

TEST REPORT

Report Number: 14523771-E1V2

Applicant : APPLE, INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, USA

Model : A2849

FCC ID : BCG-E8439A

IC : 579C-E8439A

EUT Description : SMARTPHONE

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
ISED RSS-247 ISSUE 2
ISED RSS-GEN ISSUE 5 + A1 + A2

Date Of Issue:
August 19, 2023

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REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	8/14/2023	Initial Issue	Chin Pang
V2	8/19/2023	Addressed TCB Questions section 7, 9	Chris Xiong

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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: A2849

BRAND: APPLE

FCC ID: BCG-E8439A

IC: 579C-E8439A

SERIAL NUMBER: FYFYYWKPF7, QXYQV96627

SAMPLE RECEIPT DATE: February 25, 2023

DATE TESTED: MARCH 23 – AUGUST 15, 2023

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5 + A1 + A2	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
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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 414788 D01 Radiated Test Site v01r01, KDB 662911, RSS-GEN Issue 5 + A1 + A2, and RSS-247 Issue 2.

4. FACILITIES AND ACCREDITATION

UL Verification Services Inc. is accredited by A2LA, certification #0751.05, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
☐	Building 1: 47173 Benicia Street, Fremont, CA 94538, USA	US0104	2324A	550739
☐	Building 2: 47266 Benicia Street, Fremont, CA 94538, USA			
☒	Building 3: 843 Auburn Court, Fremont, CA 94538 USA			
☒	Building 4: 47658 Kato Rd, Fremont, CA 94538 USA			
☒	Building 5: 47670 Kato Rd, Fremont, CA 94538 USA			

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}
Conducted Antenna Port Emission Measurement	1.94 dB
Time Domain Measurements Using SA	3.39dB
RF Power Measurement Direct Method Using Power Meter	0.450 dB(Peak), 1.3 dB (Ave)
Radio Frequency (Spectrum Analyzer)	141.16 Hz
Occupied Bandwidth	1.22%
Carrier Frequency Separation	19.70Hz
Number of Hopping Frequencies	0.000dB
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.78 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.40 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.87 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	6.01 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.73 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.51 dB

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

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, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC, NB UNII, 802.15.4, 802.15.4ab-NB and MSS technologies. 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	20.15	103.51
		2402 - 2480	DQPSK	19.04	80.17
		2402 - 2480	Enhanced 8PSK	19.28	84.72
	Low Power	2402 - 2480	Basic GFSK	11.15	13.03
		2402 - 2480	DQPSK	11.05	12.74
		2402 - 2480	Enhanced 8PSK	11.23	13.27
ANT 3	High Power	2402 - 2480	Basic GFSK	20.14	103.28
		2402 - 2480	DQPSK	19.03	79.98
		2402 - 2480	Enhanced 8PSK	19.25	84.14
	Low Power	2402 - 2480	Basic GFSK	12.62	18.28
		2402 - 2480	DQPSK	11.02	12.65
		2402 - 2480	Enhanced 8PSK	11.23	13.27
Beamforming, ANT 4 + ANT 3	High Power	2402 - 2480	Basic GFSK TxBF	20.13	103.04
		2402 - 2480	DQPSK TxBF	19.10	81.28
		2402 - 2480	Enhanced 8PSK TxBF	19.24	83.95
	Low Power	2402 - 2480	Basic GFSK TxBF	14.96	31.33
		2402 - 2480	DQPSK TxBF	14.06	25.47
		2402 - 2480	Enhanced 8PSK TxBF	14.27	26.73

Note: GFSK, DQPSK, 8PSK Average Power are all investigated. GFSK & 8PSK Powers are the worst case. Testing is based on these modes to show compliance.

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain, as provided by the manufacturer' are as follow:

Frequency Range (GHz)	ANT 4 (dBi)	ANT 3 (dBi)
2.4	-1.1	-0.9

Cable loss provided by client is 1.95dB.

6.4. SOFTWARE AND FIRMWARE

The EUT firmware version installed for testing is 21.1.306.2344

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, ANT 3 and 2TX Beamforming.

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

For radiated harmonic spurious emissions test, high power beamforming GFSK mode is set to maximum power per chain to cover both SISO and MIMO modes to complies with radiated spurious emissions limits in the restricted bands between 1GHz and 18GHz low/mid/high channel.

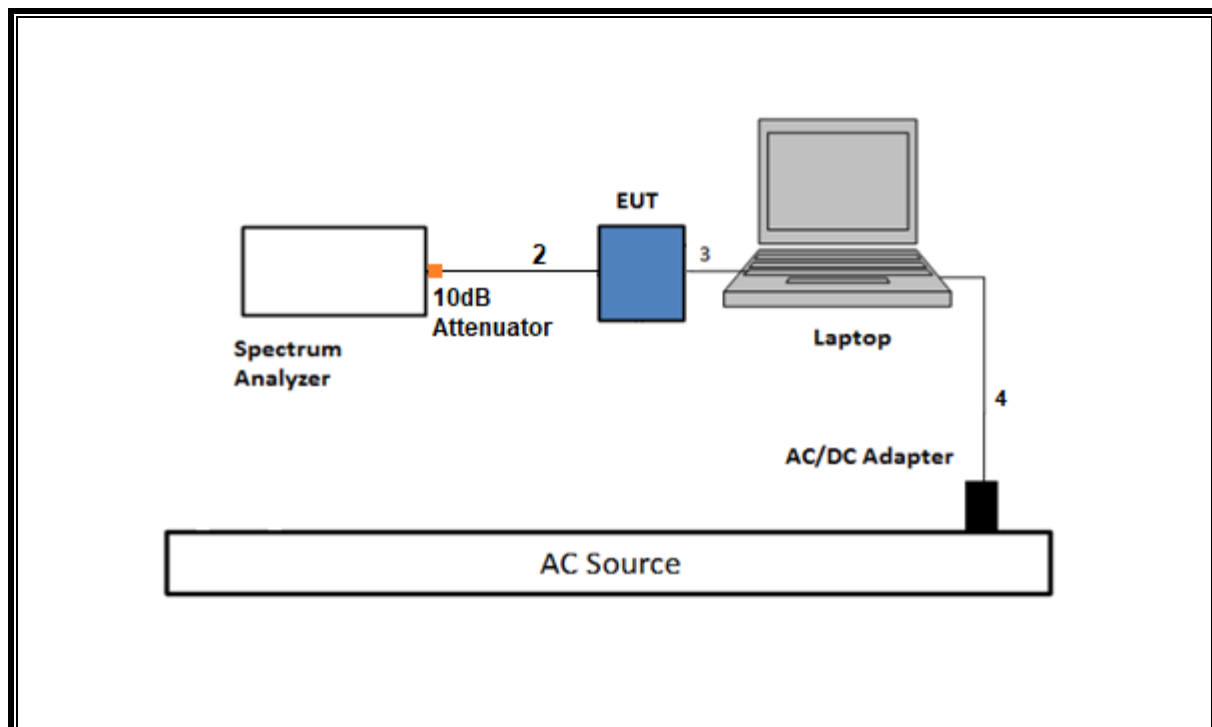
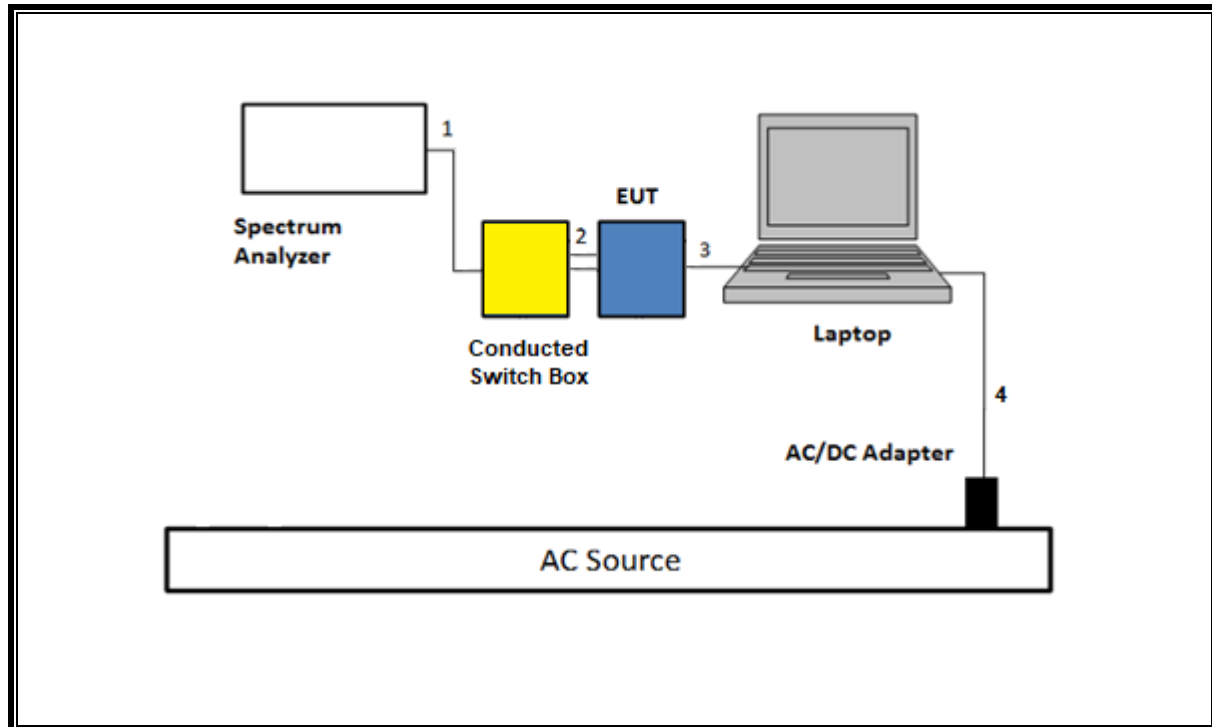
Note: In the Radiated Plots and emissions data, ANT0=ANT4 and ANT1=ANT3.

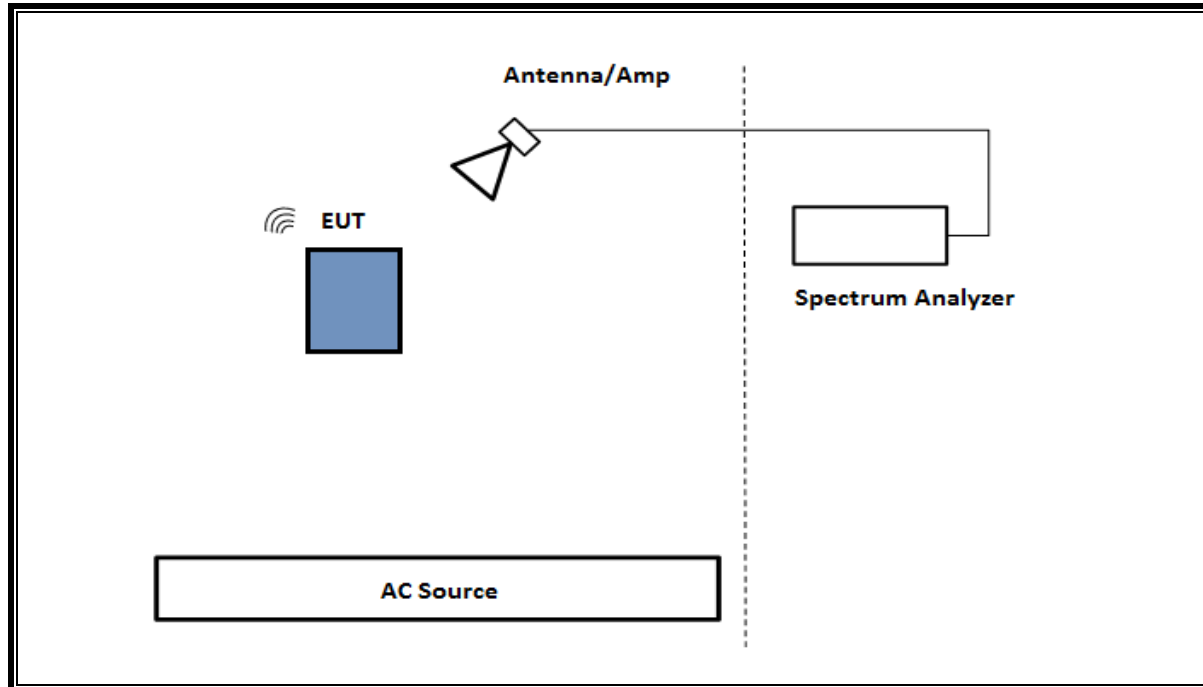
6.6. DESCRIPTION OF TEST SETUP

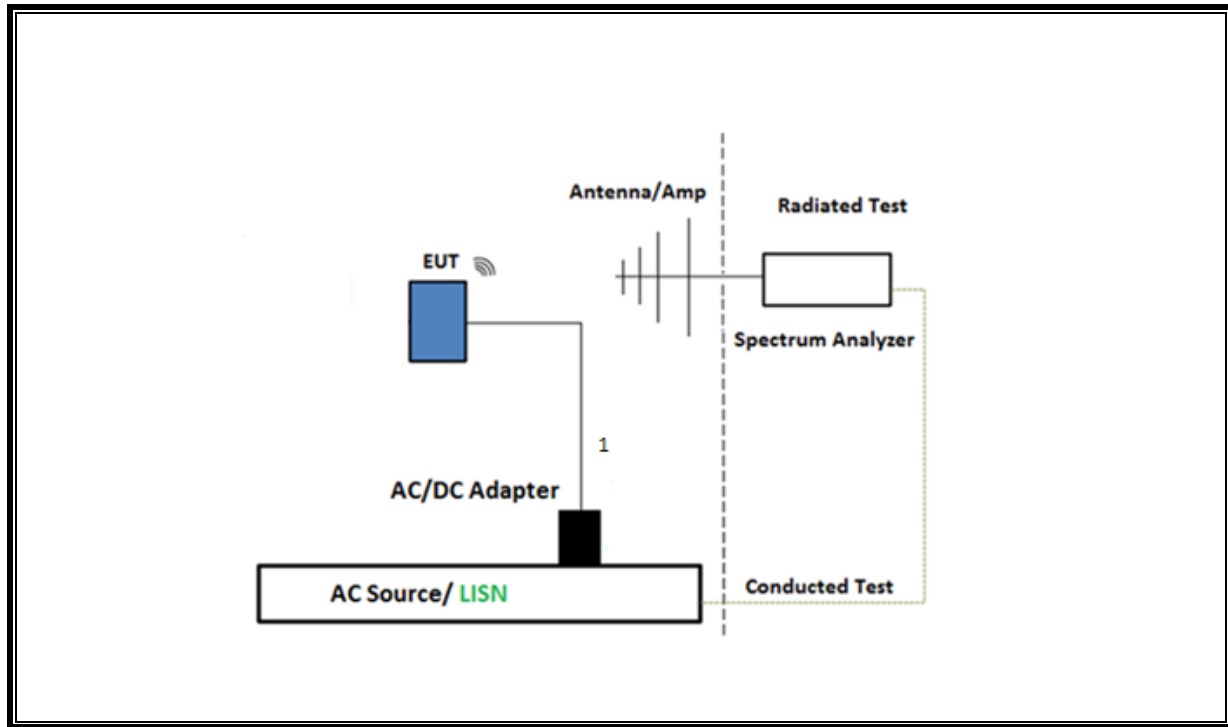
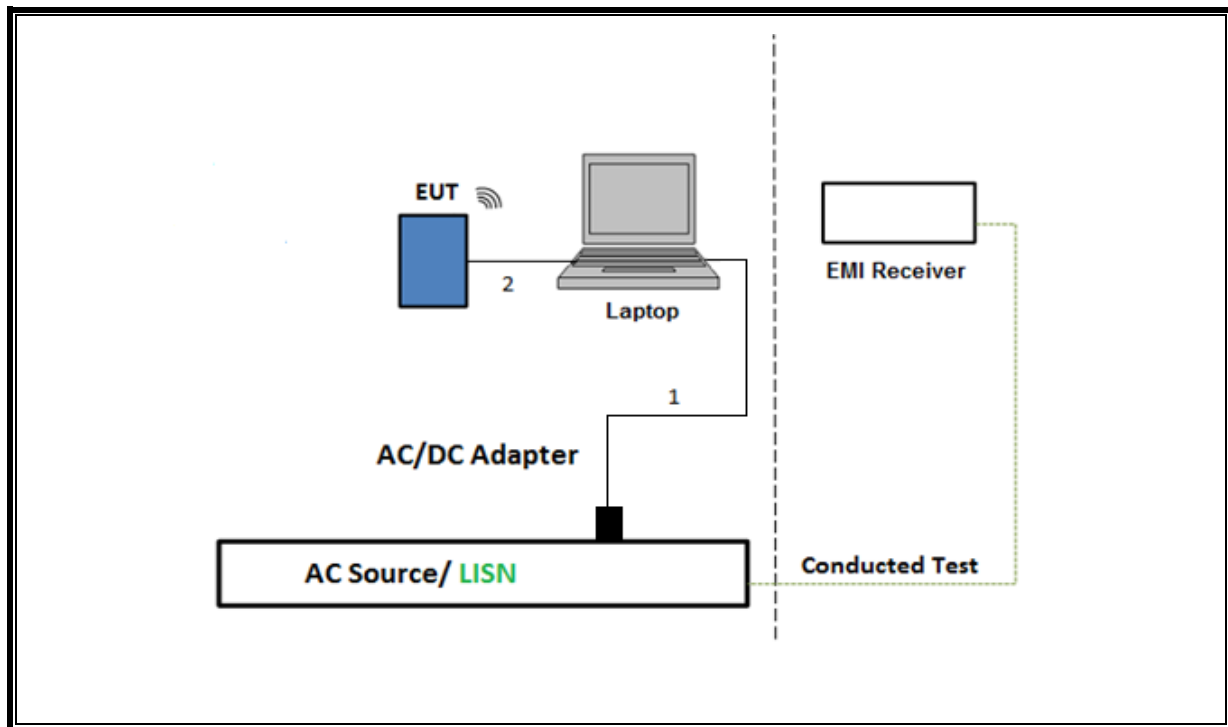
SUPPORT TEST EQUIPMENT						
Description		Manufacturer	Model	Serial Number	FCC ID/ DoC	
Laptop		Apple	Macbook Pro	C02VD7SAHV22	BCGA1708	
Laptop AC/DC adapter		Liteon Technology	A1424	NSW25679	DoC	
EUT AC/DC adapter		Apple	A1720	C3D8417A7R93KVPA8	DoC	
Conducted Switch Box		UL	n/a	208281	N/A	
10dB Fixed Attenuator, 2 Watts Up to 26.5 GHz		Pasternack Enterprises	PE7024-10	236358	N/A	
I/O CABLES (RF CONDUCTED TEST)						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	SMA	1	SMA	Shielded	0.75	To spectrum Analyzer
2	Antenna	2	SMA	Un-shielded	0.2	To Conducted Switch Box
3	USB-C	1	USB-C	Shielded	1.0	N/A
4	AC	1	AC	Un-shielded	2	N/A
I/O CABLES (RF RADIATED AND AC LINE CONDUCTED 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	Shielded	1	N/A

TEST SETUP

The EUT setup is shown as below. Test software exercised the radio card.

SETUP DIAGRAM FOR CONDUCTED TESTS

SETUP DIAGRAM FOR RADIATED TESTS Above 1 GHz

SETUP DIAGRAM FOR Below 1GHz and AC LINE CONDUCTED TEST**TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION**

7. TEST AND MEASUREMENT EQUIPMENT

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

Description	Manufacturer	Model	ID Num	Cal Due	Last Cal
Antenna, Horn 1-18GHz	ETS Lindgren	3117	230300	01/12/2024	01/12/2023
Filter Box, 1-18GHz 12 Port	UL-FR1	Frankenstein	217255	08/23/2023	08/23/2022
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	169936	02/29/2024	02/29/2023
Antenna, Horn 1-18GHz	ETS Lindgren	3117	226671	01/09/2024	01/09/2023
RF Filter Box, 1-18GHz, 17 Ports	UL-FR1	RATS 2	226781	04/30/2024	04/30/2023
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	169935	02/29/2024	02/29/2023
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	84796	09/19/2023	09/19/2022
Antenna, Broadband Hybrid, 30MHz to 3GHz	Sunol Sciences Corp	JB3	80714	10/06/2023	10/06/2022
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	204041	08/24/2023	08/24/2022
EMI Receiver	Rohde & Schwarz	ESW44	201498	02/29/2024	02/29/2023
*Antenna, Passive Loop 30Hz to 1MHz	Electro-Metrics	EM-6871	170013	07/28/2023	07/28/2022
*Antenna, Passive Loop 100KHz to 30MHz	ETS-Lindgren	EM-6872	170015	07/28/2023	07/28/2022
Link File, RF Amplifier Assembly, 18-26.5GHz, 60dB Gain	AMPLICAL	AMP18G26.5-60	221832	02/29/2024	02/29/2023
Power Sensor	Keysight	N1921A	90391	01/31/2024	01/31/2023
Power Meter, P-series single channel	Keysight	N1912A	90630	01/31/2024	01/31/2023
10dB Fixed Attenuator, 2 Watts Up to 26.5 GHz	Pasternack Enterprises	PE7024-10	236358	Verified/Characterized before use	
10dB Fixed Attenuator, 2 Watts Up to 26.5 GHz	Pasternack Enterprises	PE7024-10	236355	Verified/Characterized before use	
Conducted Switch Box	N/A	CSB	208281	04/30/2024	04/30/2023
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	80397	02/28/2024	02/28/2023
*Antenna Horn, 18 to 26.5GHz	ARA	MWH-1826/B	172353	06/01/2023	06/01/2022
RF Amplifier Assembly, 18-26.5GHz, 60dB Gain	AMPLICAL	AMP18G26.5-60	171583	02/29/2024	02/29/2023
AC Line Conducted					
Description	Manufacturer	Model	ID Num	Cal Due	Last Cal
EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESR	93091	02/29/2024	03/29/2023
LISN for Conducted Emissions CISPR-16	FISCHER CUSTOM COMMUNICATIONS	FCC-LISN-50/250-25-2-01-480V	175764	01/31/2024	01/31/2023
*Transient Limiter	TE	TBFL1	207996	07/15/2023	07/15/2022
UL AUTOMATION SOFTWARE					
Radiated Software	UL	UL EMC	Ver 9.5, May 1, 2023		
Conducted Software	UL	UL EMC	2020.8.16		
AC Line Conducted Software	UL	UL EMC	Ver 9.5, Mar 3, 2023		

*Equipment was set to test after calibration was done

8. MEASUREMENT METHODS

Test Item	Test Method
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

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

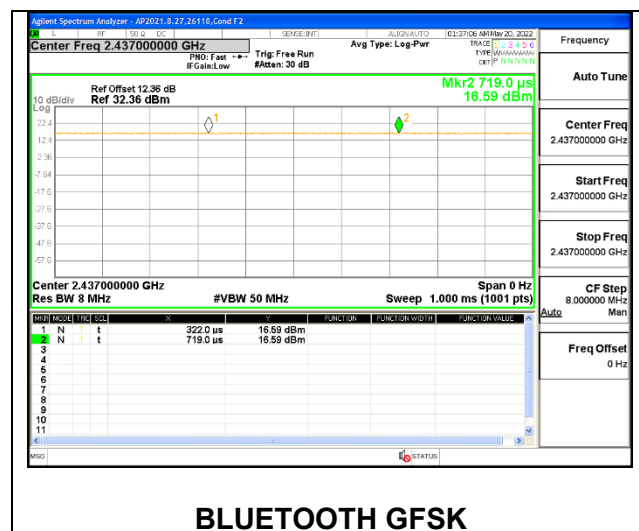
PROCEDURE

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	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

DUTY CYCLE PLOTS



Note: There are the same DC factor on 1TX and 2TX.

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 $\geq 1\%$ of the 20 dB bandwidth. The VBW is set to $\geq 3 \times \text{RBW}$. The sweep time is coupled.

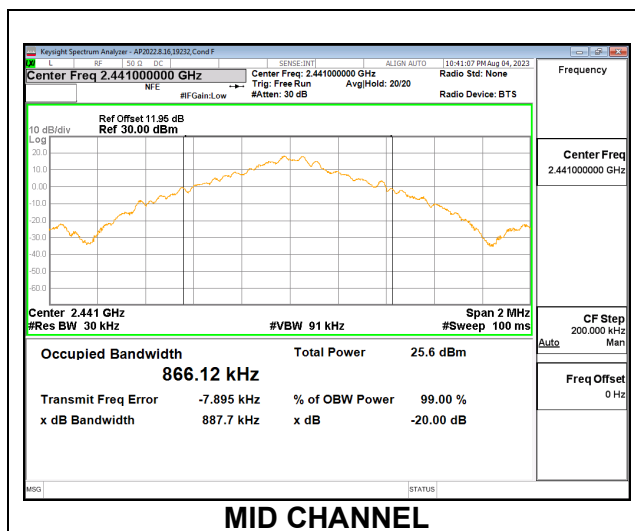
RESULTS

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.

9.2.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

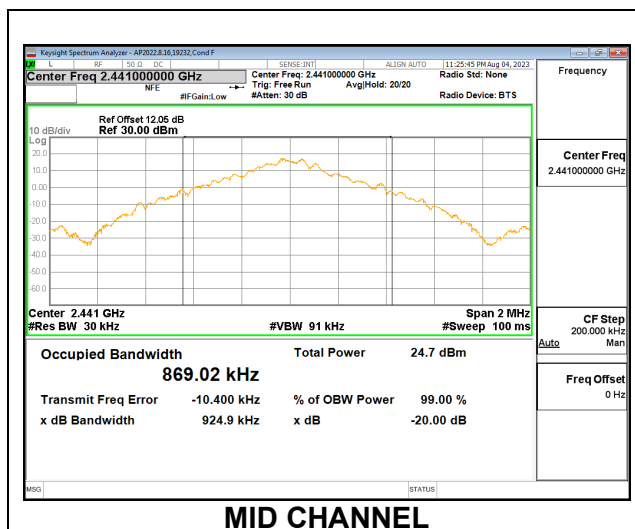
ANT 4

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.9243	0.86943
Mid	2441	0.8877	0.86612
High	2480	0.8894	0.86722



ANT 3

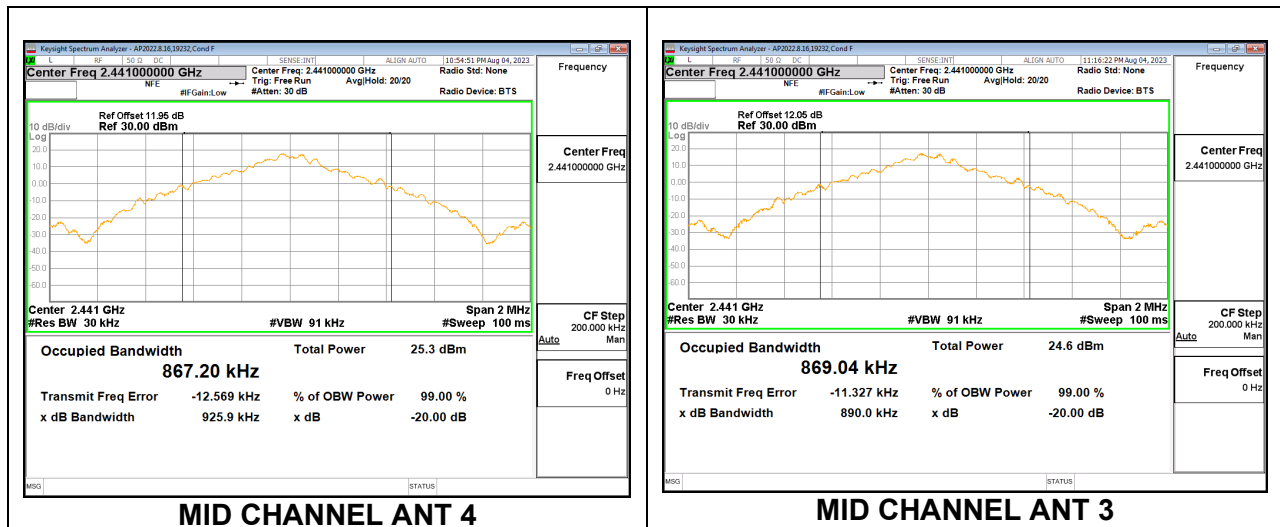
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	0.8892	0.86917
Mid	2441	0.9249	0.86902
High	2480	0.9235	0.86791



9.2.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

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

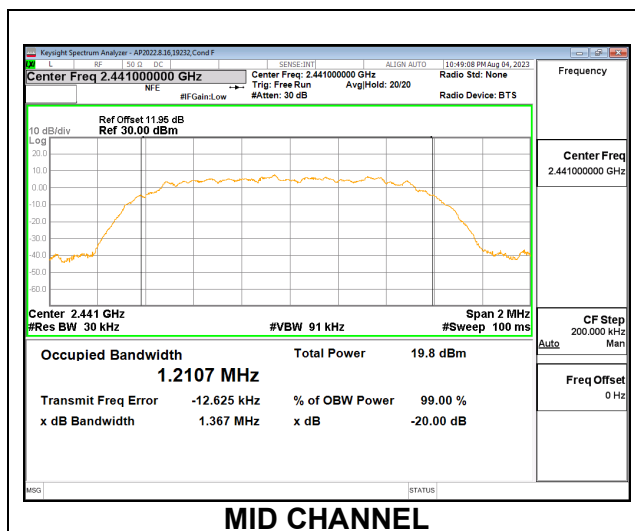
Channel	Frequency (MHz)	20dB Bandwidth ANT 4 (MHz)	20dB Bandwidth ANT 3 (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	0.8896	0.9229	0.86811	0.86957
Mid	2441	0.9259	0.8900	0.86720	0.86904
High	2480	0.8895	0.8695	0.86680	0.86907



9.2.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

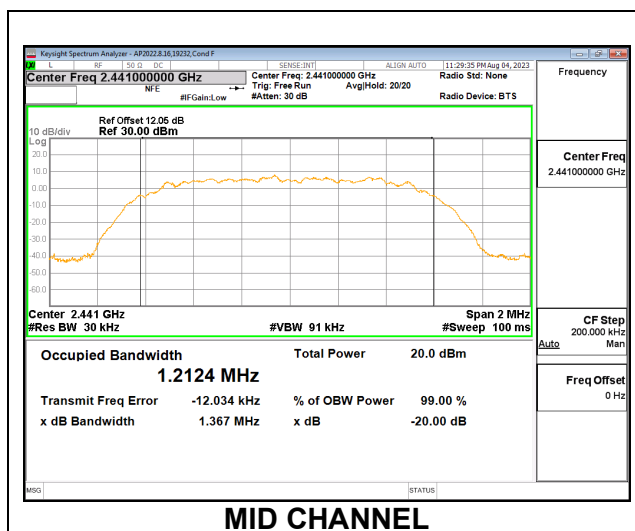
ANT 4

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.368	1.2101
Mid	2441	1.367	1.2107
High	2480	1.366	1.2094



ANT 3

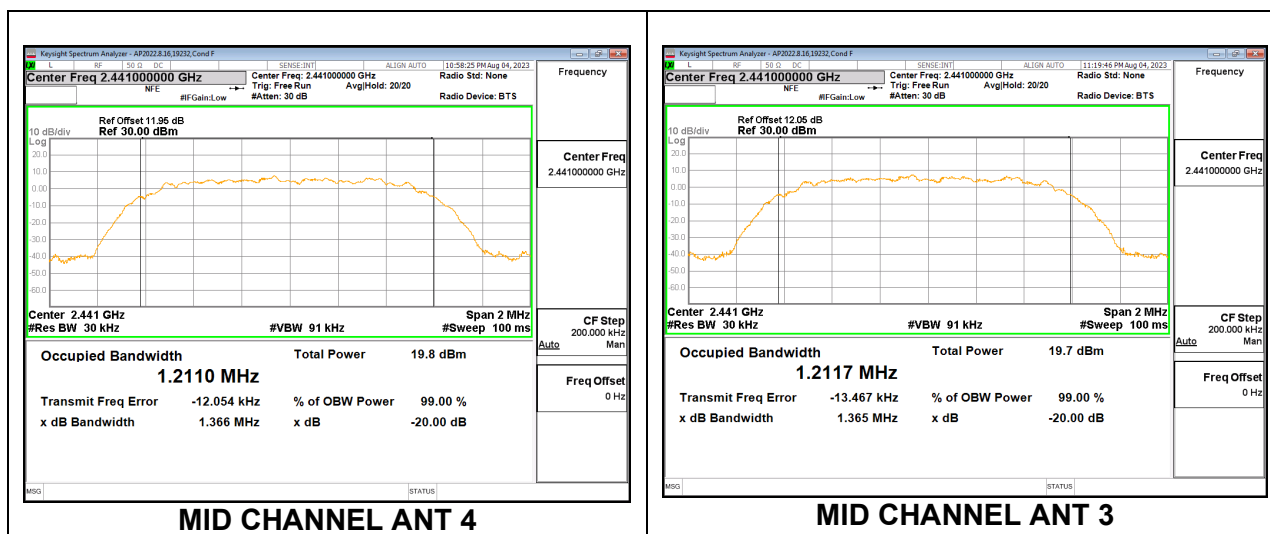
Channel	Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low	2402	1.369	1.2125
Mid	2441	1.367	1.2124
High	2480	1.364	1.2108



9.2.4. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

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

Channel	Frequency (MHz)	20dB Bandwidth ANT 4 (MHz)	20dB Bandwidth ANT 3 (MHz)	99% Bandwidth ANT 4 (MHz)	99% Bandwidth ANT 3 (MHz)
Low	2402	1.370	1.371	1.2116	1.2120
Mid	2441	1.366	1.365	1.2110	1.2117
High	2480	1.370	1.369	1.2110	1.2116



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 hopping 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

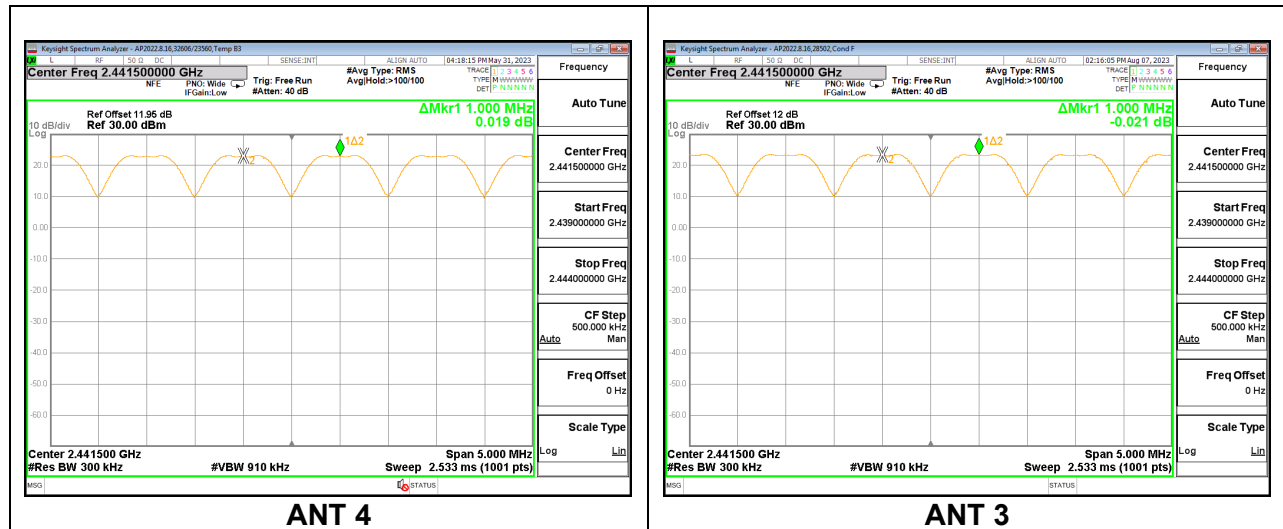
The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to $VBW \geq 3 \times RBW$. The sweep time is coupled.

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



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

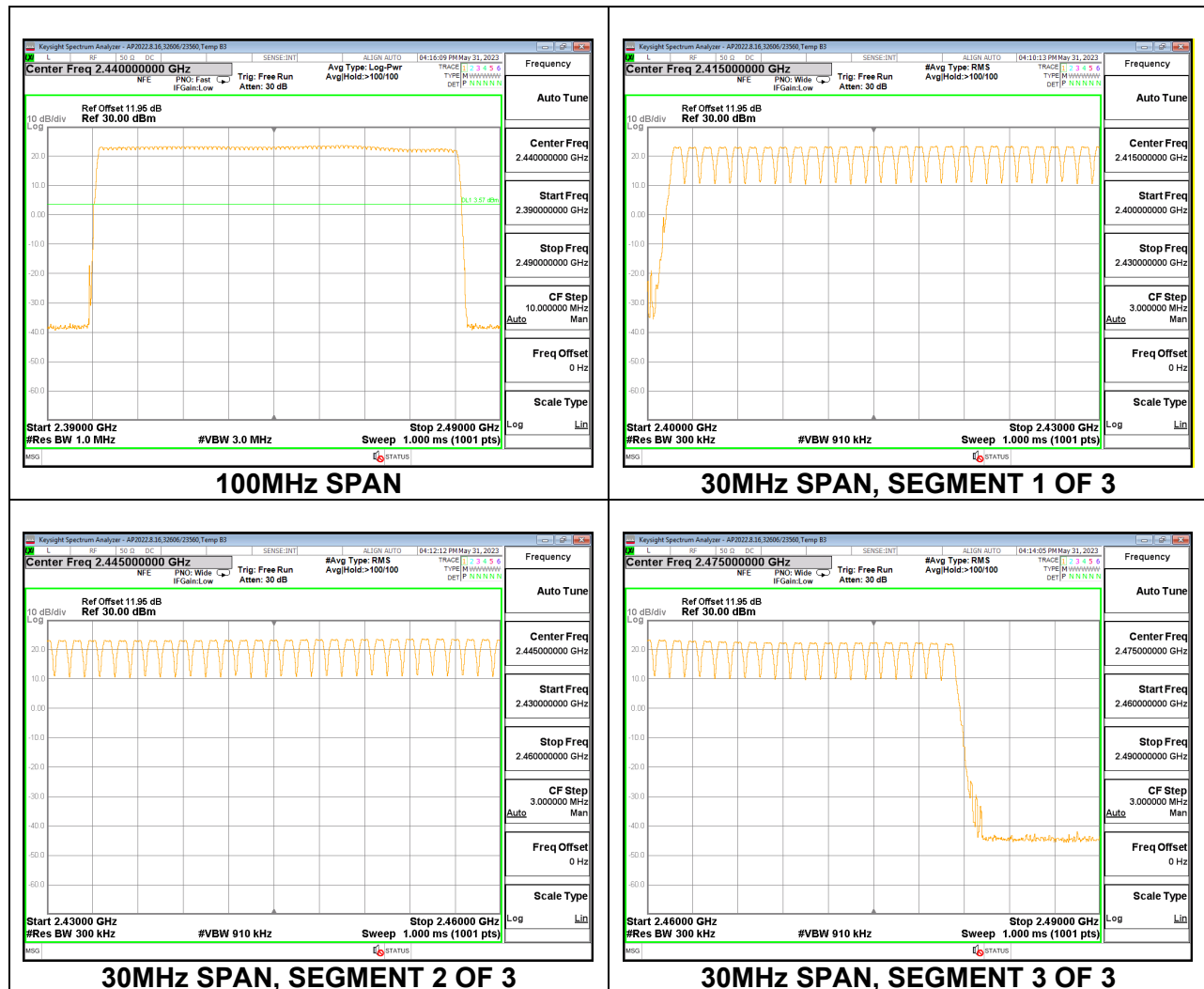
The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

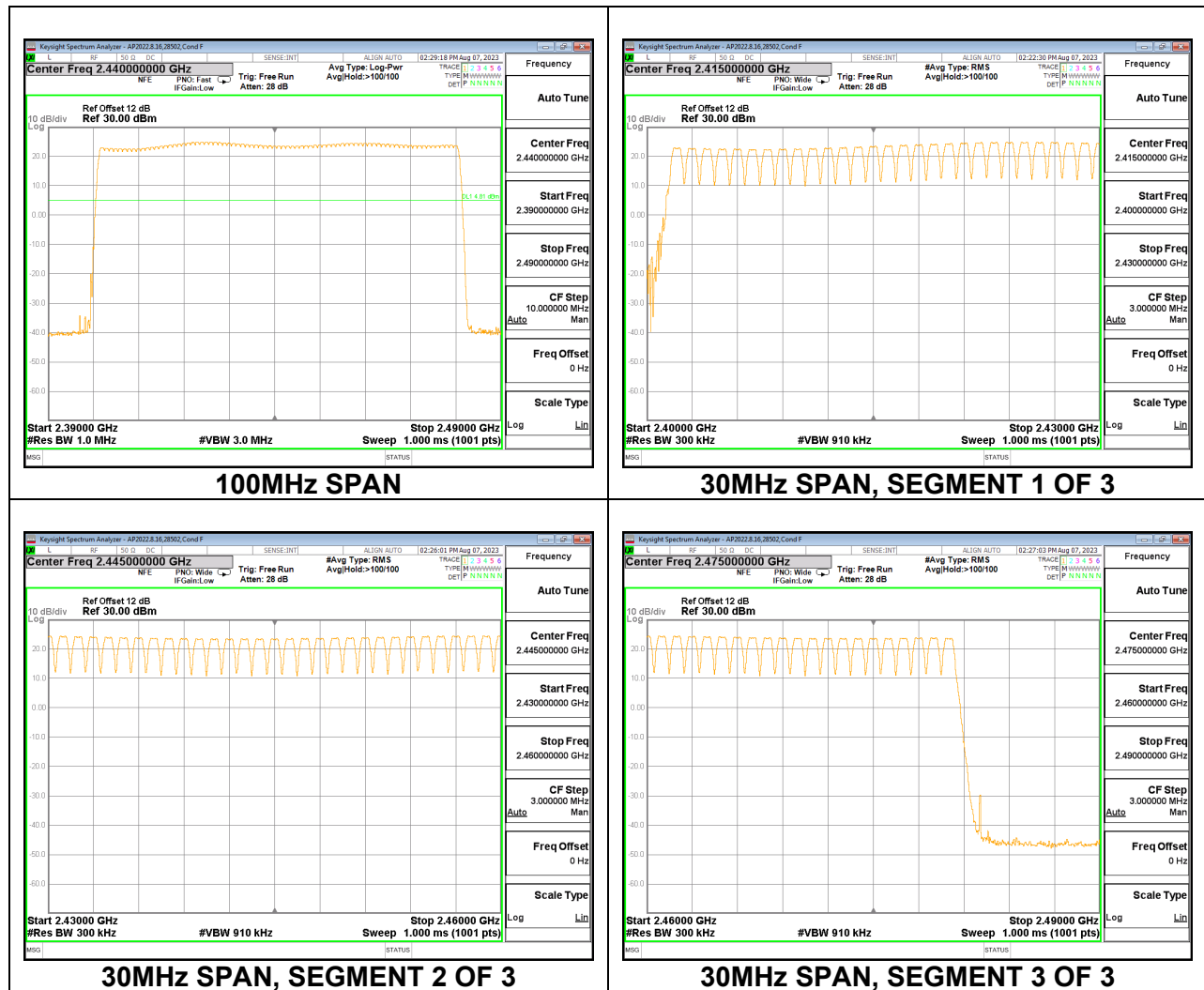
RESULTS

Normal Mode: 79 Channels Observed. Only High Power GFSK mode result is reported since EDR (QPSK/8PSK) has exact same channel plan.

9.4.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 4



ANT 3

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 $10 * (\# \text{ of pulses in } 3.16 \text{ s}) * \text{pulse width}$.

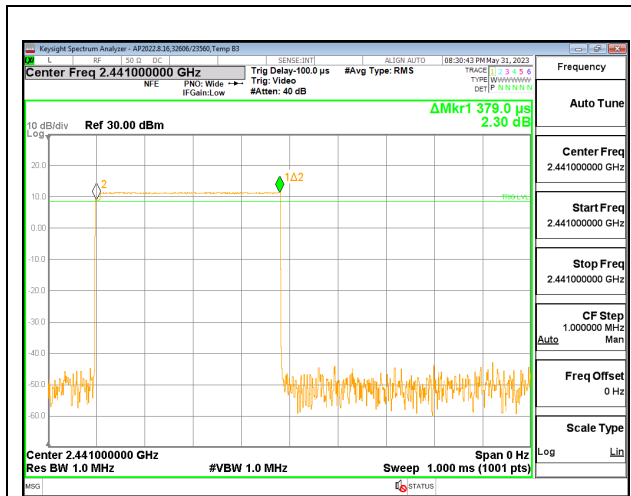
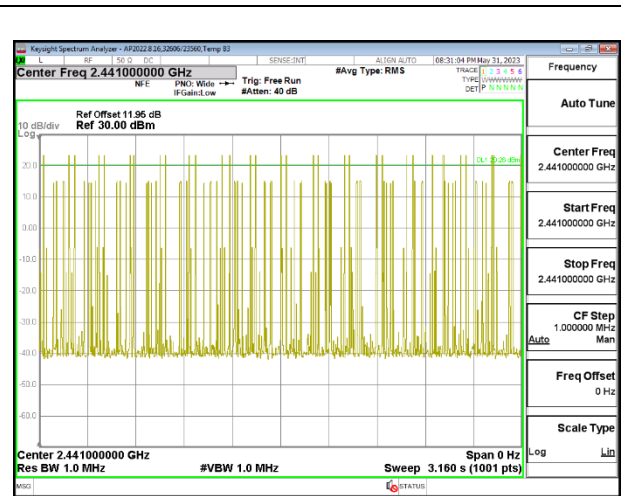
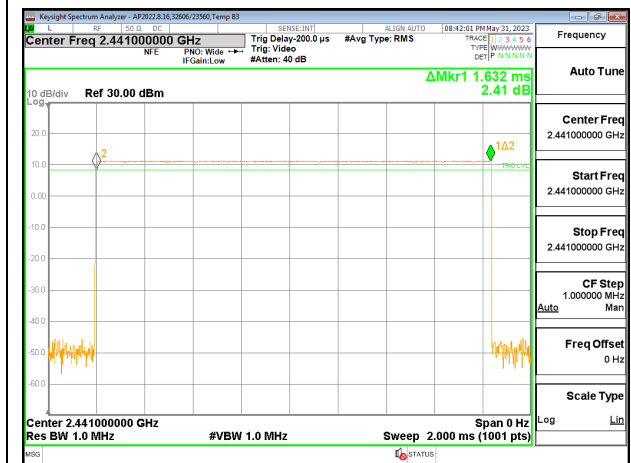
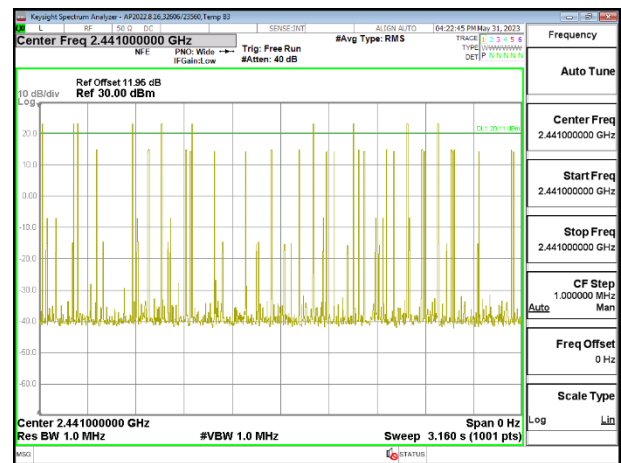
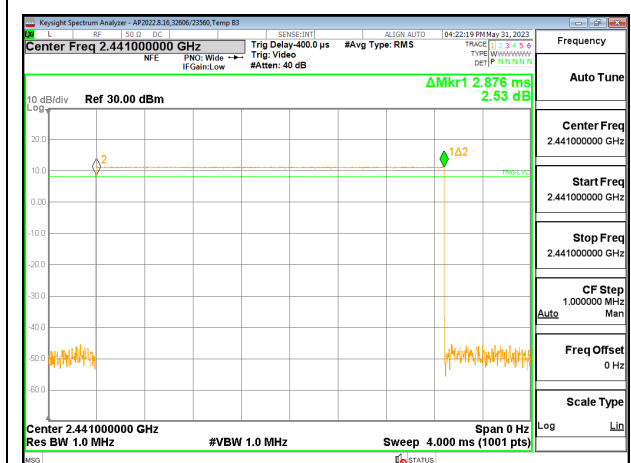
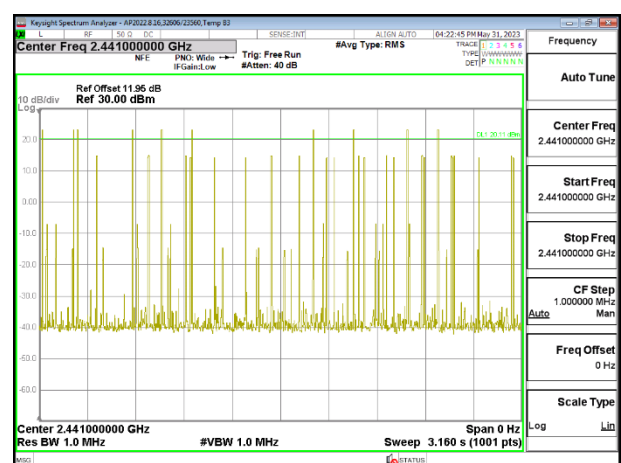
For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to $10 * (\# \text{ of pulses in } 0.8 \text{ s}) * \text{pulse width}$.

RESULTS

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

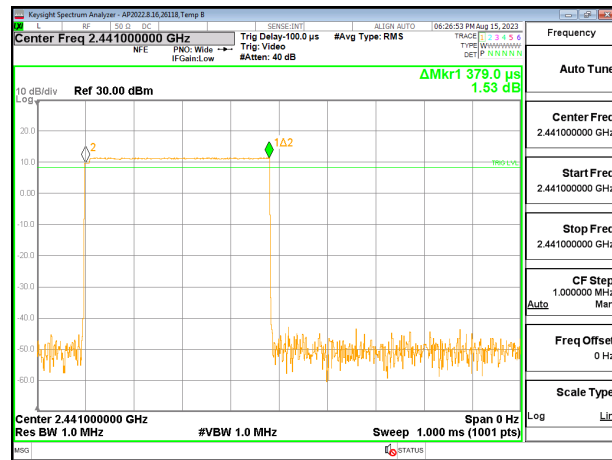
9.5.1. HIGH POWER BASIC DATA RATE GFSK MODULATION**ANT 4**

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	30	0.114	0.4	-0.286
DH3	1.632	16	0.261	0.4	-0.139
DH5	2.876	10	0.288	0.4	-0.112
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	7.5	0.028	0.4	-0.372
DH3	1.632	4	0.065	0.4	-0.335
DH5	2.876	2.5	0.072	0.4	-0.328

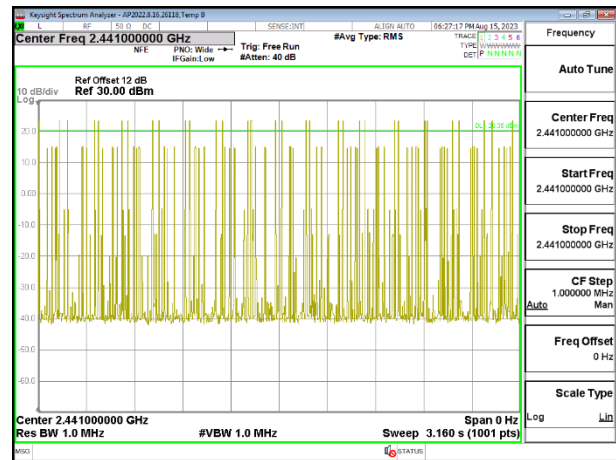
**PULSE WIDTH – DH1****NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH1****PULSE WIDTH – DH3****NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH3****PULSE WIDTH – DH5****NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH5**

ANT 3

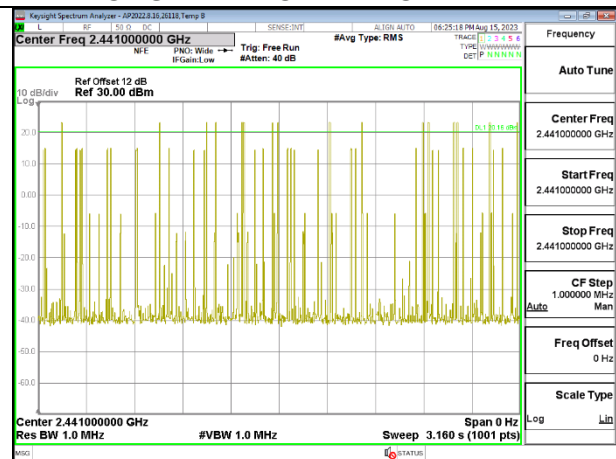
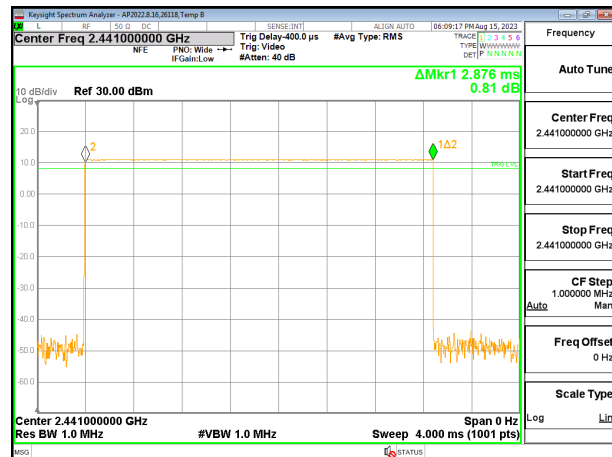
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
FSK Normal Mode					
DH1	0.379	31	0.117	0.4	-0.283
DH3	1.632	16	0.261	0.4	-0.139
DH5	2.876	8	0.230	0.4	-0.170
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
FSK AFH Mode					
DH1	0.379	7.75	0.029	0.4	-0.371
DH3	1.632	4	0.065	0.4	-0.335
DH5	2.876	2	0.058	0.4	-0.342



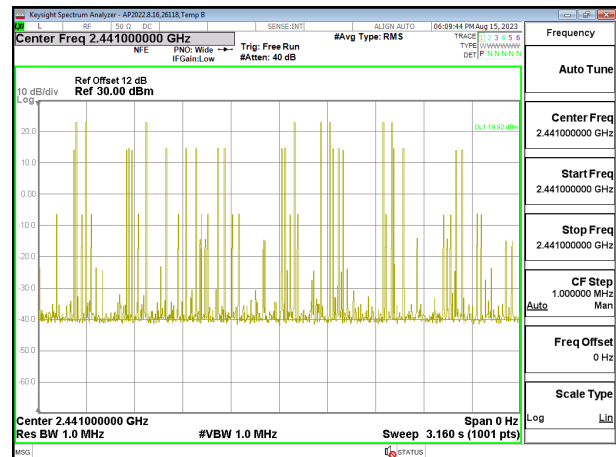
PULSE WIDTH – DH1

NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH1

PULSE WIDTH – DH3

NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH3

PULSE WIDTH – DH5

NUMBER OF PULSES IN 3.16 SECOND
OBSERVATION PERIOD – DH5

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 was perform using a power meter with wideband peak power sensor.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter via wideband peak power sensor. Peak output power was read directly from the power meter.

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 Gain (dBi)	ANT 3 Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	-1.10	-0.90	-1.00	2.01

DIRECTIONAL GAIN CALCULATION:

ANSI C63.10-2013 section 14.4.3

Uncorrelated directional gain= $10 \cdot \text{LOG}((10^{(\text{Ant1}/10)} + 10^{(\text{Ant2}/10)})/2)$

Correlated directional Gain= $10 \cdot \text{LOG}(((10^{(\text{Ant1}/20)} + 10^{(\text{Ant2}/20)})^2)/2)$

Sample Calculation:

Ant4=-1.10, Ant3=-0.9

Uncorrelated Antenna gain= $10 \log[(10^{(-1.10/10)} + 10^{(-0.9/10)})/2] = -1.00 \text{ dBi}$

Correlated Antenna gain= $10 \log[(10^{(-1.10/20)} + 10^{(-0.9/20)})^2/2] = 2.01 \text{ dBi}$

RESULTS

9.6.1. HIGH POWER BASIC DATA RATE GFSK MODULATION**ANT 4**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.15	21	-0.85
Middle	2441	20.15	21	-0.85
High	2480	20.09	21	-0.91

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	20.10	21	-0.9
Middle	2441	20.12	21	-0.88
High	2480	20.14	21	-0.86

9.6.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2015

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.12	17.10	20.12	21	-0.88
Middle	2441	17.14	17.09	20.13	21	-0.87
High	2480	17.09	17.11	20.11	21	-0.89

9.6.3. HIGH POWER ENHANCED DATA RATE QPSK MODULATION**ANT 4**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.04	21	-1.96
Middle	2441	19.02	21	-1.98
High	2480	19.00	21	-2

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.97	21	-2.03
Middle	2441	19.03	21	-1.97
High	2480	18.99	21	-2.01

9.6.4. HIGH POWER ENHANCED DATA RATE TXBF QPSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	16.10	16.08	19.10	21	-1.90
Middle	2441	16.07	16.09	19.09	21	-1.91
High	2480	16.03	16.05	19.05	21	-1.95

9.6.5. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION**ANT 4**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.23	21	-1.77
Middle	2441	19.28	21	-1.72
High	2480	19.26	21	-1.74

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.19	21	-1.81
Middle	2441	19.24	21	-1.76
High	2480	19.25	21	-1.75

9.6.6. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION**ANT 4 + ANT 3**

Tested By:	2
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	16.21	16.21	19.22	21	-1.78
Middle	2441	16.23	16.23	19.24	21	-1.76
High	2480	16.20	16.22	19.22	21	-1.78

9.6.7. LOW POWER BASIC DATA RATE GFSK MODULATION**ANT 4**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.12	21	-9.88
Middle	2441	11.15	21	-9.85
High	2480	11.14	21	-9.86

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	12.60	21	-8.4
Middle	2441	12.62	21	-8.38
High	2480	12.61	21	-8.39

9.6.8. LOW POWER BASIC DATA RATE TXBF GFSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.12	12.60	14.93	21	-6.07
Middle	2441	11.14	12.64	14.96	21	-6.04
High	2480	11.13	12.63	14.95	21	-6.05

9.6.9. LOW POWER ENHANCED DATA RATE QPSK MODULATION**ANT 4**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.02	21	-9.98
Middle	2441	11.05	21	-9.95
High	2480	11.03	21	-9.97

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.01	21	-9.99
Middle	2441	11.02	21	-9.98
High	2480	10.99	21	-10.01

9.6.10. LOW POWER ENHANCED DATA RATE TXBF QPSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.06	11.00	14.04	21	-6.96
Middle	2441	11.04	11.05	14.06	21	-6.94
High	2480	11.01	11.02	14.03	21	-6.97

9.6.11. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.21	21	-9.79
Middle	2441	11.23	21	-9.77
High	2480	11.22	21	-9.78

ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.19	21	-9.81
Middle	2441	11.23	21	-9.77
High	2480	11.21	21	-9.79

9.6.12. LOW POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Output Power ANT 4 (dBm)	Output Power ANT 3 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	11.24	11.22	14.24	21	-6.76
Middle	2441	11.26	11.25	14.27	21	-6.73
High	2480	11.23	11.21	14.23	21	-6.77

9.7. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

Measurements was performed using a power meter with wideband average power sensor.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter via wideband average power sensor. Gated average output power was read directly from power meter.

RESULTS

9.7.1. HIGH POWER BASIC DATA RATE GFSK MODULATION**ANT 4**

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.71
Middle	2441	19.73
High	2480	19.69

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	19.70
Middle	2441	19.72
High	2480	19.73

9.7.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	16.70	16.71	19.72
Middle	2441	16.72	16.69	19.72
High	2480	16.68	16.70	19.70

9.7.3. HIGH POWER ENHANCED DATA RATE QPSK MODULATION**ANT 4**

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.20
Middle	2441	16.19
High	2480	16.17

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.18
Middle	2441	16.21
High	2480	16.19

9.7.4. HIGH POWER ENHANCED DATA RATE TXBF QPSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	13.24	13.22	16.24
Middle	2441	13.22	13.23	16.24
High	2480	13.17	13.20	16.20

9.7.5. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION**ANT 4**

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.21
Middle	2441	16.25
High	2480	16.22

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	16.22
Middle	2441	16.24
High	2480	16.25

9.7.6. HIGH POWER ENHANCED DATA RATE TXBF 8PSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	13.23	13.22	16.24
Middle	2441	13.24	13.23	16.25
High	2480	13.19	13.21	16.21

9.7.7. LOW POWER BASIC DATA RATE GFSK MODULATION**ANT 4**

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	10.71
Middle	2441	10.74
High	2480	10.72

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	12.20
Middle	2441	12.22
High	2480	12.19

9.7.8. LOW POWER BASIC DATA RATE TXBF GFSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	10.70	12.23	14.54
Middle	2441	10.75	12.25	14.57
High	2480	10.73	12.20	14.54

9.7.9. LOW POWER ENHANCED DATA RATE QPSK MODULATION**ANT 4**

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.20
Middle	2441	8.21
High	2480	8.19

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.19
Middle	2441	8.19
High	2480	8.18

9.7.10. LOW POWER ENHANCED DATA RATE TXBF QPSK MODULATION**ANT 4 + ANT 3**

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	8.21	8.17	11.20
Middle	2441	8.20	8.21	11.22
High	2480	8.18	8.19	11.20

9.7.11. LOW POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.22
Middle	2441	8.24
High	2480	8.21

ANT 3

Tested By:	19232
Date	8/4/23

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	8.23
Middle	2441	8.25
High	2480	8.24

9.7.12. LOW POWER ENHANCED DATA RATE TXBF 8PSK MODULATION

ANT 4 + ANT 3

Tested By:	19232
Date:	8/4/2023

Channel	Frequency (MHz)	Average Power ANT 4 (dBm)	Average Power ANT 3 (dBm)	Total Power (dBm)
Low	2402	8.23	8.22	11.24
Middle	2441	8.25	8.24	11.26
High	2480	8.22	8.20	11.22

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.

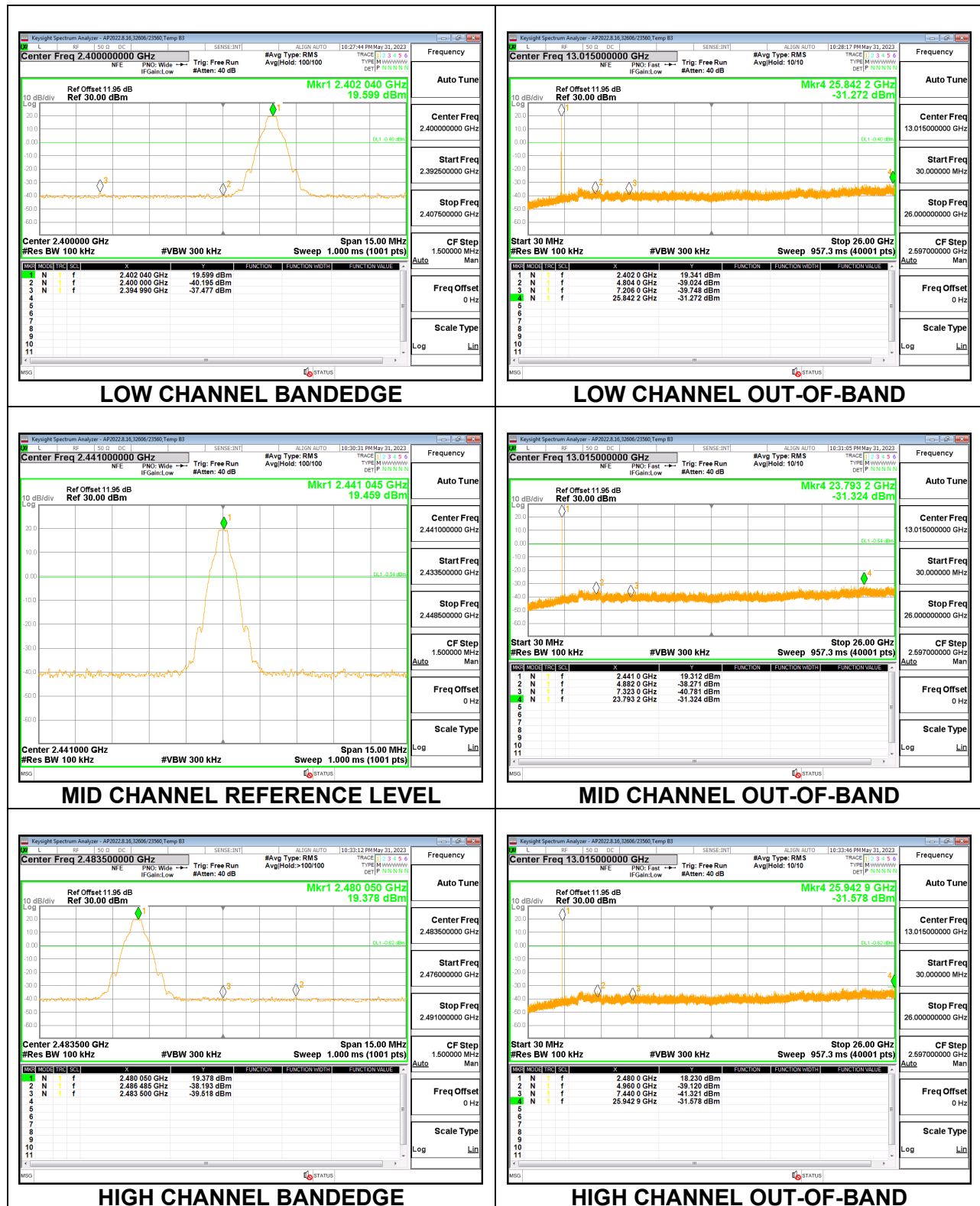
The band edges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

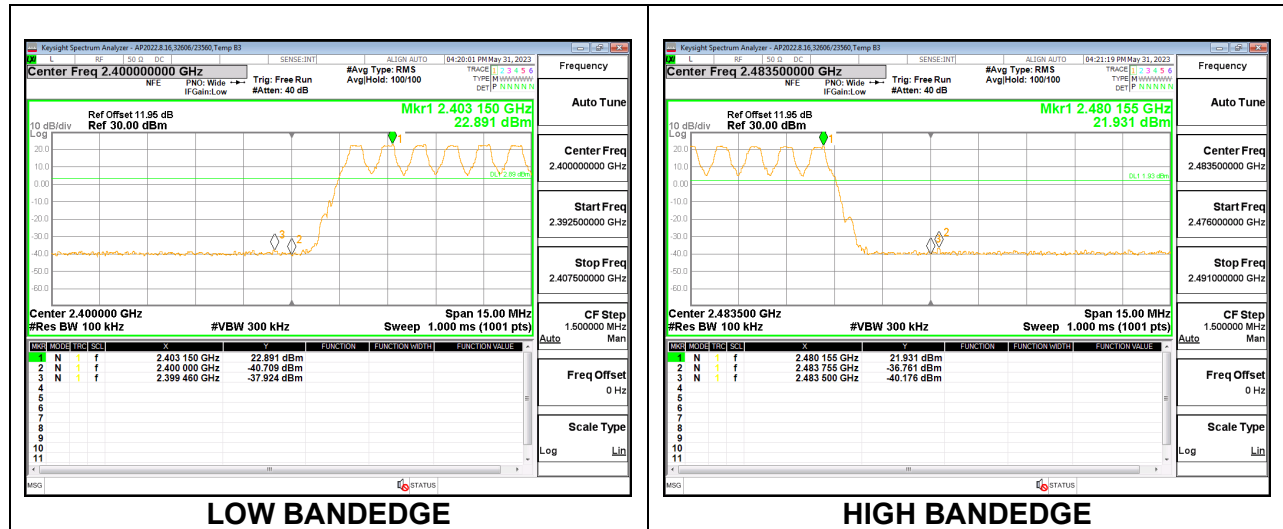
Note: Test procedure on Beamforming mode is same as BT BDR and EDR mode.

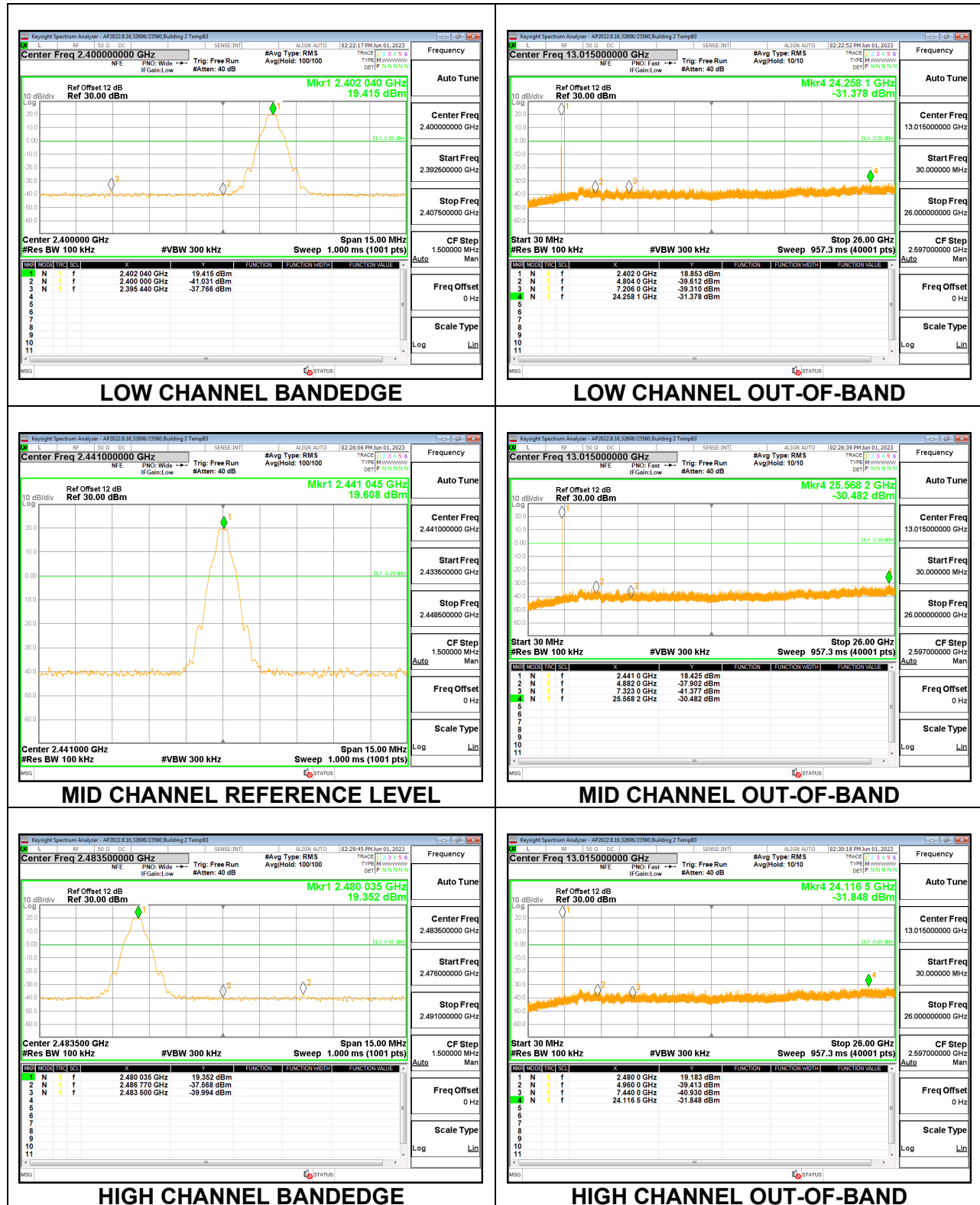
RESULTS

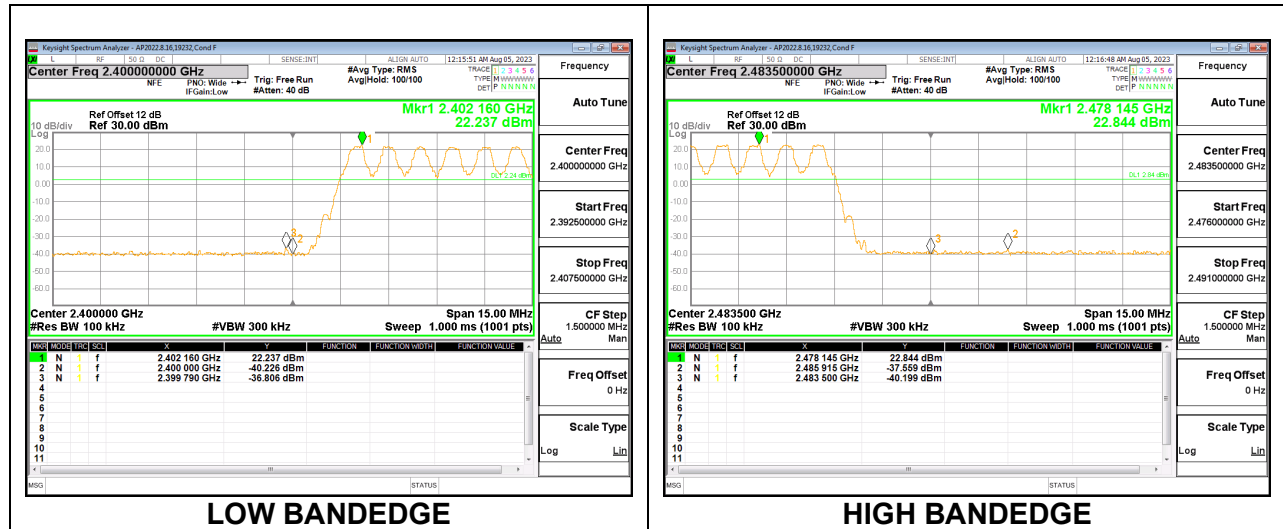
9.8.1. HIGH POWER BASIC DATA RATE GFSK MODULATION

ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



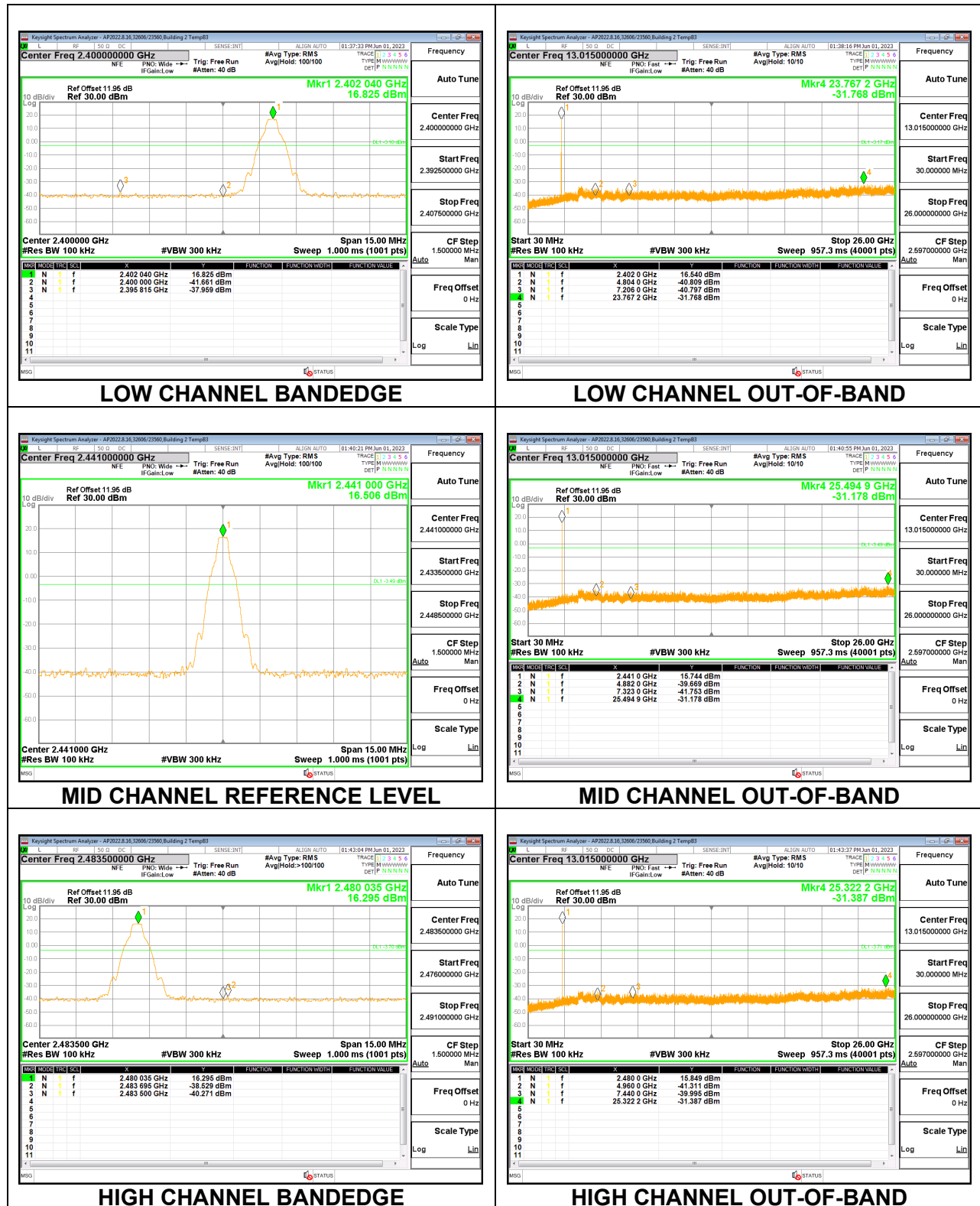
ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

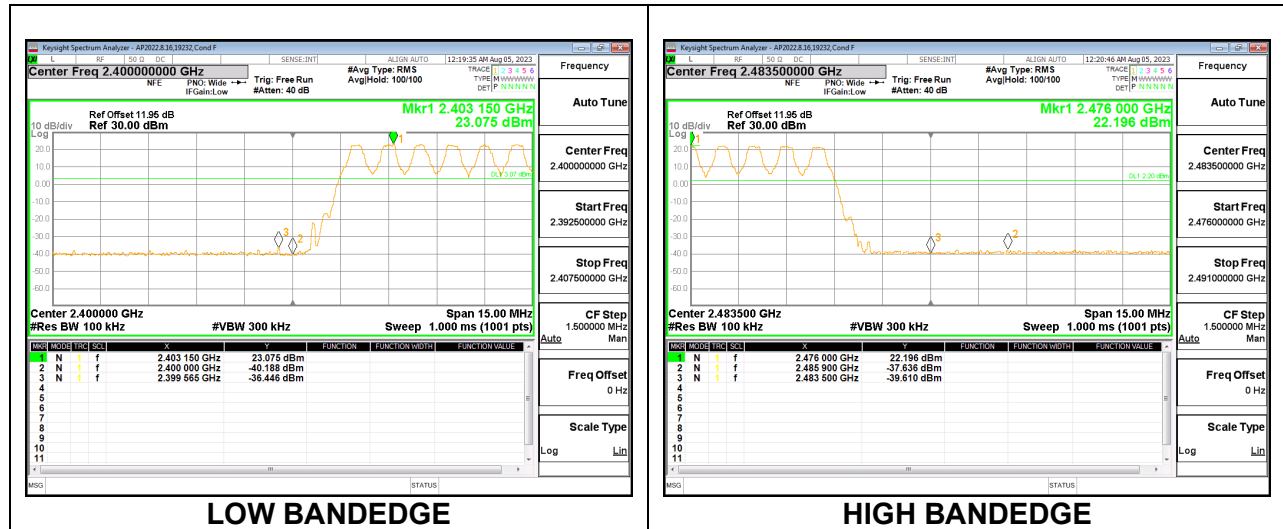
ANT 3 SPURIOUS EMISSIONS, NON-HOPPING

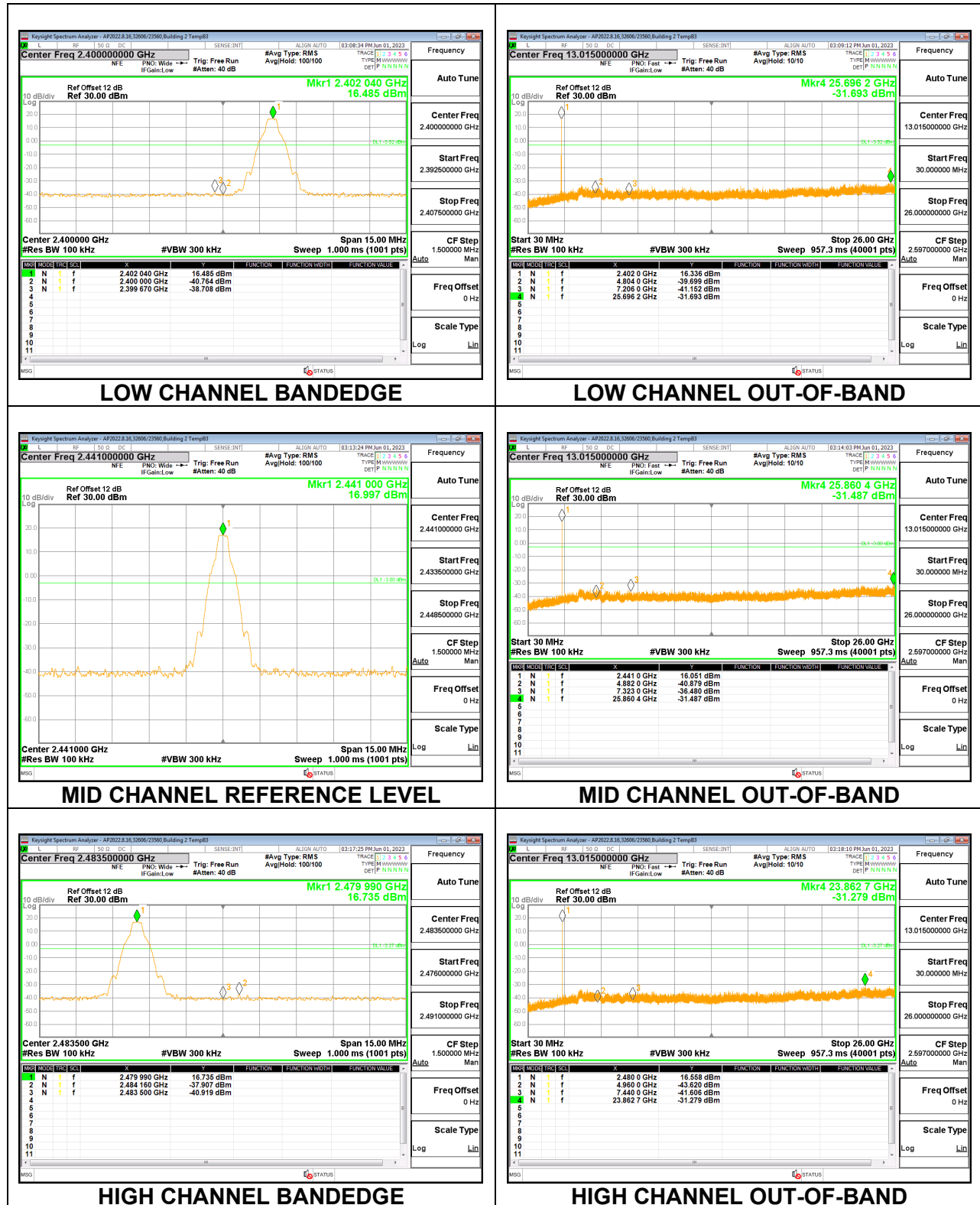
ANT 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON [Retest ~low power]

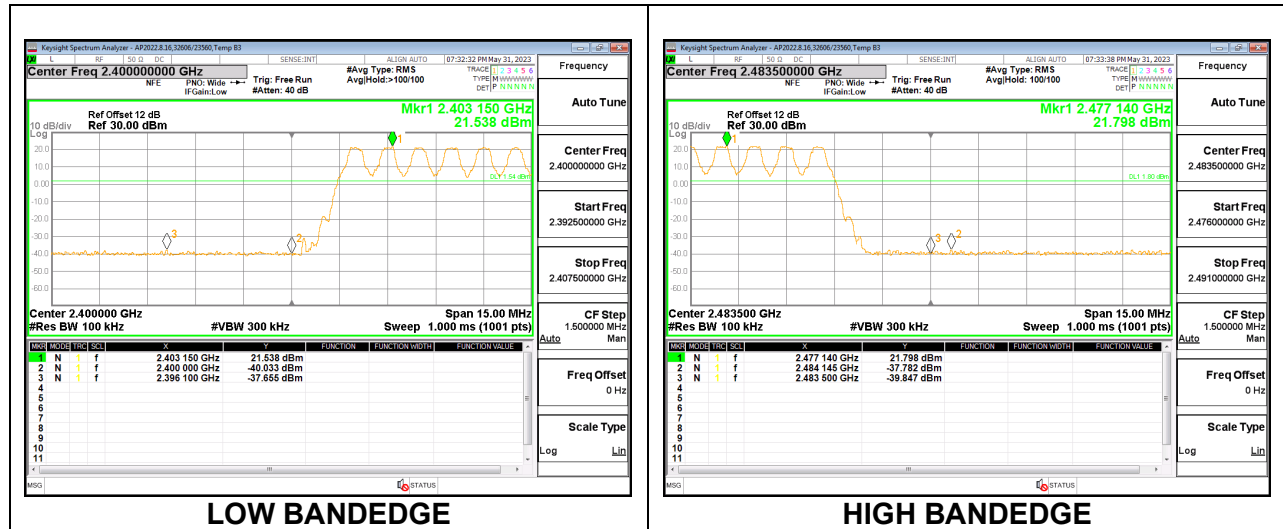
9.8.2. HIGH POWER BASIC DATA RATE TXBF GFSK MODULATION

ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



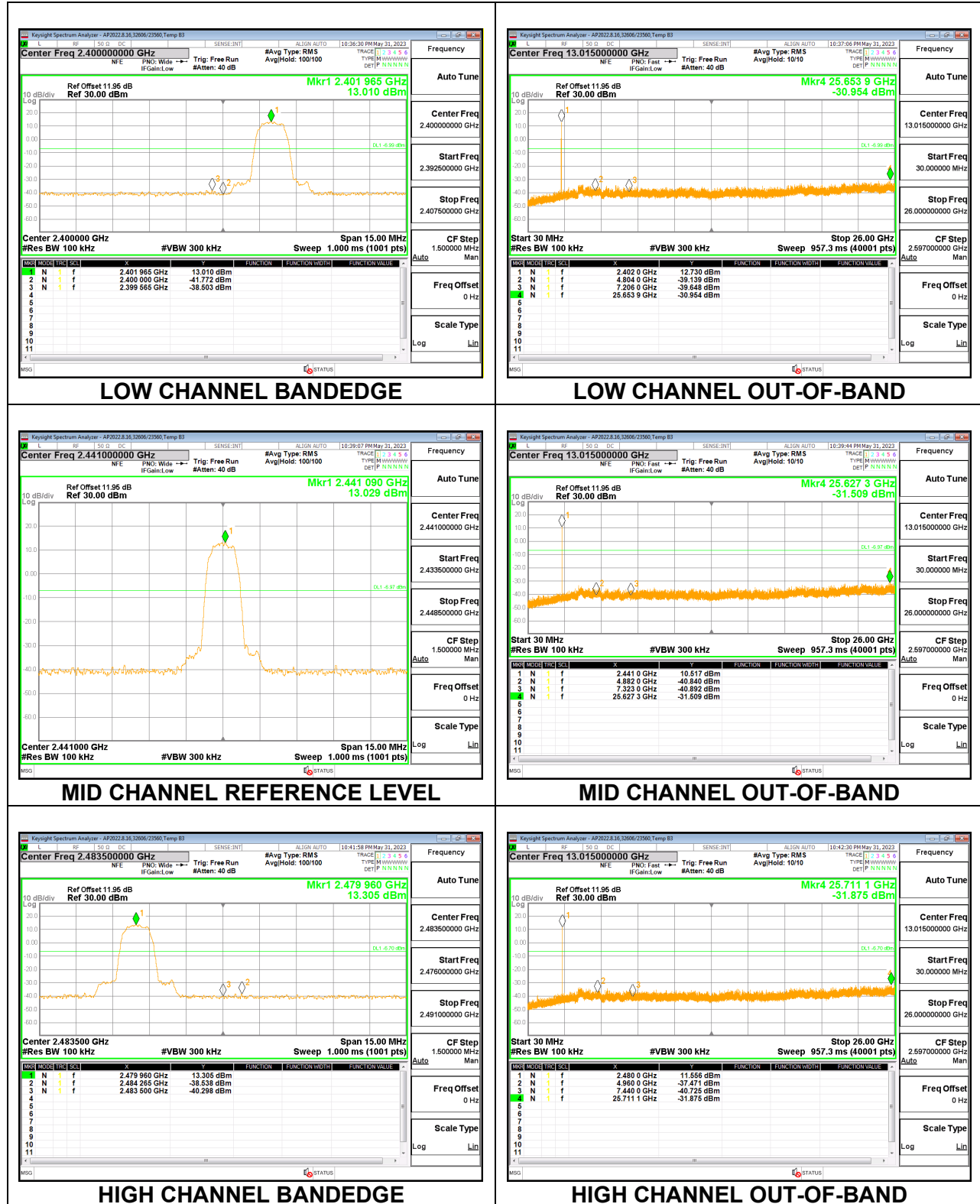
ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

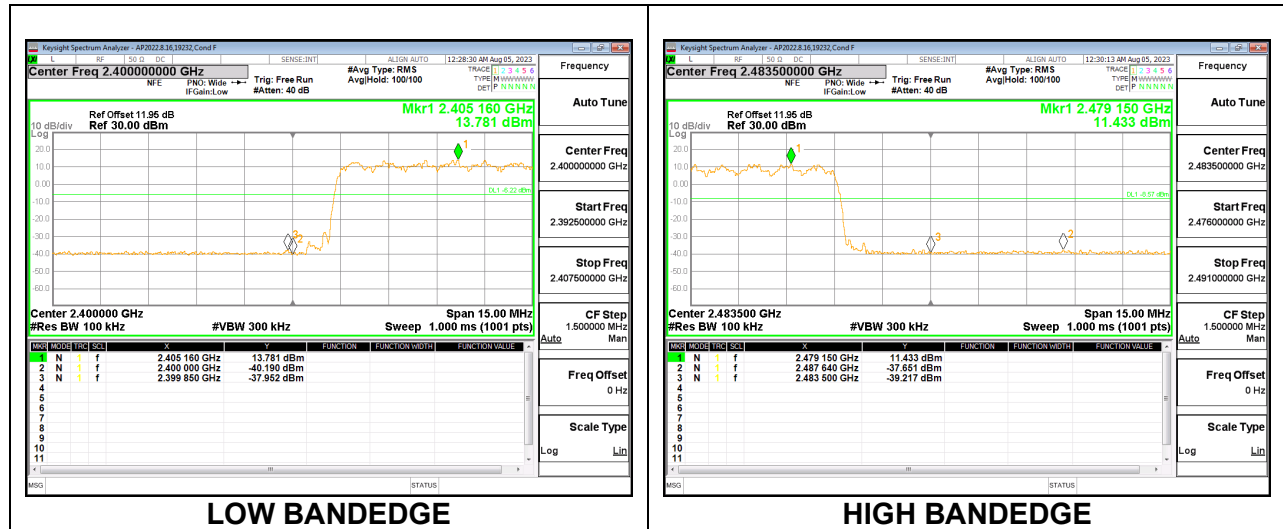
ANT 3 SPURIOUS EMISSIONS, NON-HOPPING

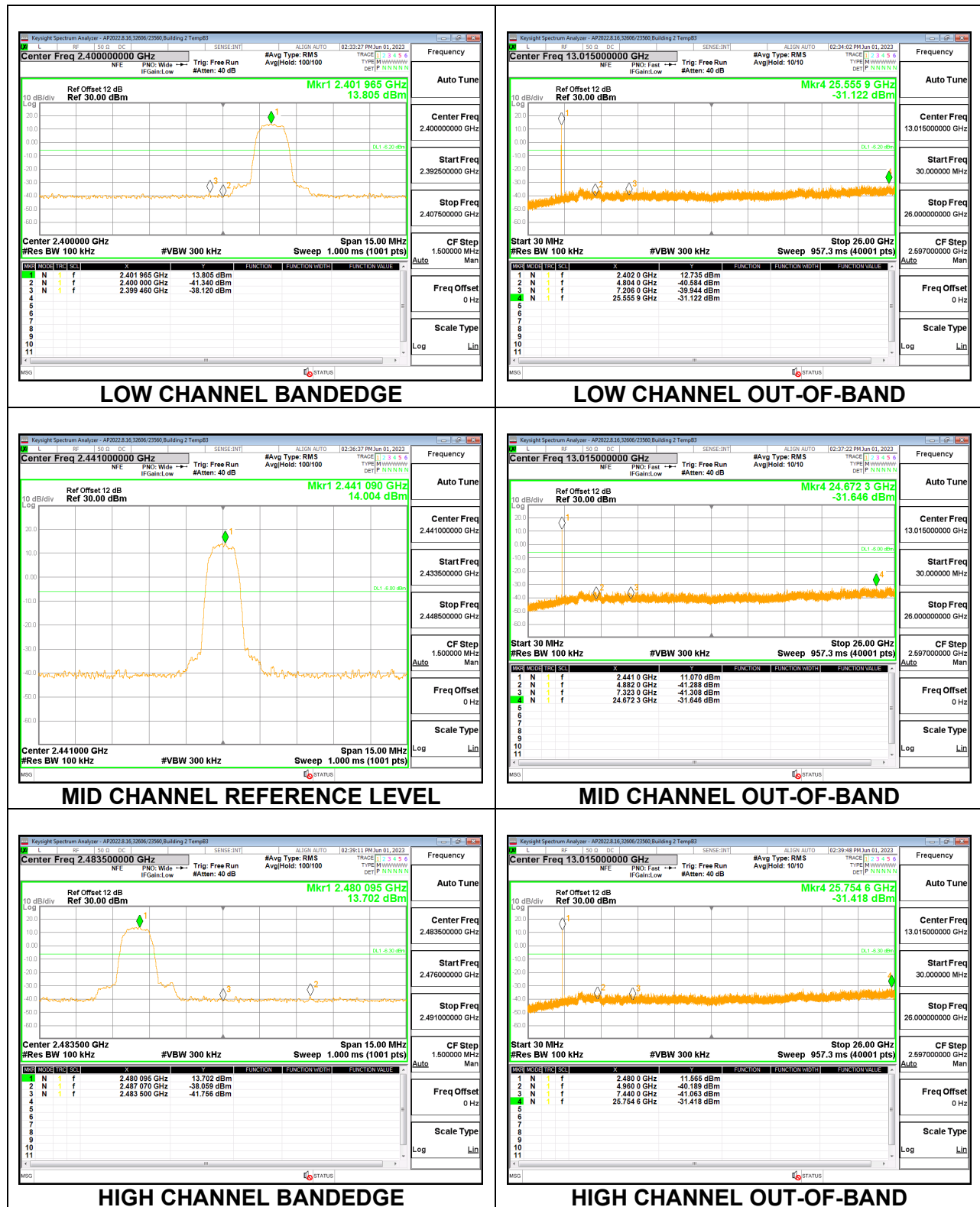
ANT 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

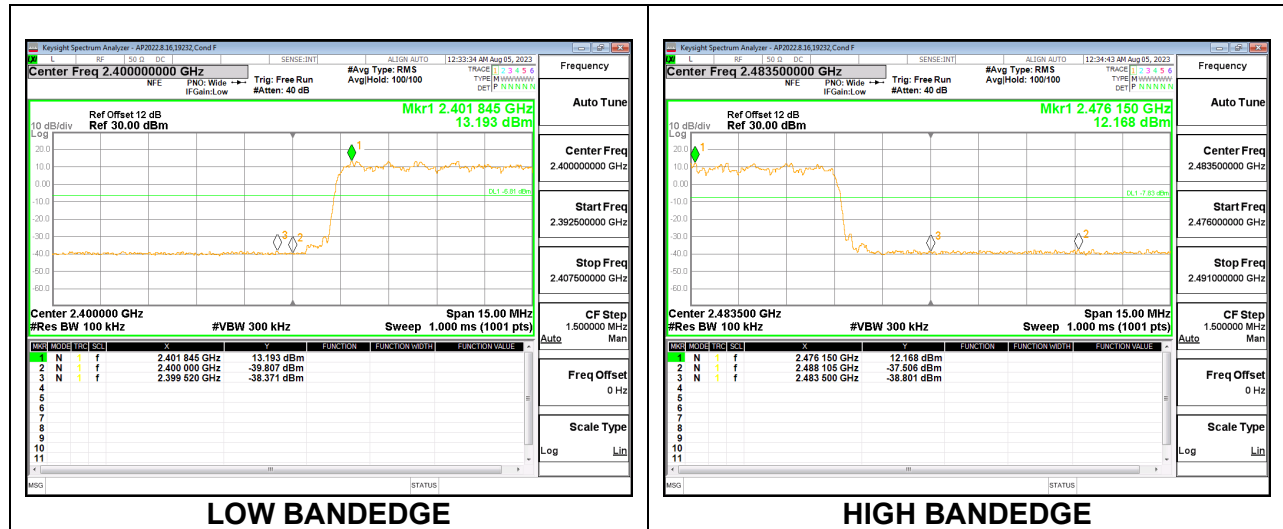
9.8.3. HIGH POWER ENHANCED DATA RATE 8PSK MODULATION

ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



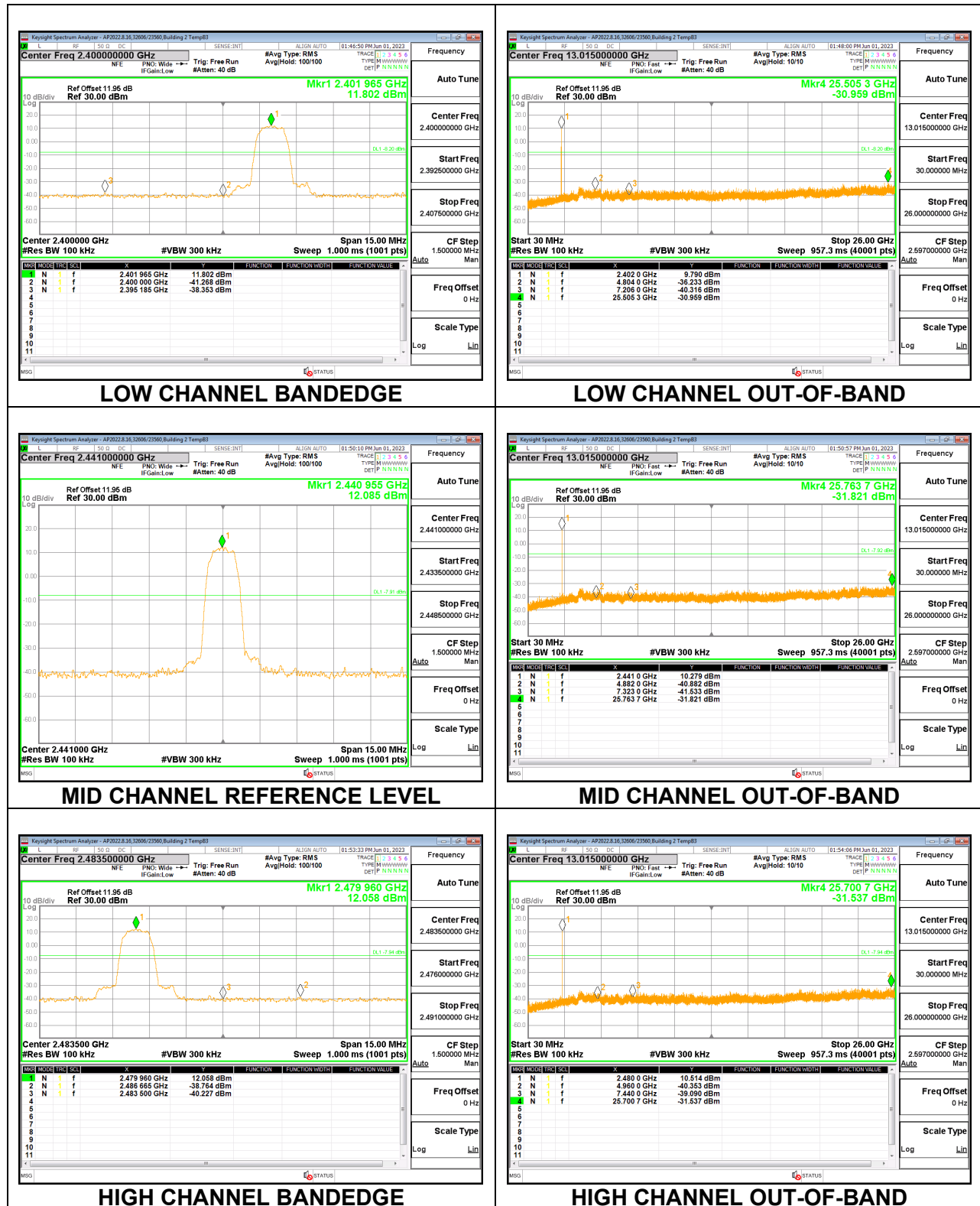
ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

ANT 3 SPURIOUS EMISSIONS, NON-HOPPING

ANT 3 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

9.8.4. HIGH POWER BASIC DATA RATE TXBF 8PSK MODULATION

ANT 4 SPURIOUS EMISSIONS, NON-HOPPING



ANT 4 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON