TEST REPORT

Report Number: R14932101-E2b

Applicant	:	Microsoft Corporation 1 Microsoft Way Redmond, WA 98052-8300, USA
Model	:	2037
FCC ID	:	C3K2037
IC	:	3048A-2037
EUT Description	:	Portable Computing Device
Test Standard(s)	:	FCC 47 CFR Part 15 Subpart C:2023 ISED RSS-247 Issue 3:2023 ISED RSS-GEN Issue 5 +A1+A2:2021

Date Of Issue:
2024-04-16

Prepared by:
UL LLC
12 Laboratory Dr.
Research Triangle Park, NC 27709 U.S.A.
TEL: (919) 549-1400

CERT #0751.06

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
1	2024-02-29	Initial Issue	B. Kiewra
2	2024-03-21	Added note to each section where data was leveraged stating from which report the data was leveraged.	B. Kiewra
3	2024-04-16	Updated KDB references in Section 3 Revised equipment class in section 7.3	B. Kiewra

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12 Laboratory Drive, Research Triangle Park, NC 27709; USA TEL:(919) 549-1400

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Microsoft Corporation
1 Microsoft Way
Redmond, WA 98052-8300, USA

EUT DESCRIPTION: Portable Computing Device

MODEL: 2037

SERIAL NUMBER: 0F3B36H23383HJ, 0F3B36F23383HJ, A81245020002335A, 2399649100000116, A81235010007335S, 0F3B36H23383HJ

SAMPLE RECEIPT DATE: 2023-10-10

DATE TESTED: 2023-10-11 to 2023-12-28

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C: 2023	Refer to Section 2
ISED RSS-247 Issue 3: 2023	Refer to Section 2
ISED RSS-GEN Issue 5+A1+A2: 2021	Refer to Section 2

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document.

Approved & Released
For UL LLC By:

Michael Antola
Staff Engineer
Consumer, Medical and IT Segment
UL LLC

Prepared By:

Brian Kiewra
Project Engineer
Consumer, Medical and IT Segment
UL LLC

2. TEST RESULTS SUMMARY

This report contains data/info provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.
Below is a list of the data/info provided by the customer:

1) Antenna gain and type (see section 6.3)

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	Compliant	None
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Number of Hopping Channels		
15.247 (a)(1)(iii)	RSS-247 (5.1) (d)	Average Time of Occupancy		
15.247 (b)(1)	RSS-247 (5.4) (b)	Output Power		
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	Compliant	None
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions		
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions		

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC 47 CFR Part 2, FCC 47 CFR Part 15, ANSI C63.10-2013, KDB 558074 D01 15.247 Meas Guidance v05r02 KDB 414788 D01 Radiated Test Site v01r01, KDB 484596 D01 Referencing Test Data v02r03, RSS-GEN Issue 5 + A1 + A2, and RSS-247 Issue 2.

4. FACILITIES AND ACCREDITATION

UL LLC is accredited A2LA, certification # 0751.06, 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: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	825374
☒	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A		27265	

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	UNCERTAINTY
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	1.22%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	1.94 dB
All emissions, radiated	6.01 dB
Conducted Emissions (0.150-30MHz) - LISN	3.40 dB
Temperature	0.57°C
Humidity	3.39%
DC Supply voltages	1.70%
Time	3.39%

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

5.4. 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

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is a Portable Computing Device.

6.2. MAXIMUM OUTPUT POWER

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

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2402 - 2480	Basic GFSK	19.50	89.13
2402 - 2480	Enhanced DQPSK	17.87	61.24
2402 - 2480	Enhanced 8PSK	18.41	69.34

Note: GFSK, DQPSK, 8PSK average Power were all investigated, The GFSK and 8PSK power are the worst case. Testing is based on these modes to showing compliance. For average power data please refer to section 10.8.

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

Chain	Frequency (MHz)	Gain (dBi)	Type
0	2400-2483.5	5.69	PIFA
1	2400-2483.5	4.66	PIFA
MIMO	2400-2483.5	6.74	PIFA

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 1.0.3808.9500

6.5. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low and high or low, middle, and high channels.

The EUT is intended to operate in only one orientation, therefore, all final radiated testing was performed with the EUT in this intended orientation of operation.

With the exception of average time of occupancy, all testing performed at DH5 as worst-case.

All conducted testing, with the exception of power, done in SISO modes to cover MIMO. Power and radiated testing performed in both MIMO and SISO modes.

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Power Supply	Orting	2062	OT3100650	NA
USB Drive	PNY	16GB	NA	NA
Headphones	Sony	NA	NA	NA
USB C to Ethernet	Tp-link	UE300C	2234082002838	NA
Switch	Linksys	EFAH05WVER.3	RA13048005308 EH1040 MA	NA
Support Laptop	Lenovo	ThinkPad	LR-0390B9	NA
Support Laptop	Lenovo	ThinkPad	LR-03N0JZ	NA
Support Laptop Charger	Lenovo	ThinkPad	38G337	NA
Support Laptop Charger	Lenovo	ThinkPad	38G337	NA
Support Laptop	Lenovo	ThinkPad	LR-0390B9	NA

I/O CABLES

I/O Cable List						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	USB-C	2	USB-C	Shielded	>3m	EUT to Power Supply
2	Aux	1	Aux	Shielded	<3m	Headphones
3	USB-A	1	USB-A	Shielded	<3m	EUT to USB Drive
4	USB-C	2	USB-C	Shielded	>3m	USB to Ethernet adapter Ethernet is unshielded

TEST SETUP

The EUT is setup as a standalone device.

SETUP DIAGRAMS

Please refer to R14932101-EP1b for setup diagrams

7. REUSE OF TEST DATA

7.1. INTRODUCTION

According to the manufacturer, C3K2036 and C3K 2037 unlicensed radios (WLAN/BT/BLE) are electrically identical. The C3K2036 test data shall remain representative of C3K2037 so, C3K2037 leverages test data from C3K2036.

The applicant takes full responsibility that the test data as referenced in this section represents compliance for this FCC ID.

Data being leveraged from C3K2036:
Duty Cycle
Output/Average Power
20dB/99% BW
Hopping Separation/Hopping Channels/Avg Time of Occupancy
Conducted Spurious Emissions – Authorized and MIMO Restricted Band

7.2. DEVICES DIFFERENCES

Difference between C3K2036 and C3K2037:

Microsoft Corporation hereby declares that the radio circuitry of WLAN 2.4GHz, WLAN 5GHz, Bluetooth, is identical among models C3K2036 and C3K2037. Therefore, the following report/data of C3K2036 may represent C3K2037. Refer to manufacturer's operational description for differences between C3K2036 and C3K2037.

7.3. REFERENCE DETAIL

Equipment Class	Reference FCC ID	Report Title/Section
DSS (BT)	C3K2036	R14932101-E2a FCC ISED BT REPORT 2036 / Section 9

7.4. SPOT CHECK VERIFICATION RESULTS SUMMARY

Spot check verification has been done on device C3K2037. The data from the application has been verified through appropriate spot checks to demonstrate compliance for this device as shown in the summary.

C3K2037 SPOT CHECK RESULTS					
Technology	**Test Item**	**Channel**	**C3K2036 Reading (Reference)**	**C3K2037 Reading (Spotcheck)**	**Difference ≤0.25**
BT	Power	2440	19.50	21.18	0.09
	CBE	2480	-26.306	-27.126	0.03
	CSE	2480	-18.853	-19.005	0.01

Note: The ≤0.25 requirement can be found in KDB 484596.
Difference equation:

$$Difference = \frac{|spot\ check\ data - reference\ data|}{|reference\ data|}$$

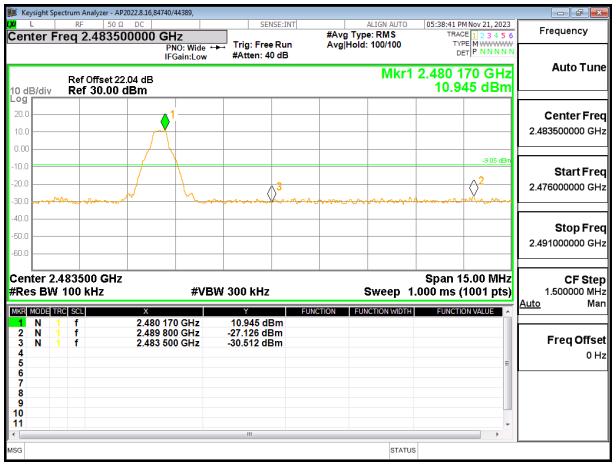
7.5. SPOT CHECK DATA

7.5.1. OUTPUT POWER

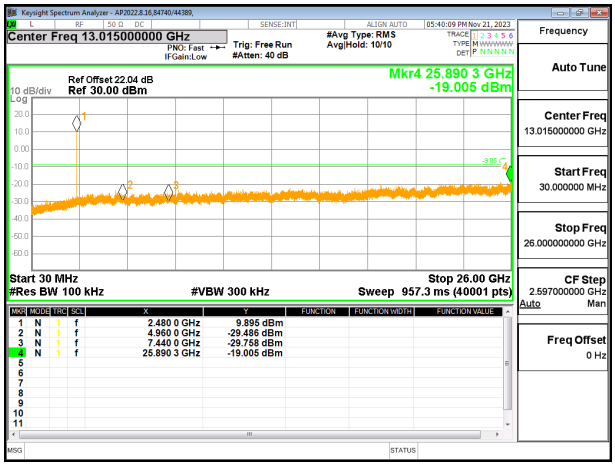
Tested By:	85502/44389
Date:	2023-11-17

Channel	Frequency (MHz)	Output Power (dBm)
Middle	2441	21.18

7.5.2. CONDUCTED SPURIOUS EMISSIONS



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

8. TEST AND MEASUREMENT EQUIPMENT

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

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
90418	Peak and Avg Power Sensor, 50MHz to 18GHz	Keysight Technologies	N1921A	2023-02-02	2024-02-02
90411	Spectrum Analyzer	Keysight Technologies	N9030A	2023-08-02	2024-08-02
90416	Spectrum Analyzer	Keysight Technologies	N9030A	2023-06-09	2024-06-30
179892	Environmental Meter	Fisher Scientific	15-077-963	2023-07-26	2024-07-31
134477	RF Power Meter	Keysight Technologies	N1912A	2023-08-04	2024-08-04
135124	Peak and Avg Power Sensor, 50MHz to 18GHz	Keysight Technologies	N1921A	2023-07-12	2024-07-31
PWM005	RF Power Meter	Keysight Technologies	N1912A	2022-09-02	2024-09-02
238710	Environmental Meter	Fisher Scientific	15-077-963	2023-06-27	2024-06-27
90410	Spectrum Analyzer	Keysight Technologies	N9030A	2023-06-14	2024-06-14
SOFTEMI	Antenna Port Software	UL	Version 2022.8.16	NA	NA
226563	SMA Coaxial 10dB Attenuator 25MHz-18GHz	CentricRF	C18S2-10	2023-02-16	2024-02-16
226552	SMA Coaxial 20dB Attenuator 25MHz-18GHz	CentricRF	C18S2-20	2023-02-16	2024-02-16
226551	SMA Coaxial 20dB Attenuator 25MHz-18GHz	CentricRF	C18S2-20	2023-02-16	2024-02-16
Pad A	SMA Coaxial 20dB Attenuator 25MHz-18GHz	CentricRF	C18S2-20	2023-02-16	2024-02-29
Pad B	SMA Coaxial 20dB Attenuator 25MHz-18GHz	CentricRF	C18S2-20	2023-02-16	2024-02-29
CBL105	Micro-Coax UTiFLEX Cable Assembly, Low Loss	Carlisle Interconnect Technologies	UFB-197C-0-0160-300300	2023-02-17	2024-02-17
CBL031	SMA Male to SMA Male Cable Using PE-P141 Coax - 12"	Pasternack	Sucoflex 104PEA	2023-06-27	2024-06-27
CBL030	SMA Male to SMA Male Cable Using PE-P141 Coax - 12"	Pasternack	Sucoflex 104PEA	2023-06-27	2024-06-27
CBL012	Micro-Coax UTiFLEX Cable Assembly, Low Loss	Carlisle Interconnect Technologies	UFB293C-0-2400-300300	2023-01-05	2024-01-05
CBL091	Micro-Coax UTiFLEX Cable Assembly, Low Loss,40Ghz	Carlisle Interconnect Technologies	UFA147A-2-0360-200200	2023-02-17	2024-02-17

Test Equipment Used - Line-Conducted Emissions – Voltage (Morrisville – Conducted 1)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
CBL087	Coax cable, RG223, N-male to BNC-male, 20-ft.	Pasternack	PE3W06143-240	2023-04-04	2024-04-04
179892	Environmental Meter	Fisher Scientific	15-077-963	2023-07-26	2024-06-31
80391	LISN, 50-ohm/50-uH, 250uH 2-conductor, 25A	Fischer Custom Com.	FCC-LISN-50/250-25-2-01	2023-07-31	2024-07-31
75141	EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESCI 7	2023-08-01	2024-08-01
52859	Transient Limiter, 0.009-100MHz	Electro-Metrics	EM-7600	2023-04-04	2024-04-04
PS214	AC Power Source	Elgar	CW2501M	NA	NA
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
91432	LISN, 50-ohm/50-uH, 2-conductor, 25A (For support gear only.)	Solar Electronics	8012-50-R-24-BNC	NA	NA

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 1)

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
1-18 GHz					
206211	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-04-06	2024-04-06
18-40 GHz					
204704	Horn Antenna, 18-26.5GHz	Com-Power	AH-826	2023-07-20	2025-07-20
Gain-Loss Chains					
91979	Gain-loss string: 1-18GHz	Various	Various	2023-05-16	2024-05-16
135999	Gain-loss string: 18-40GHz	Various	Various	2023-05-16	2024-05-16
Receiver & Software					
206496	Spectrum Analyzer	Rohde & Schwarz	ESW44	2023-03-24	2024-03-24
90416	Spectrum Analyzer	Keysight	N9030A	2023-06-09	2024-06-30
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
Additional Equipment used					
241205	Environmental Meter	Fisher Scientific	15-077-963	2023-09-05	2025-09-05

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 4)

Equipment ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
0.009-30MHz					
135144	Active Loop Antenna	ETS-Lindgren	6502	2023-01-17	2024-01-17
30-1000 MHz					
90629	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2023-01-06	2024-01-06
1-18 GHz					
89509	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-05-23	2025-05-23
18-40 GHz					
204704	Horn Antenna, 18-26.5GHz	Com-Power	AH-826	2023-07-20	2025-07-20
Gain-Loss Chains					
207638	Gain-loss string: 0.009-30MHz	Various	Various	2023-09-18	2024-09-18
207639	Gain-loss string: 25-1000MHz	Various	Various	2023-09-18	2024-09-18
207640	Gain-loss string: 1-18GHz	Various	Various	2023-05-17	2024-05-17
225795	Gain-loss string: 18-40GHz	Various	Various	2023-05-17	2024-05-17
Receiver & Software					
197955	Spectrum Analyzer	Rohde & Schwarz	ESW44	2023-04-10	2024-04-10
90416	Spectrum Analyzer	Keysight	N9030A	2023-06-09	2024-06-30
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
Additional Equipment used					
241204	Environmental Meter	Fisher Scientific	15-077-963	2023-09-05	2025-09-05

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 2)

Equipment ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
1-18 GHz					
86408	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-06-19	2025-06-19
Gain-Loss Chains					
91977	Gain-loss string: 1-18GHz	Various	Various	2023-06-06	2024-06-06
Receiver & Software					
197954	Spectrum Analyzer	Rohde & Schwarz	ESW44	2023-02-02	2024-02-02
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
Additional Equipment used					
200540	Environmental Meter	Fisher Scientific	15-077-963	2023-07-19	2025-07-19

9. 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 Band-edge: ANSI C63.10 Section 6.10.5

Radiated Spurious Emissions: ANSI C63.10-2013 Sections 6.3 to 6.6

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

UL LLC
12 Laboratory Drive, Research Triangle Park, NC 27709; USA TEL:(919) 549-1400

10. ANTENNA PORT TEST RESULTS

10.1. ON TIME AND DUTY CYCLE

LIMITS

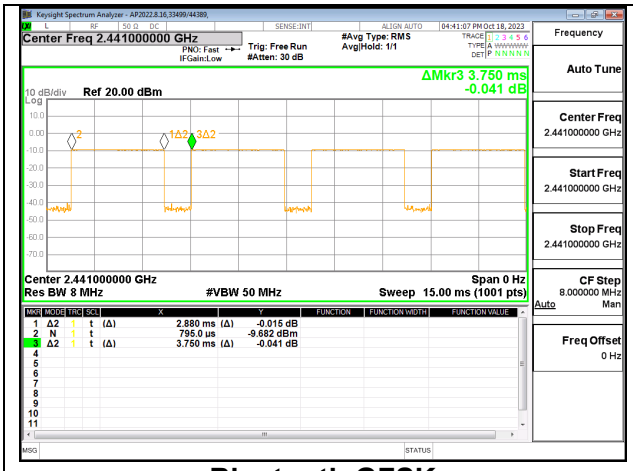
None; for reporting purposes only.

PROCEDURE

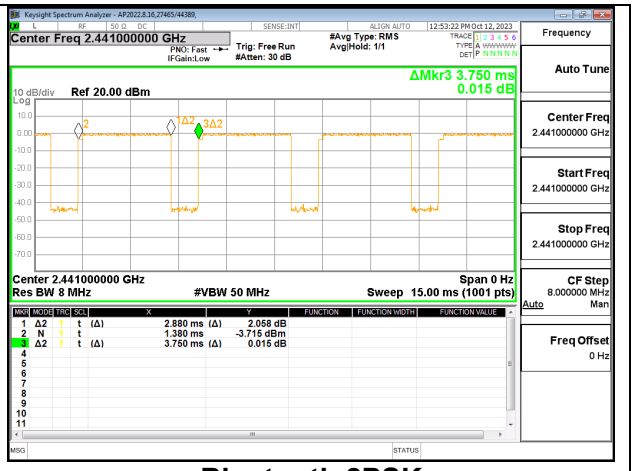
ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

Note: This data leveraged from R14932101-E2a.

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	1/T Minimum VBW (kHz)
Bluetooth GFSK	2.880	3.750	0.768	76.80	0.347
Bluetooth 8PSK	2.880	3.750	0.768	76.80	0.347



Bluetooth GFSK



Bluetooth 8PSK

Note: The DCCF used was calculated based on the worst case on-time when the device transmits DH5 packets and operates on 20 channels (5/1600 s per hop = 3.125 ms per channel). In this mode, the device will have a maximum of 2 hops on a channel in 100ms or 2x 3.125 ms = 6.25 ms on any channel. Therefore, 20log(6.25 / 100) = - 24dB.

10.2. 20 dB BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1-5% of the 20 dB bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

Note: This data leveraged from R14932101-E2a.

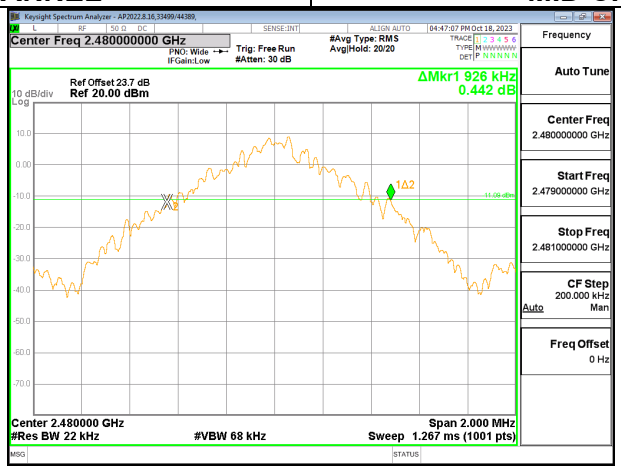
10.2.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

CHAIN 0

Channel	Frequency (MHz)	20dB Bandwidth (MHz)
Low	2402	0.866
Mid	2441	0.932
High	2480	0.926

LOW CHANNEL

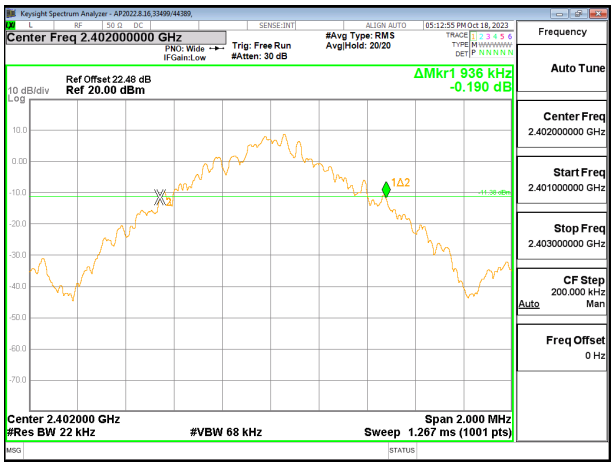
MID CHANNEL



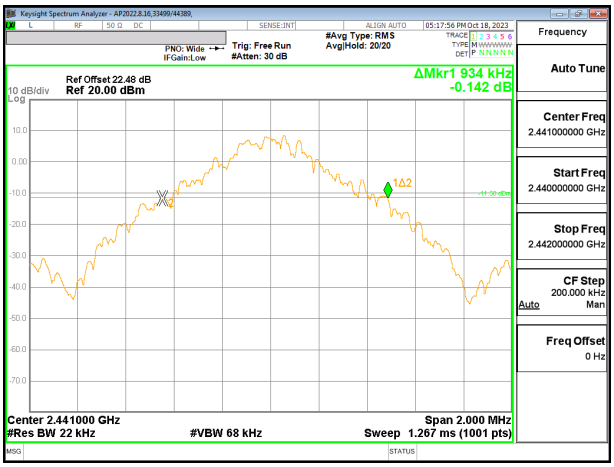
HIGH CHANNEL

CHAIN 1

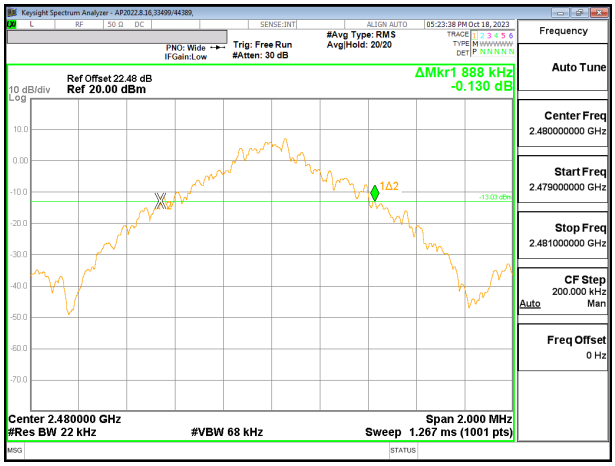
Channel	Frequency (MHz)	20dB Bandwidth (MHz)
Low	2402	0.936
Mid	2441	0.934
High	2480	0.888



LOW CHANNEL



MID CHANNEL

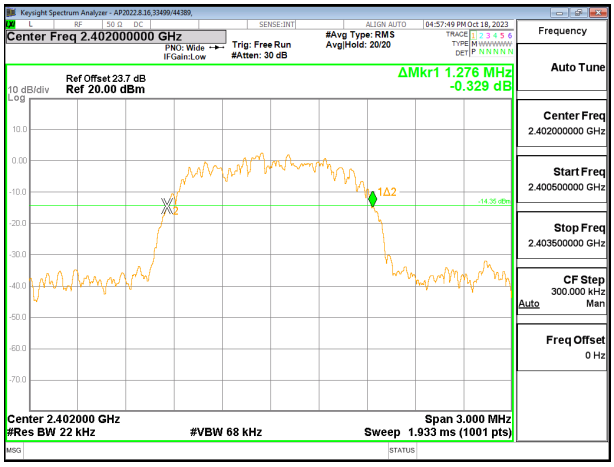


HIGH CHANNEL

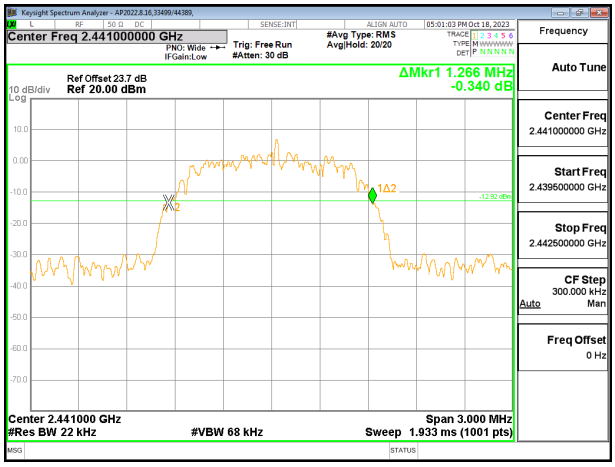
10.2.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

CHAIN 0

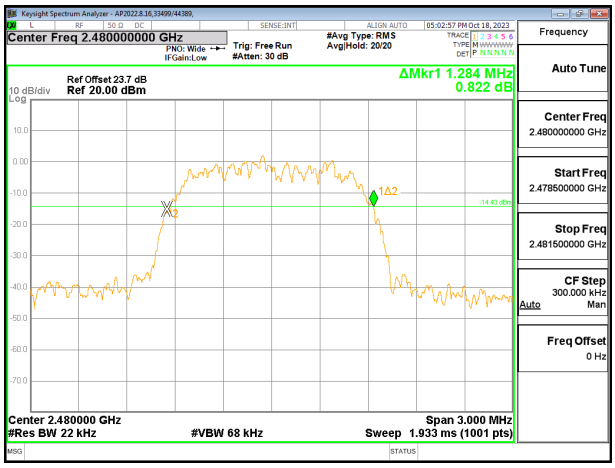
Channel	Frequency (MHz)	20dB Bandwidth (MHz)
Low	2402	1.276
Mid	2441	1.266
High	2480	1.284



LOW CHANNEL



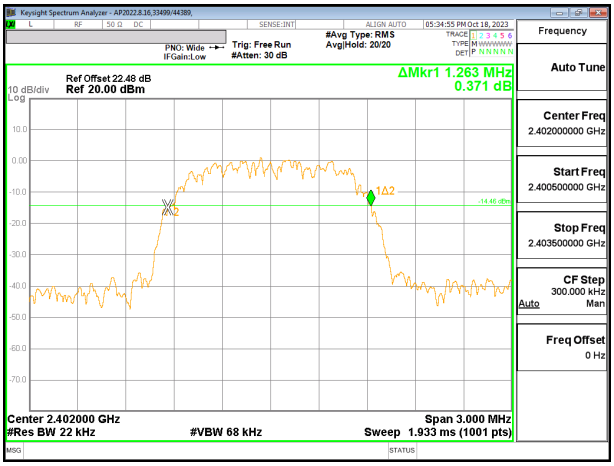
MID CHANNEL



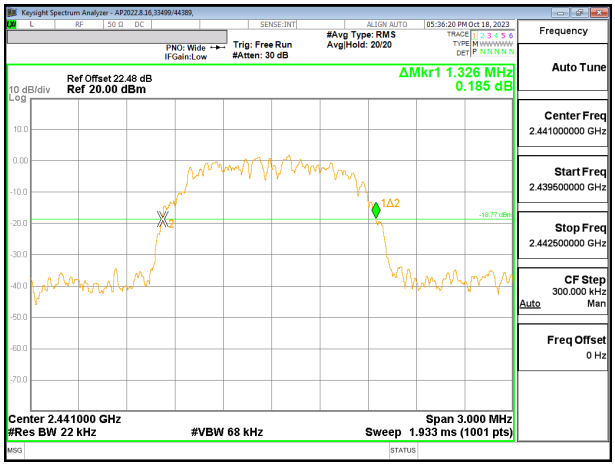
HIGH CHANNEL

CHAIN 1

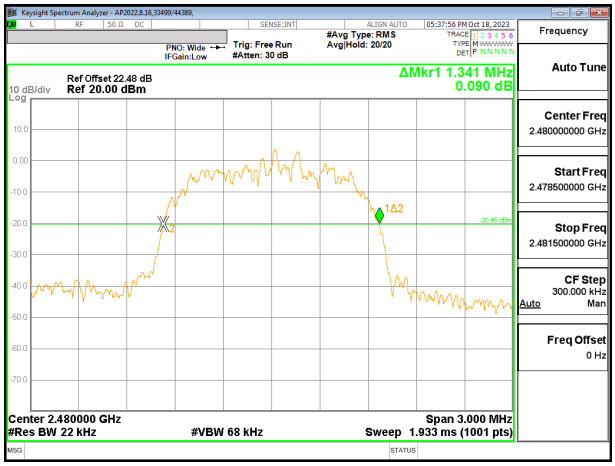
Channel	Frequency (MHz)	20dB Bandwidth (MHz)
Low	2402	1.263
Mid	2441	1.326
High	2480	1.341



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

10.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

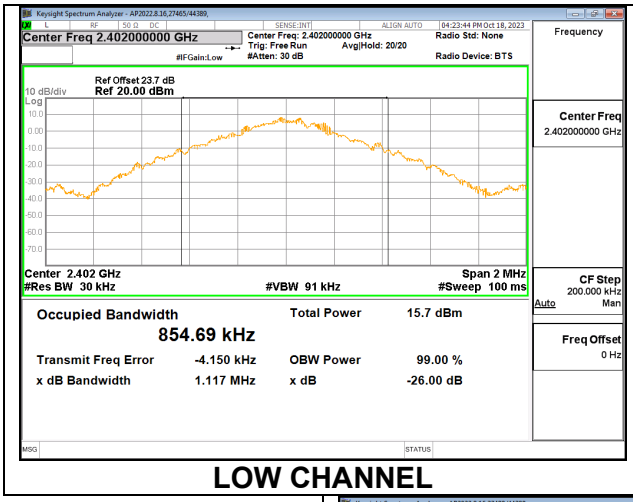
The transmitter output is connected to a spectrum analyzer. The RBW is set to 1-5% of the 99% bandwidth. The VBW is set to ≥ RBW. The sweep time is coupled.

Note: This data leveraged from R14932101-E2a.

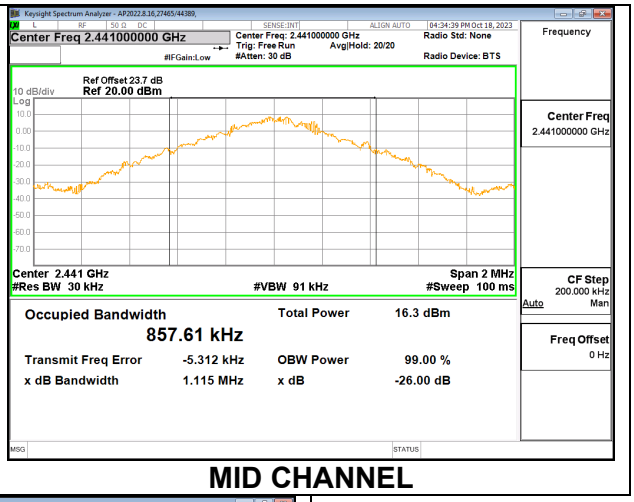
10.3.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

CHAIN 0

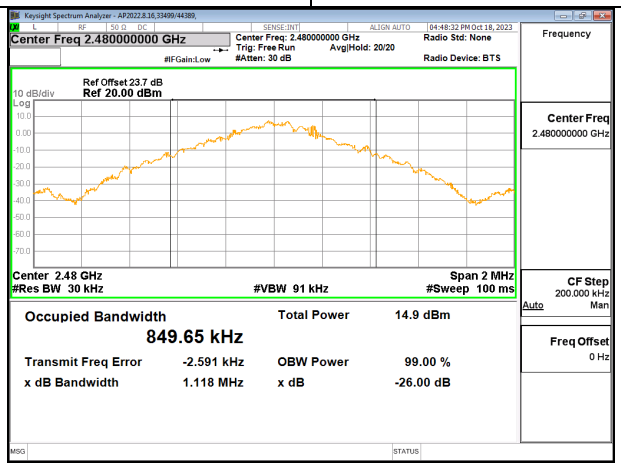
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	0.85469
Mid	2441	0.85761
High	2480	0.84965



LOW CHANNEL



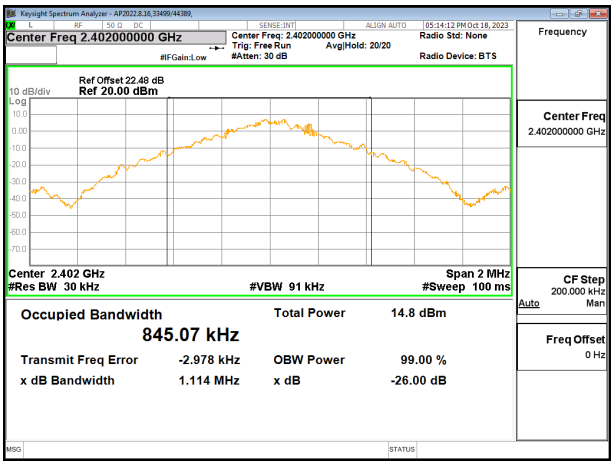
MID CHANNEL



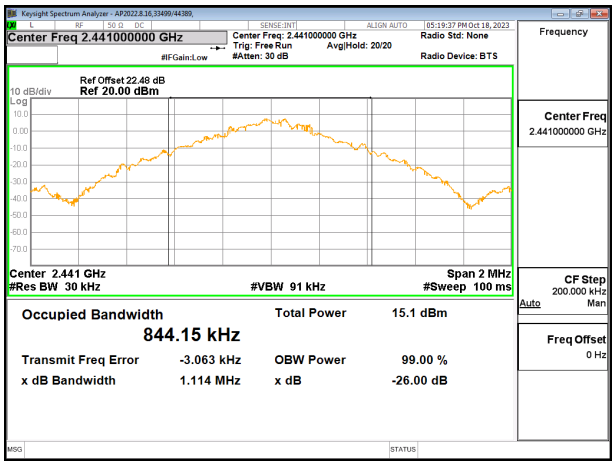
HIGH CHANNEL

CHAIN 1

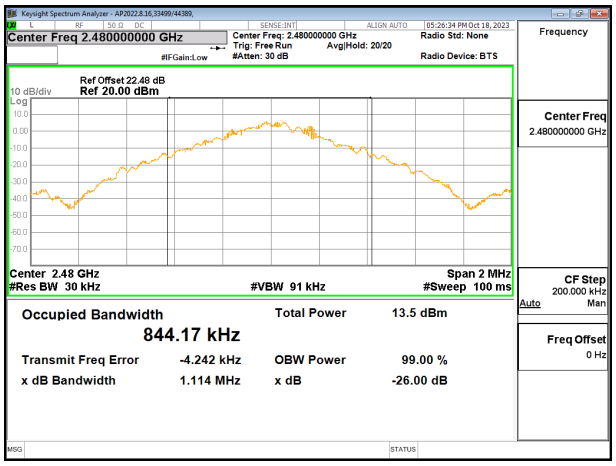
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	0.84507
Mid	2441	0.84415
High	2480	0.84417



LOW CHANNEL



MID CHANNEL

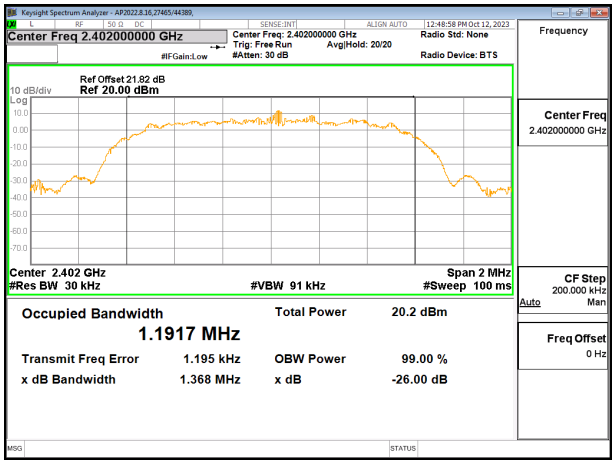


HIGH CHANNEL

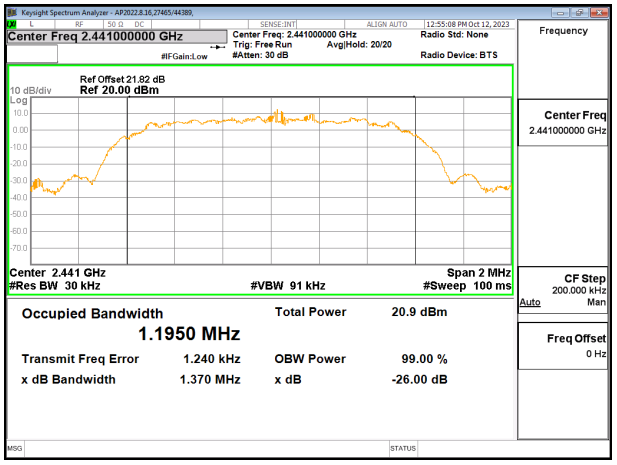
10.3.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

CHAIN 0

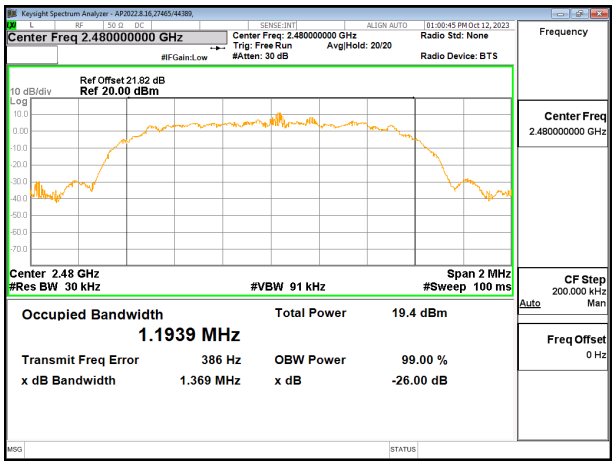
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.1917
Mid	2441	1.1950
High	2480	1.1939



LOW CHANNEL



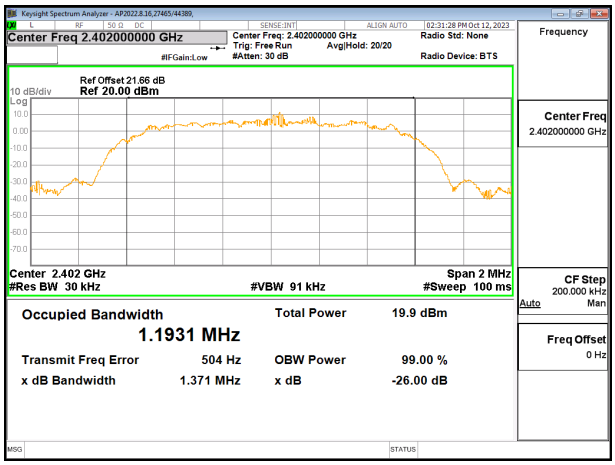
MID CHANNEL



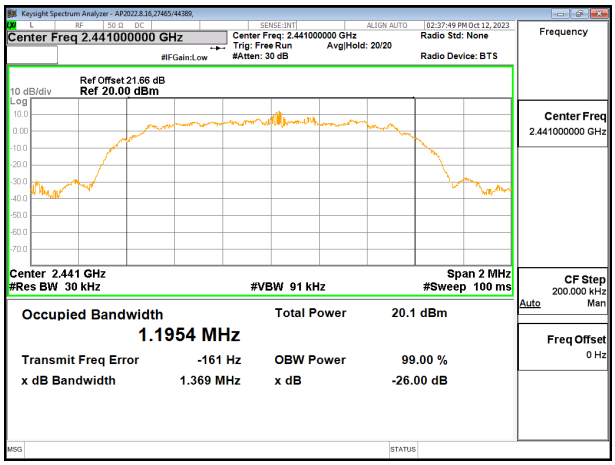
HIGH CHANNEL

CHAIN 1

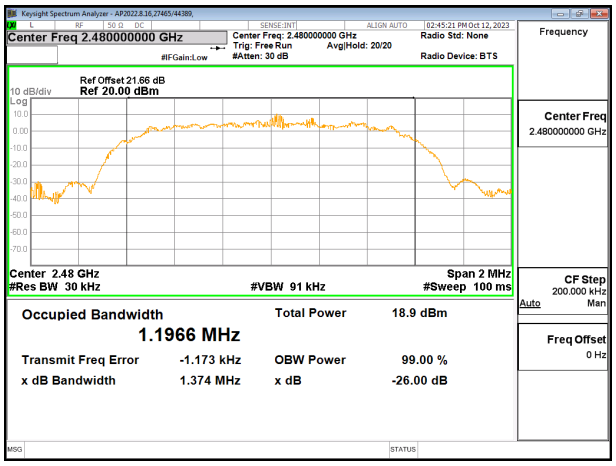
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.1930
Mid	2441	1.1954
High	2480	1.1966



LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

10.4. 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.

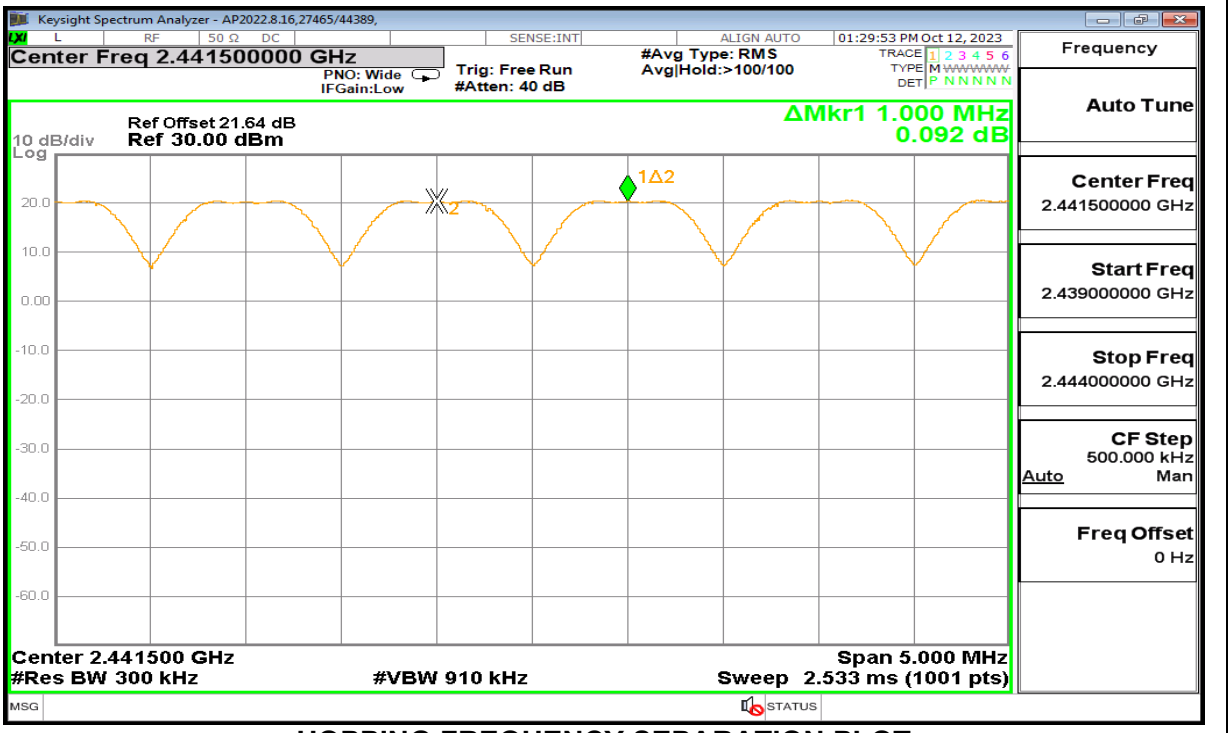
Note: This data leveraged from R14932101-E2a.

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 >= RBW. The sweep time is coupled.

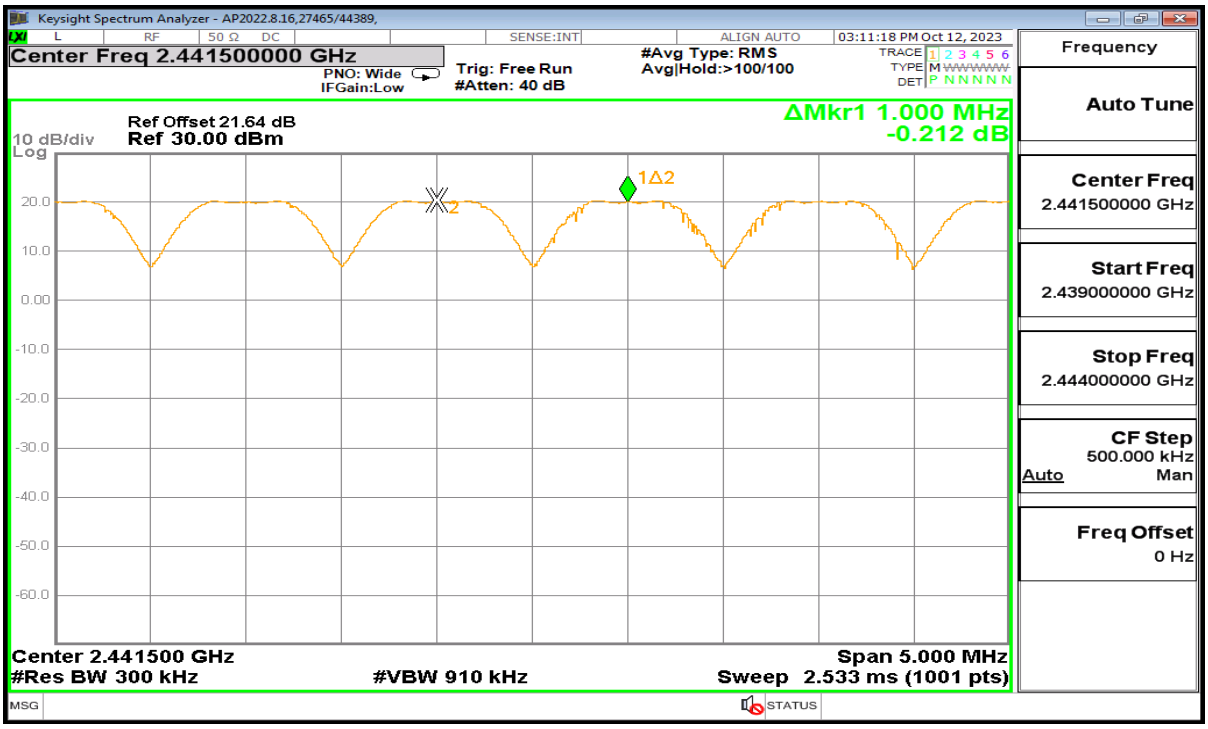
10.4.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

CHAIN 0



HOPPING FREQUENCY SEPARATION PLOT

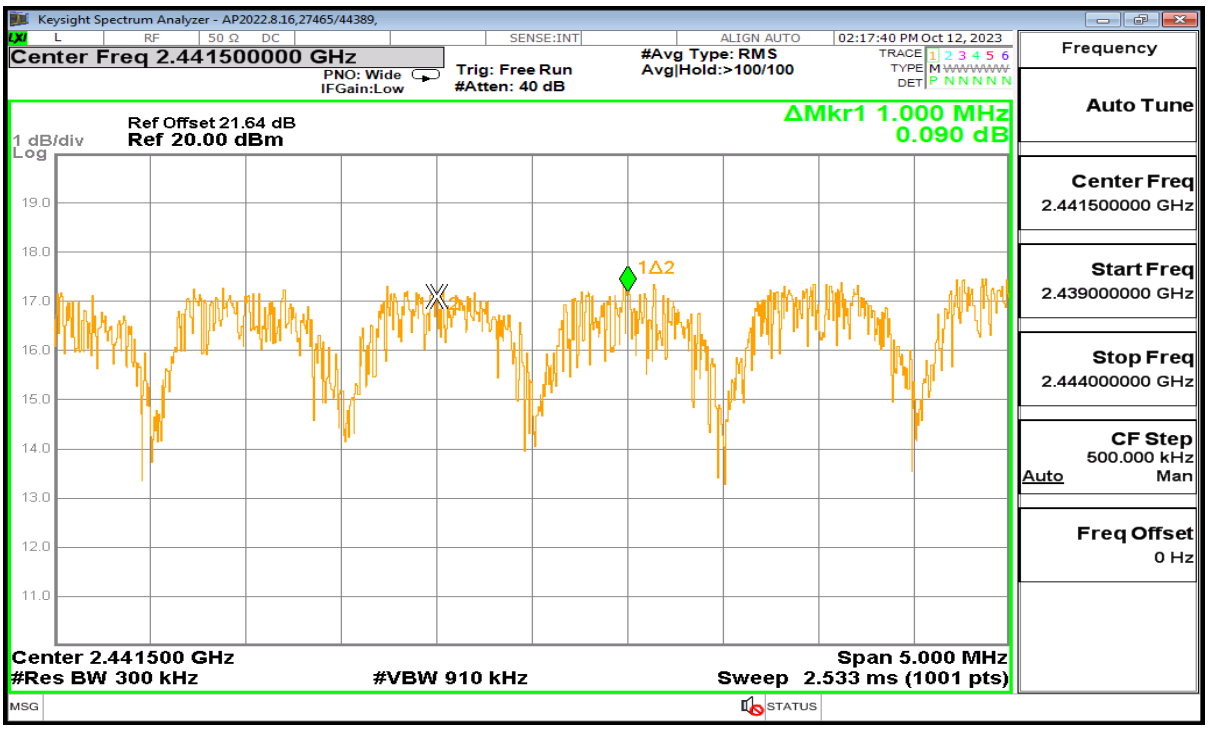
CHAIN 1



HOPPING FREQUENCY SEPARATION PLOT

10.4.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

CHAIN 0

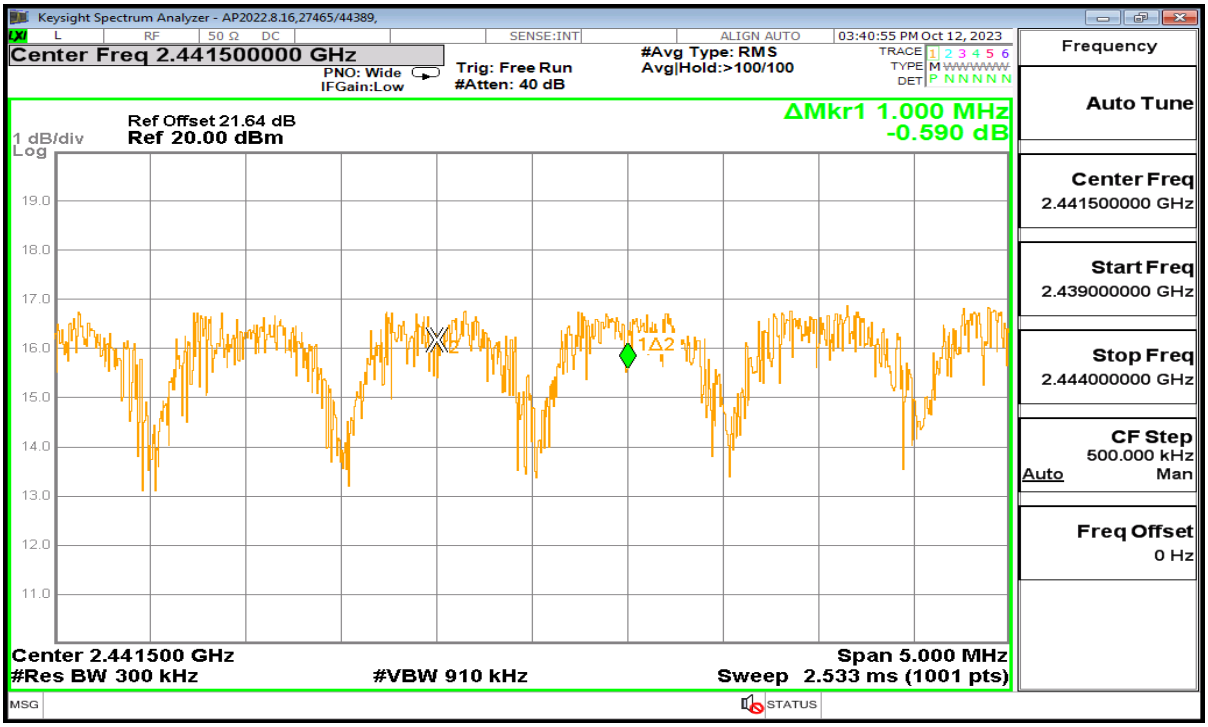


HOPPING FREQUENCY SEPARATION PLOT

Since output power is <125mW (21dBm), Separation can be > 2/3 20dB BW

Output Power (dBm)	Separation (MHz)	20dB BW (MHz)	2/3 dB BW (MHz)	Margin (MHz)
20.62	1.000	1.266	0.844	-0.156

CHAIN 1



HOPPING FREQUENCY SEPARATION PLOT

Since output power is <125mW (21dBm), Separation can be > 2/3 20dB BW

Output Power (dBm)	Separation (MHz)	20dB BW (MHz)	2/3 dB BW (MHz)	Margin (MHz)
20.43	1.000	1.263	0.842	-0.158

10.5. 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

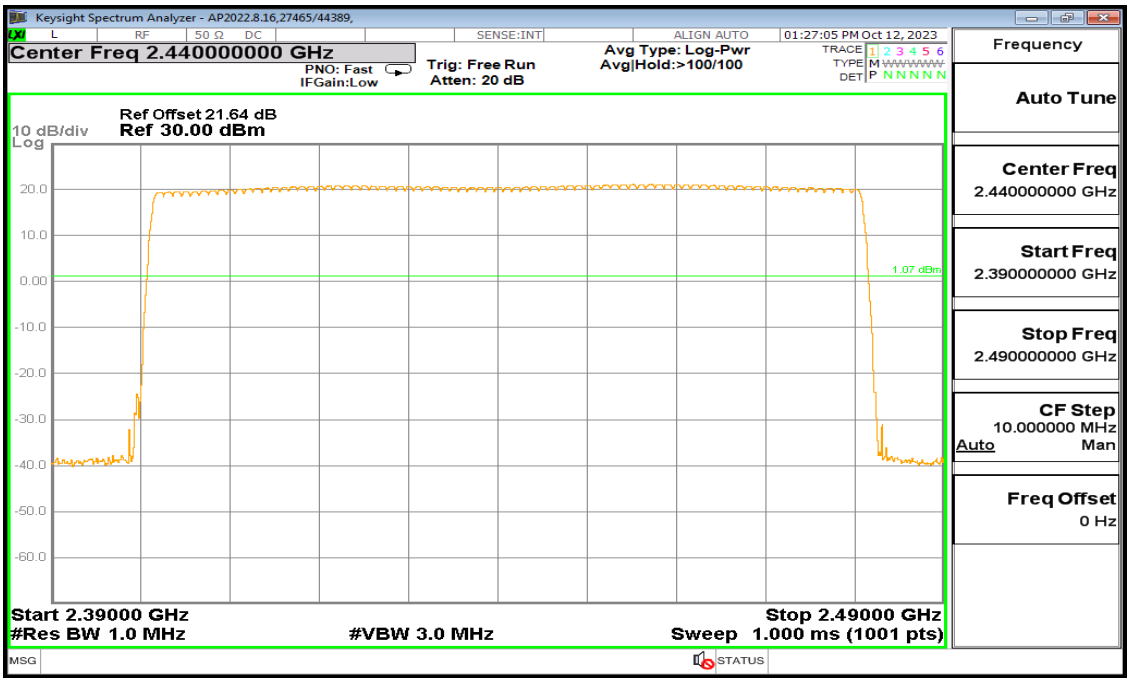
The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

Normal Mode: 79 Channels Observed

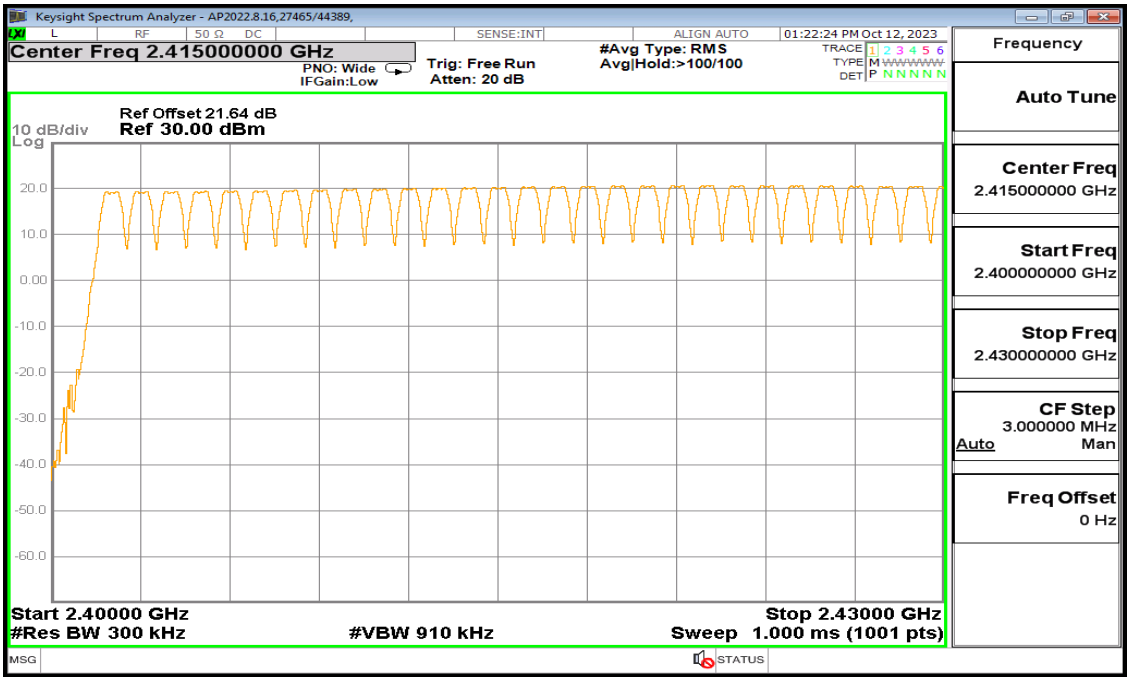
Note: This data leveraged from R14932101-E2a.

10.5.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

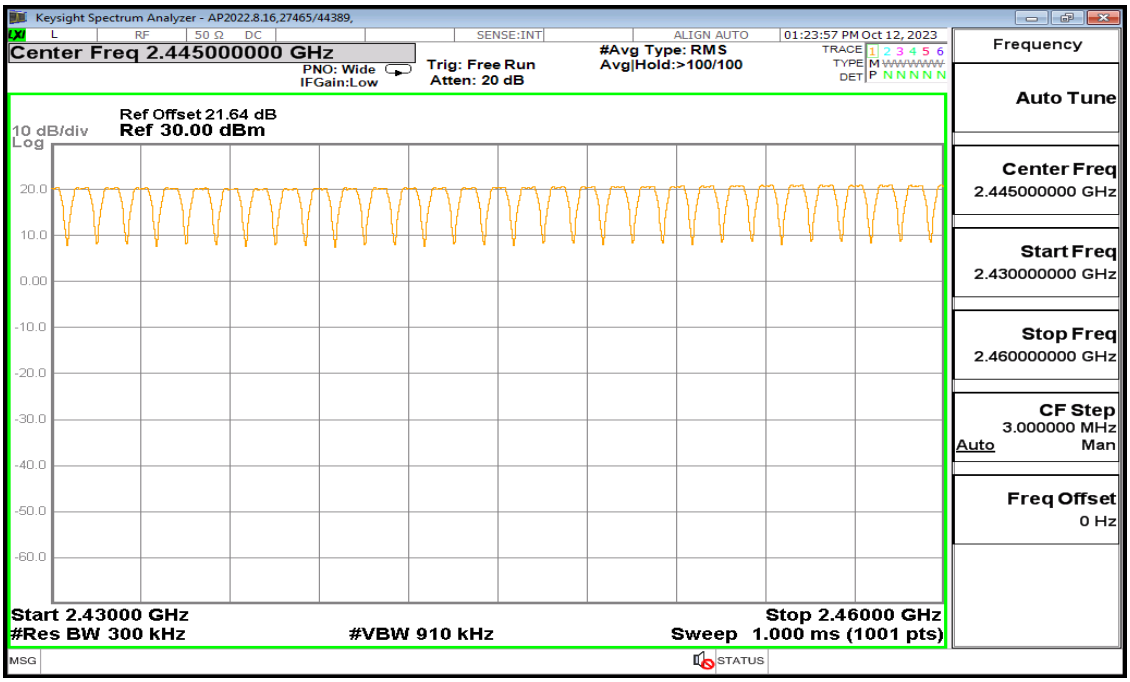
CHAIN 0



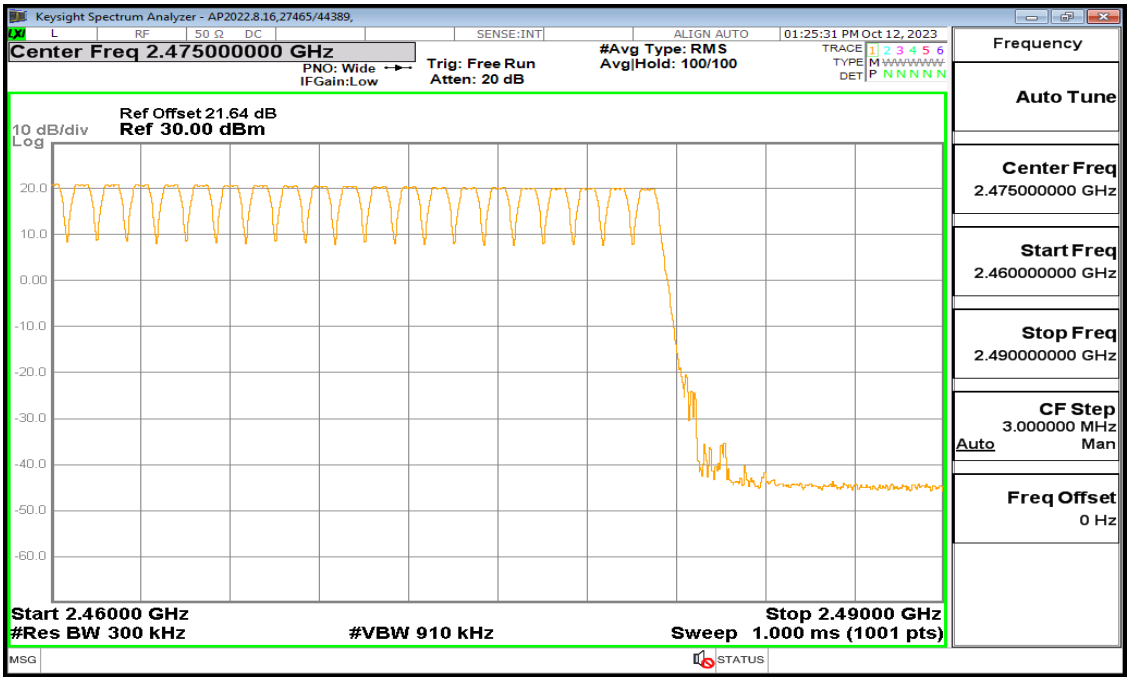
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

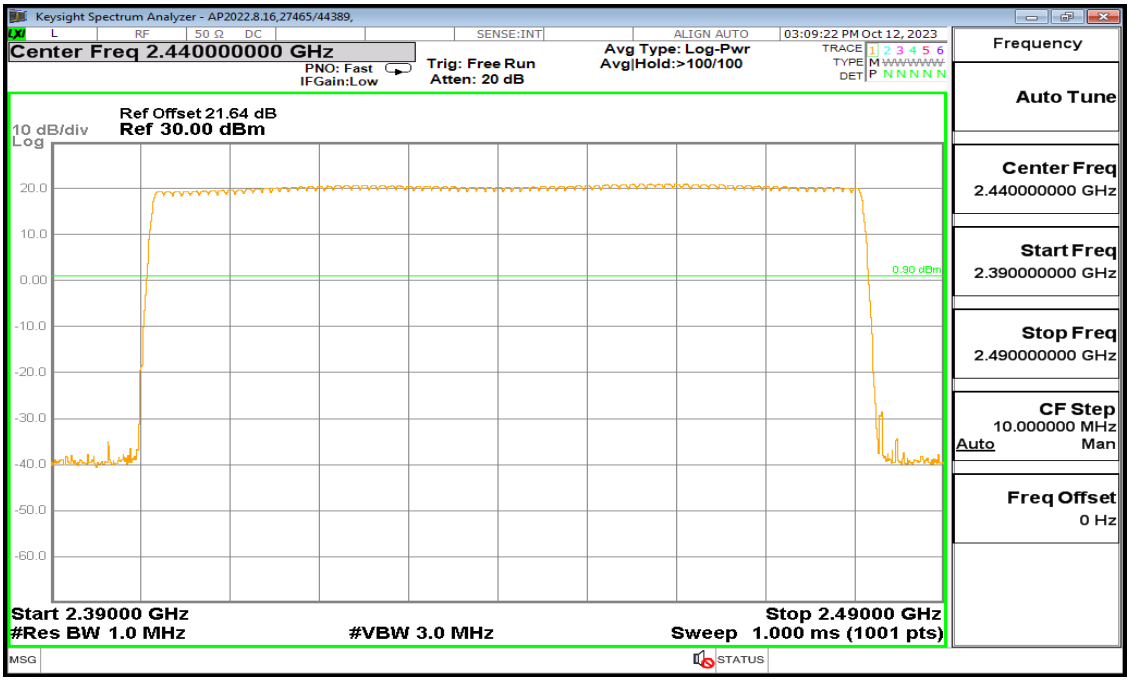


30MHz SPAN, SEGMENT 2 OF 3

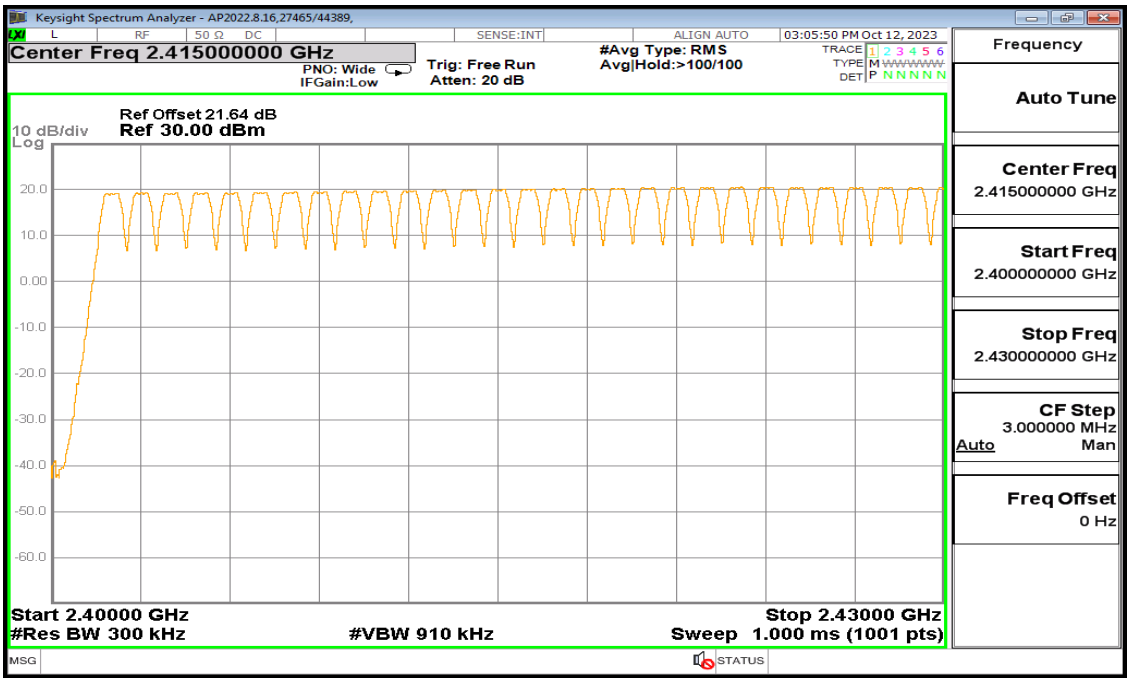


30MHz SPAN, SEGMENT 3 OF 3

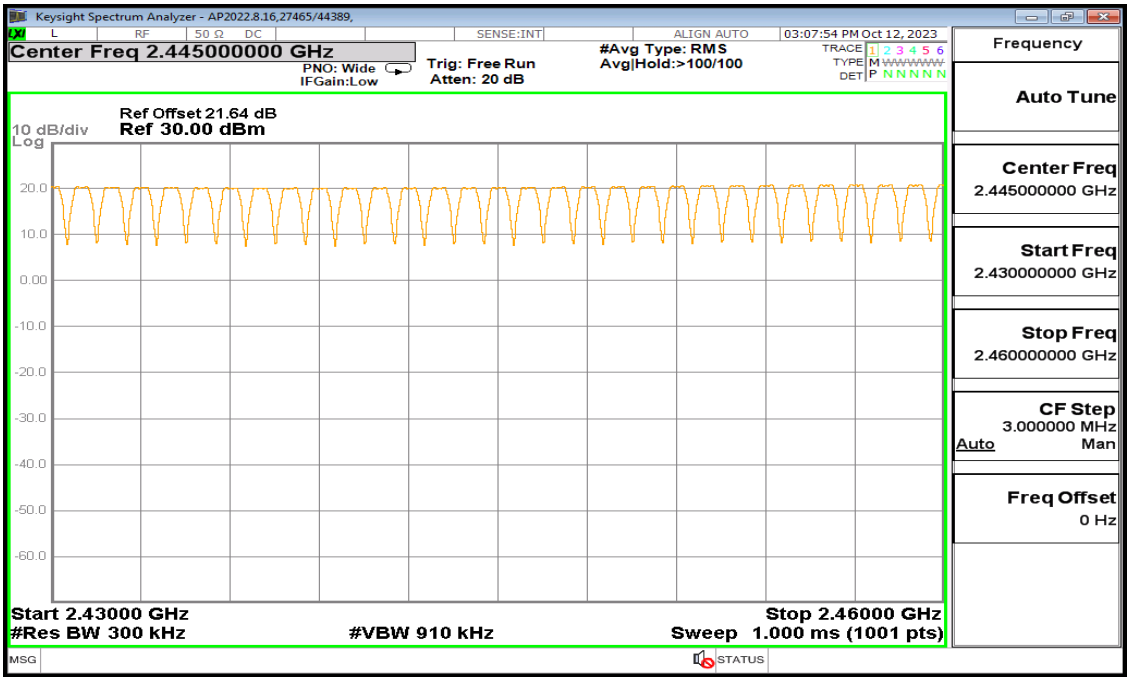
CHAIN 1



100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

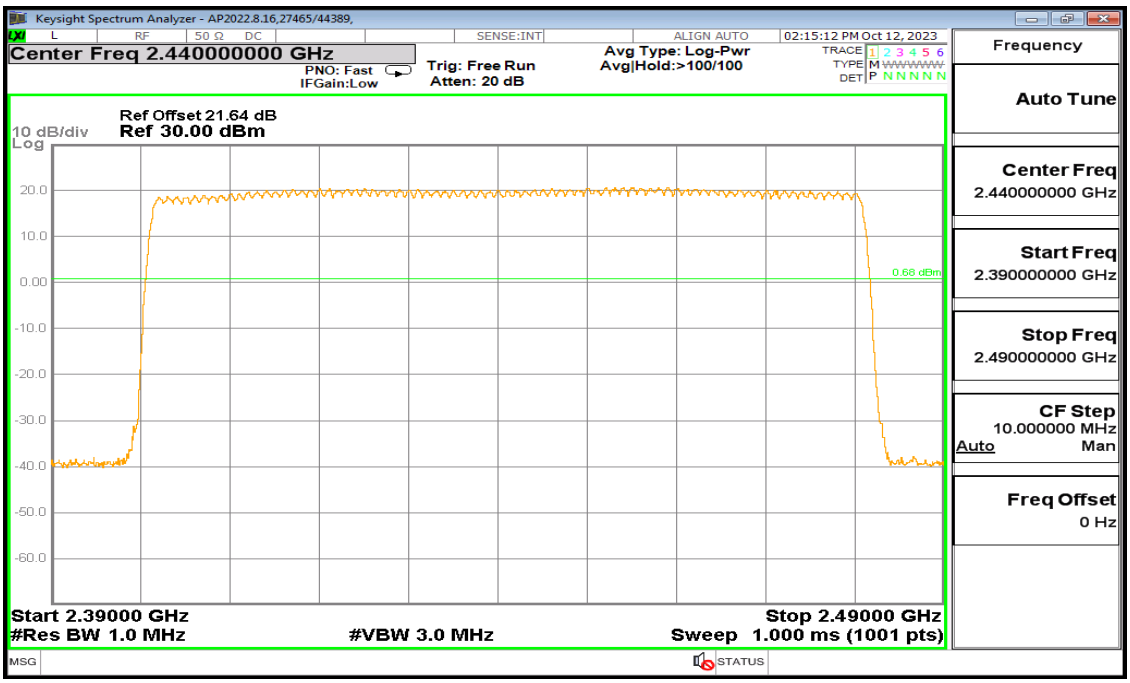


30MHz SPAN, SEGMENT 2 OF 3

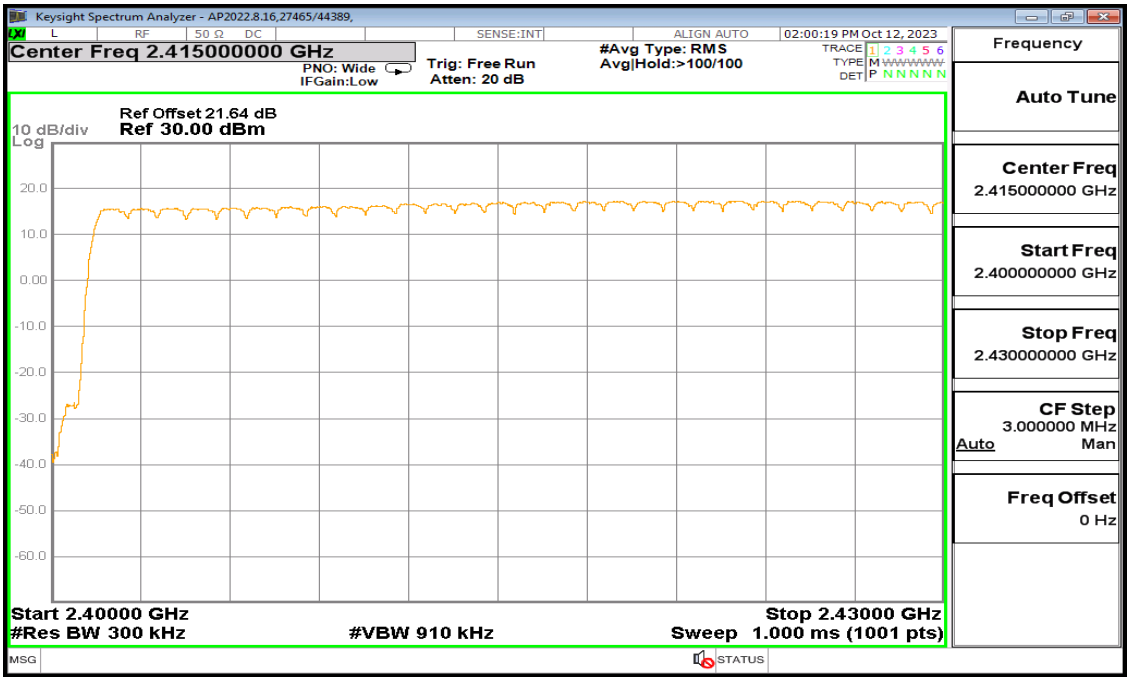
30MHz SPAN, SEGMENT 3 OF 3

10.5.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

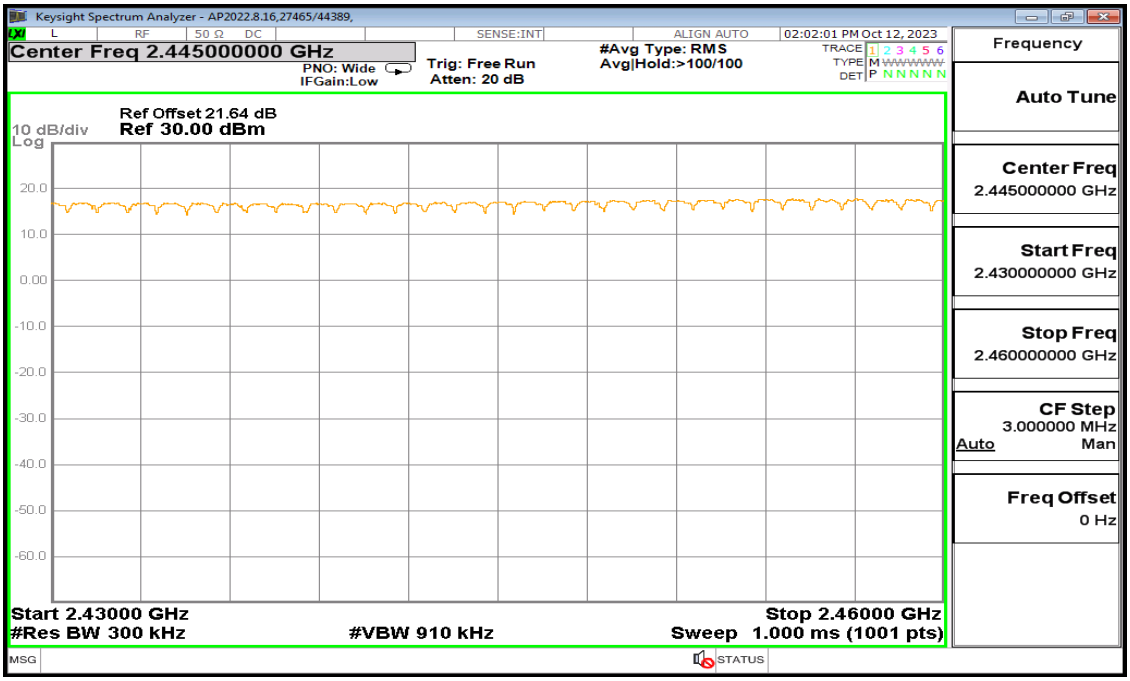
CHAIN 0



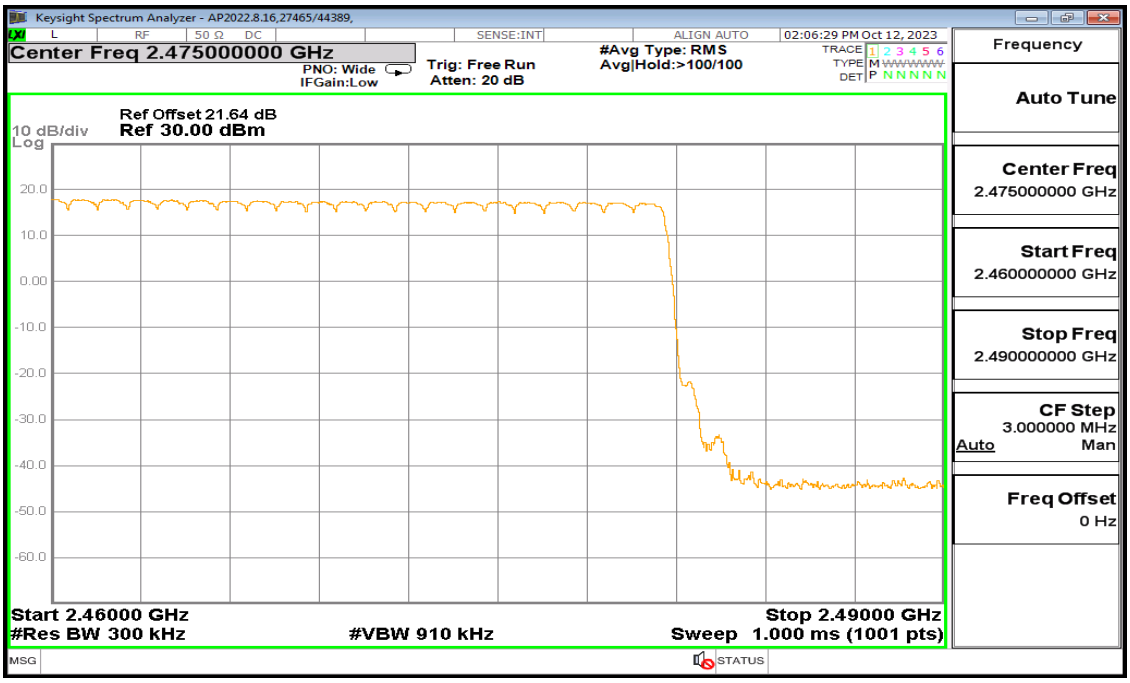
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

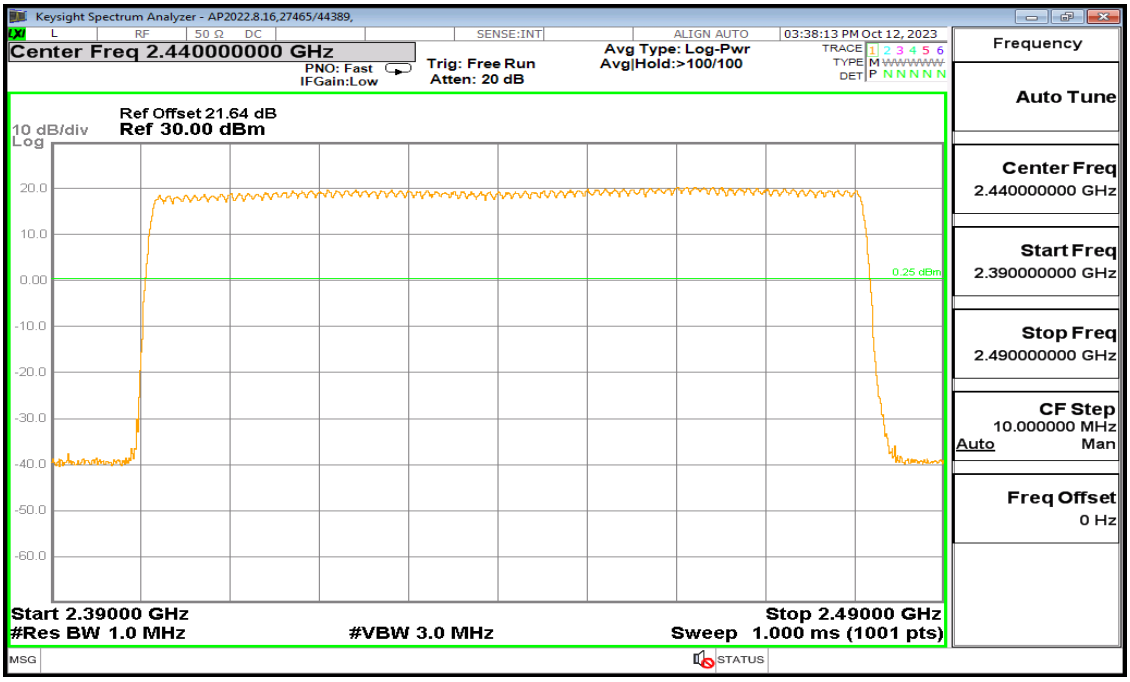


30MHz SPAN, SEGMENT 2 OF 3

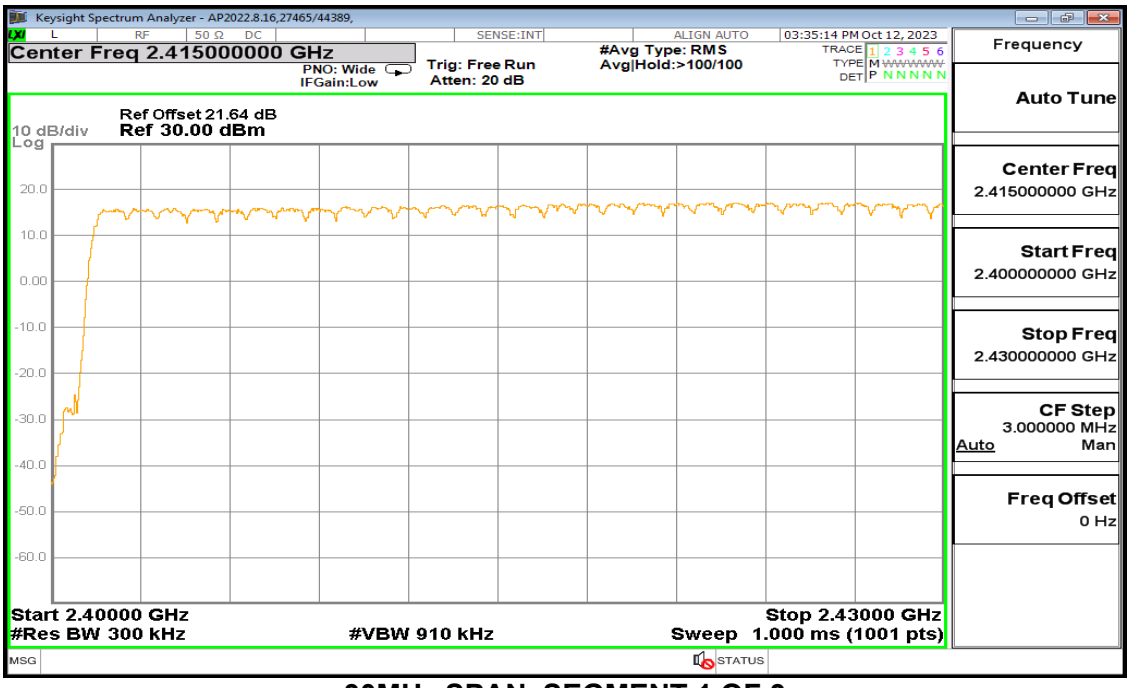


30MHz SPAN, SEGMENT 3 OF 3

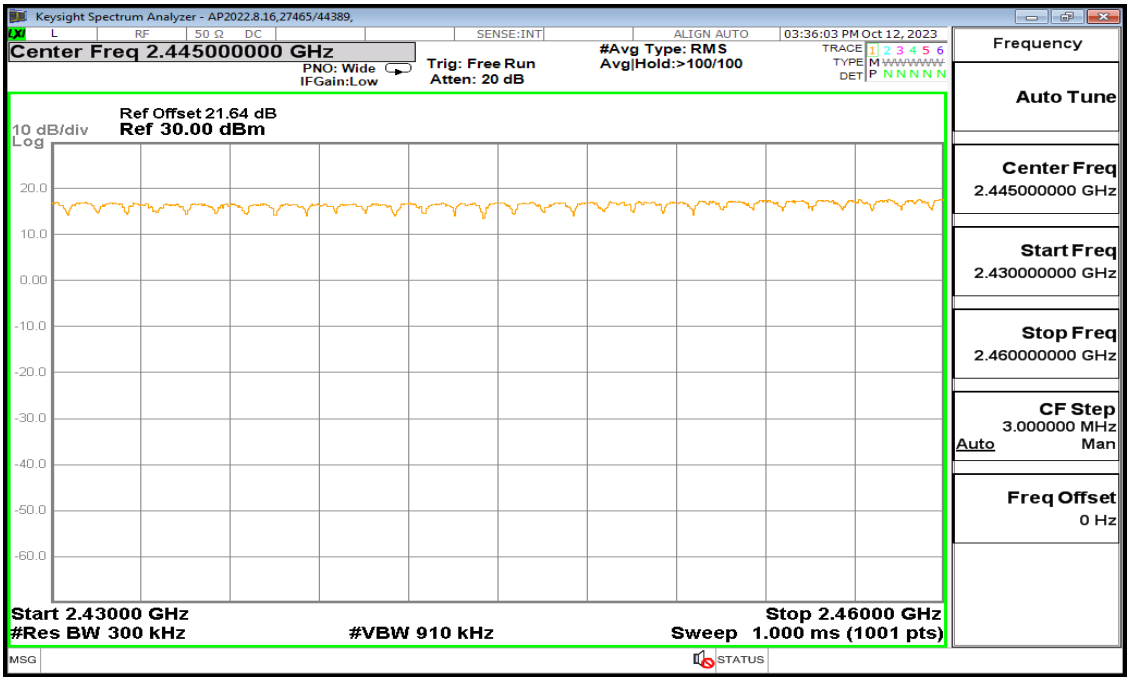
CHAIN 1



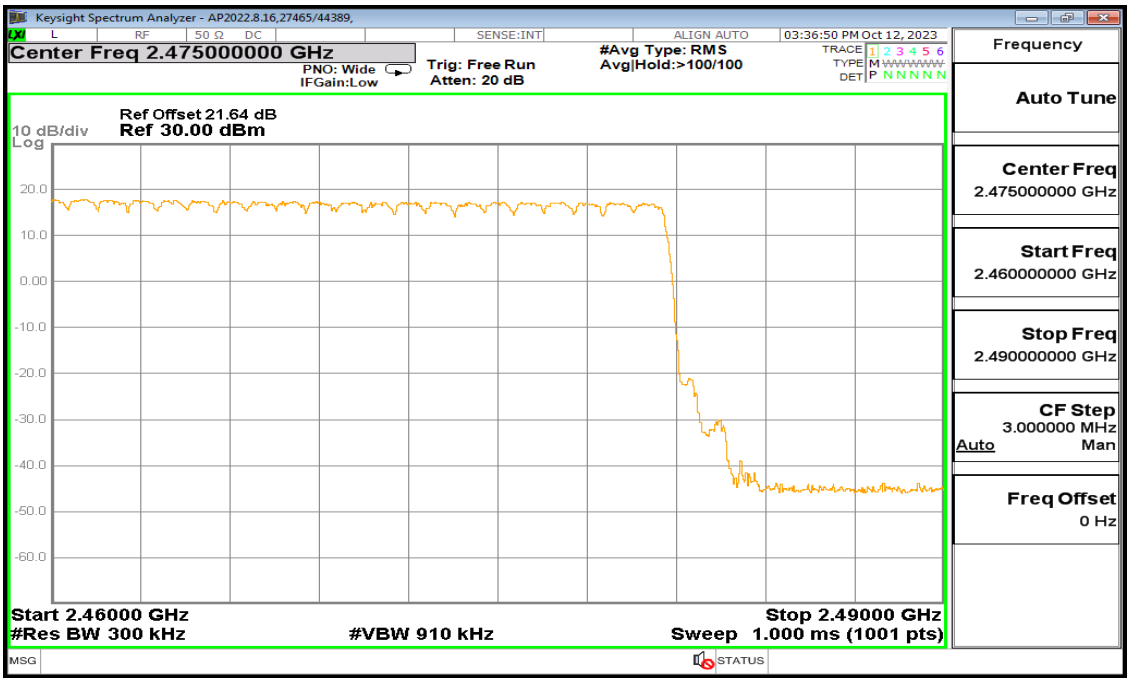
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

10.6. 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 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

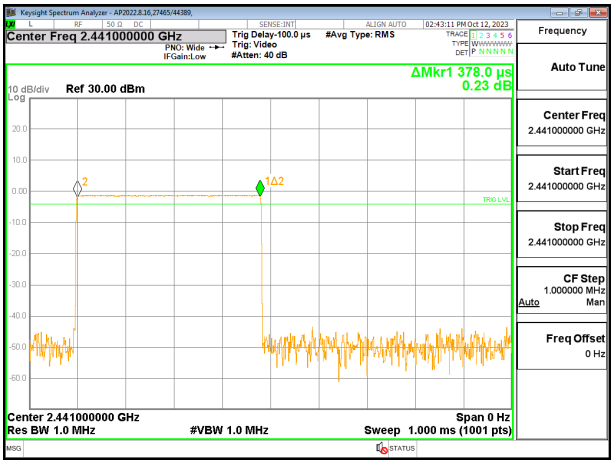
For AFH mode, the average time of occupancy in the specified 8 second period (20 channels * 0.4 seconds) is equal to 10 * (# of pulses in 0.8 s) * pulse width.

Note: This data leveraged from R14932101-E2a.

10.6.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

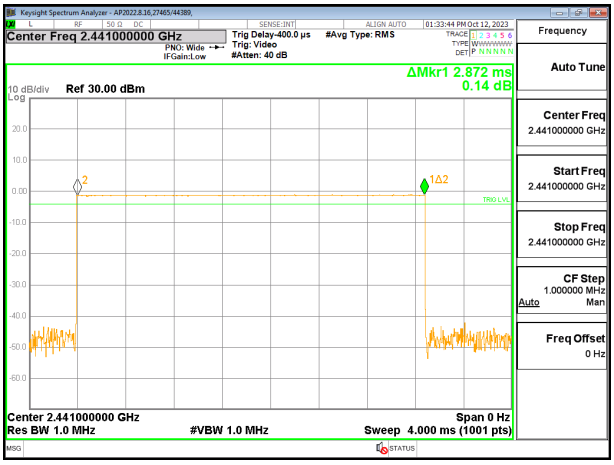
CHAIN 0

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	0.378	31	0.1172	0.4	-0.2828
DH3	1.630	14	0.2282	0.4	-0.1718
DH5	2.872	8	0.2298	0.4	-0.1702
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.378	7.75	0.02930	0.4	-0.3707
DH3	1.63	3.5	0.05705	0.4	-0.3430
DH5	2.872	2	0.05744	0.4	-0.3426

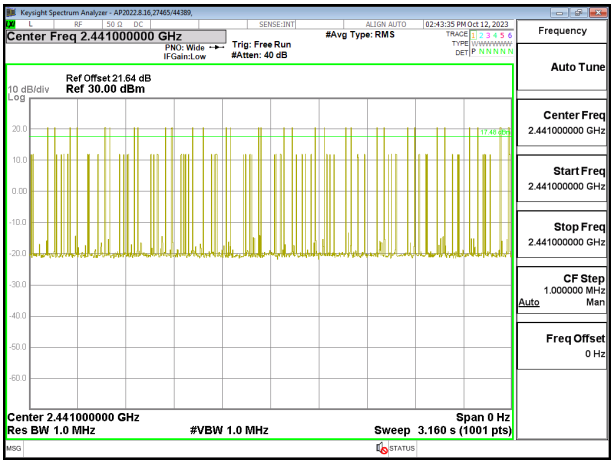


PULSE WIDTH – DH1

PULSE WIDTH – DH3

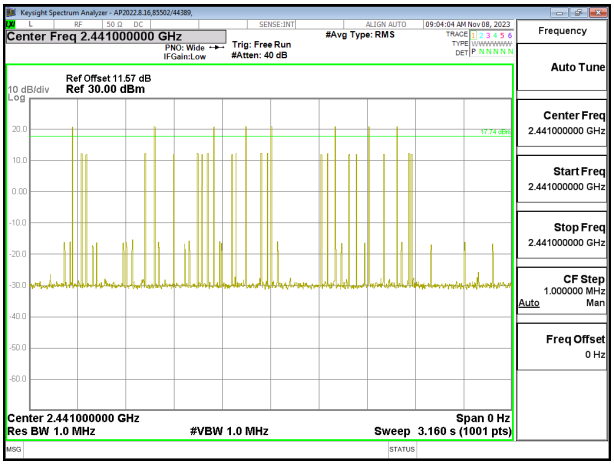


PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1

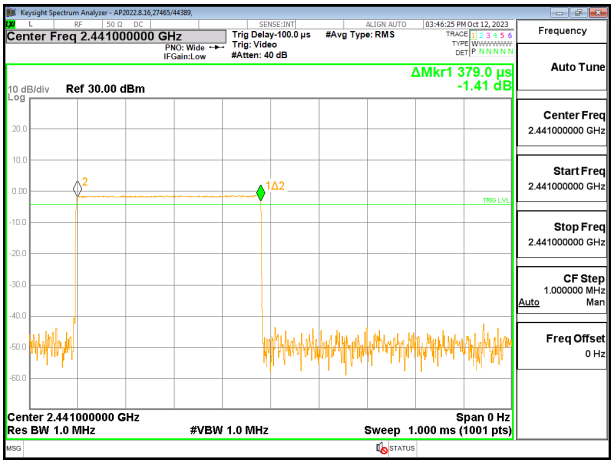
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



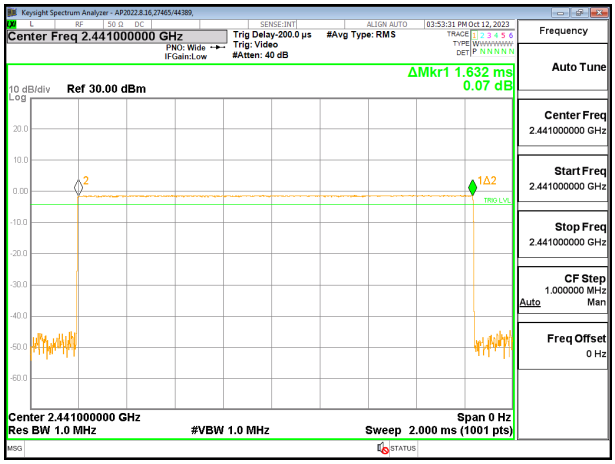
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

CHAIN 1

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	31	0.1175	0.4	-0.2825
DH3	1.632	14	0.2285	0.4	-0.1715
DH5	2.872	8	0.2298	0.4	-0.1702
DH Packet	Pulse Width (msec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.379	7.75	0.02937	0.4	-0.3706
DH3	1.632	3.5	0.05712	0.4	-0.3429
DH5	2.872	2	0.05744	0.4	-0.3426

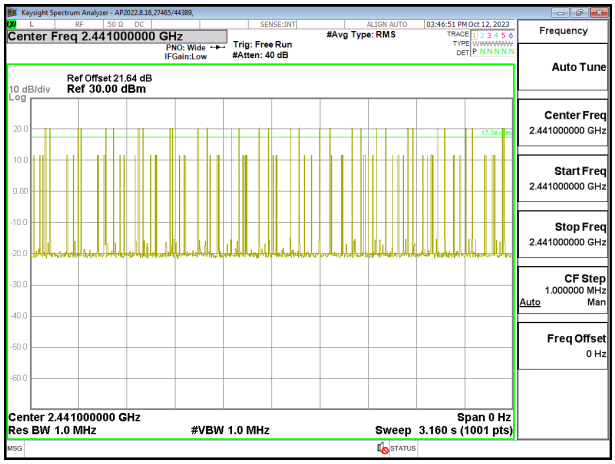


PULSE WIDTH – DH1

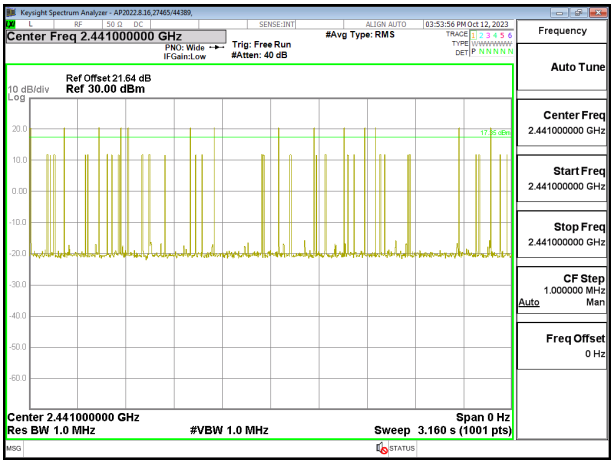


PULSE WIDTH – DH3

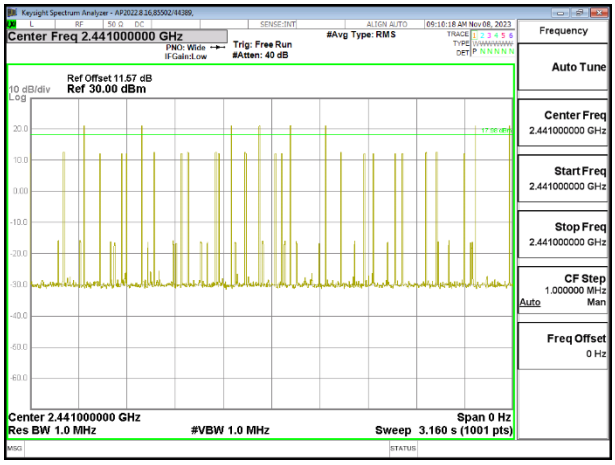
PULSE WIDTH – DH5



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

10.6.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

CHAIN 0

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	0.376	30	0.1128	0.4	-0.2872
3DH3	1.616	15	0.2424	0.4	-0.1576
3DH5	2.86	8	0.2288	0.4	-0.1712

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.

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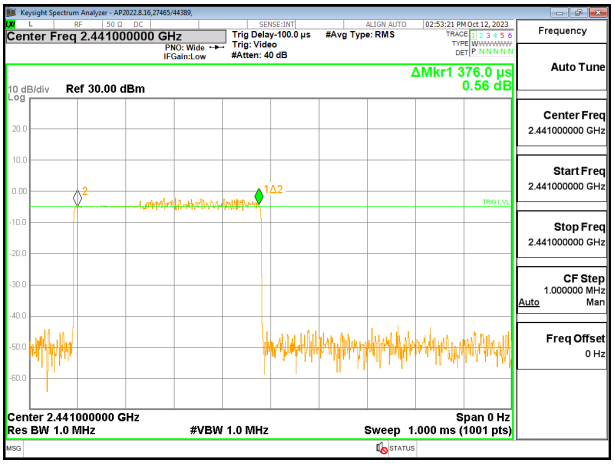
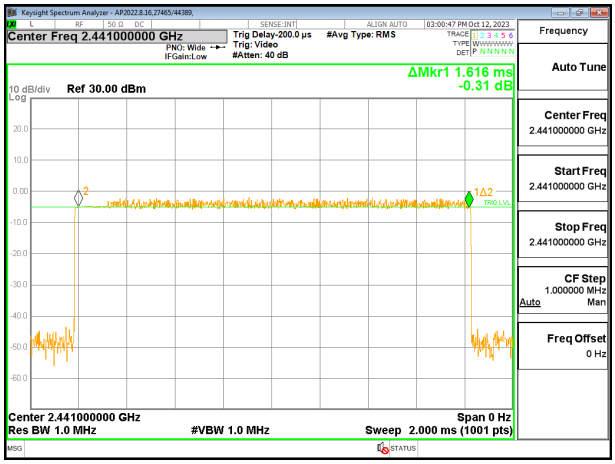
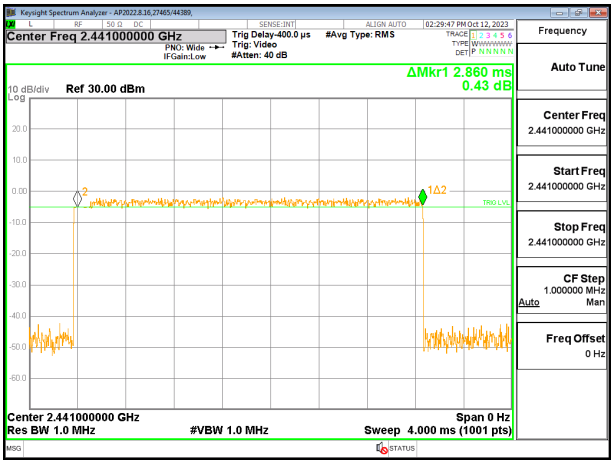


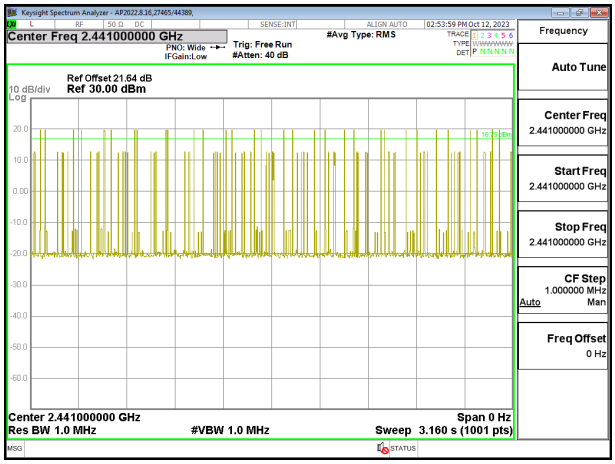
PULSE WIDTH – 3DH1



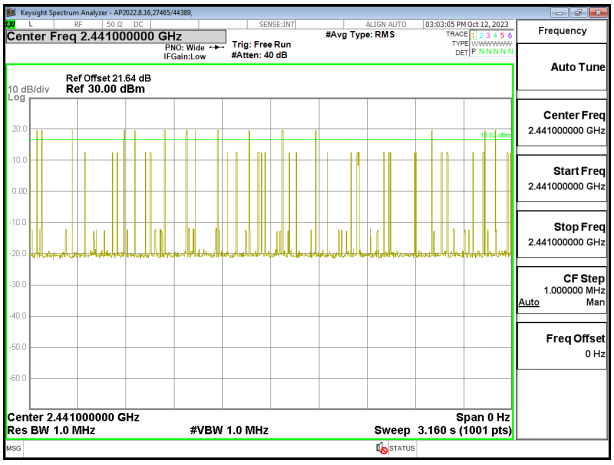
PULSE WIDTH – 3DH3



PULSE WIDTH – 3DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH1



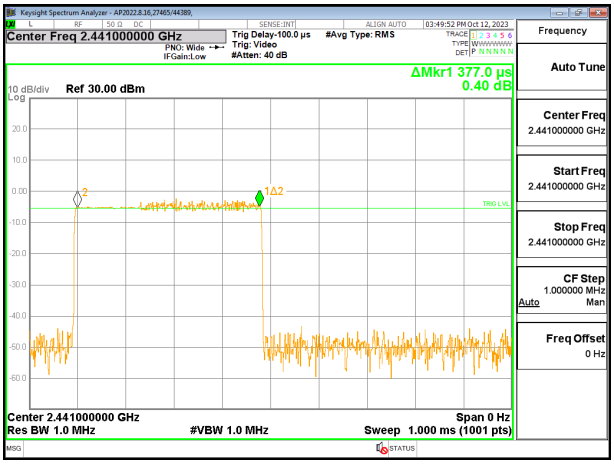
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH3

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – 3DH5

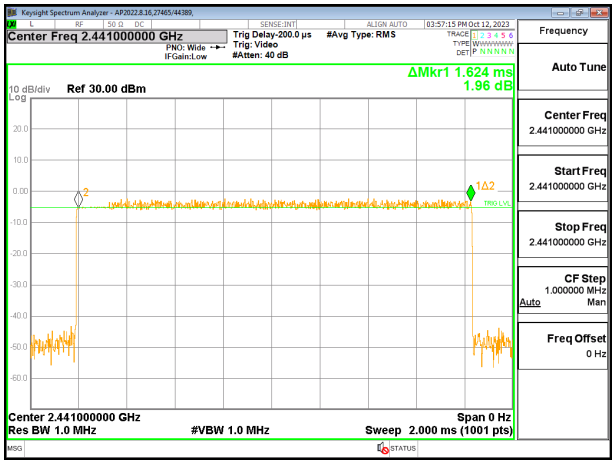
CHAIN 1

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	0.377	32	0.12064	0.4	-0.2794
3DH3	1.624	14	0.22736	0.4	-0.1726
3DH5	2.872	8	0.22976	0.4	-0.1702

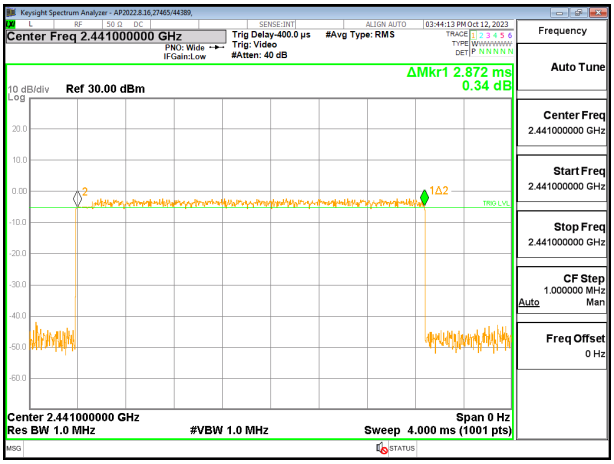
Note: for AFH(8PSK) mode, please refer to the results of AFH(GFSK) mode; the channel selection and hopping rate are the same for both EDR and Basic Rate operation, data for Basic Rate demonstrates compliance with channel occupancy when AFH is employed.



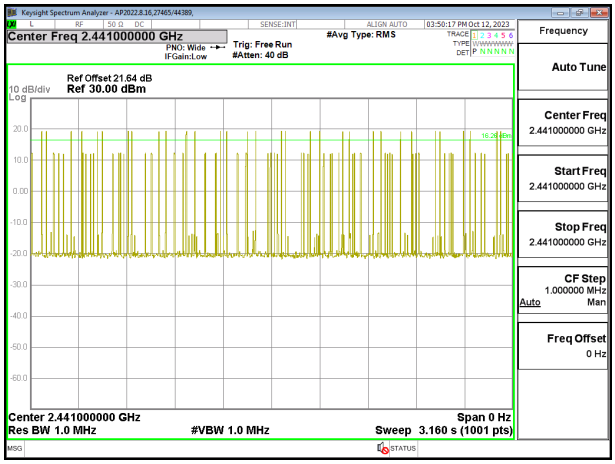
PULSE WIDTH – 3DH1



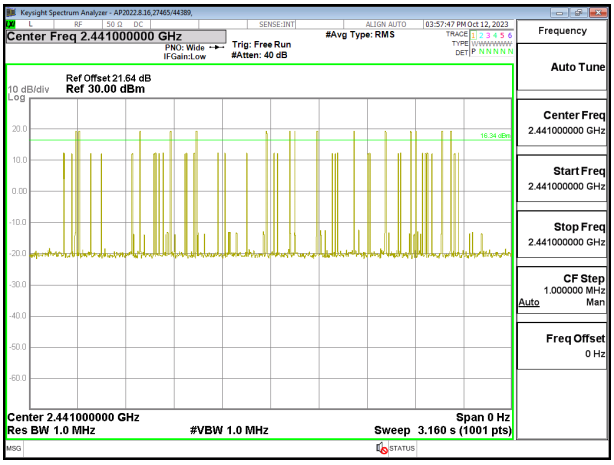
PULSE WIDTH – 3DH3



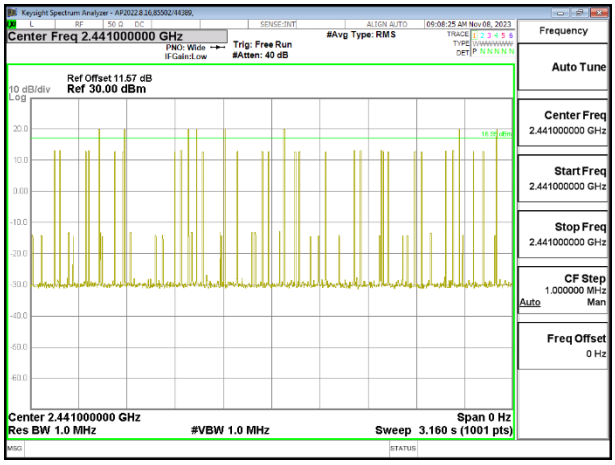
PULSE WIDTH – 3DH5



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

10.7. OUTPUT POWER

LIMITS

§15.247 (b) (1)
RSS-247 (5.4) (b)

The maximum SISO antenna gain is less than or equal to 6 dBi, therefore the limit is 30 dBm. For MIMO the gain is >6dBi, therefore the limit is reduced by the amount of the gain >6dBi, in this case 2.20dB.

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. EUT supports AFH, therefore 125mW limit used for all modes.

TEST PROCEDURE

Measurements perform using a wideband RF power meter.

The cable assembly insertion losses of 23.70 dB (including 20.20dB pad and 3.5 dB cable) for C0 and 22.60 dB (including 20.16dB pad and 2.56 dB cable) for C1 were entered as offsets in the power meter to allow for a peak reading of power.

The power output was measured on the EUT antenna port using SMA cable with 20dB attenuator connected to a power meter via wideband power sensor. Peak output power was read directly from power meter.

Note: This data leveraged from R14932101-E2a.

10.7.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

CHAIN 0

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.29	21	-1.71
Middle	2441	19.50	21	-1.50
High	2480	18.63	21	-2.37

CHAIN 1

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	19.12	21	-1.88
Middle	2441	19.22	21	-1.78
High	2480	17.72	21	-3.28

2Tx

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.43	19.19	-0.76
Middle	2441	17.92	19.19	-1.27
High	2480	17.61	19.19	-1.58

10.7.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

CHAIN 0

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	18.37	21	-2.63
Middle	2441	18.41	21	-2.59
High	2480	17.26	21	-3.74

CHAIN 1

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.85	21	-3.15
Middle	2441	18.21	21	-2.79
High	2480	16.42	21	-4.58

2Tx

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.92	19.19	-1.27
Middle	2441	18.00	19.19	-1.19
High	2480	16.04	19.19	-3.15

10.7.3. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

CHAIN 0

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.79	21	-3.21
Middle	2441	17.87	21	-3.13
High	2480	16.78	21	-4.22

CHAIN 1

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.20	21	-3.8
Middle	2441	17.60	21	-3.40
High	2480	15.88	21	-5.12

2Tx

Tested By:	33499/44389
Date:	2023-12-19

Channel	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	17.44	19.19	-1.75
Middle	2441	17.73	19.19	-1.46
High	2480	15.73	19.19	-3.46

10.8. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

Measurements perform using a wideband RF power meter.

The cable assembly insertion losses of 23.70 dB (including 20.20dB pad and 3.5 dB cable) for C0 and 22.60 dB (including 20.16dB pad and 2.56 dB cable) for C1 were entered as offsets in the power meter to allow for an average reading of power.

The power output was measured on the EUT antenna port using SMA cable with 20dB attenuator connected to a power meter via wideband power sensor. Gated average output power was read directly from power meter.

Note: This data leveraged from R14932101-E2a.

10.8.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

Tested By:	33499/44389
Date	2023-12-19

Channel	Frequency (MHz)	Average Power SISO Chain 0 (dBm)	Average Power SISO Chain 1 (dBm)	Average Power MIMO 2Tx (dBm)
Low	2402	19.09	18.90	18.27
Middle	2441	19.30	19.02	17.74
High	2480	18.43	17.49	17.39

10.8.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

Tested By:	33499/44389
Date	2023-12-19

Channel	Frequency (MHz)	Average Power SISO Chain 0 (dBm)	Average Power SISO Chain 1 (dBm)	Average Power MIMO 2Tx (dBm)
Low	2402	14.21	14.31	14.84
Middle	2441	14.76	14.84	15.55
High	2480	14.08	13.10	13.16

10.8.3. BLUETOOTH ENHANCED DATA RATE DQPSK MODULATION

Tested By:	33499/44389
Date	2023-12-19

Channel	Frequency (MHz)	Average Power SISO Chain 0 (dBm)	Average Power SISO Chain 1 (dBm)	Average Power MIMO 2Tx (dBm)
Low	2402	15.06	14.50	14.85
Middle	2441	15.26	14.90	15.54
High	2480	14.07	13.09	13.18

10.9. CONDUCTED SPURIOUS EMISSIONS – AUTHORIZED BAND

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.

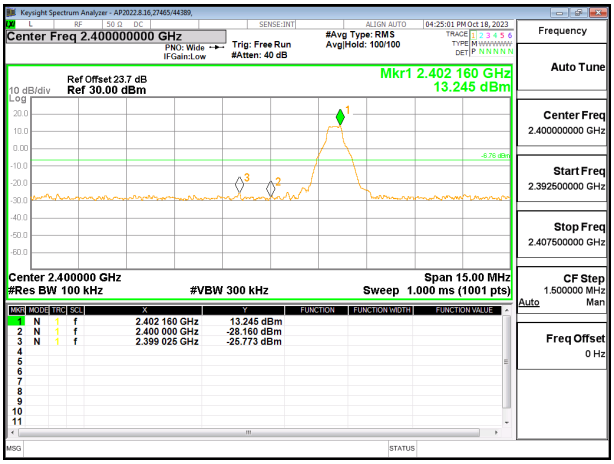
The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels with hopping disabled.

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

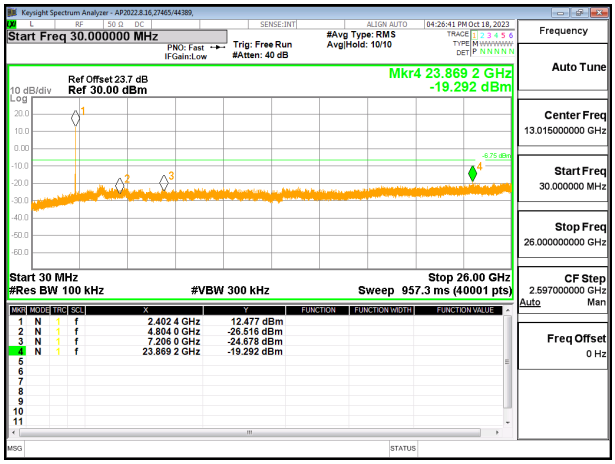
Note: This data leveraged from R14932101-E2a.

10.9.1. BLUETOOTH BASIC DATA RATE GFSK MODULATION

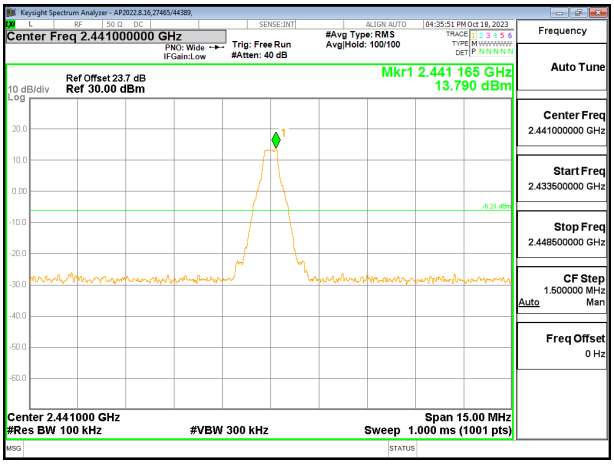
CHAIN 0 SPURIOUS EMISSIONS, NON-HOPPING



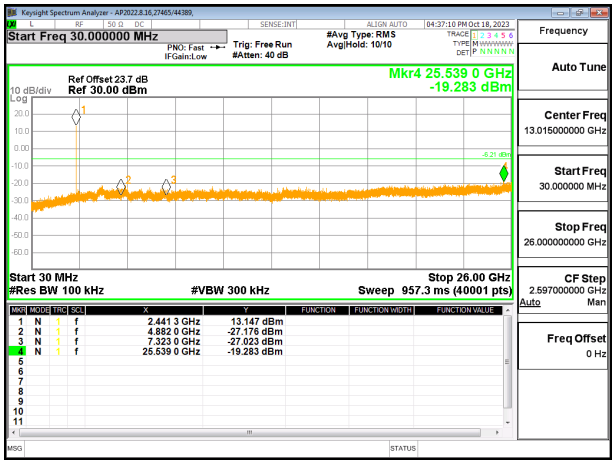
LOW CHANNEL BANDEDGE



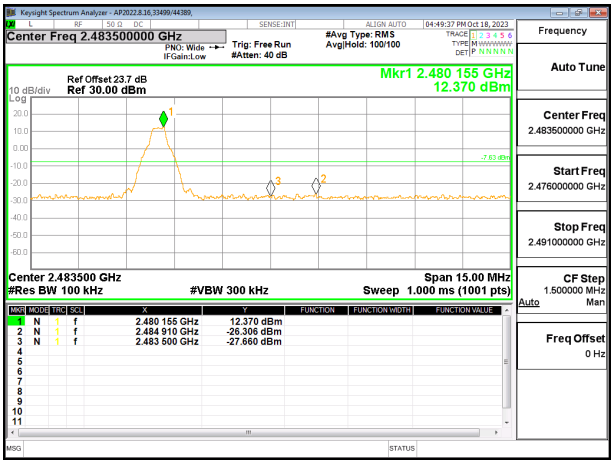
OUT-OF-BAND LOW CHANNEL



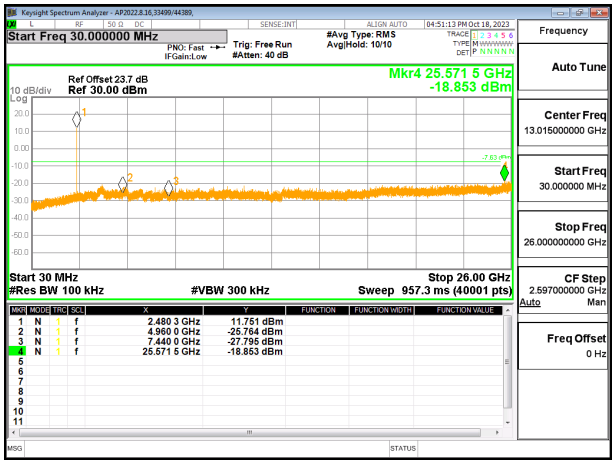
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

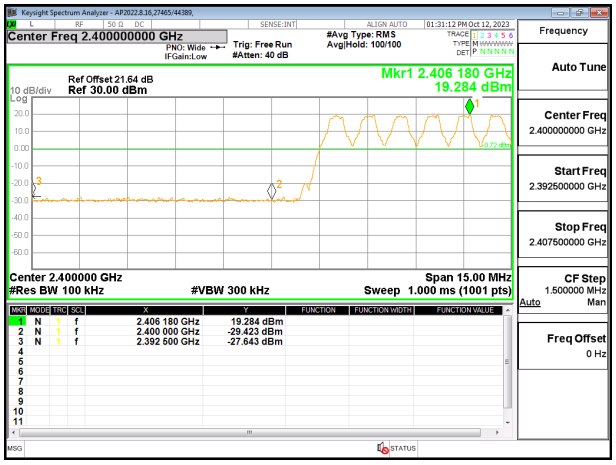


HIGH CHANNEL BANDEDGE

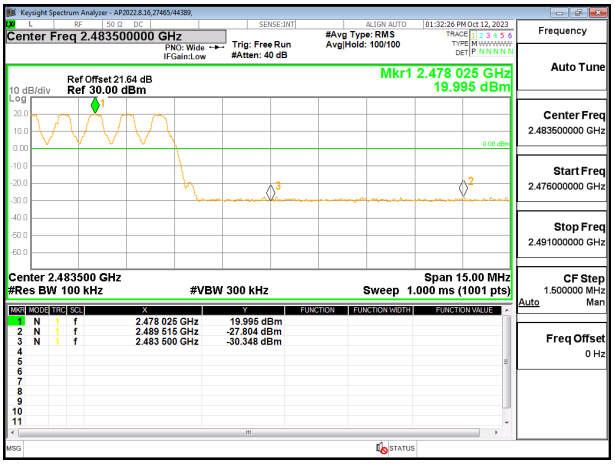


OUT-OF-BAND HIGH CHANNEL

CHAIN 0 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON

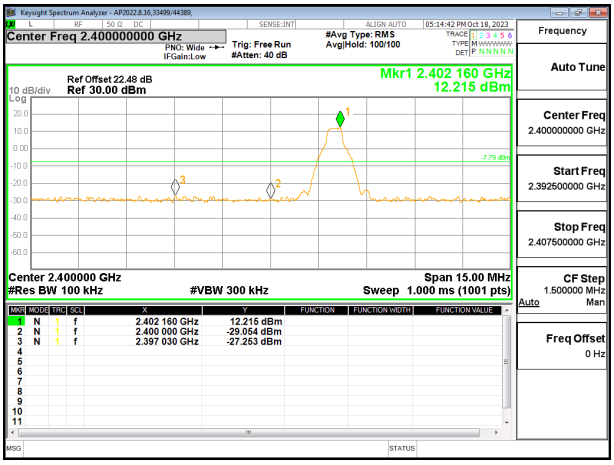


LOW BANDEDGE

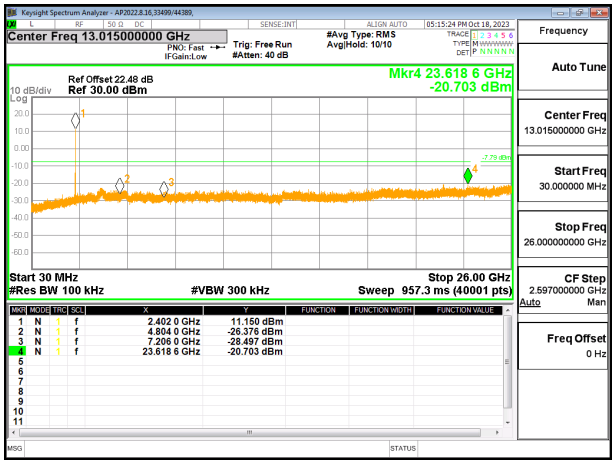


HIGH BANDEDGE

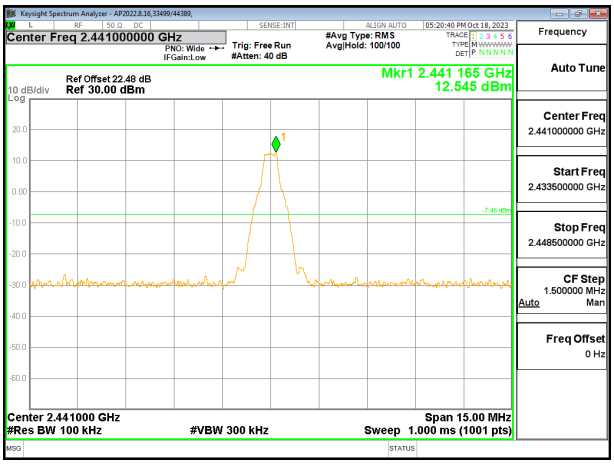
CHAIN 1 SPURIOUS EMISSIONS, NON-HOPPING



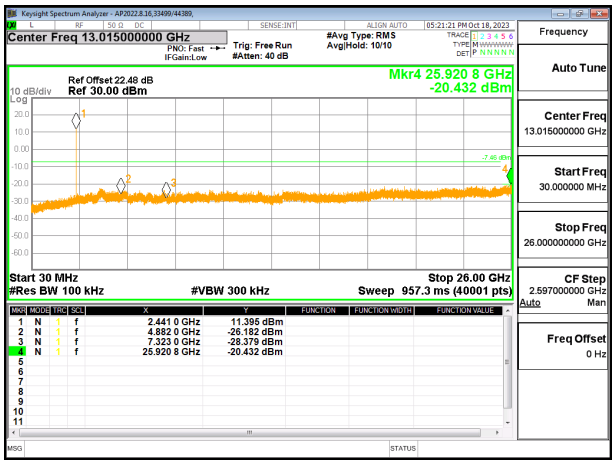
LOW CHANNEL BANDEDGE



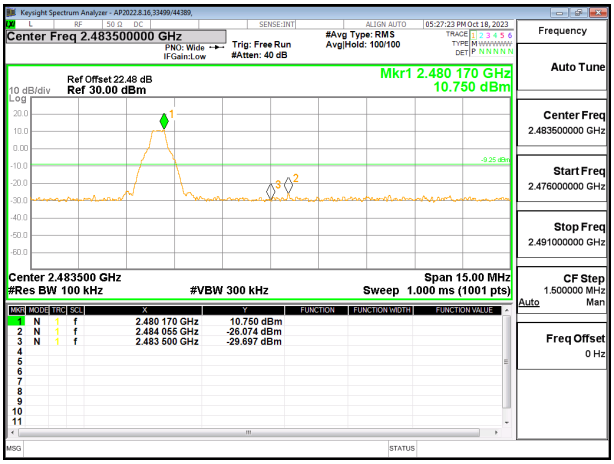
OUT-OF-BAND LOW CHANNEL



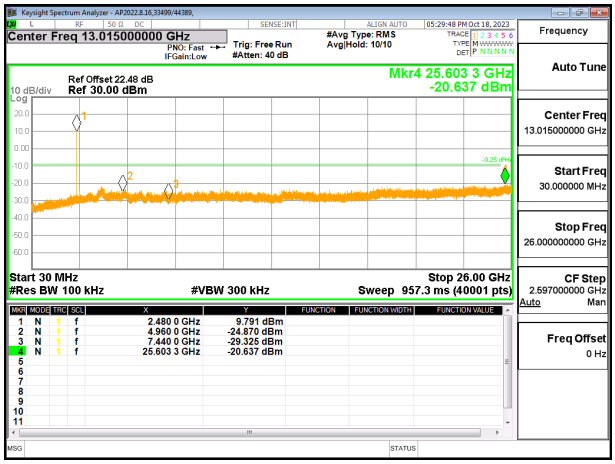
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL

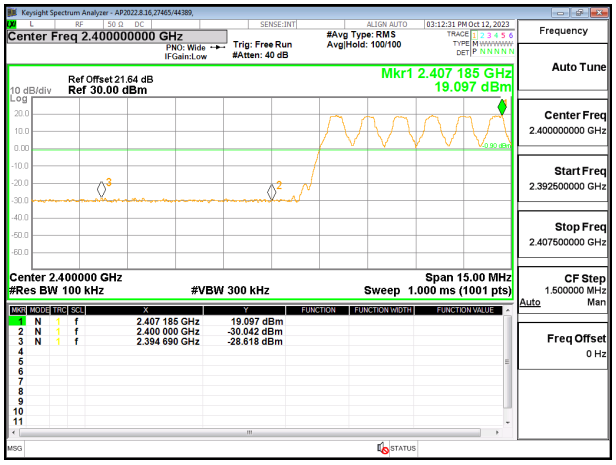


HIGH CHANNEL BANDEDGE

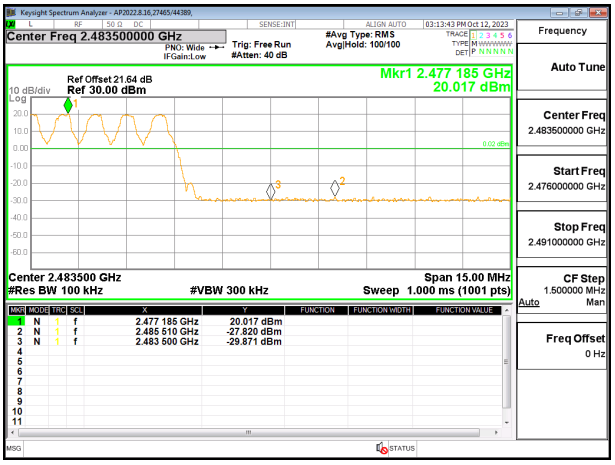


OUT-OF-BAND HIGH CHANNEL

CHAIN 1 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



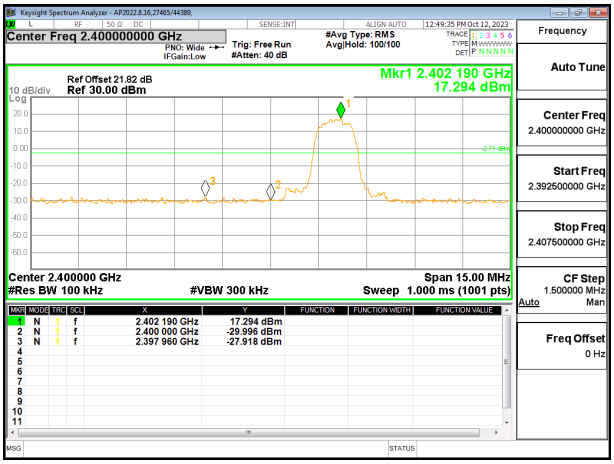
LOW BANDEDGE



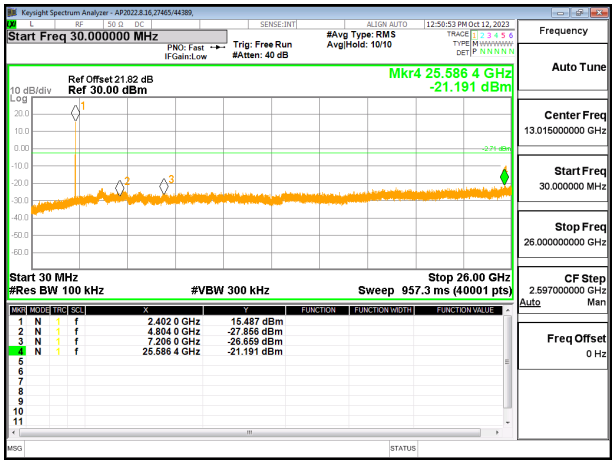
HIGH BANDEDGE

10.9.2. BLUETOOTH ENHANCED DATA RATE 8PSK MODULATION

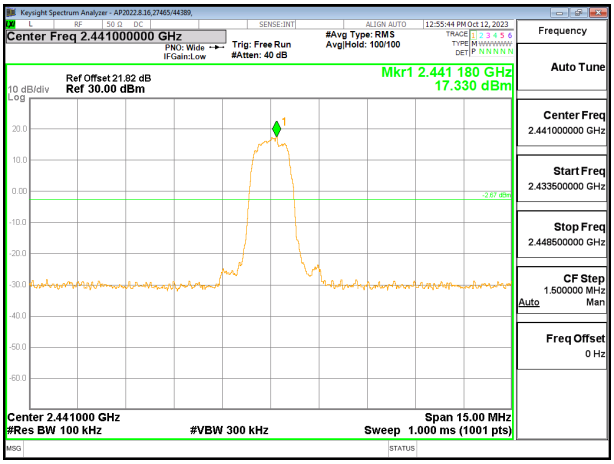
CHAIN 0 SPURIOUS EMISSIONS, NON-HOPPING



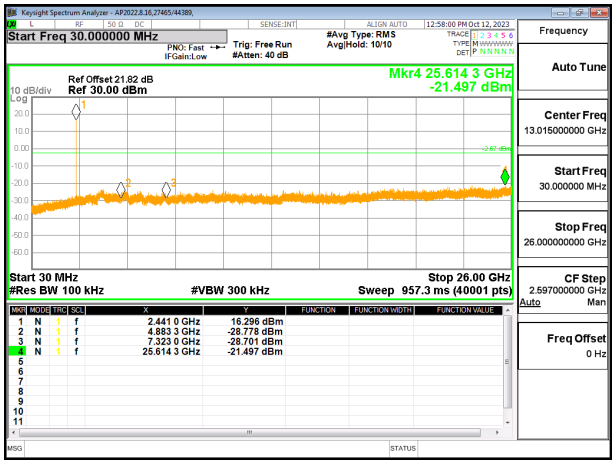
LOW CHANNEL BANDEDGE



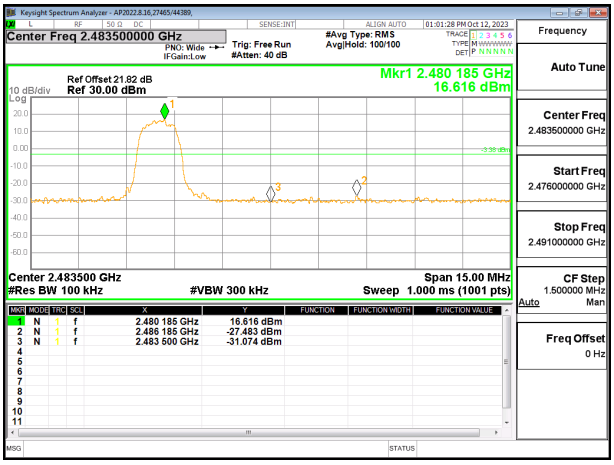
OUT-OF-BAND LOW CHANNEL



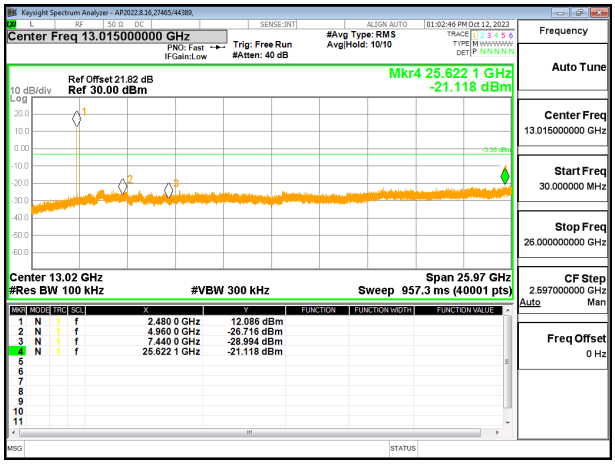
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL