

Test report

400689-2R3TRFWL

Date of issue: September 8, 2020

Applicant:

TMRW Life Sciences, Inc.

Product:

Readerboard

Model:

CA1821

FCC ID: 2AU7Q-CA1821

IC: 25647-CA1821

Specifications:

- ◆ **FCC 47 CFR Part 15, Subpart C – §15.225**
Operation within the band 13.110-14.010 MHz
- ◆ **RSS-210, Issue 10, December 2019**
License-Exempt Radio Apparatus: Category I Equipment
- ◆ **RSS-Gen, Issue 5, Amendment 1, March 2019**
General Requirements for Compliance of Radio Apparatus

Test location

Company name	Nemko USA, Inc.
Address	2210 Faraday Ave, Suite 150
City	Carlsbad
Province	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	David Hewitt, EMC Specialist
Reviewed by	James Cunningham, Wireless Supervisor
Review date	September 8, 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 contained 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.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	TMRW Life Sciences, Inc.
Address	250 Hudson Street, Suite 701
City	New York
State	NY
Postal/Zip code	10013
Country	USA

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.225	Operation within the band 13.110-14.010 MHz
RSS-210, Issue 10	License-Exempt Radio Apparatus: Category I Equipment
RSS-Gen, Issue 5, Amendment 1, March 2019	General Requirements for Compliance of Radio Apparatus

1.3 Test methods

ANSI C64.3-2014	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

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 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
400689-2TRFWL	Original report issued
400689-2R1TRFWL	Updated Applicant and Manufacturer addresses
400689-2R2TRFWL	Updated power requirements and updated model name to "Readerboard"
400689-2R3TRFWL	Updated product name to "Readerboard"

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.203 ¹	Antenna requirement	Pass
§15.215	20 dB bandwidth	Pass

Notes: ¹ The Antenna is internal to device or with unique antenna coupling.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.225(a)	Field strength within 13.553–13.567 MHz band	Pass
§15.225(b)	Field strength within 13.410–13.553 MHz and 13.567–13.710 MHz bands	Pass
§15.225(c)	Field strength within 13.110–13.410 MHz and 13.710–14.010 MHz bands	Pass
§15.225(d)	Field strength outside 13.110–14.010 MHz band	Pass
§15.225(e)	Frequency tolerance of carrier signal ¹	Pass

Note: ¹ None

2.3 IC RSS-GEN, Issue 5, test results

Part	Test description	Verdict
7.3 ¹	Receiver radiated emission limits	Not applicable
7.4 ¹	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
8.9	Transmitter emission limits	Pass
8.10	Restricted Frequency Bands	Pass
6.7	Occupied bandwidth	Pass
6.11	Transmitter frequency stability	Pass

Note: ¹ 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.

2.4 IC RSS-210, Issue 10, test results

Part	Test description	Verdict
B.6 (a)	The field strength within the band 13.553–13.567 MHz.	Pass
B.6 (b)	The field strength within the bands 13.410–13.553 MHz and 13.567–13.710 MHz	Pass
B.6 (c)	The field strength within the bands 13.110–13.410 MHz and 13.710–14.010 MHz.	Pass
B.6 (d)	The field strength outside the band 13.110–14.010 MHz.	Pass
B.6	Carrier frequency stability shall be maintained to $\pm 0.01\%$ (± 100 ppm)	Pass

Note: ¹ None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	July 9, 2020
Nemko sample ID number	NEx: 400689

3.2 EUT information

Product name	Readerboard
Model	CA1821
Model variant	N/A
Serial number	N/A

3.3 Technical information

Applicant IC company number	N/A
IC UPN number	N/A
All used IC test site(s) Reg. number	N/A
RSS number and Issue number	RSS-210, Issue 10, December 2019
Frequency band	13.553-13.567 MHz
Frequency Min (MHz)	13.56
Frequency Max (MHz)	13.56
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted/ERP/EIRP	N/A
Field strength, Units @ distance	44.18 dBμV/m @ 3m
Measured BW (Hz) (20dB)	364.70
Measured BW (kHz) (99%)	1.389290883
Type of modulation	100% ASK
Emission classification (F1D, G1D, D1D)	K1D
Power requirements	5V @ 0.5A
Antenna information	PCB 15mm diameter, 9 Turns.

3.4 Product description and theory of operation

To read stored information on RFID tags to identify containers and relative location.

3.5 EUT exercise details

EUT was set up in its normal operating configuration. EUT consists of two arrays of 50 RFID readers. A single tray of 49 RFID-tagged vials, plus the tray itself, were continually scanned, leaving the second array exercised without any tagged vials. All radiated and conducted emissions testing were performed in this system set up and this exercised configuration.

Each RFID transmits in sequence, therefore there is no simultaneous transmission of the transmitters. Software used for testing was SWDIO< SW_CLK using the STM programmer ST-Link/V2

3.6 EUT setup diagram

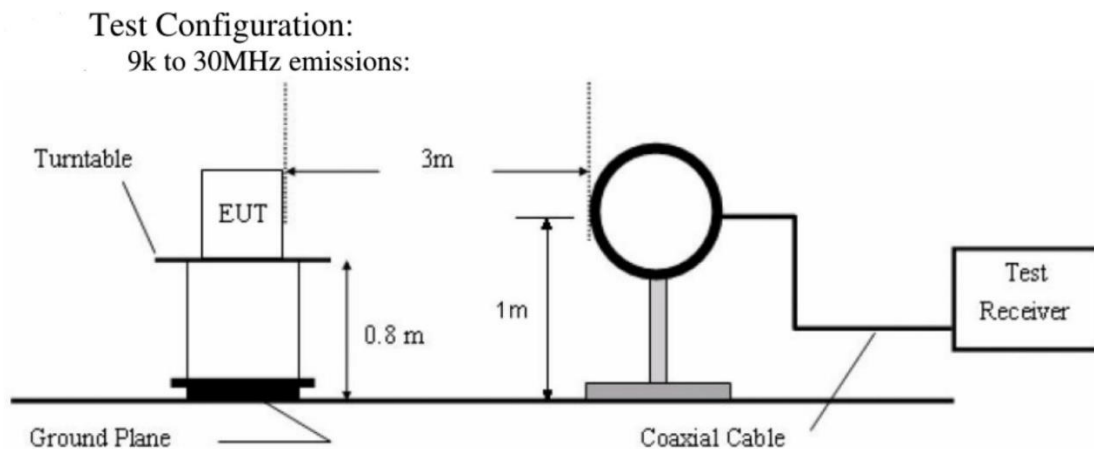


Figure 3.6-1: Radiated Emissions Test Setup – 9 kHz to 30 MHz

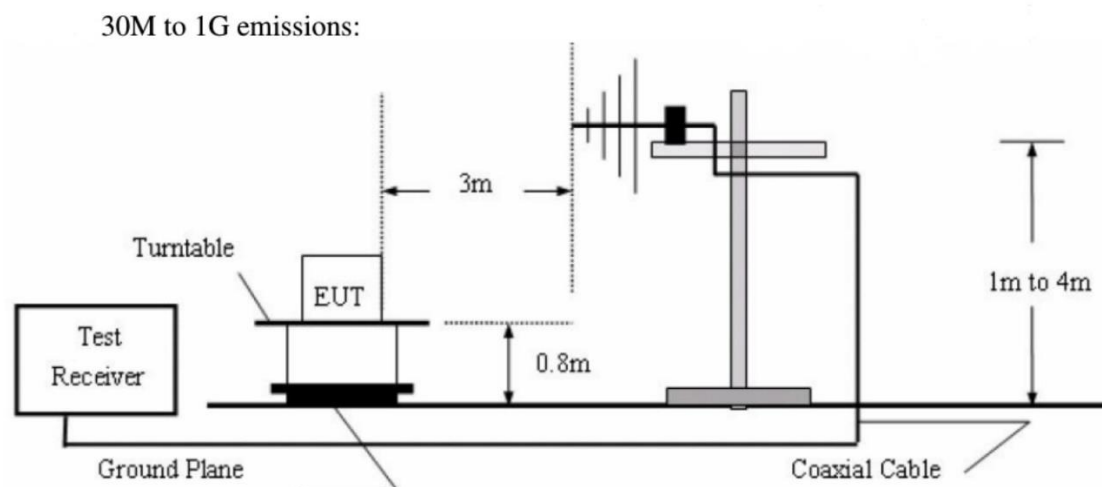


Figure 3.6-2: Radiated Emissions Test Setup – 30 MHz to 1 GHz

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number
RFID Readerboard PCBA	TMRW Life Sciences	RC2901	SN020, SN021
NUC	Intel	NUC7i5DNH1E	BTDN92700135
USB Hub	StarTech.com	ST7200USBM	610021336
Monitor	Elo	ET1402L-2UWA-1-G	K19H006317

Table 3.7-2: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
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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	860–1060 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.

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 $\pm 5\%$, 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
AC power line conducted emissions	1.38

Section 7. Test Data

7.1 FCC 15.225(a)-(d) and RSS-210 Issue 9 B.6 Field strength of spurious emissions

7.1.1 Definitions and limits

FCC:

- The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.
- Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.
- Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.
- The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

ISED:

The field strength of any emission shall not exceed the following limits:

- 15.848 mV/m (84 dBµV/m) at 30 m, within the band 13.553-13.567 MHz;
- 334 µV/m (50.5 dBµV/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz;
- 106 µV/m (40.5 dBµV/m) at 30 m, within the bands 13.110-13.410 MHz and 13.710-14.010 MHz; and
- RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz.

Table 7.1-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/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.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 7.1-2: IC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677–5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.3-2 and above 38.6 GHz are designated for low-power license-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 7.1-3: 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			

7.1.2 Test summary

Verdict	Pass		
Test date	July 9, 2020	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	10m semi anechoic chamber	Relative humidity	57 %

7.1.3 Observations, settings and special notes

Per FCC §15.33 (a), the spectrum was searched from 9 kHz to 150 MHz.

7.1.4 Setup details

Spectrum analyzer settings for radiated measurements within restricted bands from 9 kHz to 30 MHz:

Resolution bandwidth	200 Hz from 9 – 150 kHz, 9 kHz from 150 kHz – 30 MHz
Video bandwidth	600 Hz and 30 kHz respectively
Detector mode	– Peak (Preview measurement) – Quasi-peak (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak preview measurement) – 15000 ms (Quasi-peak final measurement)

Spectrum analyzer settings for radiated measurements within restricted bands from 30 – 1000 MHz:

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

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

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	– Peak (Preview measurement) – Peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak preview measurement) – 5000 ms (Peak and CAverage final measurement)

7.1.4 Setup details, continued

Table 7.1-4: Radiated disturbance equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESU 40	E1121	2 yr	25 Nov 2020
System Controller	Sunoc Sciences	SC104V	E1129	NCR	NCR
Active Loop H Field Antenna	Hewlett-Packard	6502	E1267	1 yr	12 Nov 2020
Bilog antenna	Schaffner-Chase	CBL6111C	1480	1 yr	18 Oct 2020
DRG Horn	ETS-Lindgren	3117-PA	E1160	2 yr	30 Oct 2020

Notes: None

Table 7.1-5: Radiated disturbance test software details

Manufacturer of Software	Details
Rohde & Schwarz	EMC32 V10.00.00

Notes: None

7.1.5 Testing data

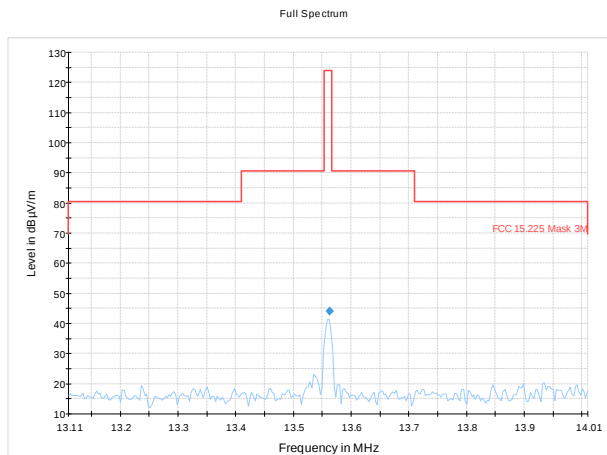


Figure 7.1.1: Radiated spurious emissions, 13-14.2 MHz (3 meters at 0°)

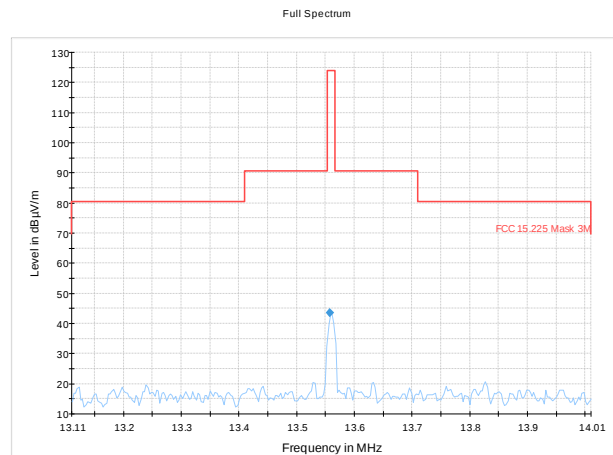


Figure 7.1.2: Radiated spurious emissions, 13-14.2 MHz (3 meters at 90°)

Table 7.1-6: Radiated field strength measurement results 13.11-14.01 MHz (Test antenna at 0 Deg)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
13.562120	44.18	124.00	79.82	15000.0	9.000	H	127.0	11.2

Table 7.1-7: Radiated field strength measurement results 13.11-14.01 MHz (Test antenna at 90 Deg)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
13.557105	43.67	124.00	80.33	15000.0	9.000	H	260.0	11.2

7.1.5 Testing data, continued

Full Spectrum

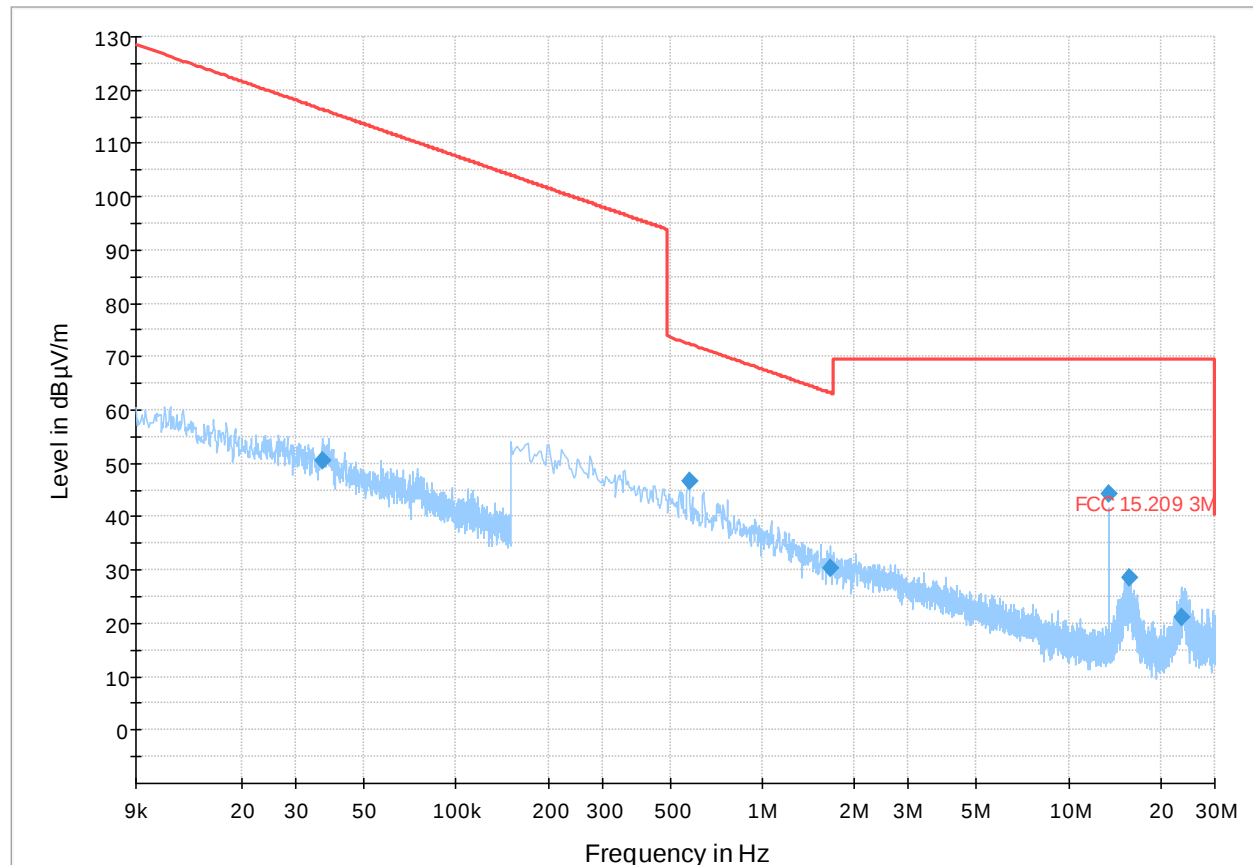


Figure 7.1-3: Radiated spurious emissions, 9 kHz-30 MHz at 0°

Table 7.1-8: Radiated disturbance (Quasi-Peak) results

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB)
0.036616	50.54	116.32	65.78	15000.0	0.200	H	294.0	13.8
0.575370	46.59	72.41	25.82	15000.0	9.000	H	-1.0	10.6
1.672865	30.25	63.17	32.92	15000.0	9.000	H	0.0	10.7
13.562120	44.18	69.50	25.32	15000.0	9.000	H	127.0	11.2
15.695380	28.70	69.50	40.80	15000.0	9.000	H	59.0	11.2
23.415605	21.23	69.50	48.27	15000.0	9.000	H	178.0	10.4

- Notes:
- ¹ Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
 - ² Correction factors = antenna factor ACF (dB) + cable loss (dB) – amplifier gain (dB)
 - ³ The maximum measured value observed over a period of 15 seconds was recorded.
 - ⁴ The spectral plot is a summation of a vertical and horizontal scan.

7.1.5 Testing data, continued

Full Spectrum

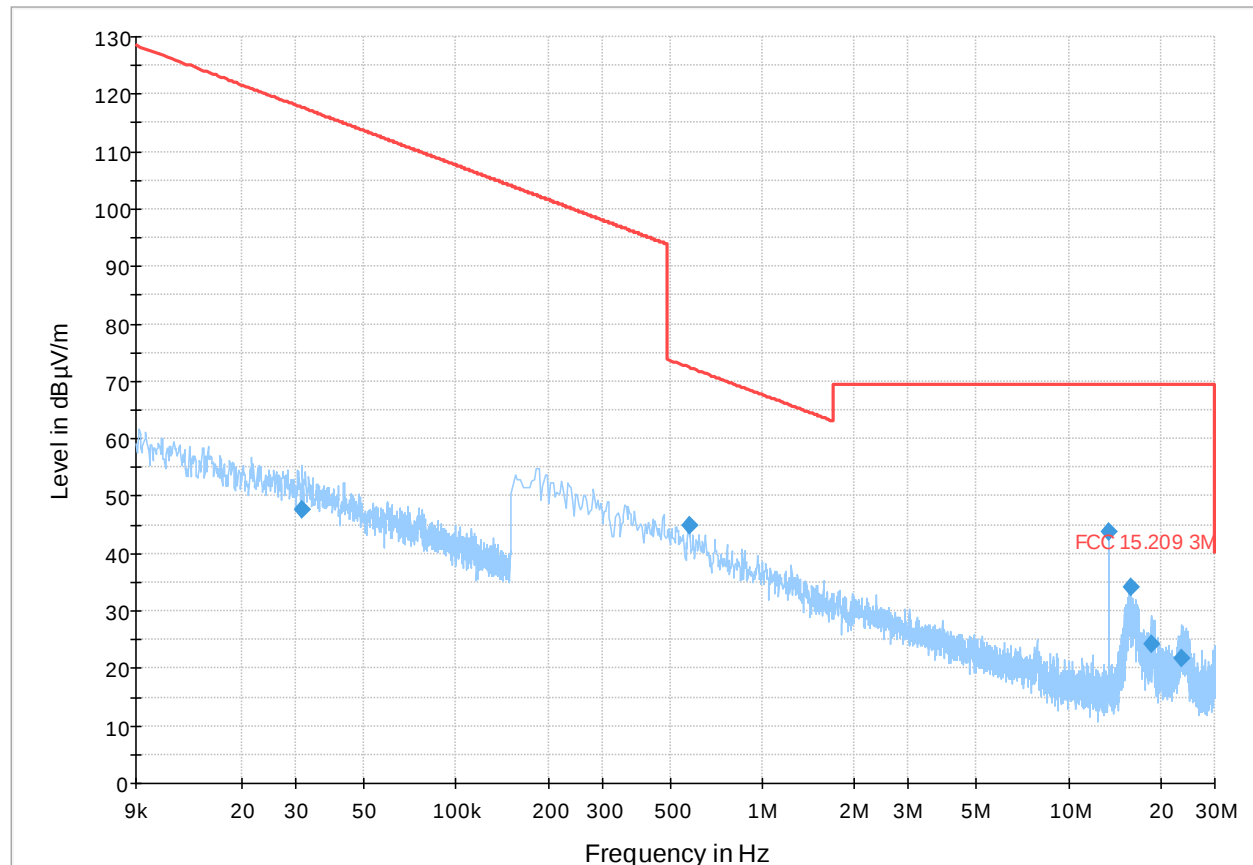


Figure 7.1-4: Radiated spurious emissions, 9 kHz-30 MHz at 90°

Table 7.1-9: Radiated disturbance (Quasi-Peak) results

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB)
0.031550	47.77	117.61	69.84	15000.0	0.200	H	144.0	14.4
0.575370	44.76	72.41	27.65	15000.0	9.000	H	278.0	10.6
13.557105	43.67	69.50	25.83	15000.0	9.000	H	260.0	11.2
15.891405	34.15	69.50	35.35	15000.0	9.000	H	82.0	11.2
18.720200	24.12	69.50	45.38	15000.0	9.000	H	144.0	11.0
23.489215	21.81	69.50	47.69	15000.0	9.000	H	331.0	10.4

- Notes:
- ¹ Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
 - ² Correction factors = antenna factor ACF (dB) + cable loss (dB) – amplifier gain (dB)
 - ³ The maximum measured value observed over a period of 15 seconds was recorded.
 - ⁴ The spectral plot is a summation of a vertical and horizontal scan.

7.1.5 Testing data, continued

Full Spectrum

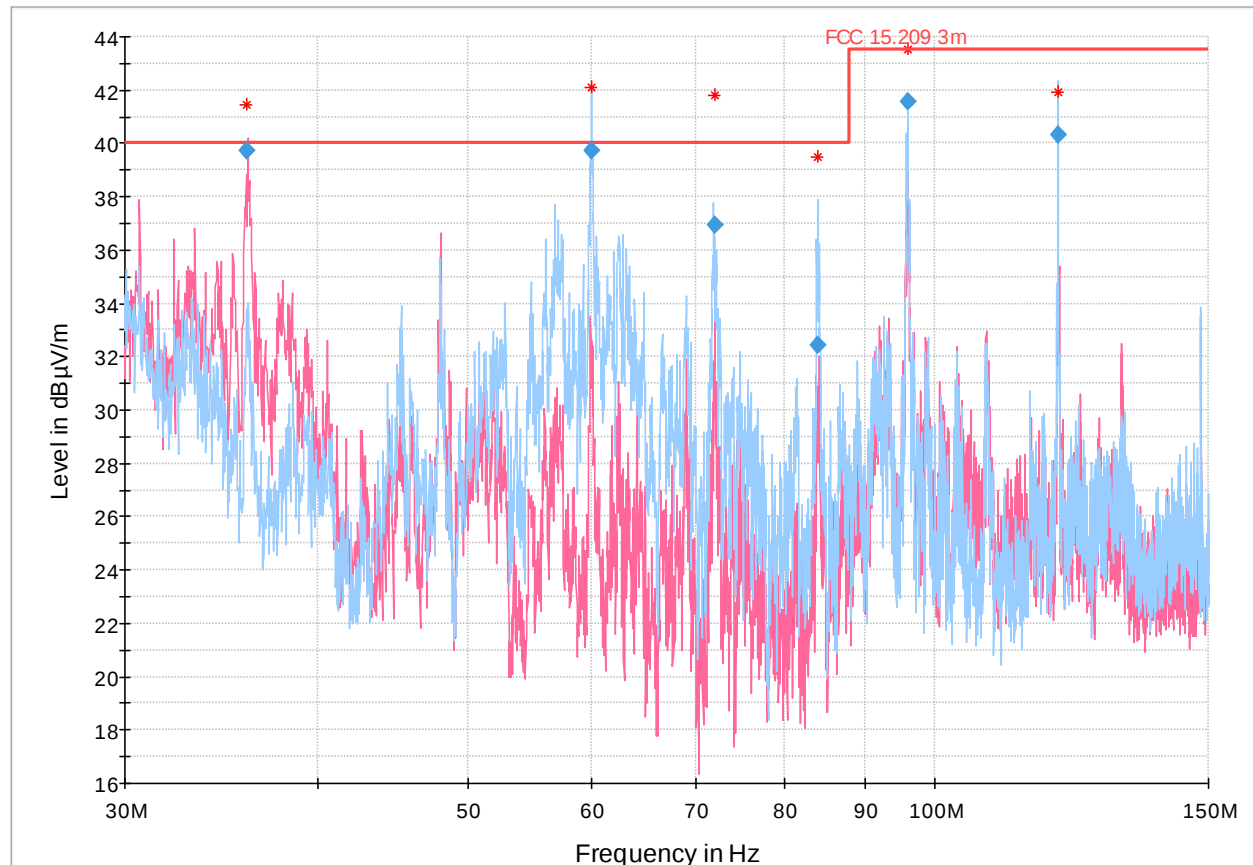


Figure 7.1-5: Radiated spurious emissions, 30 MHz – 150 MHz

Table 7.1-10: Radiated disturbance (Quasi-Peak) results

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.974000	39.71	40.00	0.29	5000.0	120.000	98.1	V	0.0	22.3
60.025333	39.72	40.00	0.28	5000.0	120.000	161.9	H	334.0	12.5
72.056333	36.95	40.00	3.05	5000.0	120.000	242.2	H	0.0	13.5
83.984333	32.46	40.00	7.54	5000.0	120.000	356.5	H	17.0	15.0
96.037000	41.55	43.50	1.95	5000.0	120.000	182.6	H	199.0	16.6
119.996000	40.35	43.50	3.15	5000.0	120.000	118.9	H	300.0	18.5

Notes:

¹ Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB) – amplifier gain (dB)

³ The maximum measured value observed over a period of 5 seconds was recorded.

⁴ The spectral plot is a summation of a vertical and horizontal scan.

⁵ The spectrum was investigated from the lowest radio frequency signal generated in the device to the tenth harmonic of the highest fundamental frequency.

7.2 Conducted limits.

7.2.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.207 / ANSI C63.4: 2014

- (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency

- (b) The limit shown in paragraph (a) of this section shall not apply to carrier current systems operating as intentional radiators on frequencies below 30 MHz. In lieu thereof, these carrier current systems shall be subject to the following standards:
- For carrier current system containing their fundamental emission within the frequency band 535-1705 kHz and intended to be received using a standard AM broadcast receiver: no limit on conducted emissions.
 - For all other carrier current systems: 1000 μ V within the frequency band 535-1705 kHz, as measured using a 50 μ H/50 ohms LISN.
 - Carrier current systems operating below 30 MHz are also subject to the radiated emission limits in §15.205, §15.209, §15.221, §15.223, or §15.227, as appropriate.
- (c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

7.2.2 Conducted Emissions Test summary

Verdict	Pass		
Test date	July 10, 2020	Temperature	20 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1006 mbar
Test location	Ground Plane	Relative humidity	64 %

7.2.3 Notes

None

7.2.4 Setup details

Port under test	AC Mains Input
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. 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.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– Peak and Average (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 5000 ms (Quasi-peak final measurement) – 5000 ms (CAverage final measurement)

Table 7.2-1: Conducted disturbance at mains port equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	2 yr	29 May 2021
Transient limiter	Hewlett-Packard	11947A	681	1 yr	20 Jan 2021
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 yr	12 Jul 2020

Notes: None

Table 7.2-2: Conducted disturbance at mains port test software details

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.20.01

Notes: None

7.2.5 Conducted Emissions Test data

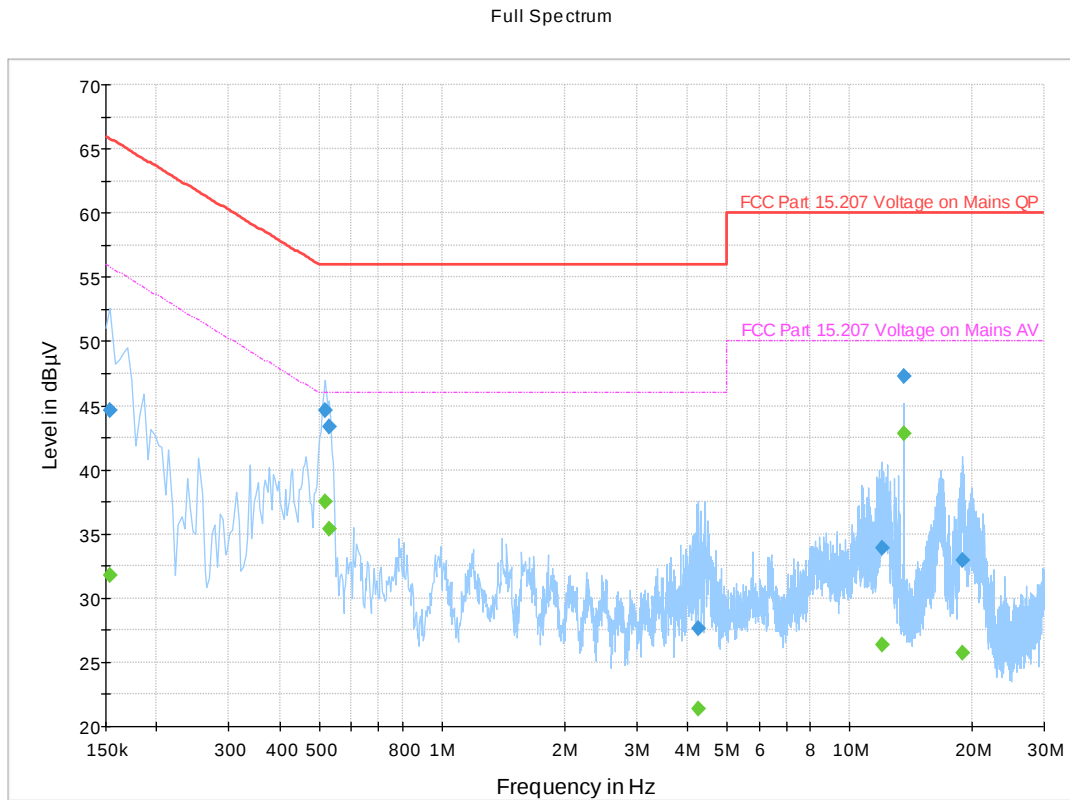


Figure 7.2.1: Conducted spurious emissions, 150 kHz-30 MHz

Table 7.2-3 Conducted disturbance at AC mains results (Quasi-Peak and Average)

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.154000	---	31.80	55.78	23.98	5000.0	9.000	L1	ON	19.6
0.154000	44.68	---	65.78	21.10	5000.0	9.000	L1	ON	19.6
0.518000	44.63	---	56.00	11.37	5000.0	9.000	N	ON	19.4
0.518000	---	37.48	46.00	8.52	5000.0	9.000	N	ON	19.4
0.530000	---	35.36	46.00	10.64	5000.0	9.000	N	ON	19.4
0.530000	43.32	---	56.00	12.68	5000.0	9.000	N	ON	19.4
4.270000	27.66	---	56.00	28.34	5000.0	9.000	N	ON	19.3
4.270000	---	21.39	46.00	24.61	5000.0	9.000	N	ON	19.3
11.994000	33.93	---	60.00	26.07	5000.0	9.000	N	ON	19.9
11.994000	---	26.37	50.00	23.63	5000.0	9.000	N	ON	19.9
13.558000	47.27	---	60.00	12.73	5000.0	9.000	L1	ON	20.1
13.558000	---	42.84	50.00	7.16	5000.0	9.000	L1	ON	20.1
18.966000	---	25.76	50.00	24.24	5000.0	9.000	N	ON	20.3
18.966000	33.00	---	60.00	27.00	5000.0	9.000	N	ON	20.3

Notes: ¹ Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)

² Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)

³ The maximum measured value observed over a period of 5 seconds was recorded.

7.3 FCC 47 CFR Part 15, Subpart C – §15.225(e) and RSS-210 Issue 9 B.6.b - Carrier frequency stability

7.3.1 References

47 CFR § 15.225 - Operation within the band 13.110-14.010 MHz

- e) The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to $+50$ degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

RSS-210 Issue 9 B.6

- b) The carrier frequency stability shall not exceed ± 100 ppm

7.3.2 Carrier frequency stability Test Summary

Verdict	Pass		
Test date	July 13, 2020	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1004 mbar
Test location	Ground Plane	Relative humidity	59 %

7.3.3 Notes

Frequency stability results were compared to Readerboard OBW Center Freq @ 20°C per RSS-Gen 6.7: 13.5598842 MHz

7.3.4 Test Methods

ANSI C63.10-2013: §6.8.1 Frequency stability with respect to ambient temperature
§6.8.2 Frequency stability when varying supply voltage

7.3.5 Test results

Temp (C°)	Voltage	T1 (F _l) (MHz)	T2 (F _h) (MHz)	F _c (MHz)	Variation (MHz)	Deviation from F _c (%)
+50	Nominal (120 Vac)	13.559233	13.56060058	13.559917	-0.000033	-0.0002%
+40	Nominal (120 Vac)	13.55926918	13.56080318	13.560036	-0.00015198	-0.0011%
+30	Nominal (120 Vac)	13.55857453	13.5605644	13.559569	0.000314735	0.0023%
+20	Nominal (120 Vac)	13.55861795	13.56052822	13.559573	0.000311115	0.0023%
+20	85% Nominal (102 Vac)	13.55862518	13.56052822	13.559577	0.0003075	0.0023%
+20	115% Nominal (138 Vac)	13.55867583	13.56059334	13.559635	0.000249615	0.0018%
+10	Nominal (120 Vac)	13.55866136	13.56057164	13.559617	0.0002677	0.0020%
+0	Nominal (120 Vac)	13.55921852	13.56085384	13.560036	-0.00015198	-0.0011%
-10	Nominal (120 Vac)	13.55858177	13.56057164	13.559577	0.000307495	0.0023%
-20	Nominal (120 Vac)	13.55916787	13.56089725	13.560033	-0.00014836	-0.0011%

Notes: The carrier frequency (F_c) was calculated at each temperature and supply voltage as follows using (F_l) as the low boundary and (F_h) as the high boundary measured during 99% OBW calculations.

$$F_c = \frac{F_l + F_h}{2}$$

7.4 Occupied Bandwidth: 99% OBW and 20 dB Bandwidth

7.4.1 References

RSS-Gen — 6.7 Occupied bandwidth (or 99% emission bandwidth) and x dB bandwidth

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “x dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

47 CFR § 15.215 - Additional provisions to the general radiated emission limitations.

- c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

7.4.2 Notes

None

7.4.3 Test Summary

Test date	July 10, 2020	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1006 mbar
Test location	Wireless workbench	Relative humidity	60 %

7.4.4 Setup Details

Spectrum analyzer settings:

Resolution bandwidth	50 Hz
Video bandwidth	200 Hz
Frequency span	6 kHz
Detector mode	Peak
Trace mode	Max Hold

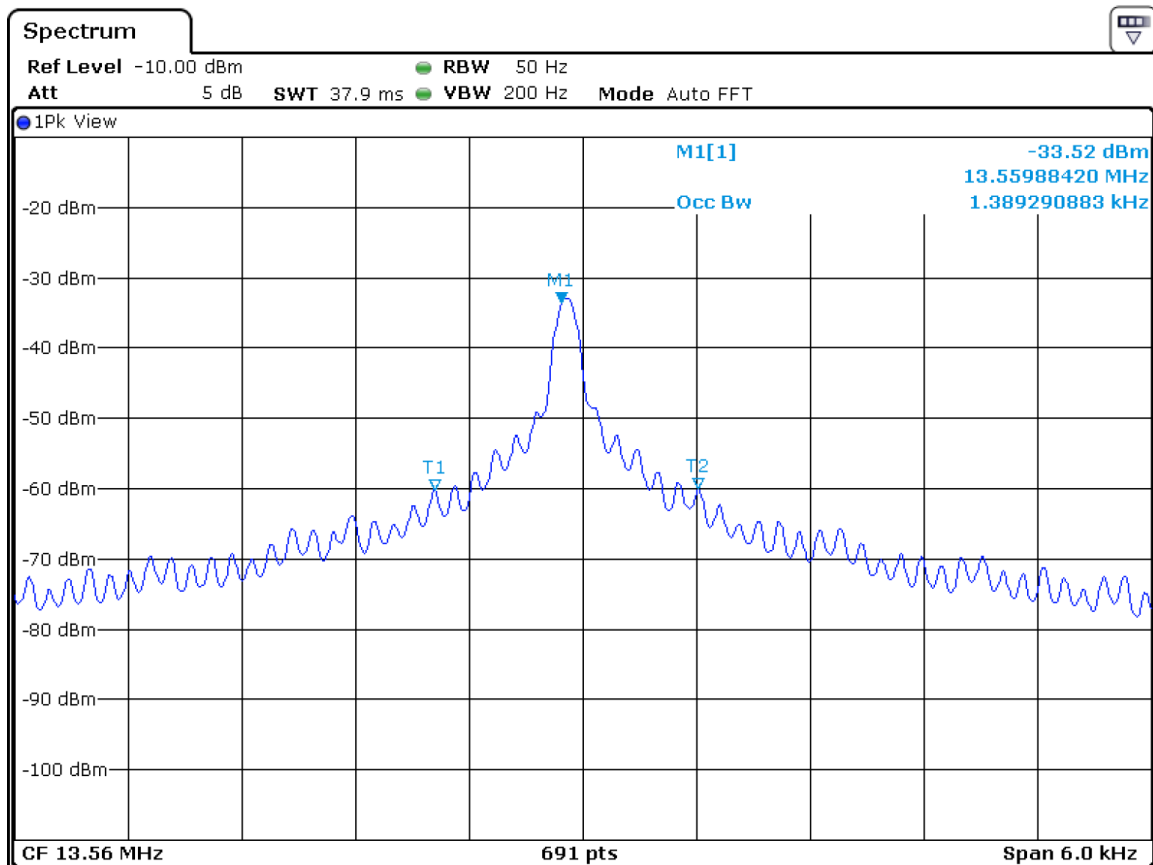
Table 7.4-1: Occupied bandwidth equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV 40	E1120	1 yr	19 Nov 2020
Active Loop H Field Antenna	Hewlett-Packard	6502	E1267	1 yr	12 Nov 2020

Notes: None

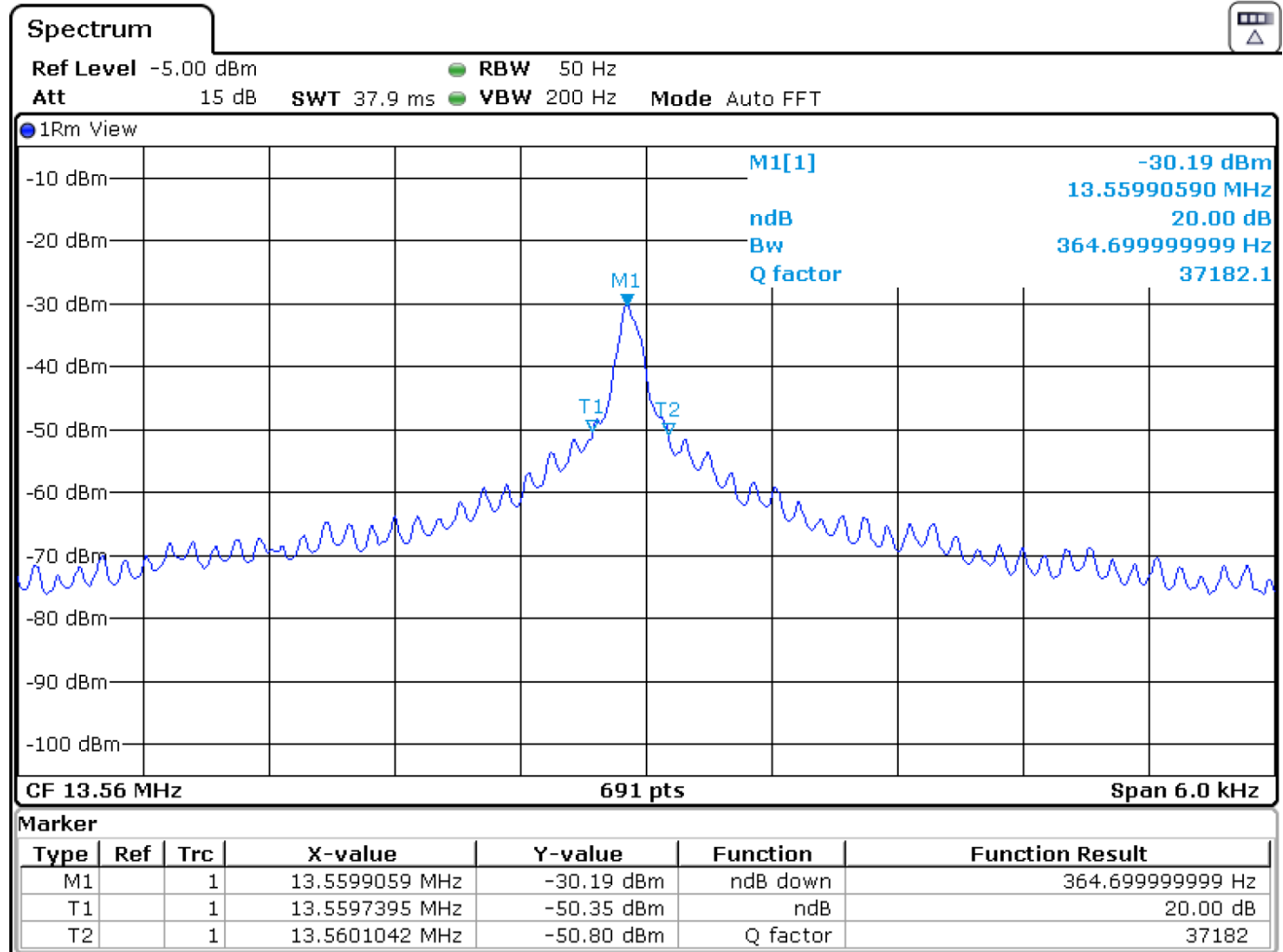
7.4.5 Test Data

99% Occupied Bandwidth



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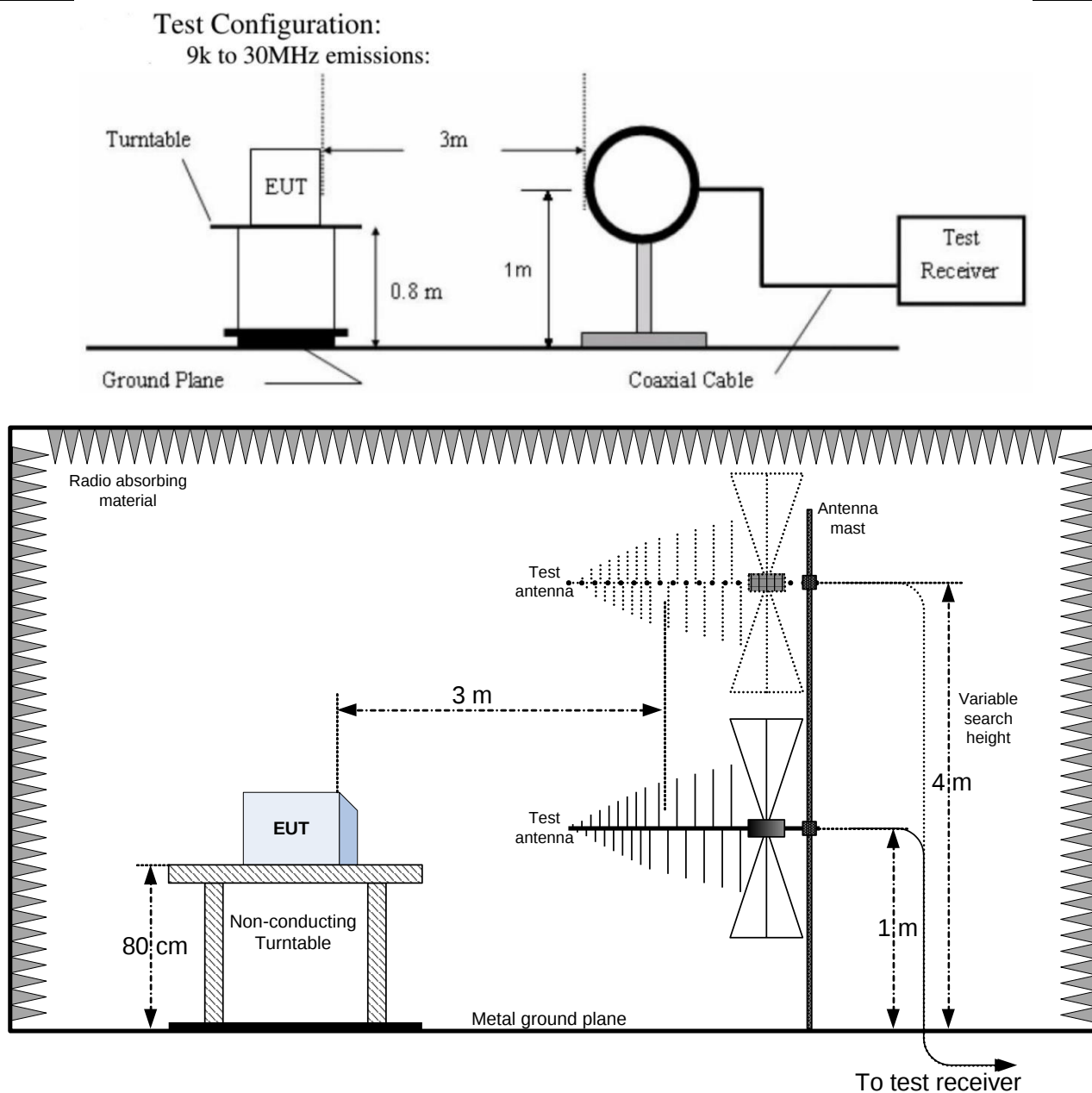
20 dB Bandwidth



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Section 8. Block diagrams of test set-ups

8.1 Radiated emissions set-up



8.2 Conducted emissions set-up

