

FCC 47 CFR PART 15 SUBPART C INDUSTRY CANADA RSS-247 ISSUE 1

CERTIFICATION TEST REPORT

FOR

APPLE WATCH

MODEL NUMBER: A1802

FCC ID: BCG-E3102 IC: 579C-E3102

REPORT NUMBER: 16U23780-E1V3

ISSUE DATE: AUGUST 27, 2016

Prepared for APPLE, INC. 1 INFINITE LOOP CUPERTINO, CA 95014, U.S.A.

Prepared by UL VERIFICATION SERVICES INC. 47173 BENICIA STREET FREMONT, CA 94538, U.S.A. TEL: (510) 771-1000 FAX: (510) 661-0888

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NVLAP LAB CODE 200065-0

Revision History

Rev.	lssue Date	Revisions	Revised By
V1	08/15/2016	Initial Review	Chin Pang
V2	08/26/2016	Revised report to address TCB's questions	Tina Chu
V3	08/27/2016	Revised Section 8.1	Tina Chu

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME:	APPLE, INC. 1 INFINITE LOOP CUPERTINO, CA 95014, U.S.A.	
EUT DESCRIPTION:	APPLE WATCH	
MODEL:	A1802	
SERIAL NUMBER:	FH7RM045H91M	
DATE TESTED:	JUNE 25 - AUGUST 23, 2016	
	APPLICABLE STANDARDS	
STANDARD		TEST RESULTS
CFR 47	CFR 47 Part 15 Subpart C	
INDUSTRY CA	NADA RSS-247 Issue 1	Pass

INDUSTRY CANADA RSS-GEN Issue 4

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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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 1.

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	Chamber D
Chamber B	Chamber E
Chamber C	🛛 Chamber F
	🛛 Chamber G
	🖂 Chamber H

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers A through H are covered under Industry Canada company address code 2324B with site numbers 2324B -1 through 2324B-8, respectively.

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

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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
Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Radiated Disturbance,1000 to 18000 MHz	4.32 dB
Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Radiated Disturbance,26000 to 40000 MHz	5.24 dB

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

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5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an Apple Watch with WLAN, Bluetooth and NFC support.

5.2. MAXIMUM OUTPUT POWER

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

Frequency Range	Mode	Output Power	Output Power
(MHz)		(dBm)	(mW)
2402 - 2480	Basic GFSK	17.60	57.54
2402 - 2480	DQPSK	16.56	45.29
2402 - 2480	Enhanced 8PSK	16.64	46.13

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Band (GHz)	Antenna Gain (dBi)	
2.4	-10.50	

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was 14S310.

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5.5. WORST-CASE CONFIGURATION AND MODE

EUT has 1 type of enclosure and various kinds of metallic and non-metallic wristbands. There are 2 types of metallic bands; Metal Links, and Metal Mesh. The worst-case configuration was investigated within these combinations charging with/without wireless charger by AC/DC adapter and it was determined that EUT with wristband charging with wireless charger by AC/DC adapter was the worst-case; therefore, all final radiated testing was performed with this configuration. There is no significant difference among various kinds of wristbands.

Radiated emission below 1G was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

The fundamental of the EUT was investigated in three orthogonal orientations X/Y/Z, it was determined that Z - portrait orientation was worst-case orientation. Therefore, all final radiated testing was performed with the EUT in Z - portrait orientation.

Worst-case data rates were:

GFSK mode: DH5 8PSK mode: 3-DH5

DQPSK mode has been verified to have the lowest power.

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5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List								
Description	Manufacturer	Model	Serial Number	FCC ID				
Laptop AC/DC adapter	Lenovo	92P1160	11S92P1160Z1ZBGH798B12	N/A				
Laptop	Lenovo	7659	L3-AL664 08/03	N/A				
Wireless Charger	Apple	A1768	DLC616200ZYHE1Y835	BCGA1768				
AC/DC adapter	Apple	A1385	D293154U2DTDHLHCW	N/A				
Test jig	Apple	-	OYOOH217	N/A				

I/O CABLES (CONDUCTED TEST)

I/O Cable List								
Cable	Port	Port # of identical Connector Type Cable Type		Cable Type	Cable	Remarks		
No		ports			Length (m)			
1	Antenna	1	SMA	Un-Shielded	0.2	To spectrum Analyzer		
2	USB	1	USB to mini USB	Shielded	1	To laptop and fixture		

I/O CABLES (BELOW AND ABOVE 1G RADIATED TEST)

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

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TEST SETUP- CONDUCTED PORT

The EUT was placed in a test jig and test jig 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- BELOW AND ABOVE 1GHZ TESTS

EUT was powered by battery and charged by AC/DC adapter via USB cable with wireless charger. 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	T Number	Cal Due		
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T120	4/5/2017		
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB3	T122	1/29/2017		
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T173	6/17/2017		
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent	N9030A	T341	10/14/2016		
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T862	4/18/2017		
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB3	T899	5/26/2017		
Amplifier, 1 - 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	Agilent	N9030A	T905	6/21/2017		
Power Meter, P-series single channel	Agilent	N1911A	T1271	7/8/2017		
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Agilent	N1921A	T1228	6/20/2017		
Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826	T447	6/16/2017		
**Spectrum Analyzer, 40 GHz	Agilent	8564E	T106	8/13/2016		
Amplifier, 1 to 26.5GHz, 23.5dB Gain minimum	Keysight	8449B	T402	7/5/2017		
	UL SOFT	WARE				
* Radiated Software	UL	UL EMC	Ver 9.5, June	e 24, 2015		
* Conducted Software	UL	UL EMC	Ver 4.0, Janua	ary 11, 2016		

Note: * indicates automation software version used in the compliance certification testing ** Test equipment was used before equipment calibration due date.

7. ANTENNA PORT TEST RESULTS

ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

HIGH POWER

Mode	ON Time	Period	Duty Cycle	Duty	Duty Cycle	1/B
	В		x	Cycle	Correction Factor	Minimum VBW
	(msec)	(msec)	(linear)	(%)	(dB)	(kHz)
Bluetooth GFSK	10.000	10.000	1.000	100.00%	0.00	0.010
Bluetooth 8PSK	10.000	10.000	1.000	100.00%	0.00	0.010

LOW POWER

Mode	ON Time	Period	Duty Cycle	Duty	Duty Cycle	1/B
	В		x	Cycle	Correction Factor	Minimum VBW
	(msec)	(msec)	(linear)	(%)	(dB)	(kHz)
Bluetooth GFSK	10.000	10.000	1.000	100.00%	0.00	0.010
Bluetooth 8PSK	10.000	10.000	1.000	100.00%	0.00	0.010

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DUTY CYCLE PLOTS

HOPPING OFF

Keysight Spectrum Analyzer - 30554,	Temp B	CENCE-INT		01-42-08 AM 3-122, 2016	
NE 10 30 32		Jei e e	Avg Type: Log-Pwr	TRACE 1 2 3 4 5 6	Frequency
Ref Offset 10.5 0 dB/div Ref 30.50 dB	PNO: Fast ↔ IFGain:Low dB m	#Atten: 30 dB		DET P NNNN	Auto Tune
og					Center Freq
20.5					2.441000000 GHz
500					Start Fred 2.441000000 GHz
3.50					Stop Fred 2.441000000 GHz
19.5					CE Oton
39.5					8.000000 MHz Auto Mar
19.5					Freq Offse
59.5					
enter 2.441000000 GH	z #VBW	(50 MHz	Sweep 1	Span 0 Hz 0.00 ms (1001 pts)	

🚺 Keysight Spectrum Analyzer - 30554, Ten XI RL RF 50 Ω DC	PNO: East	SENSE:INT	ALIGN AUTO Avg Type: Log-Pwr	01:42:45 AM Jul 23, 2016 TRACE 1 2 3 4 5 6 TYPE WWWWWW	Frequency
Ref Offset 10.5 dB 10 dB/div Ref 30.50 dBm	IFGain:Low	#Atten: 30 dB		DET PNNNN	Auto Tune
20.5	nanakan ng manakang makalana	angerigangerigangerigangeriga	nersetten en ten en ten en ten ten en ten te	Alexyoda ala ana ala ana ana ana ana ana ana an	Center Freq 2.441000000 GHz
.500					Start Freq 2.441000000 GHz
9.50					Stop Freq 2.441000000 GHz
29.5					CF Step 8.000000 MHz <u>Auto</u> Mar
49.5					Freq Offset 0 Hz
59.5					
Res BW 8 MHz	#VBW	/ 50 MHz	Sweep 1	5pan 0 Hz 0.00 ms (1001 pts)	

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keysight Spectrum Analyzer - 305 RL RF 50 Ω Center Freq 2.44100	DC DC OOOO GHZ PNO: Fas IFGain:Lo	SENSE:INT t ↔ Trig: Free Run w #Atten: 30 dB	ALIGN AUTO Avg Type: Log-Pwr	01:40:26 AM Jul 23, 2016 TRACE 1 2 3 4 5 6 TYPE WWWWWW DET P NNNN	Frequency
Ref Offset 10. 0 dB/div Ref 30.50 d	5 dB Bm				
20.5					Center Fred 2.441000000 GHz
500					Start Free 2.441000000 GH;
9.5					Stop Fred 2.441000000 GH:
9.5					CF Step 8.000000 MH <u>Auto</u> Mar
9.5					Freq Offse 0 Hi
9.5					
enter 2.441000000 G	Hz #\	/BW 50 MHz	Sweep 1	Span 0 Hz 0.00 ms (1001 pts)	



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7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

7.1.1. 20 dB AND 99% BANDWIDTH

<u>LIMIT</u>

None; for reporting purposes only.

TEST PROCEDURE

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

RESULTS

Frequency	20 dB Bandwidth	99% Bandwidth
(MHz)	(KHz)	(KHz)
2402	948.4	928.91
2441	939.2	928.23
2480	898.9	873.08

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20 dB AND 99% BANDWIDTH





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7.1.2. HOPPING FREQUENCY SEPARATION

<u>LIMIT</u>

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (2)

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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7.1.3. NUMBER OF HOPPING CHANNELS

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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.

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NUMBER OF HOPPING CHANNELS





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7.1.4. AVERAGE TIME OF OCCUPANCY

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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	Number of	Average Time	Limit	Margin
	Width	Pulses in	of Occupancy		
	(msec)	3.16	(sec)	(sec)	(sec)
		seconds			
GFSK Norma	I Mode				
DH1	0.394	30	0.118	0.4	-0.282
DH3	1.654	15	0.248	0.4	-0.152
DH5	2.888	10	0.289	0.4	-0.111
DH Packet	Pulse	Number of	Average Time	Limit	Margin
DH Packet	Pulse Width	Number of Pulses in	Average Time of Occupancy	Limit	Margin
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet GFSK AFH M	Pulse Width (msec) lode	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet GFSK AFH M DH1	Pulse Width (msec) Iode 0.394	Number of Pulses in 0.8 seconds 7.5	Average Time of Occupancy (sec) 0.030	Limit (sec) 0.4	Margin (sec) -0.370
DH Packet GFSK AFH M DH1 DH3	Pulse Width (msec) lode 0.394 1.654	Number of Pulses in 0.8 seconds 7.5 3.75	Average Time of Occupancy (sec) 0.030 0.062	Limit (sec) 0.4 0.4	Margin (sec) -0.370 -0.338

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PULSE WIDTH - DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - DH1



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PULSE WIDTH – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



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PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5



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7.1.5. OUTPUT POWER

<u>LIMIT</u>

§15.247 (b) (1)

RSS-247 (5.4) (2)

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	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	17.60	30	-12.40
Middle	2441	17.55	30	-12.45
High	2480	17.50	30	-12.50

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7.1.6. AVERAGE POWER

<u>LIMIT</u>

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.

ID:	44353	Date:	8/11/16
-----	-------	-------	---------

Channel	Frequency	Average Power
	(MHz)	(dBm)
Low	2402	17.45
Middle	2441	17.43
High	2480	17.40

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7.1.7. 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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SPURIOUS EMISSIONS, LOW CHANNEL





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SPURIOUS EMISSIONS, MID CHANNEL





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SPURIOUS EMISSIONS, HIGH CHANNEL





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SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON





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7.2. HIGH POWER ENHANCED DATA RATE QPSK MODULATION

7.2.1. OUTPUT POWER

LIMIT

§15.247 (b) (1)

RSS-247 (5.4) (2)

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

ID: 44353 Date: 8/23/16

Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	16.47	21	-4.50
Middle	2441	16.56	21	-4.41
High	2480	16.03	21	-4.94

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7.2.2. AVERAGE POWER

<u>LIMIT</u>

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter.

RESULTS

ID:	44353	Date:	8/23/16

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	Average Power
	(MHz)	(dBm)
Low	2402	13.73
Middle	2441	13.90
High	2480	13.59

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7.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

7.3.1. 20 dB AND 99% BANDWIDTH

<u>LIMIT</u>

None; for reporting purposes only.

TEST PROCEDURE

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

RESULTS

Channel	Frequency	20 dB Bandwidth	99% Bandwidth
	(MHz)	(KHz)	(MHz)
Low	2402	1310.0	1.1985
Middle	2441	1352.0	1.2195
High	2480	1301.0	1.2074

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20 dB AND 99% BANDWIDTH





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7.3.2. HOPPING FREQUENCY SEPARATION

<u>LIMIT</u>

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (2)

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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7.3.3. NUMBER OF HOPPING CHANNELS

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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.

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NUMBER OF HOPPING CHANNELS





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7.3.4. AVERAGE TIME OF OCCUPANCY

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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

8PSK (EDR) Mode

DH Packet	Pulse	Number of	Average	Limit	Margin
	Width	Pulses in	Time of		-
	(msec)	3.16	(sec)	(sec)	(sec)
		seconds			
3DH1	0.392	30	0.118	0.4	-0.282
3DH3	1.642	18	0.296	0.4	-0.104
3DH5	2.892	12	0.347	0.4	-0.053

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PULSE WIDTH - 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - 3DH1



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PULSE WIDTH – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



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PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5



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7.3.5. OUTPUT POWER

<u>LIMIT</u>

§15.247 (b) (1)

RSS-247 (5.4) (2)

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

ID: 44353 Date: 8/23/16

Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	16.54	21	-4.43
Middle	2441	16.64	21	-4.33
High	2480	16.12	21	-4.85

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7.3.6. AVERAGE POWER

<u>LIMIT</u>

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.

ID:	44353	Date:	8/23/16
-----	-------	-------	---------

Channel	Frequency	Average Power
	(MHz)	(dBm)
Low	2402	13.77
Middle	2441	13.95
High	2480	13.64

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7.3.7. 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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SPURIOUS EMISSIONS, LOW CHANNEL





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SPURIOUS EMISSIONS, MID CHANNEL





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SPURIOUS EMISSIONS, HIGH CHANNEL





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SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON





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7.4. LOW POWER BASIC DATA RATE GFSK MODULATION

7.4.1. 20 dB AND 99% BANDWIDTH

<u>LIMIT</u>

None; for reporting purposes only.

TEST PROCEDURE

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

RESULTS

Channel	Frequency	20 dB Bandwidth	99% Bandwidth
	(MHz)	(KHz)	(KHz)
Low	2402	912.9	903.29
Middle	2441	941.2	918.43
High	2480	941.2	898.95

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20 dB AND 99% BANDWIDTH





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7.4.2. HOPPING FREQUENCY SEPARATION

<u>LIMIT</u>

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (2)

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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7.4.3. NUMBER OF HOPPING CHANNELS

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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.

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NUMBER OF HOPPING CHANNELS





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7.4.4. AVERAGE TIME OF OCCUPANCY

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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	Number of	Average Time	Limit	Margin
	Width	Pulses in	of Occupancy		
	(msec)	3.16	(sec)	(sec)	(sec)
		seconds			
GFSK Norma	I Mode				
DH1	0.394	31	0.122	0.4	-0.278
DH3	1.642	15	0.246	0.4	-0.154
DH5	2.896	13	0.376	0.4	-0.024
DH Packet	Pulse	Number of	Average Time	Limit	Margin
DH Packet	Pulse Width	Number of Pulses in	Average Time of Occupancy	Limit	Margin
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet GFSK AFH M	Pulse Width (msec) lode	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
DH Packet GFSK AFH M DH1	Pulse Width (msec) Iode 0.394	Number of Pulses in 0.8 seconds 7.75	Average Time of Occupancy (sec) 0.031	Limit (sec) 0.4	Margin (sec) -0.369
DH Packet GFSK AFH M DH1 DH3	Pulse Width (msec) lode 0.394 1.642	Number of Pulses in 0.8 seconds 7.75 3.75	Average Time of Occupancy (sec) 0.031 0.062	Limit (sec) 0.4 0.4	Margin (sec) -0.369 -0.338

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PULSE WIDTH - DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - DH1



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PULSE WIDTH – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - DH3



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PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - DH5



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7.4.5. OUTPUT POWER

<u>LIMIT</u>

§15.247 (b) (1)

RSS-247 (5.4) (2)

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

ID:	30606	Date:	8/2/16
			0, 1, 10

Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	11.42	30	-18.58
Middle	2441	11.85	30	-18.15
High	2480	11.69	30	-18.31

7.4.6. AVERAGE POWER

<u>LIMIT</u>

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.

ID:	30606	Date:	8/2/16
-----	-------	-------	--------

Channel	Frequency	Average Power
	(MHz)	(dBm)
Low	2402	11.25
Middle	2441	11.47
High	2480	11.37

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7.4.7. 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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SPURIOUS EMISSIONS, LOW CHANNEL





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SPURIOUS EMISSIONS, MID CHANNEL





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SPURIOUS EMISSIONS, HIGH CHANNEL





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SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON





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7.5. LOW POWER ENHANCED DATA RATE QPSK MODULATION

7.5.1. OUTPUT POWER

LIMIT

§15.247 (b) (1)

RSS-247 (5.4) (2)

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

ID: 306	06 Date:	8/2/16
---------	----------	--------

Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	10.75	21	-10.22
Middle	2441	10.96	21	-10.01
High	2480	10.89	21	-10.08

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7.5.2. AVERAGE POWER

<u>LIMIT</u>

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	Average Power
	(MHz)	(dBm)
Low	2402	8.28
Middle	2441	8.44
High	2480	8.37

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7.6. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

7.6.1. 20 dB AND 99% BANDWIDTH

<u>LIMIT</u>

None; for reporting purposes only.

TEST PROCEDURE

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

RESULTS

Channel	Frequency	20 dB Bandwidth	99% Bandwidth
	(MHz)	(MHz)	(MHz)
Low	2402	1.331	1.2330
Middle	2441	1.358	1.2317
High	2480	1.324	1.2309

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20 dB AND 99% BANDWIDTH





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7.6.2. HOPPING FREQUENCY SEPARATION

<u>LIMIT</u>

FCC §15.247 (a) (1)

IC RSS-247 (5.1) (2)

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

L RF	50 Ω DC 1500000 GHz PNO: Wide	SENSE:INT	ALIGN AUTO #Avg Type: RMS Avg Hold:>100/100	09:14:07 PM Aug 01, 2016 TRACE 1 2 3 4 5 6 TYPE MWWWW	Frequency
Ref Offse dB/div Ref 30.0	IFGain:Lov t 10.5 dB 10 dBm	y #Atten: 40 dB	Δ	Mkr1 1.000 MHz 0.180 dB	Auto Tune
0.0			1Δ2		Center Freq 2.441500000 GHz
- M. Mah Pahingham	Ardrah San Harden Albert	TV-9ACT Mr Thylograph / Ir	when and a straight the start of the	manaling and a second and the second se	
.00					Start Freq 2.439000000 GHz
D.0					Stop Freq 2.444000000 GHz
0.0					CF Step 500.000 kHz Auto Man
0.0					Freq Offset
0.0					
enter 2.441500 G	Hz #\/		Sween	Span 5.000 MHz 2 533 ms (1001 pts)	

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7.6.3. NUMBER OF HOPPING CHANNELS

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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.

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NUMBER OF HOPPING CHANNELS





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7.6.4. AVERAGE TIME OF OCCUPANCY

<u>LIMIT</u>

FCC §15.247 (a) (1) (iii)

IC RSS-247 (5.1) (4)

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

8PSK (EDR) Mode

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of (sec)	Limit (sec)	Margin (sec)
3DH1	0.392	31	0.122	0.4	-0.278
3DH3	1.076	18	0.194	0.4	-0.206
3DH5	2.888	8	0.231	0.4	-0.169

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PULSE WIDTH - 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - 3DH1



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PULSE WIDTH – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - 3DH3



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PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD - 3DH5



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7.6.5. OUTPUT POWER

<u>LIMIT</u>

§15.247 (b) (1)

RSS-247 (5.4) (2)

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

ID: 30606 Date: 8/2/16

Channel	Frequency	Output Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	2402	11.43	21	-9.54
Middle	2441	11.20	21	-9.77
High	2480	10.72	21	-10.25

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7.6.6. AVERAGE POWER

<u>LIMIT</u>

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.

ID:	30606	Date:	8/2/16
ID:	30606	Date:	8/2/16

Channel	Frequency	Average Power
	(MHz)	(dBm)
Low	2402	8.28
Middle	2441	8.45
High	2480	8.27

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7.6.7. 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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SPURIOUS EMISSIONS, LOW CHANNEL





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SPURIOUS EMISSIONS, MID CHANNEL





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SPURIOUS EMISSIONS, HIGH CHANNEL





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SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON





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