Conducted spurious emission measurements according to CFR 47 §24.238 and §27.53(h)

Date	Temperature	Humidity
2018-03-27	22 °C ± 3 °C	9 % ± 5 %
2018-04-04	22 °C ± 3 °C	25 % ± 5 %

Test set-up and procedure

The measurements were made per definition in ANSI C63.26, 5.7.4. The output was connected to a spectrum analyzer with the RMS detector activated.

Measurement equipment	RISE number
R&S FSW 43	902 073
Directional coupler	901 496
RF attenuator	902 282
HP filter	BX40074
Testo 635, temperature and humidity meter	504 203

Measurement uncertainty: 3.7 dB

Results

Band 2 4x 40 W + Band 66A 4x 60 W configuration:

Before comparing the results to the limit, 6 dB [10 log (4)] to cover 4x4 MIMO, should be added according to ANSI C63.26 6.4.4.1 c "measure and add 10 log(N_{ANT})".

Single carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
1 a-b	M_5	RFA
2 a-b	M_5	RF B
3 a-b	B_5	RF C
4 a-b	M_5	RF C
5 a-b	M_{10}	RF C
6 a-b	M_{15}	RF C
7 a-b	M_{20}	RF C
8 a-b	T_5	RF C
9 a-b	M_5	RF D

Multi carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
10 a-c	Bim	RF C
11 a-c	Tim	RF C

Note: Measurements were mainly limited to port RF C due to the measurement result in single carrier mode that shows that the ports are electrical identical as declared by the client.

Band 2 2x 60 W + Band 66A 2x 80 W configuration:

Before comparing the results to the limit, 3 dB [10 log (2)] to cover 2x2 MIMO, should be added according to ANSI C63.26 6.4.4.1 c "measure and add 10 log(N_{ANT})".

Single carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
12 a-b	B_5	RF A
13 a-b	M_5	RF A
14 a-b	M_{10}	RF A
15 a-b	M_{15}	RF A
16 a-b	M_{20}	RF A
17 a-b	T_5	RF A
18 a-b	M_5	RF D

Multi carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
19 a-c	Bim	RF A
20 a-c	Tim	RF A

Note: Measurements were mainly limited to port RF A due to the measurement result in single carrier mode that shows that the ports are electrical identical as declared by the client.

Band 2 4x 40 W + Band 66A 4x 60 W configuration:

Before comparing the results to the limit, 6 dB [10 log (4)] to cover 4x4 MIMO, should be added according to ANSI C63.26 6.4.4.1 c "measure and add 10 log(N_{ANT})".

Single carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
21 a-b	M_5	RF E
22 a-b	B_5	RF F
23 a-b	M_5	RF F
24 a-b	M_{10}	RF F
25 a-b	M_{15}	RF F
26 a-b	M_{20}	RF F
27 a-b	T_5	RF F
28 a-b	M_5	RF G
29 a-b	M_5	RF H

Multi carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
30 a-c	Bim	RF F
31 a-c	Tim	RF F

Note: Measurements were mainly limited to port RF F due to the measurement result in single carrier mode that shows that the ports are electrical identical as declared by the client.

Band 2 2x 60 W + Band 66A 2x 80 W configuration:

Before comparing the results to the limit, 3 dB [10 log (2)] to cover 2x2 MIMO, should be added according to ANSI C63.26 6.4.4.1 c "measure and add 10 log(N_{ANT})".

Single carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
32 a-b	B_5	RF E
33 a-b	M_5	RF E
34 a-b	M_{10}	RF E
35 a-b	M_{15}	RF E
36 a-b	M_{20}	RF E
37 a-b	T_5	RF E
38 a-b	M_5	RF H

Multi carrier E-TM 1.1

Diagram	Symbolic name	Tested Port
39 a-c	Bim	RF E
40 a-c	Tim	RF E

Note: Measurements were mainly limited to port RF E due to the measurement result in single carrier mode that shows that the ports are electrical identical as declared by the client.

Remark

The emission at 9 kHz on the plots was not generated by the test object. A complementary measurement with a smaller RBW showed that it was related to the LO feed-through.

The highest fundamental frequency is 2180 MHz. The measurements were made up to 22 GHz (10x2180 MHz = 21.80 GHz).

Limits

CFR 47 §24.238 and §27.53(h)

Outside a licensee's frequency band(s) of operation the power of any emission shall be attenuated below the transmitter power (P) by at least 43 + 10 log (P) dB, resulting in a limit of -13 dBm per 1 MHz RBW.

Complies?	Yes

Diagram 1a:

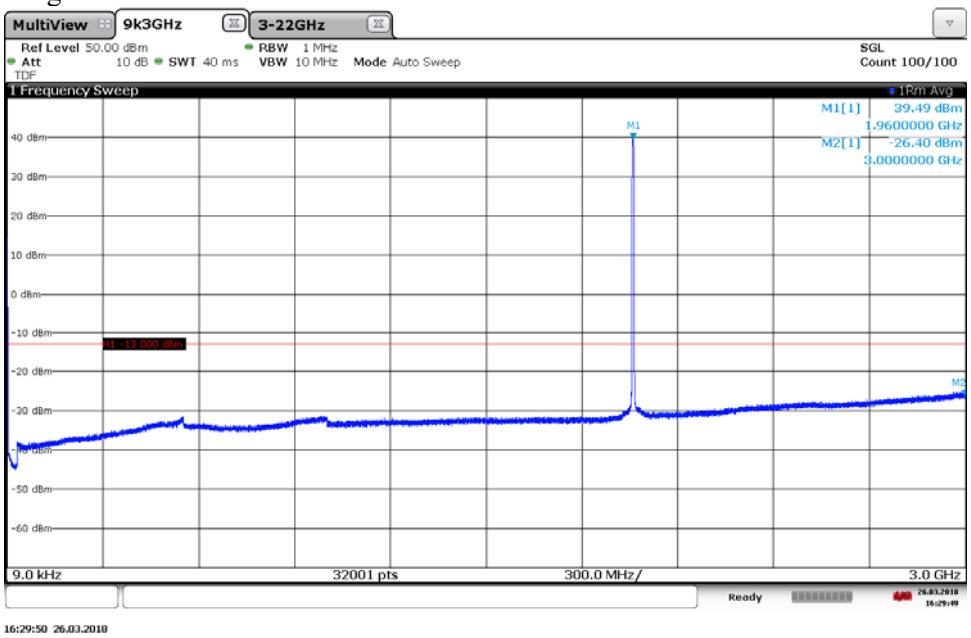


Diagram 1b:

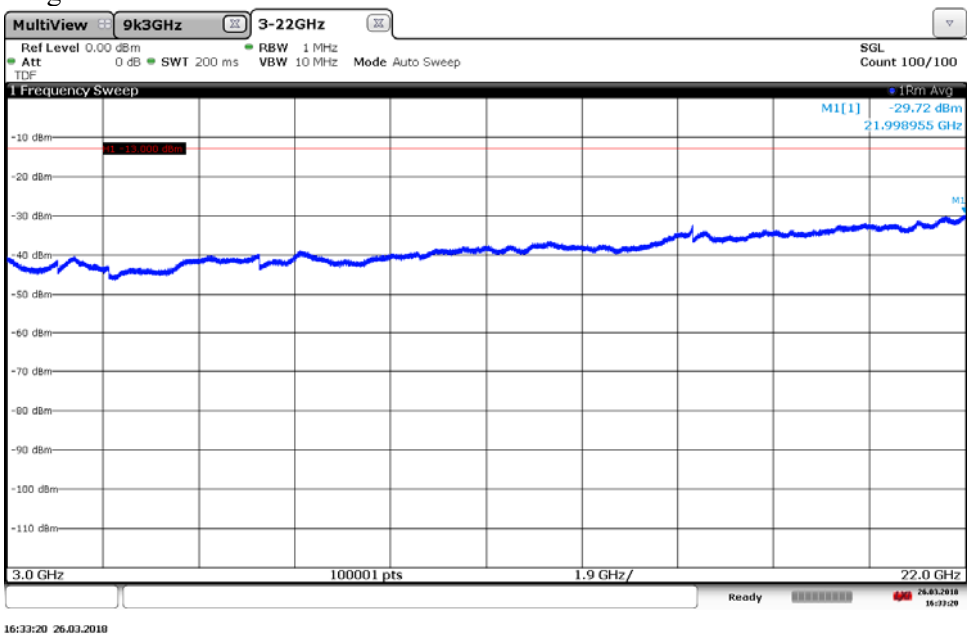


Diagram 2a:

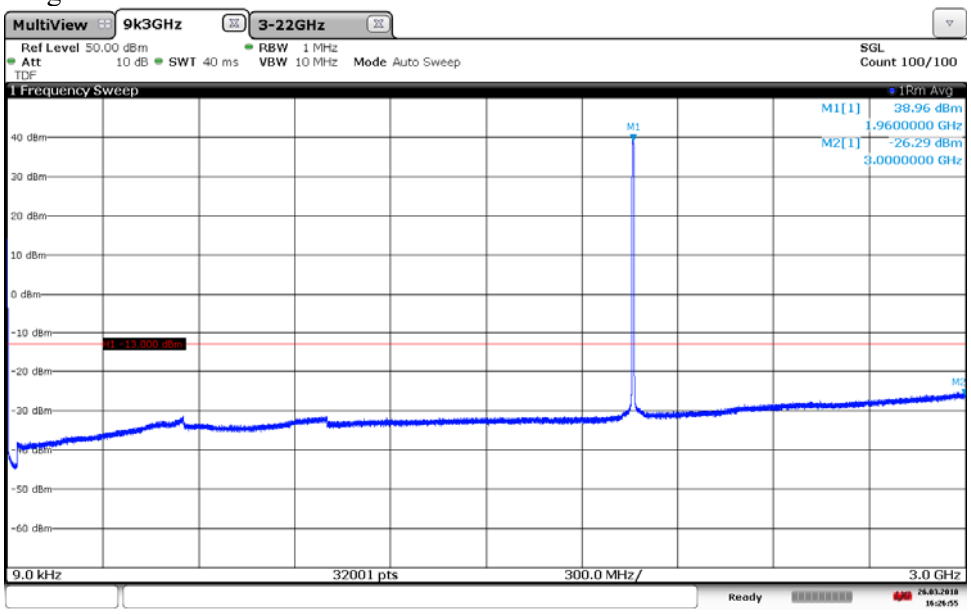


Diagram 2b:

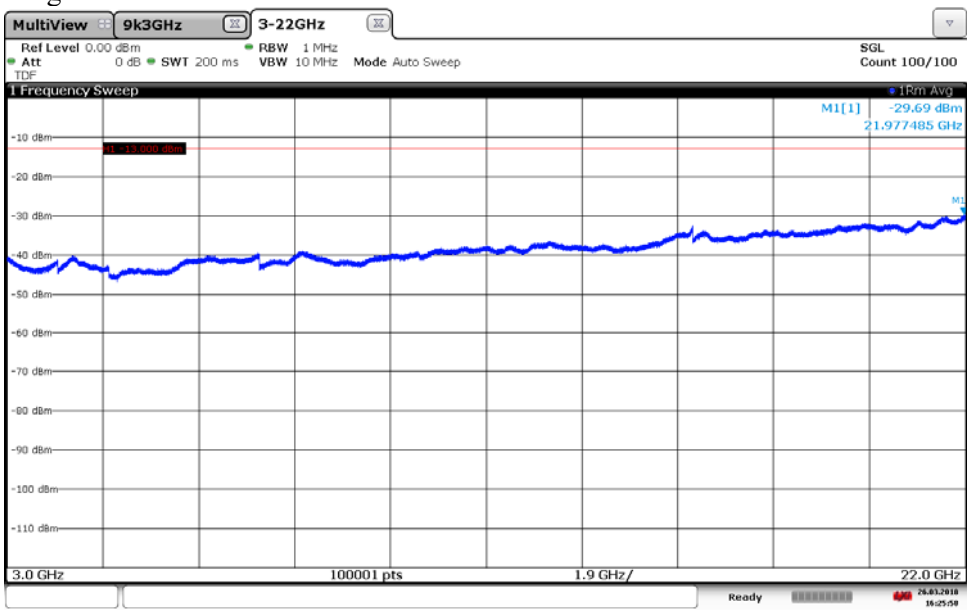


Diagram 3a:

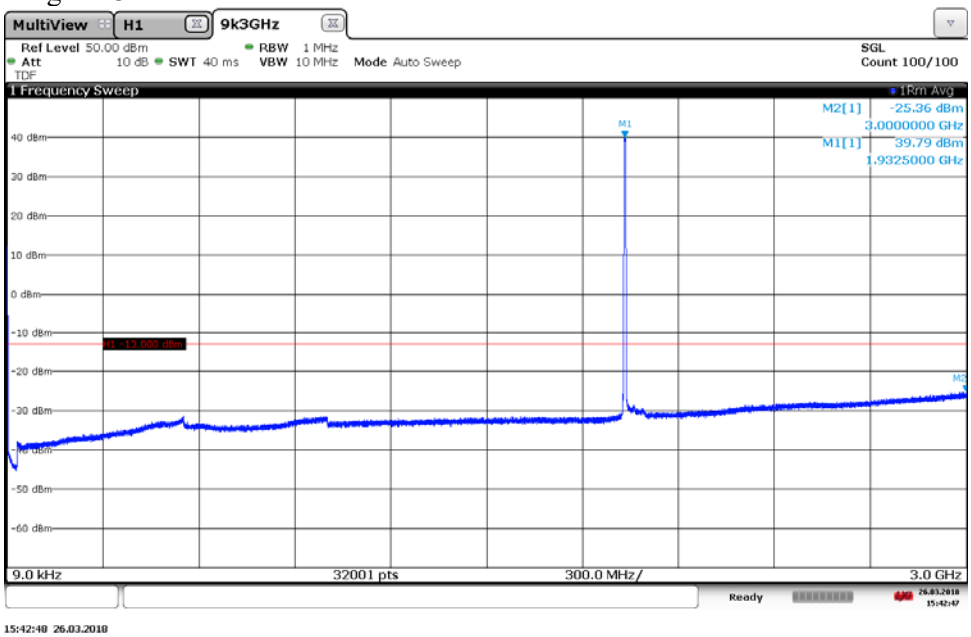


Diagram 3b:

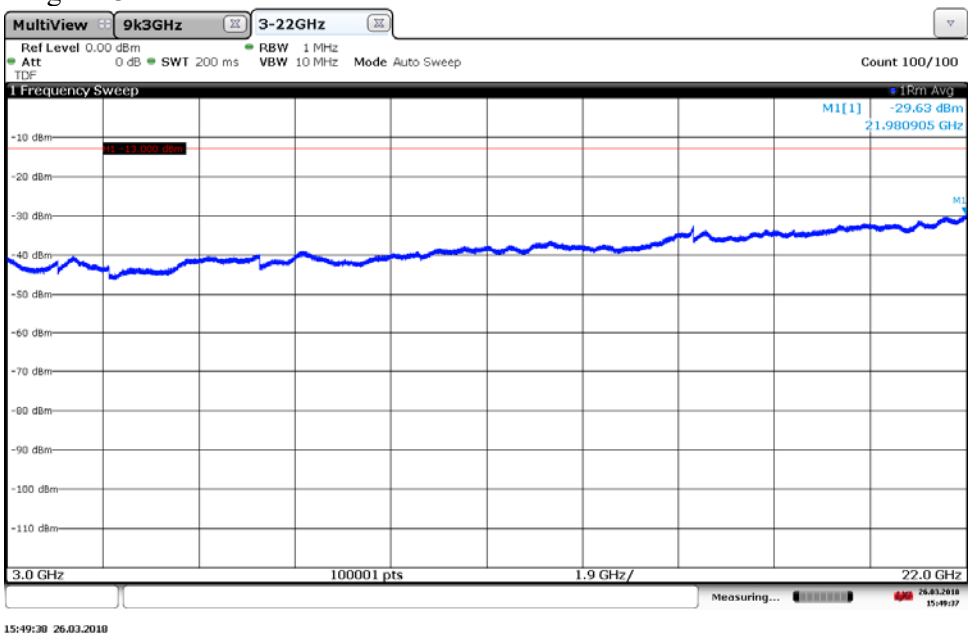


Diagram 4a:

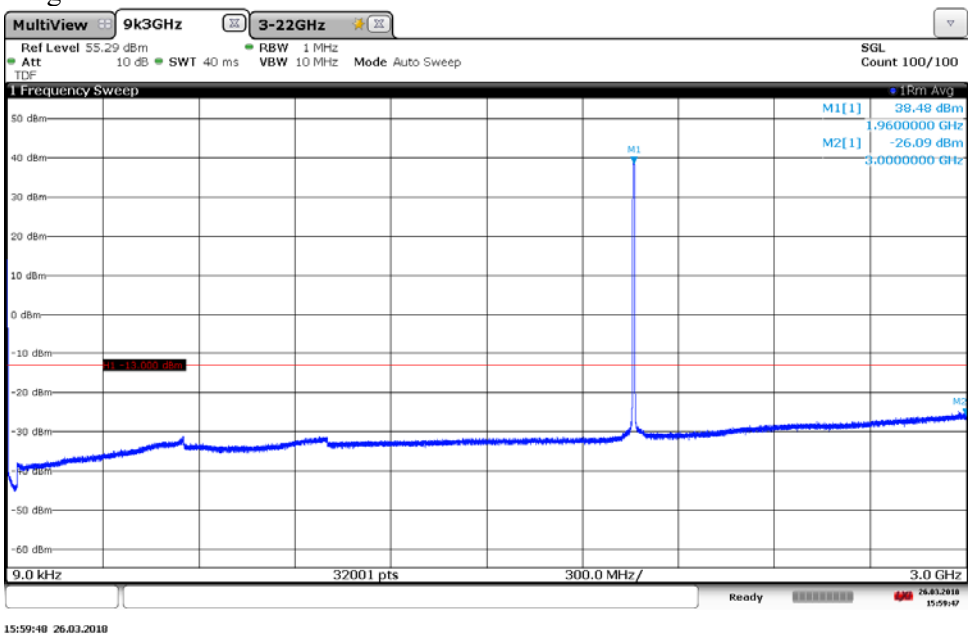


Diagram 4b:

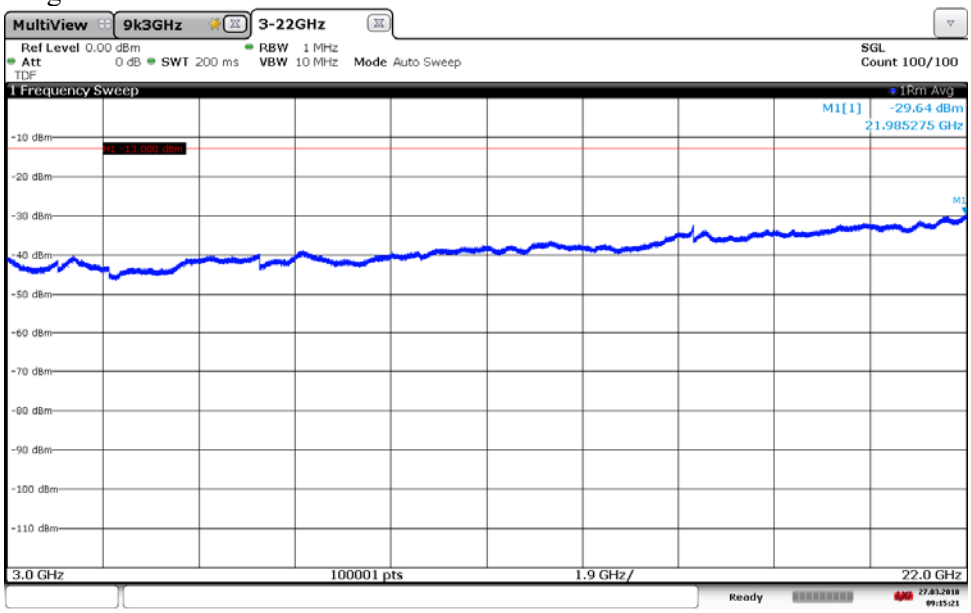


Diagram 5a:

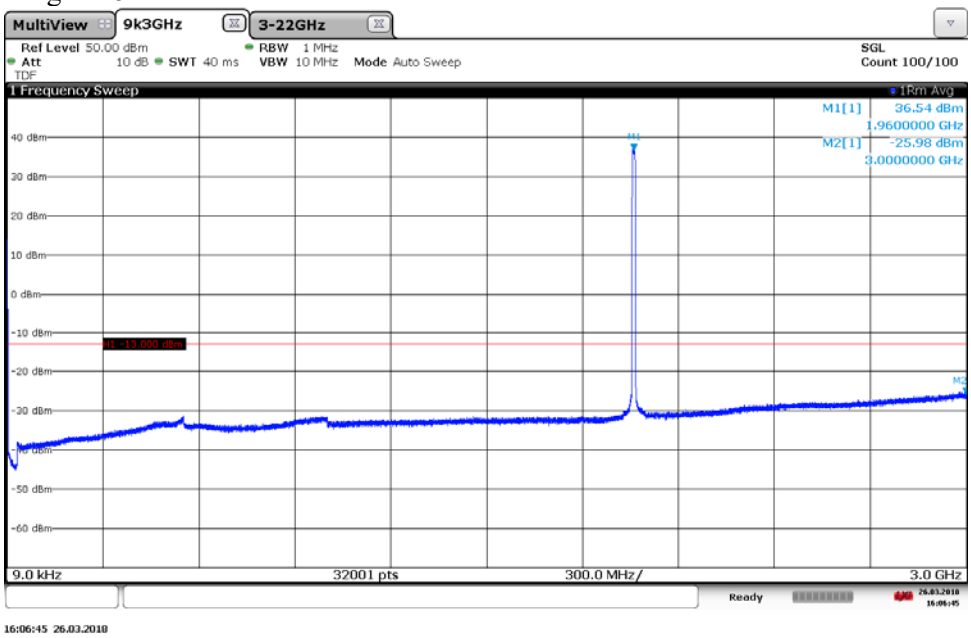


Diagram 5b:

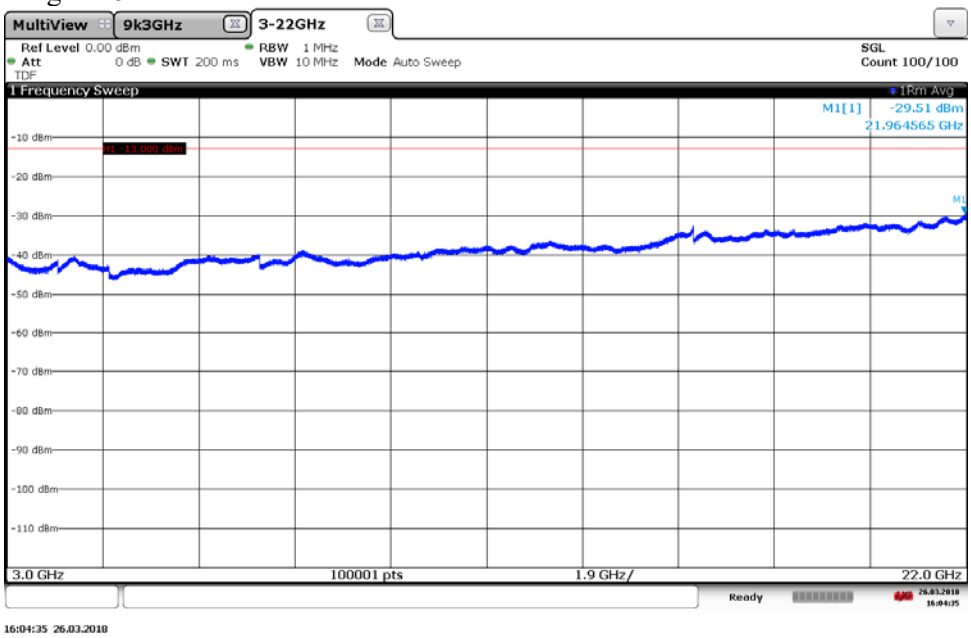


Diagram 6a:

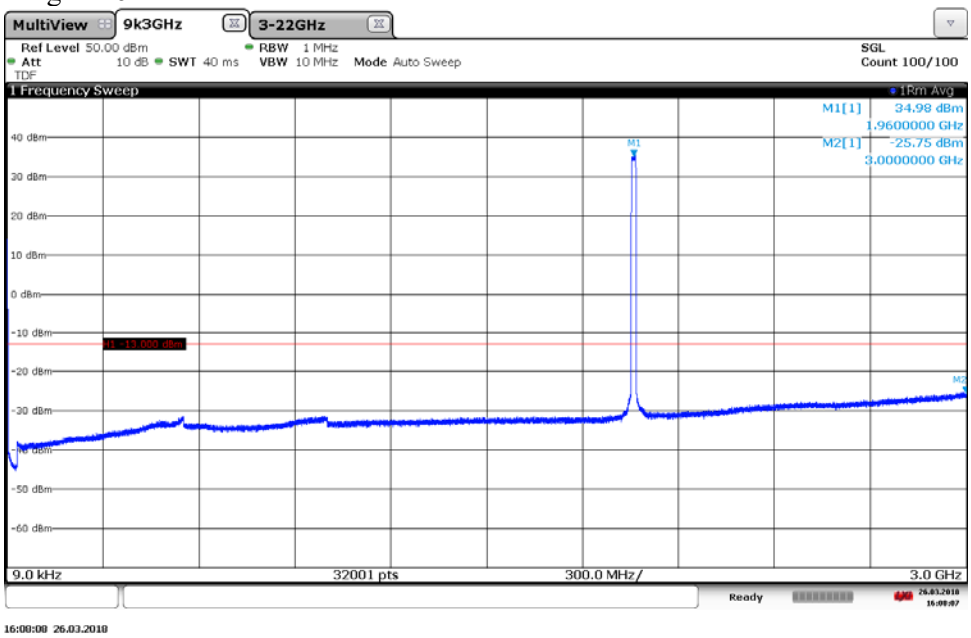


Diagram 6b:

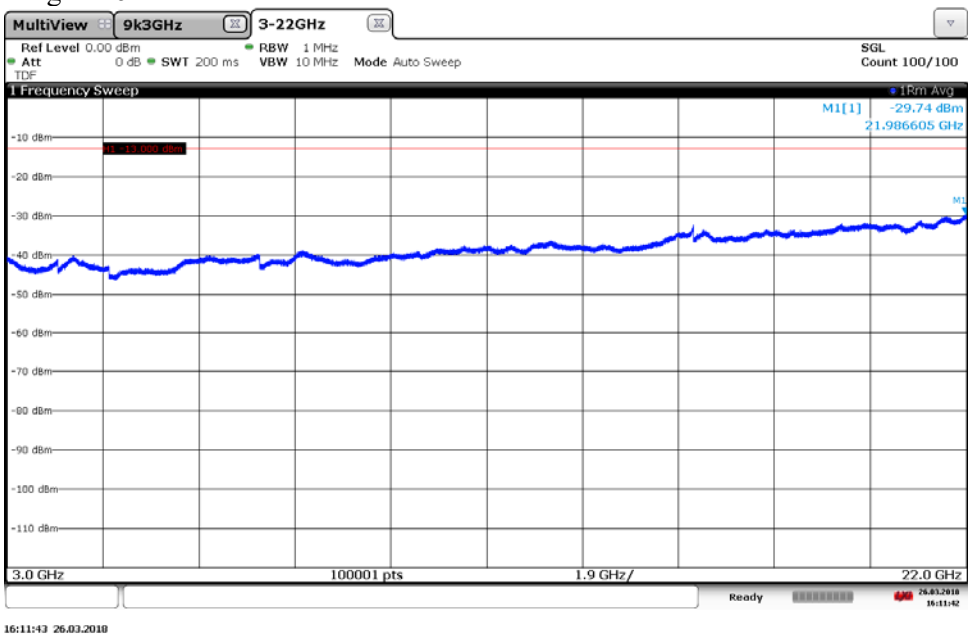


Diagram 7a:

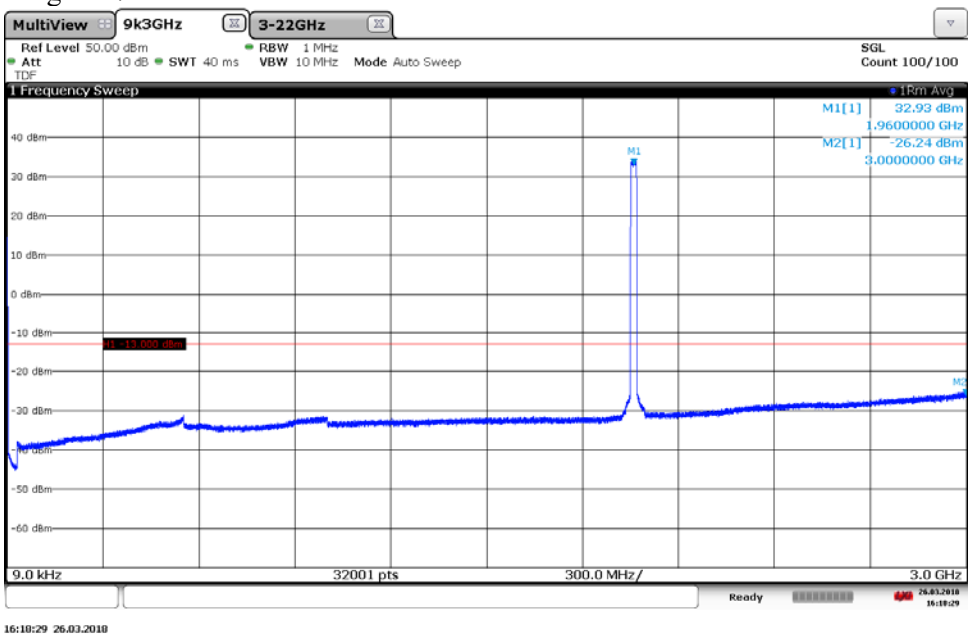


Diagram 7b:

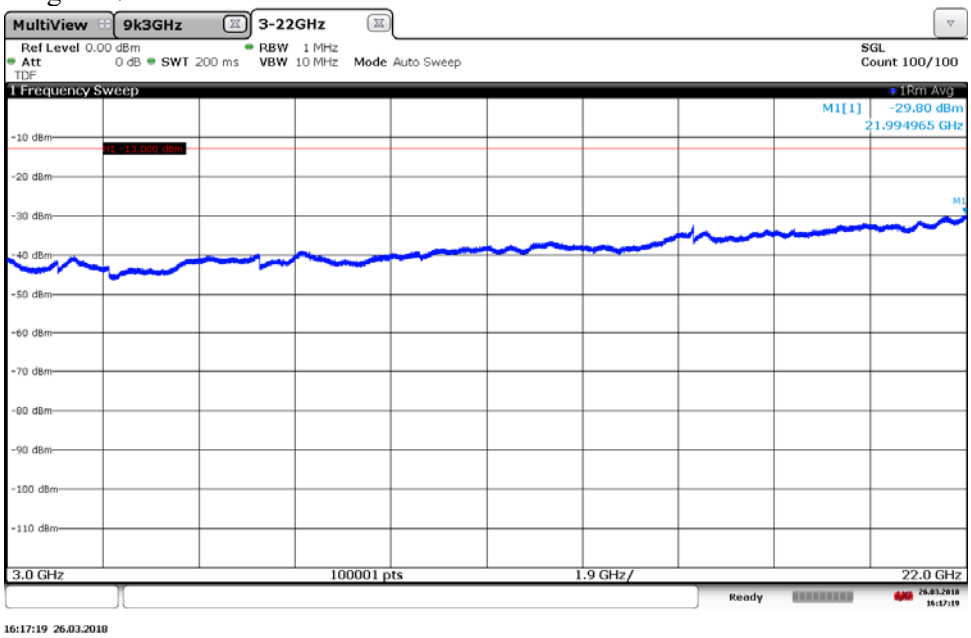


Diagram 8a:

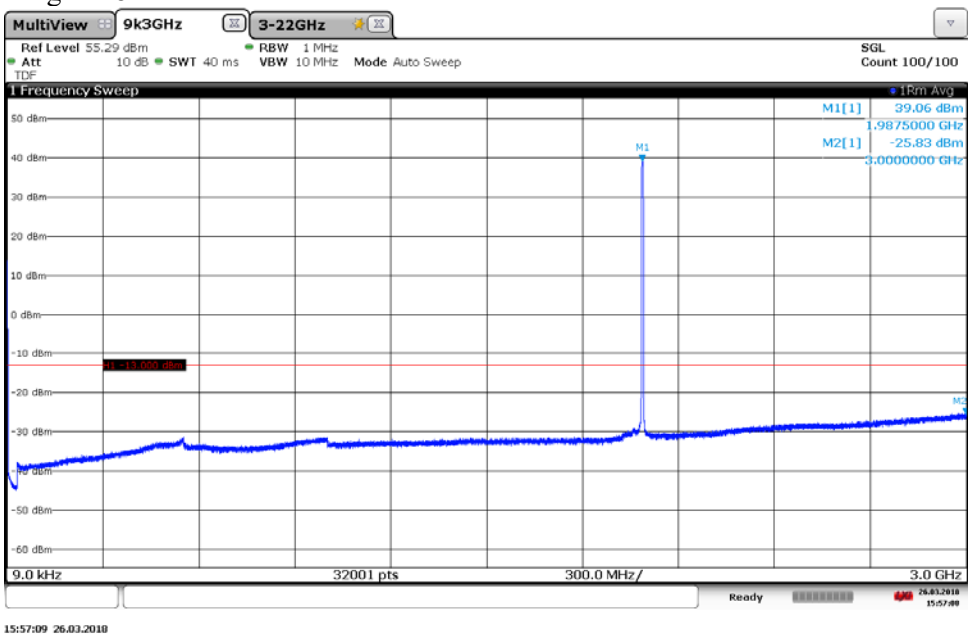


Diagram 8b:

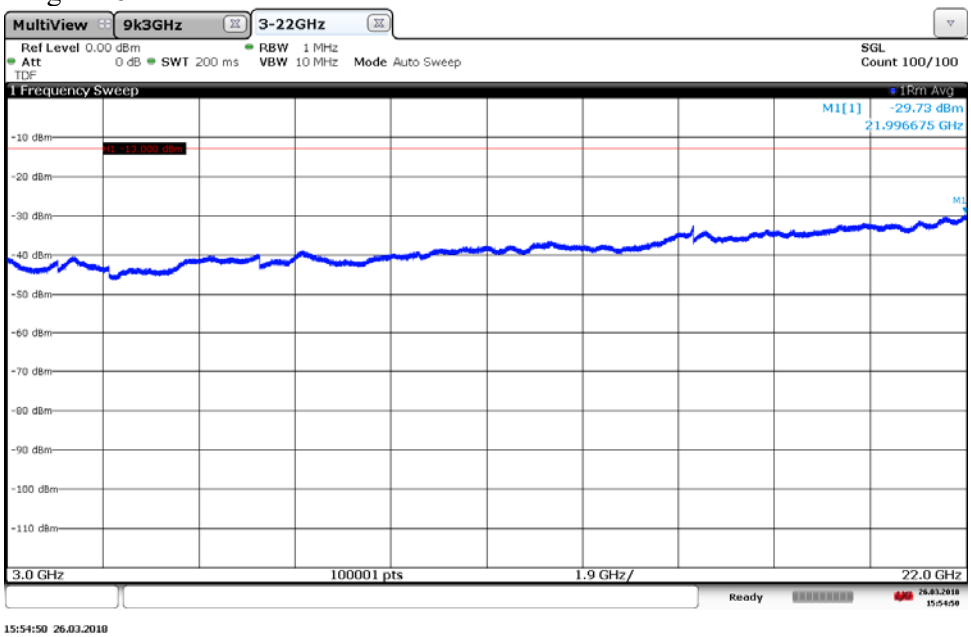


Diagram 9a:

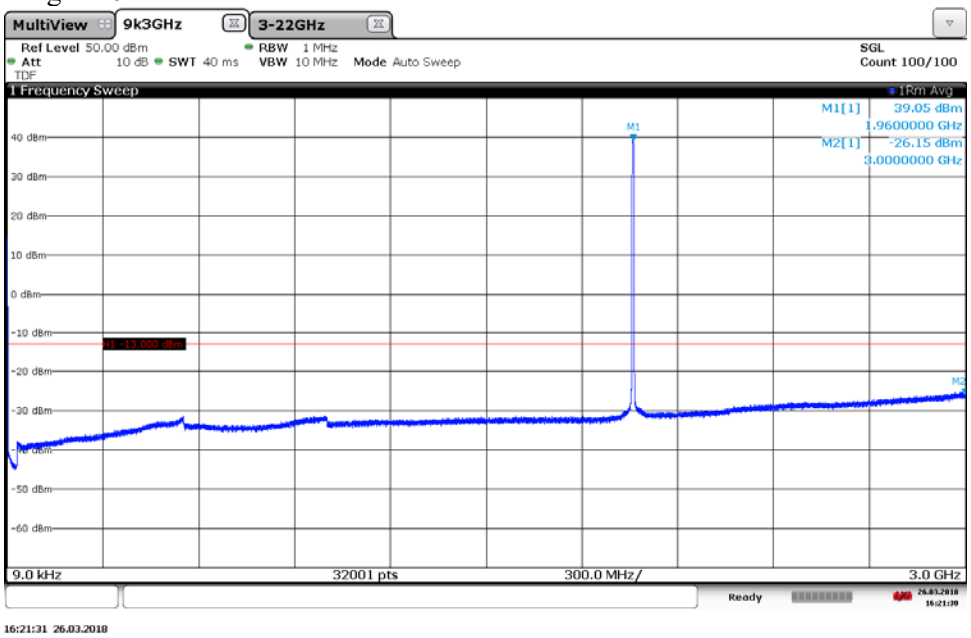


Diagram 9b:

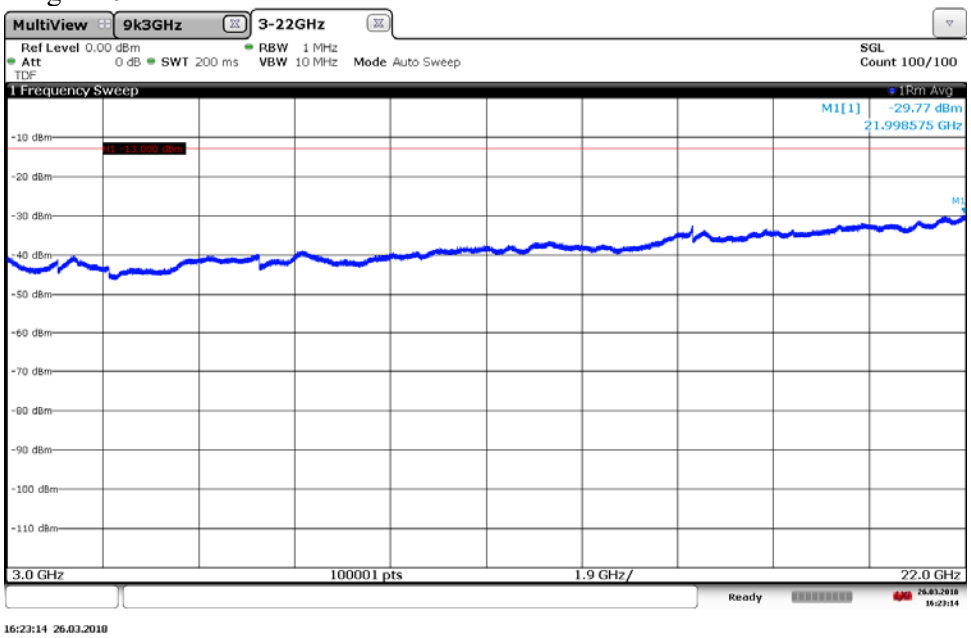


Diagram 10a:

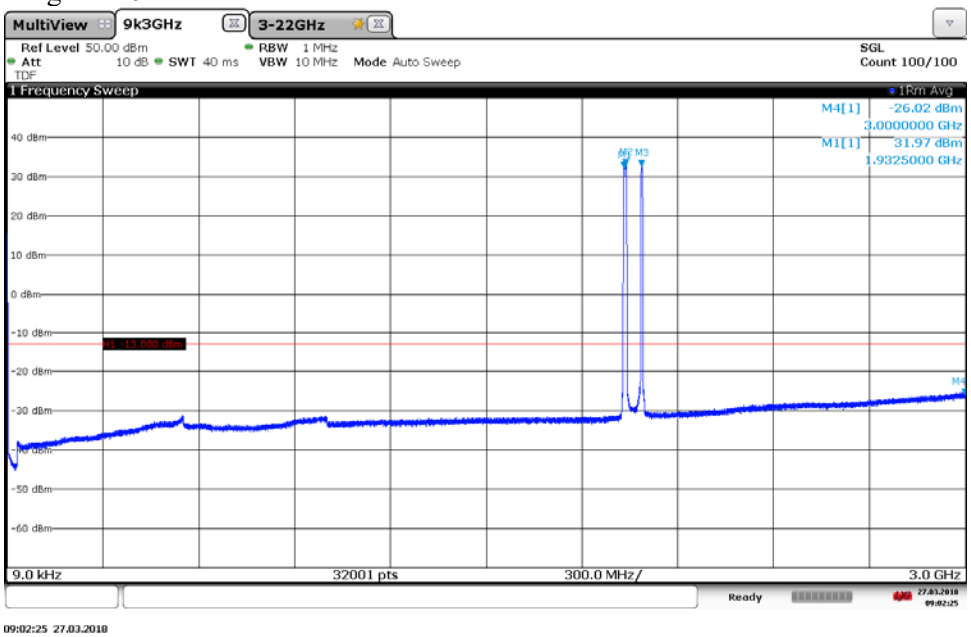


Diagram 10b:

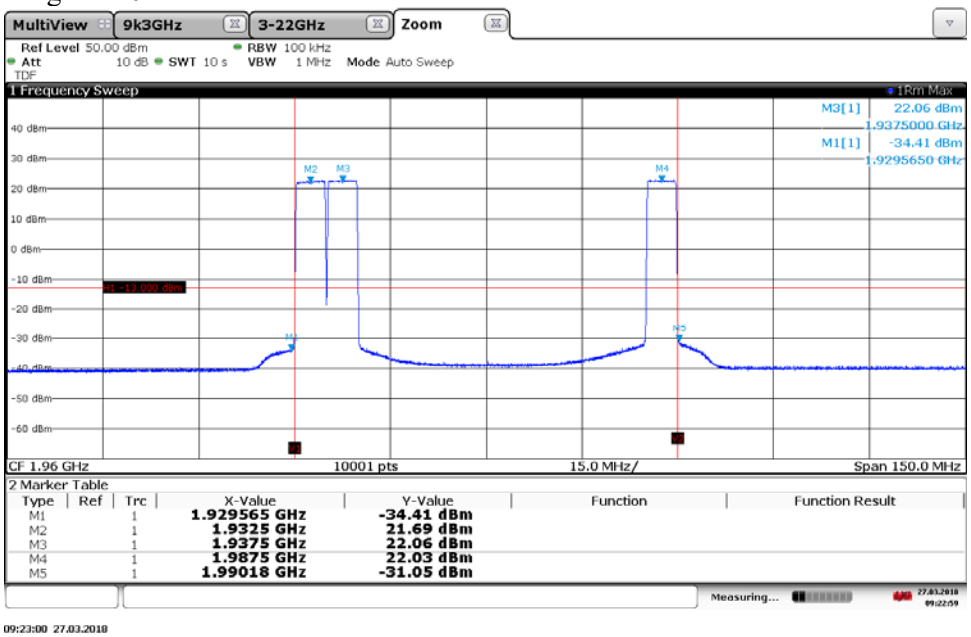


Diagram 10c:

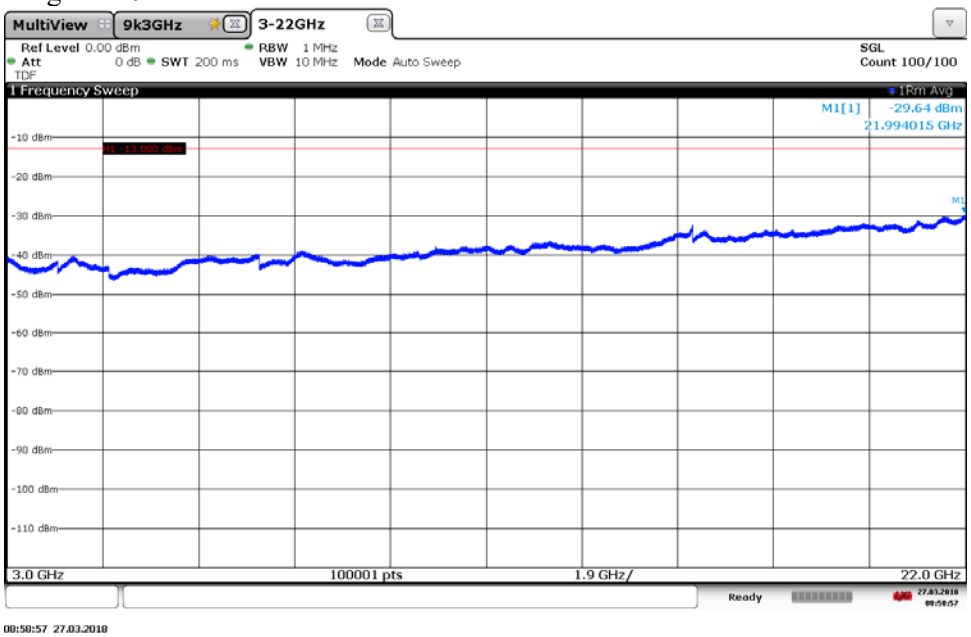

MultiView
9k3GHz
3-22GHz
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms
RBW 1 MHz
VBW 10 MHz
Mode Auto Sweep
SGL
Count 100/100
TDF
1 Frequency Sweep
1Rm Avg
M1[1] -29.64 dBm
21.994015 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
-100 dBm
-110 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Ready
00:50:57 27.03.2018

Diagram 11a:

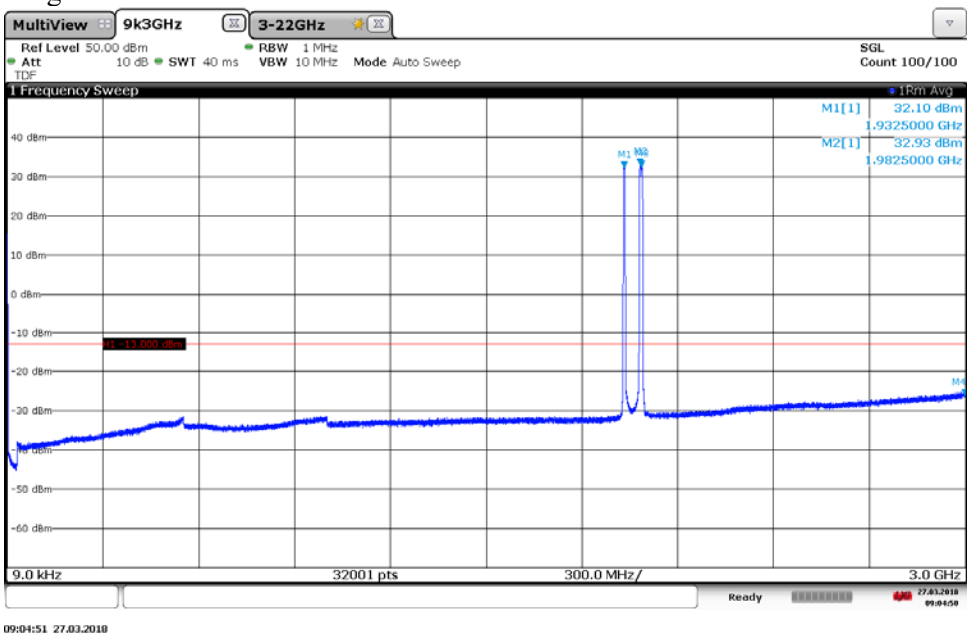


Diagram 11b:

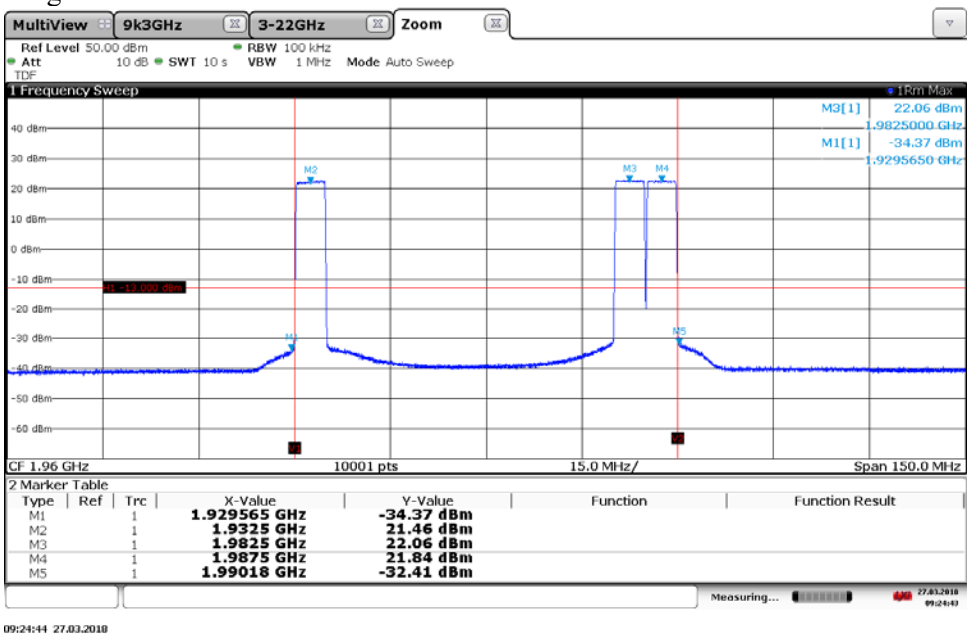


Diagram 11c:

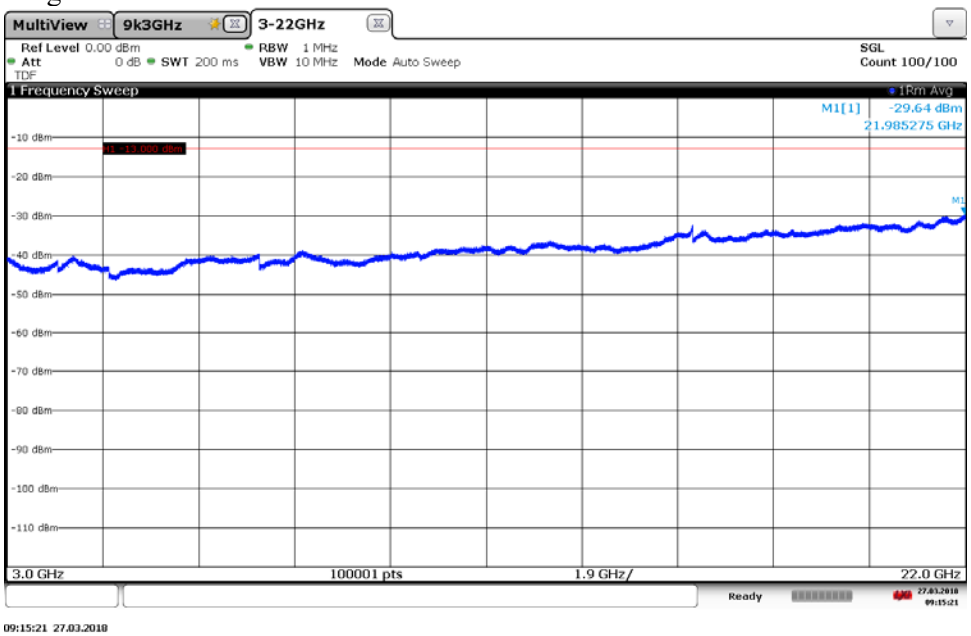

MultiView
9k3GHz
3-22GHz
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms
RBW 1 MHz
VBW 10 MHz
Mode Auto Sweep
SGL
Count 100/100
TDF
1 Frequency Sweep
1Rm Avg
M1[1] -29.64 dBm
21.985275 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
-100 dBm
-110 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Ready
09:15:21 27.03.2018

Diagram 12a:

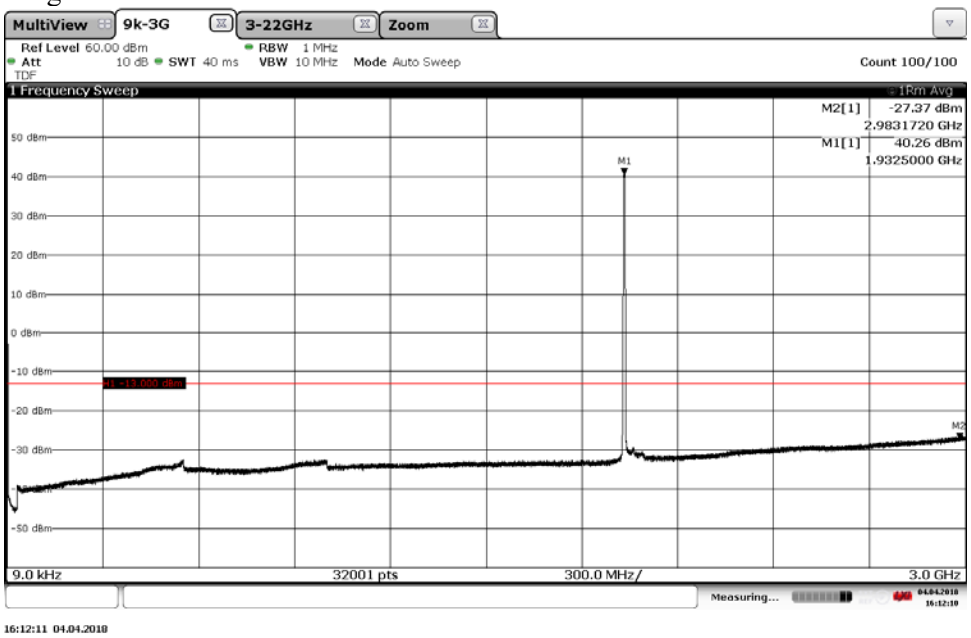


Diagram 12b:

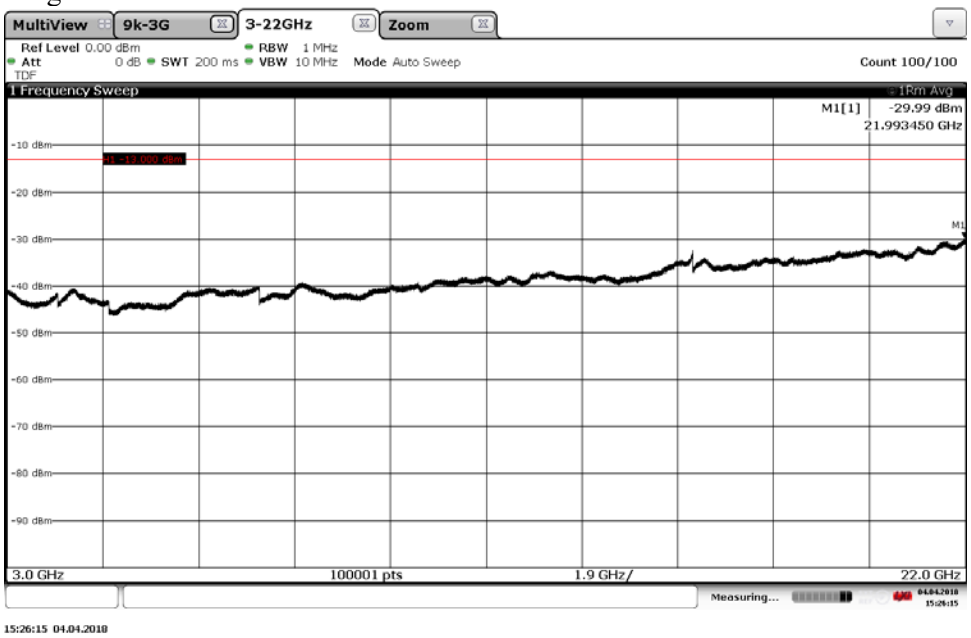


Diagram 13a:

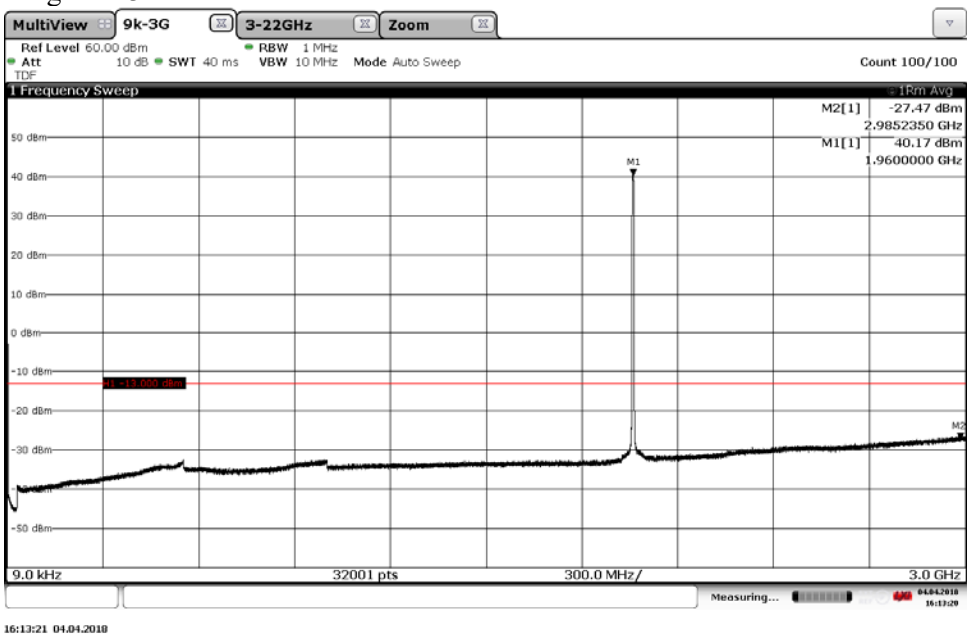


Diagram 13b:

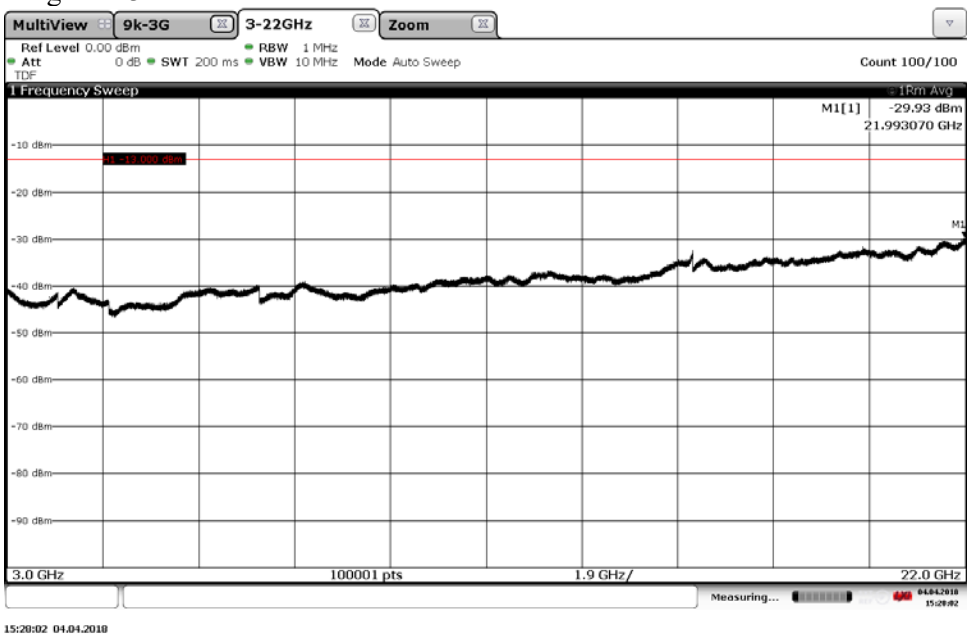


Diagram 14a:

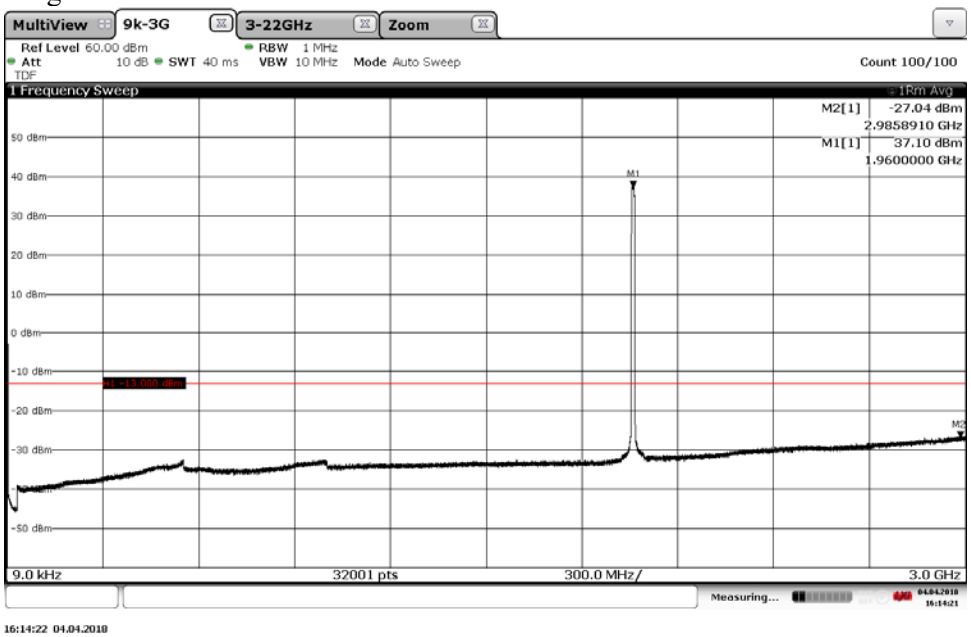


Diagram 14b:

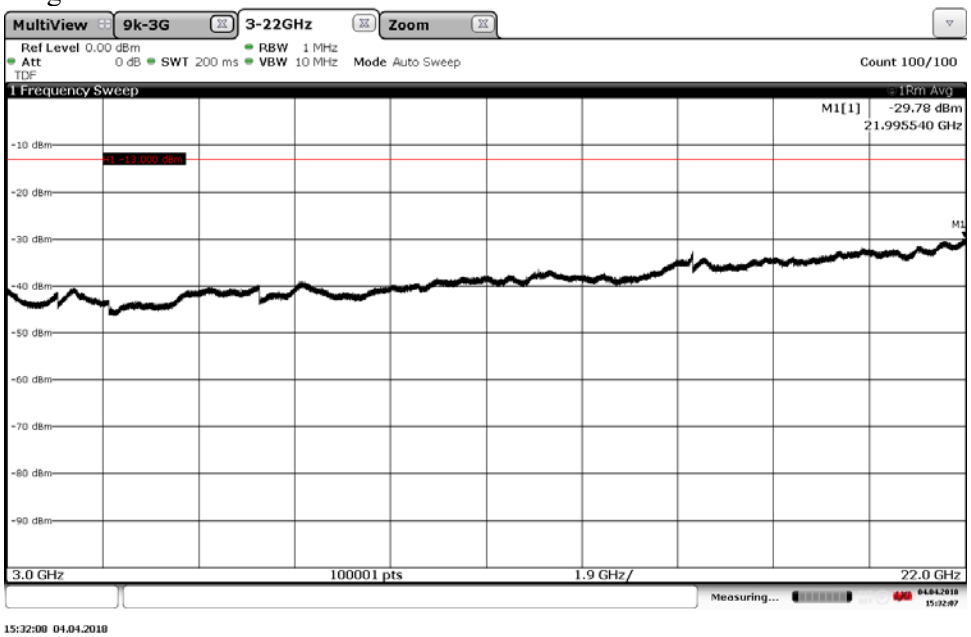


Diagram 15a:

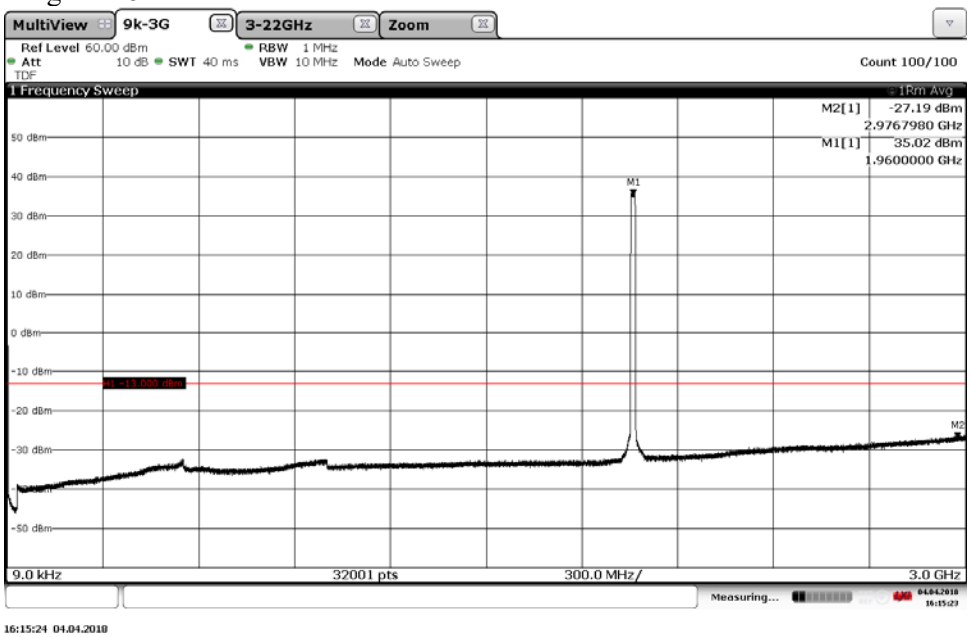


Diagram 15b:

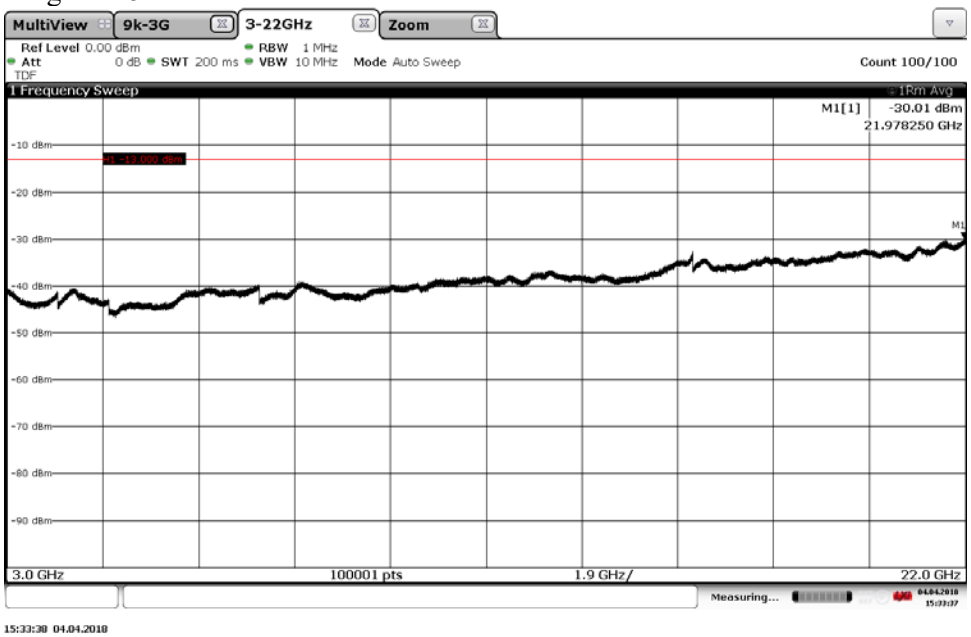


Diagram 16a:

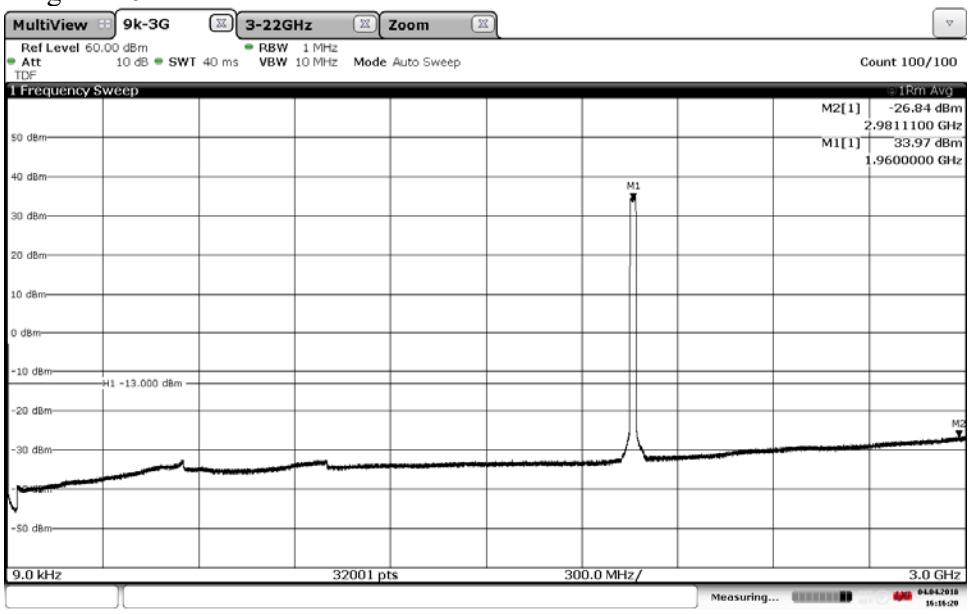


Diagram 16b:

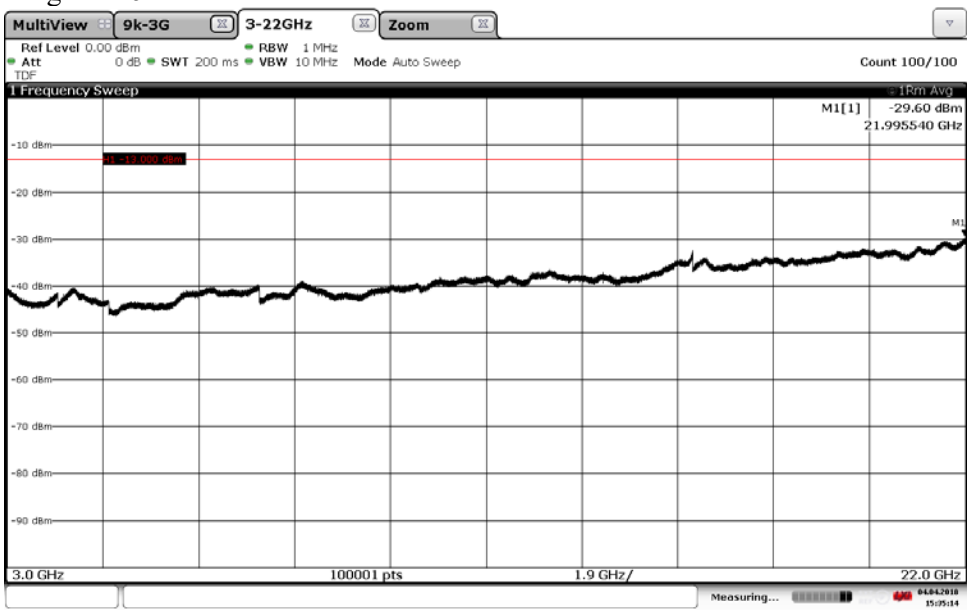


Diagram 17a:

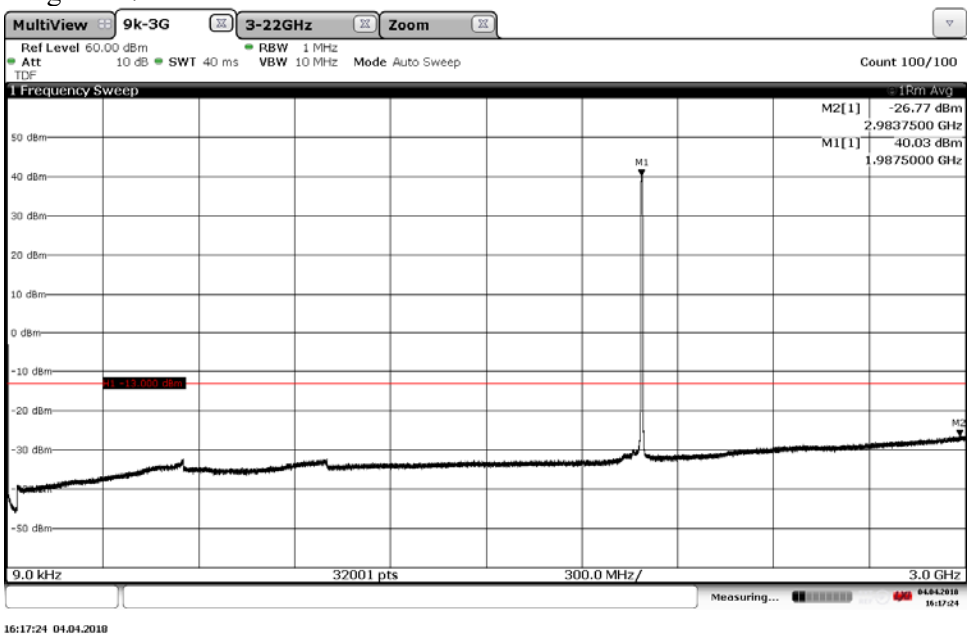


Diagram 17b:

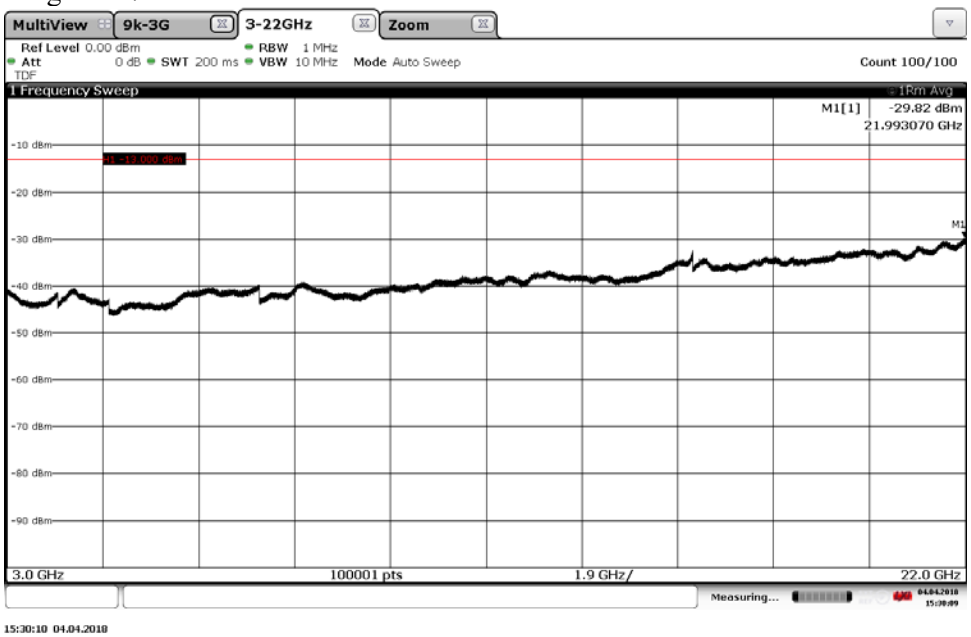


Diagram 18a:

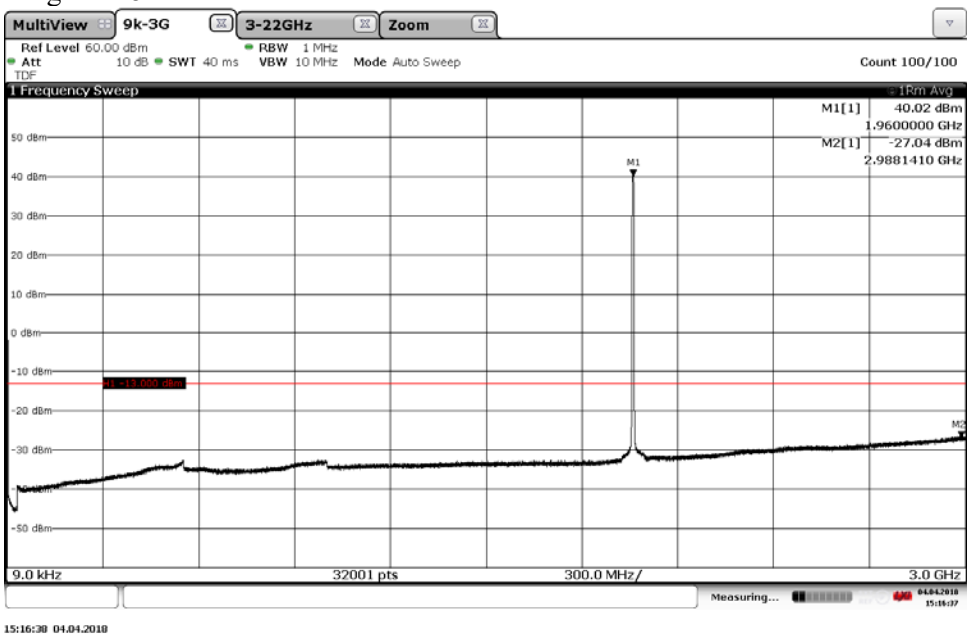


Diagram 18b:

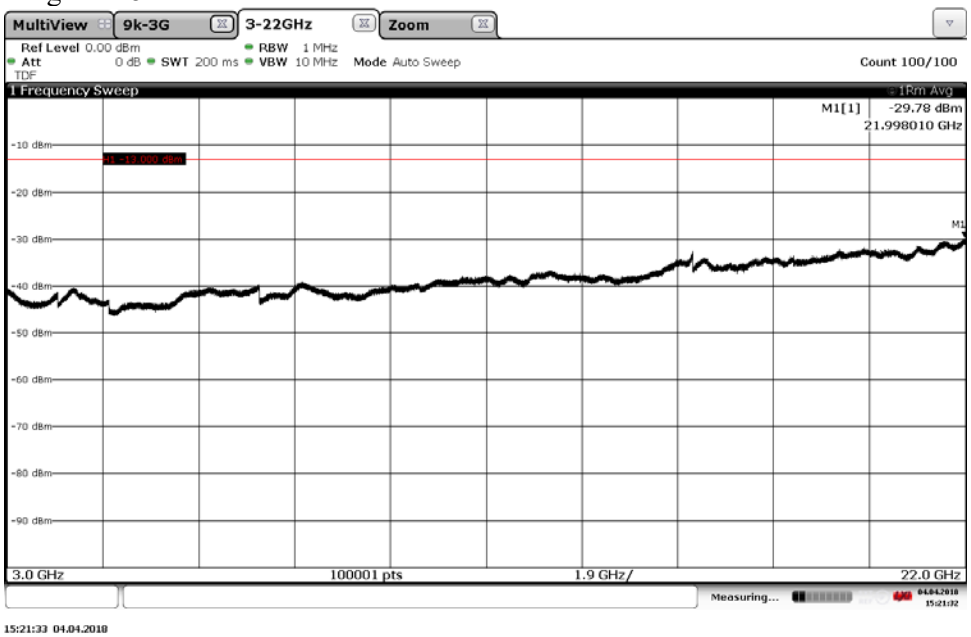


Diagram 19a:

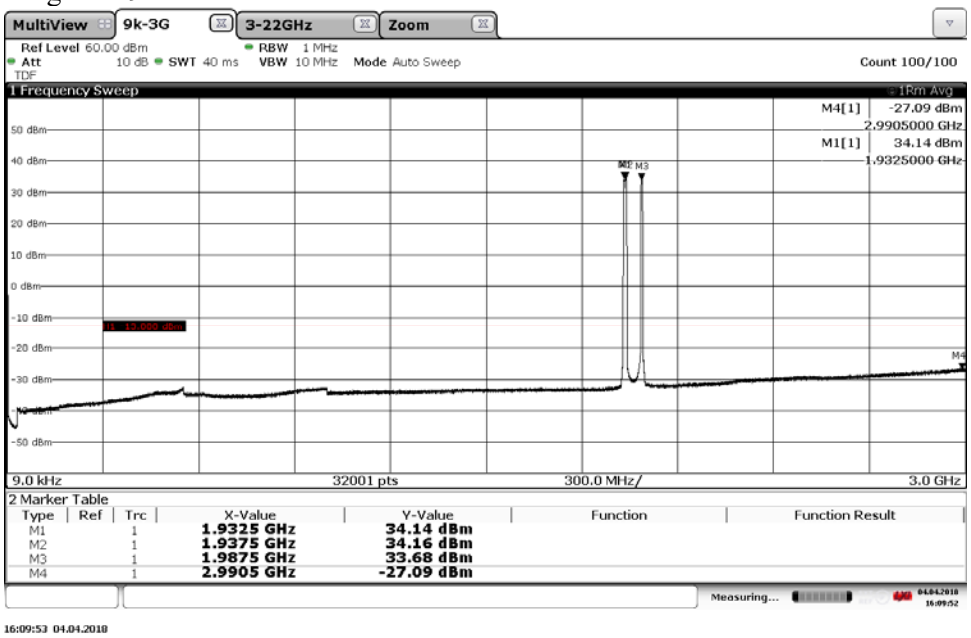


Diagram 19b:

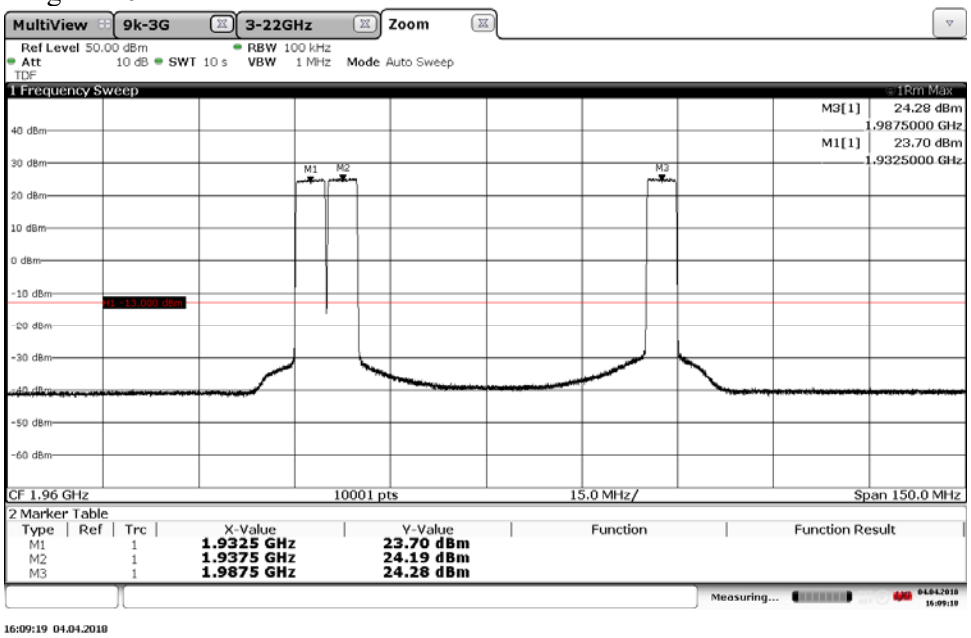


Diagram 19c:

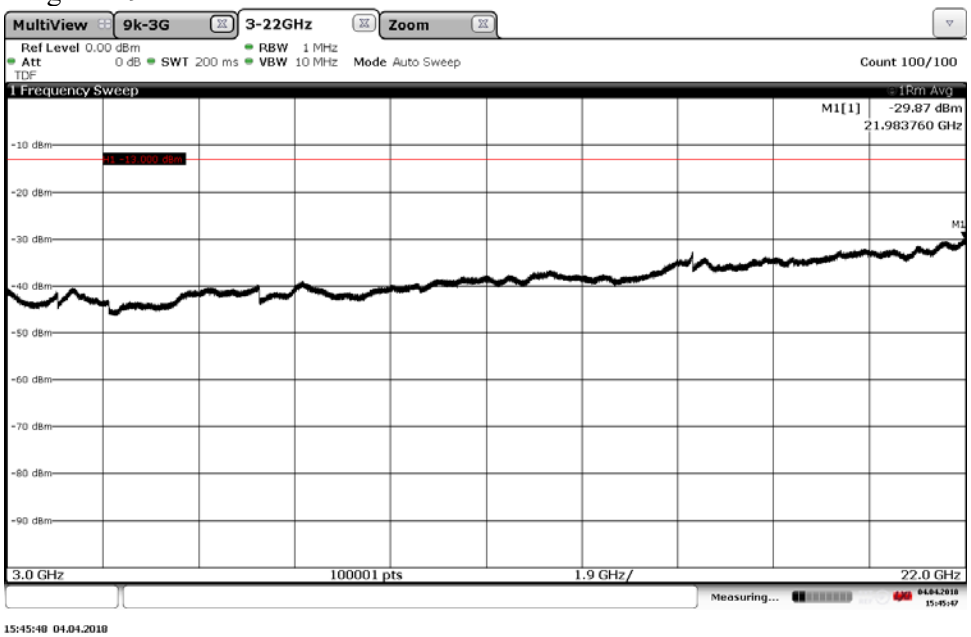

MultiView
9k-3G
3-22GHz
Zoom
Ref Level 0.00 dBm
RBW 1 MHz
Att 0 dB SWT 200 ms VBW 10 MHz Mode Auto Sweep
Count 100/100
TDF
1 Frequency Sweep
1Rm Avg
M1[1] -29.87 dBm
21.983760 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
M1
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
15:45:40 04.04.2018

Diagram 20a:

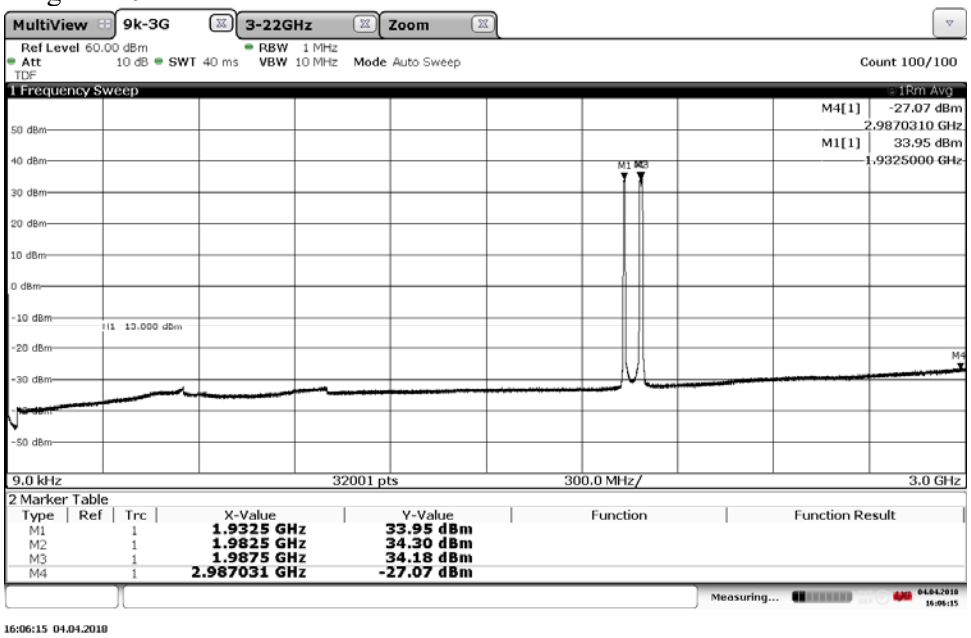


Diagram 20b:

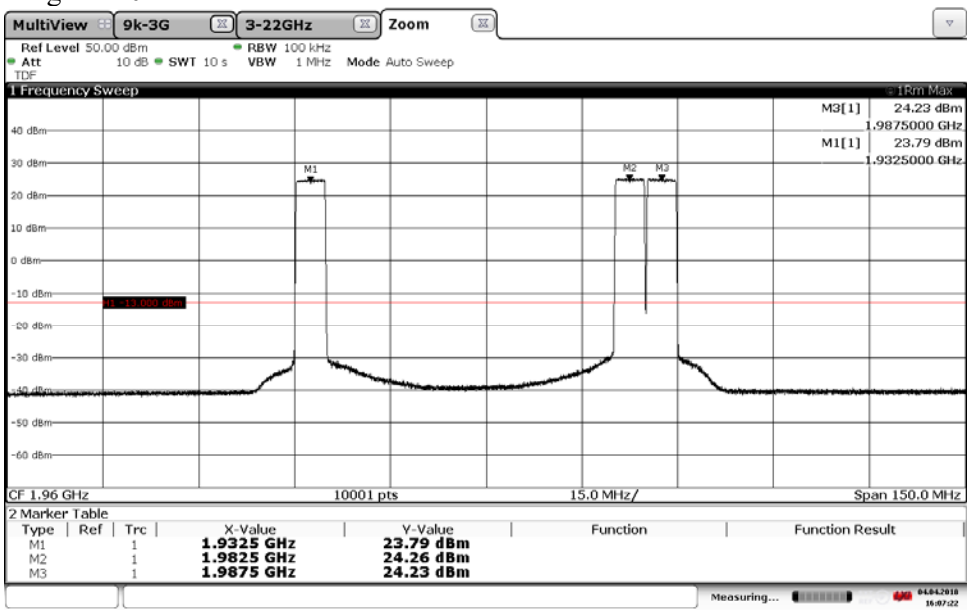


Diagram 20c:

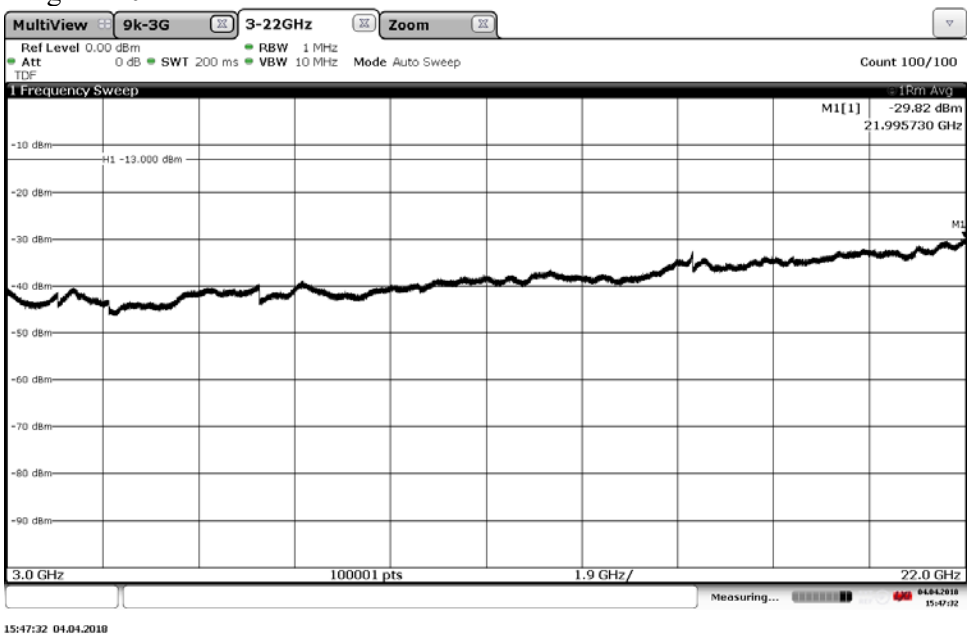

MultiView
9k-3G
3-22GHz
Zoom
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms VBW 10 MHz Mode Auto Sweep
RBW 1 MHz
TDF
Count 100/100
1 Frequency Sweep
1Rm Avg
M1[1] -29.82 dBm
21.995730 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
H1 -13.000 dBm
M1
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
15:47:32 04.04.2018

Diagram 21a:

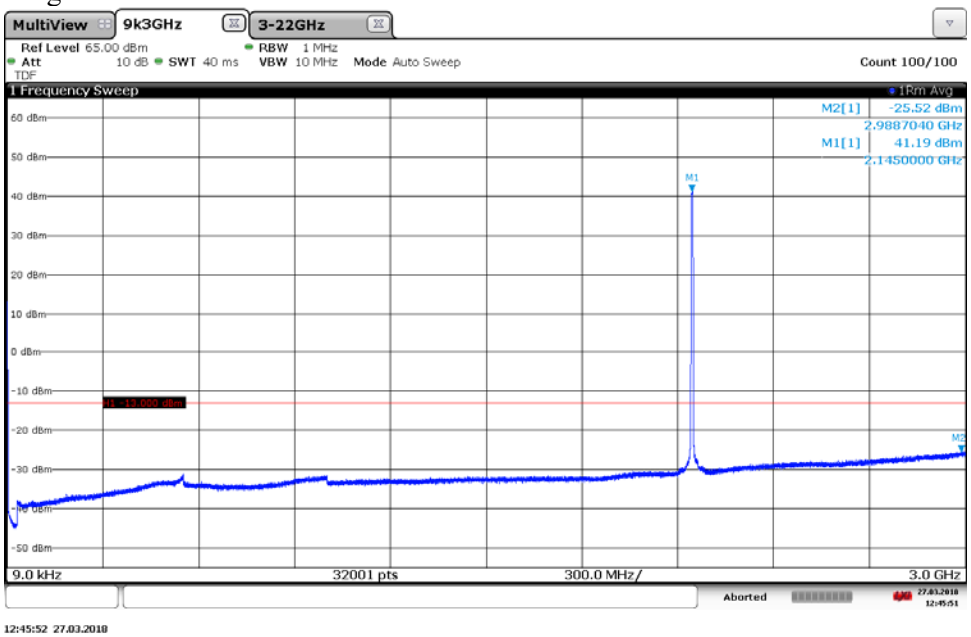


Diagram 21b:

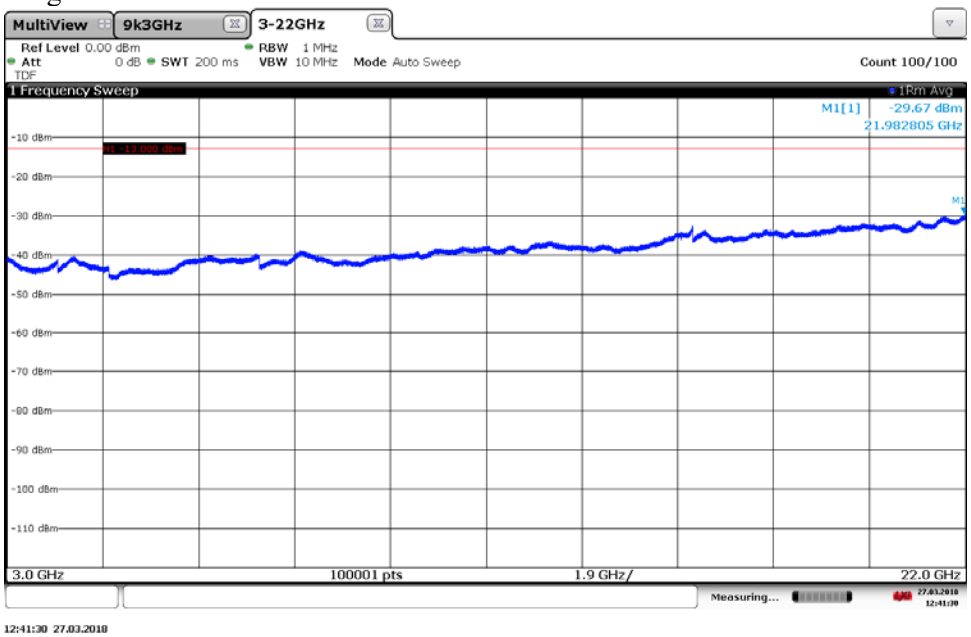


Diagram 22a:

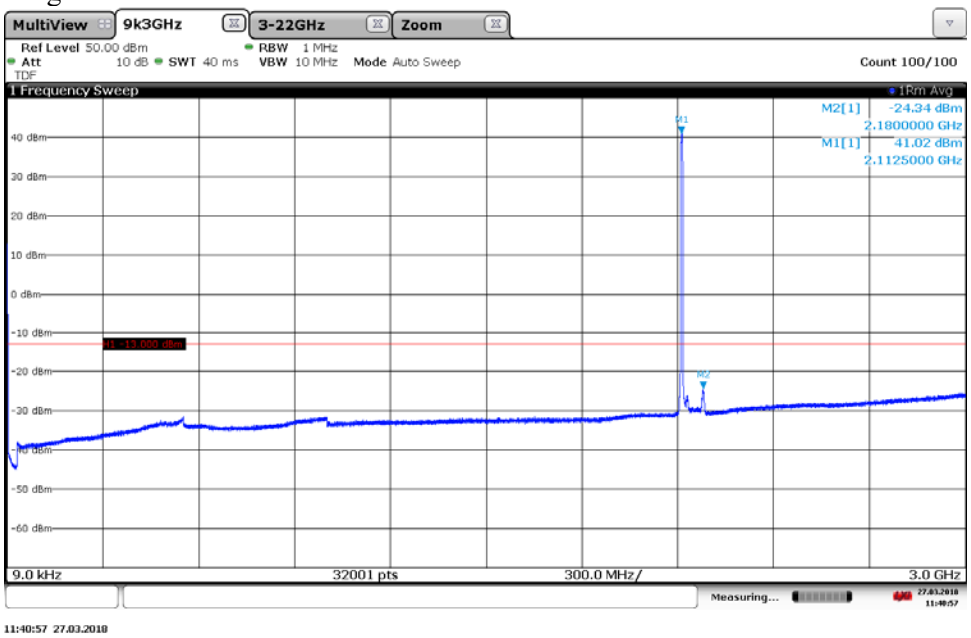


Diagram 22b:

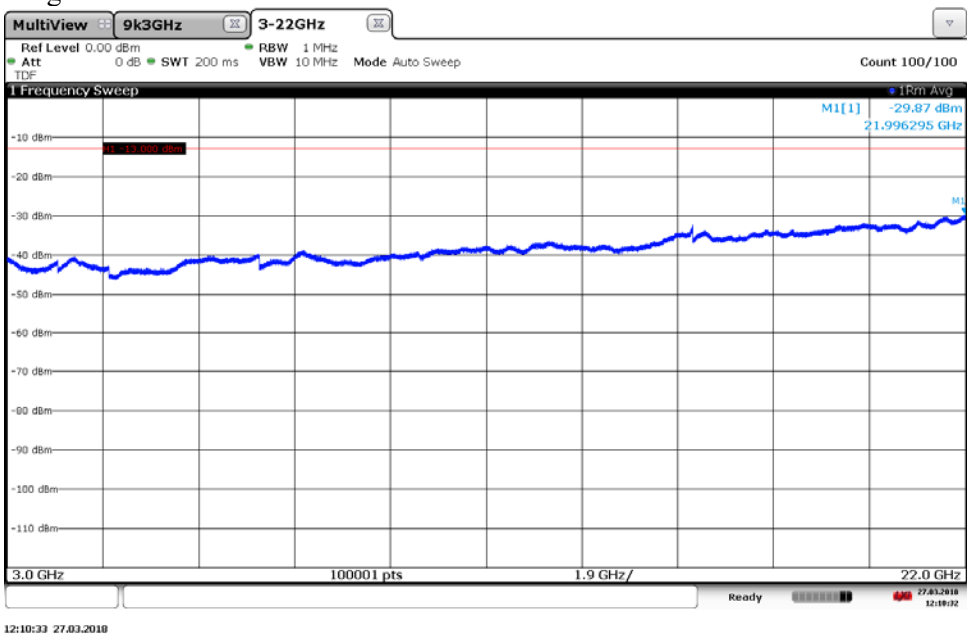


Diagram 23a:

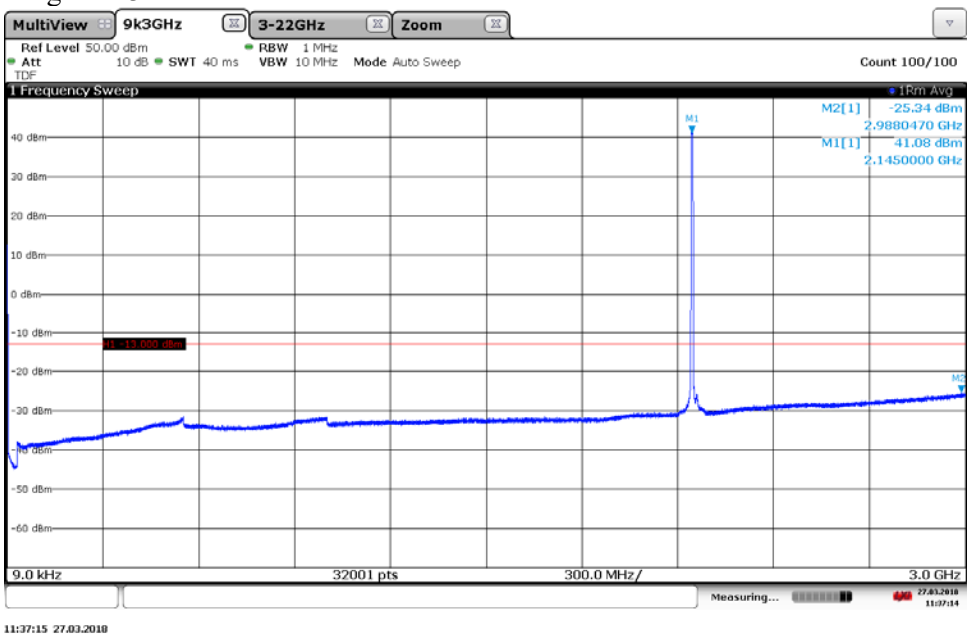


Diagram 23b:

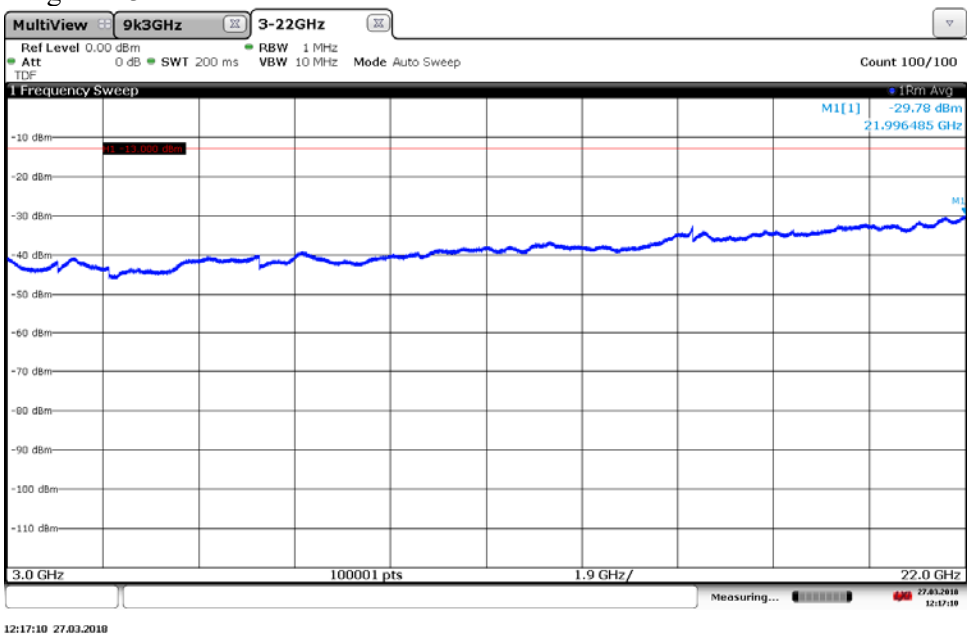


Diagram 24a:

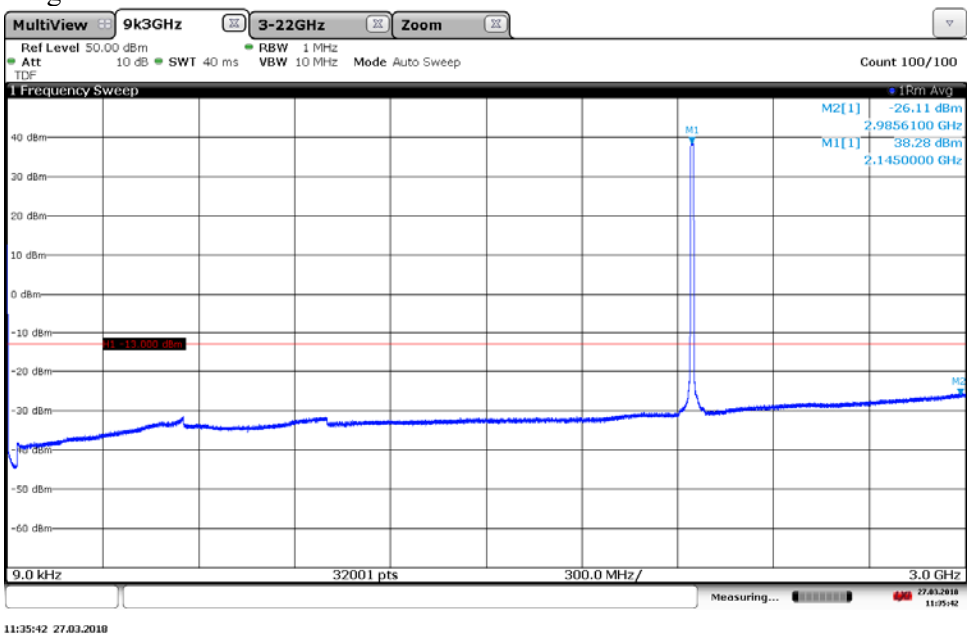


Diagram 24b:

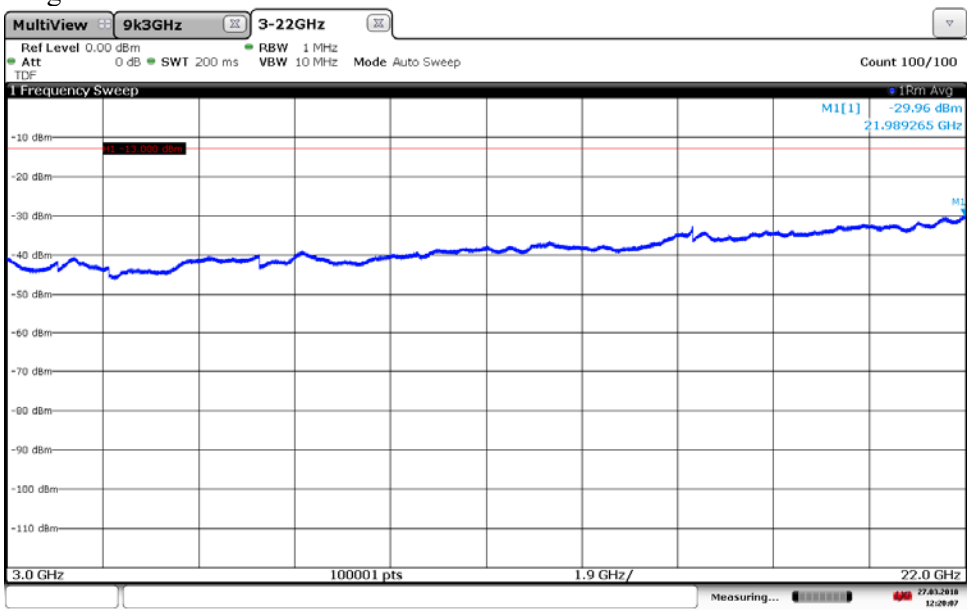


Diagram 25a:

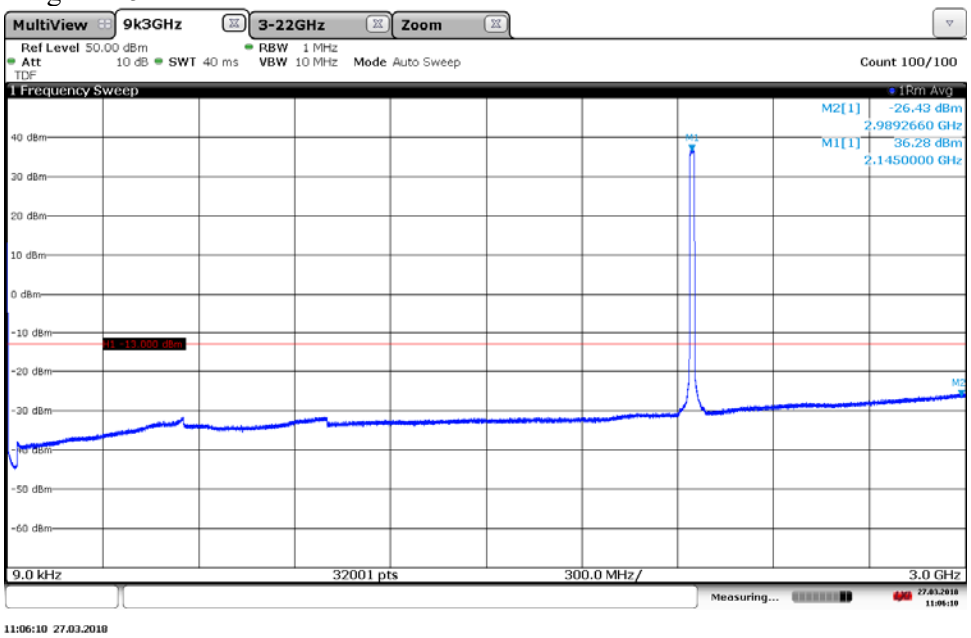


Diagram 25b:

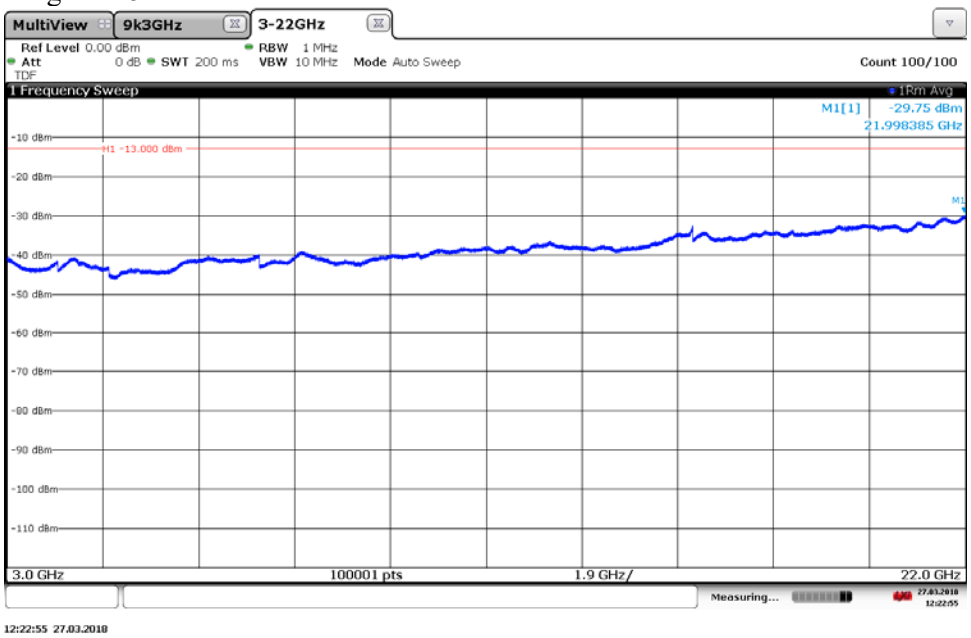


Diagram 26a:

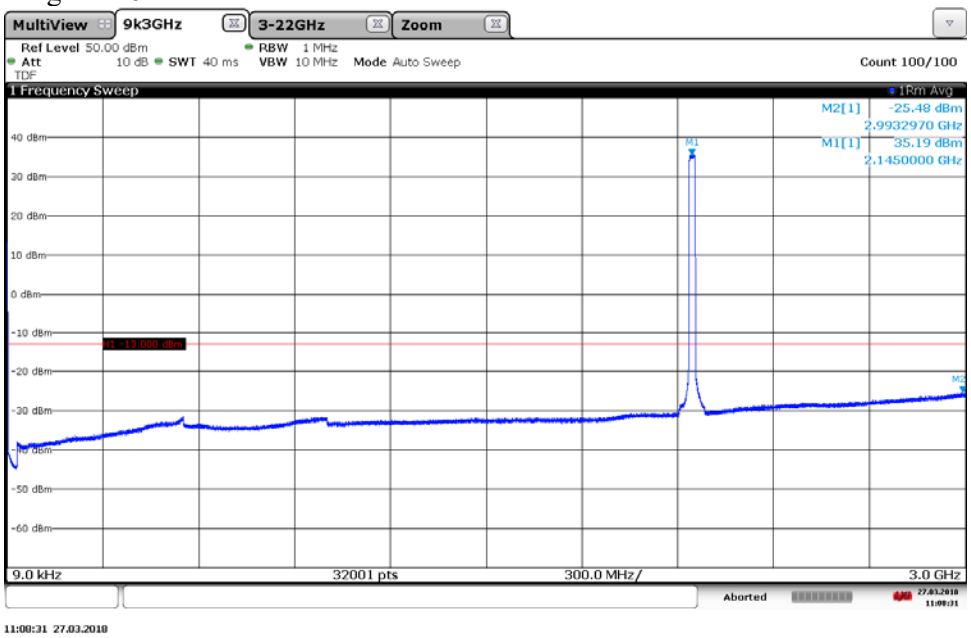


Diagram 26b:

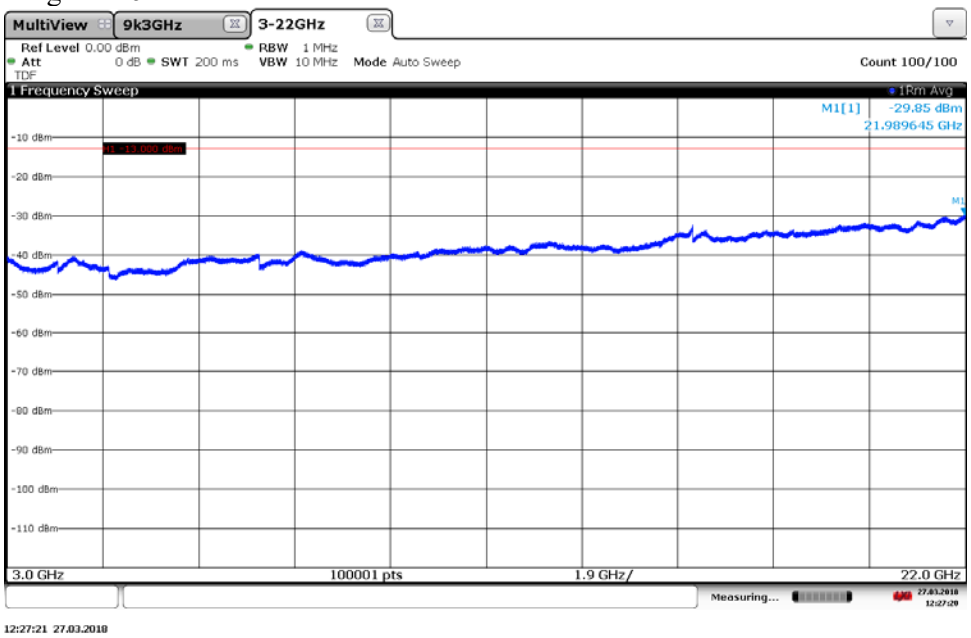


Diagram 27a:

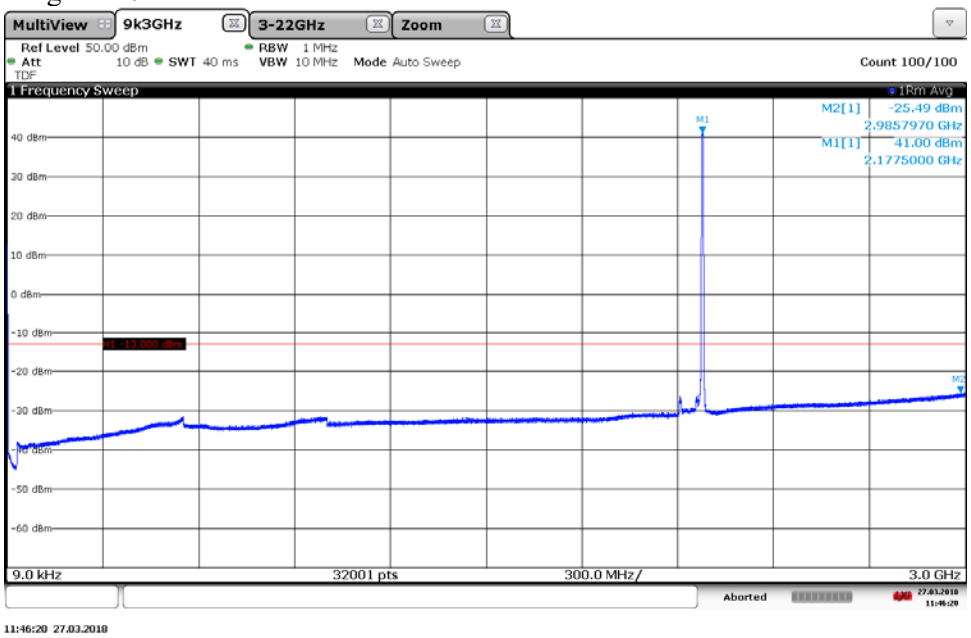


Diagram 27b:

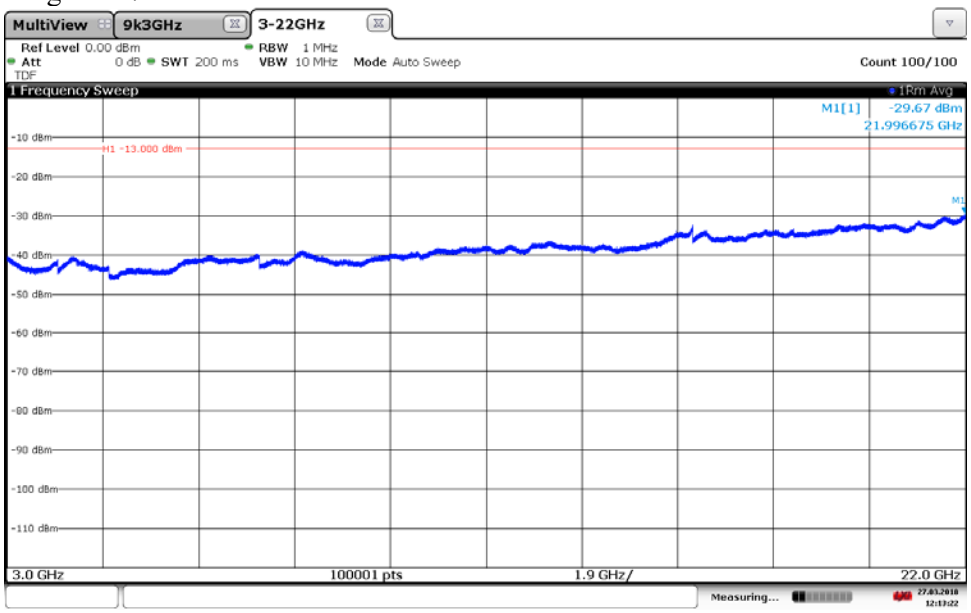


Diagram 28a:

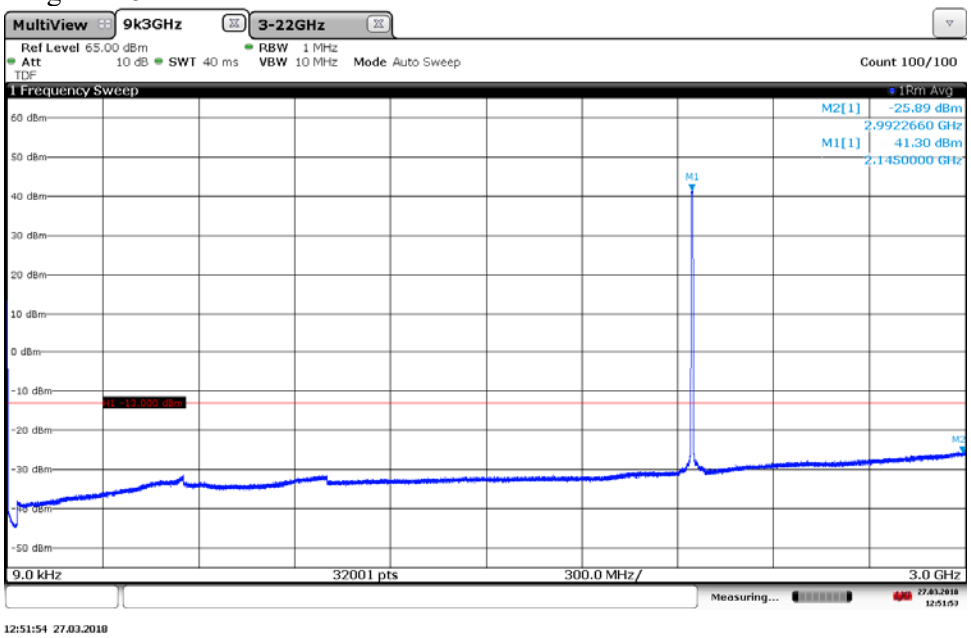


Diagram 28b:

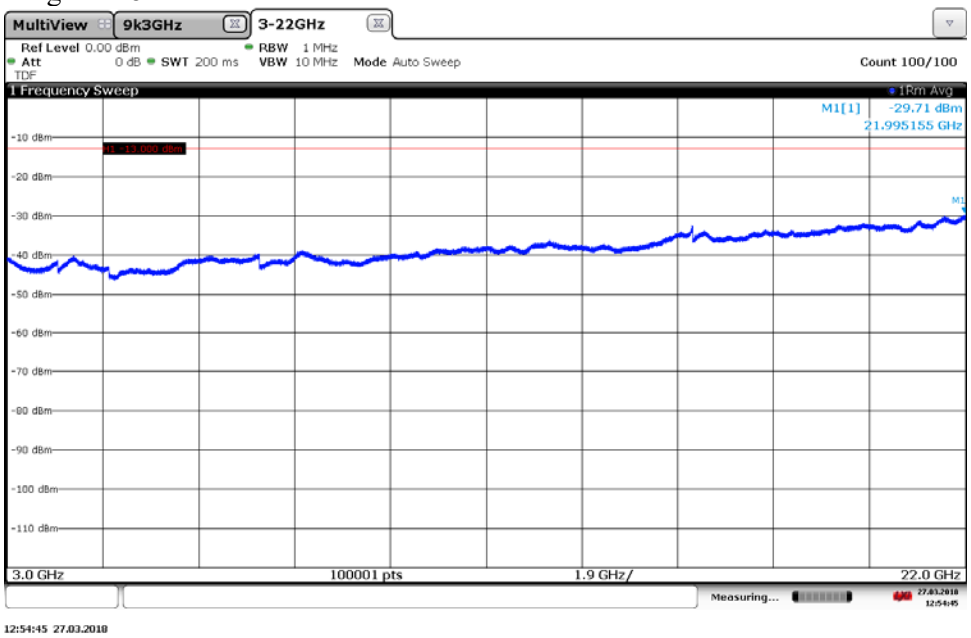


Diagram 29a:

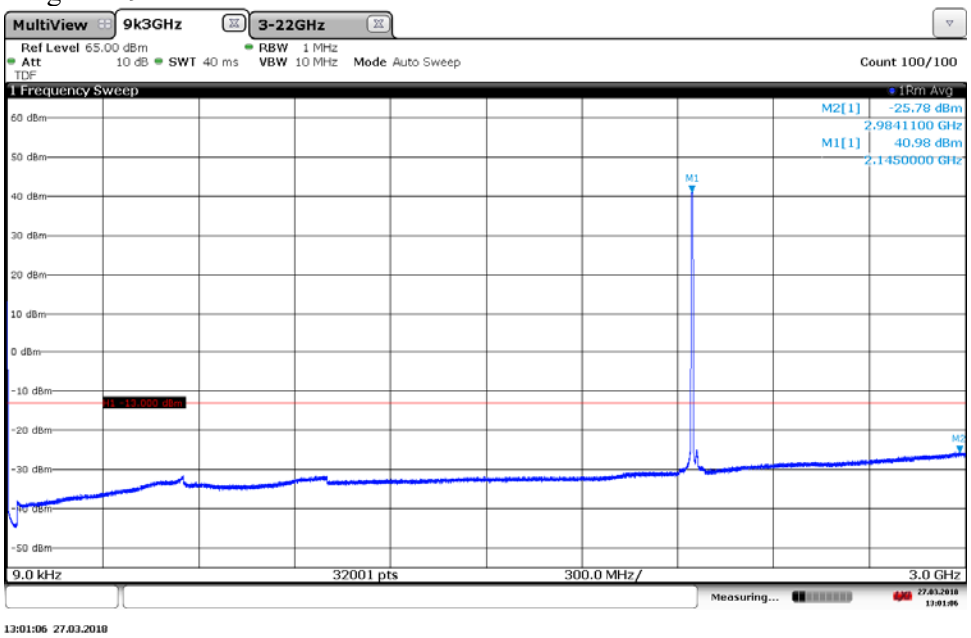


Diagram 29b:

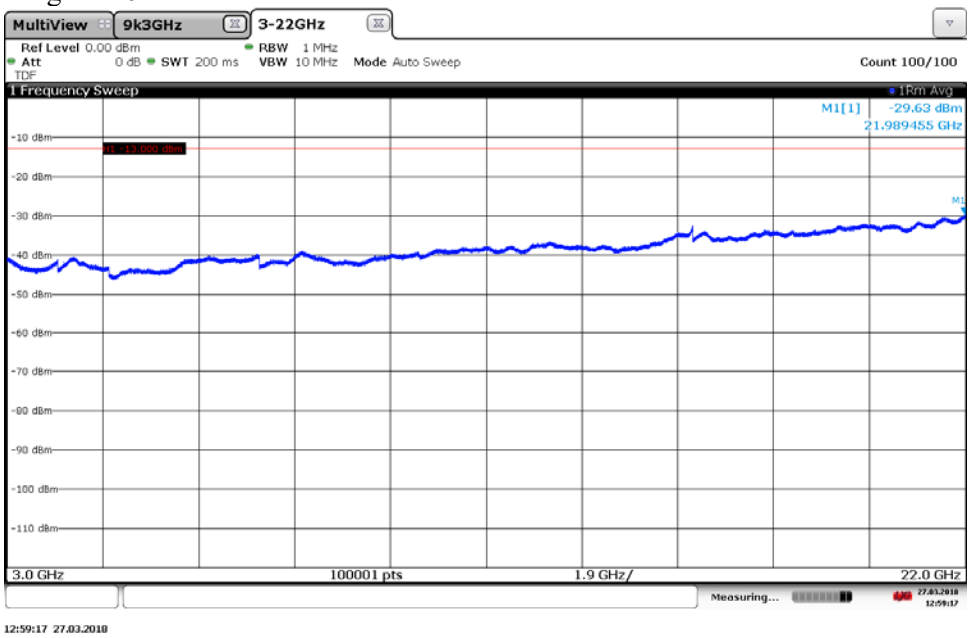


Diagram 30a:

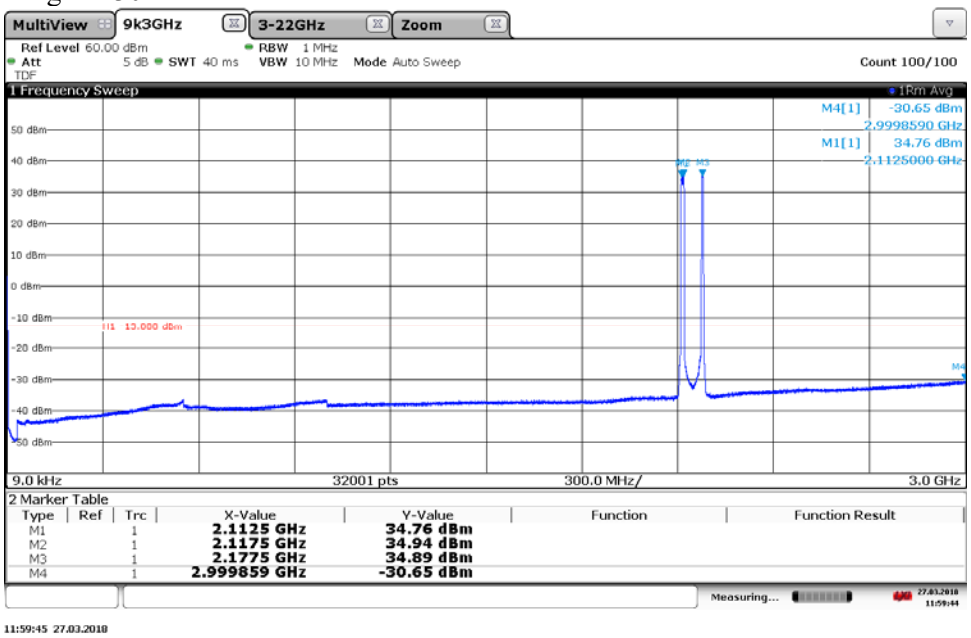


Diagram 30b:

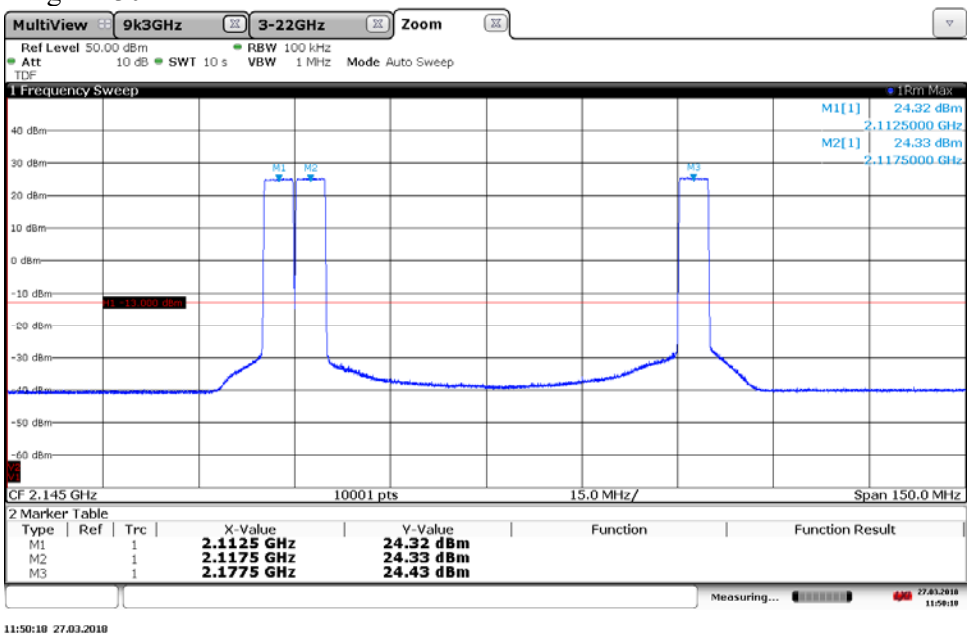


Diagram 30c:

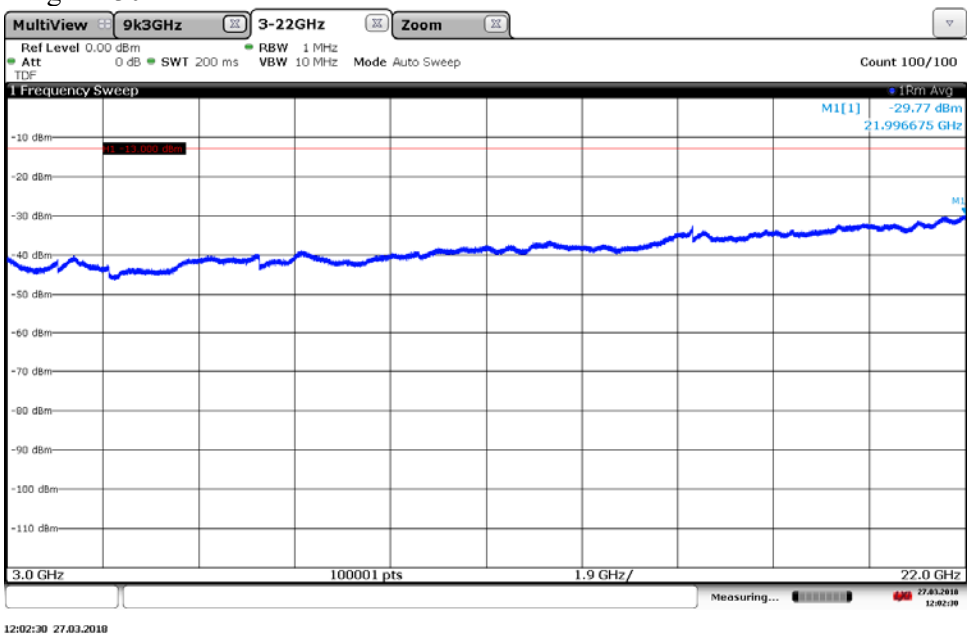

MultiView
9k3GHz
3-22GHz
Zoom
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms
RBW 1 MHz
VBW 10 MHz
Mode Auto Sweep
Count 100/100
TDF
1 Frequency Sweep
1Rm Avg
M1[1] -29.77 dBm
21.996675 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
-100 dBm
-110 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
12:02:30 27.03.2018

Diagram 31a:

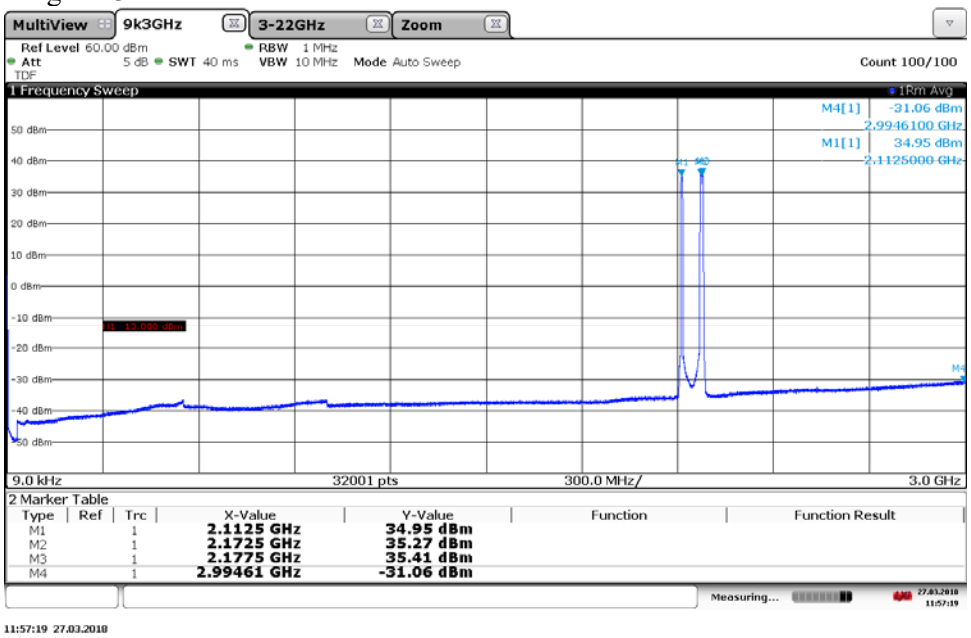


Diagram 31b:

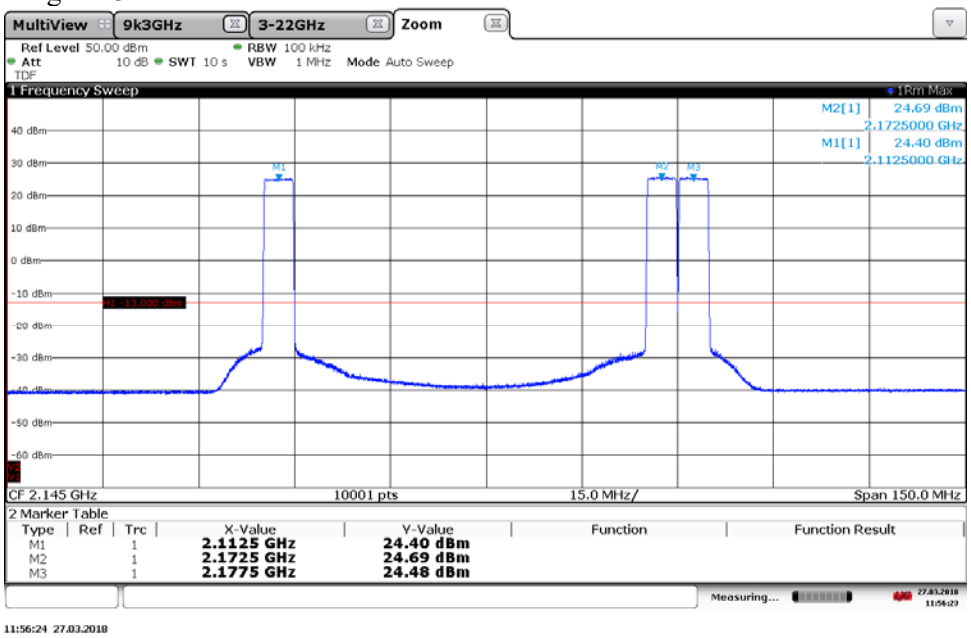


Diagram 31c:

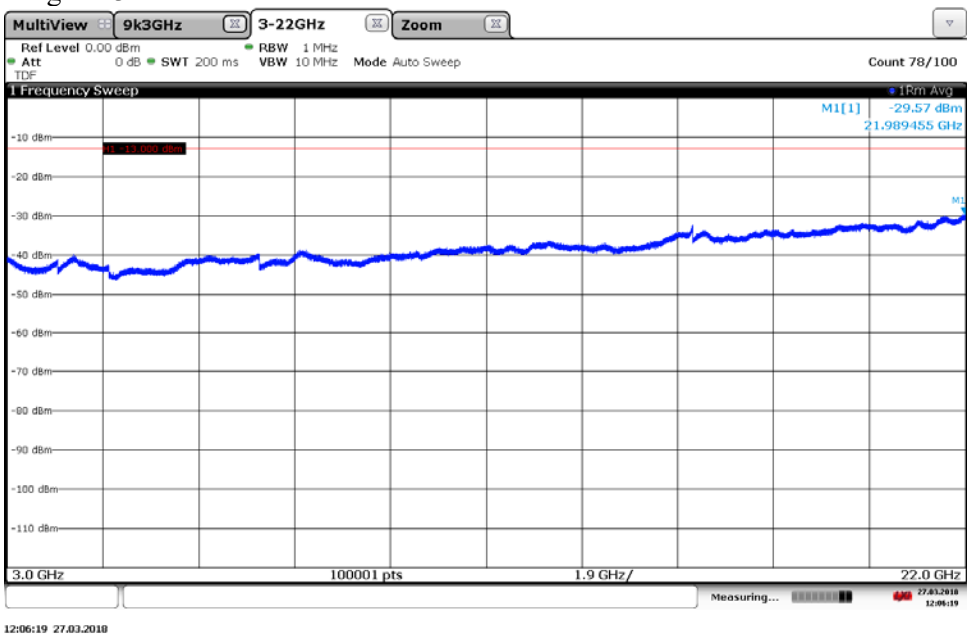

MultiView
9k3GHz
3-22GHz
Zoom
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms
RBW 1 MHz
VBW 10 MHz
Mode Auto Sweep
Count 78/100
TDF
1 Frequency Sweep
1Rm Avg
M1[1] -29.57 dBm
21.989455 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
-100 dBm
-110 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
12:06:19 27.03.2018

Diagram 32a:

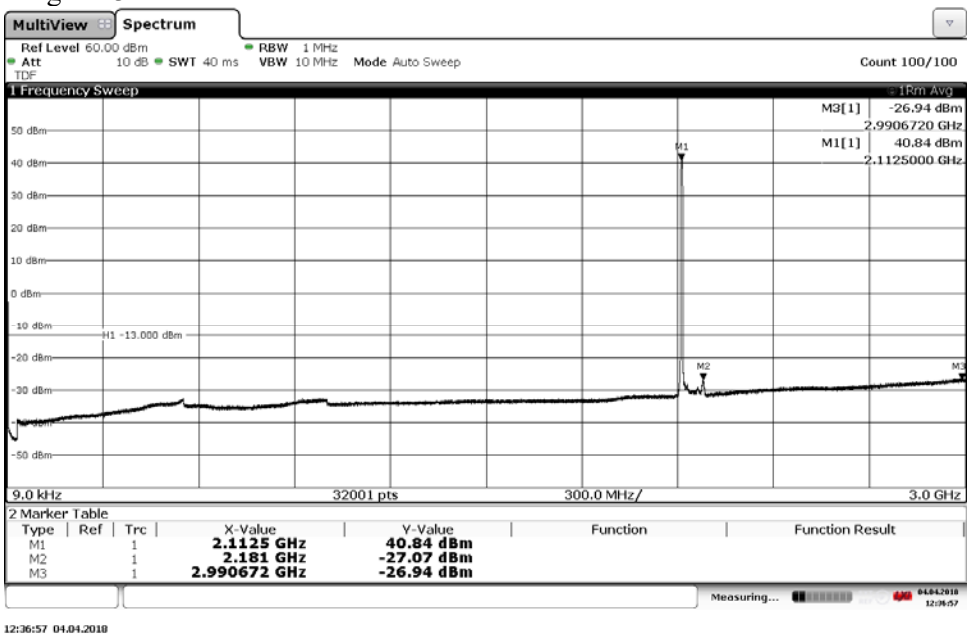


Diagram 32b:

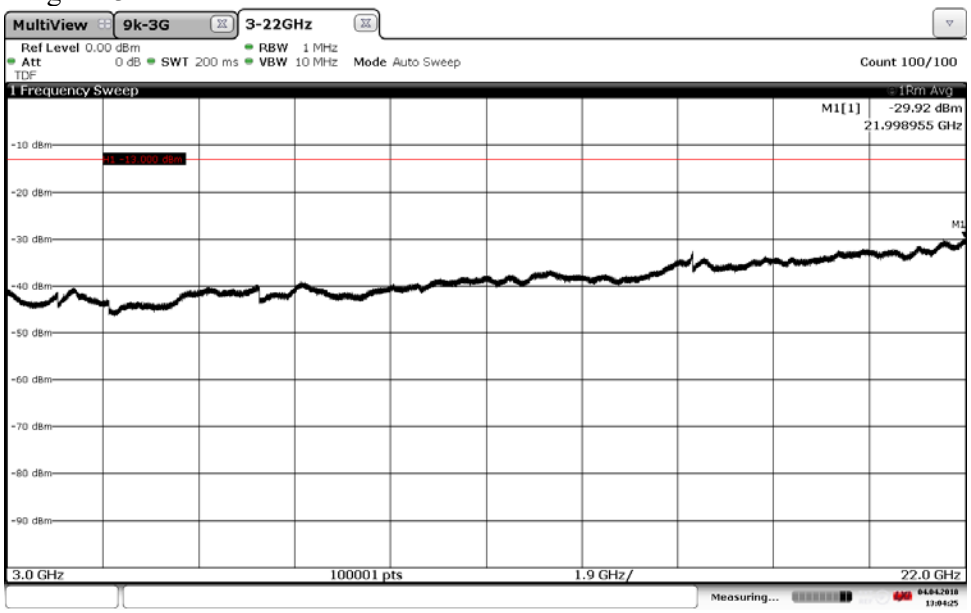


Diagram 33a:

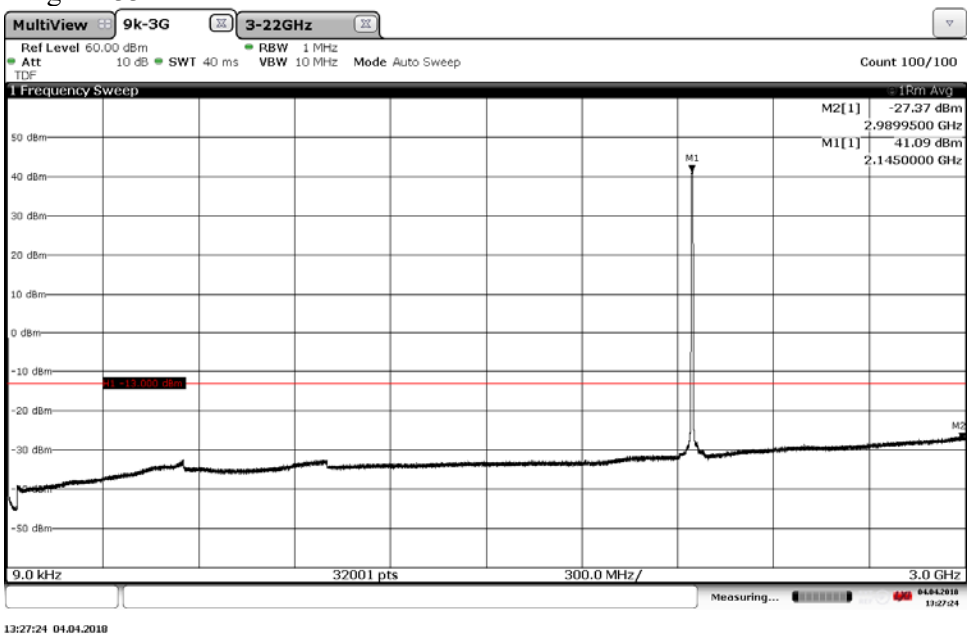


Diagram 33b:

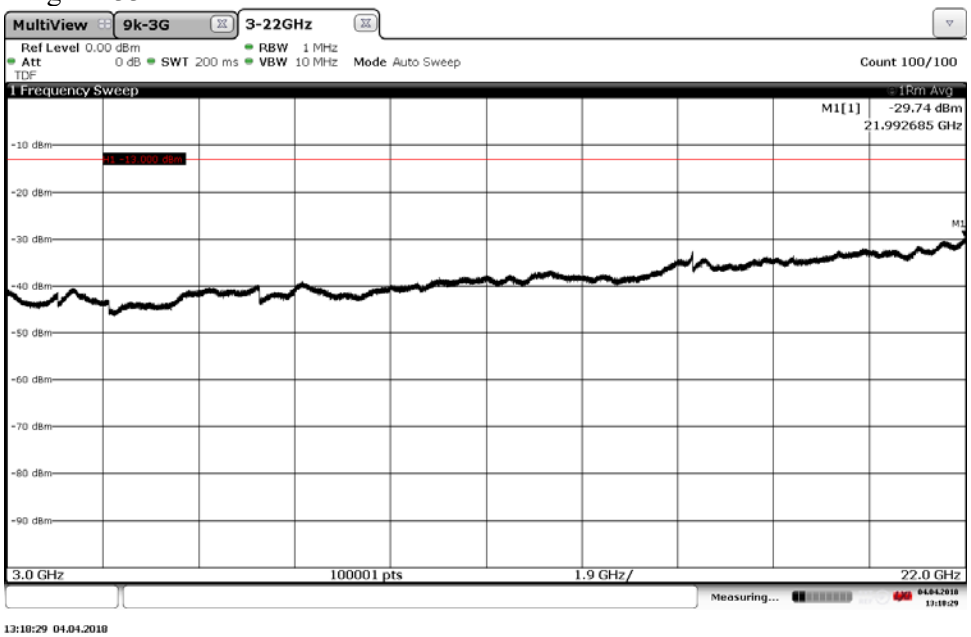


Diagram 34a:

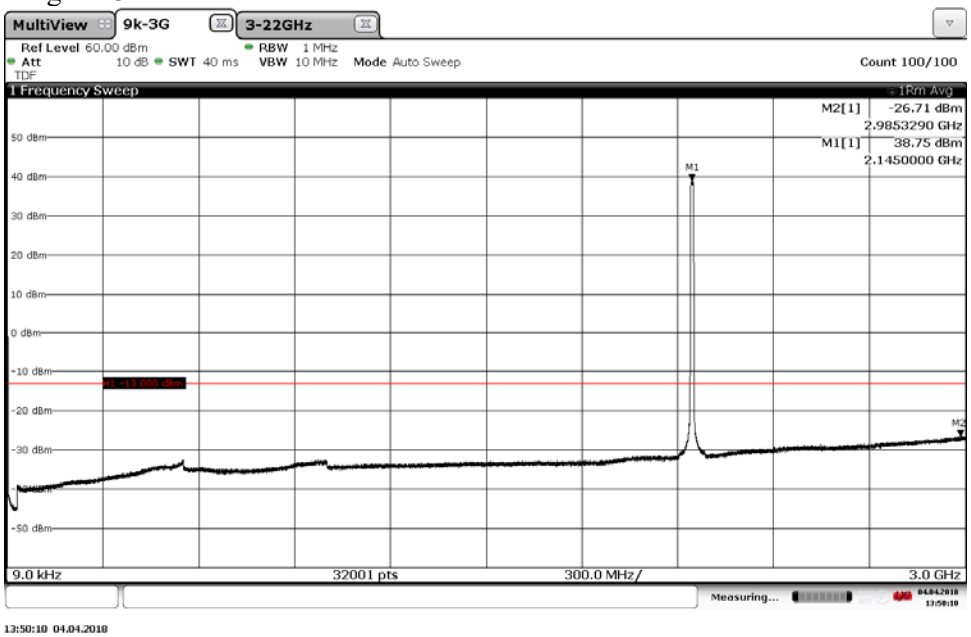


Diagram 34b:

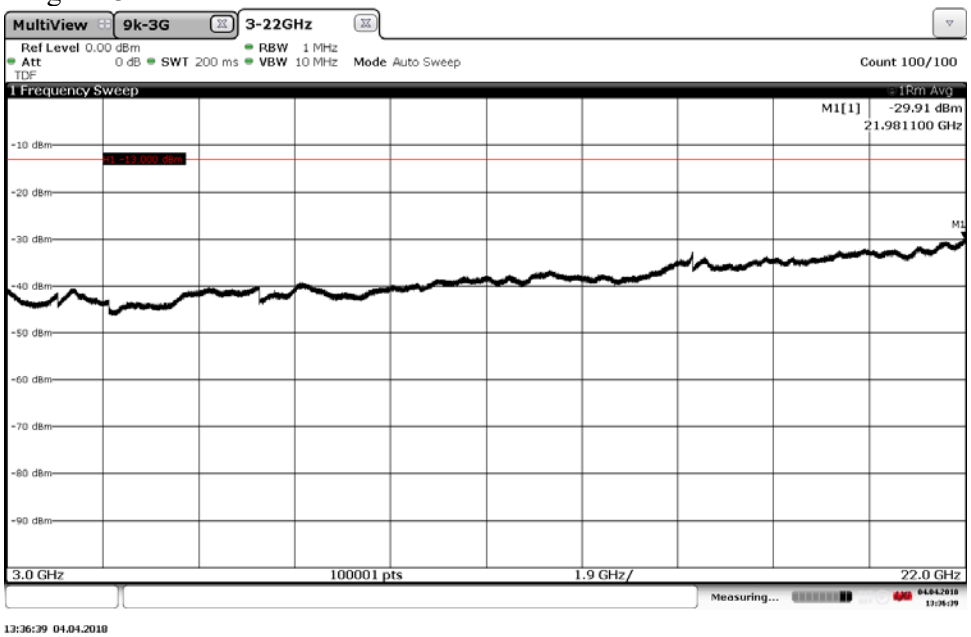


Diagram 35a:

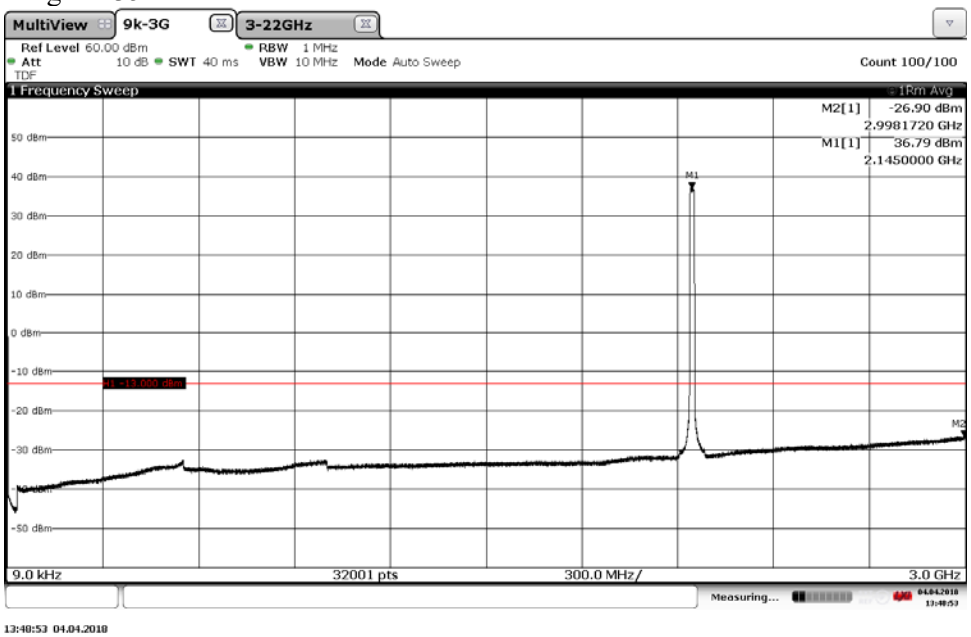


Diagram 35b:

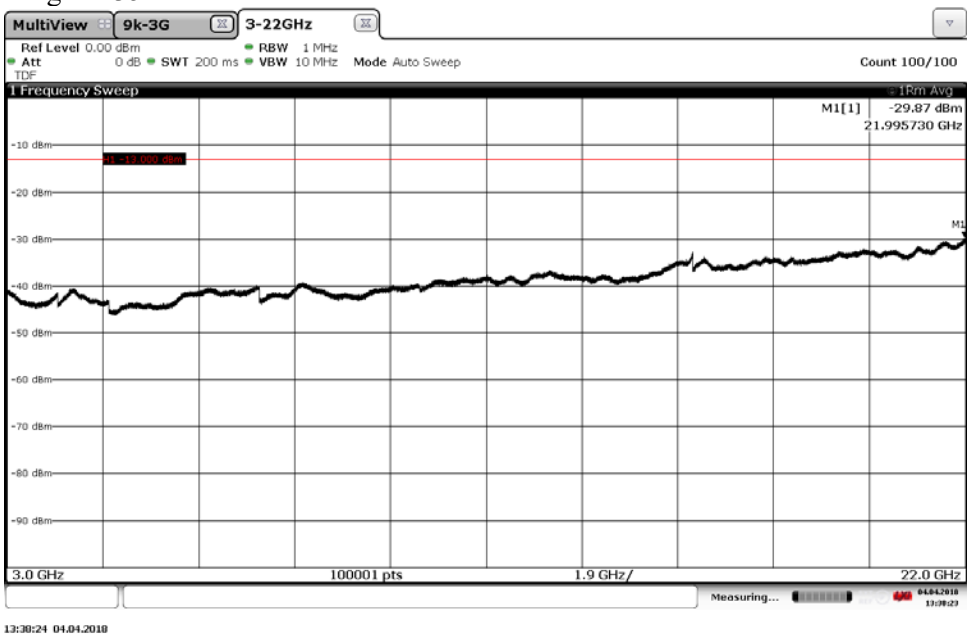


Diagram 36a:

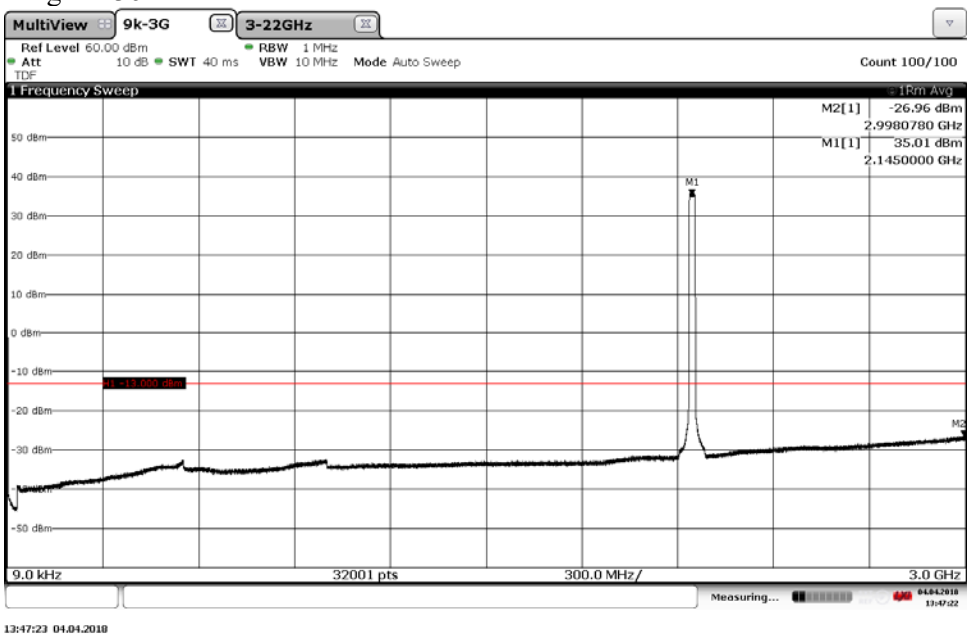


Diagram 36b:

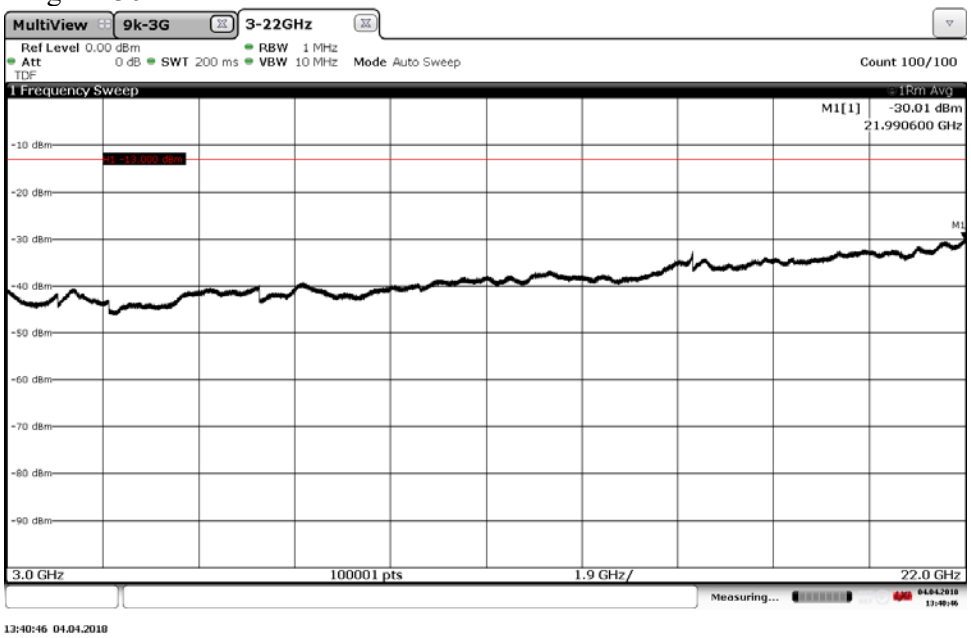


Diagram 37a:

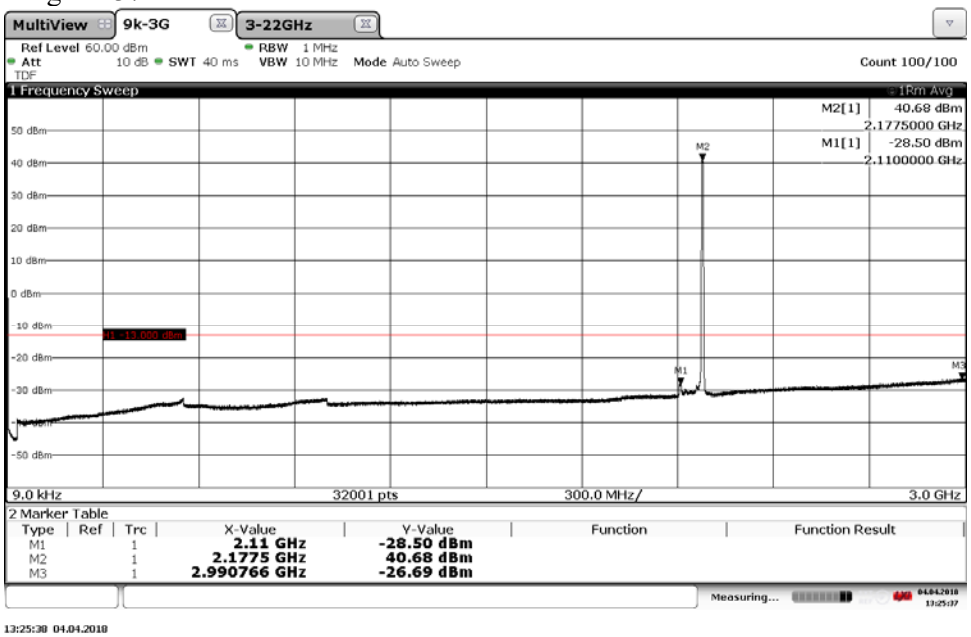


Diagram 37b:

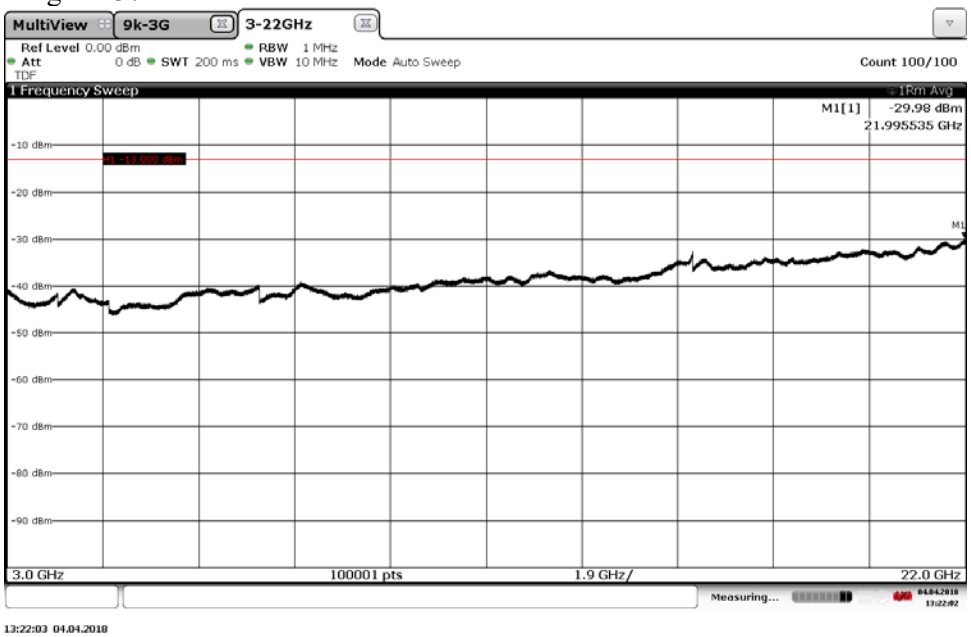


Diagram 38a:

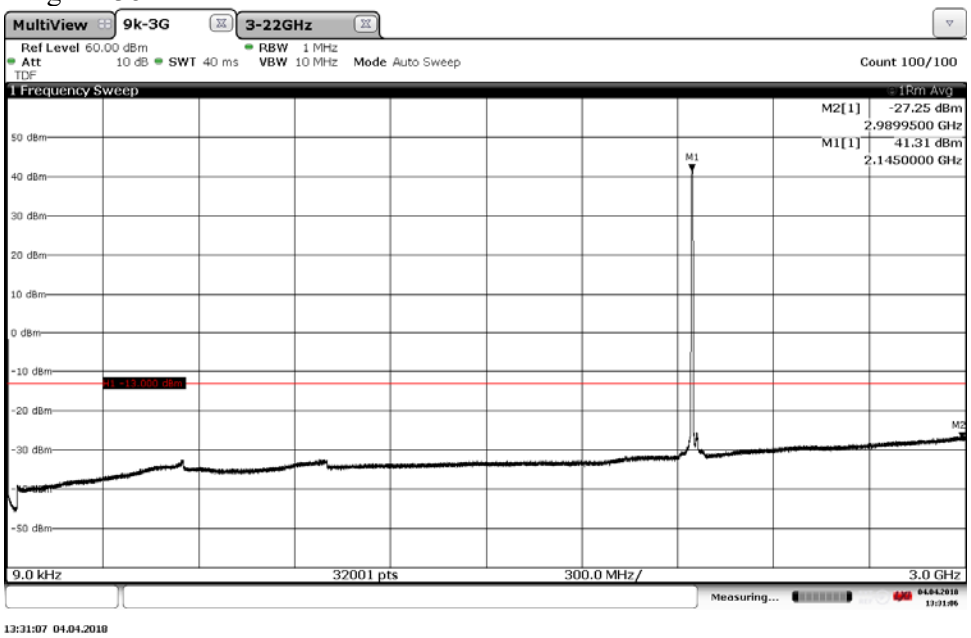


Diagram 38b:

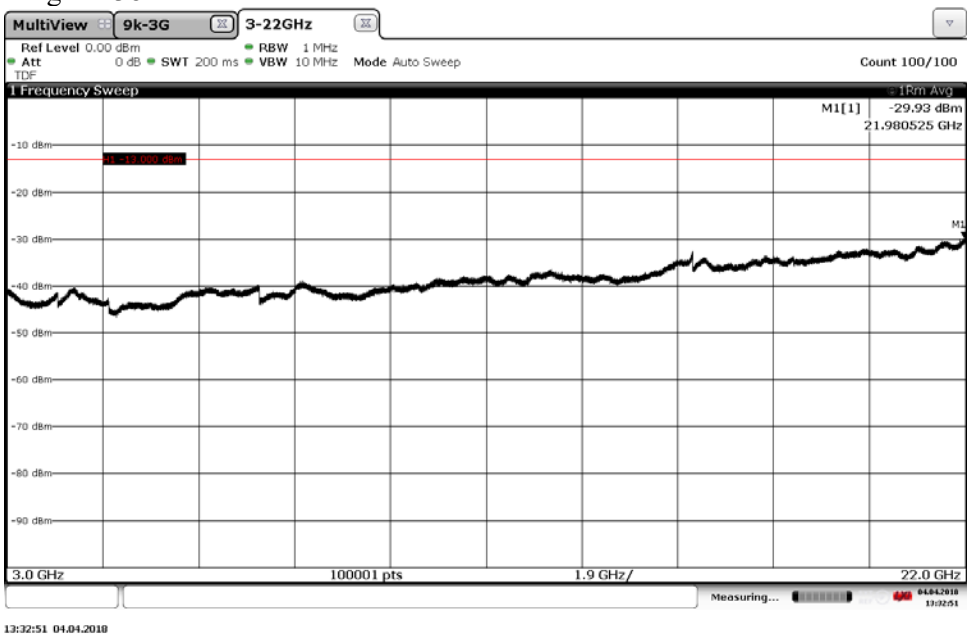


Diagram 39a:

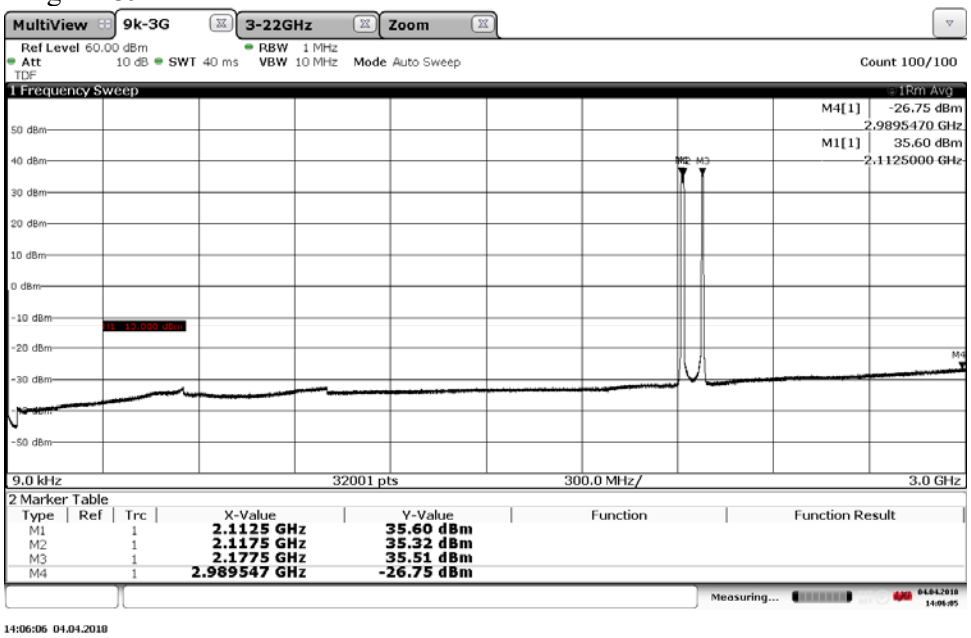


Diagram 39b:

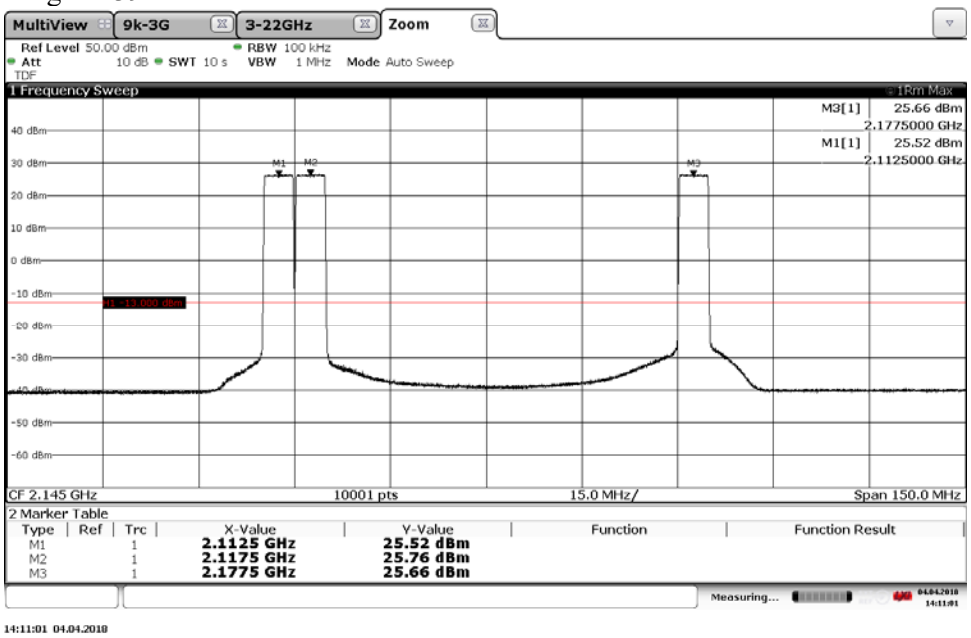


Diagram 39c:

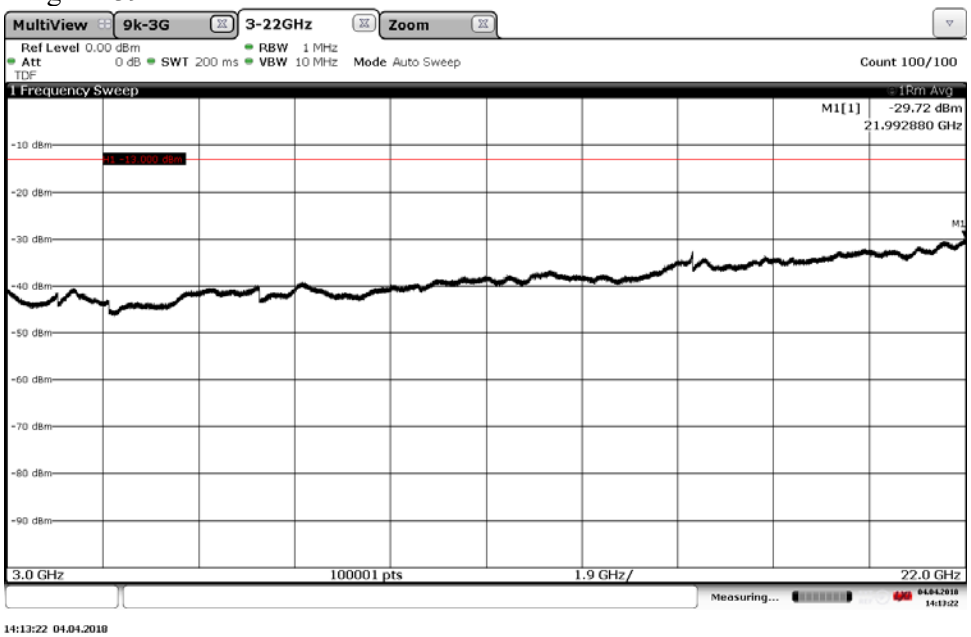

MultiView
9k-3G
3-22GHz
Zoom
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms VBW 10 MHz Mode Auto Sweep
RBW 1 MHz
TDF
Count 100/100
1 Frequency Sweep
1Rm Avg
M1[1] -29.72 dBm
21.992880 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
14:13:22 04.04.2018

Diagram 40a:

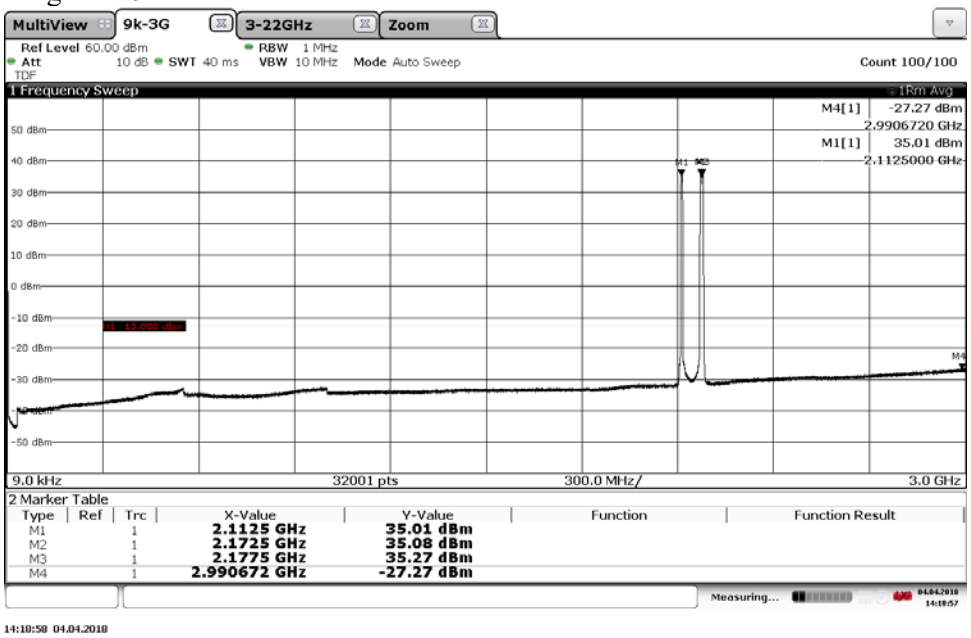


Diagram 40b:

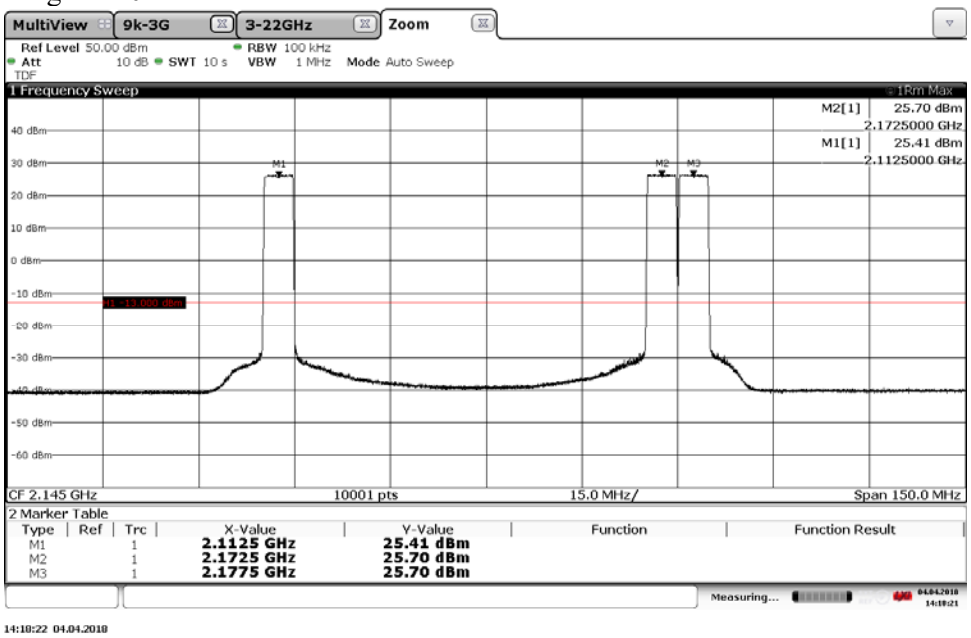
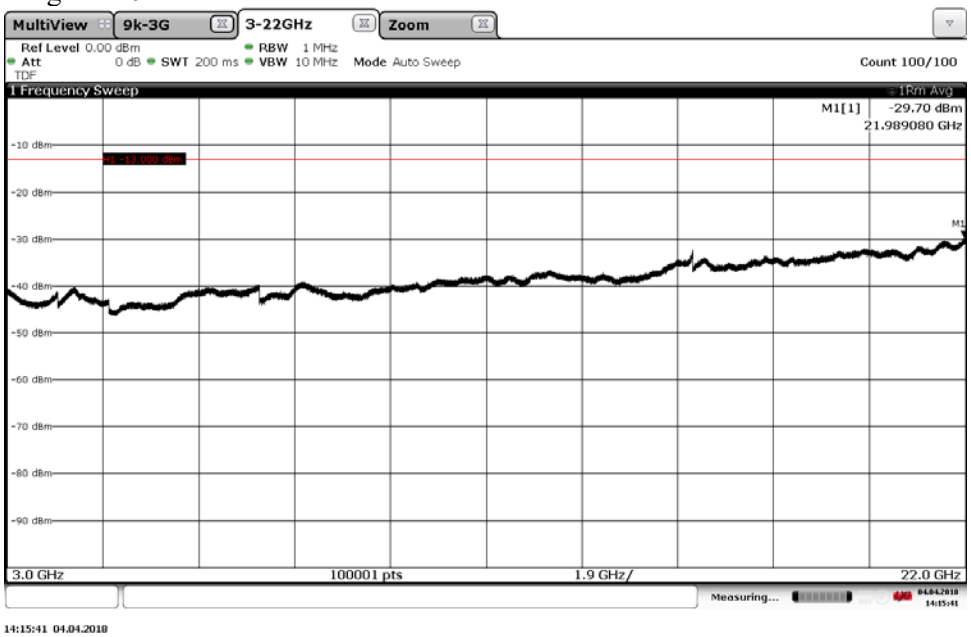


Diagram 40c:


MultiView
9k-3G
3-22GHz
Zoom
Ref Level 0.00 dBm
Att 0 dB SWT 200 ms VBW 10 MHz Mode Auto Sweep
RBW 1 MHz
TDF
Count 100/100
1 Frequency Sweep
1Rm Avg
M1[1] -29.70 dBm
21.989080 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
3.0 GHz
100001 pts
1.9 GHz/
22.0 GHz
Measuring...
14:15:41 04.04.2018

Field strength of spurious radiation measurements according to 47 CFR §2.1053

Date	Temperature	Humidity
2018-03-20	22 °C ± 3 °C	20 % ± 5 %
2018-03-21	21 °C ± 3 °C	24 % ± 5 %
2018-03-22	21 °C ± 3 °C	25 % ± 5 %
2018-03-23	21 °C ± 3 °C	27 % ± 5 %

The test site conform to the site validation criterion specified in ANSI C63.4 2014. The test site complies with RSS-Gen, Industry Canada file no. 3482A-1.

The measurements were performed with both horizontal and vertical polarization of the antenna. The antenna distance and test object height in the different frequency ranges can been seen below.

The antenna distance was 3 m in the frequency range 30 MHz – 18 GHz and 1 m in the frequency range 18 GHz – 26.5 GHz.

The EUT was placed 0.8 m above reference ground plane in frequency range 30 MHz – 1 GHz and 1.5 m above reference ground plane in frequency range 1 GHz – 26.5 GHz.

The measurement was performed with a RBW of 1 MHz.

A propagation loss in free space was calculated. The used formula was $\gamma = 20\log\left(\frac{4\pi D}{\lambda}\right)$, γ is the propagation loss and D is the antenna distance.

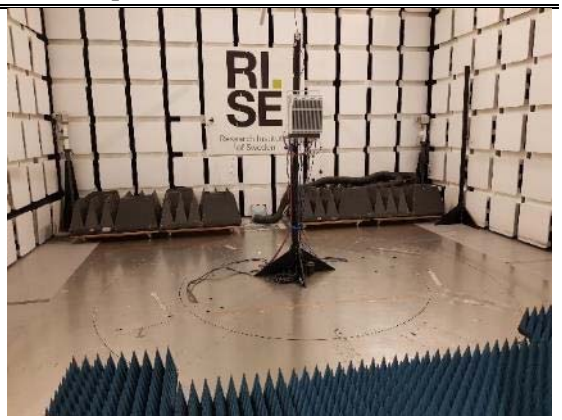
The measurement procedure was as the following:

1. A pre-measurement is performed with peak detector. For measurement < 1 GHz the test object was measured in eight directions with the antenna at three heights, 1.0 m, 1.5 m and 2.0 m. For measurements > 1 GHz the test object was measured in seventeen directions with the antenna height 1.0 m and 1.5 m.
2. Spurious radiation on frequencies closer than 20 dB to the limit in the pre-measurement is scanned 0-360 degrees and the antenna is scanned 1- 4 m for maximum response. The emission is then measured with the RMS detector and the RMS value is reported. Frequencies closer than 10 dB to the limit when measured with the RMS detector were measured with the substitution method according to ANSI 63.26.

The test set-up during the spurious radiation measurements is shown in the pictures below:

Test setup 30-1000 MHz:

Test setup 1-18 GHz:



Test setup 18-26.5 GHz:

Measurement equipment

Measurement equipment	RISE number
Test site Tesla	503 881
R&S ESU 40	901 385
Control computer with R&S software EMC32 version 10.20.01	BX62351
High pass filter 3-18 GHz	504 200
Flann Standard Gain Horn 20240-20	503 674
ETS Lindgren BiConiLog Antenna 3142E	BX61914
EMCO Horn Antenna 3115	502 175
µComp Nordic, Low Noise Amplifier	901 545
Miteq, Low Noise Amplifier	503 278
Temperature and humidity meter, Testo 625	504 188

Results

representing worst case:
Symbolic name T_5, TX top frequency, BW 5 MHz

Diagram 1a-d: Band 2 4x 40 W + Band 66A 4x 60 W configuration.
Diagram 2a-d: Band 2 2x 60 W + Band 66A 2x 80 W configuration.

Frequency (MHz)	Spurious emission level (dBm)	
	Vertical	Horizontal
30-26500	All emission > 20 dB below limit	All emission > 20 dB below limit

Measurement uncertainty: 3.1 dB

Limits

CFR 47 §24.238 and §27.53(h)

Outside a licensee's frequency band(s) of operation the power of any emission shall be attenuated below the transmitter power (P) by at least 43 + 10 log (P) dB. resulting in a limit of -13 dBm.

Complies?	Yes

Diagram 1a:

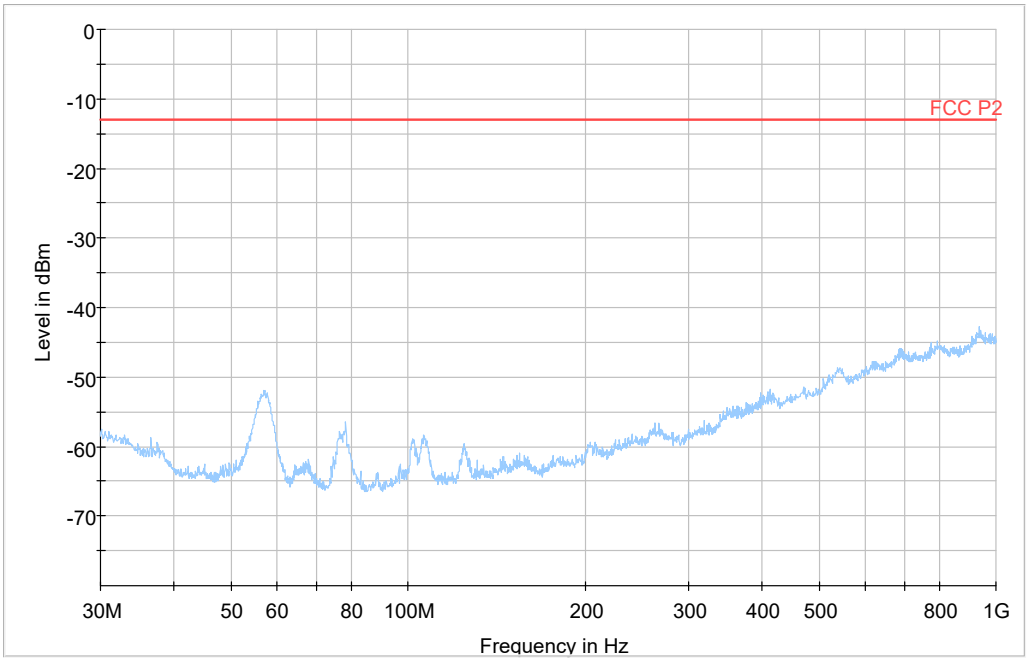
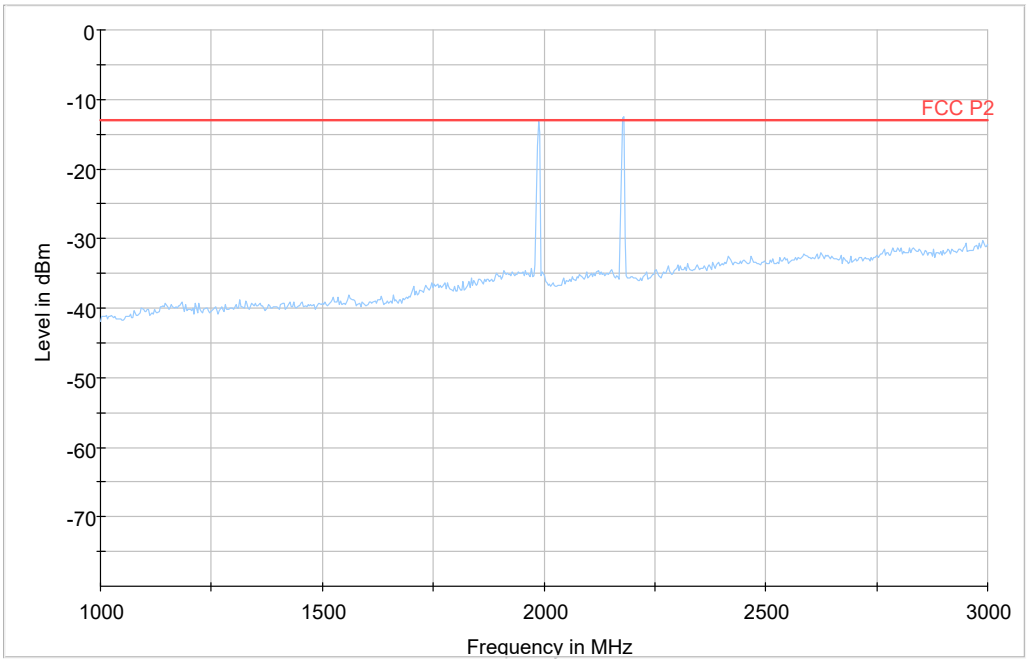


Diagram 1b:



Note: The emissions at 1987.5 MHz and 2177.5 MHz are the carrier frequency and shall be ignored in the context.

Diagram 1c:

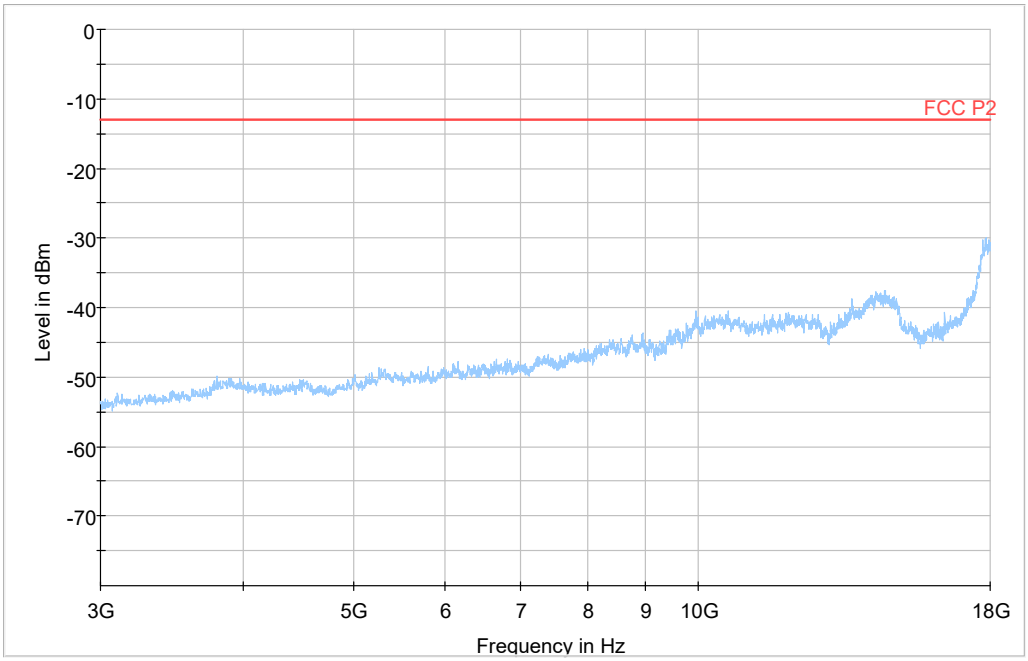


Diagram 1d:

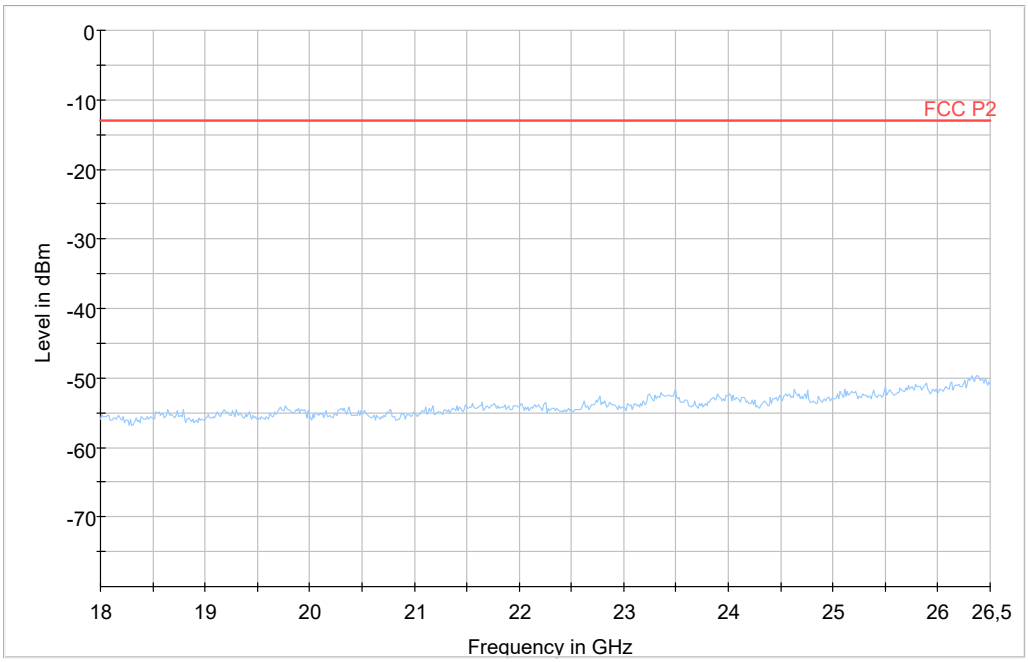


Diagram 2a:

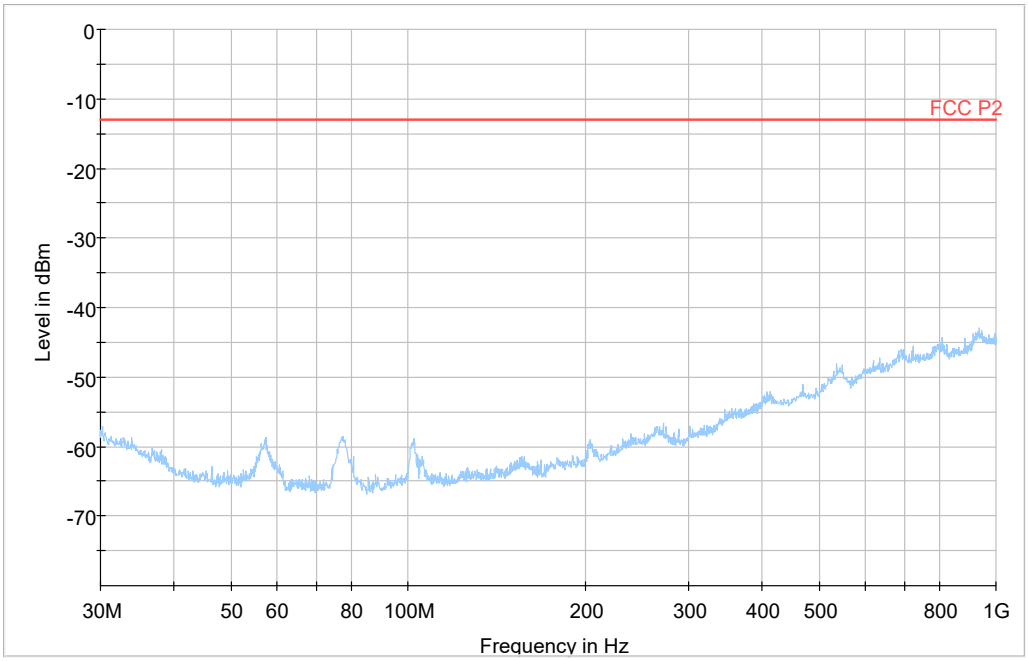
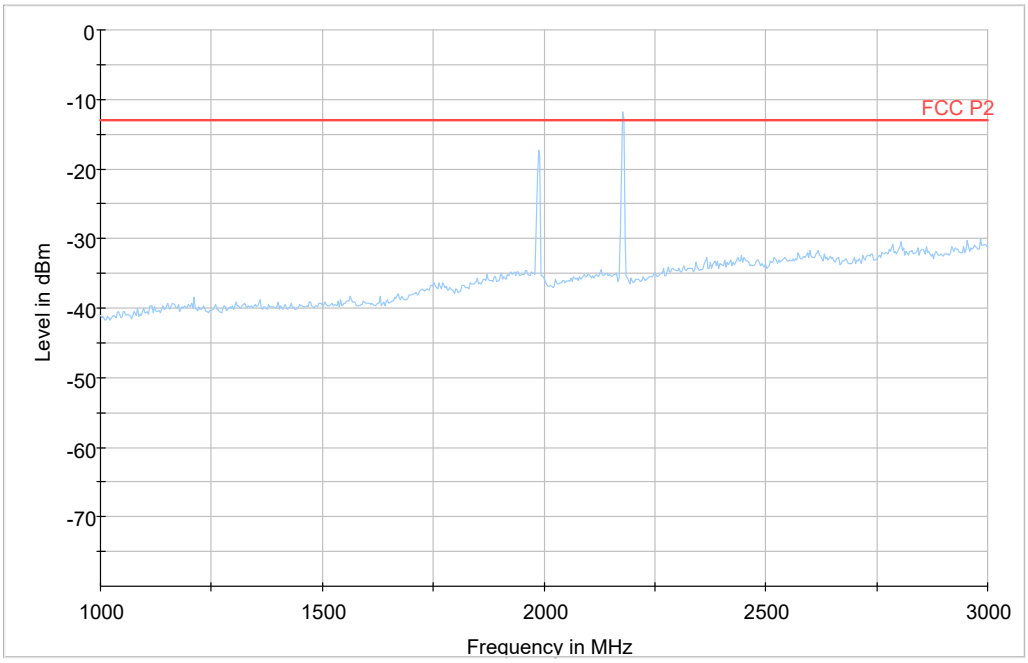


Diagram 2b:



Note: The emission at 1987.5 MHz and 2177.5 is the carrier frequency and shall be ignored in the context.

Diagram 2c:

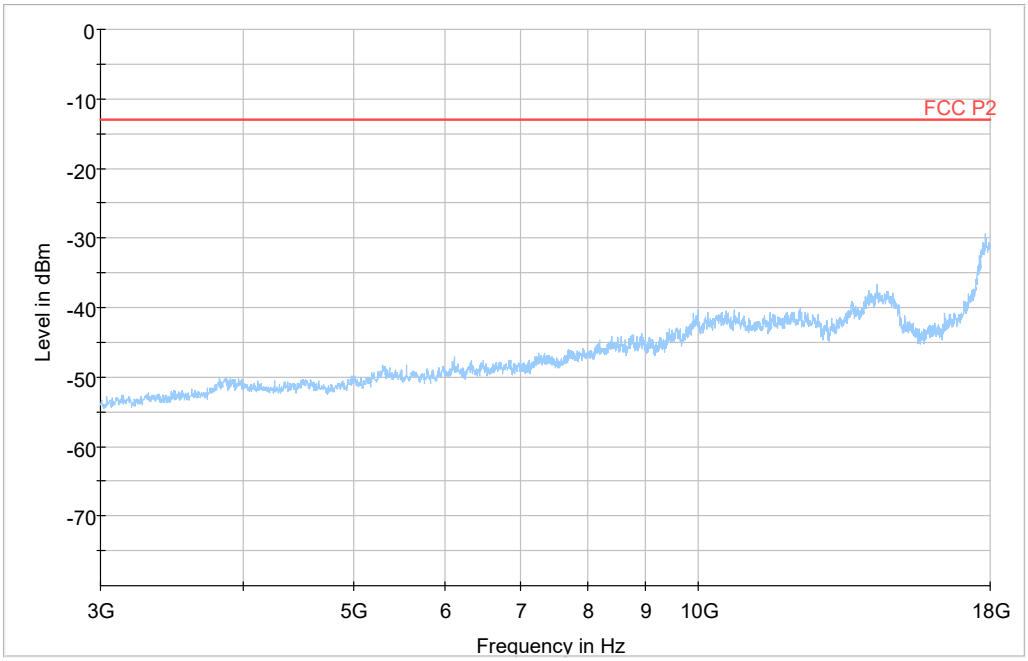
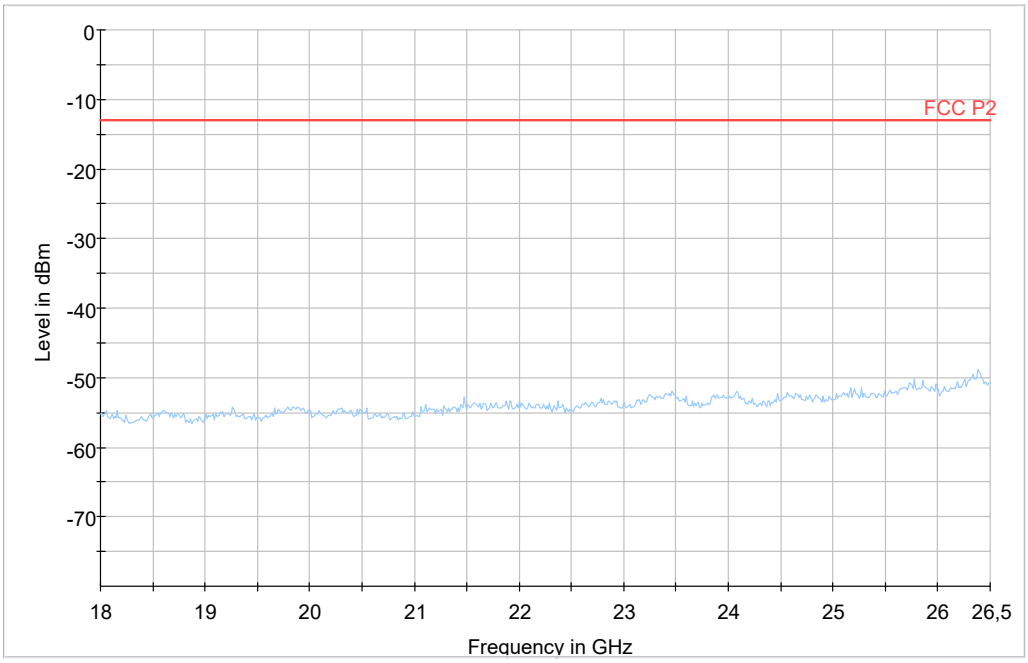


Diagram 2d:



Frequency stability measurements according to CFR 47 §24.235 and §27.54, 2.1055

Date	Temperature (test equipment)	Humidity (test equipment)
2018-03-13	23 °C ± 3 °C	16 % ± 5 %
2018-03-14	22 °C ± 3 °C	13 % ± 5 %
2018-03-15	22 °C ± 3 °C	8 % ± 5 %
2018-04-16	22 °C ± 3 °C	32 % ± 5 %

Test set-up and procedure

The measurement was made per 3GPP TS 36.141. The output was connected to a spectrum analyser. The spectrum analyser was connected to an external 10 MHz reference standard during the measurements.

Measurement equipment	RISE number
Rohde & Schwarz signal analyzer FSQ 40	504 143
Directional coupler	901 496
RF attenuator	902 282
Temperature Chamber	503 360
Testo 635, temperature and humidity meter	504 203
Multimeter Fluke 87	502 190

Results

Nominal transmitter frequency was for Band 2 1960 MHz (M) with a bandwidth of 5 MHz and rated output power level at connector RF A at 46 dBm.
Nominal transmitter frequency was for Band 66 2145 MHz (M) with a bandwidth of 5 MHz and rated output power level at connector RF E at 46 dBm.

Test conditions		Frequency error (Hz) Band 2	Frequency error (Hz) Band 66A
Supply voltage DC (V)	Temp. (°C)		
40.8	+20	12	11
55.2	+20	12	13
48	+20	13	10
48	+30	26	18
48	+40	8	8
48	+50	8	49
48	+10	9	10
48	0	7	8
48	-10	28	25
48	-20	7	8
48	-30	34	26
Maximum freq. error (Hz)		34	49
Measurement uncertainty		$< \pm 1 \times 10^{-7}$	

Band 2
Rated output power level at connector RF A (maximum): 47.8 dBm

Test conditions			Frequency margin to band edge at -16 dBm			
Supply voltage DC [V]	Temp [°C].	Carrier Bandwidth [MHz]	Test frequency Symbolic name Bottom		Test frequency Symbolic name Top	
			fL [MHz]	Offset to lower band edge (1930 MHz) [kHz]	fH [MHz]	Offset to upper band edge (1990 MHz) [kHz]
-48.0	+20	5	1932.021	21	1989.980	20
-48.0	+20	20	1930.120	120	1989.873	127

Band 66A
Rated output power level at connector RF E (maximum): 49 dBm

Test conditions			Frequency margin to band edge at -16 dBm			
Supply voltage DC [V]	Temp [°C].	Carrier Bandwidth [MHz]	Test frequency Symbolic name Bottom		Test frequency Symbolic name Top	
			fL [MHz]	Offset to lower band edge (2110 MHz) [kHz]	fH [MHz]	Offset to upper band edge (2180 MHz) [kHz]
-48.0	+20	5	2110.016	16	2179.986	14
-48.0	+20	20	2110.096	96	2179.905	95

The frequency error results clearly shows that the frequency stability is good enough to ensure that the transmitted carrier stay within the operating band.

Remark

It was deemed sufficient to test one combination of TX frequency, channel bandwidth configuration and test model (modulation), as all combinations share a common internal reference to derive the TX frequency from.

Limits

CFR 47 §24.235 and §27.54:

The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

Complies?	Yes

Photos of test object

Front side

Rear side

Left side

Right side

Bottom side

Top side

Labels:

Radiated measurements:

Test object label:

SFP module Data 1:

SFP module Data 2:

Conducted measurements:

Test object label:

SFP module Data 1:

SFP module Data 2: