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Amended

FCC/ISED Test Report

Prepared for: **Inovonics**

Address: **397 S. Taylor Ave.**
Louisville, CO 80027

Product: **TRM module**

Test Report No: **R20180316-21-03E**

Approved by:

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

DATE: **15 October 2019**

Total Pages: **53**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	1 October 2019	Original – NJohnson Prepared by KVepuri
A	2 October 2019	Corrected description in Section 4.3 Includes NCEE Labs report R20180316-21-03 and its amendment in full. -NJ
B	2 October 2019	Corrected description in Section 4.1 Includes NCEE Labs report R20180316-21-03A and its amendment in full. -NJ
C	4 October 2019	Corrected description in Section 4.1 Includes NCEE Labs report R20180316-21-03B and its amendment in full. -NJ
D	4 October 2019	Removed references to duty cycle measurements. Includes NCEE Labs report R20180316-21-03C and its amendment in full. -NJ
E	15 October 2019	Includes NCEE Labs report R20180316-21-03D and its amendment in full. -NJ

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 4
(3) ISED RSS-247, Issue 2

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	PCB antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	Pass	Pulsed emissions duty cycle was applied
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	NA	The EUT has no receiver functionality
FCC 15.247(a)(1)(i) RSS-247, 5.1(c)	Minimum Bandwidth, Limit: Min. 250kHz	Pass	Meets the requirement of the limit.
FCC 15.247(b)(1) RSS-247, 5.1	Maximum Peak Output Power, Limit: Max. 24 dBm	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-247, 5.5	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency hopping system, Limit: Max. 0.4 Seconds in 10 Second Period	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205 RSS-Gen, 8.9 RSS-247, 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	Pass	Meets the requirement of the limit.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless FHSS transmitter. It has transmit capabilities only.

EUT	TRM module
EUT Received	4/2/2018
EUT Tested	4/2/2018 - 4/4/2018, 8/6/2019 (conducted emissions), 9/24/2019 (Output Power)
Serial No.	NCEETEST1 (Assigned by the laboratory)
Operating Band	902.0 – 928.0 MHz
Device Type	FHSS
Power Supply	3 VDC Battery (CR123A)

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	902.4
Middle	914.8
High	927.6

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

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	EMC Test Engineer	Testing
3	Nic Johnson	Technical Manager	Review of Results

Notes:
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020
Rohde & Schwarz Test Receiver	ES17	100007	31 Jul 2017	30 Jan 2020
Keysight EXA Signal Analyzer**	9010A	MY56070862	14 Dec 2018	14 Dec 2020
EMCO Biconilog Antenna	3142B	1647	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3115	6416	31 Jan 2018	31 Jan 2020
EMCO Horn Antenna	3116	2576	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	26 Jul 2018	26 Jul 2019
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	NA	NA
Rohde & Schwarz LISN	ESH3-Z5	836679/010	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz Test Software	ES-K1	12575	09 Mar 2018*	09 Mar 2020*
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	26 Jan 2018	26 Jan 2020
N connector bulkhead (control room)	PE9128	NCEEBH2	31 Jan 2018	31 Jan 2020

*Internal Characterization **Used for output power measurements on Sept 30, 2019

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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Since the device featured pulsed emissions, a duty cycle correction factor was applied to peak measurements to calculate the average measurement per ANSI C63.10-2013, Section 7.5.

The manufacturer has declared that the highest possible duty cycle within any 100ms window as defined in FCC Part 15.35 is 22%. The Duty Cycle Correction Factor is calculated to be 20*log(0.22) = **-13.15 dB**

See the Operational Description for details as well as Figures 25 and 26.

4.2 RADIATED EMISSIONS

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

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

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:

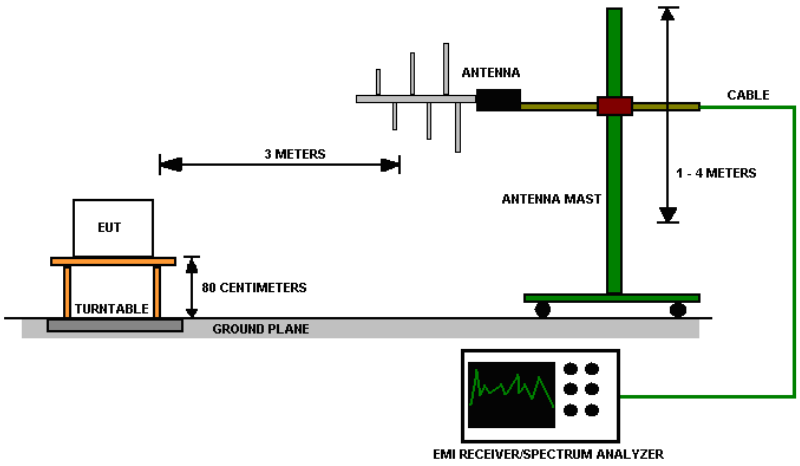


Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 3 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:

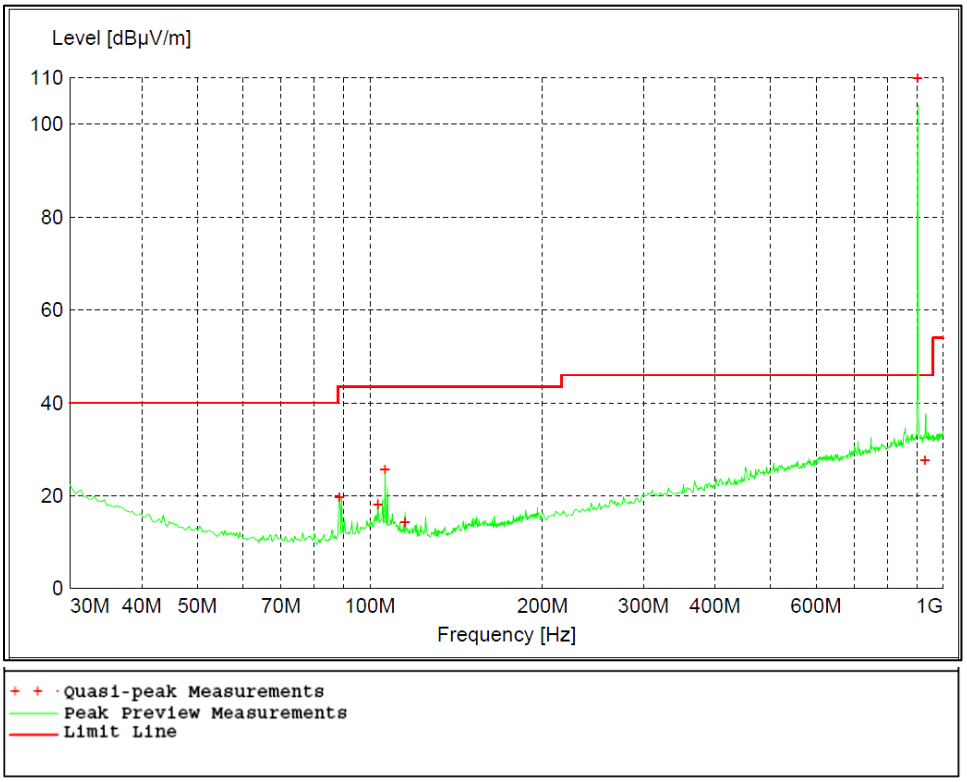


Figure 2 - Radiated Emissions Plot, Low Channel

Table 1 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
88.500000	19.54	43.50	24.00	155	323	HORI	X
103.320000	17.98	43.50	25.50	141	0	HORI	X
106.260000	25.62	43.50	17.90	118	207	HORI	X
115.200000	14.17	43.50	29.40	100	360	VERT	X
902.400000	109.75	NA	NA	100	322	HORI	X
930.120000	27.53	46.00	18.50	257	0	HORI	X

Table 2 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	50.69	54.00	3.31	187	155	HORI	X
2707.200000	47.78	54.00	6.22	100	283	HORI	X
3609.600000	32.14	54.00	21.86	100	134	HORI	X
4518.600000	26.85	54.00	27.15	389	0	VERT	X
5414.400000	35.16	54.00	18.84	99	246	VERT	X
6317.000000	33.64	54.00	20.36	99	217	HORI	X

Note: Average Level = Peak Level – Duty Cycle Correction Factor

Table 3 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	63.84	74.00	10.16	187	155	HORI	X
2707.200000	60.93	74.00	13.07	100	283	HORI	X
3609.600000	45.29	74.00	28.71	100	134	HORI	X
4518.600000	40.00	74.00	34.00	389	0	VERT	X
5414.400000	48.31	74.00	25.69	99	246	VERT	X
6317.000000	46.79	74.00	27.21	99	217	HORI	X

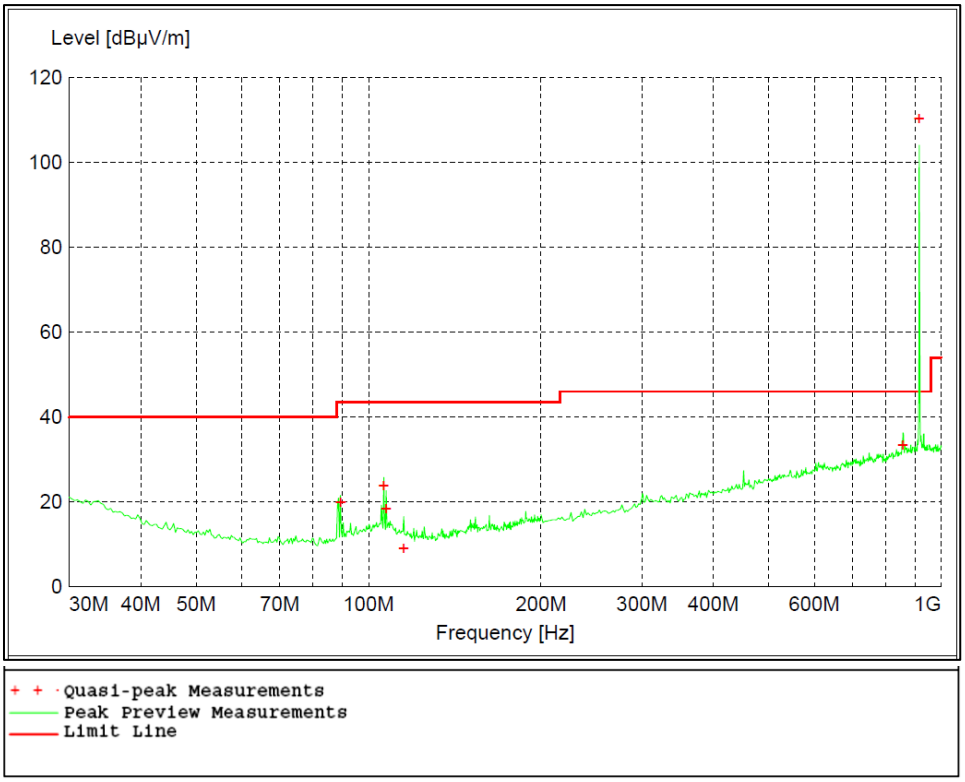


Figure 3 - Radiated Emissions Plot, Mid Channel

Table 4 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
89.340000	19.92	43.50	23.60	399	319	VERT	X
106.260000	23.83	43.50	19.70	100	121	VERT	X
107.340000	18.40	43.50	25.10	99	94	HORI	X
115.200000	8.92	43.50	34.60	100	264	VERT	X
857.220000	33.44	46.00	12.60	193	360	VERT	X
914.800000	110.33	NA	NA	100	223	HORI	X

Table 5 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1829.600000	50.85	54.00	3.15	187	150	HORI	X
2744.400000	45.55	54.00	8.45	100	290	HORI	X
3659.200000	35.08	54.00	18.92	99	263	HORI	X
4574.000000	32.09	54.00	21.91	100	121	HORI	X
5488.800000	36.91	54.00	17.09	99	130	HORI	X
6403.600000	37.20	54.00	16.80	100	140	VERT	X
7342.000000	29.79	54.00	24.21	99	309	HORI	X
8247.000000	31.86	54.00	22.14	264	134	VERT	X
9174.800000	31.96	54.00	22.04	114	126	VERT	X

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 13.14dB was used.

Table 6 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1829.600000	64.00	74.00	10.00	187	150	HORI	X
2744.400000	58.70	74.00	15.30	100	290	HORI	X
3659.200000	48.23	74.00	25.77	99	263	HORI	X
4574.000000	45.24	74.00	28.76	100	121	HORI	X
5488.800000	50.06	74.00	23.94	99	130	HORI	X
6403.600000	50.35	74.00	23.65	100	140	VERT	X
7342.000000	42.94	74.00	31.06	99	309	HORI	X
8247.000000	45.01	74.00	28.99	264	134	VERT	X
9174.800000	45.11	74.00	28.89	114	126	VERT	X

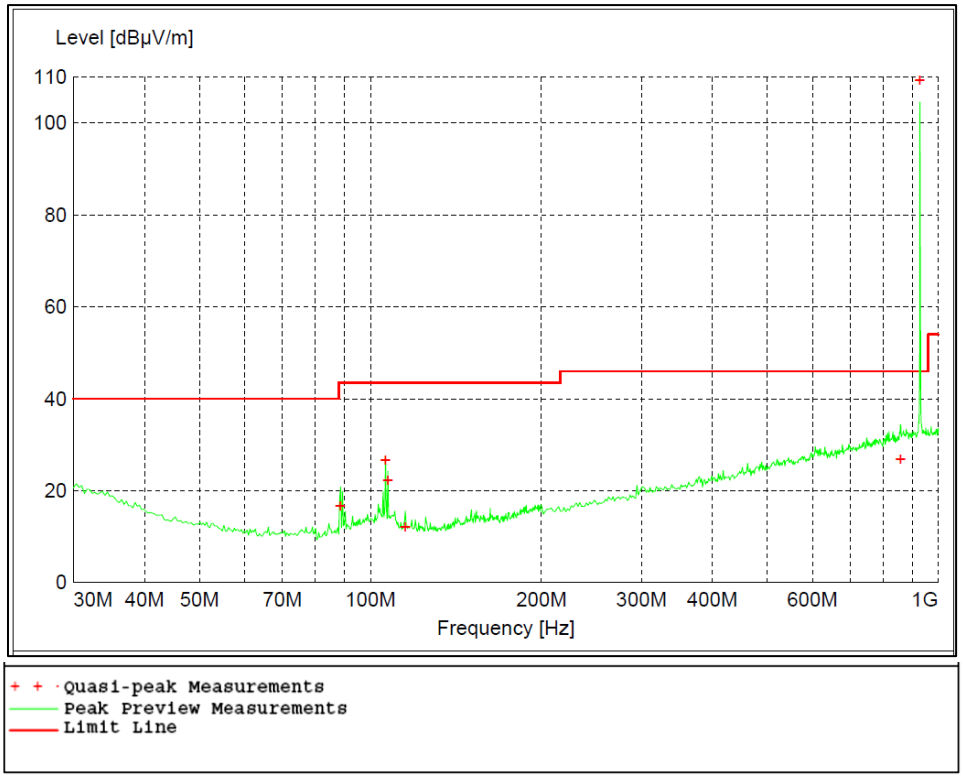


Figure 4 - Radiated Emissions Plot, High Channel

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	16.57	43.50	27.00	384	0	HORI	X
106.260000	26.62	43.50	16.90	100	217	HORI	X
107.340000	22.20	43.50	21.30	367	197	HORI	X
115.140000	12.10	43.50	31.40	100	299	VERT	X
857.700000	26.78	46.00	19.20	396	51	HORI	X
927.600000	109.23	NA	NA	100	59	HORI	X

Table 8 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	47.37	54.00	6.63	99	216	HORI	X
2782.800000	45.98	54.00	8.02	183	290	HORI	X
3710.400000	41.77	54.00	12.23	224	265	HORI	X
4638.000000	30.16	54.00	23.84	100	115	HORI	X
5565.600000	42.36	54.00	11.64	136	131	HORI	X
6493.200000	35.66	54.00	18.34	187	134	VERT	X
7420.800000	32.63	54.00	21.37	100	236	VERT	X
8335.400000	31.89	54.00	22.11	176	48	HORI	X
9279.800000	31.39	54.00	22.61	137	197	VERT	X

Note: Average Level = Peak Level – Duty Cycle Correction Factor

Table 9 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	60.52	74.00	13.48	99	216	HORI	X
2782.800000	59.13	74.00	14.87	183	290	HORI	X
3710.400000	54.92	74.00	19.08	224	265	HORI	X
4638.000000	43.31	74.00	30.69	100	115	HORI	X
5565.600000	55.51	74.00	18.49	136	131	HORI	X
6493.200000	48.81	74.00	25.19	187	134	VERT	X
7420.800000	45.78	74.00	28.22	100	236	VERT	X
8335.400000	45.04	74.00	28.96	176	48	HORI	X
9279.800000	44.54	74.00	29.46	137	197	VERT	X

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.
6. The worst case spurious were repeated on the unit without the screws and found to be lower. So, the worst case spurious were reported.

4.3 PEAK OUTPUT POWER

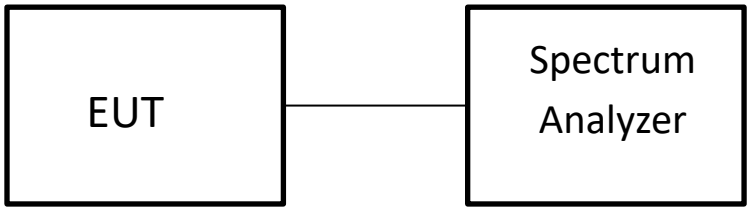
Test Method: ANSI C63.10, Section(s) 7.8.5

Limits of power measurements:
For an FHSS system with 25 channels, the output power is required to be less than 250 mW or 24 dBm.

Test procedures:
The EUT was connected to a spectrum analyzer directly with a low-loss shielded coaxial cable with 1 MHz RBW and 3 MHz VBW. .

Deviations from test standard:
No deviation.

Test setup:



EUT operating conditions:
The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in indicated modulation.

EUT operating conditions:
The EUT was powered by 3 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 POWER OUTPUT (dBm)	Method	RESULT
Low	902.4	18.016	Conducted	PASS
Middle	914.8	17.832	Conducted	PASS
High	927.6	17.641	Conducted	PASS

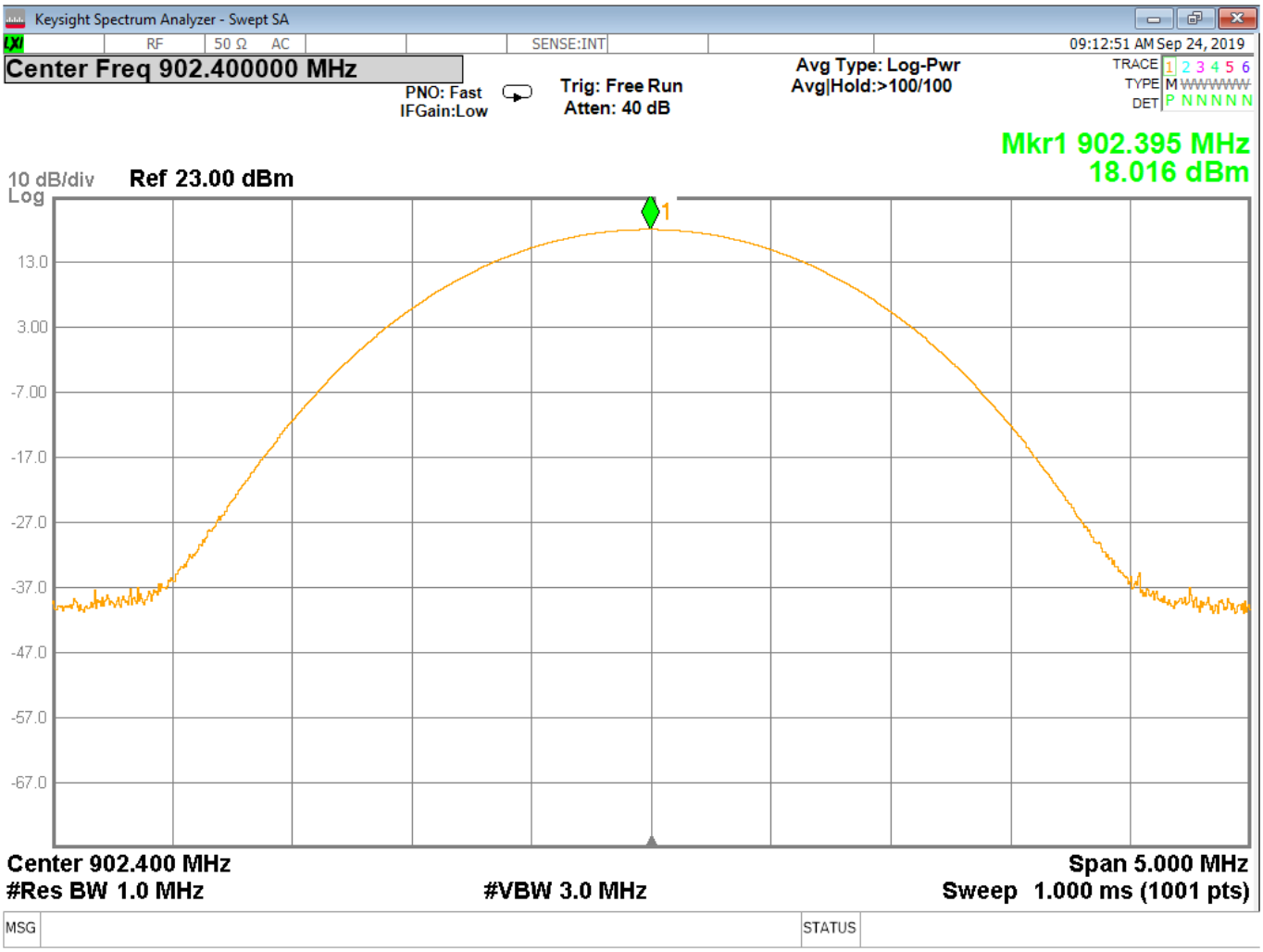


Figure 5 – Output Power, Low Channel

Output power = 18.016 dBm

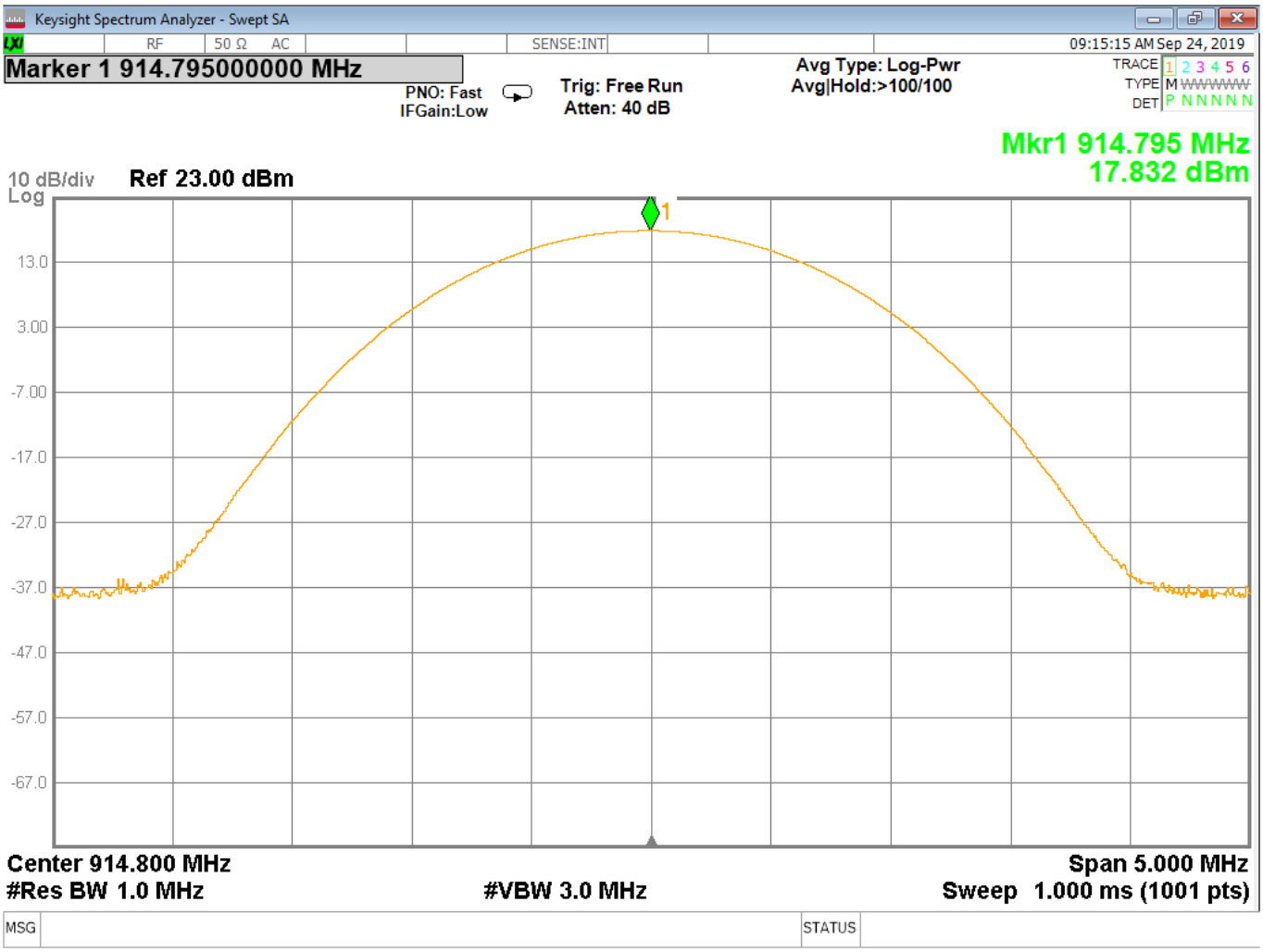


Figure 6 - Output Power, Mid Channel

Output power = 17.832 dBm

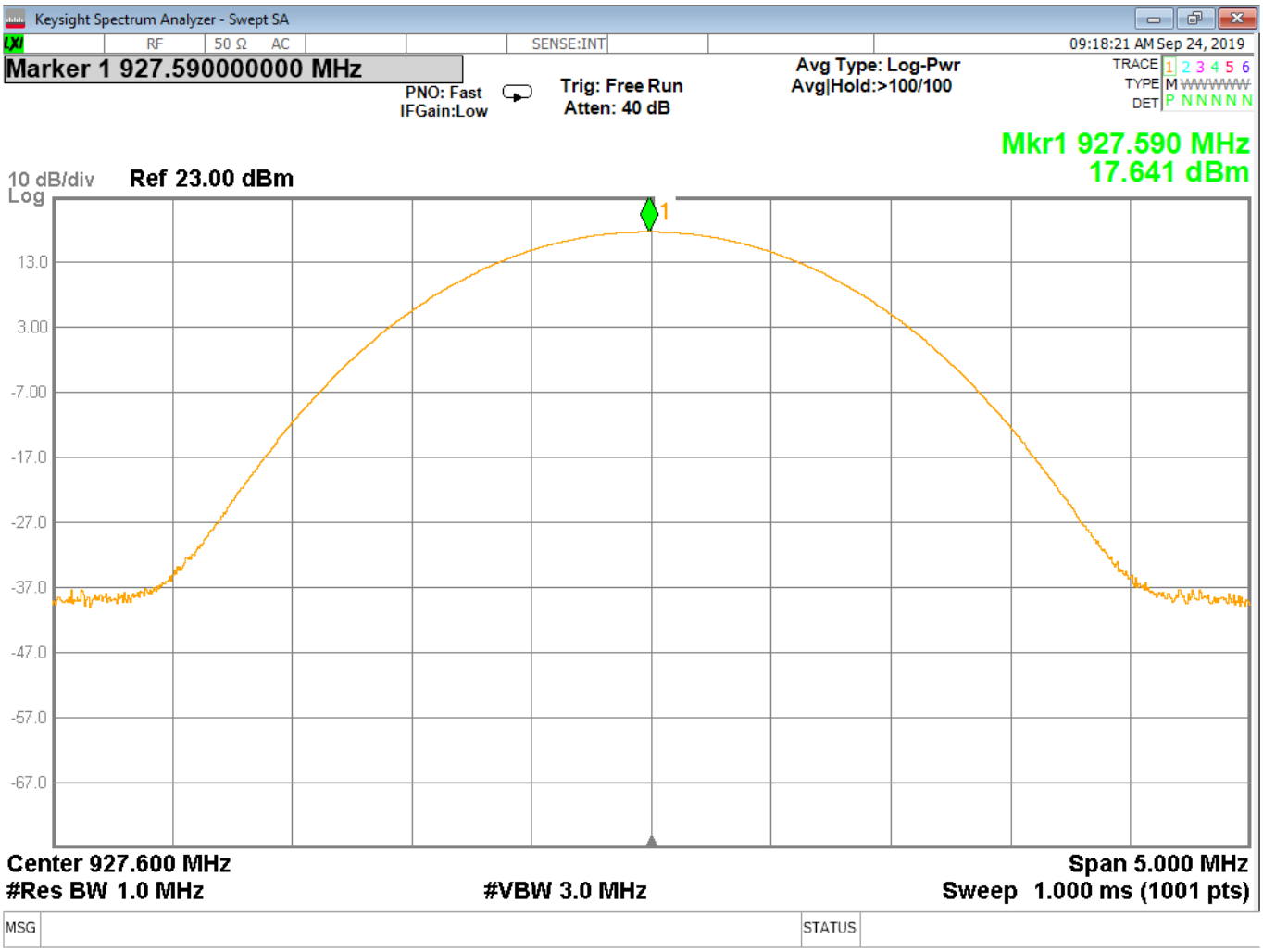


Figure 7 - Output Power, High Channel

Output power = 17.641 dBm

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 6.9.2

Limits of bandwidth measurements:
From FCC Part 15.247 (1) (i) and RSS-247 5.1(c)

The minimum allowed 20 dB bandwidth of the hopping channel is 250 kHz.

Test procedures:
Bandwidth measurement was taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 3 kHz RBW and 10 kHz VBW.

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

Test setup:

All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually. See Section 4.3 for more details.

Deviations from test standard:
No deviation.

Test setup:

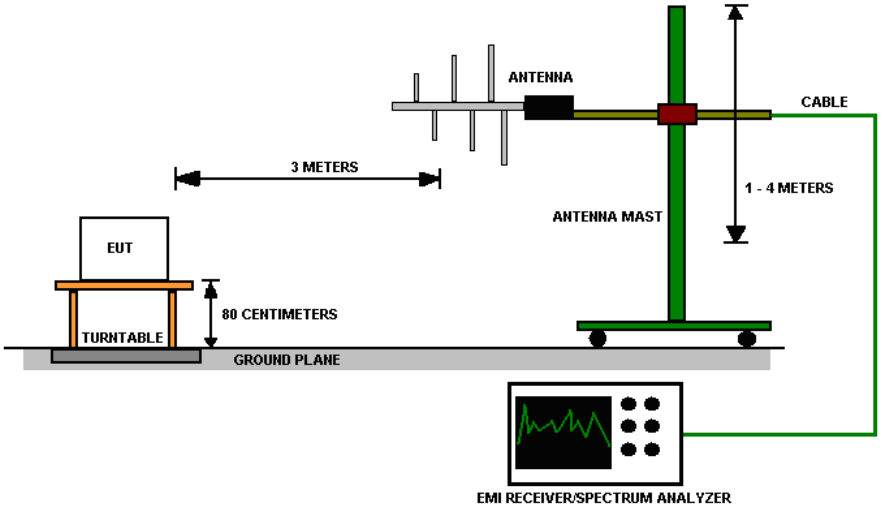


Figure 8 - Bandwidth Measurements Test Setup

EUT operating conditions:
The EUT was powered by 3 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:

20 dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	20dB BW (kHz)
Low	902.4	256.51
Mid	914.8	256.51
High	927.6	254.51

Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	20dB BW (kHz)
Low	902.4	250.50
Mid	914.8	252.51
High	927.6	250.50

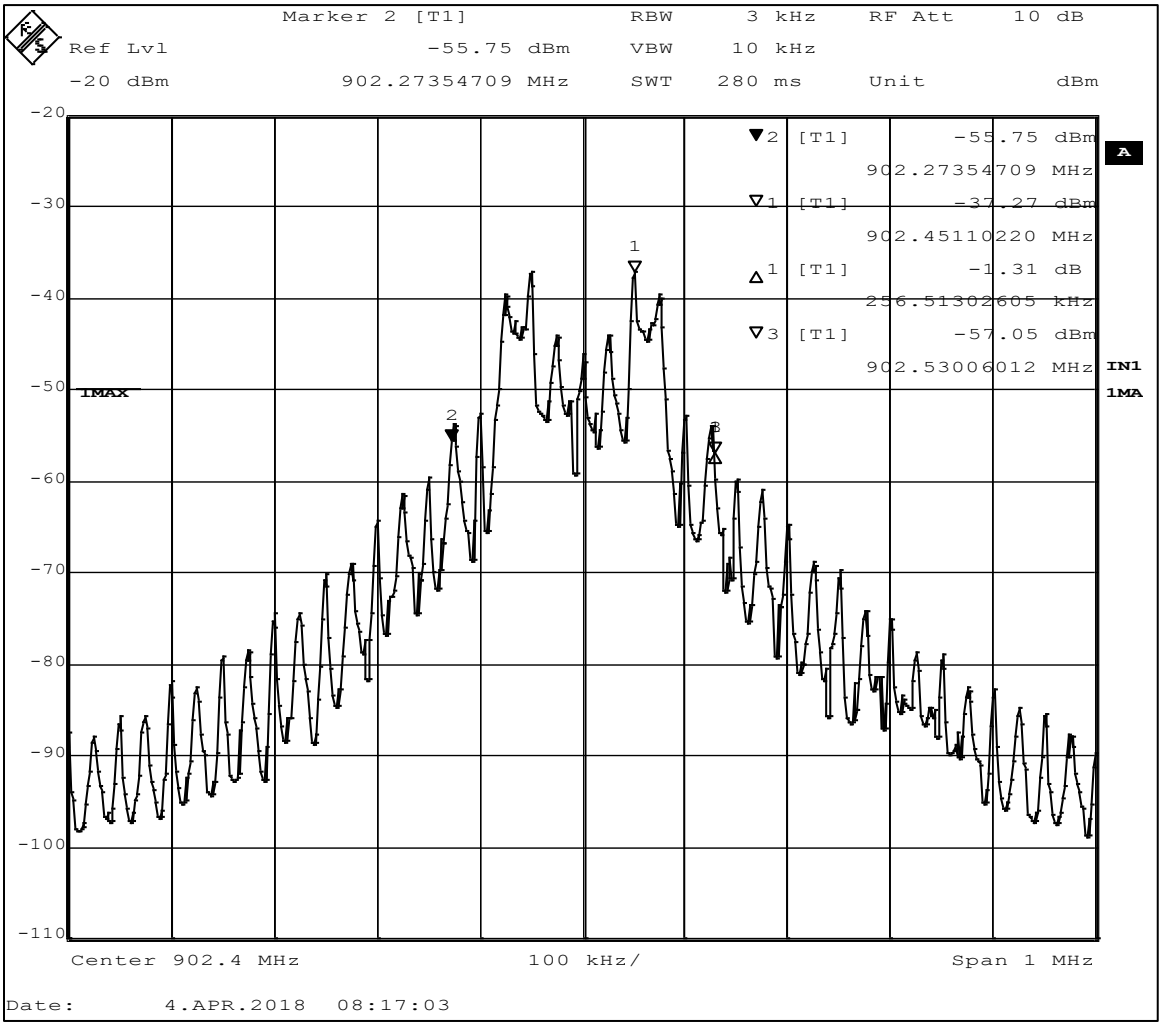


Figure 9 – 20 dB Bandwidth, Low Channel. 256.51 kHz

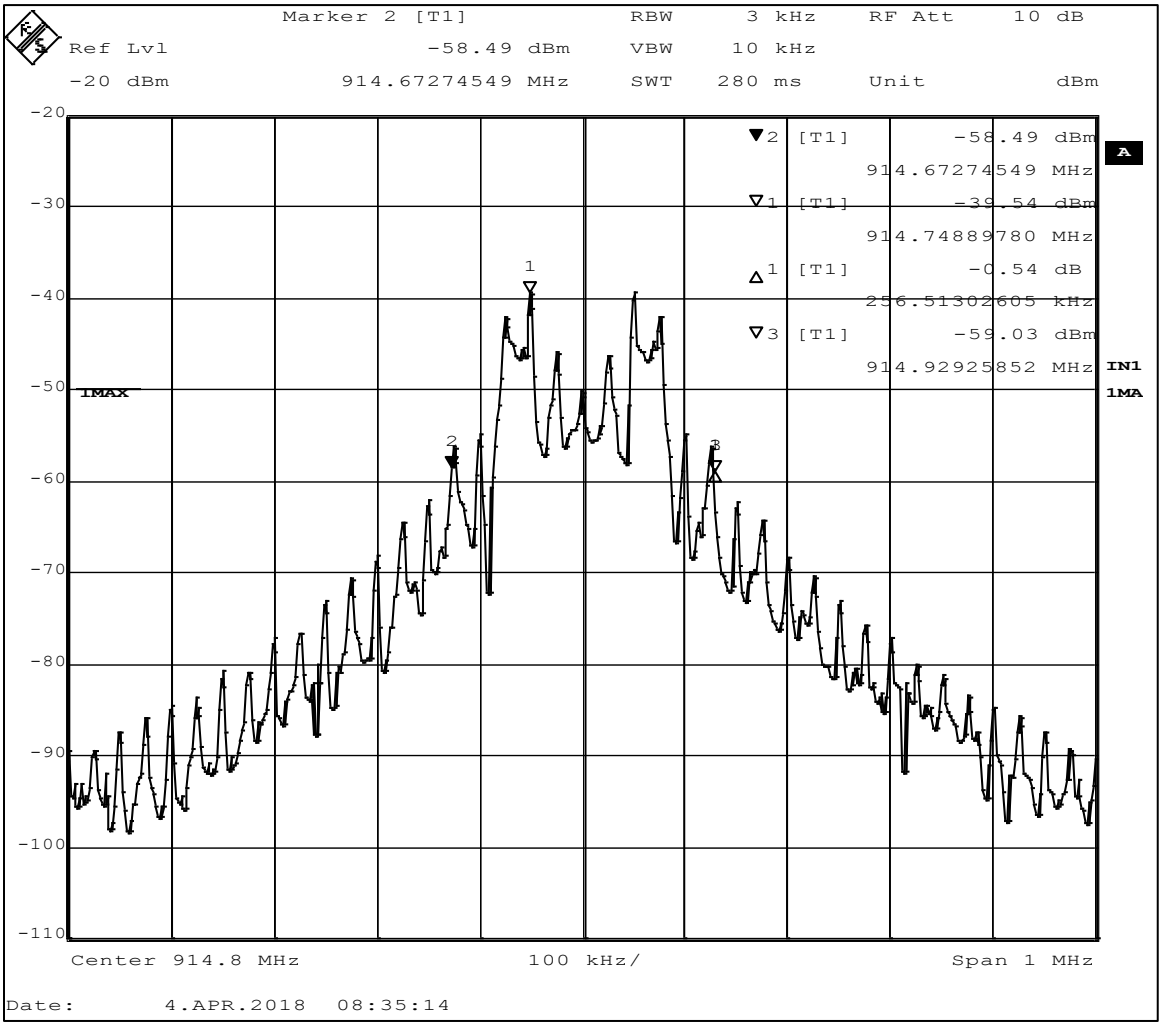


Figure 10 - 20 dB Bandwidth, Mid Channel, 256.51 kHz

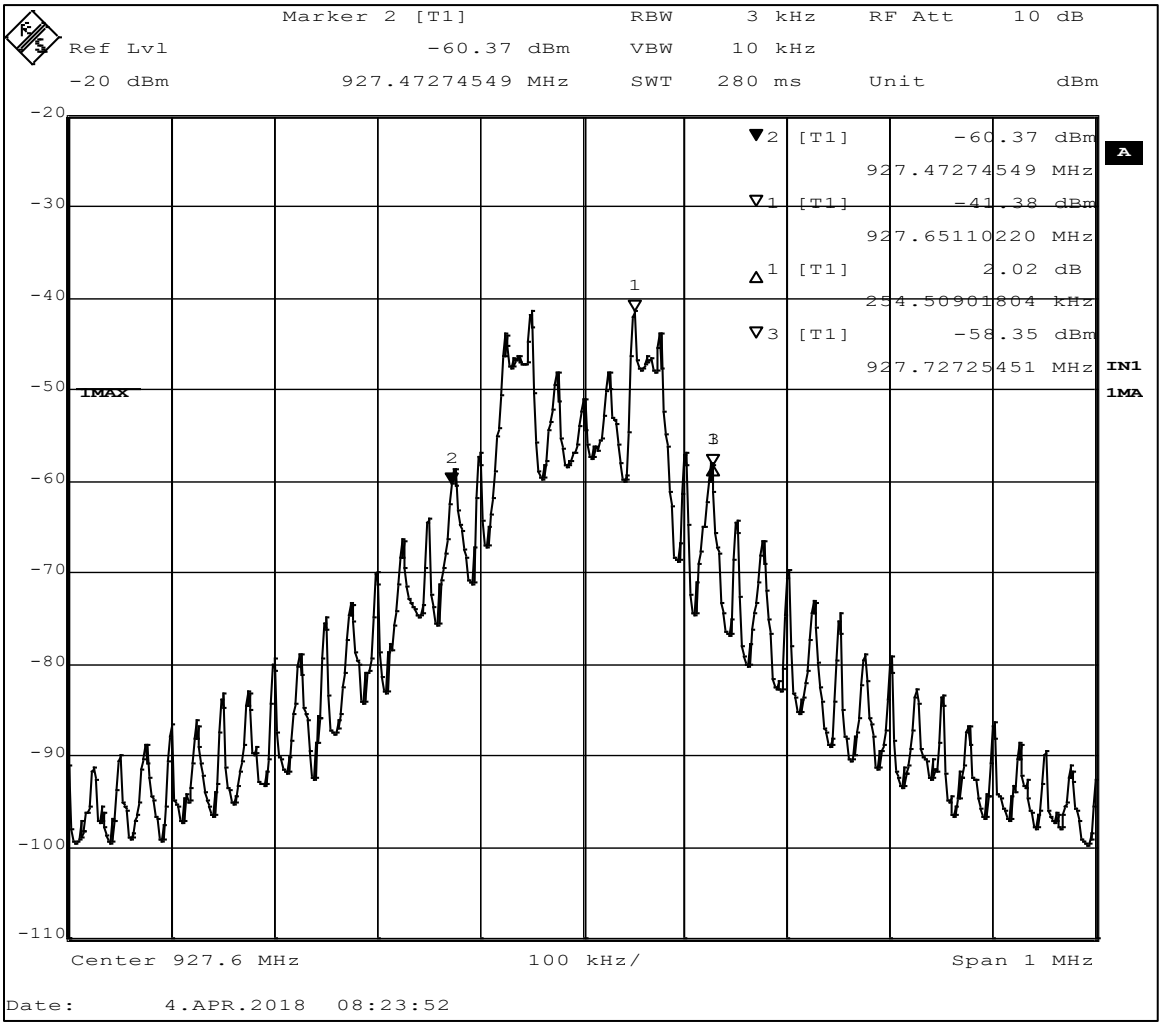


Figure 11 - 20 dB Bandwidth, High Channel, 254.51 kHz

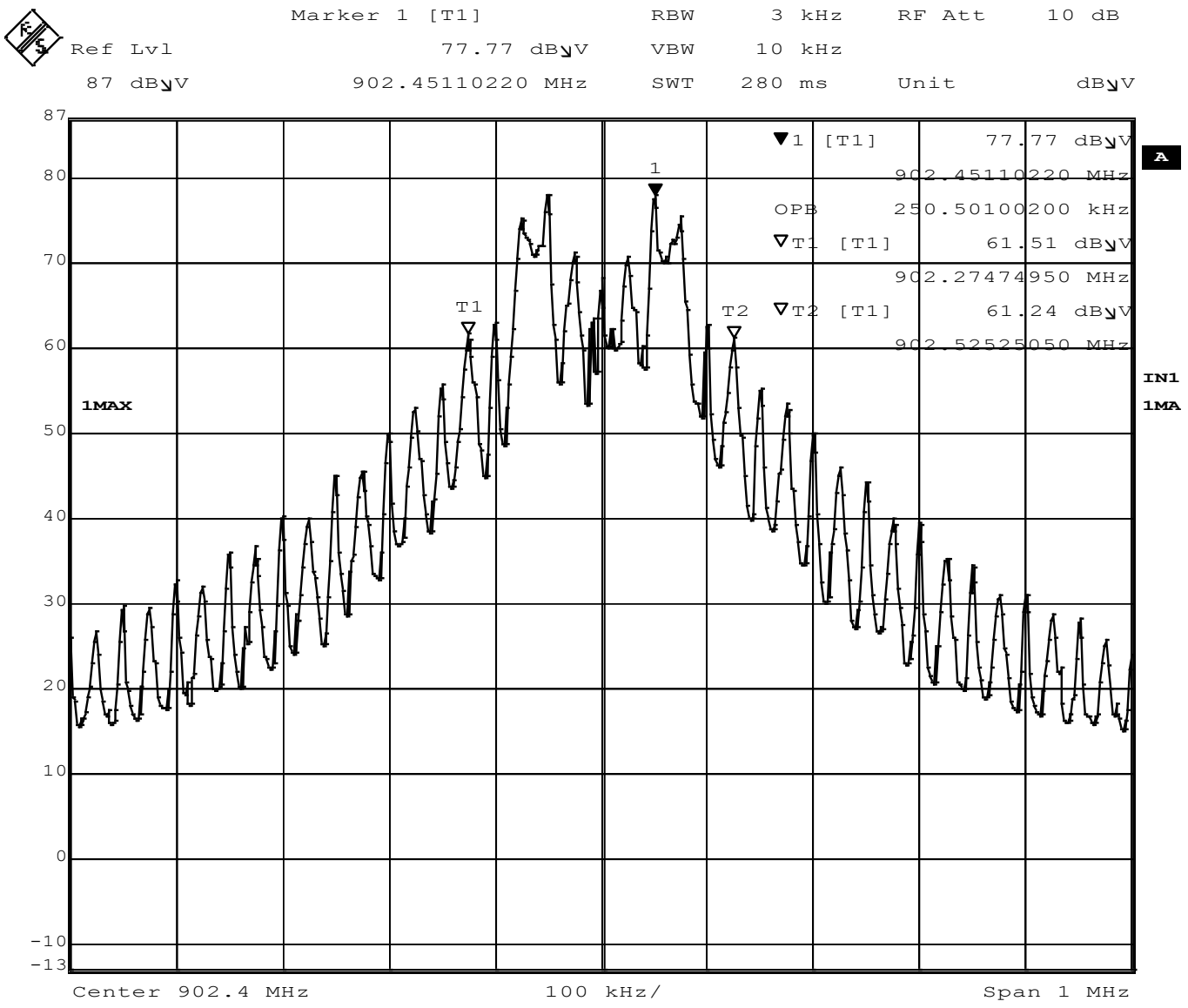


Figure 12 – Occupied Bandwidth, Low Channel. 250.50 kHz

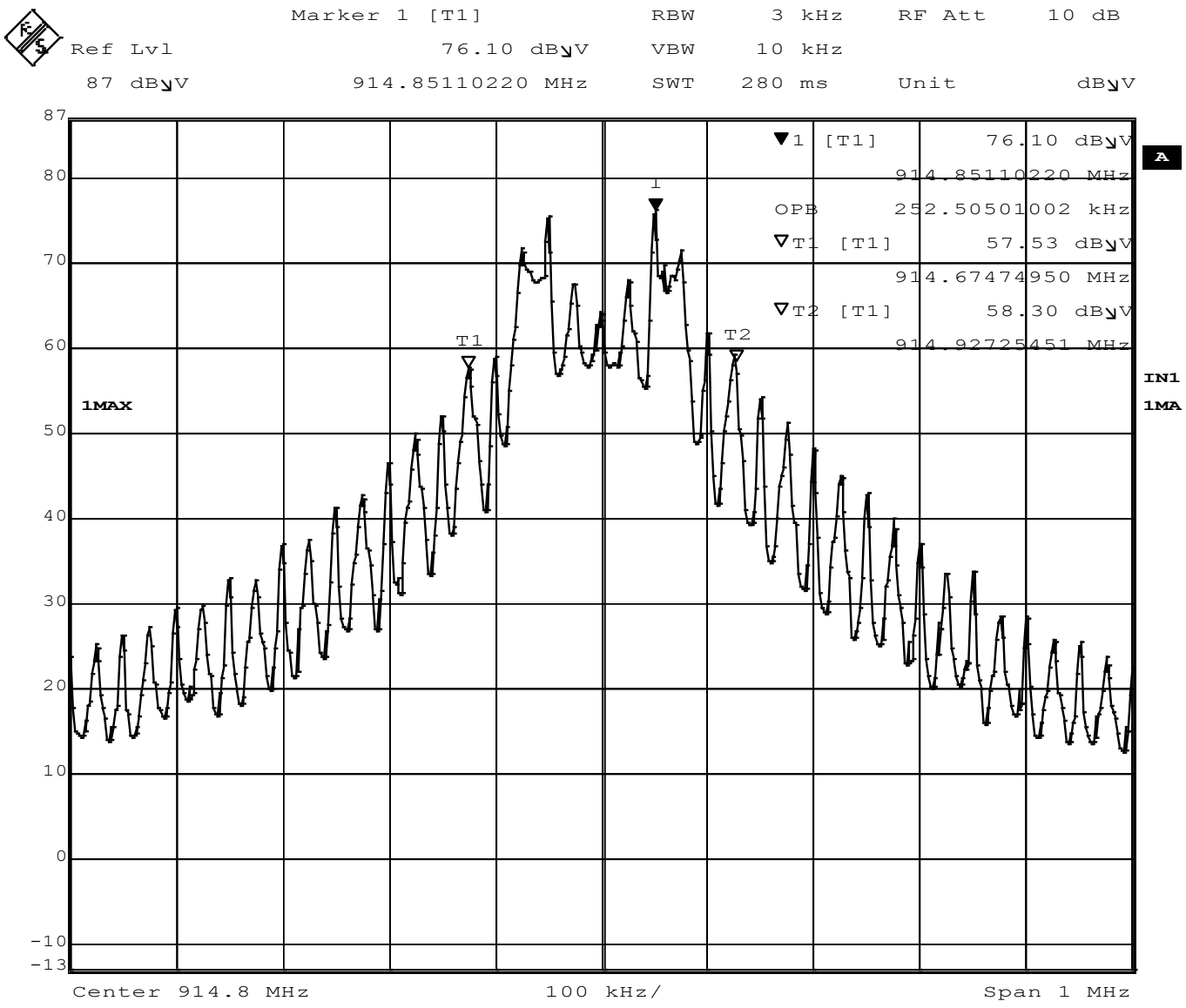


Figure 13 – Occupied Bandwidth, Mid Channel, 252.51 kHz

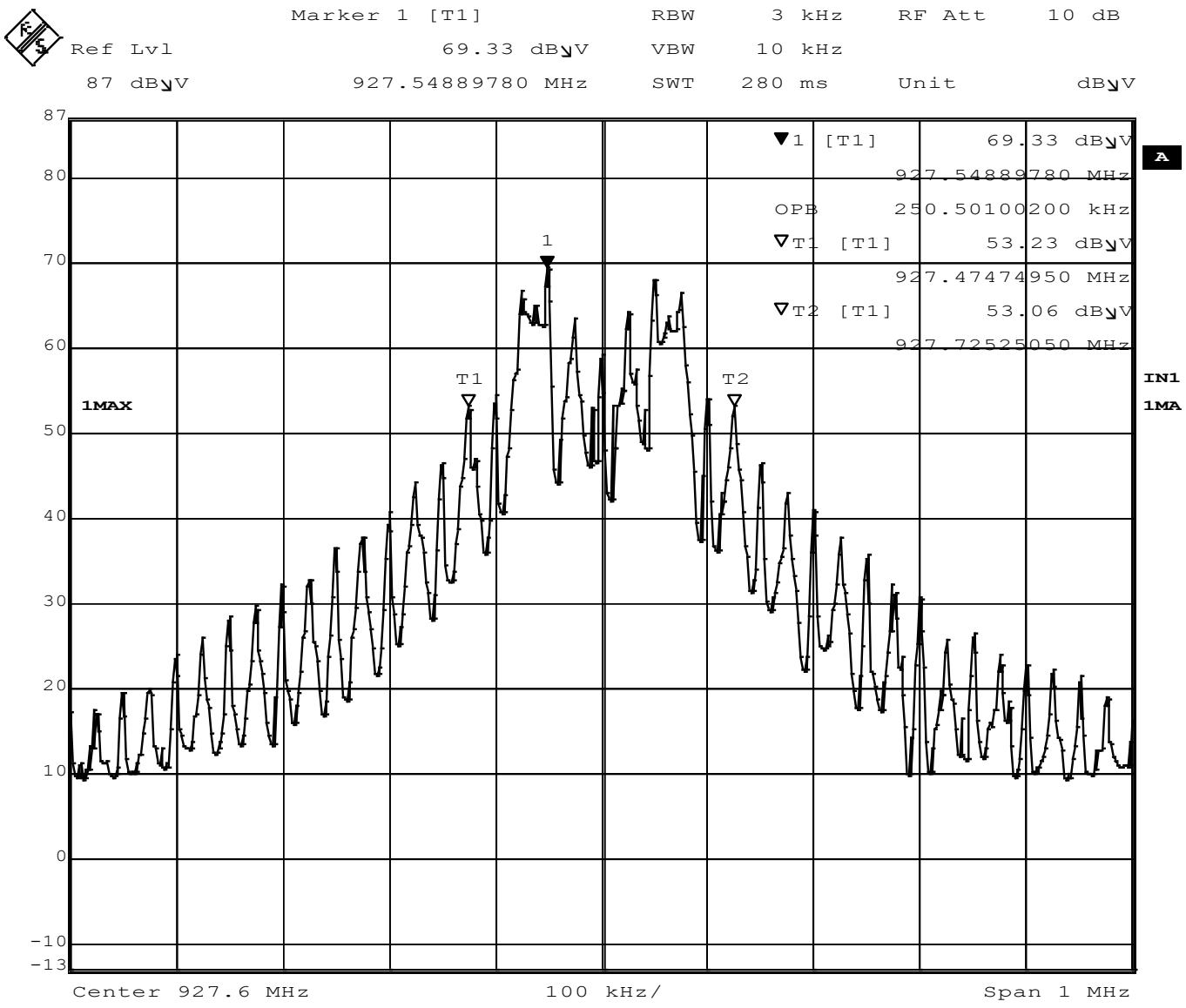


Figure 14 - Occupied Bandwidth, High Channel, 250.50 kHz

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 3 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

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	-102.12	-31.42	70.88	63.75	PASS
High, Continuous	960.0	-101.89	-35.46	66.43	63.23	PASS
Low Hopping	614.0	-101.44	-31.51	88.94	63.75	PASS
High, Hopping	960.0	-101.88	-35.53	69.93	63.23	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 902.4MHz for low channel = 109.75 dBµV/m
Fundamental average field strength at 927.6MHz for high channel = 109.23 dBµV/m

Low channel minimum delta = 109.75 – 46.0 dBµV/m = 63.75 dBc
High channel minimum delta = 109.23 – 46.0 dBµV/m = 63.23 dBc

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

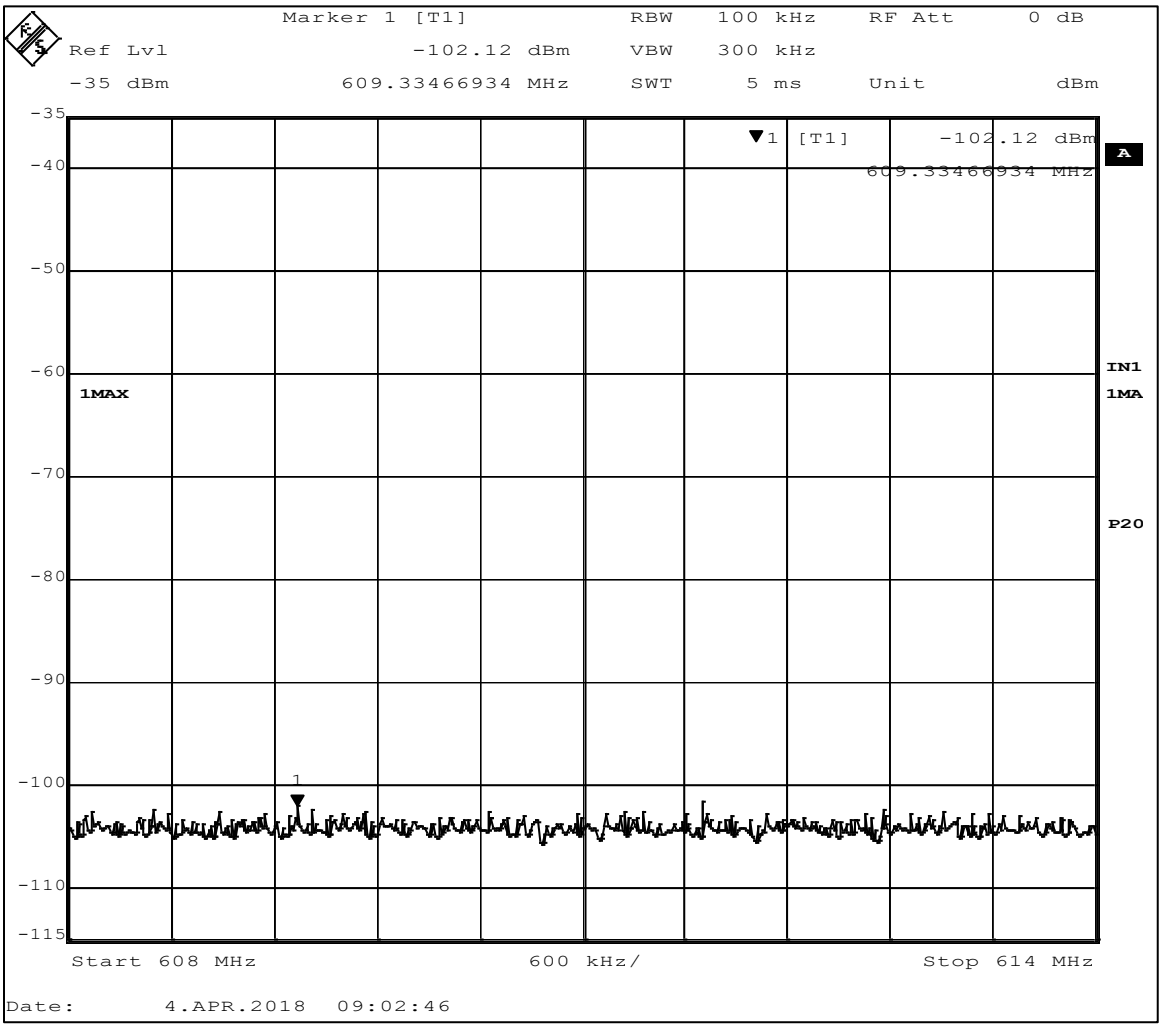


Figure 15 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit

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

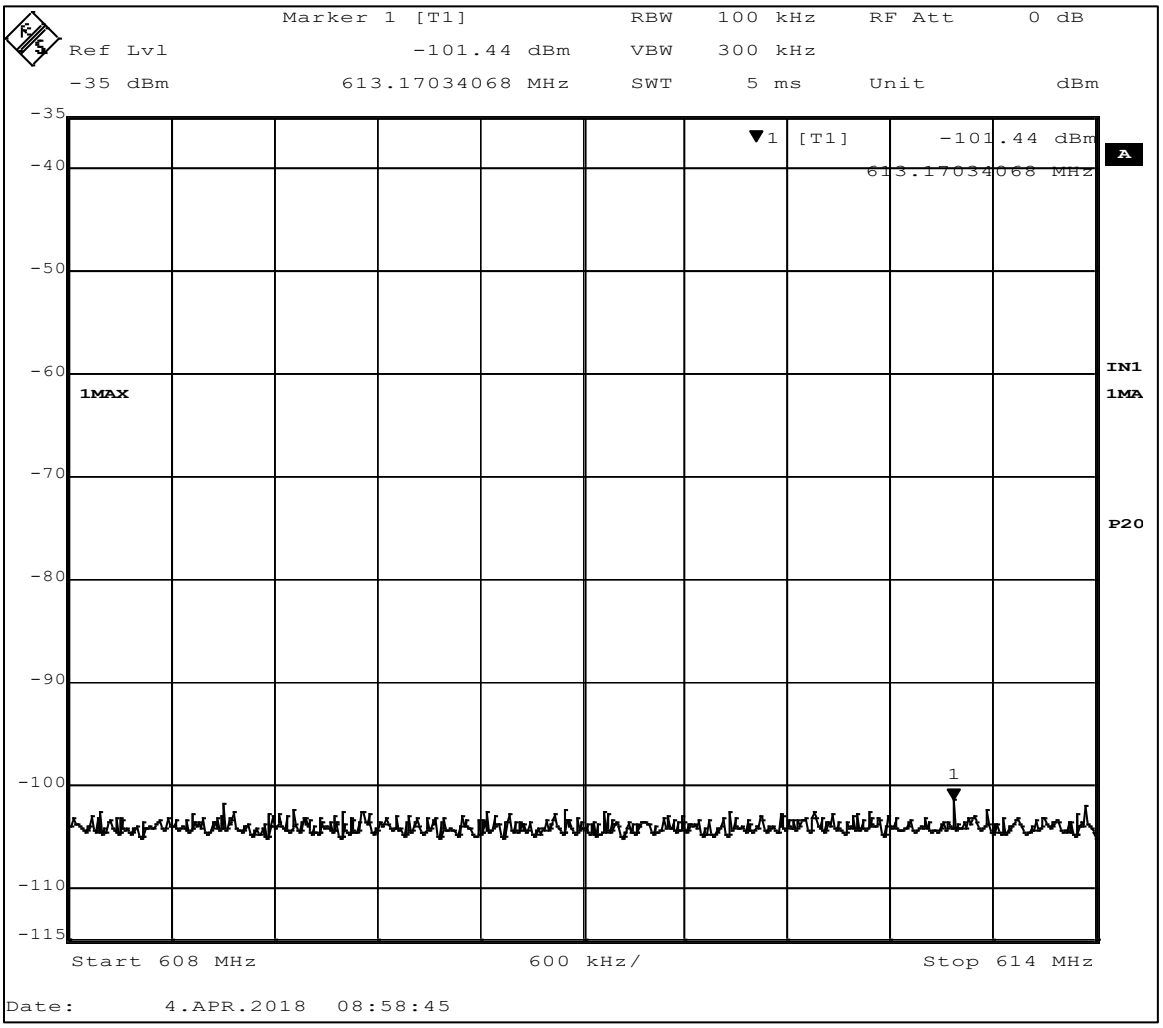


Figure 16 - Band-edge Measurement, Low Channel, Restricted Frequency, Hopping

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

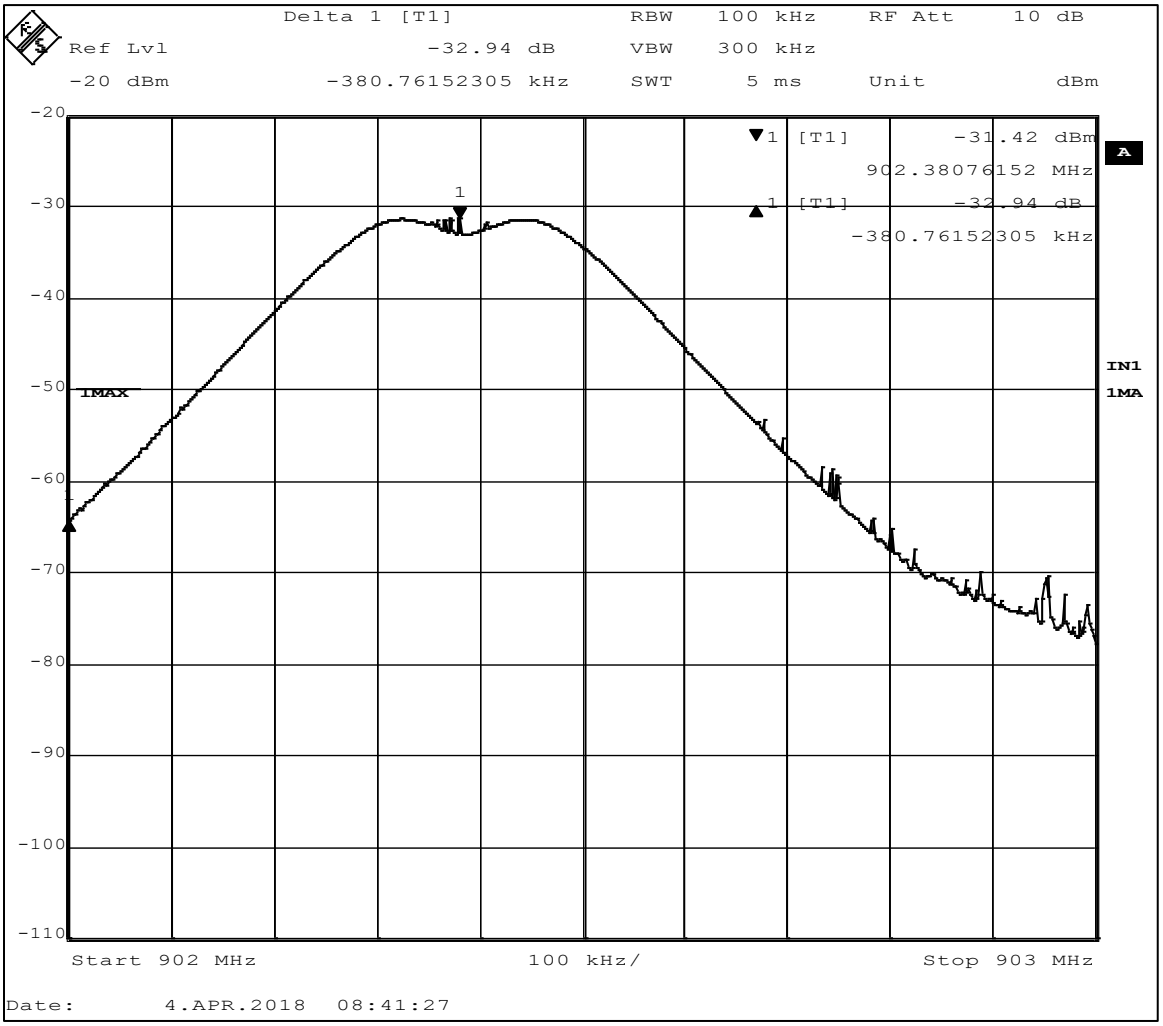


Figure 17 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit

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

Delta = 32.94 dB > 20 dB minimum

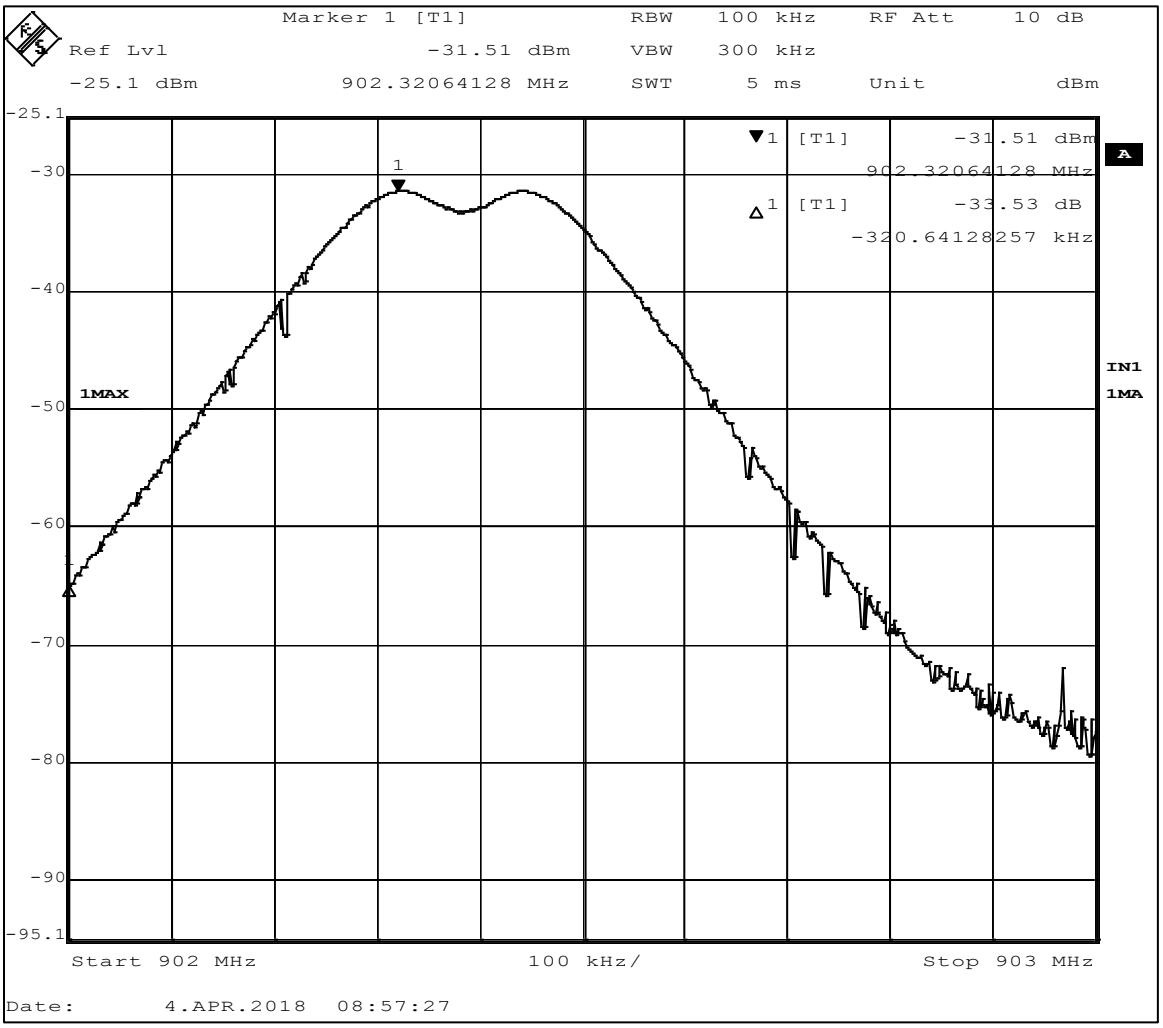


Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Hopping Transmit

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

Delta = 33.53 dB > 20 dB minimum

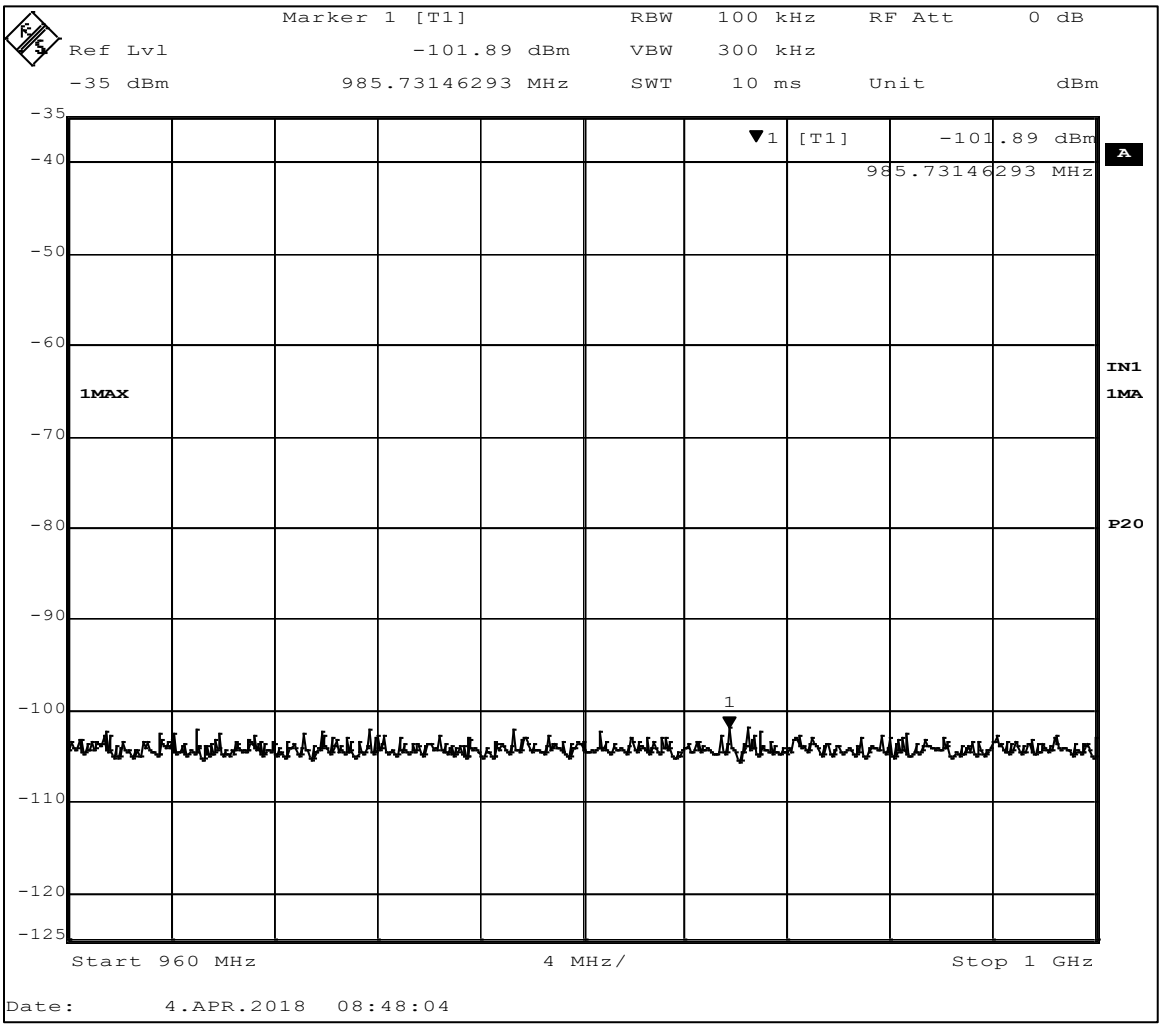


Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit

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

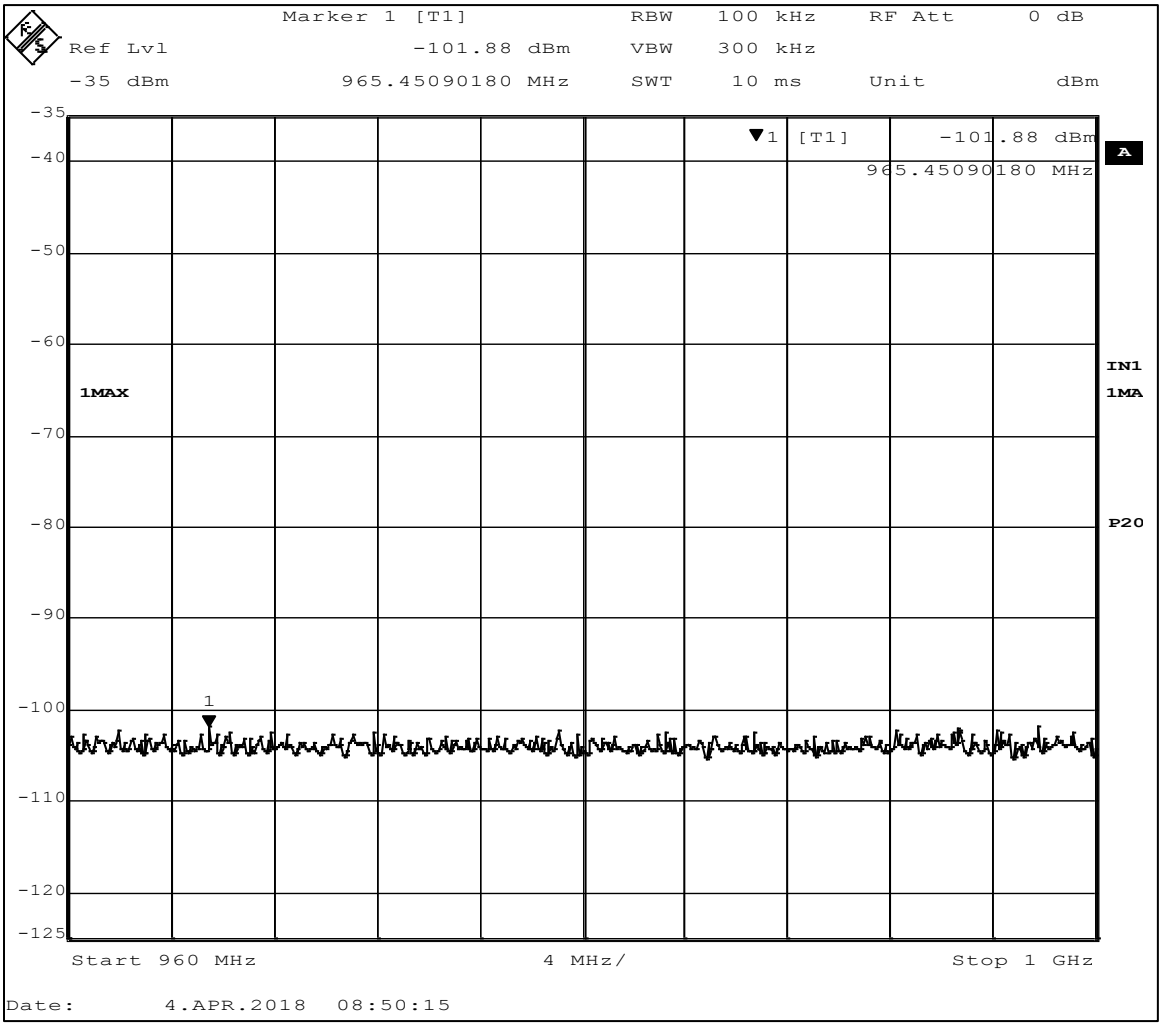


Figure 20 - Band-edge Measurement, High Channel, Restricted Frequency, Hopping

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

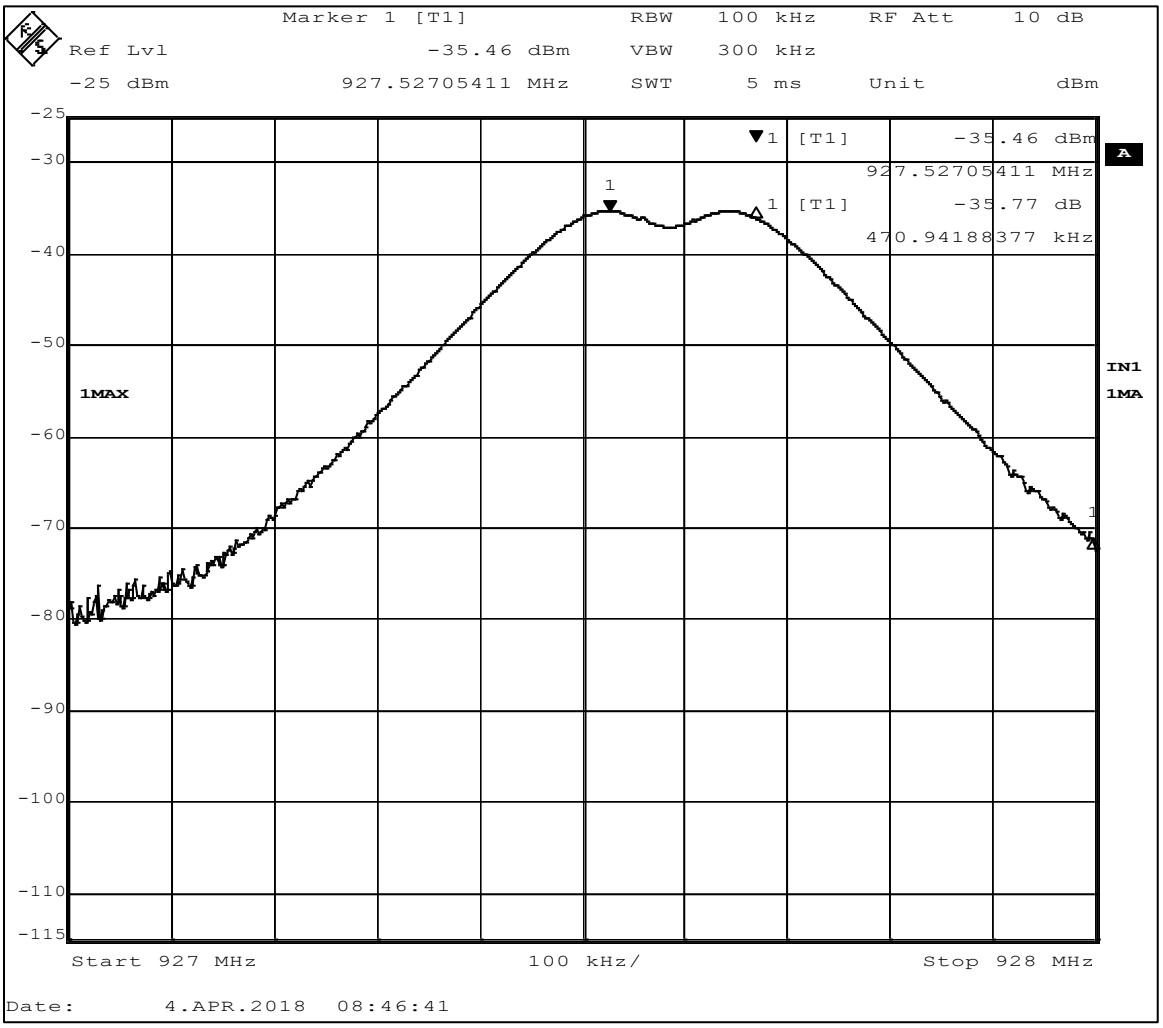


Figure 21 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

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

Delta = 35.77 dB > 20 dB minimum

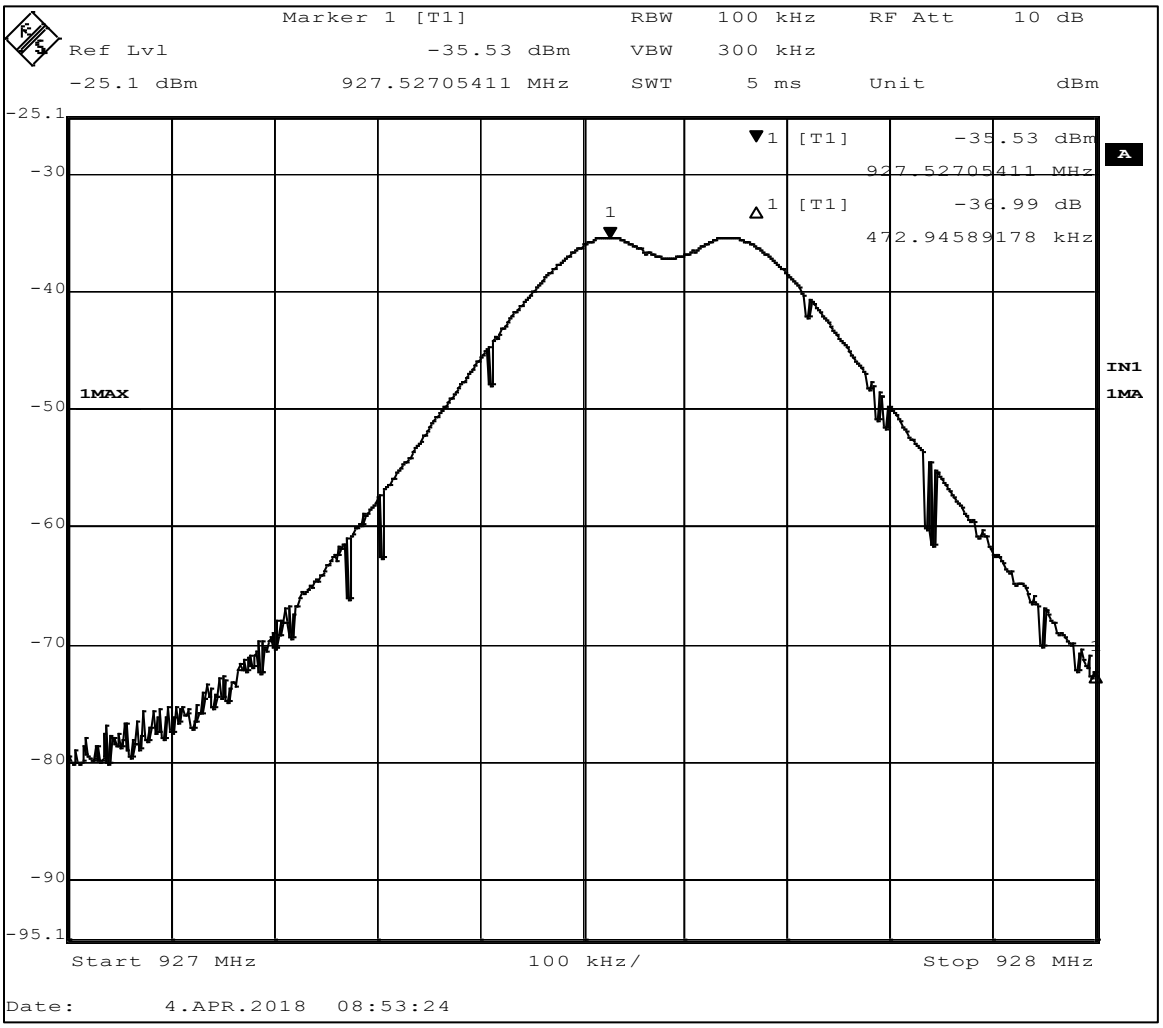


Figure 22 - Band-edge Measurement, High Channel, Fundamental, Hopping Transmit

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

Delta = 36.99 dB > 20 dB minimum

4.6 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

Average time of occupancy on any frequency, not to exceed 0.4 seconds within a 10 second period.

Test procedures:
The method from FCC DA 00-705

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

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 3VDC 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:

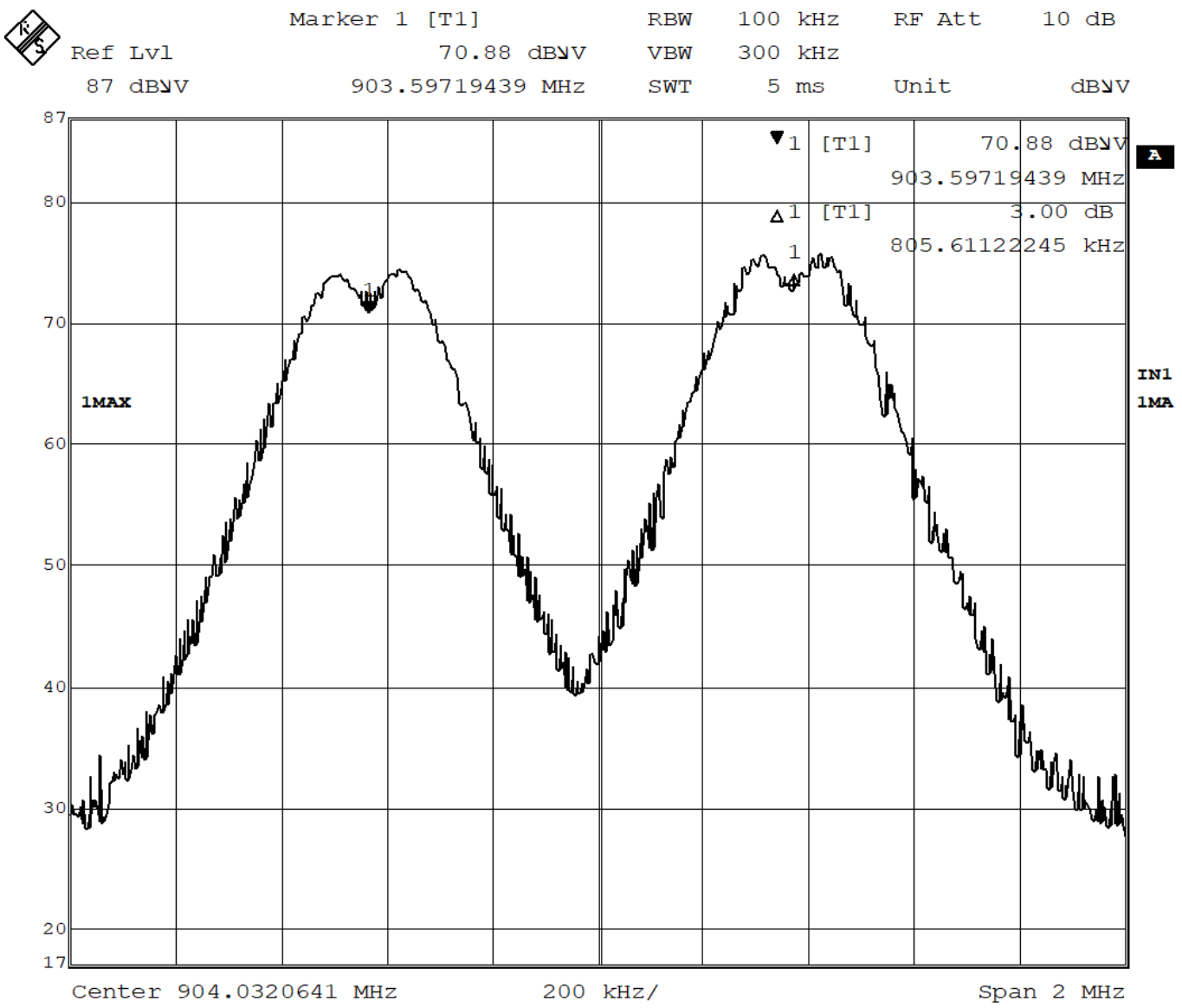


Figure 23 – Frequency Separation, 805.61 kHz

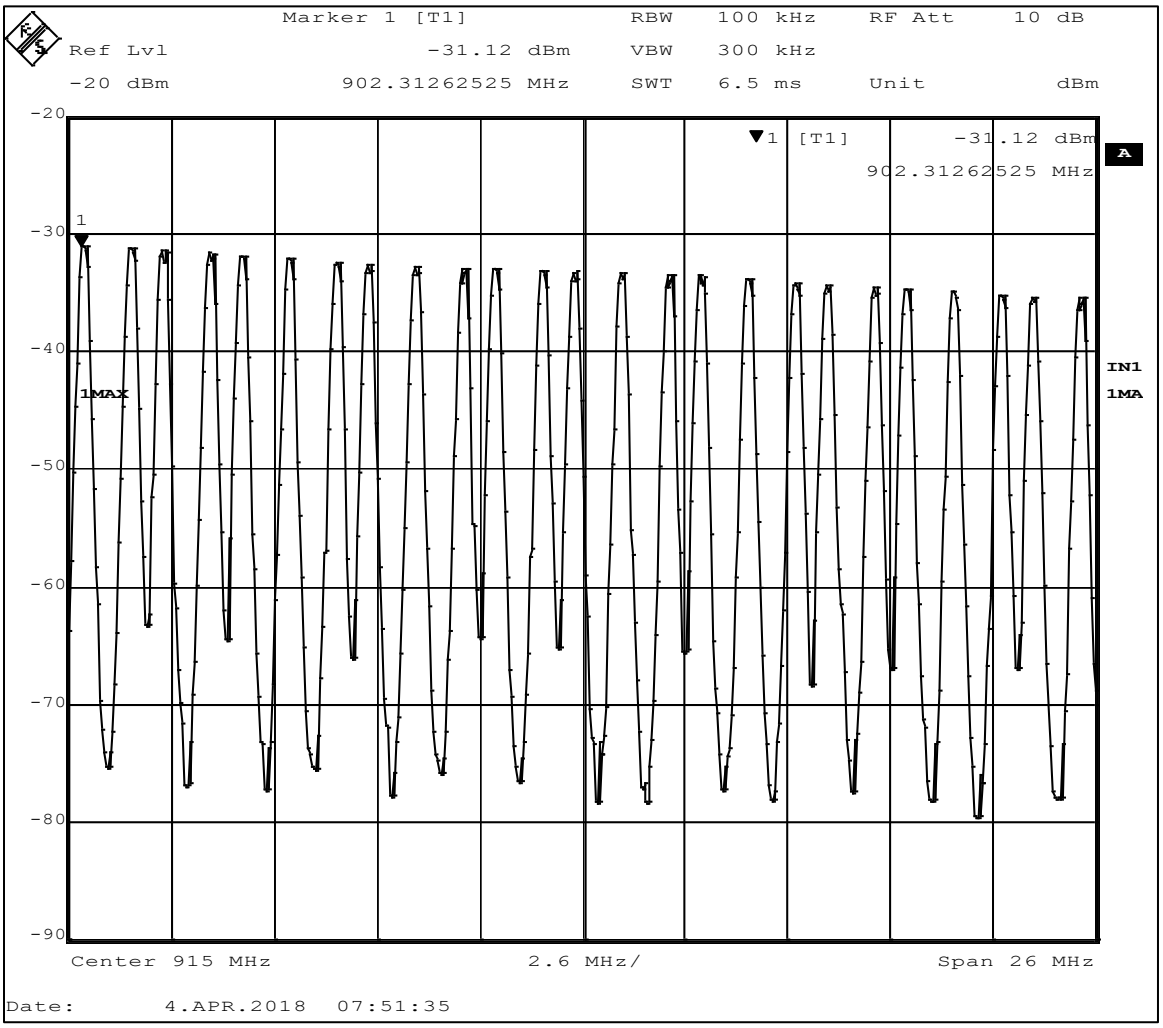


Figure 24 – Hop Count, 25 Hops

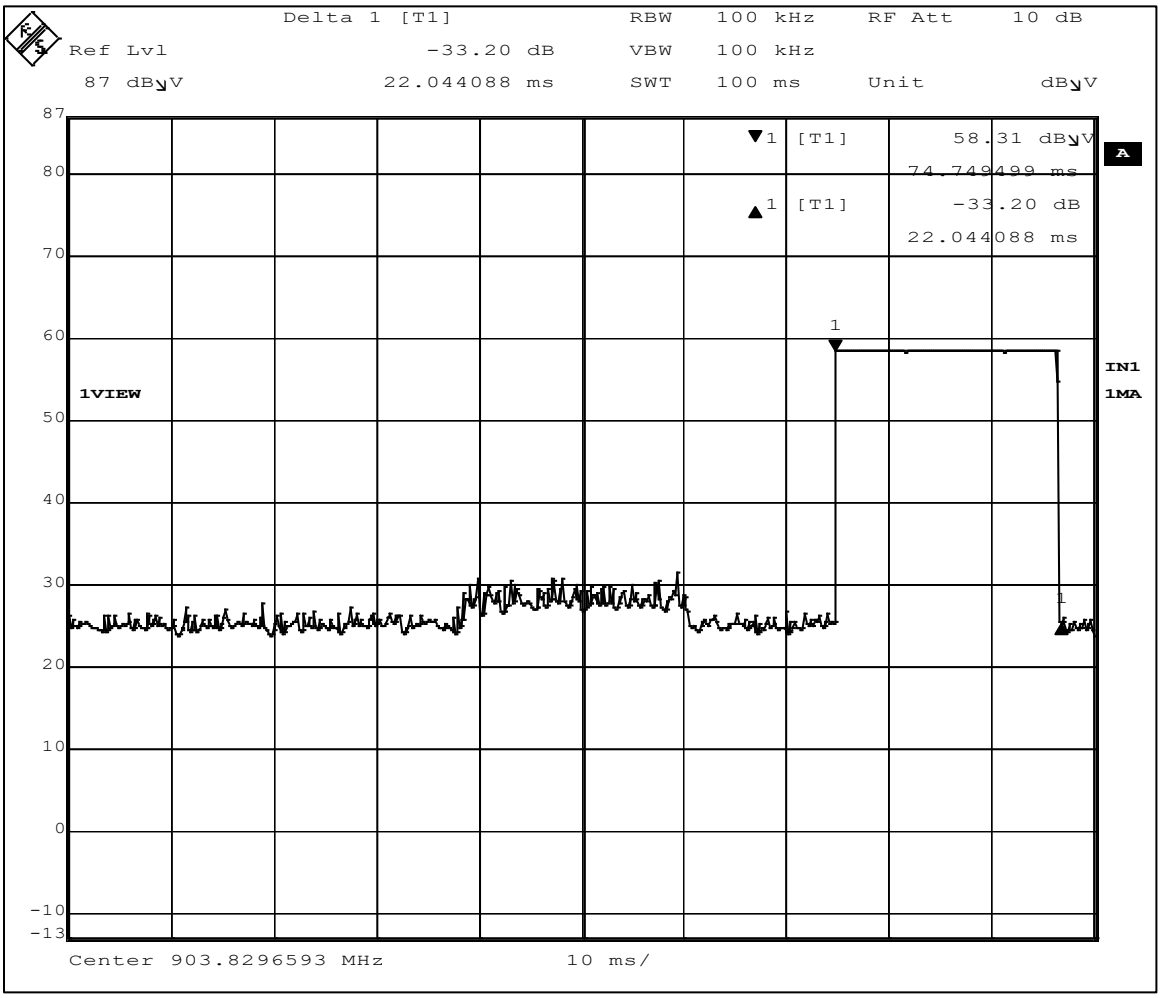


Figure 25 – Time of Occupancy, On Time

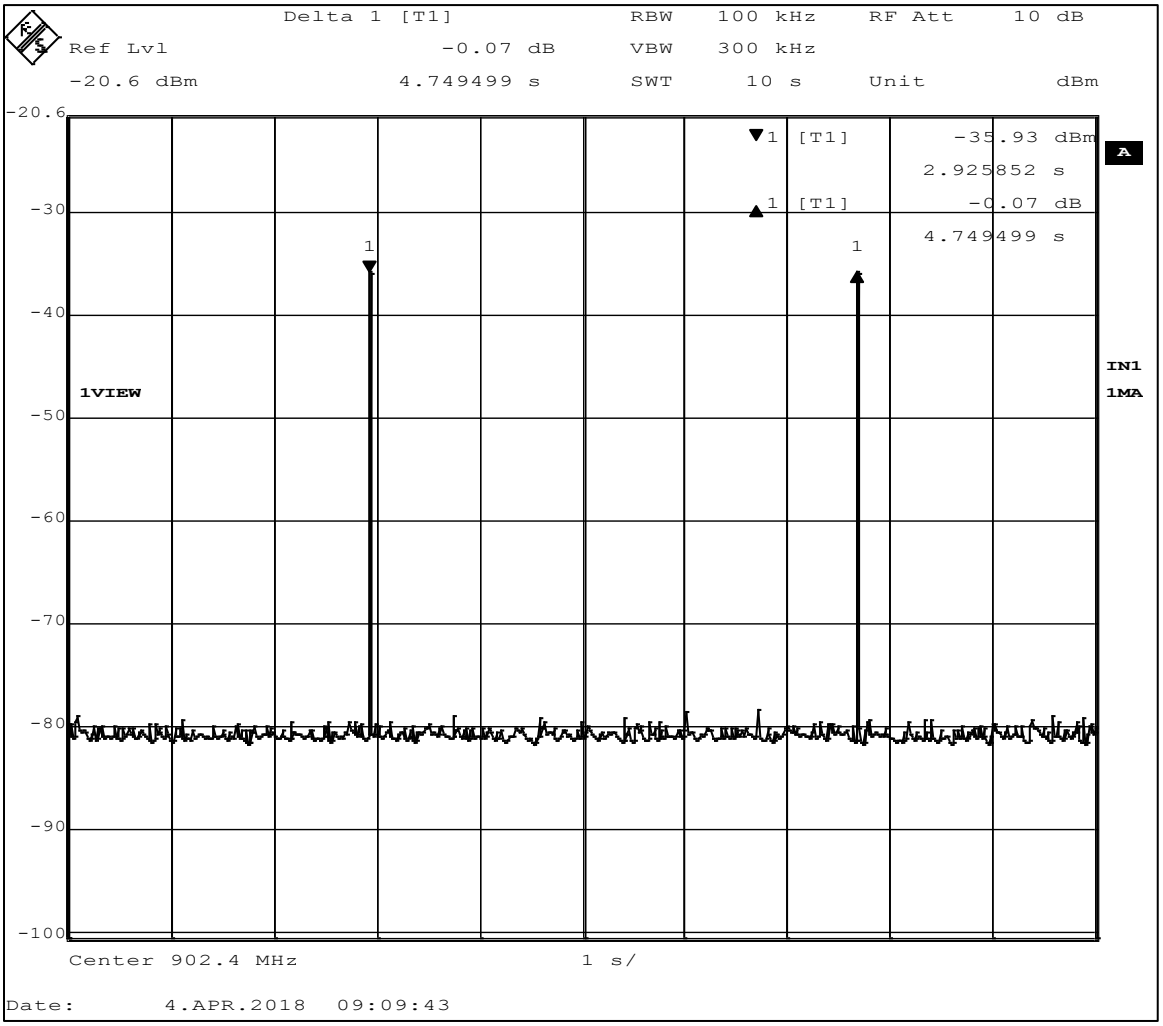


Figure 26 – Time of Occupancy, Period

*Maximum of 2 transmissions can occur in a given channel in any 10 s so the average time of occupancy is 22.04 ms x 2 =44.08 ms = 0.044 s < 0.4 s – Pass

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

EUT operating conditions:
The EUT was powered by 3 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:

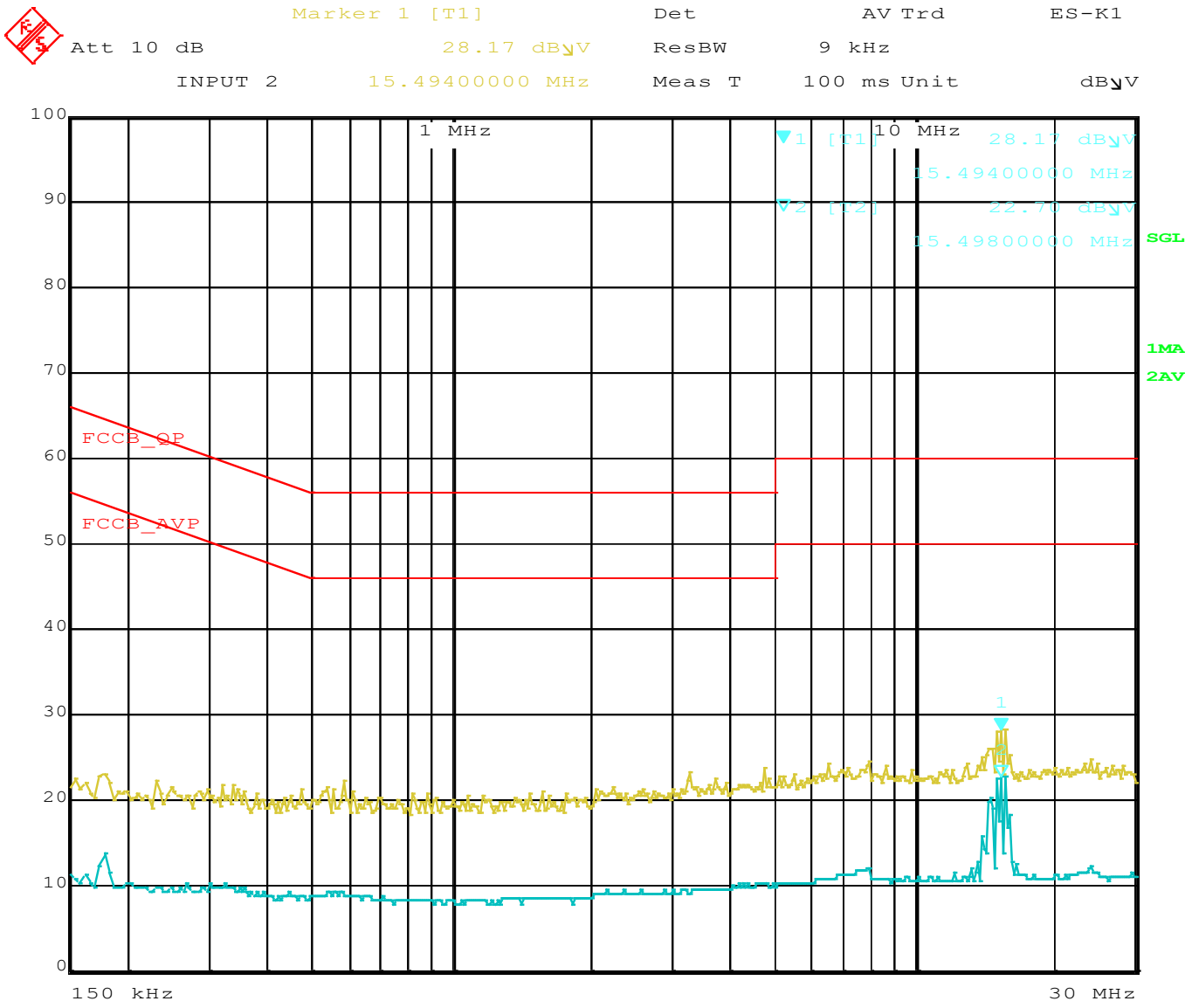


Figure 27 - Conducted Emissions Plot, +Ve Lead

All Measurements were found to be at least 10 dB below the limits.

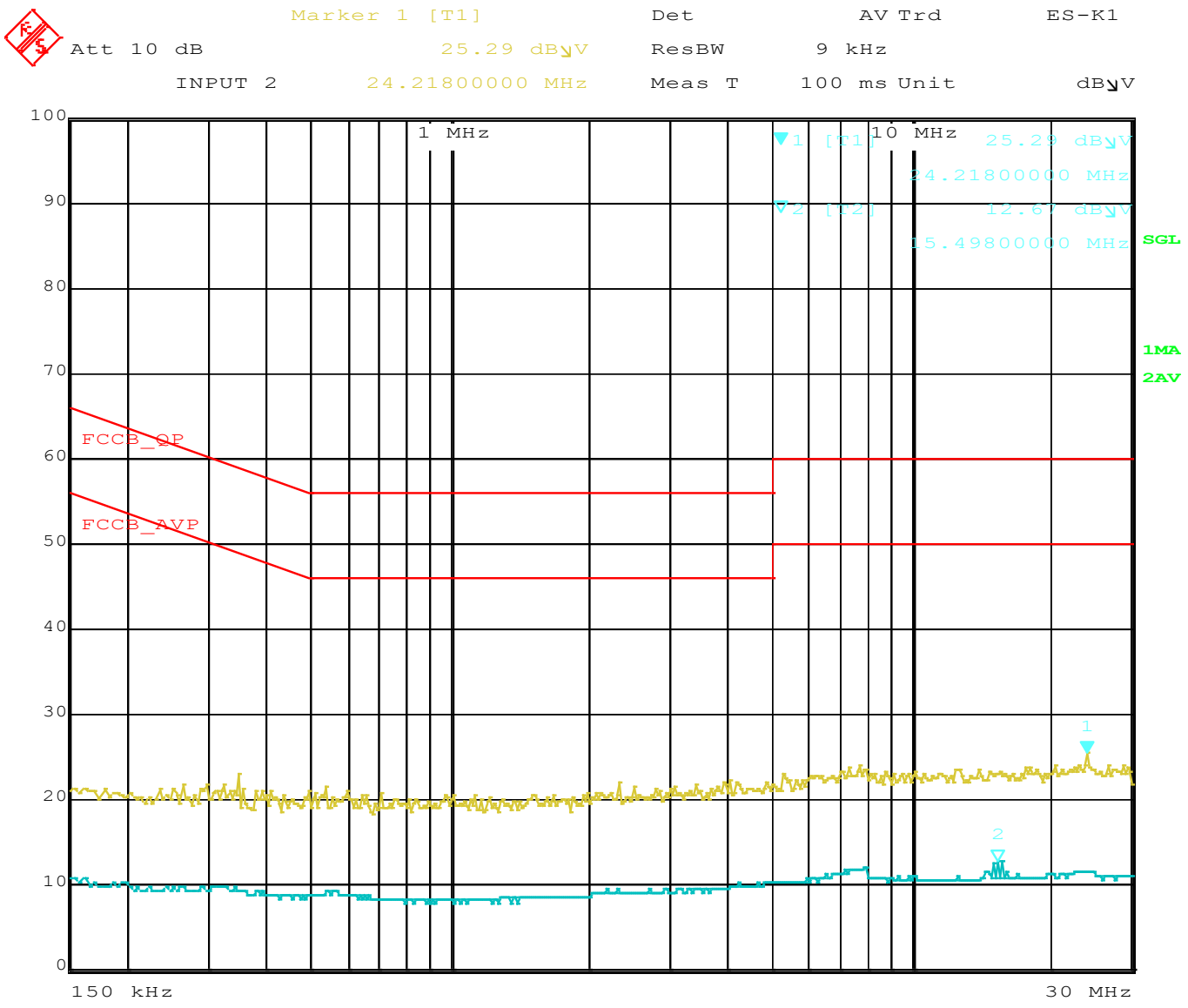


Figure 28 - Conducted Emissions Plot, - Ve Lead

All Measurements were found to be at least 10 dB below the limits.

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