TEST REPORT

Report Number: 13179116-E1V2

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A
Model	:	A2172
FCC ID	:	BCG-E3542A
IC	:	579C-E3542A
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:
September 08, 2020

Prepared by:
UL Verification Services Inc.
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NVLAP TESTING

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/26/2020	Initial Issue	Chin Pang
V2	9/8/2020	Address TCB's Questions	Chin Pang

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12. SETUP PHOTOS 146

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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: A2172

SERIAL NUMBER: G6TCN05SQ5HH, G6TCN01JQ5HL

DATE TESTED: APRIL 20, 2020 – AUGUST 17, 2020

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
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2. TEST SUMMARY

FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	Per ANSI C63.10, Section 11.6.
See Comment	RSS-GEN 6.7	20dB BW/99% OBW	Reporting purposes only	ANSI C63.10 Sections 6.9.2 and 6.9.3
15.247 (a)(1)	RSS-247 (5.1) (b)	Hopping Frequency Separation	Complies	None.
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Number of Hopping Channels	Complies	None.
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Average Time of Occupancy	Complies	None.
15.247 (b)(1)	RSS-247 (5.4) (b)	Output Power	Complies	None.
See Comment		Average Power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (d)	RSS-247 (5.5)	Conducted Spurious Emissions	Complies	None.
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Complies	None.
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Complies	None.

3. 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, KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 662911, RSS-GEN Issue 5, and RSS-247 Issue 2.

4. 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 (IC:2324B-1)	☐ Chamber D (IC:22541-1)	☐ Chamber I (IC: 2324A-5)
☐ Chamber B (IC:2324B-2)	☐ Chamber E (IC:22541-2)	☒ Chamber J (IC: 2324A-6)
☐ Chamber C (IC:2324B-3)	☐ Chamber F (IC:22541-3)	☐ Chamber K (IC: 2324A-1)
	☐ Chamber G (IC:22541-4)	☒ Chamber L (IC: 2324A-3)
	☒ Chamber H (IC:22541-5)	☐ Chamber M (IC: 2324A-2)

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: 2324A.
UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	U_{LAB}
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.39 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.07 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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6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The Apple iPhone is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and WPT. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM). The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible

6.2. 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	20.25	105.93
		2402 - 2480	DQPSK	18.27	67.14
		2402 - 2480	Enhanced 8PSK	18.34	68.23
	Low Power	2402 - 2480	Basic GFSK	12.75	18.84
		2402 - 2480	DQPSK	11.70	14.79
		2402 - 2480	Enhanced 8PSK	11.75	14.96
ANT 3	High Power	2402 - 2480	Basic GFSK	20.26	106.17
		2402 - 2480	DQPSK	18.30	67.61
		2402 - 2480	Enhanced 8PSK	18.32	67.92
	Low Power	2402 - 2480	Basic GFSK	12.72	18.71
		2402 - 2480	DQPSK	11.20	13.18
		2402 - 2480	Enhanced 8PSK	11.23	13.27
BF, ANT 4 + ANT3	High Power	2402 - 2480	Basic GFSK TxBF	20.69	117.22
		2402 - 2480	DQPSK TxBF	20.23	105.44
		2402 - 2480	Enhanced 8PSK TxBF	20.28	106.66
	Low Power	2402 - 2480	Basic GFSK TxBF	15.73	37.41
		2402 - 2480	DQPSK TxBF	14.70	29.51
		2402 - 2480	Enhanced 8PSK TxBF	14.74	29.79

Note: GFSK, DQPSK, 8PSK average Power are all investigated, The GFSK & 8PSK Power are the worst case. Testing is based on these modes to showing compliance. For average power data please refer to section 9.7.

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6.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	ANT 4 (dBi)	ANT 3 (dBi)
2.4	-2.1	-0.3

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was18.1.148.558

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on ANT 4 and ANT 3, it was determined that X (Flatbed) was the worst-case orientation for ANT 4 and 2TX Beamforming. The Y (Landscape) orientation for 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 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. There were no emissions found below 30MHz within 20dB of the limit.

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. 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 9.7.

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

GFSK mode: DH5
8PSK mode: 3-DH5
Beamforming : GFSK, DH5, 8PSK, 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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6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID/ DoC**
Laptop	Apple	A1398	C02PM012G3QD	QDS-BRCM1069
Laptop AC/DC adapter	Liteon Technology	PA-1450-BA1	B123	N/A
EUT AC/DC adapter	Apple	A1385	D29325SM03XDHLHC9	N/A

I/O CABLES (RF CONDUCTED TEST)						
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	1.0	N/A
3	AC	1	AC	Un-shielded	2	N/A

I/O CABLES (RF RADIATED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**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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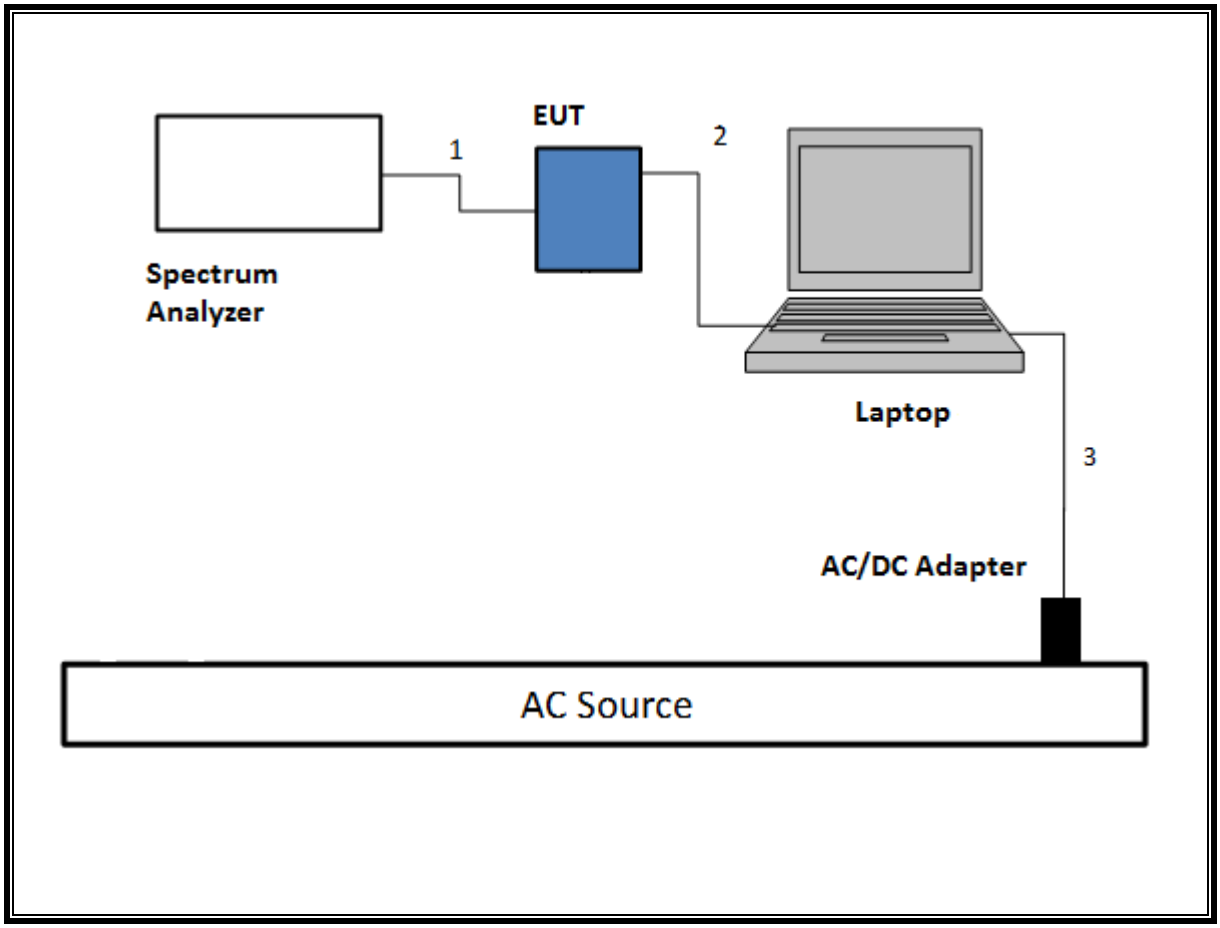
SETUP DIAGRAM FOR CONDUCTED TESTS



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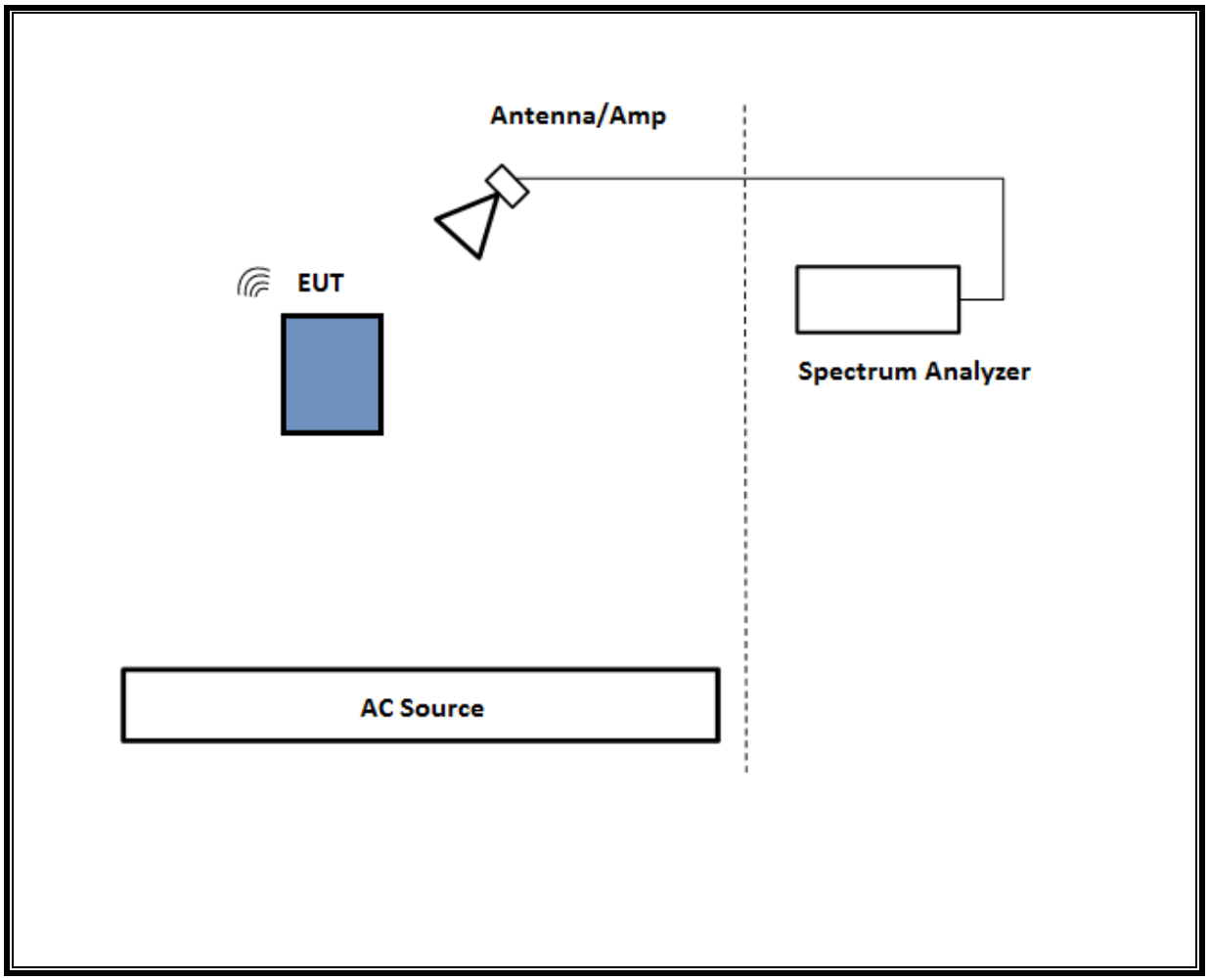
SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz



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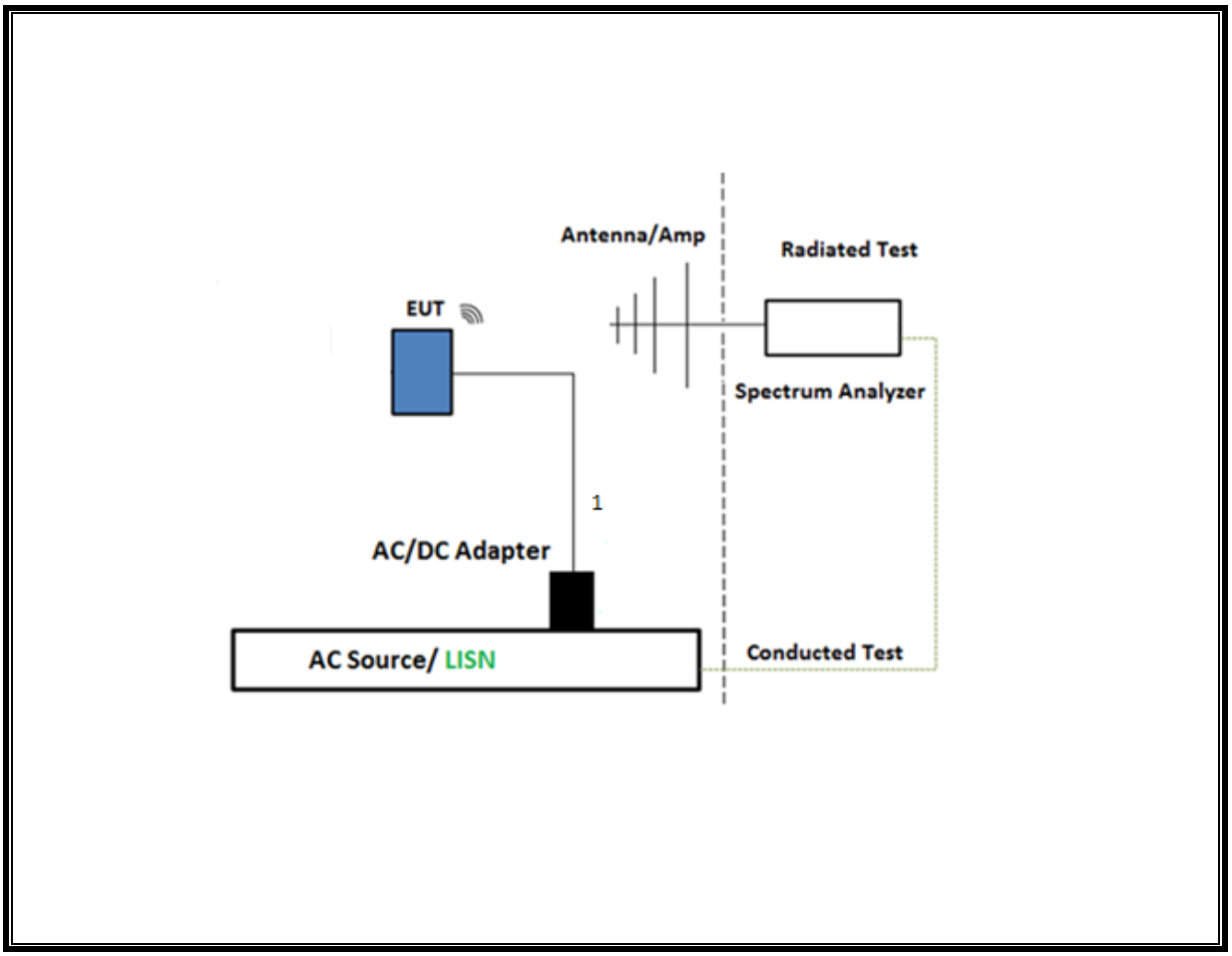
SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST



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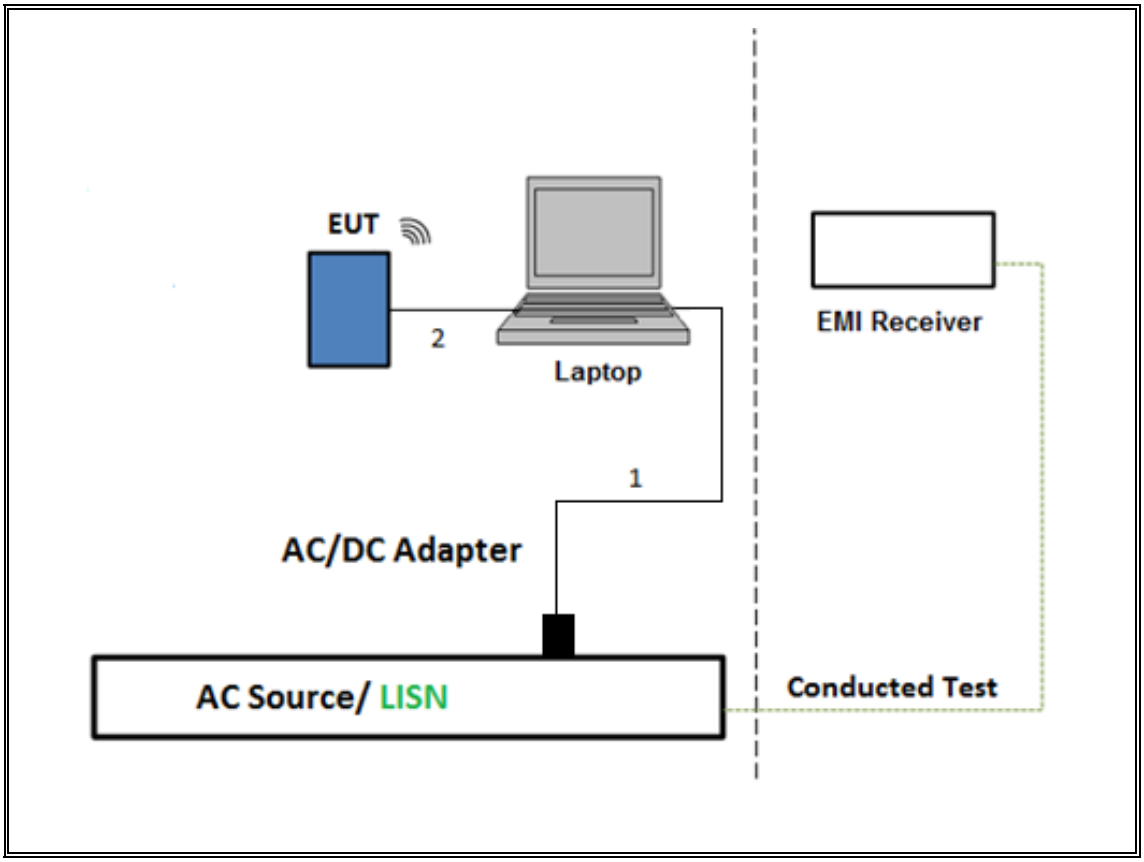
TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



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7. 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**
*Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	11/01/2020	11/01/2019
Amplifier, 1 to 18GHz, 35dB	Miteq	AFS42-00101800-25-S-42	T1567	01/24/2021	01/24/2020
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T344	05/26/2021	05/26/2020
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T1165	05/18/2021	05/18/2020
Antenna, Horn 1-18GHz	A.H. System Inc	SAS-571	T963	01/25/2021	01/25/2020
*Amplifier, 1 to 18GHz	AMPLICAL	AMP1G18-35	T1771	05/28/2020	05/28/2019
Spectrum Analyzer, PXA 3Hz to 44GHz	Keysight	N9030A	T907	01/22/2021	01/22/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T339	01/21/2021	01/21/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	PRE179522	02/20/2021	02/20/2020
Antenna Horn, 18 to 26GHz	ARA	SWH-28	T125	04/17/2021	04/17/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent (Keysight) Technologies	N9030A	T1454	01/23/2021	01/23/2020
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB3	T900	08/09/2020	08/09/2019
*Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310N	T173	06/06/2020	06/06/2019
Antenna Horn, 18 to 26GHz	ARA	SWH-28	T125	04/17/2021	04/17/2020
Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	04/08/2021	04/08/2020
Antenna, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T757	10/01/2020	10/01/2019
Power Meter, P-series single channel	Keysight	N1911A	PRE0177682	01/21/2021	01/21/2020
Power Sensor	Keysight	N1921A	T1226	02/13/2021	02/13/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	PRE0179522	02/20/2021	02/20/2020
EMI Test Receiver	Rohde & Schwarz	ESW44	PRE0179376	04/03/2021	04/03/2020

AC Line Conducted					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
EMI Test Receiver 9Khz-7GHz	Rohde & Schwarz	ESCI7	T1436	02/20/2021	02/20/2020
Power Cable, Line Conducted Emissions	UL	PG1	T861	10/27/2020	10/27/2019
LISN for Conducted Emissions CISPR-16	Fischer	50/250-25-2-01	PRE0186446	01/23/2021	01/23/2020
UL AUTOMATION SOFTWARE					
Radiated Software	UL	UL EMC	Rev 9.5, 30 Apr, 2020		
Conducted Software	UL	UL EMC	AP2020.8.6		
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 21 Feb 2020		

*Testing is completed before equipment expiration date.

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8. 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 & 13

Radiated Spurious Emissions 30-1000MHz: ANSI C63.10-2013 Section 6.3, 6.5 & 13

Radiated Spurious Emissions above 1GHz: ANSI C63.10-2013 Section 6.3, 6.6 & 13

Radiated Band-edge: ANSI C63.10-2013 Section 6.10.5 & 13

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

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9. ANTENNA PORT TEST RESULTS

9.1. 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	5.94	5.94	1.000	100.0	0.00	0.010
Bluetooth 8PSK	5.49	5.49	1.000	100.0	0.00	0.010
Bluetooth GFSK TxBF	5.38	5.38	1.000	100.0	0.00	0.010
Bluetooth 8PSK TxBF	6.23	6.23	1.000	100.0	0.00	0.010

Note: Low power duty cycle is same as high power

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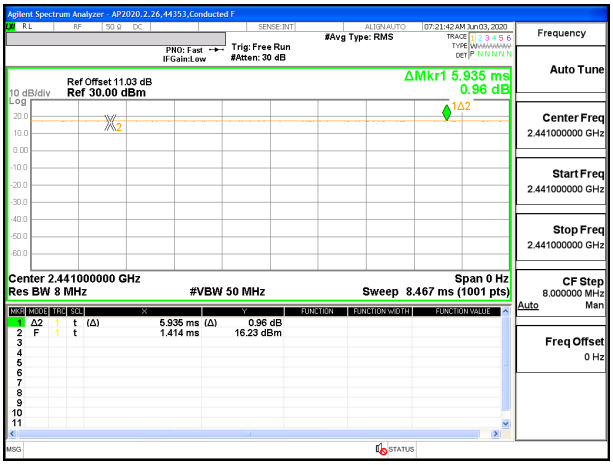
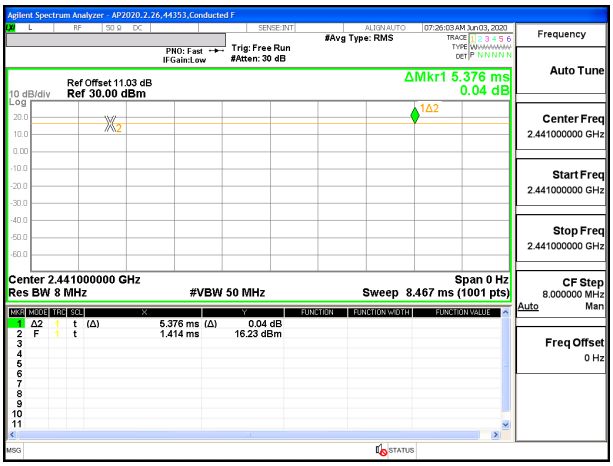
DUTY CYCLE PLOTS

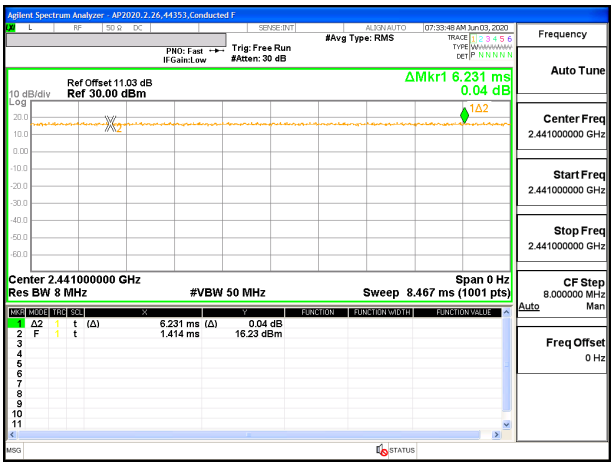


BLUETOOTH GFSK

BLUETOOTH 8PSK



BLUETOOTH GFSK TXBF



BLUETOOTH 8PSK TXBF

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9.2. 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 ≥ 3xRBW. The sweep time is coupled.

RESULTS

Only High-Power modes result is reported, it covers all Low Power modes. Only Mid channel plot is reported to show setting parameter complies with testing method/procedure.

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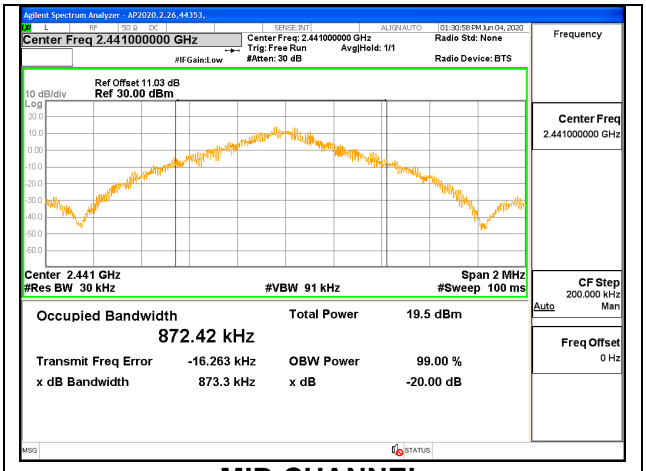
9.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 4

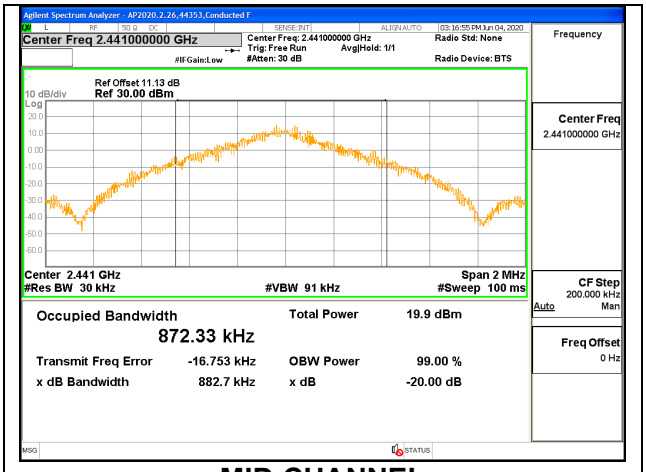
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.883	0.873
Mid	2441	0.873	0.872
High	2480	0.918	0.873



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.883	0.875
Mid	2441	0.883	0.872
High	2480	0.874	0.872



MID CHANNEL

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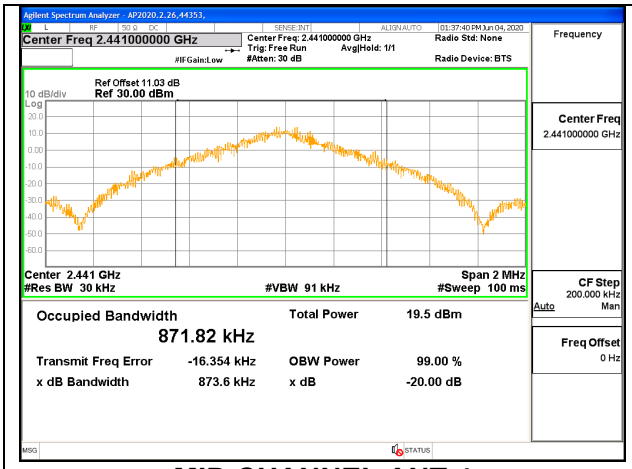
9.2.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

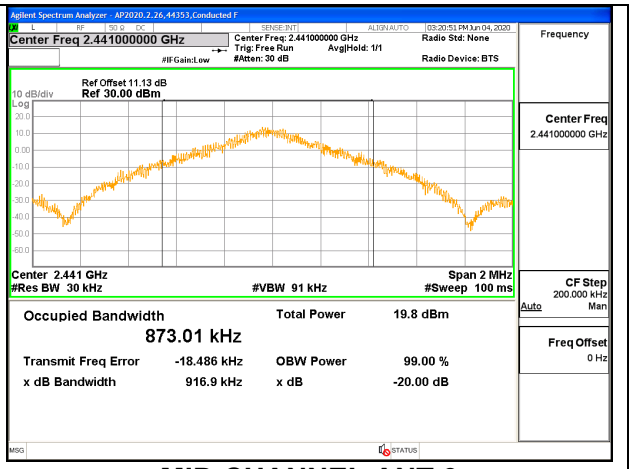
ANT 4

Channel	Frequency (MHz)	20dB Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 4 (MHz)	20dB Bandwidth ANT 3 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	0.919	0.872	0.917	0.873
Mid	2441	0.874	0.872	0.917	0.873
High	2480	0.874	0.873	0.883	0.872

Note: Test procedures and setting on beamforming mode are same as BT basic and EDR mode



MID CHANNEL ANT 4



MID CHANNEL ANT 3

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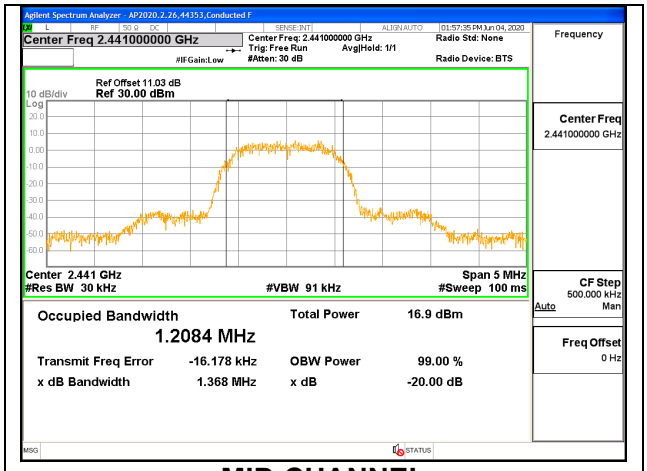
9.2.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

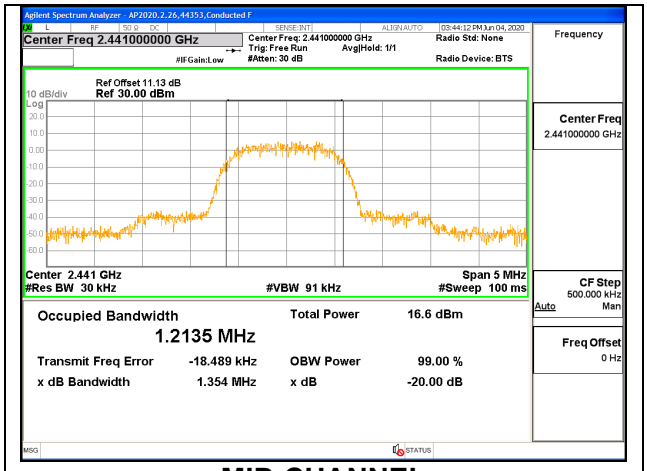
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.369	1.208
Mid	2441	1.368	1.208
High	2480	1.347	1.216



MID CHANNEL

ANT 3

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.355	1.213
Mid	2441	1.354	1.214
High	2480	1.355	1.216



MID CHANNEL

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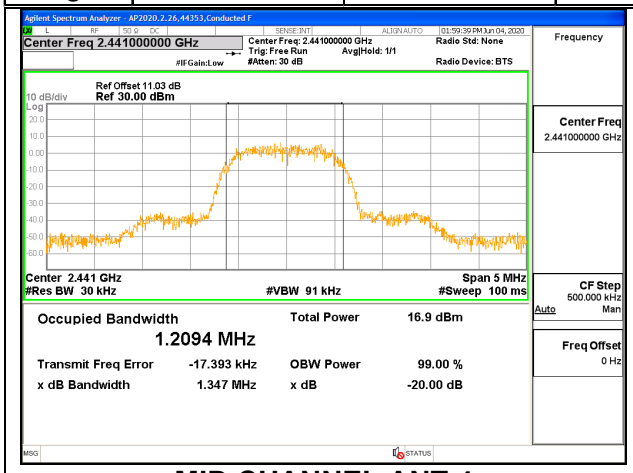
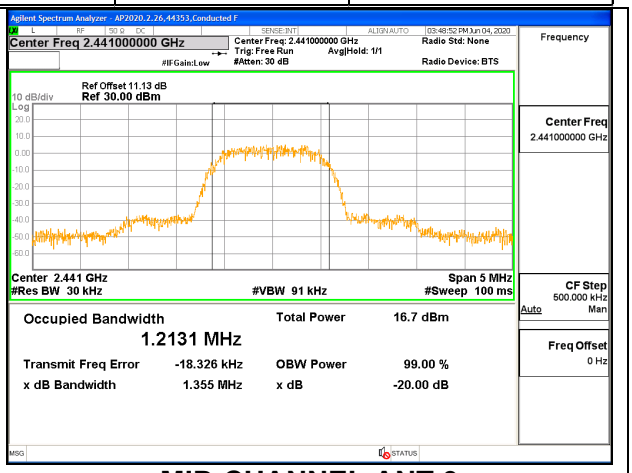
9.2.4. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

Channel	Frequency (MHz)	20dB Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 4 (MHz)	20dB Bandwidth ANT 3 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.337	1.210	1.369	1.215
Mid	2441	1.347	1.209	1.355	1.213
High	2480	1.338	1.213	1.355	1.216



MID CHANNEL ANT 4



MID CHANNEL ANT 3

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9.3. 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

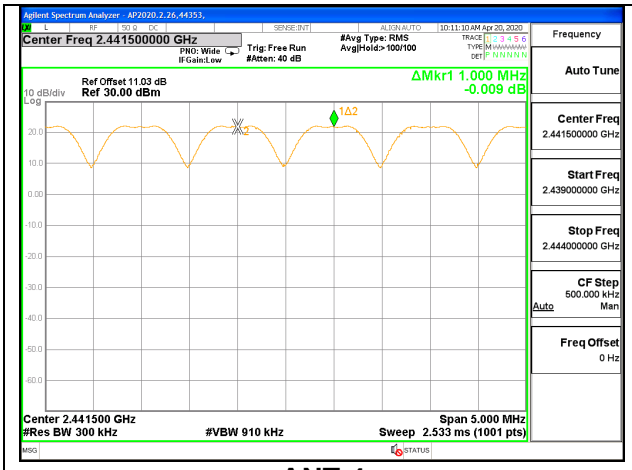
The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to VBW >= 3xRBW. The sweep time is coupled.

RESULTS

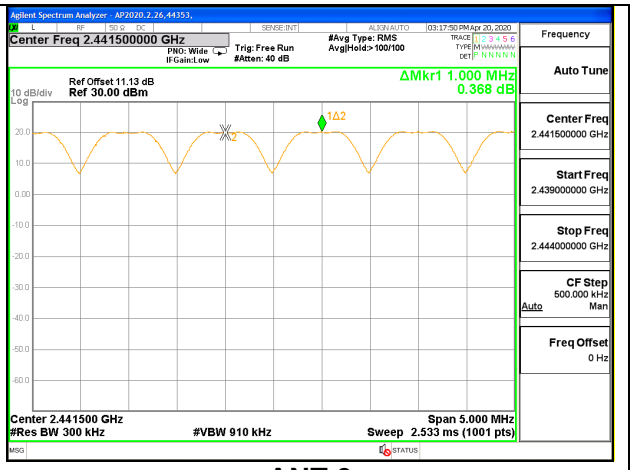
Only High Power GFSK mode result is reported since EDR (QPSK/8PSK) has exact same channel plan.

9.3.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

HOPPING FREQUENCY SEPARATION



ANT 4



ANT 3

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9.4. 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. Only High Power GFSK mode result is reported since EDR (QPSK/8PSK) has exact same channel plan.

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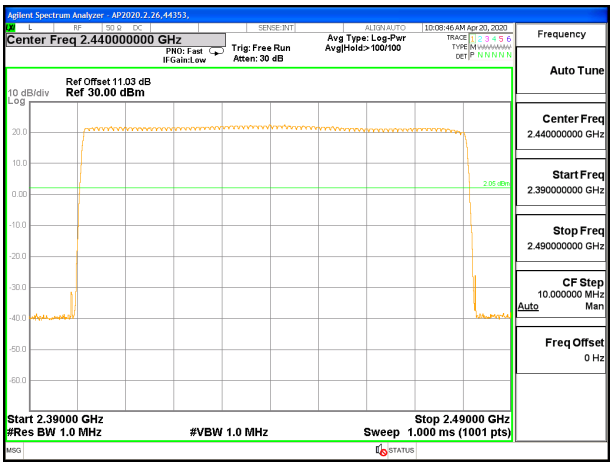
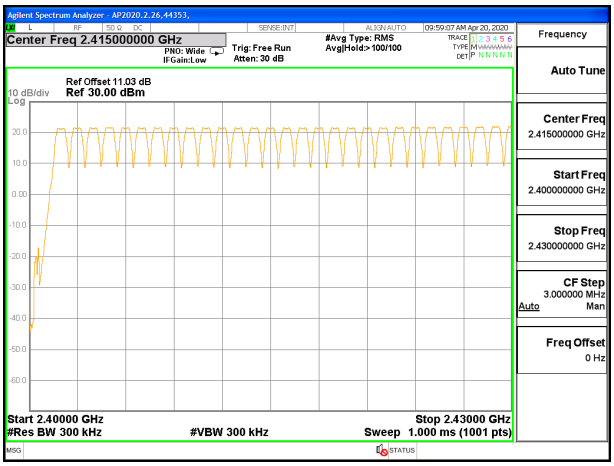
9.4.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

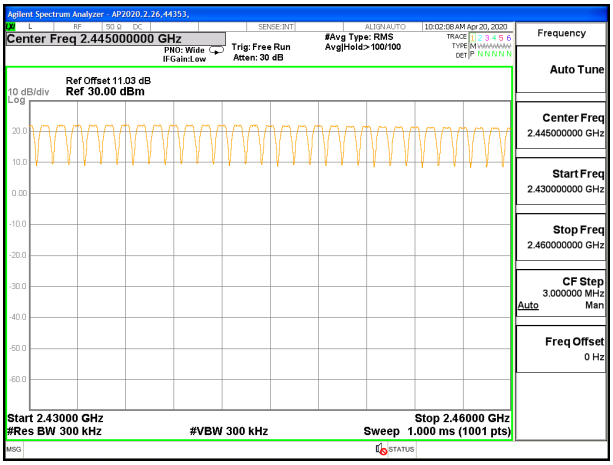
ANT 4



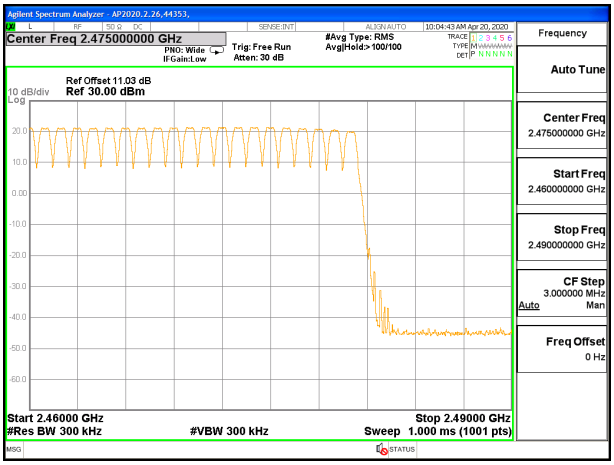
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

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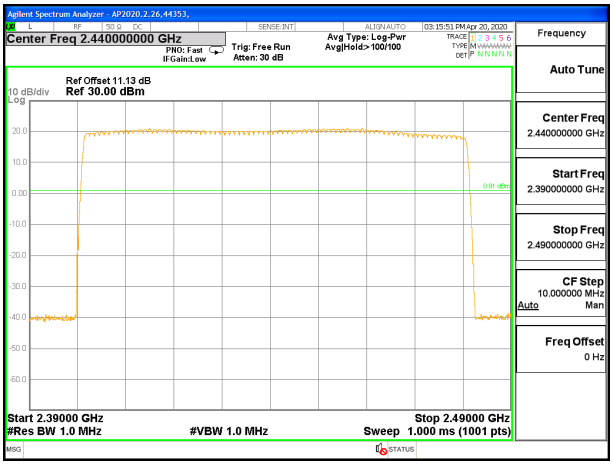
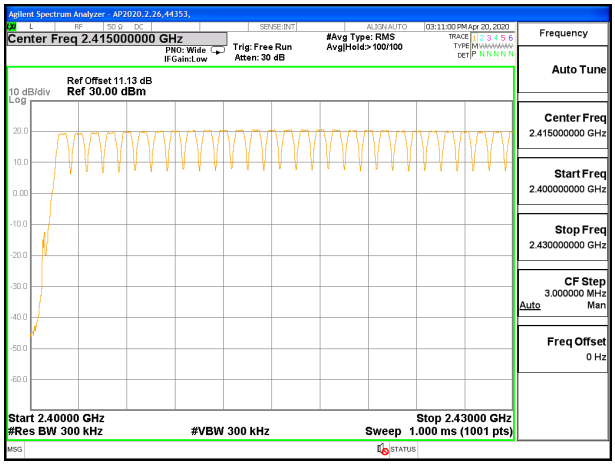
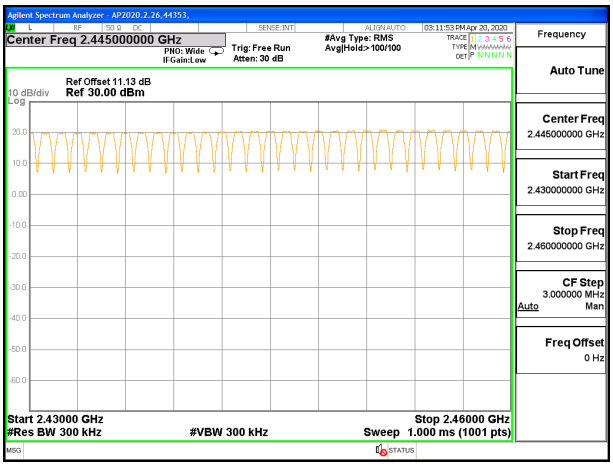
ANT 3



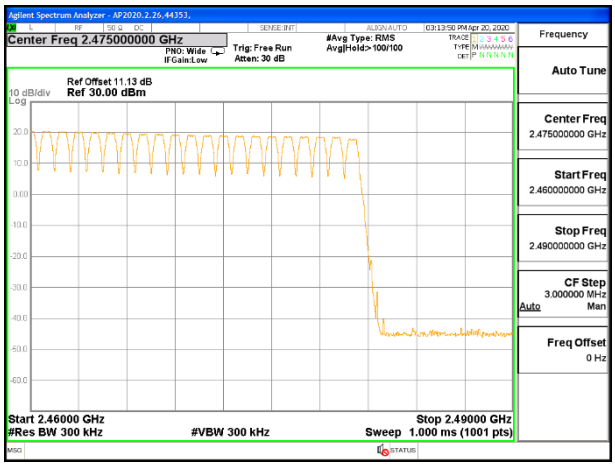
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

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9.5. 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

Only High Power GFSK mode result is reported since EDR (QPSK/8PSK) has exact same timing.

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9.5.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 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	0.379	32	0.1213	0.4	-0.2787
DH3	1.634	16	0.2614	0.4	-0.1386
DH5	2.872	11	0.3159	0.4	-0.0841
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	0.379	8	0.03032	0.4	-0.3697
DH3	1.634	4	0.06536	0.4	-0.3346
DH5	2.872	2.75	0.07898	0.4	-0.3210

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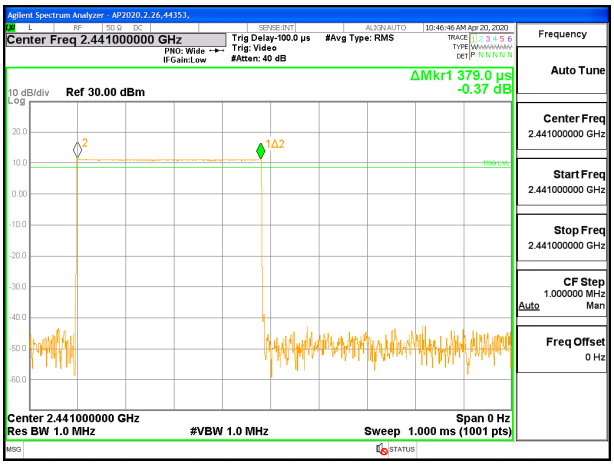
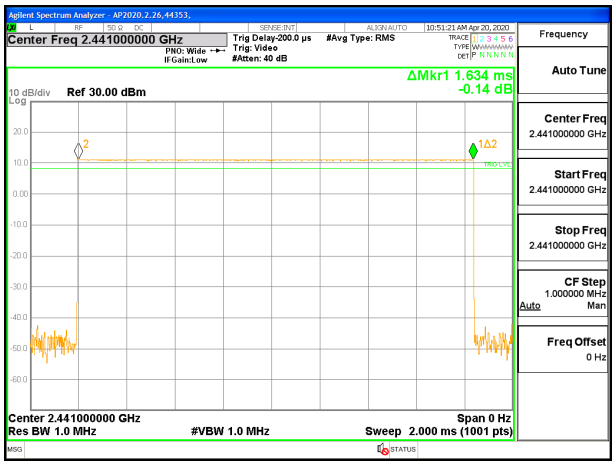
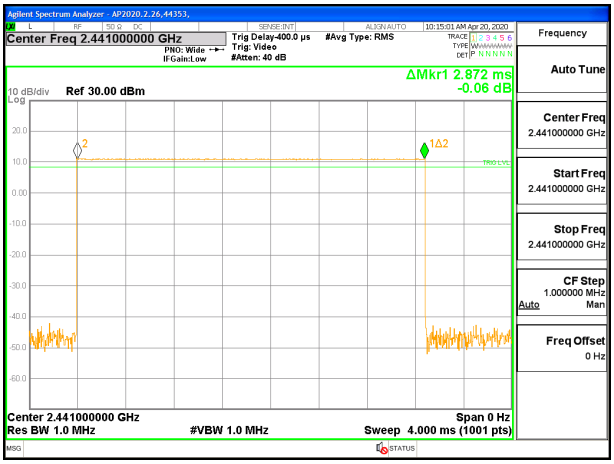


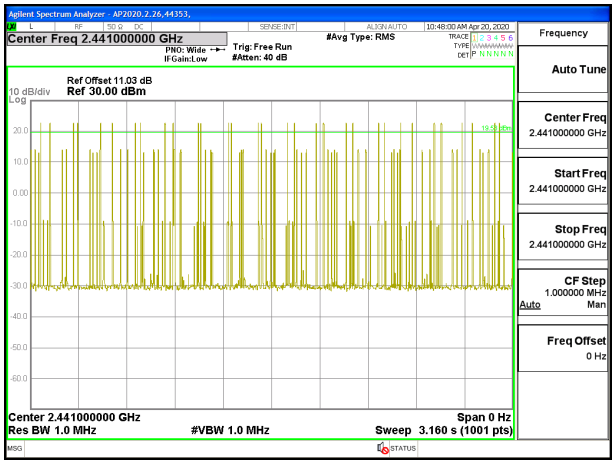
PULSE WIDTH – DH1



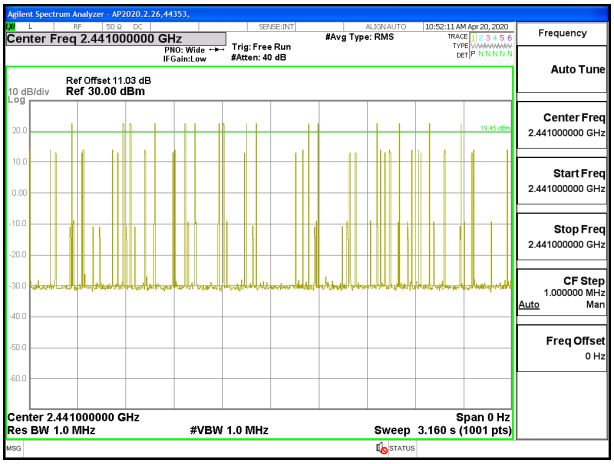
PULSE WIDTH – DH3



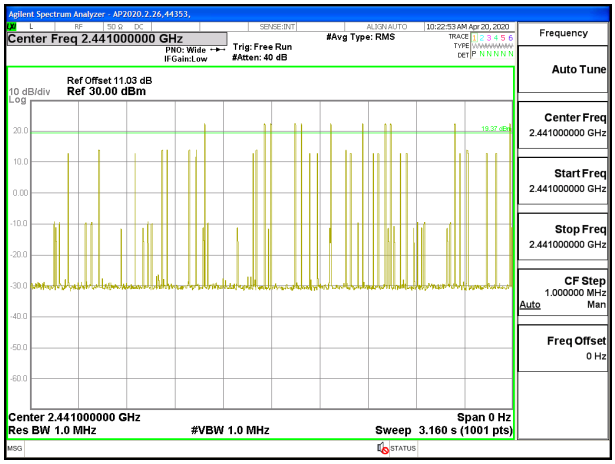
PULSE WIDTH – DH5



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

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ANT 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	0.38	32	0.1216	0.4	-0.2784
DH3	1.632	15	0.2448	0.4	-0.1552
DH5	2.872	9	0.2585	0.4	-0.1415
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	0.38	8	0.03040	0.4	-0.3696
DH3	1.632	3.75	0.06120	0.4	-0.3388
DH5	2.872	2.25	0.06462	0.4	-0.3354

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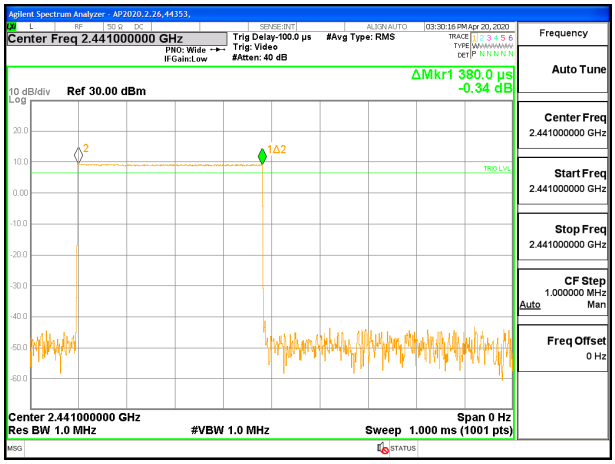
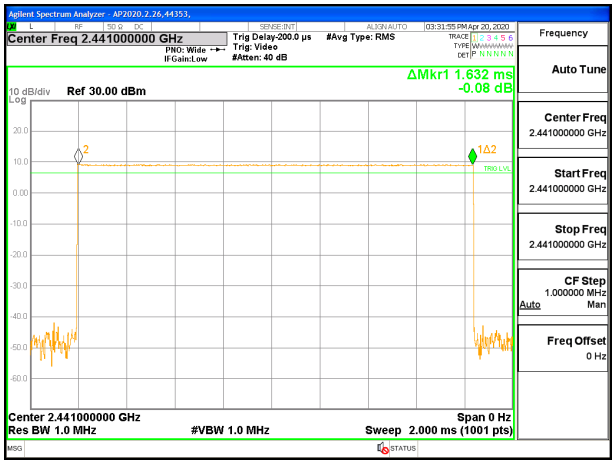
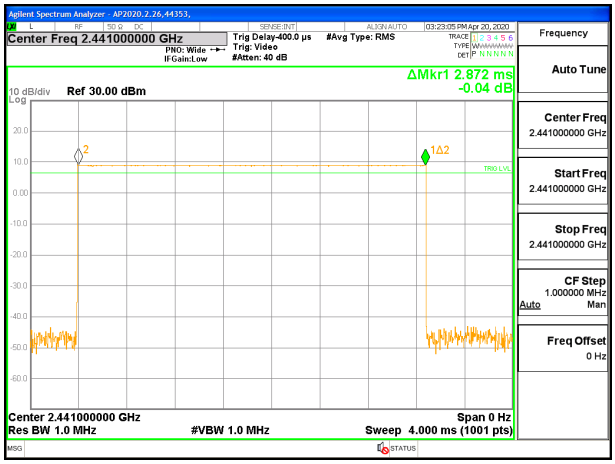


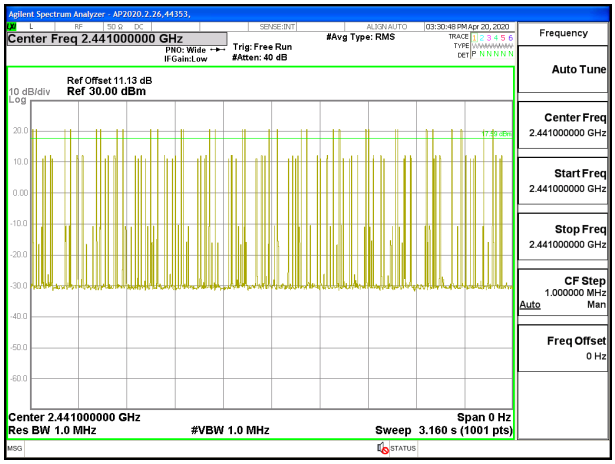
PULSE WIDTH – DH1



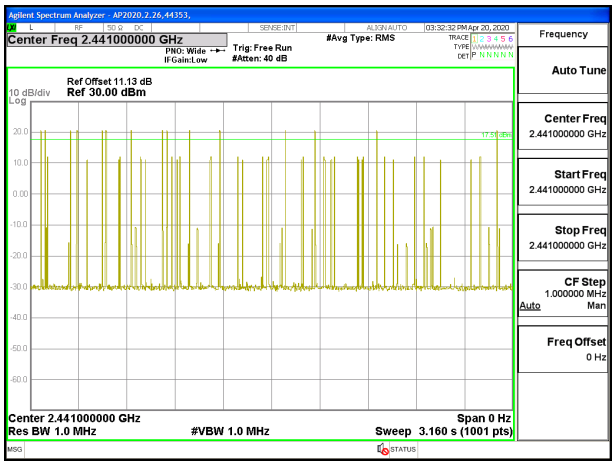
PULSE WIDTH – DH3



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

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9.6. 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. 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.

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts

TEST PROCEDURE

Measurements perform using a wideband gated RF power meter.

The cable assembly insertion loss of 11.03 dB (including 10 dB pad and 1.03 dB cable) was entered as an offset in the power meter to allow for a gated peak reading of power.

DIRECTIONAL ANTENNA GAIN

For 1 TX:
There is only one transmitter output therefore the directional gain is equal to the antenna gain.

For 2 TX:

Tx chains are correlated for power due to the device supporting Beamforming. The directional gains are as follows:

Band (GHz)	ANT 4 Antenna Gain (dBi)	ANT 3 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	-2.10	-0.30	-1.11	1.86

RESULTS

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9.6.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.17	21	-0.83
Middle	2441	20.25	21	-0.75
High	2480	20.10	21	-0.9

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.15	21	-0.85
Middle	2441	20.26	21	-0.74
High	2480	20.13	21	-0.87

9.6.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.64	17.61	20.64	21	-0.36
Middle	2441	17.70	17.65	20.69	21	-0.31
High	2480	17.62	17.60	20.62	21	-0.38

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9.6.3. HIGH POWER ENHANCED DATA RATE QPSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.23	21	-2.77
Middle	2441	18.27	21	-2.73
High	2480	18.20	21	-2.8

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.27	21	-2.73
Middle	2441	18.30	21	-2.7
High	2480	18.22	21	-2.78

9.6.4. HIGH POWER ENHANCED DATA RATE TXBF QPSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.15	17.13	20.15	21	-0.85
Middle	2441	17.23	17.21	20.23	21	-0.77
High	2480	17.10	17.11	20.12	21	-0.88

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9.6.5. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.27	21	-2.73
Middle	2441	18.34	21	-2.66
High	2480	18.25	21	-2.75

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.28	21	-2.72
Middle	2441	18.32	21	-2.68
High	2480	18.23	21	-2.77

9.6.6. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.19	17.22	20.22	21	-0.78
Middle	2441	17.26	17.28	20.28	21	-0.72
High	2480	17.15	17.13	20.15	21	-0.85

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9.6.7. LOW POWER BASIC DATA RATE GFSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.69	21	-8.31
Middle	2441	12.75	21	-8.25
High	2480	12.72	21	-8.28

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.65	21	-8.35
Middle	2441	12.72	21	-8.28
High	2480	12.6	21	-8.4

9.6.8. LOW POWER BASIC DATA RATE TXBF GFSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.68	12.66	15.68	21	-5.32
Middle	2441	12.72	12.71	15.73	21	-5.27
High	2480	12.6	12.59	15.61	21	-5.39

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9.6.9. LOW POWER ENHANCED DATA RATE QPSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.59	21	-9.41
Middle	2441	11.70	21	-9.3
High	2480	11.56	21	-9.44

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.04	21	-9.96
Middle	2441	11.20	21	-9.8
High	2480	11.07	21	-9.93

9.6.10. LOW POWER ENHANCED DATA RATE TXBF QPSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/22/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.58	11.60	14.60	21	-6.40
Middle	2441	11.70	11.68	14.70	21	-6.30
High	2480	11.60	11.55	14.59	21	-6.41

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9.6.11. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.67	21	-9.33
Middle	2441	11.75	21	-9.25
High	2480	11.60	21	-9.4

ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.1	21	-9.9
Middle	2441	11.23	21	-9.77
High	2480	11.15	21	-9.85

9.6.12. LOW POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.6	11.60	14.61	21	-6.39
Middle	2441	11.75	11.70	14.74	21	-6.26
High	2480	11.6	11.58	14.60	21	-6.40

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9.7. 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

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9.7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.84
Middle	2441	19.94
High	2480	19.79

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.83
Middle	2441	19.95
High	2480	19.81

9.7.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	17.38	17.35	20.38
Middle	2441	17.42	17.37	20.41
High	2480	17.35	17.33	20.35

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9.7.3. HIGH POWER ENHANCED DATA RATE QPSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.80
Middle	2441	15.85
High	2480	15.76

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.79
Middle	2441	15.87
High	2480	15.74

9.7.4. HIGH POWER ENHANCED DATA RATE TXBF QPSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	14.83	14.79	17.82
Middle	2441	14.90	14.88	17.90
High	2480	14.76	14.77	17.78

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9.7.5. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.92
Middle	2441	15.97
High	2480	15.89

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.91
Middle	2441	15.95
High	2480	15.87

9.7.6. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	14.90	14.91	17.92
Middle	2441	14.98	14.96	17.98
High	2480	14.86	14.85	17.87

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9.7.7. LOW POWER BASIC DATA RATE GFSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	12.42
Middle	2441	12.47
High	2480	12.44

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	12.38
Middle	2441	12.44
High	2480	12.31

9.7.8. LOW POWER BASIC DATA RATE TXBF GFSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	12.40	12.38	15.40
Middle	2441	12.45	12.43	15.45
High	2480	12.34	12.30	15.33

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9.7.9. LOW POWER ENHANCED DATA RATE QPSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.79
Middle	2441	8.90
High	2480	8.76

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.75
Middle	2441	8.88
High	2480	8.79

9.7.10. LOW POWER ENHANCED DATA RATE TXBF QPSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	8.79	8.80	11.81
Middle	2441	8.92	8.89	11.92
High	2480	8.81	8.75	11.79

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9.7.11. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.88
Middle	2441	8.98
High	2480	8.81

ANT 3

Tested By:	44353
Date	7/25/2020

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.73
Middle	2441	8.91
High	2480	8.78

9.7.12. LOW POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	44353
Date:	7/25/2020

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	8.82	8.81	11.83
Middle	2441	8.96	8.91	11.95
High	2480	8.80	8.79	11.81

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9.8. 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 band edges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

RESULTS

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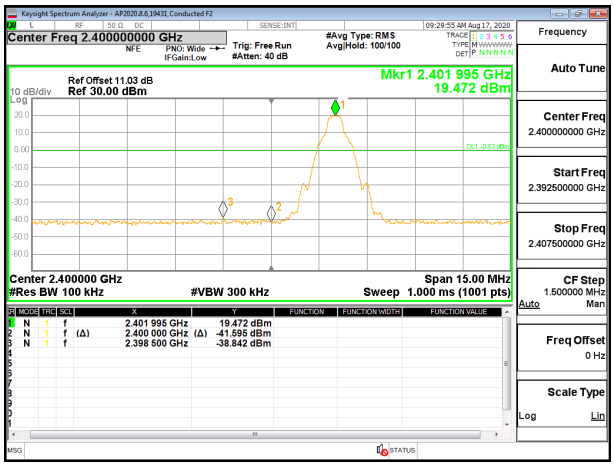
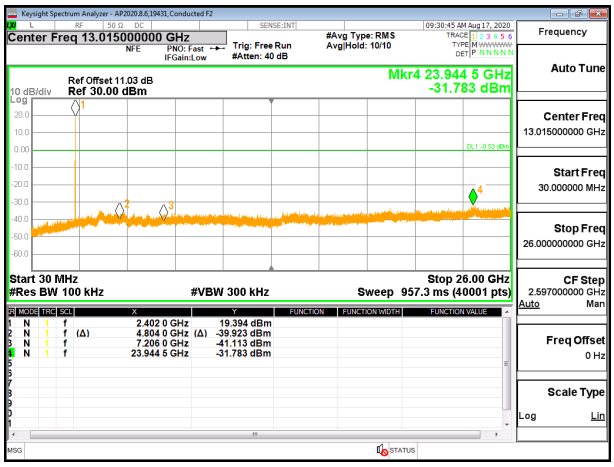
9.8.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

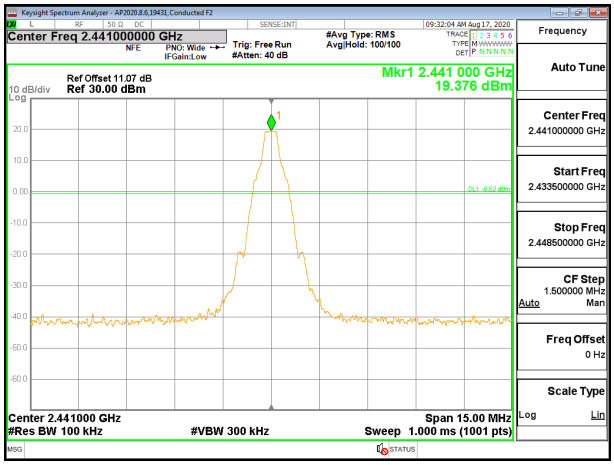
ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



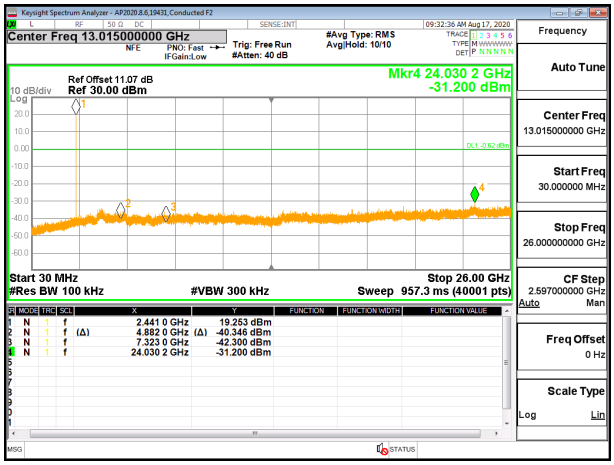
LOW CHANNEL BANDEDGE



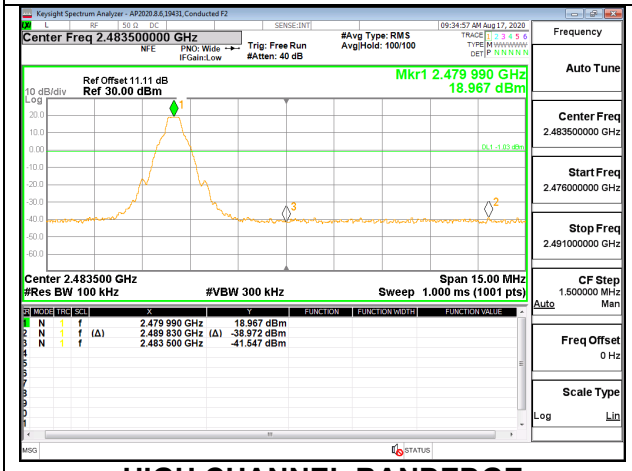
OUT-OF-BAND LOW CHANNEL



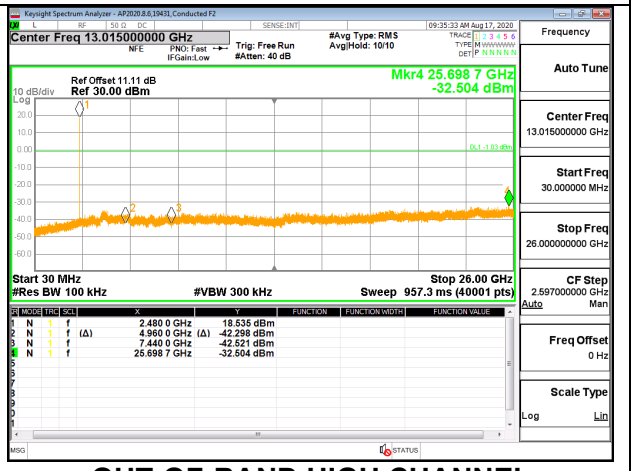
MID CHANNEL REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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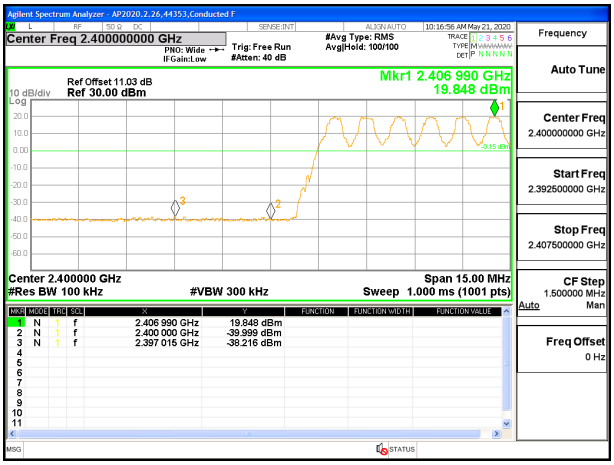
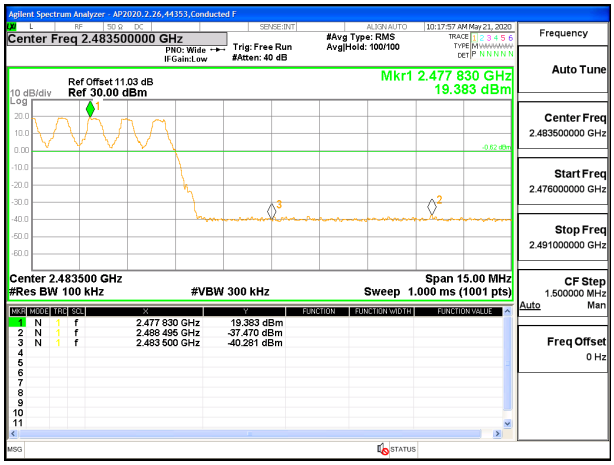
ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



HIGH BANDEDGE

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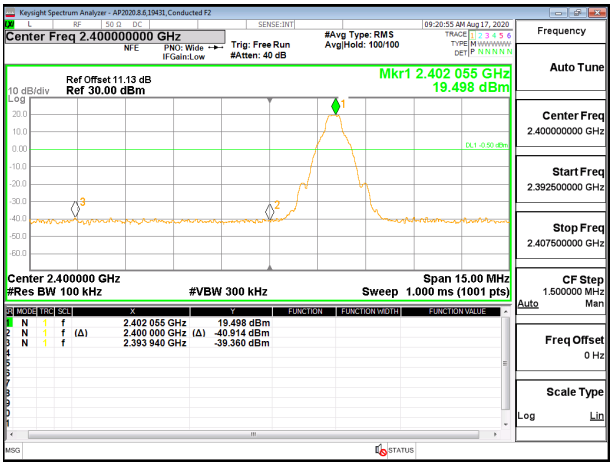
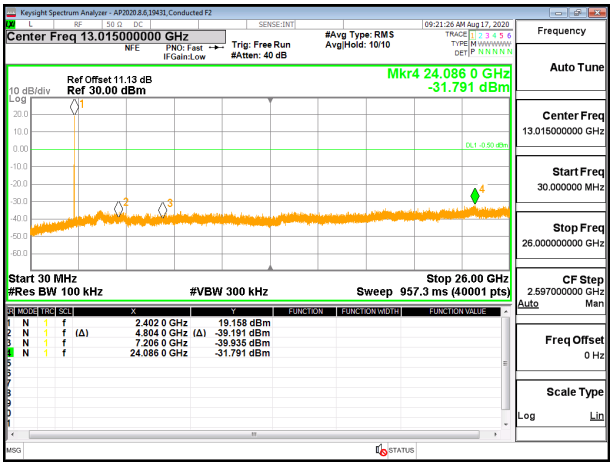
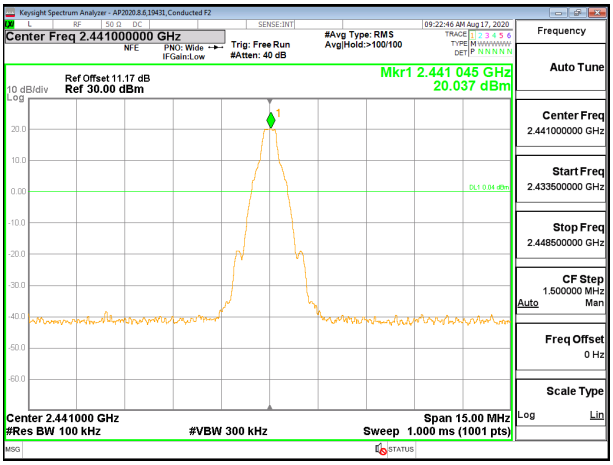
ANT 3 SPURIOUS EMISSIONS, NON-HOPPING



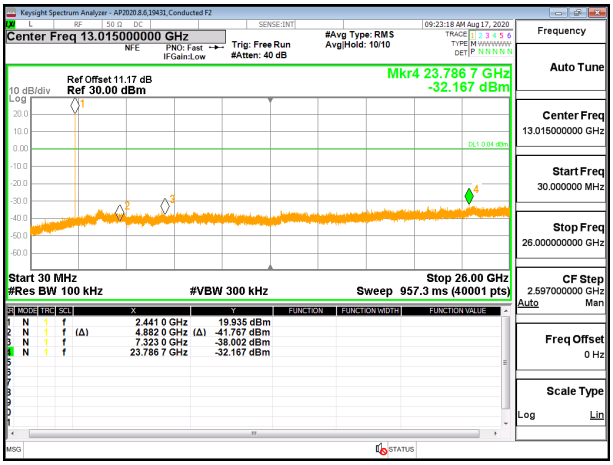
LOW CHANNEL BANDEDGE



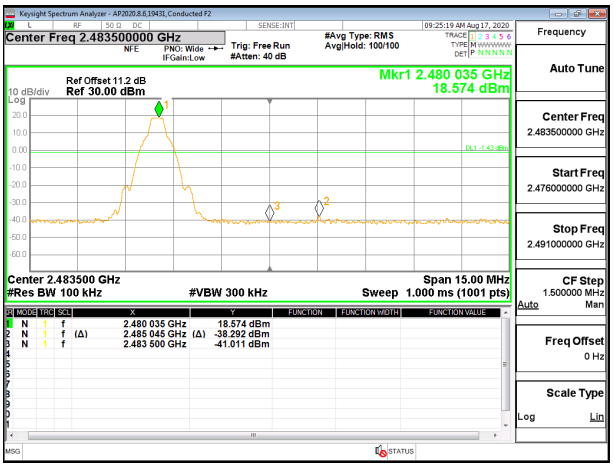
OUT-OF-BAND LOW CHANNEL



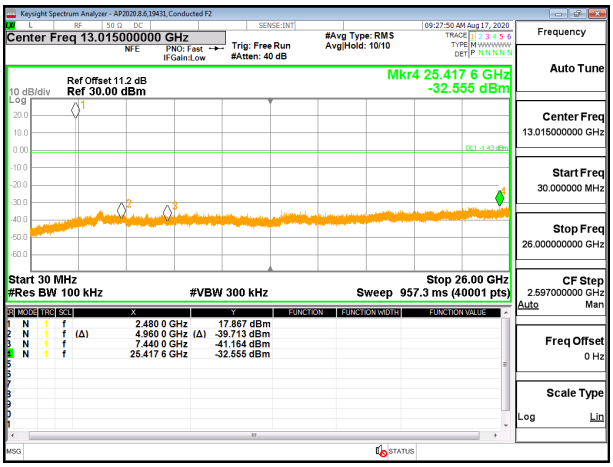
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

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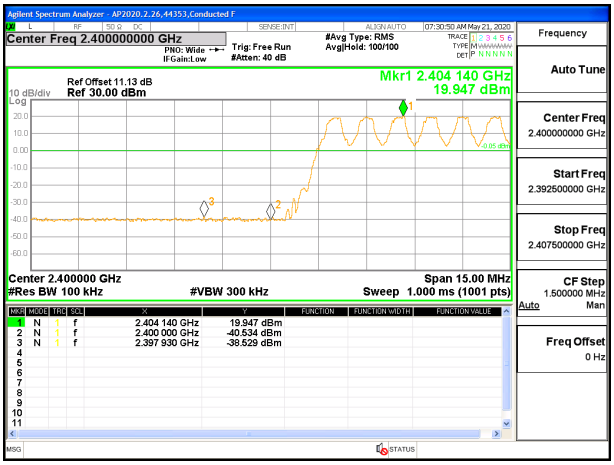
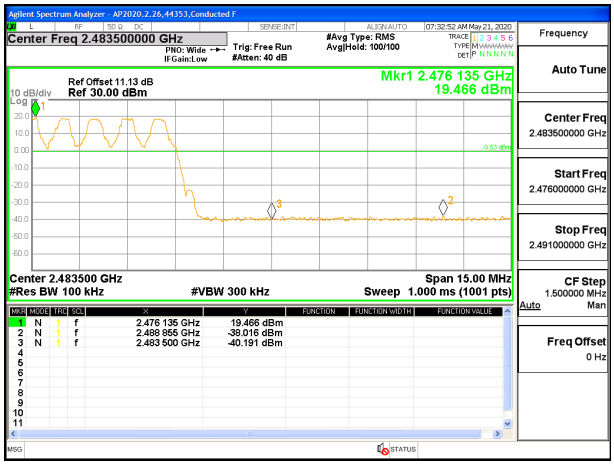
ANT 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



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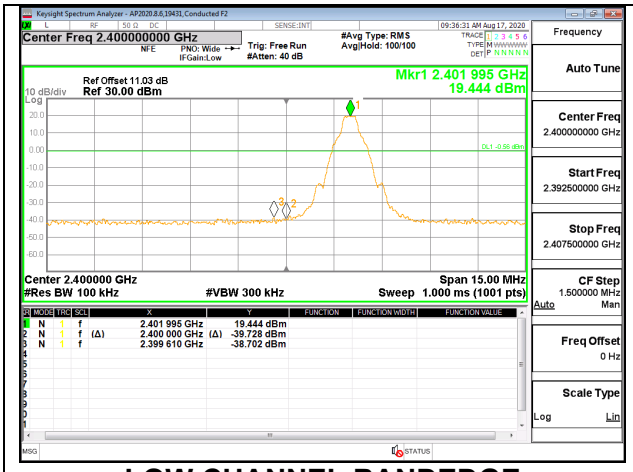
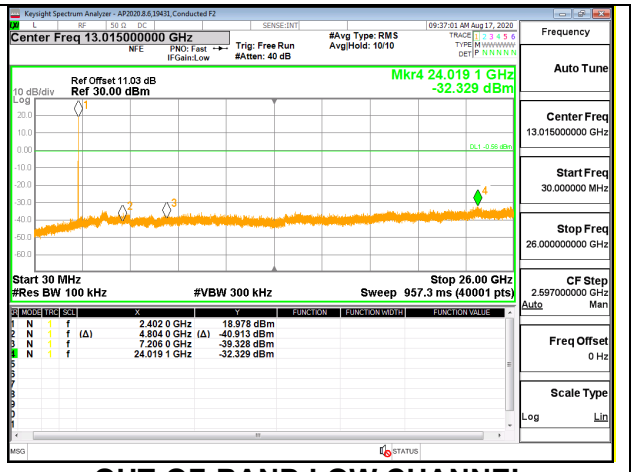
9.8.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

Note: Test procedure on beamforming mode is same as BT basic and EDR mode

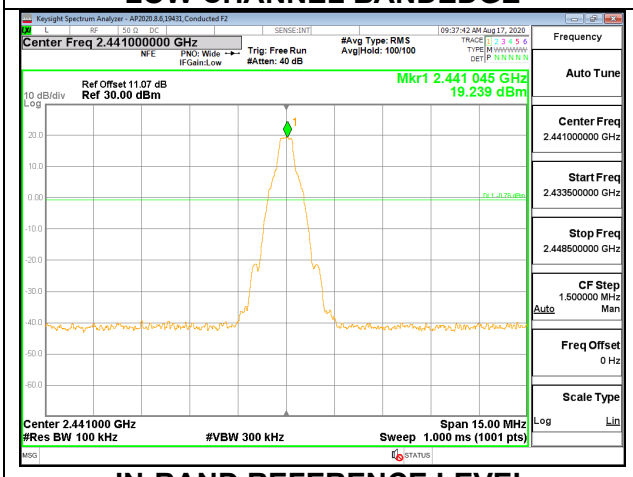
ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



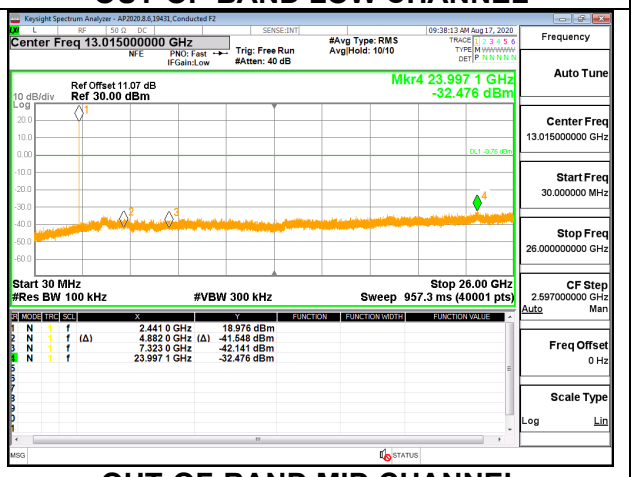
LOW CHANNEL BANDEDGE



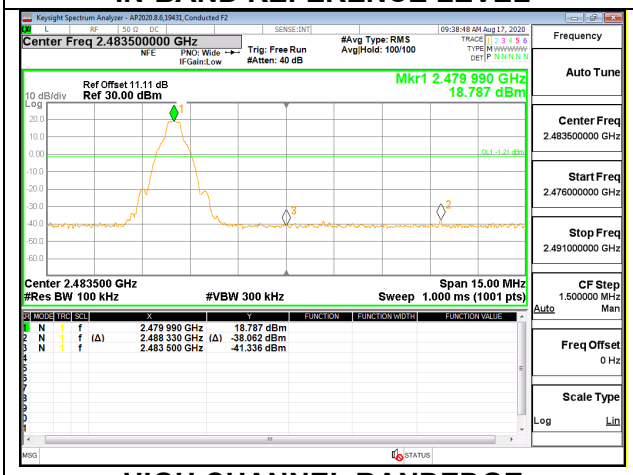
OUT-OF-BAND LOW CHANNEL



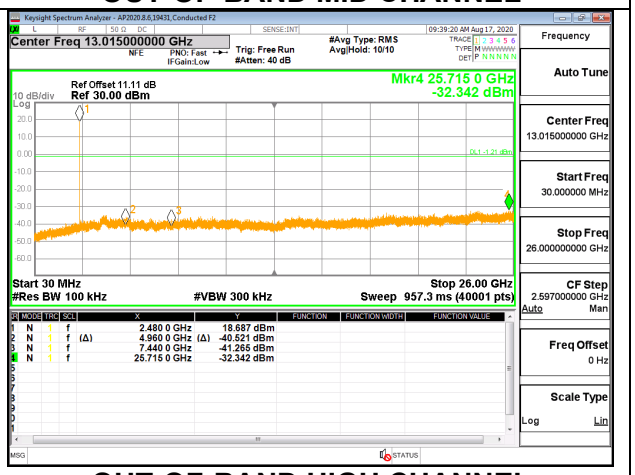
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



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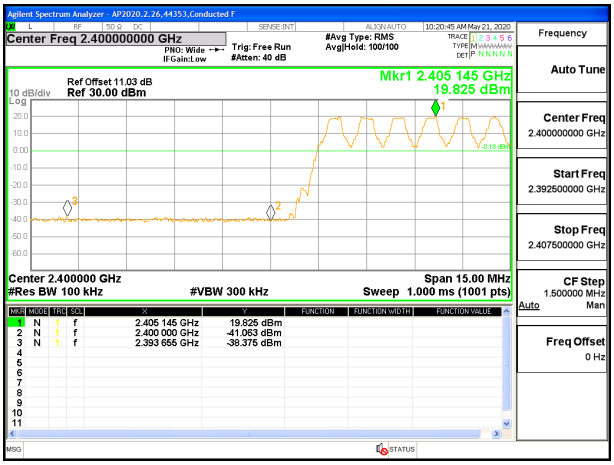
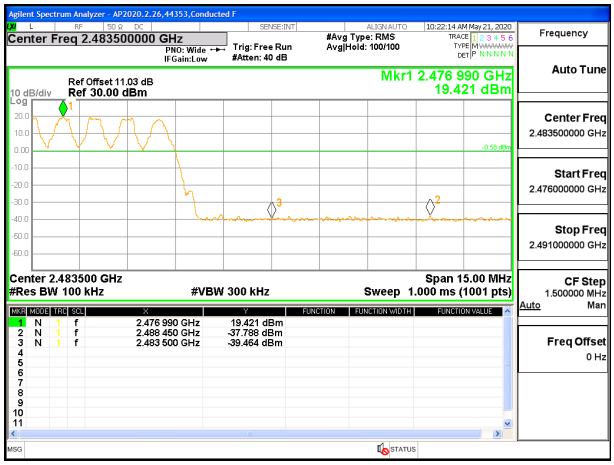
ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



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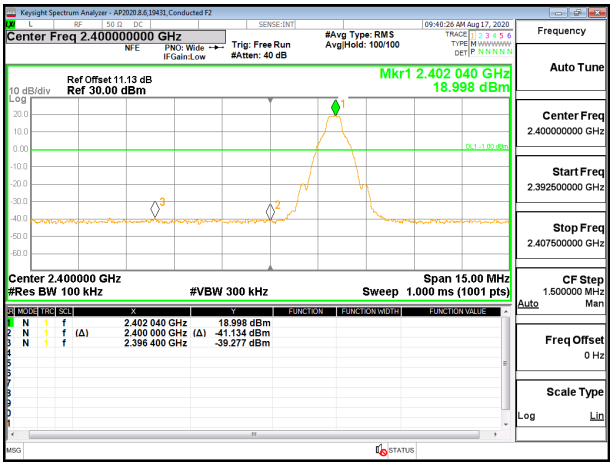
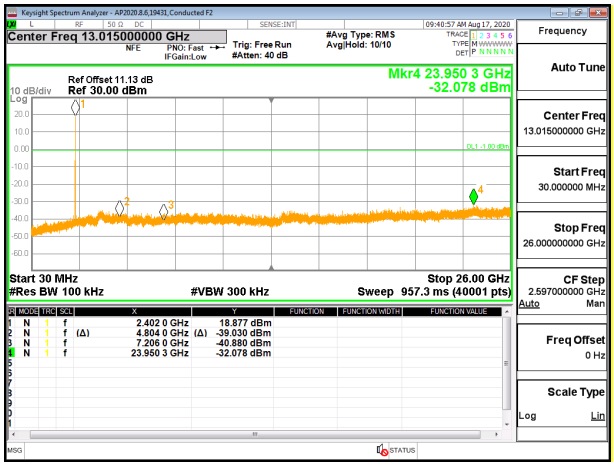
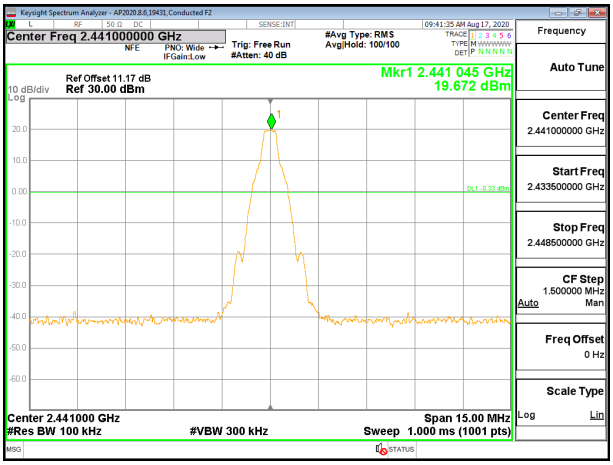
ANT 3 SPURIOUS EMISSIONS, NON-HOPPING



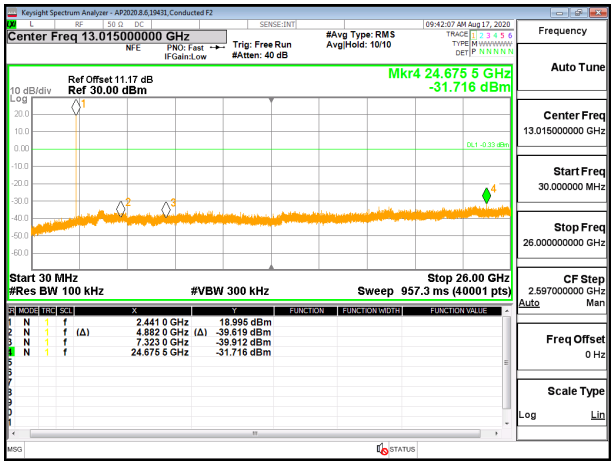
LOW CHANNEL BANDEDGE



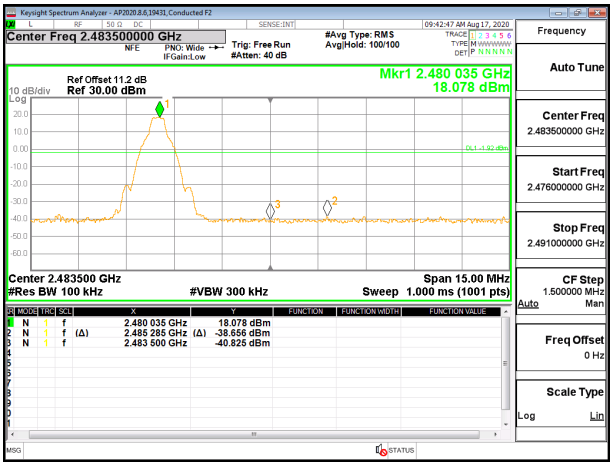
OUT-OF-BAND LOW CHANNEL



IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



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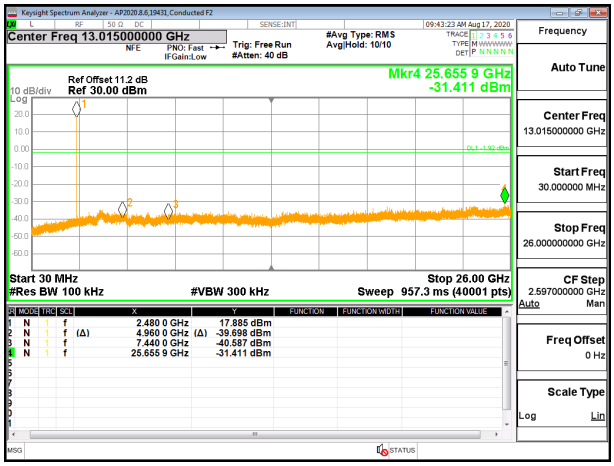

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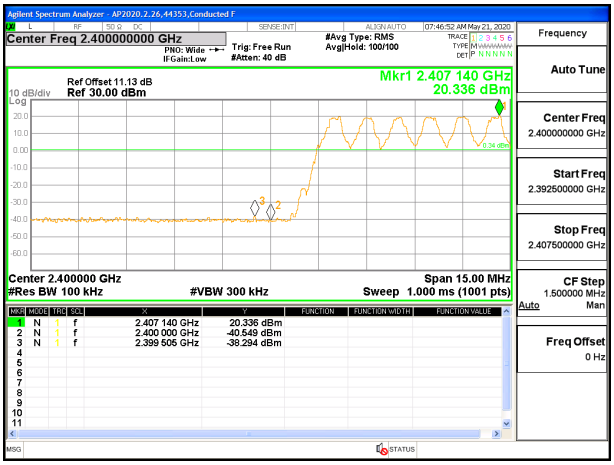
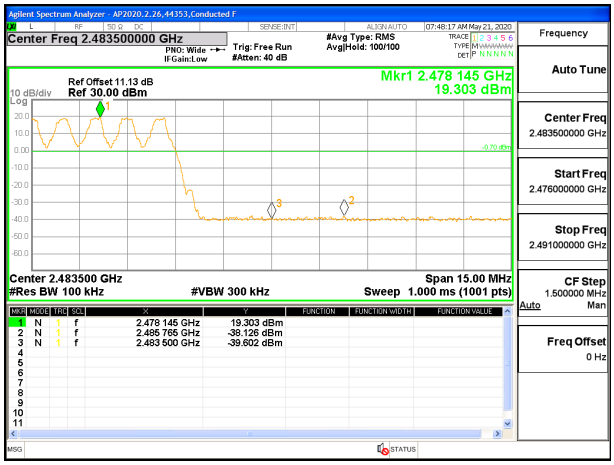
ANT 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



LOW BANDEDGE



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