

Report on the Testing of the Landis + Gyr Technology, Inc. T1501 Series-5 Mesh

In accordance with:
FCC 47 CFR part 15.247
ISED RSS-247 Issue 2, February 2017

Prepared for: Landis + Gyr Technology, Inc.
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|--------------|--|----------------------|------------|
| Kirby Munroe | Wireless / EMC Technical and Certification Manager, NA TÜV SUD America Inc. | Authorized Signatory | 11/17/2021 |

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FCC Accreditation Designation Number US1233

FCC Test Site Registration Number 967699

Innovation, Science, and Economic Development Canada Lab Code 23932

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with the standards listed above.



A2LA Cert. No. 2955.09

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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.

Table 1.1-1 – Modification Record

| Issue | Description of Change | Date of Issue |
|-------|-----------------------|---------------|
| 0 | First Issue | 11/17/2021 |

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 | Tim Walters |
| Manufacturer | Landis + Gyr Technology, Inc |
| Applicant's Email Address | Tim.walters@landisgyr.com |
| Model Number(s) | T1501 Series-5 Mesh |
| Serial Number(s) | LAN ID: 9160F62C (Conducted and Field strength measurement) LAN ID: 9160F63C (Radiated measurement) |
| FCC ID | R7PNG0R1S5LP |
| ISED Certification Number | 5294A-NG0R1S5LP |
| Hardware Version(s) | N/A |
| Software Version(s) | N/A |
| Number of Samples Tested | 1 |
| Test Specification/Issue/Date | US Code of Federal Regulation (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2021 ISED Canada Radio Standards Specification: RSS-247 – Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices, Issue 2, February 2017. |
| Order Number | 72172746 |
| Date of Receipt of EUT | 2021-October-11 |
| Start of Test | 2021-October-11 |
| Finish of Test | 2021-October-15 |



Related Document(s)

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

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, April 2, 2019

US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2021.

ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, Amendment 1 (March 2019), Amendment 2 (February 2021)

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 | ----- | 10 |
| Carrier Frequency Separation | Yes | Pass | 15.247(a)(1) | RSS-247 5.1(b) | 15 |
| Number of Hopping Channels | Yes | Pass | 15.247(a)(1)(i) | RSS-247 5.1(c) | 17 |
| Channel Dwell Time | Yes | Pass | 15.247(a)(1)(i) | RSS-247 5.1(c) | 20 |
| 20 dB Bandwidth | Yes | Pass | 15.247(a)(1)(i) | RSS-247 5.1(c) | 21 |
| 99% Bandwidth | Yes | Pass | ----- | RSS-GEN 6.7 | 21 |
| Peak Output Power | Yes | Pass | 15.247(b)(2) | RSS-247 5.4(a) | 13 |
| Band-Edge Compliance of RF Conducted Emissions | Yes | Pass | 15.247(d) | RSS-247 5.5 | 27 |
| RF Conducted Spurious Emissions | Yes | Pass | 15.247(d) | RSS-247 5.5 | 30 |
| Radiated Spurious Emissions into Restricted Frequency Bands | Yes | Pass | 15.205, 15.209 | RSS-GEN 8.9, 8.10 | 32 |
| Power Line Conducted Emissions | Yes | Pass | 15.207 | RSS-GEN 8.8 | 10 |
| Duty Cycle | No | ----- | | | ----- |

1.4 Product Information

1.4.1 Technical Description

The Series-5 RF proprietary protocol supports baud rates up to 115.2 kbps. operation in the Sub-GHz band. There are 2 types of RF proprietary protocol radios with wide band and narrow band mode.

Table 1.4-1 – Wireless Technical Information

| Detail | Description |
|-----------------------------|-----------------------------------|
| FCC ID | R7PNG0R1S5LP |
| IC ID | 5294A-NG0R1S5LP |
| Transceiver Model # | T1501 Series-5 Mesh |
| Modulation Format | Proprietary FSK |
| Antenna Type / Description: | Monopole chip antenna / 1dBi Gain |

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



Photo 1.4.1-1 –Front view of the EUT



Photo 1.4.1-2 – Back view of the EUT



Photo 1.4.1-3 –EUT with USB cable

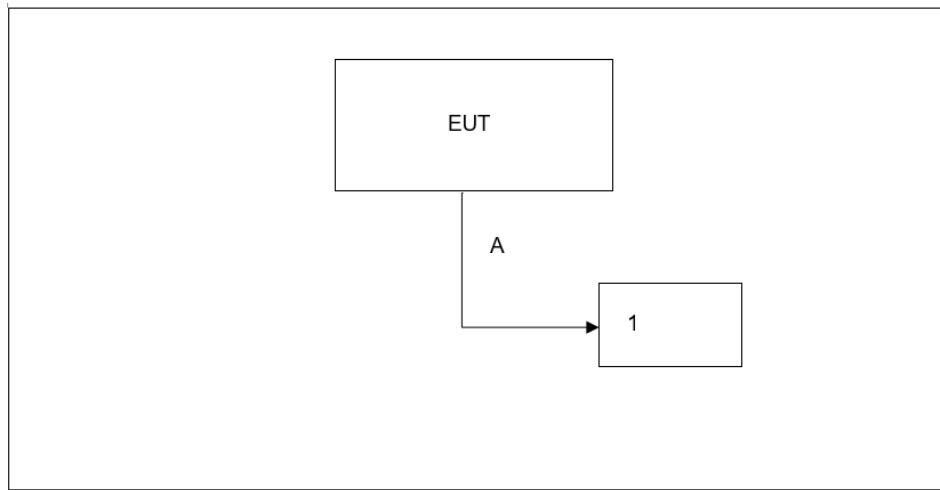


Figure 1.4.1-4 – Test Setup Block Diagram

Table 1.4.1-1 – Cable Descriptions

| Item | Cable/Port | Description |
|------|------------|-------------|
| A | USB | Power Cable |

Table 1.4.1-2 – Support Equipment Descriptions

| Item | Make/Model | Description |
|------|------------|---|
| 1 | Lenovo | Laptop used for configuring wireless module – Landis + Gyr provided |

1.4.2 Modes of Operation

T1501 Series-5 Mesh model provides 2 distinct proprietary modes of operation using FHSS classifications as outlined below.

| Mode of Operation | Frequency Range (MHz) | Number of Channels | Channel Separation (kHz) | Stack / Mode | Data Rates Supported (kbps) | Classification |
|-------------------|-----------------------|--------------------|--------------------------|------------------------|-----------------------------|----------------|
| 1 | 902.3 - 927.8 | 86 | 300 | Mesh (Wide band) FSK | 9.6, 19.2, 38.4, 115.2 | FHSS |
| 2 | 904.0 - 927.8 | 239 | 100 | Mesh (Narrow band) FSK | 9.6, 19.2, 38.4 | FHSS |

1.4.3 Monitoring of Performance

For radiated emissions, the EUT was evaluated in three orthogonal orientations. The worst-case orientation was X-position. See test setup photos for more information. The EUT was programmed to generate a continuously modulated signal on each channel evaluated.

For RF Conducted measurements, the EUT was connected to the test equipment with a MMCX to SMA connector.

Worst case mode for all other parameters measured listed below:

| Mode | Classification | 20dB Bandwidth | Number of hopping channels | RF Channel Separation | Peak Output Power | Data Rate (kbps) | | |
|------|----------------|------------------------|----------------------------|-----------------------|------------------------|------------------------------|---------------------|-----------------------------|
| | | | | | | Conducted Spurious Emissions | Conducted Band Edge | Radiated Spurious Emissions |
| 1 | FHSS | 9.6, 19.2, 38.4, 115.2 | 9.6 | 9.6 | 9.6, 19.2, 38.4, 115.2 | 9.6 | 115.2 | 9.6 |
| 2 | FHSS | * | 9.6 | 9.6 | ** | * | 38.4 | * |

* Addressed by mode 1

**Only channel 904 MHz was evaluated. All other data rates / channels addressed by mode 1.

Power setting during test: Mode of operation 1: 28.5 dBm
Mode of operation 2: 28.0 dBm

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test program. 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 |
|--------------------|---|------------------------|--------------------------|
| 0 | Initial State | | |

The equipment was tested as provided without any modifications.

1.7 Test Location

TÜV SÜD conducted the following tests at our Alpharetta, GA test laboratory.

| Test Name | Name of Engineer(s) | Accreditation |
|---|-----------------------|---------------|
| DC Powered Operating | | |
| Antenna Requirement | Divya Adusumilli | A2LA |
| Power Line Conducted Emissions | Bhagyashree Chaudhary | A2LA |
| Peak Output Power | Divya Adusumilli | A2LA |
| Carrier Frequency Separation | Divya Adusumilli | A2LA |
| Number of Hopping Channels | Divya Adusumilli | A2LA |
| 20dB / 99% Bandwidth | Divya Adusumilli | A2LA |
| Band-Edge Compliance of RF Conducted Emissions | Bhagyashree Chaudhary | A2LA |
| RF Conducted Spurious Emissions | Divya Adusumilli | A2LA |
| Radiated Spurious Emissions into Restricted Frequency Bands | Divya Adusumilli | A2LA |

Office address:

TÜV SÜD America
5945 Cabot Parkway, Suite 100
Alpharetta, GA 30005, USA

2 Test Details

2.1 Antenna Requirement

2.1.1 Specification Reference

FCC Section: 15.203

2.1.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.1.3 Date of Test

10/13/2021

2.1.4 Test Method

N/A

2.1.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.1.6 Test Results

The EUT utilizes monopole chip antenna with peak gain 1 dBi which is mounted on the bottom side of the printed circuit board, therefore satisfying the requirements of Section 15.203.

2.2 Power Line Conducted Emissions

2.2.1 Specification Reference

FCC Section: 15.207
ISED Canada: RSS-Gen 8.8

2.2.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.2.3 Date of Test

10/14/2021

2.2.4 Test Method

ANSI C63.10 section 6 was the guiding documents for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

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

2.2.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.2.6 Test Results

Table 2.2.6-1: Conducted EMI Results-Avg – Line 1

| Frequency (MHz) | Avg Limit | Avg Level Corrected | Avg Level | Correction Fact. | Avg Margin | Result |
|-----------------|-----------|---------------------|-----------|------------------|------------|--------|
| 0.15 | 56 | 42.3 | 32.6 | 9.682 | -13.7 | PASS |
| 0.8 | 46 | 22.3 | 12.6 | 9.668 | -23.7 | PASS |
| 1.6 | 46 | 23.4 | 13.7 | 9.662 | -22.6 | PASS |
| 1.64 | 46 | 22.2 | 12.6 | 9.663 | -23.8 | PASS |
| 1.68 | 46 | 23.2 | 13.5 | 9.664 | -22.8 | PASS |
| 2.47 | 46 | 22.8 | 13.1 | 9.689 | -23.2 | PASS |

Table 2.2.6-2: Conducted EMI Results-QP – Line 1

| Frequency (MHz) | QP Limit | QP Level Corrected | QP Level | Correction Fact. | QP Margin | Result |
|-----------------|----------|--------------------|----------|------------------|-----------|--------|
| 0.15 | 66 | 50.7 | 41.1 | 9.682 | -15.3 | PASS |
| 0.8 | 56 | 29.5 | 19.8 | 9.668 | -26.5 | PASS |
| 1.6 | 56 | 29.5 | 19.8 | 9.662 | -26.5 | PASS |
| 1.64 | 56 | 29.3 | 19.6 | 9.663 | -26.7 | PASS |
| 1.68 | 56 | 29.4 | 19.8 | 9.664 | -26.6 | PASS |
| 2.47 | 56 | 29.1 | 19.4 | 9.689 | -26.9 | PASS |

Table 2.2.6-3: Conducted EMI Results-Avg – Line 2

| Frequency (MHz) | Avg Limit | Avg Level Corrected | Avg Level | Correction Fact. | Avg Margin | Result |
|-----------------|-----------|---------------------|-----------|------------------|------------|--------|
| 0.15 | 56 | 40.5 | 30.8 | 9.675 | -15.5 | PASS |
| 0.5 | 46.1 | 26.4 | 16.7 | 9.631 | -19.8 | PASS |
| 1.34 | 46 | 20.2 | 10.5 | 9.667 | -25.8 | PASS |
| 1.52 | 46 | 21.8 | 12.1 | 9.67 | -24.2 | PASS |
| 1.96 | 46 | 21.8 | 12.1 | 9.661 | -24.2 | PASS |
| 3.13 | 46 | 21.7 | 12 | 9.693 | -24.3 | PASS |

Table 2.2.6-4: Conducted EMI Results-QP – Line 2

| Frequency (MHz) | QP Limit | QP Level Corrected | QP Level | Correction Fact. | QP Margin | Result |
|-----------------|----------|--------------------|----------|------------------|-----------|--------|
| 0.15 | 66 | 49.2 | 39.5 | 9.675 | -16.8 | PASS |
| 0.5 | 56.1 | 29.1 | 19.4 | 9.631 | -27.1 | PASS |
| 1.34 | 56 | 25.5 | 15.9 | 9.667 | -30.5 | PASS |
| 1.52 | 56 | 26.4 | 16.7 | 9.67 | -29.6 | PASS |
| 1.96 | 56 | 26.2 | 16.5 | 9.661 | -29.8 | PASS |
| 3.13 | 56 | 25.7 | 16 | 9.693 | -30.3 | PASS |

2.3 Peak Output Power

2.3.1 Specification Reference

FCC Sections: 15.247(b)(2)
ISED Canada: RSS-247 5.4(a)

2.3.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.3.3 Date of Test

10/12/2021

2.3.4 Test Method

The maximum conducted peak output power was measured in accordance with ANSI C63.10 Subclause 7.8.5. The RF output port of the EUT was directly connected to the input of a peak power meter. The resulting peak value was recorded.

2.3.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.3.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.3.6-1: RF Output Power - FHSS

| Frequency [MHz] | Peak Output Power (dBm) | Data Rate (kbps) | Mode(s) |
|-----------------|-------------------------|------------------|---------|
| 902.3 | 29.96 | 9.6 | 1 |
| 902.3 | 29.97 | 19.2 | 1 |
| 902.3 | 29.95 | 38.4 | 1 |
| 902.3 | 29.91 | 115.2 | 1 |
| 904.0 | 29.74 | 9.6 | 2 |
| 904.0 | 29.65 | 19.2 | 2 |
| 904.0 | 29.74 | 38.4 | 2 |
| 915.2 | 29.93 | 9.6 | 1 |
| 915.2 | 29.88 | 19.2 | 1 |
| 915.2 | 29.85 | 38.4 | 1 |
| 915.2 | 29.82 | 115.2 | 1 |
| 927.8 | 28.72 | 9.6 | 1 |
| 927.8 | 28.69 | 19.2 | 1 |
| 927.8 | 28.53 | 38.4 | 1 |
| 927.8 | 28.63 | 115.2 | 1 |

2.4 Carrier Frequency Separation

2.4.1 Specification Reference

FCC Sections: 15.247(a)(1)
ISED Canada: RSS-247 5.1(b)

2.4.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.4.3 Date of Test

10/12/2021

2.4.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer was set wide enough to capture two adjacent peaks and the RBW started at approximately 30% of the channel spacing and adjusted as necessary to best identify the center of each individual channel. The VBW was set to \geq RBW.

2.4.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.4.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See below plots for detailed results.

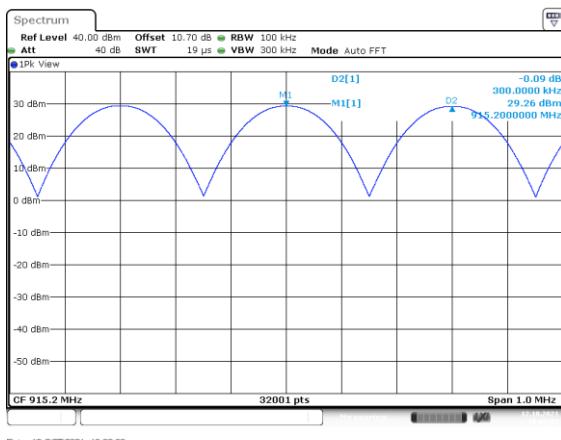


Figure 2.4.6-1: Channel Separation – Mode 1 – 9.6 kbps

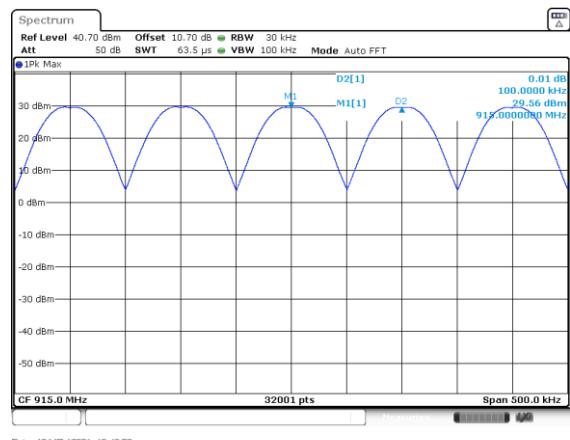


Figure 2.4.6-2: Channel Separation – Mode 2 – 9.6 kbps

2.5 Number of Hopping Channels

2.5.1 Specification Reference

FCC Sections: 15.247(a)(1)(i)
ISED Canada: RSS 247 5.1 (c)

2.5.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.5.3 Date of Test

10/12/2021

2.5.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer was set wide enough to capture the frequency band of operation. The RBW was set to less than 30% of the channel spacing or the 20dB bandwidth, whichever is smaller. The VBW was set to \geq RBW.

2.5.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.5.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See below plots for detailed results.

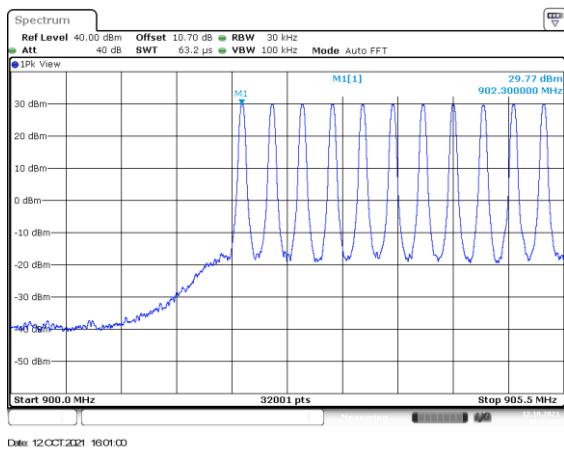


Figure 2.5.6-1: Mode 1 – 9.6 kbps (86 Channels)

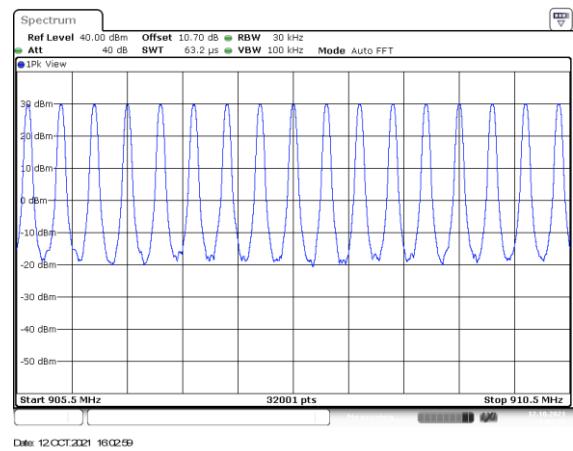


Figure 2.5.6-2: Mode 1 – 9.6 kbps (86 Channels)

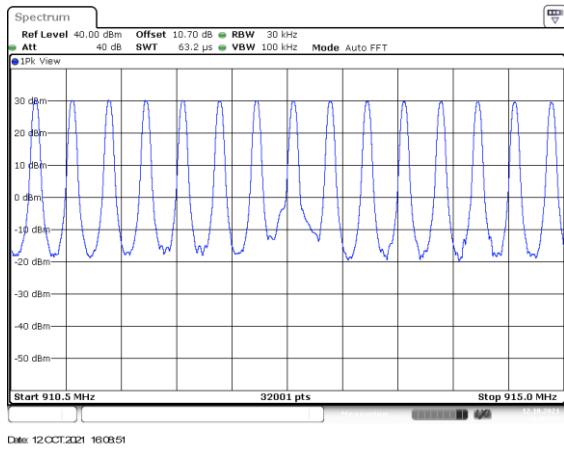


Figure 2.5.6-3: Mode 1 – 9.6 kbps (86 Channels)

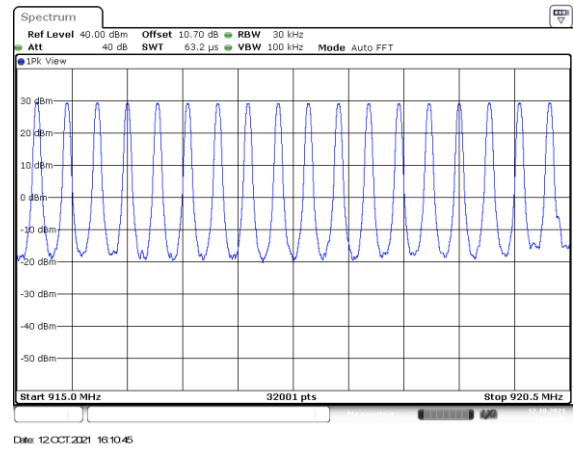


Figure 2.5.6-4: Mode 1 – 9.6 kbps (86 Channels)

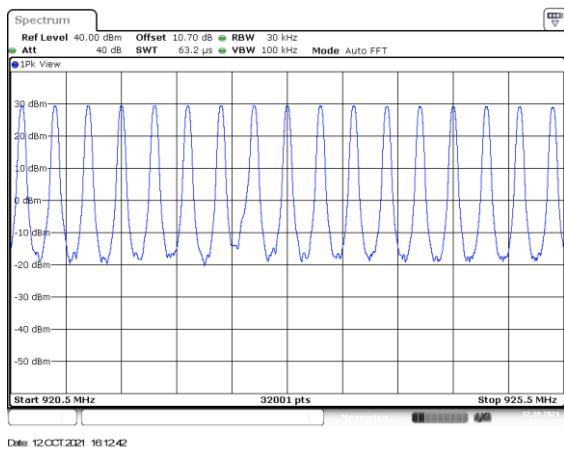


Figure 2.5.6-5: Mode 1 – 9.6 kbps (86 Channels)

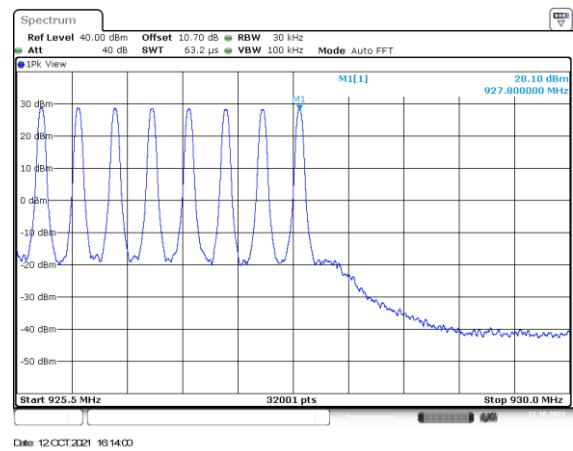
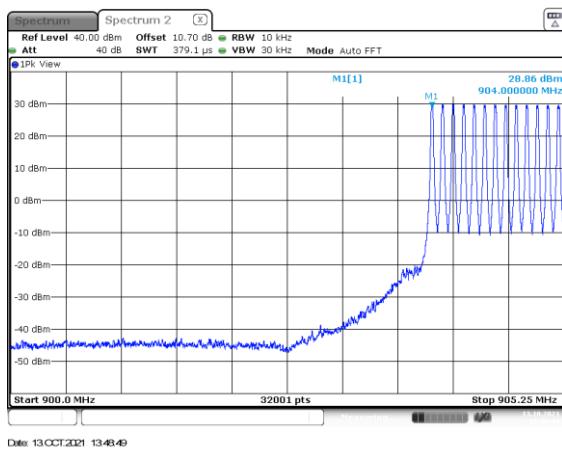
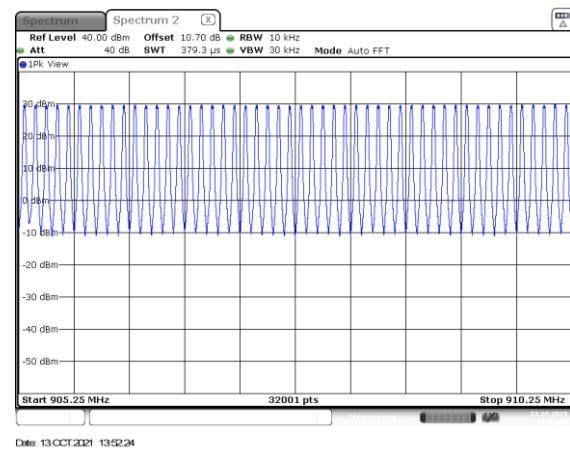


Figure 2.5.6-6: Mode 1 – 9.6 kbps (86 Channels)



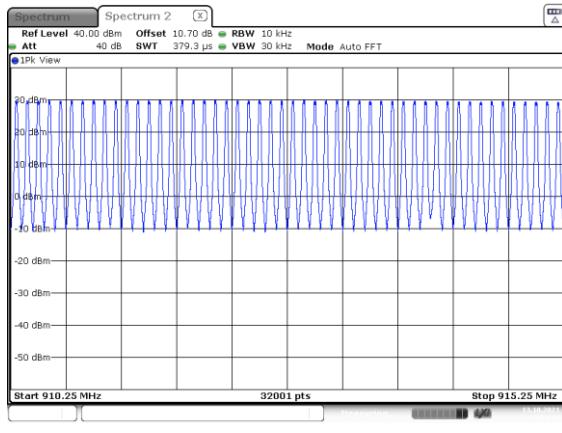
Date: 13 OCT 2021 13:48:49

Figure 2.5.6-7: Mode 2 – 9.6 kbps (239 Channels)



Date: 13 OCT 2021 13:52:24

Figure 2.5.6-8: Mode 2 – 9.6 kbps (239 Channels)



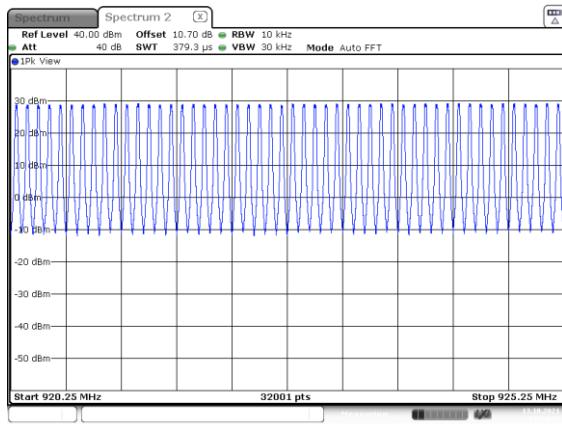
Date: 13 OCT 2021 13:54:40

Figure 2.5.6-9: Mode 2 – 9.6 kbps (239 Channels)



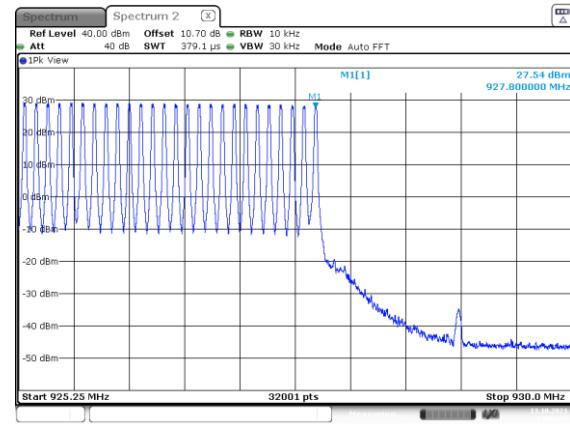
Date: 13 OCT 2021 13:57:01

Figure 2.5.6-10: Mode 2 – 9.6 kbps (239 Channels)



Date: 13 OCT 2021 13:59:13

Figure 2.5.6-11: Mode 2 – 9.6 kbps (239 Channels)



Date: 13 OCT 2021 14:03:27

Figure 2.5.6-12: Mode 2 – 9.6 kbps (239 Channels)

2.6 Channel Dwell Time

2.6.1 Specification Reference

FCC Sections: 15.247(a)(1)(i)
ISED: RSS-247 5.1(c)

2.6.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.6.3 Date of Test

10/13/2021

2.6.4 Test Method

N/A

2.6.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.6.6 Test Results

The EUT test mode does not generate a worst-case channel dwell time therefore a detailed engineering analysis is provided in the theory of operation.

2.7 20dB / 99% Bandwidth

2.7.1 Specification Reference

FCC Sections: 15.247(a)(1)(i)
ISED Canada: RSS-247 5.1(c), RSS-GEN 6.7

2.7.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.7.3 Date of Test

10/12/2021

2.7.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer display was set between two times and five times the occupied bandwidth (OBW) of the emission. The RBW of the spectrum analyzer was set to approximately 1 % to 5 % of the OBW. The trace was set to max hold with a peak detector active. The Delta and ndB down functions of the analyzer were utilized to determine the 20 dB bandwidth of the emission.

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The resolution bandwidth was set to 1% to 5% of the occupied bandwidth. The video bandwidth was set to 3 times the resolution bandwidth. A peak detector was used.

2.7.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.7.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.7.6-1: 20dB / 99% Bandwidth

| Frequency [MHz] | 20dB Bandwidth (kHz) | 99% Bandwidth (kHz) | Data Rate (kbps) | Mode(s) |
|-----------------|----------------------|---------------------|------------------|---------|
| 902.3 | 21.440 | 20.669 | 9.6 | 1 |
| 902.3 | 41.783 | 42.133 | 19.2 | 1 |
| 902.3 | 85.759 | 82.516 | 38.4 | 1 |
| 902.3 | 234.514 | 214.143 | 115.2 | 1 |
| 915.2 | 21.316 | 20.746 | 9.6 | 1 |
| 915.2 | 41.421 | 42.217 | 19.2 | 1 |
| 915.2 | 85.622 | 83.535 | 38.4 | 1 |
| 915.2 | 234.555 | 216.493 | 115.2 | 1 |
| 927.8 | 21.351 | 20.651 | 9.6 | 1 |
| 927.8 | 42.268 | 42.027 | 19.2 | 1 |
| 927.8 | 85.309 | 83.609 | 38.4 | 1 |
| 927.8 | 234.480 | 214.693 | 115.2 | 1 |



Figure 2.7.6-1: Mode 1 – 20 dB BW – LCH – 9.6 kbps

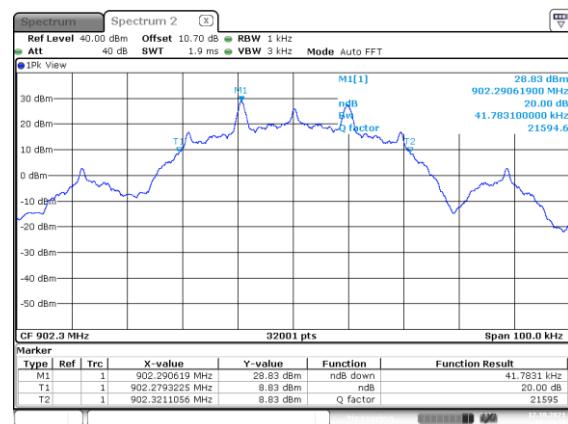


Figure 2.7.6-2: Mode 1 – 20 dB BW – LCH – 19.2 kbps

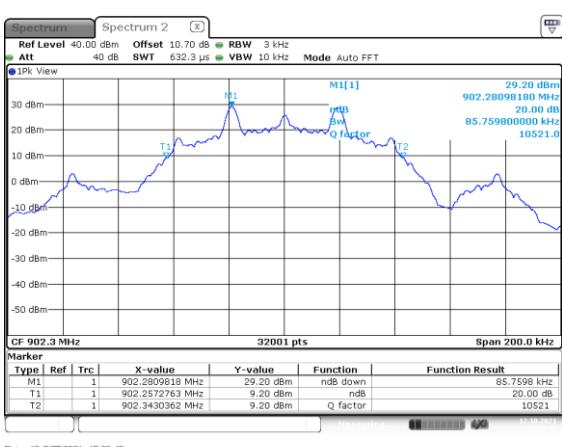


Figure 2.7.6-3: Mode 1 – 20 dB BW – LCH – 38.4 kbps

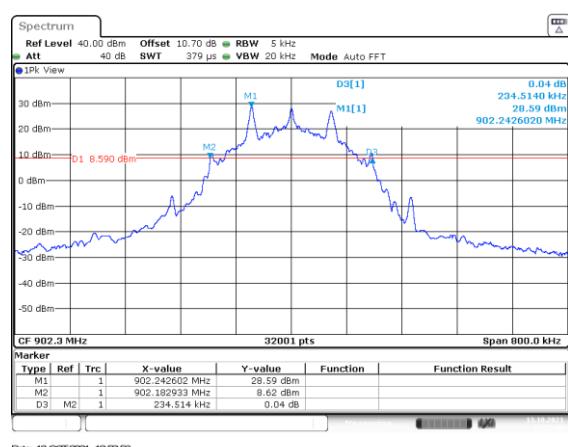
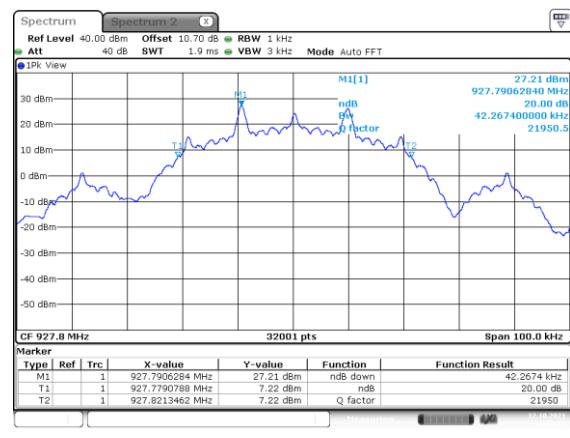
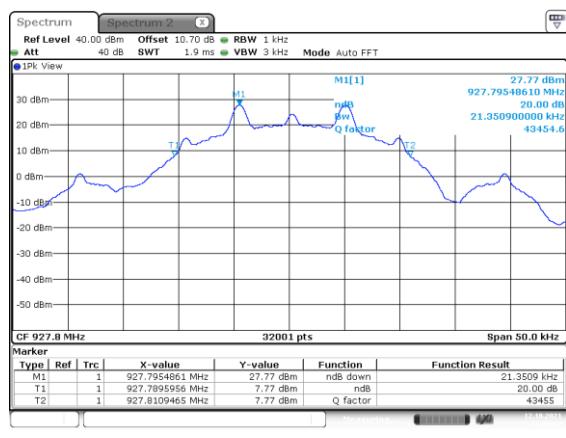
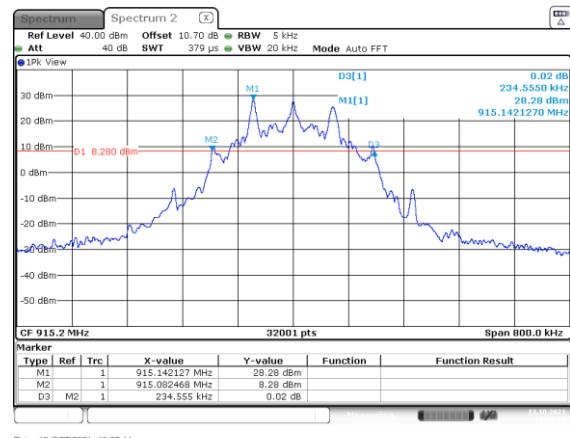
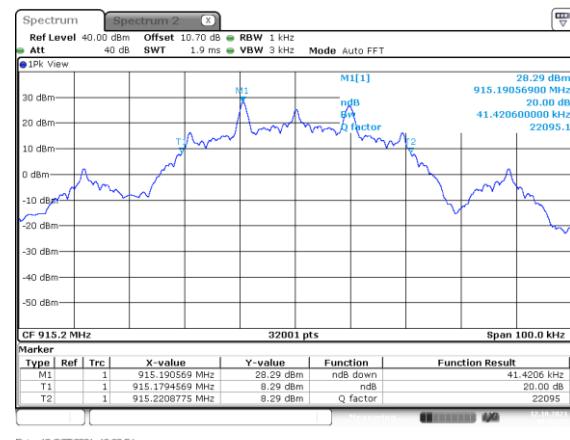
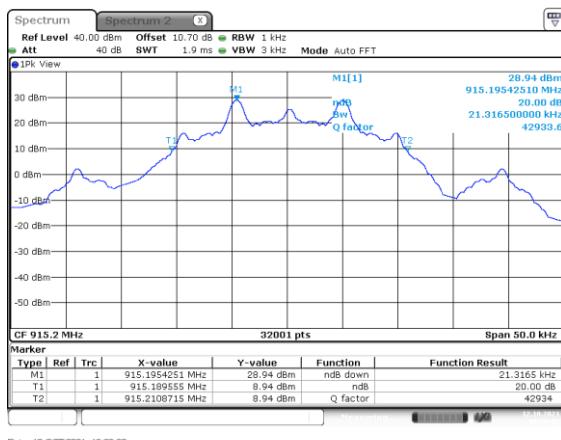
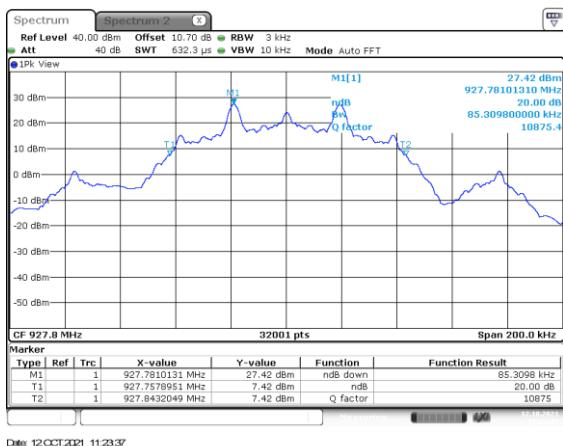


Figure 2.7.6-4: Mode 1 – 20 dB BW – LCH – 115.2





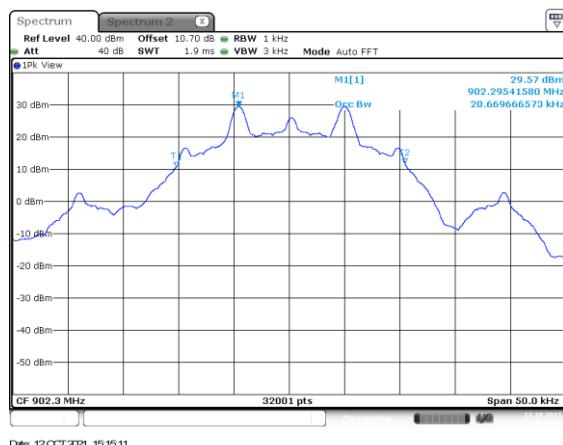
Date: 12.OCT.2021 11:23:37

Figure 2.7.6-11: Mode 1 – 20 dB BW – HCH – 38.4 kbps



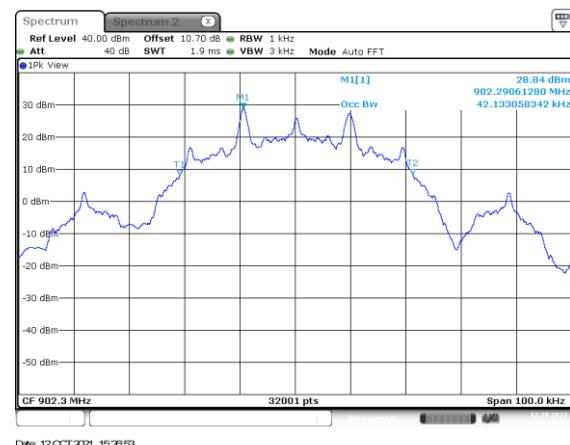
Date: 13.OCT.2021 13:42:04

Figure 2.7.6-12: Mode 1 – 20 dB BW – HCH – 115.2



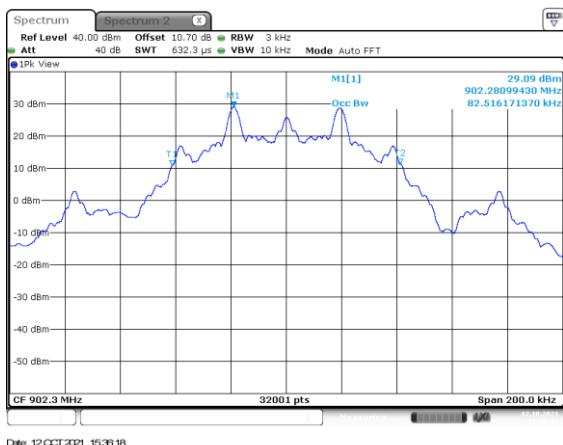
Date: 12.OCT.2021 15:15:11

Figure 2.7.6-13: Mode 1 – 99% BW – LCH – 9.6 kbps



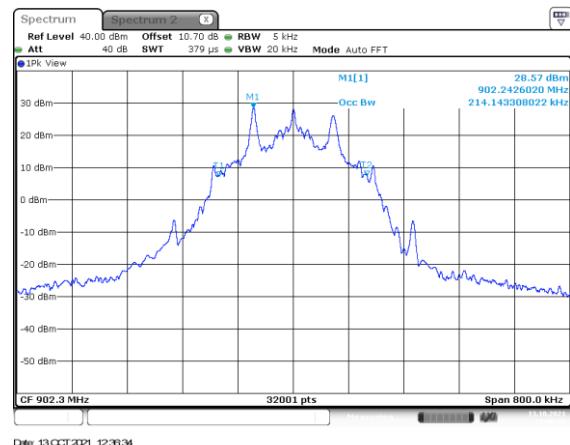
Date: 12.OCT.2021 15:28:53

Figure 2.7.6-14: Mode 1 – 99% BW – LCH – 19.2 kbps



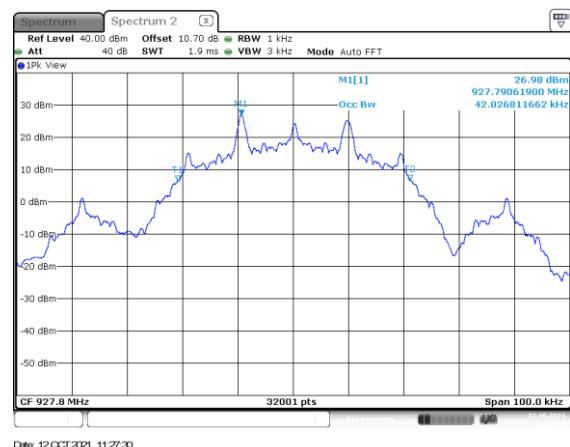
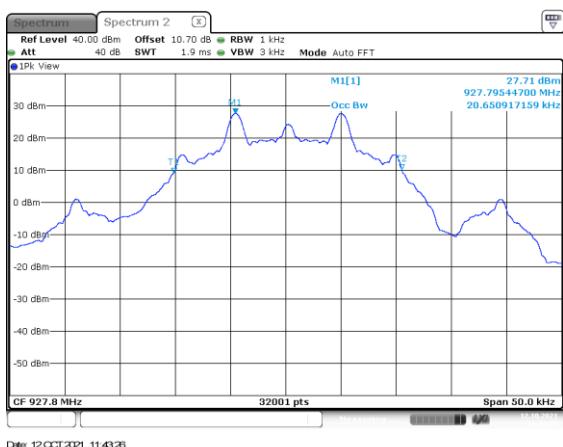
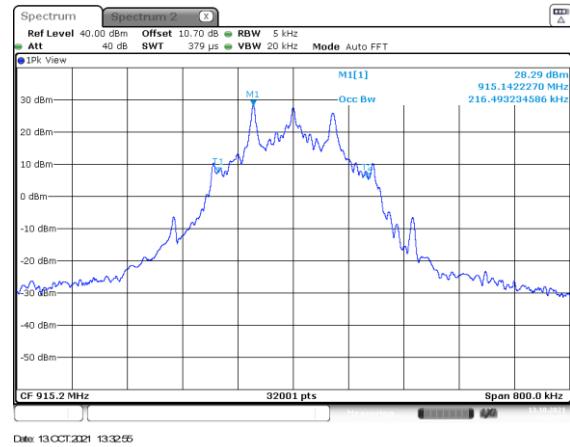
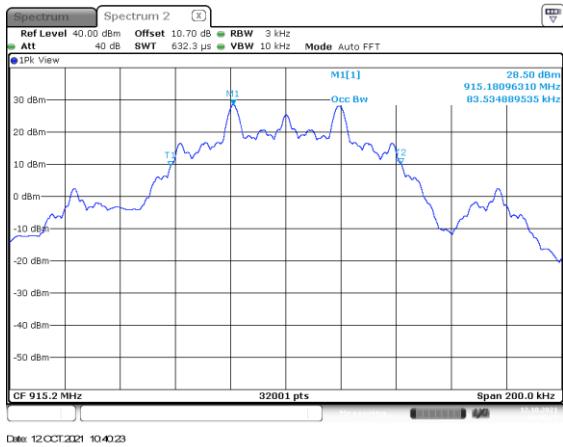
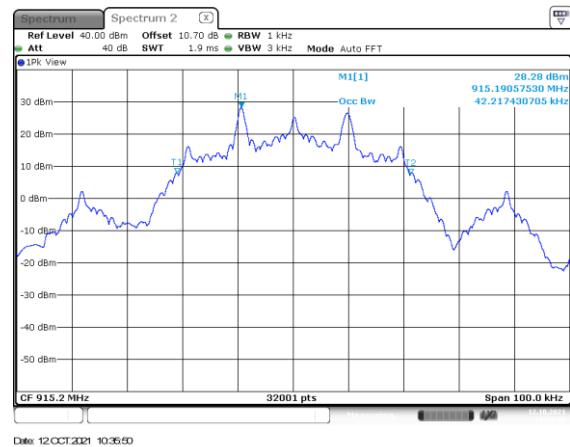
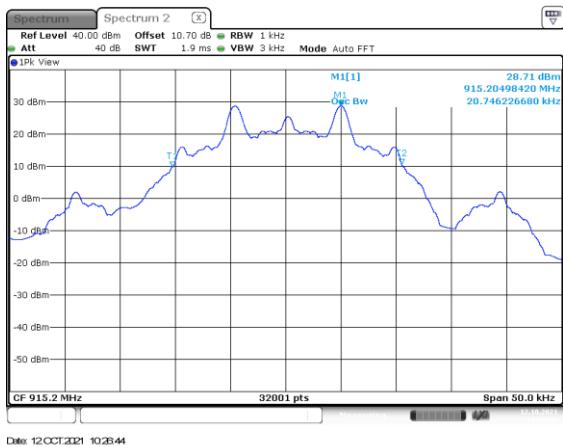
Date: 12.OCT.2021 15:36:18

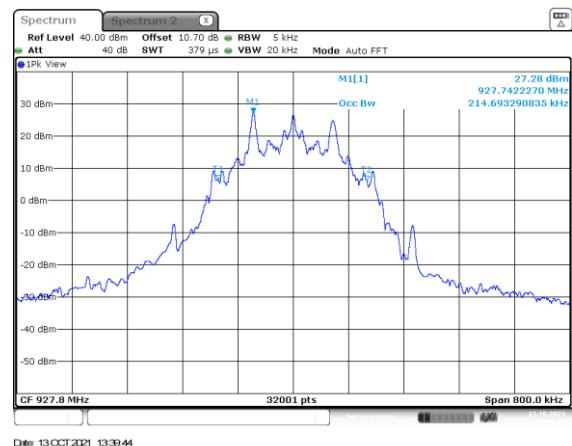
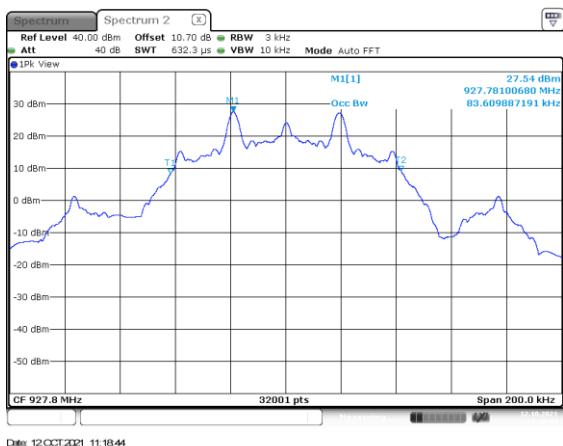
Figure 2.7.6-15: Mode 1 – 99% BW – LCH – 38.4 kbps



Date: 13.OCT.2021 12:36:34

Figure 2.7.6-16: Mode 1 – 99% BW – LCH – 115.2





2.8 Band-Edge Compliance of RF Conducted Emissions

2.8.1 Specification Reference

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

2.8.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.8.3 Date of Test

10/12/2021

2.8.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with 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 100kHz and the VBW was set to 300kHz.

If the maximum peak conducted output power procedure was used to determine compliance, then the peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc)

2.8.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.8.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

HOPPING MODE:

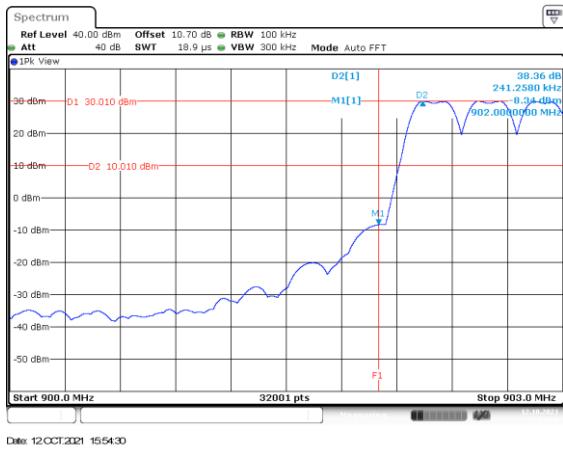


Figure 2.8.6-1: Lower Band edge – Mode 1 – 115.2 kbps

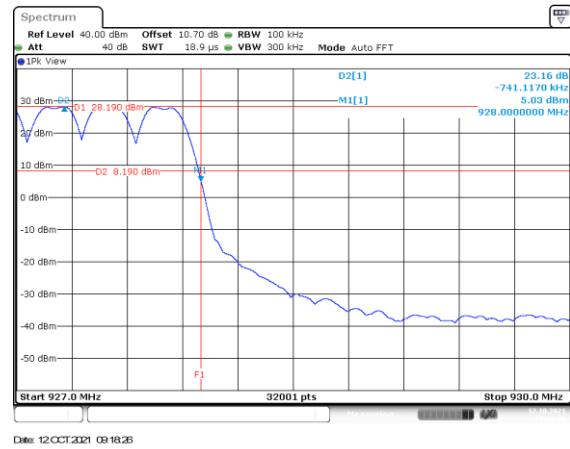


Figure 2.8.6-2: Higher Band edge – Mode 1 – 115.2 kbps

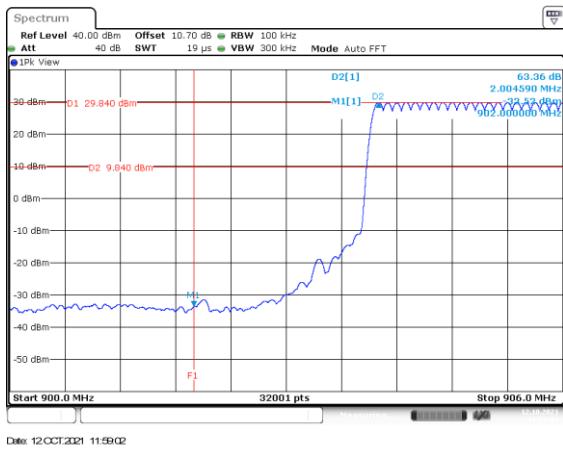


Figure 2.8.6-3: Lower Band edge – Mode 2 – 38.4 kbps

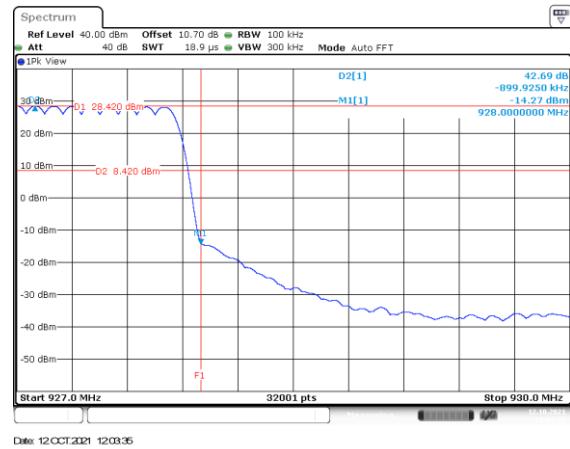


Figure 2.8.6-4: Higher Band edge – Mode 2 – 38.4 kbps

NON-HOPPING MODE:

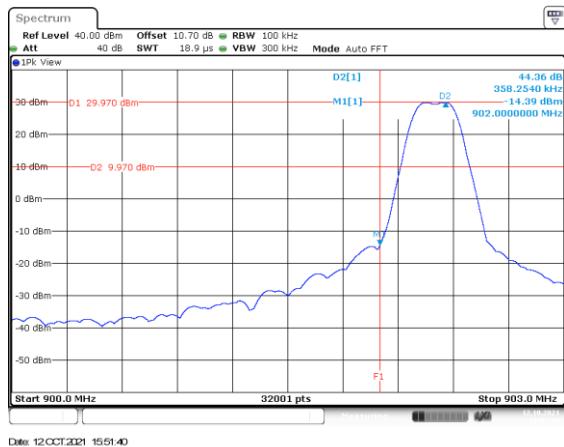


Figure 2.8.6-1: Lower Band edge – Mode 1 – 115.2 kbps

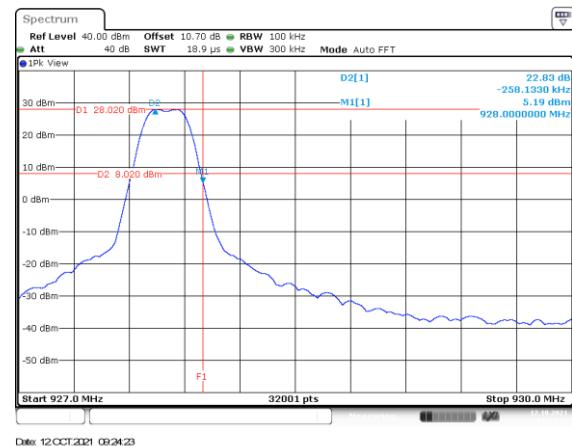


Figure 2.8.6-2: Higher Band edge – Mode 1 – 115.2 kbps

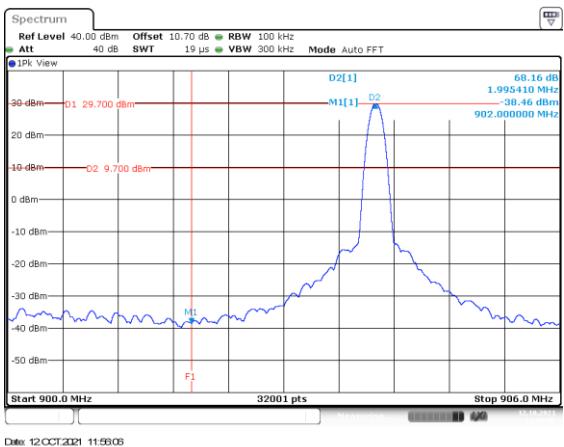


Figure 2.8.6-3: Lower Band edge – Mode 2 – 38.4 kbps

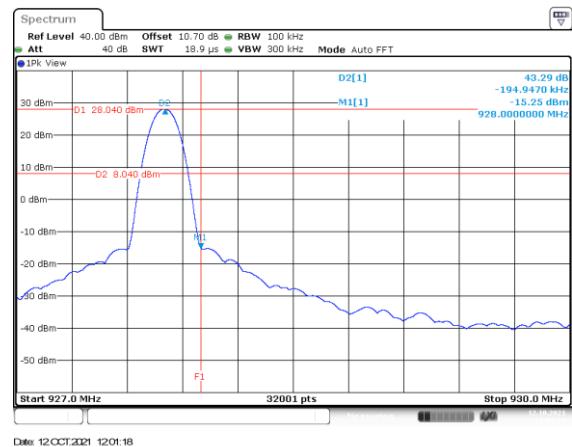


Figure 2.8.6-4: Higher Band edge – Mode 2 – 38.4 kbps

2.9 RF Conducted Spurious Emissions

2.9.1 Specification Reference

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

2.9.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.9.3 Date of Test

10/12/2021

2.9.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The EUT was investigated for conducted spurious emissions from 30MHz to 10 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 100kHz. A peak detector function was used with the trace set to max hold.

If the maximum peak conducted output power procedure was used to determine compliance, then the peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc).

2.9.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.9.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

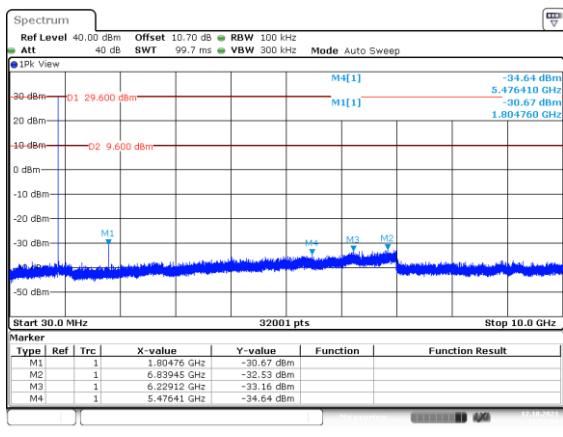


Figure 2.9.6-1: Mode 1 - 30MHz - 10GHz - LCH - 9.6 kbps

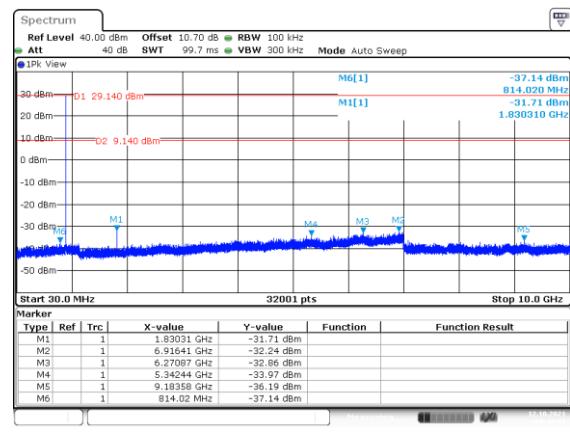


Figure 2.9.6-2: Mode 1 - 30MHz - 10GHz - MCH - 9.6 kbps

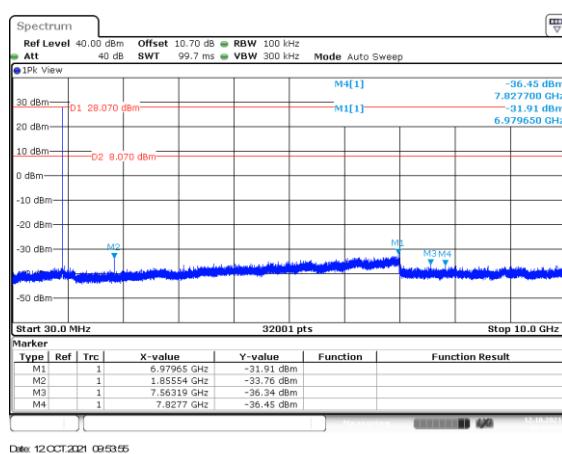


Figure 2.9.6-3: Mode 1 - 30MHz - 10GHz - HCH - 9.6 kbps

2.10 Radiated Spurious Emissions into Restricted Frequency Bands

2.10.1 Specification Reference

FCC Sections: 15.205, 15.209.
ISED Canada RSS – Gen 8.9/8.10

2.10.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.10.3 Date of Test

10/13/2021 to 10/15/2021

2.10.4 Test Method

Radiated emissions tests were made over the frequency range of 9 kHz to 10 GHz, 10 times the highest fundamental frequency of 900 MHz. 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 150 kHz, quasi-peak measurements were made using a resolution bandwidth RBW of 300 Hz and a video bandwidth VBW of 1 kHz and frequencies below 30MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 10 kHz and a video bandwidth VBW of 30 kHz. For frequencies below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 100 kHz and a video bandwidth VBW of 300 kHz. 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 and average measurements are made with RBW of 1 MHz and VBW of 3 MHz.

2.10.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

| | |
|----------------------|------------|
| Ambient Temperature | 22.3 °C |
| Relative Humidity | 53.8 % |
| Atmospheric Pressure | 972.2 mbar |

2.10.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.10.6-1: Radiated Spurious Emissions Tabulated Data – Mode 1

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity (H/V) | Correction Factors (dB) | Corrected Level (dBuV/m) | | Limit (dBuV/m) | | Margin (dB) | |
|-----------------|--------------|---------|------------------------|-------------------------|--------------------------|---------|----------------|---------|-------------|---------|
| | pk | Qpk/Avg | | | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| LCH | | | | | | | | | | |
| 1059.3 | 48.10 | 36.20 | H | -3.36 | 44.74 | 32.84 | 74.0 | 54.0 | 29.3 | 21.2 |
| 1059.3 | 46.20 | 33.30 | V | -3.36 | 42.84 | 29.94 | 74.0 | 54.0 | 31.2 | 24.1 |
| 2709.4 | 42.30 | 28.00 | H | 5.56 | 47.86 | 33.56 | 74.0 | 54.0 | 26.1 | 20.4 |
| 2709.4 | 42.40 | 28.00 | V | 5.56 | 47.96 | 33.56 | 74.0 | 54.0 | 26.0 | 20.4 |
| 4511.5 | 45.70 | 38.40 | H | 8.97 | 54.67 | 47.37 | 74.0 | 54.0 | 19.3 | 6.6 |
| 4511.5 | 48.00 | 42.70 | V | 8.97 | 56.97 | 51.67 | 74.0 | 54.0 | 17.0 | 2.3 |
| MCH | | | | | | | | | | |
| 1055.8 | 47.90 | 30.80 | H | -3.38 | 44.52 | 27.42 | 74.0 | 54.0 | 29.5 | 26.6 |
| 1055.8 | 45.40 | 30.00 | V | -3.38 | 42.02 | 26.62 | 74.0 | 54.0 | 32.0 | 27.4 |
| 2745.6 | 41.50 | 27.90 | H | 5.65 | 47.15 | 33.55 | 74.0 | 54.0 | 26.9 | 20.5 |
| 2745.6 | 43.20 | 28.30 | V | 5.65 | 48.85 | 33.95 | 74.0 | 54.0 | 25.2 | 20.1 |
| 4576.0 | 46.40 | 39.50 | H | 9.09 | 55.49 | 48.59 | 74.0 | 54.0 | 18.5 | 5.4 |
| 4576.0 | 46.30 | 40.40 | V | 9.09 | 55.39 | 49.49 | 74.0 | 54.0 | 18.6 | 4.5 |
| HCH | | | | | | | | | | |
| 1077.8 | 48.50 | 36.50 | H | -3.24 | 45.26 | 33.26 | 74.0 | 54.0 | 28.7 | 20.7 |
| 1077.8 | 47.20 | 34.20 | V | -3.24 | 43.96 | 30.96 | 74.0 | 54.0 | 30.0 | 23.0 |
| 2783.4 | 43.00 | 31.40 | H | 5.74 | 48.74 | 37.14 | 74.0 | 54.0 | 25.3 | 16.9 |
| 2783.4 | 44.40 | 31.90 | V | 5.74 | 50.14 | 37.64 | 74.0 | 54.0 | 23.9 | 16.4 |
| 4639.0 | 45.10 | 36.60 | H | 9.20 | 54.30 | 45.80 | 74.0 | 54.0 | 19.7 | 8.2 |
| 4639.0 | 47.60 | 41.80 | V | 9.20 | 56.80 | 51.00 | 74.0 | 54.0 | 17.2 | 3.0 |

Sample Calculation:

$$R_C = R_U + CF_T$$

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: $48.50 + -3.24 = 45.26$ dBuV/m

Margin: 74 dBuV/m – 45.26 dBuV/m = 28.7 dB

Example Calculation: Average

Corrected Level: $36.60 + 9.20 = 45.80$ dBuV/m

Margin: 54 dBuV/m – 45.80 dBuV/m = 8.2 dB

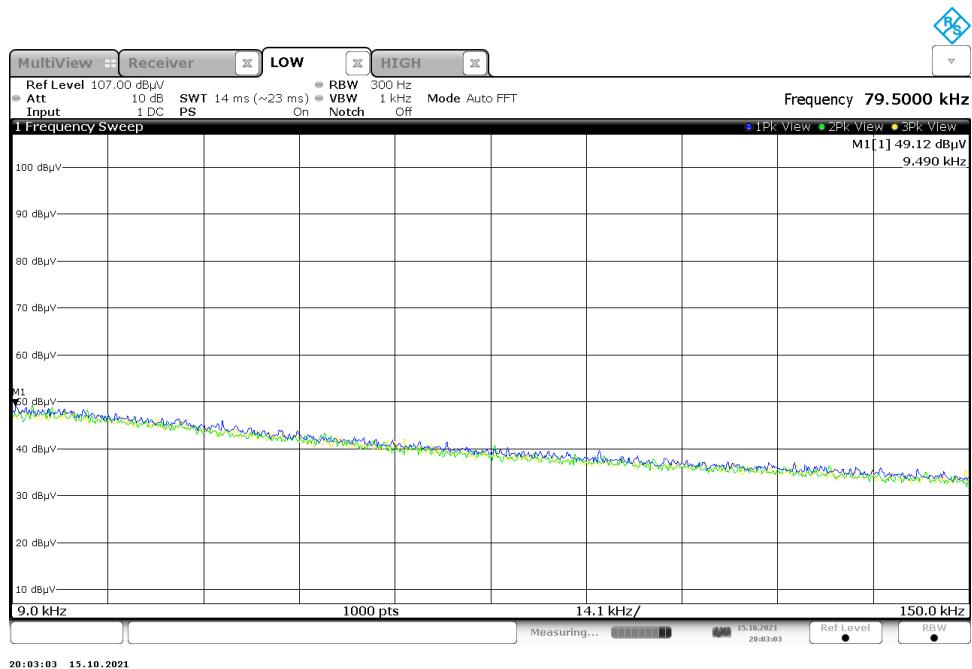


Figure 1: Reference plot for Radiated Spurious Emissions – 9 kHz – 150 kHz

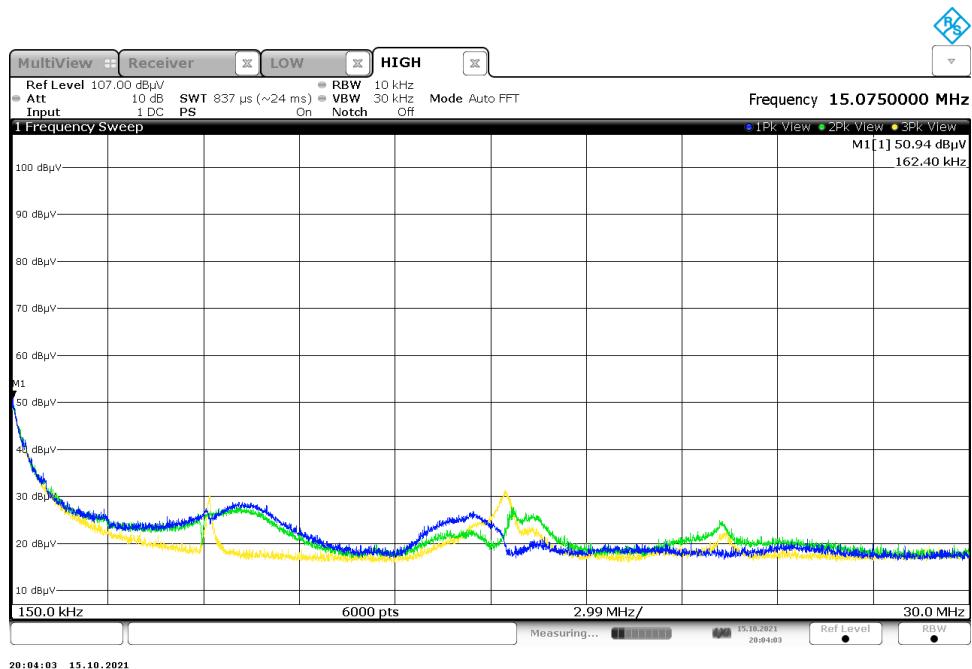


Figure 2: Reference plot for Radiated Spurious Emissions- 150 kHz – 30 kHz

Note: Emissions above the noise floor are ambient not associated with the EUT.

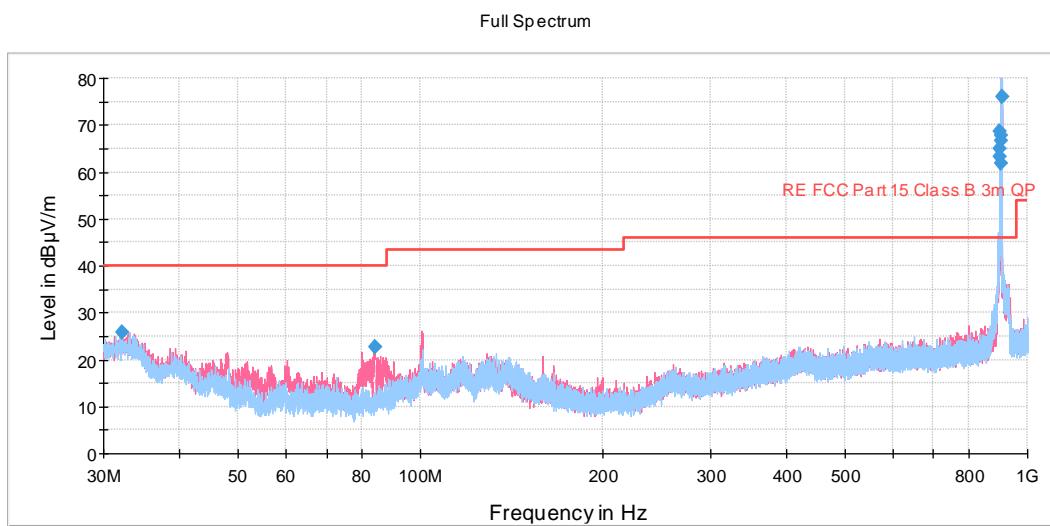


Figure 3: Reference plot for Radiated Spurious Emissions – 30 MHz – 1 GHz

Note: Emissions above the noise floor do not falls within restricted bands.

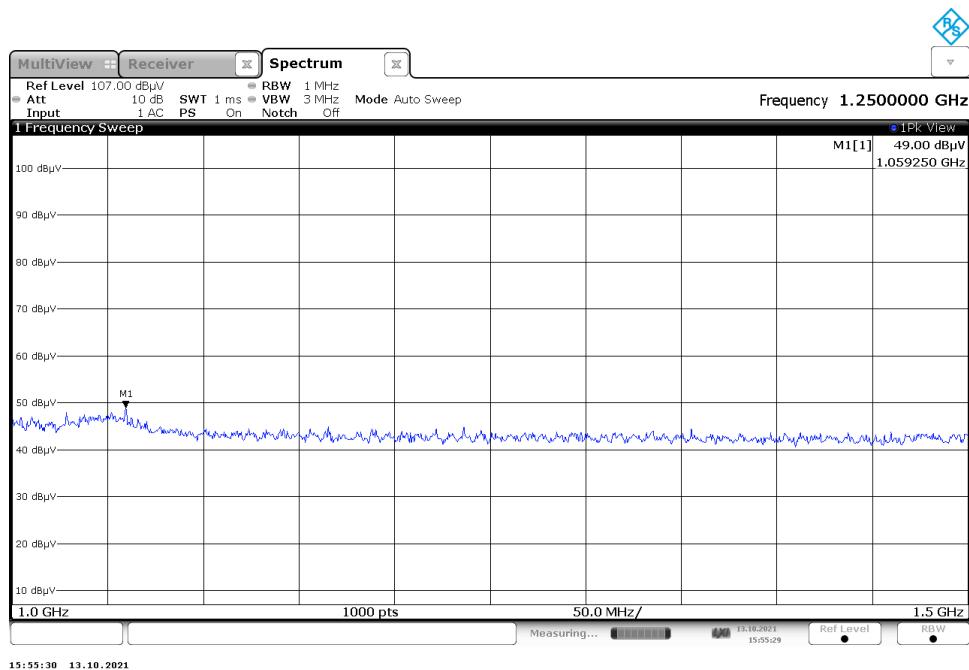


Figure 4: Reference plot for Radiated Spurious Emissions – 1 GHz – 1.5 GHz

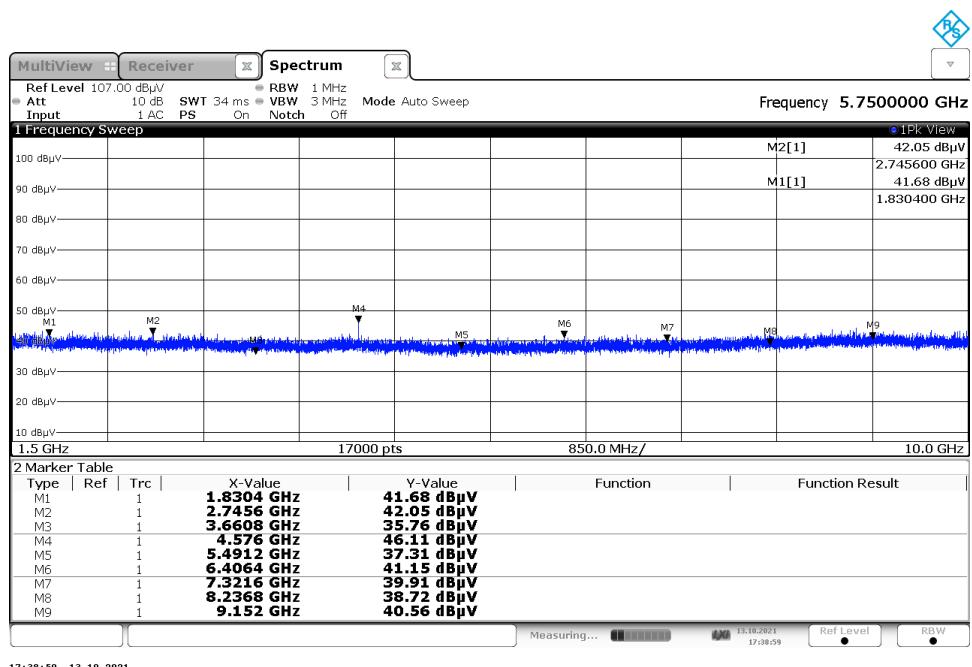


Figure 5: Reference plot for Radiated Spurious Emissions – 1.5 GHz – 10 GHz

2.11 Test Equipment Used

Table 2.111-1 –Equipment List

| Asset ID | Manufacturer | Model | Equipment Type | Serial Number | Last Calibration Date | Calibration Due Date |
|----------|-------------------------|----------------|--|---------------|-----------------------|----------------------|
| 628 | EMCO | 6502 | Active Loop Antenna 10kHz-30MHz | 9407-2877 | 6/8/2021 | 6/8/2023 |
| 857 | ETS Lindgren | 3117 | Horn Antenna 1-18GHz | 00153608 | 11/12/2019 | 11/12/2021 |
| DEMC3161 | Ametek CTS Germany GmbH | CBL 6112D | Bilog Antenna; Attenuator | 51323 | 3/19/2021 | 3/19/2022 |
| 213 | TEC | PA 102 | Amplifier | 44927 | 7/30/2021 | 7/30/2022 |
| 22 | Hewlett Packard | 8449B | High Frequency Pre-Amp | 3008A00526 | 11/19/2020 | 11/19/2021 |
| 331 | Microwave Circuits | H1G513G1 | Microwave Bandpass Filter | 31417 | 6/9/2021 | 6/9/2022 |
| 827 | (-) | 997 Rack Cable | TS8997 Rack Cable Set | N/A | 9/4/2020 | 12/4/2021 |
| 267 | Hewlett Packard | N1911A | Power Meter | MY45100129 | 7/27/2021 | 7/27/2023 |
| 882 | Rohde & Schwarz | ESW44 | Test Receiver | 111961 | 6/24/2021 | 6/24/2022 |
| 836 | ETS Lindgren | SAC Cable Set | SAC Cable Set includes 620, 837, 838 | N/A | 5/11/2021 | 5/11/2022 |
| 3010 | Rohde & Schwarz | ENV216 | Two-Line V-Network | 3010 | 6/23/2021 | 6/23/2022 |
| 872 | Agilent | E7402A | EMC Spectrum Analyzer | US40240258 | 6/22/2021 | 6/22/2022 |
| 861 | Com-Power Corporation | LI-1100C | Line Impedance Stabilization Network | 20180038 | 2/26/2021 | 2/26/2022 |
| 862 | Com-Power Corporation | LI01100C | Line Impedance Stabilization Network | 20180039 | 2/26/2021 | 2/26/2022 |
| 703 | Hewlett Packard | 8594E | Spectrum Analyzer | 3523A02134 | NCR | NCR |
| 856 | Huber & Suhner | Multiflex 104 | Blue Cable | 326050 | NCR | NCR |
| 691 | Com-Power Corp. | 691 | E-Field Fine Tip (100kHz to 5GHz), H-Field Loop (9kHz to 5GHz) | 151514 | NCR | NCR |
| 494 | Omega | IBTHX-W | Environmental Sensor | 9460211 | 11/3/2020 | 11/3/2021 |
| 813 | PMM | 9010 | EMI Receiver; RF Input 50ohm; 10Hz-50MHz; 10Hz-30MHz | 697WW30606 | 6/8/2021 | 6/8/2022 |
| 168 | Hewlett Packard | 11947A | Transient Pulse Limiter | 44829 | 3/3/2021 | 3/3/2022 |

N/A – Not Applicable

NCR – No Calibration Required

3 Diagram of Test Set-ups

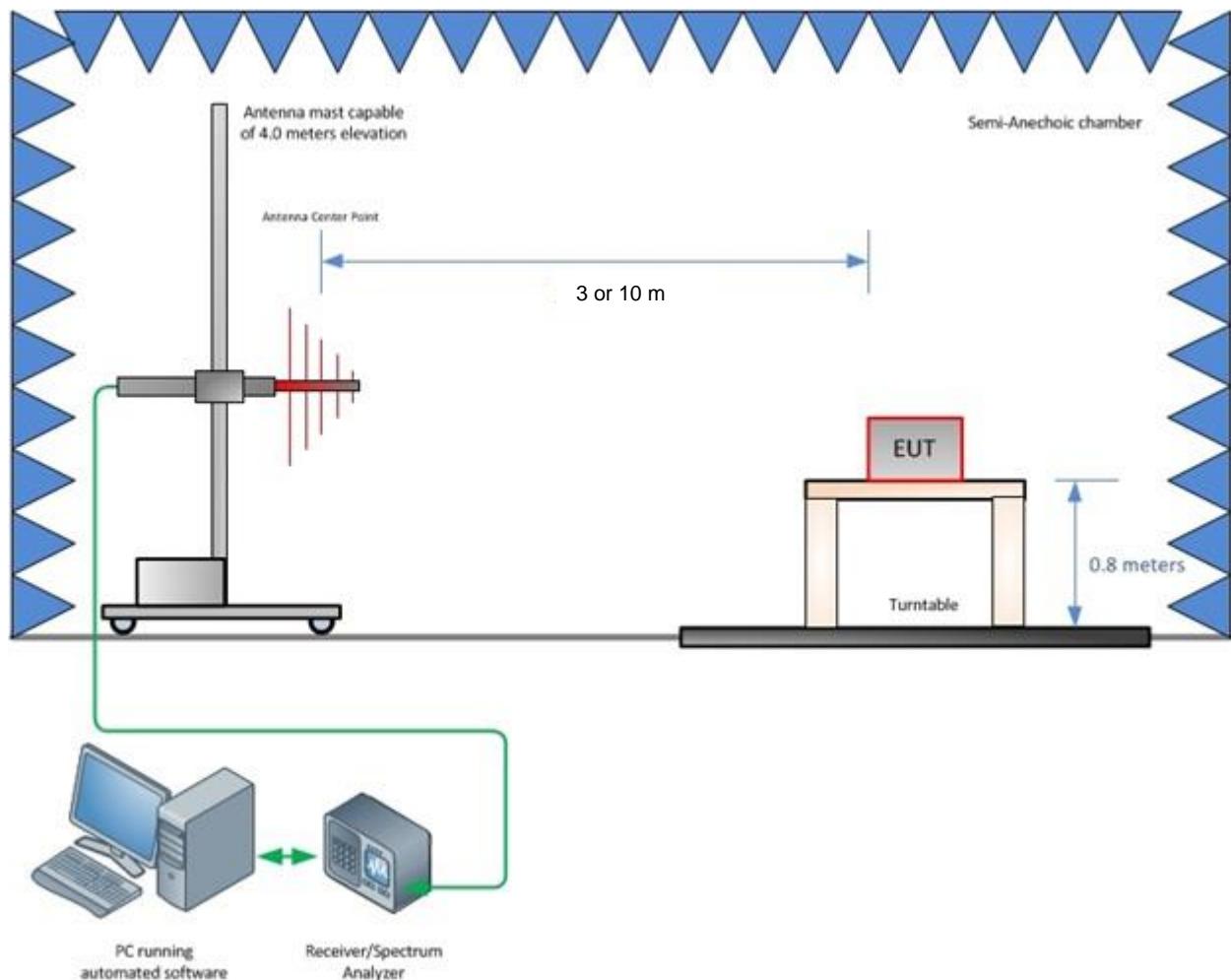


Figure 3-1 – Radiated Emissions Test Setup up to 1 GHz

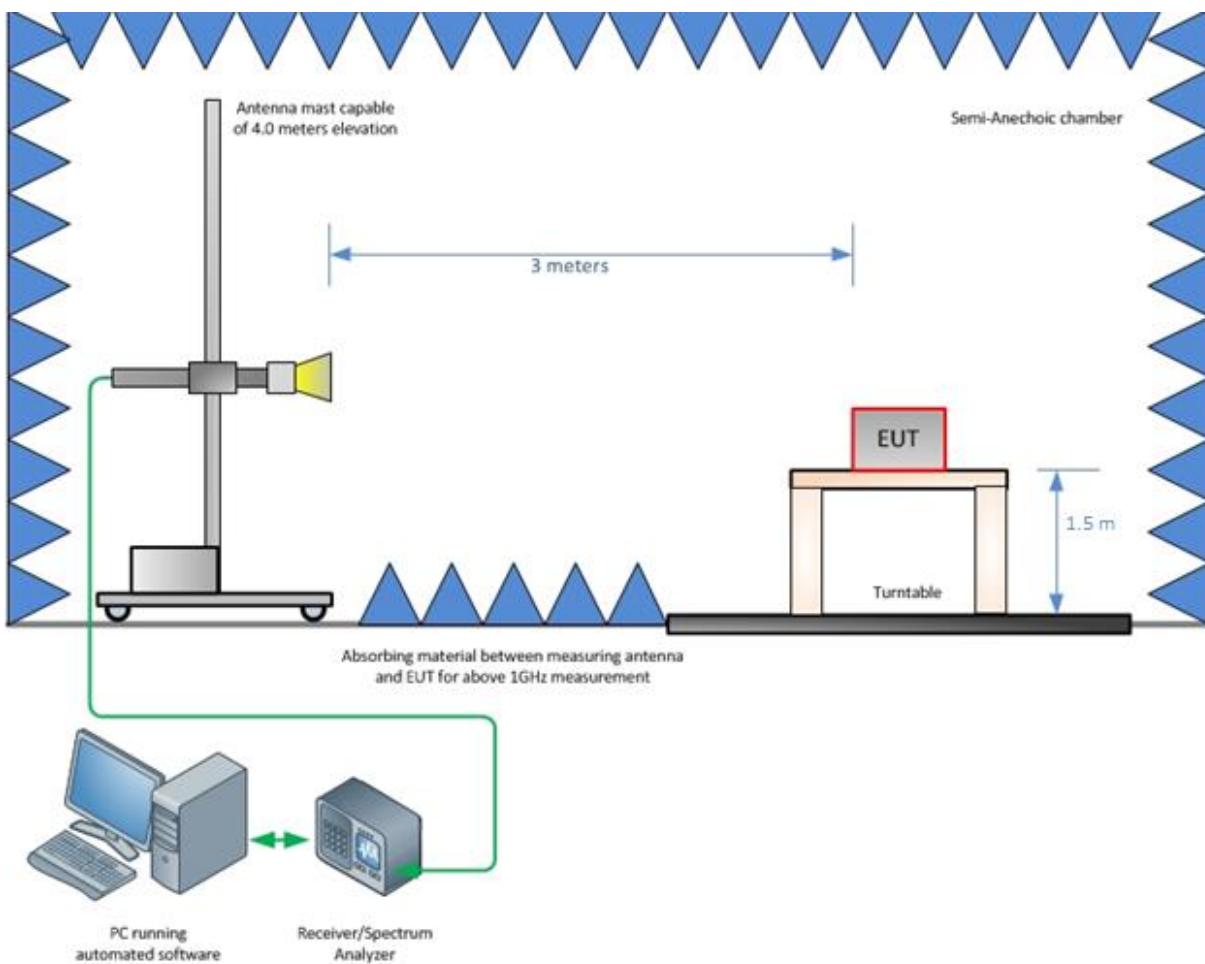


Figure 3-2 – Radiated Emissions Test Setup above 1 GHz

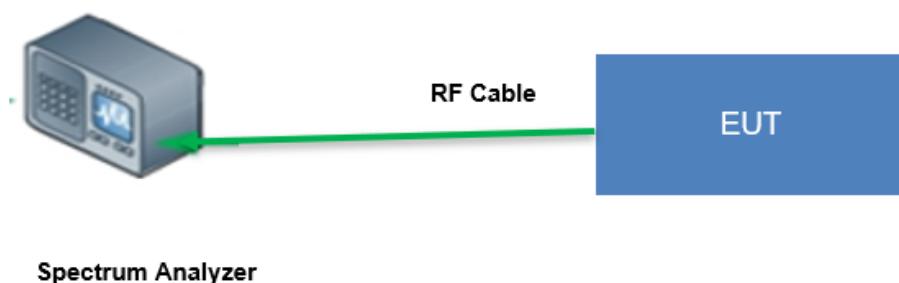


Figure 3-3 – Conducted Test Setup: Antenna Port measurement

4 Accreditation, Disclaimers and Copyright

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STATEMENT OF MEASUREMENT UNCERTAINTY

The expanded laboratory measurement uncertainty figures (U_{Lab}) provided below correspond to an expansion factor (coverage factor) $k = 1.96$ which provide confidence levels of 95%.

Table 4-1: Estimation of Measurement Uncertainty

| Parameter | U_{Lab} |
|---|--------------------------------------|
| Occupied Channel Bandwidth | $\pm 0.009 \%$ |
| RF Conducted Output Power | $\pm 0.349 \text{ dB}$ |
| Power Spectral Density | $\pm 0.372 \text{ dB}$ |
| Antenna Port Conducted Emissions | $\pm 1.264 \text{ dB}$ |
| Radiated Emissions $\leq 1 \text{ GHz}$ | $\pm 5.814 \text{ dB}$ |
| Radiated Emissions $> 1 \text{ GHz}$ | $\pm 4.318 \text{ dB}$ |
| Temperature | $\pm 0.860 \text{ }^{\circ}\text{C}$ |
| Radio Frequency | $\pm 2.832 \times 10^{-8}$ |
| AC Power Line Conducted Emissions | $\pm 3.360 \text{ dB}$ |

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications