CERTIFICATION TEST REPORT

Report Number. : 12696945-E1V3

Applicant	:	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A.
Model	:	A2221
FCC ID	:	BCG-E3304A
IC	:	579C-E3304A
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:
July 26, 2019

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

NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	7/19/2019	Initial Issue	Chris Xiong
V2	7/19/2019	Address TCB's Questions	Chin Pang
V3	7/26/2019	Address TCB's Questions on section 9.2	Chin Pang

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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: A2221

SERIAL NUMBER: C7CYQ00BMTCF, C7CYG01XMCHV

DATE TESTED: FEBRUARY 23, 2019 – JULY 26, 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.
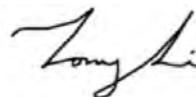
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Approved & Released For
UL Verification Services Inc. By: Prepared By:

_____   _____

Chin Pang   Tony Li
Senior Engineer   Test Engineer
Consumer Technology Division   Consumer Technology Division
UL Verification Services Inc.   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, 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

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%.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

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. 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 2	HIGH POWER	2402 - 2480	Basic GFSK	18.81	76.03
		2402 - 2480	DQPSK	18.37	68.71
		2402 - 2480	Enhanced 8PSK	18.44	69.82
	LOW POWER	2402 - 2480	Basic GFSK	12.59	18.16
		2402 - 2480	DQPSK	11.09	12.85
		2402 - 2480	Enhanced 8PSK	11.11	12.91
Antenna 5	HIGH POWER	2402 - 2480	Basic GFSK	19.97	99.31
		2402 - 2480	DQPSK	18.06	63.97
		2402 - 2480	Enhanced 8PSK	18.31	67.76
	LOW POWER	2402 - 2480	Basic GFSK	12.66	18.45
		2402 - 2480	DQPSK	11.07	12.79
		2402 - 2480	Enhanced 8PSK	11.15	13.03
BF, Antenna 2 + Antenna 5	HIGH POWER	2402 - 2480	Basic GFSK TxBF	19.99	99.77
		2402 - 2480	DQPSK TxBF	20.44	110.66
		2402 - 2480	Enhanced 8PSK TxBF	20.47	111.43
	LOW POWER	2402 - 2480	Basic GFSK TxBF	15.58	36.14
		2402 - 2480	DQPSK TxBF	13.91	24.60
		2402 - 2480	Enhanced 8PSK TxBF	14.11	25.76

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency Range (GHz)	Ant. 2 (dBi)	Ant. 5 (dBi)
2.4	-4.5	-2.6

5.4.   SOFTWARE AND FIRMWARE

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

5.5.   WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on Ant 2 (Core 0) and Ant 5 (Core 1), it was determined that X (Flatbed) was the worst-case orientation for Ant 2 and 2TX Beamforming and Y (Landscape) orientation for Ant 5.

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. 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
Beamforming : GFSK, DH5
Beamforming : 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.

5.6.   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.

SETUP DIAGRAM FOR CONDUCTED TESTS

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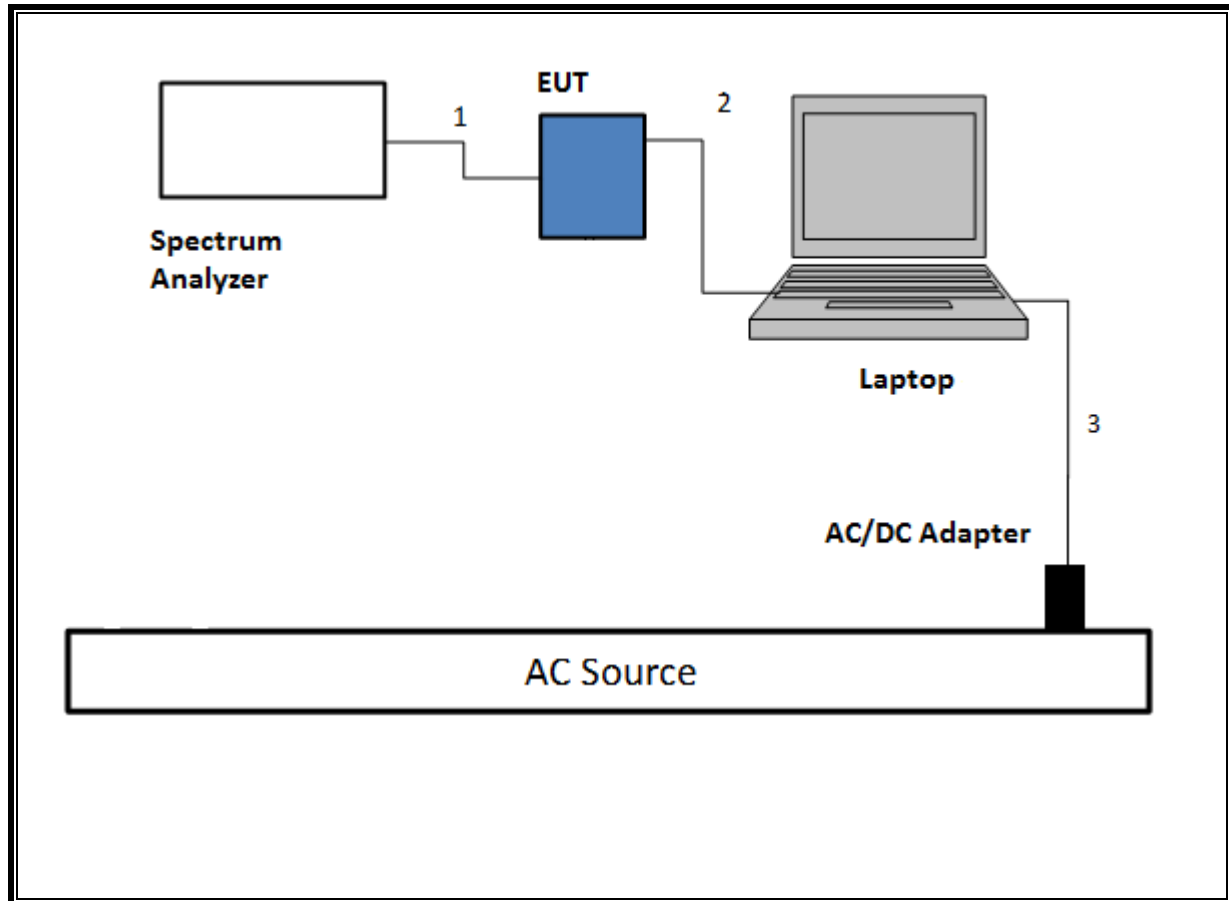
SETUP DIAGRAM FOR RADIATED TESTS Above 1GHz
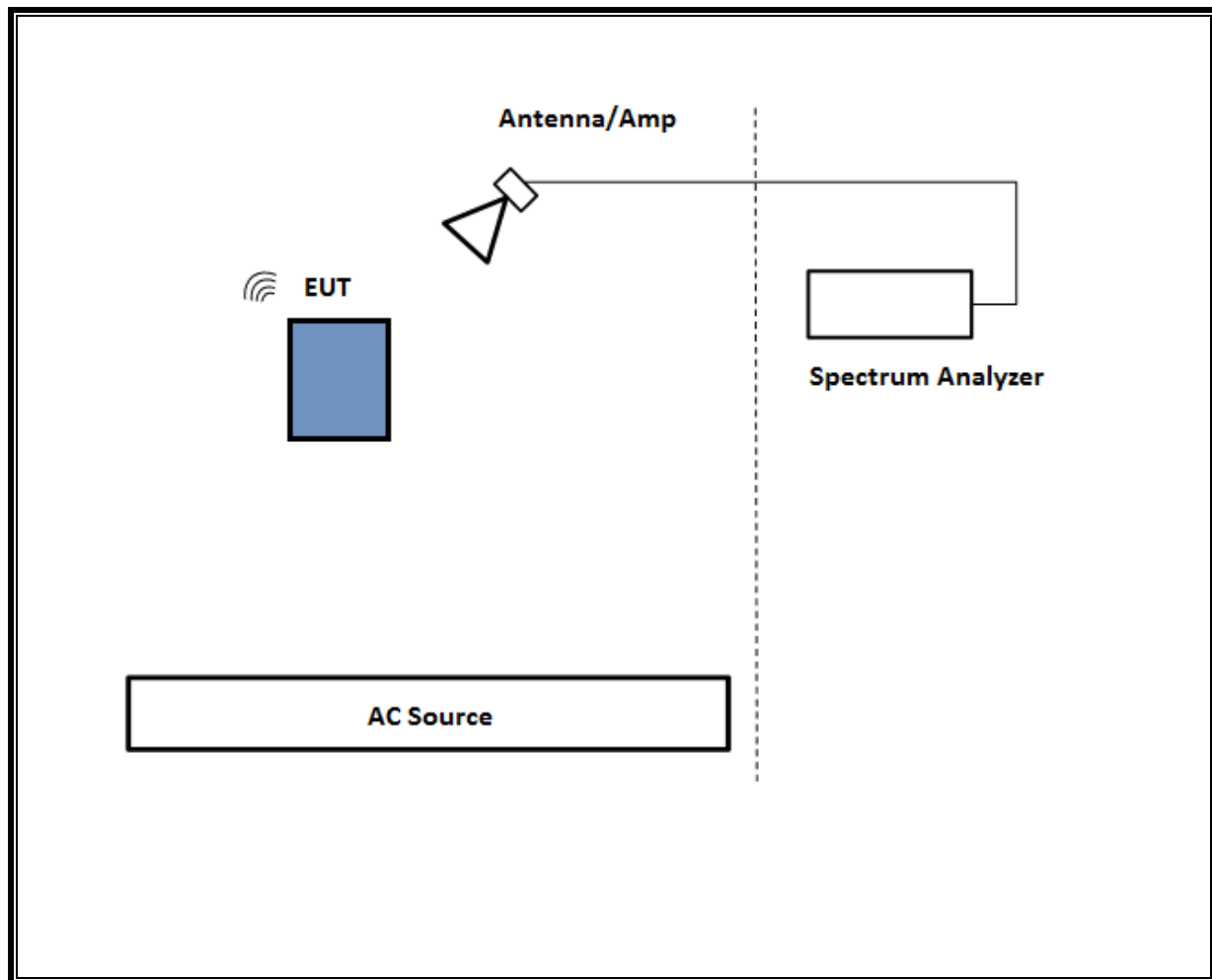
SETUP DIAGRAM FOR BELOW 1GHz and AC LINE CONDUCTED TEST

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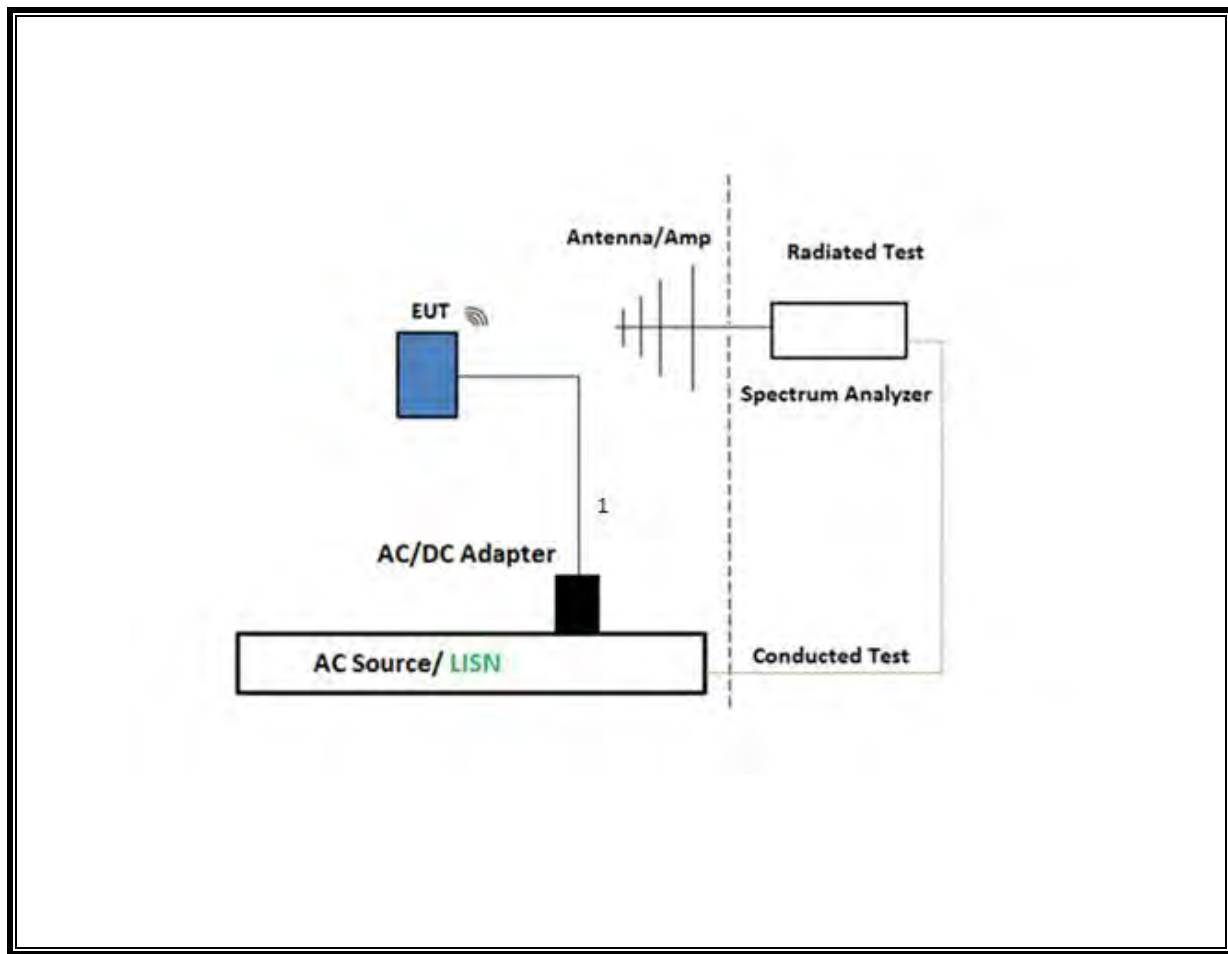
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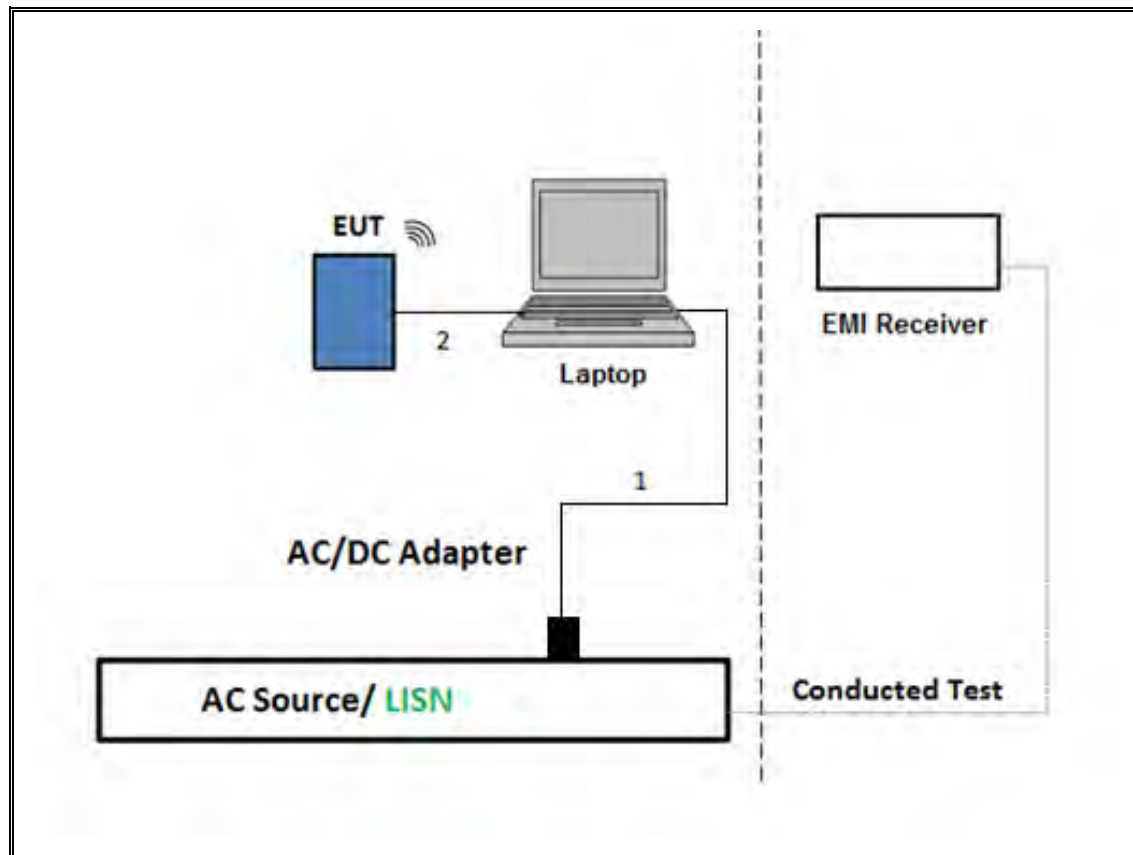
6. TEST AND MEASUREMENT EQUIPMENT

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	T340	01/22/2020	01/22/2019
Horn Antenna 1-18GHz	ETS-Lindgren	3117	T119	03/22/2020	03/22/2019
*Horn Antenna 1-18GHz	ETS-Lindgren	3117	T345	04/25/2019	04/25/2018
*Horn Antenna 1-18GHz	ETS-Lindgren	3117	T136	07/02/2019	07/02/2018
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	T863	05/30/2020	05/30/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T493	08/30/2019	08/30/2018
Amplifier, 10KHz to 1GHz, 32dB	Sonoma Instrument Co.	310N	T835	01/02/2020	01/02/2019
Antenna, Active Loop 9KHz to 30MHz	ETS-Lindgren	6502	T1616	10/18/2019	10/18/2018
*Hybrid Antenna, 30-3Ghz	SunAR rf Motion	JB3	T122	03/31/2019	03/31/2018
*Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	T447	06/16/2019	06/16/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T712	02/26/2020	02/26/2019
*Amplifier, 1 to 18GHz, 35dB	Amplical	AFS42-00101800-25-S-42	T1568	06/21/2019	6/21/2018
Antenna, Horn 1-18GHz	ETS Lindgren	3117	T346	05/14/2020	05/14/2019
Amplifier, 1 to 18GHz	Miteq	AFS42-00101800-25-S-42	T931	05/11/2020	05/11/2019
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 t0 18GHz 35dB	AMPLICAL	AMP1G18-35	138301	09/15/2019	09/15/2018
Amplifier, 1 - 18GHz	Miteq	AFS42-00101800-25-S-42	T1567	01/26/2020	01/26/2019
Antenna, Double Ridge Guide Horn Antenna 700MHz to 18GHz	A.H. SYSTEMS, INC.	SAS-571	PRE0190810	07/10/2019	07/10/2018
*Pre-Amp 18-26GHz	Agilent Technology	8449B	T404	03/23/2020	03/23/2019
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	06/19/2019	06/19/2018
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		

*Testing is completed before equipment expiration date.

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.

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	1.00	1.00	1.000	100.0%	0.00	0.010
Bluetooth 8PSK	1.00	1.00	1.000	100.0%	0.00	0.010
Bluetooth TxBF GFSK	1.00	1.00	1.000	100.0%	0.00	0.010
Bluetooth TxBF 8PSK	1.00	1.00	1.000	100.0%	0.00	0.010

Note: High power duty cycle is same as low power mode.

DUTY CYCLE PLOTS

HIGH POWER GFSK	**HIGH POWER 8PSK**
HIGH POWER TxBF GFSK	**HIGH POWER TxBF 8PSK**

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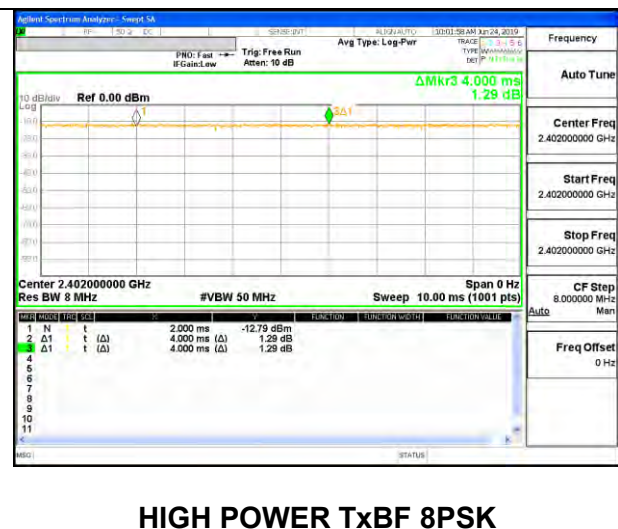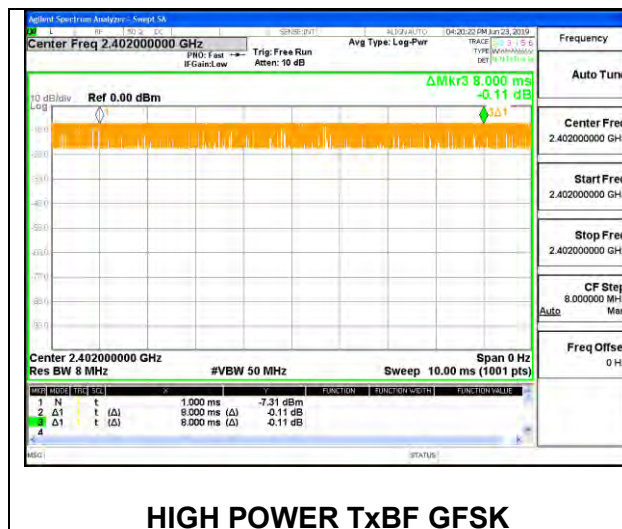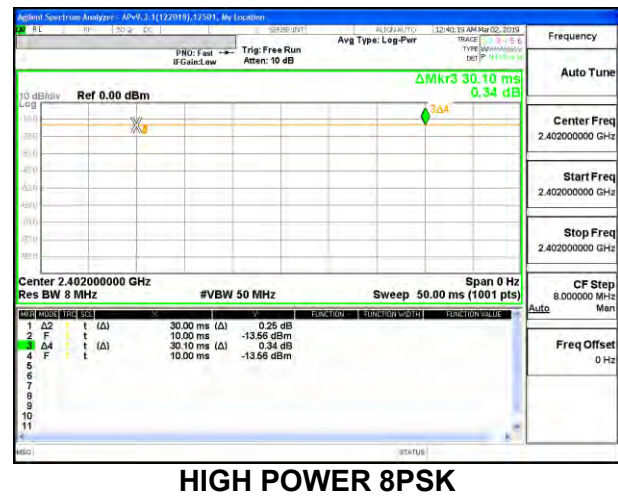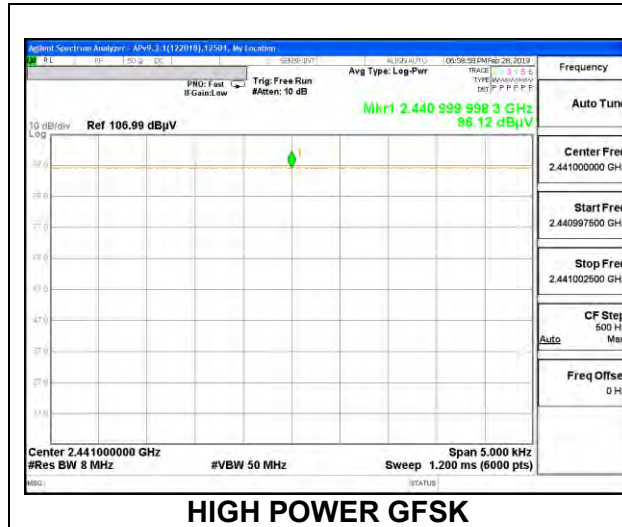
8.2. 20 dB AND 99% BANDWIDTH

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

ID:	19419	Date:	02232019

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8.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.956	0.896
Mid	2441	0.953	0.893
High	2480	0.953	0.892

LOW CHANNEL

MID CHANNEL
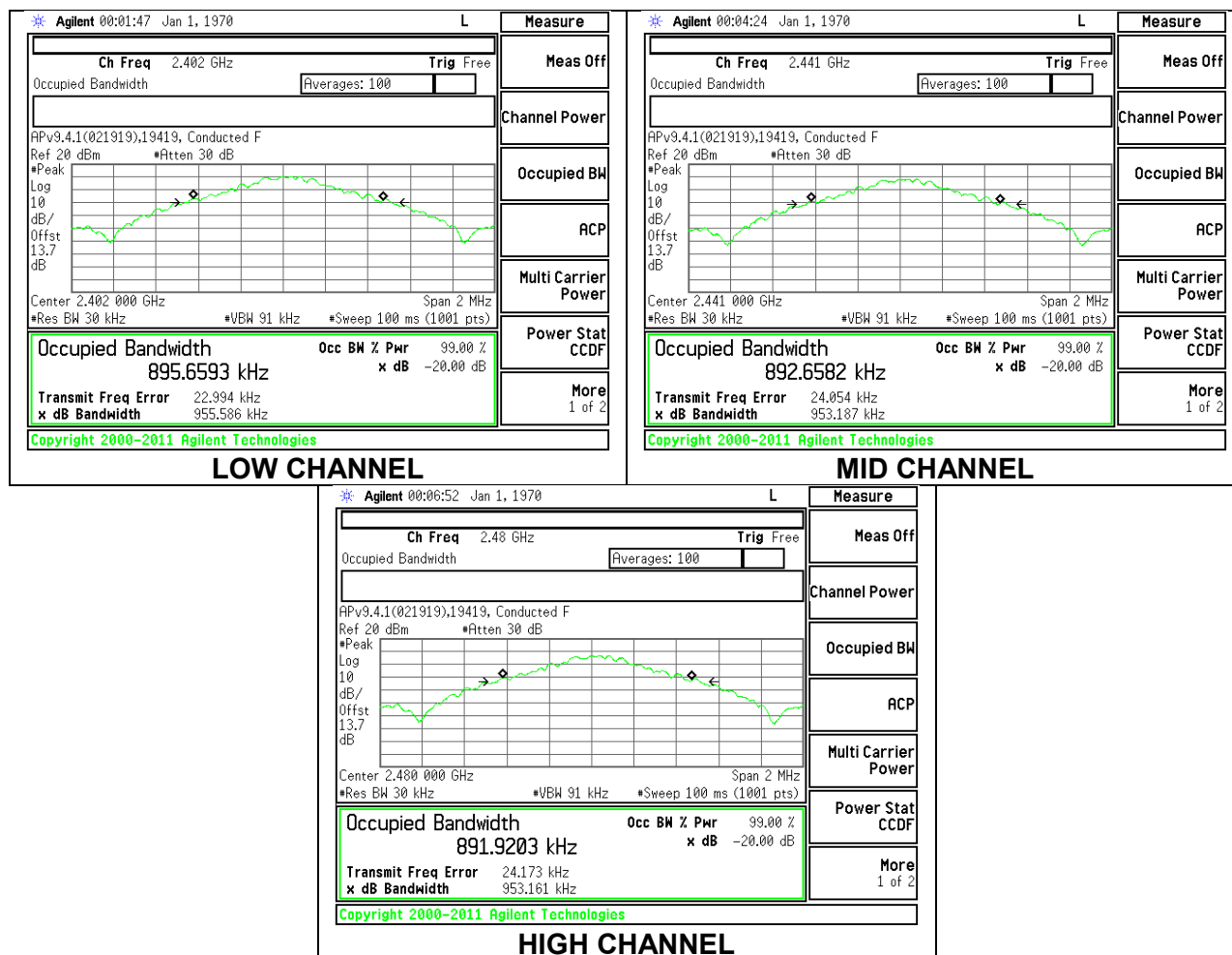
HIGH CHANNEL

Antenna 5

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.953	0.892
Mid	2441	0.953	0.892
High	2480	0.953	0.891

LOW CHANNEL

MID CHANNEL
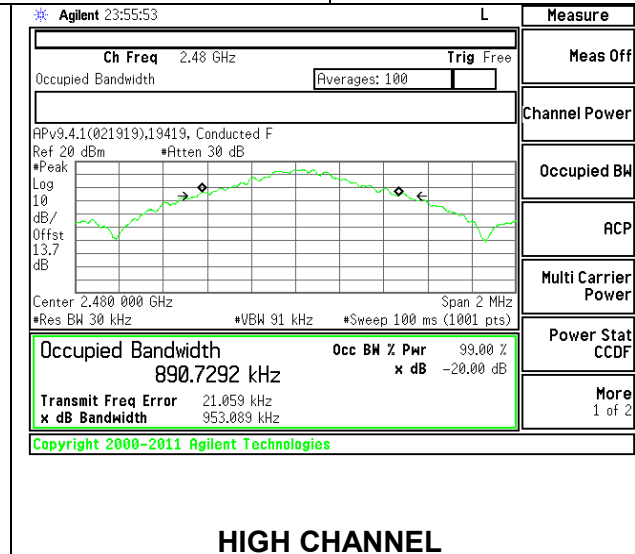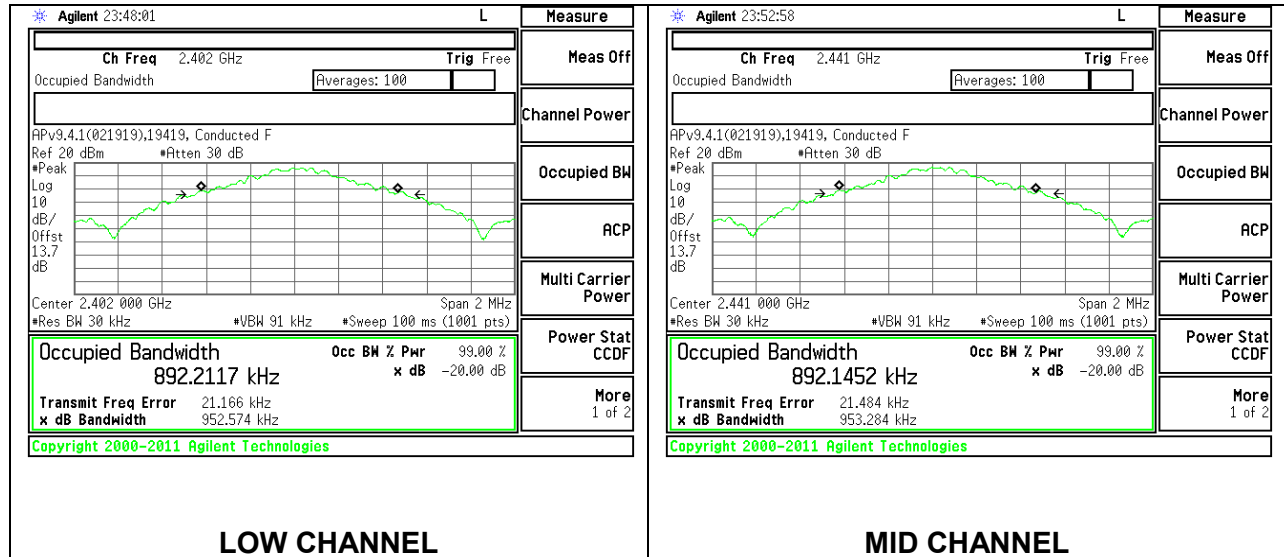
HIGH CHANNEL

8.2.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.361	1.2221
Mid	2441	1.362	1.2234
High	2480	1.363	1.2230

LOW CHANNEL

MID CHANNEL
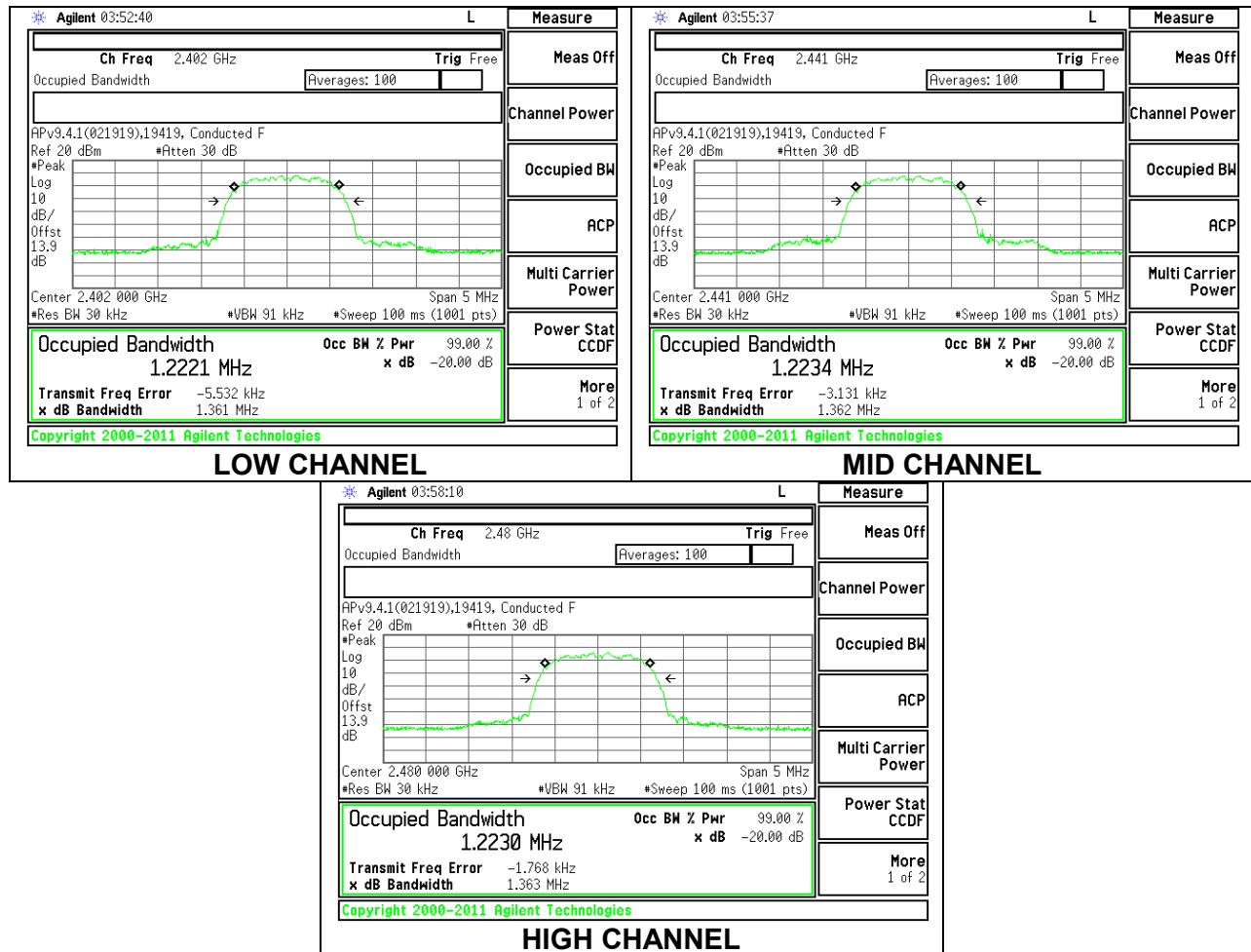
HIGH CHANNEL

Antenna 5

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.361	1.2240
Mid	2441	1.362	1.2243
High	2480	1.363	1.2239

LOW CHANNEL

MID CHANNEL

HIGH CHANNEL

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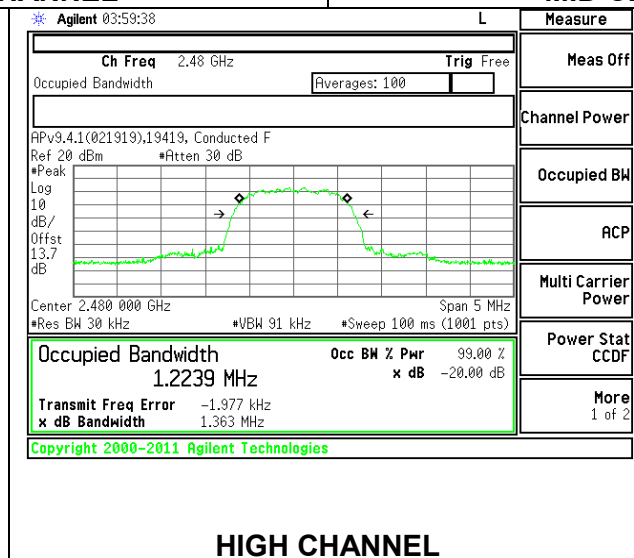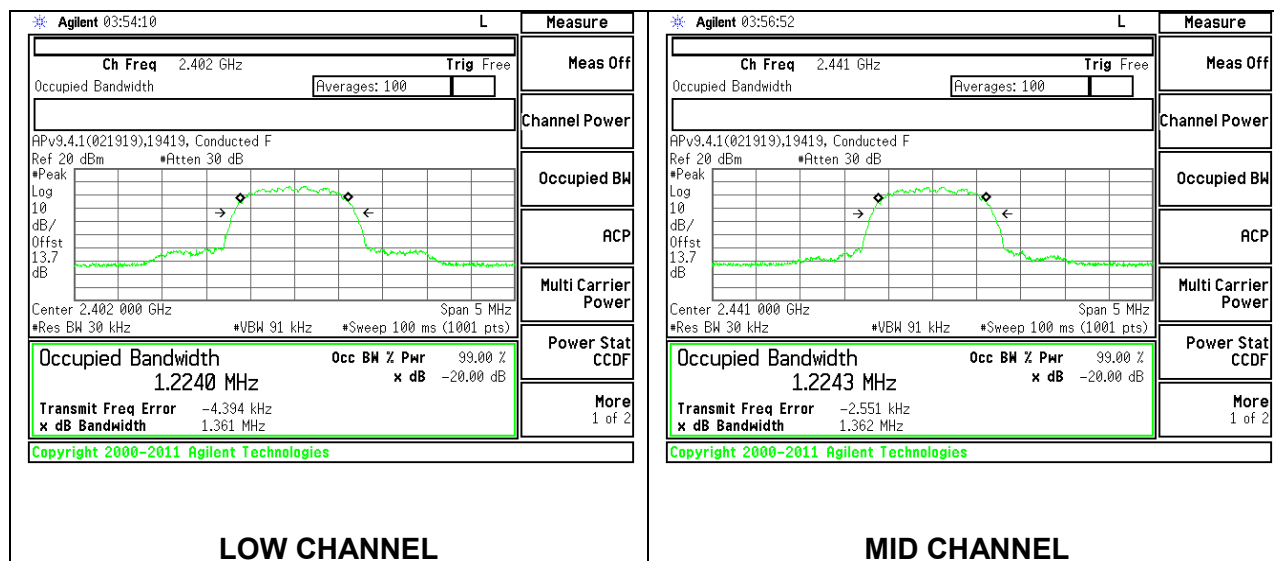
8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION
Antenna 2

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.968	0.930
Mid	2441	0.957	0.916
High	2480	0.981	0.930

LOW CHANNEL

MID CHANNEL
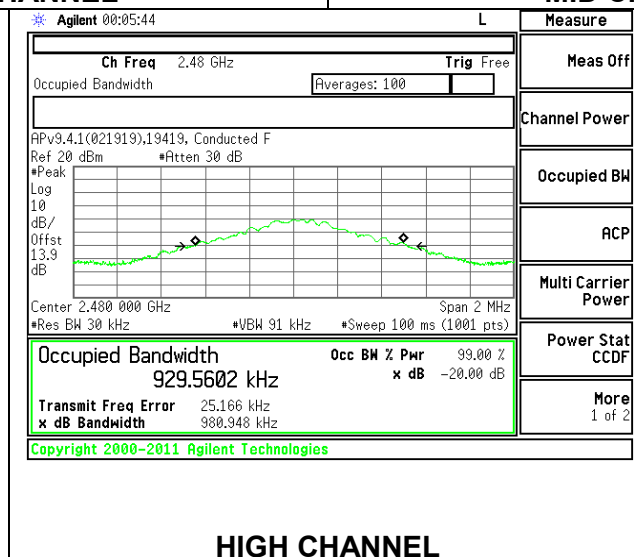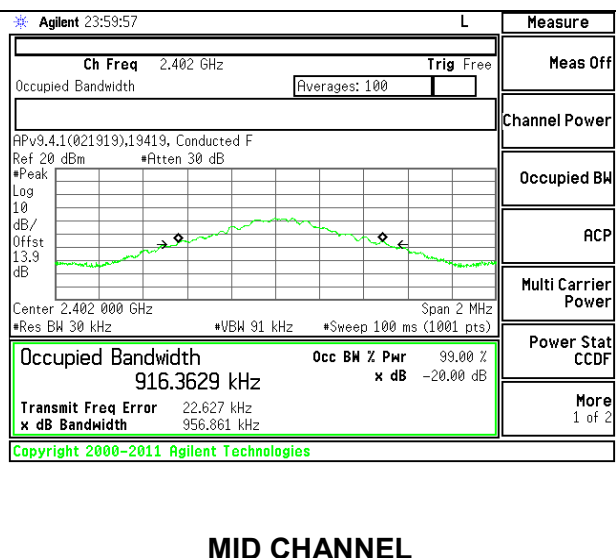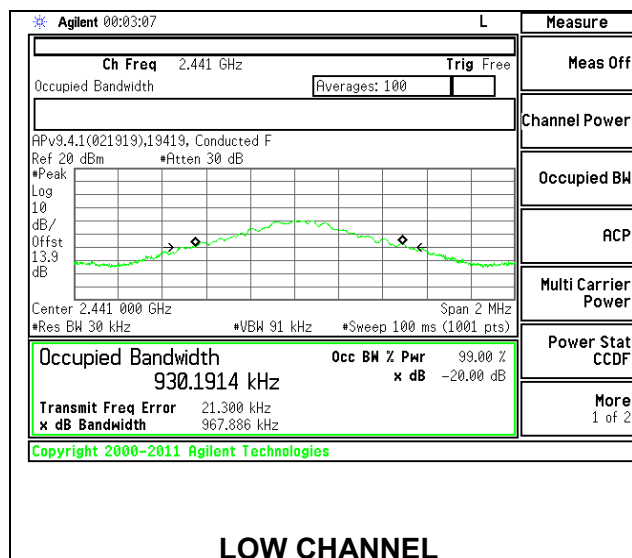
HIGH CHANNEL

Antenna 5

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.952	0.896
Mid	2441	0.953	0.898
High	2480	0.952	0.899

LOW CHANNEL

MID CHANNEL

HIGH CHANNEL

UL VERIFICATION SERVICES INC.

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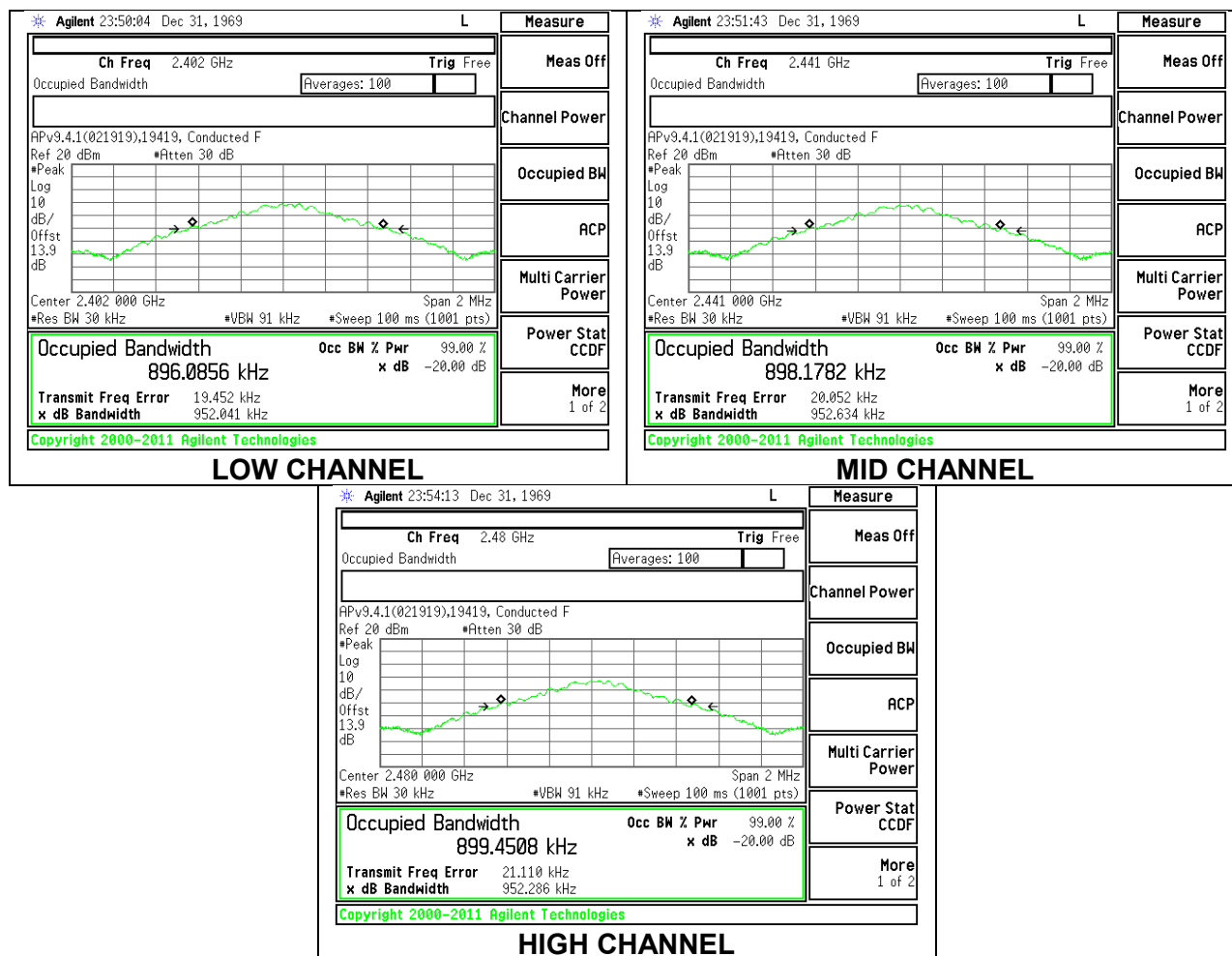
8.2.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.380	1.2231
Mid	2441	1.379	1.2212
High	2480	1.380	1.2229
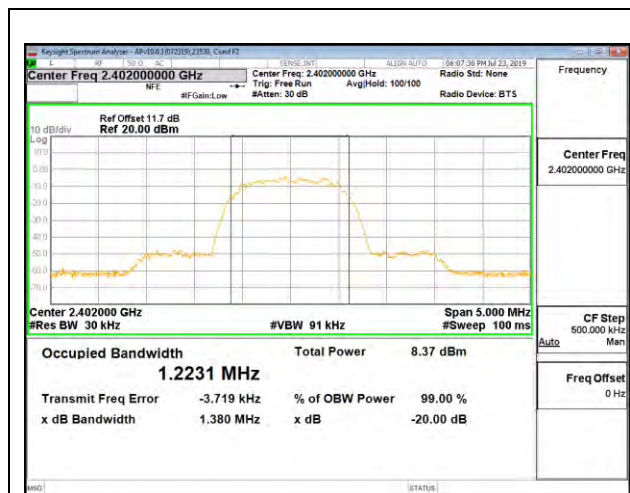
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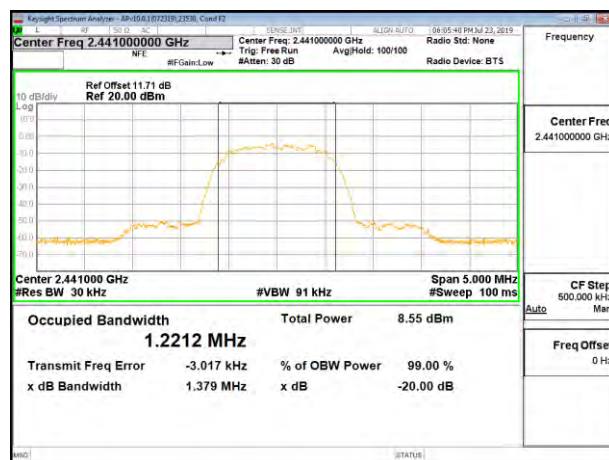
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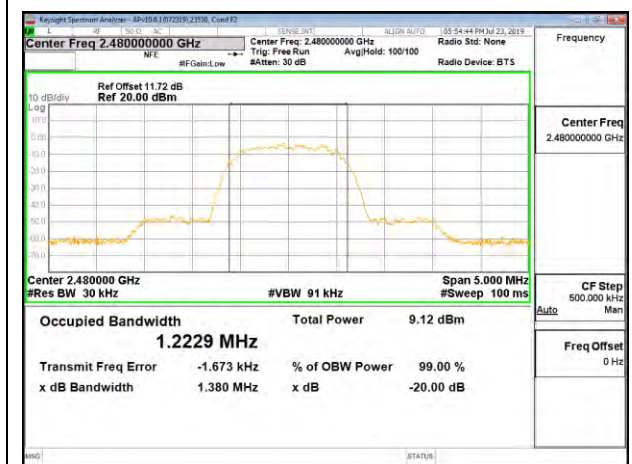
HIGH CHANNEL

Antenna 5

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.381	1.2237
Mid	2441	1.381	1.2246
High	2480	1.381	1.2238

LOW CHANNEL

MID CHANNEL

HIGH CHANNEL

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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 3x RBW.

RESULTS

8.3.1. HIGH POWER BASIC DATA RATE GFSK MODULATION
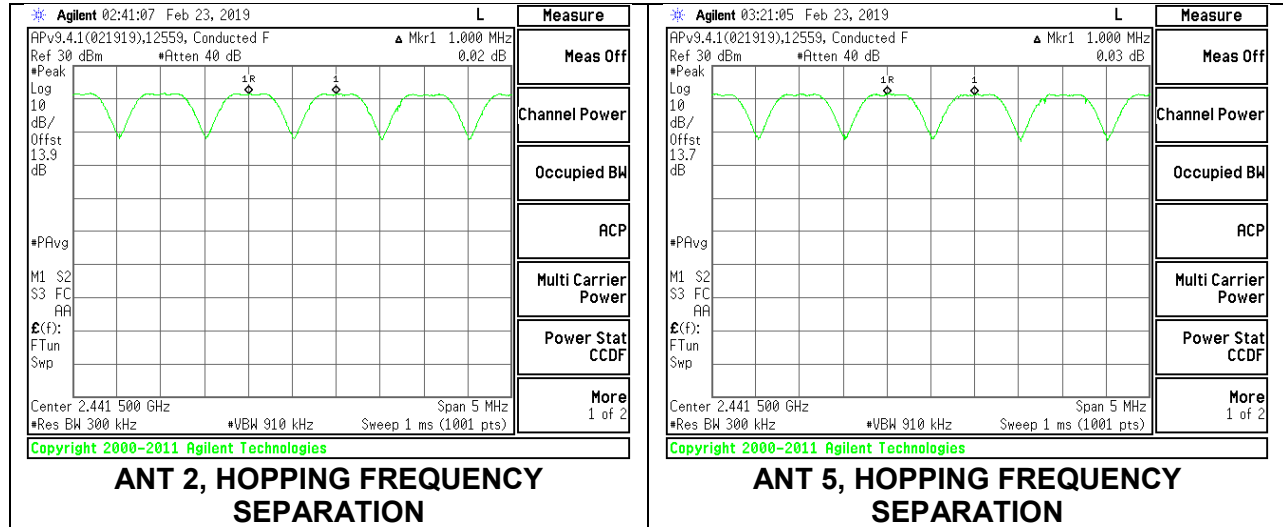
ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

8.3.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

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8.3.3. LOW POWER BASIC DATA RATE GFSK MODULATION
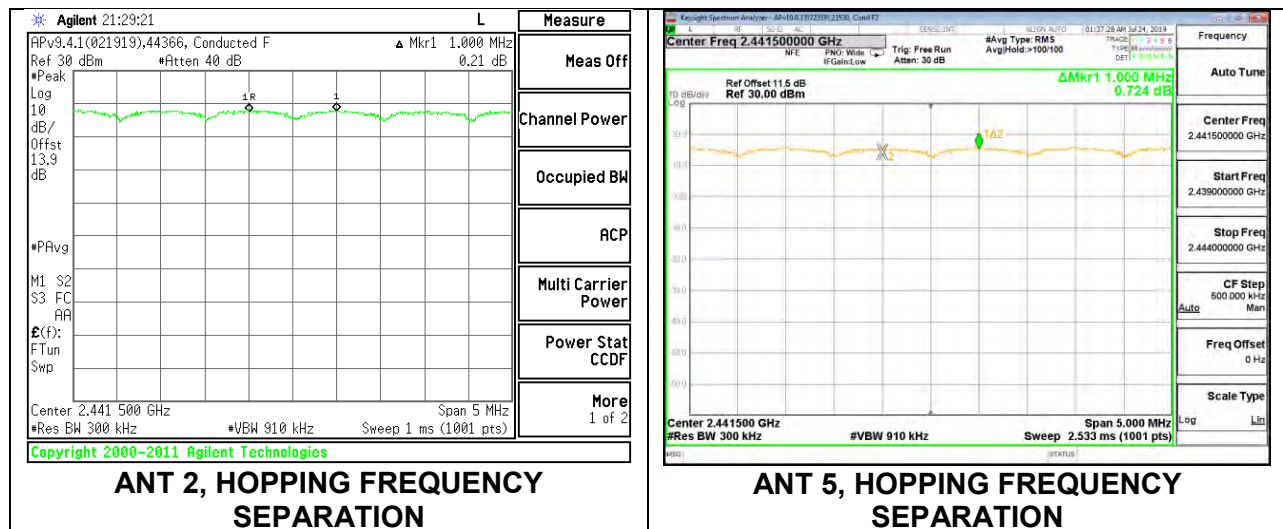
ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

8.3.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

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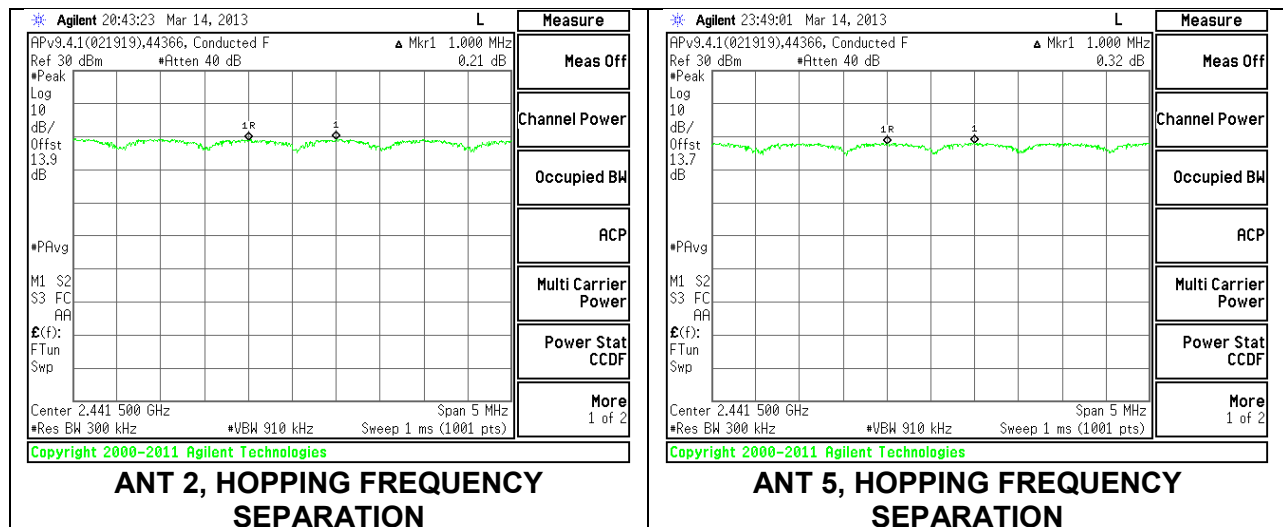
8.4. NUMBER OF HOPPING CHANNELS

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

8.4.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

Antenna 5

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

8.4.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

Antenna 5

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

8.4.3. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

Antenna 5

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

8.4.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

Antenna 5

100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

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

8.5.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

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	0.3829	32	0.1225	0.4	-0.2775
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	0.3829	8	0.03063	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

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

Antenna 5

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	0.3833	32	0.1227	0.4	-0.2773
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	0.3833	8	0.03066	0.4	-0.3693
DH3	1.639	4	0.06556	0.4	-0.3344
DH5	2.887	2.75	0.07939	0.4	-0.3206

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
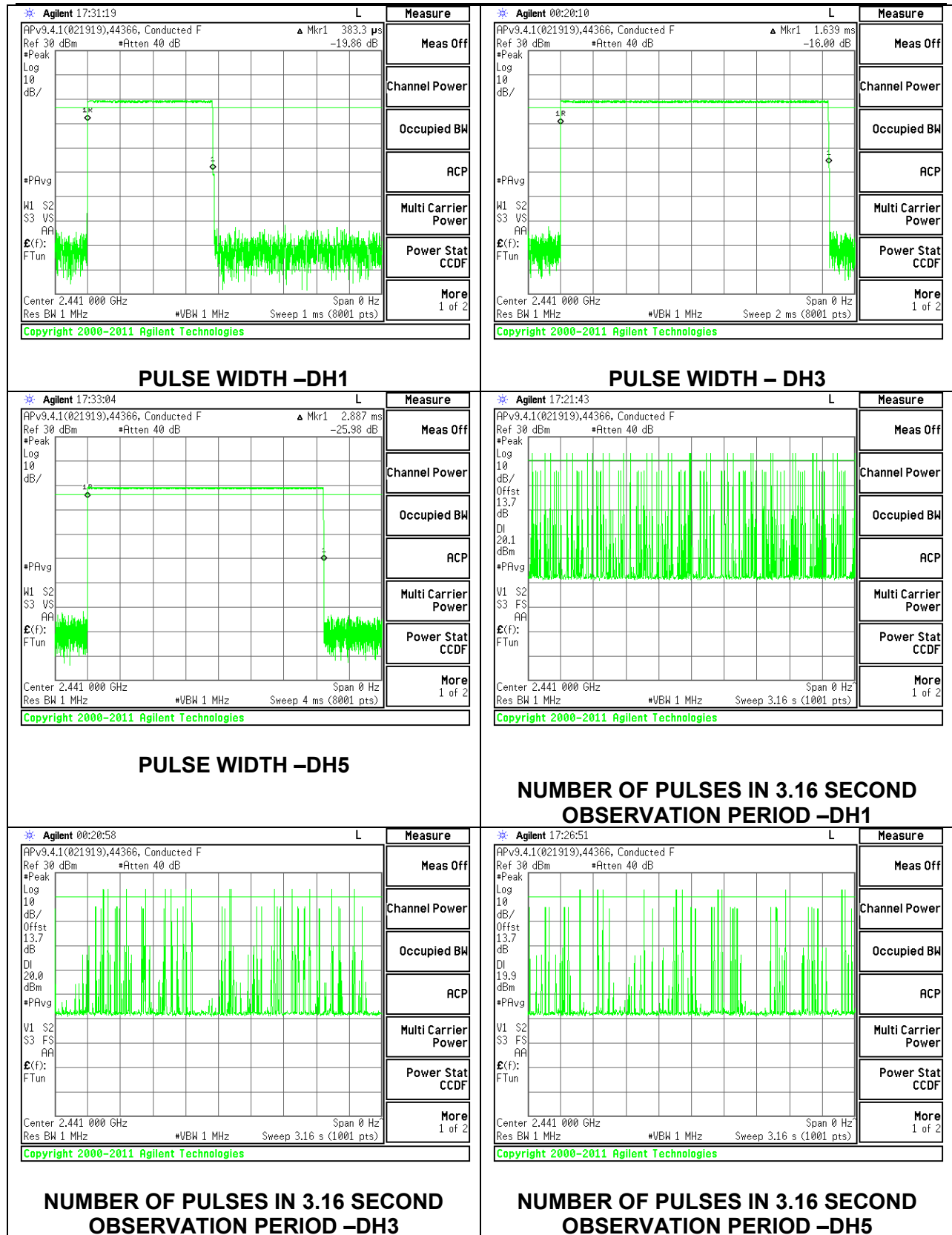
8.5.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

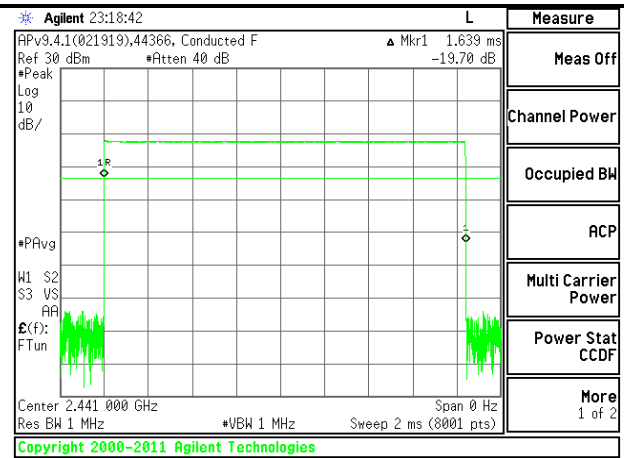| DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.389	32	0.12448	0.4	-0.2755
3DH3	1.640	16	0.2624	0.4	-0.1376
3DH5	2.891	12	0.34692	0.4	-0.0531

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 demonstrates compliance with channel occupancy when AFH is employed.

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

Antenna 5

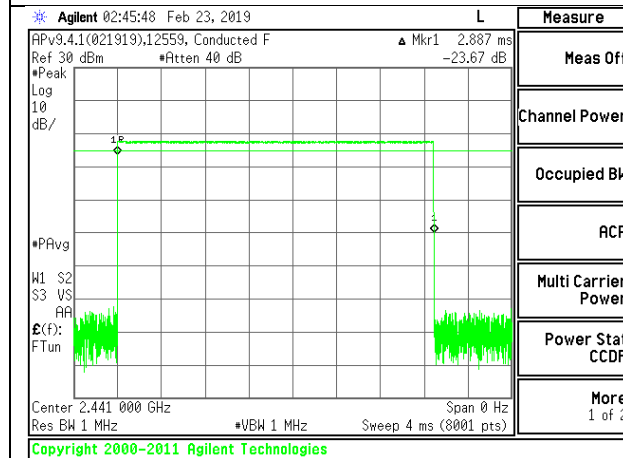| DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.3889	32	0.124448	0.4	-0.2756
3DH3	1.64	17	0.2788	0.4	-0.1212
3DH5	2.891	12	0.34692	0.4	-0.0531

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 demonstrates compliance with channel occupancy when AFH is employed.
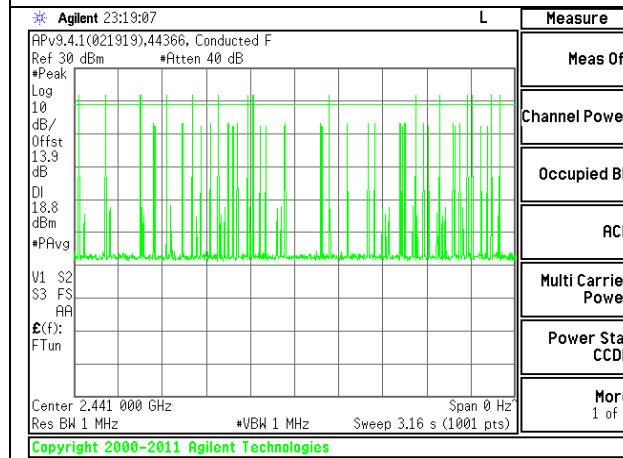
PULSE WIDTH – 3DH1
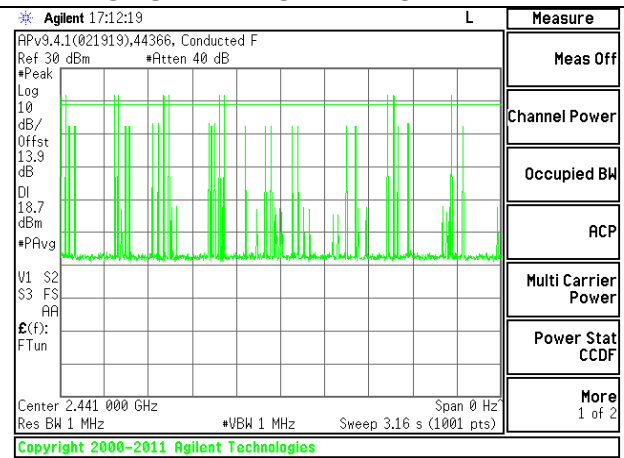

PULSE WIDTH – 3DH3

PULSE WIDTH – 3DH5

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3

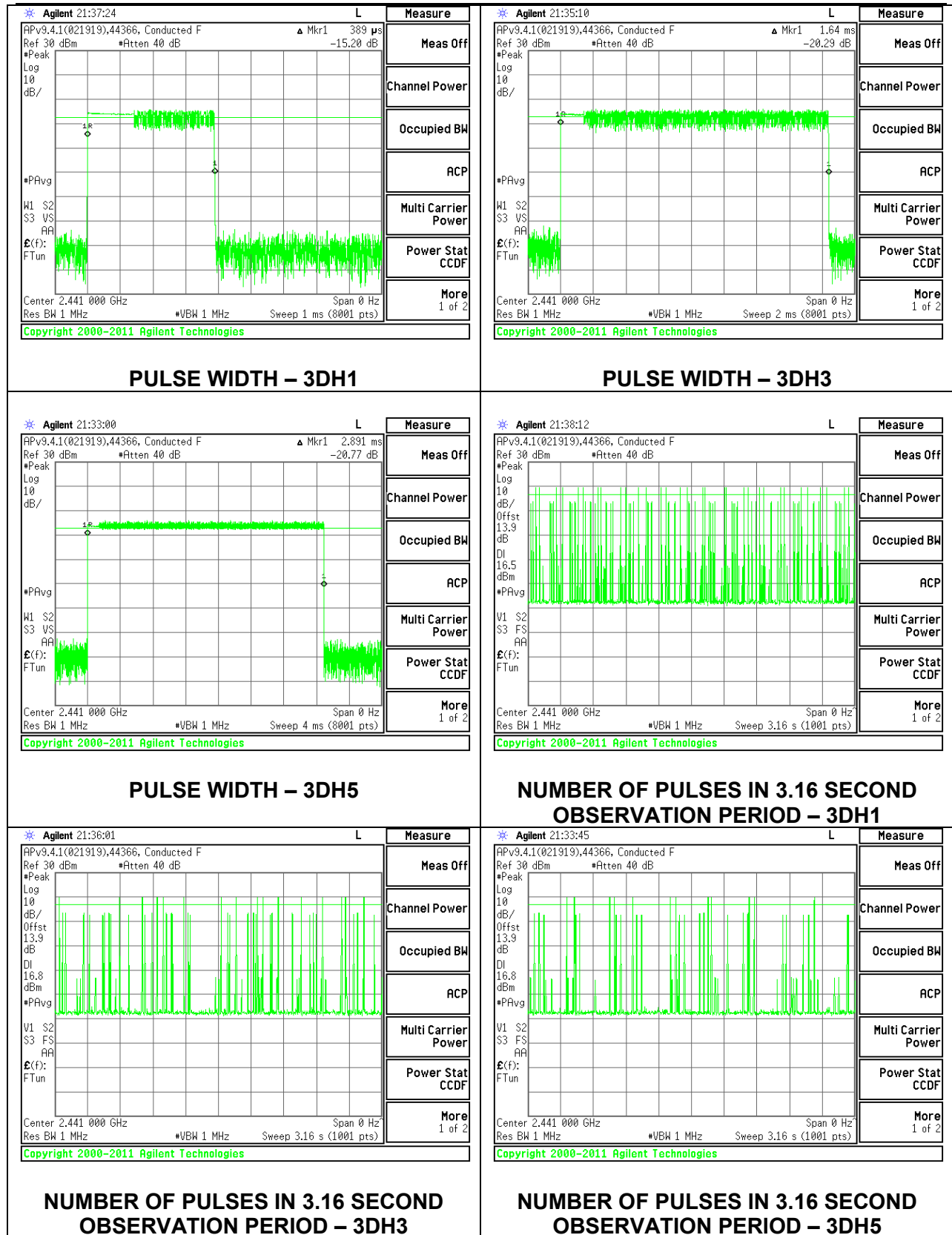**NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5**
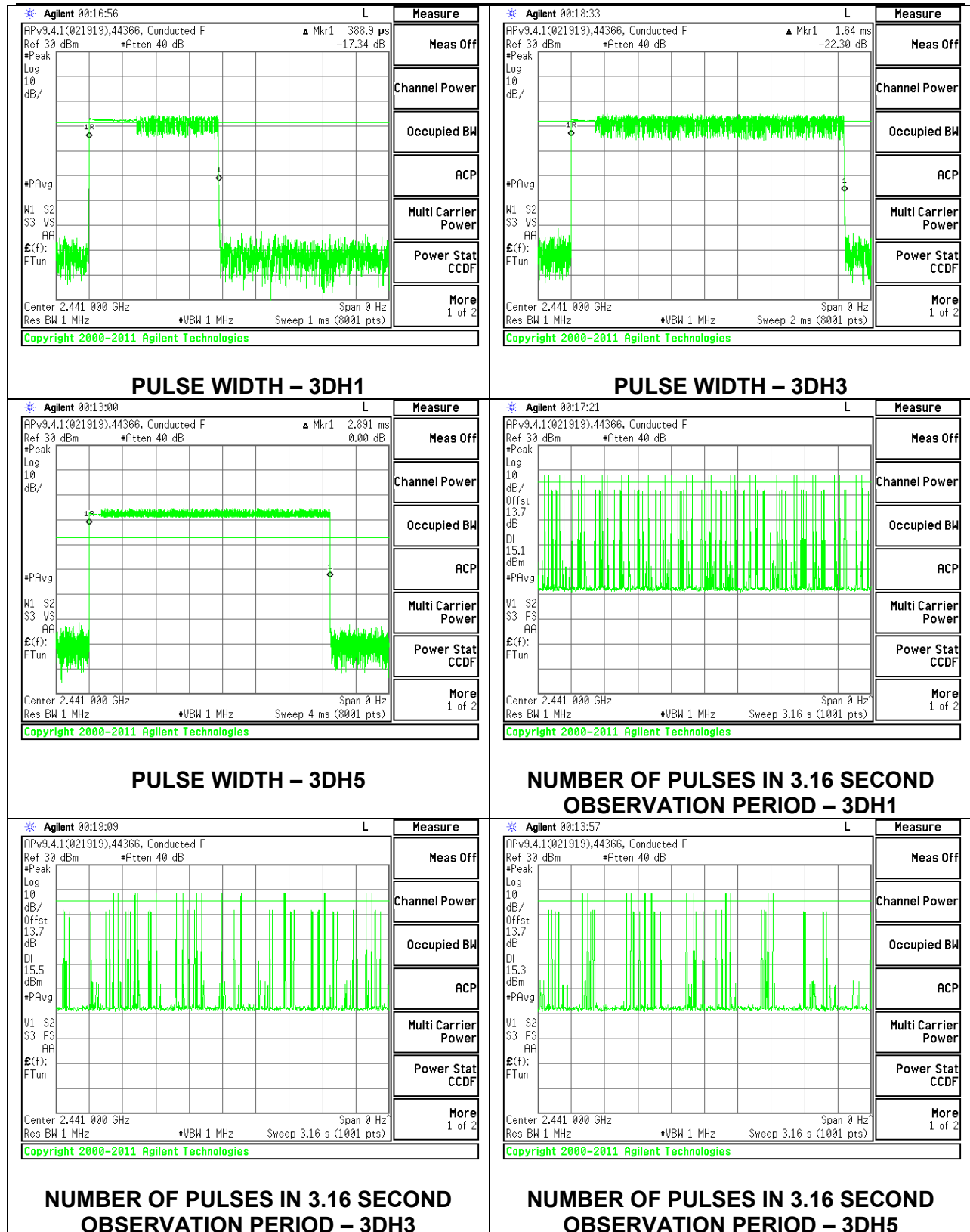
8.5.3. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

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	0.3828	31	0.1187	0.4	-0.2813
DH3	1.639	16	0.2622	0.4	-0.1378
DH5	2.887	12	0.3464	0.4	-0.0536

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	0.3828	7.75	0.02967	0.4	-0.3703
DH3	1.639	4	0.06556	0.4	-0.3344
DH5	2.887	3	0.08661	0.4	-0.3134
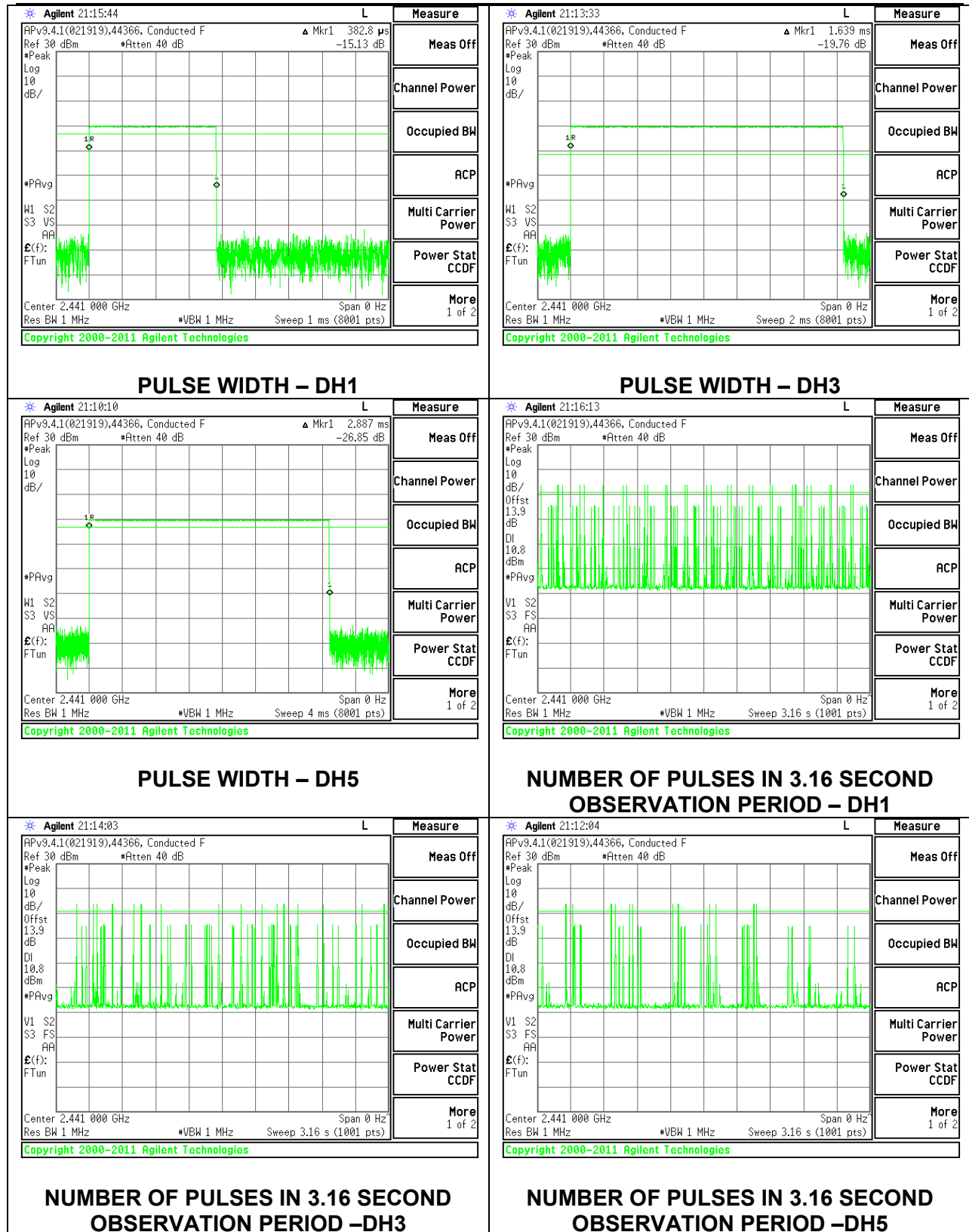
PULSE WIDTH – DH1

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

Antenna 5

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	0.1224	0.4	-0.2776
DH3	1.639	16	0.2622	0.4	-0.1378
DH5	2.887	12	0.3464	0.4	-0.0536

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	0.03061	0.4	-0.3694
DH3	1.639	4	0.06556	0.4	-0.3344
DH5	2.887	3	0.08661	0.4	-0.3134

PULSE WIDTH – DH1

PULSE WIDTH – DH3

PULSE WIDTH – DH5

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1

NUMBER OF PULSES IN 3.1 SECOND OBSERVATION PERIOD – DH3

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5
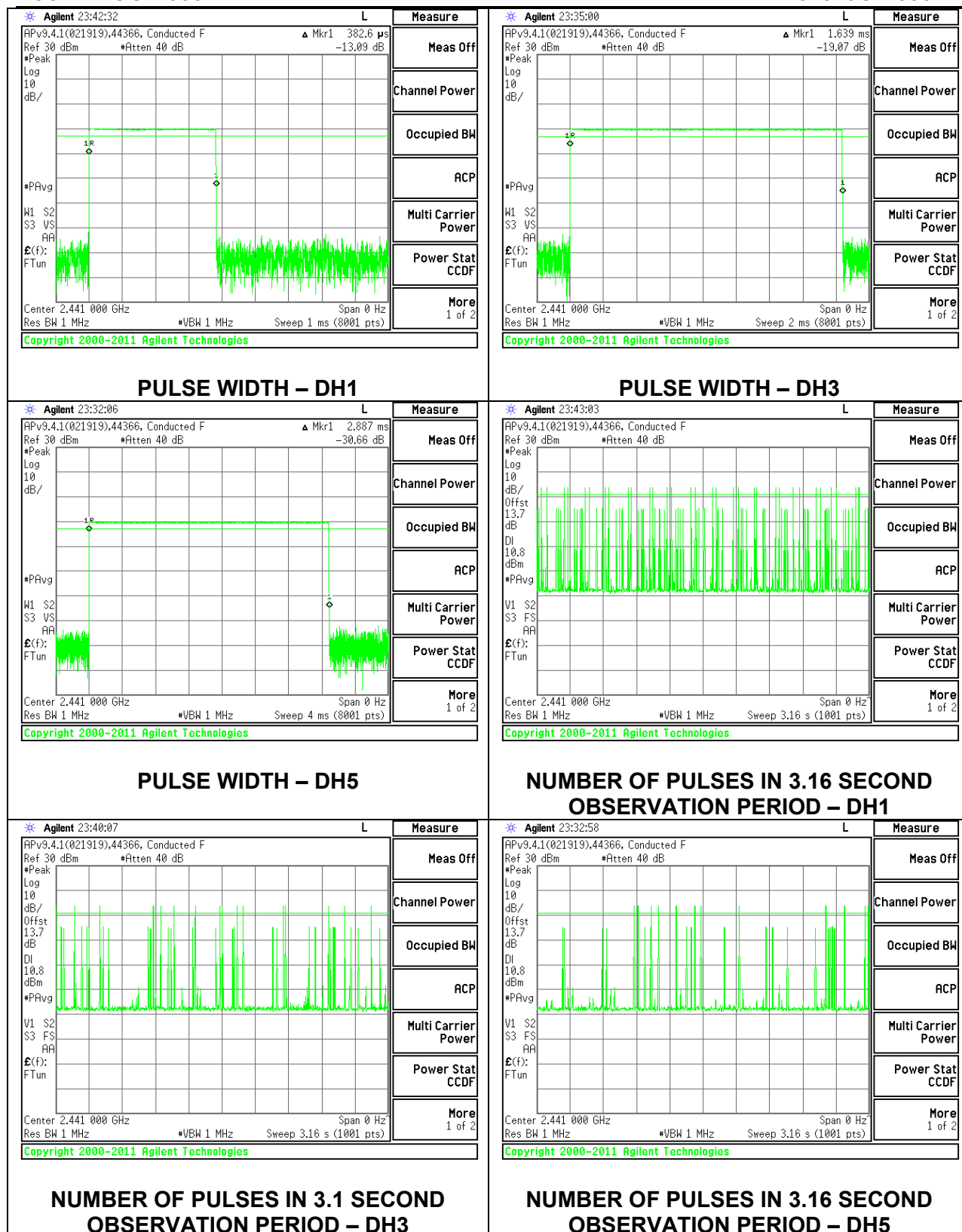
8.5.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

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	0.3886	31	0.120466	0.4	-0.2795
3DH3	1.640	16	0.2624	0.4	-0.1376
3DH5	2.891	11	0.31801	0.4	-0.082

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 demonstrates compliance with channel occupancy when AFH is employed.

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

Antenna 5

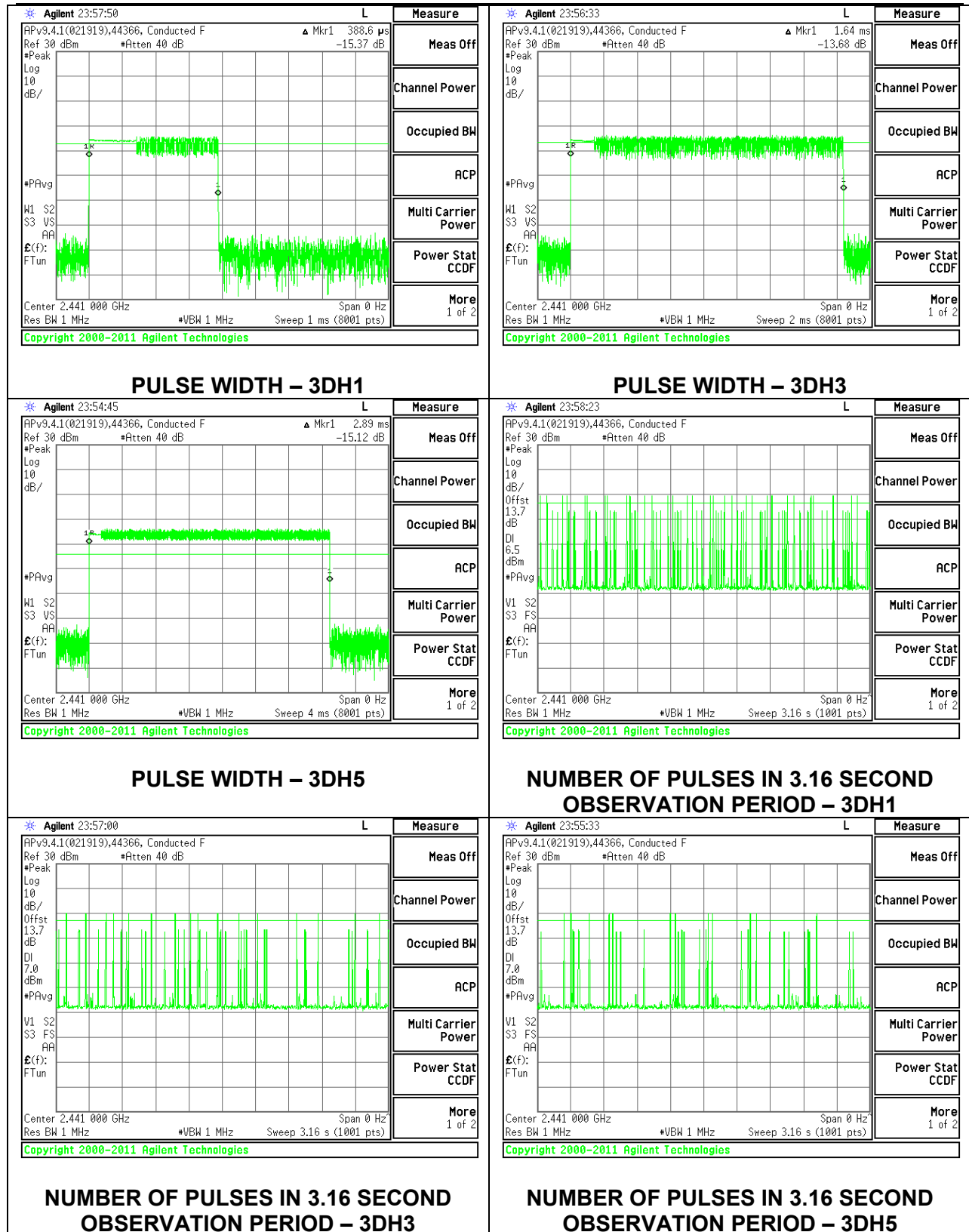| DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
8PSK Normal Mode					
3DH1	0.3886	31	0.120466	0.4	-0.2795
3DH3	1.640	16	0.2624	0.4	-0.1376
3DH5	2.89	12	0.3468	0.4	-0.0532

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 demonstrates compliance with channel occupancy when AFH is employed.

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

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. 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

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 peak reading of power.

RESULTS

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8.6.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.81	21	-2.19
Middle	2441	18.74	21	-2.26
High	2480	18.75	21	-2.25

Antenna 5

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.91	21	-1.09
Middle	2441	19.97	21	-1.03
High	2480	19.72	21	-1.28

8.6.2. HIGH POWER ENHANCED DATA RATE QPSK MODULATION

Antenna 2

Tested By:	20773
Date:	7/3/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.20	21	-2.80
Middle	2441	18.37	21	-2.63
High	2480	18.16	21	-2.84

Antenna 5

Tested By:	20773
Date:	7/3/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.05	21	-2.95
Middle	2441	18.06	21	-2.94
High	2480	18.03	21	-2.97

8.6.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Tested By:	20773
Date:	6/17/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.28	21	-2.72
Middle	2441	18.44	21	-2.56
High	2480	18.40	21	-2.60

Antenna 5

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.11	21	-2.89
Middle	2441	18.31	21	-2.69
High	2480	18.26	21	-2.74

8.6.4. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.41	30	-17.59
Middle	2441	12.59	30	-17.41
High	2480	12.49	30	-17.51

Antenna 5

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.58	30	-17.42
Middle	2441	12.66	30	-17.34
High	2480	12.55	30	-17.45

8.6.5. LOW POWER ENHANCED DATA RATE QPSK MODULATION

Antenna 2

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.00	21	-10
Middle	2441	11.09	21	-9.91
High	2480	10.92	21	-10.08

Antenna 5

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.90	21	-10.1
Middle	2441	11.07	21	-9.93
High	2480	10.82	21	-10.18

8.6.6. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.03	21	-9.97
Middle	2441	11.11	21	-9.89
High	2480	11.01	21	-9.99

Antenna 5

Tested By:	20773
Date:	6/27/2019

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	10.98	21	-10.02
Middle	2441	11.15	21	-9.85
High	2480	11.01	21	-9.99

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

8.7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	18.53
Middle	2441	18.51
High	2480	18.52

Antenna 5

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.69
Middle	2441	19.73
High	2480	19.56

8.7.2. HIGH POWER ENHANCED DATA RATE QPSK MODULATION

Antenna 2

Tested By:	20773
Date	7/3/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.57
Middle	2441	15.74
High	2480	15.68

Antenna 5

Tested By:	20773
Date	7/3/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.54
Middle	2441	15.68
High	2480	15.60

8.7.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.60
Middle	2441	15.76
High	2480	15.58

Antenna 5

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	15.65
Middle	2441	15.75
High	2480	15.62

8.7.4. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	12.09
Middle	2441	12.25
High	2480	12.12

Antenna 5

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	12.14
Middle	2441	12.19
High	2480	12.10

8.7.5. LOW POWER ENHANCED DATA RATE QPSK MODULATION

Antenna 2

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.67
Middle	2441	8.65
High	2480	8.64

Antenna 5

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.64
Middle	2441	8.61
High	2480	8.58

8.7.6. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

Tested By:	20773
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.68
Middle	2441	8.75
High	2480	8.72

Antenna 5

Tested By:	20733
Date	6/27/2019

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.74
Middle	2441	8.66
High	2480	8.62

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.

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

RESULTS

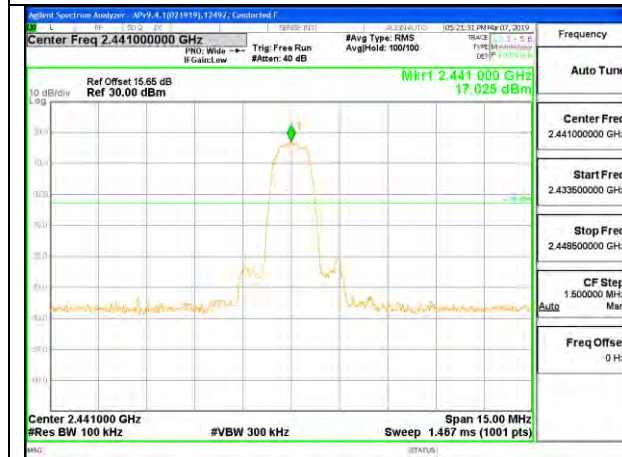# 8.8.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

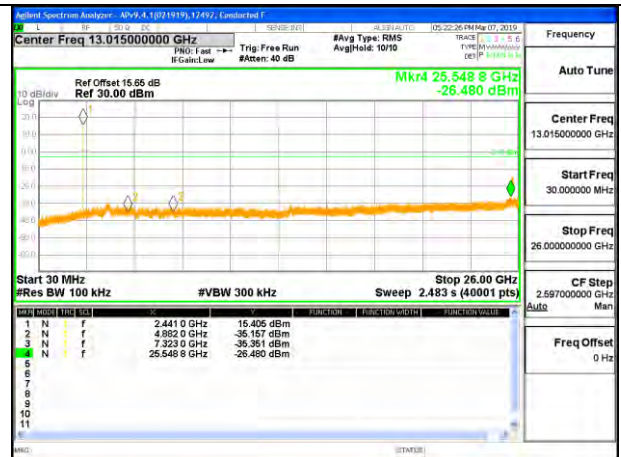**Antenna 2 SPURIOUS EMISSIONS, NON-HOPPING**

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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Antenna 2 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

| LOW BANDEDGE | HIGH BANDEDGE |

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Antenna 5 SPURIOUS EMISSIONS, NON-HOPPING

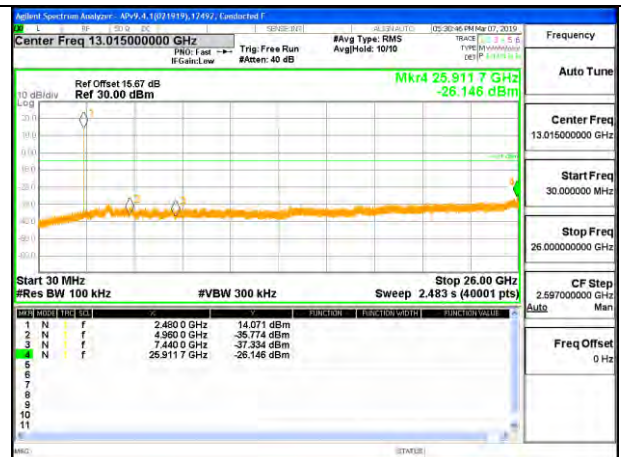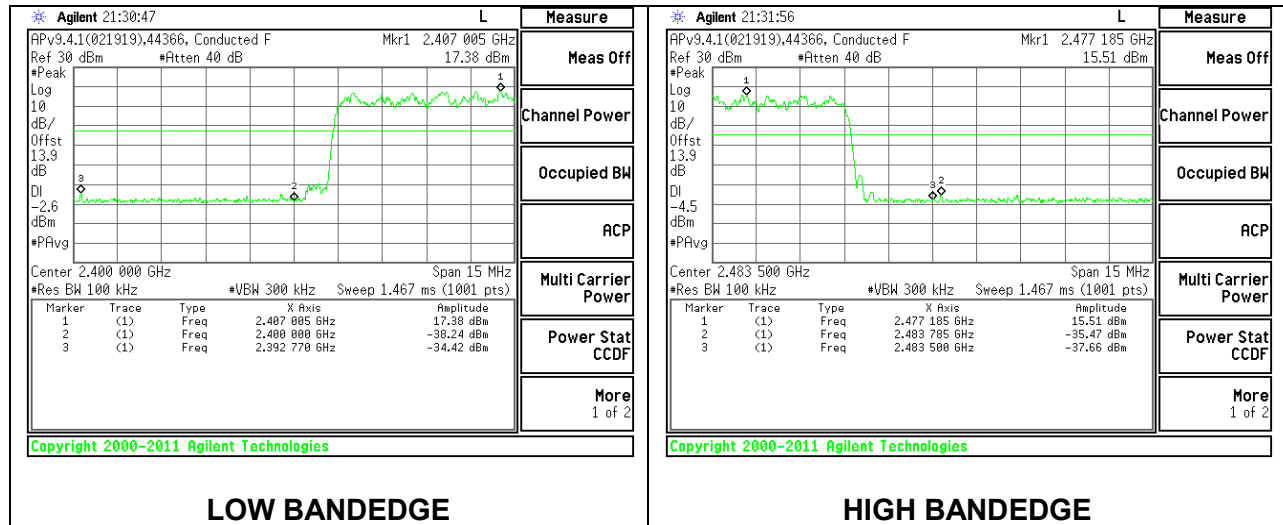LOW CHANNEL BANDEDGE

OUT-OF-BAND LOW CHANNEL
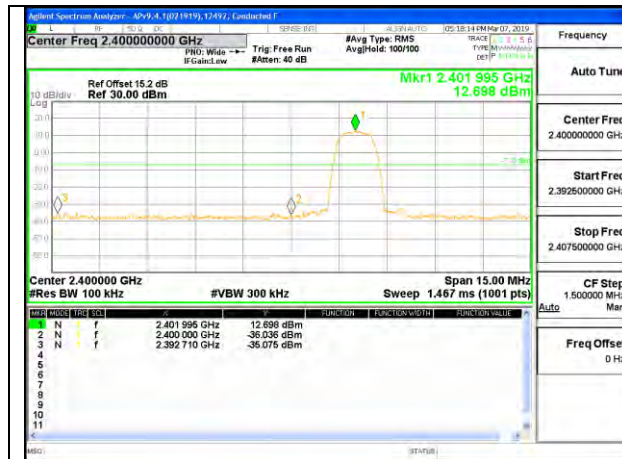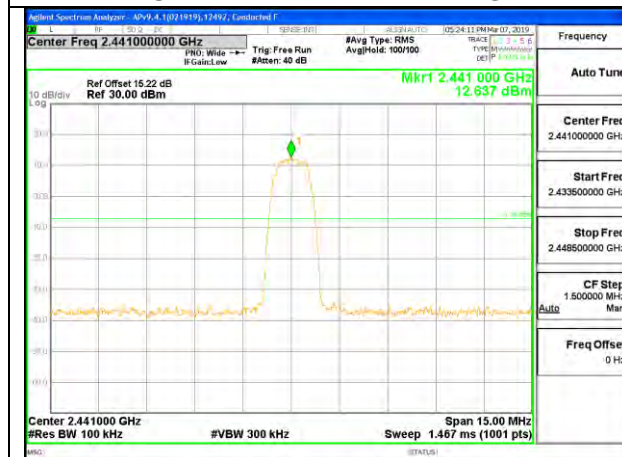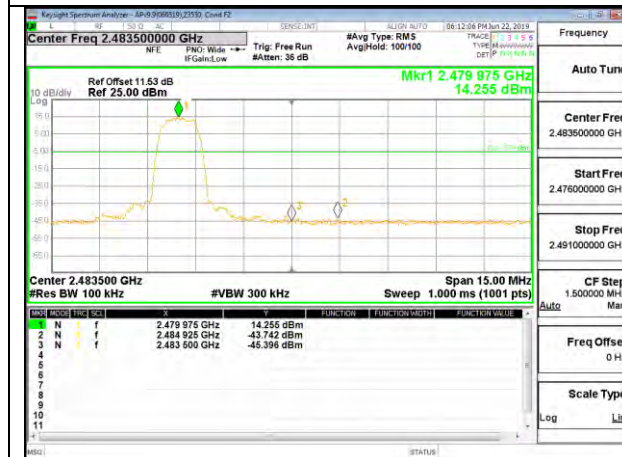

IN-BAND REFERENCE LEVEL

OUT-OF-BAND MID CHANNEL

HIGH CHANNEL BANDEDGE

OUT-OF-BAND HIGH CHANNEL

Antenna 5 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

LOW BANDEDGE

HIGH BANDEDGE

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8.8.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2 SPURIOUS EMISSIONS, NON-HOPPING

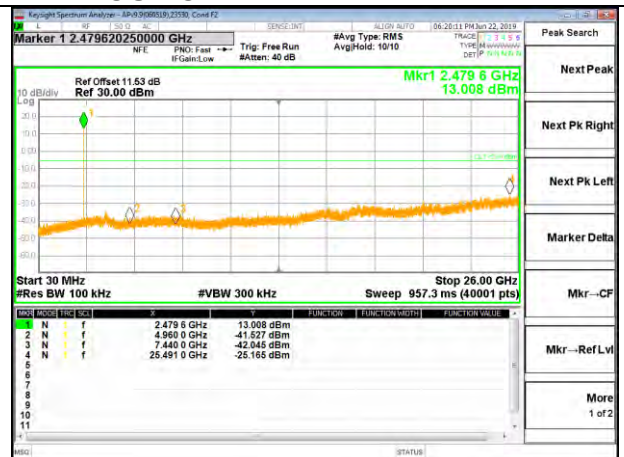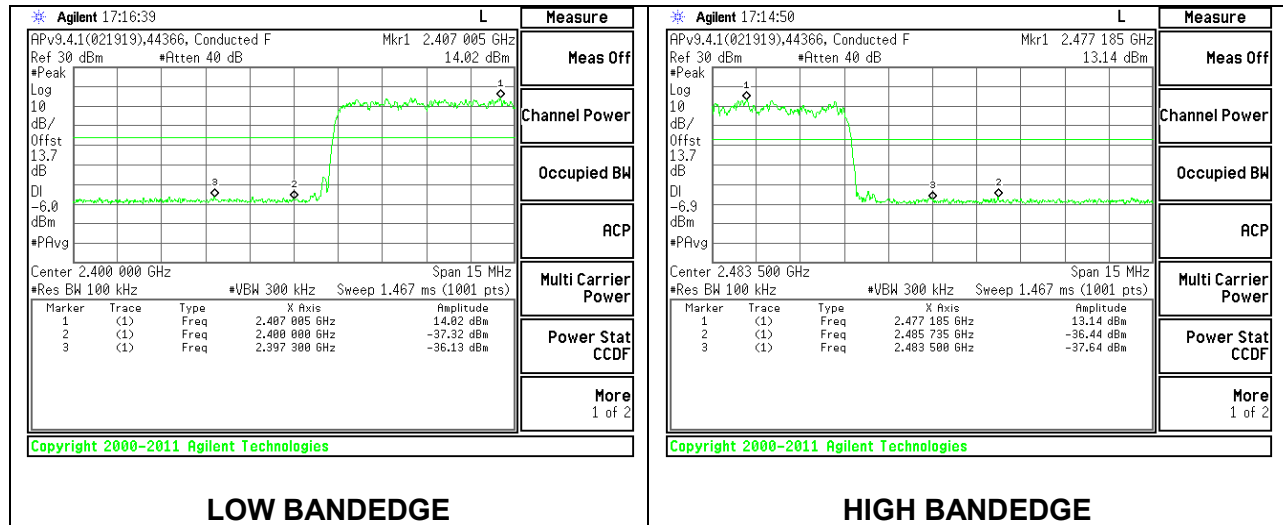LOW CHANNEL BANDEDGE

OUT-OF-BAND LOW CHANNEL

IN-BAND REFERENCE LEVEL
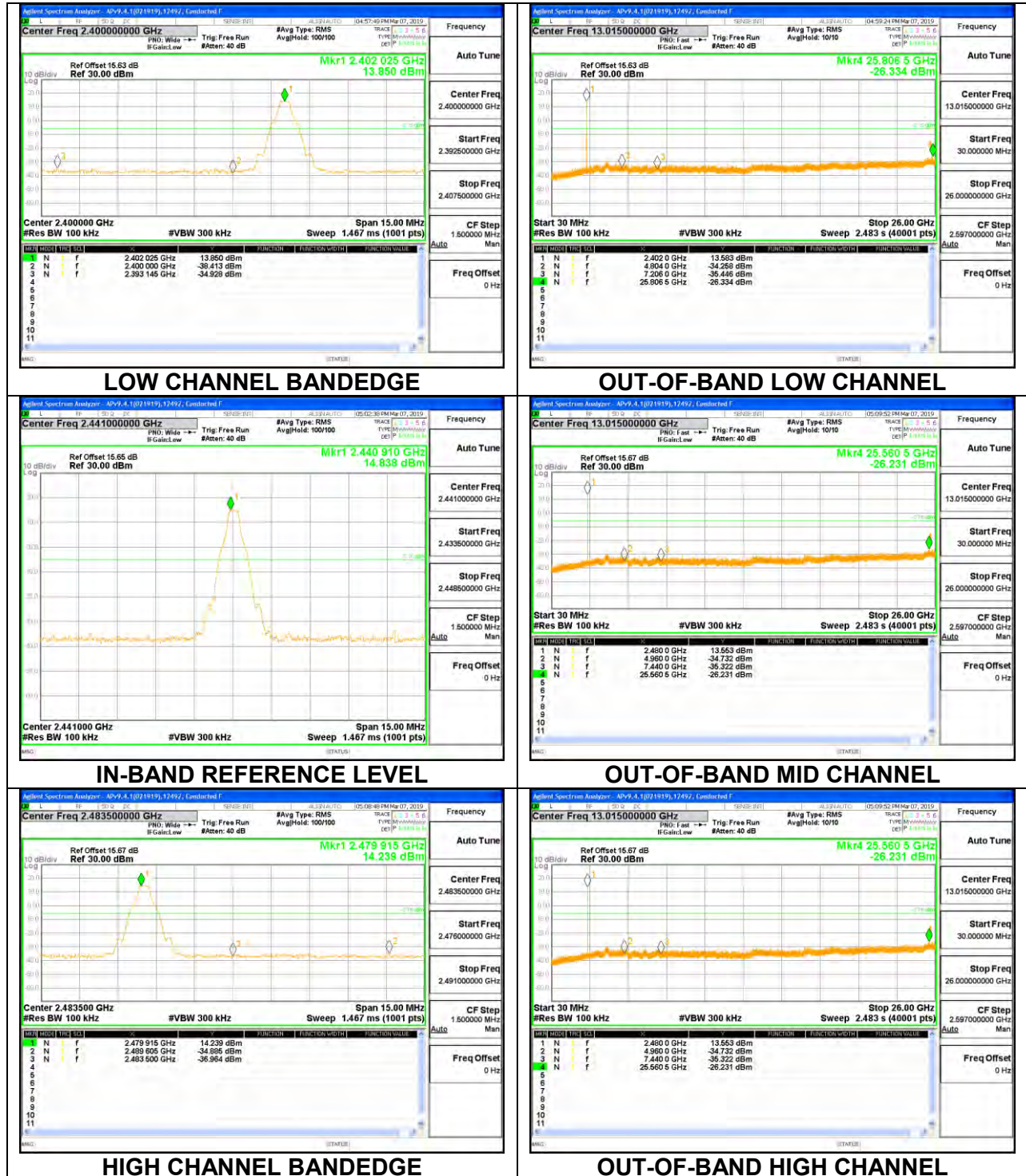

OUT-OF-BAND MID CHANNEL

HIGH CHANNEL BANDEDGE

OUT-OF-BAND HIGH CHANNEL

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Antenna 2 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

| LOW BANDEDGE | HIGH BANDEDGE |

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Antenna 5 SPURIOUS EMISSIONS, NON-HOPPING

LOW CHANNEL BANDEDGE

OUT-OF-BAND LOW CHANNEL

IN-BAND REFERENCE LEVEL

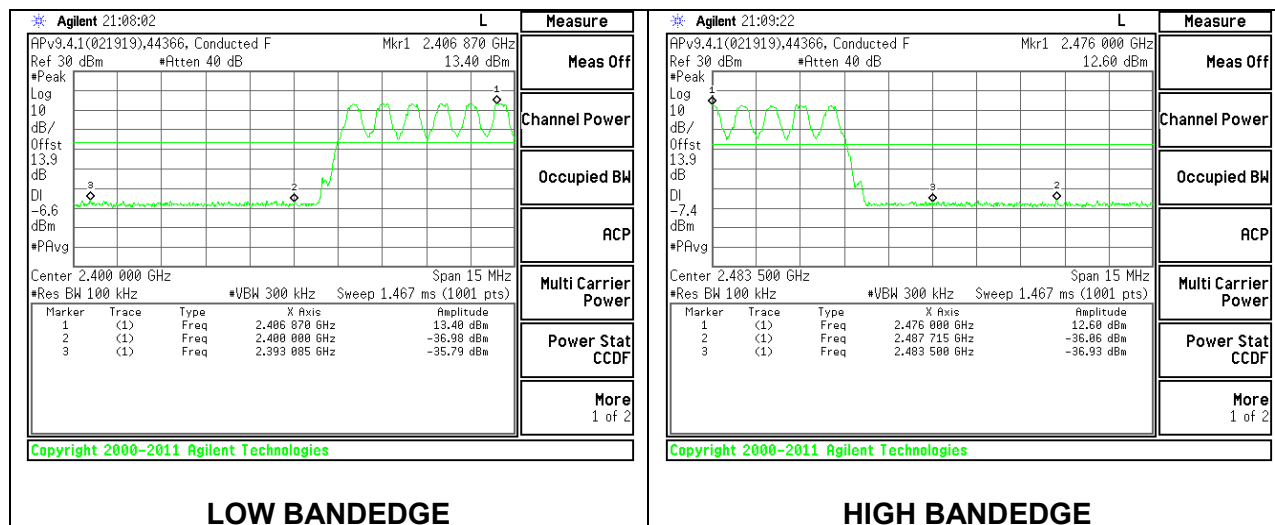OUT-OF-BAND MID CHANNEL

HIGH CHANNEL BANDEDGE
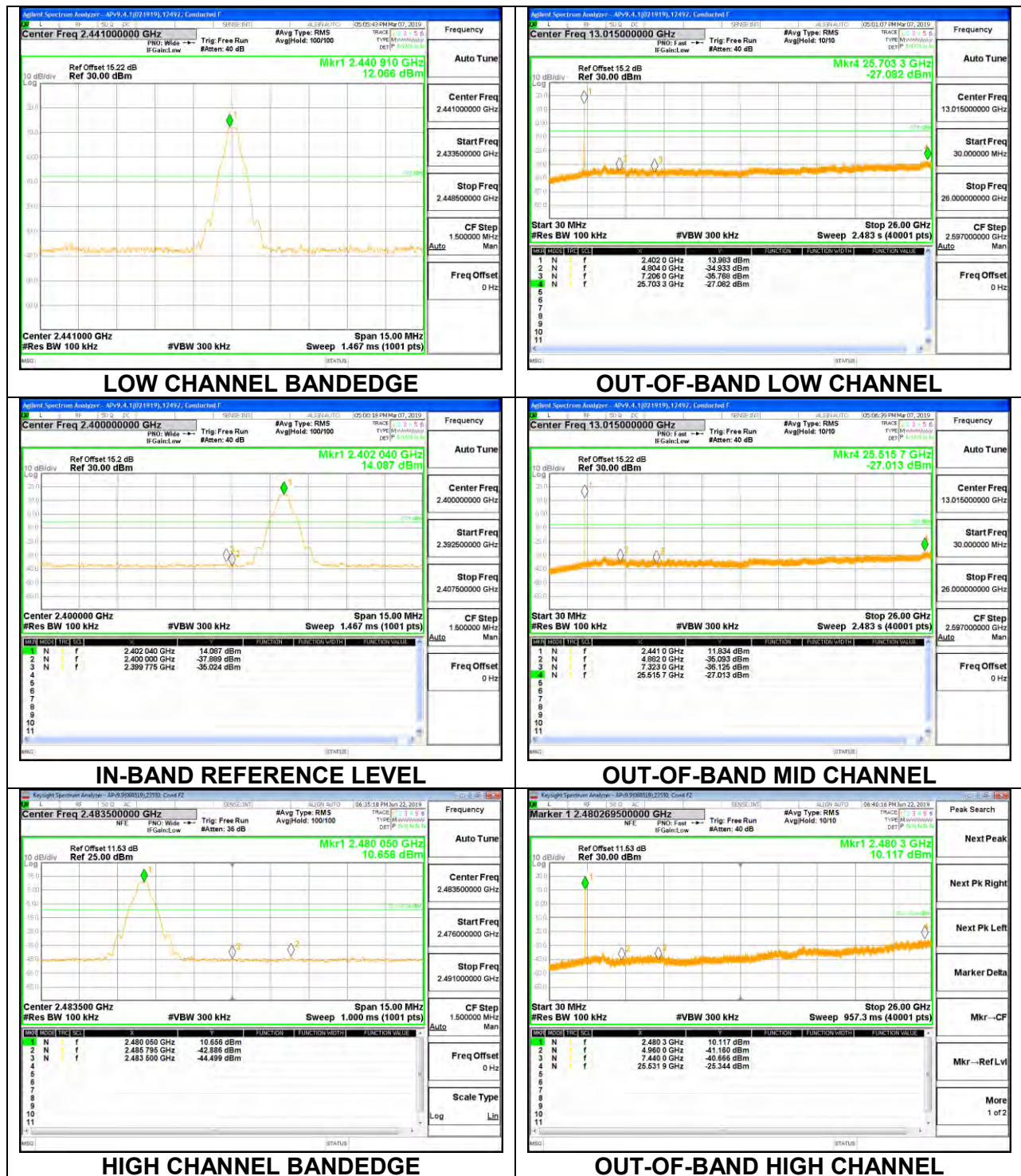

OUT-OF-BAND HIGH CHANNEL

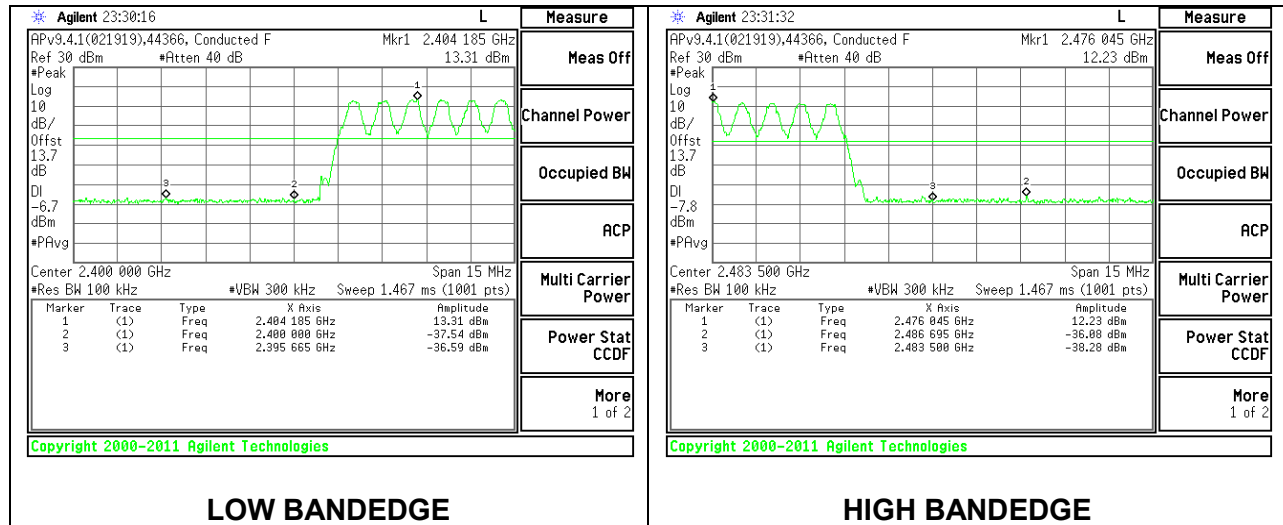**Antenna 5 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON**

LOW BANDEDGE	HIGH BANDEDGE

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8.8.3. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 2 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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Antenna 2 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

LOW BANDEDGE   **HIGH BANDEDGE**

Antenna 5 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

Antenna 5 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

LOW BANDEDGE	HIGH BANDEDGE

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8.8.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2 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**

Antenna 2 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

LOW BANDEDGE	HIGH BANDEDGE

Antenna 5 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

Antenna 5 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

LOW BANDEDGE	HIGH BANDEDGE

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8.9. BEAMFORMING 20 dB AND 99% BANDWIDTH

8.9.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Note: Test procedure on beamforming mode is same as BT basic and EDR mode
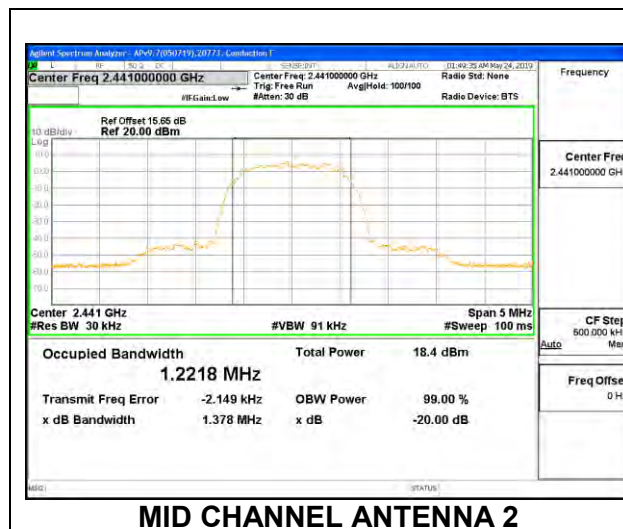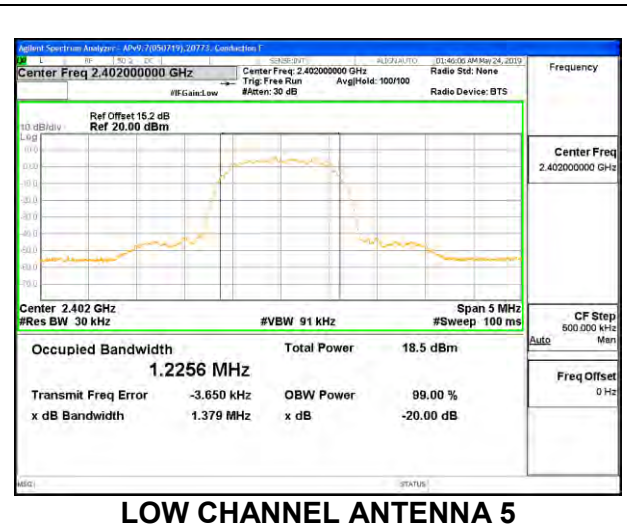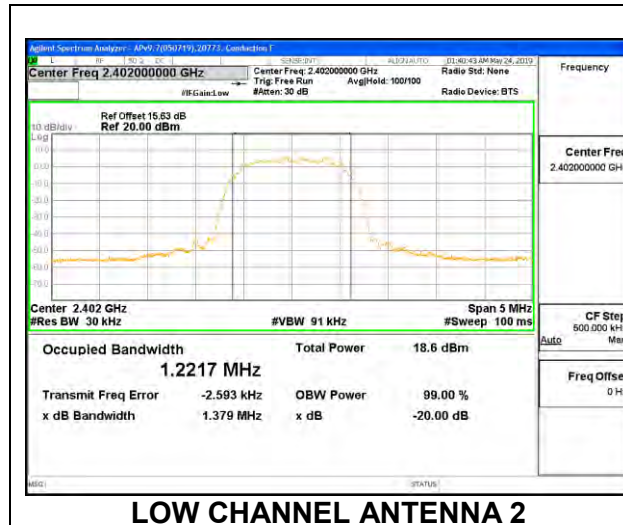
2TX Antenna 2 + Antenna 5 TxBF MODE

Channel	Frequency (MHz)	20dB Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 2 (MHz)	20dB Bandwidth Antenna 5 (MHz)	99% Bandwidth Antenna 5 (MHz)
Low	2402	0.8878	0.86665	0.9243	0.87252
Mid	2441	0.8870	0.86574	0.8892	0.87103
High	2480	0.8876	0.86649	0.8892	0.87090

LOW CHANNEL ANTENNA 2

LOW CHANNEL ANTENNA 5

MID CHANNEL ANTENNA 2

MID CHANNEL ANTENNA 5

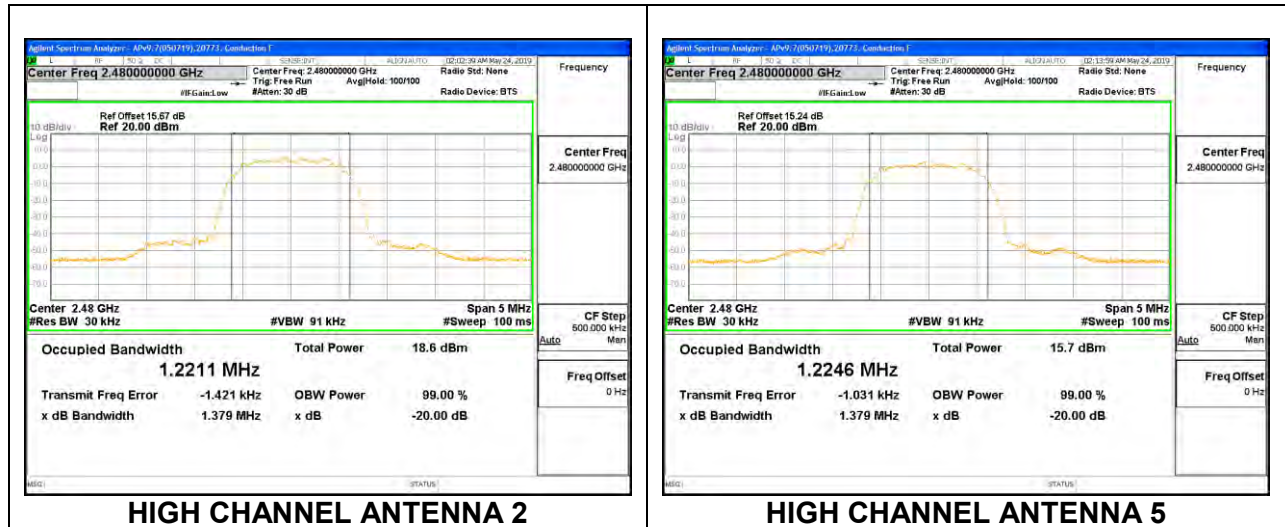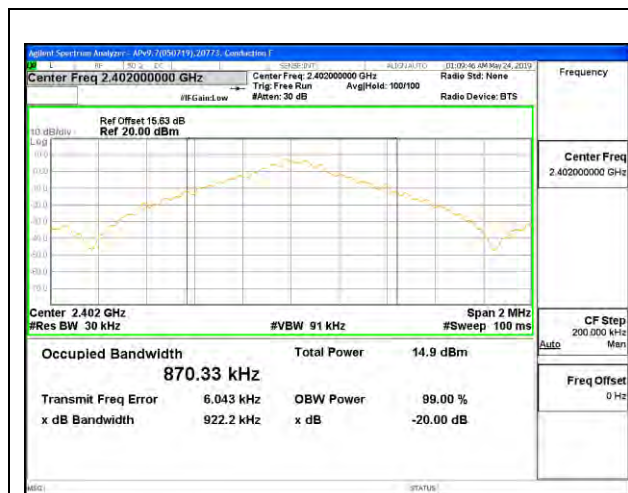| HIGH CHANNEL ANTENNA 2	HIGH CHANNEL ANTENNA 5
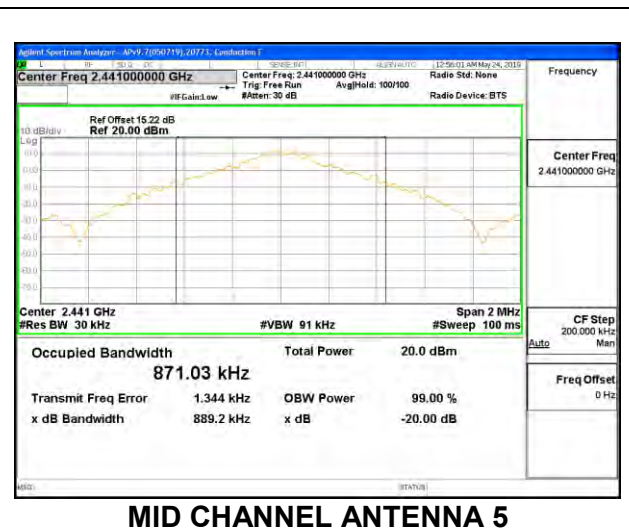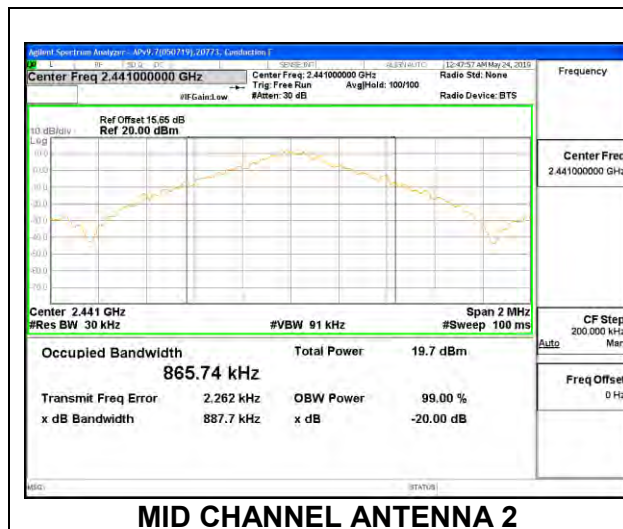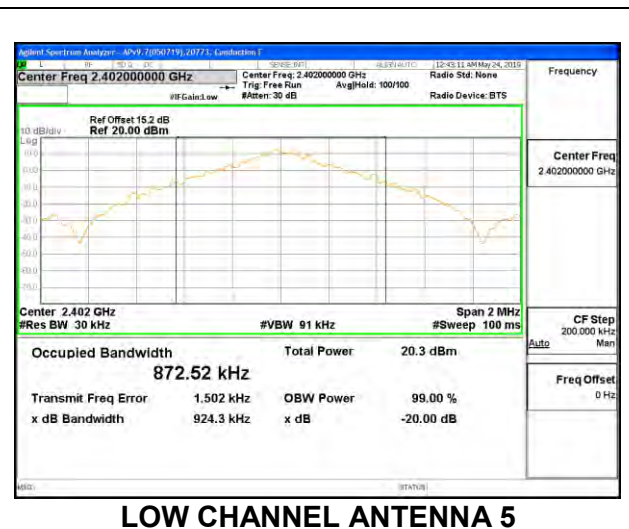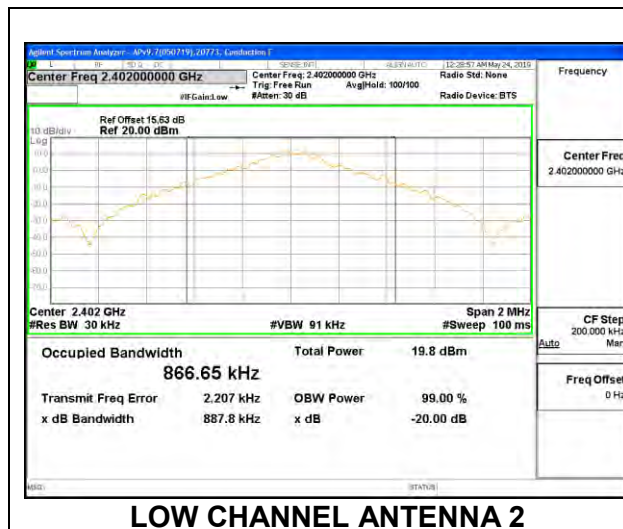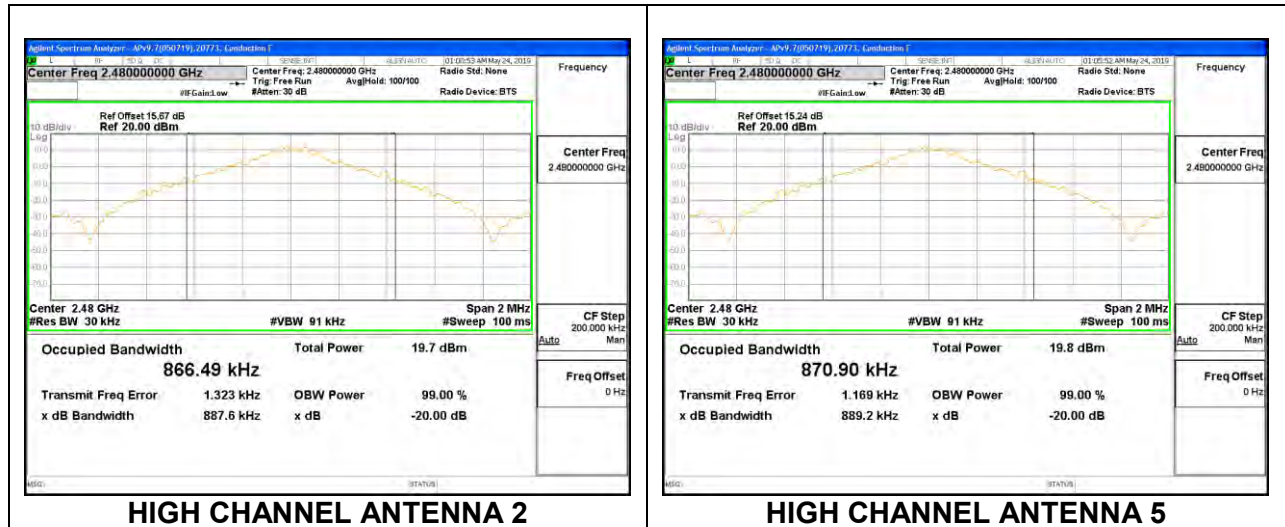
8.9.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

2TX Antenna 2 + Antenna 5 TxBF MODE

Channel	Frequency (MHz)	20dB Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 2 (MHz)	20dB Bandwidth Antenna 5 (MHz)	99% Bandwidth Antenna 5 (MHz)
Low	2402	1.379	1.2217	1.379	1.2256
Mid	2441	1.378	1.2218	1.380	1.2247
High	2480	1.379	1.2211	1.379	1.2246

LOW CHANNEL ANTENNA 2

LOW CHANNEL ANTENNA 5

MID CHANNEL ANTENNA 2

MID CHANNEL ANTENNA 5

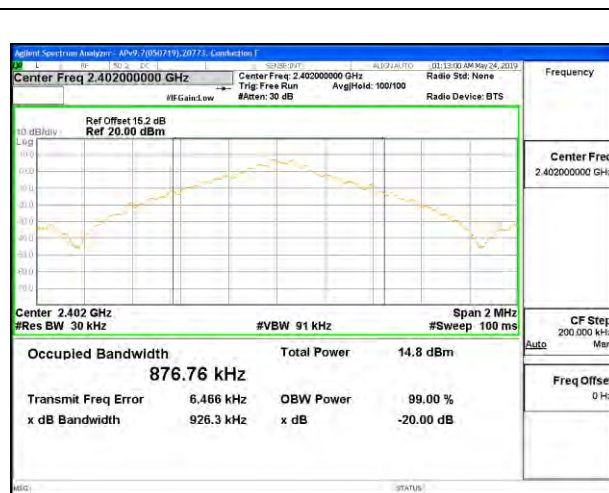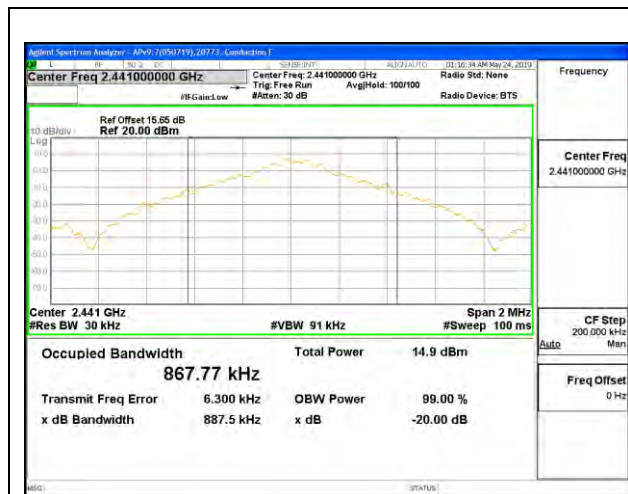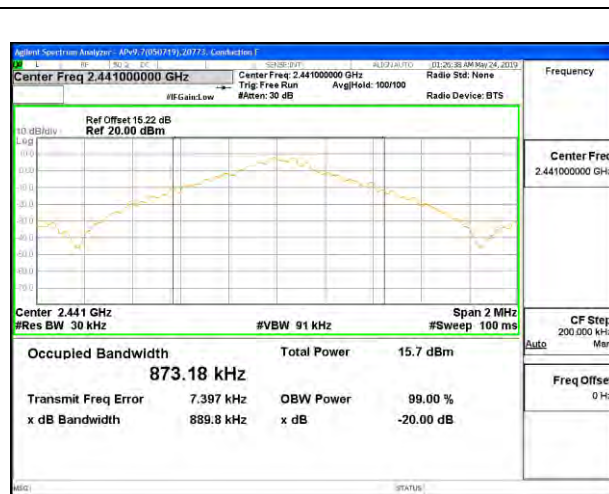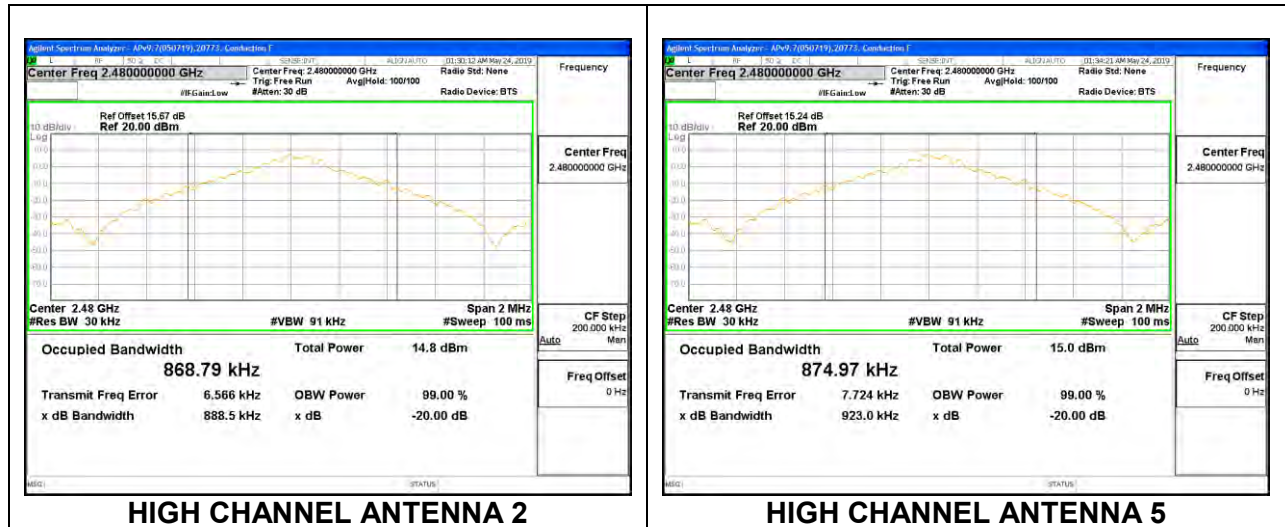| HIGH CHANNEL ANTENNA 2	HIGH CHANNEL ANTENNA 5
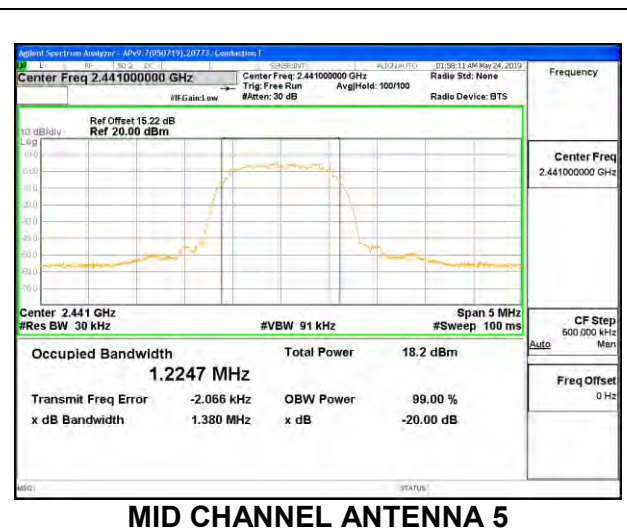
8.9.3. LOW POWER BASIC DATA RATE GFSK MODULATION

2TX Antenna 2 + Antenna 5 TxBF MODE

Channel	Frequency (MHz)	20dB Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 2 (MHz)	20dB Bandwidth Antenna 5 (MHz)	99% Bandwidth Antenna 5 (MHz)
Low	2402	0.9222	0.87033	0.9263	0.87676
Mid	2441	0.8875	0.86777	0.8898	0.87318
High	2480	0.8885	0.86879	0.9230	0.87497

LOW CHANNEL ANTENNA 2

LOW CHANNEL ANTENNA 5
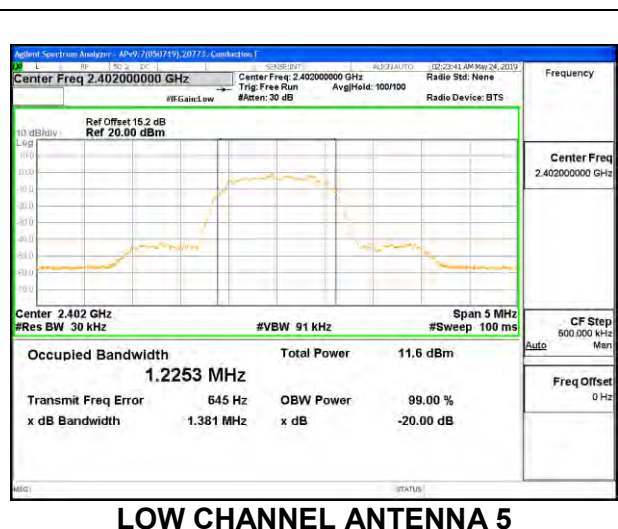

MID CHANNEL ANTENNA 2

MID CHANNEL ANTENNA 5

HIGH CHANNEL ANTENNA 2	HIGH CHANNEL ANTENNA 5
Occupied Bandwidth 868.79 kHz Total Power 14.8 dBm Transmit Freq Error 6.566 kHz OBW Power 99.00 % x dB Bandwidth 888.5 kHz x dB -20.00 dB	Occupied Bandwidth 874.97 kHz Total Power 15.0 dBm Transmit Freq Error 7.724 kHz OBW Power 99.00 % x dB Bandwidth 923.0 kHz x dB -20.00 dB

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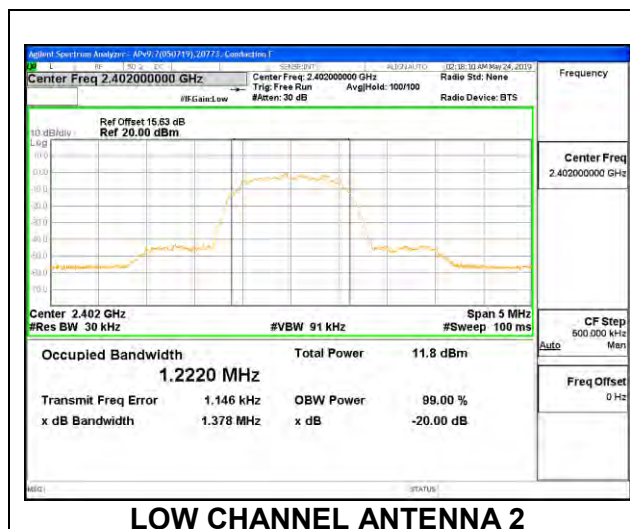*This report shall not be reproduced except in full, without the written approval of UL Verification Services Inc.*
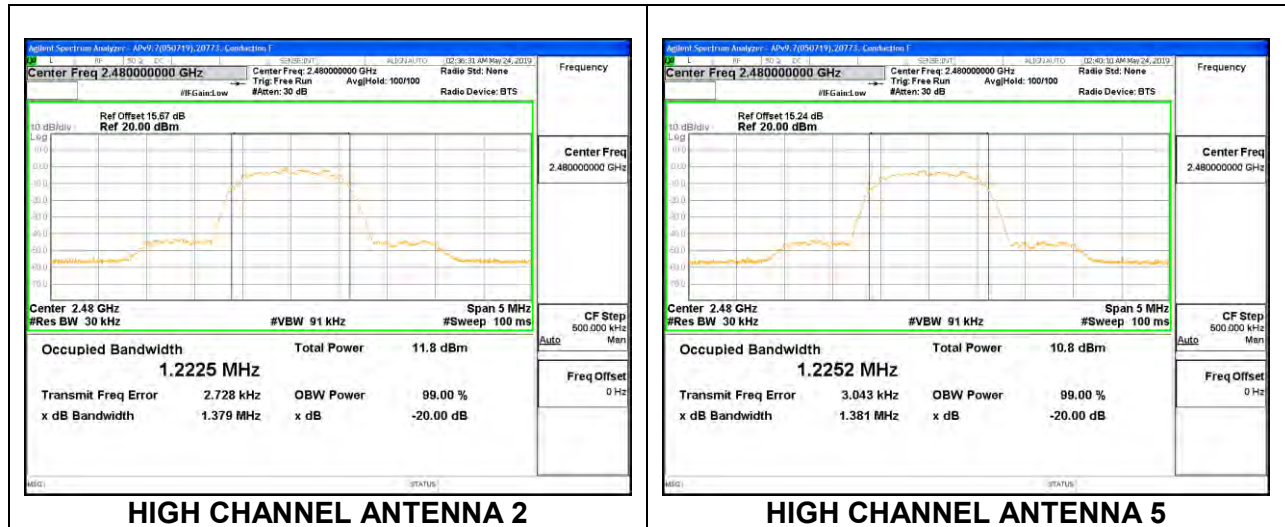
8.9.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

2TX Antenna 2 + Antenna 5 TxBF MODE

Channel	Frequency (MHz)	20dB Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 2 (MHz)	20dB Bandwidth Antenna 5 (MHz)	99% Bandwidth Antenna 5 (MHz)
Low	2402	1.378	1.2220	1.381	1.2253
Mid	2441	1.378	1.2212	1.381	1.2233
High	2480	1.379	1.2225	1.381	1.2252

LOW CHANNEL ANTENNA 2	LOW CHANNEL ANTENNA 5
MID CHANNEL ANTENNA 2	MID CHANNEL ANTENNA 5

HIGH CHANNEL ANTENNA 2	HIGH CHANNEL ANTENNA 5

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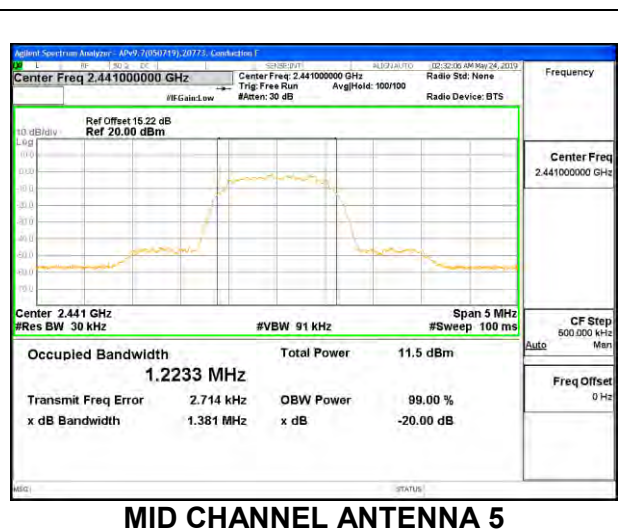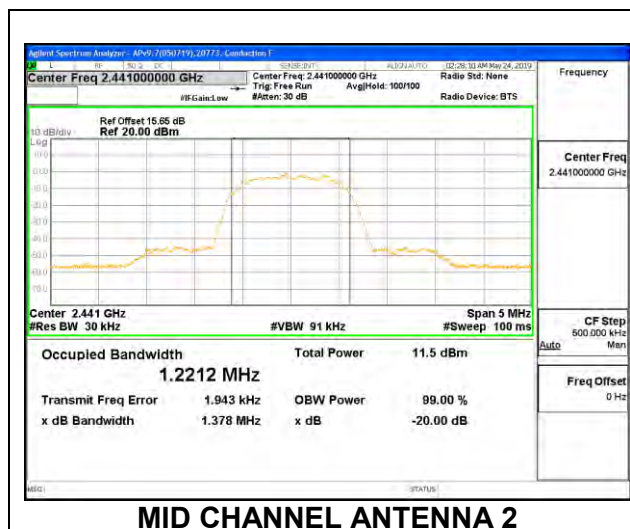
8.10. BEAMFORMING HOPPING FREQUENCY SEPARATION

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.
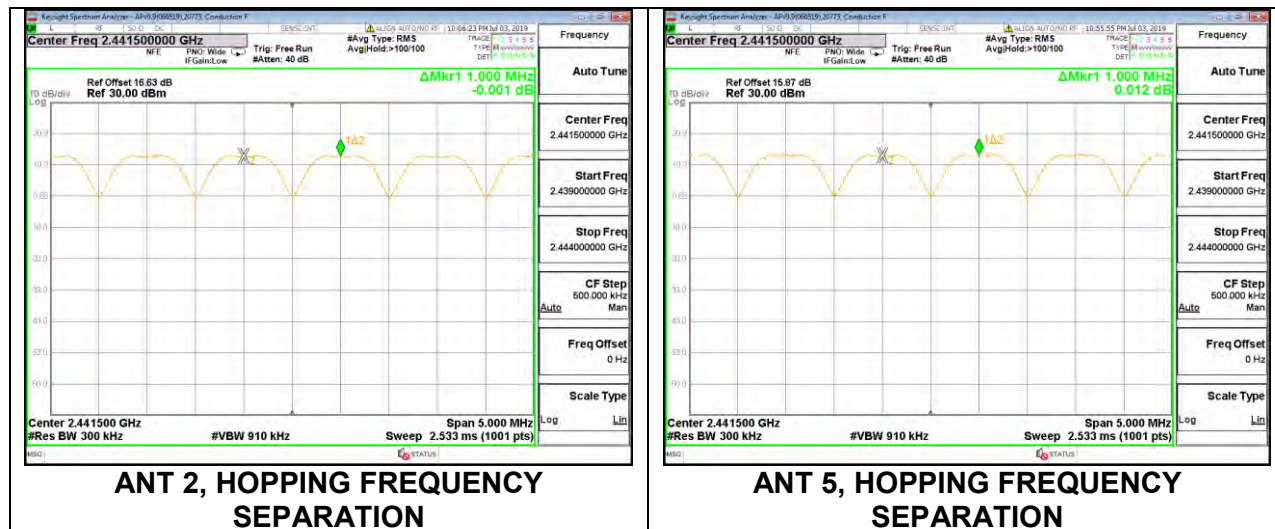
TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 3x RBW.

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

RESULTS

8.10.1. HIGH POWER BASIC DATA RATE GFSK MODULATION
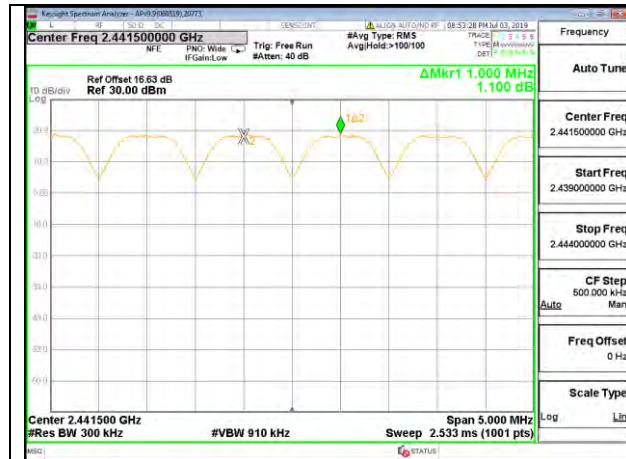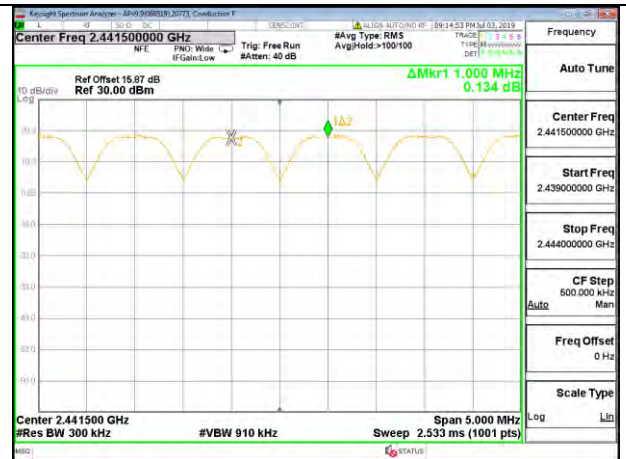
ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

8.10.2. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION
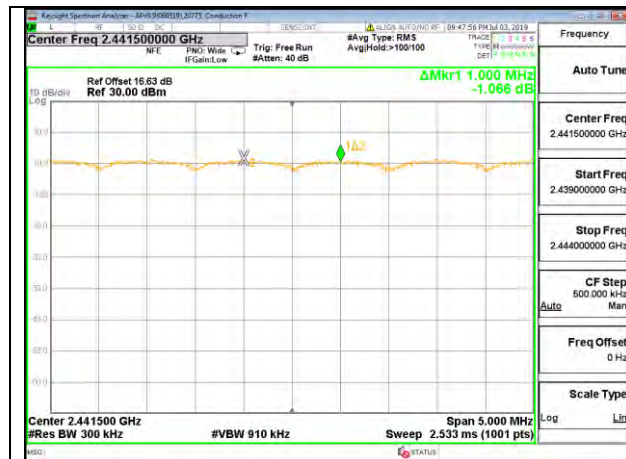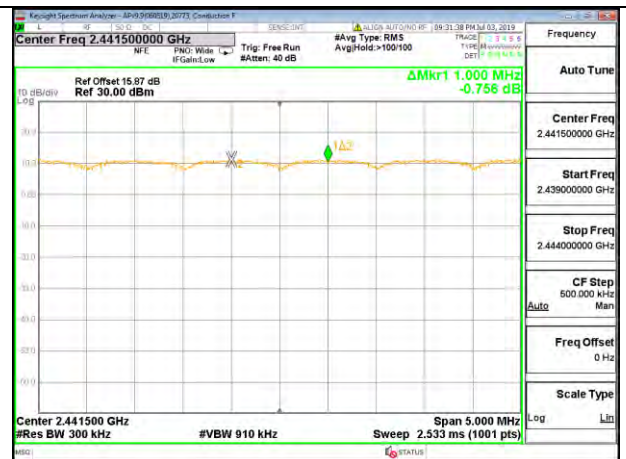
ANT 2, HOPPING FREQUENCY SEPARATION	ANT 5, HOPPING FREQUENCY SEPARATION

8.10.3. LOW POWER BASIC DATA RATE GFSK MODULATION

ANT 2, HOPPING FREQUENCY SEPARATION

ANT 5, HOPPING FREQUENCY SEPARATION

8.10.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 2, HOPPING FREQUENCY SEPARATION

ANT 5, HOPPING FREQUENCY SEPARATION
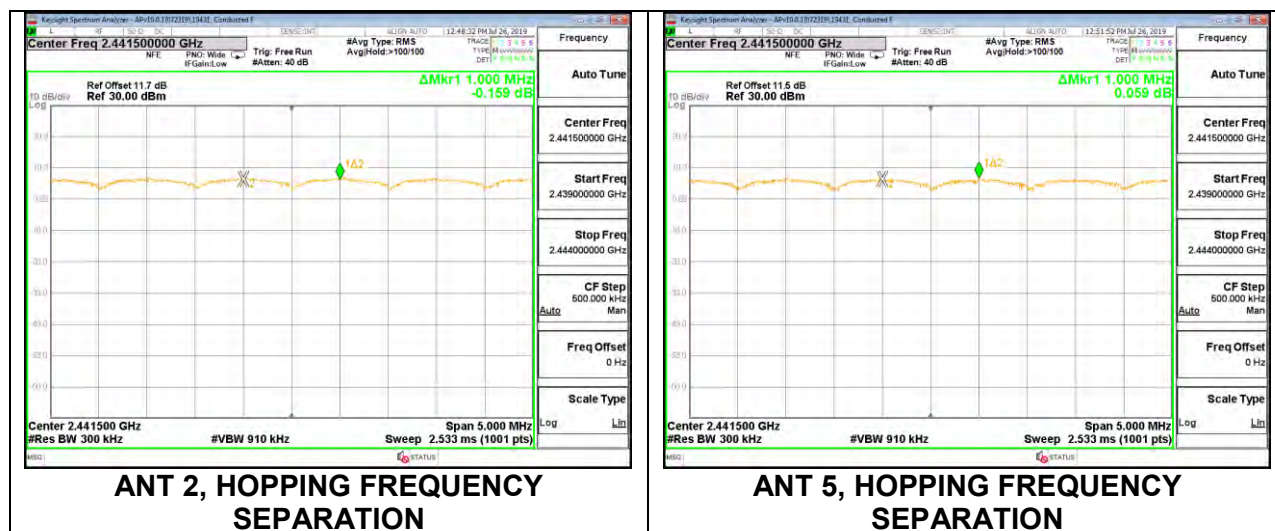
8.11. BEAMFORMING NUMBER OF HOPPING CHANNELS

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.
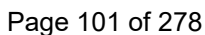
TEST PROCEDURE

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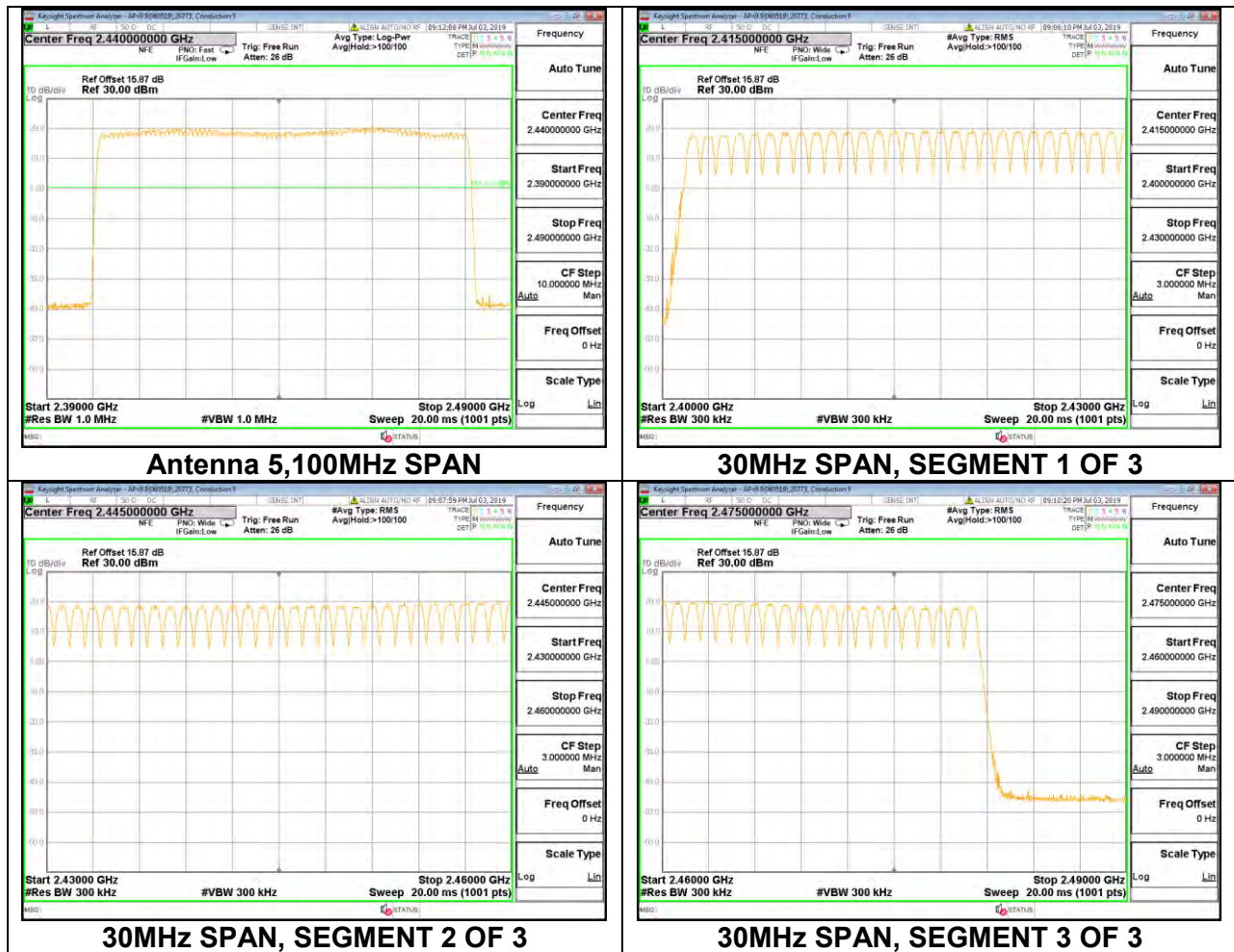
Note: Test procedure on beamforming mode is same as BT basic and EDR mode

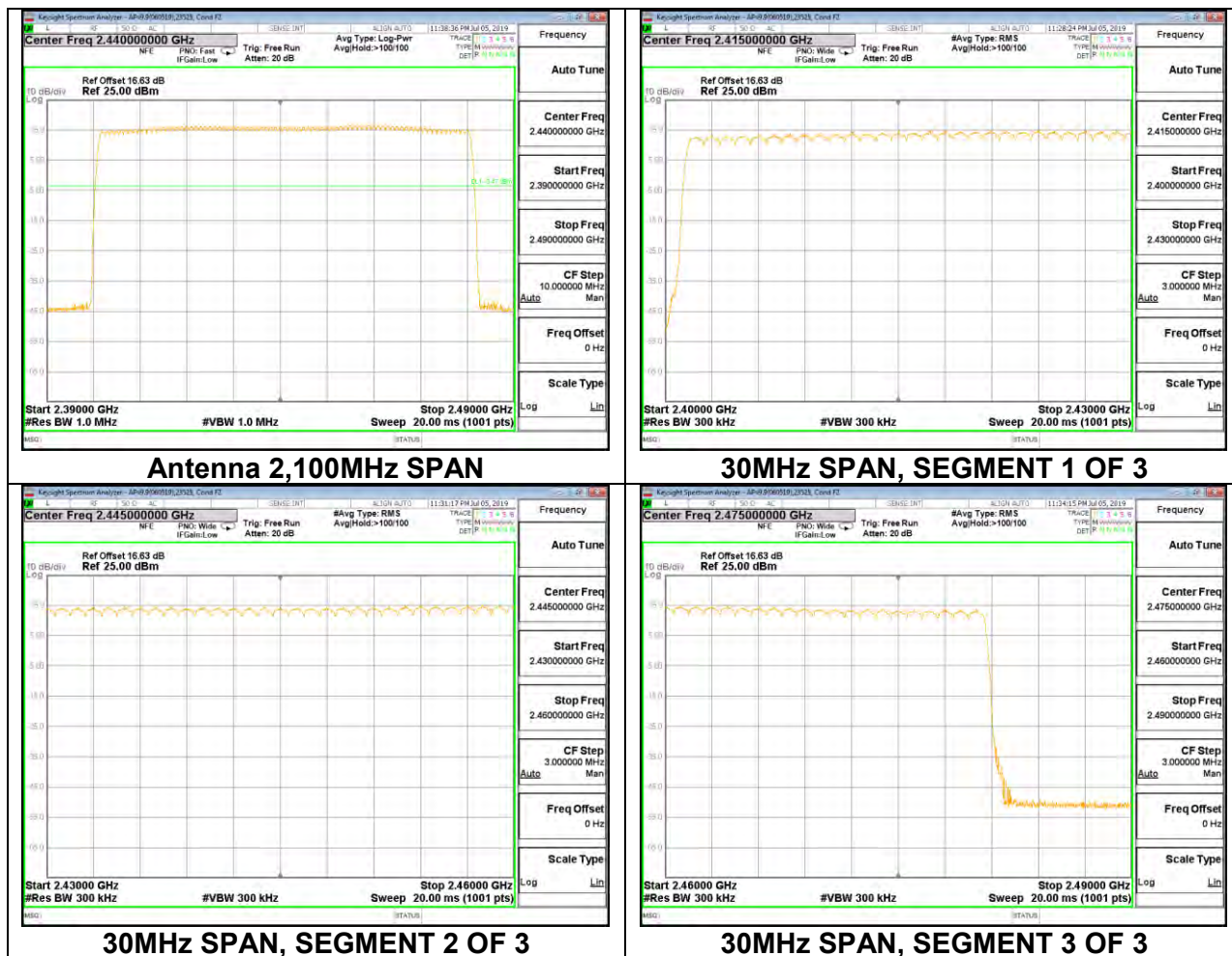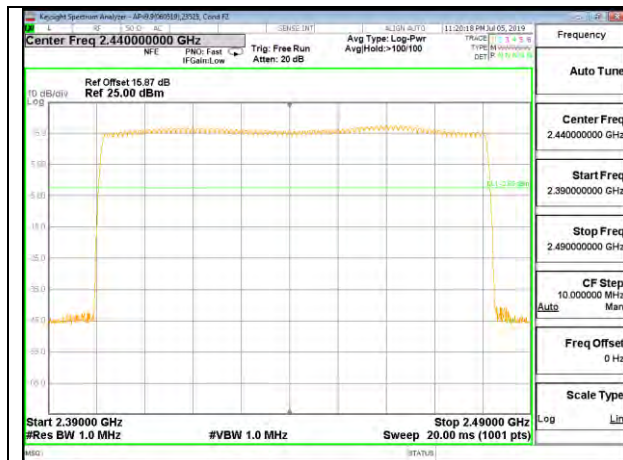**RESULTS**

Normal Mode: 79 Channels Observed

8.11.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 2

Antenna 2,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

ANTENNA 5

Antenna 5,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

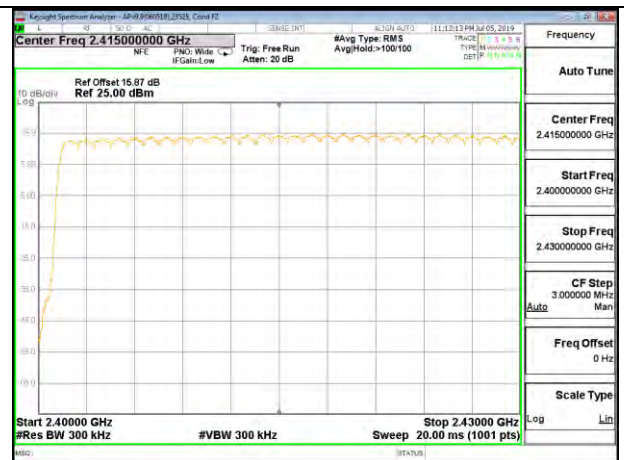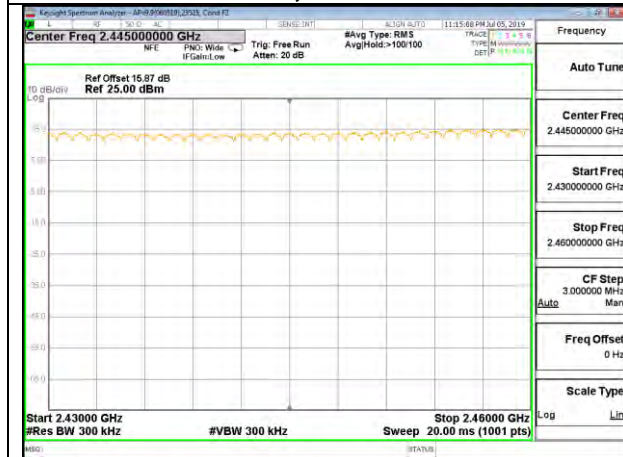## 8.11.2.   HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANTENNA 2

Antenna 2,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

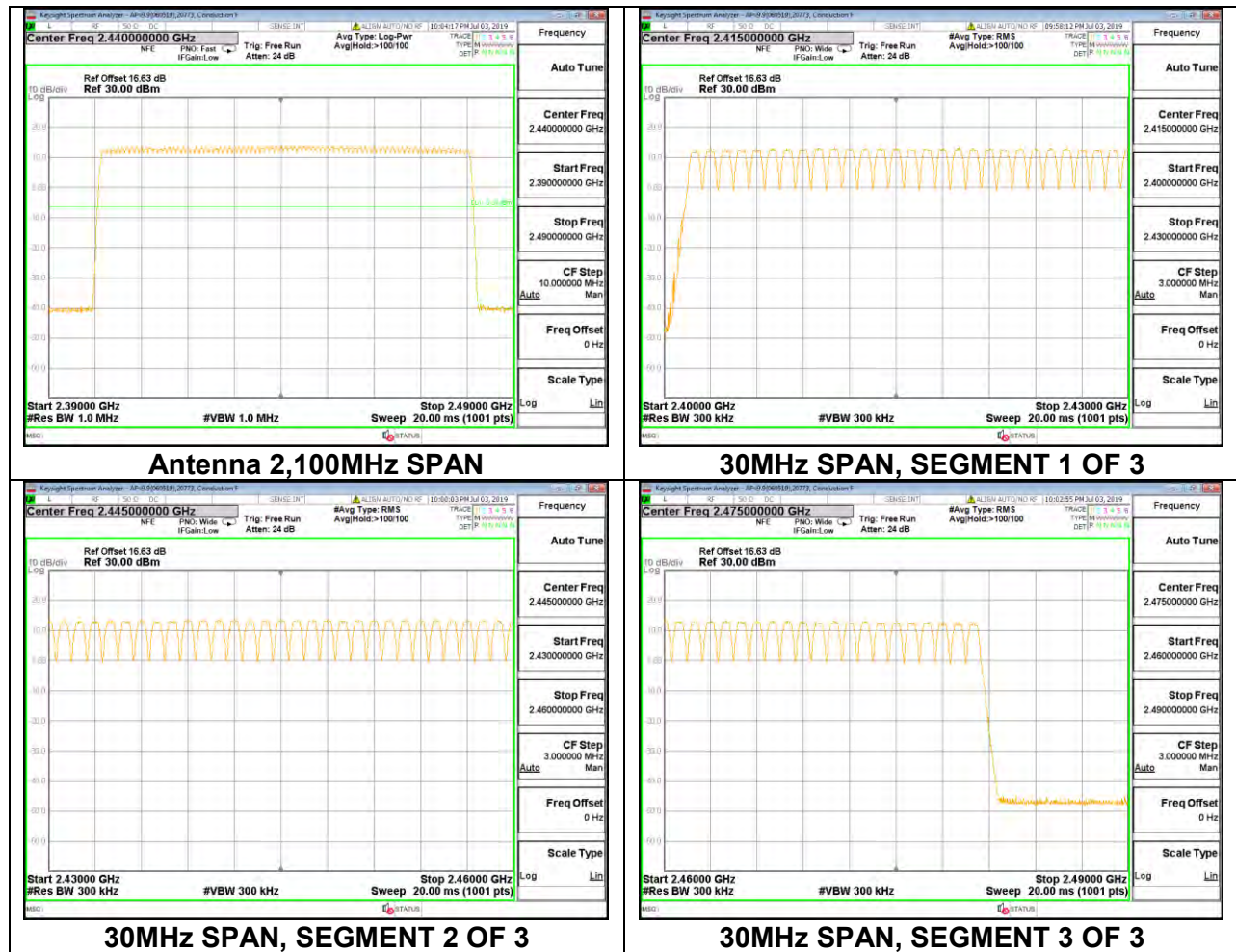**30MHz SPAN, SEGMENT 2 OF 3**

30MHz SPAN, SEGMENT 3 OF 3

ANTENNA 5

Antenna 5,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

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8.11.3. LOW POWER BASIC DATA RATE GFSK MODULATION

ANTENNA 2

Antenna 2,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

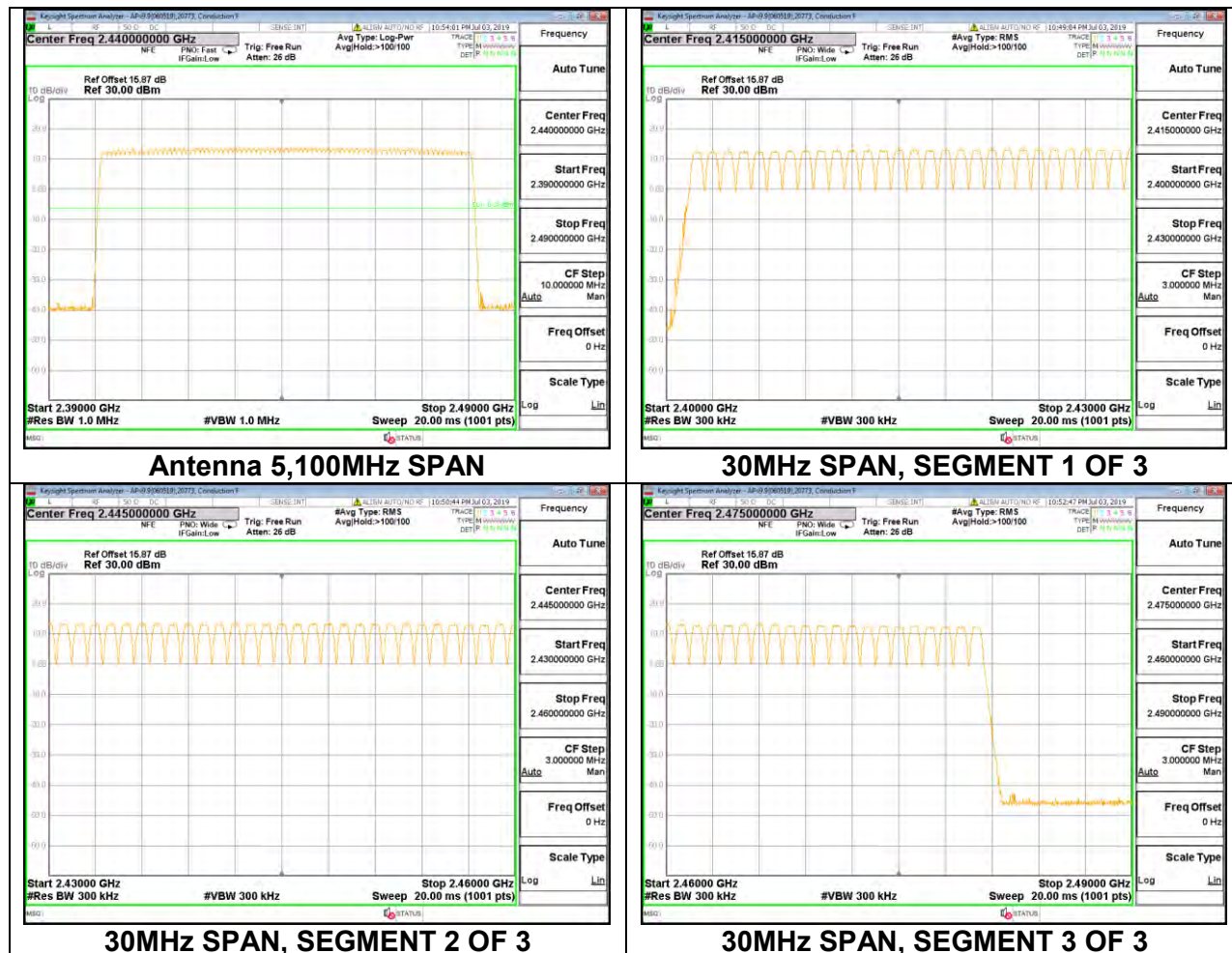**ANTENNA 5**

Antenna 5,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

8.11.4. LOW POWER ENHANCED DATA RATE 8PSK MODULATION
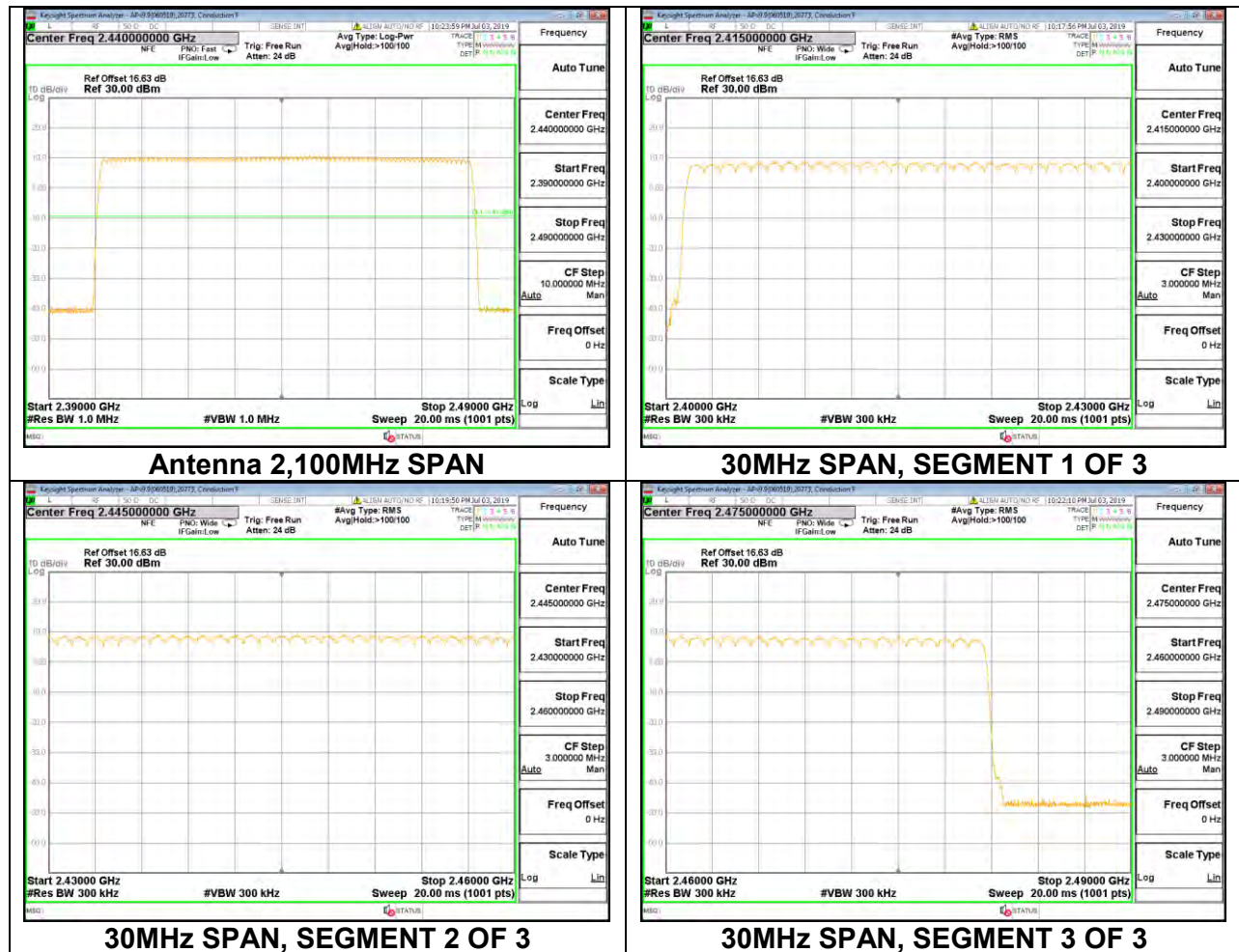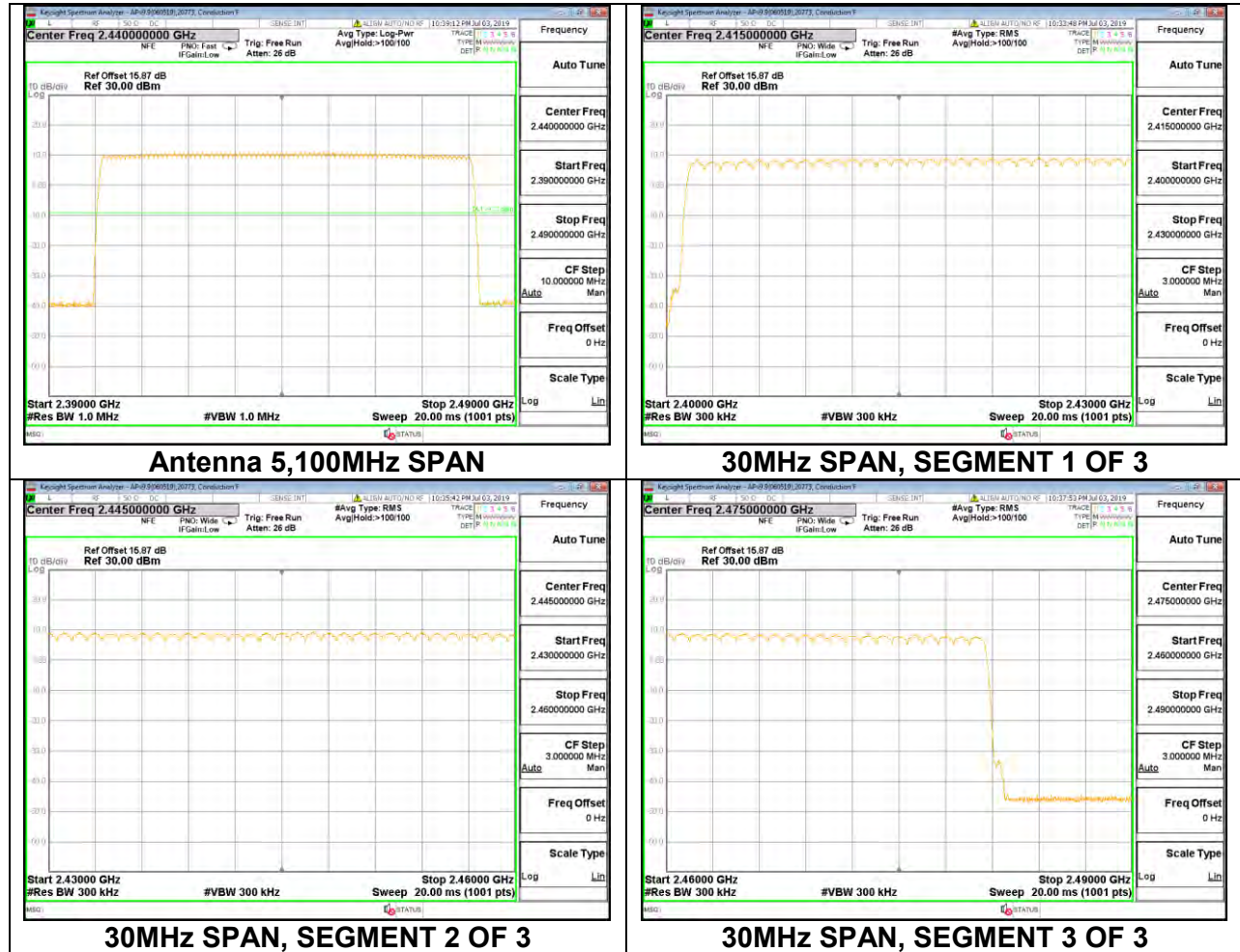
ANTENNA 2

Antenna 2,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

ANTENNA 5

Antenna 5,100MHz SPAN

30MHz SPAN, SEGMENT 1 OF 3

30MHz SPAN, SEGMENT 2 OF 3

30MHz SPAN, SEGMENT 3 OF 3

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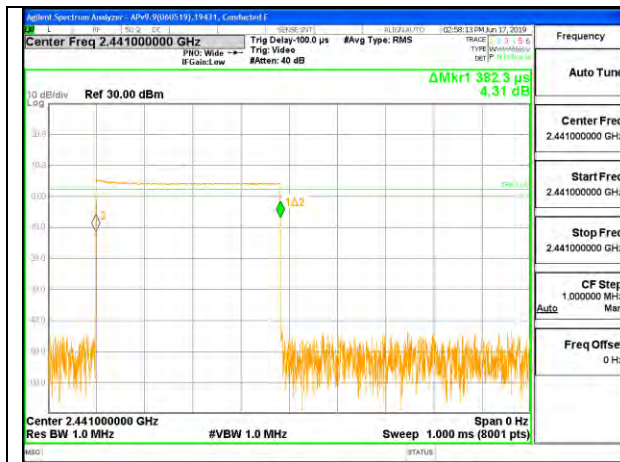
For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to 10 * (# of pulses in 0.8 s) * pulse width.

RESULTS

8.12.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

Antenna 2

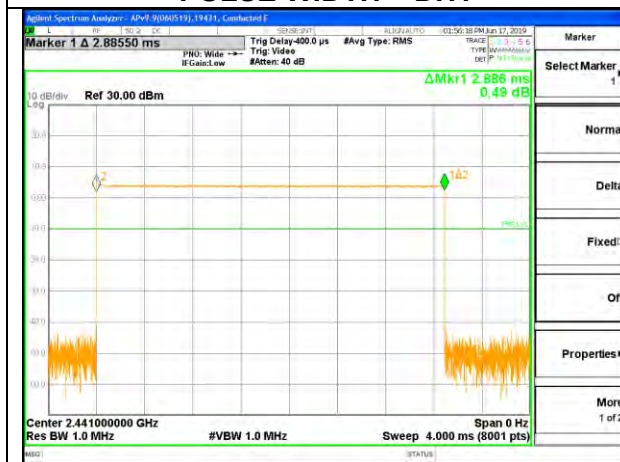| DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.382	30	0.1147	0.4	-0.2853
DH3	1.638	16	0.2621	0.4	-0.1379
DH5	2.886	11	0.3175	0.4	-0.0825

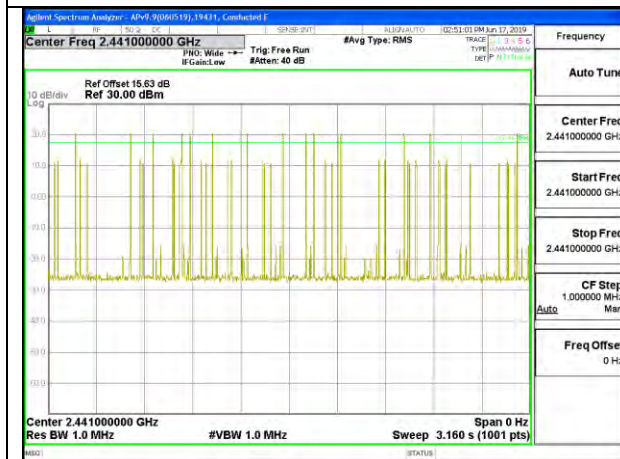| DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.3823	7.5	0.02867	0.4	-0.3713
DH3	1.638	4	0.06552	0.4	-0.3345
DH5	2.886	2.75	0.07937	0.4	-0.3206

PULSE WIDTH – DH1

PULSE WIDTH – DH3

PULSE WIDTH – DH5

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1
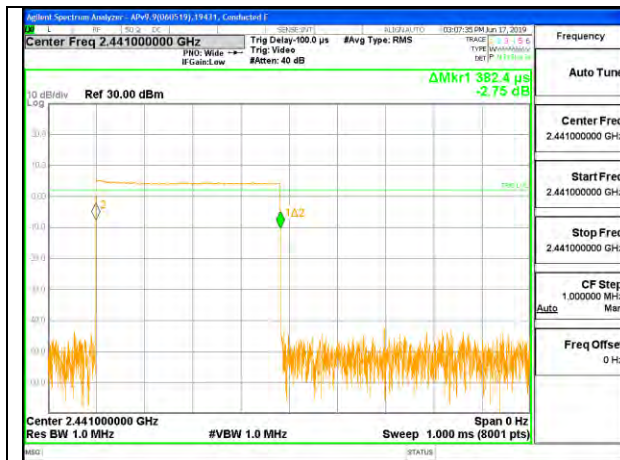

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3

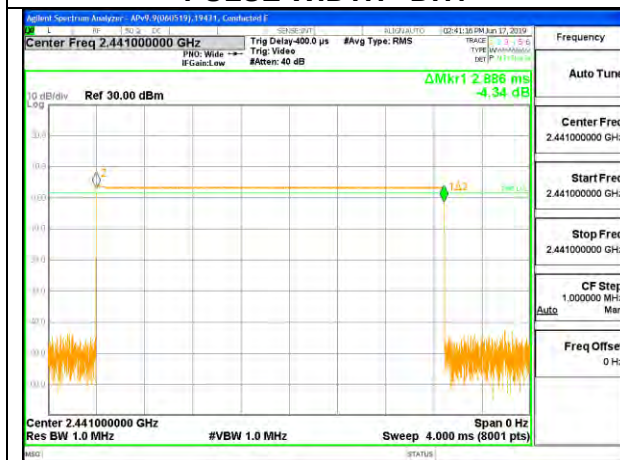**NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5**

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Antenna 5

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	0.382	32	0.1223	0.4	-0.2777
DH3	1.638	17	0.2785	0.4	-0.1215
DH5	2.886	9	0.2597	0.4	-0.1403

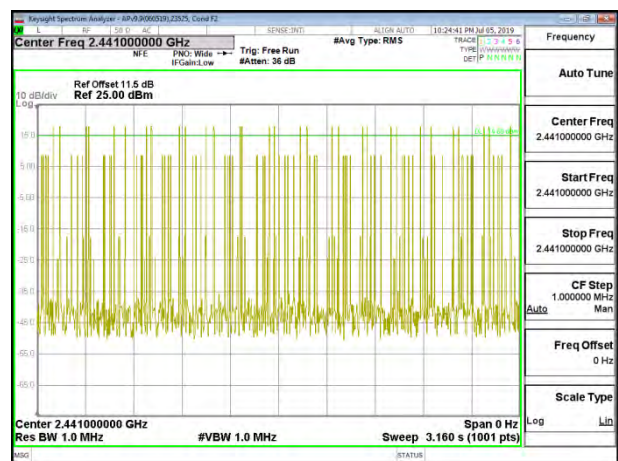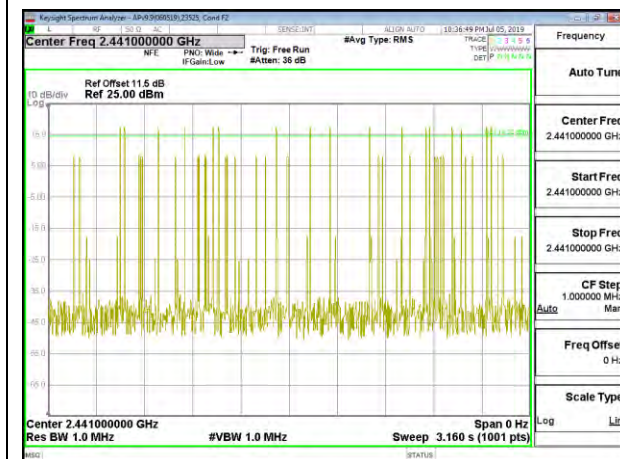| DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.3823	8	0.03058	0.4	-0.3694
DH3	1.638	4.25	0.06962	0.4	-0.3304
DH5	2.886	2.25	0.06494	0.4	-0.3351

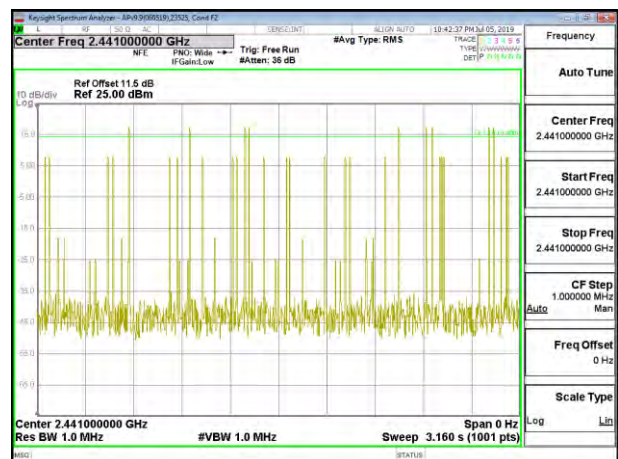**PULSE WIDTH –DH1**

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

8.12.2.   HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 2

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	0.388	32	0.1242	0.4	-0.2758
3DH3	1.639	17	0.2786	0.4	-0.1214
3DH5	2.890	10	0.2890	0.4	-0.1110

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 demonstrates compliance with channel occupancy when AFH is employed.