TEST REPORT

Report Number: 15107843-E6V3

Applicant	:	Google LLC 1600 Amphitheatre Parkway Mountain View, CA 94043 U.S.A.
Model	:	G2YBB
FCC ID	:	A4RG2YBB
EUT Description	:	Phone
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C

Date Of Issue:
2024-05-08

Prepared by:
UL VERIFICATION SERVICES
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

CERT #0751.05

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2024-05-02	Initial Issue	--
V2	2024-05-03	Revised Section 7, 9.5.1 and 9.6.2	Tina Chu
V3	2024-05-08	Revised Section 9.6 1Tx antenna gain	Tina Chu

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

TABLE OF CONTENTS

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Google LLC
1600 Amphitheatre Parkway
Mountain View, CA 94043 U.S.A.

EUT DESCRIPTION: Phone

MODEL NUMBER: G2YBB

SERIAL NUMBER: 41061FDAQ00047 (Radiated BT GFSK),
41061FDAQ0003E (BLE Mode 2 Channel Sounding)
41151FDAQ0006X (Conducted)

SAMPLE RECEIPT DATE: 2024-01-18

DATE TESTED: 2024-01-30 TO 2024-05-03

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies

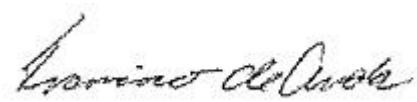
UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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

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

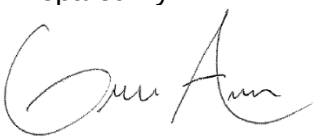
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

Approved & Released For
UL Verification Services Inc. By:



Francisco de Anda
Staff Engineer
Consumer Technology Division
UL Verification Services Inc.

Prepared By:



Gerardo Abrego
Senior Test Engineer
Consumer Technology Division
UL Verification Services Inc.

Reviewed By:

Tina Chu
Senior Project Engineer
Consumer Technology Division
UL Verification Services Inc.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for correctly integrating customer-provided data with measurements performed by UL Verification Services Inc.

Below is a list of the data provided by the customer:

1) Antenna gain and type (see section 6.3)

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

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 662911 Measurement of Transmitters with Multiple Output, MIMO
- KDB 558074 D01 15.247 Meas Guidance
- KDB 414788 D01 Radiated Test Site

4. FACILITIES AND ACCREDITATION

UL Verification Services Inc. is accredited by A2LA, Certificate Number 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			

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

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}
Radio Frequency (Spectrum Analyzer)	141.16 Hz
Occupied Bandwidth	1.22%
RF Power Measurement Direct Method Using Power Meter	1.3 dB (PK) / 0.45 dB (AV)
Unwanted Emissions, Conducted	1.94 dB
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
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.29 dB
Time Domain Measurements	3.39%
Temperature	0.57˚C
Humidity	3.39%
DC Supply Voltages	0.57%

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is a phone.

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	BT Basic GFSK, TXBF	22.91	195.43
2404 - 2478	BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING)	20.02	100.46
	BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)	20.07	101.62

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

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

The radio utilizes one IFA antenna (Ant4) and one ILA antenna (Ant3) for unlicensed radios.

Band	Antenna Peak Gain	
	Tx0 (Ant4) (dBi)	Tx1 (Ant3) (dBi)
2.4G	-1.10	0.9

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

6.4. WORST-CASE CONFIGURATION AND MODE

BT GFSK supports SISO diversity antennas and MIMO beamforming. Beamforming is chosen as worse case to cover SISO diversity antennas.

BLE ASK modulated 1Mbps/2Mbps only supports SISO diversity antennas.

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. There were no emissions found with less than 20dB of margin from 9kHz to 30MHz and above 18GHz.

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

Investigation was performed with/without adapter. Also, the fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, the following is the worst-case orientation:

- For BT GFSK: Y (Landscape) orientation was worst-case orientation with adapter
- For BLE channel sounding:
  Tx0: Z (Portrait) orientation was worst-case orientation with adapter
  Tx1: X (Flatbed) orientation was worst case orientation with adapter

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

GFSK mode: DH5
BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING): 1Mbps
BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING): 2Mbps

Plots included in the report are representative of the method and settings parameters used for the test.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

7. TEST AND MEASUREMENT EQUIPMENT

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

TEST EQUIPMENT LIST					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO METRICS	EM-6871	219908	2024-09-30	2023-09-13
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO METRICS	EM-6872	219910	2024-05-31	2023-05-31
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB1	80293	2024-04-30	2023-04-11
Amplifier,9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	213877	2024-12-31	2023-12-27
Antenna, Horn 1-18GHz (Chamber T)	ETS-Lindgren	3117	80430	2024-08-31	2022-08-08
Antenna, Horn 1-18GHz (Chamber I)	ETS-Lindgren	3117	84797	2024-09-30	2023-09-25
Antenna, Horn 1-18GHz (Chamber J)	ETS-Lindgren	3117	222741	2024-08-31	2022-08-22
Antenna, Horn 1-18GHz (Chamber Q)	ETS-Lindgren	3117	84796	2024-09-30	2023-09-25
RF Filter Box, 1-18GHz (Chamber T)	UL-FR1	RATS 2	226781	2024-09-30	202-09-30
RF Filter Box, 1-18GHz (Chamber I)	UL-FR1	NA	171389	2024-05-31	2023-05-15
RF Filter Box, 1-18GHz (Chamber J)	UL-FR1	NA	171875	2024-05-31	2023-05-30
RF Filter Box, 1-18GHz (Chamber Q)	UL-FR1	NA	217521	*2024-03-31	2023-08-16
EMI TEST RECEIVER (Chamber T)	Rohde & Schwarz	ESW44	169935	2025-02-28	2024-02-11
EMI TEST RECEIVER (Chamber I)	Rohde & Schwarz	ESW44	201497	2025-02-28	2024-02-11
EMI TEST RECEIVER (Chamber J)	Rohde & Schwarz	ESW44	171875	2024-05-31	2023-05-30
EMI TEST RECEIVER (Chamber Q)	Rohde & Schwarz	ESW44	223461	2025-02-28	2024-02-10
Antenna, Horn 18 to 26.5GHz	A.R.A.	MWH-1826/B	199659	2024-12-31	2022-12-06
Amplifier 18-26.5GHz, +5Vdc, -54dBm P1dB	AMPLICAL	AMP18G26.5-60	234683	*2024-03-31	2023-03-18
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030B	222074	2024-08-31	2023-08-14
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030B	222073	2024-08-31	2023-08-14
10dB Fixed Attenuator, up to 26GHz	Pasternack Enterprises	PE7087-10	236189	Verified/characterized before use	
Power Meter, P-series single channel	Keysight Technologies Inc	N1921A	90731	2025-01-31	2024-01-25
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1911A	90388	2024-06-30	2023-06-23
AC Line Conducted					
LISN	Fischer Custom Communications, Inc	FCC-LISN-50/250-25-2-01-480V	175765	2025-01-31	2024-01-26
EMI TEST RECEIVER	Rohde & Schwarz	ESR	171646	2025-02-28	2024-02-27
Transient Limiter	TE	TBFL1	127455	2025-02-28	2024-02-27
UL TEST SOFTWARE LIST					
Radiated Software	UL	UL EMC	Ver 2023-01-18, 2023-03-03, 2023-05-01		
Antenna Port Software	UL	UL RF	Ver 2022-08-16		
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 2022-02-17		

*Test was performed before calibration due date

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

8. MEASUREMENT METHODS

On Time and Duty Cycle: ANSI C63.10-2013 Section 11.6

Occupied BW (20dB): ANSI C63.10-2013 Section 6.9.2

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Carrier Frequency Separation: ANSI C63.10-2013 Section 7.8.2

Number of Hopping Frequencies: ANSI C63.10-2013 Section 7.8.3

Time of Occupancy (Dwell Time): ANSI C63.10-2013 Section 7.8.4

Peak Output Power: ANSI C63.10-2013 Section 7.8.5

Average Output Power: ANSI C63.10-2013 Section 11.9.2.3.2

Conducted Spurious Emissions: ANSI C63.10-2013 Section 7.8.8

Conducted Band-Edge: ANSI C63.10-2013 Section 6.10.4

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

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

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

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

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

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

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.

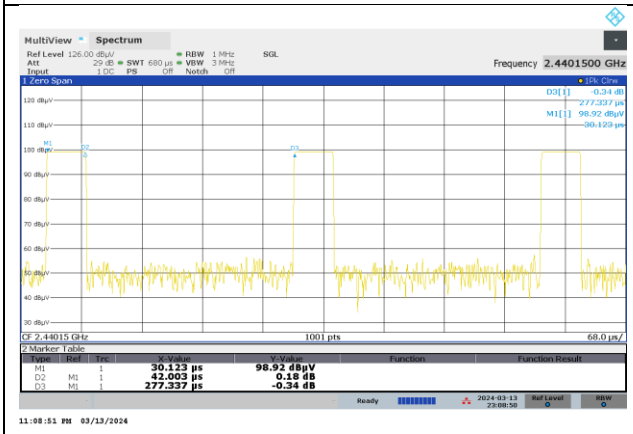
ON TIME AND DUTY CYCLE RESULTS

Test By:	24971 BN

Mode	ON Time T (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	DCCF (dB)	1/T Minimum VBW (kHz)
BT GFSK	2.87746	3.74897	0.77	76.75	1.15	0.35
BLE 1Mbps (channel sounding, ASK modulated)	0.041323	0.278017	0.15	14.86	8.28	24.20
BLE 2Mbps (channel sounding, ASK modulated)	0.042003	0.277337	0.15	15.15	8.20	23.81

BT GFSK

BLE 1Mbps ASK, MODE 2



BLE 2Mbps ASK, MODE 2

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.2. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to ≥ 1% of the 20 dB/ 99% bandwidth. The VBW shall be approximately three times RBW. The sweep time is coupled.

RESULTS

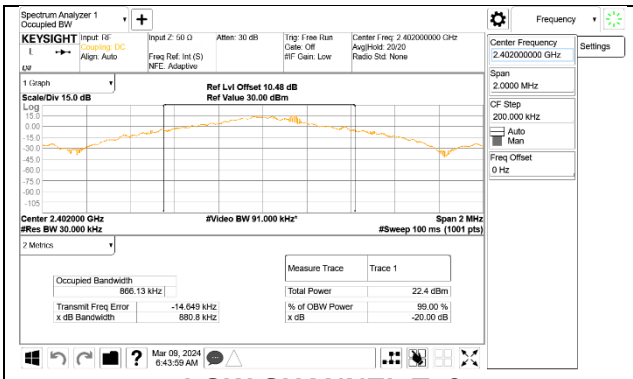
Test By:	NM 19232 & HN 27979

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

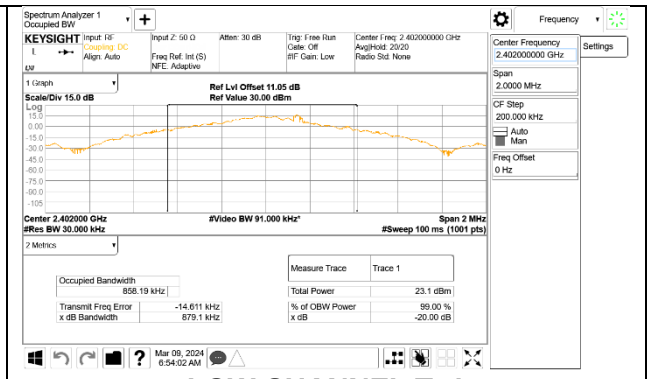
9.2.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

2Tx

No. of Tx	Channel	Frequency (MHz)	20dB Bandwidth (MHz)		99% Bandwidth (MHz)	
			Tx0	Tx1	Tx0	Tx1
2	Low	2402	0.8808	0.8791	0.86613	0.85819
	Mid	2441	0.8784	0.8839	0.86871	0.87308
	High	2480	0.9155	0.9261	0.88255	0.87775



LOW CHANNEL Tx0

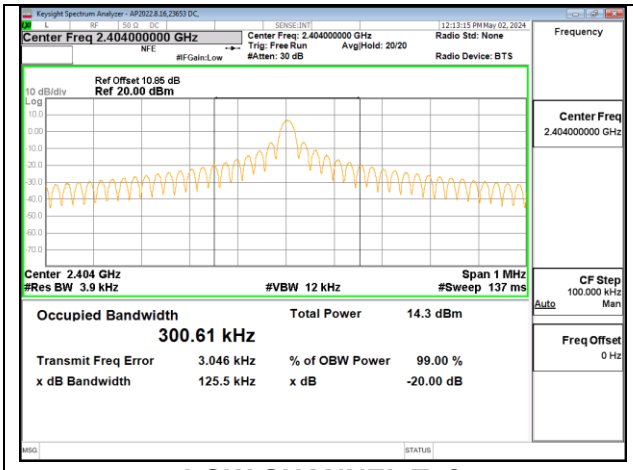


LOW CHANNEL Tx1

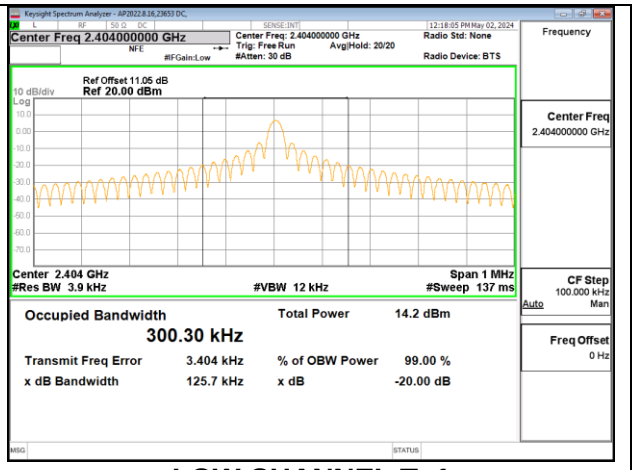
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.2.2. BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING)

No. of Tx	Channel	Frequency (MHz)	20dB Bandwidth (MHz)		99% Bandwidth (MHz)	
			Tx0	Tx1	Tx0	Tx1
1	Low	2404	0.1255	0.1257	0.30061	0.30030
	Mid	2440	0.1259	0.1256	0.30088	0.30045
	High	2478	0.1253	0.1256	0.30027	0.30145



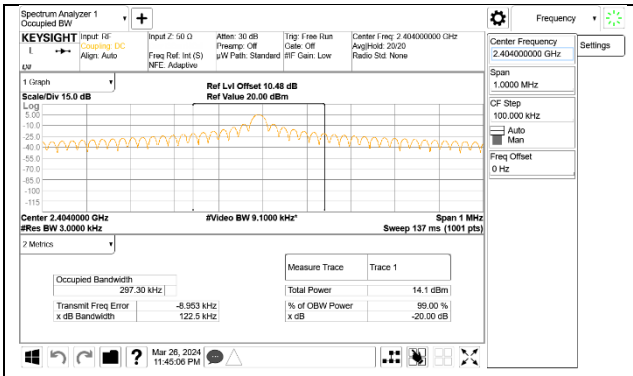
LOW CHANNEL Tx0



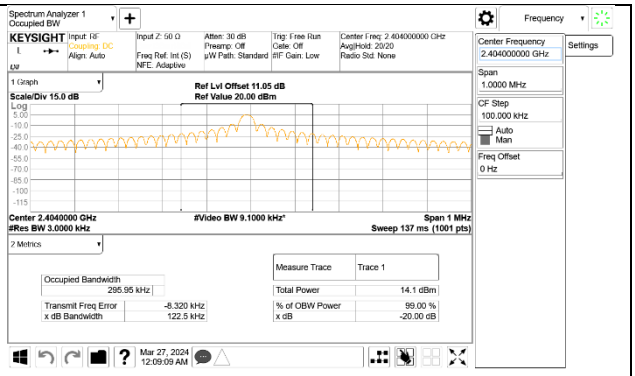
LOW CHANNEL Tx1

9.2.3. BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)

No. of Tx	Channel	Frequency (MHz)	20dB Bandwidth (MHz)		99% Bandwidth (MHz)	
			Tx0	Tx1	Tx0	Tx1
1	Low	2404	0.1225	0.1225	0.29730	0.29595
	Mid	2440	0.1226	0.1224	0.29659	0.29606
	High	2478	0.1226	0.1223	0.29806	0.29701



LOW CHANNEL Tx0



LOW CHANNEL Tx1

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.3. HOPPING FREQUENCY SEPARATION

LIMITS

FCC §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

TEST PROCEDURE

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

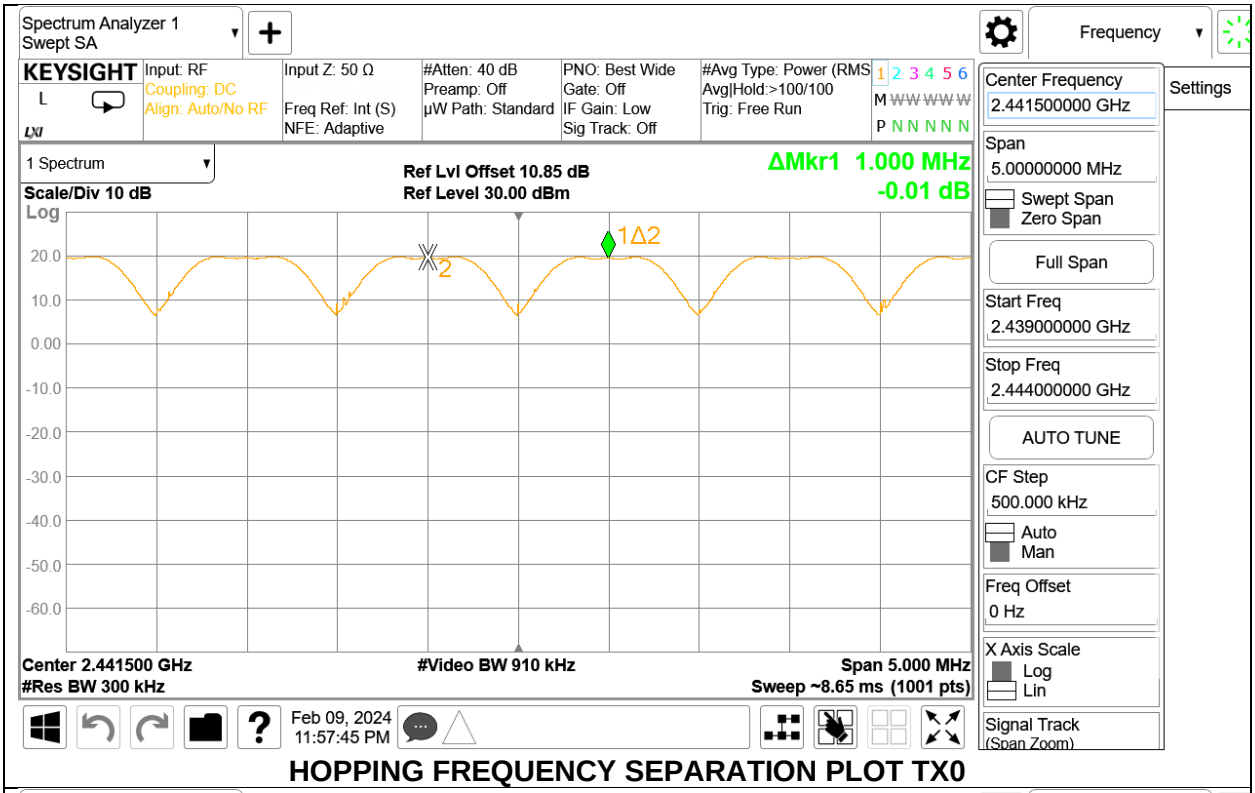
RESULTS

Test By:	NM 19232 & HN 27979

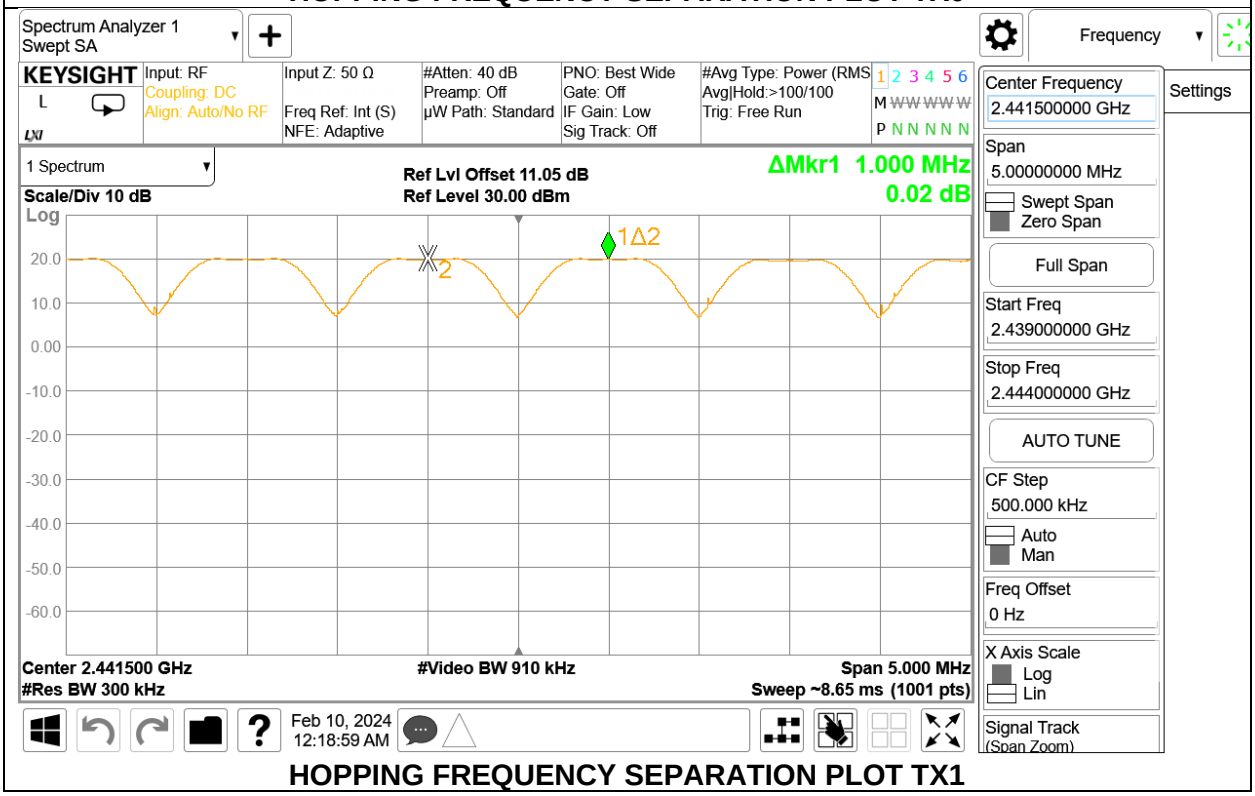
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.3.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

2Tx



HOPPING FREQUENCY SEPARATION PLOT TX0

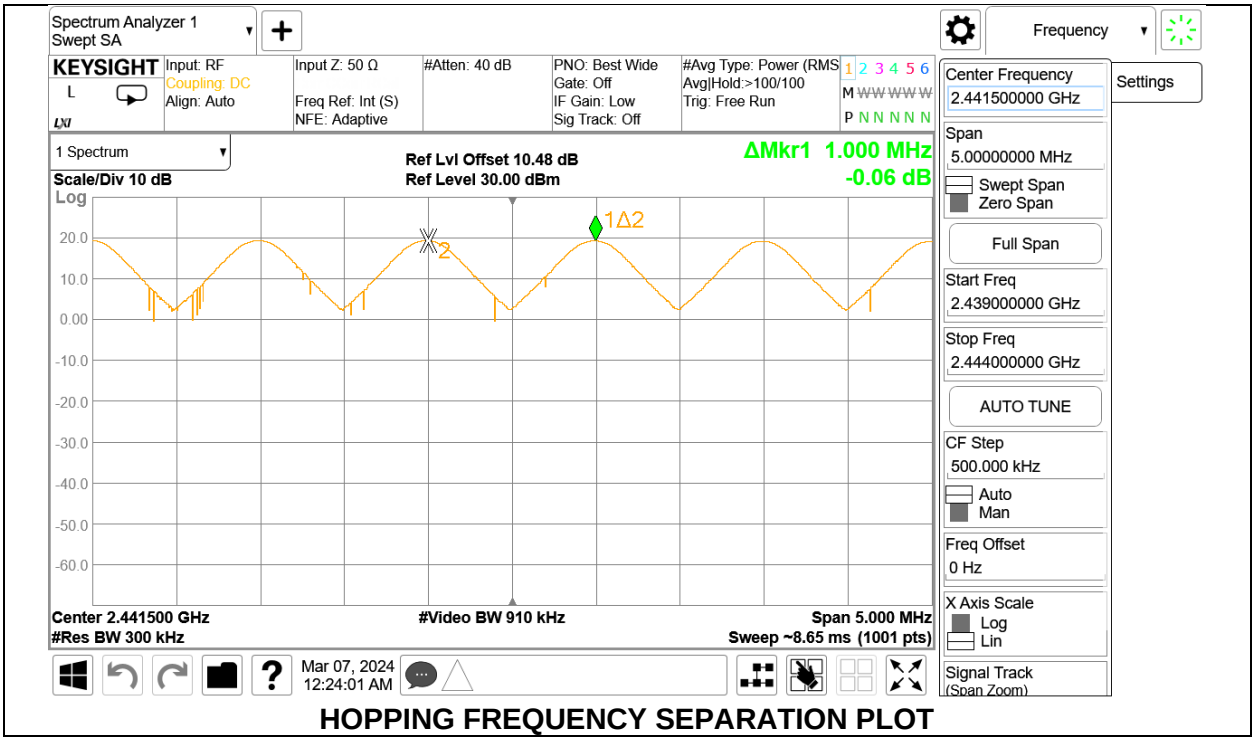


HOPPING FREQUENCY SEPARATION PLOT TX1

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

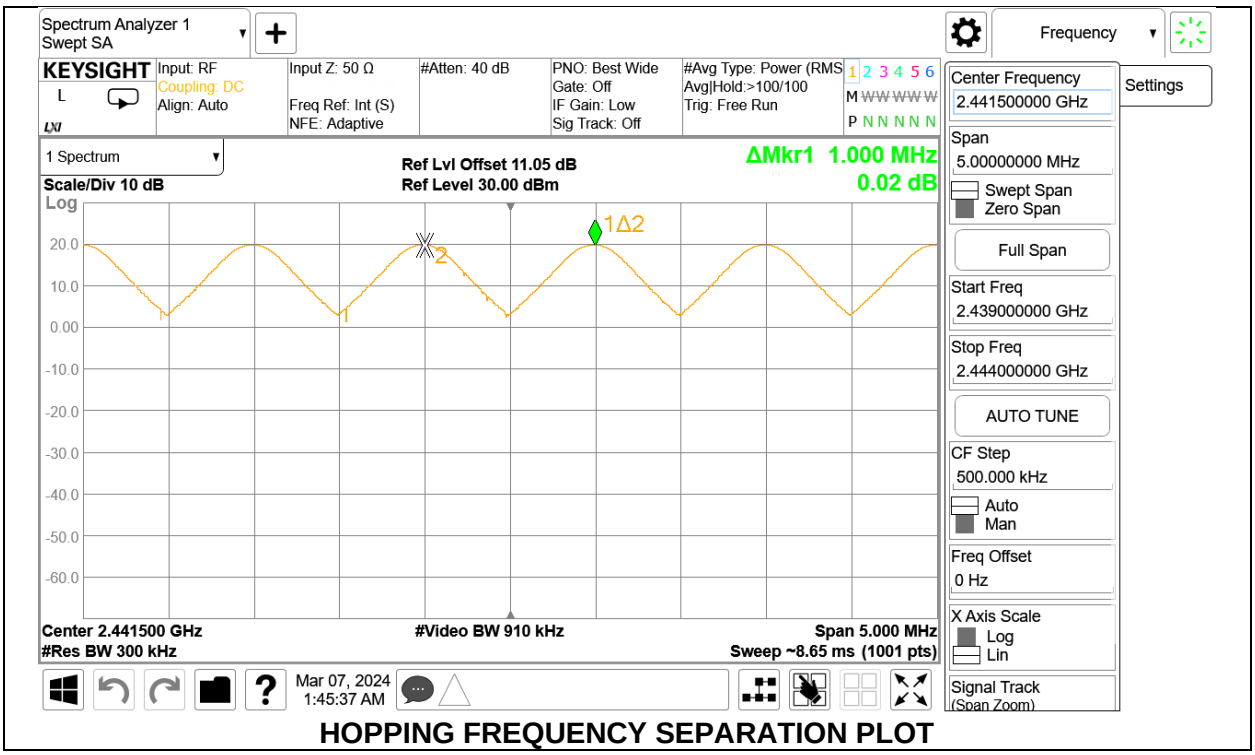
9.3.2. BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING)

Tx0



HOPPING FREQUENCY SEPARATION PLOT

Tx1

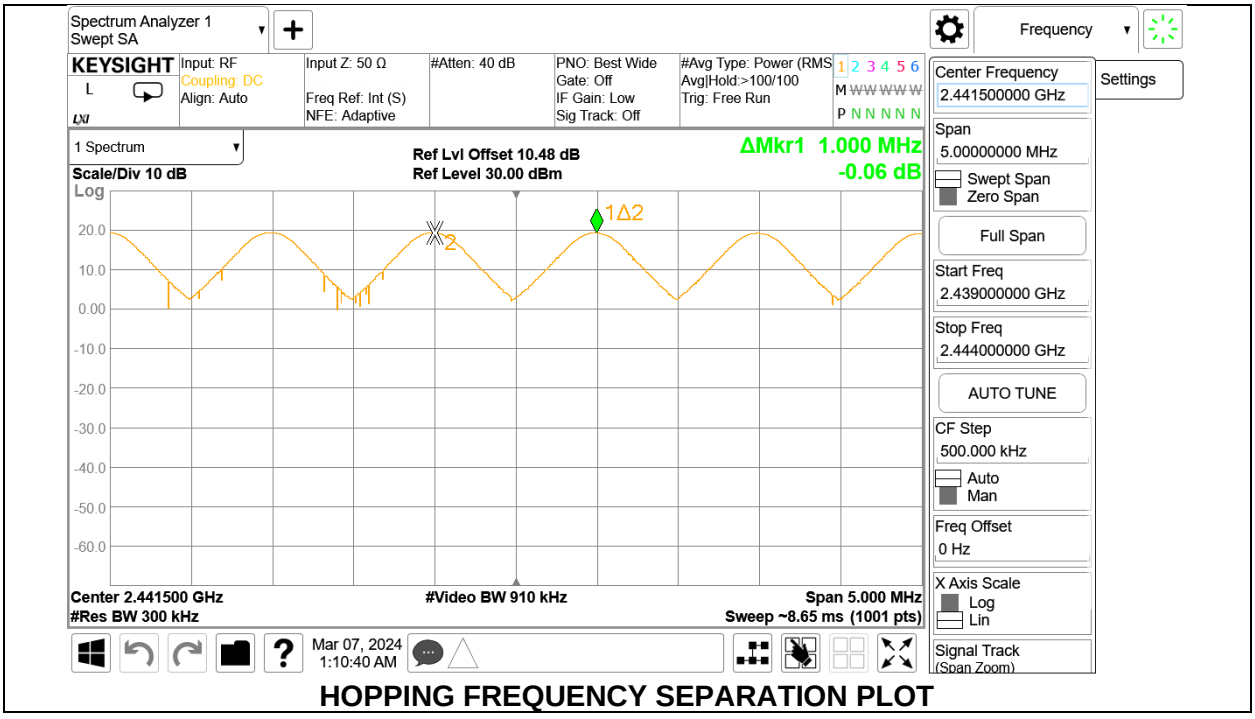


HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

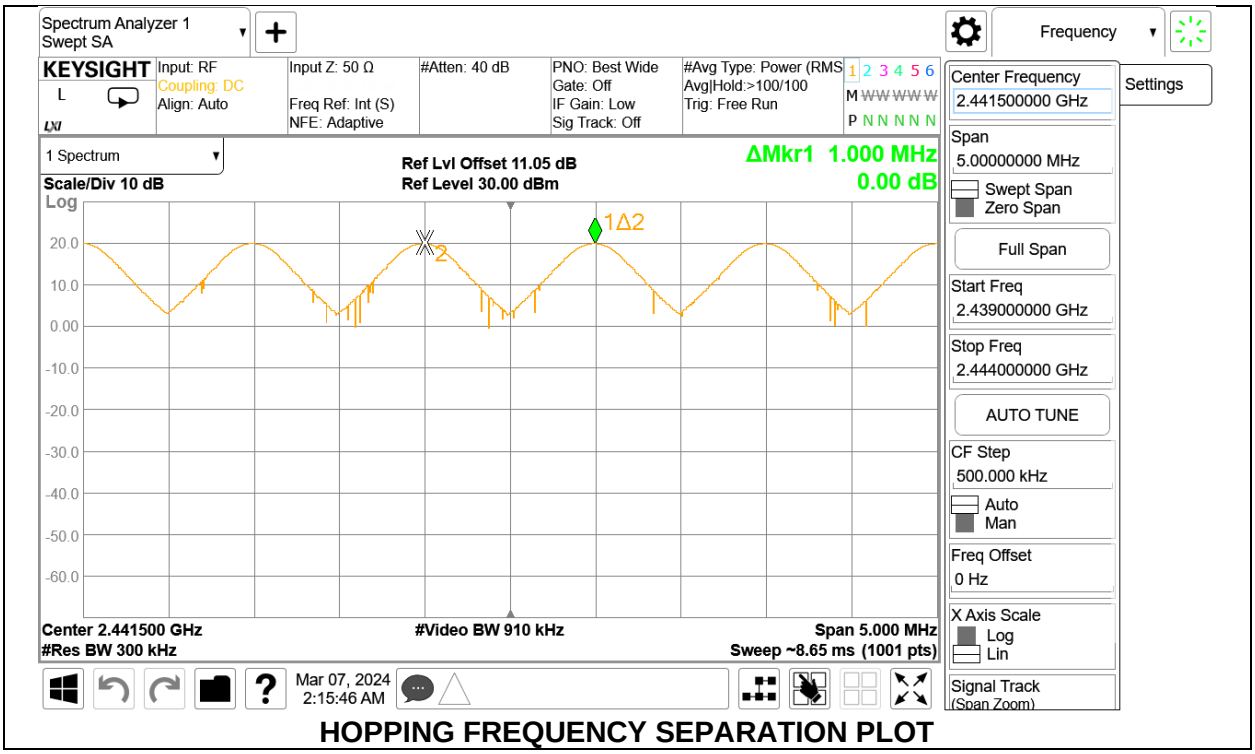
9.3.3. BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)

Tx0



HOPPING FREQUENCY SEPARATION PLOT

Tx1



HOPPING FREQUENCY SEPARATION PLOT

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.4. NUMBER OF HOPPING CHANNELS

LIMITS

FCC §15.247 (a) (1) (iii)

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

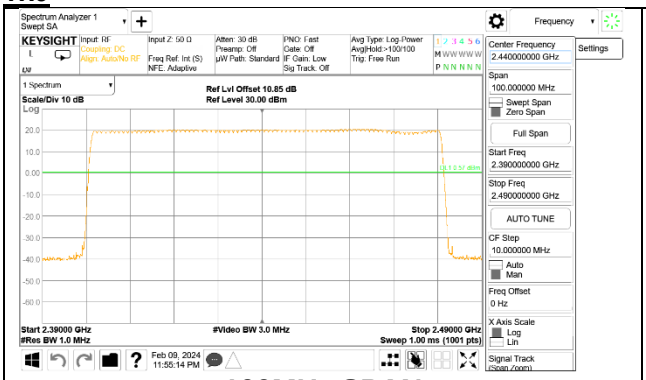
BT GFSK: 79 Channels Observed
BLE Channel Sounding 1Mbps: 72 Channels Observed
BLE Channel Sounding 2Mbps: 72 Channels Observed

Test By:	24971 BN

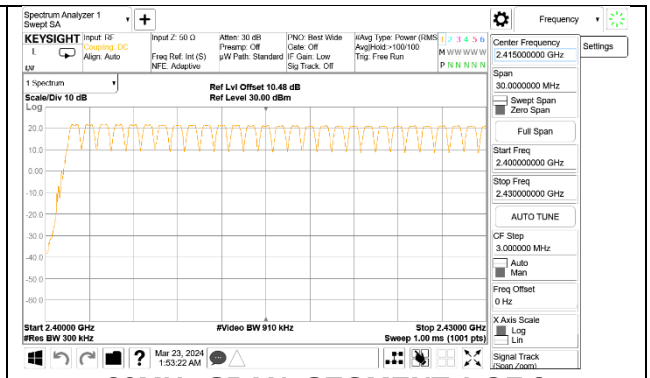
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.4.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

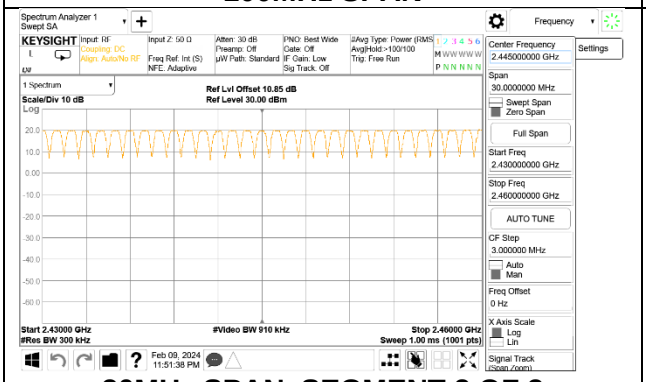
Tx0



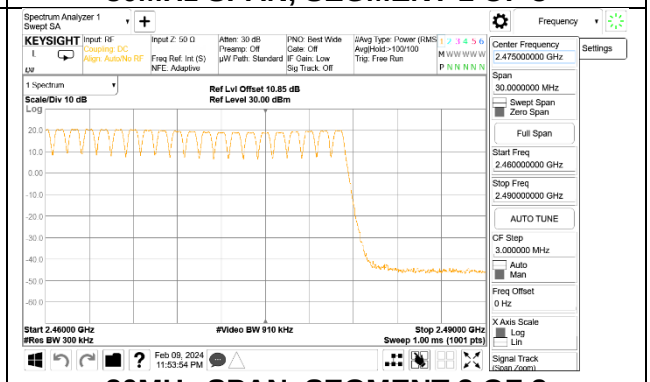
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

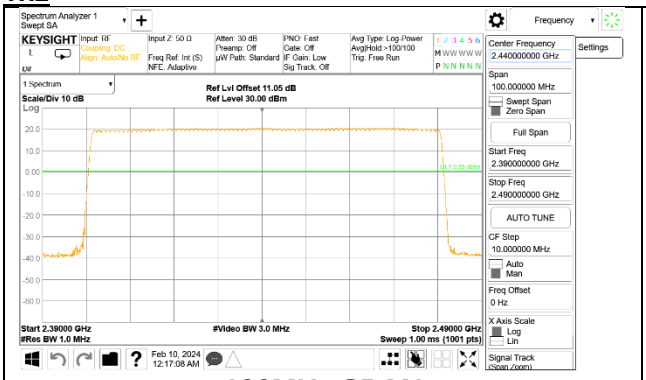


30MHz SPAN, SEGMENT 2 OF 3

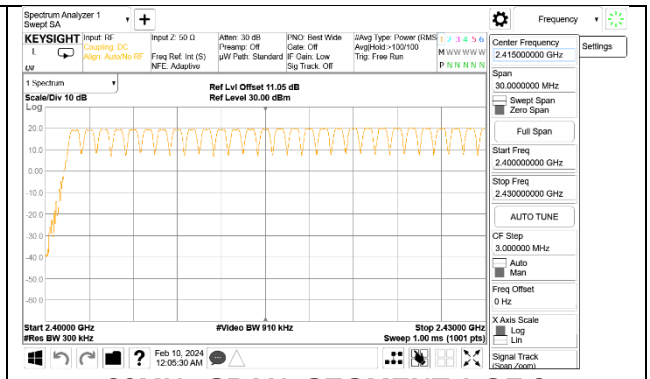


30MHz SPAN, SEGMENT 3 OF 3

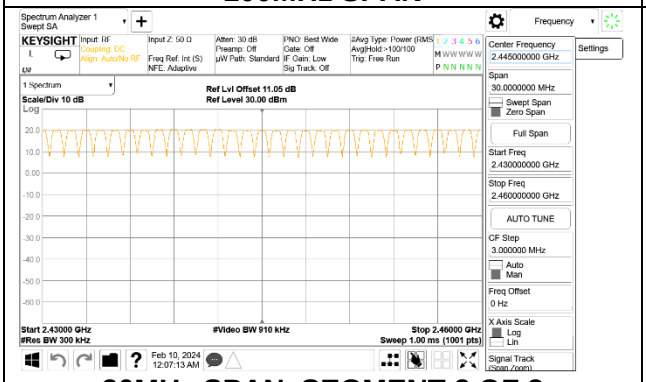
Tx1



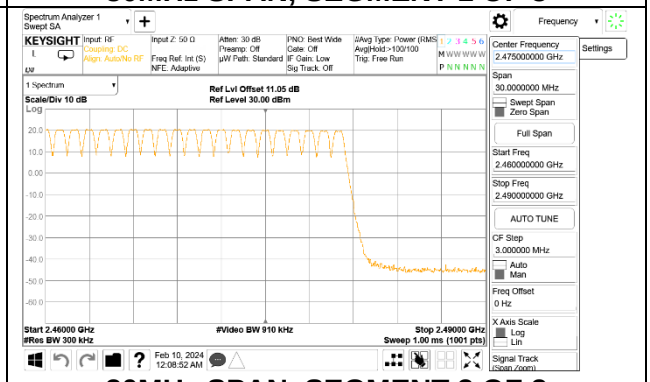
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3

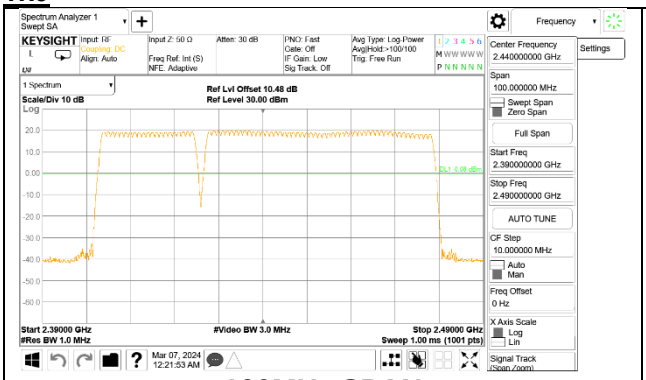


30MHz SPAN, SEGMENT 3 OF 3

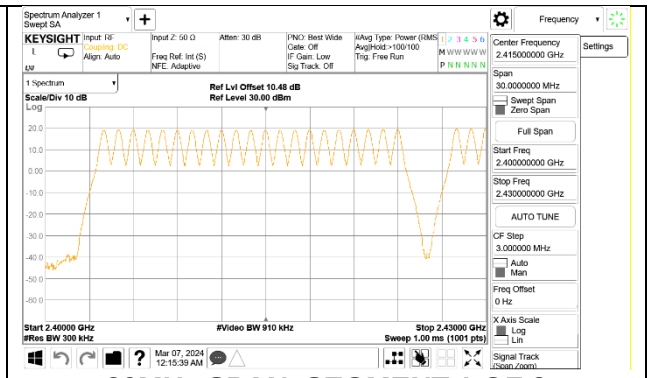
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.4.2. BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING)

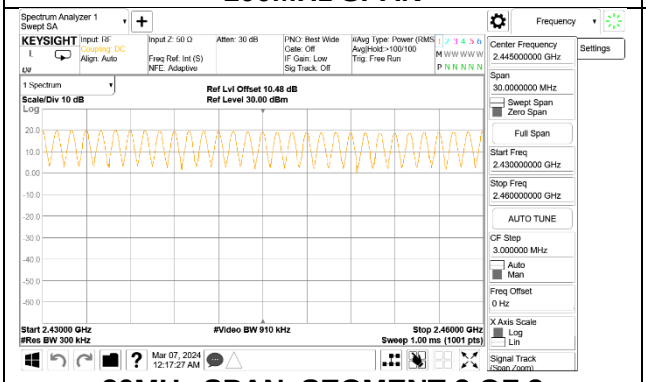
Tx0



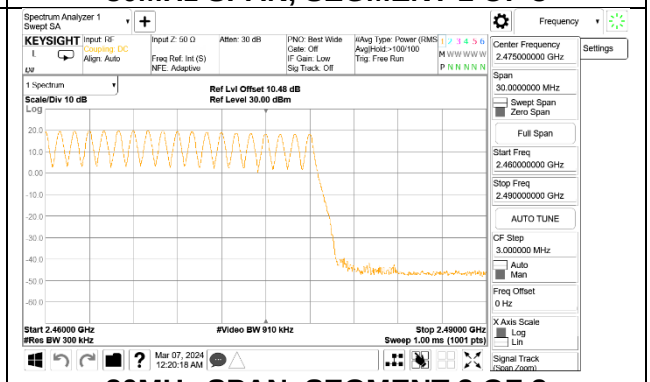
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

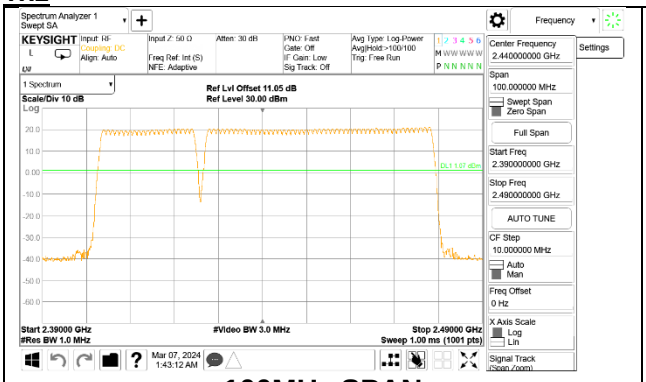


30MHz SPAN, SEGMENT 2 OF 3

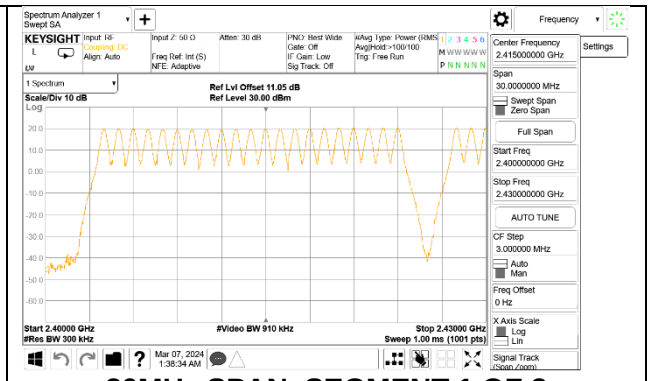


30MHz SPAN, SEGMENT 3 OF 3

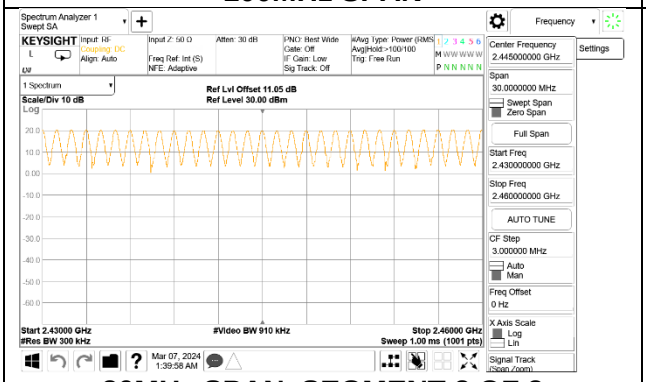
Tx1



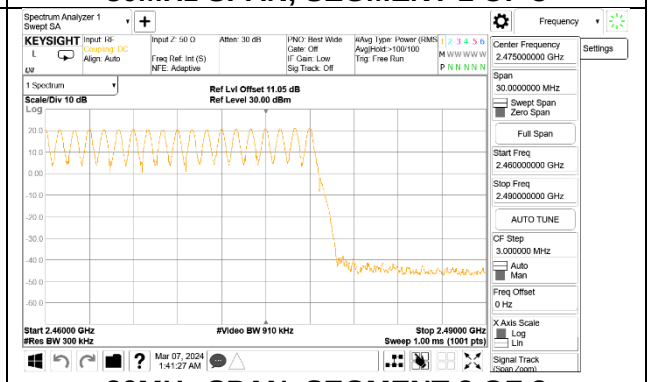
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3

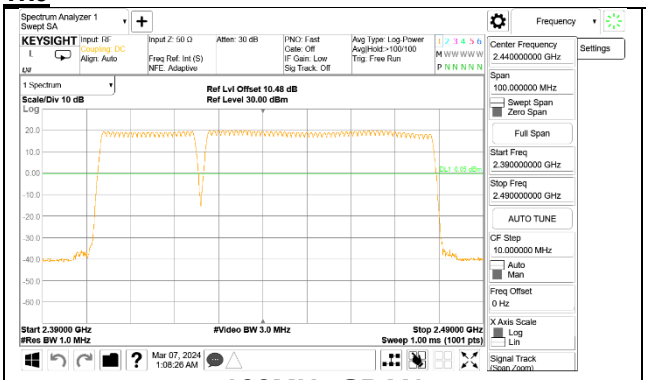


30MHz SPAN, SEGMENT 3 OF 3

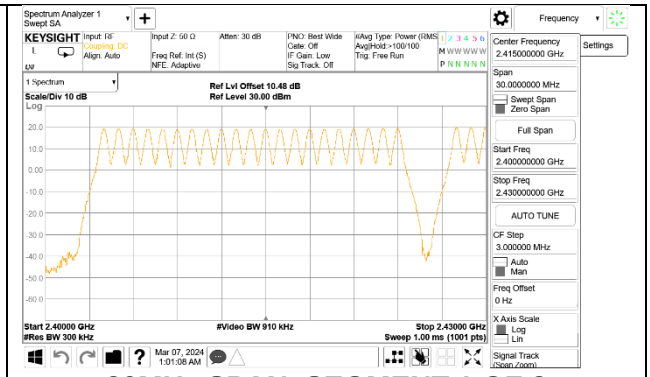
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.4.3. BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)

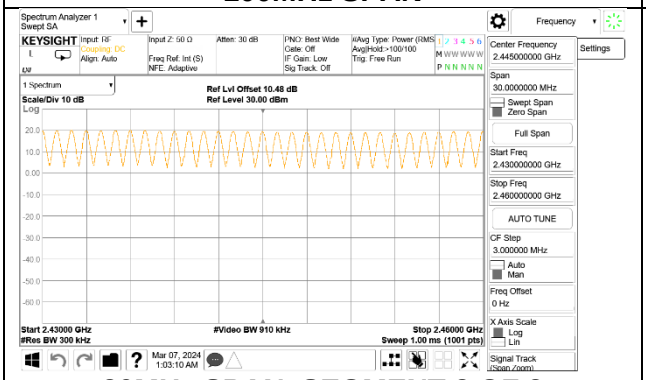
Tx0



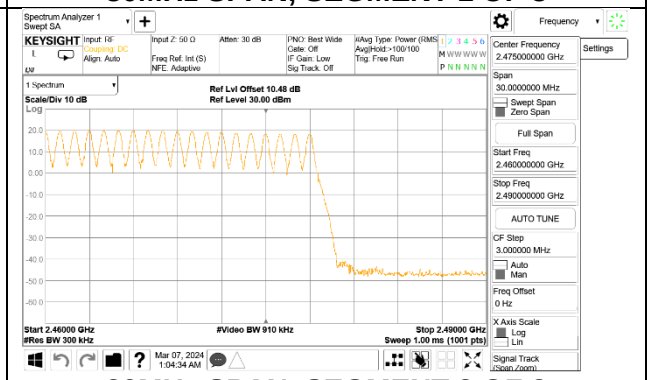
100MHz SPAN



30MHz SPAN, SEGMENT 1 OF 3

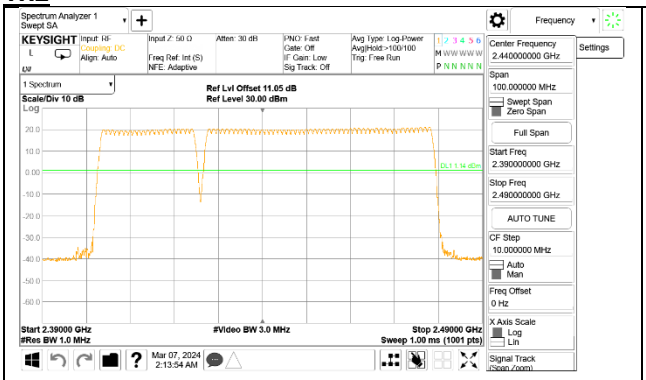


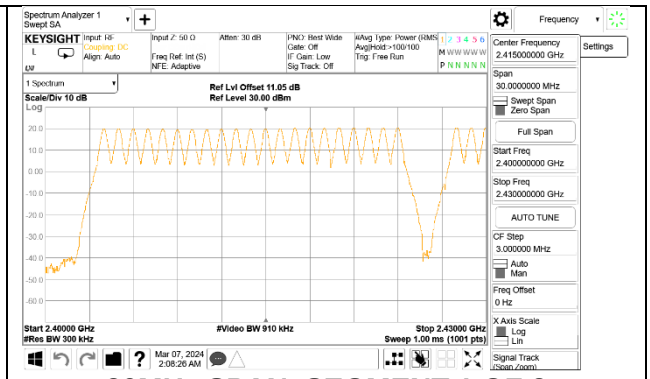
30MHz SPAN, SEGMENT 2 OF 3



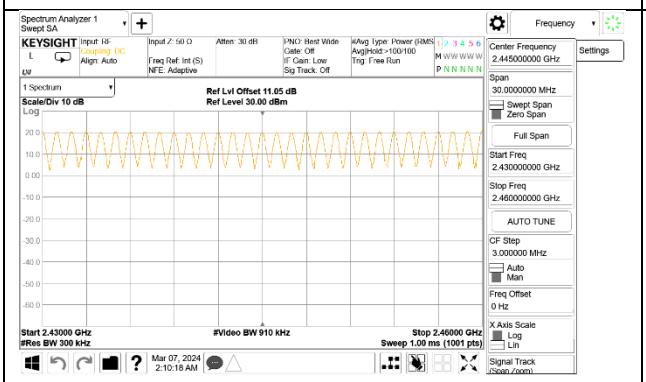
30MHz SPAN, SEGMENT 3 OF 3

Tx1

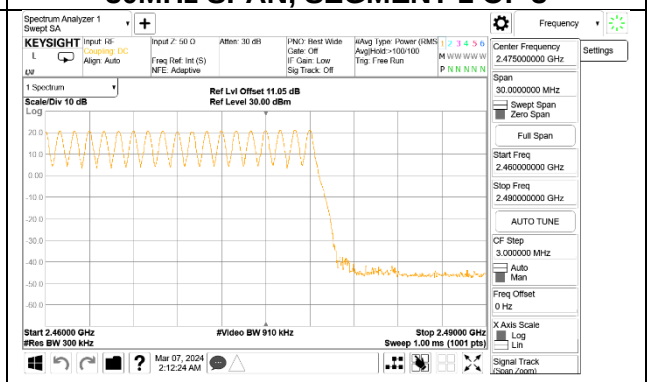




30MHz SPAN, SEGMENT 1 OF 3



30MHz SPAN, SEGMENT 2 OF 3



30MHz SPAN, SEGMENT 3 OF 3

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.5. AVERAGE TIME OF OCCUPANCY

LIMITS

FCC §15.247 (a) (1) (iii)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.

The average time of occupancy in the specified 3.16 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

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

The average time of occupancy in the specified 2.88 second period (72 channels * 0.4 s) is equal to 10 * (# of pulses in 2.88 s) * pulse width.

RESULTS

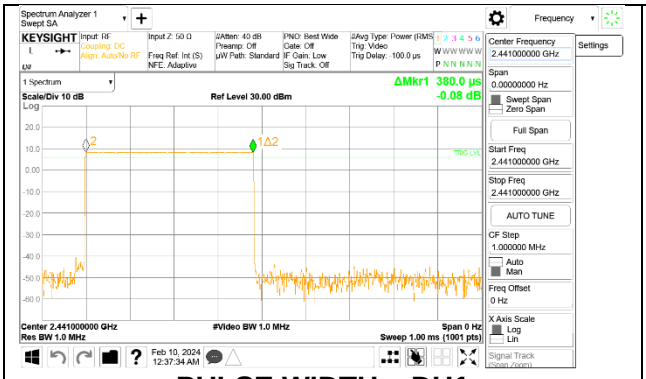
Test By:	24971 BN

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.5.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

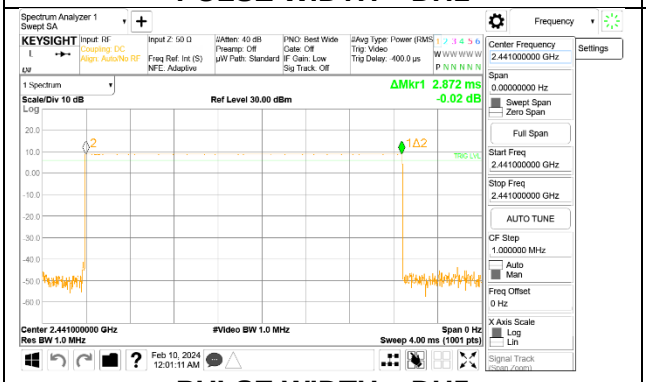
Tx0

DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.38	32	0.1216	0.4	-0.2784
DH3	1.632	15	0.2448	0.4	-0.1552
DH5	2.872	9	0.2585	0.4	-0.1415
DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.38	8	0.03040	0.4	-0.3696
DH3	1.632	3.75	0.06120	0.4	-0.3388
DH5	2.872	2.25	0.06462	0.4	-0.3354

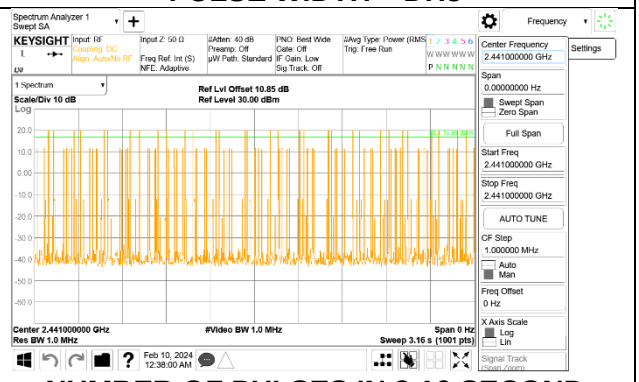


PULSE WIDTH – DH1

PULSE WIDTH – DH3



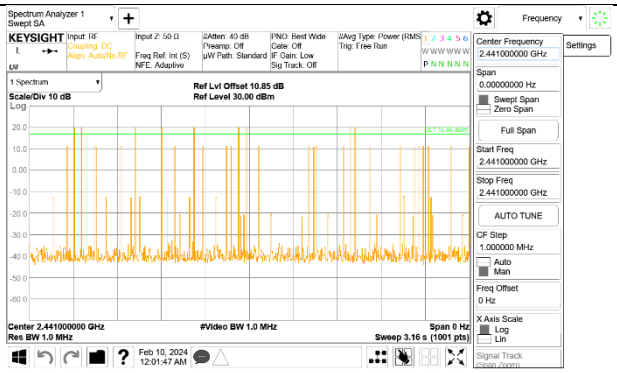
PULSE WIDTH – DH5



NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



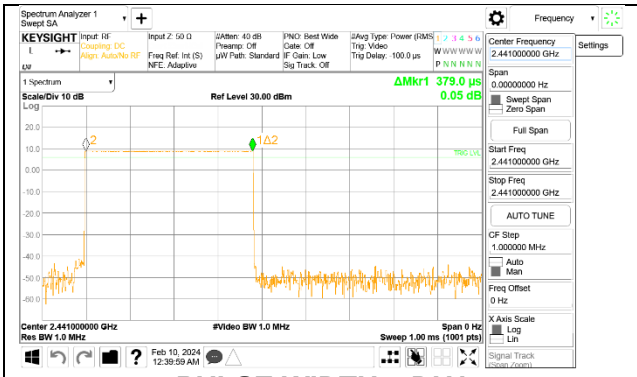
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

Tx1

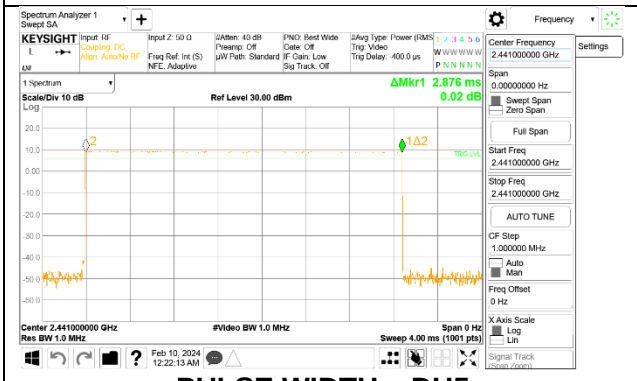
DH Packet	Pulse Width (msec)	Number of Pulses in 3.16 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK Normal Mode					
DH1	0.379	32	0.1213	0.4	-0.2787
DH3	1.632	15	0.2448	0.4	-0.1552
DH5	2.876	12	0.3451	0.4	-0.0549

DH Packet	Pulse Width (sec)	Number of Pulses in 0.8 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
GFSK AFH Mode					
DH1	0.379	8	0.03032	0.4	-0.3697
DH3	1.632	3.75	0.06120	0.4	-0.3388
DH5	2.876	3	0.08628	0.4	-0.3137



PULSE WIDTH – DH1

PULSE WIDTH – DH3

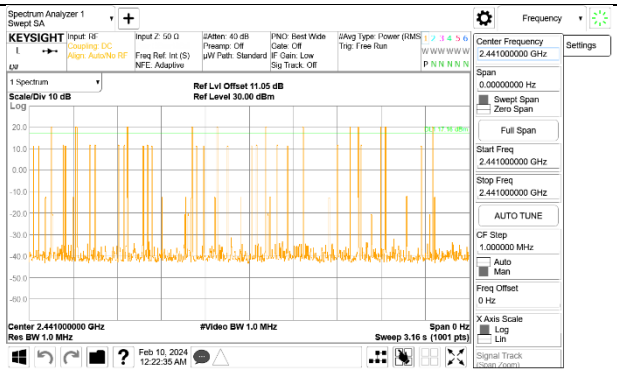


PULSE WIDTH – DH5

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH1

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH3



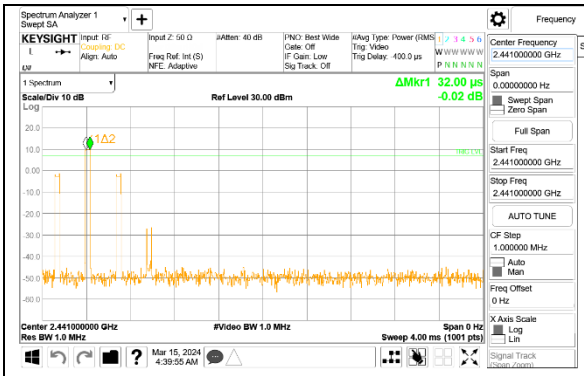
NUMBER OF PULSES IN 3.16 SECOND OBSERVATION PERIOD – DH5

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

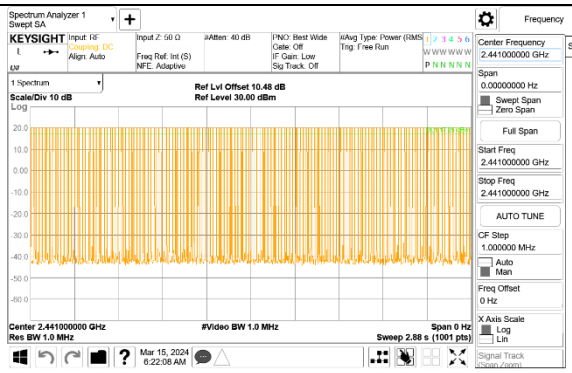
9.5.2. BLE 1Mbps ASK, MODE 2 (CHANNEL SOUNDING)

Tx0

DH Packet	Pulse Width (msec)	Number of Pulses in 2.88 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
BLE 1Mbps ASK Mode 2 (Channel Sounding)	0.032	163	0.05216	0.4	-0.34784



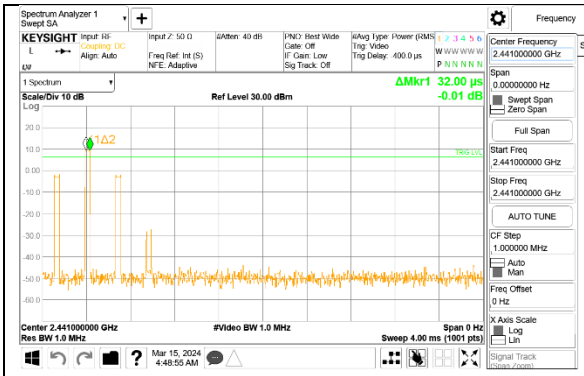
PULSE WIDTH



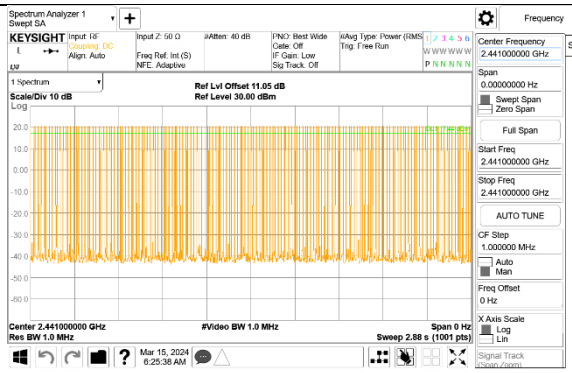
NUMBER OF PULSES IN 2.88 SECOND OBSERVATION PERIOD

Tx1

DH Packet	Pulse Width (msec)	Number of Pulses in 2.88 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
BLE 1Mbps ASK Mode 2 (Channel Sounding)	0.032	163	0.05216	0.4	-0.3478



PULSE WIDTH



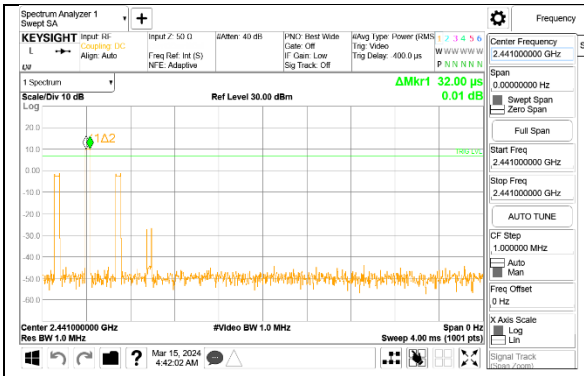
NUMBER OF PULSES IN 2.88 SECOND OBSERVATION PERIOD

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.5.3. BLE 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)

Tx0

DH Packet	Pulse Width (msec)	Number of Pulses in 2.88 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
BLE 2Mbps ASK Mode 2 (Channel Sounding)	0.032	162	0.05184	0.4	-0.3482

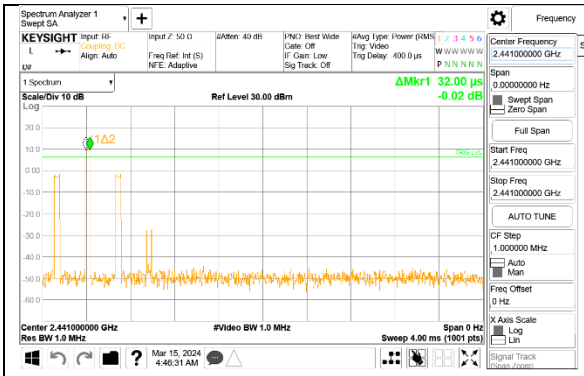


PULSE WIDTH

NUMBER OF PULSES IN 2.88 SECOND OBSERVATION PERIOD

Tx1

DH Packet	Pulse Width (msec)	Number of Pulses in 2.88 seconds	Average Time of Occupancy (sec)	Limit (sec)	Margin (sec)
BLE 2Mbps ASK Mode 2 (Channel Sounding)	0.032	162	0.05184	0.4	-0.3482



PULSE WIDTH

NUMBER OF PULSES IN 2.88 SECOND OBSERVATION PERIOD

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.6. OUTPUT POWER

PEAK POWER LIMITS

§15.247 (b) (1)

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

PEAK POWER TEST PROCEDURE

Measurements perform using a wideband RF power meter.

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.

AVERAGE POWER LIMITS

None; for reporting purposes only

AVERAGE POWER TEST PROCEDURE

Measurements perform using a wideband RF power meter.

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.

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

DIRECTIONAL ANTENNA GAIN

For 1 TX:

There is only one transmitter output therefore the directional gain is equal to the antenna gain.

Band (GHz)	Antenna Gain (dBi)	Uncorrelated Directional Gain (dBi)	Correlated Directional Gain (dBi)	FCC Power Limit (dBm)
BLE ASK, MODE 2 (Channel Sounding) Tx0	-1.10	-1.10	-1.10	30.00
BLE ASK, MODE2 (Channel Sounding) Tx1	0.90	0.90	0.90	30.00

For 2 TX:

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

Band (GHz)	Tx0 Gain (dBi)	Tx1 Gain (dBi)	Uncorrelated Directional Gain (dBi)	Correlated Directional Gain (dBi)	FCC Power Limit (dBm)
BT GFSK (Beamforming)	-1.10	0.90	0.01	2.97	30.00

DIRECTIONAL ANTENNA GAIN CALCULATION

ANSI C63.10-2013 section 14.4.3

Uncorrelated directional gain=10*LOG((10^(Ant1/10)+10^(Ant2/10))/2)
Correlated directional Gain=10*LOG(((10^(Ant1/20)+10^(Ant2/20))^2)/2)

Sample Calculation:

Tx0=-1.10dBi, Tx1=0.9dBi

Uncorrelated Antenna gain=10log[(10^(-1.10/10)+10^(0.9/10))/2]=0.01dBi

Correlated Antenna gain=10log[(10^(-1.10/20)+10^(0.9/20))^2)/2]=2.97dBi

RESULTS

Test By:	24971 BN
Date:	2024-02-11 – 2024-05-03

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.6.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

Mode	No. of Tx	Channel	Freq (MHz)	Measured Conducted Avg Power (dBm) Tx0	Measured Conducted Avg Power (dBm) Tx1	Measured Total Conducted Avg Power (dBm)	Measured Conducted Peak Power (dBm) Tx0	Measured Conducted Peak Power (dBm) Tx1	Measured Total Conducted Peak Power (dBm)	Output Power Limit (dBm)	Output Power Margin (dB)
GFSK (DH5) (beamforming)	2	0	2402	19.03	18.62	21.84	19.19	18.83	22.02	30.00	-7.98
		39	2441	19.75	19.71	22.74	19.90	19.90	**22.91**	30.00	-7.09
		78	2480	19.47	19.07	22.28	19.63	19.27	22.46	30.00	-7.54

9.6.2. BLE 1Mbps and 2Mbps ASK, MODE 2 (CHANNEL SOUNDING)

Mode	No. of Tx	Channel	Freq (MHz)	Measured Conducted Avg Power (dBm)	Measured Conducted Peak Power (dBm)	Output Power Limit (dBm)	Output Power Margin (dB)
BLE 1Mbps (channel sounding, ASK modulated)	1 (Tx0)	1	2404	19.22	19.30	30.00	-10.70
		19	2440	19.45	19.51	30.00	-10.49
		38	2478	18.24	18.33	30.00	-11.67
	1 (Tx1)	1	2404	19.26	19.32	30.00	-10.68
		19	2440	19.42	19.51	30.00	-10.49
		38	2478	19.95	**20.02**	30.00	-9.98
BLE 2Mbps (channel sounding, ASK modulated)	1 (Tx0)	1	2404	19.31	19.39	30.00	-10.61
		19	2440	19.52	19.61	30.00	-10.39
		38	2478	18.33	18.41	30.00	-11.59
	1 (Tx1)	1	2404	19.33	19.41	30.00	-10.59
		19	2440	19.48	19.56	30.00	-10.44
		38	2478	20.00	**20.07**	30.00	-9.93

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.7. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

Limit = -20 dBc

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

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

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

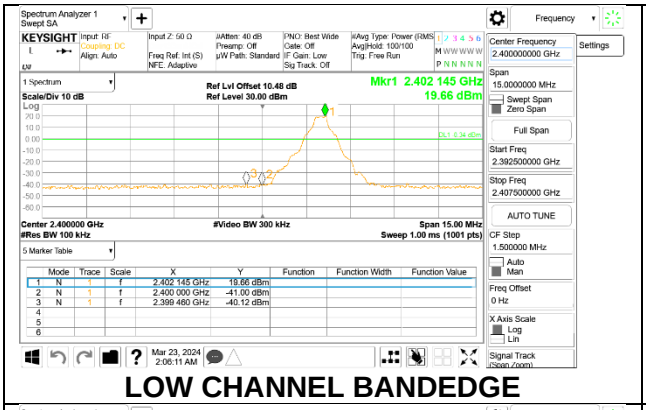
RESULTS

Test By:	24971 BN

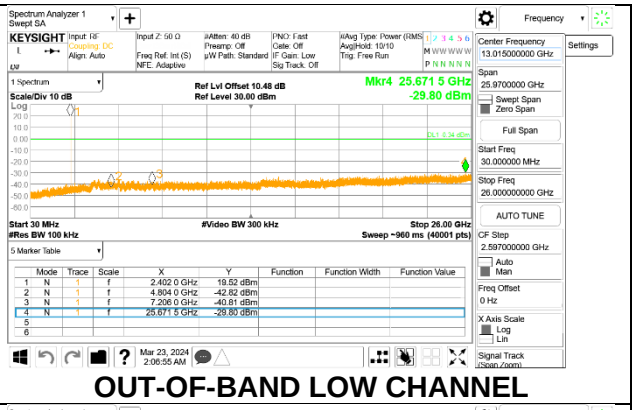
UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.7.1. BLUETOOTH BASIC DATA RATE TXBF GFSK MODULATION

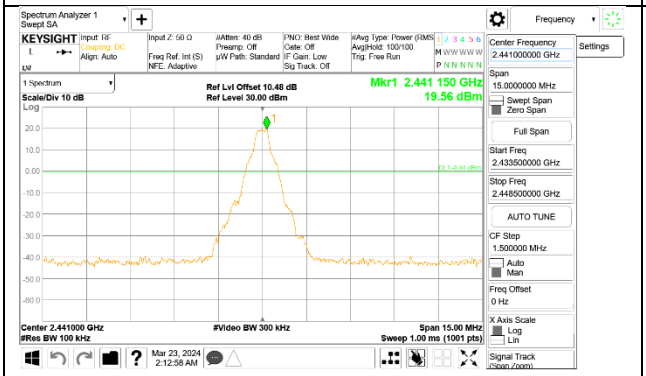
Tx0 SPURIOUS EMISSIONS, NON-HOPPING



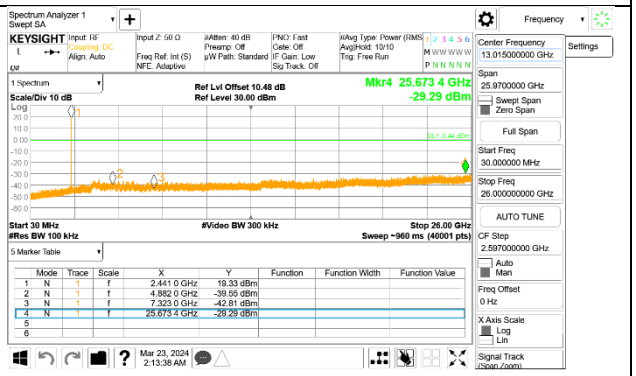
LOW CHANNEL BANDEDGE



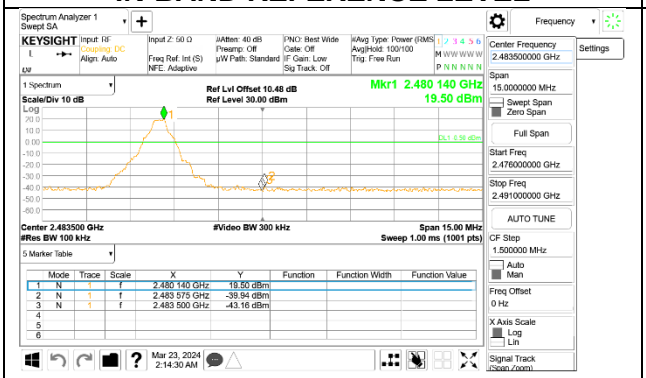
OUT-OF-BAND LOW CHANNEL



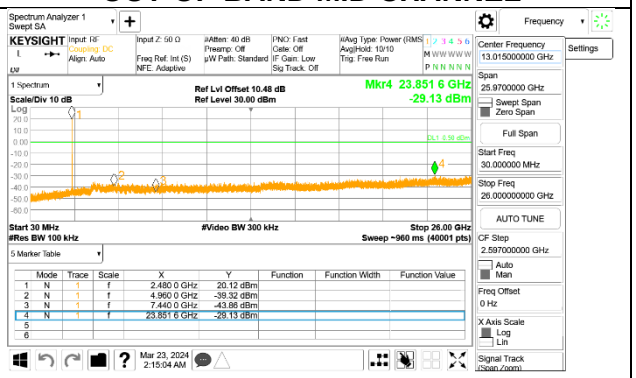
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



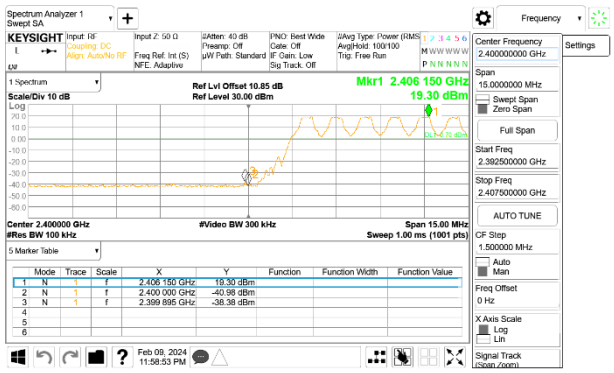
HIGH CHANNEL BANDEDGE



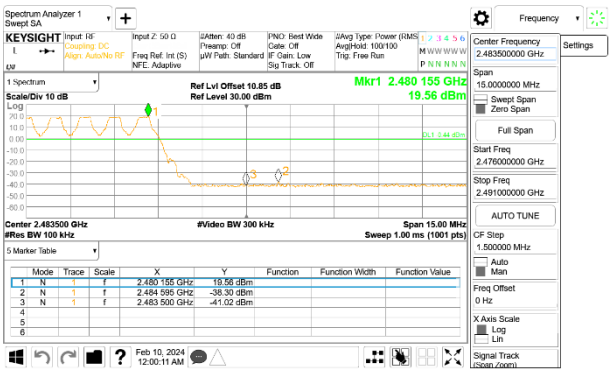
OUT-OF-BAND HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

Tx0 SPURIOUS BANDEDGE EMISSIONS WITH HOPPING ON



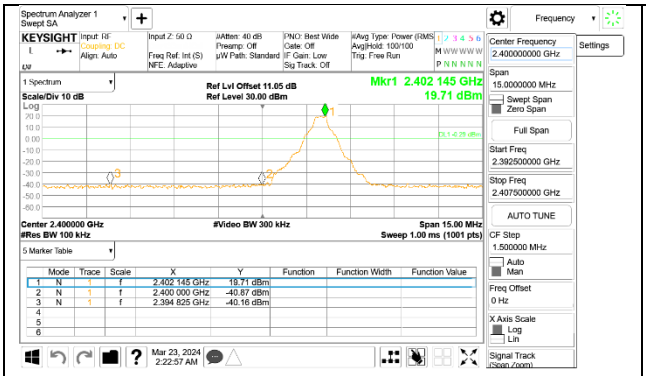
LOW BANDEDGE



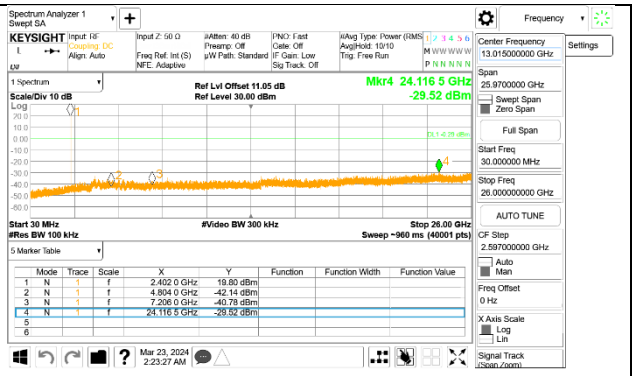
HIGH BANDEDGE

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888

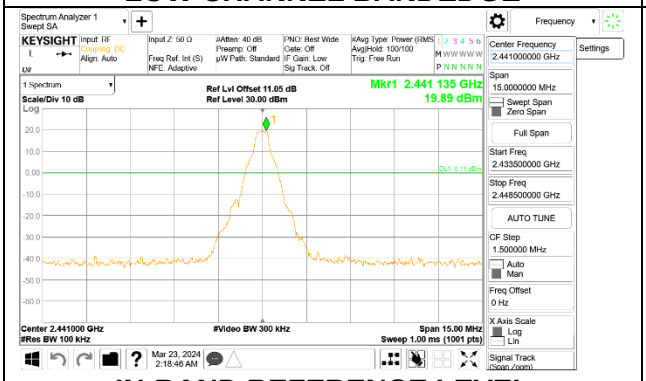
Tx1 SPURIOUS EMISSIONS, NON-HOPPING



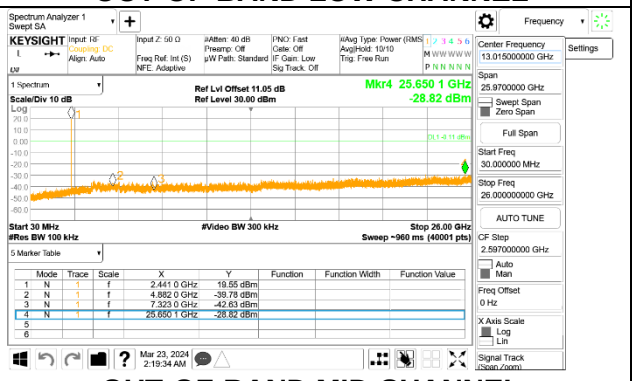
LOW CHANNEL BANDEDGE



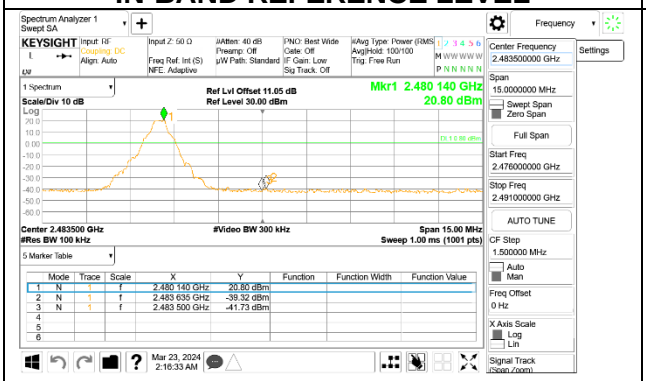
OUT-OF-BAND LOW CHANNEL



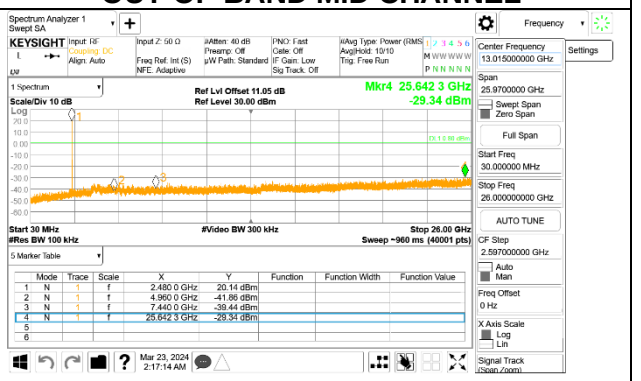
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

UL VERIFICATION SERVICES INC.
47173 Benicia Street, Fremont, CA 94538, USA TEL:(510) 319-4000 FAX:(510) 661-0888