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Test Report Date:

11 November 2021

Project Number:

1527

EMC Test Report - New Filing

Applicant:



Watts Water Technologies
815 Chestnut St.
North Andover, MA, 01845
USA

Watts Water Technologies Canada, Inc.
5435 North Service Road
Burlington, ON, L7L 5H7
Canada

FCC ID:

2AFJT-11400A

Product Model Number / HVIN

1140-01

IC Registration Number

20938-11400A

Product Name / PMN

R4 Relay

In Accordance With:

FCC 47 CFR , Part 15 Subpart C (§15.249)

Part 15 Low Power Communication Device Transmitter (DXX)

RSS-Gen, RSS-210 Issue 10

Licence-Exempt Radio Apparatus: Category I Equipment

Approved By:

Ben Hewson, President

Celltech Labs Inc.

21-364 Lougheed Rd.

Kelowna, BC, V1X 7R8

Canada



Test Lab Certificate: 2470.01



**Industry
Canada**

IC Registration 3874A



FCC Registration: CA3874

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1.0 DOCUMENT CONTROL

Revision History					
Samples Tested By:		Art Voss, P.Eng.	Date(s) of Evaluation:		6 June - 23 July, 2021
Report Prepared By:		Art Voss, P.Eng.	Report Reviewed By:		Ben Hewson
Report Revision	Description of Revision		Revised Section	Revised By	Revision Date
0.1	Draft Release		n/a	Art Voss	11 August 2021
1.0	Initial Release		n/a	Art Voss	11 November 2021

2.0 CLIENT AND DUT INFORMATION

Client Information	
Applicant Name (FCC)	Watts Water Technologies
Applicant Address (FCC)	815 Chestnut St.
	North Andover, MA, 01845
	USA
Applicant Name (ISED)	Watts Water Technologies Canada, Inc.
Applicant Address (ISED)	5435 North Service Road
	Burlington, ON, L7L 5H7
	Canada
DUT Information	
Device Identifier(s):	FCC ID: 2AFJT-11400A
	ISED ID: 20938-11400A
Device Type:	Floor Heating Transceiver
Device Model(s) / HVIN:	1140-01
Product Marketing Name / PMN:	R4 Relay
Firmware Version ID Number / FVIN:	-
Test Sample Serial No.:	Engineering Sample 4
Equipment Class (FCC):	Part 15 Low Power Communication Device Transmitter (DXX)
Equipment Class (ISED):	General Field Strength Device
Transmit Frequency Range:	912MHz
Number of Channels:	1
Manuf. Max. Rated Output Power:	0dBm (1mW)
Antenna Make and Model:	PCB Single Ended Whip
Antenna Type and Gain:	0dBi
Modulation:	FSK
Mode:	Simplex
DUT Power Source:	120VAC
DUT Dimensions [HxWxD] (mm)	H x W x D: 120mm x 80mm x 50mm
Deviation(s) from standard/procedure:	None
Modification of DUT:	None

3.0 SCOPE

Preface:

This Certification Report was prepared on behalf of:

Watts Water Technologies

, (the '*Applicant*'), in accordance with the applicable Federal Communications Commission (FCC) CFR 47 and Innovation, Scientific and Economic Development (ISED) Canada rules parts and regulations (the '*Rules*'). The scope of this investigation was limited to only the equipment, devices and accessories (the '*Equipment*') supplied by the *Applicant*. The tests and measurements performed on this *Equipment* were only those set forth in the applicable *Rules* and/or the Test and Measurement Standards they reference. The *Rules* applied and the Test and Measurement Standards used during this evaluation appear in the Normative References section of this report. The limits set forth in the technical requirements of the applicable *Rules* were applied to the measurement results obtained during this evaluation and, unless otherwise noted, these limits were used as the Pass/Fail criteria. The Pass/Fail statements made in this report apply to only the tests and measurements performed on only the *Equipment* tested during this evaluation. Where applicable and permissible, information including test and measurement data and/or results from previous evaluations of same or similar equipment, devices and/or accessories may be cited in this report.

Device Description:

The HVIN: 1140-01, PMN: SR4 Relay is a Class A Industrial remote floor heating device with a low power 912MHz Transceiver. It is intended to be used with the ConnectPlus floor heat controller, FCC ID:2AFJT-11400A, IC ID:20938-11400A..

Application:

This is an application for a New Certification, Single.

Regulatory Requirement:

As per FCC 47 CFR 2 Subpart I and the Radiocommunication Regulations of Canada, Equipment Authorization is required for this *Equipment* by means of Certification in accordance with FCC 47 CFR §15.249 and ISED RSS-210.

Scope of Work:

The scope of this investigation is limited only to the evaluation of the R4 Relay to determine compliance to the *Rules* identified herein.

RF Exposure:

As per FCC 47 CFR §2.1091 and Canada Health Safety Code 6, an RF Exposure (MPE) evaluation is required for this *Equipment* and the results of the RF Exposure (MPE) evaluation appear in a separate report.

4.0 TEST SUMMARY

TEST SUMMARY						
Section	Description of Test	Procedure Reference	Applicable Rule Part(s) FCC	Applicable Rule Part(s) ISCED	Test Date	Result
7.0	Occupied Bandwidth	ANSI C63.10-2013 KDB 558074 D01v05	§2.1049	RSS-Gen (6.7)	23 July 2021	Pass
8.0	20dB Bandwidth	ANSI C63.10-2013 KDB 558074 D01v05	§15.247(a)(2)	RSS-Gen (6.7) RSS-247 (5.2)(a)	23 July 2021	Pass
9.0	Field Strength (Fundamental)	ANSI C63.10-2013 KDB 558074 D01v05	§15.249(a)(e)	RSS-Gen (6.12) RSS-210 (B.10)	2 June 2021	n/a
10.0	Restricted Bands	ANSI C63.10-2013 KDB 558074 D01v05	§15.249(d)(e) §15.209	RSS-Gen (8.10)	2 June 2021	Pass
11.0	Radiated Rx Emissions	ANSI C63.4-2014	§15.109	ICES-003(6.1)	2 June 2021	Pass
12.0	Power Line Conducted Emissions	ANSI C63.4-2014	§15.107	ICES-003(6.1)	23 July 2021	Pass

Test Station Day Log

Date	Ambient Temp (°C)	Relative Humidity (%)	Barometric Pressure (kPa)	Test Station	Tests Performed Section(s)
2 June 2021	22.0	50	101.2	OATS	9, 10, 11
3 June 2021	21.0	50	101.2	OATS	9, 10, 11
23 July 2021	23.2	17	101.9	EMC	7, 8
23 July 2021	27.6	23	101.9	LISN	12

EMC - EMC Test Bench

SAC - Semi-Anechoic Chamber

OATS - Open Area Test Site

TC - Temperature Chamber

LISN - LISN Test Area

ESD - ESD Test Bench

IMM - Immunity Test Area

RI - Radiated Immunity Chamber

I attest that the data reported herein is true and accurate within the tolerance of the Measurement Instrument Uncertainty; that all tests and measurements were performed in accordance with accepted practices or procedures; and that all tests and measurements were performed by me or by trained personnel under my direct supervision. The results of this investigation are based solely on the test sample(s) provided by the client which were not adjusted, modified or altered in any manner whatsoever, except as required to carry out specific tests or measurements. This test report has been completed in accordance with ISO/IEC 17025.


Art Voss, P.Eng.
Technical Manager
Celltech Labs Inc.
11 August 2021
Date



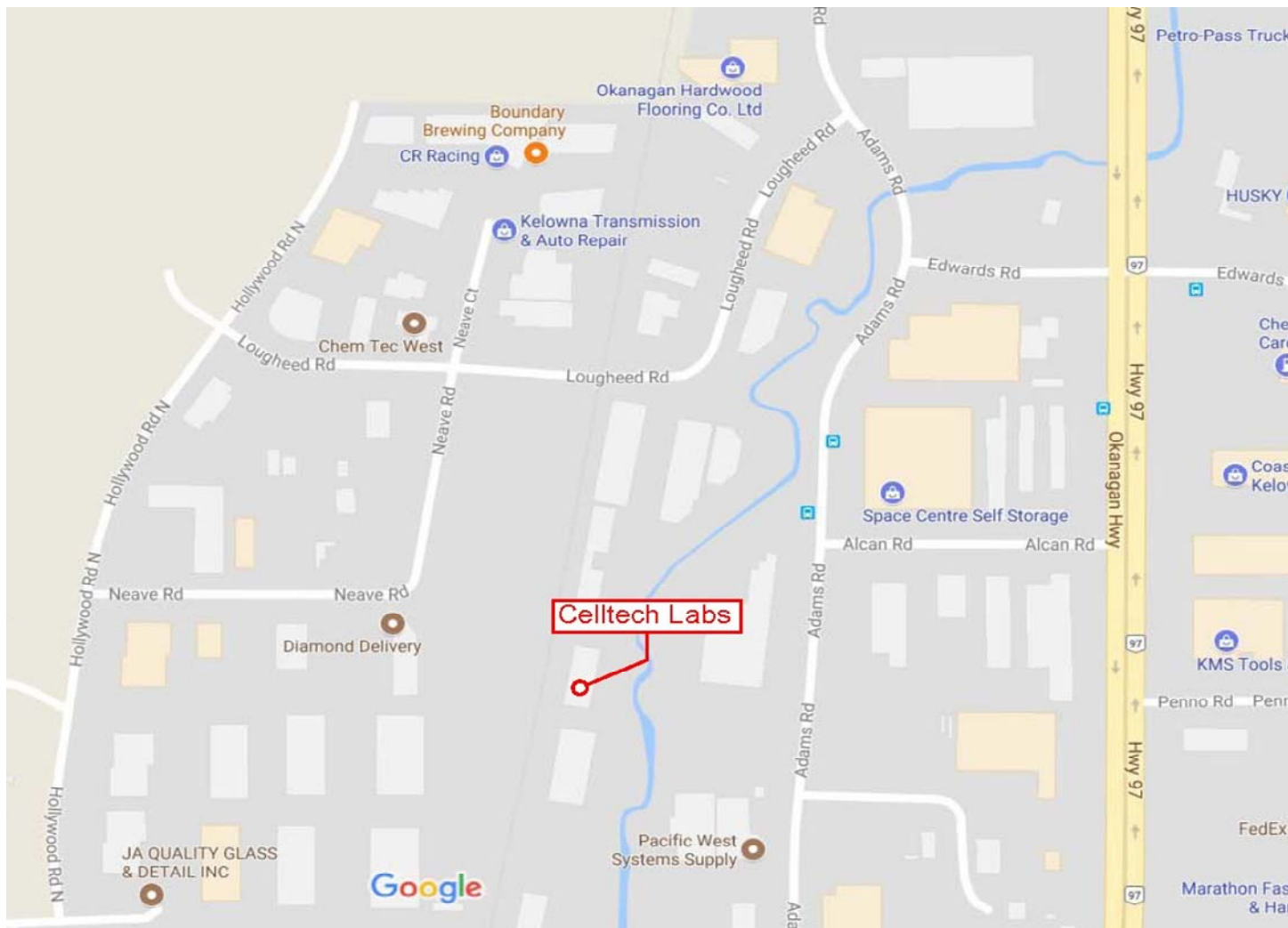
5.0 NORMATIVE REFERENCES

Normative References	
ISO/IEC 17025:2017	General requirements for the competence of testing and calibration laboratories
ANSI C63.4-2014	American National Standard of Procedures for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electric and Electronic Equipment in the Range of 9kHz to 40GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
CFR	Code of Federal Regulations Title 47: Telecommunication Part 2: Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
CFR	Code of Federal Regulations Title 47: Telecommunication Part 15: Radio Frequency Devices Sub Part C (15.249) Intentional Radiators
ISED	Innovation, Science and Economic Development Canada RSS-Gen Issue 5A1: Spectrum Management and Telecommunications Radio Standards Specification March 2019 General Requirements and Information for the Certification of Radiocommunication Equipment
ISED	Innovation, Science and Economic Development Canada Spectrum Management and Telecommunications Radio Standards Specification RSS-210 Issue 10A1: Licence-Exempt Radio Apparatus: December 2029 Category I Equipment
FCC KDB 558074 D01v05r02	OET Major Guidance Publications, Knowledge Data Base Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247

6.0 FACILITIES AND ACCREDITATIONS

Facility and Accreditation:

The facilities used to evaluate this device outlined in this report are located at 21-364 Loughheed Road, Kelowna, British Columbia, Canada V1X 7R8. The radiated emissions site (OATS) conforms to the requirements set forth in ANSI C63.4 and is filed and listed with the FCC under Test Firm Registration Number CA3874 and Innovation, Science and Economic Development Canada under Test Site File Number ISED 3874A. Celltech is accredited to ISO 17025, through accrediting body A2LA and with certificate 2470.01.



7.0 OCCUPIED BANDWIDTH

Test Procedure

Normative	FCC 47 CFR §2.1049, RSS-Gen (6.7)
References	ANSI C63.26 (5.4.4)

Requirement / Limits

47 CFR §2.1049	§ 2.1049 Measurements required: Occupied Bandwidth. The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured...
RSS-Gen (6.7)	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.

General Procedure

C63.26 (5.4.4)	5.4.4 Occupied bandwidth—Power bandwidth (99%) measurement procedure The OBW is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring (99%) power bandwidth: - The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be set wide enough to capture all modulation products including the emission skirts (typically a span of $1.5 \times \text{OBW}$ is sufficient). - The nominal IF filter 3 dB bandwidth (RBW) shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be $\geq 3 \times \text{RBW}$. - Set the reference level of the instrument as required to prevent the signal amplitude from exceeding the maximum spectrum analyzer input mixer level for linear operation. - Set the trace mode to max-hold. - Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
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Test Setup

Appendix A - Figure A.1

Measurement Procedure

The DUT was connected to the SA via a 30dB attenuator and the SA was configured as described above using the 99% Occupied Bandwidth function. The output power of the DUT was set to the manufacturer's highest output power setting at the nominal transmit frequency. The 99% Occupied Bandwidth was measured and recorded.

Plot 7.1 – Occupied Bandwidth

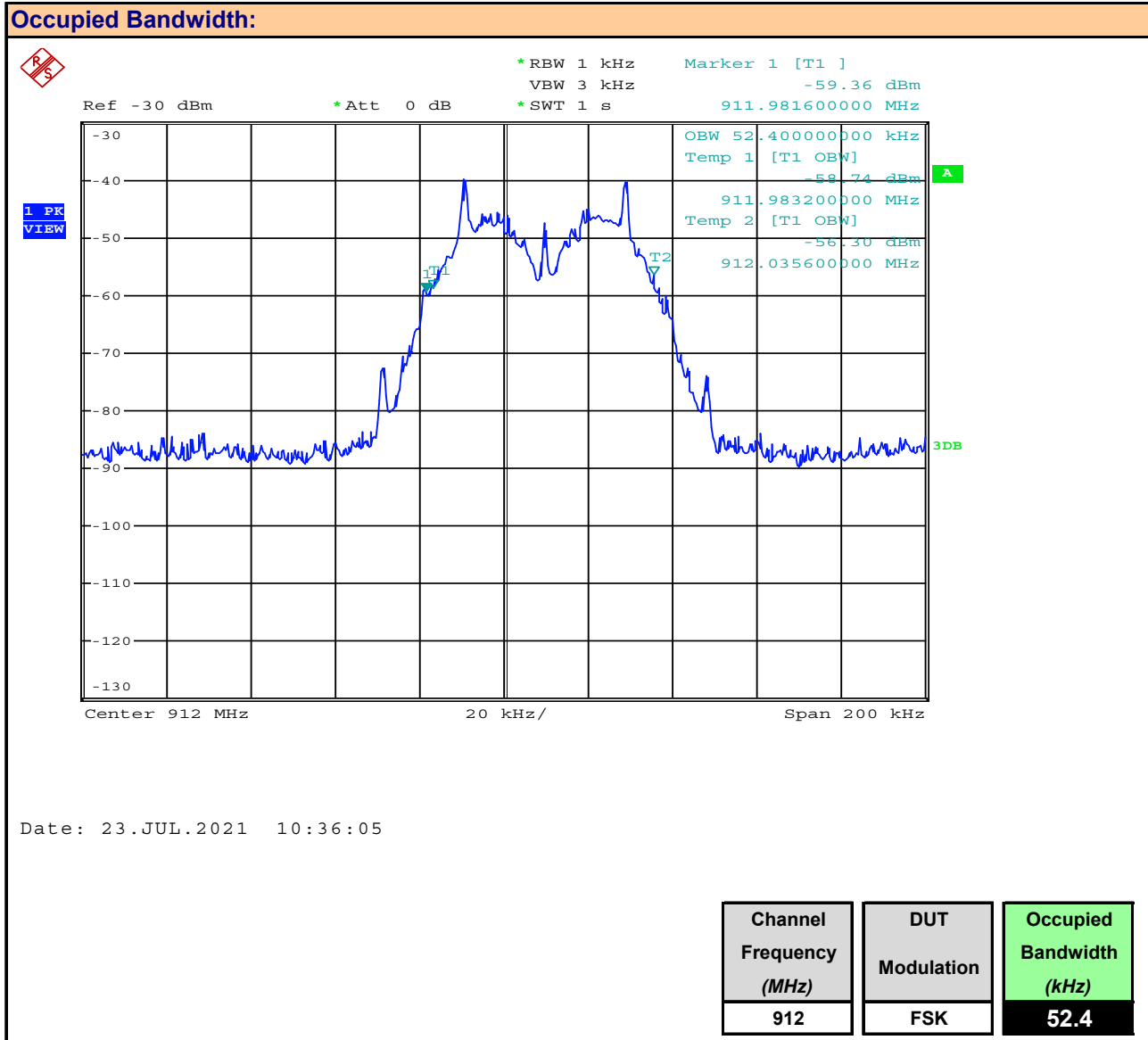


Table 7.1 – Summary of Occupied Bandwidth Measurements

Occupied Bandwidth Results:			
Channel Frequency (MHz)	Modulation	Measured Occupied Bandwidth (kHz)	Emission Designator
912.0	FSK	52.4	52K4F1D
			Complies

8.0 20DB BANDWIDTH

Test Procedure

Normative Reference	FCC 47 CFR §2.1051, §15.215
	ANSI C63.10 (6.10.3)

Limits

§15.215(c)	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.
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General Procedure

C63.10 (6.3.10)	6.10.3 Unlicensed wireless device operational configuration Set the EUT to operate at 100% duty cycle or equivalent "normal mode of operation." ⁵⁴ Testing shall be performed at the lowest frequency channel and highest frequency channel within the allowed operating band. ⁵⁵ Testing shall be performed for each frequency with every applicable unlicensed wireless device configuration. If more than one power output level is available, then testing shall be done with the appropriate maximum power output for each antenna combination or modulation, as recorded in the unlicensed wireless device conducted power measurement results. The highest gain of each antenna type shall be used for this test.
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⁵⁴ For unlicensed wireless devices unable to be configured for 100% duty cycle even in test mode, configure the system for the longest duration duty cycle supported.

⁵⁵ Some radios operating, for example, in the 2.4 GHz band, have hardware capability to operate at frequencies outside the band permitted by the regulatory authority. Testing shall only be done at the lowest and highest frequencies within the allowed frequency band (see Annex A for examples of regulatory requirements and frequency ranges).

Test Setup	Appendix A	Figure A.1
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Measurement Procedure

The DUT was placed on a turntable on an Open Area Test Site (OATS). The SA was configured as described above using the 20dB Bandwidth function. The output power of the DUT was set to the manufacturer's highest output power setting at the nominal transmit frequency. The 20dB Bandwidth was measured and recorded.

Plot 8.1 – 20dB Bandwidth

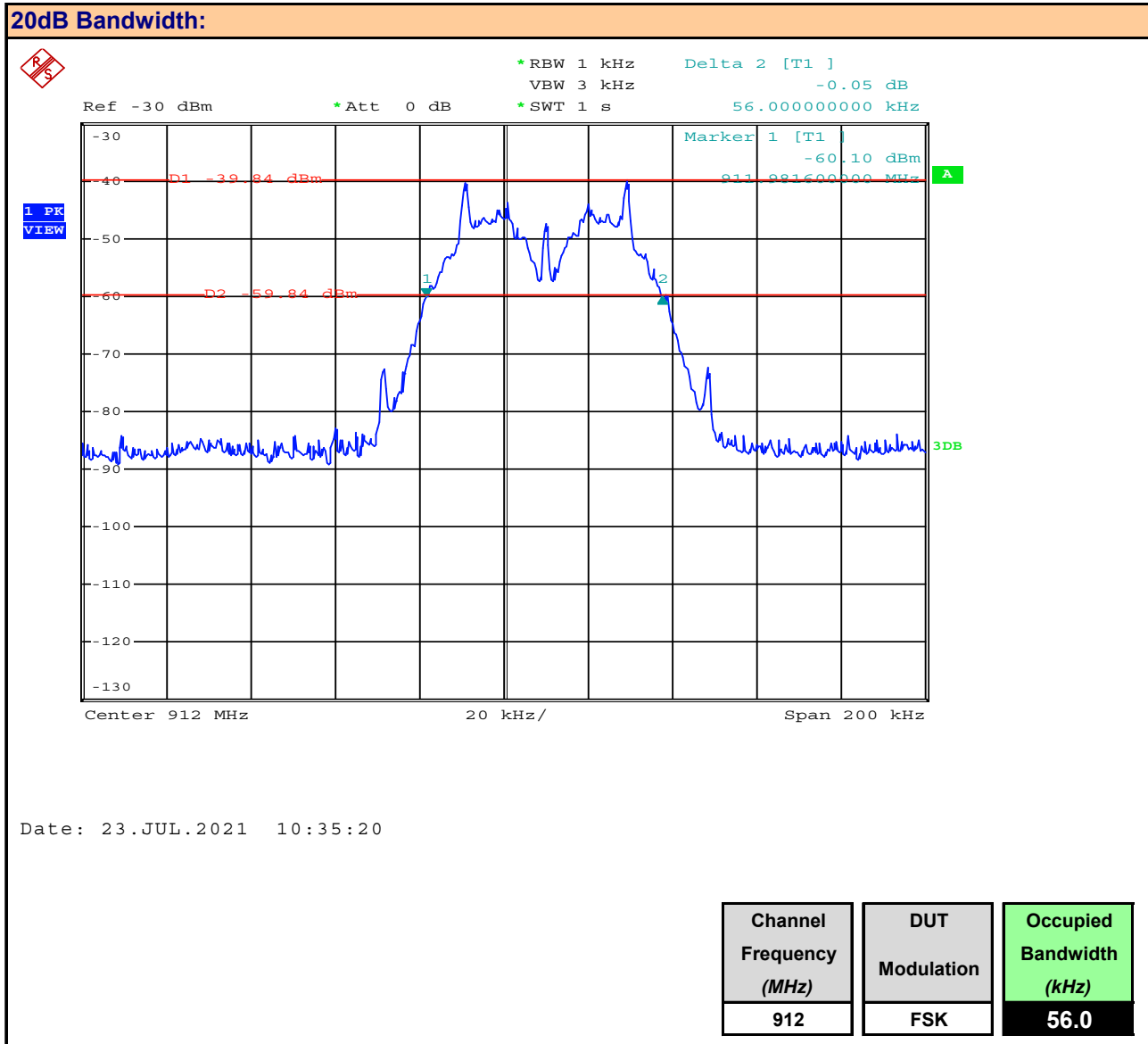


Table 8.1 – Summary of 20dB Bandwidth Measurement

20dB Bandwidth Results:		
Channel Frequency (MHz)	Modulation	Measured 20dB Bandwidth (kHz)
912.0	FSK	56.0
		Complies

Operating Band: 902-928MHz

Operating Frequency: 912MHz

20dB BW / 2 = 28kHz

$912\text{MHz} + 0.028\text{MHz} = 912.028\text{MHz} < 928\text{MHz}$

$912\text{MHz} - 0.028\text{MHz} = 911.972\text{MHz} > 902\text{MHz}$

9.0 FIELD STRENGTH

Test Procedure

Normative Reference	FCC 47 CFR §2.1046, §15.249, RSS-210
	ANSI C63.10 (11.9.2.2.6)

Limits

§15.249(a)	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz. (a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following: 902 - 928MHz, Fundamental Field Strength: 50mV/m, Harmonic: 500uV/m
RSS-210 B.10(a)	Bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz and 24-24.25 GHz (a) The field strength of fundamental and harmonic emissions measured at 3 m shall not exceed the limits in table B2. 902 - 928MHz, Fundamental Field Strength: 50mV/m, Harmonic: 500uV/m

General Procedure

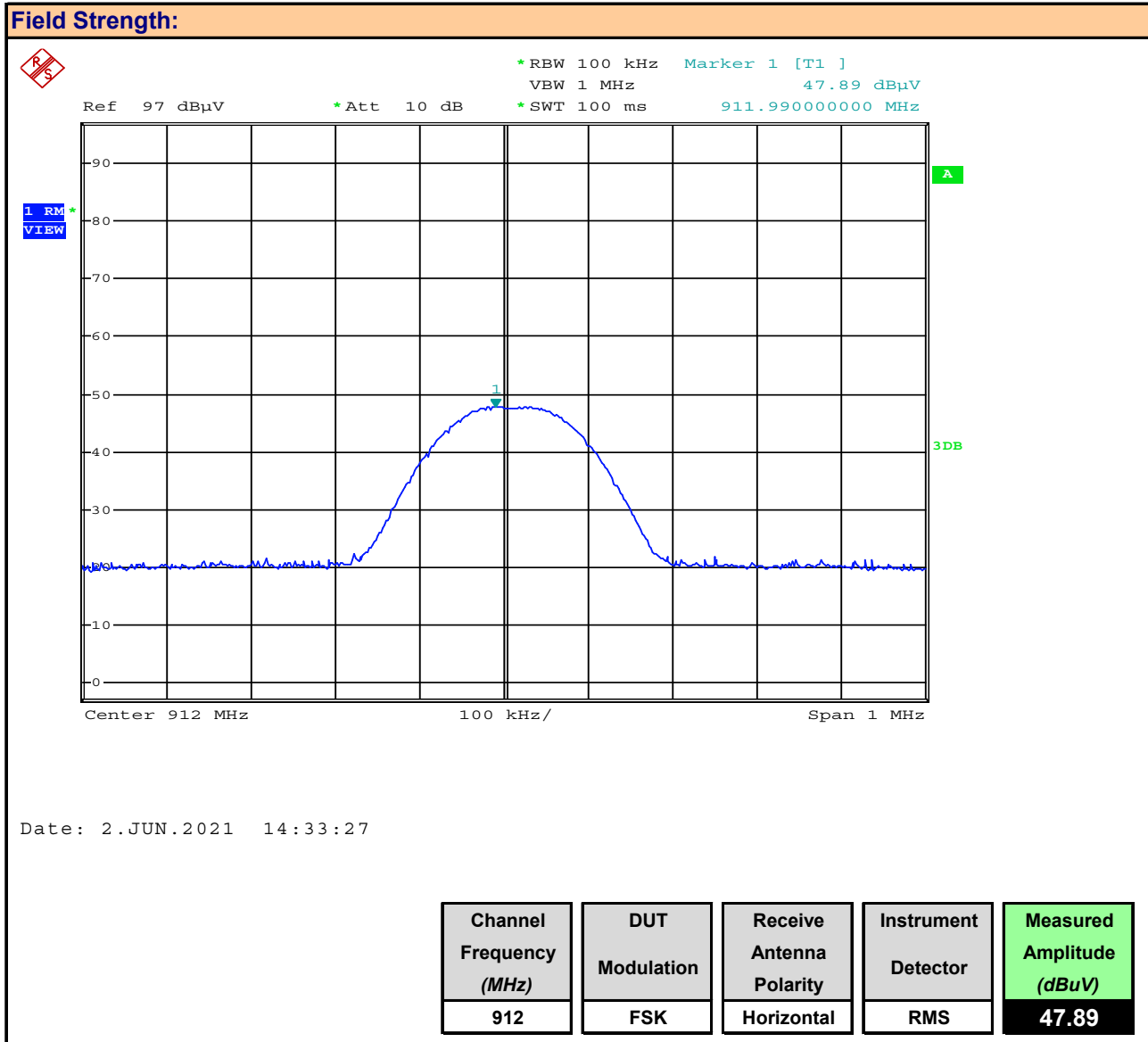
C63.10 (6.5.4)	6.5.4 Final radiated emission tests Using the orientation and equipment arrangement of the EUT, and based on the measurement results found during the exploratory measurement in 6.5.3, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable) and the frequency and amplitude of the six highest spurious emissions relative to the limit; emissions more than 20 dB below the limit do not need to be reported. Measurements are performed with the EUT rotated from 0° to 360°, the antenna height scanned between 1 m and 4 m, and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.
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Test Setup	Appendix A	Figure A.2
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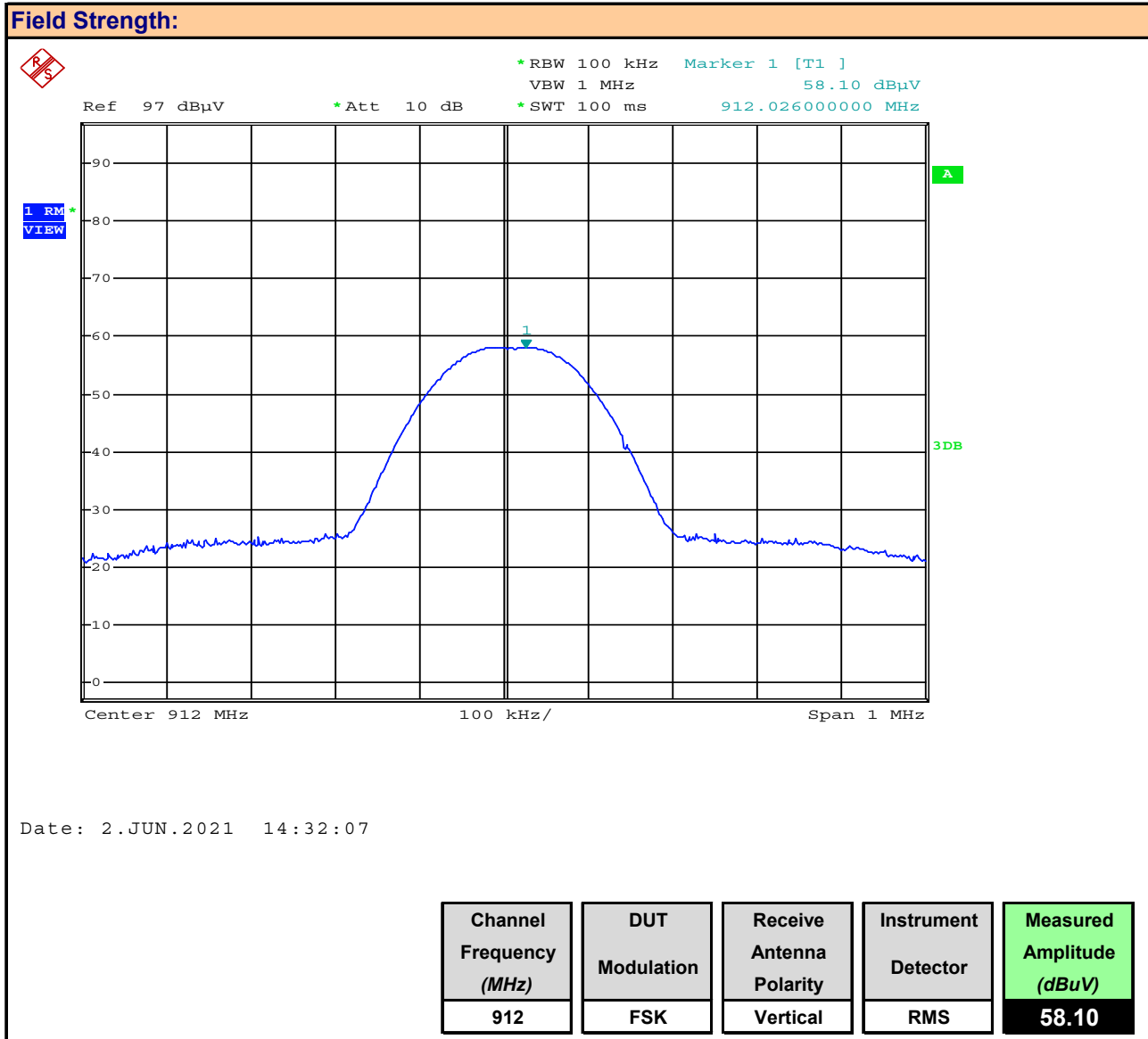
Measurement Procedure

The DUT place on a 80cm high turntable on an Open Area Test Site (OATS) at a distance of 3m from the measurement antenna. The DUT was set to transmit at maximum power and duty cycle. The DUT was rotated 360 degrees and scanned with the receive antenna elevated from 1 to 4m. The emissions were measured and recorded.

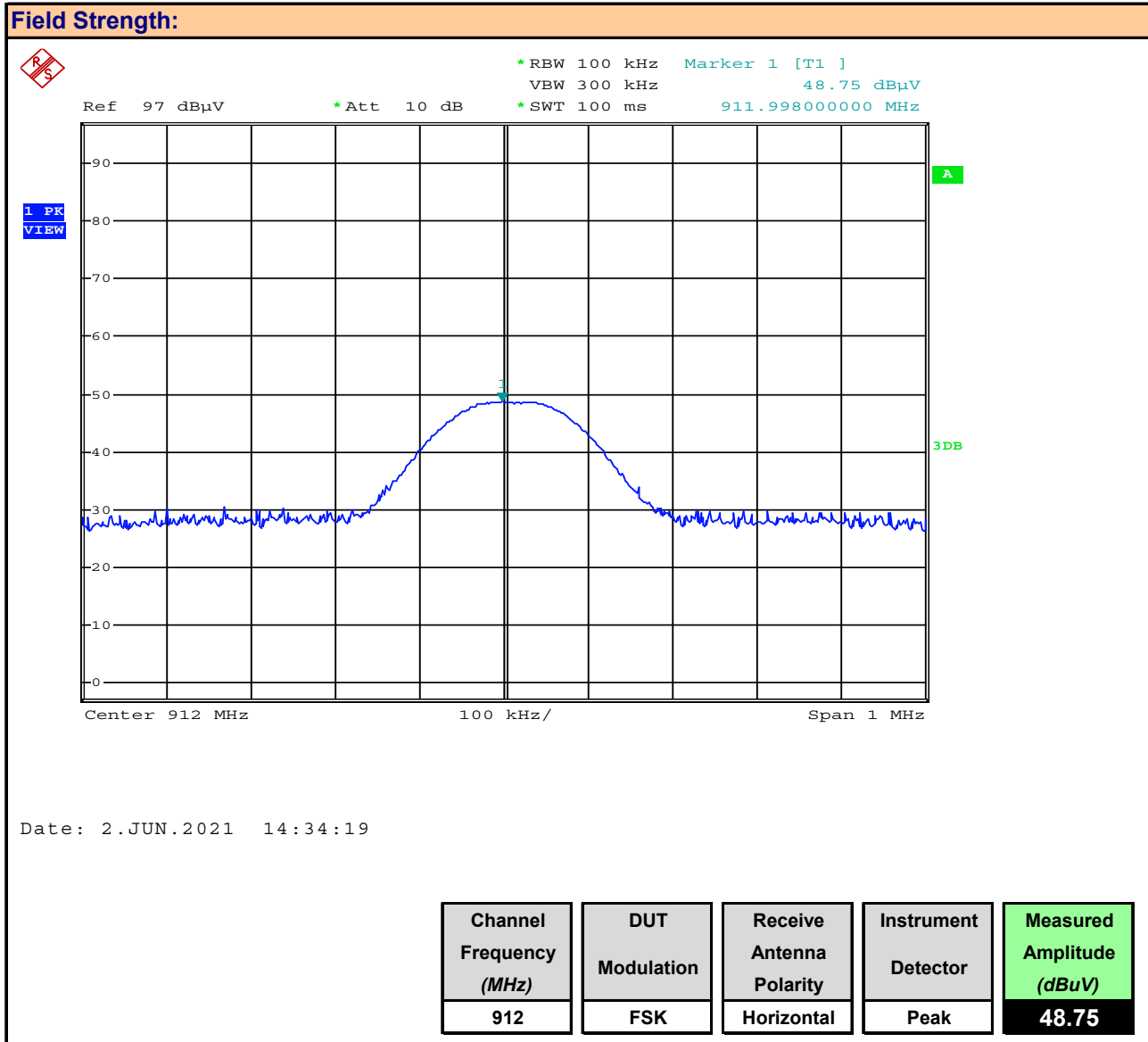
Plot 9.1 – Field Strength Measurement, RMS, Horizontal



Plot 9.2 – Field Strength Measurement, RMS, Vertical



Plot 9.3 – Field Strength Measurement, Peak, Horizontal



Plot 9.4 – Field Strength Measurement, Peak, Vertical

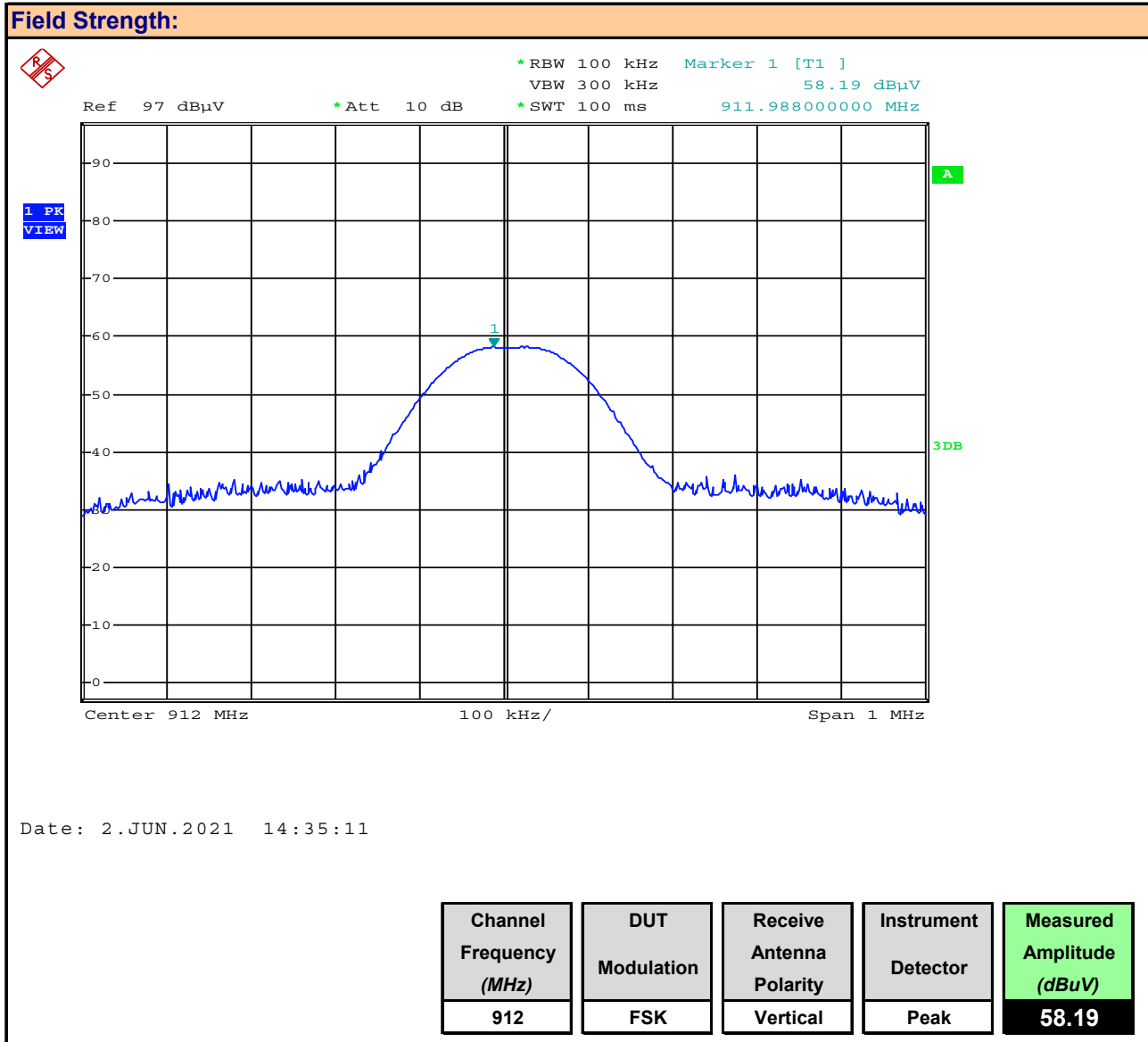


Table 9.1 – Summary of Field Strength Measurements

Conducted Power Measurement Results:									
Frequency (MHz)	DUT Modulation	Instrument Detector	Receive Antenna Polarity	Measured FS [FS _{Meas}] (dBuV)	Receive ACF [ACF] (dB)	Cable Loss [L _c] (dB)	Corrected FS [FS _{Corr}] (dBuV/m@3m)	Limit [FS _{Limit}] (dBuV/m)	Margin (dB)
912.00	FSK	RMS	Horizontal	47.89	29.5	2.97	80.36	94	13.6
			Vertical	58.10			90.57		3.4
		Peak	Horizontal	48.75			81.22	114	32.8
			Vertical	58.19			90.66		23.3
			Result:						

Conducted Margin = $P_{Limit} - P_{Meas}$

EIRP Margin = $E_{Limit} - E_{Meas}$

10.0 RESTRICTED BAND

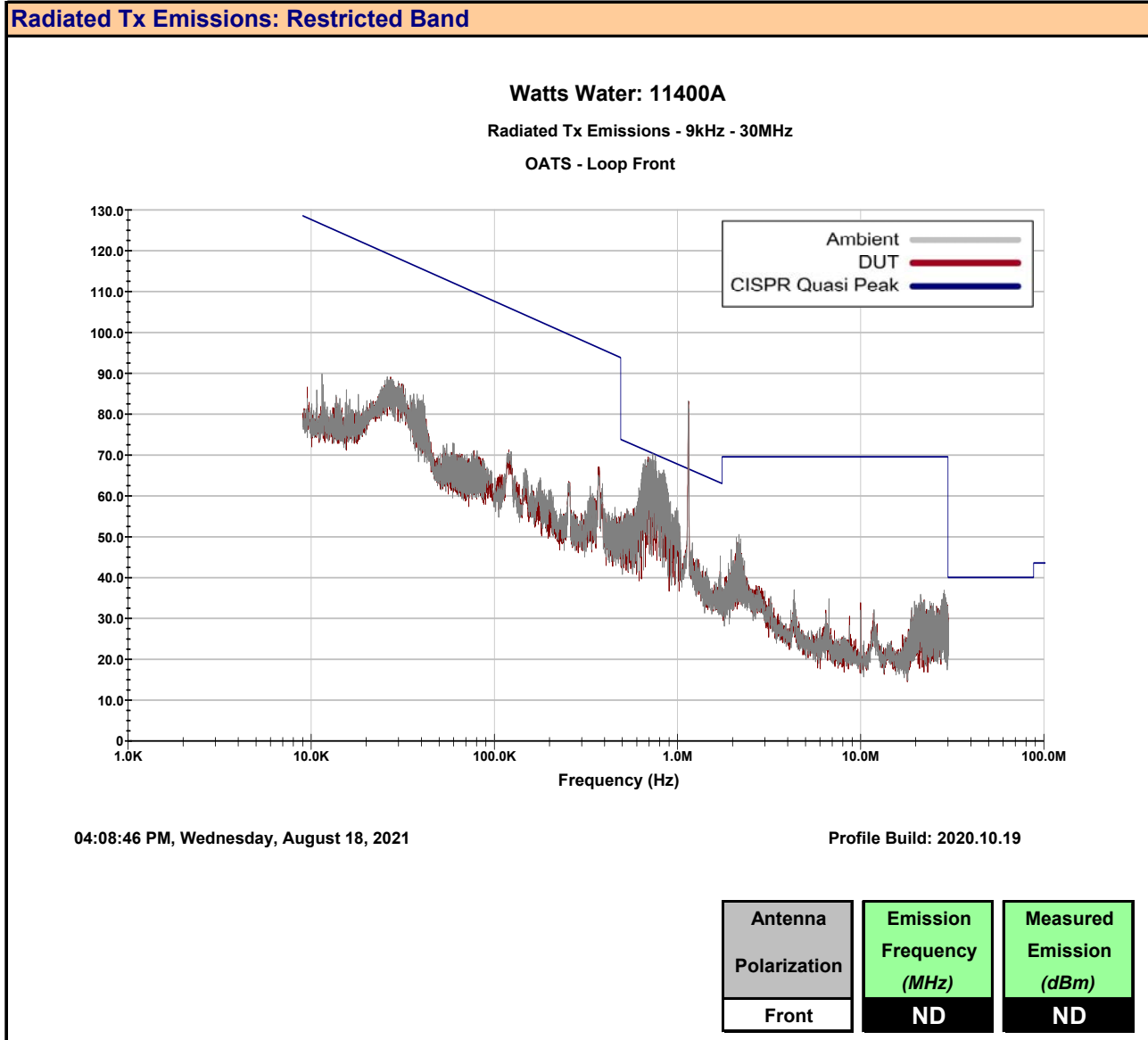
Test Procedure

Normative Reference	FCC 47 CFR §2.1051, §15.249(d), §15.209(a), RSS-GEN (8.10)
	KDB 558074 (8.6), ANSI C63.10 (11.12)

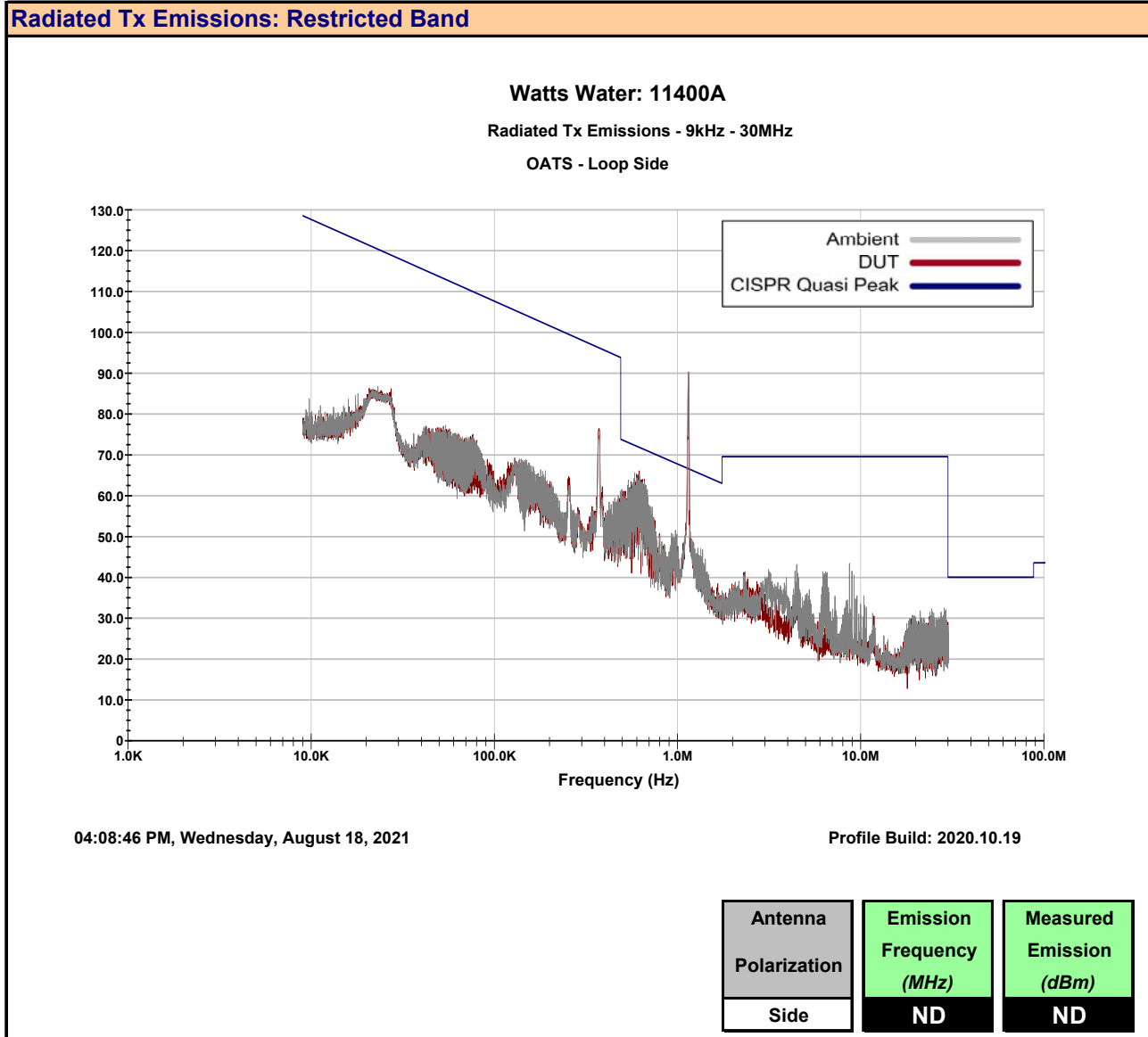
Limits

47 CFR §15.249(d)	(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.																
47 CFR §15.209(a)	§15.209 Radiated emission limits; general requirements. (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table: <table border="1"> <thead> <tr> <th>Frequency (MHz)</th><th>Field Strength (microvolts/meter)</th></tr> </thead> <tbody> <tr> <td>0.009 - 0.490</td><td>2400/F (kHz) @300m</td></tr> <tr> <td>0.490 - 1.705</td><td>24000/F (kHz) @30m</td></tr> <tr> <td>1.705 - 30</td><td>30 @ 30m</td></tr> <tr> <td>30 - 88</td><td>100 @3m</td></tr> <tr> <td>88 - 216</td><td>150 @3m</td></tr> <tr> <td>216 - 960</td><td>200 @3m</td></tr> <tr> <td>Above 960</td><td>500 @3m</td></tr> </tbody> </table>	Frequency (MHz)	Field Strength (microvolts/meter)	0.009 - 0.490	2400/F (kHz) @300m	0.490 - 1.705	24000/F (kHz) @30m	1.705 - 30	30 @ 30m	30 - 88	100 @3m	88 - 216	150 @3m	216 - 960	200 @3m	Above 960	500 @3m
Frequency (MHz)	Field Strength (microvolts/meter)																
0.009 - 0.490	2400/F (kHz) @300m																
0.490 - 1.705	24000/F (kHz) @30m																
1.705 - 30	30 @ 30m																
30 - 88	100 @3m																
88 - 216	150 @3m																
216 - 960	200 @3m																
Above 960	500 @3m																

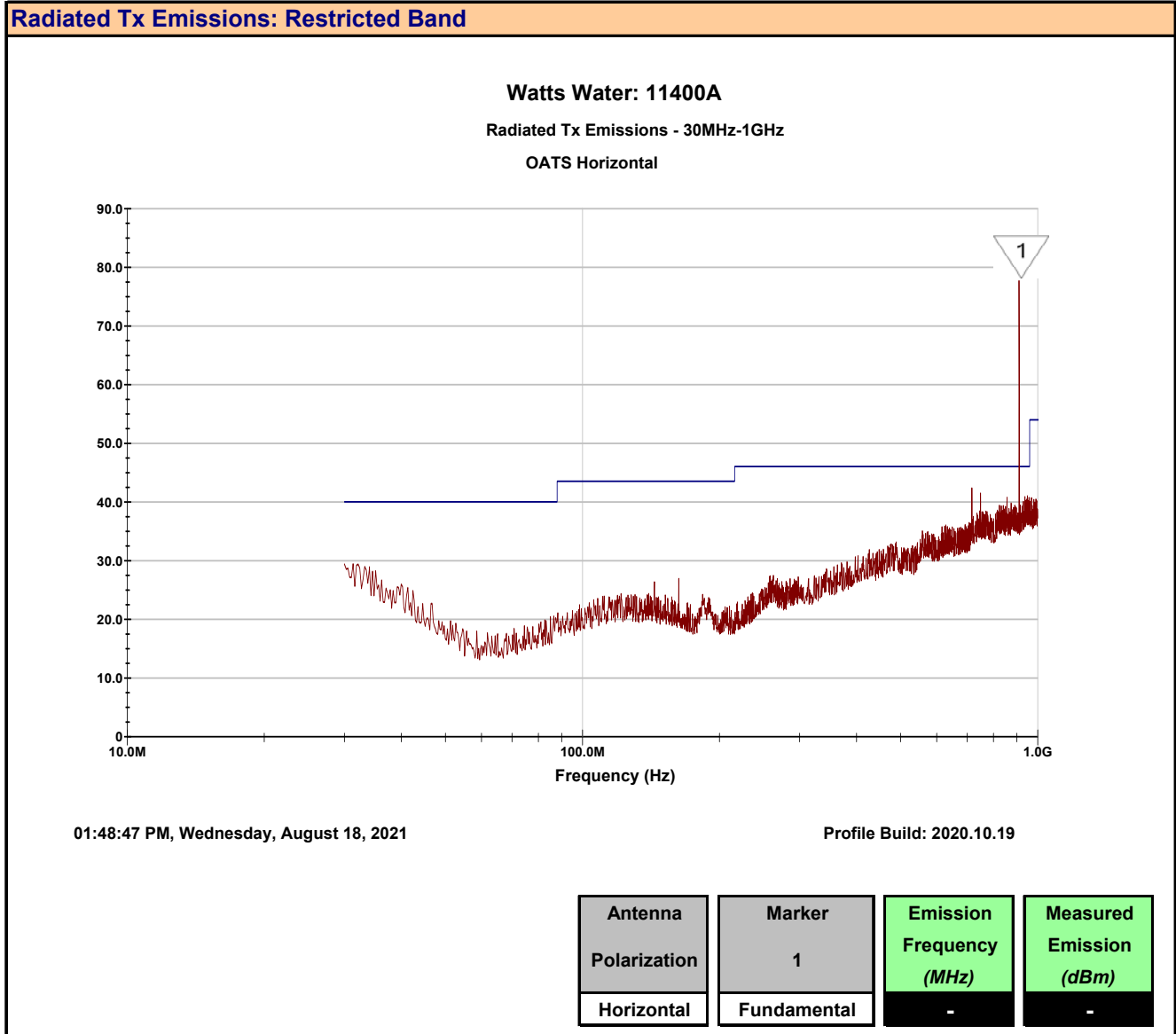
Plot 10.1 – Restricted Band, 9kHz – 30MHz, Front



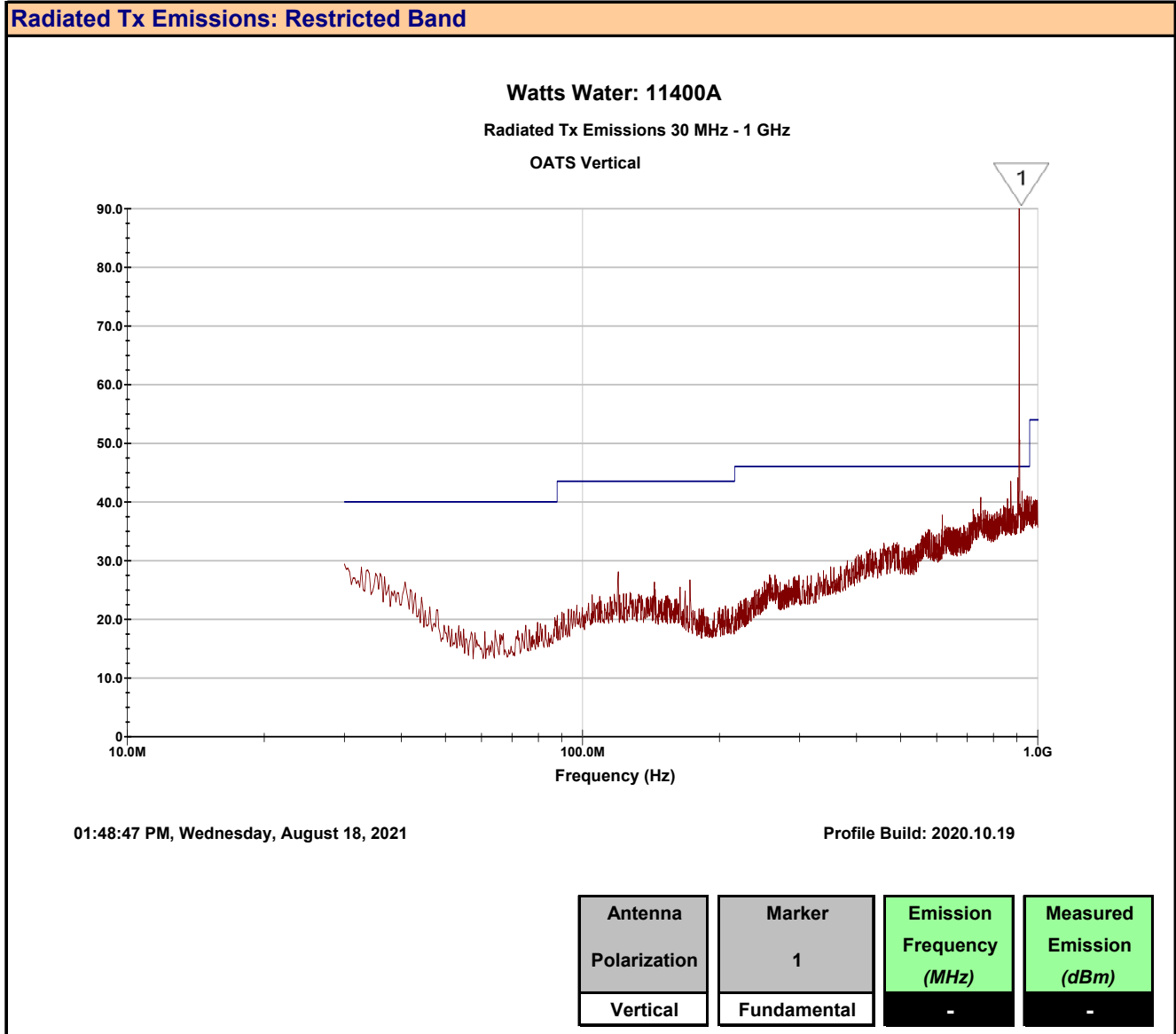
Plot 10.2 – Restricted Band, 9kHz – 30MHz, Side



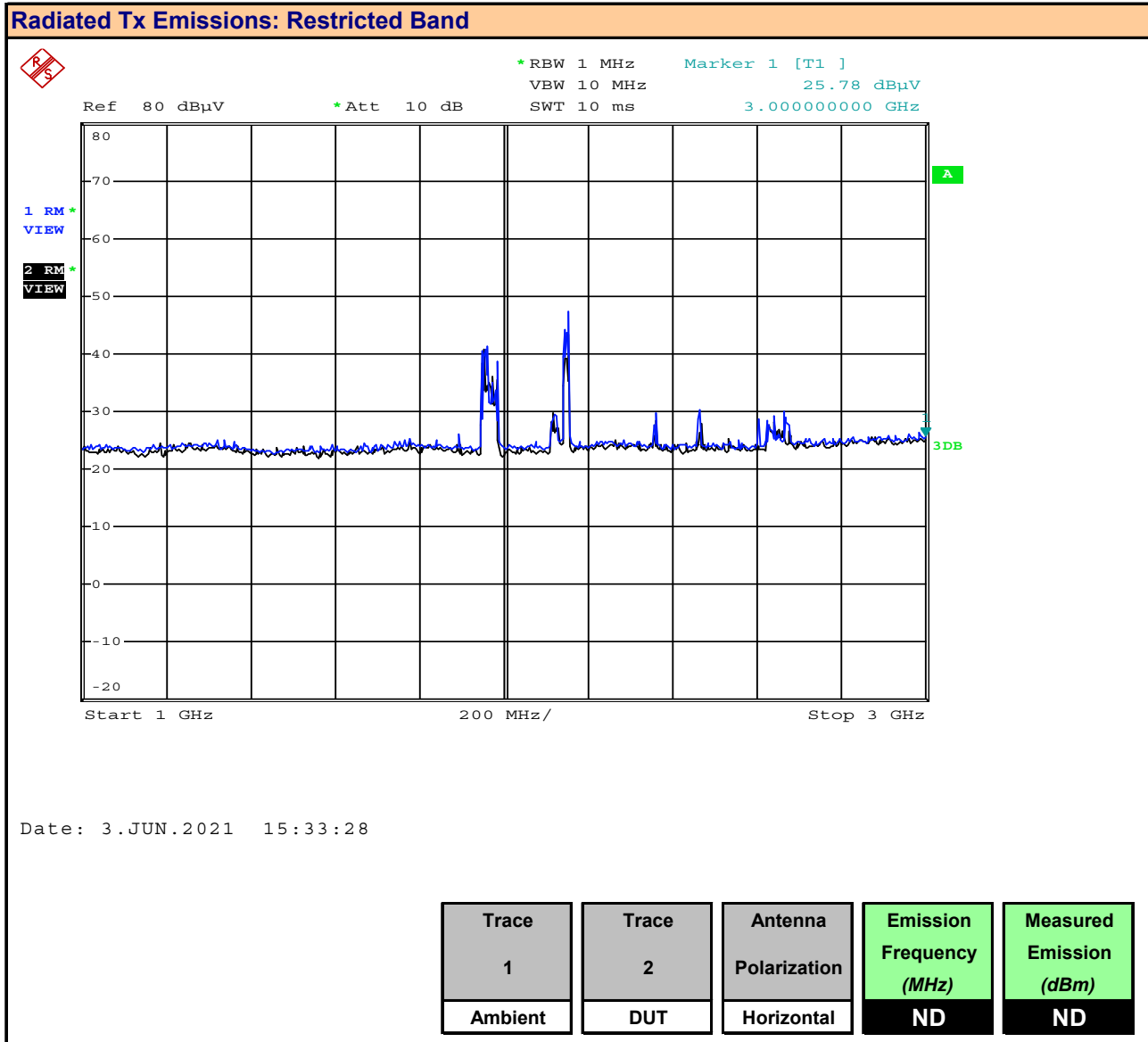
Plot 10.3 – Restricted Band, 30 - 1000MHz, Horizontal



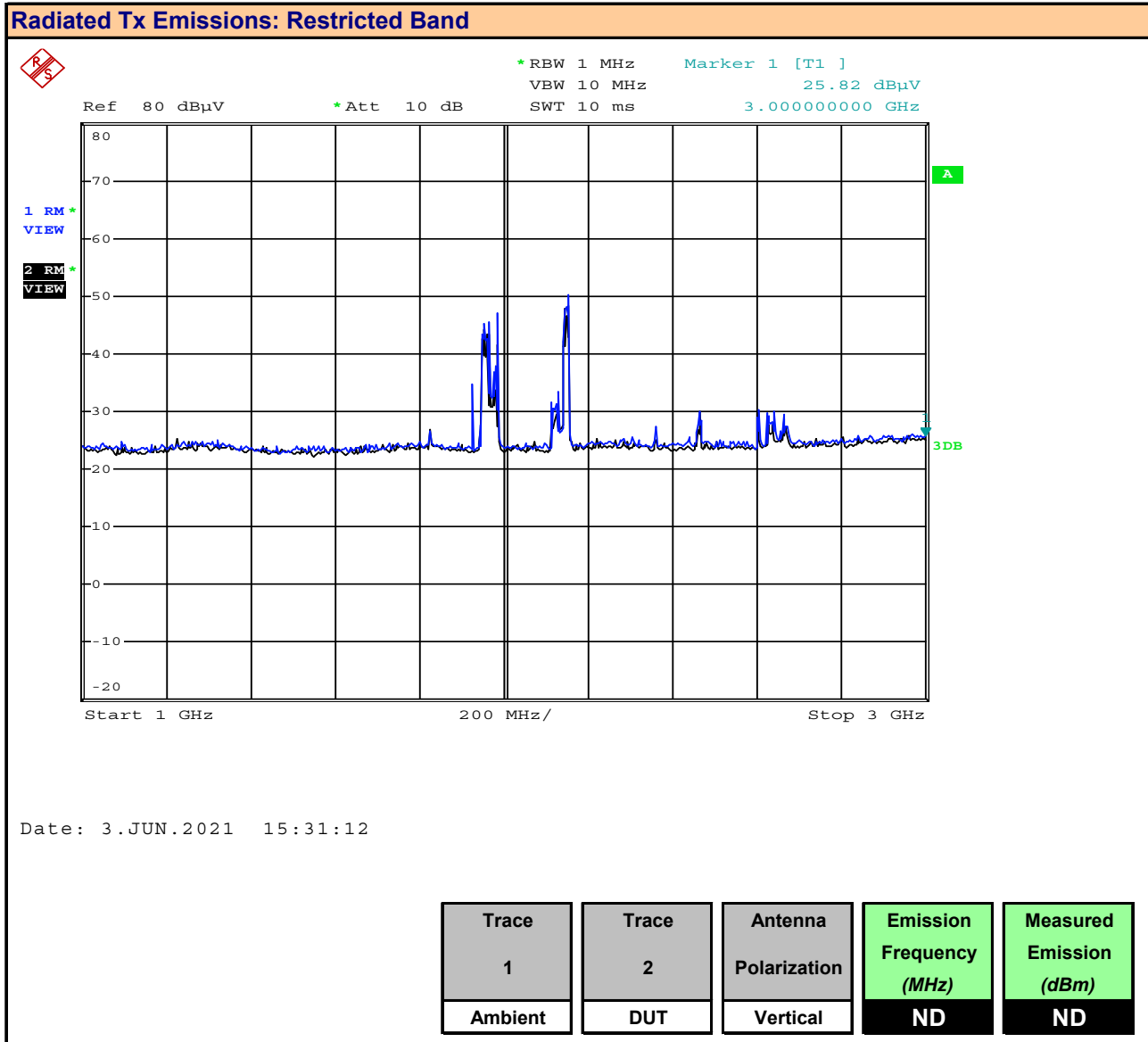
Plot 10.4 – Restricted Band, 30 - 1000MHz, Vertical



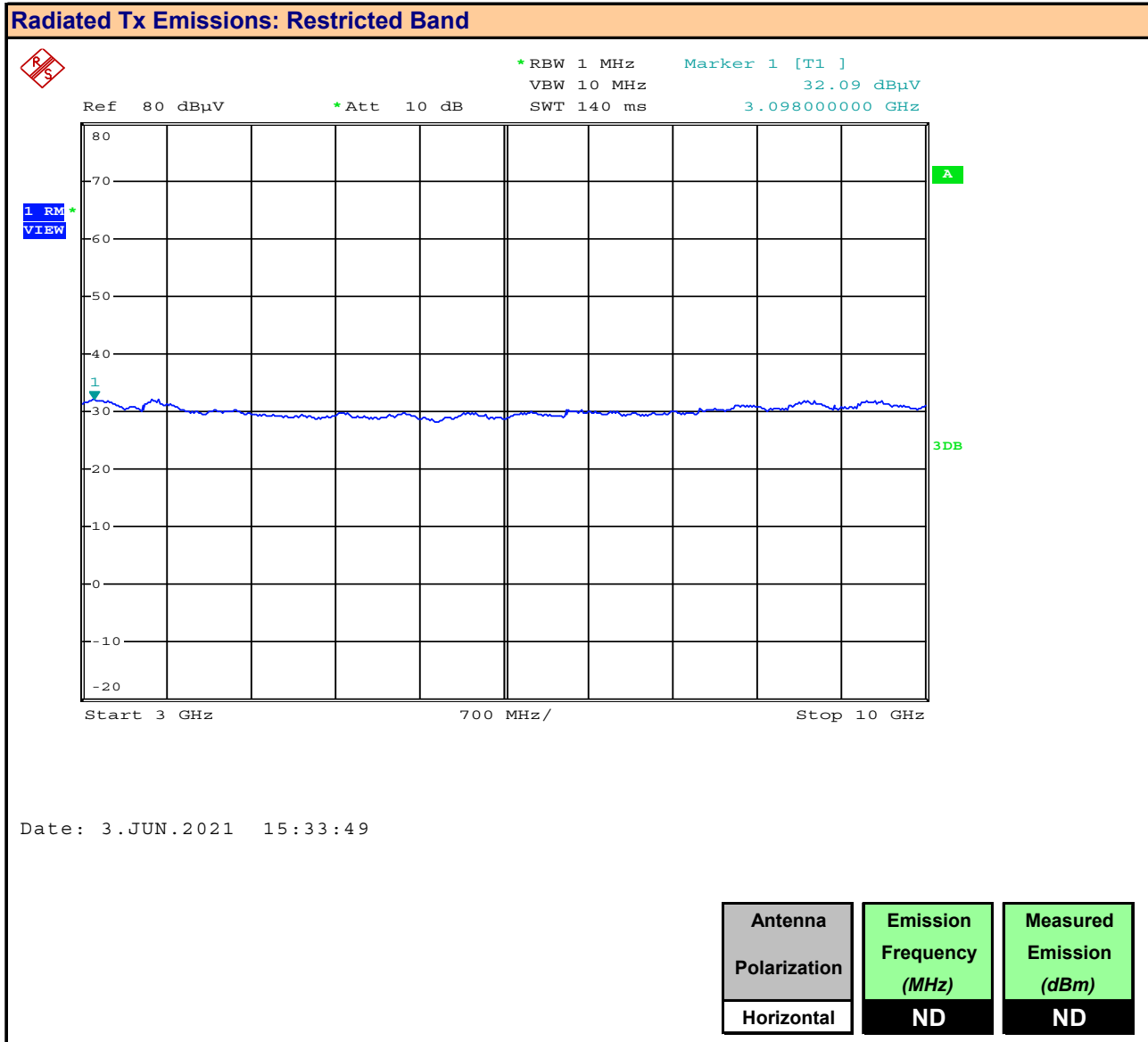
Plot 10.5 – Restricted Band, 1 – 3GHz, Horizontal



Plot 10.6 – Restricted Band, 1 – 3GHz, Vertical



Plot 10.7 – Restricted Band, 3 – 10GHz, Horizontal



Plot 10.8 – Restricted Band, 3 – 10GHz, Vertical

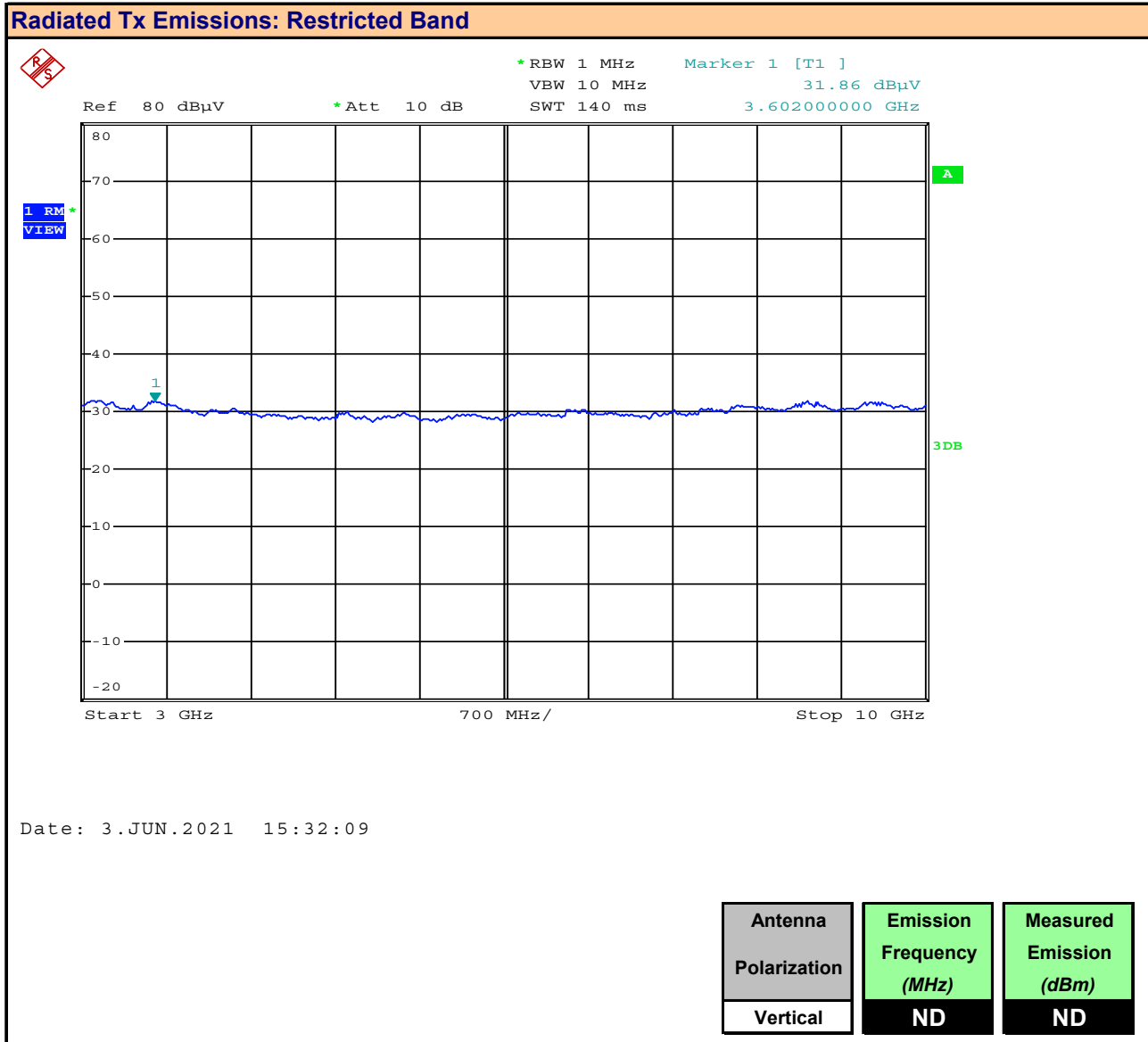


Table 10.1 – Summary of Restricted Band Measurements

Summary of Radiated Tx Emissions (Restricted Band)										
Measured Frequency Range (MHz)	Channel Frequency (MHz)	Antenna Polarization	Emission Frequency	Measured Emission [E _{Meas}] (dBuV)	Antenna ACF [ACF] (dB)	Cable Loss [L _C] (dB)	Amplifier Gain [G _A] (dB)	Corrected Emission [E _{Corr}] (dBuV/m)	Limit (dBuV)	Margin (dB)
9kHz - 30MHz	912.0	Front	ND	ND (1)	0.00	0.00	0.00 (3)	ND (2)	n/a	n/a
		Side	ND	ND (1)	0.00	0.00	0.00 (3)	ND (2)	n/a	n/a
Horizontal		143.94	25.3	0.00	0.00	0.00 (3)	25.3 (2)	43.5	18.2	
		162.84	25.8	0.00	0.00	0.00 (3)	25.8 (2)	43.5	17.7	
		717.20	39.7	0.00	0.00	0.00 (3)	39.7 (2)	46.0	6.3	
		749.40	38.8	0.00	0.00	0.00 (3)	38.8 (2)	46.0	7.2	
Vertical		119.91	27.0	0.00	0.00	0.00 (3)	27.0 (2)	43.5	16.5	
		143.94	25.3	0.00	0.00	0.00 (3)	25.3 (2)	43.5	18.2	
		172.29	25.5	0.00	0.00	0.00 (3)	25.5 (2)	43.5	18.0	
		617.80	35.2	0.00	0.00	0.00 (3)	35.2 (2)	46.0	10.8	
		750.10	38.1	0.00	0.00	0.00 (3)	38.1 (2)	46.0	7.9	
		873.30	40.6	0.00	0.00	0.00 (3)	40.6 (2)	46.0	5.4	
1 - 3GHz		Horizontal	ND	ND (1)	27.40	4.58	0.00 (3)	ND	60.0	n/a
		Vertical	ND	ND (1)	27.40	4.58	0.00 (3)	ND	60.0	n/a
3-10GHz	Horizontal	ND	ND (1)	36.76	9.86	0.00 (3)	ND	60.0	n/a	
	Vertical	ND	ND (1)	36.76	9.86	0.00 (3)	ND	60.0	n/a	
Results:									Complies	

(1) No Emissions Detected (ND) above ambient or within 20dB of the limit

(2) Antenna ACF, Cable Loss and Amplifier Gain corrected in Spectrum Analyzer Transducer Factor

(3) External Amplifier not used

$$E_{\text{Corr}} = E_{\text{Meas}} + \text{ACF} + L_C - G_A$$

Summary of Radiated Tx Emissions ISED RSS-Gen 6.5 (Below 30MHz)										
Measured Frequency Range (MHz)	Channel Frequency (MHz)	Antenna Polarization	Emission Frequency	Measured Emission [E _{Meas}] (dBuV)	Antenna ACF [ACF ^H] (dB/Ωm)	Cable Loss [L _C] (dB)	Amplifier Gain [G _A] (dB)	Corrected Emission [H _{Corr}] (dBuA/m)	Limit (dBuA/m)	Margin (dB)
9kHz - 30MHz	912.0	Front	ND	ND (1)	0.00	0.00	0.00 (3)	ND (2)	n/a	n/a
		Side	ND	ND (1)	0.00	0.00	0.00 (3)	ND (2)	n/a	n/a

(1) No Emissions Detected (ND) above ambient or within 20dB of the limit

(2) Antenna ACF, Cable Loss and Amplifier Gain corrected in Spectrum Analyzer Transducer Factor

(3) External Amplifier not used

$$H_{\text{Corr}}(\text{dBuA/m}) = E_{\text{Meas}}(\text{dBuV}) + \text{ACF}^H(\text{dB}/\Omega\text{m}) + L_C - G_A$$

Where ACF^H is the Magnetic Antenna Correction Factor

$$\text{ACF}^H(\text{dB}/\Omega\text{m}) = Z_0(\text{dB}\Omega) - \text{ACF}^E(\text{dB/m})$$

$$\text{Where } Z_0 = 120\pi\Omega = 377\Omega, Z_0(\text{dB}\Omega) = 20\text{Log}(377) = 51.5\text{dB}\Omega$$

11.0 RADIATED RX EMISSIONS

Test Procedure

Normative Reference	FCC 47 CFR §15.109, ICES-003(6.2) ANSI C63.4-2014
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Limits

47 CFR §15.109	(b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following: 30-88MHz: 39.1dBuV/m 88-216MHz: 43.5dBuV/m 216-960MHz: 46.4dBuV/m > 960MHz: 49.5dBuV/m		30-88MHz: 49.6dBuV/m @ 3m 88-216MHz: 54.0dBuV/m @ 3m 216-960MHz: 56.9dBuV/m @ 3m > 960MHz: 60.0dBuV/m @ 3m	
ICES-003(6.2.1)	6.2.1 - Radiated Emissions Limits Below 1 GHz Class A: ITE that meets the conditions for Class A operation defined in Section 2.2 shall comply with the Class A radiated limits set out in Table 4 determined at a distance of 10 metres. 30-88MHz: 39.1dBuV/m 88-216MHz: 43.5dBuV/m 216-960MHz: 46.4dBuV/m > 960MHz: 49.5dBuV/m			30-88MHz: 49.6dBuV/m @ 3m 88-216MHz: 54.0dBuV/m @ 3m 216-960MHz: 56.9dBuV/m @ 3m > 960MHz: 60.0dBuV/m @ 3m

Test Setup

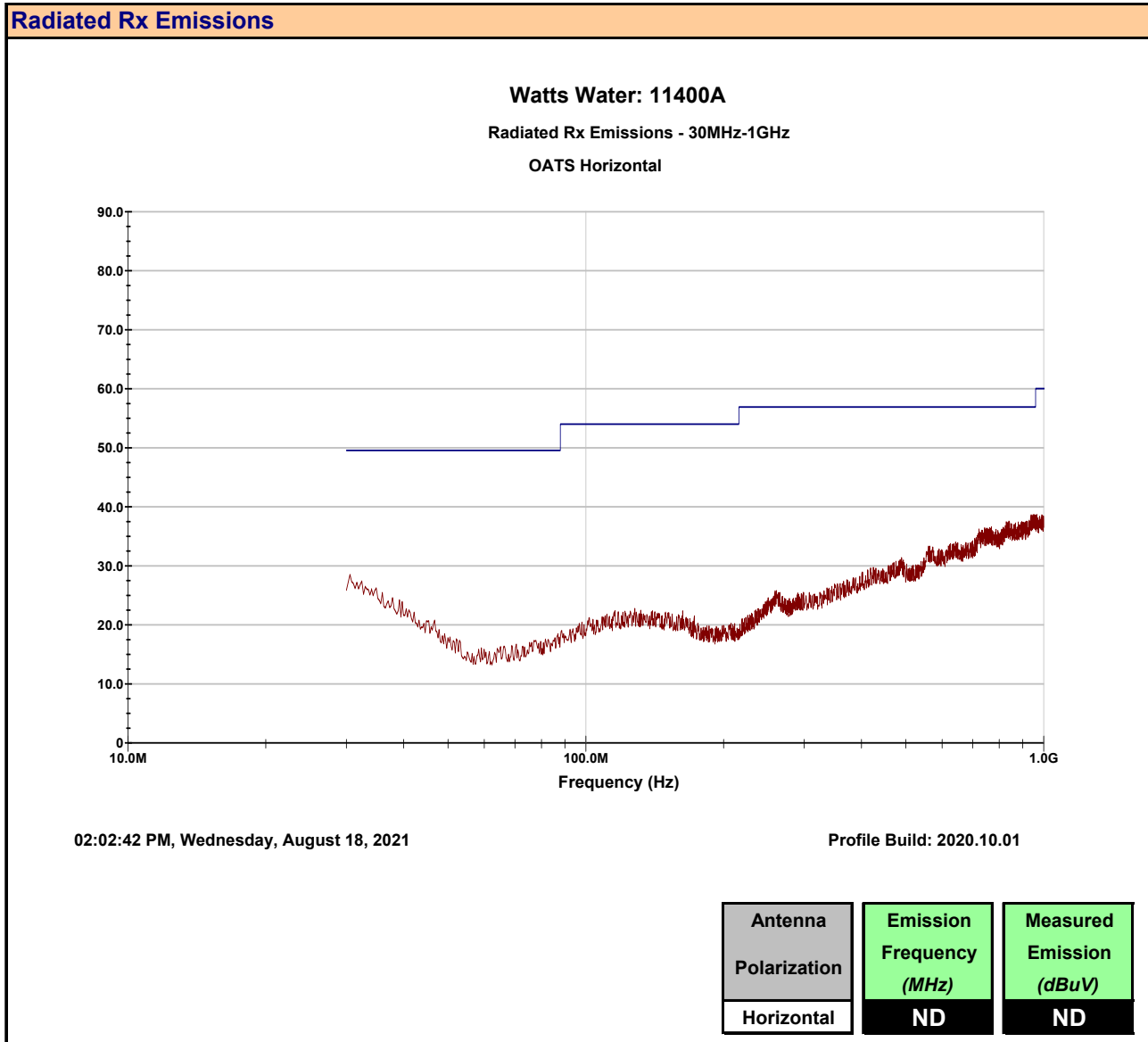
Appendix A

Figure A.1

Measurement Procedure

The DUT was set up as per ANSI C63.4:2014. Emissions were scanned between 30MHz and 1000MHz. The turntable was rotated 360 degrees and the antenna was elevated to 4m to optimize the measured emissions.

Plot 11.1 – Radiated Rx Emissions, Horizontal



Plot 11.2 – Radiated Rx Emissions, Vertical

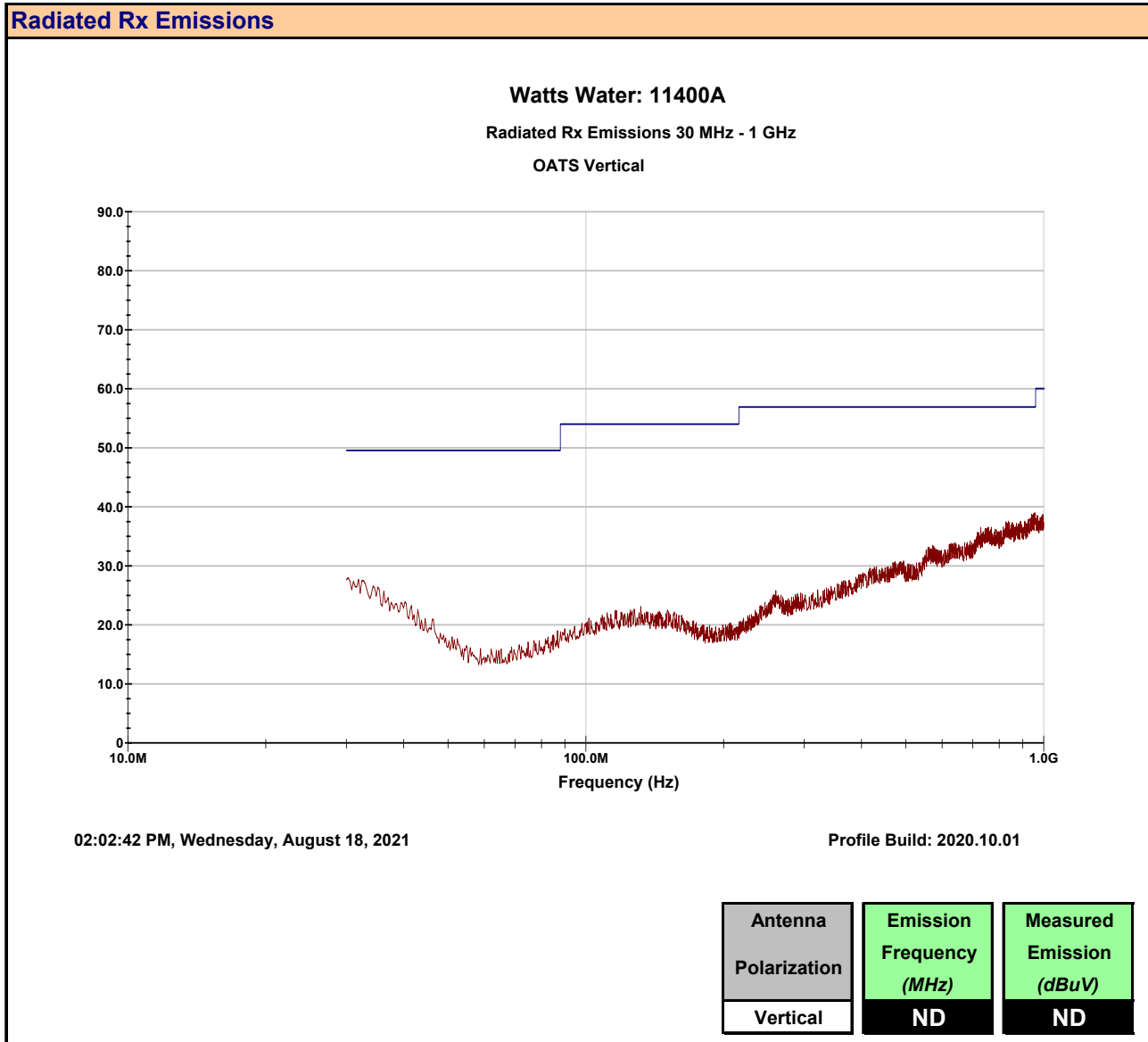


Table 11.1 – Summary of Radiated Rx Measurements

Measurement Results				
Frequency Range	Antenna Polarization	Measured Emission [FS _{Meas}] (dBµV)	Limit [FS _L] (dBµV/m)	Margin (dB)
30-1000MHz	Horizontal	ND	60.0	n/a
30-1000MHz	Vertical	ND	60.0	n/a
Results:			Complies	

ND: No emissions detected above ambient or within 20dB of the limit

12.0 POWER LINE CONDUCTED EMISSIONS

Test Procedure

Normative Reference	FCC 47 CFR §15.107, ICES-003(6.1) ANSI C63.4-2014
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Limits

47 CFR §15.107	(b) For a Class A digital device 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 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. 0.15 - 0.5 MHz: 79 dBuV Quasi Peak, 66 dBuV Average 0.5 - 30.0 MHz: 73 dBuV Quasi Peak, 60 dBuV Average
ICES-003(6.1)	6.1 - AC Power Line Conducted Emissions Limits Class A: ITE that meets the conditions for Class A operation defined in Section 2.2 shall comply with the Class A conducted limits set out below in Table 1. 0.15 - 0.5 MHz: 79 dBuV Quasi Peak, 66 dBuV Average 0.5 - 30.0 MHz: 73 dBuV Quasi Peak, 60 dBuV Average

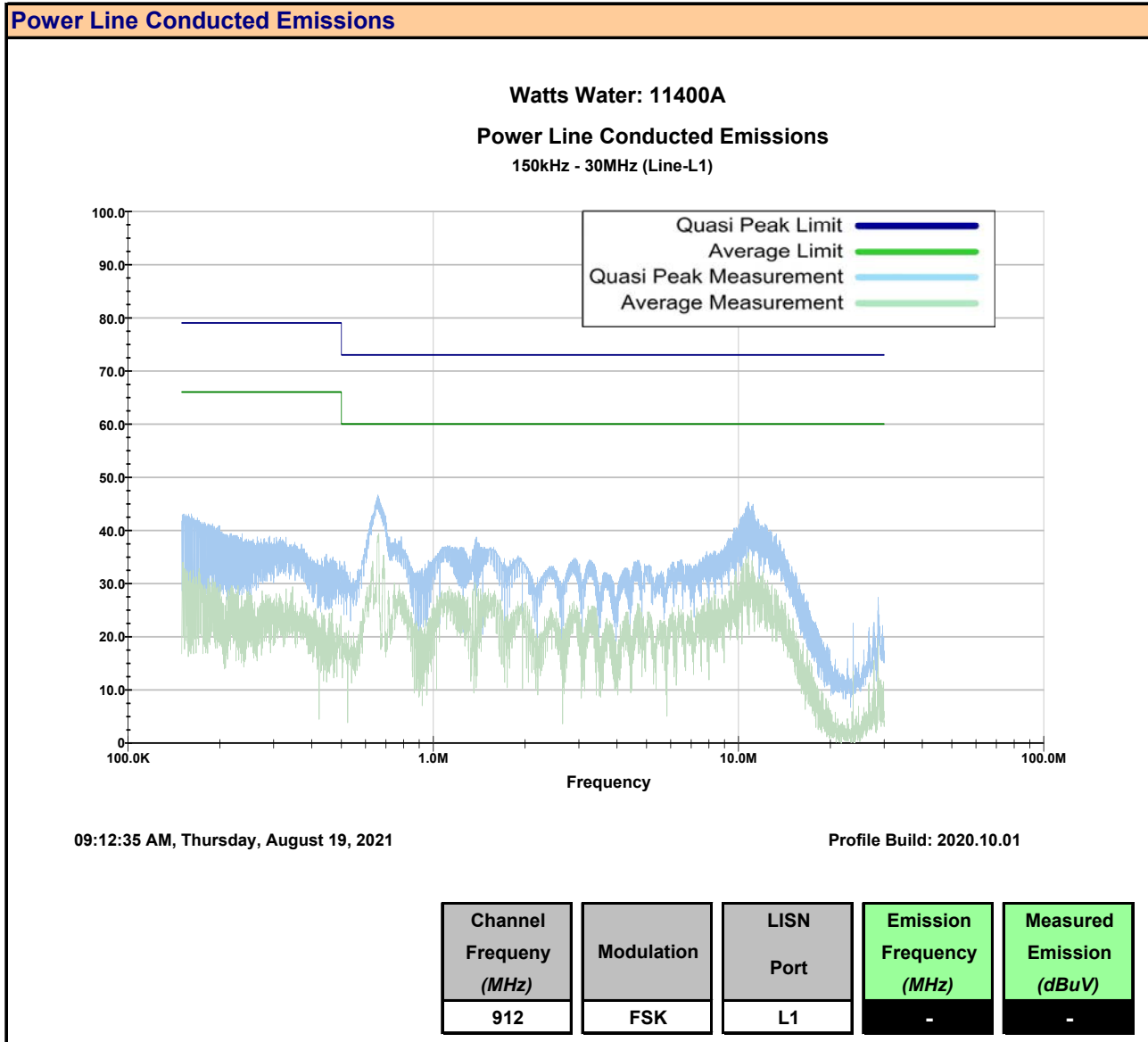
Test Setup

Appendix A Figure A.1

Measurement Procedure

The device was connected to the LISN as shown in Appendix A. The input power supply was connected to a 208VAC, 1PH power source. The AC Line Conducted emissions were measured from 150kHz to 30MHz on both Lines L1 and L2 while the DUT was set to maximum output power.

Plot 12.1 – Power Line Conducted Emissions, Line 1



Plot 12.2 – Power Line Conducted Emissions, Line 2

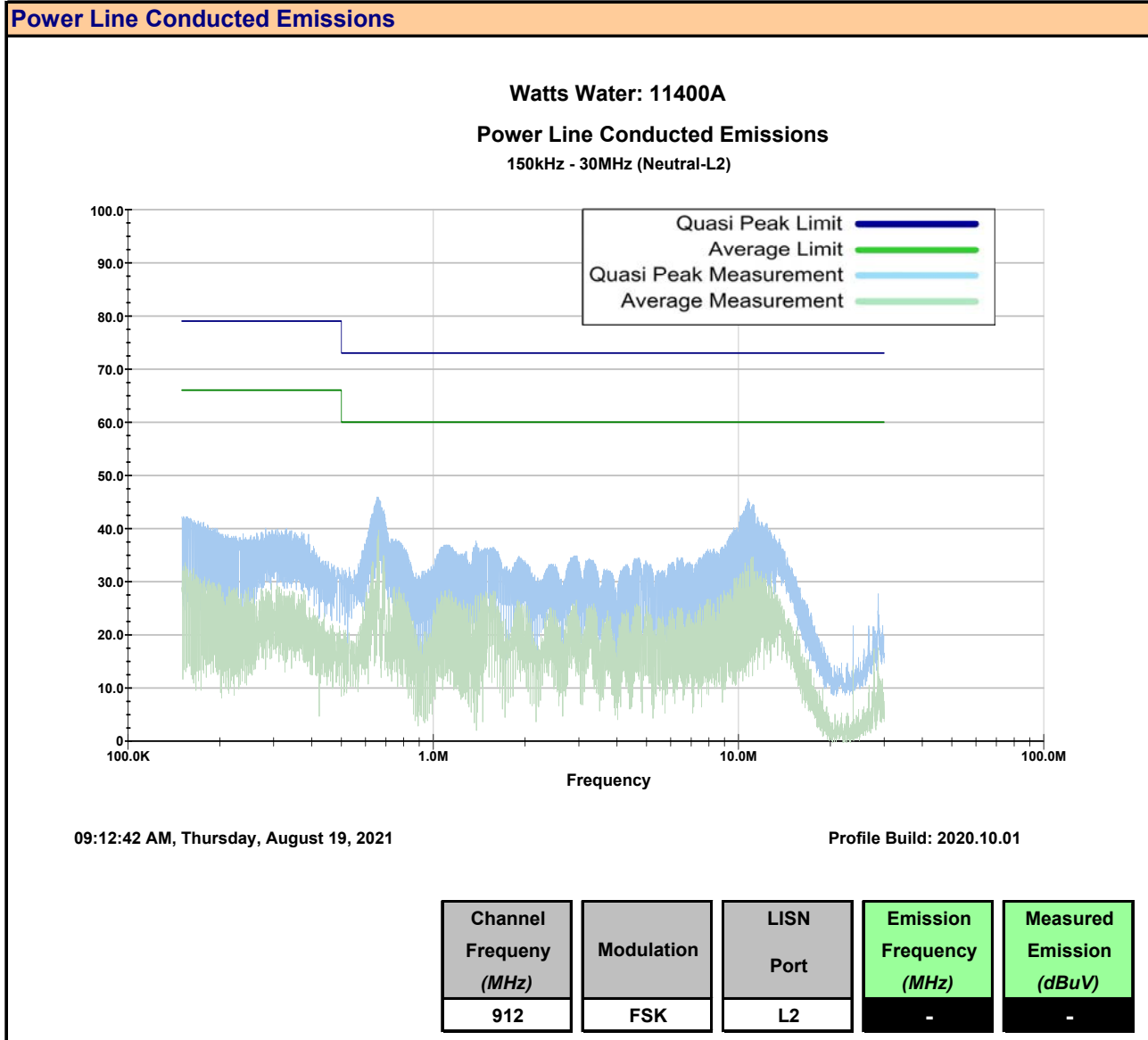


Table 12.1 – Summary of Power Line Conducted Measurements, Line 1

Summary of Power Line Conducted Tx Emissions											
Measured Frequency Range (MHz)	Channel Frequency (MHz)	LISN Port	Emission Frequency [f _{Emm}]	Measured Emission [E _{Meas}] (dBuV)	Detector*	Insertion Loss [L _{LISN}] (dB)	Cable Loss [L _c] (dB)	Amplifier Gain [G _A] (dB)	Corrected Emission [E _{Corr}] (dBuV)	Limit (dBuV)	Margin (dB)
150kHz - 30MHz	912.0	L1	658.90 kHz	45.95	Peak	0.40	0.25	0.00 (3)	46.60 (2)	73.0	26.4
			10.80 MHz	44.73		0.30	0.26		45.29 (2)	73.0	27.7
			658.90 kHz	38.18	Average	0.40	0.26		38.84 (2)	60.0	21.2
			10.80 MHz	34.72		0.30	0.27		35.29 (2)	60.0	24.7
Results:										Complies	

* In accordance with FCC §15.35 and ANSI C63.4, a Peak detector may be used to demonstrate compliance to Quasi-Peak limits provided the Resolution Bandwidth (RBW) is equal to or greater than Quasi-Peak bandwidth. The Detector RBW employed was ≥ 9kHz.

(2) LISN Insertion Loss, Cable Loss and Amplifier Gain corrected in Spectrum Analyzer Transducer Factor

(3) External Amplifier not used

$$E_{Corr} = E_{Meas} + L_{LISN} + L_C - G_A$$

Class B QP Limit = 56 - 20Log (f_{Emm}/500) for f_{Emm} = 150kHz to 500kHz

Class B Avg Limit = 46 - 20Log (f_{Emm}/500) for f_{Emm} = 150kHz to 500kHz

Class A QP Limit = 79dBuV for f_{Emm} = 150kHz to 500kHz

Class A Avg Limit = 66dBuV for f_{Emm} = 150kHz to 500kHz

$$\text{Margin} = \text{Limit} - E_{Corr}$$

Table 12.2 – Summary of Power Line Conducted Measurements, Line 2

Summary of Power Line Conducted Tx Emissions											
Measured Frequency Range (MHz)	Channel Frequency (MHz)	LISN Port	Emission Frequency [f _{Emm}]	Measured Emission [E _{Meas}] (dBuV)	Detector*	Insertion Loss [L _{LISN}] (dB)	Cable Loss [L _c] (dB)	Amplifier Gain [G _A] (dB)	Corrected Emission [E _{Corr}] (dBuV)	Limit (dBuV)	Margin (dB)
150kHz - 30MHz	912.0	L2	662.00 kHz	45.19	Peak	0.40	0.25	0.00 (3)	45.84 (2)	73.0	27.2
			11.20 MHz	45.04		0.30	0.26		45.60 (2)	73.0	27.4
			662.00 kHz	38.98	Average	0.40	0.26		39.64 (2)	60.0	20.4
			11.20 MHz	34.03		0.30	0.27		34.60 (2)	60.0	25.4
Results:										Complies	

* In accordance with FCC §15.35 and ANSI C63.4, a Peak detector may be used to demonstrate compliance to Quasi-Peak limits provided the Resolution Bandwidth (RBW) is equal to or greater than Quasi-Peak bandwidth. The Detector RBW employed was ≥ 9kHz.

(2) LISN Insertion Loss, Cable Loss and Amplifier Gain corrected in Spectrum Analyzer Transducer Factor

(3) External Amplifier not used

$$E_{Corr} = E_{Meas} + L_{LISN} + L_C - G_A$$

Class B QP Limit = 56 - 20Log (f_{Emm}/500) for f_{Emm} = 150kHz to 500kHz

Class B Avg Limit = 46 - 20Log (f_{Emm}/500) for f_{Emm} = 150kHz to 500kHz

Class A QP Limit = 79dBuV for f_{Emm} = 150kHz to 500kHz

Class A Avg Limit = 66dBuV for f_{Emm} = 150kHz to 500kHz

$$\text{Margin} = \text{Limit} - E_{Corr}$$

APPENDIX A – TEST SETUP DRAWINGS

Table A.1 – Conducted Measurement Setup

Equipment List				
Asset Number	Manufacturer	Model Number	Serial Number	Description
00241	R&S	FSU40	100500	Spectrum Analyzer
00263	Koaxis	KP10-1.00M-TD	263	1m Armoured Cable

Figure A.1 – Test Setup – Conducted Measurements

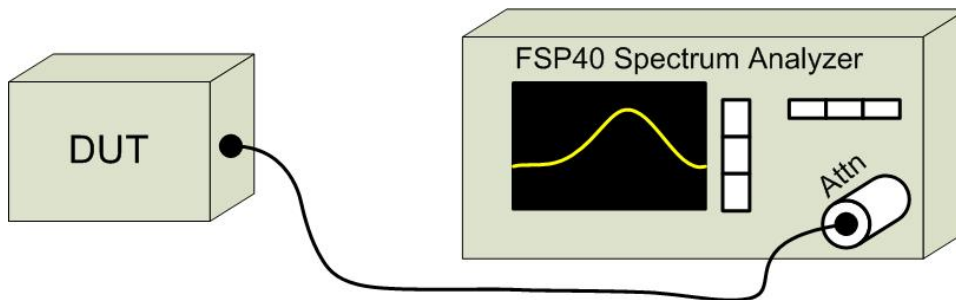


Table A.2 – Radiated Emissions Measurement Equipment

Equipment List				
Asset Number	Manufacturer	Model Number	Serial Number	Description
00050	Chase	CBL-6111A	1607	Bilog Antenna
00034	ETS	3115	6267	Double Ridged Guide Horn
00035	ETS	3115	6276	Double Ridged Guide Horn
00085	EMCO	6502	9203-2724	Loop Antenna
00161	Waveline Inc.	889		Standard Gain Horn 18-26GHz
00162	Waveline Inc.	889		Standard Gain Horn 18-26GHz
00165	Waveline Inc.	801-KF		Waveguide Adapter 18-26GHz
00166	Waveline Inc.	801-KF		Waveguide Adapter 18-26GHz
00333	HP	85685A	3010A01095	RF Preselector
00049	HP	85650A	2043A00162	Quasi-peak Adapter
00051	HP	8566B	2747A05510	Spectrum Analyzer
00241	R&S	FSU40	100500	Spectrum Analyzer
00265	Miteq	JS32-00104000-58-5P	1939850	Microwave L/N Amplifier
00071	EMCO	2090	9912-1484	Multi-Device Controller
00072	EMCO	2075	0001-2277	Mini-mast
00073	EMCO	2080	0002-1002	Turn Table
00263	Koaxis	KP10-1.00M-TD	263	1m Armoured Cable
00263B	Koaxis	KP10-1.00M-TD	263B	1m Armoured Cable
00275	TMS	LMR400	n/a	25m Cable
00278	TILE	34G3	n/a	TILE Test Software

Figure A.2 – Test Setup Radiated Measurements 9kHzMHz – 30MHz

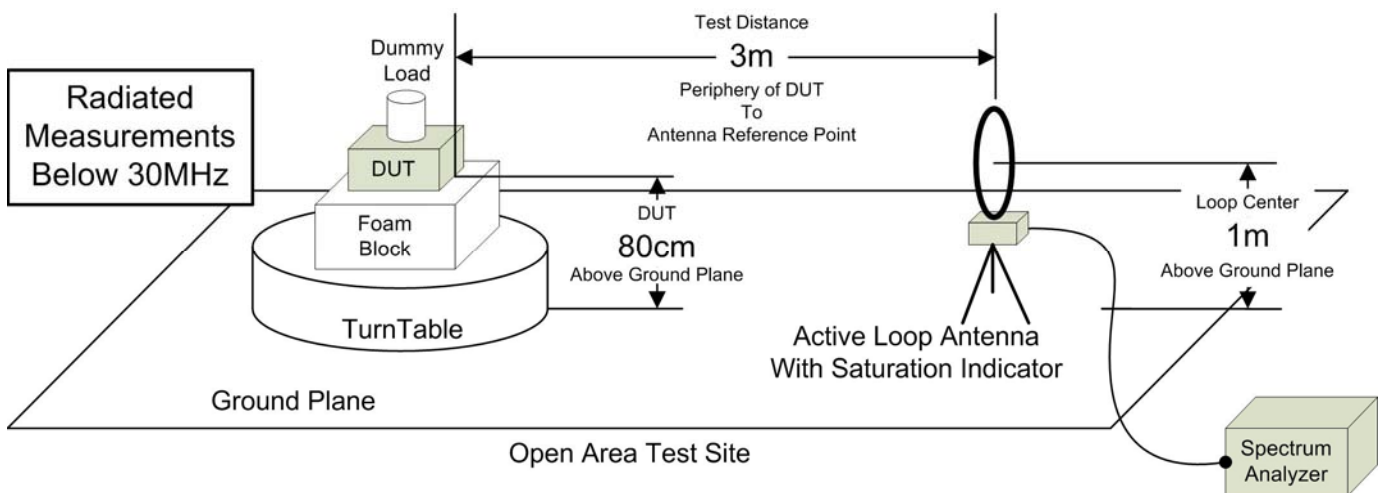


Figure A.3 – Test Setup Radiated Measurements 30MHz – 1GHz

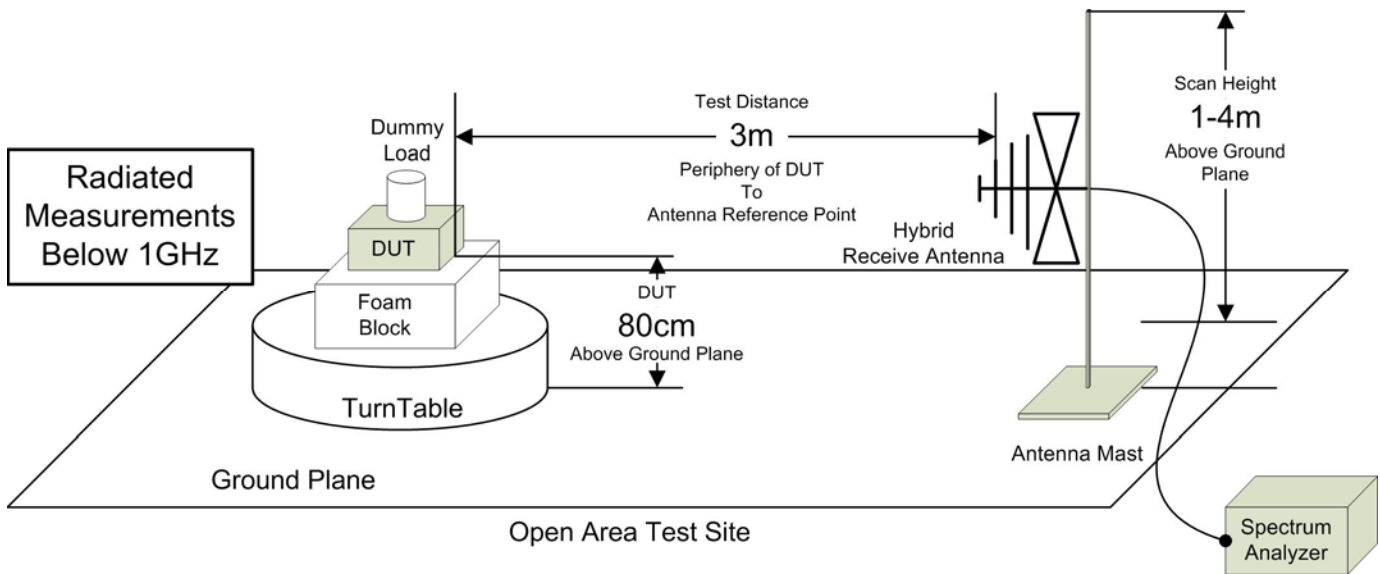


Figure A.4 – Test Setup Radiated Measurements 30MHz – 1GHz, Signal Substitution

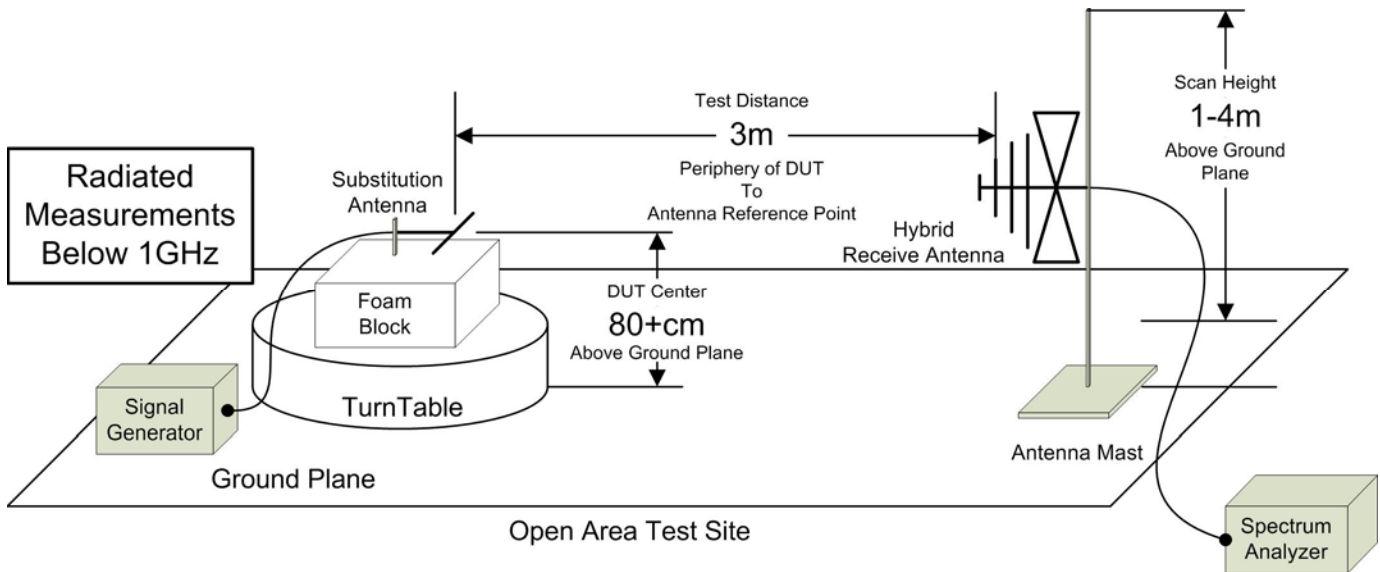


Figure A.5 – Test Setup Radiated Measurements 1 – 18GHz,

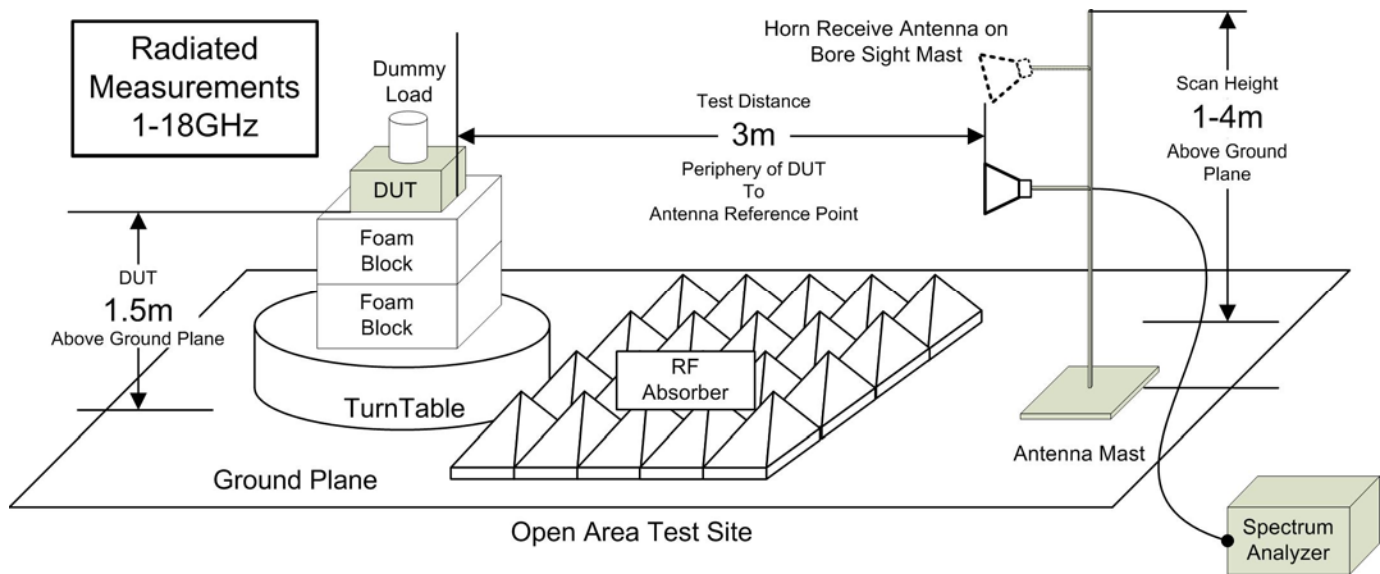


Figure A.6 – Test Setup Radiated Measurements 18 – 26.5GHz,

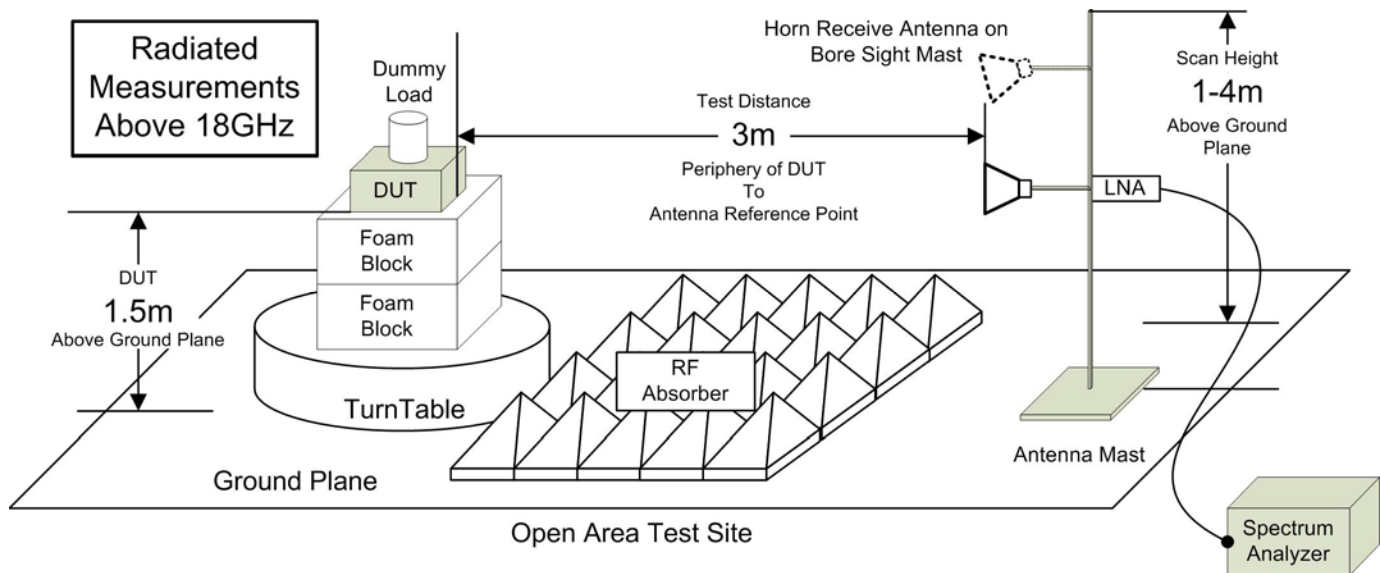


Table A.3 – Setup – Conducted Emissions Equipment List

Equipment List				
Asset Number	Manufacturer	Model Number	Serial Number	Description
00333	HP	85685A	3010A01095	RF Preselector
00049	HP	85650A	2043A00162	Quasi-peak Adapter
00051	HP	8566B	2747A05510	Spectrum Analyzer
00223	HP	8901A	3749A07154	Modulation Analyzer
00257	Com-Power	LI-215A	191934	LISN
00276	TMS	LMR400	n/a	4m Cable

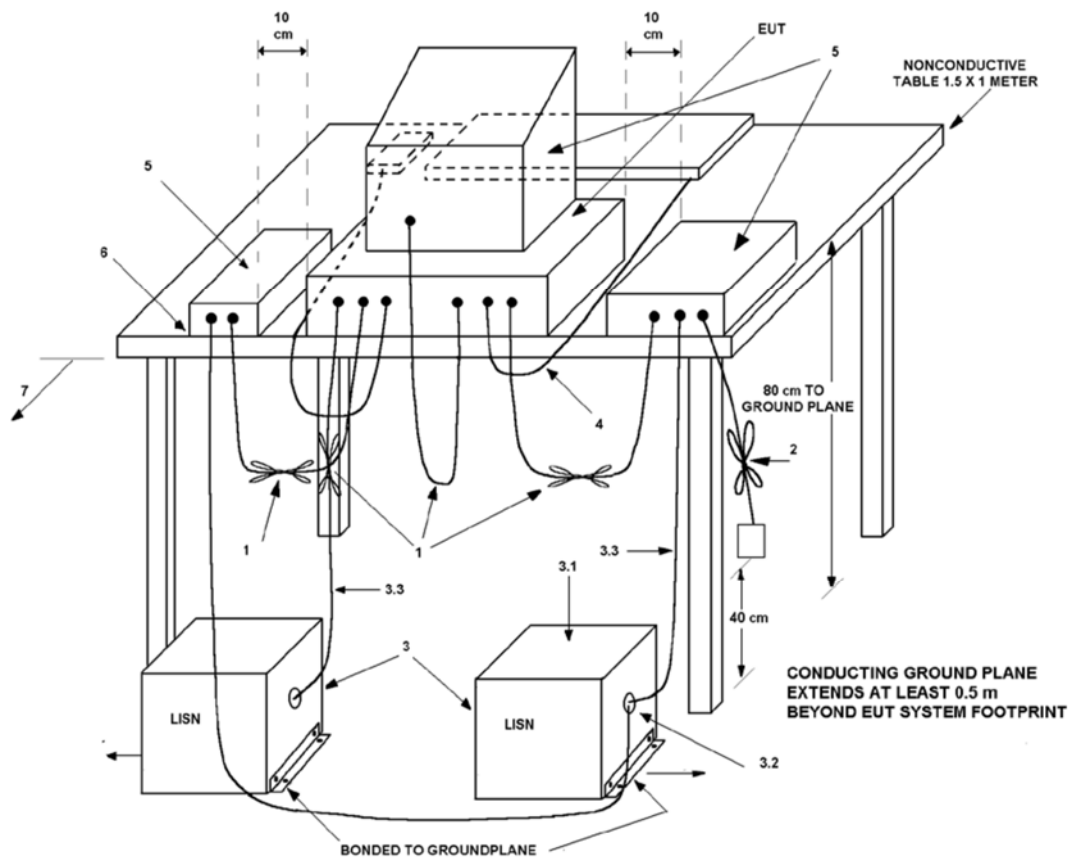


Figure A.7 – Test Setup Conducted Emissions Measurements

APPENDIX B – EQUIPMENT LIST AND CALIBRATION

Equipment List							
Asset Number	Manufacturer	Model Number	Serial Number	Description	Last Calibrated	Calibration Interval	Calibration Due
00050	Chase	CBL-6111A	1607	Bilog Antenna	3 Jan 2019	Triennial	3 Jan 2022
00034	ETS	3115	6267	Double Ridged Guide Horn	26 Nov 2018	Triennial	26 Nov 2021
00035	ETS	3115	6276	Double Ridged Guide Horn	22 Mar 2019	Triennial	21 Mar 2022
00085	EMCO	6502	9203-2724	Loop Antenna	11 Jun 2019	Triennial	11 Jun 2022
00333	HP	85685A	3010A01095	RF Preselector	23 Jun 2020	Triennial	30 Jun 2023
00049	HP	85650A	2043A00162	Quasi-peak Adapter	23 Jun 2020	Triennial	23 Jun 2023
00051	HP	8566B	2747A05510	Spectrum Analyzer	23 Jun 2020	Triennial	23 Jun 2023
00241	R&S	FSU40	100500	Spectrum Analyzer	10 Aug 2021	Triennial	10 Aug 2024
00257	Com-Power	LI-215A	191934	LISN	5 Sep 2018	Triennial	5 Sep 2021
00071	EMCO	2090	9912-1484	Multi-Device Controller	n/a	n/a	n/a
00072	EMCO	2075	0001-2277	Mini-mast	n/a	n/a	n/a
00073	EMCO	2080	0002-1002	Turn Table	n/a	n/a	n/a
00263	Koaxis	KP10-1.00M-TD	263	1m Armoured Cable	COU	n/a	COU
00263B	Koaxis	KP10-1.00M-TD	263B	1m Armoured Cable	COU	n/a	COU
00264	Koaxis	KP10-7.00M-TD	264	7m Armoured Cable	COU	n/a	COU
00275	TMS	LMR400	n/a	25m Cable	COU	n/a	COU
00276	TMS	LMR400	n/a	4m Cable	COU	n/a	COU
00278	TILE	34G3	n/a	TILE Test Software	NCR	n/a	NCR

NCR: No Calibration Required

COU: Calibrate On Use

APPENDIX C – MEASUREMENT INSTRUMENT UNCERTAINTY

CISPR 16-4 Measurement Uncertainty (U_{LAB})

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence interval using a coverage factor of $k=2$

Radiated Emissions 30MHz - 200MHz

$U_{LAB} = 5.14\text{dB}$ $U_{CISPR} = 6.3\text{dB}$

Radiated Emissions 200MHz - 1000MHz

$U_{LAB} = 5.90\text{dB}$ $U_{CISPR} = 6.3\text{dB}$

Radiated Emissions 1GHz - 6GHz

$U_{LAB} = 4.80\text{dB}$ $U_{CISPR} = 5.2\text{dB}$

Radiated Emissions 6GHz - 18GHz

$U_{LAB} = 5.1\text{dB}$ $U_{CISPR} = 5.5\text{dB}$

Power Line Conducted Emissions 9kHz to 150kHz

$U_{LAB} = 2.96\text{dB}$ $U_{CISPR} = 3.8\text{dB}$

Power Line Conducted Emissions 150kHz to 30MHz

$U_{LAB} = 3.12\text{dB}$ $U_{CISPR} = 3.4\text{dB}$

If the calculated uncertainty U_{lab} is **less** than U_{CISPR} then:

- | | |
|---|---|
| 1 | Compliance is deemed to occur if NO measured disturbance exceeds the disturbance limit |
| 2 | Non-Compliance is deemed to occur if ANY measured disturbance EXCEEDS the disturbance limit |

If the calculated uncertainty U_{lab} is **greater** than U_{CISPR} then:

- | | |
|---|--|
| 3 | Compliance is deemed to occur if NO measured disturbance, increased by ($U_{lab} - U_{CISPR}$), exceeds the disturbance limit |
| 4 | Non-Compliance is deemed to occur if ANY measured disturbance, increased by ($U_{lab} - U_{CISPR}$), EXCEEDS the disturbance limit |

Other Measurement Uncertainties (U_{LAB})

RF Conducted Emissions 9kHz - 40GHz

$U_{LAB} = 1.0\text{dB}$ $U_{CISPR} = \text{n/a}$

Frequency/Bandwidth 9kHz - 40GHz

$U_{LAB} = 0.1\text{ppm}$ $U_{CISPR} = \text{n/a}$

Temperature

$U_{LAB} = 1^{\circ}\text{C}$ $U_{CISPR} = \text{n/a}$

END OF REPORT