GARMIN
Garmin International, Inc.
1200 East 151st Street
Olathe, Kansas 66062
P: 913-397-8200 F: 913-397-8282

20-Feb-26

Manufacturer: Garmin International, Inc.
Address: 1200 E. 151st St.
Olathe, KS 66062-3426
U.S.A.
Chile Representative: Matías Rodríguez Correa
Rosario Norte 660 piso 24, Las Condes Santiago
Province CP 7550083, Chile
Contact Email: matias.rodriguez@garmin.com

Subject: SUBTEL, Chile (Resolution 737) Certification Compliance 2026

Commercial Name: Varia Rearview Radar RTL515

	Información (Information)
Tipo de equipo (Equipment type)	Portable Digital Transceiver
Marca (Brand)	Garmin GARMIN.
Modelo (Model)	A04024
Tecnología o modulación (Technology or modulation)	GFSK for ANT/ GFSK for BLE / CW for 24 GHz
Frecuencias (Frequencies)	2402-2480 MHz / 2402-2480 MHz / 24039.2-24208.2 MHz
Ganancia de antena (dBi) (Antenna gain (dBi)	ANT –1.90 dBi / BLE –1.90 dBi / 24 GHz 10.55 dBm
P.i.r.e. (E.I R P.)	2.16 dBm, 1.64 mW / -1.85 dBm, 0.65 mW / -55.78 dBm, 0.00 mW
Módulos (Modules)	ANT, BLE, 24 GHz

Declaration of Conformity Statement: the equipment previously identified complies with the provisions established in the Technical Standard for Small Range Equipment, approved by Exempt Resolution No.1,985 of 2017, of the Undersecretary of Telecommunications.

Declaración de conformidad: El equipo anteriormente identificado cumple con las disposiciones establecidas en la Norma Técnica para Equipos de Corto Alcance, aprobada mediante la Resolución Exenta N° 1.985 de 2017, de la Subsecretaría de Telecomunicaciones.

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Amended

DXX
FCC/ISED Test Report

Prepared for: Garmin International Inc.

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

Product: A04024

Test Report No: R20191119-20-E2B

Approved by:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 17 March 2020

Total Pages: 54

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	24 February 2020	Original – NJohnson Prepared by KVepuri/CFarrington
A	11 March 2020	Updated Data table on Page 3. Edited band edge measurement table. Update calibration table. Updated test description in Section 4.4. Includes NCEE Labs report R20191119-20-E2 and its amendment in full. -NJ
B	17 March 2020	Updated band edge measurements Includes NCEE Labs report R20191119-20-E2A and its amendment in full. -NJ

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15.249
(2) ISED RSS-Gen, Issue 5
(3) ISED RSS-210, Issue 10

SUMMARY			
Requirement	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	PCB Antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	N/A	Not required
NA	Maximum Peak Output Power	N/A	Informational Purpose Only
NA	Minimum Bandwidth	N/A	Informational Purpose Only
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-210 A1.2 FCC 15.249(a)	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205, 15.249(d) RSS-Gen, 8.9 RSS-210, 5.5	Band Edge Measurement	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	Pass	Meets the requirement of the limit.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

The Equipment Under Test (EUT) was a battery powered GFSK and GMSK transceiver manufactured by GARMIN Inc.

EUT	A04024
EUT Received	14 January 2020
EUT Tested	17 February 2020- 24 February 2020
Serial No.	3321088777 (conducted antenna port measurements); 3321088851 (conducted antenna port measurements); 3321088804 (radiated measurements); 3321088807 (radiated measurements);
Operating Band	2400 – 2483.5 MHz
Device Type	GFSK, GMSK
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAF10R-050Q (Representative Power Supply)

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

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, middle and highest frequency channels.

The EUT was tested for spurious emissions while running off of battery power.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY 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 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Nic Johnson	Technical Manager	Review/editing
2	Karthik Vepuri	Test Engineer	Testing and report
3	Caleb Farrington	Test Technician	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.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
SunAR RF Motion	JB1	A082918-1	15 Oct 2018	15 Oct 2020
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Mar 2020**
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Mar 2020**
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	25 Jul 2019	25 Jul 2020
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*

*Internal Characterization **Extended calibration

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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: NA

4.2 PEAK OUTPUT POWER

Test Method: N/A

For Informational Purposes only

Test procedures:

1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable

2. The resolution bandwidth was set to 10 MHz and the video bandwidth was set to 10 MHz to capture the signal. The analyzer used a peak detector in max hold mode.

Deviations from test standard:
No deviation.

Test setup:
The field strength was measured by connecting the EUT directly to the spectrum analyzer.
See Section 4.2.

EUT operating conditions:
The EUT was powered by 5 VDC power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in GMSK and GFSK.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	Method	Transmitter
1	2402	-0.365	0.919	Conducted	GFSK
2	2440	-0.263	0.941	Conducted	GFSK
3	2480	-0.765	0.838	Conducted	GFSK
1	2402	0.050	1.01	Conducted	GMSK
2	2440	0.008	1.00	Conducted	GMSK
3	2480	-0.297	0.934	Conducted	GMSK

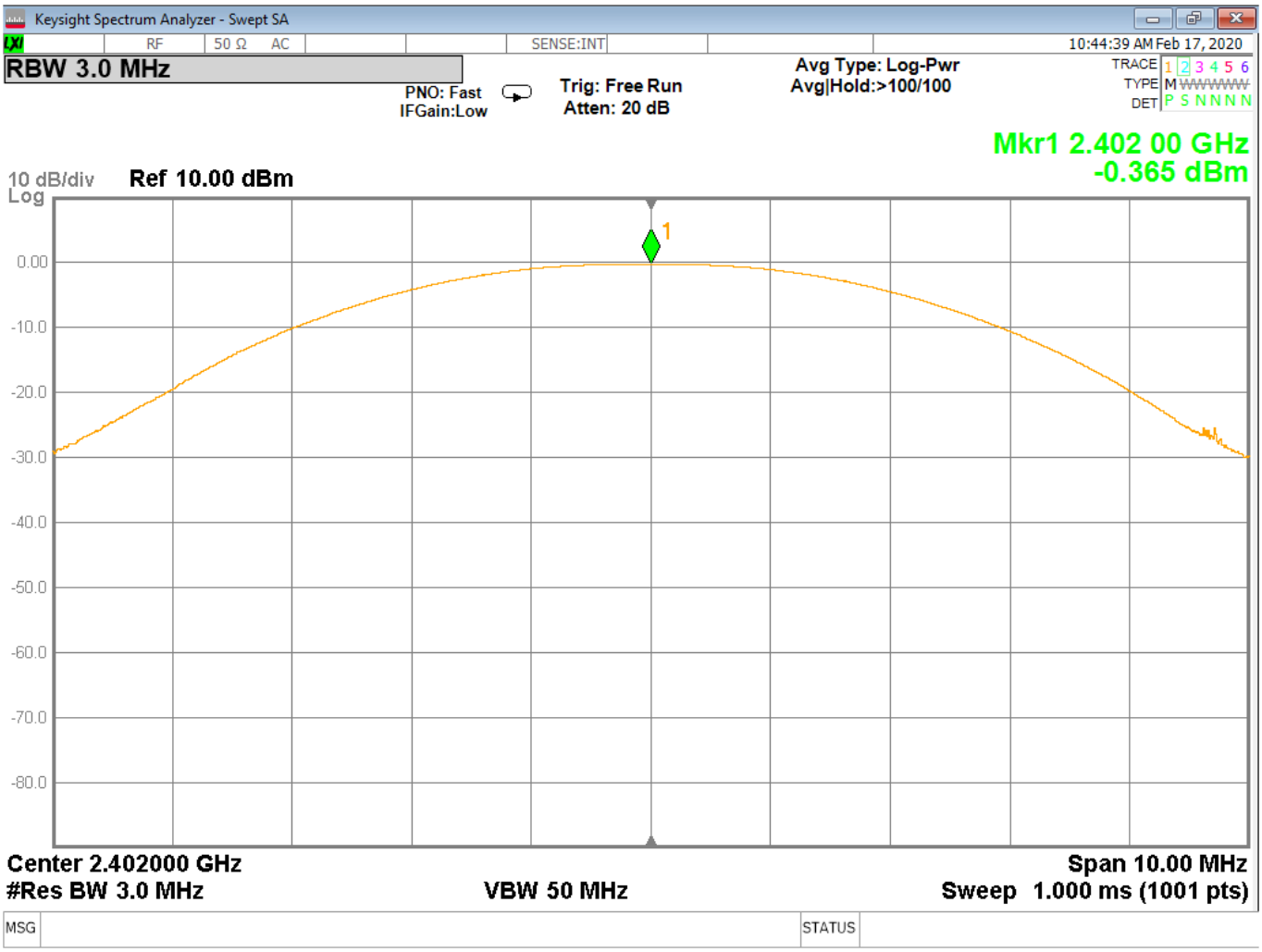


Figure 1 - Output Power, Low Channel, GMSK

Output power = -0.365 dBm

Cable loss was less than 0.1 dB and not included

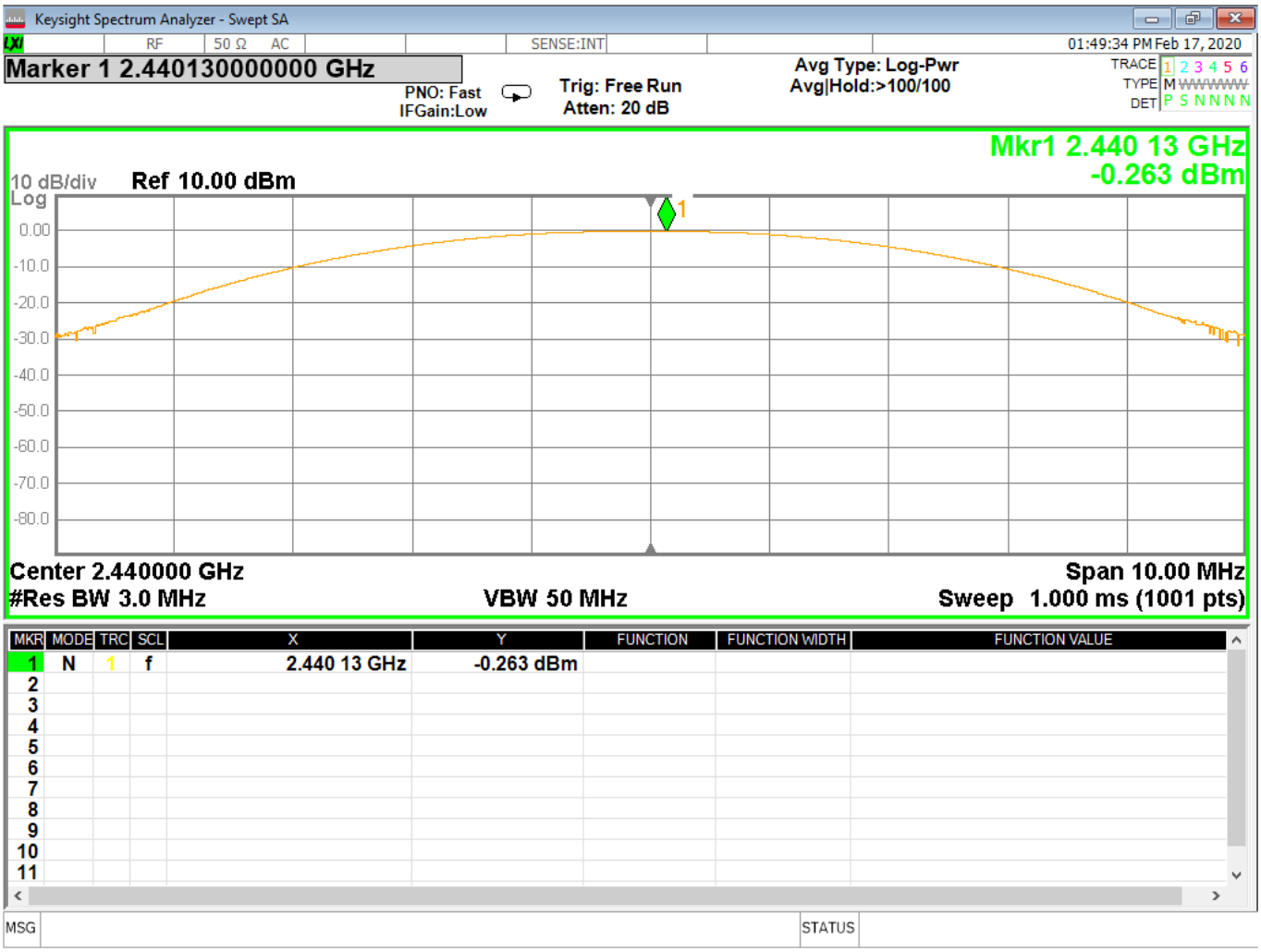


Figure 2 - Output Power, Mid Channel, GMSK

Output power = -0.263 dBm

Cable loss was less than 0.1 dB and not included

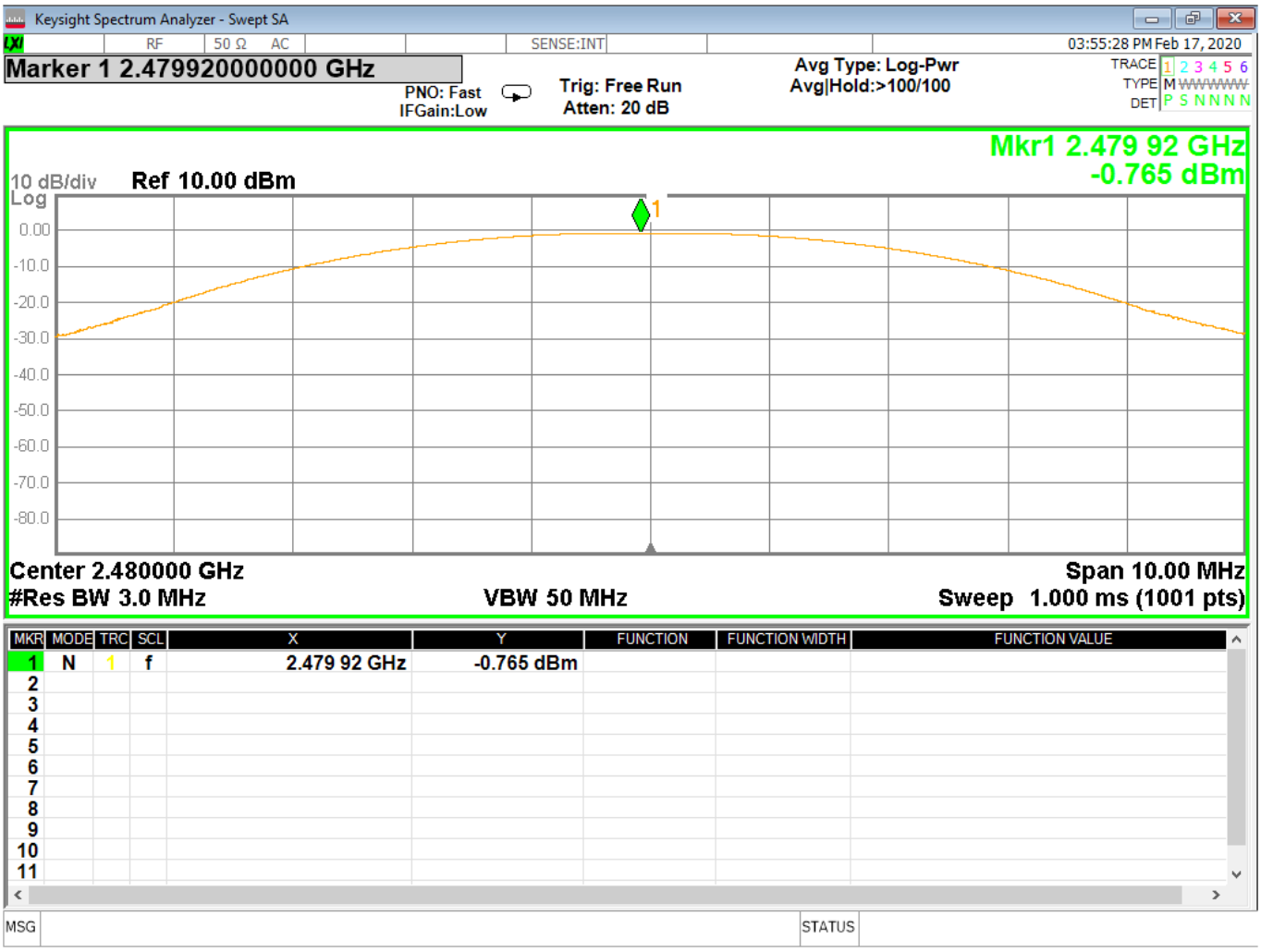


Figure 3 - Output Power, High Channel, GMSK

Output power = -0.765 dBm

Cable loss was less than 0.1 dB and not included

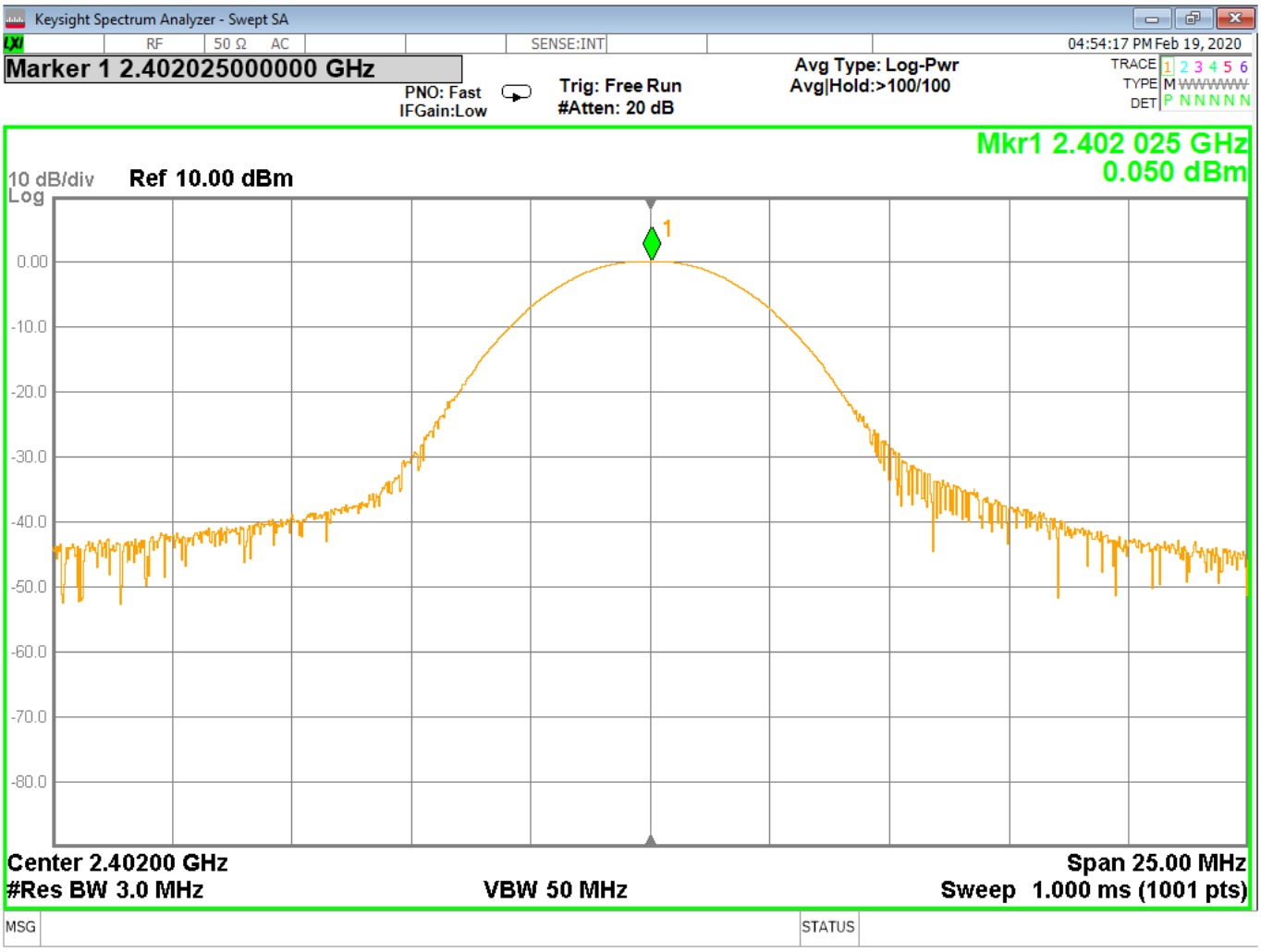


Figure 4 - Output Power, Low Channel, GFSK

Output power = 0.050 dBm

Cable loss was less than 0.1 dB and not included

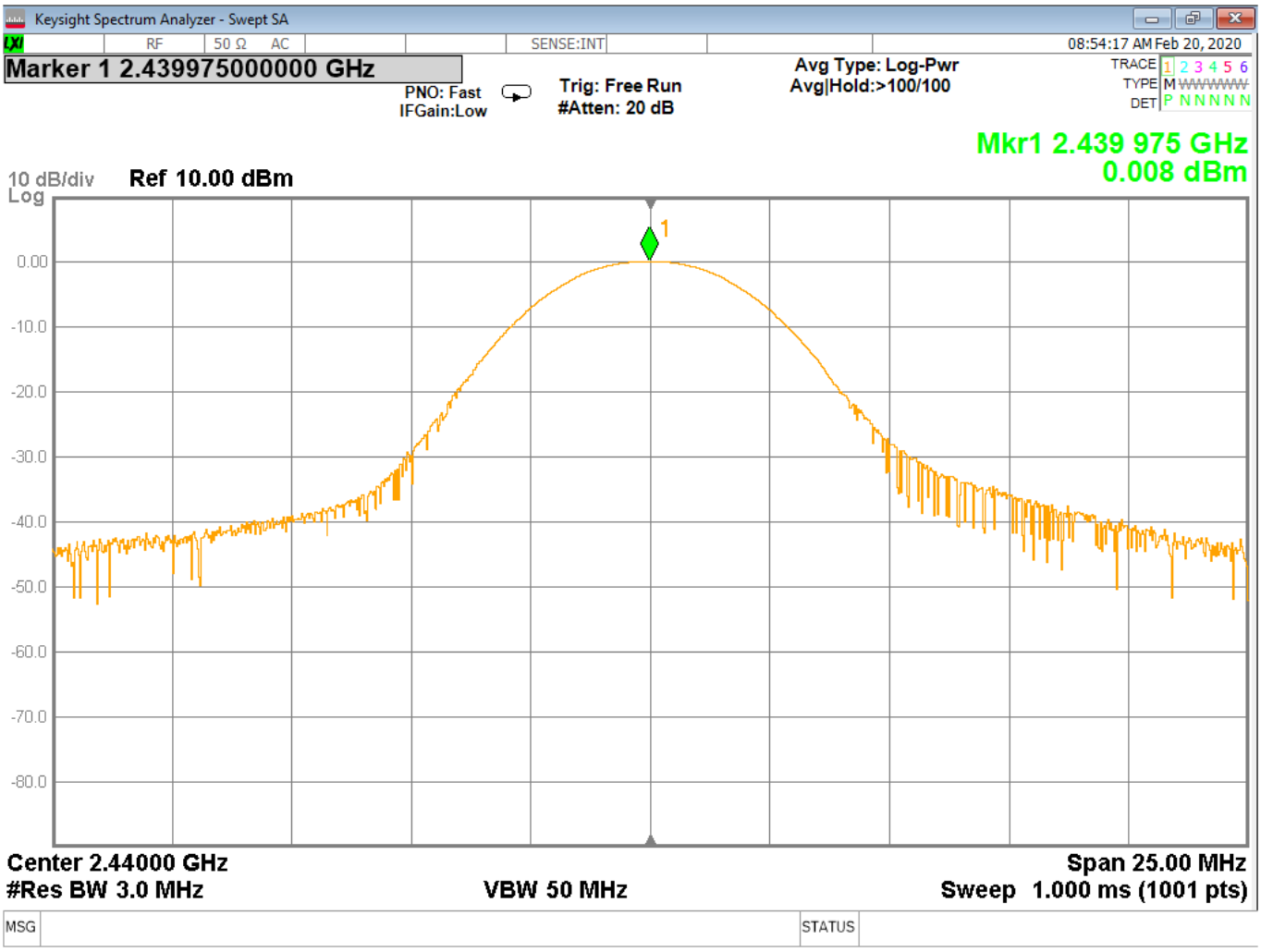


Figure 5 - Output Power, Mid Channel, GFSK

Output power = 0.008 dBm

Cable loss was less than 0.1 dB and not included

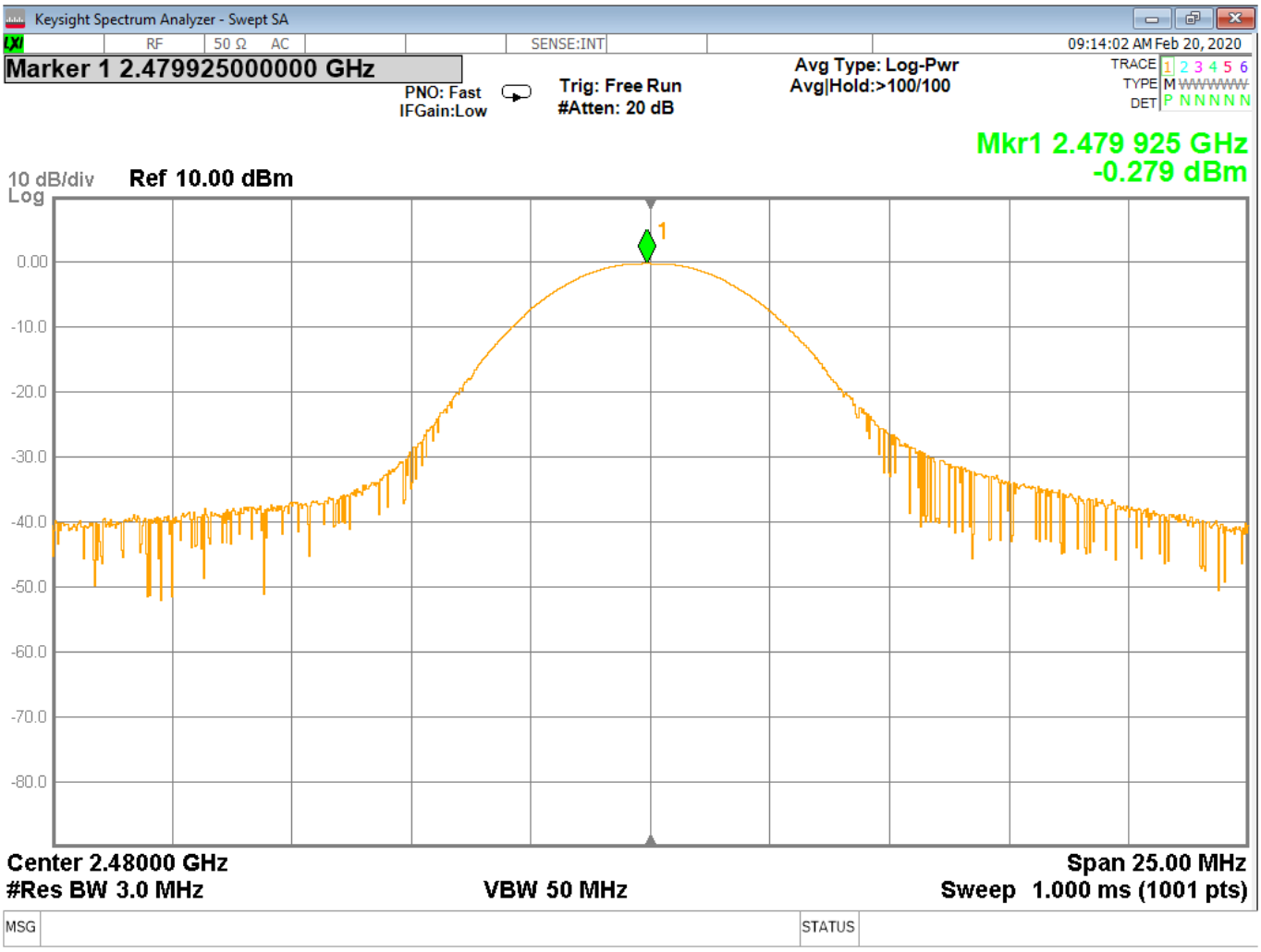


Figure 6 - Output Power, High Channel, GFSK

Output power = -0.297 dBm

Cable loss was less than 0.1 dB and not included

4.3 BANDWIDTH

Test Method: ANSI C63.10-2013, Section(s) 11.9.1.1

Limits of bandwidth measurements:

For Informational Purposes only

Test procedures:

1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable

2. The resolution bandwidth was set to 100 kHz and the video bandwidth was set to 300 kHz to capture the signal. The analyzer used a peak detector in max hold mode.

3. The Occupied Bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB.

Test setup:
The field strength was measured by connecting the EUT directly to the spectrum analyzer.

Deviations from test standard:
No deviation.

Test setup:

Figure 7 - Bandwidth Measurements Test Setup

EUT operating conditions:
The EUT was powered by 5 VDC power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in GMSK and GFSK.

Test results:

Occupied Bandwidth

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (KHz)
Low	GMSK	2402	1072.8
Mid	GMSK	2440	1077.7
High	GMSK	2480	1078.1
Low	GFSK	2402	989.48
Mid	GFSK	2440	983.13
High	GFSK	2480	986.52

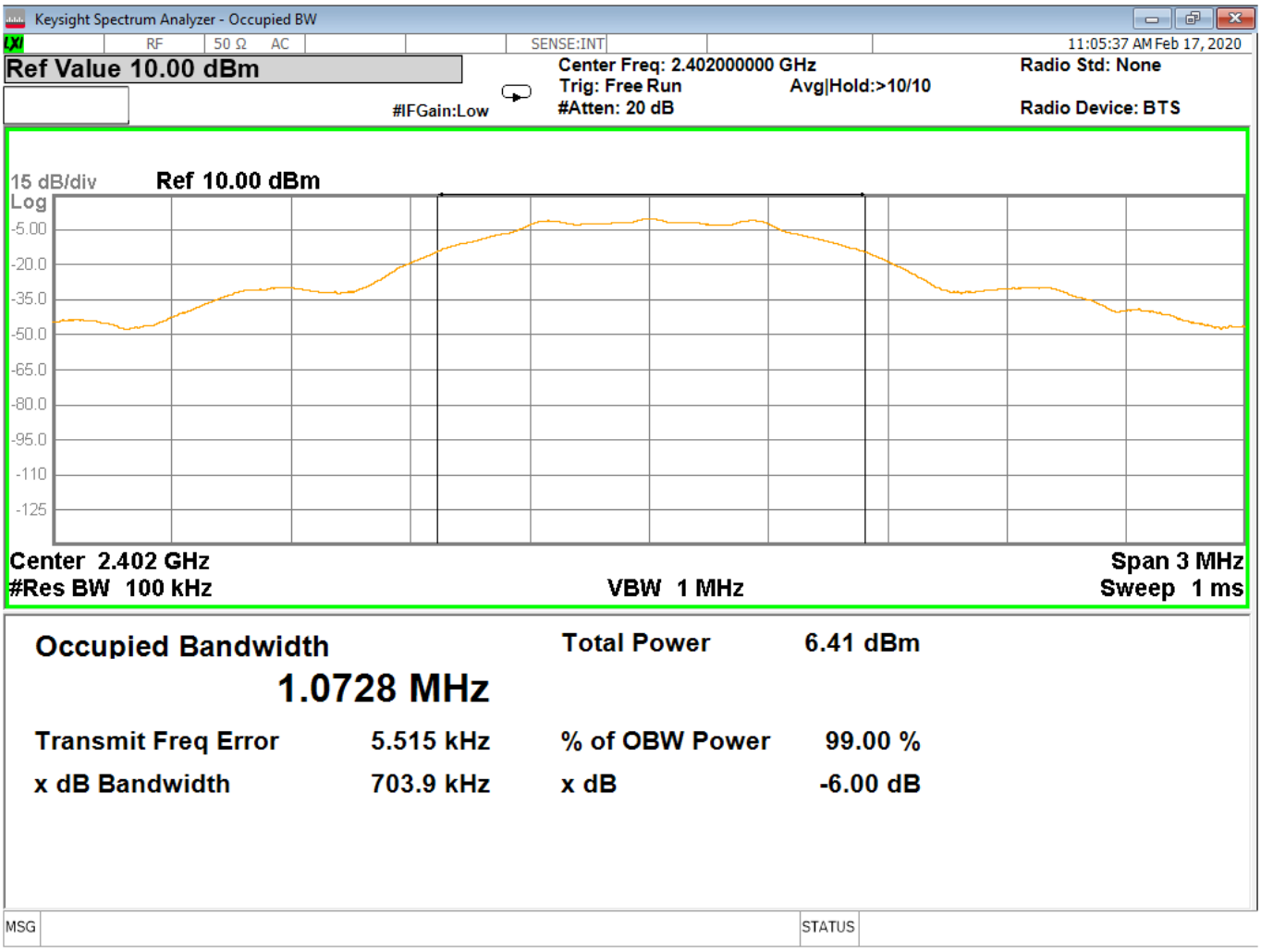


Figure 8 – Occupied Bandwidth, Low Channel, GMSK

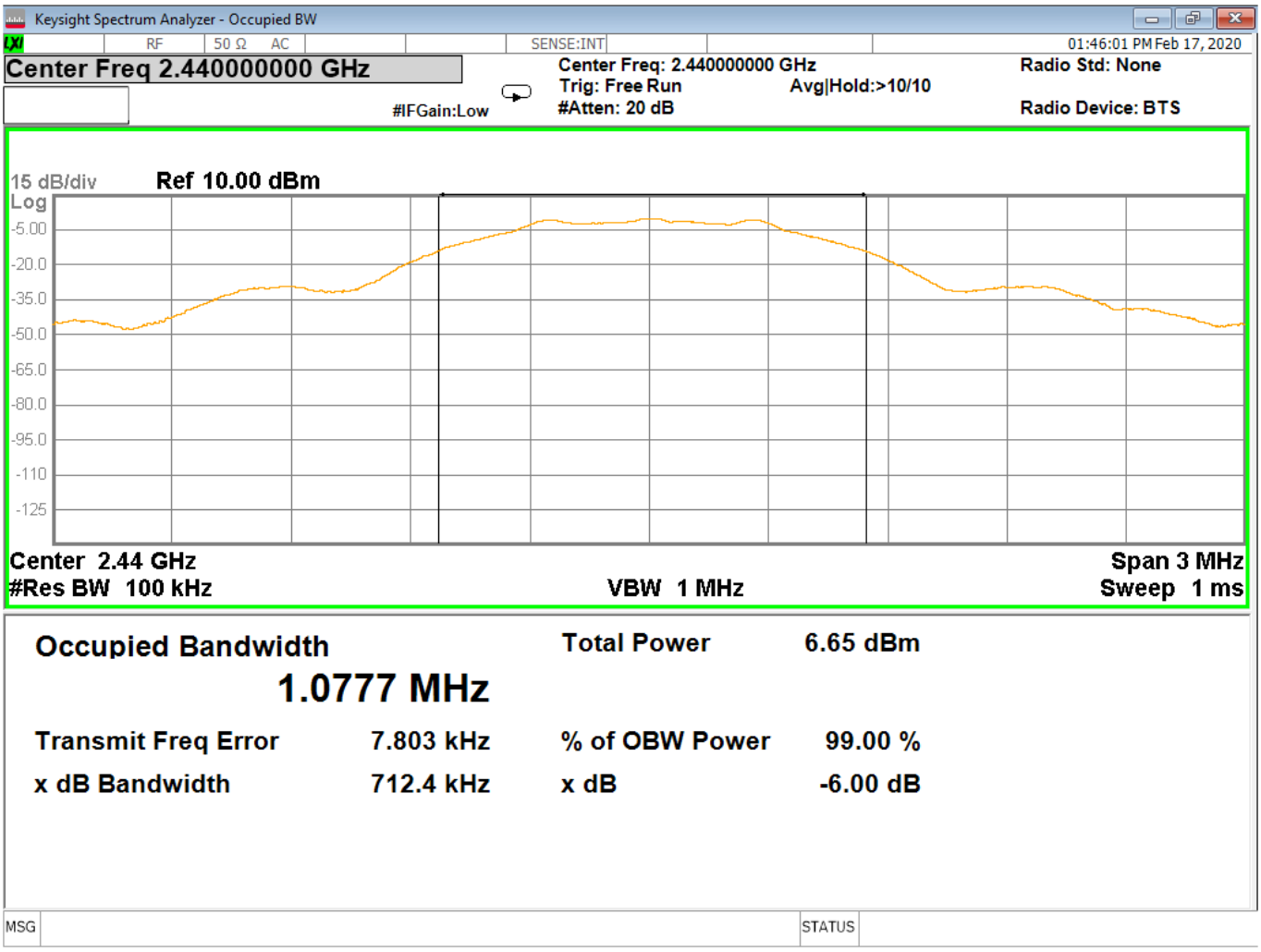


Figure 9 - Occupied Bandwidth, Mid Channel, GMSK

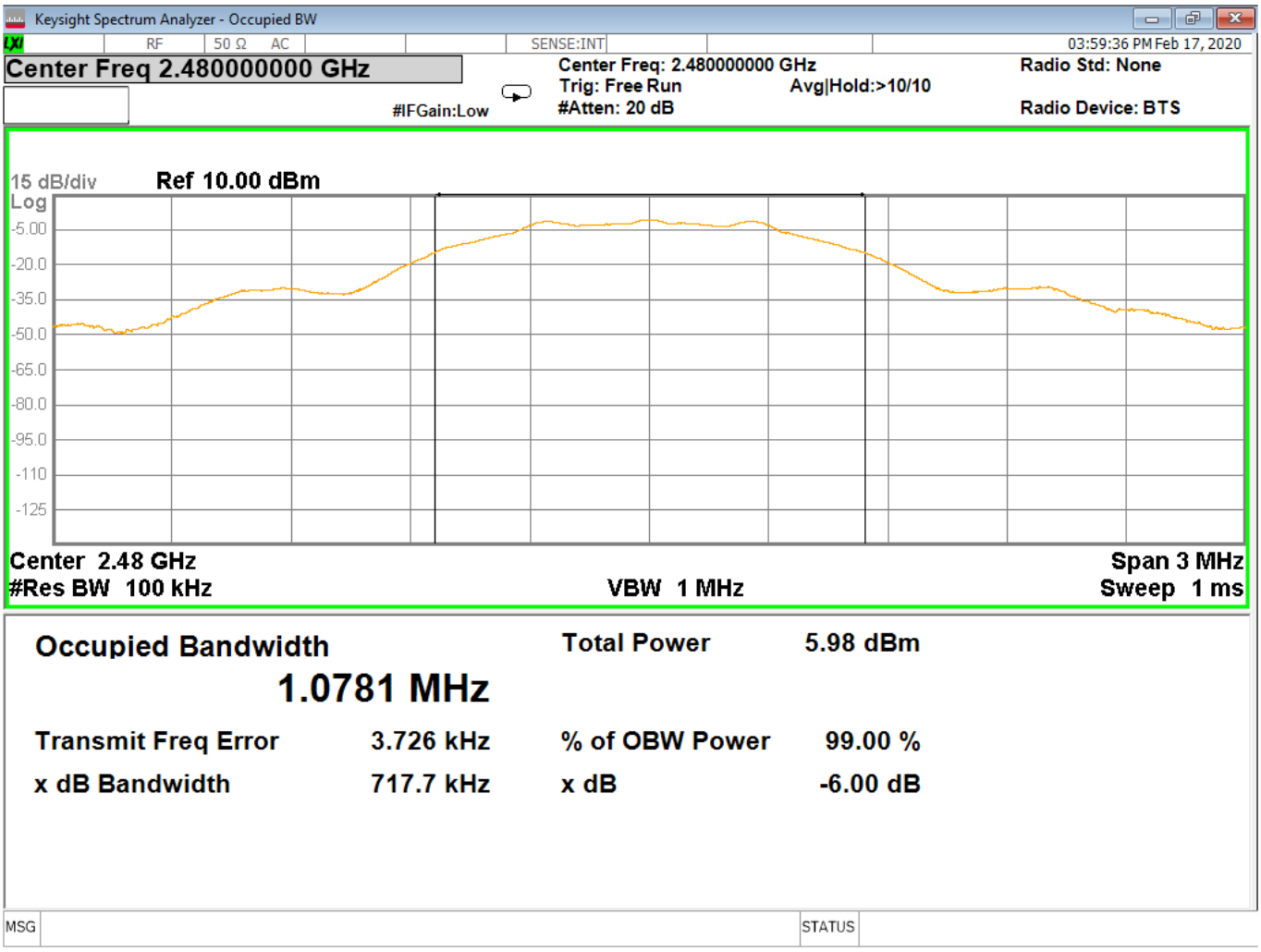


Figure 10 – Occupied Bandwidth, High Channel, GMSK

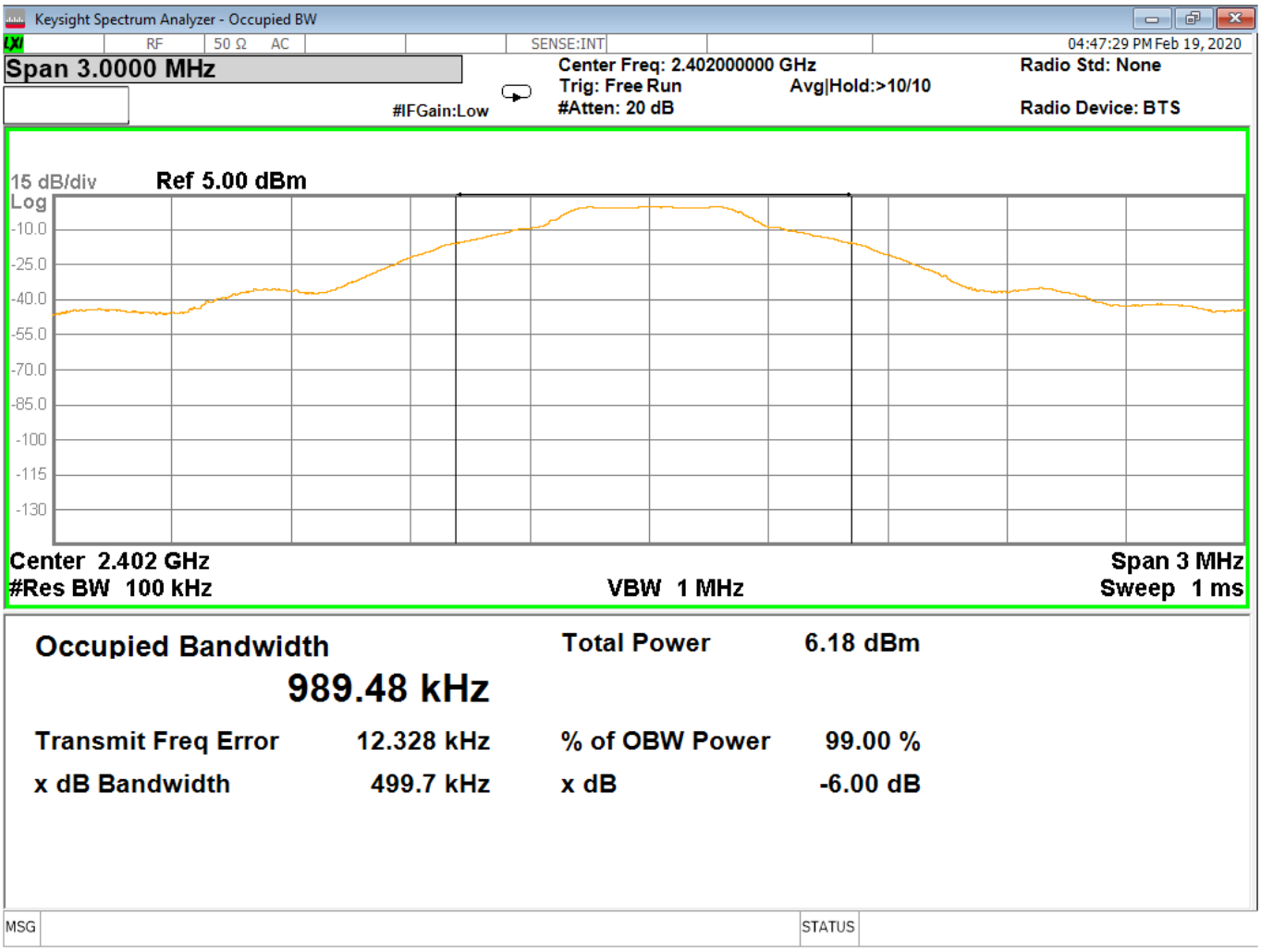


Figure 11 - Occupied Bandwidth, Low Channel, GFSK

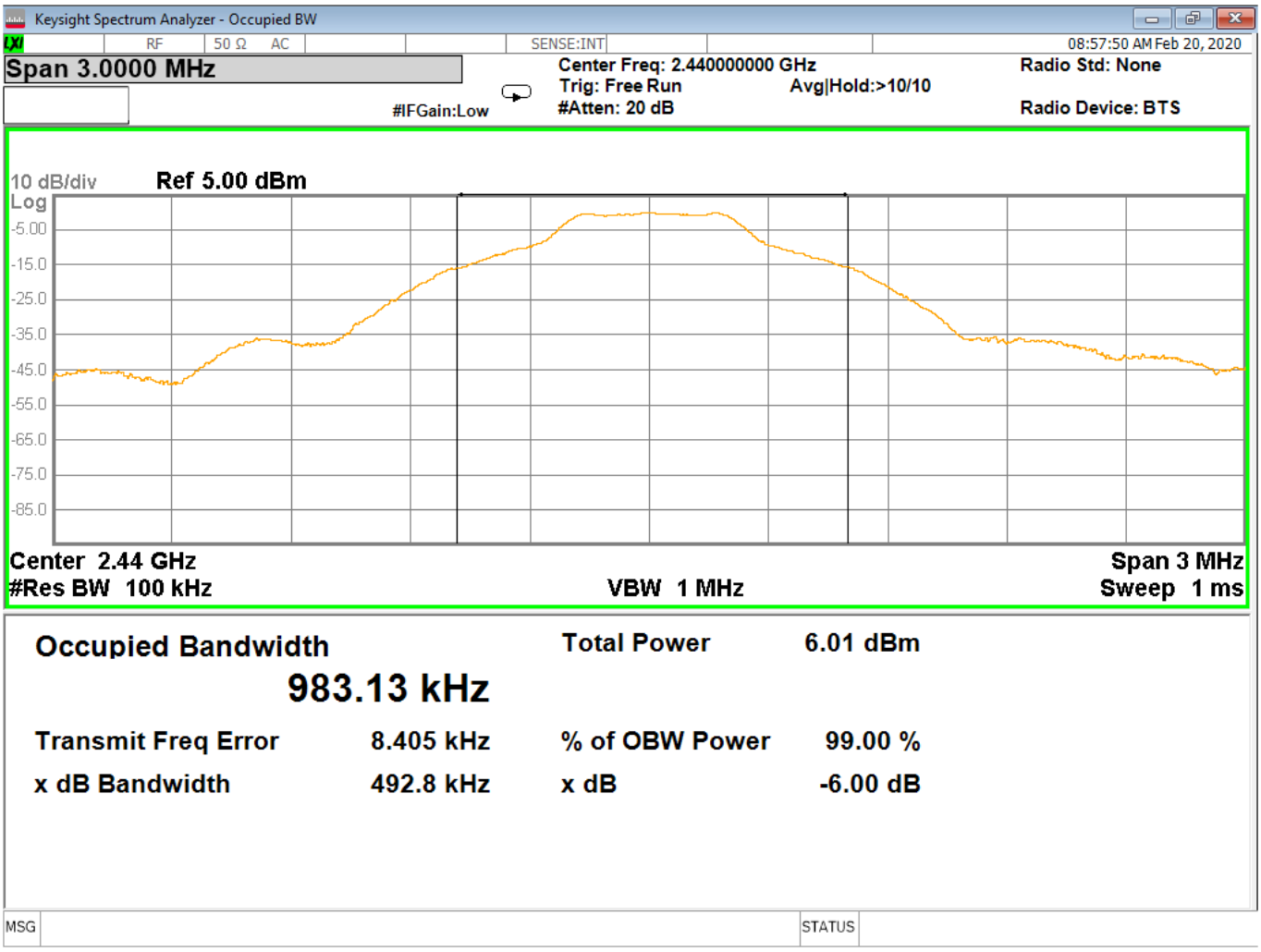


Figure 12 - Occupied Bandwidth, Mid Channel, GFSK

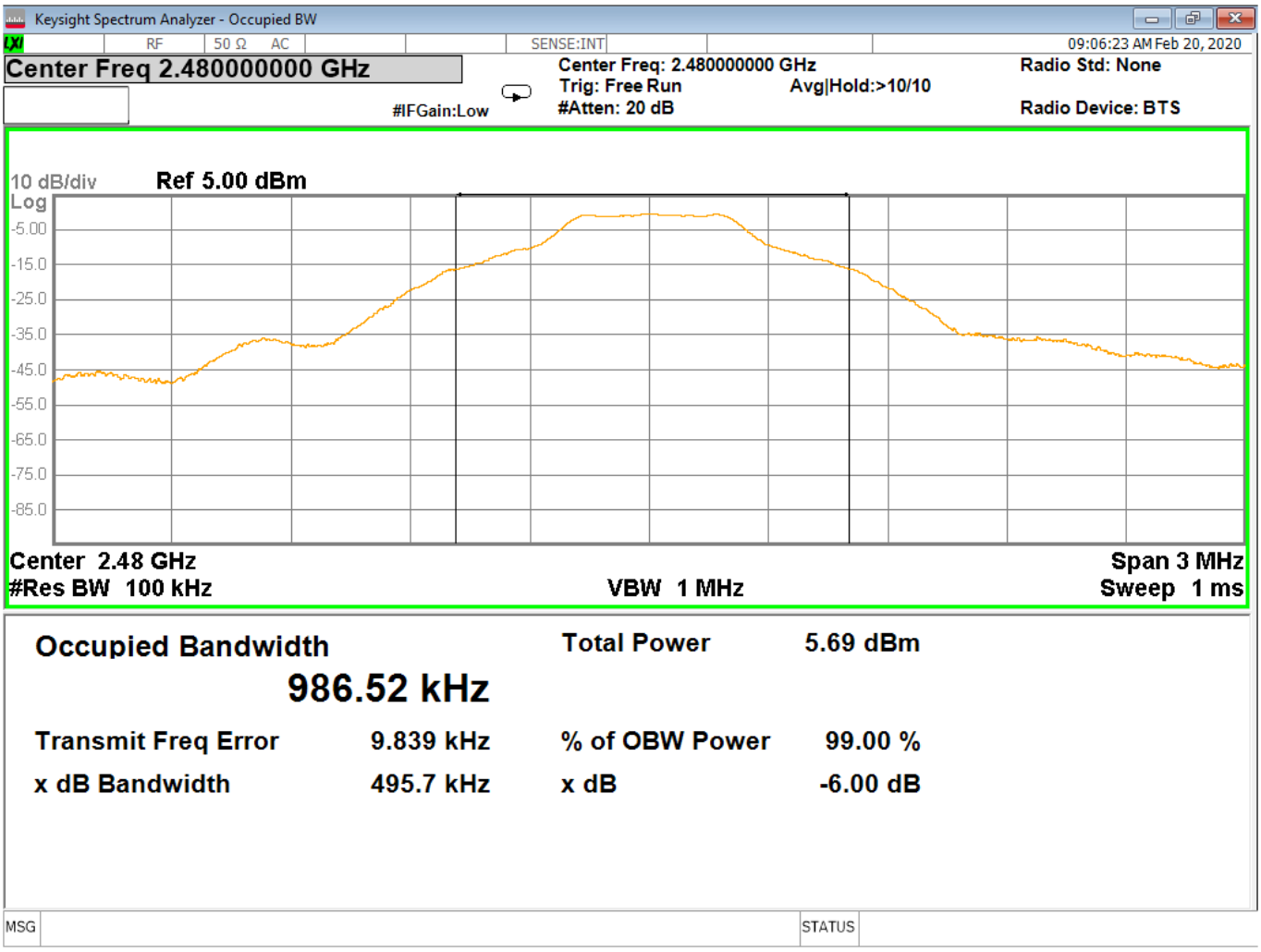


Figure 13 – Occupied Bandwidth, High Channel, GFSK

4.4 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 (µV/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 * Emission level (µV/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 tested 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.

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. Average measurements were performed with a linear average detector which meets the specifications in CISPR 16-1-1:2010.

Test setup:

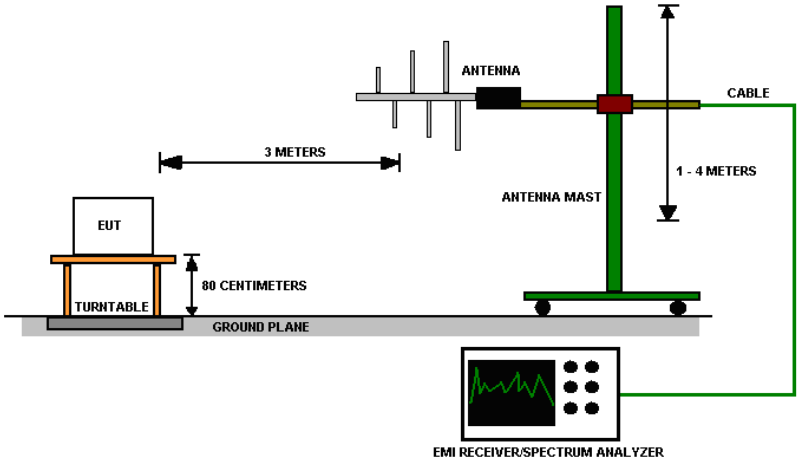


Figure 14 - Radiated Emissions Test Setup

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
The EUT was powered by 5 VDC power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in GMSK and GFSK.

Test results:

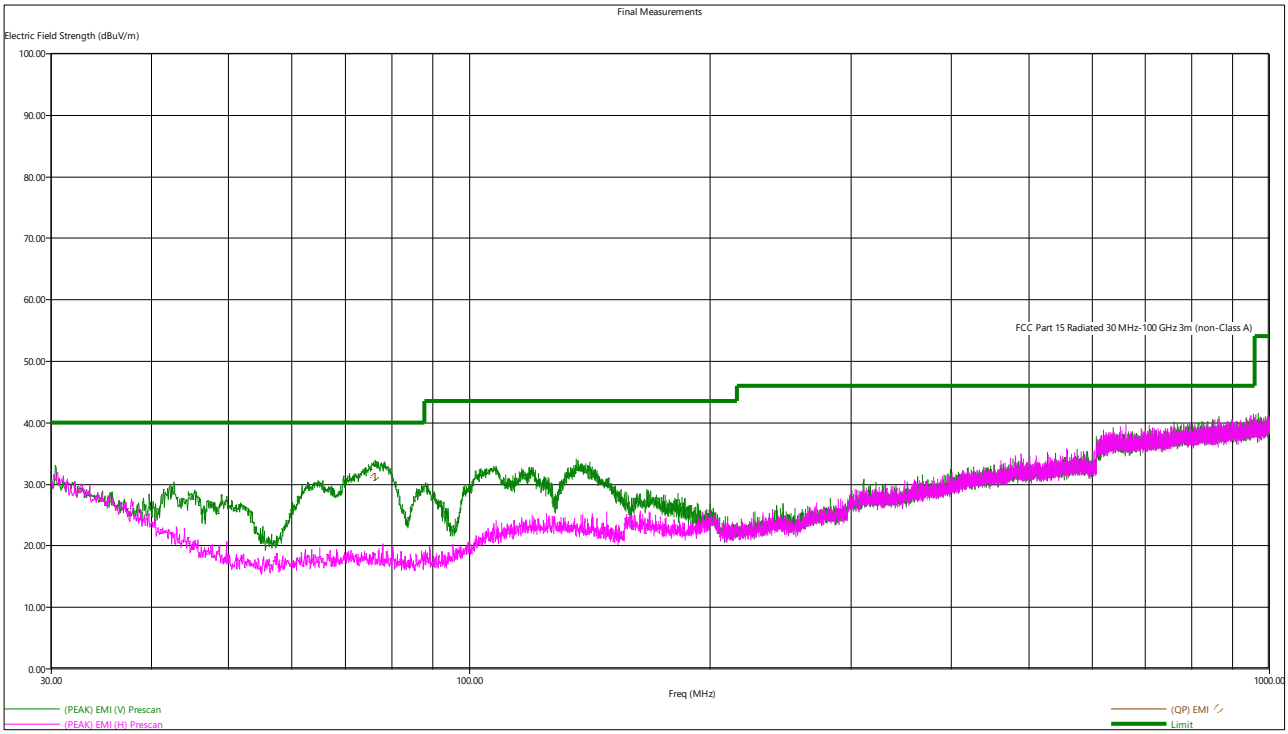


Figure 15 - Radiated Emissions Plot, Receive, GMSK

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 = Emission level – Limit value

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
76.26	31.14	40.00	8.86	250.00	110.00	V

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

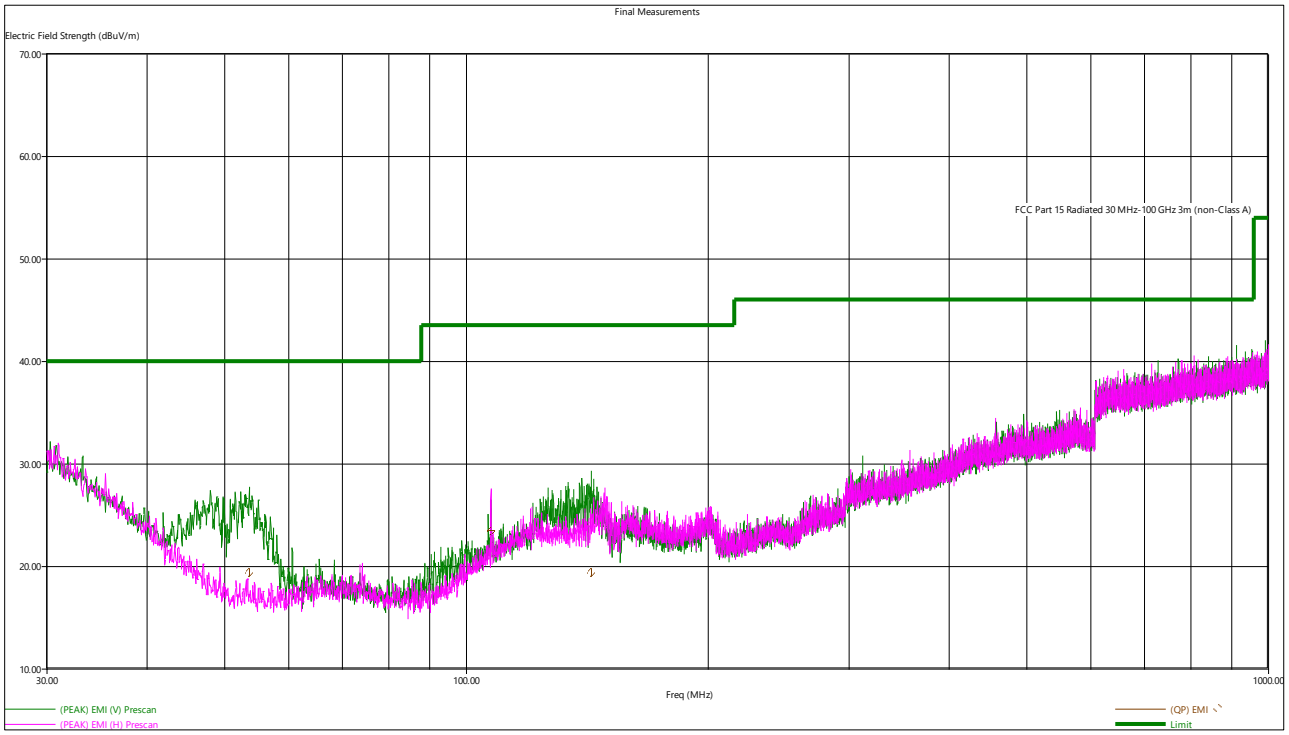


Figure 16 - Radiated Emissions Plot, Low Channel, GMSK

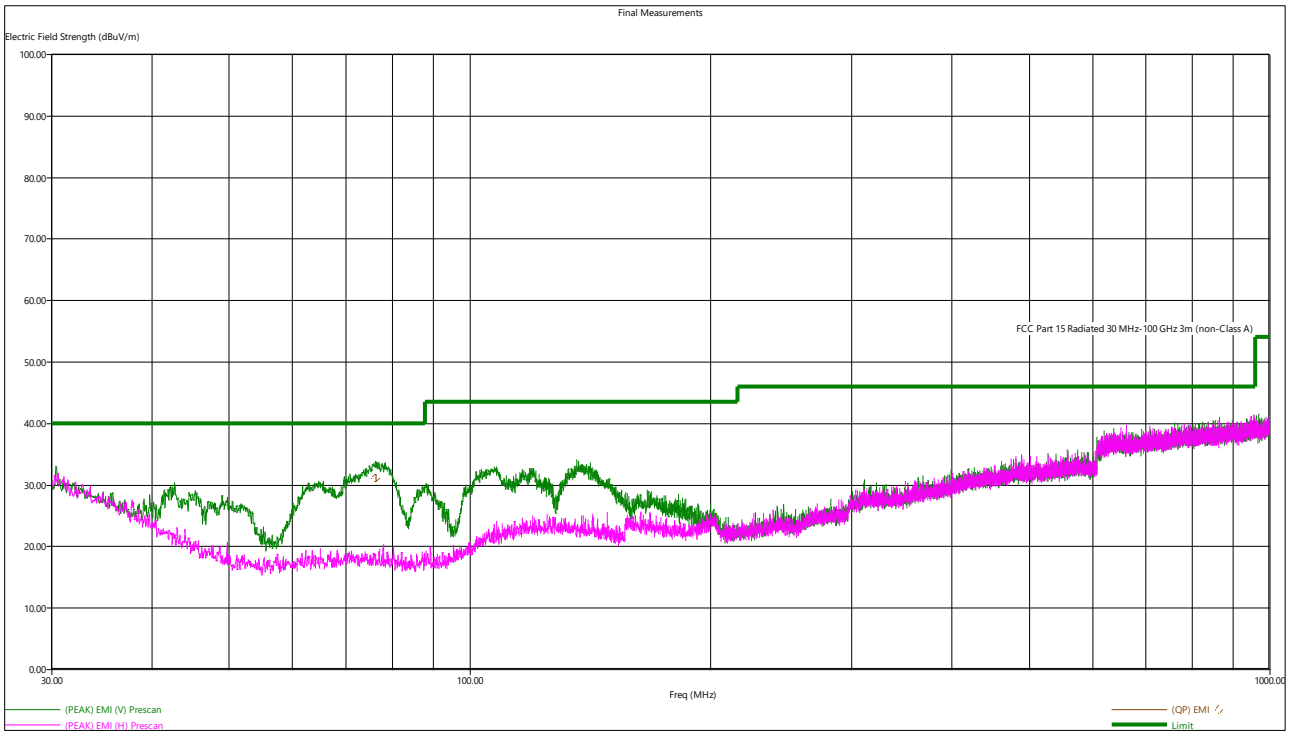


Figure 17 - Radiated Emissions Plot, Mid Channel, GMSK

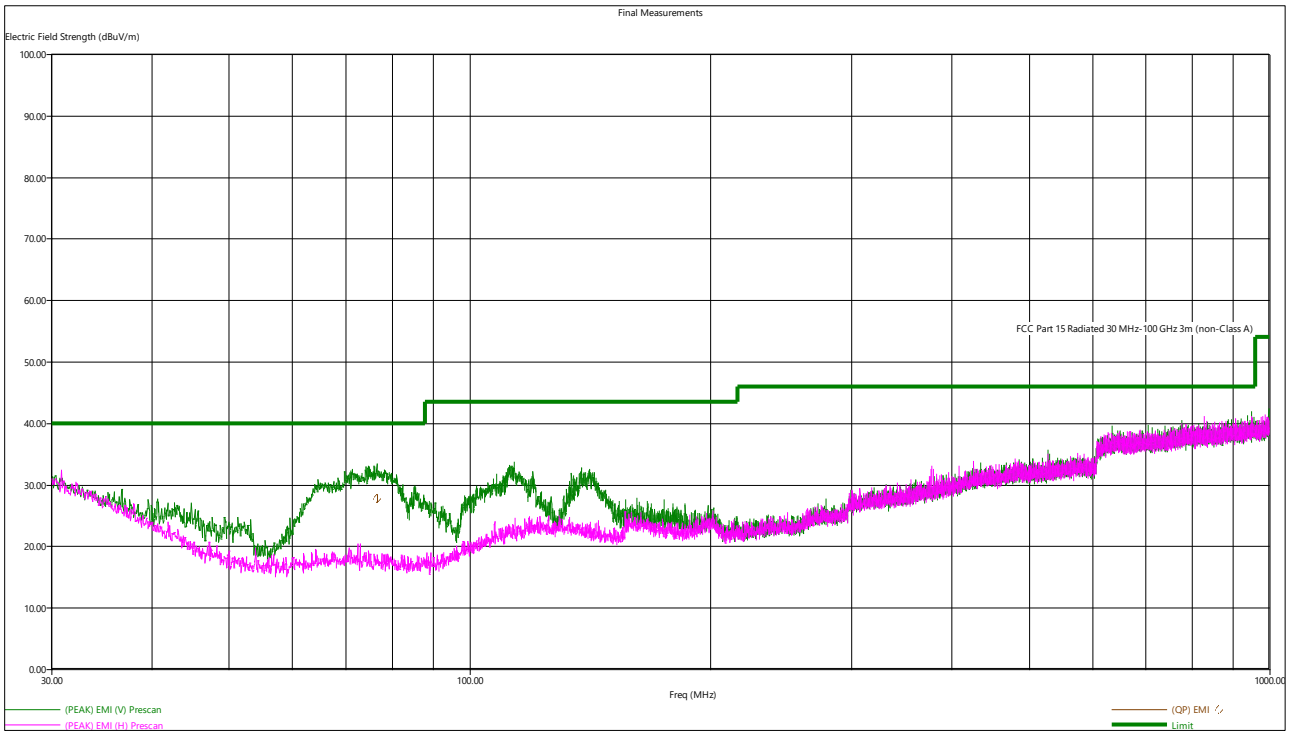


Figure 18 - Radiated Emissions Plot, High Channel, GMSK

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 = Emission level – Limit value

Table 2 - Radiated Emissions Quasi-peak Measurements, High Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
76.26	31.14	40.00	8.86	250.00	110.00	V

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

Table 3 - Radiated Emissions Peak Measurements, Low Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2402.00	97.75	114.00	16.25	269.00	H
8416.00	50.49	54.00	3.49	116.00	H
4803.50	48.80	54.00	5.18	140.00	V
7205.00	52.32	54.00	1.66	256.00	V

Table 4 - Radiated Emissions Average Measurements, Low Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2402.00	89.11	94.00	4.89	269.00	H

Table 5 - Radiated Emissions Peak Measurements, Mid Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2440.00	99.37	114.00	14.63	269.00	H
7320.50	18.42	54.00	35.58	121.00	V
10377.50	24.39	54.00	29.61	82.00	V

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.

Table 6 - Radiated Emissions Average Measurements, Mid Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2440.00	91.00	94.00	3.00	269.00	H

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.

Table 7 - Radiated Emissions Peak Measurements, High Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2480.00	100.14	114.00	13.86	0	H

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.

Table 8 - Radiated Emissions Average Measurements, High Channel, GMSK

Frequency	Level	Limit	Margin	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	deg.	
2480.00	90.89	94.00	3.11	0	H

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.

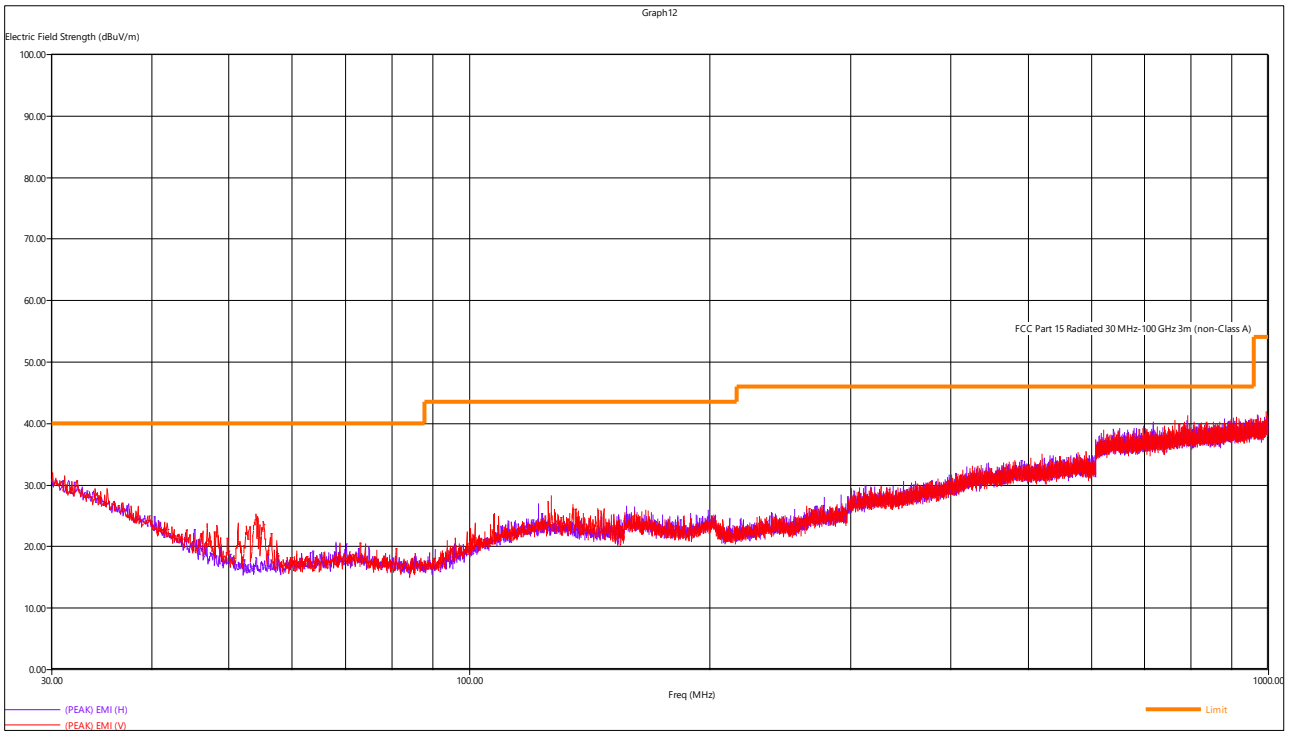


Figure 19 - Radiated Emissions Plot, Receive, GFSK

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 = Emission level – Limit value

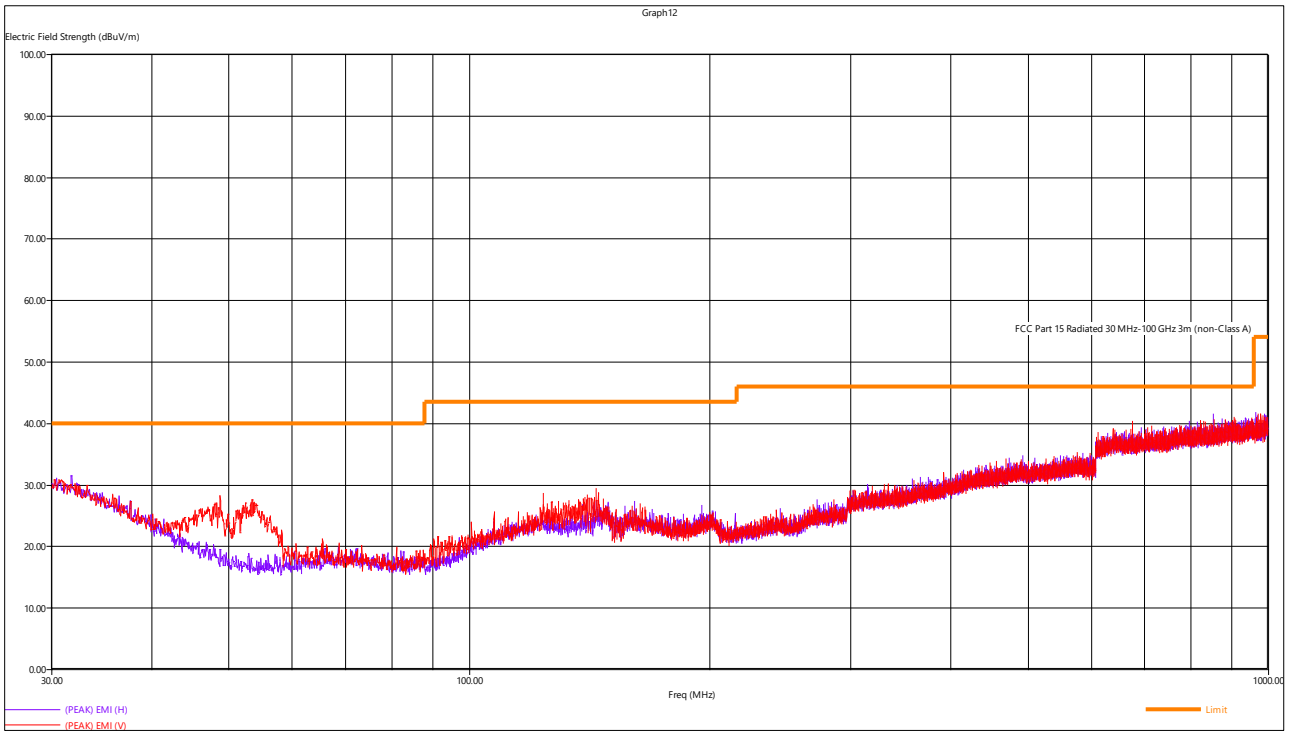


Figure 20 – Radiated Emission Plot, Low Channel GFSK

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 = Emission level – Limit value

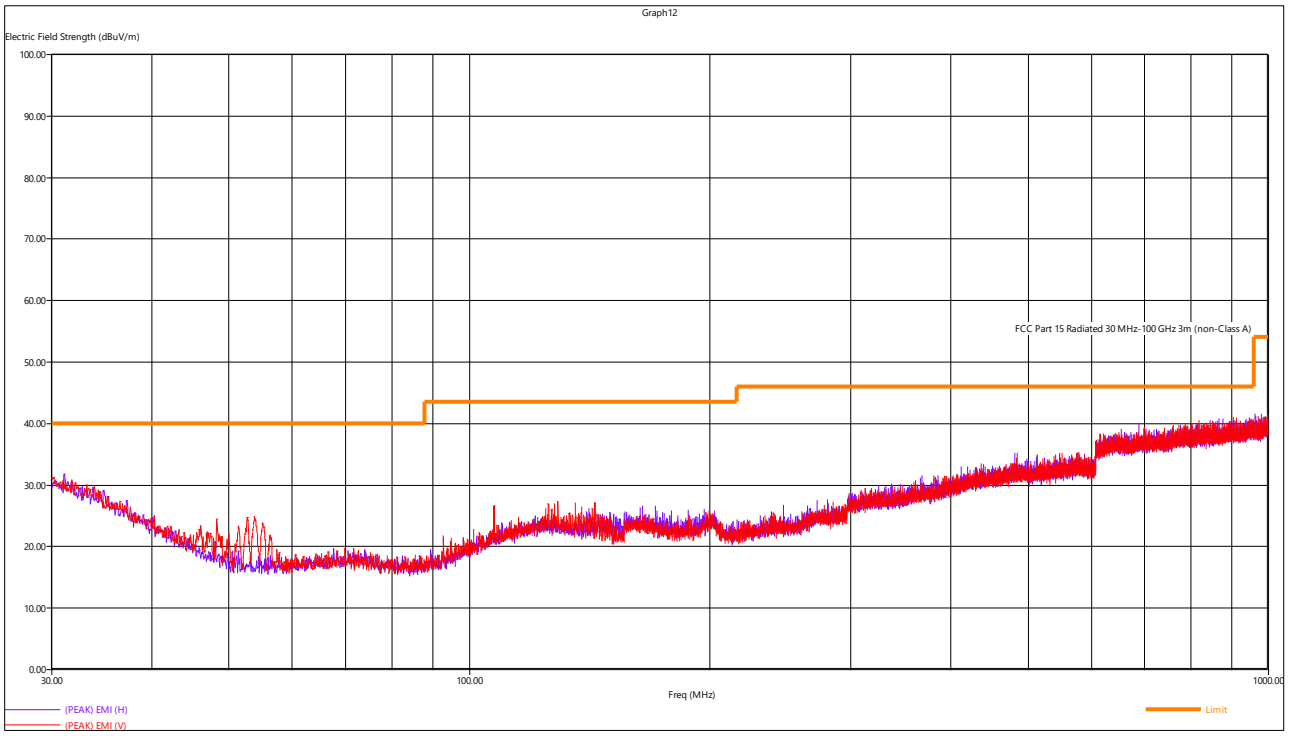


Figure 21 – Radiated Emission Plot, Mid Channel GFSK

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 = Emission level – Limit value

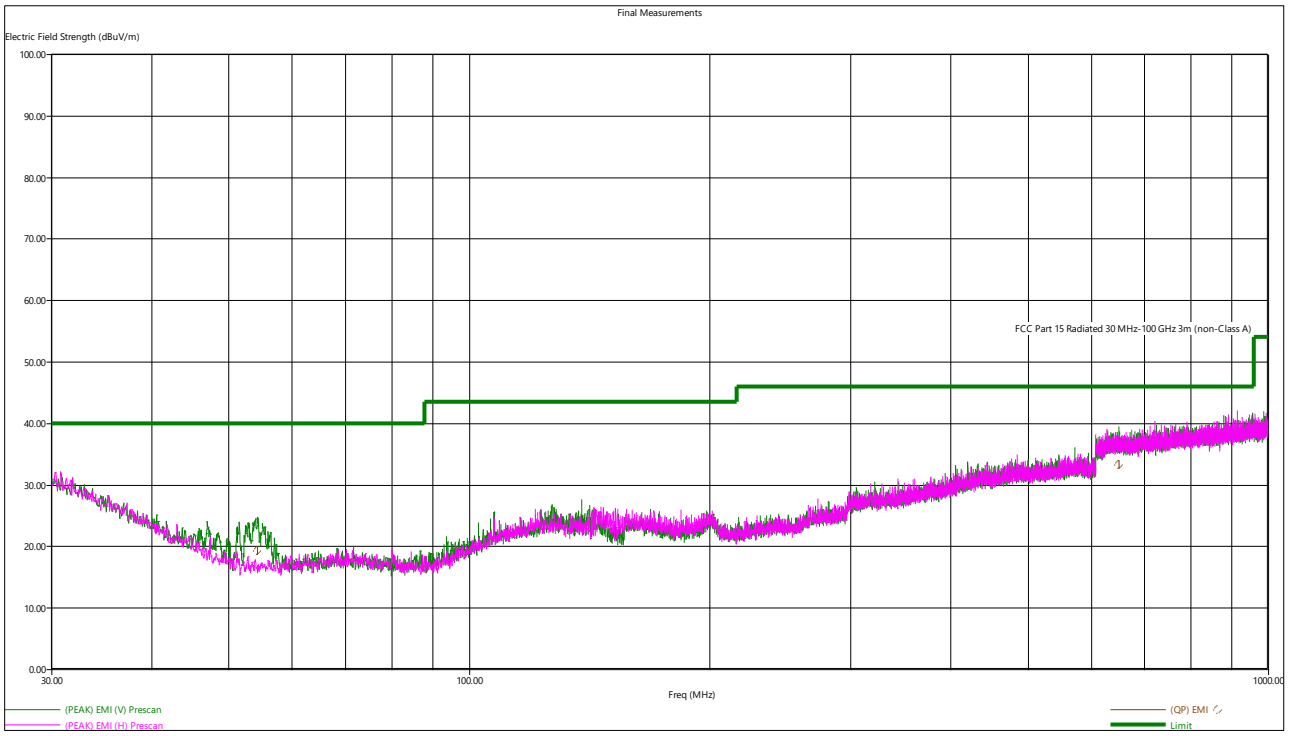


Figure 22 – Radiated Emission Plot, High Channel GFSK

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 = Emission level – Limit value

Table 9 - Radiated Emissions Quasi-peak Measurements, High Channel, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
54.30	19.24	40.00	20.76	120.00	256.00	V
649.32	33.38	46.02	12.64	230.00	293.00	V

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer. All the other measurements were found to have margins higher than 6dB from the limit.

Table 10 - Radiated Emissions Peak Measurements Vs Average Limits, Low Channel, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.00	92.29	94.00*	1.71	190.00	225.00	H
4804.00	45.28	54.00*	8.72	99.00	354.00	V
7205.50	51.24	54.00*	2.76	200.00	253.00	V

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.
*Peak Measurements were compared with average limits and found to be below the limits.

Table 11 - Radiated Emissions Peak Measurements Vs Average Limits, Mid Channel, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.00	91.95	94.00*	2.05	160.00	53.00	H
7319.00	51.76	54.00*	2.24	200.00	257.00	V

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.
*Peak Measurements were compared with average limits and found to be below the limits.

Table 12 - Radiated Emissions Peak Measurements Vs Average Limits, High Channel, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.00	92.76	94.00*	1.24	132.00	40.00	H
7440.50	51.99	54.00*	2.01	199.00	233.00	V

The EUT was tested in Z axis only (EUT vertically placed with aperture facing out) as this would be the typical configuration of the EUT in the final installation according to the user manual provided by the manufacturer.
*Peak Measurements were compared with average limits and found to be below the limits.

4.5 BAND EDGES

Test Method: ANSI C63.10-2013, Section(s) 6.10.5

Limits of band-edge measurements:
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:
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 resolution bandwidth was set to 100 kHz and the EMI receiver was used to scan from the band-edge to the fundamental frequency with a peak detector. 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.

To calculate the level at the band-edge frequencies, the difference between the peak and the band edge level was subtracted from the peak radiated value at the fundamental. This value was compared to the 15.209 radiated limits for compliance.

Deviations from test standard:
No deviation.

Test setup:
The field strength was measured by connecting the EUT directly to the spectrum analyzer.

EUT operating conditions:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in GMSK and GFSK.

Test results:

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental dBm	Delta (dB)	Min Delta (dB)	Result
Low, Continuous, Restricted	GFSK	2390	-54.880	-0.045	54.835	38.29	PASS
Low, Continuous, Restricted	GMSK	2390	-65.531	-0.508	65.023	43.75	PASS
High, Continuous, Restricted	GFSK	2483.5	-53.494	-0.359	53.135	38.76	PASS
High, Continuous, Restricted	GMSK	2483.5	-55.238	-0.891	54.347	46.14	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

From Section 4.2

Fundamental peak field strength at Low Channel GFSK= 92.29 dBµV/m
Fundamental peak field strength at High Channel GFSK= 92.76 dBµV/m
Fundamental peak field strength at Low Channel GMSK = 97.75 dBµV/m
Fundamental peak field strength at High Channel GMSK = 100.14 dBµV/m

Low Channel minimum delta GFSK= 92.29 – 54.0 dBµV/m = 38.29 dBc
High Channel minimum delta GFSK= 92.76– 54.0 dBµV/m = 38.76 dBc
Low Channel minimum delta GMSK = 97.75 – 54.0 dBµV/m = 43.75 dBc
High Channel minimum delta GMSK = 100.14 – 54.0 dBµV/m = 46.14 dBc

FCC Part 15.249 requires the attenuation of all emissions outside of the specified band to be at least 50 dB or below the 15.209 limits, whichever is the lesser. In this case, the 15.209 limits were the lesser and used to show compliance.

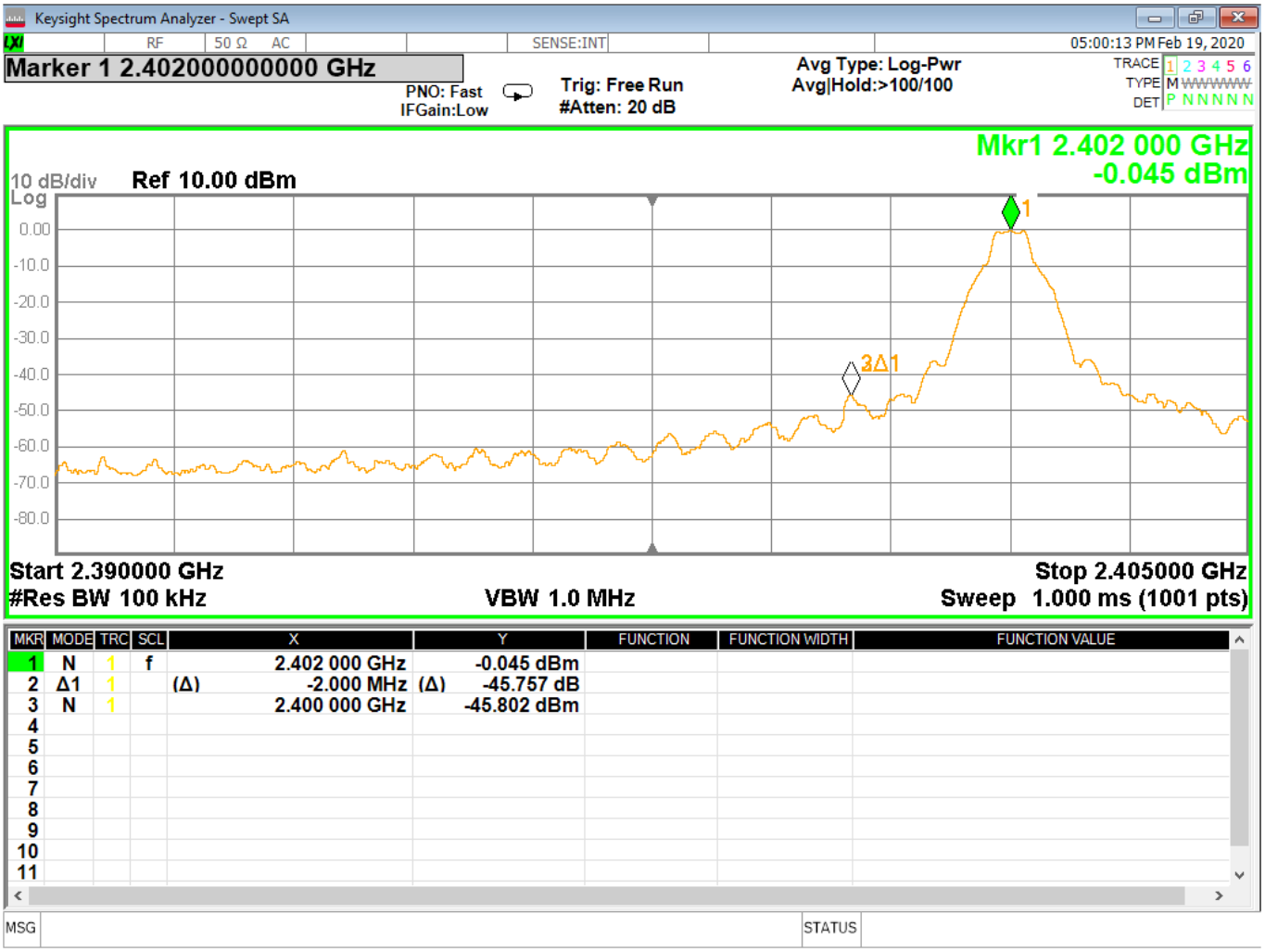


Figure 23 - Band Edge, Low Channel, Unrestricted, GFSK

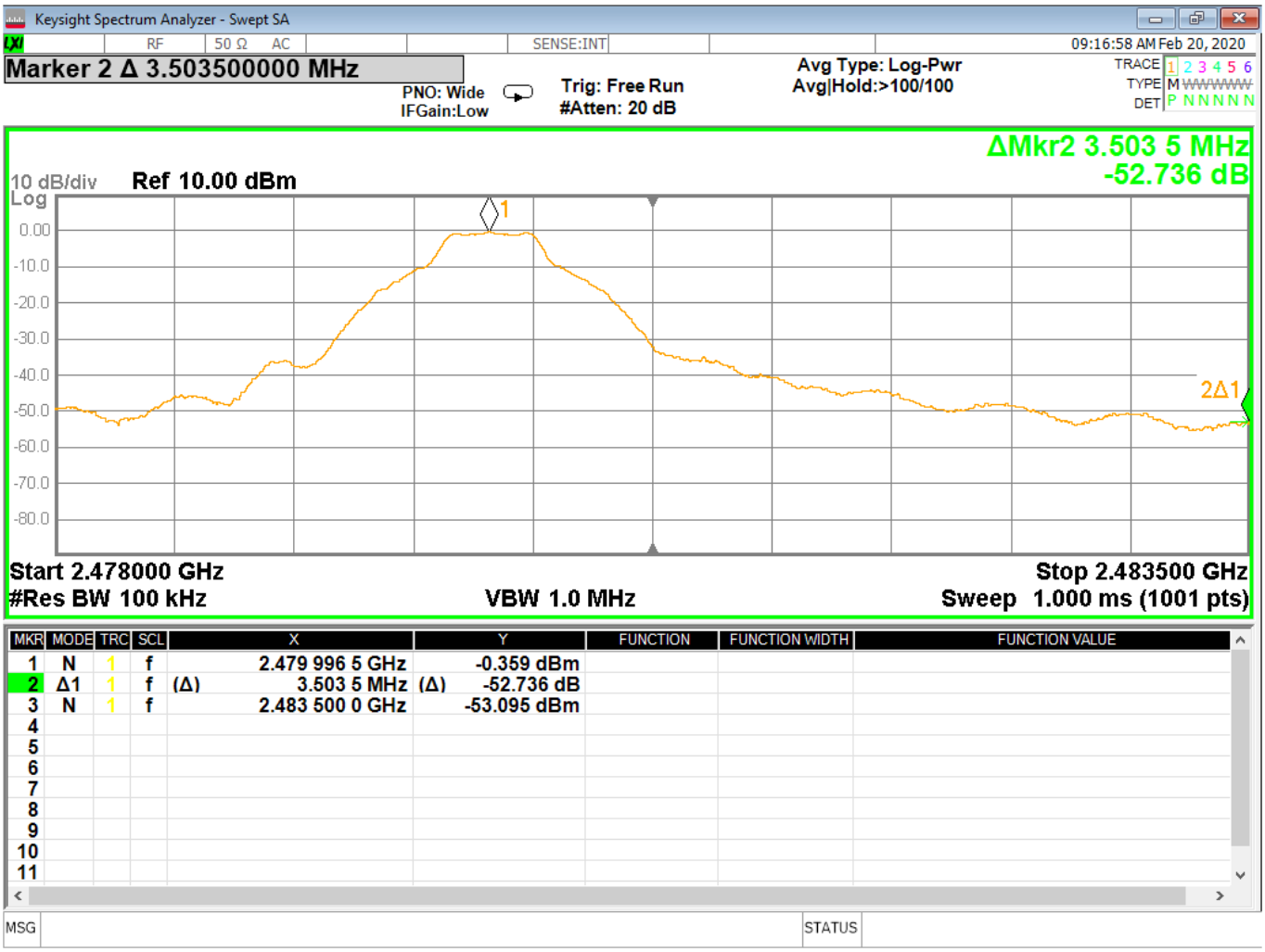


Figure 24 –Band Edge Measurement, High Channel, Unrestricted, GFSK

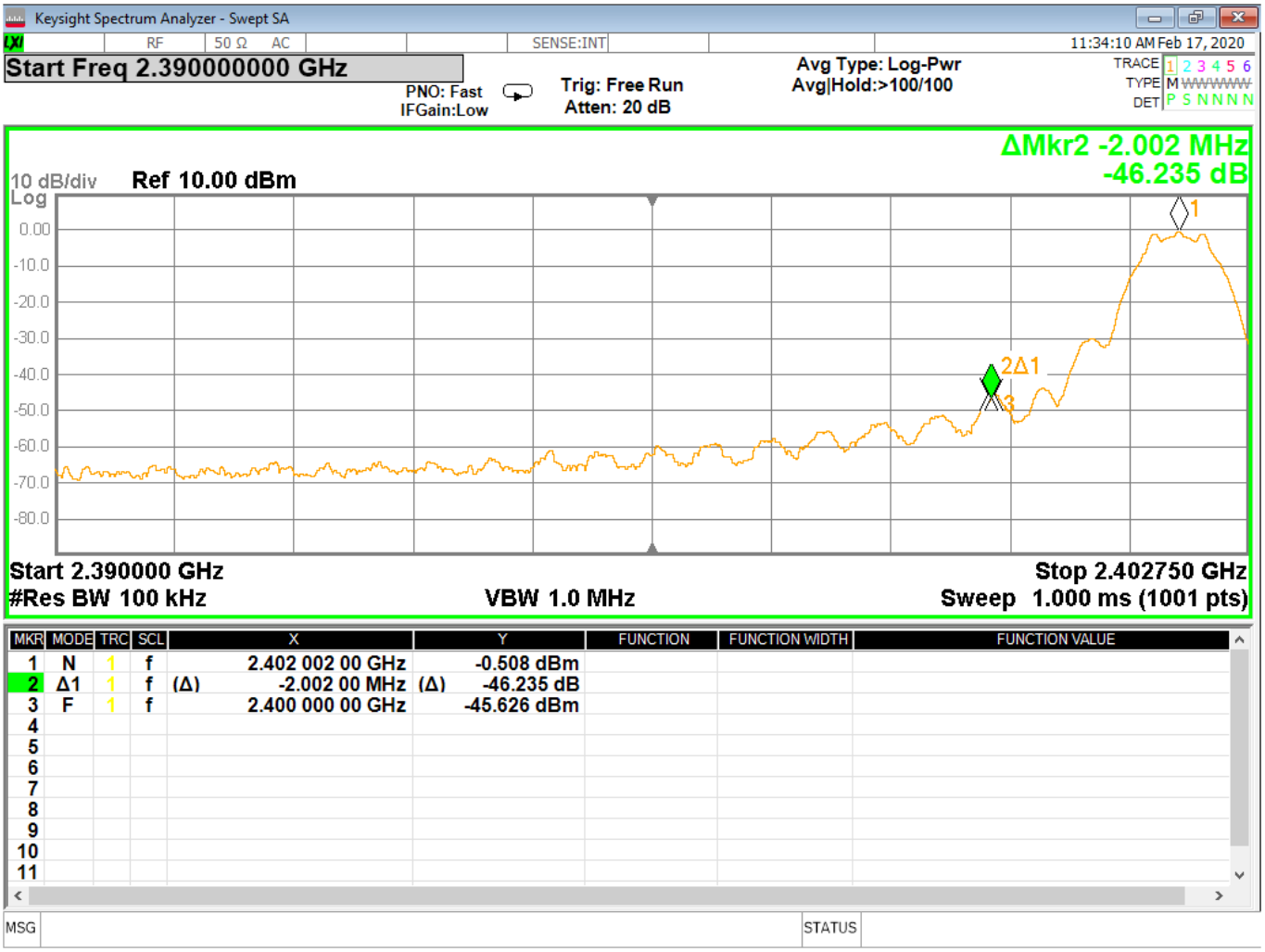


Figure 25 –Band Edge, Low Channel, Unrestricted, GMSK

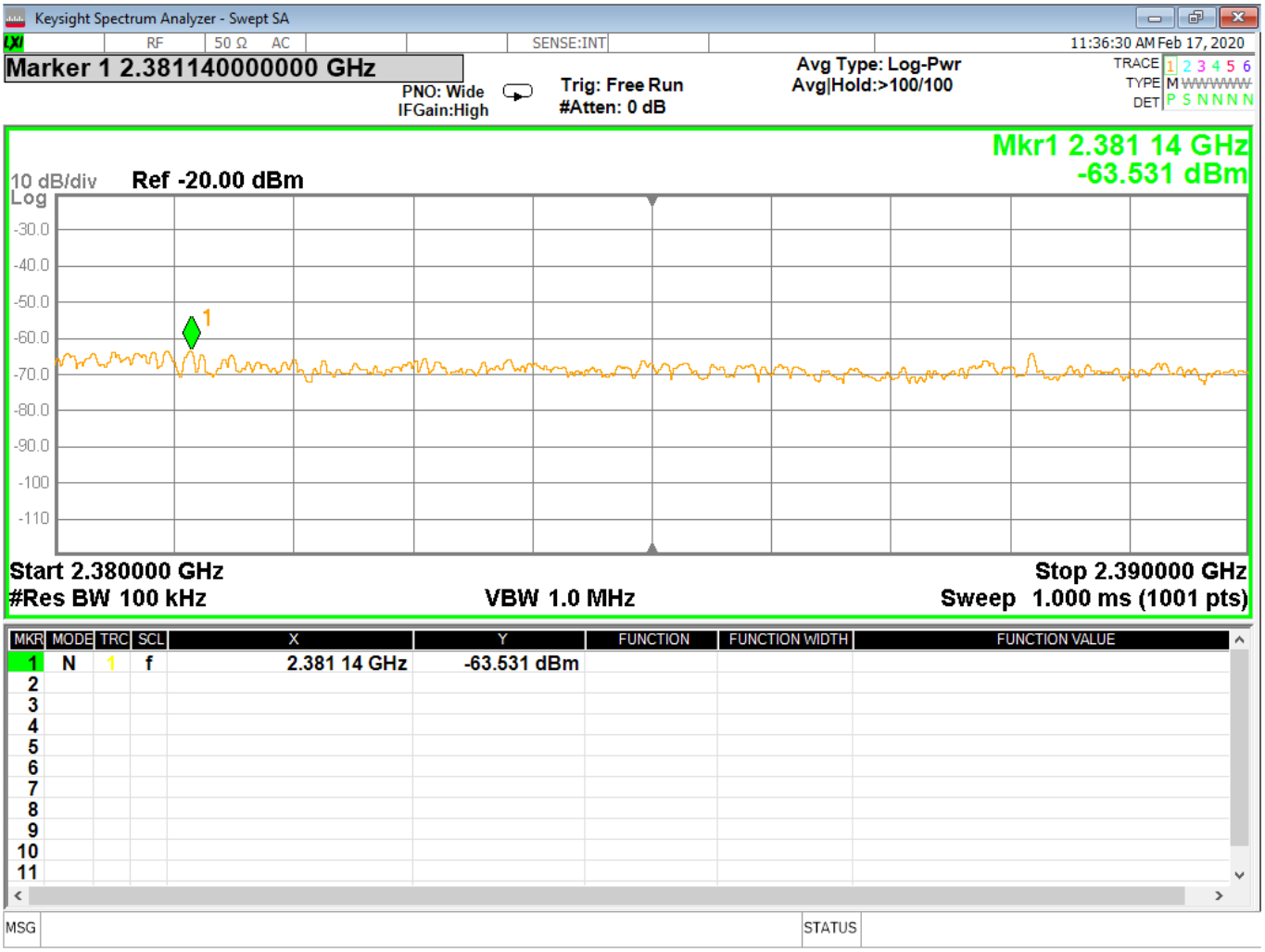


Figure 26 – Band Edge Measurement, Low Channel, restricted, GMSK

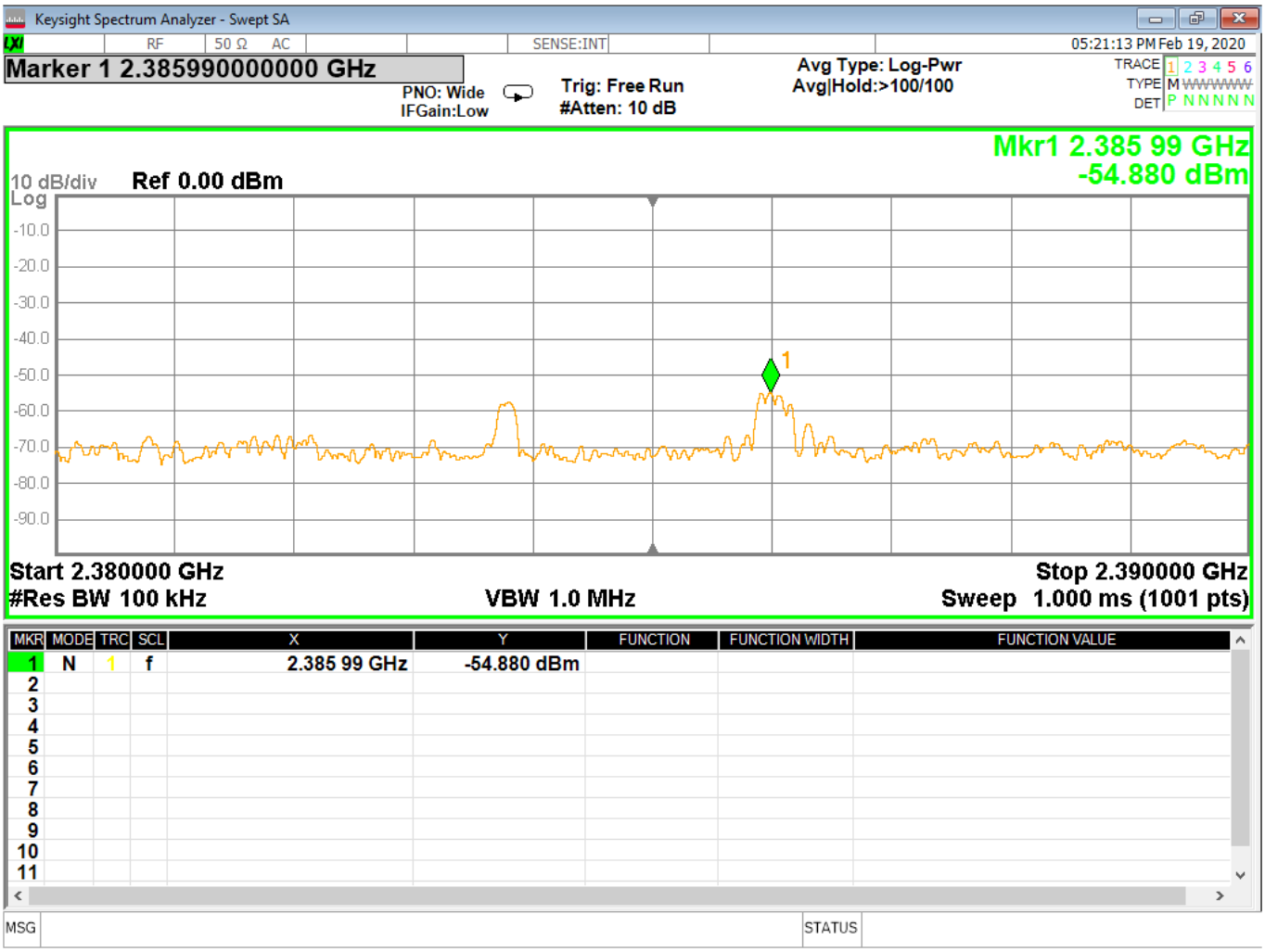


Figure 27 - Band Edge, Low Channel, Restricted, GFSK

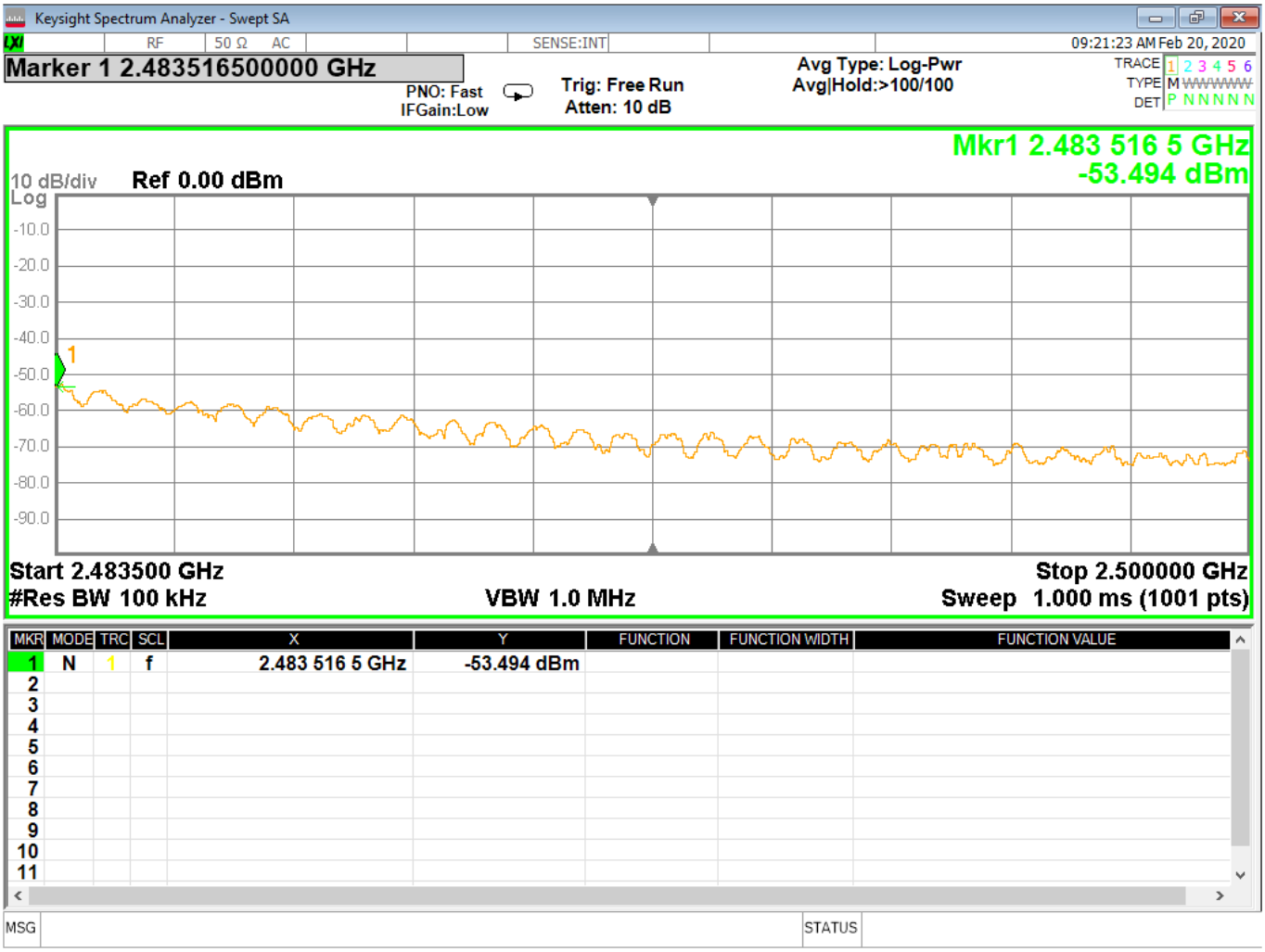


Figure 28 –Band Edge Measurement, High Channel, Restricted, GFSK

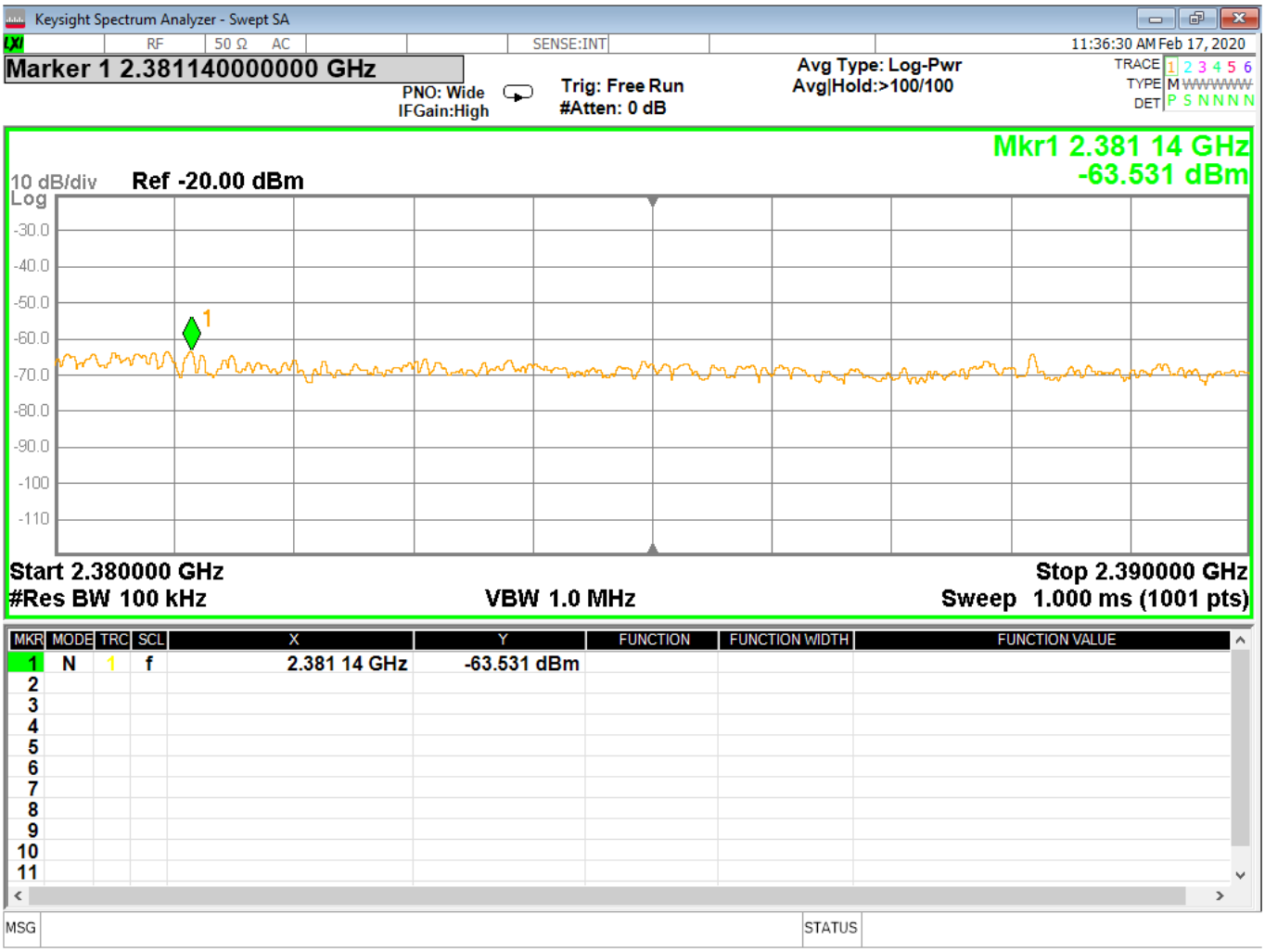


Figure 29 –Band Edge, Low Channel, Restricted, GMSK

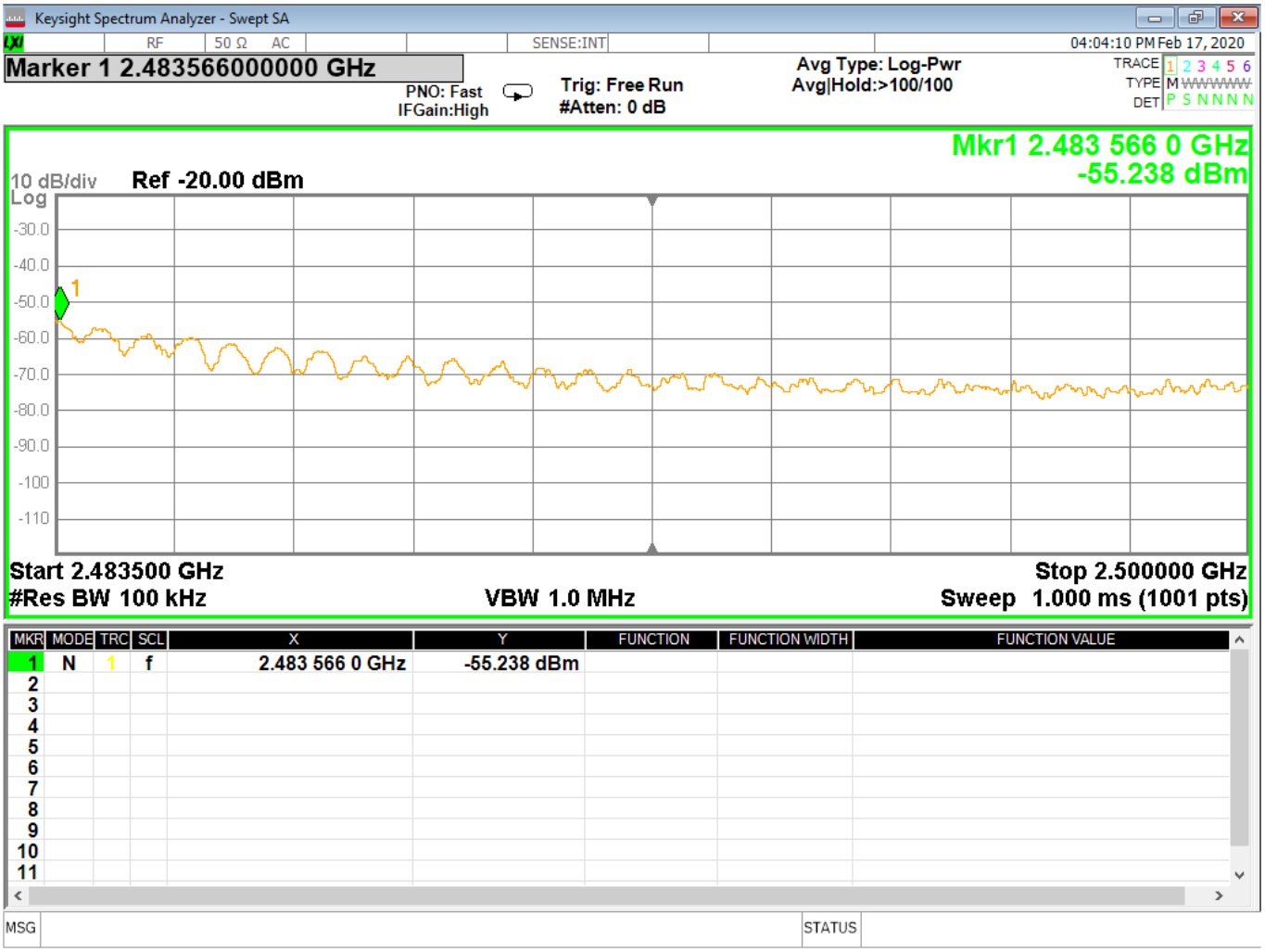


Figure 30 – Band Edge Measurement, High Channel, Restricted, GMSK

4.6 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 (dBµV)	
	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.

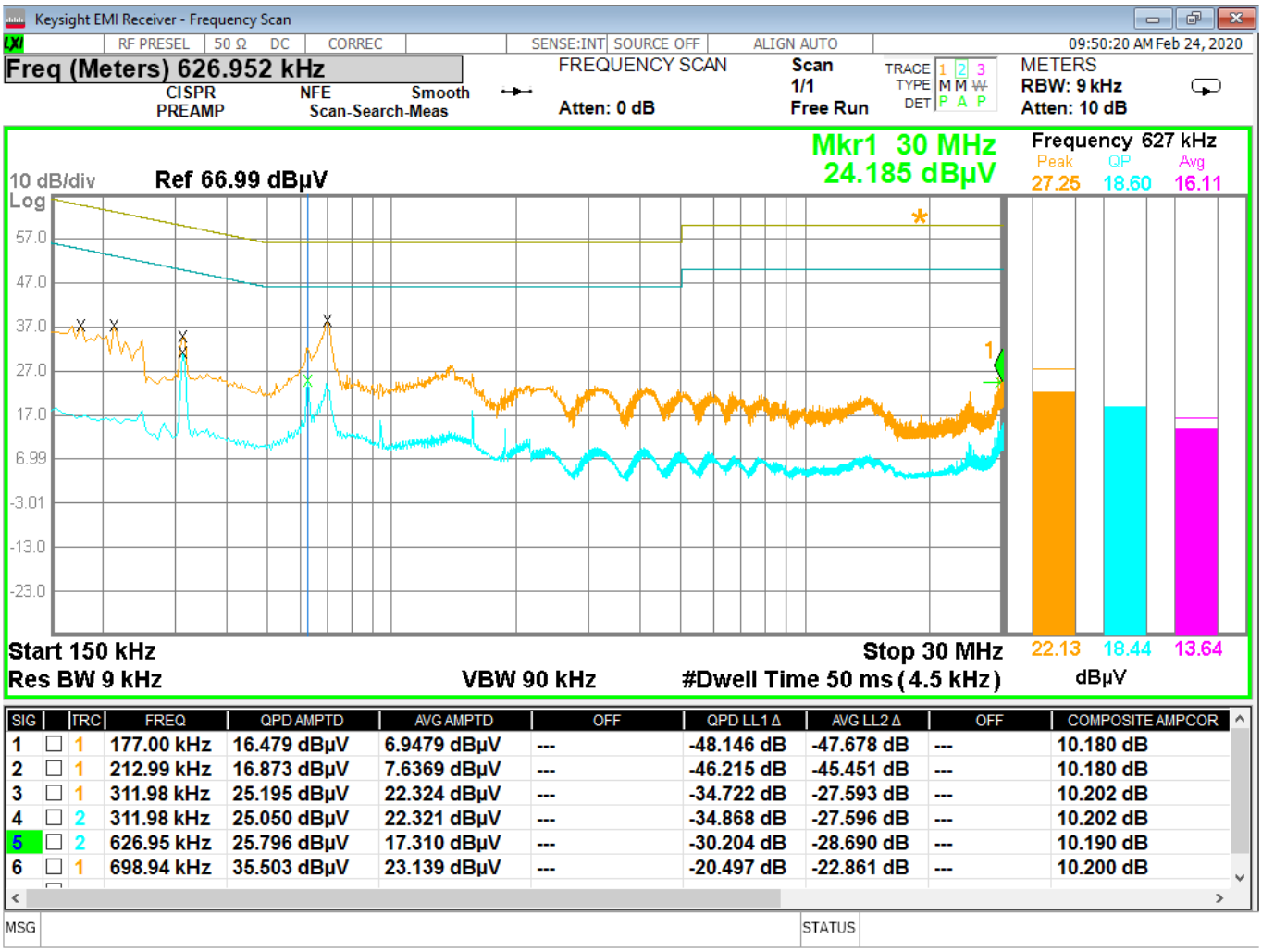
Test Procedures:

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

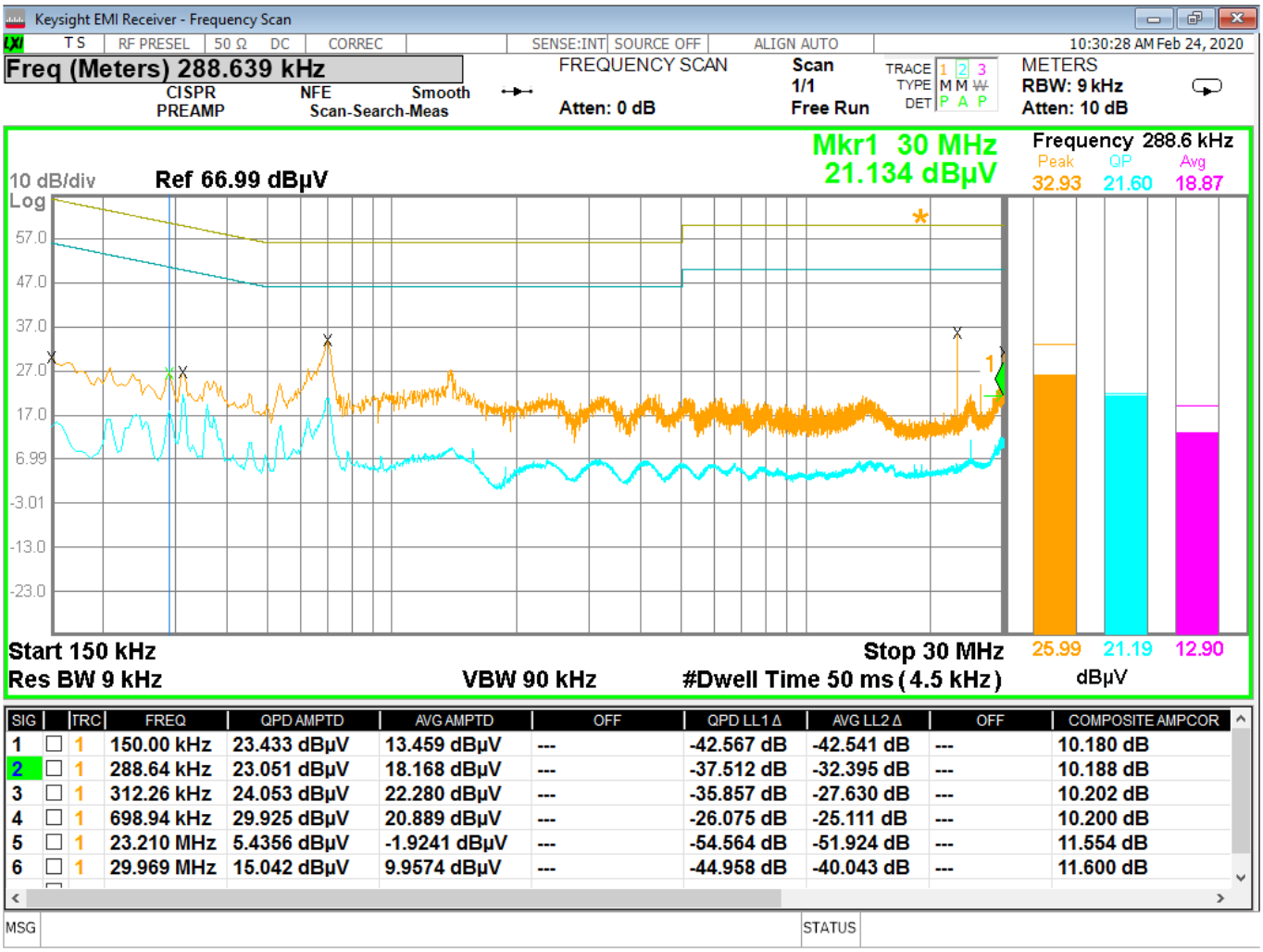
EUT operating conditions:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:



SIG		TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	☐	1	177.00 kHz	16.479 dBµV	6.9479 dBµV	---	-48.146 dB	-47.678 dB	---	10.180 dB
2	☐	1	212.99 kHz	16.873 dBµV	7.6369 dBµV	---	-46.215 dB	-45.451 dB	---	10.180 dB
3	☐	1	311.98 kHz	25.195 dBµV	22.324 dBµV	---	-34.722 dB	-27.593 dB	---	10.202 dB
4	☐	2	311.98 kHz	25.050 dBµV	22.321 dBµV	---	-34.868 dB	-27.596 dB	---	10.202 dB
5	☐	2	626.95 kHz	25.796 dBµV	17.310 dBµV	---	-30.204 dB	-28.690 dB	---	10.190 dB
6	☐	1	698.94 kHz	35.503 dBµV	23.139 dBµV	---	-20.497 dB	-22.861 dB	---	10.200 dB

Figure 31 - Conducted Emissions Plot, Line



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	1	150.00 kHz	23.433 dBµV	13.459 dBµV	---	-42.567 dB	-42.541 dB	---	10.180 dB
2	1	288.64 kHz	23.051 dBµV	18.168 dBµV	---	-37.512 dB	-32.395 dB	---	10.188 dB
3	1	312.26 kHz	24.053 dBµV	22.280 dBµV	---	-35.857 dB	-27.630 dB	---	10.202 dB
4	1	698.94 kHz	29.925 dBµV	20.889 dBµV	---	-26.075 dB	-25.111 dB	---	10.200 dB
5	1	23.210 MHz	5.4356 dBµV	-1.9241 dBµV	---	-54.564 dB	-51.924 dB	---	11.554 dB
6	1	29.969 MHz	15.042 dBµV	9.9574 dBµV	---	-44.958 dB	-40.043 dB	---	11.600 dB

Figure 32 - Conducted Emissions Plot, Neutral

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 dBμV/m

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

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*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 (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

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

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	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

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

REPORT END

4740 Discovery Drive | Lincoln, NE 68521
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info@nceelabs.com | http://nceelabs.com

Amended

DXX
FCC/ISED Test Report

Client: **Garmin International Inc.**

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

Product: **A04024**

Test Report No.: **R20191119-20-E3B**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

Date: **17 March 2020**

Total Pages: **58**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	2/25/2020	Original – NJohnson Prepared by KVepuri
A	3/11/2020	Added note about near-field measurements on Page 8. Corrected Table on Page 7. Added notes below plots of spurious harmonics specifying the signals were transmitting continuously on 1 channel. Includes NCEE Labs report R20191119-20-E3 and its amendment in full. -NJ
B	3/17/2020	Added the spurious data for single frequency measurements on radar. Includes NCEE Labs report R20191119-20-E3A and its amendment in full. -NJ

Table of Contents

1 Summary of Test Results

1.1 Emissions Test Results

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-210, Issue 10

Testing was performance in accordance with the methods published in ANSI C63.10-2013

Table 1 - Emissions Test Results

Emissions Tests	Test Method and Limits	Result
Fundamental, Harmonics and Band Edges	FCC Part 15.249 RSS-210, Issue 10, Annex B.10	Complies

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 - Equipment under Test (EUT)

EUT	A04024
EUT Received	1/21/2020
EUT Tested	2/17/2020 - 3/17/2020
Serial No.	3321088804 (Used for Radiated emissions measurements)
Operating Band	24 GHz
Device Type	Low power transceiver
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAF10R-050Q (Representative Power Supply)

2.2 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 32 ± 4%
Temperature of 22 ± 3° Celsius

2.3 EUT Setup

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the selected frequency channel.

3 Test Results

3.1 Fundamental Emissions

Test: FCC Part 15.249, RSS-210, Issue 10, Annex B.10

Test Result: Complies

3.1.1 Test Description

Emissions measurements were made using a 26 GHz spectrum analyzer with an external mixer and horn antenna. Measurements were taken at a distance of 1 meter. Measurements above 40 GHz were performed at 5 cm test distance. The analyzer was set to a resolution bandwidth of 10 MHz and a video bandwidth of 10 MHz for the fundamental measurement. The resolution bandwidth was set to 1 MHz and video bandwidth set to 1 MHz for the harmonic measurement. The results were compared against the limits published in FCC Part 15.249

3.1.2 Test Results

No radiated emissions measurements were found in excess of the limits. Test result data can be seen below.

3.1.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 33 ± 5%
Temperature of 22 ±2° C

3.1.4 Test Setup

See Section 2.3 for further details.

3.1.5 Test Equipment Used for all the tests

Serial No.	Manufacturer	Model	Description	Last Cal.	Calibration due
2576	ETS	3116	Horn Antenna	31 Jan 2018	31 Jan 2021
MY59050111	Keysight	N9038A	MXE Signal Analyzer	26 Mar 2019	26 Mar 2020
MY59050109	Keysight	N9010A	EXA Signal Analyzer	14 Dec 2018	14 Dec 2020
836679/010	Rohde & Schwarz	ESH3-Z5	Artificial Mains	25 Jul 2019	25 Jul 2020
MY51391050	Keysight	M1970V-002	Mixer	13 Apr 2019	13 Apr 2020
32/2016	Pasternack	PE9881-24	Horn Antenna	CNR***	CNR***
3903A03916	Agilent	11970Q	Mixer	CNR**	CNR**
Ncee1	Pasternack	SH122-23	Horn Antenna	CNR***	CNR***
181004-2	OML	DPL313B	Diplexer	CNR**	CNR**

**Calibration Not Required, internal verification ***Calibration not required, standard gain horn antenna.

All mixers and pre-amplifiers were calibrated with associated cables.

3.1.6 Test Pictures and/or Figures

Table 3 - Fundamental and Harmonic Emissions Data, 24 MHz and 48 MHz, Swept Frequency
Measurements made at 1m for fundamental and 0.05m for Harmonics. Limits were extrapolated accordingly.

Channel	Freq	Fundamental Level	Corrected Peak	Corrected Average	Peak Limit	Average Limit	Peak Margin	Average Margin
	(GHz)	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dB	dB
Low (24 MHz)	24.039170	13.363	59.373	48.740	77.50	57.50	18.127	8.760
Mid (24 MHz)	24.130270	13.232	59.242	48.609	77.50	57.50	18.258	8.891
High (24 MHz)	24.208170	12.428	58.438	47.805	77.50	57.50	19.062	9.695
Low (48 MHz)	24.064300	13.584	59.594	48.961	77.50	57.50	17.906	8.539
Mid (48 MHz)	24.142400	13.250	59.260	48.627	77.50	57.50	18.240	8.873
High (48 MHz)	24.167920	13.032	59.042	48.409	77.50	57.50	18.458	9.091
Channel	**Freq**	**2nd Harmonic Level**	**Corrected Peak**	**Corrected Average**	**Peak Limit**	**Average Limit**	**Peak Margin**	**Average Margin**
	(GHz)	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dB**	**dB**
Low (24 MHz)	48.066400	-33.401	29.559	18.926	63.52	43.52	33.961	24.594
Mid (24 MHz)	48.263000	-34.201	28.759	18.126	63.52	43.52	34.761	25.394
High (24 MHz)	48.467600	-33.082	29.878	19.245	63.52	43.52	33.642	24.275
Low (48 MHz)	48.022400	-29.742	33.218	22.585	63.52	43.52	30.302	20.935
Mid (48 MHz)	48.183400	-33.196	29.764	19.131	63.52	43.52	33.756	24.389
High (48 MHz)	48.337800	-31.857	31.103	20.470	63.52	43.52	32.417	23.050
Channel	**Frequency**	**3rd Harmonic Level**	**Corrected Peak**	**Corrected Average**	**Peak Limit**	**Average Limit**	**Peak Margin**	**Average Margin**
	(GHz)	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dB**	**dB**
Low (24 MHz)	72.155600	-4.063	39.447	28.814	63.52	43.52	24.073	14.706
Mid (24 MHz)	72.466000	-4.678	38.832	28.199	63.52	43.52	24.688	15.321
High (24 MHz)	72.623200	-3.332	40.178	29.545	63.52	43.52	23.342	13.975
Low (48 MHz)	72.198230	-6.389	37.121	26.488	63.52	43.52	26.399	17.032
Mid (48 MHz)	72.588190	-3.106	40.404	29.771	63.52	43.52	23.116	13.749
High (48 MHz)	72.505140	-4.145	39.365	28.732	63.52	43.52	24.155	14.788

Table 4 - Fundamental and Harmonic Emissions Data, Single Frequency

Measurements made at 1m for fundamental and 0.05m for Harmonics. Limits were extrapolated accordingly.

Channel	Frequency	Fundamental Level	Corrected Peak	Corrected Average	Peak Limit	Average Limit	Peak Margin	Average Margin
	(GHz)	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dBmV/m	dB	dB
Low (CW)	24.039170	12.967	58.977	48.344	77.50	57.50	18.523	9.156
Mid (CW)	24.130270	12.305	58.315	47.682	77.50	57.50	19.185	9.818
High (CW)	24.208170	11.133	57.143	46.510	77.50	57.50	20.357	10.990
Channel	**Frequency**	**2nd Harmonic Level**	**Corrected Peak**	**Corrected Average**	**Peak Limit**	**Average Limit**	**Peak Margin**	**Average Margin**
	(GHz)	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dB**	**dB**
Low (CW)	48.049860	-46.560	16.400	5.767	63.52	43.52	47.120	37.753
Mid (CW)	48.283900	-46.669	16.291	5.658	63.52	43.52	47.229	37.862
High (CW)	48.441700	-47.396	15.564	4.931	63.52	43.52	47.956	38.589
Channel	**Frequency**	**3rd Harmonic Level**	**Corrected Peak**	**Corrected Average**	**Peak Limit**	**Average Limit**	**Peak Margin**	**Average Margin**
	(GHz)	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dBmV/m**	**dB**	**dB**
Low (CW)	72.074800	-16.112	27.398	16.765	63.52	43.52	36.122	26.755
Mid (CW)	72.423000	-22.990	20.520	9.887	63.52	43.52	43.000	33.633
High (CW)	72.662600	-20.558	22.952	12.319	63.52	43.52	40.568	31.201

Remarks relating to 5 cm measurements of 2nd and 3rd harmonics:

Per FCC Part 15.31 (f) the distance is defined as:

To the extent practicable, the device under test shall be measured at the distance specified in the appropriate rule section. The distance specified corresponds to the horizontal distance between the measurement antenna and the closest point of the equipment under test, support equipment or interconnecting cables as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the system containing the equipment under test. The equipment under test, support equipment and any interconnecting cables shall be included within this boundary.

Per FCC Part 15.31(f)(1)

(1) At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. Measurements shall not be performed at a distance greater than 30 meters unless it can be further demonstrated that measurements at a distance of 30 meters or less are impractical. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

The measurements presented for 2nd and 3rd harmonics in this report meet both of the criteria for allowing near-field measurements

1. it can be shown that near field measurements are appropriate due to the characteristics of the device - (better signal to noise ratio when measuring an extremely narrow beam width.)

2. it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. (yes it can)

Even if the measurement was made in the near-field, the fact that a 20 dB/decade fall-off factor was applied represents a more conservative extrapolation of the signal level out to the specified measurement distance, and that the results represent a worst-case situation by only applying the 20 dB/decade factor.

Fundamental limit: 250 mV/m at 3 meters = 47.96 dBmV/m = 57.50 dBmV/m at 1 meter.
Level Measurement: 13.363 dBmV/m + 46.01 dB corrections = 59.373 dBmV/m.

Margin = 4.14 dB

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Second Harmonic limit: 2.5 mV/m at 3 meters = 7.95 dBmV/m = 43.52 dBmV/m at 0.05 meter.

Harmonic Measurement: -33.401 dBmV/m + 62.96 dB corrections = 29.559 dBmV/m.

Margin = 13.961 dB

Corrections:

Mixer	22.10 dB
Antenna factor	40.86 dB/m (standard gain horn, gain = 23 dBi)

The antenna was 5.6 x 4.4 x 9 cm long

Third Harmonic limit: 2.5 mV/m at 3 meters = 7.95 dBmV/m = 43.52 dBmV/m at 0.05 meter.

Harmonic Measurement: -4.063 dBmV/m + 43.51 dB corrections = 39.447 dBmV/m.

Margin = 4.07 dB

Corrections:

Antenna factor	43.51 dB/m (standard gain horn, gain = 24 dBi)

*Mixer correction was accounted in the values shown in plots.

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

The antenna was 3.7 x 2.2 x 6.8 cm long

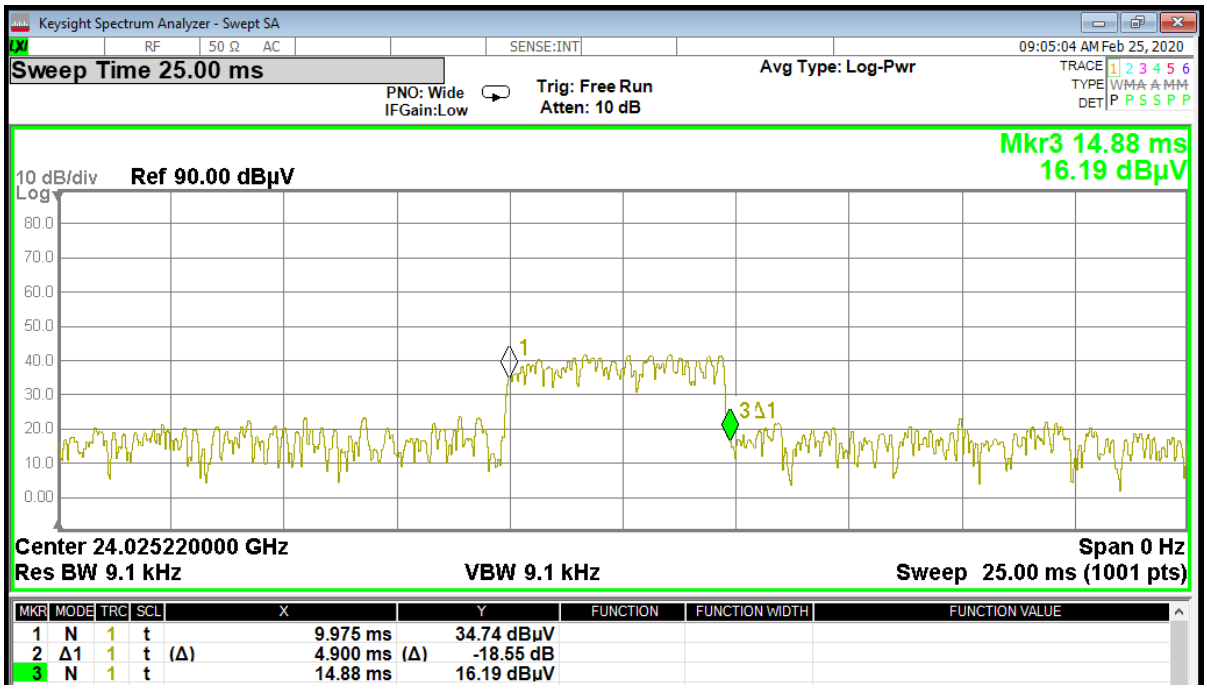

Figure 1 - On time / pulse width = 4.9 ms

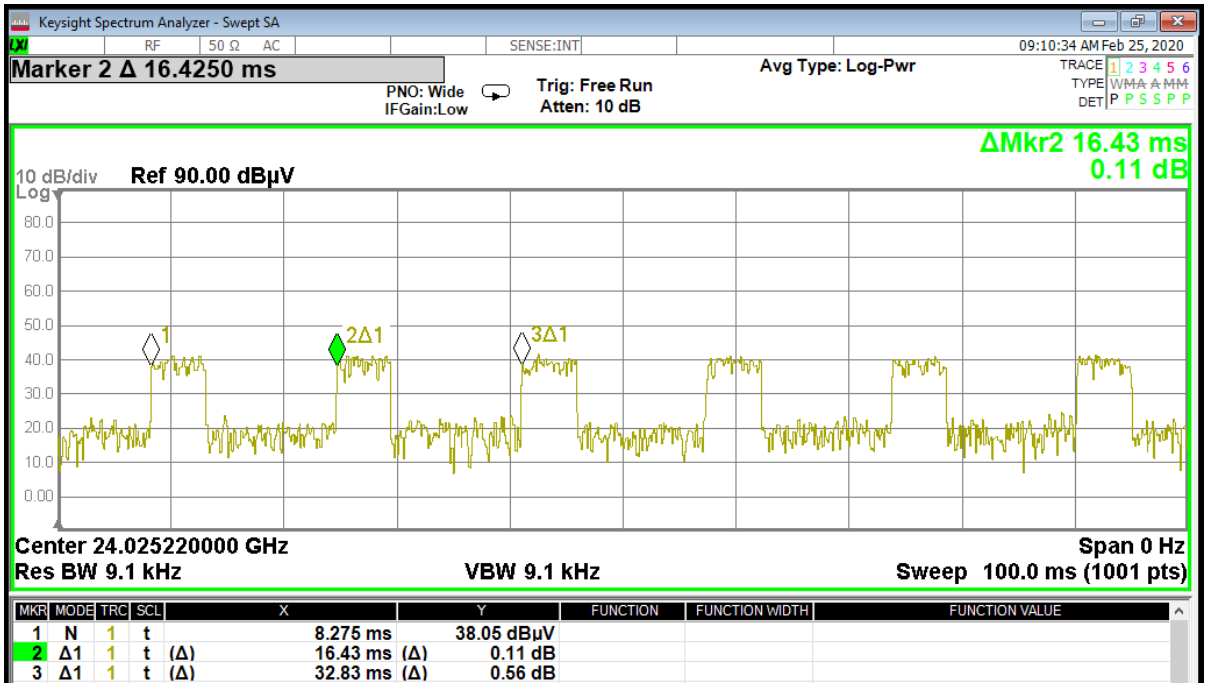

Figure 2 - Period = 16.43 ms

Duty cycle = 4.90 / 16.43 = 29.8 %
= -10.51 dB (field strength) =-5.26 dB (power)

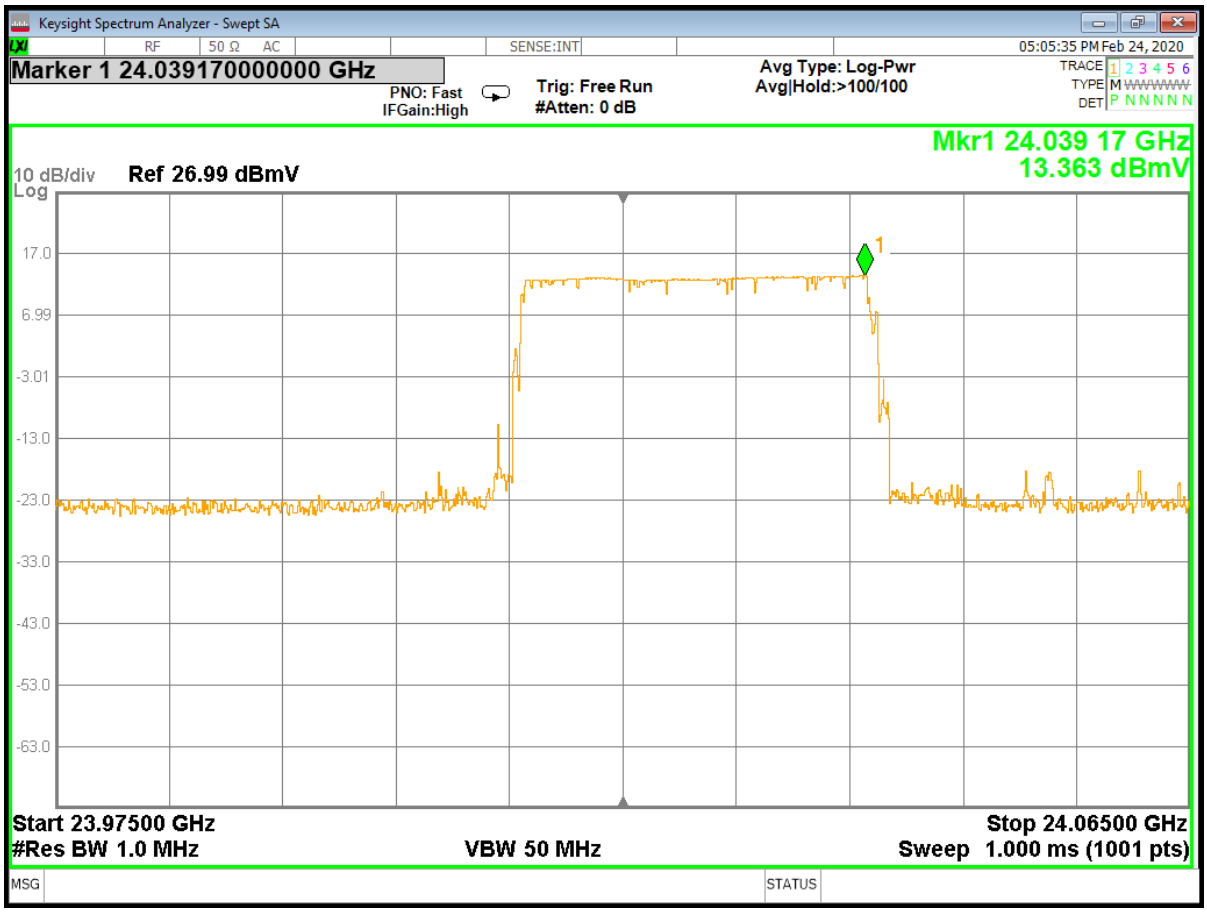

Figure 3 - Analyzer Measurement – Fundamental, Low Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

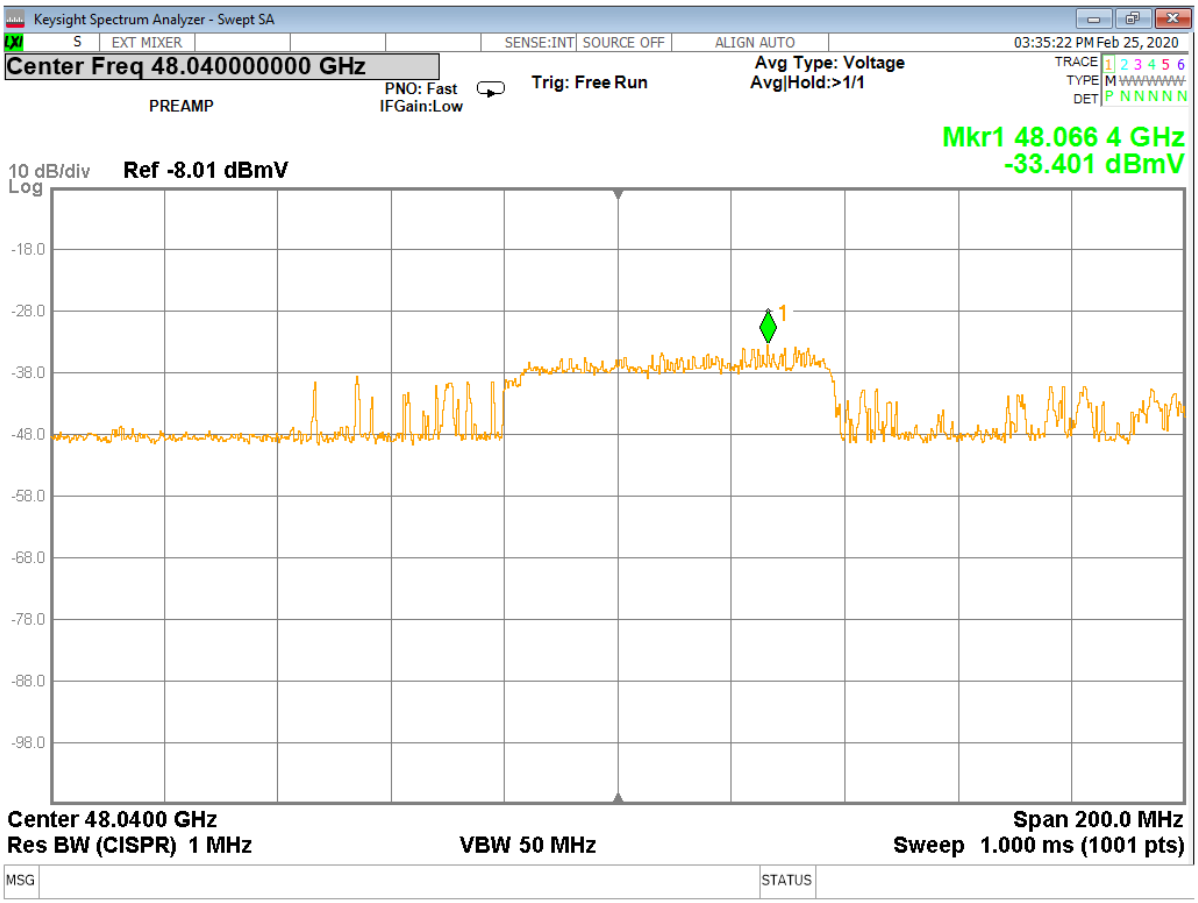

Figure 4 - Analyzer Measurement – 2nd Harmonic, Low Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

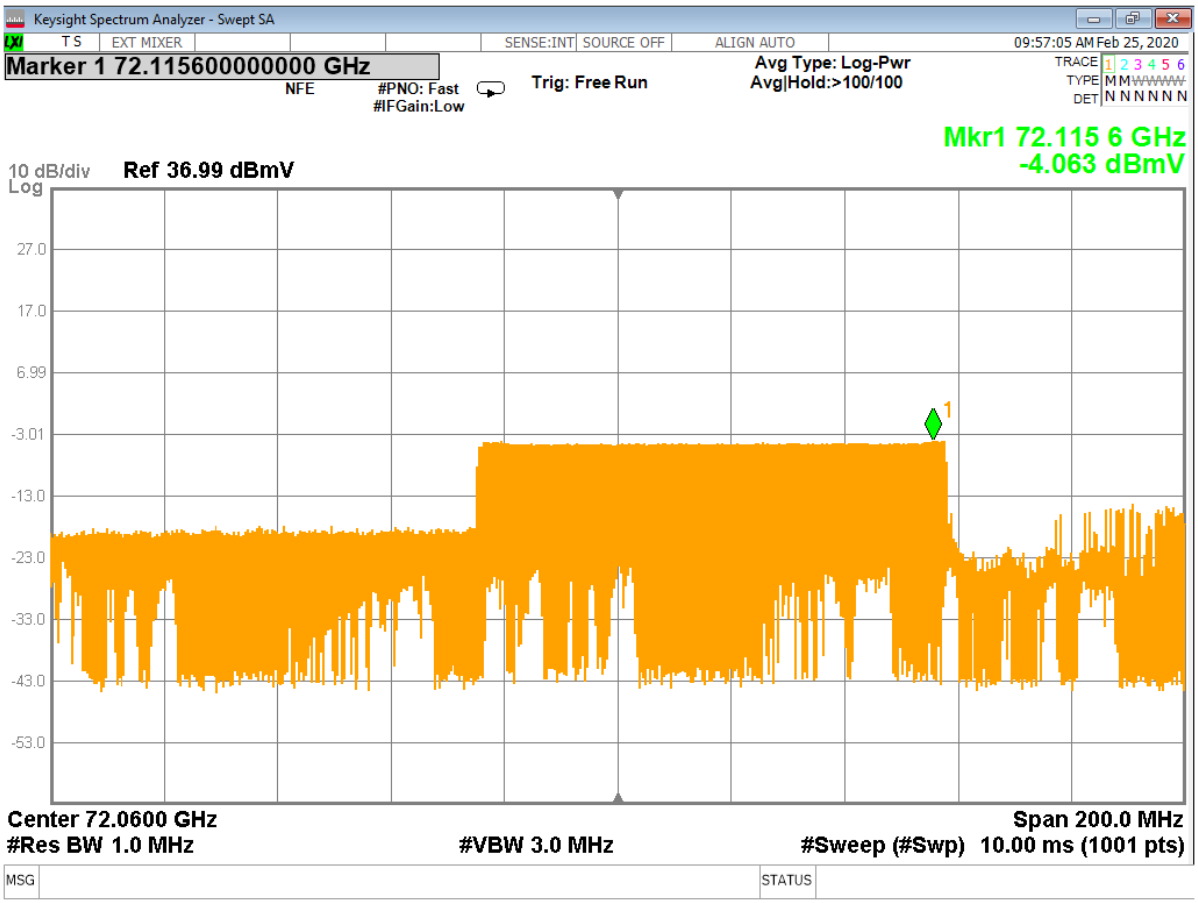

Figure 5 - Analyzer Measurement – 3rd Harmonic, Low Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

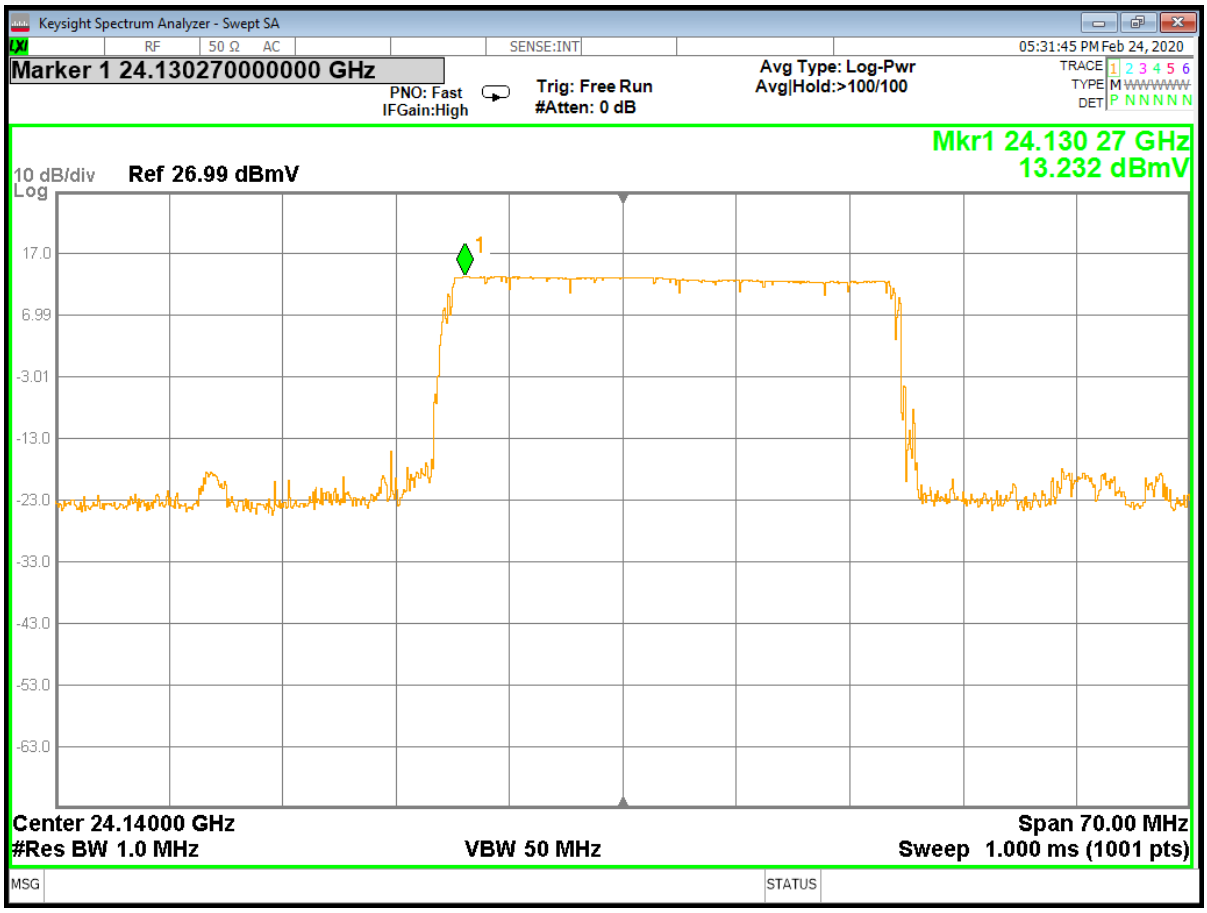

Figure 6 - Analyzer Measurement – Fundamental, Mid Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

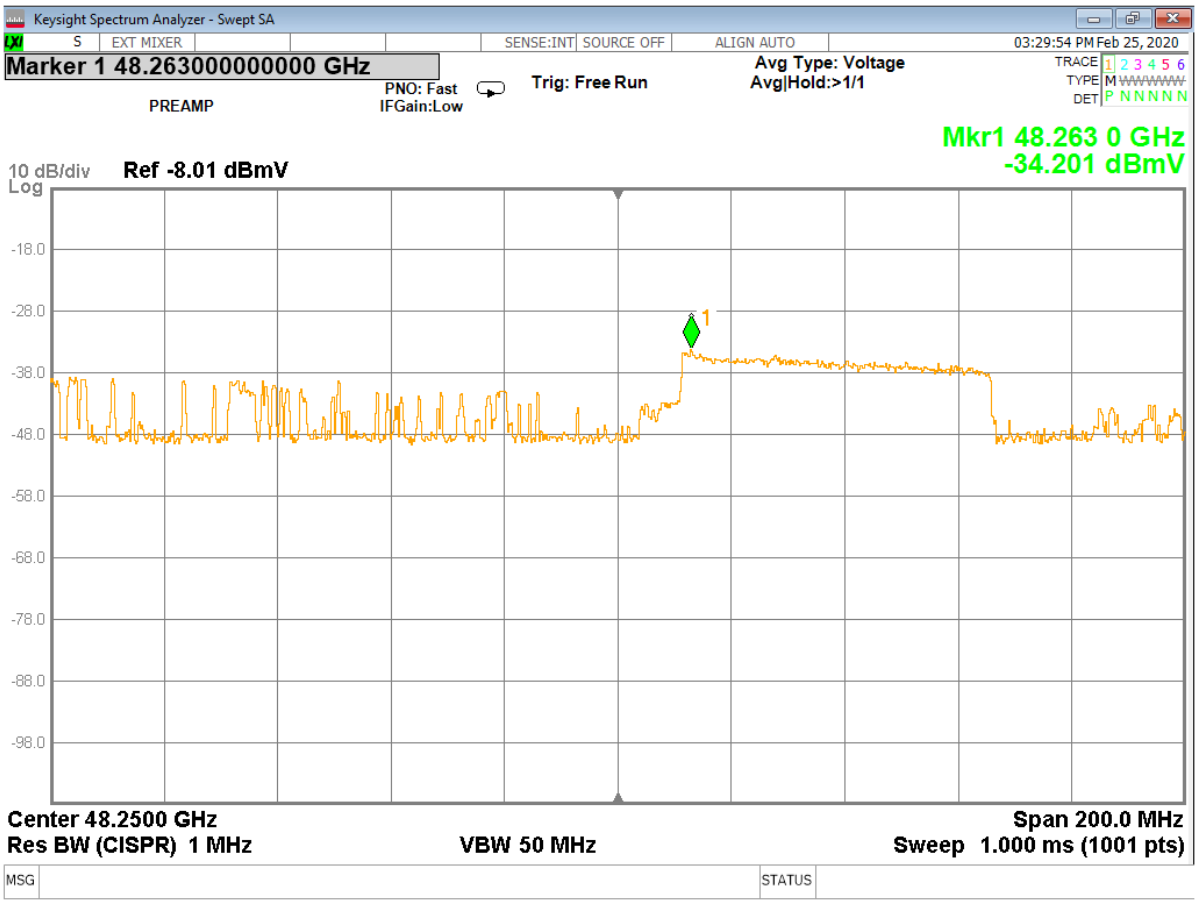

Figure 7 - Analyzer Measurement – 2nd Harmonic, Mid Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

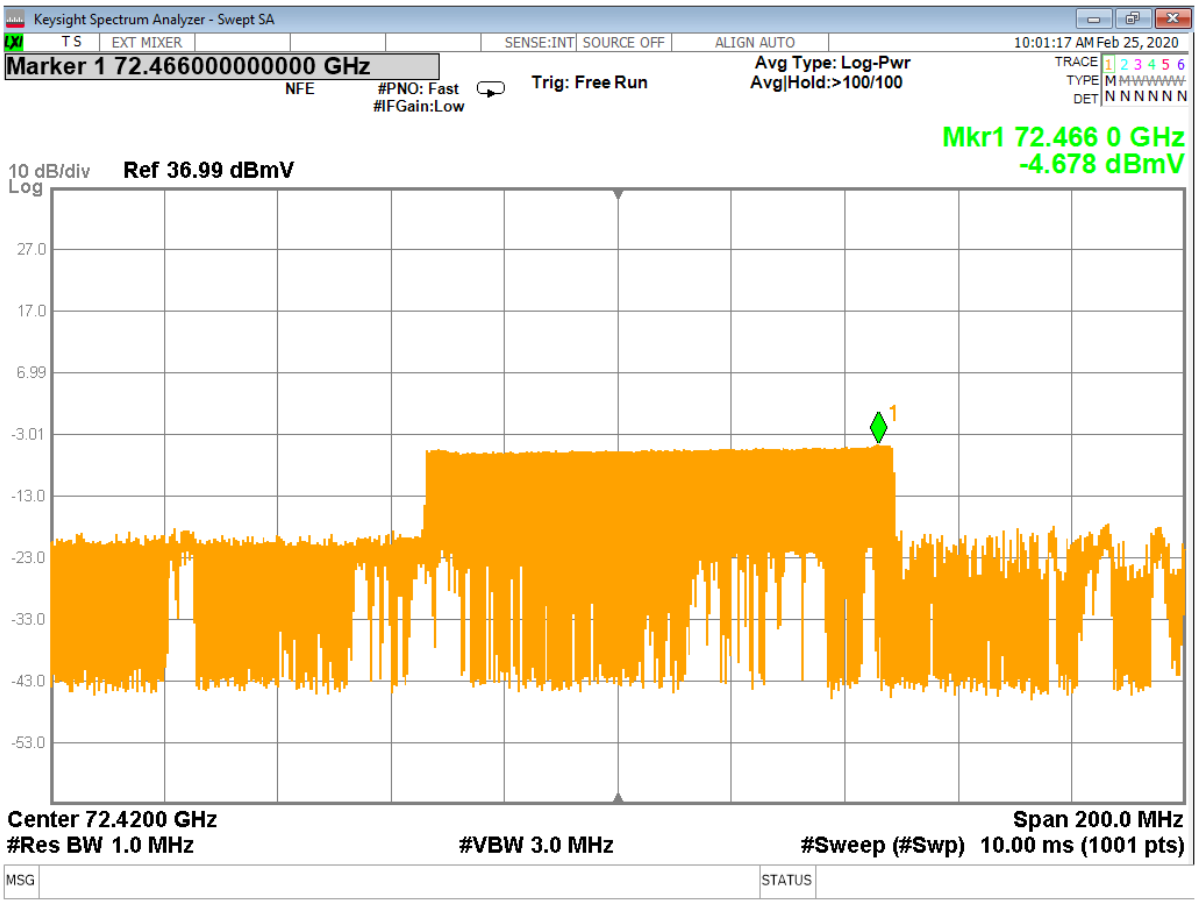

Figure 8 - Analyzer Measurement – 3rd Harmonic, Mid Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

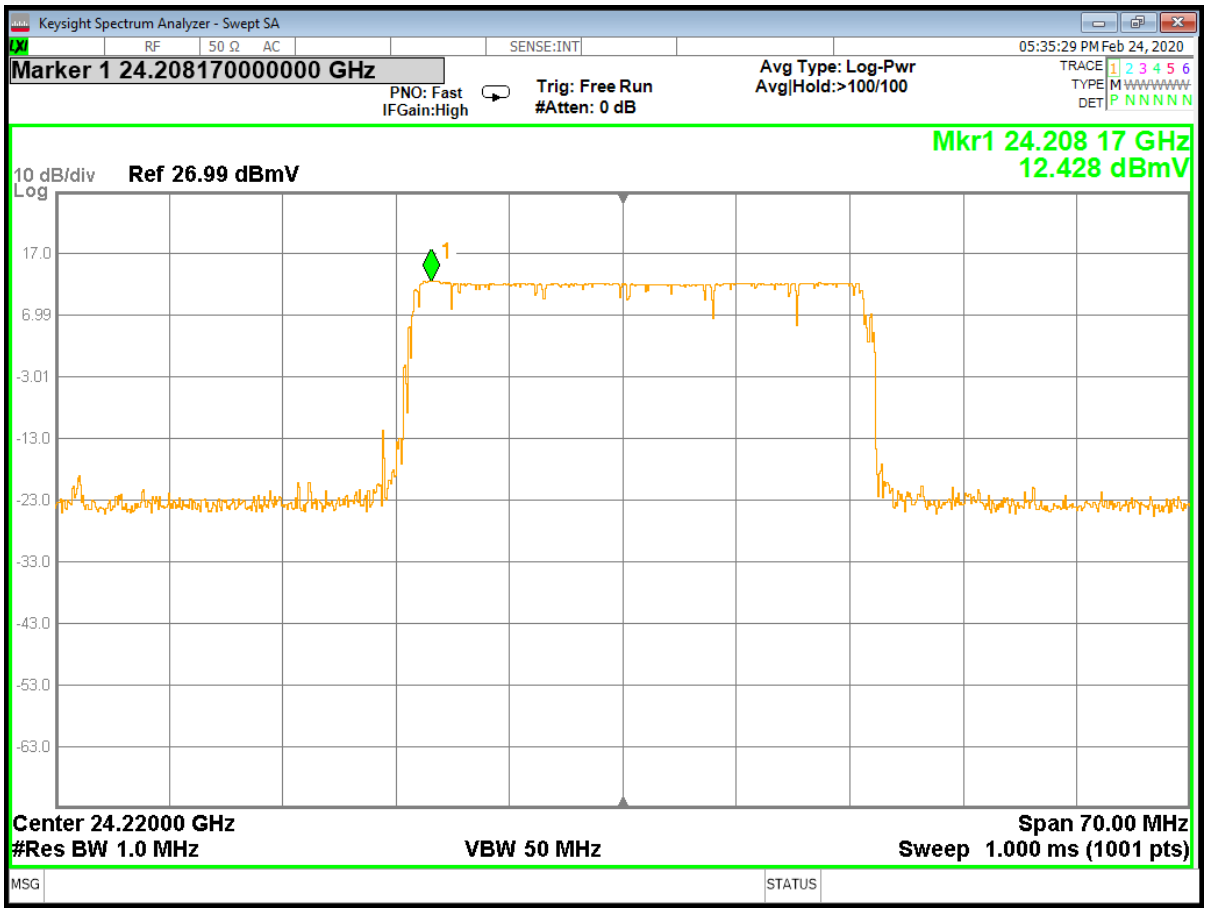

Figure 9 - Analyzer Measurement – Fundamental, High Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

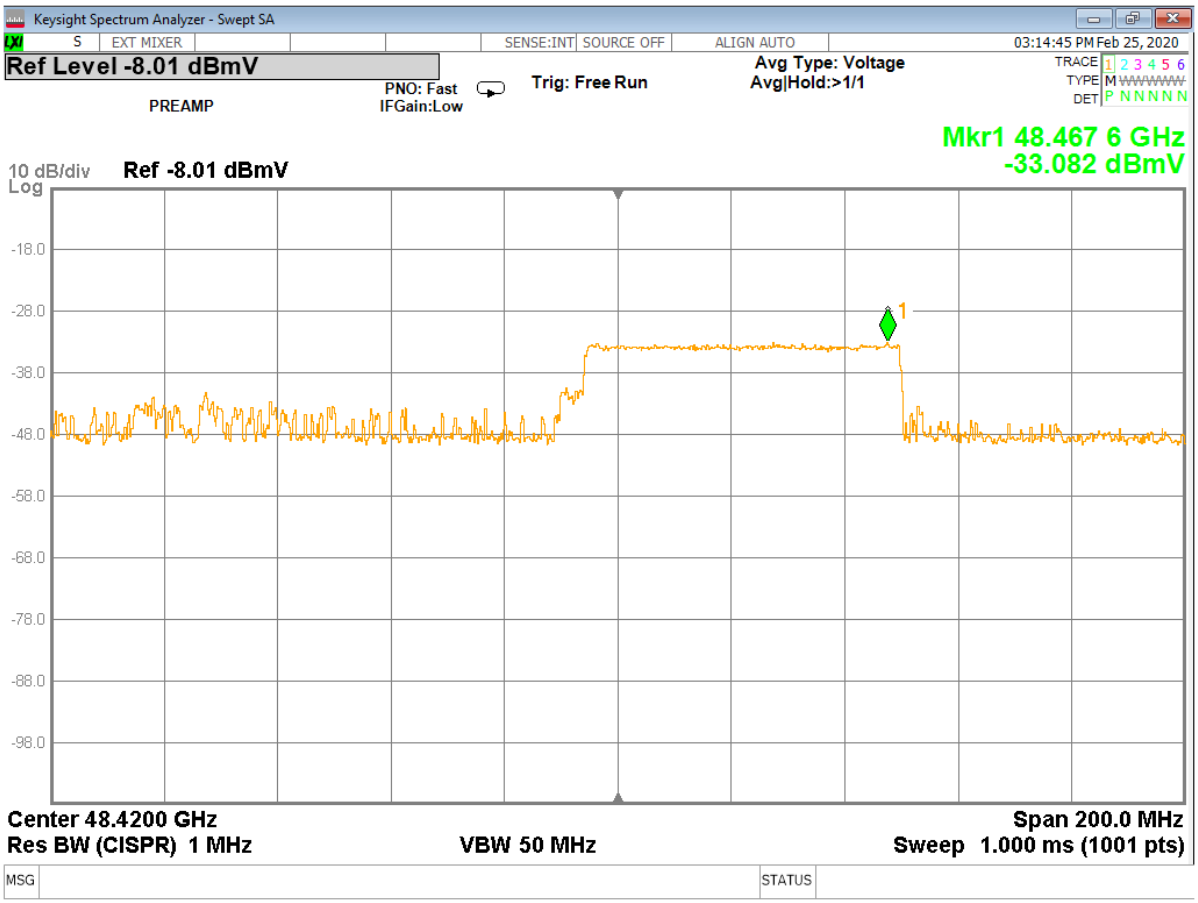

Figure 10 - Analyzer Measurement – 2nd Harmonic, High Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

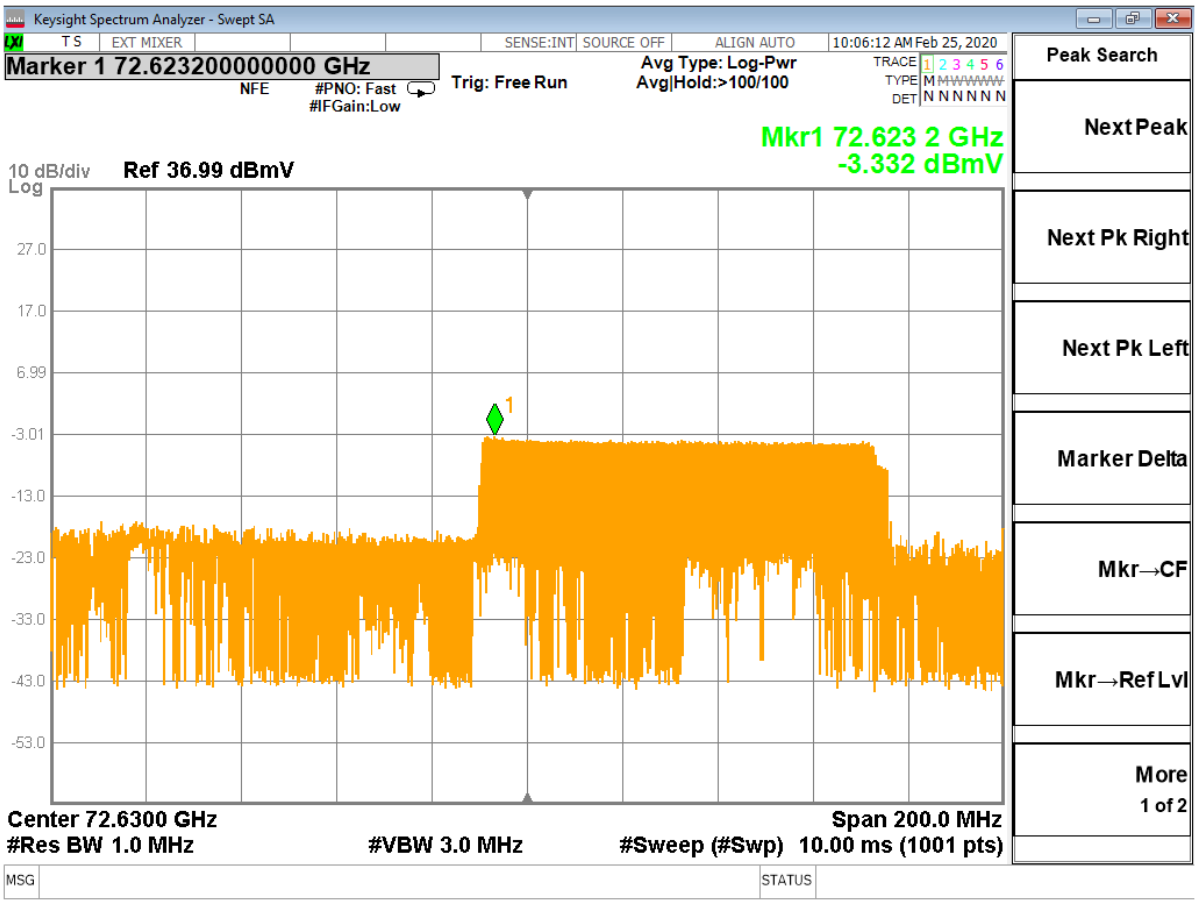

Figure 11 - Analyzer Measurement – 3rd Harmonic, High Channel (24 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

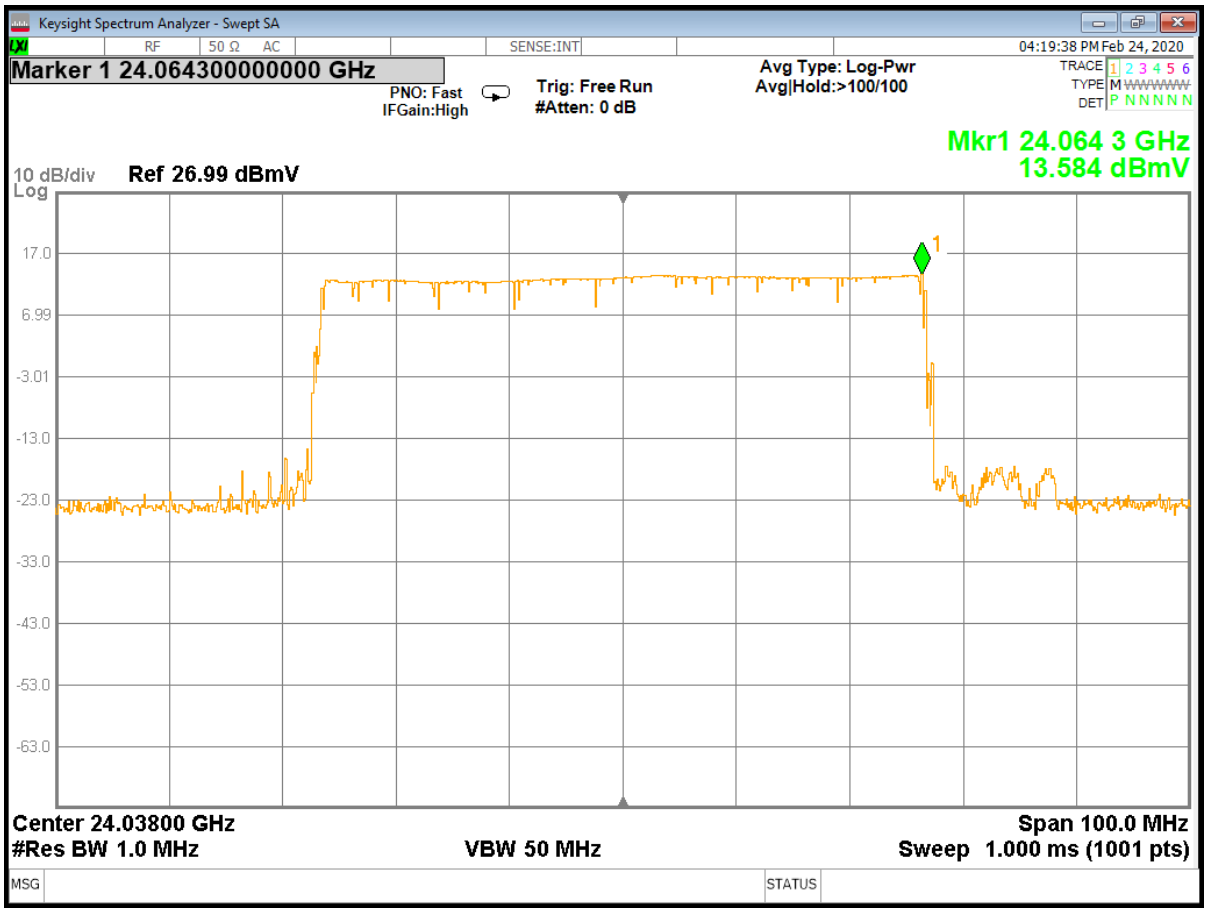

Figure 12 - Analyzer Measurement – Fundamental, Low Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Figure 13 - Analyzer Measurement – 2nd Harmonic, Low Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

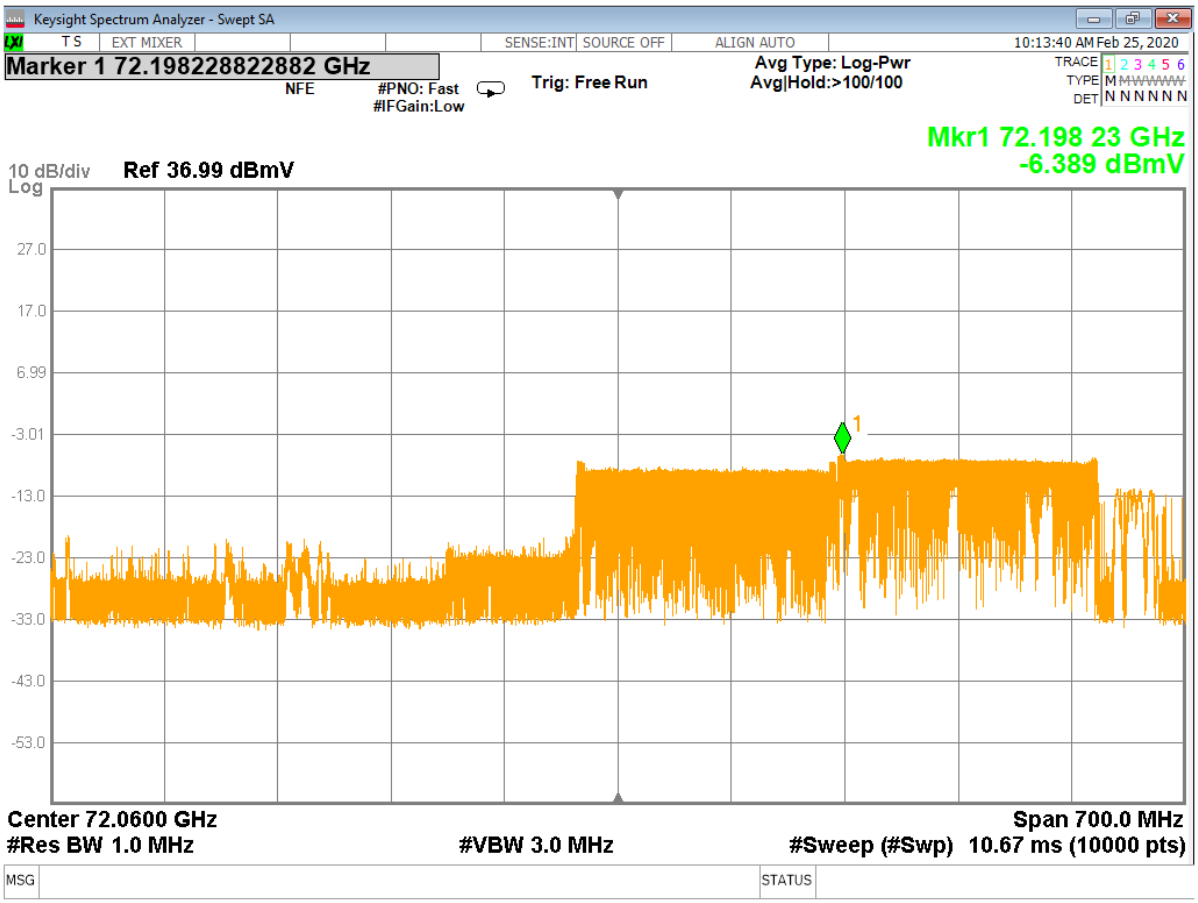

Figure 14 - Analyzer Measurement – 3rd Harmonic, Low Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

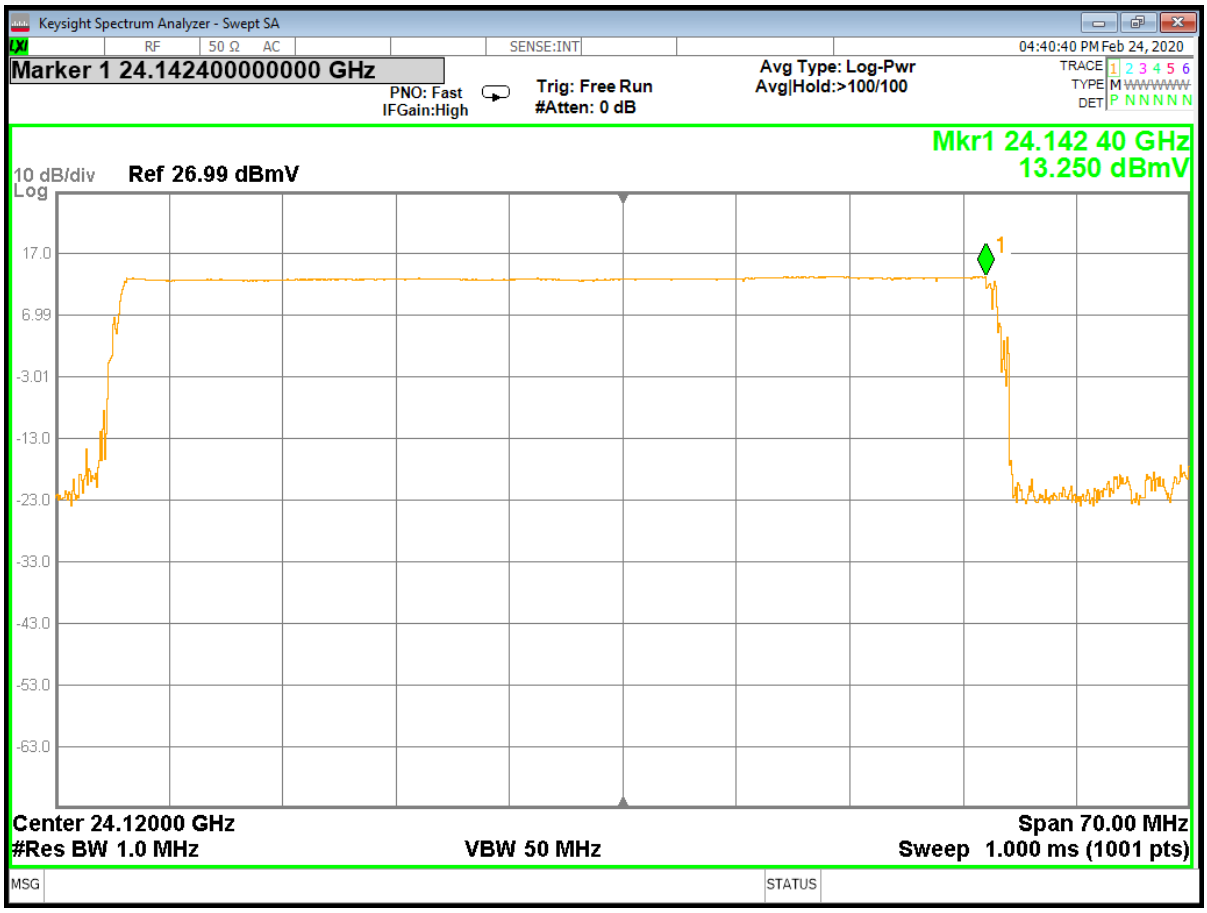

Figure 15 - Analyzer Measurement – Fundamental, Mid Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

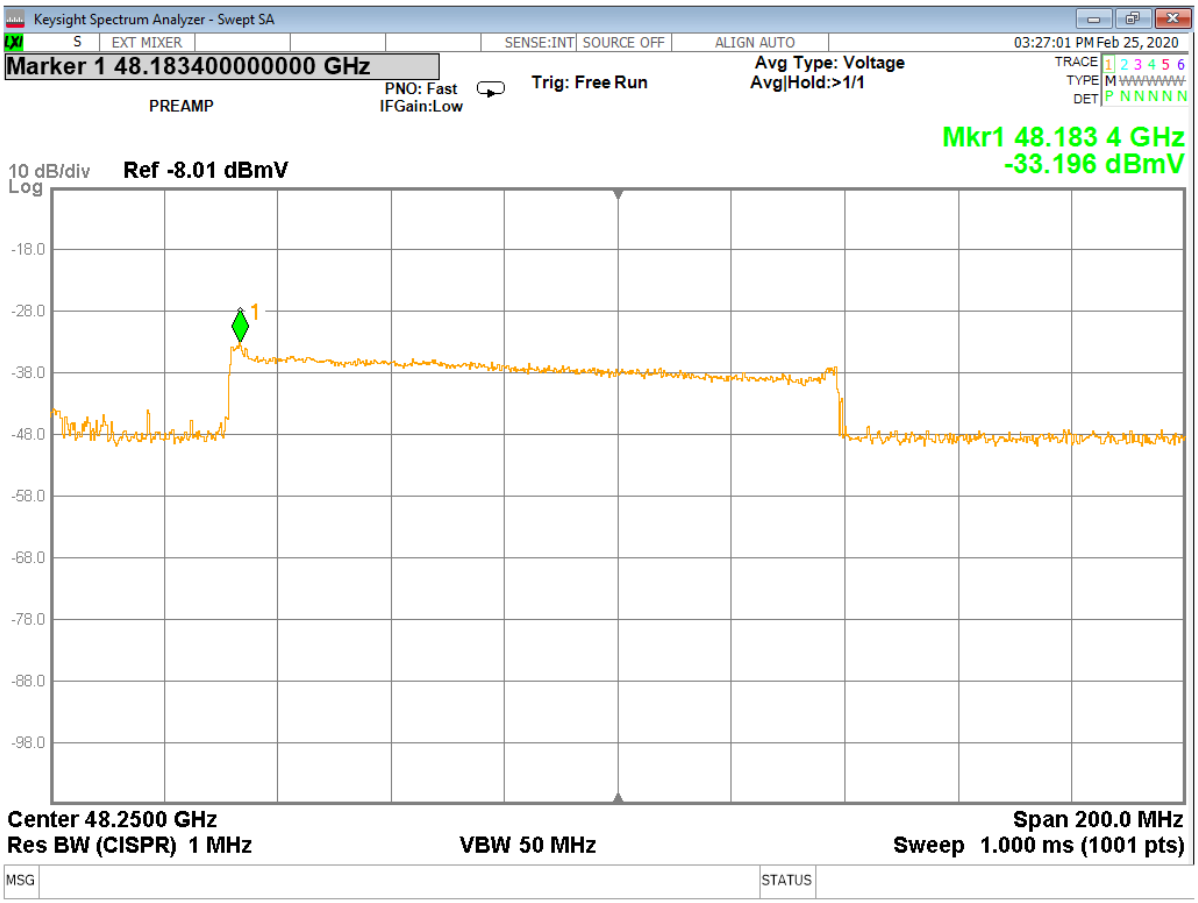

Figure 16 - Analyzer Measurement – 2nd Harmonic, Mid Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

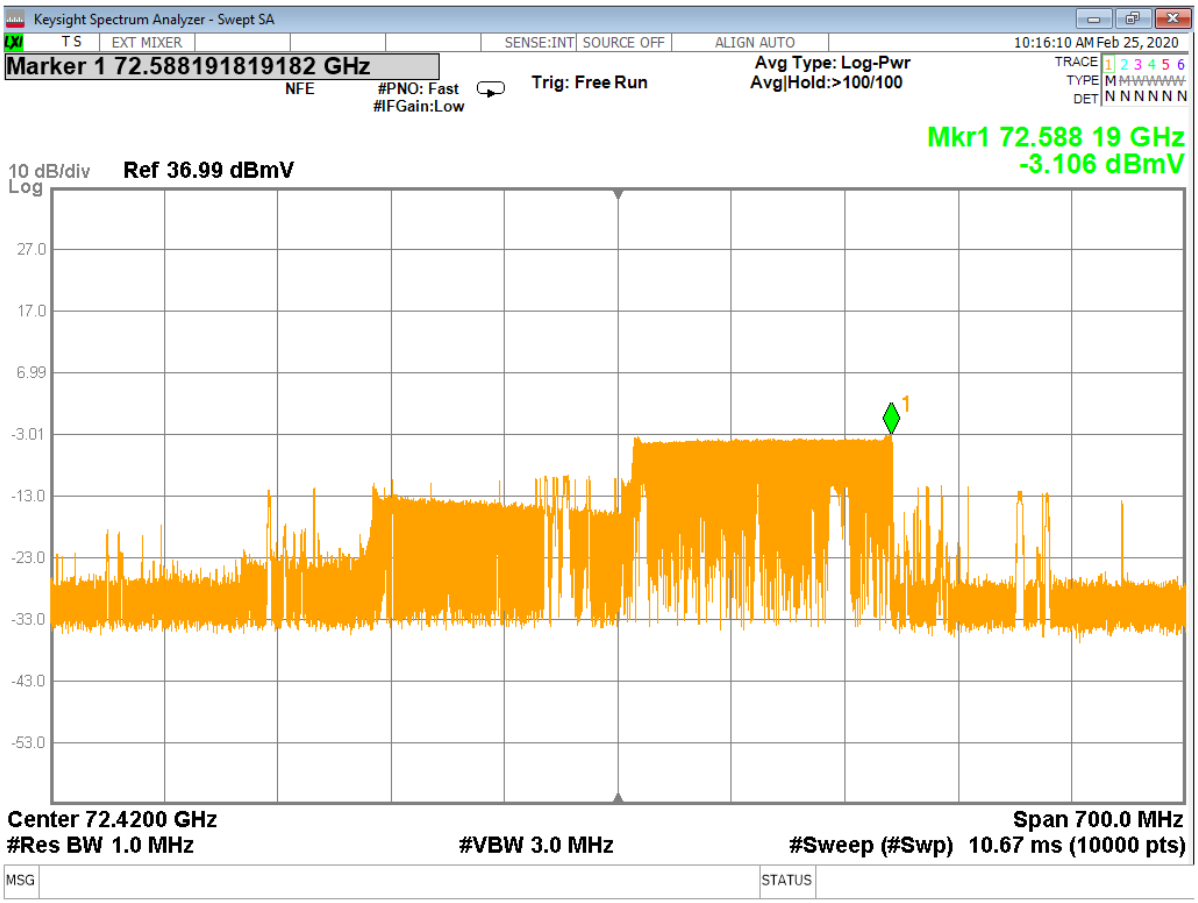

Figure 17 - Analyzer Measurement – 3rd Harmonic, Mid Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

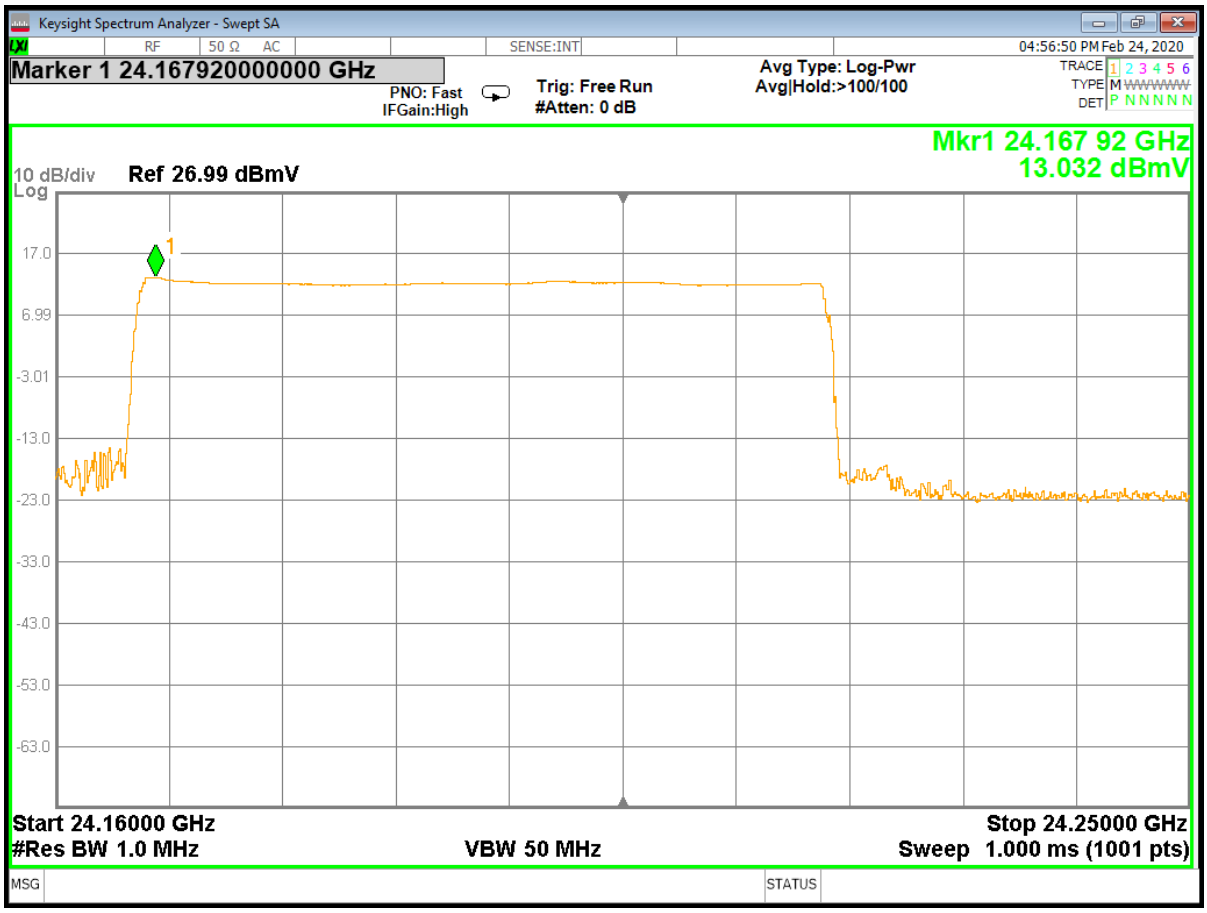

Figure 18 - Analyzer Measurement – Fundamental, High Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Figure 19 - Analyzer Measurement – 2nd Harmonic, High Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

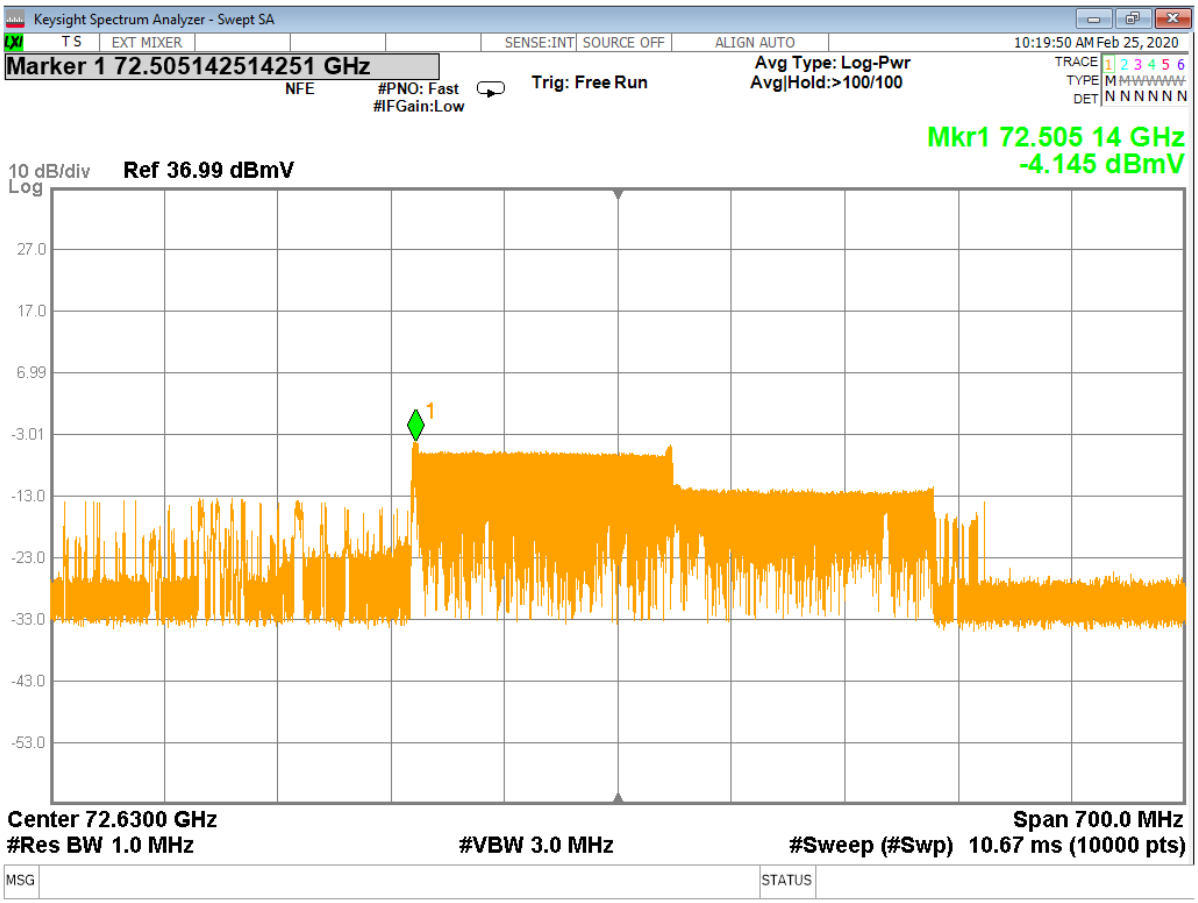

Figure 20 - Analyzer Measurement – 3rd Harmonic, High Channel (48 MHz) (swept frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

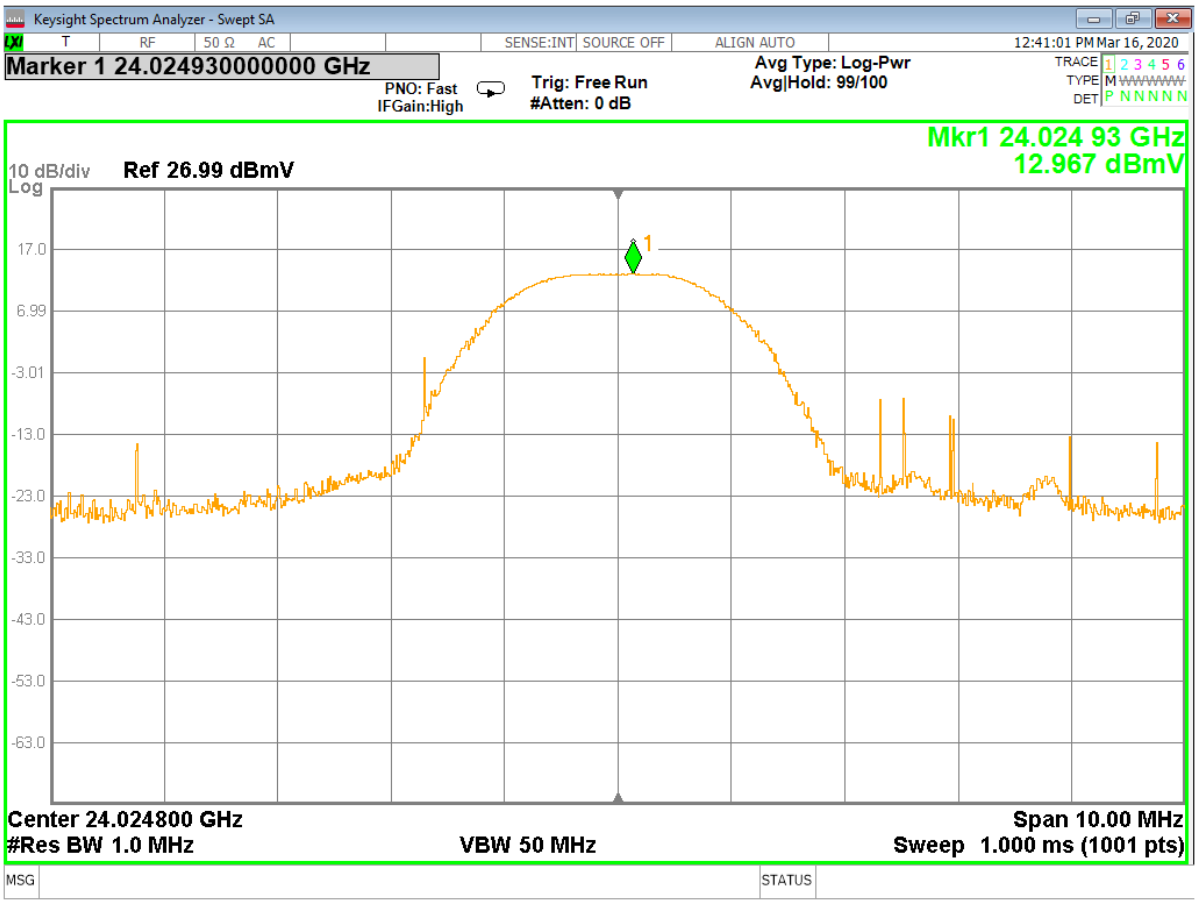

Figure 21 - Analyzer Measurement – Fundamental, Low Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

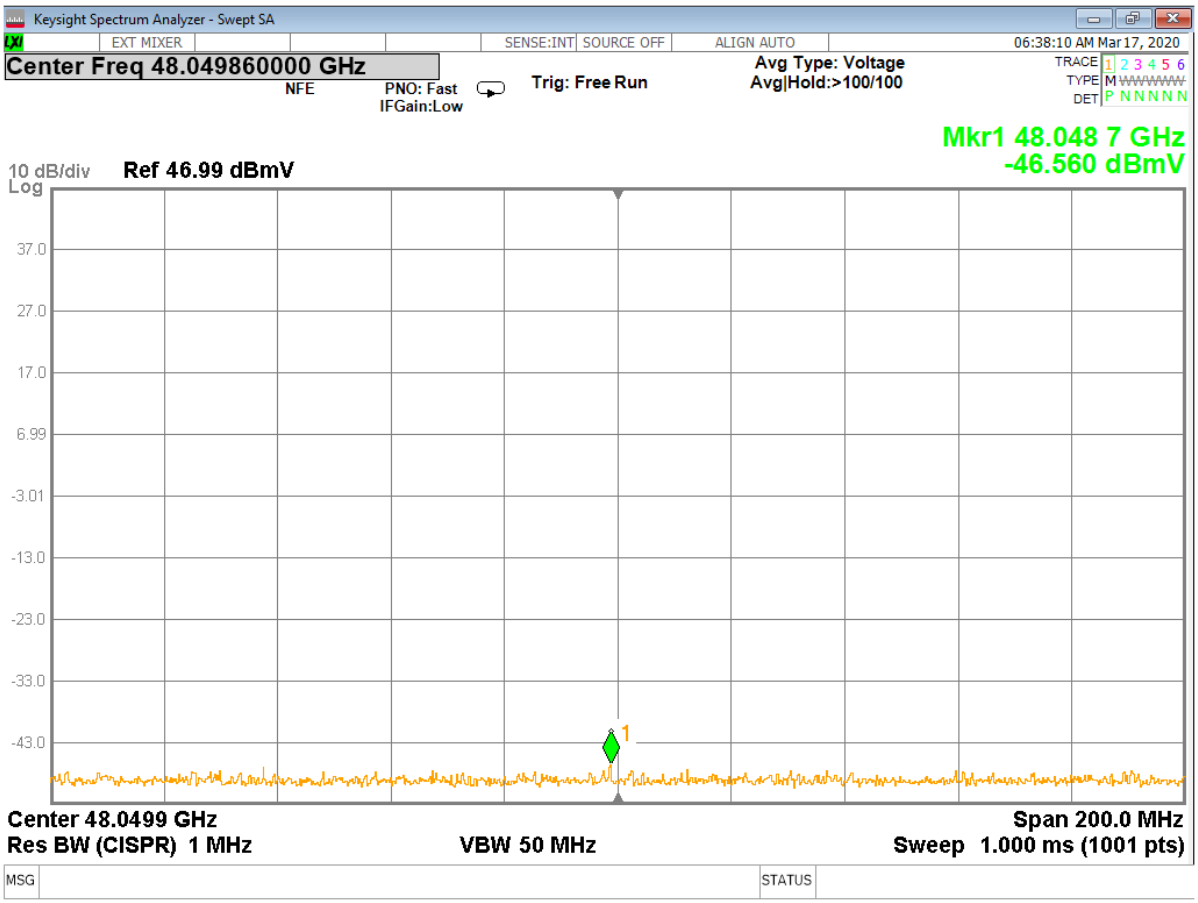

Figure 22 - Analyzer Measurement – 2nd Harmonic, Low Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

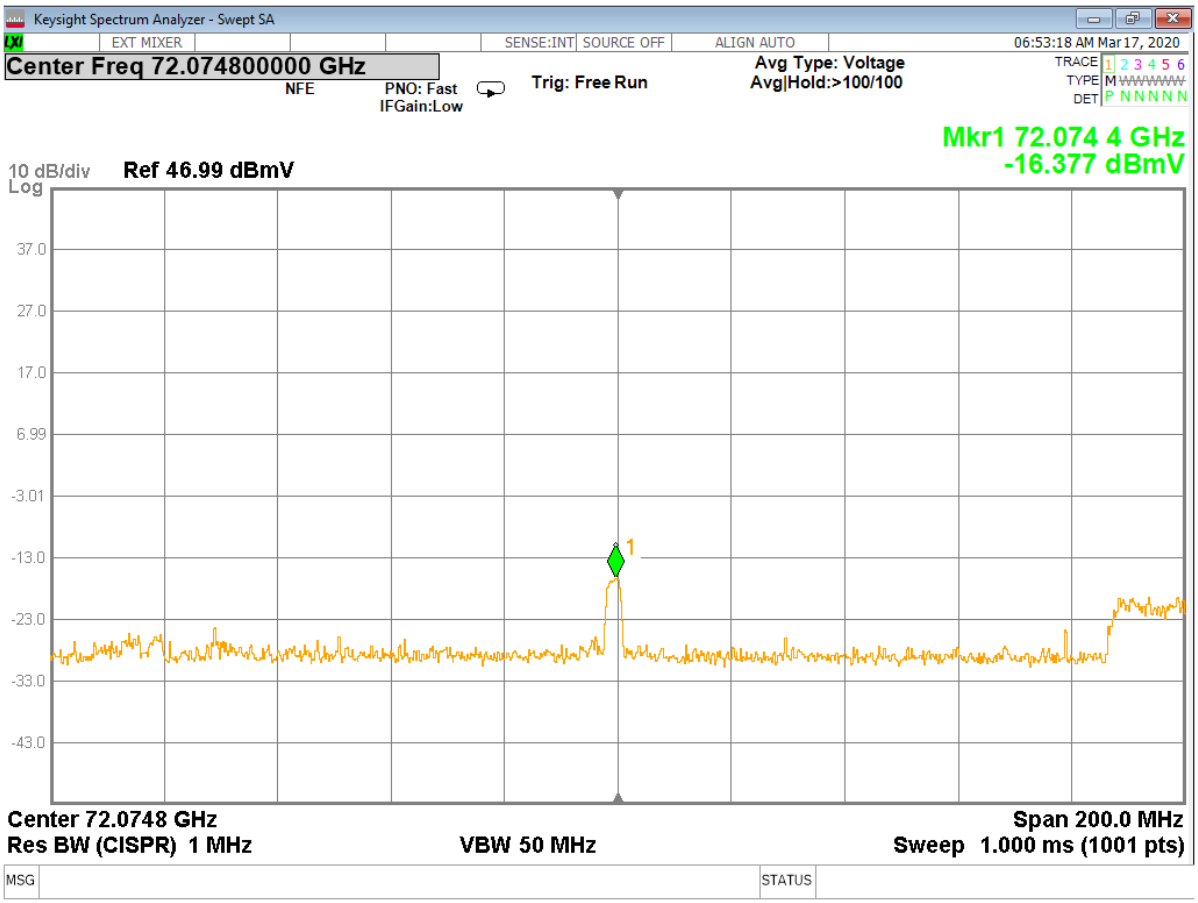

Figure 23 - Analyzer Measurement – 3rd Harmonic, Low Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

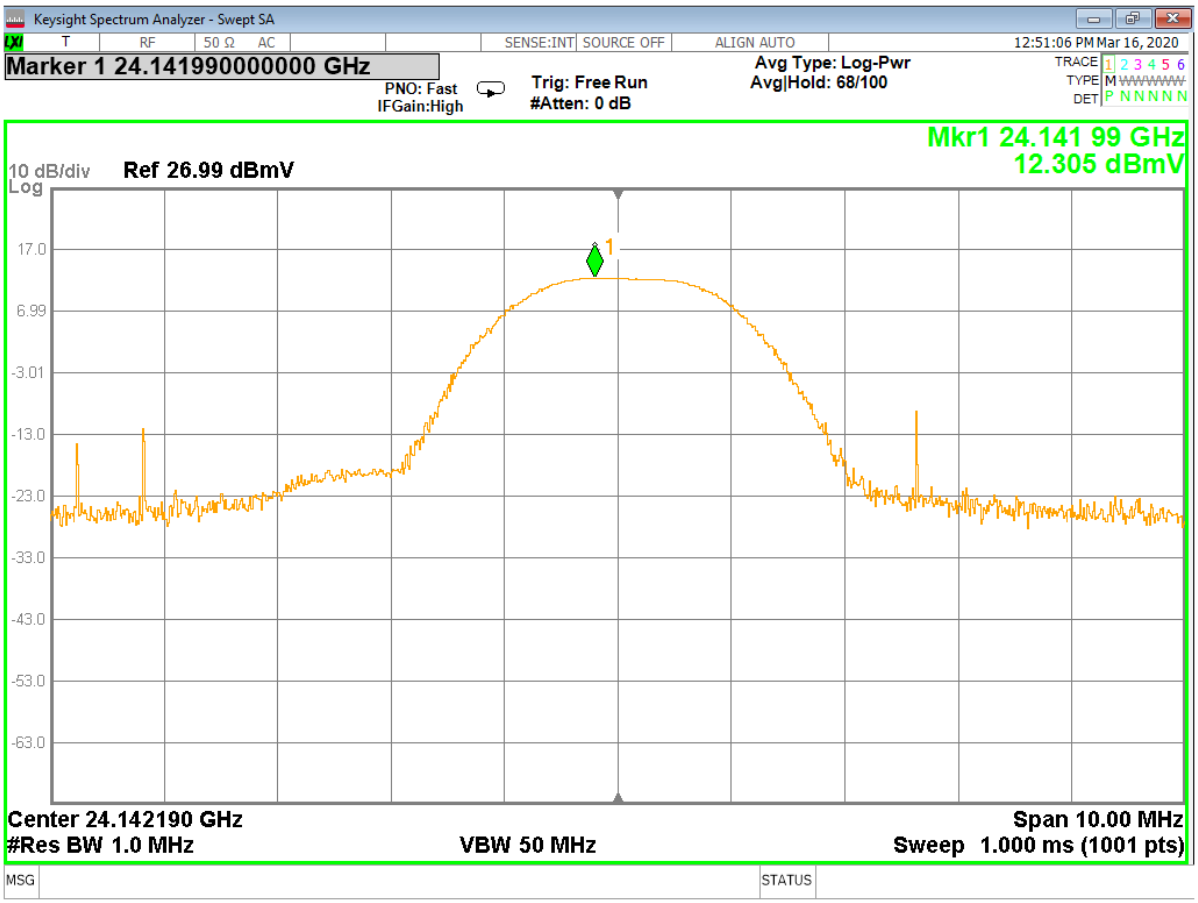

Figure 24 - Analyzer Measurement – Fundamental, Mid Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

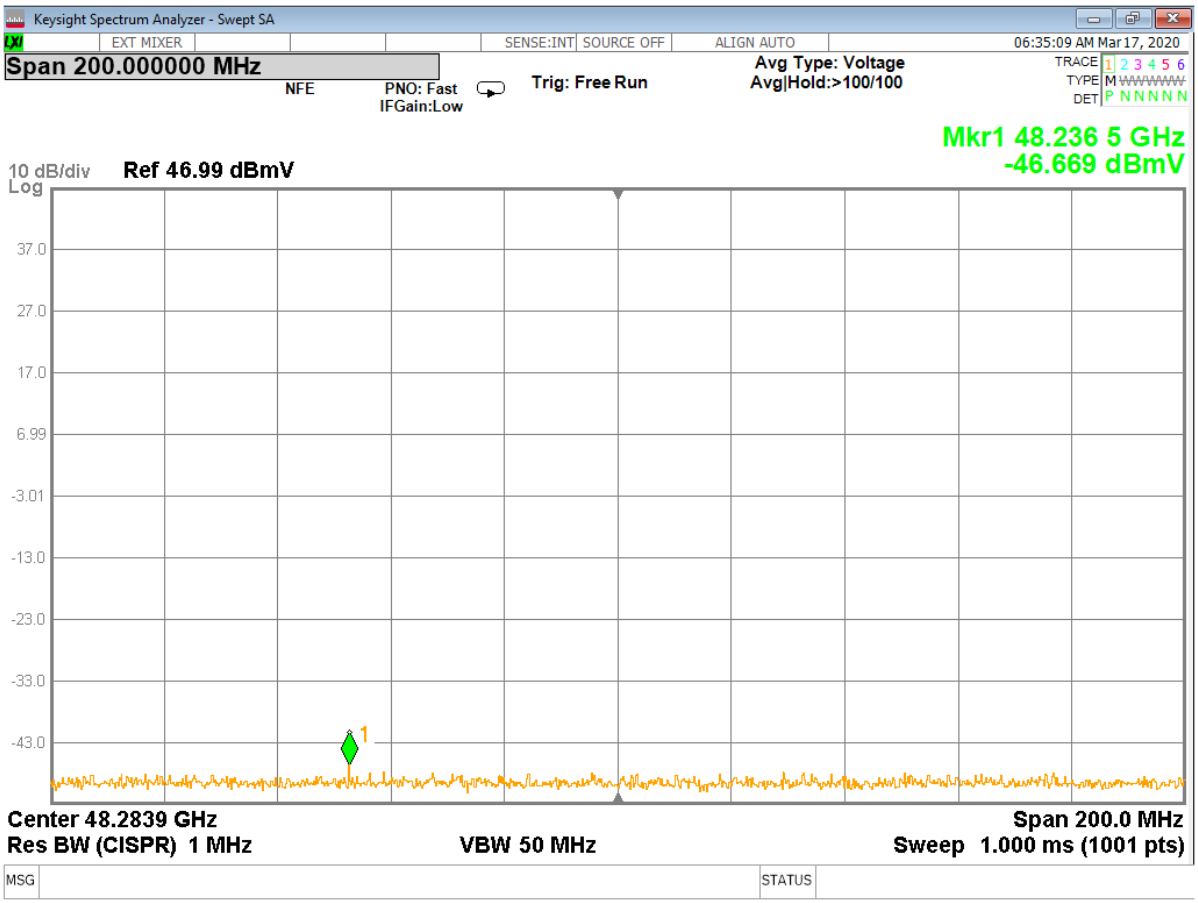

Figure 25 - Analyzer Measurement – 2nd Harmonic, Mid Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

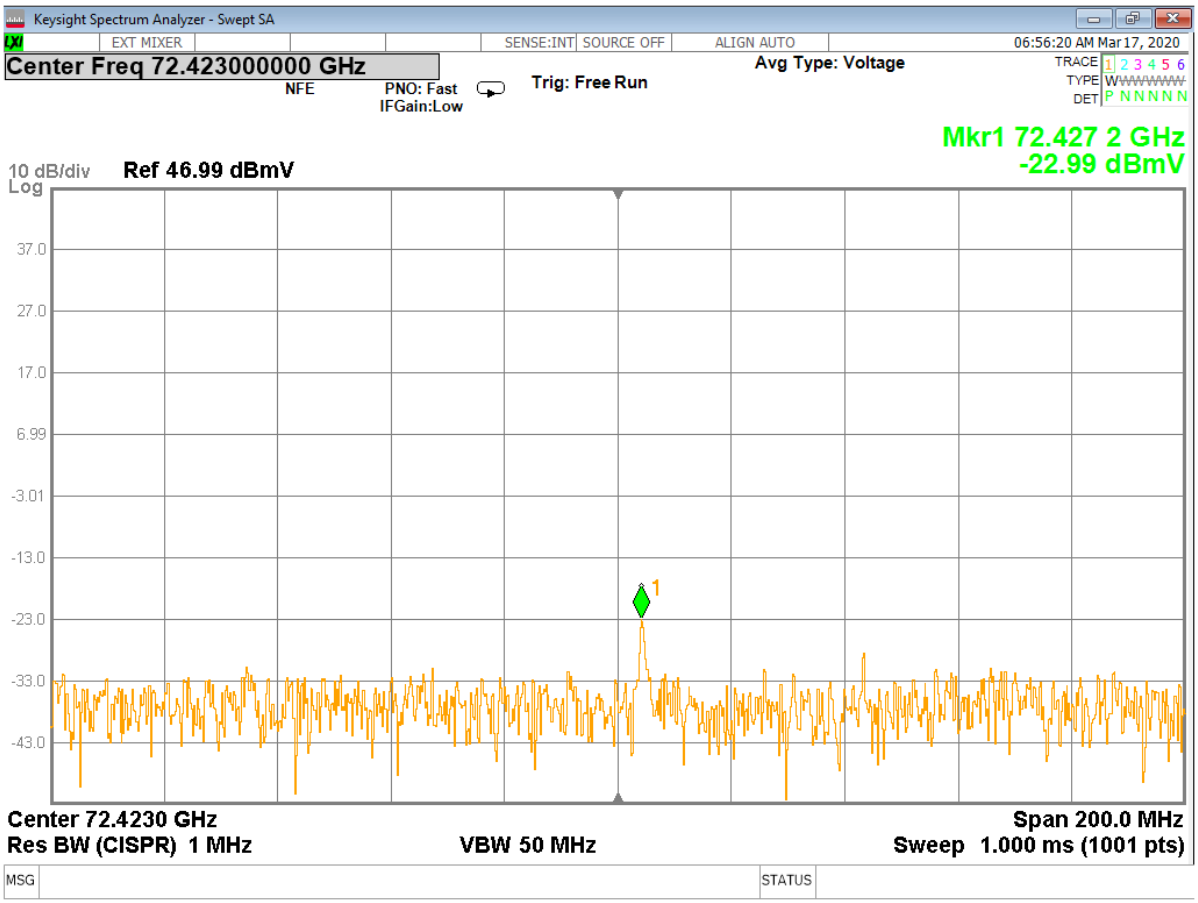

Figure 26 - Analyzer Measurement – 3rd Harmonic, Mid Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

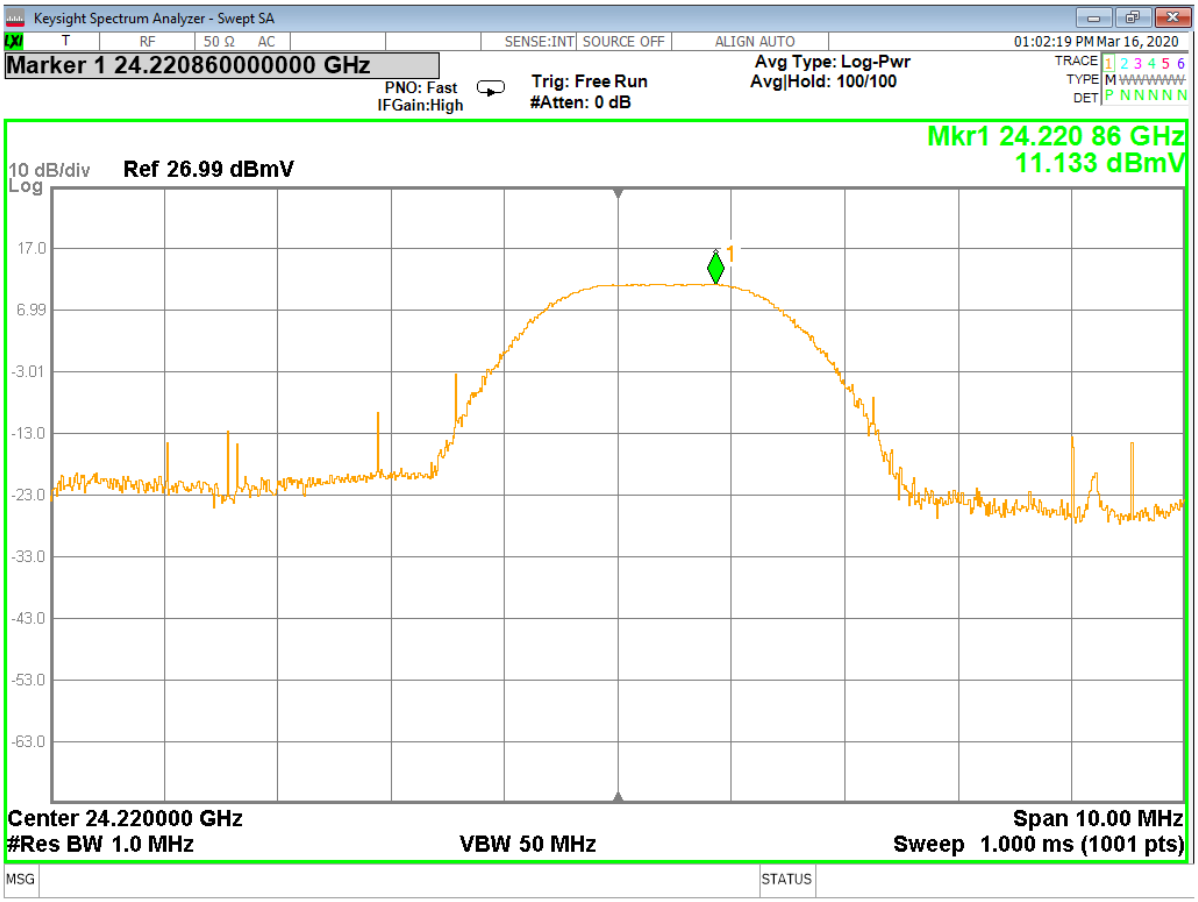

Figure 27 - Analyzer Measurement – Fundamental, High Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

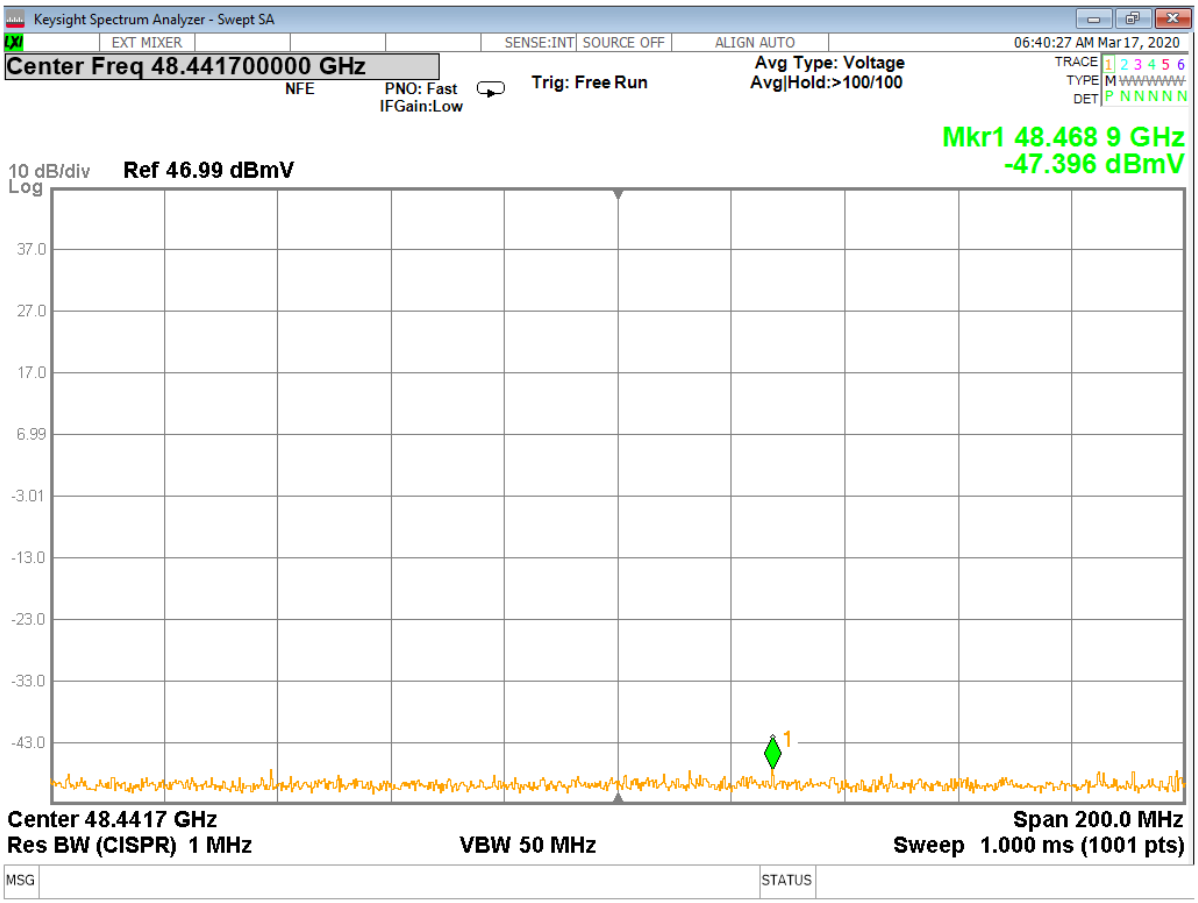

Figure 28 - Analyzer Measurement – 2nd Harmonic, High Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

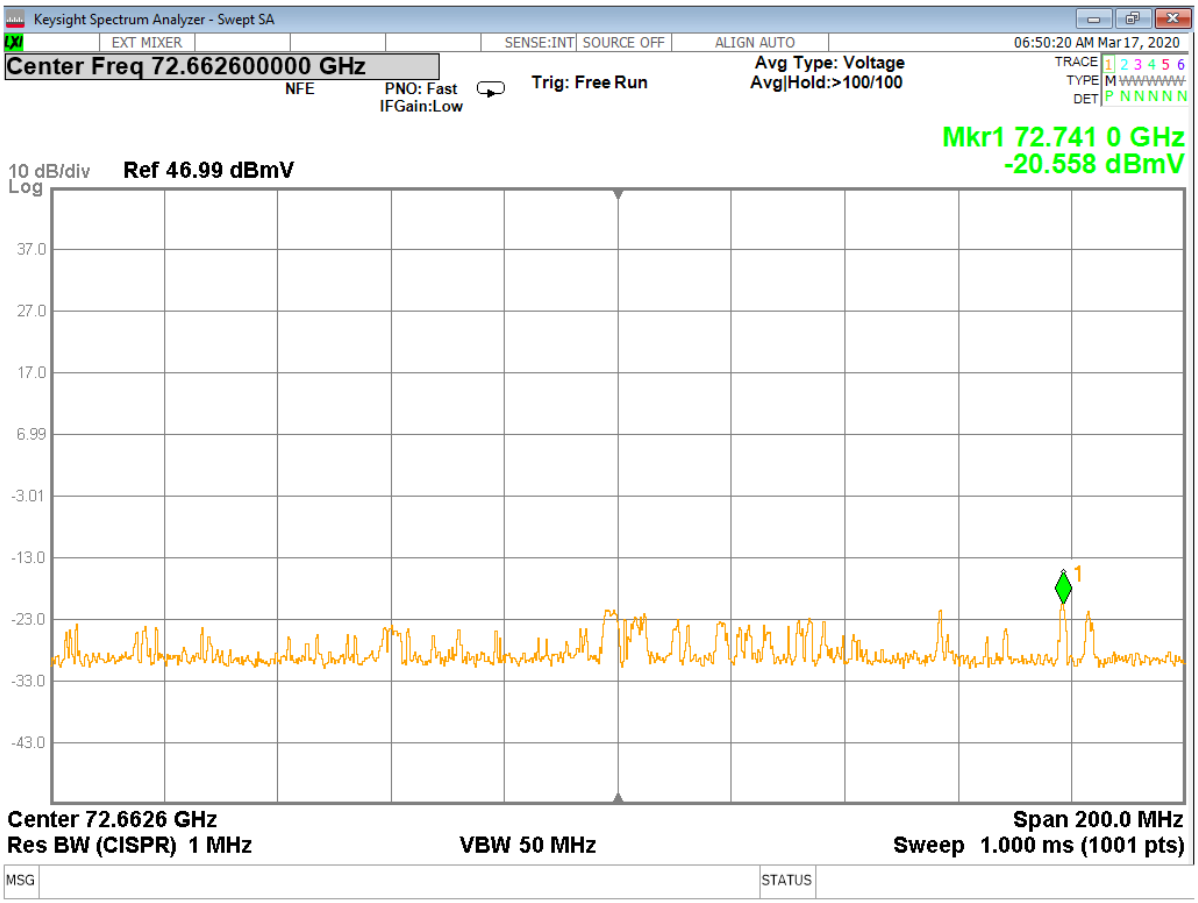

Figure 29 - Analyzer Measurement – 3rd Harmonic, High Channel (Single Frequency)

Uncorrected measurement as recorded on spectrum analyzer

Note: the plot may contain some additional mixing products from the use of an RF mixer to measure at these frequencies.

3.2 Band edges and Occupied Bandwidth

Test Method: ANSI C63.10-2013, Section(s) 6.10.5, 6.10.6

3.2.1 Limits of bandedge measurements:

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.

The limit from FCC Part 15.209 for all frequencies above 960 MHz is 500 µV/m at 3m.

500 µV/m = 20log (500) = 54 dBµV/m = 54 – 60 = -6 dBmV/m at 3m average

Peak limit = average limit + 20 dB = 14 dBmV/m at 3m peak

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

3.2.2 Test procedures:

The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 1MHz. 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.

Measurements were performed as radiated measurements in the same manner as Section 3.1 of this report.

The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW. The occupied bandwidth was measured using the spectrum analyzers 99% occupied bandwidth setting.

3.2.3 Deviations from test standard:

No deviation.

3.2.4 Test setup:

All the measurements were done at 1m test distance.

3.2.5 EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.

Test results:

3.2.6 Band Edges

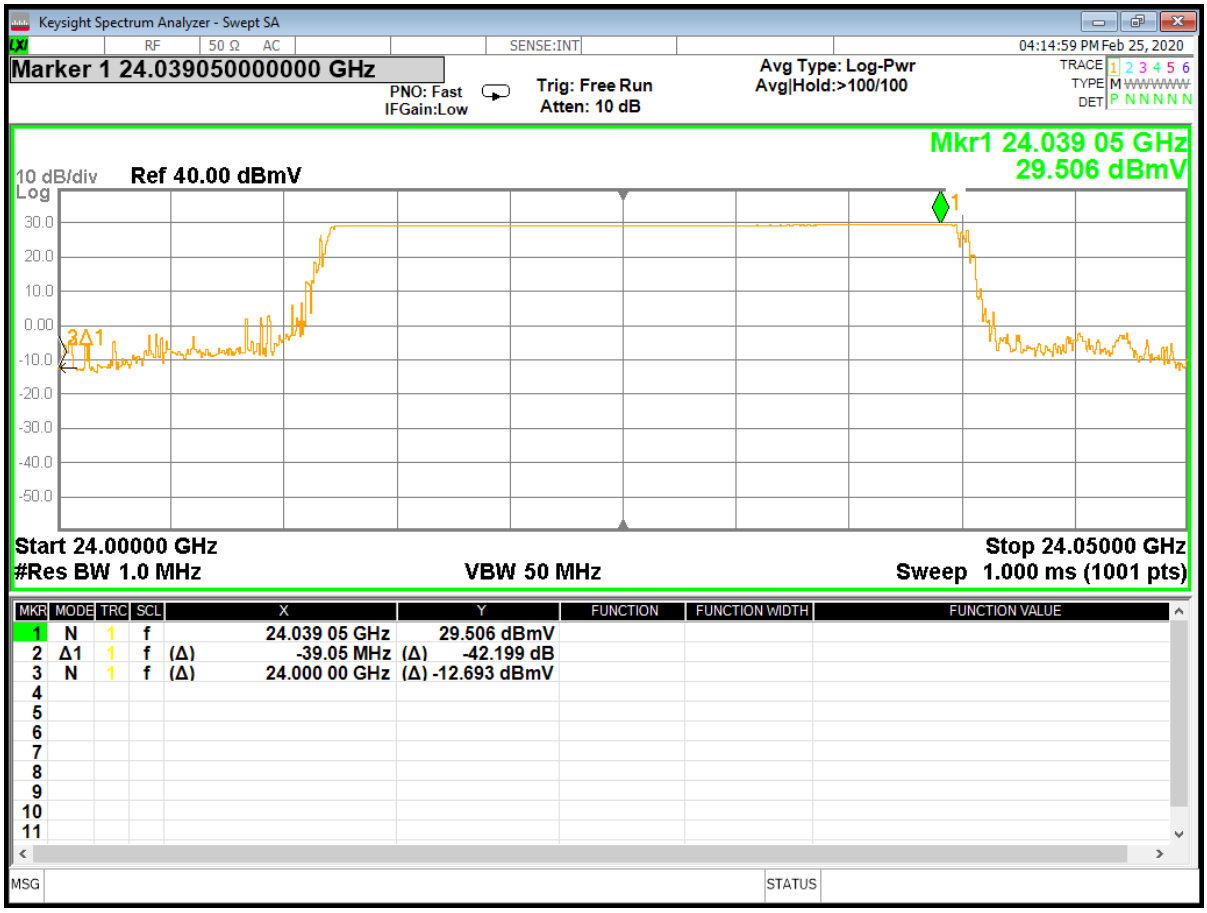

Figure 30 – Lower Band Edge (24 MHz) (swept frequency), 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

Low Band Edge Measurement at 24.25 GHz

Peak level at 24 GHz = -12.693 dBmV
Corrected Restricted Band Peak Level = -12.693 dBmV/m + 46.01 dB (corrections)
= 33.317 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 10.63 (dccf) =
=22.687 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05)+(-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

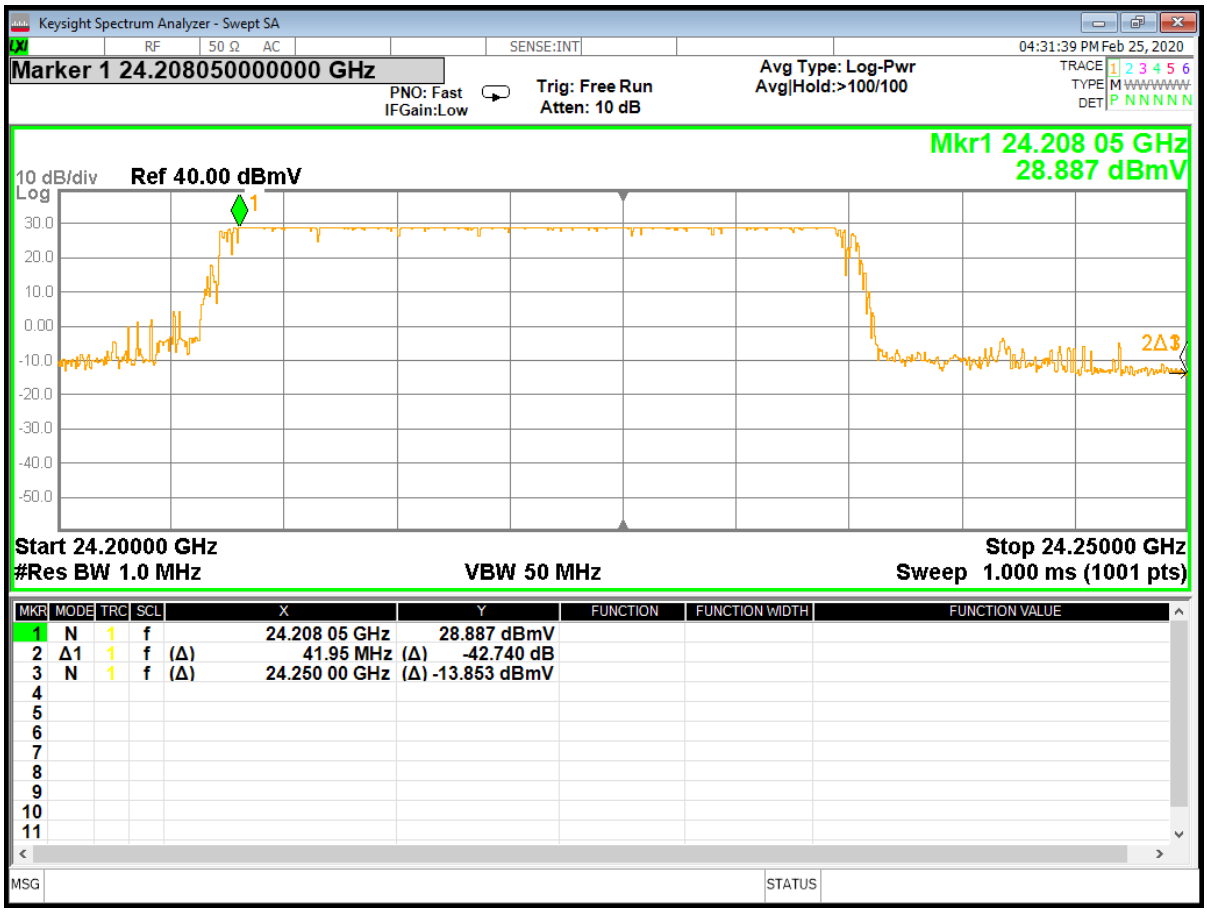

Figure 31 - Higher Band Edge (24 MHz) (swept frequency), 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

High Band Edge Measurement at 24.25 GHz

Peak level at 24.25 GHz = -13.853 dBmV
Corrected Restricted Band Peak Level = -13.853 dBmV/m + 46.01 dB (corrections)
= 32.157 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 10.63 (dccf) =
= 21.65 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05) + (-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

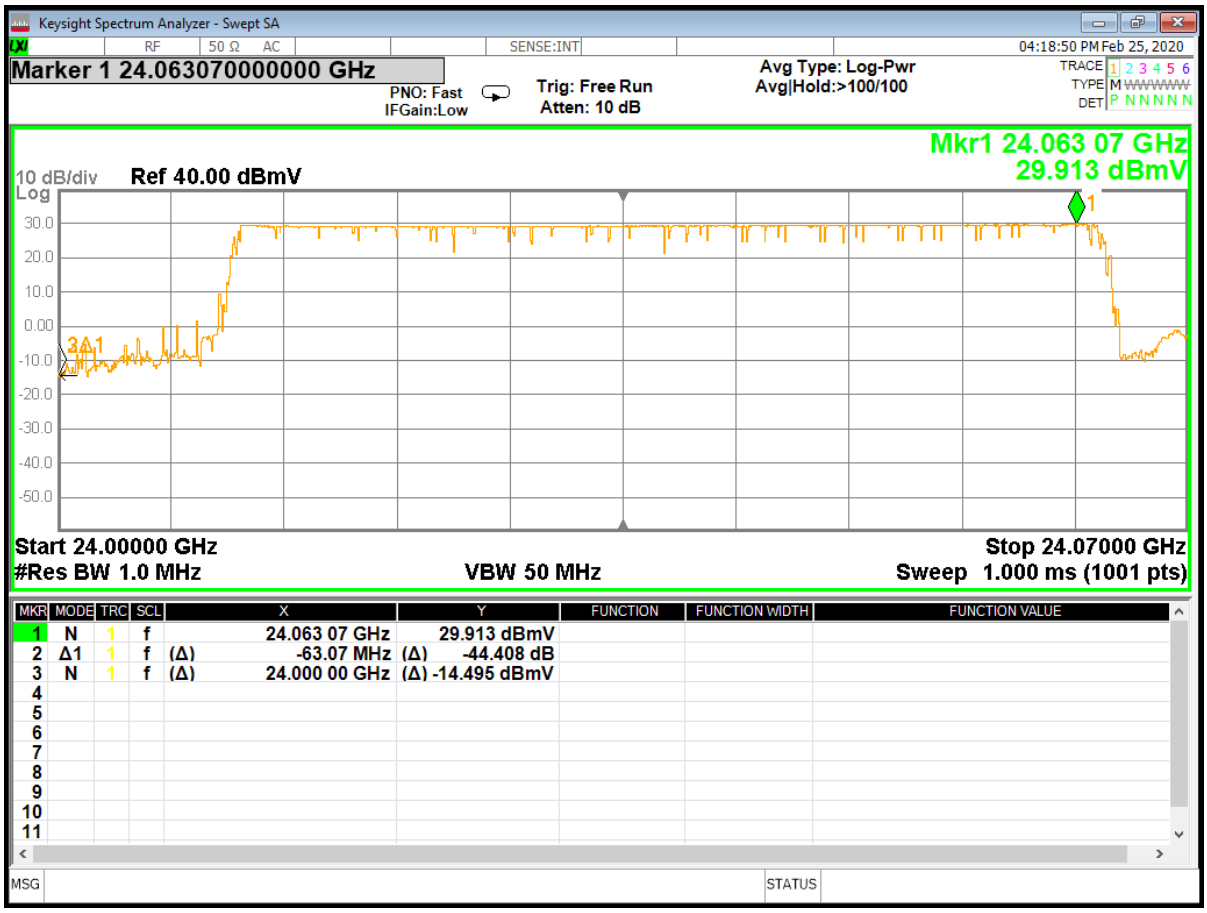

Figure 32 – Lower Band Edge (48 MHz) (swept frequency), 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

Low Band Edge Measurement at 24.00 GHz

Peak level at 24 GHz = -14.495 dBmV
Corrected Restricted Band Peak Level = -14.495 dBmV/m + 46.01 dB (corrections)
= 31.515 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 10.51 (dccf) =
=21.00 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05)+(-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

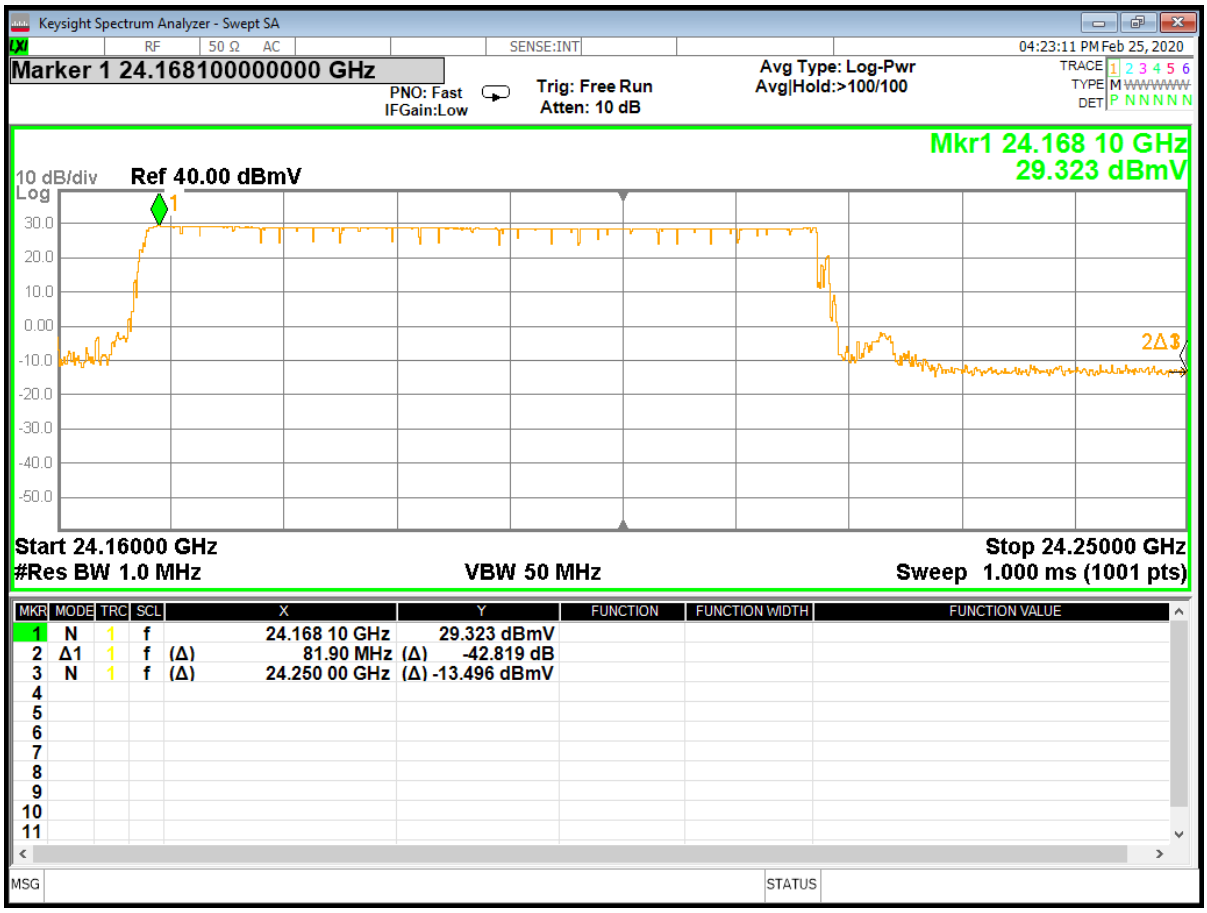

Figure 33 - Higher Band Edge (48 MHz) (swept frequency), 24.25 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

High Band Edge Measurement at 24.25 GHz

Peak level at 24.25 GHz = -13.496 dBmV
Corrected Restricted Band Peak Level = -13.496 dBmV/m + 46.01 dB (corrections)
= 32.514 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 10.51 (dccf) =
= 22.00 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05) + (-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

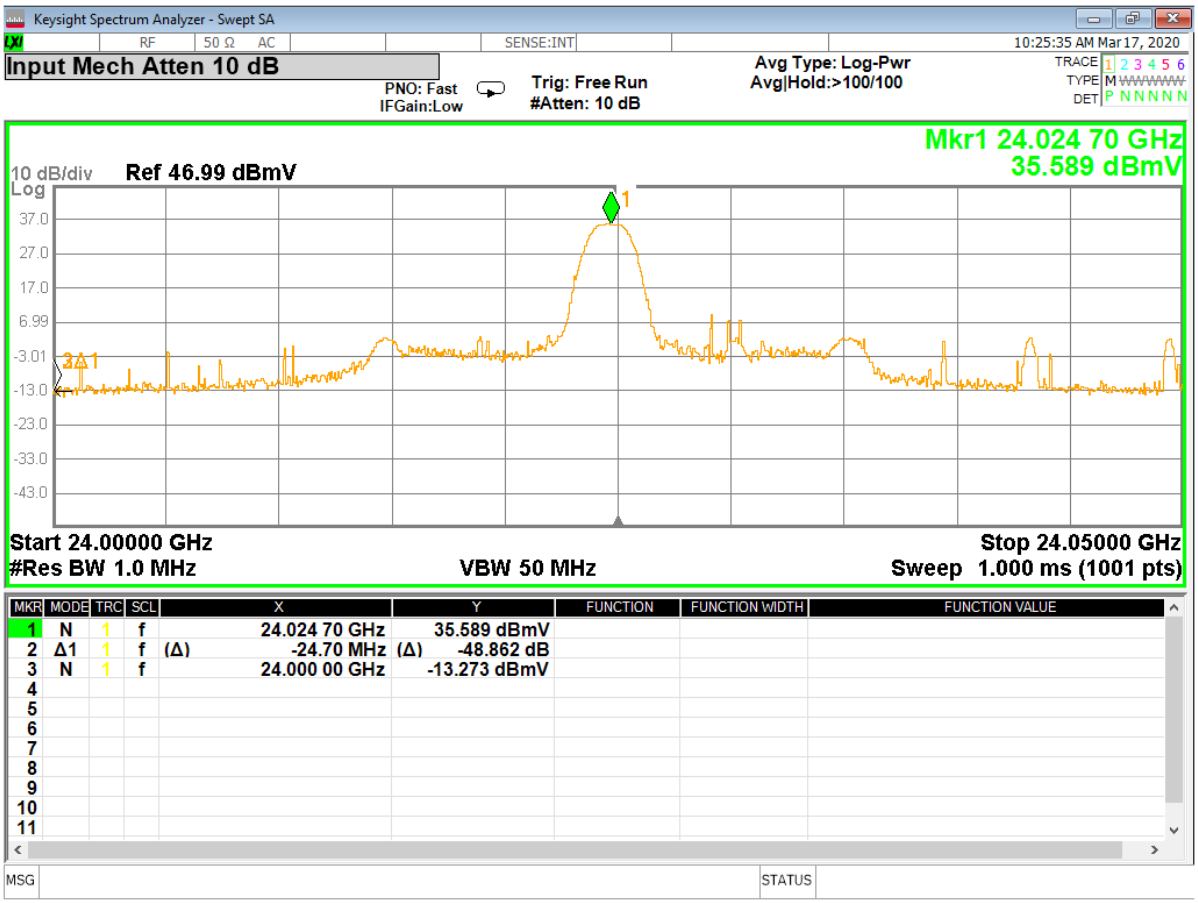

Figure 34 – Lower Band Edge (Single Frequency), 24.00 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

Low Band Edge Measurement at 24.00 GHz

Peak level at 24 GHz = -13.273 dBmV
Corrected Restricted Band Peak Level = -13.273 dBmV/m + 46.01 dB (corrections)
= 32.737 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log (3/0.05) +14 dBmV/m]

Average Level = peak level – 10.63 (dccf) =
=22.107 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log (3/0.05) +(-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

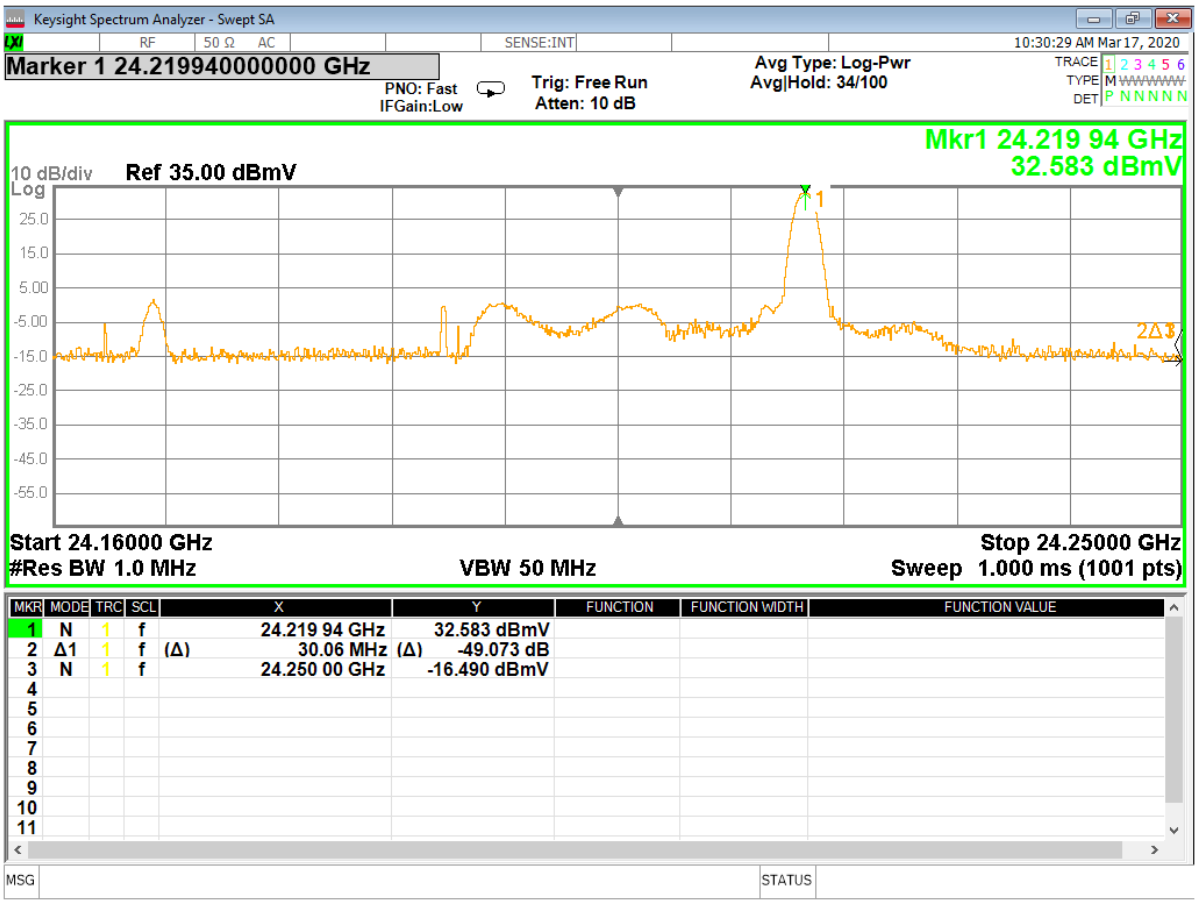

Figure 35 - Higher Band Edge (Single Frequency), 24.25 GHz
Uncorrected measurement as recorded on spectrum analyzer, 5 cm test distance

High Band Edge Measurement at 24.25 GHz

Peak level at 24.25 GHz = -16.490 dBmV
Corrected Restricted Band Peak Level = -16.490 dBmV/m + 46.01 dB (corrections)
= 29.52 dBmV/m < 49.56 dBmV/m [limit at 5cm = 20log(3/0.05)+14 dBmV/m]

Average Level = peak level – 10.63 (dccf) =
= 18.89 dBmV/m < 29.56 dBmV/m [limit at 5cm = 20log(3/0.05) + (-4) dBmV/m]

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

Measurements were performed at 5 cm to achieve required sensitivity without preamplifier saturation

Occupied Bandwidth

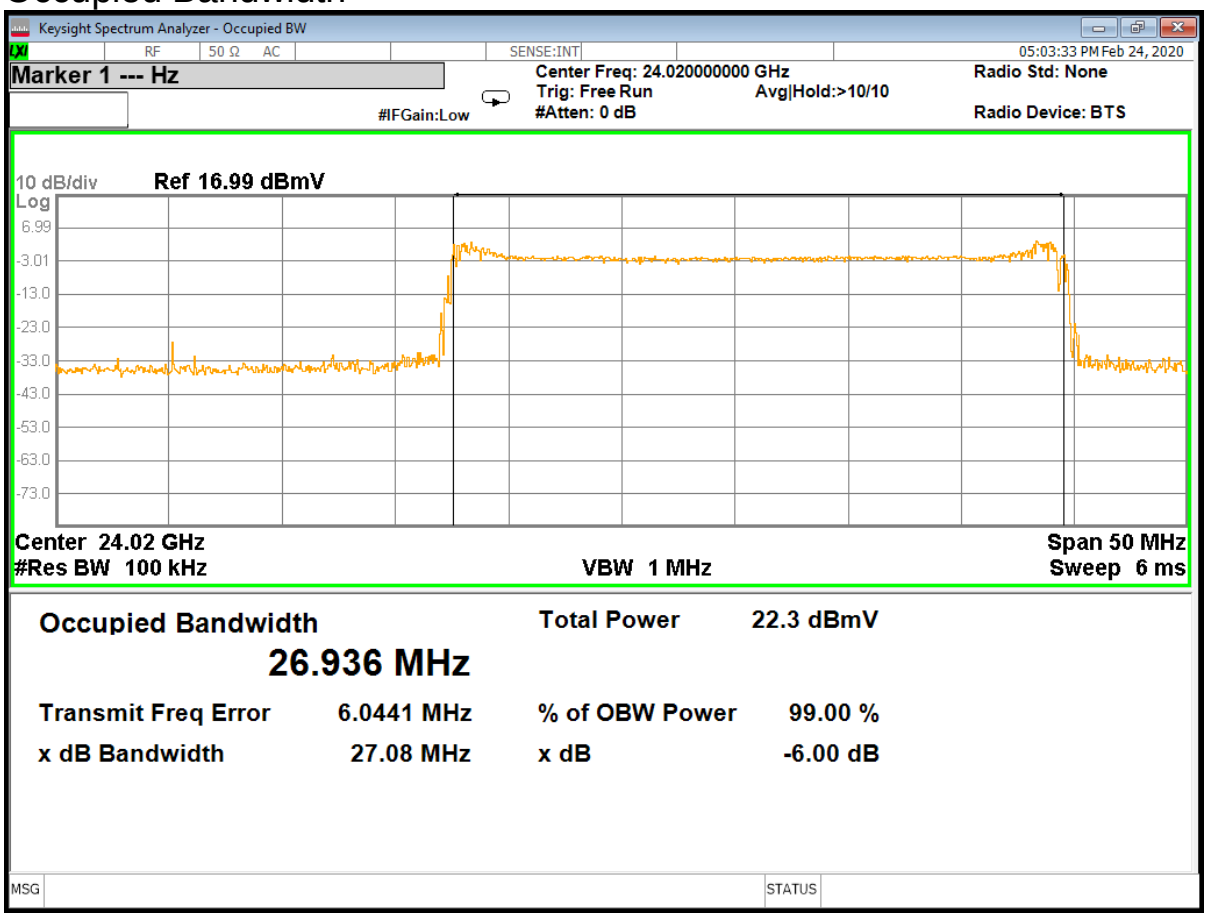

Figure 36 – Occupied Bandwidth, Low channel (24 MHz)
Uncorrected measurement as recorded on spectrum analyzer

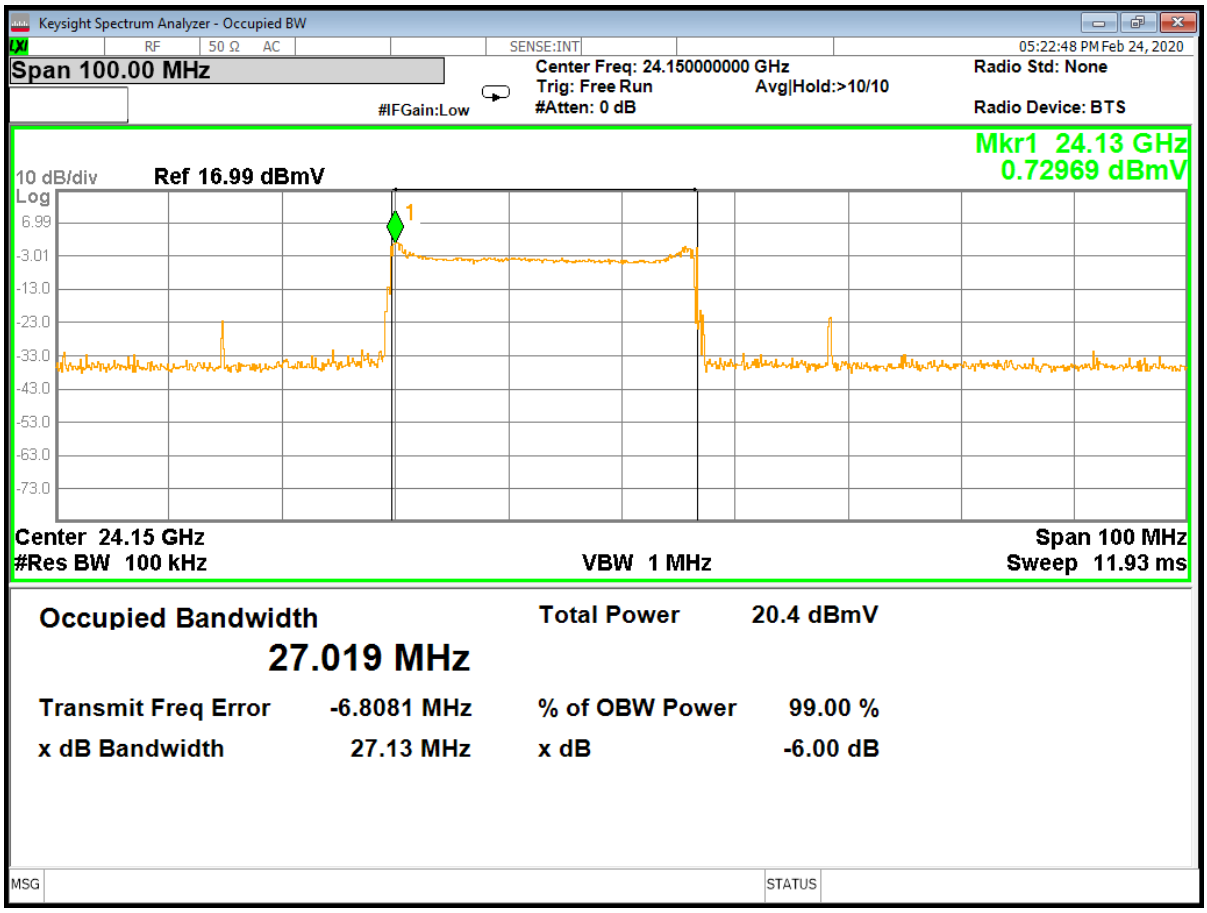

Figure 37 – Occupied Bandwidth, Mid channel (24 MHz)
Uncorrected measurement as recorded on spectrum analyzer

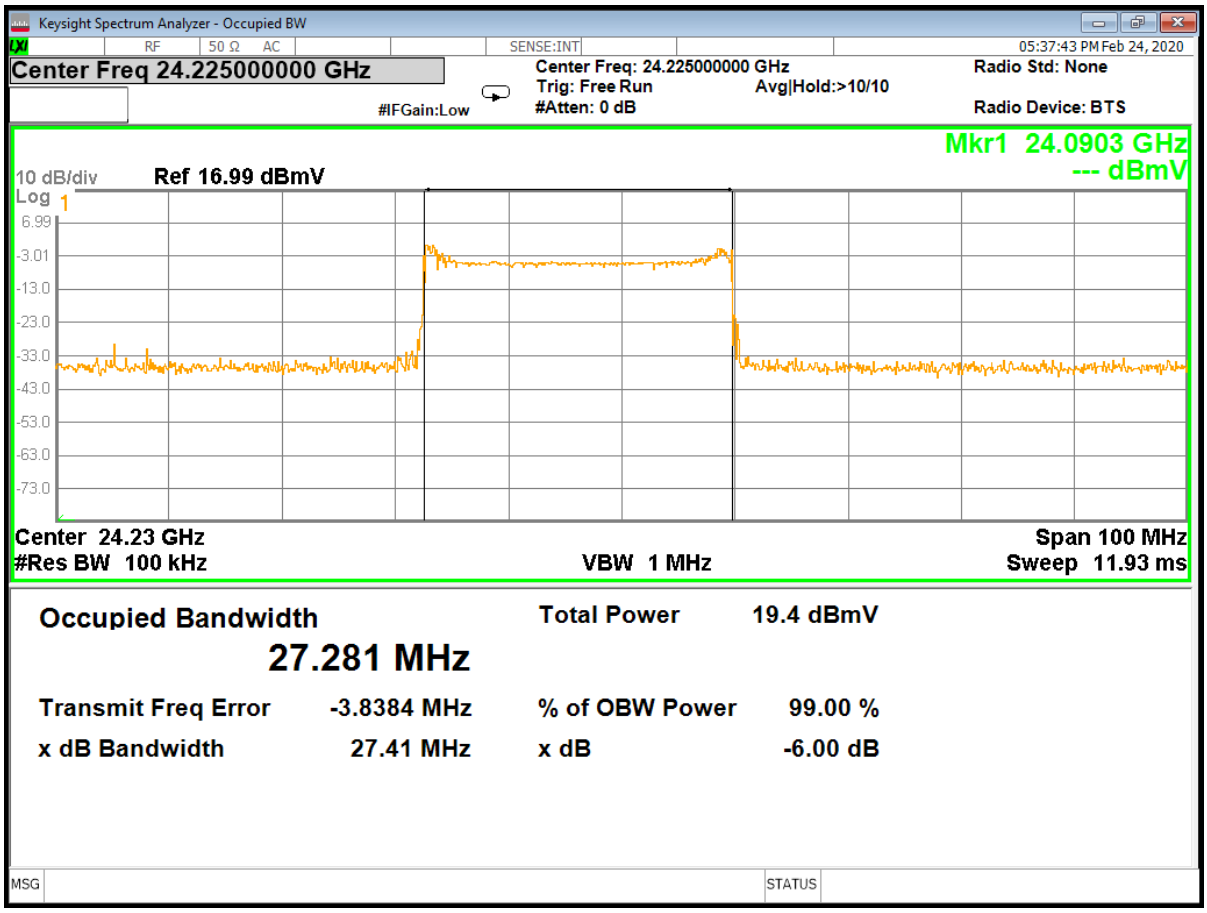

Figure 38 – Occupied Bandwidth, High channel (24 MHz)
Uncorrected measurement as recorded on spectrum analyzer

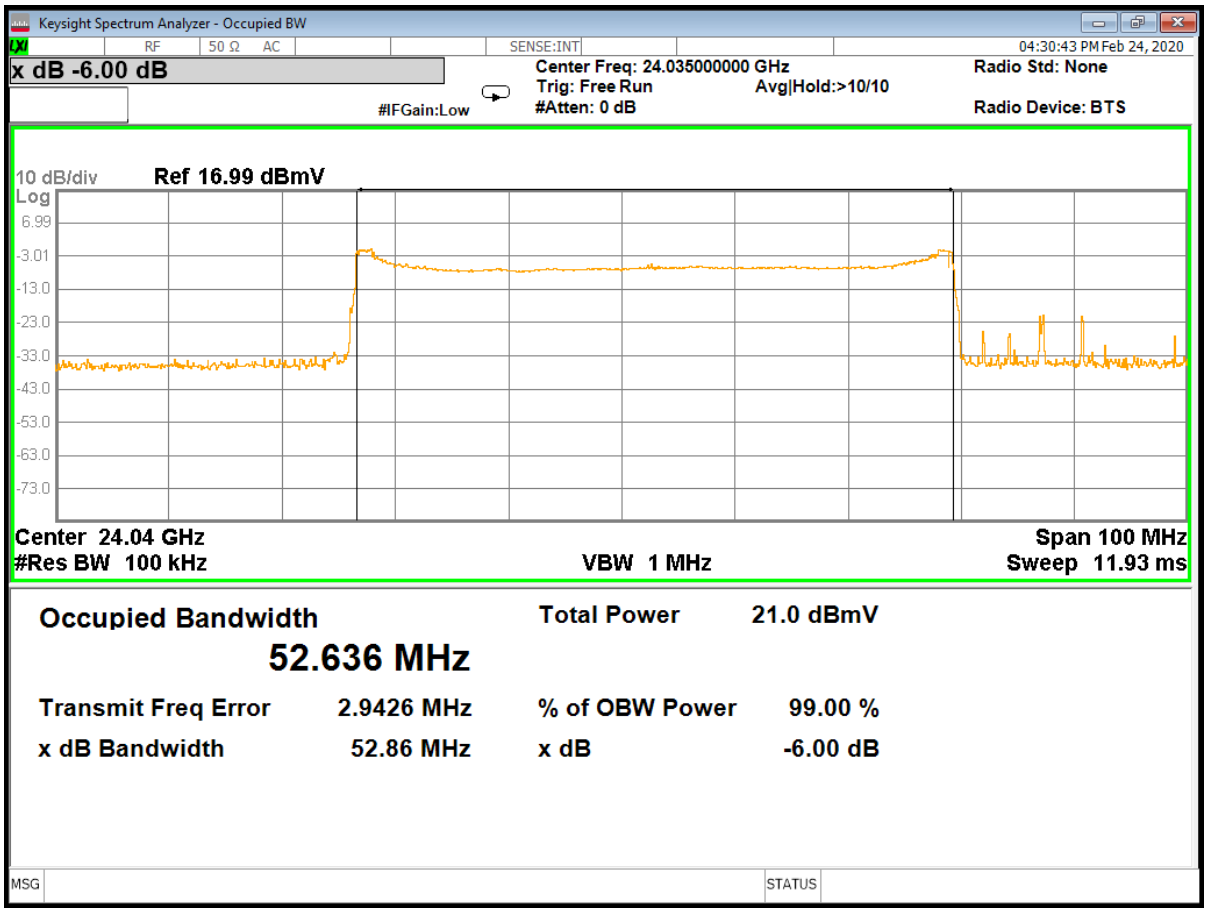

Figure 39 – Occupied Bandwidth, Low channel (48 MHz)
Uncorrected measurement as recorded on spectrum analyzer

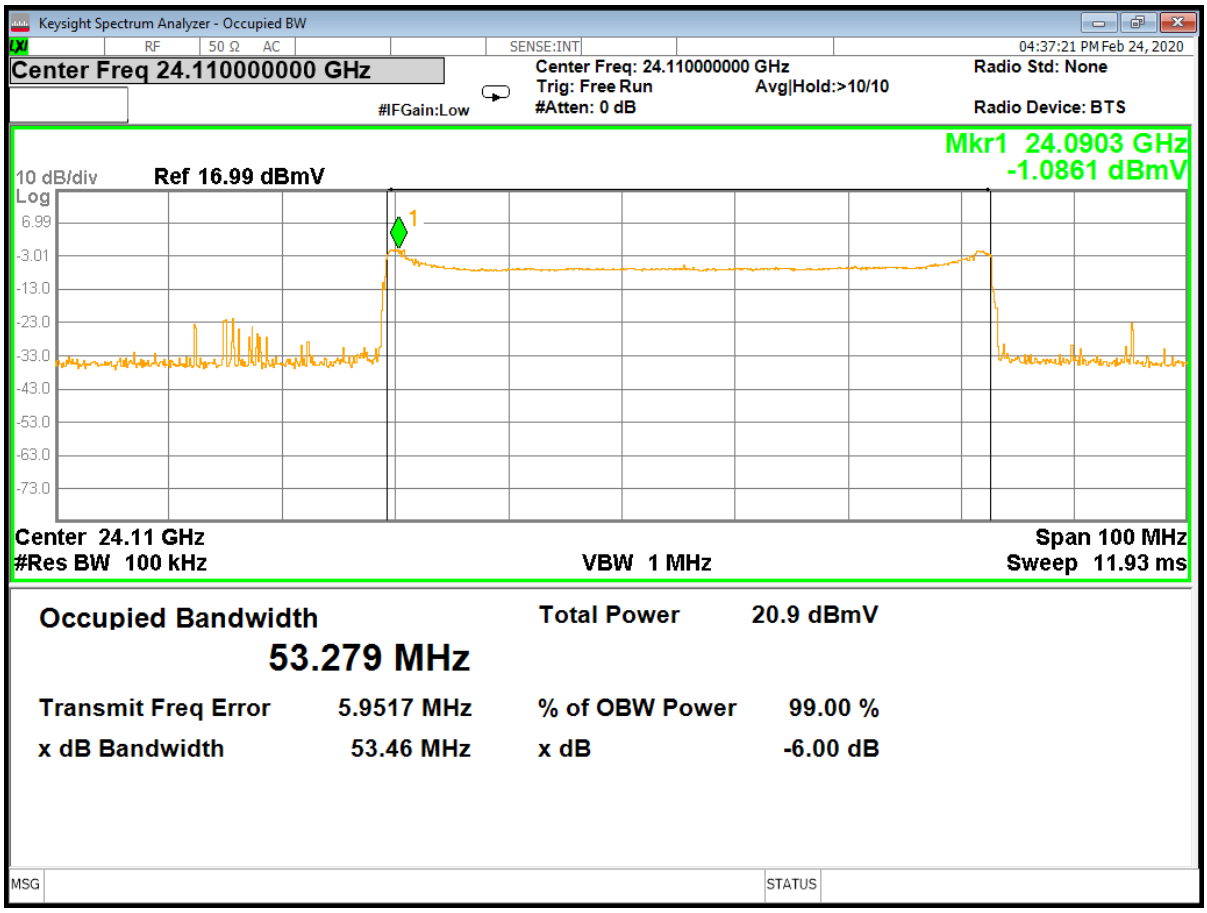

Figure 40 – Occupied Bandwidth, Mid channel (48 MHz)
Uncorrected measurement as recorded on spectrum analyzer

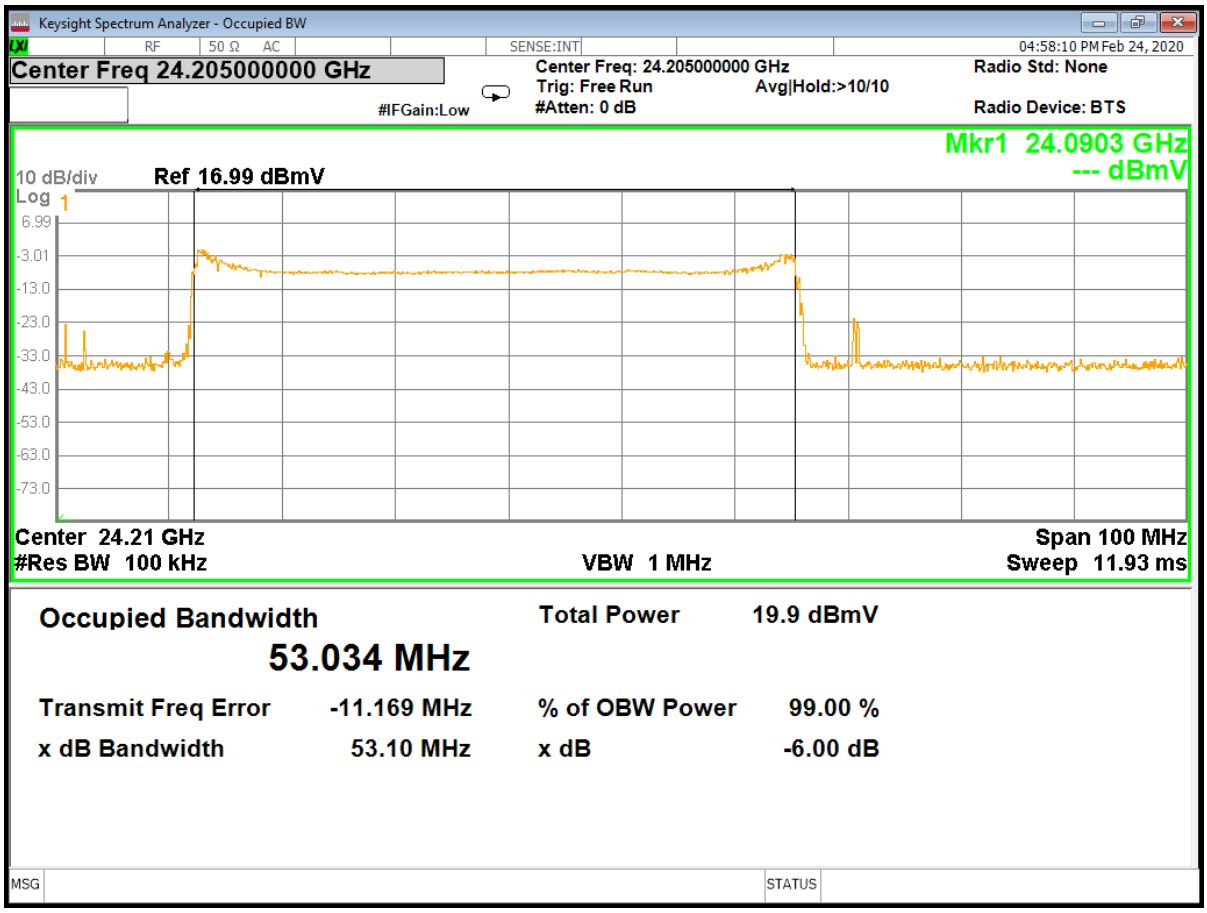

Figure 41 – Occupied Bandwidth, High channel (48 MHz)
Uncorrected measurement as recorded on spectrum analyzer

3.3 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 (dBµV)	
	Quasi-peak	Average
0.15-0.5 0.5-5 5-30	66 to 56 56 60	56 to 46 46 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:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results: PASS

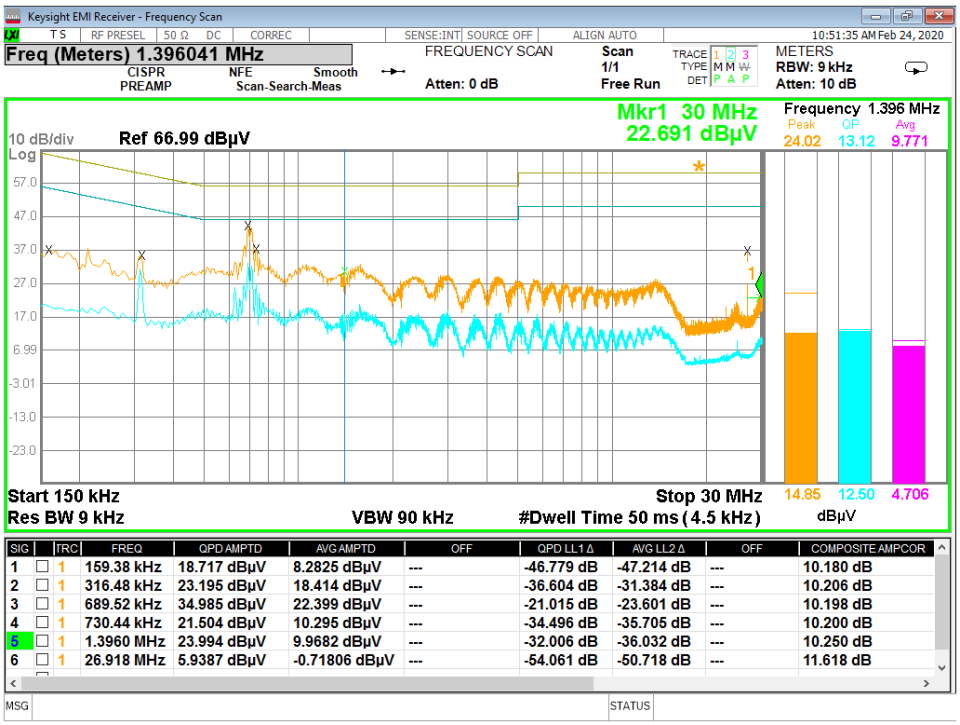

Figure 42 - Conducted Emissions Plot, Line

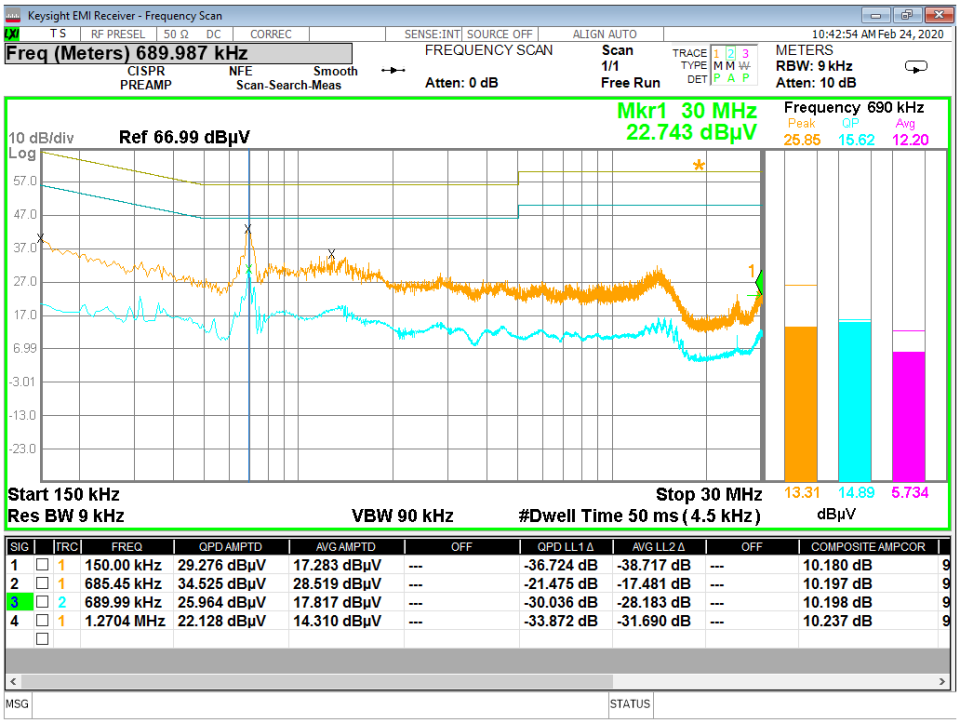

Figure 43 - Conducted Emissions Plot, Neutral

Annex A - Sample Calculations

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 dBμV/m

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

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*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 (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

Power (watts) = 10^[Power (dBm)/10] x 1000

Field Strength (dBµV/m) = Field Strength (dBm) = 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = (FS x d^2)/30 = FS [(d^2)/30] = FS [0.3}

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = -95.23

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

Annex 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	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	150kHz – 18GHz	3.30

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

CISPR 16-4-2:2011 was used to calculate the above values.

REPORT END

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RF Exposure

The 1 mW conducted exclusion at 24064 MHz for portable devices was taken from the FCC's presentation at the TCB Council Workshop on Nov 13. 2019, Titled "5G NR FR1 NSA EN-DC UE SAR Evaluations", Page/slide 11, second bullet point.

Fundamental:

Level Measurement: 13.363 dBmV/m + 46.01 dB corrections = 59.373 dBmV/m at 1 meter

Corrections:

Cable	0.50 dB
Antenna	45.51 dB

EIRP = 14.60 dBm peak.
Duty cycle correction = 5.26 dB
EIRP (AV) = 3.97

Conducted power = EIRP – antenna gain.
Antenna gain = 10.55

Power (conducted) = 3.97 – 5.26 = -1.29 dBm = 0.74 mW

Result = Exempt

Note: the duty-cycle is source-based, i.e. it is factory set and cannot be adjusted by an installer or user.

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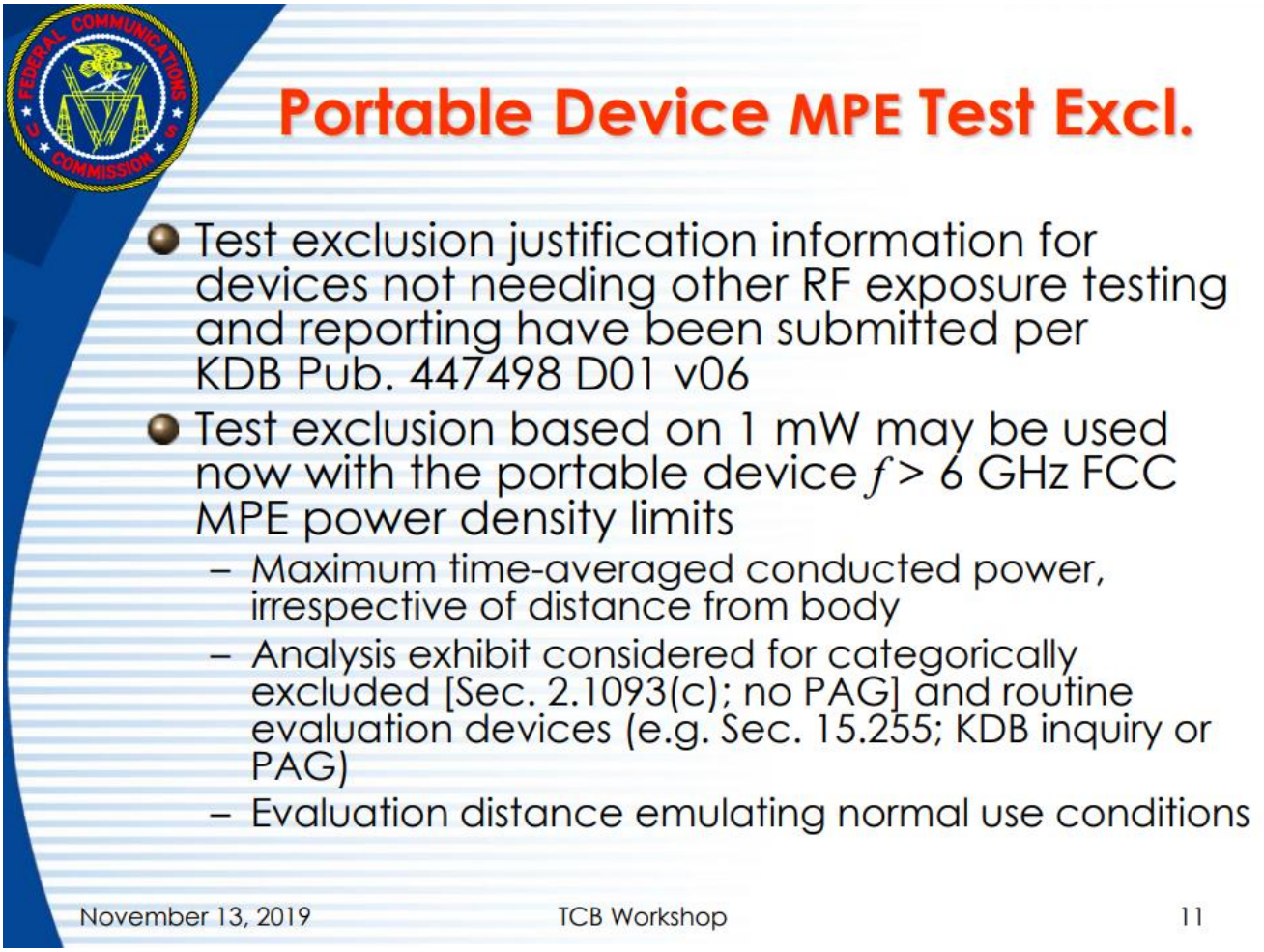
RF Exposure



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FCC RF Exposure Evaluation

2.4 GHz portable radio per KDB 447498 D01

	1-g	10-g	
Limit	1		Contributor
Duty Cycle	100	%	1
Tune up Tolerance	10	%	1.1
Antenna Gain	0	dBi	1
Min. Seperation	5	mm	

Frequency	Power	Value	Limit	Exempt?
GHz	mW	no unit	no unit	Yes/No
2.4020	1.010	0.34	3.0	YES
2.4400	1.000	0.34	3.0	YES
2.4800	0.934	0.32	3.0	YES

KDB Link KDB 447498
Portable Part 2.1093

"value" calculated from Section 4.3 of the KDB:

[(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR,[30] where

- $f_{(GHz)}$ is the RF channel transmit frequency in GHz