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# Test report

392836-1R2TRFWL

Date of issue: September 9, 2020

Applicant:
ABG Tag and Traq, Inc.

Product:
Indoor Ultra-wideband transmitter module

Model:
LRTNTMOD1

| FCC ID | IC ID |
|---|---|
| 2AAXVLRTNTMOD1 | 11400A-LRTNTMOD1 |

Specifications:

- FCC 47 CFR Part 15, Subpart F – §15.519
- Industry Canada RSS-220, Issue 1 + Amendment 1

## Lab and test locations

| | |
|---|---|
| Company name | Nemko USA Inc. |
| Address | 2210 Faraday Ave, Suite 150 |
| City | Carlsbad |
| State | California |
| Postal code | 92008 |
| Country | USA |
| Telephone | +1 760 444 3500 |
| Website | www.nemko.com |
| FCC Site Number | Test Firm Registration Number: 392943 Designation Number: US5058 |
| ISED Test Site | 2040B-3 |

| | |
|---|---|
| Tested by | James Cunningham, Wireless Supervisor |
| Reviewed by | Juan M Gonzalez, EMC & Wireless Divisions Manager |
| Review date | September 9, 2020 |
| Reviewer signature |  |

## Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.
This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

## Copyright notification

# Table of Contents

# Section 1 Report summary

## 1.1 Test specifications

| | |
|---|---|
| FCC 47 CFR Part 15, Subpart D – §15.519<br>IC RSS-220 Issue 1 + Amendment 1 | Technical requirements for hand held UWB systems<br>Devices using ultra-wideband (UWB) technology |

## 1.2 Test methods

| | |
|---|---|
| ANSI C63.10-2013 | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |

## 1.3 Exclusions

None

## 1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

*See "Summary of test results" for full details.*

## 1.5 Test report revision history

***Table 1.5-1: Test report revision history***

| Revision # | Details of changes made to test report |
|---|---|
| 392836-1TRFWL | Original report issued |
| 392836-R11TRFWL | Corrected model name, FCC ID and IC ID |
| 392836-1R2TRFWL | Updated to cover FCC Part 15.519 |

Notes:

# Section 2 Summary of test results

## 2.1 FCC Part 15.519 / RSS-220.

| Part | Test description | Verdict |
|---|---|---|
| §15.203 | Antenna requirements | Pass |
| §15.207 / RSS-Gen §7.2.4 | Conducted limits | Not applicable |
| §15.503(d) / RSS-220 §2 | Definition of UWB | Pass |
| §15.519(c) / RSS-220 §5.3.1(c) | Radiated emissions below 960 MHz | Pass |
| §15.519(c), (d) / RSS-220 §5.4.1(d), (e) | Radiated emissions above 960 MHz | Pass |
| §15.519(e) / RSS-220 §5.2.1(g) | Peak emission at $f_M$ | Pass |
| §15.519(a)(1) / RSS-220 §5.3.1(b) | Ceasing operation/Acknowledgment | Pass |

Note: EUT is battery powered

## 2.2 Operating modes investigated.

Measurements were performed with the EUT operating at 3.5 GHz and 4GHz.

# Section 3 Equipment under test (EUT) details

## 3.1 Applicant

| | |
|---|---|
| Company name | ABG Tag and Traq, Inc. |
| Address | 510 E. Memorial Road |
| City | Oklahoma City |
| Province/State | OK |
| Postal/Zip code | 73114-2214 |
| Country | USA |

## 3.2 Manufacturer

| | |
|---|---|
| Company name | ABG Tag and Traq, Inc. |
| Address | 510 E. Memorial Road |
| City | Oklahoma City |
| Province/State | OK |
| Postal/Zip code | 73114-2214 |
| Country | USA |

## 3.3 Sample information

| | |
|---|---|
| Receipt date | February 18, 2020 |
| Nemko sample ID number | NEx: 392836 |

## 3.4 EUT information

| | |
|---|---|
| Product name | Modular radio |
| Model | LRTNTMOD1 |
| Serial number | 2711 (configured for 3.5 GHz operation)<br>2745 (configured for 4 GHz operation) |
| Part number | N/A |
| Power requirements | Internal battery |
| Description/theory of operation | The EUT is an Ultra-wideband transmitter module intended for hand held applications. |
| Operational frequencies | 2 operating frequencies centered on 3.5 GHz and 4 GHz |
| Software details | ABG Tag and Traq Software Version 3 was used to test the EUT |

## 3.5 EUT exercise and monitoring details

The EUT was configured such that when it was switched on, it would begin transmitting on one of the defined operating frequencies at max power. Testing was performed using ABG Tag and Trag software which they label as Version 3. The power output was set before testing to maximum power (20dBm) with OOK modulation. This was set using the ABG Tag and Trag software Version 3. The ABG Tag and Trag firmware version is identified by them as version 14
INPUT/OUTPUT: Since this is a module there are no input/output signal to and from the EUT to describe
For testing at Nemko only power was provided to operate the EUT.Table 3.5-1: EUT sub assemblies

| Description | Brand name | Model/Part number | Serial number | Rev. |
|---|---|---|---|---|
| None | | | | |

***Table 3.5-2: EUT interface ports***

| Description | Qty. |
|---|---|
| None | |

***Table 3.5-3: Support equipment***

| Description | Brand name | Model/Part number | Serial number | Rev. |
|---|---|---|---|---|
| None | | | | |

***Table 3.5-4: Inter-connection cables***

| Cable description | From | To | Length (ft) |
|---|---|---|---|
| None | | | |

# Section 4 Engineering considerations

## 4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

## 4.2 Technical judgment

None

## 4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures

# Section 5 Test conditions

## 5.1 Atmospheric conditions

| | |
|---|---|
| Temperature | 15-30 °C |
| Relative humidity | 20-75 % |
| Air pressure | 86–106 kPa |

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

## 5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

# Section 6 Measurement uncertainty

## 6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

| Test name | Measurement uncertainty, dB |
|---|---|
| Radiated spurious emissions | 3.78 |
| Powerline conducted emissions | 1.38 |

# Section 7 Testing data

## 7.1 Antenna requirement

### 7.1.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §§15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

### 7.1.2 Test summary

| | |
|---|---|
| Verdict | Pass – The EUT has an integral antenna which is permanently attached |
| Test date | February 26, 2020 |
| Test engineer | James Cunningham |

## 7.2 Definition of UWB operating Bandwidth

### 7.2.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.503(d) / ANSI C63.10: 2013
RSS-220 → §2

### 7.2.2 Test summary

| | | | |
|---|---|---|---|
| Verdict | Pass | | |
| Test date | February 27, 2020 | Temperature | 23°C |
| Test engineer | James Cunningham | Air pressure | 1009 mbar |
| Test location | Wireless bench | Relative humidity | 26.3% |

### 7.2.3 Notes

Testing was performed with both 3.5 GHz and 4 GHz transmitter operation.

### 7.2.4 Setup details and Method

| | |
|---|---|
| EUT setup configuration | Tabletop |
| Test facility | Wireless bench |
| Measurement details | A horn antenna was connected to a spectrum analyzer and the EUT switched on. A max-hold sweep was used until the trace had stabilized. Using the spectrum analyzer markers, the frequencies $f_l$ and $f_h$ were measured. |
| ANSI C63.10 (2013) | Section 10.1 |

Receiver/spectrum analyzer settings:

| | |
|---|---|
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Detector mode | Peak |
| Trace mode | Max Hold |
| Measurement time | Long enough for trace to stabilize |

***Table 7.2-1: Definition of UWB equipment list***

| Equipment | Manufacturer | Model no. | Asset no. | Cal cycle | Next cal. |
|---|---|---|---|---|---|
| Signal and spectrum analyzer | Rohde & Schwarz | FSV | E1120 | 1 year | 19 Nov 2020 |
| Horn antenna | EMCO | 3115 | 0752 | 2 years | 21 Aug 2021 |

### 7.2.5 Test data, definition of UWB, 3.5 GHz operating channel

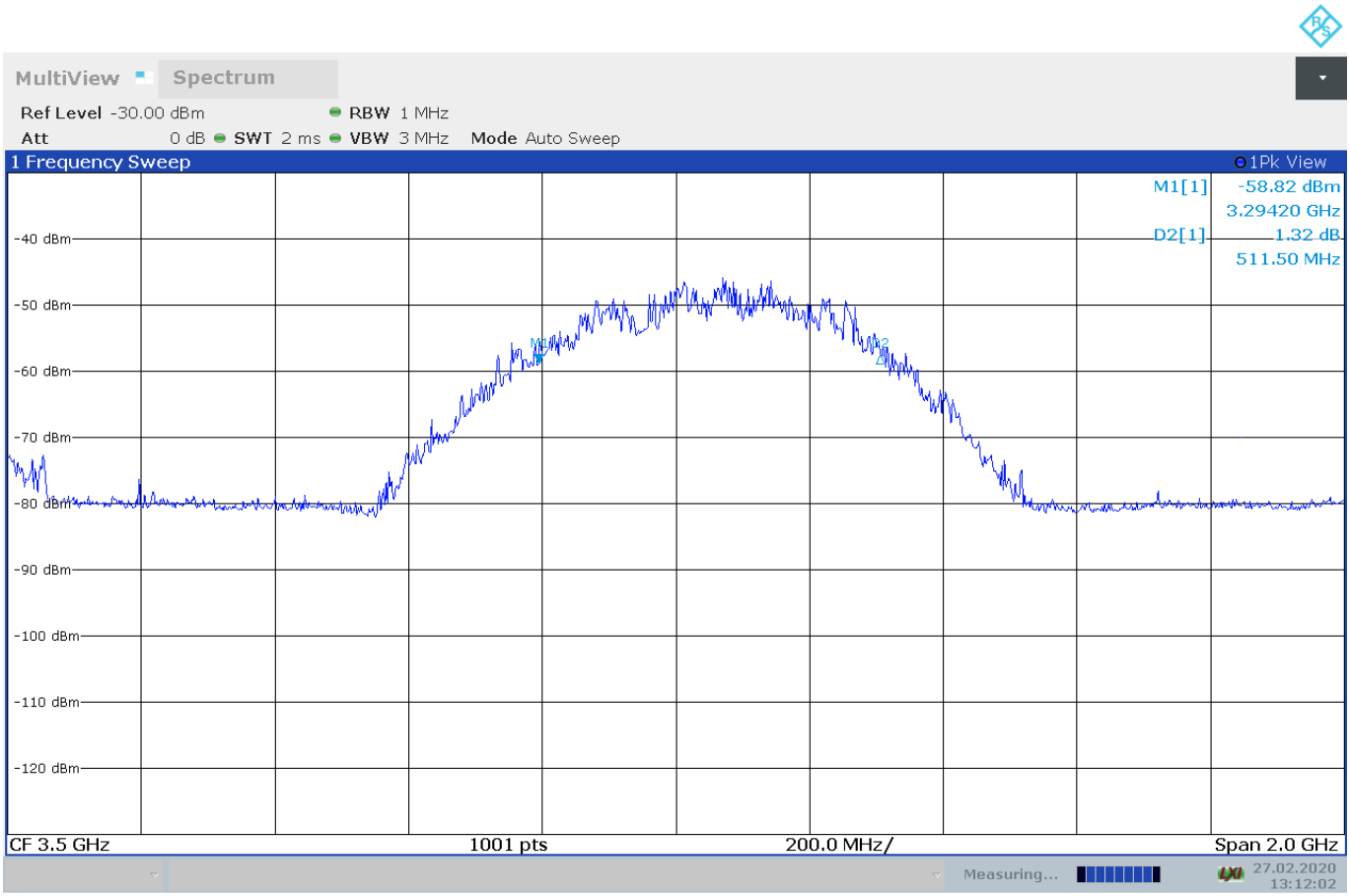


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***Figure 7.2-1: Definition of UWB, 3.5 GHz operating channel***

**Requirement: The 10 dB bandwidth shall be at least 500 MHz or the fractional bandwidth shall be >= 0.2 (§15.503(d))**

| Lower edge $f_l$ (GHz) | Upper edge $f_h$ (GHz) | 10 dB Bandwidth (MHz) | Limit (MHz) | Verdict |
|---|---|---|---|---|
| 3.29420 | 3.80570 | 511.5 | > 500 | PASS |

**Requirement: The 10 dB bandwidth of the device shall be totally contained in the band 3.1 GHz to 10.6 GHz (RSS-220 §5.1(a))**

| Frequency (GHz) | Limit (GHz) | Verdict |
|---|---|---|
| 3.29420 | > 3.1000 | PASS |
| 3.80570 | < 10.6000 | PASS |

### 7.2.6 Test data, definition of UWB, 4 GHz operating channel

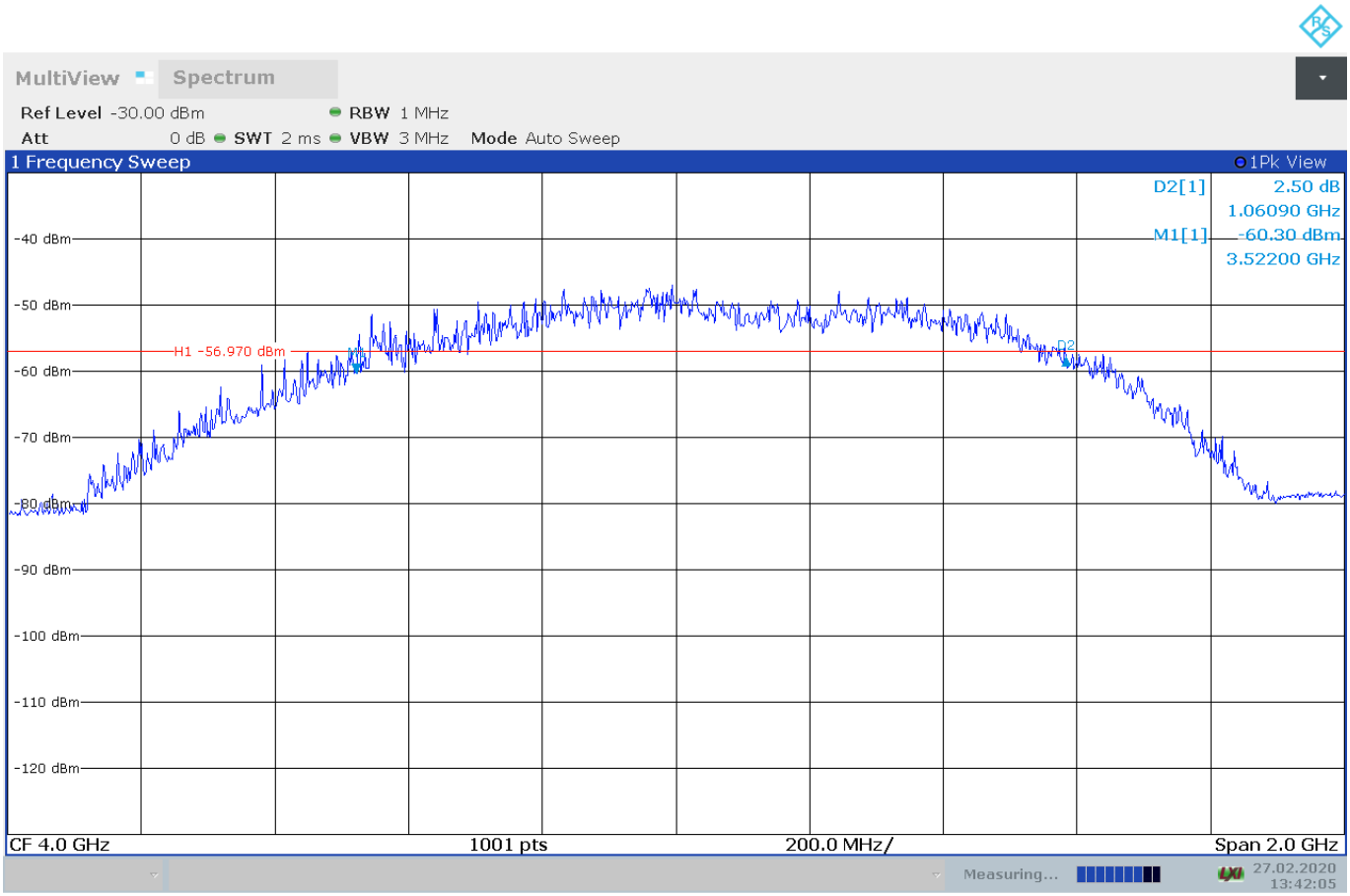


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***Figure 7.2-2: Definition of UWB, 4 GHz operating channel***

**Requirement: The 10 dB bandwidth shall be at least 500 MHz or the fractional bandwidth shall be >= 0.2 (§15.503(d))**

| Lower edge $f_l$ (GHz) | Upper edge $f_h$ (GHz) | 10 dB Bandwidth (MHz) | Limit (MHz) | Verdict |
|---|---|---|---|---|
| 3.52200 | 4.58290 | 1060.90 | > 500 | PASS |

**Requirement: The 10 dB bandwidth of the device shall be totally contained in the band 3.1 GHz to 10.6 GHz (RSS-220 §5.1(a))**

| Frequency (GHz) | Limit (MHz) | Verdict |
|---|---|---|
| 3.52200 | > 3.1000 | PASS |
| 4.58290 | < 10.6000 | PASS |

## 7.3 Radiated emissions below 960 MHz

### 7.3.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.519(c) and (d) / ANSI C63.10: 2013

(c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209.

| Frequency (MHz) | Field strength (microvolts/meter) | Measurement distance (meters) |
|---|---|---|
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 30 |
| 30-88 | 100** | 3 |
| 88-216 | 150** | 3 |
| 216-960 | 200** | 3 |
| Above 960 | 500 | 3 |

RSS-220 → §5.3.1(c)

(c) Radiated emission limits below 960 MHz from a device shall not exceed the limits in section 3.4:

| Frequency (MHz) | Field Strength (Microvolts/m) | Measurement Distance (Metres) | E.i.r.p. (dBmW) |
|---|---|---|---|
| 0.009-0.490 | 2,400/F (F in kHz) | 300 | 10 log (17.28 / $F^2$) (F in kHz) |
| 0.490-1.705 | 24,000/F (F in kHz) | 30 | 10 log (17.28 / $F^2$) (F in kHz) |
| 1.705-30 | 30 | 30 | -45.7 |
| 30-88 | 100 | 3 | -55.2 |
| 88-216 | 150 | 3 | -51.7 |
| 216-960 | 200 | 3 | -49.2 |

### 7.3.2 Test summary

| | | | |
|---|---|---|---|
| Verdict | Pass | | |
| Test date | February 26, 2020 | Temperature | 22 °C |
| Test engineer | James Cunningham, Wireless Supervisor | Air pressure | 1012 mbar |
| Test location | 10m semi anechoic chamber | Relative humidity | 21 % |

### 7.3.3 Notes

Testing was performed with both 3.5 GHz and 4 GHz transmitter operation.

### 7.3.4 Setup details

| | |
|---|---|
| EUT setup configuration | Table top |
| Test facility | 10 m Semi anechoic chamber |
| Measuring distance | 3 m |
| Antenna height variation | 1–4 m |
| Turn table position | 0–360° |
| Measurement details | A preview measurement was generated with receiver in continuous scan or sweep mode while the EUT was rotated and antenna adjusted to maximize radiated emission. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement. |
| ANSI C63.10 (2013) | Section 10.2 |

Receiver/spectrum analyzer settings for frequencies below 1 GHz:

| | |
|---|---|
| Resolution bandwidth | 120 kHz |
| Video bandwidth | 300 kHz |
| Detector mode | – Peak (Preview measurement)<br>– Quasi-peak (Final measurement) |
| Trace mode | Max Hold |
| Measurement time | – 100 ms (Peak preview measurement)<br>– 5000 ms (Quasi-peak final measurement) |

***Table 7.3-1: Radiated disturbance equipment list***

| Equipment | Manufacturer | Model no. | Asset no. | Cal cycle | Next cal. |
|---|---|---|---|---|---|
| EMI Test Receiver | Rohde & Schwarz | ESU40 | E1121 | 1 year | 25 May 2020 |
| System Controller | Sunol Sciences | SC104V | E1129 | NCR | NCR |
| Bilog Antenna | Schaffner | CBL6111C | 1480 | 1 year | 18 Apr 2020 |

Notes: NCR - no calibration required

***Table 7.3-2: Radiated disturbance test software details***

| Manufacturer of Software | Details |
|---|---|
| Rohde & Schwarz | EMC 32 V10.00.00 |

Notes: None

### 7.3.5 Test data, 3.5 GHz operation

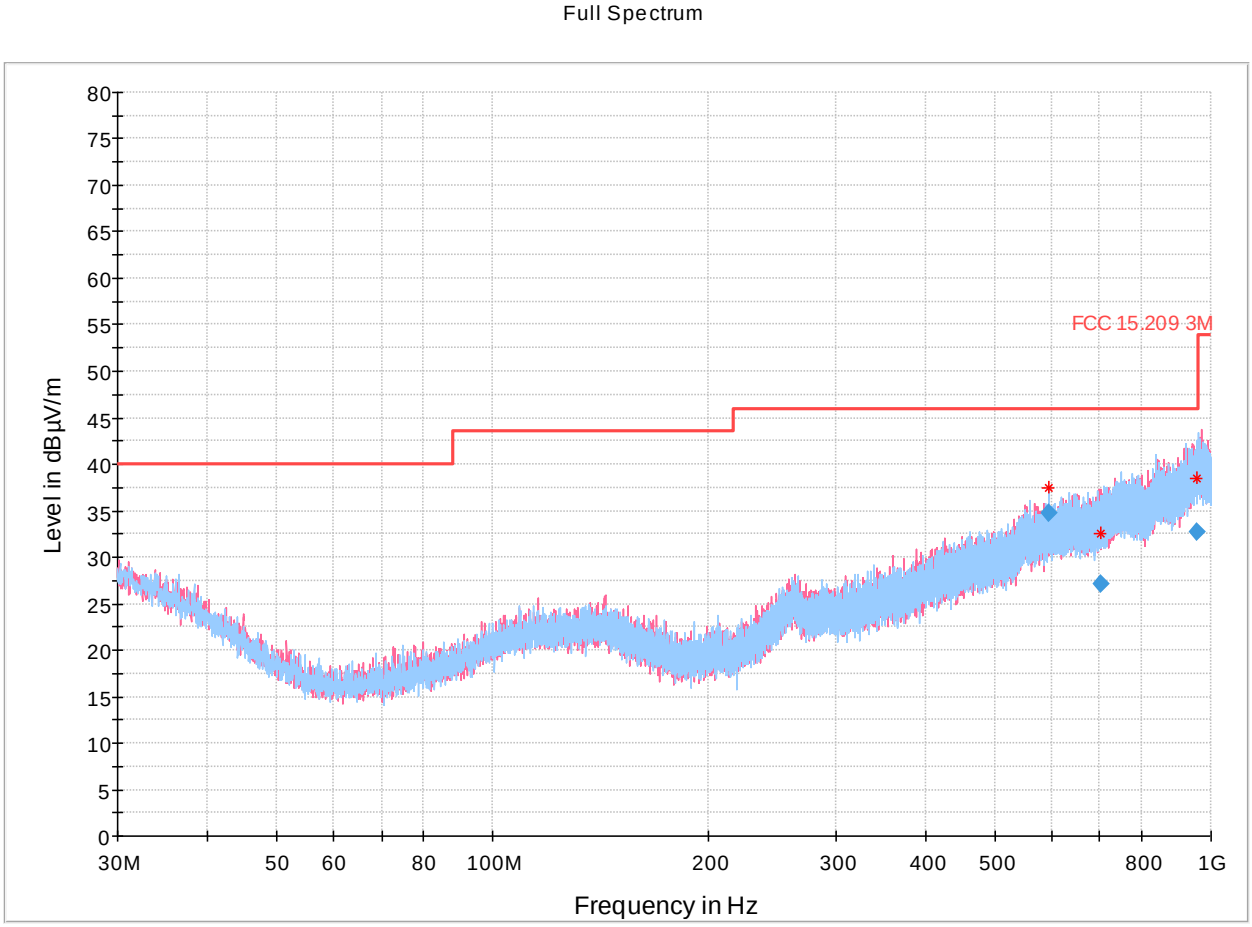



***Figure 7.3-3: Radiated emissions, 30 – 1000 MHz, 3.5 GHz operation***

***Table 7.3-3: Radiated Emissions, 30 – 1000 MHz, 3.5 GHz operation***

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 593.998000 | 34.82 | 46.00 | 11.18 | 5000.0 | 120.000 | 392.1 | H | 58.0 | 29.4 |
| 701.761667 | 27.15 | 46.00 | 18.85 | 5000.0 | 120.000 | 281.7 | V | 185.0 | 30.4 |
| 953.738667 | 32.78 | 46.00 | 13.22 | 5000.0 | 120.000 | 221.1 | H | 171.0 | 35.9 |

Notes: None
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

### 7.3.6 Test data, 4 GHz operation

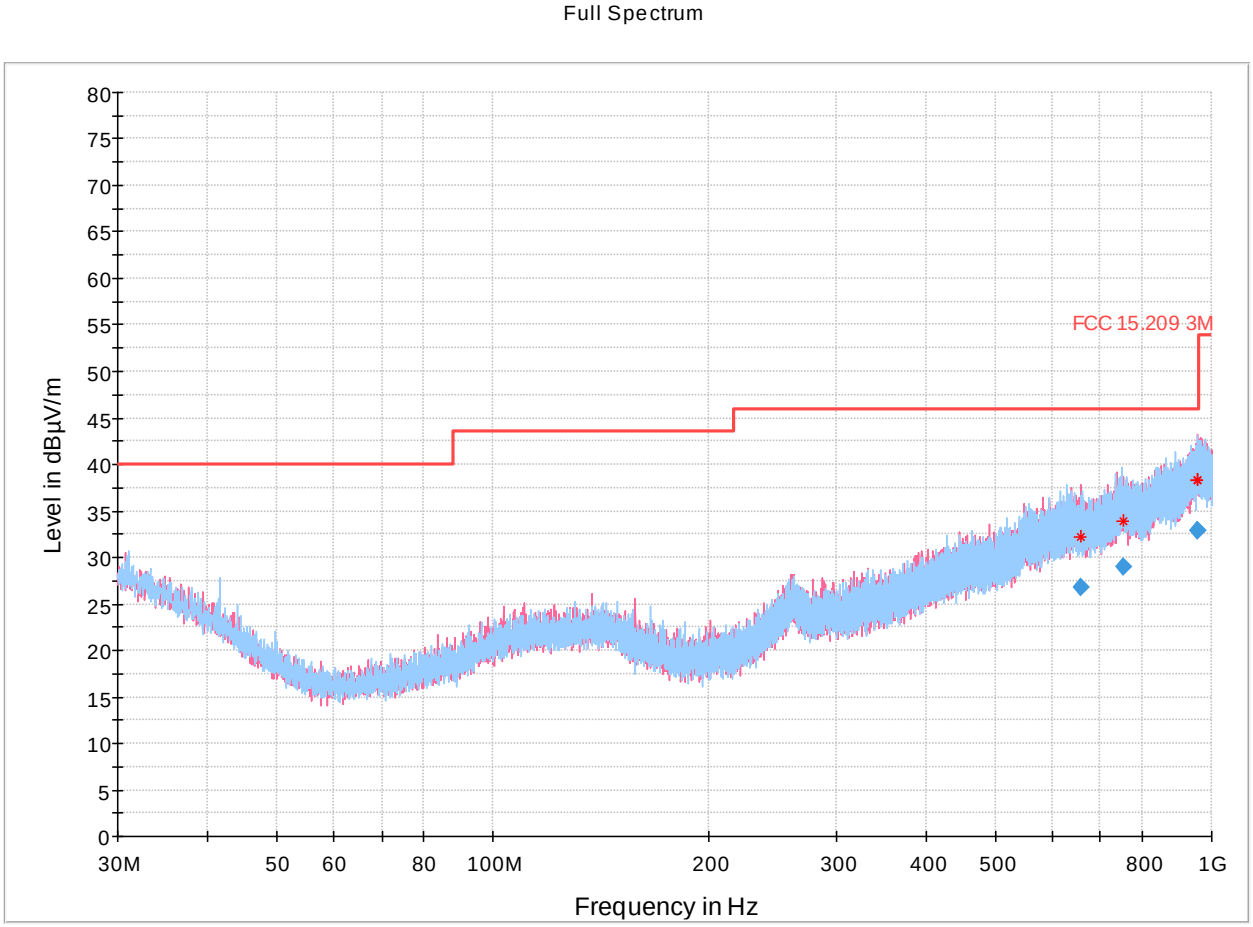



***Figure 7.3-4: Radiated emissions, 30 – 1000 MHz, 4 GHz operation***

***Table 7.3-4: Radiated Emissions, 30 – 1000 MHz, 4 GHz operation***

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 656.761667 | 26.77 | 46.00 | 19.23 | 5000.0 | 120.000 | 155.0 | V | 324.0 | 30.1 |
| 751.942667 | 28.92 | 46.00 | 17.08 | 5000.0 | 120.000 | 365.3 | H | 292.0 | 32.2 |
| 954.787667 | 32.81 | 46.00 | 13.19 | 5000.0 | 120.000 | 398.7 | V | 58.0 | 35.9 |
| 955.635667 | 32.92 | 46.00 | 13.08 | 5000.0 | 120.000 | 177.4 | H | 342.0 | 36.0 |

Notes: None
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

## 7.4 Radiated emissions above 960 MHz

### 7.4.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.519(c) and (d) / ANSI C63.10: 2013

(c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

| Frequency in MHz | EIRP in dBm |
|---|---|
| 960-1610 | −75.3 |
| 1610-1990 | −53.3 |
| 1990-3100 | −51.3 |
| 3100-10600 | −41.3 |
| Above 10600 | −51.3 |

(d) In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

| Frequency in MHz | EIRP in dBm |
|---|---|
| 1164-1240 | −85.3 |
| 1559-1610 | −85.3 |

RSS-220 → §5.3.1(d) and (e)

Radiated emissions above 960 MHz from a device shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

| Frequency in MHz | EIRP in dBm |
|---|---|
| 960-1610 | −75.3 |
| 1610-4750 | -70.0 |
| 4750-10600 | -41.3 |
| Above 10600 | -51.3 |

In addition to the limits specified in paragraph (d) of this section, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth of greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used:

| Frequency in MHz | EIRP in dBm |
|---|---|
| 1164-1240 | −85.3 |
| 1559-1610 | −85.3 |

15.521(h) The highest frequency employed in §15.33 to determine the frequency range over which radiated measurements are made shall be based on the center frequency, $f_C$, unless a higher frequency is generated within the UWB device. For measuring emission levels, the spectrum shall be investigated from the lowest frequency generated in the UWB transmitter, without going below 9 kHz, up to the frequency range shown in §15.33(a) or up to $f_C + 3/$(pulse width in seconds), whichever is higher. There is no requirement to measure emissions beyond 40 GHz provided $f_C$ is less than 10 GHz; beyond 100 GHz if $f_C$ is at or above 10 GHz and below 30 GHz; or beyond 200 GHz if $f_C$ is at or above 30 GHz.

No Emissions were noted above the 18GHz for this EUT.

### 7.4.2 Test summary

| | | | |
|---|---|---|---|
| Verdict | Pass | | |
| Test date | February 25, 2020<br>February 26, 2020 | Temperature | 22 °C<br>22 °C |
| Test engineer | James Cunningham, Wireless Supervisor | Air pressure | 1010 mbar<br>1012 mbar |
| Test location | 3m semi anechoic chamber | Relative humidity | 48 %<br>21 % |

### 7.4.3 Notes

Testing was performed with both 3.5 GHz and 4 GHz transmitter operation.

### 7.4.4 Setup details

| | |
|---|---|
| EUT setup configuration | Table top |
| Test facility | 3 m Semi anechoic chamber |
| Measuring distance | 0.5 m |
| Antenna height variation | 1–4 m |
| Turn table position | 0–360° |
| Measurement details | Measurements were performed with RF absorber on the floor of the chamber.<br><br>Due to the low limits, measurements were performed at 0.5m to have sufficiently low noise floor.<br><br>An initial analysis was performed to identity the orientation that maximized the transmitter level. All sweeps were performed in that orientation.<br><br>The EUT was rotated 360 degrees and the measurement antenna height and polarization varied while the receiver was sweeping in max-hold mode. |
| ANSI C63.10 (2013) | Section 10.3 |

Receiver/spectrum analyzer settings for frequencies above 1 GHz:

| | |
|---|---|
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 10 MHz |
| Detector mode | RMS |
| Trace mode | Max Hold |

Except in the frequency ranges 1164 – 1240 MHz and 1559 – 1610 MHz where the following settings were used:

| | |
|---|---|
| Resolution bandwidth | 1 kHz |
| Video bandwidth | 10 kHz |
| Detector mode | RMS |
| Trace mode | Max Hold |

***Table 7.4-1: Radiated disturbance equipment list***

| Equipment | Manufacturer | Model no. | Asset no. | Cal cycle | Next cal. |
|---|---|---|---|---|---|
| EMI Test Receiver | Rohde & Schwarz | ESU40 | E1131 | 1 year | 19-Nov-2020 |
| System Controller | Sunol Sciences | SC104V | E1129 | NCR | NCR |
| Horn Antenna | ETS Lindgren | 3117-PA | E1139 | 1 year | 21-Mar-2020 |

Notes: NCR - no calibration required

### 7.4.5 Test data, 3.5 GHz operation

***Table 7.4-2: Radiated Emissions, 1 - 18 GHz, 3.5 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (MHz) | Measured (dBµV) (RMS Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | FCC 15.519(c) Limit (dBm) | RSS-220 5.2.1(d) Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| 1000.0 | 1 | 39.6 | -19.0 | 3.7 | 24.3 | -86.5 | -75.3 | -75.3 | Pass |
| 1620.0 | 1 | 40.4 | -19.5 | 4.7 | 25.5 | -85.2 | -63.3 | -70.0 | Pass |
| 2550.0 | 1 | 39.5 | -16.2 | 5.8 | 29.1 | -81.6 | -61.3 | -70.0 | Pass |
| 7000.0 | 1 | 34.5 | -10.7 | 10.3 | 34.1 | -76.7 | -41.3 | -41.3 | Pass |
| 16000.0 | 1 | 31.1 | -8.9 | 16.7 | 38.9 | -71.8 | -61.3 | -61.3 | Pass |
| 18000.0 | 1 | 28.9 | -7.2 | 18.5 | 40.2 | -70.5 | -61.3 | -61.3 | Pass |

Notes: No spurious emissions detected
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)

E [dBµV/m]= EIRP [dBm]+20log(d [m])-104.8
Field strength (dBµV/m) converted to EIRP at 0.5 meters: EIRP = Field Strength -110.8

***Table 7.4-3: Radiated Emissions, 1164 - 1240 MHz and 1559 – 1610 MHz, 3.5 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (kHz) | Measured (dBµV) (Average Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | FCC 15.519(d) / RSS 220 5.2.1(e) Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|
| 1164.0 | 1 | 9.2 | -18.9 | 3.9 | -5.8 | -116.6 | -85.3 | Pass |
| 1200.0 | 1 | 22.0 | -18.4 | 4.0 | 7.5 | -103.3 | -85.3 | Pass |
| 1240.0 | 1 | 10.0 | -18.6 | 4.0 | -4.6 | -115.3 | -85.3 | Pass |
| 1559.0 | 1 | 10.9 | -20.0 | 4.6 | -4.5 | -115.3 | -85.3 | Pass |
| 1560.0 | 1 | 15.4 | -20.0 | 4.6 | 0.0 | -110.8 | -85.3 | Pass |
| 1610.0 | 1 | 10.6 | -19.7 | 4.7 | -4.4 | -115.1 | -85.3 | Pass |

Notes:
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Field strength (dBµV/m) converted to EIRP: EIRP = Field Strength -110.8

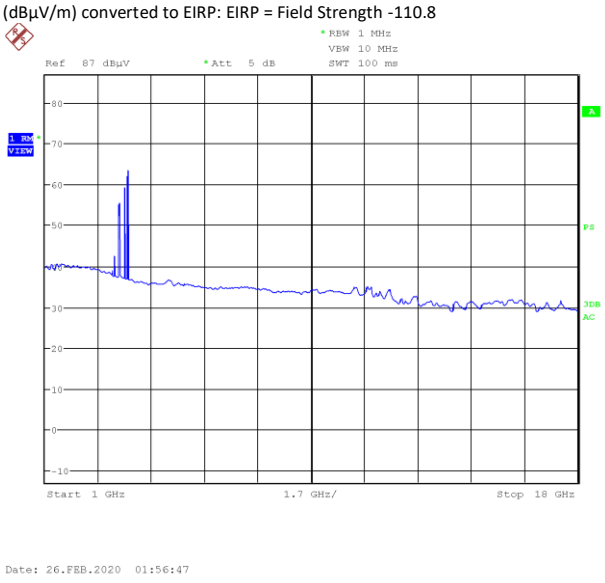



***Figure 7.4-5: Radiated emissions, 1 – 18 GHz, 3.5 GHz operation***

Note: Emissions observed around 3.5 GHz are due to the intentional transmissions of the UWB transmitter and are not evaluated here.
Per 15.521(h) – the spectrum was scanned up to 40GHz and no emissions were noted

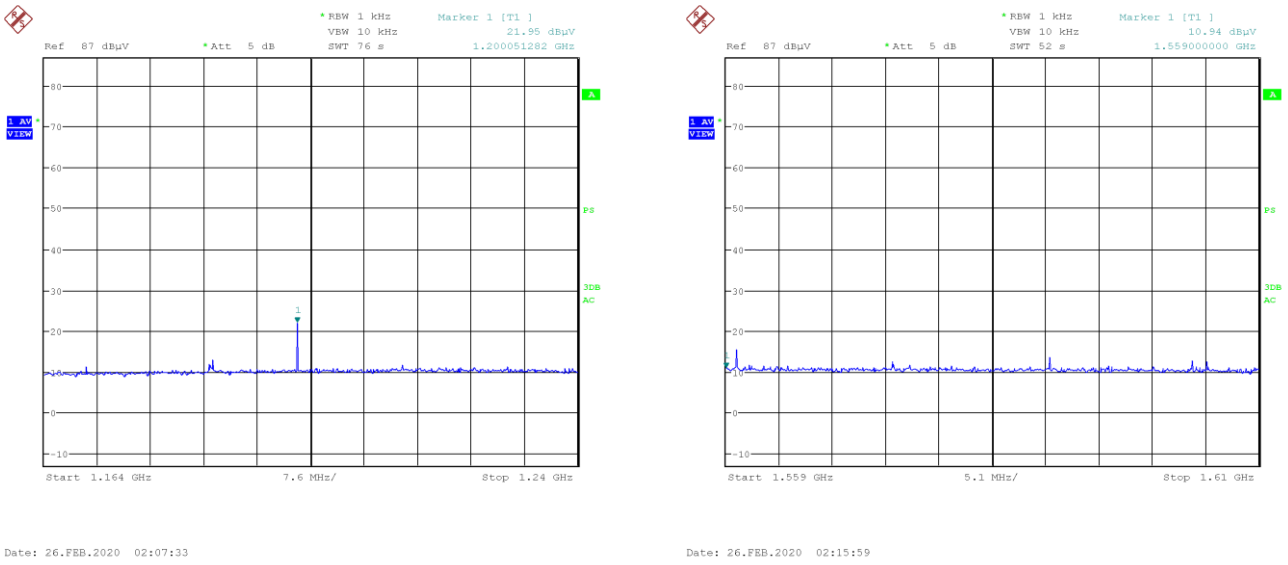



***Figure 7.4-6: Radiated emissions, 1164 - 1240 MHz and 1559 – 1610 MHz, 3.5 GHz operation***

### 7.4.6 Test data, 4 GHz operation

***Table 7.4-4: Radiated Emissions, 1 - 18 GHz, 4 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (MHz) | Measured (dBµV) (RMS Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | FCC 15.519(c) Limit (dBm) | RSS-220 5.2.1(d) Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| 1000.0 | 1 | 39.7 | -19.0 | 3.7 | 24.4 | -86.4 | -75.3 | -75.3 | Pass |
| 1620.0 | 1 | 40.5 | -19.5 | 4.7 | 25.7 | -85.1 | -63.3 | -70.0 | Pass |
| 2550.0 | 1 | 39.6 | -16.2 | 5.8 | 29.3 | -81.5 | -61.3 | -70.0 | Pass |
| 7000.0 | 1 | 34.7 | -10.7 | 10.3 | 34.3 | -76.5 | -41.3 | -41.3 | Pass |
| 16000.0 | 1 | 31.2 | -8.9 | 16.7 | 38.9 | -71.8 | -61.3 | -61.3 | Pass |
| 18000.0 | 1 | 29.0 | -7.2 | 18.5 | 40.3 | -70.4 | -61.3 | -61.3 | Pass |

Notes: No spurious emissions detected
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Field strength (dBµV/m) converted to EIRP: EIRP = Field Strength -110.8

***Table 7.4-5: Radiated Emissions, 1164 - 1220 MHz and 1559 – 1610 MHz, 4 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (kHz) | Measured (dBµV) (Average Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | FCC 15.519(d) / RSS 220 5.2.1(e) Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|
| 1164.0 | 1 | 9.5 | -18.9 | 3.9 | -5.4 | -116.2 | -85.3 | Pass |
| 1200.0 | 1 | 22.3 | -18.4 | 4.0 | 7.9 | -102.9 | -85.3 | Pass |
| 1240.0 | 1 | 10.2 | -18.6 | 4.0 | -4.3 | -115.1 | -85.3 | Pass |
| 1559.0 | 1 | 11.0 | -20.0 | 4.6 | -4.5 | -115.2 | -85.3 | Pass |
| 1560.0 | 1 | 16.9 | -20.0 | 4.6 | 1.4 | -109.4 | -85.3 | Pass |
| 1610.0 | 1 | 10.0 | -19.7 | 4.7 | -5.0 | -115.7 | -85.3 | Pass |

Notes:
Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Field strength (dBµV/m) converted to EIRP: EIRP = Field Strength -110.8

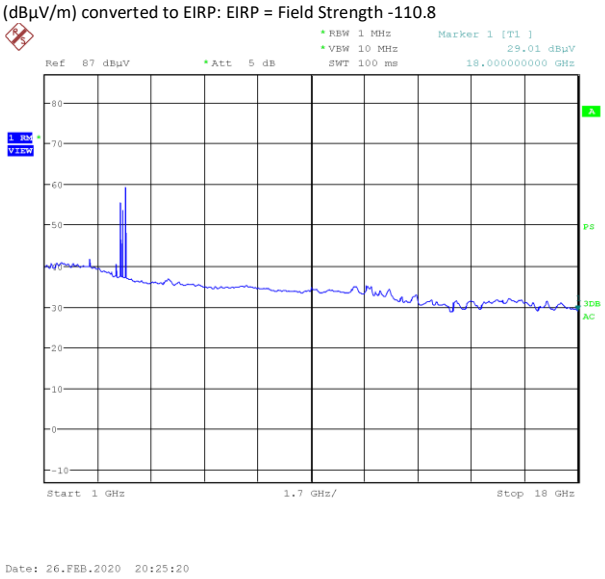



***Figure 7.4-7: Radiated emissions, 1 – 18 GHz, 4 GHz operation***

Note: Emissions observed around 4 GHz are due to the intentional transmissions of the UWB transmitter and are not evaluated here.

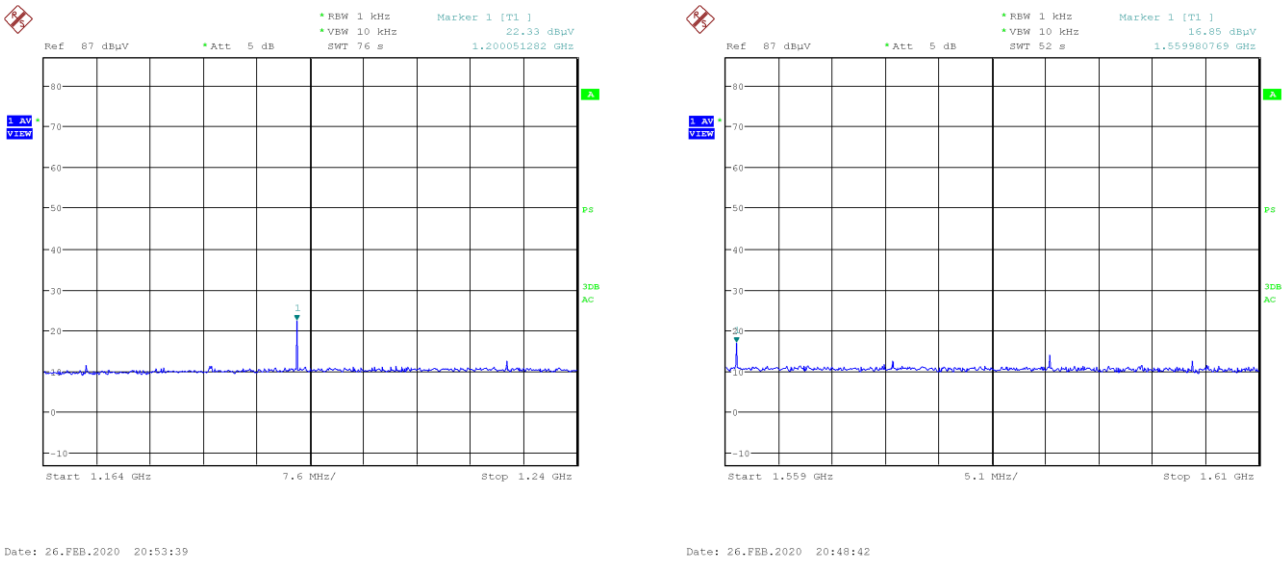



***Figure 7.4-8: Radiated emissions, 1164 - 1240 MHz and 1559 – 1610 MHz, 4 GHz operation***

## 7.5 Peak emission $f_M$

### 7.5.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.519(e)

(e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, $f_M$. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521.

RSS-220 -> §5.3.1(g) and Annex 4(c)

(g) The peak level of transmissions shall not exceed the peak equivalent of the average limit contained within any 50 MHz bandwidth, as defined in Section 4 of the Annex.
Peak Power: the peak level of transmission contained within a 50 MHz bandwidth centered on the frequency at which the highest average radiated power occurs ($f_M$). If a resolution bandwidth (RBW) other than 50 MHz is employed, the peak EIRP limit shall be 20Log(RBW/50) dBm where RBW is in units of megahertz.

### 7.5.2 Test summary

| | | | |
|---|---|---|---|
| Verdict | Pass | | |
| Test date | February 26, 2020 | Temperature | 22°C |
| Test engineer | James Cunningham | Air pressure | 1012 mbar |
| Test location | Ground Plane 1 | Relative humidity | 20 % |

### 7.5.3 Notes

Testing was performed with both 3.5 GHz and 4 GHz transmitter operation.

### 7.5.4 Setup Details

| | |
|---|---|
| EUT setup configuration | Table top |
| Test facility | 3 m Semi anechoic chamber |
| Measuring distance | 0.5 m |
| Antenna height variation | 1–4 m |
| Turn table position | 0–360° |
| Measurement details | Measurements were performed with RF absorber on the floor of the chamber.<br><br>Due to the low limits, measurements were performed at 0.5m to have sufficiently low noise floor.<br><br>An initial analysis was performed to identity the orientation that maximized the transmitter level. All sweeps were performed in that orientation.<br><br>The EUT was rotated 360 degrees and the measurement antenna height and polarization varied while the receiver was sweeping in max-hold mode. The sweep was left to run until the trace stabilized. |
| ANSI C63.10 (2013) | Section 10.3 |

Receiver/spectrum analyzer settings for frequencies above 1 GHz:

| | |
|---|---|
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Detector mode | Peak |
| Trace mode | Max Hold |

***Table 7.5-1: Peak emission equipment list***

| Equipment | Manufacturer | Model no. | Asset no. | Cal cycle | Next cal. |
|---|---|---|---|---|---|
| EMI Test Receiver | Rohde & Schwarz | ESU40 | E1131 | 1 year | 19-Nov-2020 |
| System Controller | Sunol Sciences | SC104V | E1129 | NCR | NCR |
| Horn Antenna | ETS Lindgren | 3117-PA | E1139 | 1 year | 21-Mar-2020 |

Notes: NCR - no calibration required

## 7.5.5 Test data peak emission, 3.5 GHz operation

***Table 7.5-2: Peak emission, 3.5 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (MHz) | Measured (dBµV) (Peak Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|
| 3418.3 | 1 | 79.6 | -14.4 | 6.8 | 71.9 | -38.8 | -34.0 | Pass |

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Field strength (dBµV/m) converted to EIRP: EIRP = Field Strength -110.8
Limit adjusted for 1 MHz resolution bandwidth per ANSI C63.10 §10.3.6: Adjusted Limit = Limit "0" + 20Log(1/50) dBm = -34 dBm

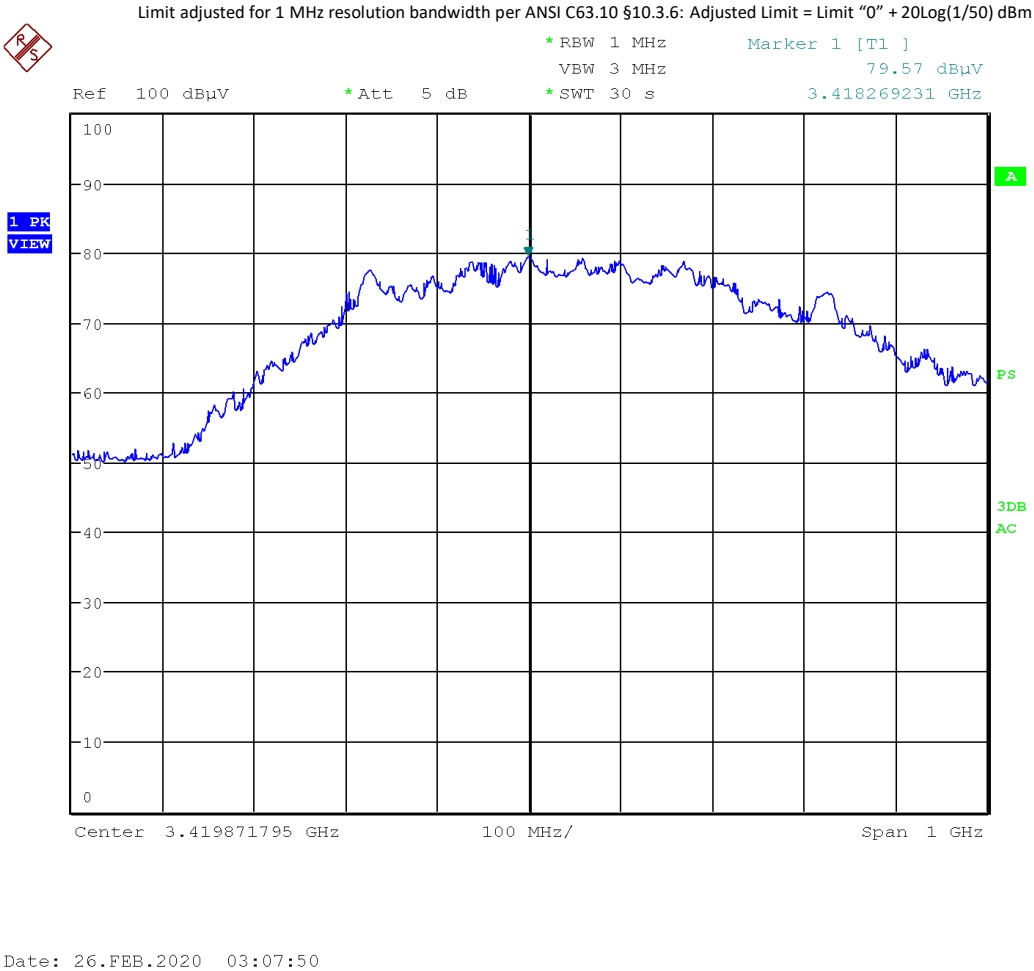



***Figure 7.5.1: Peak emission $f_M$: 3.5 GHz operation***

## 7.5.6 Test data peak emission, 4 GHz operation

***Table 7.5-3: Peak emission, 4 GHz operation***

| Frequency (MHz) | Resolution Bandwidth (MHz) | Measured (dBµV) (Peak Detector) | Antenna Factor (dB/m) | Cable Loss (dB) | Field Strength at 0.5 m (dBµV/m) | EIRP (dBm) | Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|
| 4346.2 | 1 | 73.9 | -11.9 | 7.8 | 69.8 | -41.0 | -34.0 | Pass |

Notes:

Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factors = antenna factor ACF (dB) + cable loss (dB)
Field strength (dBµV/m) converted to EIRP: EIRP = Field Strength -110.8
Limit adjusted for 1 MHz resolution bandwidth per ANSI C63.10 §10.3.6: Adjusted Limit = Limit "0" + 20Log(1/50) dBm = -34 dBm

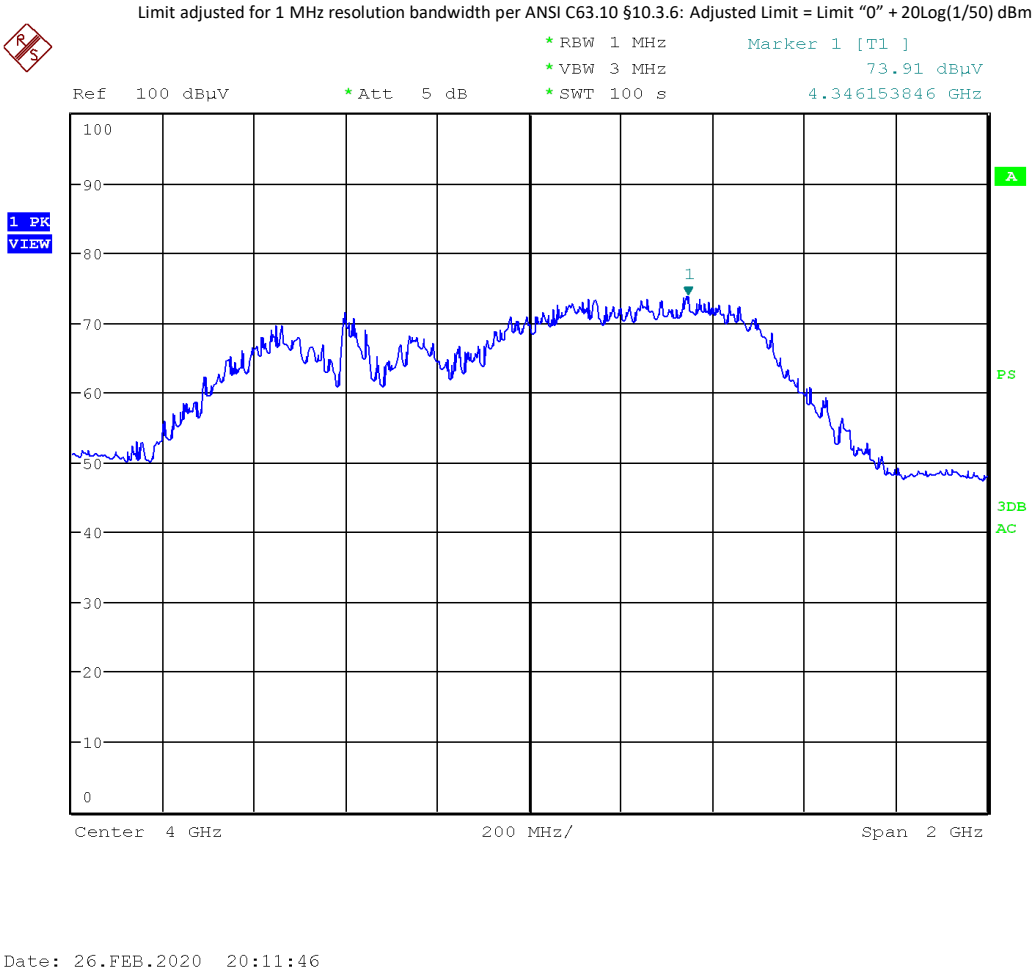



***Figure 7.5.2: Peak emission $f_M$: 4 GHz operation***

## 7.6 Operation of hand help equipment

### 7.6.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.519(a)

§15.519 Technical requirements for hand held UWB systems.

(a) UWB devices operating under the provisions of this section must be hand held, *i.e.*, they are relatively small devices that are primarily hand held while being operated and do not employ a fixed infrastructure.

(1) A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

RSS-220 -> §5.3.1(b)

b. The device is to transmit only when it is sending information to an associated receiver. The device shall cease transmission of information within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB device at least every 10 seconds or the UWB device shall cease transmitting any information other than periodic signals used for the establishment or re-establishment of a communication link with an associated receiver.

### 7.6.2 Test summary – Declared information from customer with plot

| | |
|---|---|
| Verdict | Pass |

### 7.6.3 Notes

Npme

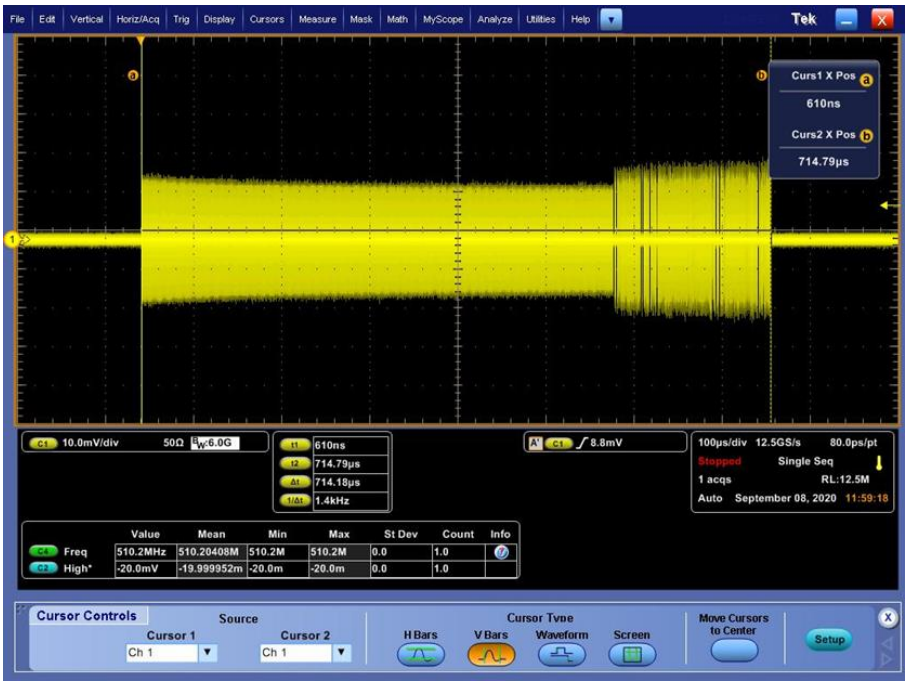
### 7.6.4 Setup Details

| | |
|---|---|
| EUT setup configuration | Table top |
| ANSI C63.10 (2013) | None |

### 7.6.5 Test data – operation time < 10s

Per the 15.519(a)(1) requirement, the UWB transmitter is allowed to operate up to 10 seconds after which it must cease its transmission if it has not received an acknowledgement from the associated receiver. As demonstrated, the UWB transmitter will automatically cease its transmission after only 715 microseconds, meeting the requirement in much less than the allowed 10 seconds.

***Picture showing operation is 0.715ms long***



# Section 8 Block diagrams of test set-ups

## 8.1 Radiated emissions set-up

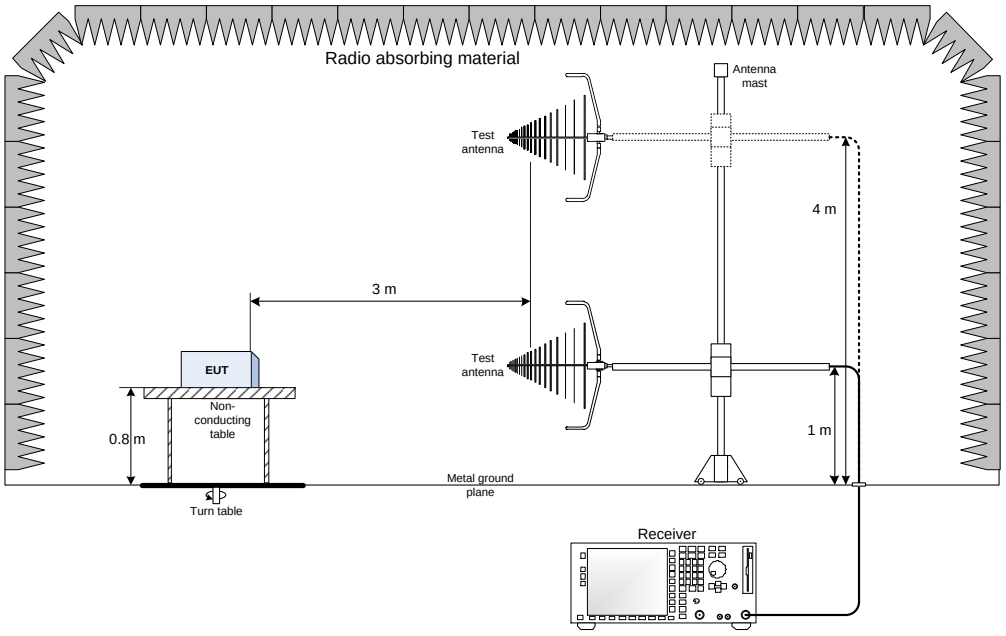



***Figure 3 30 MHz - 1000 MHz Setup***

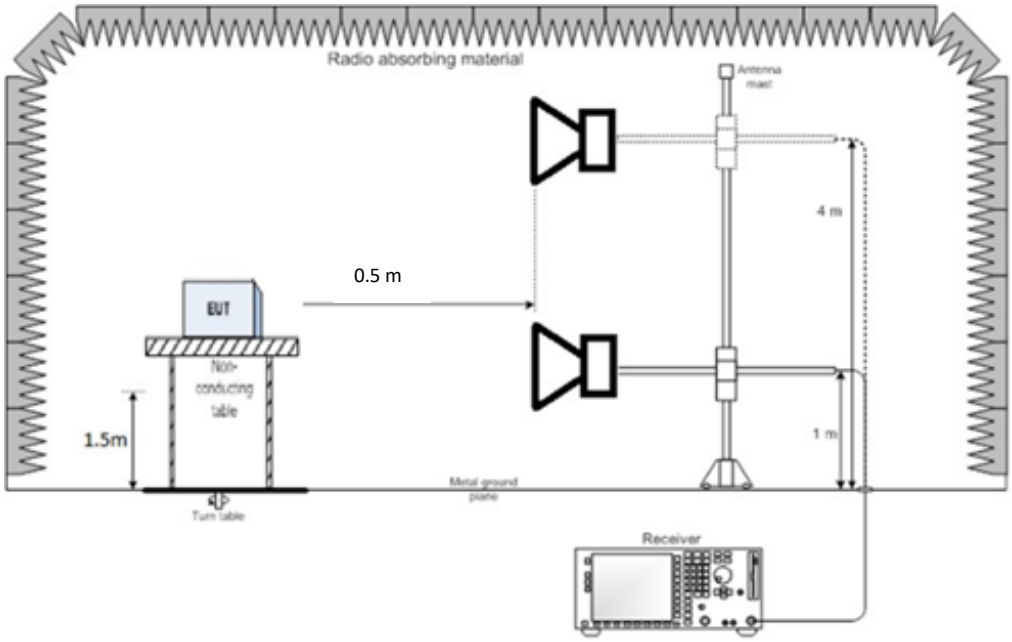



***Figure 4 1 GHz – 40 GHz Setup***

Thank you for choosing