

## Test Report

|                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Product                                                                                                                                   | Electronic Control Unit for vehicle Integration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |
| Name and address of the applicant                                                                                                         | CPAC Systems AB<br>Bergskroken 3<br>431 37 Mölndal, Sweden                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |
| Name and address of the manufacturer                                                                                                      | CPAC Systems AB<br>Bergskroken 3<br>431 37 Mölndal, Sweden                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |
| Model                                                                                                                                     | SID 2.0MLTE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |
| Rating                                                                                                                                    | 24VDC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |
| Trademark                                                                                                                                 | CPAC Systems AB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |
| Additional information                                                                                                                    | WiFi, Bluetooth                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |
| Tested according to                                                                                                                       | FCC Part 15.247<br>Frequency Hopping Transmitters / Digital Transmission Systems<br>ISED Canada RSS-247, Issue 2<br>Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |
| Order number                                                                                                                              | PRJ0043386                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |
| Tested in period                                                                                                                          | 2023-02-28 to 2023-05-04                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |  |
| Issue date                                                                                                                                | 2023-11-15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |
| Name and address of the testing laboratory                                                                                                | <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;"> <br/> Nemko Scandinavia AS<br/> Instituttveien 6<br/> 2007 Kjeller, Norway<br/> www.nemko.com </div> <div style="text-align: center;"> CAB Number:<br/> FCC: NO0001<br/> ISED: NO0470<br/> ISED No: 2040D-1 </div> <div style="text-align: center;"> <br/>  </div> </div> <p style="text-align: center; color: red; font-weight: bold;">An accredited technical test executed under the Norwegian accreditation scheme</p> |  |  |
|                                                                                                                                           | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <br/> Prepared by [Frode Sveinsen] </div> <div style="text-align: center;"> <br/> Approved by [ ] </div> </div>                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |
| This report was originally distributed electronically with digital signatures. For more information, please contact Nemko Scandinavia AS. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |

## Revision history

| Revision | Date       | Comment       | Sign |
|----------|------------|---------------|------|
| A        | 2023-11-15 | First edition | FS   |
|          |            |               |      |

## GENERAL REMARKS

This report applies only to the sample(s) tested. It is the manufacturer's responsibility to ensure the additional production units of this product are manufactured with identical electrical and mechanical components. The manufacturer is solely responsible for any modifications to the product that could result in non-compliance with the relevant regulations.

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Opinions expressed within this report regarding general assessments and qualifications for PASS or FAIL to the standards limits and requirements, are not part of the current accreditation. Neither are opinions expressed regarding model variants covered by the testing of this report.

## CALIBRATION

All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Between calibrations all test set-ups are controlled and verified on a regular basis by periodic checks to ensure, with 95% confidence, that the instruments remain within the calibrated levels.

## MEASUREMENT UNCERTAINTY

Measurement uncertainties are calculated or considered for all instruments and instrument set-ups used during these tests. Uncertainty figures are found in a separate clause in this report.

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# 1 INFORMATION

## 1.1 Test Item

|                                  |                                                                                       |
|----------------------------------|---------------------------------------------------------------------------------------|
| Name                             | CPAC Systems AB                                                                       |
| Model/version                    | SID 2.0MLTE                                                                           |
| FCC ID                           | AHV-SID2MLTE                                                                          |
| ISED ID                          | 10111A-SID2MLTE                                                                       |
| Serial number                    | HYD-3891                                                                              |
| Hardware identity and/or version | P-01                                                                                  |
| Software identity and/or version | Hydra_BT SW_1.0                                                                       |
| Frequency Range                  | 2402–2480 MHz                                                                         |
| Number of Channels               | 79                                                                                    |
| Operating Modes                  | Bluetooth Basic Rate, Bluetooth 2-EDR and Bluetooth 3-EDR                             |
| Type of Modulation               | BT Basic Rate: GFSK<br>BT 2-EDR: $\pi/4$ -DPSK<br>BT 3-EDR: 8-DPSK                    |
| Conducted Output Power           | BT Basic Rate: 1.03 mW (Peak)<br>BT 2-EDR: 0.83 mW (Peak)<br>BT 3-EDR: 1.98 mW (Peak) |
| Antenna Connector                | FAKRA                                                                                 |
| Number of Antennas               | 1                                                                                     |
| Diversity or Smart Antennas      | No                                                                                    |
| Power Supply                     | External Power Supply, 12-24 V <sub>DC</sub>                                          |

## Description of Test Item

The EUT is an electronic control unit for vehicle integration. The EUT contains WiFi, Bluetooth, and LTE modules.

| Model Overview |                                     |                                     |                                     |              |                 |                          |
|----------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------|-----------------|--------------------------|
| Model Name     | U-NII                               | Marine                              | LTE                                 | FCC ID       | IC ID           | Description              |
| SID 2.0        | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | AHV-SID2     | 10111A-SID2     | Model without 5GHz WiFi  |
| SID 2.0        | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | AHV-SID2B    | 10111A-SID2B    | Model with 5GHz WiFi     |
| SID 2.0M       | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | AHV-SID2M    | 10111A-SID2M    | Marine Model without LTE |
| SID 2.0MLTE    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | AHV-SID2MLTE | 10111A-SID2MLTE | Marine Model with LTE    |

All models are electrically identical, except SID 2.0M does not have the LTE module installed.

## 1.2 Antenna Types

| Name                                                  | P/N             | Function       | Number of inputs | Description |
|-------------------------------------------------------|-----------------|----------------|------------------|-------------|
| 2J 2× 4G/3G/2G MIMO,<br>+2× 2.4/5.0 GHz MIMO and GNSS | 2J #2J4A50PCFa  | 2.4GHz Wifi+BT | 2                | COMBI ANT   |
|                                                       |                 | 2G+3G+4G       | 2                |             |
| TE ANTENNA BASE FULL FEAT                             | Volvo #23311779 | 2.4GHz Wifi+BT | 1                | WHIP ANT    |
|                                                       |                 | 2G+3G+4G       | 1                |             |
| TE ANTENNA INTERIOR WLAN                              | Volvo #23311706 | 2.4GHz Wifi+BT | 1                | PATCH ANT   |

## 1.3 Normal test condition

|                      |            |
|----------------------|------------|
| Temperature:         | 20 - 24 °C |
| Relative humidity:   | 20 - 50 %  |
| Normal test voltage: | 24 V DC    |

The values are the limit registered during the test period.

The EUT was powered from a regulated power supply during all tests.

## 1.4 Test Engineer

Frode Sveinsen

## 1.5 Antenna Requirement

|                                                          |                                         |                             |
|----------------------------------------------------------|-----------------------------------------|-----------------------------|
| Does the EUT have detachable antenna(s)?                 | <input checked="" type="checkbox"/> YES | <input type="checkbox"/> NO |
| If detachable, is the antenna connector(s) non-standard? | <input checked="" type="checkbox"/> YES | <input type="checkbox"/> NO |
| The tested equipment has FAKRA antenna connectors.       |                                         |                             |

Requirement: FCC 15.203, 15.204

## 1.6 EUT Operating Modes

|                        |                                                                                                       |
|------------------------|-------------------------------------------------------------------------------------------------------|
| Operating modes        | Continuous TX and Hopping, Basic Rate, 2-EDR and 3-EDR                                                |
| Additional information | The following settings were used for all tests:<br>Bit Pattern: PSRB<br>Frame Type: DH1, 2-DH1, 3-DH1 |

## 1.7 Comments

The EUT uses the Bluetooth protocol as a Frequency Hopping Spread Spectrum Device.

All ports were populated during spurious emission measurements.

Test Voltages between 85% and 115% of the nominal voltage were checked and did not influence the output power.

## 2 TEST REPORT SUMMARY

### 2.1 General

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and ISED Canada RSS-247 Issue 3 and RSS-GEN Issue 5.

Tests were performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

Radiated tests were made in a semi-anechoic chamber at measuring distance 3m.

A description of the test facility is on file with FCC and ISED.

|                                                     |                                                     |
|-----------------------------------------------------|-----------------------------------------------------|
| <input checked="" type="checkbox"/> New Submission  | <input checked="" type="checkbox"/> Production Unit |
| <input type="checkbox"/> Class II Permissive Change | <input type="checkbox"/> Pre-production Unit        |
| DSS      Equipment Code                             | <input type="checkbox"/> Family Listing             |

### 2.2 Test Summary

| Name of test                           | FCC Part 15 reference               | RSS-247 Issue 3, RSS-GEN Issue 5 reference      | ANSI C63.10-2013 Reference          | Result   |
|----------------------------------------|-------------------------------------|-------------------------------------------------|-------------------------------------|----------|
| Supply Voltage Variations              | 15.31(e)                            | 6.11 (RSS-GEN)                                  | 5.13                                | Complies |
| Antenna Requirement                    | 15.203                              | 6.8 (RSS-GEN)                                   | 5.8                                 | Complies |
| Power Line Conducted Emission          | 15.107(a)<br>15.207(a)              | 7.2 / 8.8 (RSS-GEN)                             | 6.2                                 | N/A      |
| Channel Separation and 20 dB BW        | 15.247(a)(1)                        | 5.1 (4) (RSS-247)                               | 7.8.2 (FHSS)                        | Complies |
| Number of Hopping Frequencies          | 15.31(m)                            | 5.1 (6) (RSS-247)                               | 7.8.3 (FHSS)                        | Complies |
| Pseudorandom Hopping Algorithm         | 15.247(a)(1)                        | 5.1 (3) (RSS-247)                               | N/A (FHSS)                          | Complies |
| Time of Occupancy (dwell time)         | 15.247(a)(1)(iii)                   | 5.1 (5) (RSS-247)                               | 7.8.4 (FHSS)                        | Complies |
| Occupied Bandwidth                     | 15.247(a)(1)                        | 5.1 (7) (RSS-247)                               | 6.9.2 FHSS)                         | Complies |
| Occupied Bandwidth (99% BW)            | N/A                                 | 6.7 (RSS-GEN)                                   | 6.9.3                               | Complies |
| Peak Power Output                      | 15.247(b)                           | 5.4 (RSS-247)                                   | 11.9.1.1                            | Complies |
| Spurious Emissions (Antenna Conducted) | 15.247(c)                           | 5.5 (RSS-247)                                   | 6.7<br>7.8.6 (FHSS)<br>7.8.8 (FHSS) | Complies |
| Spurious Emissions (Radiated)          | 15.247(c)<br>15.109(a)<br>15.209(a) | 3.3 (RSS-247)<br>7.3 (RSS-GEN)<br>8.9 (RSS-GEN) | 6.3, 6.5, 6.6, 6.10<br>11.12        | Complies |

### 3 TEST RESULTS

#### 3.1 20dB Bandwidth

FCC Part 15.247(a)(1)

ISED RSS-247 Issue 3, Clause 5.1 (b)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.2

Test Results: Complies

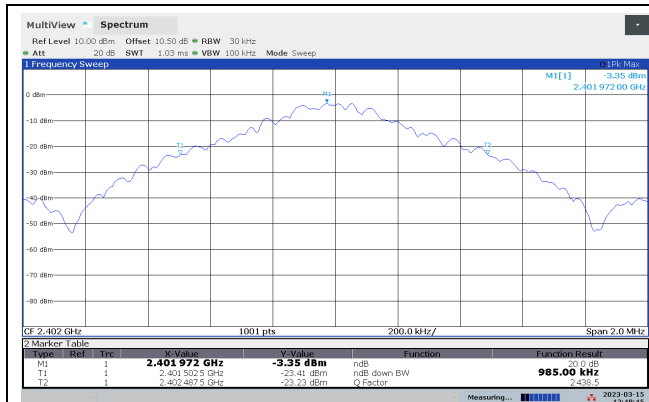
Measurement Data:

| Modulation             | 20dB Bandwidth |           |           |
|------------------------|----------------|-----------|-----------|
|                        | 2402 MHz       | 2441 MHz  | 2480 MHz  |
| Basic Rate (GFSK)      | 0.985 MHz      | 0.987 MHz | 0.989 MHz |
| 2-EDR ( $\pi/4$ -DPSK) | 1.41 MHz       | 1.41 MHz  | 1.41 MHz  |
| 3-EDR (8-DPSK)         | 1.41 MHz       | 1.41 MHz  | 1.41 MHz  |

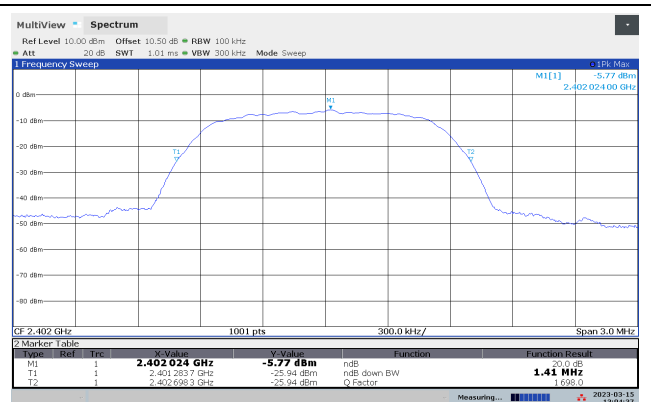
RF channel has no influence on 20 dB bandwidth.

See attached plots.

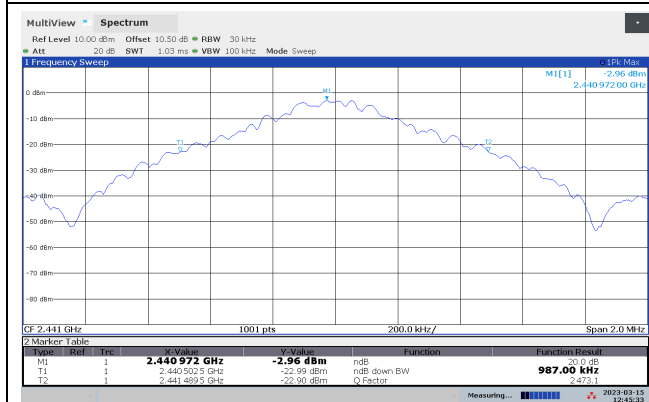
| Frequency Band  | Requirement for Frequency Hopping                                                                                                                           |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2400-2483.5 MHz | The maximum 20 dB bandwidth shall be less than channel separation, alternatively, less than 150% of channel separation if output power is less than 125 mW. |



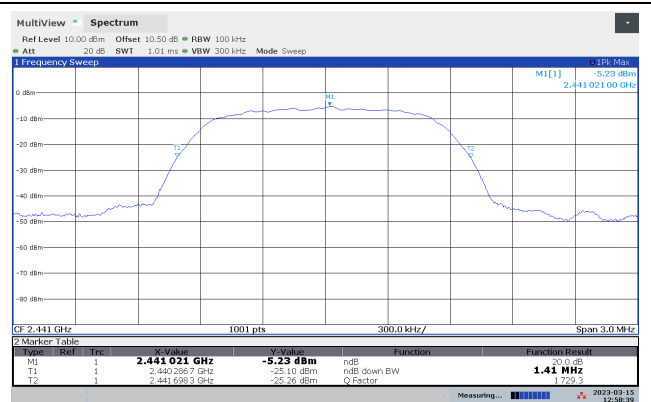
20dB Bandwidth 2402 MHz, GFSK



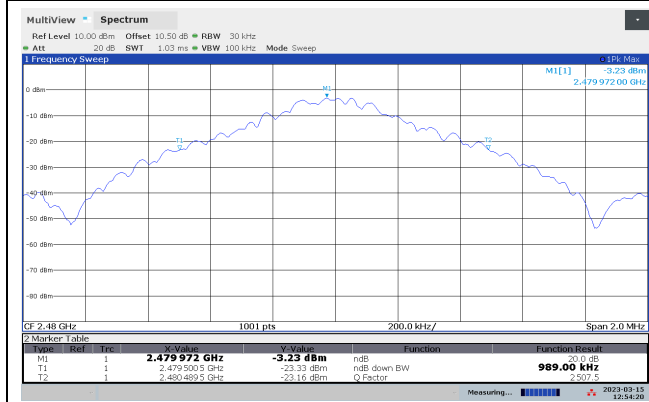
20dB Bandwidth 2402 MHz,  $\pi/4$ -DPSK



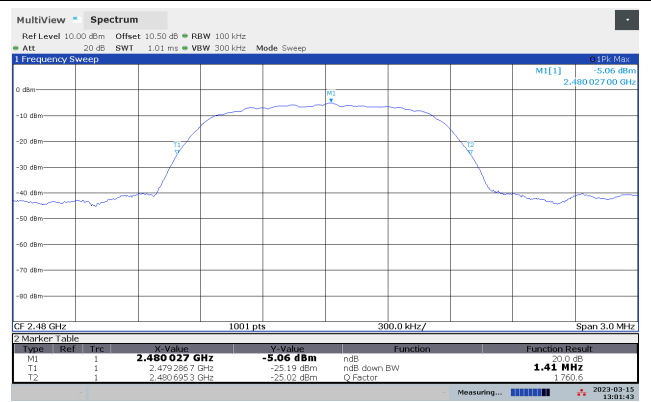
20dB Bandwidth 2441 MHz, GFSK



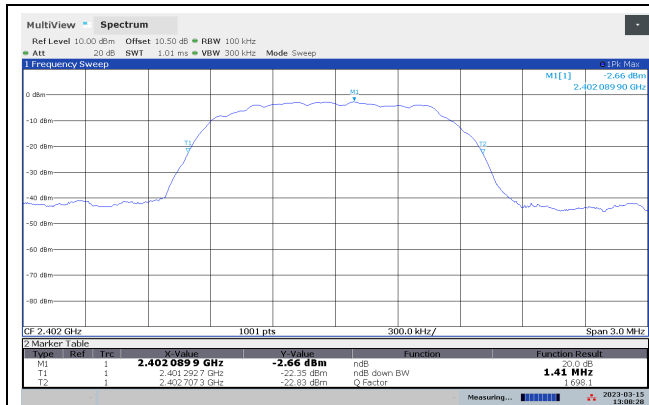
20dB Bandwidth 2441 MHz,  $\pi/4$ -DPSK



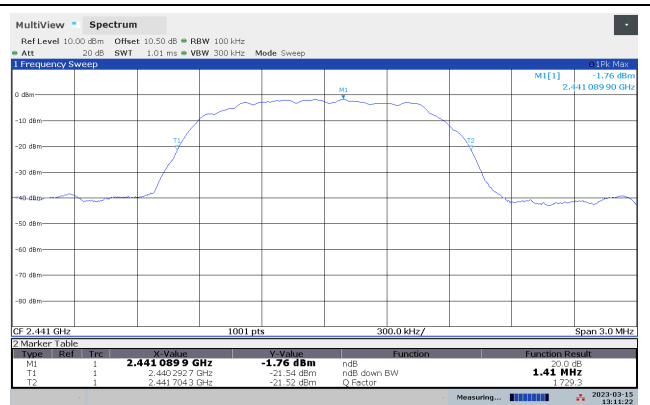
20dB Bandwidth 2480 MHz, GFSK



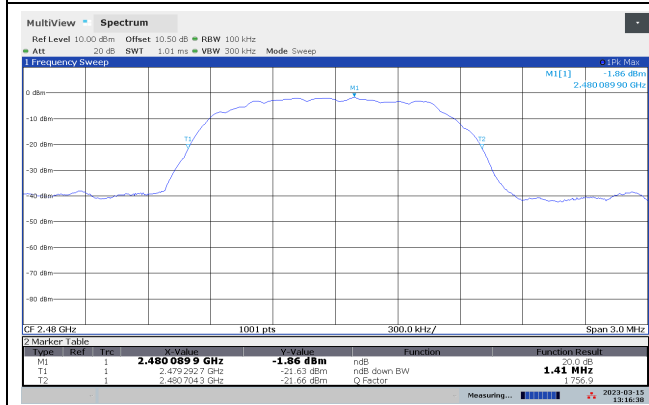
20dB Bandwidth 2480 MHz,  $\pi/4$ -DPSK



20dB Bandwidth 2402 MHz, 8-DPSK



20dB Bandwidth 2441 MHz, 8-DPSK



20dB Bandwidth 2480 MHz, 8-DPSK

## 3.2 Pseudorandom Hopping Algorithm

FCC Part 15.247 (a)(1)

ISED Canada RSS-247 Issue 3, Clause 5.1

Test Results: **Complies**

| Requirements                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies.<br>Each frequency must be used equally by the transmitter. |

### Base Table Hopping Sequence

The hopping sequence is according to the Bluetooth standard.

### 3.3 Hopping Bandwidth

FCC Part 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 3, Clause 5.1

Measurement procedure: ANSI C63.10-2013 Clause 6.9.2 / 7.8.3

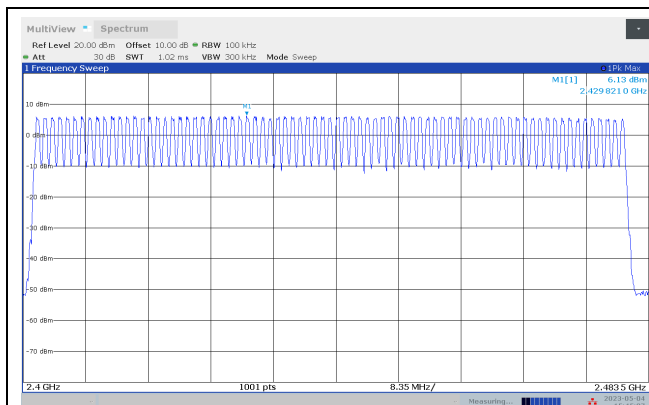
Test Results: Complies

#### Measurement Data:

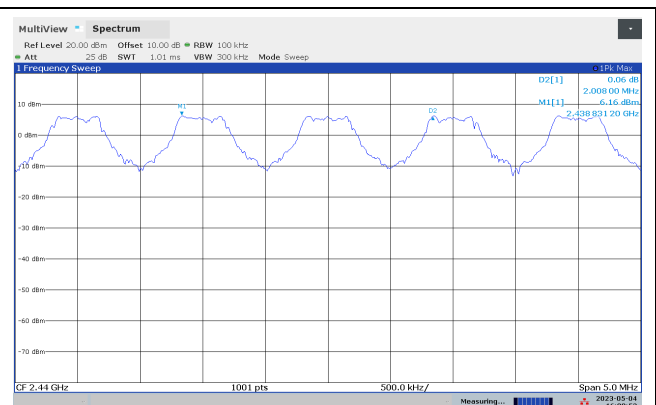
|                              |                  |
|------------------------------|------------------|
| Number of RF Channels in use | 20 to 79         |
| Channel Centre Frequencies   | 2402 to 2480 MHz |
| Channel Separation           | 1 MHz            |

See attached plots.

| Frequency Band  | Requirement for Frequency Hopping                                                                                                                                                                                                         |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2400-2483.5 MHz | Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.<br>Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used. |



RF Channels in Use, Basic Rate



Channel Separation, Basic Rate

### 3.4 Occupancy Time

FCC Part 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 3, Clause 5.1 (c)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.4

Test Results: Complies

#### Measurement Data:

| Frame Type and Data Rate | Burst Length (ms) | Frame Length (ms) | Time of Occupancy (ms) | Verdict  |
|--------------------------|-------------------|-------------------|------------------------|----------|
| DH1                      | 0.384             | 1.25              | 123                    | Complies |
| DH3                      | 1.64              | 3.75              | 175                    | Complies |
| DH5                      | 2.89              | 6.25              | 185                    | Complies |

Burst length is the same for all data rates.

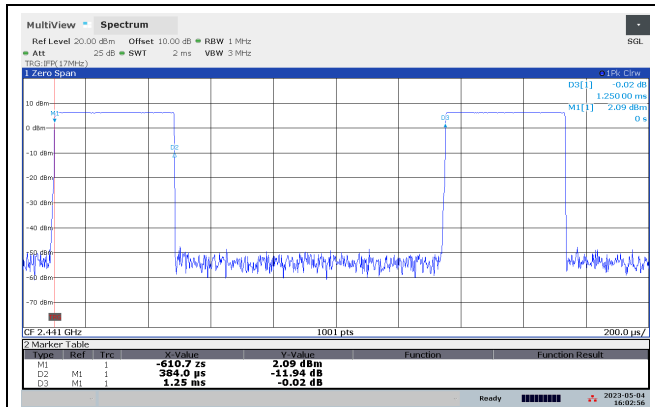
Time between RF burst on same channel = Frame Length \* Number of Channels

Time of occupancy = (Burst Length \* Number of Channels \* 400 ms) / Time Between Burst on Same Channel  
= (Burst Length \* 400 ms) / Frame Length

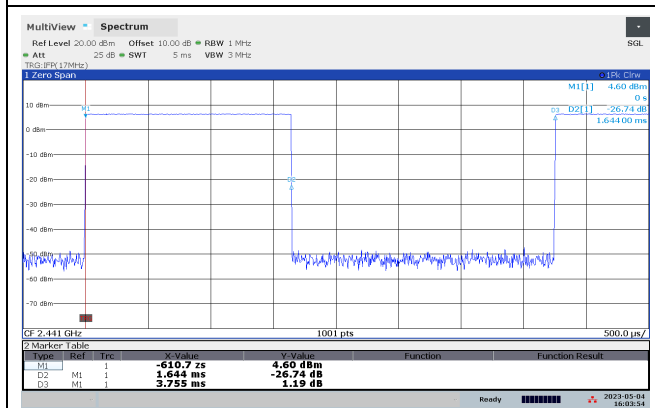
Number of RF channels is minimum 20 and maximum 78.

See attached plots.

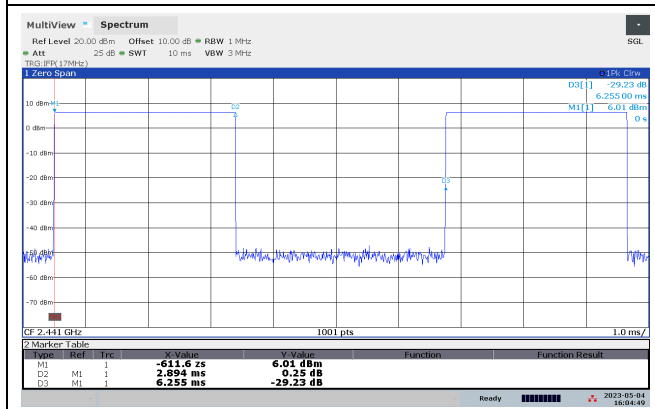
| Frequency Band  | Requirement for Frequency Hopping                                                                                                                                        |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2400-2483.5 MHz | The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. |



RF Burst, DH1



RF Burst, DH3



RF Burst DH5

### 3.5 Occupied Bandwidth (99% BW)

FCC Part 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 3, Clause 5.1

ISED Canada RSS-GEN Issue 5, Clause 6.7

Measurement procedure: ANSI C63.10-2013 Clause 6.9.3 / 7.8.3

Test Results: Complies

#### Measurement Data:

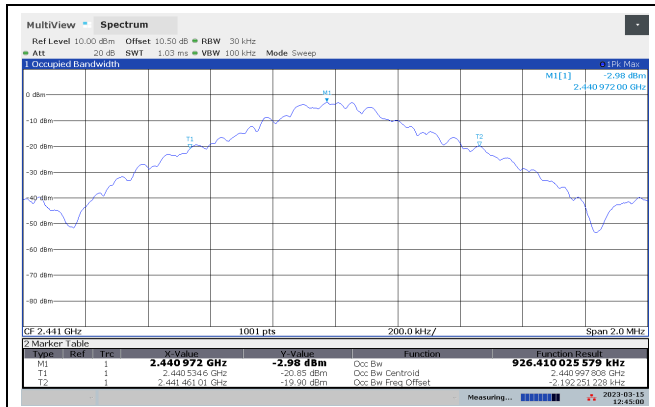
| Data Rate and Modulation | Occupied Bandwidth (99% BW) |
|--------------------------|-----------------------------|
| Basic Rate (GFSK)        | 0.926 MHz                   |
| 2-EDR ( $\pi/4$ -DPSK)   | 1.20 MHz                    |
| 3-EDR (8-DPSK)           | 1.20 MHz                    |

Occupied Bandwidth is the same for all channels.

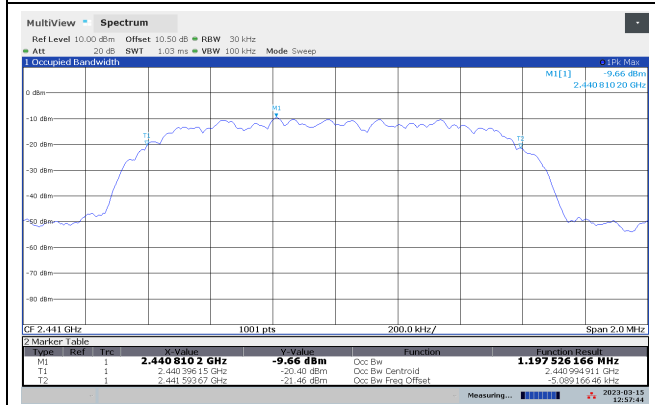
See attached plots.

#### Requirements:

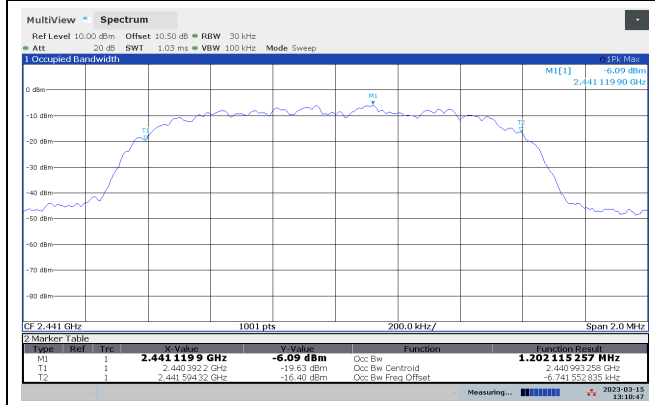
No requirement for 99% BW, reported for information only.



99% Occupied BW, GFSK



99% Occupied BW,  $\pi/4$ -DPSK



99% Occupied BW, 8-DPSK

### 3.6 Peak Power Output

FCC Part 15.247 (b)

ISED Canada RSS-247 Issue 3, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

| Modulation Type | Carrier Frequency (MHz) | Conducted Power (dBm) | Conducted Power (mW) | EIRP, Combi Antenna, dBm | EIRP, Whip Antenna, dBm | Gain Combi Antenna, dBi | Gain Whip Antenna, dBi |
|-----------------|-------------------------|-----------------------|----------------------|--------------------------|-------------------------|-------------------------|------------------------|
| GFSK            | 2402                    | -0.23                 | 0.95                 | 1.41                     | -0.84                   | 1.6                     | -0.6                   |
|                 | 2441                    | 0.14                  | 1.03                 | 5.00                     | 1.24                    | 4.9                     | 1.1                    |
|                 | 2480                    | -0.14                 | 0.97                 | 3.85                     | -1.13                   | 4.0                     | -1.0                   |
| $\pi/4$ -DPSK   | 2402                    | -1.28                 | 0.74                 | /                        | /                       | /                       | /                      |
|                 | 2441                    | -0.83                 | 0.83                 | /                        | /                       | /                       | /                      |
|                 | 2480                    | -0.93                 | 0.81                 | /                        | /                       | /                       | /                      |
| 8-DPSK          | 2402                    | 2.15                  | 1.64                 | /                        | /                       | /                       | /                      |
|                 | 2441                    | 2.96                  | 1.98                 | /                        | /                       | /                       | /                      |
|                 | 2480                    | 2.79                  | 1.90                 | /                        | /                       | /                       | /                      |

Output Power reported is Maximum Peak Power.

The Integrated Band Power Method was used to measure Output Power

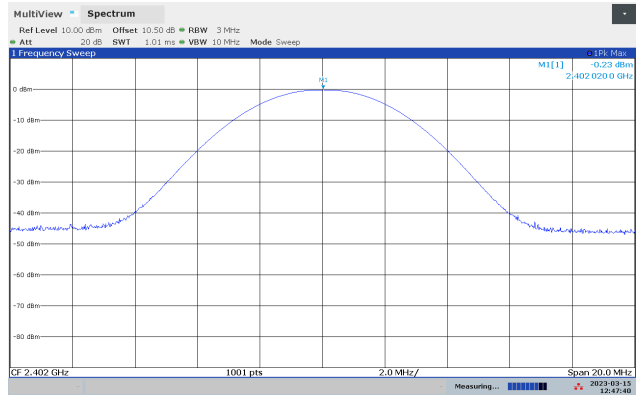
Radiated Power was calculated from measured Field Strength using the method described in FCC KDB 412172 D01.

Antenna Gain is less than 6 dBi.

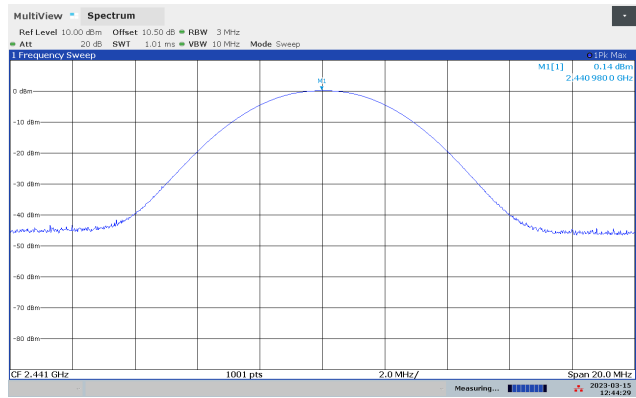
See attached plots.

| Frequency Band                                                                                                                                                                                                                                          | Requirements for Frequency Hopping systems                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 2400-2483.5 MHz                                                                                                                                                                                                                                         | For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels: 1 watt |
|                                                                                                                                                                                                                                                         | For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts                                                   |
| <b>Maximum allowed Antenna Gain</b>                                                                                                                                                                                                                     |                                                                                                                                    |
| If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi. |                                                                                                                                    |

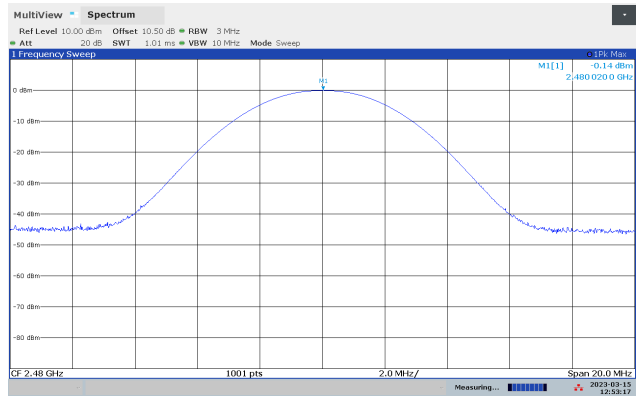
## Conducted



### Peak Power, 2402 MHz, GFSK

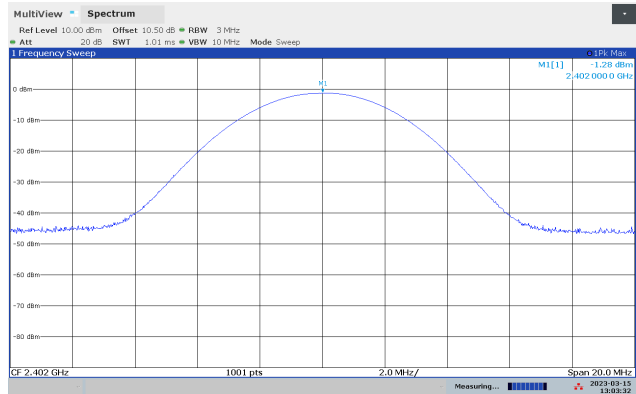


### Peak Power, 2441 MHz, GFSK

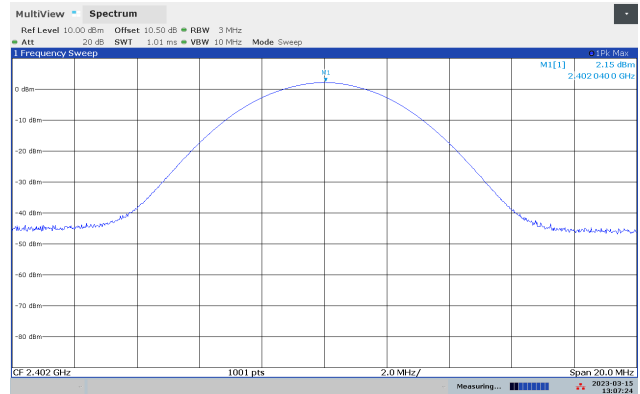


### Peak Power, 2480 MHz, GFSK

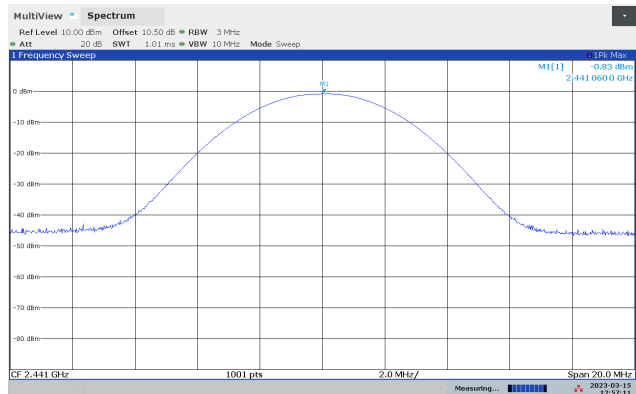
## Conducted



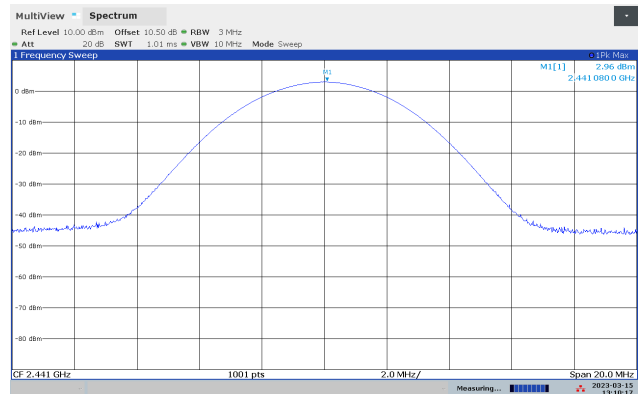
Peak Power, 2402 MHz,  $\pi/4$ -DPSK



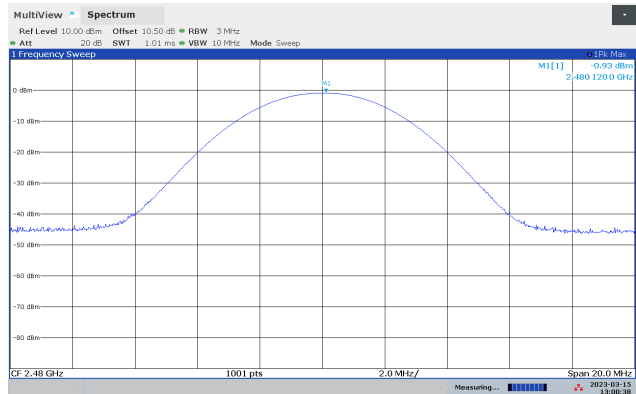
Peak Power, 2402 MHz, 8-DPSK



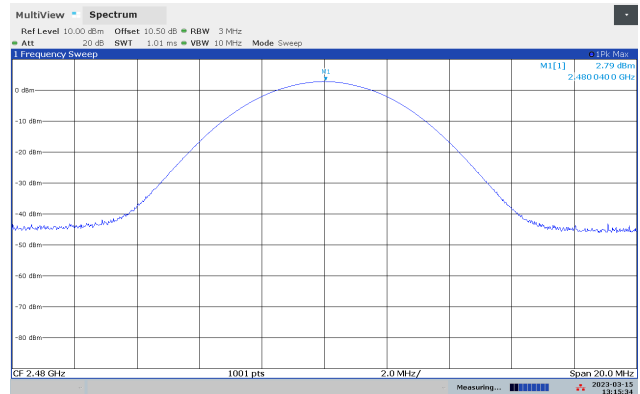
Peak Power, 2441 MHz,  $\pi/4$ -DPSK



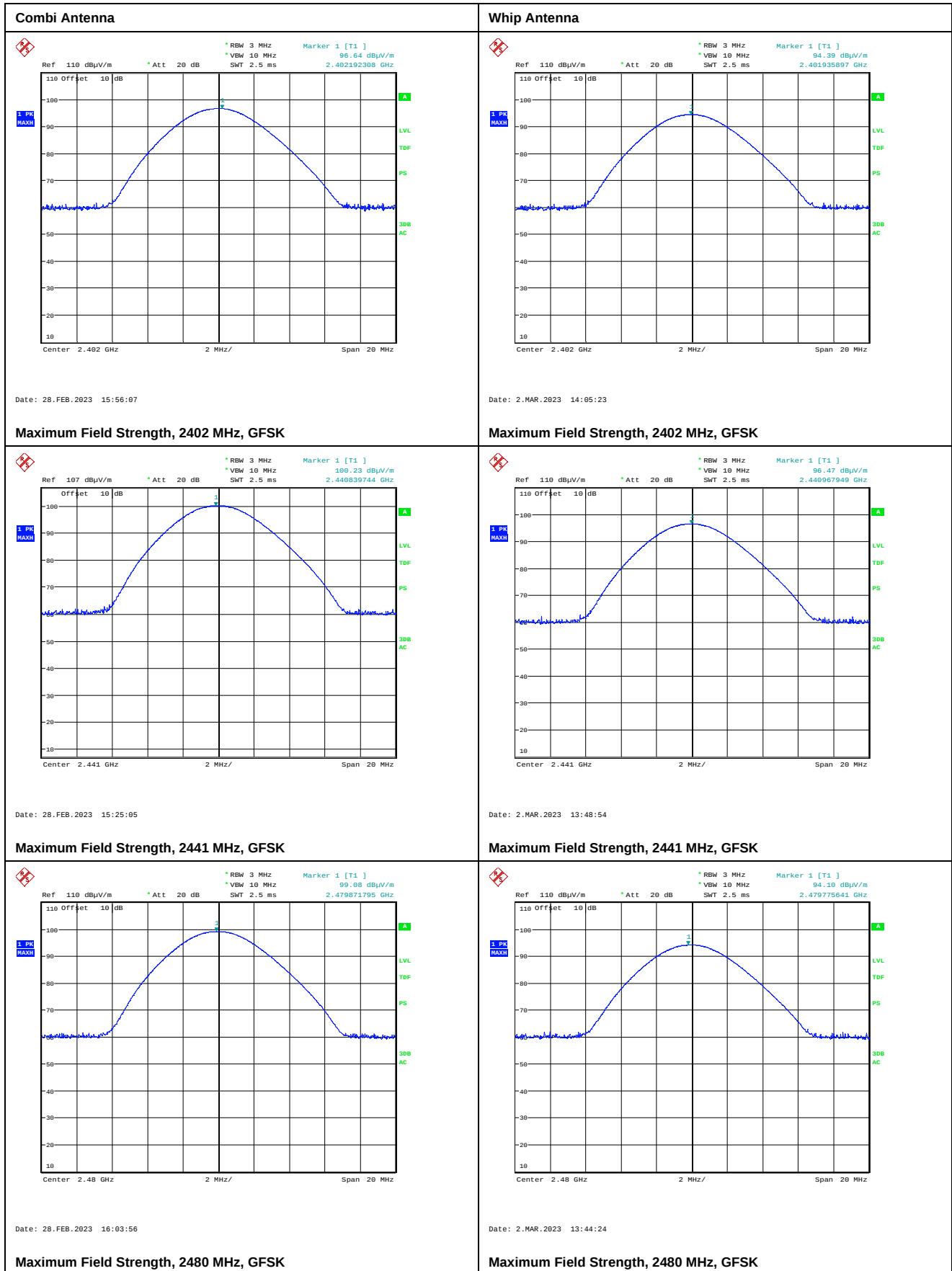
Peak Power, 2441 MHz, 8-DPSK



Peak Power, 2480 MHz,  $\pi/4$ -DPSK



Peak Power, 2480 MHz, 8-DPSK



### 3.7 Conducted Emissions at Antenna Connector

FCC Part 15.247 (d)

ISED Canada RSS-247 Issue 3, Clause 5.5

Measurement procedure: ANSI C63.10-2013 Clause 11.11

Test Results: Complies

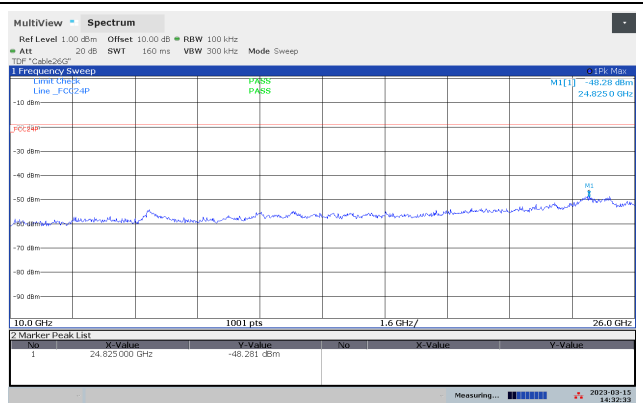
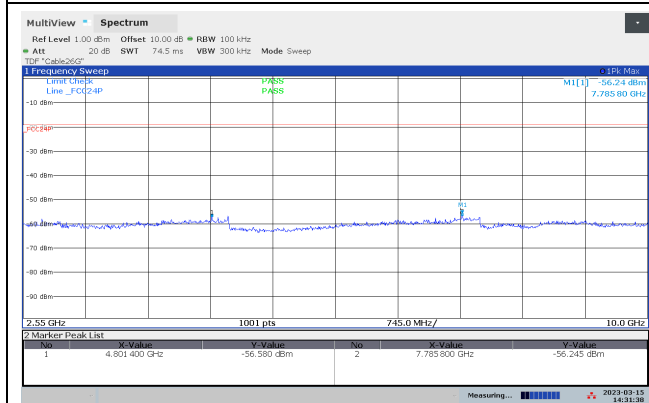
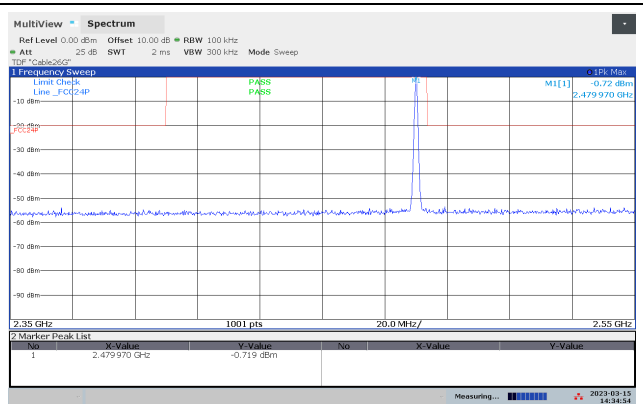
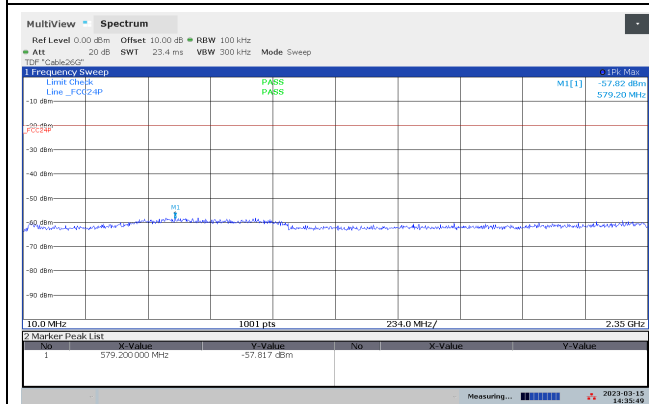
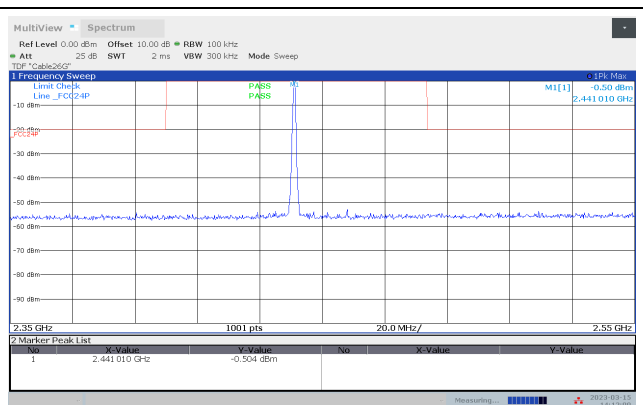
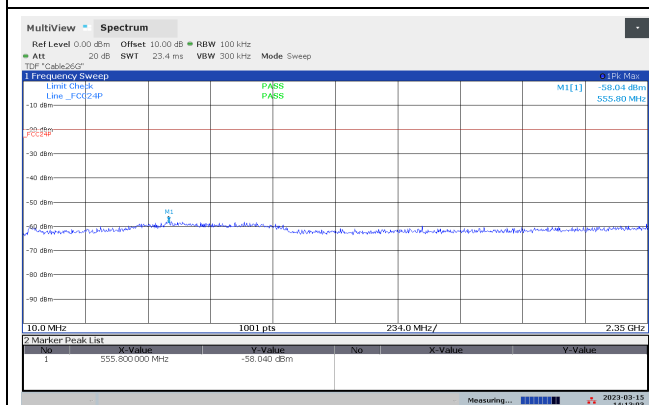
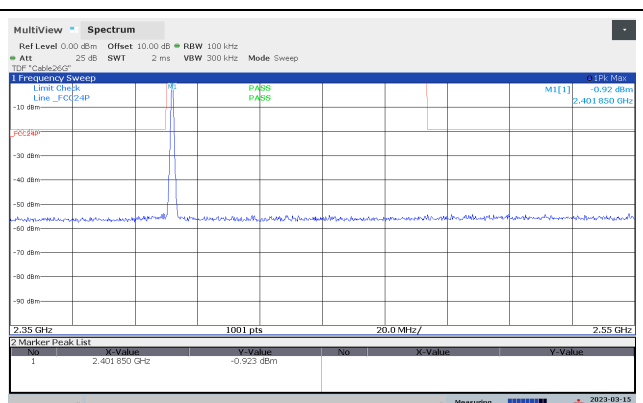
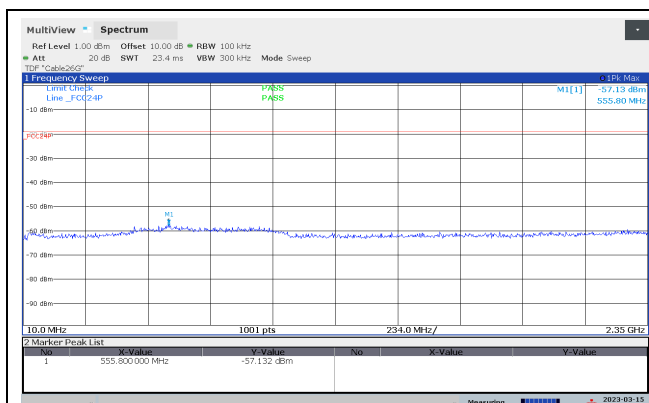
#### Measurement Data:

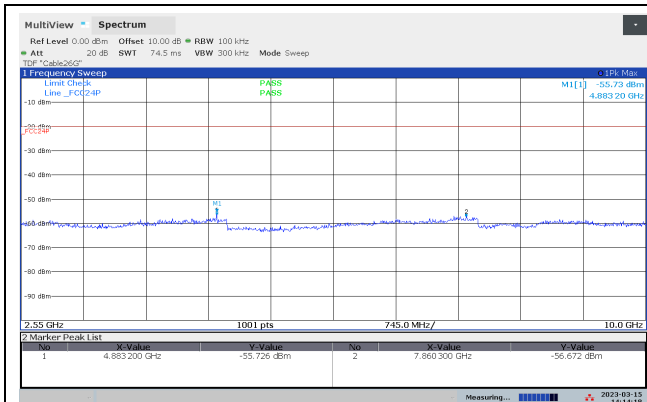
| Carrier Frequency | Highest Value (dBc) | Margin (dB) | Verdict |
|-------------------|---------------------|-------------|---------|
| 2402 MHz          | > 40                | > 20        | Pass    |
| 2441 MHz          | > 40                | > 20        | Pass    |
| 2480 MHz          | > 40                | > 20        | Pass    |

Measured with Peak Detector

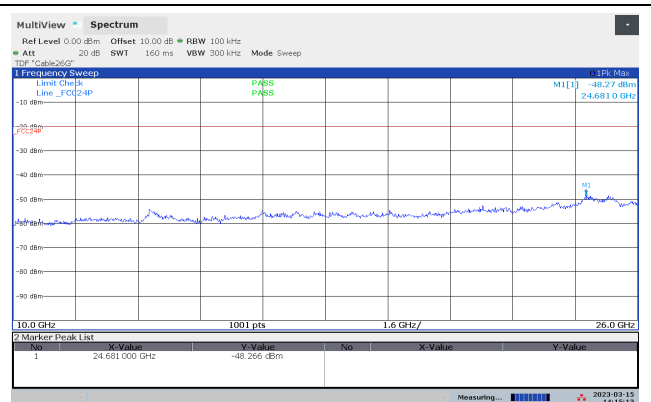
RF conducted power to 25 GHz: see attached plots.

| Requirements for all systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| Peak measurement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | RMS averaging (alternative measurement)                   |
| 20 dB or more below carrier measured in 100 kHz bandwidth                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 30 dB or more below carrier measured in 100 kHz bandwidth |
| <p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.</p> <p>Attenuation below the general limits specified in § 15.209(a) is not required.</p> |                                                           |

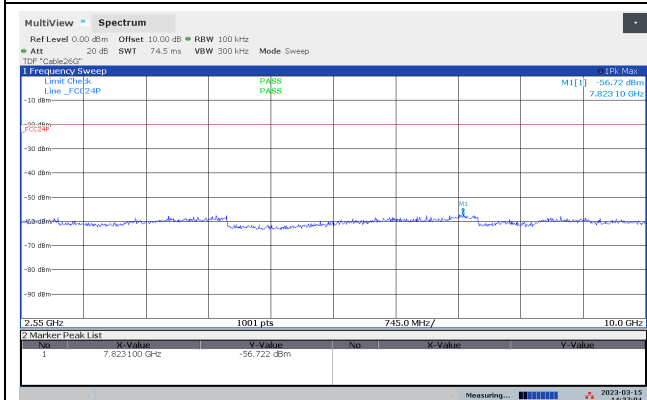




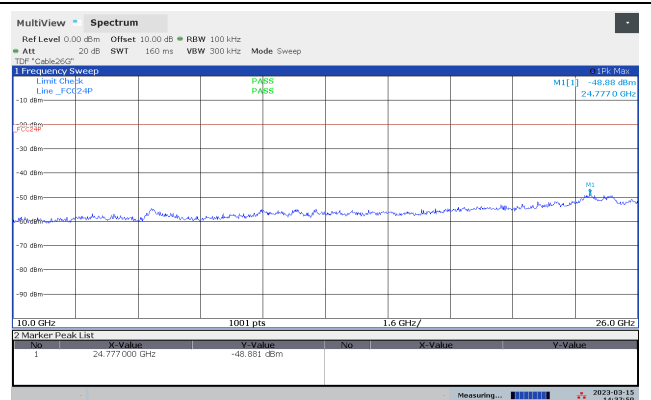
Conducted Emissions 2550-10000 MHz, 2441 MHz, GFSK



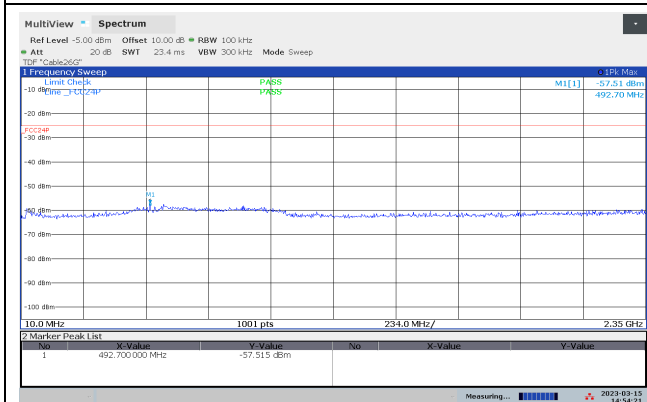
Conducted Emissions 10000-26000 MHz, 2441 MHz, GFSK



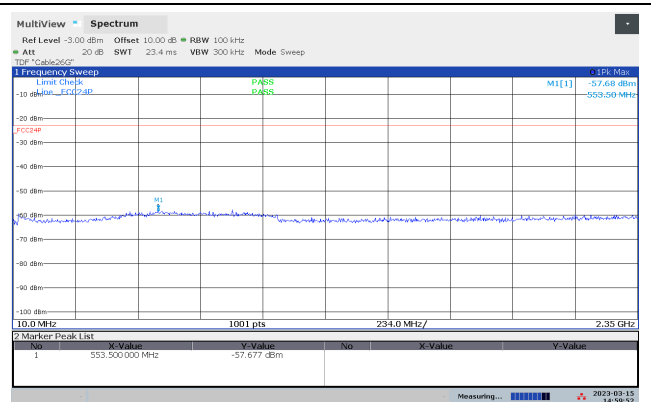
Conducted Emissions 2550-10000 MHz, 2480 MHz, GFSK



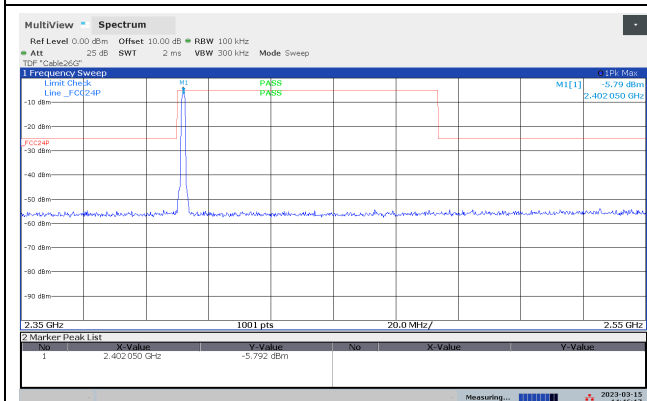
Conducted Emissions 10000-26000 MHz, 2480 MHz, GFSK



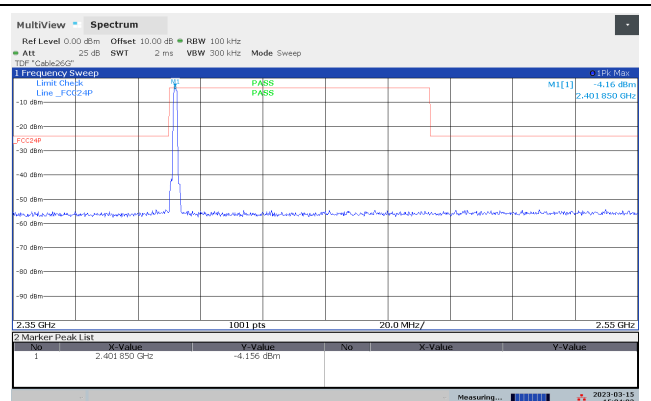
Conducted Emissions 10-2350 MHz, 2441 MHz,  $\pi/4$ -DPSK



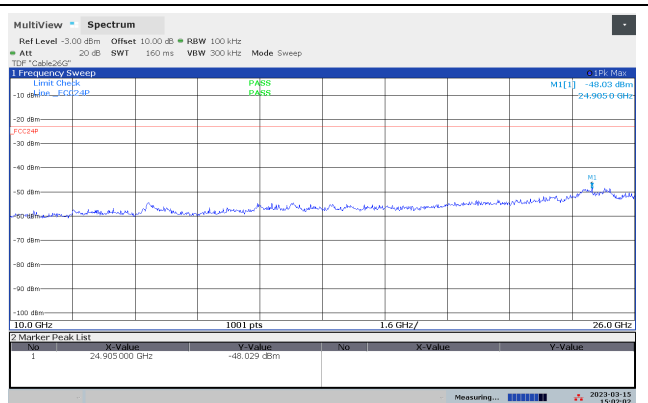
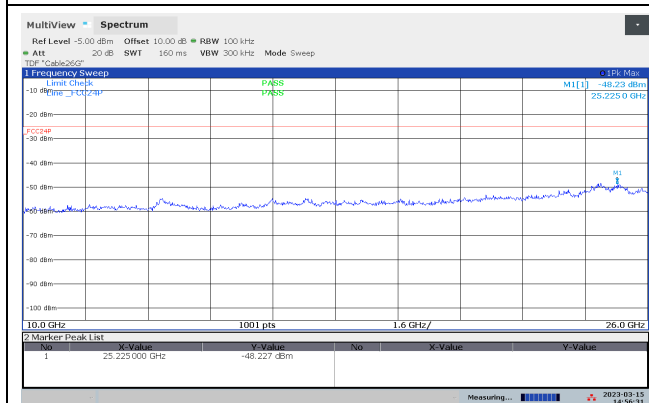
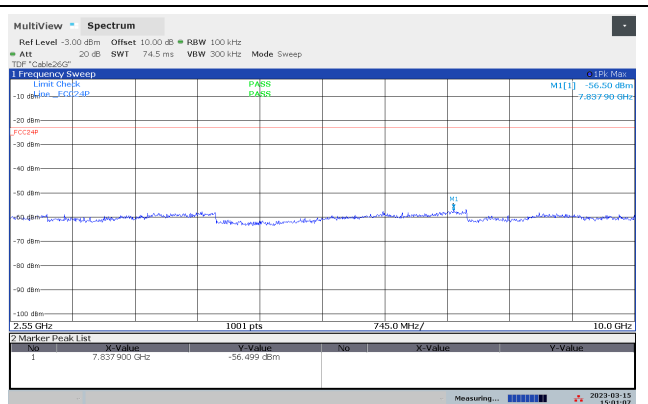
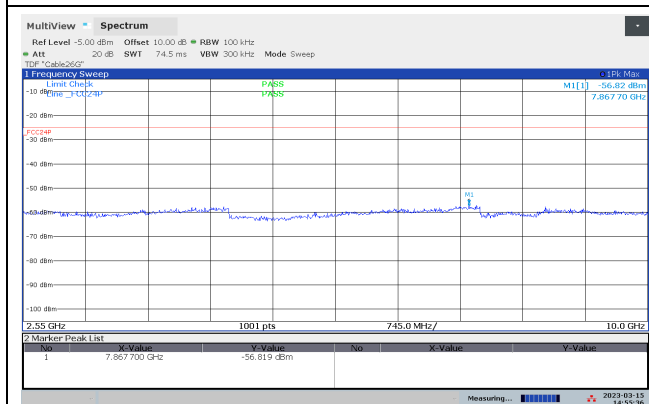
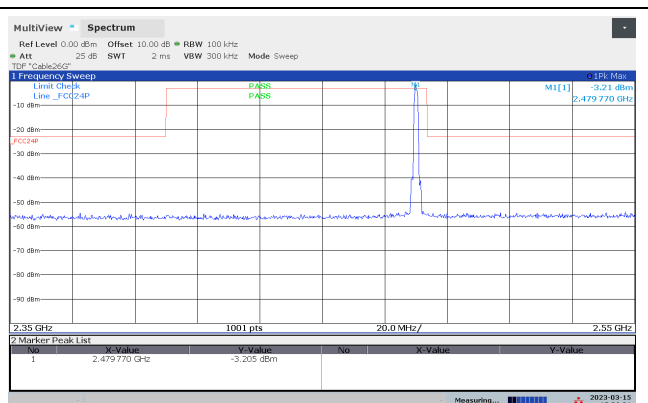
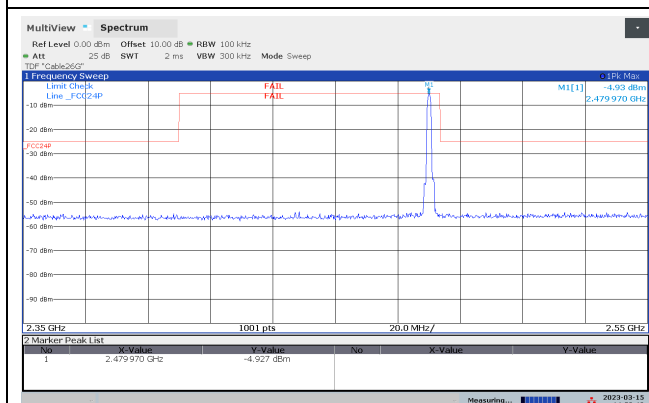
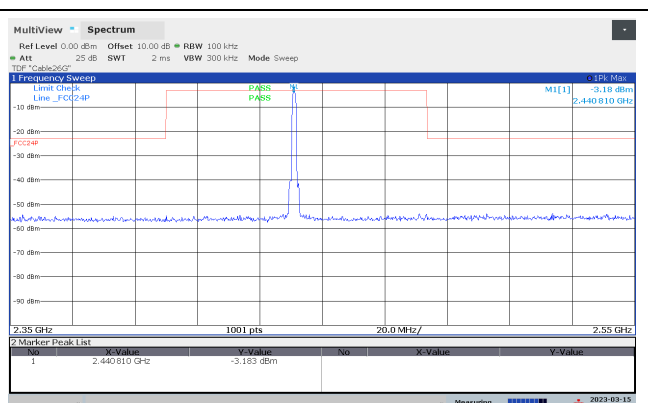
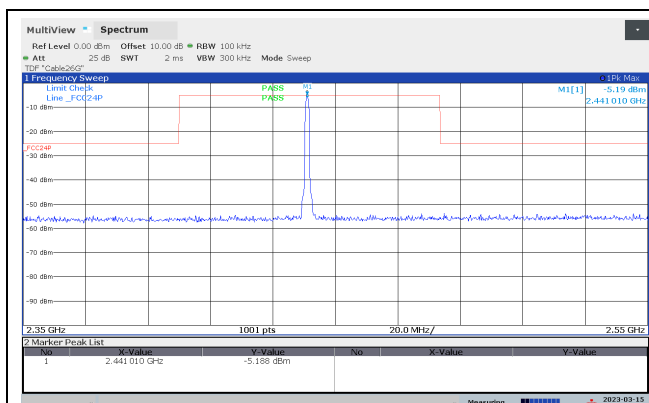
Conducted Emissions 10-2350 MHz, 2441 MHz, 8-DPSK

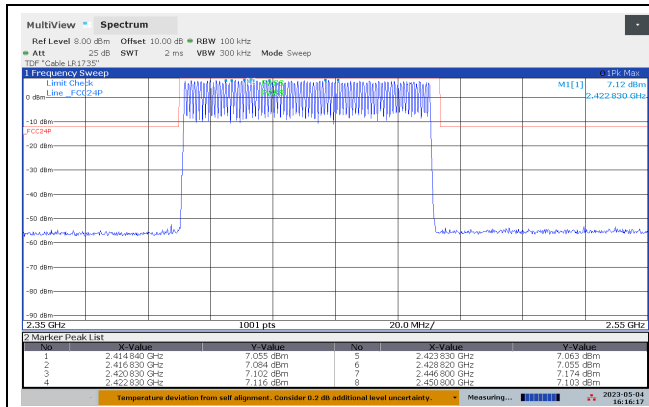


Conducted Emissions 2350-2550 MHz, 2402 MHz,  $\pi/4$ -DPSK

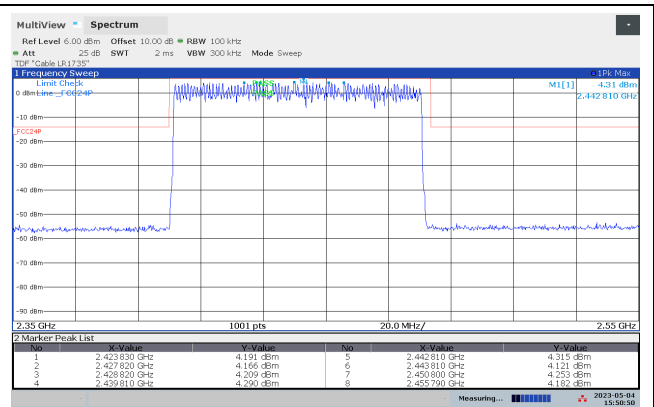


Conducted Emissions 2350-2550 MHz, 2402 MHz, 8-DPSK

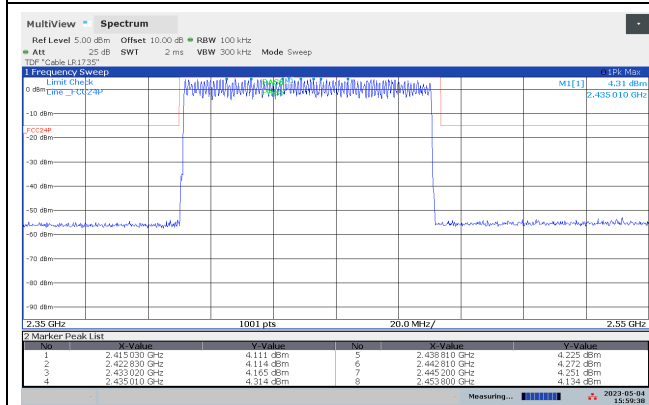




Conducted Emissions 2300-2600 MHz, Hopping, GFSK



Conducted Emissions 2300-2600 MHz, Hopping,  $\pi/4$ -DPSK



Conducted Emissions 2300-2600 MHz, Hopping, 8-DPSK

### 3.8 Restricted Bands of operation

Restricted Bands of operation for FCC and ISED are defined in FCC Part 15.205 and ISED RSS-GEN, Issue 5 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 5, clause 8.9.

| FCC (MHz)                           | ISED Canada (MHz)  | FCC (GHz)                            | ISED Canada (GHz) |
|-------------------------------------|--------------------|--------------------------------------|-------------------|
| 0.090-0.110                         |                    | <b>0.96-1.24</b><br><b>1.3-1.427</b> | <b>0.96-1.427</b> |
| 0.495-0.505                         |                    | 1.435-1.6265                         |                   |
| 2.1735-2.1905                       |                    | 1.6455-1.6465                        |                   |
|                                     | <b>3.020-3.026</b> | 1.660-1.710                          |                   |
| 4.125-4.128                         |                    | 1.7188-1.7222                        |                   |
| 4.17725-4.17775                     |                    | 2.2-2.3                              |                   |
| 4.20725-4.20775                     |                    | 2.31-2.39                            |                   |
|                                     | <b>5.677-5.683</b> | 2.4835-2.5                           |                   |
| 6.215-6.218                         |                    | <b>2.69-2.9</b>                      | <b>2.655-2.9</b>  |
| 6.26775-6.26825                     |                    | 3.26-3.267                           |                   |
| 6.31175-6.31225                     |                    | 3.332-3.339                          |                   |
| 8.291-8.294                         |                    | 3.3458-3.358                         |                   |
| 8.362-8.366                         |                    | <b>3.6-4.4</b>                       | <b>3.5-4.4</b>    |
| 8.37625-8.38675                     |                    | 4.5-5.15                             |                   |
| 8.41425-8.41475                     |                    | 5.35-5.46                            |                   |
| 12.29-12.293                        |                    | 7.25-7.75                            |                   |
| 12.51975-12.52025                   |                    | 8.025-8.5                            |                   |
| 12.57675-12.57725                   |                    | 9.0-9.2                              |                   |
| 13.36-13.41                         |                    | 9.3-9.5                              |                   |
| 16.42-16.423                        |                    | 10.6-12.7                            |                   |
| 16.69475-16.69525                   |                    | 13.25-13.4                           |                   |
| 16.80425-16.80475                   |                    | 14.47-14.5                           |                   |
| 25.5-25.67                          |                    | 15.35-16.2                           |                   |
| 37.5-38.25                          |                    | 17.7-21.4                            |                   |
| 73-74.6                             |                    | 22.01-23.12                          |                   |
| 74.8-75.2                           |                    | 23.6-24.0                            |                   |
| <b>108-121.94</b><br><b>123-138</b> | <b>108-138</b>     | 31.2-31.8                            |                   |
| 149.9-150.05                        |                    | 36.43-36.5                           |                   |
| 156.52475-156.52525                 |                    | Above 38.6                           |                   |
| 156.7-156.9                         |                    |                                      |                   |
| 162.0125-167.17                     |                    |                                      |                   |
| 167.72-173.2                        |                    |                                      |                   |
| 240-285                             |                    |                                      |                   |
| 322-335.4                           |                    |                                      |                   |
| 399.9-410                           |                    |                                      |                   |
| 608-614                             |                    |                                      |                   |

Frequencies in **Bold** text are specific for FCC or ISED, all other frequencies are common.

### 3.9 Radiated Emissions, Band Edge

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3 / 8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

| Combi Antenna                   |                     |                                  |                  |                |             |             |             |
|---------------------------------|---------------------|----------------------------------|------------------|----------------|-------------|-------------|-------------|
| Carrier Frequency and Data Rate | Band Edge Frequency | Measured Field Strength (dBμV/m) |                  | Limit (dBμV/m) |             | Margin (dB) |             |
|                                 |                     | Peak Detector                    | Average Detector | Peak Det       | Average Det | Peak Det    | Average Det |
| 2402 MHz GFSK                   | 2390 MHz            | 52.9                             | 32.9             | 74             | 54          | 21.1        | 21.1        |
| 2480 MHz GFSK                   | 2483.5 MHz          | 57.2                             | 37.2             |                |             | 16.8        |             |

| Whip Antenna                    |                     |                                  |                  |                |             |             |             |
|---------------------------------|---------------------|----------------------------------|------------------|----------------|-------------|-------------|-------------|
| Carrier Frequency and Data Rate | Band Edge Frequency | Measured Field Strength (dBμV/m) |                  | Limit (dBμV/m) |             | Margin (dB) |             |
|                                 |                     | Peak Detector                    | Average Detector | Peak Det       | Average Det | Peak Det    | Average Det |
| 2402 MHz GFSK                   | 2390 MHz            | 52.8                             | 32.8             | 74             | 54          | 21.2        | 21.2        |
| 2480 MHz GFSK                   | 2483.5 MHz          | 54.3                             | 34.3             |                |             | 19.7        | 19.7        |
| 2402 MHz 2-EDR                  | 2390 MHz            | 52.9                             | 32.9             |                |             | 21.1        | 21.1        |
| 2480 MHz 2-EDR                  | 2483.5 MHz          | 54.0                             | 34.0             |                |             | 20.0        | 20.0        |
| 2402 MHz 3-EDR                  | 2390 MHz            | 52.8                             | 32.8             |                |             | 21.2        | 21.2        |
| 2480 MHz 3-EDR                  | 2483.5 MHz          | 56.3                             | 36.3             |                |             | 17.7        | 17.7        |

Average Detector values are measured with Peak Detector and corrected for Duty Cycle.

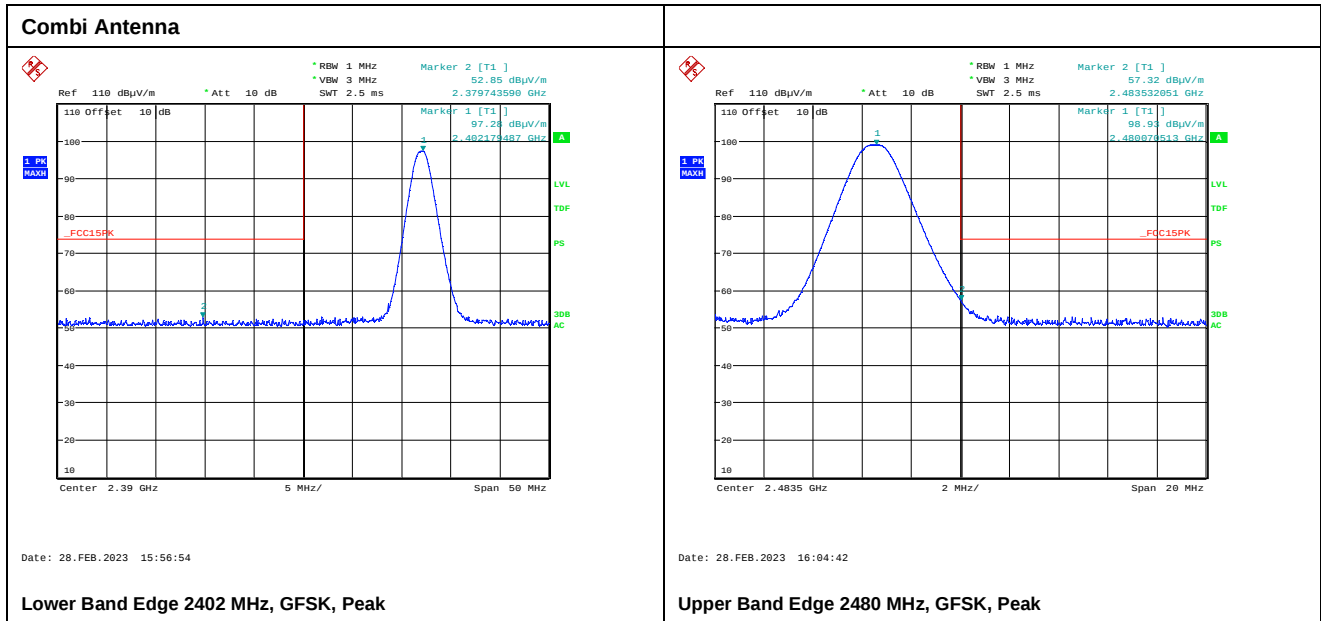
See attached plots.

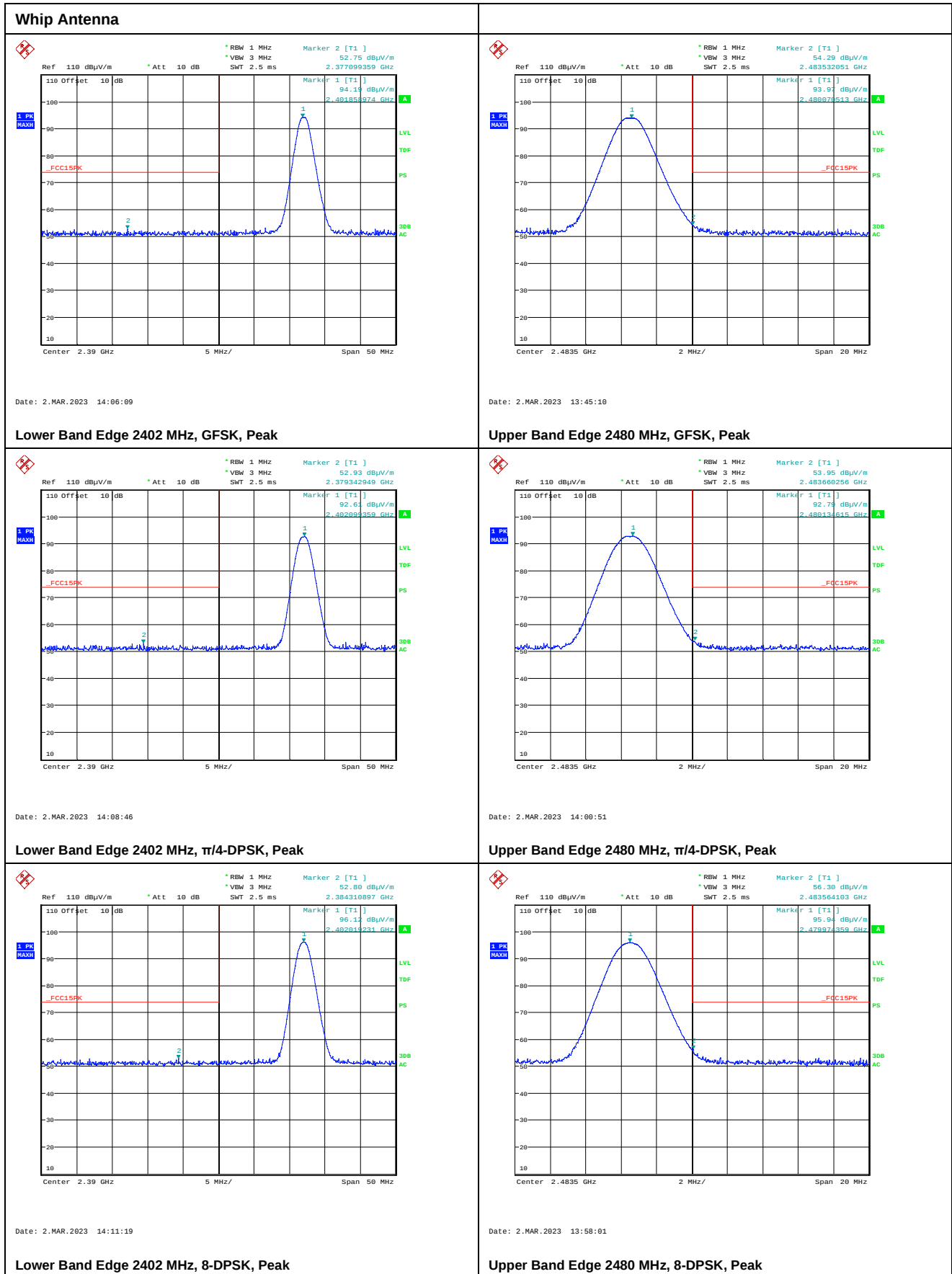
#### Duty Cycle Correction Factor Calculation:

Duty Cycle = slot length / frame length

Duty Cycle Correction factor =  $-20 \times \log(\text{Duty Cycle}) = 27.5 \text{ dB}$

**Maximum Duty Cycle Correction Factor according to Para 15.35 (b): 20 dB**





### 3.10 Radiated Emission, 30 – 1000 MHz.

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

#### Measurement Data:

Detector: Peak (found frequencies were measured with Quasi-Peak Detector)

Measuring distance 3 m

Tested in test mode with BT transmitting.

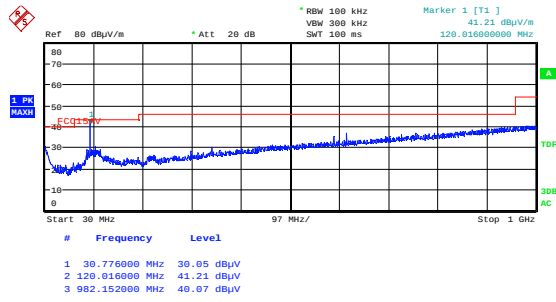
| Measured Frequency (MHz) | Carrier Frequency (MHz) | Modulation | Measured Emission (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
|--------------------------|-------------------------|------------|----------------------------|----------------|-------------|
| 30 – 88                  | Any                     | GFSK       | < 35                       | 40.0           | > 5         |
| 88 – 216                 | Any                     | GFSK       | < 40                       | 43.5           | > 3.5       |
| 216 – 960                | Any                     | GFSK       | < 40                       | 46.0           | > 6         |
| 960 – 1000               | Any                     | GFSK       | < 44                       | 54.0           | > 10        |
| 120.01                   | Any                     | Any        | 40.0                       | 43.5           | 3.5         |

See attached plots

#### Requirements/Limit

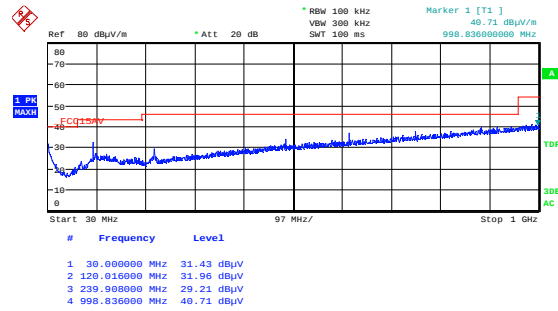
|                                           |                                                                  |             |
|-------------------------------------------|------------------------------------------------------------------|-------------|
| FCC                                       | Part 15.209 @ frequencies defined in §15.205                     |             |
| ISED                                      | RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10 |             |
| Frequency                                 | Radiated emission limit @3 meters                                |             |
| 30 – 88 MHz                               | 100 μV/m                                                         | 40.0 dBμV/m |
| 88 – 216 MHz                              | 150 μV/m                                                         | 43.5 dBμV/m |
| 216 – 960 MHz                             | 200 μV/m                                                         | 46.0 dBμV/m |
| 960 – 1000 MHz                            | 500 μV/m                                                         | 54.0 dBμV/m |
| Limits above are with Quasi Peak Detector |                                                                  |             |

### Combi Antenna



Date: 10.MAR.2023 15:48:44

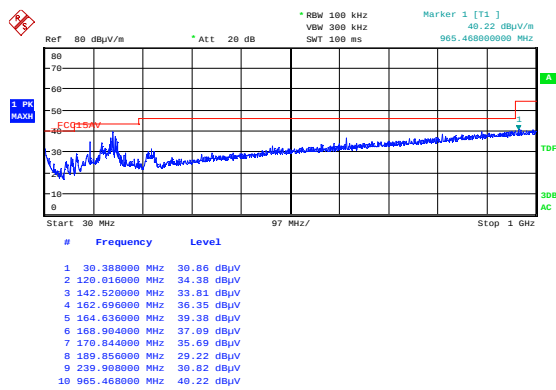
### Radiated Emissions 30 - 1000 MHz, GFSK, HP



Date: 10.MAR.2023 15:50:41

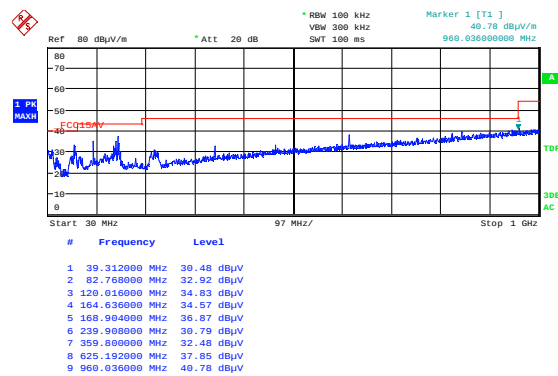
### Radiated Emissions 30 - 1000 MHz, GFSK, VP

### Whip Antenna



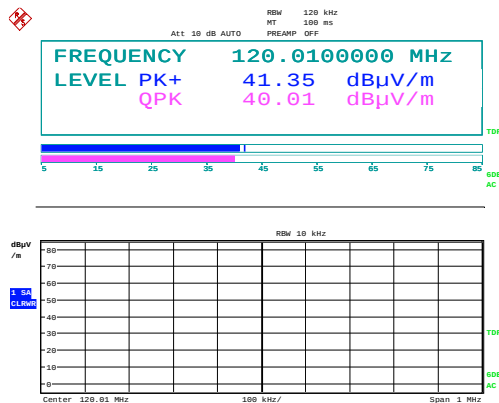
Date: 13.MAR.2023 10:26:18

### Radiated Emissions 30 - 1000 MHz, GFSK, HP



Date: 13.MAR.2023 10:24:21

### Radiated Emissions 30 - 1000 MHz, GFSK, VP



Date: 10.MAR.2023 16:05:41

### Emission 120 MHz, Max: VP

### 3.11 Radiated Emissions, 1-26 GHz

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Measuring distance: 3m (1 – 18 GHz)  
1m (18 – 26 GHz)

No spurious were detected.

Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

A Band Reject Filter was used for measurements from 1 GHz to 18 GHz.

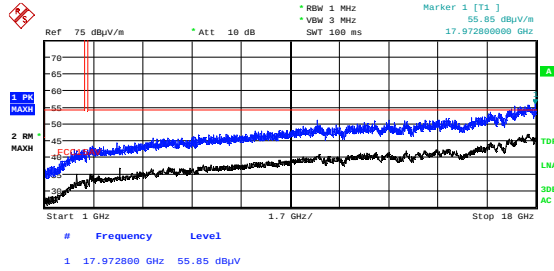
Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor".

See plots.

#### Requirements/Limit

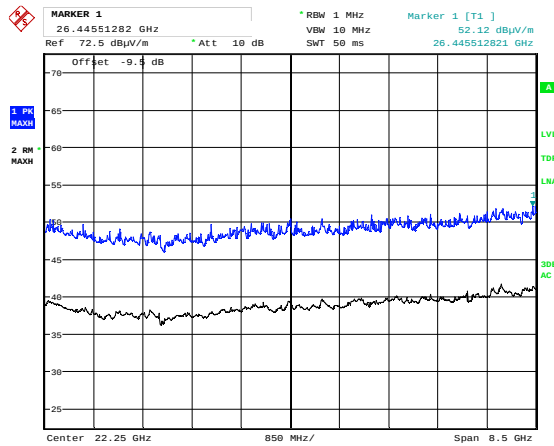
|            |                                                                  |               |
|------------|------------------------------------------------------------------|---------------|
| FCC        | Part 15.209 @ frequencies defined in §15.205                     |               |
| ISED       | RSS-GEN Issue 5, clause 8.9 @ frequencies defined in clause 8.10 |               |
|            | Radiated emission limit @3 meters                                |               |
| Frequency  | Average Detector                                                 | Peak Detector |
| 1 – 26 GHz | 54.0 dBµV/m                                                      | 74.0 dBµV/m   |

### Combi Antenna



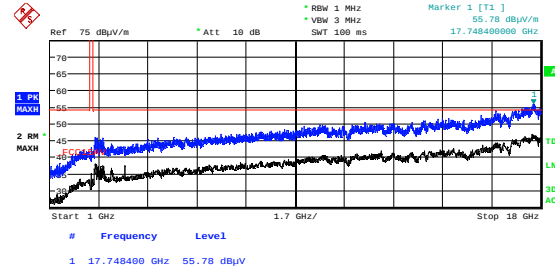
Date: 28.FEB.2023 15:04:44

### Radiated Emissions 1 - 18 GHz, 2441 MHz, GFSK, HP



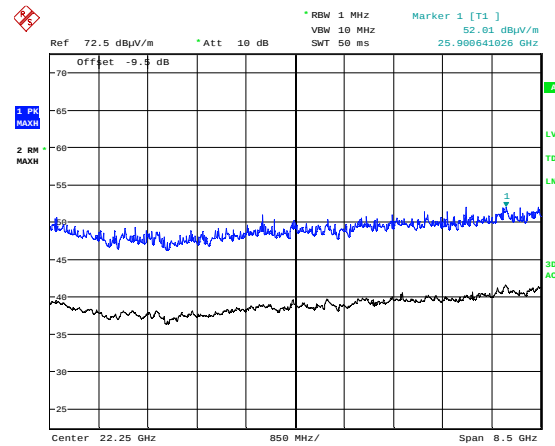
Date: 14.MAR.2023 10:47:22

### Radiated Emissions 18 - 26 GHz, 2441 MHz, GFSK, HP, @1m



Date: 28.FEB.2023 15:02:20

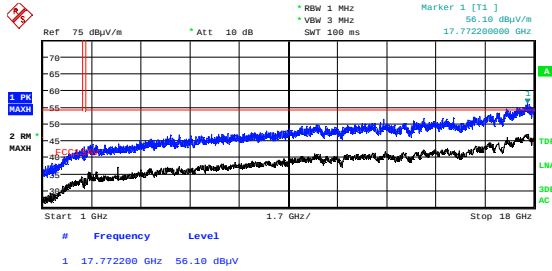
### VP



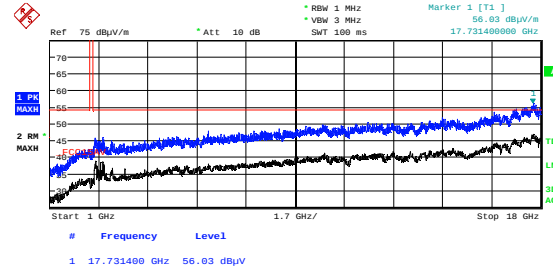
Date: 14.MAR.2023 10:44:37

### VP

## Whip Antenna

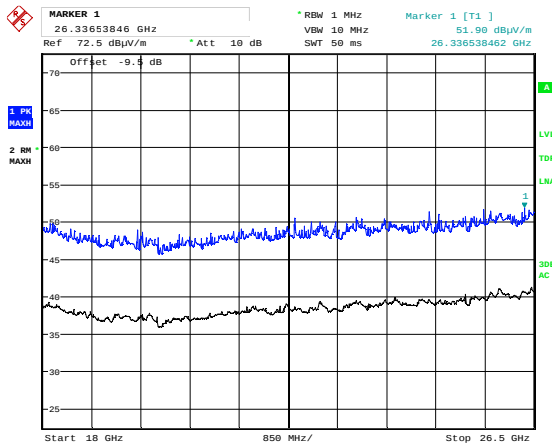


Date: 2.MAR.2023 14:30:39



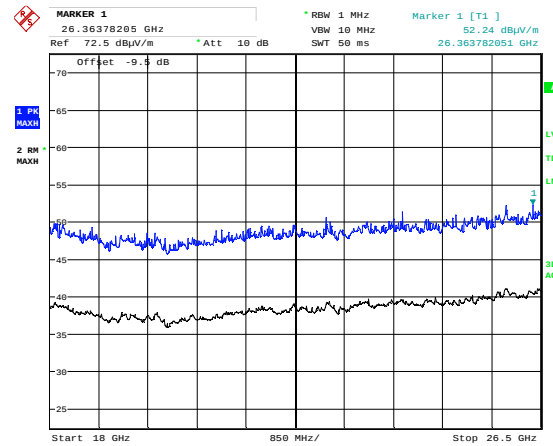
Date: 2.MAR.2023 14:28:16

## Radiated Emissions 1 - 18 GHz, 2441 MHz, GFSK, HP



Date: 14.MAR.2023 16:10:00

## VP



Date: 14.MAR.2023 16:07:40

## Radiated Emissions 18 - 26 GHz, 2441 MHz, GFSK, HP

## VP

## 4 Measurement Uncertainty

| Measurement Uncertainty Values   |           |                |
|----------------------------------|-----------|----------------|
| Test Item                        |           | Uncertainty    |
| Output Power                     |           | ±0.5 dB        |
| Power Spectral Density           |           | ±0.5 dB        |
| Out of Band Emissions, Conducted | < 3.6 GHz | ±0.6 dB        |
|                                  | > 3.6 GHz | ±0.9 dB        |
| Spurious Emissions, Radiated     | < 1 GHz   | ±2.5 dB        |
|                                  | > 1 GHz   | ±2.2 dB        |
| Emission Bandwidth               |           | ±4 %           |
| Power Line Conducted Emissions   |           | +2.9 / -4.1 dB |
| Spectrum Mask Measurements       | Frequency | ±5 %           |
|                                  | Amplitude | ±1.0 dB        |
| Frequency Error                  |           | ±0.6 ppm       |
| Temperature Uncertainty          |           | ±1 °C          |

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

## 5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

| No. | Model number             | Description                 | Manufacturer       | Ref. no. | Cal. date | Cal. Due |
|-----|--------------------------|-----------------------------|--------------------|----------|-----------|----------|
| 1   | FSW43                    | Spectrum Analyzer           | Rohde & Schwarz    | LR 1690  | 2023-01   | 2024-01  |
| 2   | ESU40                    | Measuring Receiver          | Rohde & Schwarz    | LR 1639  | 2023-01   | 2024-01  |
| 3   | 6810.17B                 | Attenuator                  | Suhner             | LR 1669  | 2022-08   | 2023-08  |
| 4   | NO324415                 | Band Reject Filter (2.4GHz) | Microwave Circuits | LR 1760  | COU       |          |
| 5   | JB3                      | BiLog Antenna               | Sunol              | N-4525   | 2022-09   | 2025-09  |
| 6   | 317                      | Preamplifier                | Sonoma Inst.       | LR 1687  | 2022-08   | 2023-08  |
| 7   | 3117-PA                  | Horn Antenna +PreAmp        | EMCO               | LR 1717  | 2022-08   | 2023-08  |
| 8   | 3115                     | Horn Antenna                | EMCO               | LR 1226  | 2022-12   | 2027-12  |
| 9   | 8449A                    | Pre-amplifier               | Hewlett Packard    | LR 1322  | 2022-08   | 2023-08  |
| 10  | WLK5-1100-1485-7000-40SS | Low Pass Filter             | Wainwright Inst.   | LR 1761  | COU       |          |
| 11  | 638                      | Antenna Horn                | Narda              | LR 1480  | N/A       |          |
| 12  | 6032A                    | System Power Supply         | Hewlett Packard    | LR 1062  | COU       |          |
| 13  | Model 87V                | Multimeter                  | Fluke              | LR 1600  | 2022-03   | 2024-03  |
| 14  | ST18/SMA/N/36            | RF Cable                    | Suhner             | LR 1627  | COU       |          |

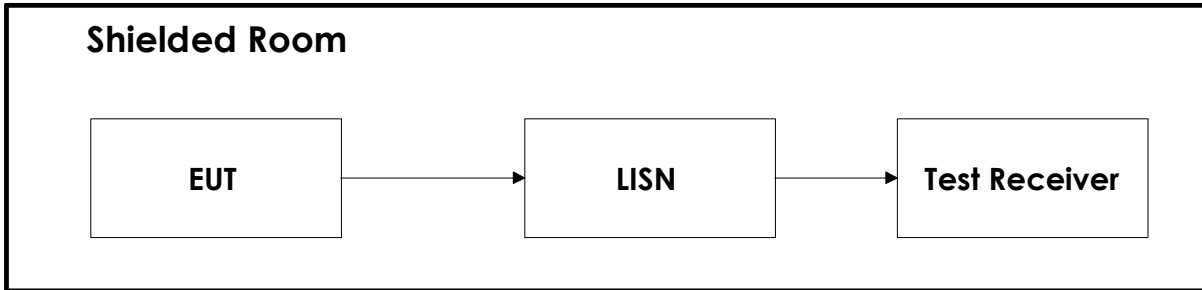
COU = Calibrate on Use

The software listed below has been used for one or more tests.

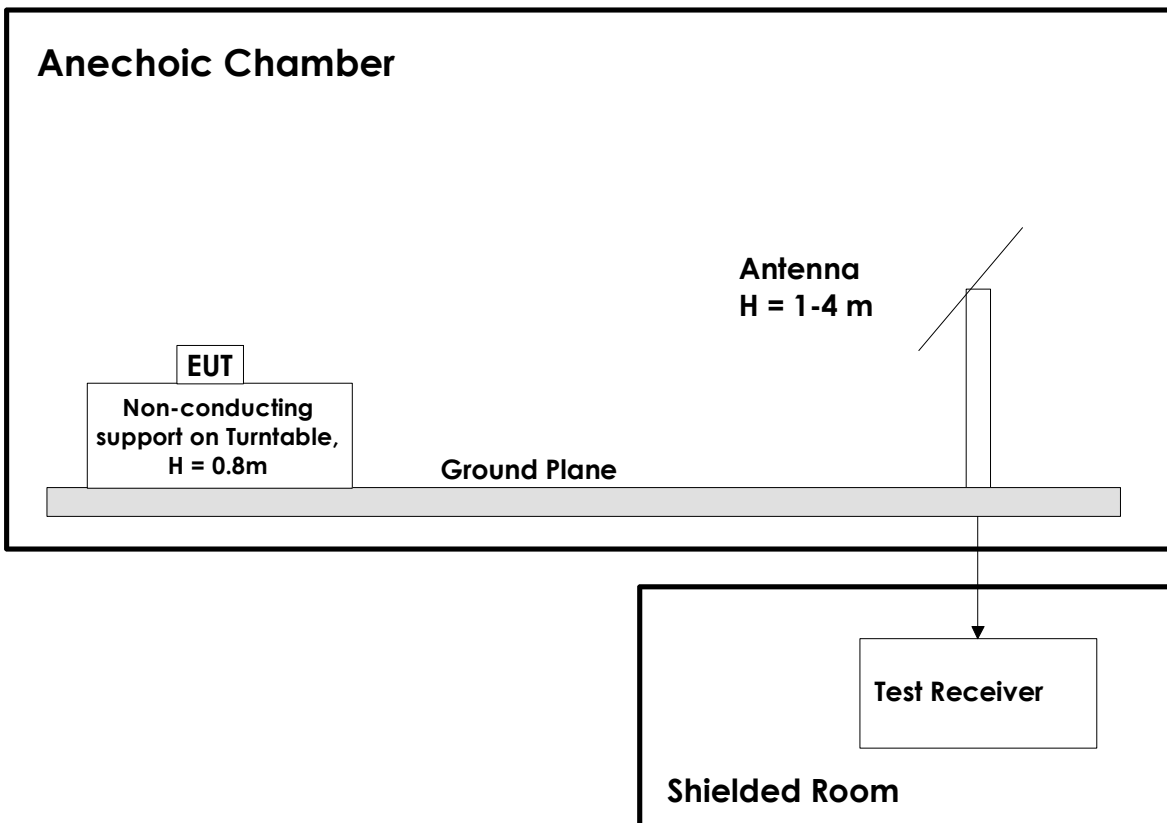
| No. | Manufacturer    | Name   | Version  | Comment                                    |
|-----|-----------------|--------|----------|--------------------------------------------|
| 1   | Rohde & Schwarz | EMC32  | 10.60.20 | EMC test software                          |
| 2   | Nemko AS        | RSPlot | 1.0.8.0  | Screen capture from R&S Spectrum Analyzers |
|     |                 |        |          |                                            |

## 6 BLOCK DIAGRAM

### 6.1 Power Line Conducted Emission



### 6.2 Test Site Radiated Emission



This test setup is used for all radiated emissions tests. For frequencies below 30 MHz the measuring distance is 10m, for all other frequencies it is 3m or 1m. Emissions above 1 GHz are measured with a Spectrum Analyzer and Horn Antenna. For measurements above 18 GHz the test receiver is moved inside the anechoic chamber and located next to the antenna to minimize the cable loss. All measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers. A pre-amplifier is used for all measurements above 30 MHz, and a High-Pass or Band-Pass filter is used for all harmonics.