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FCC/ISED Test Report

Prepared for: **Conductix-Wamplfer Inc.**

Address: **10102 F Street**
Omaha, NE 68127

Product: **VersaReel Blue**

Test Report No: **R20180910-22C**

Approved by:

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

DATE: **12 January 2021**

Total Pages: **36**

REVISION PAGE

Rev. No.	Date	Description
0	28 June 2019	Original – NJohnson Prepared by KVepuri/CFarrington
A	26 October 2020	Updated cover page and date. -NJ
B	5 January 2021	Updated Product name on cover Updated RSS-210 references Added test F/W to Section 2.2 Removed RSS-247/FCC Part 15.247 references
C	12 January 2021	Added PMN and HVIN to Section 2.0

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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 5
(3) ISED RSS-210, Issue 10
(4) ANSI C63.10-2013

SUMMARY			
Requirement	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	PCB Antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	N/A	Not required
NA	Maximum Peak Output Power	N/A	Informational Purpose Only
NA	Minimum Bandwidth	N/A	Informational Purpose Only
FCC 15.209 RSS-Gen, 7.3	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-210 B.10 FCC 15.249(a)	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205, 15.249(d) RSS-Gen, 8.9	Band Edge Measurement	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 7.2	Conducted AC Emissions	Pass	Meets the requirement of the limit.

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

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

The Equipment Under Test (EUT) was transceiver manufactured by CONDUCTIX-WAMPLFER inc.

EUT	0083- VersaReel
HVIN	VersaReelBlue
PMN	VersaReel Blue
EUT Received	9 May 2019
EUT Tested	9 May 2019 - 28 June 2019
Serial No.	10180007
Operating Band	2400 – 2483.5 MHz
Device Type	GMSK
Power Supply	120VAC / 60 Hz

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

2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

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

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

Test FW version: “FCC TEST FIRMWARE”

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

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

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

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
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 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
Rohde & Schwarz Test Software	ES-K1	12575	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*

*Internal Characterization

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

4.0 DETAILED RESULTS

4.1 BANDWIDTH

Test Method: ANSI C63.10,

1. Section(s) 6.9.3

Limits of bandwidth measurements:
The 99% occupied bandwidth is displayed.

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 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. 99% occupied bandwidth was measured using the automated function in the spectrum analyzer.

Deviations from test standard:
No deviation

Test setup:
All the measurements were done at 3m test distance. See Section 4.3 for more details

EUT operating conditions:
The EUT was powered by 120 VAC 60 Hz power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range on each indicated modulation.

Test results:

Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	OBW (MHz)	RESULT
Low	2402	1.10	PASS
Mid	2440	1.10	PASS
High	2480	1.12	PASS

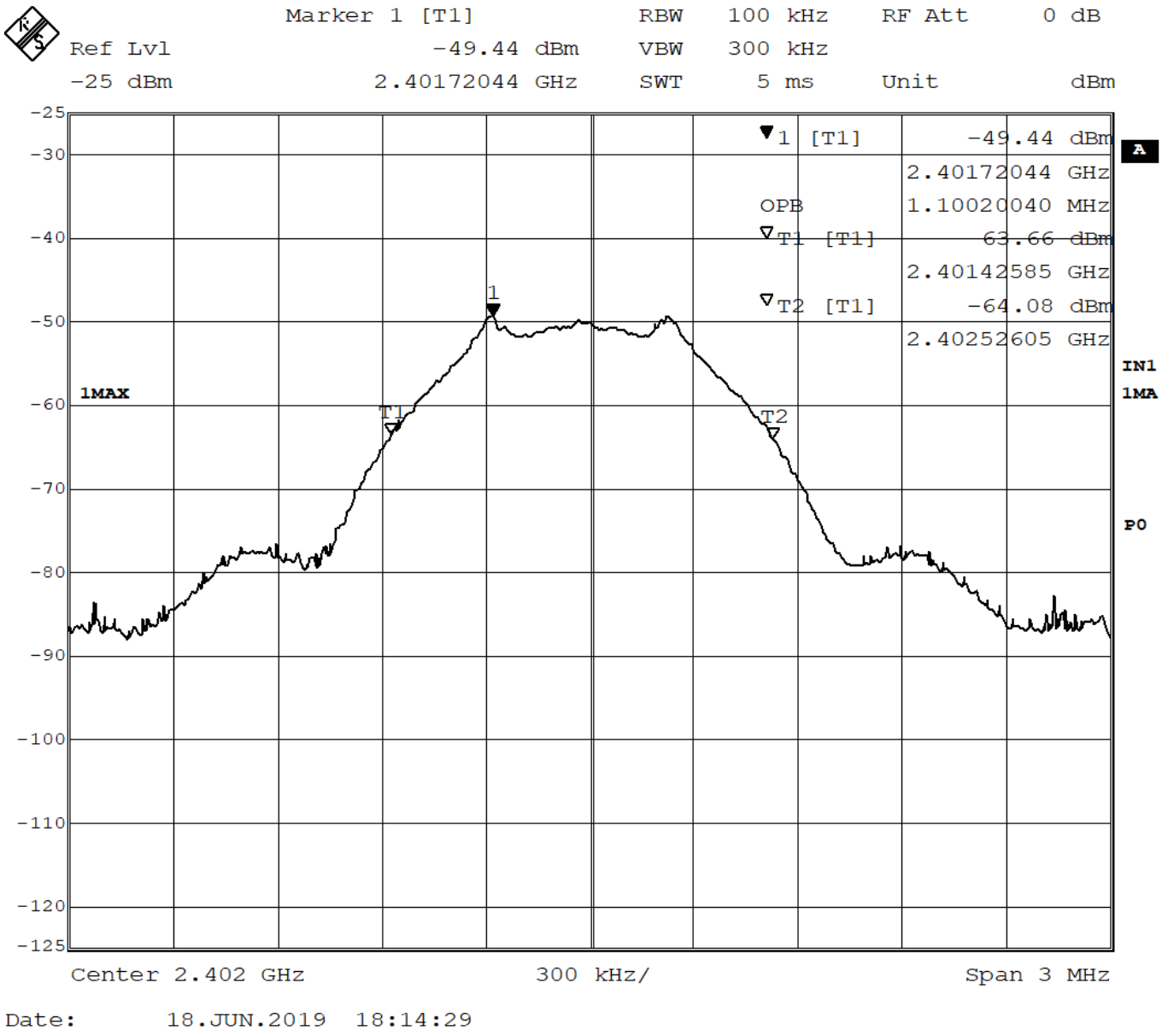

Figure 1 – Occupied Bandwidth, Low Channel

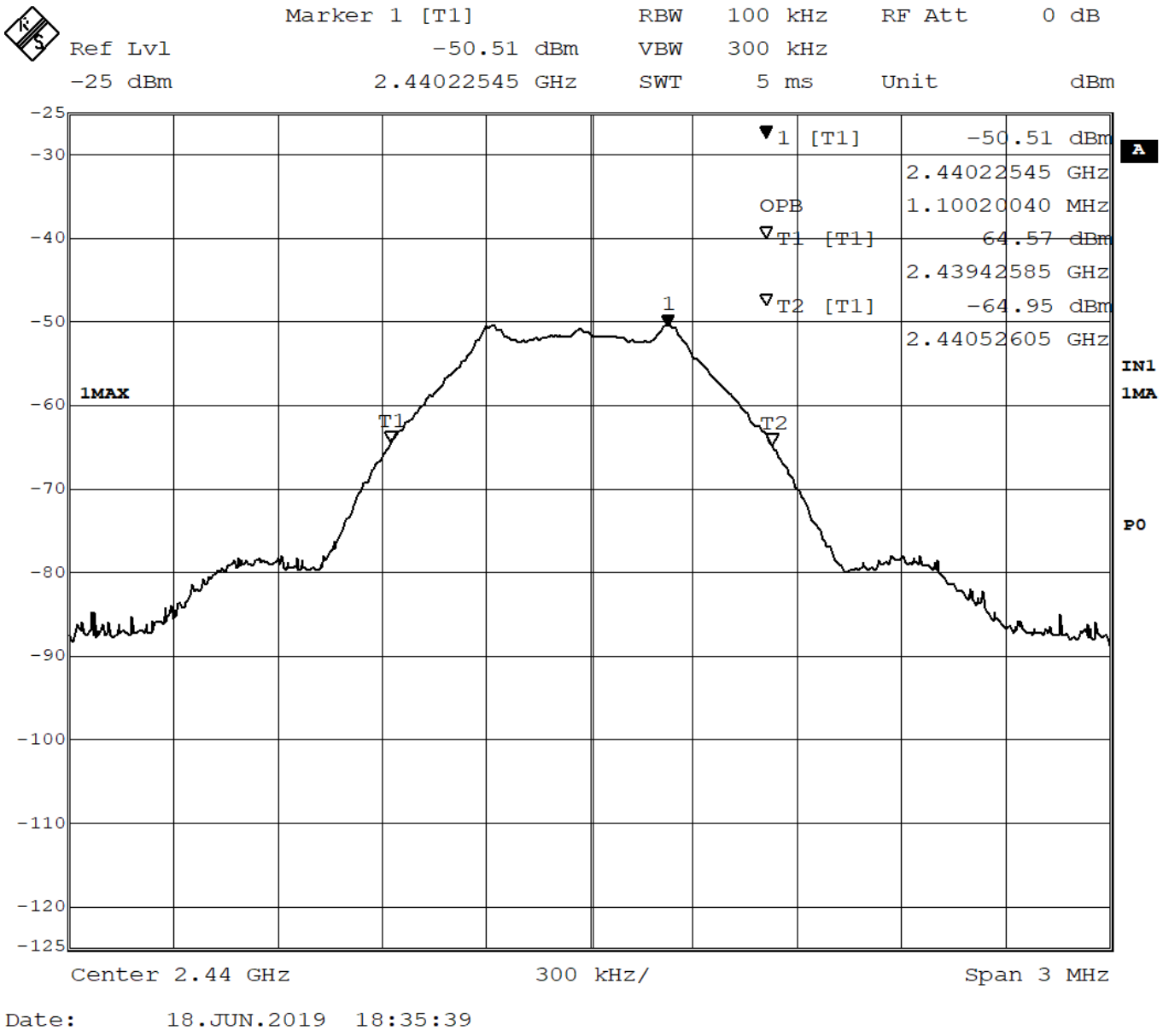

Figure 2 - Occupied Bandwidth, Mid Channel

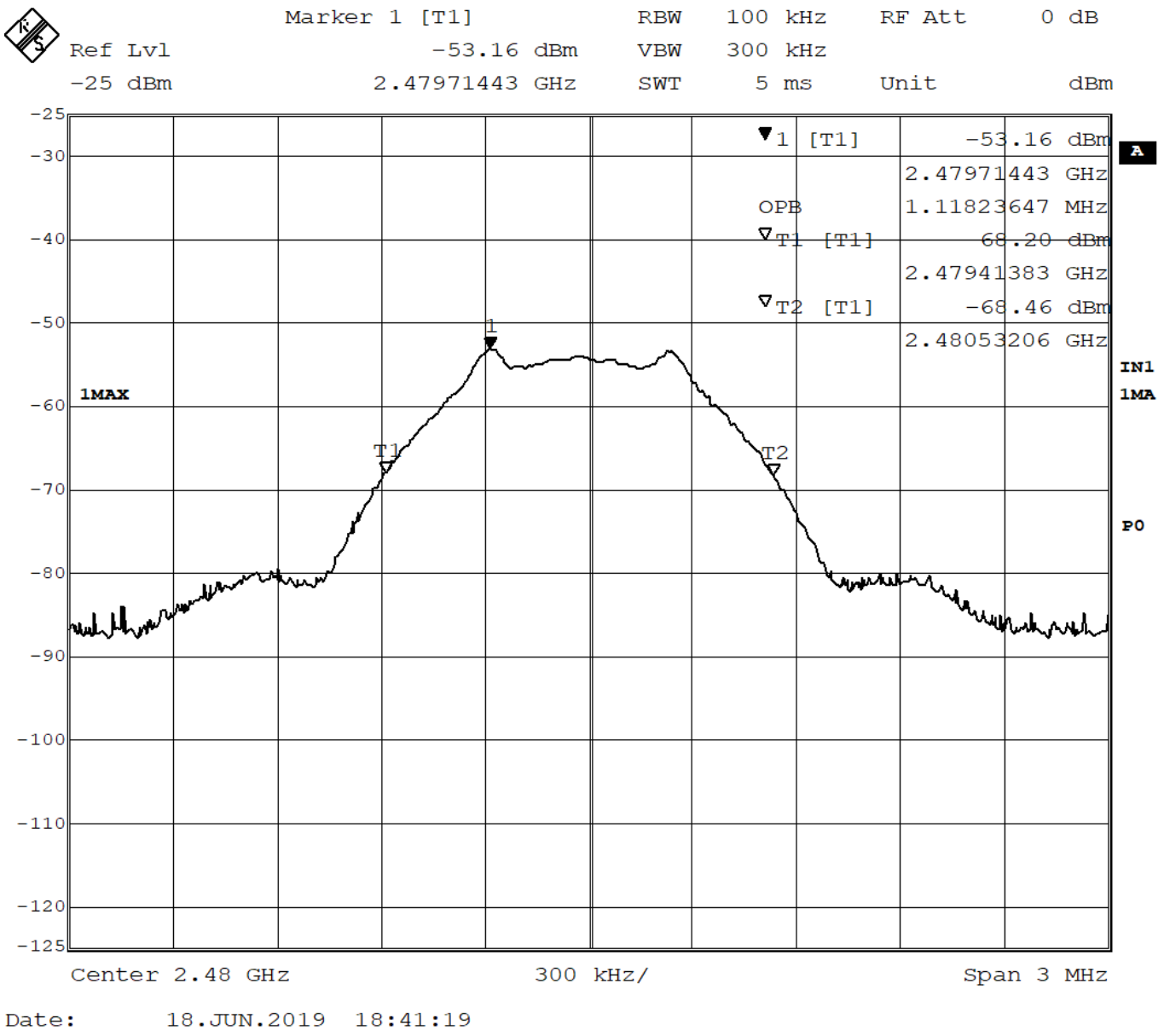

Figure 3 - Occupied Bandwidth, High Channel

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013:

1. Section 6.5, “Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to 1000 MHz”
2. Section 6.6, “Radiated emissions from unlicensed wireless devices above 1 GHz”

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

Since the fundamental emissions was at least 20 dB over the spurious emissions limtis from 15.209 and all spurious emissions were below the 15.209 limit, this requirement was met.

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. All final measurements were performed with the EUT transmitting continuously in this mode.

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:

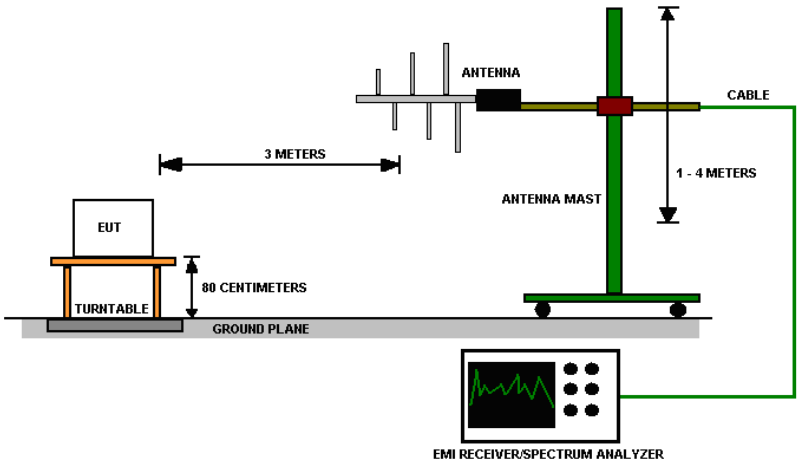

Figure 4 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 120 VAC 60 Hz power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range on each indicated modulation.

Test results:

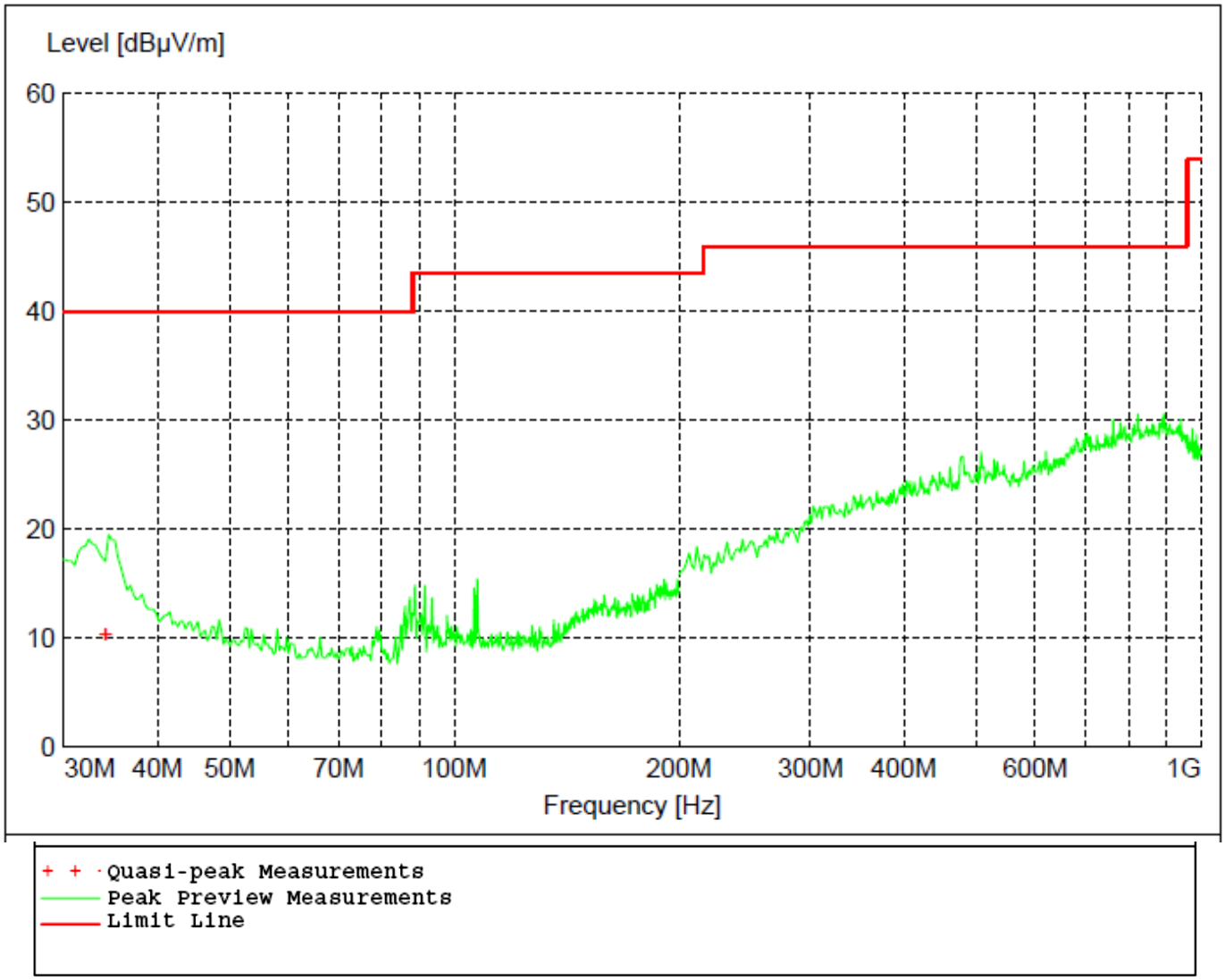

Figure 5 - Radiated Emissions Plot, Receive

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
34.140000	10.27	40.00	29.70	115	74	VERT

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

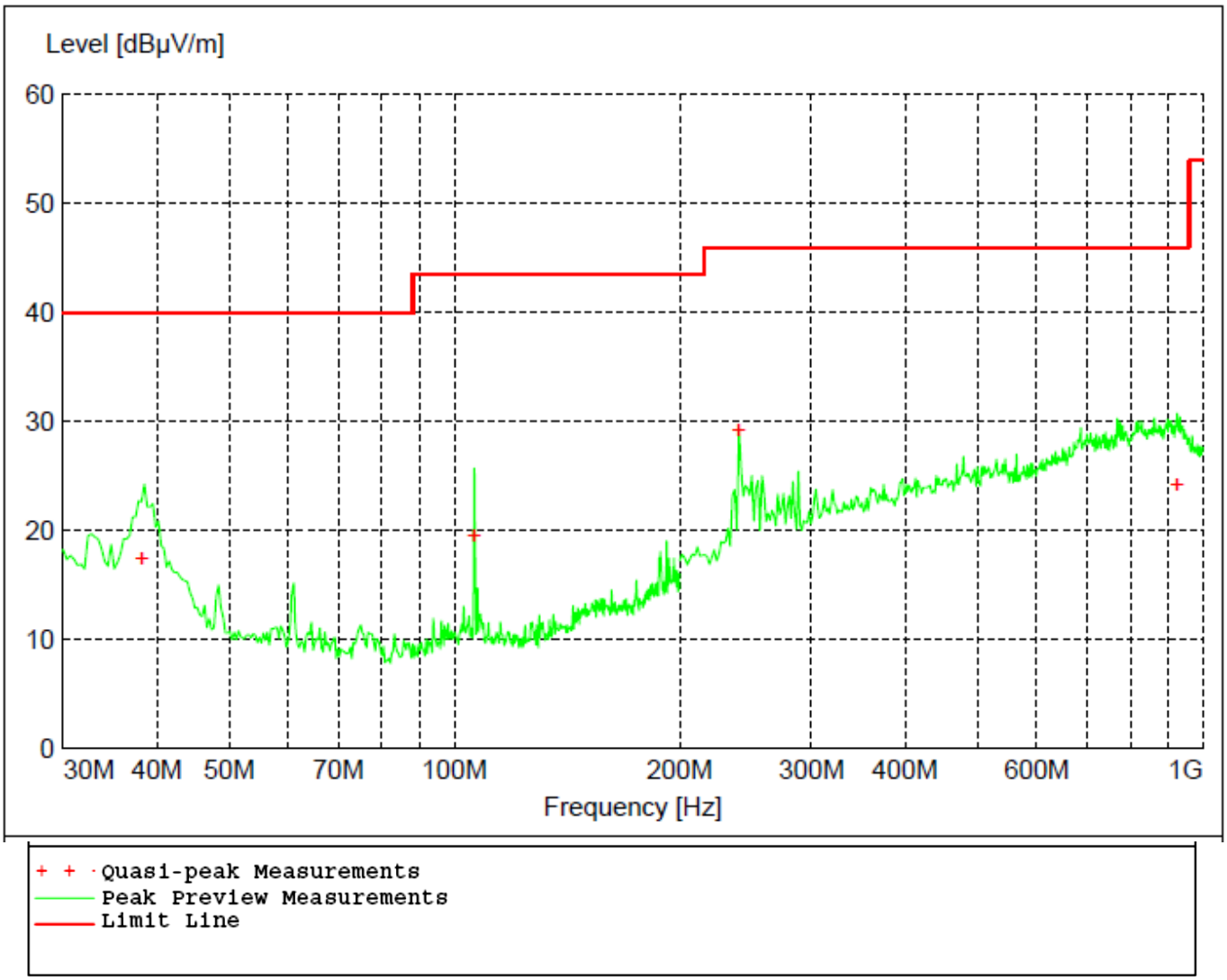

Figure 6 - Radiated Emissions Plot, Low Channel

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

Table 2 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
38.220000	17.38	40.00	22.60	99	0	VERT
106.320000	19.47	43.50	24.10	101	21	VERT
240.000000	29.20	46.00	16.80	98	299	VERT
924.180000	24.21	46.00	21.80	400	135	HORI

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

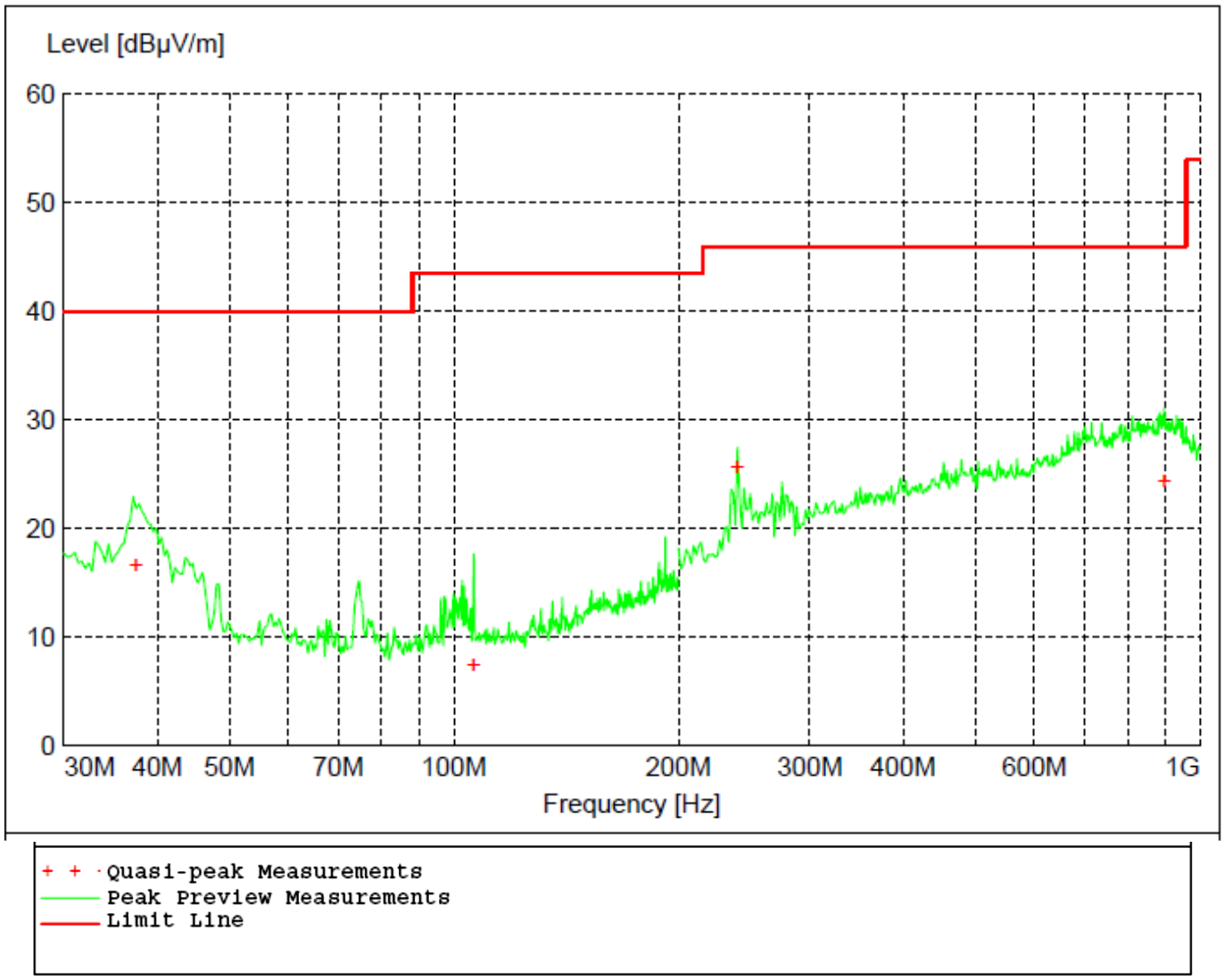

Figure 7 - Radiated Emissions Plot, Mid Channel

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
37.500000	16.59	40.00	23.40	102	156	VERT
106.260000	7.38	43.50	36.10	107	256	VERT
240.000000	25.54	46.00	20.50	99	309	VERT
896.460000	24.34	46.00	21.70	400	272	HORI

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

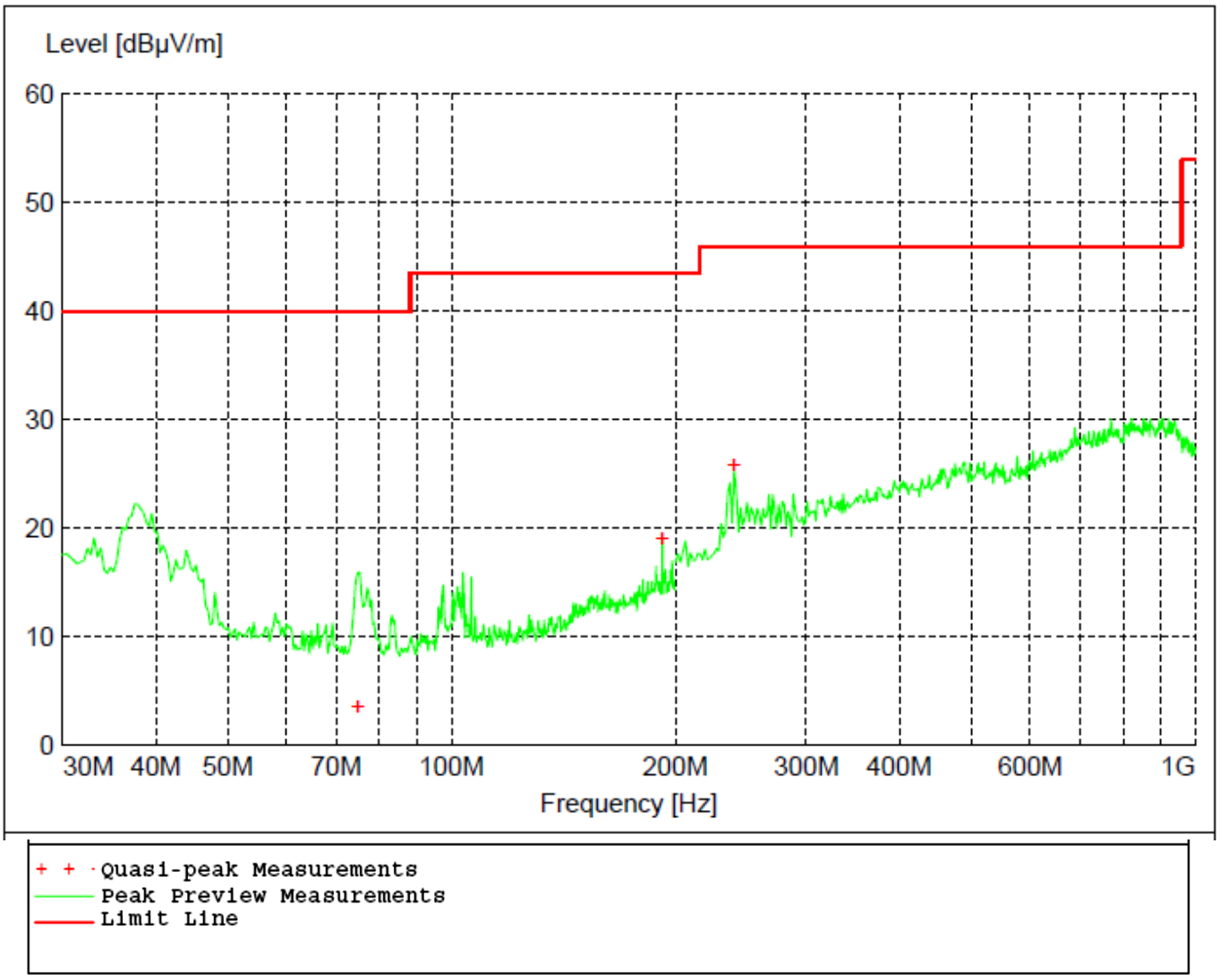

Figure 8 - Radiated Emissions Plot, High Channel

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
74.880000	3.50	40.00	36.50	186	145	VERT
192.000000	18.94	43.50	24.60	99	304	VERT
240.000000	25.73	46.00	20.30	99	292	VERT

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

Table 5 - Radiated Emissions Average Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	92.63	94.00	1.37	177	139	VERT	Low
2440.000000	91.02	94.00	2.98	101	262	VERT	Mid
2480.000000	88.33	94.00	5.67	224	63	VERT	High
4804.400000	45.22	54.00	8.78	180	47	HORI	Low
4880.400000	30.66	54.00	23.34	210	88	HORI	Mid
4959.400000	29.51	54.00	24.49	99	116	VERT	High
7205.200000	50.02	54.00	3.98	268	23	VERT	Low
7319.200000	48.54	54.00	5.46	267	22	VERT	Mid
7439.200000	45.29	54.00	8.71	265	327	VERT	High

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

Table 6 - Radiated Emissions Peak Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	94.22	114.00	19.78	177	139	VERT	Low
2440.000000	92.71	114.00	21.29	101	262	VERT	Mid
2480.000000	90.53	114.00	23.47	224	63	VERT	High
4804.400000	52.85	74.00	21.15	180	47	HORI	Low
4880.400000	43.95	74.00	30.05	210	88	HORI	Mid
4959.400000	42.86	74.00	31.14	99	116	VERT	High
7205.200000	58.35	74.00	15.65	268	23	VERT	Low
7319.200000	56.75	74.00	17.25	267	22	VERT	Mid
7439.200000	53.93	74.00	20.07	265	327	VERT	High

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

4.3 BAND EDGES

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

Limits of bandedge measurements:
For emissions outside of the allowed band of operation, 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:
Measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The resolution bandwidth was set to 100kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a 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.

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

Deviations from test standard:
No deviation.

Test setup:
All the measurements were done at 3m test distance.

EUT operating conditions:
The EUT was powered by 120 VAC 60 Hz power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range on each indicated modulation.

Test results:

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental dBm	Delta (dB)	Min Delta (dB)	Result
Low, Continuous (restricted)	2390	-100.93	-49.43	51.50	38.63	PASS
High, Continuous (restricted)	2483.5	-101.93	-53.18	48.75	34.33	PASS
Low, Continuous (unrestricted)	2400	-82.85	-49.43	33.42	20.00	PASS
High, Continuous (unrestricted)	2483.5	-86.46	-53.18	33.28	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 peak field strength at Low Channel BT BR (GFSK) = 92.63 dBµV/m
Fundamental peak field strength at High Channel BT BR (GFSK) = 88.33 dBµV/m

Low Channel minimum delta BT BR (GFSK) = 92.63 – 54.0 dBµV/m = 38.63 dBc
High Channel minimum delta BT BR (GFSK) = 88.33 – 54.0 dBµV/m = 34.33 dBc

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

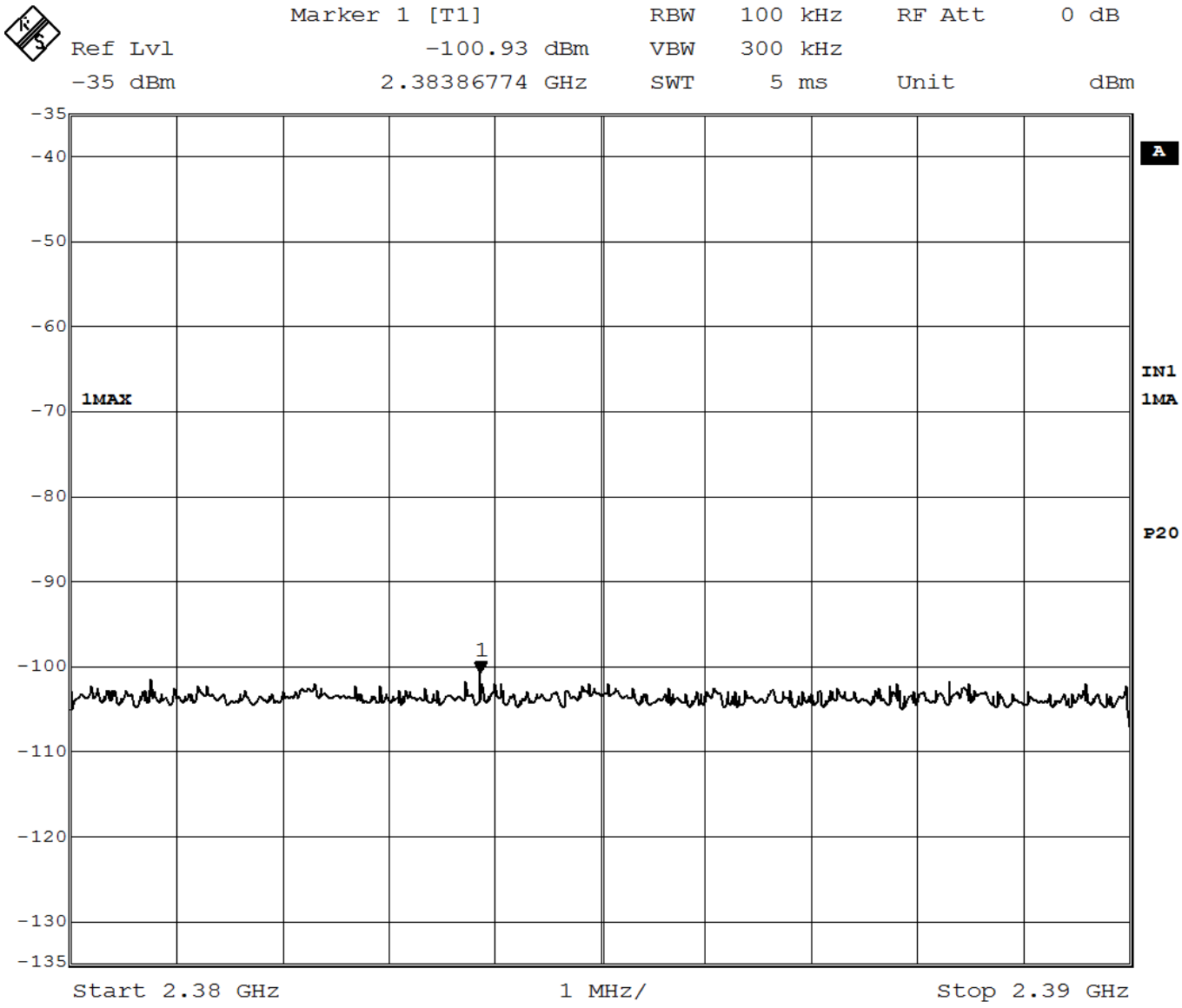

Figure 9 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

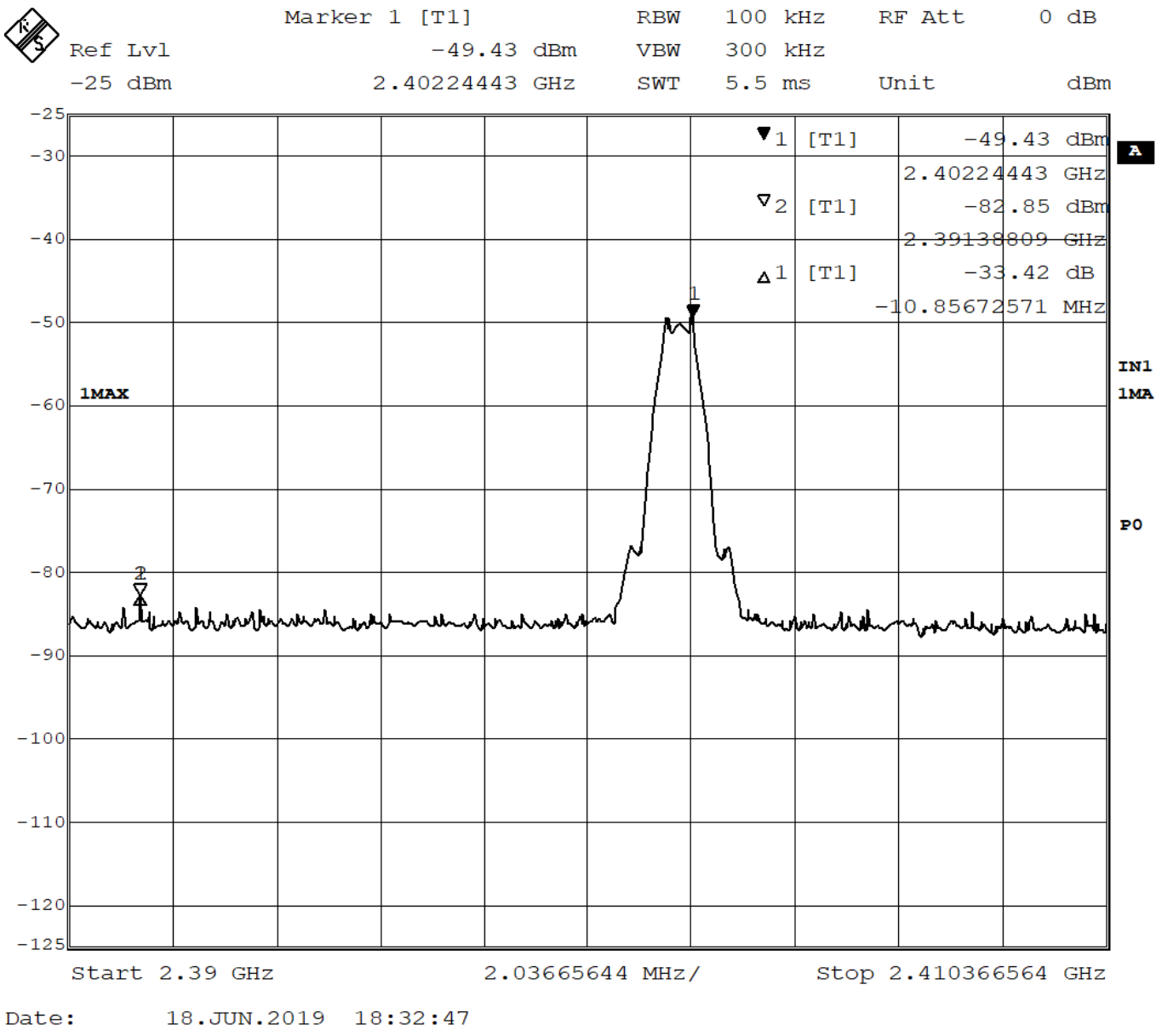

Figure 10 - Band-edge Measurement, Low Channel, Fundamental, Peak

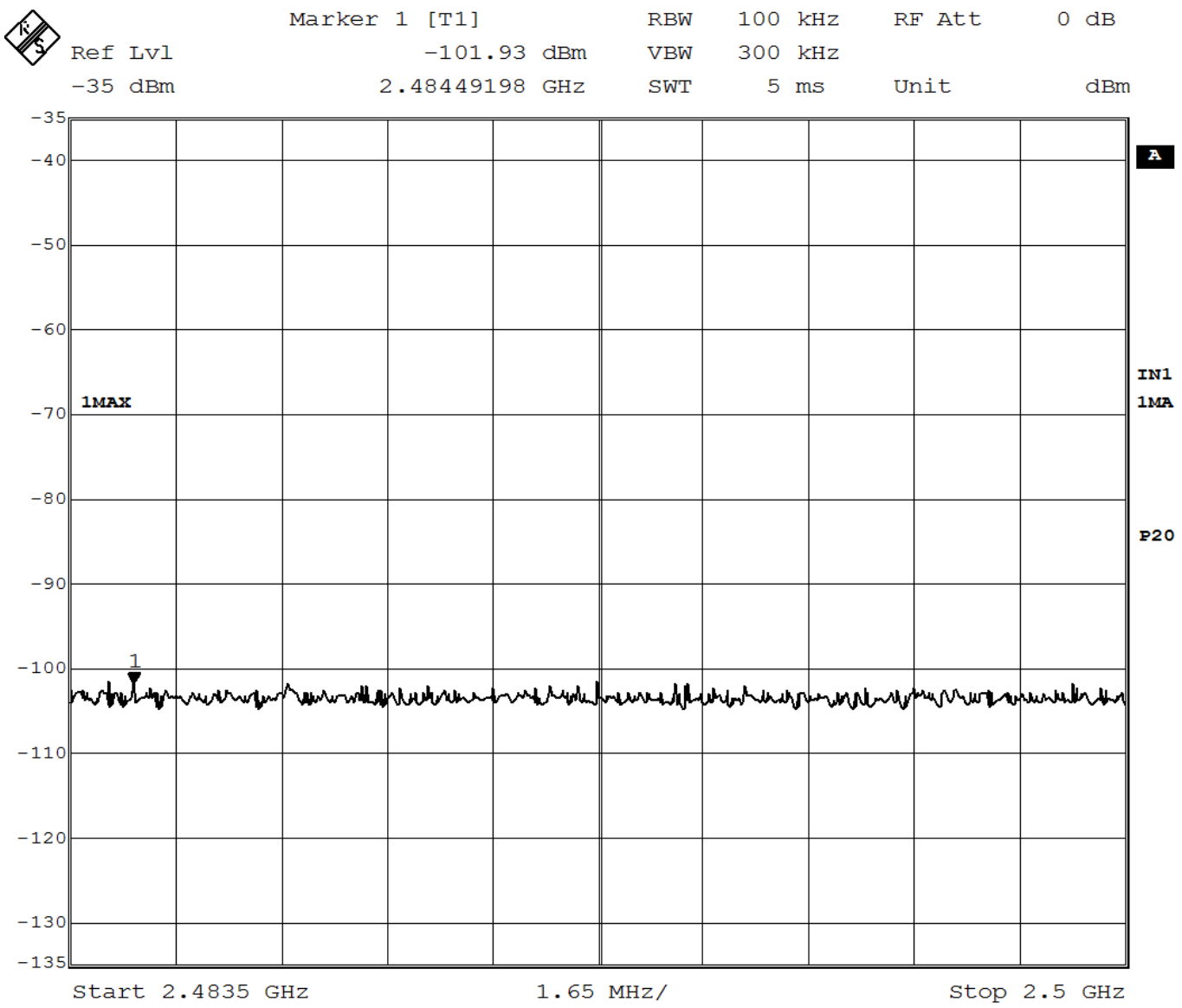

Figure 11 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

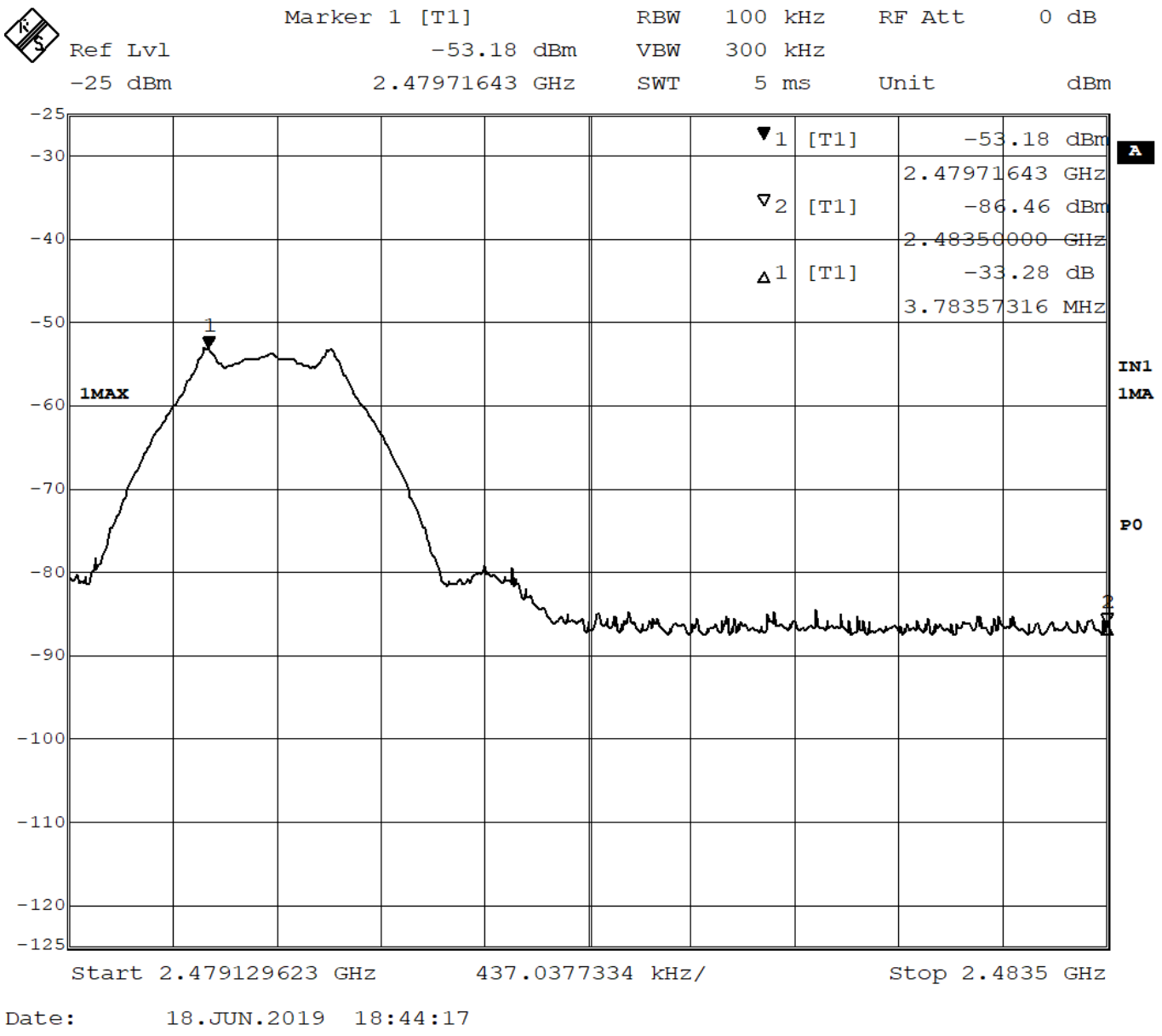

Figure 12 - Band-edge Measurement, High Channel, Fundamental, Peak

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 120 VAC 60 Hz unless specified and set to transmit continuously on the middle channel.

Test Results:

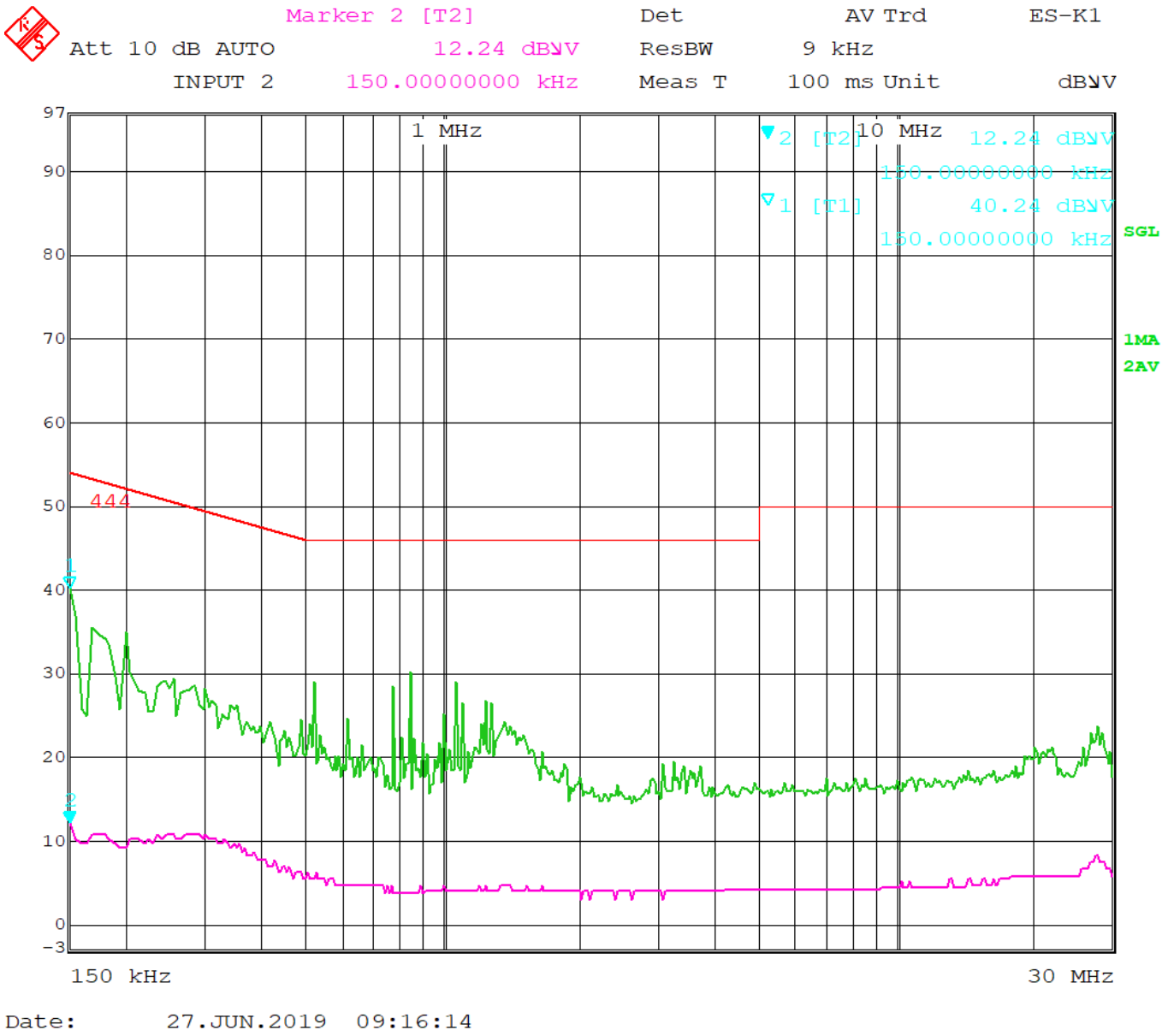

Figure 13 - Conducted Emissions Plot, Line-Ground

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

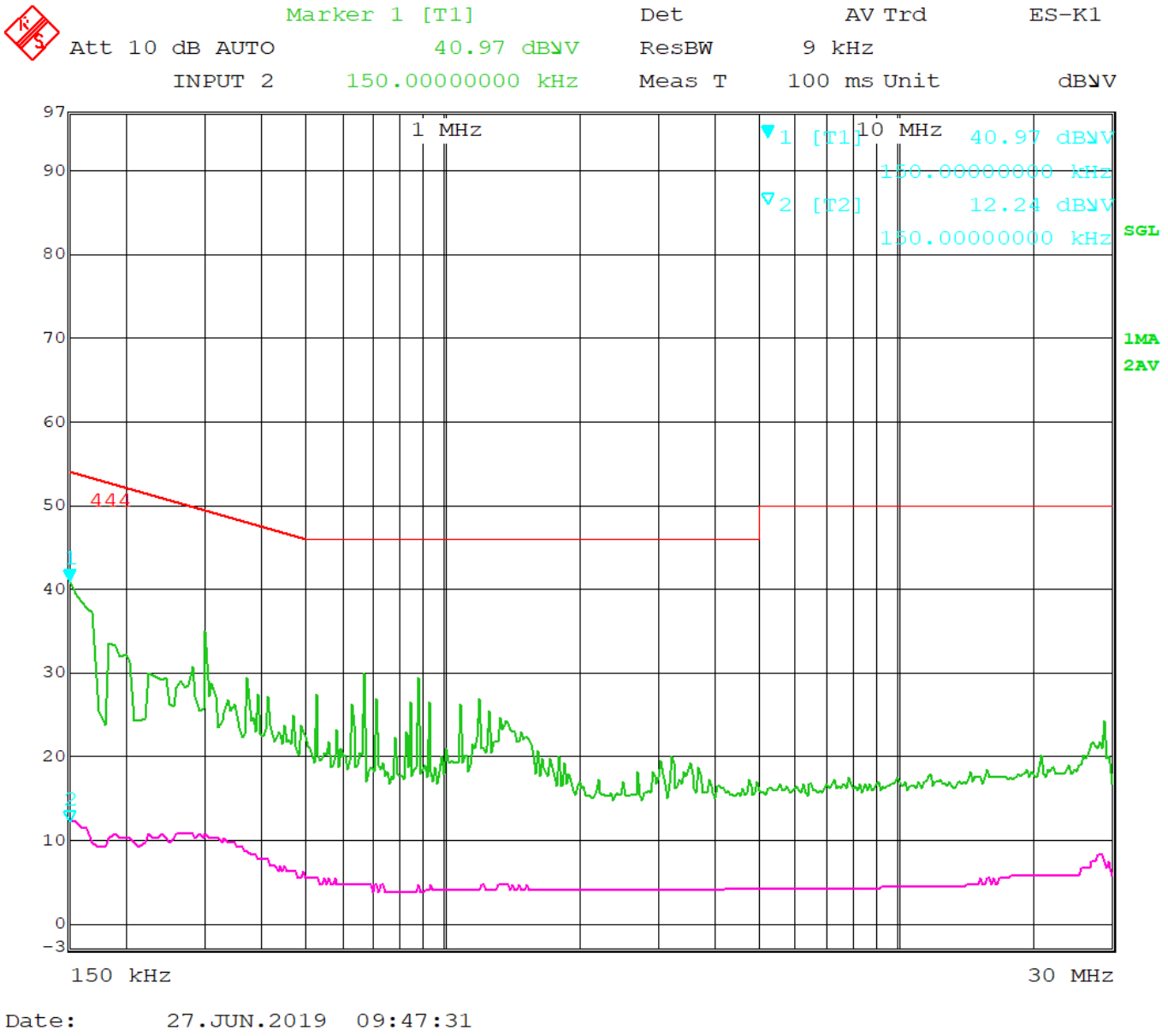

Figure 14 - Conducted Emissions Plot, Neutral-Ground

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

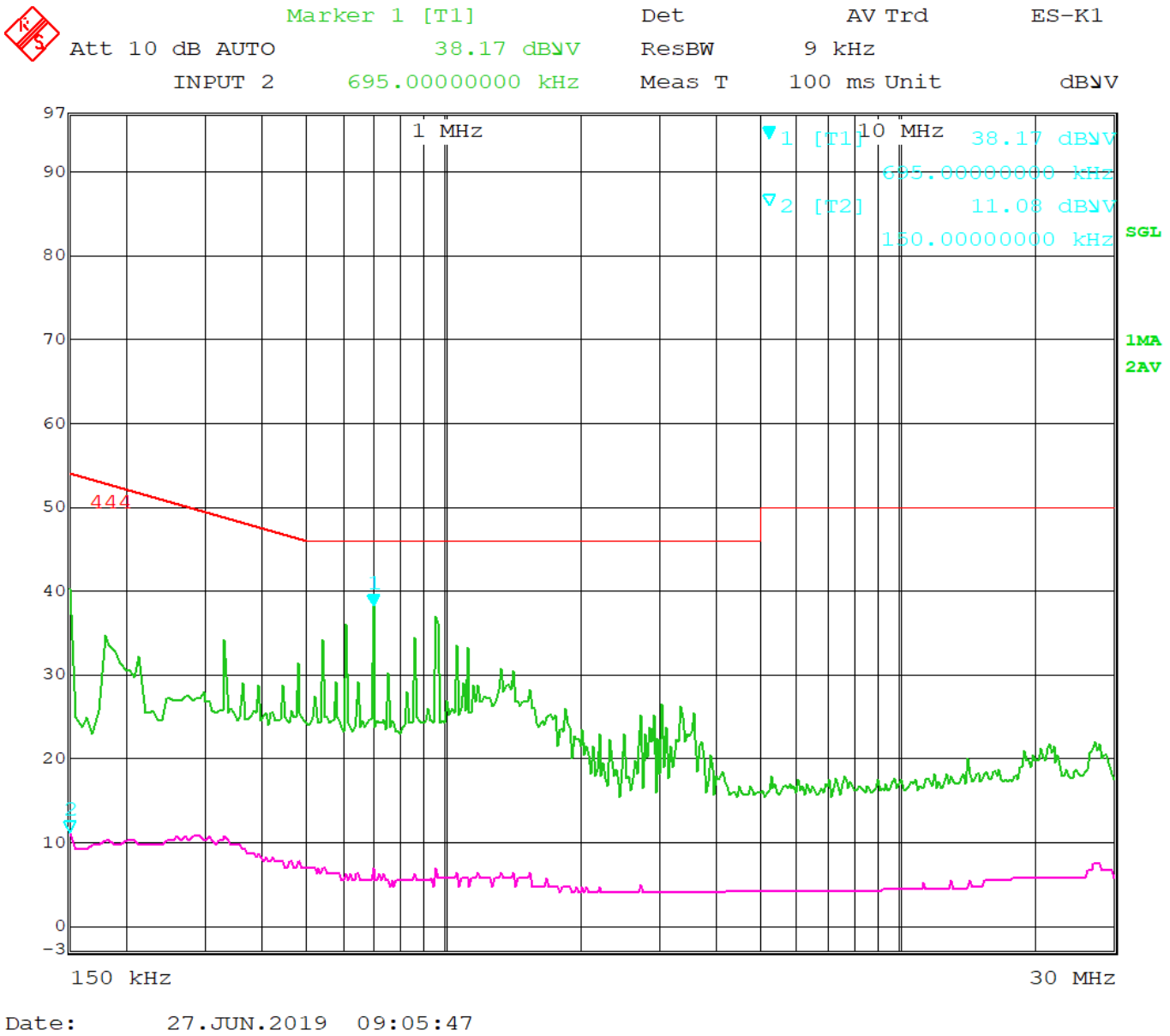

Figure 15 - Conducted Emissions Plot, Line-Floating

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

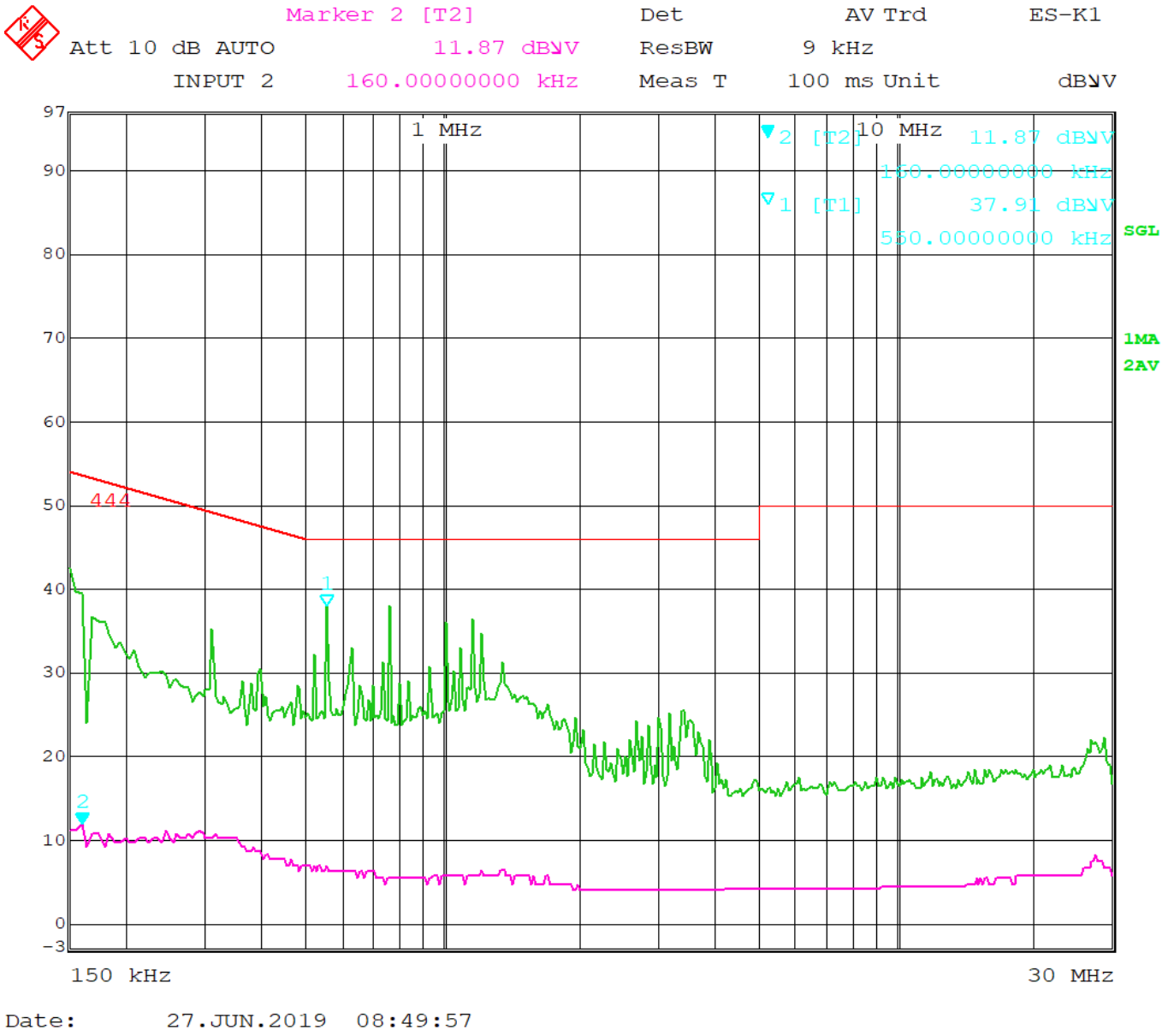

Figure 16 - Conducted Emissions Plot, Neutral-Floating

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

The plot shows the composite maximum value of both the line and neutral conductors. It shows the worse-case at each frequency.

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