CERTIFICATION TEST REPORT

Report Number. : 12204447-E1V3

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A.
Model	:	A2097
FCC ID	:	BCG-E3232A
IC	:	579C-E3232A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C IC RSS-247 ISSUE 2

Date Of Issue:
August 10, 2018

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	7/13/2018	Initial Issue	Chin Pang
V2	7/16/2018	Address TCB's Questions	Chin Pang
V3	8/10/2018	Address TCB's Questions	Jingang Li

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TABLE OF CONTENTS

REPORT REVISION HISTORY 2

TABLE OF CONTENTS 3

1. ATTESTATION OF TEST RESULTS 5

2. TEST METHODOLOGY 6

3. FACILITIES AND ACCREDITATION 6

4. CALIBRATION AND UNCERTAINTY 7

4.1. MEASURING INSTRUMENT CALIBRATION 7

4.2. SAMPLE CALCULATION 7

4.3. MEASUREMENT UNCERTAINTY 7

5. EQUIPMENT UNDER TEST 8

5.1. EUT DESCRIPTION 8

5.2. MAXIMUM OUTPUT POWER 8

5.3. DESCRIPTION OF AVAILABLE ANTENNAS 8

5.4. SOFTWARE AND FIRMWARE 8

5.5. WORST-CASE CONFIGURATION AND MODE 9

5.6. DESCRIPTION OF TEST SETUP 10

6. TEST AND MEASUREMENT EQUIPMENT 15

7. MEASUREMENT METHODS 16

8. ANTENNA PORT TEST RESULTS 17

8.1. ON TIME AND DUTY CYCLE 17

8.2. 20 dB AND 99% BANDWIDTH 18

8.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 19
8.2.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 21
8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION 23
8.2.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 25

8.3. HOPPING FREQUENCY SEPARATION 27

8.3.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 28
8.3.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 30
8.3.3. LOW POWER BASIC DATA RATE GFSK MODULATION 32
8.3.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 34

8.4. NUMBER OF HOPPING CHANNELS 36

8.4.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 37
8.4.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 41
8.4.3. LOW POWER BASIC DATA RATE GFSK MODULATION 45
8.4.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 49

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.5. AVERAGE TIME OF OCCUPANCY 53
8.5.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 54
8.5.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 58
8.5.3. LOW POWER BASIC DATA RATE GFSK MODULATION 62
8.5.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 66

8.6. OUTPUT POWER 70
8.6.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 71
8.6.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 72
8.6.3. HIGH POWER ENCHANCED DATA RATE DQPSK MODULATION 73
8.6.4. LOW POWER BASIC DATA RATE GFSK MODULATION 74
8.6.5. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 75
8.6.6. LOW POWER ENCHANCED DATA RATE DQPSK MODULATION 76

8.7. AVERAGE POWER 77
8.7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 78
8.7.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 79
8.7.3. HIGH POWER ENCHANCED DATA RATE DQPSK MODULATION 80
8.7.4. LOW POWER BASIC DATA RATE GFSK MODULATION 81
8.7.5. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 82
8.7.6. LOW POWER ENCHANCED DATA RATE DQPSK MODULATION 83

8.8. CONDUCTED SPURIOUS EMISSIONS 84
8.8.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 85
8.8.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 89
8.8.3. LOW POWER BASIC DATA RATE GFSK MODULATION 93
8.8.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 97

9. RADIATED TEST RESULTS 101

9.1. TRANSMITTER ABOVE 1 GHz 102
9.1.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 102
9.1.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION 122
9.1.3. LOW POWER BASIC DATA RATE GFSK MODULATION 142
9.1.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION 162

9.2. Worst Case Below 1 GHz 182

9.3. Worst Case 18-26 GHz 184

10. AC POWER LINE CONDUCTED EMISSIONS 186

10.1.1. AC Power Line Host 187
10.1.2. AC Power Line Norm 189

11. SETUP PHOTOS 191

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A.

EUT DESCRIPTION: SMARTPHONE

MODEL: A2097

SERIAL NUMBER: C39WP04UK95F

DATE TESTED: JANUARY 30, 2018 – MAY 03, 2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

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 the U.S. government.

Approved & Released For
UL Verification Services Inc. By:

Chin Pang
CONSUMER TECHNOLOGY DIVISION
Senior Engineer
UL Verification Services Inc.

Prepared By:

Jingang Li
CONSUMER TECHNOLOGY DIVISION
Lab Engineer
UL Verification Services Inc.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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 5, 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 (ISED:2324B-1)	☒ Chamber D (ISED:22541-1)
☐ Chamber B (ISED:2324B-2)	☐ Chamber E (ISED:22541-2)
☐ Chamber C (ISED:2324B-3)	☒ Chamber F (ISED:22541-3)
	☒ Chamber G (ISED:22541-4)
	☐ Chamber H (ISED:22541-5)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers A through C is covered under ISED company address code 2324B with site numbers 2324B -1 through 2324B-3, respectively. Chambers D through H are covered under ISED company address code 22541 with site numbers 22541 -1 through 22541-5, respectively.

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 NVLAP Lab Search.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

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

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

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The Apple iPhone, is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, TD-SCDMA, CDMA, IEEE 802.11a/b/g/n/ac, Bluetooth, GPS and NFC. All models support at least one UICC based SIM. The second SIM is either UICC based, electronic SIM (e-SIM), or second SIM is not present. The device has a built-in inductive charging receiver which is not user accessible. The rechargeable battery is not user accessible.

5.2. 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)
Ant 4	High Power	2402 - 2480	Basic GFSK	16.72	46.99
		2402 - 2480	DQPSK	19.00	79.43
		2402 - 2480	Enhanced 8PSK	19.02	79.80
	Low Power	2402 - 2480	Basic GFSK	11.28	13.43
		2402 - 2480	DQPSK	10.19	10.45
		2402 - 2480	Enhanced 8PSK	10.25	10.59
Ant 3	High Power	2402 - 2480	Basic GFSK	20.42	110.15
		2402 - 2480	DQPSK	20.00	100.00
		2402 - 2480	Enhanced 8PSK	20.35	108.39
	Low Power	2402 - 2480	Basic GFSK	11.14	13.00
		2402 - 2480	DQPSK	10.15	10.35
		2402 - 2480	Enhanced 8PSK	10.19	10.45

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	Ant. 4 (dBi)	Ant. 3 (dBi)
2.4	-2.8	-4.1

5.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was v16.1.69.1066

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on Ant 4 (Antenna 4) and Ant 3 (Antenna 3), it was determined that Z(Portrait) orientation was the worst-case orientation for both Ant 4 and Ant 3.

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

Radiated emissions below 30MHz, below 1GHz, 18-26GHz and power line conducted emissions were performed with the EUT transmits at the channel with the highest output power as worst-case scenario

For below 1GHz tests EUT was connected to AC power adapter as the worst case; and for above 1GHz, the worst-case configuration reported was tested with EUT only. There were no emissions found below 30MHz within 20dB of the limit. For AC line conducted emission, test was investigated with AC power adapter and with laptop.

For simultaneous transmission of multiple channels in the 2.4GHz BT and 5GHz bands, No noticeable emission was found

GFSK, DQPSK, 8PSK average power are all investigated, The GFSK & 8PSK power are the worst case. For average power data please refer to section 8.7.

Worst-case data rates as provided by the client were:

GFSK mode: DH5
8PSK mode: 3-DH5

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.

Bluetooth RF output path is switched when the power exceeds 11dBm. Measurements were made therefore at the maximum power setting (with amplifier switched in) and also at the 11dBm power level (amplifier switched out) , and they are the high power and low power modes documented in this report respectively.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Apple	MacBook Pro	HRP007154	FCC Doc
AC/DC adapter	Delta Electronic	A1343	ADP-85EBT V85	NA
EUT AC Adapter	Apple	A1385	D293062F3WVDHLHCF	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	2	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
None Used						

I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

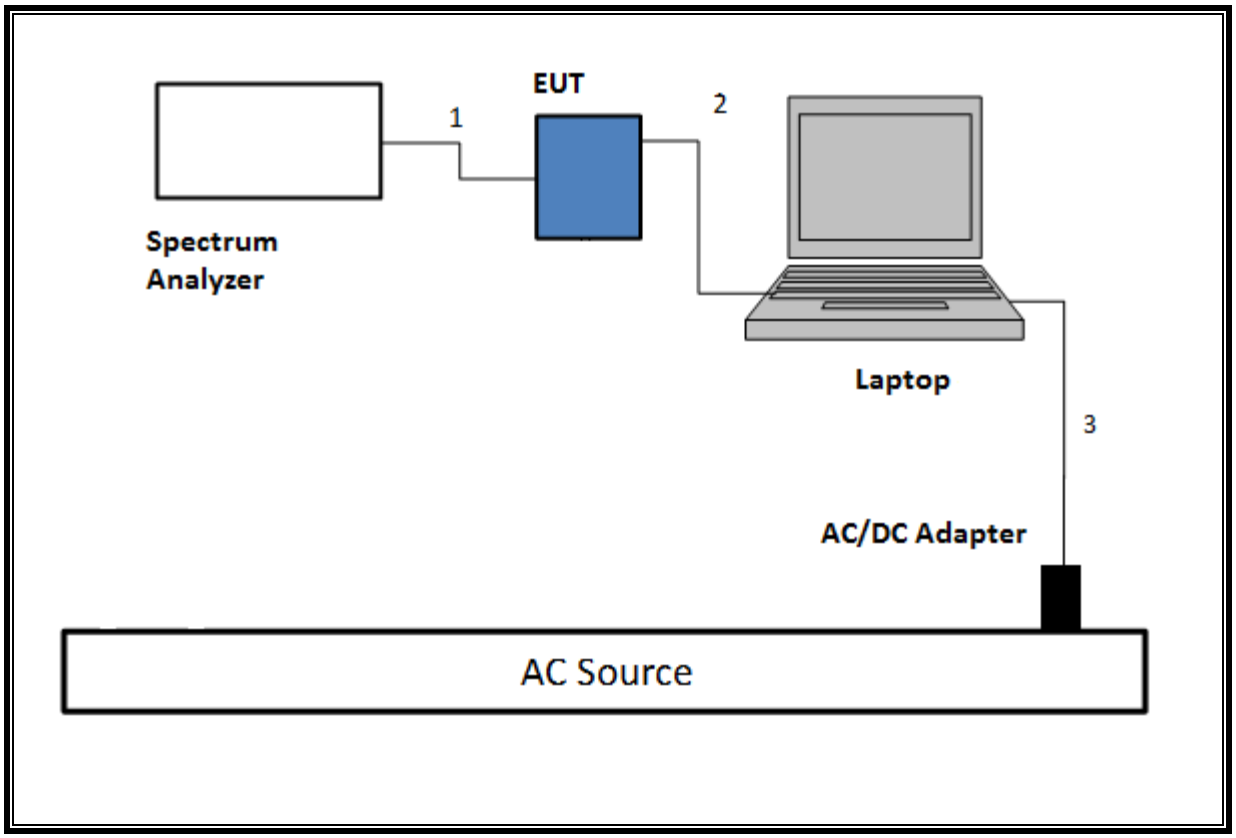
I/O Cable List						
Cable No	Port	# of identical	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shielded	2	N/A
2	USB	1	USB	Un-shielded	1	N/A

TEST SETUP

The EUT is connected to a test laptop during the tests. Test software exercised the EUT.

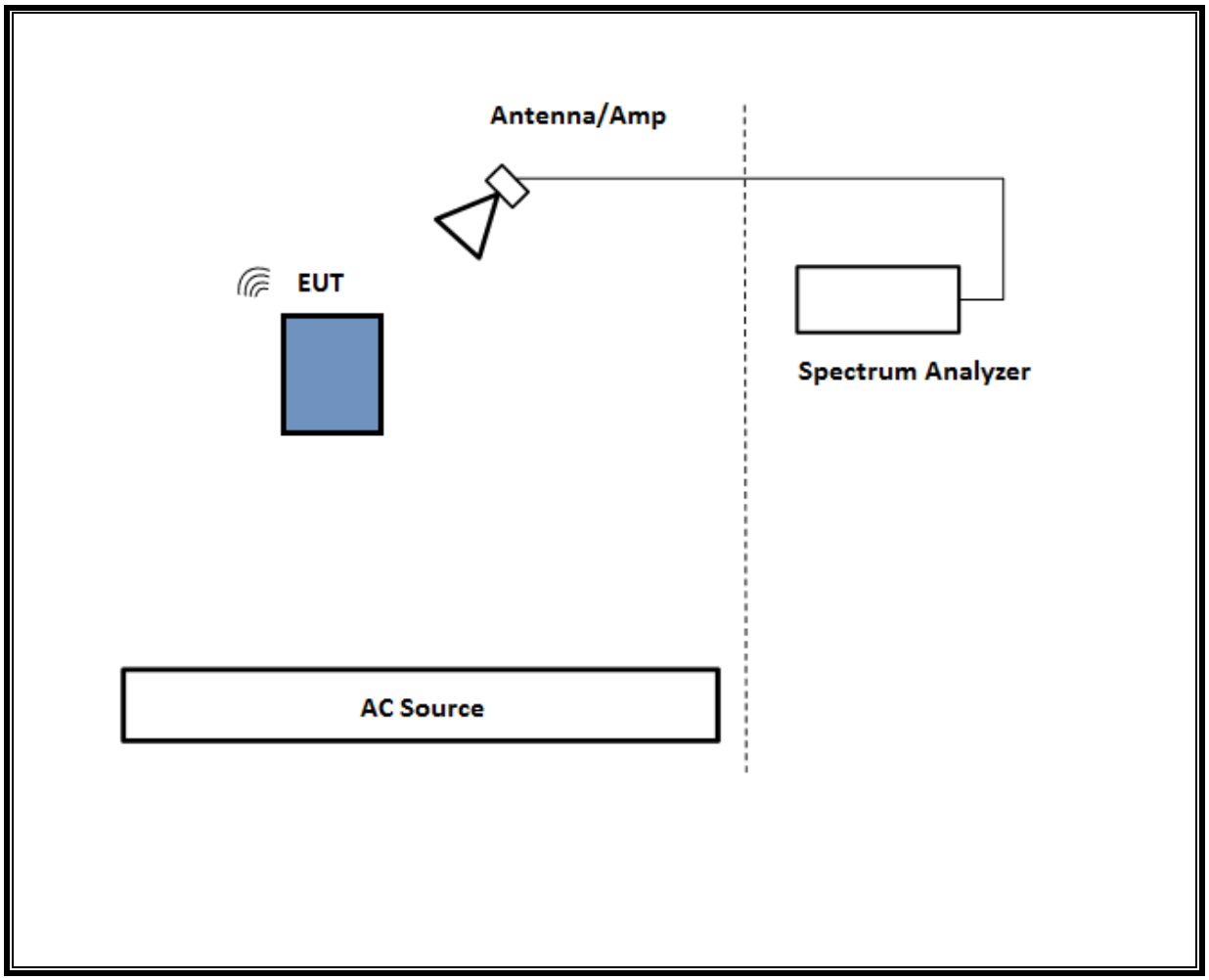
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

SETUP DIAGRAM FOR CONDUCTED TESTS



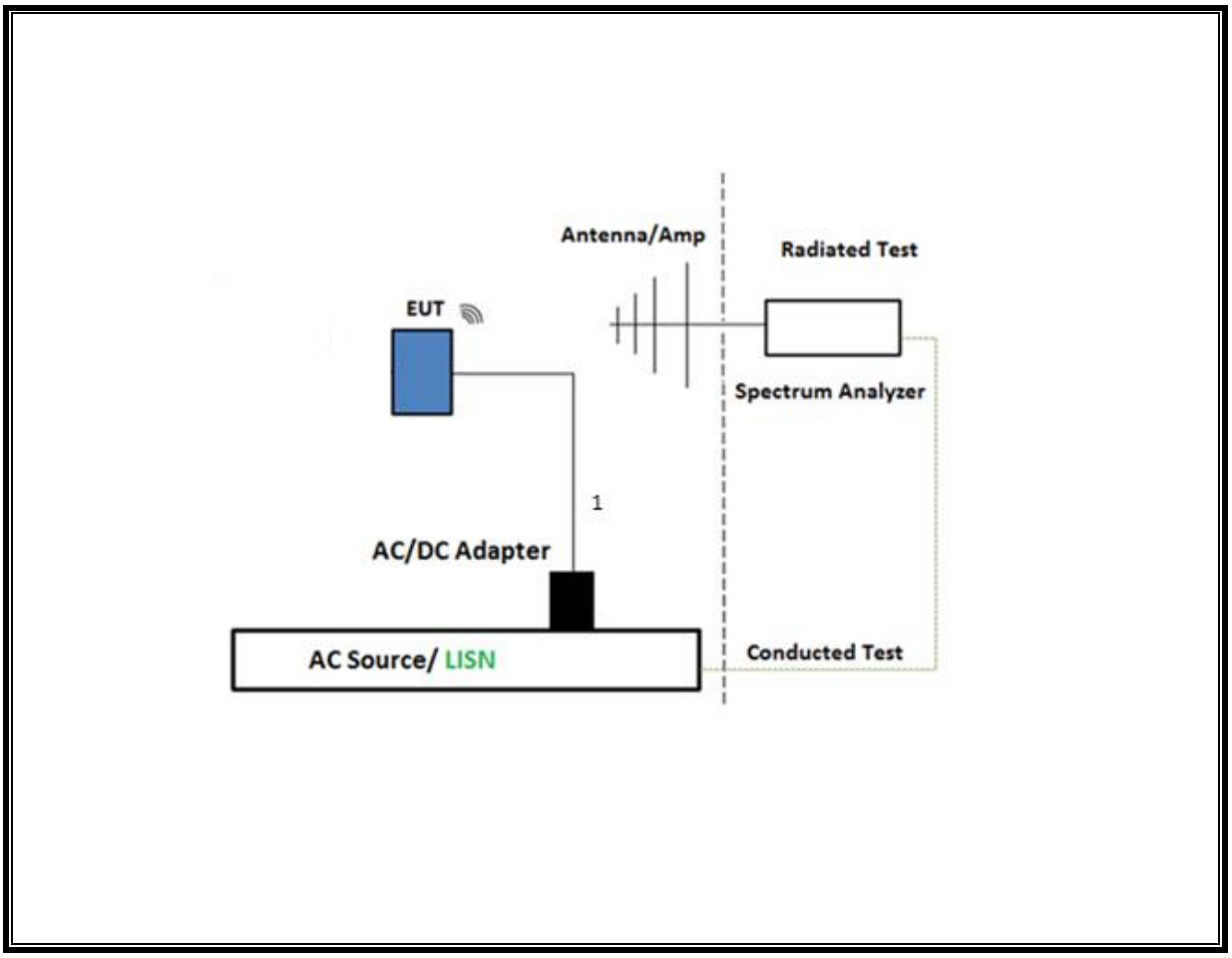
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

SETUP DIAGRAM FOR RADIATED TESTS Above 1GHz



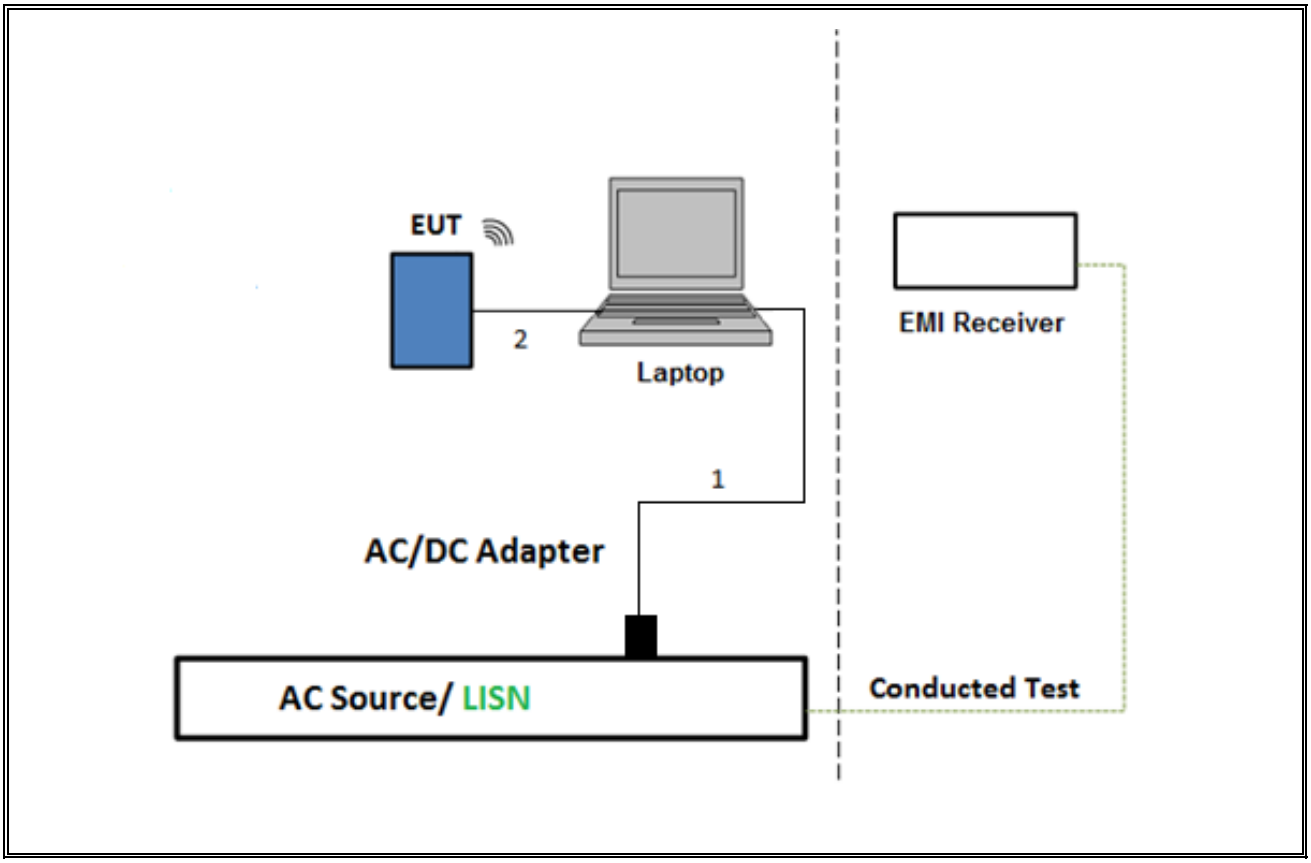
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

6. TEST AND MEASUREMENT EQUIPMENT

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

Description	Manufacturer	Model	ID Num	Cal Due
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T907	02/07/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T136	06/26/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T742	12/04/2018
Spectrum Analyzer, PSA, 3Hz to 44GHz	Agilent (Keysight) Technologies	E4446A	T177	04/12/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T119	04/03/2019
*Antenna, Horn 1-18GHz	ETS Lindgren	3117	T345	04/14/2018
*Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB3	T407	04/14/2018
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	06/01/2018
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T834	06/01/2018
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A-544	T341	11/12/2018
Antenna Horn, 18 to 26GHz	ARA	MWH-1826	T447	06/24/2018
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	07/23/2018
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1454	01/08/2019
Power Meter, P-series single channel	Keysight	N1912A	T1273	07/17/2018
Antenna, Active Loop 9KHz to 30MHz	EMCO	6502	T35	12/15/2018
Power Sensor	Keysight	N1921A	T1226	08/30/2018
AC Line Conducted				
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	01/25/2019
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/15/2018
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2018
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	06/15/2018
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 expiration date.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

7. MEASUREMENT METHODS

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

Occupied BW (20dB): ANSI C63.10-2013 Section 6.9.2

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.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

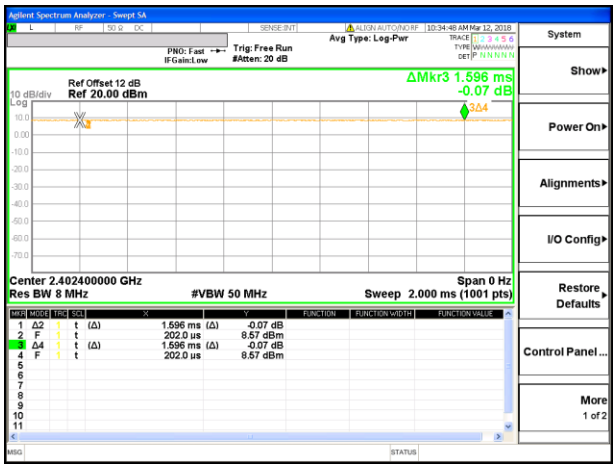
PROCEDURE

ANSI C63.10-2013 Section 11.6

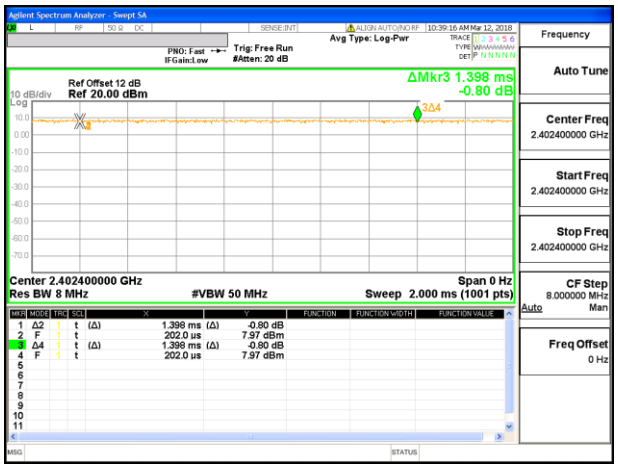
ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/T Minimum VBW (kHz)
Bluetooth GFSK	1.60	1.60	1.000	100.0%	0.00	0.010
Bluetooth 8PSK	1.40	1.40	1.000	100.0%	0.00	0.010

DUTY CYCLE PLOTS



BLUETOOTH GFSK



BLUETOOTH 8PSK

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.2. 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.

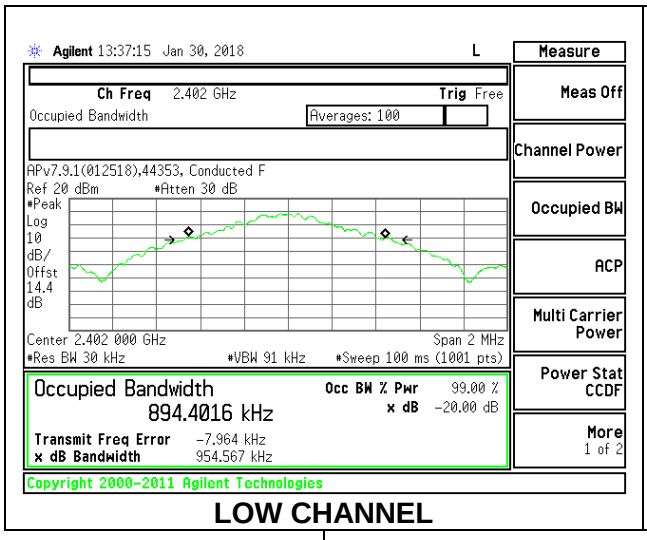
RESULTS

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

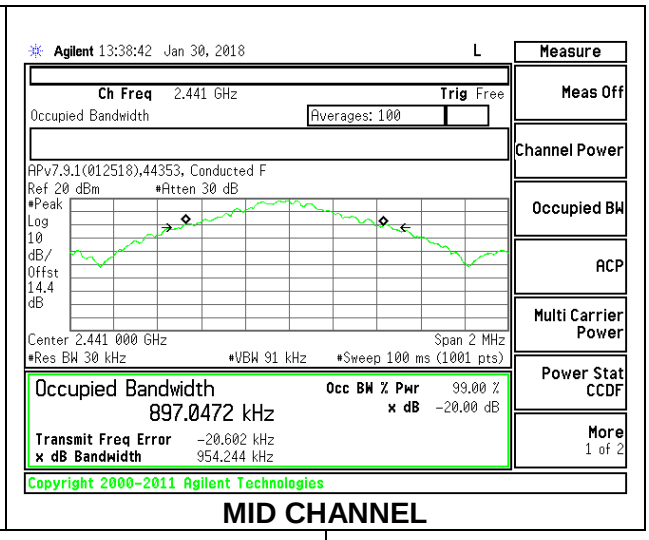
8.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

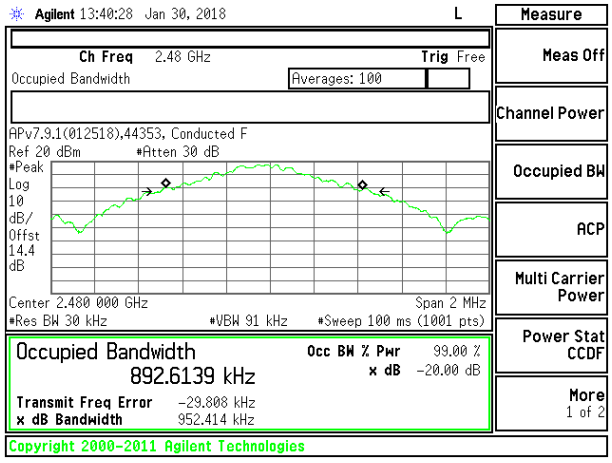
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.955	0.894
Mid	2441	0.954	0.897
High	2480	0.952	0.893



LOW CHANNEL



MID CHANNEL

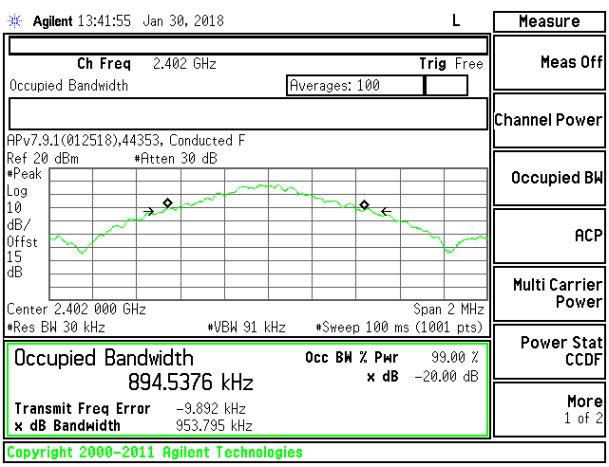


HIGH CHANNEL

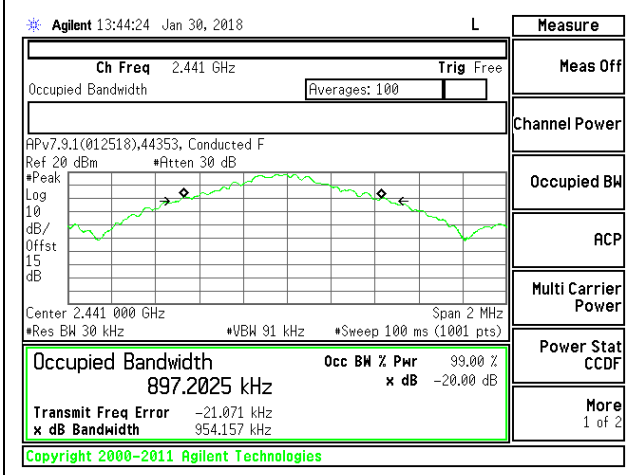
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

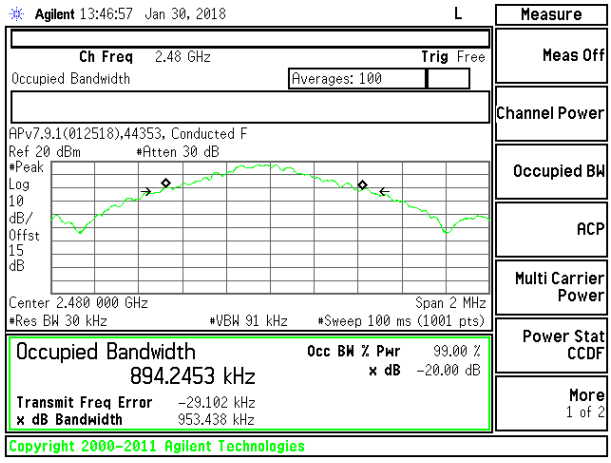
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.954	0.895
Mid	2441	0.954	0.897
High	2480	0.953	0.894



LOW CHANNEL



MID CHANNEL



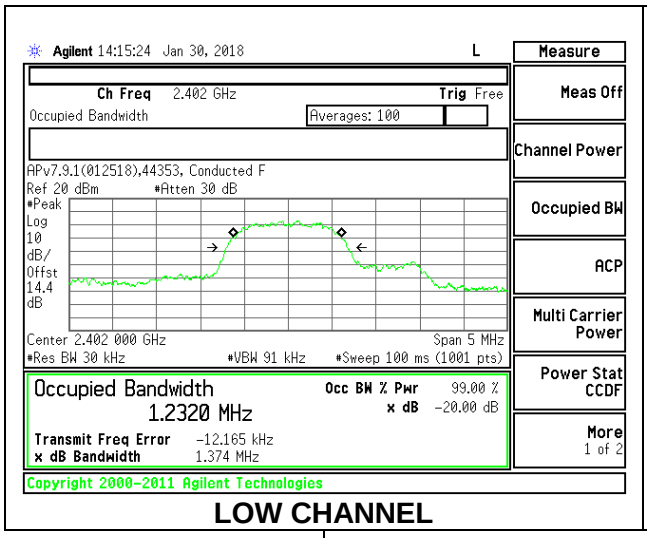
HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

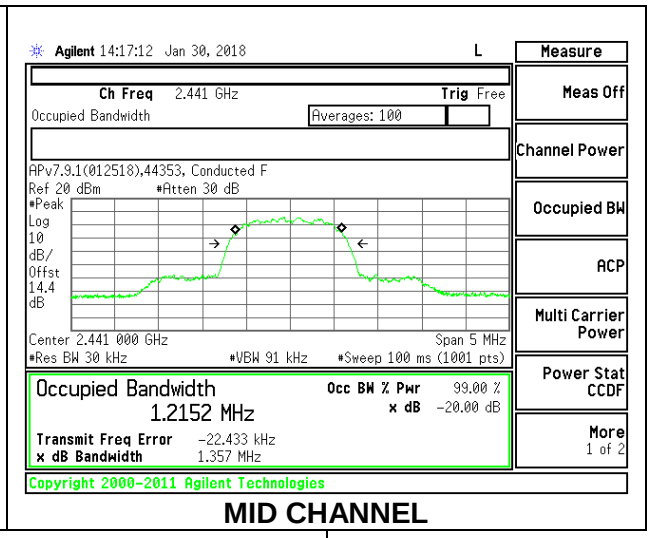
8.2.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

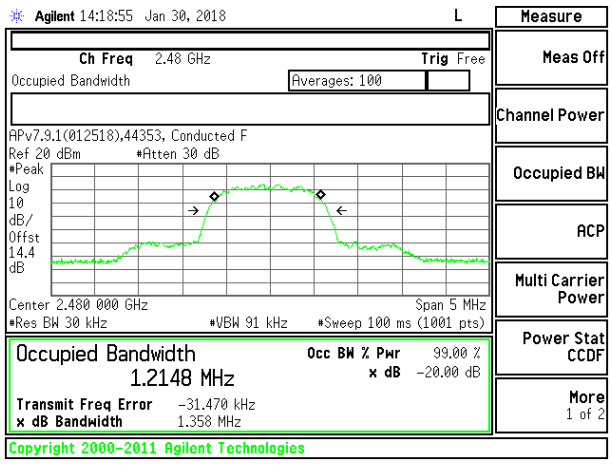
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.374	1.232
Mid	2441	1.357	1.215
High	2480	1.358	1.215



LOW CHANNEL



MID CHANNEL

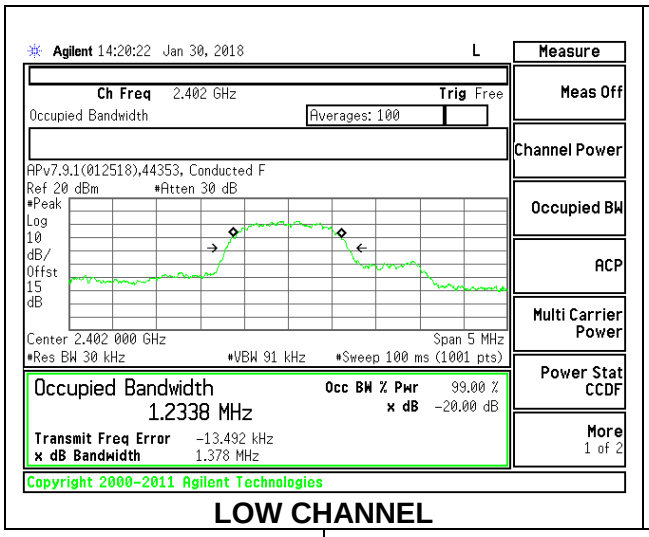


HIGH CHANNEL

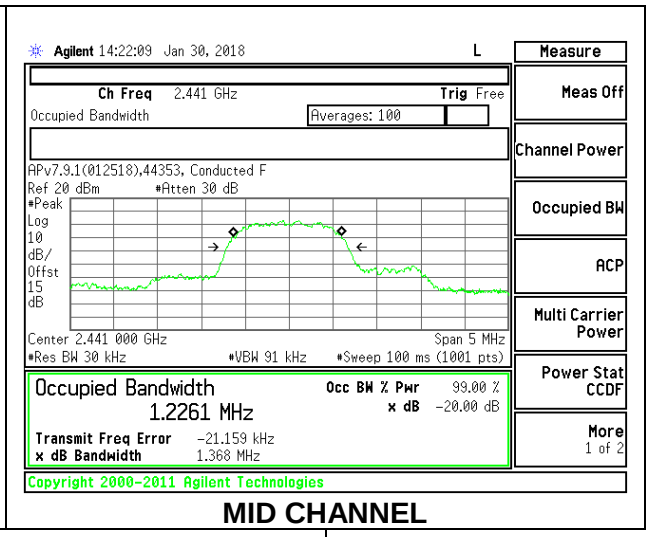
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

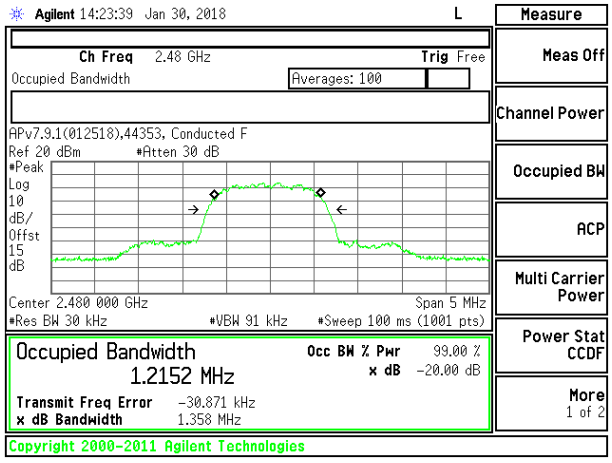
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.378	1.234
Mid	2441	1.368	1.226
High	2480	1.358	1.215



LOW CHANNEL



MID CHANNEL



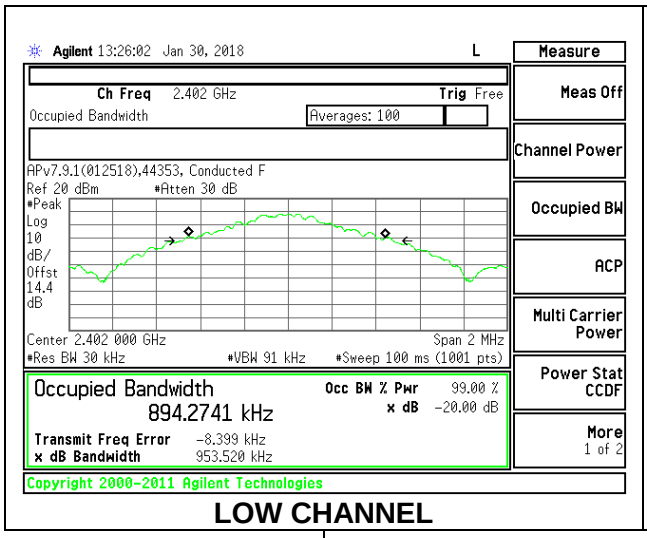
HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

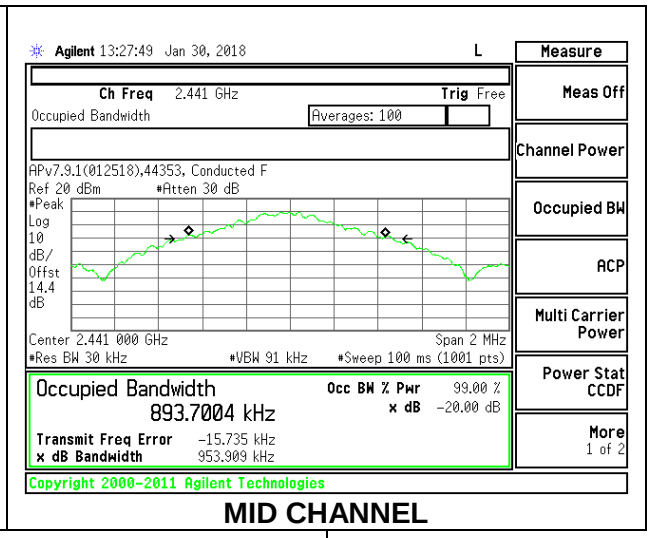
8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

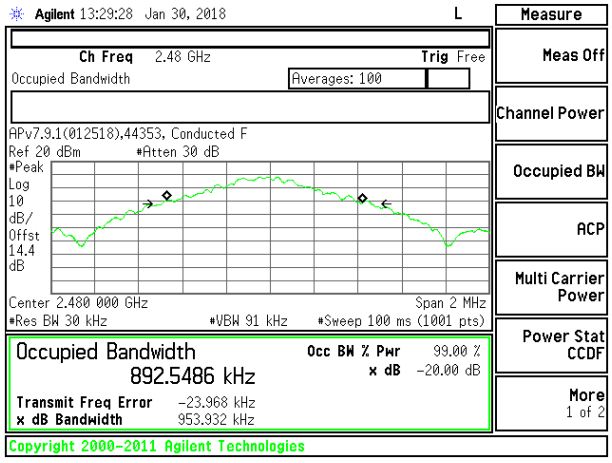
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.954	0.894
Mid	2441	0.954	0.894
High	2480	0.954	0.893



LOW CHANNEL



MID CHANNEL

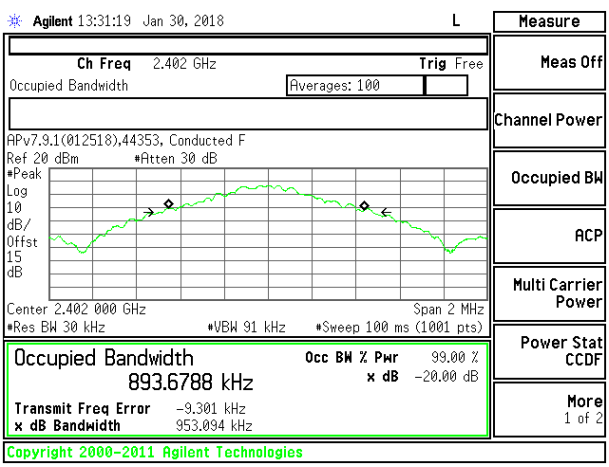


HIGH CHANNEL

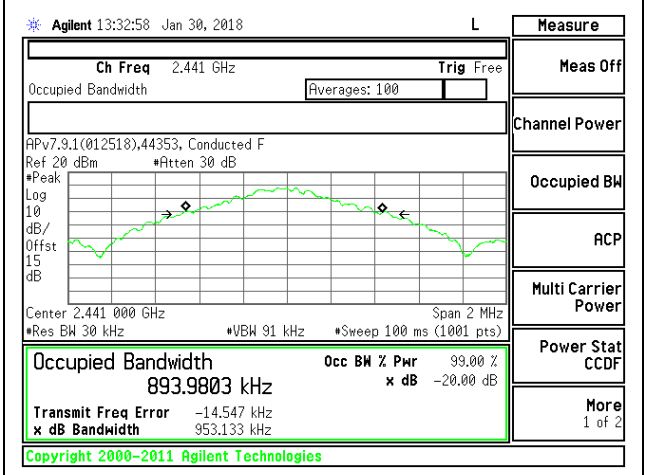
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

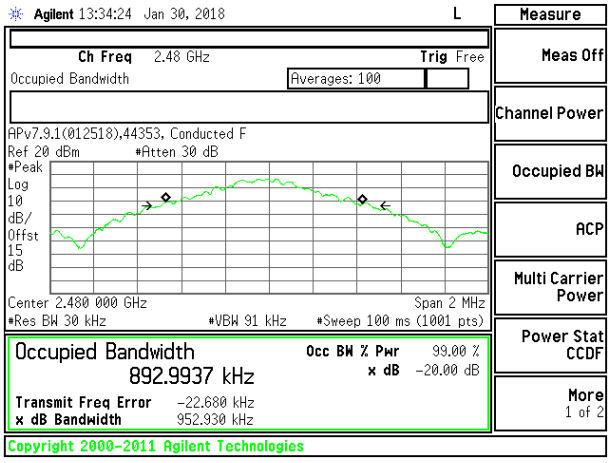
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.953	0.894
Mid	2441	0.953	0.894
High	2480	0.953	0.893



LOW CHANNEL



MID CHANNEL



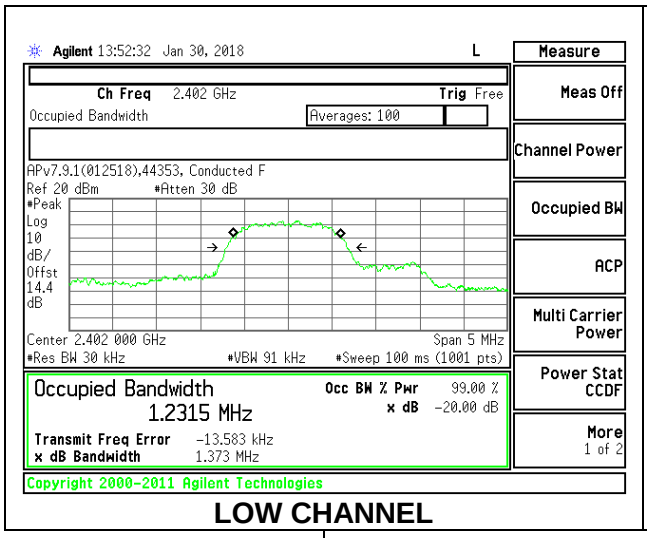
HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

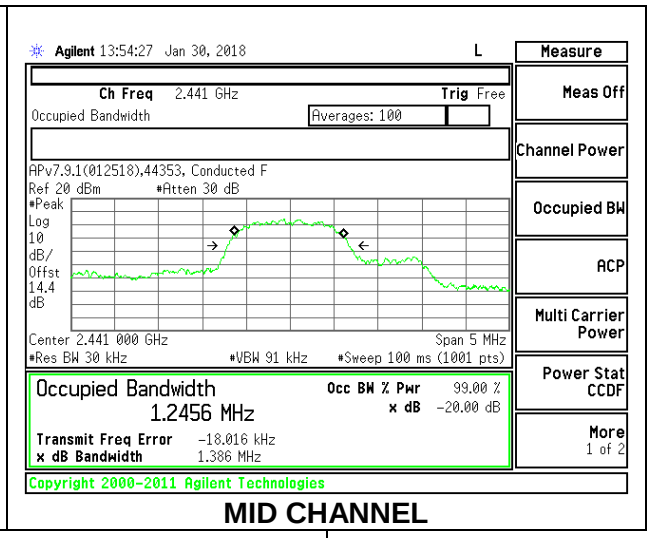
8.2.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

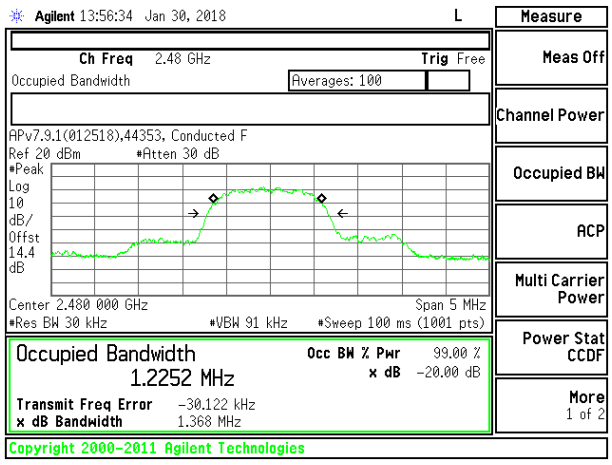
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.373	1.231
Mid	2441	1.386	1.246
High	2480	1.368	1.225



LOW CHANNEL



MID CHANNEL

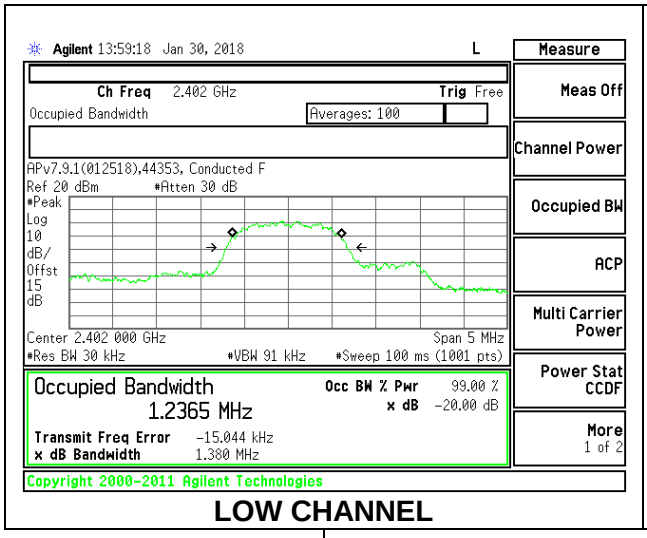


HIGH CHANNEL

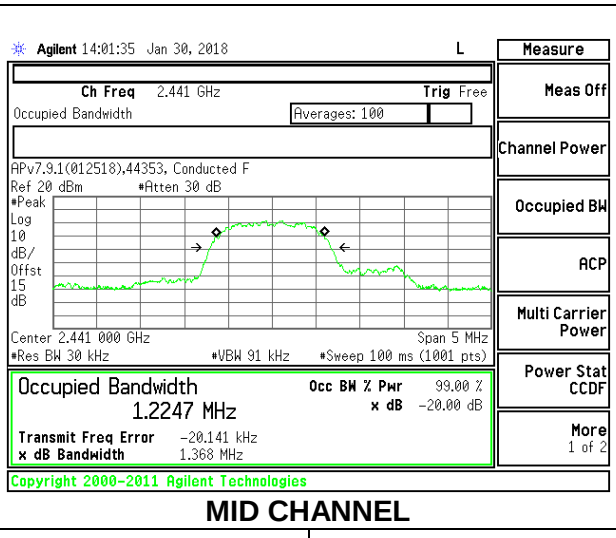
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

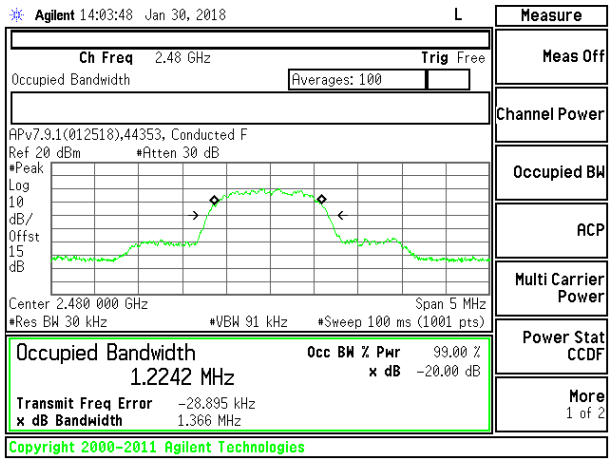
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.380	1.236
Mid	2441	1.368	1.225
High	2480	1.366	1.224



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

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

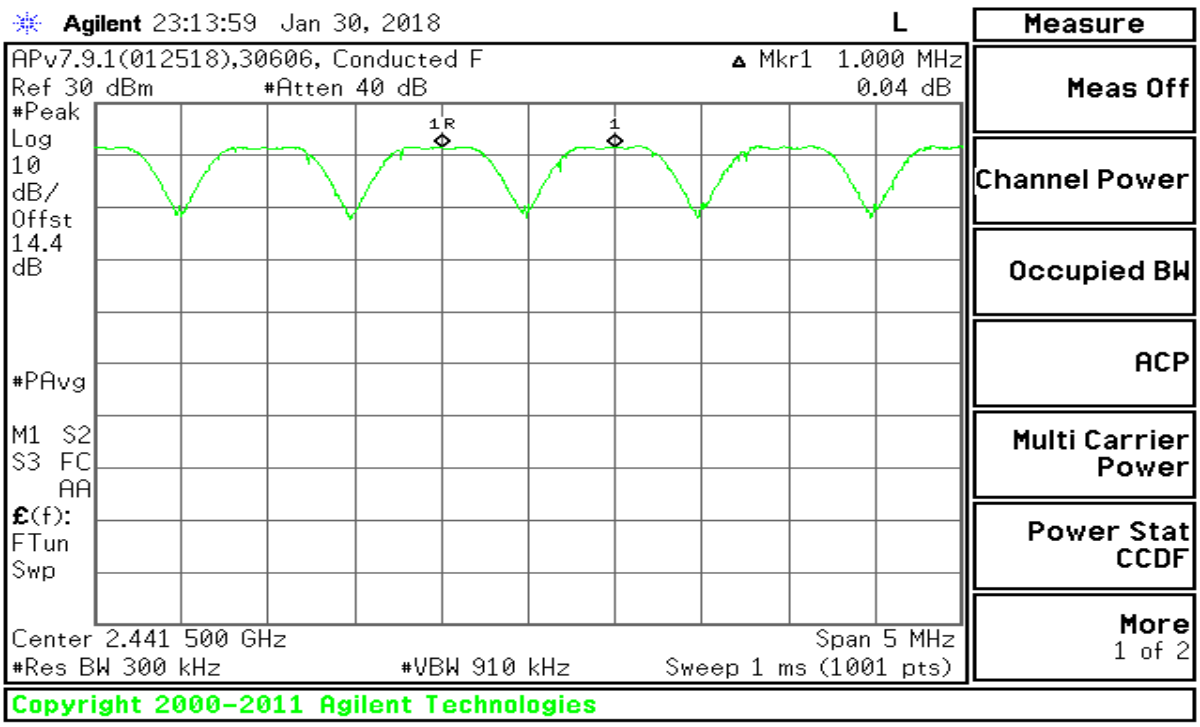
The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

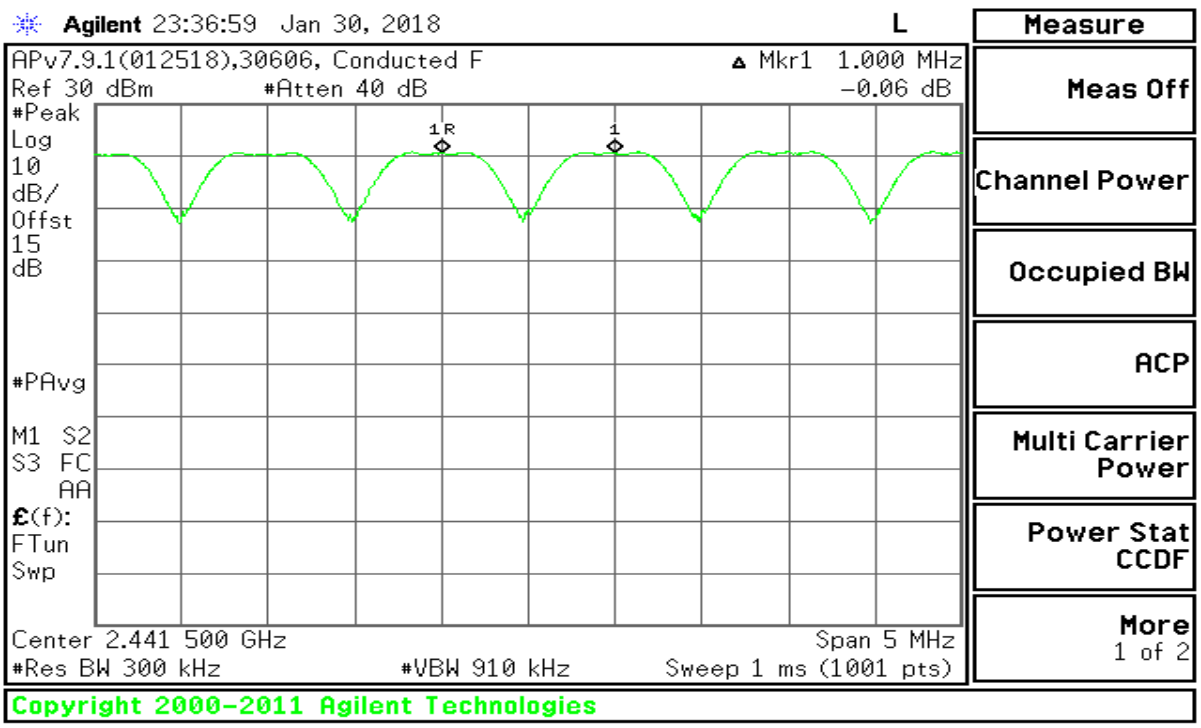
ANTENNA 4



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3



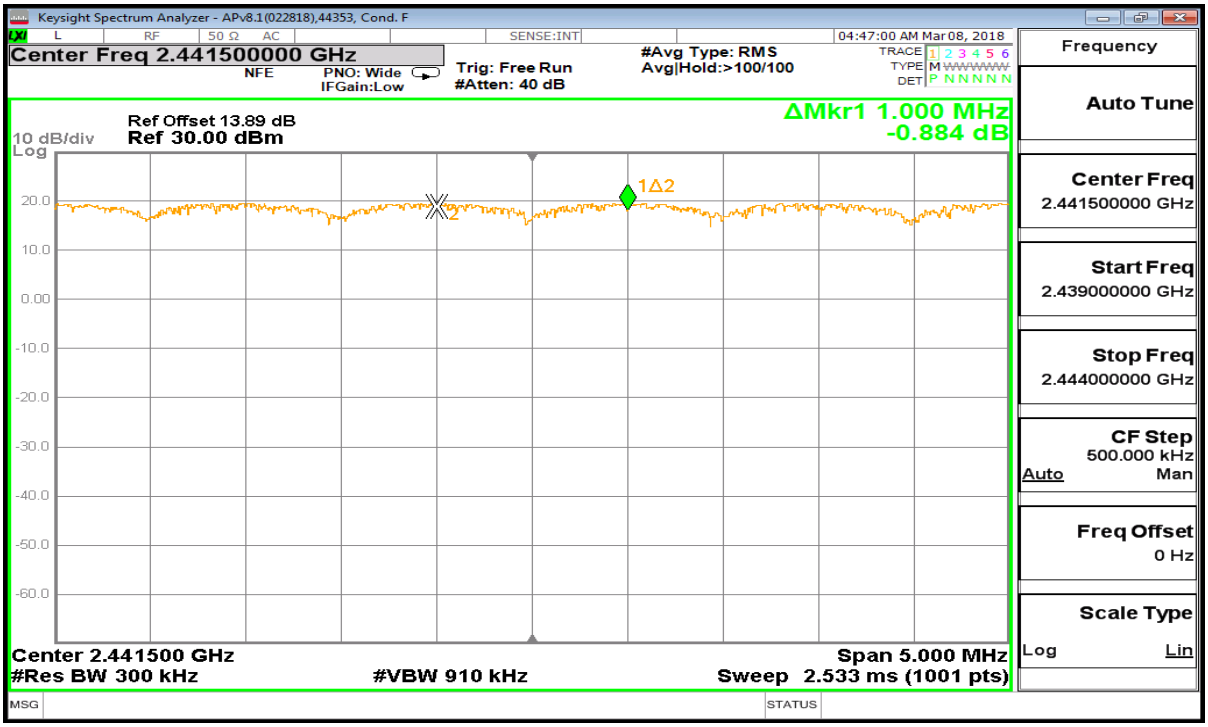
HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

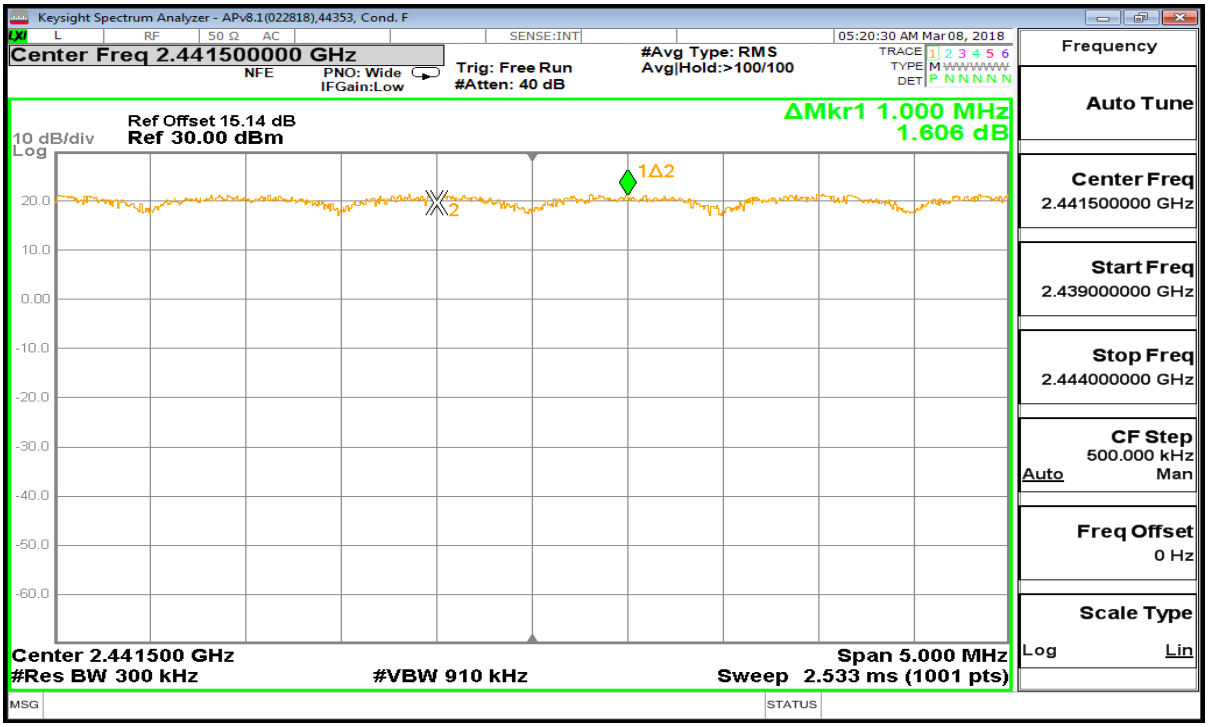
ANTENNA 4



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

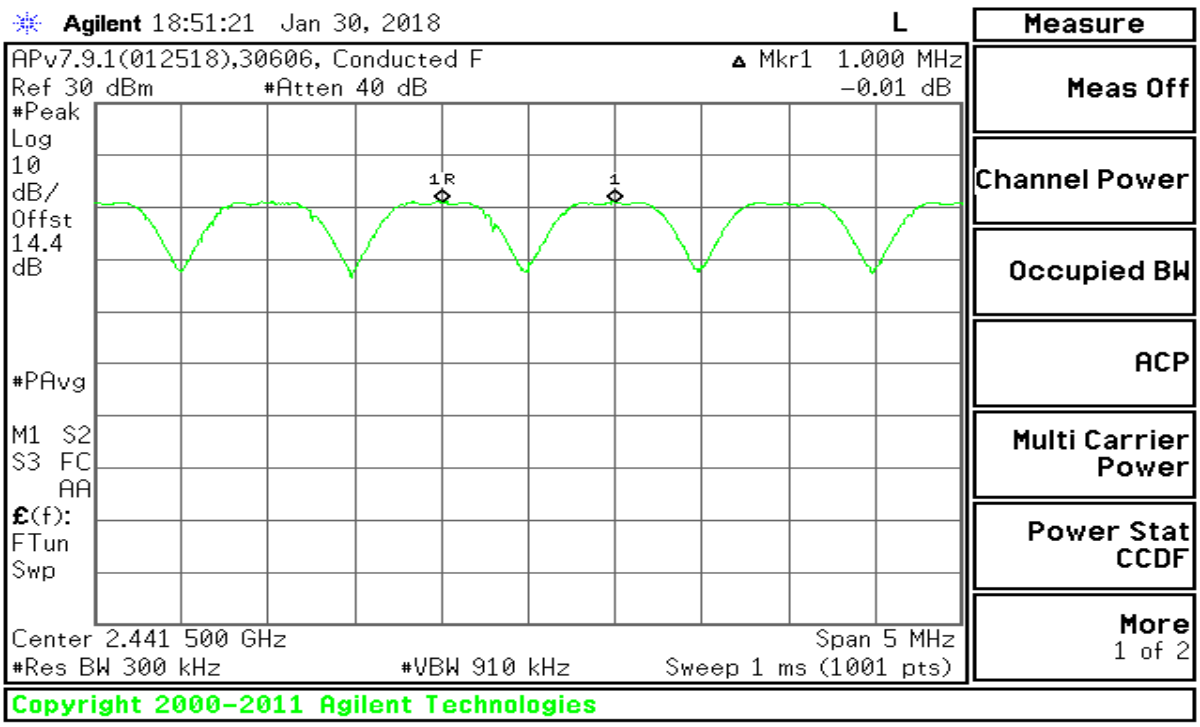


HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3.3. LOW POWER BASIC DATA RATE GFSK MODULATION

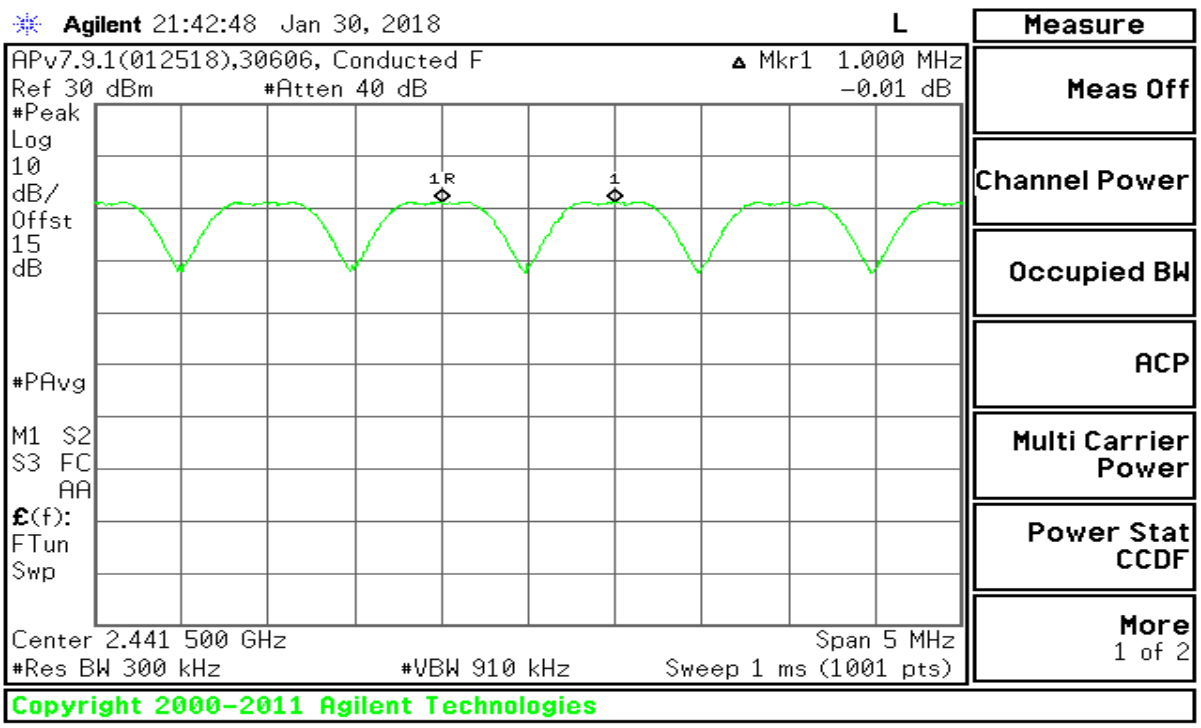
ANTENNA 4



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

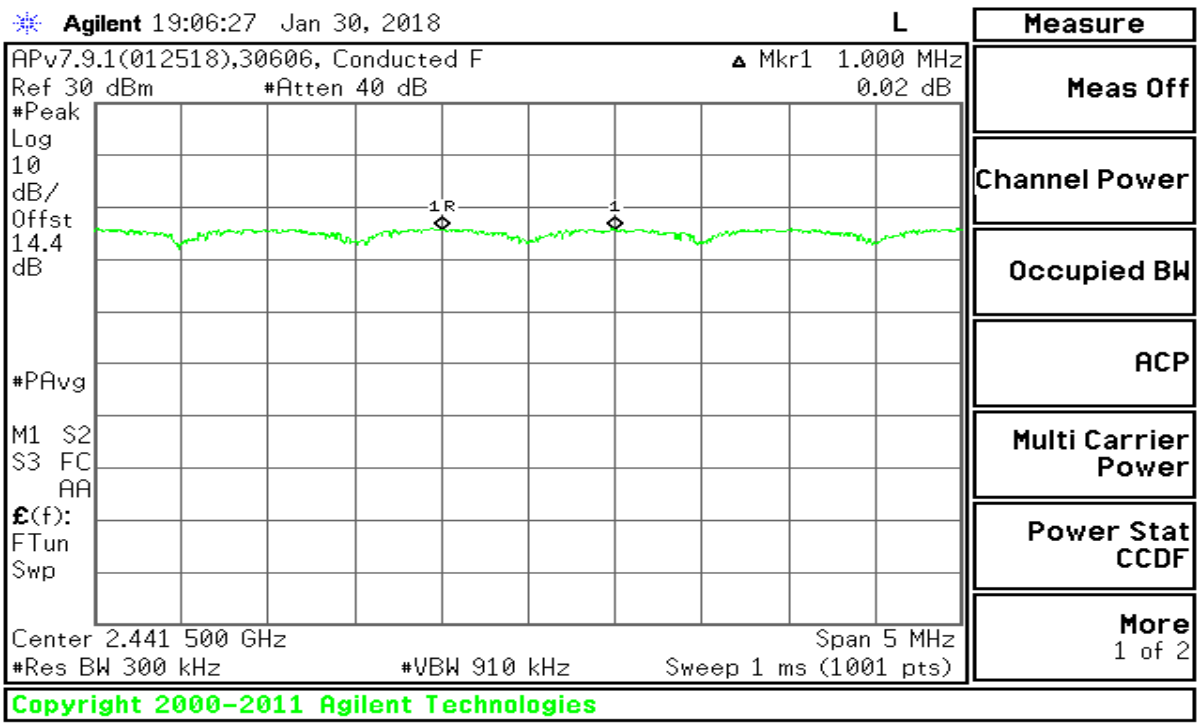


HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.3.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

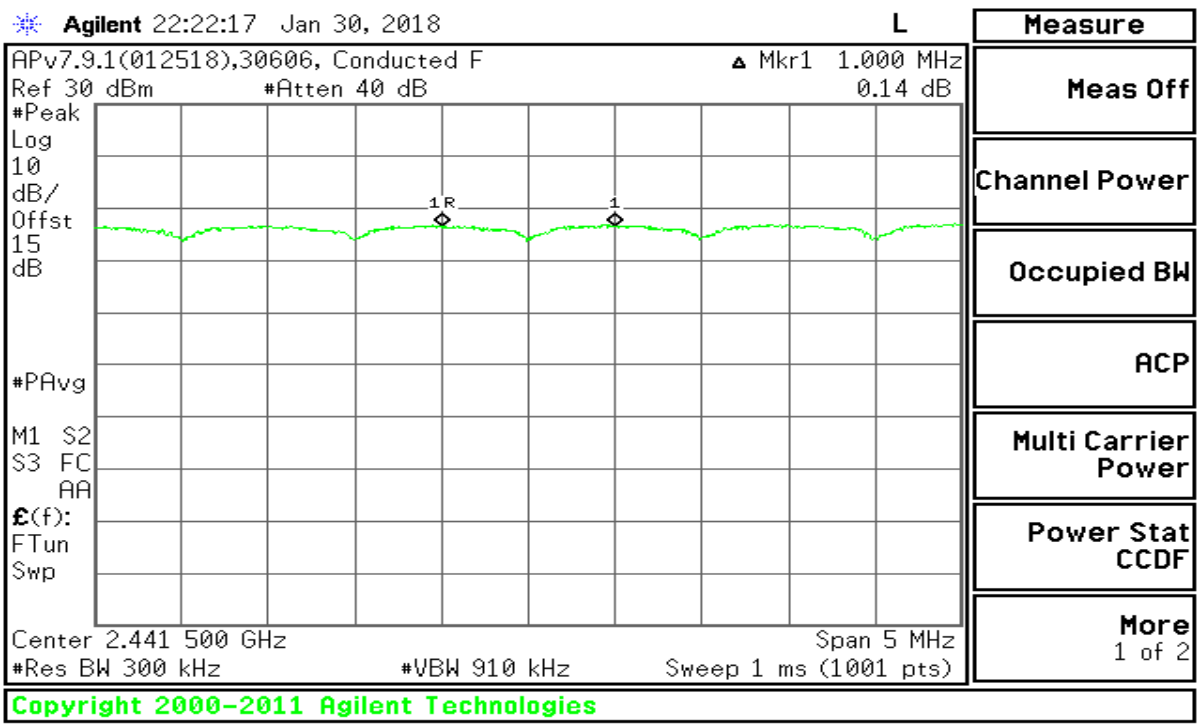
ANTENNA 4



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.4. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

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.

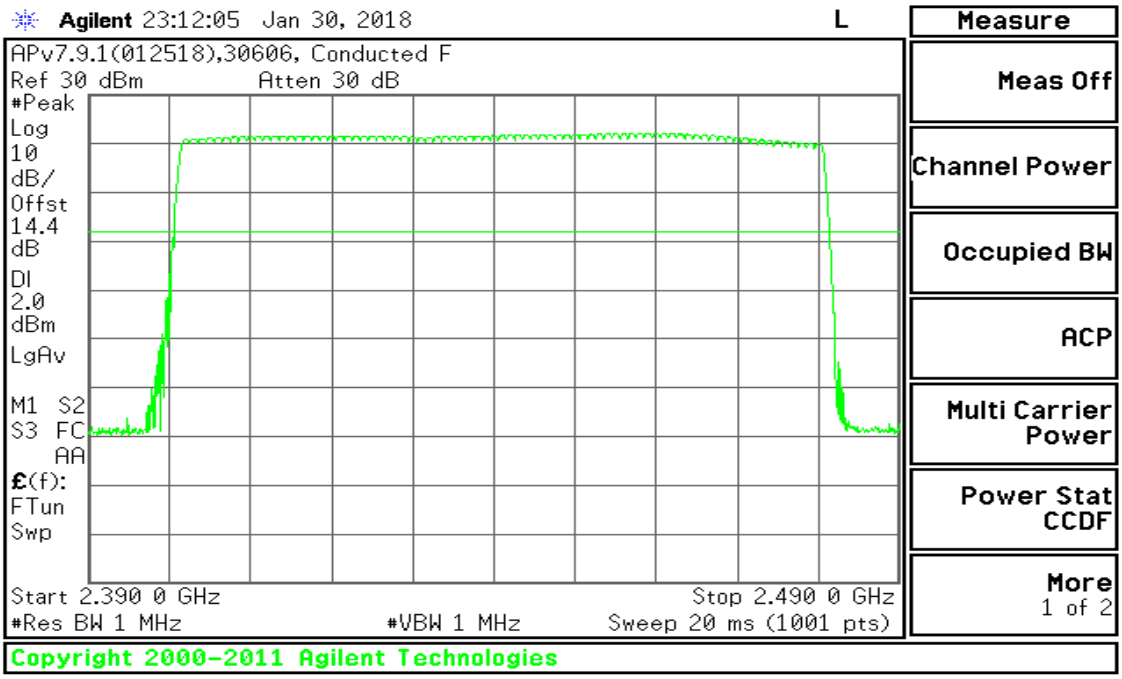
RESULTS

Normal Mode: 79 Channels Observed

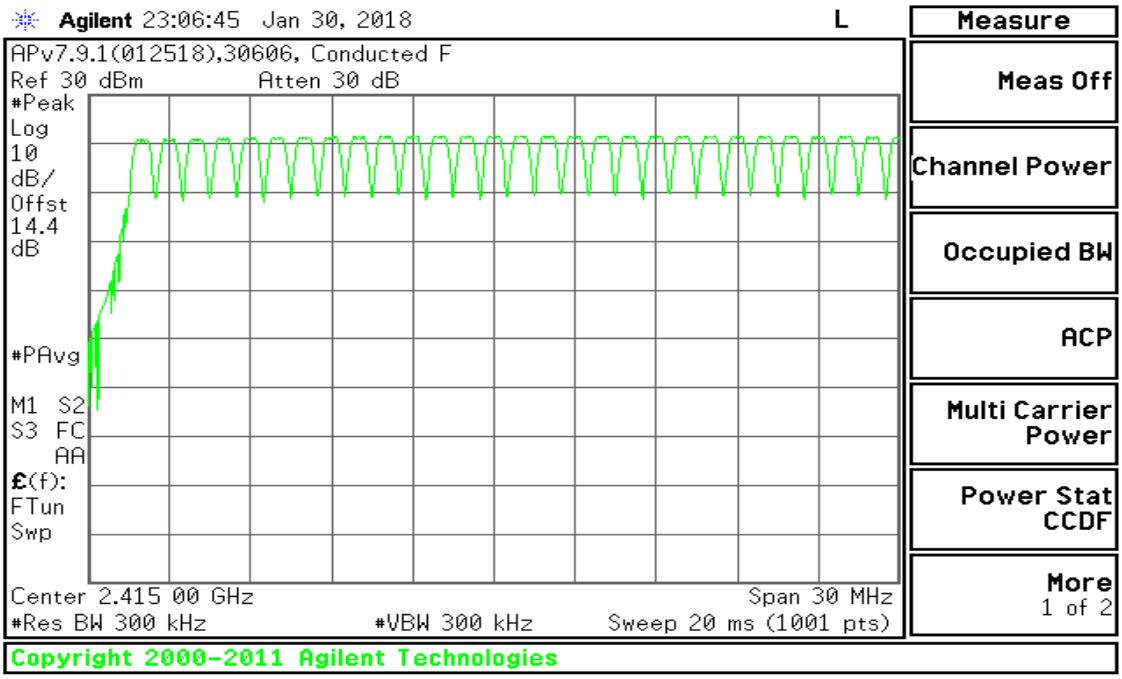
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.4.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

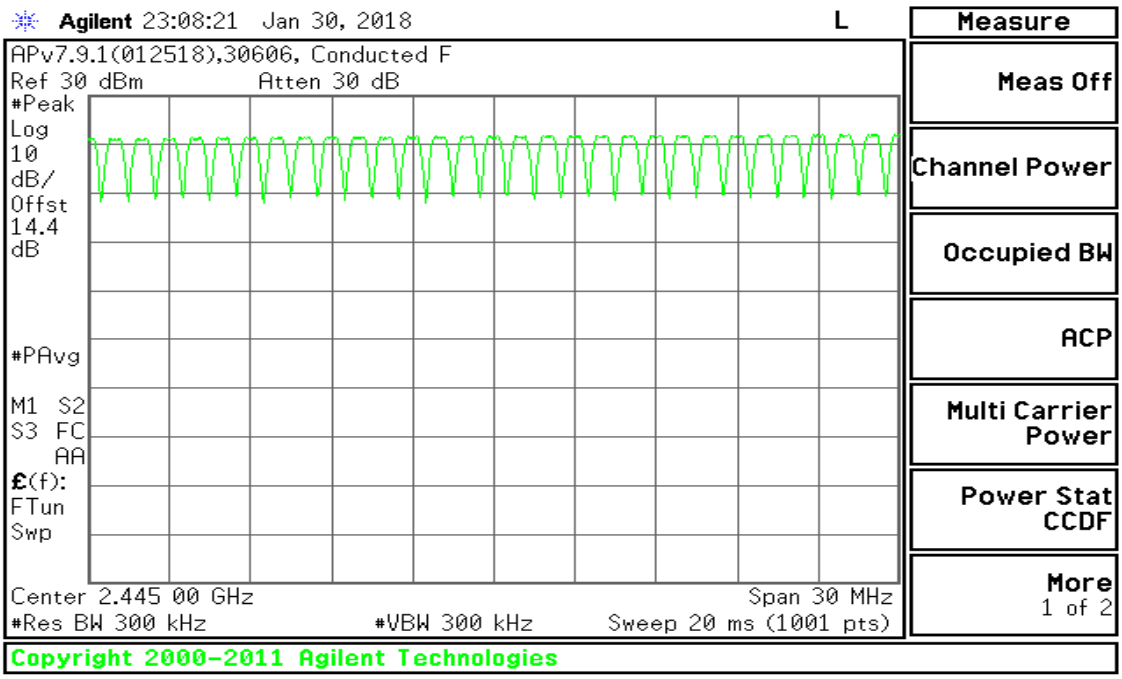


100MHz SPAN

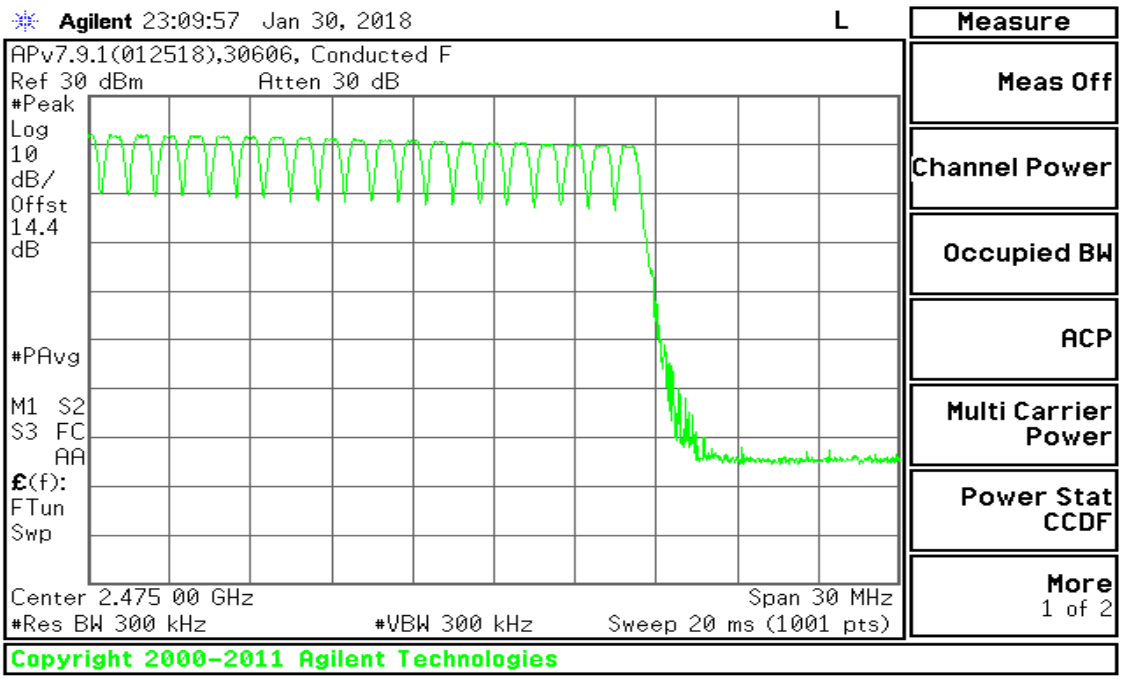


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



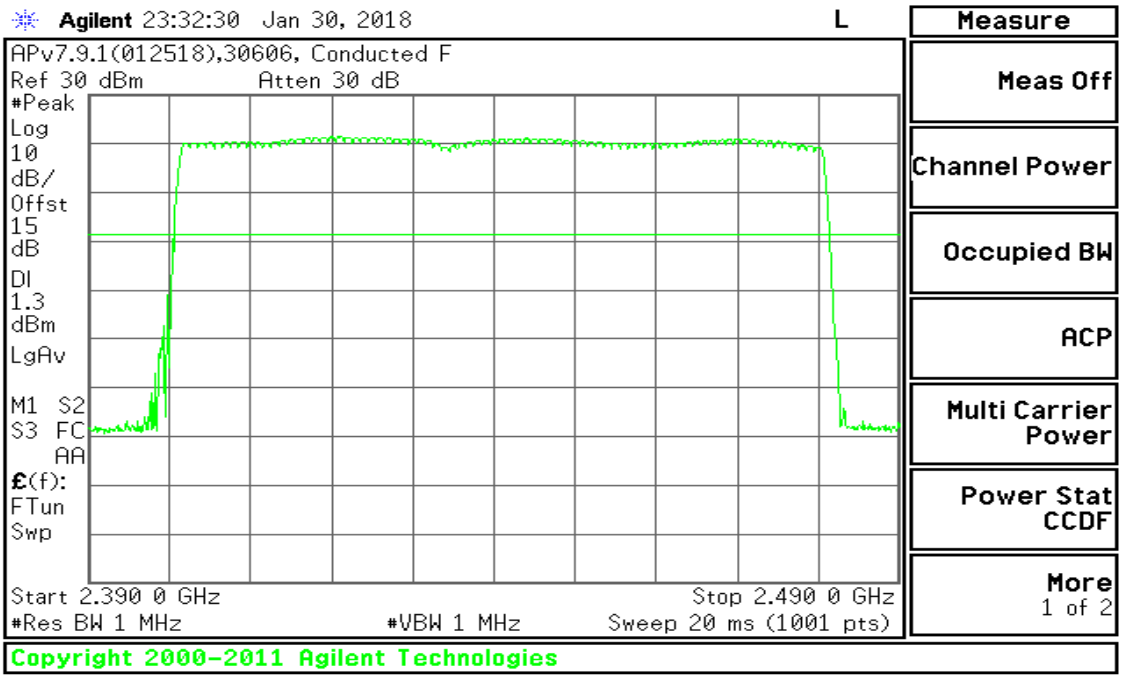
30MHz SPAN, SEGMENT 2 OF 3



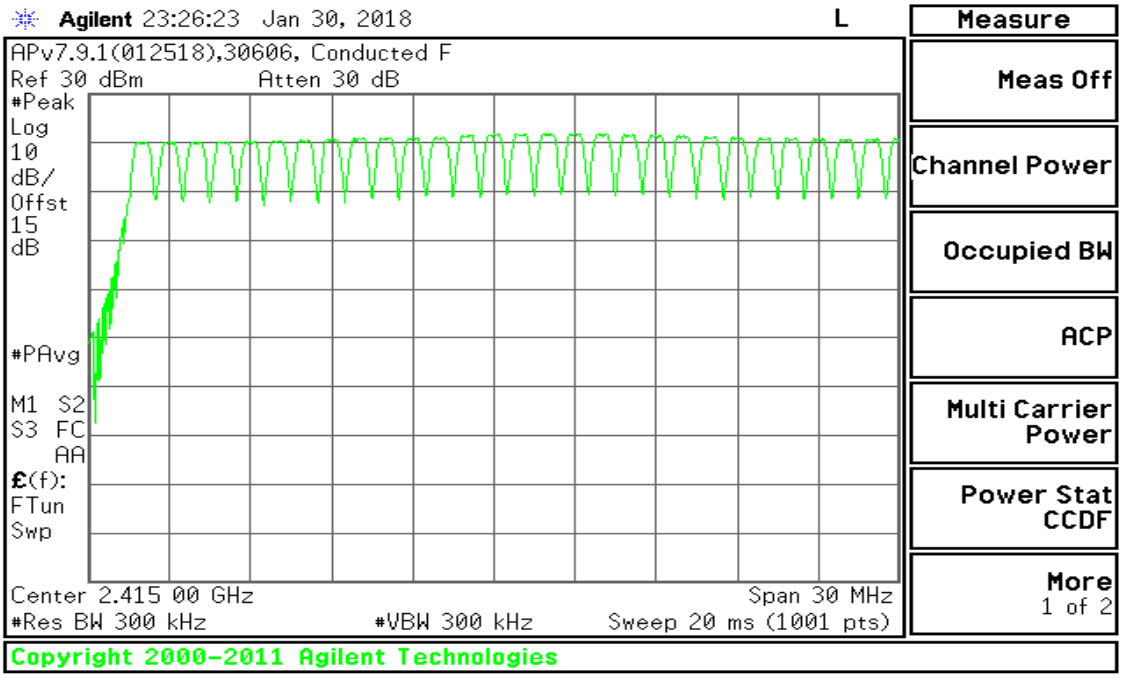
30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

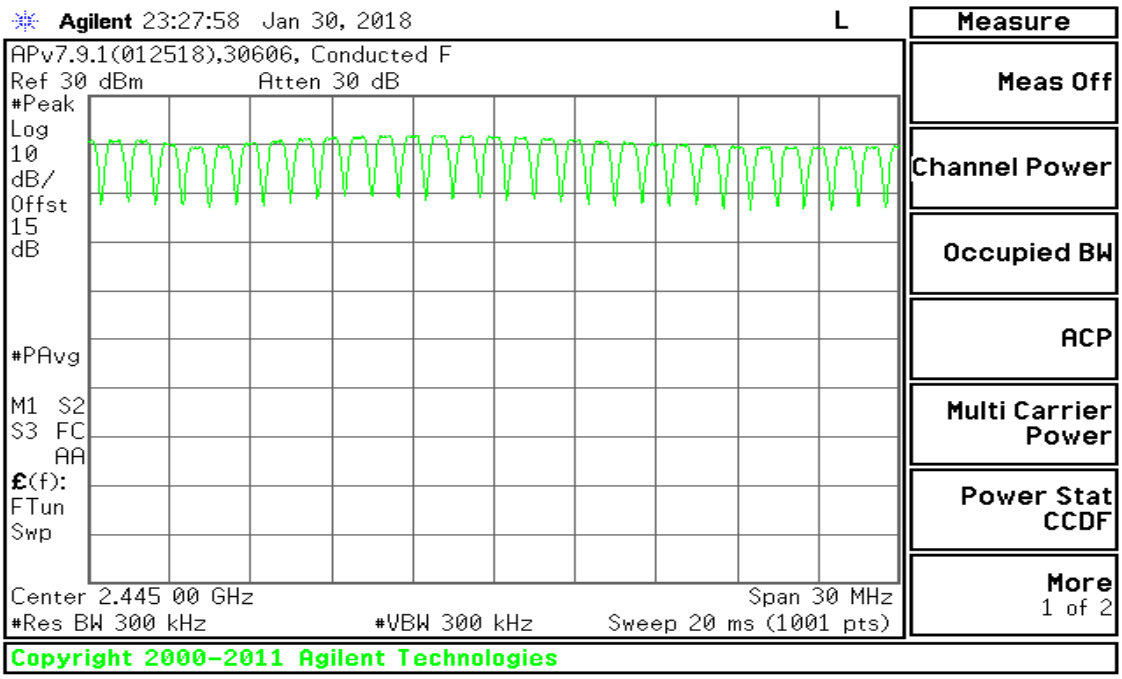


100MHz SPAN

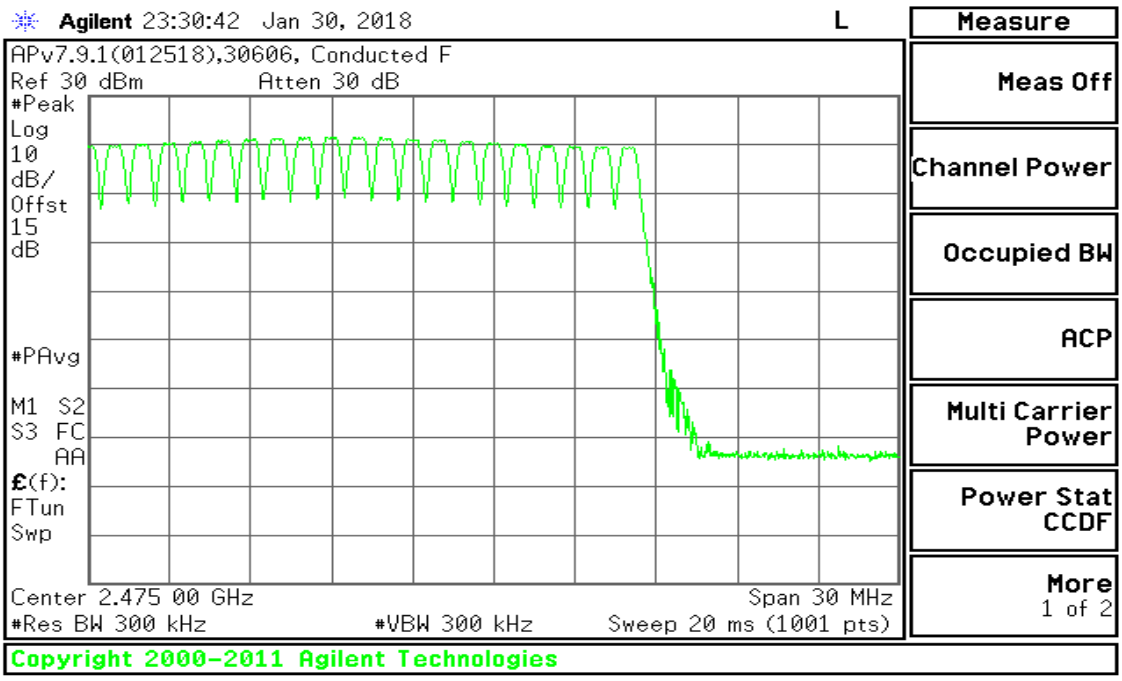


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



30MHz SPAN, SEGMENT 2 OF 3

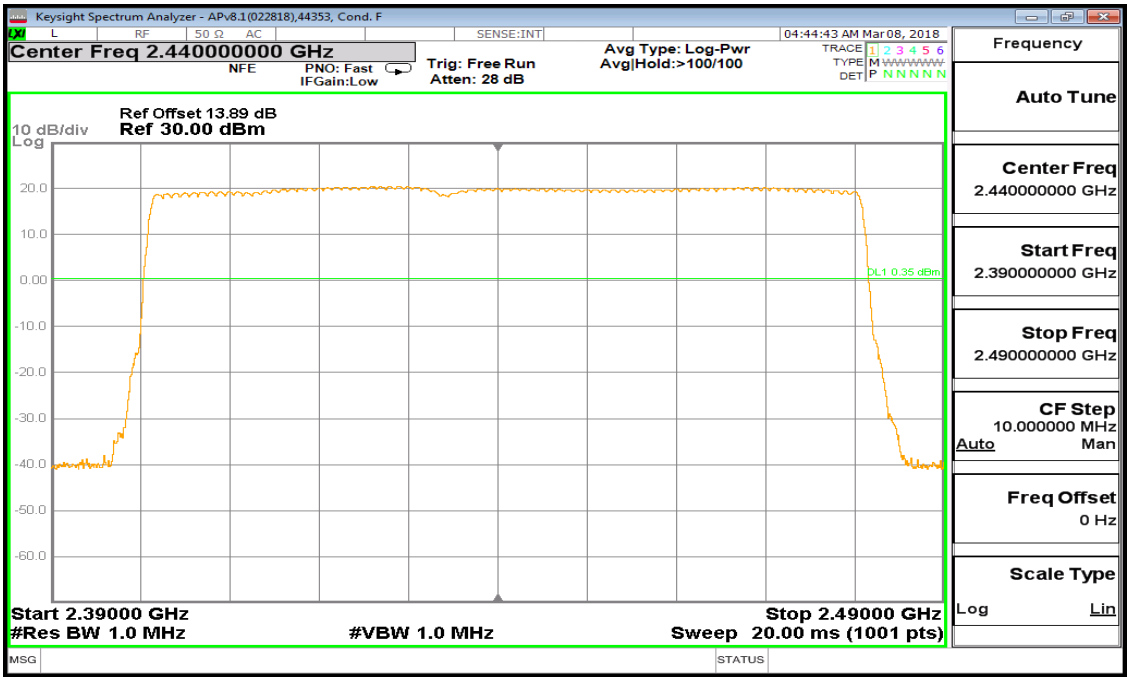


30MHz SPAN, SEGMENT 3 OF 3

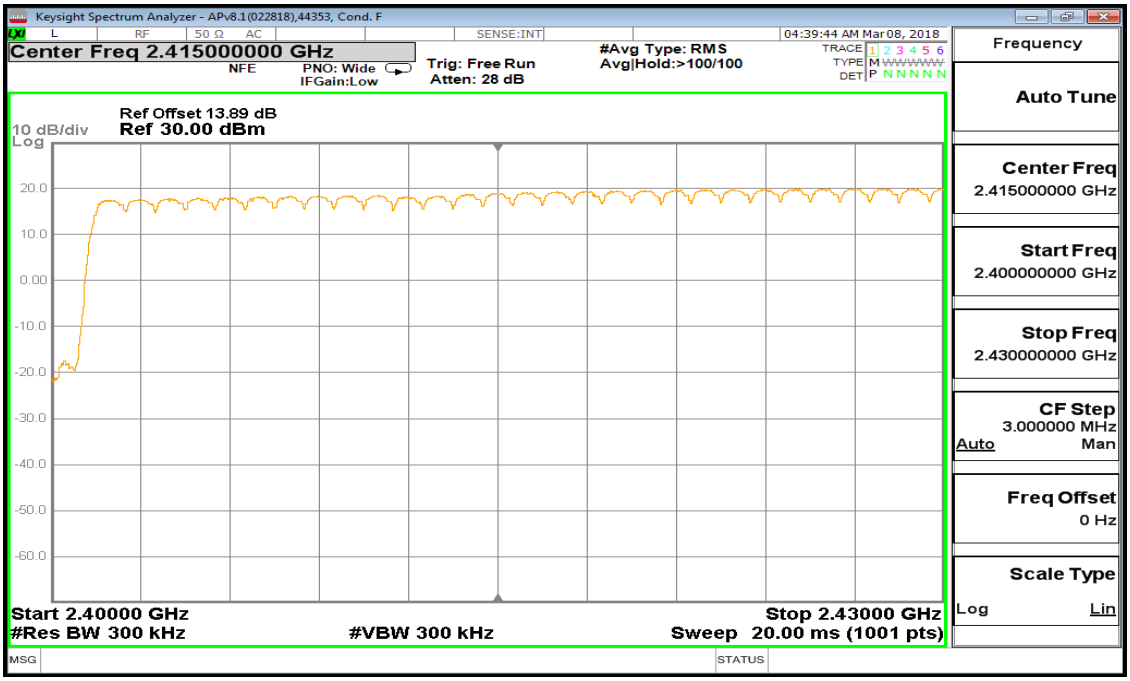
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.4.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

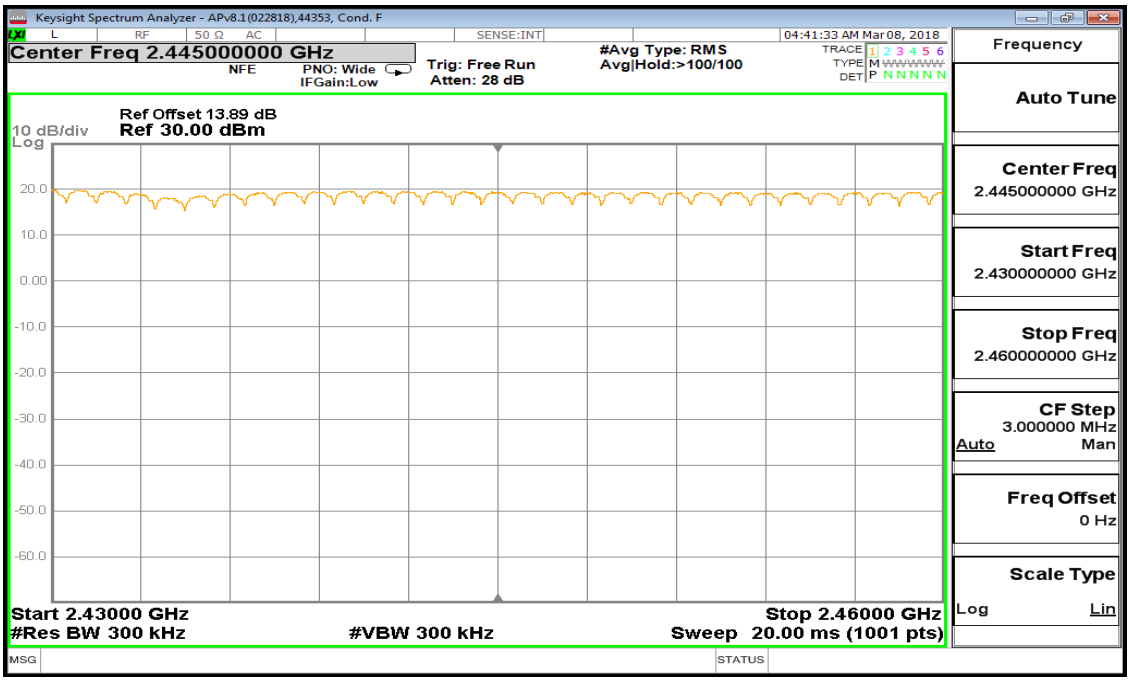


100MHz SPAN

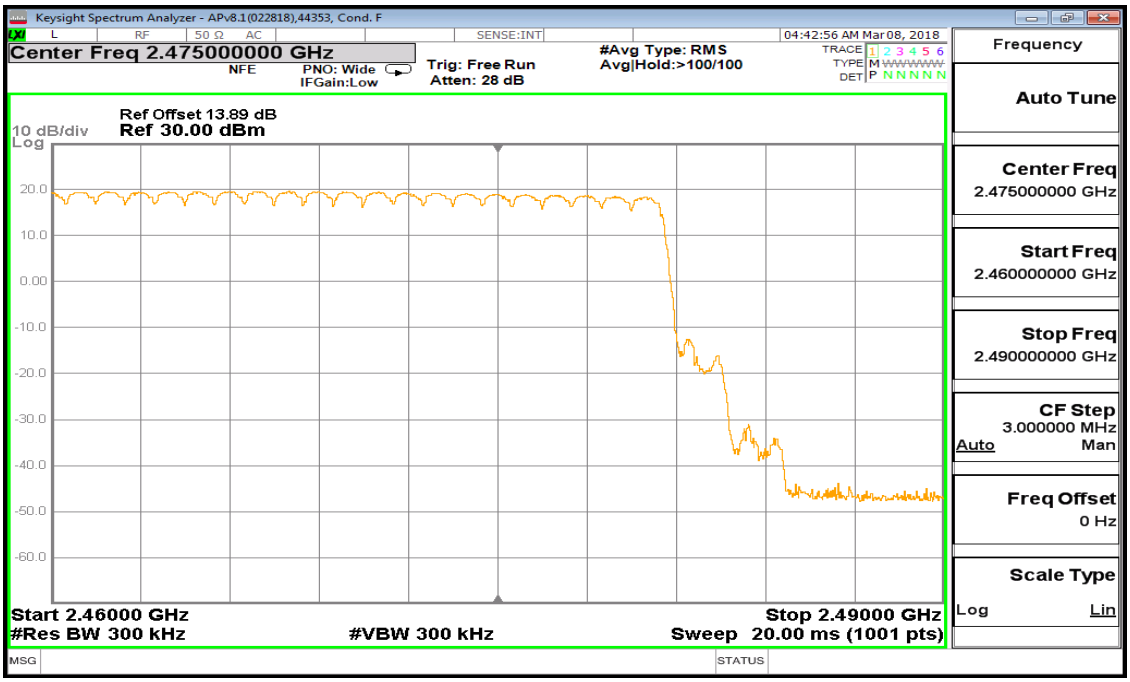


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



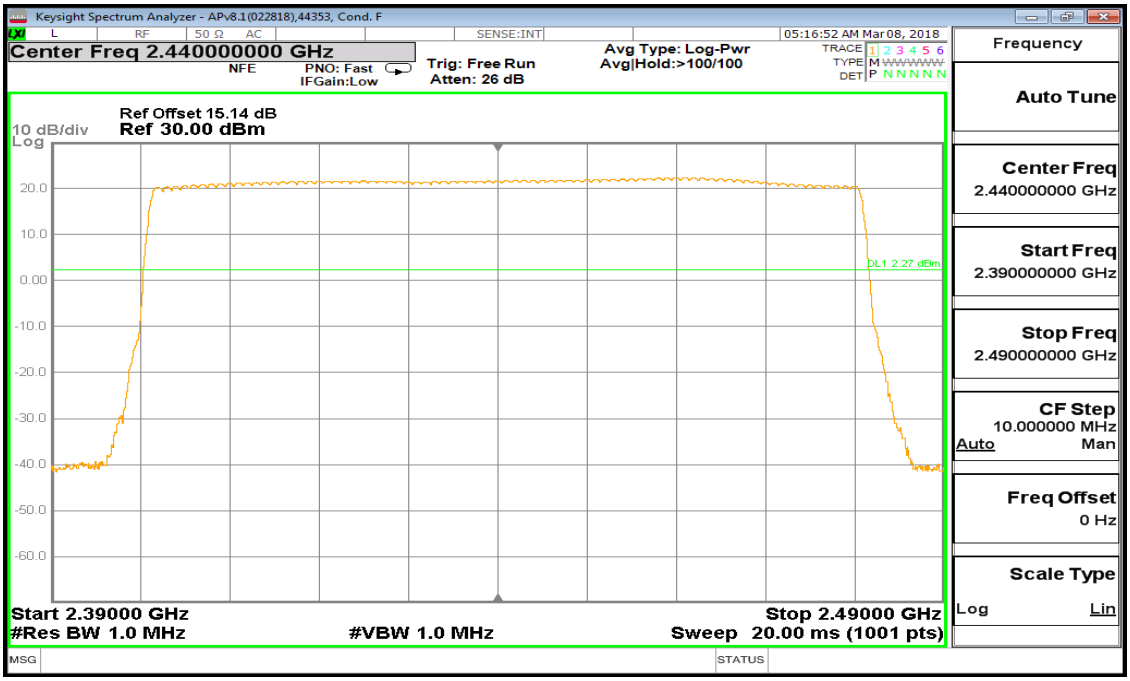
30MHz SPAN, SEGMENT 2 OF 3



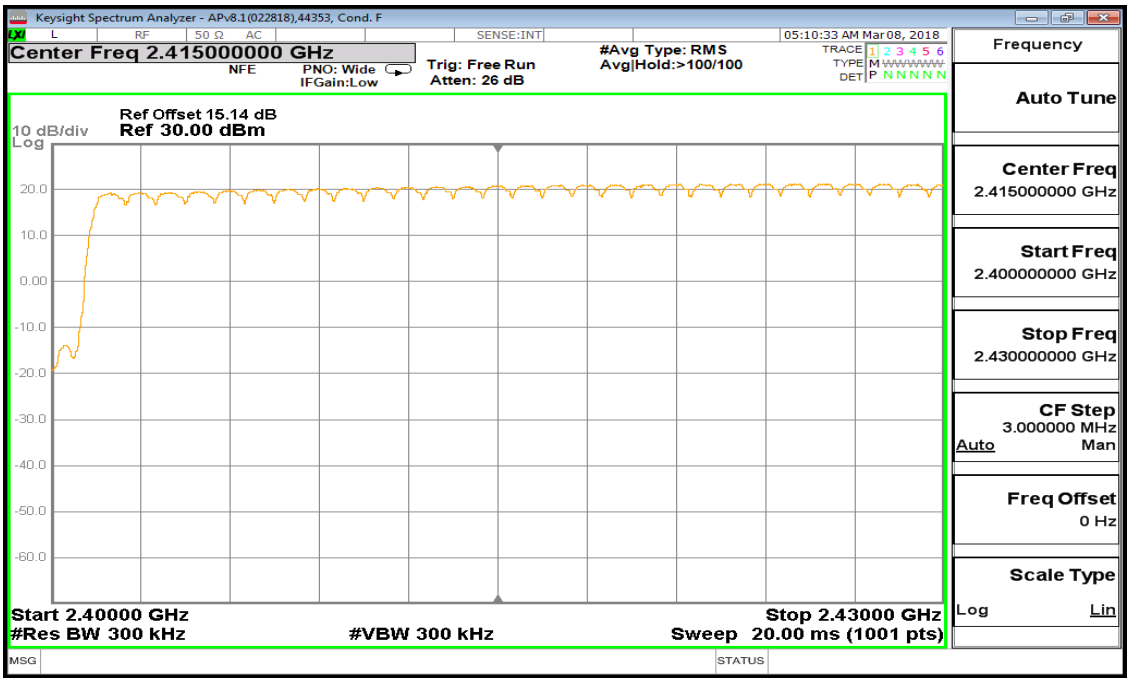
30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

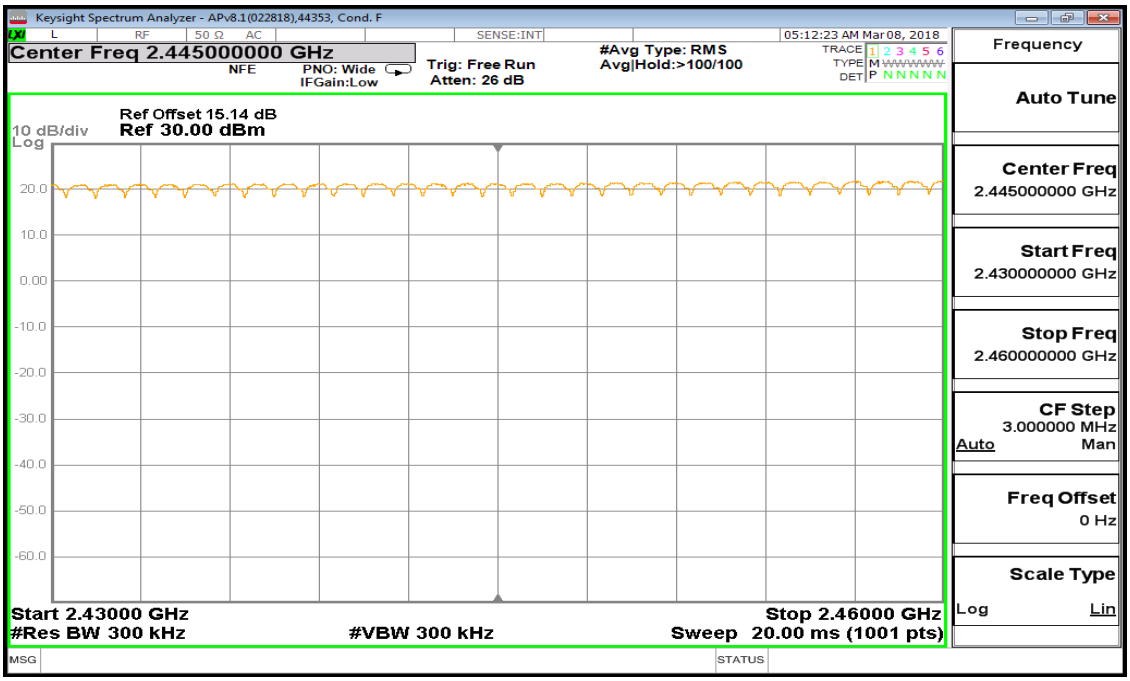


100MHz SPAN

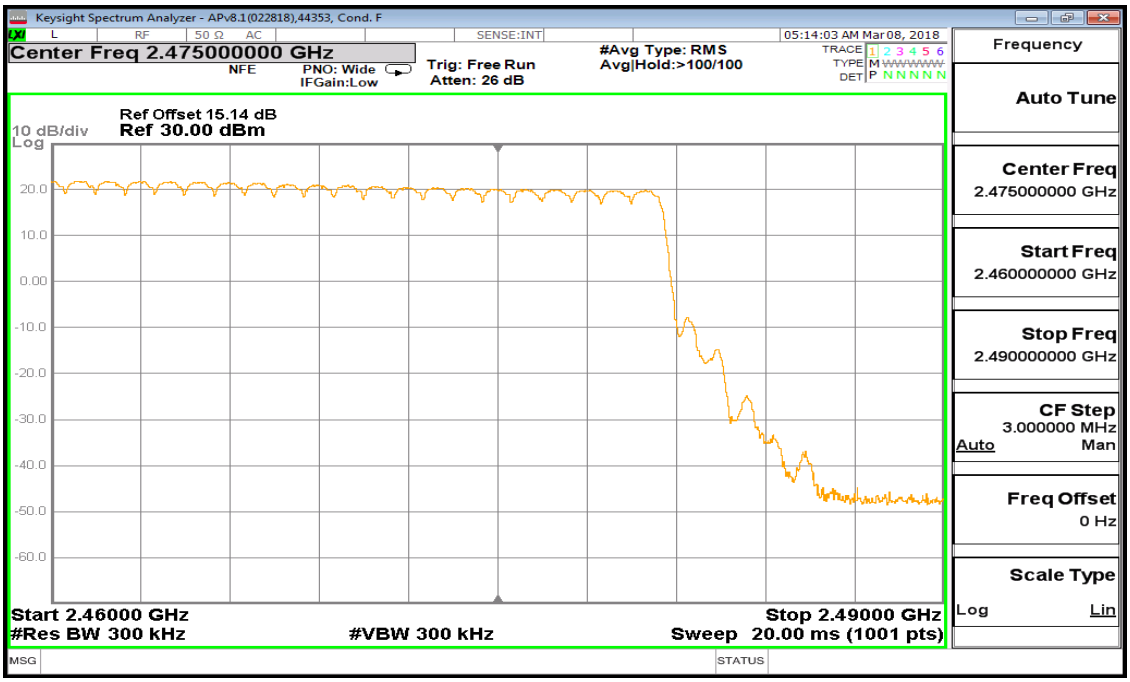


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



30MHz SPAN, SEGMENT 2 OF 3

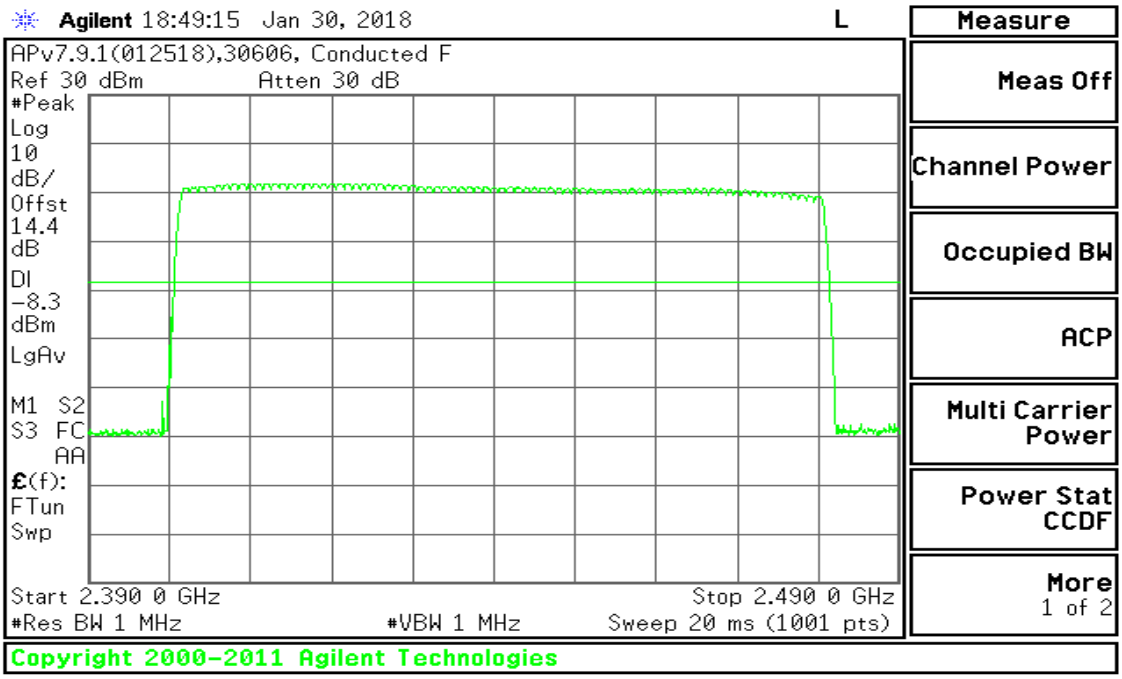


30MHz SPAN, SEGMENT 3 OF 3

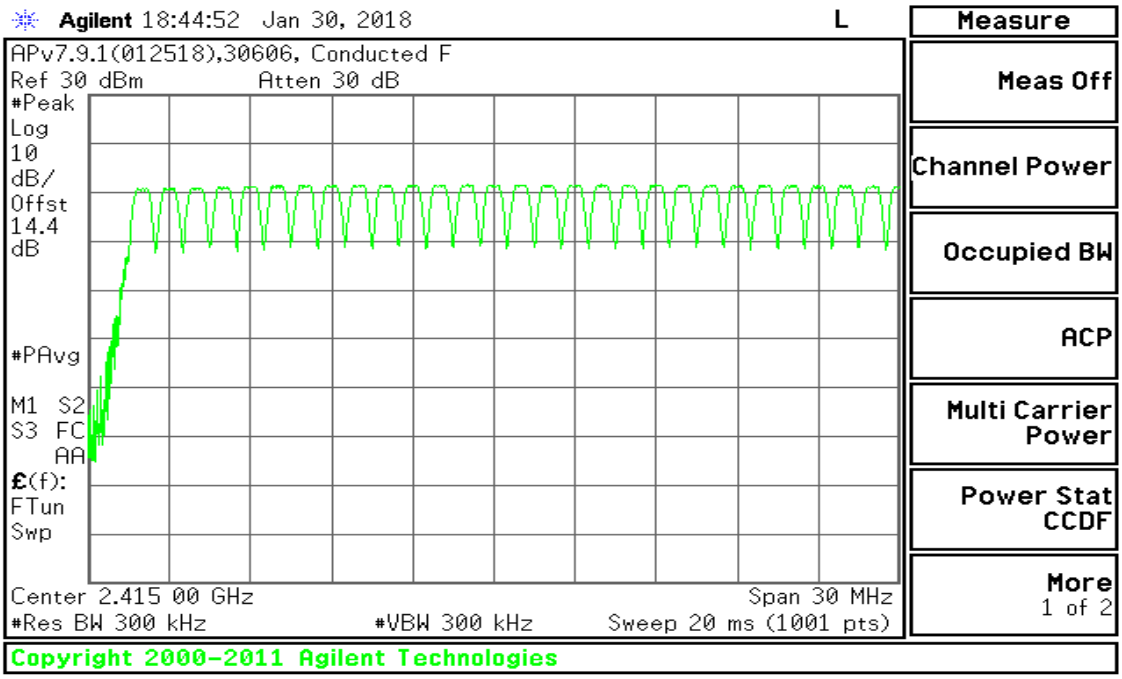
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.4.3. LOW POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

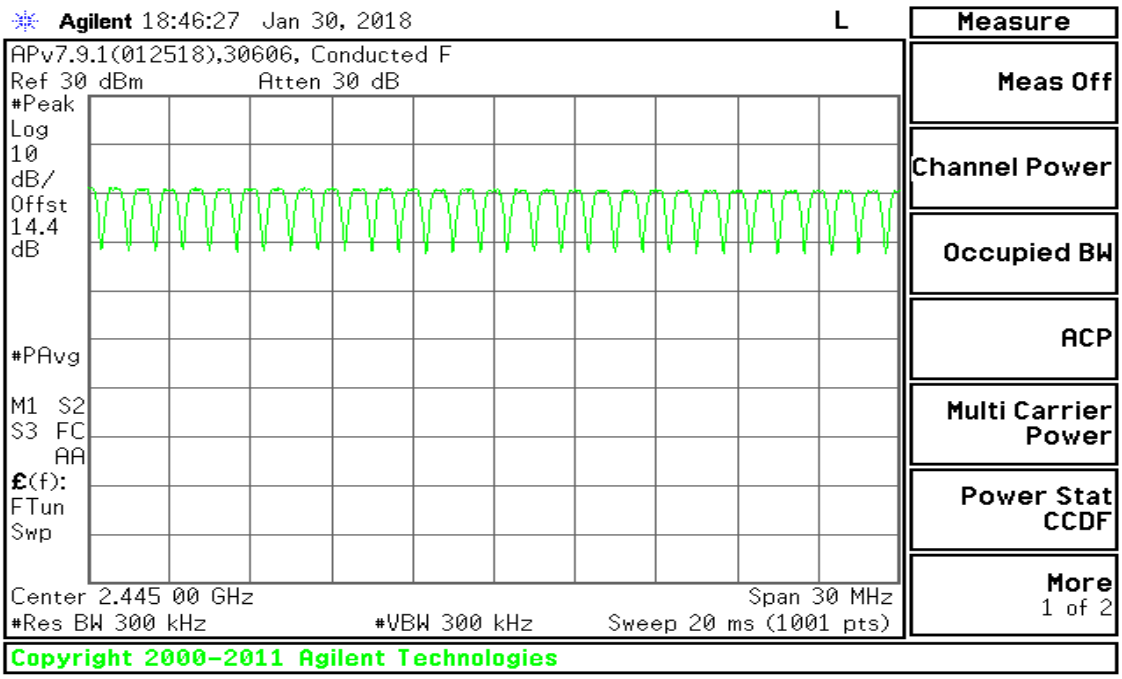


100MHz SPAN

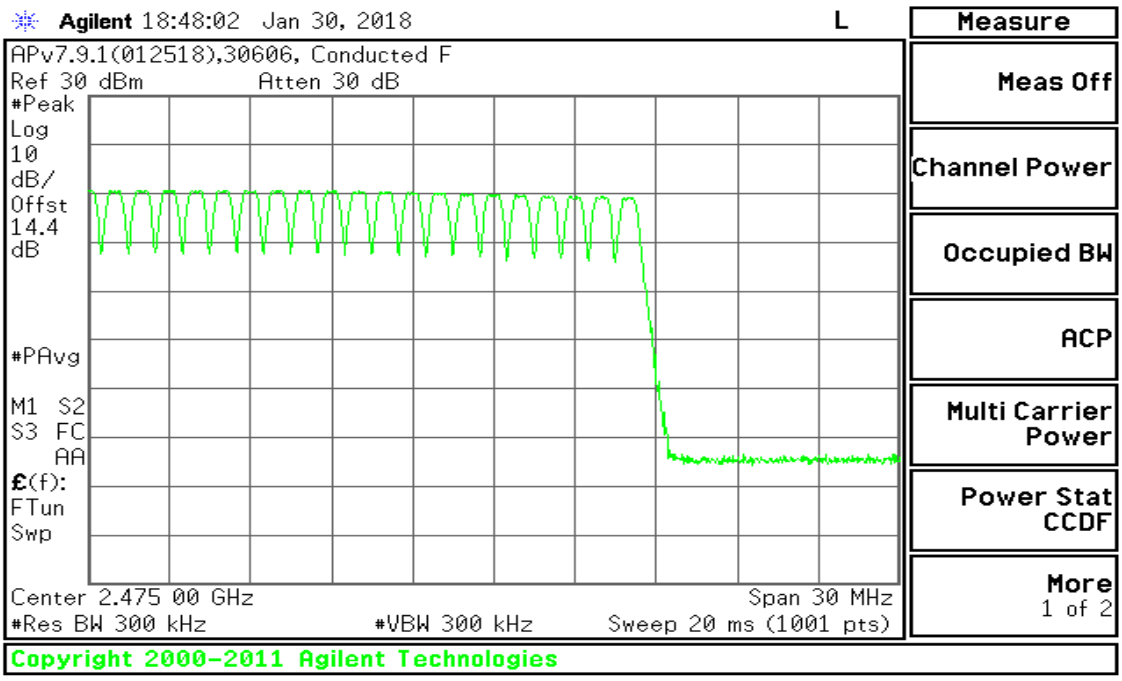


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



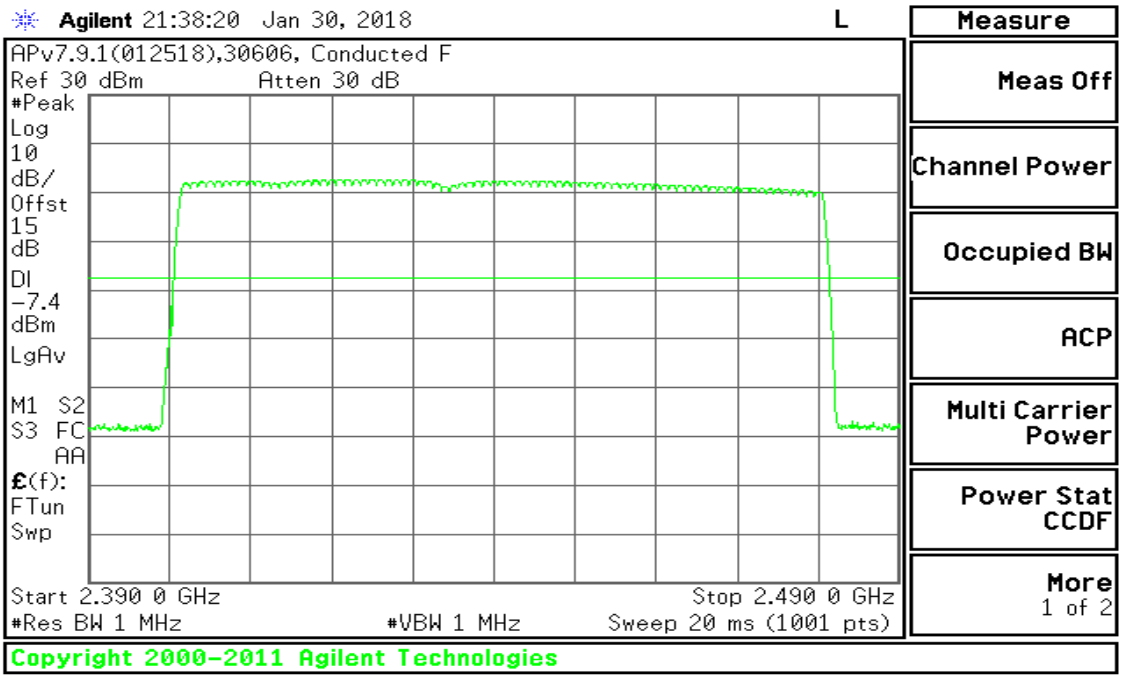
30MHz SPAN, SEGMENT 2 OF 3



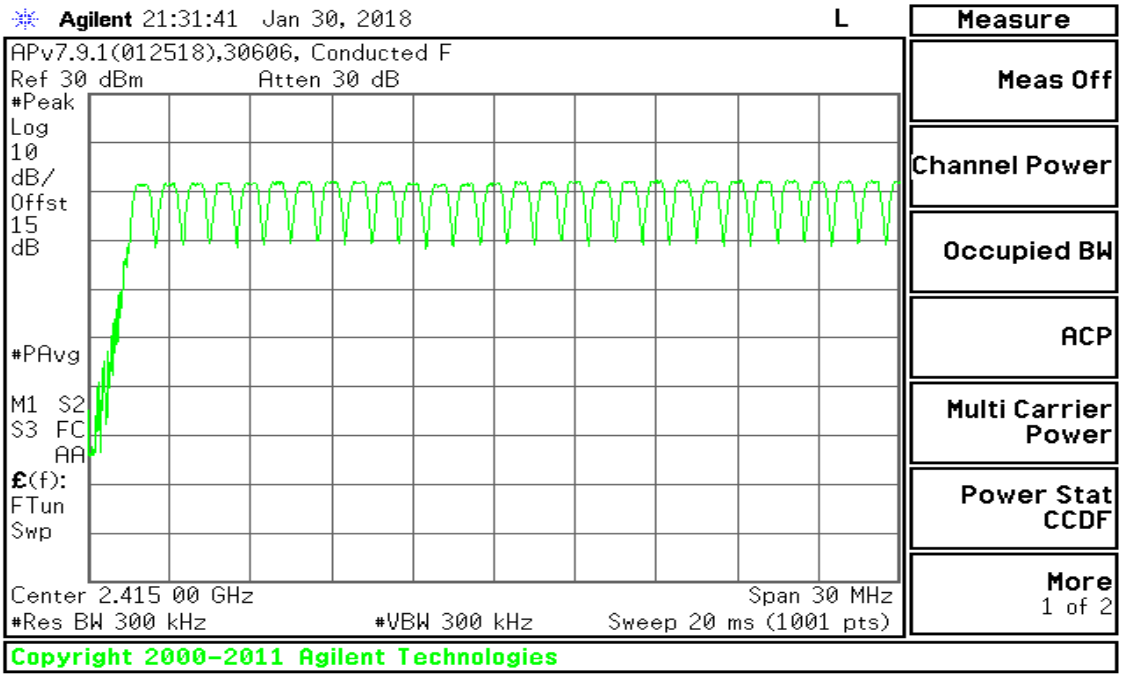
30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

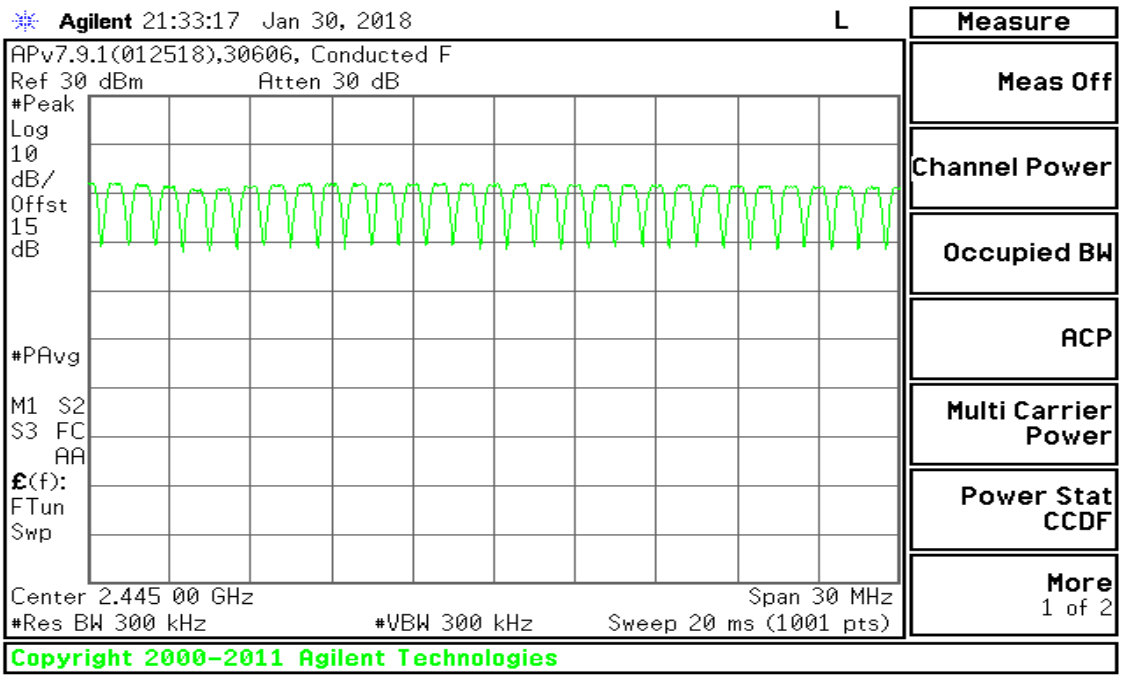


100MHz SPAN

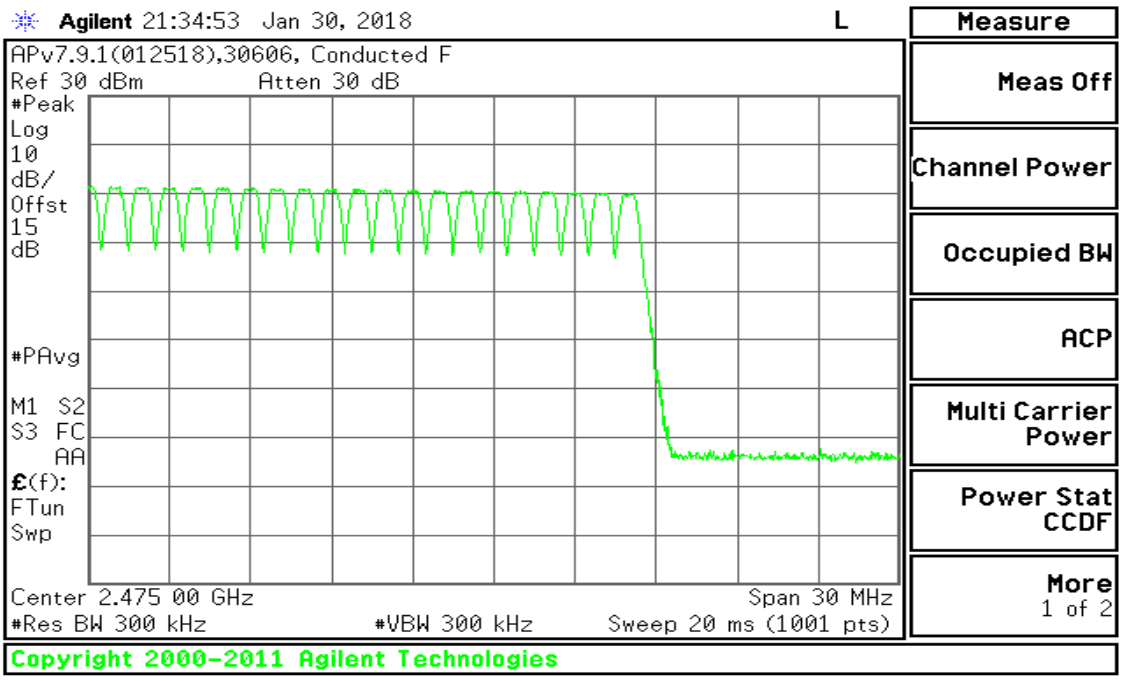


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



30MHz SPAN, SEGMENT 2 OF 3

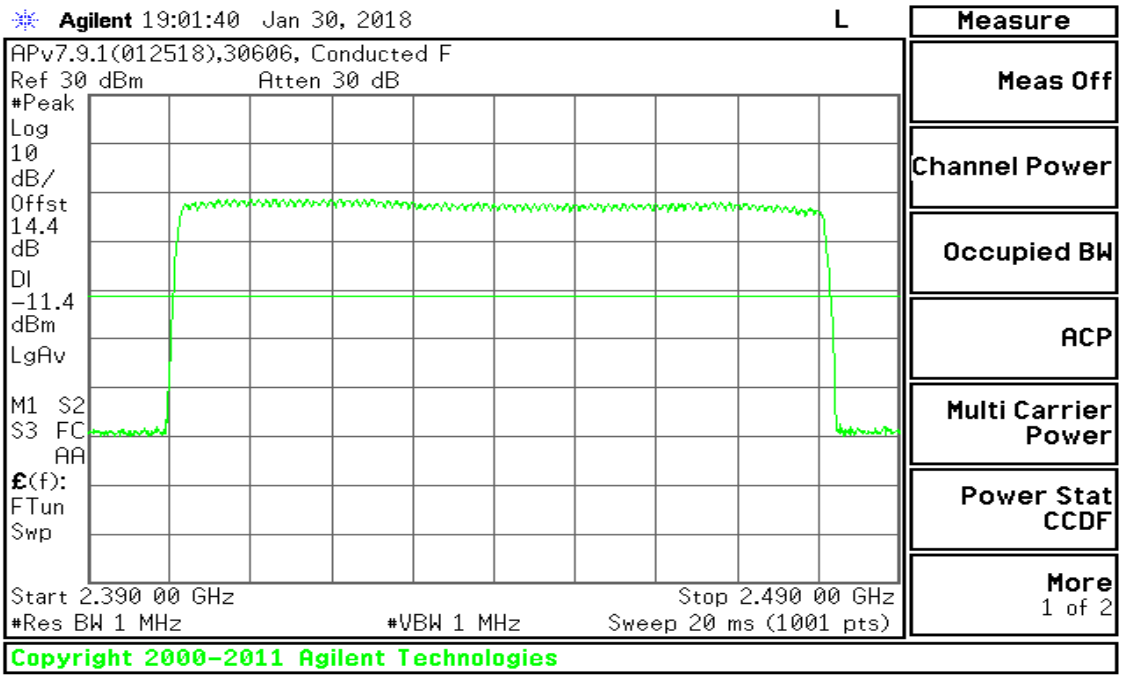


30MHz SPAN, SEGMENT 3 OF 3

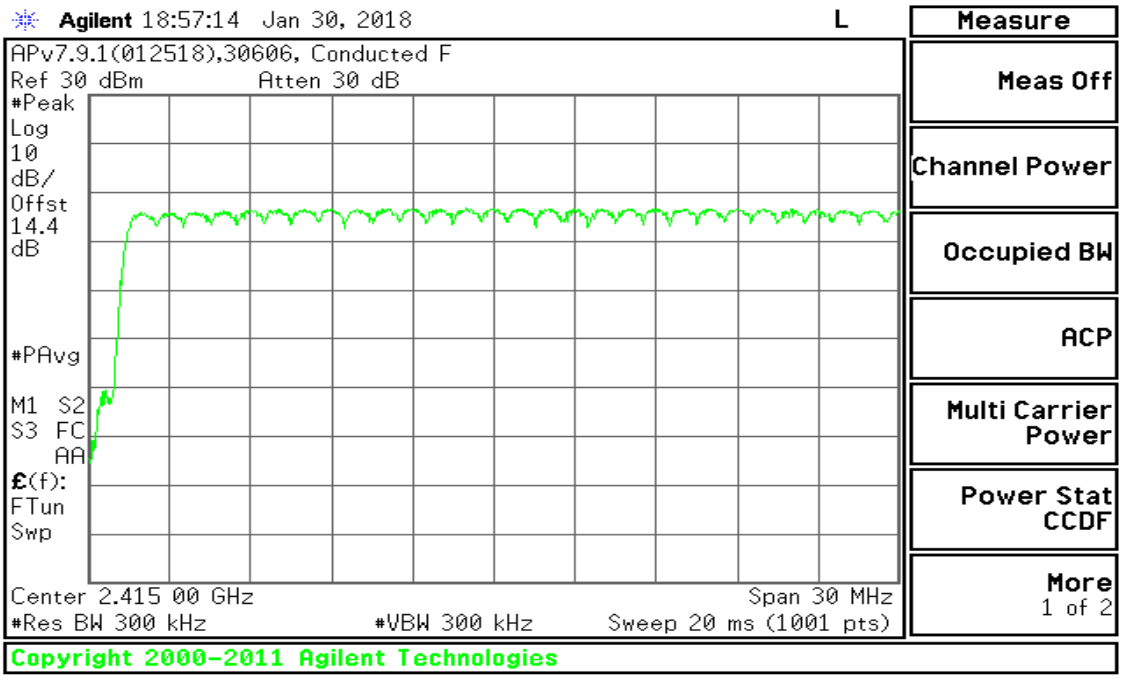
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.4.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

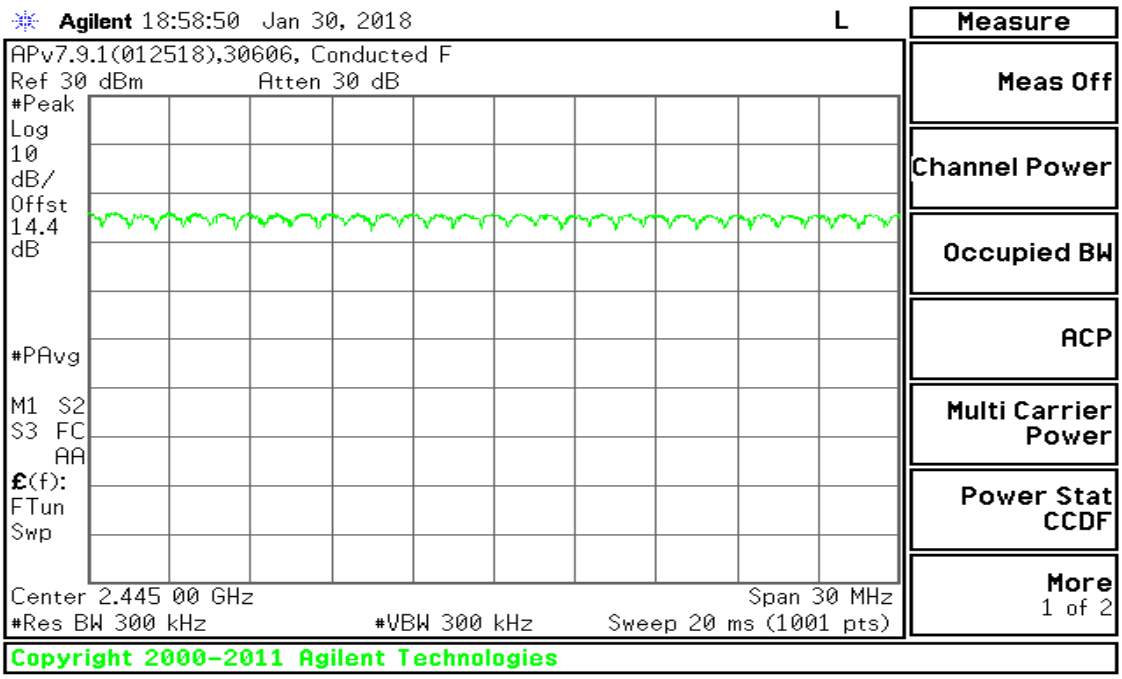


100MHz SPAN

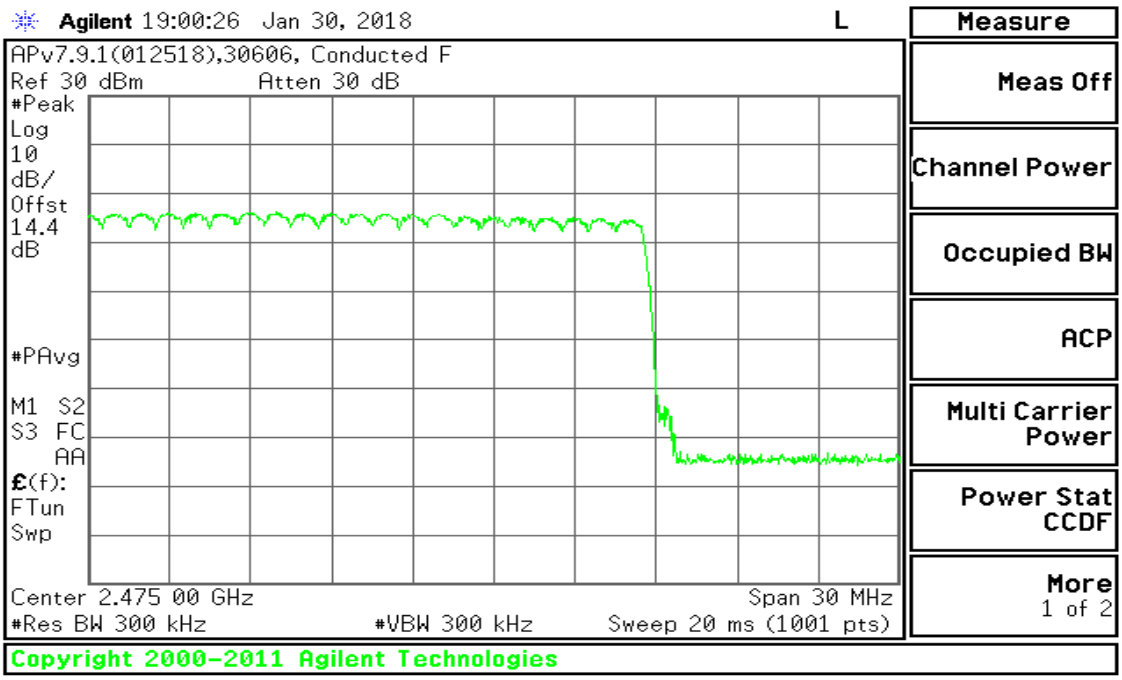


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



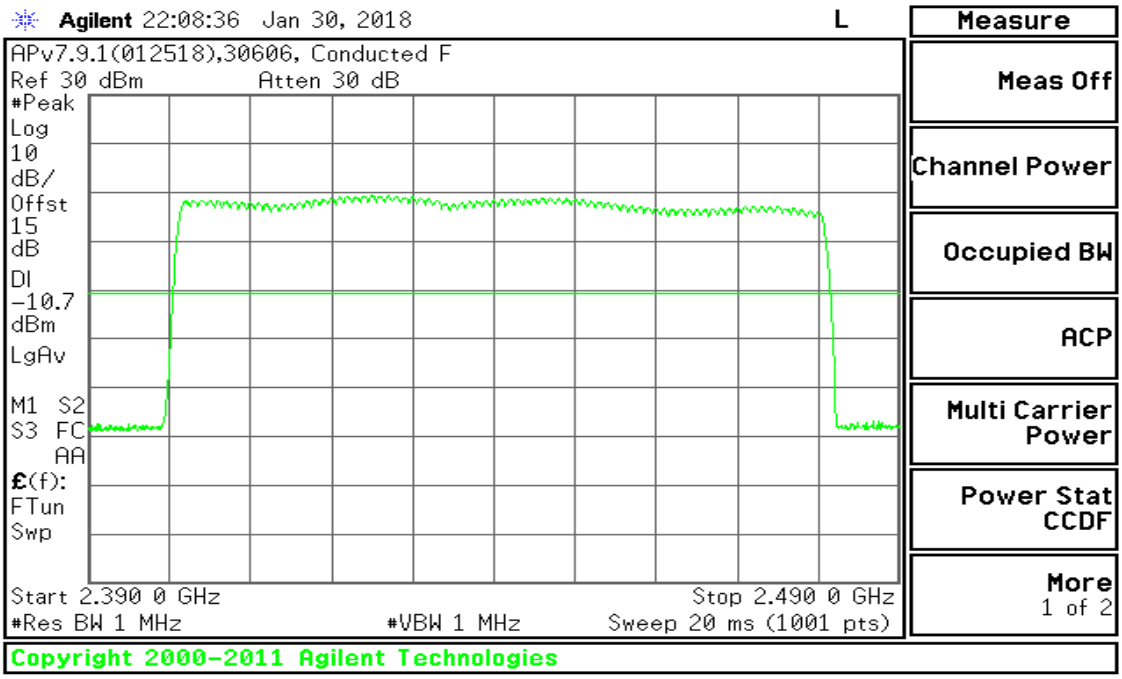
30MHz SPAN, SEGMENT 2 OF 3



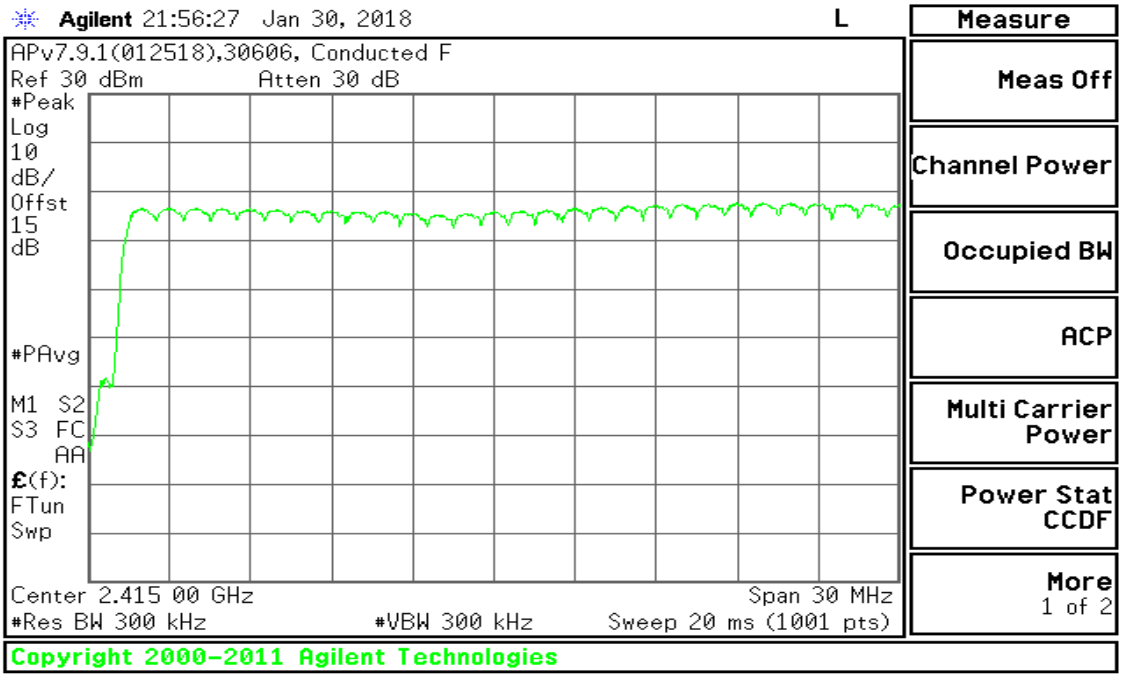
30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

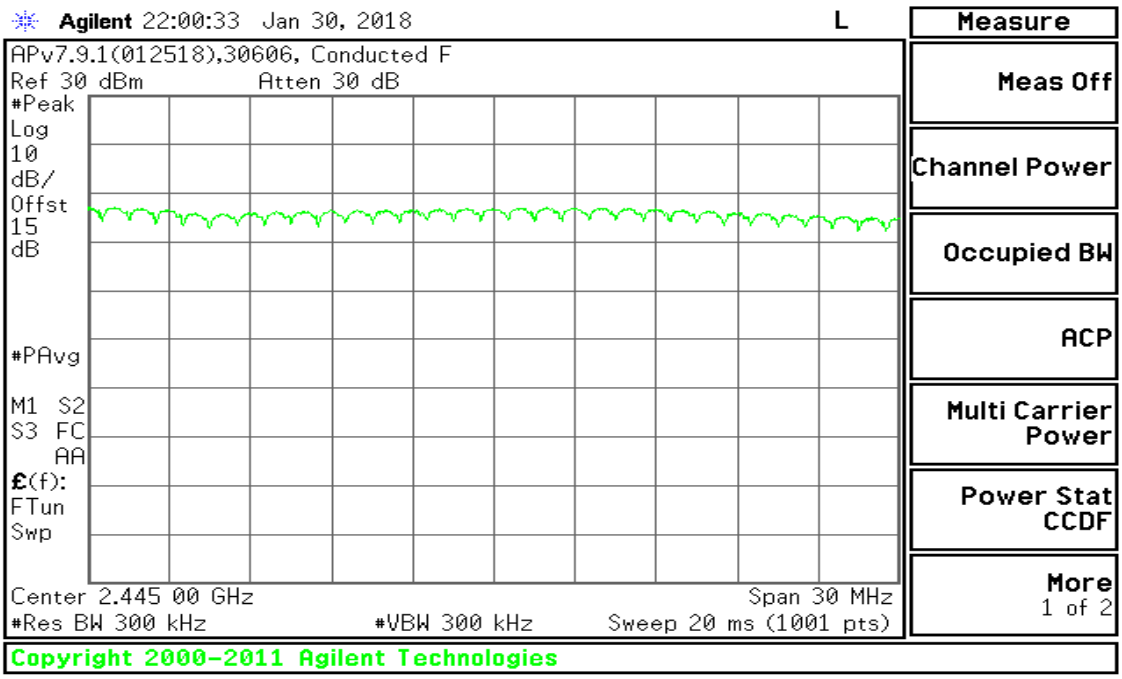


100MHz SPAN

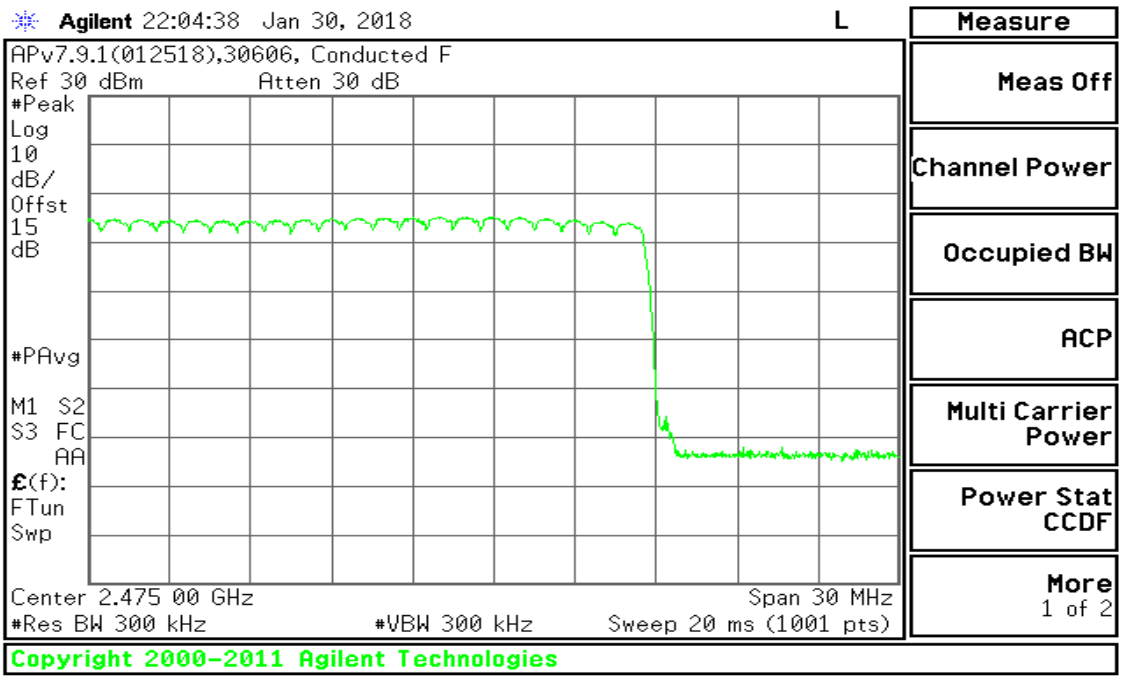


30MHz SPAN, SEGMENT 1 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.5. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

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 3.16 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

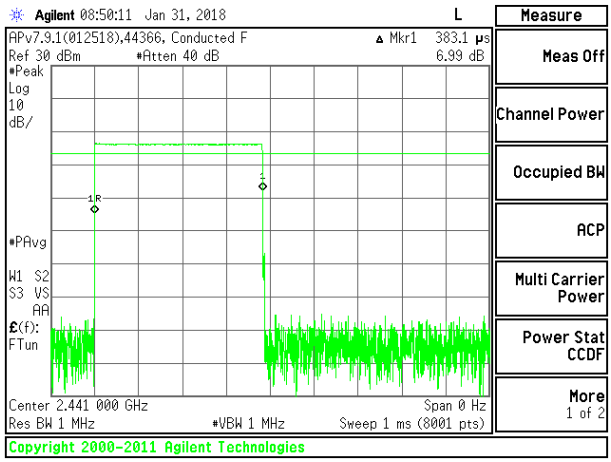
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.5.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

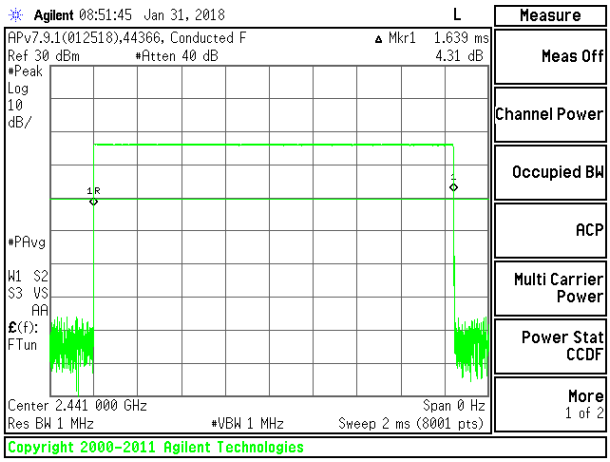
ANTENNA 4

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	0.383	31	0.1187	0.4	-0.2813
DH3	1.639	16	0.2622	0.4	-0.1378
DH5	2.887	11	0.3176	0.4	-0.0824
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.383	7.75	0.02968	0.4	-0.3703
DH3	1.639	4	0.06556	0.4	-0.3344
DH5	2.887	2.75	0.07939	0.4	-0.3206

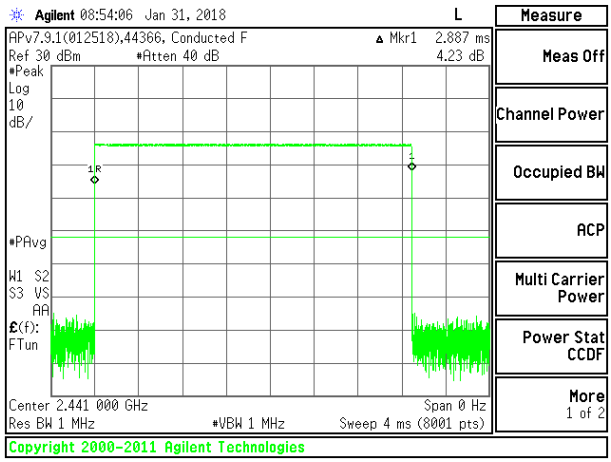
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



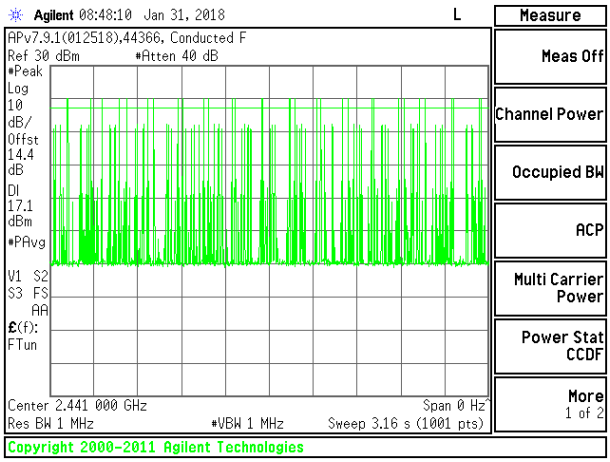
PULSE WIDTH – DH1



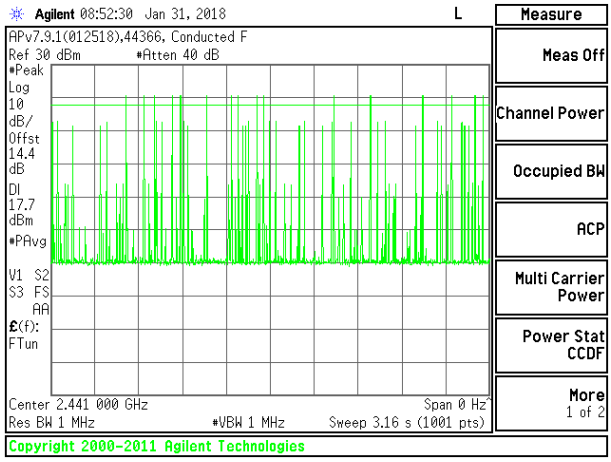
PULSE WIDTH – DH3



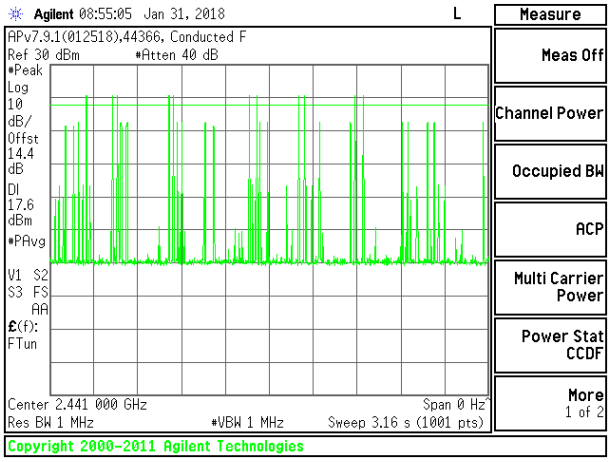
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

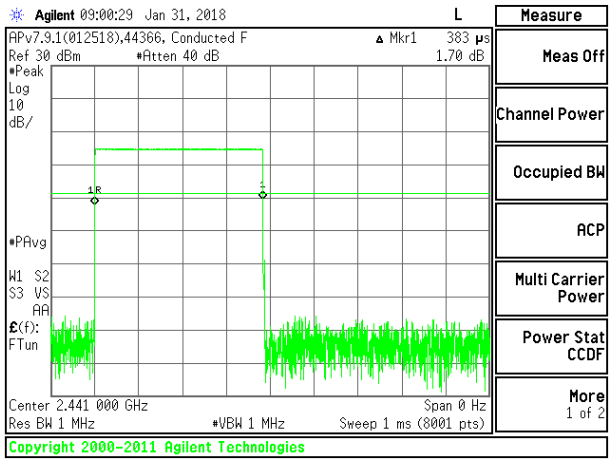
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

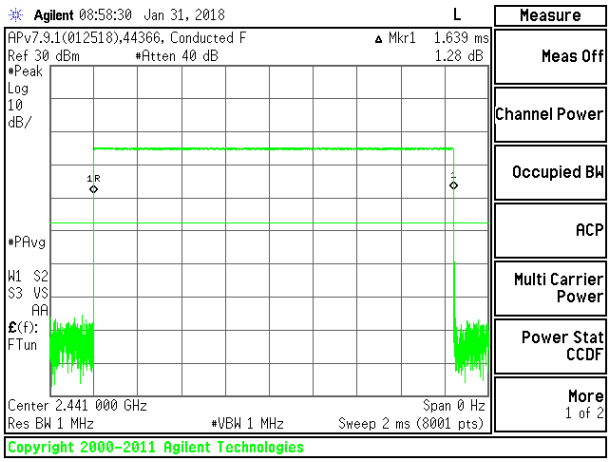
ANTENNA 3

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	0.383	31	0.1187	0.4	-0.2813
DH3	1.639	17	0.2786	0.4	-0.1214
DH5	2.887	11	0.3176	0.4	-0.0824
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.383	7.75	0.02968	0.4	-0.3703
DH3	1.639	4.25	0.06966	0.4	-0.3303
DH5	2.887	2.75	0.07939	0.4	-0.3206

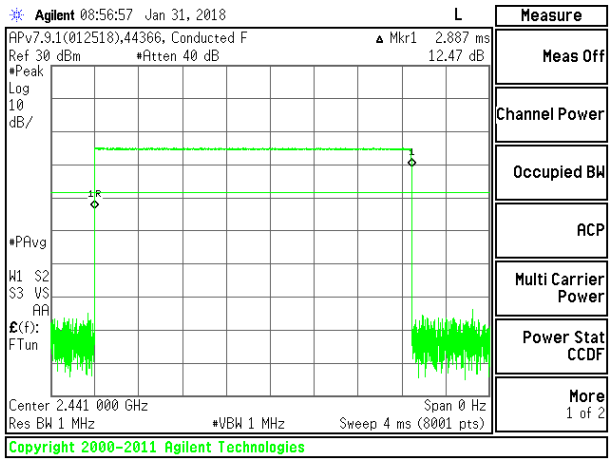
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



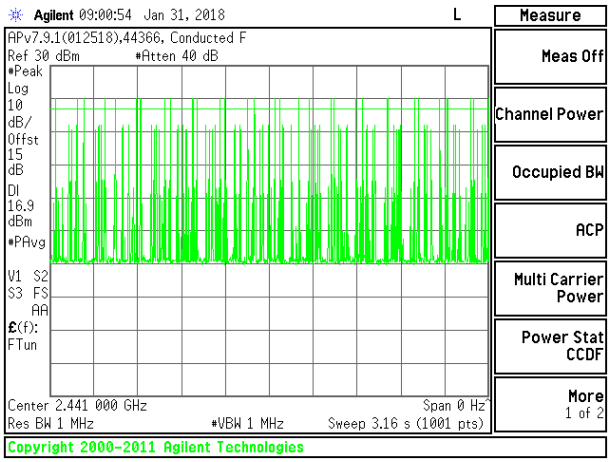
PULSE WIDTH – DH1



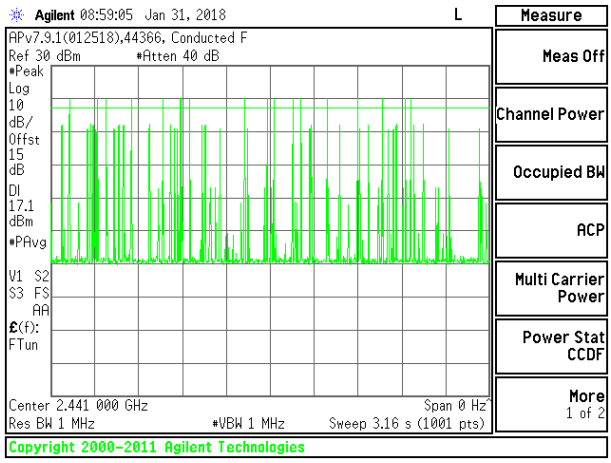
PULSE WIDTH – DH3



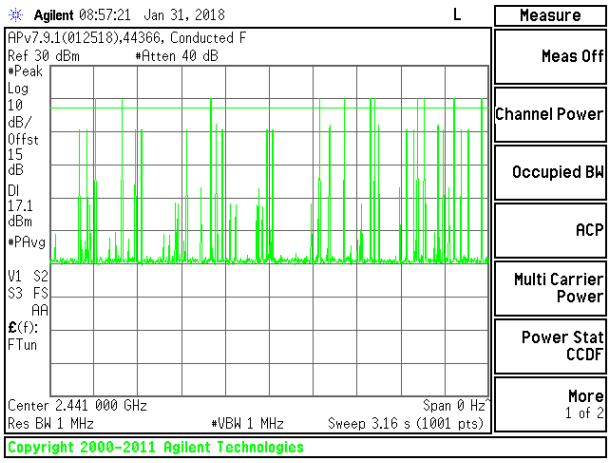
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

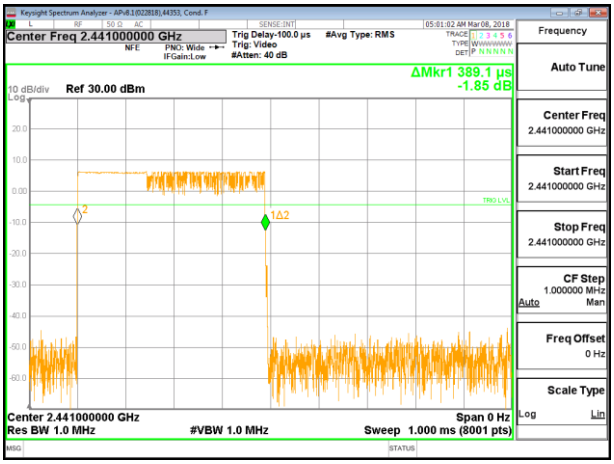
8.5.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

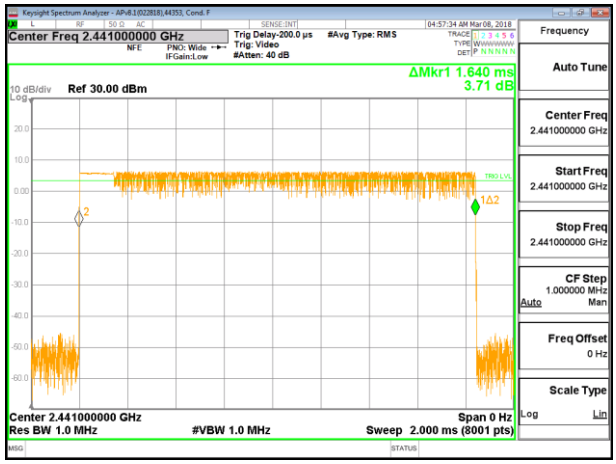
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.389	32	0.12448	0.4	-0.2755
3DH3	1.64	17	0.2788	0.4	-0.1212
3DH5	2.892	12	0.34704	0.4	-0.053

Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate in section 8.5.1 demonstrates compliance with channel occupancy when AFH is employed.

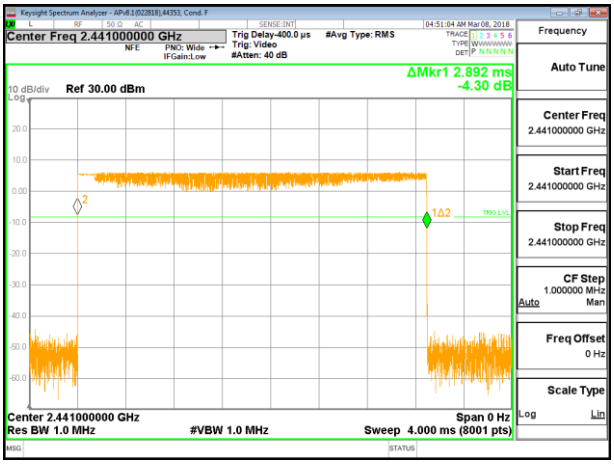
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



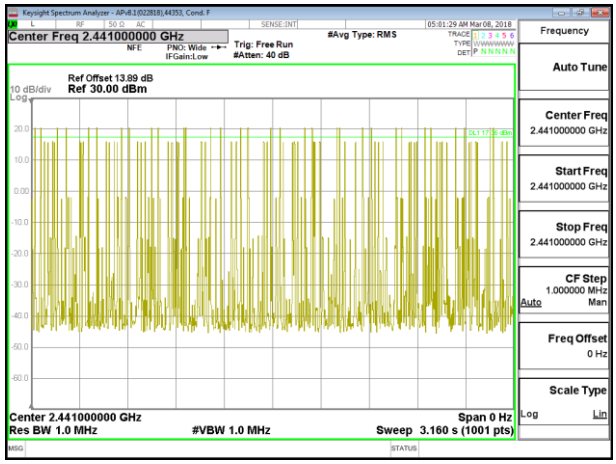
PULSE WIDTH – 3DH1



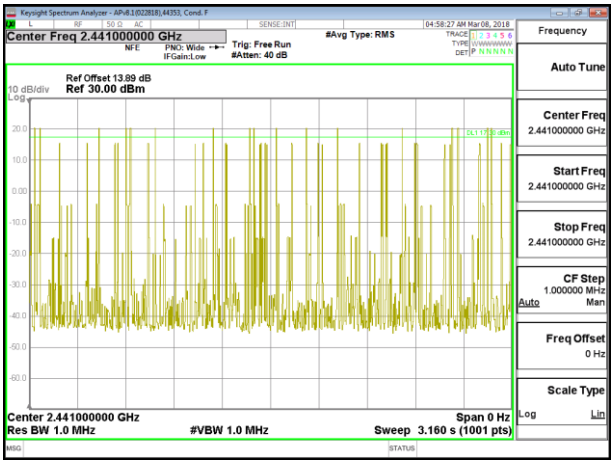
PULSE WIDTH – 3DH3



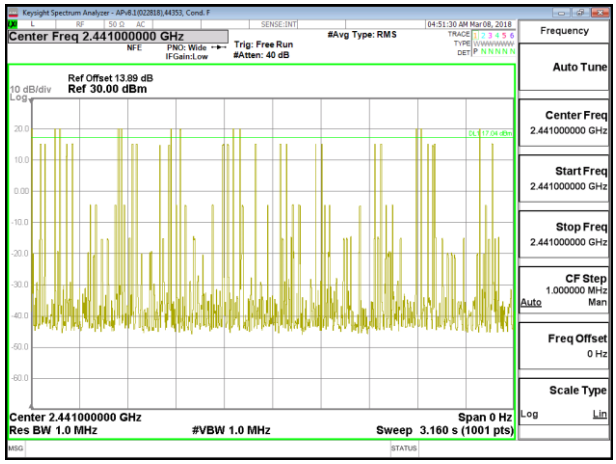
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

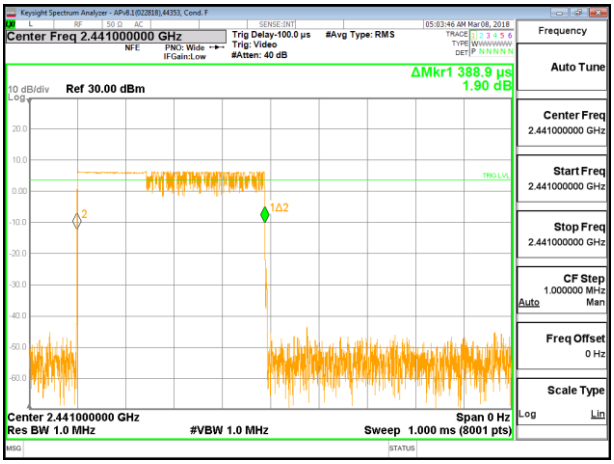
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

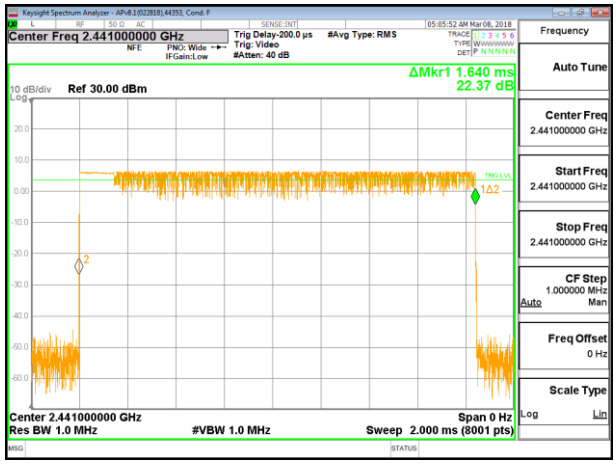
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.389	31	0.12059	0.4	-0.2794
3DH3	1.64	15	0.246	0.4	-0.154
3DH5	2.891	12	0.34692	0.4	-0.0531

Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate in section 8.5.1 demonstrates compliance with channel occupancy when AFH is employed.

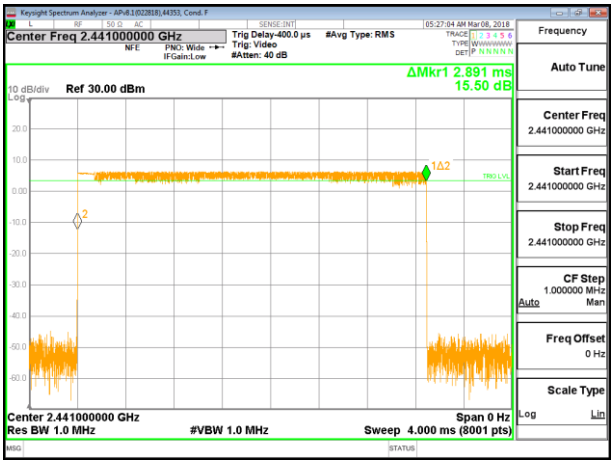
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



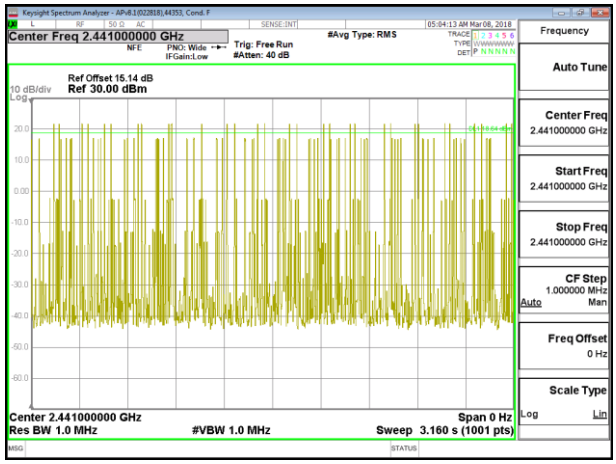
PULSE WIDTH – 3DH1



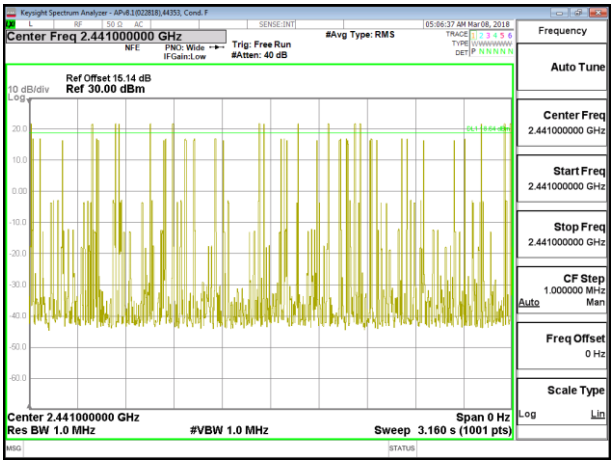
PULSE WIDTH – 3DH3



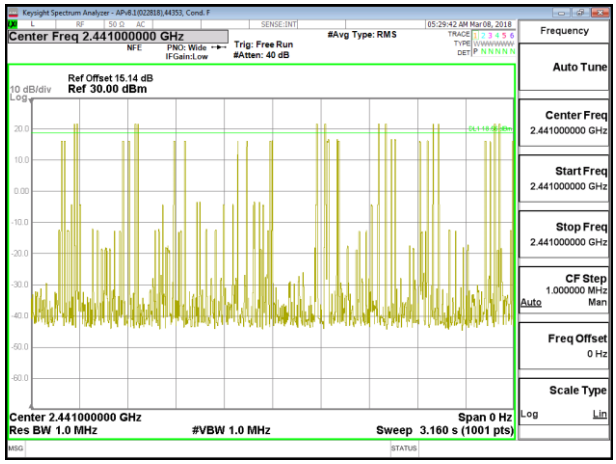
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

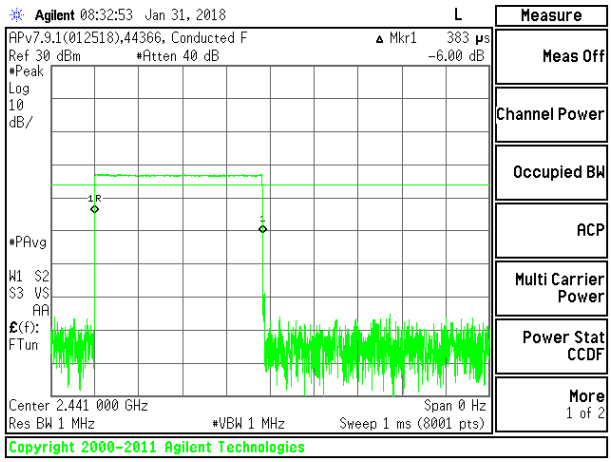
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.5.3. LOW POWER BASIC DATA RATE GFSK MODULATION

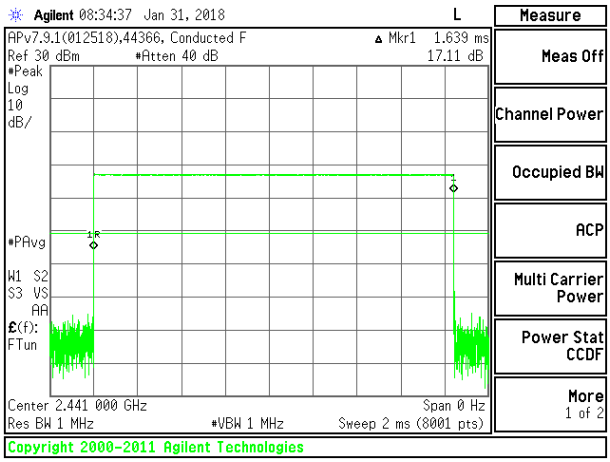
ANTENNA 4

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	0.383	32	0.1226	0.4	-0.2774
DH3	1.639	17	0.2786	0.4	-0.1214
DH5	2.887	11	0.3176	0.4	-0.0824
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.383	8	0.03064	0.4	-0.3694
DH3	1.639	4.25	0.06966	0.4	-0.3303
DH5	2.887	2.75	0.07939	0.4	-0.3206

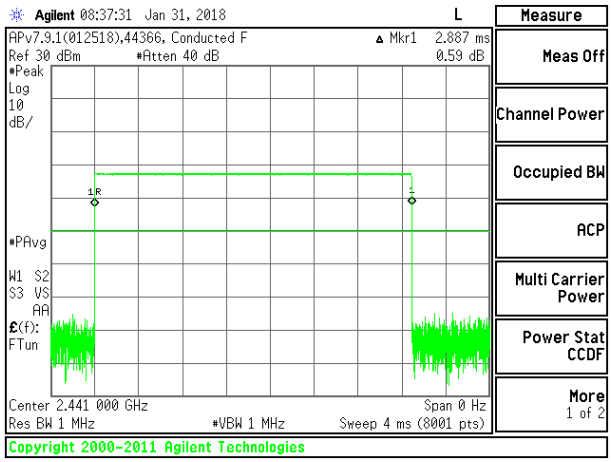
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



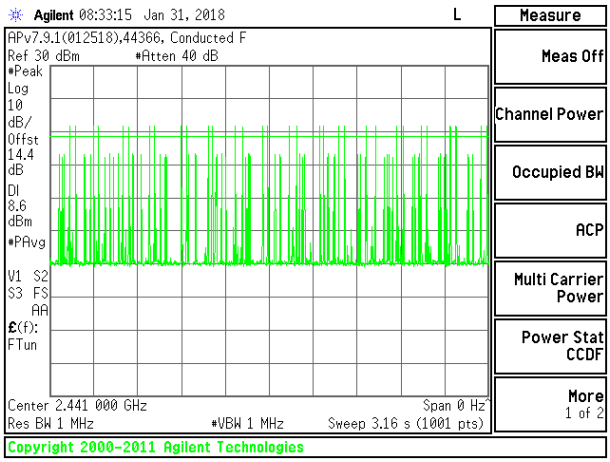
PULSE WIDTH – DH1



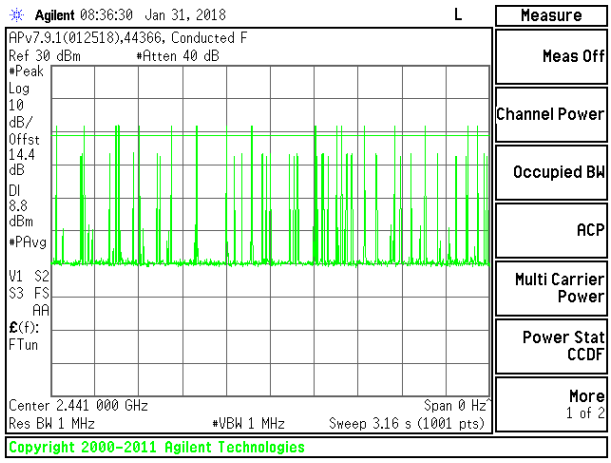
PULSE WIDTH – DH3



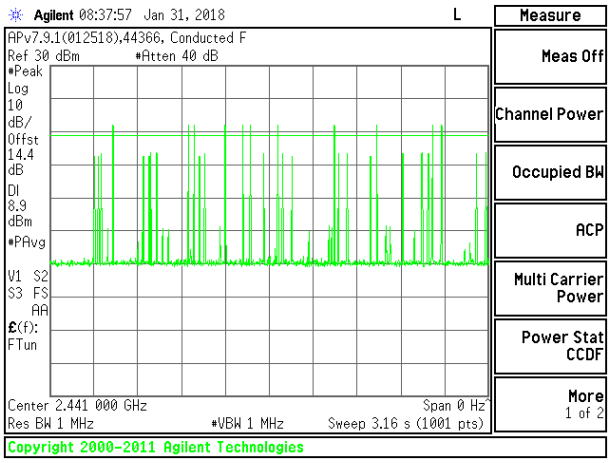
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



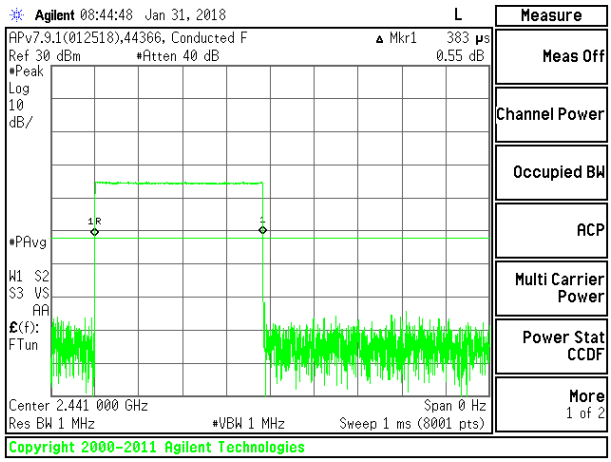
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

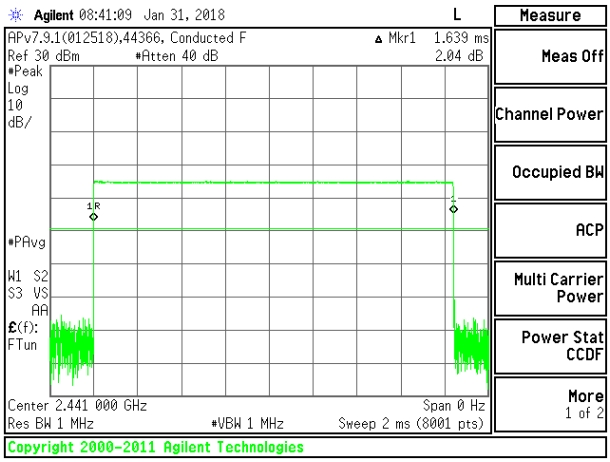
ANTENNA 3

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	0.383	32	0.1226	0.4	-0.2774
DH3	1.639	16	0.2622	0.4	-0.1378
DH5	2.887	11	0.3176	0.4	-0.0824
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.383	8	0.03064	0.4	-0.3694
DH3	1.639	4	0.06556	0.4	-0.3344
DH5	2.887	2.75	0.07939	0.4	-0.3206

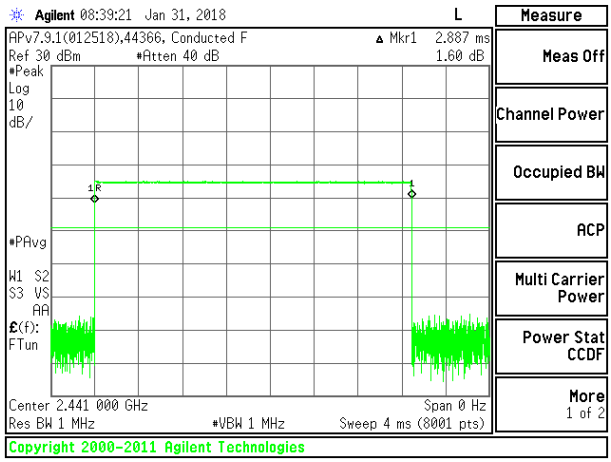
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



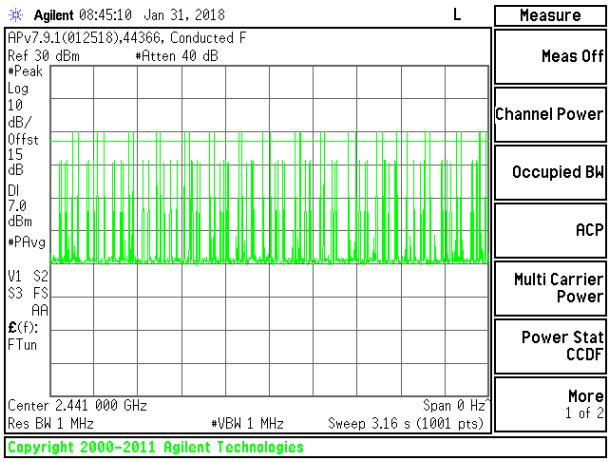
PULSE WIDTH – DH1



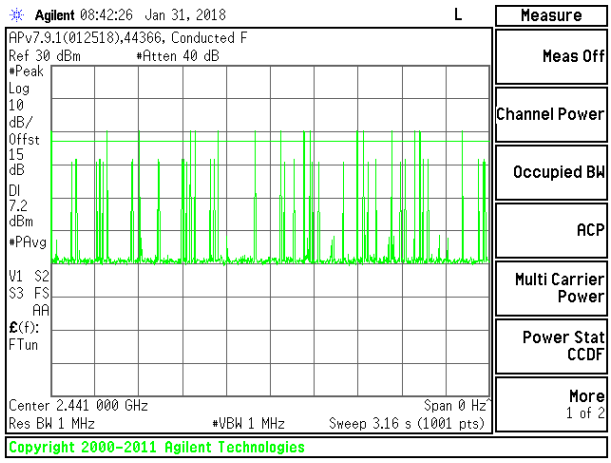
PULSE WIDTH – DH3



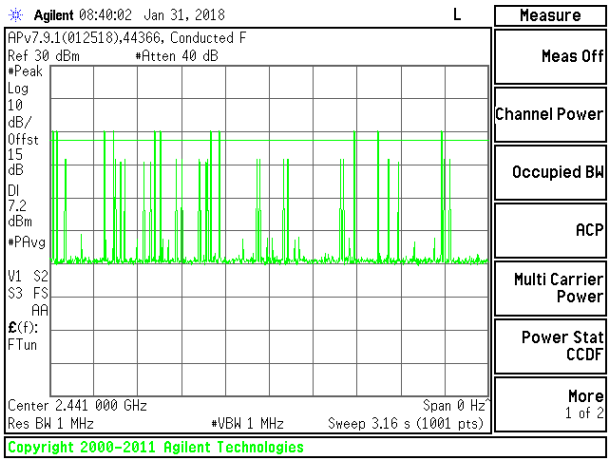
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

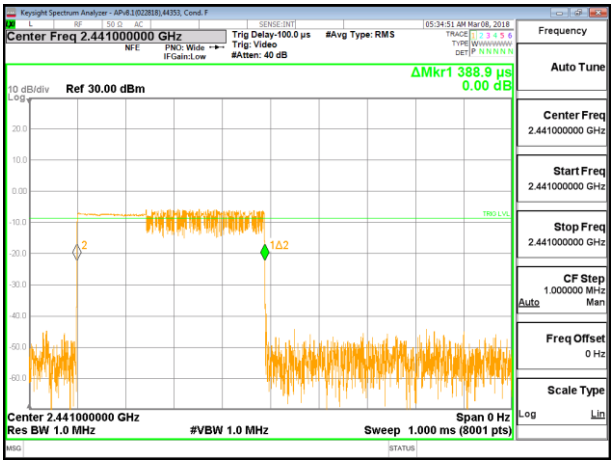
8.5.4. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

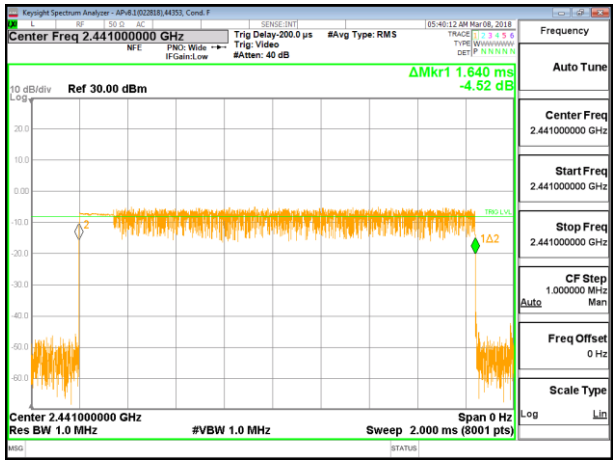
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.3889	32	0.124448	0.4	-0.2756
3DH3	1.64	16	0.2624	0.4	-0.1376
3DH5	2.892	13	0.37596	0.4	-0.024

Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate in section 8.5.3 demonstrates compliance with channel occupancy when AFH is employed.

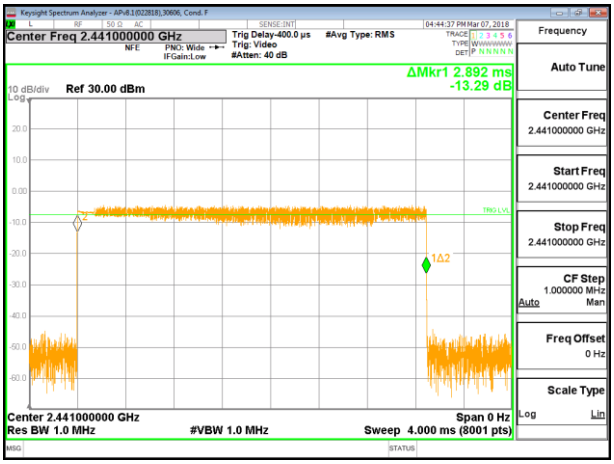
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



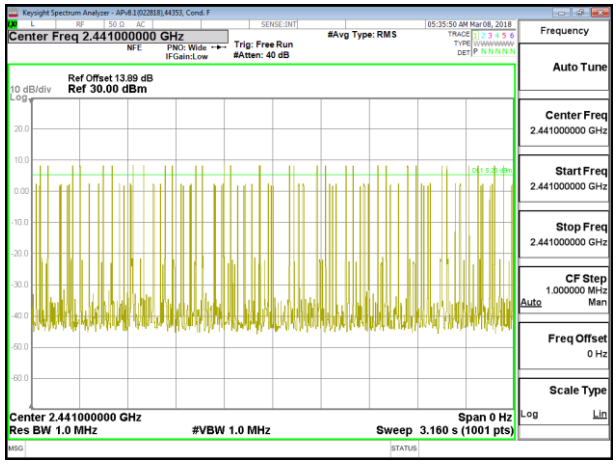
PULSE WIDTH – 3DH1



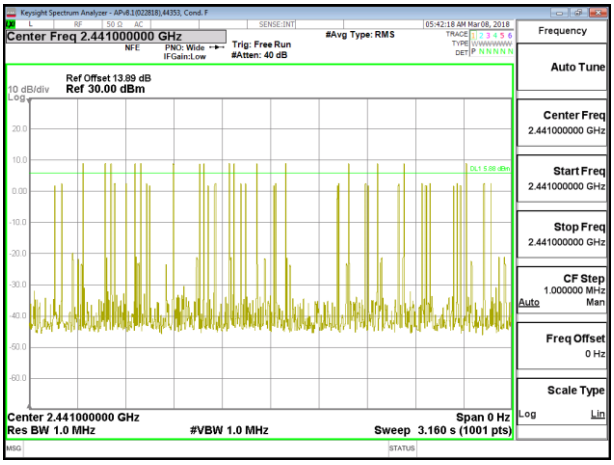
PULSE WIDTH – 3DH3



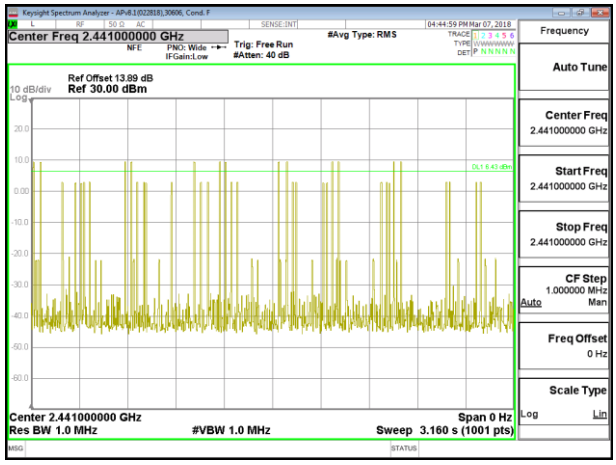
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

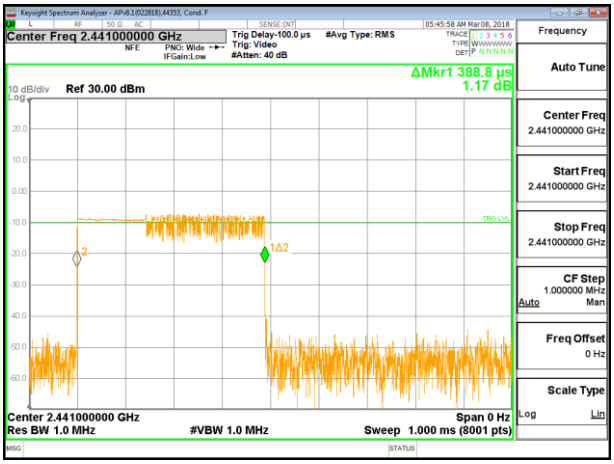
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3

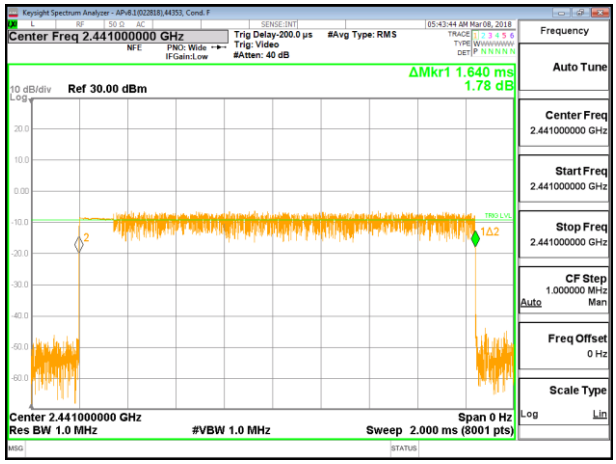
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.389	32	0.12448	0.4	-0.2755
3DH3	1.64	16	0.2624	0.4	-0.1376
3DH5	2.891	7	0.20237	0.4	-0.1976

Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate in section 8.5.3 demonstrates compliance with channel occupancy when AFH is employed.

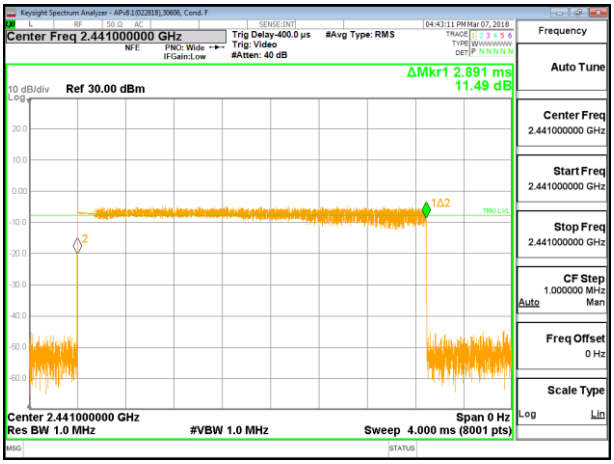
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.



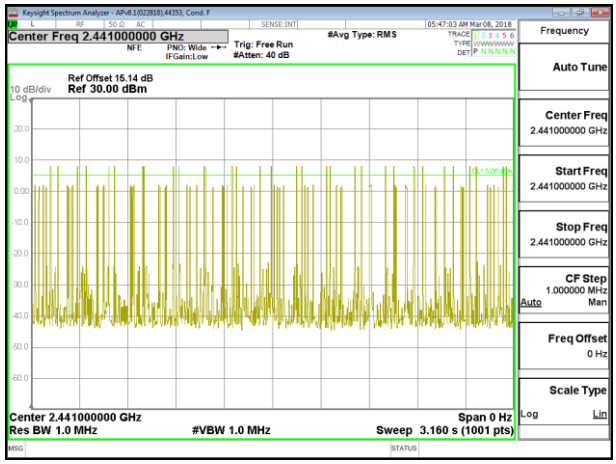
PULSE WIDTH – 3DH1



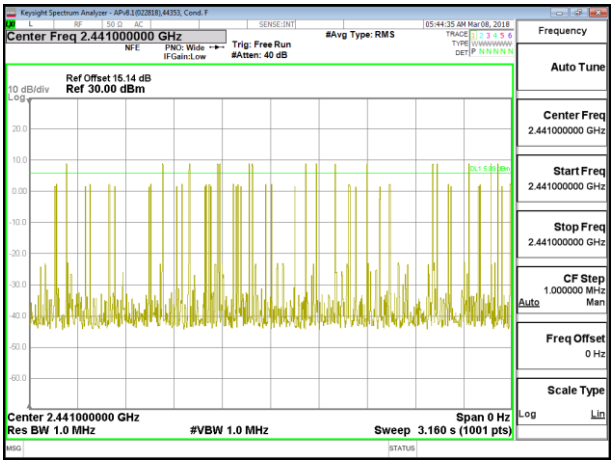
PULSE WIDTH – 3DH3



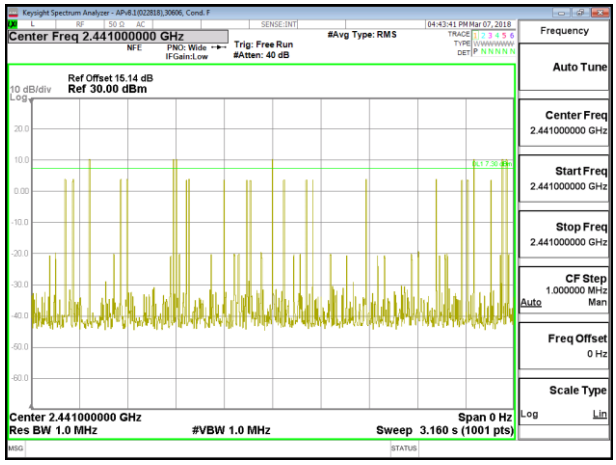
PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6. OUTPUT POWER

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

Measurements perform using peak power meter.

The cable assembly insertion loss of 10.5 dB (including 10 dB pad and 0.5 dB cable) was entered as an offset in the power meter to allow for a gated peak reading of power.

RESULTS

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	16.66	30	-13.34
Middle	2441	16.71	30	-13.29
High	2480	16.72	30	-13.28

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.14	30	-9.86
Middle	2441	20.42	30	-9.58
High	2480	20.03	30	-9.97

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.97	21	-2.03
Middle	2441	19.02	21	-1.98
High	2480	18.96	21	-2.04

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.31	21	-0.69
Middle	2441	20.35	21	-0.65
High	2480	20.28	21	-0.72

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.3. HIGH POWER ENCHANCED DATA RATE DQPSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.96	21	-2.04
Middle	2441	19.00	21	-2
High	2480	18.98	21	-2.02

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.98	21	-1.02
Middle	2441	20.00	21	-1.00
High	2480	19.96	21	-1.04

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.4. LOW POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.13	30	-18.87
Middle	2441	11.28	30	-18.72
High	2480	11.11	30	-18.89

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.07	30	-18.93
Middle	2441	11.14	30	-18.86
High	2480	11.10	30	-18.9

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.5. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.23	21	-10.77
Middle	2441	10.25	21	-10.75
High	2480	10.21	21	-10.79

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.12	21	-10.88
Middle	2441	10.19	21	-10.81
High	2480	10.14	21	-10.86

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.6.6. LOW POWER ENCHANCED DATA RATE DQPSK MODULATION

ANTENNA 4

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.16	21	-10.84
Middle	2441	10.19	21	-10.81
High	2480	10.13	21	-10.87

ANTENNA 3

Tested By:	39919
Date:	5/3/2018

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.11	21	-10.89
Middle	2441	10.15	21	-10.85
High	2480	10.14	21	-10.86

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

Measurements perform using a wideband gated RF power meter.

The cable assembly insertion loss of 10.5 dB (including 10 dB pad and 0.5 dB cable) was entered as an offset in the power meter to allow for a gated average reading of power.

RESULTS

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.39
Middle	2441	16.42
High	2480	16.45

ANTENNA 3

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.84
Middle	2441	19.92
High	2480	19.83

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.2. HIGH POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.39
Middle	2441	16.46
High	2480	16.40

ANTENNA 3

Tested By:	39919	
Date	5/3/2018	
Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	17.44
Middle	2441	17.48
High	2480	17.42

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.3. HIGH POWER ENCHANCED DATA RATE DQPSK MODULATION

ANTENNA 4

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.40
Middle	2441	16.46
High	2480	16.43

ANTENNA 3

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	17.39
Middle	2441	17.45
High	2480	17.33

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.4. LOW POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 4

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	10.93
Middle	2441	10.98
High	2480	10.91

ANTENNA 3

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	10.87
Middle	2441	10.93
High	2480	10.90

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.5. LOW POWER ENCHANCED DATA RATE 8PSK MODULATION

ANTENNA 4

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.45
Middle	2441	7.50
High	2480	7.43

ANTENNA 3

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.40
Middle	2441	7.46
High	2480	7.41

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.7.6. LOW POWER ENCHANCED DATA RATE DQPSK MODULATION

ANTENNA 4

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.39
Middle	2441	7.42
High	2480	7.36

ANTENNA 3

Tested By:	39919
Date	5/3/2018

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	7.35
Middle	2441	7.40
High	2480	7.38

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.8. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

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.

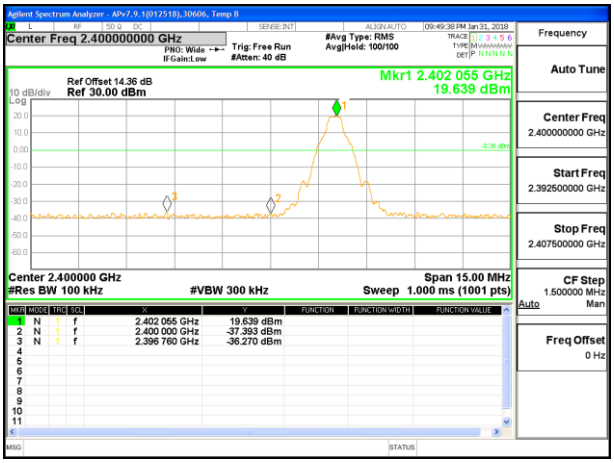
The bandedges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

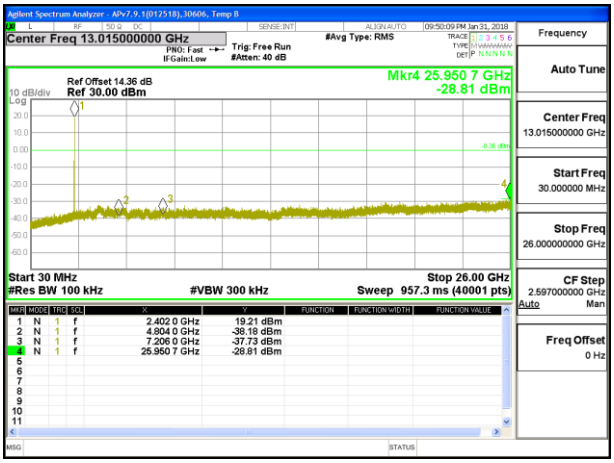
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

8.8.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

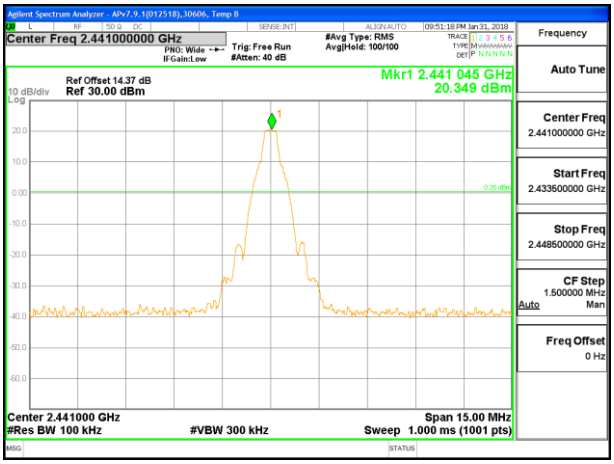
ANTENNA 4 SPURIOUS EMISSIONS, NON-HOPPING



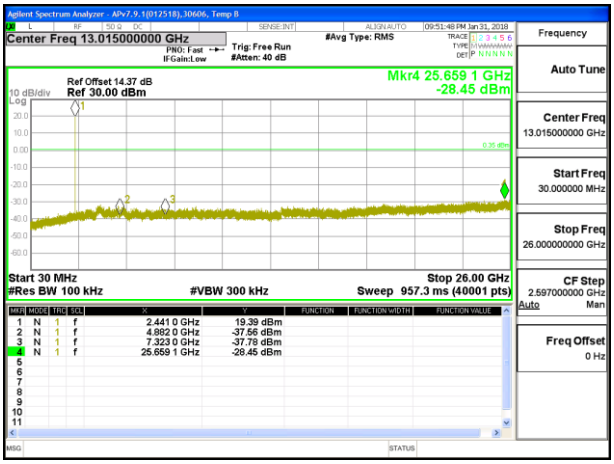
LOW CHANNEL BANDEDGE



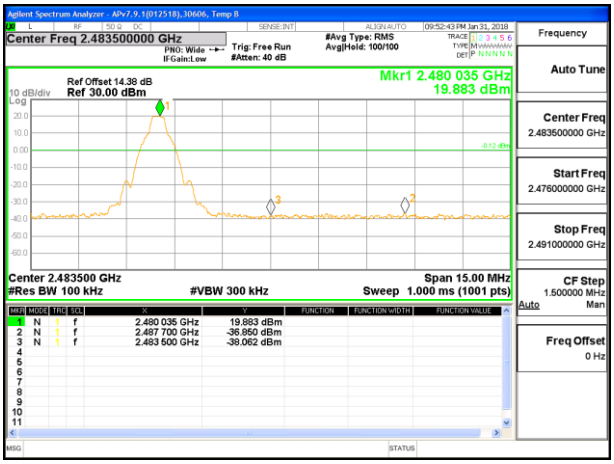
LOW CHANNEL BANDEDGE



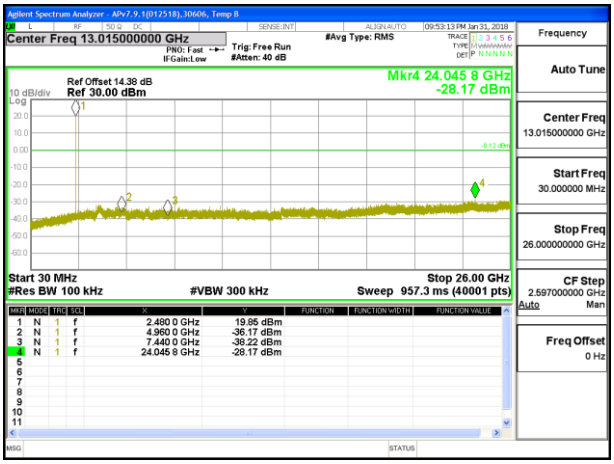
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE

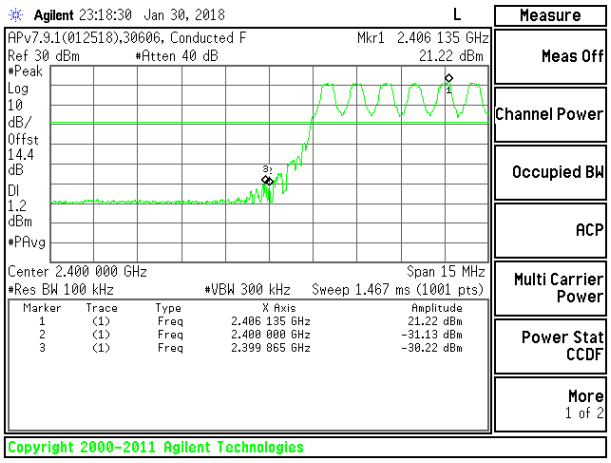


HIGH CHANNEL BANDEDGE

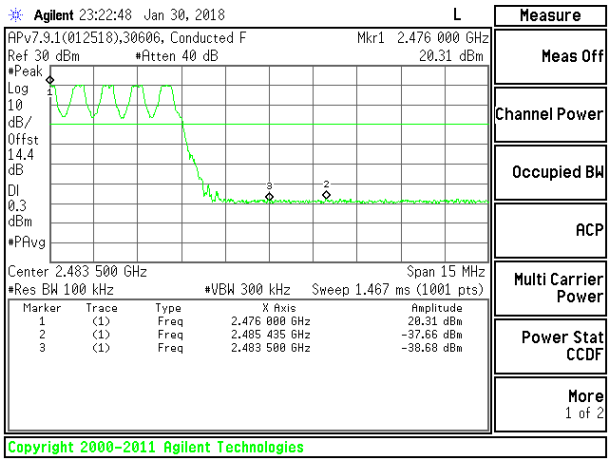
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



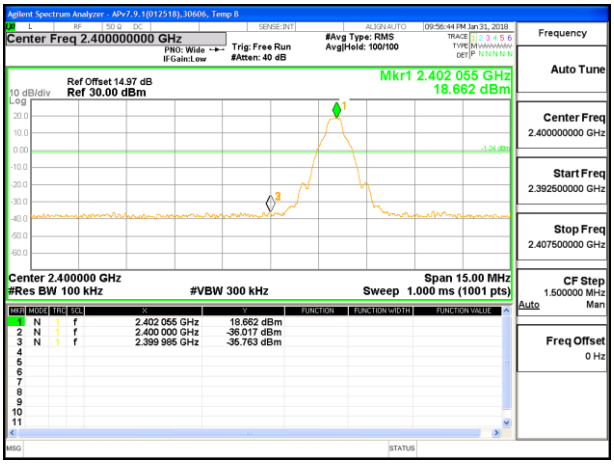
LOW BANDEDGE



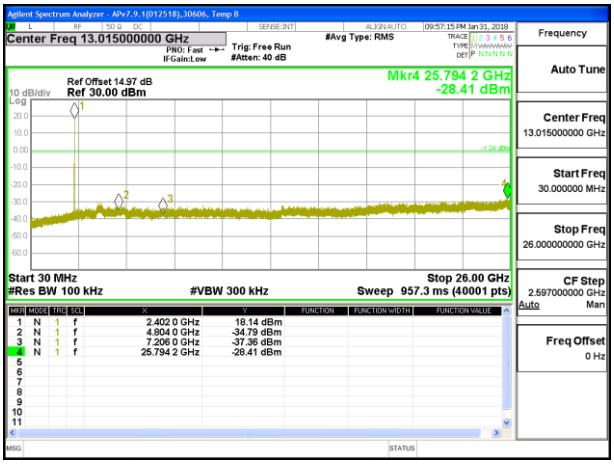
HIGH BANDEDGE

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

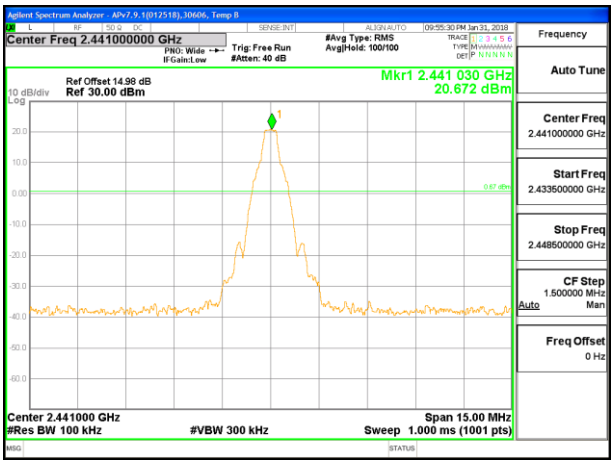
ANTENNA 3 SPURIOUS EMISSIONS, NON-HOPPING



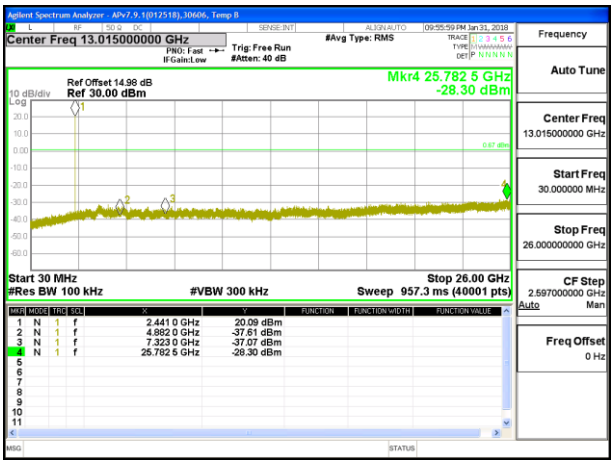
LOW CHANNEL BANDEDGE



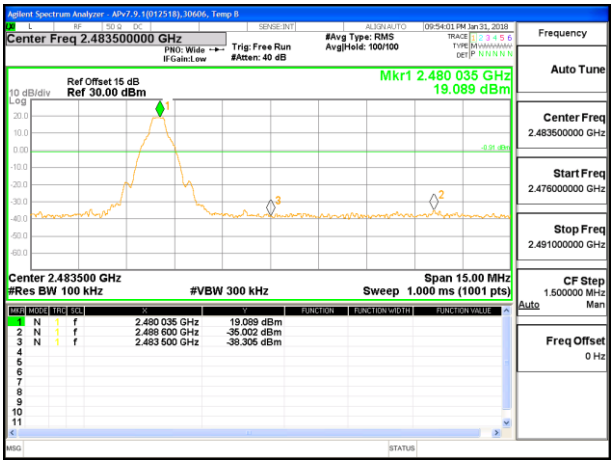
LOW CHANNEL BANDEDGE



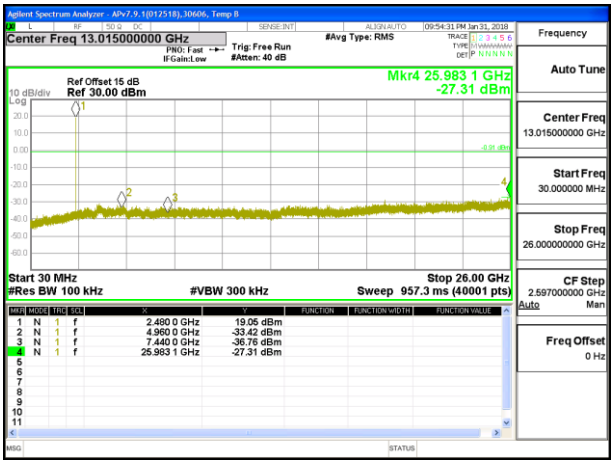
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



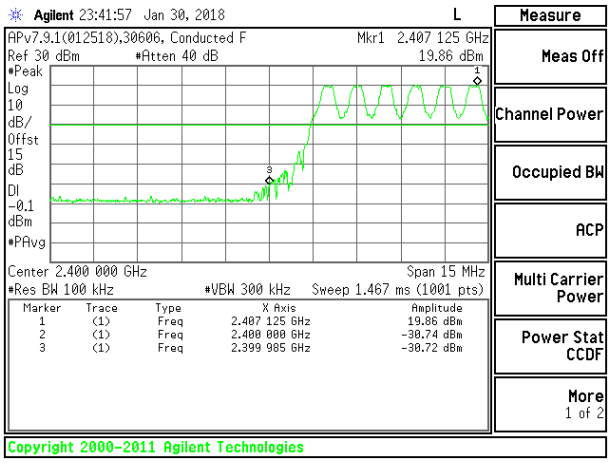
HIGH CHANNEL BANDEDGE



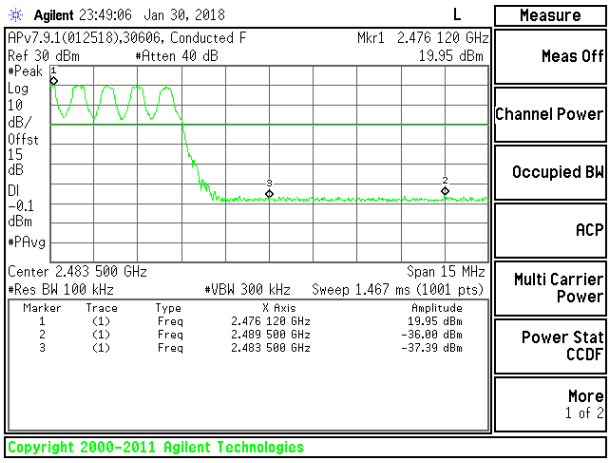
HIGH CHANNEL BANDEDGE

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.

ANTENNA 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



HIGH BANDEDGE

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.