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Amended

FCC/ISED Test Report

Prepared for: **RealmFive, Inc.**

Address: **3300 Folkways Cir.**
Lincoln, NE 68504

Product: **SID-WD**

Test Report No: **R20171017-22-02C**

Approved By:

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

DATE: **15 May 2023**

Total Pages: **57**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	1 October 2018	Original – NJohnson Prepared by KVepuri
A	16 September 2019	Modified Section 2.2 Includes NCEE Labs report R20171017-22-02 and its amendment in full. -NJ
B	8 May 2023	20 dB BW added Updated conducted output power limit
C	15 May 2023	Corrected typo in Section 4.3. Added ntoe about 10 MHz RBW used for EIRP.

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 4, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency Hopping System	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Not applicable. Battery power only, no charger.
FCC 15.203	Unique Antenna Requirement	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

EUT	SID-WD
EUT Received	11 April 2018
EUT Tested	11 April 2018
Model No.	Rev. 6
Serial No.	NCEETEST1 (Assigned)
Operating Band	902.0 – 928.0 MHz
Device Type	Hybrid
Power Supply	Internal Battery/ Solar Powered
Antenna gain	6.4 dBi peak

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	902.3
Middle	908.5
High	914.9

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, highest and one channel in the middle.

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

All testing was performed by Karthik Vepuri of NCEE Labs. The results were reviewed by Nic Johnson.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2019
Rohde & Schwarz Test Receiver	ES17	100007	31 Jul 2017	31 Jul 2018
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2018
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	25 Jul 2017	25 Jul 2018
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

*Internal Characterization

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Not applicable

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013, Section 6.5, 6.6, 11.11, 11.12

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.

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 form 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.

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.

Test setup:

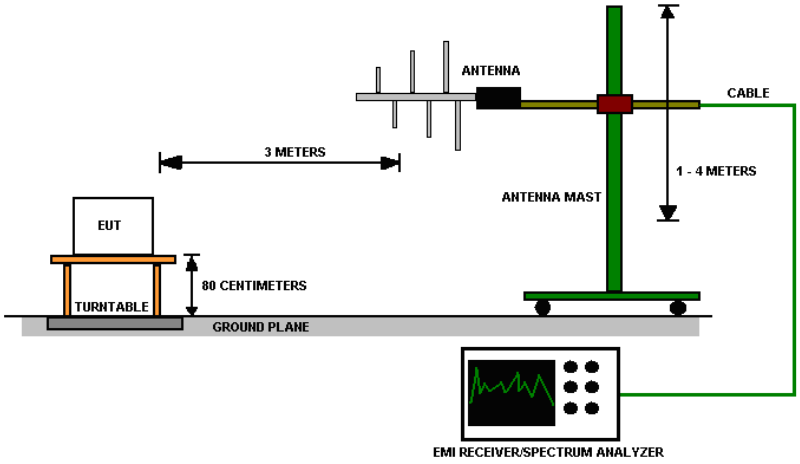

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions

The EUT was powered by 6.4 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.

Test results:

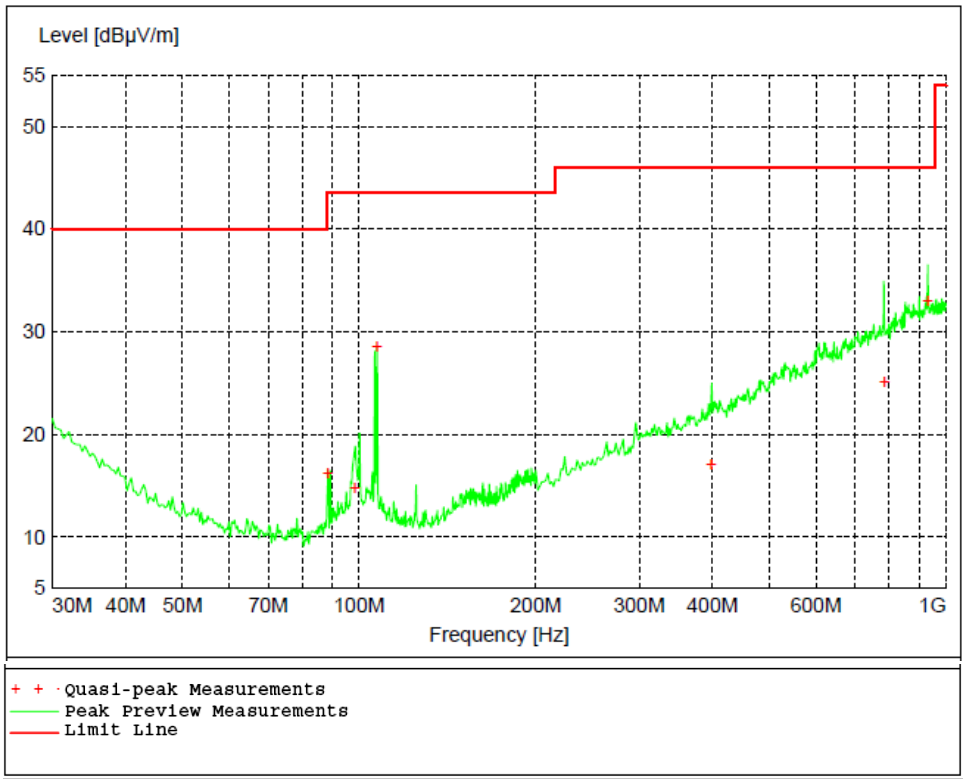

Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
88.440000	16.30	43.50	27.20	129	360	VERT	X
98.400000	14.86	43.50	28.70	169	65	HORI	X
107.280000	28.60	43.50	14.90	143	216	HORI	X
398.520000	17.12	46.00	28.90	312	145	HORI	X
785.100000	25.14	46.00	20.90	121	360	HORI	X
931.380000	32.97	46.00	13.00	131	185	VERT	X

Table 2 - Radiated Emissions Peak Measurements vs. Average Limit, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1806.600000	31.64	54.00	22.40	100	170	HORI	X
2729.200000	33.58	54.00	20.40	399	360	HORI	X
3621.800000	37.79	54.00	16.20	100	261	VERT	X
4535.600000	40.41	54.00	13.60	100	12	VERT	X
5455.600000	41.39	54.00	12.60	399	288	HORI	X

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

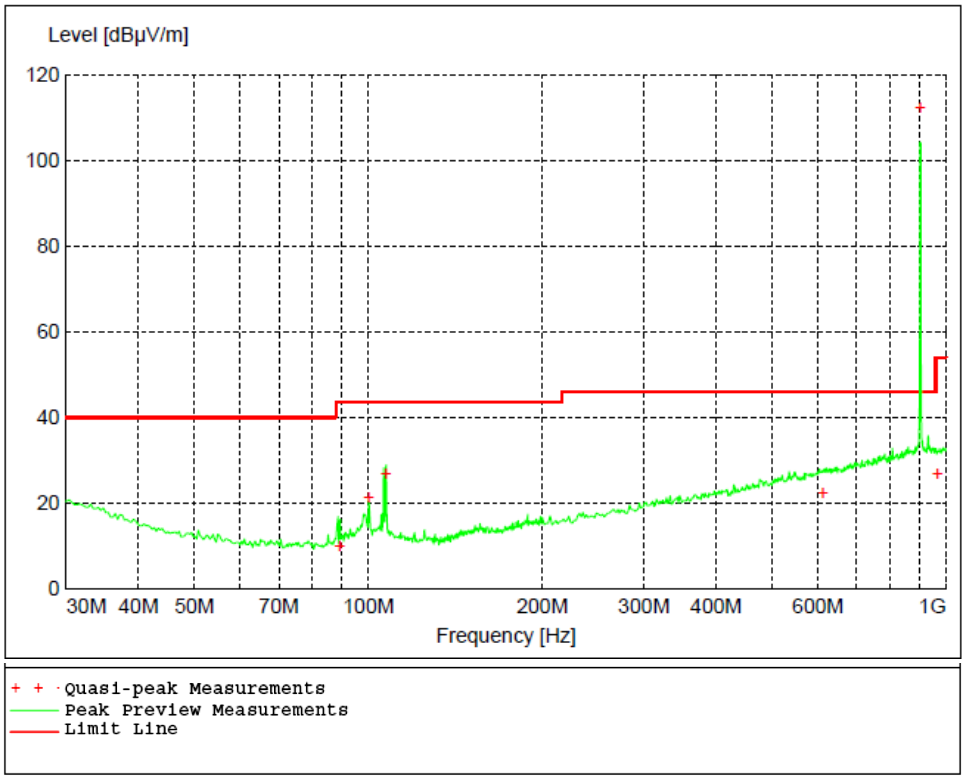

Figure 3 - Radiated Emissions Plot, Low Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
89.280000	10.12	43.50	33.40	179	354	VERT	X
100.200000	21.53	43.50	22.00	193	72	HORI	X
107.280000	26.92	43.50	16.60	150	168	HORI	X
613.020000	22.68	46.00	23.30	237	204	VERT	X
902.340000	112.28	NA	NA	186	98	HORI	X
966.600000	27.02	54.00	27.00	138	87	VERT	X

Table 4 - Radiated Emissions Peak Measurements vs. Average Limit, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.600000	52.25	54.00	1.70	197	211	HORI	X
2707.000000	50.12	54.00	3.90	190	226	HORI	X
3609.000000	42.18	54.00	11.80	130	214	HORI	X
4511.200000	41.36	54.00	12.60	100	179	HORI	X
5408.200000	41.45	54.00	12.50	100	0	VERT	X
6315.400000	43.63	54.00	10.40	399	153	VERT	X
7213.400000	43.14	54.00	10.90	100	275	VERT	X
8111.000000	45.38	54.00	8.60	213	139	VERT	X
9021.800000	46.61	54.00	7.40	399	151	HORI	X

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

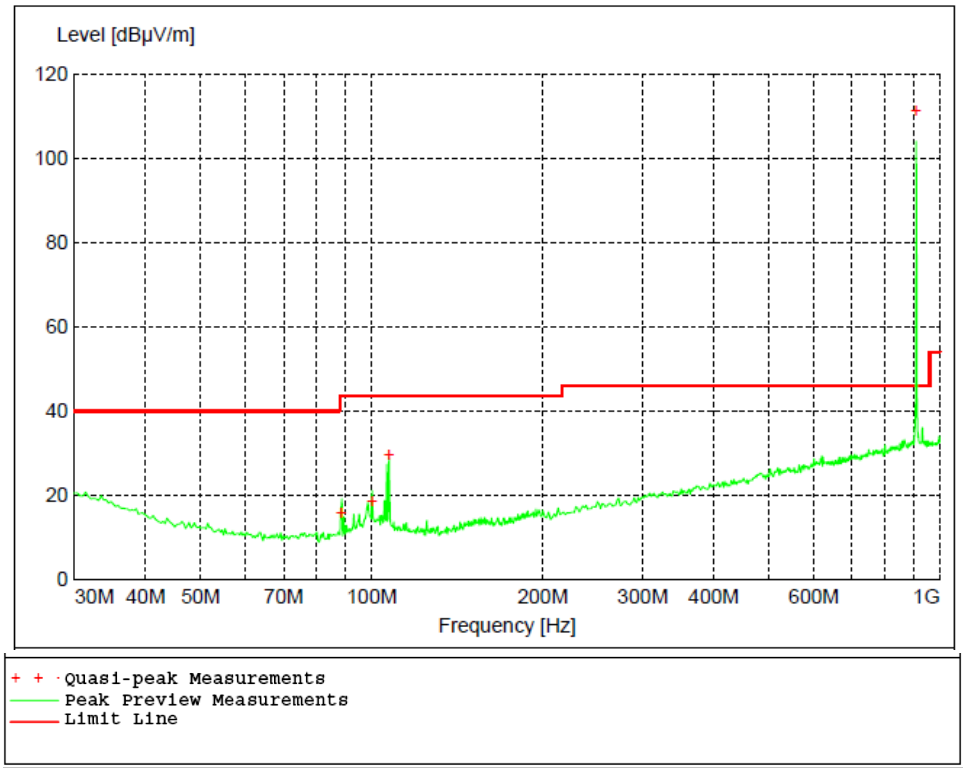

Figure 4 - Radiated Emissions Plot, Mid Channel

Table 5 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
88.440000	15.96	43.50	27.60	115	353	VERT	X
100.200000	18.78	43.50	24.70	288	335	VERT	X
107.280000	29.79	43.50	13.70	163	314	HORI	X
908.460000	111.31	NA	NA	190	102	HORI	X

Table 6 - Radiated Emissions Peak Measurements vs. Average Limit, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1817.000000	53.69	54.00	0.30	186	333	HORI	X
2725.400000	48.09	54.00	5.90	186	234	HORI	X
3634.200000	42.90	54.00	11.10	133	212	HORI	X
4526.000000	40.32	54.00	13.70	99	277	VERT	X
5448.400000	41.92	54.00	12.10	100	41	VERT	X
6348.600000	42.47	54.00	11.50	99	271	HORI	X
7242.800000	42.09	54.00	11.90	250	355	HORI	X
8153.000000	45.52	54.00	8.50	110	74	VERT	X
9083.400000	44.55	54.00	9.40	99	94	VERT	X
1817.000000	53.69	54.00	0.30	186	333	HORI	X

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

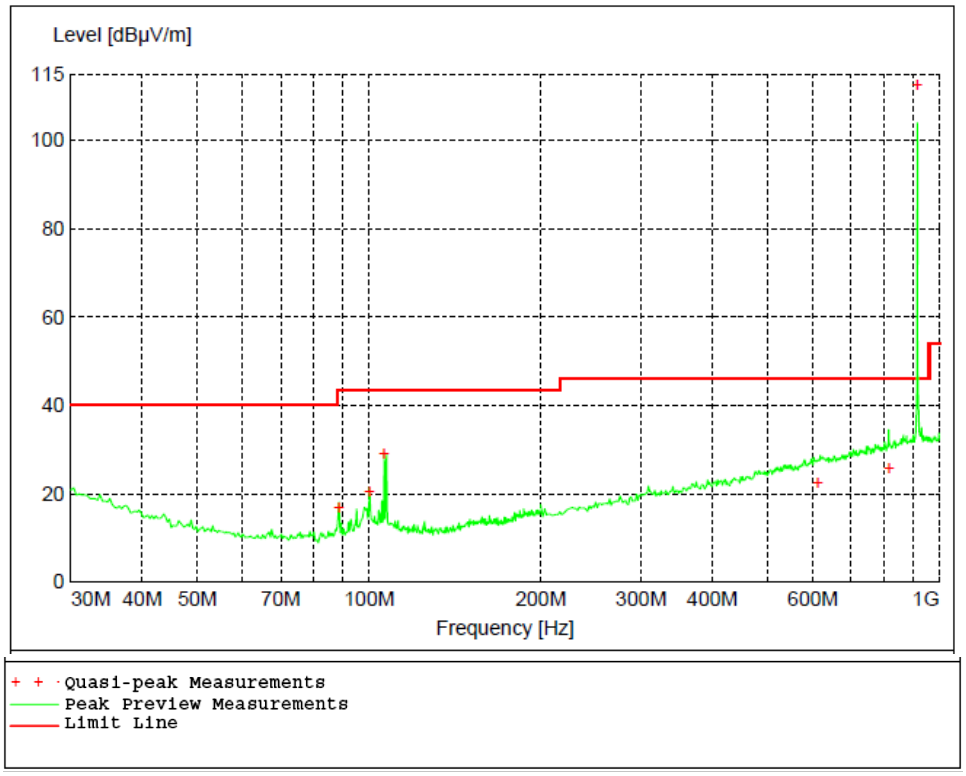

Figure 5 - Radiated Emissions Plot, High Channel

Table 7 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
88.500000	16.82	43.50	26.70	129	124	VERT	X
100.200000	20.62	43.50	22.90	173	9	HORI	X
106.320000	29.02	43.50	14.50	210	360	HORI	X
613.080000	22.68	46.00	23.30	384	360	HORI	X
817.260000	25.85	46.00	20.10	300	131	HORI	X
914.940000	112.59	NA	NA	183	98	HORI	X

Table 8 - Radiated Emissions Peak Measurements vs. Average Limit, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1829.800000	53.71	54.00	0.30	184	329	HORI	X
2744.600000	46.11	54.00	7.90	100	33	HORI	X
3659.600000	44.10	54.00	9.90	318	255	HORI	X
4558.000000	41.65	54.00	12.30	399	231	VERT	X
5495.000000	42.14	54.00	11.90	100	60	HORI	X
6405.000000	42.56	54.00	11.40	113	346	HORI	X
7307.600000	42.41	54.00	11.60	120	214	HORI	X
8232.000000	45.14	54.00	8.90	315	288	VERT	X
9164.600000	45.01	54.00	9.00	140	279	VERT	X

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

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.
5. The EUT was measured in all 3 orthagonal axis. It was found that the Y-axis produced the highest emissions, and this orientation was used for all testing. See the test setup photo exhibit for details on the orientations.

4.3 PEAK OUTPUT POWER

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

Limits of bandwidth measurements:
The maximum allowed peak output power is 29.6 dBm. (30 dBm – (6.4 – 6)). Maximum gain is reduced to account for antenna gain > 6 dBi

Test procedures:
All measurements were taken at a distance of 3m from the EUT.

The EUT was maximized in all 3 orthogonal positions in a similar manner as described in Section 4.2.

Deviations from test standard:
No deviation.

Test setup:

See Section 4.2

EUT operating conditions:
The EUT was powered by 6.4 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.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	Method	RESULT
Low	902.3	17.94	EIRP	PASS
Middle	908.5	17.41	EIRP	PASS
High	914.9	18.13	EIRP	PASS

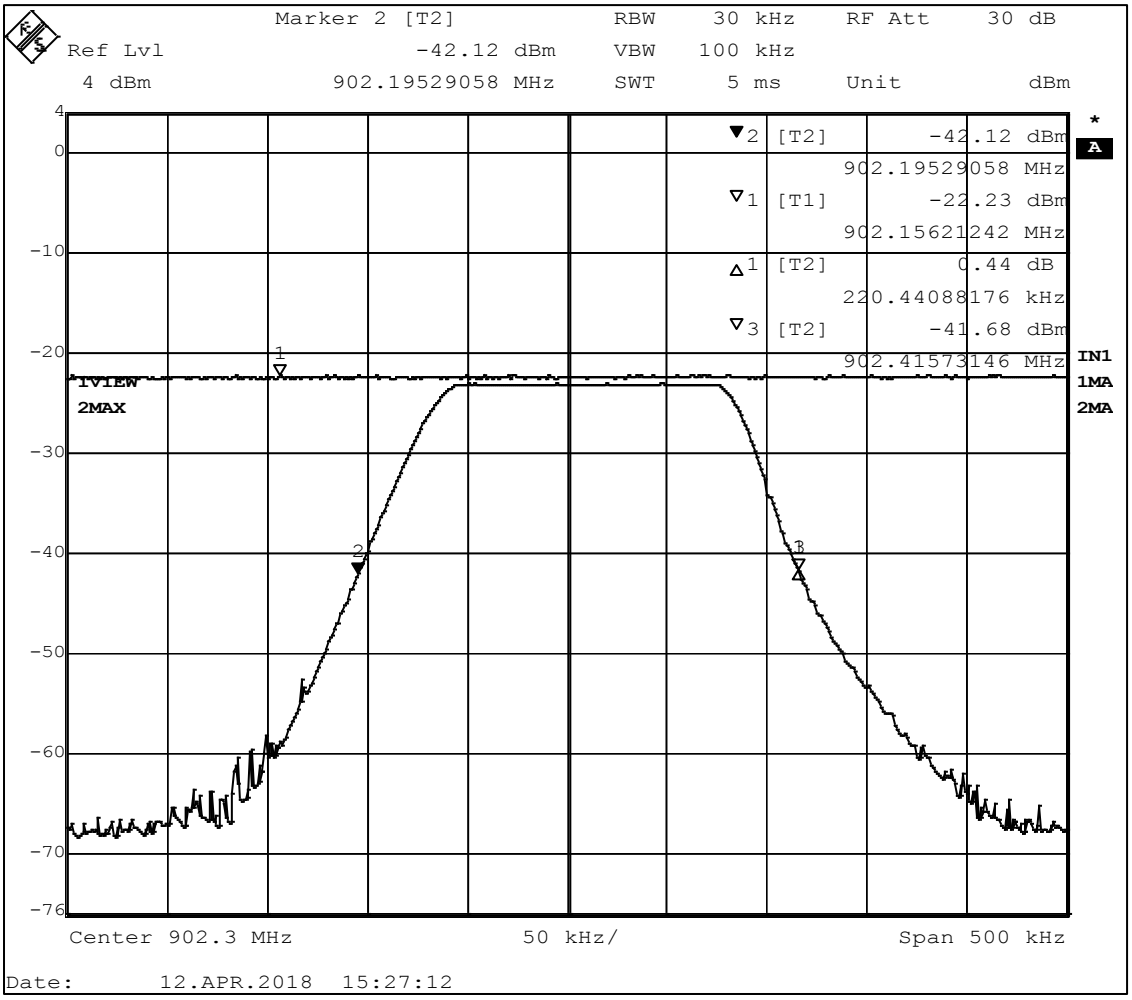

Figure 6 – Output Power, Low Channel

Maximum power = -22.23 dBm + 107 + CL + AF - 95.23 = 17.94 dBm

CL = cable loss = 4.70 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Trace measured with marker 1 was taken with 10 MHz RBW.

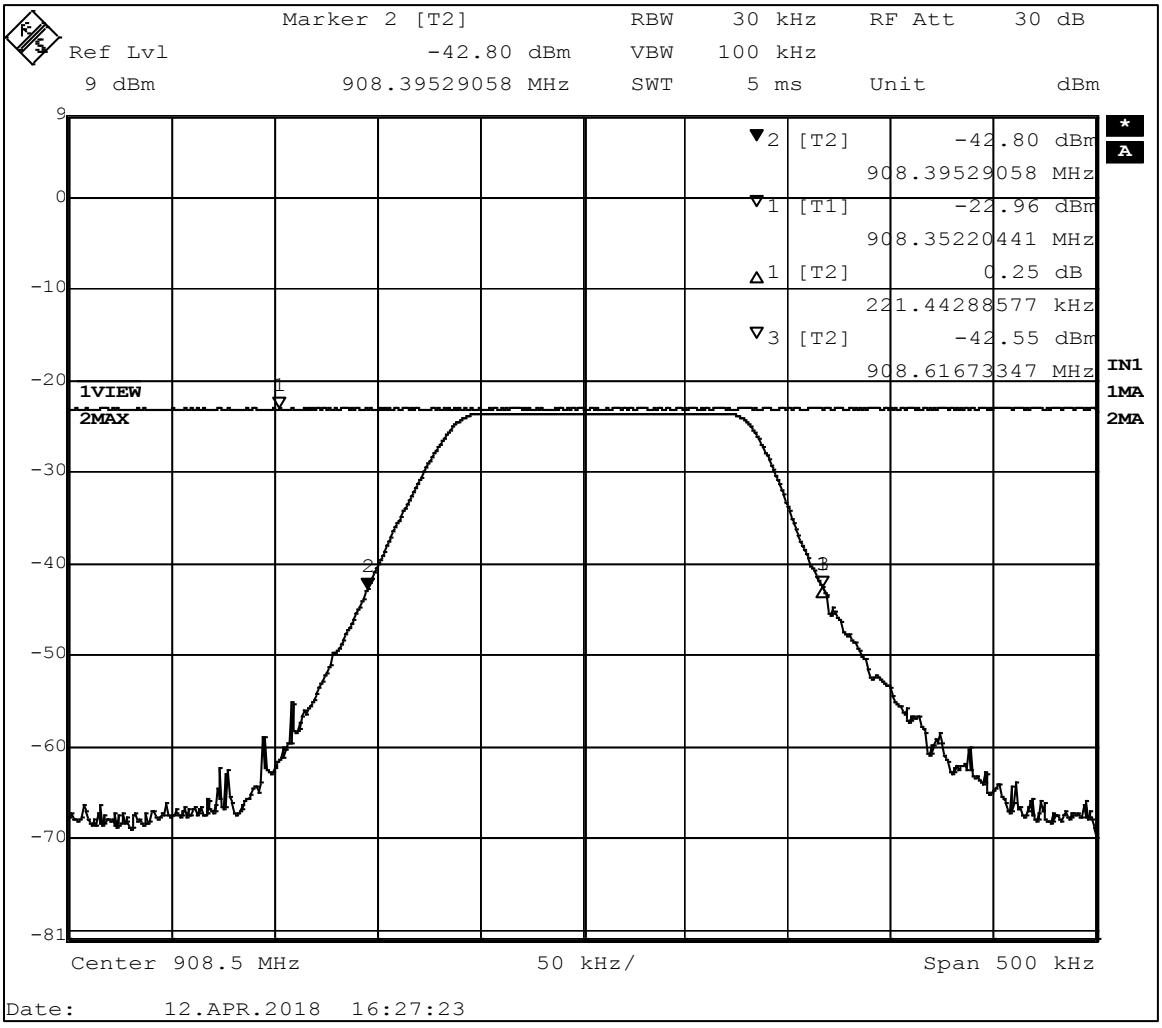

Figure 7 - Output Power, Mid Channel

Maximum power = -22.96 dBm + 107 + CL + AF - 95.23 = 17.41 dBm

CL = cable loss = 4.80 dB
AF = antenna factor = 23.80 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Trace measured with marker 1 was taken with 10 MHz RBW.

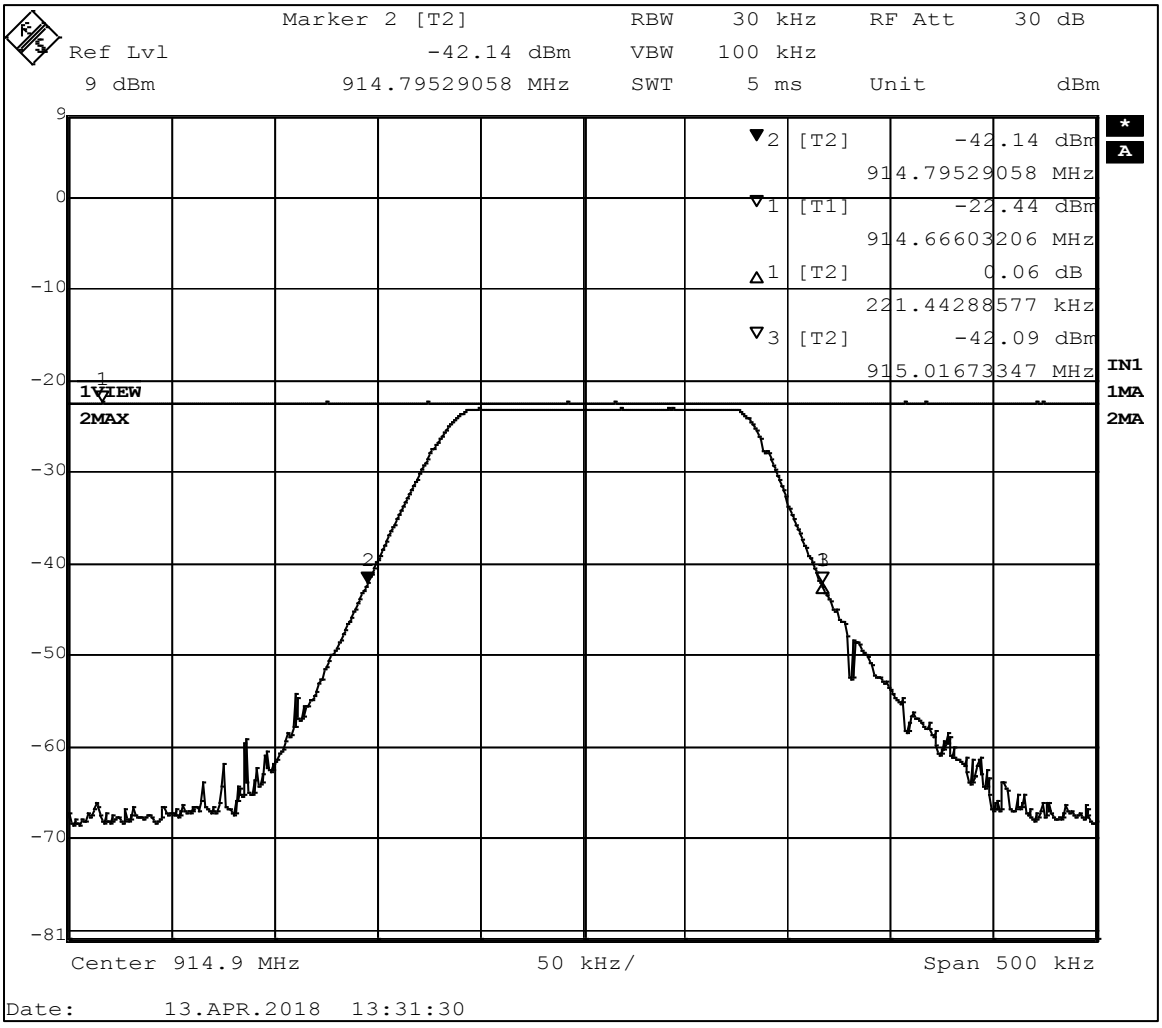

Figure 8 - Output Power, High Channel

Maximum power = -22.44 dBm + 107 + CL + AF - 95.23 = 18.13 dBm

CL = cable loss = 4.90 dB
AF = antenna factor = 23.90 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Trace measured with marker 1 was taken with 10 MHz RBW.

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 11.8.1

Limits of bandwidth measurements:
The 99% occupied bandwidth and peak output powers are displayed. The maximum allowed peak output power is 30 dBm.

The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 1 MHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

For peak output power measurements, the EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW.

Deviations from test standard:
No deviation.

Test setup:

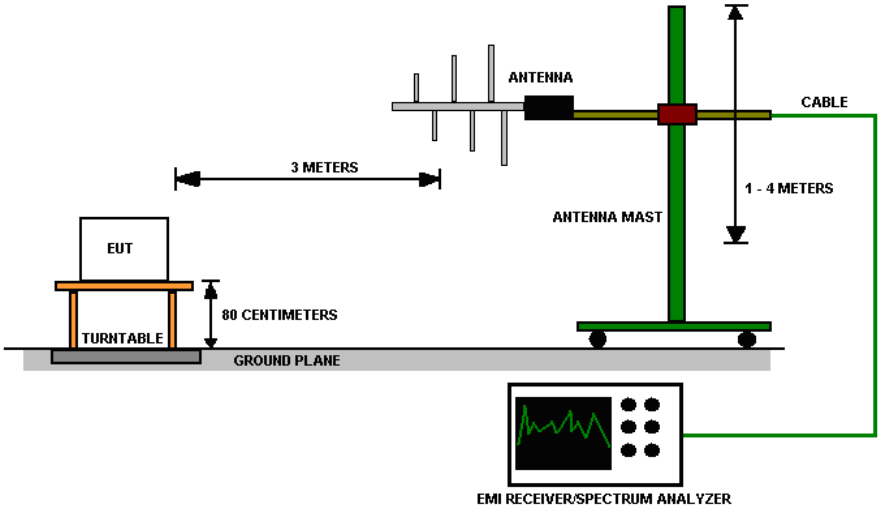

Figure 9 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 6.4 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.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
1	902.3	220.44
2	908.5	221.44
3	914.9	221.44

6dB / 20 dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)	20 dB BW* (kHz)
1	902.3	169.34	< 135
2	908.5	169.33	< 142.5
3	914.9	169.34	< 142.5

*20 dB bandwidth values were taken from PSD plots and overestimated from values on graph. The plots can be found in Figures 28 – 30, pages 45 – 47. Calculations are shown below each plot.

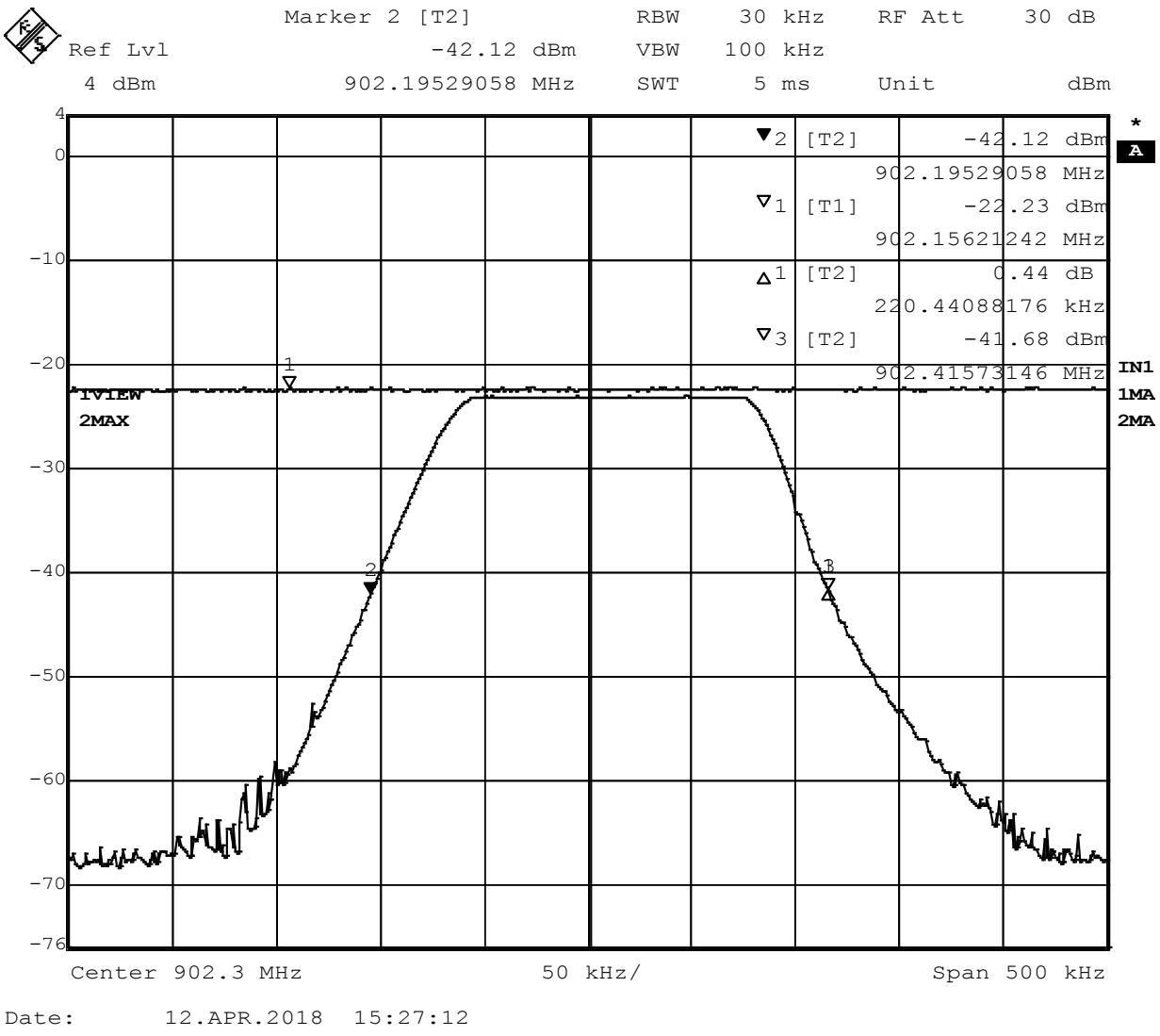

Figure 10 - 99% Occupied Bandwidth, Low Channel

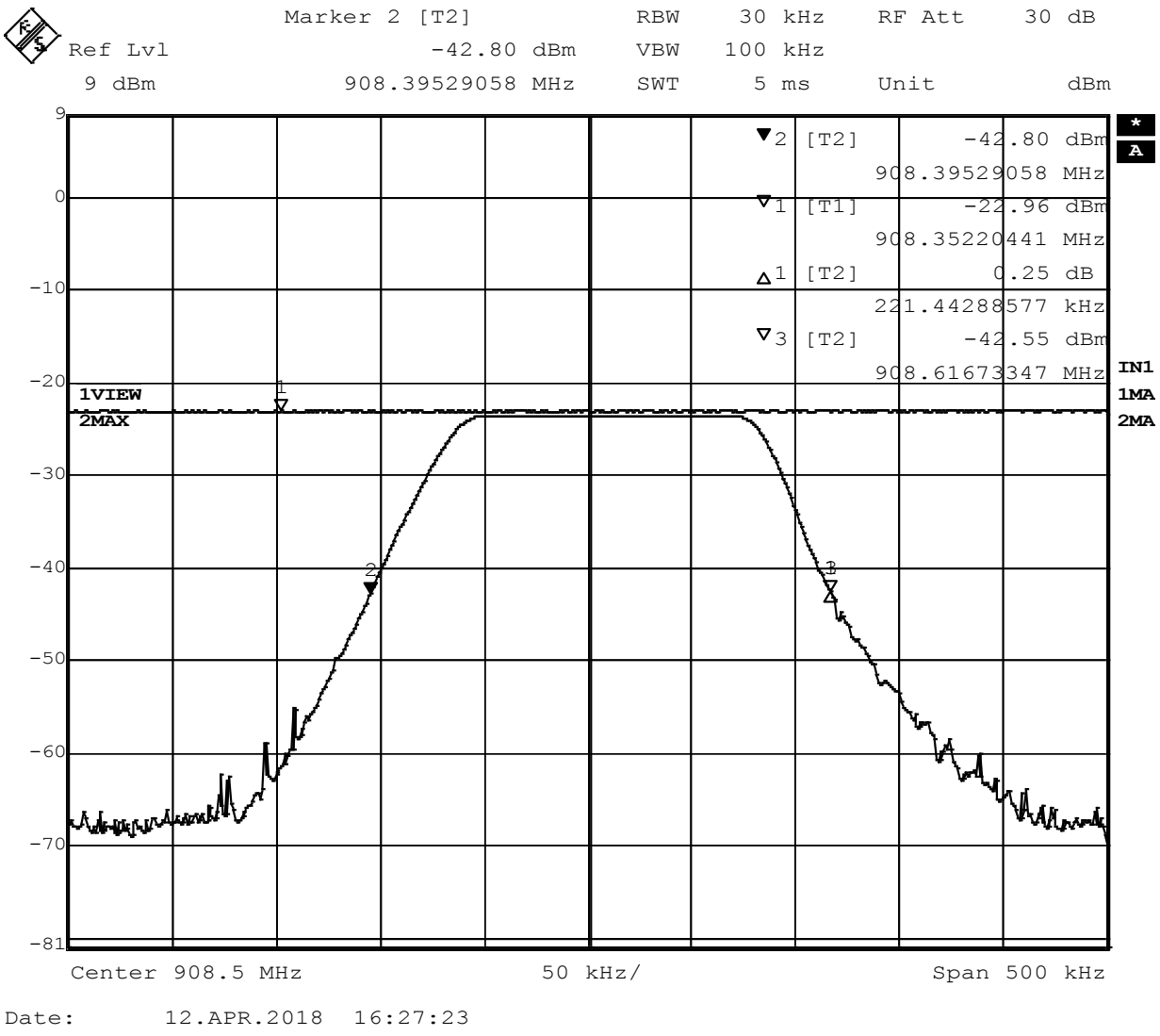

Figure 11 - 99% Occupied Bandwidth, Mid Channel

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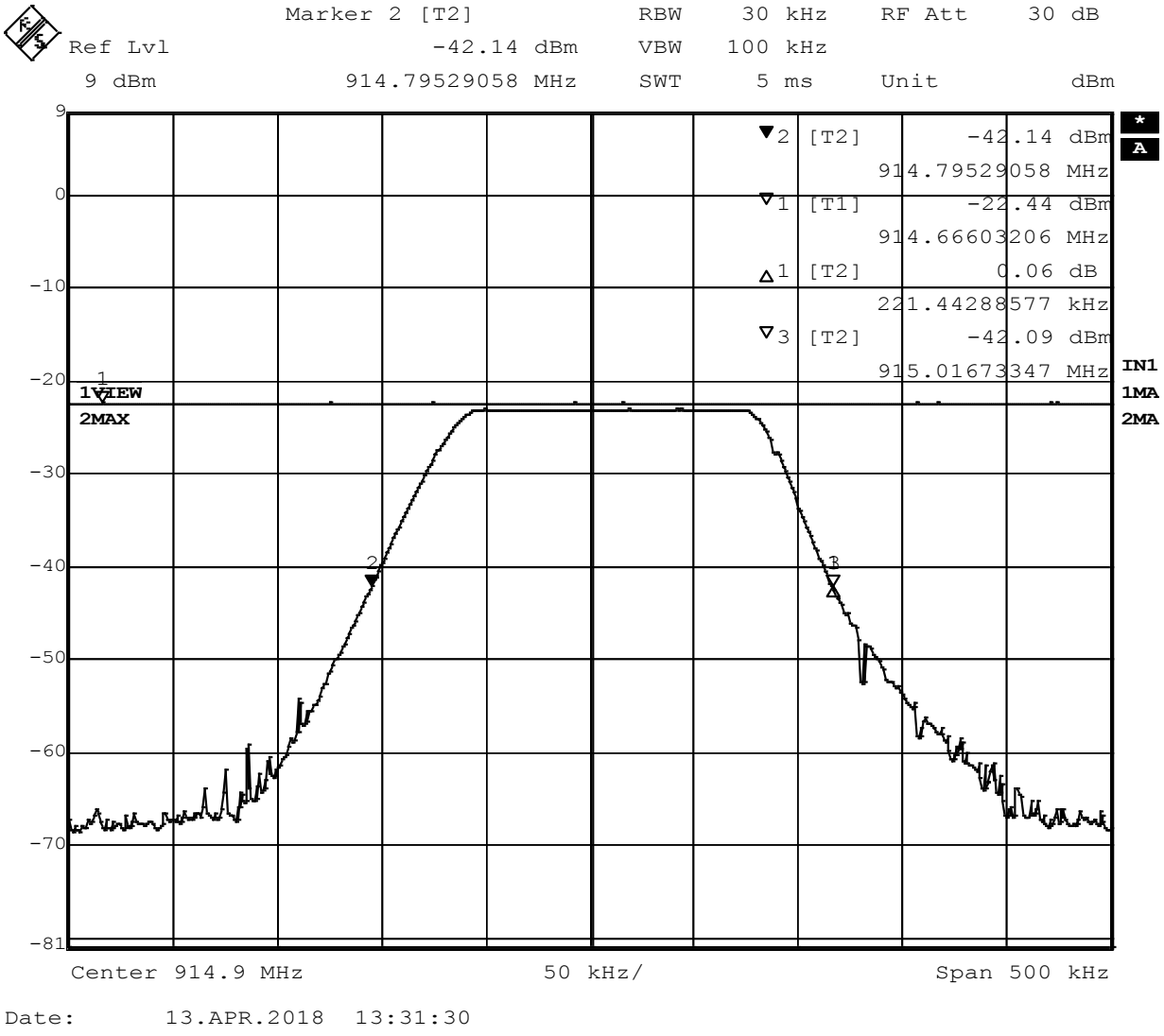

Figure 12 - 99% Occupied Bandwidth, High Channel

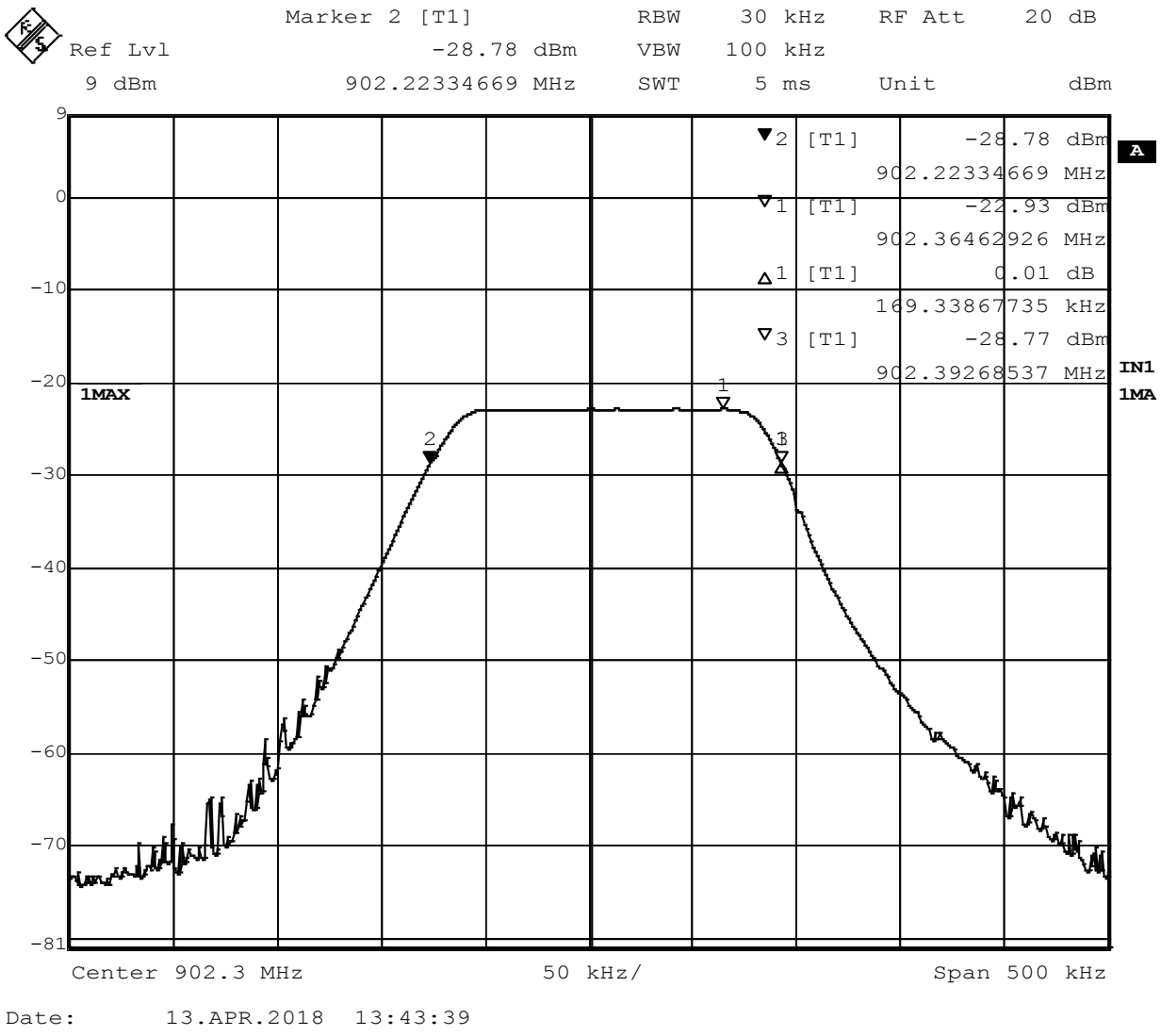

Figure 13 - 6dB Bandwidth, Low Channel

20 dB BW =

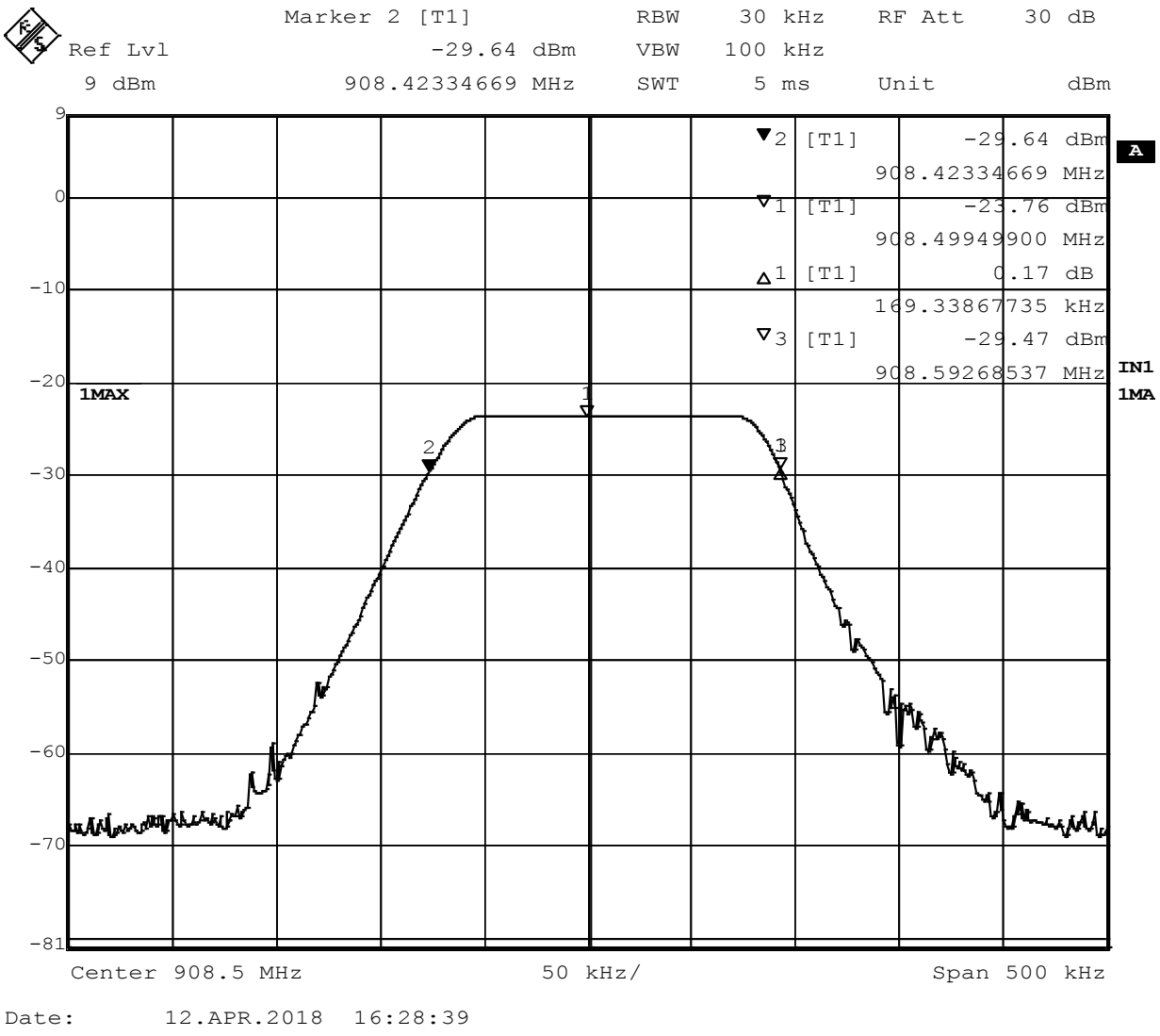

Figure 14 - 6dB Bandwidth, Mid Channel

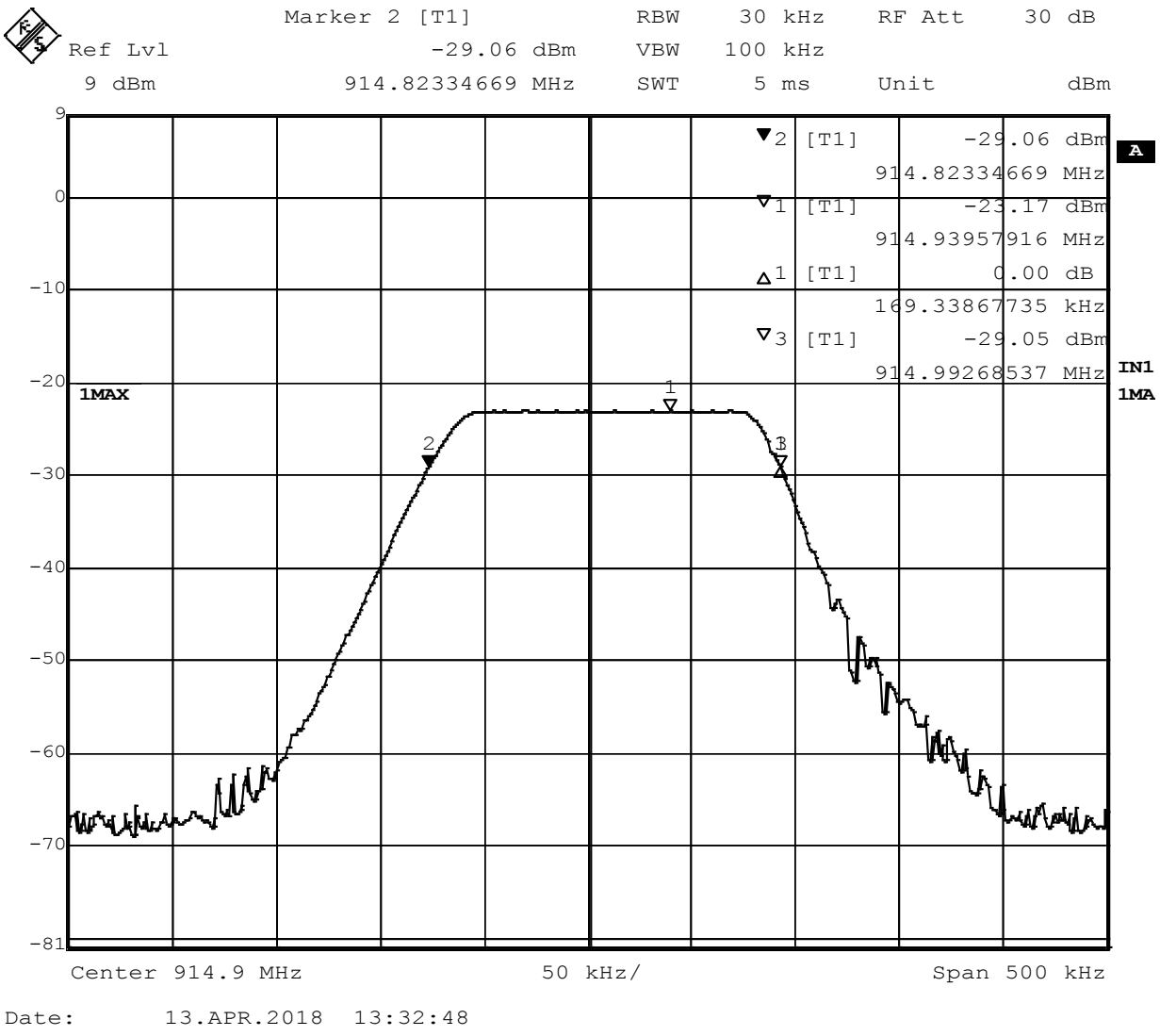

Figure 15 - 6dB Bandwidth, High Channel

4.5 BANDEDGES

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

Limits of bandedge measurements:
For emissions outside of the allowed band of operation (902 – 928MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:
The EUT was tested in the same method as described in section *4.4 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

Deviations from test standard:
No deviation.

Test setup:
All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 6.4 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.

Test results:

Highest Out of Band Emissions, Restricted Band

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low, Continuous	614.0	-108.06	-23.11	84.95	66.28	PASS
High, Continuous	960.0	-107.24	-23.10	84.14	66.59	PASS
Low Hopping	614.0	-108.00	-23.40	84.60	66.28	PASS
High, Hopping	960.0	-106.84	-23.32	83.52	66.59	PASS

Highest Out of Band Emissions, Unrestricted bands

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low, Continuous	902.0	-52.64	-22.74	29.90	20.00	PASS
High, Continuous	928.0	-69.63	-22.73	46.90	20.00	PASS
Low Hopping	902.0	-53.10	-22.88	30.22	20.00	PASS
High, Hopping	928.0	-80.63	-22.47	58.16	20.00	PASS

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

From Section 4.2

Fundamental average field strength at 902.3 MHz for low channel = 112.28 dBμV/m
Fundamental average field strength at 914.9 MHz for high channel = 112.59 dBμV/m

Low channel minimum delta = 112.28 – 46.0 dBμV/m = 66.28 dBc
High channel minimum delta = 112.59 – 46.0 dBμV/m = 66.59 dBc

Measurements do not include correction factors and are intended to be relative measurements only.

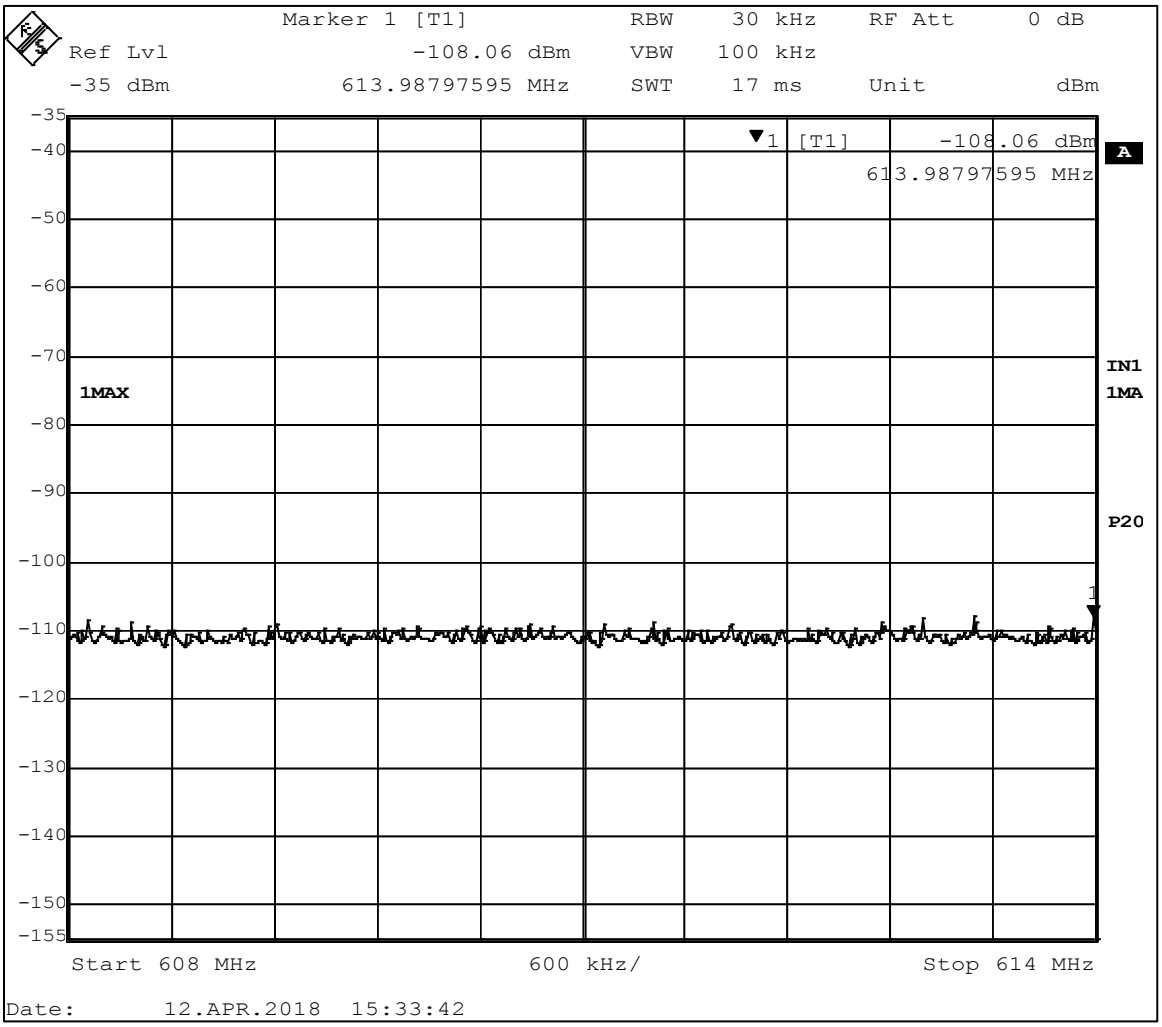

Figure 16 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

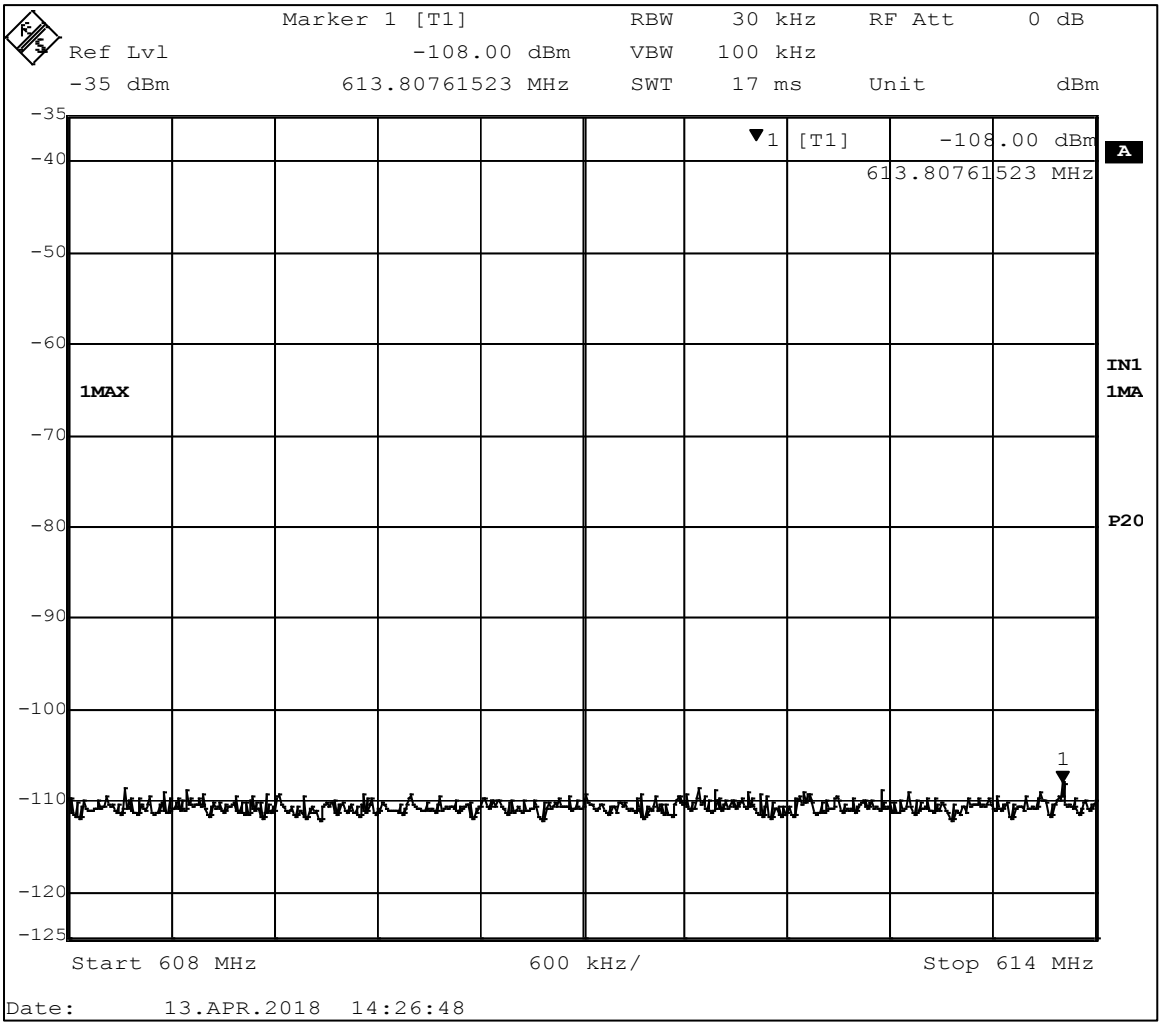

Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

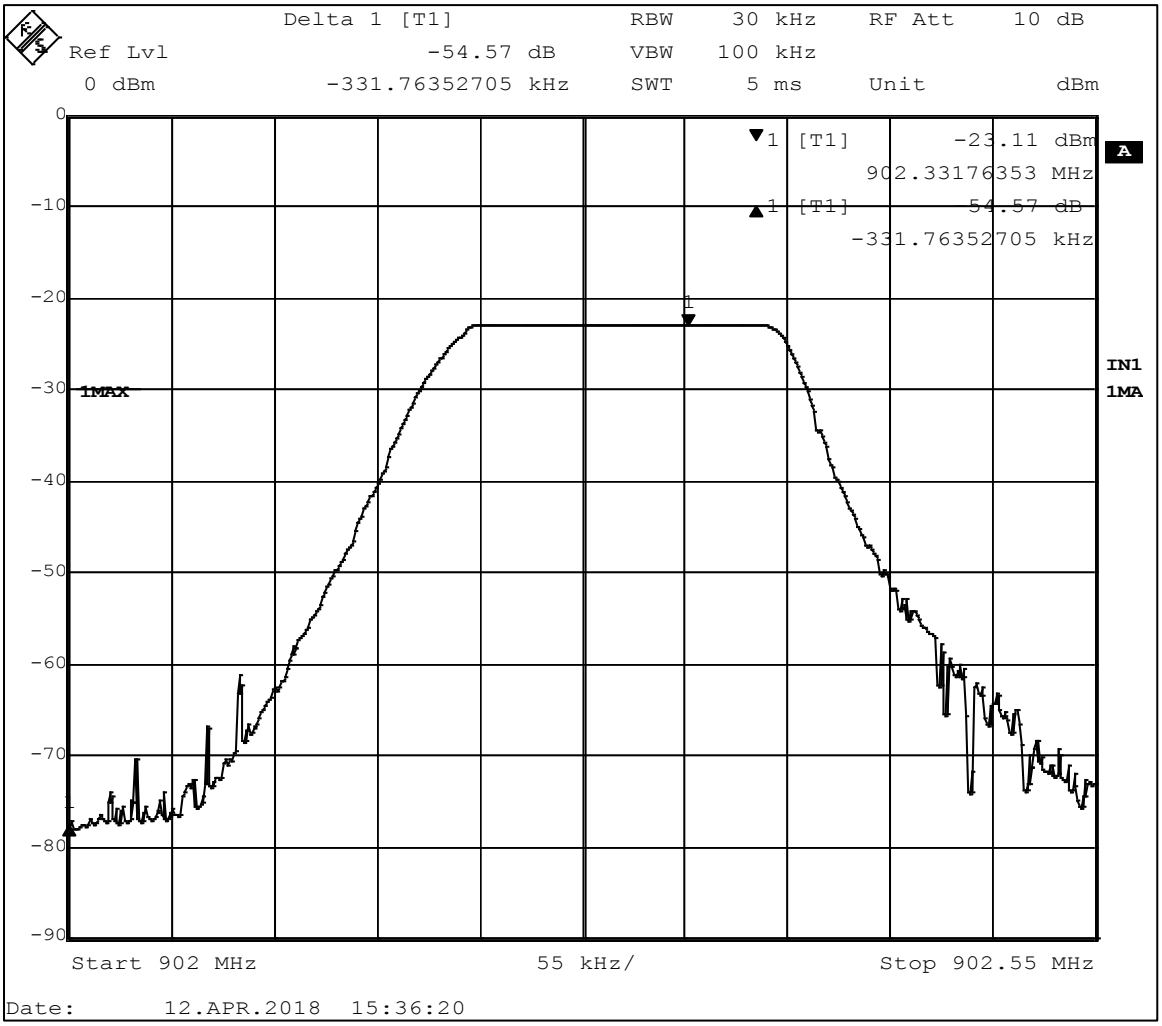

Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 54.57 dB > 20 dB minimum

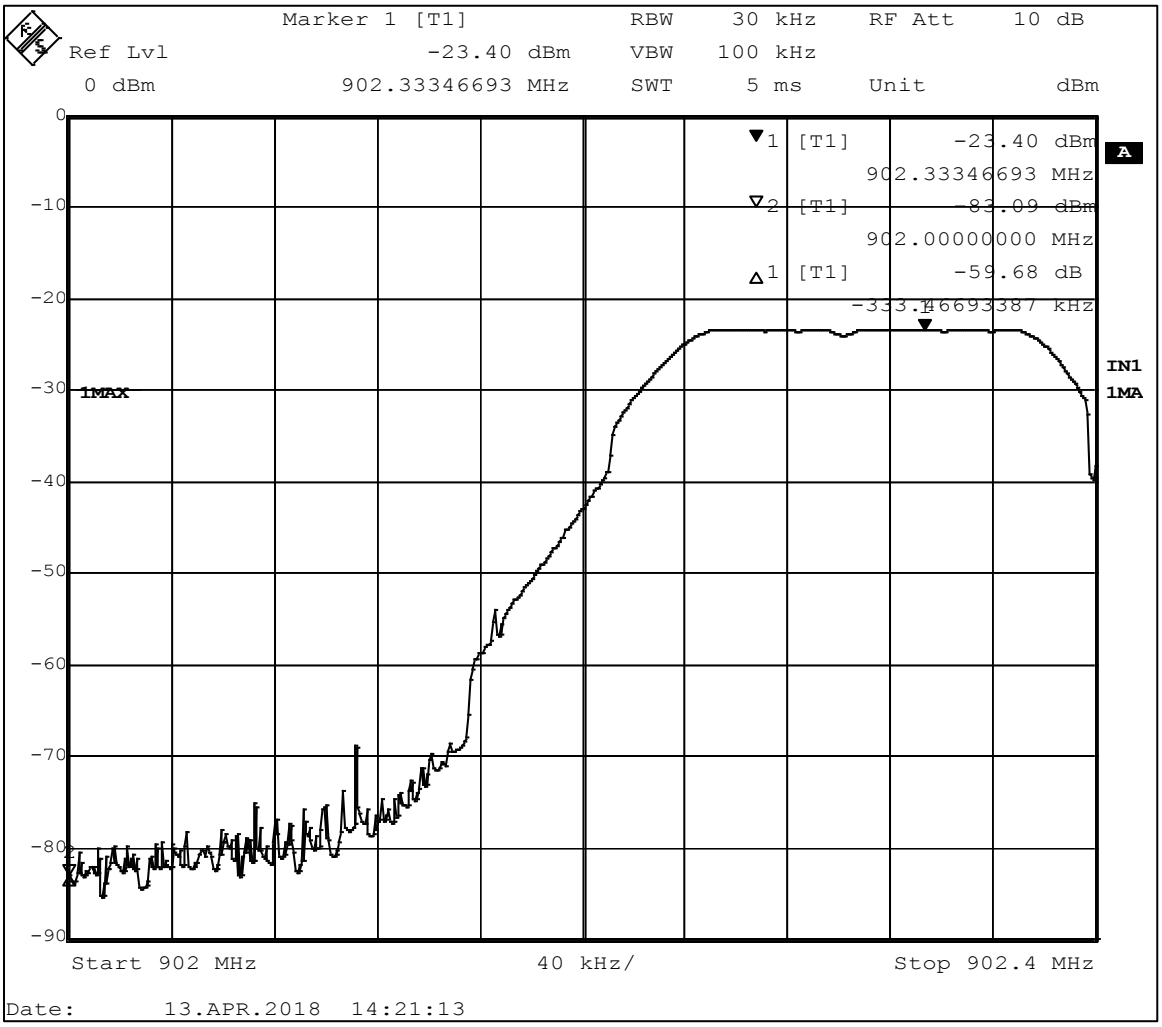

Figure 19 - Band-edge Measurement, Low Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 59.68 dB > 20 dB minimum

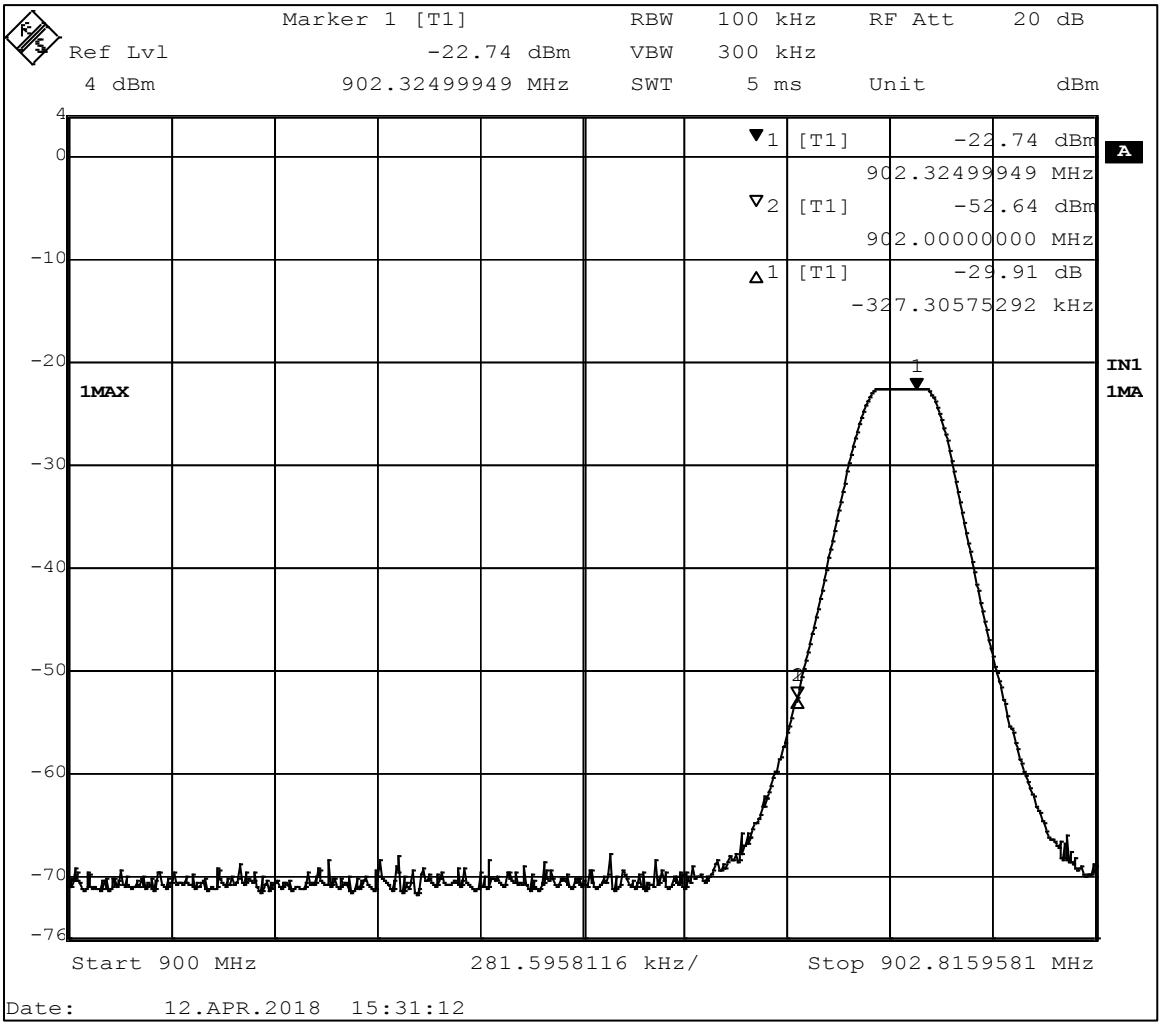

Figure 20 - Band-edge Measurement, Low Channel, Unrestricted, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 29.91 dB > 20 dB minimum

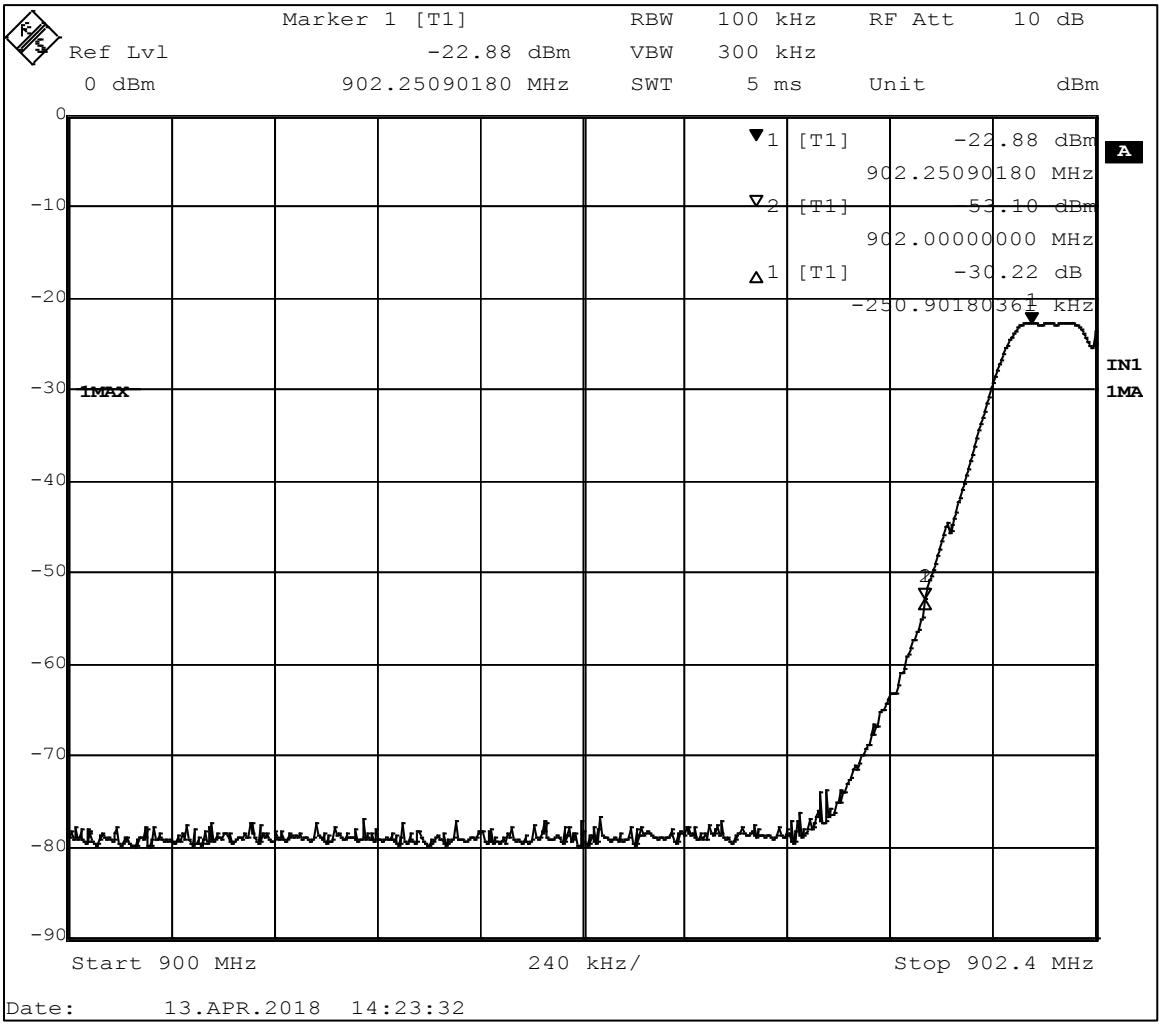

Figure 21 - Band-edge Measurement, Low Channel, Unrestricted, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 30.22 dB > 20 dB minimum

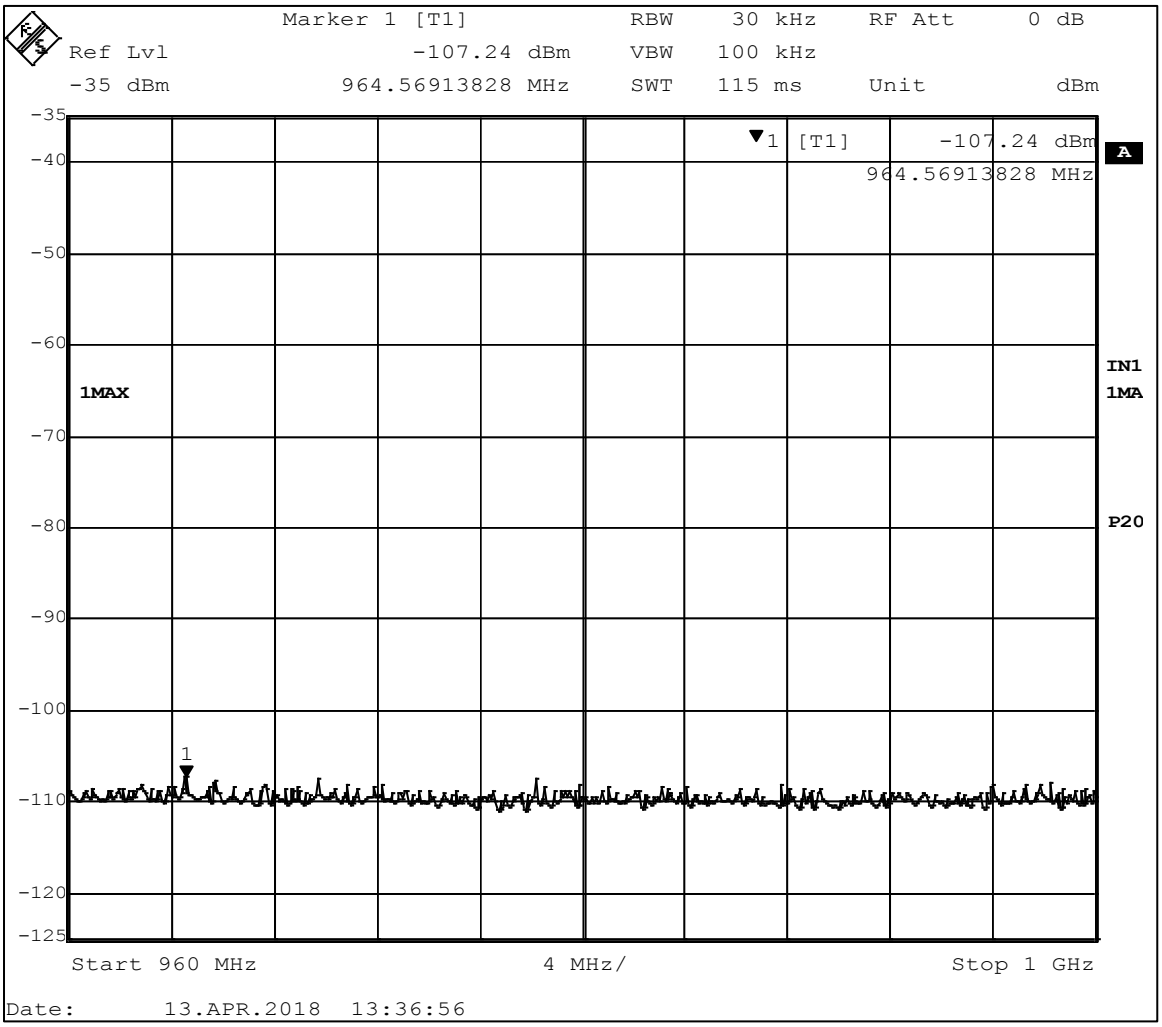

Figure 22 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

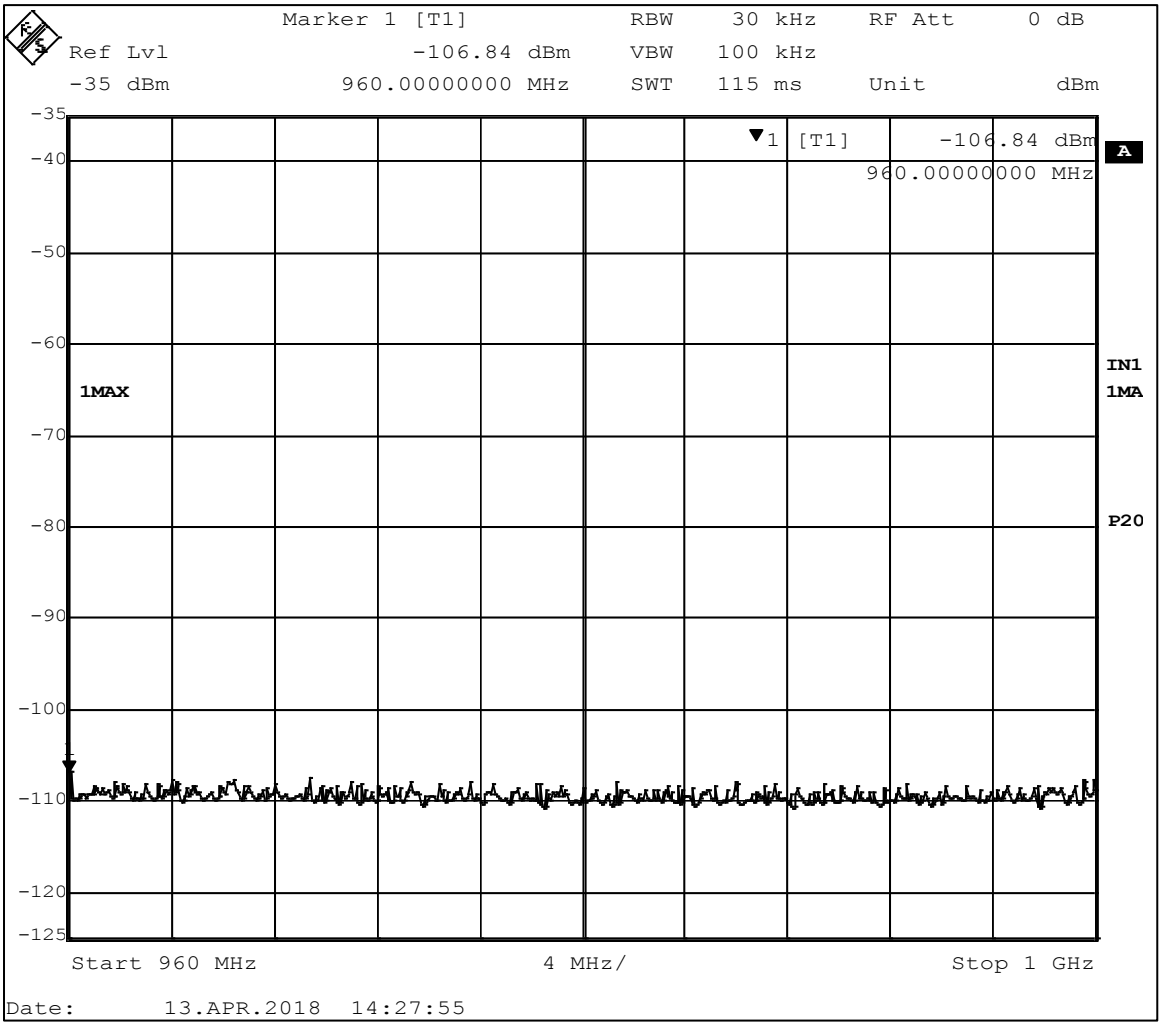

Figure 23 - Band-edge Measurement, High Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

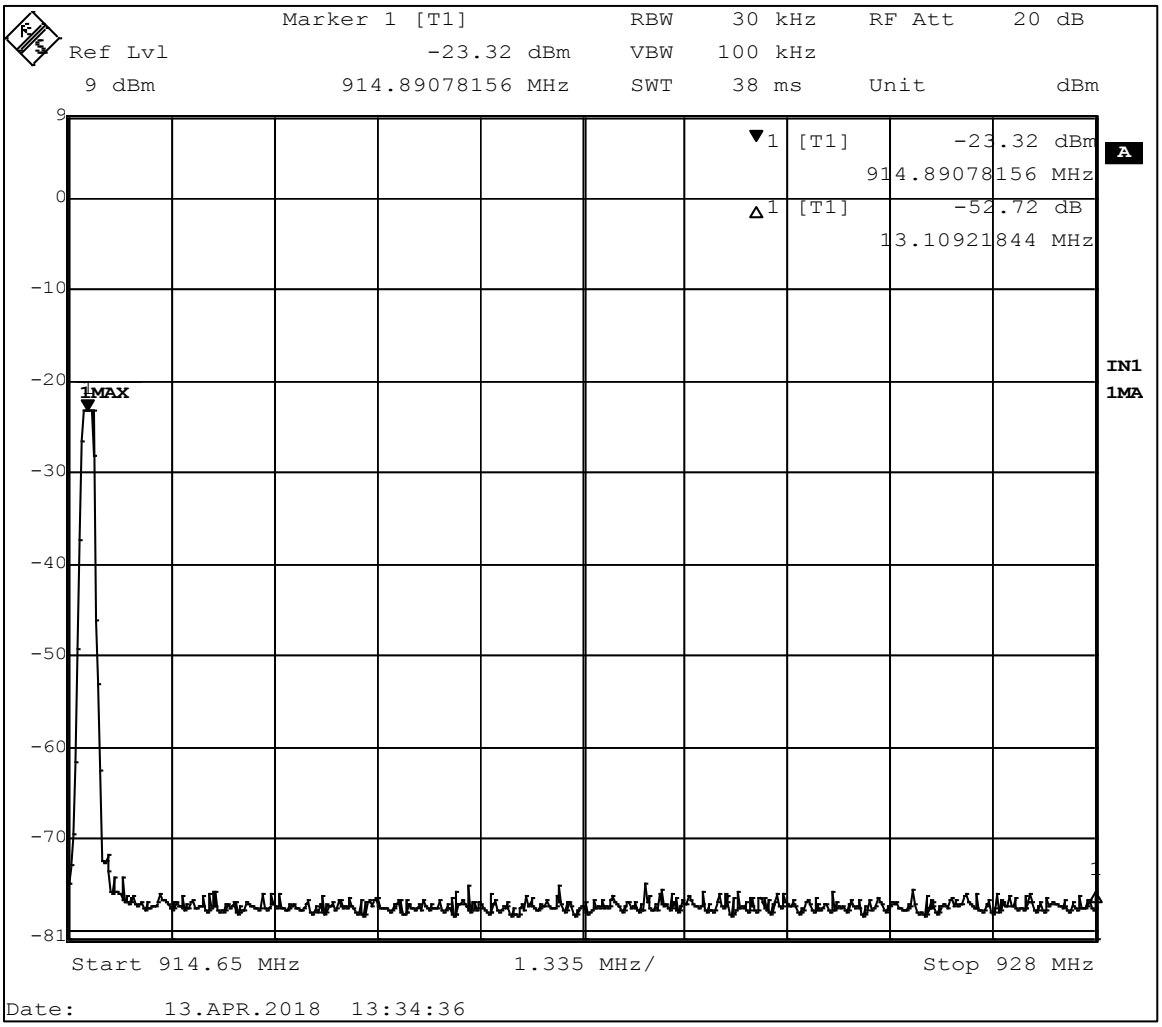

Figure 24 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 52.72 dB > 20 dB minimum

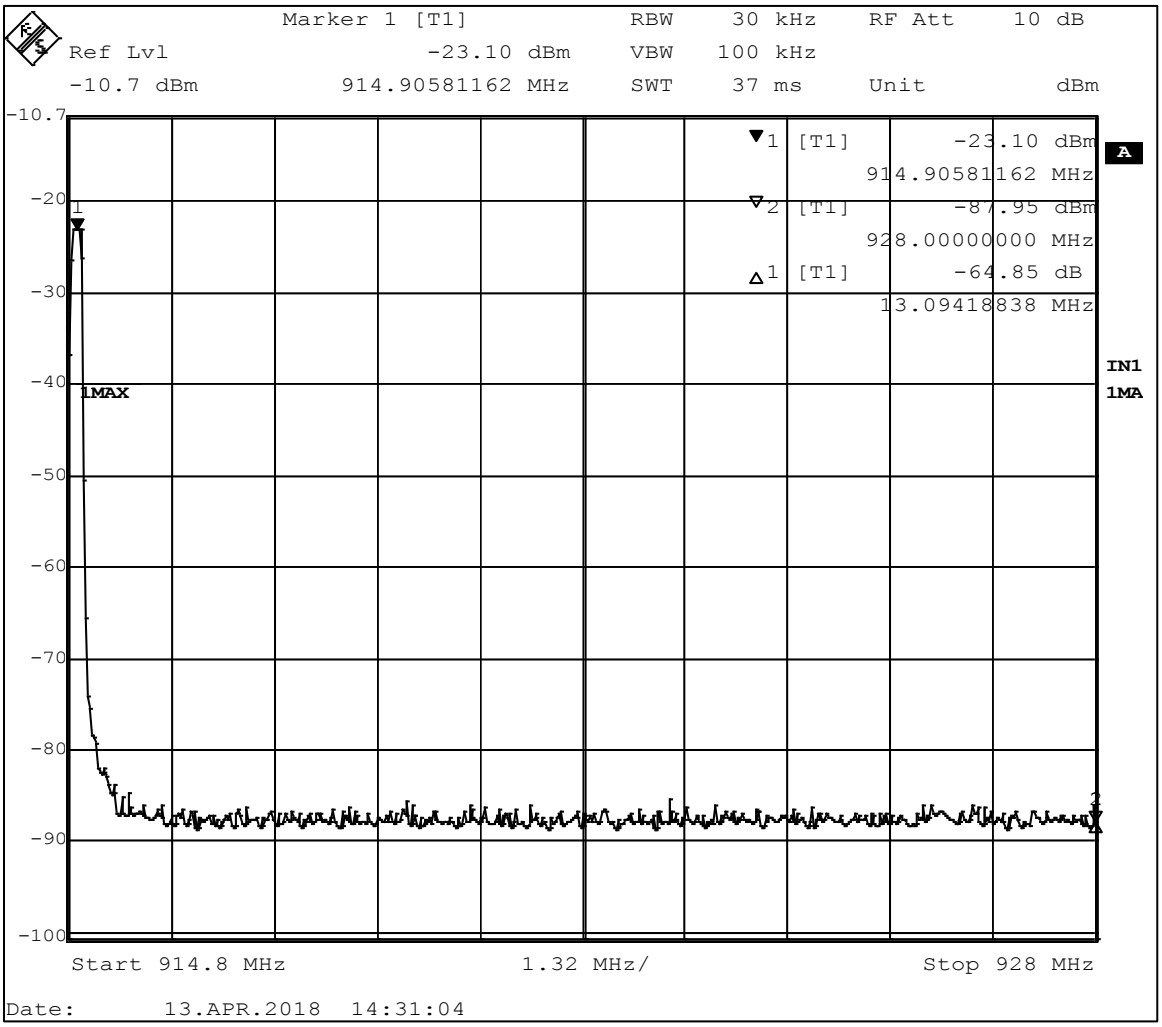

Figure 25 - Band-edge Measurement, High Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 64.85 dB > 20 dB minimum

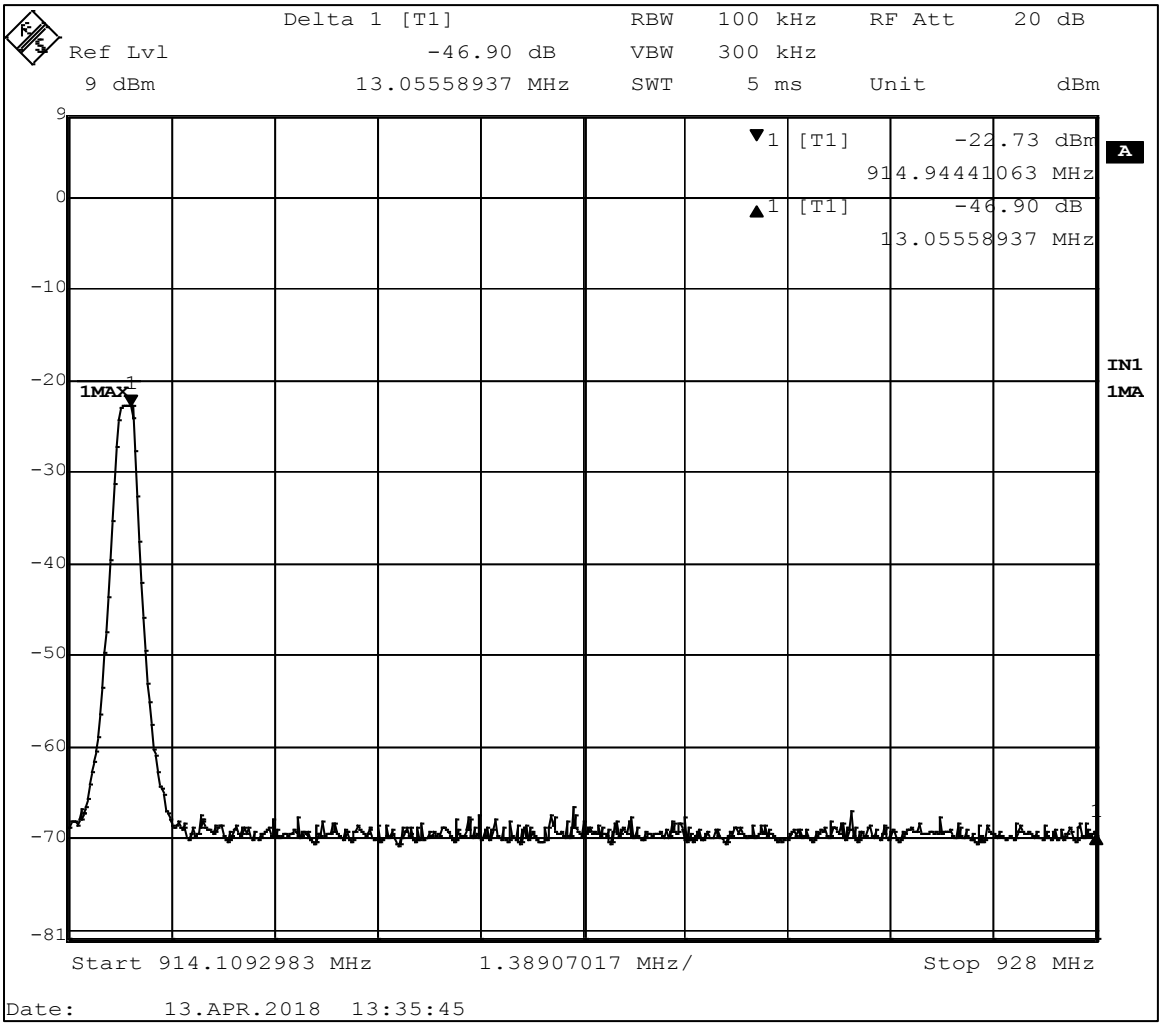

Figure 26 - Band-edge Measurement, High Channel, Unrestricted, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 46.90 dB > 20 dB minimum

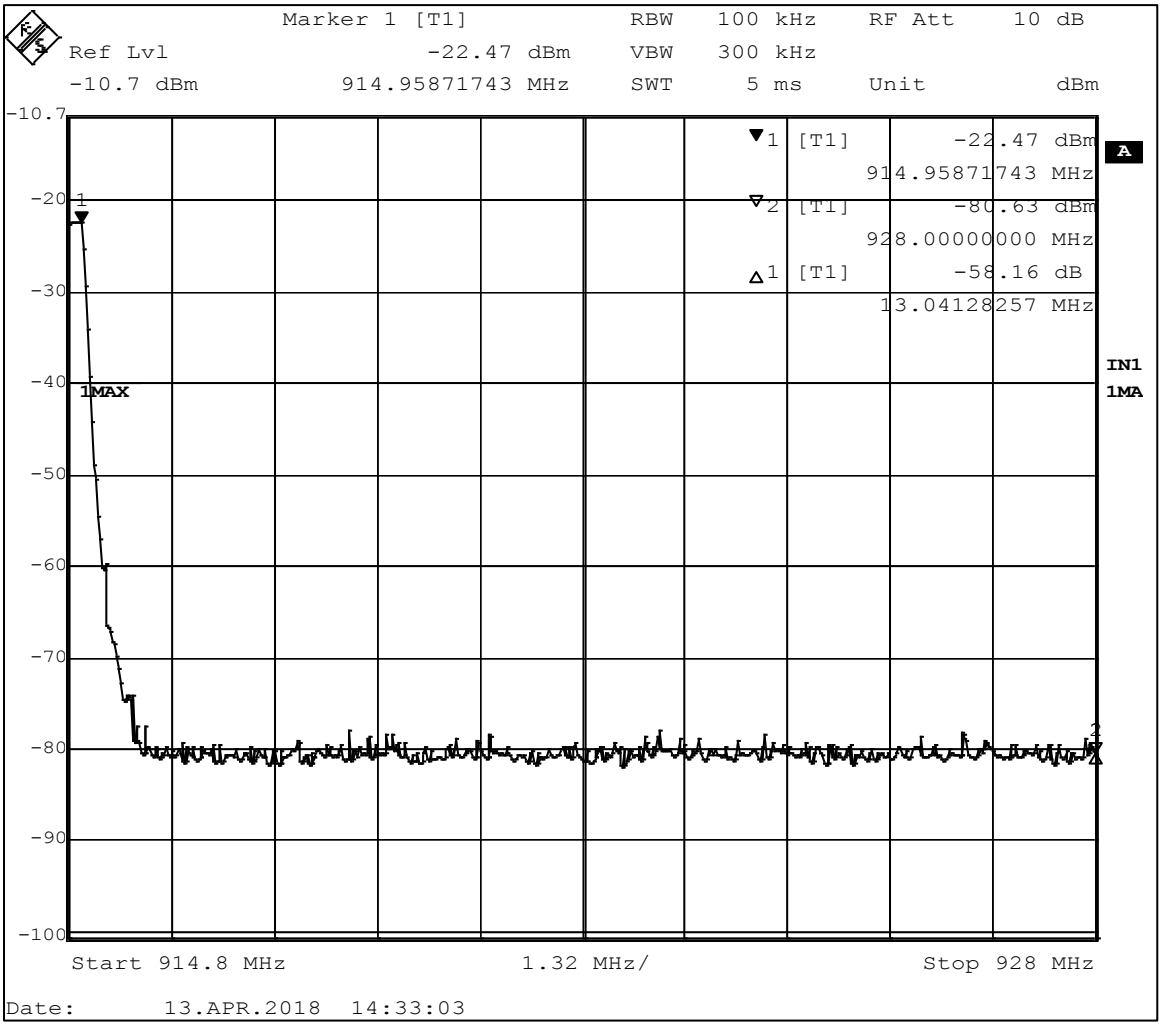

Figure 27 - Band-edge Measurement, High Channel, Unrestricted, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 58.16 dB > 20 dB minimum

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10, Section 11.10.2

Limits of power measurements:
The maximum PSD allowed is 8 dBm.

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

Test setup:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable on a bench top.

EUT operating conditions:
The EUT was powered by 6.4 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.

Test results:

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	Method	MAXIMUM POWER LIMIT (dBm)	RESULT
1	902.3	-0.45	Conducted	8.00	PASS
2	908.5	-0.68	Conducted	8.00	PASS
3	914.9	0.17	Conducted	8.00	PASS

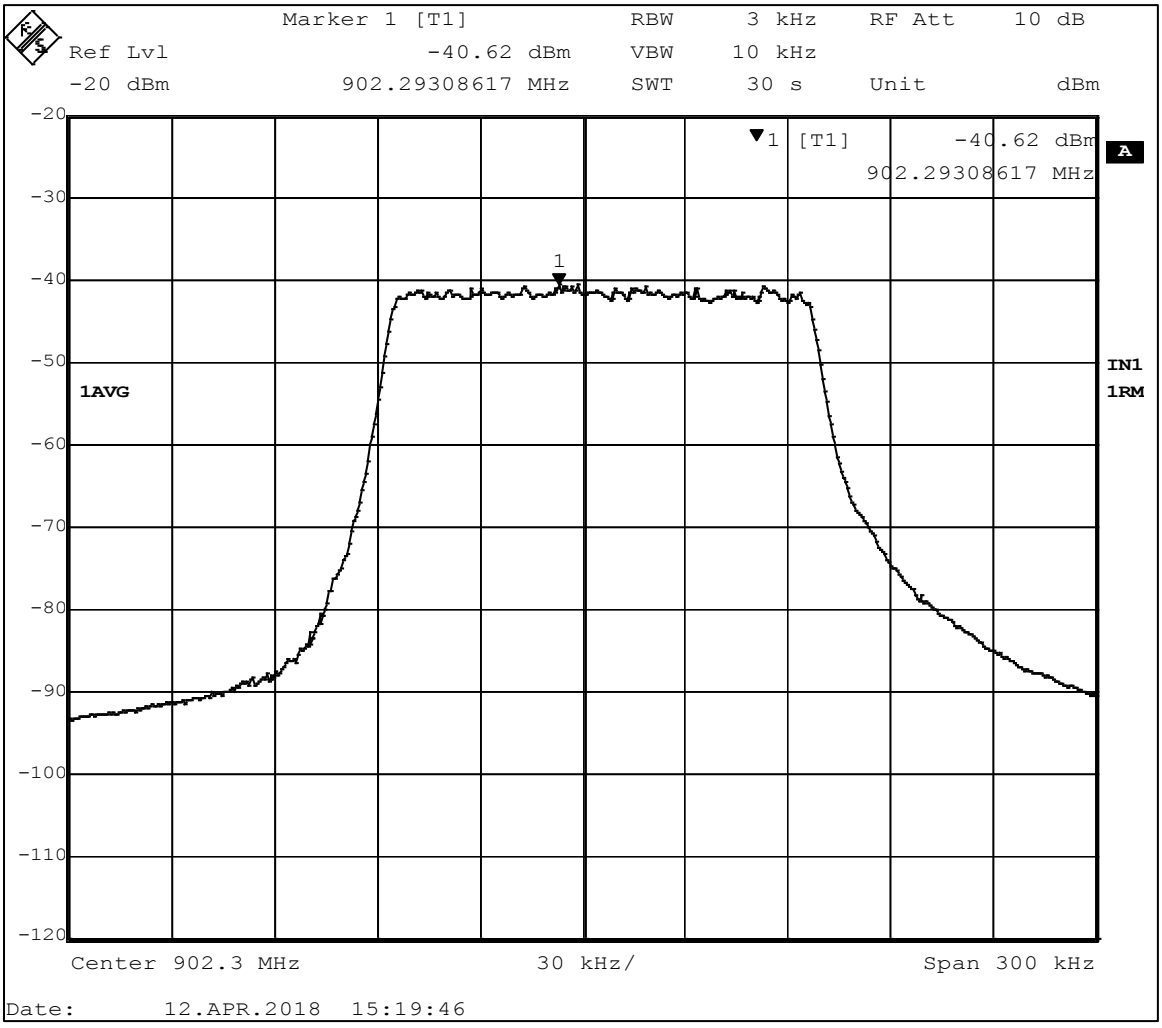

Figure 28 - Power Spectral Density, Low Channel

Maximum power = -40.62 dBm + 107 + CL + AF - 95.23 = -0.45 dBm

CL = cable loss = 4.70 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

20 dB BW = < 135 kHz
value was taken from estimating to closest 0.25 delineation and rounding up to over-estimate
30 kHz per delineation x (4 + 0.25 x 2) = 135 kHz

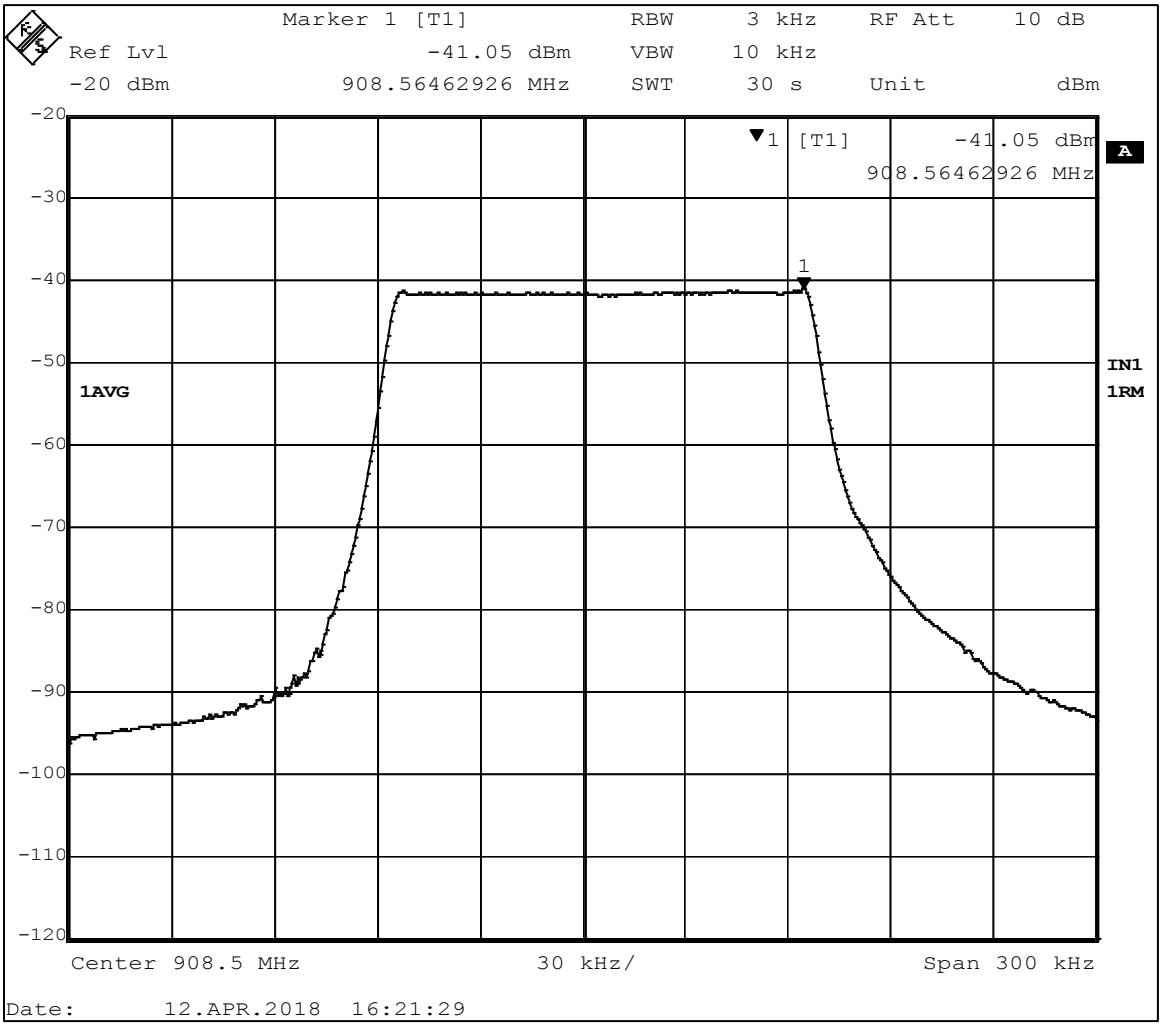

Figure 29 - Power Spectral Density, Mid Channel

Maximum power = -41.05 dBm + 107 + CL + AF - 95.23 = -0.68 dBm

CL = cable loss = 4.80 dB
AF = antenna factor = 23.80 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

20 dB BW = < 135 kHz
value was taken from estimating to closest 0.25 delineation and rounding up to over-estimate
30 kHz per delineation x (4 + 0.25 + 0.5) = 142.5 kHz

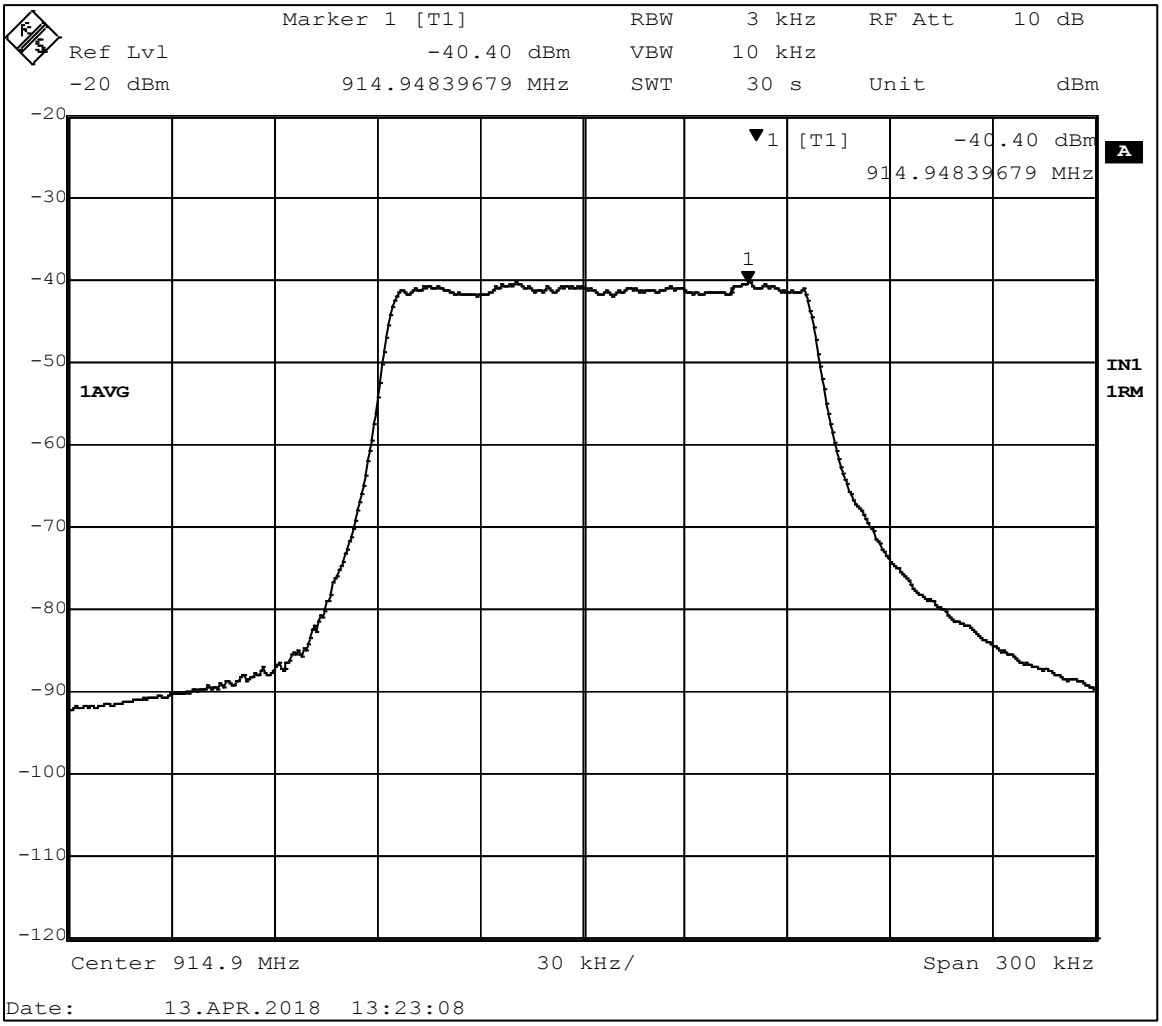

Figure 30 - Power Spectral Density, High Channel

Maximum power = -40.40 dBm + 107 + CL + AF - 95.23 = 0.17 dBm

CL = cable loss = 4.90 dB
AF = antenna factor = 23.90 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

20 dB BW = < 135 kHz
value was taken from estimating to closest 0.25 delineation and rounding up to over-estimate
30 kHz per delineation x (4 + 0.25 + 0.5) = 1342.5kHz

4.7 CARRIER FREQUENCY SEPERATION, NUMBER OF HOPPING CHANNELS, TIME OF OCCUPANCY

Test Method: ANSI C63.10, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy
The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.
Test procedures:
The method from FCC DA 00-705

Test setup:
All the measurements were done on the bench while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 6.4 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.

Test results:

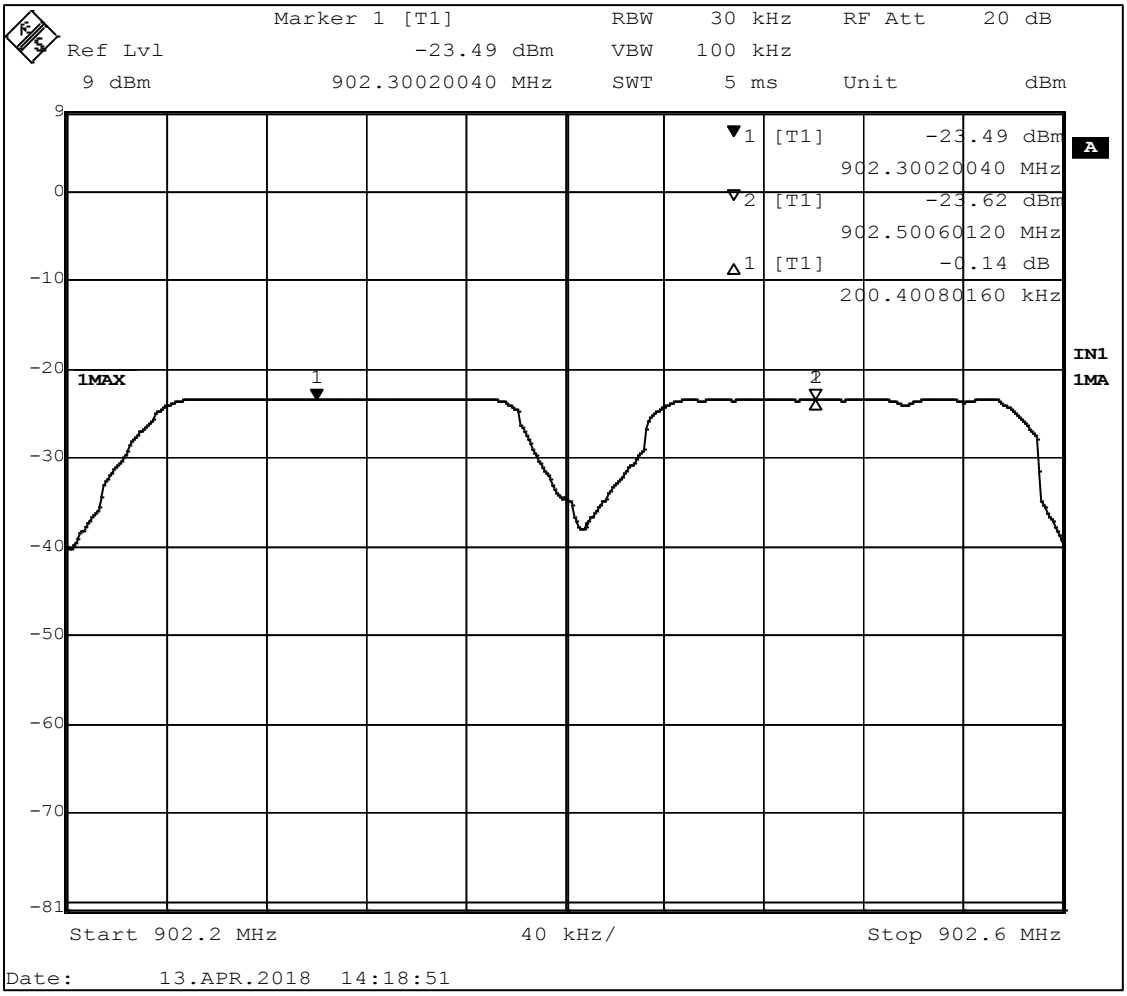

Figure 31 – Frequency Separation, 200.40 kHz

Channel separation (200.40 kHz) > 20 dB BW (142.5 kHz)

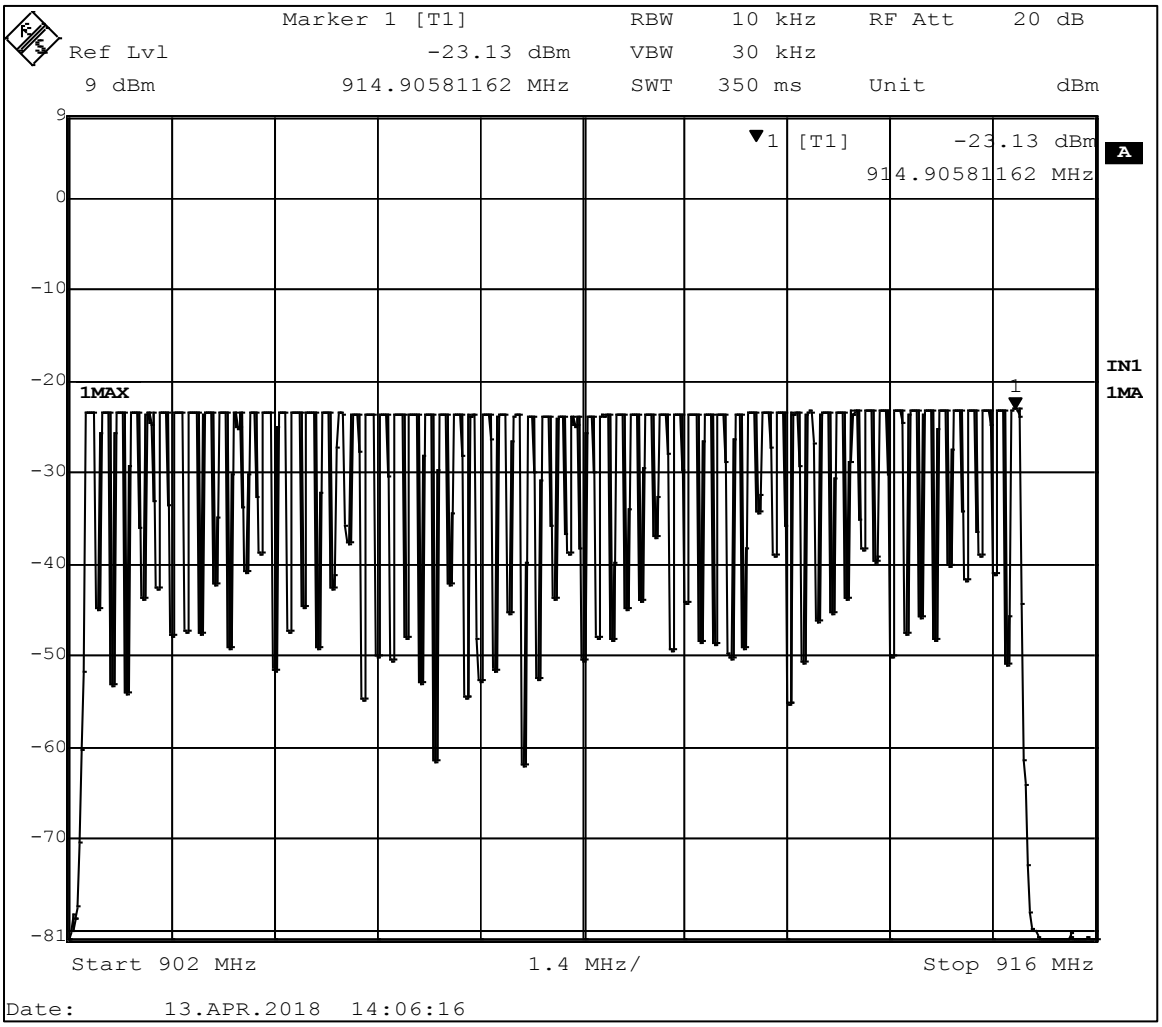

Figure 32 – Hop Count, 64 Hops

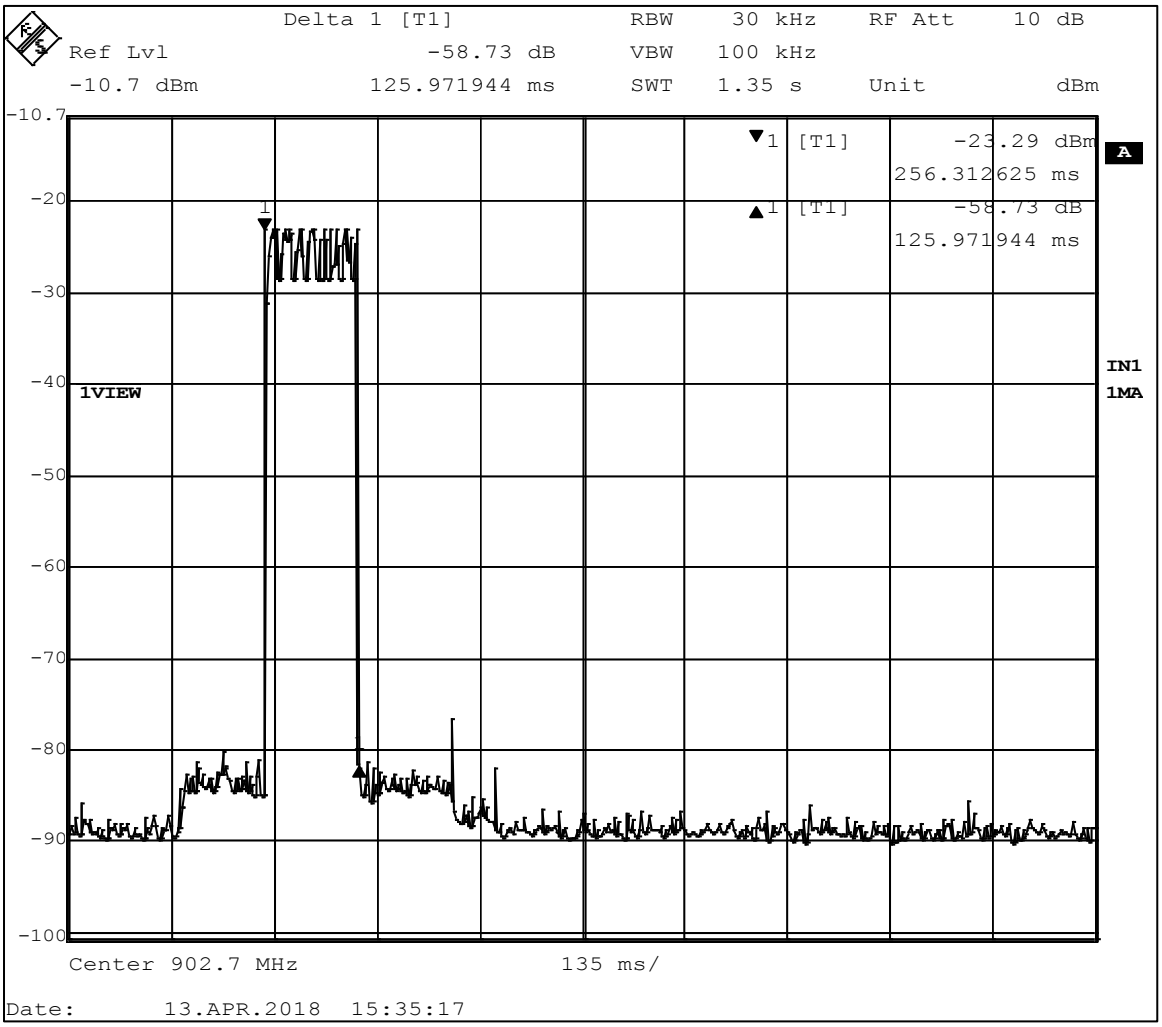

Figure 33 – Time of Occupancy, On Time

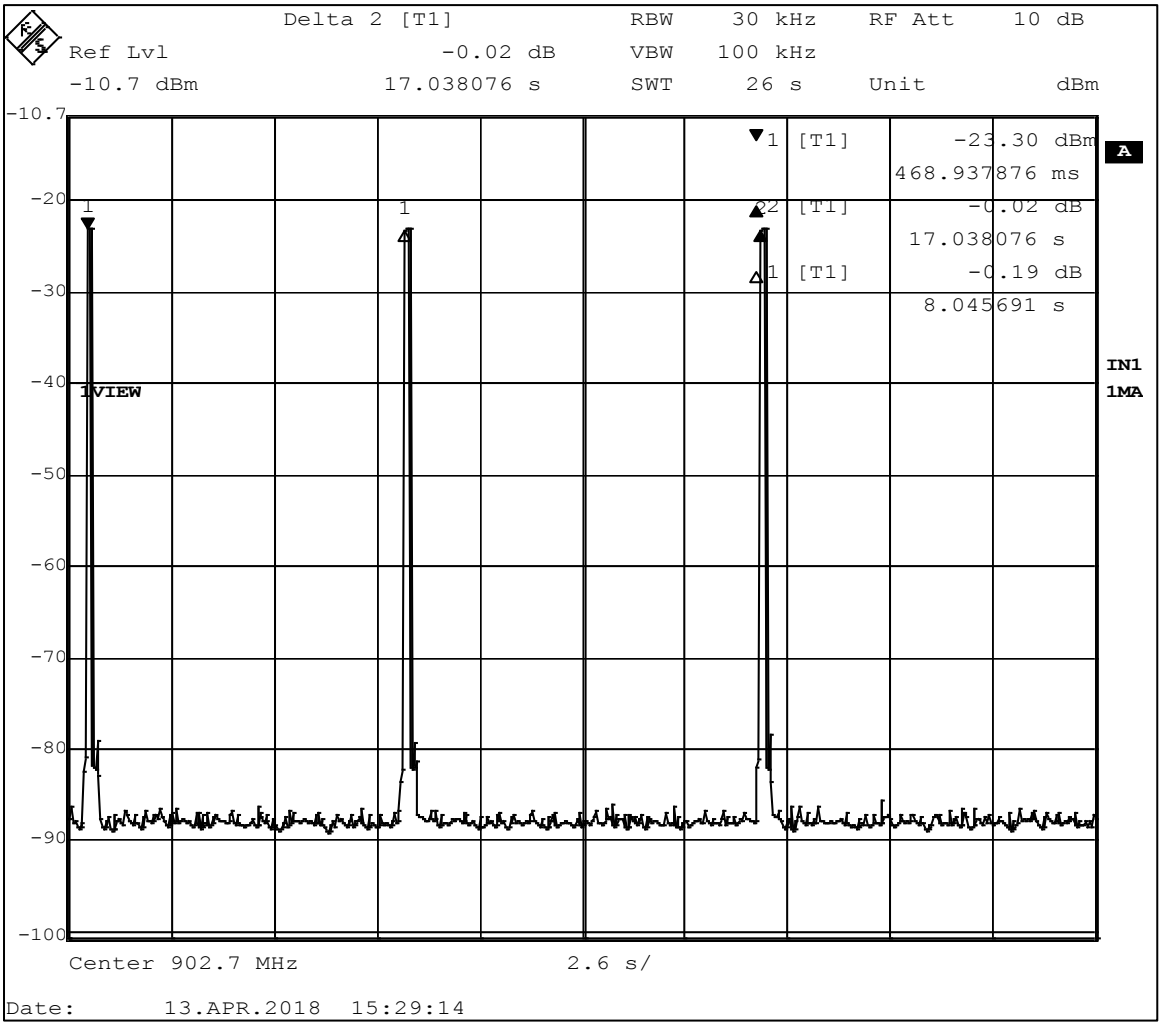

Figure 34 – Time of Occupancy, Period

*Maximum of 1 transmissions can occur in a given channel in any 10 s so the average time of occupancy is 125.97 ms = 0.13% over 10 seconds < 0.4 s – Pass

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