



CONDUCTED BANDEDGE MID CH



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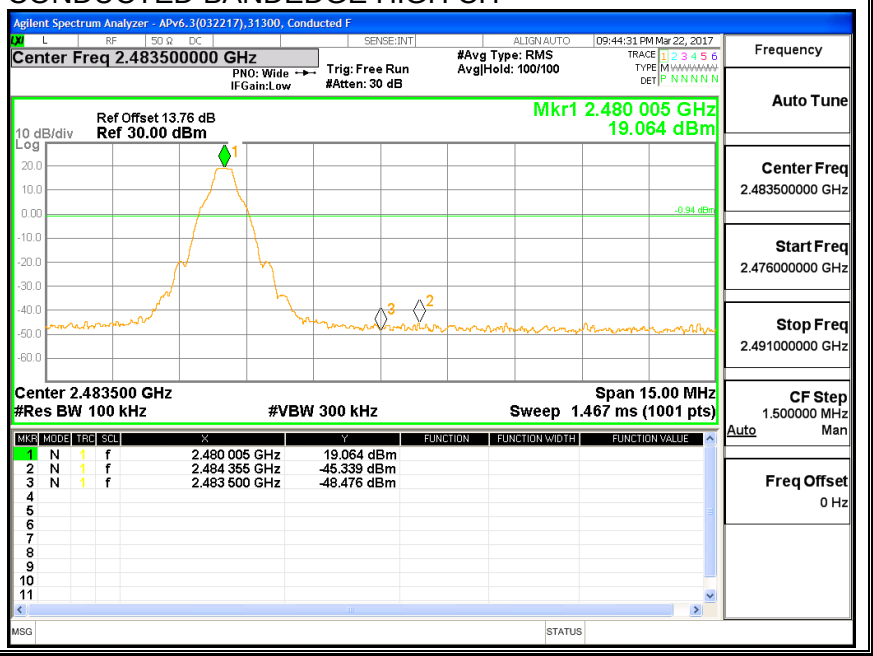
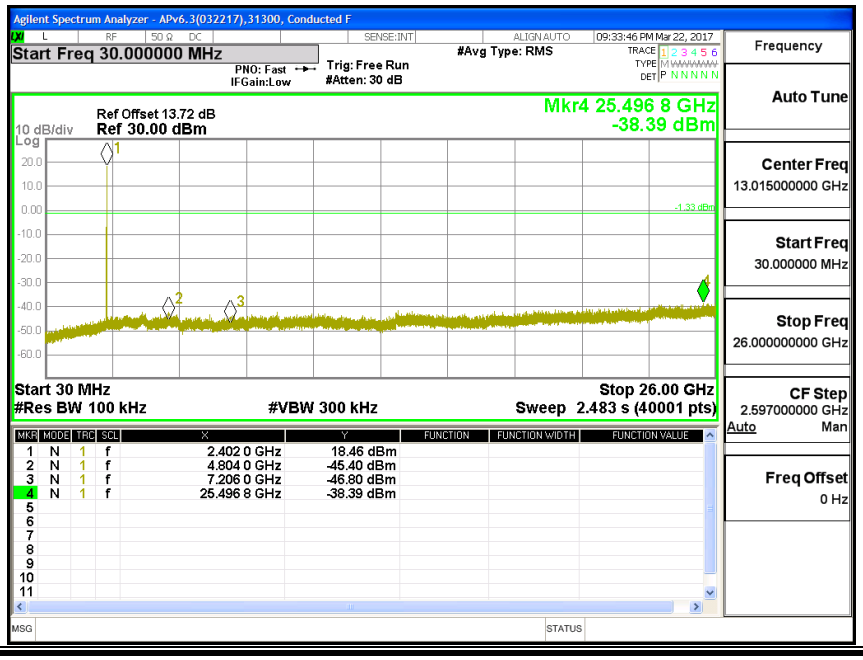
CONDUCTED BANDEDGE HIGH CH



CONDUCTED SPURIOUS EMISSIONS LOW CH



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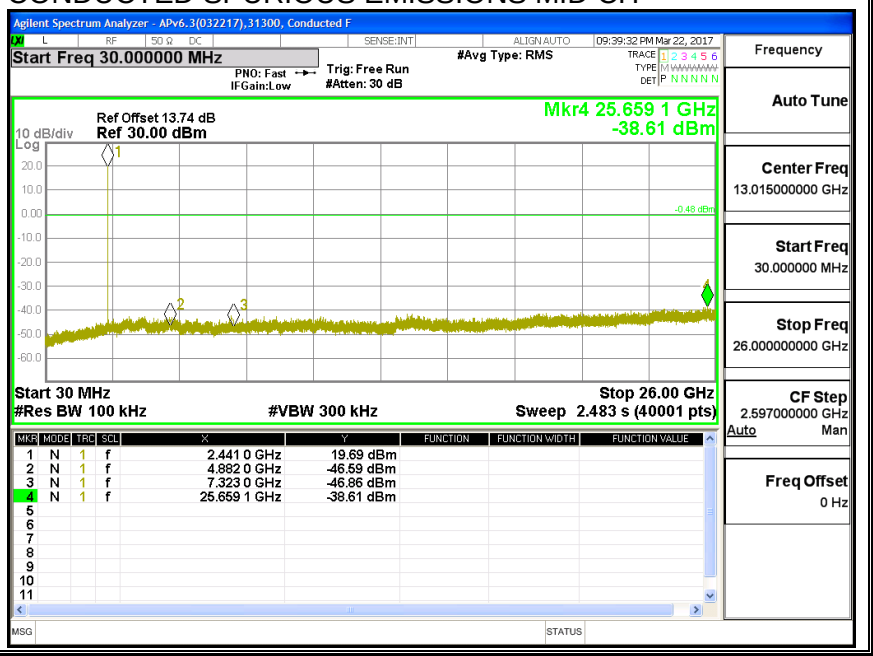
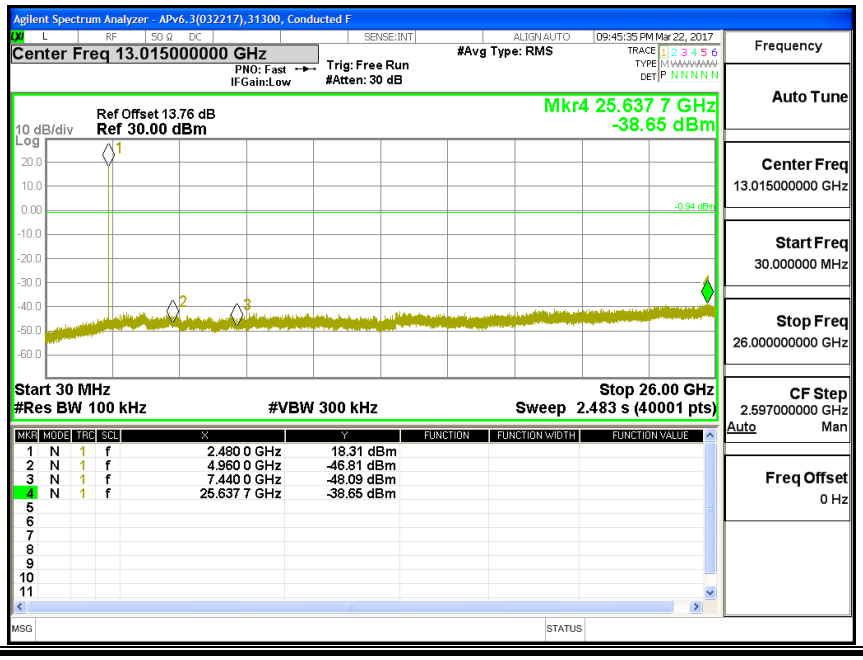
CONDUCTED SPURIOUS EMISSIONS MID CH



CONDUCTED SPURIOUS EMISSIONS HIGH CH



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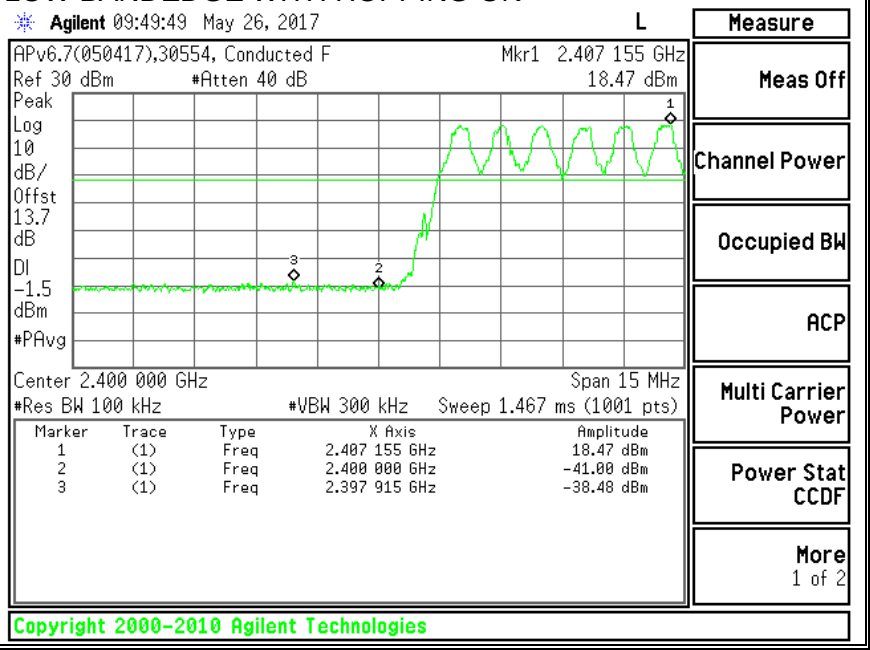
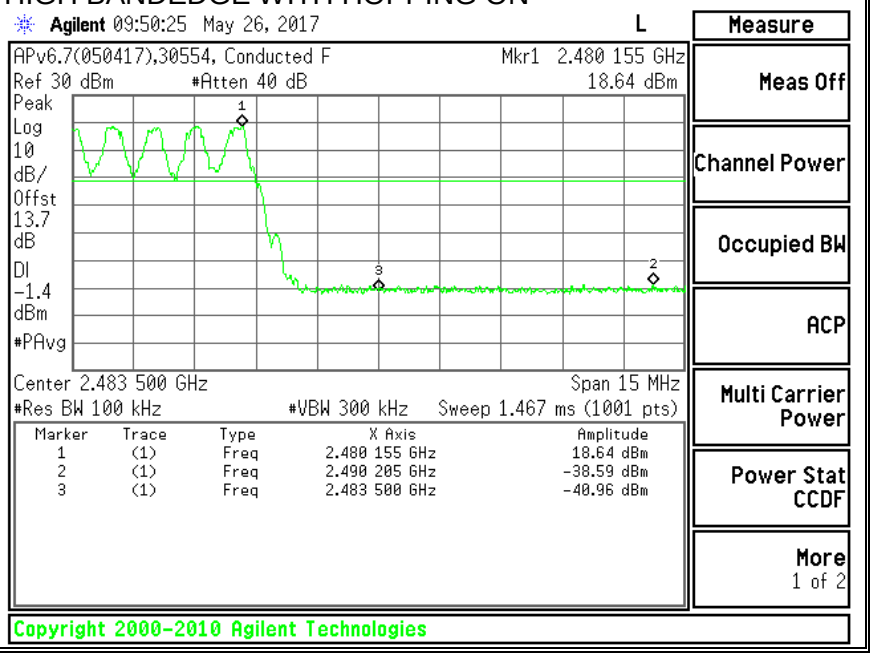
LOW BANDEDGE WITH HOPPING ON



HIGH BANDEDGE WITH HOPPING ON



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8.2. UAT 1, PMAX ENHANCED DATA RATE QPSK MODULATION

8.2.1. OUTPUT POWER

ID:	39472	Date:	6/14/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.
Alternatively, 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

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.21	21	-0.76
Middle	2441	20.03	21	-0.94
High	2480	20.36	21	-0.61

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8.2.2. AVERAGE POWER

ID:	39472	Date:	16/14/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	17.42
Middle	2441	17.31
High	2480	17.48

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8.3. UAT 1, PMAX ENHANCED DATA RATE 8PSK MODULATION

8.3.1. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

Channel	Frequency (MHz)	20 dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	2402	1328	1204.2
Middle	2441	1345	1223.7
High	2480	1343	1227.1

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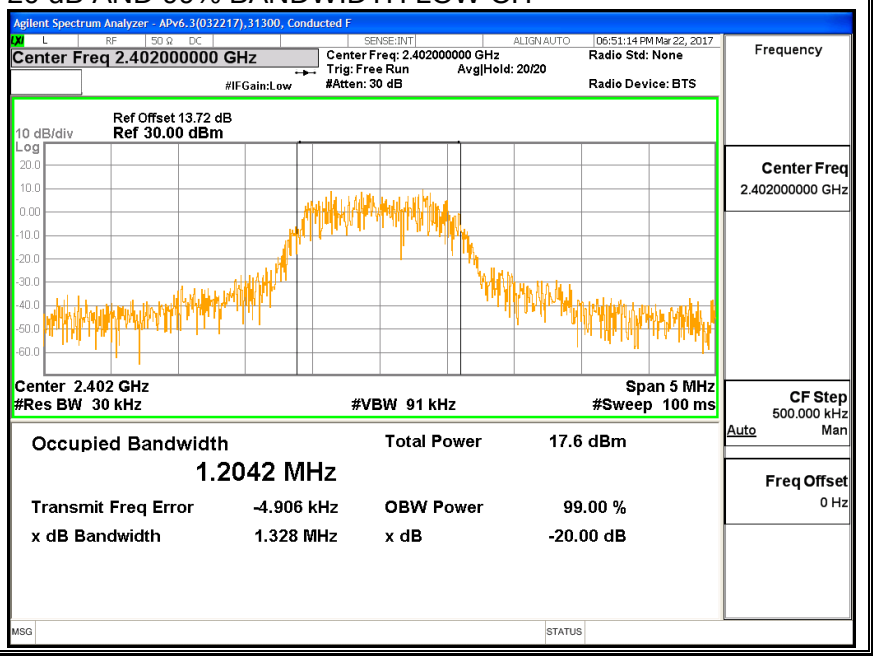
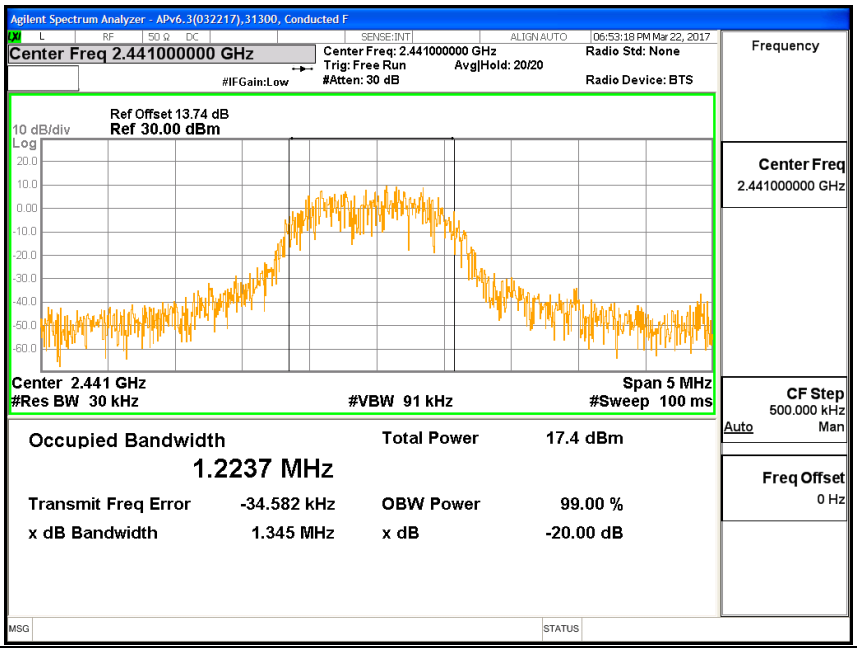
20 dB AND 99% BANDWIDTH LOW CH



20 dB AND 99% BANDWIDTH MID CH



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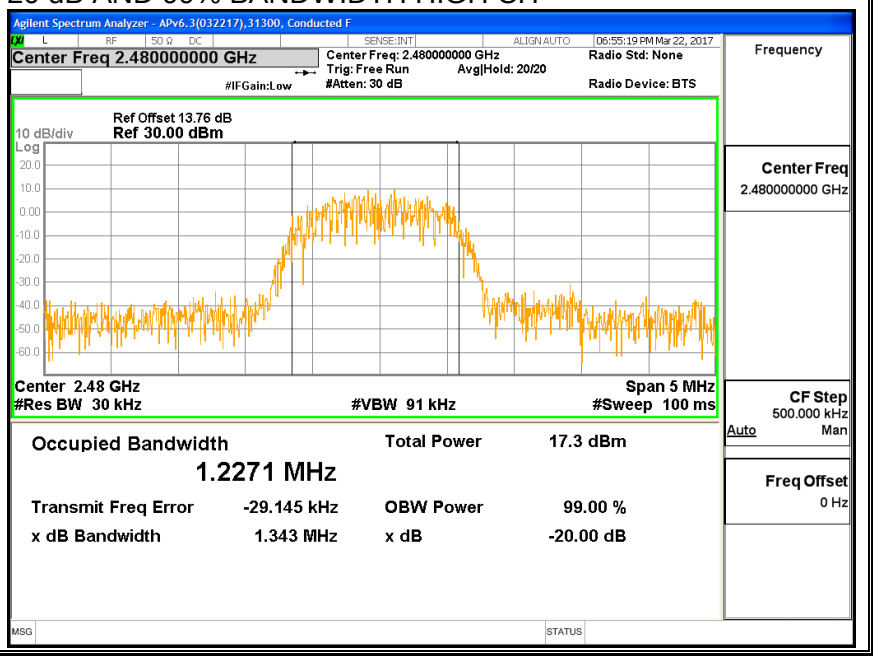
20 dB AND 99% BANDWIDTH HIGH CH



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8.3.2. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (b)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

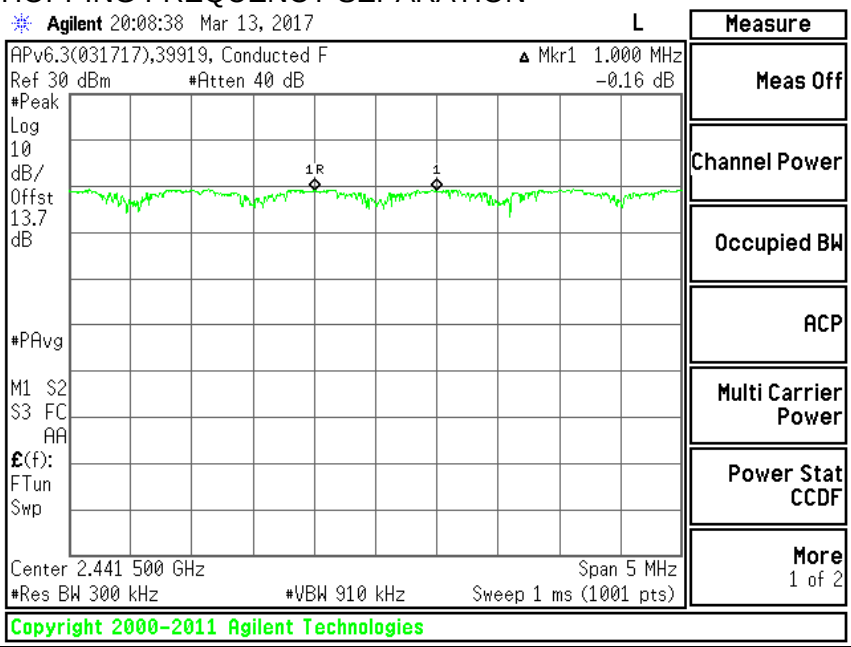
Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than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

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS

HOPPING FREQUENCY SEPARATION



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8.3.3. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

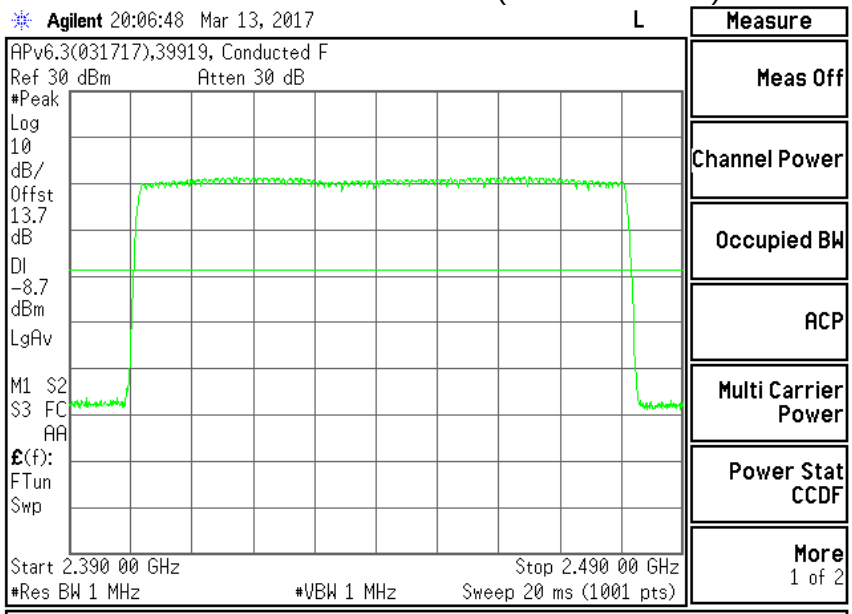
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 79 Channels observed.

NUMBER OF HOPPING CHANNELS (100 MHz SPAN)



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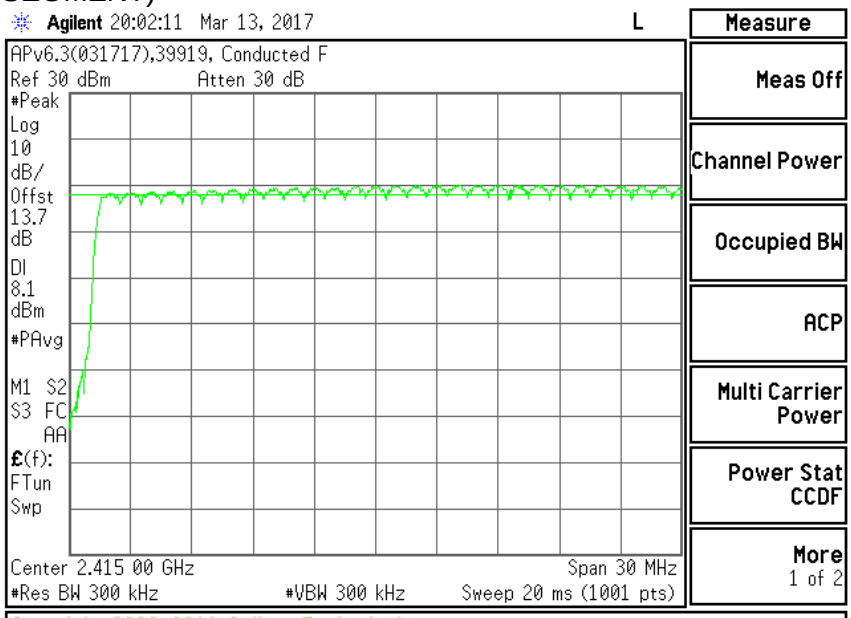
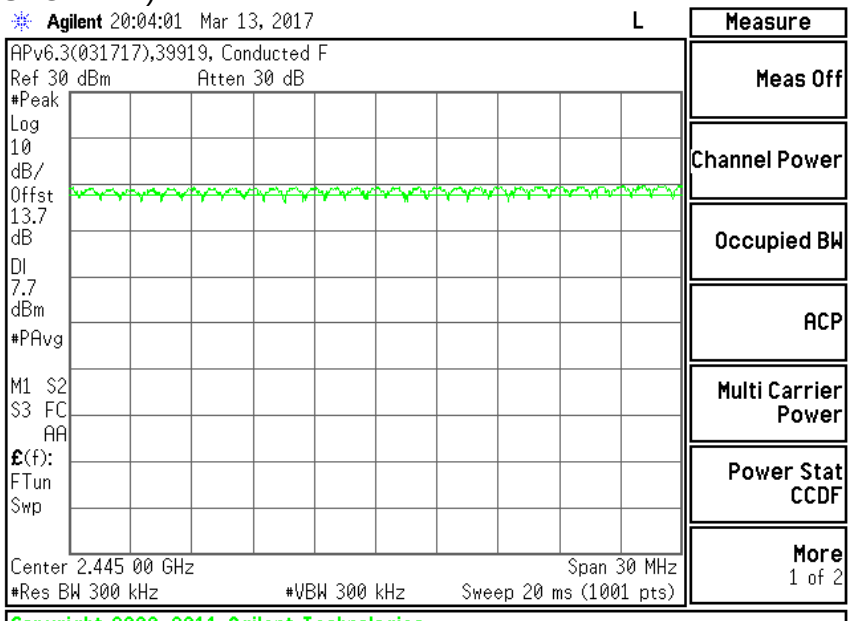
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, FIRST SEGMENT)



NUMBER OF HOPPING CHANNELS (30 MHz SPAN, SECOND SEGMENT)



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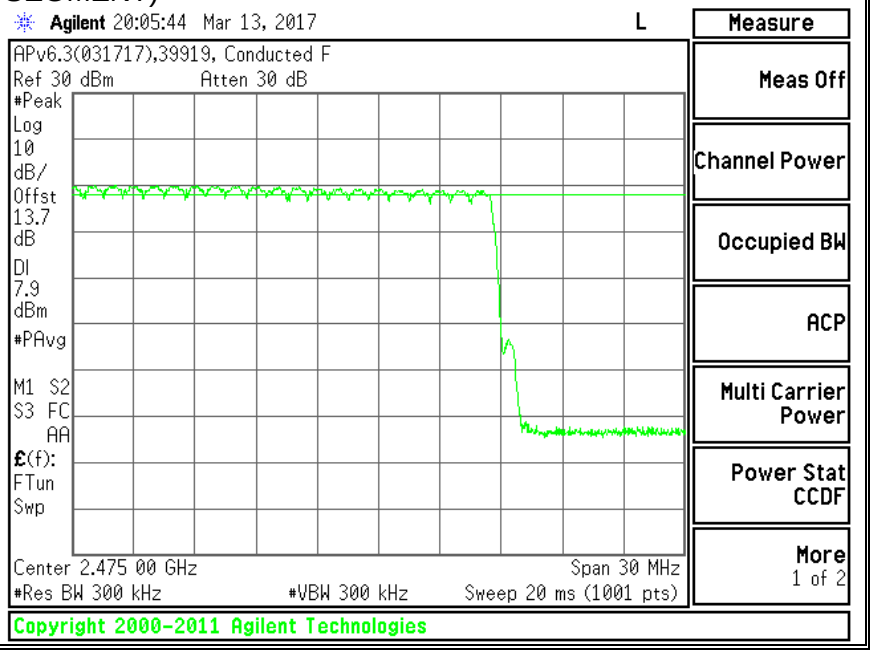
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, THIRD SEGMENT)



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8.3.4. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

RESULTS

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK (EDR) Mode					
3DH1	0.3889	32	0.124	0.4	-0.276
3DH3	1.64	18	0.295	0.4	-0.105
3DH5	2.891	10	0.289	0.4	-0.111

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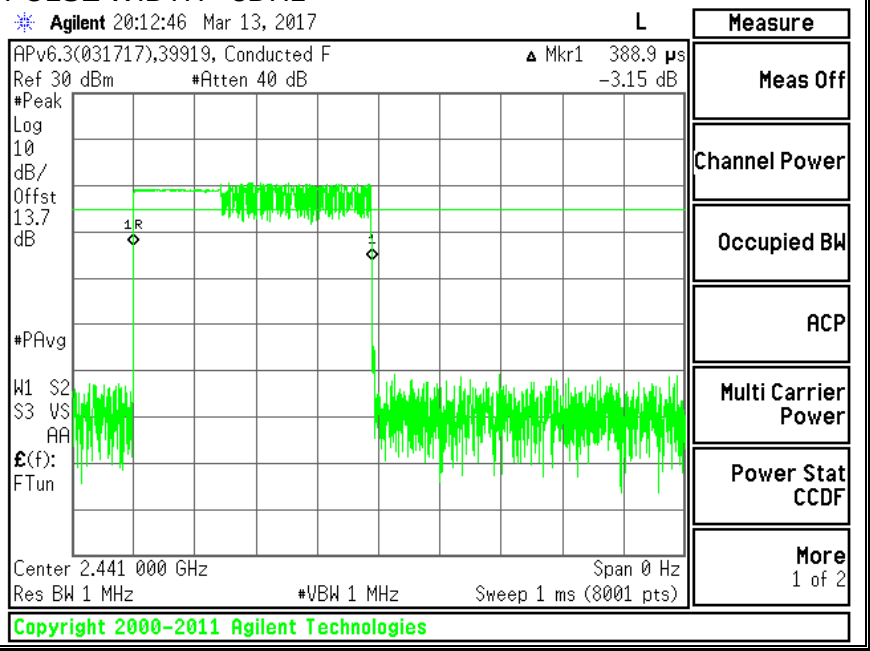
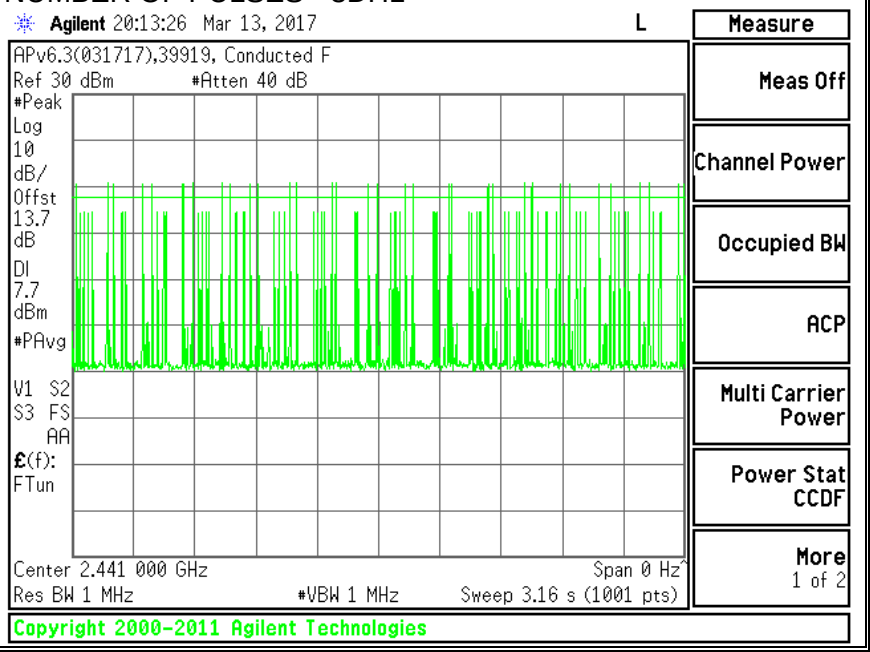
PULSE WIDTH - 3DH1



NUMBER OF PULSES - 3DH1



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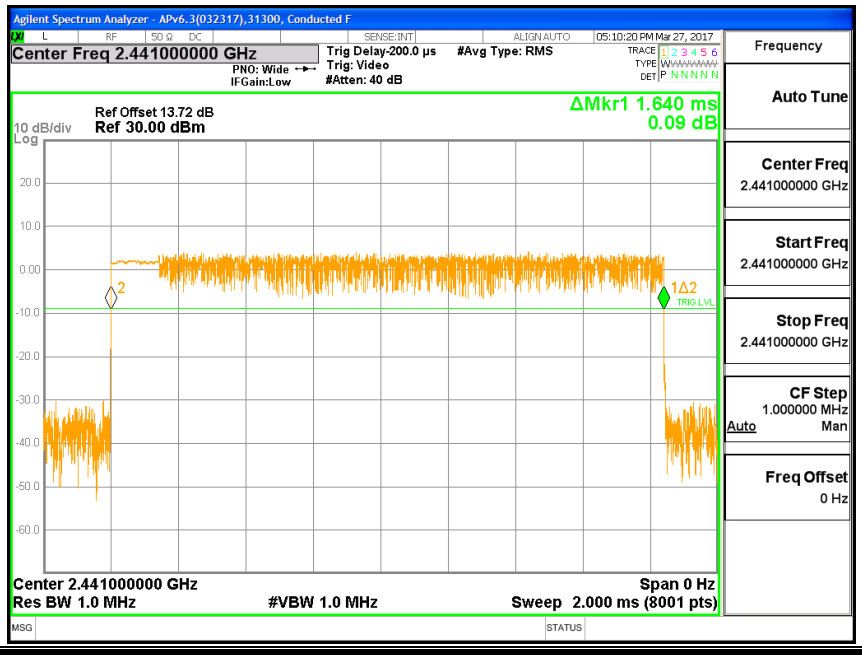
PULSE WIDTH - 3DH3



NUMBER OF PULSES - 3DH3

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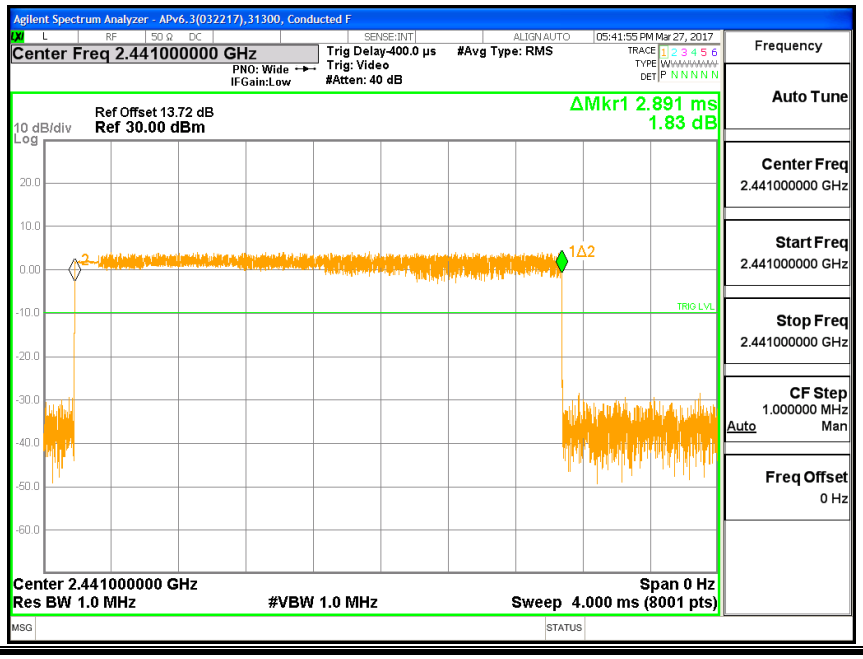
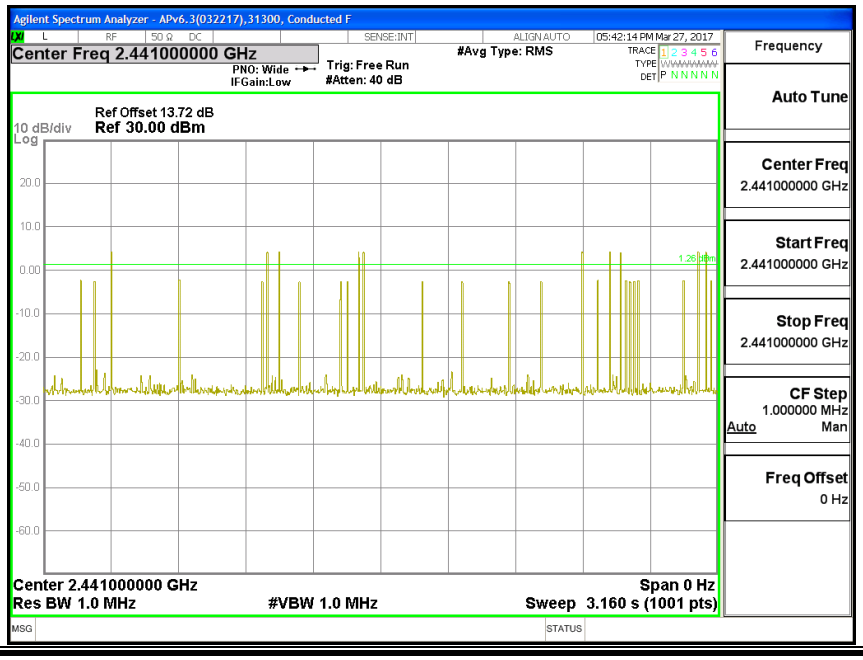
PULSE WIDTH - 3DH5



NUMBER OF PULSES - 3DH5



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8.3.5. OUTPUT POWER

ID:	30554	Date:	6/11/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.
Alternatively, 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

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.34	21	-0.63
Middle	2441	20.20	21	-0.77
High	2480	20.42	21	-0.55

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8.3.6. AVERAGE POWER

ID:	30554	Date:	6/11/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	17.43
Middle	2441	17.35
High	2480	17.48

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8.3.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-247 (5.5)

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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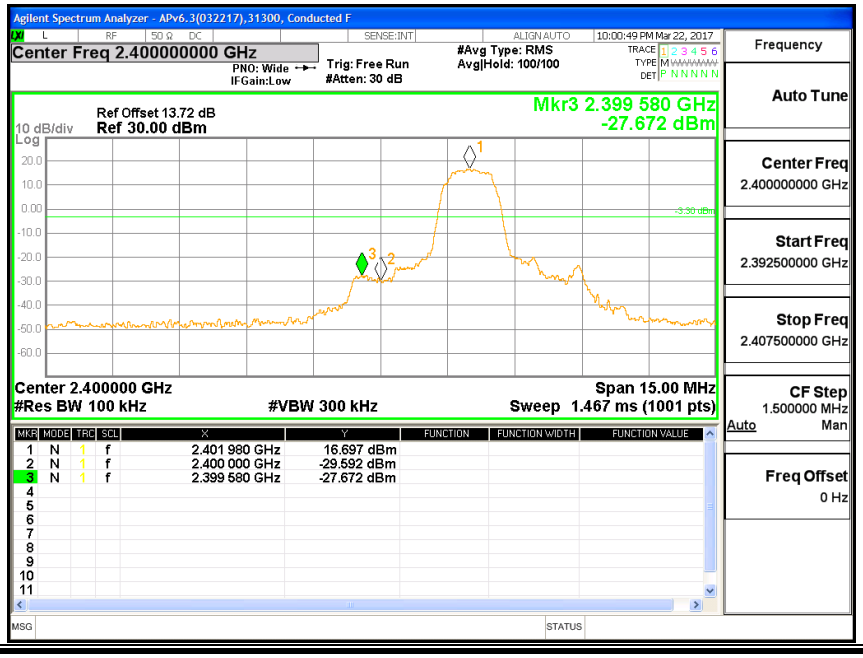
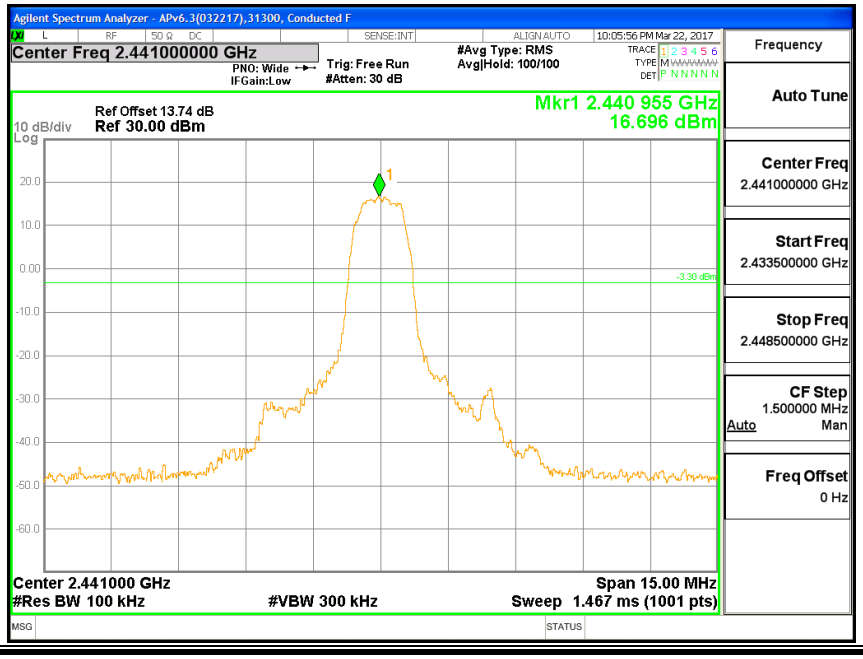
CONDUCTED BANDEDGE AND SPURIOUS EMISSIONS

CONDUCTED BANDEDGE LOW CH



CONDUCTED BANDEDGE MID CH



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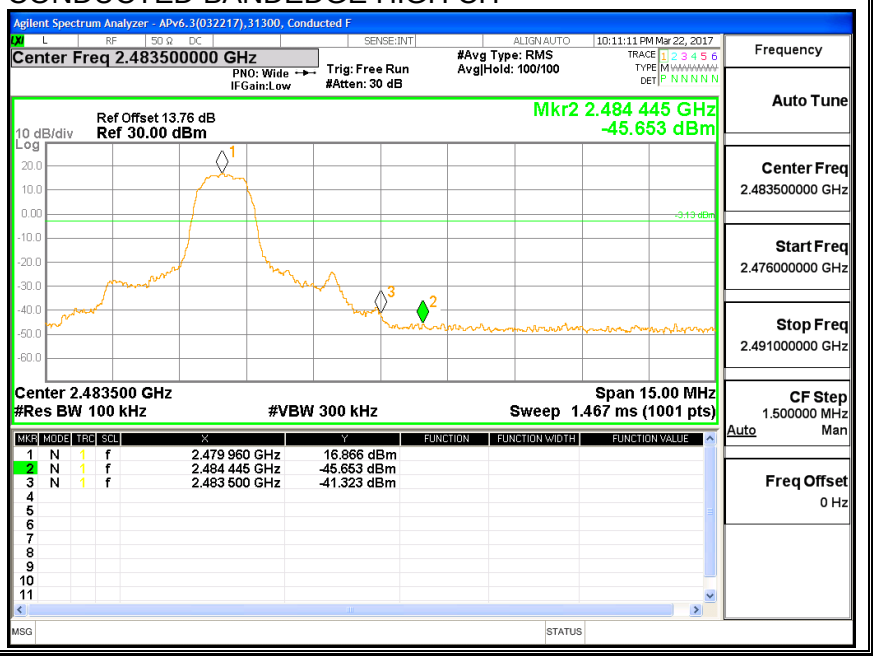
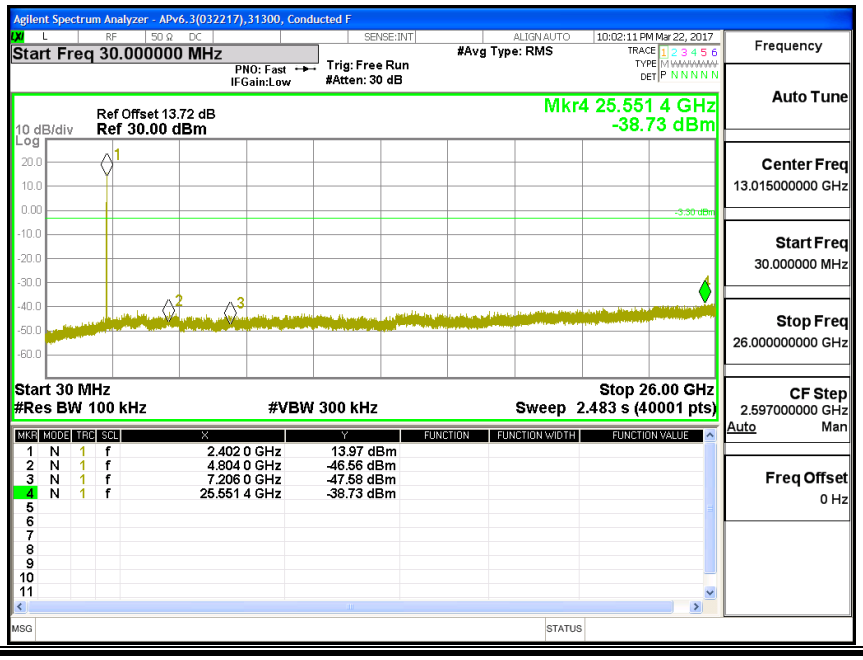
CONDUCTED BANDEDGE HIGH CH



CONDUCTED SPURIOUS EMISSIONS LOW CH



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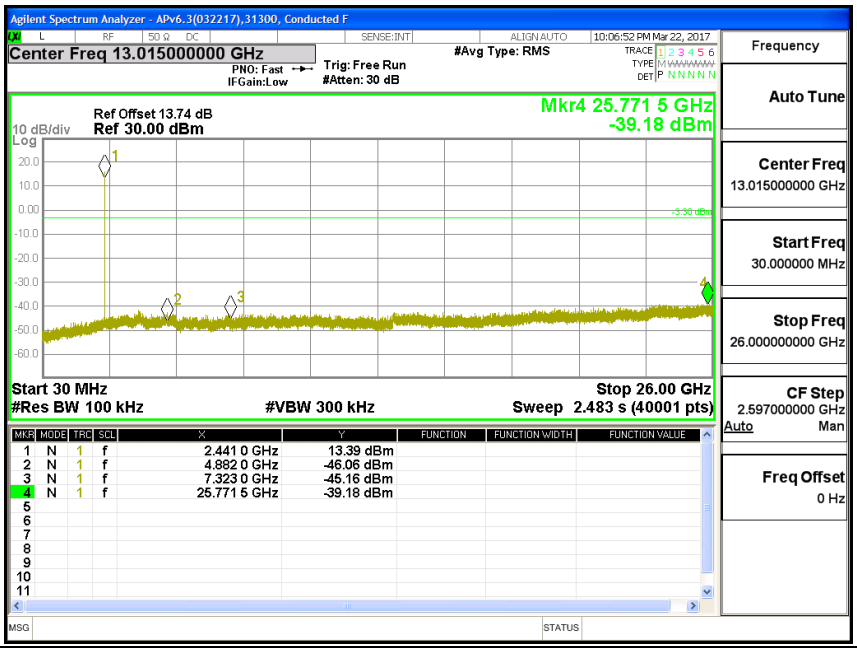
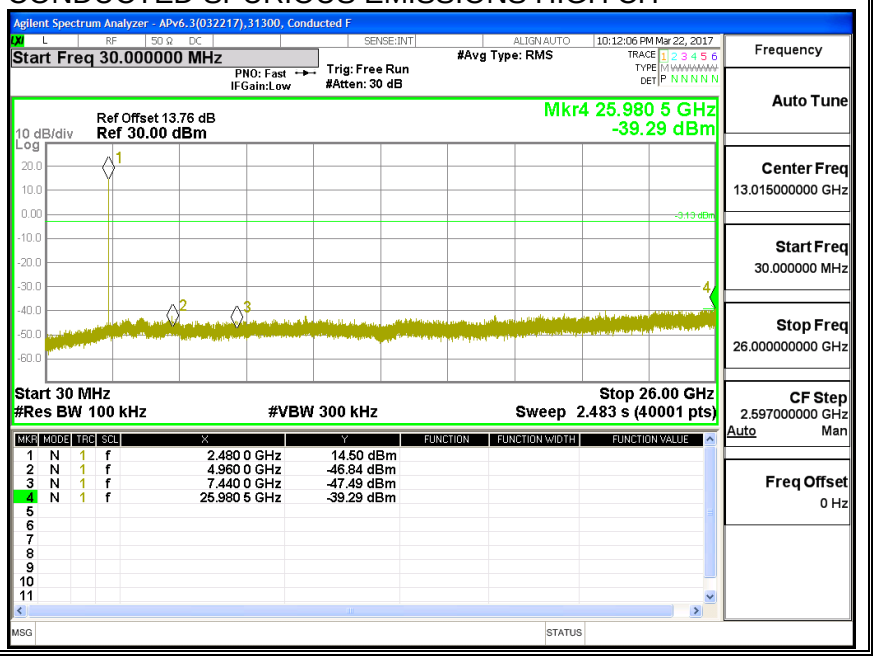
CONDUCTED SPURIOUS EMISSIONS MID CH



CONDUCTED SPURIOUS EMISSIONS HIGH CH



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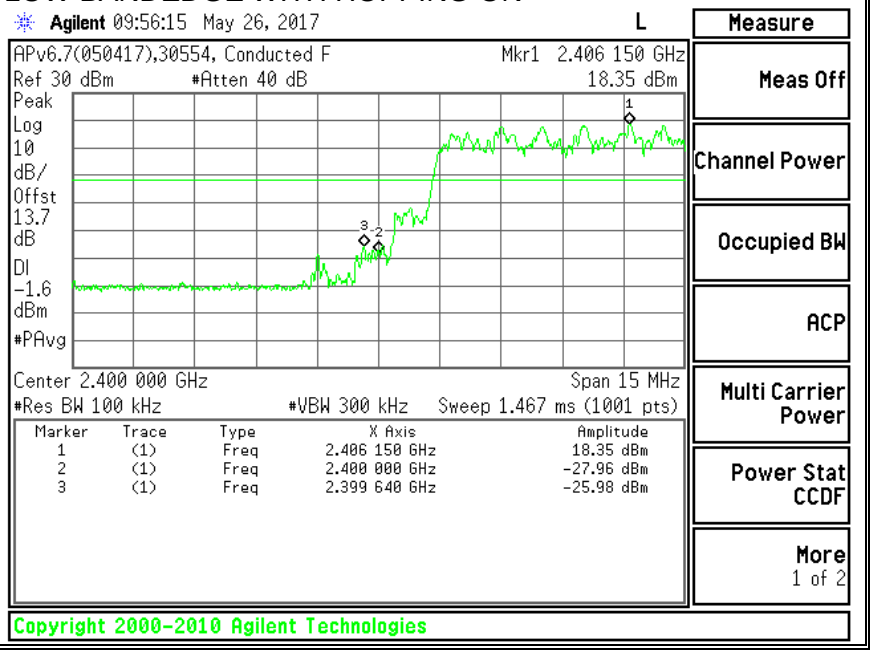
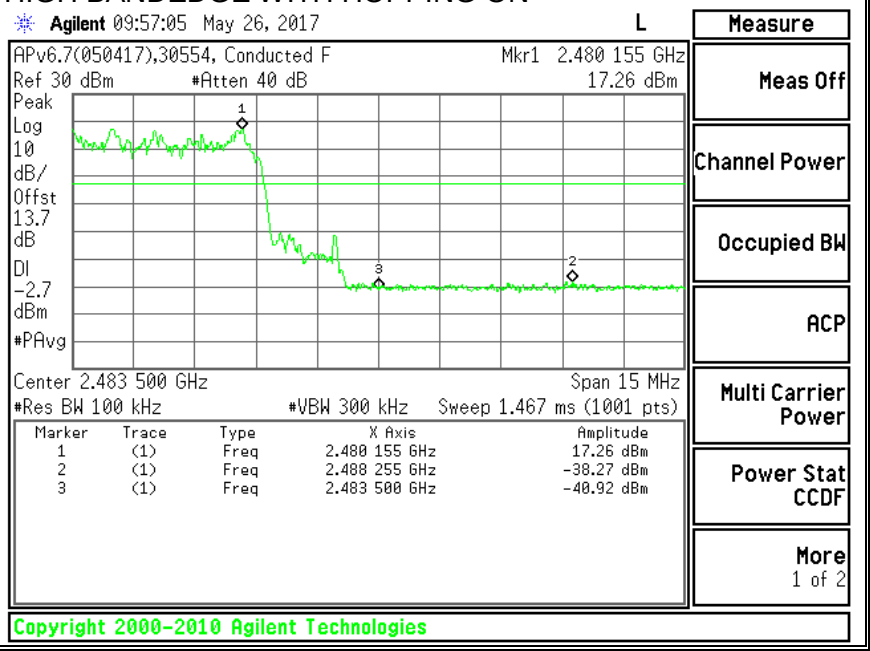
LOW BANDEDGE WITH HOPPING ON



HIGH BANDEDGE WITH HOPPING ON



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8.4. UAT 1, PLOW BASIC DATA RATE GFSK MODULATION

8.4.1. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

Channel	Frequency (MHz)	20 dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	2402	858.3	861.50
Middle	2441	913.7	896.76
High	2480	912.9	888.04

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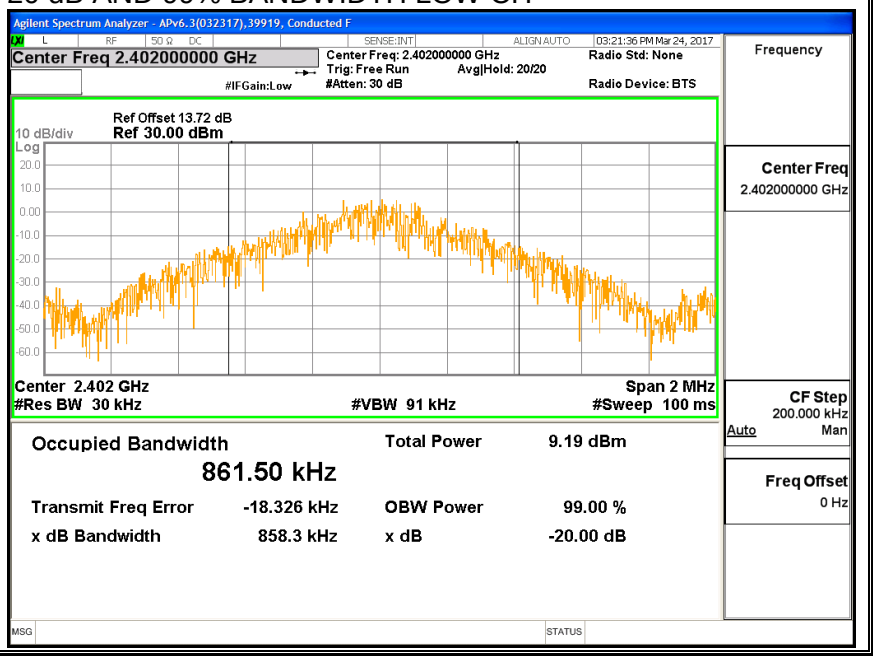
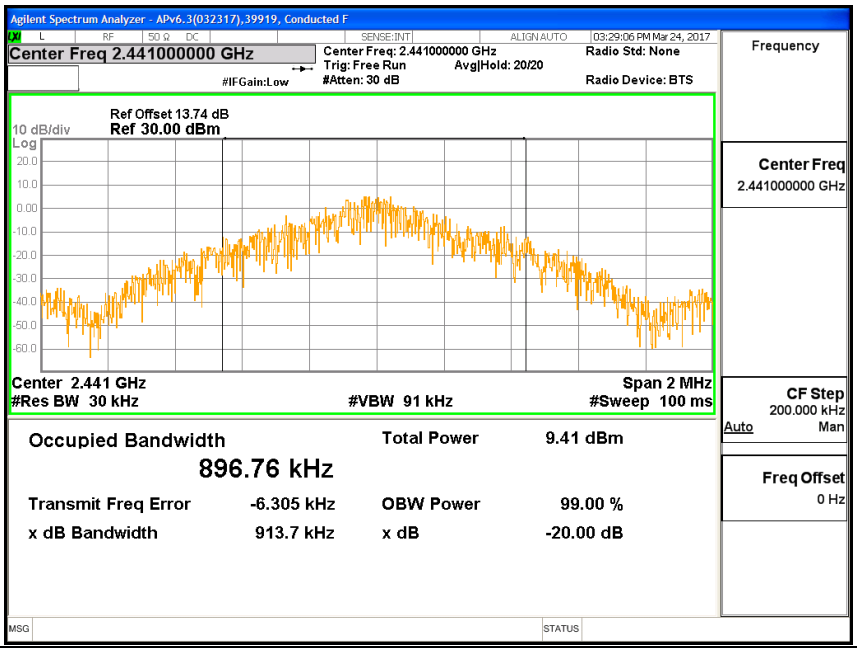
20 dB AND 99% BANDWIDTH LOW CH



20 dB AND 99% BANDWIDTH MID CH



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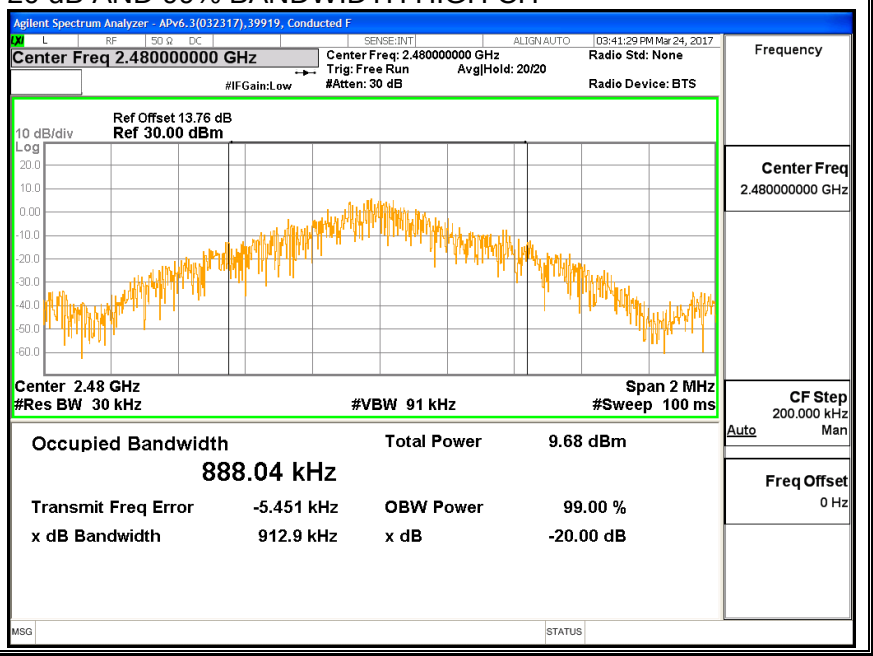
20 dB AND 99% BANDWIDTH HIGH CH



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8.4.2. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (b)

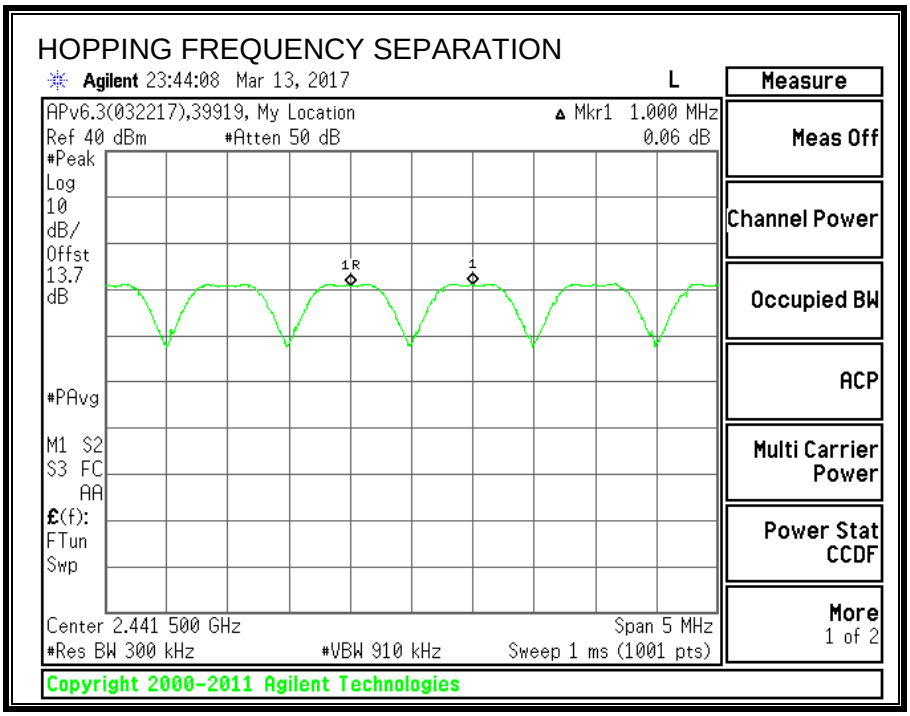
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

Alternatively, 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS



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8.4.3. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

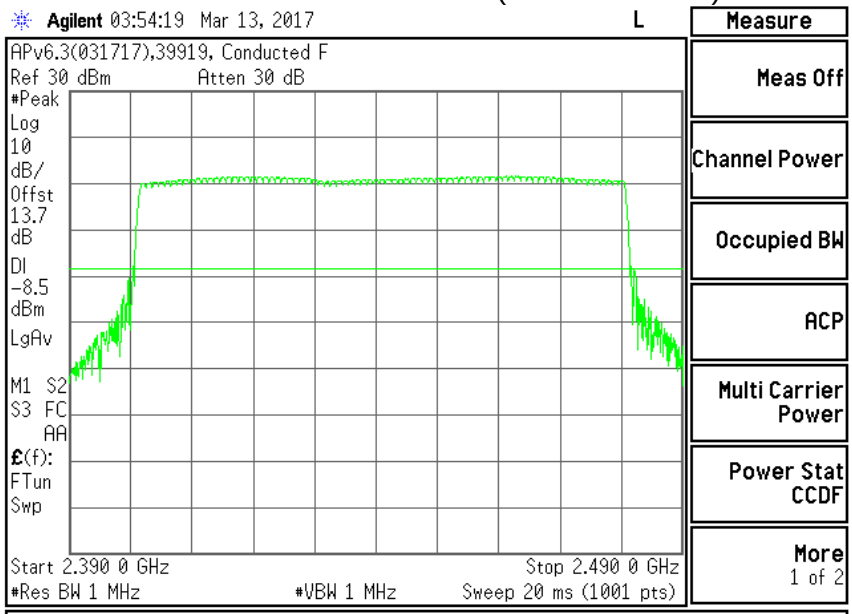
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 79 Channels observed.

NUMBER OF HOPPING CHANNELS (100 MHz SPAN)



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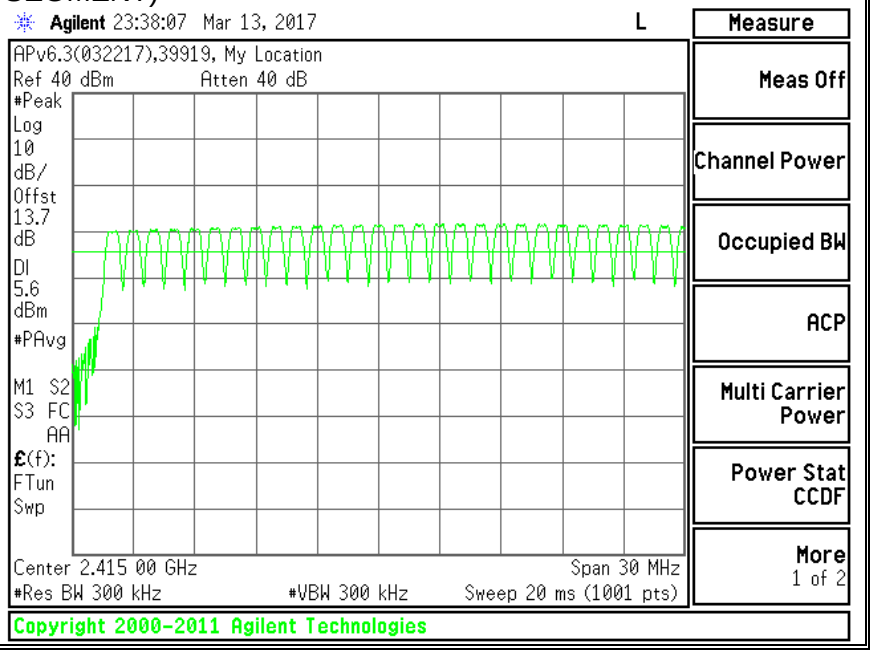
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, FIRST SEGMENT)



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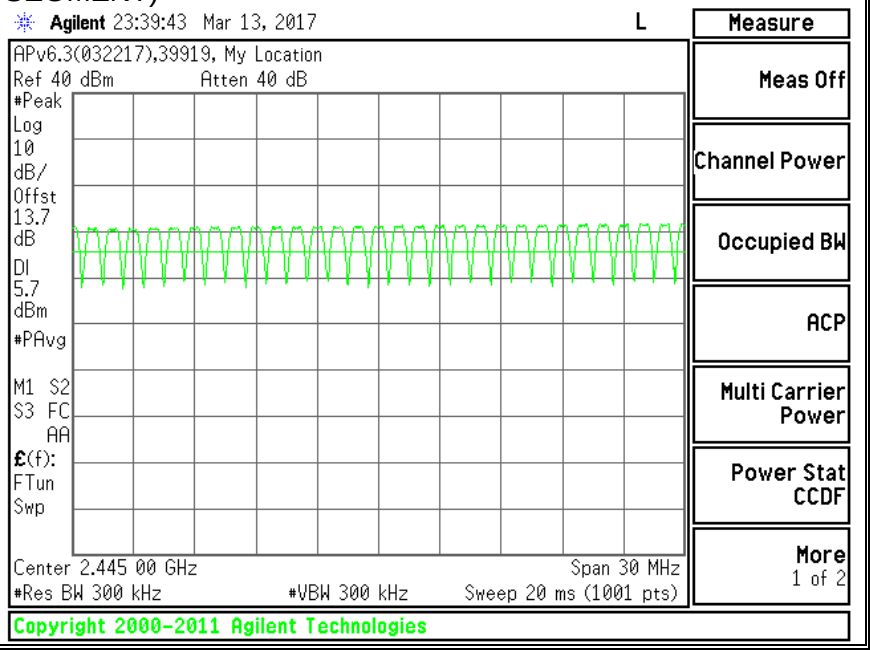
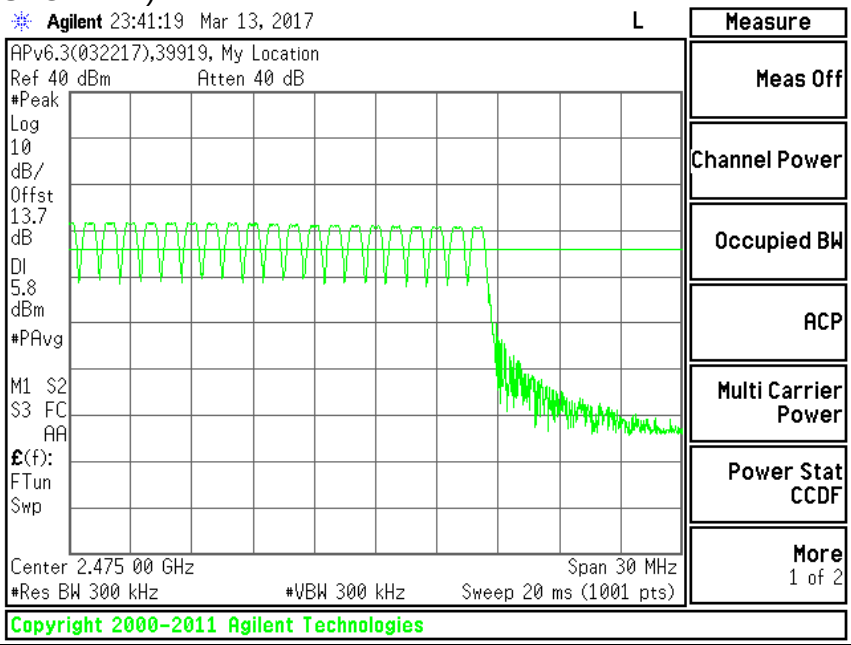
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, SECOND SEGMENT)



NUMBER OF HOPPING CHANNELS (30 MHz SPAN, THIRD SEGMENT)



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8.4.4. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to 10 * (# of pulses in 0.8 s) * pulse width.

RESULTS

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.3878	30	0.116	0.4	-0.284
DH3	1.644	16	0.263	0.4	-0.137
DH5	2.892	12	0.347	0.4	-0.053
DH Packet	**Pulse Width (msec)**	**Number of Pulses in 0.8 seconds**	**Average Time of Occupancy (sec)**	**Limit (sec)**	**Margin (sec)**
GFSK AFH Mode					
DH1	0.3878	8	0.031	0.4	-0.369
DH3	1.644	4	0.263	0.4	-0.137
DH5	2.892	3	0.347	0.4	-0.053

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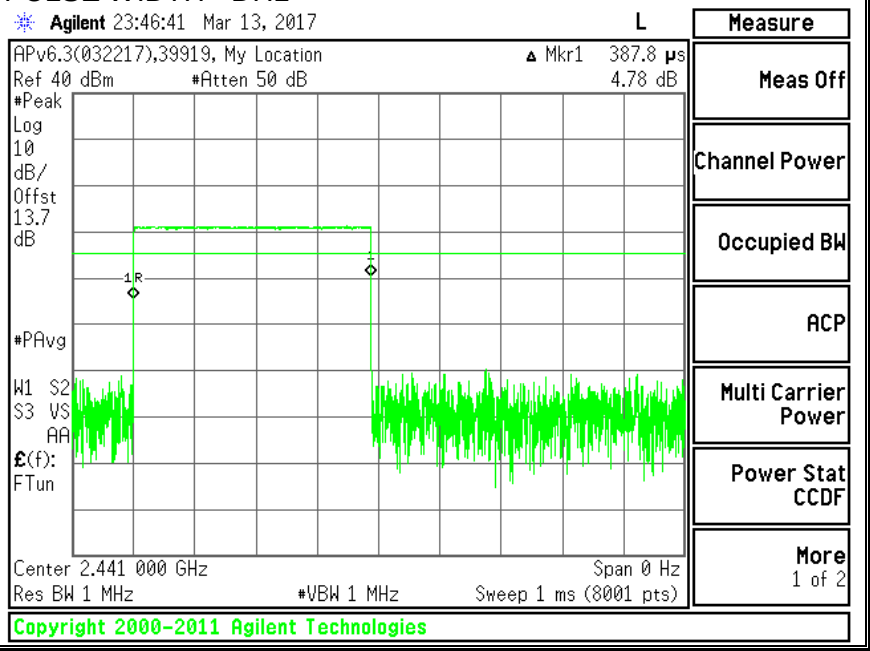
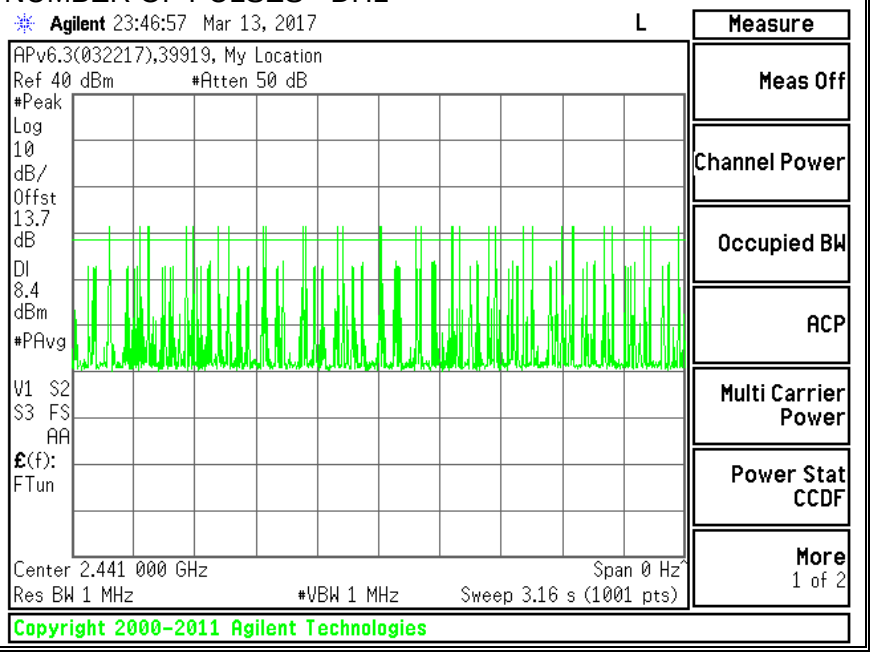
PULSE WIDTH - DH1



NUMBER OF PULSES - DH1



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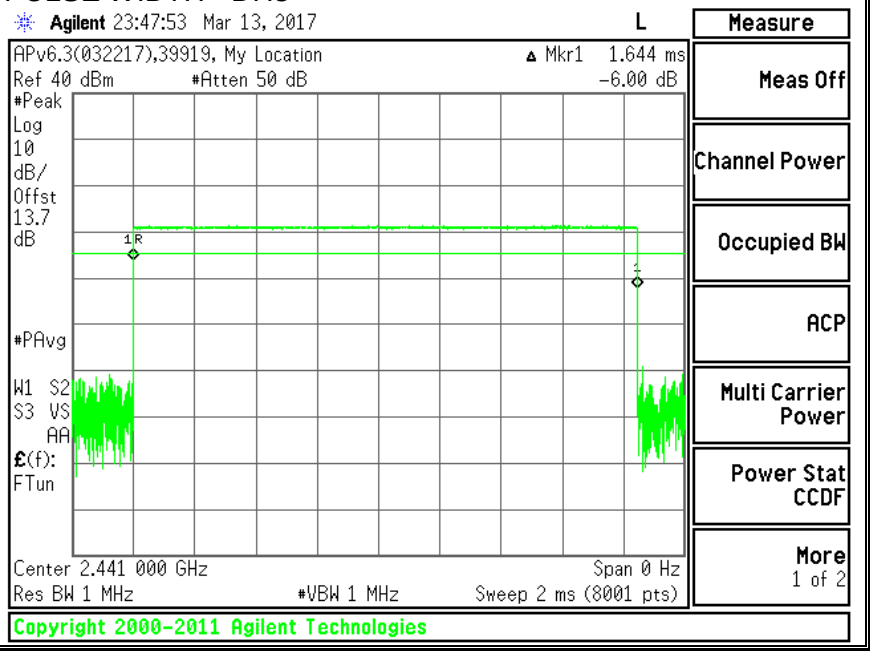
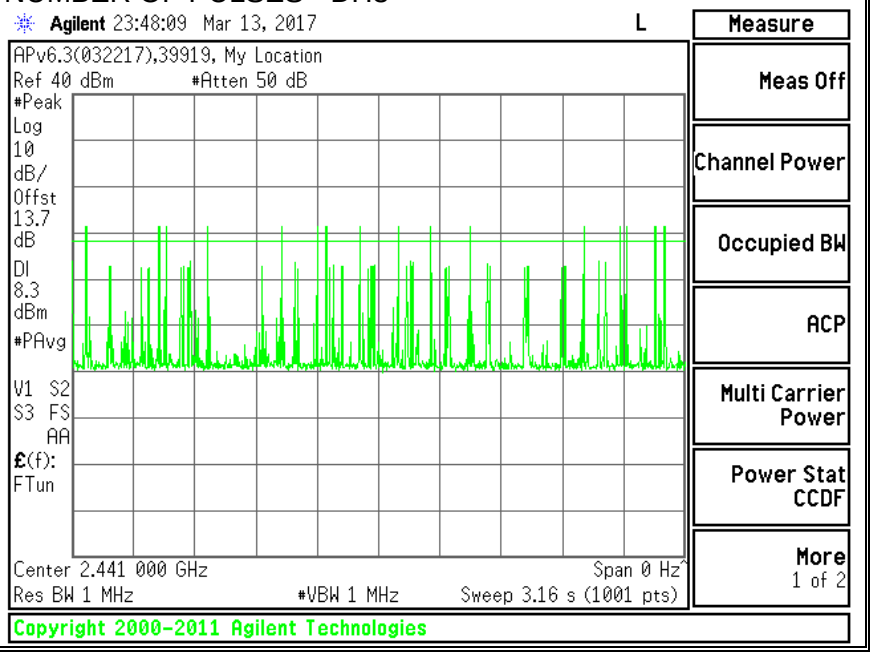
PULSE WIDTH - DH3



NUMBER OF PULSES - DH3



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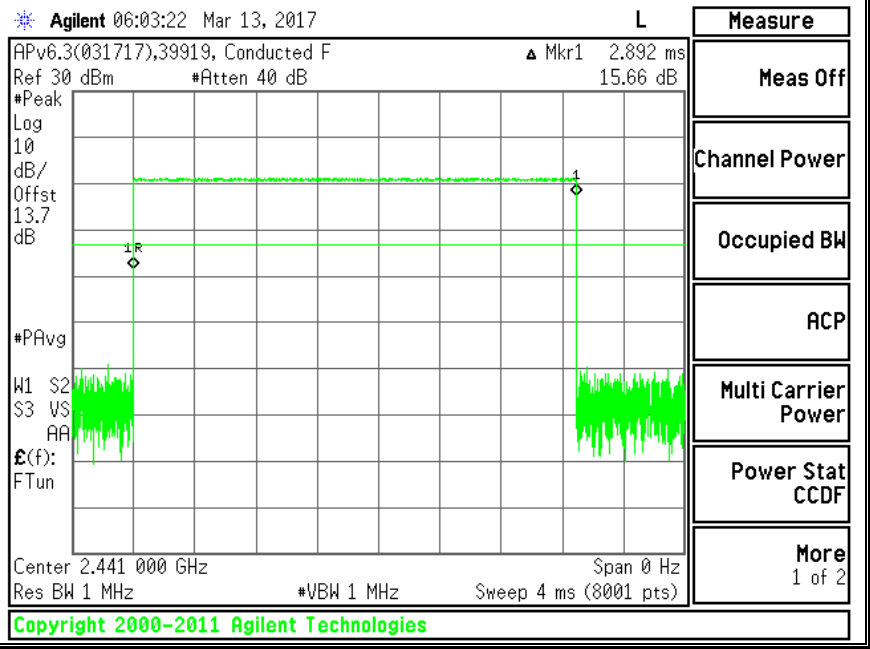
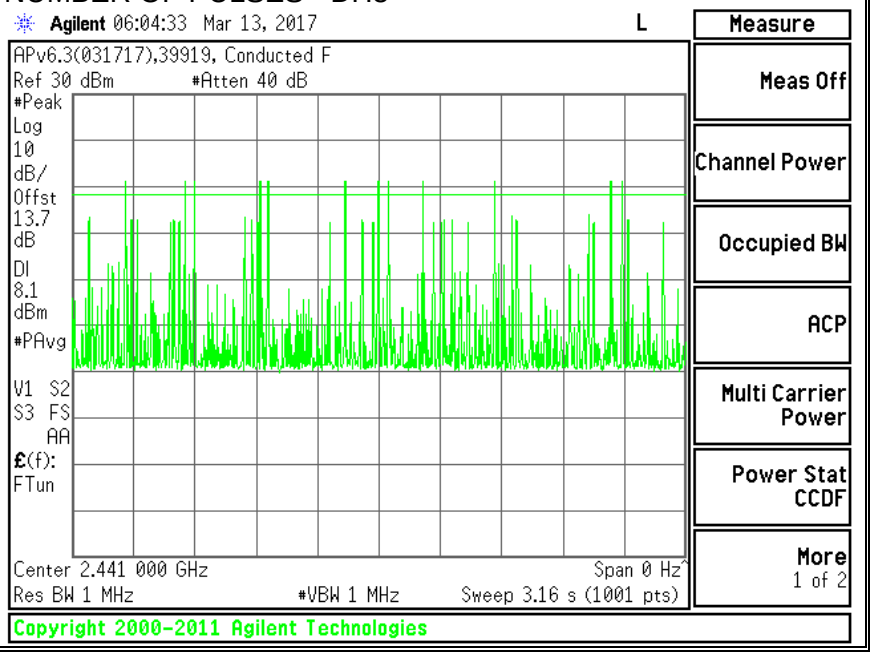
PULSE WIDTH - DH5



NUMBER OF PULSES - DH5



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8.4.5. OUTPUT POWER

ID:	30554	Date:	6/11/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	9.82	30	-20.18
Middle	2441	10.28	30	-19.72
High	2480	10.25	30	-19.75

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8.4.6. AVERAGE POWER

ID:	30554	Date:	6/11/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	9.40
Middle	2441	9.90
High	2480	9.90

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8.4.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-247 (5.5)

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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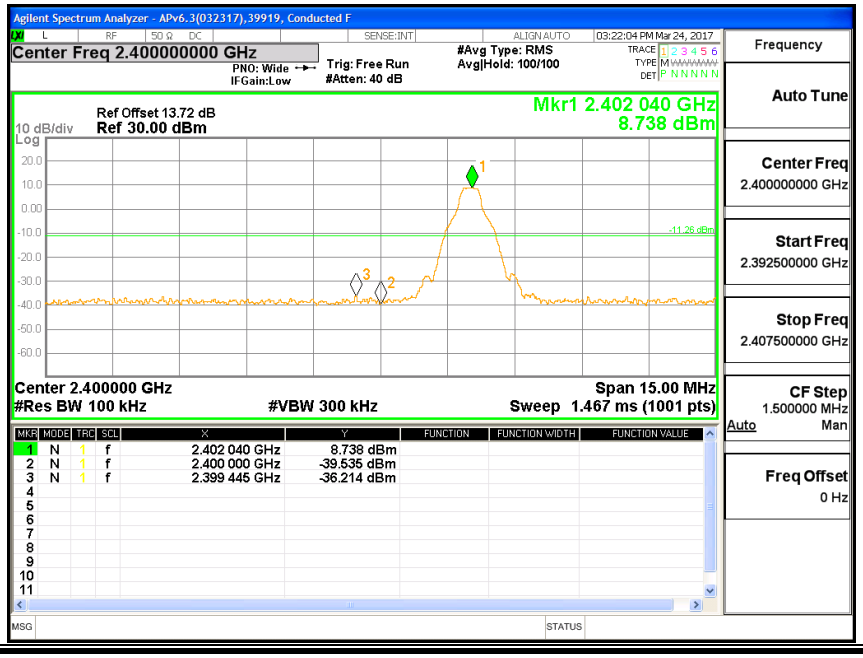
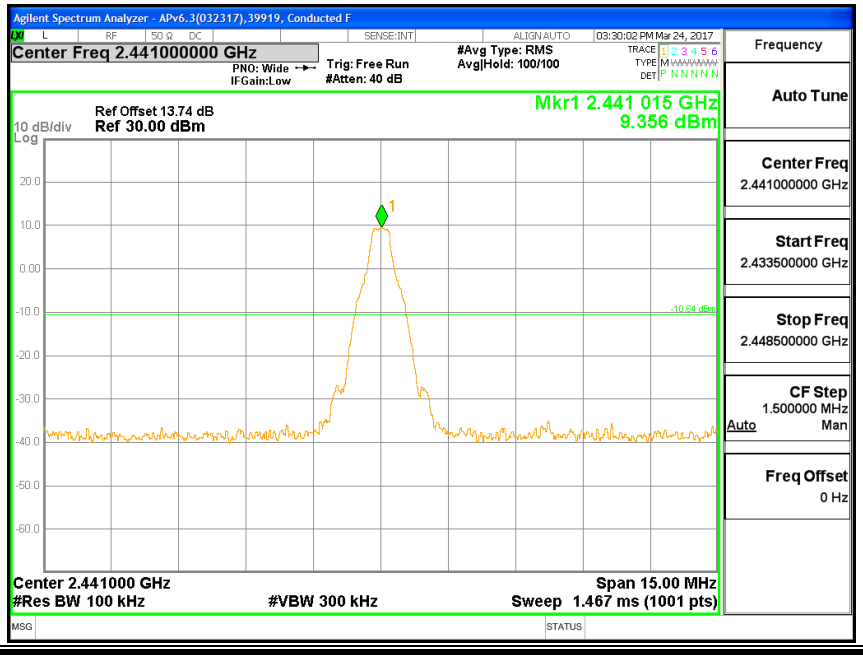
CONDUCTED BANDEDGE AND SPURIOUS EMISSIONS

CONDUCTED BANDEDGE LOW CH



CONDUCTED BANDEDGE MID CH



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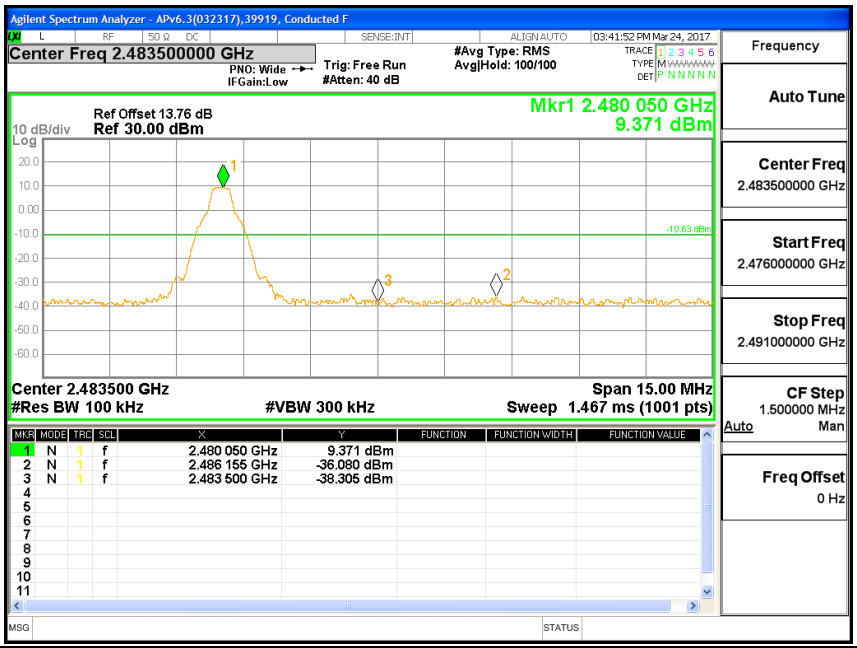
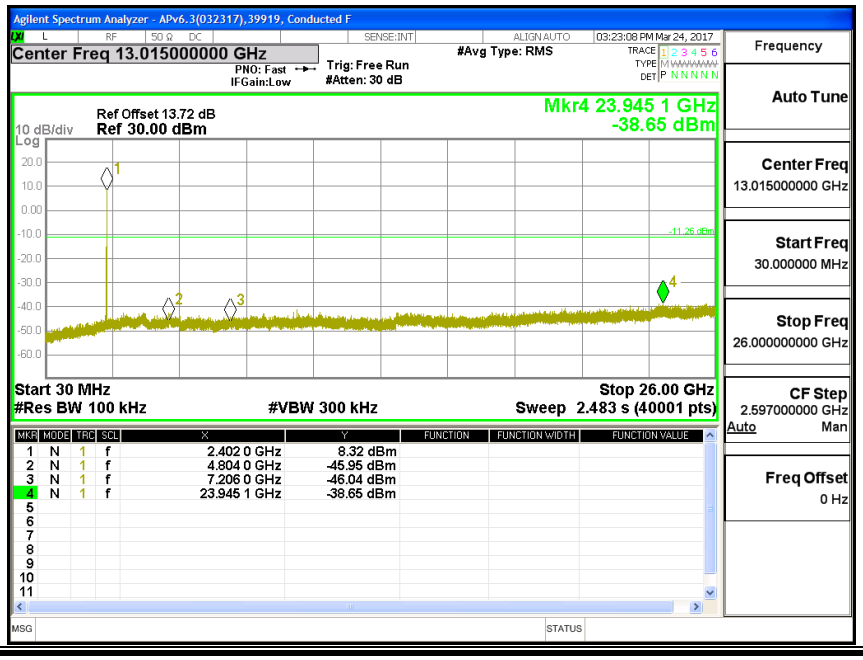
CONDUCTED BANDEDGE HIGH CH



CONDUCTED SPURIOUS EMISSIONS LOW CH



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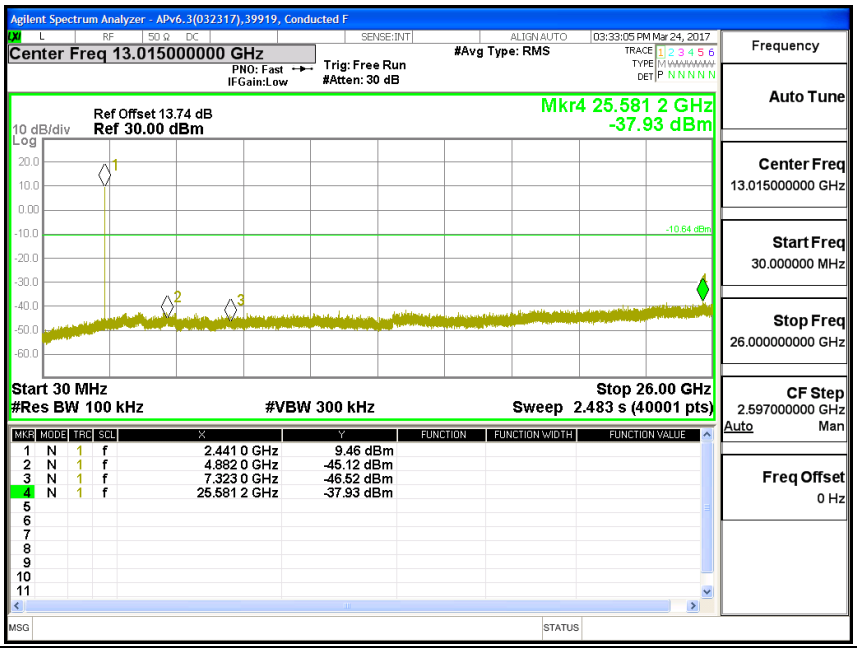
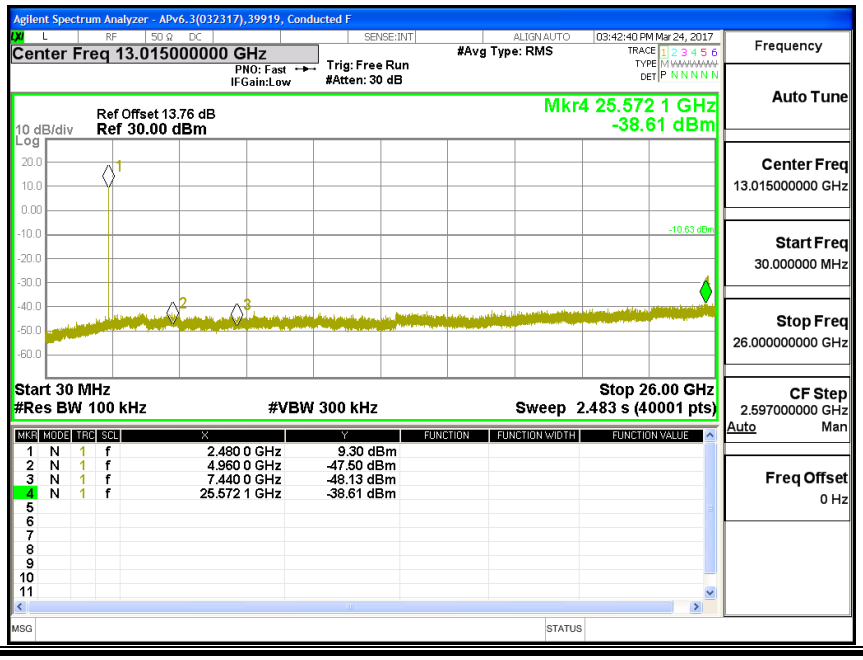
CONDUCTED SPURIOUS EMISSIONS MID CH



CONDUCTED SPURIOUS EMISSIONS HIGH CH



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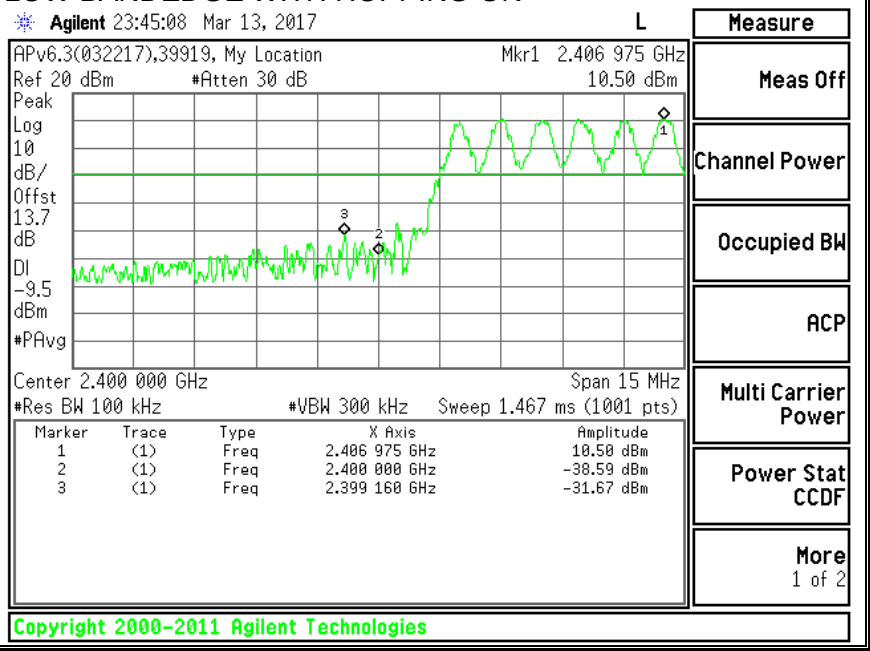
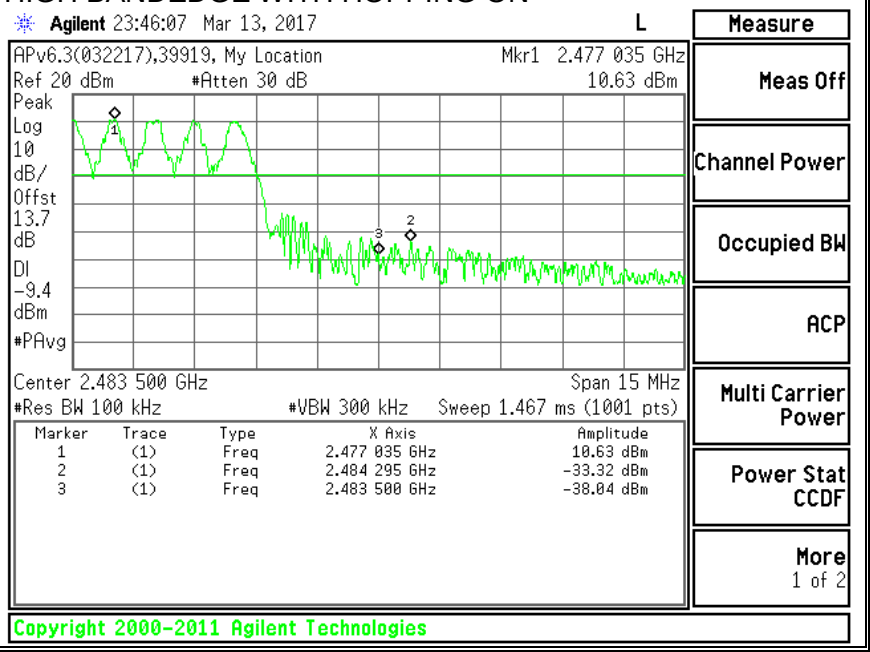
LOW BANDEDGE WITH HOPPING ON



HIGH BANDEDGE WITH HOPPING ON



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8.5. UAT 1, PLOW ENHANCED DATA RATE QPSK MODULATION

8.5.1. OUTPUT POWER

ID:	39472	Date:	6/14/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.
Alternatively, 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

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.17	21	-10.80
Middle	2441	10.31	21	-10.66
High	2480	10.12	21	-10.85

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8.5.2. AVERAGE POWER

ID:	39472	Date:	6/14/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.69
Middle	2441	7.78
High	2480	7.72

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8.6. UAT 1, PLOW ENHANCED DATA RATE 8PSK MODULATION

8.6.1. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

Channel	Frequency (MHz)	20 dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	2402	1364	1214.7
Middle	2441	1353	1236.2
High	2480	1329	1227.2

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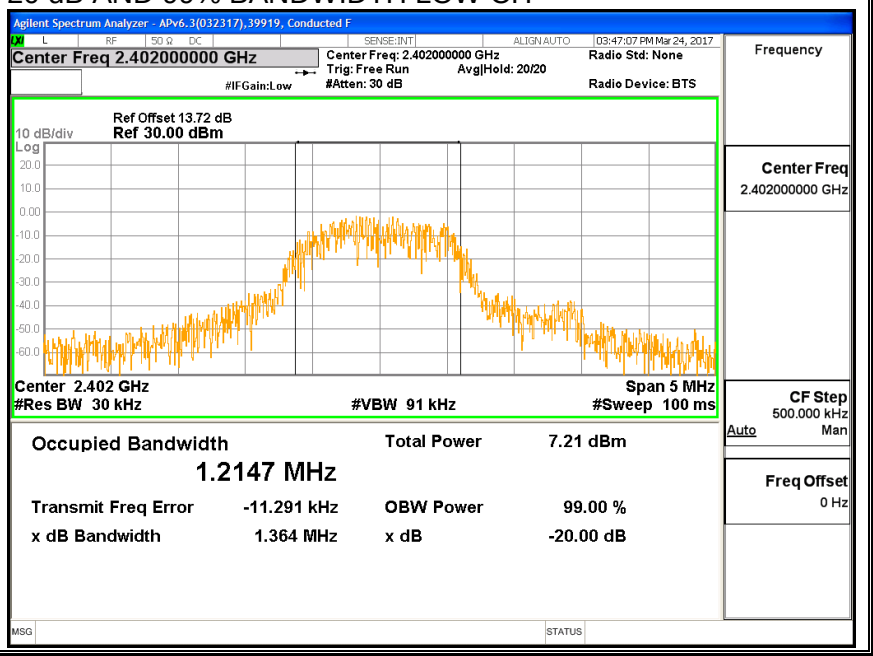
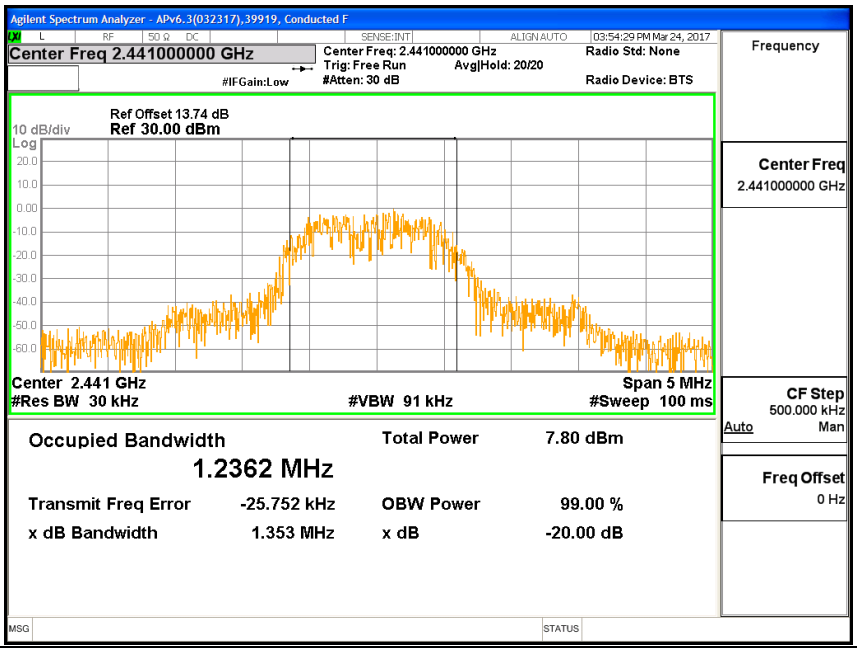
20 dB AND 99% BANDWIDTH LOW CH



20 dB AND 99% BANDWIDTH MID CH



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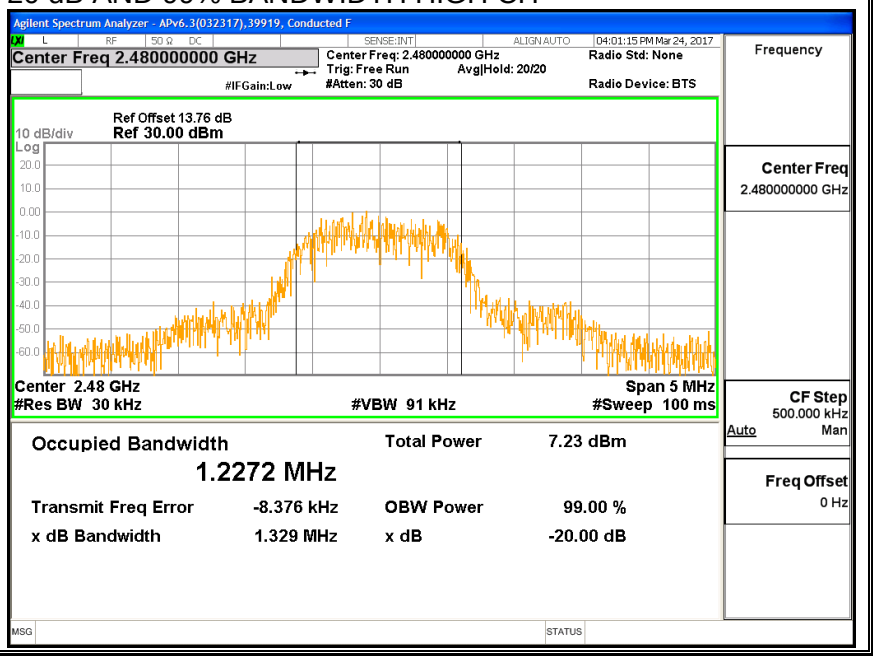
20 dB AND 99% BANDWIDTH HIGH CH



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8.6.2. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (b)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

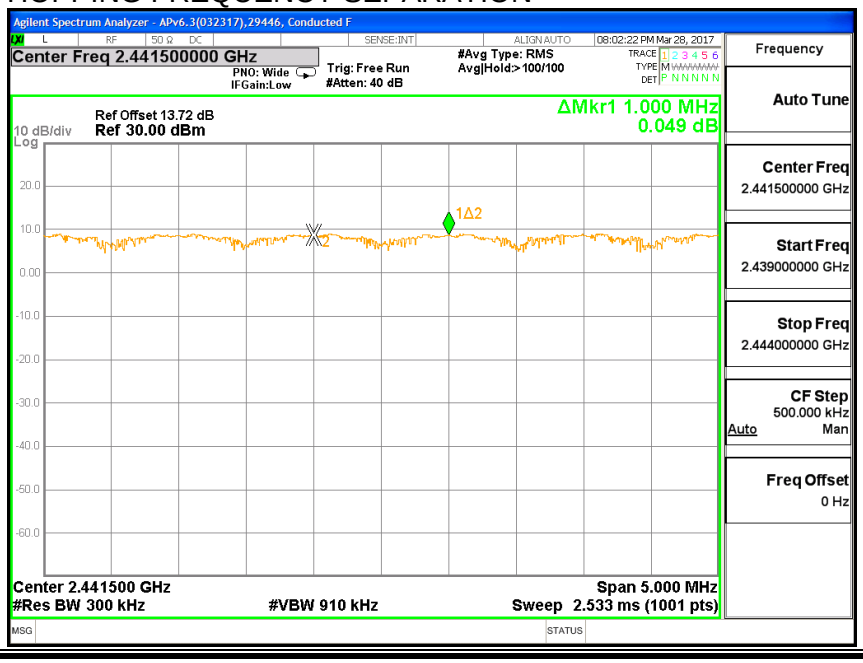
Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than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

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS

HOPPING FREQUENCY SEPARATION



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8.6.3. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

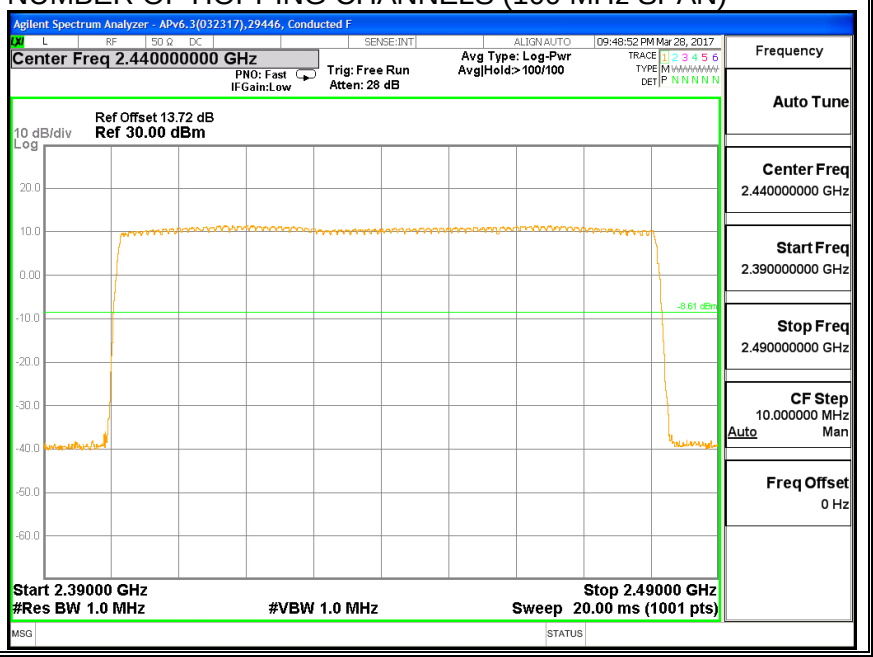
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

RESULTS

Normal Mode: 79 Channels observed.

NUMBER OF HOPPING CHANNELS (100 MHz SPAN)



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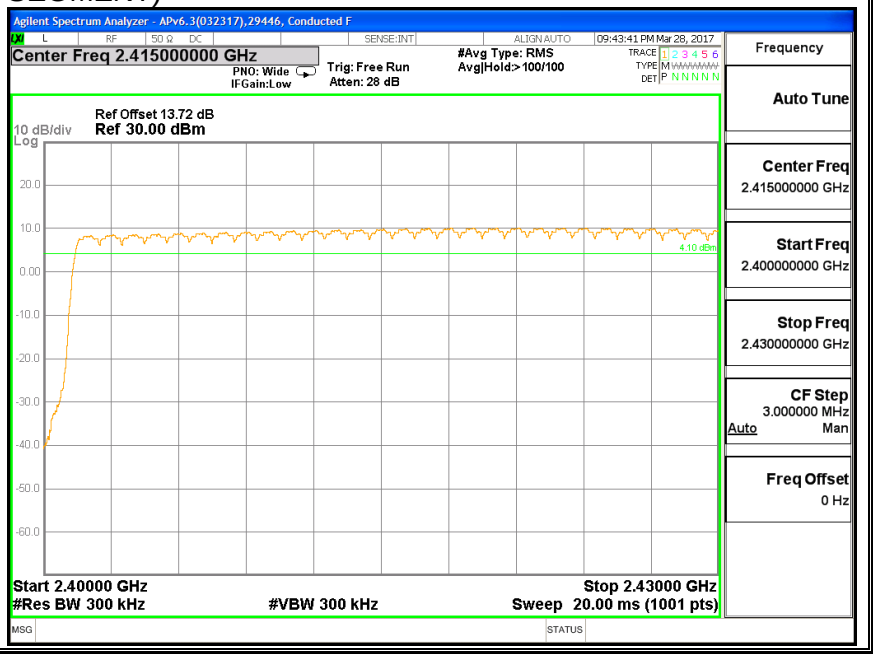
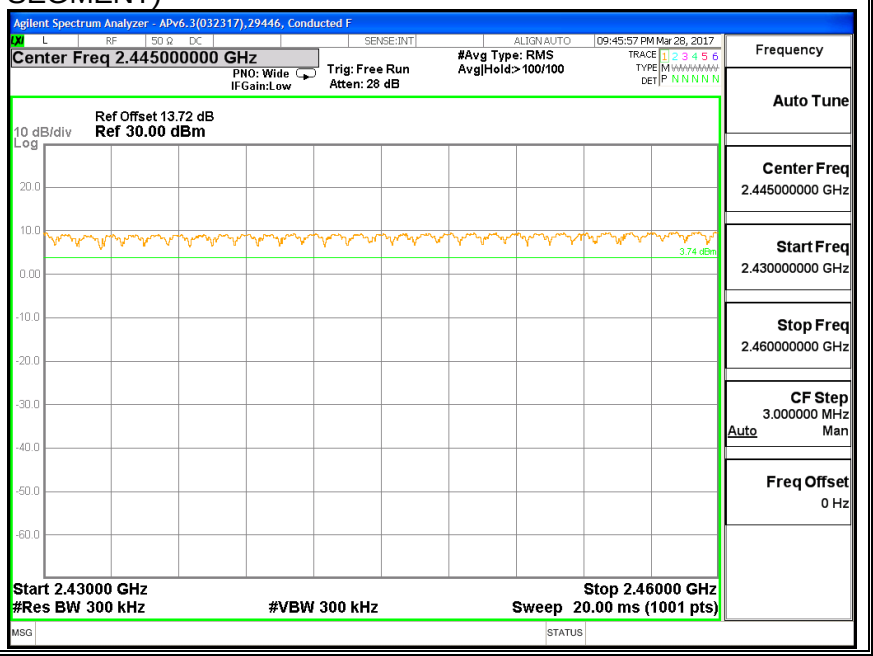
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, FIRST SEGMENT)



NUMBER OF HOPPING CHANNELS (30 MHz SPAN, SECOND SEGMENT)



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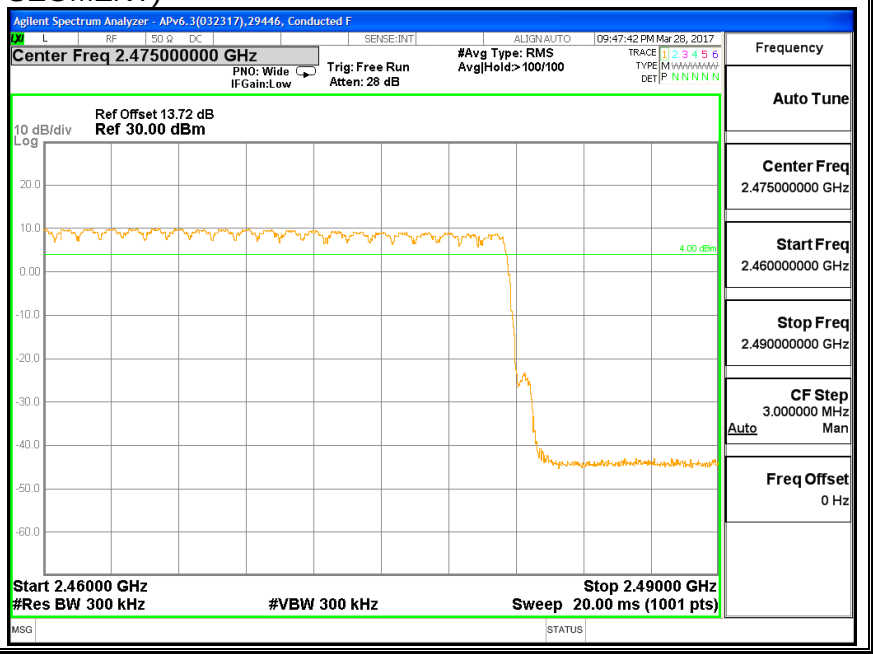
NUMBER OF HOPPING CHANNELS (30 MHz SPAN, THIRD SEGMENT)



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8.6.4. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

RESULTS

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK (EDR) Mode					
3DH1	0.3938	32	0.126	0.4	-0.274
3DH3	1.64	15	0.246	0.4	-0.154
3DH5	2.891	11	0.318	0.4	-0.082

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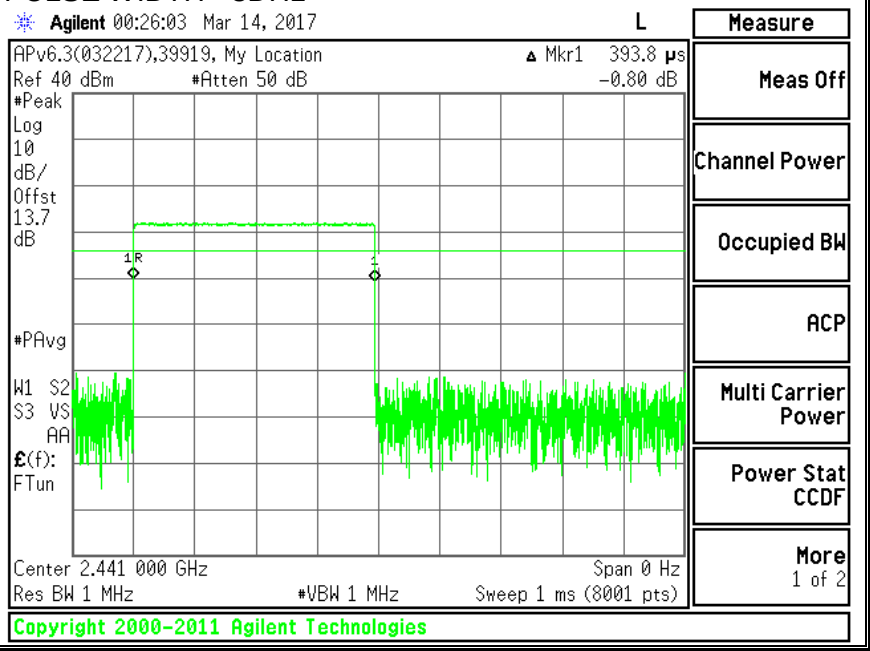
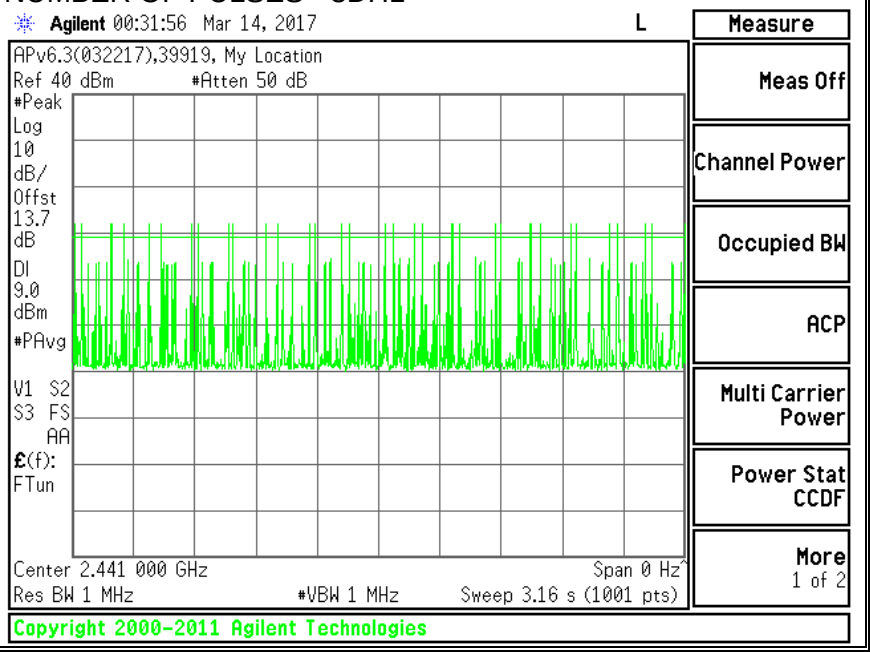
PULSE WIDTH - 3DH1



NUMBER OF PULSES - 3DH1



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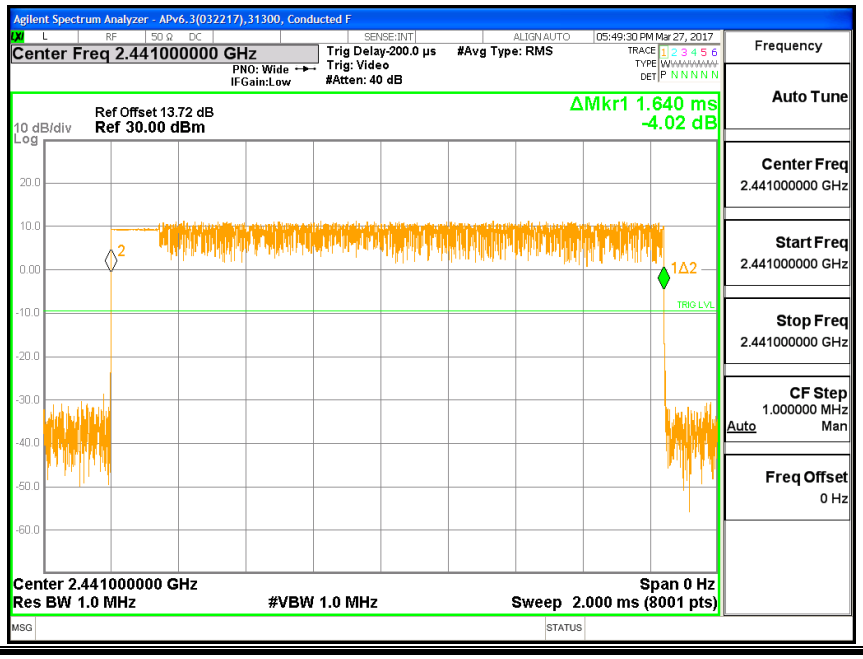
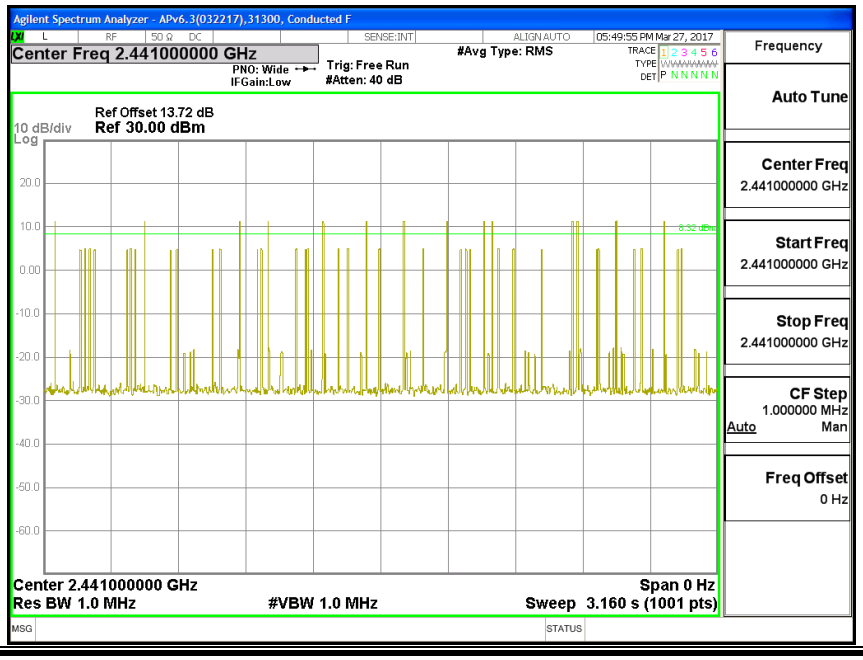
PULSE WIDTH - 3DH3



NUMBER OF PULSES - 3DH3



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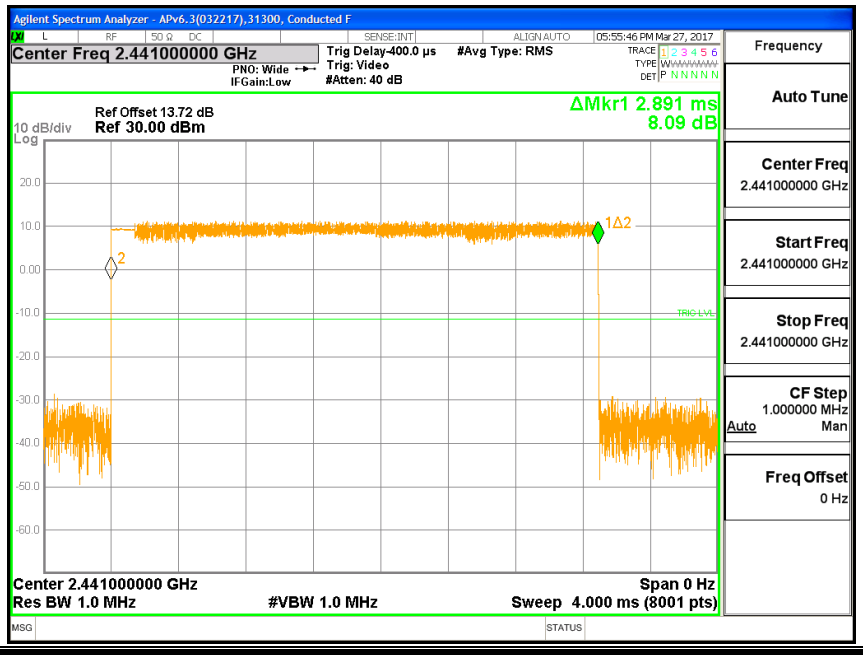
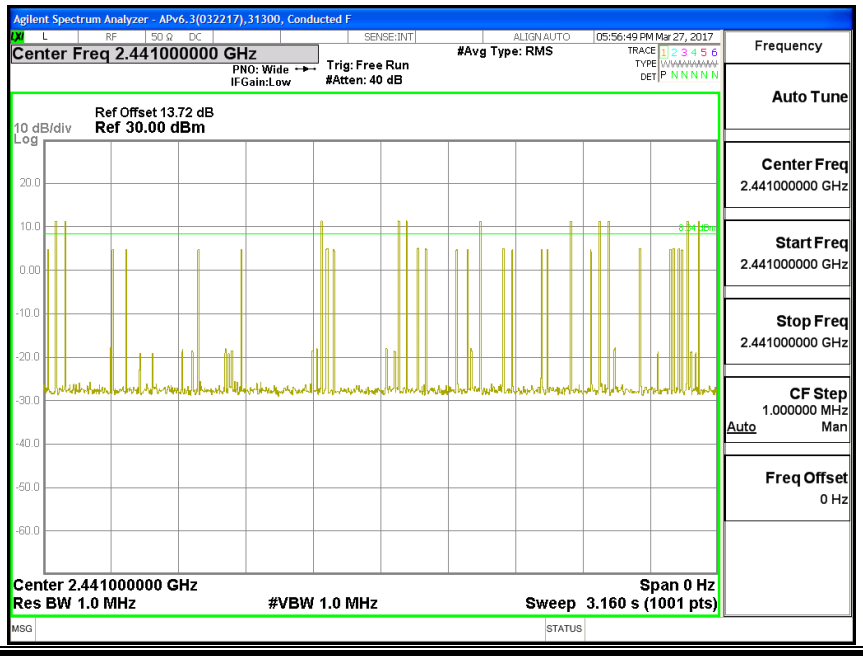
PULSE WIDTH - 3DH5



NUMBER OF PULSES - 3DH5



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8.6.5. OUTPUT POWER

ID:	30554	Date:	6/11/17

LIMITS

§15.247 (b) (1)

RSS-247 (5.4) (b)

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.
Alternatively, 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

TEST PROCEDURE

The transmitter output is connected to a wideband peak and average power meter.

RESULTS

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.28	21	-10.69
Middle	2441	10.51	21	-10.46
High	2480	10.29	21	-10.68

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8.6.6. AVERAGE POWER

ID:	30554	Date:	6/11/17

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

The cable assembly insertion loss of 11 dB (including 10 dB pad and 1 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.80
Middle	2441	7.88
High	2480	7.92

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8.6.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

IC RSS-247 (5.5)

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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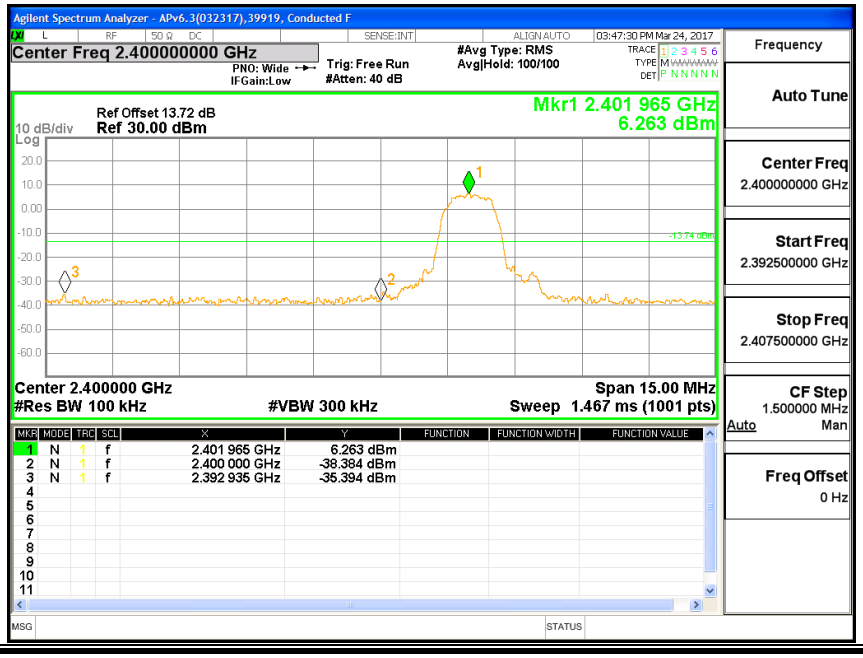
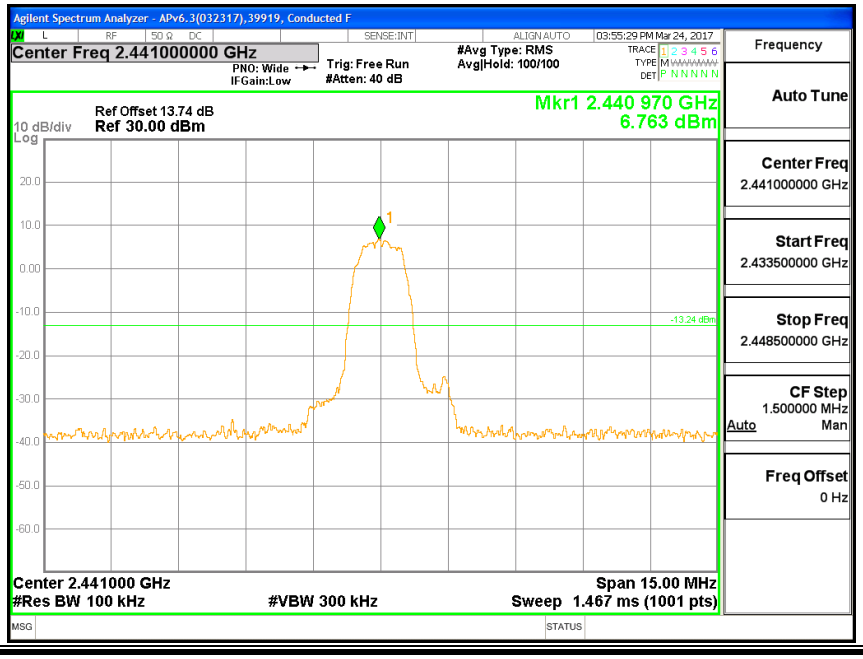
CONDUCTED BANDEDGE AND SPURIOUS EMISSIONS

CONDUCTED BANDEDGE LOW CH



CONDUCTED BANDEDGE MID CH



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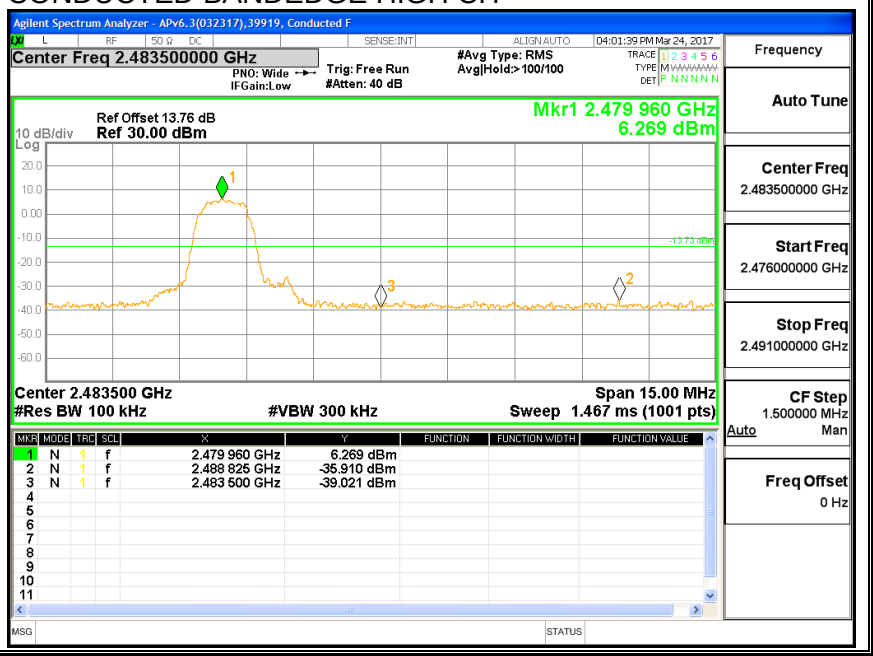
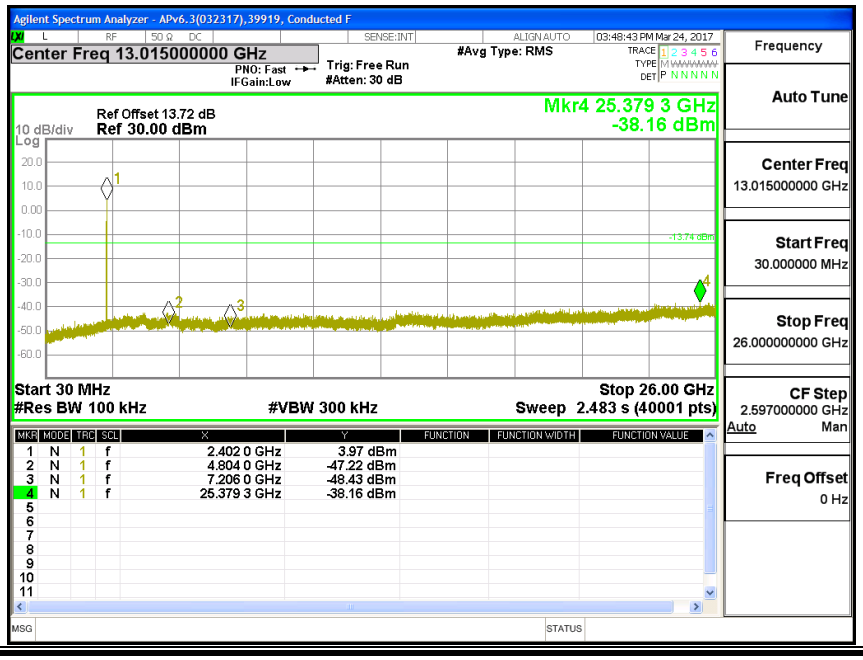
CONDUCTED BANDEDGE HIGH CH



CONDUCTED SPURIOUS EMISSIONS LOW CH



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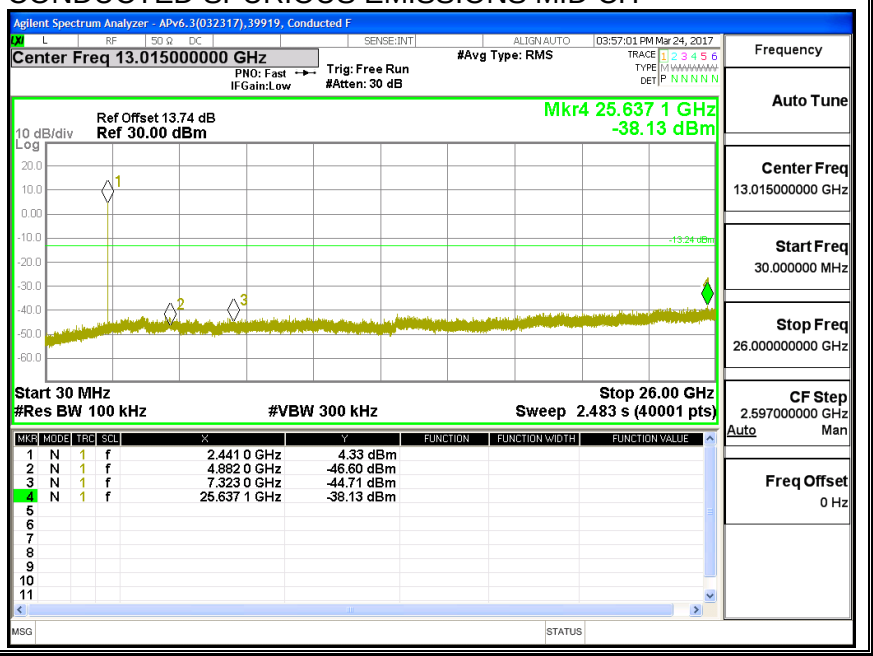
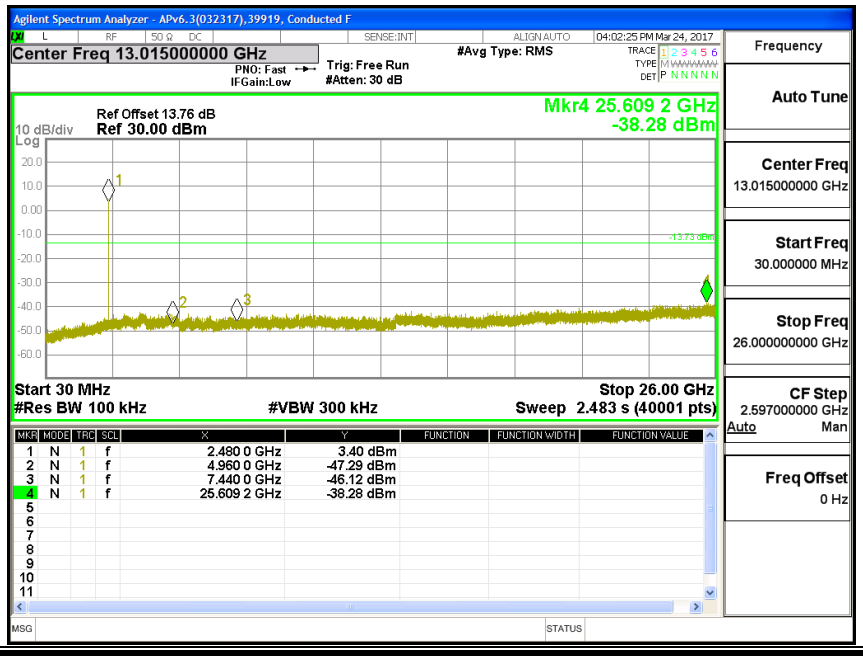
CONDUCTED SPURIOUS EMISSIONS MID CH



CONDUCTED SPURIOUS EMISSIONS HIGH CH



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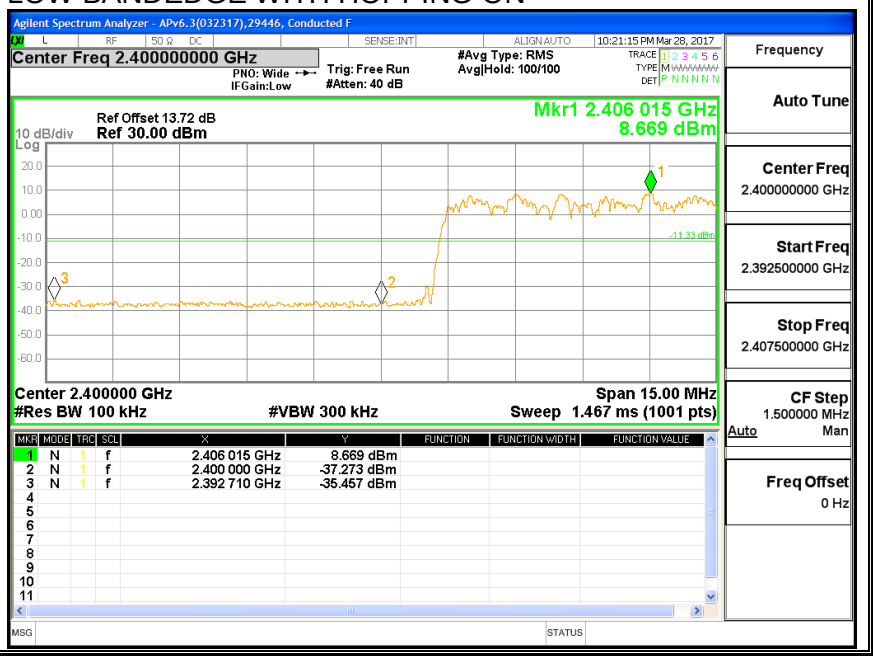
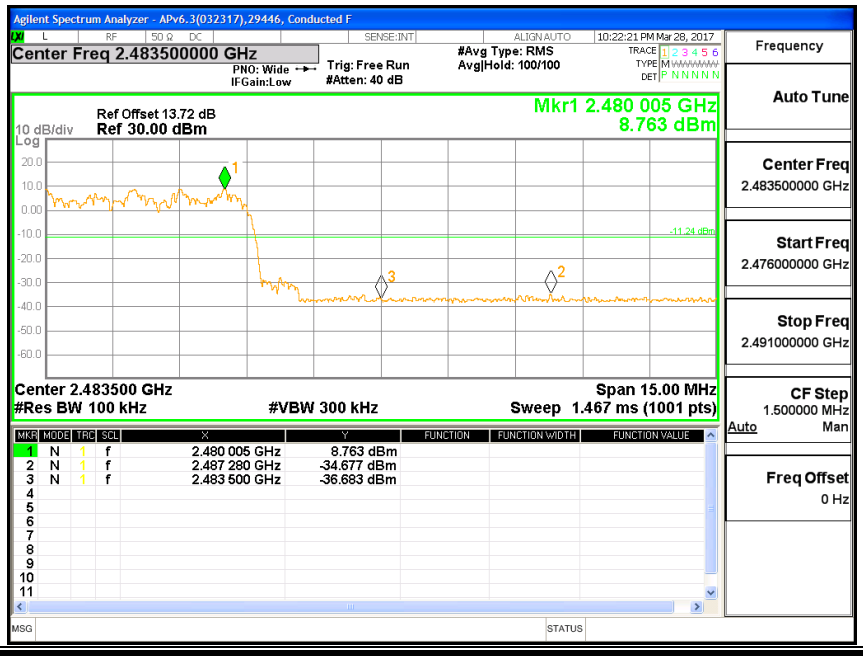
LOW BANDEDGE WITH HOPPING ON



HIGH BANDEDGE WITH HOPPING ON



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8.7. LAT 3, PMAX BASIC DATA RATE GFSK MODULATION

8.7.1. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

RESULTS

Channel	Frequency (MHz)	20 dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	2402	890.6	858.11
Middle	2441	913.0	901.45
High	2480	898.7	852.91

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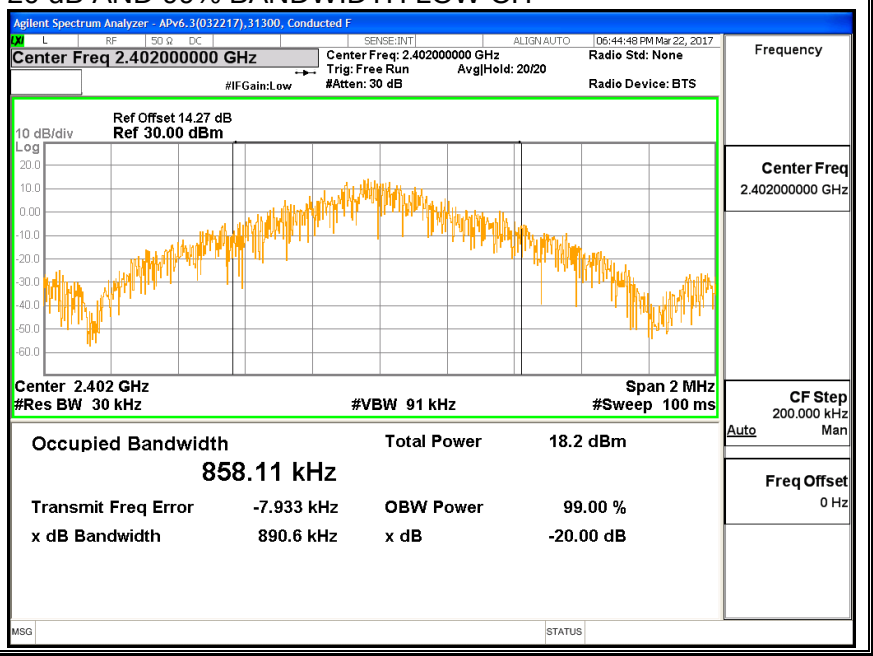
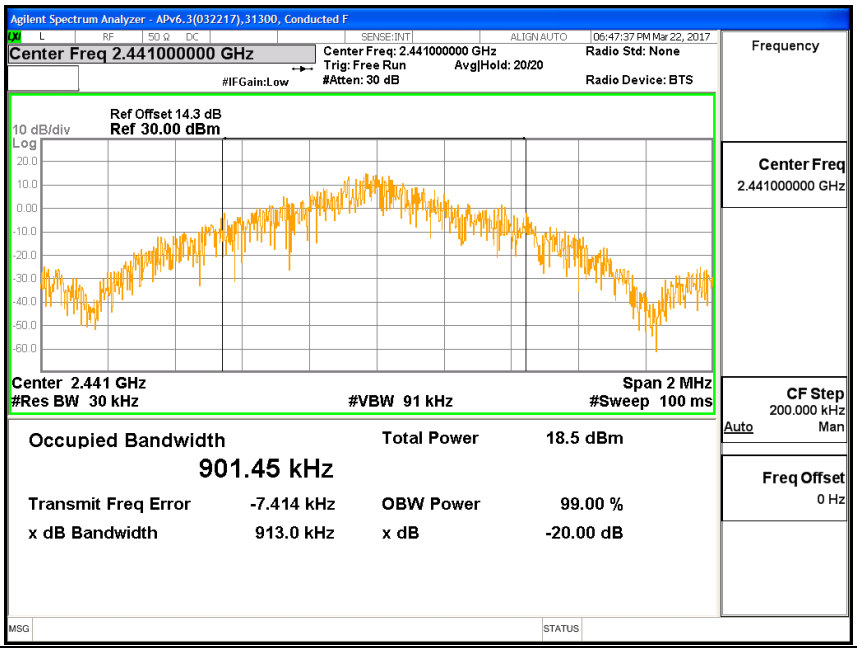
20 dB AND 99% BANDWIDTH LOW CH



20 dB AND 99% BANDWIDTH MID CH



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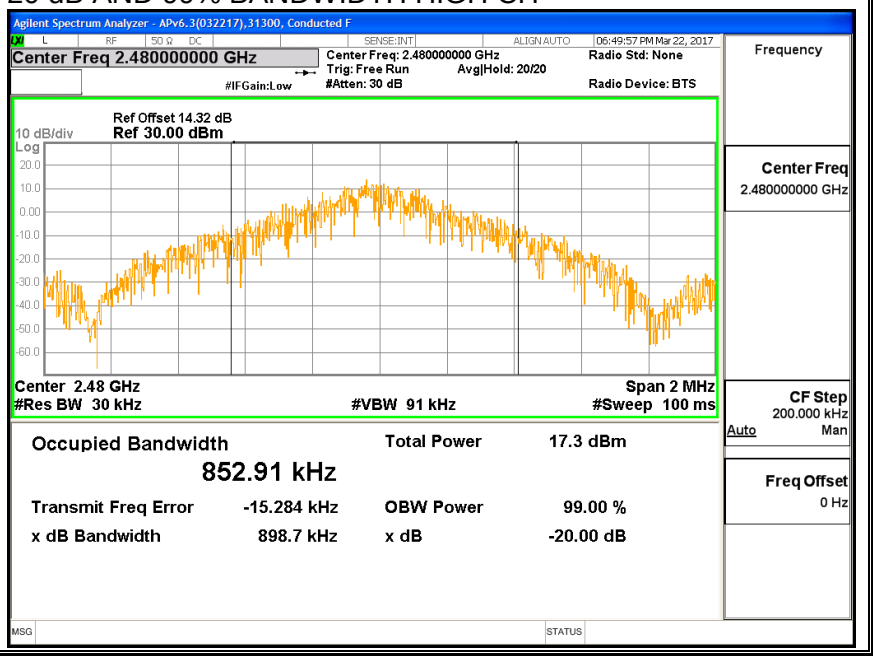
20 dB AND 99% BANDWIDTH HIGH CH



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8.7.2. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (b)

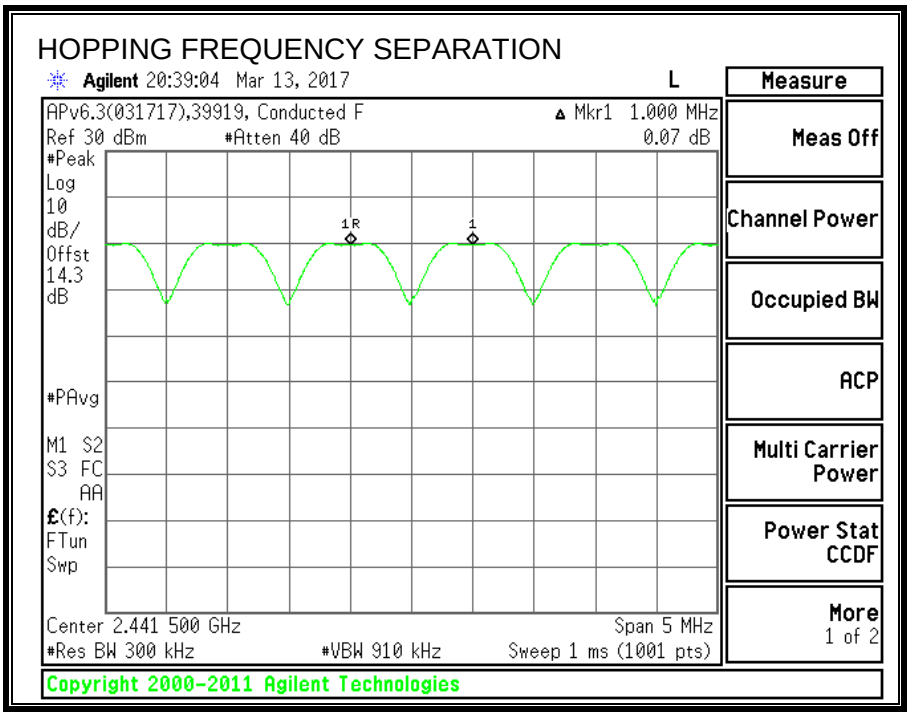
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

Alternatively, 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS



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