

Amended  
**DXX**  
**FCC/ISED Test Report**

**Prepared for:** Garmin International Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** A03491

**Test Report No:** R20181015-20-01A

**Approved by:**



**Nic S. Johnson, NCE**

Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

**DATE:** 24 May 2019

**Total Pages:** 39

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|                                                                                  |                |                 |     |   |
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## REVISION PAGE

| Rev. No. | Date             | Description                                                                                                  |
|----------|------------------|--------------------------------------------------------------------------------------------------------------|
| 0        | 28 February 2019 | Original – NJohnson<br>Prepared by KVepuri/CFarrington                                                       |
| A        | 24 May 2019      | Updated table in Section 1.<br><br>-Includes NCEE Labs report R20181015-20-01 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 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<br>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<br>RSS-Gen, 7.1                                       | Receiver Radiated Emissions    | Pass   | Meets the requirement of the limit. |
| FCC 15.209<br>RSS-Gen, 8.9<br>RSS-210 B1.2<br>FCC 15.249(a)      | Transmitter Radiated Emissions | Pass   | Meets the requirement of the limit. |
| FCC 15.209, 15.205,<br>15.249(d)<br>RSS-Gen, 8.9<br>RSS-210, 5.5 | Band Edge Measurement          | Pass   | Meets the requirement of the limit. |
| FCC 15.207<br>RSS-Gen. 8.8                                       | Conducted AC Emissions         | Pass   | Meets the requirement of the limit. |



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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary

|                |                         |
|----------------|-------------------------|
| EUT            | A03491                  |
| EUT Received   | 1/14/2019               |
| EUT Tested     | 1/14/2019 - 2/19/2019   |
| Serial No.     | 3492 398407923bw 00     |
| Operating Band | 2400 – 2483.5 MHz       |
| Device Type    | BLE                     |
| Power Supply   | PHIHong MN:PSAF10R-050Q |

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



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## 2.2 DESCRIPTION OF TEST MODES

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

| Channel | Frequency |
|---------|-----------|
| 1       | 2402 MHz  |
| 2       | 2440 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.

## 2.3 DESCRIPTION OF SUPPORT UNITS

None

|                                                                                  |                |                 |     |   |
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### 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  $35 \pm 4\%$   
Temperature of  $22 \pm 3^\circ$  Celsius



#### 3.2 TEST PERSONNEL

| No. | PERSONNEL        | TITLE               | ROLE               |
|-----|------------------|---------------------|--------------------|
| 1   | Nic Johnson      | Technical Manager   | Review of Results  |
| 2   | Karthik Vepuri   | EMC Test Engineer   | Testing and Report |
| 3   | Caleb Farrington | EMC 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.

|                                                                                  |                |                 |     |   |
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### 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   | 26 Jul 2018           | 26 Jul 2019          |
| 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*         |
| Software Version 1.60                                    | ESK-1      | 2575         | N/A                   | N/A                  |

\*Internal Characterization

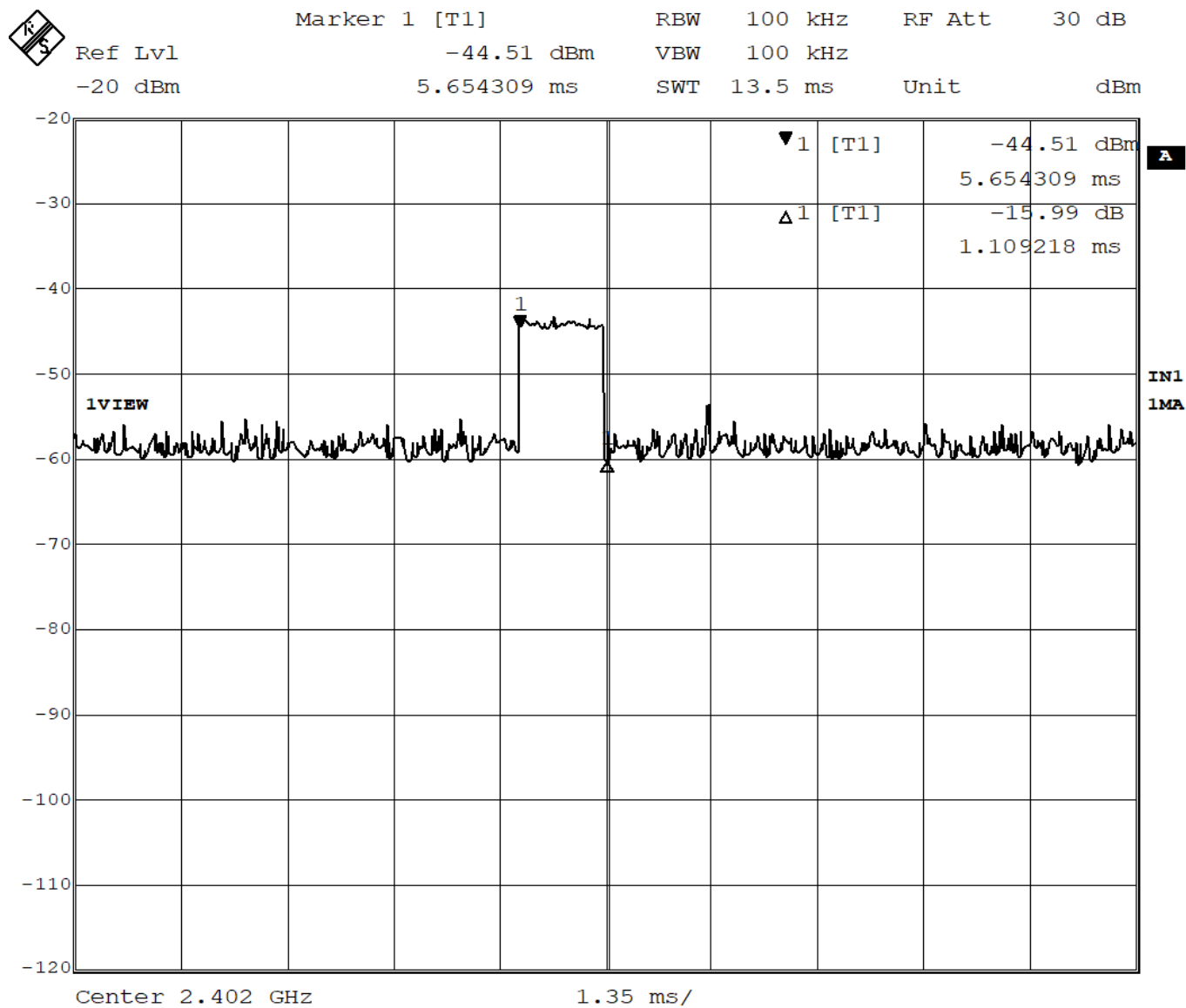
\*\* Extended Cal

#### Notes:

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

## 4.0 DETAILED RESULTS

### 4.1 DUTY CYCLE



Date: 28.FEB.2019 07:30:46

Figure 1 – On Time



Delta 1 [T1]

RBW 100 kHz RF Att 30 dB

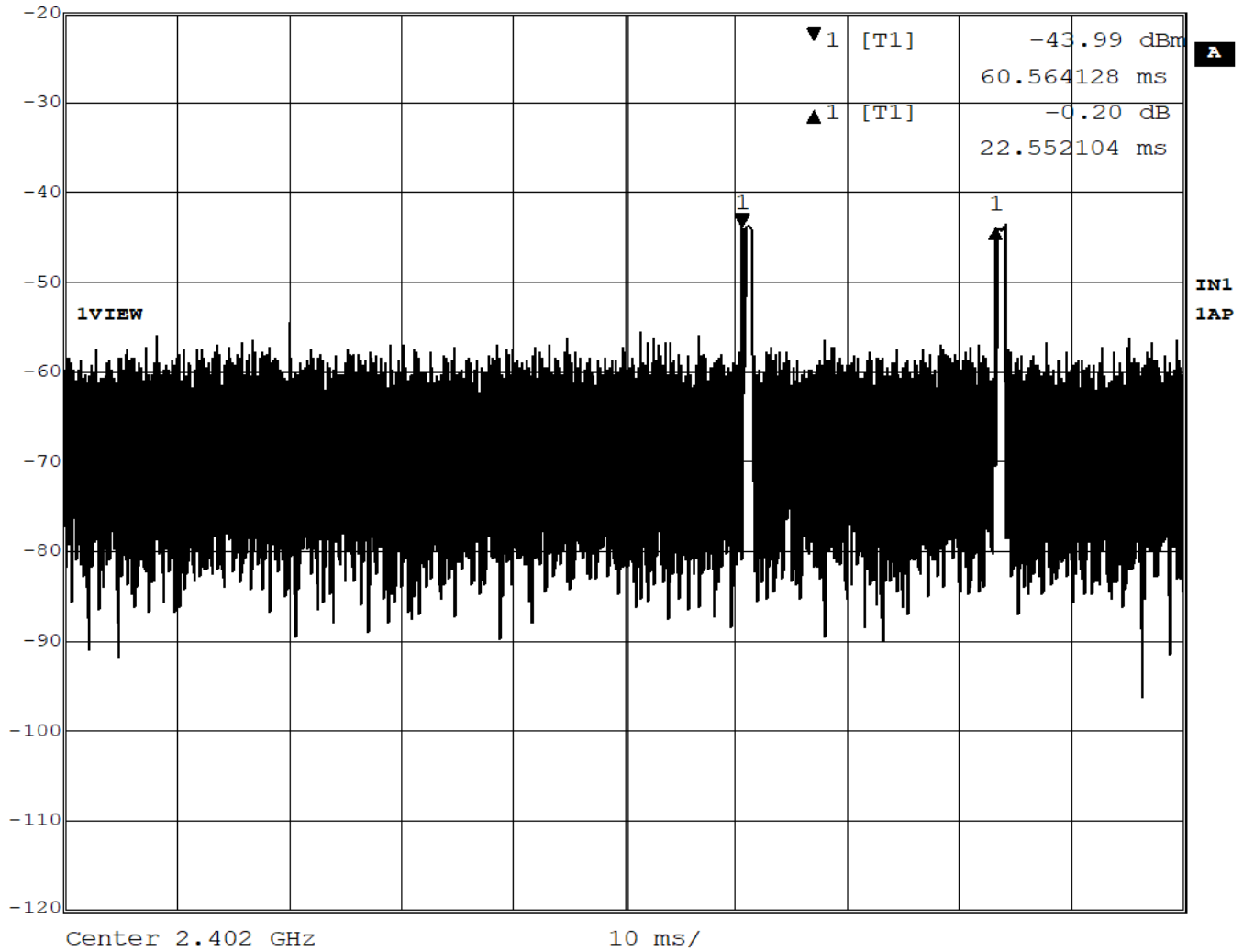
Ref Lvl -0.20 dB

VBW 100 kHz

-20 dBm 22.552104 ms

SWT 100 ms

Unit dBm



Date: 28.FEB.2019 07:34:31

Figure 2 – Period



Delta 2 [T1]

RBW 100 kHz RF Att 30 dB

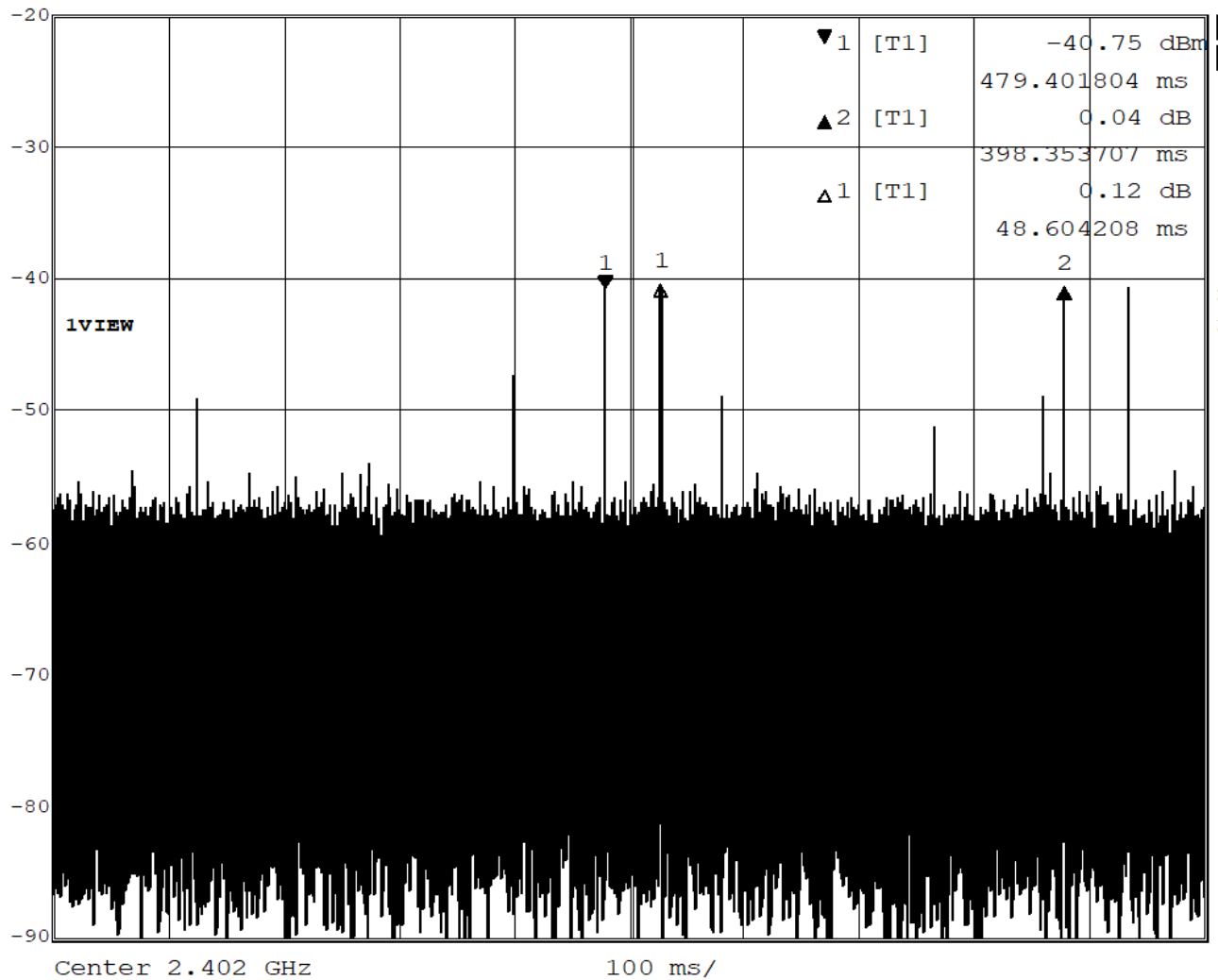
Ref Lvl 0.04 dB

VBW 100 kHz

-20 dBm 398.353707 ms

SWT 1 s

Unit dBm



Date: 28.FEB.2019 07:36:09

Figure 3 – Period-2

\*Maximum of 2 transmissions are possible in a given 100 ms window

Maximum duty cycle declared by the manufacturer = 1.1 ms

Duty cycle correction factor =  $20 \cdot \log((1.1 \times 2)/100) = -33.15 \text{ dB} = -20 \text{ dB}$  (Maximum used)

## 4.2 RADIATED EMISSIONS

**Test Method:** ANSI C63.10, 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<br>(MHz) | FIELD<br>STRENGTH<br>( $\mu\text{V/m}$ ) | MEASUREMENT<br>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) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
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.



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**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 from 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.

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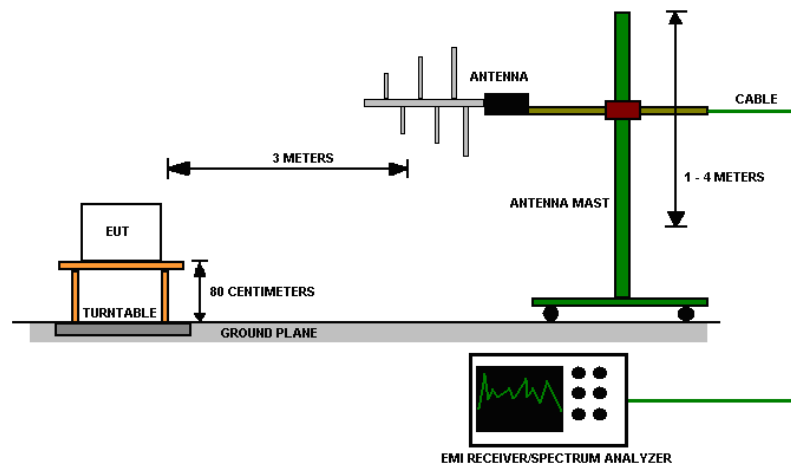
**NOTE:**

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, middle and highest frequency channels.

### Test results:

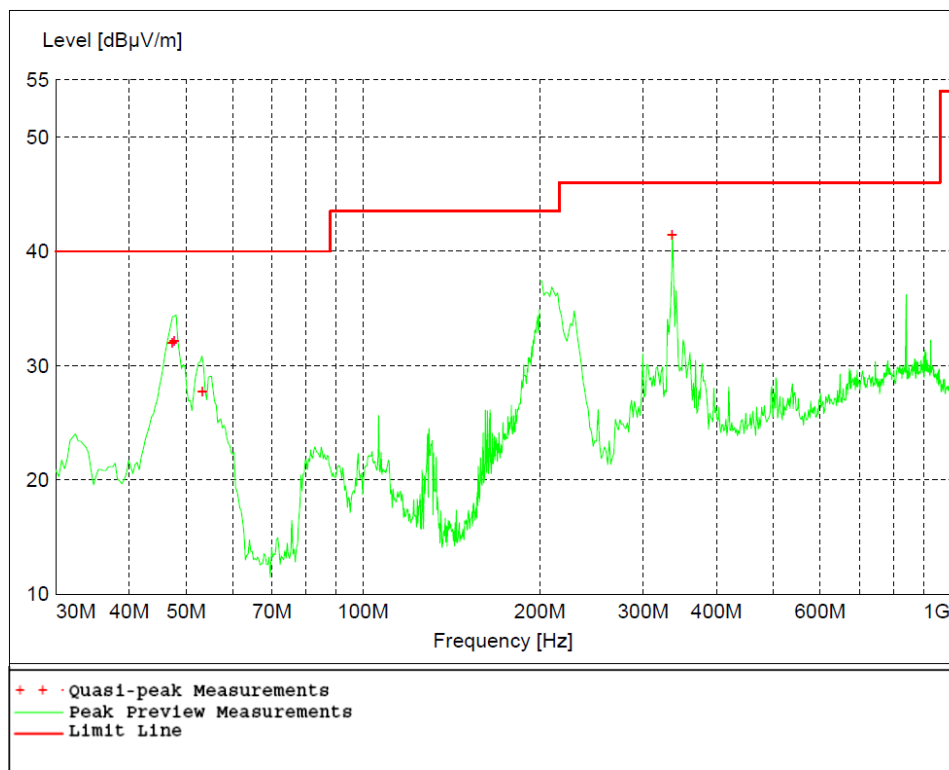


Figure 5 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

| Frequency  | Level  | Limit  | Margin | Height | Angle | Pol  |
|------------|--------|--------|--------|--------|-------|------|
| MHz        | dBμV/m | dBμV/m | dB     | cm.    | deg.  |      |
| 47.340000  | 32.03  | 40.00  | 8.00   | 100    | 291   | VERT |
| 47.700000  | 32.15  | 40.00  | 7.90   | 100    | 226   | VERT |
| 53.280000  | 27.71  | 40.00  | 12.30  | 100    | 175   | VERT |
| 336.000000 | 41.49  | 46.00  | 4.50   | 100    | 285   | HORI |

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

| Frequency   | Level  | Limit  | Margin | Height | Angle | Pol  |
|-------------|--------|--------|--------|--------|-------|------|
| MHz         | dBμV/m | dBμV/m | dB     | cm.    | deg.  |      |
| 2430.000000 | 39.49  | 54.00  | 14.50  | 142    | 182   | VERT |
| 4532.800000 | 44.09  | 54.00  | 9.90   | 102    | 234   | HORI |

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

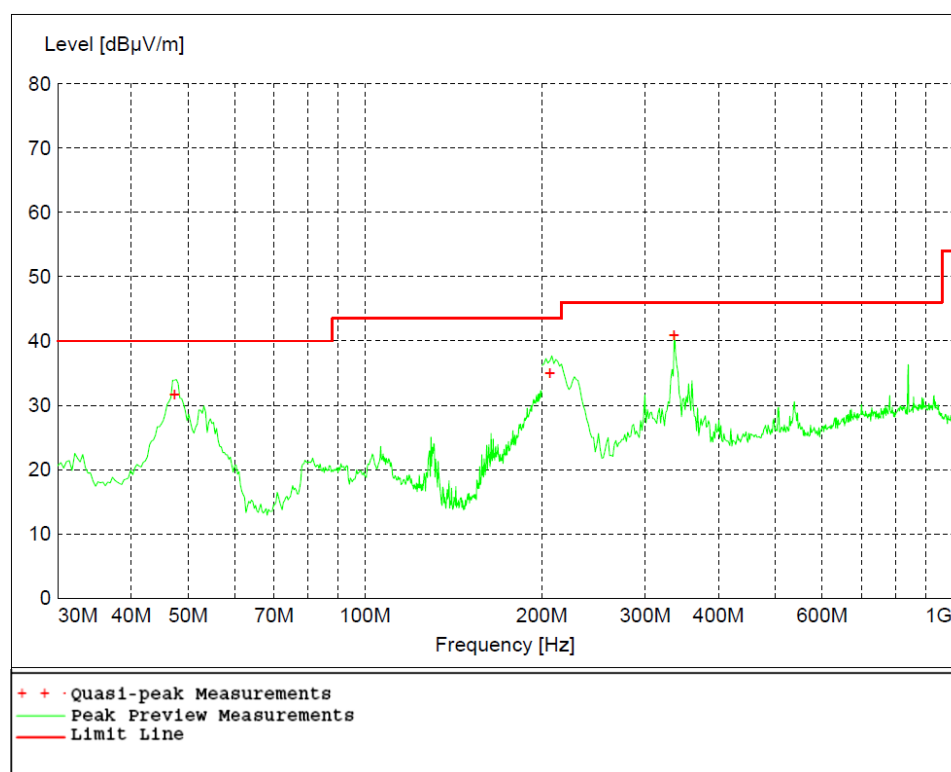


Figure 6 - Radiated Emissions Plot, Low Channel

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

| Frequency  | Level  | Limit  | Margin | Height | Angle | Pol  |
|------------|--------|--------|--------|--------|-------|------|
| MHz        | dBμV/m | dBμV/m | dB     | cm.    | deg.  |      |
| 47.400000  | 31.73  | 40.00  | 8.30   | 100    | 256   | VERT |
| 206.640000 | 35.09  | 43.50  | 8.40   | 100    | 79    | VERT |
| 336.000000 | 40.91  | 46.00  | 5.10   | 100    | 269   | HORI |

|                |                 |     |   |
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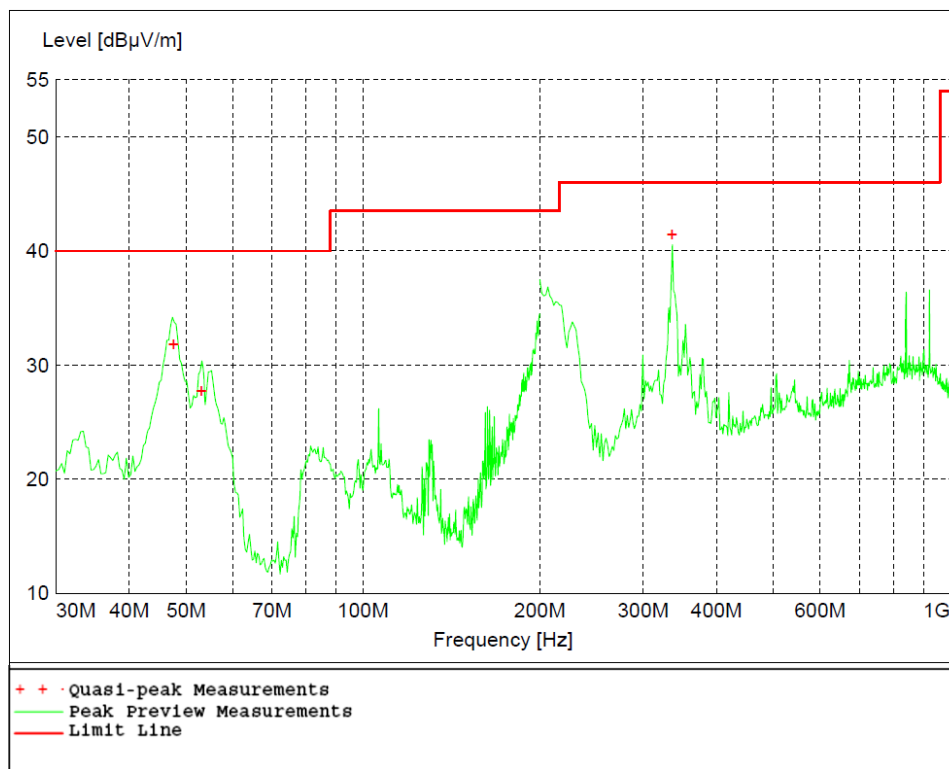
**Table 4 - Radiated Emissions Average Measurements, Low Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2402.000000 | 73.84        | 94.00        | 20.16  | 201    | 299   | VERT |
| 4810.200000 | 24.98        | 54.00        | 29.02  | 382    | 65    | VERT |
| 7205.400000 | 29.55        | 54.00        | 24.45  | 268    | 219   | VERT |

Note: Average Level = Peak Level – Duty Cycle Correction Factor  
Duty Cycle Correction Factor is 20.00 dB.

**Table 5 - Radiated Emissions Peak Measurements, Low Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2402.000000 | 93.84        | NA           | NA     | 201    | 299   | VERT |
| 4810.200000 | 44.98        | 74.00        | 29.02  | 382    | 65    | VERT |
| 7205.400000 | 49.55        | 74.00        | 24.45  | 268    | 219   | VERT |



**Figure 7 - Radiated Emissions Plot, Mid Channel**

**Table 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel**

| Frequency  | Level        | Limit        | Margin | Height | Angle | Pol  |
|------------|--------------|--------------|--------|--------|-------|------|
| MHz        | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 47.580000  | 31.82        | 40.00        | 8.20   | 100    | 336   | VERT |
| 53.100000  | 27.74        | 40.00        | 12.30  | 100    | 241   | VERT |
| 336.000000 | 41.45        | 46.00        | 4.50   | 100    | 290   | HORI |

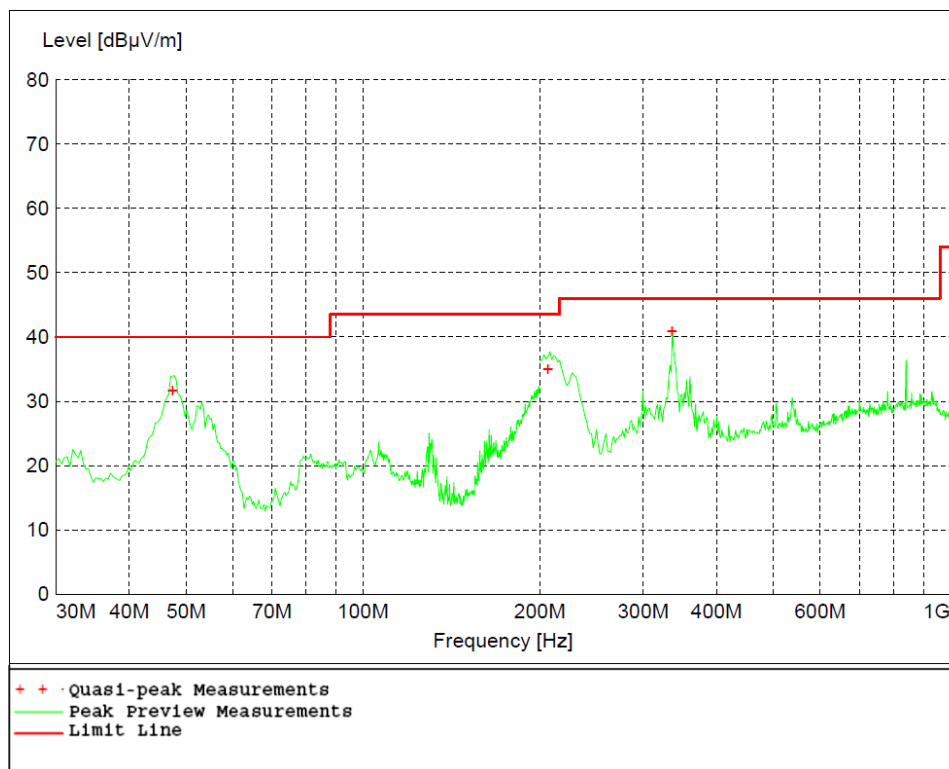
**Table 7 - Radiated Emissions Average Measurements, Mid Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2442.000000 | 71.70        | 94.00        | 22.30  | 244    | 140   | HORI |
| 4896.400000 | 25.43        | 54.00        | 28.57  | 356    | 360   | HORI |

Note: Average Level = Peak Level – Duty Cycle Correction Factor  
Duty Cycle Correction Factor is 20.00 dB.

**Table 8 - Radiated Emissions Peak Measurements, Mid Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2442.000000 | 91.70        | NA           | NA     | 244    | 140   | HORI |
| 4896.400000 | 45.43        | 74.00        | 28.57  | 356    | 360   | HORI |


**Figure 8 - Radiated Emissions Plot, High Channel**

|                |                 |     |   |
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**Table 9 - Radiated Emissions Quasi-peak Measurements, High Channel**

| Frequency  | Level        | Limit        | Margin | Height | Angle | Pol  |
|------------|--------------|--------------|--------|--------|-------|------|
| MHz        | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 47.400000  | 31.73        | 40.00        | 8.30   | 100    | 256   | VERT |
| 206.640000 | 35.09        | 43.50        | 8.40   | 100    | 79    | VERT |
| 336.000000 | 40.91        | 46.00        | 5.10   | 100    | 269   | HORI |

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

**Table 10 - Radiated Emissions Average Measurements, High Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2480.000000 | 72.27        | 94.00        | 21.73  | 234    | 131   | HORI |
| 4971.200000 | 24.29        | 54.00        | 29.71  | 400    | 30    | VERT |
| 7440.600000 | 26.20        | 54.00        | 27.80  | 301    | 226   | VERT |

Note: Average Level = Peak Level – Duty Cycle Correction Factor  
Duty Cycle Correction Factor is 20 dB.

**Table 11 - Radiated Emissions Peak Measurements, High Channel**

| Frequency   | Level        | Limit        | Margin | Height | Angle | Pol  |
|-------------|--------------|--------------|--------|--------|-------|------|
| MHz         | dB $\mu$ V/m | dB $\mu$ V/m | dB     | cm.    | deg.  |      |
| 2480.000000 | 92.27        | NA           | NA     | 234    | 131   | HORI |
| 4971.200000 | 44.29        | 74.00        | 29.71  | 400    | 30    | VERT |
| 7440.600000 | 46.20        | 74.00        | 27.80  | 301    | 226   | VERT |

**REMARKS:**

1. Emission level (dB $\mu$ V/m) = Raw Value (dB $\mu$ V) + 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

### 4.3 PEAK OUTPUT POWER

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

**Limits of bandwidth measurements:**

For informational purposes only

**Test procedures:**

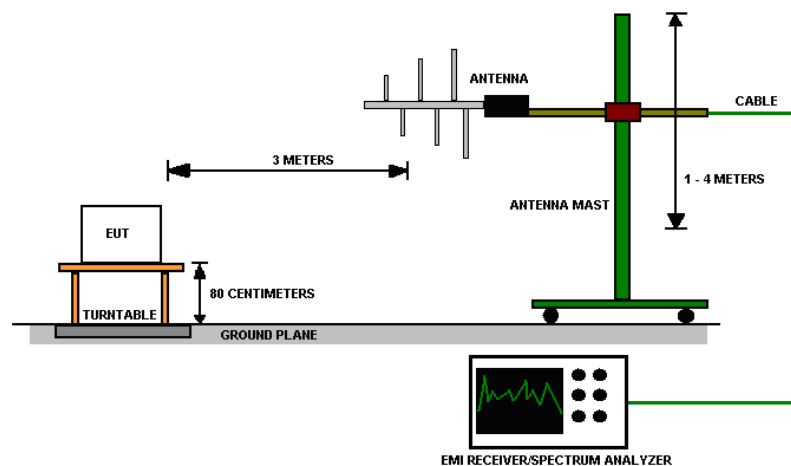
EIRP was calculated from field strength measurements using ANSI C63.10, Section 9.5, Equation (22). The field strength was measured at a 3m distance and maximized.

For Informational Purposes only

**Deviations from test standard:**

No deviation.

**Test setup:**



**Figure 9 - Peak Output Power Measurements Test Setup**

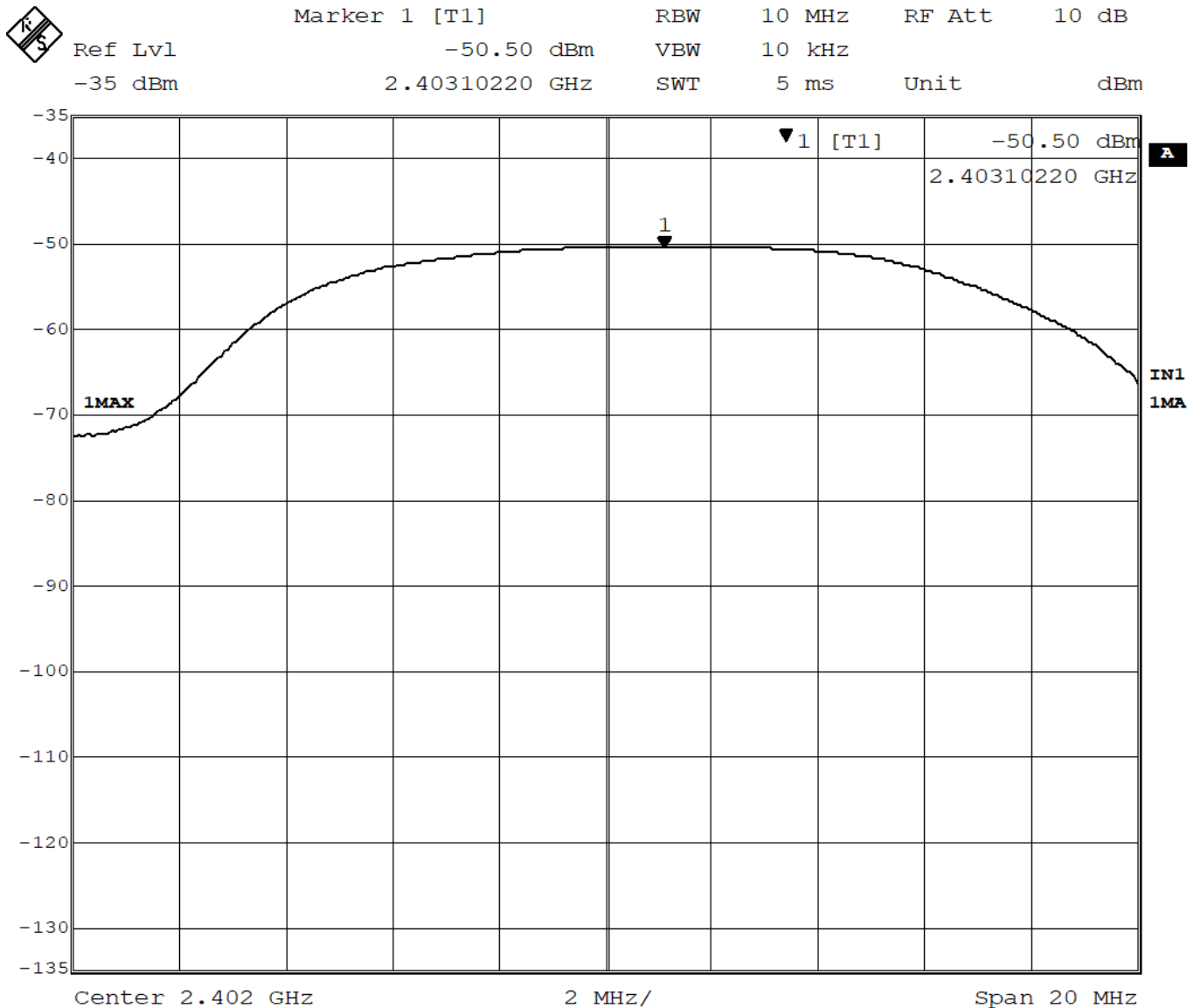
**EUT operating conditions:**

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

**Test results:**

**Peak Output Power**

| CHANNEL | CHANNEL FREQUENCY (MHz) | PEAK OUTPUT POWER (dBm) | Method   |
|---------|-------------------------|-------------------------|----------|
| 1       | 2402 MHz                | -2.82                   | Radiated |
| 2       | 2440 MHz                | -0.74                   | Radiated |
| 3       | 2480 MHz                | -1.64                   | Radiated |



Date: 14.FEB.2019 12:56:17

**Figure 10 – Output Power, Low Channel**

$$\text{Maximum power} = -50.50 \text{ dBm} + 107 + \text{CL} + \text{AF} - 95.23 = -2.82 \text{ dBm}^*$$

CL = cable loss = 7.60 dB

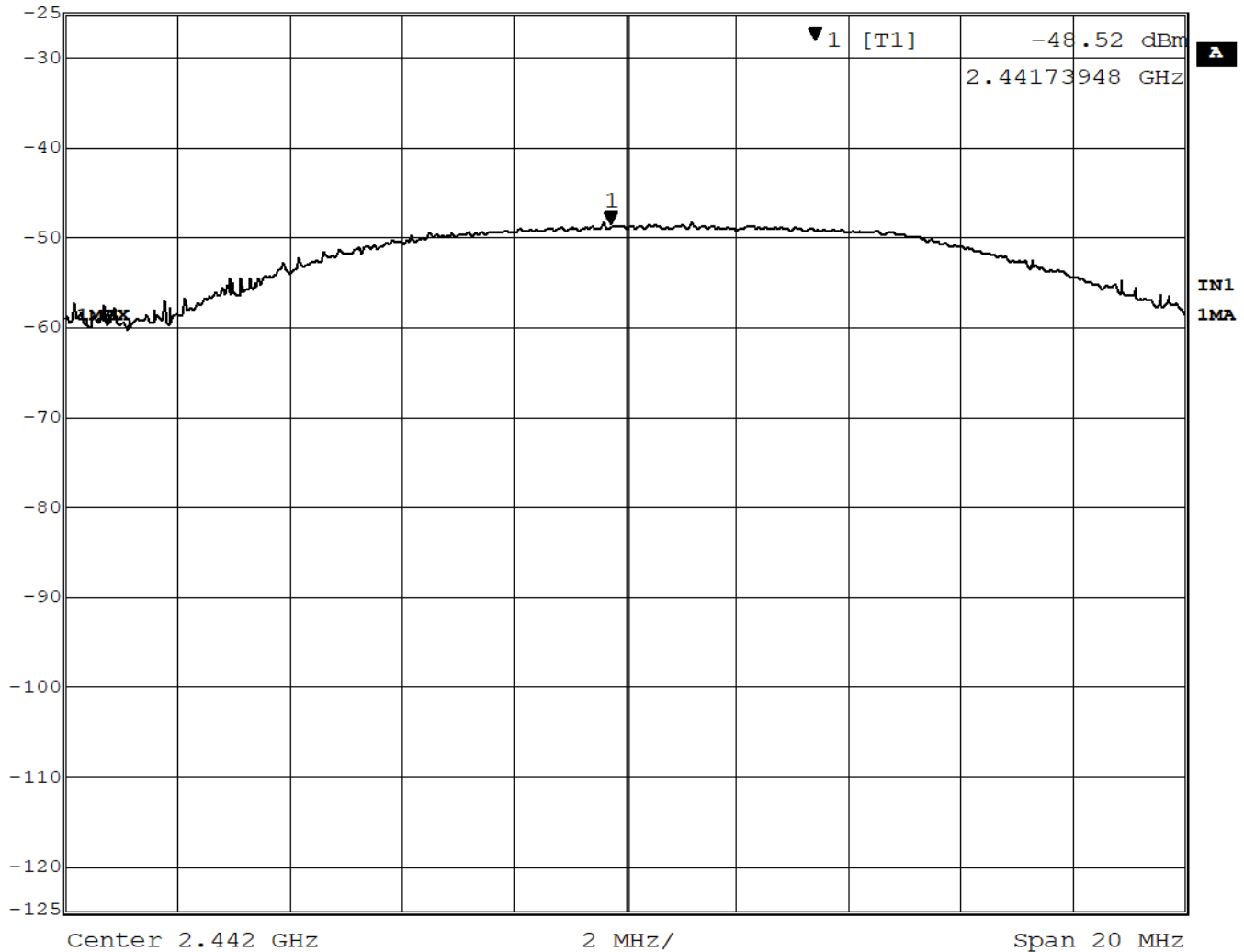
AF = antenna factor = 28.31 dB

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



Marker 1 [T1] RBW 10 MHz RF Att 10 dB  
 Ref Lvl -48.52 dBm VBW 10 MHz  
 -25 dBm 2.44173948 GHz SWT 5 ms Unit dBm



Date: 14.FEB.2019 13:53:53

**Figure 11 – Output Power, Mid Channel**

. Maximum power =  $-48.52 \text{ dBm} + 107 + \text{CL} + \text{AF} - 95.23 = -0.74 \text{ dBm}^*$

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



Marker 1 [T1]

RBW

10 MHz

RF Att

10 dB

Ref Lvl

-49.31 dBm

VBW

10 MHz

-25 dBm

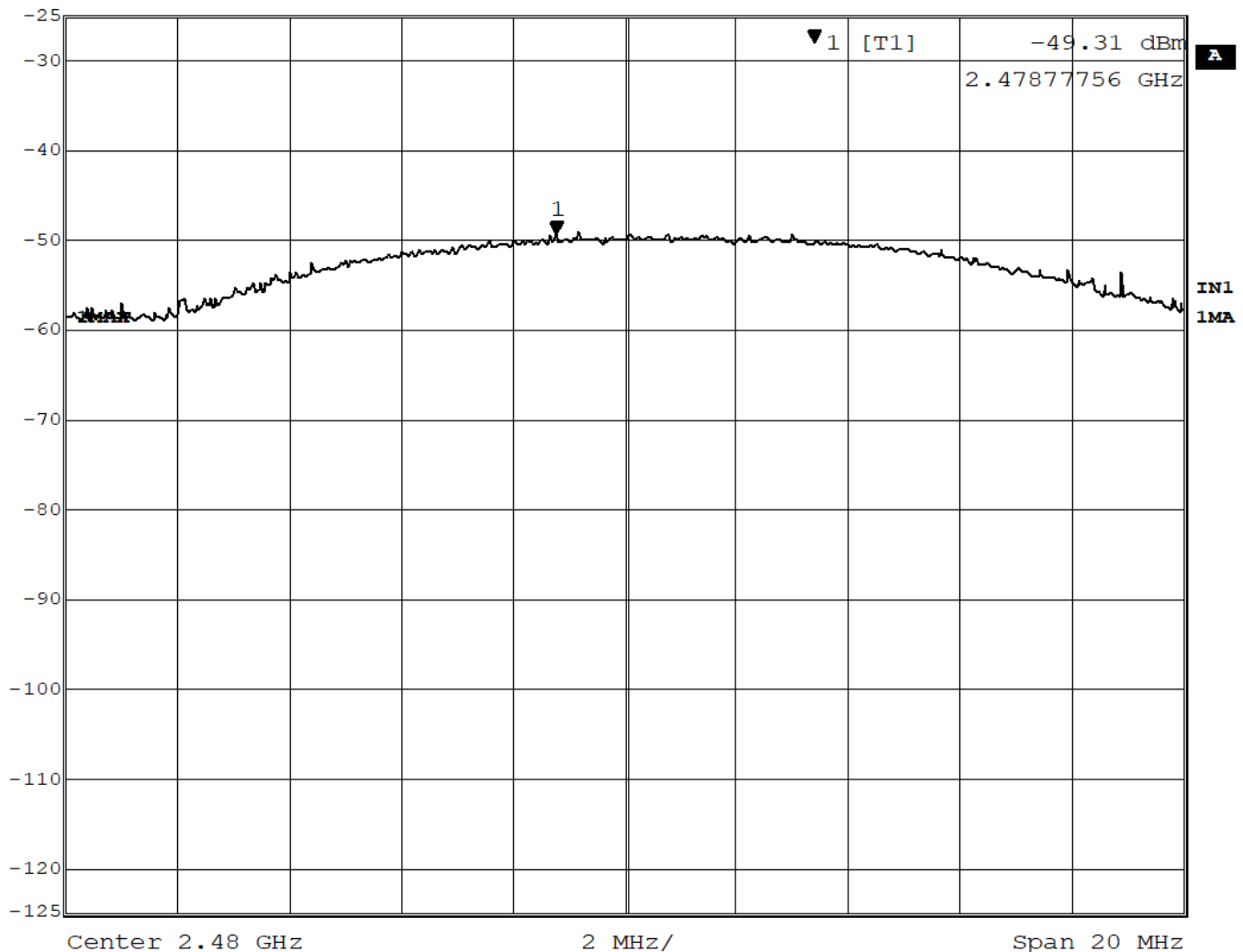
2.47877756 GHz

SWT

5 ms

Unit

dBm



Date: 14.FEB.2019 12:34:58

**Figure 12 – Output Power, High Channel**

Maximum power =  $-49.31 \text{ dBm} + 107 + \text{CL} + \text{AF} - 95.23 = -1.64 \text{ dBm}^*$

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



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#### 4.4 BANDWIDTH

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

**Limits of bandwidth measurements:**

For Informational Purposes only

**Test procedures:**

The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW. The occupied bandwidth was measured using the spectrum analyzers 99% occupied bandwidth setting.

**Test setup:**

Bandwidth measurements were performed as radiated. See Section 4.2 for more details.

**Deviations from test standard:**

No deviation.

**Test setup:**



|                |                 |     |   |
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**EUT operating conditions:**

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

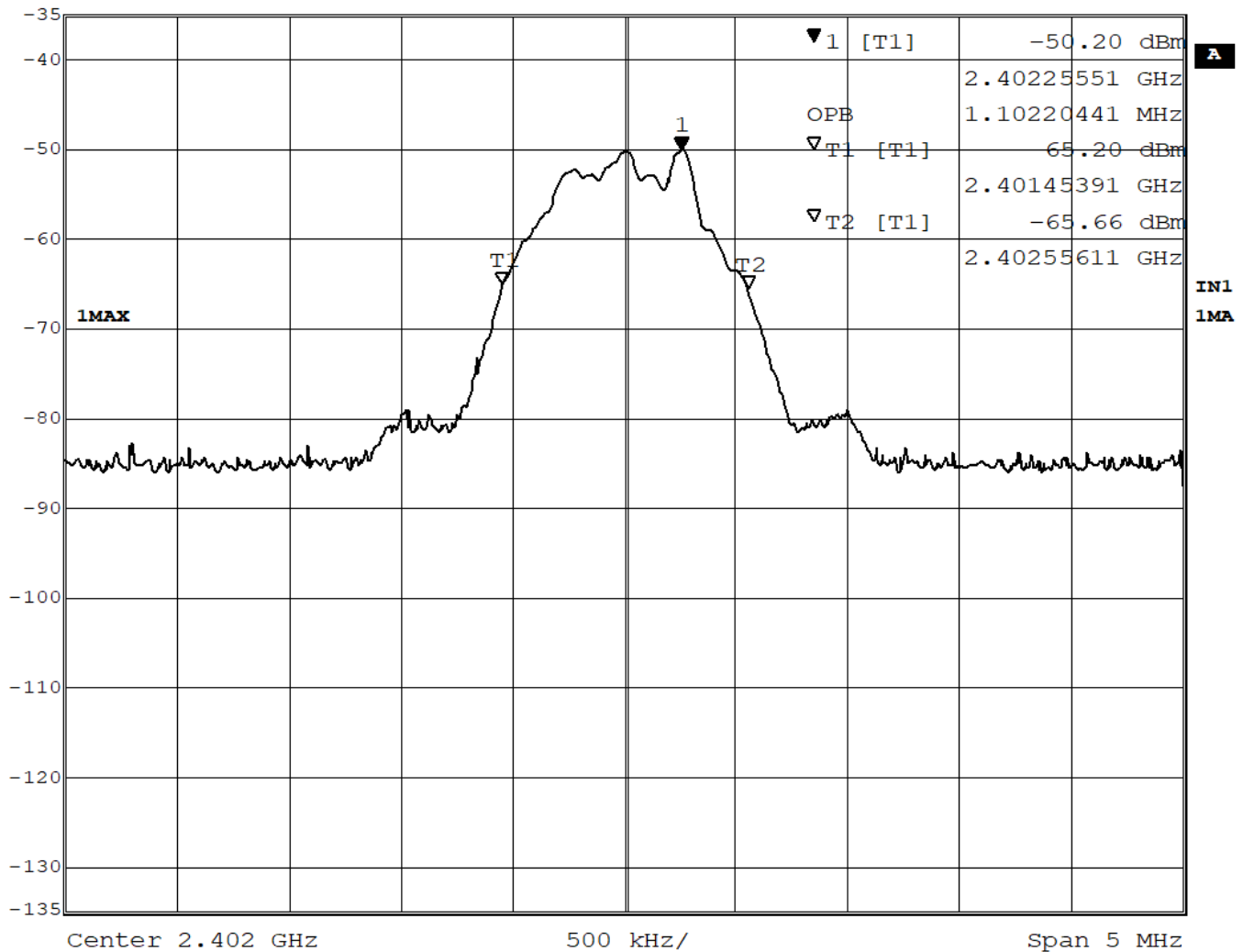
**Test results:**

**Occupied Bandwidth**

| CHANNEL | CHANNEL<br>FREQUENCY<br>(MHz) | BW (MHz) | RESULT |
|---------|-------------------------------|----------|--------|
| 1       | 2402 MHz                      | 1.10     | PASS   |
| 2       | 2440 MHz                      | 1.08     | PASS   |
| 3       | 2480 MHz                      | 1.06     | PASS   |



Marker 1 [T1] RBW 100 kHz RF Att 0 dB  
 Ref Lvl -50.20 dBm VBW 300 kHz  
 -35 dBm 2.40225551 GHz SWT 5 ms Unit dBm

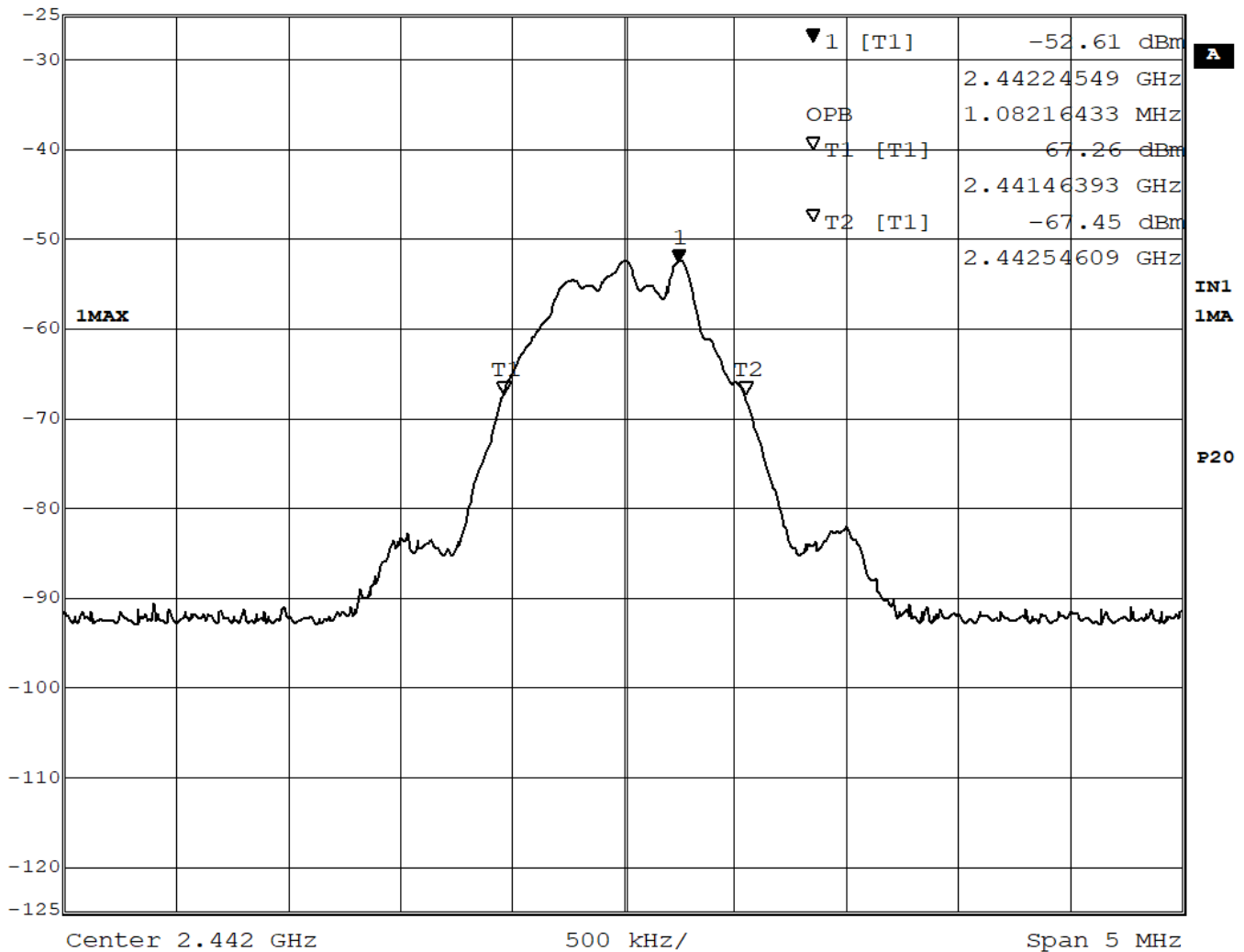


Date: 14.FEB.2019 12:52:27

Figure 13 – Occupied Bandwidth, Low Channel



Marker 1 [T1] RBW 100 kHz RF Att 10 dB  
 Ref Lvl -52.61 dBm VBW 300 kHz  
 -25 dBm 2.44224549 GHz SWT 5 ms Unit dBm

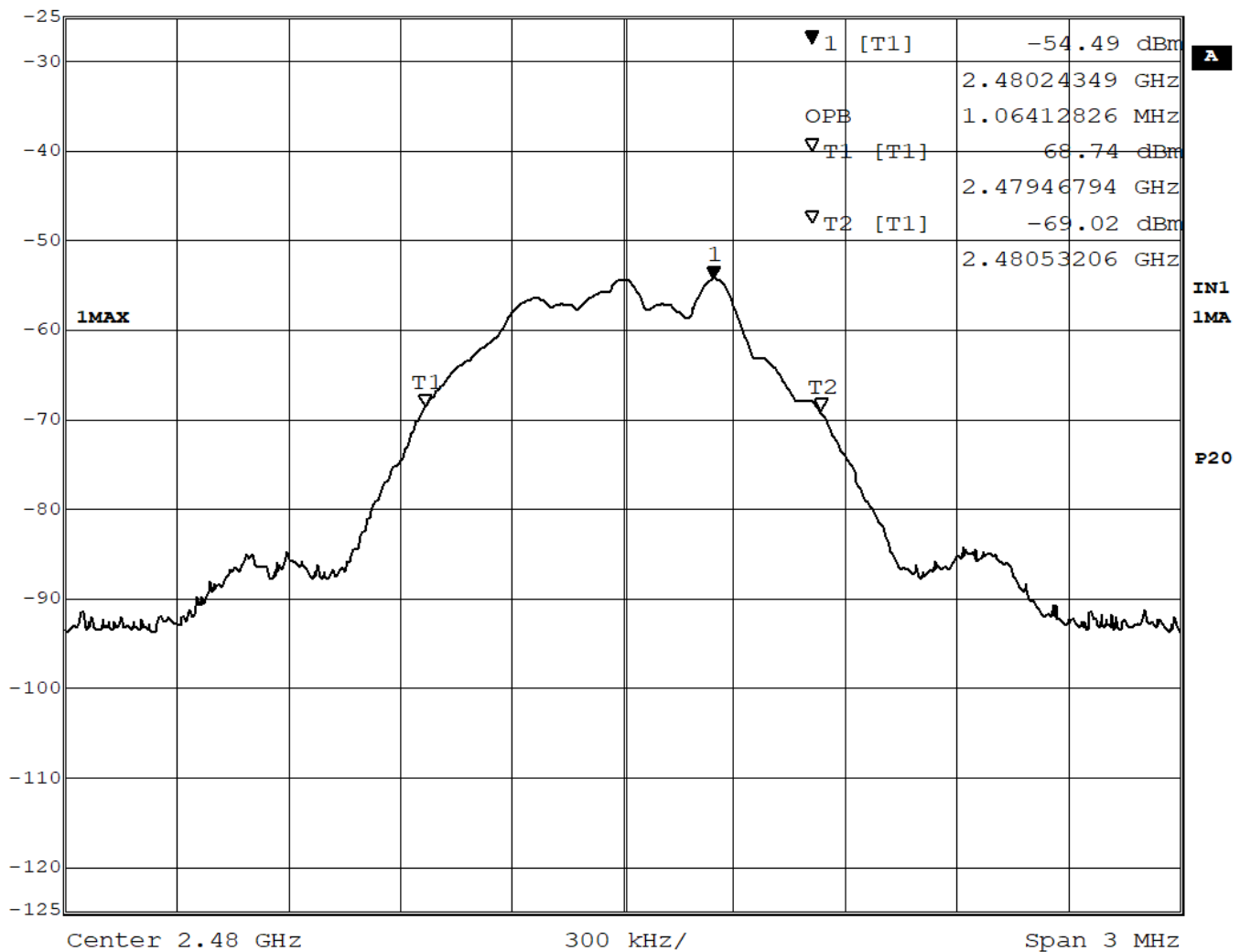


Date: 14.FEB.2019 13:51:19

Figure 14 - Occupied Bandwidth, Mid Channel



Marker 1 [T1] RBW 100 kHz RF Att 10 dB  
 Ref Lvl -54.49 dBm VBW 300 kHz  
 -25 dBm 2.48024349 GHz SWT 5 ms Unit dBm



Date: 14.FEB.2019 12:38:16

Figure 15 - Occupied Bandwidth, High Channel



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#### 4.5 BANDEDGES

**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:**

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 100kHz 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, middle and highest frequency channels.



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**Test results:**

## Highest Out of Band Emissions

| CHANNEL | Band edge /<br>Measureme<br>nt<br>Frequency<br>(MHz) | Band                              | Relative<br>Highest<br>out of<br>band level<br>dBm | Relative<br>Fundamental<br>Level (dBm) | Delta | Min<br>(dB) | Result |
|---------|------------------------------------------------------|-----------------------------------|----------------------------------------------------|----------------------------------------|-------|-------------|--------|
| 1       | 2400.0                                               | Band edge from FCC<br>Part 15.249 | -83.96                                             | -50.27                                 | 33.69 | 19.84       | PASS   |
| 3       | 2483.5                                               | Band edge from FCC<br>Part 15.249 | -92.00                                             | -54.51                                 | 37.49 | 18.27       | 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 = 73.84 dB $\mu$ V/m

Fundamental average field strength at High Channel = 72.27 dB $\mu$ V/m

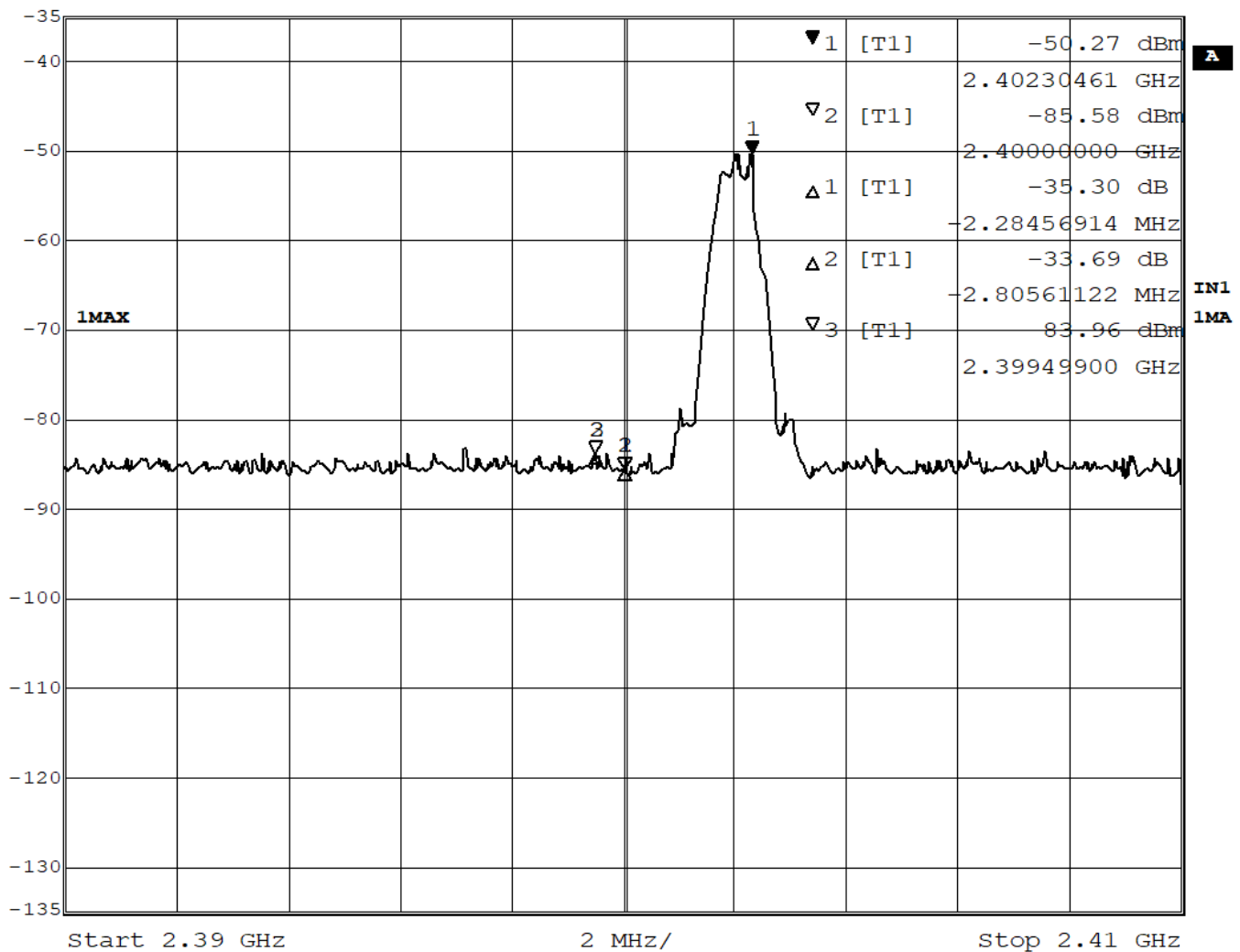
Low Channel minimum delta = 73.84 – 54.0 dB $\mu$ V/m = 19.84 dBc

High Channel minimum delta = 72.27 – 54.0 dB $\mu$ V/m = 18.27 dBc

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



Marker 1 [T1] RBW 100 kHz RF Att 0 dB  
 Ref Lvl -50.27 dBm VBW 300 kHz  
 -35 dBm 2.40230461 GHz SWT 5 ms Unit dBm



Date: 14.FEB.2019 12:49:56

**Figure 16 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit**

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



Marker 1 [T1]

RBW 100 kHz

RF Att 10 dB

Ref Lvl

-54.51 dBm

VBW 300 kHz

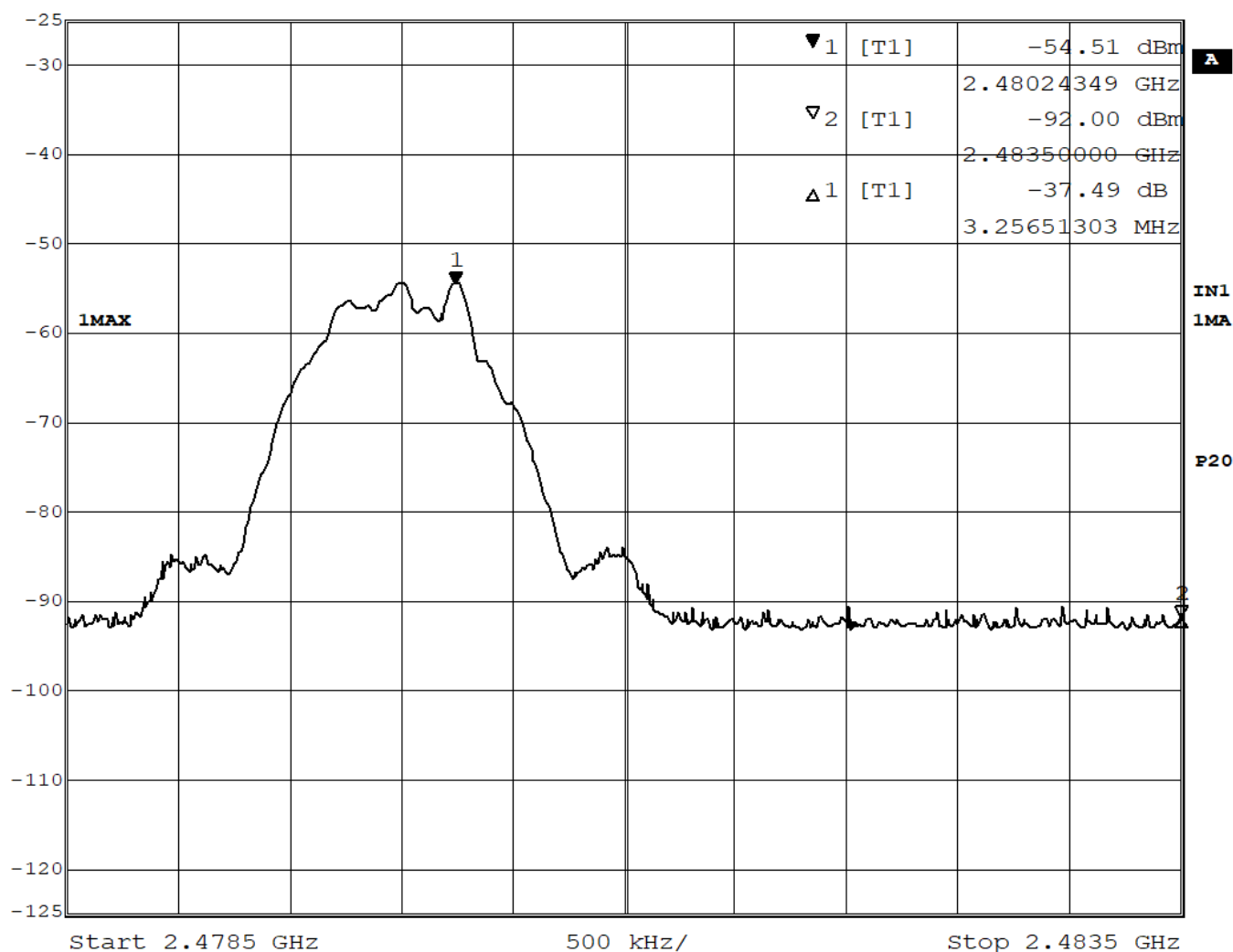
-25 dBm

2.48024349 GHz

SWT 5 ms

Unit

dBm



Date: 14.FEB.2019 12:44:47

**Figure 17 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit**

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

#### 4.6 CONDUCTED AC MAINS EMISSIONS

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

**Limits for conducted emissions measurements:**

| FREQUENCY OF EMISSION<br>(MHz) | CONDUCTED LIMIT<br>(dB $\mu$ V) |          |
|--------------------------------|---------------------------------|----------|
|                                | 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:



UNCAL

Marker 2 [T2]

Det

AV Trd

ES-K1

Att 10 dB AUTO

34.90 dBμV

ResBW

9 kHz

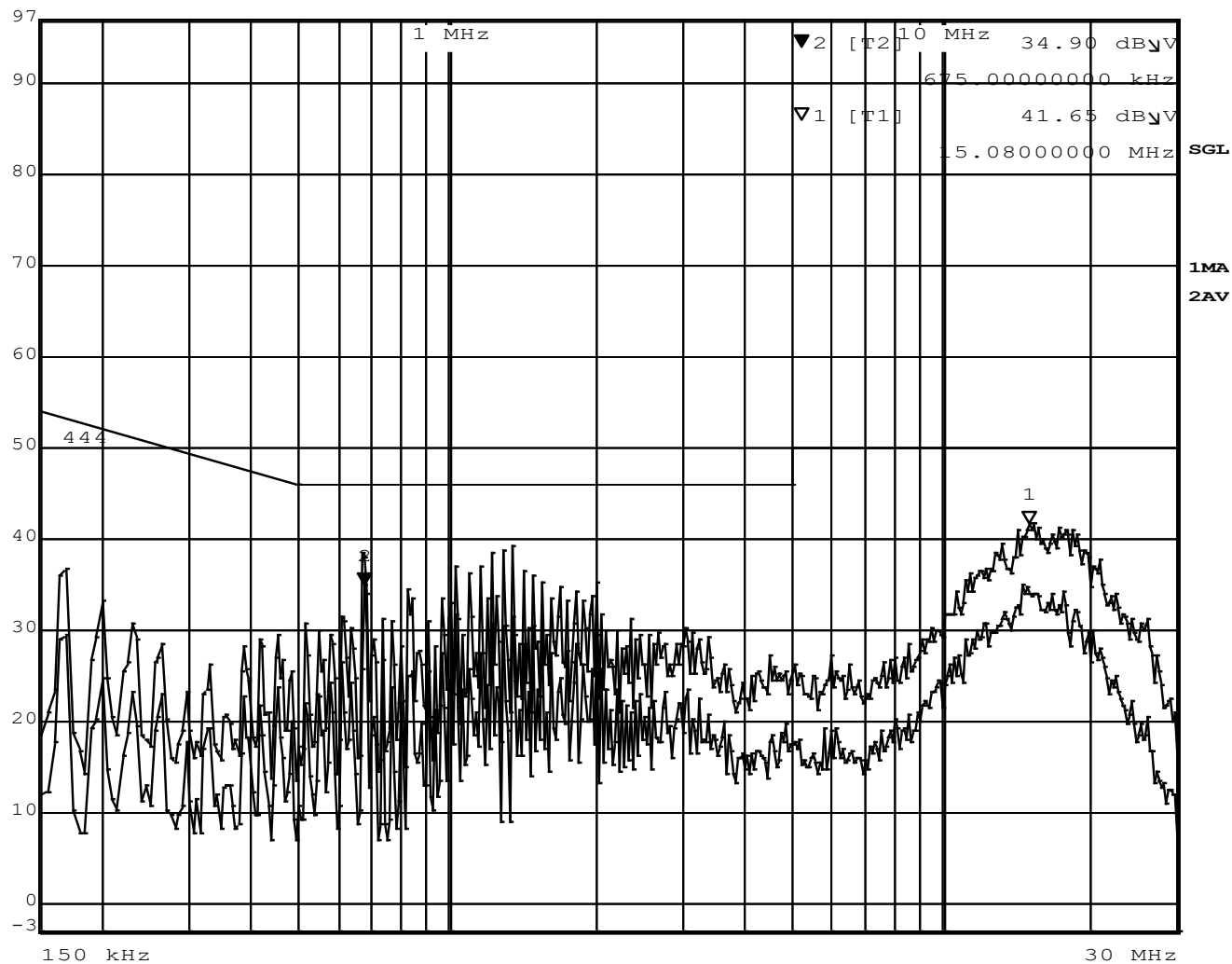
INPUT 2

675.00000000 kHz

Meas T

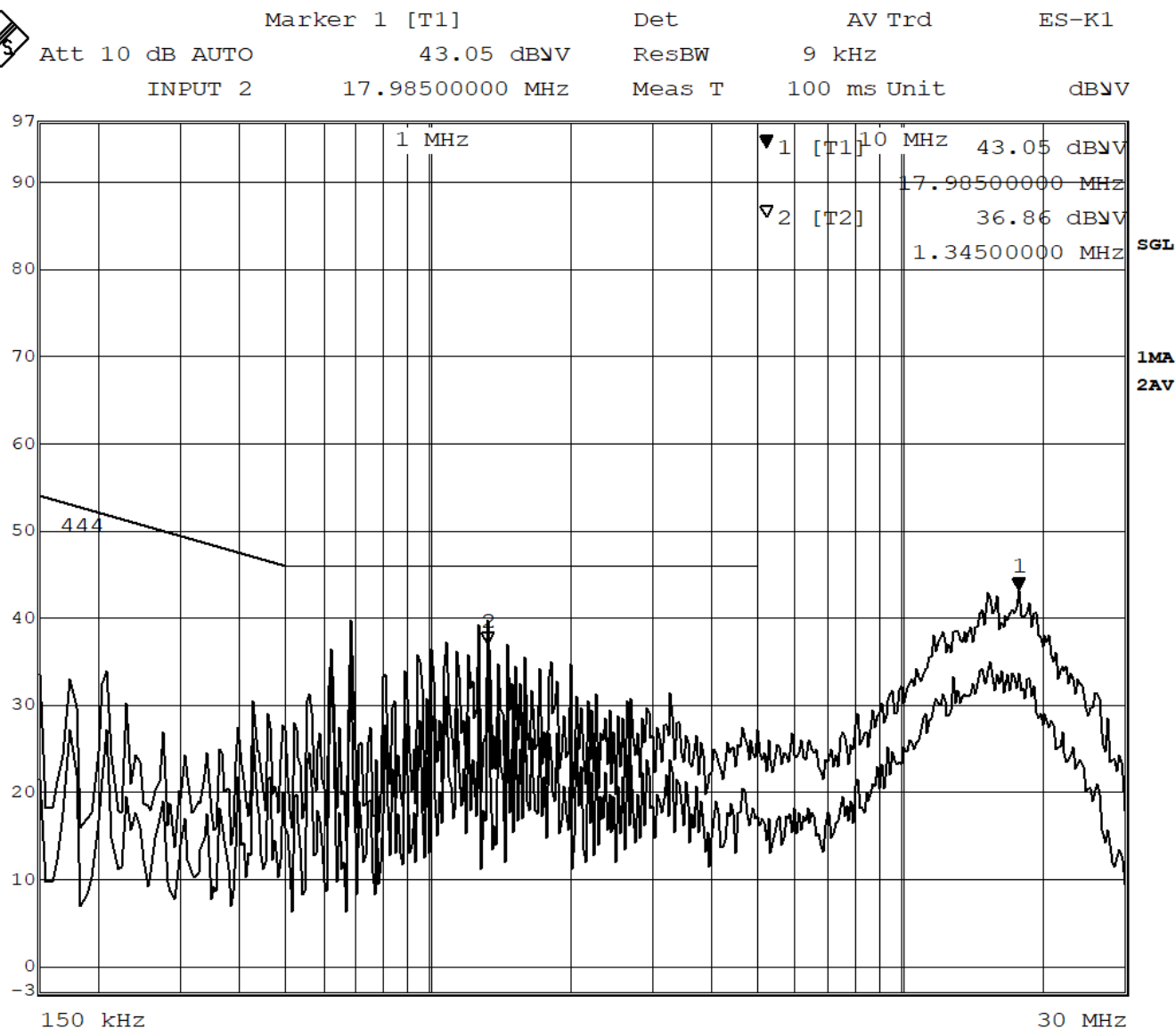
100 ms Unit

dBμV



**Figure 18 - Conducted Emissions Plot, L-F**

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



**Figure 19 - Conducted Emissions Plot, N-F**

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



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## 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 dB $\mu$ V 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 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



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## 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;

$$EIRP \text{ (Watts)} = [Field \text{ Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[Power \text{ (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

$10\log(10^9)$  is the conversion from micro to milli



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## 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%.



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REPORT END