FCC and ISED Canada Testing of the

Progda Oy Ltd
Xampion BLE Sensor Module

In accordance with FCC 47 CFR part 15.247 and ISED Canada's Radio Standards Specifications RSS-247

America

Add value.
Inspire trust.

Prepared for: Progda Oy Ltd
Kaarikatu 8
20760 PIISPANRISTI
FINLAND

FCC ID: 2AZB26430074203061
IC: 27068-PROGDAHW3

COMMERCIAL-IN-CONFIDENCE

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Peter Walsh	2021 -May-17	
Testing	Thierry Jean Charles	2021-May-17	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

FCC Accreditation
Designation Number US1063 Tampa, FL Test Laboratory

Innovation, Science, and Economic Development Canada Accreditation
Site Number 2087A-2 Tampa, FL Test Laboratory

EXECUTIVE SUMMARY
Samples of this product were tested and found to be in compliance with 15.247 and ISED Canada's RSS-247.

A2LA Cert. No. 2955.15

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	2021-May-17

1.2 Introduction

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations Section 15.247 and Innovation Science and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented herein.

Applicant	Progda Oy Ltd
Manufacturer	Progda Oy Ltd
Applicant's Email Address	tero.suominen@progda.com
Model Number(s)	Xampion BLE Sensor Module
Serial Number(s)	N/A
FCC ID	2AZB26430074203061
ISED Certification Number	27068-PROGDAHW3
Hardware Version(s)	HW3
Software Version(s)	fw59
Number of Samples Tested	2
Test Specification/Issue/Date	US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2021 Innovation, Science and Economic Development Canada Radio Standards Specification: RSS-247 — Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices, Issue 2, February 2017
Test Plan/Issue/Date	2020-October-06
Order Number	72167778
Date	2021-March-12
Date of Receipt of EUT	2021-March-08
Start of Test	2021-April-29
Finish of Test	2021-May-08
Name of Engineer(s)	Thierry Jean-Charles
Related Document(s)	ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2021. FCC OET KDB 558074 D01 15.247 Meas Guidance v05r02: Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating under Section 15.247 of the FCC Rules. Innovation, Science and Economic Development Canada Radio Standards Specification: RSS-GEN - General

Requirements for Compliance of Radio Apparatus, Issue 5, Amendment 1, March 2019

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC Part 15.247 and ISED Canada's RSS-247 is shown below.

Table 1.3-1: Test Result Summary

Test Parameter	Test Plan (Yes/No)	Test Result	FCC 47 CFR Rule Part	ISED Canada's RSS	Test Report Page No
Antenna Requirement	Yes	Pass	15.203, 15.204	-------	11
6 dB Bandwidth	Yes	Pass	15.247(a)(2)	RSS-247 5.2(a)	12
99% Bandwidth	Yes	Pass	-------	RSS-GEN 6.7	15
Peak Output Power	Yes	Pass	15.247(b)(3)	RSS-247 5.4(d)	18
Band-Edge Compliance of RF Conducted Emissions	Yes	Pass	15.247(d)	RSS-247 5.5	21
RF Conducted Spurious Emissions	Yes	Pass	15.247(d)	RSS-247 5.5	24
Radiated Spurious Emissions into Restricted Frequency Bands	Yes	Pass	15.205, 15.209	RSS-GEN 8.9, 8.10	27
Power Spectral Density	Yes	Pass	15.247(e)	RSS-247 5.2(b)	34
Power Line Conducted Emissions	Yes	Pass	15.207	RSS-GEN 8.8	37
Duty Cycle of Test Mode of Operation	No	--------	-------	-------	41

1.4 Product Information

1.4.1 Technical Description

The EUT is a tracking and analysis system which includes a Bluetooth Low Energy Radio.

Technical Details
Mode of Operation: Bluetooth Low Energy (BLE)
Frequency Range: 2402 - 2480 MHz
Number of Channels: 40
Channel Separation: 2 MHz
Data Rate: 1 Mbps
Modulations: GFSK
Antenna Type/Gain: PCB trace antenna, -1.5 dBi
Input Power: 3VDC internal Battery, 5 VDC external power supply

A full description and detailed product specification details are available from the manufacturer.

Table 1.4.1-1 – Cable Descriptions

Cable/Port	Description
USB to TTL Serial Cable	1.8m, model TTL-232R-3V3
Power Supply Cable	1.83 mm, Laptop to Power Supply
Power Cord	0.9 m, Power Supply to AC Mains

Table 1.4.1-2 – Support Equipment Descriptions

Make/Model	Description
Amazon / FANA7R	5VDC AC Adapter, S/N: AH15501166399
Dell / Latitude E7250	Laptop
Dell / LA65NS2-01	19.5 VDC Laptop Power Supply

Notes:

The laptop and power supplies were used for test purposes only. They are not marketed with the equipment under test.

1.5 Declaration of Build Status

EQUIPMENT DESCRIPTION	
Model Name/Number	Xampion BLE sensor module
Part Number	Project# **0072167778**
Hardware Version	HW3
Software Version	fw59
FCC ID (if applicable)	
ISED ID (if applicable)	
Technical Description (Please provide a brief description of the intended use of the equipment)	The Xampion system is based on Nordic semiconductor nRF52832 BLE microcontroller.

UN-INTENTIONAL RADIATOR	
Highest frequency generated or used in the device or on which the device operates or tunes	**2480 MHz**
Lowest frequency generated or used in the device or on which the device operates or tunes	**2402 MHz**
Class A Digital Device (Use in commercial, industrial or business environment); **Class A** Class B Digital Device (Use in residential environment only)	

Power Source			
AC	Single Phase	Three Phase	Nominal Voltage
External DC	Nominal Voltage	Maximum Current	
	5V	100mA	
Battery	Nominal Voltage	Battery Operating End Point Voltage	
	3.7V	4.2V	

EXTREME CONDITIONS					
Maximum temperature	+40	°C	Minimum temperature	-10	°C

Ancillaries
Please list all ancillaries which will be used with the device. Test units Direct Test Mode Controlling by Nordic semiconductor nRF-studioGo application.

I hereby declare that the information supplied is correct and complete.

Name: Tero Suominen

Position held: Chairman of the Board Date: 19.03.2021

1.6 Product Information

1.6.1 Modes of Operation

The EUT was configured with a cable to allow programming via the UART interface. The EUT was evaluated for the BLE radio operating in Direct Test Mode (DTM). A test software power setting of 4 dBm was used for the evaluation. The EUT was operating at the maximum configurable transmission duty cycle of 63%.

1.6.2 Monitoring of Performance

The EUT was evaluated for radiated, RF Conducted and power line conducted emissions.

For the radiated emissions evaluation, preliminary measurementes were performed for the EUT in three orthogonal orienations. The final measurements were performed on the EUT flat on the table top as the overall worst case orientation.

For the RF conducted measurements, the EUT was configured with an SMA connector at the antenna port to allow direct coupling to the measuring equipment.

For the power line conducted emissions evaluation, the EUT was powered through an off-the-shelf power supply and was in the constant TX mode.

1.6.3 Performance Criteria

The EUT was evaluated to the parameters described below.

Table 1.6.3 -1: Performance Criteria

Parameter	Requirement
Antenna Requirement	FCC: Section 15.203. 15.204
6 dB Bandwidth	FCC: Section 15.247(a)(2); ISED Canada: RSS-247 5.2(a)
99% Bandwidth	ISED Canada: RSS-GEN 6.6
Peak Output Power	FCC: Section 15.247(b)(3); ISED Canada:RSS-247 5.4(d)
Band-Edge Compliance of RF Conducted Emissions	FCC: Section 15.247(d); ISED Canada: RSS-247 5.5
RF Conducted Spurious Emissions	FCC: Section 15.247(d); ISED Canada: RSS-247 5.5
Radiated Spurious Emissions into Restricted Frequency Bands	FCC: Sections 15.205, 15.209; ISED Canada: RSS-GEN 8.9, 8.10
Power Spectral Density	FCC: Section 15.247(e); ISED Canada: RSS-247(b)
Power Line Conducted Emissions	FCC: Section 15.207; ISED Canada: RSS-GEN 8.8

1.7 Deviations from the Standard

The EUT was evaluated without any deviation from the test standards.

1.8 EUT Modification Record

The table below details modifications made to the EUT during the test programme. The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
None			

The equipment was tested as provided without any modifications.

1.9 Test Location

TÜV SÜD Product Service conducted the following tests at our Tampa FL Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
AC Powered Operating		
Antenna Requirement	Thierry Jean-Charles	A2LA
6 dB Bandwidth	Thierry Jean-Charles	A2LA
99% Bandwidth	Thierry Jean-Charles	A2LA
Peak Output Power	Thierry Jean-Charles	A2LA
Band-Edge Compliance of RF Conducted Emissions	Thierry Jean-Charles	A2LA
RF Conducted Spurious Emissions	Thierry Jean-Charles	A2LA
Radiated Spurious Emissions into Restricted Frequency Bands	Thierry Jean-Charles	A2LA
Power Spectral Density	Thierry Jean-Charles	A2LA
Power Line Conducted Emissions	Thierry Jean-Charles	A2LA
Duty Cycle	Thierry Jean-Charles	A2LA

Office Address:

TÜV SÜD America, Inc.
5610 W. Sligh Ave, Suite 100
Tampa, FL 33634
USA

2 Test Details

2.1 Antenna Requirements

2.1.1 Specification Reference

FCC: Section 15.203, 15.204

2.1.2 Equipment Under Test and Modification State

S/N: N/A

2.1.3 Date of Test

4/29/2021

2.1.4 Test Method

N/A

2.1.5 Environmental Conditions

Ambient Temperature	N/A
Relative Humidity	N/A
Atmospheric Pressure	N/A

2.1.6 Test Results

Limit Clause FCC Sections: 15.203, 15,204

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 EUT uses an integral PCB antenna. The antenna is not removable and therefore meets the requirements of FCC Section 15.203.

2.1.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

As this is a visual inspection, no test equipment was used.

2.2 6 dB Bandwidth

2.2.1 Specification Reference

FCC: Section 15.247(a)(2)
ISED Canada: RSS-247 5.2(a)

2.2.2 Equipment Under Test and Modification State

S/N: N/A

2.2.3 Date of Test

5/4/2021

2.2.4 Test Method

The 6dB bandwidth was measured in accordance with ANSI C63.10 Subclause 11.8.1 Option 1. The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. Span was set large enough to capture the emissions and >> RBW. A peak detector was used for the measurements.

2.2.5 Environmental Conditions

Ambient Temperature	24.6°C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

2.2.6 Test Results

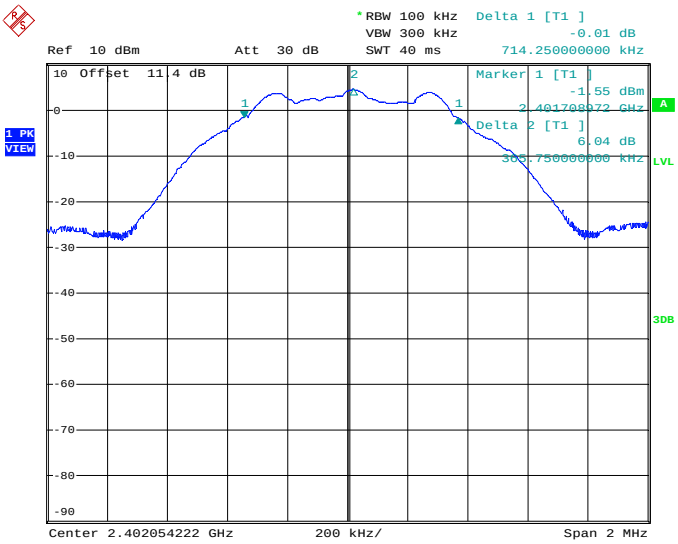
AC Powered Operating

Limit Clause FCC Part 15.247(a)(2), ISED RSS-247 5.2(a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

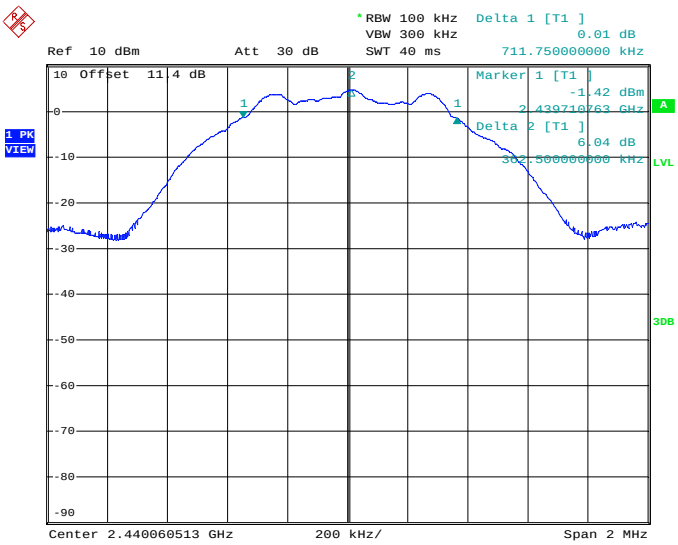
Table 2.2.6-1: 6 dB Bandwidth Test Results

Frequency (MHz)	6 dB Bandwidth (kHz)
2402	714.2500
2440	711.7500
2480	715.2845



Date: 4.MAY.2021 15:43:57

Figure 2.2.6-1: 6 dB Bandwidth Test Results Low Channel



Date: 4.MAY.2021 16:35:54

Figure 2.2.6-2: 6 dB Bandwidth Test Results Middle Channel

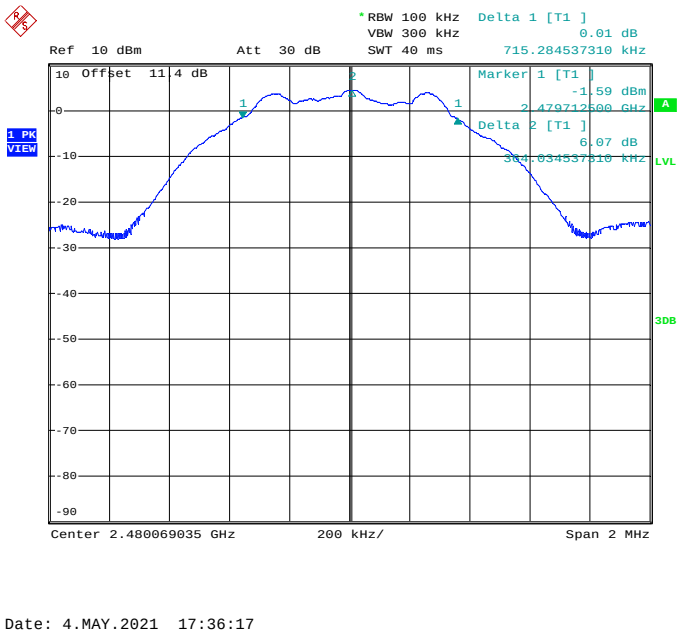


Figure 2.2.6-3: 6 dB Bandwidth Test Results High Channel

2.2.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.3 99% Bandwidth

2.3.1 Specification Reference

ISED Canada: RSS-GEN 6.7

2.3.2 Equipment Under Test and Modification State

S/N: N/A

2.3.3 Date of Test

5/4/2021

2.3.4 Test Method

The 99% occupied bandwidth was measured with the spectrum analyzer span set to fully display the emission. The RBW was set to 1% to 5% of the approximated bandwidth. The occupied 99% bandwidth was measured by using 99% bandwidth equipment function of the spectrum analyzer using a peak detector.

2.3.5 Environmental Conditions

Ambient Temperature	24.6°C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

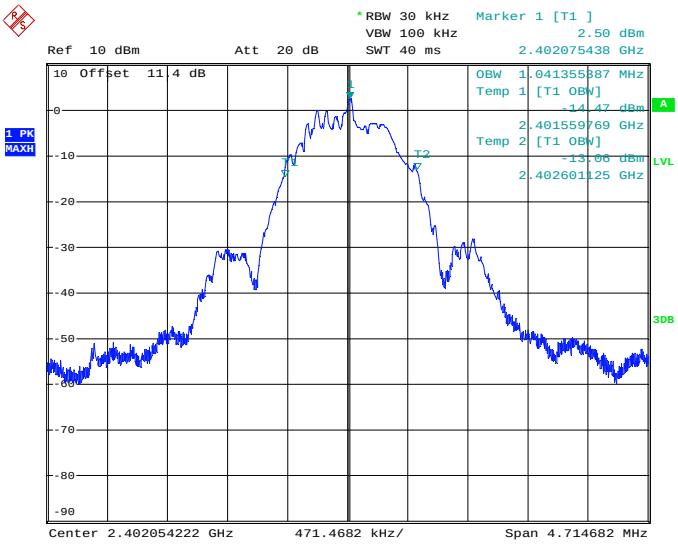
2.3.6 Test Results

AC Powered Operating

Limit Clause ISED RSS-GEN 6.7

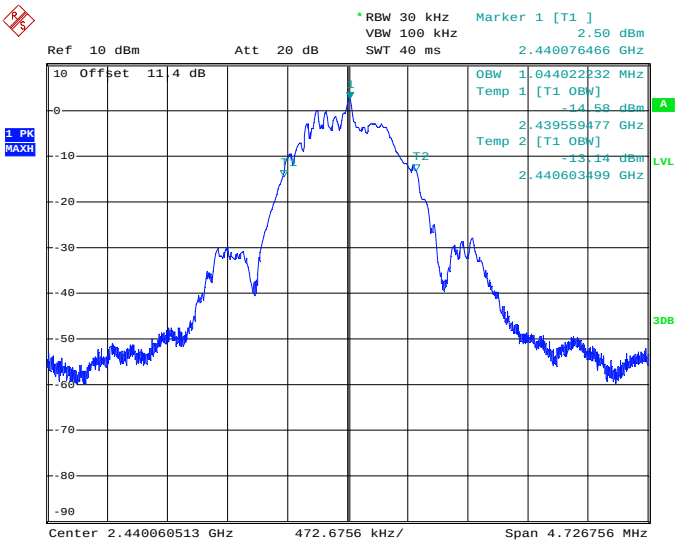
Table 2.3.6-1: 99% Bandwidth Test Results

Frequency (MHz)	99% Bandwidth (MHz)
2402	1.0414
2440	1.0440
2480	1.0460



Date: 4.MAY.2021 15:45:42

Figure 2.3.6-1: 99% Bandwidth Test Results Low Channel



Date: 4.MAY.2021 16:37:36

Figure 2.3.6-2: 99% Bandwidth Test Results Middle Channel

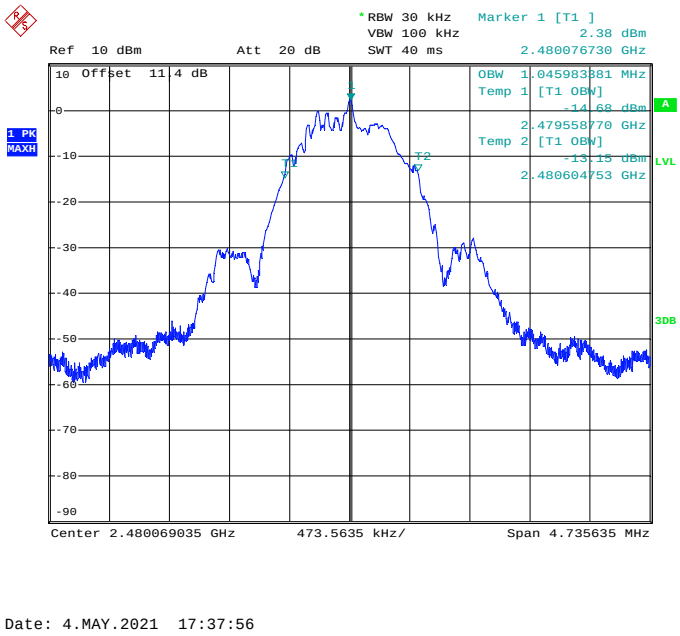


Figure 2.3.6-3: 99% Bandwidth Test Results High Channel

2.3.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.4 Peak Output Power

2.4.1 Specification Reference

FCC Section 15.247(b)(3)
ISED Canada: RSS-247 5.4(d)

2.4.2 Equipment Under Test and Modification State

S/N: N/A

2.4.3 Date of Test

5/4/2021

2.4.4 Test Method

The fundamental emission output power was measured in accordance with ANSI C63.10 Subclause 11.9.1.1 RBW ≥ DTS bandwidth. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer through suitable attenuation.

2.4.5 Environmental Conditions

Ambient Temperature	24.6°C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

2.4.6 Test Results

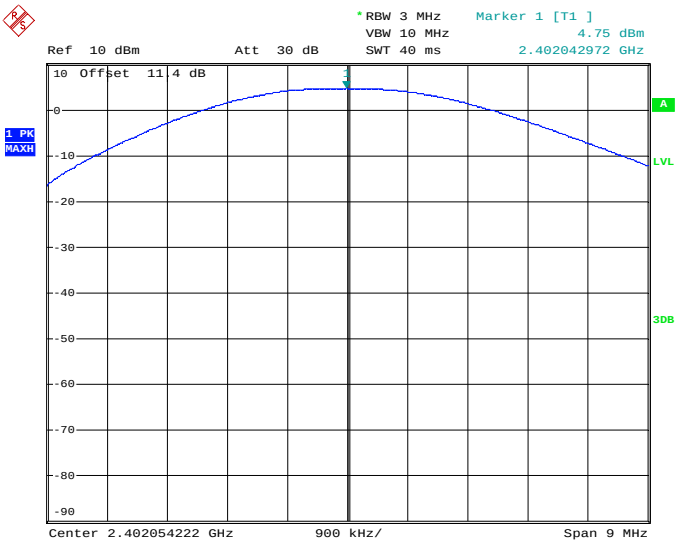
AC Powered Operating

Limit Clause FCC Part 15.247(b)(3), ISED RSS-247 5.4(d)

The Maximum Output Power allowed for systems using digital modulation is 1 Watt (30 dBm)

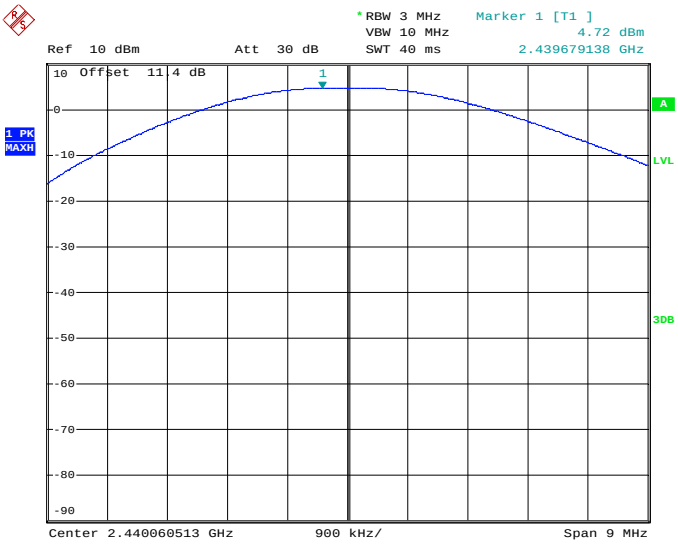
Table 2.4.6-1: Maximum Output Power Results

Frequency (MHz)	Output Power (dBm)
2402	4.75
2440	4.72
2480	4.63



Date: 4.MAY.2021 15:47:21

Figure 2.4.6-1: Maximum Output Power Results Low Channel



Date: 4.MAY.2021 16:39:13

Figure 2.4.6-2: Maximum Output Power Results Middle Channel

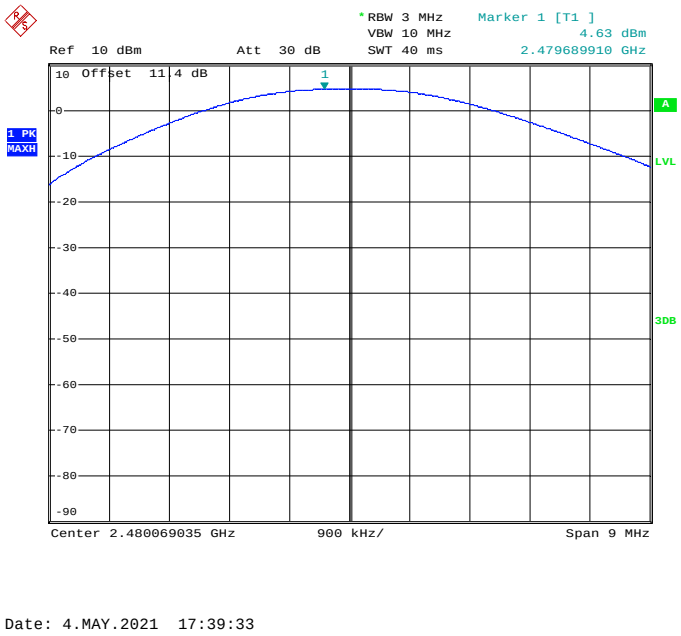


Figure 2.4.6-3: Maximum Output Power Results High Channel

2.4.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.5 Band-Edge Compliance of RF Conducted Emissions

2.5.1 Specification Reference

FCC: Section 15.247(d)
ISED Canada: RSS-247 5.5

2.5.2 Equipment Under Test and Modification State

S/N: N/A

2.5.3 Date of Test

5/4/2021

2.5.4 Test Method

The RF Conducted Emissions at the Band-Edges were measured in accordance with Subclause 11.11 of ANSI C63.10. The RF output port of the EUT was connected to the input of the spectrum analyzer through suitable attenuation. The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement the spectrum analyzer's RBW was set to 100 kHz, and the VBW was set to >= 300 kHz.

2.5.5 Environmental Conditions

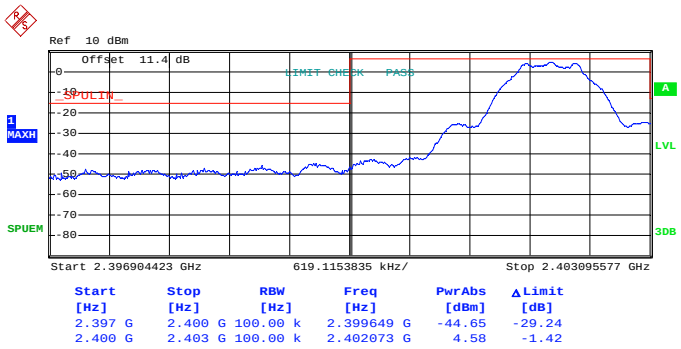
Ambient Temperature	24.6 °C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

2.5.6 Test Results

AC Powered Operating

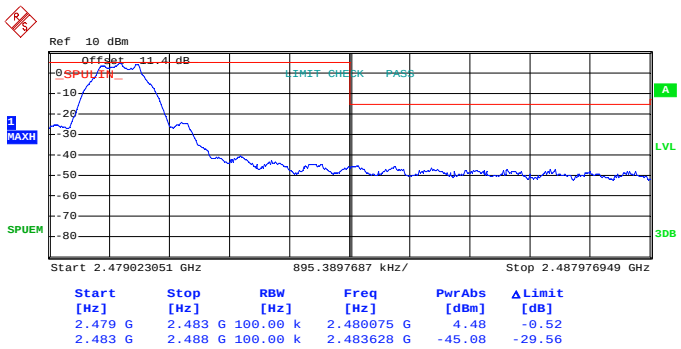
Limit Clause FCC Section 15.247(d), ISED Canada: RSS-247 5.5

In any 100 kHz bandwidth outside of the frequency band the radio frequency power shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.



Date: 4.MAY.2021 15:52:14

Figure 2.5.6-1: RF Conducted Band-Edge Results Low Channel



Date: 4.MAY.2021 17:44:26

Figure 2.5.6-2: RF Conducted Band-Edge Results High Channel

2.5.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.6 RF Conducted Spurious Emissions

2.6.1 Specification Reference

FCC: Section 15.247(d)
ISED Canada: RSS-247 5.5

2.6.2 Equipment Under Test and Modification State

S/N: N/A

2.6.3 Date of Test

5/4/2021

2.6.4 Test Method

The RF Conducted Spurious Emissions were measured in accordance with Subclause 11.11 of ANSI C63.10. The RF output port of the equipment under test was directly connected to the input of the spectrum analyzer. The EUT was investigated for conducted spurious emissions from 30 MHz to 25 GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz. The peak Max Hold function of the analyzer was utilized.

2.6.5 Environmental Conditions

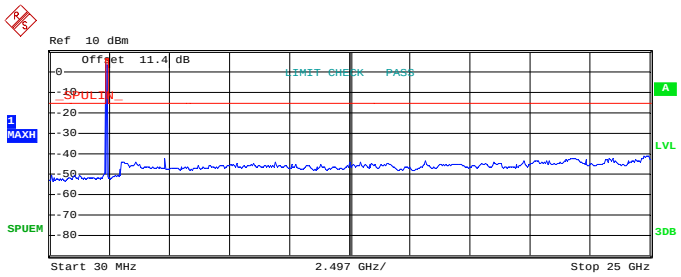
Ambient Temperature	24.6 °C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

2.6.6 Test Results

AC Powered Operating

Limit Clause FCC Section 15.247(d), ISED Canada: RSS-247 5.5

In any 100 kHz bandwidth outside of the frequency band the radio frequency power shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
30.000 M	902.000 M	100.00 k	111.859000 M	-50.34	-34.94
902.000 M	928.000 M	100.00 k	911.025250 M	-51.91	-36.50
928.000 M	2.400 G	100.00 k	2.399264 G	-49.26	-33.86
2.400 G	2.483 G	100.00 k	2.402087 G	3.93	-2.07
2.483 G	5.725 G	100.00 k	4.804819 G	-42.28	-26.87
5.725 G	5.850 G	100.00 k	5.763063 G	-46.31	-30.91
5.850 G	13.500 G	100.00 k	12.505500 G	-44.30	-28.89
13.500 G	20.000 G	100.00 k	15.684813 G	-43.30	-27.90
20.000 G	25.000 G	100.00 k	24.948750 G	-41.11	-25.70

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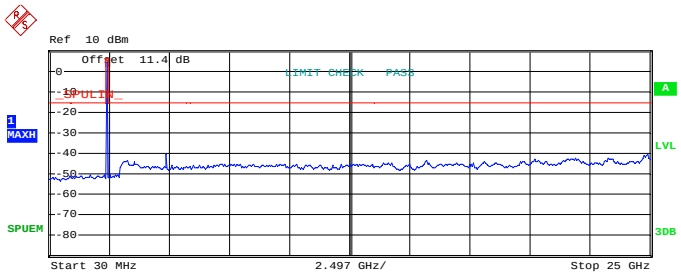
Figure 2.6.6-1: RF Conducted Spurious Emissions Results Low Channel



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
30.000 M	902.000 M	100.00 k	294.543000 M	-51.68	-36.31
902.000 M	928.000 M	100.00 k	903.878500 M	-51.27	-35.90
928.000 M	2.400 G	100.00 k	1.743856 G	-50.45	-35.08
2.400 G	2.483 G	100.00 k	2.440059 G	4.39	-1.61
2.483 G	5.725 G	100.00 k	4.880994 G	-40.82	-25.45
5.725 G	5.850 G	100.00 k	5.729875 G	-46.47	-31.10
5.850 G	13.500 G	100.00 k	7.118944 G	-44.99	-29.61
13.500 G	20.000 G	100.00 k	15.702688 G	-43.66	-28.29
20.000 G	25.000 G	100.00 k	24.882500 G	-40.39	-25.02

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Figure 2.6.6-2: RF Conducted Spurious Emissions Results Middle Channel

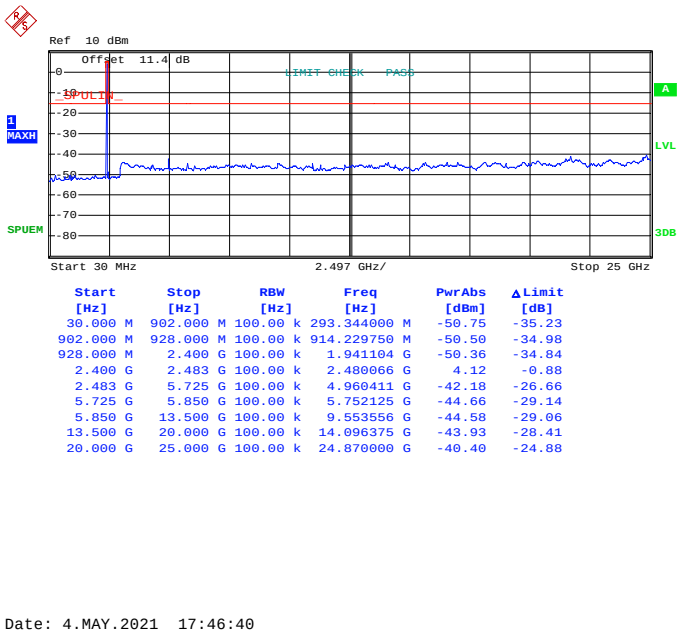

Figure 2.6.6-3: RF Conducted Spurious Emissions Results High Channel

2.6.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.7 Radiated Spurious Emissions into Restricted Frequency Bands

2.7.1 Specification Reference

FCC Sections: 15.205, 15.209;
ISED Canada: RSS-GEN 8.9, 8.10

2.7.2 Equipment Under Test and Modification State

S/N: N/A

2.7.3 Date of Test

4/29/2021 to 5/1/2021

2.7.4 Test Method

Radiated emissions tests were made over the frequency range of 9 kHz to 25 GHz, 10 times the highest fundamental frequency. Each emission found to be in a restricted band as defined by section 15.205, including any emission at the operational band-edge, was compared to the radiated emission limits as defined in Section 15.209.

For measurements below 30 MHz, the receive antenna height was set to 1 m and the EUT was rotated through 360 degrees. The resolution bandwidth was set to 200 Hz below 150 kHz and to 9 kHz above 150 kHz.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak measurements are made with RBW of 1 MHz and VBW of 3 MHz. Average measurements are performed in the linear scale using VBW of 3 kHz.

2.7.5 Duty Cycle Correction

The EUT was configured to transmit at the 63% maximum configurable duty cycle during the evaluation. No duty cycle correction factors were applied to the average measurements for the corrected average results.

2.7.6 Environmental Conditions

Ambient Temperature	25.1 °C
Relative Humidity	42 %
Atmospheric Pressure	1017.1 mbar

2.7.7 Test Results

<u>AC Powered Operating</u>

Limit Clause FCC Sections 15.205, 15.209, ISED Canada: RSS-GEN 8.9, 8.10

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009-0.490	2400/F(kHz)	300
0.4090-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

Table 2.7.7-1: Radiated Emissions Test Results

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel										
2390	56.79	44.11	H	-5.37	51.42	38.74	74.0	54.0	22.6	15.3
2390	55.60	43.95	V	-5.37	50.23	38.58	74.0	54.0	23.8	15.4
4804	51.05	45.11	H	-0.21	50.84	44.90	74.0	54.0	23.2	9.1
4804	47.93	40.44	V	-0.21	47.72	40.23	74.0	54.0	26.3	13.8
19216	39.24	29.00	H	11.75	50.99	40.75	83.5	63.5	32.5	22.8
19216	39.56	28.88	V	11.75	51.31	40.63	83.5	63.5	32.2	22.9
Middle Channel										
4880	51.45	45.38	H	-0.09	51.36	45.29	74.0	54.0	22.6	8.7
4880	47.57	39.58	V	-0.09	47.48	39.49	74.0	54.0	26.5	14.5
7320	47.65	40.12	H	5.11	52.76	45.23	74.0	54.0	21.2	8.8
7320	47.28	39.66	V	5.11	52.39	44.77	74.0	54.0	21.6	9.2
19520	39.11	28.93	H	11.64	50.75	40.57	83.5	63.5	32.7	22.9
19520	39.00	28.74	V	11.64	50.64	40.38	83.5	63.5	32.9	23.1
High Channel										
2483.5	64.90	51.50	H	-5.21	59.69	46.29	74.0	54.0	14.3	7.7
2483.5	58.71	46.49	V	-5.21	53.50	41.28	74.0	54.0	20.5	12.7
4960	54.04	48.62	H	0.04	54.08	48.66	74.0	54.0	19.9	5.3
4960	48.71	42.08	V	0.04	48.75	42.12	74.0	54.0	25.3	11.9
7440	44.95	36.40	H	5.32	50.27	41.72	74.0	54.0	23.7	12.3
7440	45.96	36.55	V	5.32	51.28	41.87	74.0	54.0	22.7	12.1
19840	39.56	28.62	H	11.68	51.24	40.30	83.5	63.5	32.3	23.2
19840	39.35	28.76	V	11.68	51.03	40.44	83.5	63.5	32.5	23.1

Notes:

- All the emissions above 19.9 GHz were attenuated below the limits and the noise floor of the measurement equipment.
- The emissions above 18 GHz were performed at a test distance of 1m. The limits are adjusted accordingly using a test distance factor of 20*log(3/1) = 9.54 dB.

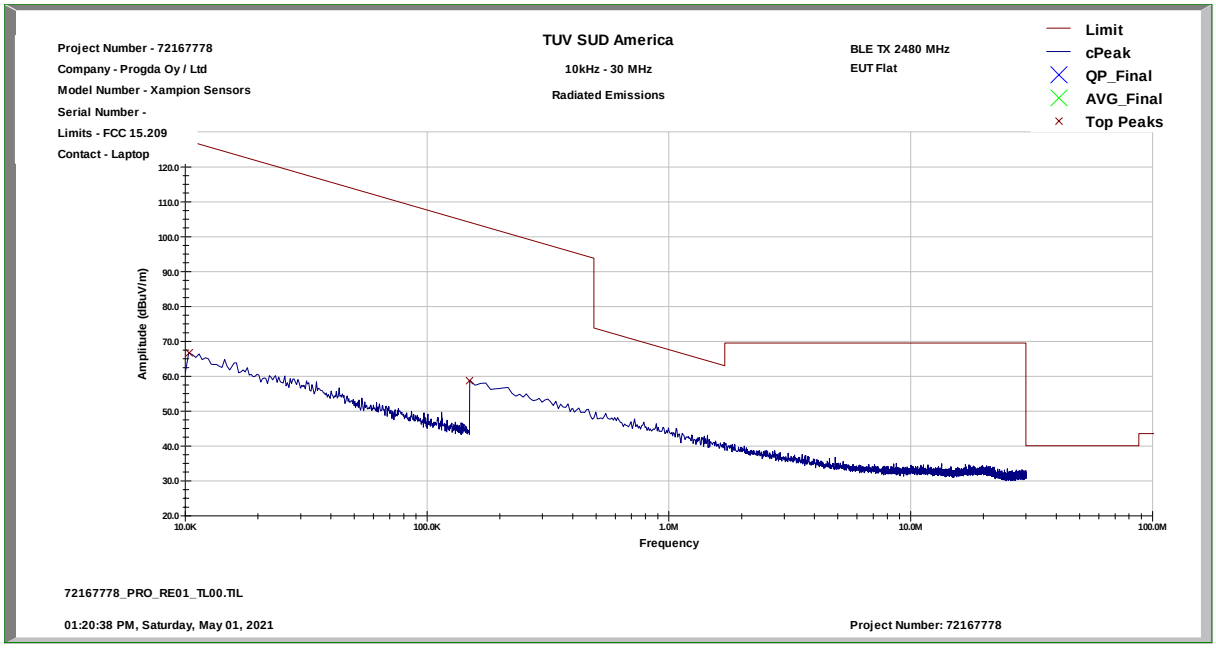

Figure 2.7.7-1: Radiated Emissions Representative Scan below 30 MHz

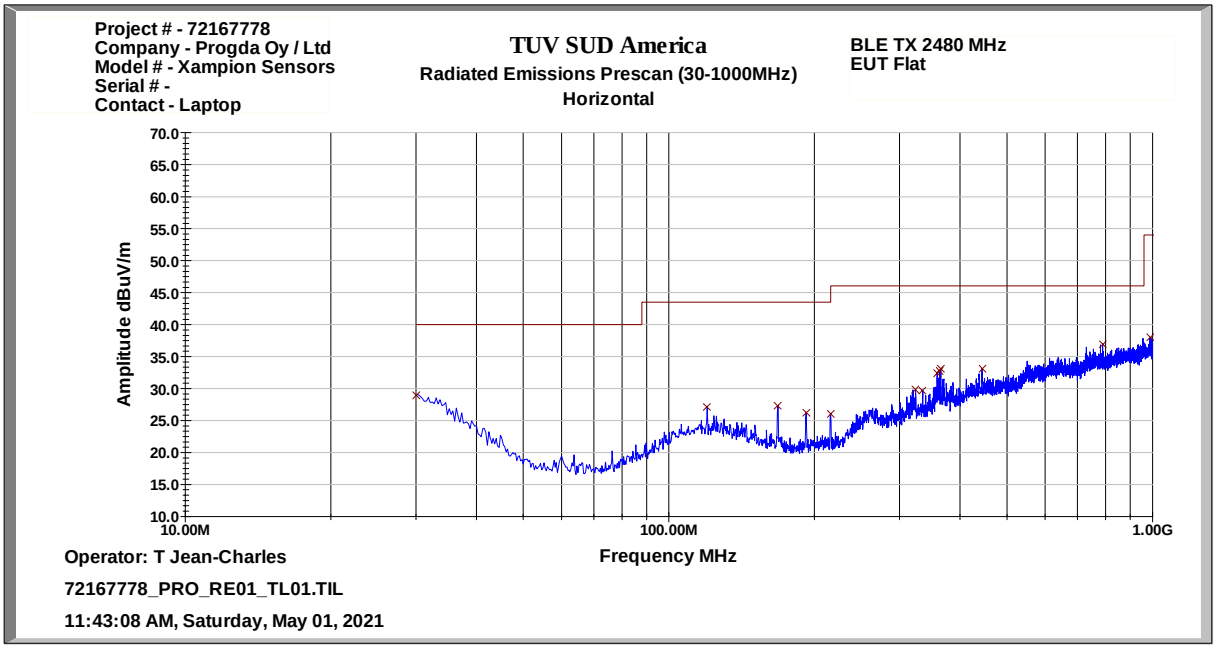

Figure 2.7.7-2: Radiated Emissions Representative Scan - 30 MHz – 1 GHz – Horizontal Polarization

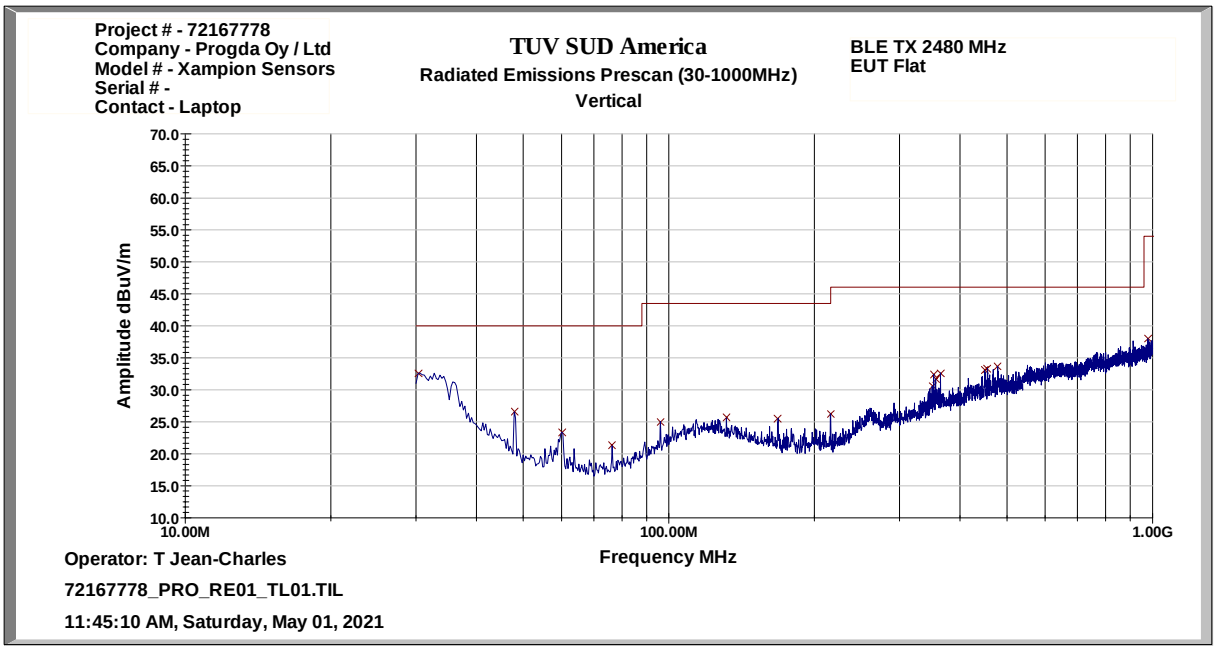

Figure 2.7.7-3: Radiated Emissions Representative Scan - 30 MHz – 1 GHz –Vertical Polarization

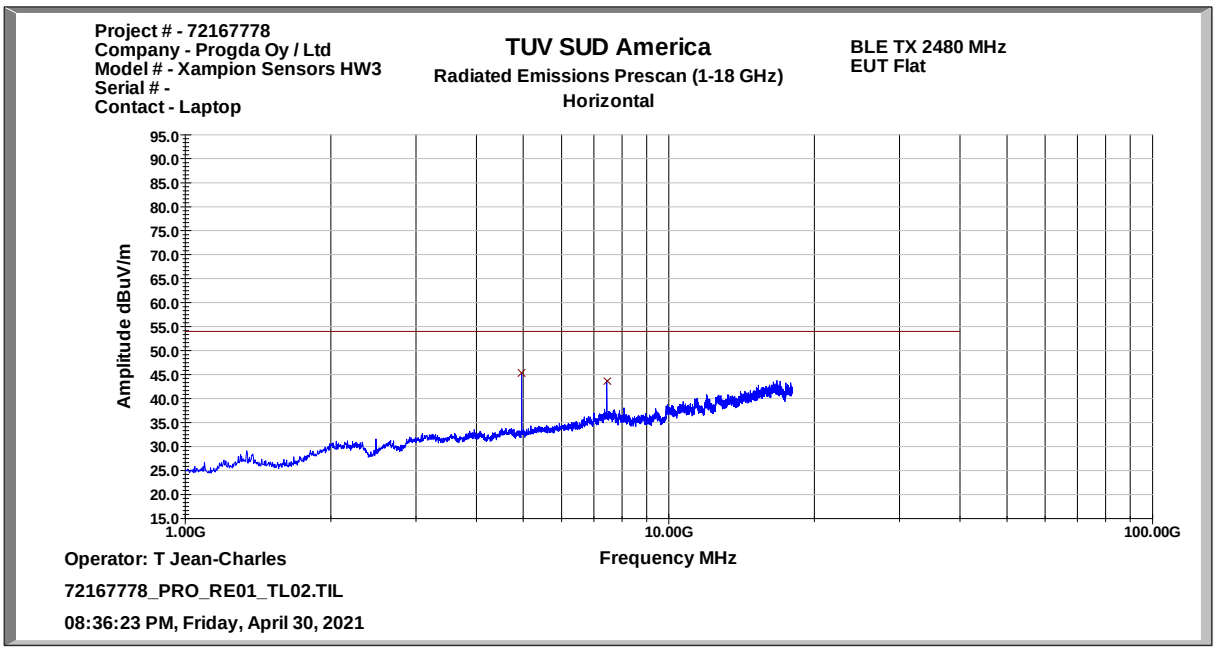

Figure 2.7.7-4: Radiated Emissions Representative Scan – 1 GHz – 18 GHz – Horizontal Polarization

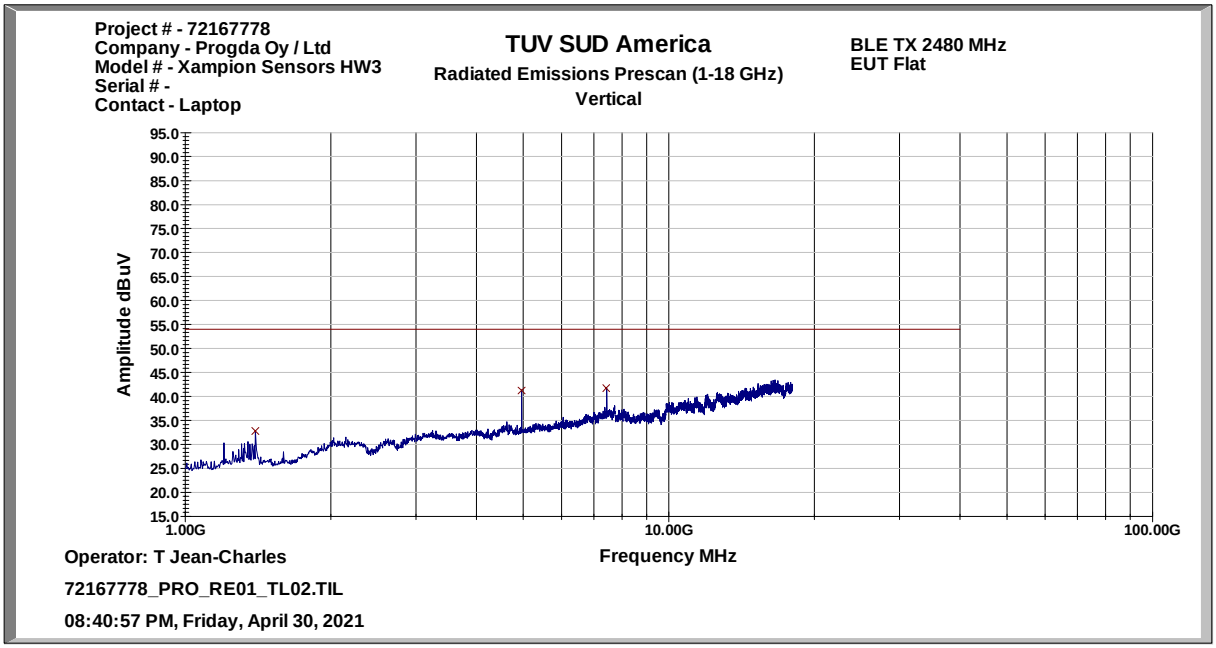

Figure 2.7.7-5: Radiated Emissions Representative Scan – 1 GHz – 18 GHz – Vertical Polarization

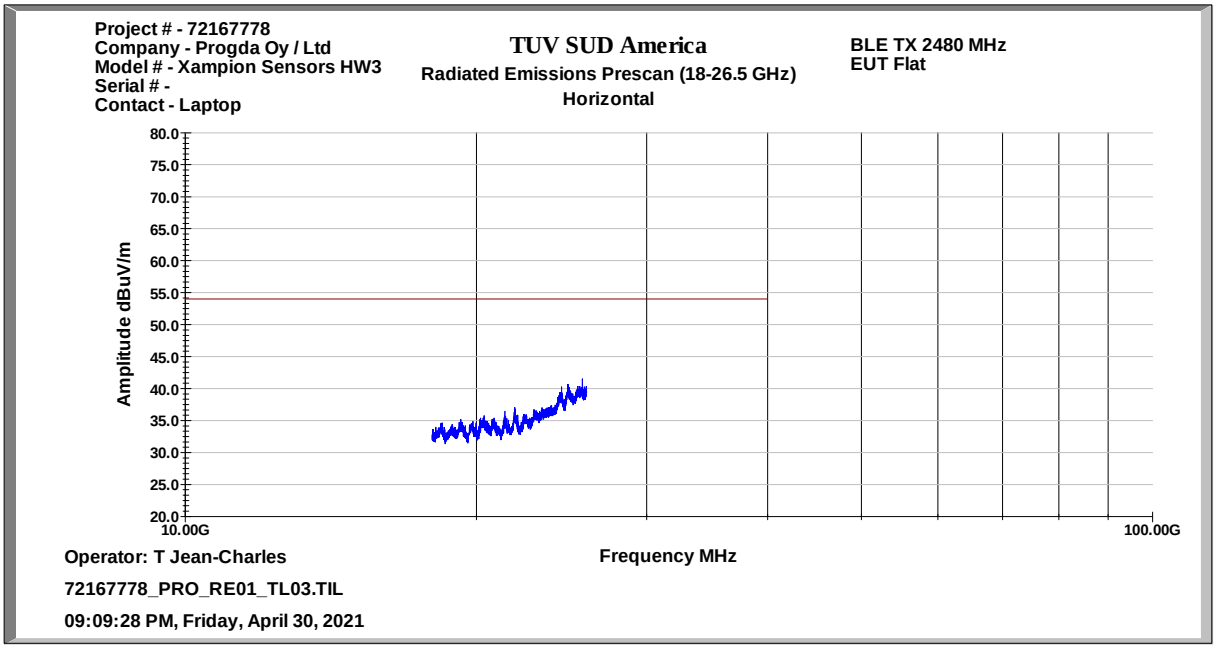

Figure 2.7.7-6: Radiated Emissions Representative Scan – 18 GHz – 26 GHz – Horizontal Polarization

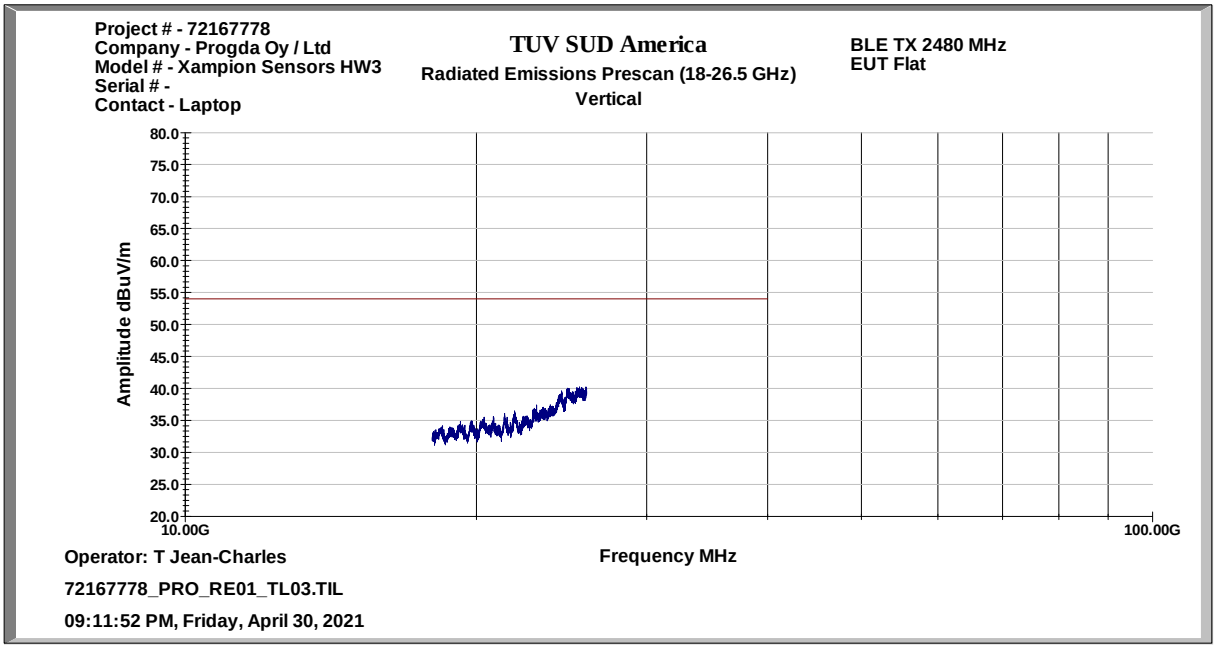

Figure 2.7.7-7: Radiated Emissions Representative Scan – 18 GHz – 26 GHz – Vertical Polarization

2.7.8 Sample Calculations

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation: Peak
Corrected Level: 56.79 + (-5.37) = 51.42 dBµV/m
Margin: 74 dBµV/m – 51.42 dBµV/m = 22.58 dB

Example Calculation: Average
Corrected Level: 44.11 + (-5.37) -0 = 38.74 dBµV/m
Margin: 54 dBµV/m – 38.74 dBµV/m = 15.26 dB

2.7.9 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
10dB Attenuator	Merrimac	FAN-6-10K	BEMC02086	N/A	12	19-Oct-2021
Tile Automation Software	ETS Lindgren	TILE4! - Version 4.2.A	BEMC02095	4.2A	N/A	NCR
BI LOG PERIODIC, ANTENNA	Schaffner	CBL6112B	TEMC00005	N/A	24	31-Oct-2021
EMC Analyzer	Agilent	E7405A	TEMC00012	A.09.02	24	27-Mar-2022
Loop Antenna	Com Power	AL-130	TEMC00025	N/A	24	26-Sep-2021
Horn Antenna	Schwarzbeck	BBHA-9170	TEMC00029	N/A	60	23-Aug-2021
EMC Chamber	Panasheild	N/A	TEMC00031	N/A	36	28-Jan-2024
Double Ridge Guide Horn	ETS Lindgren	3117	TEMC00061	N/A	24	07-Feb-2022
18 GHz-40 GHz Microwave Preamplifier	COM-power	PAM-840A	TEMC00147	N/A	12	06-Jul-2021
PAM-118A	Com-Power Corporation	PAM-118A	TEMC00160	N/A	12	10-Apr-2022
2.4 GHz Notch Filter	Micro-Tronics	BRM50702-01	TEMC00176	N/A	12	09-Mar-2022
A81-0303 18 GHz Cable Set	Teledyne Storm Products	A81-0303-360/96	TEMC00201	N/A	12	10-Apr-2022
DC-1000 MHz Low Pass Filter	Mini-Circuits	NLP-1200+	TEMC00202	N/A	12	30-Mar-2022

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable
NCR – No Calibration Required

2.8 Power Spectral Density

2.8.1 Specification Reference

FCC: Section 15.247(e)
ISED Canada: RSS-247 5.2(b)

2.8.2 Equipment Under Test and Modification State

S/N: N/A

2.8.3 Date of Test

5/4/2021

2.8.4 Test Method

The power spectral density was measured in accordance with ANSI C63.10 Subclause 11.10.2 Method PKPSD (peak PSD). The RF output port of the EUT was directly connected to the input of the spectrum analyzer. Offset values were input for cable and external attenuation. The spectrum analyzer's RBW was set to 3 kHz and VBW to 10 kHz. The Span was adjusted to 1.5 times the DTS bandwidth and the sweep time was set to auto. The measurements were performed using a Peak detector.

2.8.5 Environmental Conditions

Ambient Temperature	24.6 °C
Relative Humidity	44.3 %
Atmospheric Pressure	1015.7 mbar

2.8.6 Test Results

AC Powered Operating

Limit FCC: Section 15.247(e), ISED Canada: RSS-247 5.2(b)

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time of continuous transmission.

Table 2.8.6-1: Power Spectral Density Results

Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
2402	-10.94	8.0	18.94
2440	-10.90	8.0	18.9
2480	-11.10	8.0	19.1

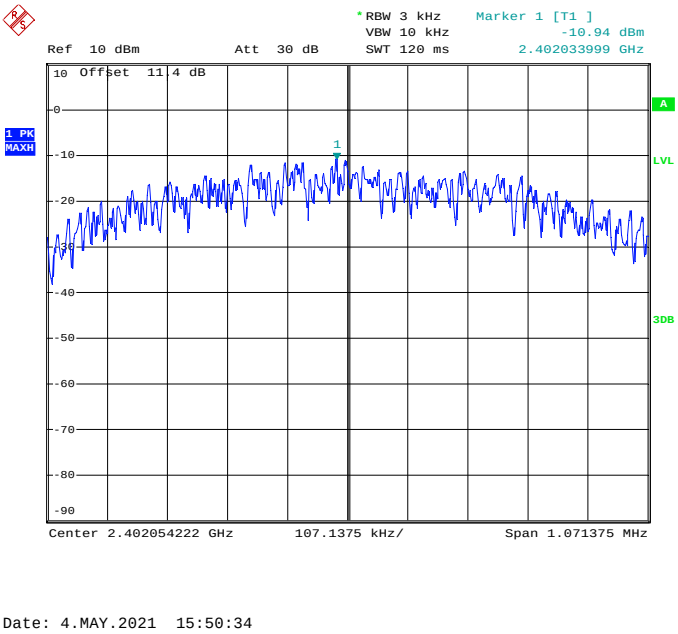

Figure 2.8.6-1: Power Spectral Density Results – Low Channel

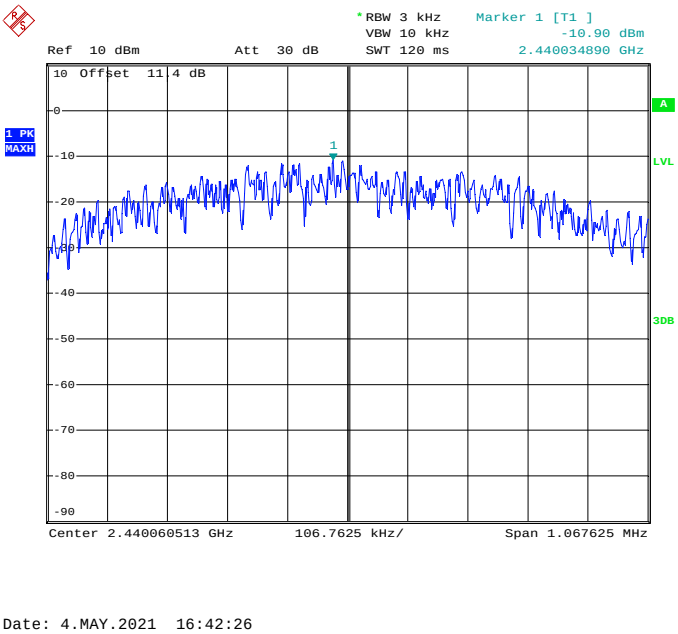

Figure 2.8.6-2: Power Spectral Density Results – Middle Channel

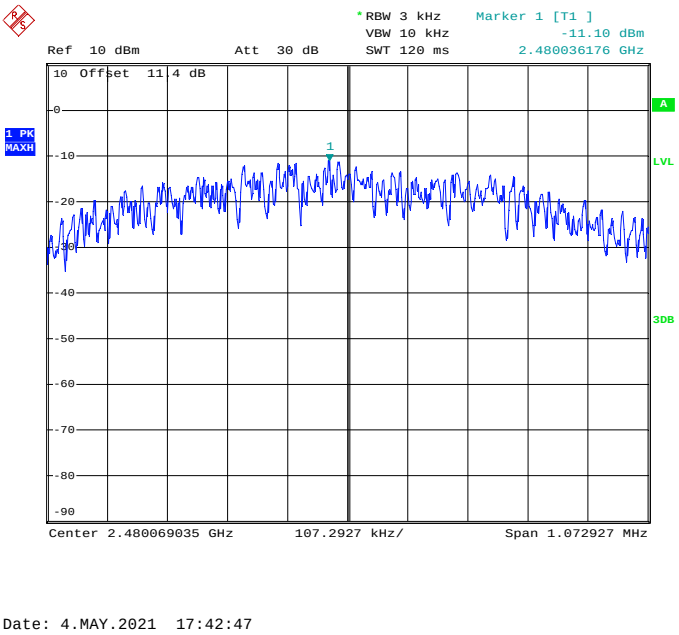

Figure 2.8.6-3: Power Spectral Density Results – High Channel

2.8.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable - 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.9 Power Line Conducted Emissions

2.9.1 Specification Reference

FCC: Section 15.207
ISED Canada; RSS-GEN 8.8

2.9.2 Equipment Under Test and Modification State

S/N: N/A

2.9.3 Date of Test

5/7/2021

2.9.4 Test Method

ANSI C63.10 section 6.2 was the guiding document for this evaluation. Conducted emissions were performed from 150 kHz to 30 MHz with the spectrum analyzer's resolution bandwidth set to 9 kHz and the video bandwidth set to 30 kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Applicable Limit - Corrected Reading

2.9.5 Environmental Conditions

Ambient Temperature	23.7 °C
Relative Humidity	41.4 %
Atmospheric Pressure	1015.8 mbar

2.9.6 Test Results

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	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.

Table 2.9.6-1: Power Line Conducted Emissions – Quasi-Peak Detector Results

Frequency (MHz)	Quasi-peak (dBµV)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	41.16	N	10.2	24.84	66.00
0.289500	31.15	N	10.3	29.39	60.54
0.501000	38.60	N	10.3	17.40	56.00
1.185000	25.12	N	10.5	30.88	56.00
1.648500	25.52	L1	10.2	30.48	56.00
2.764500	25.53	N	10.6	30.47	56.00
3.768000	27.11	N	10.6	28.89	56.00
18.618000	28.89	N	11.4	31.11	60.00

Table 2.9.6-2: Power Line Conducted Emissions – Average Detector Results

Frequency (MHz)	Average (dBµV)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.159000	28.47	N	10.2	27.04	55.52
0.190500	27.58	N	10.2	26.44	54.02
0.222000	26.81	N	10.3	25.94	52.74
0.501000	29.91	L1	10.0	16.09	46.00
0.901500	16.34	L1	10.1	29.66	46.00
1.351500	17.03	L1	10.2	28.97	46.00
2.773500	16.17	L1	10.3	29.83	46.00
25.174500	19.46	L1	11.8	30.54	50.00

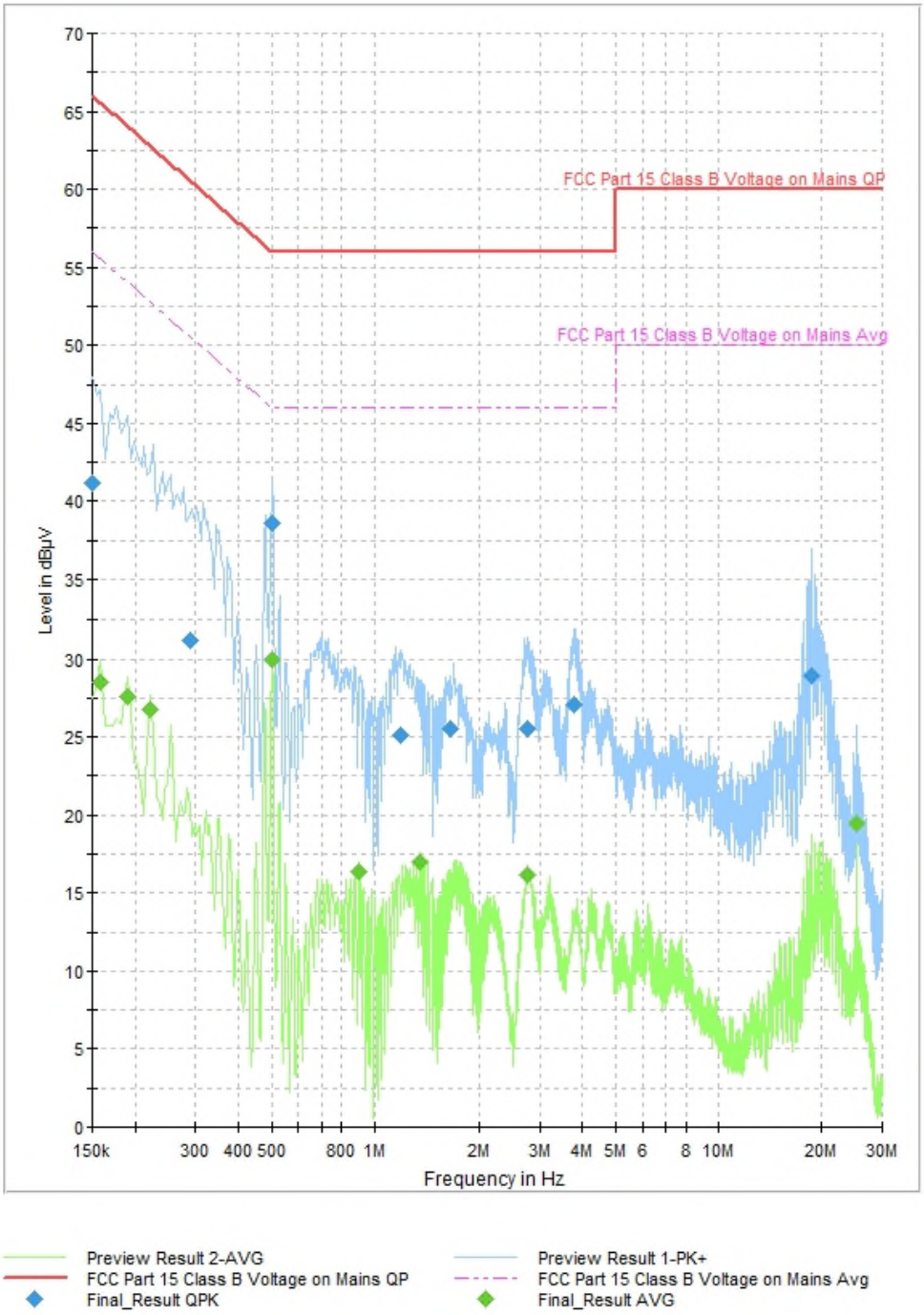

Figure 2.9.6-1: Composite Power Line Conducted Emissions Plots

2.9.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
LISN	Rohde & Schwarz	ESH3-Z5	TEMC00002	N/A	12	04-Feb-2022
EMI Test Receiver	Rohde & Schwarz	ESCS30	TEMC00011	2.3002.0102.36	24	03-Oct-2021
RFI/EMI Shielded Enclosure	UNIVERSAL SHIELDING CORP.	N/A	TEMC00100	N/A	N/A	NCR
Test Software	Rohde & Schwarz	EMC32	TEMC00184	10.50.00	N/A	NCR

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

2.10 Duty Cycle of Test Mode of Operation

2.10.1 Specification Reference

FCC: N/A
ISED Canada: N/A

2.10.2 Equipment Under Test and Modification State

S/N: N/A

2.10.3 Date of Test

5/8/2021

2.10.4 Test Method

The transmitter duty cycle was measured in accordance with FCC KDB 558074 D01 15.247 Meas Guidance v05r02. The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The reference level of the measuring equipment was offset to account for the insertion loss of the measurement cable and external attenuation. The spectrum analyzer RBW was set to greater than the 99% bandwidth of the signal. The measurements were performed using a Peak detector.

2.10.5 Environmental Conditions

Ambient Temperature	23.4 °C
Relative Humidity	42.1 %
Atmospheric Pressure	1018.9 mbar

2.10.6 Test Results

Table 2.10.6-1: Transmission Duty Cycle Test Results

Tx On (us)	Period (us)	Duty Cycle (%)
394.125	625.125	63.05

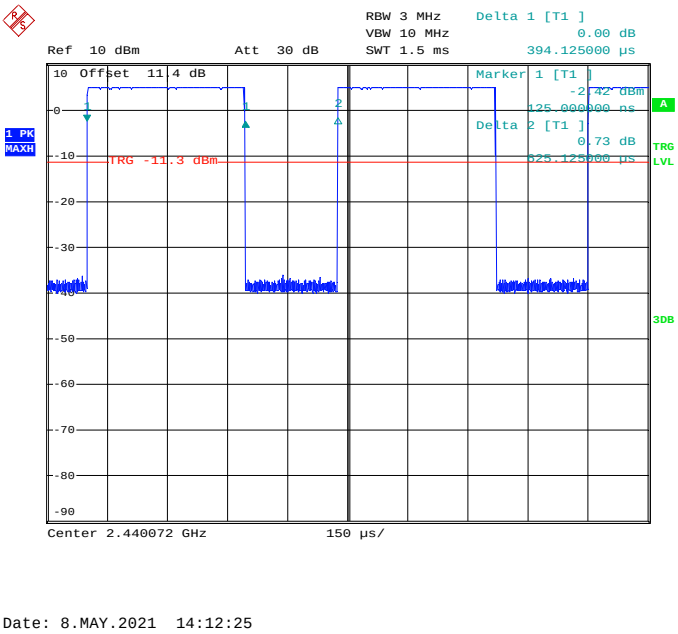

Figure 2.10.6-1: Transmission Duty Cycle Test Results

2.10.7 Test Location and Test Equipment Used

This test was carried out in TÜV SÜD America, Inc., 5610 W. Sligh Ave, Suite 100, Tampa, FL 33634, USA.

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable, 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021

TU - Traceability Unscheduled
O/P MON - Traceability Unscheduled
N/A - Not Applicable

3 Test Equipment Information

3.1 General Test Equipment Used

Instrument	Manufacturer	Type No	TE No	Software / Firmware Revision	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSP40	BEMC00283	4.50 SP5	24	04-Oct-2021
10dB Attenuator	Merrimac	FAN-6-10K	BEMC02086	N/A	12	19-Oct-2021
Tile Automation Software	ETS Lindgren	TILE4! - Version 4.2.A	BEMC02095	4.2A	N/A	NCR
Attenuator 10dB, 2.9 mm-M/F, DC-40GHz 2 W	Aeroflex Inmet	40AH2W-10	BEMC02110	N/A	12	24-Jul-2021
Duratest High Frequency Cable, 26.5GHz	Teledyne Storm Products	921-0101-036	BEMC02112	N/A	12	19-Oct-2021
LISN	Rohde & Schwarz	ESH3-Z5	TEMC00002	N/A	12	04-Feb-2022
BI LOG PERIODIC, ANTENNA	Schaffner	CBL6112B	TEMC00005	N/A	24	31-Oct-2021
EMI Test Receiver	Rohde & Schwarz	ESCS30	TEMC00011	2.3002.0102.36	24	03-Oct-2021
EMC Analyzer	Agilent	E7405A	TEMC00012	A.09.02	24	27-Mar-2022
Loop Antenna	Com Power	AL-130	TEMC00025	N/A	24	26-Sep-2021
Horn Antenna	Schwarzbeck	BBHA-9170	TEMC00029	N/A	60	23-Aug-2021
EMC Chamber	Panasheild	N/A	TEMC00031	N/A	36	28-Jan-2024
Double Ridge Guide Horn	ETS Lindgren	3117	TEMC00061	N/A	24	07-Feb-2022
RFI/EMI Shielded Enclosure	UNIVERSAL SHIELDING CORP.	N/A	TEMC00100	N/A	N/A	NCR
18 GHz-40 GHz Microwave Preamplifier	COM-power	PAM-840A	TEMC00147	N/A	12	06-Jul-2021
PAM-118A	Com-Power Corporation	PAM-118A	TEMC00160	N/A	12	10-Apr-2022
2.4 GHz Notch Filter	Micro-Tronics	BRM50702-01	TEMC00176	N/A	12	09-Mar-2022
Test Software	Rohde & Schwarz	EMC32	TEMC00184	10.50.00	N/A	NCR
A81-0303 18 GHz Cable Set	Teledyne Storm Products	A81-0303-360/96	TEMC00201	N/A	12	10-Apr-2022
DC-1000 MHz Low Pass Filter	Mini-Circuits	NLP-1200+	TEMC00202	N/A	12	30-Mar-2022

N/A - Not Applicable
NCR - No Calibration Required

4 Diagram of Test Set-ups

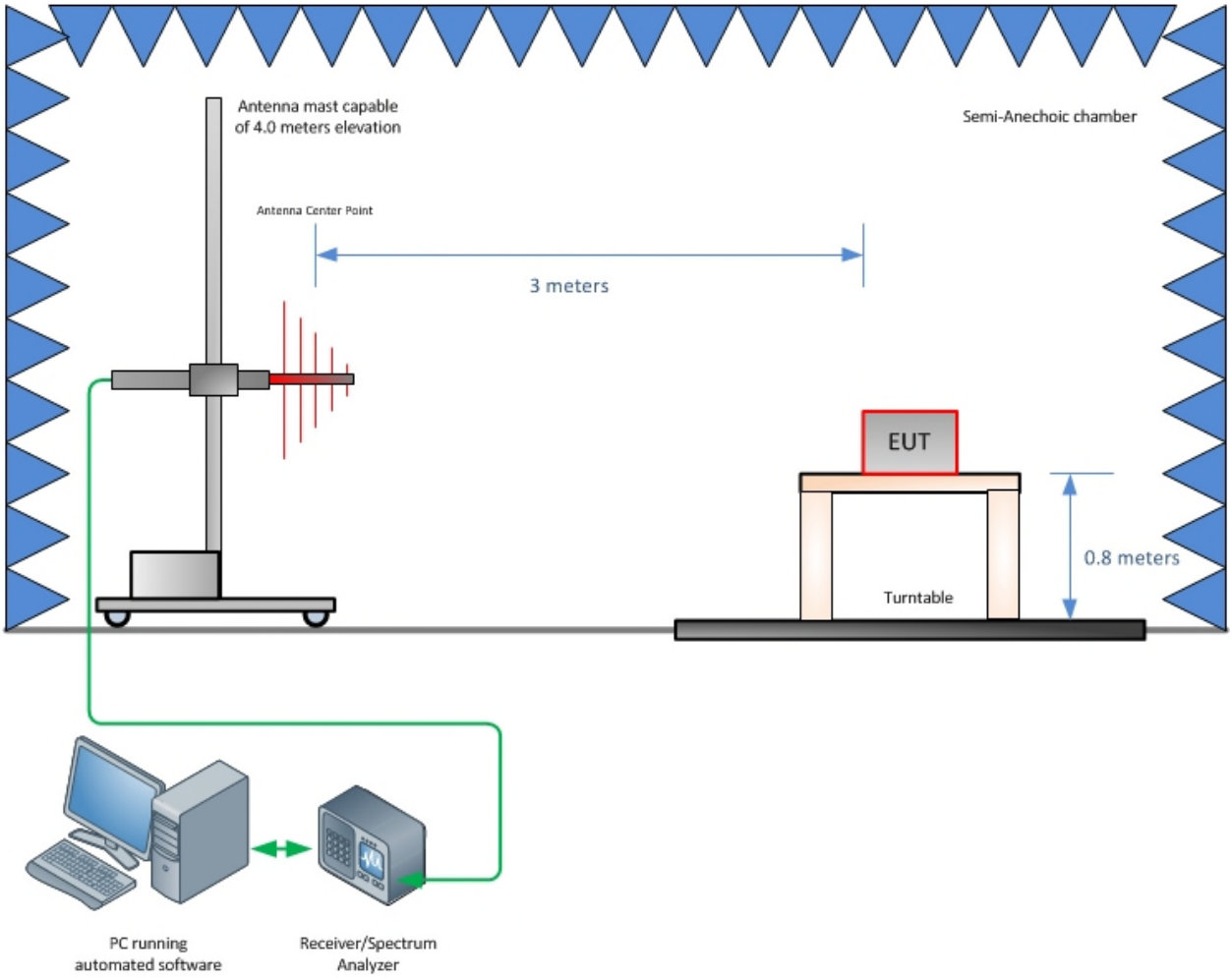

Figure 4-1 - Radiated Emissions Test Setup up to 1 GHz

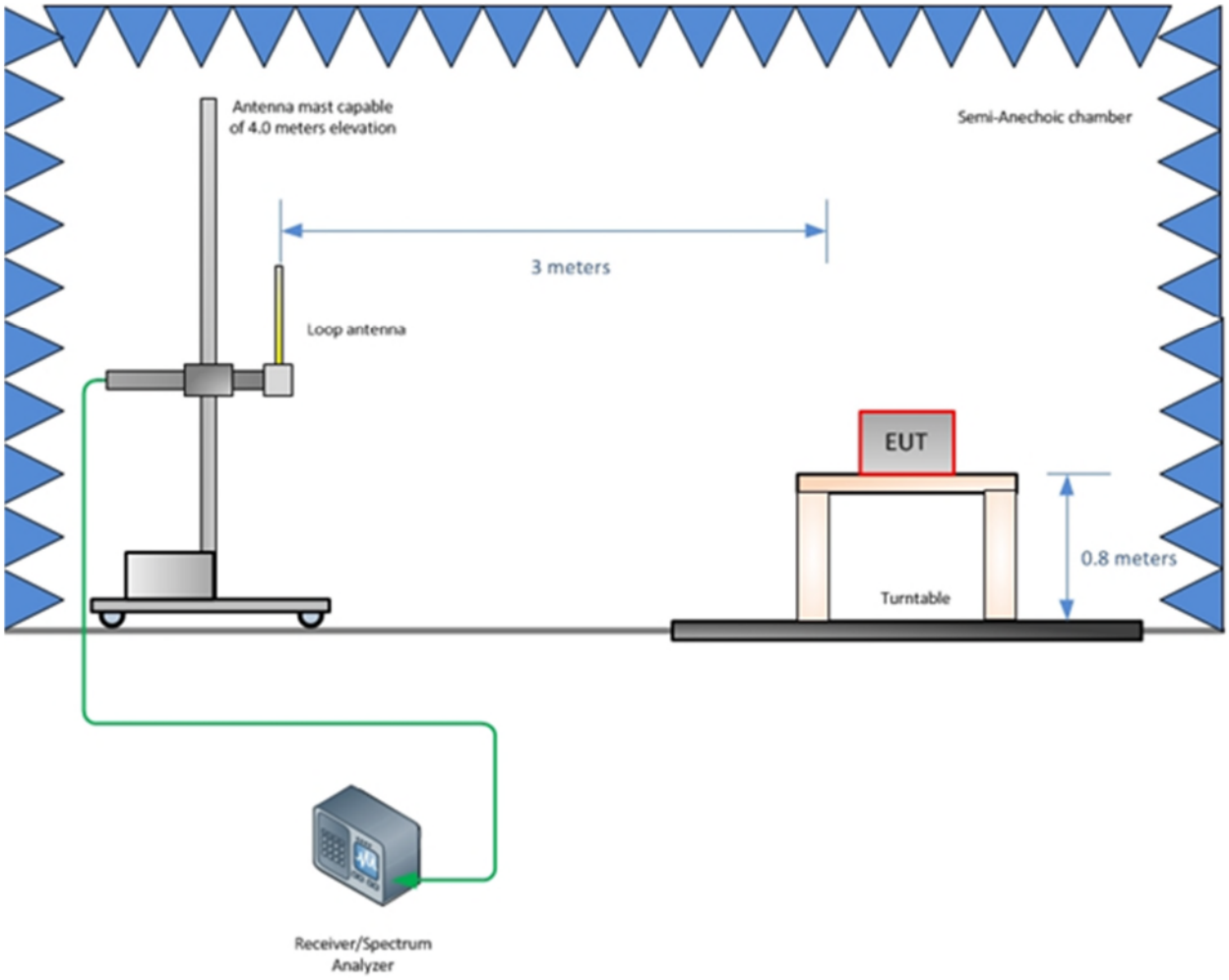

Figure 4-2 - Radiated Emissions Test Setup up to 30 MHz

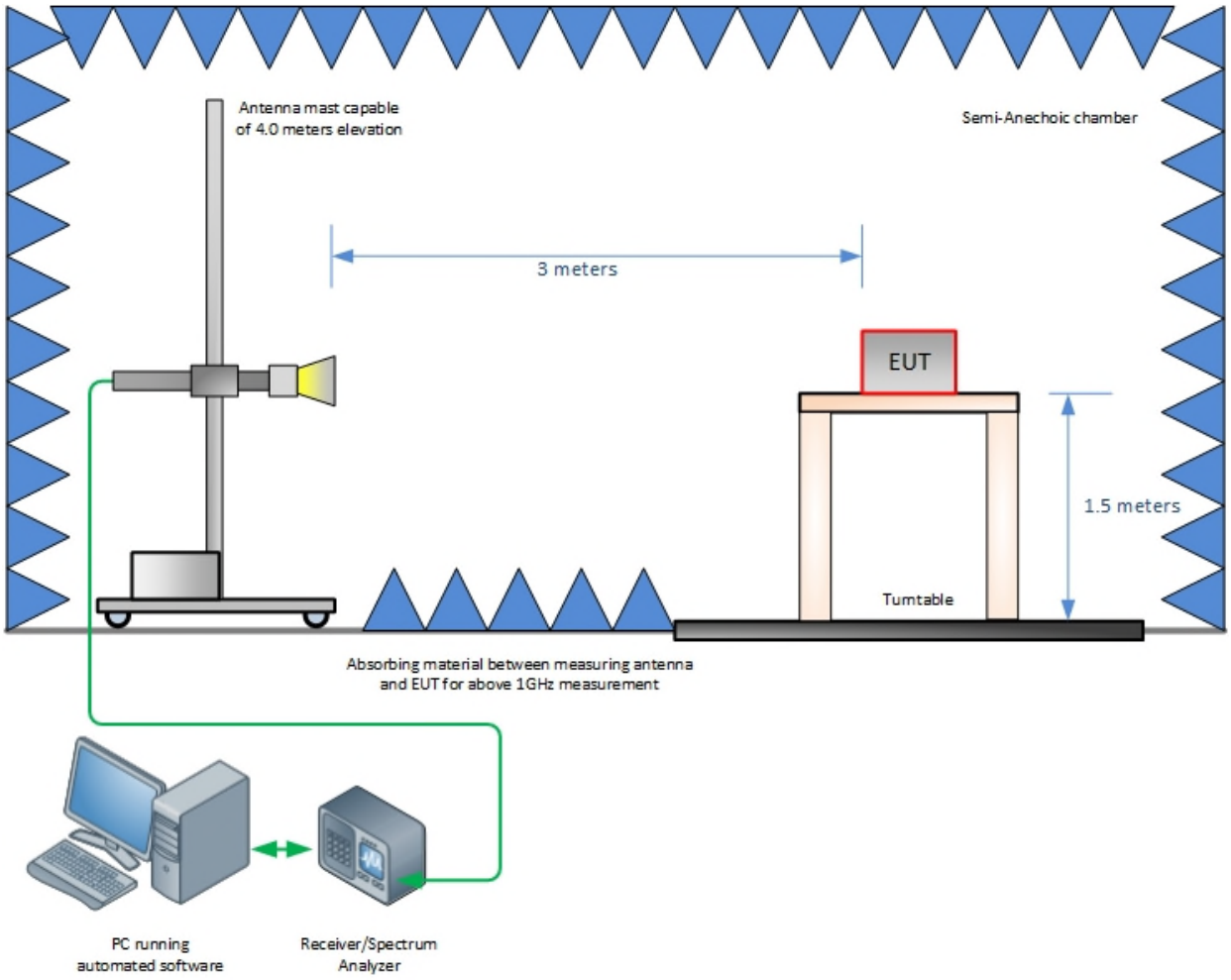

Figure 4-3 - Radiated Emissions Test Setup above 1 GHz

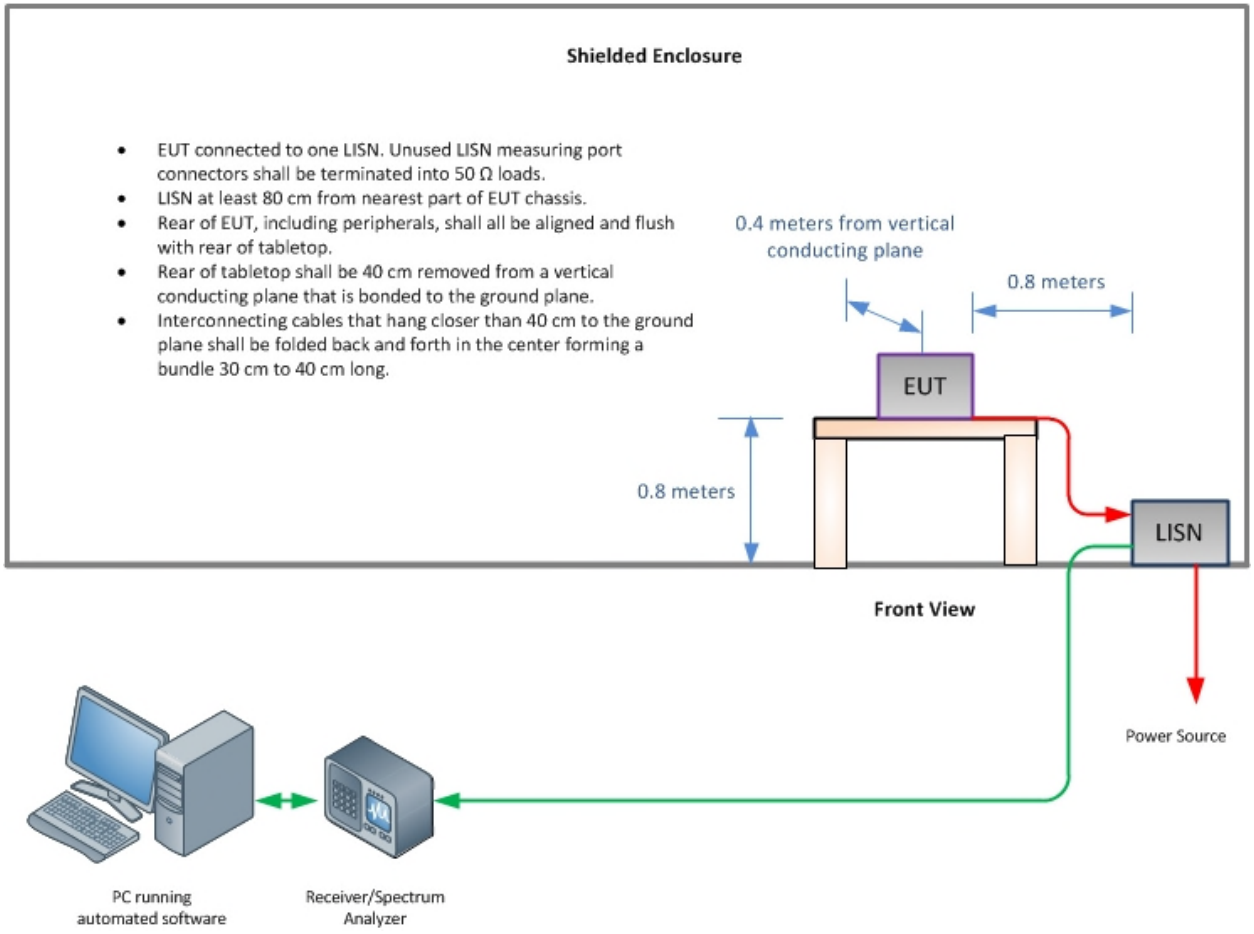

Figure 4-4 – Conducted Emissions Test Setup

5 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Table 5-1 - Values of U_{cispr} and U_{Lab}

Measurement	U_{cispr}	U_{Lab}
Conducted disturbance (mains port) (9 kHz – 150 kHz) (150 kHz – 30 MHz)	 3.8 dB 3.4 dB	 3.71 dB 3.31 dB
Conducted disturbance (telecom port) (150 kHz – 30 MHz 55 dB LCL) (150 kHz – 30 MHz 65 dB LCL) (150 kHz – 30 MHz 75 dB LCL)	5.0 dB 5.0 dB 5.0 dB	4.11 dB 4.50 dB 4.94 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1 000 MHz) (1 – 6 GHz) (6-18 GHz)	 6.3 dB 5.2 dB 5.5 dB	 5.85 dB 4.48 dB 4.48 dB

Notes:

U_{cispr} resembles a value of measurement uncertainty for a specific test, which was determined by considering uncertainties associated with the quantities listed in CISPR 16-4-2:2011.

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