

FCC Test Report

Prepared for: Garmin International, Inc.

Address: 1200 E. 151st Street
Olathe, Kansas, 66062, USA

Product: A04223

Test Report No: R20220512-20-E10A

Approved by:



Mahendra Karthik Vepuri, NCE
EMC Test Engineer,
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DATE: 13 January 2023

Total Pages: 32

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REVISION PAGE

Rev. No.	Date	Description
0	10 January 2023	Original – KVepuri Prepared by FLane, KVepuri
A	13 January 2023	Removed ISED from title page Added extra radiated emissions data – FL



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1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

FCC Part 15.249

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) IEEE ANSI C63.10-2013

SUMMARY			
Requirement	Test Type and Limit	Result	Remark
FCC 15.203	Unique Antenna Requirement	Pass	SMT (chip) Antenna
FCC 15.35	Duty cycle of pulsed emissions	N/A	Informational Purpose Only
NA	Minimum Bandwidth	N/A	Informational Purpose Only
FCC 15.209	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209 FCC 15.249(a)	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205, 15.249(d)	Band Edge Measurement	Pass	Meets the requirement of the limit.
FCC 15.207	Conducted AC Emissions	Pass	Meets the requirement of the limit.



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2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04223
FCC ID:	IPH-04223
EUT Received	22 September 2022
EUT Tested	22 September 2022 - 27 December 2022
Serial No.	3428794068 (Conducted Unit) 3428794249(Radiated Unit)
Operating Band	2400 – 2483.5 MHz
Device Type	<input type="checkbox"/> GMSK <input checked="" type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x
Power Supply / Voltage	Internal Battery/ Charger: Garmin MN: 362-00113-00

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

For GFSK Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2441 MHz
High	2480 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31. See the operational description for a list of all channel frequency and designations.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY AND GENERAL TEST DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
 4740 Discovery Drive
 Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of $35 \pm 4\%$
 Temperature of $22 \pm 3^\circ$ Celsius



3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing and Report
2	Karthik Vepuri	Test Engineer	Review/Editing and Report
3	Blake Winter	Test Engineer	Testing
4	Grace Larsen	Test Engineer	Testing and Report

Notes:

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)***	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A091418-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	March 21, 2022	March 21, 2024
8447F POT H64 Preamplifier	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	March 21, 2022	March 21, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

*Internal Characterization

**2 Year Cal Cycle

Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

3.4 General test procedure and setup for radio measurements

Measurement type presented in this report (Please see the checked box below):

Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

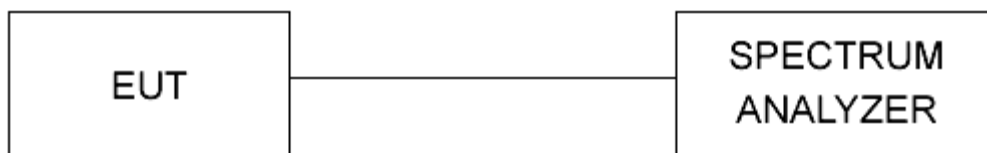


Figure 1 - Bandwidth Measurements Test Setup

Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

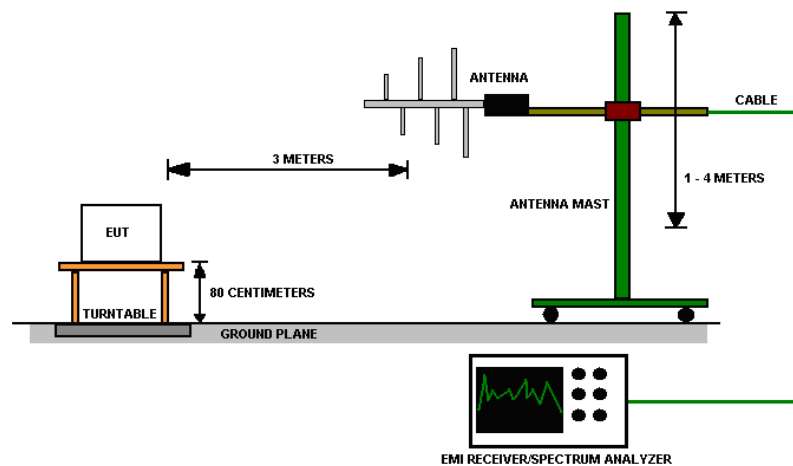


Figure 2 - Radiated Emissions Test Setup



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4.0 RESULTS

Unrestricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	GFSK	2400.00	53.868	105.597	51.729	50.00	PASS
High	GFSK	2483.50	48.895	105.729	56.834	50.00	PASS

Peak Restricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GFSK	2390.00	53.647	Peak	73.98	20.333	PASS
High	GFSK	2483.50	54.868	Peak	73.98	19.112	PASS

*Limit shown is the peak limit taken from FCC Part 15.209

Average Restricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Average Highest out of band level (dBuV/m @ 3m)**	Measurement Type	Limit (dBuV/m @ 3m)*	Margin	Result
Low	GFSK	2390.00	36.447	Average	53.98	17.533	PASS
High	GFSK	2483.50	37.668	Average	53.98	16.312	PASS

*Limit shown is the average limit taken from FCC Part 15.209

**Average Highest out of band level = SA Peak Level + DCCF (For Emissions). C63.10 Sec. 11.12.2.5.2. Example: 36.447 (Avg Level) = 53.647(Peak Level)-17.2 (DCCF)

See Sec 4.1 for more information on DCCF

See Appendix C for SA peak levels or Peak Restricted band edge table.



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4.1 DUTY CYCLE

Test Method: N/A

Manufacturer declared the worst-case duty cycle as follows:

Protocol	Duty Cycle	dB conversion- (DCCF for Emissions)
ANT (transmitting)	13.8%	-17.2 dB

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4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ($\mu\text{V}/\text{m}$)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

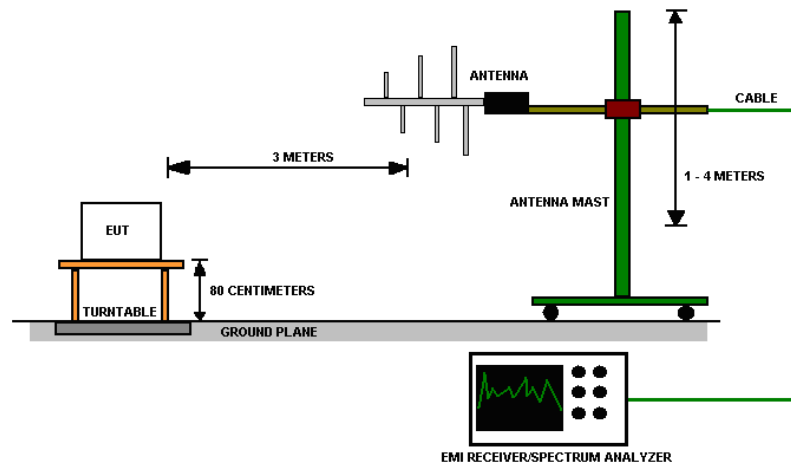
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = $20 * \log * \text{Emission level } (\mu\text{V}/\text{m})$.
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was investigated for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



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Test procedures:

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.
- h. The EUT was tested with all radios transmitting simultaneously as part of the preview scan. If intermodulation products were found during the preview scan, they were maximized and reported in the data and identified as intermodulation products.

Test setup:

Figure 3 - Radiated Emissions Test Setup
NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

EUT operating conditions

Details can be found in section 2.1 of this report.

Test results:

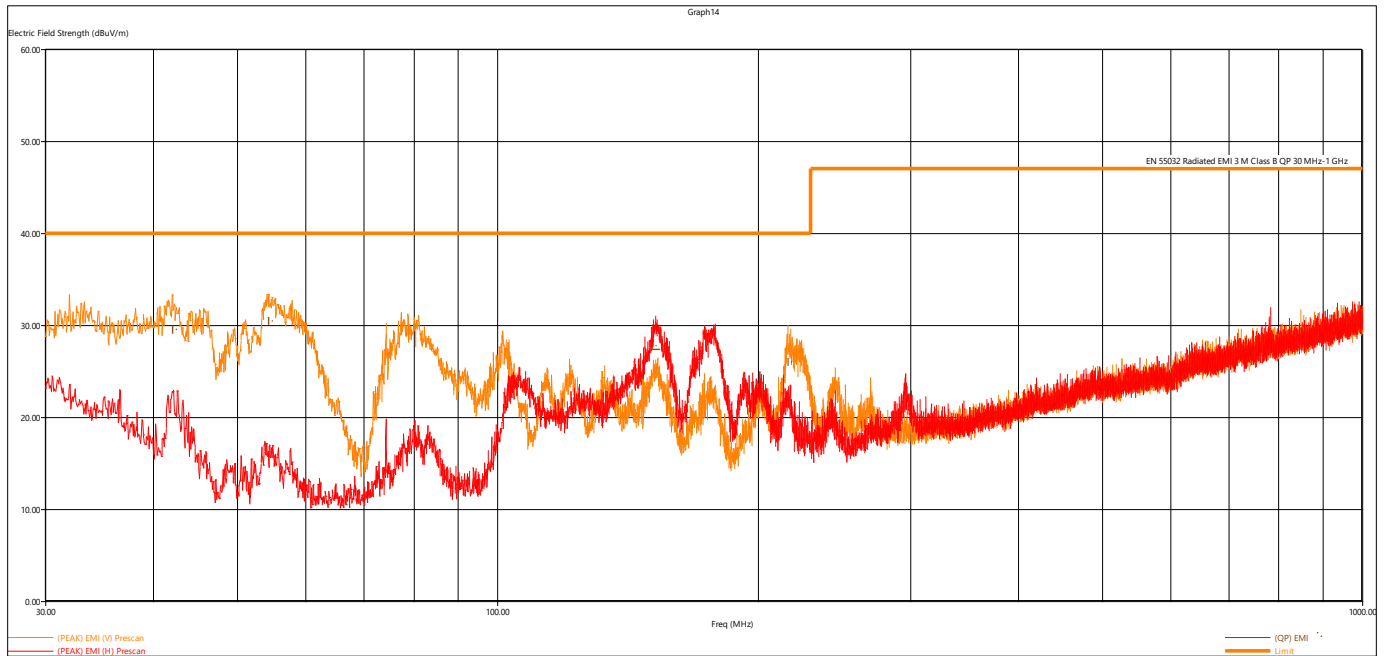


Figure 4 - Radiated Emissions Plot, Receive

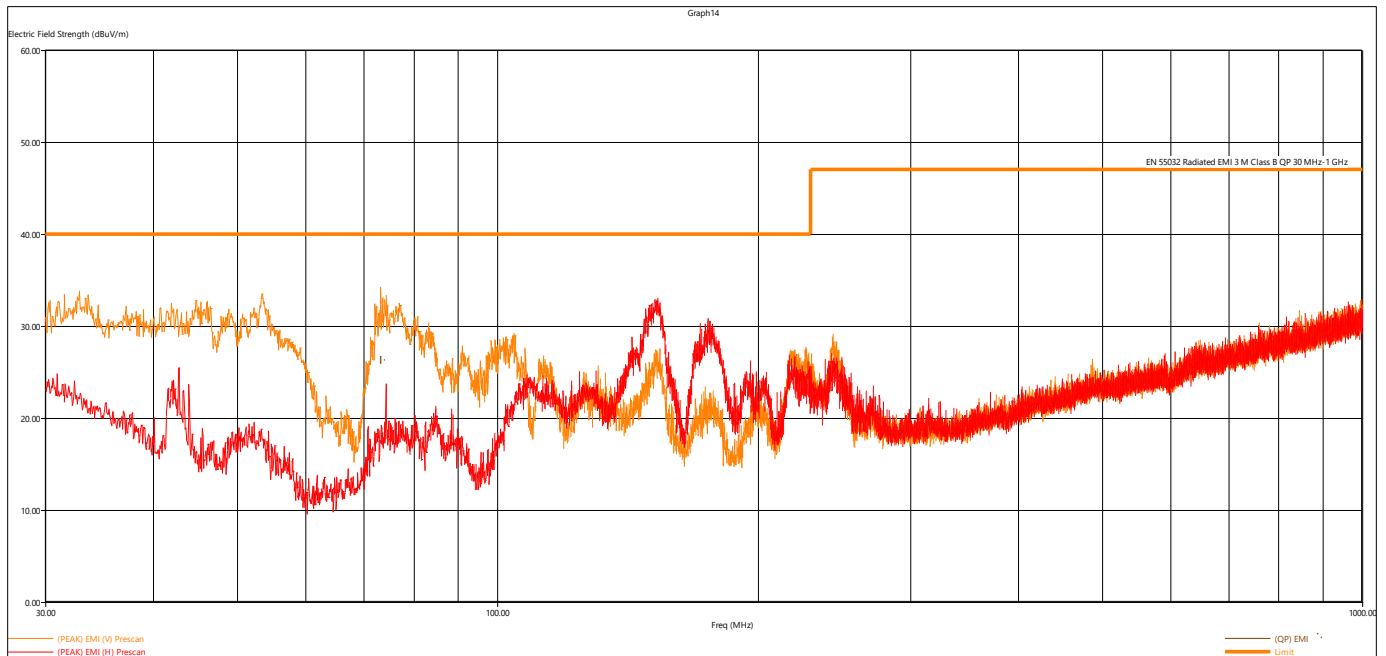


Figure 5 - Radiated Emissions Plot, GFSK



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REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value – Emission Level

Quasi-Peak Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
73.236240	26.28	40.00	13.72	104.00	204.00	V	Low	GFSK
152.266560	27.32	40.00	12.68	182.00	3.00	H	Receive	
41.995680	29.49	40.00	10.51	104.00	265.00	V	Receive	
54.320160	30.38	40.00	9.62	110.00	2.00	V	Receive	
216.453600	25.97	40.00	14.03	198.00	326.00	V	Receive	

The EUT was maximized in all 3 orthogonal axes and multiple data rates were investigated.

Peak Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2400.714000	88.98	114.00	25.02	330.00	299.00	V	Low	GFSK
2439.560000	89.62	114.00	24.38	207.00	300.00	V	Mid	GFSK
2478.800000	91.90	114.00	22.1	200.00	298.00	V	High	GFSK

All other emissions were found to be at least 6dB below applicable limit

Average Measurements, GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2400.714000	71.78	94.00	22.22	330.00	299.00	V	Low	GFSK
2439.560000	72.42	94.00	21.58	207.00	300.00	V	Mid	GFSK
2478.800000	74.70	94.00	19.3	200.00	298.00	V	High	GFSK

Average Level = Peak Level + DCCF for emissions, see section 4.1 for more info

All other emissions were found to be at least 6dB below applicable limit

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4.3 BAND EDGES

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of band-edge measurements:

For FCC Part 15.249 Device:

For emissions outside of the allowed band of operation, the emission level needs to be 50dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

Deviations from test standard:

No deviation.

Test setup:

Test setup details can be found in section 3.4 of this report.

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the band edge plots can be found in the Appendix C.
2. All data is in the table in results section 4.0.
3. If the device falls under FCC Part 15.249 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 50 dB between peak and the band edge or band edge was compared to FCC Part 209 limit.
4. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

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4.4 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

Deviation from the test standard:

No deviation

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test Results:

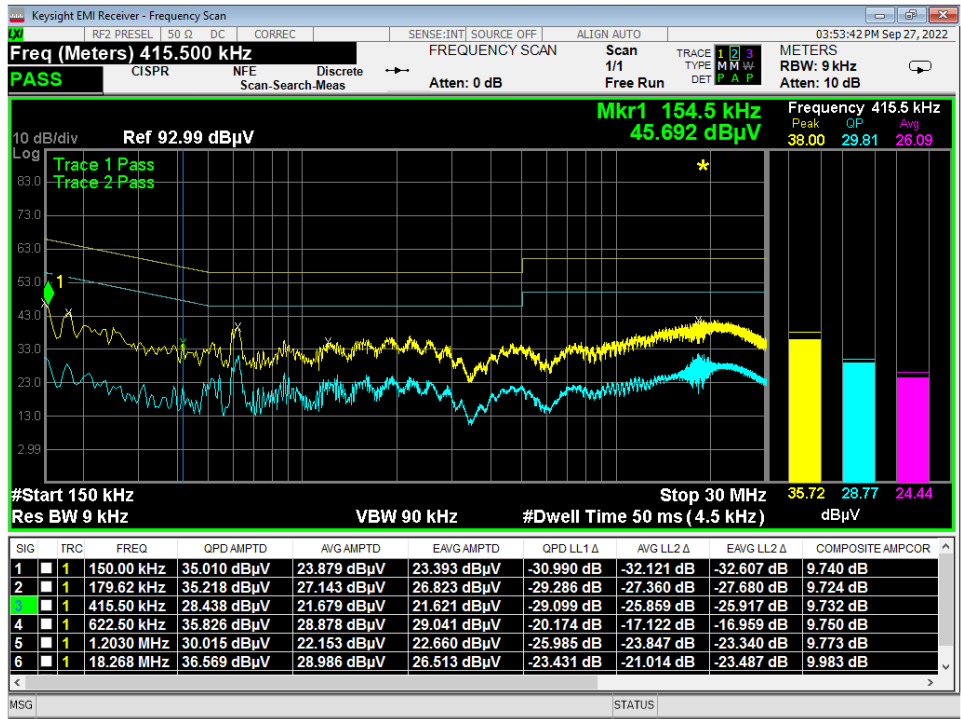


Figure 6 - Conducted Emissions Plot, Line, TX

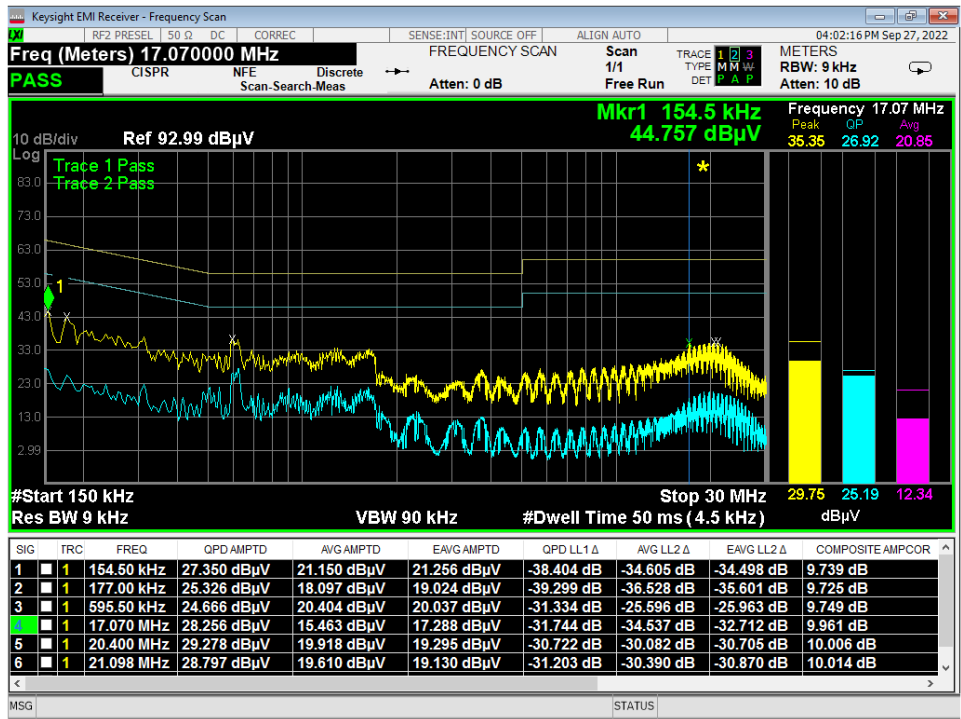


Figure 7 - Conducted Emissions Plot, Neutral, TX

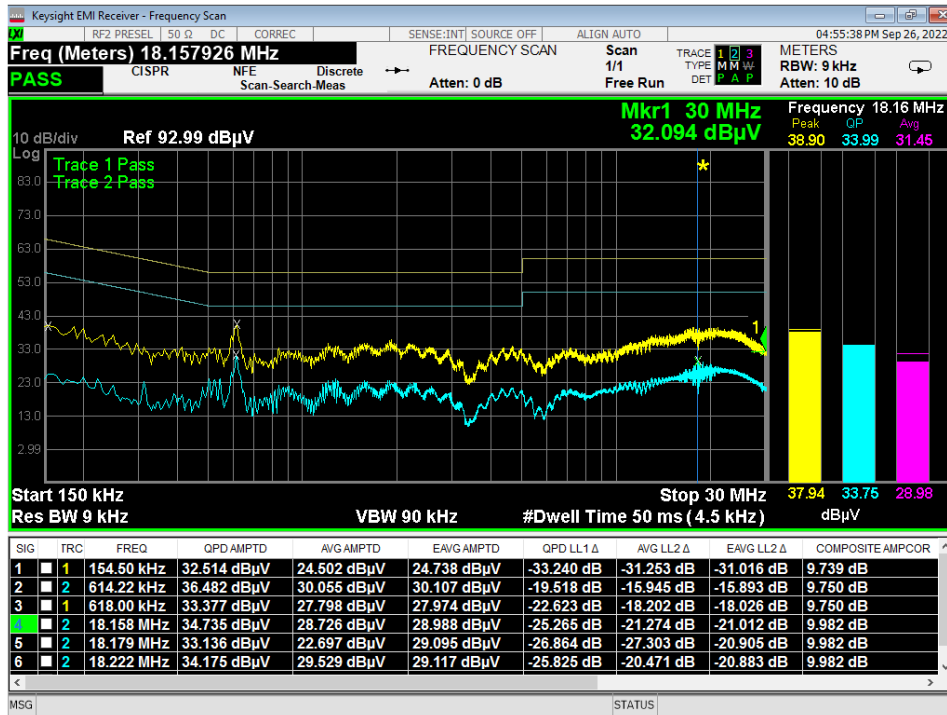


Figure 8 - Conducted Emissions Plot, Line, IDLE

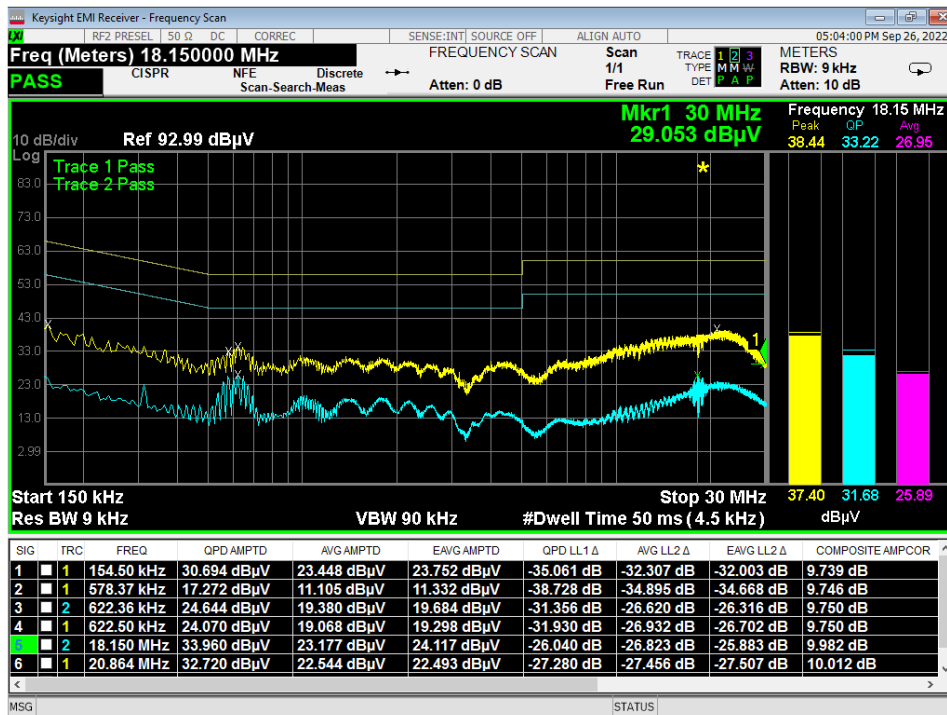


Figure 9 - Conducted Emissions Plot, Neutral, IDLE



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APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

- RA = Receiver Amplitude
- AF = Antenna Factor
- CF = Cable Attenuation Factor
- AG = Amplifier Gain
- AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm} [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the $20 \cdot \log(T_{on}/100)$ where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

- $EIRP \text{ (Watts)} = [\text{Field Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$
- $\text{Power (watts)} = 10^{[\text{Power (dBm)} / 10]} / 1000$
- $\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$
- $\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$
- $\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$
- $\text{Conversion from 3m field strength to EIRP (d=3):}$

$$EIRP = [FS(V/m) \times d^2] / 30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

10log(10^9) is the conversion from micro to milli



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APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

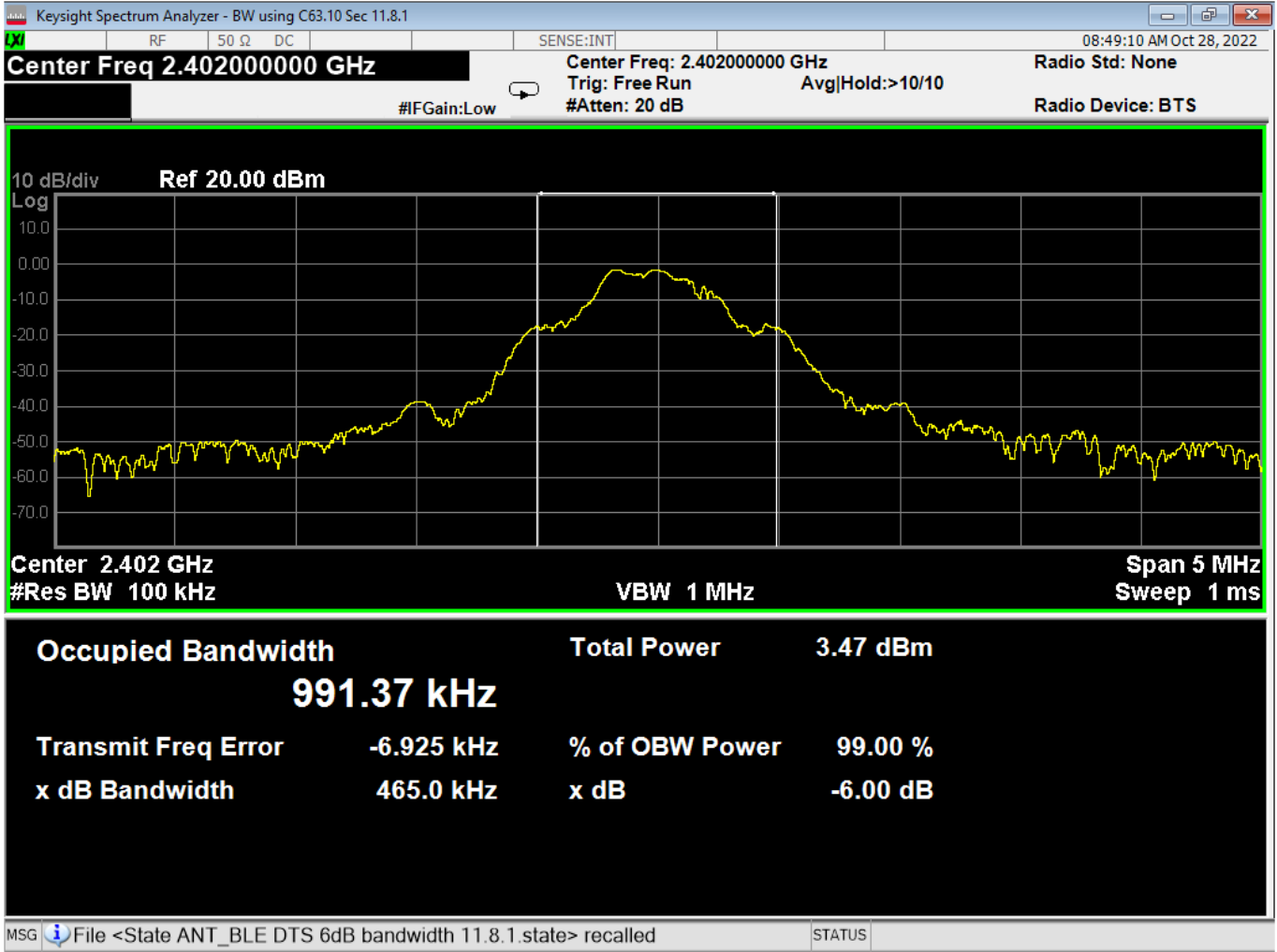
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.



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APPENDIX C – GRAPHS AND TABLES



1 6dB Bandwidth, Low Channel, GFSK



Report Number:

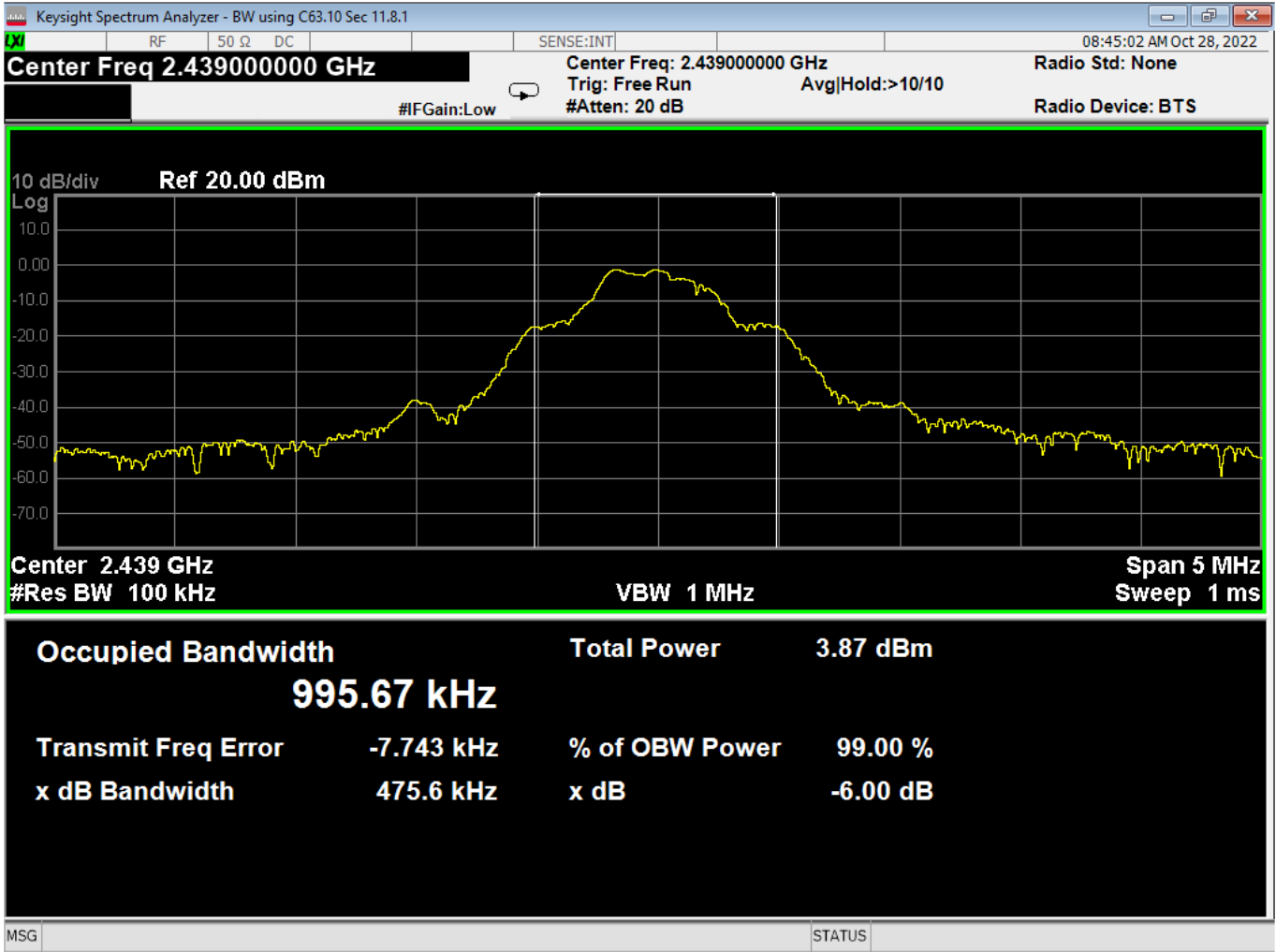
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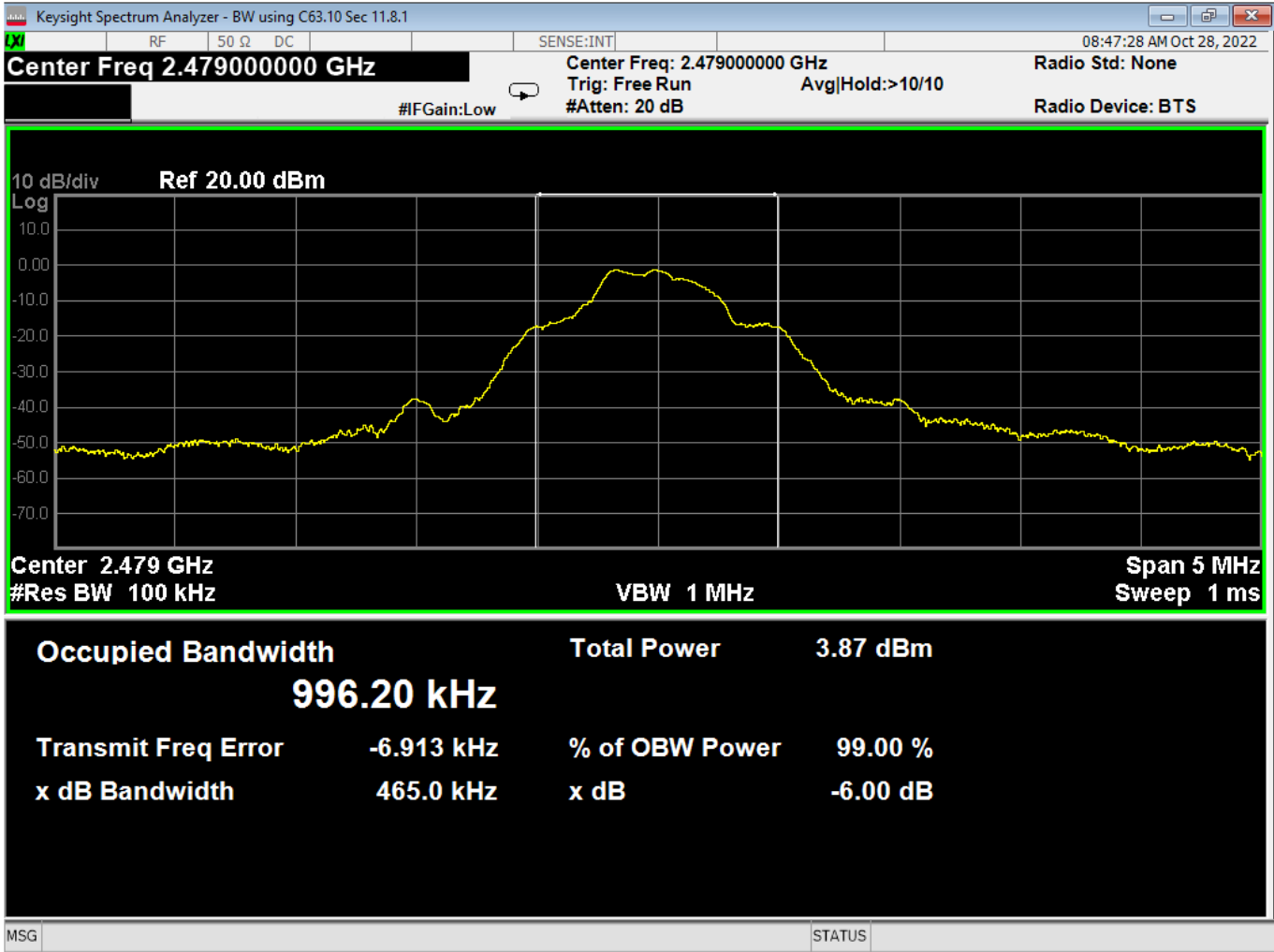
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2 6dB Bandwidth, Mid Channel, GFSK



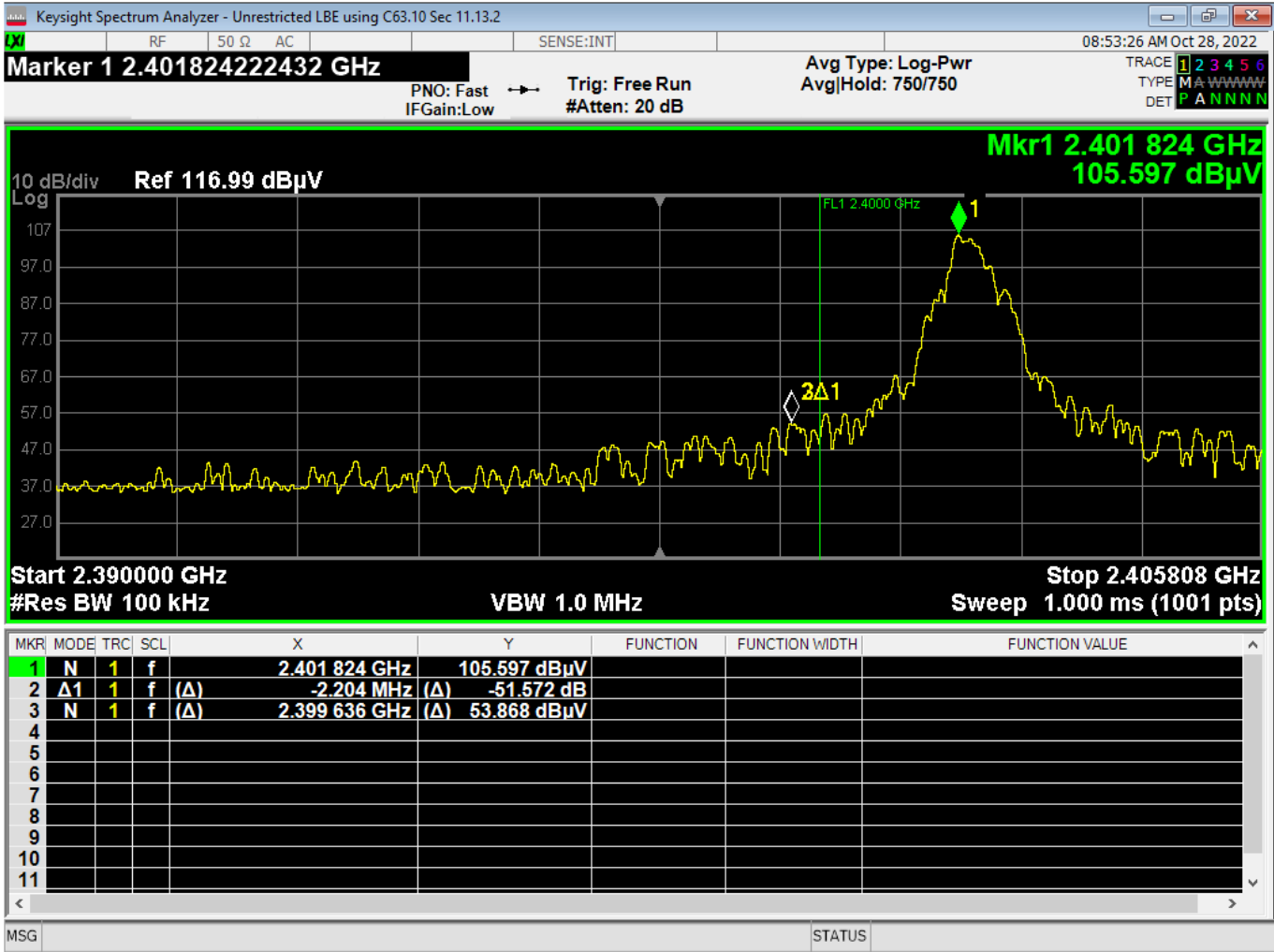
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3 6dB Bandwidth, High Channel, GFSK



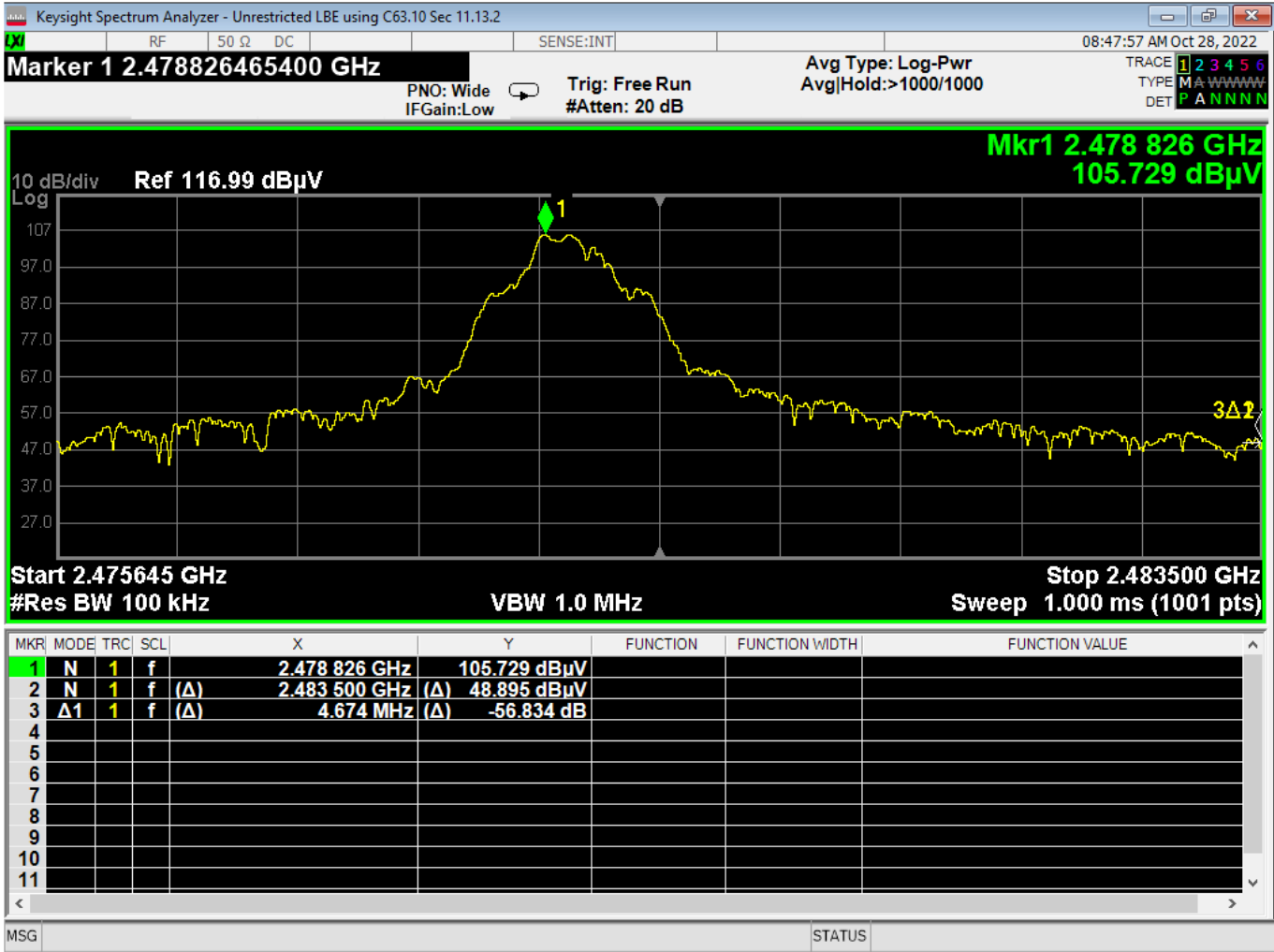
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4 LBE, Unrestricted, GFSK



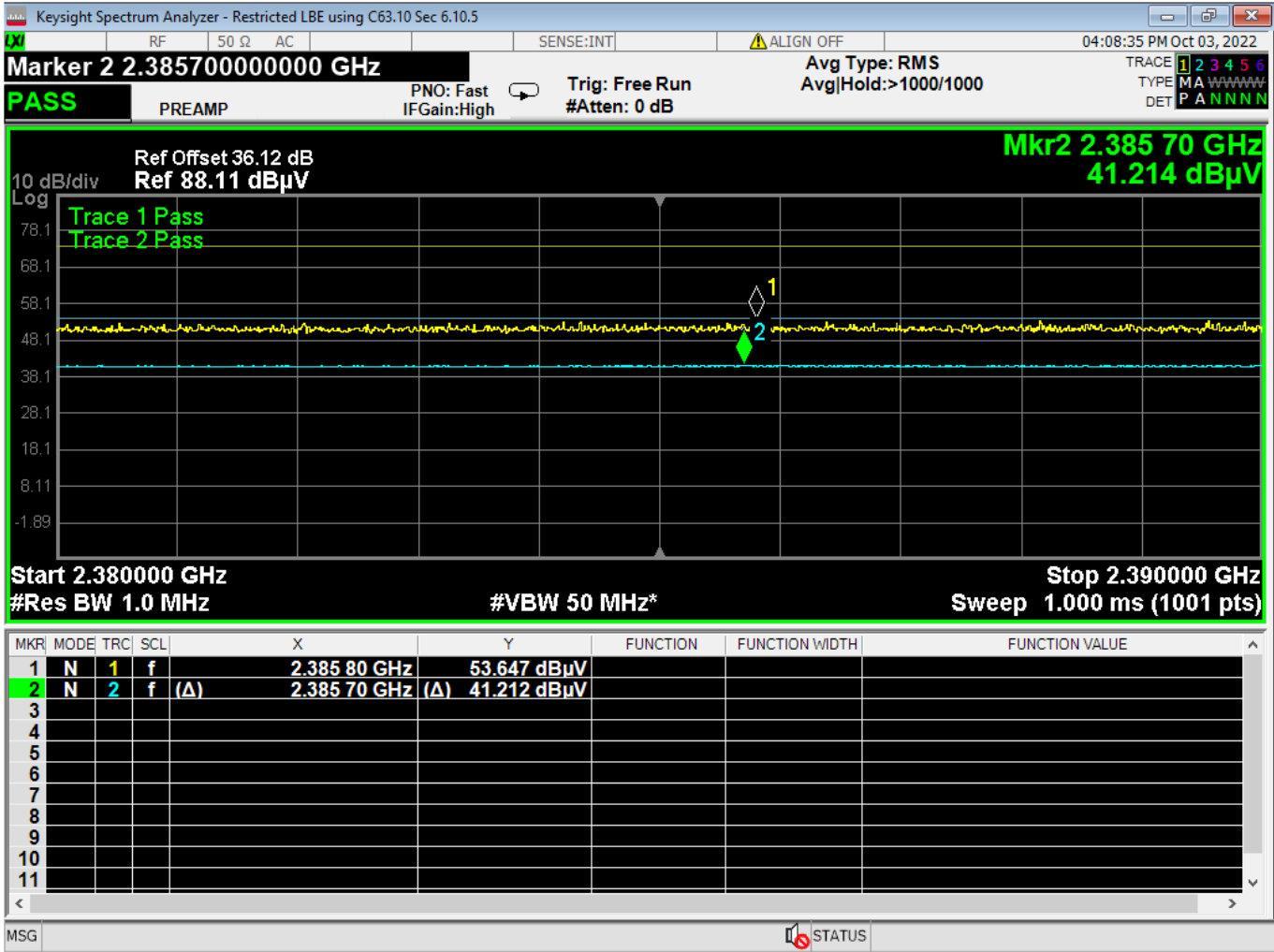
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5 HBE, Unrestricted, GFSK

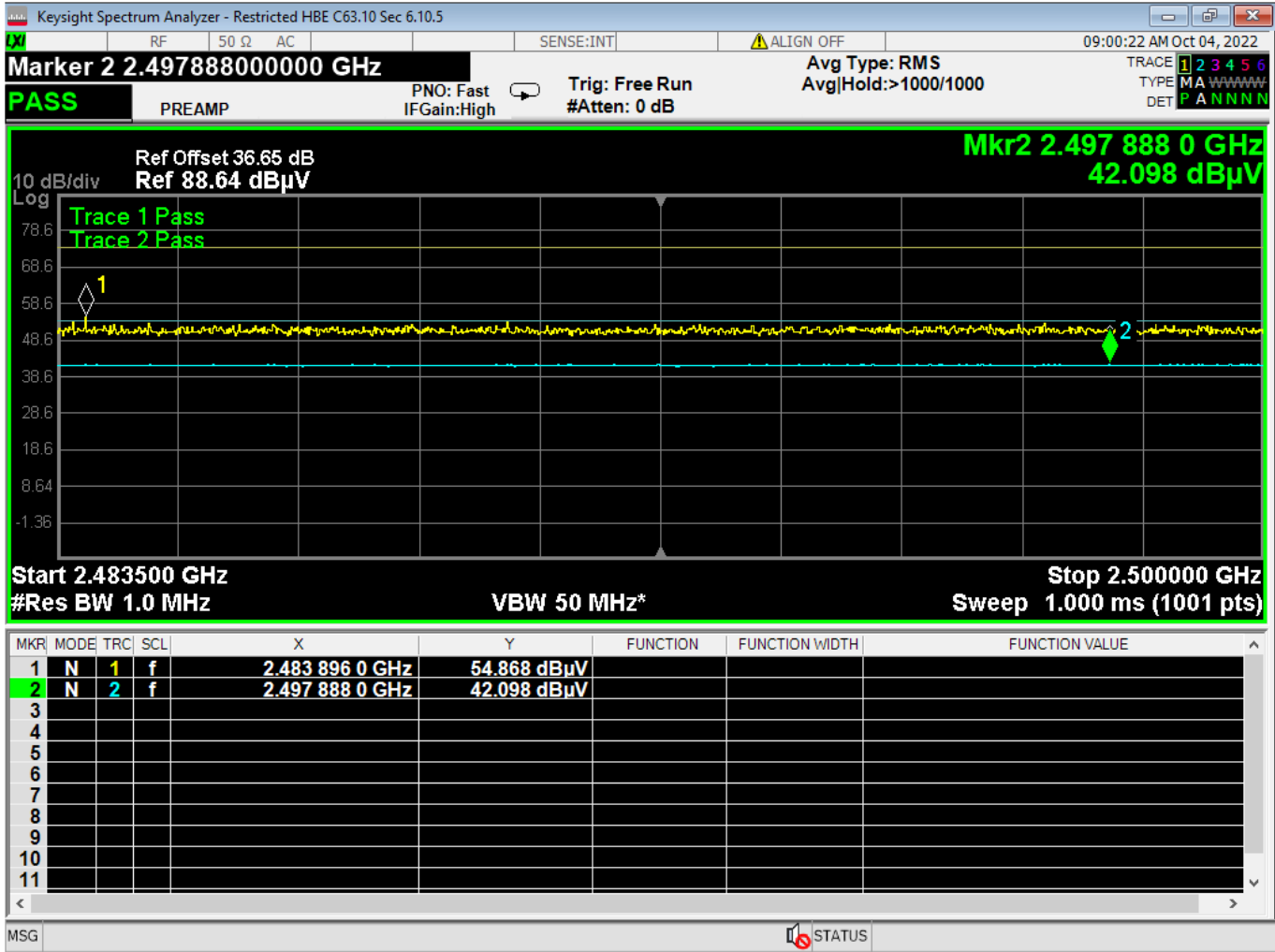


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6 LBE, Restricted, GFSK

*Please ignore the average value listed in the plot. Average measurement in section 4 is calculated by adding duty cycle correction factor (DCCF) to peak measurement.



7 HBE, Restricted, GFSK

*Please ignore the average value listed in the plot. Average measurement in section 4 is calculated by adding duty cycle correction factor (DCCF) to peak measurement.



Report Number:

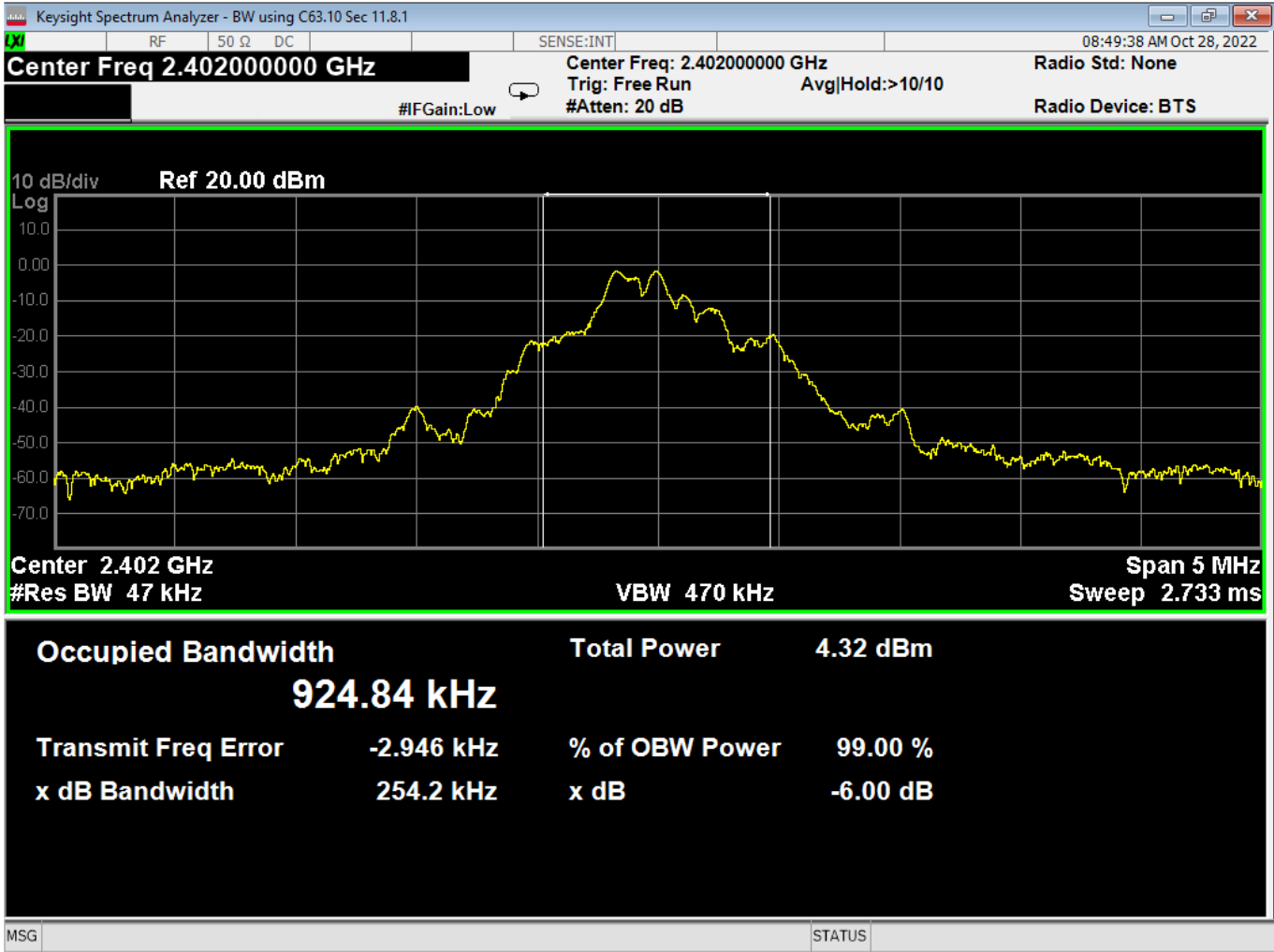
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A

Prepared for:

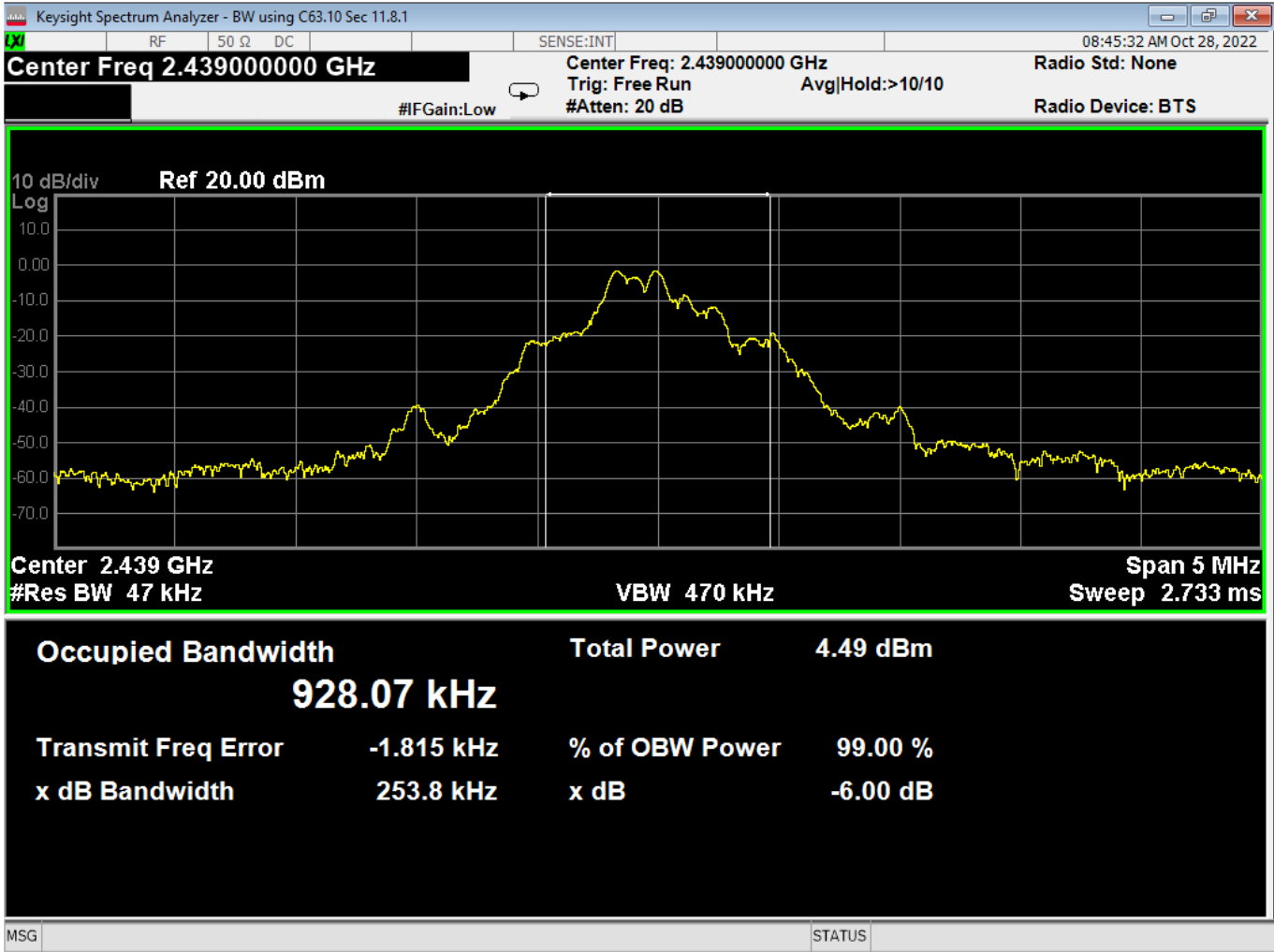
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8 Occupied Bandwidth, Low Channel, GFSK



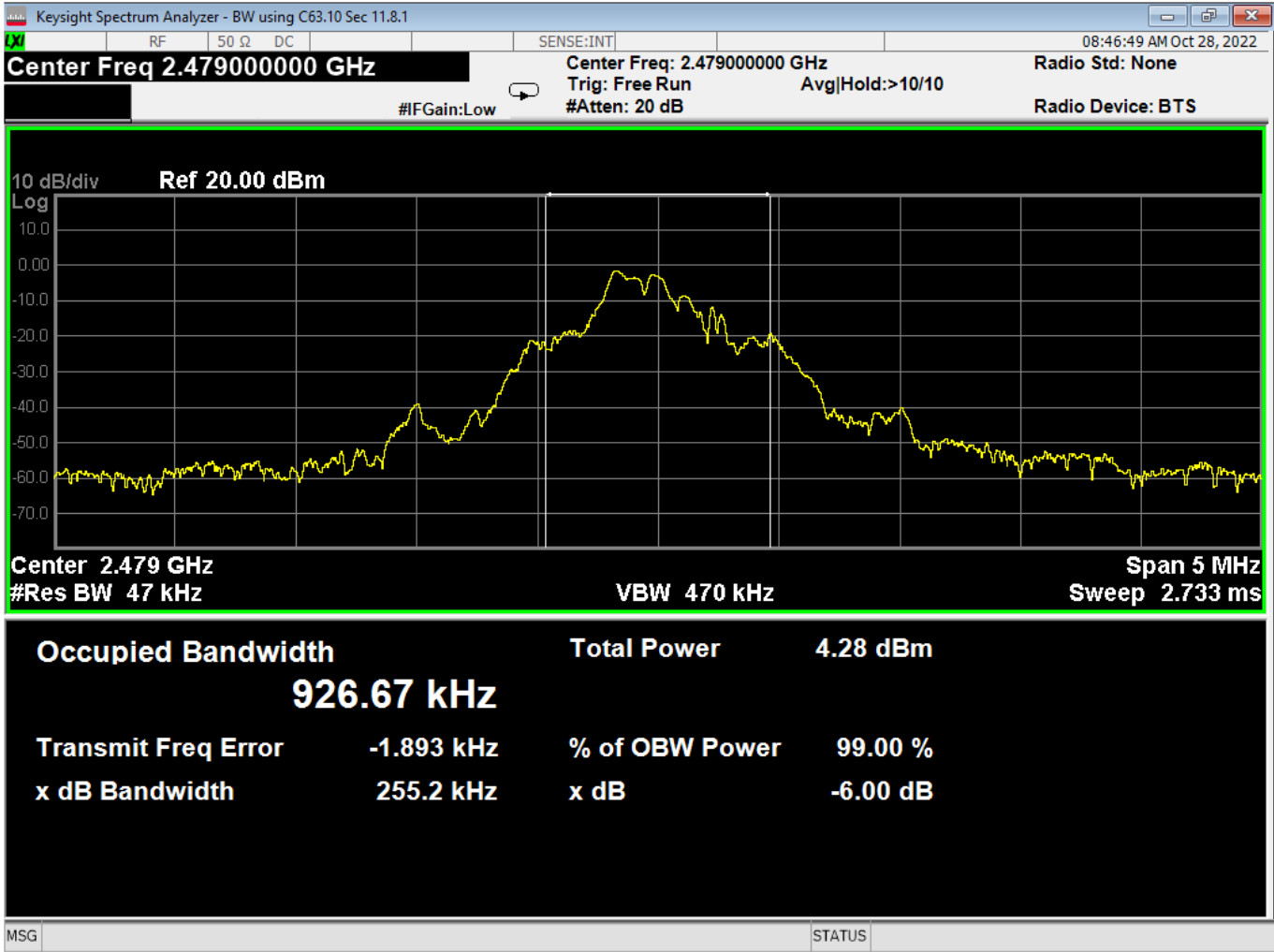
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9 Occupied Bandwidth, Mid Channel, GFSK



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10 Occupied Bandwidth, High Channel, GFSK



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REPORT END