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# RADIO TEST REPORT – 419806-3TRFWL

Type of assessment:

**Final product testing**

Applicant:

**Mobilaris AB**

Product name (type):

**Tracking Device**

Model:

**Multitag 1.0**

FCC ID:

**2AL7AMULTITAG1**

IC Registration number:

**22755-MULTITAG1**

Specifications:

- ◆ FCC 47 CFR Part 15, Subpart F, §15.519
- ◆ RSS-220, Issue 1, July 2018

Date of issue: **June 25, 2021**

**Kevin Rose, Senior EMC/RF Specialist**

Tested by

Signature

**David Duchesne, EMC/RF Lab Manager**

Reviewed by

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#### 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 contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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## Section 1. Report summary

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### 1.1 Test specifications

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FCC 47 CFR Part 15, Subpart F, Clause 15.519	Technical Requirements for Handheld UWB systems
RSS-220, Issue 1, July 2018	Devices Using Ultra-Wideband (UWB) Technology

### 1.2 Test methods

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ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC KDB 393764 DO1 v 02 Jan 2018	Ultra-Wide Band (UWB) Devices
RSS-Gen, Issue 5, March 2019	General Requirements for Compliance of Radio Apparatus

### 1.3 Exclusions

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None

### 1.4 Statement of compliance

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In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.3 above. 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

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

Revision #	Date of issue	Details of changes made to test report
TRF	June 25, 2021	Original report issued

## Section 2. Engineering considerations

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### 2.1 Modifications incorporated in the EUT for compliance

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

### 2.2 Technical judgment

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None

### 2.3 Deviations from laboratory tests procedures

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No deviations were made from laboratory procedures.

## Section 3. Test conditions

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### 3.1 Atmospheric conditions

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Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

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.

### 3.2 Power supply range

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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  $\pm 5\%$ , for which the equipment was designed.

## Section 4. Measurement uncertainty

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### 4.1 Uncertainty of measurement

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UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

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

**Table 4.1-1:** Measurement uncertainty calculations for Radio

Test name	Measurement uncertainty, $\pm$ dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

## Section 5. Information provided by the applicant

### 5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

### 5.2 Applicant

Applicant name	Mobilaris AB
Applicant address	Kyrkogatan 2; 973 23 Luleå; Sweden
Manufacture name	Same as applicant
Manufacture address	Same as applicant

### 5.3 EUT information

Product	Tracking Device
Model	Multitag 1.0
Serial number	00071
Power supply requirements	Operational mode: Battery: 3.7 V <sub>DC</sub>
Product description and theory of operation	<p>Intended use for the Mobilaris MultiTag are:</p> <ul style="list-style-type: none"> <li>To send positioning data (<b>GPS</b>) and environmental parameters to Mobilaris Backend via <b>LTE Cat-M1 or NB-IoT</b>.</li> <li>To be used as a key to open doors (<b>NFC</b>), gates and give access to enter areas from moving vehicles and or by pedestrians.</li> <li>To be connected via <b>BLE</b> to other devices such as gas sensors from Dräger or others.</li> <li>To detect a "man down" scenario and push a note to rescue personal.</li> <li>Proximity detection via <b>UWB</b>, tag to tag ranging.</li> <li>Proximity notifications may vary from customer to costumer, buzzer, light or other warning signal can be connected to the tag via the proprietary 3.5 mm interface.</li> <li>Workers inside various industrial sites will be equipped with a tag that send their position in order to prevent serious injuries.</li> <li>To track (<b>GPS or BLE positioning</b>) personal in case of evacuation.</li> <li>Send notifications to personal lacking sufficient training to enter certain areas.</li> </ul> <p>Set up geofences, temporarily or permanently, to avoid or minimize entrance.</p>

## 5.4 Technical information

Applicant IC company number	22755
IC UPN number	MULTITAG1
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-220 Issue 1
Operation type	<input checked="" type="checkbox"/> Periodic <input type="checkbox"/> Non-periodic
Frequency band	3100 – 10600 MHz
Frequency (MHz)	3494.4 MHz, 3993.6 MHz, 4492.8 MHz, 6489.6 MHz
Channel numbers	1, 2, 3, and 5
Field strength, dB $\mu$ V/m @ 3 m	CH1: 89.19 dB $\mu$ V/m, CH2: 87.51 dB $\mu$ V/m, CH3: 94.85 dB $\mu$ V/m, CH5: 94.21 dB $\mu$ V/m
Full average EIRP power in dBm over full BW	CH1: -39.96 dBm, CH2: -40.37 dBm, CH3: -33.84 dBm, CH5: -33.58 dBm
Measured BW (MHz), 99% OBW	779.97 MHz
Measured BW (MHz), 10 dB BW	CH1: 540.7 MHz, CH2: 625.7 MHz, CH3: 569.8 MHz, CH5: 632.4 MHz,
Type of modulation	BPM, BPSK
Emission classification	632MG1D
Transmitter spurious, dB $\mu$ V/m @ 3 m	6.72 dB $\mu$ V/m @ 1187 MHz
Power supply requirements	Operational mode: Battery: 3.7 V <sub>DC</sub>
Antenna information	Integrated circuit
Test software	nRF Connect V3.6.1

## 5.5 EUT setup details

### 5.5.1 Radio exercise details

Operating conditions	The EUT is loaded with the test firmware that enables the control of UWB channels via AT Command interface.
Transmitter state	Transmitter set into continuous mode.

### 5.5.2 EUT test configuration



**Figure 5.5-1:** Radiated testing block diagram

## Section 6. Summary of test results

### 6.1 Testing location

Test location (s) Ottawa

### 6.2 Testing period

Test start date April 28, 2021 Test end date April 28, 2021

### 6.3 Sample information

Receipt date April 19, 2021 Nemko sample ID number(s) 1

### 6.4 FCC Part 15 Subpart C, general requirements test results

**Table 6.4-1: FCC general requirements results**

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable
§15.31l	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is a battery-operated device, the testing was performed using fully charged batteries.

### 6.5 FCC Part 15 Subpart F, intentional radiators test results

**Table 6.5-1: FCC 15.519 requirements results**

Part	Test description	Verdict
§15.519(a)	Operational Requirements	Pass
§15.519(c)	Field strength of emissions	Pass
§15.519(b)	Emission bandwidth	Pass
§15.519(d)	Field Strength of emissions within 1164-1240 and 1559-1610 MHz	Pass
§15.519(e)	Peak Emissions within 50 MHz band	Pass

## 6.6 ISED RSS-Gen, Issue 5, test results

**Table 6.6-1: RSS-Gen results**

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Not applicable

Notes: <sup>1</sup> According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

## 6.7 ISED RSS-220, Issue 1, test results

**Table 6.7-1: RSS-220 results**

Section	Test description	Verdict
5.3.1 (a)	Antenna requirements	Pass
5.3.1 (b)	Operational requirements	Pass
5.3.1 (c) and (d)	Field strength of emissions	Pass
5.3.1 (e)	Field strength of emissions within 1164-1240 and 1559 -1610 MHz band	Pass
5.3.1 (g)	Peak emissions within 50 MHz bandwidth	Pass
5.1 (b)	Emission bandwidth	Pass

## Section 7. Test equipment

### 7.1 Test equipment list

**Table 7.1-1: Equipment list**

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	March 26, 2022
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	November 6, 2021
Preamplifier (1–18 GHz)	ETS Lindgren	124334	FA002877	1 year	October 13, 2021
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	February 2, 2022
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 13, 2021
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	May 7, 2021
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	April 31, 2021
Pre-amplifier (26–40 GHz)	Narda	DBL-2640N610	FA001556	—	VOU
50 Ω coax cable	C.C.A.	None	FA002556	1 year	March 24, 2022

Note: NCR - no calibration required, VOU - verify on use

## Section 8. Testing data

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### 8.1 FCC 15.31(e) Variation of power source

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#### 8.1.1 References, definitions and limits

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For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

#### 8.1.2 Test summary

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Verdict	Pass		
Tested by	Kevin Rose	Test date	April 28, 2021

#### 8.1.3 Observations, settings and special notes

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None

#### 8.1.4 Test data

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EUT Power requirements:

	<input type="checkbox"/> AC	<input type="checkbox"/> DC	<input checked="" type="checkbox"/> Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A
If EUT is battery operated, was the testing performed using fresh batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	<input checked="" type="checkbox"/> YES	<input type="checkbox"/> NO	<input type="checkbox"/> N/A

## 8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

### 8.2.1 References, definitions and limits

**FCC:**

Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

**ISED:**

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

**Table 8.2-1: Frequency Range of Operation**

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Note: “near” means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

### 8.2.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021

### 8.2.3 Observations, settings and special notes

The EUT is an UWB device, so its full operating bandwidth is examined.

### 8.2.4 Test data

**Table 8.2-2: Test channels selection**

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Center Frequency, MHz
3100	10600	540.7	3494.4
3100	10600	625.7	3993.6
3100	10600	569.8	4492.8
3100	10600	632.4	6489.6



## 8.3 FCC 15.203 and RSS-Gen , section 6.8 Antenna requirement

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### 8.3.1 References, definitions and limits

---

**FCC:**

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 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.

**ISED:**

**RSS-Gen**

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

### 8.3.2 Test summary

---

Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021

### 8.3.3 Observations, settings and special notes

---

None

### 8.3.4 Test data

---

Must the EUT be professionally installed?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO
Does the EUT have detachable antenna(s)?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO
If detachable, is the antenna connector(s) non-standard?	<input type="checkbox"/> YES	<input type="checkbox"/> NO <input checked="" type="checkbox"/> N/A

## 8.4 FCC 15.519 (e) and RSS-220 5.3.1 (g) Peak emissions within 50 MHz band

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### 8.4.1 References, definitions and limits

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#### **FCC:**

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

When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs,  $f_m$ . If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be  $20 \log(RBW/50)$  dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using  $E(dB\mu V/m) = P(dBm \text{ EIRP}) + 95.2$ . If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing

#### **ISED:**

The peak level of the 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 measurements shall be made in addition to average measurements. Transmissions shall not exceed 0 dBm e.i.r.p. in any 50 MHz bandwidth when the average limit is -41.3 dBm/MHz This is the equivalent peak limit as calculated by combining the 6 dB peak-to-average conversion with a resolution bandwidth (RBW) scaling factor of  $20 \log(1 \text{ MHz}/50 \text{ MHz})$ . Only the 50 MHz bandwidth, centered on the frequency,  $f_m$  where the highest power occurs, needs to be measured to satisfy the peak requirements for all frequencies. A different resolution bandwidth and a correspondingly different peak limit may also be used, in which case the RBW may be set anywhere between 1 MHz and 50 MHz The peak e.i.r.p. limit is then calculated as  $20 \log(RBW/50)$  dBm where the RBW is in MHz This may be converted to a peak field strength level at 3 meters using  $E(dB\mu V/m) = P(e.i.r.p.(dBm)) + 95.2$ . If the RBW is greater than 3 MHz, the application for certification shall contain a detailed description of the test procedure, the calibration of the test set-up and the instrumentation used in the testing.

**Section 8****Test name****Specification***Testing data**FCC 15.519 (e) and RSS-220 5.3.1 (g) Peak emissions within 50 MHz band**FCC Part 15 Subpart F and RSS-220, Issue 1***8.4.2 Test summary**

---

Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021

**8.4.3 Observations, settings and special notes**

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The EUT was set up as indicted in radiated procedures of ANSI C.63.10 v2.0.1. Receiver settings for preview measurements:

Resolution bandwidth	50 MHz
Video bandwidth	50 MHz
Detector mode	Peak
Trace mode	Max Hold

#### 8.4.4 Test data

**Table 8.4-1: Peak emissions within 50 MHz band results**

Frequency, MHz	Peak result, dBμV/m	Limit, dBμV/m	Margin, dB
3494.4	89.19	95.23	6.04
3993.6	87.51	95.23	7.72
4492.8	94.85	95.23	0.38
6489.6	94.21	95.23	1.02

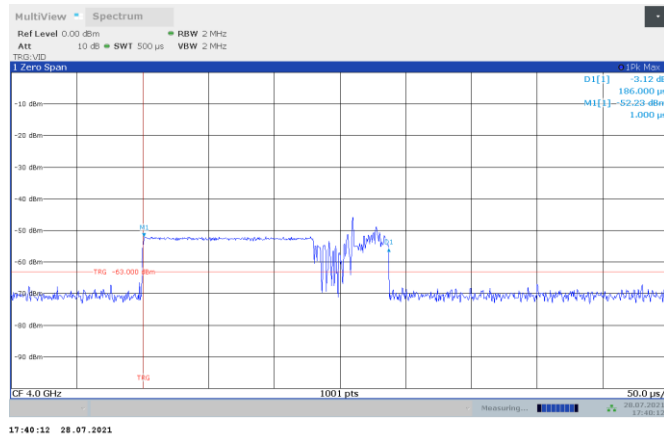
**Table 8.4-2: Maximum integrated power band results**

Frequency, MHz	Frequency range bandwidth, MHz	Peak result, dBμV/m per 50 MHz	Integration factor, dB (20log (OBW/50 MHz))	Maximum integrated fieldstrength result, dBμV/m	Maximum EIRP integrated result, dBm
3494.4	540.7	89.19	20.68	109.87	14.64
3993.6	625.7	87.51	21.95	109.46	14.23
4492.8	569.8	94.85	21.14	115.99	20.76
6489.6	632.4	94.21	22.04	116.25	21.02

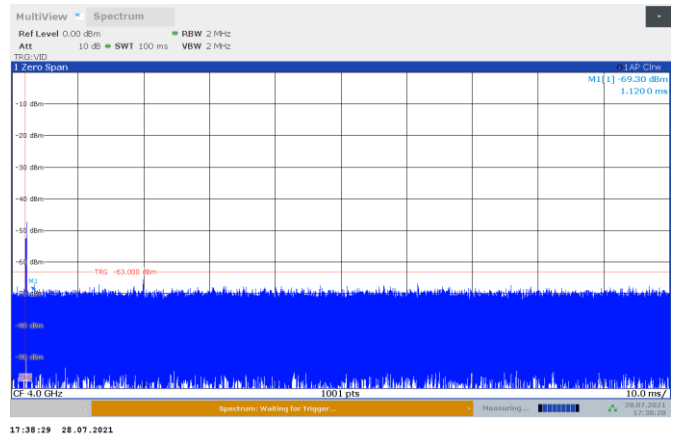
**Table 8.4-3: DCCF EIRP results**

Frequency, MHz	Maximum integrated fieldstrength result, dBμV/m	DCCF factor, dB	Corrected, dBμV/m	Corrected EIRP integrated result, dBm	Corrected power result, Watts
3494.4	109.87	54.6	55.27	-39.96	0.0000001
3993.6	109.46	54.6	54.86	-40.37	0.00000009
4492.8	115.99	54.6	61.39	-33.84	0.00000041
6489.6	116.25	54.6	61.65	-33.58	0.00000044

Note: DCCF is 20 log (186 us on in 100ms)



**Figure 8.4-1: Pulse width**



**Figure 8.4-2: number of pulses in 100 ms**



## 8.5    FCC 15.519(a) and RSS-220 5.3.1 (a) (b) Operational requirements for devices using UWB Technology

---

### 8.5.1    References, definitions and limits

---

**FCC:**

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.

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.

UWB devices operating under the provisions of this section may operate indoors or outdoors

**ISED:**

The device shall be designed so as to prevent its connection to antennas mounted on outdoor structures, e.g., antennas mounted on the outside of a building or on a telephone pole, or any fixed outdoors infrastructure.

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.

### 8.5.2    Test summary

---

Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021

### 8.5.3    Observations, settings and special notes

---

None

#### 8.5.4 Test data

- EUT shall cease transmission within 10 seconds
- EUT may operate indoors or outdoors
- The Antenna may be mounted only on handheld UWB device
- The Antenna will not be mounted on the outside of a building or on telephone pole or any fixed outdoor infrastructure
- The Antenna is designed to prevent its connection to antennas mounted on outdoor structures

Customer provided description of operation:

**4) Per 15.519(a)(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 is transmission is being received'. Please submit supporting documentation describing how this requirement is fulfilled.**

The UWB transmitter operates as part of a system in which it sends short duration UWB packets to one or more receivers. The transmitter's cycle of operation is as follows: 1) the transmitter's microcontroller begins in a non-transmitting sleep state, 2) the transmitter transitions to an active state, in which it sends a short UWB packet of fixed duration of 101 microseconds, 3) the transmitter microcontroller ceases the transmission and returns to a sleep state.

An oscilloscope screen capture of the 101 microsecond packet is shown in the figure below.



Figure 2. UWB Packet. Each line is a 2 nanosecond pulse.

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 101 microseconds, meeting the required behavior in much less than the allowed 10 seconds.

## 8.6 FCC 15.519(c) and RSS-220 5.3.1 (c) (d) Field strength of emissions

### 8.6.1 References, definitions and limits

#### FCC:

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 below:

#### ISED:

Radiated emissions at or below 960 MHz from a device shall not exceed the limits in section 3.4 (RSS-Gen) given below:

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

**Table 8.6-1: FCC 15.19 (c) Field strength limits**

Spurious emission frequency (MHz)	dBm	EIRP in RBW of 1MHz	(dBμV/m)
960 - 1610	-75.3		19.93
1610 – 1990	-63.3		31.93
1990 – 3100	-61.3		33.93
3100 – 10600	-41.3		53.93
10600 - 40000	-61.3		33.93

Notes: In the emission table above, the tighter limit applies at the band edges

**Table 8.6-2: RSS-220 5.3.1 (d) Field strength limits**

Spurious emission frequency (MHz)	dBm	EIRP in RBW of 1MHz	(dBμV/m)
960 - 1610	-75.3		19.93
1610 – 4750	-70.0		25.23
4750 – 10600	-41.3		53.93
Above 10600	-61.3		33.93

## 8.6.1 References, definitions and limits, continued

Table 8.6-3: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	$\mu\text{V/m}$	$\text{dB}\mu\text{V/m}$	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.

The limit above 960 MHz is not applicable

Table 8.6-4: ISSED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	Above 38.6
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in this table and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.6-5: FCC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

**Section 8****Test name****Specification***Testing data**FCC 15.519(c) and RSS-220 A.1.2 Field strength of emissions**FCC Part 15 Subpart F and RSS-220, Issue 1***8.6.2 Test summary**

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Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021 and June 1, 2021

**8.6.3 Observations, settings and special notes**

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The spectrum was searched from 30 MHz to 40 GHz

Radiated measurements were performed at a distance of 30 cm.

Field Strength (dBμV/m) = Measured raw value (dBμV/m) + Path losses (dB) + Distance Correction Factor ( -20 dB)

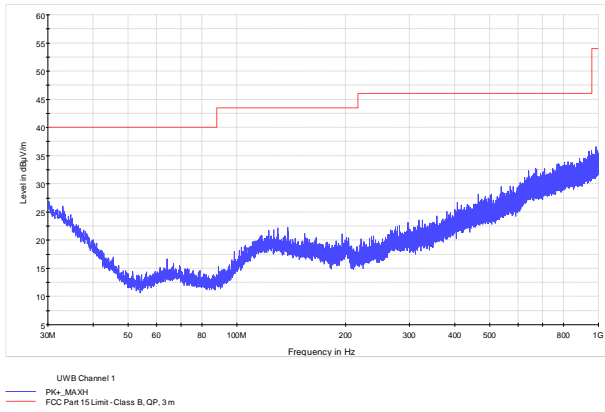
Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	RMS
Trace mode	Max Hold

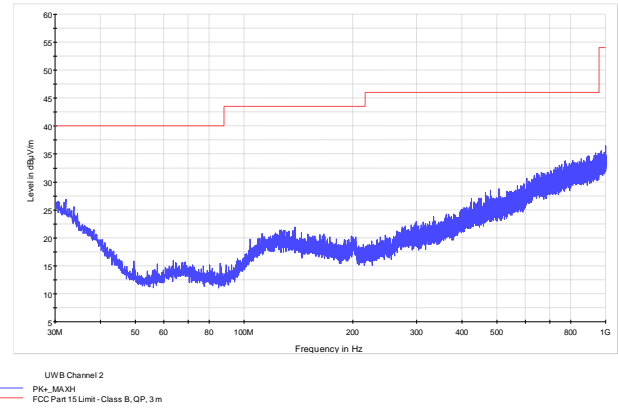
Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	RMS
Trace mode	Max Hold

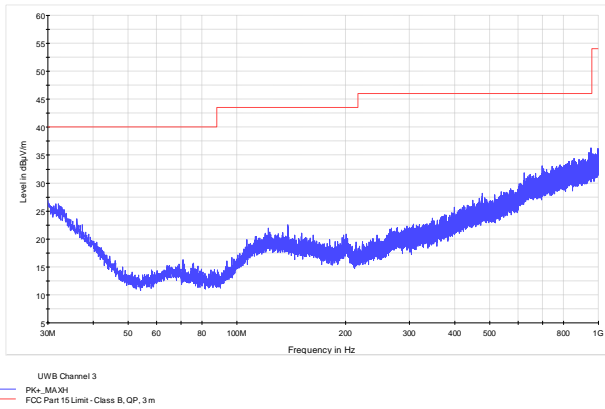
## 8.6.4 Test data



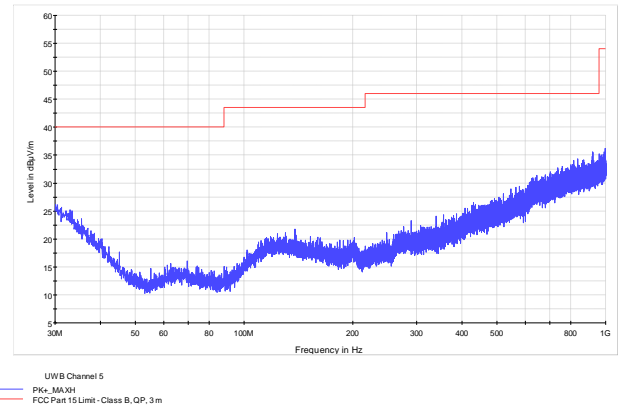
**Figure 8.6-1: Channel 1 – Spurious Emissions 30-1000 MHz**



**Figure 8.6-2: Channel 2 – Spurious Emissions 30-1000 MHz**

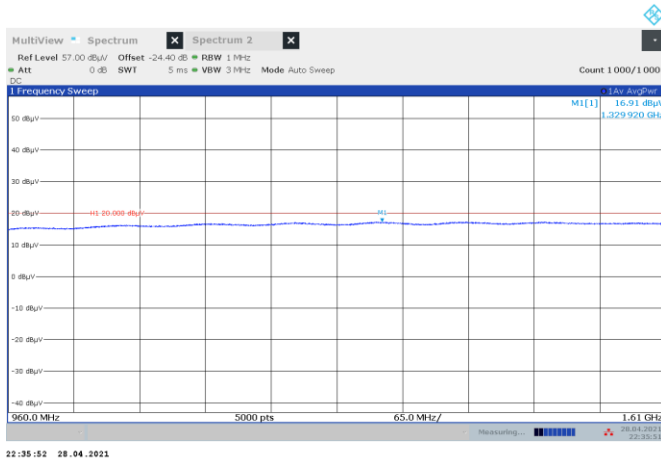


**Figure 8.6-3: Channel 3 – Spurious Emissions 30-1000 MHz**

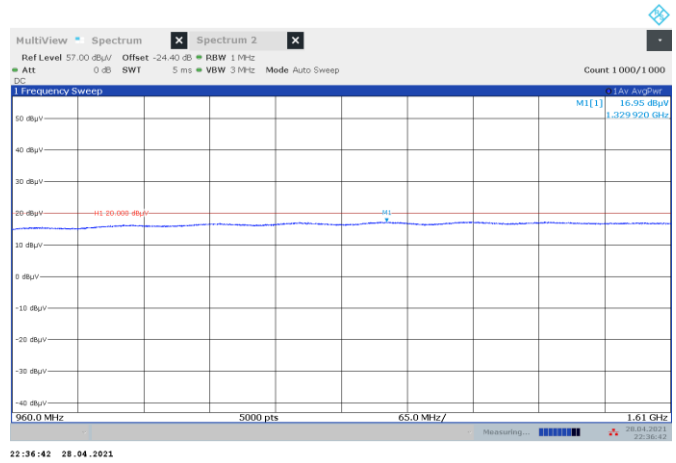


**Figure 8.6-4: Channel 5 – Spurious Emissions 30-1000 MHz**

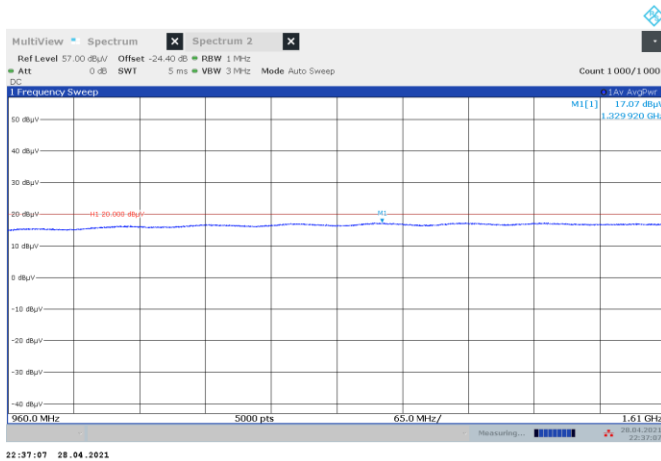
Test data, continued



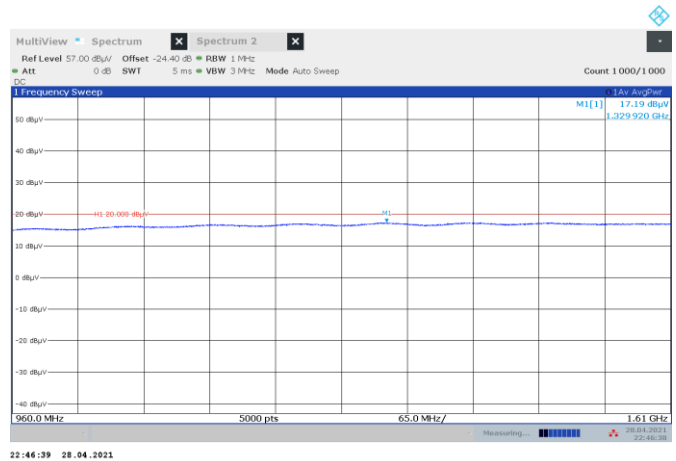
**Figure 8.6-5:** Channel 1 – Spurious Emissions 960-1610 MHz



**Figure 8.6-6:** Channel 2 – Spurious Emissions 960-1610 MHz



**Figure 8.6-7:** Channel 3 – Spurious Emissions 960-1610 MHz



**Figure 8.6-8:** Channel 5 – Spurious Emissions 960-1610 MHz

Test data, continued

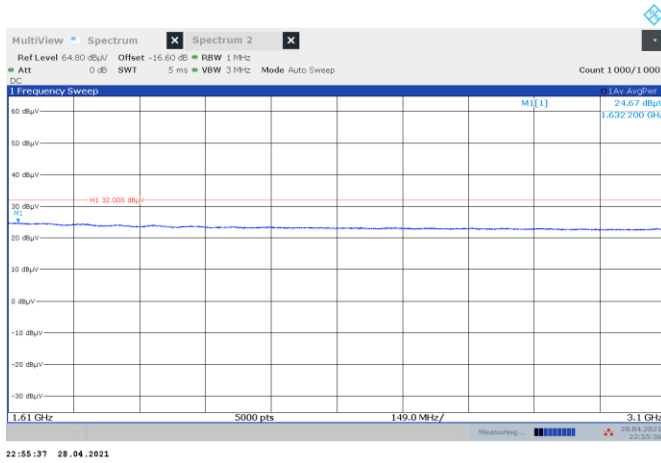


Figure 8.6-9: Channel 1 – Spurious Emissions 1610-3100 MHz

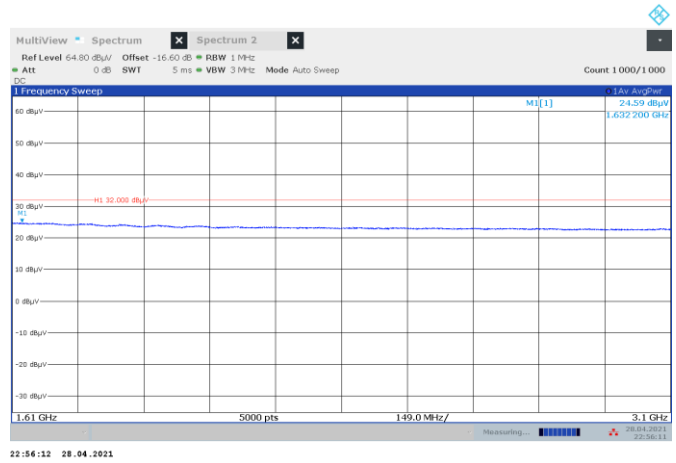


Figure 8.6-10: Channel 2 – Spurious Emissions 1610-3100 MHz

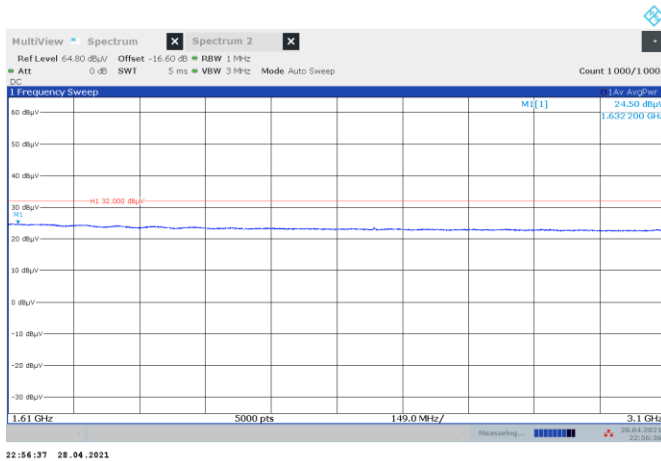


Figure 8.6-11: Channel 3 – Spurious Emissions 1610-3100 MHz

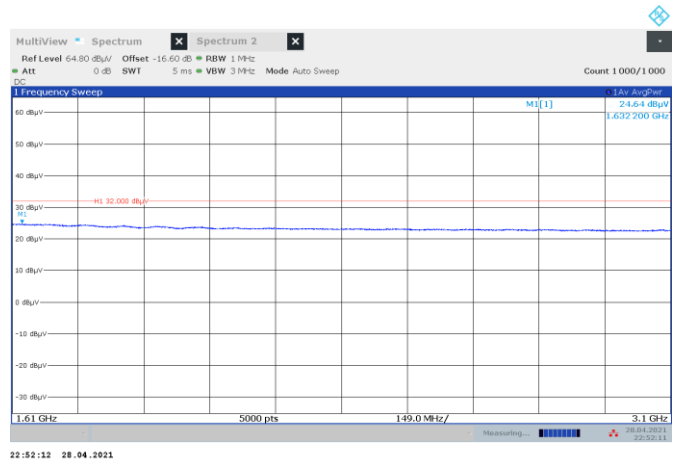
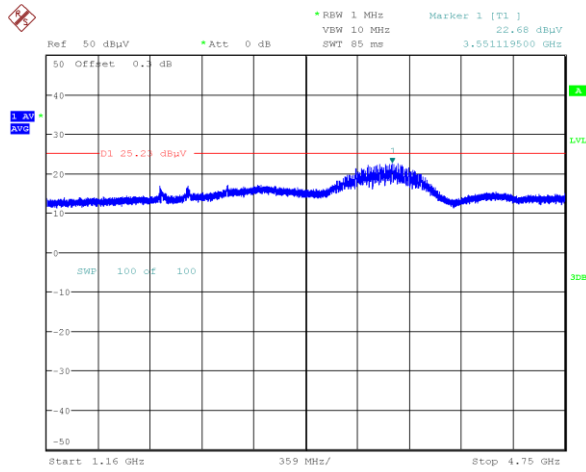


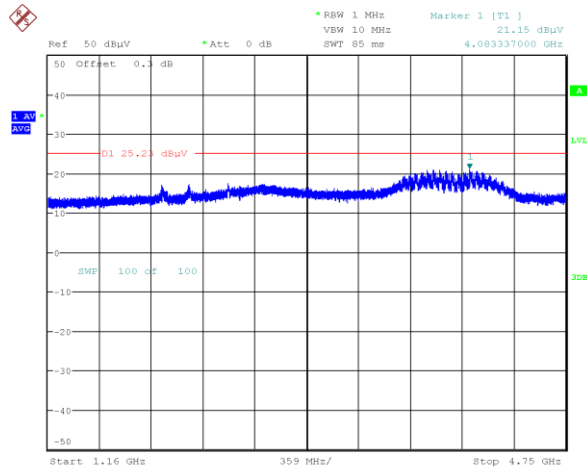
Figure 8.6-12: Channel 5 – Spurious Emissions 1610-3100 MHz

## Test data, continued



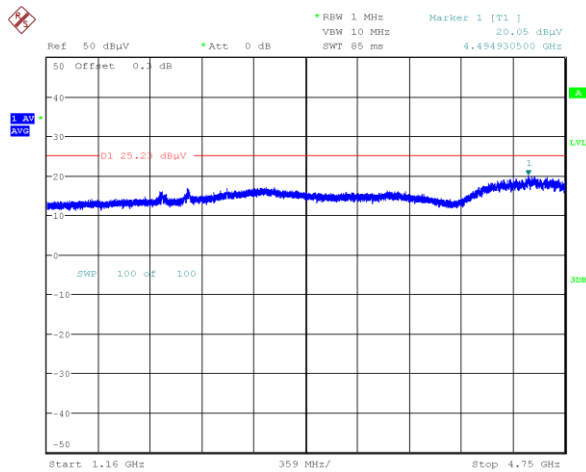
Date: 13.MAY.2021 09:49:09

**Figure 8.6-13: Channel 1 – Spurious Emissions 1600-4750 MHz**



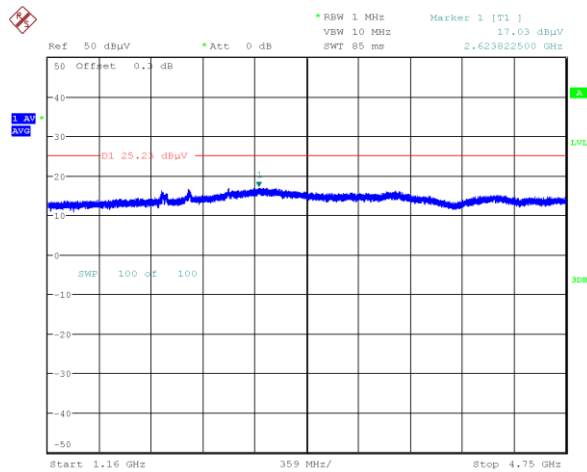
Date: 13.MAY.2021 10:02:03

**Figure 8.6-14: Channel 2 – Spurious Emissions 1600-4750 MHz**



Date: 13.MAY.2021 09:54:40

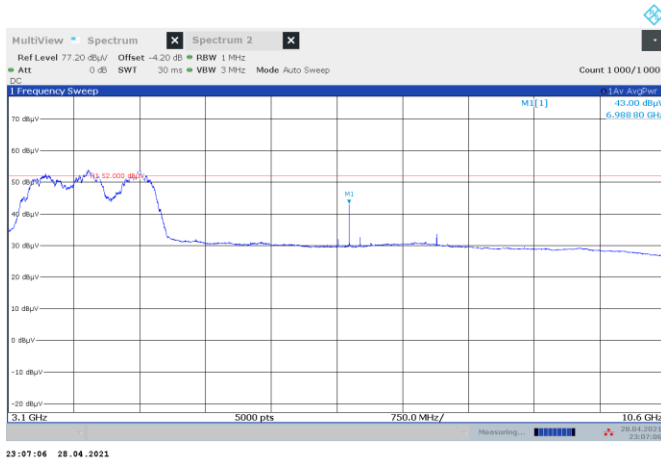
**Figure 8.6-15: Channel 3 – Spurious Emissions 1600-4750 MHz**



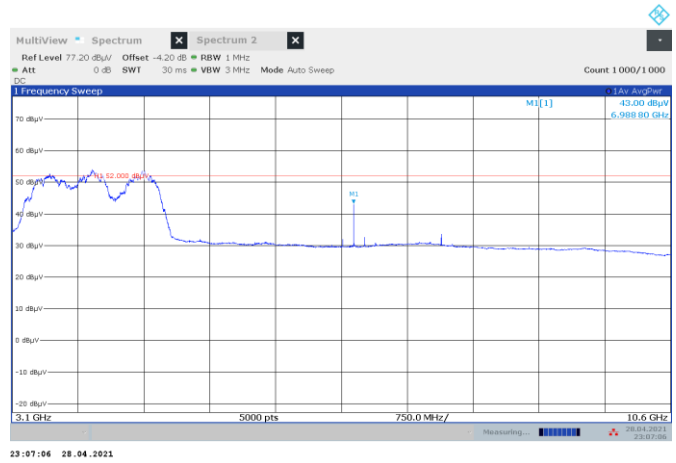
Date: 13.MAY.2021 10:10:00

**Figure 8.6-16: Channel 5 – Spurious Emissions 1600-4750 MHz**

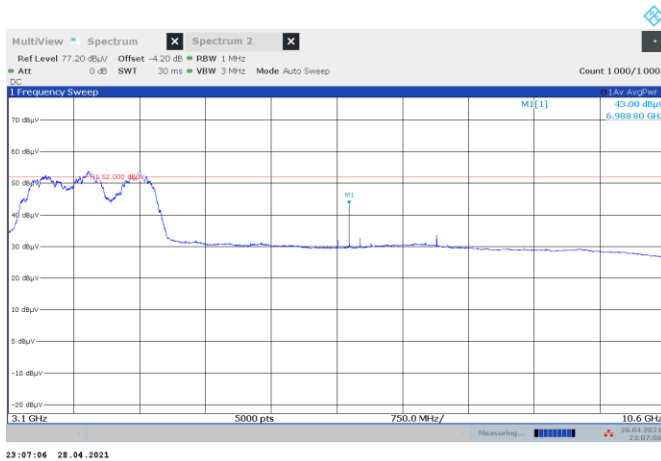
## Test data, continued



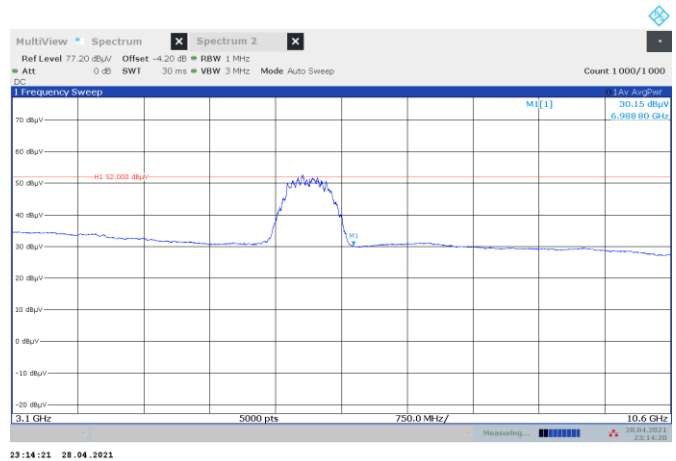
**Figure 8.6-17: Channel 1 – Spurious Emissions 3100-10600 MHz**



**Figure 8.6-18: Channel 2 – Spurious Emissions 3100-10600 MHz**

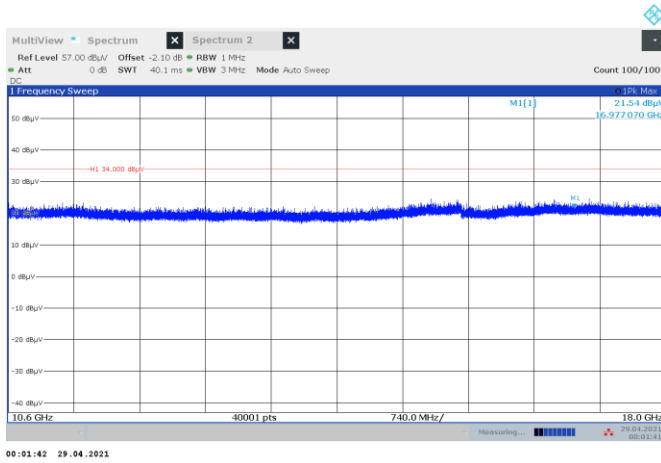


**Figure 8.6-19: Channel 3 – Spurious Emissions 3100-10600 MHz**

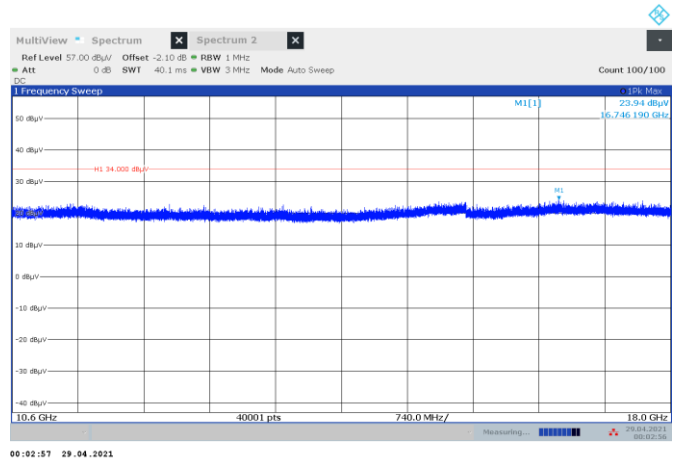


**Figure 8.6-20: Channel 5 – Spurious Emissions 3100-10600 MHz**

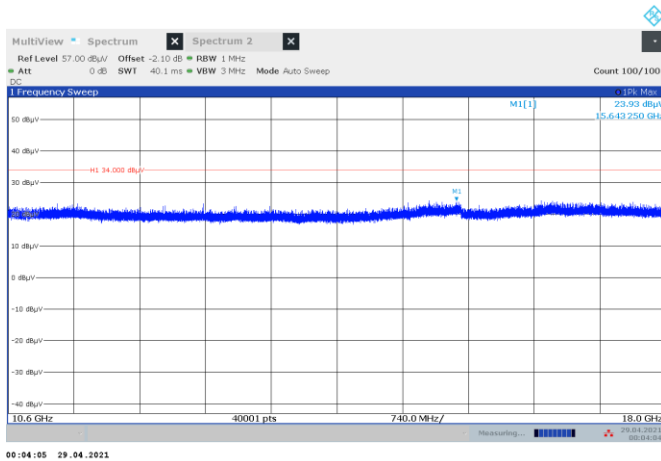
Test data, continued



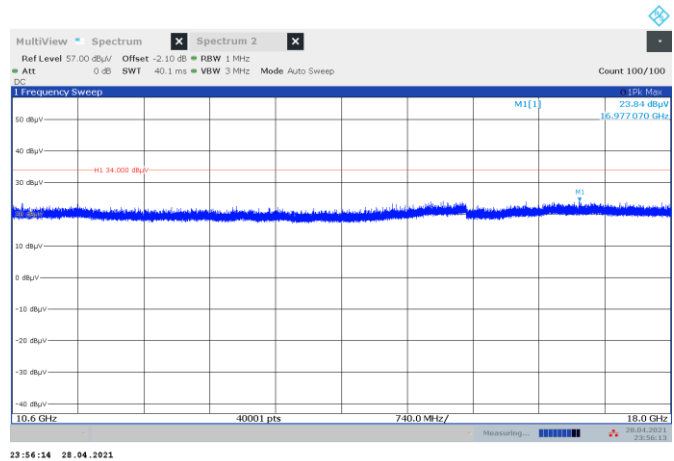
**Figure 8.6-21: Channel 1 – Spurious Emissions 10.6-18 GHz**



**Figure 8.6-22: Channel 2 – Spurious Emissions 10.6-18 GHz**



**Figure 8.6-23: Channel 3 – Spurious Emissions 10.6-18 GHz**



**Figure 8.6-24: Channel 5 – Spurious Emissions 10.6-18 GHz**



## Section 8

### Test name

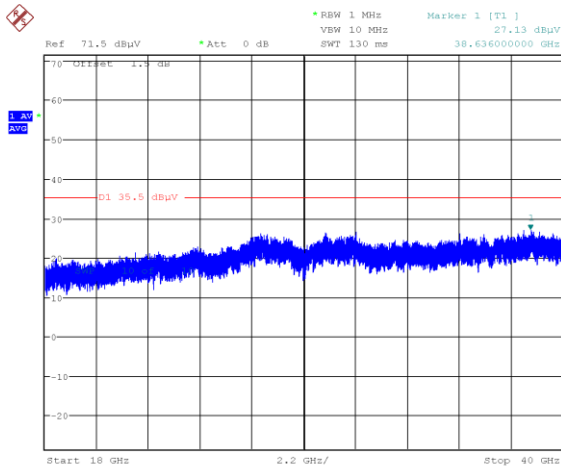
### Specification

## Testing data

FCC 15.519(c) and RSS-220 A.1.2 Field strength of emissions

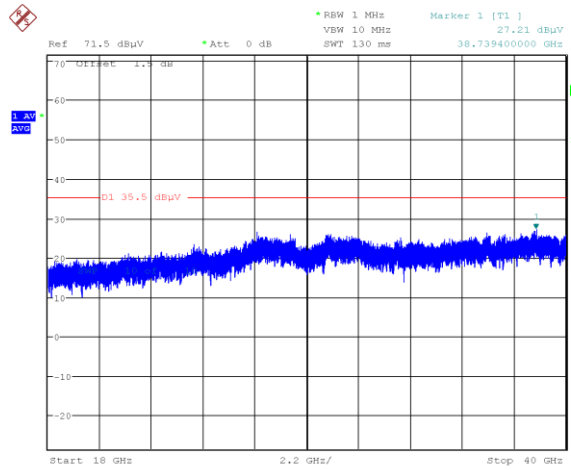
FCC Part 15 Subpart F and RSS-220, Issue 1

## Test data, continued



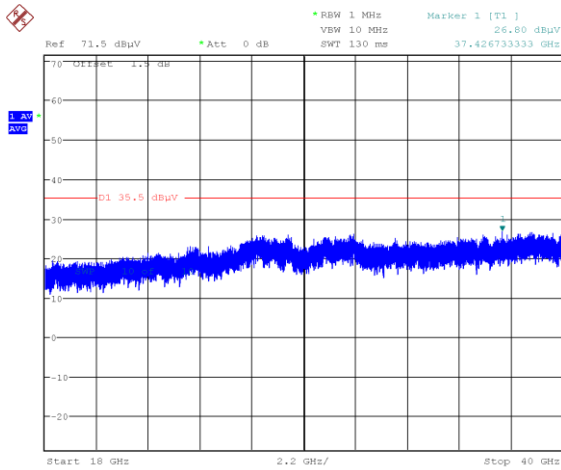
Date: 1.JUN.2021 21:33:12

Figure 8.6-25: Channel 1 – Spurious Emissions 10.6-18 GHz



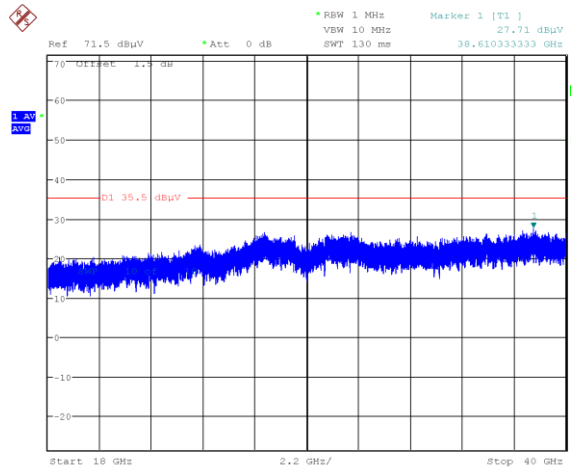
Date: 1.JUN.2021 21:34:45

Figure 8.6-26: Channel 2 – Spurious Emissions 10.6-18 GHz



Date: 1.JUN.2021 21:37:36

Figure 8.6-27: Channel 3 – Spurious Emissions 10.6-18 GHz



Date: 1.JUN.2021 21:37:59

Figure 8.6-28: Channel 5 – Spurious Emissions 10.6-18 GHz

## 8.7 FCC 15.519(b) and RSS-220 5.1 (a) Emission bandwidth

### 8.7.1 References, definitions and limits

#### FCC:

The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz. The frequency at which the highest radiated emission occurs,  $f_M$ , must be contained within the UWB bandwidth

Definitions.

(a) UWB bandwidth. For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated  $f_H$  and the lower boundary is designated  $f_L$ . The frequency at which the highest radiated emission occurs is designated  $f_M$ .

(b) Center frequency. The center frequency,  $f_C$ , equals  $(f_H + f_L)/2$ .

(c) Fractional bandwidth. The fractional bandwidth equals  $2(f_H - f_L) / (f_H + f_L)$ .

(d) Ultra-wideband (UWB) transmitter. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth

#### ISED:

The -10 dB bandwidth of the device shall be totally contained in the band 3.1-10.6 GHz.

### 8.7.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2021

### 8.7.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	$\geq 1\%$ of emission bandwidth
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	Wider than emission bandwidth
Detector mode	Peak

#### 8.7.4 Test data

**Table 8.7-1: 10 dB bandwidth measurement result**

Center Frequency, MHz	Frequency range bandwidth, MHz	Limit, >500 MHz	Margin
3494.4	540.7	500	40.7
3993.6	625.7	500	125.7
4492.8	569.8	500	69.8
6489.6	632.4	500	132.4

**Table 8.7-2: Bandwidth within frequency band measurement result**

Center Frequency, MHz	Frequency range bandwidth, MHz	Start of Frequency range, Margin	Start of Frequency range, Margin	End of Frequency range, MHz	End of Frequency range, Margin, MHz
3494.4	540.7	3100	-124.0	10600	7375.9
3993.6	625.7	3100	-580.7	10600	6919.2
4492.8	569.8	3100	-1107.9	10600	6392.1
6489.6	632.4	3100	-3073.4	10600	4426.6

**Table 8.7-3: 99 % bandwidth within frequency band measurement result**

99% occupied bandwidth, MHz	Limit, MHz	Margin, MHz
779.97	>500	279.97

## 8.7.1 Test data

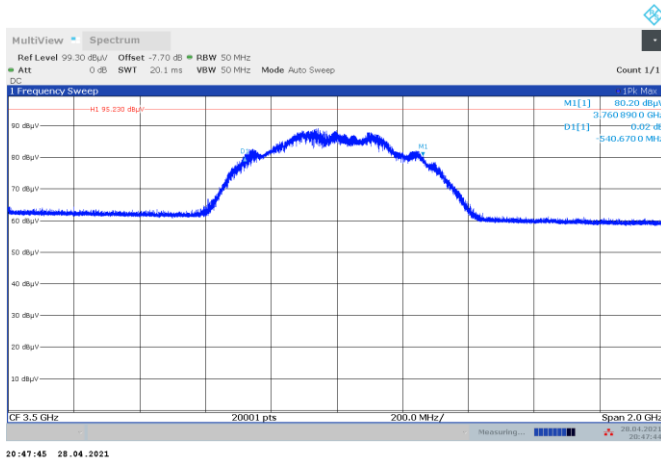


Figure 8.7-1: Channel 1 – 10 dB

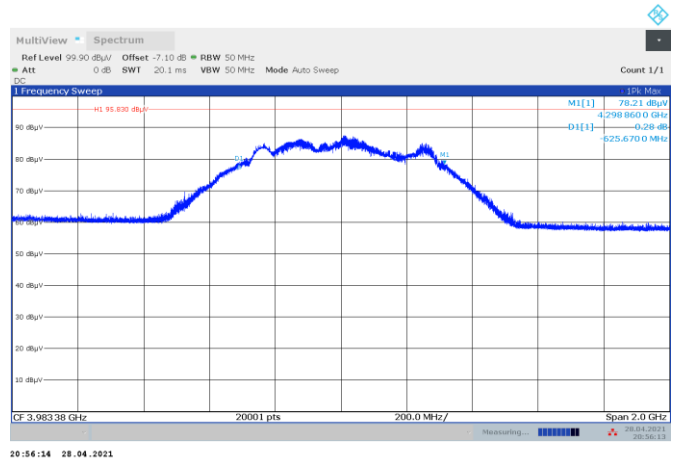


Figure 8.7-2: Channel 2 – 10 dB

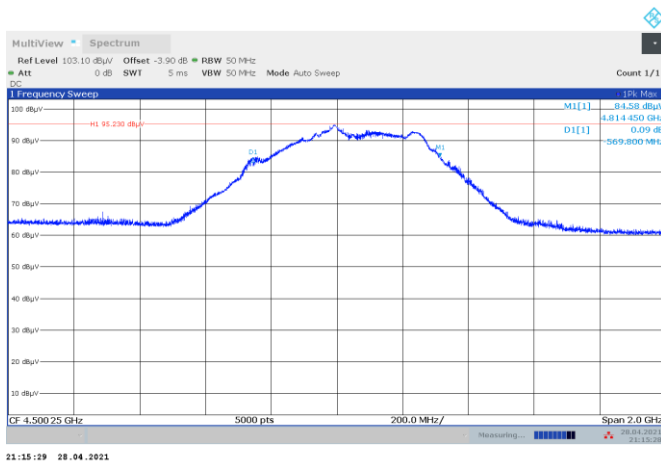


Figure 8.7-3: Channel 3 – 10 dB

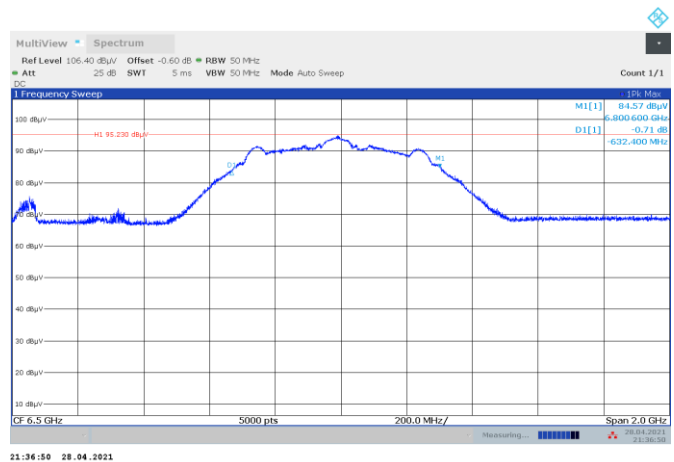


Figure 8.7-4: Channel 5 – 10 dB

Test data, continued

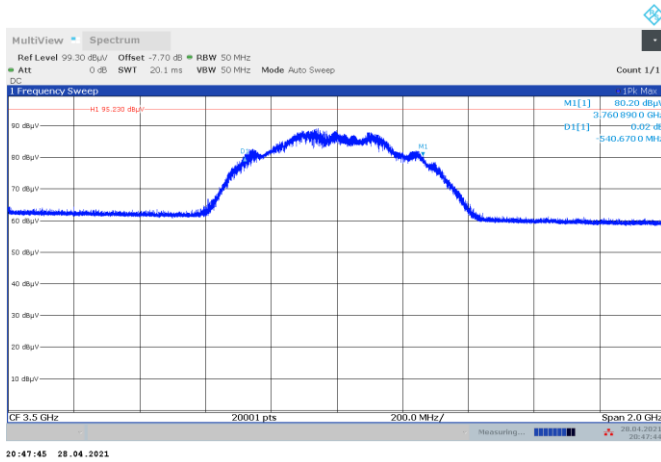


Figure 8.7-5: Channel 1 – 99 %

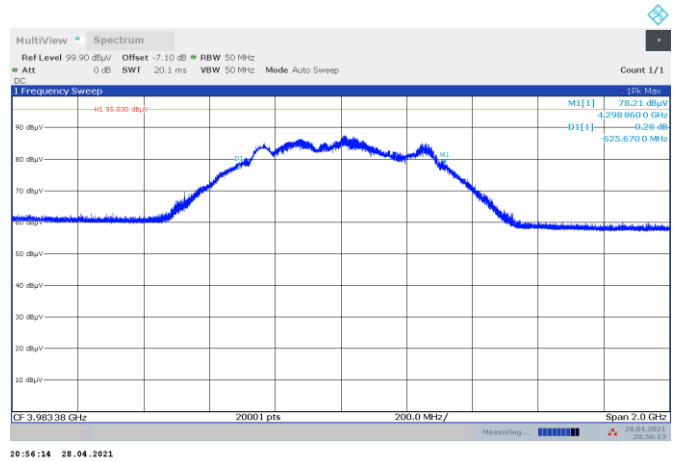


Figure 8.7-6: Channel 2 – 99 %

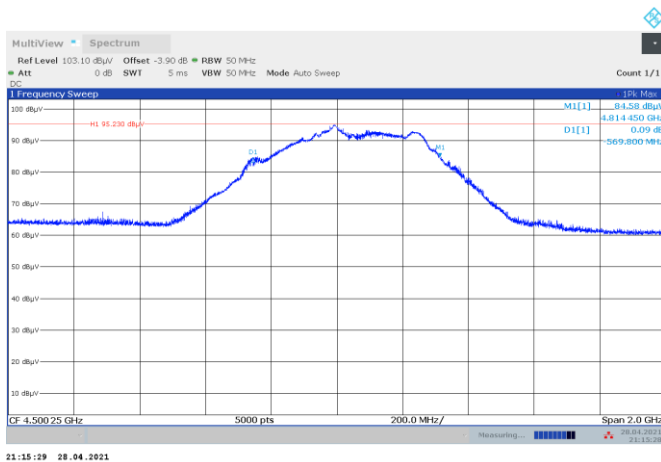


Figure 8.7-7: Channel 3 – 99 %

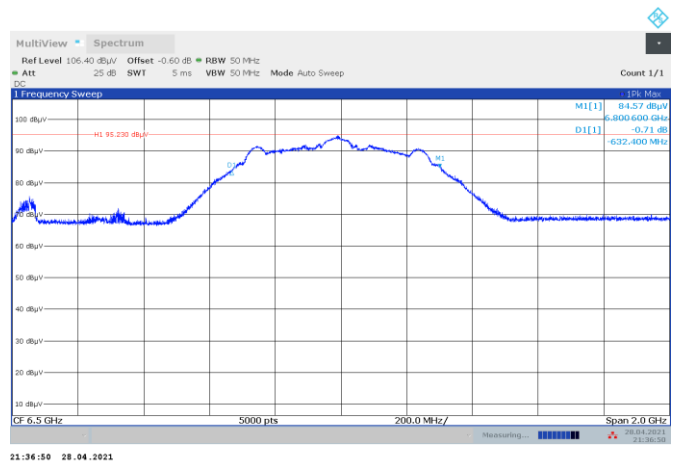


Figure 8.7-8: Channel 5 – 99 %

## 8.8 FCC 15.519(d) and RSS-220 (e) Field strength of emissions within 1164-1240 and 1559-1610 MHz band

### 8.8.1 References, definitions and limits

**FCC:**

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 below:

**ISED:**

In addition to the limits specified in below table, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

**Table 8.8-1: Field strength limits**

Fundamental frequency (MHz)	EIRP in RBW no less than 1 kHz	
	dBm	(dBμV/m)
1164-1240	-85.3	9.93
1559-1610	-85.3	9.93

Notes: In the emission table above, the tighter limit applies at the band edges

### 8.8.2 Test summary

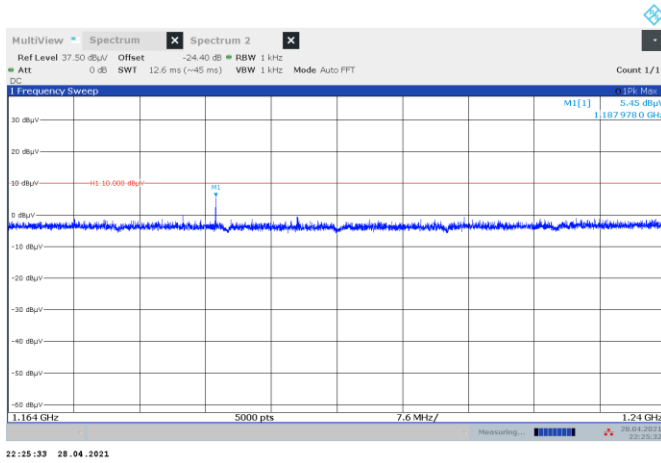
Verdict	Pass		
Tested by	Kevin Rose	Test date	April 29, 2020

### 8.8.3 Observations, settings and special notes

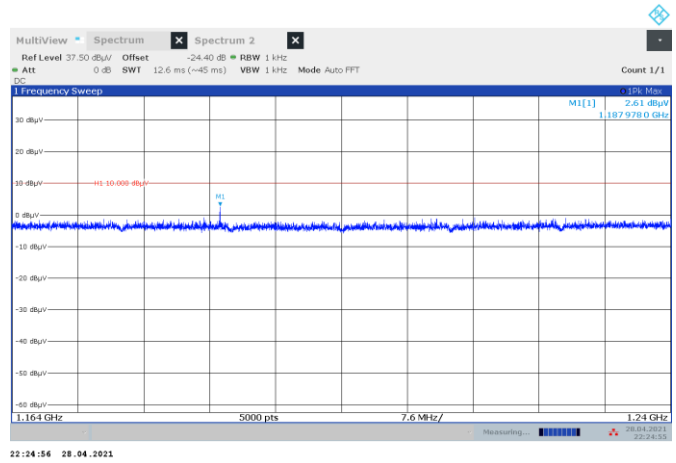
Spectrum analyser settings:

Resolution bandwidth	1 kHz
Video bandwidth	3 kHz
Detector mode	Peak
Trace Mode	Max Hold

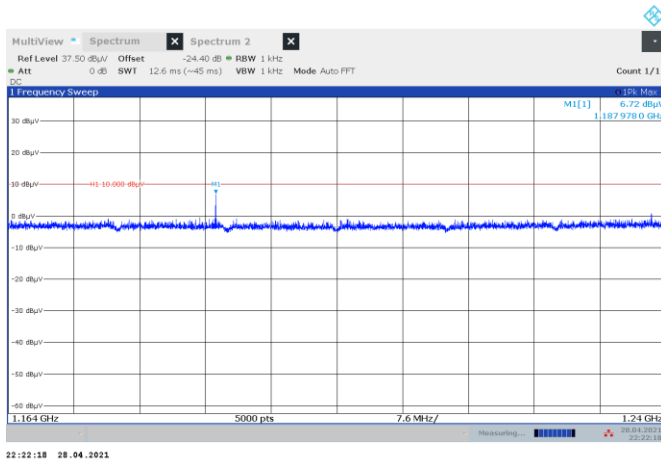
## 8.8.4 Test data, continued



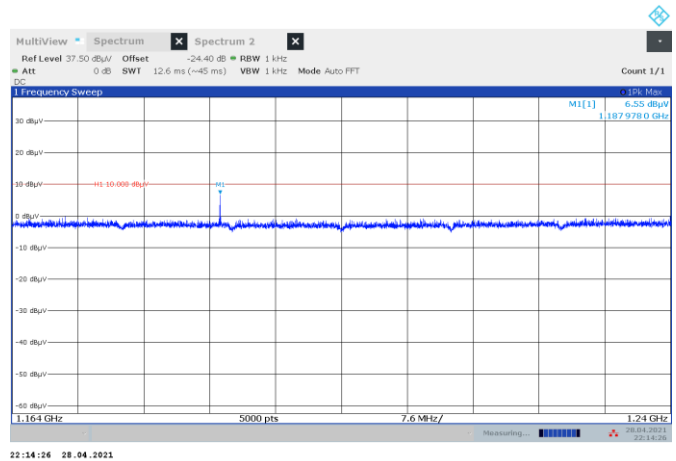
**Figure 8.8-1: Channel 1 – Spurious Emissions within 1164-1240 MHz**



**Figure 8.8-2: Channel 2 – Spurious Emissions within 1164-1240 MHz**

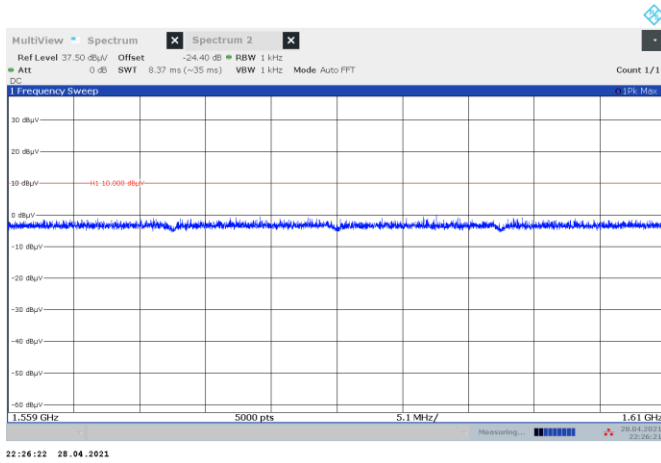


**Figure 8.8-3: Channel 3 – Spurious Emissions within 1164-1240 MHz**

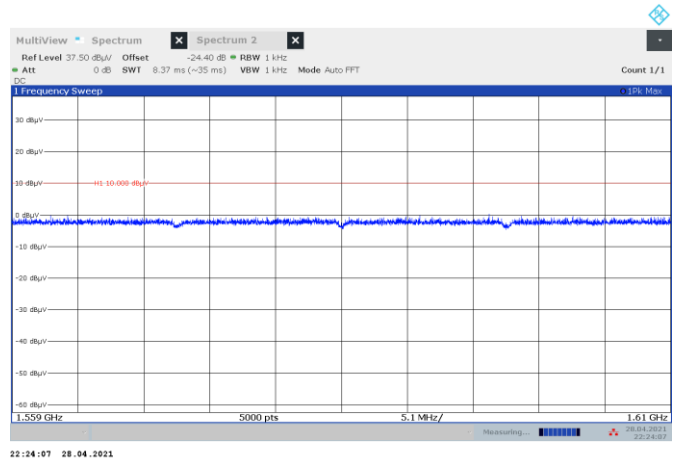


**Figure 8.8-4: Channel 5 – Spurious Emissions within 1164-1240 MHz**

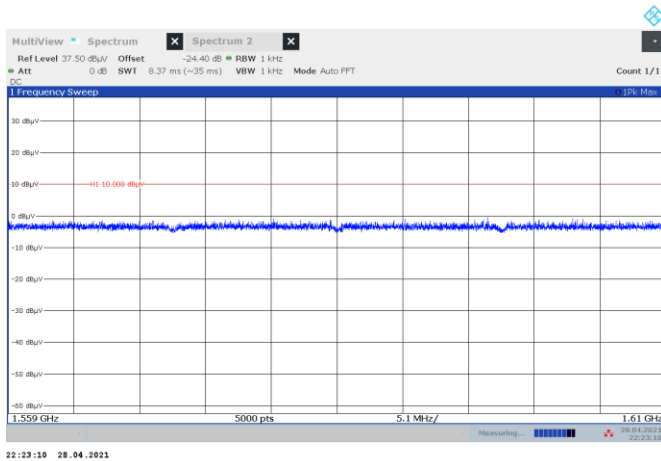
Test data, continued



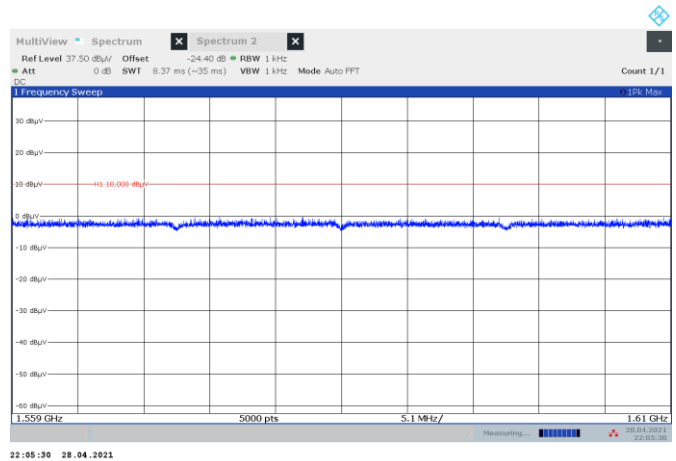
**Figure 8.8-5: Channel 1 – Spurious Emissions within 1559-1610 MHz**



**Figure 8.8-6: Channel 2 – Spurious Emissions within 1559-1610 MHz**



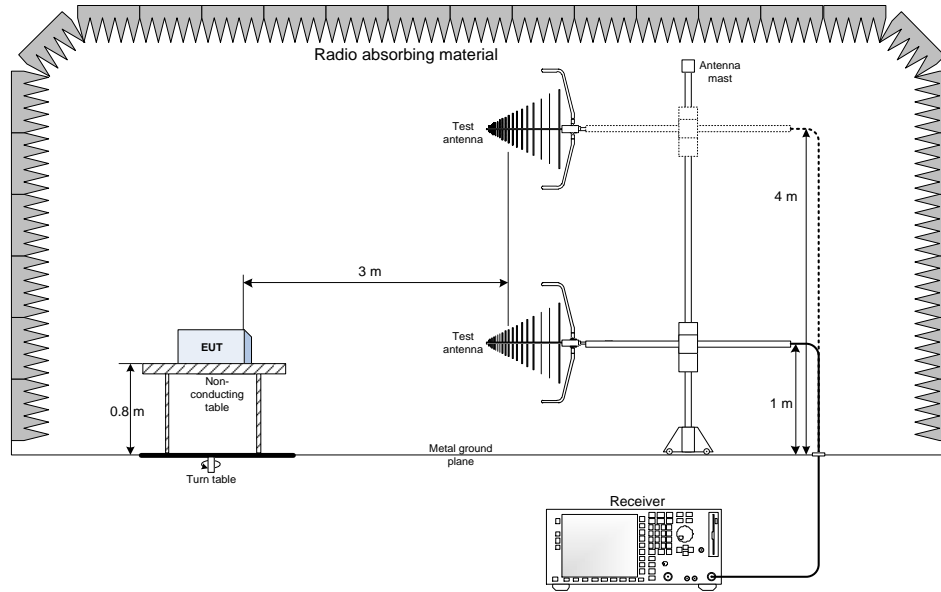
**Figure 8.8-7: Channel 3 – Spurious Emissions within 1559-1610 MHz**



**Figure 8.8-8: Channel 5 – Spurious Emissions within 1559-1610 MHz**

## Section 9. Block diagrams of test set-ups

### 9.1 Radiated emissions set-up for frequencies below 1 GHz



### 9.2 Radiated emissions set-up for frequencies above 1 GHz

