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FCC/ISED Test Report

Prepared for: **Garmin International Inc.**

Address: **1200 E. 151st Street**
Olathe, Kansas, 66062, USA

Product: **AA1156**

Test Report No: **R20180514-24-01C**

Approved by:

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

DATE: **11 September 2018**

Total Pages: **46**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	15 June 2018	Original – NJohnson Prepared by KVepuri
A	3 August 2018	Includes NCEE Labs report R20180514-24-01 and its amendment in full. -NJ
B	15 August 2018	Includes NCEE Labs report R20180514-24-01A and its amendment in full. -NJ
C	11 September 2018	Includes NCEE Labs report R20180514-24-01B and its amendment in full. -KV/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 5
(3) ISED RSS-210, Issue 9

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	Informational Purpose Only
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
NA	Minimum Bandwidth	N/A	Informational Purpose Only
NA	Maximum Peak Output Power	N/A	Informational Purpose Only
FCC 15.209 RSS-Gen, 8.9 RSS-210 A1.2 FCC 15.249(a)	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205 RSS-Gen, 8.9 RSS-249, 5.5	Band Edge Measurement	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

Summary

The Equipment Under Test (EUT) was an AA1156 Bluetooth GPS receiver for IOS and Android manufactured by GARMIN inc. It has a Bluetooth radio that operates in 2400 MHz -2483.5 MHz band and it has transmit and receive capabilities.

EUT	AA1156
EUT Received	5/29/2018
EUT Tested	6/1/2018 - 6/12/2018
Serial No.	2NV081210
Operating Band	2400 – 2483.5 MHz
Device Type	BTLE
Power Supply	YI Power Adapter (5 VDC output) MN: A8-501000 (Power supply used was a representative power supply only unit doesn't ship with a power supply)

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
1	2402 MHz
2	2441 MHz
3	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.

The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

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 2019
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

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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: ANSI C63.10-2013, Section 7.5

Limits for duty cycle:

As shown in FCC Part 15.35(b), and RSS-Gen, Section 6.1, 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.

(c) Unless otherwise specified, *e.g.,* §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Test procedures:

The duty cycle was measured on bench with the test receiver set to “Zero span” mode.

All field strength or power measurements shown in these plots are arbitrary and only the times and levels of the EUT relative to the remote are considered for compliance.

Deviations from test standard:

No deviation.

Test setup:

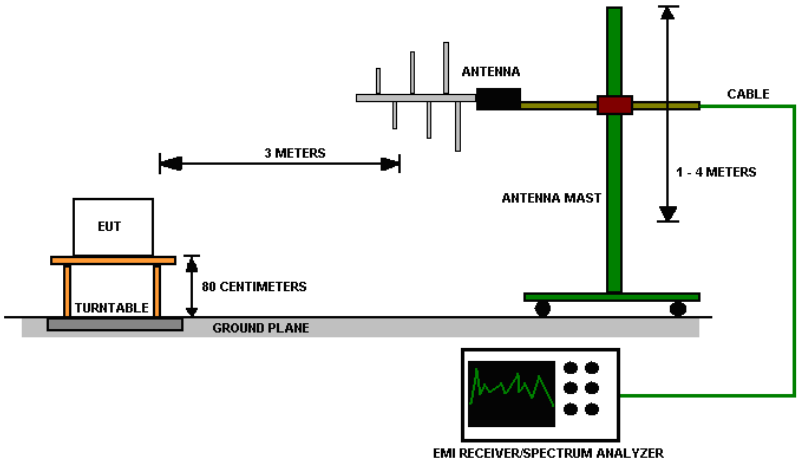

Figure 1 - Radiated Emissions Test Setup, 30MHz – 1GHz

EUT operating conditions:

The EUT was powered by 5 VDC unless specified. The duty cycle was only tested on only one channel as it will be identical for all channels.

Test results:

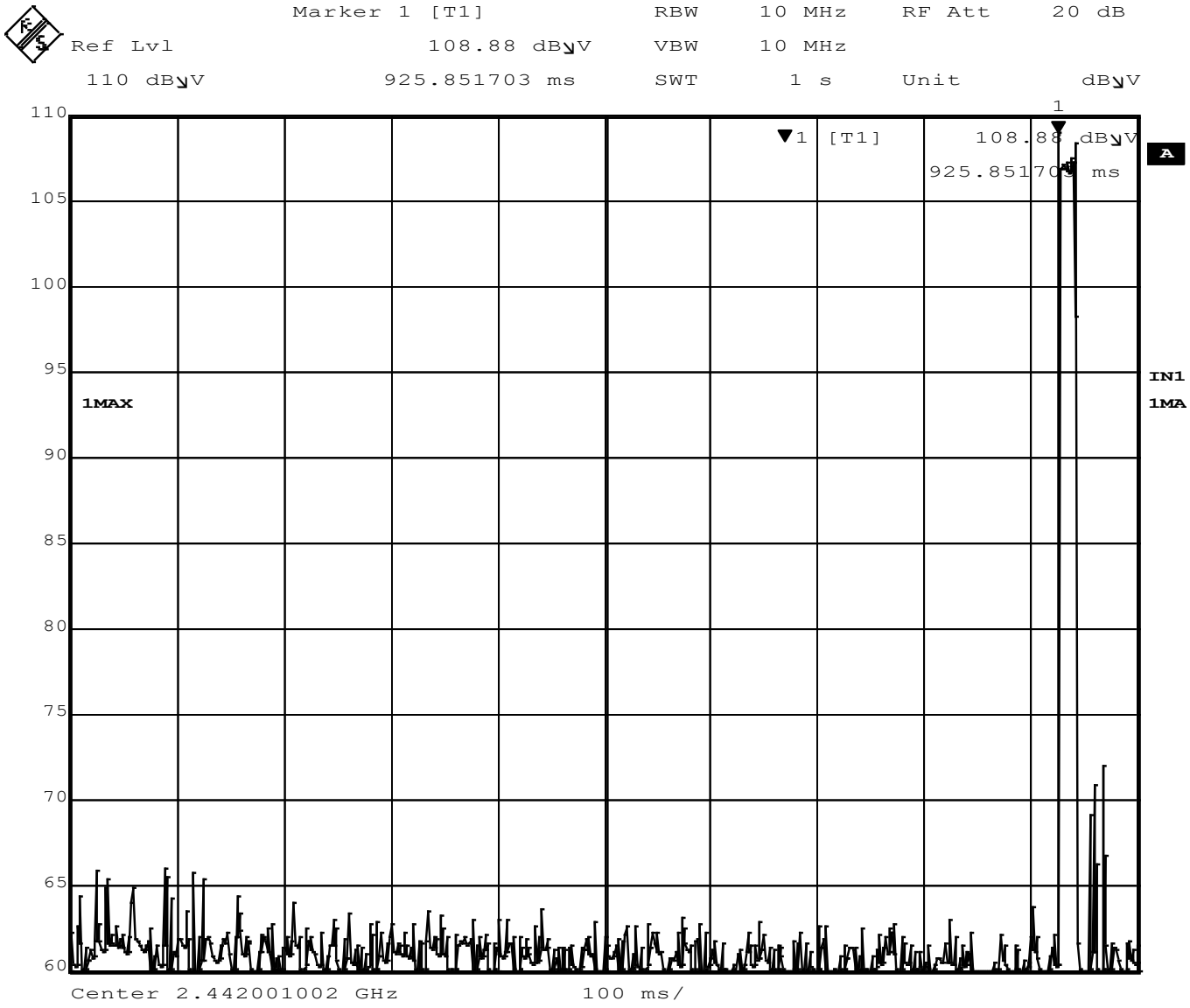

Figure 2 – Duty Cycle

Maximum of 1 pulse can occur in any 100 ms window on any one frequency channel.

Note: the short pulse following the fundamental was the response from the paired device.

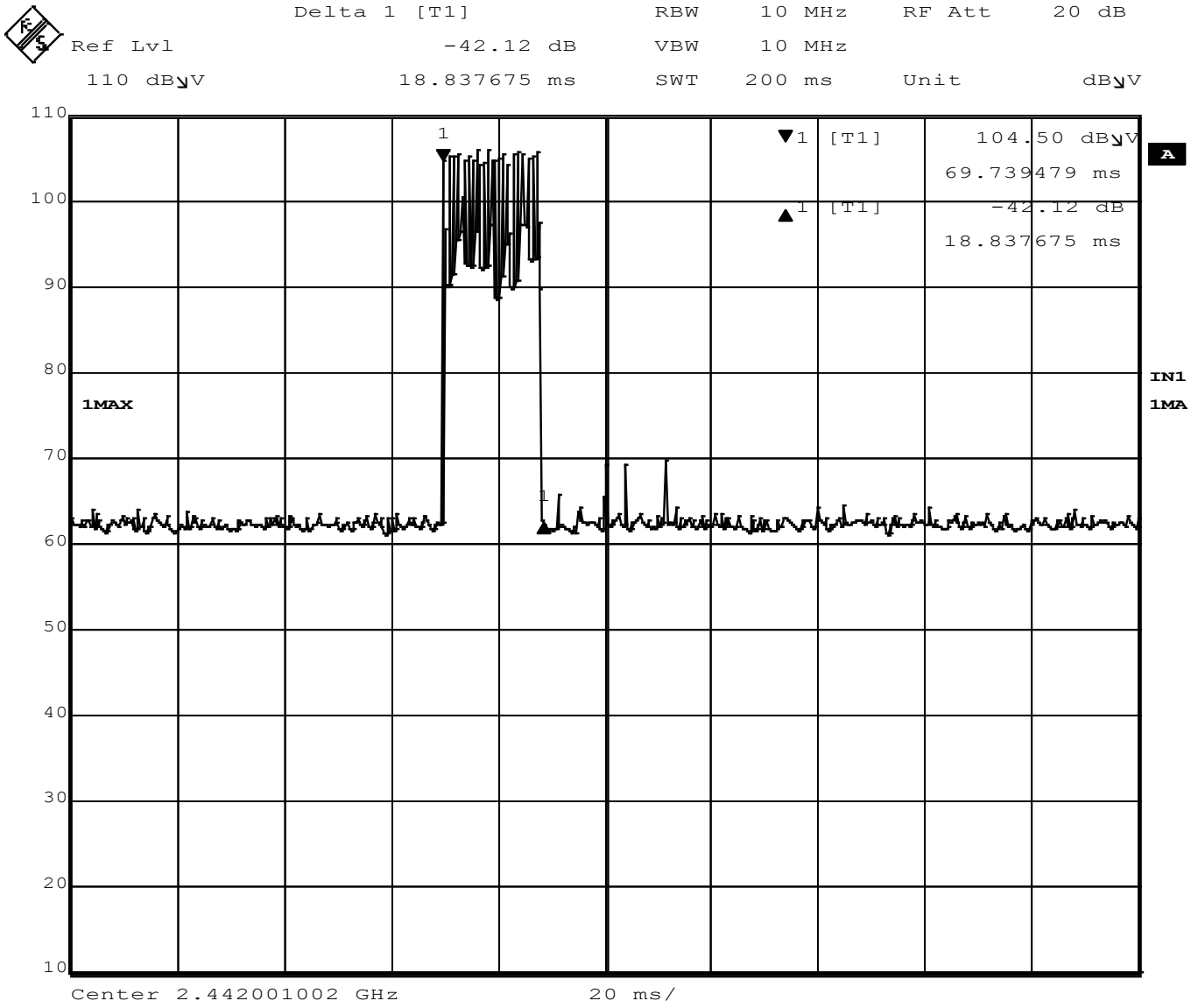

Figure 3 – Maximum Pulse Width

Duty cycle correction factor = 20*log(18.83)/100) = -14.50 dB

On time = 18.83 ms per Figure 3

Period = 100 ms (Figure 2 shows 1 peak in 100 ms)

Note: the short pulse following the fundamental was the response from the paired device.

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.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

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:

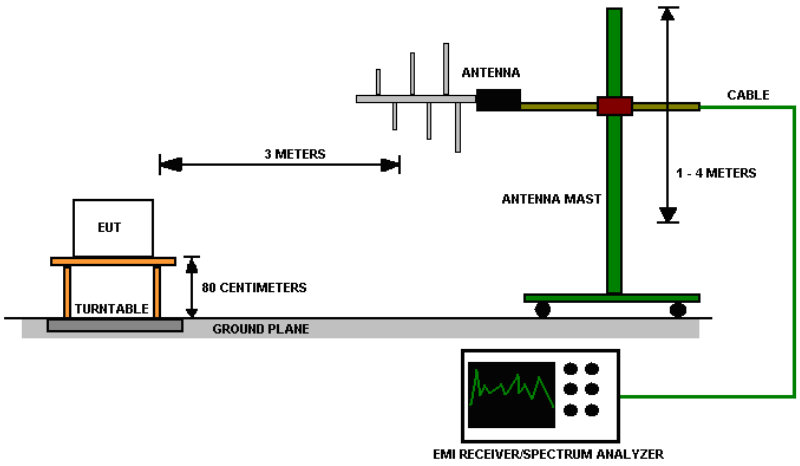

Figure 4 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest and highest frequency channels.

Test results:

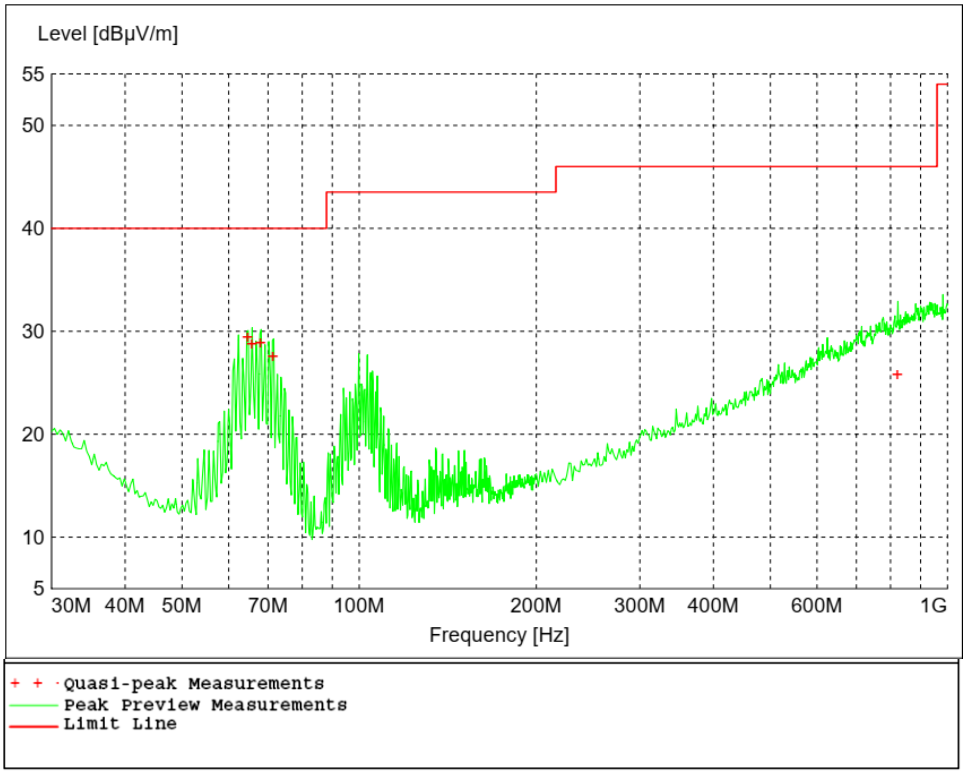

Figure 5 - Radiated Emissions Plot, Receive

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	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
64.620000	29.45	40.00	10.50	115	265	VERT	Y-axis
65.700000	28.78	40.00	11.20	106	320	VERT	Y-axis
67.980000	28.91	40.00	11.10	100	324	VERT	Y-axis
71.400000	27.58	40.00	12.40	129	265	VERT	Y-axis
822.240000	25.76	46.00	20.20	363	1	VERT	Y-axis

Table 2 - Radiated Emissions Peak Measurement vs Average Limits, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2449.400000	35.16	54.00	18.80	161	0	VERT	X-axis
4871.400000	39.38	54.00	14.60	400	168	VERT	X-axis
7352.400000	40.51	54.00	13.50	278	98	HORI	X-axis
9766.600000	44.36	54.00	9.60	224	164	HORI	X-axis

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

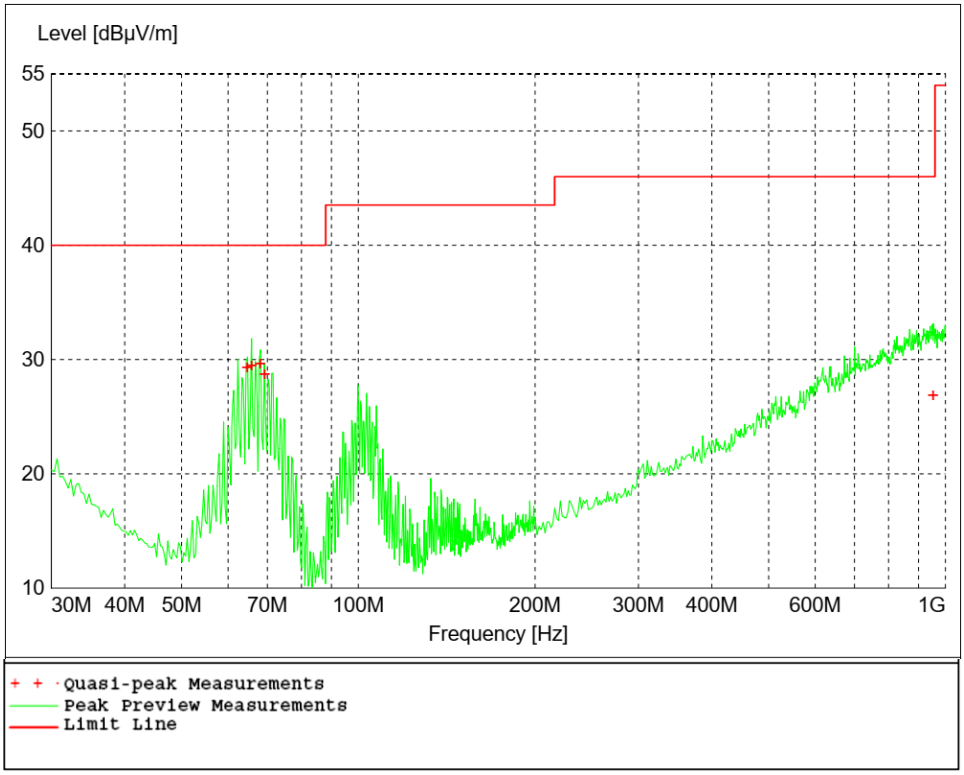

Figure 6 - Radiated Emissions Plot, Low Channel

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 3 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
64.680000	29.25	40.00	10.80	98	280	VERT	Y-axis
65.820000	29.39	40.00	10.60	101	2	VERT	Y-axis
68.100000	29.62	40.00	10.40	99	261	VERT	Y-axis
69.240000	28.69	40.00	11.30	114	265	VERT	Y-axis
953.460000	26.83	46.00	19.20	400	348	HORI	Y-axis

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

Table 4 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	87.04	113.98	26.94	187	263	VERT	X-axis
4804.000000	53.38	74.00	20.62	100	166	HORI	X-axis
7206.000000	49.85	74.00	24.15	126	256	HORI	X-axis
9599.800000	44.71	74.00	29.29	107	50	HORI	X-axis
12010.000000	53.43	74.00	20.57	107	250	HORI	X-axis
14412.200000	53.81	74.00	20.19	99	260	VERT	X-axis
16828.400000	48.45	74.00	25.55	168	180	HORI	X-axis

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

Table 5 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	72.54	NA	NA	187	263	VERT	X-axis
4804.000000	38.88	54.00	15.12	100	166	HORI	X-axis
7206.000000	35.35	54.00	18.65	126	256	HORI	X-axis
9599.800000	30.21	54.00	23.79	107	50	HORI	X-axis
12010.000000	38.93	54.00	15.07	107	250	HORI	X-axis
14412.200000	39.31	54.00	14.69	99	260	VERT	X-axis
16828.400000	33.95	54.00	20.05	168	180	HORI	X-axis

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Average values = Peak measurement – 14.50 dB (averaging factor)

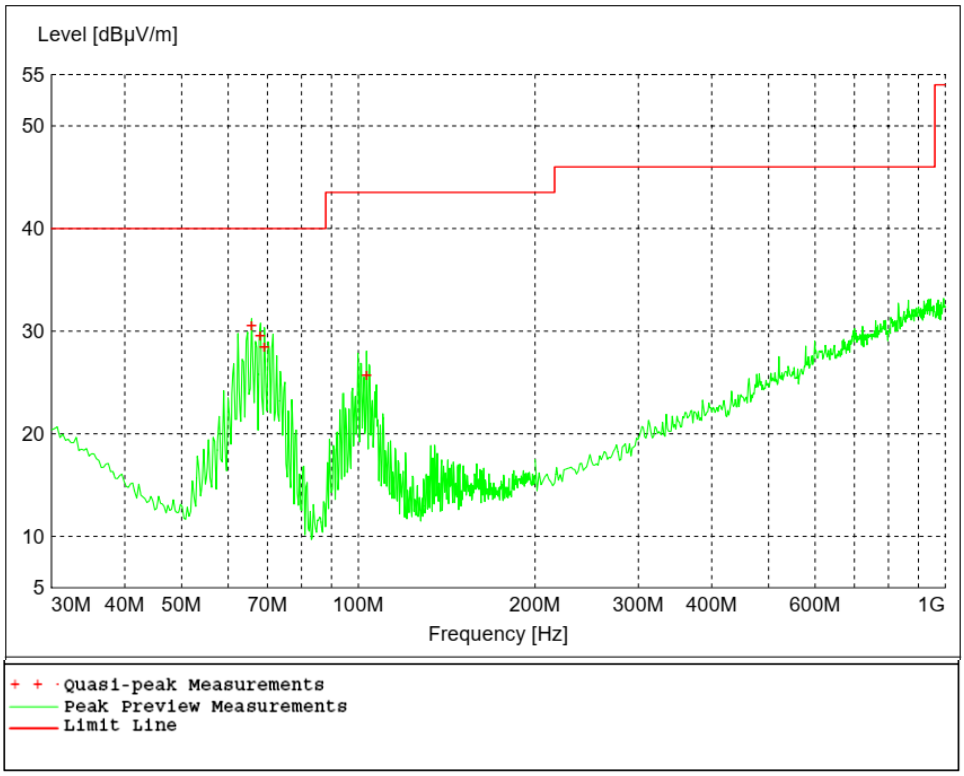

Figure 7 - Radiated Emissions Plot, Mid Channel

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 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
65.820000	30.53	40.00	9.50	115	309	VERT	Y-axis
68.100000	29.61	40.00	10.40	129	329	VERT	Y-axis
69.180000	28.46	40.00	11.50	100	251	VERT	Y-axis
103.320000	25.70	43.50	17.80	100	295	VERT	Y-axis

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

Table 7 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2441.000000	88.08	113.98	25.93	197	360	HORI	X-axis
4882.000000	55.30	74.00	18.70	187	124	HORI	X-axis
7323.000000	51.28	74.00	22.72	106	143	HORI	X-axis
12205.200000	51.26	74.00	22.74	100	255	HORI	X-axis
14645.800000	53.76	74.00	20.24	100	75	VERT	X-axis

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

Table 8 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2441.000000	73.58	NA	NA	197	360	HORI	X-axis
4882.000000	40.80	54.00	13.20	187	124	HORI	X-axis
7323.000000	36.78	54.00	17.22	106	143	HORI	X-axis
12205.200000	36.76	54.00	17.24	100	255	HORI	X-axis
14645.800000	39.26	54.00	14.74	100	75	VERT	X-axis

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Average values = Peak measurement – 14.50 dB (averaging factor)

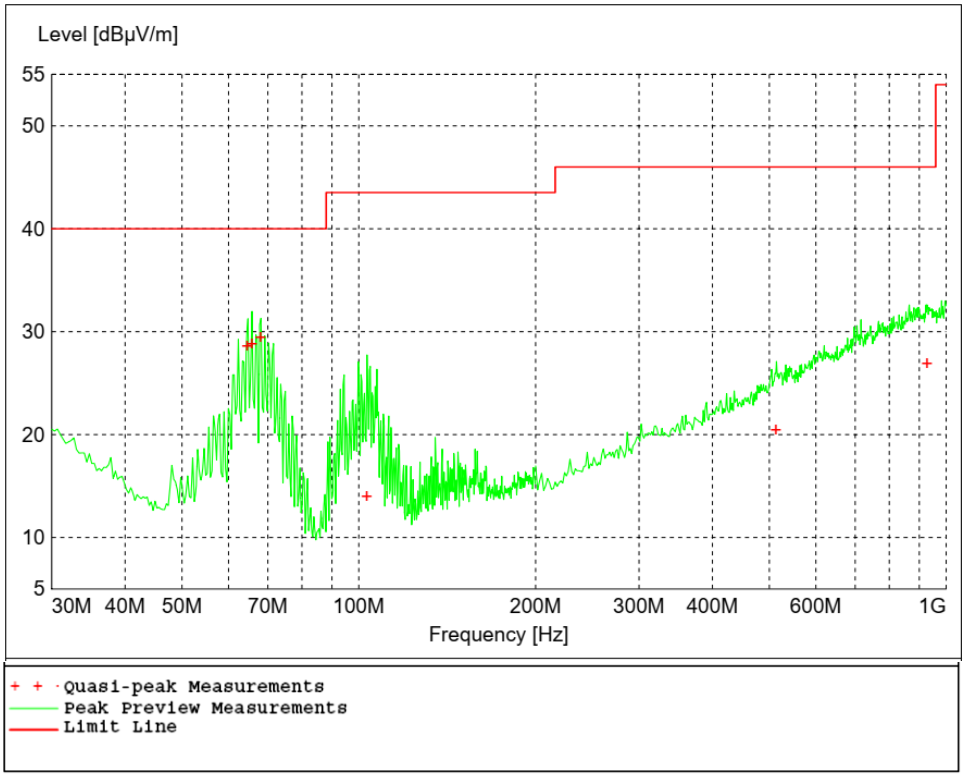

Figure 8 - Radiated Emissions Plot, High Channel

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 9 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
64.620000	28.68	40.00	11.30	106	275	VERT	Y-axis
65.760000	28.86	40.00	11.10	129	305	VERT	Y-axis
68.100000	29.46	40.00	10.50	100	245	VERT	Y-axis
103.260000	13.99	43.50	29.50	106	242	VERT	Y-axis
513.000000	20.54	46.00	25.50	247	114	VERT	Y-axis
928.320000	26.97	46.00	19.00	156	357	HORI	Y-axis

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

Table 10 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	88.73	113.98	25.25	100	360	HORI	X-axis
4960.000000	60.10	74.00	13.90	281	39	VERT	X-axis
7440.000000	50.85	74.00	23.15	99	48	VERT	X-axis
9916.600000	43.82	74.00	30.18	277	83	HORI	X-axis
12400.000000	52.48	74.00	21.52	98	244	HORI	X-axis
14880.000000	56.78	74.00	17.22	101	302	HORI	X-axis
17370.600000	52.31	74.00	21.69	318	282	HORI	X-axis

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

Table 11 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	74.23	NA	NA	100	360	HORI	X-axis
4960.000000	45.60	54.00	8.40	281	39	VERT	X-axis
7440.000000	36.35	54.00	17.65	99	48	VERT	X-axis
9916.600000	29.32	54.00	24.68	277	83	HORI	X-axis
12400.000000	37.98	54.00	16.02	98	244	HORI	X-axis
14880.000000	42.28	54.00	11.72	101	302	HORI	X-axis
17370.600000	37.81	54.00	16.19	318	282	HORI	X-axis

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Average values = Peak measurement – 14.50 dB (averaging factor)

4.3 PEAK OUTPUT POWER

Test Method: N/A

EIRP was calculated from field strength measurements using ANSI C63.10-2013, Annex G, Equation G.1. The field strength was measured at a 3m distance and maximized. Test from ANSI C63.10-2013, Section 11.9.1.1 was used as a reference.

For Informational Purposes only

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. The power was measured using a 10 MHz RBW.

Deviations from test standard:
No deviation.

Test setup:

See Section 4.2.

EUT operating conditions:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest and highest frequency channel.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	Method	RESULT
1	2402	-4.66	EIRP	PASS
2	2441	-3.69	EIRP	PASS
3	2480	-3.80	EIRP	PASS

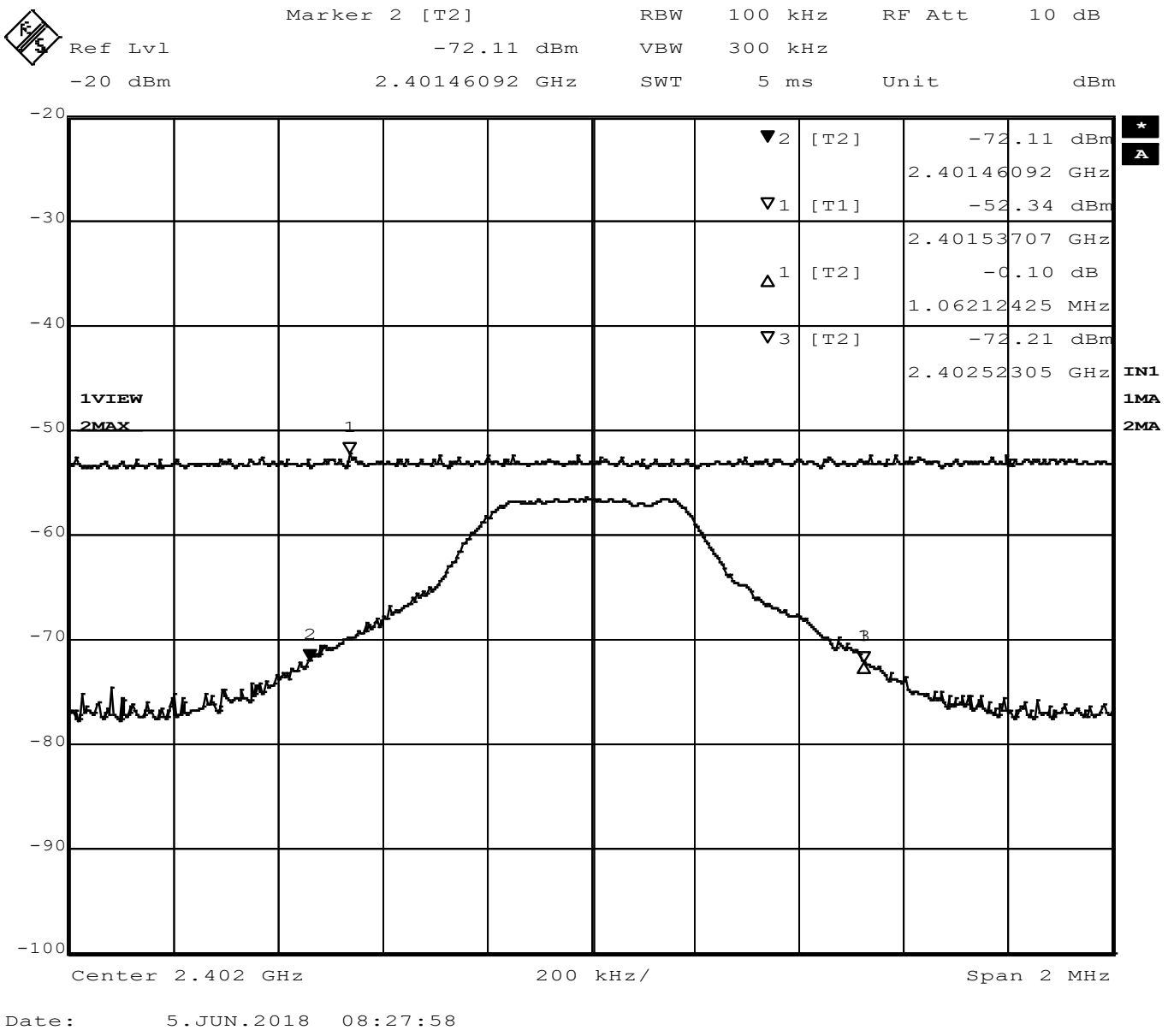

Figure 9 – Output Power

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

Maximum power = -52.34 dBm + 107 + CL + AF - 95.23 = -4.66 dBm*

CL = cable loss = 7.60 dB

AF = antenna factor = 28.31 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.

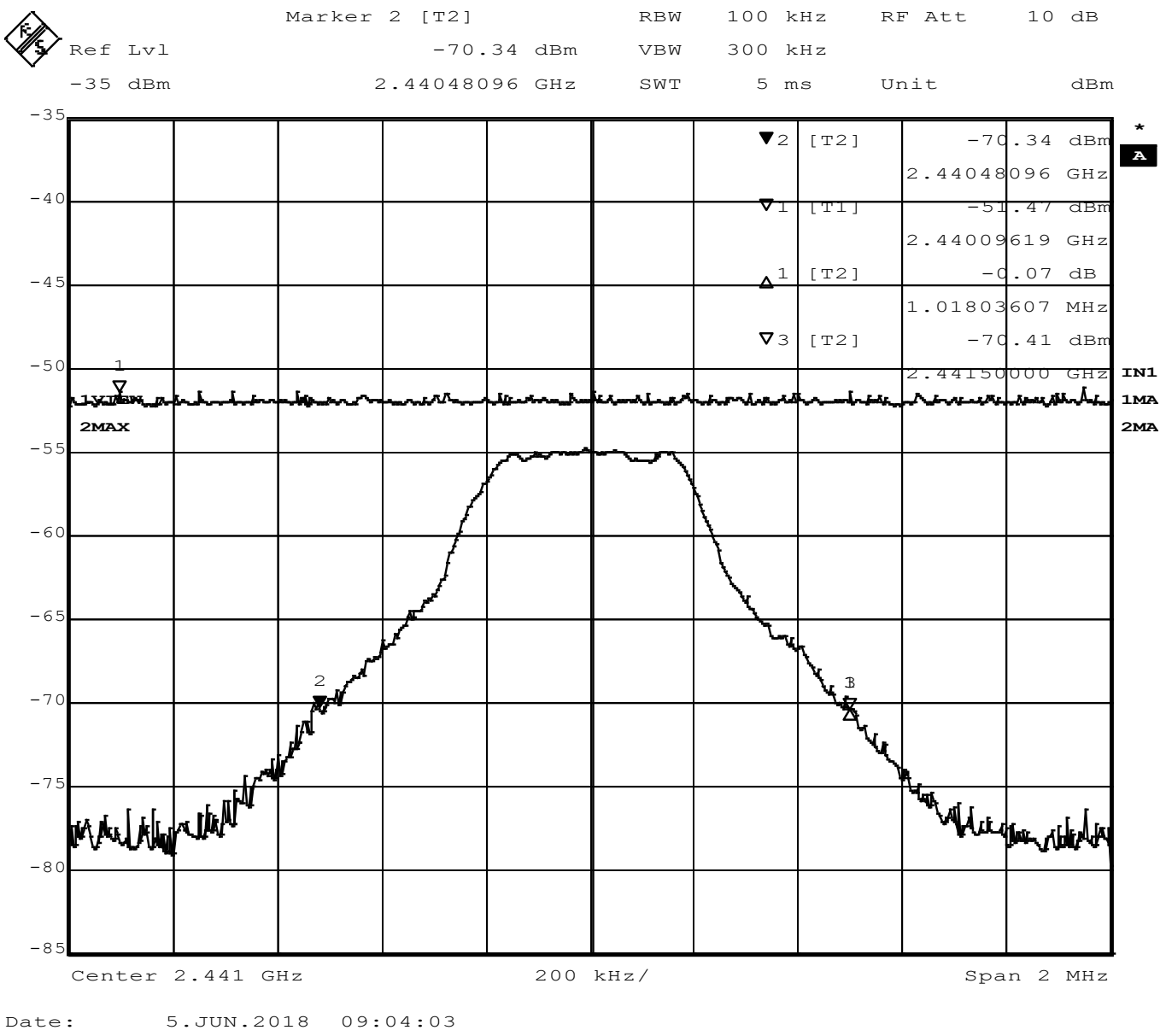

Figure 10 – Output Power

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

Maximum power = -51.47 dBm + 107 + CL + AF - 95.23 = -3.69 dBm*

CL = cable loss = 7.70 dB

AF = antenna factor = 28.31 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.

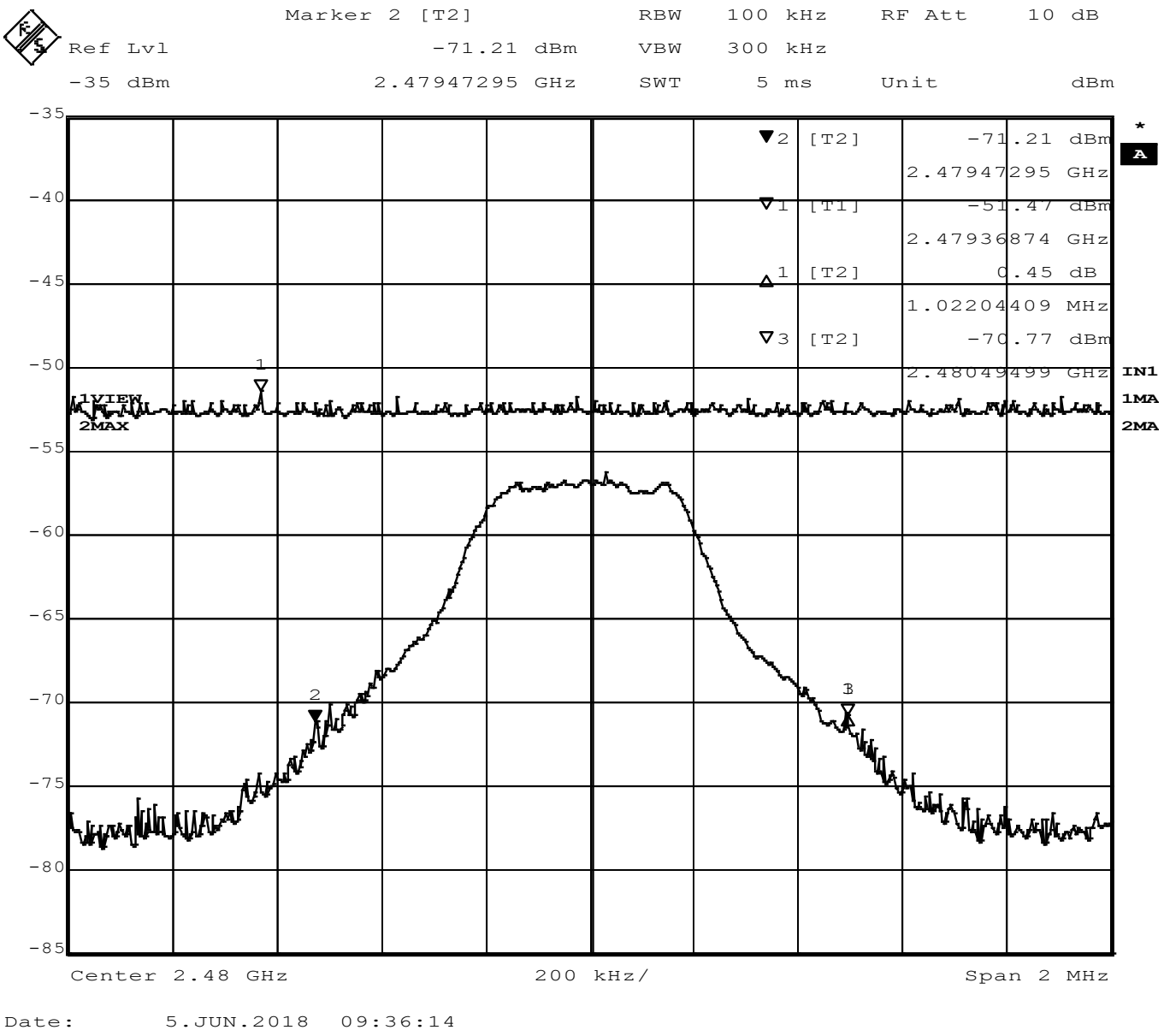

Figure 11 – Output Power

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

Maximum power = -51.47 dBm + 107 + CL + AF - 95.23 = -3.80 dBm*

CL = cable loss = 7.70 dB

AF = antenna factor = 28.20 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.

4.4 BANDWIDTH

Test Method: ANSI C63.10-2013, Section(s) 6.9.2

Limits of bandwidth measurements:

For Informational Purposes only

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 Occupied 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:

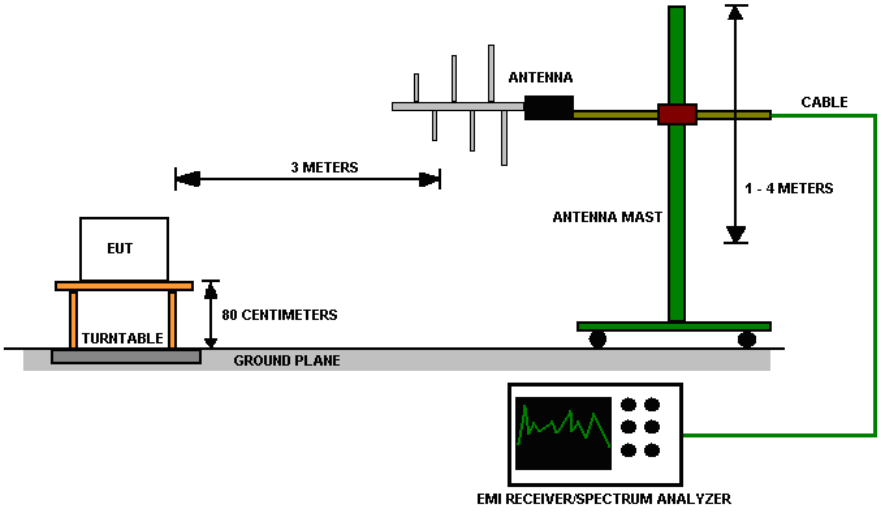

Figure 12 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest and highest frequency channel.

Test results:

Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	OBW (MHz)	RESULT
1	2402	1.06	PASS
2	2441	1.01	PASS
3	2480	1.02	PASS

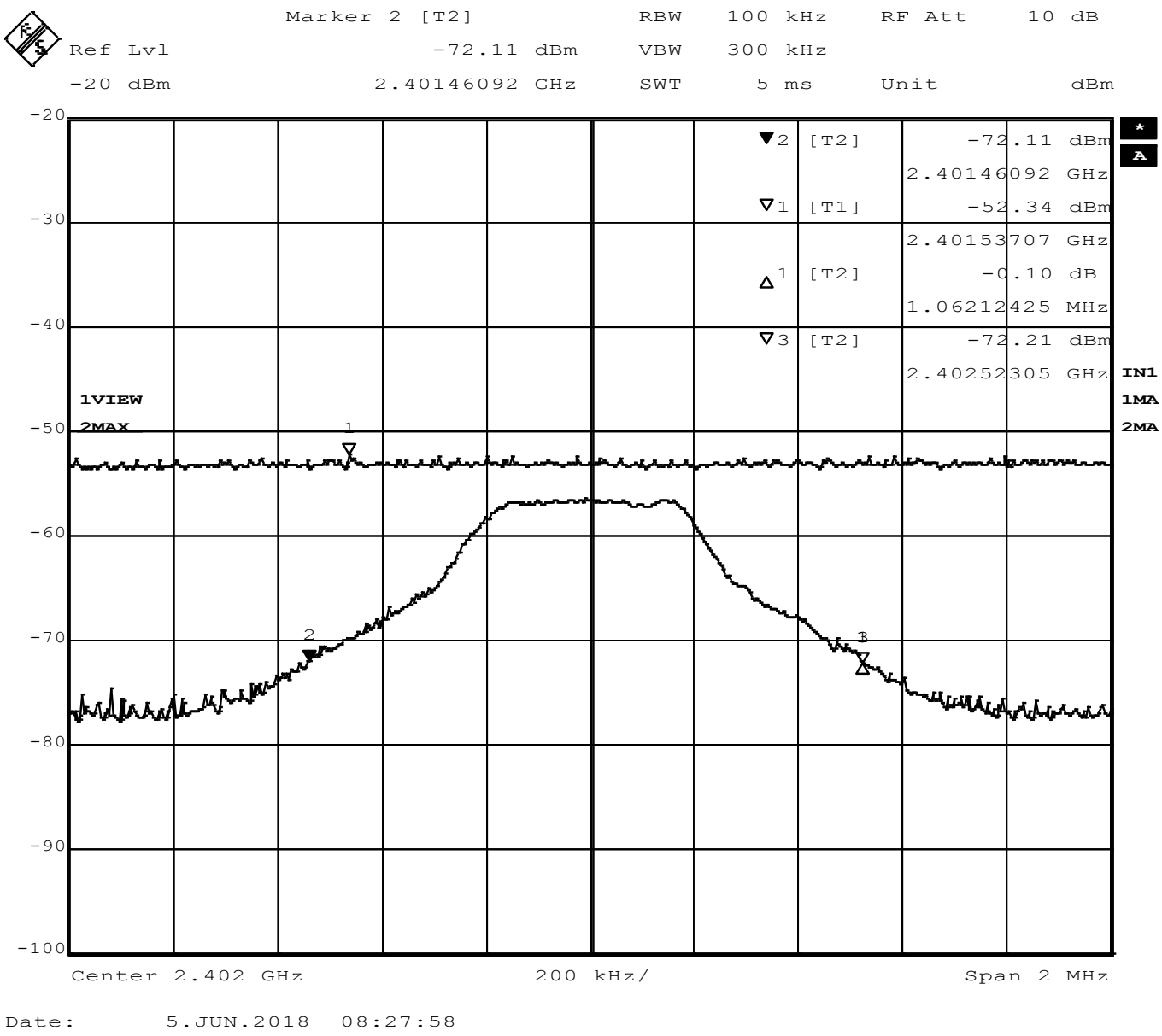

Figure 13 – Occupied Bandwidth

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

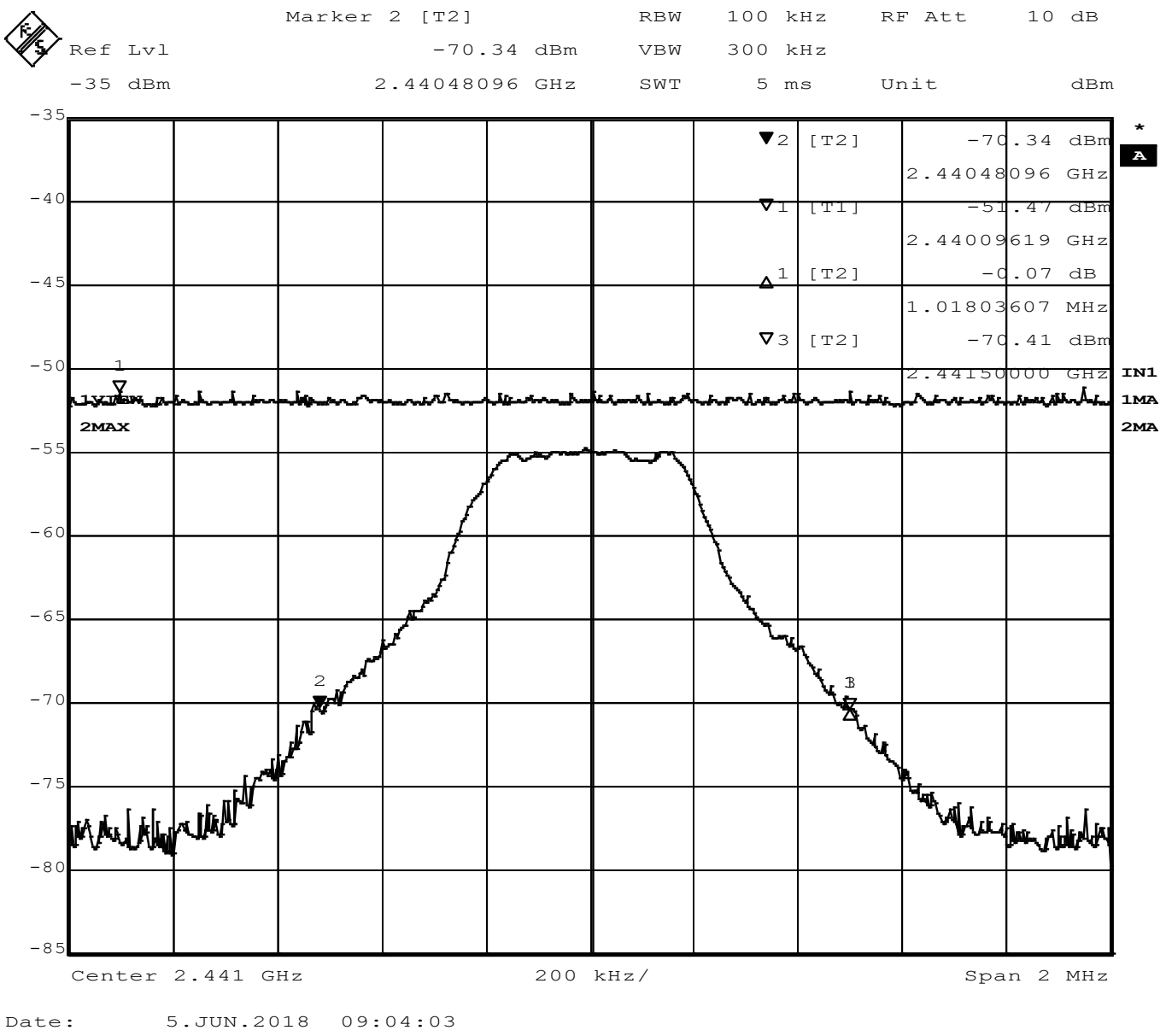

Figure 14 - Occupied Bandwidth

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

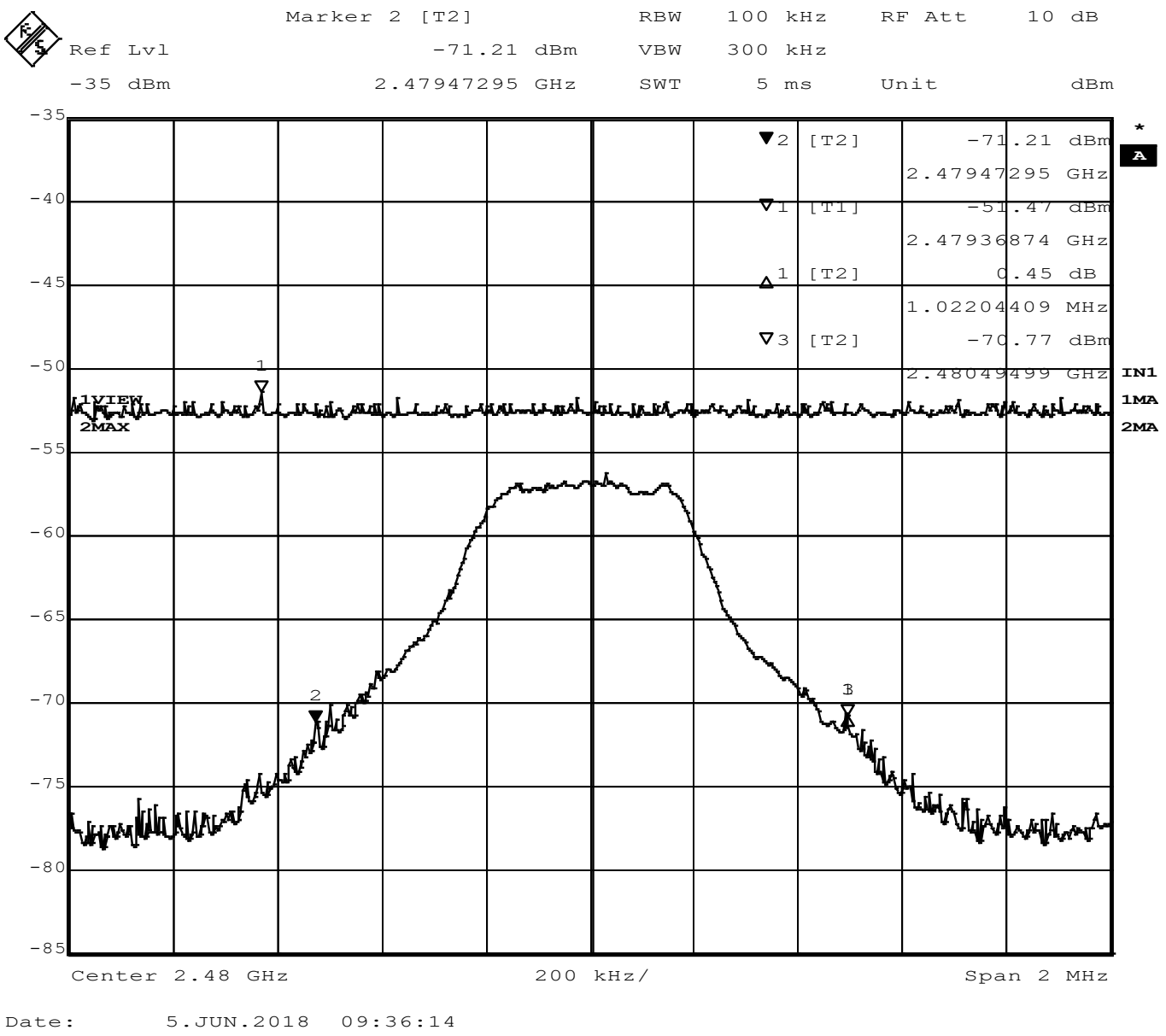

Figure 15 - Occupied Bandwidth

Note*: Trace 1 was measured using a 10 MHz RBW. The waveform was saved on the display, then the RBW was changed to 100 kHz to measure the BW.

4.5 BANDEDGES

Test Method: ANSI C63.10-2013, Section(s) 6.10.6

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:
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 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.

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	2400.0	-83.69	-56.95	26.74	18.54	PASS
High, Continuous	2483.5	-87.41	-57.13	30.28	20.23	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 Low Channel = 72.54 dBµV/m
Fundamental average field strength at High Channel = 74.23 dBµV/m

Low Channel minimum delta = 72.54 – 54.0 dBµV/m = 18.54 dBc
High Channel minimum delta = 74.23– 54.0 dBµV/m = 20.23 dBc

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

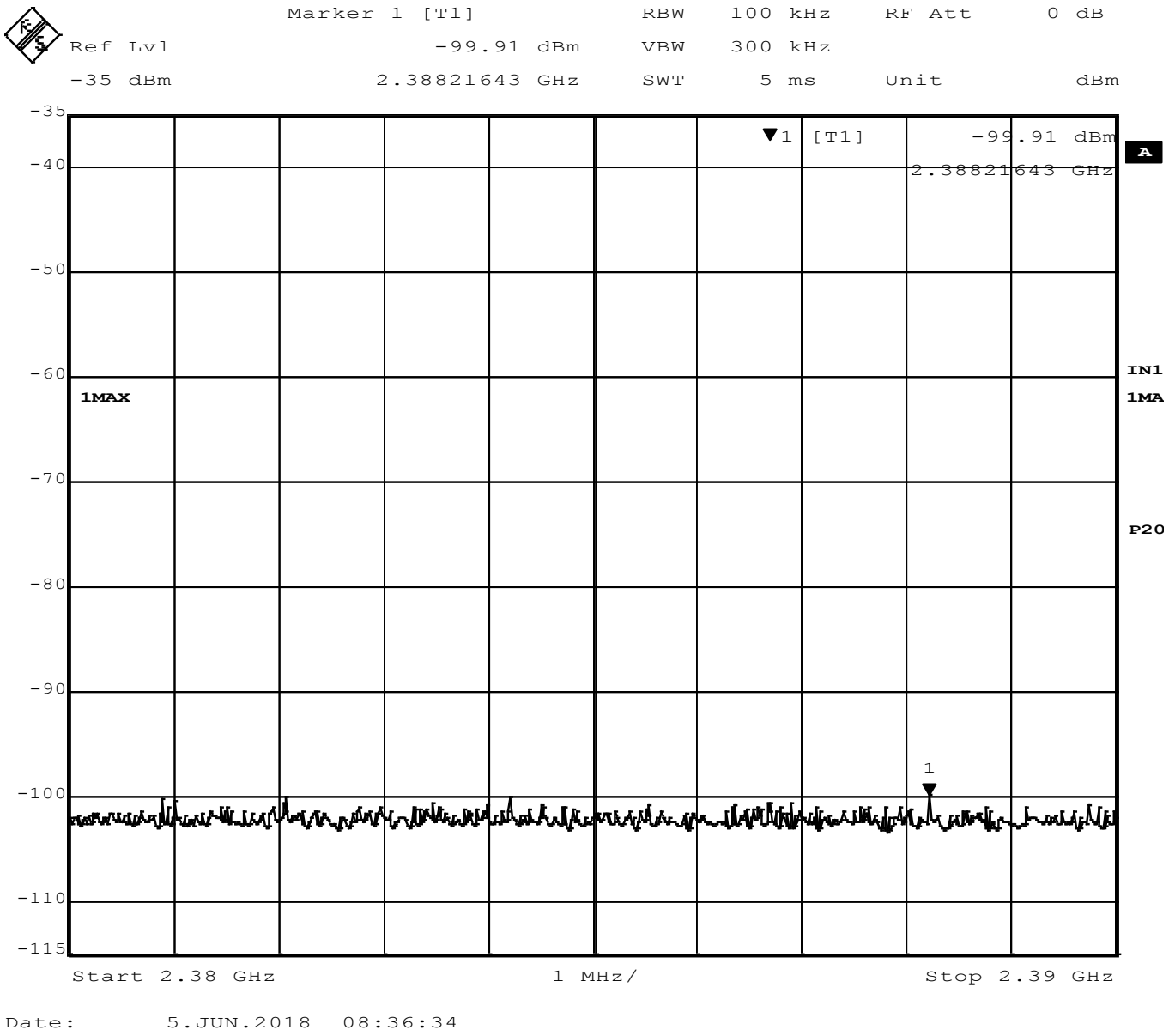

Figure 16 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit

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

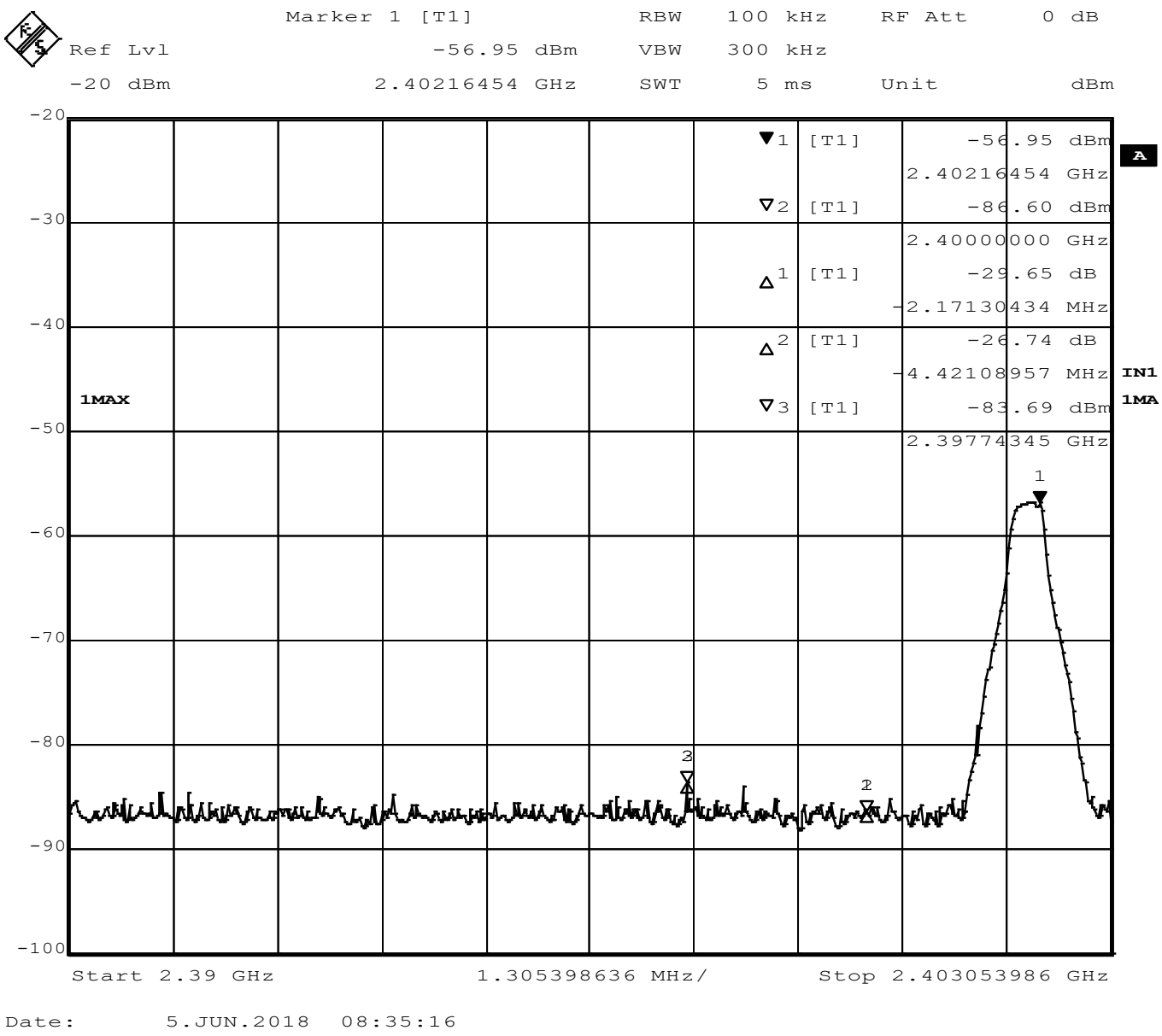

Figure 17 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit

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

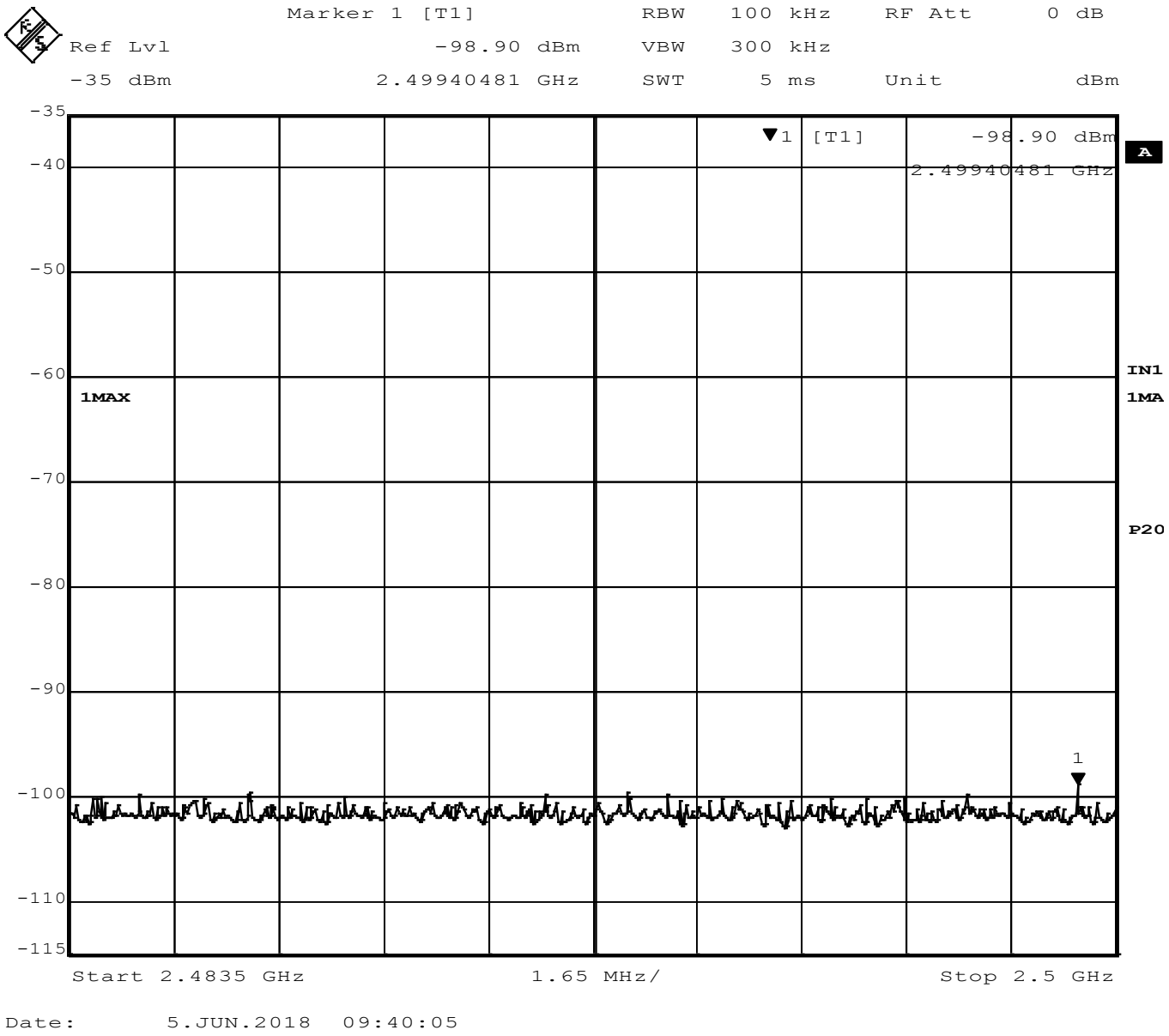

Figure 18 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit

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

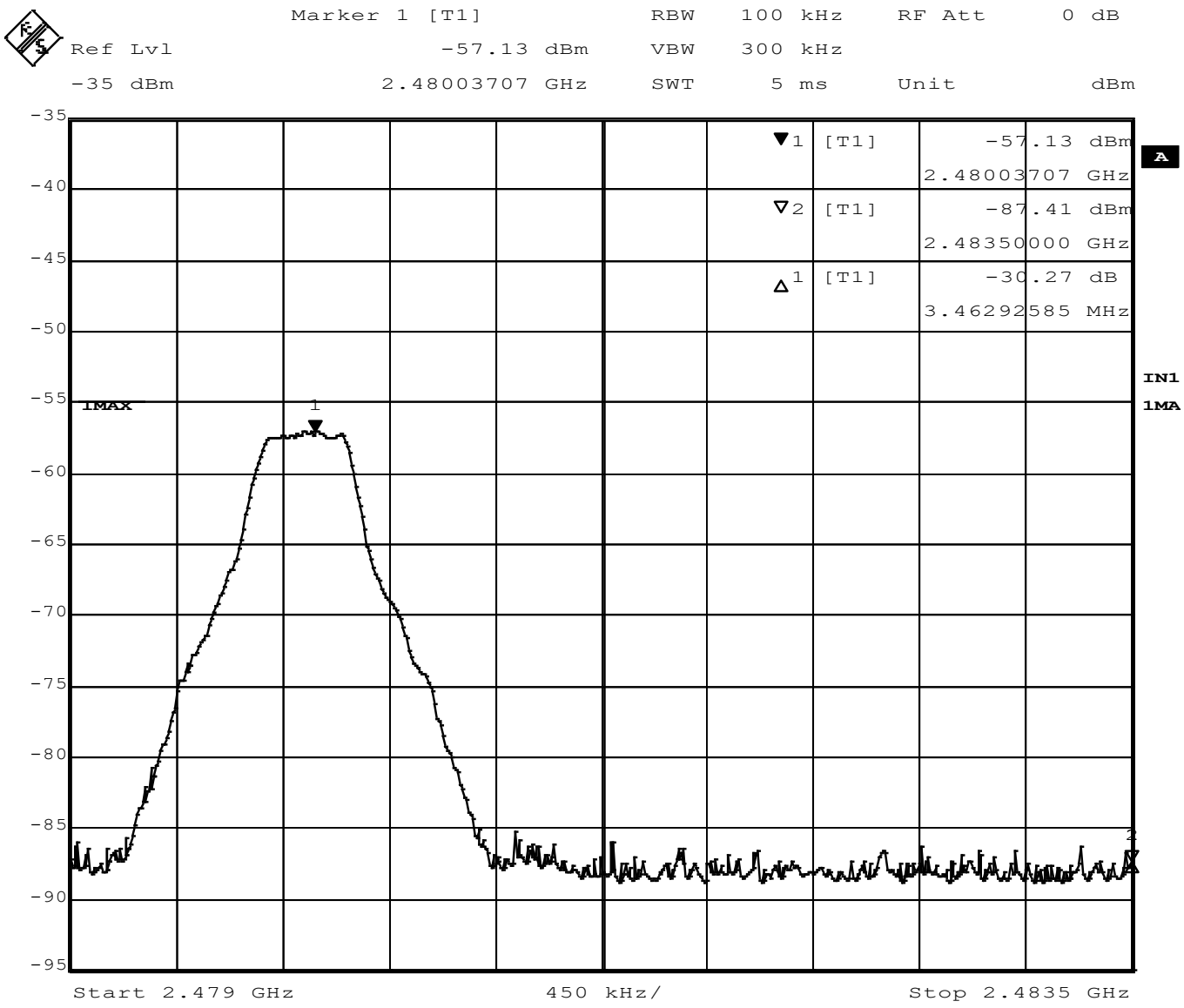

Figure 19 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

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

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 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:

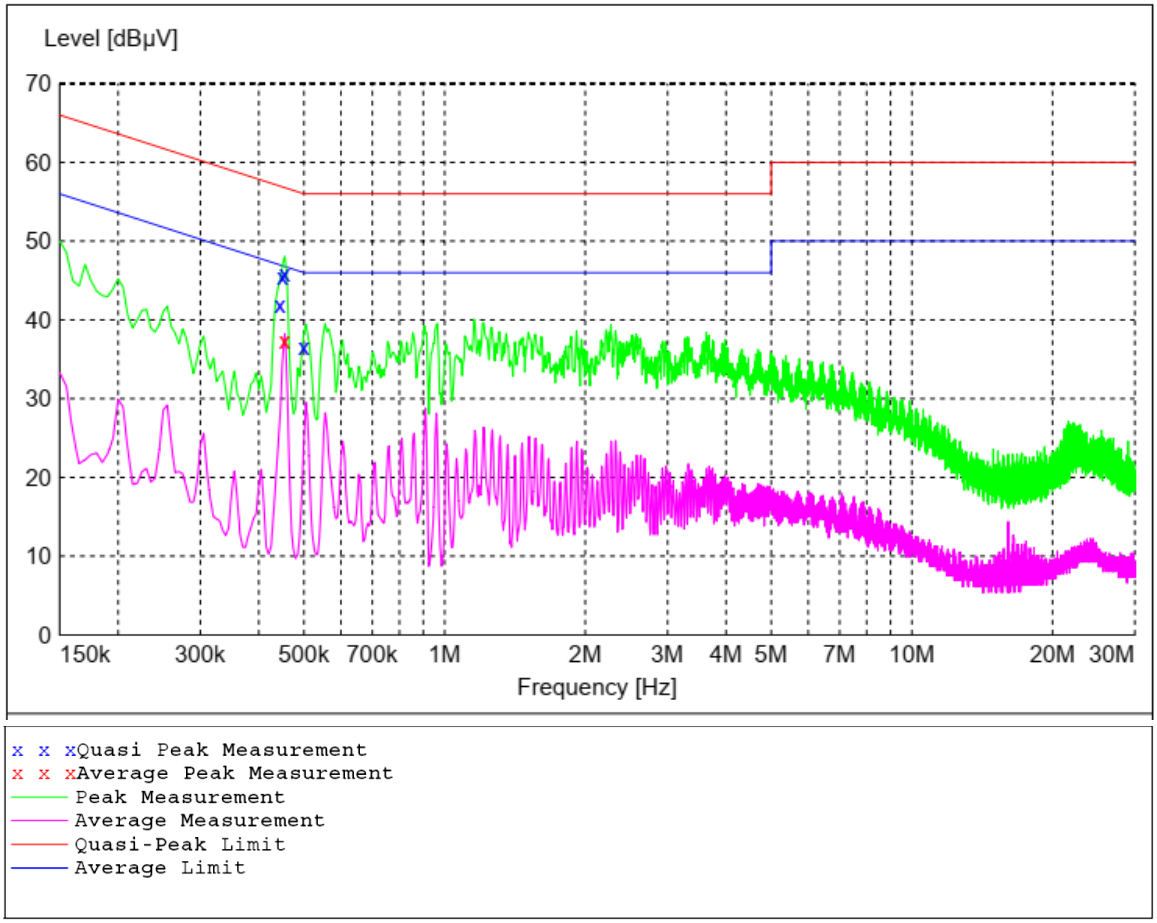

Figure 20 - Conducted Emissions Plot

Table 12 – Conducted Emissions Peak Measurements

Frequency	Level	Limit	Margin	Line	PE
MHz	dBµV/m	dBµV/m	dB		
0.445000	41.90	57.00	15.00	N	FLO
0.450000	45.40	57.00	11.50	L1	FLO
0.455000	45.80	57.00	11.00	L1	FLO
0.500000	36.60	56.00	19.40	N	FLO

Table 13 - Conducted Emissions Average Measurements

Frequency	Level	Limit	Margin	Line	PE
MHz	dBµV/m	dBµV/m	dB		
0.455000	37.40	47.00	9.40	L1	FLO

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