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Confidential Report

Project No.	**23E10540-1b**
Quotation	**Q23-1805-1**
Prepared For	**Sensoteq Ltd**
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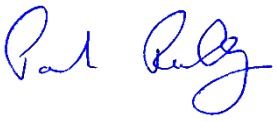
Tested By	**Joy Dalayap**
Test Report By	**Michael Kirby**
FCC Designation Number	**IE0002**
ISED CAB identifier:	**IE0001**
Date	**18th Dec 2023**
EUT Description	**Sensor**
FCC ID	**2ANL3SPR433TA**
IC ID	**23633-SPR433TA**
Authorised by	**Paul Reilly**
Authorised Signature:	

TEST SUMMARY

The equipment complies with the requirements according to the following standards.

FCC Part Section(s)	Industry Canada	TEST PARAMETERS	Test Result
15.231(e) 15.35	RSS-210 A1.4 RSS-Gen 6.10	Duty Cycle	PASS
15.231(e) 15.209	RSS-210 A1.4 RSS-210 8.9	Radiated Emissions	PASS
15.231(c)	RSS-210 A1.3	20dB Bandwidth 99% Bandwidth	PASS

RSS 210 Issue 10 Dec 2019 (Amd Apr 2020)
RSS-Gen Issue 5 Apr 2018 (Amd 1 Mar 2019) (Amd 2 Feb 2021)

Contents

1. EUT Description

Type of radio:	Standalone
Transmitter Type:	FSK
Operating Frequency Range(s):	433.4 MHz
Number of Channels:	1
Antenna:	Internal trace pcb antenna
Transmitter power configuration:	3V6
Classification:	DXX
HVIN:	WMVM
PMN:	WMVM
FVIN:	4.0
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013

The Hose/Spool Monitoring (WMVM) sensor is used to continuously monitor the condition of rubber hoses, within the mining industry, for the transferring of minerals. Wear of the hoses is detected using two copper wires placed within different construction layers of the hose section. Wear indicated remotely via RF and locally by an LED light.

The EUT was a sensor which communicated data via RF link in the 433MHz Band. It also contained a pre-certified BLE module for commissioning.
The EUT was powered from its 3.6V Lithium internal battery.
The EUT was potted.

There are 2 mounting options

a) a hose interface (supplied with sensor as a Hose Sensor Kit under order code WM-K0H)
b) a spool interface (supplied with sensor as a Spool Sensor Kit under order code WM-K0P)

This report covers the 433.4 MHz radio operating on its own.
Ref report 23E10540-2a for testing with 433.4MHz and BLE operating together.

1.1. EUT Operation

Operating Conditions during Test:

The equipment under test was operated during the measurement under the following conditions:

The EUT was programmed to operate in test mode (un modulated CW mode) was used for all tests except duty cycle and bandwidth.

The duty cycle test was performed with test firmware programmed to operate at the highest duty cycle possible.
Note all tests were performed as radiated on EUT labelled “5bdecf” on both mounting options.
Worst case results are reported here.

The EUT was powered from battery and a new battery was used for tests.

433 Radio for transmission of data
:

2-FSK modulation
9600bps baud rate
Forward error correction enabled

Frame table (bits):

2 identical frames of information transmitted for redundancy

Preamble	Sync	Type	Len	Payload	Diag
4	4	1	1	7	2

The host pcb controller

Environmental conditions:

During the measurement the environmental conditions were within the listed ranges:

Temperature: +20 to +24 ° C
Humidity: +38 to +43 %

1.2. Modifications

No modifications were required in order to pass the test specifications.

1.3. Date of Test

The tests were carried out on one sample of the EUT on 28th ,29th ,30th Jun and 5th Jul 2023

1.4 Measurement Uncertainty

The measurement uncertainty (with a 95% confidence level) for the conducted emissions test was ±3.5 dB.
The measurement uncertainty (with a 95% confidence level) for the radiated emissions test was ±5.3 dB (from 30 to 100 MHz), ±4.7 dB (from 100 to 300 MHz), ±3.9 dB (from 300 to 1000 MHz) and ±3.8 dB (from 1 GHz to 40 GHz).

1.5 Special Test Software

Tests were performed manually, and no special test software was used.

2. Emissions Measurements

2.1. Conducted Emissions Measurements

Test not performed as EUT is powered from a 3.6V battery.

2.2. Radiated Emissions Measurements

Radiated Power measurements were made at the Compliance Engineering Ireland Ltd anechoic chamber located in Dunshaughlin, Co. Meath, Ireland to determine the radio noise radiated from the EUT. A "Description of Measurement Facilities" has been submitted to the FCC and approved pursuant to Section 2.948 of CFR 47 of the FCC rules.

2.2.1. General

Emissions below 1GHz were measured using resolution bandwidth 100kHz at a measurement distance of 3 metres with EUT on a motorised turntable which allowed 360 degrees rotation.

Emissions above 1GHz were measured with resolution bandwidth of 1MHz at a measurement distance of 3 metres with EUT on a motorised turntable which allowed 360 degrees rotation.

2.2.2. Measurements in Transmit mode

A Radiated Emission pre-scan was performed which covered the x, and y orientations in horizontal and vertical polarizations. In each case the emission was maximised.
The result of this pre-scan showed that the highest emission for vertical polarization was with the EUT vertical (orientation O1).
The EUT in a horizontal (orientation2 O2) gave the highest emissions for horizontal polarization.
A full scan for radiated emission was performed in orientation O1 for vertical polarization and in orientation O2 for horizontal polarization.

The radiated emissions were maximised by configuring the EUT, by rotating the EUT, and by raising and lowering the antenna from 1 to 4 metres.
Significant peaks from the EUT were then recorded to determine margin to the limits.

Tests were carried out as per Ansi C63.10 -2013

Antenna Requirements

According to FCC 47 CFR 15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

*The antenna of this EUT is permanently attached.

*The EUT Complies with the requirement of 15.203.

2.3. Occupied Bandwidth

Requirement - 15.231 (c) & IC RSS-210 A1.3

The bandwidth of the emission shall be no wider than 0.25% of the centre frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz. the emission shall be no wider than 0.5% of the centre frequency. Bandwidth is determined at the points 20dB down from the modulated carrier.

TEST PROCEDURE

RESULTS

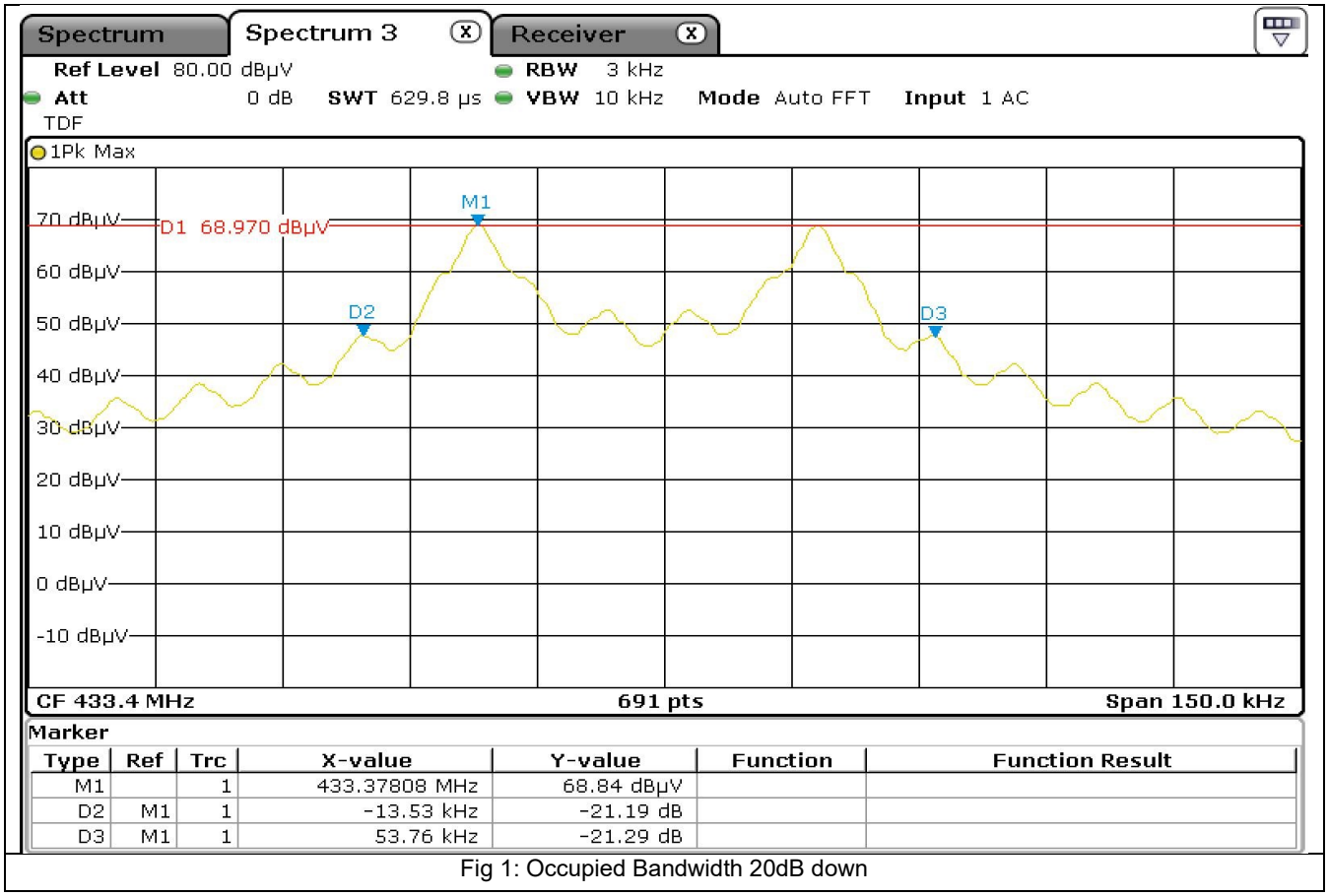


Fig 1: Occupied Bandwidth 20dB down

Operating Frequency	20dB Bandwidth	Limit	Margin	Result
MHz	KHz	KHz	KHz	
433.4	67.15	1083.5	1066.15	Pass

Test Result Pass

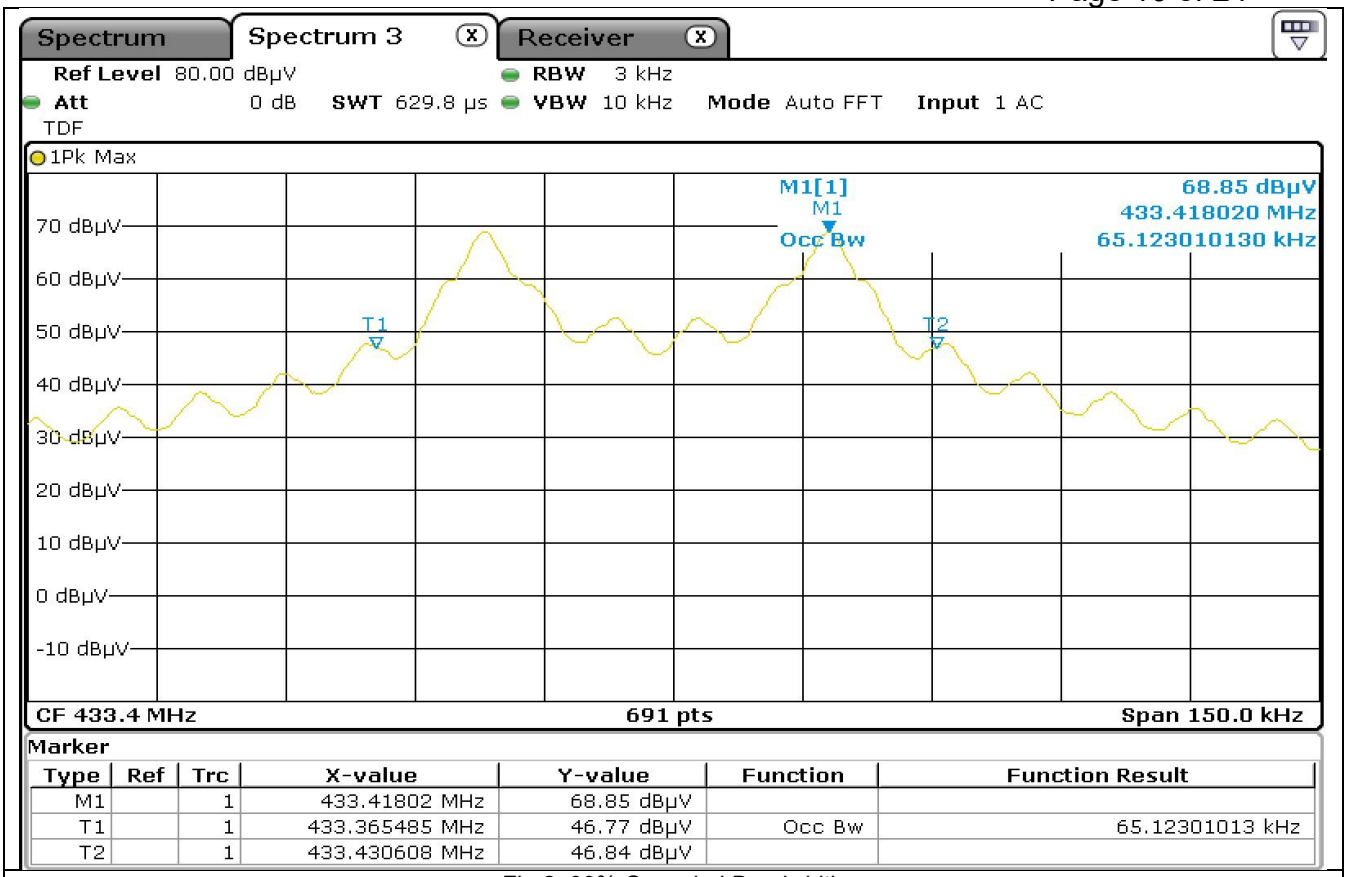


Fig 2: 99% Occupied Bandwidth

Operating Frequency	99% Bandwidth	Limit	Margin	Result
MHz	KHz	KHz	KHz	
433.4	65.12	1083.5	1018.38	Pass

Test Result Pass

3. MAXIMUM MODULATION PERCENTAGE (M%)/Duty cycle

LIMIT

Requirement 15.35 (c), 15.231(e), IC RSS210 A1.4 & IC RSS-Gen 6.10

The measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

TEST PROCEDURE

The transmitter output was connected to a spectrum analyzer or radiated field strength. The RBW was set to 100 kHz and the VBW is set to 300KHz. The sweep time was coupled, and the span was set to 0 Hz. The number of pulses was measured and calculated in a 100ms scan.

RESULTS

MAXIMUM MODULATION PERCENTAGE/Duty Cycle

One Period(mS)	Pulse Width (mS)	No of Pulses	Duty Cycle	20 log duty cycle (dB)	Duty Cycle %	Test Result
100	**40.58**	**1**	**0.4058**	**-7.83**	**40.6**	**Pass**

CALCULATION

Average Reading = Peak Reading dB(µV/m) +20log (Duty Cycle),
*where Duty Cycle is (No of pulses*pulse width)/100 or T*
Note correction for pulse mode operation is:

20 log duty cycle (dB)
-7.83

15.231e duty cycle limits
The duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds

Result

Duration of each transmission = 81.16mS	Limit <1sec	Comply
Silent period between transmissions 15.94Secs	Limit >10secs	Comply

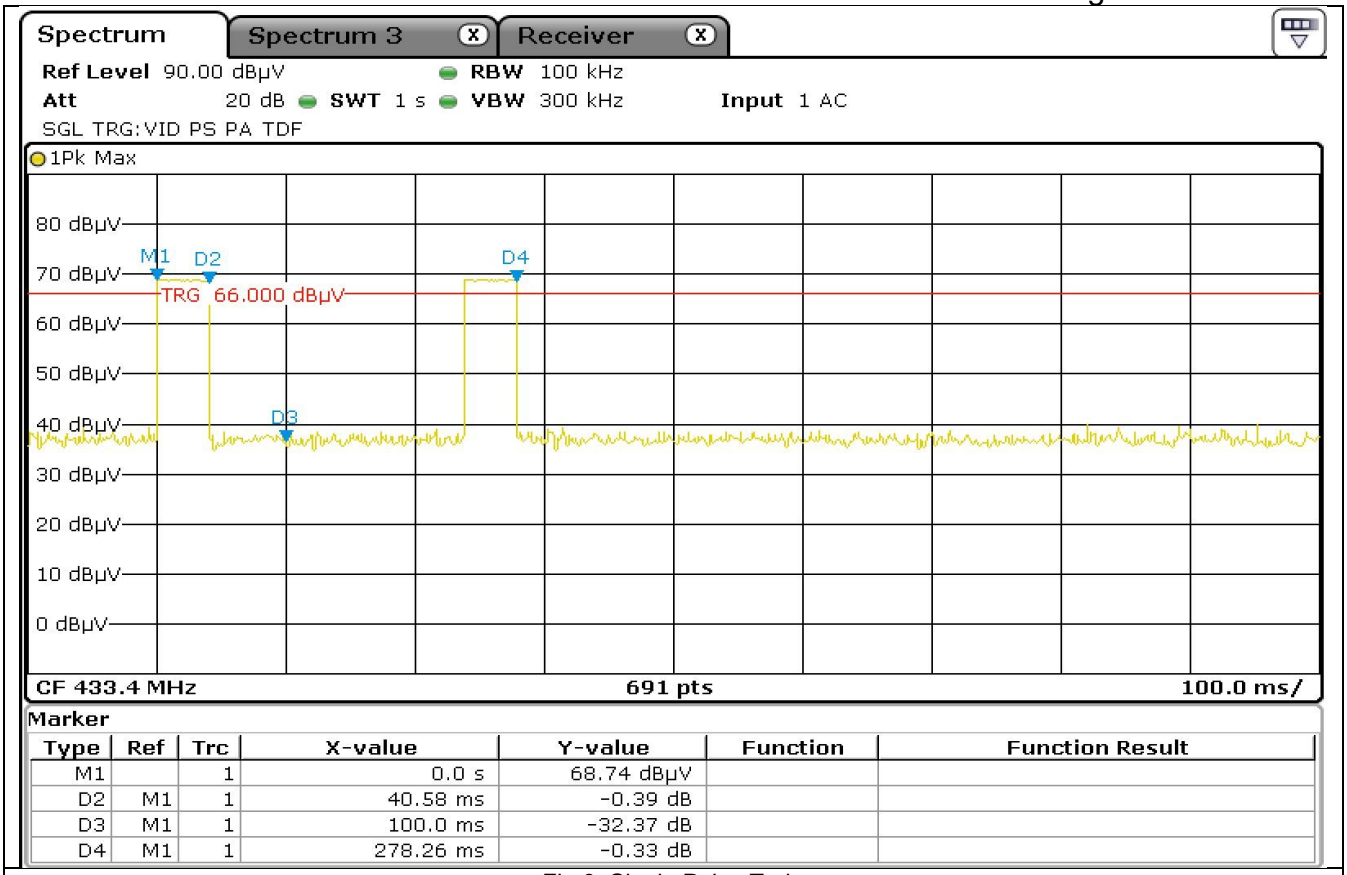


Fig 3: Single Pulse Train

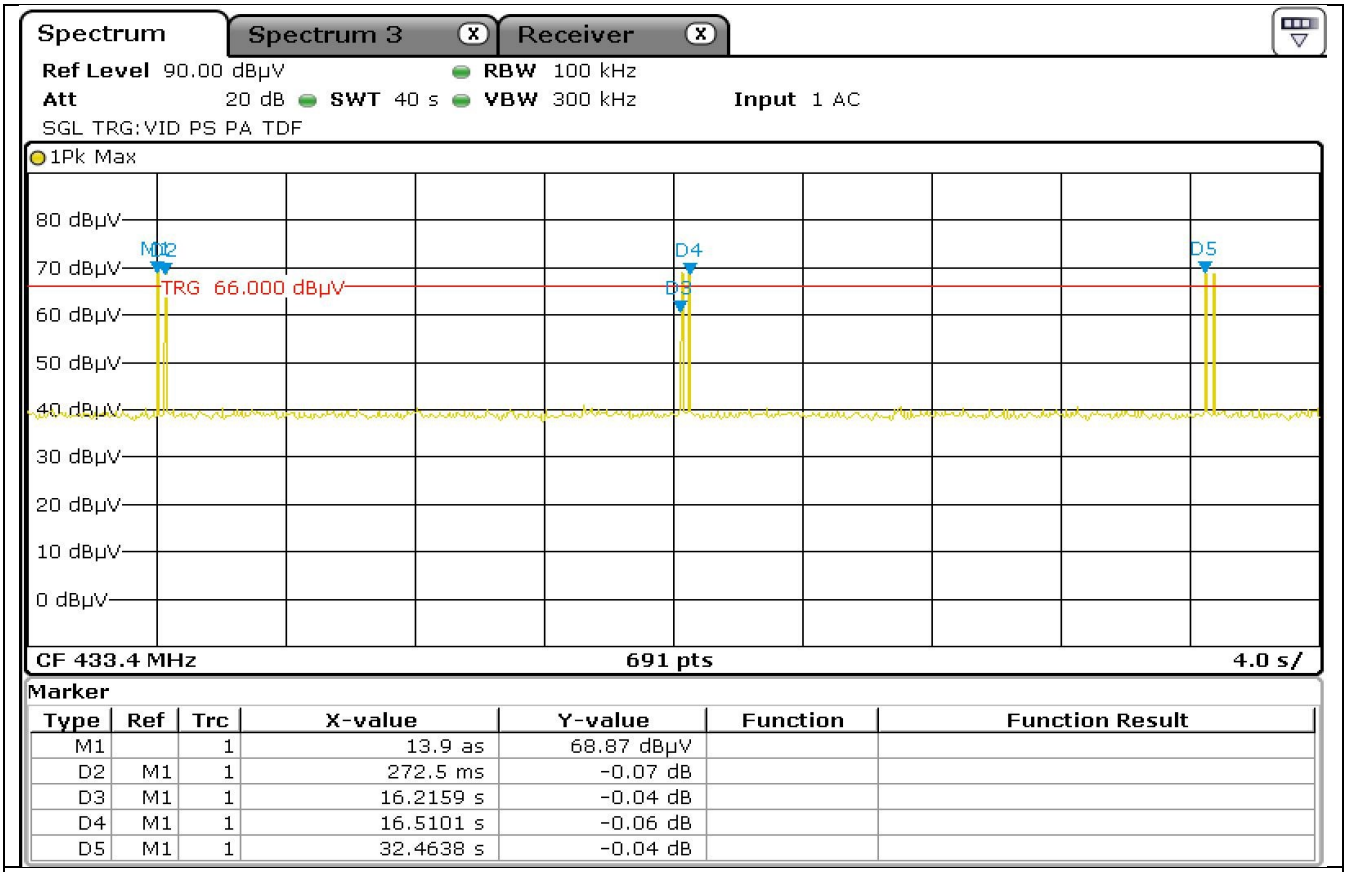


Fig 4: Pulse Repetition Rate Transmitted Pulses

4. Field Strength of Radiated Emissions

Test Specification: FCC 15.231(e) and RSS-210 A1.4

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emission (microvolts/meter)
40.66–40.70	1,000	100
70–130	500	50
130–174	500 to 1,500[1]	50 to 150[1]
174–260	1,500	150
260–470	1,500 to 5,000[1]	150 to 500[1]
Above 470	5,000	500

[1] Linear interpolations.

Interpolation Formula = 16.67 x Freq MHz - 2833.33

For operating frequency of 433.4 MHz the following limits apply (using interpolation formula above)

Fundamental Frequency	Field Strength of fundamental	Field Strength of fundamental	Field Strength of Spurious Emissions	Field Strength of Spurious Emissions
MHz	µV/m	dBµV/m	µV/m	dBµV/m
433.400	4391.778	72.853	439.178	52.853

Test Specification: FCC PART 15, SECTION 47 CFR 15.209, RSS Gen 8.9

Frequency (MHz)	Field Strength (µV/m)	Field Strength (dBµV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
Above 960	500	54.0

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., Sections 15.231 and 15.241

Duty cycle correction = 20Log (duty cycle) dB
Duty Cycle correction for Average measurement of pulsed signal = Peak -7.83dB
as per ANSI C63.10-2013 Section 7.5

Results for Radiated Emissions

Test Specification: FCC 15.231(e) and RSS-210 A1.4

Appendix A shows the results of the scans in the anechoic chamber.

4.1.1. Fundamental Measurements (30MHz to 1GHz)

Frequency	Reading Peak	EUT Orientation	Antenna Polarity	Antenna Factor	Preamp Gain	Cable loss	Final Field Strength Peak	Average Limit	Margin for Peak v Average Limit +20dB	Result
MHz	dBuV/m		V/H	dB	dB	dB	dBuV/m	dBuV/m	dB	P/F
433.400	43.6	O1	Vertical	16.9	0	3.3	63.8	72.9	29.1	Pass
433.400	48.8	O2	Horizontal	16.9	0	3.3	69.0	72.9	23.9	Pass

Calculation example
Final Field Strength Peak (dBuV/m) =Reading Peak (dBuV/m) + Antenna Factor (dB)- Pre-amp Gain (dB) +Cable Loss (dB)
69 = 48.8+16.9 – 0 + 3.3

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 7.83dB Duty Cycle factor)	Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
433.400	63.8	O1	Vertical	55.9	72.9	17	Pass
433.400	69.0	O2	Horizontal	61.1	72.9	11.8	Pass

Calculation example
Average Level (dBuV/m)=Final Field Strength Peak (dBuV/m) + Duty cycle factor (dB)
61.1 = 69 - 7.8

Test Result: Pass

4.1.2. Harmonics Spurious Emissions Measurements (30MHz to 1GHz)

Test Specification: FCC 15.231(e) and RSS-210 A1.4

Frequency	Reading Peak	EUT Orientation	Antenna Polarity	Antenna Factor	Preamp Gain	Cable loss	Final Field Strength Peak	Average Limit	Margin for Peak v Average Limit +20dB	Result
MHz	dBuV/m		V/H	dB	dB	dB	dBuV/m	dBuV/m	dB	P/F
866.800	2.1	O1	Vertical	23.4	0	5.3	30.8	52.9	42.1	Pass
866.800	5.0	O2	Horizontal	23.4	0	5.3	33.7	52.9	39.2	Pass

Calculation example
Final Field Strength Peak (dBuV/m) =Reading Peak (dBuV/m) + Antenna Factor (dB)- Pre-amp Gain (dB) +Cable Loss (dB)
33.7 = 5+23.4+0+5.3

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 7.8dB Duty Cycle factor)	Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
866.800	30.8	O1	Vertical	23.0	52.9	29.9	Pass
866.800	33.7	O2	Horizontal	25.9	52.9	27	Pass

Calculation example
Average Level (dBuV/m)=Final Field Strength Peak (dBuV/m) + Duty cycle factor (dB)
25.9 =33.7 - 7.8

Test Result: Pass

4.1.3. Harmonics Spurious Emissions Measurements (above 1GHz)

Test Specification: FCC 15.231(e) and RSS-210 A1.4

Frequency	Reading Peak	EUT Orientation	Antenna Polarity	Antenna Factor	Preamp Gain	Cable loss	Final Field Strength Peak	Average Limit	Margin for Peak v Average Limit +20dB	Result
GHz	dBuV/m		V/H	dB	dB	dB	dBuV/m	dBuV/m	dB	P/F
1.300	11.8	O1	Vertical	25.3	0	3.5	40.6	52.9	32.3	Pass
1.734	10.1	O1	Vertical	26.8	0	4	40.9	52.9	32.0	Pass
2.167	11.4	O1	Vertical	27.9	0	4.6	43.9	52.9	29.0	Pass
2.600	13.1	O1	Vertical	29	0	5.1	47.2	52.9	25.7	Pass
3.034	13.1	O1	Vertical	30.3	0	5.4	48.8	52.9	24.1	Pass
3.467	15.3	O1	Vertical	31.3	0	6	52.6	52.9	20.3	Pass
3.901	46.2	O1	Vertical	32.9	38.3	6.1	46.9	52.9	26.0	Pass
4.334	46.6	O1	Vertical	32.2	38.3	6.6	47.1	52.9	25.8	Pass
1.300	17.8	O2	Horizontal	25.3	0	3.5	46.6	52.9	26.3	Pass
1.734	11.2	O2	Horizontal	26.8	0	4	42.0	52.9	30.9	Pass
2.167	12.2	O2	Horizontal	27.9	0	4.6	44.7	52.9	28.2	Pass
2.600	13.7	O2	Horizontal	29	0	5.1	47.8	52.9	25.1	Pass
3.034	13.1	O2	Horizontal	30.3	0	5.4	48.8	52.9	24.1	Pass
3.467	15.8	O2	Horizontal	31.3	0	6	53.1	52.9	19.8	Pass
3.901	47.1	O2	Horizontal	32.9	38.3	6.1	47.8	52.9	25.1	Pass
4.334	44.9	O2	Horizontal	32.2	38.3	6.6	45.4	52.9	27.5	Pass

Calculation example
Final Field Strength Peak (dBuV/m) =Reading Peak (dBuV/m) + Antenna Factor (dB)- Pre-amp Gain (dB) +Cable Loss (dB)
45.4 =44.9+32.2-38.3+6.6

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 7.8dB Duty Cycle factor)	Average Limit	Margin	Result
GHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
3.467	53.1	O2	Horizontal	45.3	52.9	7.6	Pass

The Average level was not computed for peaks where the peak level was below the average limit (52.9 dBuV/m)

Calculation example
Average Level (dBuV/m)=Final Field Strength Peak (dBuV/m) + Duty cycle factor (dB)
45.3 =53.1 - 7.8

Test Result: Pass

5. List of Test Equipment

Instrument	Manufacturer	Model	Serial Num	CEI Ref	Cal Date	Cal Interval Months
Microwave Preamplifier	Hewlett Packard	83017A	3123A00175	805	30-Sep-22	12
Spectrum Analyser 30Hz-40GHz	Rohde& Schwarz	FSP40	100053	850	10-Dec-21	36
Test Receiver 3.6GHz	Rohde& Schwarz	ESR	1316.3003k03-101625-s	869	23-May-23	36
LISN	Rohde & Schwarz	ESH3-Z5	825460/003	604	09-Mar-22	36
Antenna Horn	EMCO	3115	9905-5809	655	21-Jan-22	24
Fully Anechoic Chamber	CEI	FAR 3M	906	906	23-Jul-22	36
Anechoic Chamber	CEI	SAR 10M	845	845	12-Sep-22	36
Antenna Biconical	Schwarzbeck	VHBB 9124	9124 667	871	06-Oct-21	36
Antenna Log Periodic	Chase	UPA6108	1072	609	09-Sep-21	36
Cable Ntype 20m				1213	15-May-23	12
Cable purple Ktype 1.8m				917	29-Jul-22	12
Cable Ntype 10m				914	29-Jul-22	12
Cable HF Ktype 1.5m				705	29-Jul-22	12

Appendix A: Scans for Radiated Spurious Emissions 433.4MHz transmitter

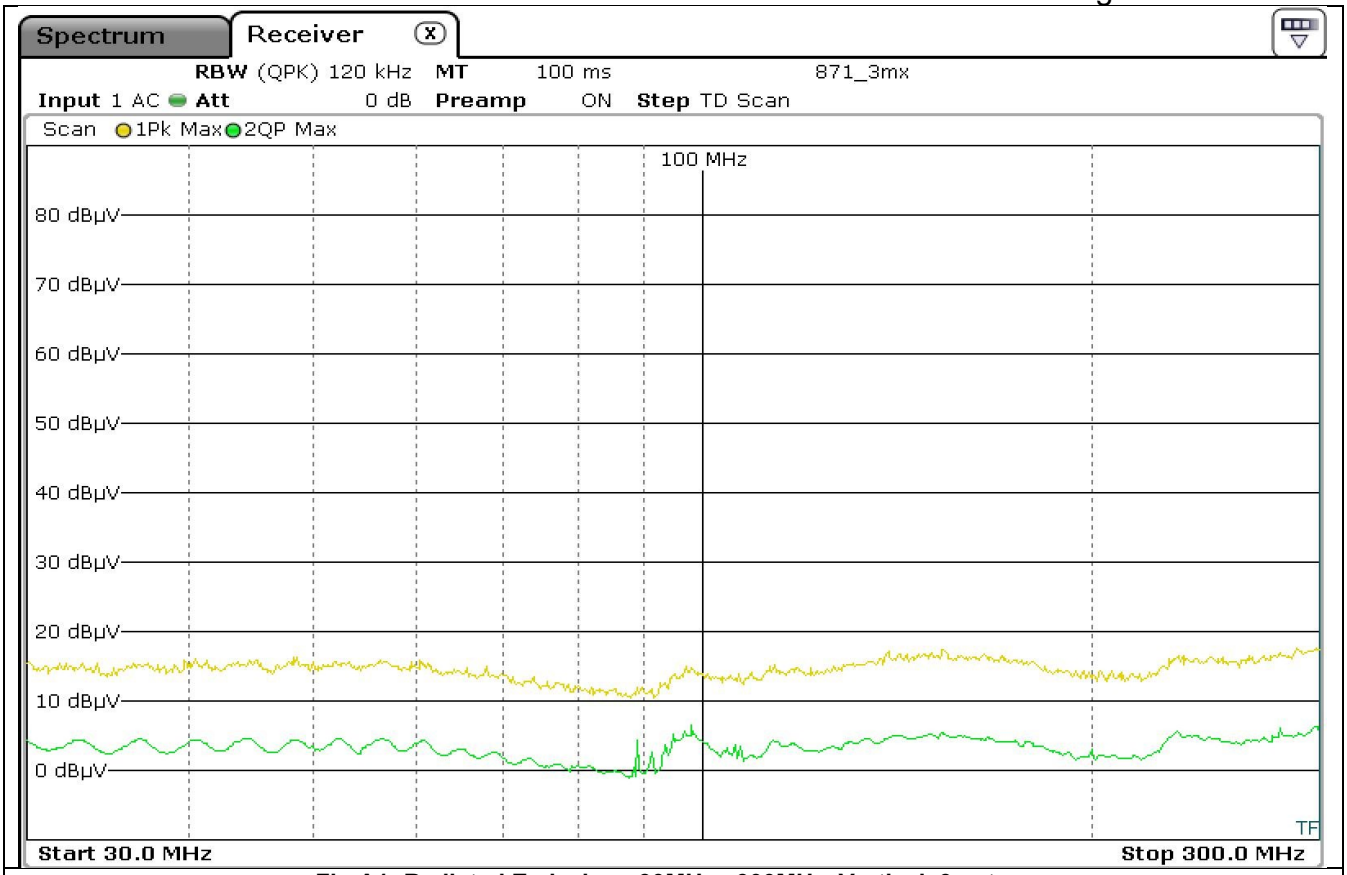


Fig A1: Radiated Emissions 30MHz - 300MHz, Vertical, 3metres

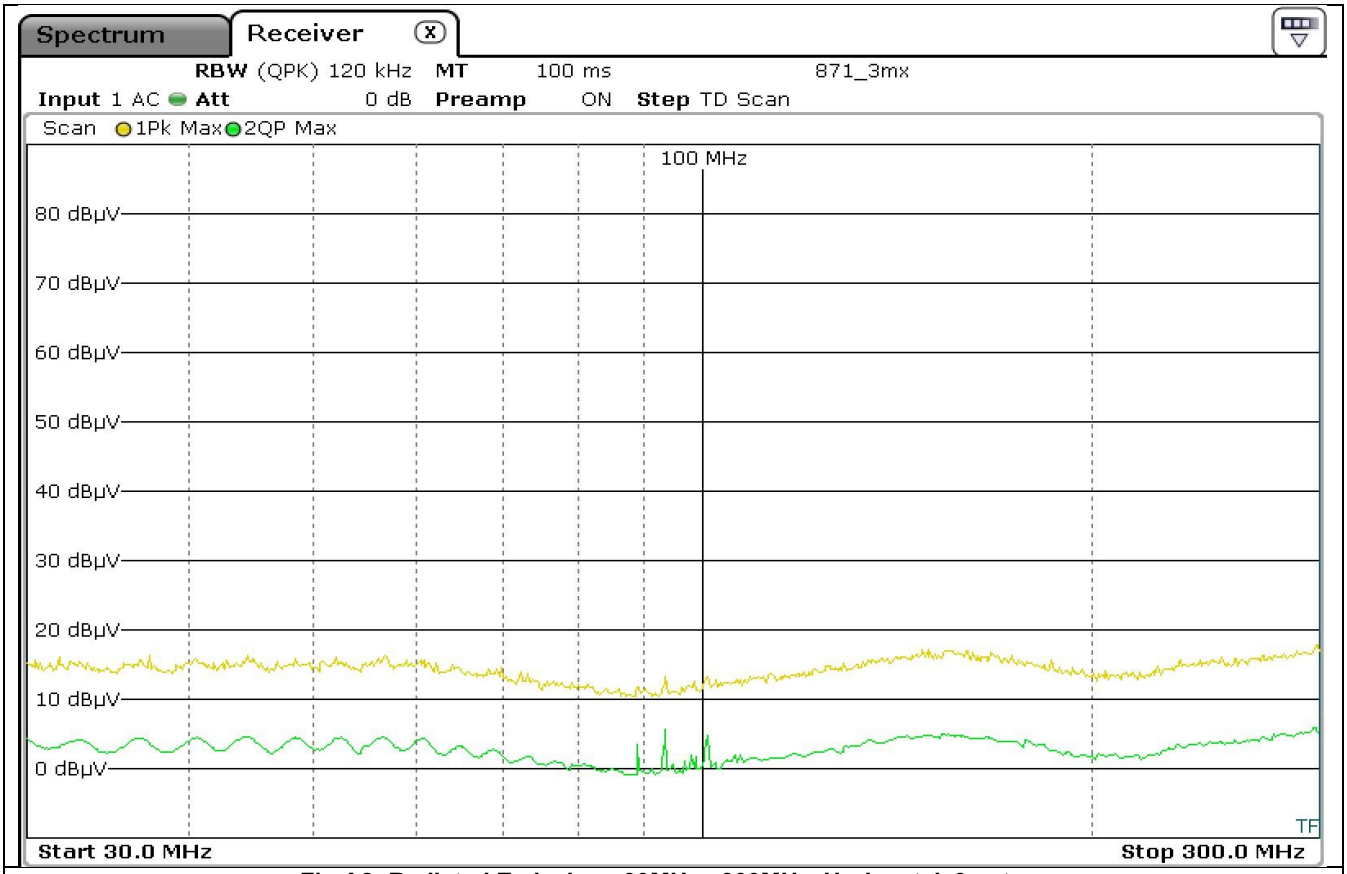


Fig A2: Radiated Emissions 30MHz - 300MHz, Horizontal, 3metres

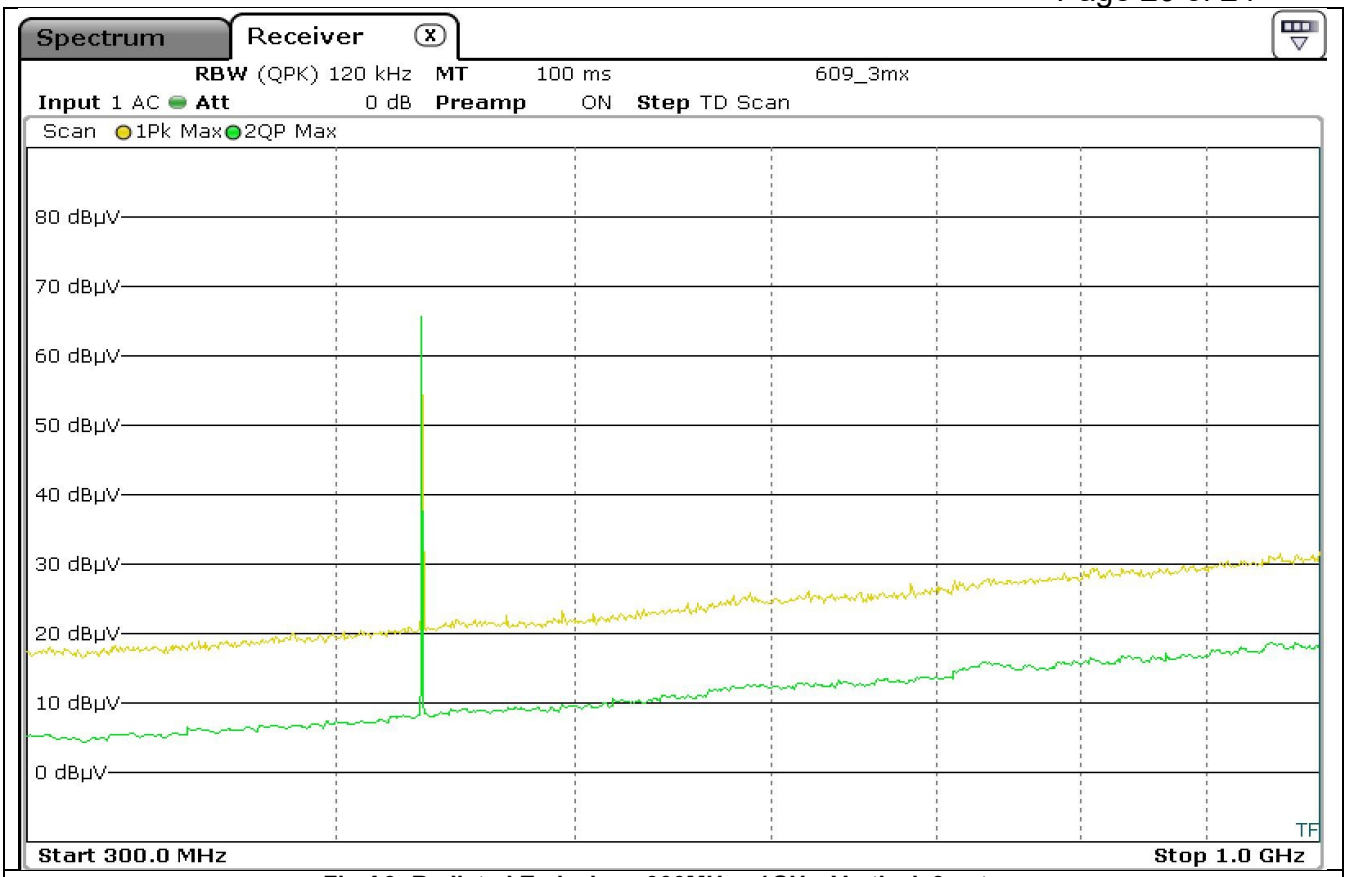


Fig A3: Radiated Emissions 300MHz - 1GHz, Vertical, 3metres

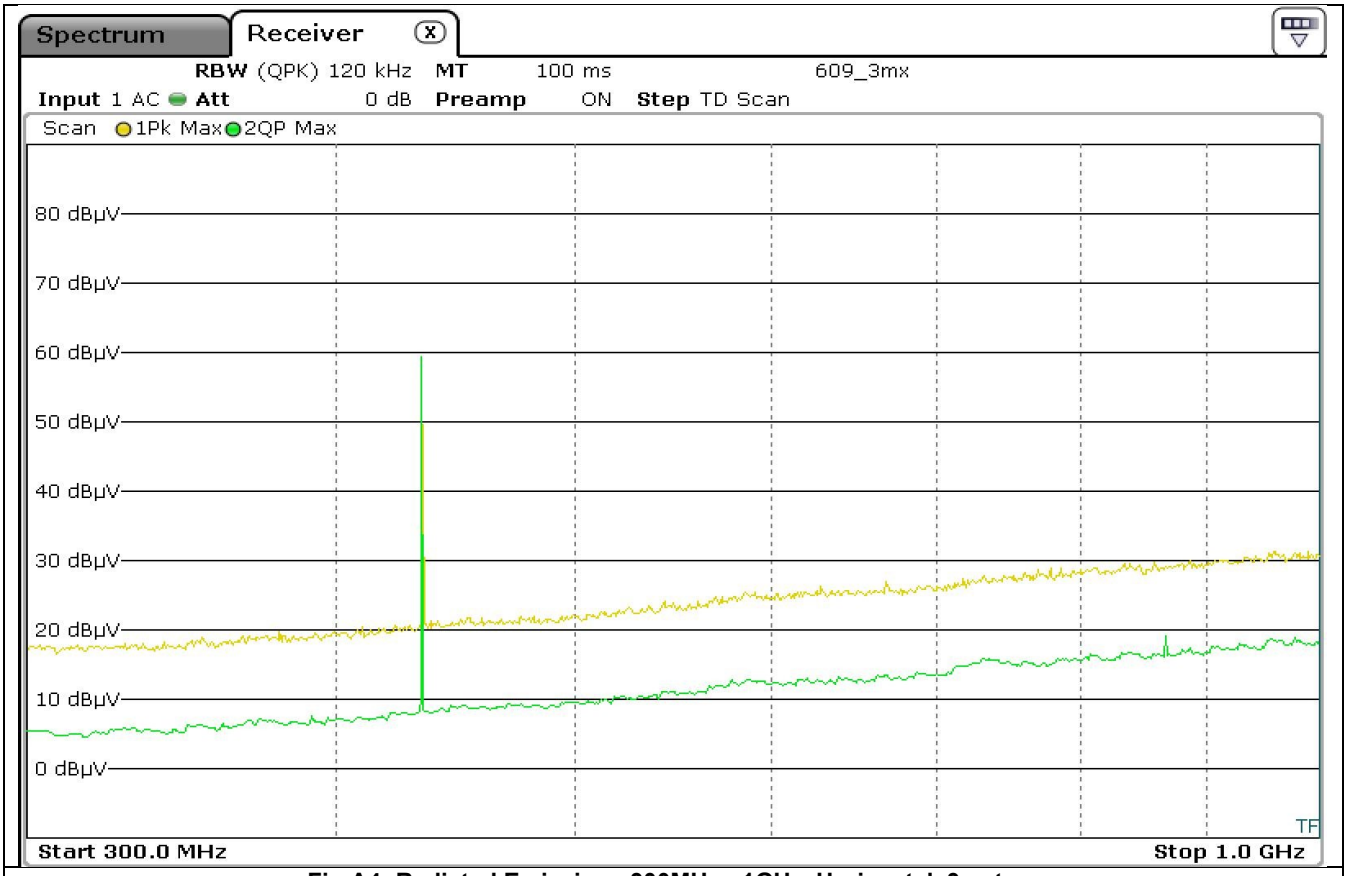


Fig A4: Radiated Emissions 300MHz - 1GHz, Horizontal, 3metres

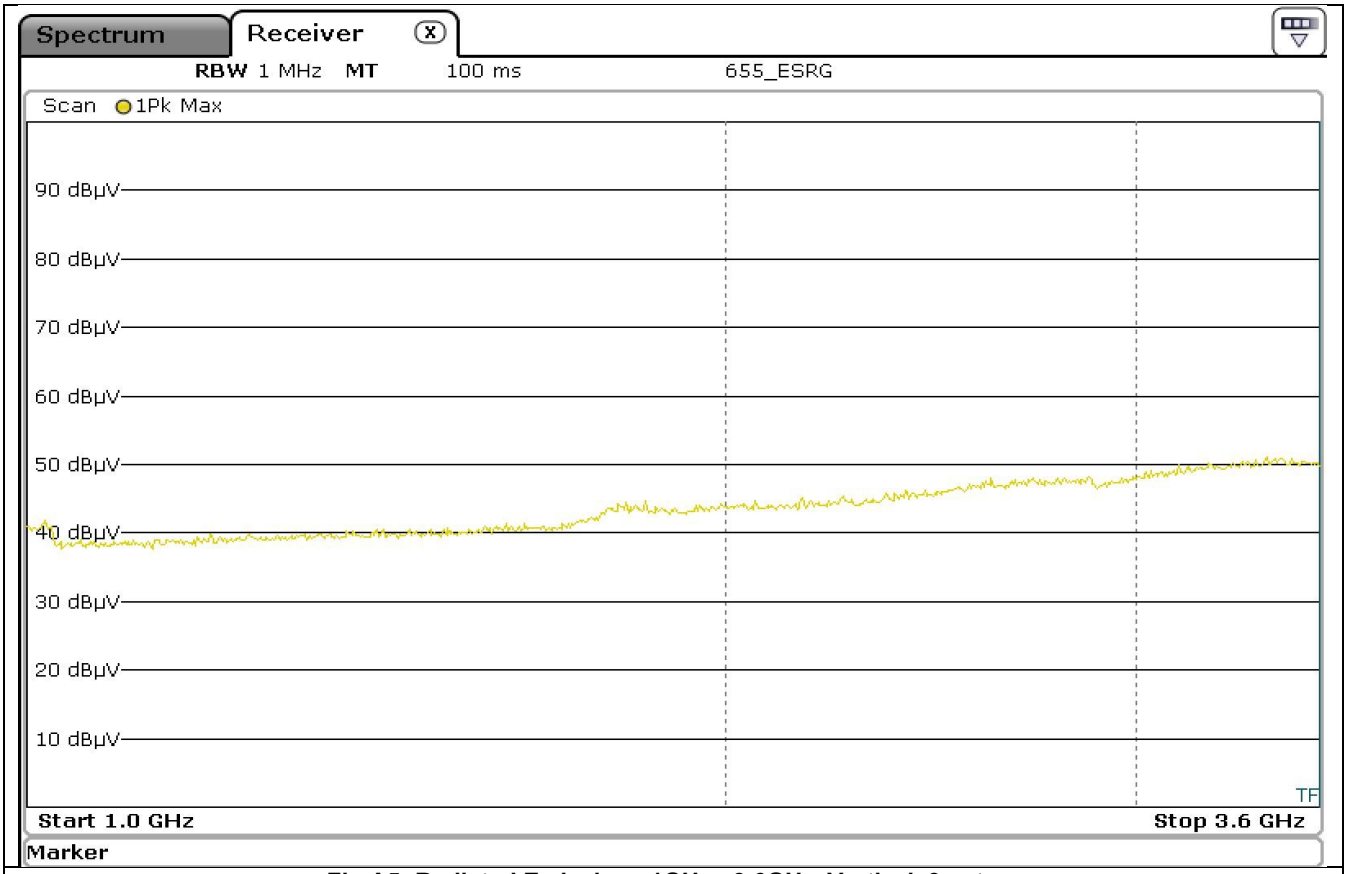


Fig A5: Radiated Emissions 1GHz - 3.6GHz, Vertical, 3metres

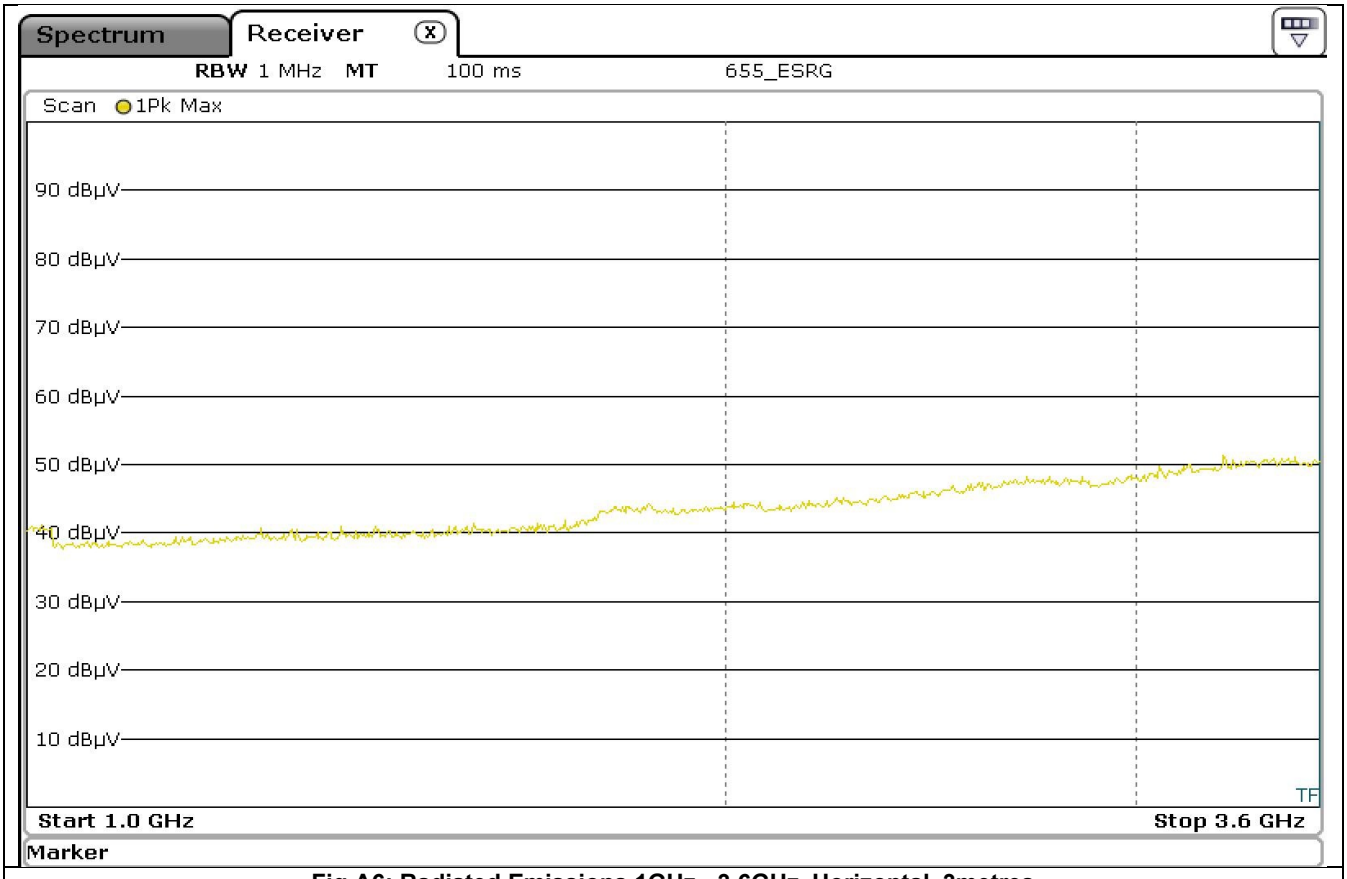


Fig A6: Radiated Emissions 1GHz - 3.6GHz, Horizontal, 3metres

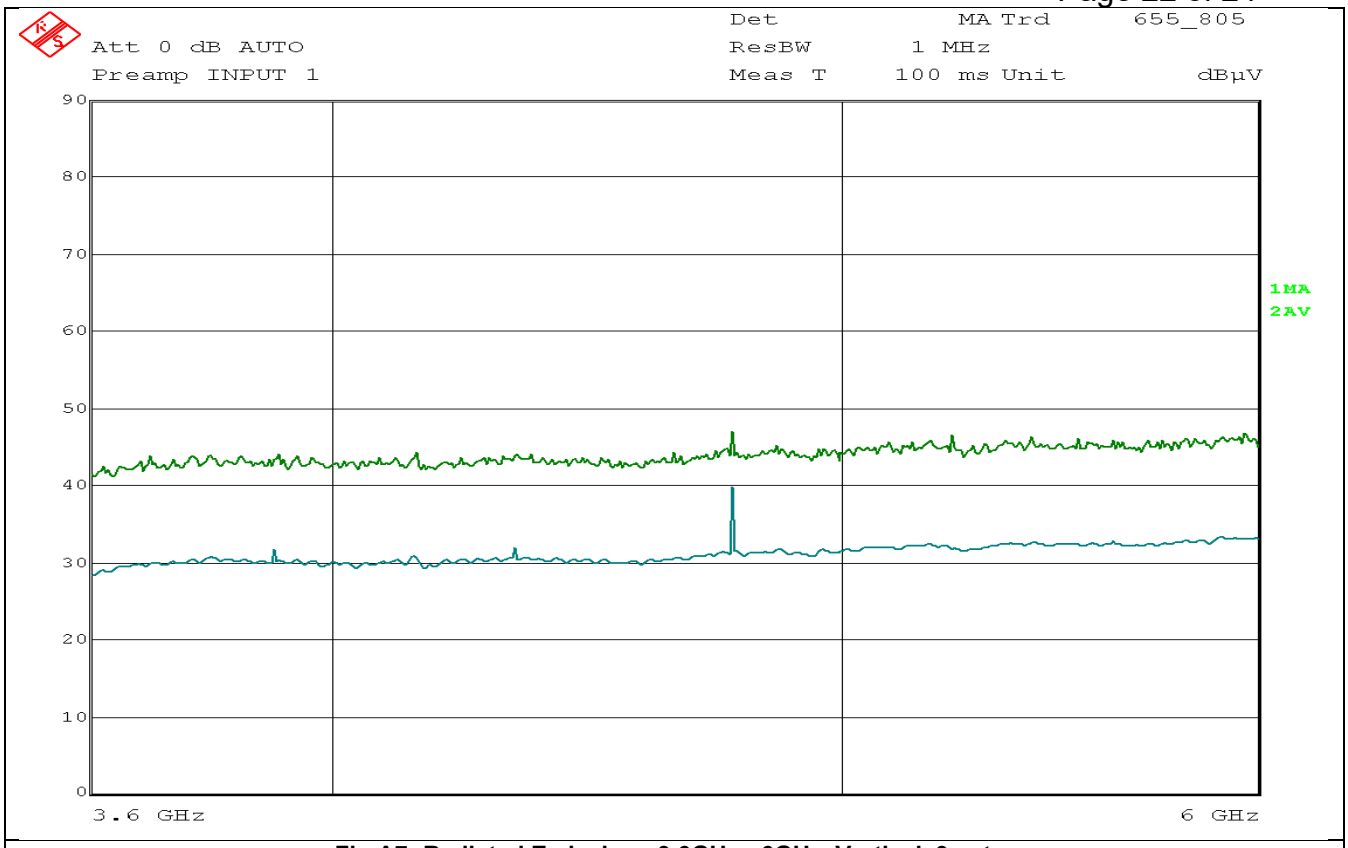


Fig A7: Radiated Emissions 3.6GHz - 6GHz, Vertical, 3metre

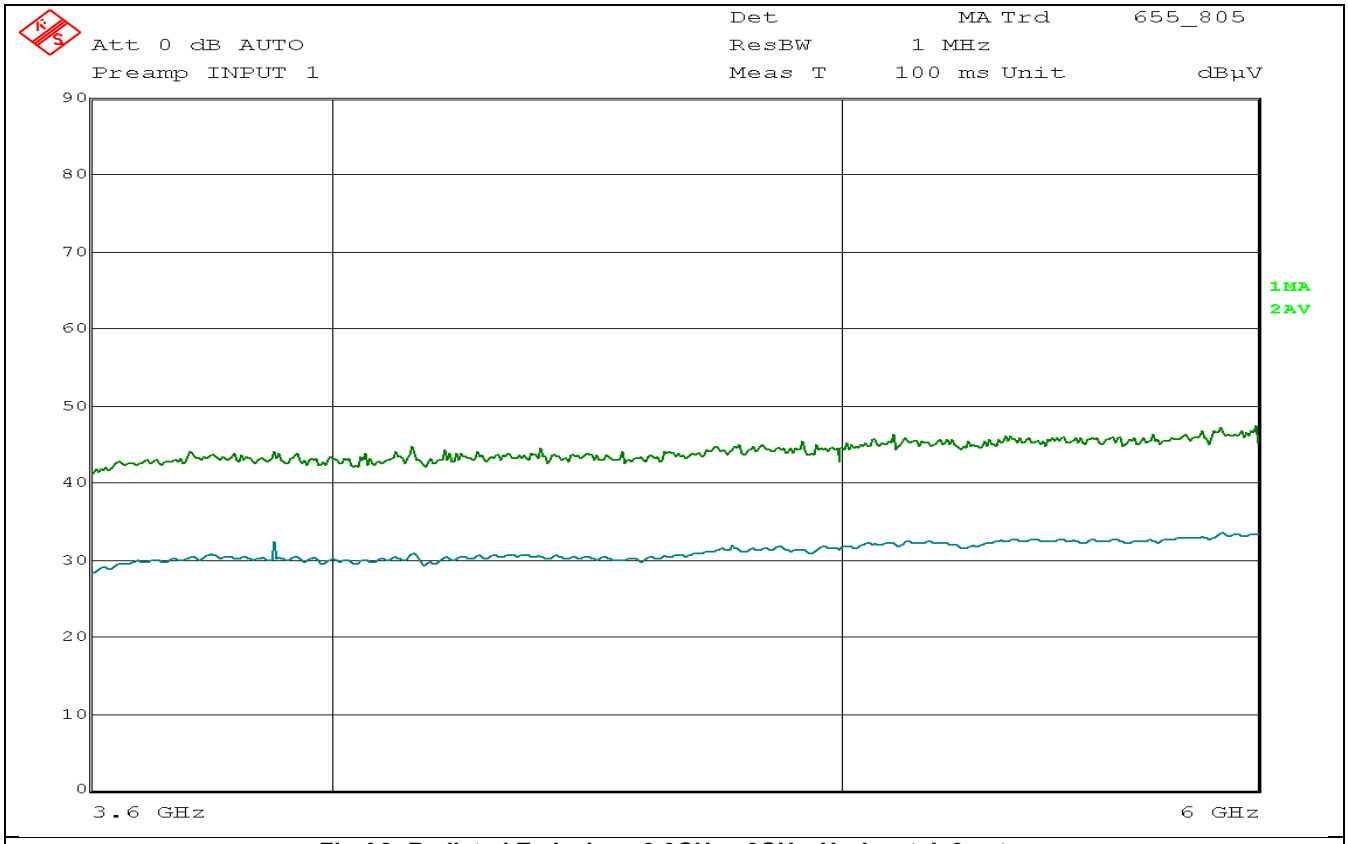


Fig A8: Radiated Emissions 3.6GHz - 6GHz, Horizontal, 3metre

Appendix B: Test Configurations:

Orientations for Radiated Emissions

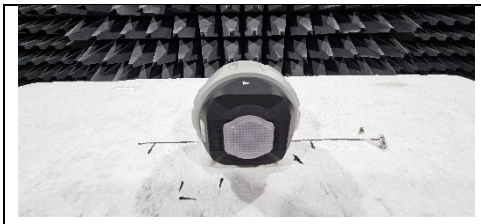
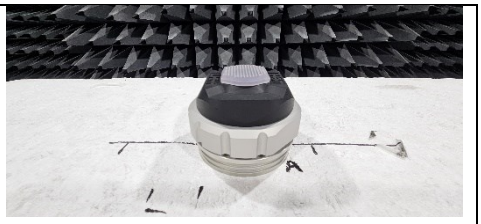
	

Fig B1: EUT orientation “O1”	Fig B2: EUT orientation “O2”

Appendix C: Block Diagrams of Test Setup

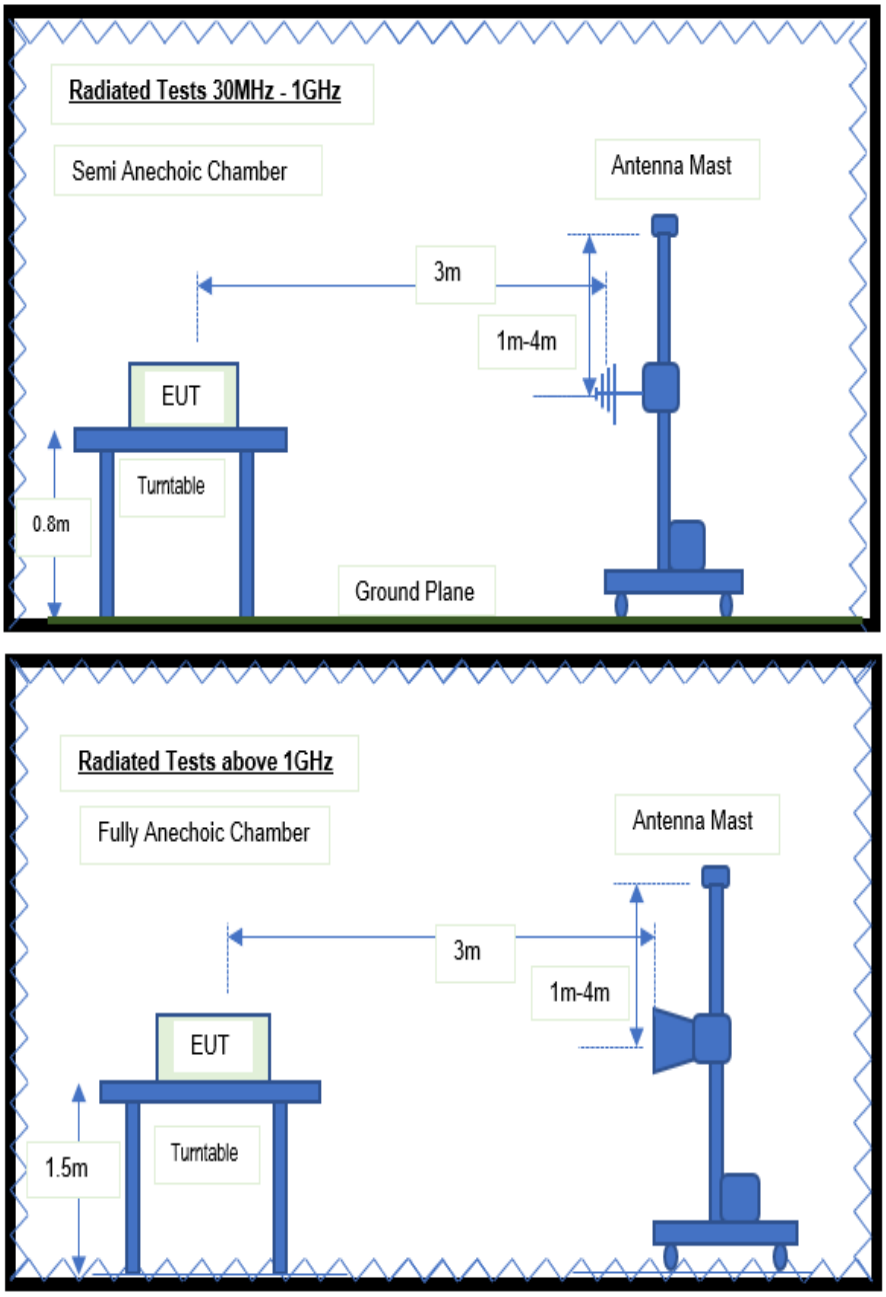


Fig C1: Test Setup

End of Report