

Test Report

Product	Condition Monitor with Bluetooth Low Energy Transceiver
Name and address of the applicant	Alfa Laval Kolding AS Albuen 31 6000 Kolding, Denmark
Name and address of the manufacturer	Alfa Laval Kolding AS Albuen 31 6000 Kolding, Denmark
Model	CM1
Rating	3.6V DC
Trademark	Alfa Laval
Serial number	See clause 1.1
Additional information	Bluetooth LE 4.2
Tested according to	FCC Part 15.247 Frequency Hopping Transmitters / Digital Transmission Systems Industry Canada RSS-247, Issue 2 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	405508
Tested in period	2020-11-10 to 2020-11-17
Issue date	2021-04-29
Name and address of the testing laboratory	 Institutveien 6 Kjeller, Norway www.nemko.com <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> CAB Number: FCC: NO0001 ISED: NO0470 TEL: +47 22 96 03 30 FAX: +47 22 96 05 50 </div> <div style="width: 45%;">   NORWEGIAN ACCREDITATION TEST 033 </div> </div> <p style="text-align: center;">An accredited technical test executed under the Norwegian accreditation scheme</p>
	 Prepared by [Frode Sveinsen]
	 Approved by [G.Suhanthakumar]
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1 INFORMATION

1.1 Test Item

Name	Alfa Laval
Model/version	CM1
FCC ID	2AX74-CM1-BUHFH
ISED ID	26704-CM1BUHFH
Serial number	Radiated Sample: 38 Conducted Sample: 35
Hardware identity and/or version	V1.0
Software identity and/or version	V3.5
Frequency Range	2402–2480 MHz
Number of Channels	40
Operating Modes	Bluetooth 5 Low Energy (Operating only in BT 4.2 Mode)
Type of Modulation	GFSK
Conducted Output Power	0.0026
Antenna Connector	None
Number of Antennas	1
Diversity or Smart Antennas	No
Power Supply	Primary Battery (High Energy Lithium Battery, 3.6V DC)
Desktop Charger	N/A

Description of Test Item

The EUT is a Condition Monitor with a Bluetooth 5 Low Energy Transceiver.

The BLE chip supports Bluetooth 5, but is operating only in BT 4.2 mode with date rate 1Mbps.

1.2 Normal test condition

Temperature: 20 - 24 °C
 Relative humidity: 20 - 50 %
 Normal test voltage: 3.6 V DC (Nominal Battery Voltage)

The values are the limit registered during the test period.

1.3 Test Engineer(s)

Frode Sveinsen

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO
If detachable, is the antenna connector(s) non-standard?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
The tested equipment has only integral antennas. Conducted tests were performed with a temporary antenna connector.		

Requirement: FCC 15.203, 15.204

1.5 EUT Operating Modes

Description of operating modes	Continuous TX and Burst TX. The EUT is programmed from a computer using the Texas Instruments Test Jig connected by USB. All tests were performed with the EUT transmitting BLE frames with length PL40 continuously.
Additional information	The following settings were used for all tests: Power Setting: Default Bit Pattern: PSRB Frame Setting: PL40
Test Jig	 Texas Instruments Test Jig

1.6 Comments

The EUT uses the Bluetooth 5, Low Energy Protocol with 1Mbit data rate.

The measurements were done with the EUT powered by from a new battery.

2 TEST REPORT SUMMARY

2.1 General

All measurements are traceable to national standards.

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and Industry Canada RSS-247 Issue 2 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 distances of 1m, 3m and 10m.

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
DTS Equipment Code	<input type="checkbox"/> Family Listing



THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.

Deviations from, additions to, or exclusions from the test specifications are described in "Summary of Test Data".

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2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 2, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	5.13	N/A ¹
Antenna Requirement	15.203	6.8 (RSS-GEN)	5.8	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	6.2	N/A ¹
Occupied Bandwidth (99% BW)	N/A	6.7 (RSS-GEN)	6.9.3	Complies
DTS Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	11.8 Option 2	Complies
Peak Power Output	15.247(b)	5.4 (RSS-247)	11.9.1.1	Complies
Power Spectral Density	15.247(d)	5.2 (2) (RSS-247)	11.10.2 PKPSD (DTS)	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	6.7 11.11 (DTS)	Complies
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	6.3, 6.5, 6.6, 6.10 11.12, 11.13 (DTS)	Complies

¹ The EUT operates only from a primary battery

Revision history

Revision	Date	Comment	Sign
00	2021-01-05	First edition	FS

3 TEST RESULTS

3.1 Occupied Bandwidth (99% BW)

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

ISED Canada RSS-247 Issue 2, 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:

Carrier Frequency and Data Rate	Occupied Bandwidth (99% BW)
2440 MHz GFSK	1.03 MHz

Occupied Bandwidth is the same for all channels

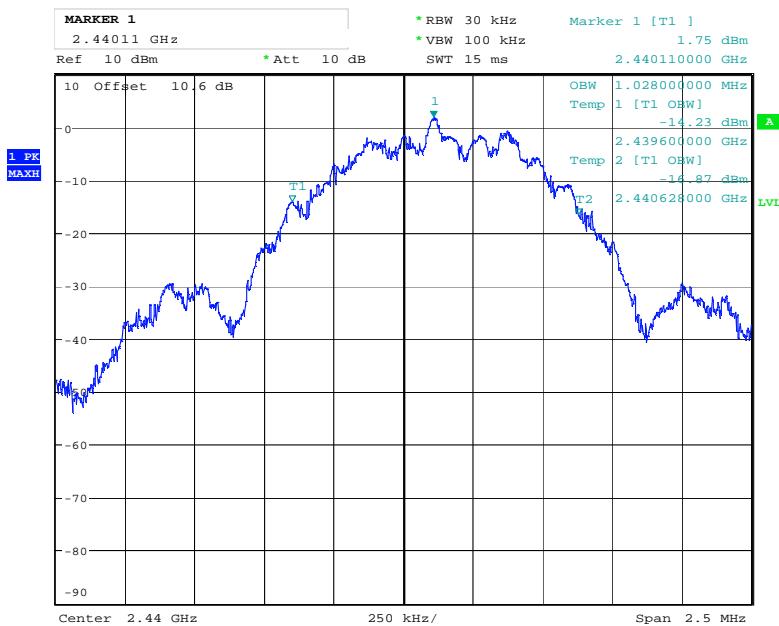
See attached plots.

Requirements:

Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels. No requirements for bandwidth for this frequency band.

No requirements for Digital Transmission Systems.

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



Date: 17.NOV.2020 13:57:47

99% Occupied BW, GFSK, 2440 MHz

3.2 DTS Bandwidth

FCC Part 15.247 (a)(2)

ISED Canada RSS-247 Issue 2, Clause 5.2 (a)

Measurement procedure: ANSI C63.10-2013 Clause 11.8

Test Results: Complies

Measurement Data:

Operating Mode	DTS Bandwidth (6dB BW)		
	2402 MHz	2440 MHz	2480 MHz
BLE, 1Mb	668 kHz	663 kHz	649 kHz

Requirements:

For Digital Transmission Systems in the 2400-2483.5 MHz band the minimum 6 dB bandwidth shall be at least 500 KHz.

No requirements for Frequency Hopping Systems.



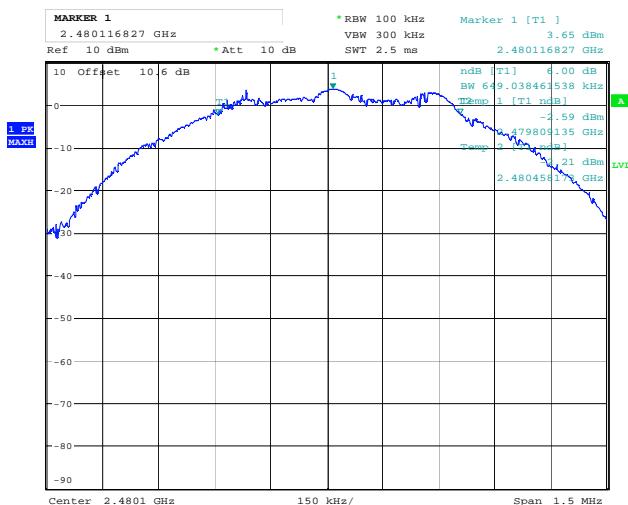
Date: 11.NOV.2020 13:54:27

DTS BW, 2402 MHz



Date: 11.NOV.2020 13:52:59

DTS BW, 2440 MHz



Date: 11.NOV.2020 13:49:25

DTS BW, 2480 MHz

3.3 Peak Power Output

FCC Part 15.247 (b)

ISED Canada RSS-247 Issue 2, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

Carrier Frequency (MHz)	Modulation Type	Conducted Power (dBm)	Conducted Power (mW)	Field Strength (dB μ V/m)	EIRP (mW)	Antenna gain (dBi)
2402	GFSK	4.2	2.6	102.6	5.5	3.2
2440	GFSK	4.1	2.6	103.5	6.7	4.2
2480	GFSK	3.9	2.5	103.1	6.1	4.0

Measured Output Power is Maximum Peak 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.

Requirements:

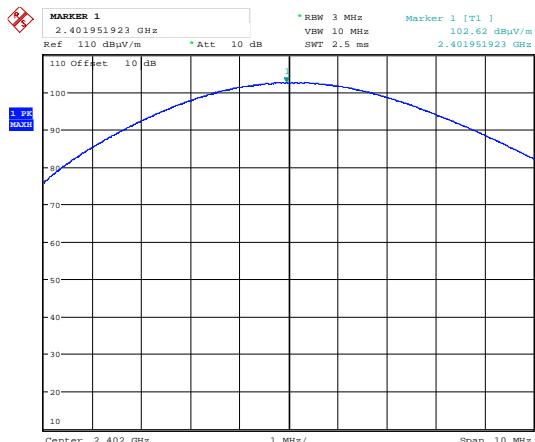
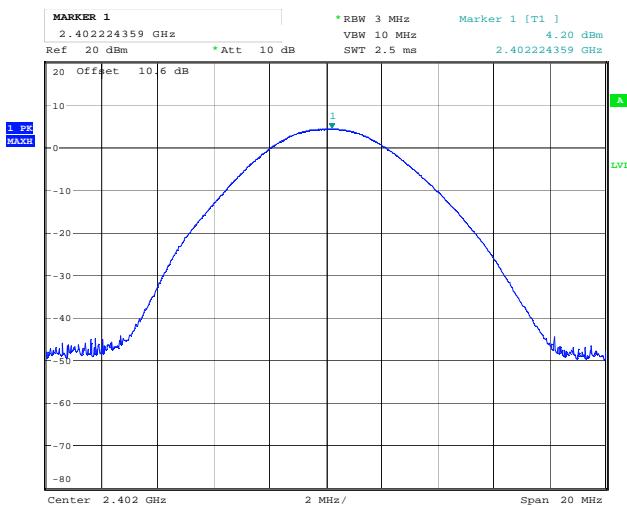
The maximum peak output power shall not exceed the following limits:

For frequency hopping systems employing at least 75 hopping channels: 1 Watt

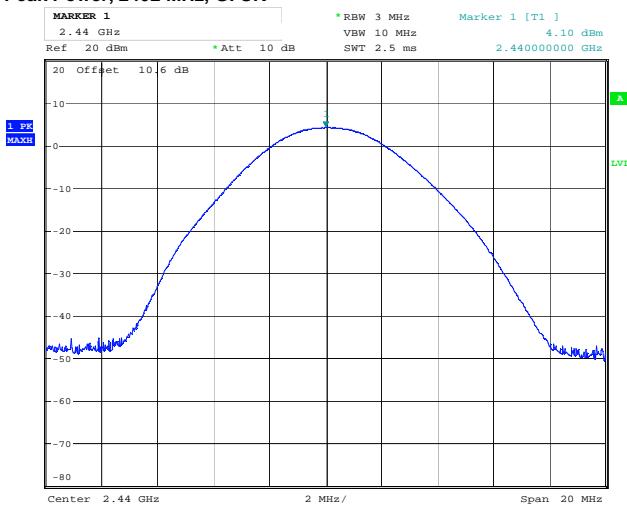
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

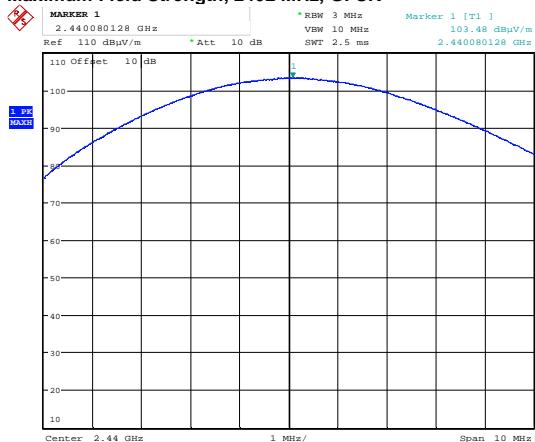
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



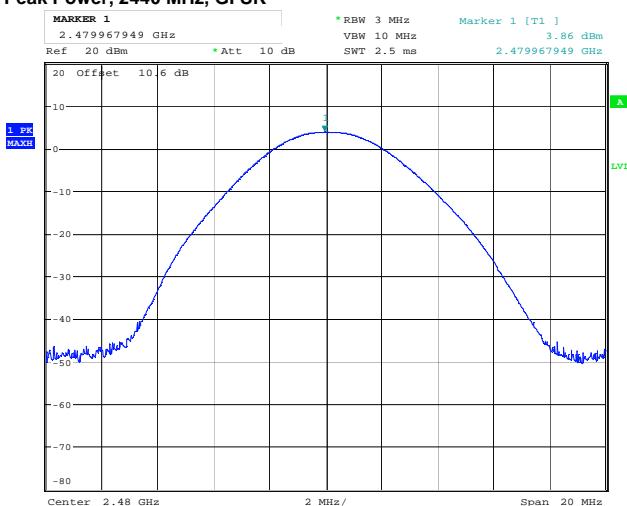
Date: 11.NOV.2020 13:09:46
Peak Power, 2402 MHz, GFSK



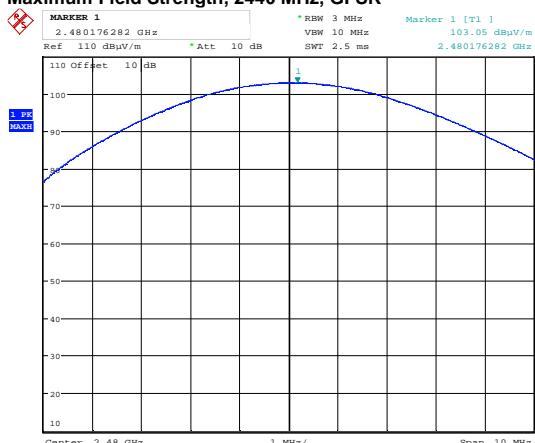
Maximum Field Strength, 2402 MHz, GFSK



Date: 11.NOV.2020 13:09:03
Peak Power, 2440 MHz, GFSK



Maximum Field Strength, 2440 MHz, GFSK



Date: 11.NOV.2020 13:10:39
Peak Power, 2480 MHz, GFSK

Maximum Field Strength, 2480 MHz, GFSK

3.4 Conducted Emissions at Antenna Connector

FCC Part 15.247 (d)

ISED Canada RSS-247 Issue 2, 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
2440 MHz	> 40	> 20	Pass
2480 MHz	> 40	> 20	Pass

Measured with Peak Detector

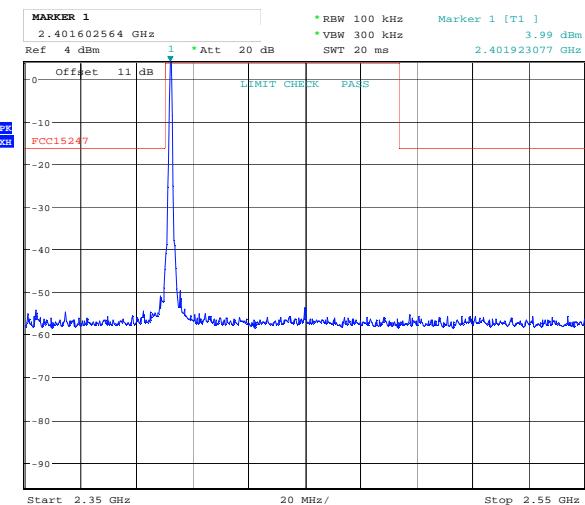
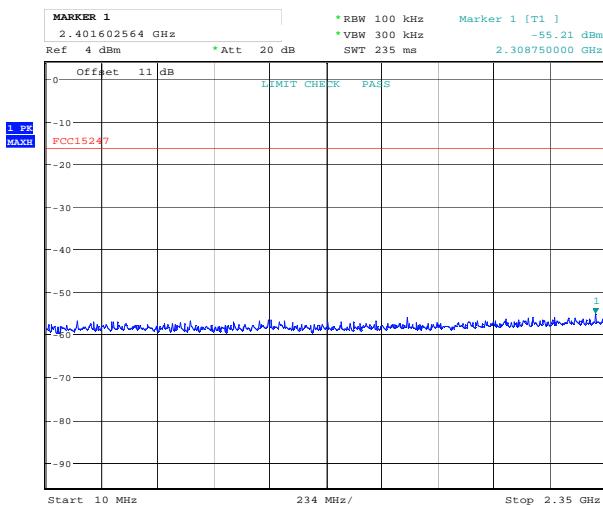
RF conducted power to 25 GHz: see attached plots.

Limit

Peak measurement	RMS averaging
20 dBc or more in 100 kHz bandwidth	30 dBc or more in 100 kHz bandwidth

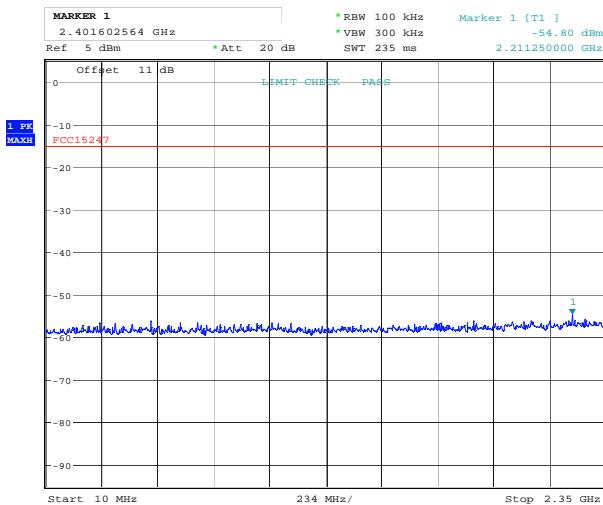
Detector type shall be the same as used for measuring Output Power.

Attenuation below the general limits specified in part 15.209(a) is not required.



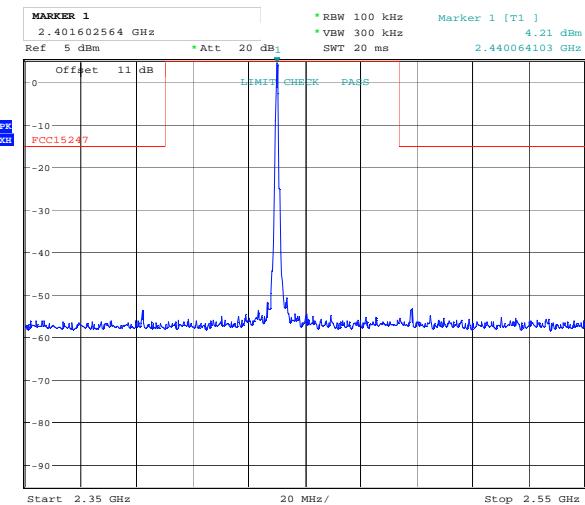
Date: 11.NOV.2020 15:39:58

Conducted Emissions 10-2350 MHz, 2402 MHz, GFSK



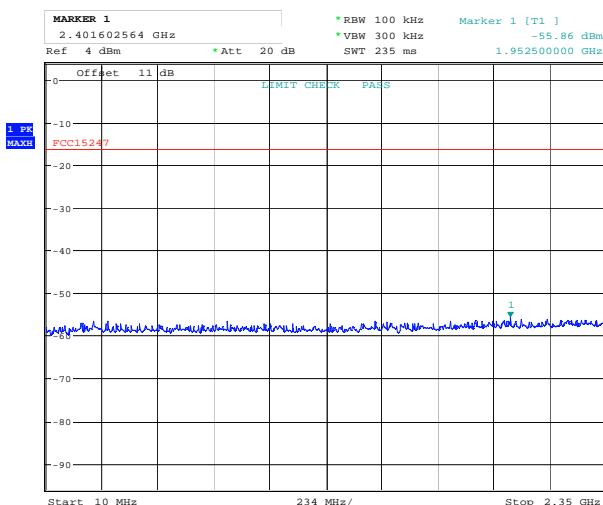
Date: 11.NOV.2020 15:39:00

Conducted Emissions 2350-2550 MHz, 2402 MHz, GFSK



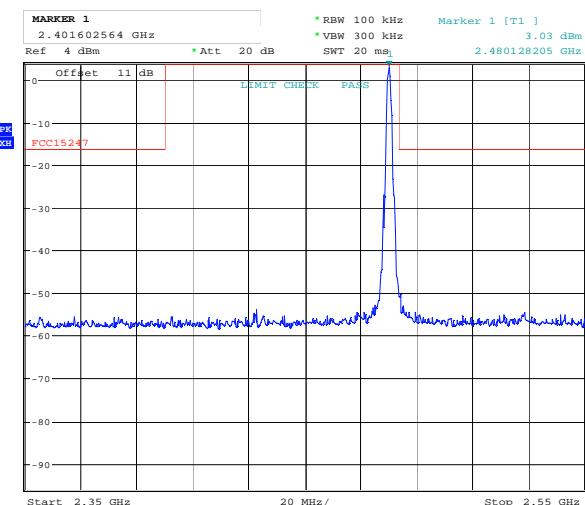
Date: 11.NOV.2020 15:45:47

Conducted Emissions 10-2350 MHz, 2440 MHz, GFSK



Date: 11.NOV.2020 15:44:49

Conducted Emissions 2350-2550 MHz, 2440 MHz, GFSK

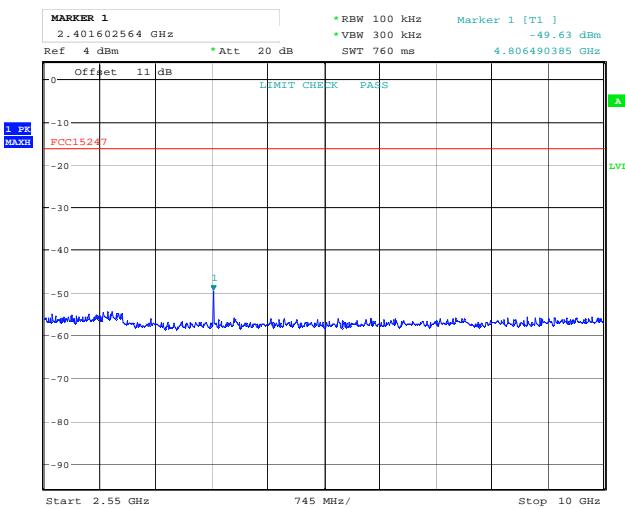


Date: 11.NOV.2020 15:51:34

Conducted Emissions 10-2350 MHz, 2480 MHz, GFSK

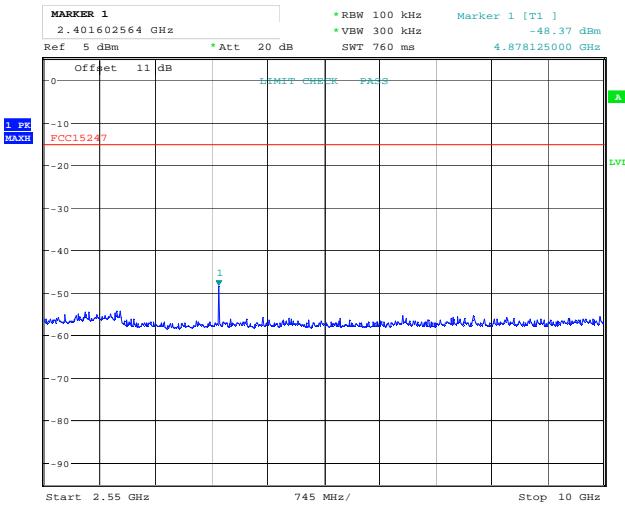
Date: 11.NOV.2020 15:12:12

Conducted Emissions 2350-2550 MHz, 2480 MHz, GFSK



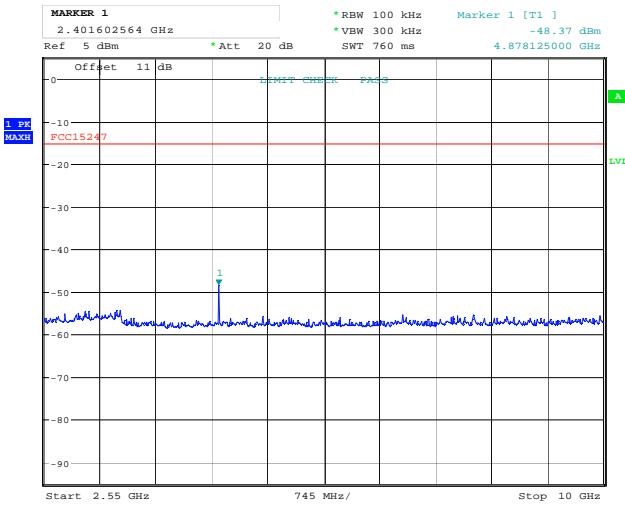
Date: 11.NOV.2020 15:41:15

Conducted Emissions 2550-10000 MHz, 2402 MHz, GFSK



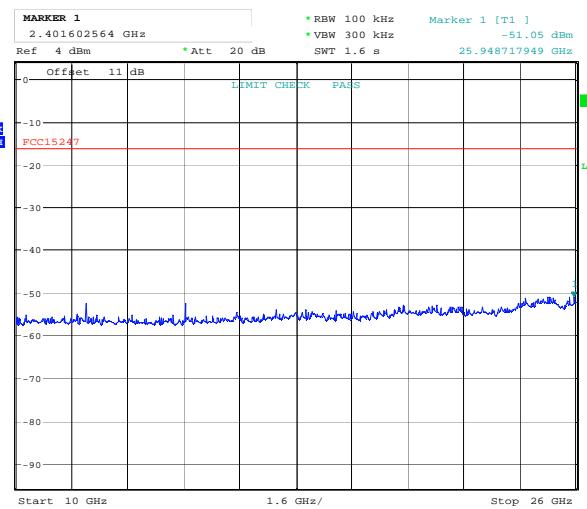
Date: 11.NOV.2020 15:47:04

Conducted Emissions 2550-10000 MHz, 2440 MHz, GFSK



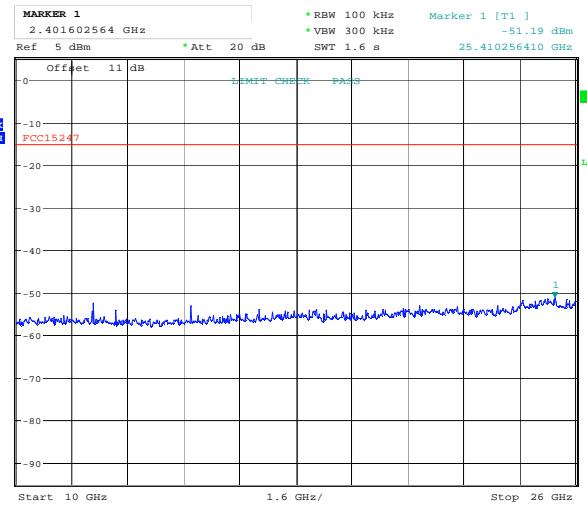
Date: 11.NOV.2020 15:47:04

Conducted Emissions 2550-10000 MHz, 2480 MHz, GFSK



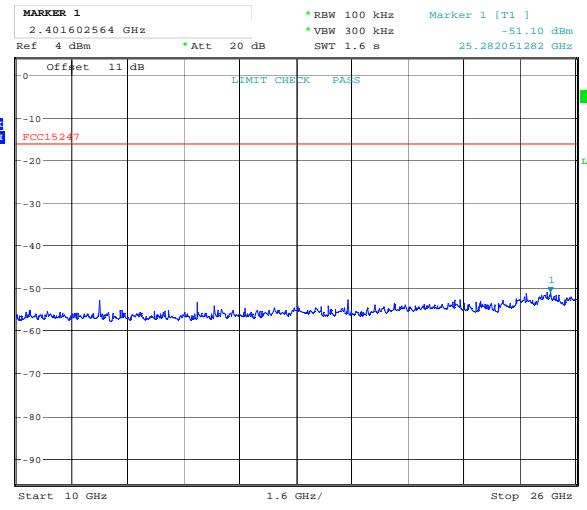
Date: 11.NOV.2020 15:42:13

Conducted Emissions 10000-26000 MHz, 2402 MHz, GFSK



Date: 11.NOV.2020 15:48:02

Conducted Emissions 10000-26000 MHz, 2440 MHz, GFSK



Date: 11.NOV.2020 15:53:49

Conducted Emissions 10000-26000 MHz, 2480 MHz, GFSK

3.5 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		0.96-1.24 1.3-1.427	0.96-1.427
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	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	
	5.677-5.683	2.4835-2.5	
6.215-6.218		2.69-2.9	2.655-2.9
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		3.6-4.4	3.5-4.4
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	
108-121.94 123-138	108-138	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.

3.6 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

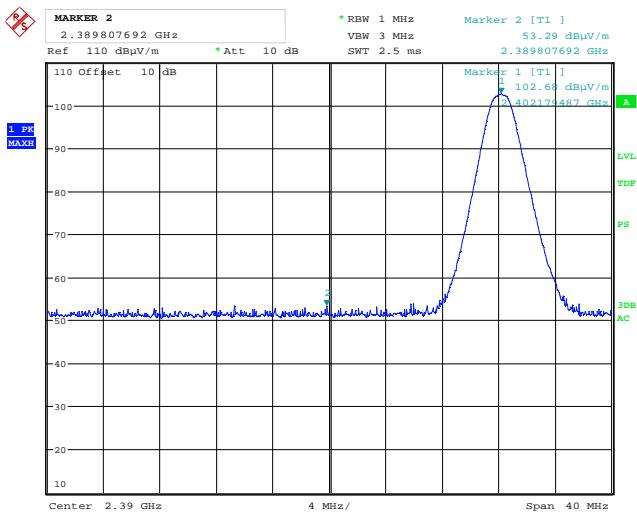
Test Results: Complies

Measurement Data:

Carrier Frequency and Data Rate	Band Edge Frequency	Measured Field Strength (dB μ V/m)		Limit (dB μ V/m)		Margin (dB)	
		Peak Detector	Average Detector	Peak Det	Average Det	Peak Det	Average Det
2402 MHz GFSK	2390 MHz	53.3	/	74	54	20.7	/
2480 MHz GFSK	2483.5 MHz	52.3	/			21.7	/

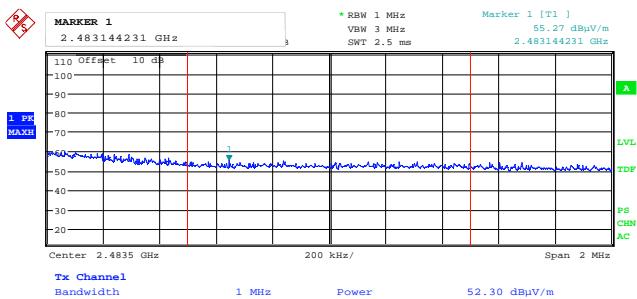
The measured Peak values are below the Average Limit.

See attached plots.



Date: 10.NOV.2020 15:20:07

Lower Band Edge 2402 MHz, GFSK, Peak



Date: 10.NOV.2020 15:13:11

Upper Band Edge 2480 MHz, GFSK, Peak

3.7 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

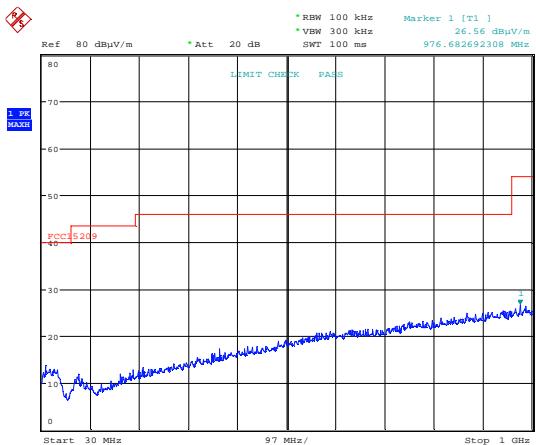
Tested in speech mode with active connection

Measured Frequency (MHz)	Carrier Frequency (MHz)	Modulation	Measured Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
30 – 88	2440	GFSK, 1Mb	< 20	40.0	> 20
88 – 216	2440	GFSK, 1Mb	< 20	43.5	> 23
216 – 960	2440	GFSK, 1Mb	< 26	46.0	> 20
960 – 1000	2440	GFSK, 1Mb	< 30	54.0	> 24

See attached plots

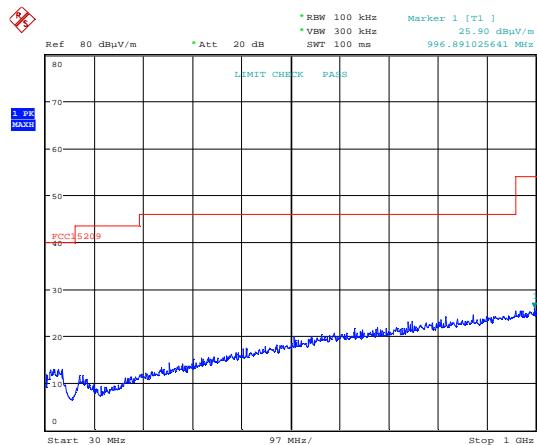
Requirements/Limit

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 μ V/m	40.0 dB μ V/m
88 – 216 MHz	150 μ V/m	43.5 dB μ V/m
216 – 960 MHz	200 μ V/m	46.0 dB μ V/m
960 – 1000 MHz	500 μ V/m	54.0 dB μ V/m
Limits above are with Quasi Peak Detector		



Date: 10.NOV.2020 13:07:53

Radiated Emissions 30 - 1000 MHz, HP



Date: 10.NOV.2020 13:00:44

Radiated Emissions 30 - 1000 MHz, VP

3.8 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)

A pre-scan was performed above 18 GHz and no spurious emissions were detected.

Peak Detector, RBW=1 MHz

Carrier freq. (MHz)	Measured Frequency (GHz)	Modulation	Measured Emissions (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2402	Any	GFSK, 1Mbit	< 60	74	> 14
2440	Any	GFSK, 1Mbit	< 60	74	> 14
2480	Any	GFSK, 1Mbit	< 60	74	> 14

Average Detector, RBW=1 MHz

Carrier freq. (MHz)	Measured Frequency (GHz)	Modulation	Measured Emissions (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2402	Any	GFSK, 1Mbit	< 44	54	> 10
2440	Any	GFSK, 1Mbit	< 44	54	> 10
2480	Any	GFSK, 1Mbit	< 44	54	> 10

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

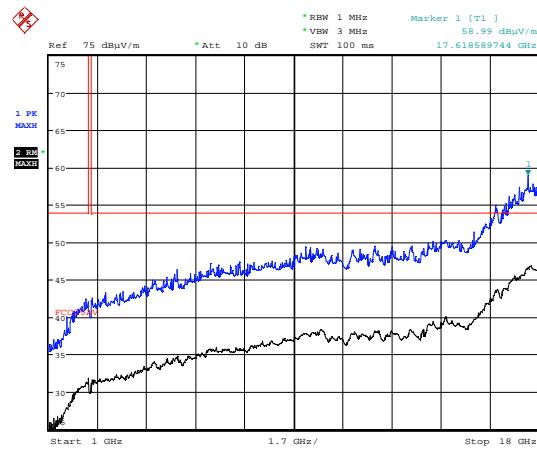
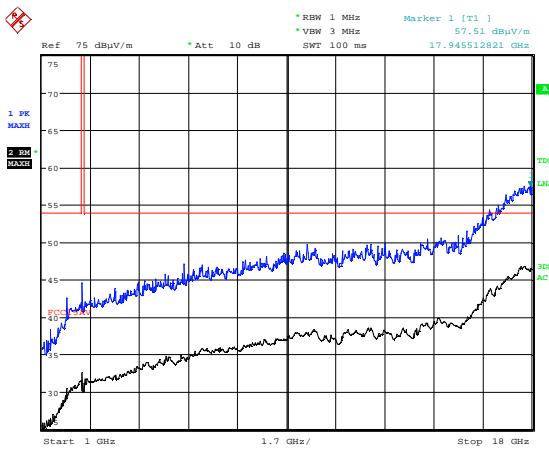
A Band Reject Filter was used for measurements from 1 GHz to 18 GHz

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

See plots

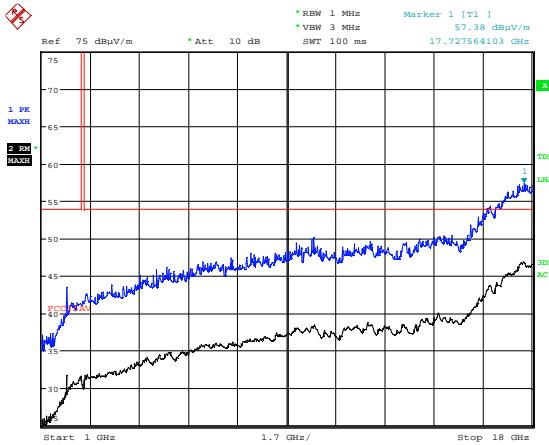
Requirements/Limit

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 dB μ V/m	74.0 dB μ V/m



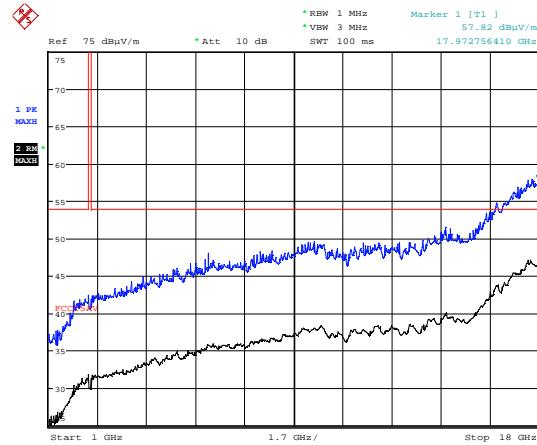
Date: 10.NOV.2020 17:02:44

Radiated Emissions 1 - 18 GHz, 2402 MHz, GFSK, HP



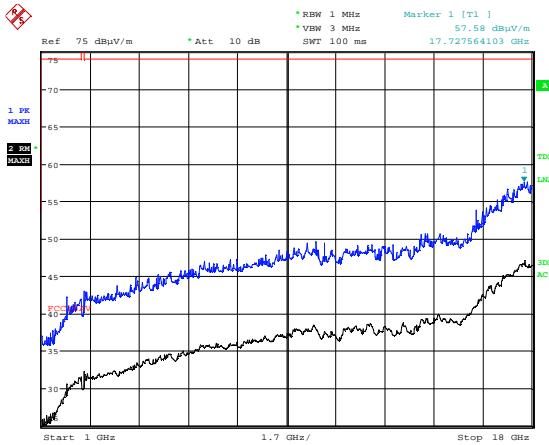
Date: 10.NOV.2020 17:00:44

Radiated Emissions 1 - 18 GHz, 2402 MHz, GFSK, VP



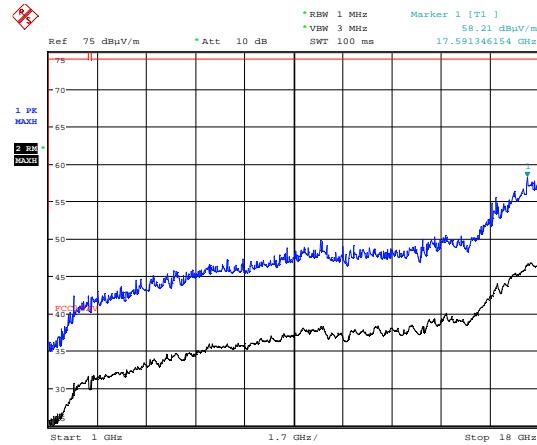
Date: 10.NOV.2020 16:49:29

Radiated Emissions 1 - 18 GHz, 2440 MHz, GFSK, HP



Date: 10.NOV.2020 16:37:21

Radiated Emissions 1 - 18 GHz, 2440 MHz, GFSK, VP

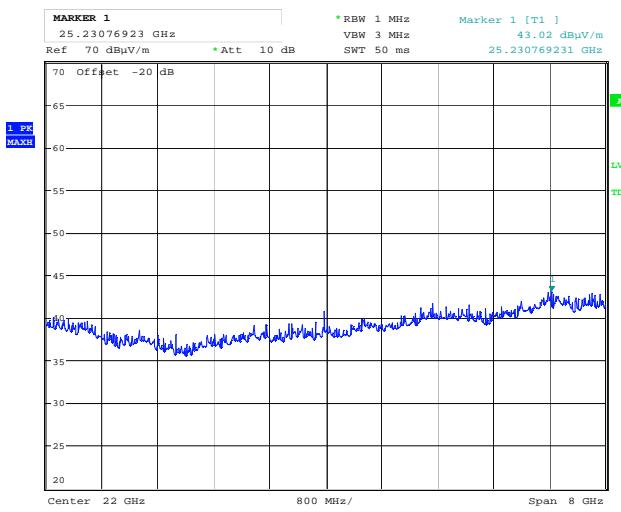


Date: 10.NOV.2020 17:09:23

Radiated Emissions 1 - 18 GHz, 2480 MHz, GFSK, HP

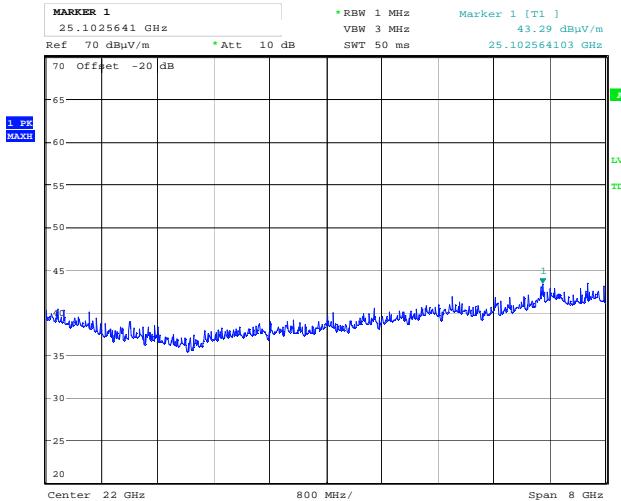
Date: 10.NOV.2020 17:07:23

Radiated Emissions 1 - 18 GHz, 2480 MHz, GFSK, VP



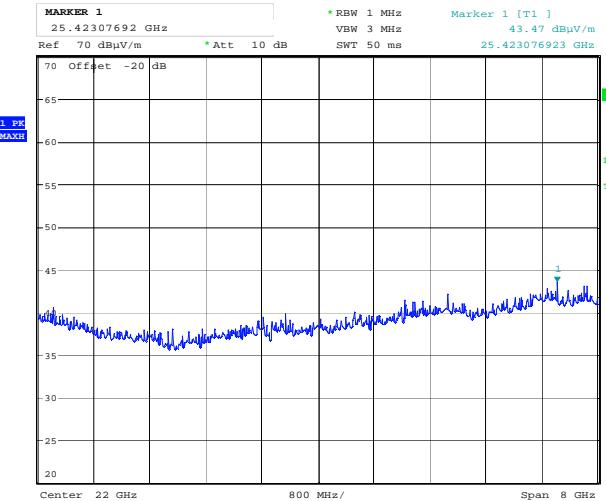
Date: 11.NOV.2020 11:28:25

Pre-scan 18 - 26 GHz, 2402 MHz, GFSK, @approx 10cm



Date: 11.NOV.2020 11:25:30

Pre-scan 18 - 26 GHz, 2440 MHz, GFSK, @approx 10cm



Date: 11.NOV.2020 11:30:25

Pre-scan 18 - 26 GHz, 2480 MHz, GFSK, @approx 10cm

3.9 Power Spectral Density (PSD)

FCC part 15.247(d)

ISED Canada RSS-247 Issue 2, Clause 5.2 (2)

Measurement procedure: ANSI C63.10-2013 Clause 11.10

Test Results: Complies

Measurement Data:

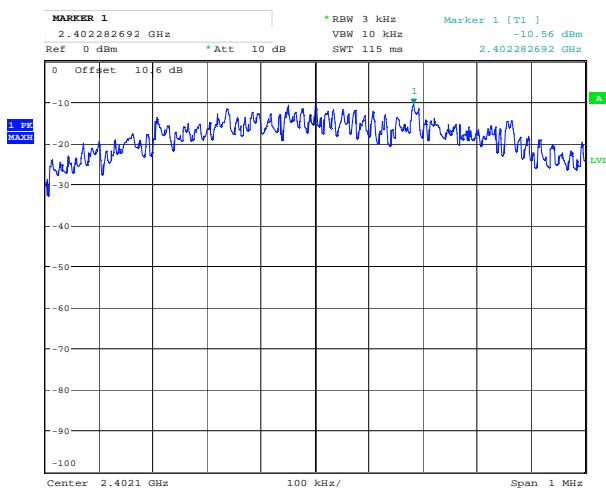
The measurement procedure PKPSD described in ANSI C63.10-2013 was used.

Modulation Type	Measured Power Spectral Density (dBm/3kHz)		
	2402 MHz	2440 MHz	2480 MHz
GFSK, 1Mb	-10.5	-8.6	-10.3

Requirements:

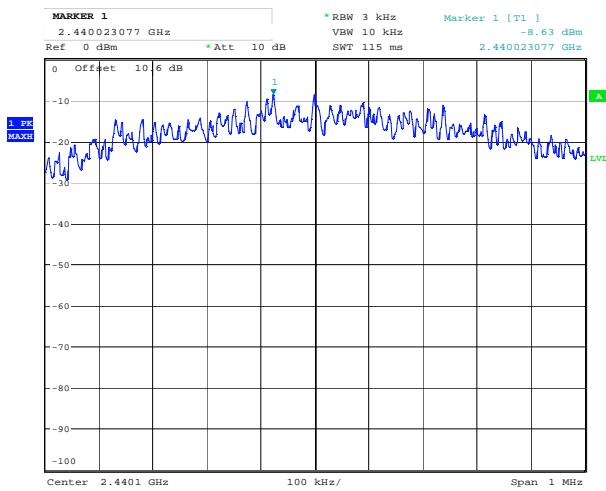
The Power Spectral Density of a Digital Transmission System shall be no greater than +8 dBm in any 3 kHz band

No requirements for Frequency Hopping Systems.



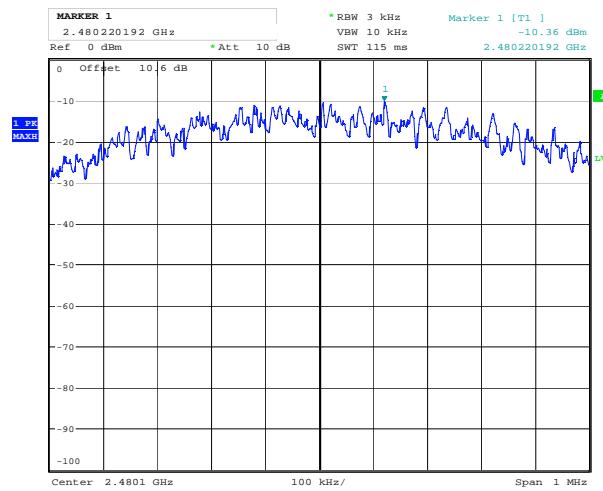
Date: 11.NOV.2020 13:57:40

PSD, 2402 MHz, GFSK



Date: 11.NOV.2020 14:00:51

PSD, 2440 MHz, GFSK



Date: 11.NOV.2020 14:03:58

PSD, 2480 MHz, GFSK

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.

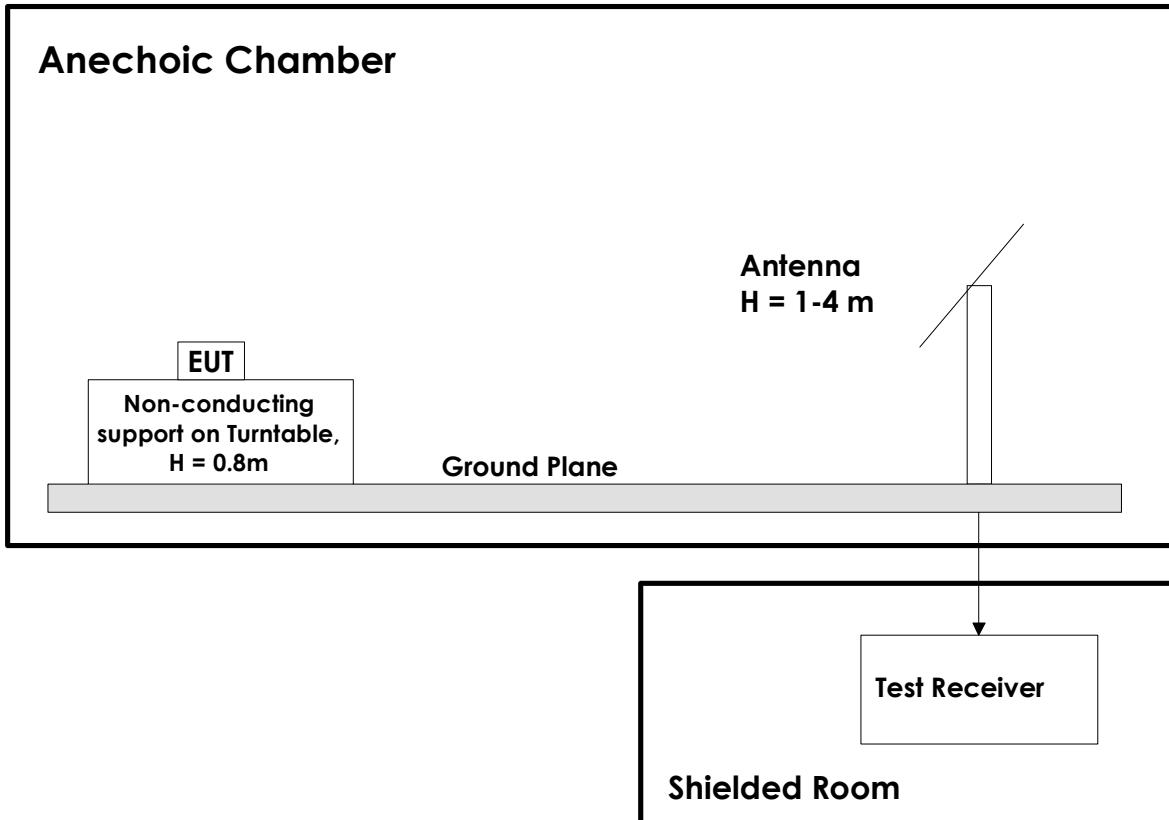
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	FSU26	Spectrum Analyzer	Rohde & Schwarz	LR 1502	2020-01	2021-01
2	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2020-01	2021-01
3	6810.17B	Attenuator	Suhner	LR 1669	2020-08	2021-08
4	NO324415	Band Reject Filter	Microwave Circuits	LR 1760	COU	
5	VULB 9163	BiLog Antenna	Schwarzbech	LR 1616	2020-01	2023-01
6	317	Preamplifier	Sonoma Inst.	LR 1687	2020-08	2021-08
7	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2017-12	2020-12
8	WLK5-1100-1485-7000-40SS	Low Pass Filter	Wainwright Inst.	LR 1761	COU	
9	638	Antenna Horn	Narda	LR 1480	2010-06	2030-06
10	8449A	Preamplifier	Hewlett Packard	N		
11	ST18/SMA/N/36	RF Cable	Suhner	LR 1627	COU	

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

No.	Manufacturer	Name	Version	Comment
1	Nemko AS	RSPlot	1.0.10.0	Screenshots from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 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 High-Pass or Band-Pass filter is used for all harmonics.