CERTIFICATION TEST REPORT

Report Number. : 12901678-E3V2

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A.
Model	:	A2161, A2219, AND A2220
FCC ID	:	BCG-E3306A
IC	:	579C-E3306A
EUT Description	:	SMARTPHONE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:

August 23, 2019

Prepared by:

UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/19/2019	Initial Issue	Chin Pang
V2	8/23/2019	Addressed TCB's initial questions	Chris Xiong

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TABLE OF CONTENTS

REPORT REVISION HISTORY 2

TABLE OF CONTENTS 3

1. ATTESTATION OF TEST RESULTS 6

2. TEST METHODOLOGY 7

3. FACILITIES AND ACCREDITATION 7

4. CALIBRATION AND UNCERTAINTY 8

4.1. MEASURING INSTRUMENT CALIBRATION 8

4.2. SAMPLE CALCULATION 8

4.3. MEASUREMENT UNCERTAINTY 8

5. EQUIPMENT UNDER TEST 9

5.1. EUT DESCRIPTION 9

5.2. DIFFERENCE IN MODEL NUMBER 9

5.3. MAXIMUM OUTPUT POWER 9

5.4. DESCRIPTION OF AVAILABLE ANTENNAS 10

5.5. SOFTWARE AND FIRMWARE 10

5.6. WORST-CASE CONFIGURATION AND MODE 10

5.7. DESCRIPTION OF TEST SETUP 11

6. TEST AND MEASUREMENT EQUIPMENT 16

7. MEASUREMENT METHODS 17

8. ANTENNA PORT TEST RESULTS 18

8.1. ON TIME AND DUTY CYCLE 18

8.2. 20 dB AND 99% BANDWIDTH 20

8.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION 21
8.2.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 23
8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION 25
8.2.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 27

8.3 HOPPING FREQUENCY SEPARATION 29

8.3.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 30
8.3.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 30
8.3.3 LOW POWER BASIC DATA RATE GFSK MODULATION 31
8.3.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 31

8.4 NUMBER OF HOPPING CHANNELS 32

8.4.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 33
8.4.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 35
8.4.3 LOW POWER BASIC DATA RATE GFSK MODULATION 37
8.4.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 39

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8.5 AVERAGE TIME OF OCCUPANCY....41
8.5.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....42
8.5.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....46
8.5.3 LOW POWER BASIC DATA RATE GFSK MODULATION....50
8.5.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....54

8.6 OUTPUT POWER....58
8.6.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....59
8.6.2 HIGH POWER ENHANCED DATA RATE QPSK MODULATION....60
8.6.3 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....61
8.6.4 LOW POWER BASIC DATA RATE GFSK MODULATION....62
8.6.5 LOW POWER ENHANCED DATA RATE QPSK MODULATION....63
8.6.6 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....64

8.7 AVERAGE POWER....65
8.7.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....66
8.7.2 HIGH POWER ENHANCED DATA RATE QPSK MODULATION....67
8.7.3 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....68
8.7.4 LOW POWER BASIC DATA RATE GFSK MODULATION....69
8.7.5 LOW POWER ENHANCED DATA RATE QPSK MODULATION....70
8.7.6 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....71

8.8 CONDUCTED SPURIOUS EMISSIONS....72
8.8.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....73
8.8.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....77
8.8.3 LOW POWER BASIC DATA RATE GFSK MODULATION....81
8.8.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....85

8.9 BEAMFORMING, 99% BANDWIDTH....89
8.9.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....89
8.9.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....91
8.9.3 LOW POWER BASIC DATA RATE GFSK MODULATION....93
8.9.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....95

8.10 BEAMFORMING, 20 dB BANDWIDTH....97
8.10.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....97
8.10.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....99
8.10.3 LOW POWER BASIC DATA RATE GFSK MODULATION....101
8.10.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....103

8.11 BEAMFORMING, HOPPING FREQUENCY SEPARATION....105
8.11.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....106
8.11.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....106
8.11.3 LOW POWER BASIC DATA RATE GFSK MODULATION....107
8.11.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....107

8.12 BEAMFORMING, NUMBER OF HOPPING CHANNELS....108
8.12.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....109
8.12.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....111
8.12.3 LOW POWER BASIC DATA RATE GFSK MODULATION....113
8.12.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....115

8.13 BEAMFORMING, AVERAGE TIME OF OCCUPANCY....117
8.13.1 HIGH POWER BASIC DATA RATE GFSK MODULATION....118
8.13.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION....122
8.13.3 LOW POWER BASIC DATA RATE GFSK MODULATION....126
8.13.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION....130

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8.14 BEAMFORMING, OUTPUT POWER 134
8.14.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 134
8.14.2 HIGH POWER ENHANCED DATA RATE QPSK MODULATION 134
8.14.3 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 134
8.14.4 LOW POWER BASIC DATA RATE GFSK MODULATION 135
8.14.5 LOW POWER ENHANCED DATA RATE QPSK MODULATION 135
8.14.6 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 135

8.15 BEAMFORMING, AVERAGE POWER 136
8.15.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 136
8.15.2 HIGH POWER ENHANCED ENHANCED RATE QPSK MODULATION 136
8.15.3 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 136
8.15.4 LOW POWER BASIC DATA RATE GFSK MODULATION 137
8.15.5 LOW POWER ENHANCED DATA RATE QPSK MODULATION 137
8.15.6 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 137

8.16 BEAMFORMING, CONDUCTED SPURIOUS EMISSIONS 138
8.16.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 138
8.16.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 142
8.16.3 LOW POWER BASIC DATA RATE GFSK MODULATION 146
8.16.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 150

9. RADIATED TEST RESULTS 154

9.1 TRANSMITTER ABOVE 1 GHz 156
9.1.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 156
9.1.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 176
9.1.3 LOW POWER BASIC DATA RATE GFSK MODULATION 196
9.1.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 216

9.2 BEAMFORMING, TRANSMITTER ABOVE 1 GHz 236
9.2.1 HIGH POWER BASIC DATA RATE GFSK MODULATION 236
9.2.2 HIGH POWER ENHANCED DATA RATE 8PSK MODULATION 246
9.2.3 LOW POWER BASIC DATA RATE GFSK MODULATION 256
9.2.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION 266

9.3 WORST CASE BELOW 1 GHZ 276

9.4 WORST CASE 18-26 GHZ 278

10. AC POWER LINE CONDUCTED EMISSIONS 280

10.1. AC Power Line Host 281

10.2. AC Power Line Norm 283

11. SETUP PHOTOS 285

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1. ATTESTATION OF TEST RESULTS

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

EUT DESCRIPTION: SMARTPHONE

MODEL: A2161, A2219, AND A2220

SERIAL NUMBER: Radiated & Conducted
G6TYW00YN393, G6TYW010N393, G6TYW05BN393, G6TYW005N395

DATE TESTED: JUNE 1, 2019 – AUGUST 23, 2019

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. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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
Senior Engineer
Consumer Technology Division
UL Verification Services Inc.

Prepared By:

Chris Xiong
Test Engineer
Consumer Technology Division
UL Verification Services Inc.

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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 5, KDB 558074 D01v05r02 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, and 47658 Kato Road, 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	47658 Kato Rd
☒ Chamber A (ISED:2324B-1)	☒ Chamber D (ISED:22541-1)	☐ Chamber I (ISED:2324A-5)
☒ Chamber B (ISED:2324B-2)	☒ Chamber E (ISED:22541-2)	☐ Chamber J (ISED:2324A-6)
☐ Chamber C (ISED:2324B-3)	☒ Chamber F (ISED:22541-3)	☒ Chamber K (ISED:2324A-1)
	☒ Chamber G (ISED:22541-4)	☐ Chamber L (ISED:2324A-3)
	☒ Chamber H (ISED:22541-5)	

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

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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

RADIATED EMISSIONS
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

MAINS CONDUCTED EMISSIONS
Where relevant, the following sample calculation is provided:
Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

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	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

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

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5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT 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/ax, Bluetooth, Ultra-Wide band, GPS and NFC. All models support at least one UICC based SIM. The second SIM, if present, is either UICC based pSIM (physical SIM) or e-SIM (electronic SIM). The device has a built-in inductive charging receiver. The rechargeable battery is also not user accessible.

5.2. DIFFERENCE IN MODEL NUMBER

Model A2161, A2219, and A2220 is electrically identical to Model A2161. Three model numbers are allocated for marketing and logistic purposes only. A2161 was used to perform all final tests.

5.3. MAXIMUM OUTPUT POWER

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

Antenna	Config	Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
Antenna 4	High Power	2402 - 2480	Basic GFSK	17.22	52.72
		2402 - 2480	QPSK	17.98	62.81
		2402 - 2480	Enhanced 8PSK	18.20	66.07
	Low Power	2402 - 2480	Basic GFSK	12.69	18.58
		2402 - 2480	QPSK	10.99	12.56
		2402 - 2480	Enhanced 8PSK	11.28	13.43
Antenna 3	High Power	2402 - 2480	Basic GFSK	19.62	91.62
		2402 - 2480	QPSK	17.95	62.37
		2402 - 2480	Enhanced 8PSK	18.15	65.31
	Low Power	2402 - 2480	Basic GFSK	12.72	18.71
		2402 - 2480	QPSK	11.01	12.62
		2402 - 2480	Enhanced 8PSK	11.30	13.49
Antenna 4 + Antenna 3	High Power	2402 - 2480	Basic GFSK TxBF	20.27	106.41
		2402 - 2480	QPSK TxBF	19.99	99.77
		2402 - 2480	Enhanced 8PSK TxBF	20.26	106.17
	Low Power	2402 - 2480	Basic GFSK TxBF	15.75	37.58
		2402 - 2480	QPSK TxBF	14.04	25.35
		2402 - 2480	Enhanced 8PSK TxBF	14.31	26.98

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5.4. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	Ant. 4 (dBi)	Ant. 3 (dBi)
2.4	-0.9	-2.3

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was BT FW Version: 17.1.140.1283.

5.6. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on Antenna 4 (Core 0) and Antenna 3 (Core 1). It was determined that X (Flatbed) orientation was the worst-case orientation for Ant 4, Ant 3, and 2TX Beamforming.

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

Radiated emissions below 30MHz, below 1GHz, 18-26GHz and power line conducted emissions were performed with the EUT transmitting 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 tests, the worst-case configuration reported was with EUT only. There was no emission 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 new 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
BFTX, DH5
BFTX, 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.

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5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Apple	A1502	HRP003436	QDS-BRCM1080
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	NA
EUT AC Adapter	Apple	A1385	D29325SM03XDHLHC9	NA

I/O CABLES

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 (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 radio card.

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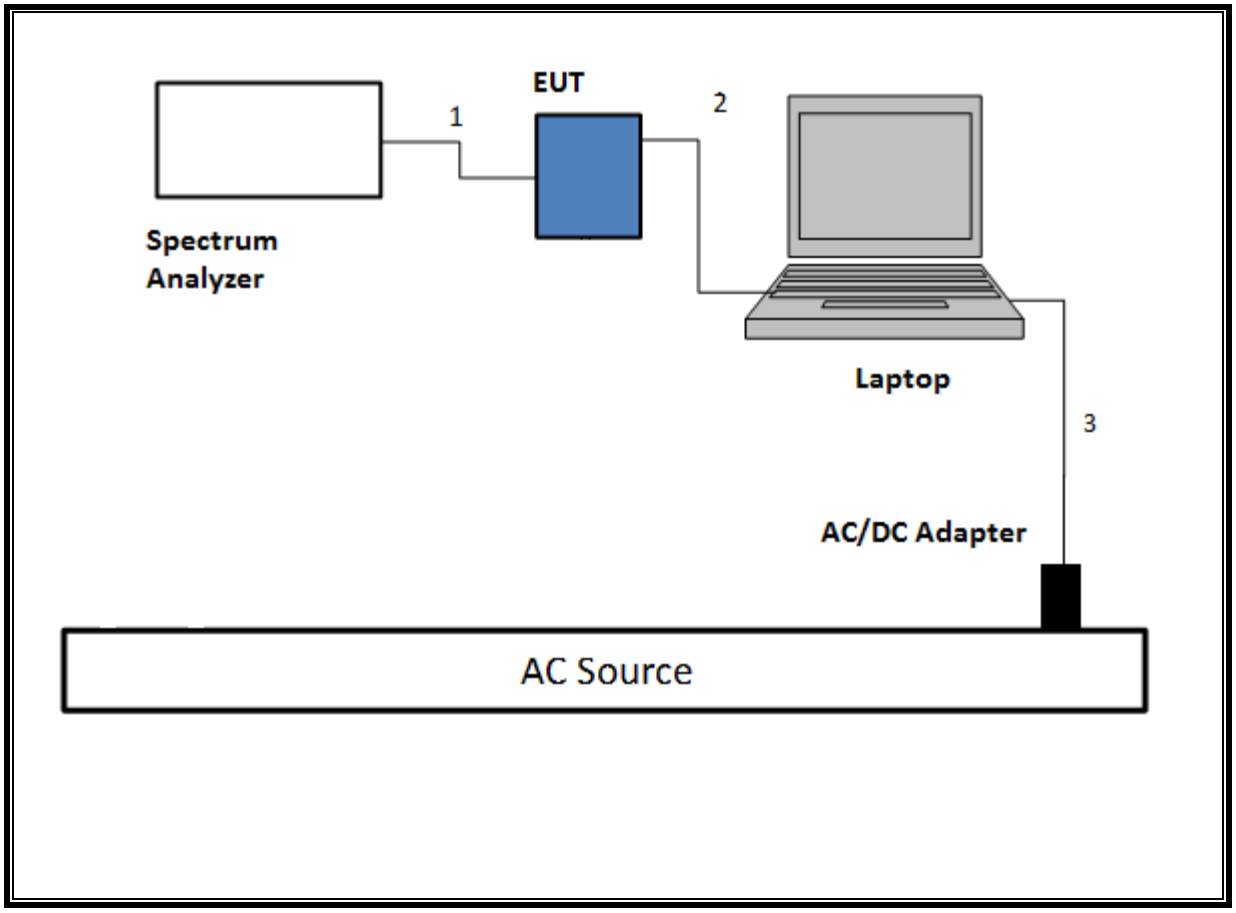
SETUP DIAGRAM FOR CONDUCTED TESTS



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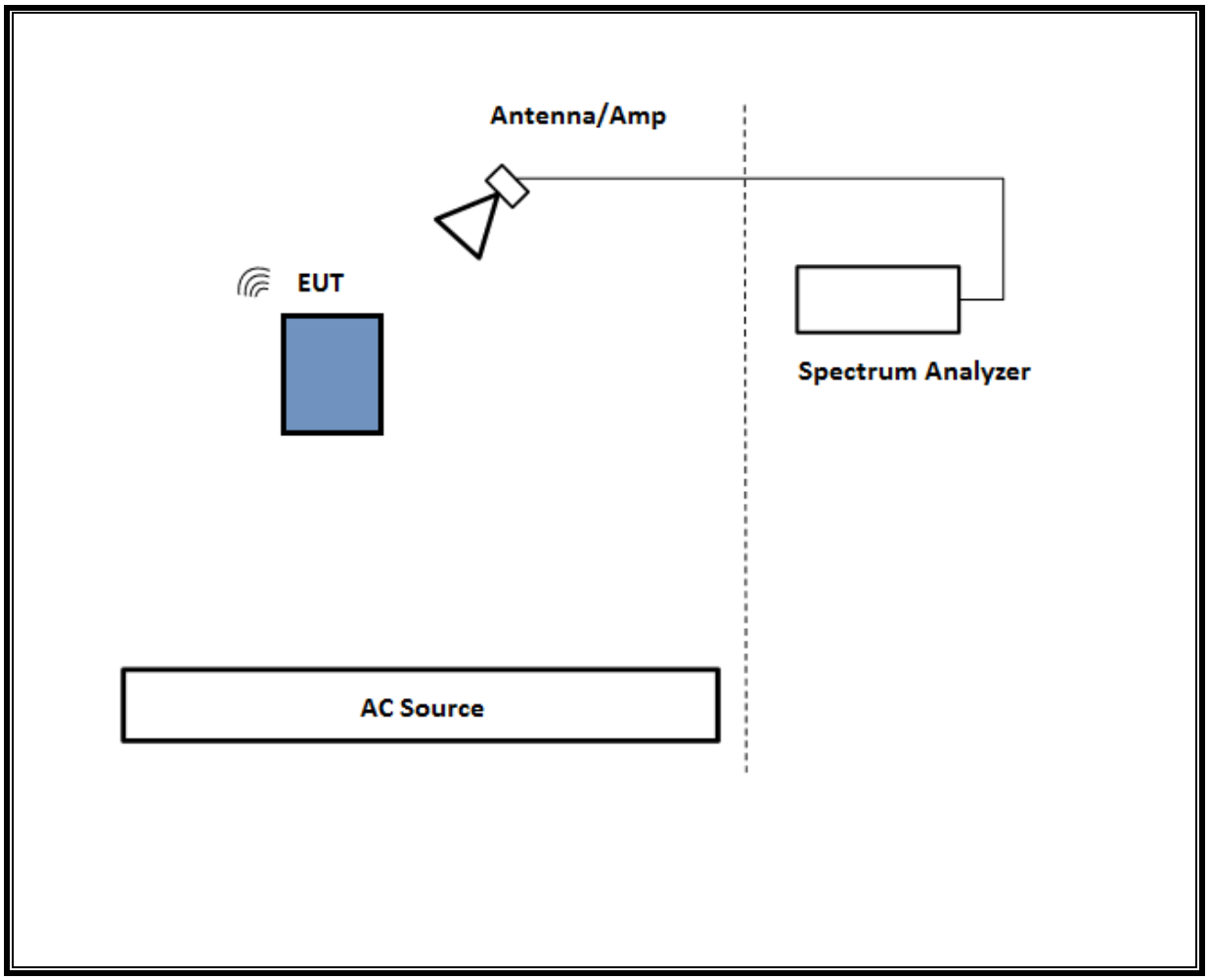
SETUP DIAGRAM FOR RADIATED TESTS Above 1GHz



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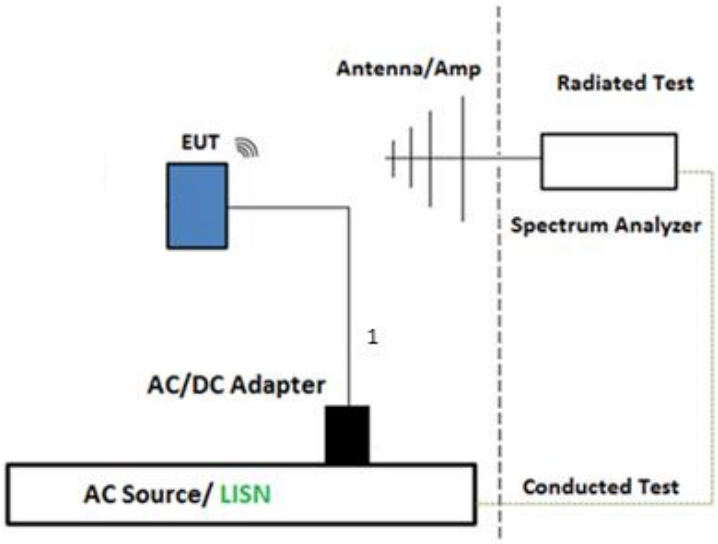
SETUP DIAGRAM FOR BELOW 1GHz and AC LINE CONDUCTED TEST



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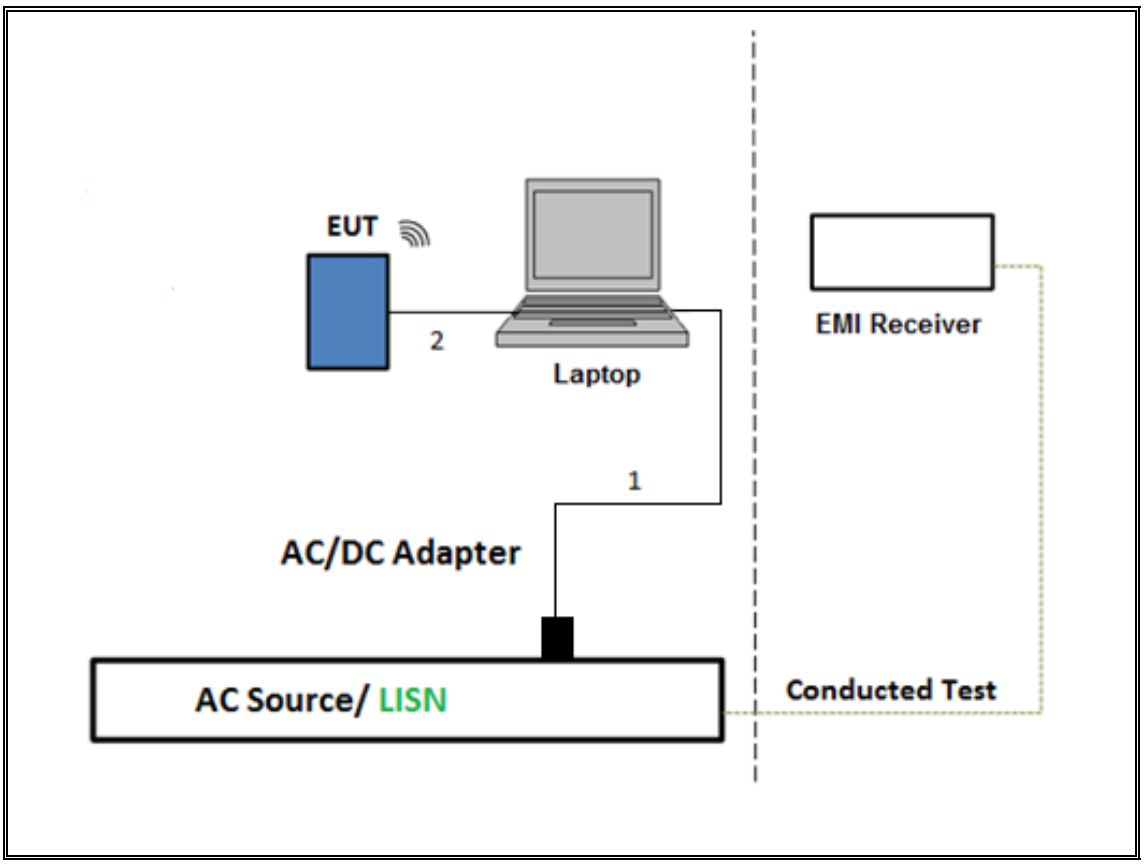
TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



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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**	**ID Num**	**Cal Due**	**Last Cal**
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T908	01/23/2020	01/23/2019
Horn Antenna 1-18GHz	ETS-Lindgren	3117	T136	06/14/2020	06/14/2019
Horn Antenna 1-18GHz	ETS-Lindgren	3117	T345	04/20/2020	04/25/2019
Amplifier, 10KHz to 1GHz, 32dB	Sonoma Instrument Co.	310N	T15	10/20/2019	10/20/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T712	02/26/2020	02/26/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	138301	09/15/2019	09/15/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T120	05/10/2020	05/10/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T1454	01/23/2020	01/23/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T491	05/30/2020	05/30/2019
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	05/30/2020	05/30/2019
Amplifier, 1 to 8GHz, 35dB	Miteq	AMF-4D-01000800-30-29P	T1156	08/30/2019	08/30/2018
Antenna, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T1616	10/18/2019	10/18/2018
*Hybrid Antenna, 30-3Ghz	SunAR rf Motion	JB3	PRE0181574	08/01/2019	08/01/2018
*Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	T447	06/16/2019	06/16/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T119	03/22/2020	03/22/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T740	10/062019	10/062018
Amplifier, 1 - 18GHz	Miteq	AFS42-00101800-25-S-42	T1165	02/02/2020	02/02/2019
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T340	01/22/2020	01/22/2019
Amplifier, 1 - 18GHz	Miteq	AFS42-00101800-25-S-42	T1567	01/26/2020	01/26/2019
*Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020	03/23/2019
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T344	05/07/2020	05/07/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T931	05/11/2020	05/11/2019
Power Meter, P-series single channel	Agilent (Keysight) Technologies	N1911A	T227	10/29/2019	10/29/2018
Filter, HPF 3GHz	Micro-Tronics	HPM17543	T1014	01/26/2020	01/26/2019
Power Sensor	Power Sensor	Keysight	T1226	02/06/2020	02/06/2019
AC Line Conducted					
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	02/14/2020	02/14/2019
Power Cable, Line Conducted Emissions	UL	PG1	T861	08/31/2019	08/31/2018
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	T1310	01/24/2020	01/24/2019
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		

*Testing is completed before equipment expiration date.

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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 Below 30MHz: ANSI C63.10-2013 Section 6.4

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

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

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

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

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8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

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

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/T Minimum VBW (kHz)
Bluetooth GFSK	2.57	2.57	1.000	100.0%	0.00	0.010
Bluetooth 8PSK	2.57	2.57	1.000	100.0%	0.00	0.010
Bluetooth GFSK TxBF	2.57	2.57	1.000	100.0%	0.00	0.010
Bluetooth 8PSK TxBF	2.57	2.57	1.000	100.0%	0.00	0.010

Note: Low power duty cycle is same as high power

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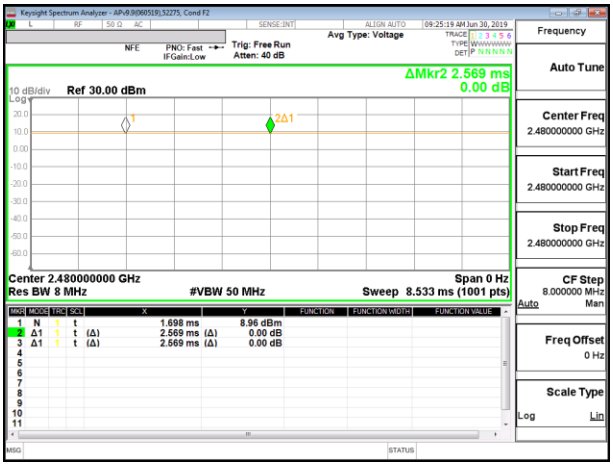
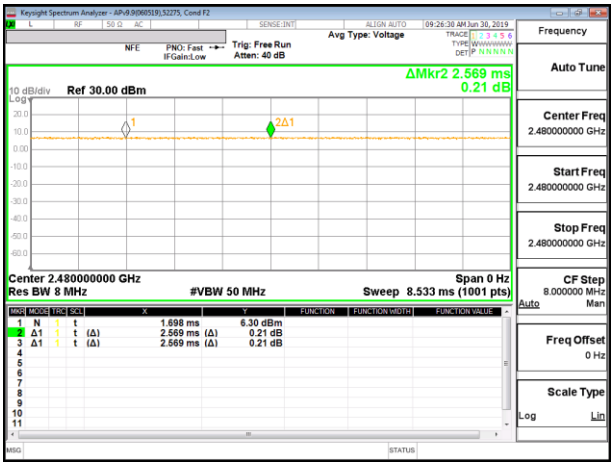
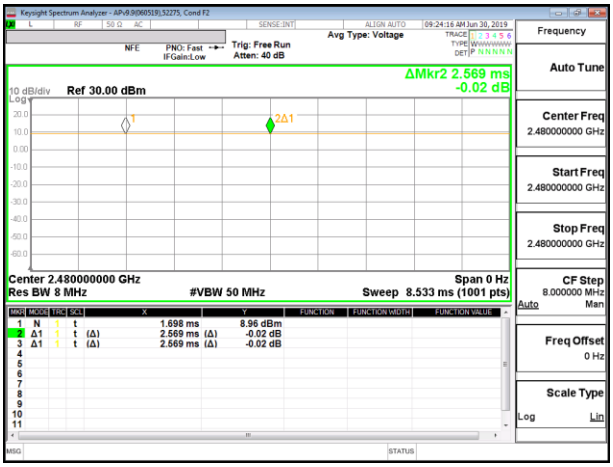
DUTY CYCLE PLOTS



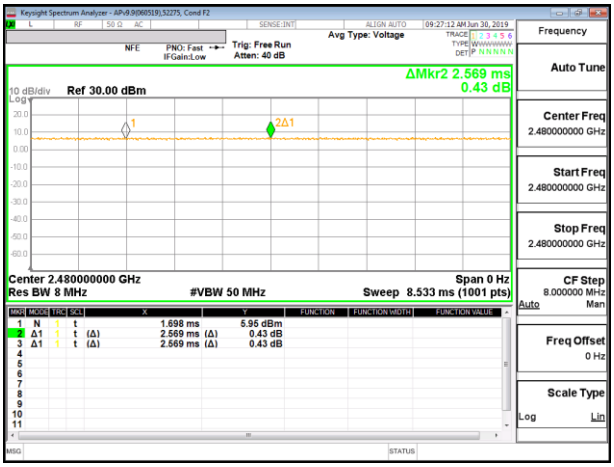
BLUETOOTH GFSK



BLUETOOTH 8PSK



BLUETOOTH TxBF GFSK



BLUETOOTH TxBF 8PSK

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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

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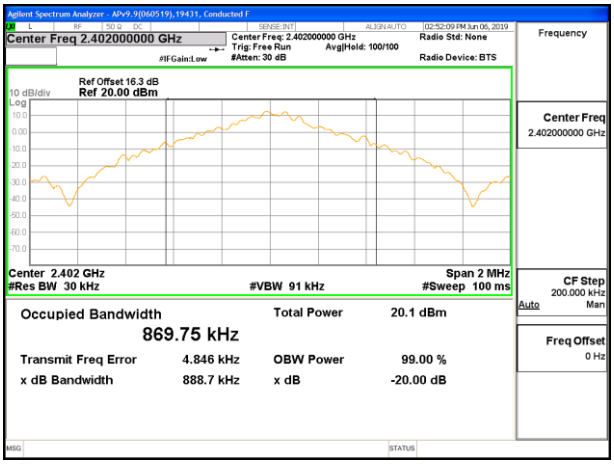
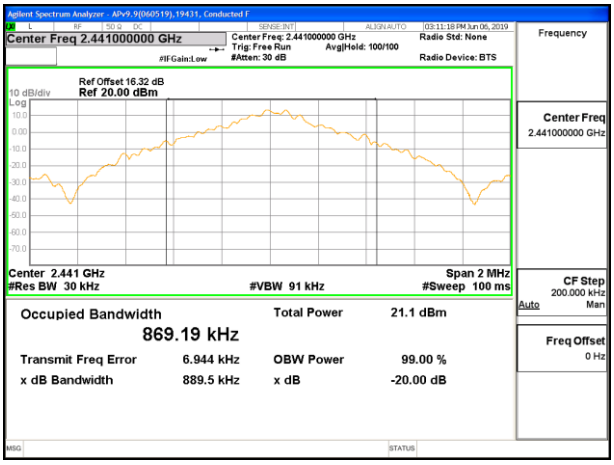
8.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 4

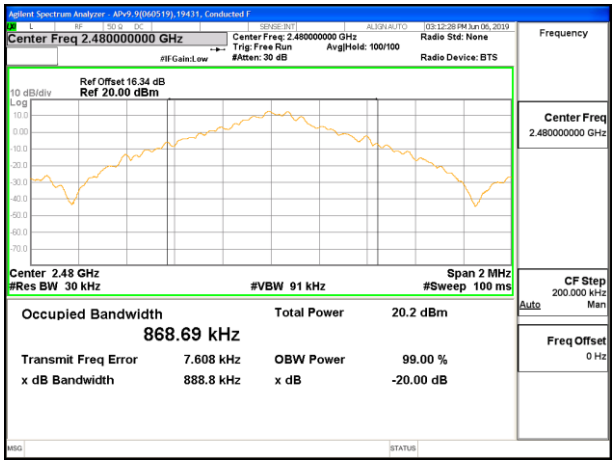
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.889	0.8698
Mid	2441	0.890	0.8692
High	2480	0.889	0.8687



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

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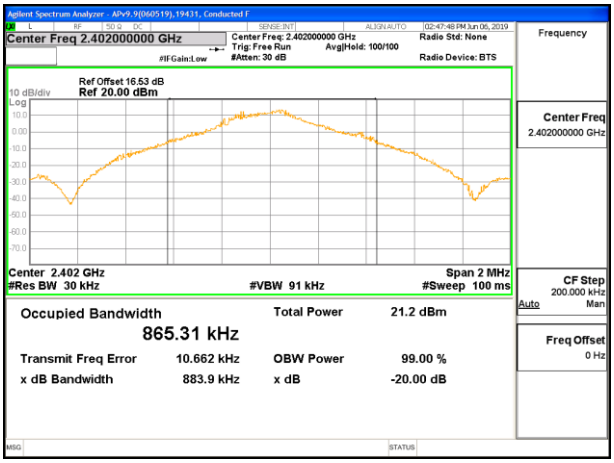
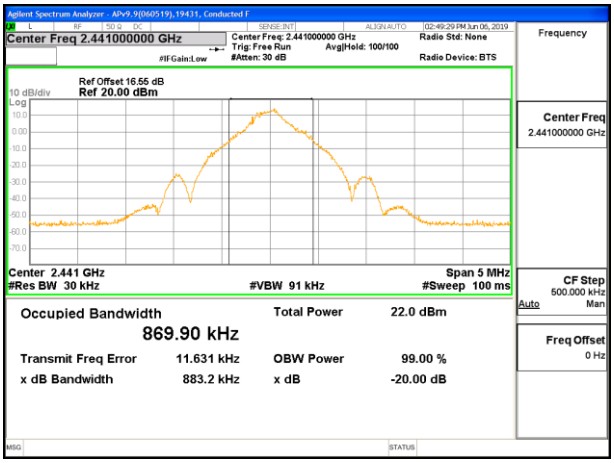
Antenna 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.884	0.8653
Mid	2441	0.883	0.8699
High	2480	0.886	0.8674



LOW CHANNEL



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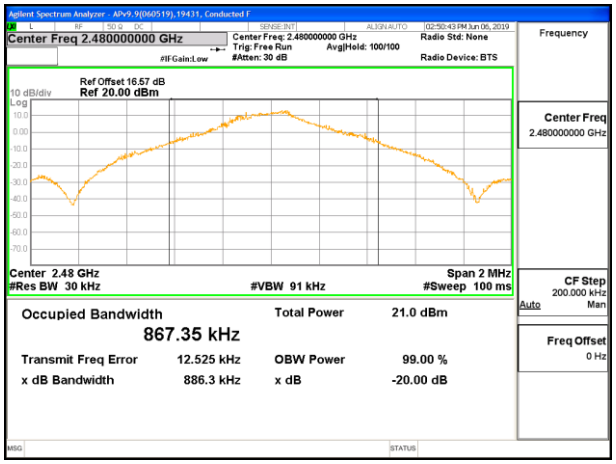

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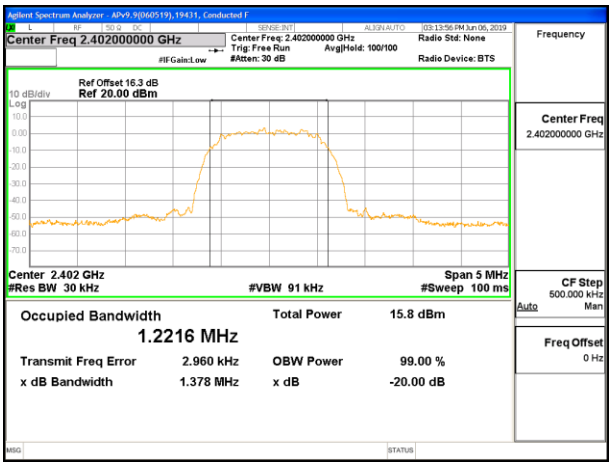
8.2.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 4

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.378	1.2216
Mid	2441	1.378	1.2216
High	2480	1.378	1.2214



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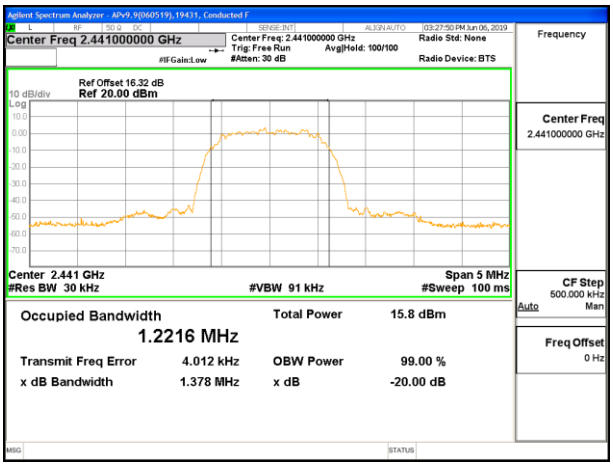

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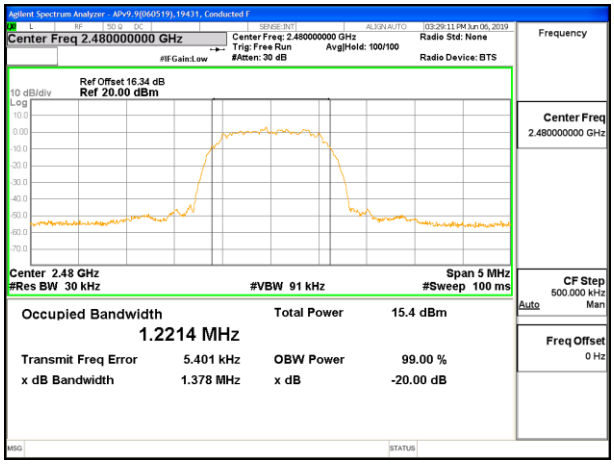

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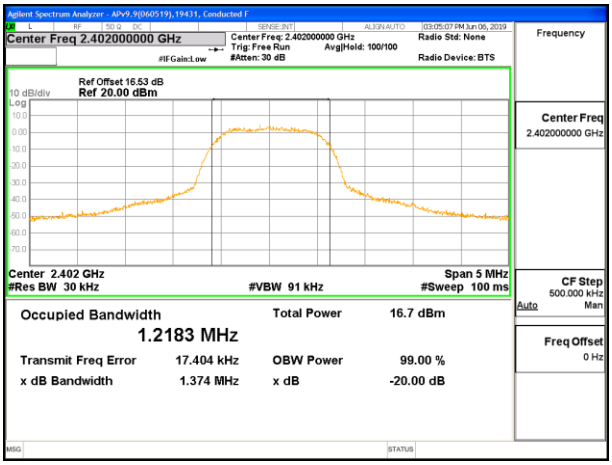
Antenna 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.374	1.2183
Mid	2441	1.366	1.2216
High	2480	1.390	1.2122



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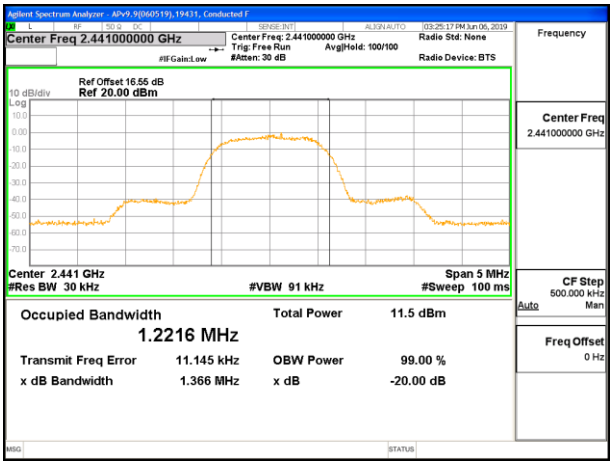

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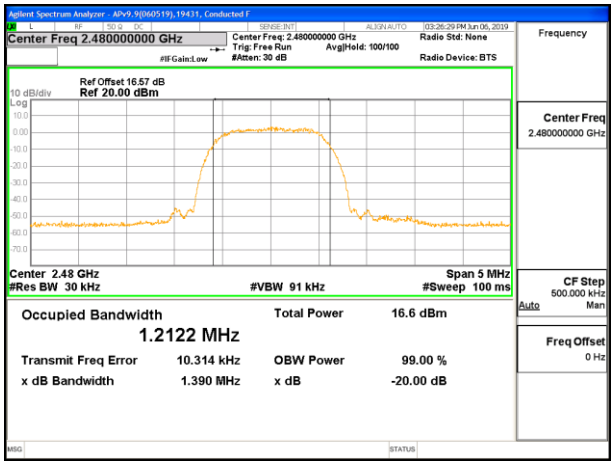

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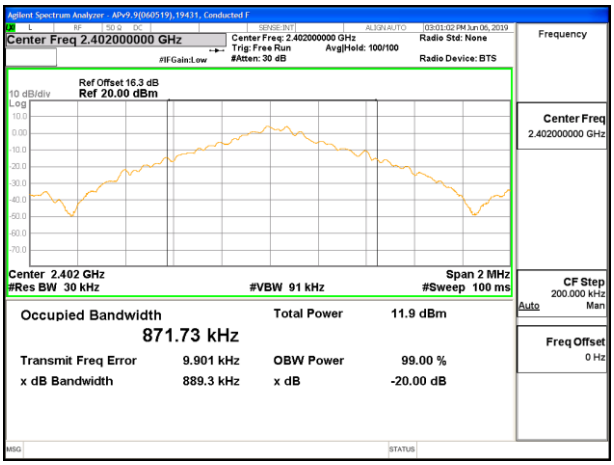
8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 4

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.889	0.8717
Mid	2441	0.890	0.8712
High	2480	0.889	0.8703



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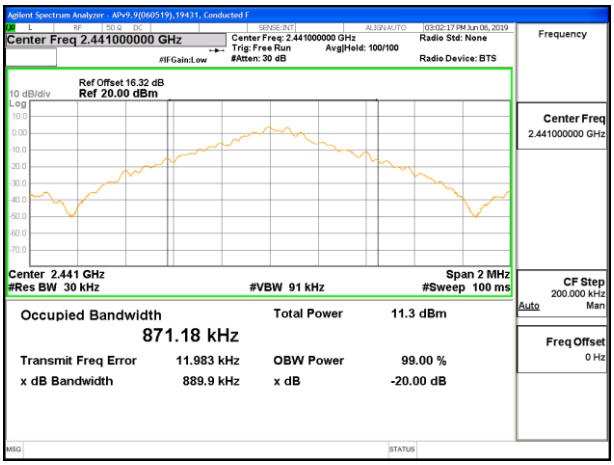

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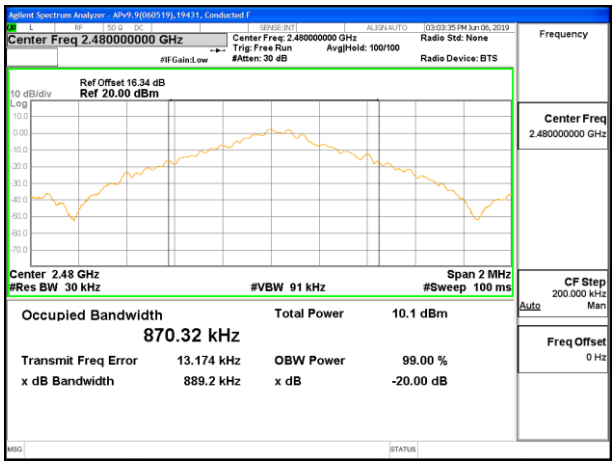

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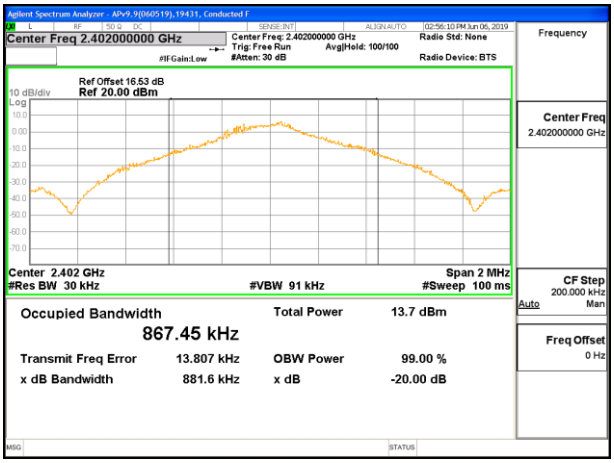
Antenna 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.882	0.8675
Mid	2441	0.871	0.8655
High	2480	0.876	0.8675



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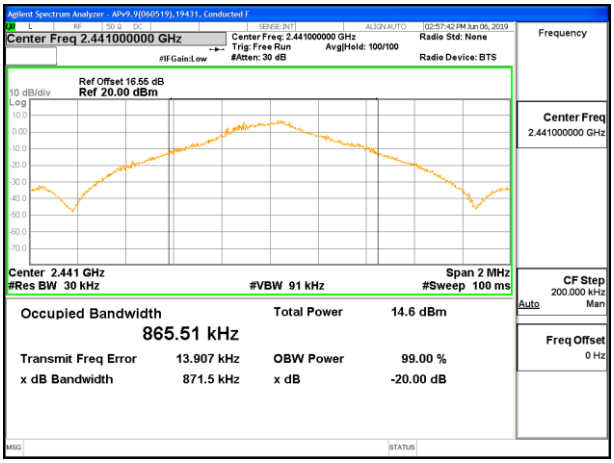

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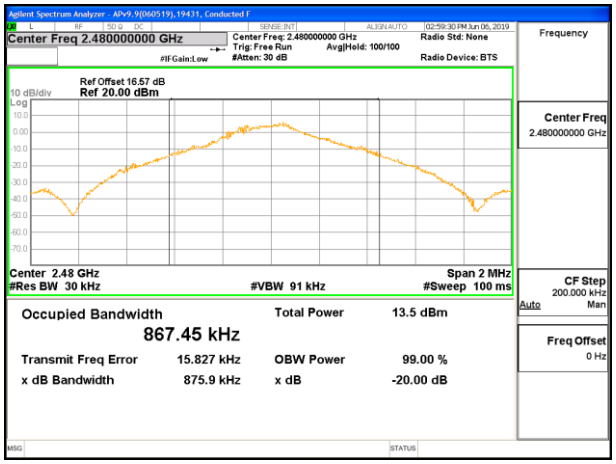

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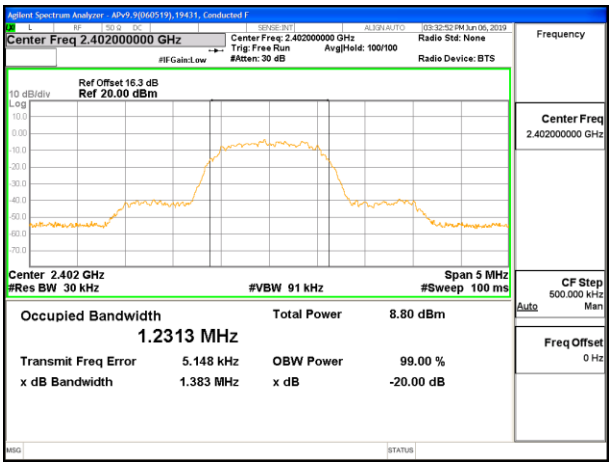
8.2.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 4

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.383	1.2313
Mid	2441	1.381	1.2238
High	2480	1.380	1.2237



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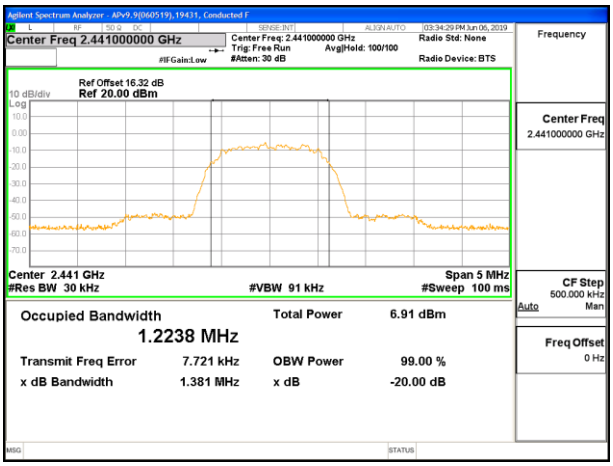

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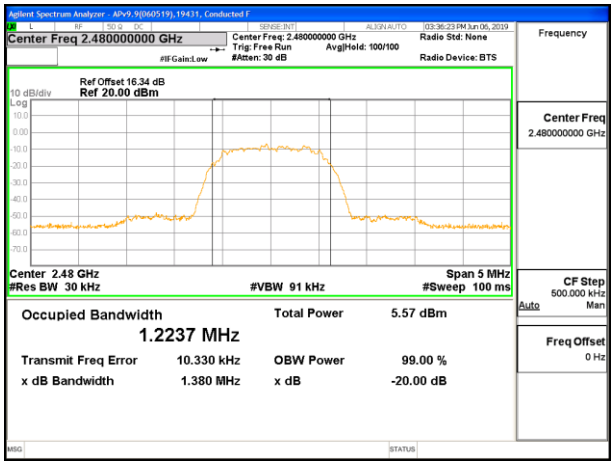

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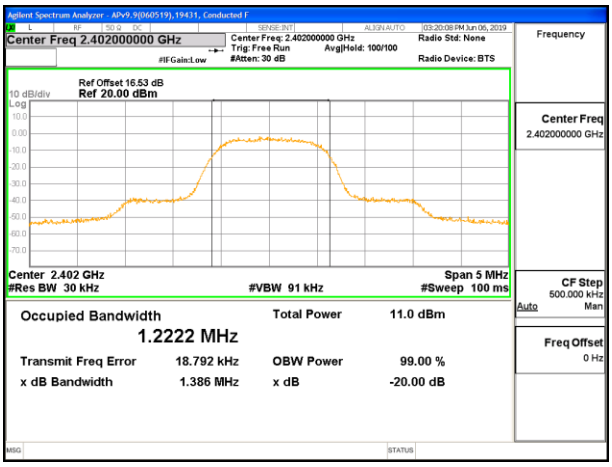
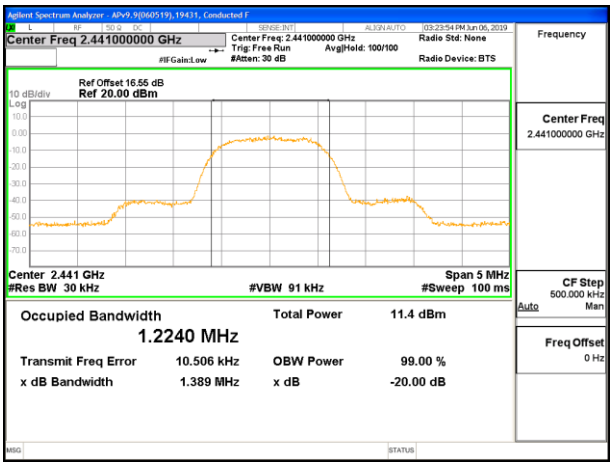
Antenna 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.386	1.2222
Mid	2441	1.389	1.2240
High	2480	1.398	1.2226



LOW CHANNEL



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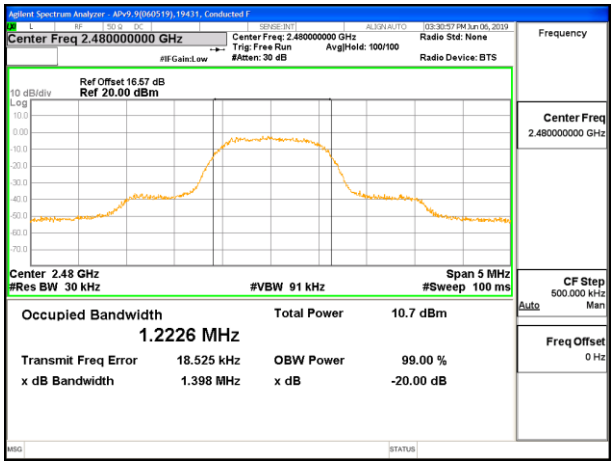

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