4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

# FCC/ISED Test Report

**Prepared for:** **Perforce Outdoors**

**Address:** **60 Hampshire Street**
**Cambridge, MA 02139**
**USA**

**Product:** **CC3220MODASF12MON**

**Test Report No:** **R20180518-22**

**Approved By:**

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

**DATE:** **19 October 2018**

**Total Pages:** **64**

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## REVISION PAGE

| Rev. No. | Date | Description |
|---|---|---|
| 0 | 19 October 2018 | Original – NJohnson<br>Prepared by KVepuri |

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## 1.0 SUMMARY OF TEST RESULTS

This report is intended to cover a class II permissive change of TI WIFi module (MN: CC3220MOD3M2M0B FCC ID: Z64-CC3220MOD); Higher gain antenna is used so class II permissive change was required. The worst-case measurements were reported in this report.
The EUT has been tested according to the following specifications:

| APPLIED STANDARDS AND REGULATIONS | | |
|---|---|---|
| **Standard Section** | **Test Type** | **Result** |
| FCC Part 15.35<br>RSS Gen, Issue 4, Section 6.10 | Duty Cycle | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Peak output power | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Bandwidth | Pass |
| FCC Part 15.209<br>RSS-Gen Issue 4, Section 7.1 | Receiver Radiated Emissions | Pass |
| FCC Part 15.209 (restricted bands), 15.247 (unrestricted)<br>RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9 | Transmitter Radiated Emissions | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Power Spectral Density | Pass |
| FCC Part 15.209, 15.247(d)<br>RSS-247 Issue 2 Section 11.13 | Band Edge Measurement | Pass |
| FCC Part 15.207<br>RSS-Gen Issue 4, Section 7.1 | Conducted Emissions | Not applicable as solar panel will be used to power this device as declared by manufacturer |

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

# 2.0 EUT DESCRIPTION

## 2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a Perforce Timer from Perforce Outdoors It features a TI WIFi module (MN: CC3220MOD3M2M0B FCC ID: Z64-CC3220MOD) and has transmit and receives capabilities.

| | |
|---|---|
| EUT | Perforce Timer |
| EUT Received | 5 September 2018 |
| EUT Tested | 5 September 2018 - 5 October 2018 |
| Serial No. | NCEETEST1 (assigned) |
| Operating Band | 2400.0 - 2483.5 GHz |
| Device Type | DTS |
| Antenna | Monopole (5 dBi max gain) |
| Power Supply | 16 VDC Power Supply (used primarily to simulate a solar panel, EUT will not be shipped with a power supply)<br><br>Model: L5A-160090R<br><br>Input: 120 VAC, 0.3 A<br><br>Output: 12 VDC, 0.9 A |

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 (Channel 1) | 2412 |
| Middle (Channel 6) | 2437 |
| High (Channel 11) | 2462 |

As well as the following modes:

| WIFI Mode |
|---|
| 802.11b |
| 802.11g |
| 802.11n (HT20)* |

*This mode was not reported as the manufacturer declared that they won't be using this mode in actual deployment.

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

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

## 2.3 DESCRIPTION OF SUPPORT UNITS

NA

# 3.0 LABORATORY DESCRIPTION

## 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

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

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

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

## 3.2 TEST PERSONNEL

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

## 3.3 TEST EQUIPMENT

| DESCRIPTION AND MANUFACTURER | MODEL NO. | SERIAL NO. | LAST CALIBRATION DATE | CALIBRATION DUE DATE |
|---|---|---|---|---|
| Rohde & Schwarz Test Receiver | ES126 | 100037 | 30 Jan 2018 | 30 Jan 2019 |
| 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* |
| RF Cable (preamplifier to antenna) | MFR-57500 | 01-07-002 | 09 Mar 2018* | 09 Mar 2019* |
| RF Cable (antenna to 10m chamber bulkhead) | FSCM 64639 | 01E3872 | 09 Mar 2018* | 09 Mar 2019* |
| RF Cable (10m chamber bulkhead to control room bulkhead) | FSCM 64639 | 01E3874 | 09 Mar 2018* | 09 Mar 2019* |
| RF Cable (Control room bulkhead to RF switch) | FSCM 64639 | 01E3871 | 09 Mar 2018* | 09 Mar 2019* |
| RF Cable (RF switch to test receiver) | FSCM 64639 | 01F1206 | 09 Mar 2018* | 09 Mar 2019* |
| RF switch – Rohde and Schwarz | TS-RSP | 1113.5503.14 | 09 Mar 2018* | 09 Mar 2019* |
| N connector bulkhead (10m chamber) | PE9128 | NCEEBH1 | 09 Mar 2018* | 09 Mar 2019* |
| N connector bulkhead (control room) | PE9128 | NCEEBH2 | 09 Mar 2018* | 09 Mar 2019* |

*Internal Characterization

# 4.0 DETAILED RESULTS

## 4.1 DUTY CYCLE

Duty Cycle measurements were not conducted as the EUT is capable of continuous transmission.

## 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”
3. Section 11.11, “Measurement in nonrestricted frequency bands”
4. Section 11.12, “Emissions in restricted bands”

**Limits for radiated emissions measurements:**

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

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

**NOTE:**

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

**Test procedures:**

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

h. All 802.11 modes were examined (b, g, n, HT20) and it was found the 802.11b mode produced the highest emissions. 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:**

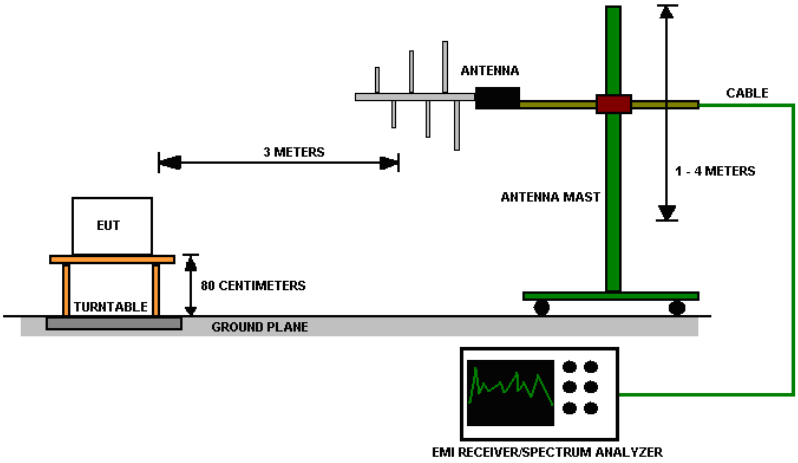



Figure 1 - Radiated Emissions Test Setup

**EUT operating conditions**

The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in 80211b which was determined as worst case after investigation.

**Test results:**

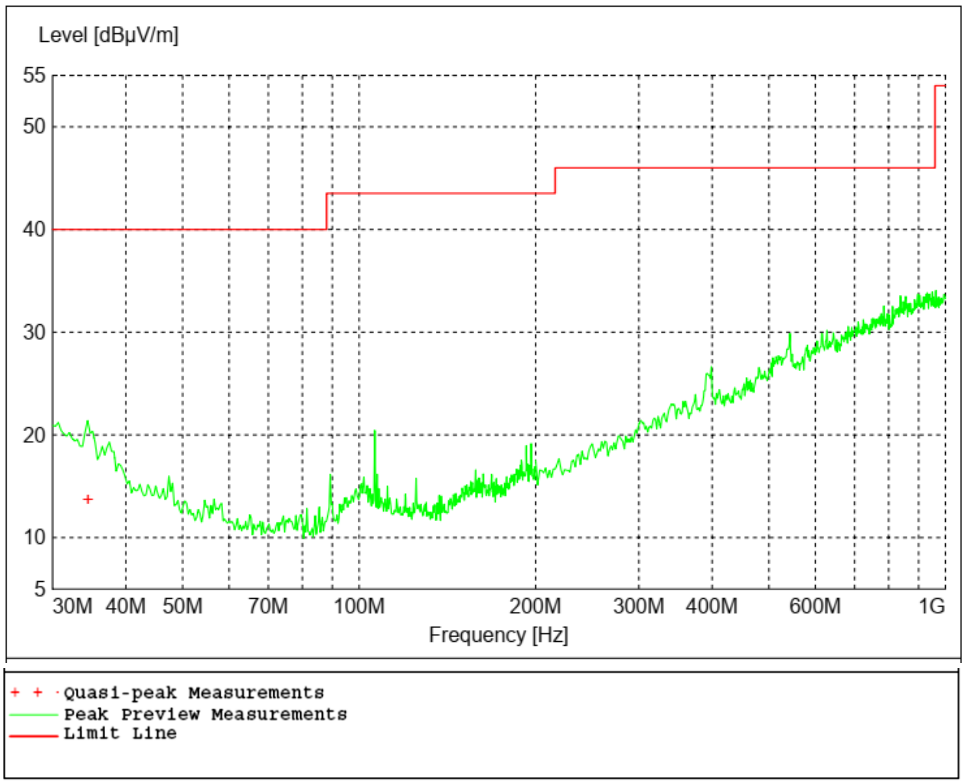



Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 34.500000 | 13.68 | 40.00 | 26.30 | 196 | 192 | VERT | y |

Table 2 - Radiated Emissions Peak Measurements vs. Average Limit, Receive, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 6049.400000 | 47.12 | 54.00 | 6.90 | 188 | 190 | VERT | y |

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

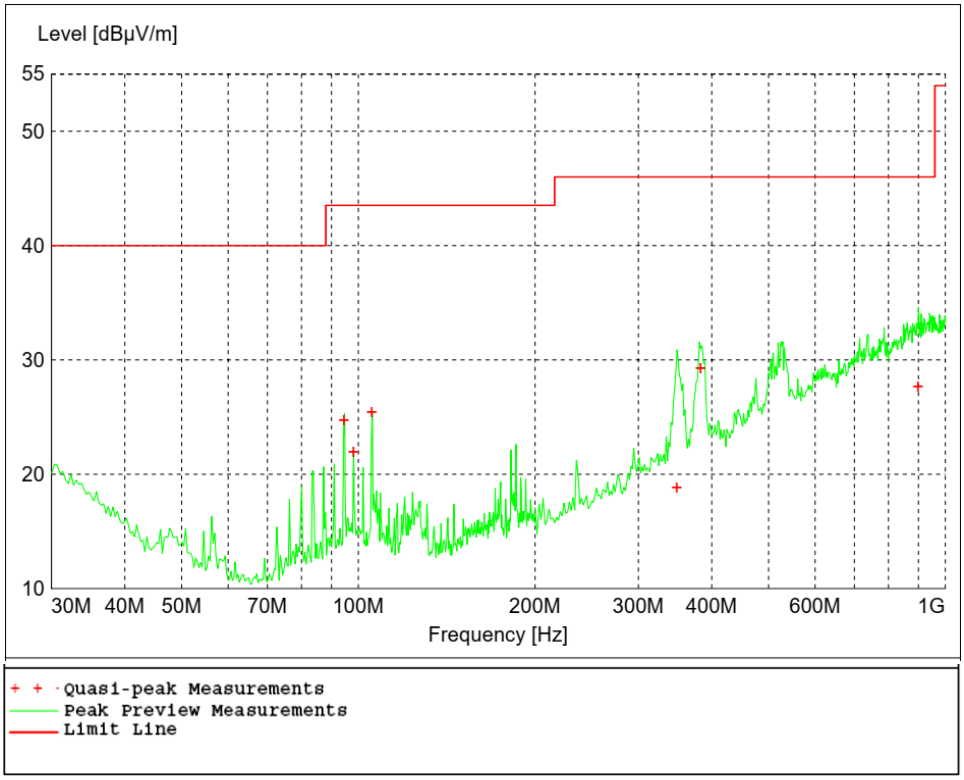



Figure 3 - Radiated Emissions Plot, Low Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Low Channel, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 94.560000 | 24.70 | 43.50 | 18.80 | 104 | 285 | VERT | X |
| 98.160000 | 21.95 | 43.50 | 21.60 | 100 | 285 | VERT | X |
| 105.480000 | 25.45 | 43.50 | 18.10 | 99 | 280 | VERT | X |
| 349.260000 | 18.78 | 46.00 | 27.20 | 169 | 74 | VERT | X |
| 383.340000 | 29.30 | 46.00 | 16.70 | 142 | 75 | VERT | X |
| 899.820000 | 27.62 | 46.00 | 18.40 | 132 | 333 | VERT | X |

Table 4 - Radiated Emissions Peak Measurements vs. Average Limit, Low Channel, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 2412.000000 | 107.42 | NA | NA | 163 | 165 | HORI | X |
| 4019.000000 | 52.72 | 54.00 | 1.30 | 100 | 118 | HORI | X |
| 6432.000000 | 57.32 | 87.42 | 30.10 | 99 | 192 | HORI | X |

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed. All 3 orthogonal axis were measured and the worse-case is presented.

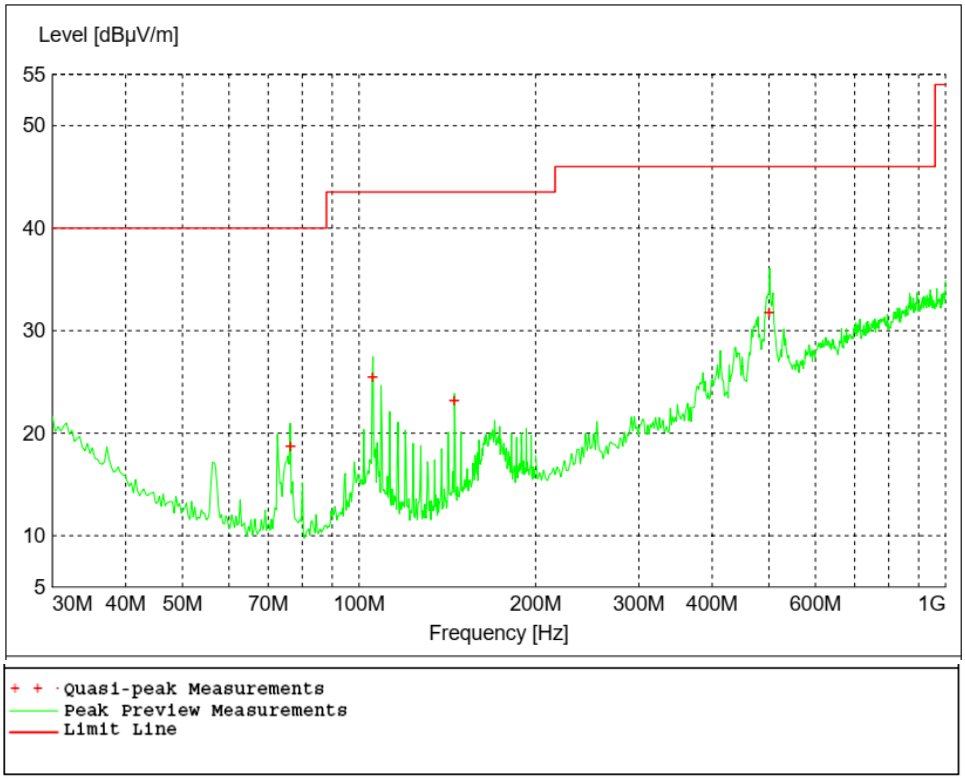



Figure 4 - Radiated Emissions Plot, Mid Channel

Table 5 - Radiated Emissions Quasi-peak Measurements, Mid Channel, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 76.380000 | 18.72 | 40.00 | 21.30 | 104 | 60 | VERT | X |
| 105.420000 | 25.50 | 43.50 | 18.00 | 99 | 95 | VERT | X |
| 145.440000 | 23.17 | 43.50 | 20.30 | 223 | 359 | HORI | X |
| 500.340000 | 31.68 | 46.00 | 14.30 | 109 | 109 | VERT | X |

All 3 orthogonal axis were measured and the worse-case is presented.

Table 6 - Radiated Emissions Peak Measurements vs. Average Limit, Mid Channel, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Axis |
|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | |
| 2437.000000 | 109.49 | NA | NA | 150 | 270 | HORI | X |
| 4060.800000 | 50.94 | 54.00 | 3.10 | 231 | 303 | HORI | X |
| 4874.200000 | 42.75 | 54.00 | 11.20 | 334 | 70 | VERT | X |
| 6498.600000 | 58.77 | 89.49 | 30.72 | 132 | 162 | HORI | X |

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed. All 3 orthogonal axis were measured and the worse-case is presented.

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. The EUT was measured in all 3 orthagonal axis. It was found that the Y-axis produced the highest emissions, and this orientation was used for all testing. See the test setup photo exhibit for details on the orientations.

## 4.3 PEAK OUTPUT POWER

**Test Method:** ANSI C63.10:

1. Section(s) 11.9.2.3 “Measurement using a power meter (PM)”

**Limits of power measurements:**
The maximum allowed peak output power is 30 dBm.

**Test procedures:**
The EUT was connected to ab RF power meter directly with a low-loss shielded coaxial cable with 10 MHz RBW and 10 MHz VBW. The intention was to verify that the measurement results were the same as the original filing for this device within the measurement uncertainty of the laboratory.

**Deviations from test standard:**
No deviation.

**Test setup:**

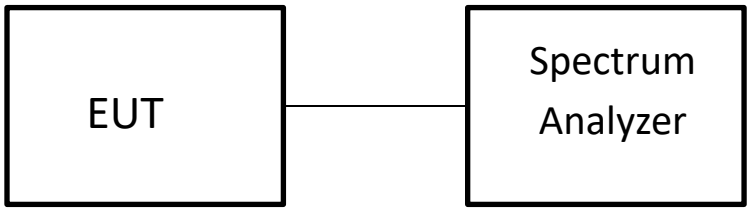



**Figure 5 – Peak Output Power Measurements Test Setup**
*6 dB of cable loss was used for peak and average output power.

**EUT operating conditions:**
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

**Test results:**

The uncertainty for conducted peak power measurements is ±1.1 dB and average power is ±1.37 dB

**Peak Output Power**

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | PEAK OUTPUT POWER (dBm) MU = ±1.1 dB | EIRP with antenna gain* | Method | RESULT |
|---|---|---|---|---|---|---|
| Low | 2412 | 802.11b | 16.08 | 21.08 | Conducted | PASS |
| Middle | 2437 | 802.11b | 16.17 | 21.17 | Conducted | PASS |
| High | 2462 | 802.11b | 15.68 | 20.68 | Conducted | PASS |
| Low | 2412 | 802.11g | 16.08 | 21.08 | Conducted | PASS |
| Middle | 2437 | 802.11g | 20.28 | 25.28 | Conducted | PASS |
| High | 2462 | 802.11g | 15.63 | 20.63 | Conducted | PASS |

**Average Output Power**

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | Average OUTPUT POWER (dBm) MU = ±1.37 | EIRP with antenna gain* | Method | RESULT |
|---|---|---|---|---|---|---|
| Low | 2412 | 802.11b | 13.17 | 18.17 | Conducted | PASS |
| Middle | 2437 | 802.11b | 12.77 | 17.77 | Conducted | PASS |
| High | 2462 | 802.11b | 12.24 | 17.24 | Conducted | PASS |
| Low | 2412 | 802.11g | 8.20 | 13.20 | Conducted | PASS |
| Middle | 2437 | 802.11g | 13.22 | 18.22 | Conducted | PASS |
| High | 2462 | 802.11g | 8.08 | 13.08 | Conducted | PASS |

*Advertised Antenna gain of 5 dBi Maximum was used.

## 4.4 BANDWIDTH

**Test Method:** ANSI C63.10,
1. Section(s) 11.8.1 "DTS Bandwidth, Option 1"

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

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

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

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

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

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

**Deviations from test standard:**
No deviation

**Test setup:**

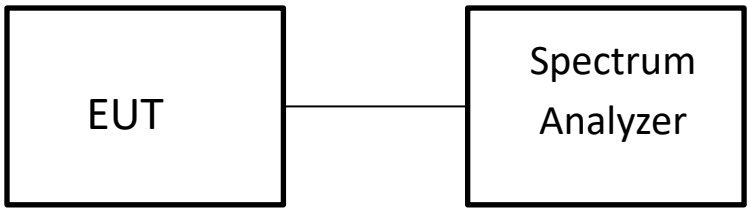



**Figure 6 – Peak Output Power Measurements Test Setup**

**EUT operating conditions:**
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

**Test results:**

**99% Occupied Bandwidth**

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | 99% Occupied BW (MHz) |
|---|---|---|---|
| Low | 2412 | 802.11b | 13.93 |
| Middle | 2437 | 802.11b | 14.08 |
| High | 2462 | 802.11b | 14.08 |
| Low | 2412 | 802.11g | 16.33 |
| Middle | 2437 | 802.11g | 16.38 |
| High | 2462 | 802.11g | 16.28 |

**6dB Bandwidth**

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | 6 dB BW (MHz) |
|---|---|---|---|
| Low | 2412 | 802.11b | 9.12 |
| Middle | 2437 | 802.11b | 9.37 |
| High | 2462 | 802.11b | 9.11 |
| Low | 2412 | 802.11g | 15.13 |
| Middle | 2437 | 802.11g | 15.03 |
| High | 2462 | 802.11g | 15.13 |

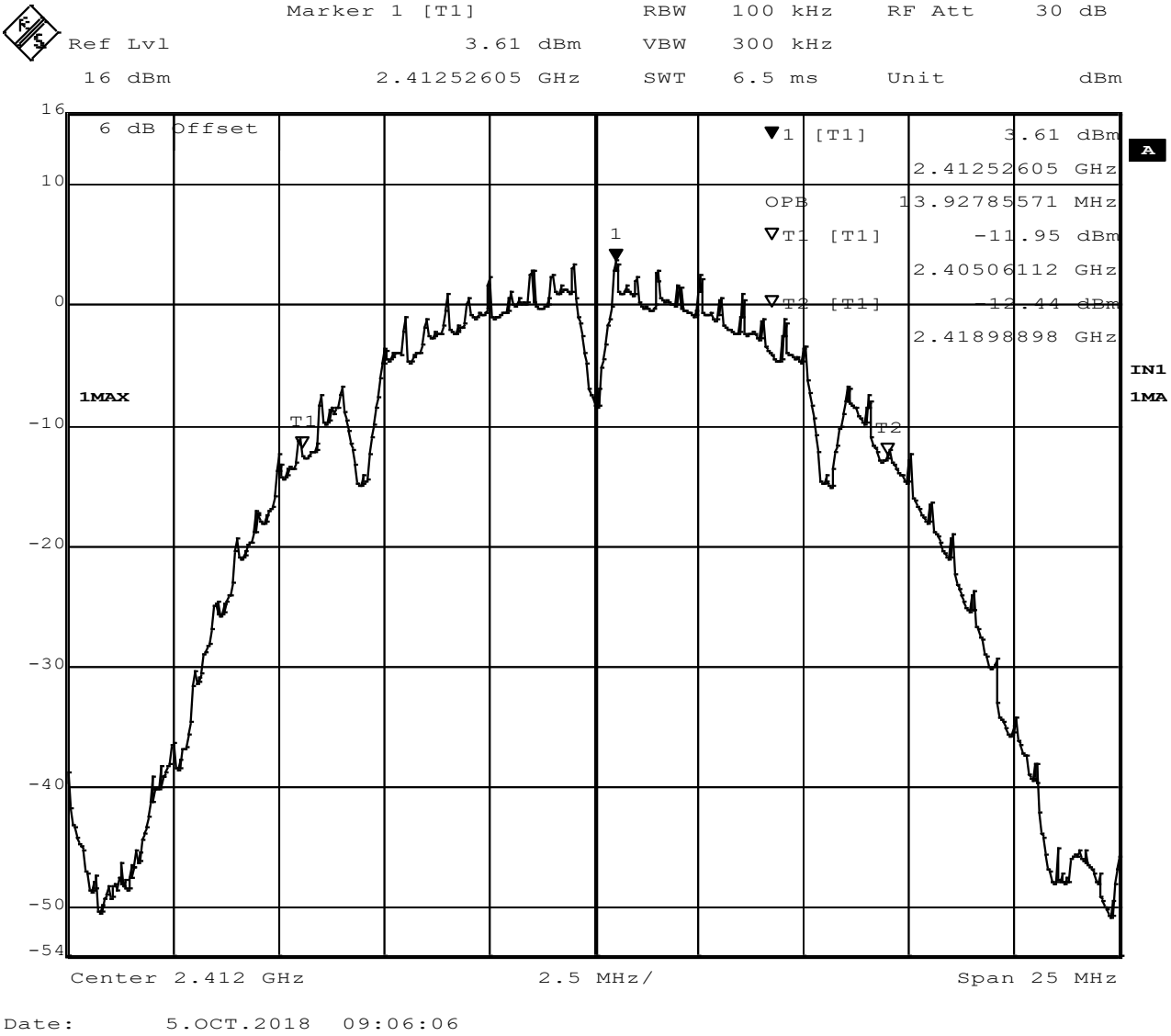
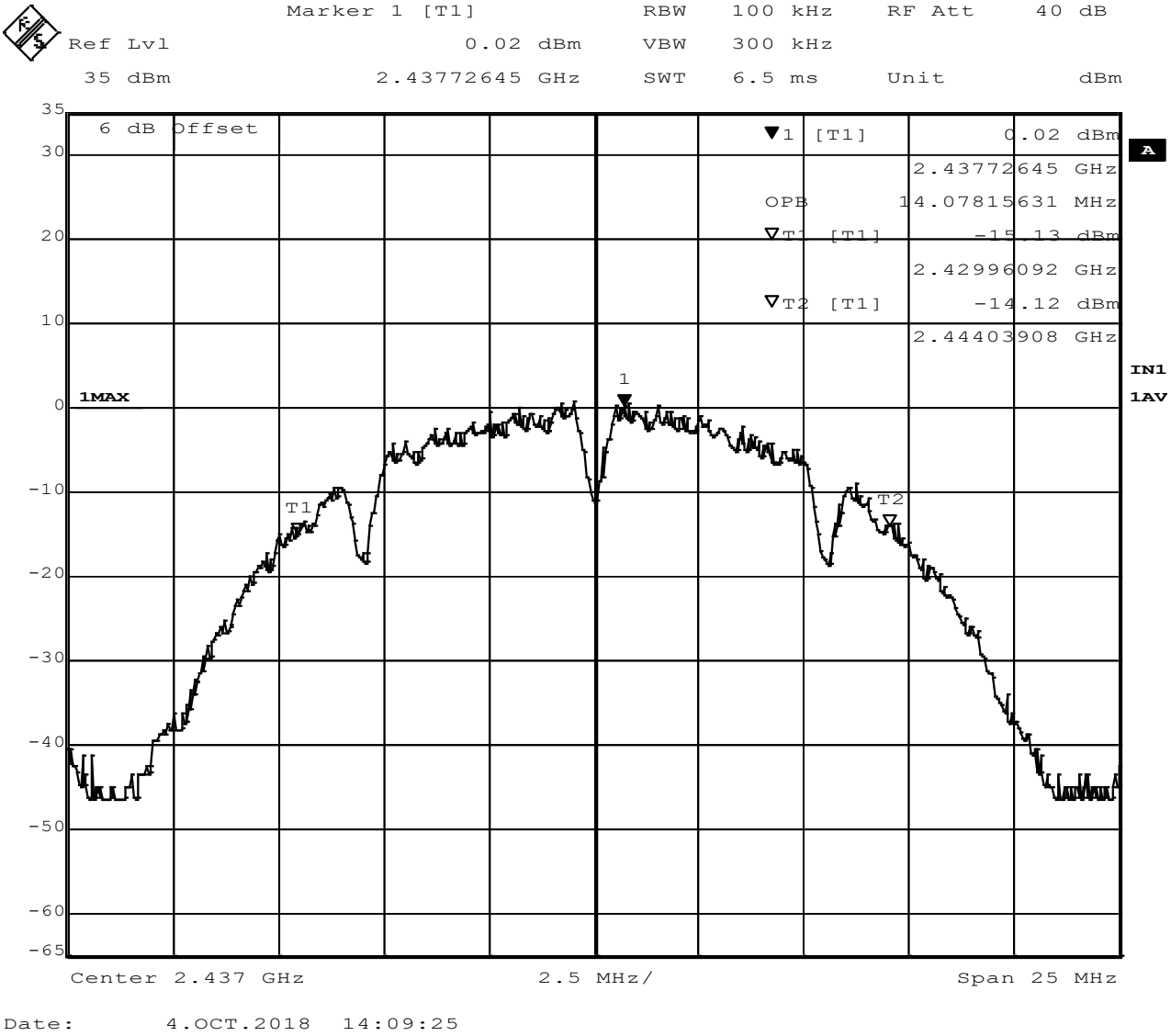
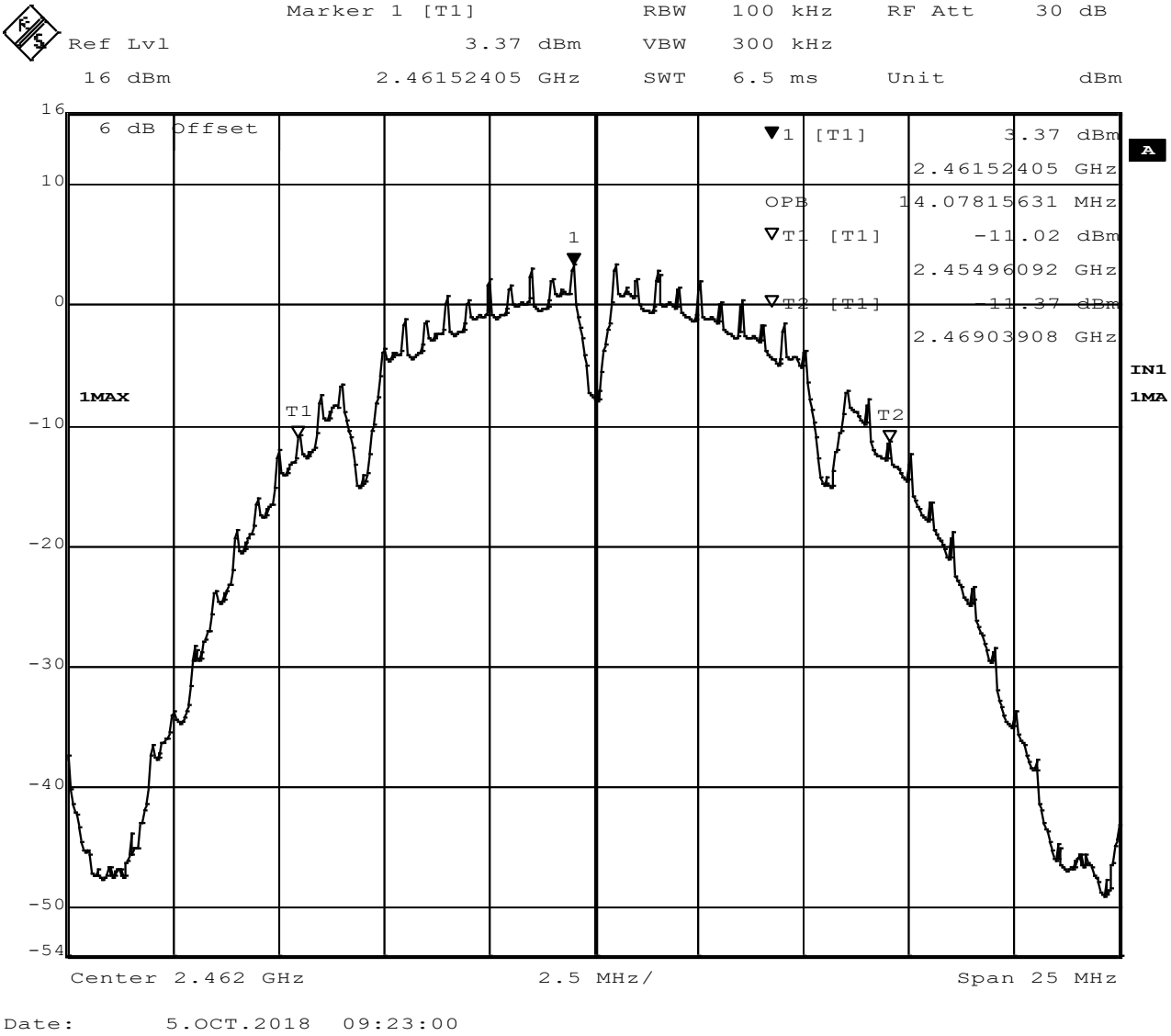



**Figure 7 - 99% Occupied Bandwidth, Low Channel, 802.11b**




Date: 4.OCT.2018 14:09:25

**Figure 8 - 99% Occupied Bandwidth, Mid Channel, 802.11b**




Date: 5.OCT.2018 09:23:00

**Figure 9 - 99% Occupied Bandwidth, High Channel, 802.11b**

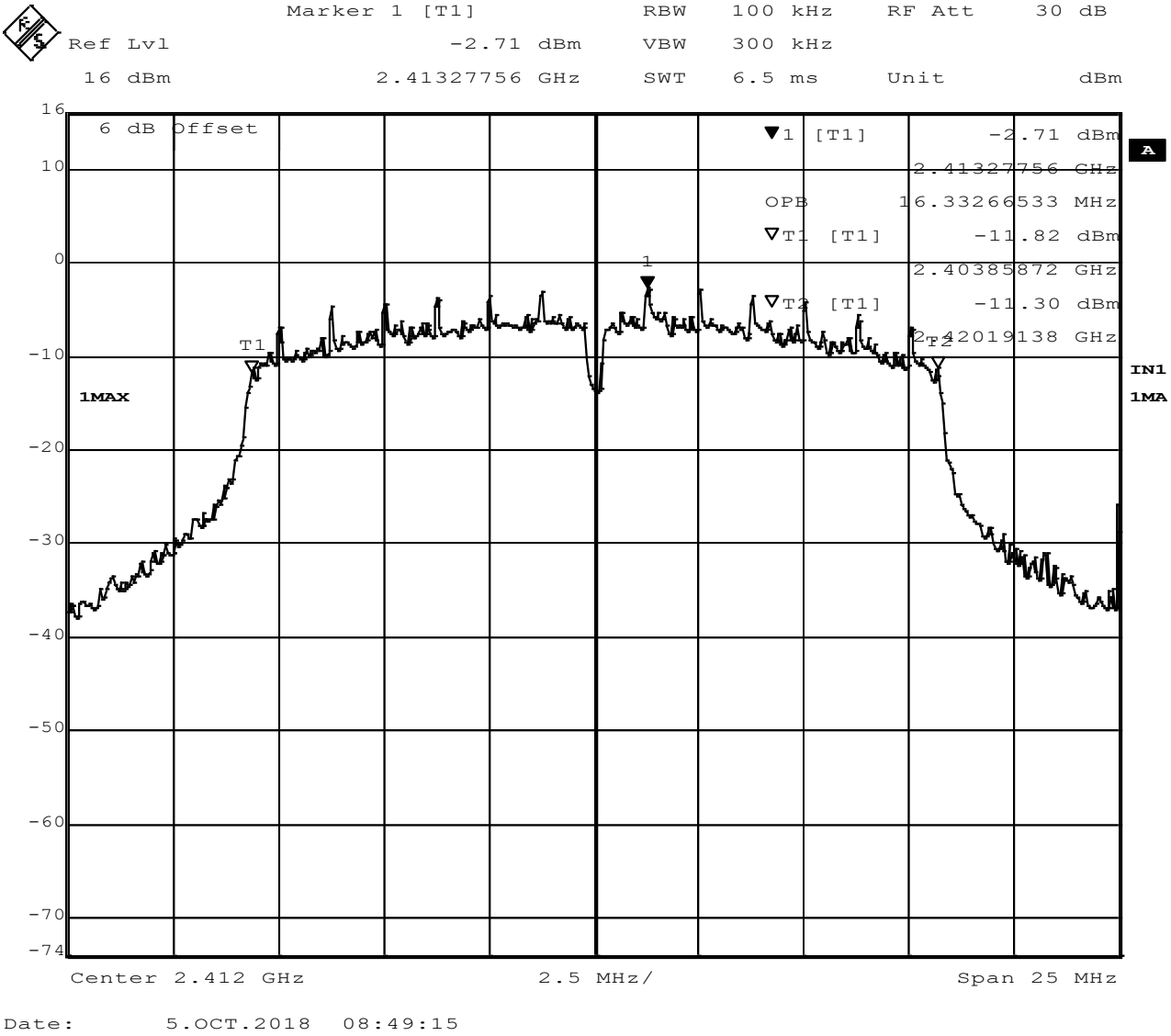
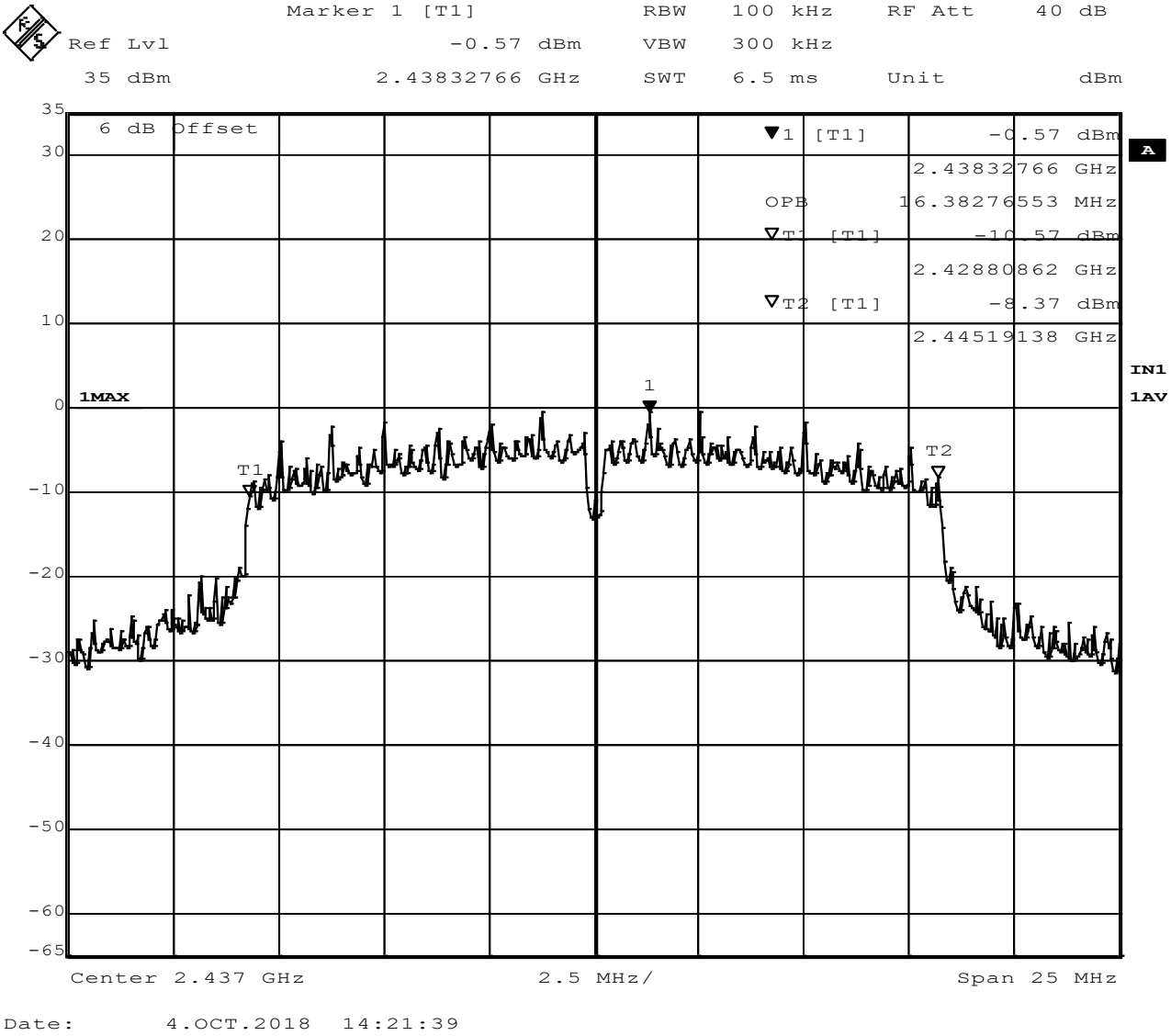
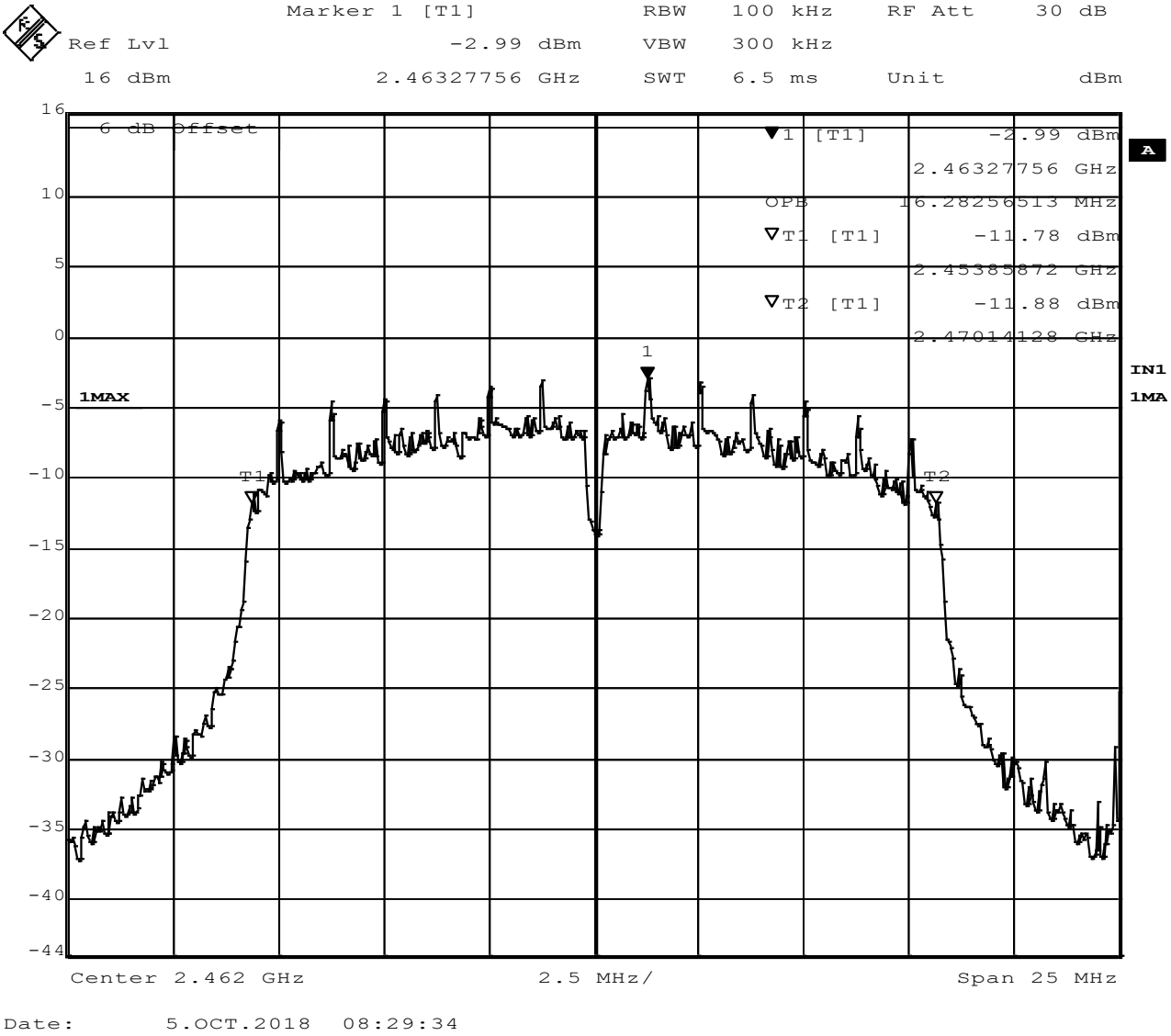



**Figure 10 - 99% Occupied Bandwidth, Low Channel, 802.11g**



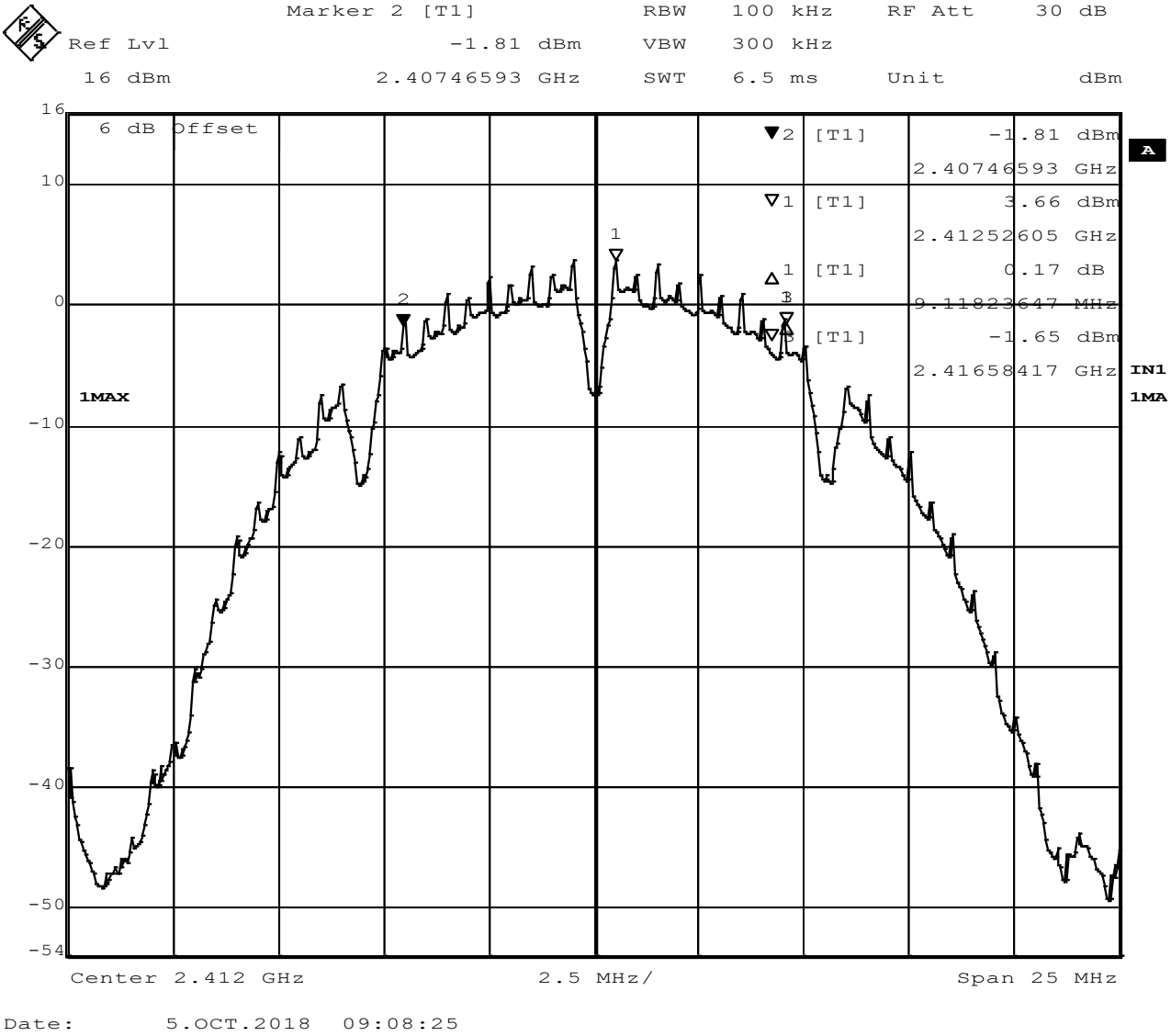

Date: 4.OCT.2018 14:21:39

**Figure 11 - 99% Occupied Bandwidth, Mid Channel, 802.11g**



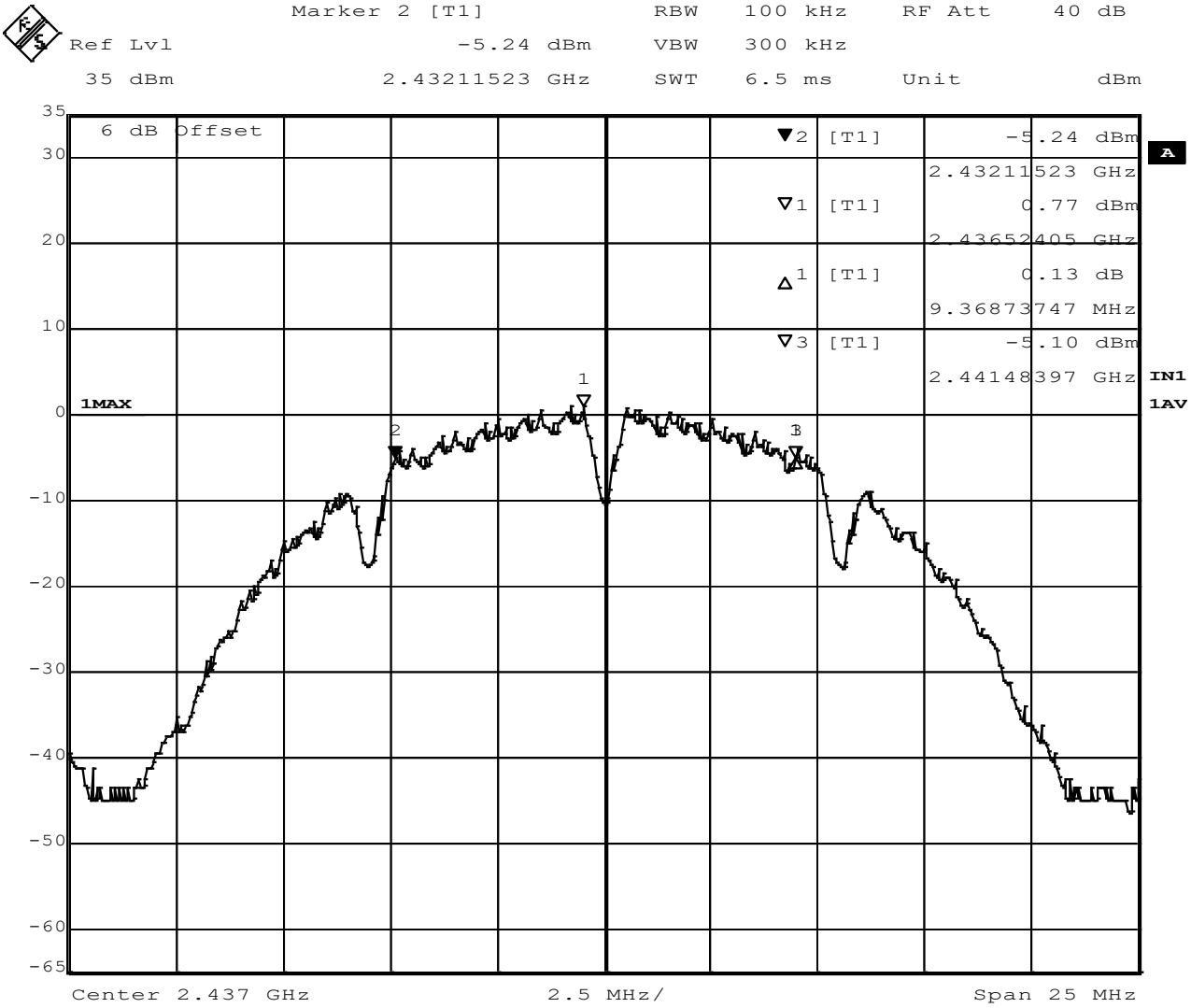

Date: 5.OCT.2018 08:29:34

**Figure 12 - 99% Occupied Bandwidth, High Channel, 802.11g**



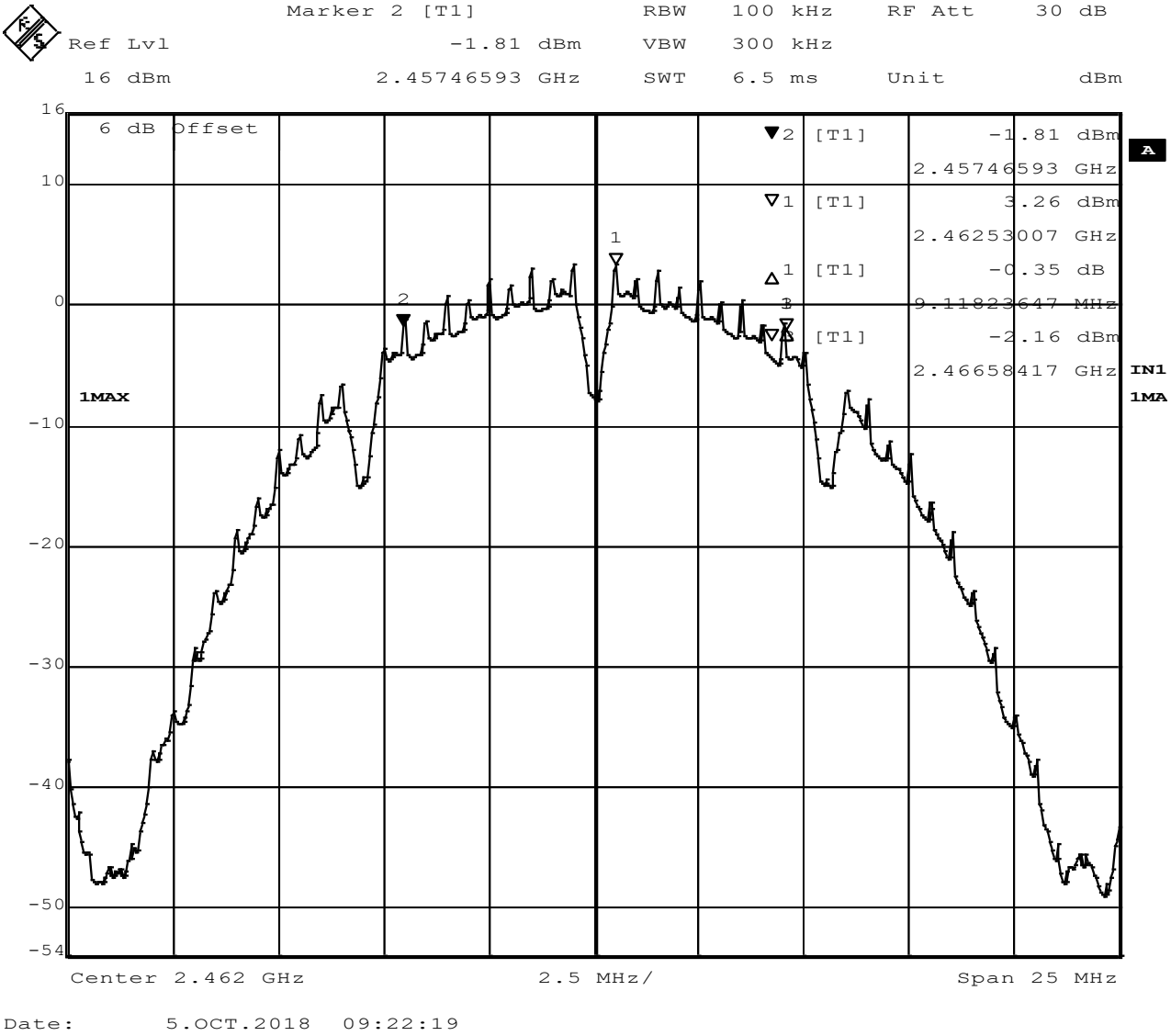

Date: 5.OCT.2018 09:08:25

**Figure 13 - 6dB Bandwidth, Low Channel, 802.11b**




Date: 4.OCT.2018 14:11:11

**Figure 14 - 6dB Bandwidth, Mid Channel, 802.11b**




Date: 5.OCT.2018 09:22:19

**Figure 15 - 6dB Bandwidth, High Channel, 802.11b**

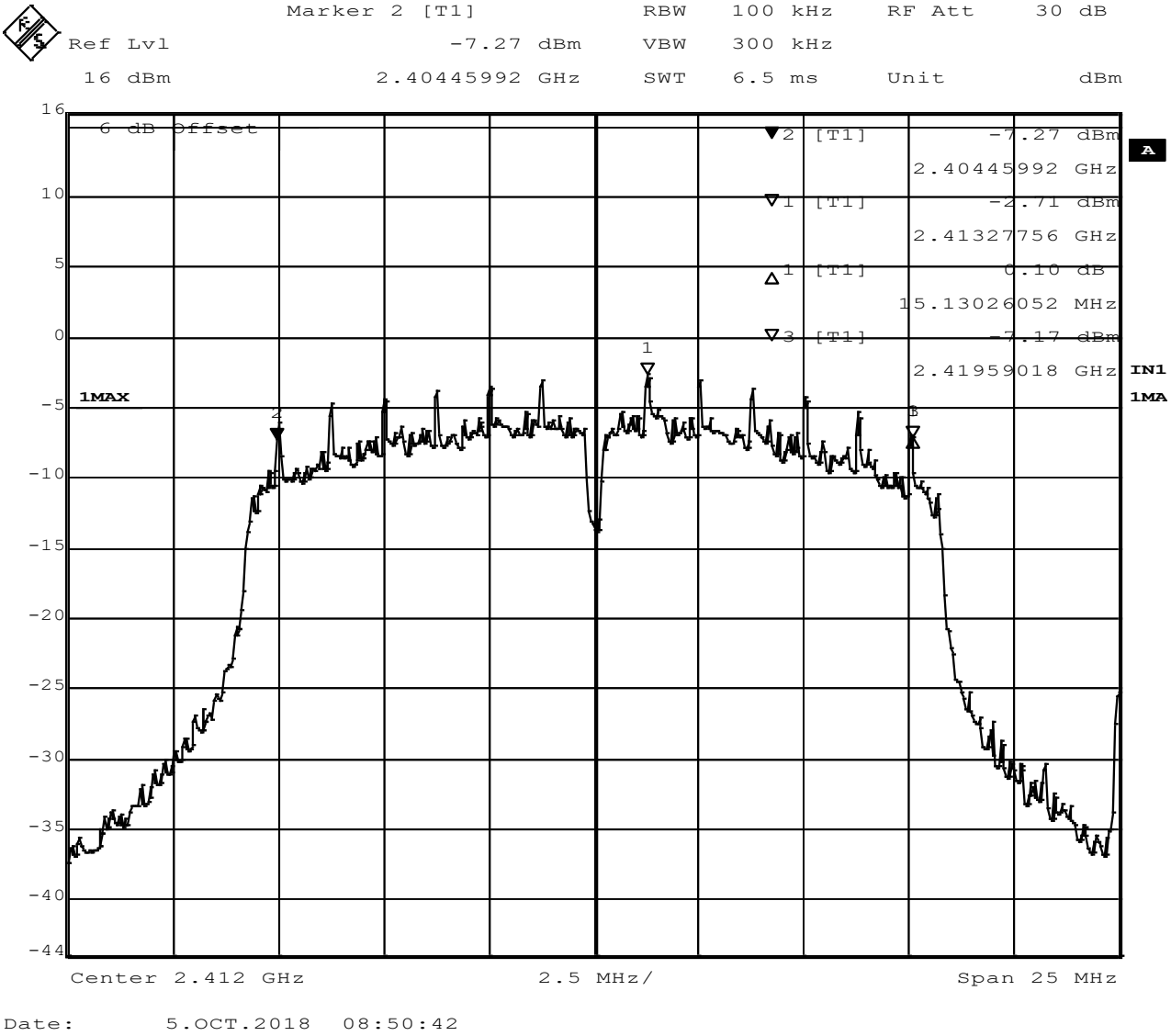
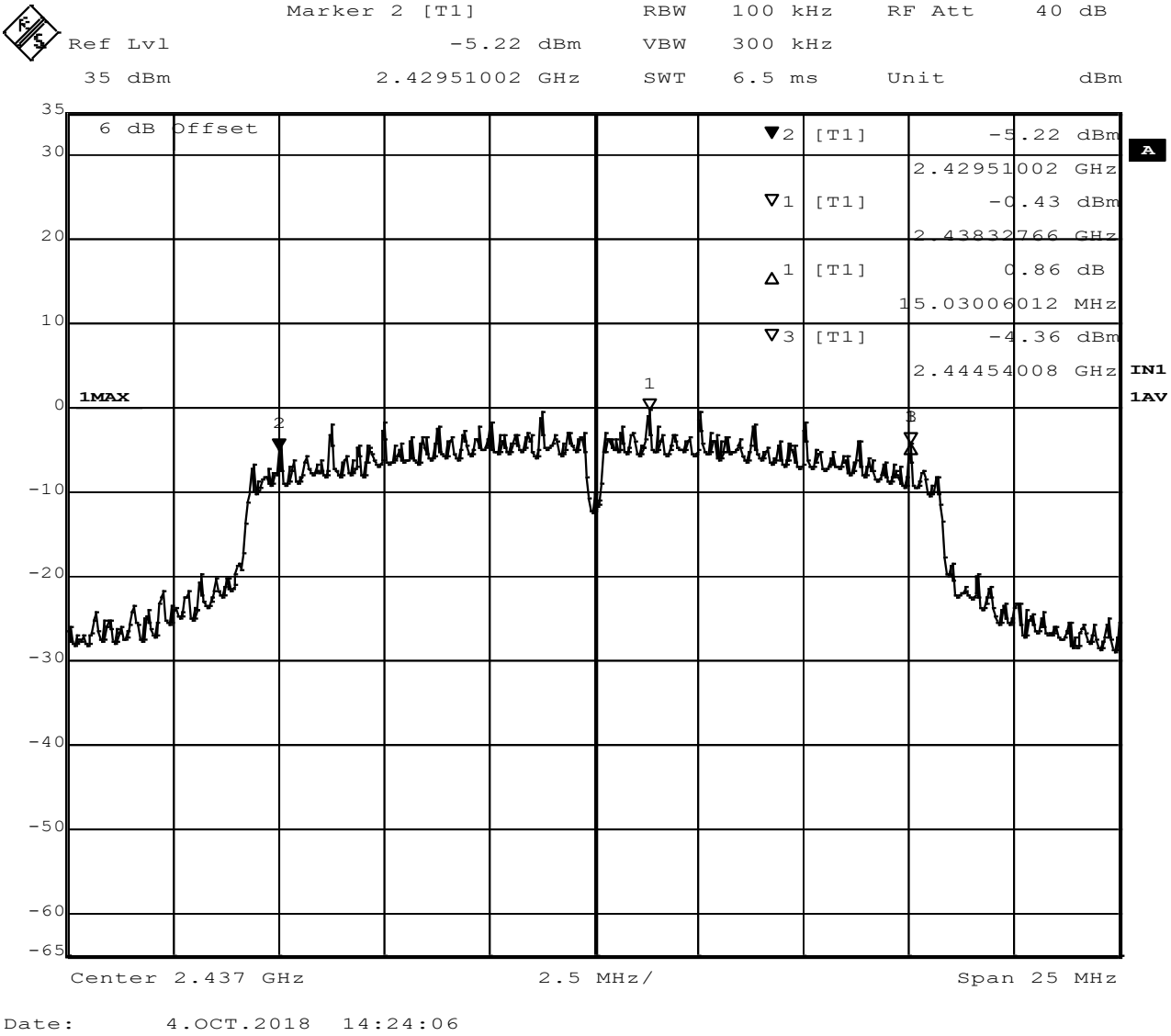
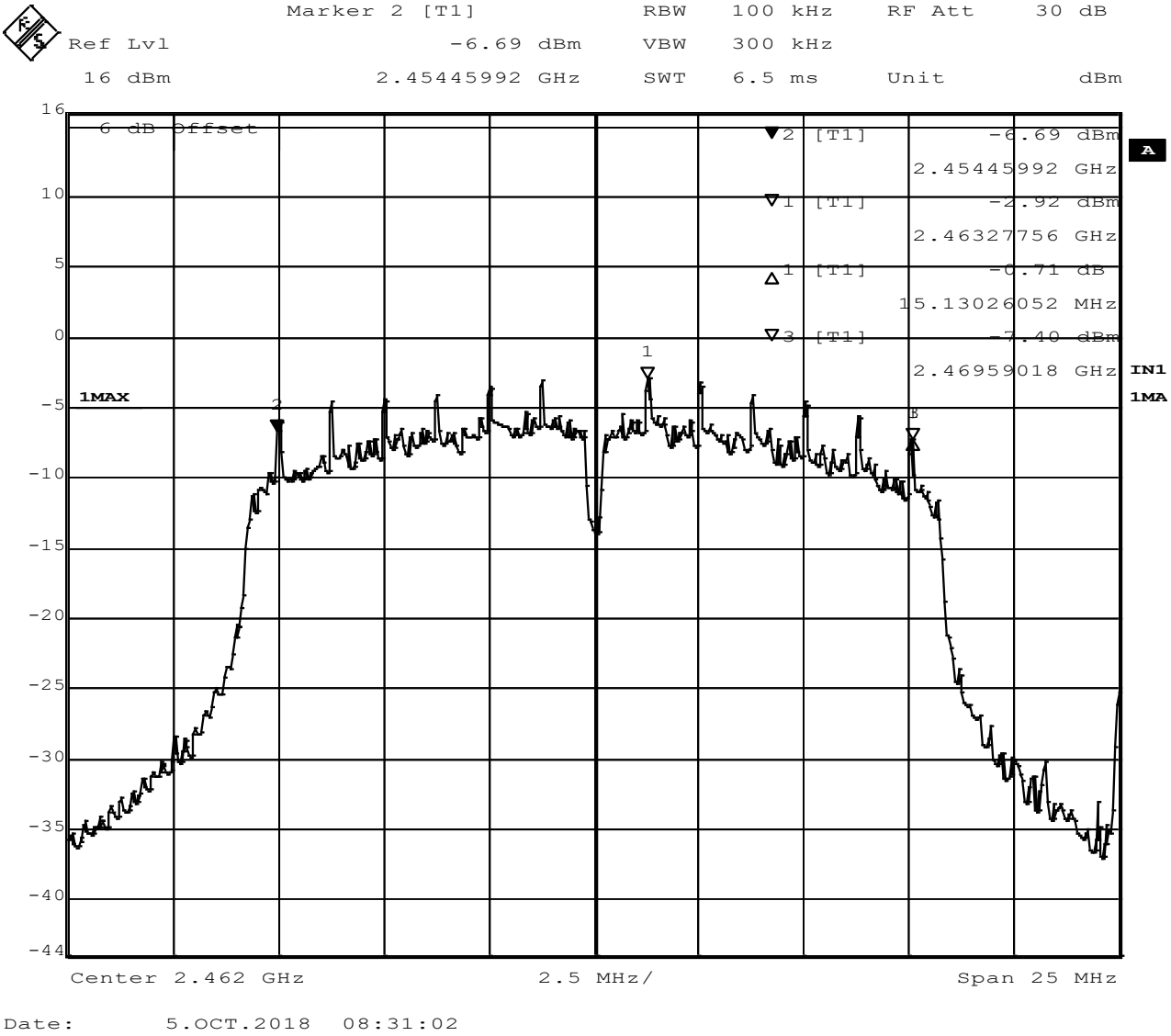



**Figure 16 - 6dB Bandwidth, Low Channel, 802.11g**




Date: 4.OCT.2018 14:24:06

**Figure 17 - 6dB Bandwidth, Mid Channel, 802.11g**




Date: 5.OCT.2018 08:31:02

**Figure 18 - 6dB Bandwidth, High Channel, 802.11g**

## 4.5 BANDEDGES

**Test Method**: ANSI C63.10:

1. Section 6.10.5 (used for restricted bands)
2. Section 11.13.2 “Marker-delta method” (for unrestricted bands)
3. Section 11.11, “Measurement in unrestricted frequency bands”

**Limits of bandedge measurements:**
For emissions outside of the allowed band of operation (2400.0MHz – 2480.0MHz), 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 *4.3 - Bandwidth*. The resolution bandwidth was set to 30kHz and 100 kHz 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:**
See Section 4.3

**EUT operating conditions:**
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

**Test results:**

Highest Out of Band Emissions, 802.11b

| CHANNEL | Band edge /Measurement Frequency (MHz) | Highest out of band level dBm | Fundamental Level (dBm) | Delta | Min (dBc) | Limit | Result |
|---|---|---|---|---|---|---|---|
| 1 | 2340.0 (Restricted, Peak) | -46.86* | 3.64 | NA | NA | -21.23 | PASS |
| 1 | 2390.0 (Unrestricted, Peak) | -35.52+ | 3.64 | 39.16 | 20 | NA | PASS |
| 1 | 2340.0 (Restricted, Average) | -48.99* | 0.31 | NA | NA | -41.23 | PASS |
| 1 | 2390.0 (Unrestricted, Average) | -35.52+ | 0.31 | 35.83 | 20 | NA | PASS |
| 3 | 2483.5 (Restricted, Peak) | -46.74* | -0.47 | NA | NA | -21.23 | PASS |
| 3 | 2483.5 (Unrestricted, Peak) | -54.46+ | -0.47 | 53.99 | 20 | NA | PASS |
| 3 | 2483.5 (Restricted, Average) | -49.96* | -0.47 | NA | NA | -41.23 | PASS |
| 3 | 2483.5 (Unrestricted, Average) | -54.46+ | -0.47 | 53.99 | 20 | NA | PASS |

*Includes antenna gain of 5 dBi. The plots show uncorrected value.

+Used as relative measurement

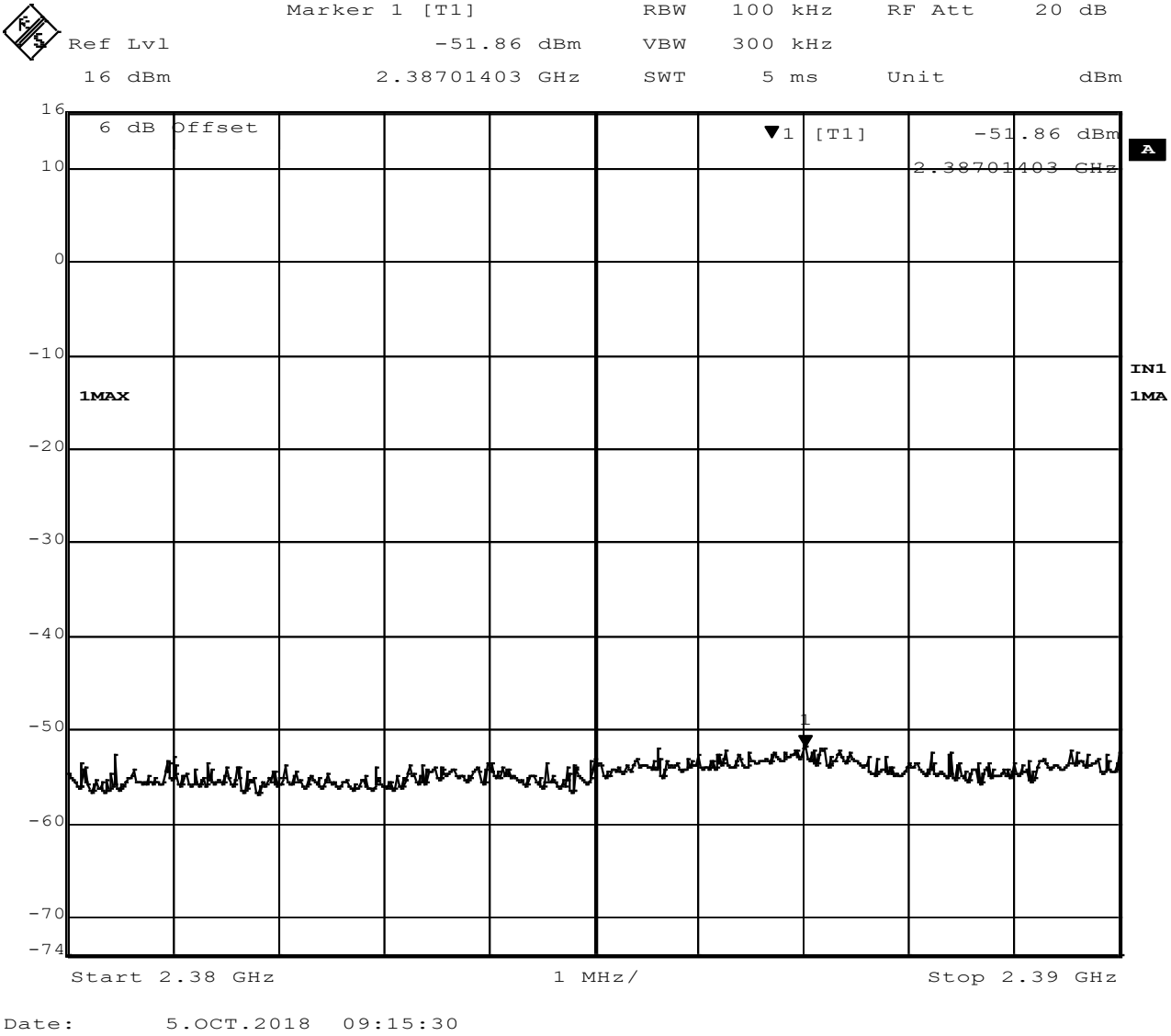
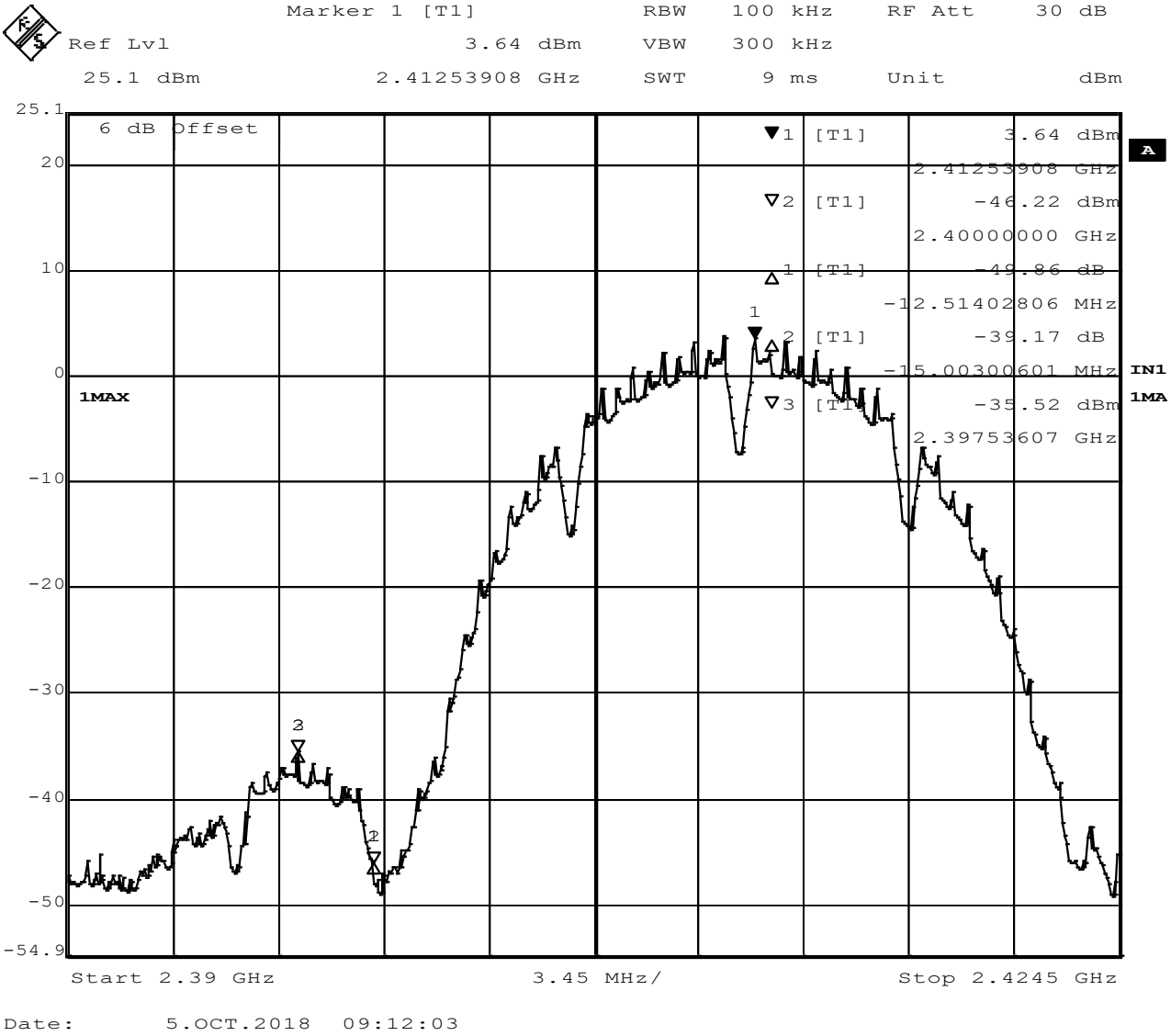
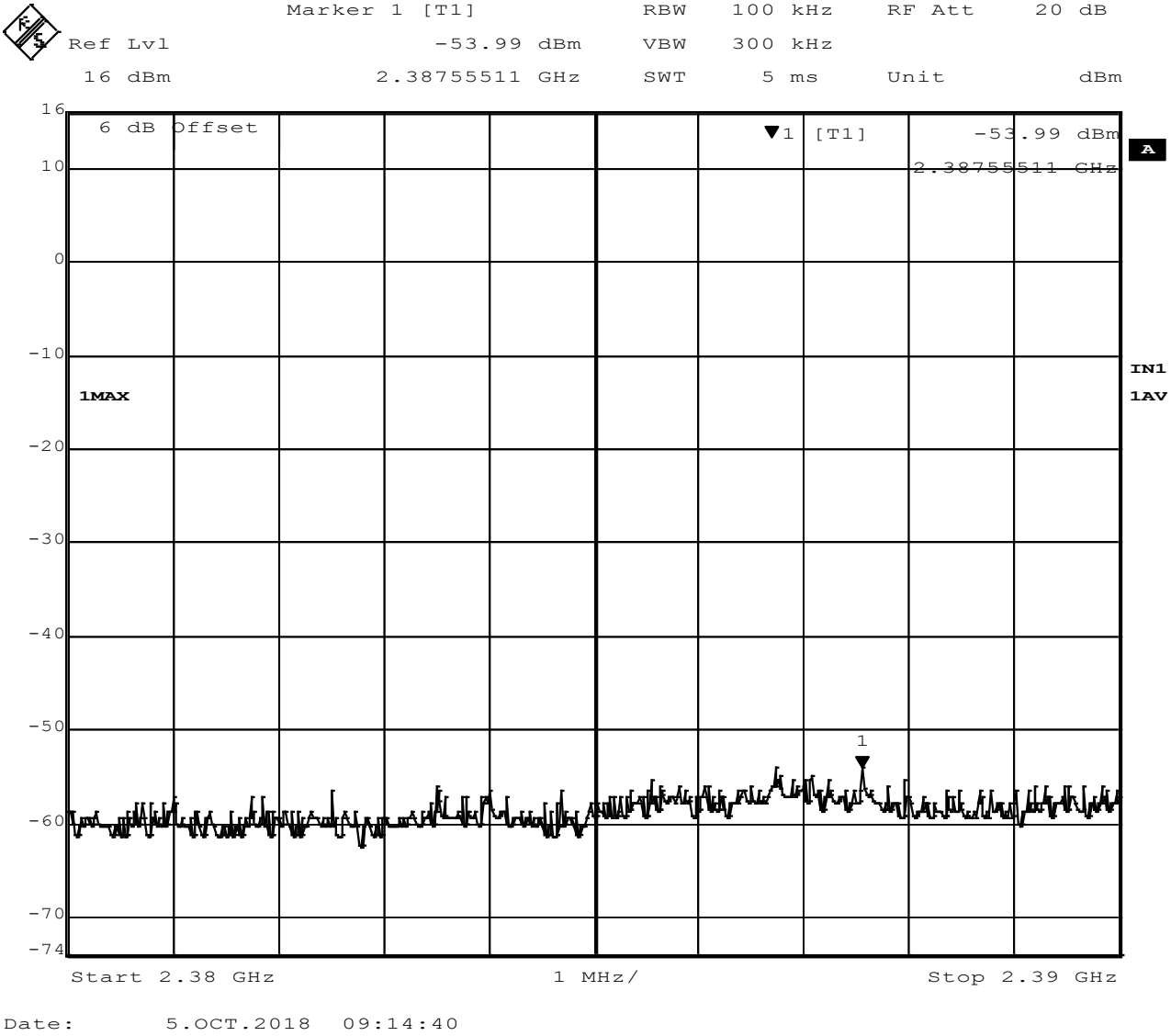



**Figure 19 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak**



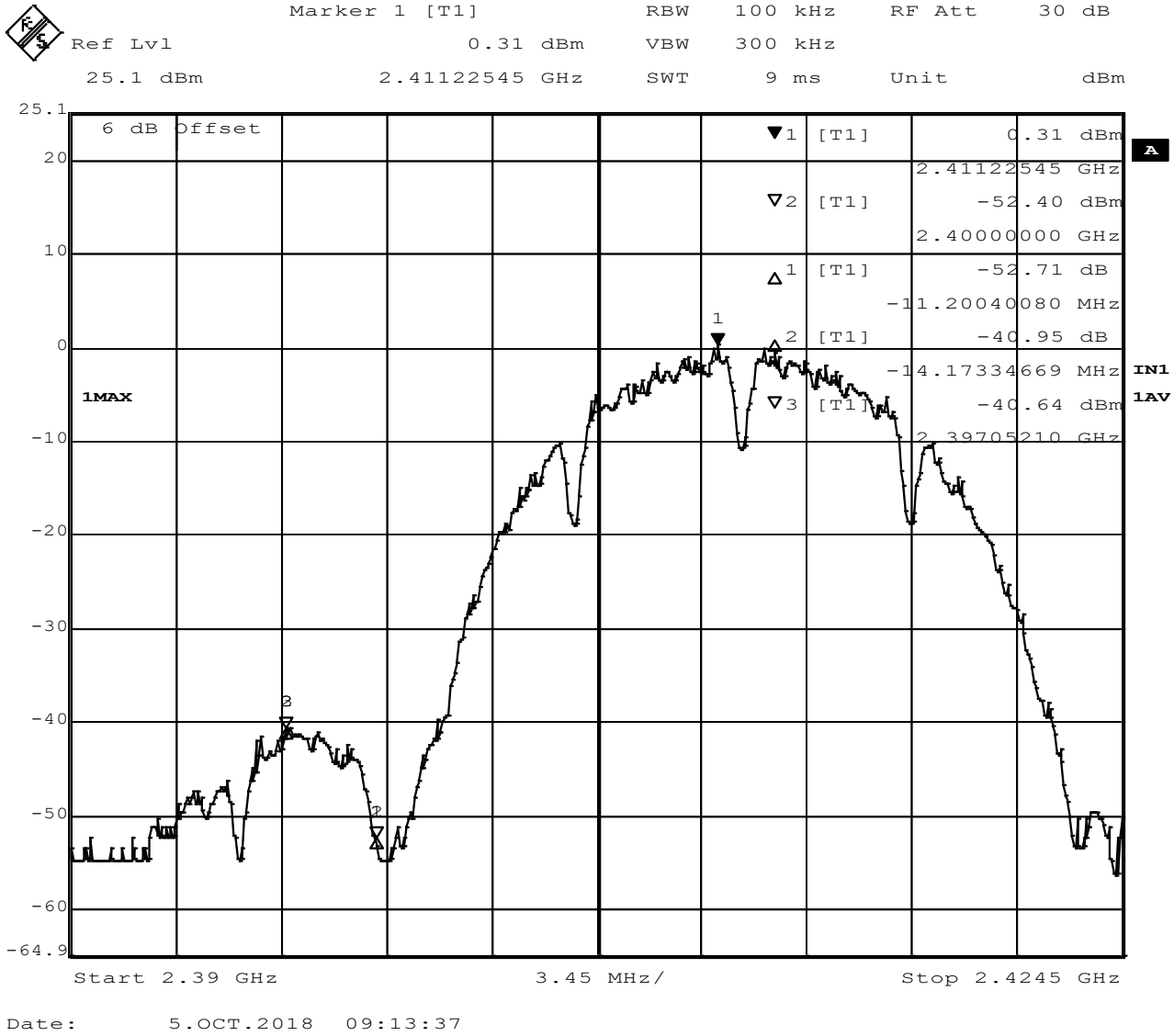

Date: 5.OCT.2018 09:12:03

**Figure 20 - Band-edge Measurement, Low Channel, Fundamental, Peak**



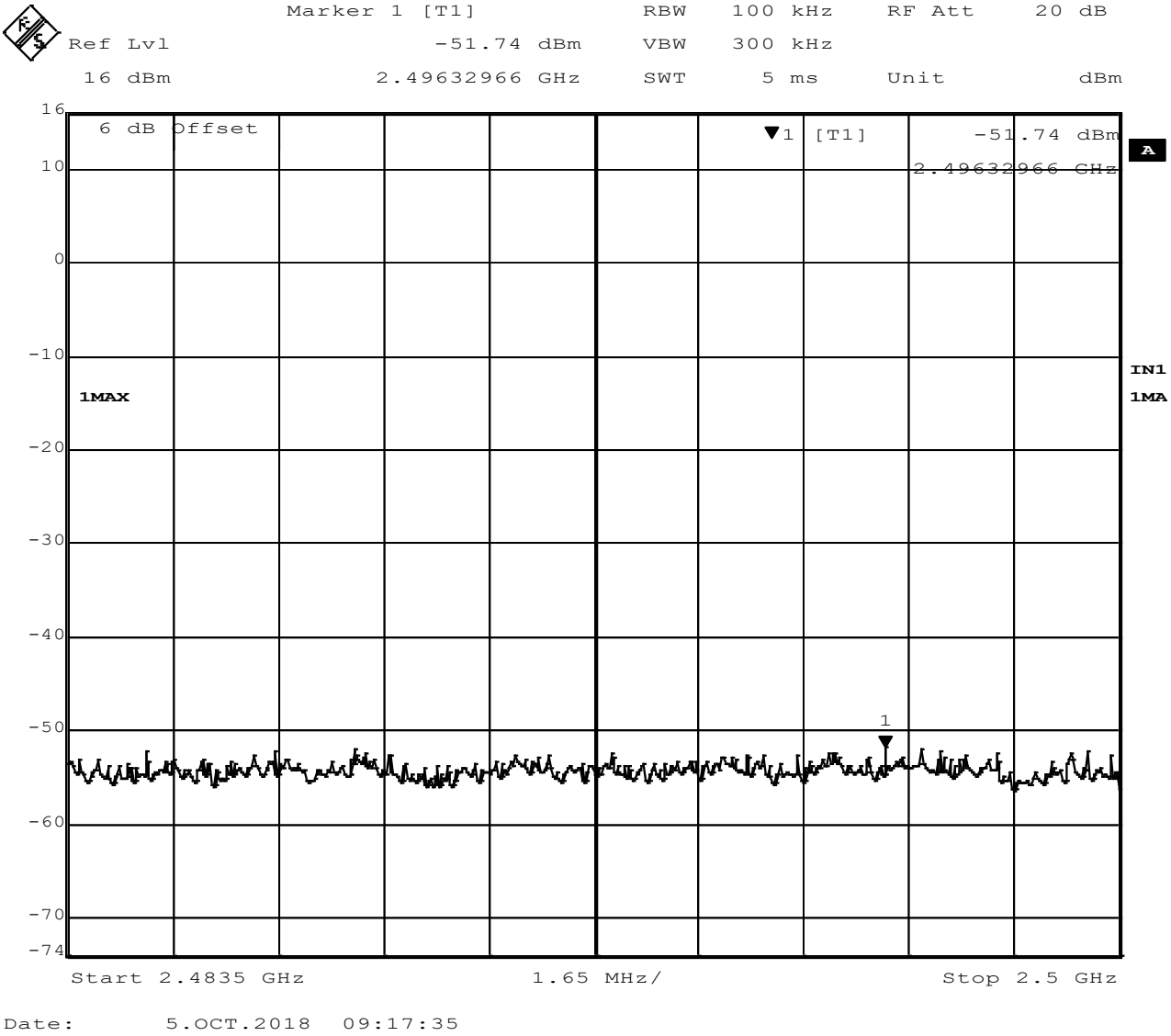

Date: 5.OCT.2018 09:14:40

**Figure 21 - Band-edge Measurement, Low Channel, Restricted Frequency, Average**



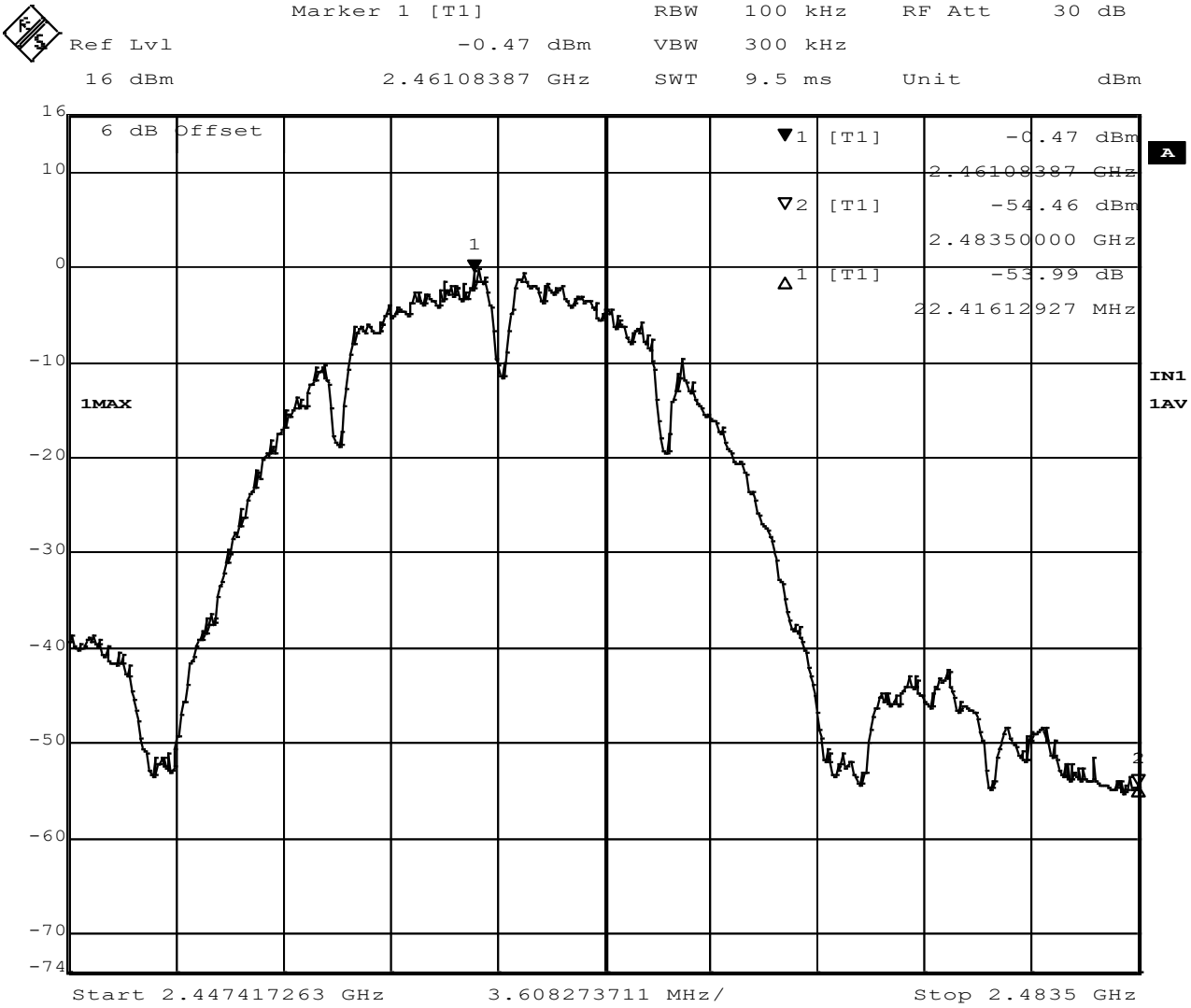

Date: 5.OCT.2018 09:13:37

**Figure 22 - Band-edge Measurement, Low Channel, Fundamental, Average**



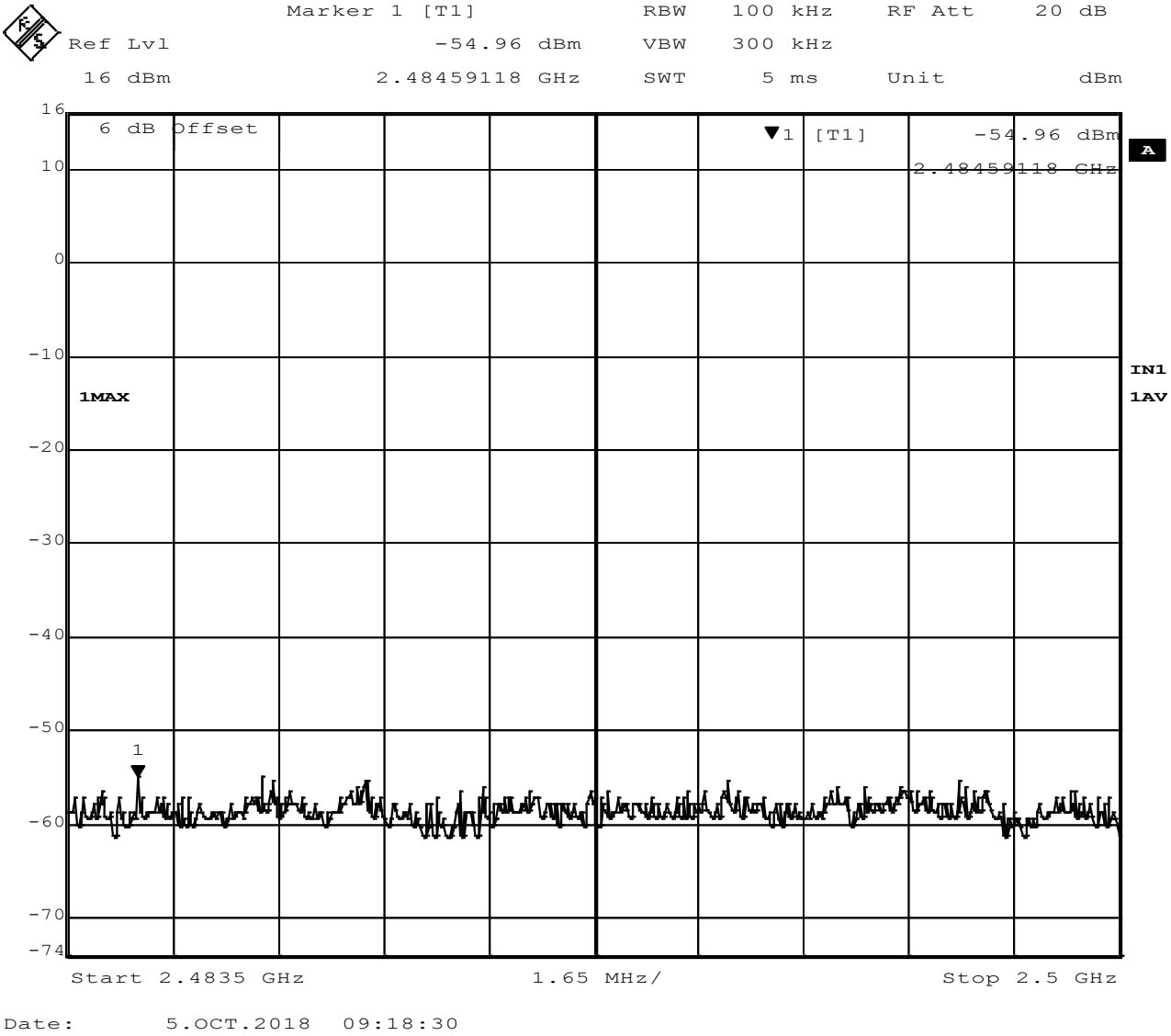

Date: 5.OCT.2018 09:17:35

**Figure 23 - Band-edge Measurement, High Channel, Restricted Frequency, Peak**



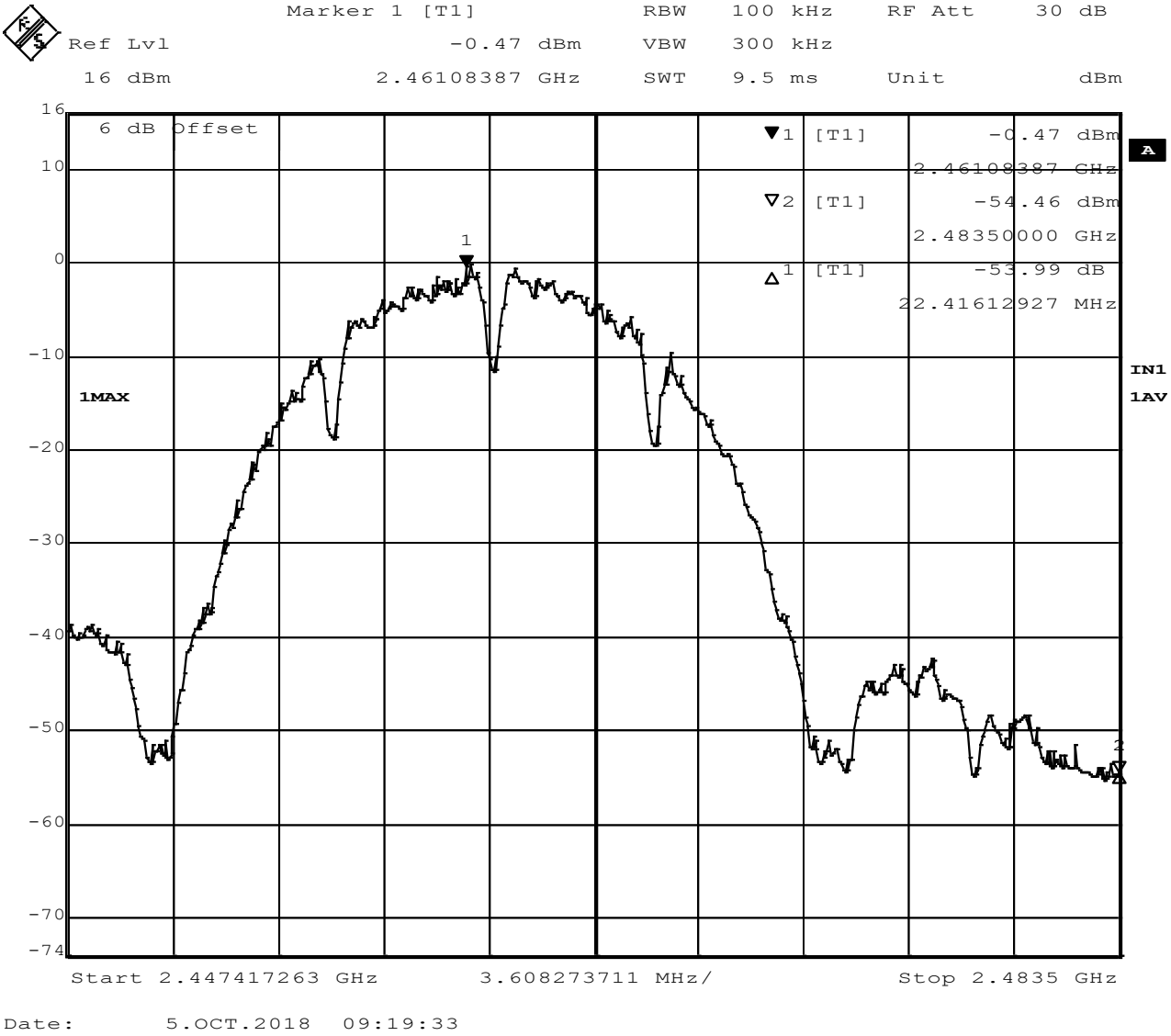

Date: 5.OCT.2018 09:19:33

**Figure 24 - Band-edge Measurement, High Channel, Fundamental, Peak**




Date: 5.OCT.2018 09:18:30

**Figure 25 - Band-edge Measurement, High Channel, Restricted Frequency, Average**




Date: 5.OCT.2018 09:19:33

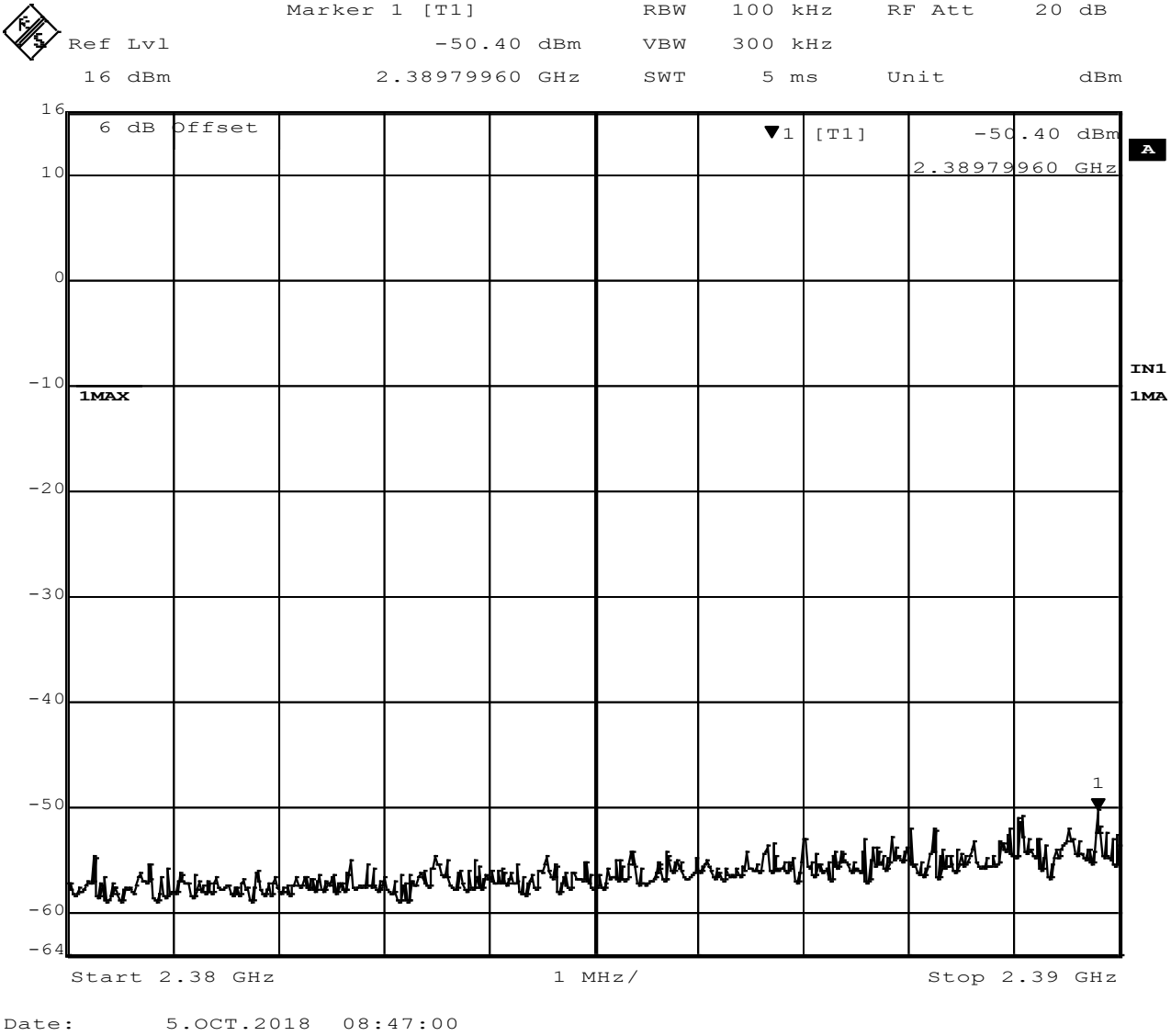
**Figure 26 - Band-edge Measurement, High Channel, Fundamental, Average**

Highest Out of Band Emissions, 802.11g

| CHANNEL | Band edge /Measurement Frequency (MHz) | Highest out of band level dBm | Fundamental Level (dBm) | Delta | Min (dBc) | Limit | Result |
|---|---|---|---|---|---|---|---|
| 1 | 2340.0 (Restricted, Peak) | -45.40* | -2.96 | 42.44 | NA | -21.23 | PASS |
| 1 | 2390.0 (Unrestricted, Peak) | -27.18+ | -2.96 | 24.22 | 20 | NA | PASS |
| 1 | 2340.0 (Restricted, Average) | -48.99* | -6.65 | 42.34 | NA | -41.23 | PASS |
| 1 | 2390.0 (Unrestricted, Average) | -36.96+ | -6.65 | 30.31 | 20 | NA | PASS |
| 3 | 2483.5 (Restricted, Peak) | -46.36* | -3.09 | 43.27 | NA | -21.23 | PASS |
| 3 | 2483.5 (Unrestricted, Peak) | -47.12+ | -3.09 | 44.03 | 20 | NA | PASS |
| 3 | 2483.5 (Restricted, Average) | -51.04* | -7.02 | 44.02 | NA | -41.23 | PASS |
| 3 | 2483.5 (Unrestricted, Average) | -54.96+ | -7.02 | 47.94 | 20 | NA | PASS |

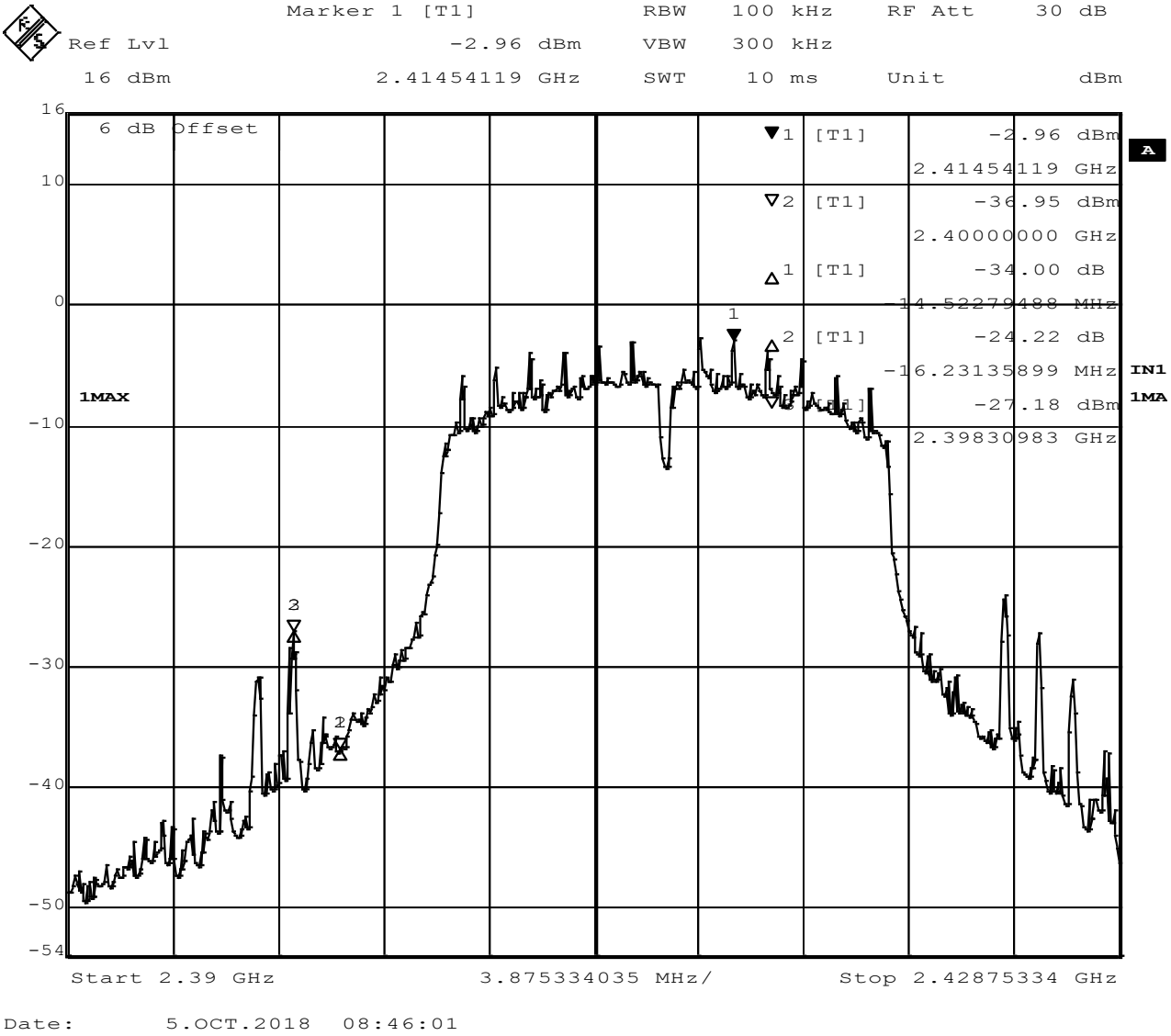
*Includes antenna gain of 5 dBi. The plots show uncorrected value.

+Used as relative measurement




Date: 5.OCT.2018 08:47:00

**Figure 27 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak**




Date: 5.OCT.2018 08:46:01

**Figure 28 - Band-edge Measurement, Low Channel, Fundamental, Peak**

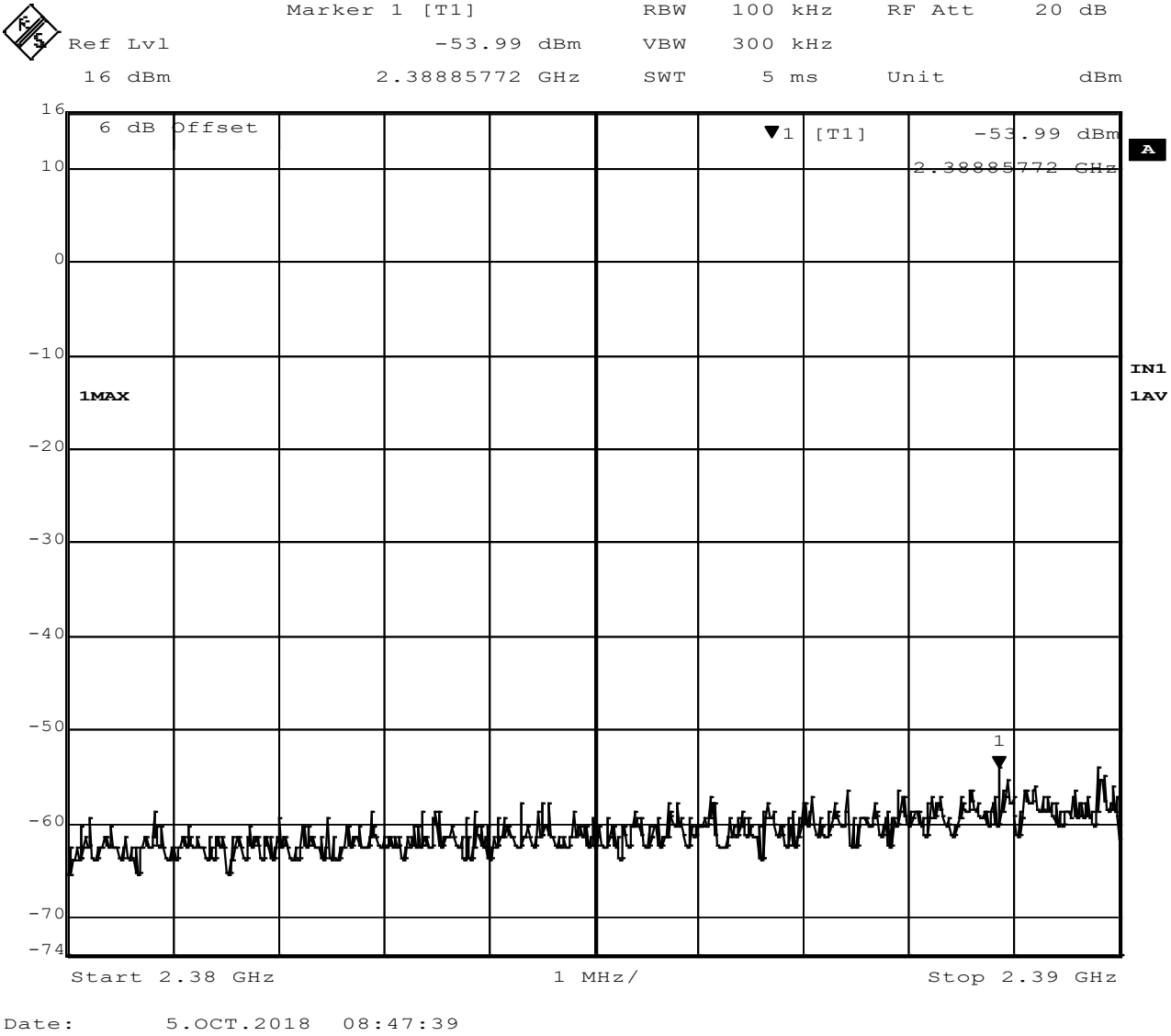
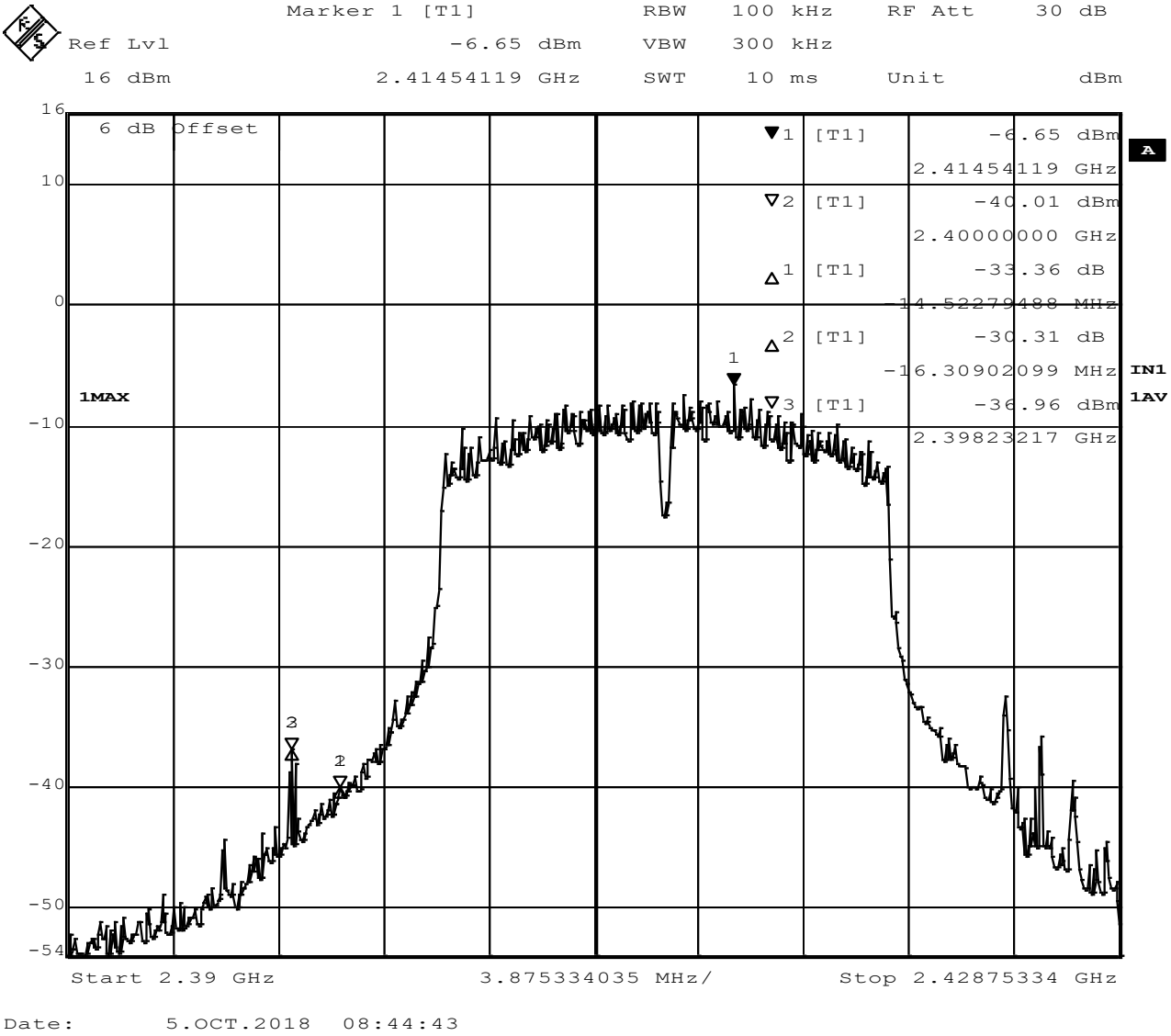
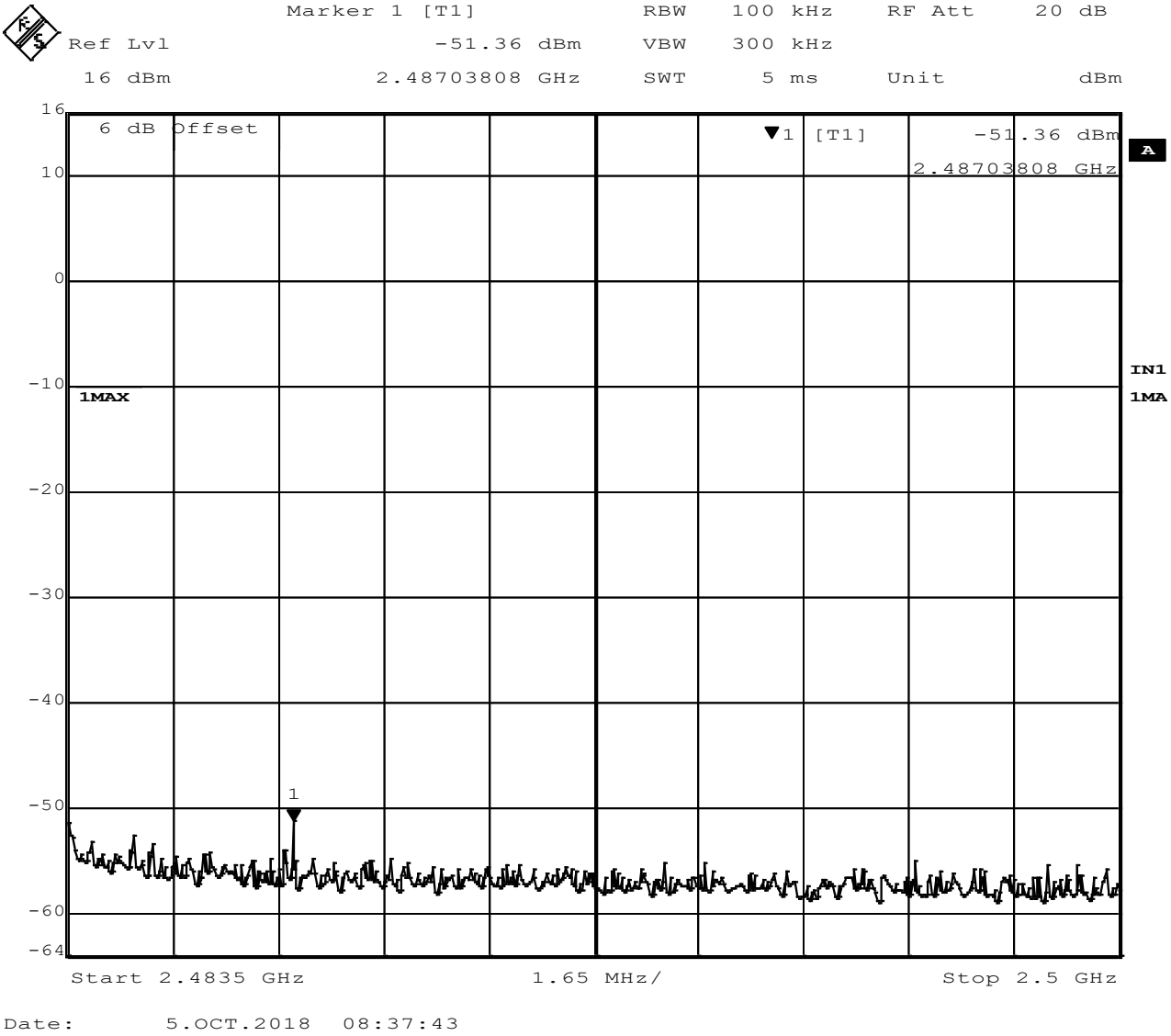



**Figure 29 - Band-edge Measurement, Low Channel, Restricted Frequency, Average**



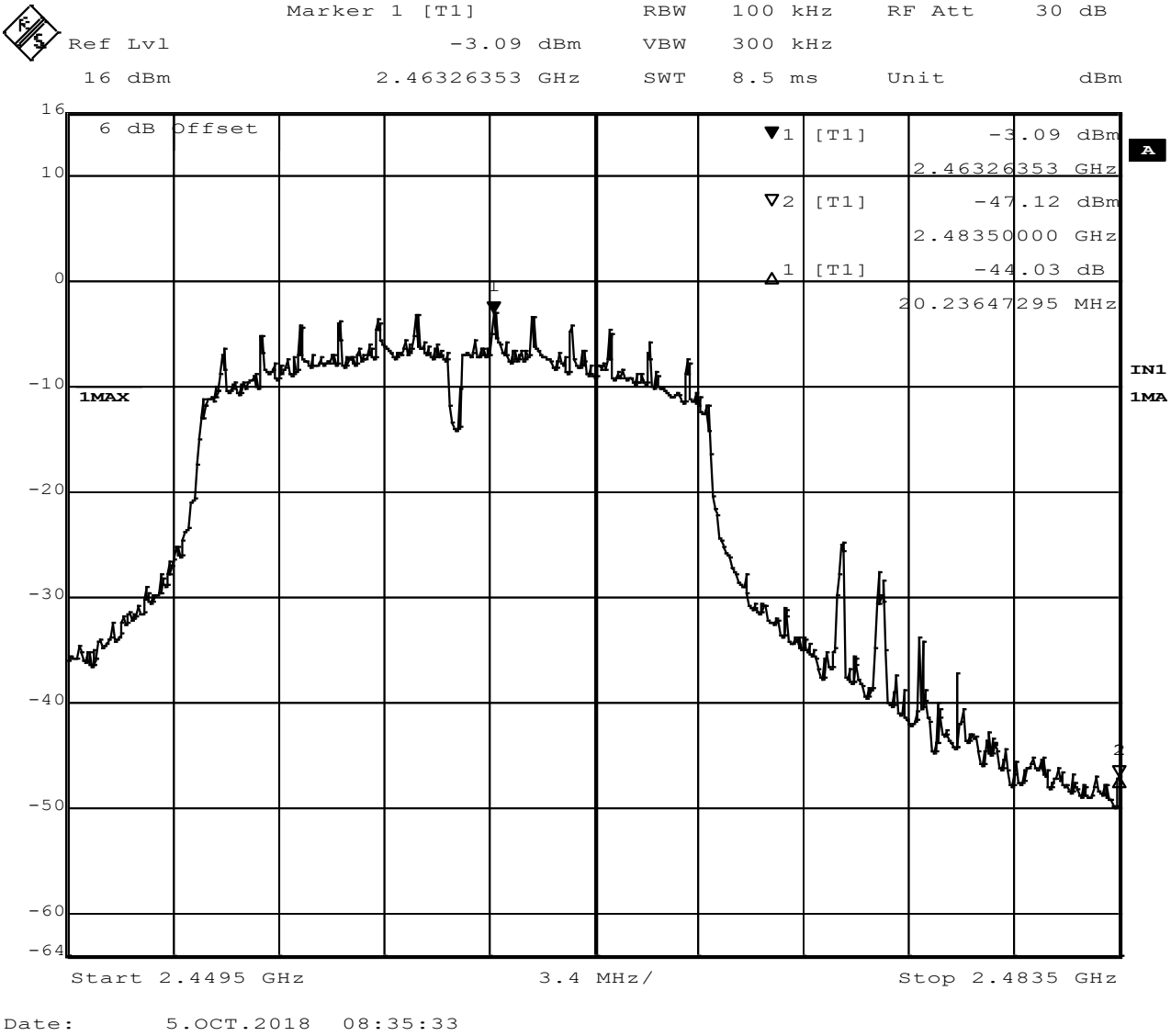

Date: 5.OCT.2018 08:44:43

**Figure 30 - Band-edge Measurement, Low Channel, Fundamental, Average**



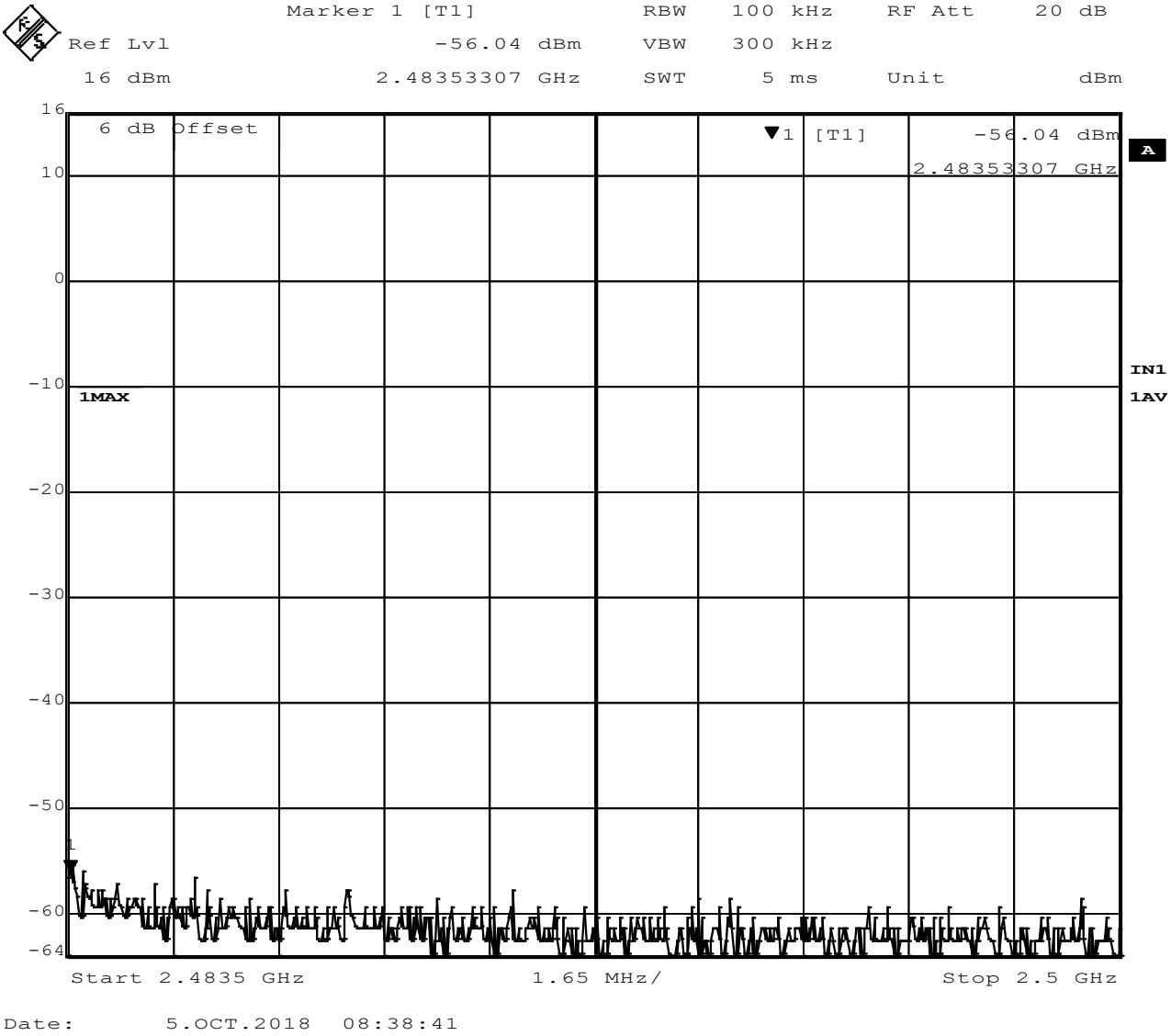

Date: 5.OCT.2018 08:37:43

**Figure 31 - Band-edge Measurement, High Channel, Restricted Frequency, Peak**



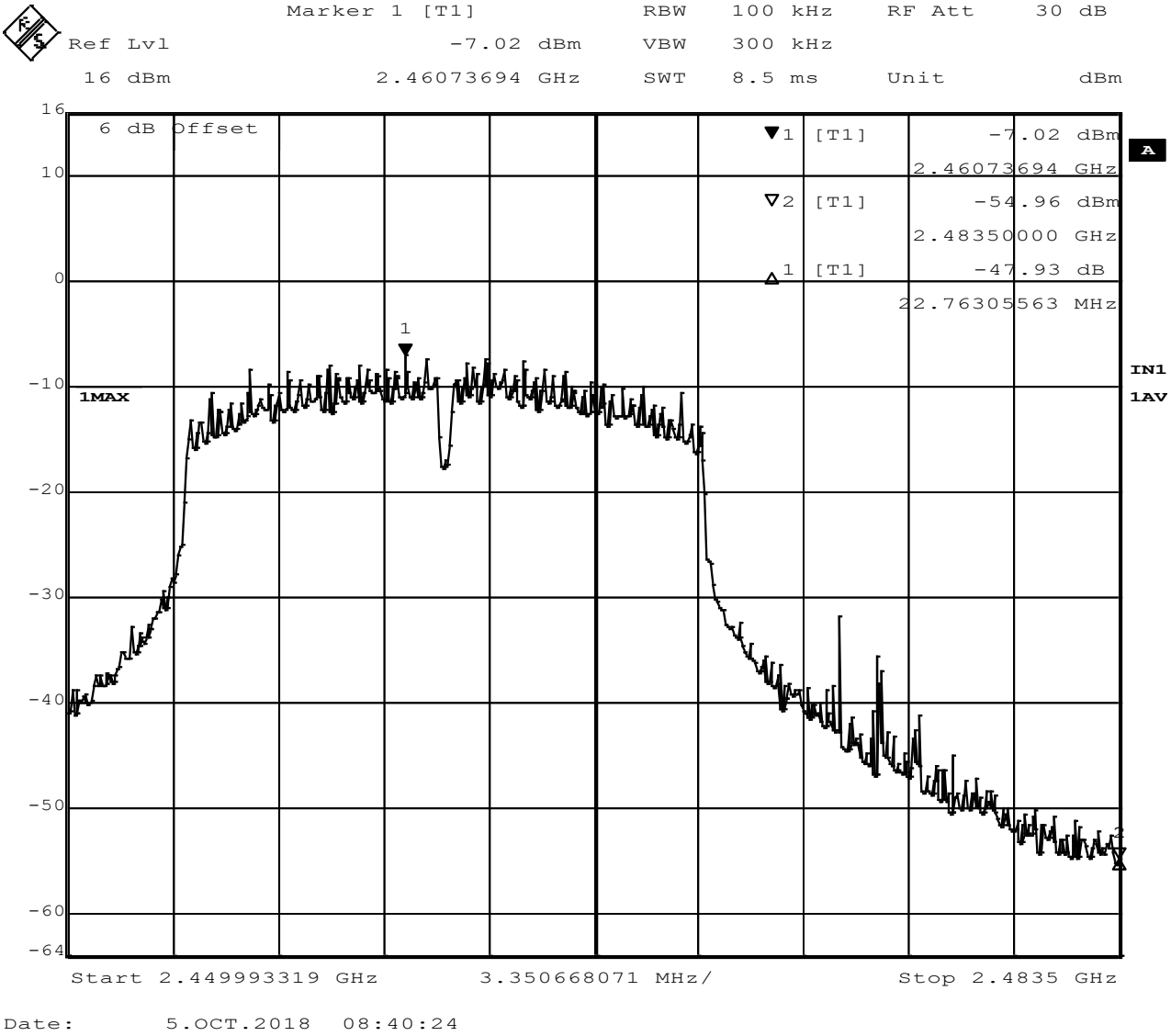

Date: 5.OCT.2018 08:35:33

**Figure 32 - Band-edge Measurement, High Channel, Fundamental, Peak**




Date: 5.OCT.2018 08:38:41

**Figure 33 - Band-edge Measurement, High Channel, Restricted Frequency, Average**




Date: 5.OCT.2018 08:40:24

**Figure 34 - Band-edge Measurement, High Channel, Fundamental, Average**

## 4.6 POWER SPECTRAL DENSITY

**Test Method**: ANSI C63.10,
1. Section 11.10.2 "Method PKPSD (peak PSD)"

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

**Test procedures:**
1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

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

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

**EUT operating conditions:**
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

**Test results:**

**Power Spectral Density**

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | PEAK PSD(dBm) | EIRP with antenna gain* | Method | RESULT |
|---|---|---|---|---|---|---|
| Low | 2412 | 802.11b | -11.56 | -6.56 | Conducted | PASS |
| Middle | 2437 | 802.11b | -21.38 | -16.38 | Conducted | PASS |
| High | 2462 | 802.11b | -11.99 | -6.99 | Conducted | PASS |
| Low | 2412 | 802.11g | -18.87 | -13.87 | Conducted | PASS |
| Middle | 2437 | 802.11g | -14.15 | -9.15 | Conducted | PASS |
| High | 2462 | 802.11g | -18.63 | -13.63 | Conducted | PASS |

* 5dBi (Max) of antenna gain was added in order to get EIRP measurements

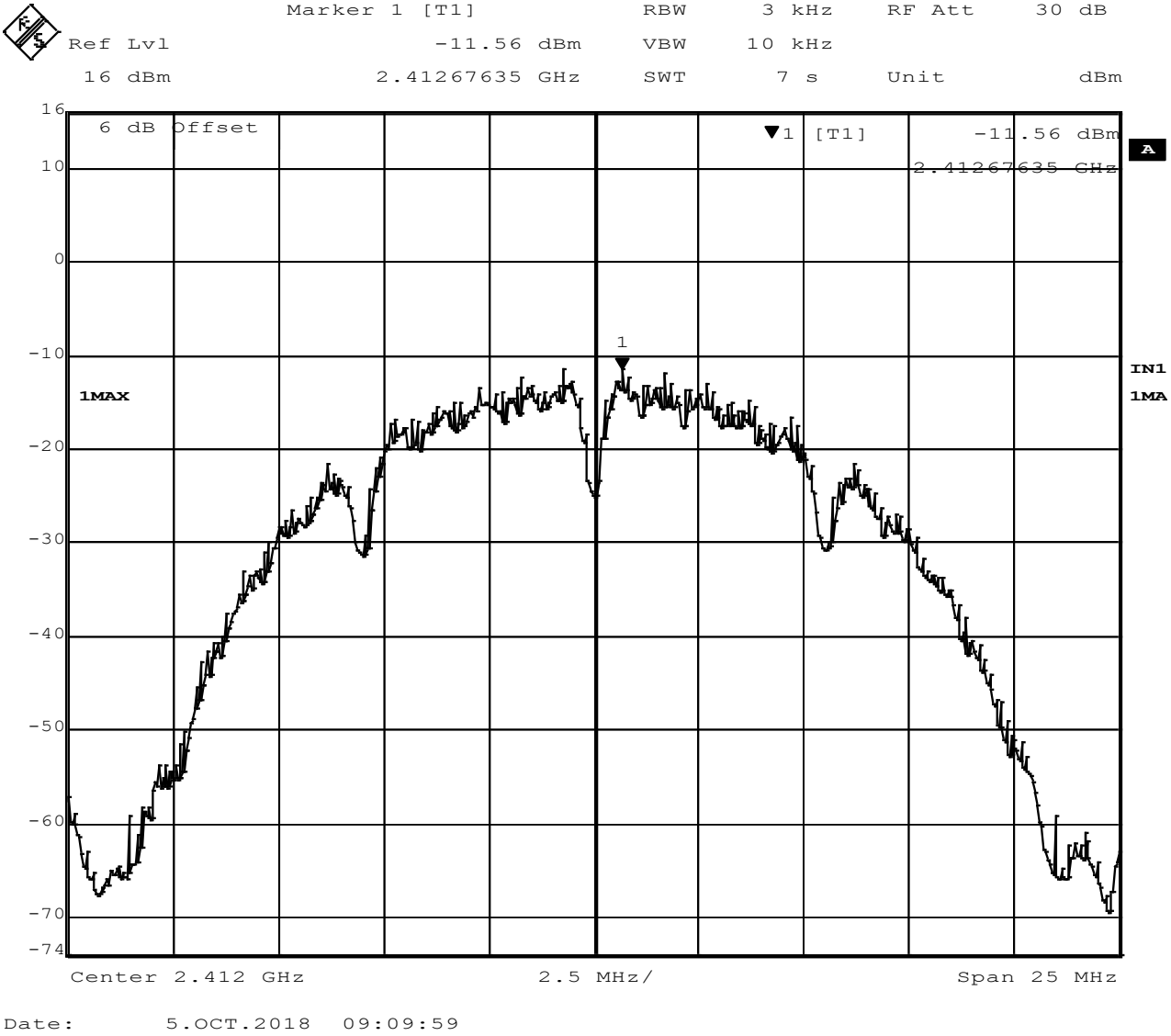
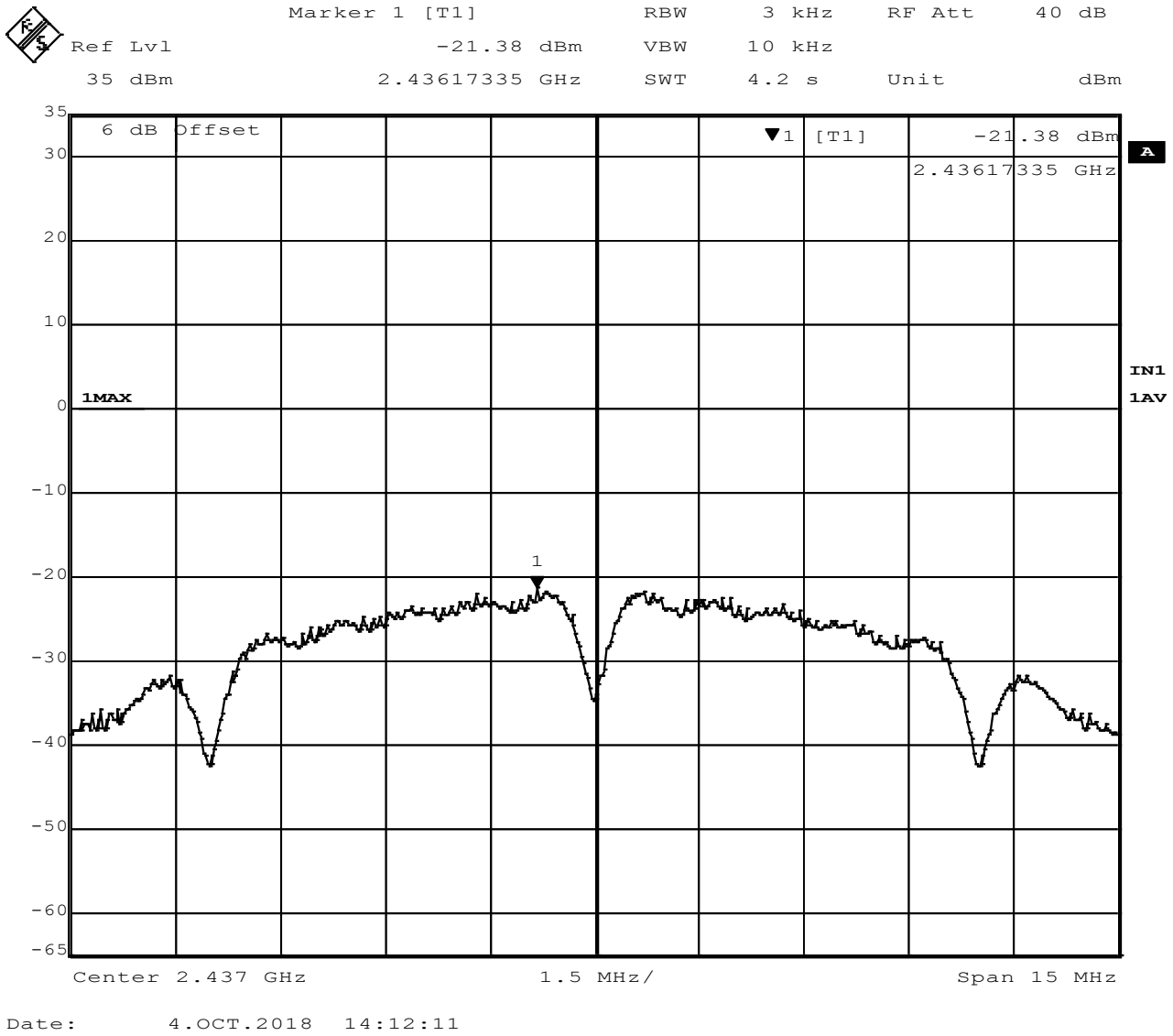



**Figure 35 - Power Spectral Density, Low Channel, 802.11b**




Date: 4.OCT.2018 14:12:11

**Figure 36 - Power Spectral Density, Mid Channel, 802.11b**

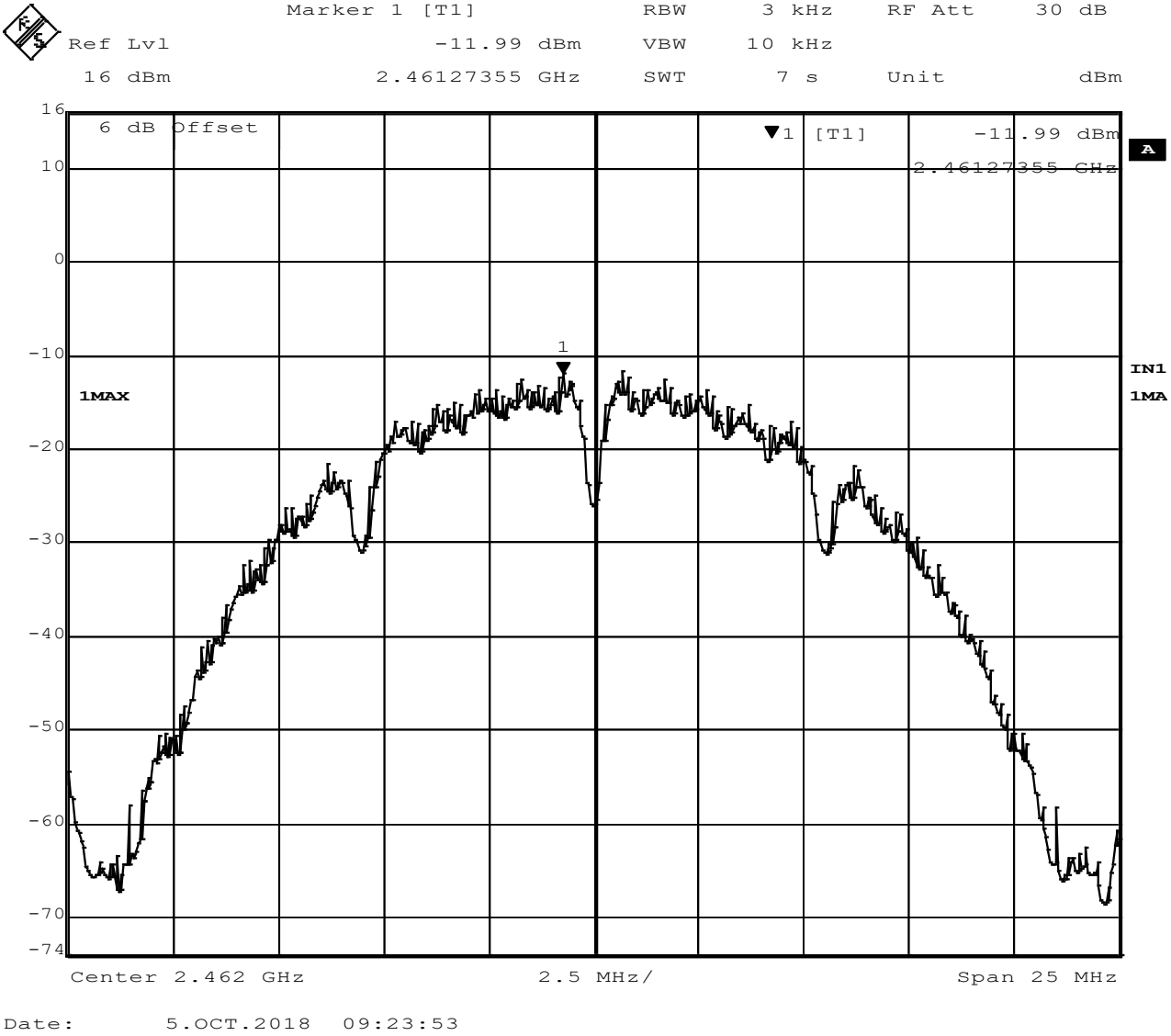
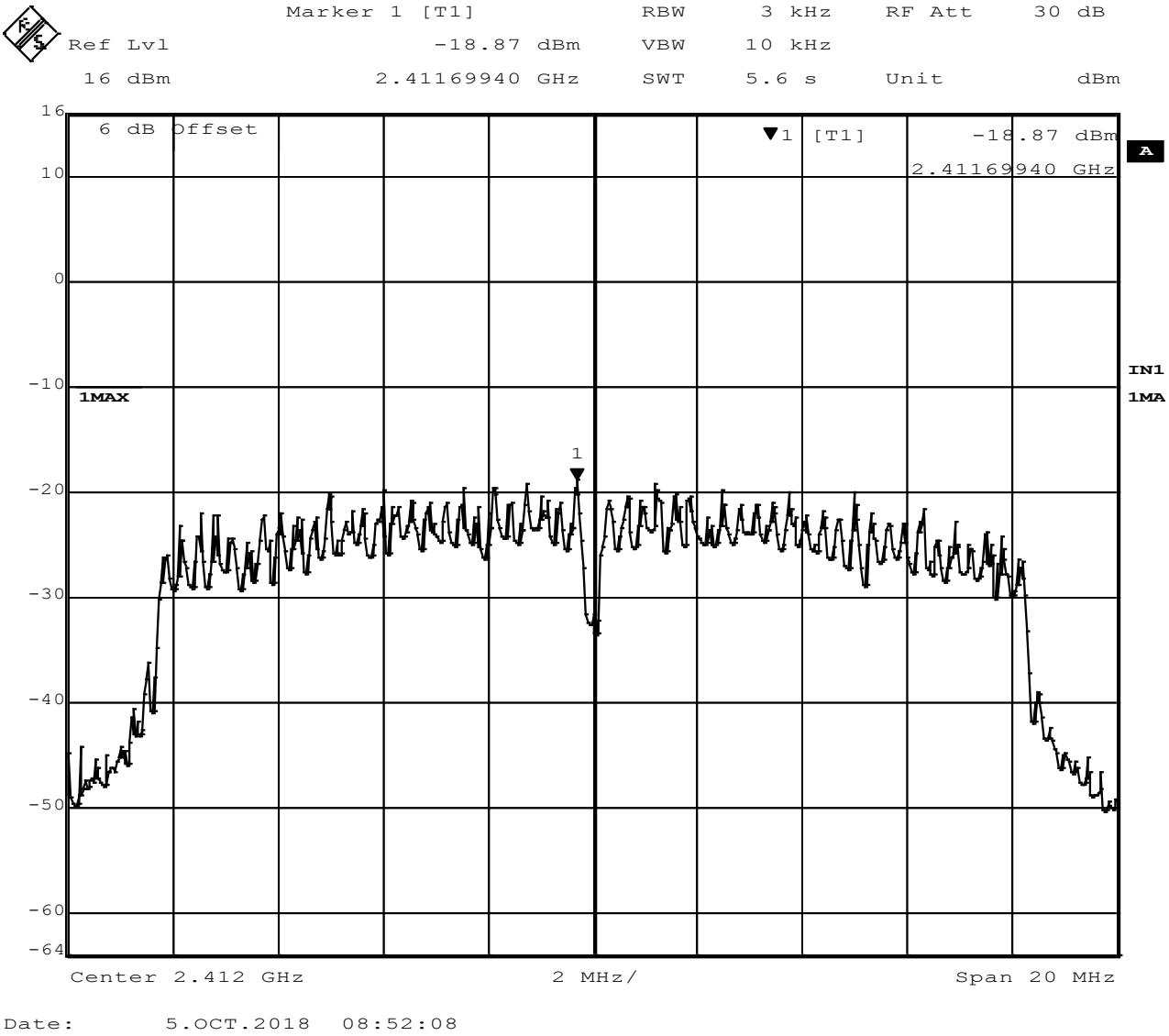
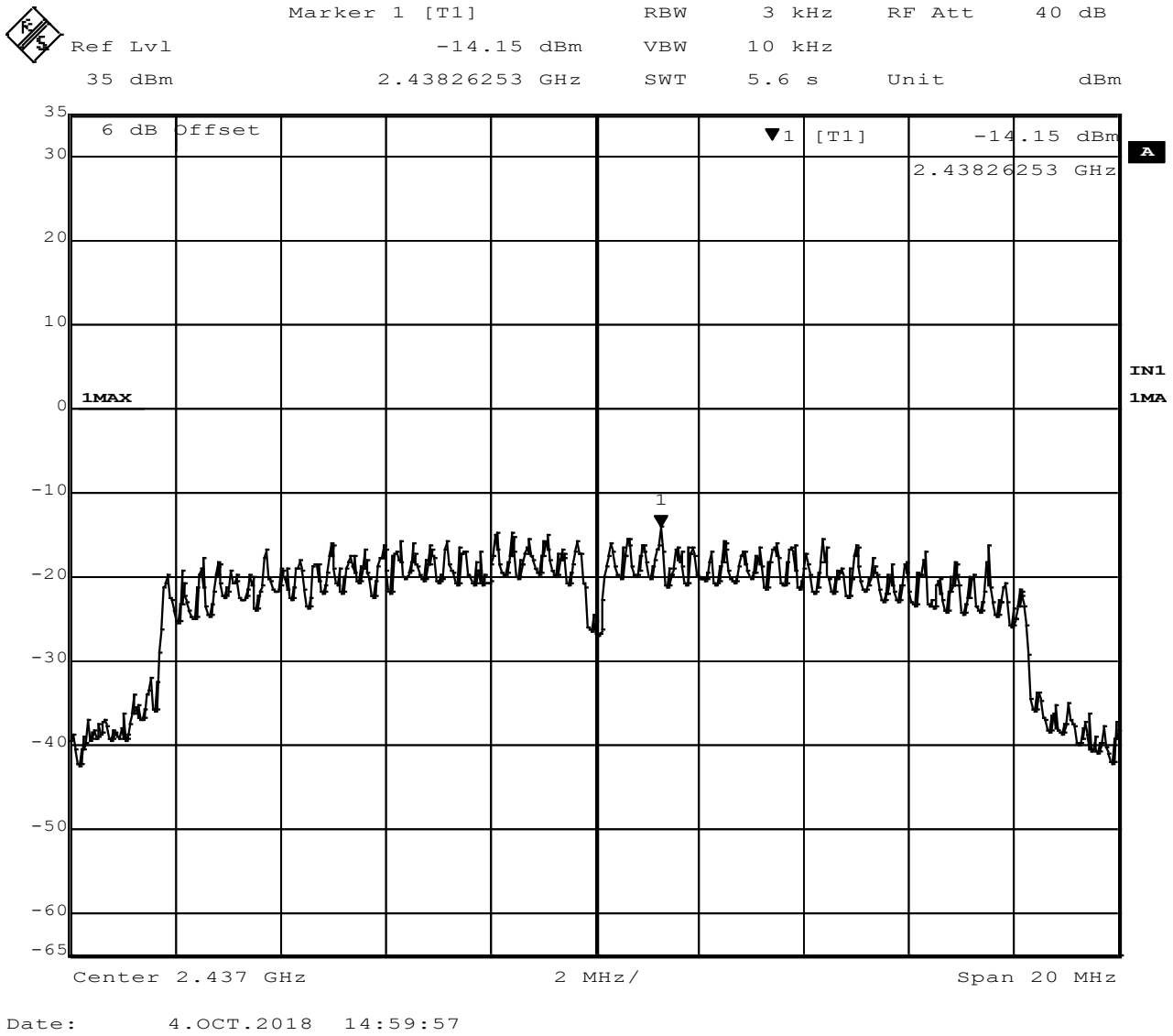



Figure 37 - Power Spectral Density, High Channel, 802.11b



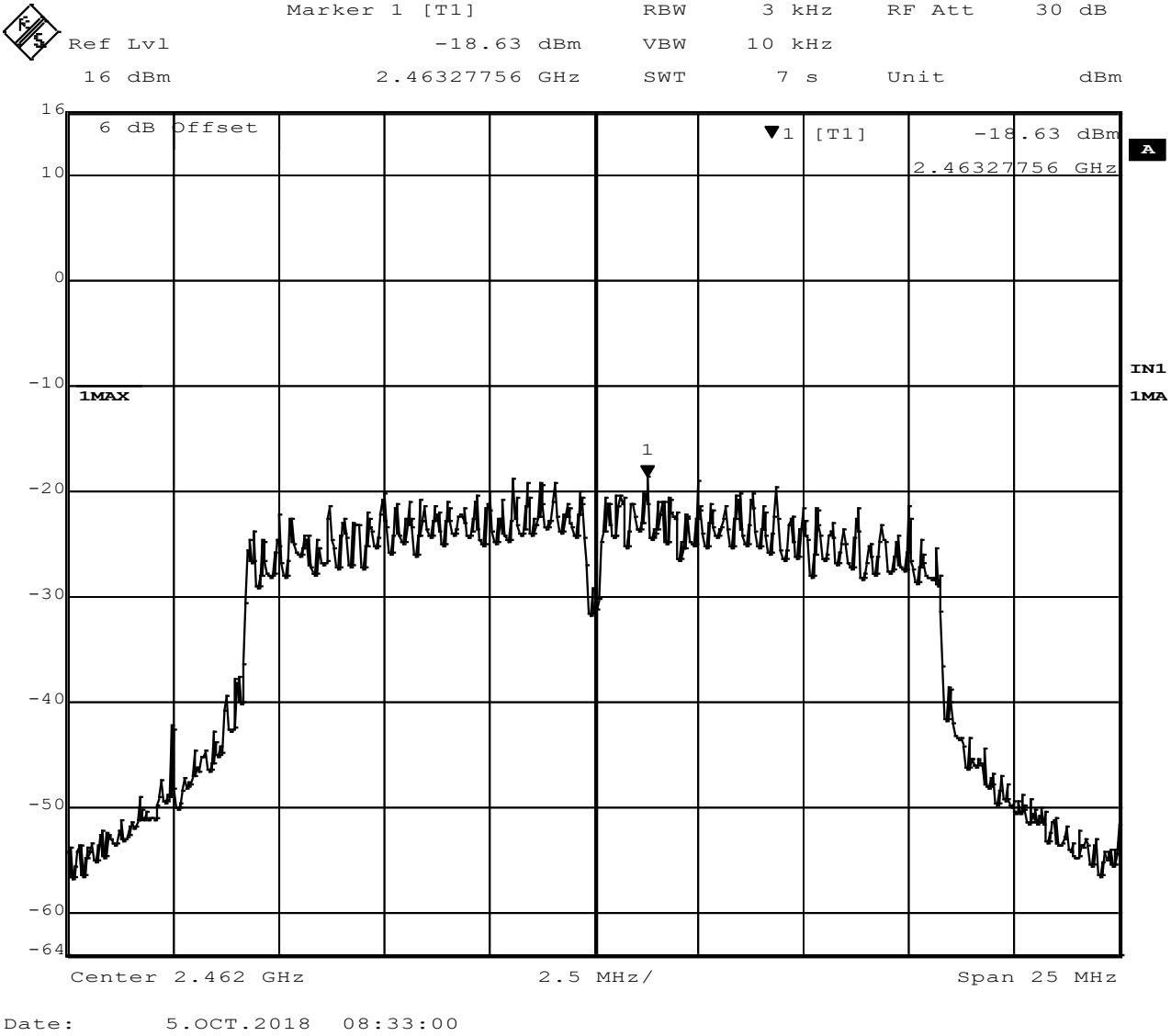

Date: 5.OCT.2018 08:52:08

**Figure 38 - Power Spectral Density, Low Channel, 802.11g**




Date: 4.OCT.2018 14:59:57

**Figure 39 - Power Spectral Density, Mid Channel, 802.11g**




Date: 5.OCT.2018 08:33:00

**Figure 40 - Power Spectral Density, High Channel, 802.11g**

# 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 dB |
| Radiated Emissions, 3m | 1GHz - 18GHz | ±4.44 dB |
| Emissions limits, conducted | 30MHz – 18GHz | ±3.30 dB |
| Antenna port conducted | 9 kHz – 25 GHz | ±0.50 dB |

Values were calculated per CISPR 16-4-2:2011

Expanded uncertainty values are calculated to a confidence level of 95%.

# REPORT END