F2 Labs
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Middlefield, Ohio 44062
United States of America
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PCII TEST REPORT

Manufacturer:	**LSI Industries, Inc.** **10000 Alliance Road** **Cincinnati, Ohio 45242 USA**
Applicant:	**Same as Above**
Product Name:	**Stand-alone Bluetooth 5 Low Energy Module**
Model:	**BMD-341**
Operating Voltage/Freq. of EUT During Testing:	**5VDC from USB**
FCC ID:	**2AWNNBMD341**
Testing Commenced:	2022-03-15
Testing Ended:	2023-01-27
Summary of Test Results:	**In Compliance, with Modifications**

The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications and/or manufacturer's statement. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant.

Note: Test report reflects Radiated Spurious measurements only for PCII due to custom antenna.

Standards:

- **FCC Part 15 Subpart C, Section 15.247**
- **ANSI C63.10:2020**

Evaluation Conducted by:

Julius Chiller, Senior Wireless Project Engineer

Report Reviewed by:

Ken Littell, Vice President of Operations

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1 ADMINISTRATIVE INFORMATION

1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD**.**

1.2 Measurement Procedure:

All measurements were performed according to ANSI C63.10 and recommended FCC procedure of measurement under Section 15.247 and in KDB558074. A list of the measurement equipment can be found in Section 5.

1.3 Uncertainty Budget:

The uncertainty in EMC measurements arises from several factors which affect the results, some associated with environmental conditions in the measurement room, the test equipment being used, and the measurement techniques adopted.

The measurement uncertainty budgets detailed below are calculated from the test and calibration data and are expressed with a 95% confidence factor. Note: Only measurements listed below which relate to tests included in this Test Report are applicable to it.

Measurement Range	Expanded Uncertainty	Combined Uncertainly
Radiated Emissions <1 GHz @ 3m	±5.07dB	±2.54
Radiated Emissions <1 GHz @10m	±5.09dB	±2.55
Radiated Emissions 1 GHz to 2.7 GHz	±3.62dB	±1.81
Radiated Emissions 2.7 GHz to 18 GHz	±3.10dB	±1.55
AC Power Line Conducted Emissions, 150kHz to 30 MHz	±2.76dB	±1.38

This Uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.4 Document History

Document Number	Description	Issue Date	Approved By
F2P26688A-01E	First Issue	2023-01-27	K. Littell

2 SUMMARY OF TEST RESULTS / EUT MODIFICATIONS

Test Name	Standard(s)	Results
Radiated Spurious Emission	CFR 47 Part 15.247(d) / Part 15.209 / KDB558074	Complies
Occupied Bandwidth	CFR 47 Part 15.247(a)(2) / KDB558074	Complies
Conducted Output Power	CFR 47 Part 15.247(b)(3) / KDB558074	Complies
Peak Power Spectral Density	CFR 47 Part 15.247(e) / KDB558074	Complies

Modifications Made to the Equipment
Power setting reduced to "0" due to 2nd Harmonic Level.

3 TABLE OF MEASURED RESULTS

Test		Low Channel 2.402 GHz	Mid Channel 2.440 GHz	High Channel 2.480 GHz
Conducted Output Power	BLE GFSK	3.32mW / 5.21 dBm	3.40mW / 5.32 dBm	2.79mW / 4.46 dBm
	BLE GFSK 2Mbps	2.98 / 4.74	2.81 / 4.48	3.01 / 4.79
	Other OQPSK	2.52 / 4.02	2.49 / 3.96	2.34 / 3.70
Conducted Output Power Limit*		6.7dBm	6.7dBm	6.7dBm
Peak Power Spectral Density	BLE GFSK	-11.27 dBm	-12.15 dBm	-12.66 dBm
	BLE GFSK 2Mbps	-12.81	-13.03	-13.39
	Other OQPSK	-13.59	-13.83	-14.19
Peak Power Spectral Density Limit		8 dBm	8 dBm	8 dBm
-20dB Occupied Bandwidth		1.163 MHz	1.162 MHz	1.165 MHz
-20dB Occupied Bandwidth Limit		≥ 500KHz	≥ 500KHz	≥ 500KHz

The original grant of certification is authorized up to 6.7dBm.

4 ENGINEERING STATEMENT

This report has been prepared on behalf of **LSI Industries, Inc.,** to provide documentation for the testing described herein. This equipment has been tested and found to comply with Part 15.247 of the FCC Rules using ANSI C63.10 and KDB558074 standards. The test results found in this test report relate only to the items tested.

5 EUT INFORMATION AND DATA

5.1 Equipment Under Test:

Product: **Stand-alone Bluetooth 5 Low Energy**
Model: BMD-341
Serial No.: 408730
FCC ID: **2AWNNBMD341**

5.2 Power Supply:

USB

5.3 Applicable Rules:

CFR 47, Part 15.247, subpart C

5.4 Equipment Category:

Radio Module-DTS

5.5 Antenna:

Monopole, -2.5dBi Gain

5.6 Accessories:

Device	Manufacturer	Model Number	Serial Number
Antenna	IPEX	Custom	None

5.7 Test Item Condition:

The equipment to be tested was received in good condition.

5.8 Testing Algorithm:

EUT was set to transmit continuously on the low, mid and high channel in the 2.4 GHz BLE band.

1 Mbps GFSK modulation was used for testing as worst-case due to the higher power output and high channel band edge margin.

6 LIST OF MEASUREMENT INSTRUMENTATION

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber	CL166-E	AlbatrossProjects	B83117-DF435-T261	US140023	2022-06-09
Temp/Hum. Recorder	CL232	Extech	445814	01	2022-04-01
Receiver	CL151	Rohde & Schwarz	ESU40	100319	2023-03-31
Horn Antenna	CL098	Emco	3115	9809-5580	2023-01-26
Antenna, JB3 Combination	CL175	Sunol Sciences	JB3	A030315	2022-09-14
Antenna, Horn	CL114	A. H. Systems, Inc.	SAS-572	237	2023-07-30
Amplifier w/Monopole & 18" Loop	CL163-Loop	A.H. Systems, Inc.	EHA-52B	100	2023-10-23
Software:	Tile Version 3.4.B.3.		Software Verified: 2022-03-15; 2023-01-11		
Software:	EMC 32, Version 8.53.0		Software Verified: 2022-03-15; 2023-01-11		

7 RADIATED SPURIOUS EMISSION

Radiated emissions were measured in a Semi-Anechoic Chamber. All emissions generated that fall in the restricted bands per FCC Part 15.205 were examined.

7.1 Requirements:

All emissions that fall in the restricted bands defined in FCC Part 15.205 shall not exceed the maximum field strength listed in FCC Part 15.209(a).

7.2 Radiated Spurious Emission Test Data

Test Date(s):	2022-03-15	**Test Engineer:**	J. Chiller
Standard(s):	CFR 47 Part 15.247(d); Part 15.209 / KDB558074	**Air Temperature:**	21.8ºC
		Relative Humidity:	28%

Notes: Plots are peak, max hold prescan data included only to determine what frequencies to investigate and measure. The EUT was initially placed in a semi-anechoic chamber and rotated in all three orthogonal positions to maximize the emissions. Characterization measurements were then performed to determine at which frequencies significant emissions occurred. These graphs are shown below.

The equipment was fully exercised with all cabling attached to the EUT and was positioned for maximum emissions. While the equipment was energized, the receiving antenna was scanned from 1.0 meter to 4.0 meters in both vertical and horizontal polarities while the turntable was adjusted 360 degrees to determine the maximum field strength. The tables of measured results can be found below.

In the following plots, the black line indicates ambient noise, and the red line indicates the measurement with the EUT on. Emissions to be found by the EUT were measured and listed in tables. The plots are for reference only and the limit lines are not actual limit lines but merely a guide.

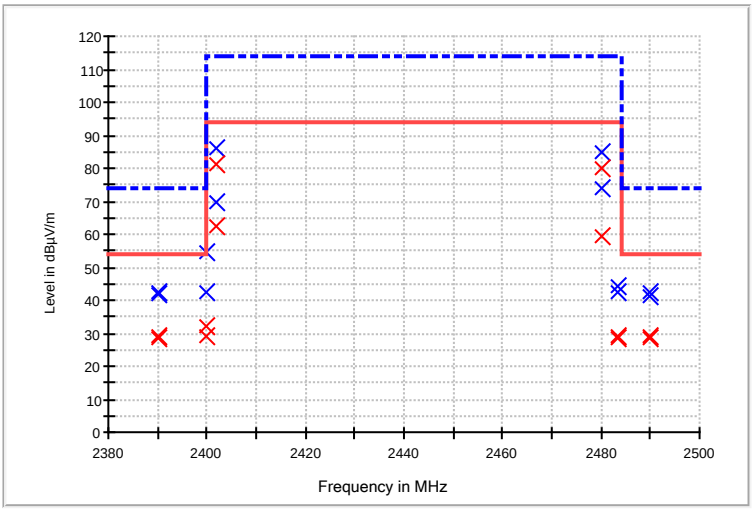
Measurements, Band Edge

MaxPeak

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2390.000000	H	150.00	168.00	36.4	5.9	42.3	74.0	-31.7
2390.000000	V	150.00	32.00	36.1	5.9	42.0	74.0	-32.0
2400.000000	H	150.00	168.00	48.7	5.8	54.5	74.0	-19.5
2400.000000	V	150.00	32.00	36.7	5.8	42.5	74.0	-31.5
2483.500000	V	150.00	226.00	36.6	5.8	42.4	74.0	-31.6
2483.500000	H	150.00	175.00	38.7	5.8	44.5	74.0	-29.5
2490.000000	V	150.00	226.00	36.4	5.8	42.2	74.0	-31.8
2490.000000	H	150.00	175.00	35.5	5.8	41.3	74.0	-32.7

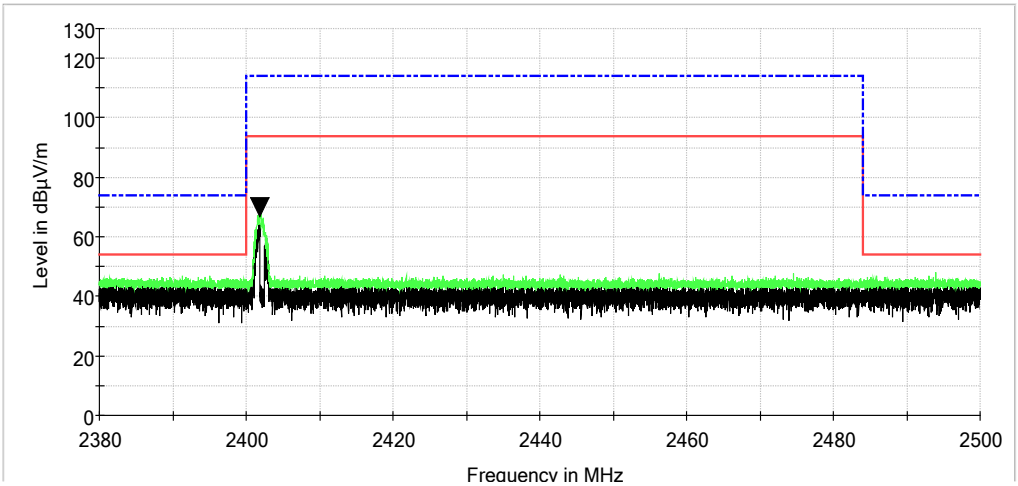
AVG

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2390.000000	H	150.00	168.00	22.9	5.9	28.8	54.0	-25.2
2390.000000	V	150.00	32.00	22.9	5.9	28.8	54.0	-25.2
2400.000000	H	150.00	168.00	26.5	5.8	32.3	54.0	-21.7
2400.000000	V	150.00	32.00	23.1	5.8	28.9	54.0	-25.1
2483.500000	V	150.00	226.00	22.9	5.8	28.7	54.0	-25.3
2483.500000	H	150.00	175.00	23.4	5.8	29.2	54.0	-24.8
2490.000000	V	150.00	226.00	22.9	5.8	28.7	54.0	-25.3
2490.000000	H	150.00	175.00	35.5	5.8	41.3	74.0	-32.7

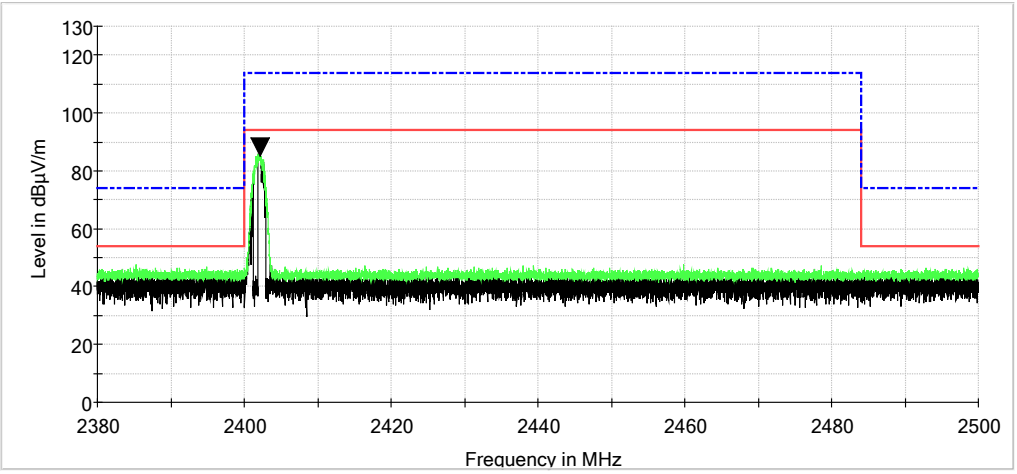


Band Edge

Low Channel: Vertical

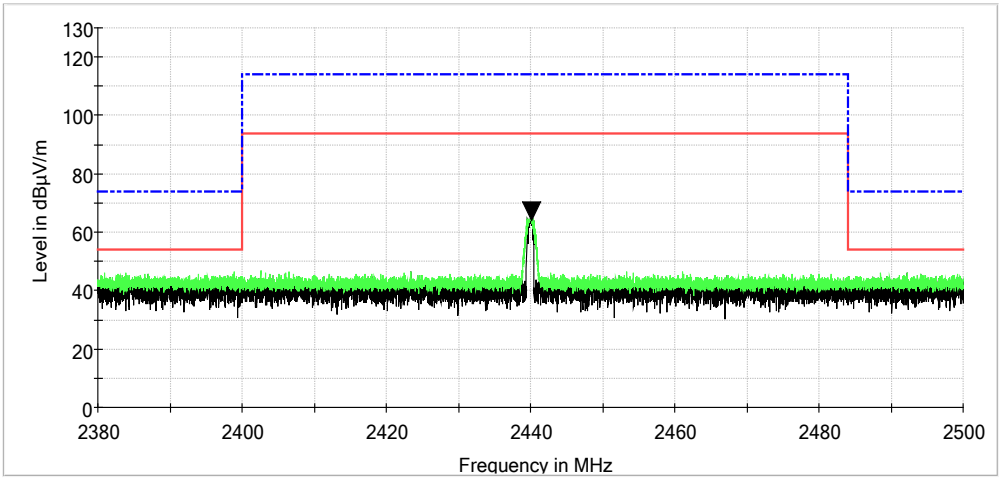


Low Channel: Horizontal

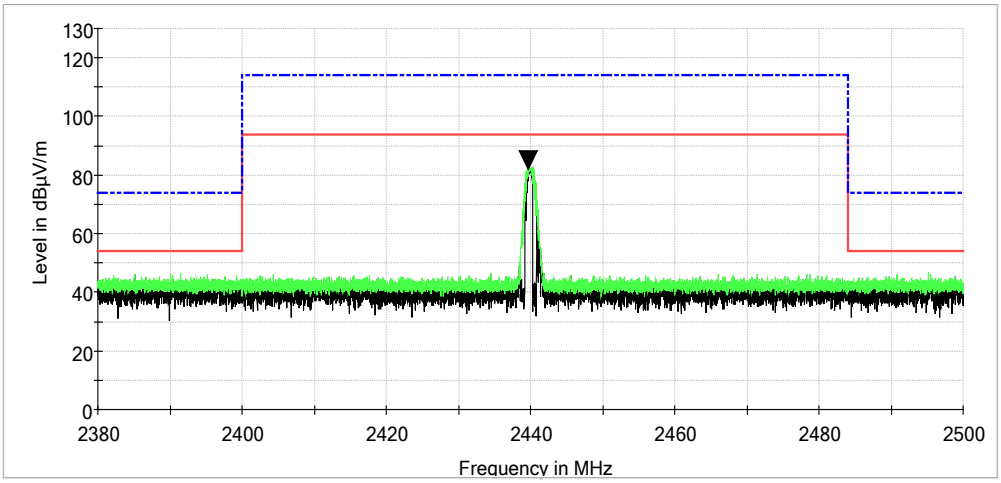


Band Edge

Mid Channel: Vertical

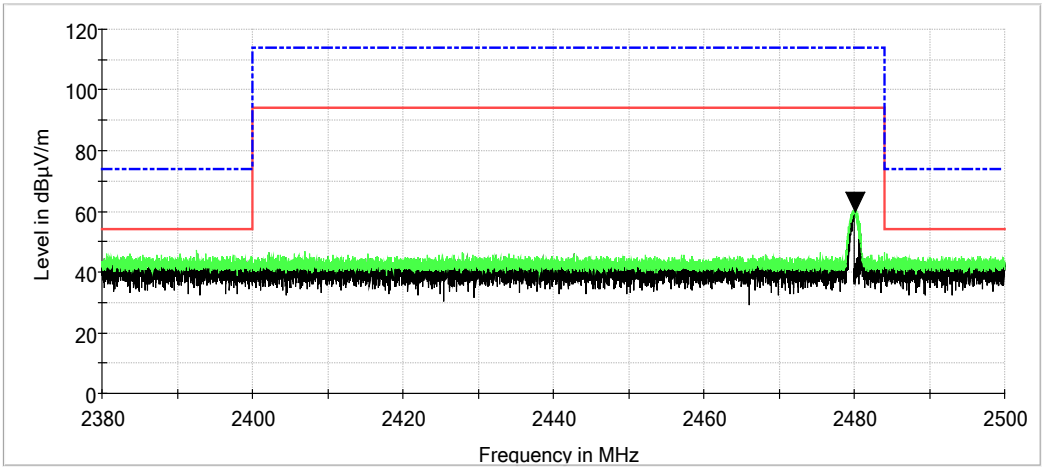


Mid Channel: Horizontal

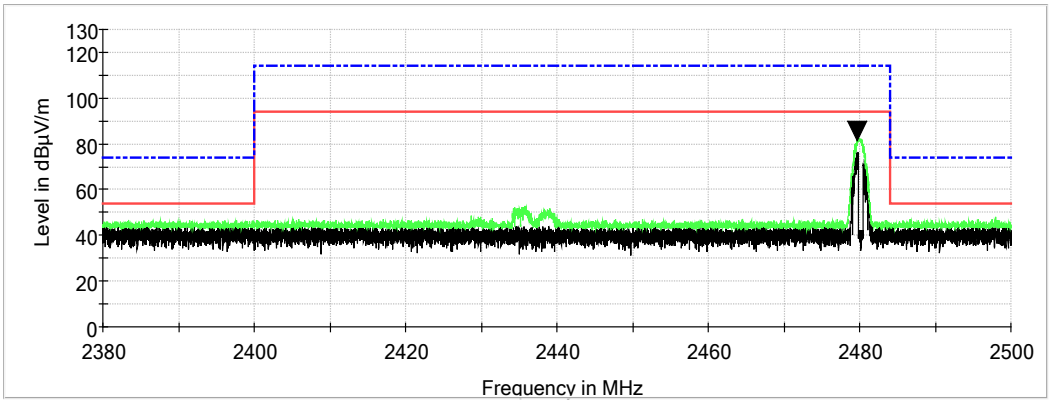


Band Edge

High Channel: Vertical



High Channel: Horizontal



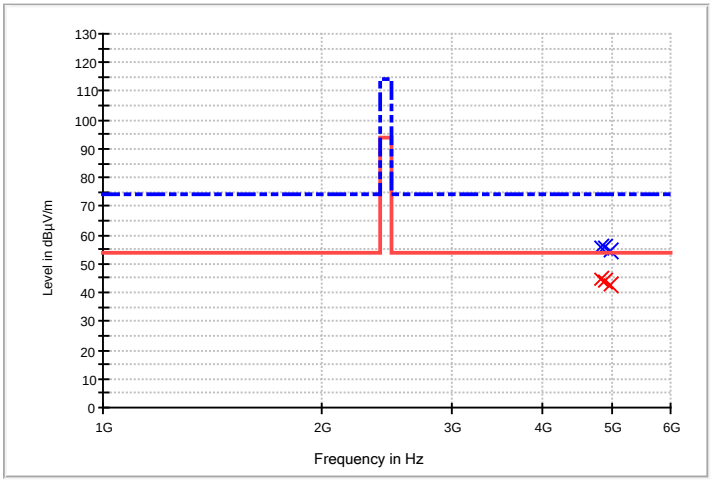
Measurements – BLE 2nd Harmonic

Measurements – MaxPeak

Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4804.000000	H	150.00	176.00	44.3	11.2	55.5	74.0	-18.5
4880.000000	H	150.00	176.00	44.2	11.4	55.6	74.0	-18.4
4960.000000	H	150.00	176.00	42.7	11.6	54.3	74.0	-19.7

Measurements – AVG

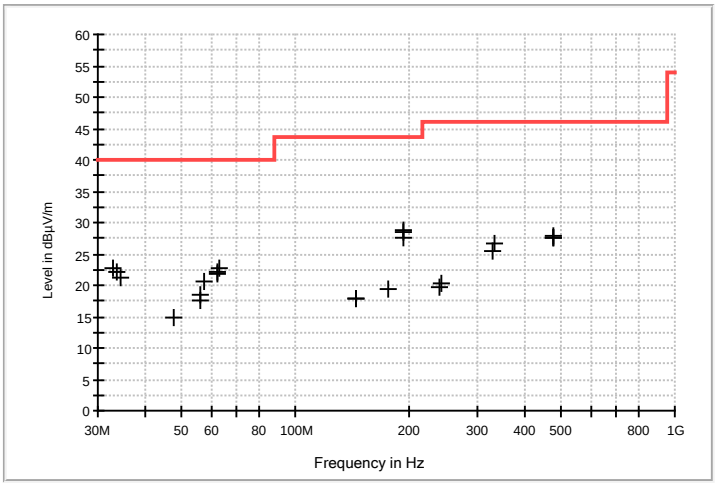
Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4804.000000	H	150.00	176.00	33.2	11.2	44.4	54.0	-9.6
4880.000000	H	150.00	176.00	32.3	11.4	43.7	54.0	-10.3
4960.000000	H	150.00	176.00	30.7	11.6	42.3	54.0	-11.7



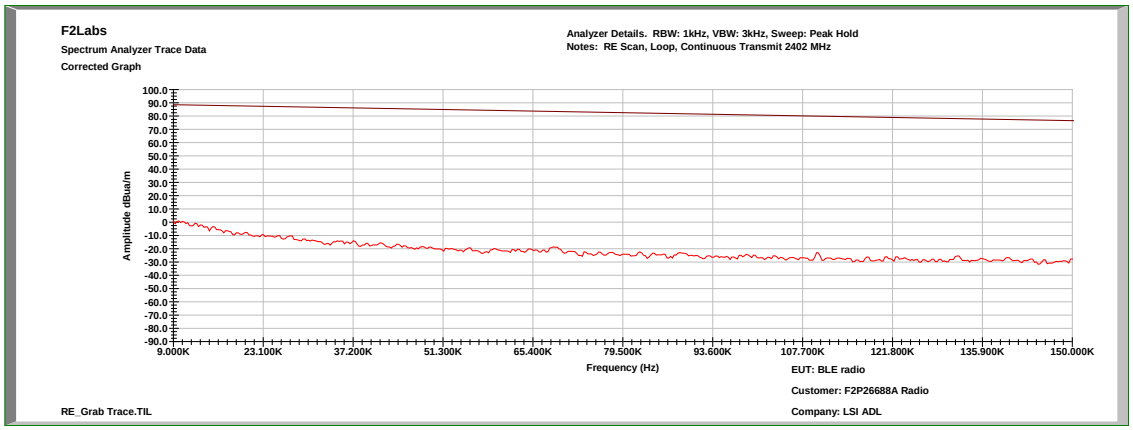
Measurements, 30 MHz to 1000 MHz: QuasiPeak

Note: Measurements include data from all channels.

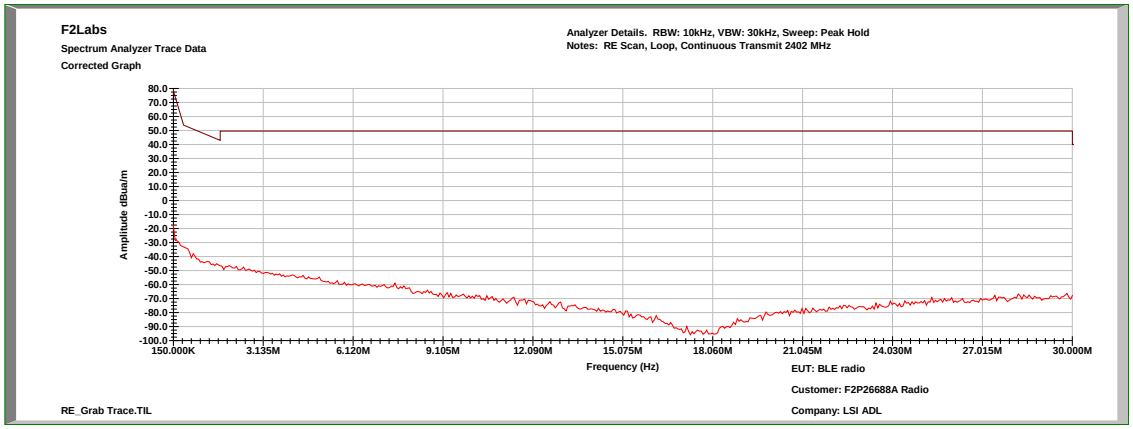
Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (deg)	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
32.720000	V	100.00	0.00	25.9	-3.2	22.70	40.0	-17.3
33.480000	V	100.00	0.00	26.0	-3.8	22.20	40.0	-17.8
34.640000	V	100.00	0.00	25.9	-4.6	21.30	40.0	-18.7
47.480000	V	100.00	0.00	28.2	-13.3	14.90	40.0	-25.1
55.800000	V	100.00	303.00	33.3	-14.9	18.40	40.0	-21.6
55.800000	V	100.00	31.00	32.4	-14.9	17.50	40.0	-22.5
56.960000	V	100.00	23.00	35.6	-15.0	20.60	40.0	-19.4
62.400000	V	100.00	334.00	36.6	-14.9	21.70	40.0	-18.3
62.400000	V	100.00	108.00	37.1	-14.9	22.20	40.0	-17.8
62.800000	V	100.00	0.00	37.5	-14.8	22.70	40.0	-17.3
144.080000	V	100.00	127.00	27.0	-9.1	17.90	43.5	-25.6
144.080000	V	100.00	2.00	27.0	-9.1	17.90	43.5	-25.6
175.520000	H	100.00	111.00	29.7	-10.3	19.40	43.5	-24.1
192.000000	H	100.00	156.00	38.6	-10.0	28.60	43.5	-14.9
192.000000	H	100.00	145.00	38.9	-10.0	28.90	43.5	-14.6
192.000000	H	100.00	118.00	37.7	-10.0	27.70	43.5	-15.8
238.560000	H	100.00	216.00	29.3	-9.6	19.70	46.0	-26.3
241.480000	H	100.00	222.00	29.7	-9.5	20.20	46.0	-25.8
331.880000	V	100.00	155.00	31.8	-6.4	25.40	46.0	-20.6
333.240000	V	100.00	156.00	33.0	-6.4	26.60	46.0	-19.4
480.080000	H	100.00	205.00	29.8	-2.2	27.60	46.0	-18.4
480.080000	H	100.00	262.00	30.0	-2.2	27.80	46.0	-18.2
480.080000	H	100.00	263.00	29.9	-2.2	27.70	46.0	-18.3



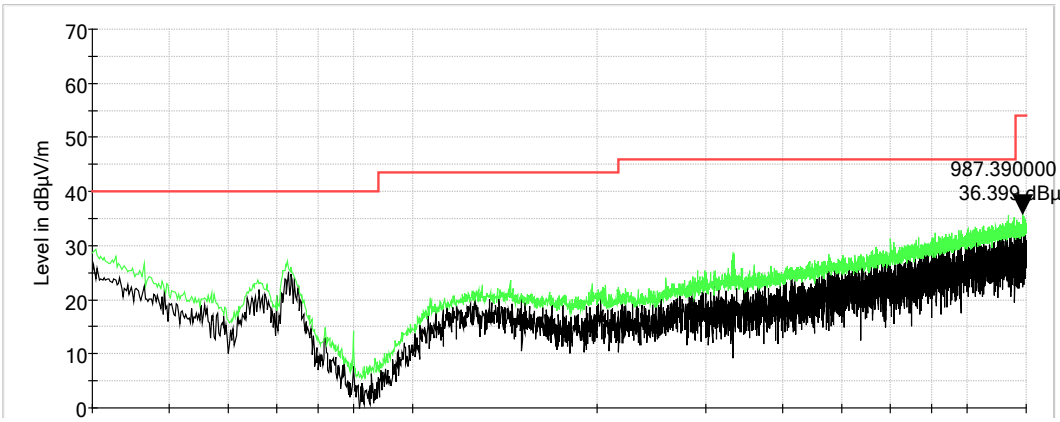
Low Channel: 0.009 MHz to 0.15 MHz



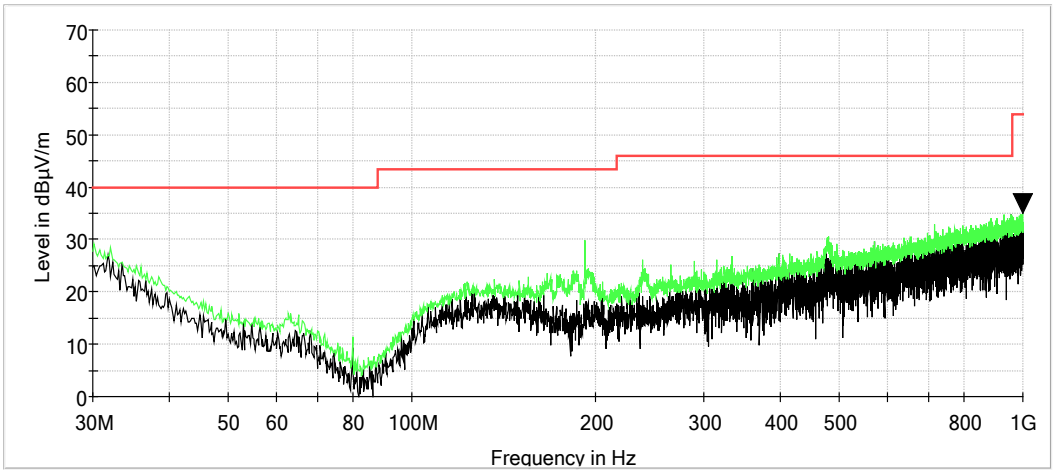
Low Channel: 0.15 MHz to 30.0 MHz



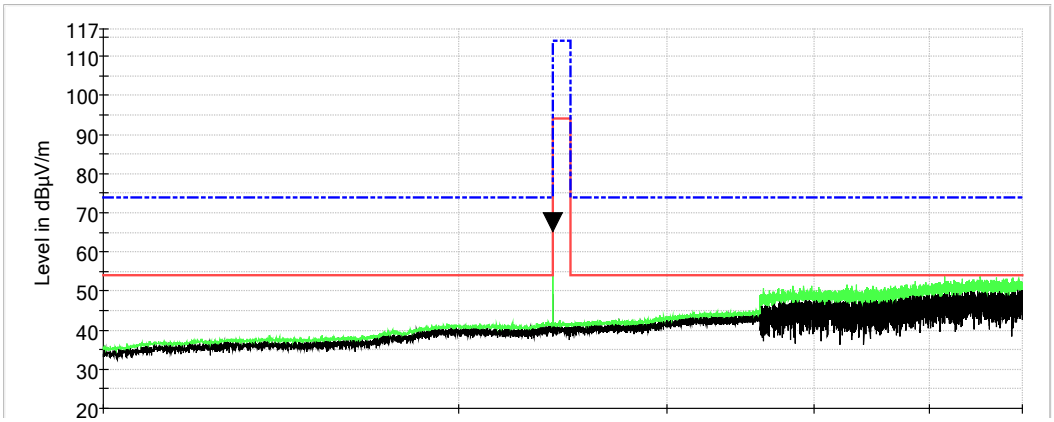
Low Channel: 30 MHz to 1000 MHz - Vertical



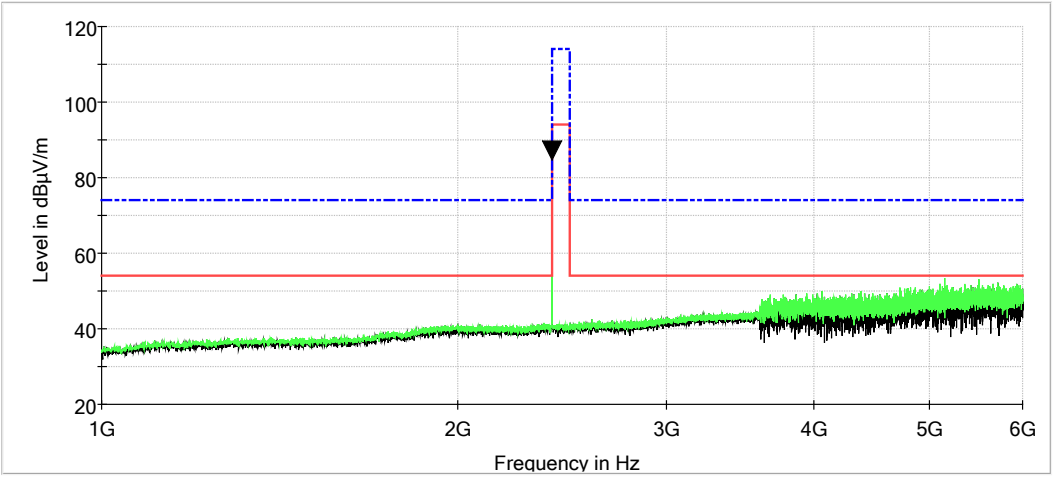
Low Channel: 30 MHz to 1000 MHz - Horizontal



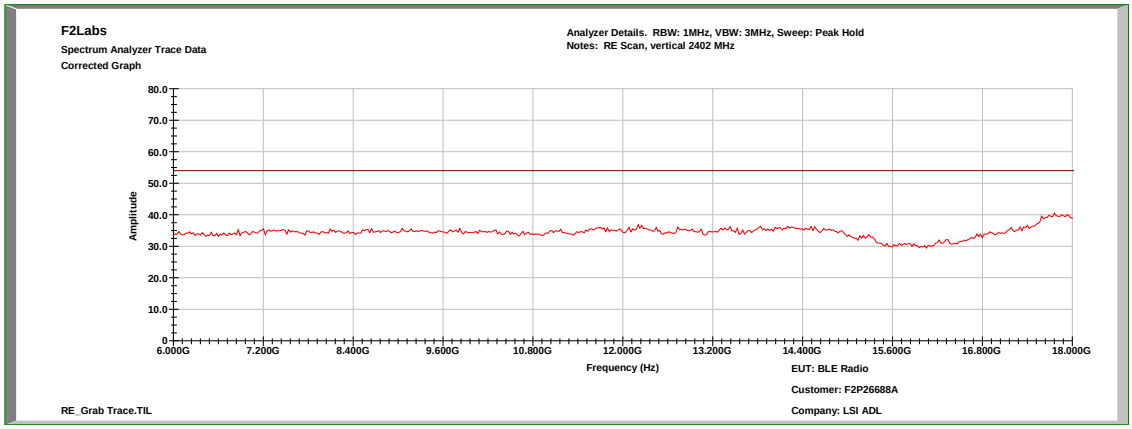
Low Channel: 1 GHz to 6 GHz - Vertical



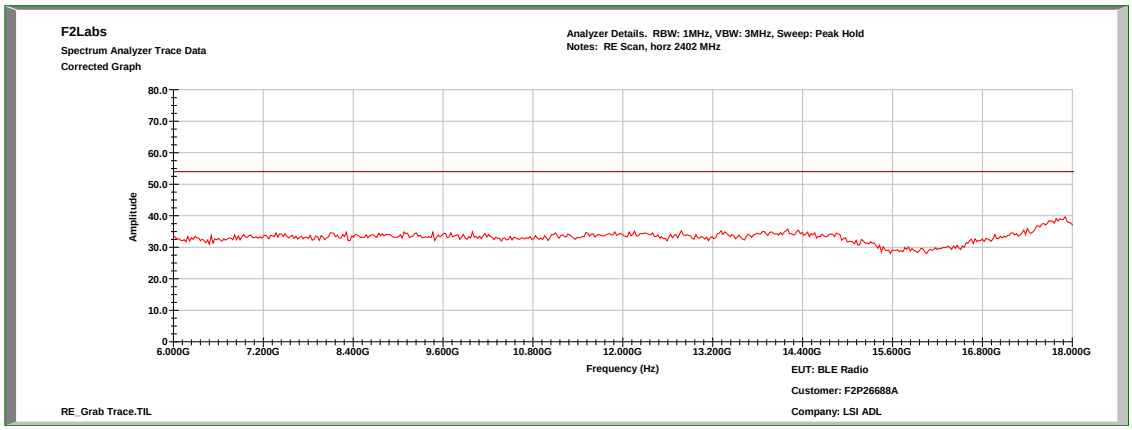
Low Channel: 1 GHz to 6 GHz - Horizontal



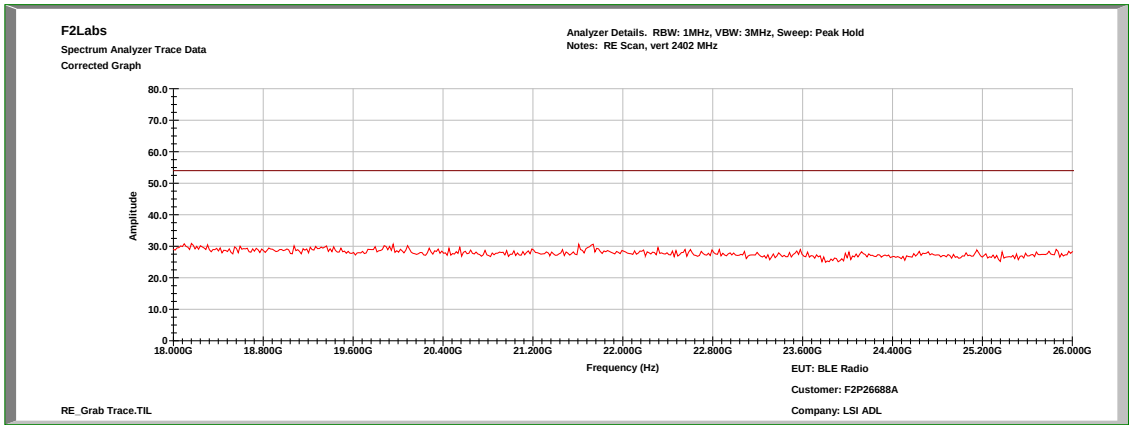
Low Channel: 6 GHz to 18 GHz - Vertical



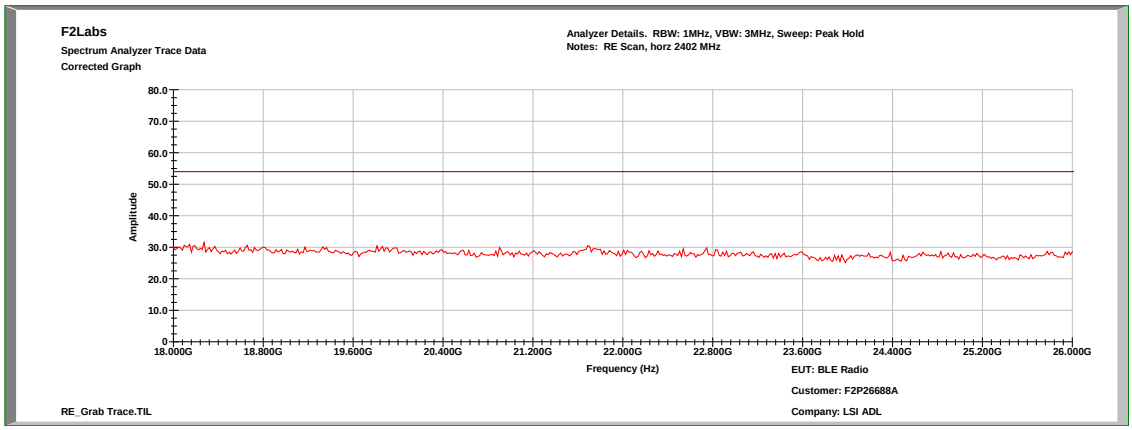
Low Channel: 6 GHz to 18 GHz - Horizontal



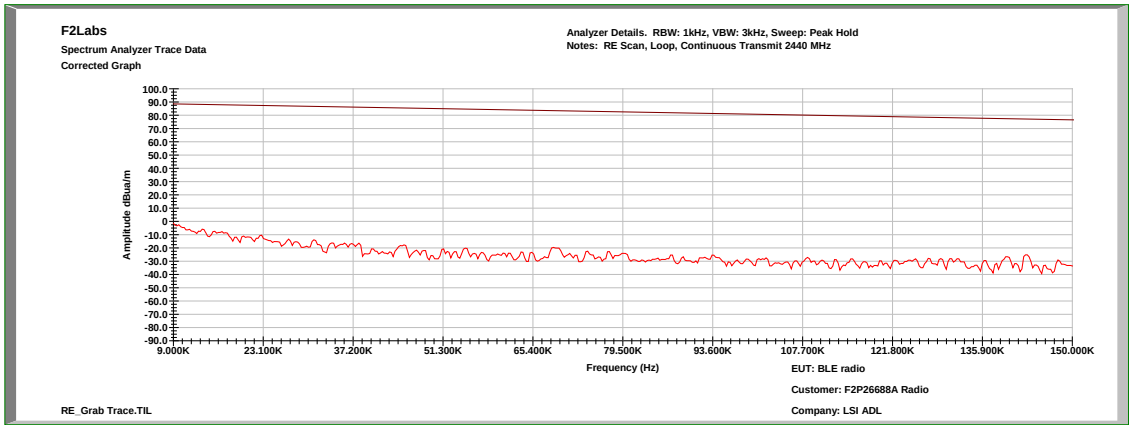
Low Channel: 18 GHz to 26 GHz - Vertical



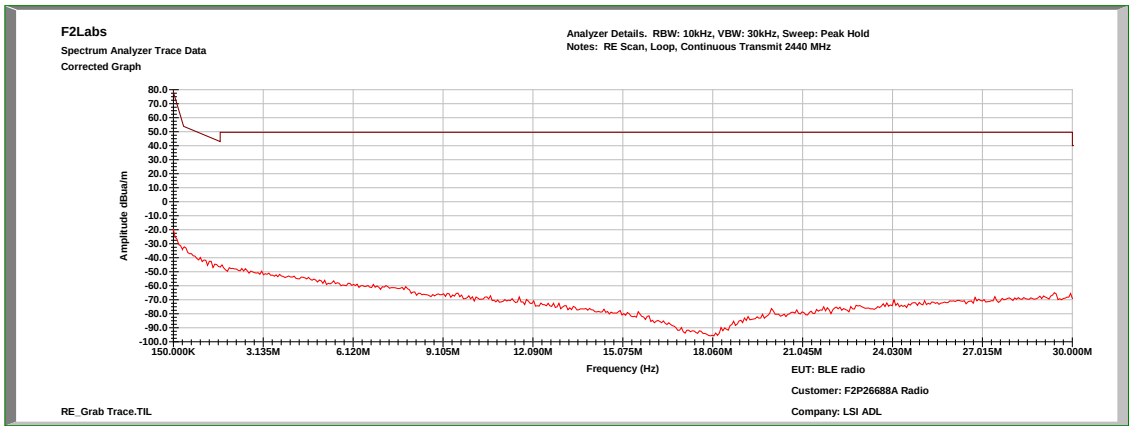
Low Channel: 18 GHz to 26 GHz - Horizontal



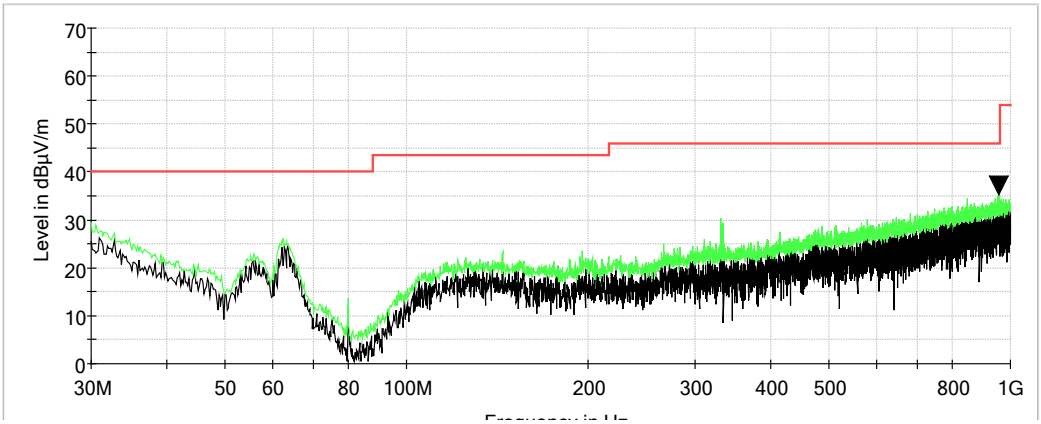
Mid Channel: 0.009 MHz to 0.15 MHz



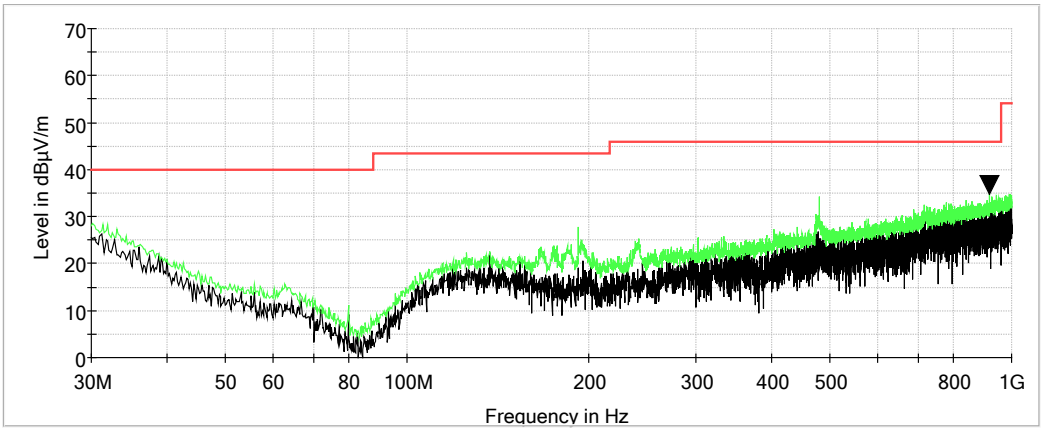
Mid Channel: 0.15 MHz to 30.0 MHz



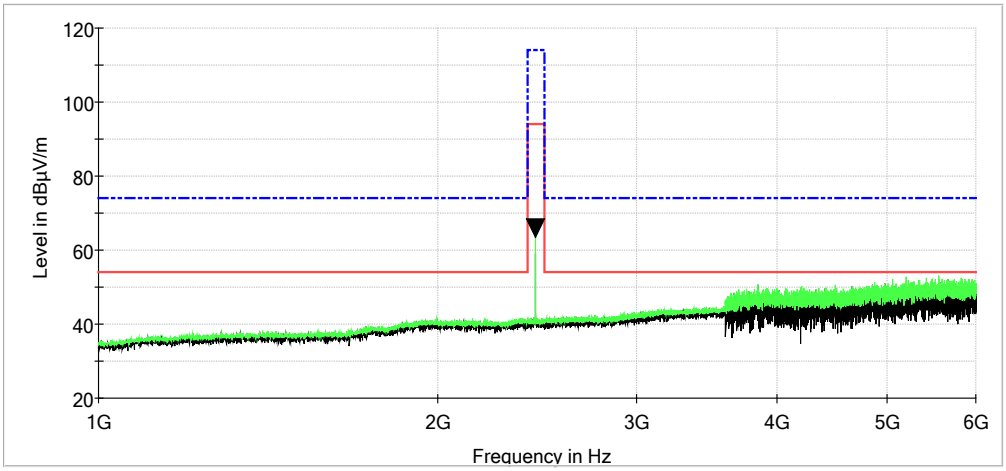
Mid Channel: 30 MHz to 1000 MHz - Vertical



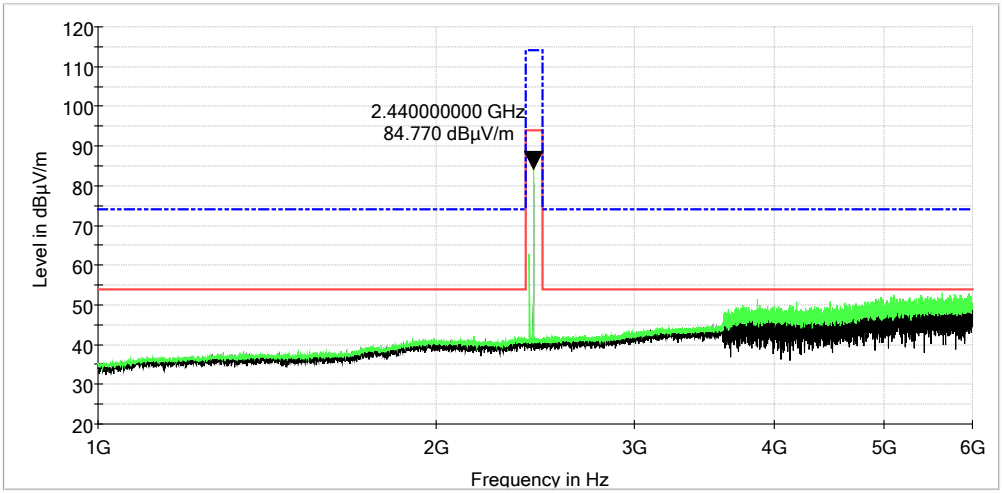
Mid Channel: 30 MHz to 1000 MHz - Horizontal



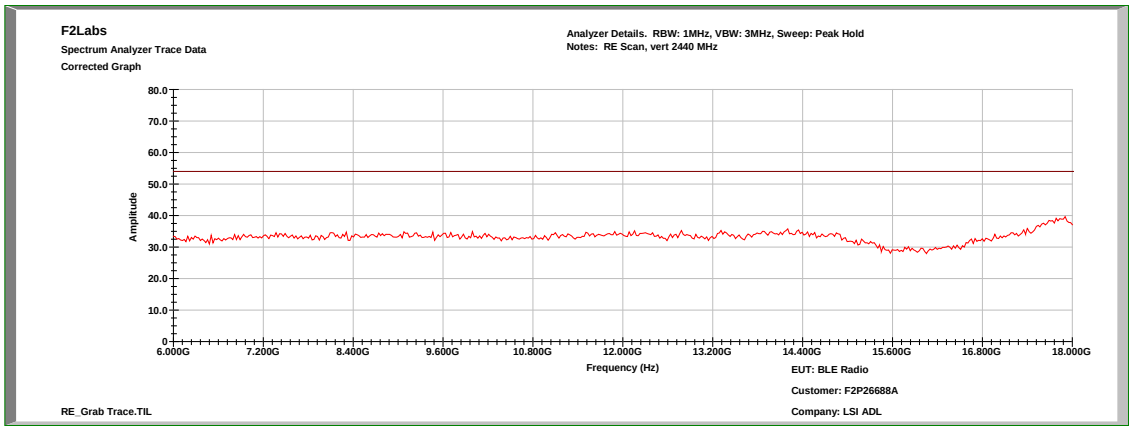
Mid Channel: 1 GHz to 6 GHz - Vertical



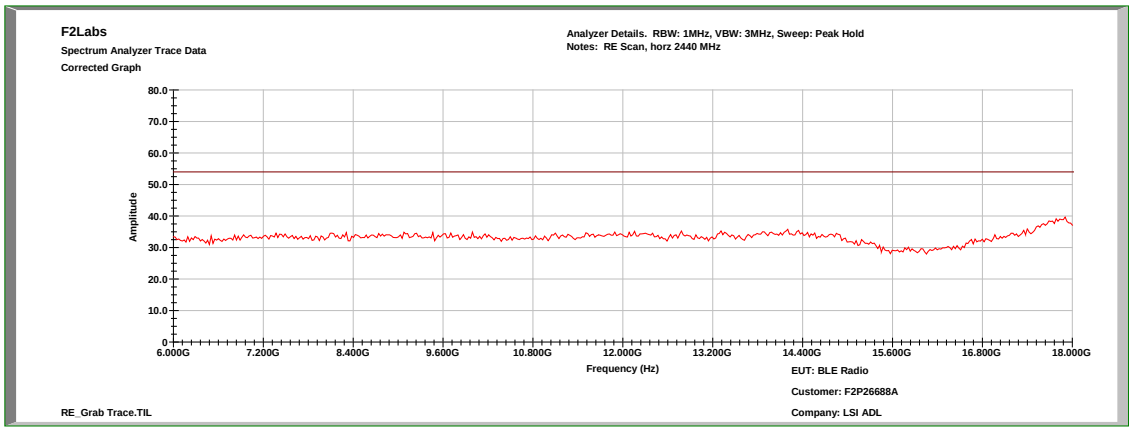
Mid Channel: 1 GHz to 6 GHz - Horizontal



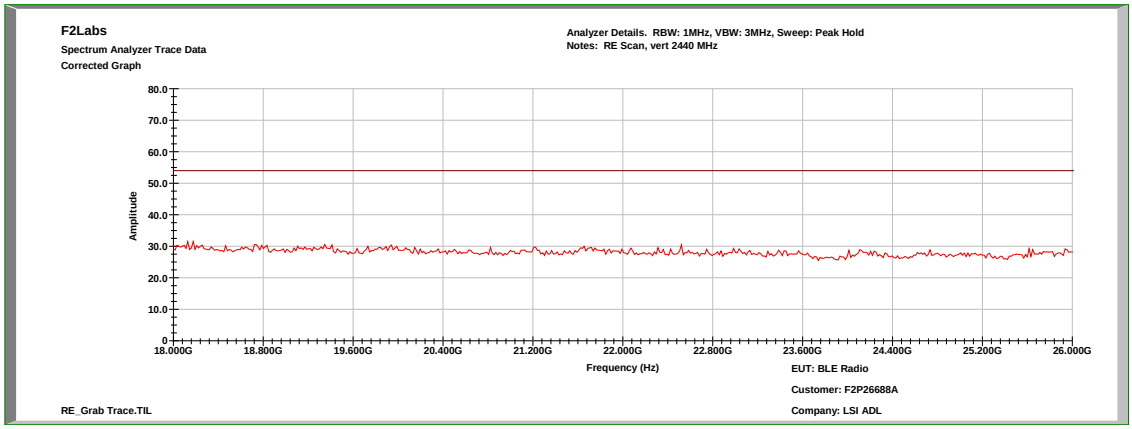
Mid Channel: 6 GHz to 18 GHz - Vertical



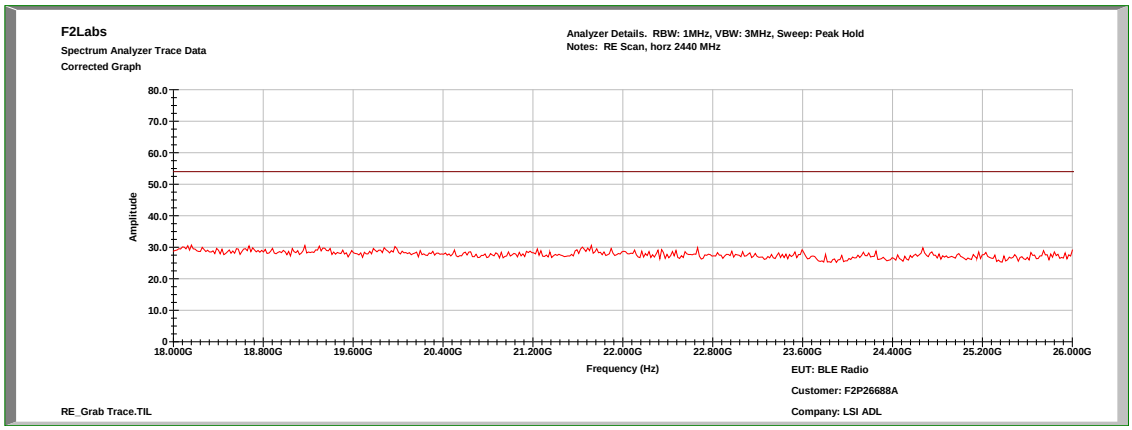
Mid Channel: 6 GHz to 18 GHz - Horizontal



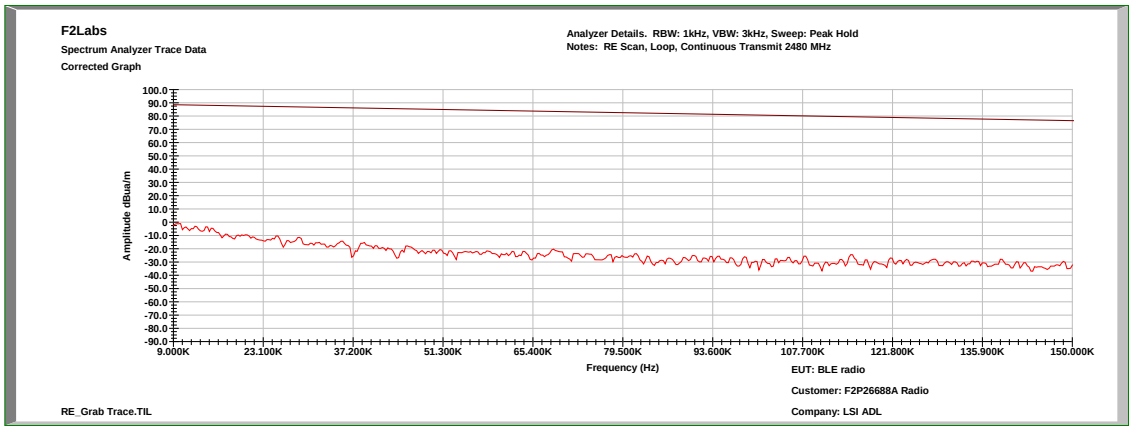
Mid Channel: 18 GHz to 26 GHz - Vertical



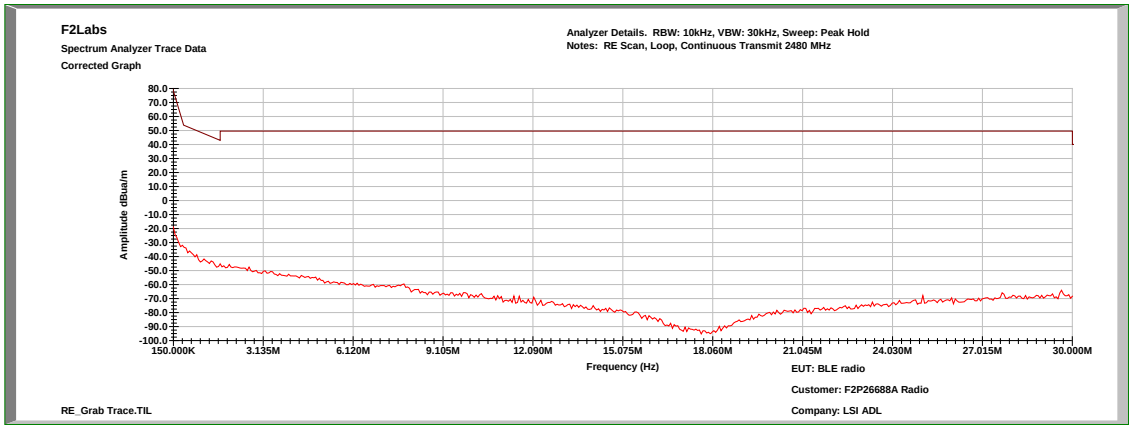
Mid Channel: 18 GHz to 26 GHz - Horizontal



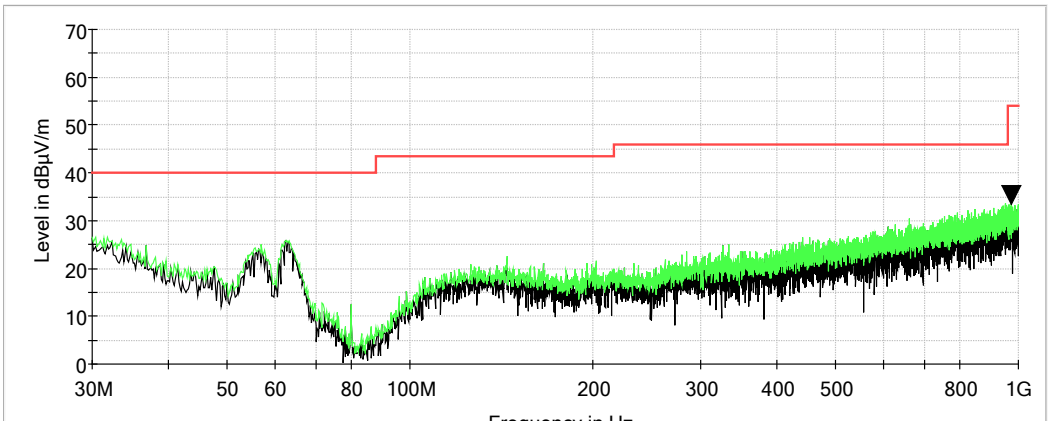
High Channel: 0.009 MHz to 0.15 MHz



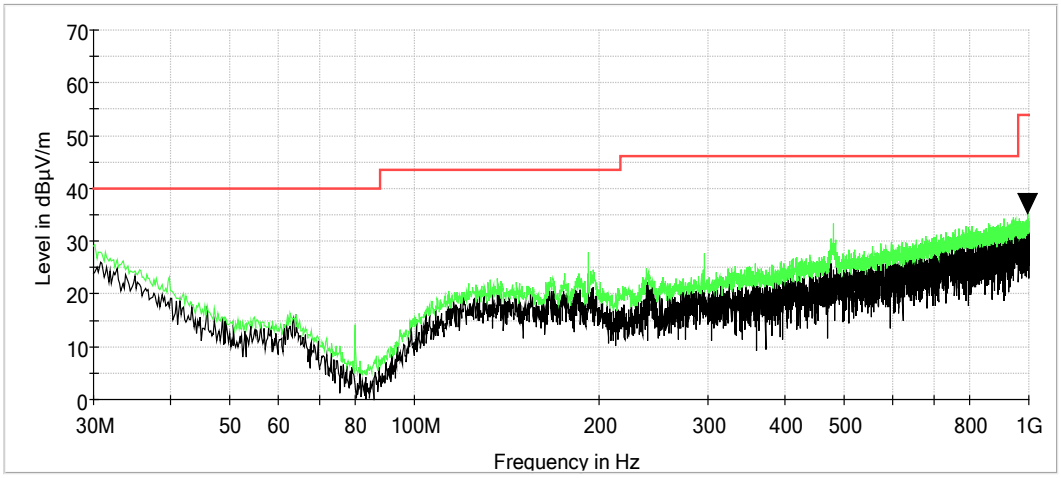
High Channel: 0.15 MHz to 30.0 MHz



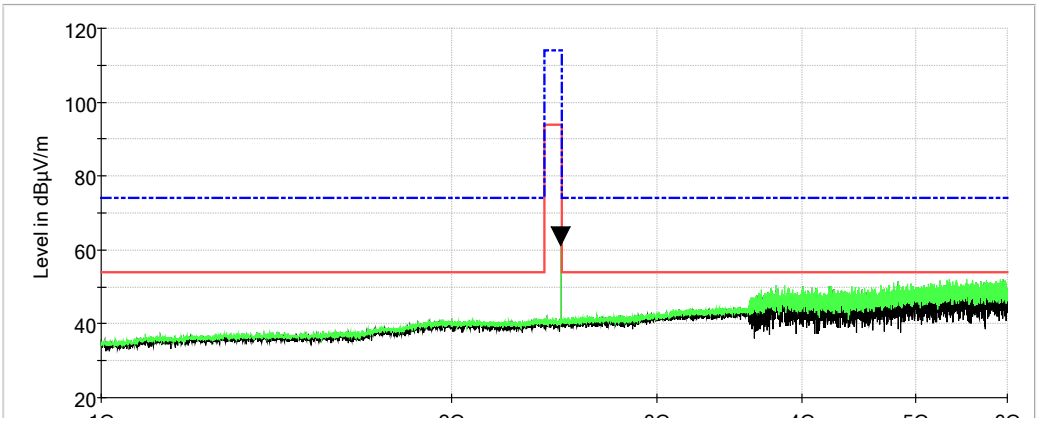
High Channel: 30 MHz to 1000 MHz - Vertical



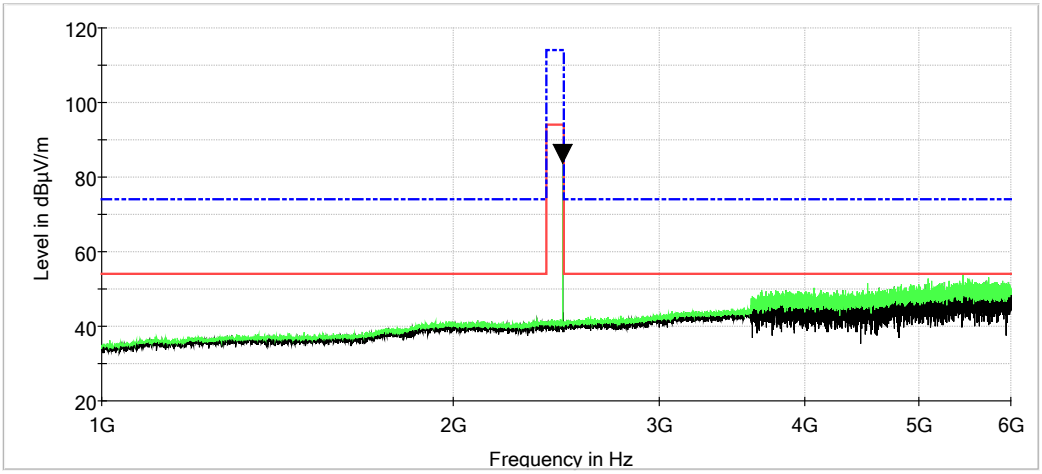
High Channel: 30 MHz to 1000 MHz - Horizontal



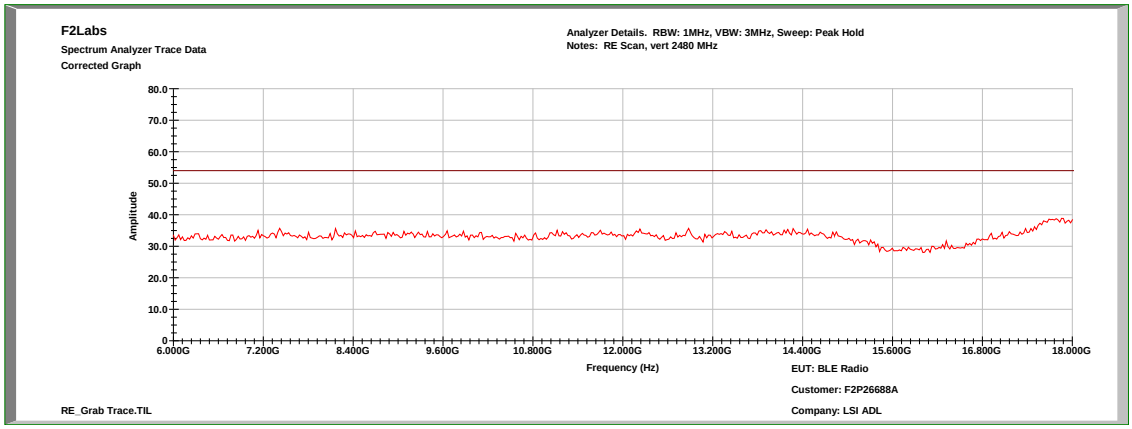
High Channel: 1 GHz to 6 GHz - Vertical



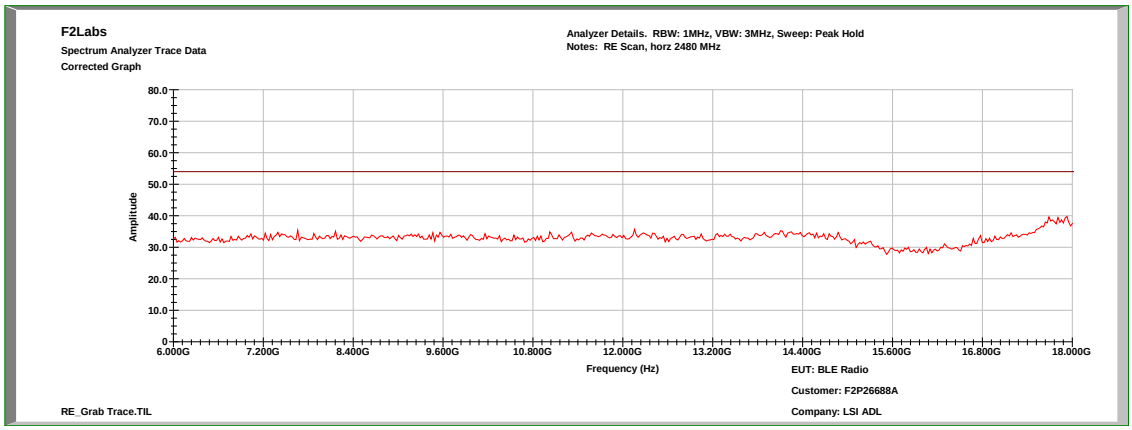
High Channel: 1 GHz to 6 GHz - Horizontal



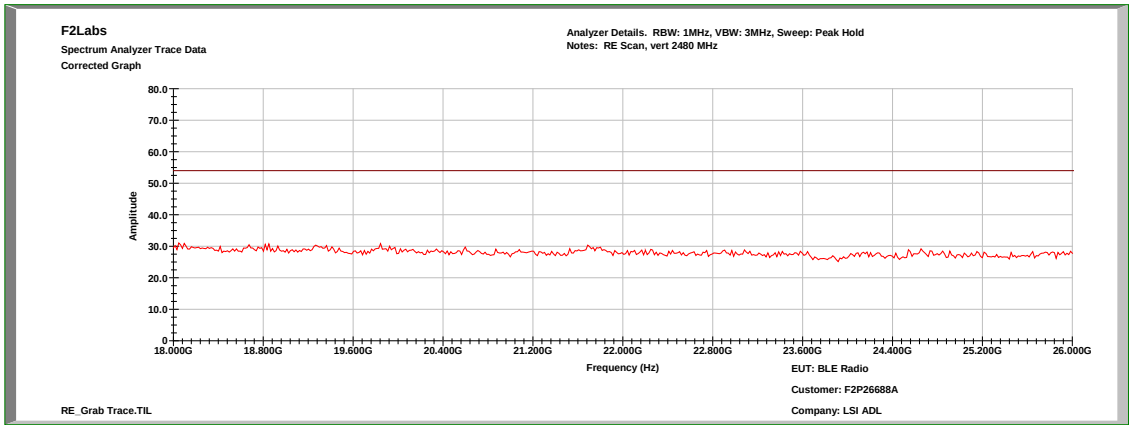
High Channel: 6 GHz to 18 GHz - Vertical



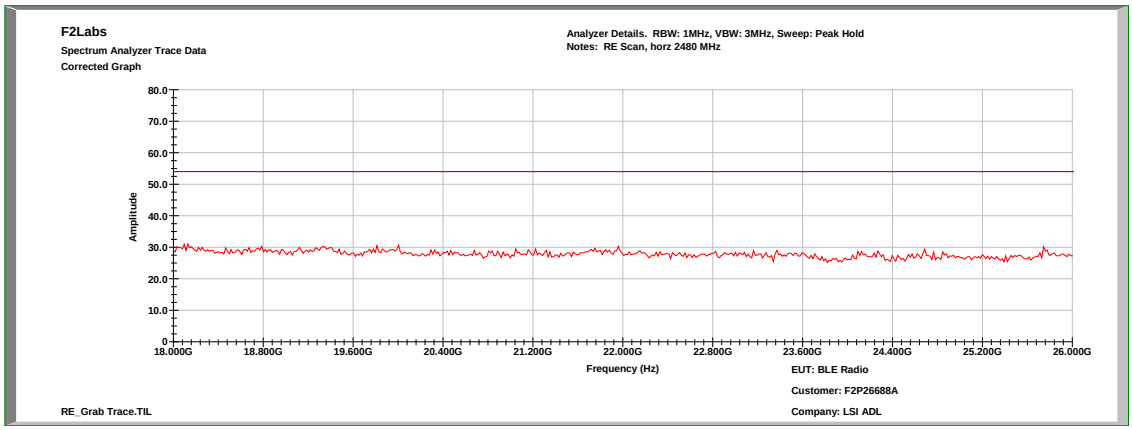
High Channel: 6 GHz to 18 GHz - Horizontal



High Channel: 18 GHz to 26 GHz - Vertical



High Channel: 18 GHz to 26 GHz - Horizontal



8 FCC PART 15.247(a)(2) – OCCUPIED BANDWIDTH

8.1 Requirements:

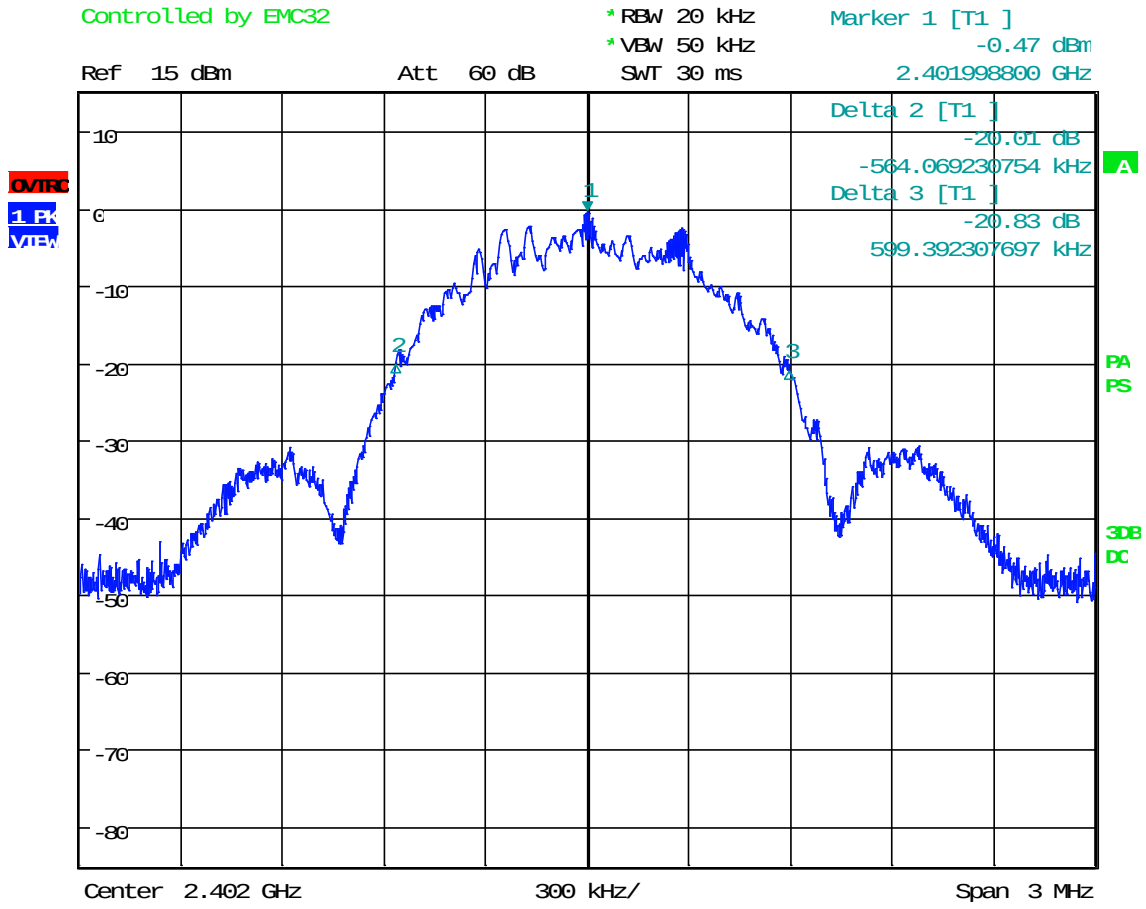
The 6dB bandwidth shall be greater than 500 kHz.

Bandwidth measurements were made at the low (2.405 GHz), mid (2.440 GHz) and upper (2.480 GHz) frequencies with the resolution Bandwidth set at 20 kHz (video bandwidth set at 50 kHz) while the span was set at 3 MHz. The bandwidth was measured using the marker delta method.

8.2 Occupied Bandwidth Test Data

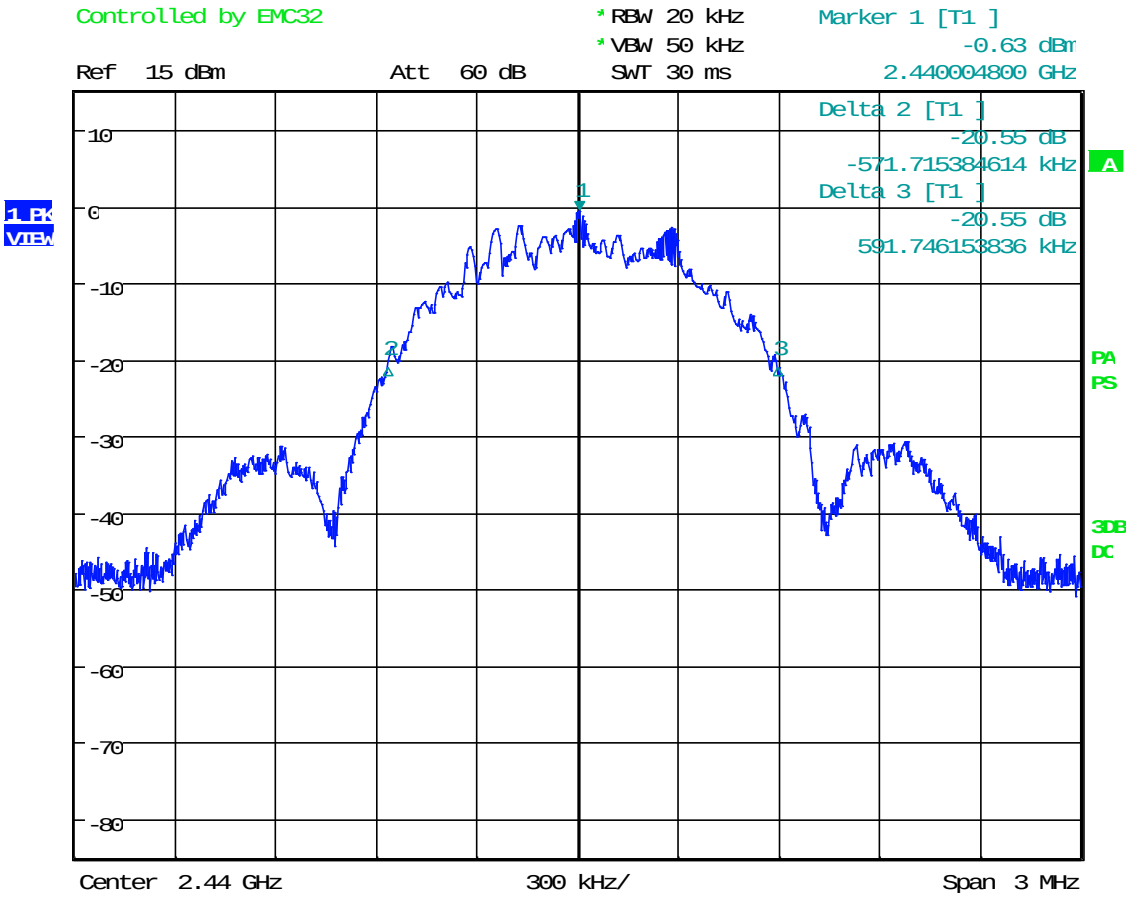
Test Date(s):	2023-01-11	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(a)(2); KDB558074	Air Temperature:	21.2ºC
		Relative Humidity:	33%

GFSK, 1 Mbps: Low Channel



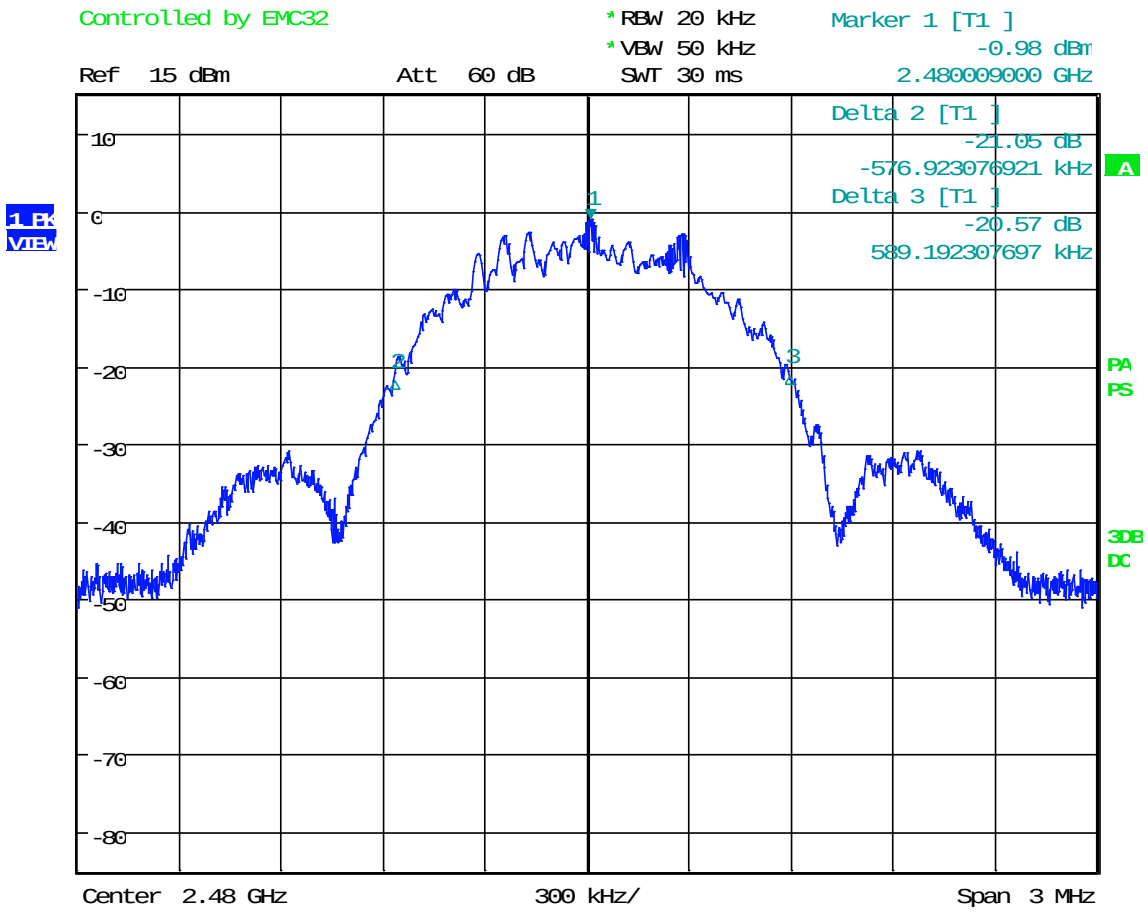
Date: 11.JAN.2023 11:41:06

GFSK, 1 Mbps: Mid Channel



Date: 11.JAN.2023 11:44:24

GFSK, 1 Mbps: High Channel



Date: 11.JAN.2023 11:46:28

9 FCC PART 15.247(b)(3) – CONDUCTED OUTPUT POWER

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the receiver. The peak power output was measured.

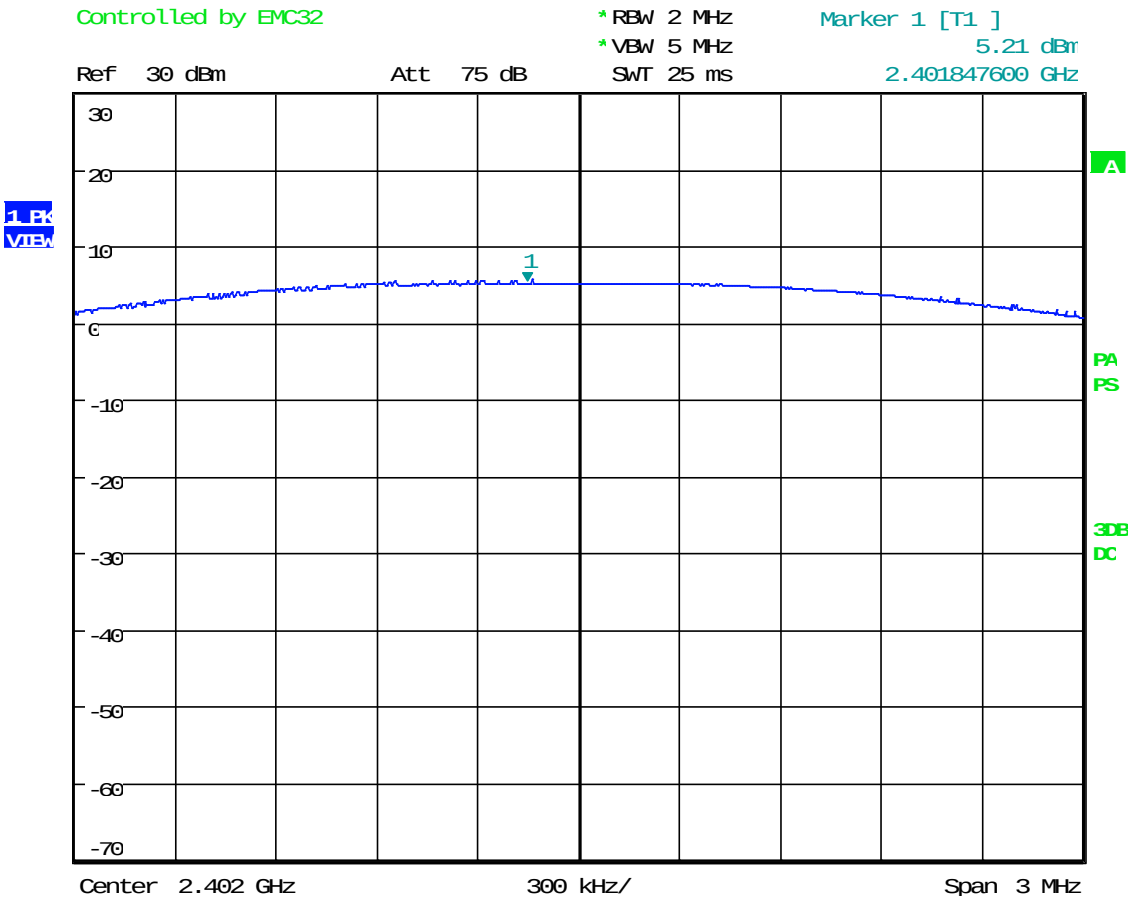
9.1 Requirements:

The peak power output shall be 1 watt (30 dBm) or less when using an antenna with a gain of less than 6dBi. For antennas having a gain of more than 6dBi, the limit is reduced by 1dB for every dB the antenna gain is over 6dBi.

9.2 Conducted Output Power Test Data

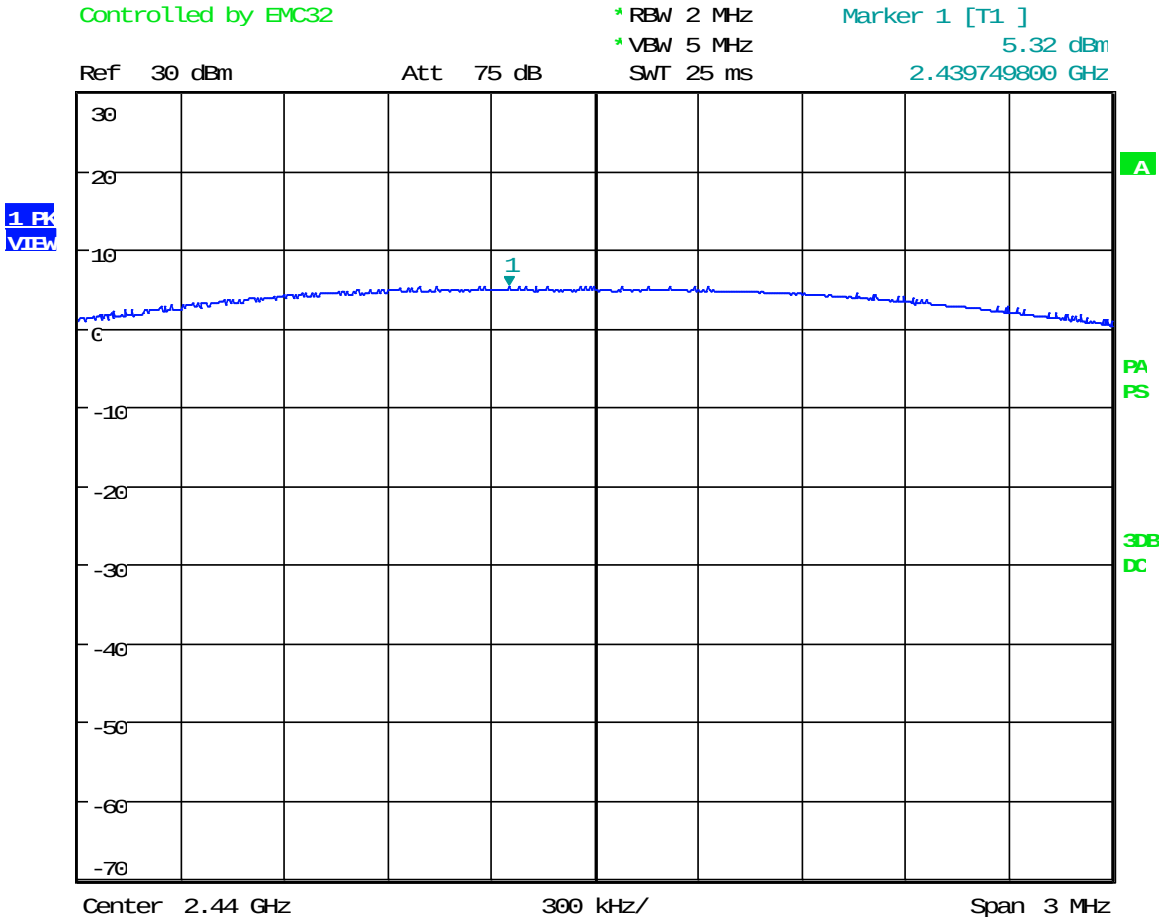
Test Date:	2023-01-11	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(b)(3); KDB558074	**Air Temperature:**	21.2ºC
		Relative Humidity:	33%

GFSK, 1Mbps: Low Channel



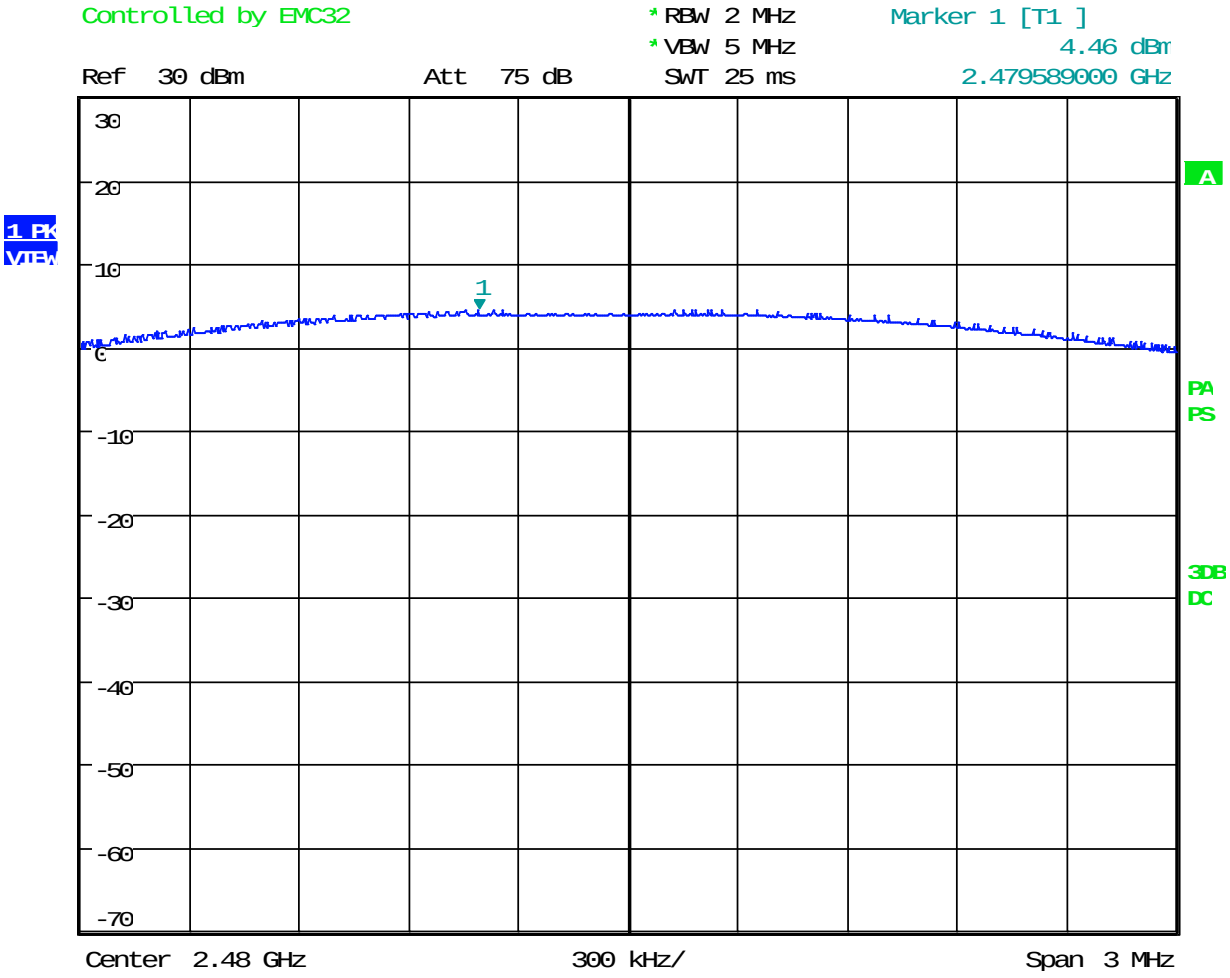
Date: 11.JAN.2023 11:12:42

GFSK, 1Mbps: Mid Channel



Date: 11.JAN.2023 11:14:39

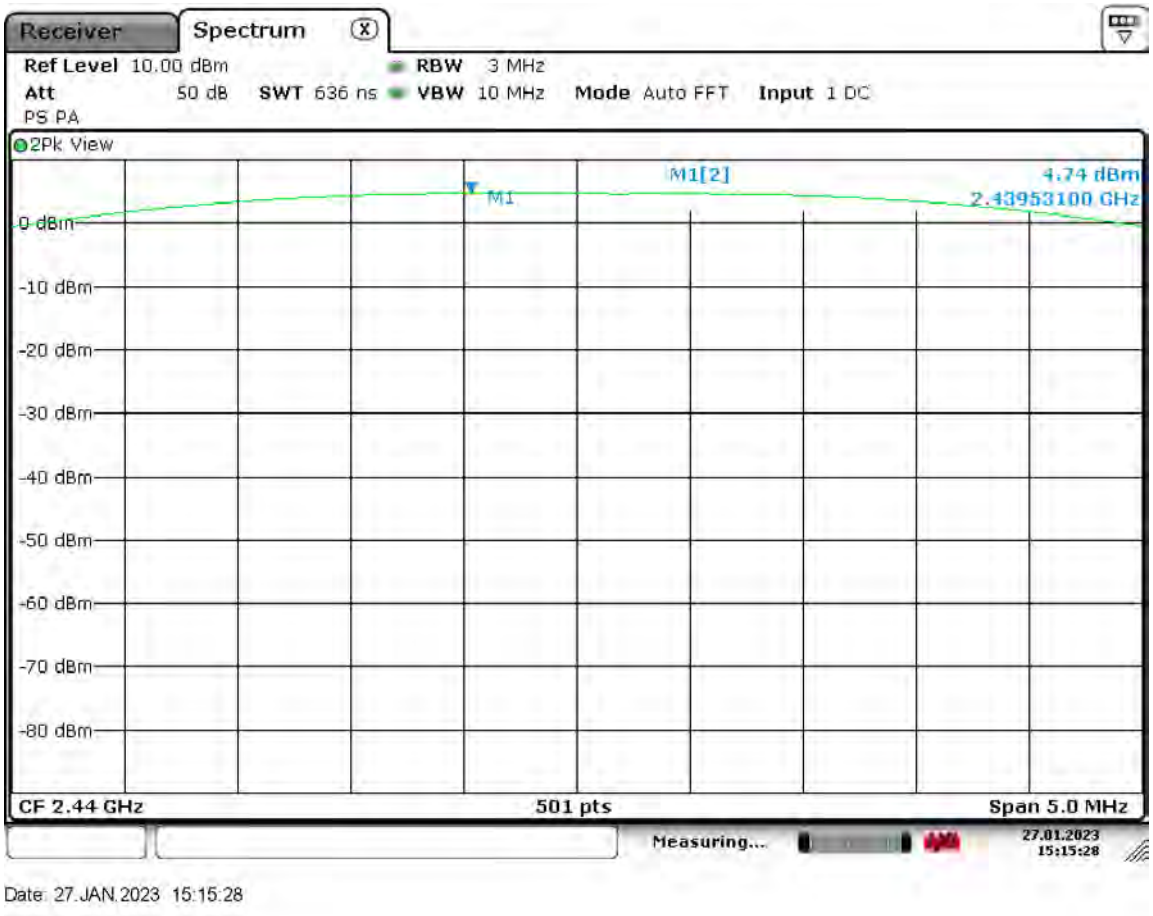
GFSK, 1Mbps: High Channel



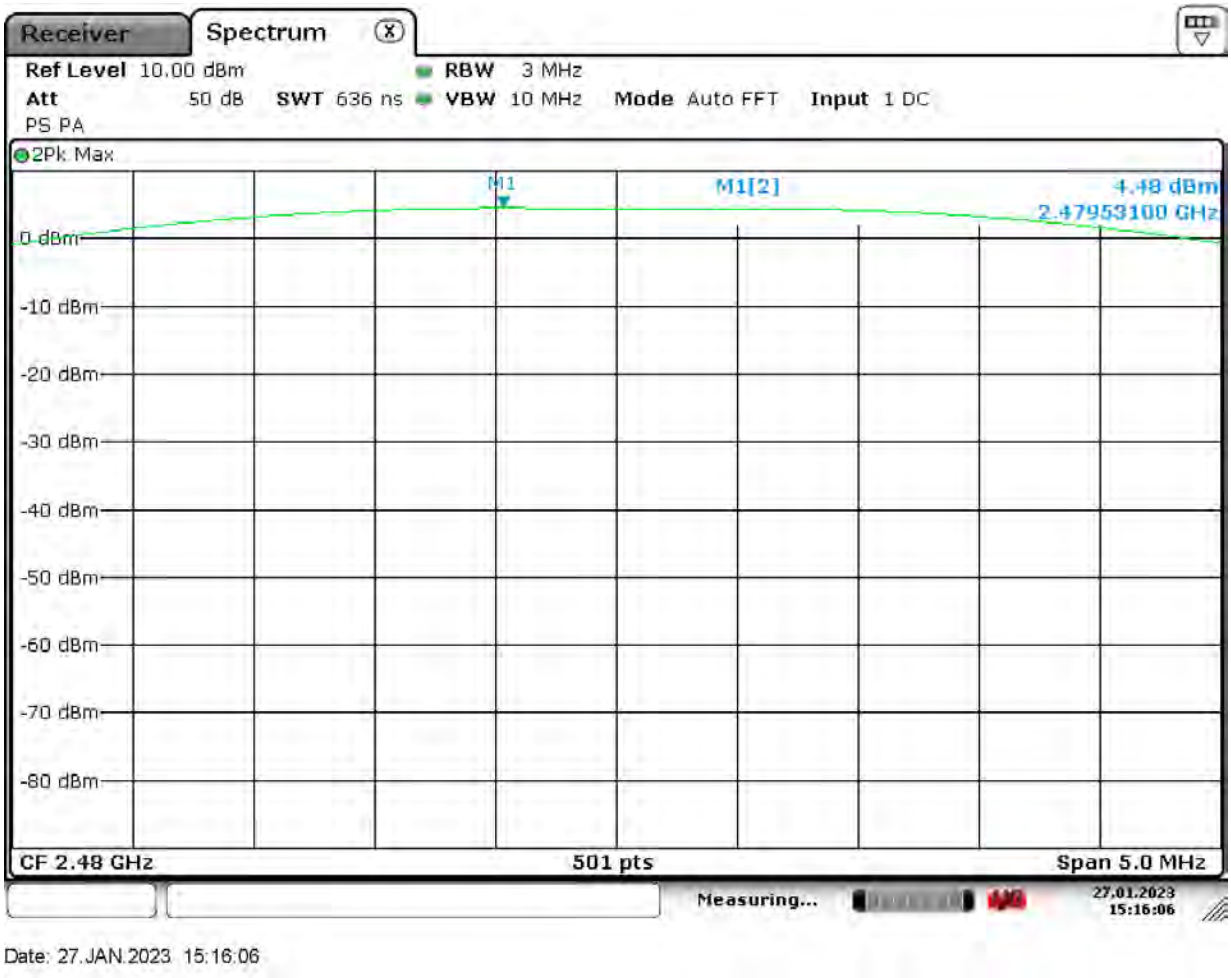
Date: 11.JAN.2023 11:16:56

Test Date:	2023-01-27	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(b)(3); KDB558074	**Air Temperature:**	21.4ºC
		Relative Humidity:	30%

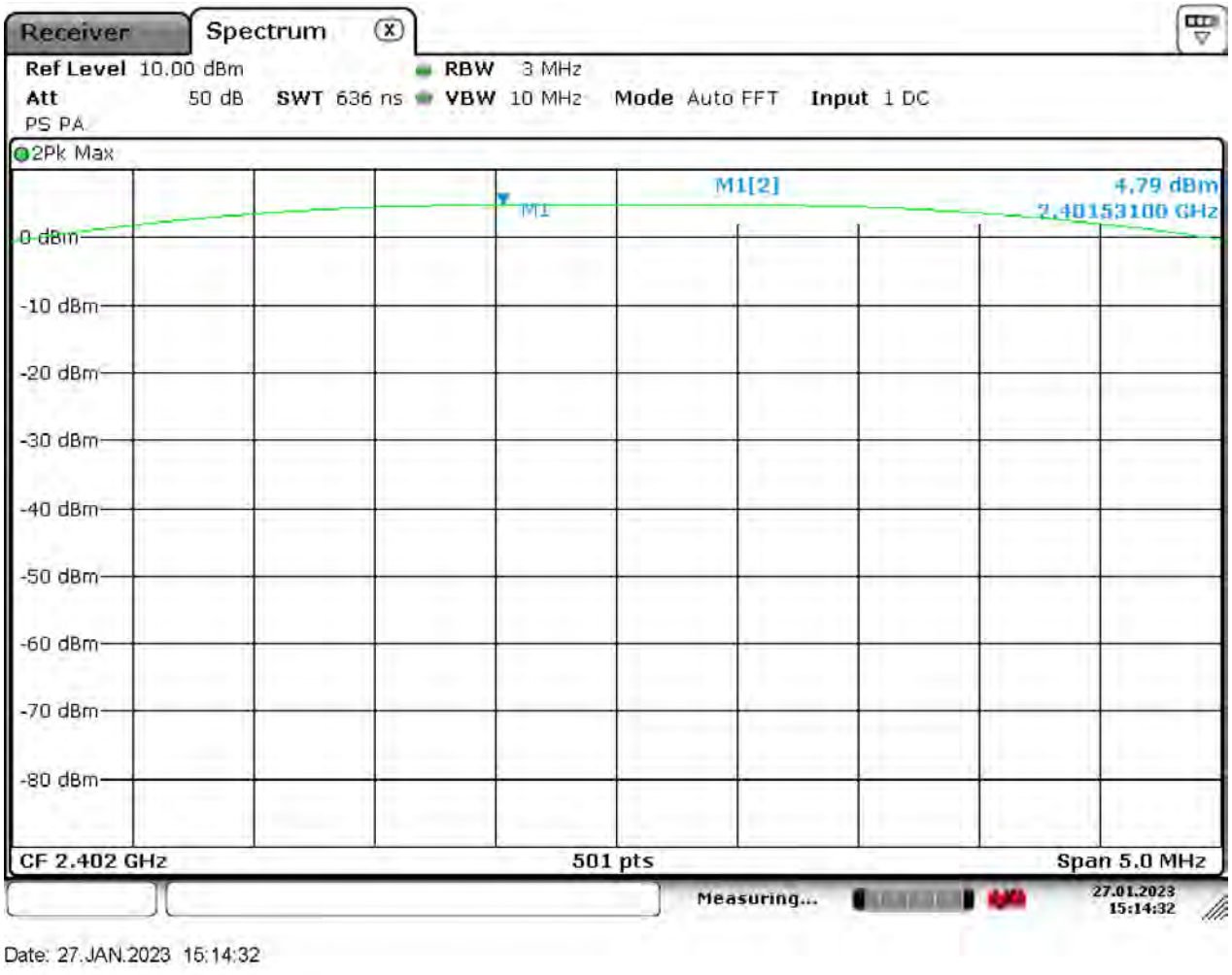
GFSK, 2Mbps: Low Channel



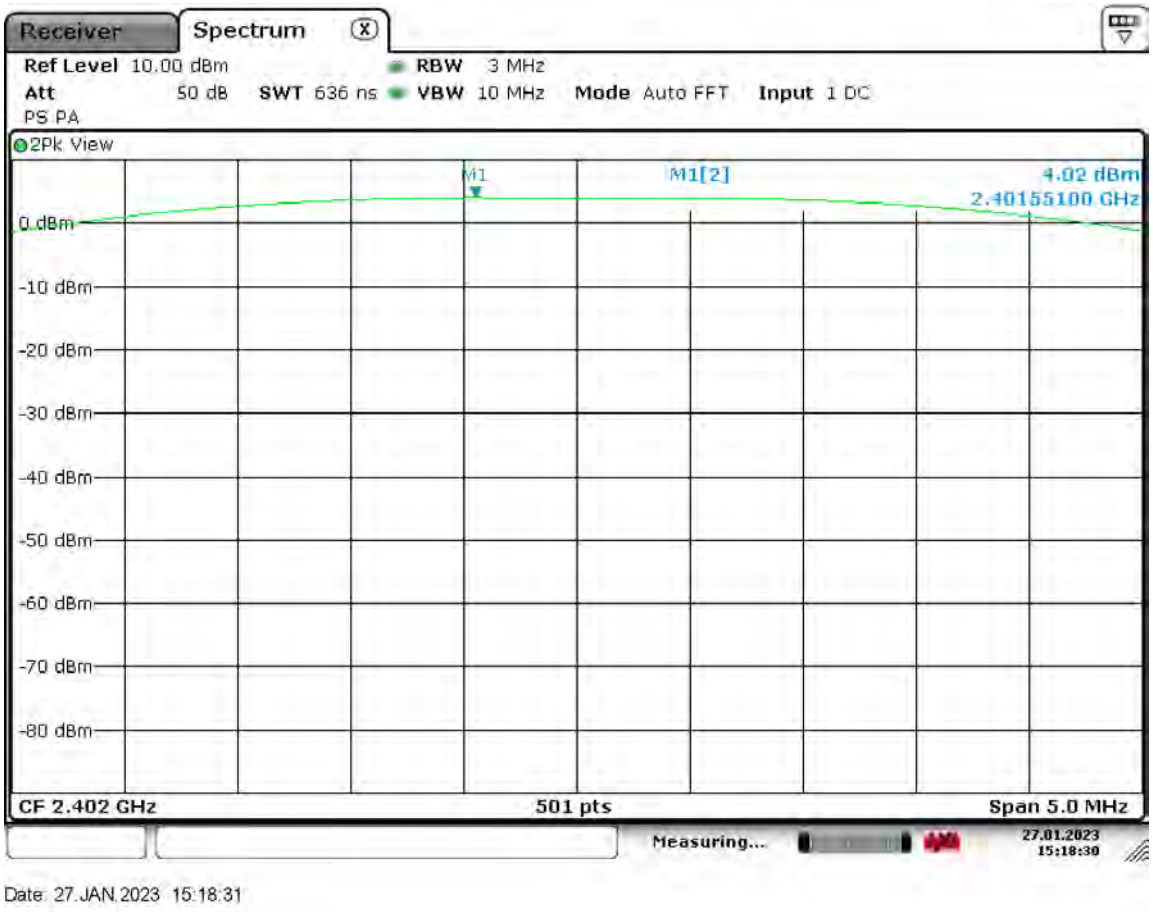
GFSK, 2Mbps: Mid Channel



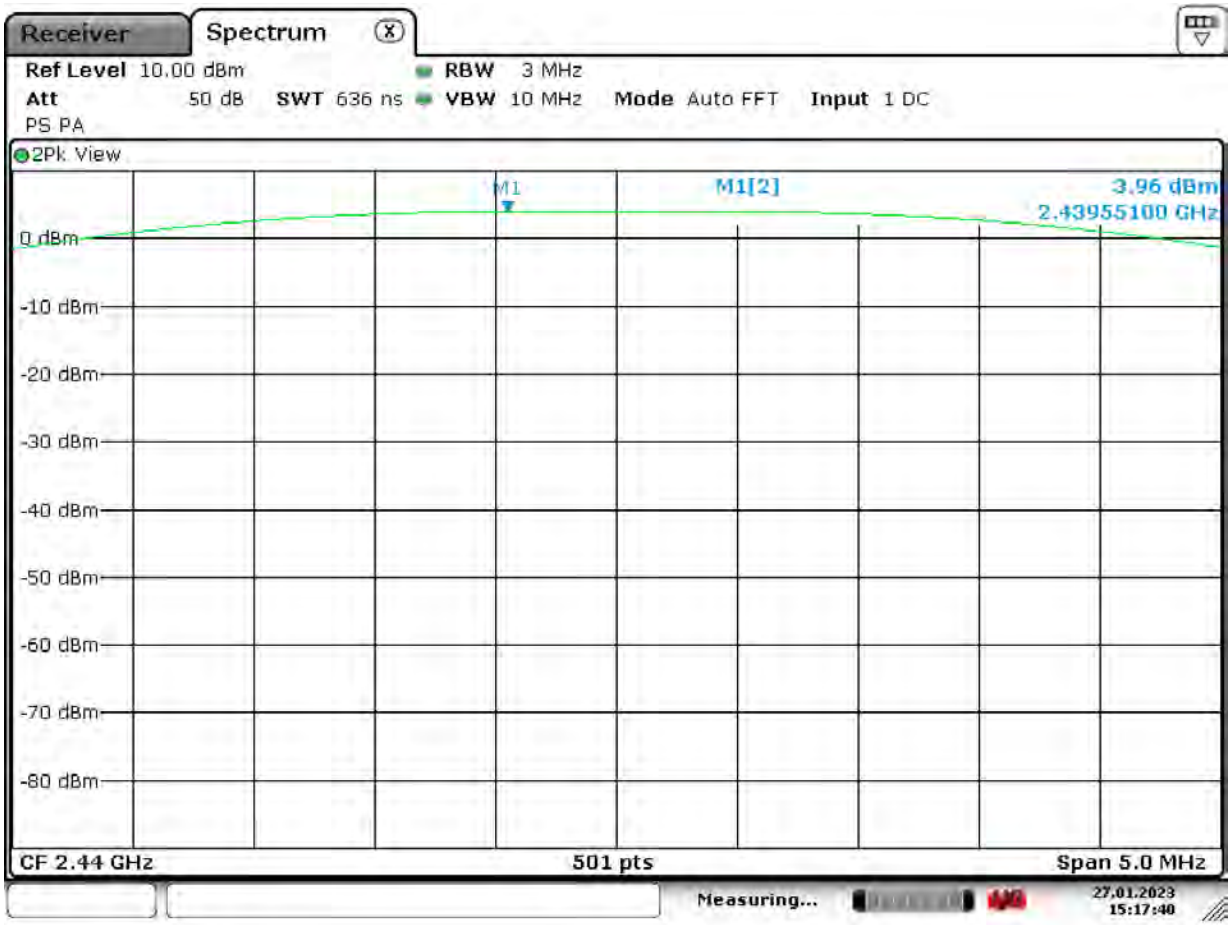
GFSK, 2Mbps: High Channel



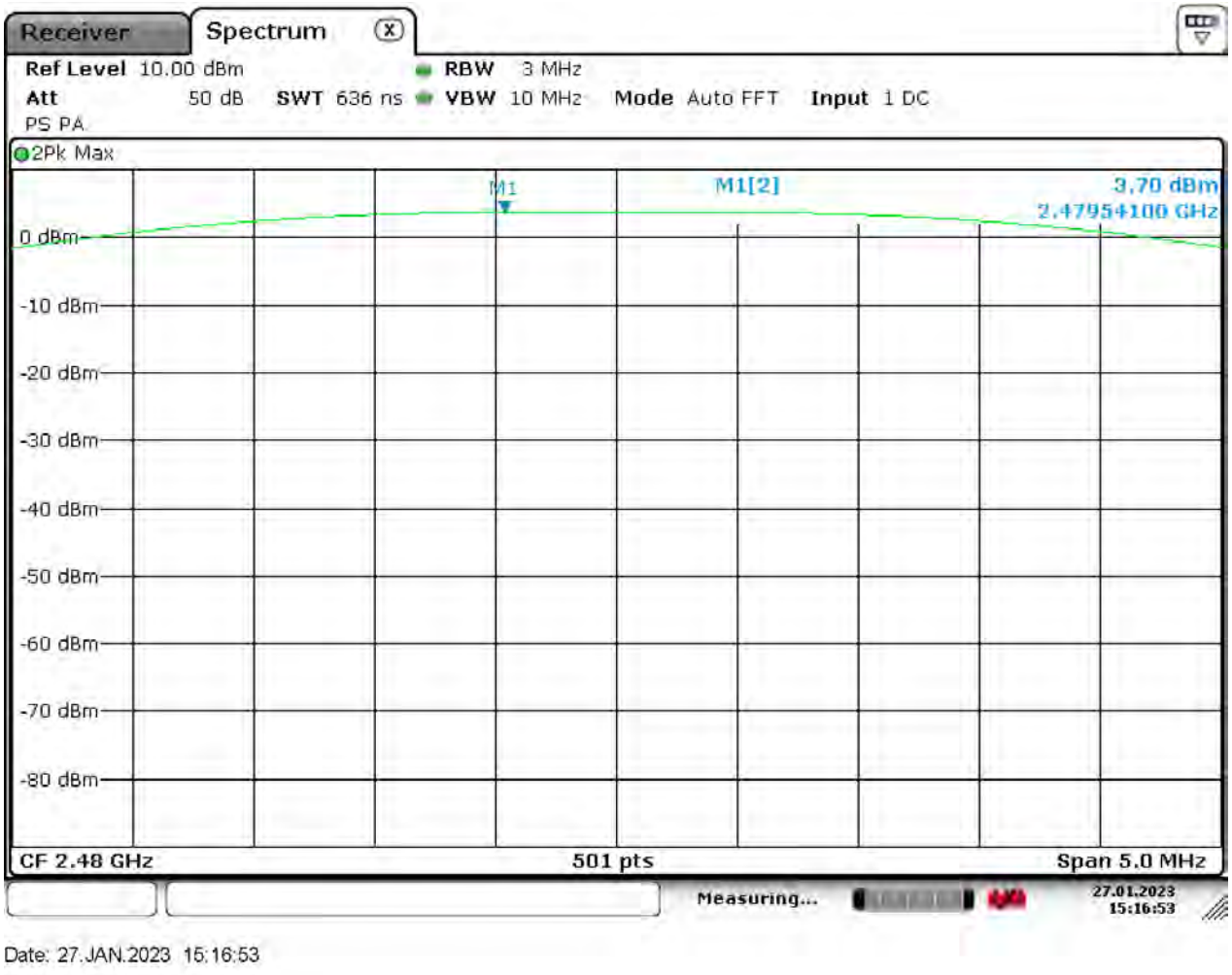
OQPSK, 2Mbps: Low Channel



OQPSK, 2Mbps: Mid Channel



OQPSK, 2Mbps: High Channel



10 FCC PART 15.247(e) – PEAK POWER SPECTRAL DENSITY (PSD)

Peak power spectral density measurements were performed.

10.1 Requirements:

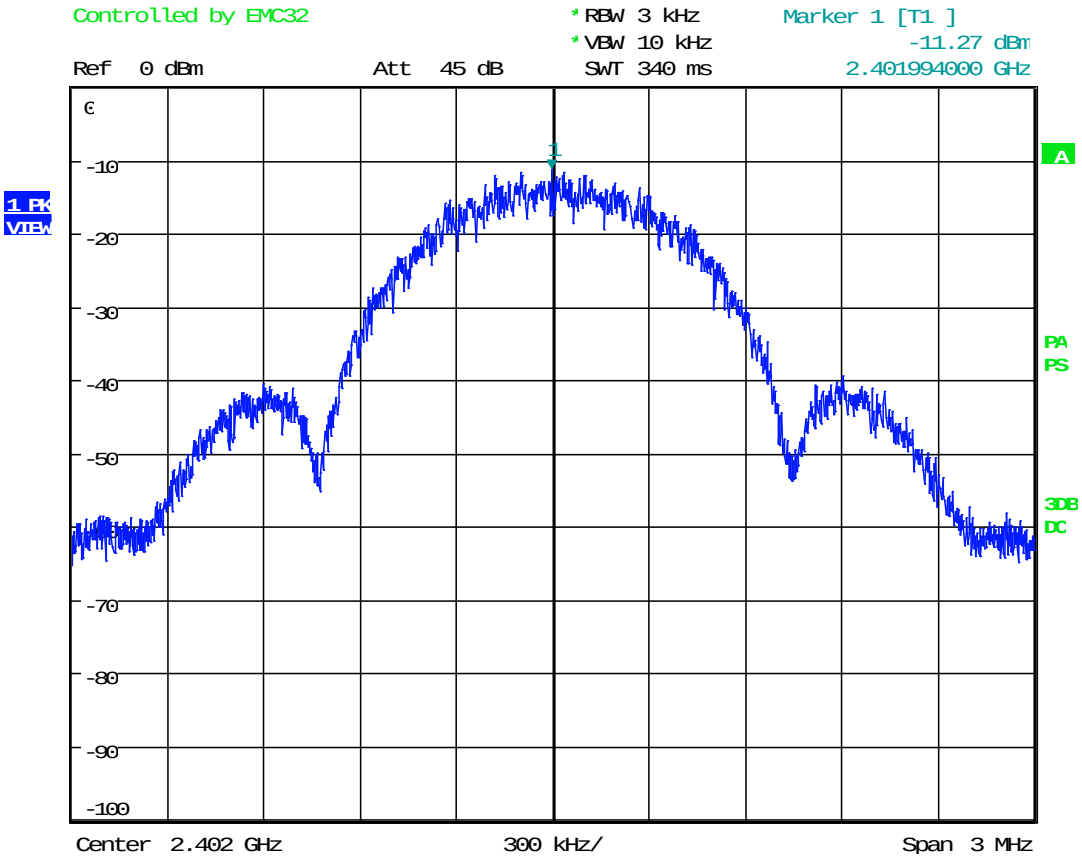
The peak power spectral density shall not exceed +8dBm in any 3 kHz band during any time interval of continuous transmission.

Power spectral density measurements were performed at a resolution bandwidth of 3 kHz (video bandwidth set at 10 KHz). The peak spectral densities were measured at the low, mid, and upper channels.

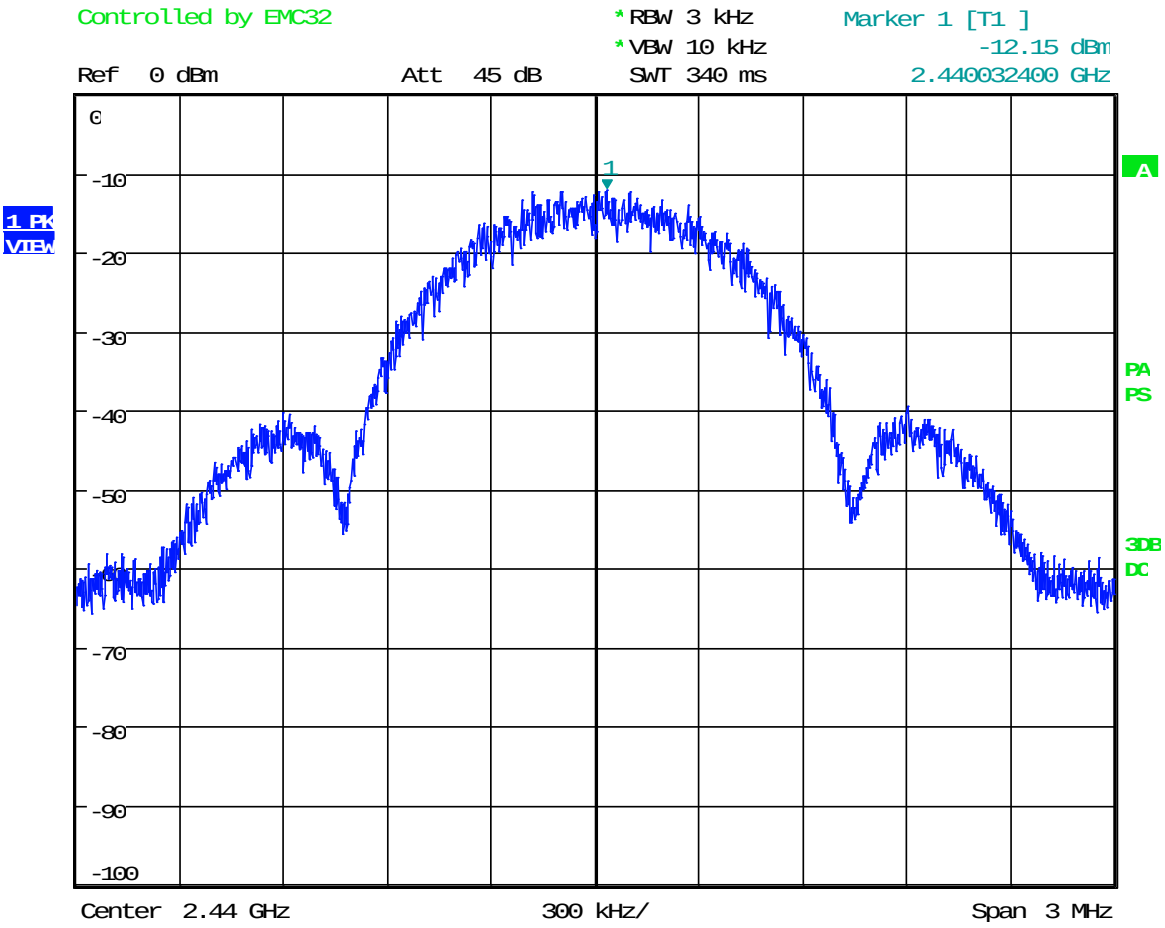
10.2 Peak Power Spectral Density Test Data

Test Date(s):	2023-01-11	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(e); KDB558074	Air Temperature:	21.2ºC
		Relative Humidity:	33%

GFSK, 1Mbps: Low Channel

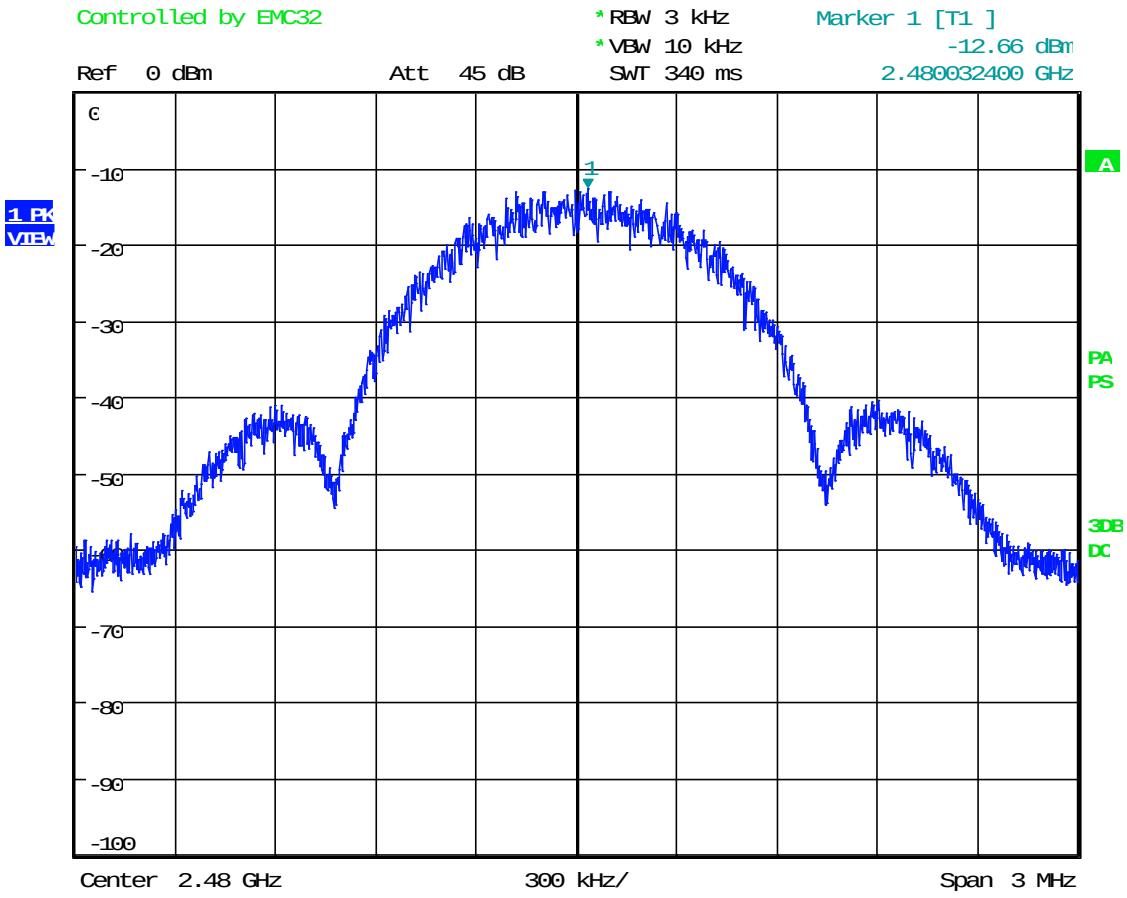


GFSK, 1Mbps: Mid Channel



Date: 11.JAN.2023 11:19:15

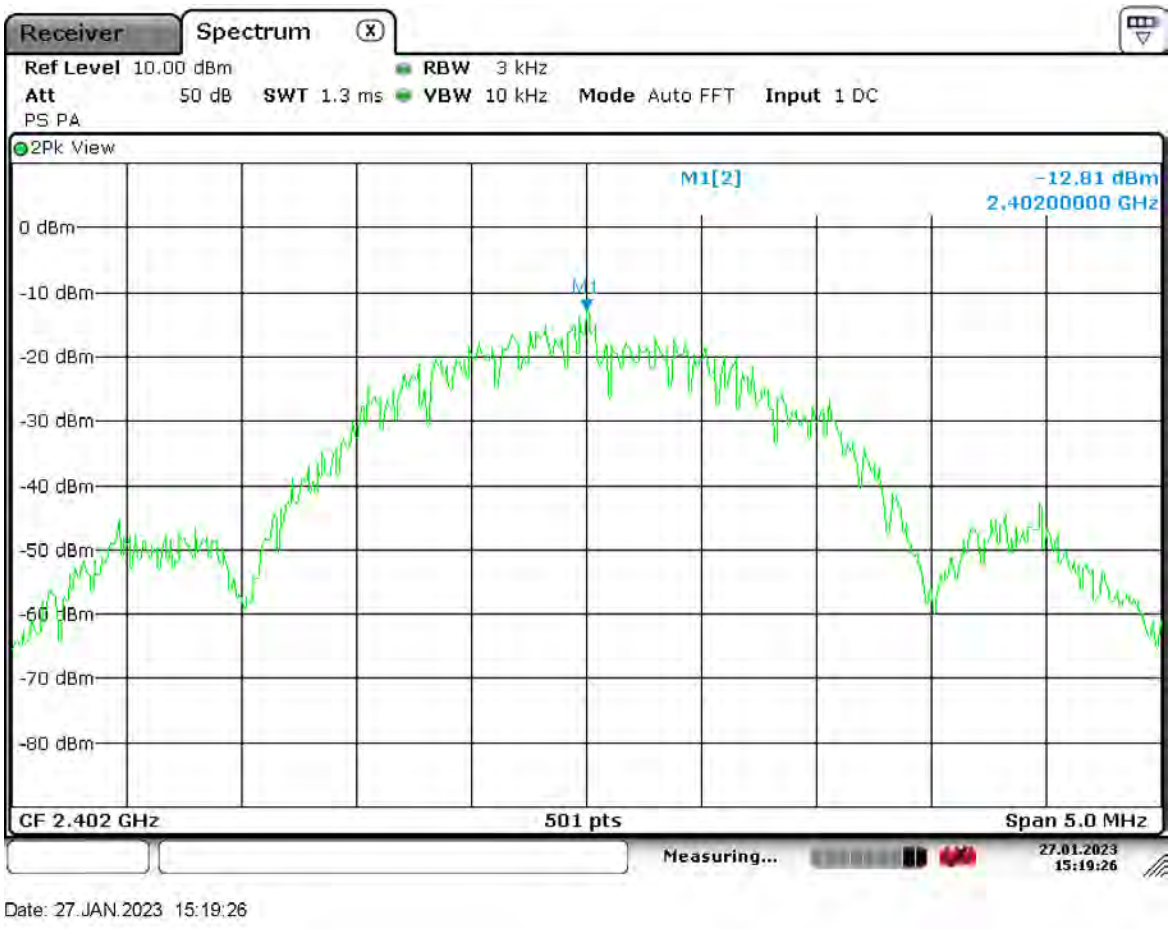
GFSK, 1Mbps: High Channel



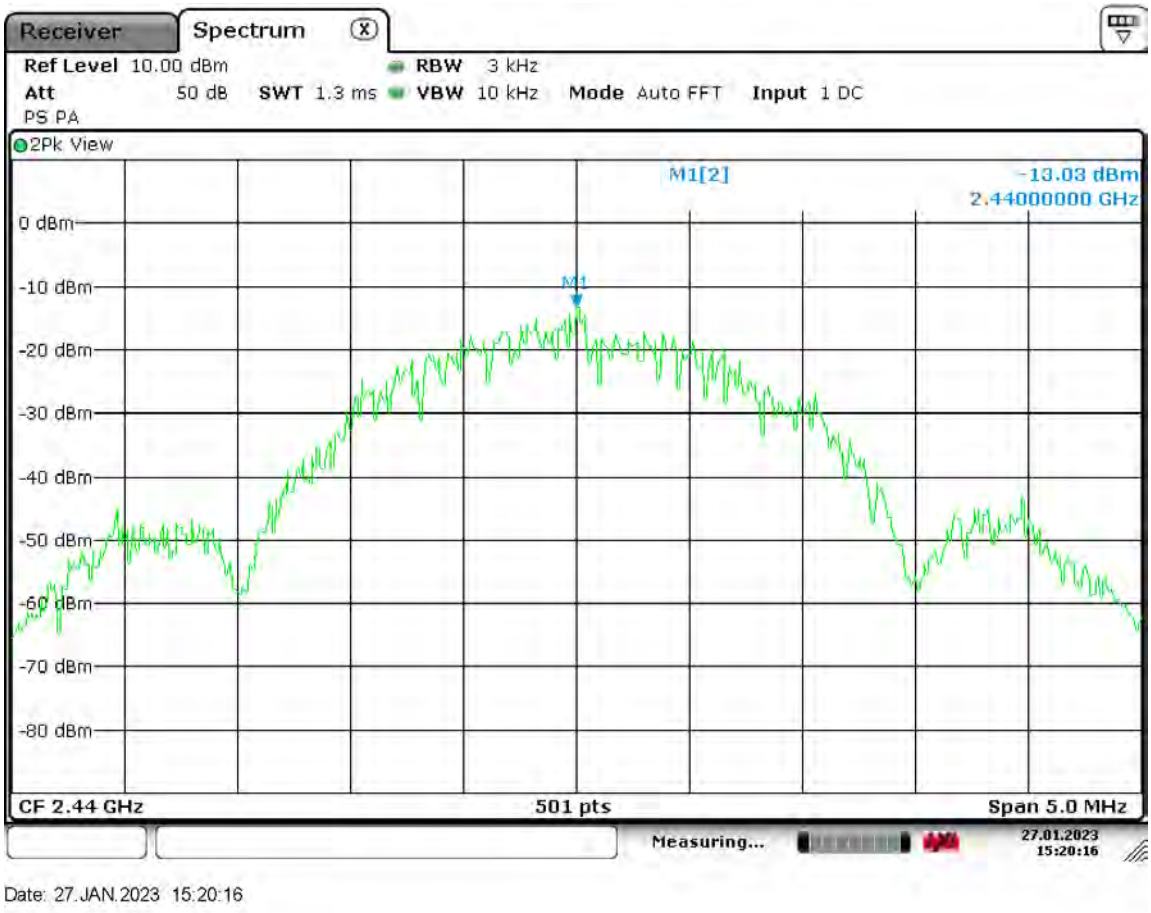
Date: 11.JAN.2023 11:18:26

Test Date(s):	2023-01-27	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(e); KDB558074	**Air Temperature:**	21.4ºC
Test Results:	Pass	**Relative Humidity:**	30%

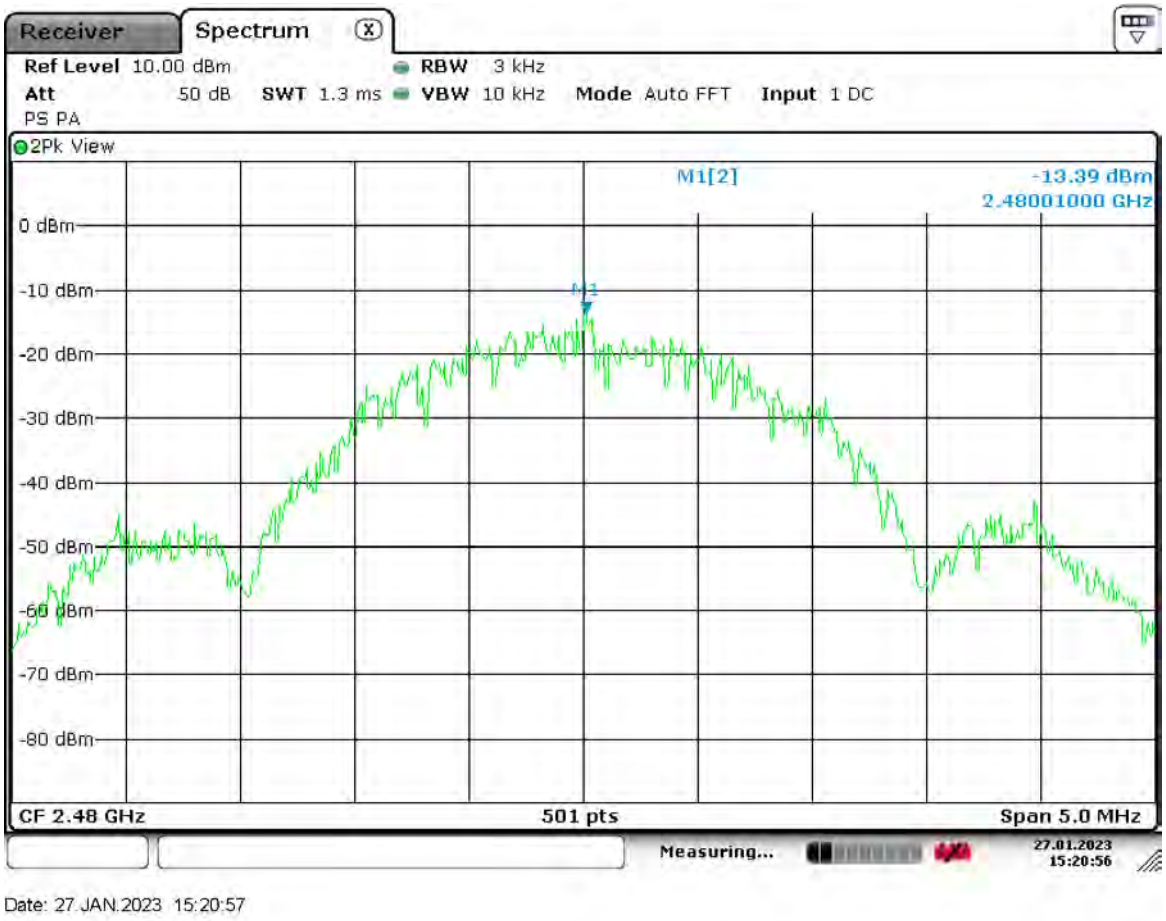
GFSK, 2 Mbps: Low Channel



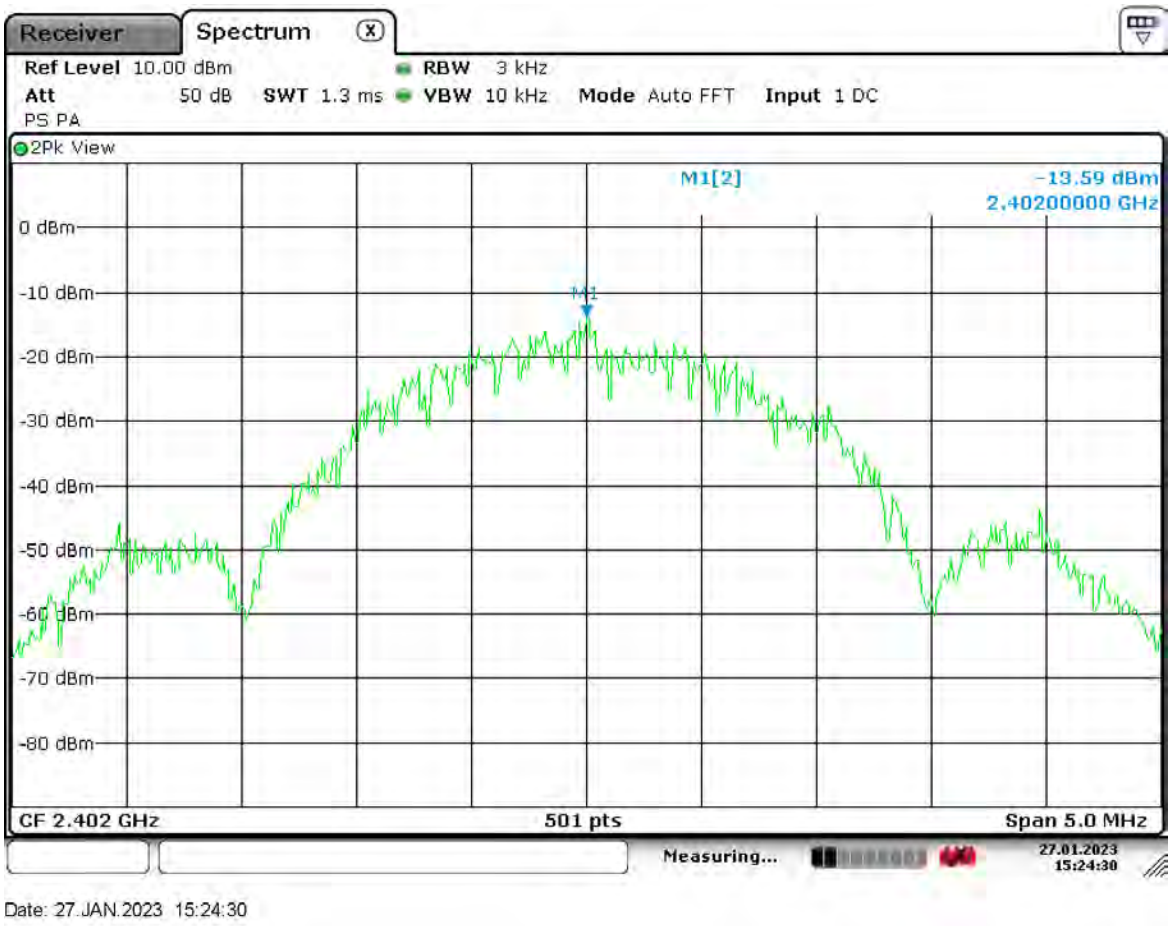
GFSK, 2 Mbps: Mid Channel



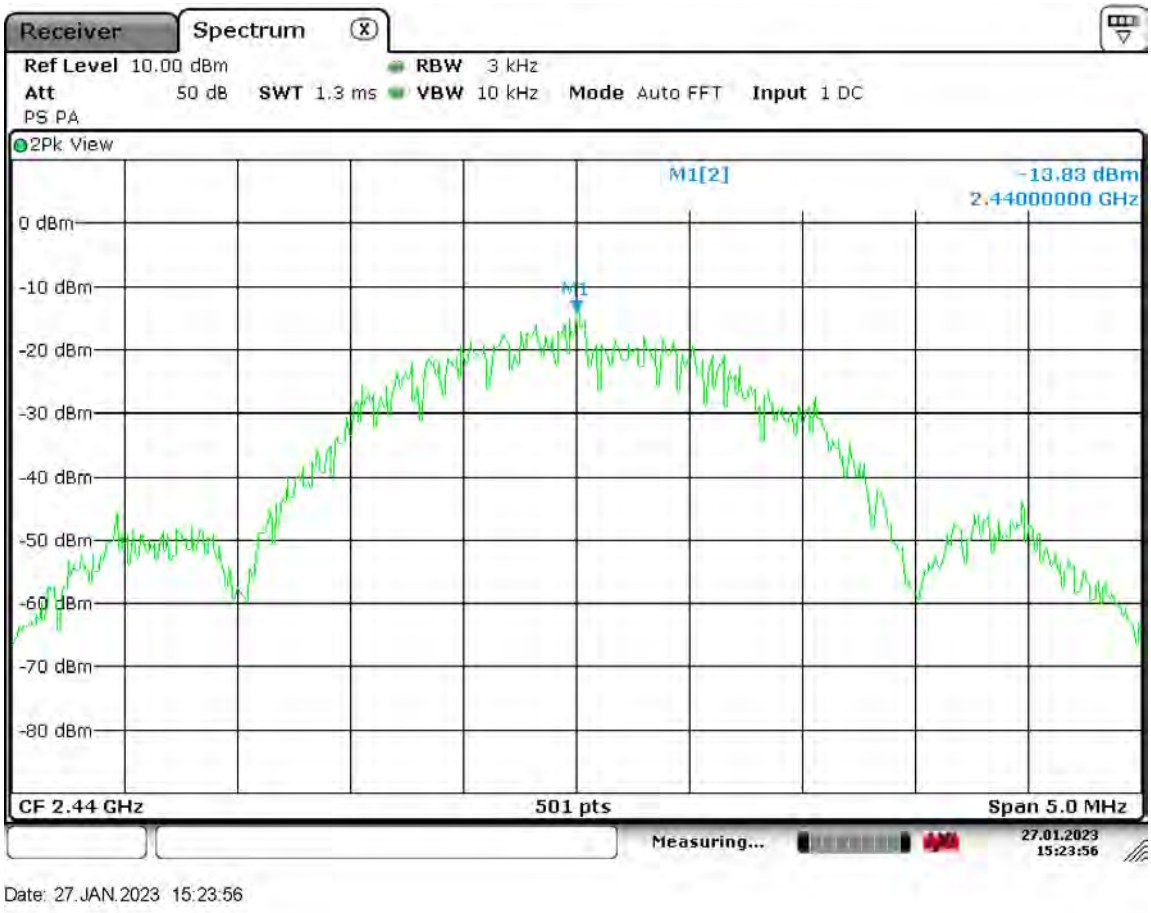
GFSK, 2 Mbps: High Channel



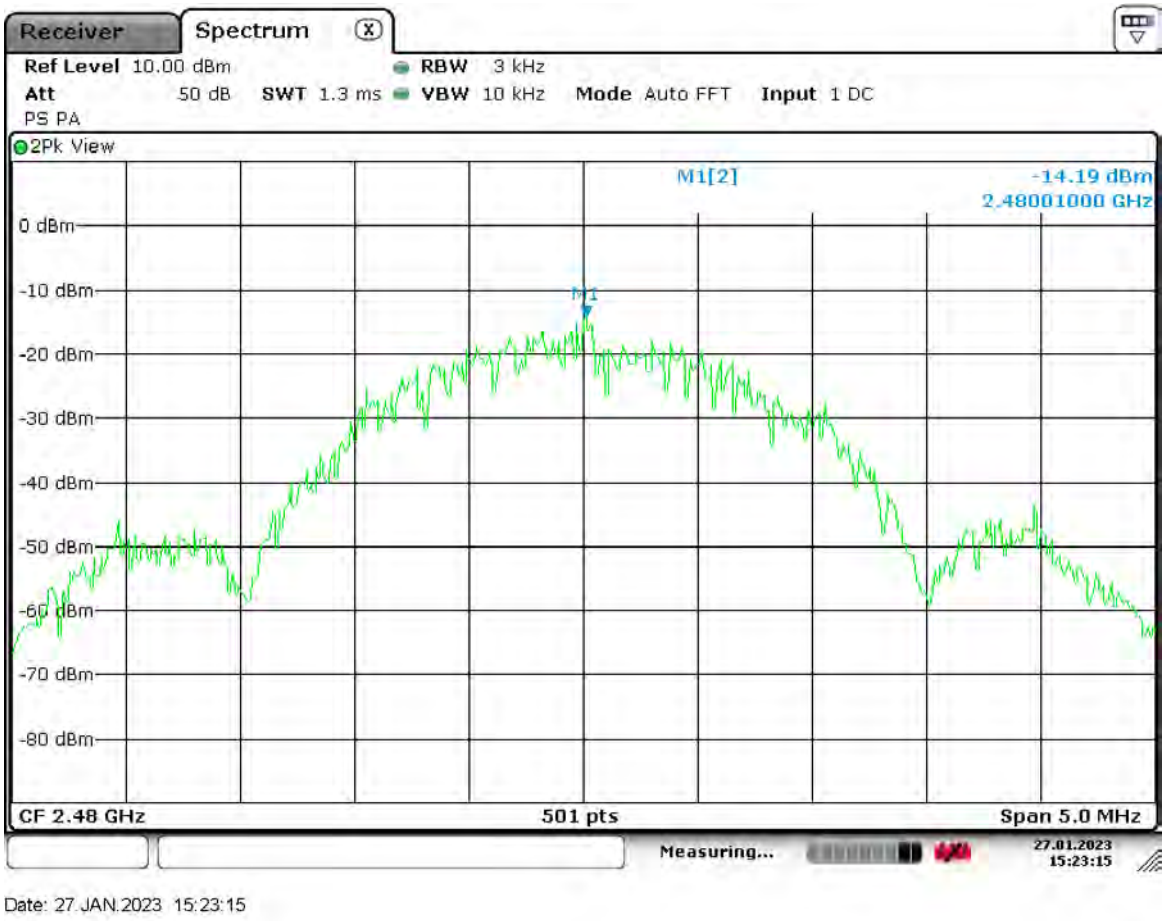
OQPSK, 2 Mbps: Low Channel



OQPSK, 2 Mbps: Mid Channel



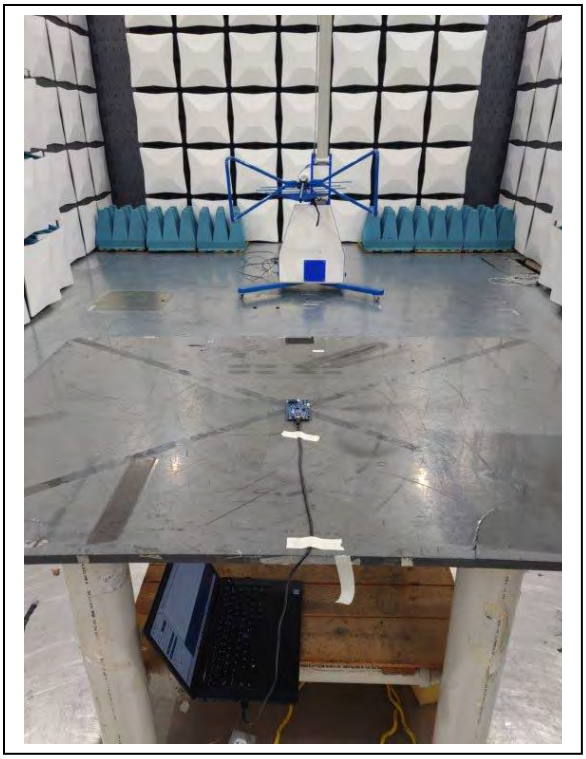
OQPSK, 2 Mbps: High Channel



11 TEST SETUP PHOTOGRAPHS

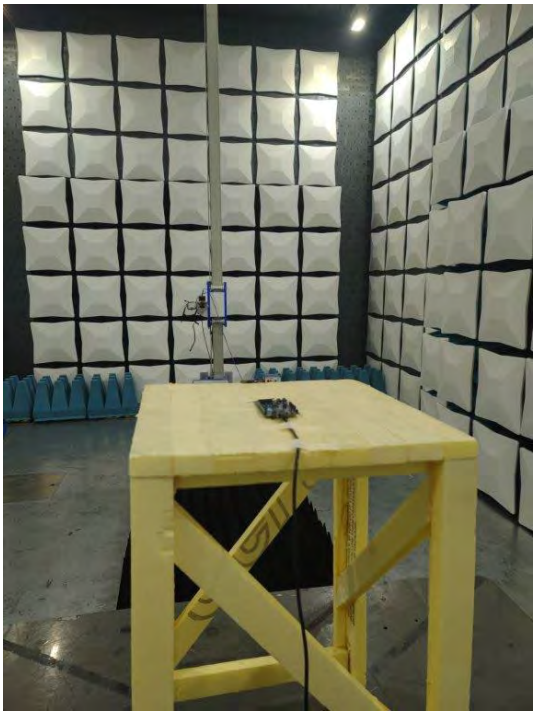
Radiated Spurious Emission, 0.009 MHz to 30 MHz

Radiated Spurious Emission, 30 MHz to 1000 MHz



Radiated Spurious Emission, 1 GHz to 18 GHz

Radiated Spurious Emission, 18 GHz to 26 GHz



Occupied Bandwidth, Conducted Output Power, PSD