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CERTIFICATION TEST REPORT

Manufacturer: TeraCode Inc.
801 Brickell Avenue, 8th Floor.
Miami, Florida 33131 USA

Applicant: Same as Above

Product Description: LoRa radio used in telemetry device built for the purpose of relaying bathroom fixture sensor data

Operating Voltage/Freq. of EUT During Testing: 3.3VAC from AC Adapter

Equipment Under Test: **Communication Card**
Trade Name: TeraCode Inc.
Model: **TCCC024**

FCC ID: **2BCX2TCCC024**

Testing Commenced: 2023-10-13

Testing Ended: 2023-12-22

Summary of Test Results: **In Compliance**

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.

Rules:

- **FCC Part 15 Subpart C, Section 15.247**
- **FCC15.207 - Conducted Limits**
- **FCC Part 15.31(e)**
- **ANSI C63.10:2013**



Order No(s): F2P30494A

Applicant: TeraCode Inc.
Model: TCCC024

Evaluation Conducted by:

Julius Chiller, Senior Wireless Project Engineer

Report Reviewed by:

Ken Littell, Vice President of Operations

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TABLE OF CONTENTS

1	<u>ADMINISTRATIVE INFORMATION</u>
2	<u>SUMMARY OF TEST RESULTS/MODIFICATIONS</u>
3	<u>TABLE OF MEASURED RESULTS</u>
4	<u>ENGINEERING STATEMENT</u>
5	<u>EUT INFORMATION AND DATA</u>
6	<u>LIST OF MEASUREMENT INSTRUMENTATION</u>
7	<u>OCCUPIED BANDWIDTH</u>
8	<u>CONDUCTED OUTPUT POWER</u>
9	<u>VOLTAGE VARIATIONS</u>
10	<u>CONDUCTED SPURIOUS EMISSIONS</u>
11	<u>RADIATED SPURIOUS EMISSIONS</u>
12	<u>PEAK POWER SPECTRAL DENSITY (PSD)</u>
13	<u>CONDUCTED EMISSIONS</u>
14	<u>PHOTOGRAPH(S) – TEST SETUPS</u>



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 ANSI C63.10 and recommended FCC procedure of measurement of DTS operating under Section 15.247 and in KDB558074. A list of the measurement equipment can be found in Section 6.

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 Uncertainty
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
F2P30494A-02E	First Issue	2023-12-28	K. Littell

**2 SUMMARY OF TEST RESULTS**

Test Name	Standard(s)	Results
Occupied Bandwidth	CFR 47 Part 15.247(a)(2) / KDB558074	Complies
Conducted Output Power	CFR 47 Part 15.247(b)(2) / KDB558074	Complies
Voltage Variations	CFR 47 Part 15.31(e)	Complies
Conducted Spurious Emissions	CFR 47 Part 15.247(d) / Part 15.207 / KDB558074	Complies
Radiated Spurious Emission with 1.2dBi Integral Antenna	CFR 47 Part 15.247(d) / Part 15.209 / KDB558074	Complies
Peak Power Spectral Density	CFR 47 Part 15.247(e) / KDB558074	Complies
Frequency Separation	ANSI 63.10 2013 (7.8.2)	Not Applicable
Number of Hopping Frequencies	ANSI 63.10 2013 (7.8.3)	Not Applicable
Dwell Time	ANSI 63.10 2013 (7.8.4)	Not Applicable
Conducted Emissions	CFR 47 Part 15.207(a)	Complies

Modifications Made to the Equipment
Power setting was reduced to 13dBm to meet PSD requirements.

**3 TABLE OF MEASURED RESULTS**

Test		Low Channel 903 MHz	Mid Channel 914.2 MHz	High Channel 927.5 MHz
Conducted Output Power	500kHz, SF7 Power Setting: 13	15.38mW / 11.87dBm	14.45mW / 11.60dBm	13.15mW / 11.19dBm
	500kHz, SF12 Power Setting: 13	15.35mW / 11.86dBm	14.49mW / 11.61dBm	13.12mW / 11.18dBm
Conducted Output Power Limit		1 Watt / 30dBm	1 Watt / 30dBm	1 Watt / 30dBm
E.I.R.P. with 1.2dBi Integral Antenna	500kHz, SF7	20.75mW / 13.17dBm	19.5mW / 12.9dBm	17.74mW / 12.49dBm
	500kHz, SF12	20.7mW / 13.16dBm	19.54mW / 12.91dBm	17.7mW / 12.48dBm
E.I.R.P. Limit		4 Watts / 36.02dBm	4 Watts / 36.02dBm	4 Watts / 36.02dBm
Peak Power Spectral Density	500kHz, SF7 Power Setting: 13	-1.77dBm	-1.99dBm	-1.53dBm
	500kHz, SF12 Power Setting: 13	7.84dBm	7.7dBm	7.39dBm
Peak Power Spectral Density Limit		8dBm	8dBm	8dBm
-6dB Occupied Bandwidth	500kHz, SF7	0.621 MHz	0.624 MHz	0.621 MHz
	500kHz, SF12	0.646 MHz	0.651 MHz	0.643 MHz
99% Occupied Bandwidth	500kHz, SF7	0.663 MHz	0.682 MHz	0.669 MHz
	500kHz, SF12	0.680 MHz	0.704 MHz	0.674 MHz
Occupied Bandwidth Limit		≥ 500KHz	≥ 500KHz	≥ 500KHz
Voltage Variations*	Nominal: 110V(dBm)	11.87	--	11.16
	Nominal: 110V(mW)	15.38	--	13.06
	-15%: 100V(dBm)	11.84	--	11.14
	-15%: 100V(mW)	15.28	--	13.00
	+15%: 140V(dBm)	11.87	--	11.16
	+15%: 140V(mW)	15.38	--	13.06
Limit		1W 30dBm	1W 30dBm	1W 30dBm

**To meet the requirements of 15.31, voltage was varied by ±15% of the nominal voltage. All tests were then performed at the highest output power voltage setting.*



4 ENGINEERING STATEMENT

This report has been prepared on behalf of TeraCode 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: Communication Card - 900 MHz LoRa Radio

Model: TCCC024

Serial No.: TCCC024-63294153DA022CF8

Firmware: v14.0.10

Hardware: v2.4

FCC ID: 2BCX2TCCC024

5.2 Trade Name:

TeraCode Inc.

5.3 Power Supply:

3.3VDC AC Adapter

5.4 Applicable Rules:

CFR 47, Part 15.247, subpart C

5.5 Equipment Category:

Radio Transmitter-DTS

5.6 Antenna:

Molex Model 206764 Dipole

5.7 Accessories:

Device	Manufacturer	Model Number	Serial Number
UART Interface	Moyina	FT232	None Specified
Power Adapter	CUI	SW16-3.3N	None Specified
Laptop	Dell	Latitude	11DLWT2

5.8 Test Item Condition:

The equipment to be tested was received in good condition.

5.9 Testing Algorithm:

EUT was set to transmit on low, mid and high frequency in the 900 MHz band. EUT transmitted a continuous signal using low and high spread factors and data rates. The highest emissions were recorded in the data tables.

**6 LIST OF MEASUREMENT INSTRUMENTATION**

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber	CL166-E	Albatross Projects	B83117-DF435-T261	US140023	2024-11-15
Receiver	CL151	Rohde & Schwarz	ESU40	100319	2024-04-10
Low Loss Cable Set	CL315/C L318	Fairview Microwave	FMC0202914-72/FMC0202914-240	None Spec.	2024-04-14
Horn Antenna	CL098	Emco	3115	9809-5580	2024-01-19
Horn Antenna 18-26.5 GHz	CL114	A.H. Systems, Inc.	SAS-572	237	2024-01-19
Preamplifier	CL284	A.H. Systems, Inc.	PAM-1001	131	2024-04-12
Active 18" Loop Antenna	CL163-Loop	A.H. Systems, Inc.	EHA-52B	100	2024-12-14
Antenna, JB3 Combination	CL175	Sunol Sciences	JB3	A030315	2024-09-25
Software:	Tile Version 3.4.B.3		Software Verified: 2023-10-13 to 2023-10-18		
Software:	EMC 32, Version 8.53.0		Software Verified: 2023-10-13 to 2023-10-18		
Spectrum Analyzer	0204	Hewlett Packard	HP8591A	3149A02546	2024-04-11
Software:	EMC Analyzer 8712D Rev. A.00.01			Date Verified	2023-10-18
Transient Limiter	0202	Hewlett Packard	11947A	3107A00729	2024-04-11
Software:	Tile Version 3.4.B.3.		Software Verified: 2023-10-13 to 2023-10-18		
LISN	CL181	Com-Power	LI-125A	191226	2026-11-20
LISN	CL182	Com-Power	LI-125A	191225	2026-11-21
Temp/Hum. Recorder	CL295	Thermpro	TP50	3	2024-04-27
Temp/Hum. Recorder	CL296	Thermpro	TP50	4	2024-04-27



7 OCCUPIED BANDWIDTH

7.1 Requirements:

The 6dB bandwidth shall be greater than 500 kHz.

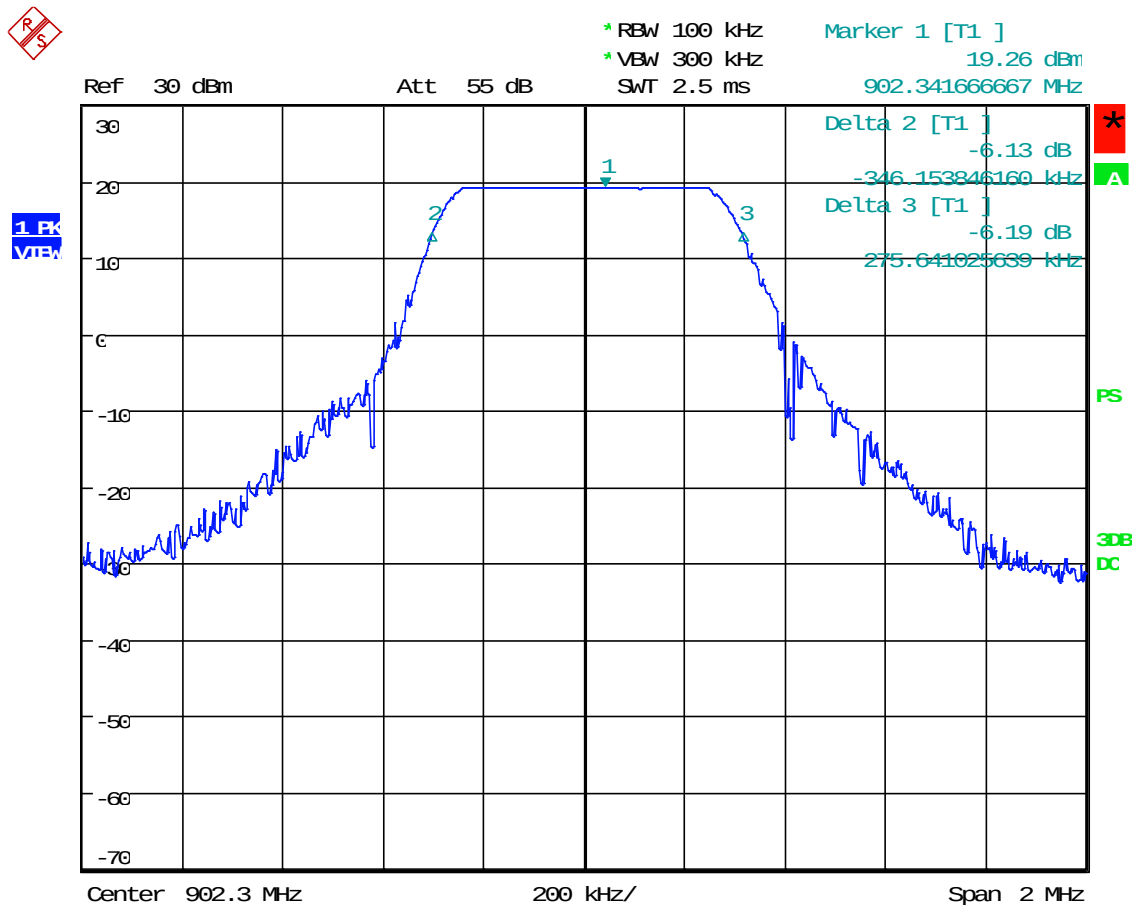
Bandwidth measurements were made at the low (903 MHz), mid (914.2 MHz) and upper (927.5 MHz) frequencies with the resolution Bandwidth set at 100 kHz (video bandwidth set at 300 kHz) while the span was set at 2 MHz. The bandwidth was measured using the marker delta method.



7.2 Occupied Bandwidth Test Data

Test Date:	2023-10-13	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(a)(2); KDB558074	Air Temperature:	21.8°C
		Relative Humidity:	44%

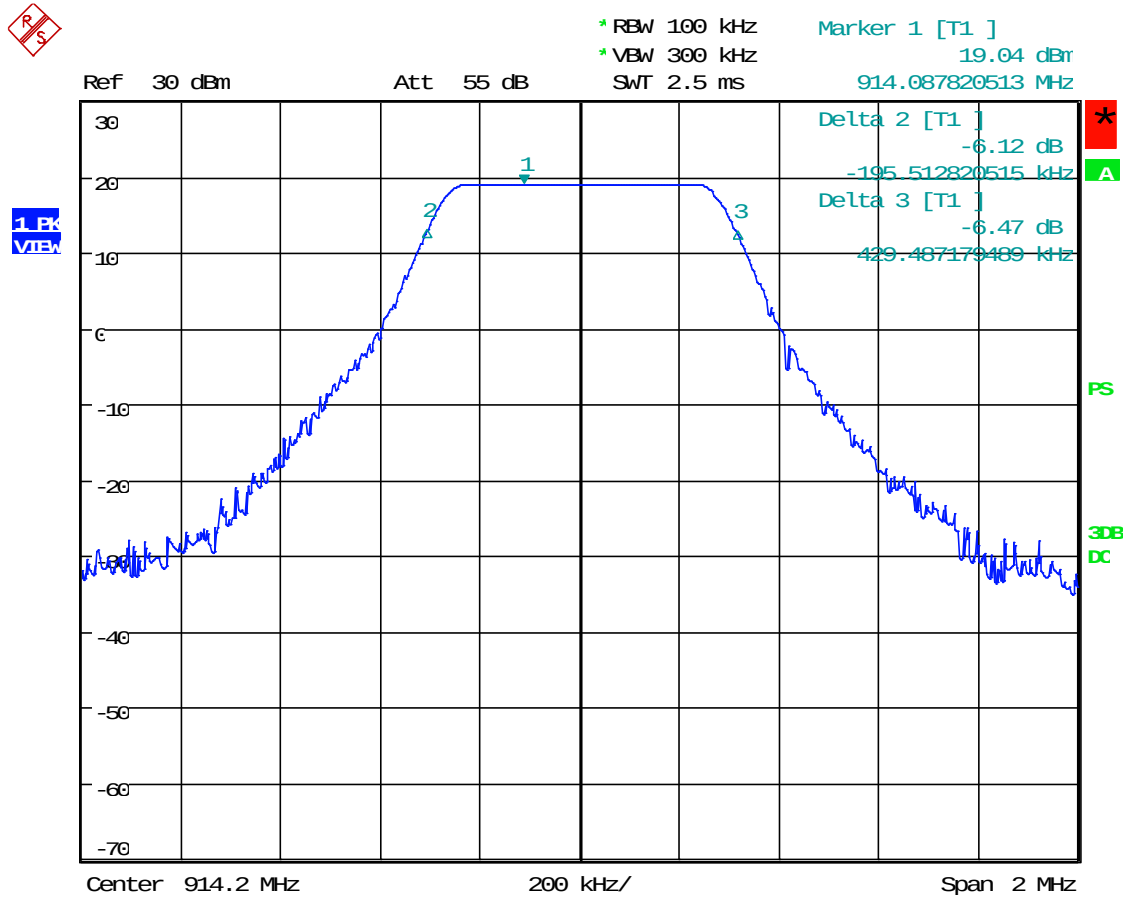
SF7, -6dB: Low Channel



Date: 13.OCT.2023 13:20:55



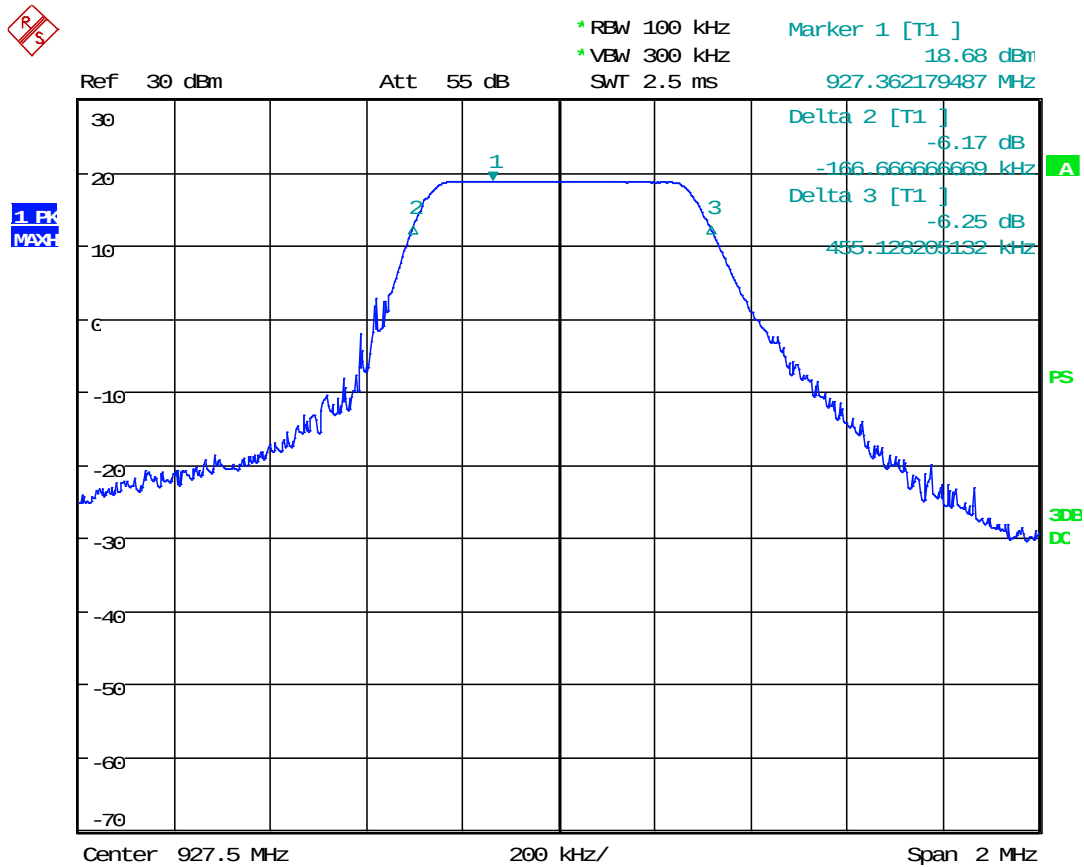
SF7, -6dB: Mid Channel



Date: 13.OCT.2023 13:24:57



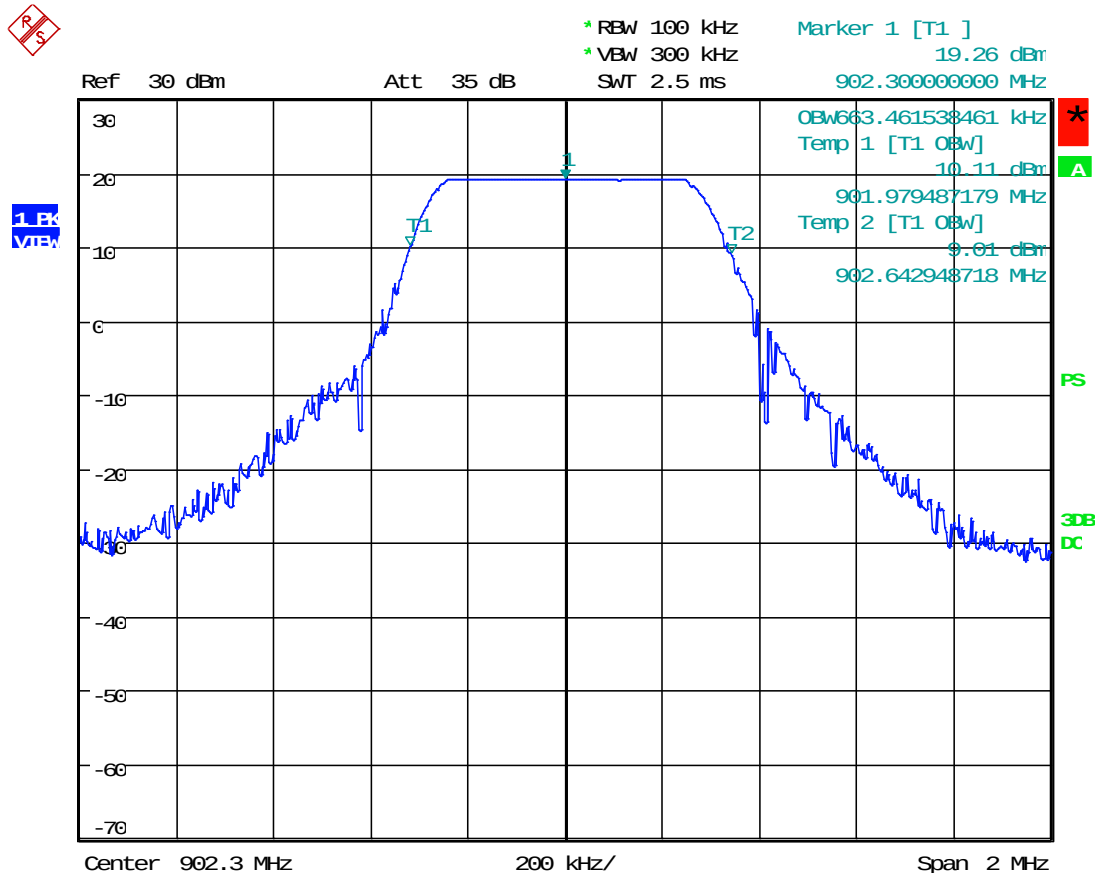
SF7, -6dB: High Channel



Date: 13.OCT.2023 13:39:22



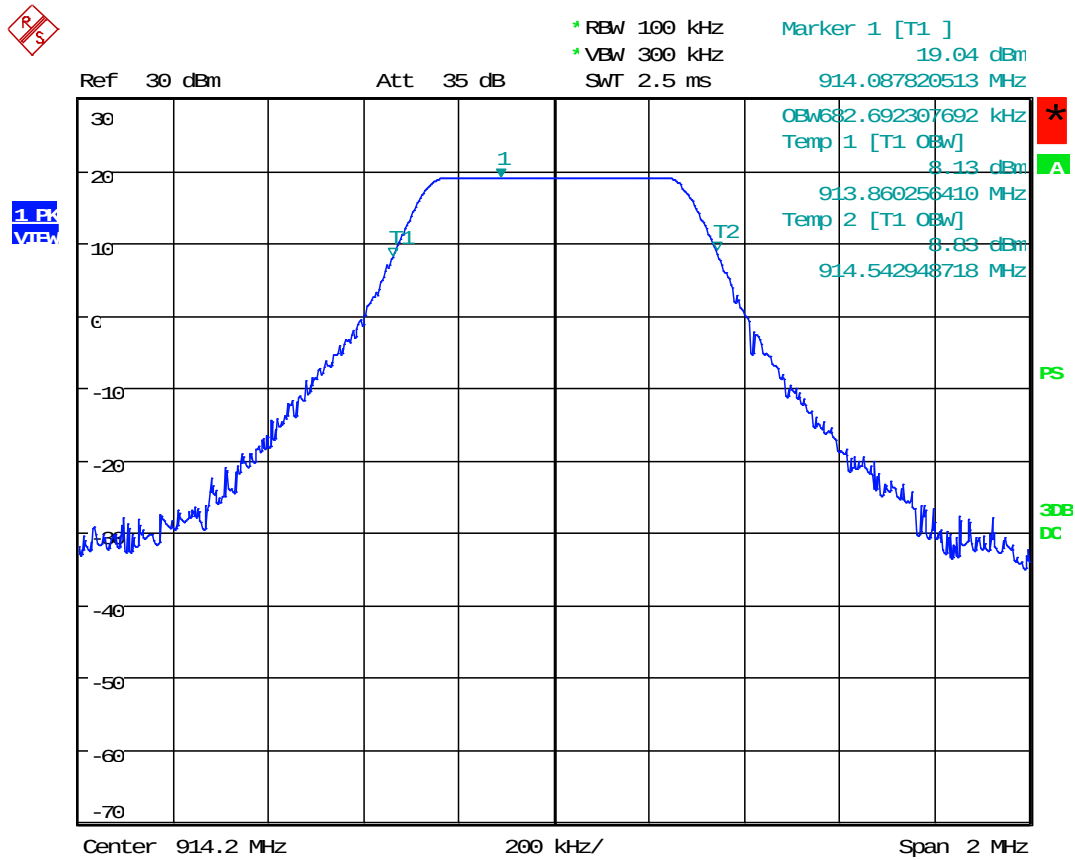
SF7, 99%: Low Channel



Date: 13.OCT.2023 13:20:05



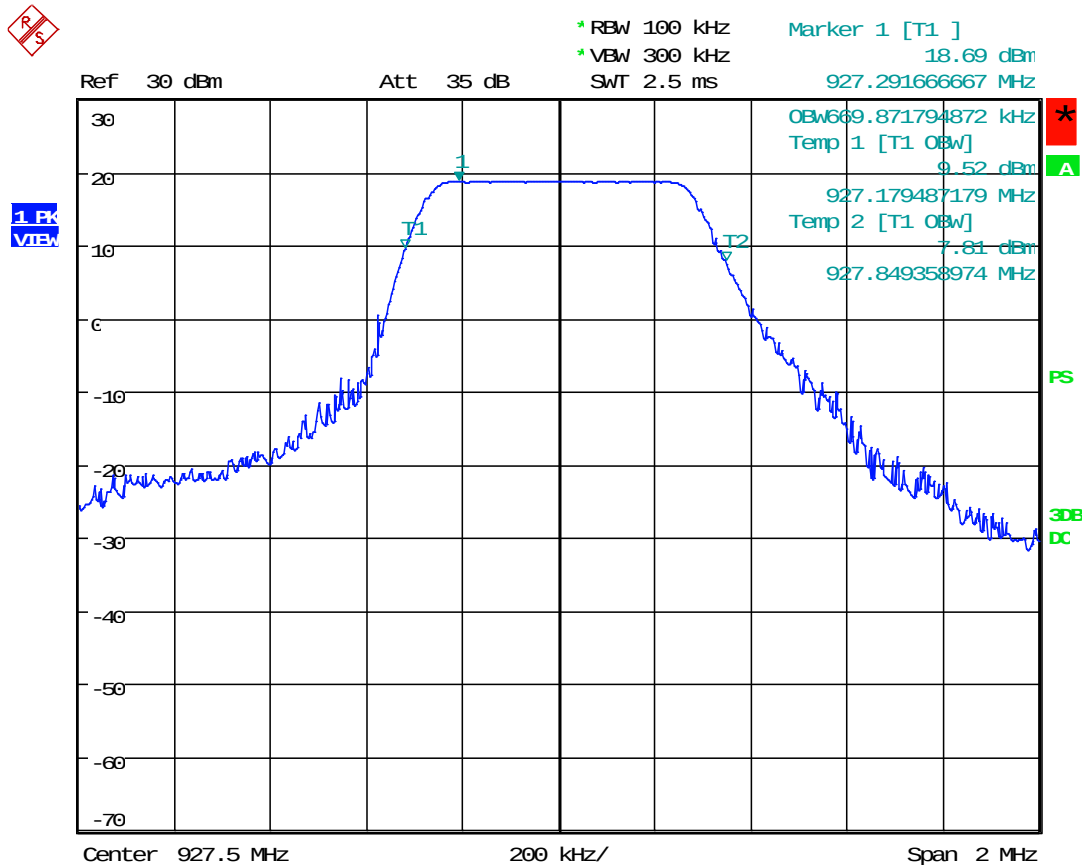
SF7, 99%: Mid Channel



Date: 13.OCT.2023 13:24:22



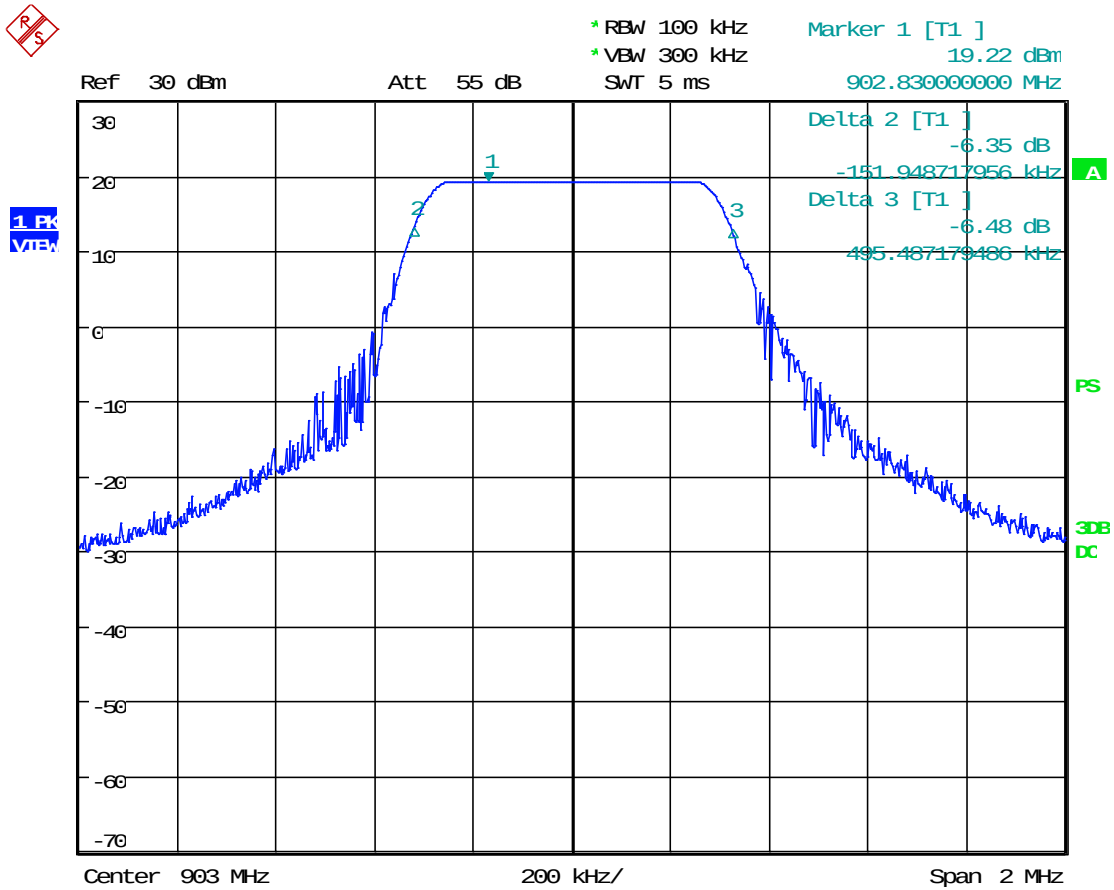
SF7, 99%: High Channel



Date: 13.OCT.2023 13:30:41



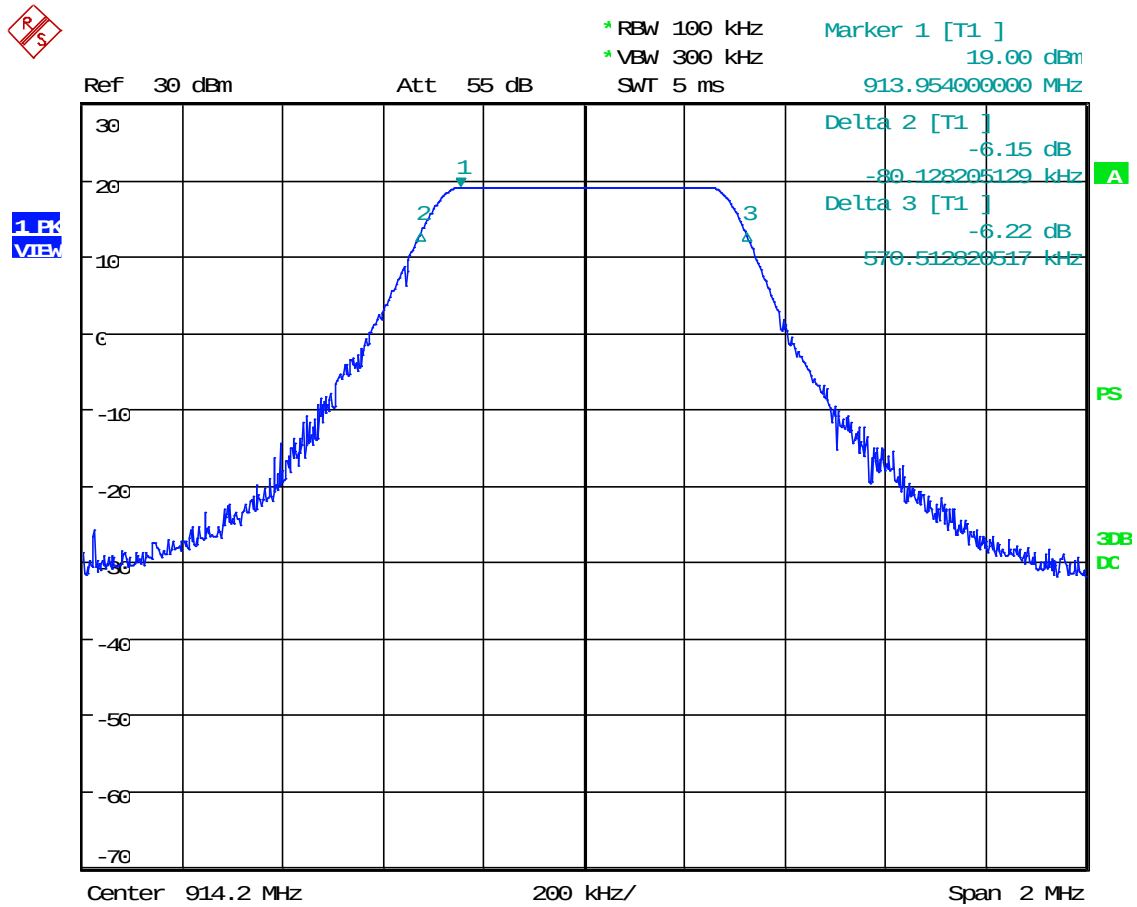
SF12, -6dB: Low Channel



Date: 13.OCT.2023 14:08:41



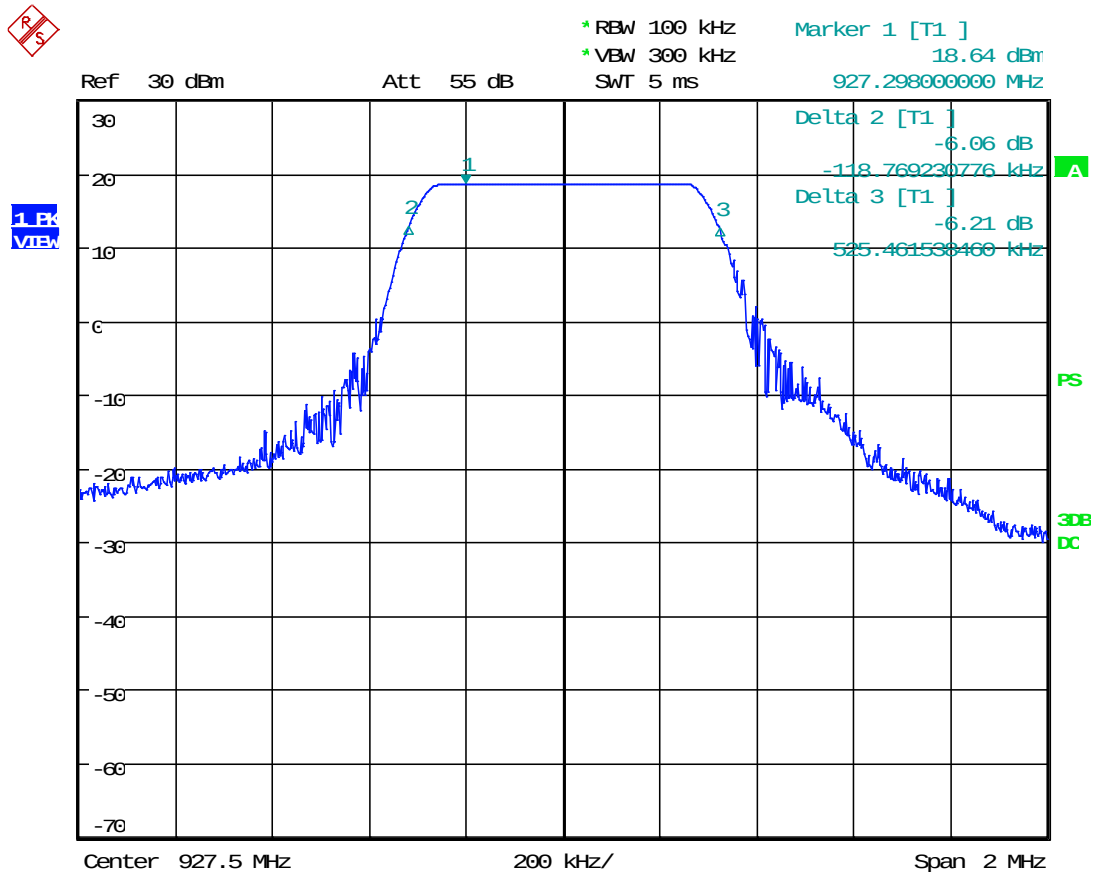
SF12, -6dB: Mid Channel



Date: 13.OCT.2023 13:54:28



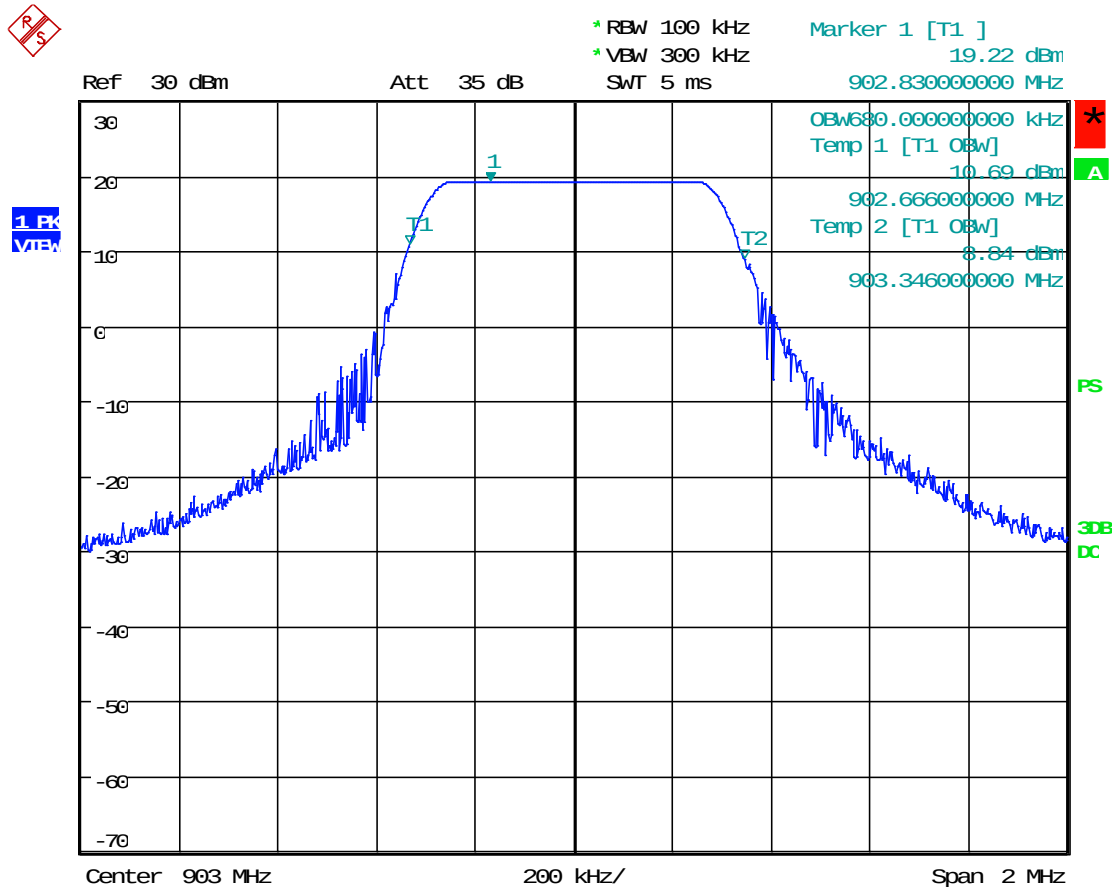
SF12, -6dB: High Channel



Date: 13.OCT.2023 13:49:22



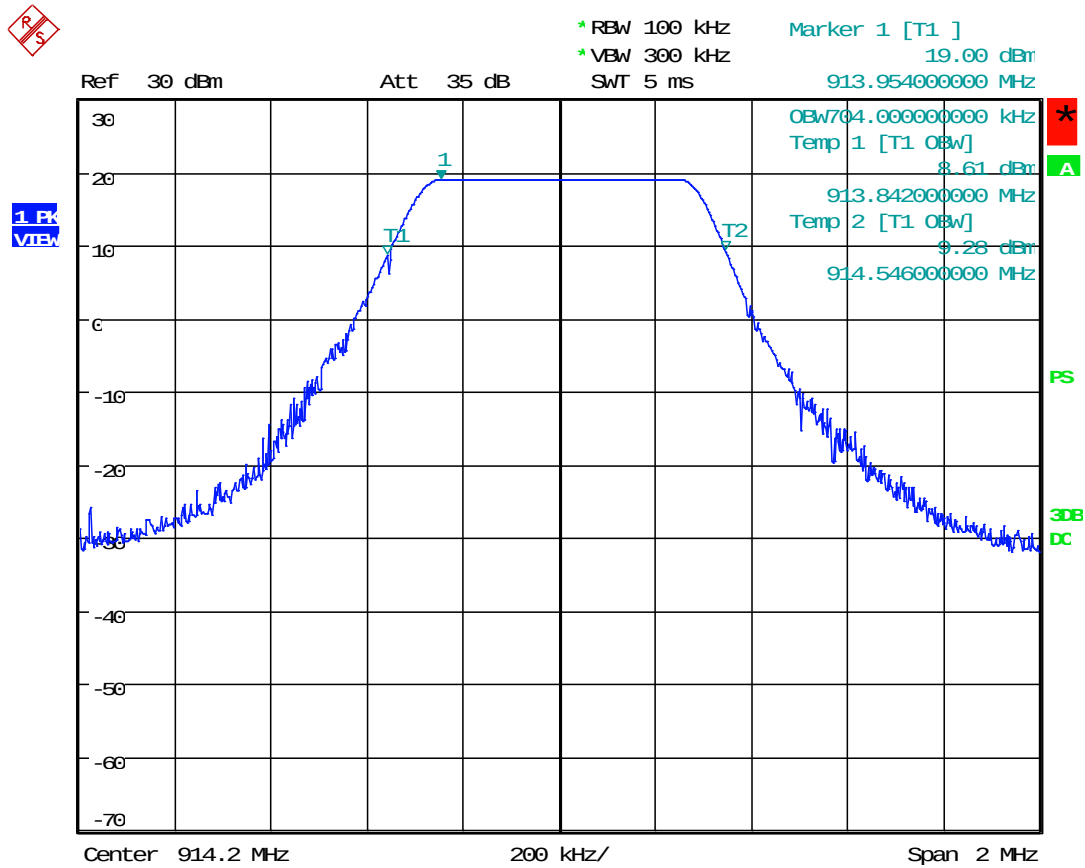
SF12, 99%: Low Channel



Date: 13.OCT.2023 14:08:58



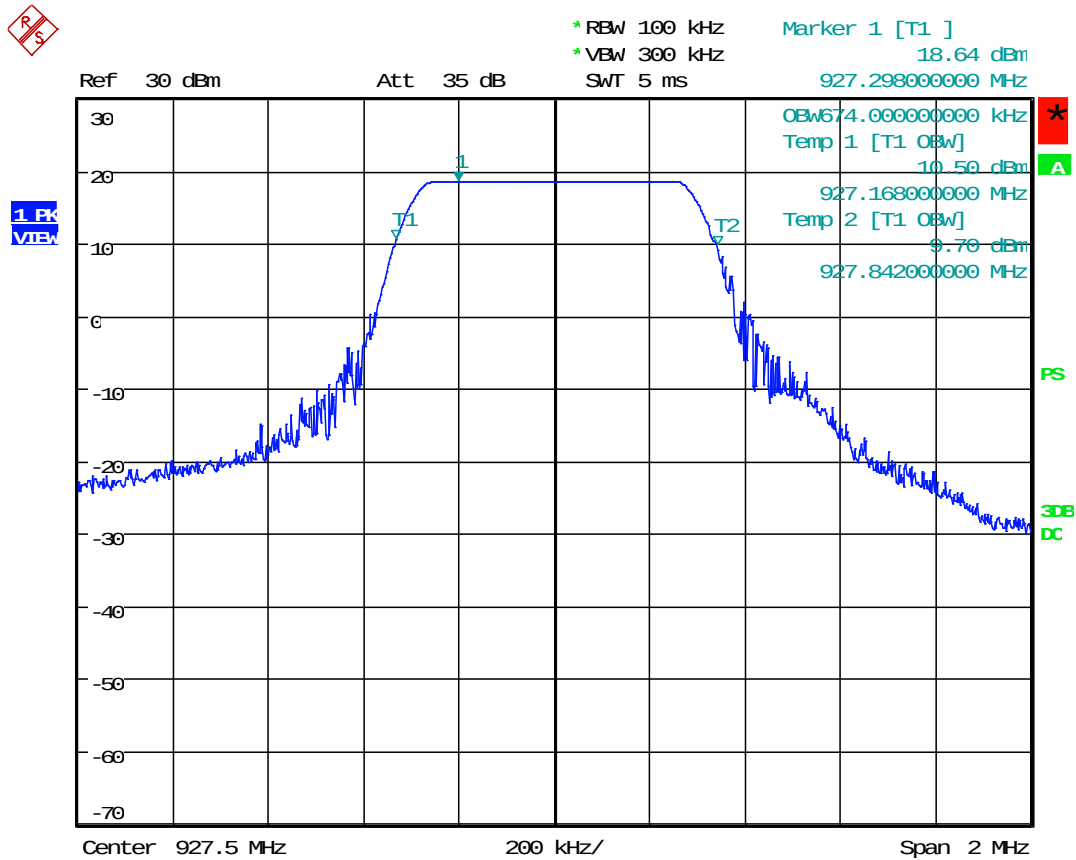
SF12, 99%: Mid Channel



Date: 13.OCT.2023 13:55:34



SF12, 99%: High Channel



Date: 13.OCT.2023 13:50:21



8 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.

8.1 Requirements:

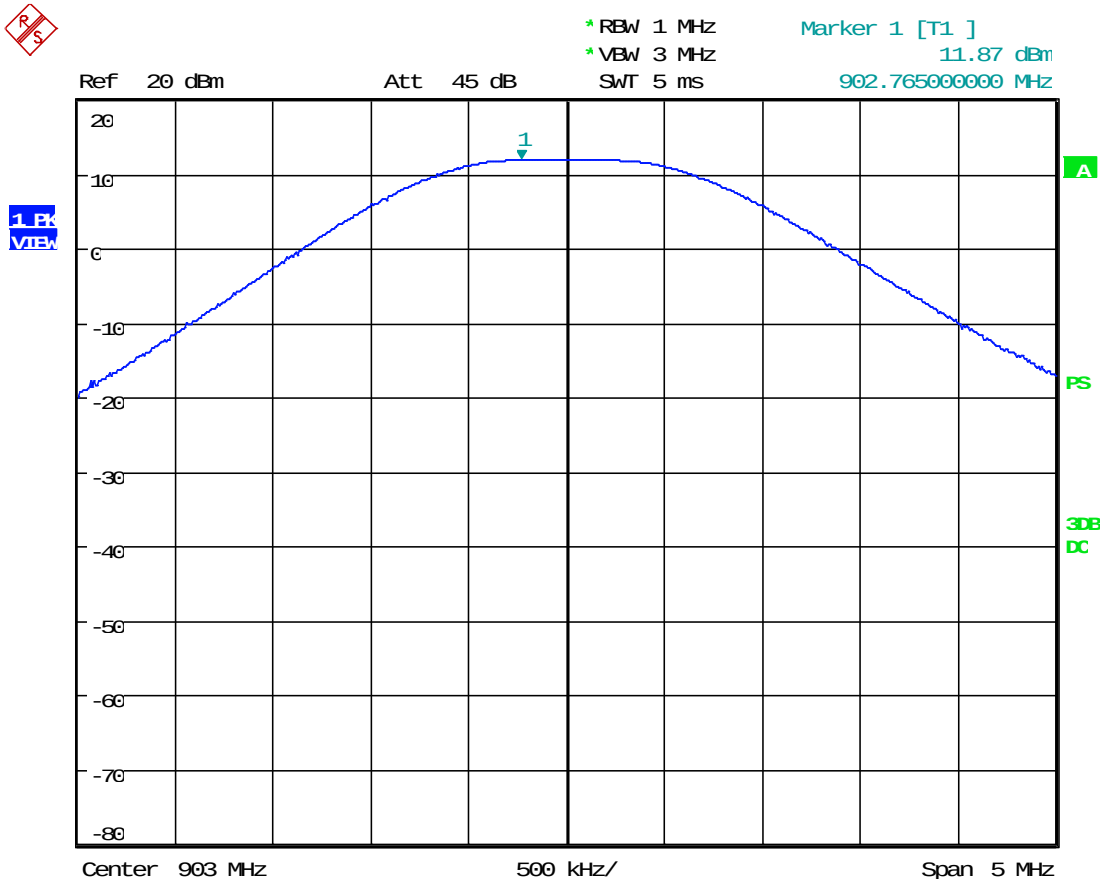
The peak power output shall be 1 watt (30 dBm) or less when using an antenna with a gain of less than 6dBi. For antennas having a gain of more than 6dBi, the limit is reduced by 1dB for every dB the antenna gain is over 6dBi.



8.2 Conducted Output Power Test Data

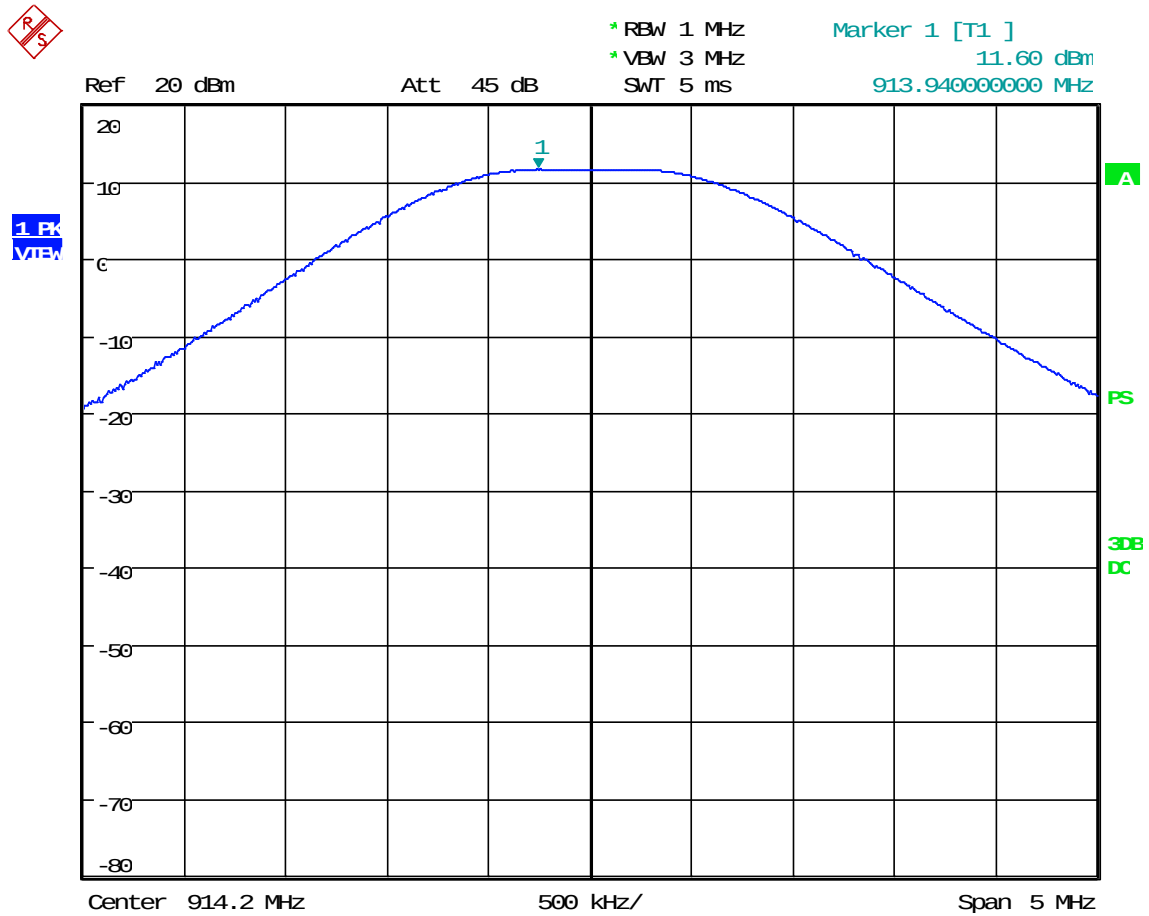
Test Date:	2023-10-17	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(b)(3); KDB558074	Air Temperature:	20.6°C
		Relative Humidity:	46%

SF7: Low Channel





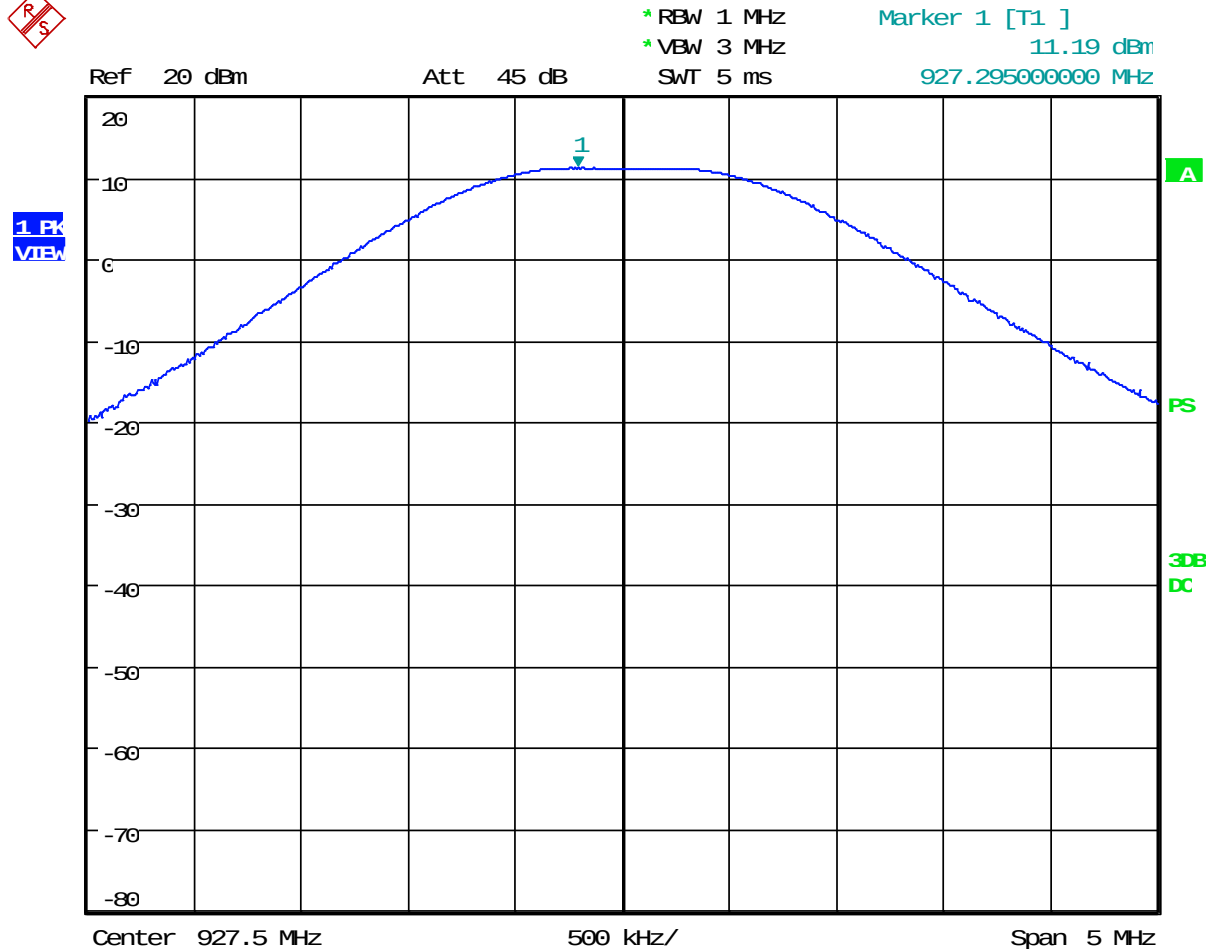
SF7: Mid Channel



Date: 17.OCT.2023 09:52:09



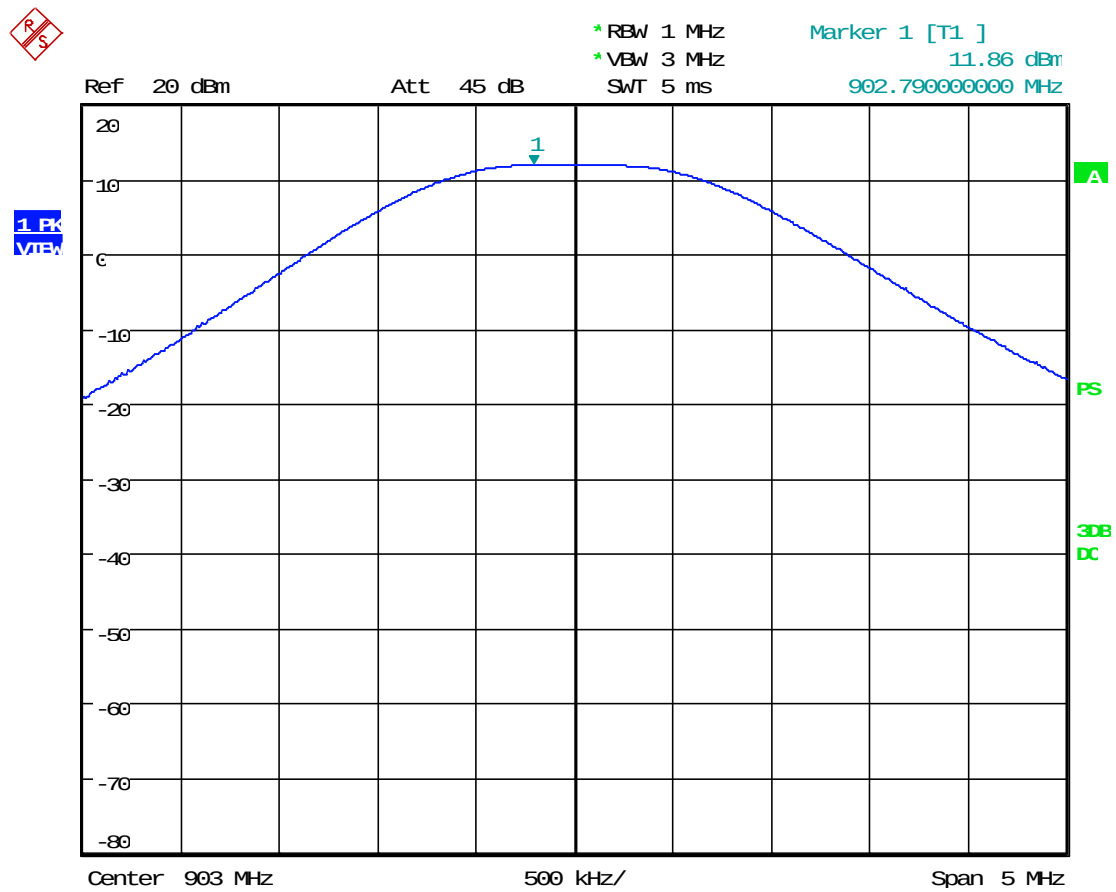
SF7: High Channel



Date: 17.OCT.2023 09:56:13

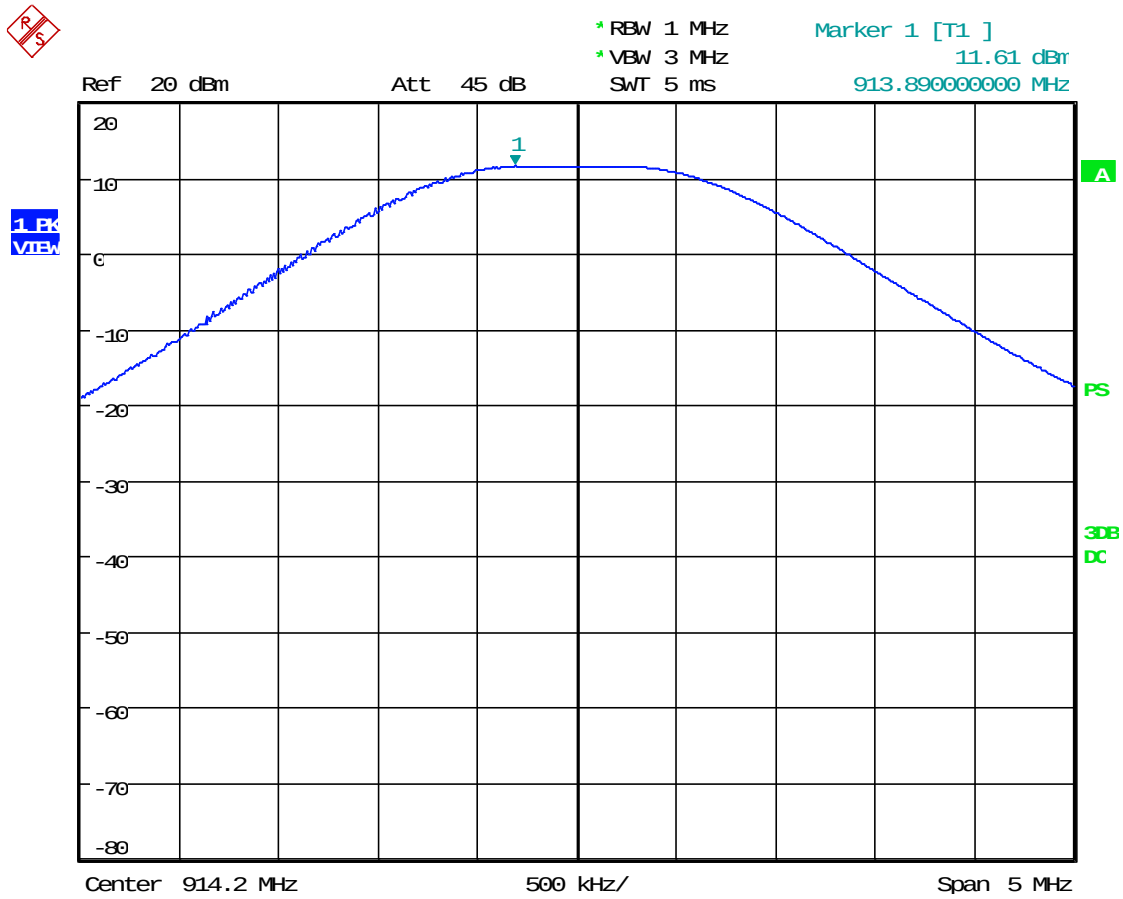


SF12: Low Channel





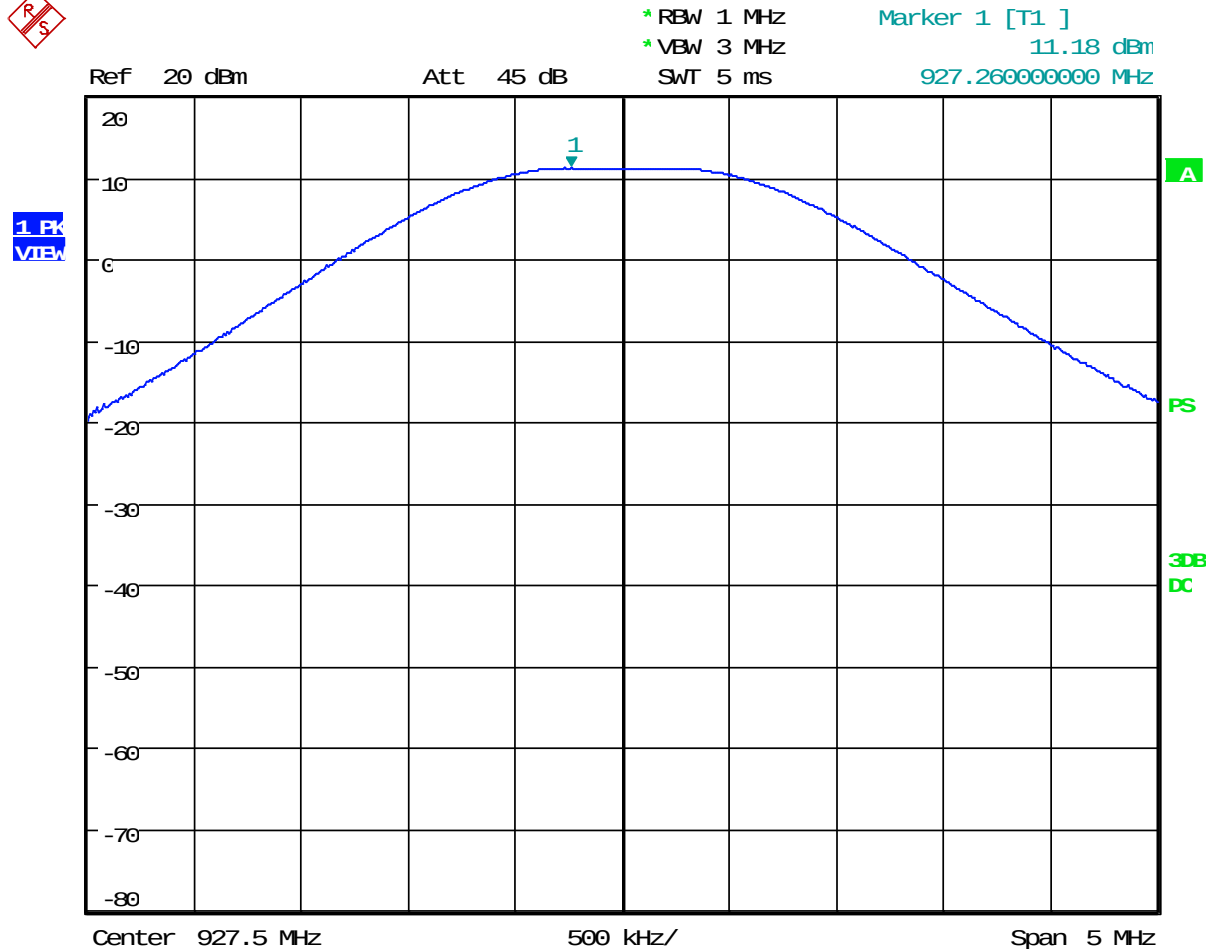
SF12: Mid Channel



Date: 17.OCT.2023 09:53:48



SF12: High Channel



Date: 17.OCT.2023 09:58:02



9 VOLTAGE VARIATIONS

9.1 Requirements

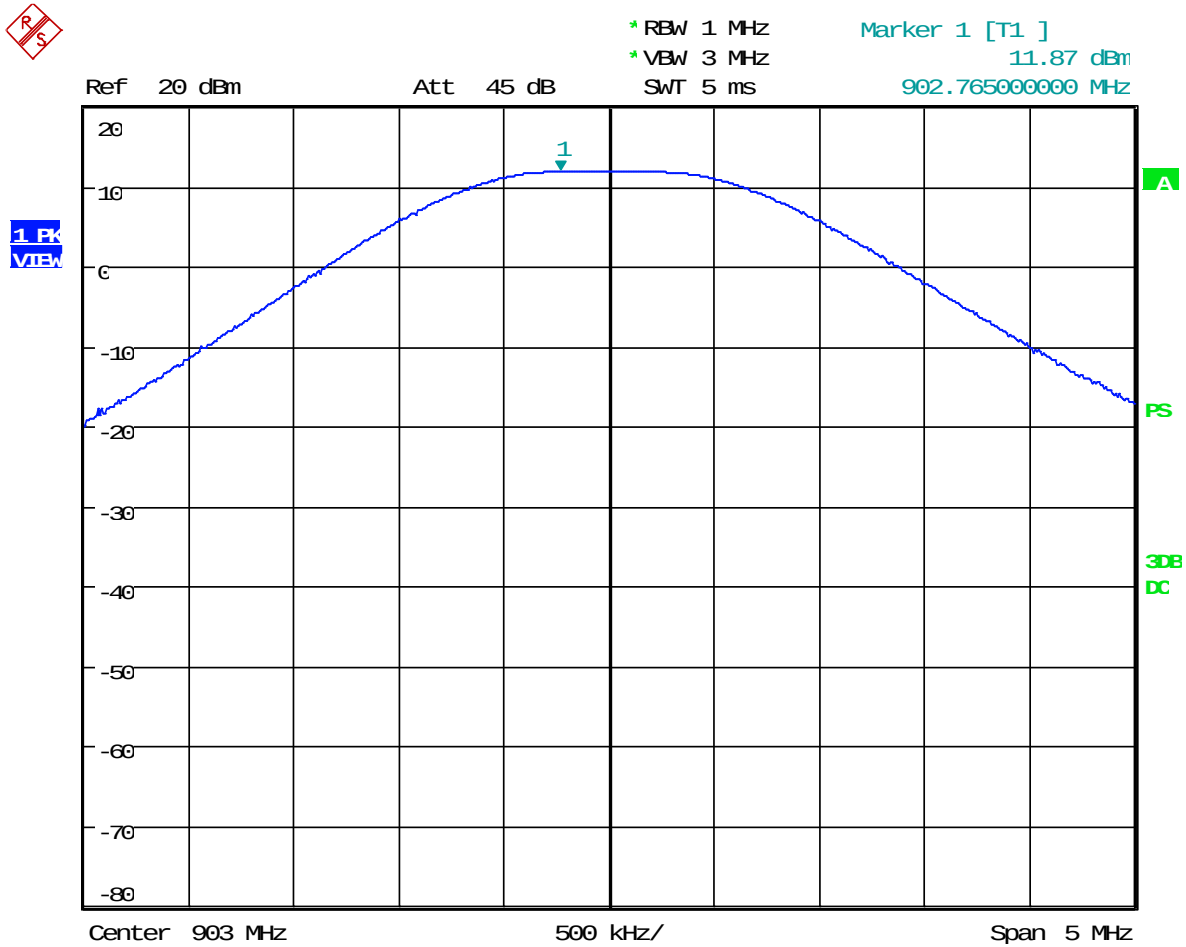
For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery-operated equipment, the equipment tests shall be performed using a new battery.



9.2 Voltage Variations Test Data

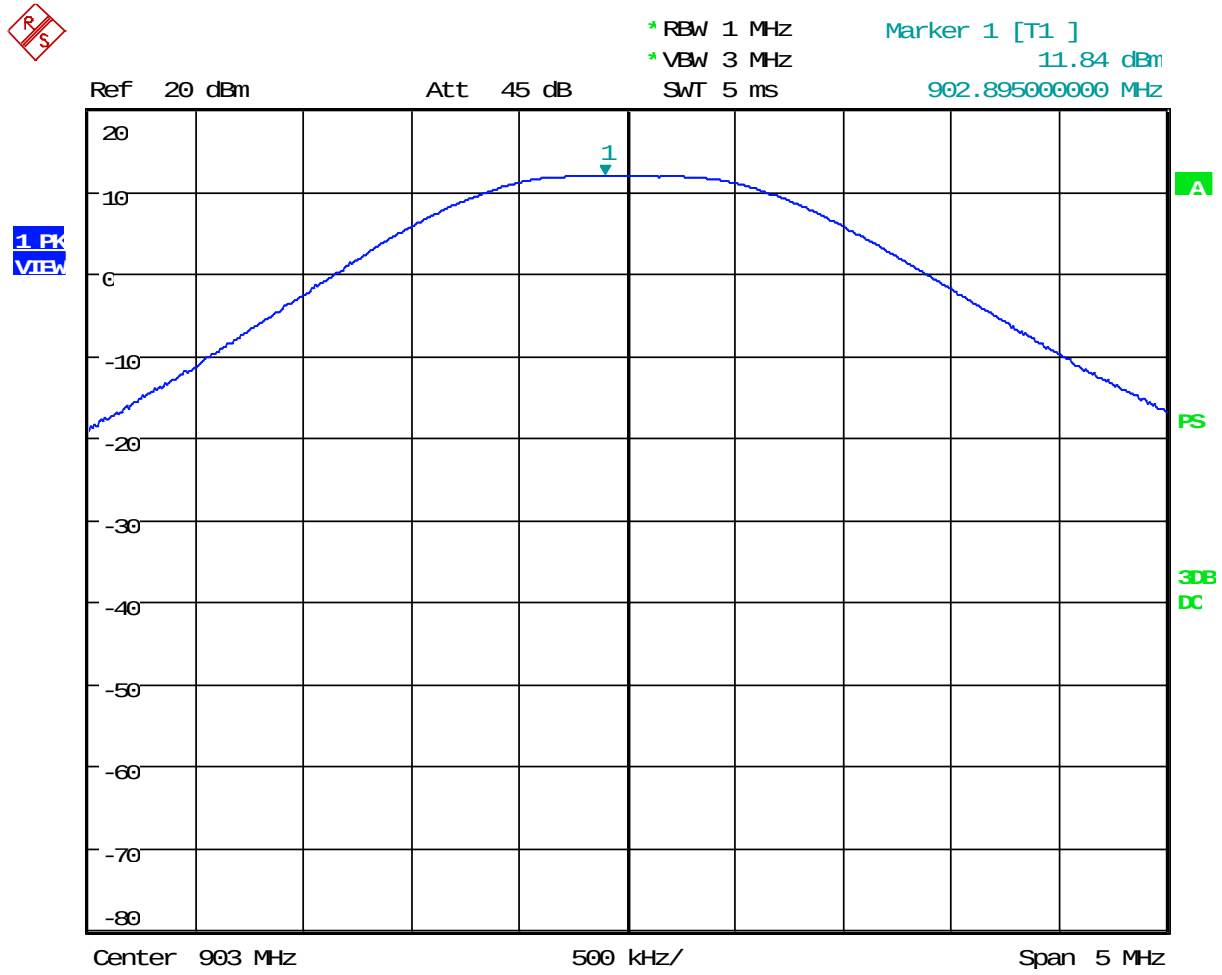
Test Date(s):	2023-10-17	Test Engineer:	J Chiller
Rule:	15.31(e)	Air Temperature:	20.6° C
Test Results:	Complies	Relative Humidity:	46%

Low Channel: Nominal (110V)





Low Channel: -15% (100V)



Date: 17.OCT.2023 10:10:27



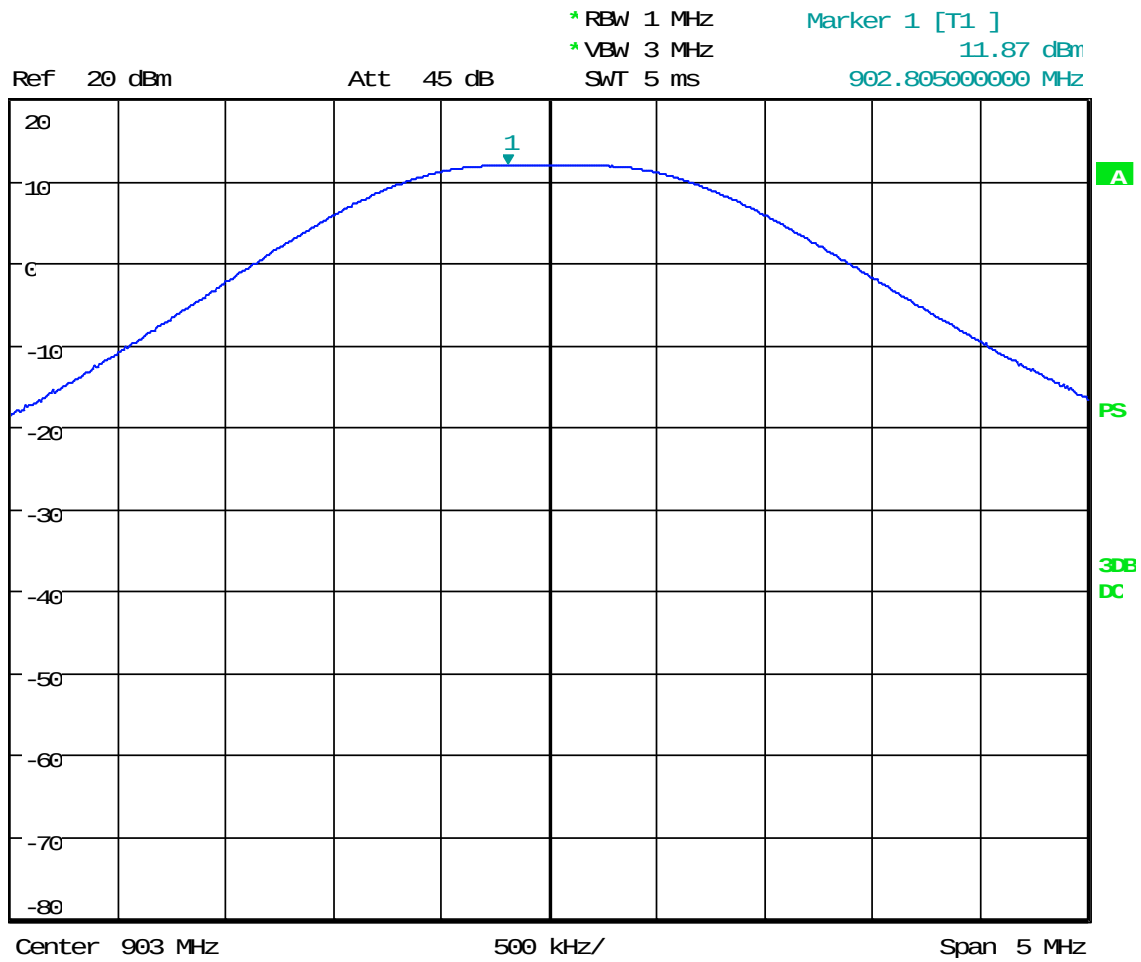
Order No(s): F2P30494A

Applicant: TeraCode Inc.
Model: TCCC024

Low Channel: +15% (140V)



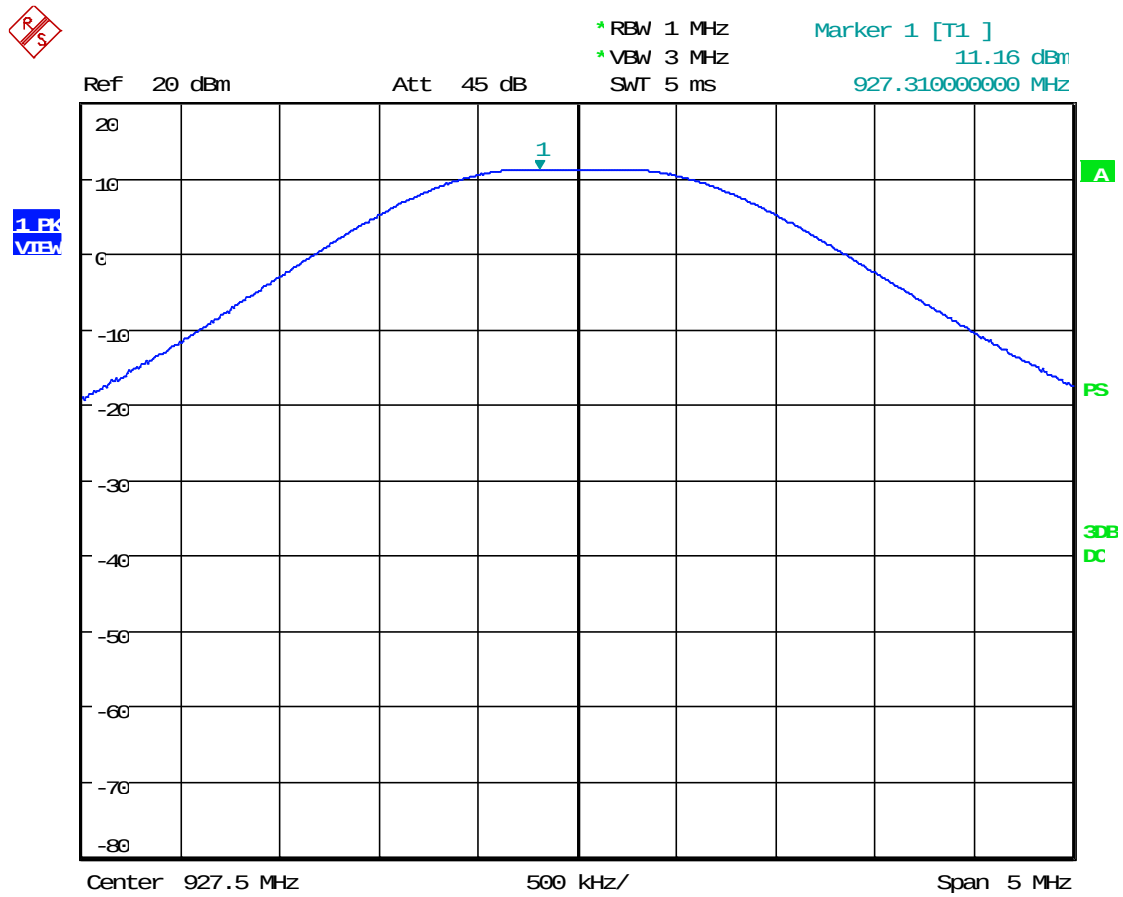
1.8k
VIBW



Date: 17.OCT.2023 10:12:01



High Channel: Nominal (110V)



Date: 17.OCT.2023 10:14:05



High Channel: -15% (100V)



* RBW 1 MHz

Marker 1 [T1]

* VBW 3 MHz

11.14 dBm

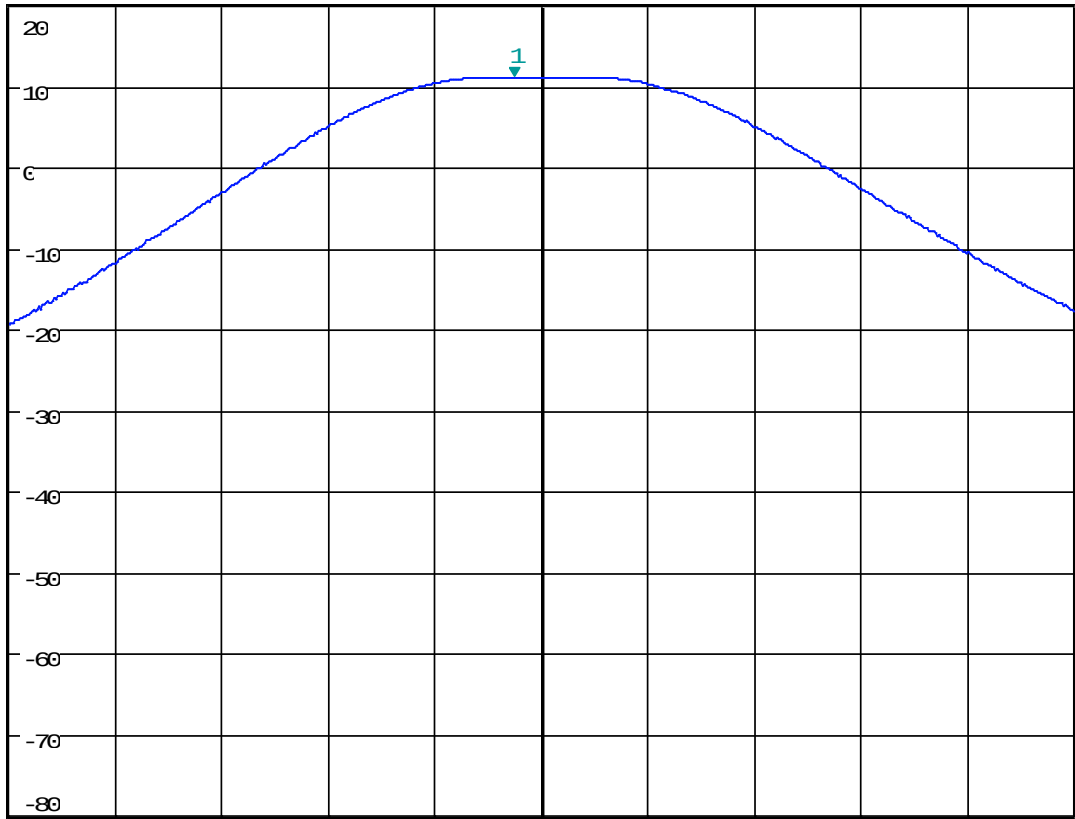
SWT 5 ms

927.370000000 MHz

Ref 20 dBm

Att 45 dB

1 PK
VIEW



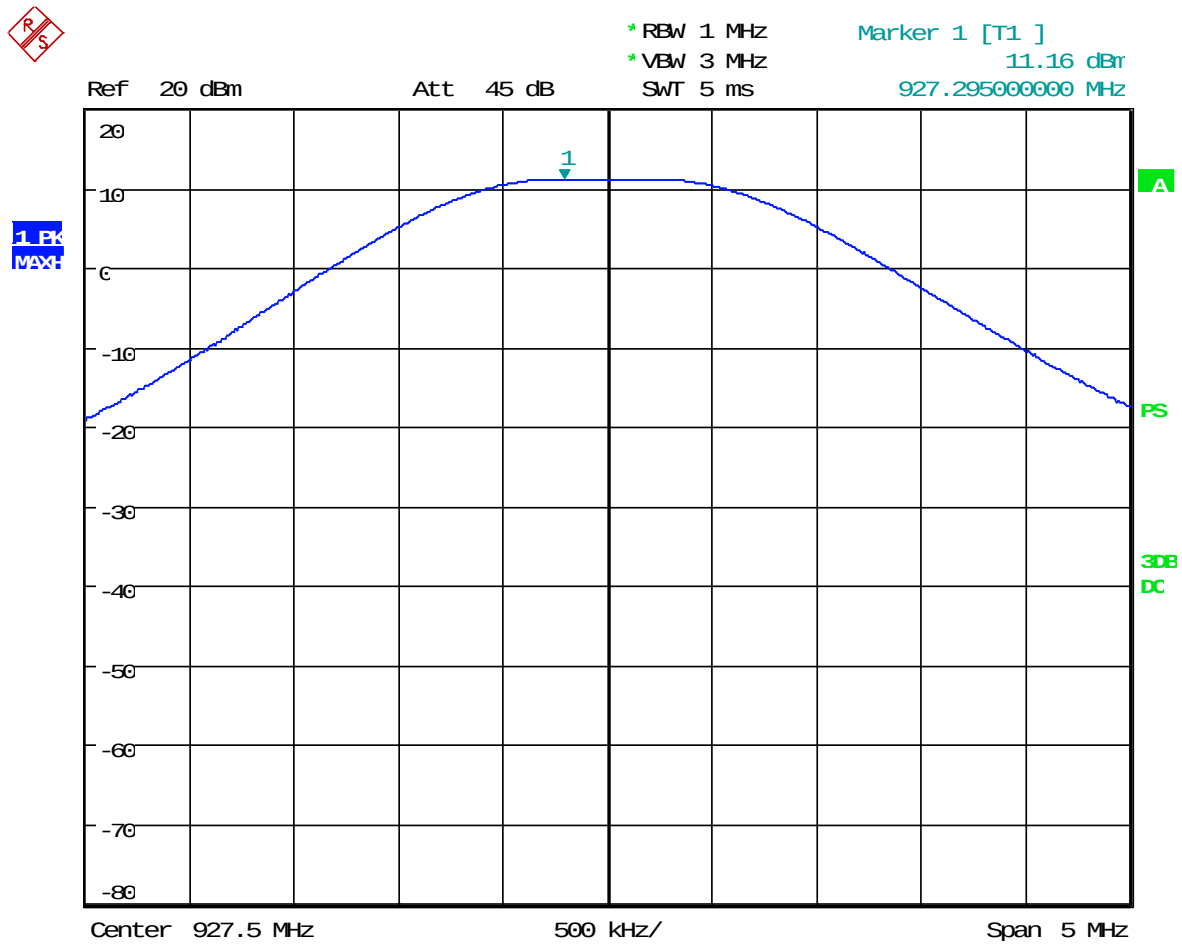
Date: 17.OCT.2023 10:14:38



Order No(s): F2P30494A

Applicant: TeraCode Inc.
Model: TCCC024

High Channel: +15% (140V)



Date: 17.OCT.2023 10:15:57



10 CONDUCTED SPURIOUS EMISSIONS

The following tests were performed to demonstrate compliance.

RF Antenna Conducted Test

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the spectrum analyzer.

10.1 Requirements:

All Spurious Emissions must be at least 20dB down from the highest emission level measured within the authorized band up through the tenth harmonic.

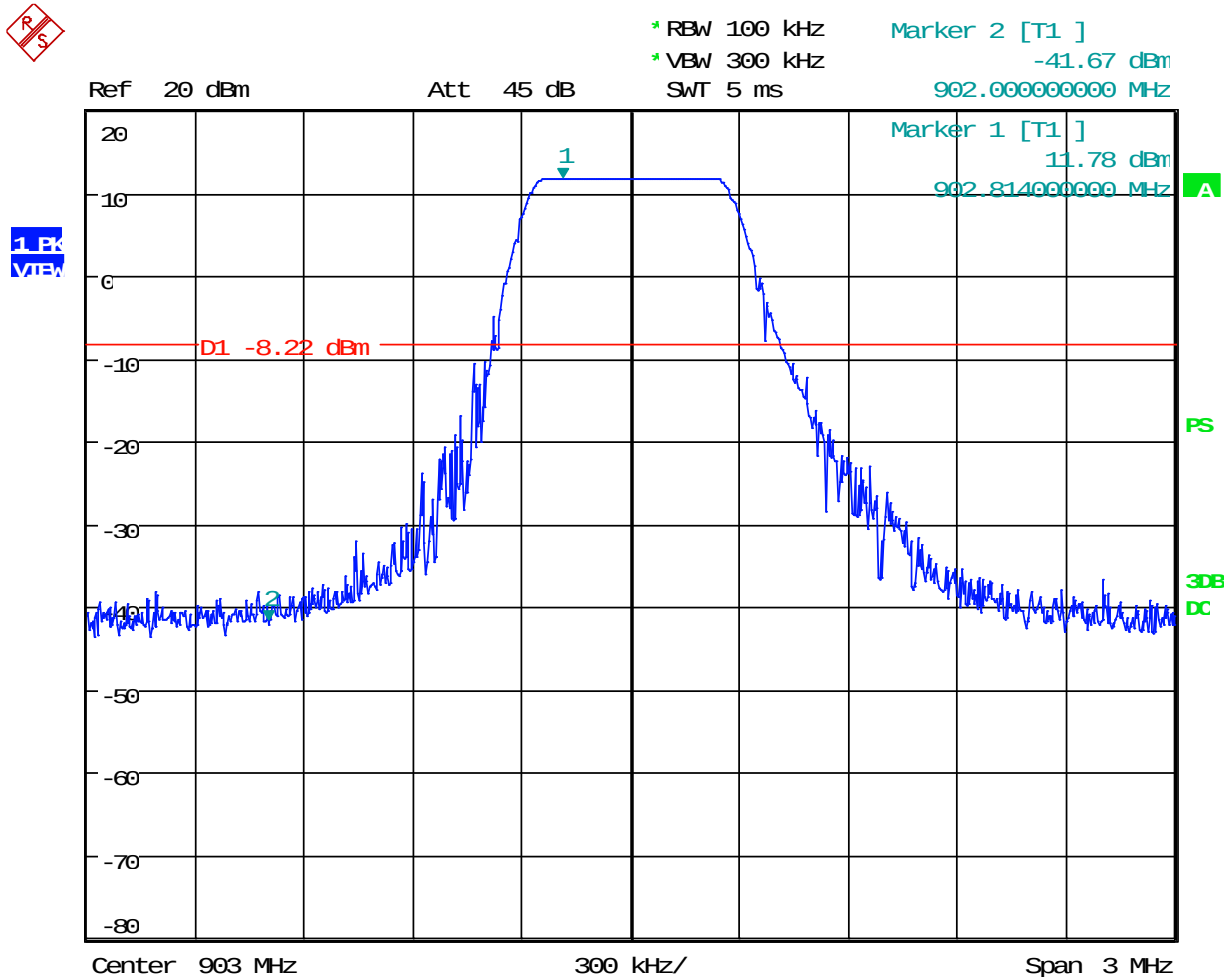
Spurious emissions measurements were made at the low, mid, and upper channels with the appropriate spectrum analyzer impulse bandwidth. Additionally, 20dB down points were measured for the low and high channels to verify band edge compliance.



10.2 Conducted Spurious Emissions Test Data

Test Date:	2023-10-17	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(d) / Part 15.207 KDB558074	Air Temperature:	21.0°C
		Relative Humidity:	47%

SF7, Low Channel: Lower Band Edge



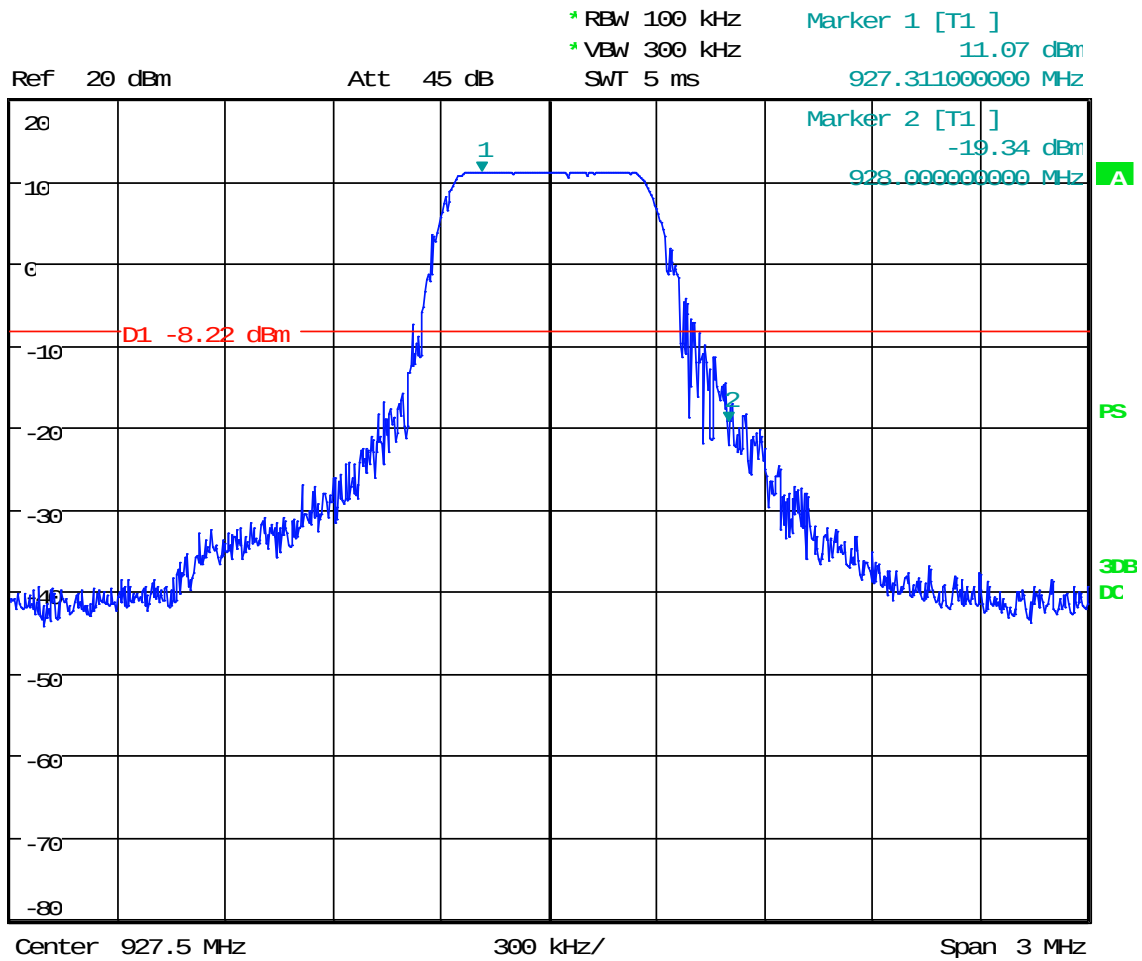
Date: 17.OCT.2023 10:32:51



SF7, Low Channel: Upper Band Edge



1 PK
VIEW



Date: 17.OCT.2023 10:39:00



SF7, Low Channel: 0.009 MHz to 0.15 MHz



* RBW 1 kHz

Marker 1 [T1]

* VBW 3 kHz

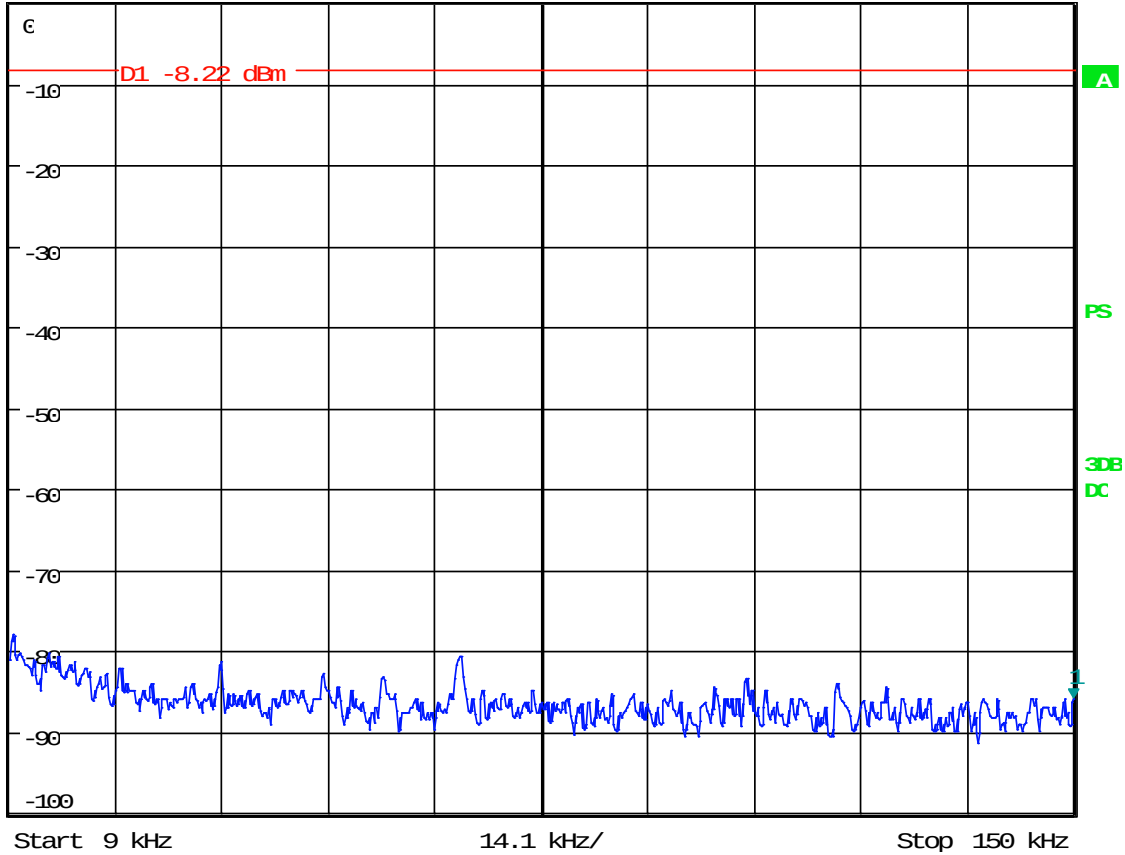
-85.82 dBm

Ref 0 dBm

Att 25 dB

SWT 145 ms

150.000000000 kHz



Date: 17.OCT.2023 10:49:09



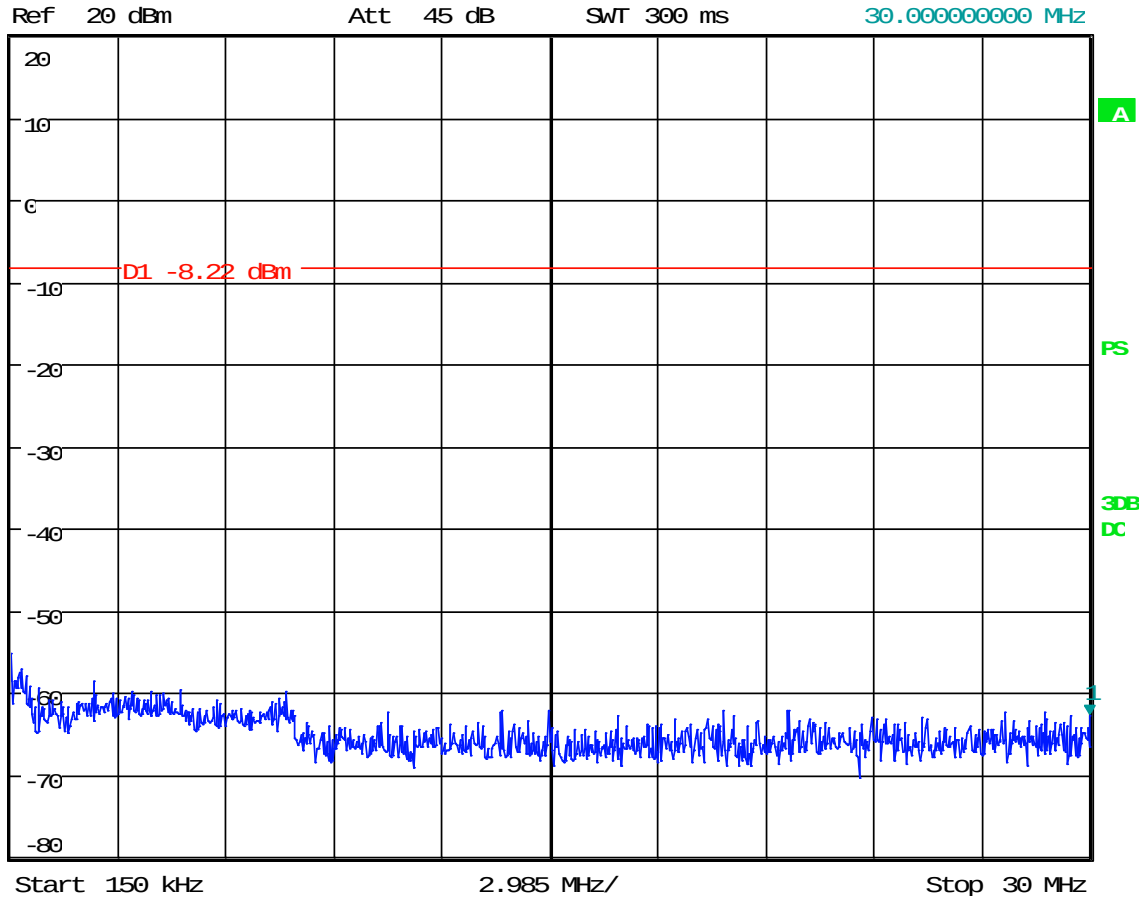
SF7, Low Channel: 0.15 MHz to 30 MHz



*RBW 10 kHz
*VBW 30 kHz
SWT 300 ms

Marker 1 [T1]
-62.76 dBm
30.000000000 MHz

1.8k
VTH



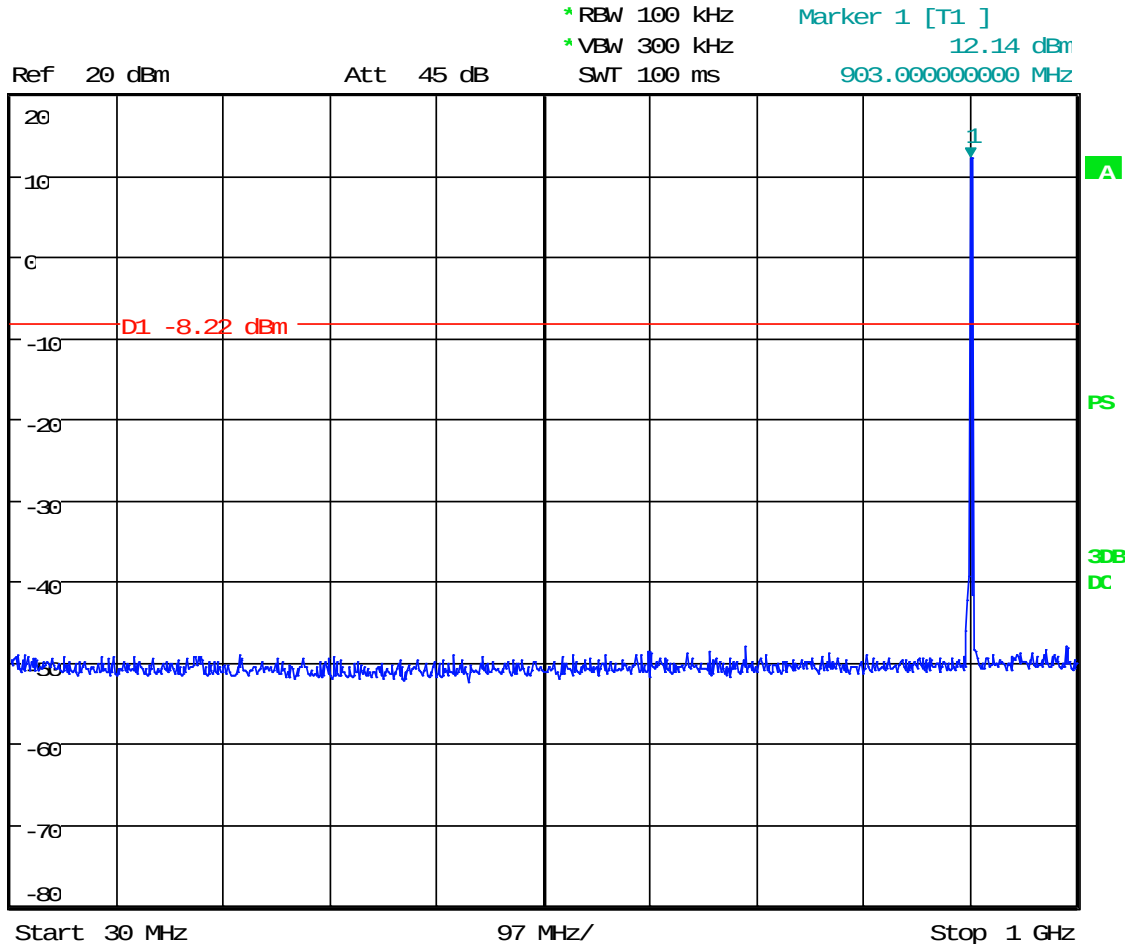
Date: 17.OCT.2023 10:48:22



SF7, Low Channel: 30 MHz to 1000 MHz



1. PK
VTRM



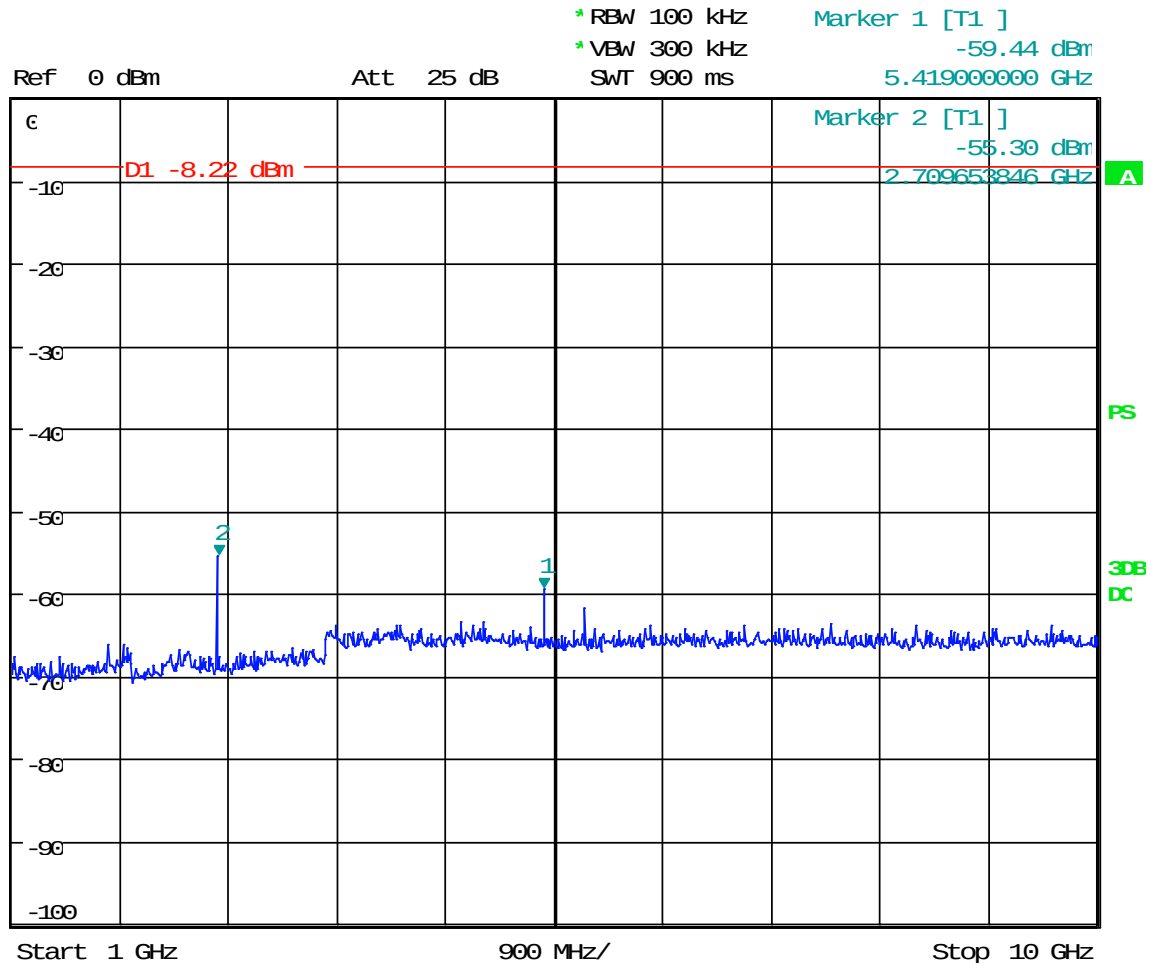
Date: 17.OCT.2023 10:47:45



SF7, Low Channel: 1 GHz to 10 GHz



1 PK
VIB



Date: 17.OCT.2023 10:46:27



SF7, Mid Channel: 0.009 MHz to 0.15 MHz



* RBW 1 kHz

Marker 1 [T1]

* VBW 3 kHz

-83.07 dBm

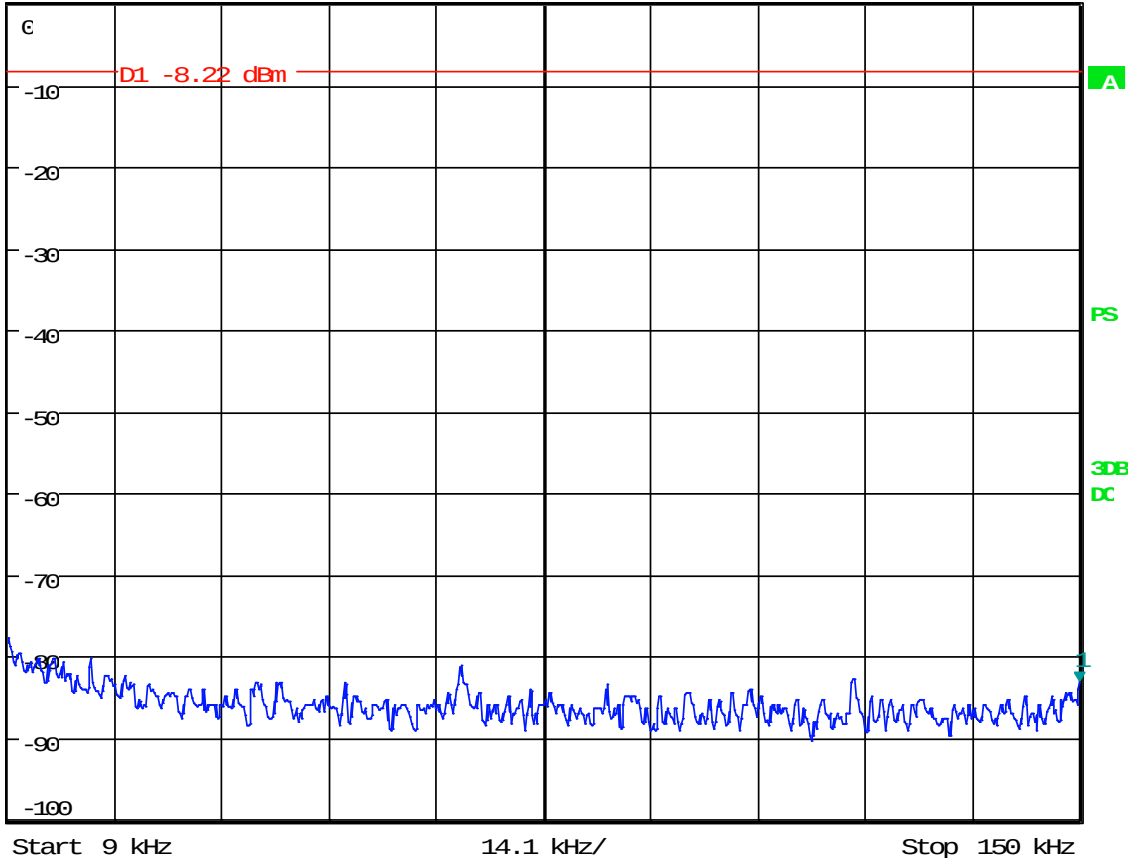
Ref 0 dBm

Att 25 dB

SWT 145 ms

150.000000000 kHz

1.0k
VIEW



Date: 17.OCT.2023 10:59:10



SF7, Mid Channel: 0.15 MHz to 30 MHz



* RBW 10 kHz

Marker 1 [T1]

* VBW 30 kHz

-65.10 dBm

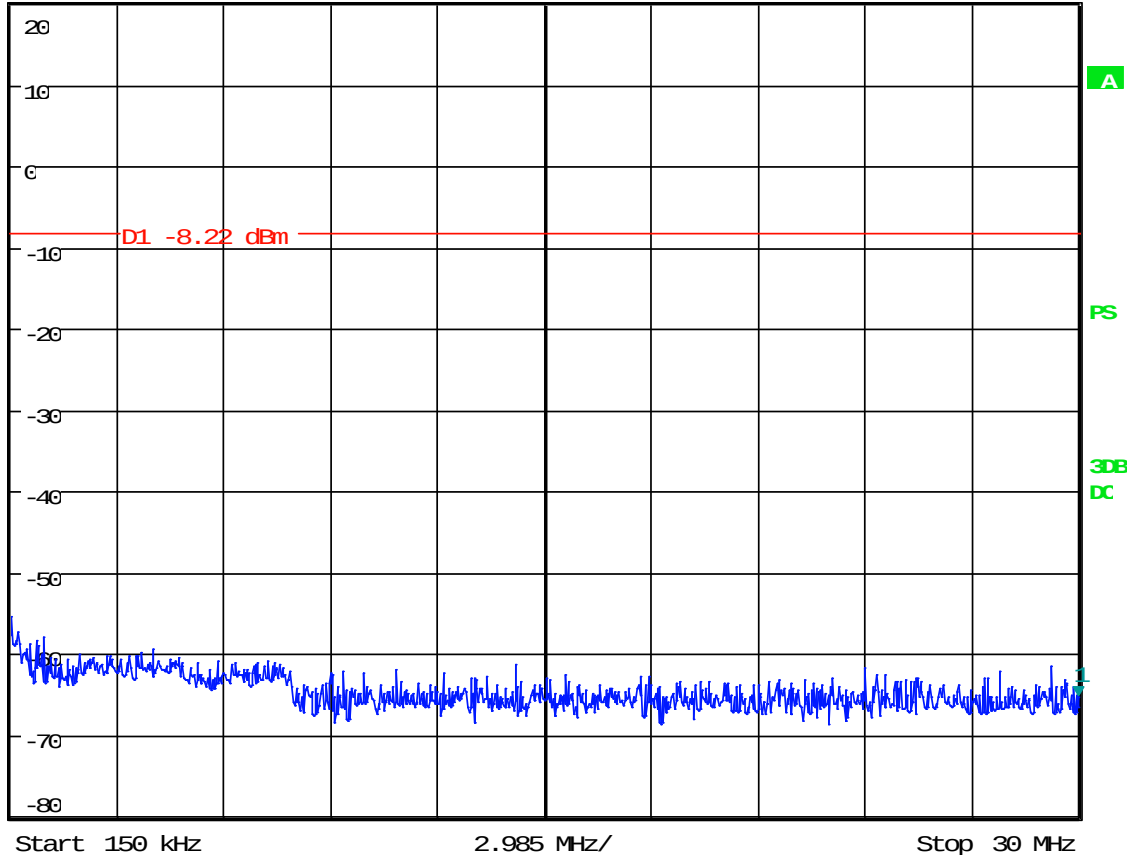
SWT 300 ms

30.000000000 MHz

Ref 20 dBm

Att 45 dB

1 PK
VTRM



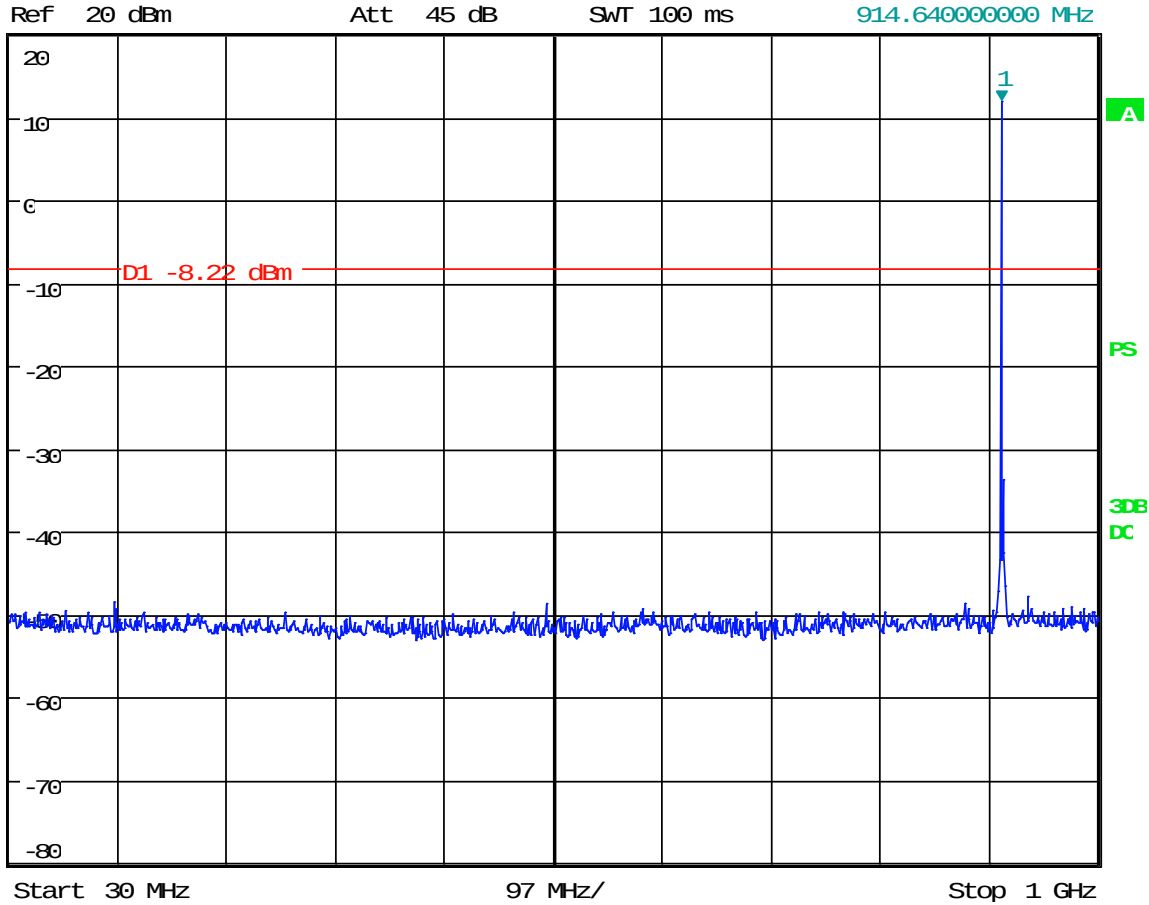
Date: 17.OCT.2023 10:58:35



SF7, Mid Channel: 30 MHz to 1000 MHz



RBW 100 kHz
VBW 300 kHz
Marker 1 [T1]
11.86 dBm
914.640000000 MHz



Date: 17.OCT.2023 10:57:57



SF7, Mid Channel: 1 GHz to 10 GHz



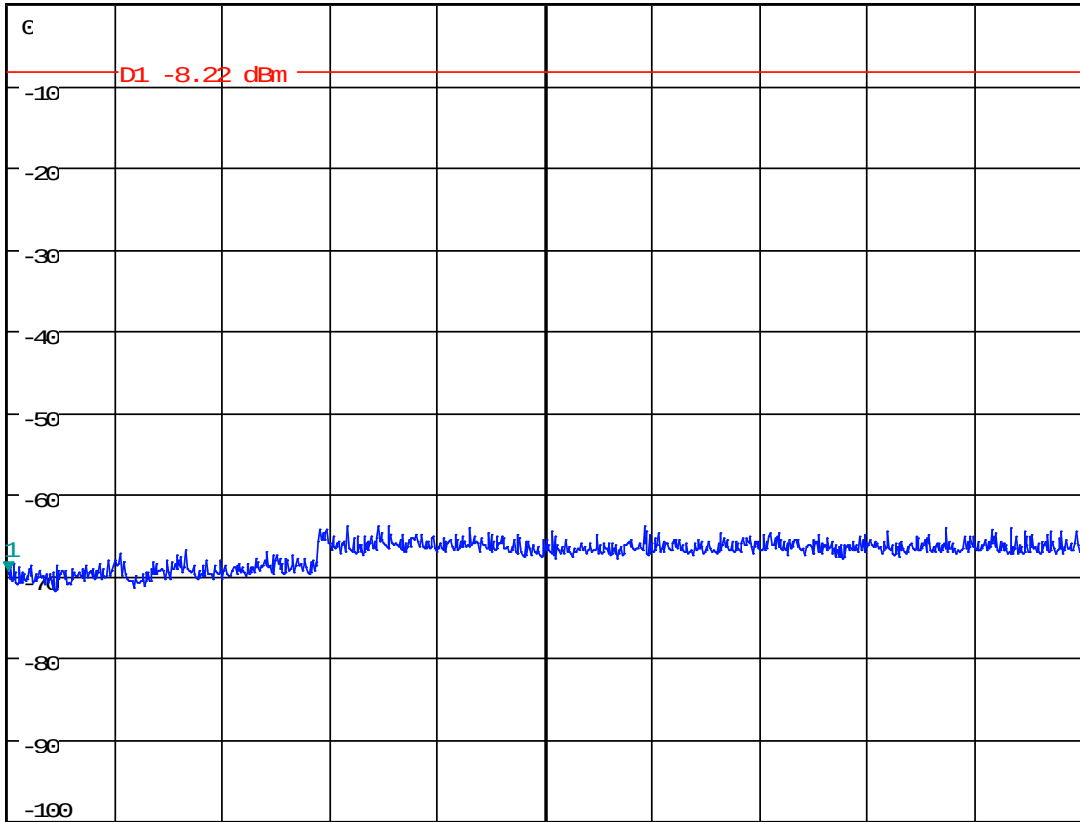
* RBW 100 kHz
* VBW 300 kHz
SWT 900 ms

Marker 1 [T1]
-69.37 dBm
1.000000000 GHz

Ref 0 dBm

Att 25 dB

1.00
VIEW



Start 1 GHz

900 MHz/

Stop 10 GHz

Date: 17.OCT.2023 10:57:03



SF7, High Channel: 0.009 MHz to 0.15 MHz



RBW 1 kHz

Marker 1 [T1]

VBW 3 kHz

-86.02 dBm

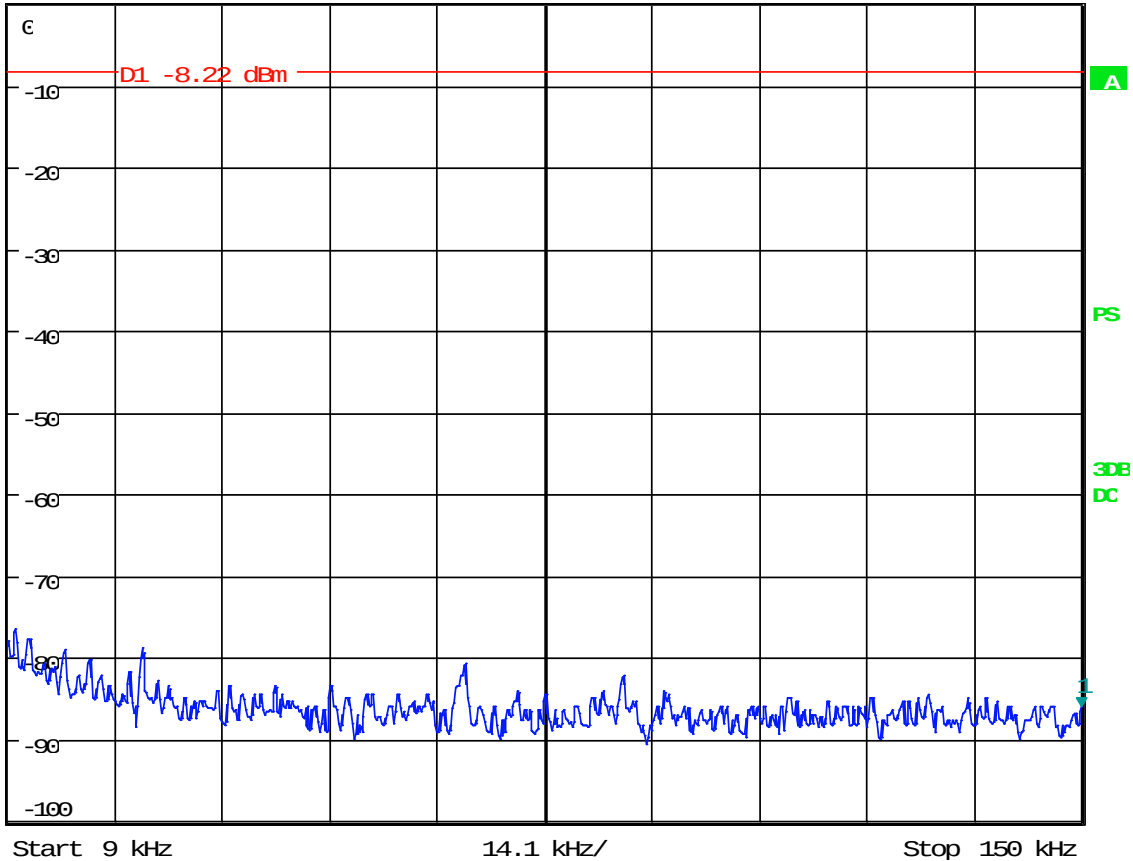
Ref 0 dBm

Att 25 dB

SWT 145 ms

150.000000000 kHz

1 PK
VIEW



Date: 17.OCT.2023 11:08:52



SF7, High Channel: 0.15 MHz to 30 MHz



* RBW 10 kHz

Marker 1 [T1]

* VBW 30 kHz

-84.10 dBm

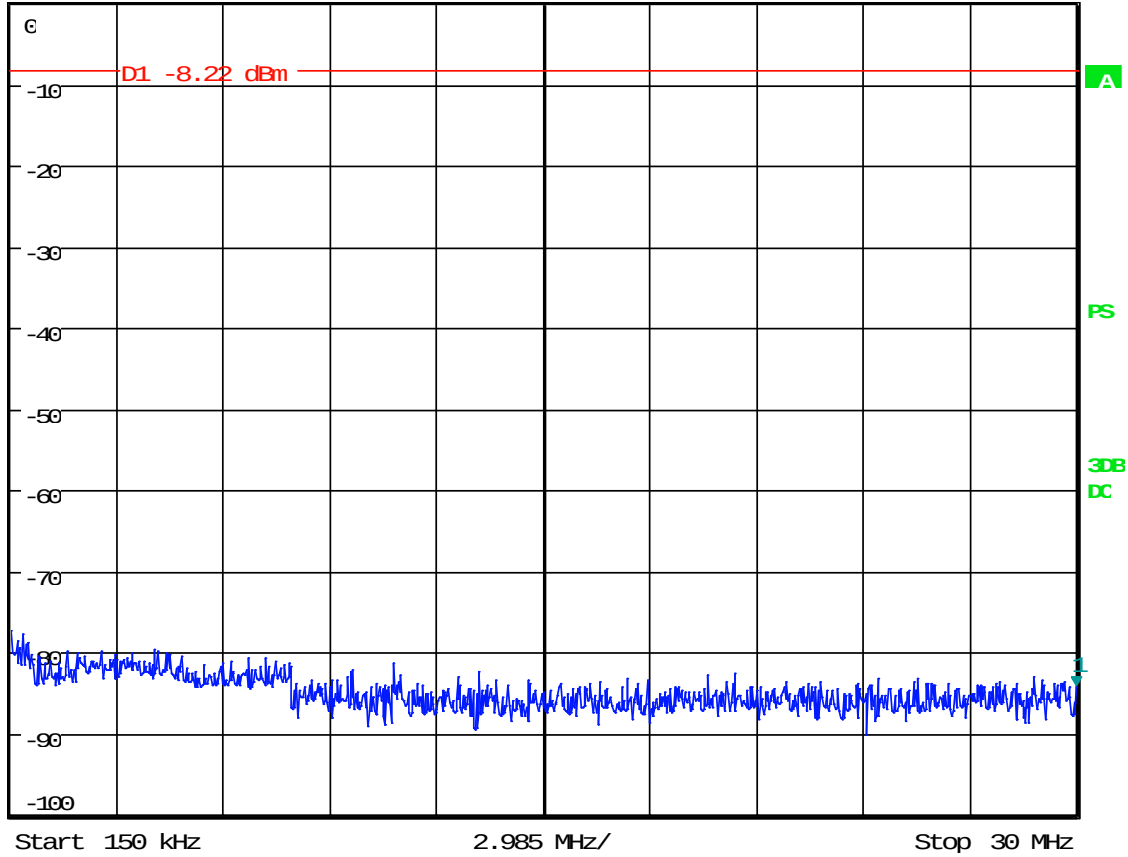
Ref 0 dBm

Att 25 dB

SWT 300 ms

30.000000000 MHz

1.86
VIB



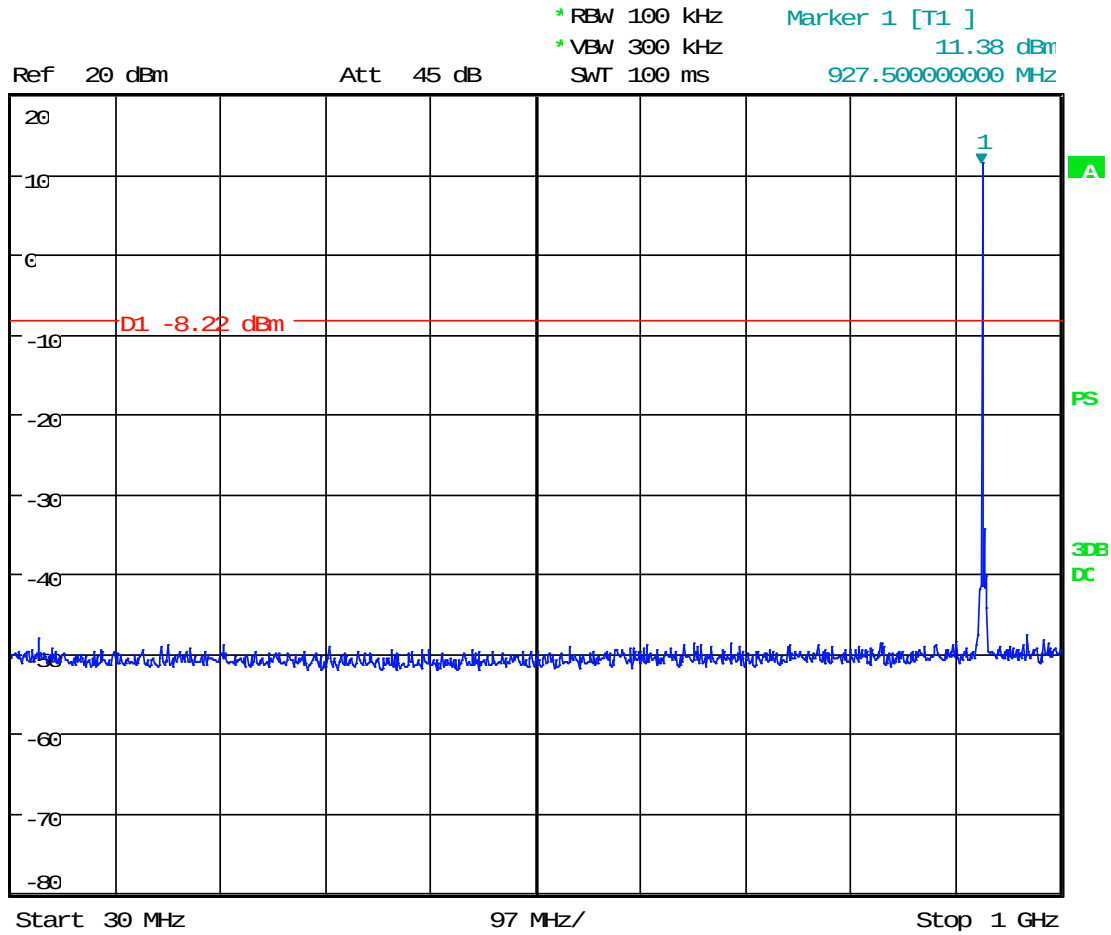
Date: 17.OCT.2023 11:08:23



SF7, High Channel: 30 MHz to 1000 MHz



PK
VIEW



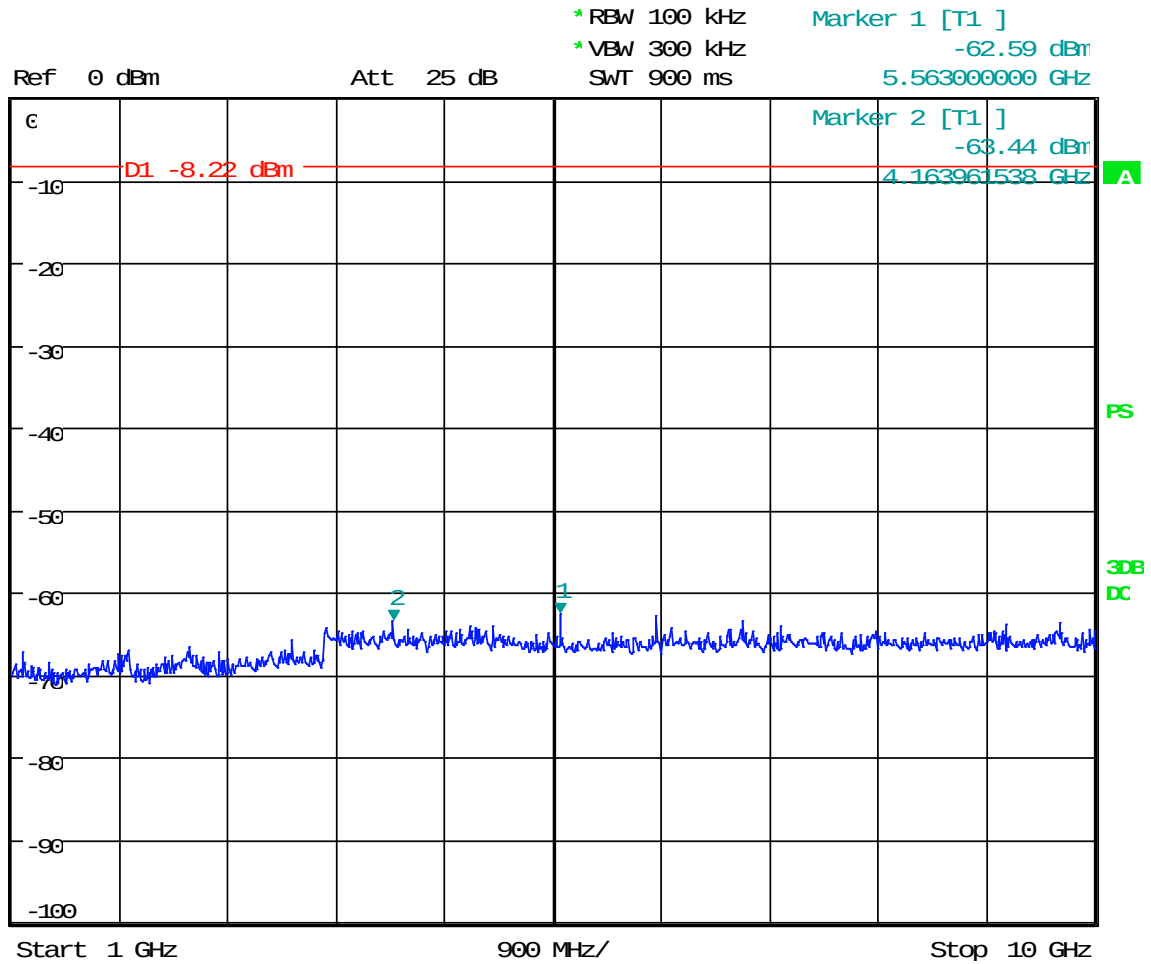
Date: 17.OCT.2023 11:07:31



SF7, High Channel: 1 GHz to 10 GHz



1 Bk
VTR



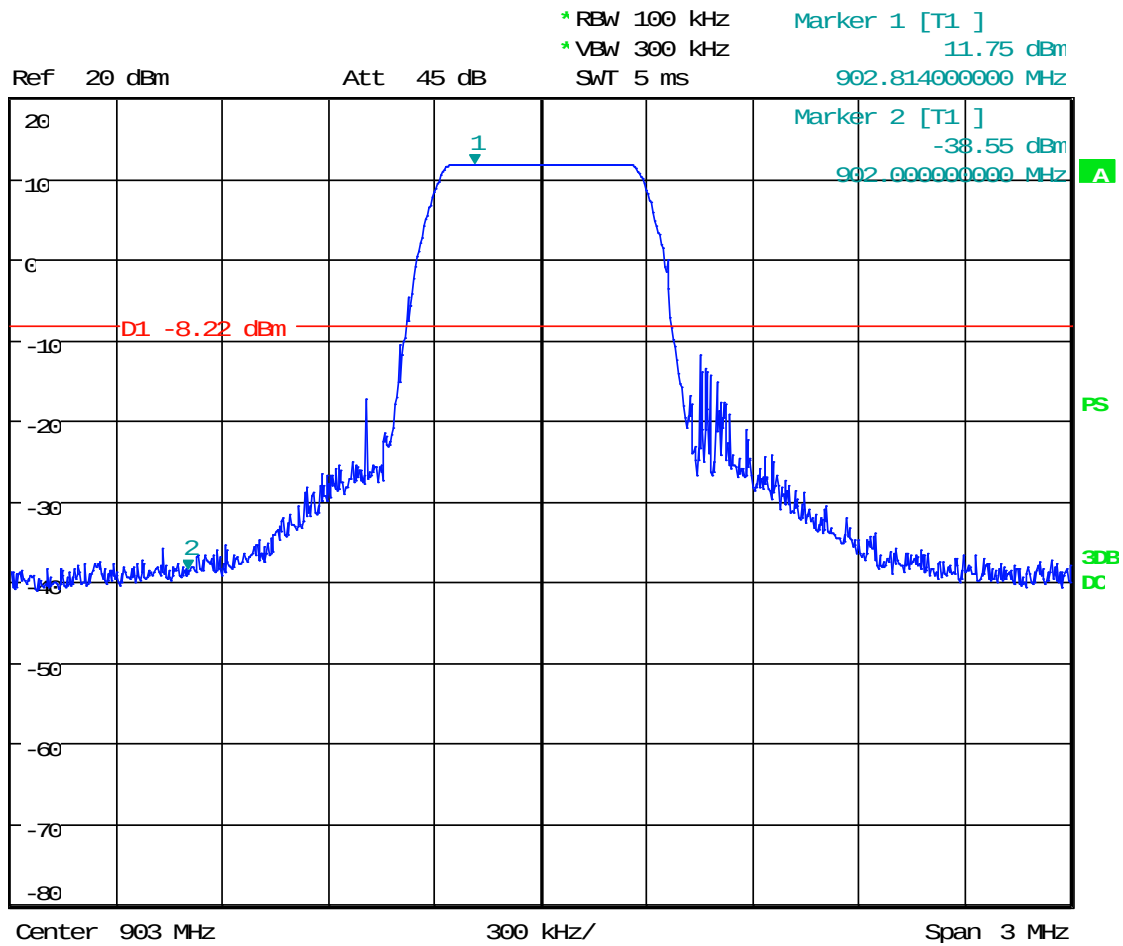
Date: 17.OCT.2023 11:06:12



SF12, Low Channel: Lower Band Edge



1 PK
VIEW

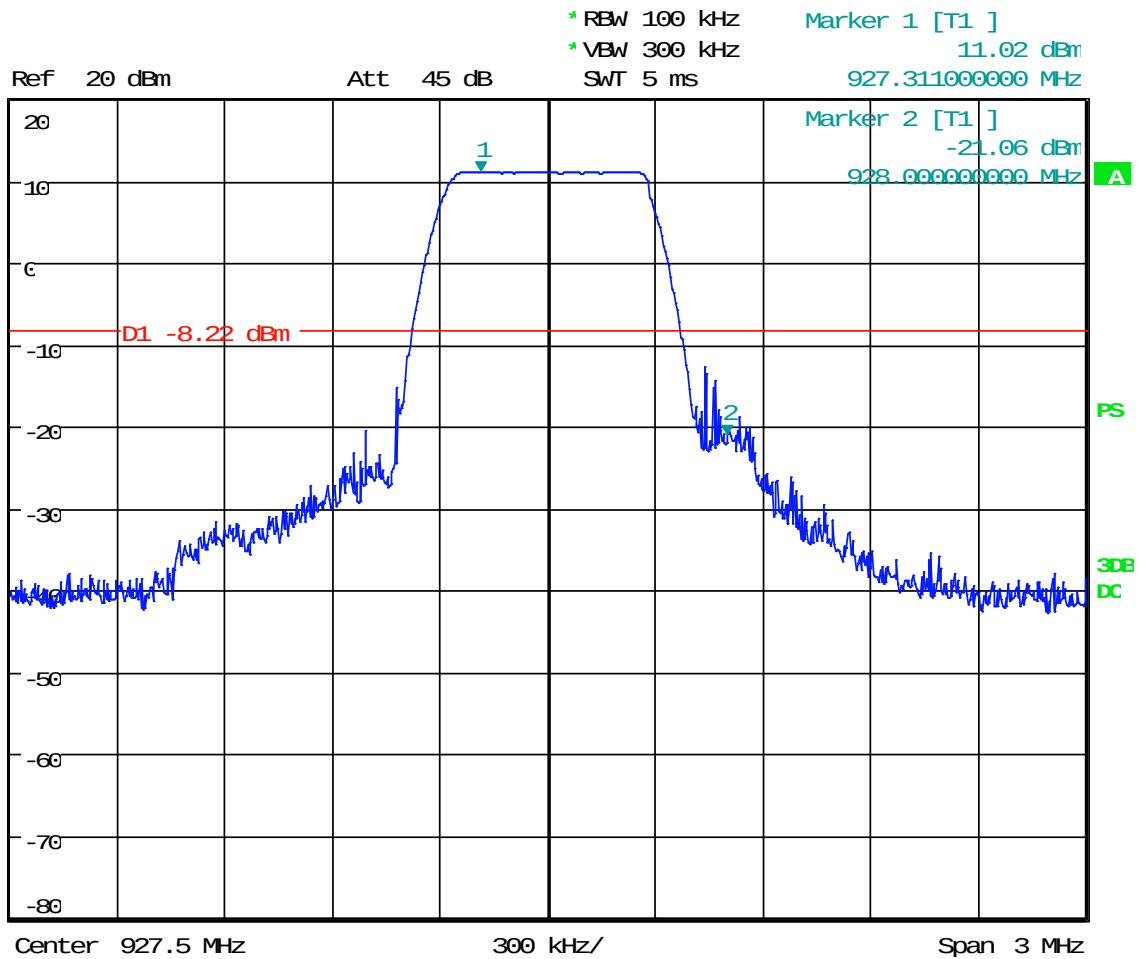




SF12, Low Channel: Upper Band Edge

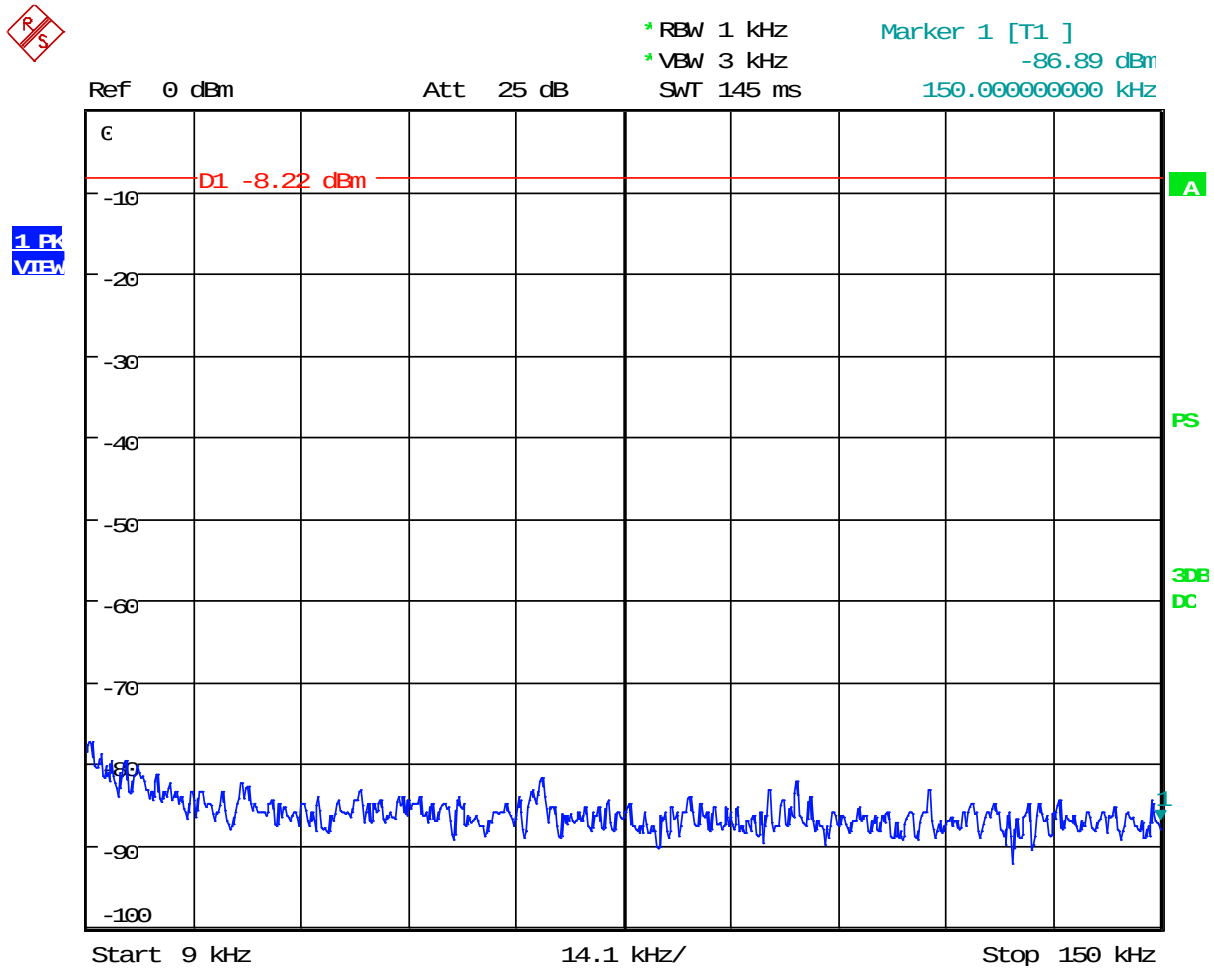


1. PK
VIEW



Date: 17.OCT.2023 10:40:46

SF12, Low Channel: 0.009 MHz to 0.15 MHz



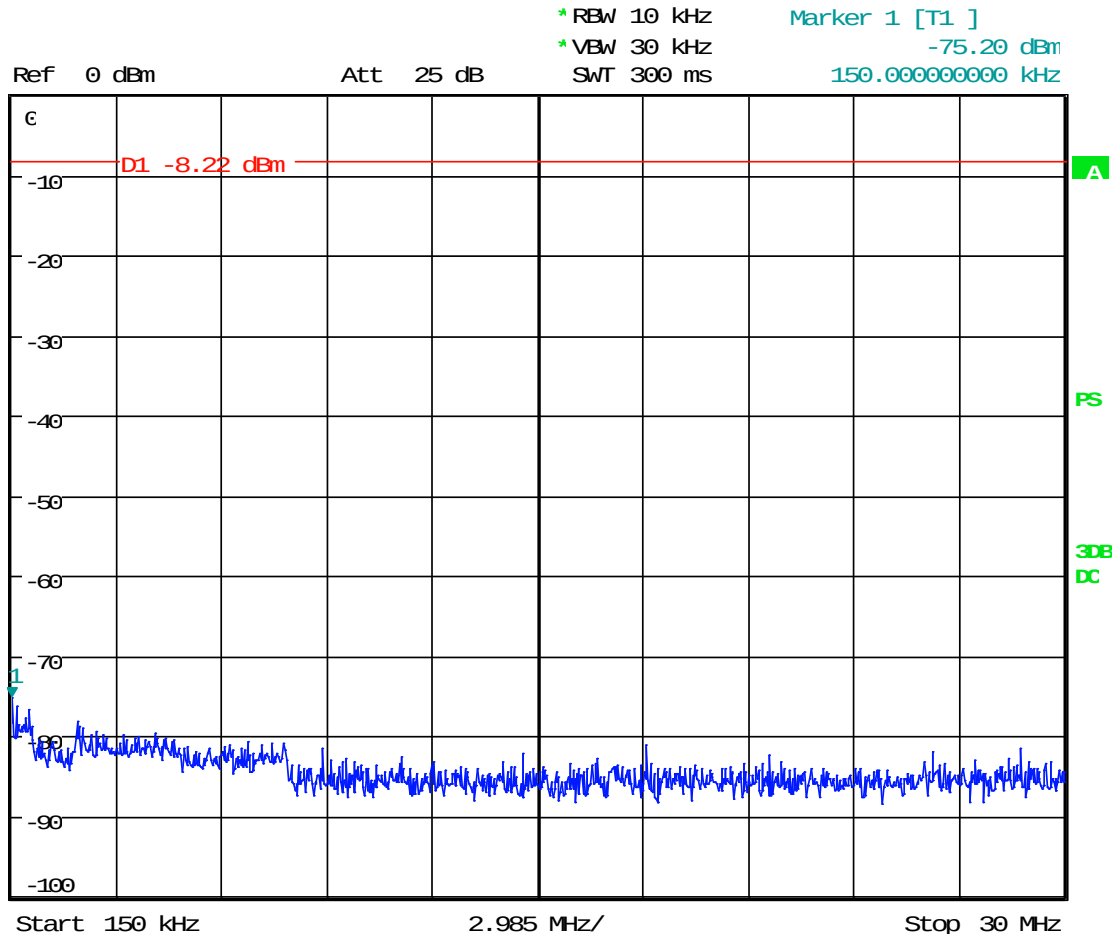
Date: 17.OCT.2023 10:51:18



SF12, Low Channel: 0.15 MHz to 30 MHz



1 PK
VIEW



Date: 17.OCT.2023 10:51:52



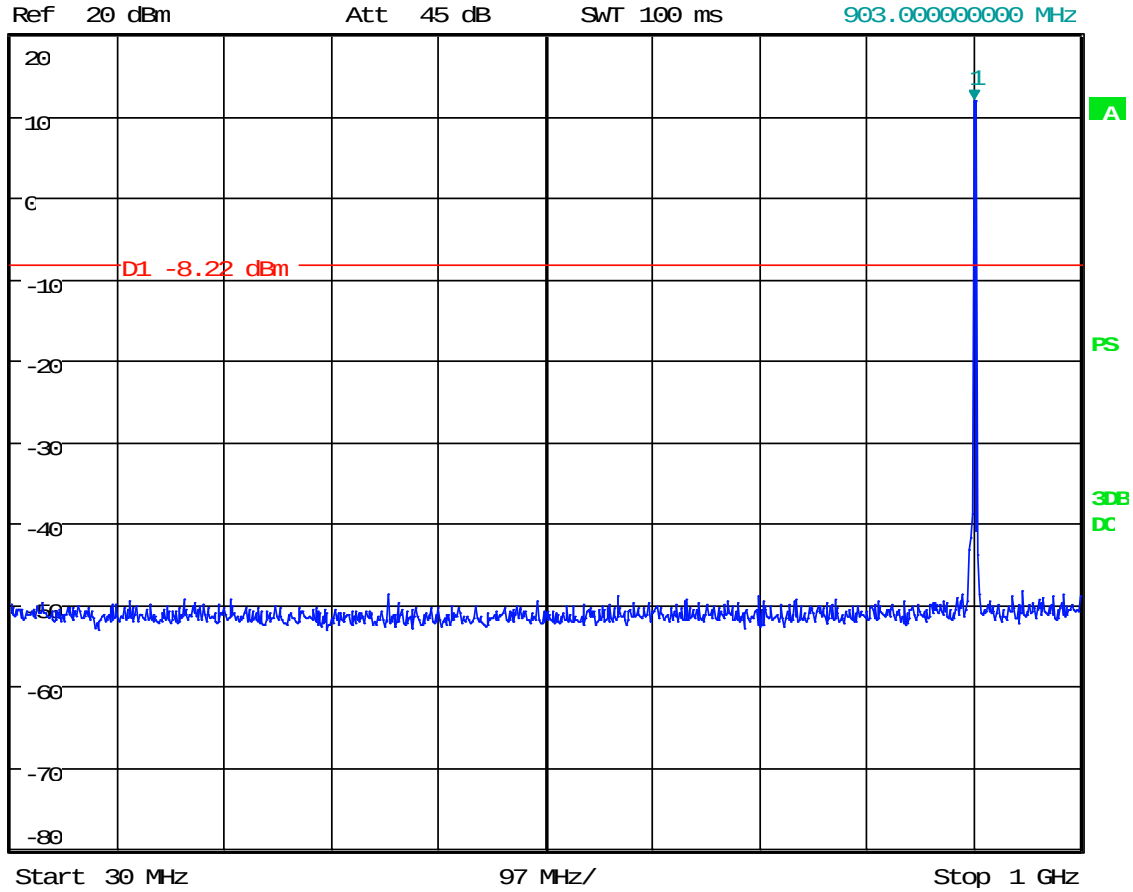
SF12, Low Channel: 30 MHz to 1000 MHz



* RBW 100 kHz
* VBW 300 kHz
SWT 100 ms

Marker 1 [T1]
11.95 dBm
903.000000000 MHz

1.84
VIB



Date: 17.OCT.2023 10:52:51

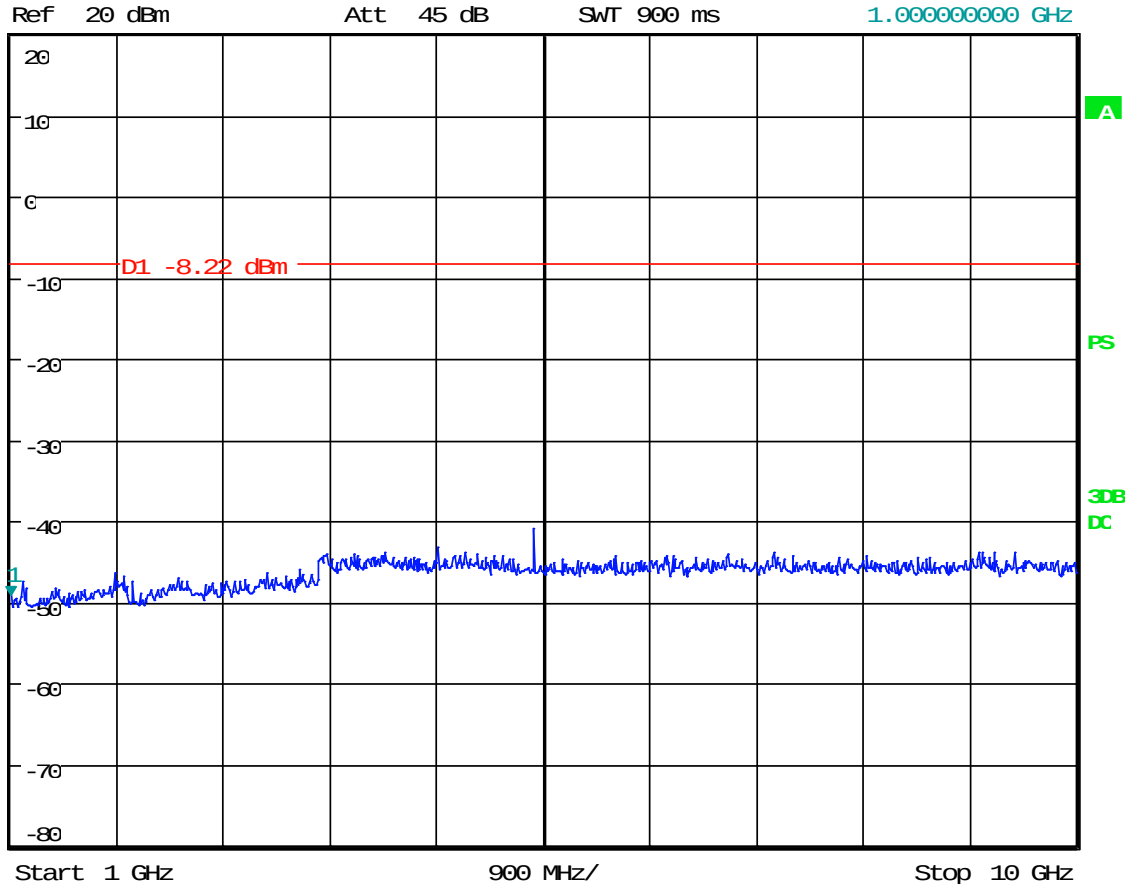


SF12, Low Channel: 1 GHz to 10 GHz



* RBW 100 kHz
* VBW 300 kHz
Marker 1 [T1]
-49.12 dBm
1.000000000 GHz

1. PK
VTRM



Date: 17.OCT.2023 10:54:02



SF12, Mid Channel: 0.009 MHz to 0.15 MHz



* RBW 1 kHz

* VBW 3 kHz

Marker 1 [T1]

-87.60 dBm

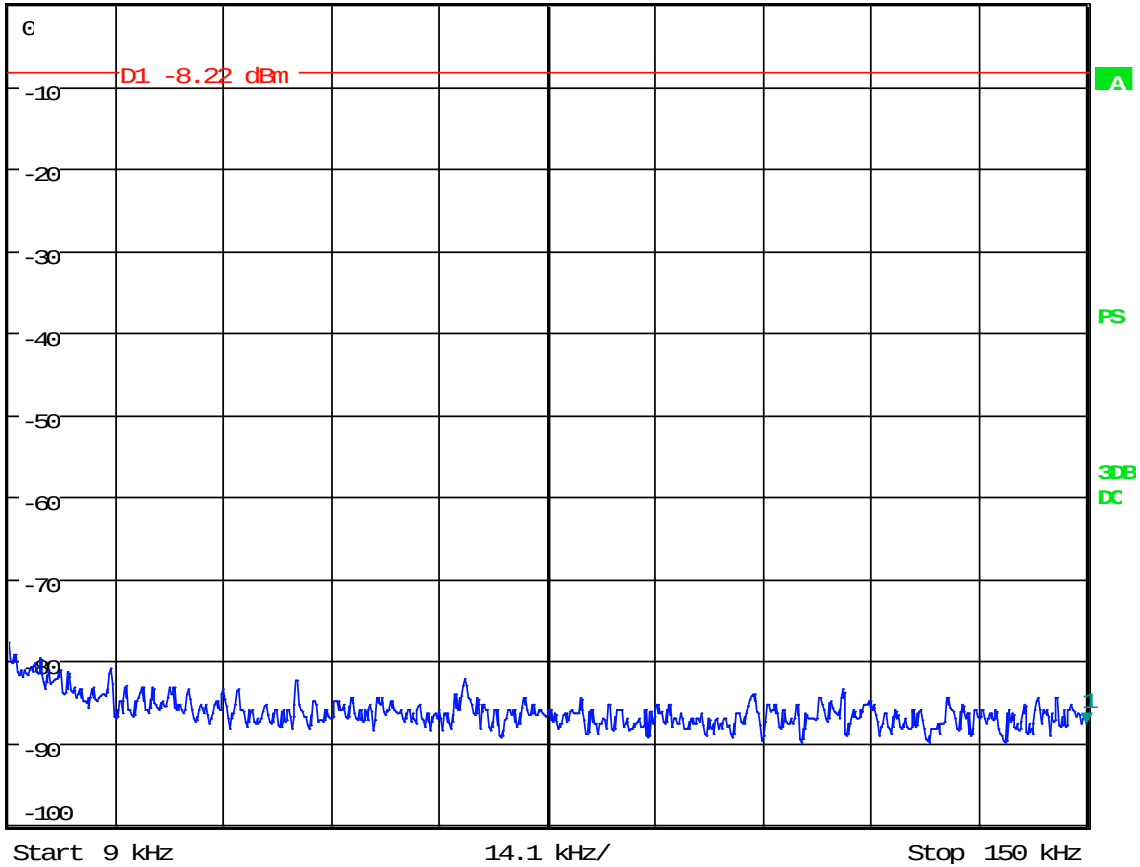
Ref 0 dBm

Att 25 dB

SWT 145 ms

150.000000000 kHz

1 PK
VIEW



Date: 17.OCT.2023 11:00:52



SF12, Mid Channel: 0.15 MHz to 30 MHz



* RBW 10 kHz
* VBW 30 kHz
Marker 1 [T1]
-75.14 dBm
150.000000000 kHz

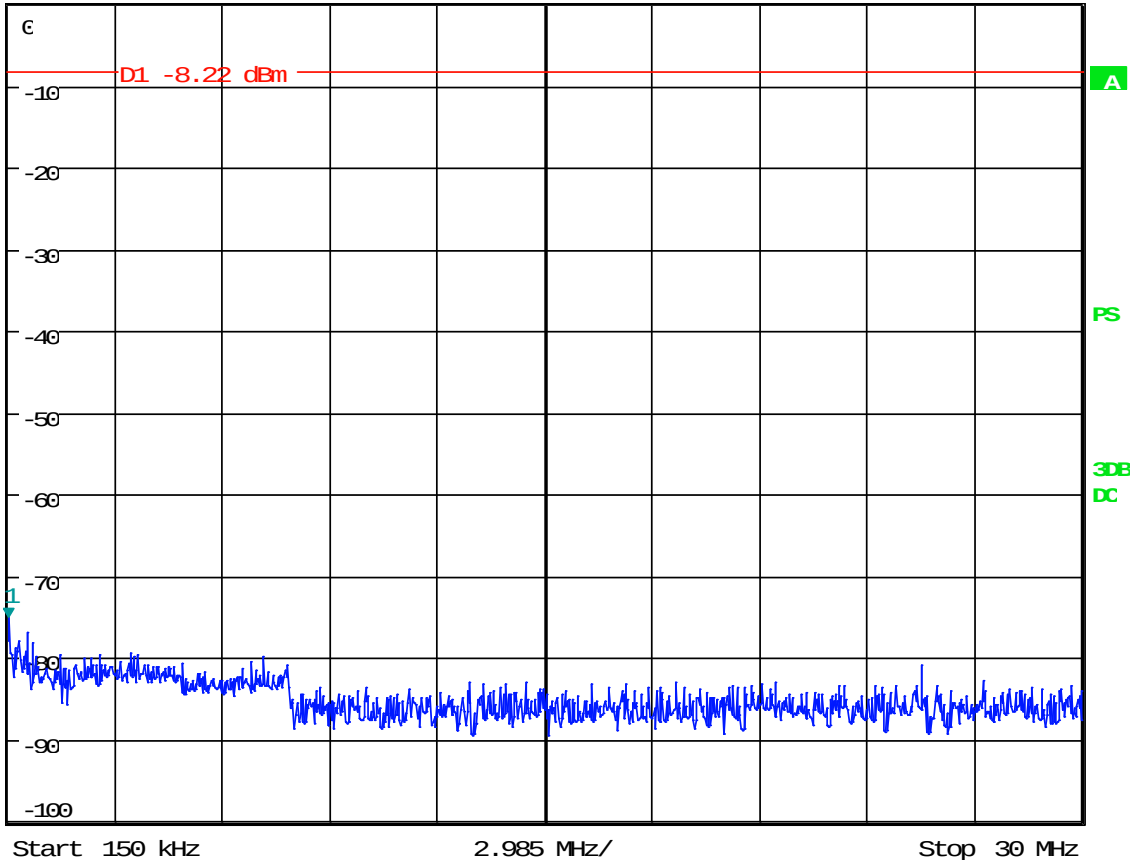
Ref 0 dBm

Att 25 dB

SWT 300 ms

150.000000000 kHz

1.00
VIEW



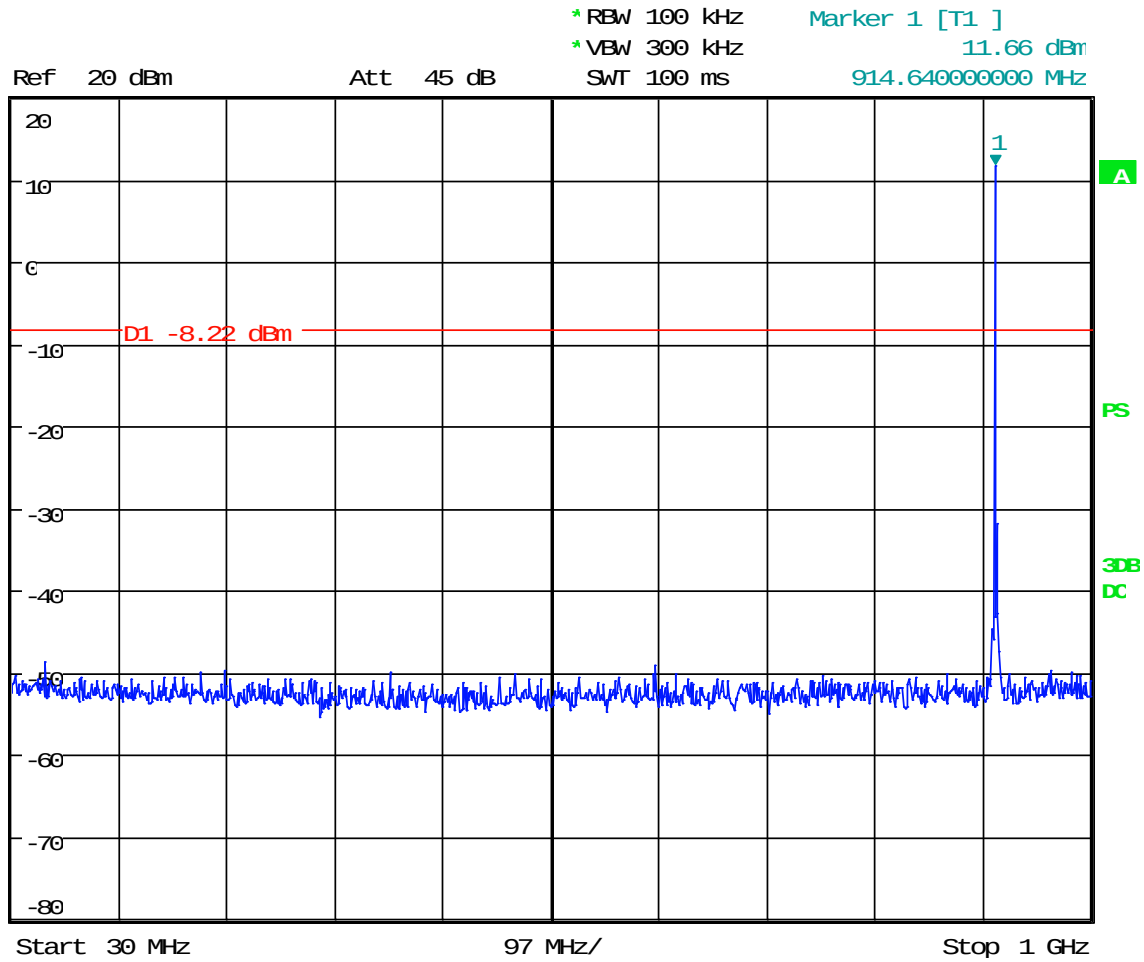
Date: 17.OCT.2023 11:01:26



SF12, Mid Channel: 30 MHz to 1000 MHz



1.8k
VTR



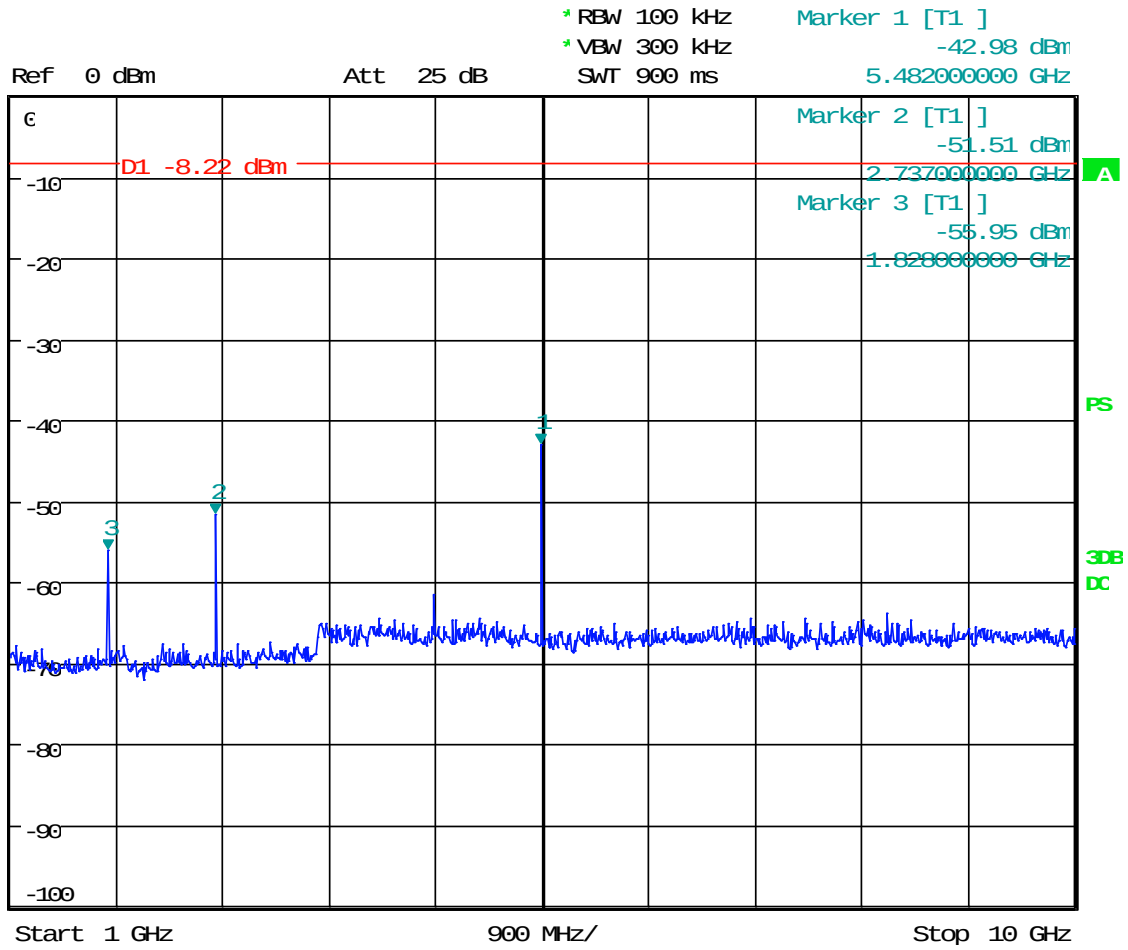
Date: 17.OCT.2023 11:02:11



SF12, Mid Channel: 1 GHz to 10 GHz



1 PK
VTB



Date: 17.OCT.2023 11:03:09



Order No(s): F2P30494A

Applicant: TeraCode Inc.
Model: TCCC024

SF12, High Channel: 0.009 MHz to 0.15 MHz



RBW 1 kHz

Marker 1 [T1]

VBW 3 kHz

-89.86 dBm

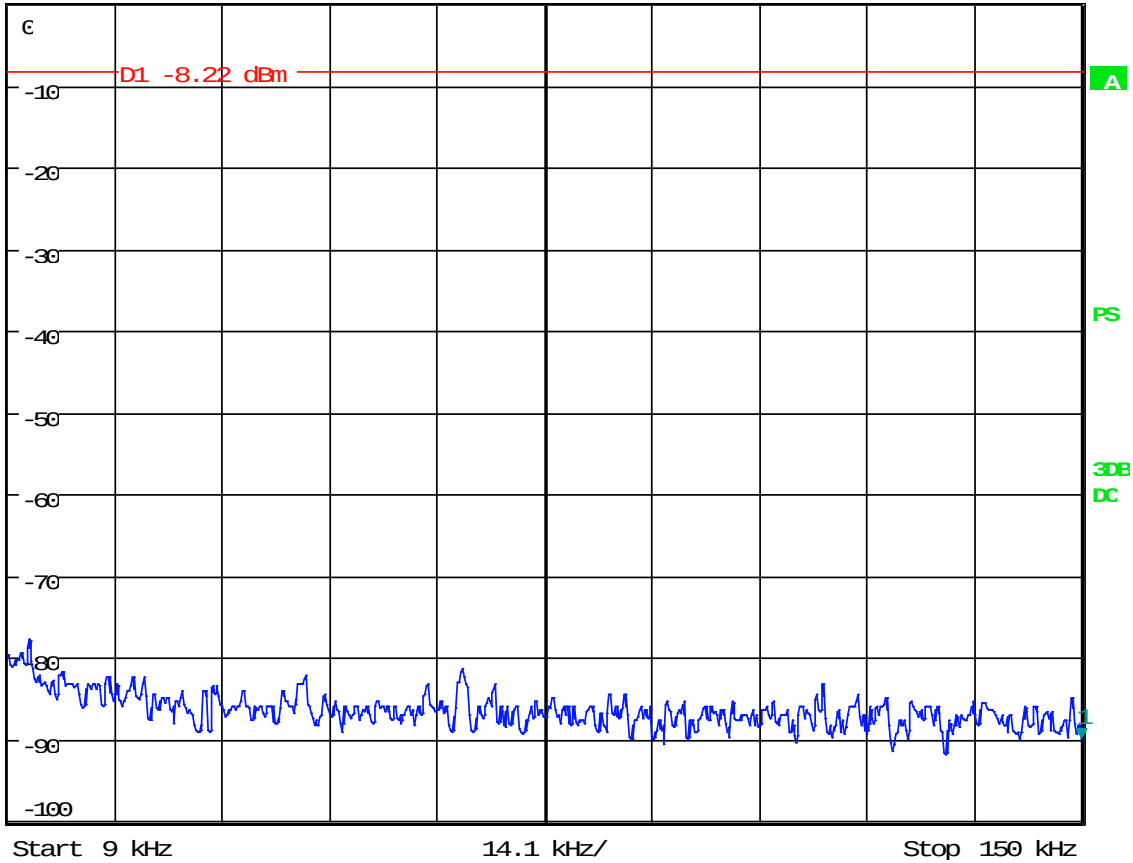
Ref 0 dBm

Att 25 dB

SWT 145 ms

150.000000000 kHz

1 PK
VIEW



Date: 17.OCT.2023 11:10:37



Order No(s): F2P30494A

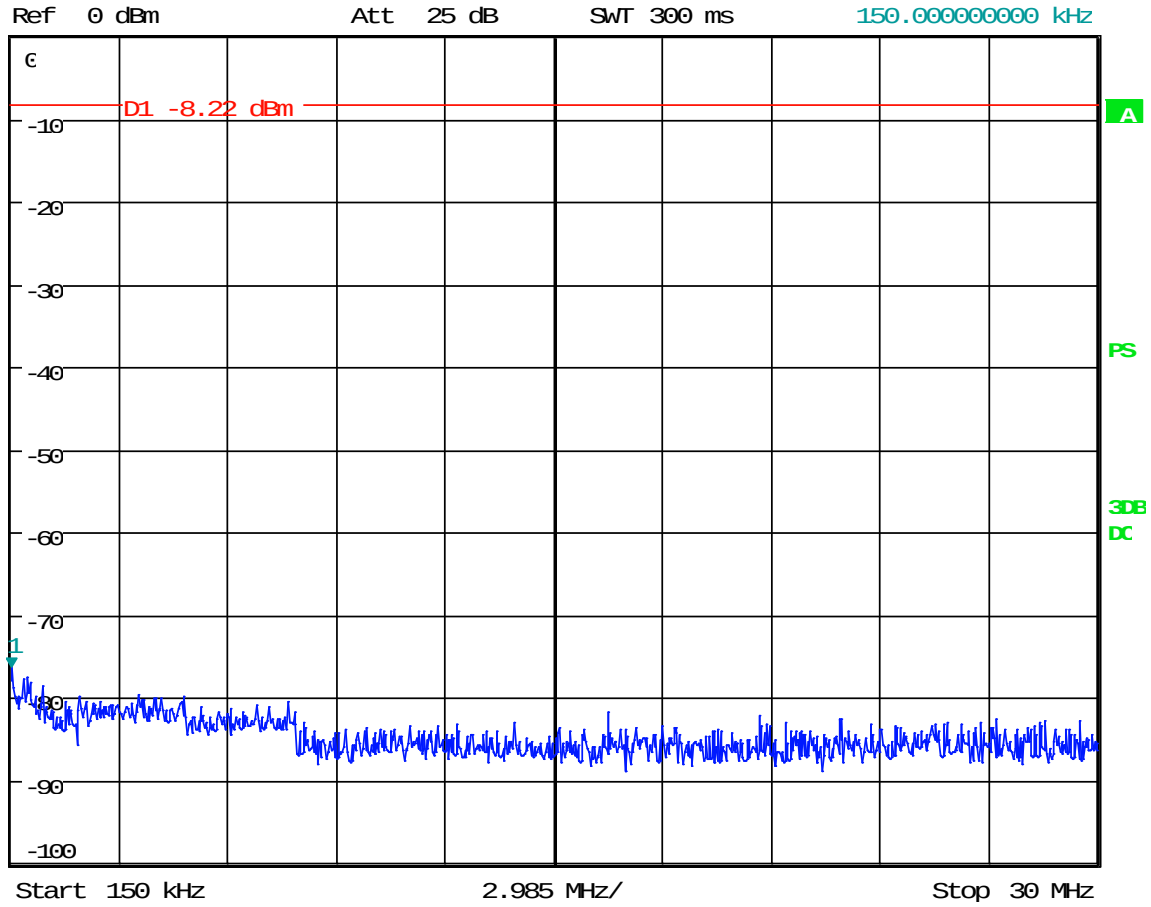
Applicant: TeraCode Inc.
Model: TCCC024

SF12, High Channel: 0.15 MHz to 30 MHz



* RBW 10 kHz
* VBW 30 kHz
SWT 300 ms
Marker 1 [T1]
-76.27 dBm
150.000000000 kHz

1 Pk
VTR



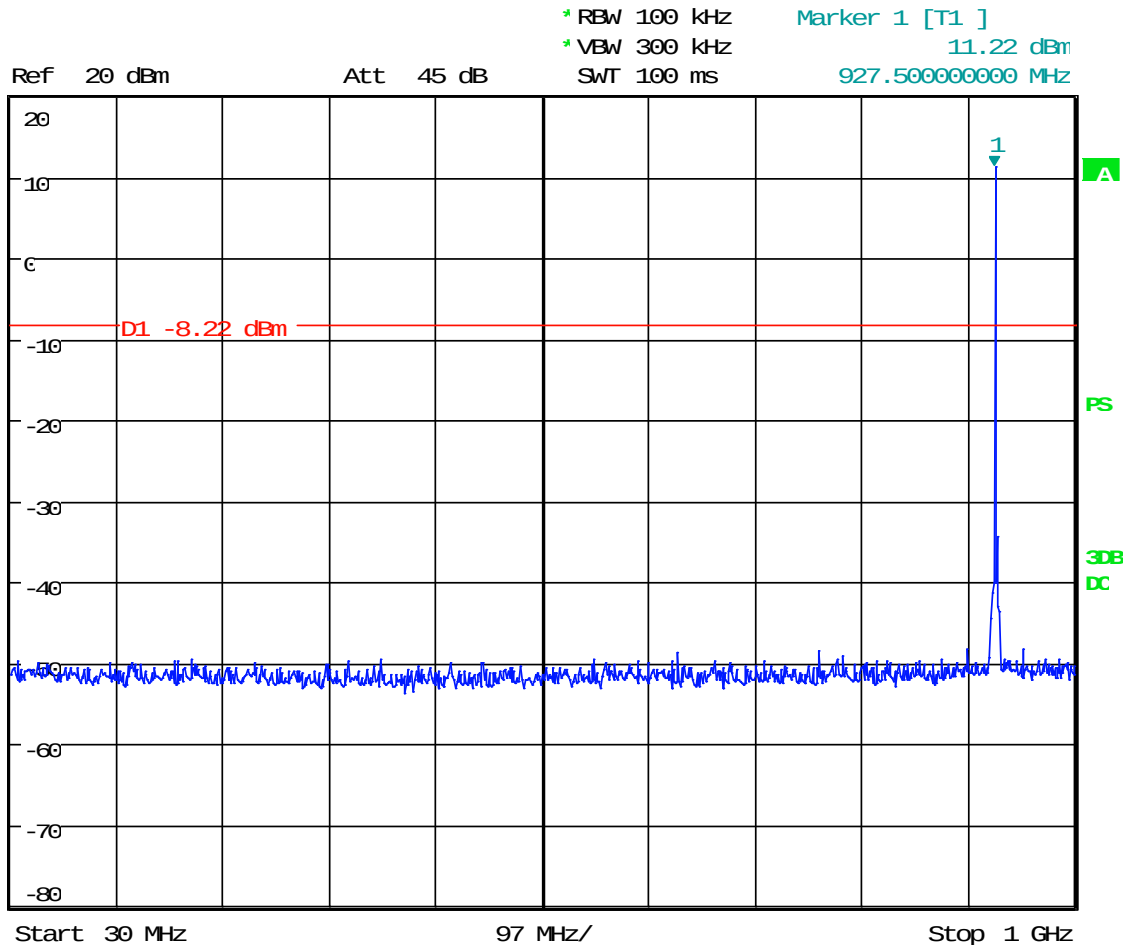
Date: 17.OCT.2023 11:11:10



SF12, High Channel: 30 MHz to 1000 MHz



1 PK
VTB



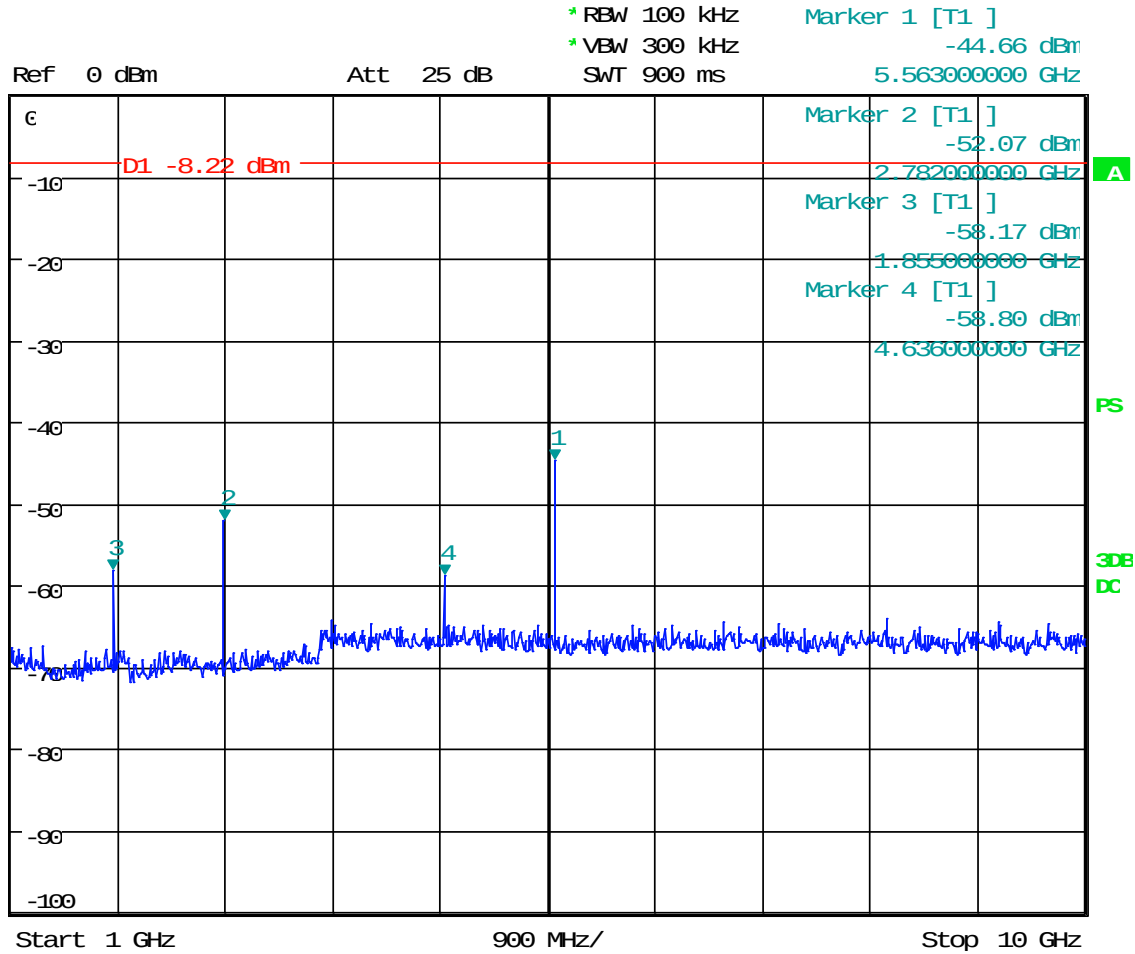
Date: 17.OCT.2023 11:13:50



SF12, High Channel: 1 GHz to 10 GHz



1.8k
VIEW



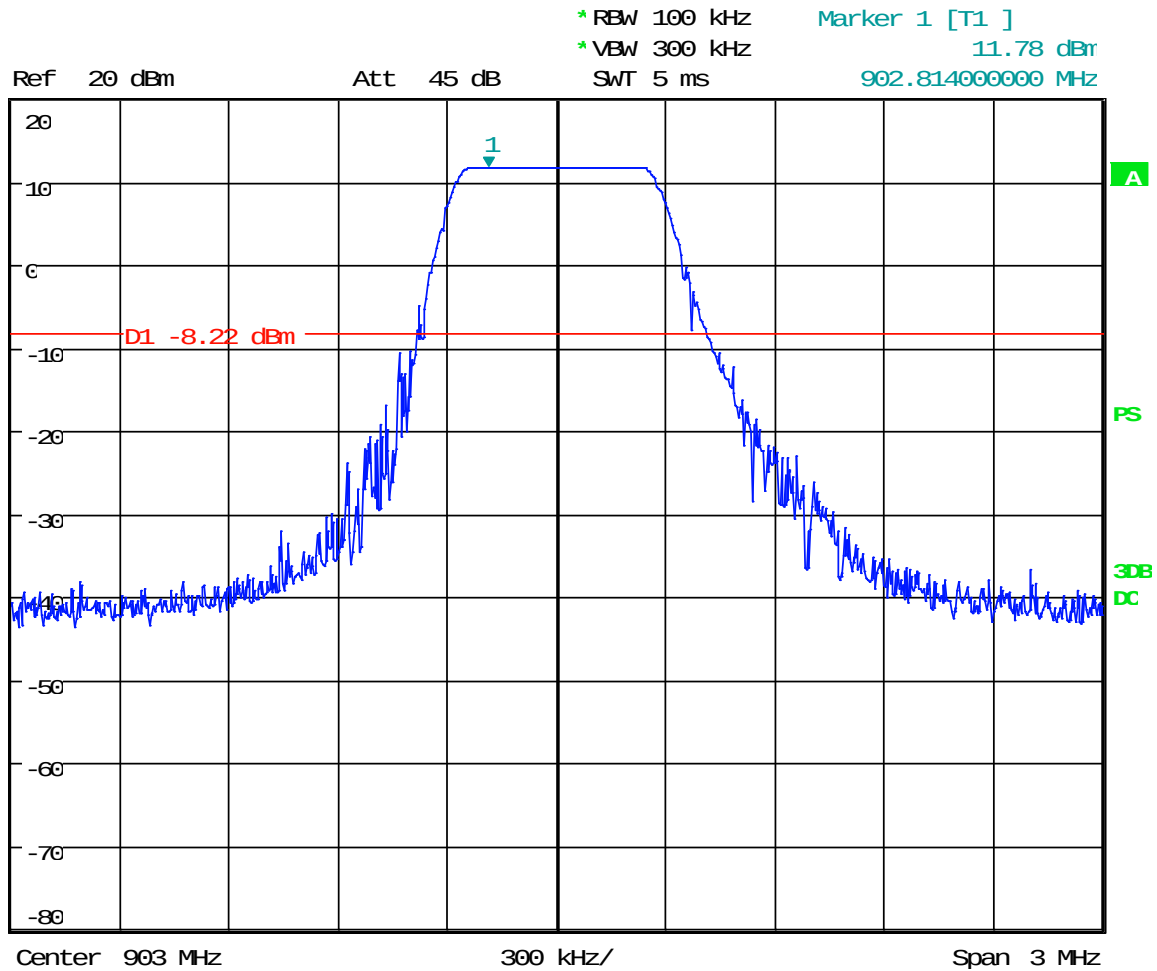
Date: 17.OCT.2023 11:15:18



Spurious Reference



1. PK
VIEW





11 RADIATED SPURIOUS EMISSIONS

The EUT antenna port was fitted with the client supplied 1.2 dBi Dipole antenna. 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.

11.1 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).

Scans were performed from 9kHz to 10 GHz at the low, mid, and high channels. Low channel data is presented as the worst case. The tables of measured results follow in data presented and include measurements from all channels.



11.2 Radiated Spurious Emissions Test Data

Test Date(s):	2023-10-17; 2023-12-22	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(d); Part 15.209 / KDB558074	Air Temperature:	22.6°C; 21.7 °C
		Relative Humidity:	43%; 44%

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.

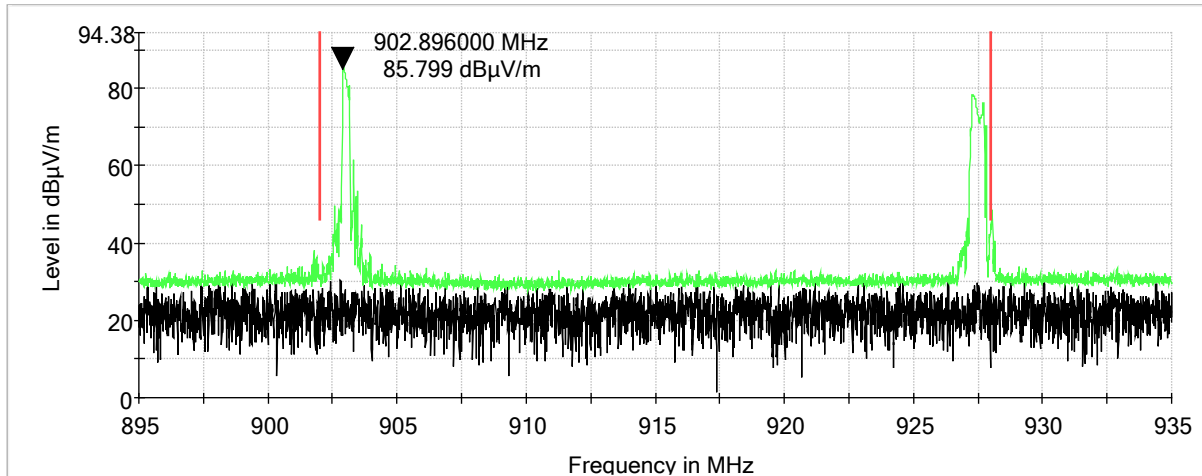
The equipment was fully exercised with all cabling attached to the EUT and was positioned on a turntable in the Semi-Anechoic Chamber for maximum emissions. While the equipment was energized, the receiving antenna was scanned from 1.0 meter to 4.0 meters in both vertical and horizontal polarities while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

Some of the frequencies did not change with the EUT on or off. At those frequencies, the test distance was shortened to 1 meter and still no emissions from the EUT were visible or over the ambient or limit.

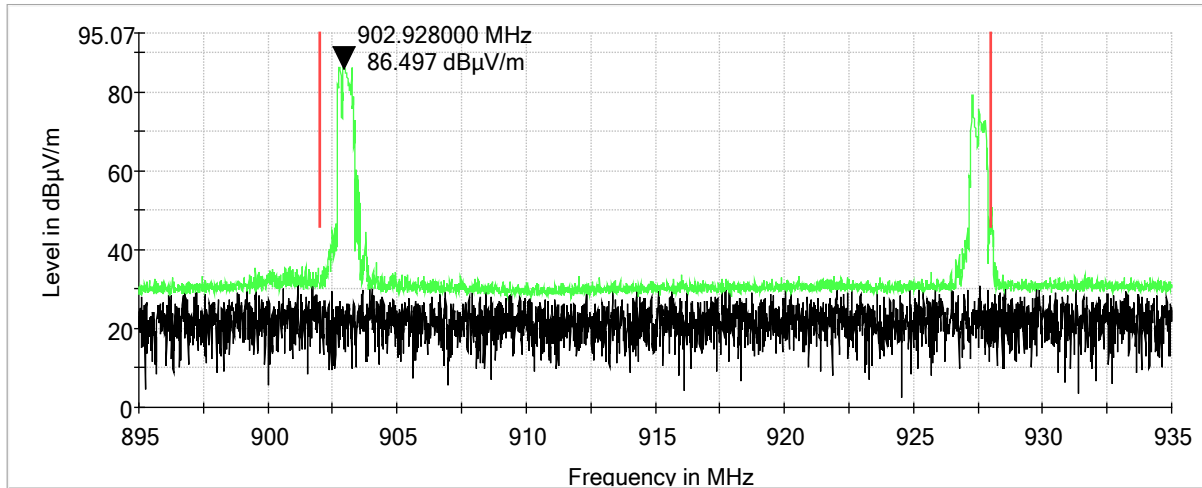
In the following plots, the black line indicates ambient noise and the red line indicates the measurement with the EUT on. Emissions to be found by the EUT were measured and listed in tables. The plots are for reference only and the limit lines are not actual limit lines but merely a guide.



SF7: Band Edge – Vertical



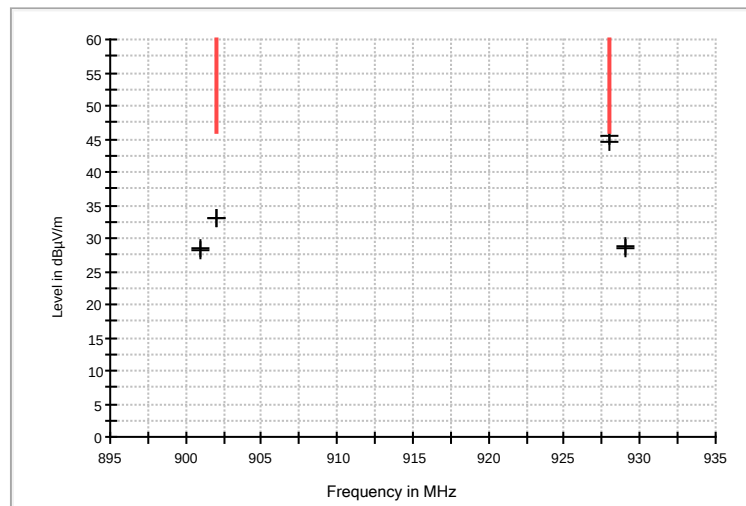
SF7: Band Edge – Horizontal





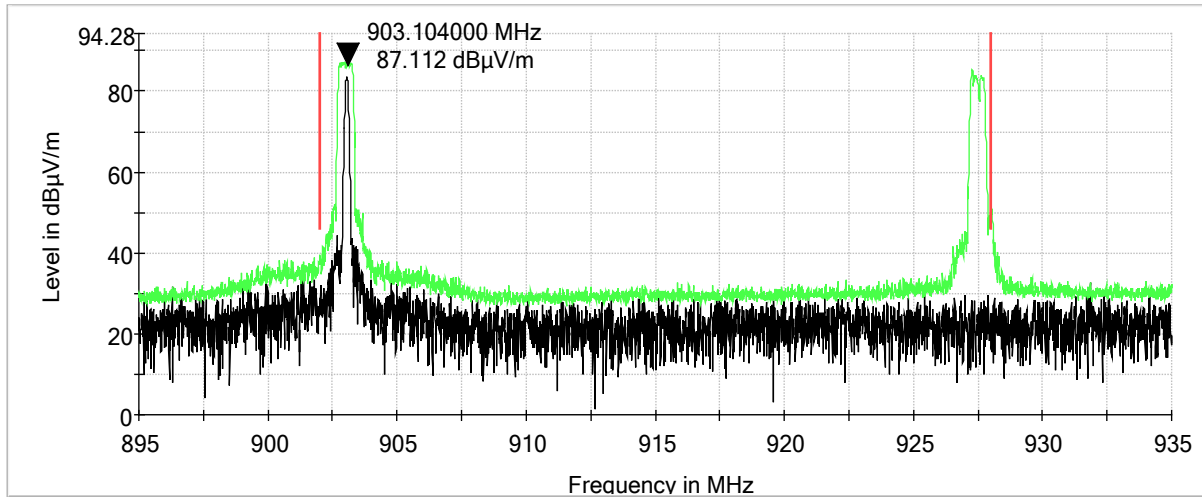
SF7: Band Edge – Measurements

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBμV/m)
901.000000	28.1	120.000	100.0	H	339.0	-13.8	38.4	66.5
901.000000	28.4	120.000	159.0	V	347.0	-13.8	38.1	66.5
902.000000	33.2	120.000	100.0	H	0.0	-13.9	33.3	66.5
902.000000	33.1	120.000	159.0	V	347.0	-13.9	33.4	66.5
928.000000	45.3	120.000	150.0	V	35.0	-13.2	21.2	66.5
928.000000	44.5	120.000	100.0	H	26.0	-13.2	22.0	66.5
929.000000	28.3	120.000	100.0	H	26.0	-13.1	38.2	66.5
929.000000	28.9	120.000	150.0	V	35.0	-13.1	37.6	66.5

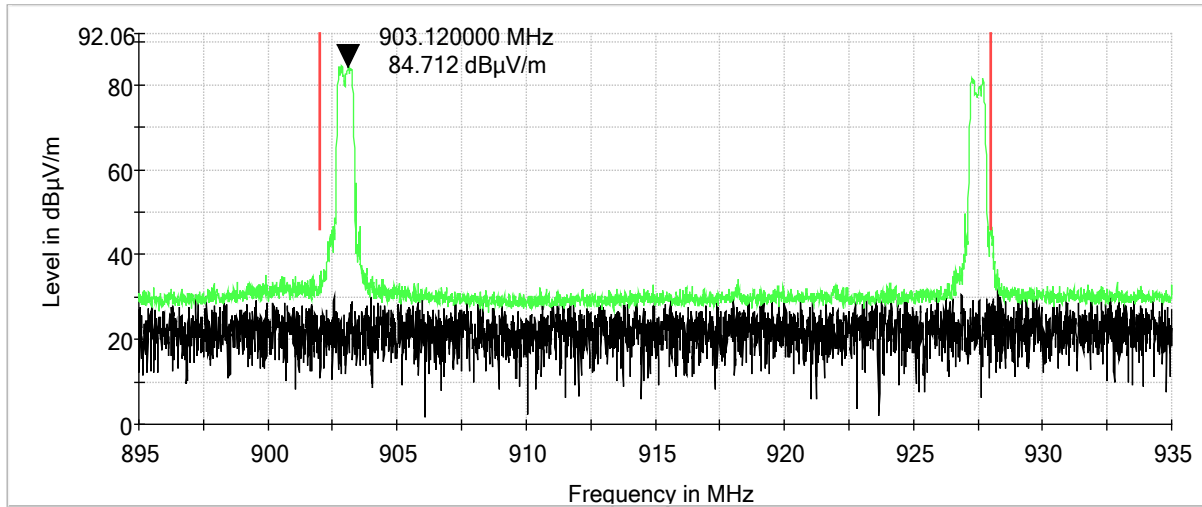




SF12: Band Edge – Vertical



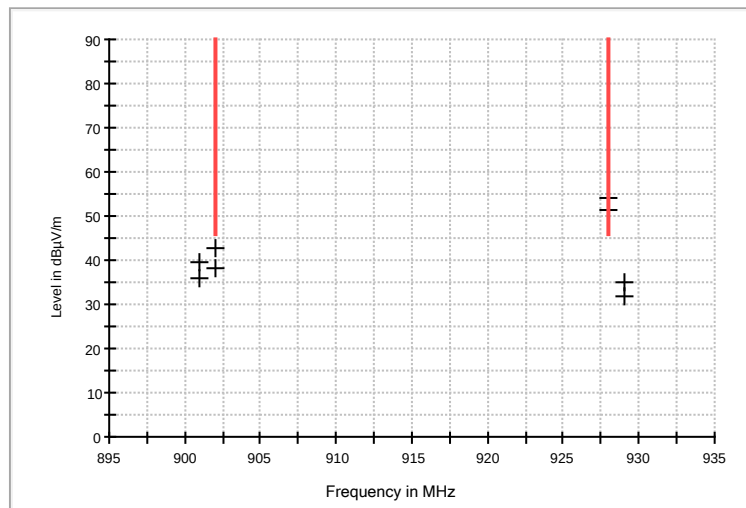
SF12: Band Edge – Horizontal





SF12: Band Edge – Measurements

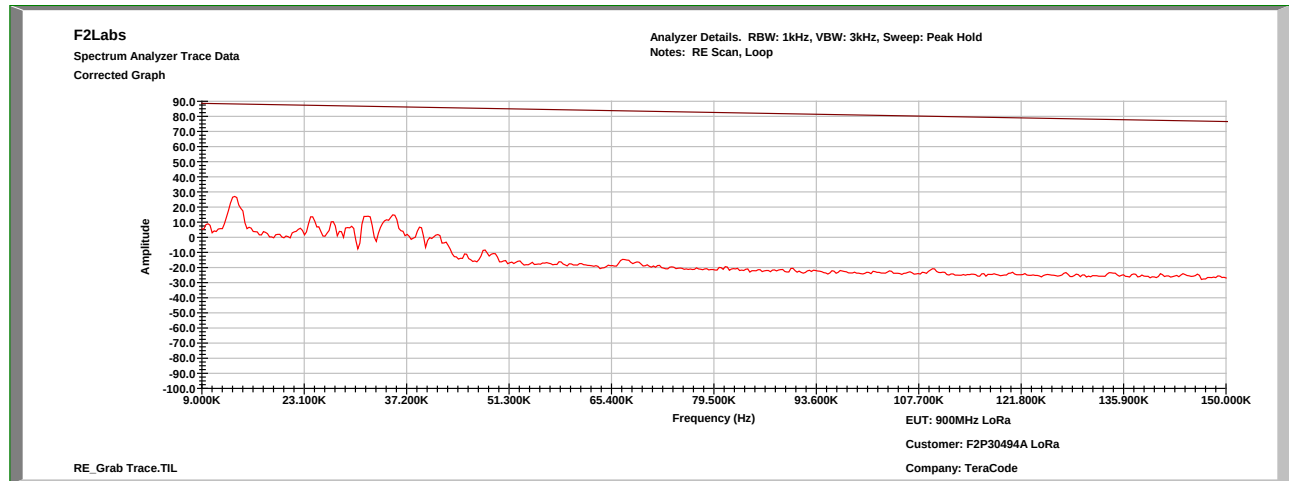
Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBμV/m)
901.000000	39.5	120.000	207.0	H	142.0	-13.8	47.6	87.1
901.000000	35.7	120.000	100.0	V	104.0	-13.8	51.4	87.1
902.000000	42.9	120.000	207.0	H	142.0	-13.9	44.2	87.1
902.000000	38.0	120.000	100.0	V	104.0	-13.9	49.1	87.1
928.000000	51.3	120.000	100.0	V	114.0	-13.2	35.8	87.1
928.000000	54.1	120.000	207.0	H	145.0	-13.2	33.0	87.1
929.000000	34.8	120.000	207.0	H	145.0	-13.1	52.3	87.1
929.000000	31.6	120.000	100.0	V	113.0	-13.1	55.5	87.1



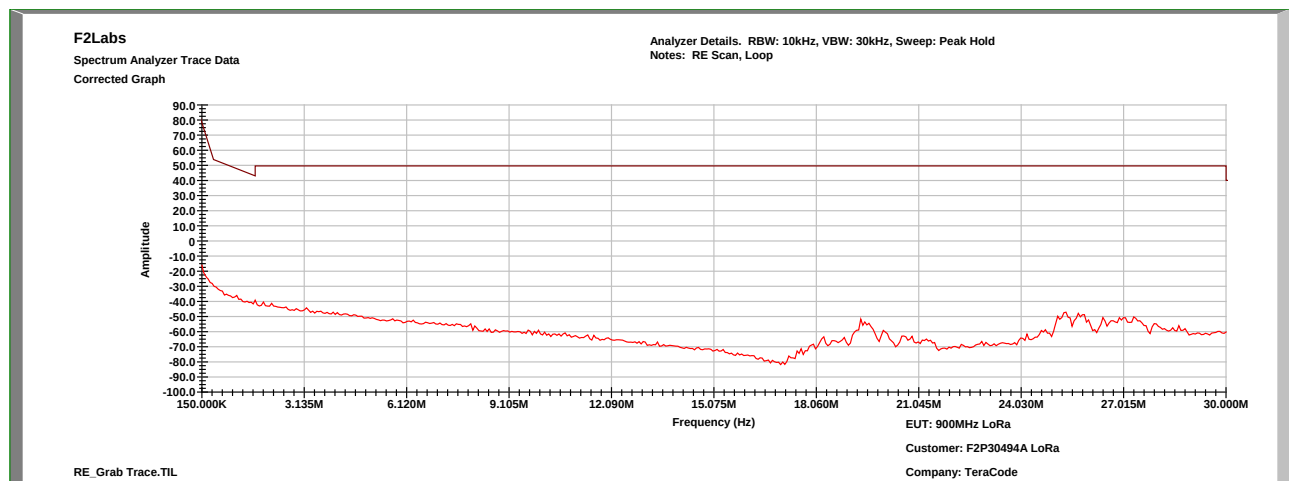


The following plots are from the Low Channel 500kHz, SF7, which was the worst case of all Channels and Data Rates

Characterization Scan: 0.009 MHz to 0.15 MHz – Loop Antenna

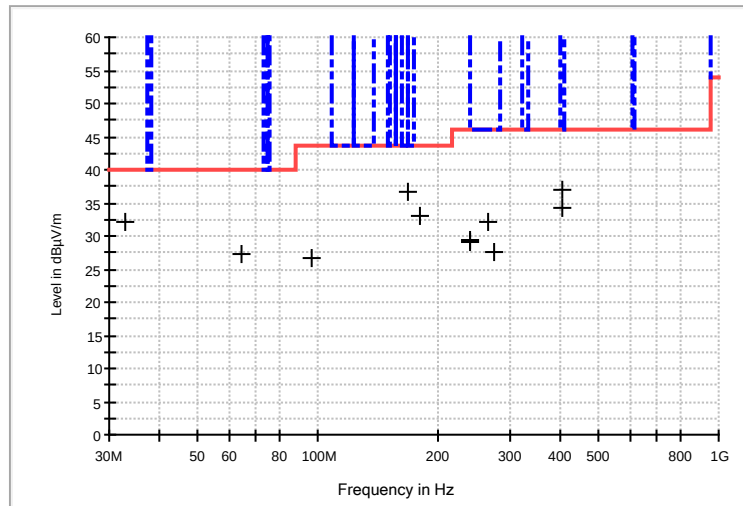


Characterization Scan: 0.15 MHz to 30.0 MHz – Loop Antenna



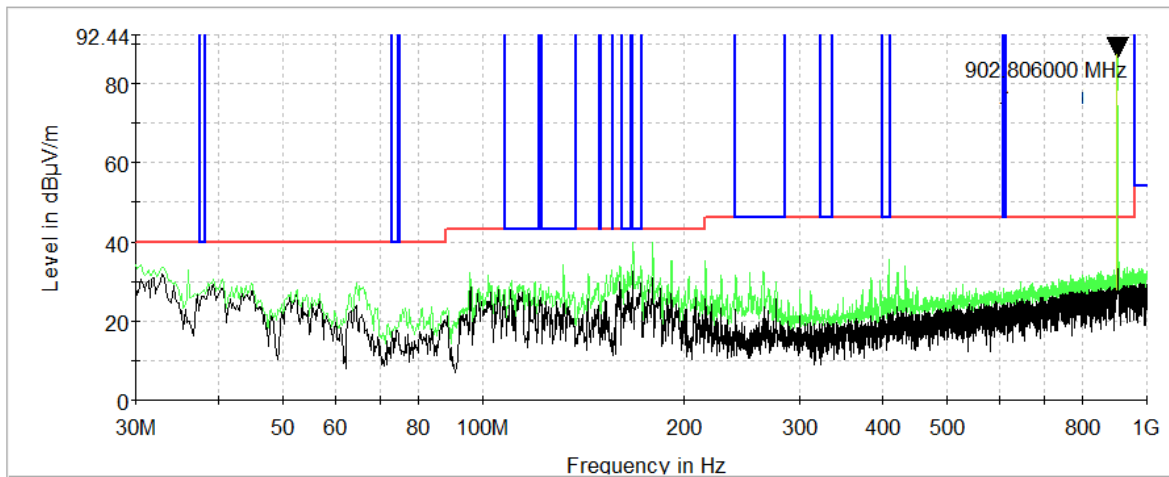
**Measurements: 30 MHz to 1000 MHz
QuasiPeak**

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBμV/m)
32.920000	32.0	120.000	100.0	V	144.0	-21.4	8.0	40.0
64.520000	27.1	120.000	100.0	V	207.0	-32.3	12.9	40.0
95.760000	26.7	120.000	100.0	V	128.0	-31.2	16.8	43.5
168.120000	36.7	120.000	100.0	V	223.0	-27.6	6.8	43.5
179.560000	33.2	120.000	100.0	V	230.0	-28.3	10.3	43.5
239.320000	29.5	120.000	110.0	H	114.0	-27.2	16.5	46.0
239.320000	29.1	120.000	110.0	H	90.0	-27.2	16.9	46.0
263.960000	32.1	120.000	110.0	H	130.0	-26.2	13.9	46.0
276.000000	27.4	120.000	110.0	H	124.0	-25.7	18.6	46.0
407.320000	37.1	120.000	110.0	H	254.0	-22.7	8.9	46.0
408.120000	34.2	120.000	100.0	V	273.0	-22.7	11.8	46.0

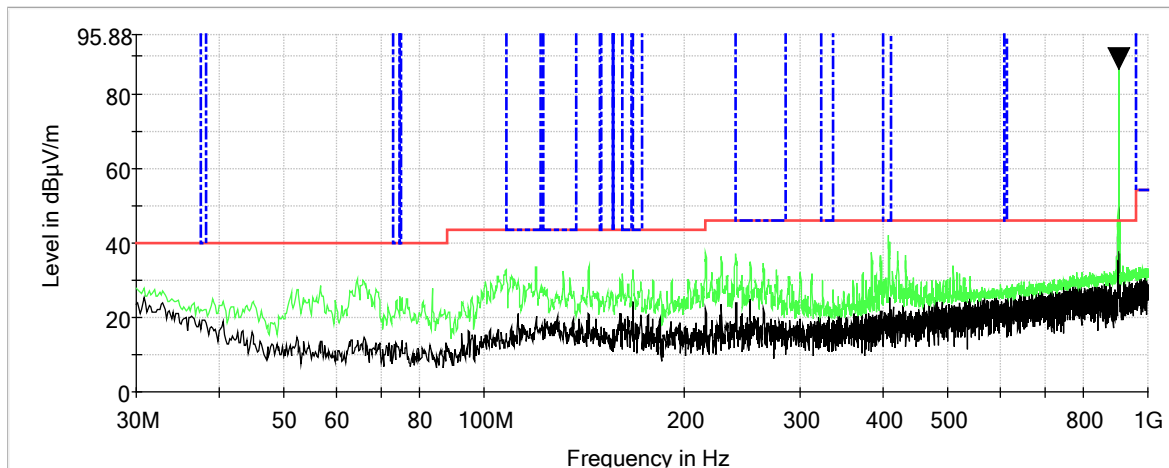




Characterization Scan, 30 MHz to 1000 MHz – Vertical



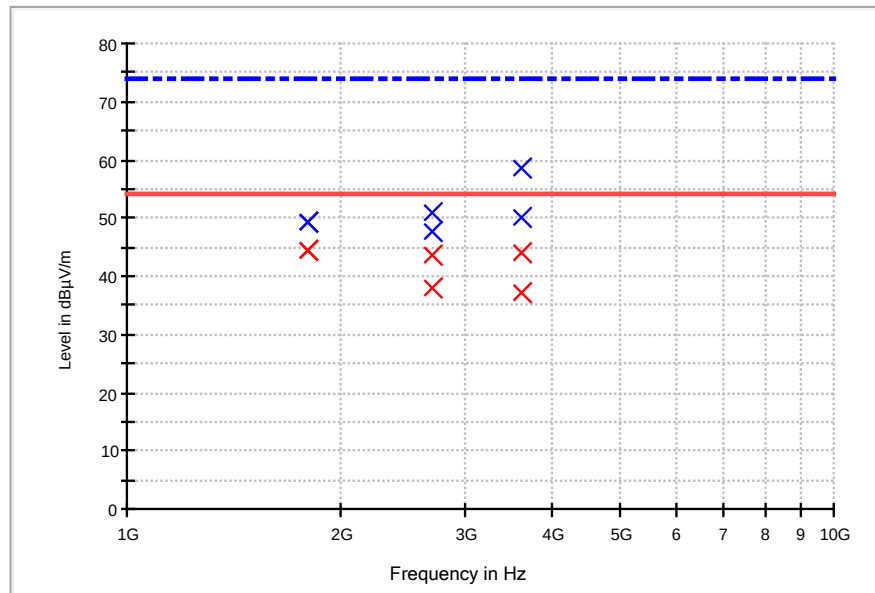
Characterization Scan, 30 MHz to 1000 MHz – Horizontal





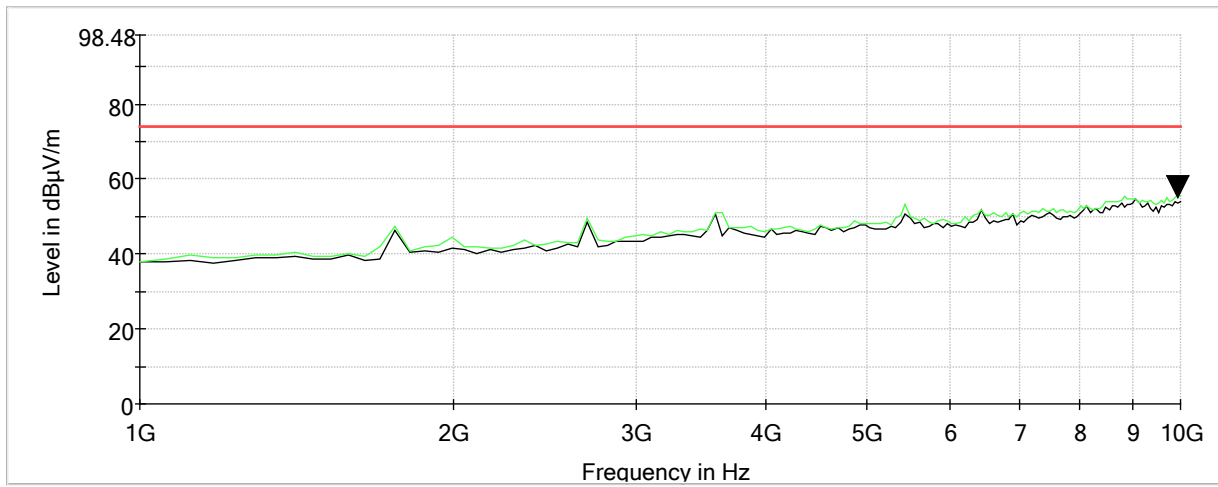
Measurements Above 1 GHz

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin - AVG (dB)	Limit - AVG (dBμV/m)
1806.000000	49.3	44.5	1000.0	1000.000	150.0	H	27.0	4.4	9.5	54.0
1806.000000	49.1	44.4	1000.0	1000.000	150.0	V	353.0	4.4	9.6	54.0
2709.000000	47.8	37.9	1000.0	1000.000	150.0	H	194.0	7.2	16.1	54.0
2709.000000	50.8	43.5	1000.0	1000.000	150.0	V	347.0	7.2	10.5	54.0
3612.000000	50.2	37.1	1000.0	1000.000	150.0	H	327.0	9.9	16.9	54.0
3612.000000	58.5	44.2	1000.0	1000.000	150.0	V	353.0	9.9	9.8	54.0

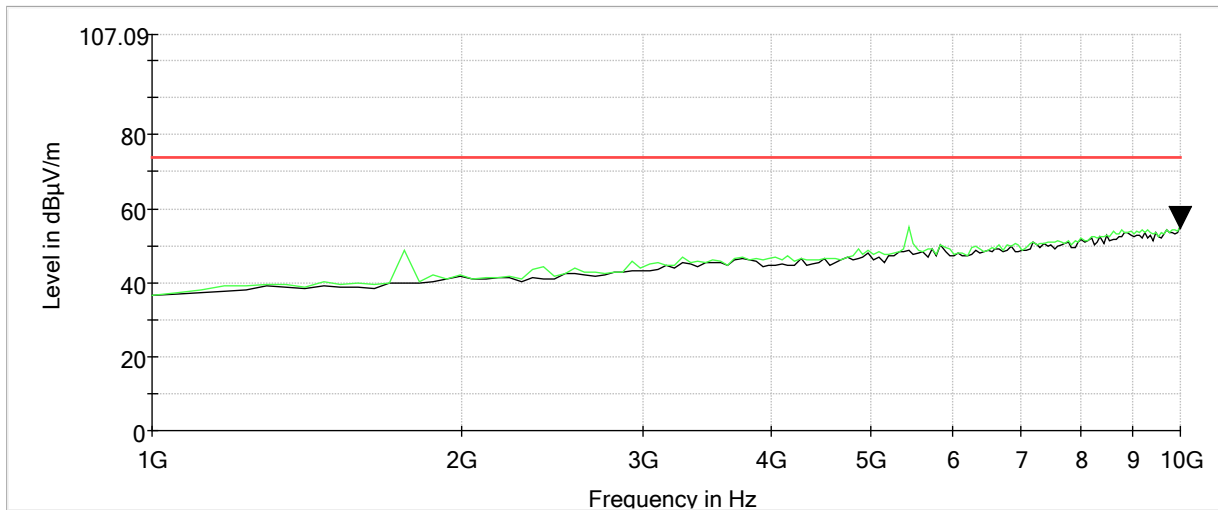




Characterization Scan, 1 GHz to 10 GHz - Vertical



Characterization Scan, 1 GHz to 10 GHz - Horizontal





12 PEAK POWER SPECTRAL DENSITY (PSD)

Peak power spectral density measurements were performed.

12.1 Requirements:

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

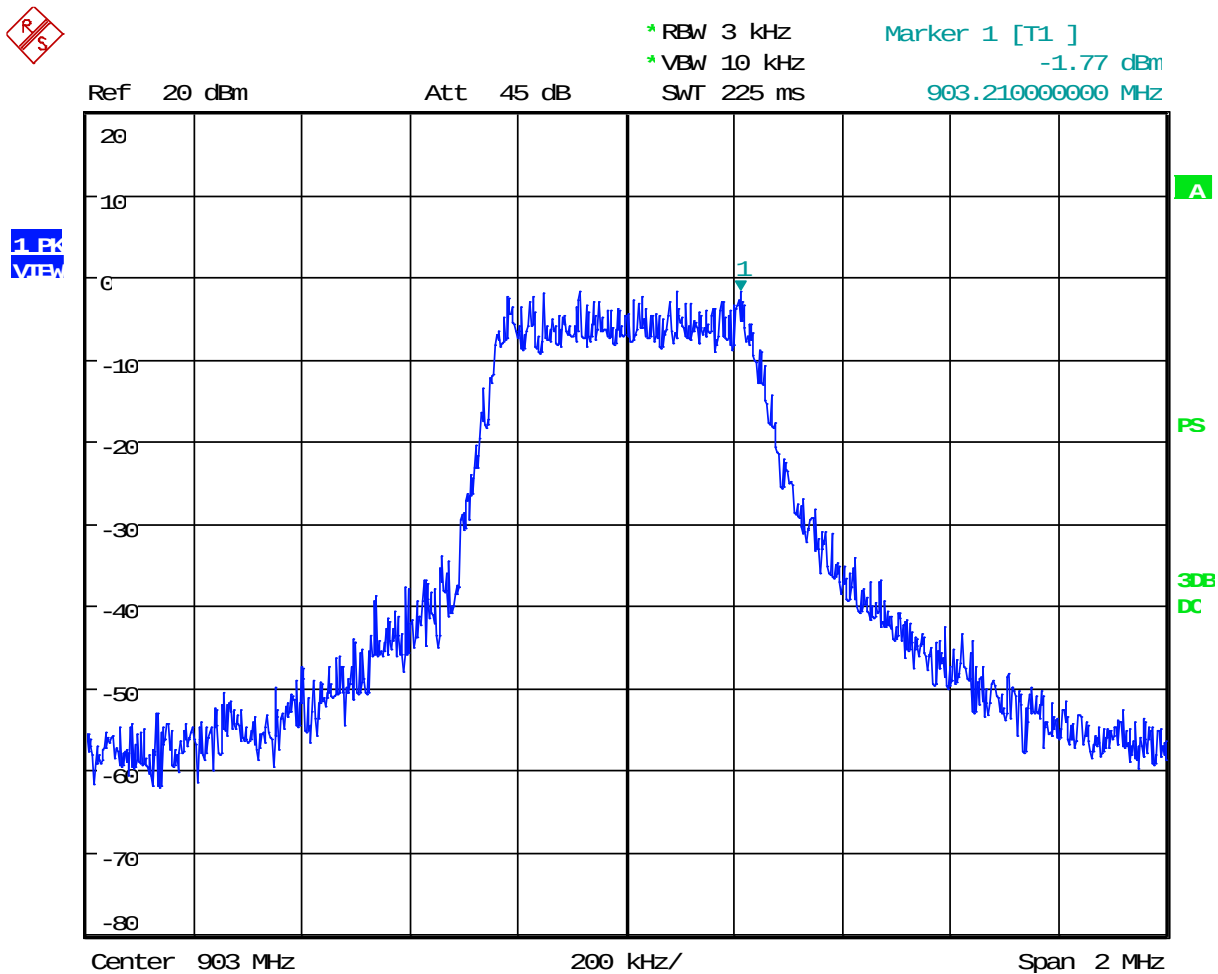
Power spectral density measurements were performed at a resolution bandwidth of 3 kHz (video bandwidth set at 10 KHz). The peak spectral densities were measured at the low, mid, and upper channels.



12.2 Peak Power Spectral Density Test Data

Test Date(s):	2023-10-13	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(e); KDB558074	Air Temperature:	22.1°C
		Relative Humidity:	44%

SF7: Low Channel



Date: 13.OCT.2023 15:40:36



SF7: Mid Channel



* RBW 3 kHz

Marker 1 [T1]

* VBW 10 kHz

-1.99 dBm

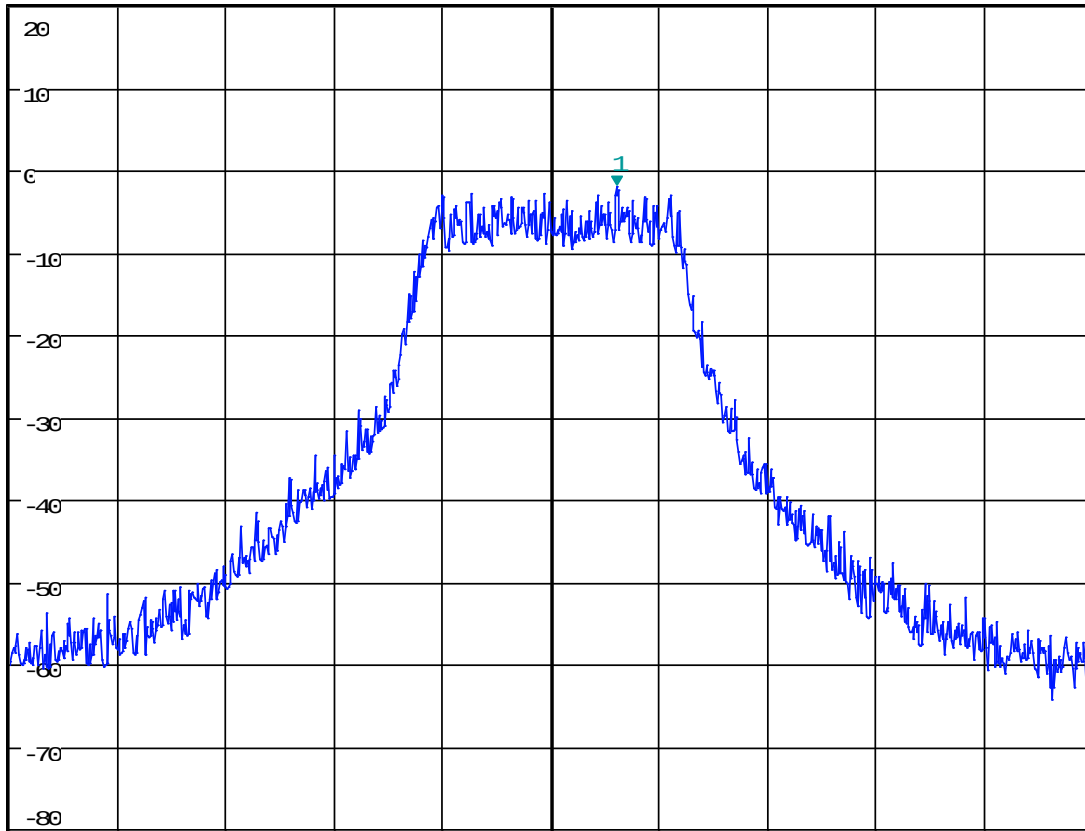
SWT 225 ms

914.322000000 MHz

Ref 20 dBm

Att 45 dB

1 PK
VIEW



A

PS

3dB
DC

Center 914.2 MHz

200 kHz/

Span 2 MHz

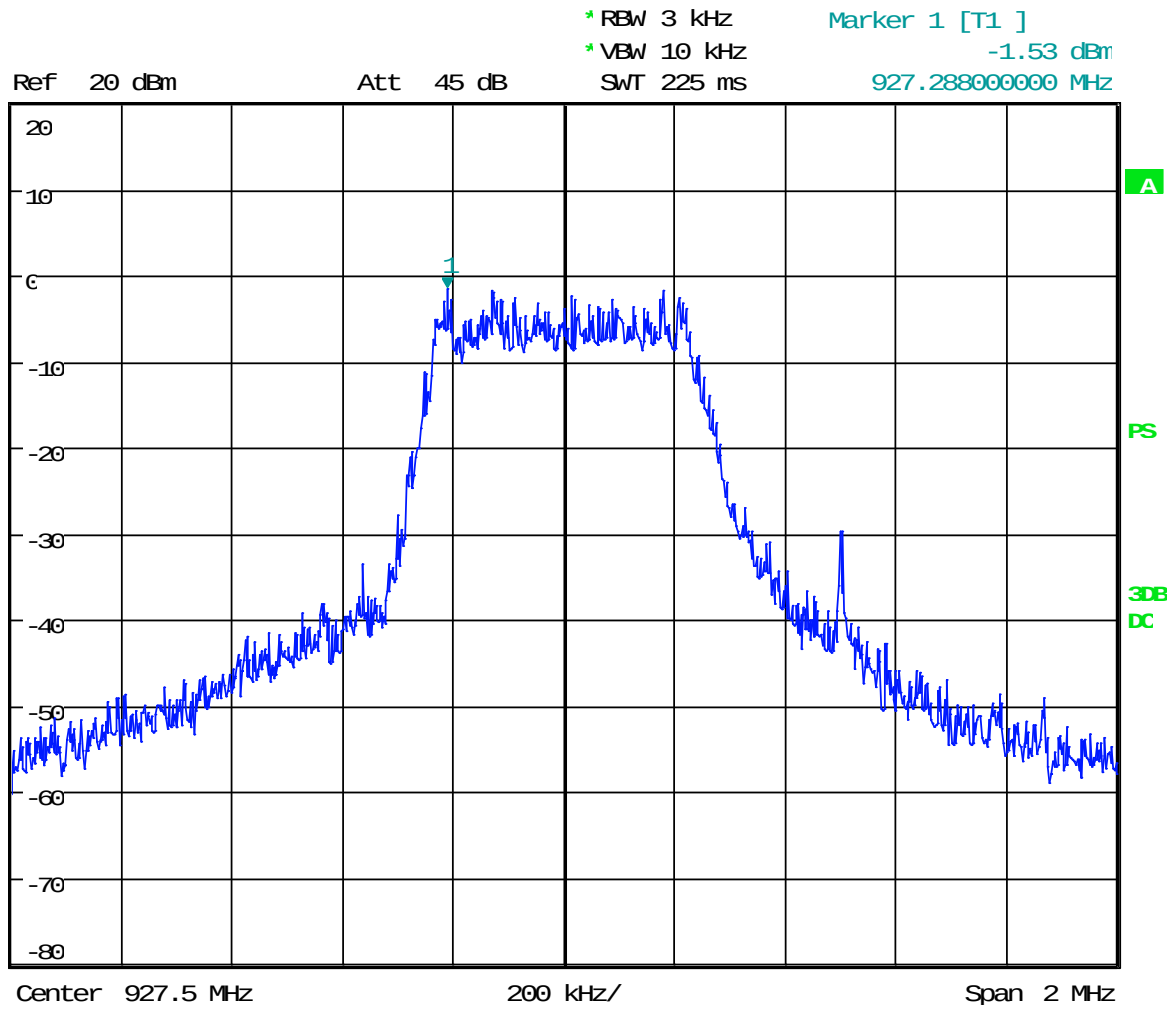
Date: 13.OCT.2023 15:38:25



SF7: High Channel



1 PK
VIEW



Date: 13.OCT.2023 15:36:24

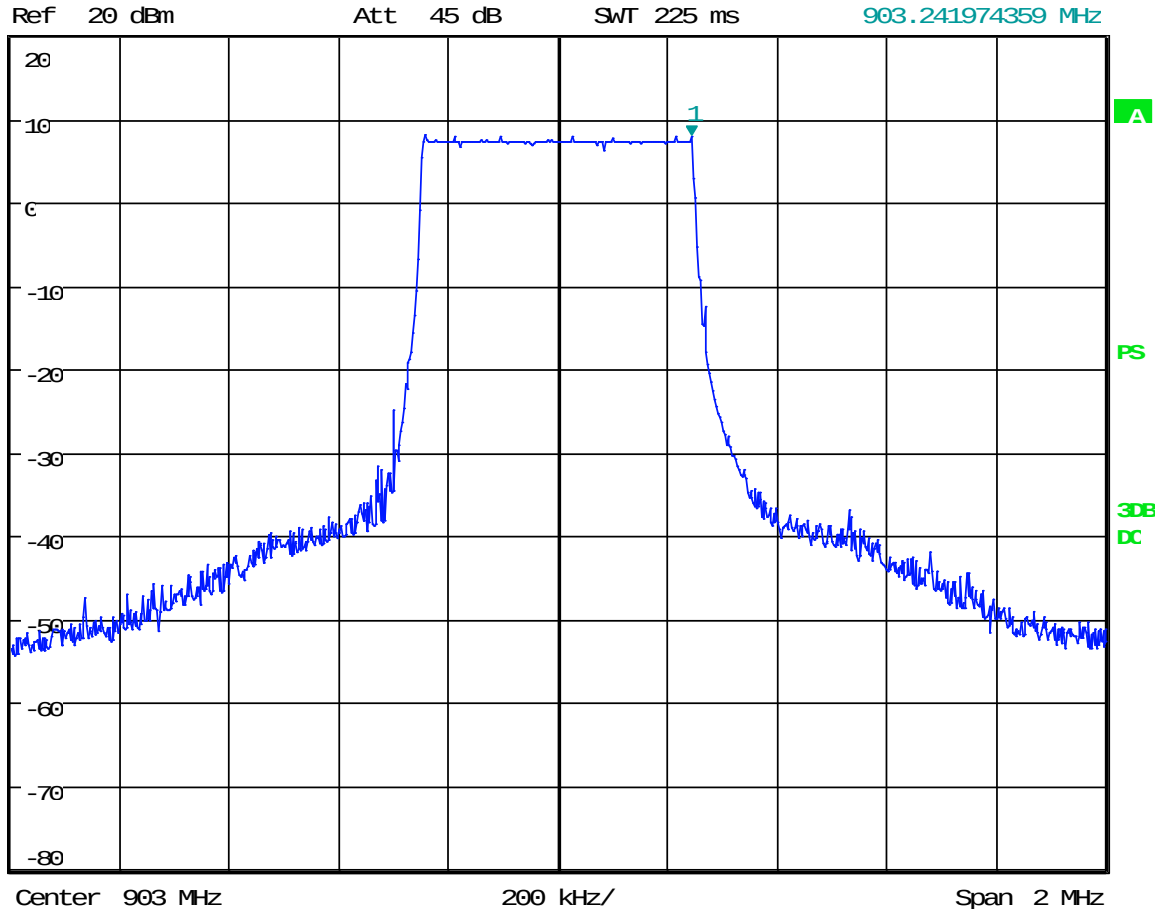


SF12: Low Channel



* RBW 3 kHz
* VBW 10 kHz
SWT 225 ms
Marker 1 [T1]
7.84 dBm
903.241974359 MHz

1 PK
VIEW



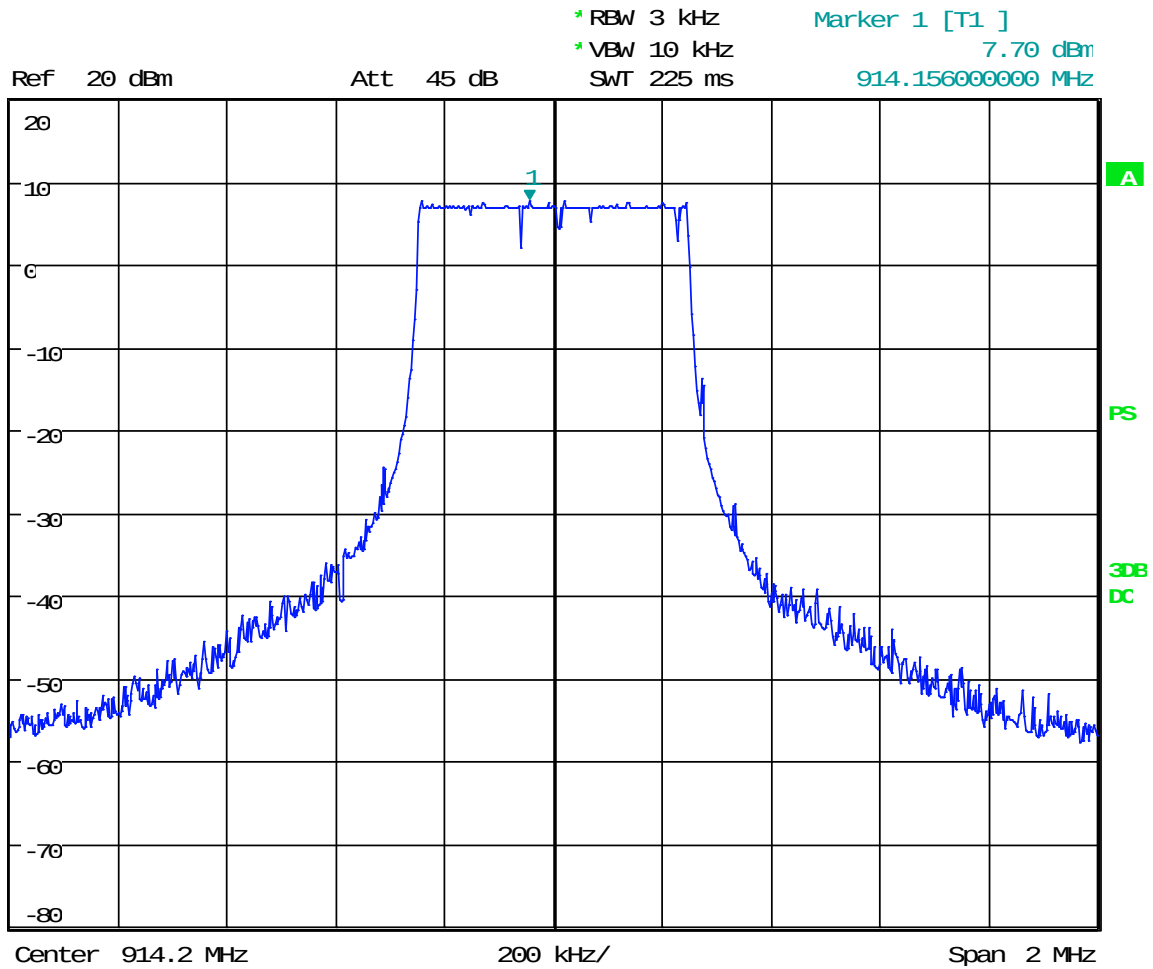
Date: 13 OCT 2023 15:28:41



SF12: Mid Channel



1 PK
VIEW



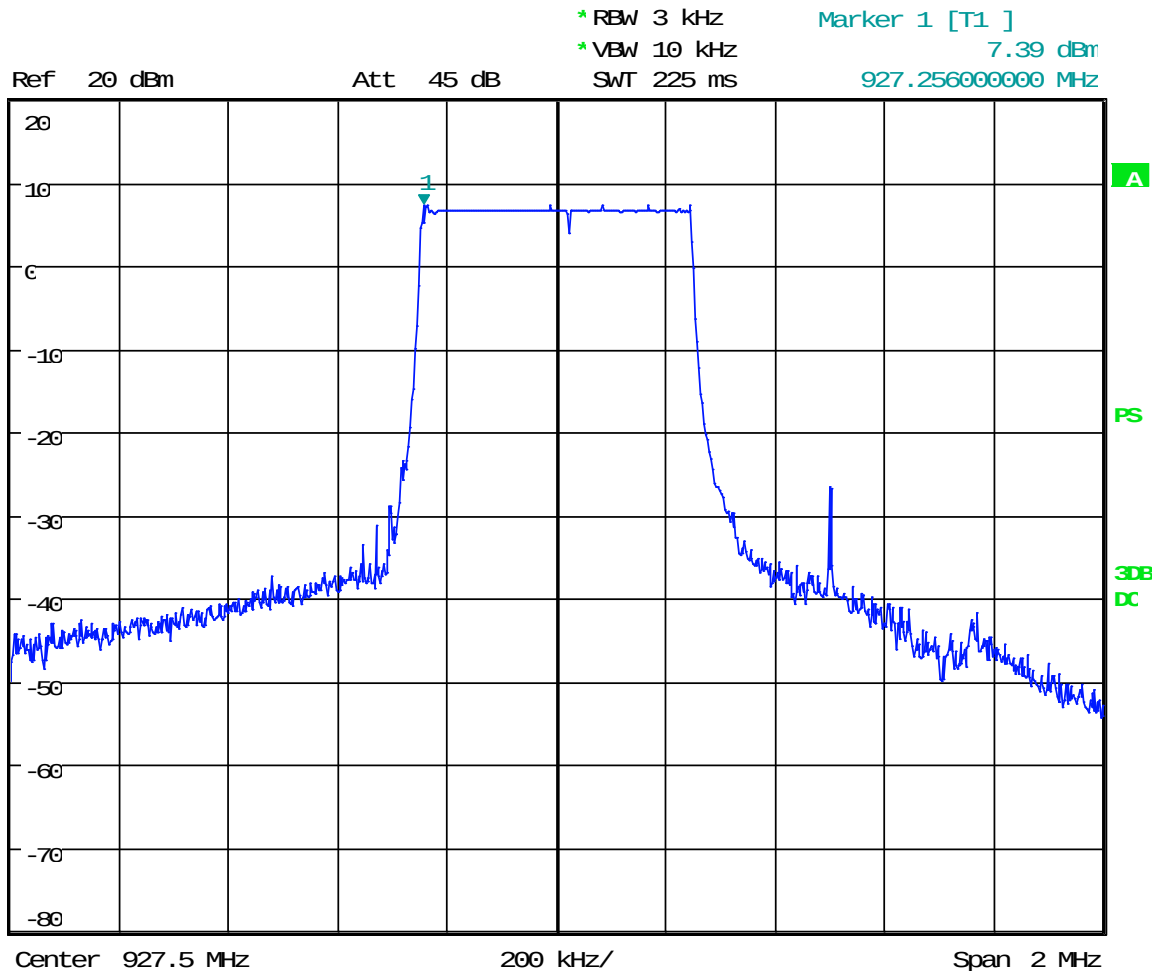
Date: 13.OCT.2023 15:31:27



SF12: High Channel



1 PK
VIEW



Date: 13.OCT.2023 15:33:57



13 CONDUCTED EMISSIONS

13.1 Requirements

In accordance with FCC CFR 47 Part 15.207(a), "Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

13.2 Procedure

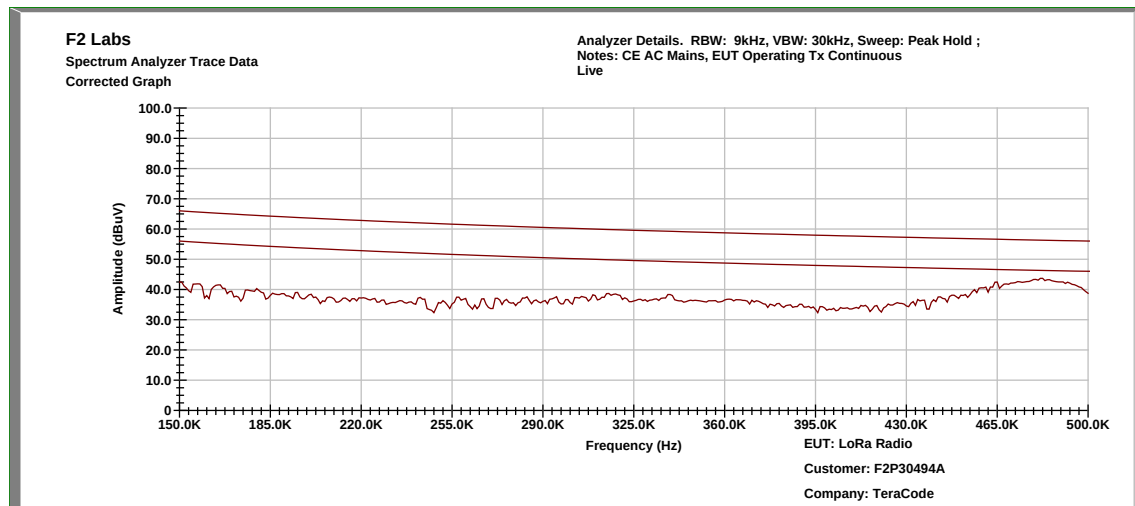
The EUT was placed on a 1.0 x 1.5 meter non-conductive table, 0.8 meter above a horizontal ground plane and 0.4 meter from a vertical ground plane. Power was provided to the EUT through a LISN bonded to a 3 x 2 meter ground plane. The LISN and peripherals were supplied power through a filtered AC power source. The output of the LISN was connected to the input of the receiver via a transient limiter, and emissions in the range 150 kHz to 30 MHz were measured. The measurements were recorded using the quasi-peak and average detectors as directed by the standard, and the resolution bandwidth during testing was 9 kHz. The raw measurements were corrected to allow for attenuation from the LISN, transient limiter and cables.



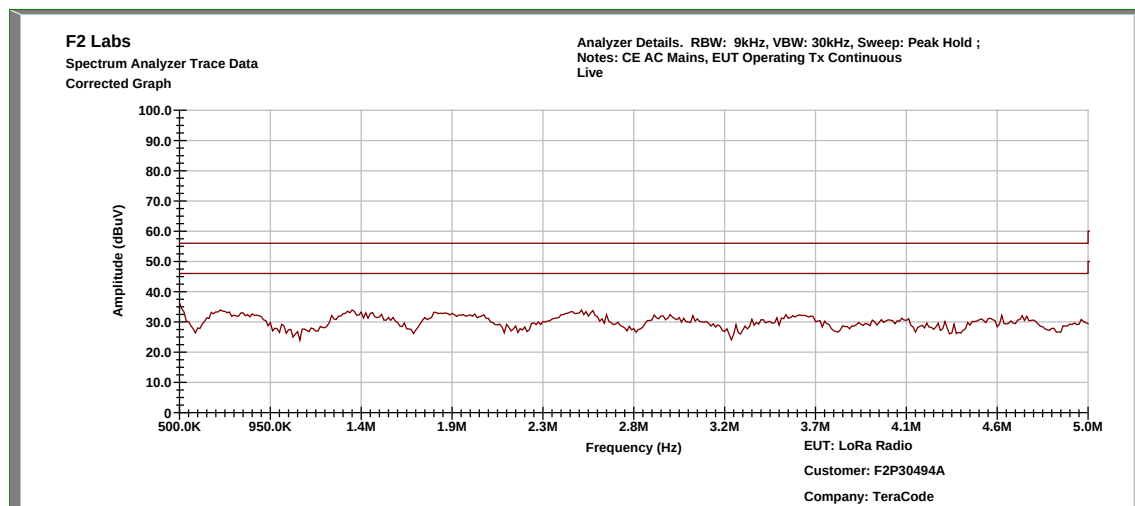
13.3 Conducted Emissions Test Data

Test Date:	2023-10-18	Test Engineer:	J. Chiller
Rule:	15.207	Air Temperature:	22.1° C
Test Results:	Pass	Relative Humidity:	44%

Conducted Test – Live: 0.15 MHz to 0.5 MHz

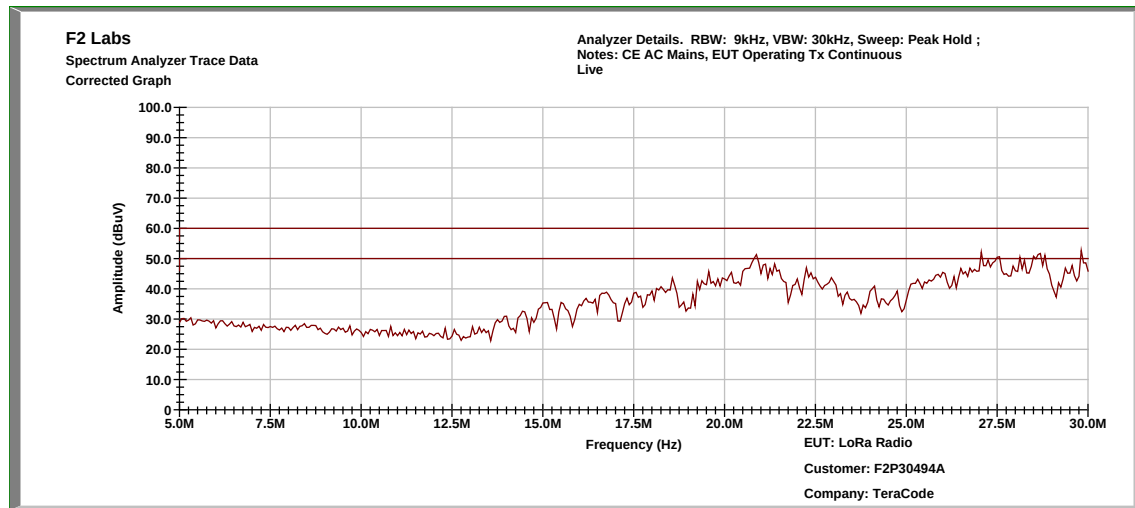


Conducted Test – Live: 0.5 MHz to 5.0 MHz





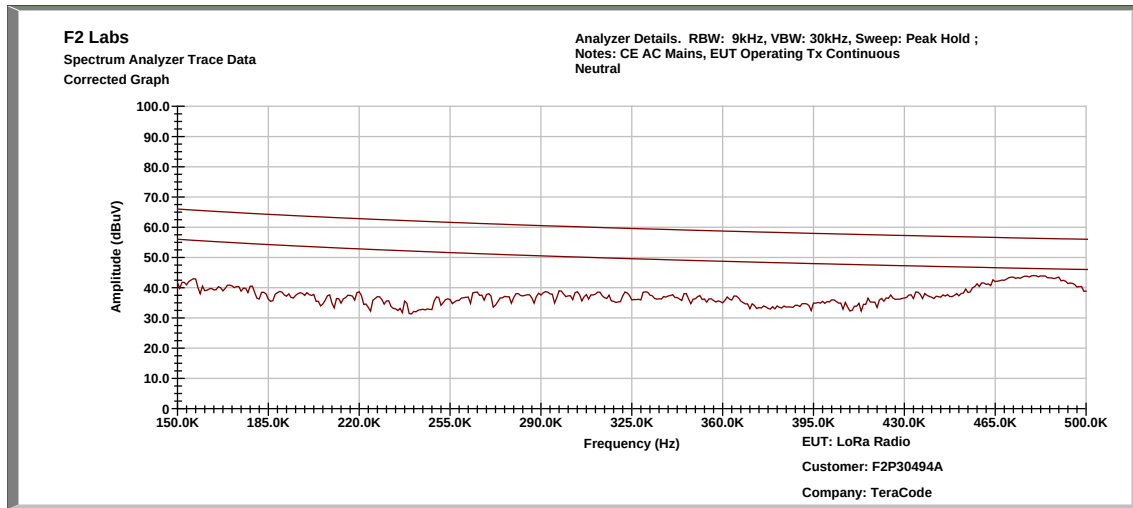
Conducted Test – Live: 5.0 MHz to 30.0 MHz



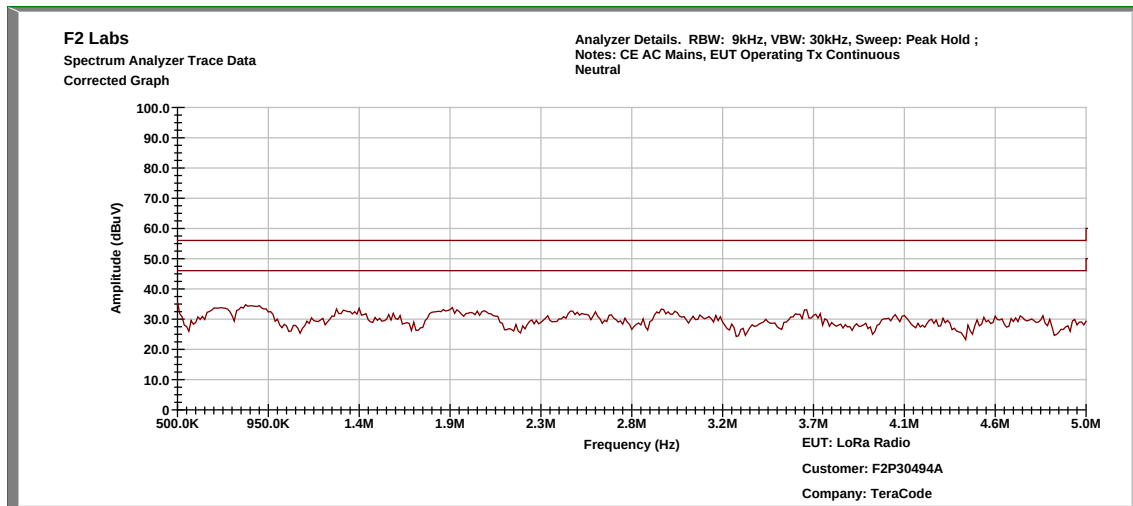
Top Discrete Measurements								
No.	Conductor	Frequency (MHz)	Detector	Level (dBμV)	Adjustment (dB)	Results (dBμV)	Limit (dBμV)	Margin (dB)
1	Live	Live	Quasi-Peak	31.56	10.833	42.39	60.0	-17.6
			Average	27.14	10.833	37.97	50.0	-12.0
2	Live	Live	Quasi-Peak	32.35	11.532	43.88	60.0	-16.1
			Average	26.35	11.532	37.88	50.0	-12.1
3	Live	Live	Quasi-Peak	33.36	11.303	44.66	60.0	-15.3
			Average	28.09	11.303	39.39	50.0	-10.6
4	Live	Live	Quasi-Peak	33.41	10.947	44.36	60.0	-15.6
			Average	18.76	10.947	29.71	50.0	-20.3
5	Live	Live	Quasi-Peak	31.92	11.052	42.97	60.0	-17.0
			Average	23.11	11.052	34.16	50.0	-15.8

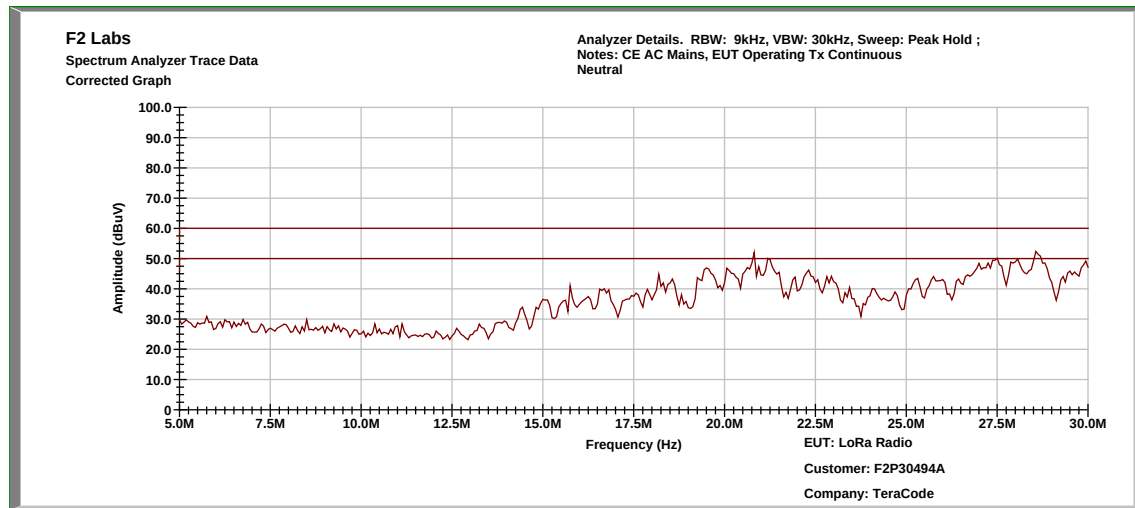


Conducted Test – Neutral: 0.15 MHz to 0.5 MHz



Conducted Test – Neutral: 0.5 MHz to 5.0 MHz



**Conducted Test – Neutral: 5.0 MHz to 30.0 MHz**

Top Discrete Measurements								
No.	Conductor	Frequency (MHz)	Detector	Level (dBμV)	Adjustment (dB)	Results (dBμV)	Limit (dBμV)	Margin (dB)
1	Neutral	0.481	Quasi-Peak	30.56	10.710	41.27	56.311	-15.0
			Average	20.98	10.710	31.69	46.311	-14.6
2	Neutral	20.812	Quasi-Peak	31.96	11.199	43.16	60.0	-16.8
			Average	27.32	11.199	38.52	50.0	-11.5
3	Neutral	21.25	Quasi-Peak	33.33	11.218	44.55	60.0	-15.5
			Average	22.56	11.218	33.78	50.0	-16.2
4	Neutral	27.5	Quasi-Peak	33.53	11.496	45.03	60.0	-15.0
			Average	26.46	11.496	37.96	50.0	-12.0
5	Neutral	28.062	Quasi-Peak	35.08	11.511	46.59	60.0	-13.4
			Average	25.71	11.511	37.22	50.0	-12.8
6	Neutral	28.562	Quasi-Peak	36.91	11.523	48.43	60.0	-11.6
			Average	28.53	11.523	40.05	50.0	-9.9



14 PHOTOGRAPH(S) – TEST SETUPS

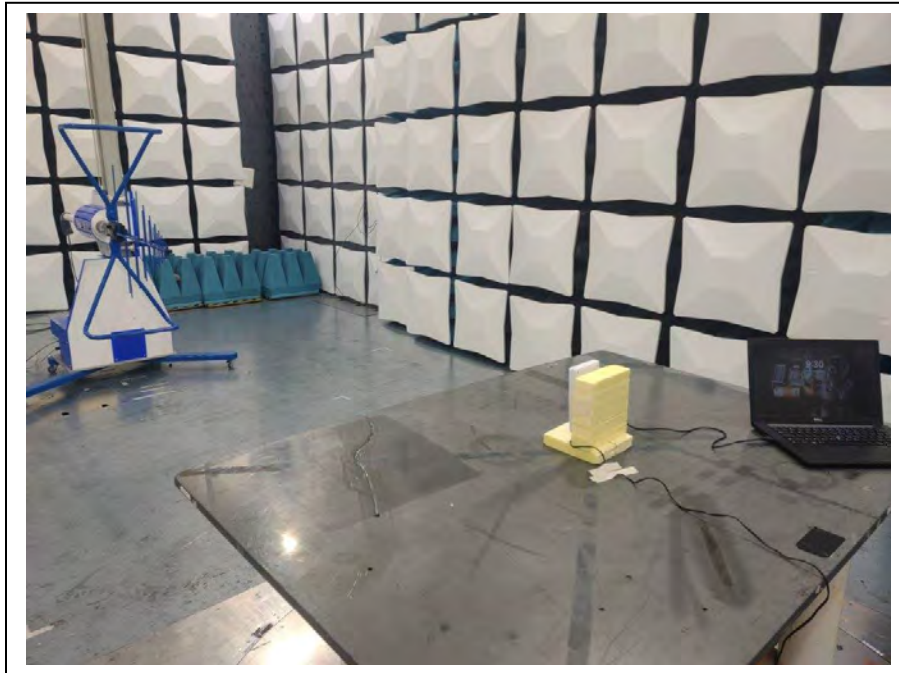
Radio Setup: Less Than 1 GHz



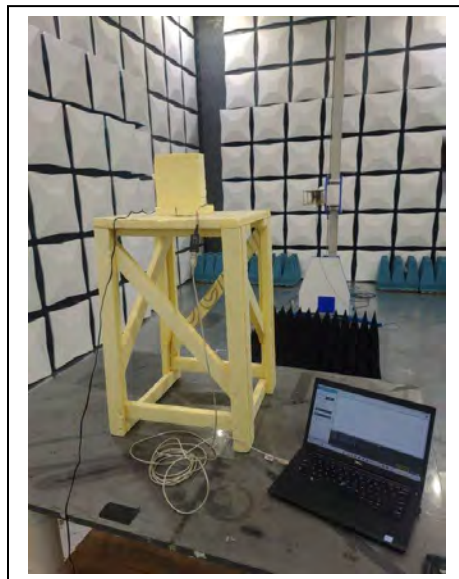
Radio Setup: Greater Than 1 GHz



Radiated Spurious Emissions: Less Than 1 GHz



Radiated Spurious Emissions: Greater Than 1 GHz





AC Conducted Emissions

