HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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# TEST REPORT

**ACCORDING TO:**

**FCC 47 CFR part 15 subpart C (DTS) and B;**

**RSS-247 (DTS) Issue 2 and ICES-003 Issue 6**

**FOR:**

## AeroScout Ltd.

## Wireless sensor tag

## Model: T15e

## FCC ID:Q3HTAG15E

## IC: 5115A-TAG15E

# Table of contents

# 1 Applicant information

| | |
|---|---|
| **Client name:** | AeroScout Ltd. |
| **Address:** | 2 Ilan Ramon St. ,Science Park, Ness-Ziona, 7403635, Israel |
| **Telephone:** | +972-8-936-9393 |
| **Fax:** | +972-8-936-5977 |
| **E-mail:** | reuven.amsalem@sbdinc.com |
| **Contact name:** | Mr. Reuven Amsalem |

# 2 Equipment under test attributes

| | |
|---|---|
| **Product name:** | Wireless sensor tag |
| **Product type:** | Transceiver |
| **Model(s):** | T15e |
| **Serial number:** | 150253 |
| **Hardware version:** | 3.02 |
| **Software release:** | 2.1.14 |
| **Receipt date** | 20-Jan-19 |

# 3 Manufacturer information

| | |
|---|---|
| **Manufacturer name:** | AeroScout Ltd. |
| **Address:** | 2 Ilan Ramon St. ,Science Park, Ness-Ziona, 7403635, Israel |
| **Telephone:** | +972-8-936-9393 |
| **Fax:** | +972-8-936-5977 |
| **E-Mail:** | Eli.Aharon@sbdinc.com |
| **Contact name:** | Mr. Eli Aharon |

# 4 Test details

| | |
|---|---|
| **Project ID:** | 32144 |
| **Location:** | Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel |
| **Test started:** | 17-Feb-19 |
| **Test completed:** | 23-May-19 |
| **Test specification(s):** | FCC 47 CFR part 15 subpart C and B; RSS-210 and ICES-003 |

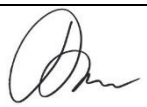
# 5 Tests summary

| Test | Status |
|---|---|
| **Transmitter characteristics** | |
| FCC section 15.247(a)(2), RSS-247 section 5.2(a), 6 dB bandwidth | Pass |
| FCC section 15.247(b)3, RSS-247 section 5.4(d) ,Peak output power | Pass |
| FCC section 15.247(b)5, RSS-102 section 2.5.1, RF exposure | Pass* |
| FCC section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions | Pass |
| FCC section 15.247(d), RSS-247 section 5.5, Band edge emissions | Pass |
| FCC section 15.247(e), RSS-247 5.2(b), Peak power density | Pass |
| FCC section 15.203, RSS-Gen section 8.3, Antenna requirement | Pass |
| FCC section 15.207(a), RSS-Gen section 8.2, Conducted emission | Not required |
| **Unintentional emissions** | |
| FCC section 15.107, RSS-Gen section 8.8, Conducted emission at AC power port, Class B | Not required |
| FCC section 15.109, RSS-Gen section 7.1.2, Radiated emission, Class B | Pass |

* - The exhibit to the application of certification is provided.

This test report supersedes the previously issued test report identified by Doc ID: AERRAD_FCC.32144_WiFi

Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.
The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

| | Name and Title | Date | Signature |
|---|---|---|---|
| **Tested by:** | Mr. A. Morozov, test engineer | 17-Feb-19 – 23-May-19 |  |
| | Mr. S. Samokha, test engineer | |  |
| **Reviewed by:** | Mrs. Y. Rapin, technical writer | 12-June-19 |  |
| **Approved by:** | Mr. K. Zushchyk, project and customer manager, EMC and radio group | 14-Jun-19 |  |

# 6 EUT description

Note: The following data in this clause is provided by the customer and represents his sole responsibility

## 6.1 General information

The tag, model T15e, is a platform for environmental monitoring, which can take measurements of internal sensors of humidity and ambient temperature or external sensors via 3 or less USB type C connectors located at the bottom of the device.

The tag has also data logging capabilities, optional display, up to 4 pushbuttons and wireless connectivity features (802.11b/g/n WIFI and BLE 5.0).

There are dedicated printed antennas on board, one for BLE and one for WIFI. External antennas are not supported for both RFs.

It can be powered by a standard 5V USB wall adapter connected to one of the USB connectors OR by non-rechargeable, replaceable AA alkaline batteries (2 in series).

When external power is connected, the batteries are for backup (not powering the device) which automatically engaged when the external power is disconnected.

The tag also supports an external temperature probe (RTD), contact sensor, voltage sensor (up-to 24V) and a current sensor (4-20mA) which either can be connected to any of the 3 USB connectors.

The cables length for the temperature probe and the contact sensor is up-to 15M, typically 3M and for the 2 other sensors is 3M.

## 6.2 Ports and lines

| Port type | Port description | Conn. from | Conn. to | Qty. | Cable type | Cable length, m | Indoor / outdoor |
|---|---|---|---|---|---|---|---|
| Signal | Signal | EUT | RTD probe (temperature) | 1 | Unshielded | 3-15 m | Indoor |
| Signal | Signal | EUT | Sensors (open/close contact) | 2 | Unshielded | 3-15 m | Indoor |
| Signal | Signal | EUT | Sensors (voltage measure,current measure) | 2 | Unshielded | 3 m | Indoor |
| Power | DC | EUT | Power supply | 1 | Unshielded | 2.5 m | Indoor |

## 6.3 Support and test equipment

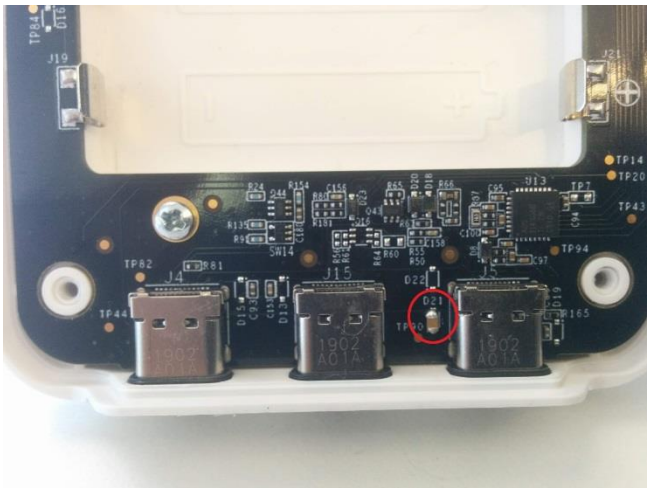
| Description | Manufacturer | Model number | Serial number |
|---|---|---|---|
| PC | Lenovo | T420 | NA |
| Gateway | Aeroscout | GW3100 | MAC: 662055 |
| Smartphone | IPhone | NA | NA |

## 6.4 Operating frequencies

| Source | Frequency, MHz | | | | | |
|---|---|---|---|---|---|---|
| Clock | 40 | - | - | - | - | - |
| Clock | 32 | - | - | - | - | - |
| Tx Rx Bluetooth | 2402-2480 | - | - | - | - | - |
| Tx Rx Wi-Fi | 2412-2462 | - | - | - | - | - |

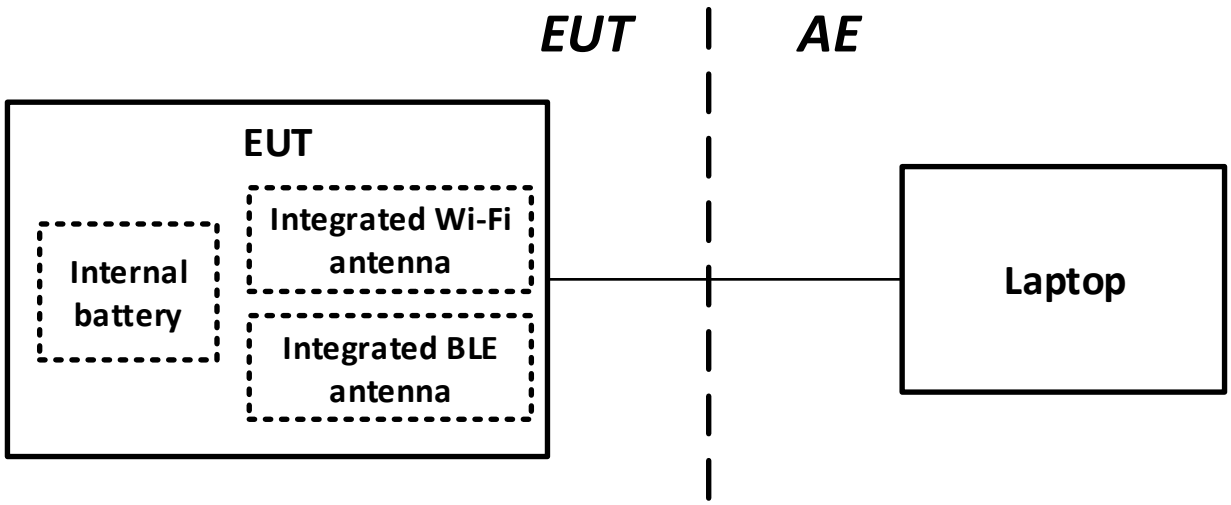
## 6.5 Changes made in EUT

Capacitor 1nF 0805 MLCC was added to the temperature probe input (on an unused location of D21).



It is manufacturer's responsibility to implement the change in the production version of the EUT. In any case the test report applies to the tested item only.

## 6.6 Test configuration



## 6.7 Transmitter characteristics

| **Type of equipment** | |
|---|---|
| **V** | Stand-alone (Equipment with or without its own control provisions) |
| | Combined equipment (Equipment where the radio part is fully integrated within another type of equipment) |
| | Plug-in card (Equipment intended for a variety of host systems) |

| **Intended use** | | **Condition of use** |
|---|---|---|
| | fixed | Always at a distance more than 2 m from all people |
| **V** | mobile | Always at a distance more than 20 cm from all people |
| | portable | May operate at a distance closer than 20 cm to human body |

| | |
|---|---|
| **Assigned frequency range** | 2400.0 – 2483.5 MHz |
| **Operating frequency range** | 2412.0 – 2462.0 MHz |
| **RF channel spacing** | 5 MHz |

| | | |
|---|---|---|
| **Maximum rated output power** | At transmitter 50 Ω RF output connector (aggregate power of both RF chains) | NA |
| | EIRP density dBm / MHz (aggregate power of both RF chains) with maximum declared antenna gain | NA |

| | | | | |
|---|---|---|---|---|
| **Is transmitter output power variable?** | | No | | |
| | **V** | Yes | | continuous variable |
| | | | **V** | stepped variable with stepsize: 1.0 dB |
| | | | | minimum RF power: 0 dBm |
| | | | | maximum RF power: 13.39 dBm |

| **Antenna connection** | | | |
|---|---|---|---|
| unique coupling | standard connector | **V** Integral | with temporary RF connector |
| | | | **V** without temporary RF connector |

| **Antenna/s technical characteristics** | | | |
|---|---|---|---|
| Type | Manufacturer | Model number | Gain |
| Printed | N/A | N/A | 5.3 dB |

| Transmitter aggregate data rate/s, Mbps | | | | | |
|---|---|---|---|---|---|
| Transmitter 99% power bandwidth | WiFi standard | Type of modulation | | | |
| | | BPSK | QPSK | 16QAM | 64QAM |
| 20 MHz | 802.11 b | 1 Mbps | 2, 5.5, 11 Mbps | NA | NA |
| | 802.11 g | 1 Mbps | 6, 9, 12, 18 Mbps | 24, 36 Mbps | 48, 54 Mbps |

| | |
|---|---|
| Type of multiplexing | DSSS / OFDM |
| Modulating test signal (baseband) | PRBS |
| Maximum transmitter duty cycle in normal use | 1 % |

| Transmitter power source | | | |
|---|---|---|---|
| V | DC | Nominal rated voltage | 5 VDC |
| V | DC | Nominal rated voltage | 3V by 2 x 1.5V AA alkaline batteries connected in series |

| | | | |
|---|---|---|---|
| Common power source for transmitter and receiver | V | yes | no |

| Test specification: | FCC 47 CFR 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 section 11.8.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 17-Feb-19 - 21-May-19 | | |
| Temperature: 25 ºC | Relative Humidity: 44 % | Air Pressure: 1016 hPa | Power: 3 VDC |
| Remarks: | | | |

# 7 Transmitter tests according to FCC 47CFR part 15 subpart C and RSS-247

## 7.1 Minimum 6 dB bandwidth

### 7.1.1 General

This test was performed to measure 6 dB bandwidth of the EUT carrier frequency. Specification test limits are given in Table 7.1.1.

**Table 7.1.1 The 6 dB bandwidth limits**

| Assigned frequency, MHz | Modulation envelope reference points*, dBc | Minimum bandwidth, kHz |
|---|---|---|
| 902.0 – 928.0 | **6.0** | **500.0** |
| **2400.0 – 2483.5** | | |
| 5725.0 – 5850.0 | | |

* - Modulation envelope reference points provided in terms of attenuation below the peak of modulated carrier.

### 7.1.2 Test procedure

**7.1.2.1** The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

**7.1.2.2** The EUT was set to transmit modulated carrier.

**7.1.2.3** The transmitter minimum 6 dB bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided inTable 7.1.2 and associated plot.

**Figure 7.1.1 The 6 dB bandwidth test setup**

| **Test specification:** | **FCC 47 CFR 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10 section 11.8.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 17-Feb-19 - 21-May-19 | | |
| **Temperature:** 25 ºC | **Relative Humidity:** 44 % | **Air Pressure:** 1016 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.1.2 6 dB bandwidth test results**

ASSIGNED FREQUENCY BAND: 2400.0 -2483.5 MHz
DETECTOR USED: Peak
SWEEP MODE: Max hold
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: >RBW
MODULATION ENVELOPE REFERENCE POINTS: 6.0 dBc
MODULATING SIGNAL: PRBS

| Carrier frequency, MHz | 6 dB bandwidth, kHz | Limit, kHz | Margin, kHz* | Verdict |
|---|---|---|---|---|
| **Modulation CCK Bitrate 1 Mbps** | | | | |
| 2412.0 | 9108.0 | 500.0 | -8608 | Pass |
| 2437.0 | 9110.0 | 500.0 | -8610 | Pass |
| 2462.0 | 9278.0 | 500.0 | -8778 | Pass |
| **Modulation 64 QAM Bitrate 54 Mbps** | | | | |
| 2412.0 | 16493.0 | 500.0 | -15993 | Pass |
| 2437.0 | 16446.0 | 500.0 | -15946 | Pass |
| 2462.0 | 16564.0 | 500.0 | -16064 | Pass |

* - Margin = Specification limit – Measured Bandwidth

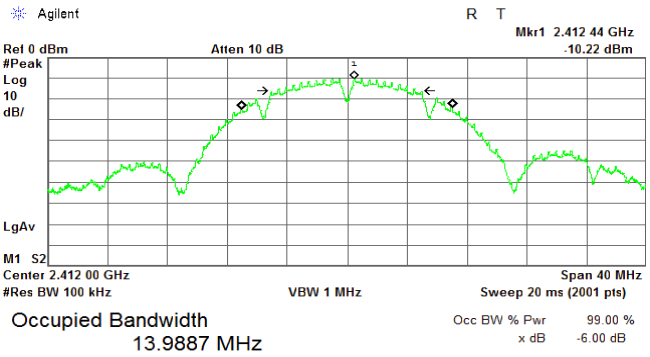
**Reference numbers of test equipment used**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| HL 3818 | HL 4135 | | | | | | | |

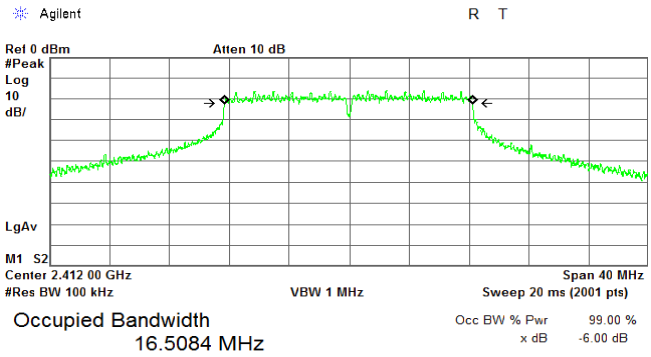
Full description is given in Appendix A.

| Test specification: | FCC 47 CFR 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 section 11.8.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 17-Feb-19 - 21-May-19 | | |
| Temperature: 25 ºC | Relative Humidity: 44 % | Air Pressure: 1016 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.1.1 The 6 dB bandwidth test result at low frequency**

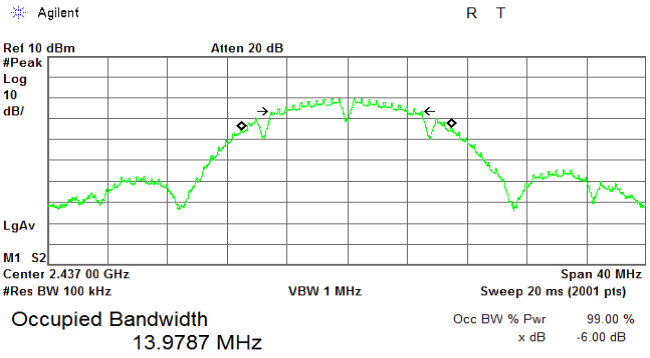



1 Mbps

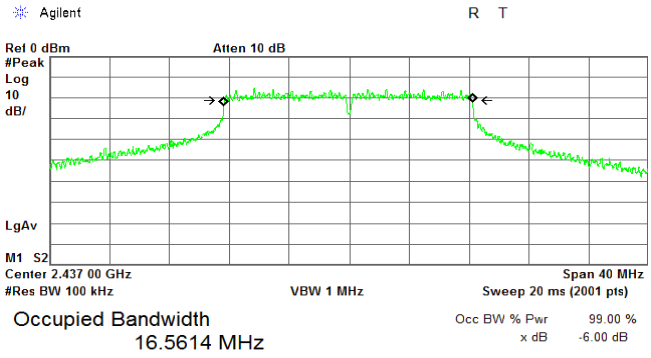



54 Mbps

**Plot 7.1.2 The 6 dB bandwidth test result at mid frequency**

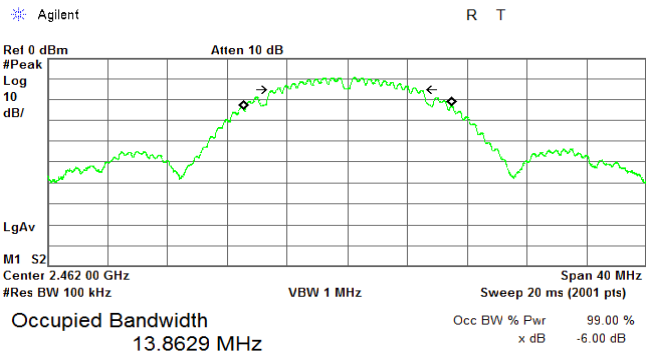



1 Mbps

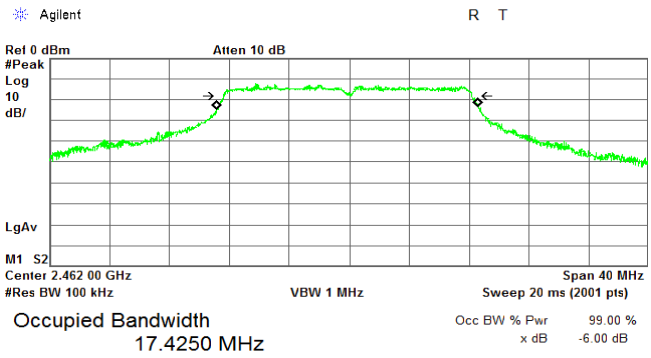



54 Mbps

**Plot 7.1.3 The 6 dB bandwidth test result at high frequency**




1 Mbps




54 Mbps

| **Test specification:** | **FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10-2013, section 11.9 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

## 7.2 Peak output power

### 7.2.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.2.1.

**Table 7.2.1 Peak output power limits**

| Assigned frequency range, MHz | Maximum antenna gain, dBi | Peak output power* | | Equivalent field strength limit @ 3m, dB(μV/m)** |
|---|---|---|---|---|
| | | W | dBm | |
| 902.0 – 928.0 | 6.0 | 1.0 | 30.0 | 131.2 |
| **2400.0 – 2483.5** | | | | |
| 5725.0 – 5850.0 | | | | |

*- The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;

without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;

by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

**- Equivalent field strength limit was calculated from the peak output power as follows: E=sqrt(30×P×G)/r, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

### 7.2.2 Test procedure

**7.2.2.1** The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

**7.2.2.2** The EUT was adjusted to produce maximum available to end user RF output power.

**7.2.2.3** The resolution bandwidth of spectrum analyzer was set wider than 6 dB bandwidth of the EUT and the field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated $360^0$ and the measuring antenna height was swept in both vertical and horizontal polarizations.

**7.2.2.4** The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.2.2 and associated plots.

**7.2.2.5** The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

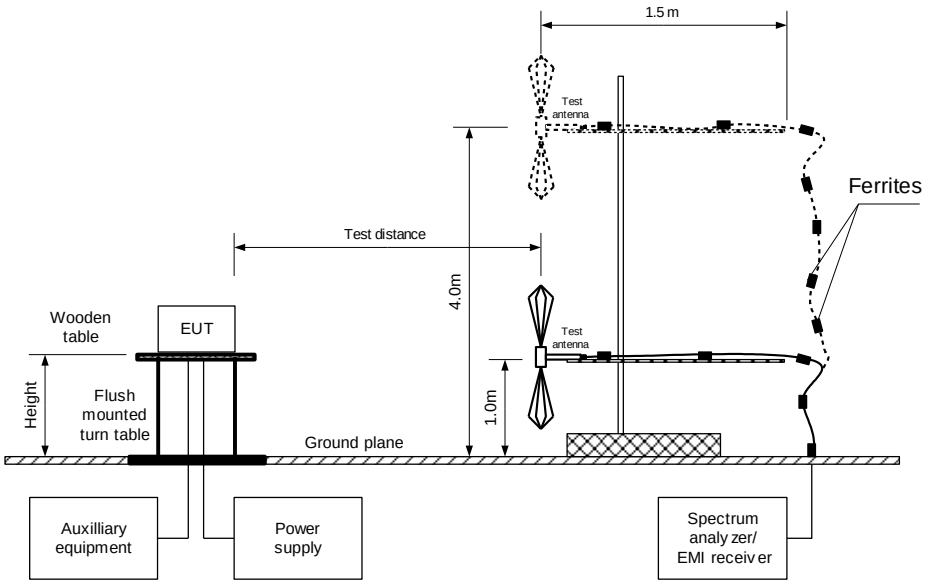
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB

**7.2.2.6** The worst test results (the lowest margins) were recorded in Table 7.2.2.

| Test specification: | FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10-2013, section 11.9 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Figure 7.2.1 Setup for carrier field strength measurements**



| **Test specification:** | **FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10-2013, section 11.9 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.2.2 Peak output power test results**

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
EUT HEIGHT: 1.5 m
DETECTOR USED: Peak
TEST ANTENNA TYPE: Double ridged guide (above 1000 MHz)
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1 MHz
VIDEO BANDWIDTH: 3 MHz

MODULATION: BPSK
BIT RATE: 1 Mbps

| Frequency, MHz | Field strength, dB(μV/m) | Antenna polarization | Antenna height, m | Azimuth, degrees* | EUT antenna gain, dBi | Peak output power, dBm** | Limit, dBm | Margin, dB*** | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| 2412.0 | 113.25 | Horizontal | 1.5 | 147 | 5.3 | 12.75 | 30.0 | -17.25 | Pass |
| 2437.0 | 112.53 | Horizontal | 1.5 | 152 | 5.3 | 12.03 | 30.0 | -17.97 | Pass |
| 2462.0 | 112.02 | Horizontal | 1.5 | 140 | 5.3 | 11.52 | 30.0 | -18.48 | Pass |

MODULATION: 64QAM
BIT RATE: 54 Mbps

| Frequency, MHz | Field strength, dB(μV/m) | Antenna polarization | Antenna height, m | Azimuth, degrees* | EUT antenna gain, dBi | Peak output power, dBm** | Limit, dBm | Margin, dB*** | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| 2412.0 | 113.89 | Horizontal | 1.5 | 147 | 5.3 | 13.39 | 30.0 | -16.61 | Pass |
| 2437.0 | 112.92 | Horizontal | 1.5 | 152 | 5.3 | 12.42 | 30.0 | -17.58 | Pass |
| 2462.0 | 112.21 | Horizontal | 1.5 | 140 | 5.3 | 11.71 | 30.0 | -18.29 | Pass |

*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance:
*Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB*
***- Margin = Peak output power – specification limit.

**Reference numbers of test equipment used**

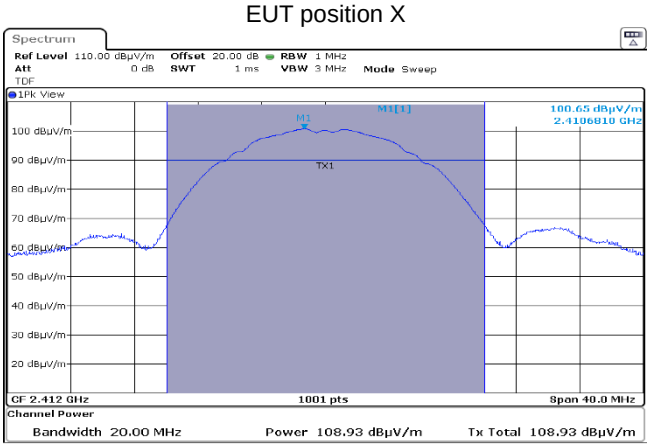
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL 3903 | HL 4360 | HL 4933 | HL 5405 | | | | |

Full description is given in Appendix A.

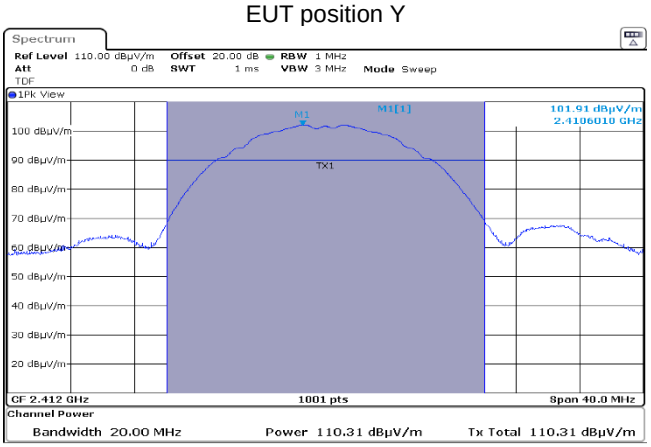
| Test specification: | FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10-2013, section 11.9 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.2.1 Field strength of carrier at low frequency with BPSK 1 Mbps**

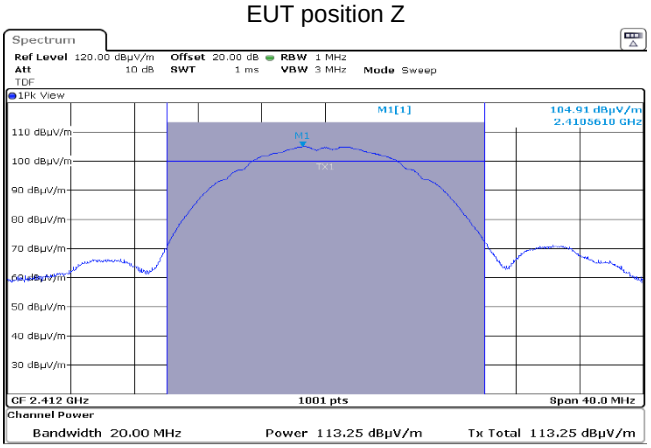
EUT position X




EUT position Y



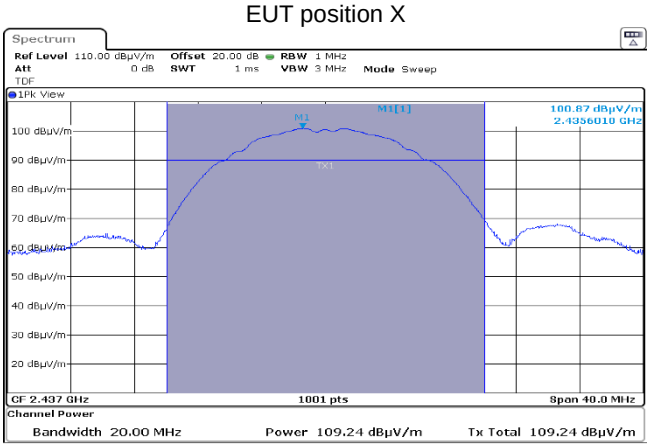

EUT position Z



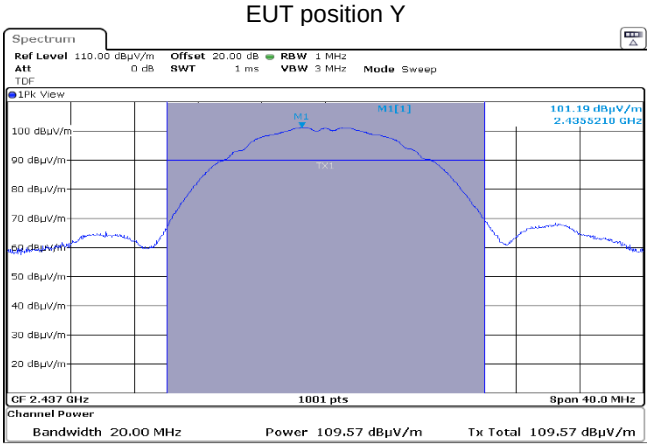
| Test specification: | FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10-2013, section 11.9 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.2.2 Field strength of carrier at mid frequency with BPSK 1 Mbps**

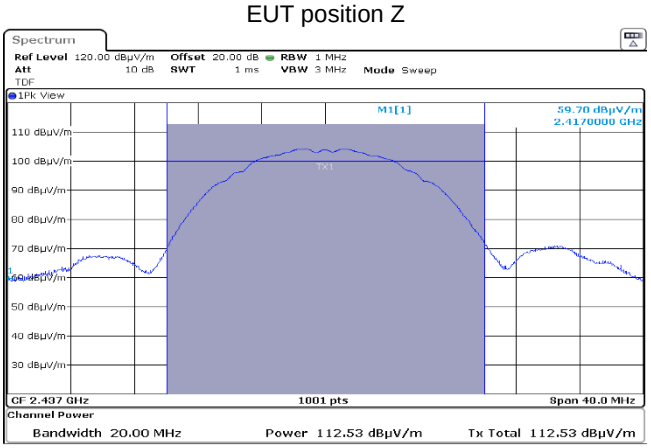
EUT position X




EUT position Y



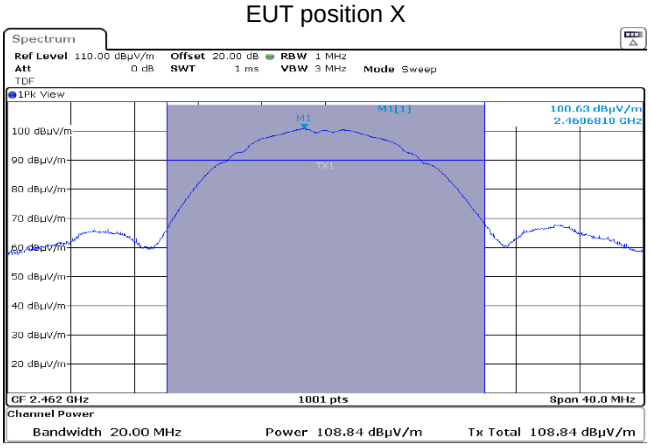

EUT position Z



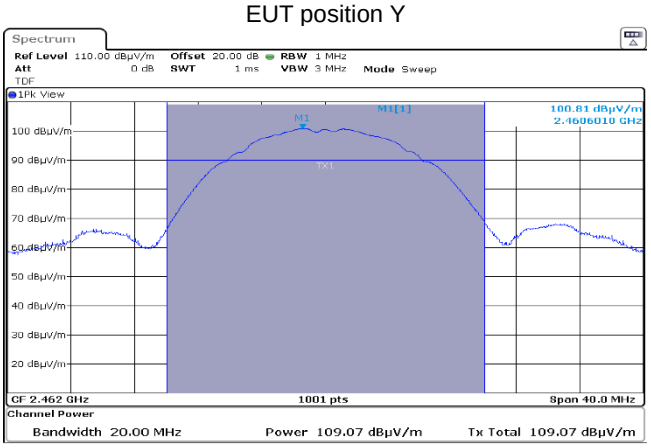
| Test specification: | FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10-2013, section 11.9 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.2.3 Field strength of carrier at high frequency with BPSK 1 Mbps**

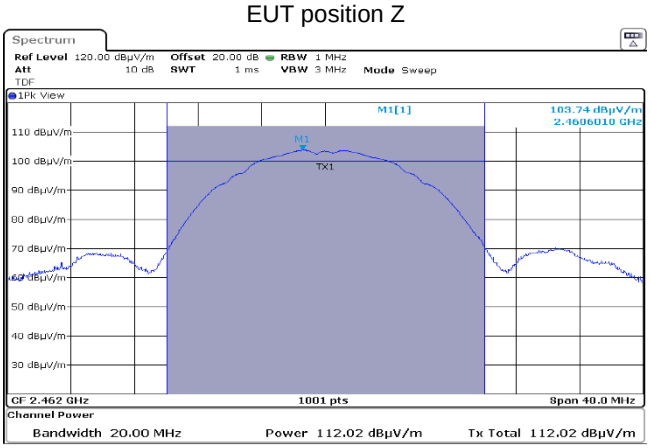
EUT position X




EUT position Y



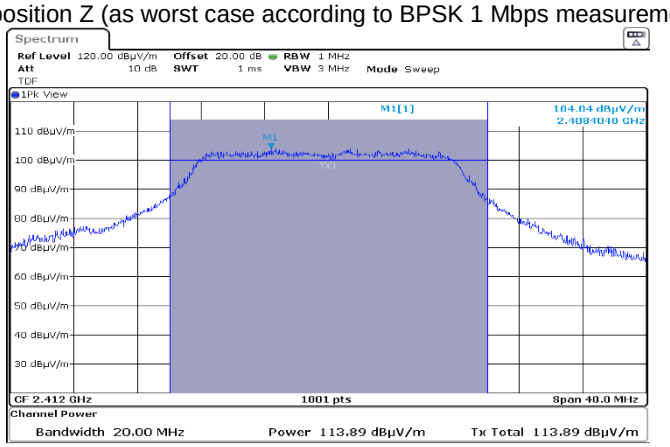

EUT position Z



| Test specification: | FCC 47 CFR 15.247(b)3 / RSS-247 section 5.4(4), Peak output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10-2013, section 11.9 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

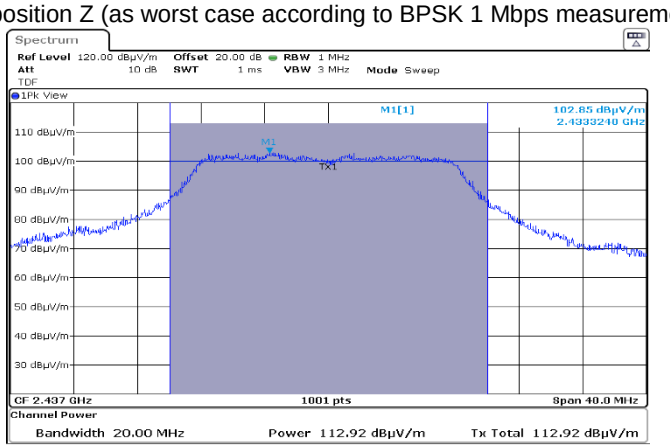
**Plot 7.2.4 Field strength of carrier at low frequency with 64QAM 54 Mbps**

EUT position Z (as worst case according to BPSK 1 Mbps measurements)



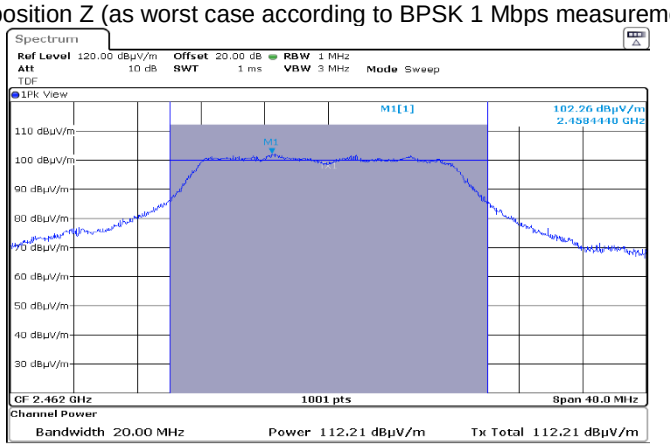

**Plot 7.2.5 Field strength of carrier at mid frequency with 64QAM 54 Mbps**

EUT position Z (as worst case according to BPSK 1 Mbps measurements)




**Plot 7.2.6 Field strength of carrier at high frequency with 64QAM 54 Mbps**

EUT position Z (as worst case according to BPSK 1 Mbps measurements)



| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

## 7.3 Field strength of spurious emissions

### 7.3.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.3.1.

**Table 7.3.1 Radiated spurious emissions limits**

| Frequency, MHz | Field strength at 3 m within restricted bands, dB(μV/m)* | | | Attenuation of field strength of spurious versus carrier outside restricted bands, dBc*** |
|---|---|---|---|---|
| | Peak | Quasi Peak | Average | |
| 0.009 – 0.090 | 148.5 – 128.5 | NA | 128.5 – 108.5** | 20.0 |
| 0.090 – 0.110 | NA | 108.5 – 106.8** | NA | |
| 0.110 – 0.490 | 126.8 – 113.8 | NA | 106.8 – 93.8** | |
| 0.490 – 1.705 | NA | 73.8 – 63.0** | NA | |
| 1.705 – 30.0* | | 69.5 | | |
| 30 – 88 | | 40.0 | | |
| 88 – 216 | | 43.5 | | |
| 216 – 960 | | 46.0 | | |
| 960 - 1000 | | 54.0 | | |
| 1000 – 10th harmonic | 74.0 | NA | 54.0 | |

*- The limit for 3 m test distance was calculated using the inverse square distance extrapolation factor as follows:

$$Lim_{S2} = Lim_{S1} + 40 \log (S_1/S_2),$$

where $S_1$ and $S_2$ – standard defined and test distance respectively in meters.

**- The limit decreases linearly with the logarithm of frequency.

*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the $10^{th}$ harmonic of the highest fundamental frequency.

### 7.3.2 Test procedure for spurious emission field strength measurements in 9 kHz to 30 MHz band

**7.3.2.1** The EUT was set up as shown in Figure 7.3.1, energized and the performance check was conducted.

**7.3.2.2** The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated $360^0$ and the measuring antenna was rotated around its vertical axis.

**7.3.2.3** The worst test results (the lowest margins) were recorded and shown in the associated plots.

### 7.3.3 Test procedure for spurious emission field strength measurements above 30 MHz

**7.3.3.1** The EUT was set up as shown in Figure 7.3.2 / Figure 7.3.3, energized and the performance check was conducted.

**7.3.3.2** The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated $360^0$, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

**7.3.3.3** The worst test results (the lowest margins) were recorded and shown in the associated plots.

| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Figure 7.3.1 Setup for spurious emission field strength measurements below 30 MHz**

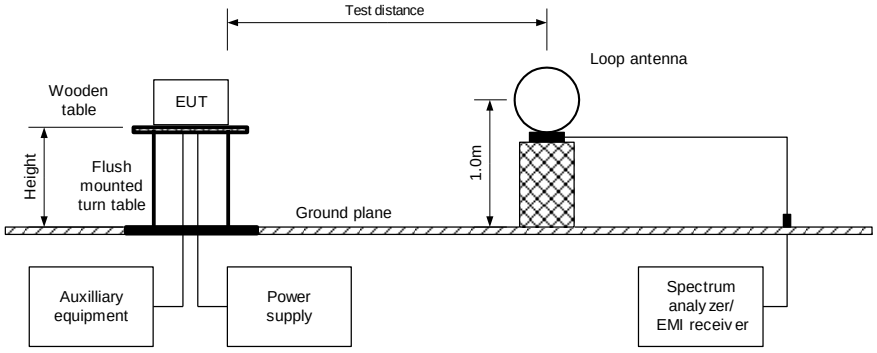



**Figure 7.3.2 Setup for spurious emission field strength measurements in 30 -1000 MHz**

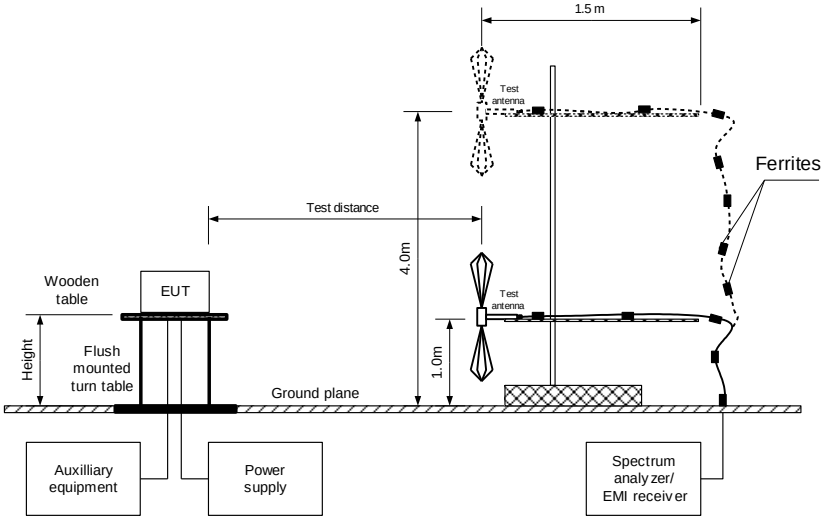
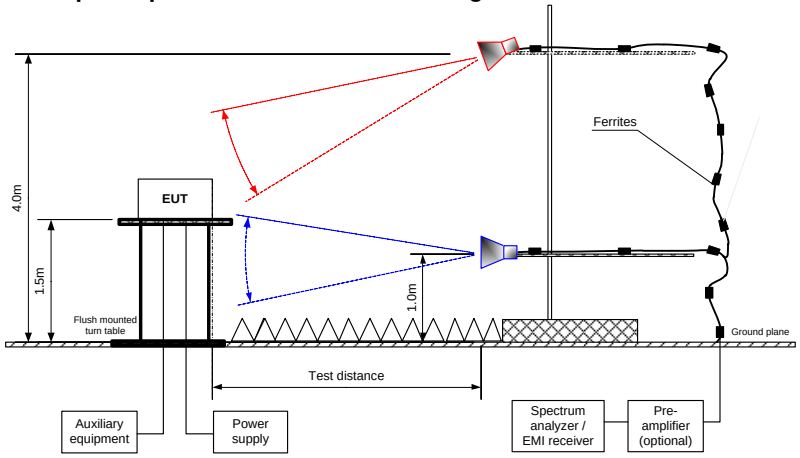



**Figure 7.3.3 Setup for spurious emission field strength measurements above1000 MHz**



| **Test specification:** | **FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.3.2 Field strength of emissions outside restricted bands**

| | |
|---|---|
| ASSIGNED FREQUENCY: | 2400.0 – 2483.5 MHz |
| INVESTIGATED FREQUENCY RANGE: | 0.009 - 25000 MHz |
| TEST DISTANCE: | 3 m |
| MODULATION: | BPSK |
| MODULATING SIGNAL: | PRBS |
| BIT RATE: | 1 Mbps |
| DUTY CYCLE: | 100 % |
| TRANSMITTER OUTPUT POWER SETTINGS: | Maximum |
| DETECTOR USED: | Peak |
| RESOLUTION BANDWIDTH: | 100 kHz |
| VIDEO BANDWIDTH: | 300 kHz |
| TEST ANTENNA TYPE: | Active loop (9 kHz – 30 MHz)<br>Biconilog (30 MHz – 1000 MHz)<br>Double ridged guide (above 1000 MHz) |

| Frequency, MHz | Field strength of spurious, dB(µV/m) | Antenna polarization | Antenna height, m | Azimuth, degrees* | Field strength of carrier, dB(µV/m) | Attenuation below carrier, dBc | Limit, dBc | Margin, dB** | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| **Low carrier frequency** | | | | | | | | | |
| 2400.000 | 67.23 | Horizontal | 1.56 | 56 | 100.33 | 33.10 | 20.0 | 13.10 | Pass |
| 2562.537 | 56.95 | Horizontal | 1.53 | 8 | | 43.38 | | 23.38 | |
| 6432.000 | 49.00 | Horizontal | 2.3 | 13.00 | | 51.33 | | 31.33 | |
| 7236.800 | 50.50 | Horizontal | 2.3 | 347.00 | | 49.83 | | 29.83 | |
| 12863.600 | 50.69 | Horizontal | 1.3 | 270.00 | | 49.64 | | 29.64 | |
| **Mid carrier frequency** | | | | | | | | | |
| 2527.762 | 58.09 | Horizontal | 1.61 | 201 | 99.62 | 41.53 | 20.0 | 21.53 | Pass |
| 2594.909 | 54.76 | Horizontal | 1.79 | 8 | | 44.86 | | 24.86 | |
| 3249.500 | 42.01 | Vertical | 1.8 | 190.00 | | 57.61 | | 37.61 | |
| 6498.500 | 48.75 | Horizontal | 2.1 | 360.00 | | 50.87 | | 30.87 | |
| 12979.500 | 48.99 | Horizontal | 2.3 | 284.00 | | 50.63 | | 30.63 | |
| **High carrier frequency** | | | | | | | | | |
| 6565.000 | 49.11 | Horizontal | 2.1 | 360.00 | 99.21 | 50.10 | 20.0 | 30.10 | Pass |
| 13130.500 | 49.46 | Horizontal | 2.3 | 302.00 | | 49.75 | | 29.75 | |

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Attenuation below carrier – specification limit.

| **Test specification:** | **FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.3.3 Field strength of spurious emissions above 1 GHz within restricted bands**

| | |
|---|---|
| ASSIGNED FREQUENCY: | 2400.0 – 2483.5 MHz |
| INVESTIGATED FREQUENCY RANGE: | 1000 - 25000 MHz |
| TEST DISTANCE: | 3 m |
| MODULATION: | GFSK |
| MODULATING SIGNAL: | PRBS |
| BIT RATE: | 2 Mbps |
| DUTY CYCLE: | 100 % |
| TRANSMITTER OUTPUT POWER SETTINGS: | Maximum |
| DETECTOR USED: | Peak |
| RESOLUTION BANDWIDTH: | 1000 kHz |
| TEST ANTENNA TYPE: | Double ridged guide |

| Frequency, MHz | Antenna | | Azimuth, degrees* | Peak field strength(VBW=3 MHz) | | | Average field strength(VBW=10 Hz) | | | Verdict |
|---|---|---|---|---|---|---|---|---|---|---|
| | Polarization | Height, m | | Measured, dB(μV/m) | Limit, dB(μV/m) | Margin, dB** | Measured, dB(μV/m) | Limit, dB(μV/m) | Margin, dB** | |
| **Low carrier frequency** | | | | | | | | | | |
| 2263.947 | Horizontal | 1.53 | 337 | 56.90 | 74.0 | -17.10 | 46.60 | 54.00 | -7.40 | Pass |
| 2325.593 | Horizontal | 1.53 | 204 | 56.21 | 74.0 | -17.79 | 46.55 | 54.00 | -7.45 | |
| 2499.042 | Horizontal | 1.53 | 331 | 57.59 | 74.0 | -16.41 | 46.05 | 54.00 | -7.95 | |
| 4019.200 | Vertical | 1.6 | 14.00 | 51.92 | 74.0 | -22.08 | 45.67 | 54.00 | -8.33 | |
| 4823.867 | Horizontal | 1.6 | 41.00 | 54.32 | 74.0 | -19.68 | 50.42 | 54.00 | -3.58 | |
| **Mid carrier frequency** | | | | | | | | | | |
| 2278.987 | Horizontal | 1.00 | 0 | 57.35 | 74.0 | -16.65 | 45.96 | 54.00 | -8.04 | Pass |
| 2345.967 | Horizontal | 1.00 | 199 | 58.72 | 74.0 | -15.28 | 47.03 | 54.00 | -6.97 | |
| 2498.500 | Horizontal | 1.61 | 204 | 54.68 | 74.0 | -19.32 | 43.40 | 54.00 | -10.60 | |
| 4061.000 | Vertical | 1.8 | 229.00 | 53.29 | 74.0 | -20.71 | 47.81 | 54.00 | -6.19 | |
| 4874.000 | Horizontal | 2.1 | 45.00 | 56.64 | 74.0 | -17.36 | 52.98 | 54.00 | -1.02 | |
| 7311.500 | Horizontal | 2.3 | 344.00 | 49.30 | 74.0 | -24.70 | 37.76 | 54.00 | -16.24 | |
| **High carrier frequency** | | | | | | | | | | |
| 2315.413 | Horizontal | 2.14 | 209 | 56.33 | 74.0 | -17.67 | 46.23 | 54.00 | -7.77 | Pass |
| 2371.253 | Horizontal | 2.14 | 203 | 58.35 | 74.0 | -15.65 | 47.08 | 54.00 | -6.92 | |
| 2487.500 | Horizontal | 1.79 | 338 | 56.19 | 74.0 | -17.81 | 43.15 | 54.00 | -10.85 | |
| 3282.500 | Vertical | 2.6 | 234.00 | 42.55 | 74.0 | -31.45 | 32.88 | 54.00 | -21.12 | |
| 4104.000 | Vertical | 2.6 | 242.00 | 52.86 | 74.0 | -21.14 | 46.71 | 54.00 | -7.29 | |
| 4924.000 | Horizontal | 2.1 | 55.00 | 56.44 | 74.0 | -17.56 | 52.93 | 54.00 | -1.07 | |

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Measured field strength - specification limit.

| **Test specification:** | **FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.3.4 Field strength of spurious emissions below 1 GHz within restricted bands**

| | |
|---|---|
| ASSIGNED FREQUENCY: | 2400.0 – 2483.5 MHz |
| INVESTIGATED FREQUENCY RANGE: | 0.009 – 1000 MHz |
| TEST DISTANCE: | 3 m |
| MODULATION: | BPSK |
| MODULATING SIGNAL: | PRBS |
| BIT RATE: | 1 Mbps |
| DUTY CYCLE: | 100 % |
| TRANSMITTER OUTPUT POWER SETTINGS: | Maximum |
| RESOLUTION BANDWIDTH: | 0.2 kHz (9 kHz – 150 kHz)<br>9.0 kHz (150 kHz – 30 MHz)<br>120 kHz (30 MHz – 1000 MHz) |
| VIDEO BANDWIDTH: | > Resolution bandwidth |
| TEST ANTENNA TYPE: | Active loop (9 kHz – 30 MHz)<br>Biconilog (30 MHz – 1000 MHz) |

| **Frequency, MHz** | **Peak emission, dB(μV/m)** | **Quasi-peak** | | | **Antenna polarization** | **Antenna height, m** | **Turn-table position**, degrees** | **Verdict** |
|---|---|---|---|---|---|---|---|---|
| | | **Measured emission, dB(μV/m)** | **Limit, dB(μV/m)** | **Margin, dB*** | | | | |
| **Low carrier frequency** | | | | | | | | |
| No emission were found | | | | | | | | Pass |
| **Mid carrier frequency** | | | | | | | | |
| No emission were found | | | | | | | | Pass |
| **High carrier frequency** | | | | | | | | |
| No emission were found | | | | | | | | Pass |

*****- Margin = Measured emission - specification limit.
******- EUT front panel refer to 0 degrees position of turntable.

| **Test specification:** | **FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.3.5 Restricted bands according to FCC section 15.205**

| MHz | MHz | MHz | MHz | MHz | GHz |
|---|---|---|---|---|---|
| 0.09 - 0.11 | 8.37625 - 8.38675 | 73 - 74.6 | 399.9 - 410 | 2690 - 2900 | 10.6 - 12.7 |
| 0.495 - 0.505 | 8.41425 - 8.41475 | 74.8 - 75.2 | 608 - 614 | 3260 - 3267 | 13.25 - 13.4 |
| 2.1735 - 2.1905 | 12.29 - 12.293 | 108 - 121.94 | 960 - 1240 | 3332 - 3339 | 14.47 - 14.5 |
| 4.125 - 4.128 | 12.51975 - 12.52025 | 123 - 138 | 1300 - 1427 | 3345.8 - 3358 | 15.35 - 16.2 |
| 4.17725 - 4.17775 | 12.57675 - 12.57725 | 149.9 - 150.05 | 1435 - 1626.5 | 3600 - 4400 | 17.7 - 21.4 |
| 4.20725 - 4.20775 | 13.36 - 13.41 | 156.52475 - 156.52525 | 1645.5 - 1646.5 | 4500 - 5150 | 22.01 - 23.12 |
| 6.215 - 6.218 | 16.42 - 16.423 | 156.7 - 156.9 | 1660 - 1710 | 5350 – 5460 | 23.6 - 24 |
| 6.26775 - 6.26825 | 16.69475 - 16.69525 | 162.0125 - 167.17 | 1718.8 - 1722.2 | 7250 - 7750 | 31.2 - 31.8 |
| 6.31175 - 6.31225 | 16.80425 - 16.80475 | 167.72 - 173.2 | 2200 - 2300 | 8025 – 8500 | 36.43 - 36.5 |
| 8.291 - 8.294 | 25.5 - 25.67 | 240 - 285 | 2310 - 2390 | 9000 - 9200 | Above 38.6 |
| 8.362 - 8.366 | 37.5 - 38.25 | 322 - 335.4 | 2483.5 - 2500 | 9300 - 9500 | |

**Table 7.3.6 Restricted bands according to RSS-Gen**

| MHz | MHz | MHz | MHz | MHz | GHz |
|---|---|---|---|---|---|
| 0.09 - 0.11 | 8.291 - 8.294 | 16.80425 - 16.80475 | 399.9 - 410 | 3260 - 3267 | 10.6 - 12.7 |
| 2.1735 - 2.1905 | 8.362 - 8.366 | 25.5 - 25.67 | 608 - 614 | 3332 – 3339 | 13.25 - 13.4 |
| 3.020 – 3.026 | 8.37625 - 8.38675 | 37.5 - 38.25 | 960 – 1427 | 3345.8 – 3358 | 14.47 – 14.5 |
| 4.125 – 4.128 | 8.41425 - 8.41475 | 73 - 74.6 | 1435 – 1626.5 | 3500 – 4400 | 15.35 – 16.2 |
| 4.17725 – 4.17775 | 12.29 – 12.293 | 74.8 - 75.2 | 1645.5 – 1646.5 | 4500 – 5150 | 17.7 – 21.4 |
| 4.20725 – 4.20775 | 12.51975 – 12.52025 | 108 – 138 | 1660 - 1710 | 5350 – 5460 | 22.01 – 23.12 |
| 5.677 – 5.683 | 12.57675 – 12.57725 | 156.52475 – 156.52525 | 1718.8 - 1722.2 | 7250 - 7750 | 23.6 - 24 |
| 6.215 - 6.218 | 13.36 – 13.41 | 156.7 - 156.9 | 2200 - 2300 | 8025 – 8500 | 31.2 - 31.8 |
| 6.26775 - 6.26825 | 16.42 - 16.423 | 240 - 285 | 2310 - 2390 | 9000 - 9200 | 36.43 - 36.5 |
| 6.31175 - 6.31225 | 16.69475 - 16.69525 | 322 - 335.4 | 2655 - 2900 | 9300 - 9500 | Above 38.6 |

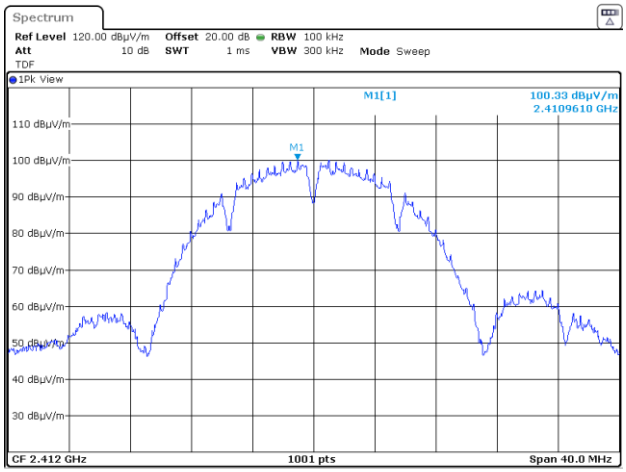
**Reference numbers of test equipment used**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL 0446 | HL 3903 | HL 4360 | HL 4933 | HL 4956 | HL 5111 | HL 5405 | |

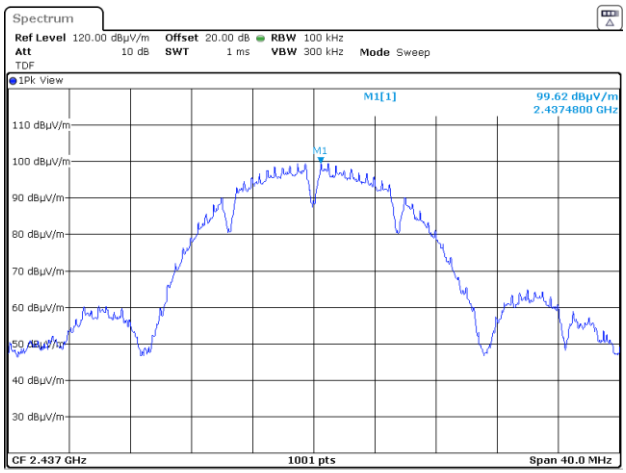
Full description is given in Appendix A.

| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

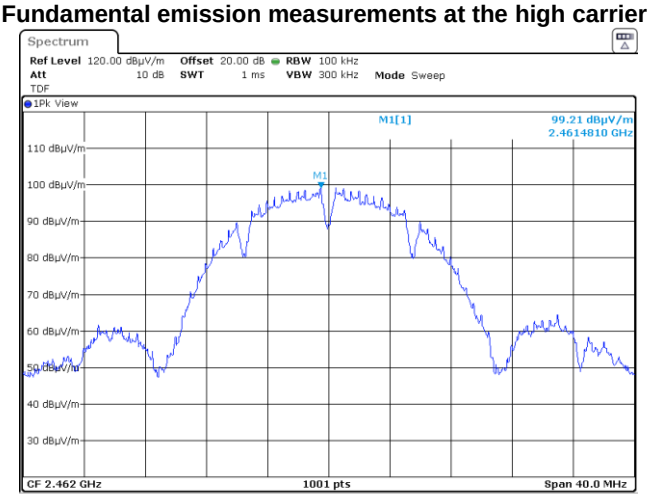
**Plot 7.3.1 Fundamental emission measurements at the low carrier frequency**




**Plot 7.3.2 Fundamental emission measurements at the mid carrier frequency**



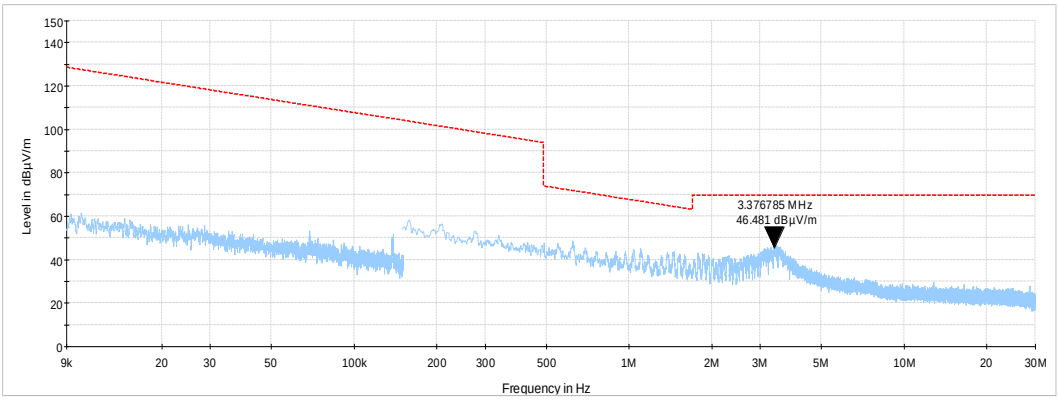

**Plot 7.3.3 Fundamental emission measurements at the high carrier frequency**



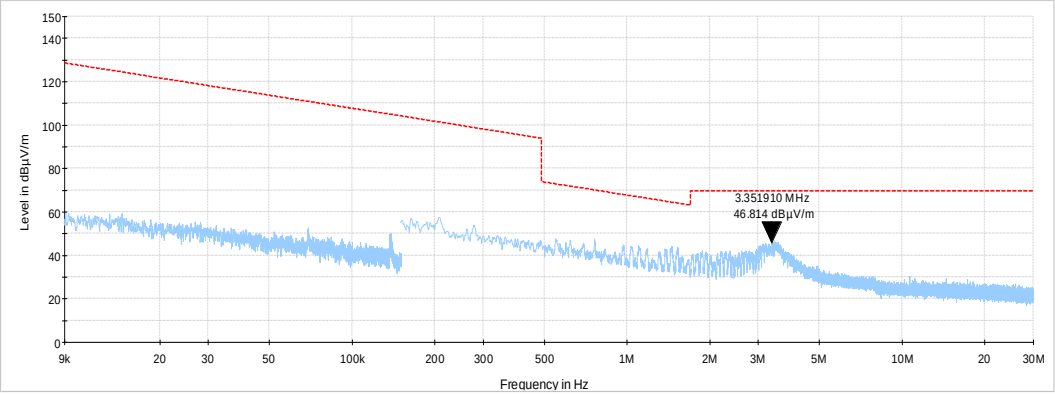
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.4 Radiated emission measurements from 9 kHz to 30 MHz**

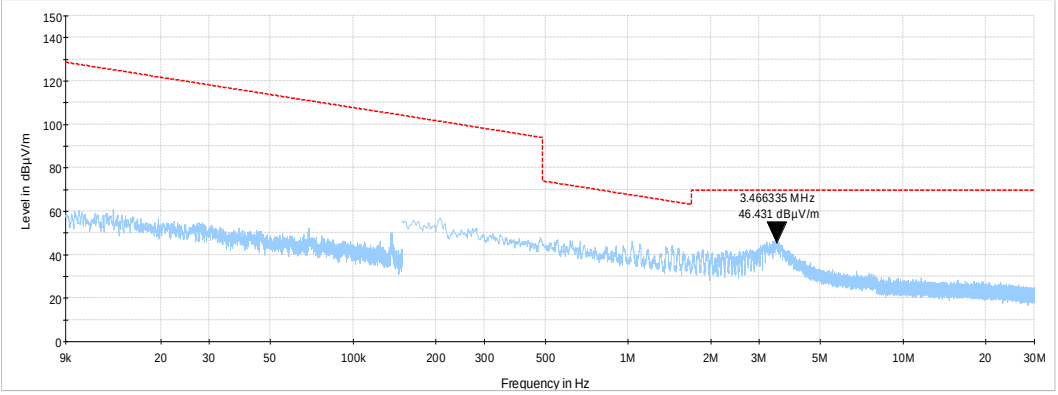
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY

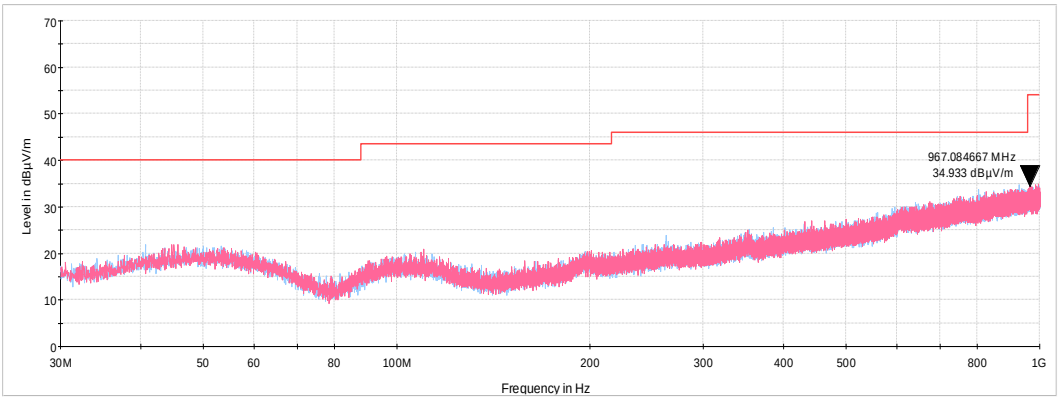



HIGH CARRIER FREQUENCY

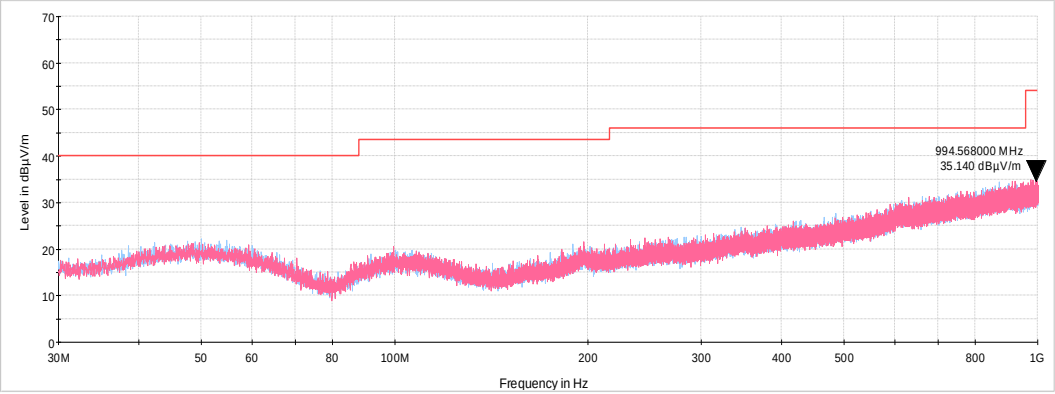
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.5 Radiated emission measurements from 30 to 1000 MHz**

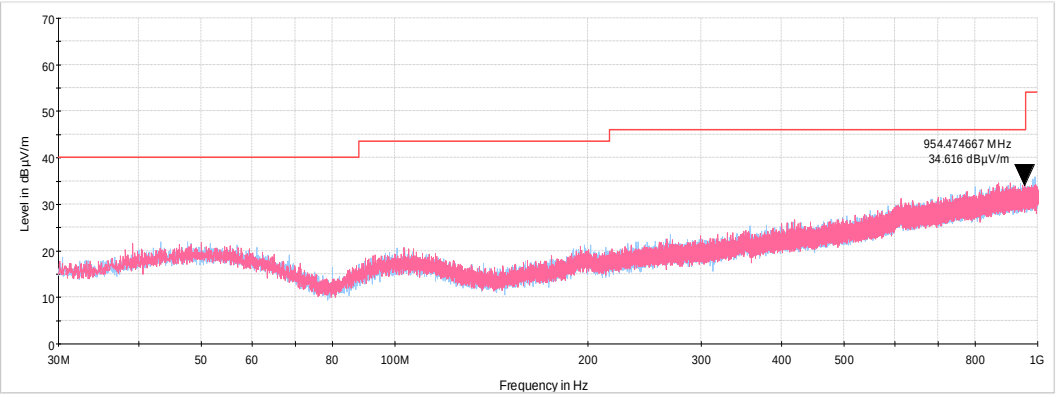
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY

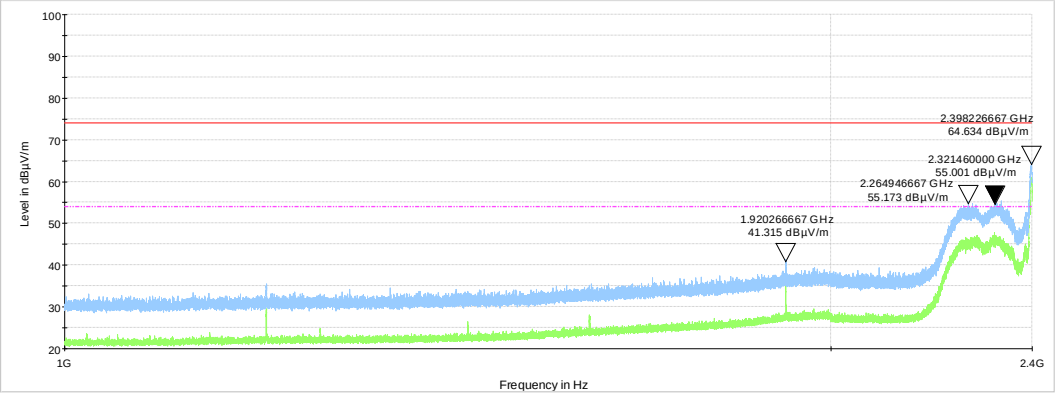



HIGH CARRIER FREQUENCY

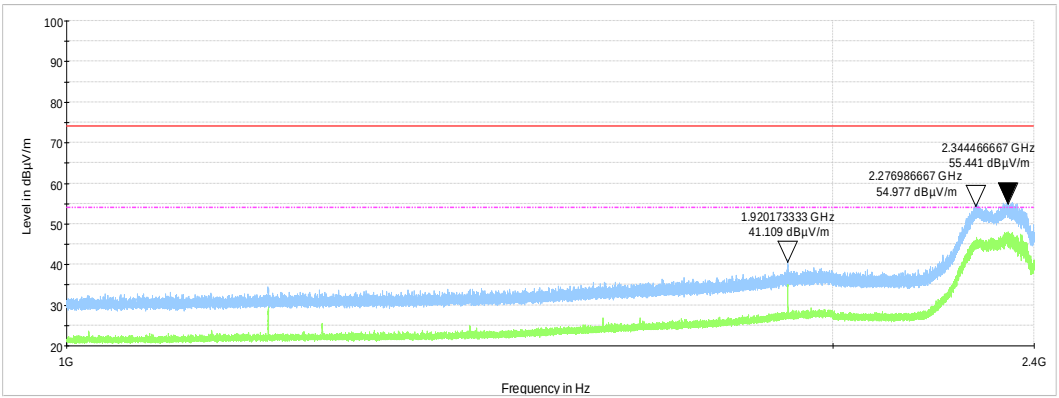
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.6 Radiated emission measurements from 1 to 2.4 GHz**

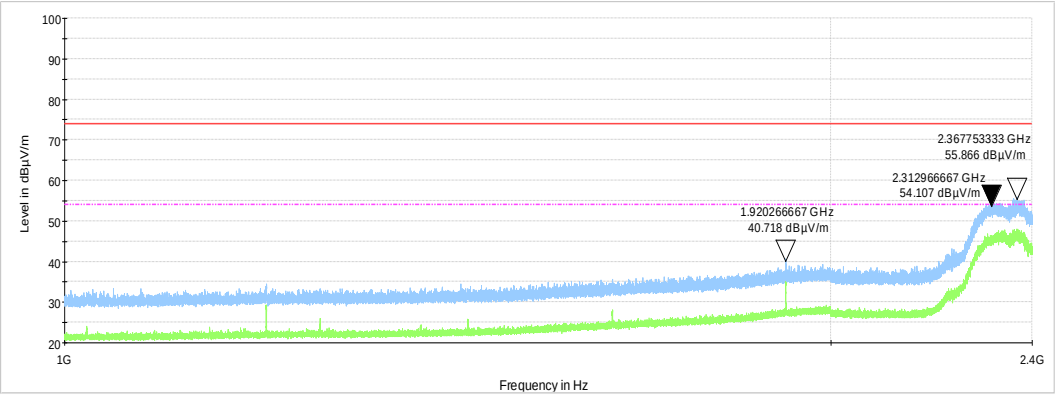
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY

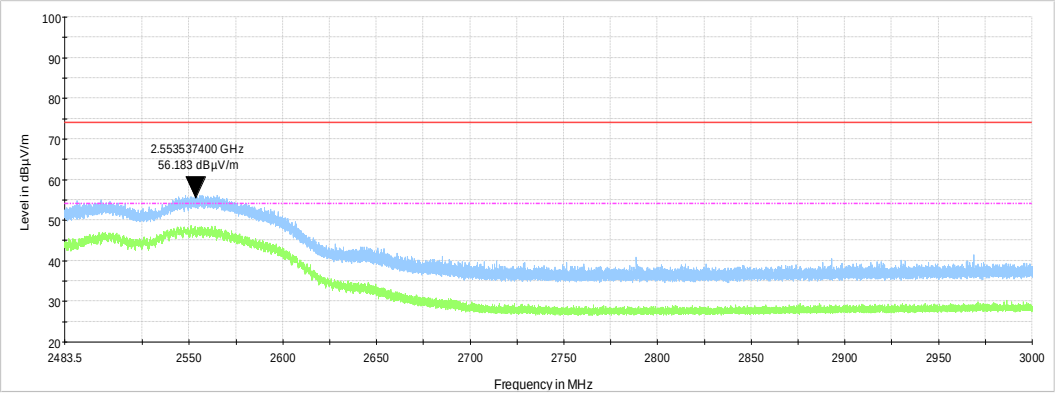



HIGH CARRIER FREQUENCY

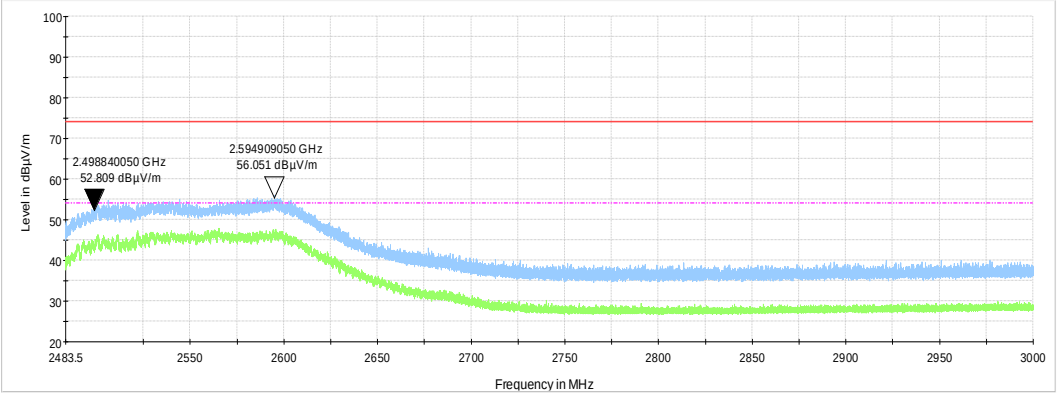
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.7 Radiated emission measurements from 2.4835 to 3 GHz**

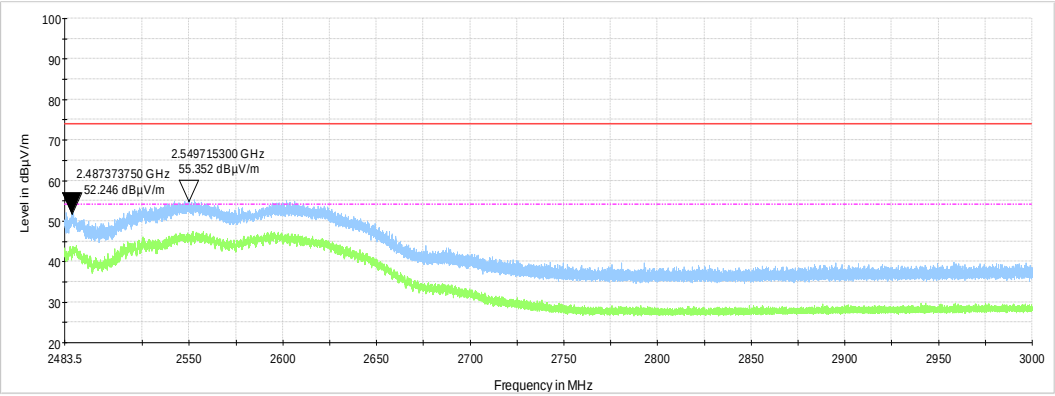
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY

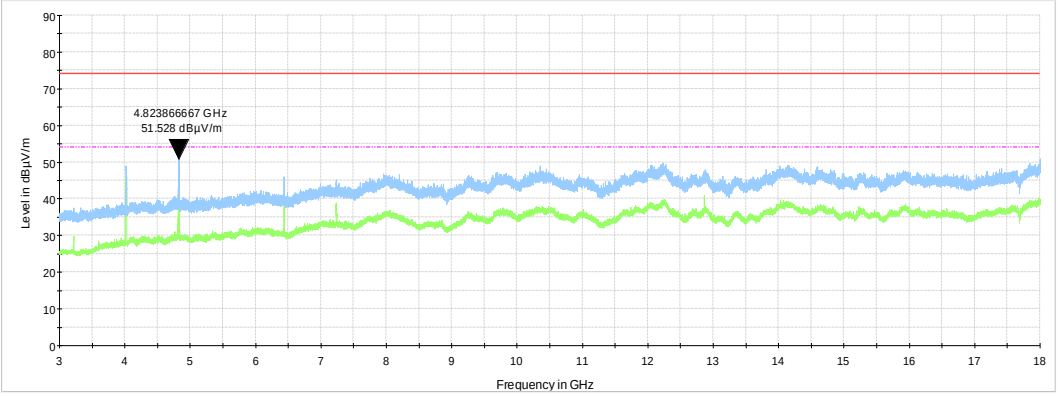



HIGH CARRIER FREQUENCY

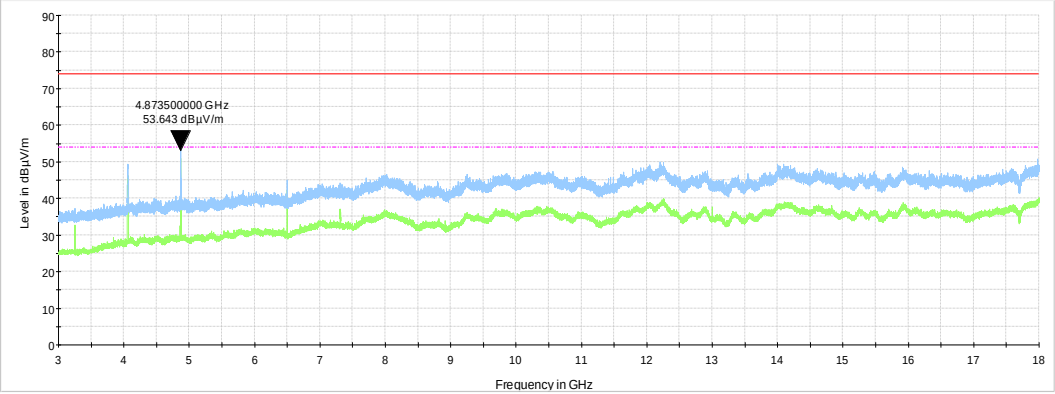
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.8 Radiated emission measurements from 3 to 18 GHz**

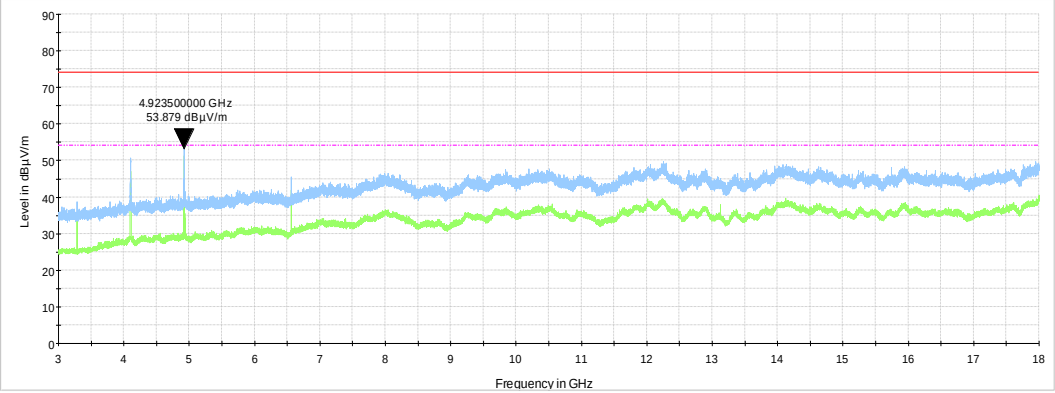
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY

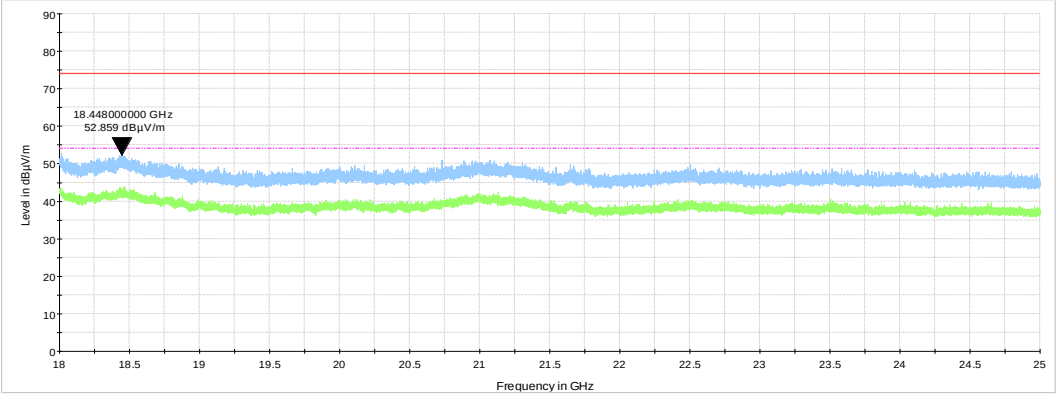



HIGH CARRIER FREQUENCY

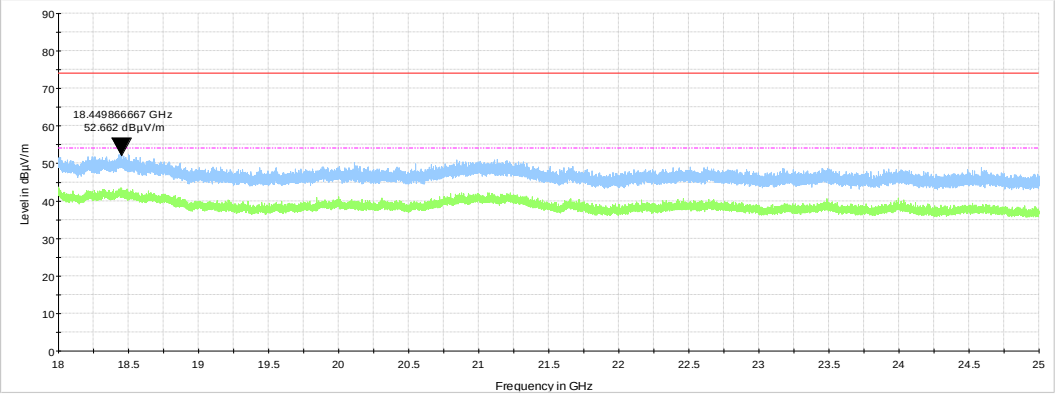
| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Sections 11.11 and 11.12.1 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.3.9 Radiated emission measurements from 18 to 25 GHz**

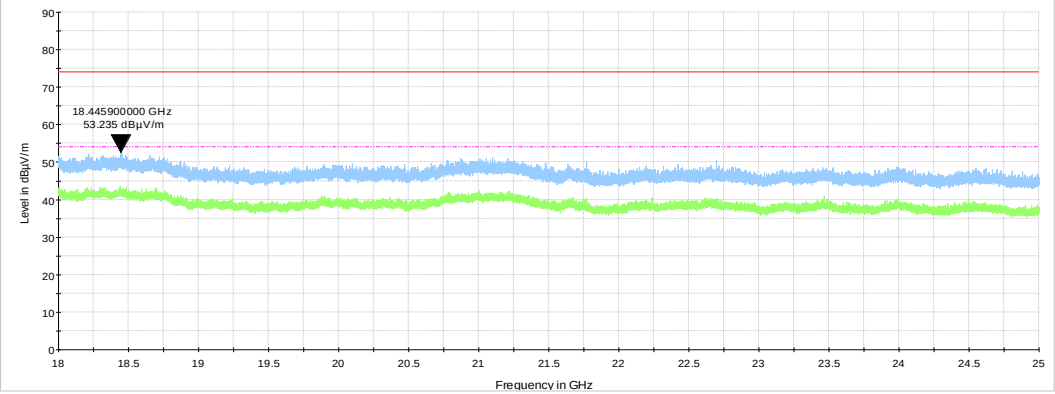
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal




LOW CARRIER FREQUENCY




MID CARRIER FREQUENCY




HIGH CARRIER FREQUENCY

| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Band edge emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 section 11.13 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 20-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

## 7.4 Band edge radiated emissions

### 7.4.1 General

This test was performed to measure emissions, radiated from the EUT at the assigned frequency band edges. Specification test limits are given in Table 7.4.1.

**Table 7.4.1 Band edge emission limits**

| Output power | Assigned frequency, MHz | Attenuation below carrier*, dBc | Field strength at 3 m within restricted bands, dB(µV/m) | |
|---|---|---|---|---|
| | | | Peak | Average |
| Peak | 902.0 – 928.0 | 20.0 | 74.0 | 54.0 |
| | **2400.0 – 2483.5** | | | |
| | 5725.0 – 5850.0 | | | |
| Averaged over a time interval | 902.0 – 928.0 | 30.0 | 74.0 | 54.0 |
| | 2400.0 – 2483.5 | | | |
| | 5725.0 – 5850.0 | | | |

* - Band edge emission limit is provided in terms of attenuation below the peak of modulated carrier measured with the same resolution bandwidth.

### 7.4.2 Test procedure

**7.4.2.1** The EUT was set up as shown in Figure 7.4.1, energized normally modulated at the maximum data rate and its proper operation was checked.

**7.4.2.2** The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.

**7.4.2.3** The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

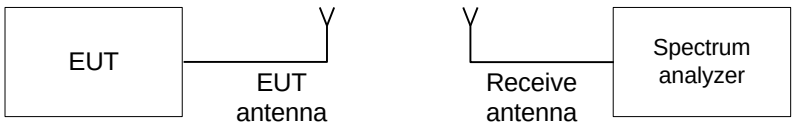
**7.4.2.4** The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.

**7.4.2.5** The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.4.2 and associated plots and referenced to the highest emission level measured within the authorized band.

**7.4.2.6** The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.

**7.4.2.7** The above procedure was repeated with the frequency hopping function enabled.

**Figure 7.4.1 Band edge emission test setup**



| **Test specification:** | **FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Band edge emissions** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10 section 11.13 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 20-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.4.2 Low band edge emission test results**

ASSIGNED FREQUENCY RANGE: 2400.0 – 2483.5 MHz
DETECTOR USED: Peak
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
TRANSMITTER OUTPUT POWER: 101.67 dBuV/m at low carrier frequency
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW

MODULATION: BPSK
BIT RATE: 1 Mbps

| Frequency, MHz | Band edge emission, dBuV/m | Emission at carrier, dBuV/m | Attenuation below carrier, dBc | Limit, dBc | Margin, dB* | Verdict |
|---|---|---|---|---|---|---|
| 2397.950 | 71.81 | 100.33 | 28.52 | 20.0 | 8.52 | Pass |

MODULATION: 64QAM
BIT RATE: 54 Mbps

| Frequency, MHz | Band edge emission, dBuV/m | Emission at carrier, dBuV/m | Attenuation below carrier, dBc | Limit, dBc | Margin, dB* | Verdict |
|---|---|---|---|---|---|---|
| 2398.600 | 73.44 | 94.28 | 20.84 | 20.0 | 0.84 | Pass |

*****- Margin = Attenuation below carrier – specification limit.

**Table 7.4.3 High band edge emission test results**

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1000 kHz

MODULATION: BPSK
BIT RATE: 1 Mbps

| Frequency, MHz | Peak field strength(VBW=3 MHz) | | | Average field strength(VBW=10 Hz) | | | Verdict |
|---|---|---|---|---|---|---|---|
| | Measured, dB(µV/m) | Limit, dB(µV/m) | Margin, dB** | Measured, dB(µV/m) | Limit, dB(µV/m) | Margin, dB** | |
| 2483.500 | 56.54 | 74.0 | -17.46 | 47.42 | 54.0 | -6.58 | Pass |
| 2488.159 | 57.41 | 74.0 | -16.59 | 47.48 | 54.0 | -6.52 | Pass |

MODULATION: 64QAM
BIT RATE: 54 Mbps

| Frequency, MHz | Peak field strength(VBW=3 MHz) | | | Average field strength(VBW=10 Hz) | | | Verdict |
|---|---|---|---|---|---|---|---|
| | Measured, dB(µV/m) | Limit, dB(µV/m) | Margin, dB** | Measured, dB(µV/m) | Limit, dB(µV/m) | Margin, dB** | |
| 2435.500 | 73.81 | 74.0 | -0.19 | 45.75 | 54.0 | -8.25 | Pass |

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Measured field strength - specification limit.

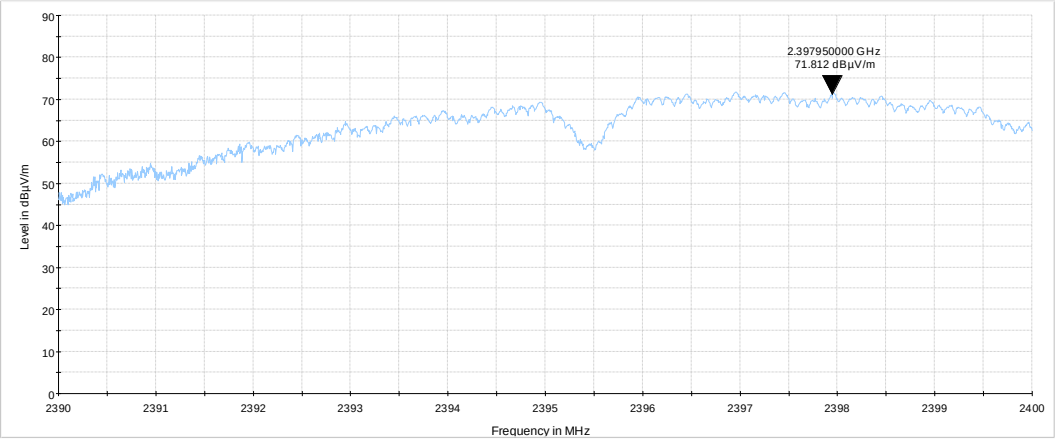
**Reference numbers of test equipment used**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL 3903 | HL 4360 | HL 4933 | HL 5405 | | | | |

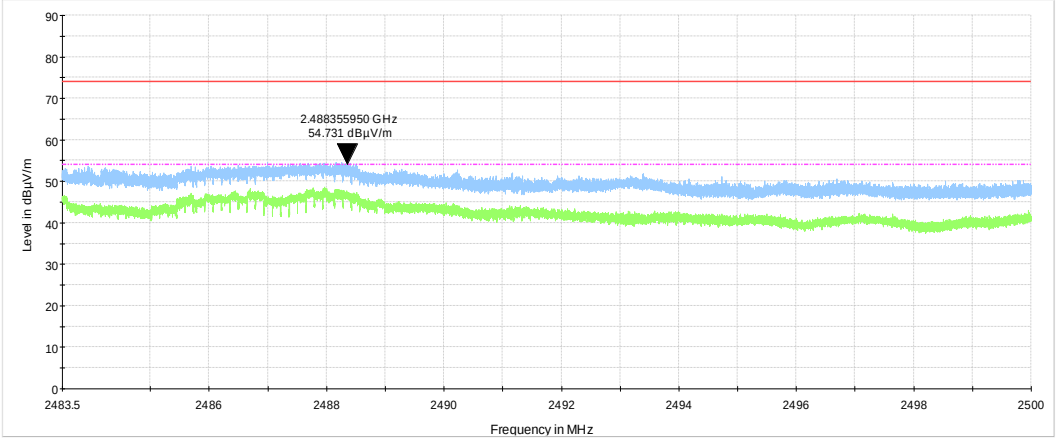
Full description is given in Appendix A.

| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Band edge emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 section 11.13 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 20-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.4.1 The highest emission level within the assigned band with BPSK 1 MHz**



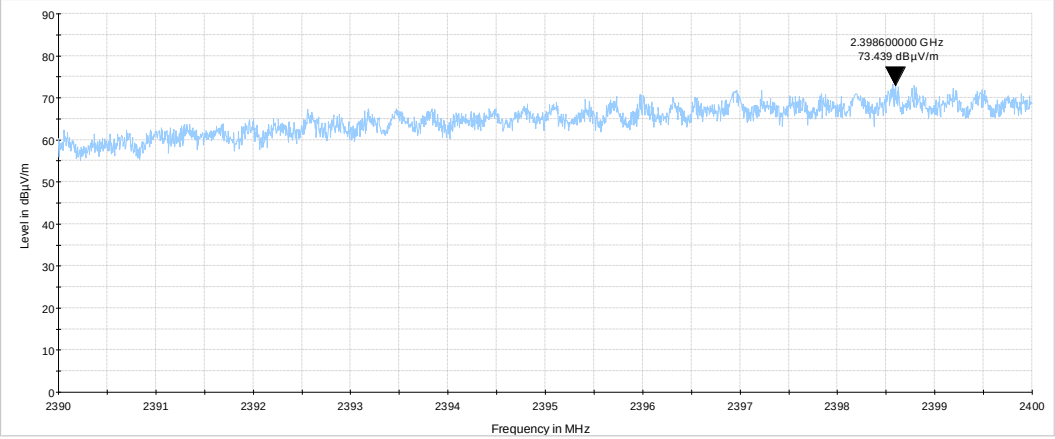

LOW CARRIER FREQUENCY



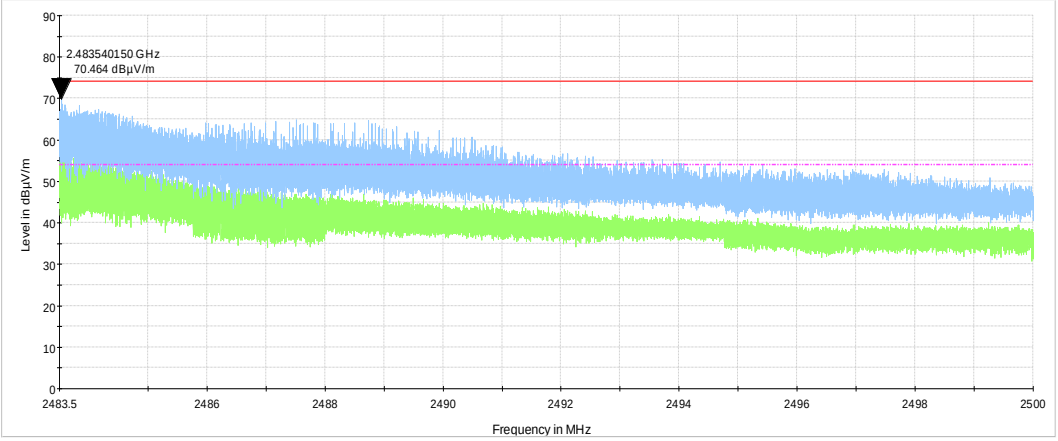

HIGH CARRIER FREQUENCY

| Test specification: | FCC 47 CFR 15.247(d) / RSS-247 section 5.5, Band edge emissions | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 section 11.13 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 20-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Plot 7.4.2 The highest emission level within the assigned band with 64QAM 54 MHz**




LOW CARRIER FREQUENCY




HIGH CARRIER FREQUENCY

| **Test specification:** | **FCC 47 CFR 15.247(e) / RSS-247 section 5.2(2), Peak power density** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Section 11.10.2 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 20-May-19 | | |
| **Temperature:** 25 ºC | **Relative Humidity:** 45 % | **Air Pressure:** 1014 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

## 7.5 Peak spectral power density

### 7.5.1 General

This test was performed to measure the peak spectral power density radiated by the transmitter RF antenna. Specification test limits are given in Table 7.5.1.

**Table 7.5.1 Peak spectral power density limits**

| Assigned frequency range, MHz | Measurement bandwidth, kHz | Peak spectral power density, dBm | Equivalent field strength limit @ 3m, dB(μV/m)* |
|---|---|---|---|
| 902.0 – 928.0 | 3.0 | 8.0 | 103.2 |
| 2400.0 – 2483.5 | | | |
| 5725.0 – 5850.0 | | | |

* - Equivalent field strength limit was calculated from the peak spectral power density as follows: E=sqrt(30×P)/r, where P is peak spectral power density and r is antenna to EUT distance in meters.

### 7.5.2 Test procedure for field strength measurements

**7.5.2.1** The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.

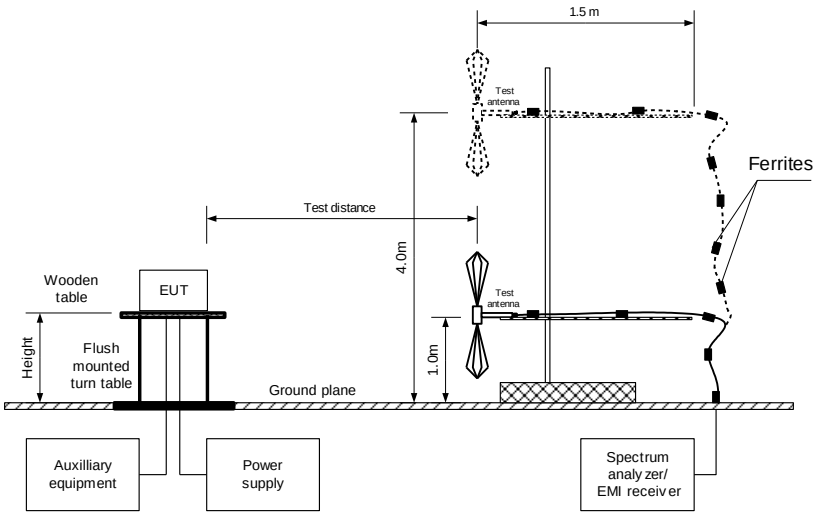
**7.5.2.2** The EUT was adjusted to produce maximum available to end user RF output power.

**7.5.2.3** The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated $360^0$ and the measuring antenna height was swept in both vertical and horizontal polarizations.

**7.5.2.4** The frequency span of spectrum analyzer was set to capture the entire 6 dB band of the transmitter, in peak hold mode with resolution bandwidth set to 3.0 kHz, video bandwidth wider than resolution bandwidth, auto sweep time and sufficient number of sweeps was allowed for trace stabilization. The spectrum lines spacing was verified to be wider than 3 kHz. Otherwise the resolution bandwidth was reduced until individual spectrum lines were resolved and the power of individual spectrum lines was integrated over 3 kHz band.

**7.5.2.5** The peak of emission was zoomed with span set just wide enough to capture the emission peak area and sweep time was set equal to span width divided by resolution bandwidth. Spectrum analyzer was set in peak hold mode, sufficient number of sweeps was allowed for trace stabilization and peak spectral power density was measured as provided in Table 7.5.2 and associated plots.

**Figure 7.5.1 Setup for carrier field strength measurements**



| **Test specification:** | **FCC 47 CFR 15.247(e) / RSS-247 section 5.2(2), Peak power density** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10, Section 11.10.2 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 20-May-19 | | |
| **Temperature:** 25 ºC | **Relative Humidity:** 45 % | **Air Pressure:** 1014 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 7.5.2 Field strength measurement of peak spectral power density**

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
EUT HEIGHT: 1.5 m
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 30 kHz
VIDEO BANDWIDTH: 100 kHz
TEST ANTENNA TYPE: Double ridged guide (above 1000 MHz)
MODULATING SIGNAL: PRBS
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

MODULATION: BPSK
BIT RATE: 1 Mbps

| Frequency, MHz | Field strength, dB(μV/m) | EUT antenna gain, dBi | Limit, dBm | Margin, dB* | Antenna polarization | Antenna height, m | Turn-table position**, degrees |
|---|---|---|---|---|---|---|---|
| 2412.0 | 95.21 | 5.3 | 8.0 | -13.29 | Horizontal | 1.5 | 147 |
| 2437.0 | 94.50 | 5.3 | 8.0 | -14.00 | Horizontal | 1.5 | 152 |
| 2462.0 | 93.98 | 5.3 | 8.0 | -14.52 | Horizontal | 1.5 | 140 |

MODULATION: 64QAM
BIT RATE: 54 Mbps

| Frequency, MHz | Field strength, dB(μV/m) | EUT antenna gain, dBi | Limit, dBm | Margin, dB* | Antenna polarization | Antenna height, m | Turn-table position**, degrees |
|---|---|---|---|---|---|---|---|
| 2412.0 | 90.52 | 5.3 | 8.0 | -17.98 | Horizontal | 1.5 | 147 |
| 2437.0 | 89.09 | 5.3 | 8.0 | -19.41 | Horizontal | 1.5 | 152 |
| 2462.0 | 88.00 | 5.3 | 8.0 | -20.50 | Horizontal | 1.5 | 140 |

*****- Margin = Field strength - EUT antenna gain - calculated field strength limit.
******- EUT front panel refer to 0 degrees position of turntable.

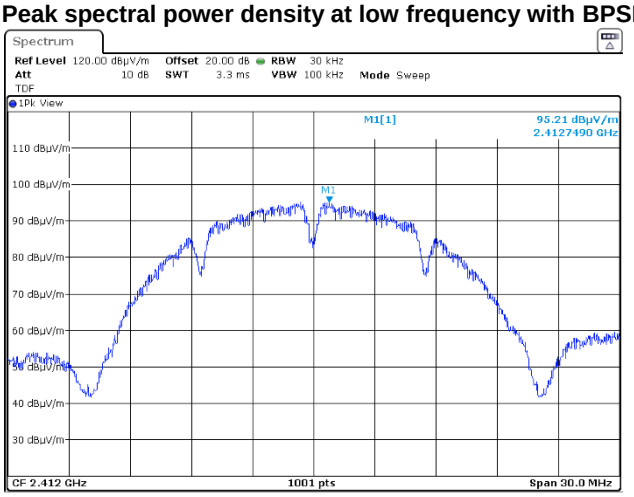
**Reference numbers of test equipment used**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL 3903 | HL 4360 | HL 4933 | HL 5405 | | | | |

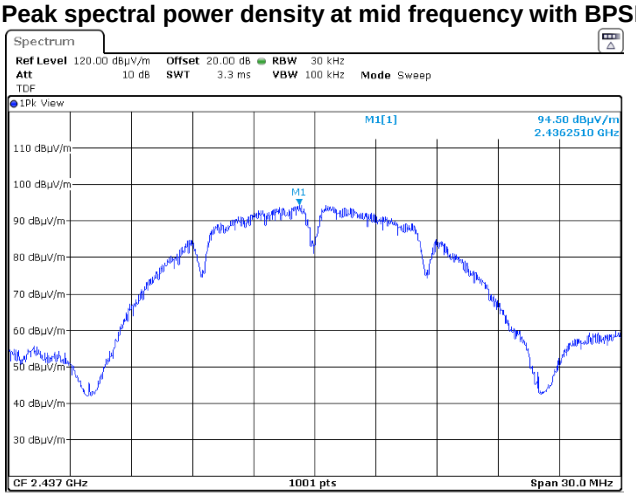
Full description is given in Appendix A.

| Test specification: | FCC 47 CFR 15.247(e) / RSS-247 section 5.2(2), Peak power density | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Section 11.10.2 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 20-May-19 | | |
| Temperature: 25 ºC | Relative Humidity: 45 % | Air Pressure: 1014 hPa | Power: 3 VDC |
| Remarks: | | | |

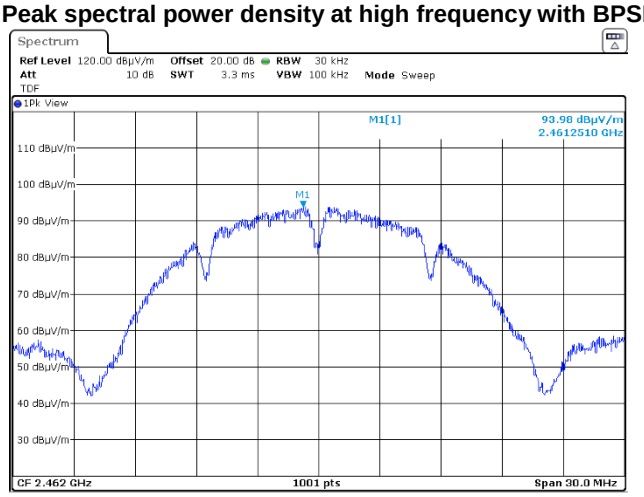
**Plot 7.5.1 Peak spectral power density at low frequency with BPSK 1 Mbps**




**Plot 7.5.2 Peak spectral power density at mid frequency with BPSK 1 Mbps**

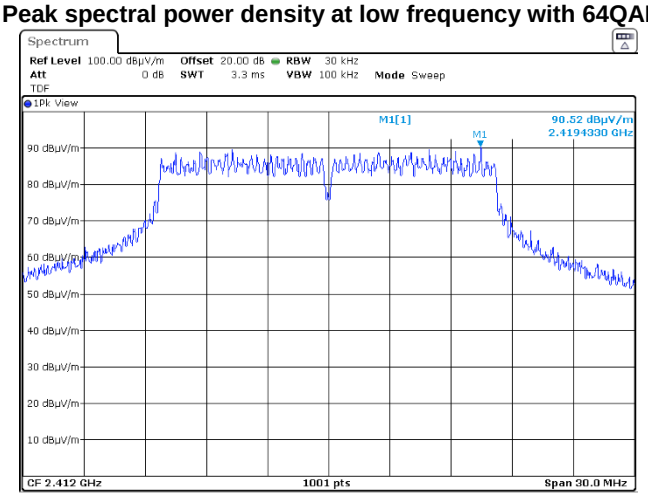



**Plot 7.5.3 Peak spectral power density at high frequency with BPSK 1 Mbps**

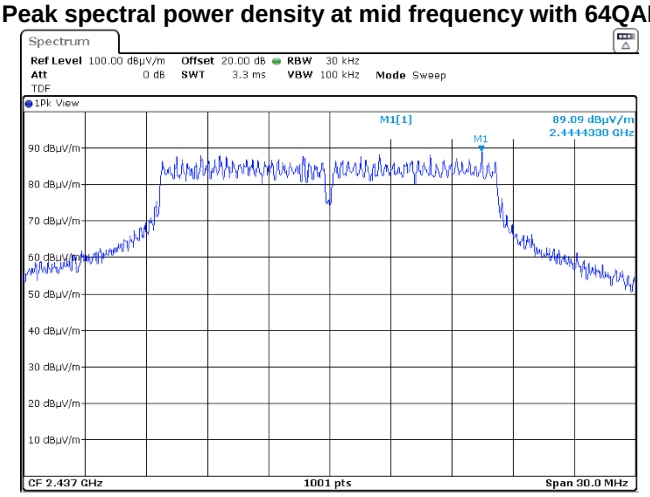


| Test specification: | FCC 47 CFR 15.247(e) / RSS-247 section 5.2(2), Peak power density | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10, Section 11.10.2 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 20-May-19 | | |
| Temperature: 25 ºC | Relative Humidity: 45 % | Air Pressure: 1014 hPa | Power: 3 VDC |
| Remarks: | | | |

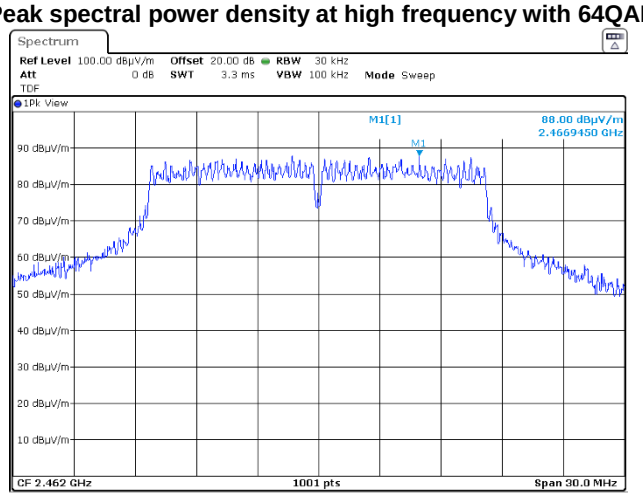
**Plot 7.5.4 Peak spectral power density at low frequency with 64QAM 54 Mbps**




**Plot 7.5.5 Peak spectral power density at mid frequency with 64QAM 54 Mbps**




**Plot 7.5.6 Peak spectral power density at high frequency with 64QAM 54 Mbps**



| Test specification: | FCC 47 CFR 15.203, RSS-Gen section 8.3, Antenna requirements | | |
|---|---|---|---|
| Test procedure: | | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: NA |
| Remarks: | | | |

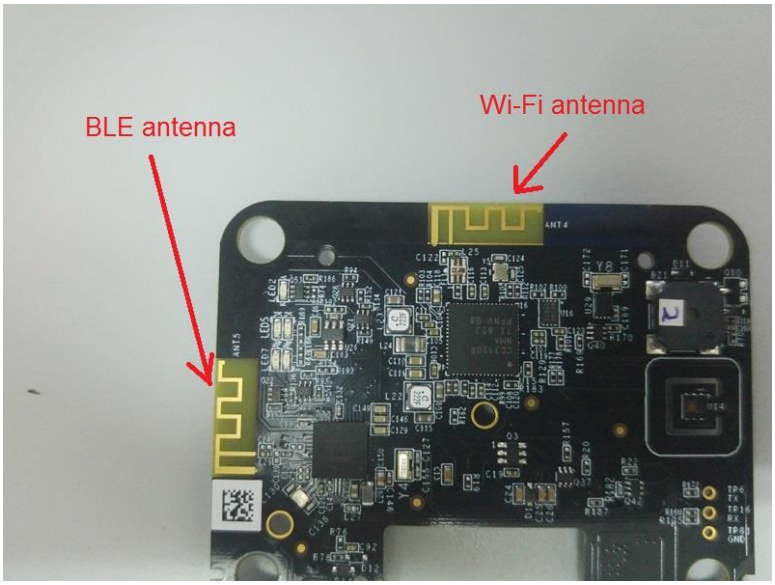
## 7.6 Antenna requirements

The EUT was verified for compliance with antenna requirements. A transmitter shall be designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. It may be either permanently attached or employs a unique antenna connector for every antenna proposed for use with the EUT. This requirement does not apply to professionally installed transmitters.
The rationale for compliance with the above requirements was either visual inspection results or supplier declaration. The summary of results is provided in Table 7.6.1.

**Table 7.6.1 Antenna requirements**

| Requirement | Rationale | Verdict |
|---|---|---|
| The transmitter antenna is permanently attached | Visual inspection | Comply |
| The transmitter employs a unique antenna connector | NA | |
| The transmitter requires professional installation | NA | |

**Photograph 7.6.1 Antenna assembly**



| Test specification: | FCC 47 CFR 15.109 / ICES-003 section 6.2, Radiated emission | | |
|---|---|---|---|
| Test procedure: | ANSI C63.4, Sections 11.6 and 12.1.4 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

# 8 Unintentional emissions according to FCC 47CFR part 15 subpart B and ICES-003

## 8.1 Radiated emission measurements

### 8.1.1 General

This test was performed to measure radiated emissions from the EUT enclosure. The specification test limits are given in Table 8.1.1.

**Table 8.1.1 Radiated emission test limits**

| Frequency, MHz | Class B limit, dB(μV/m) | | Class A limit, dB(μV/m) | |
|---|---|---|---|---|
| | 10 m distance | 3 m distance | 10 m distance | 3 m distance |
| 30 - 88 | 29.5* | 40.0 | 39.0 | 49.5* |
| 88 - 216 | 33.0* | 43.5 | 43.5 | 54.0* |
| 216 - 960 | 35.5* | 46.0 | 46.4 | 56.9* |
| Above 960 | 43.5* | 54.0 | 49.5 | 60.0* |

* The limit for test distance other than specified was calculated using the inverse linear distance extrapolation factor as follows: $Lim_{S2} = Lim_{S1} + 20 \log (S_1/S_2)$,
where $S_1$ and $S_2$ – standard defined and test distance respectively in meters.

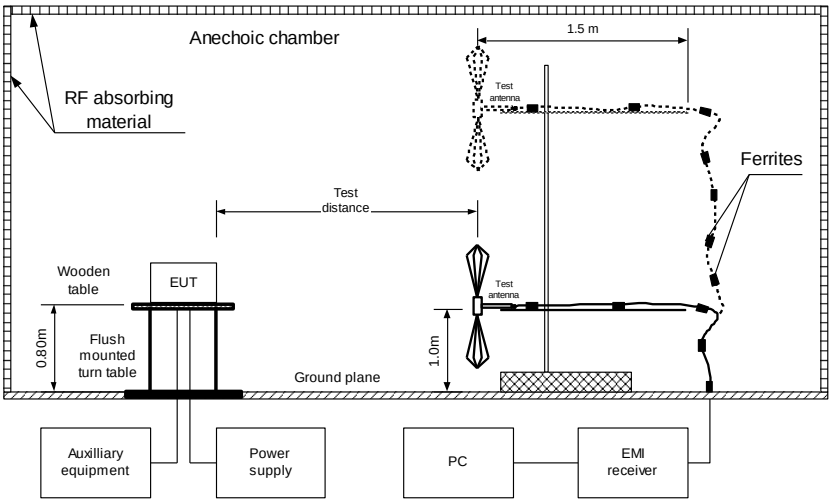
### 8.1.2 Test procedure for measurements in semi-anechoic chamber

**8.1.2.1** The EUT was set up as shown in Figure 8.1.1 and the associated photographs, energized and the EUT performance was checked.

**8.1.2.2** The measurements were performed in the anechoic chamber at 3 m test distance. The specified frequency range was investigated with the antenna connected to the EMI receiver. To find the highest emission the turntable was rotated $360^0$ and the measuring antenna height was swept from 1 to 4 m in both, vertical and horizontal polarizations. The EUT cables position was varied to maximize emission.

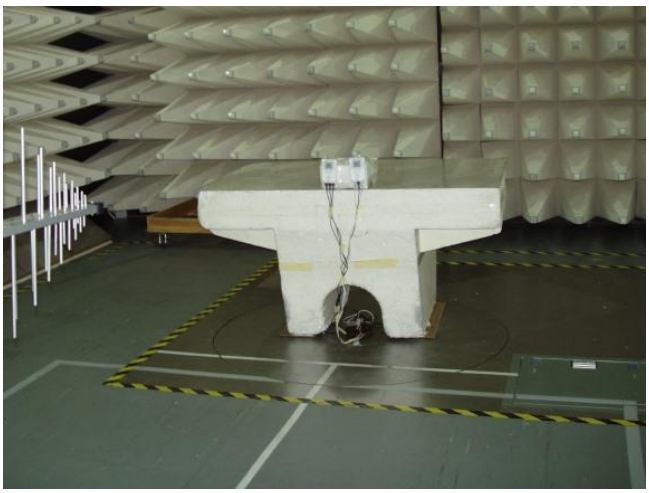
**8.1.2.3** The worst test results with respect to the limits were recorded in Table 8.1.2 and shown in the associated plots.

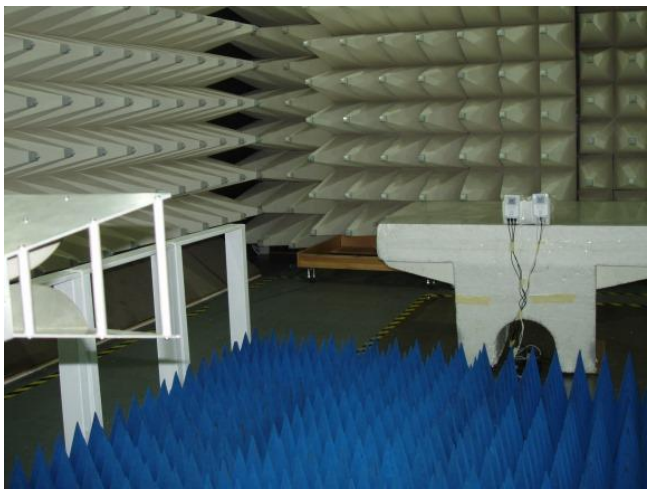
**Figure 8.1.1 Setup for radiated emission measurements**



| Test specification: | FCC 47 CFR 15.109 / ICES-003 section 6.2, Radiated emission | | |
|---|---|---|---|
| Test procedure: | ANSI C63.4, Sections 11.6 and 12.1.4 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

**Photograph 8.1.1 Setup for radiated emission measurements, general view**





**Photograph 8.1.2 Setup for final radiated emission measurements, EUT cabling**

| **Test specification:** | **FCC 47 CFR 15.109 / ICES-003 section 6.2, Radiated emission** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.4, Sections 11.6 and 12.1.4 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 19-May-19 | | |
| **Temperature:** 24 ºC | **Relative Humidity:** 46 % | **Air Pressure:** 1012 hPa | **Power:** 3 VDC |
| **Remarks:** | | | |

**Table 8.1.2 Radiated emission test results**

EUT SET UP: TABLE-TOP
TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / QUASI-PEAK
FREQUENCY RANGE: 30 MHz – 1000 MHz
RESOLUTION BANDWIDTH: 120 kHz

| Frequency, MHz | Peak emission, dB(μV/m) | Quasi-peak | | | Antenna polarization | Antenna height, m | Turn-table position**, degrees | Verdict |
|---|---|---|---|---|---|---|---|---|
| | | Measured emission, dB(μV/m) | Limit, dB(μV/m) | Margin, dB* | | | | |
| 30.021900 | 28.36 | 21.70 | 40.0 | -18.30 | Horizontal | 4.00 | 283 | Pass |
| 39.456630 | 23.90 | 15.12 | 40.0 | -24.88 | Vertical | 1.00 | 351 | |
| 46.586173 | 24.06 | 17.38 | 40.0 | -22.62 | Vertical | 1.24 | 82 | |
| 66.595271 | 25.06 | 21.00 | 40.0 | -19.00 | Horizontal | 2.16 | 8 | |
| 71.984533 | 28.91 | 23.70 | 40.0 | -16.30 | Horizontal | 1.02 | 250 | |
| 80.020167 | 27.20 | 24.41 | 40.0 | -15.59 | Horizontal | 1.02 | 7 | |
| 148.527232 | 26.18 | 20.24 | 43.5 | -23.26 | Horizontal | 2.46 | 102 | |
| 445.493728 | 38.57 | 34.50 | 46.0 | -11.50 | Horizontal | 1.53 | 180 | |
| 30.021900 | 28.36 | 21.70 | 40.0 | -18.30 | Horizontal | 4.00 | 283 | |
| 891.016075 | 40.97 | 35.82 | 46.0 | -10.18 | Vertical | 4.00 | 321 | |

TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1000 MHz -
RESOLUTION BANDWIDTH: 1000 kHz

| Frequency, MHz | Peak | | | Average | | | Antenna polarization | Antenna height, m | Turn-table position**, degrees | Verdict |
|---|---|---|---|---|---|---|---|---|---|---|
| | Measured emission, dB(μV/m) | Limit, dB(μV/m) | Margin, dB* | Measured emission, dB(μV/m) | Limit, dB(μV/m) | Margin, dB* | | | | |
| No emissions for measurements were found | | | | | | | | | | Pass |

*****- Margin = Measured emission - specification limit.
******- EUT front panel refers to 0 degrees position of turntable.

**Reference numbers of test equipment used**

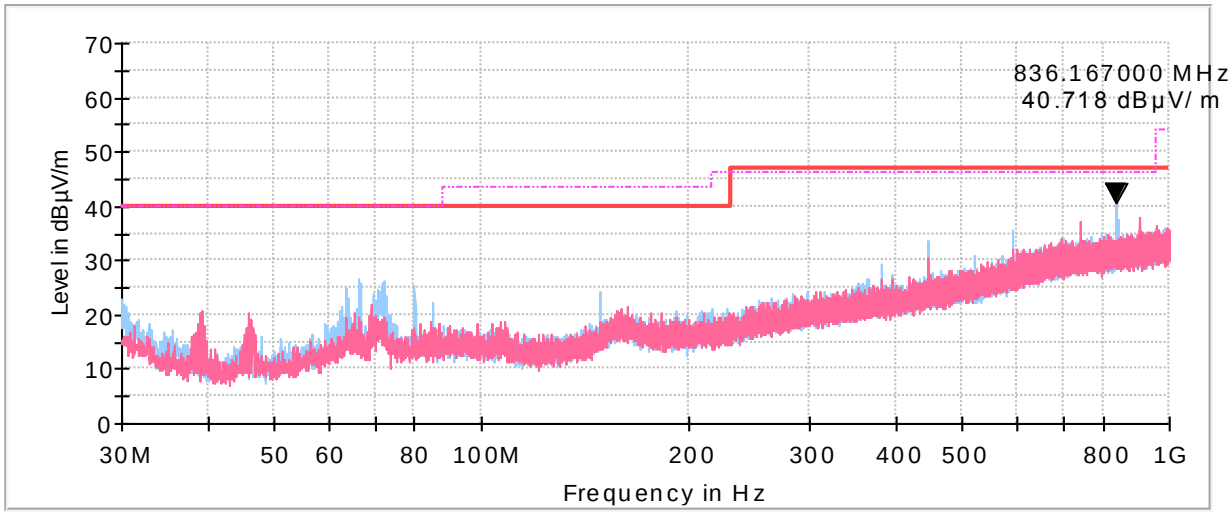
| HL 0604 | HL 3903 | HL 4011 | HL 4360 | HL 4933 | HL 5084 | HL 5405 | |
|---|---|---|---|---|---|---|---|

Full description is given in Appendix A.

| Test specification: | FCC 47 CFR 15.109 / ICES-003 section 6.2, Radiated emission | | |
|---|---|---|---|
| Test procedure: | ANSI C63.4, Sections 11.6 and 12.1.4 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 19-May-19 | | |
| Temperature: 24 ºC | Relative Humidity: 46 % | Air Pressure: 1012 hPa | Power: 3 VDC |
| Remarks: | | | |

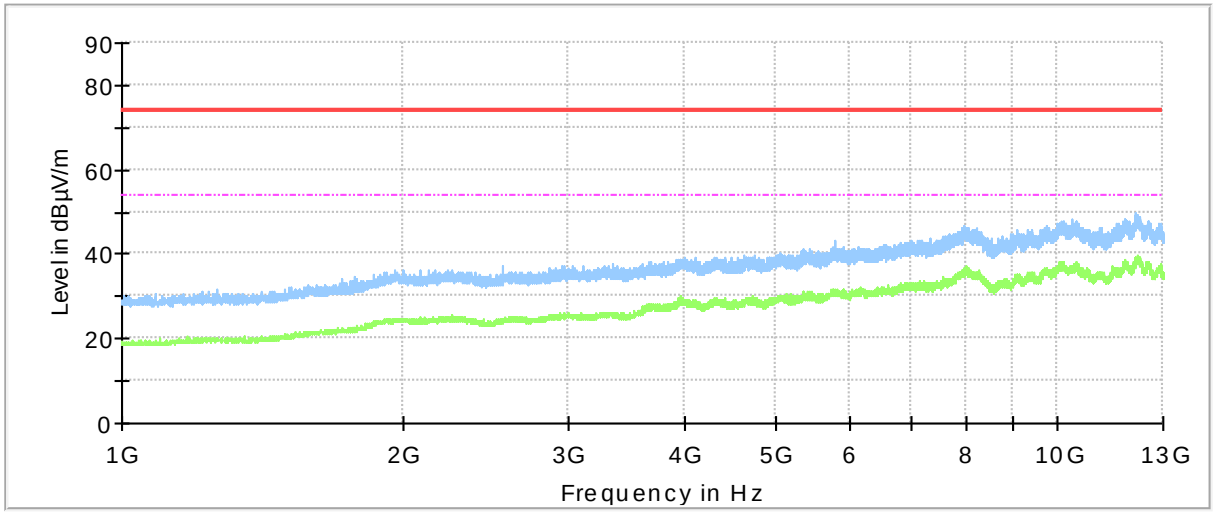
**Plot 8.1.1 Radiated emission measurements in 30 - 1000 MHz range, vertical and horizontal antenna polarization**

TEST SITE: Anechoic chamber
TEST DISTANCE: 3 m




**Plot 8.1.2 Radiated emission measurements above 1000 MHz, vertical and horizontal antenna polarization**

TEST SITE: Anechoic chamber
TEST DISTANCE: 3 m



# 9 APPENDIX A Test equipment and ancillaries used for tests

| HL No | Description | Manufacturer | Model | Ser. No. | Last Cal./ Check | Due Cal./ Check |
|---|---|---|---|---|---|---|
| 0446 | Antenna, Loop, Active, 10 (9) kHz - 30 MHz | EMCO | 6502 | 2857 | 24-Feb-19 | 24-Feb-20 |
| 0604 | Antenna BiconiLog Log-Periodic/T Bow-TIE, 26 - 2000 MHz | EMCO | 3141 | 9611-1011 | 03-Jun-18 | 03-Jun-19 |
| 3818 | PSA Series Spectrum Analyzer, 3 Hz- 44 GHz | Agilent Technologies | E4446A | MY48250288 | 24-Apr-19 | 24-Apr-20 |
| 3903 | Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA | Huber-Suhner | SUCOFLEX 102A | 1226/2A | 07-Apr-19 | 07-Apr-20 |
| 4011 | Temp. & Humidity Meter, (-50 - +70) deg, (20 - 99 )% RH | Mad Electronics | HTC-1 | NA | 06-Aug-18 | 06-Aug-19 |
| 4135 | Shield Box | TESCOM CO., LTD | TC-5916A | 5916A000136 | 24-Apr-19 | 24-Apr-20 |
| 4360 | EMI Test Receiver, 20 Hz to 40 GHz. | Rohde & Schwarz | ESU40 | 100322 | 31-Dec-18 | 31-Dec-19 |
| 4933 | Active Horn Antenna, 1 GHz to 18 GHz | COM-POWER CORPORATION | AHA-118 | 701046 | 06-Jan-19 | 06-Jan-20 |
| 4956 | Active horn antenna, 18 to 40 GHz | COM-POWER CORPORATION | AHA-840 | 105004 | 25-Jan-19 | 25-Jan-20 |
| 5084 | Attenuator, 4 dB, DC - 6 GHz, 1 W | Mini-Circuits | UNAT-4+ | NA | 05-Jun-18 | 05-Jun-19 |
| 5111 | RF cable, 40 GHz, 5.5 m, K-type | Huber-Suhner | SF102EA/11SK/11SK/5500MM | 502493/2EA | 18-Apr-19 | 18-Apr-20 |
| 5405 | RF cable, 18 GHz, N-N, 6 m | Huber-Suhner | SF118/11N(x2) | 500023/118 | 01-Aug-18 | 01-Aug-19 |

# 10 APPENDIX B Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.
Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), CAB identifier is IL1001, ISED# number 2186A; Certified by VCCI, Japan (the registration numbers are R-10808 for OATS, R-1082 for anechoic chamber, G-10869 for RE measurements above 1 GHz, C-10845 for conducted emissions site and T-11606 for conducted emissions at telecommunication ports).
The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

Address: P.O. Box 23, Binyamina 3055001, Israel
Telephone: +972 4628 8001
Fax: +972 4628 8277
e-mail: mail@hermonlabs.com
website: www.hermonlabs.com

Person for contact: Mr. M. Nikishin, EMC and radio group leader

# 11 APPENDIX C Test equipment correction factors

**HL 0446: Active Loop Antenna**
**EMCO, model: 6502, s/n 2857**

| Frequency, | Measured antenna factor, dBS/m | Measurement uncertainty, dB |
|---|---|---|
| 10 | -33.4 | ±1.0 |
| 20 | -37.8 | ±1.0 |
| 50 | -40.5 | ±1.0 |
| 75 | -41.0 | ±1.0 |
| 100 | -41.2 | ±1.0 |
| 150 | -41.2 | ±1.0 |
| 250 | -41.1 | ±1.0 |
| 500 | -41.2 | ±1.0 |
| 750 | -41.3 | ±1.0 |
| 1000 | -41.3 | ±1.0 |

| Frequency, | Measured antenna factor, dBS/m | Measurement uncertainty, dB |
|---|---|---|
| 2000 | -41.4 | ±1.0 |
| 3000 | -41.4 | ±1.0 |
| 4000 | -41.5 | ±1.0 |
| 5000 | -41.5 | ±1.0 |
| 10000 | -41.7 | ±1.0 |
| 15000 | -42.1 | ±1.0 |
| 20000 | -42.7 | ±1.0 |
| 25000 | -44.2 | ±1.0 |
| 30000 | -45.8 | ±1.0 |

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμA/m.

**HL 0604: Antenna BiconiLog Log-Periodic/T Bow-TIE**
**EMCO, model 3141, serial number 9611-1011**

| Frequency, MHz | Antenna factor, dB/m |
|---|---|
| 30 | 12.1 |
| 35 | 9.1 |
| 40 | 8.0 |
| 45 | 8.3 |
| 50 | 9.0 |
| 60 | 10.5 |
| 70 | 11.4 |
| 80 | 12.3 |
| 90 | 13.4 |
| 100 | 13.0 |
| 120 | 11.4 |
| 140 | 12.5 |

| Frequency, MHz | Antenna factor, dB/m |
|---|---|
| 160 | 14.9 |
| 180 | 14.4 |
| 200 | 13.7 |
| 250 | 16.3 |
| 300 | 17.2 |
| 400 | 19.8 |
| 500 | 22.0 |
| 600 | 24.3 |
| 700 | 25.8 |
| 800 | 26.9 |
| 900 | 27.3 |
| 1000 | 28.5 |

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

**HL 4933: Active Horn Antenna**
**COM-POWER CORPORATION, model: AHA-118, s/n 701046**

| Frequency, MHz | Measured antenna factor (with preamplifier), dB/m |
|---|---|
| 1000 | -16.1 |
| 1500 | -15.1 |
| 2000 | -10.9 |
| 2500 | -11.9 |
| 3000 | -11.1 |
| 3500 | -10.6 |
| 4000 | -8.6 |
| 4500 | -8.3 |
| 5000 | -5.9 |
| 5500 | -5.7 |
| 6000 | -3.3 |
| 6500 | -4.0 |
| 7000 | -2.2 |
| 7500 | -1.7 |
| 8000 | 1.1 |
| 8500 | -0.8 |
| 9000 | -1.5 |
| 9500 | -0.2 |

| Frequency, MHz | Measured antenna factor (with preamplifier), dB/m |
|---|---|
| 10000 | 1.8 |
| 10500 | 1.0 |
| 11000 | 0.3 |
| 11500 | -0.5 |
| 12000 | 3.1 |
| 12500 | 1.4 |
| 13000 | -0.3 |
| 13500 | -0.4 |
| 14000 | 2.5 |
| 14500 | 2.2 |
| 15000 | 1.9 |
| 15500 | 0.5 |
| 16000 | 2.1 |
| 16500 | 1.2 |
| 17000 | 0.6 |
| 17500 | 3.1 |
| 18000 | 4.2 |

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

**HL 4956: Active horn antenna**
**COM-POWER Corp., model: AHA-840, s/n 105004**

| Frequency, MHz | Measured antenna factor, dB/m |
|---|---|
| 18000 | 5.1 |
| 18500 | 3.6 |
| 19000 | 2.2 |
| 19500 | 0.7 |
| 20000 | 0.7 |
| 20500 | 0.8 |
| 21000 | 0.5 |
| 21500 | -1.3 |
| 22000 | -2.1 |
| 22500 | -2.0 |
| 23000 | -1.6 |
| 23500 | -2.9 |
| 24000 | -2.3 |
| 24500 | -2.6 |
| 25000 | -1.8 |
| 25500 | -1.2 |
| 26000 | -0.5 |
| 26500 | -1.2 |
| 27000 | -0.1 |
| 27500 | -1.0 |
| 28000 | -0.7 |
| 28500 | 0.5 |

| Frequency, MHz | Measured antenna factor, dB/m |
|---|---|
| 29500 | 1.4 |
| 30000 | 2.9 |
| 30500 | 2.9 |
| 31000 | 2.9 |
| 31500 | 1.2 |
| 32000 | 0.7 |
| 32500 | 0.2 |
| 33000 | -1.7 |
| 33500 | -2.2 |
| 34000 | 2.3 |
| 34500 | -1.1 |
| 35000 | 0.7 |
| 35500 | -1.1 |
| 36000 | 0.1 |
| 36500 | 1.4 |
| 37000 | 3.7 |
| 37500 | 5.8 |
| 38000 | 6.6 |
| 38500 | 7.3 |
| 39000 | 6.5 |
| 39500 | 7.3 |
| 40000 | 7.1 |

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

**HL 5111: RF cable**

**Huber-Suhner, SF102EA/11SK/11SK/5500MM, s/n 502493/2EA**

| Set / Applied, MHz | Measured, dB | Uncertainty, dB |
|---|---|---|
| 100 | 0.70 | ±0.07 |
| 200 | 0.99 | ±0.08 |
| 300 | 1.21 | ±0.08 |
| 500 | 1.56 | ±0.08 |
| 1000 | 2.20 | ±0.08 |
| 1500 | 2.69 | ±0.08 |
| 2000 | 3.11 | ±0.08 |
| 2500 | 3.50 | ±0.10 |
| 3000 | 3.85 | ±0.10 |
| 3500 | 4.16 | ±0.10 |
| 4000 | 4.47 | ±0.10 |
| 4500 | 4.74 | ±0.10 |
| 5000 | 5.03 | ±0.10 |
| 5500 | 5.30 | ±0.10 |
| 6000 | 5.57 | ±0.10 |
| 6500 | 5.76 | ±0.10 |
| 7000 | 6.00 | ±0.10 |
| 7500 | 6.20 | ±0.10 |
| 8000 | 6.44 | ±0.10 |
| 8500 | 6.67 | ±0.10 |
| 9000 | 6.82 | ±0.10 |
| 9500 | 7.04 | ±0.10 |
| 10000 | 7.18 | ±0.10 |
| 10500 | 7.36 | ±0.10 |
| 11000 | 7.55 | ±0.10 |
| 11500 | 7.75 | ±0.10 |
| 12000 | 7.90 | ±0.10 |
| 12500 | 8.08 | ±0.13 |
| 13000 | 8.19 | ±0.13 |
| 13500 | 8.39 | ±0.13 |
| 14000 | 8.58 | ±0.13 |
| 14500 | 8.76 | ±0.18 |
| 15000 | 8.92 | ±0.18 |
| 15500 | 9.03 | ±0.18 |
| 16000 | 9.18 | ±0.18 |
| 16500 | 9.34 | ±0.18 |
| 17000 | 9.51 | ±0.18 |
| 17500 | 9.66 | ±0.18 |
| 18000 | 9.80 | ±0.18 |
| 18500 | 9.94 | ±0.23 |
| 19000 | 10.05 | ±0.23 |
| 19500 | 10.22 | ±0.23 |

| Set / Applied, MHz | Measured, dB | Uncertainty, dB |
|---|---|---|
| 20000 | 10.32 | ±0.23 |
| 20500 | 10.48 | ±0.23 |
| 21000 | 10.60 | ±0.23 |
| 21500 | 10.73 | ±0.23 |
| 22000 | 10.87 | ±0.23 |
| 22500 | 10.97 | ±0.29 |
| 23000 | 11.09 | ±0.29 |
| 23500 | 11.26 | ±0.29 |
| 24000 | 11.37 | ±0.29 |
| 24500 | 11.50 | ±0.29 |
| 25000 | 11.61 | ±0.23 |
| 25500 | 11.72 | ±0.23 |
| 26000 | 11.87 | ±0.23 |
| 26500 | 11.99 | ±0.23 |
| 27000 | 12.09 | ±0.33 |
| 27500 | 12.24 | ±0.33 |
| 28000 | 12.34 | ±0.40 |
| 28500 | 12.47 | ±0.40 |
| 29000 | 12.61 | ±0.40 |
| 29500 | 12.70 | ±0.40 |
| 30000 | 12.86 | ±0.40 |
| 30500 | 12.92 | ±0.33 |
| 31000 | 13.09 | ±0.33 |
| 31500 | 13.16 | ±0.33 |
| 32000 | 13.33 | ±0.33 |
| 32500 | 13.40 | ±0.33 |
| 33000 | 13.62 | ±0.33 |
| 33500 | 13.70 | ±0.33 |
| 34000 | 13.88 | ±0.33 |
| 34500 | 13.97 | ±0.40 |
| 35000 | 14.05 | ±0.40 |
| 35500 | 14.23 | ±0.40 |
| 36000 | 14.25 | ±0.40 |
| 36500 | 14.46 | ±0.40 |
| 37000 | 14.49 | ±0.33 |
| 37500 | 14.72 | ±0.33 |
| 38000 | 14.77 | ±0.33 |
| 38500 | 14.97 | ±0.33 |
| 39000 | 15.04 | ±0.33 |
| 39500 | 15.22 | ±0.33 |
| 40000 | 15.63 | ±0.47 |

**HL 5405: RF cable**
**Huber-Suhner, SF118/11N(x2), s/n 500023/118**

| Set / Applied, MHz | Measured, dB | Uncertainty, dB |
|---|---|---|
| 0.1 | 0.01 | ±0.07 |
| 50 | 0.23 | ±0.07 |
| 100 | 0.32 | ±0.07 |
| 200 | 0.45 | ±0.08 |
| 300 | 0.55 | ±0.08 |
| 400 | 0.64 | ±0.08 |
| 500 | 0.71 | ±0.08 |
| 600 | 0.78 | ±0.08 |
| 700 | 0.85 | ±0.08 |
| 800 | 0.91 | ±0.08 |
| 900 | 0.97 | ±0.08 |
| 1000 | 1.02 | ±0.08 |
| 1100 | 1.07 | ±0.08 |
| 1200 | 1.12 | ±0.08 |
| 1300 | 1.16 | ±0.08 |
| 1400 | 1.21 | ±0.08 |
| 1500 | 1.25 | ±0.08 |
| 1600 | 1.30 | ±0.08 |
| 1700 | 1.34 | ±0.08 |
| 1800 | 1.38 | ±0.08 |
| 1900 | 1.42 | ±0.08 |
| 2000 | 1.47 | ±0.08 |
| 2500 | 1.64 | ±0.10 |
| 3000 | 1.81 | ±0.10 |
| 3500 | 1.97 | ±0.10 |
| 4000 | 2.11 | ±0.10 |
| 4500 | 2.25 | ±0.10 |

| Set / Applied, MHz | Measured, dB | Uncertainty, dB |
|---|---|---|
| 5000 | 2.38 | ±0.10 |
| 5500 | 2.48 | ±0.10 |
| 6000 | 2.59 | ±0.10 |
| 6500 | 2.72 | ±0.10 |
| 7000 | 2.84 | ±0.13 |
| 7500 | 2.97 | ±0.13 |
| 8000 | 3.08 | ±0.13 |
| 8500 | 3.21 | ±0.13 |
| 9000 | 3.31 | ±0.13 |
| 9500 | 3.42 | ±0.13 |
| 10000 | 3.52 | ±0.13 |
| 10500 | 3.62 | ±0.13 |
| 11000 | 3.72 | ±0.13 |
| 11500 | 3.81 | ±0.13 |
| 12000 | 3.93 | ±0.13 |
| 12500 | 4.00 | ±0.18 |
| 13000 | 4.09 | ±0.18 |
| 13500 | 4.18 | ±0.18 |
| 14000 | 4.26 | ±0.18 |
| 14500 | 4.35 | ±0.18 |
| 15000 | 4.45 | ±0.22 |
| 15500 | 4.54 | ±0.22 |
| 16000 | 4.61 | ±0.22 |
| 16500 | 4.69 | ±0.22 |
| 17000 | 4.78 | ±0.22 |
| 17500 | 4.84 | ±0.22 |
| 18000 | 4.92 | ±0.27 |

# 12 APPENDIX D Measurement uncertainties

**Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements**

| Test description | Expanded uncertainty |
|---|---|
| Conducted carrier power at RF antenna connector | Below 12.4 GHz: ± 1.7 dB<br>12.4 GHz to 40 GHz: ± 2.3 dB |
| Conducted emissions at RF antenna connector | 9 kHz to 2.9 GHz: ± 2.6 dB<br>2.9 GHz to 6.46 GHz: ± 3.5 dB<br>6.46 GHz to 13.2 GHz: ± 4.3 dB<br>13.2 GHz to 22.0 GHz: ± 5.0 dB<br>22.0 GHz to 26.8 GHz: ± 5.5 dB<br>26.8 GHz to 40.0 GHz: ± 4.8 dB |
| Occupied bandwidth | ± 8.0 % |
| Duty cycle, timing (Tx ON / OFF) and average factor measurements | ± 1.0 % |
| Conducted emissions with LISN | 9 kHz to 150 kHz: ± 3.9 dB<br>150 kHz to 30 MHz: ± 3.8 dB |
| Radiated emissions at 3 m measuring distance<br>Horizontal polarization<br><br><br>Vertical polarization | <br>Biconilog antenna: ± 5.3 dB<br>Biconical antenna: ± 5.0 dB<br>Log periodic antenna: ± 5.3 dB<br>Double ridged horn antenna: ± 5.3 dB<br>Biconilog antenna: ± 6.0 dB<br>Biconical antenna: ± 5.7 dB<br>Log periodic antenna: ± 6.0 dB<br>Double ridged horn antenna: ± 6.0 dB |

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

# 13 APPENDIX E Specification references

| | |
|---|---|
| FCC 47CFR part 15:2017 | Radio Frequency Devices. |
| RSS-247:2017, Issue 2 | Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices |
| RSS-Gen:2018, Issue 5 +A1(19) | General Requirements for Compliance of Radio Apparatus |
| ICES-003:2016, Issue 6 updated (2019) | Information Technology Equipment (Including Digital Apparatus) — Limits and Methods of Measurement |
| ANSI C63.2:2016 | American National Standard for Instrumentation-Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz-Specifications. |
| ANSI C63.4:2014 | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz. |
| ANSI C63.10:2013 | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| 558074 D01 DTS Meas_Guidance v05 | Guidance for compliance measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices operating under section 15.247 of the FCC rules |

# 14 APPENDIX F Abbreviations and acronyms

| | |
|---|---|
| A | ampere |
| AC | alternating current |
| AM | amplitude modulation |
| AVRG | average (detector) |
| cm | centimeter |
| dB | decibel |
| dBm | decibel referred to one milliwatt |
| dB(μV) | decibel referred to one microvolt |
| dB(μV/m) | decibel referred to one microvolt per meter |
| dB(μA) | decibel referred to one microampere |
| DC | direct current |
| EIRP | equivalent isotropically radiated power |
| ERP | effective radiated power |
| EUT | equipment under test |
| F | frequency |
| GHz | gigahertz |
| GND | ground |
| H | height |
| HL | Hermon laboratories |
| Hz | hertz |
| k | kilo |
| kHz | kilohertz |
| LO | local oscillator |
| m | meter |
| MHz | megahertz |
| min | minute |
| mm | millimeter |
| ms | millisecond |
| μs | microsecond |
| NA | not applicable |
| NB | narrow band |
| OATS | open area test site |
| Ω | Ohm |
| PM | pulse modulation |
| PS | power supply |
| ppm | part per million ($10^{-6}$) |
| QP | quasi-peak |
| RE | radiated emission |
| RF | radio frequency |
| rms | root mean square |
| Rx | receive |
| s | second |
| T | temperature |
| Tx | transmit |
| V | volt |
| WB | wideband |

END OF DOCUMENT