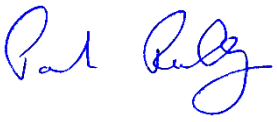
Compliance Engineering Ireland Ltd
Clonross Lane, Derrockstown, Dunshaughlin
Co. Meath, Ireland A85 XN59
Ph +353 1 8017000 , 8256722

Confidential Report

Project No.	**22E9851-1a**
Quotation	**Q22-1501-1**
Prepared For	**Sensoteq Ltd**
Company Address	**Unit 23, Ormeau Business Park, Cromac Ave, BT7 2JA Belfast**
Contact	**Martin McNeill**
Contact Email	**amccall@sensoteq.co.uk**
Contact Phone	**+44 2896 208 453**
Prepared By	**Compliance Engineering Ireland**
Test Lab Address	**Clonross Lane, Derrockstown, Dunshaughlin, Co. Meath, Ireland**
Tested By	**Joy Dalayap**
Test Report By	**Michael Kirby**
FCC Designation Number	**409640**
ISED CAB identifier:	**IE0001**
Date	**24th Nov 2022**
EUT Description	**Wireless Sensor**
FCC ID	**2ANL3SPR433CA**
IC ID	**23633-SPR433CA**
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 chip antenna, -1.72dBi max 50 ohms
Transmitter power configuration:	3V6
HVIN1:	KPX1001
HVIN2:	KPX1001V4
PMN:	KappaX
Classification:	DSC
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013

The EUT is product which contains a custom transmitter in the 433MHz band and a pre-certified BLE module.
There are two models based on single artwork and bill of materials. and the only difference is the inclusion of epoxy covering a resistor in the power supply section for ATEX applications (model KPX1001).
The EUT was powered from its internal non-rechargeable 3.6V battery.

1.1. EUT Operation

Operating Conditions during Test:

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

The BLE radio was switched off during the test.
A sample of EUT which was programmed to operate in test mode (CW mode) was used for all tests except duty cycle and bandwidth.

The duty cycle test was performed on a sample of EUT programmed to operate at the highest duty cycle possible.

A new battery was used for tests.
Note a pre scan was performed on the 2 models and final measurements (which represent the worst case results) were performed on EUT labelled “Sample#1” (KPX1001)

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 17th , 18th, 21st , 22nd Nov 2022.

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 non-rechargeable 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, y, and z 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

2.3 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.

2.4 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

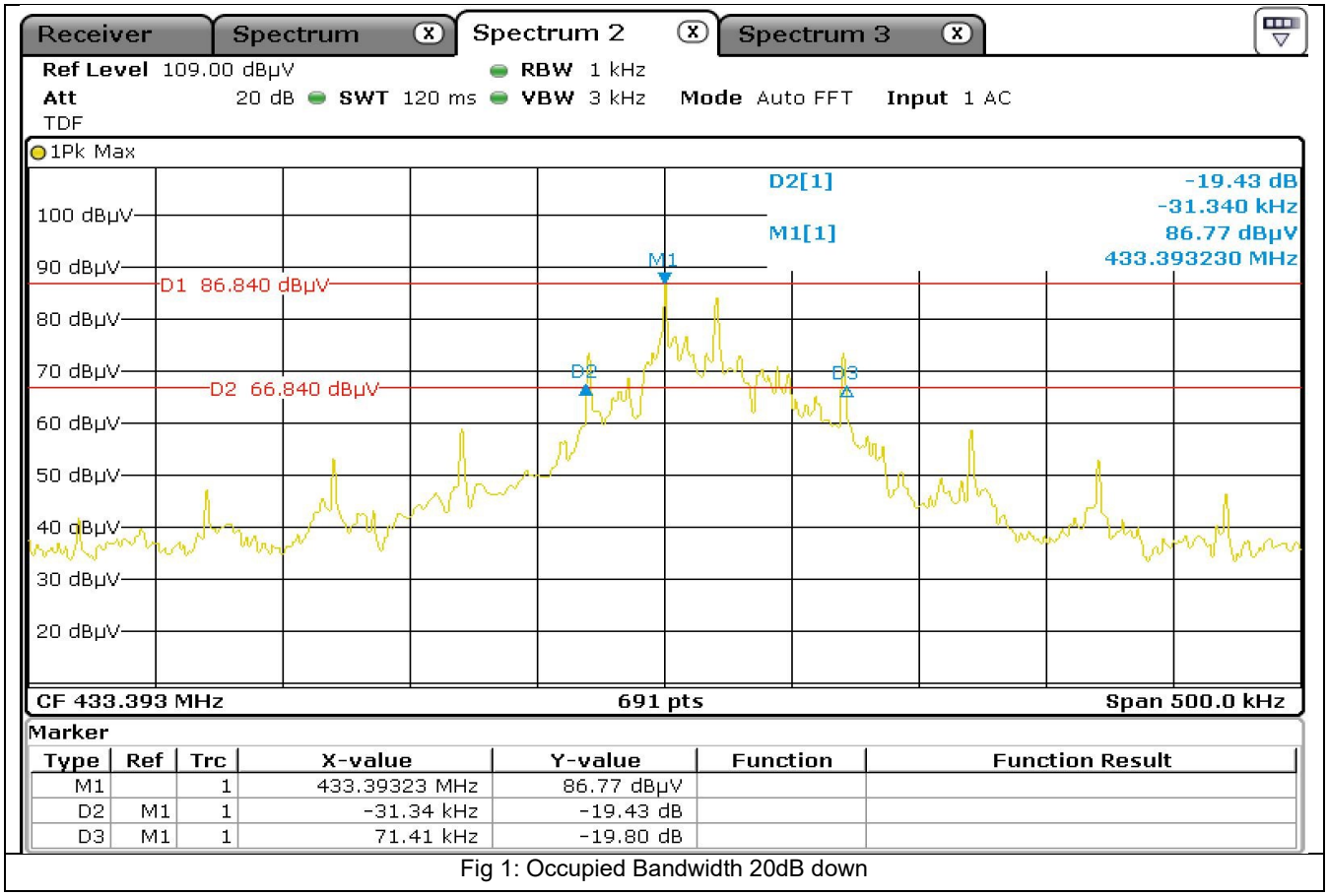


Fig 1: Occupied Bandwidth 20dB down

Operating Frequency	20dB Bandwidth	Limit	Margin	Result
MHz	KHz	KHz	KHz	
433.4	102.75	1083.5	980.75	Pass

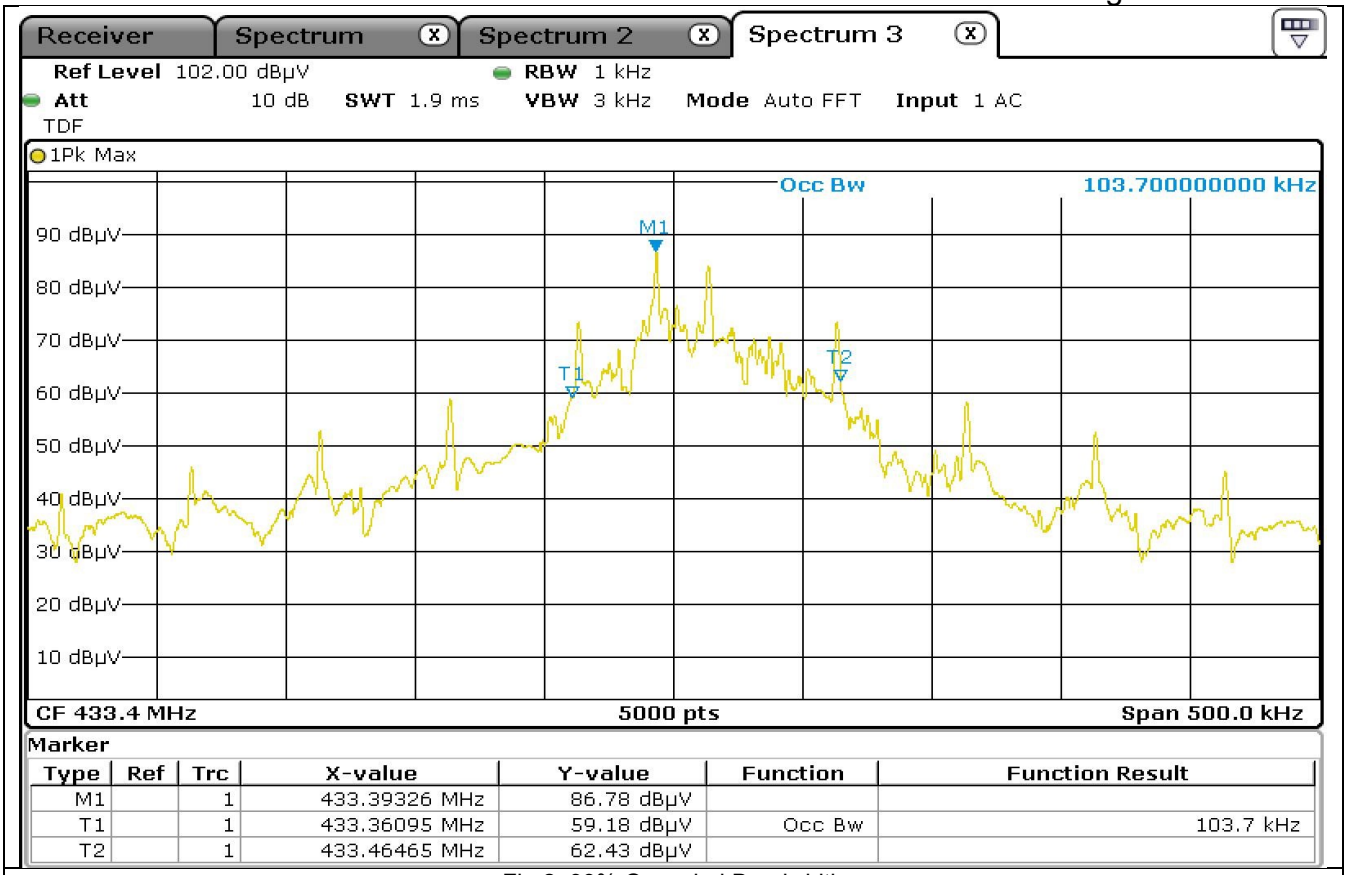


Fig 2: 99% Occupied Bandwidth

Operating Frequency	99% Bandwidth
MHz	KHz
433.4	103.7

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

Worst case Duty cycle

One Period(mS)	Pulse Width (mS)	No of Pulses	Duty Cycle	20 log duty cycle (dB)	Duty Cycle %	Test Result
100	**8.029**	**1**	**0.0803**	**-21.91**	**8.0**	**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)
-21.91

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 = 17.535mS	Limit 1sec	Comply
Silent period between transmissions >20Secs	Limit 10secs	Comply

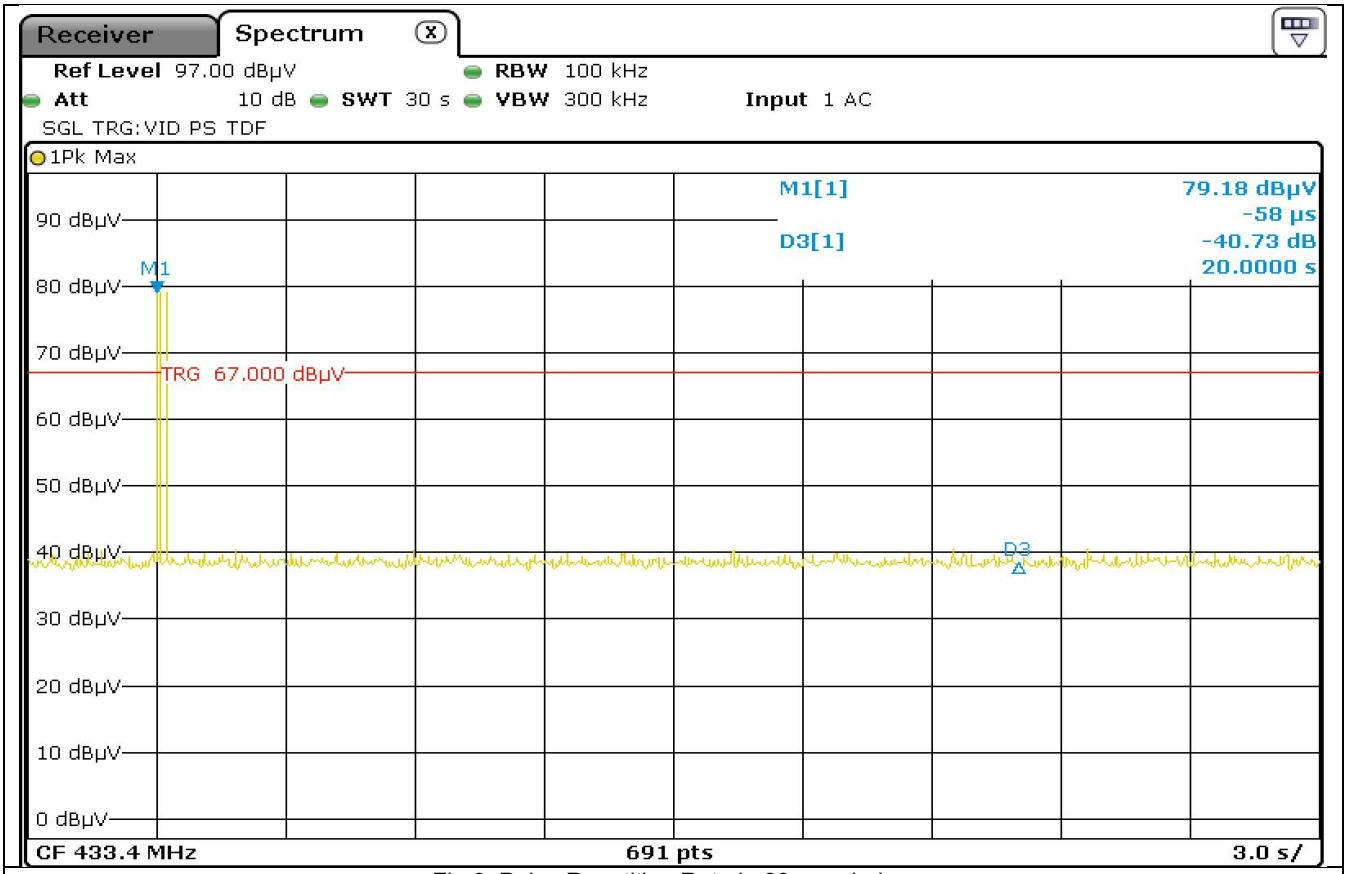
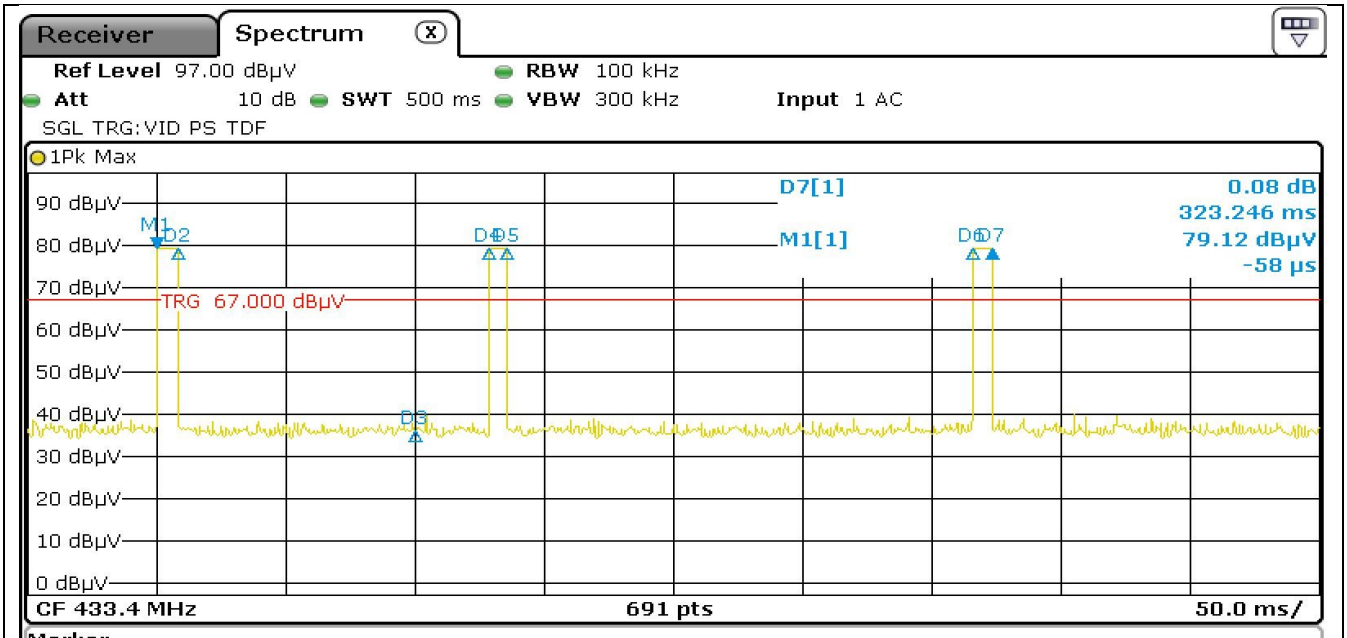


Fig 3: Pulse Repetition Rate in 20sec window



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	-58.0 µs	79.12 dBµV		
D2	M1	1	8.029 ms	0.04 dB		
D3	M1	1	100.0 ms	-43.03 dB		
D4	M1	1	128.319 ms	0.01 dB		
D5	M1	1	135.565 ms	0.07 dB		
D6	M1	1	316.0 ms	0.02 dB		
D7	M1	1	323.246 ms	0.08 dB		

Fig 4: Pulse Repetition Rate Transmitted Pulses

4. Field Strength of Radiated Emissions 433.4MHz transmitter

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

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

**** 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 -21.91dB 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

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	69.5	O1	Vertical	16.1	0	1.2	86.8	72.9	6.1	Pass
433.400	70.6	O2	Horizontal	16.1	0	1.2	87.9	72.9	5.0	Pass

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 21.91dB Duty Cycle factor)	Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
433.400	86.8	O1	Vertical	64.9	72.9	8	Pass
433.400	87.9	O2	Horizontal	66.0	72.9	6.9	Pass

Results of the fundamental

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

Test Specification: FCC 15.231(e) and RSS-210 A1.1.5

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	29.3	O1	Vertical	22.2	0	1.4	52.9	52.9	20.0	Pass
866.800	29.1	O2	Horizontal	22.2	0	1.4	52.7	52.9	20.2	Pass

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 21.91dB Duty Cycle factor)	Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
866.800	52.9	O1	Vertical	31.0	52.9	21.9	Pass
866.800	52.7	O2	Horizontal	30.8	52.9	22.1	Pass

Results of the harmonics below 1GHz

Result: Pass

Harmonics Spurious Emissions (1GHz – 6 GHz)

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
1.301	66.3	O1	Vertical	23.6	39.8	3.8	53.9	52.9	19.0	Pass
1.734	71.9	O1	Vertical	24.8	39.3	2.8	60.2	52.9	12.7	Pass
2.167	72.1	O1	Vertical	28	39	3.2	64.3	52.9	8.6	Pass
2.600	69.7	O1	Vertical	29.4	38.9	3.6	63.8	52.9	9.1	Pass
3.034	61.1	O1	Vertical	30.6	38.9	3.8	56.6	52.9	16.3	Pass
3.467	64.5	O1	Vertical	30.6	38.4	4.5	61.2	52.9	11.7	Pass
3.901	58.6	O1	Vertical	30.6	37.7	4.8	56.3	52.9	16.6	Pass
4.334	52.3	O1	Vertical	32	37.3	5	52.0	52.9	20.9	Pass
1.300	65.7	O2	Horizontal	23.6	39.8	3.8	53.3	52.9	19.6	Pass
1.734	62.8	O2	Horizontal	24.8	39.3	2.8	51.1	52.9	21.8	Pass
2.167	75.6	O2	Horizontal	28	39	3.2	67.8	52.9	5.1	Pass
2.600	61.4	O2	Horizontal	29.4	38.9	3.6	55.5	52.9	17.4	Pass
3.034	62.0	O2	Horizontal	30.6	38.9	3.8	57.5	52.9	15.4	Pass
3.467	62.2	O2	Horizontal	30.6	38.4	4.5	58.9	52.9	14.0	Pass
3.901	53.1	O2	Horizontal	30.6	37.7	4.8	50.8	52.9	22.1	Pass
4.334	54.4	O2	Horizontal	32	37.3	5	54.1	52.9	18.8	Pass

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 21.91dB Duty Cycle factor)	Average Limit	Margin	Result
GHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
1.301	53.9	O1	Vertical	32.0	52.9	20.9	Pass
1.734	60.2	O1	Vertical	38.3	52.9	14.6	Pass
2.167	64.3	O1	Vertical	42.4	52.9	10.5	Pass
2.600	63.8	O1	Vertical	41.9	52.9	11	Pass
3.034	56.6	O1	Vertical	34.7	52.9	18.2	Pass
3.467	61.2	O1	Vertical	39.3	52.9	13.6	Pass
3.901	56.3	O1	Vertical	34.4	52.9	18.5	Pass
4.334	52.0	O1	Vertical	30.1	52.9	22.8	Pass
1.300	53.3	O2	Horizontal	31.4	52.9	21.5	Pass
1.734	51.1	O2	Horizontal	29.2	52.9	23.7	Pass
2.167	67.8	O2	Horizontal	45.9	52.9	7	Pass
2.600	55.5	O2	Horizontal	33.6	52.9	19.3	Pass
3.034	57.5	O2	Horizontal	35.6	52.9	17.3	Pass
3.467	58.9	O2	Horizontal	37.0	52.9	15.9	Pass
3.901	50.8	O2	Horizontal	28.9	52.9	24	Pass
4.334	54.1	O2	Horizontal	32.2	52.9	20.7	Pass

Results of the harmonics above 1GHz

Duty Cycle correction for Average measurement of pulsed signal = Peak -21.91dB as per ANSI C63.10-2013 Section 7.5

Result: Pass

5. List of Test Equipment

Instrument	Manufacturer	Model	Serial Num	CEI Ref	Cal Due Date	Cal Interval Months
Microwave Preamplifier	Hewlett Packard	83017A	3123A00175	805	30-Sep-23	12
Spectrum Analyser 30Hz-40GHz	Rohde& Schwarz	FSP40	100053	850	10-Dec-24	36
Test Receiver 3.6GHz	Rohde& Schwarz	ESR	1316.3003k03-101625-s	869	28-May-23	36
LISN	Rohde & Schwarz	ESH3-Z5	825460/003	604	16-Feb-23	36
Antenna Horn	EMCO	3115	9905-5809	655	21-Jan-24	24
Fully Anechoic Chamber	CEI	FAR 3M	906	906	23-Jul-25	36
Anechoic Chamber	CEI	SAR 10M	845	845	17-May-25	36
Antenna Biconical	Schwarzbeck	VHBB 9124	9124 667	871	06-Oct-24	36
Antenna Log Periodic	Chase	UPA6108	1072	609	09-Sep-24	36
Cable Ntype 10m				963	29-Jul-23	12
Cable Ntype 2m				828	29-Jul-23	12
Cable purple Ktype 1.8m				917	29-Jul-23	12
Cable Ntype 10m				914	29-Jul-23	12
Cable HF Ktype 1.5m				705	29-Jul-23	12

Appendix A: Scans for Radiated Spurious Emissions

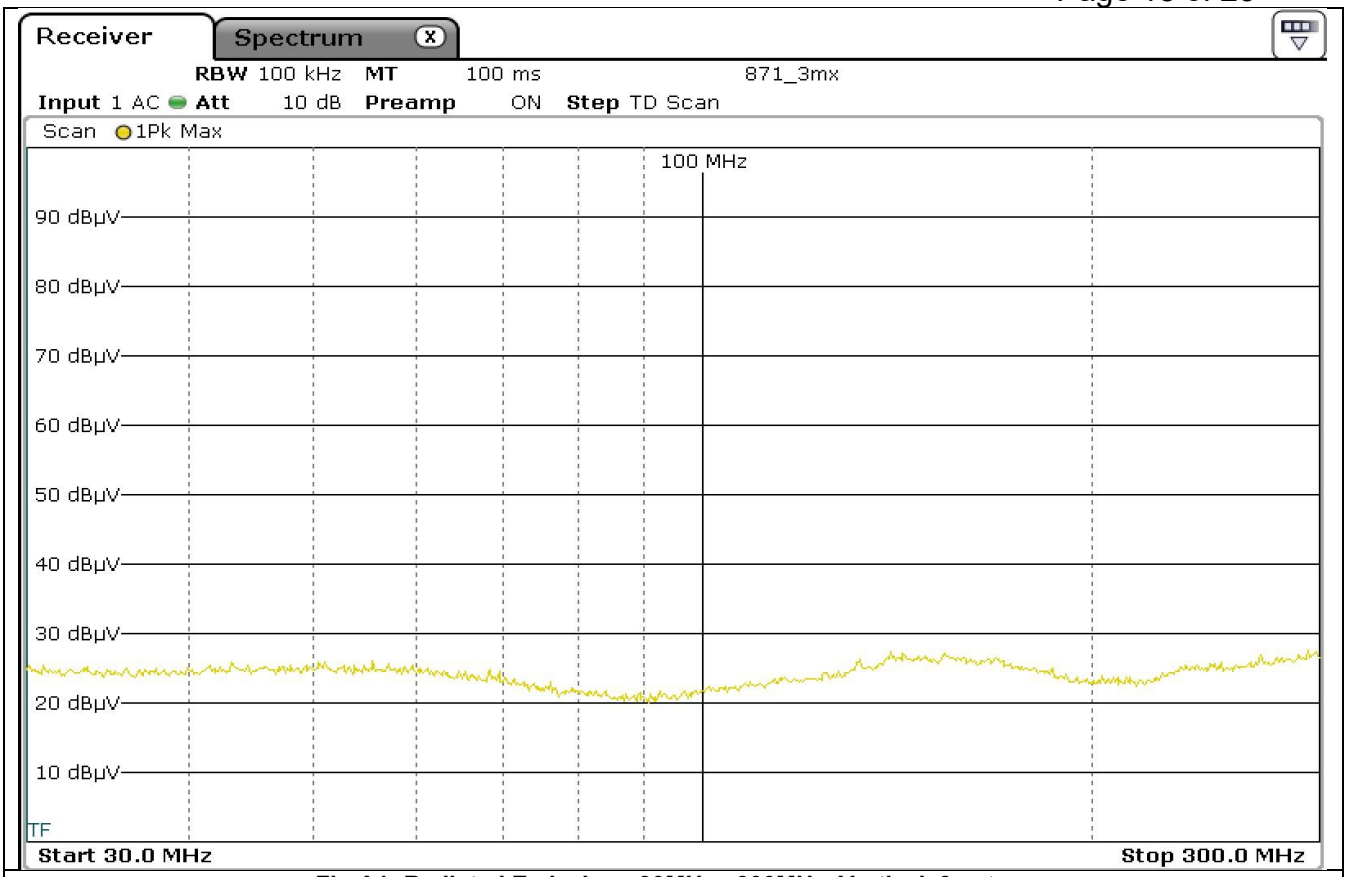


Fig A1: Radiated Emissions 30MHz - 300MHz, Vertical, 3metres

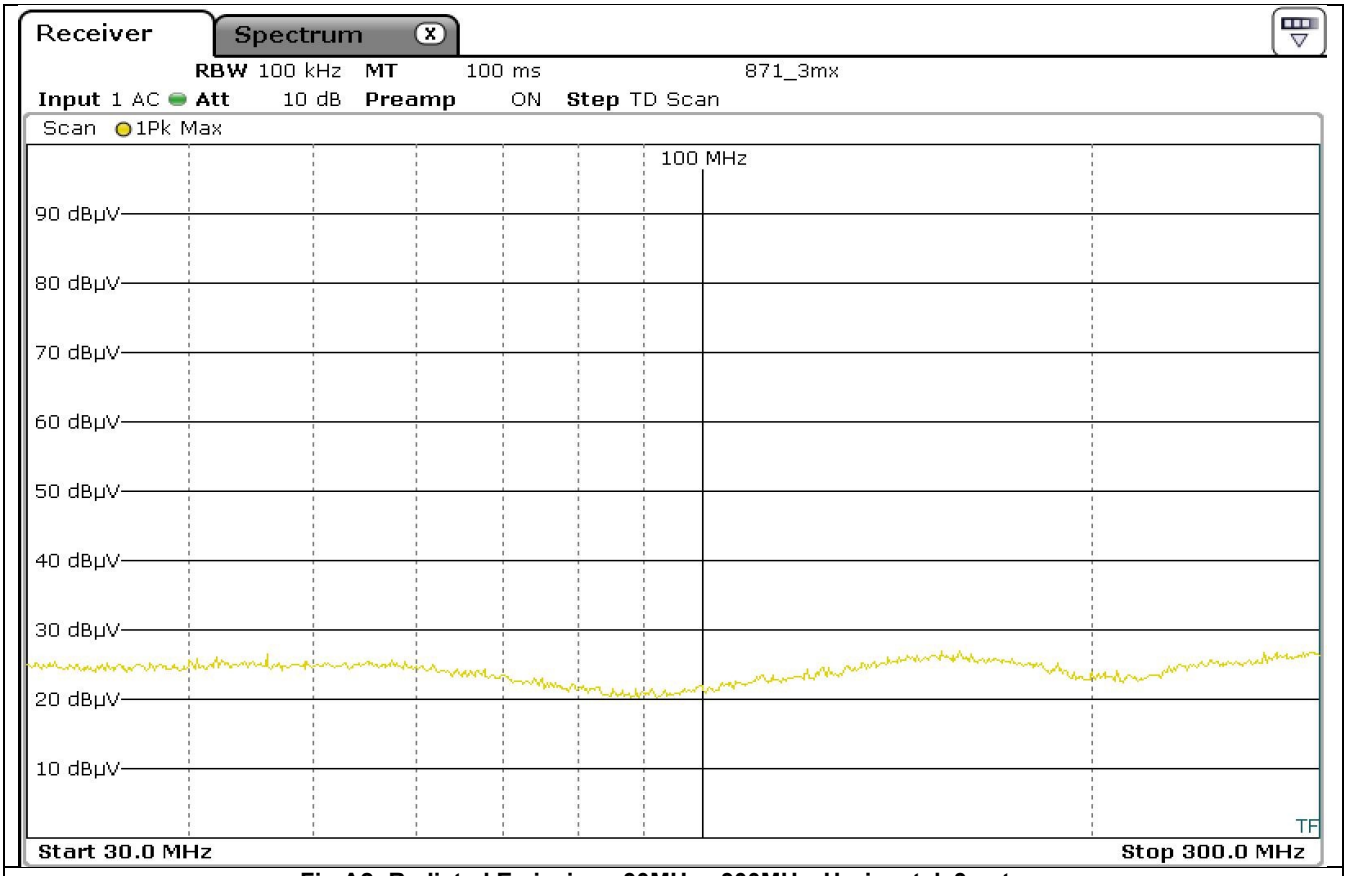


Fig A2: Radiated Emissions 30MHz - 300MHz, Horizontal, 3metres

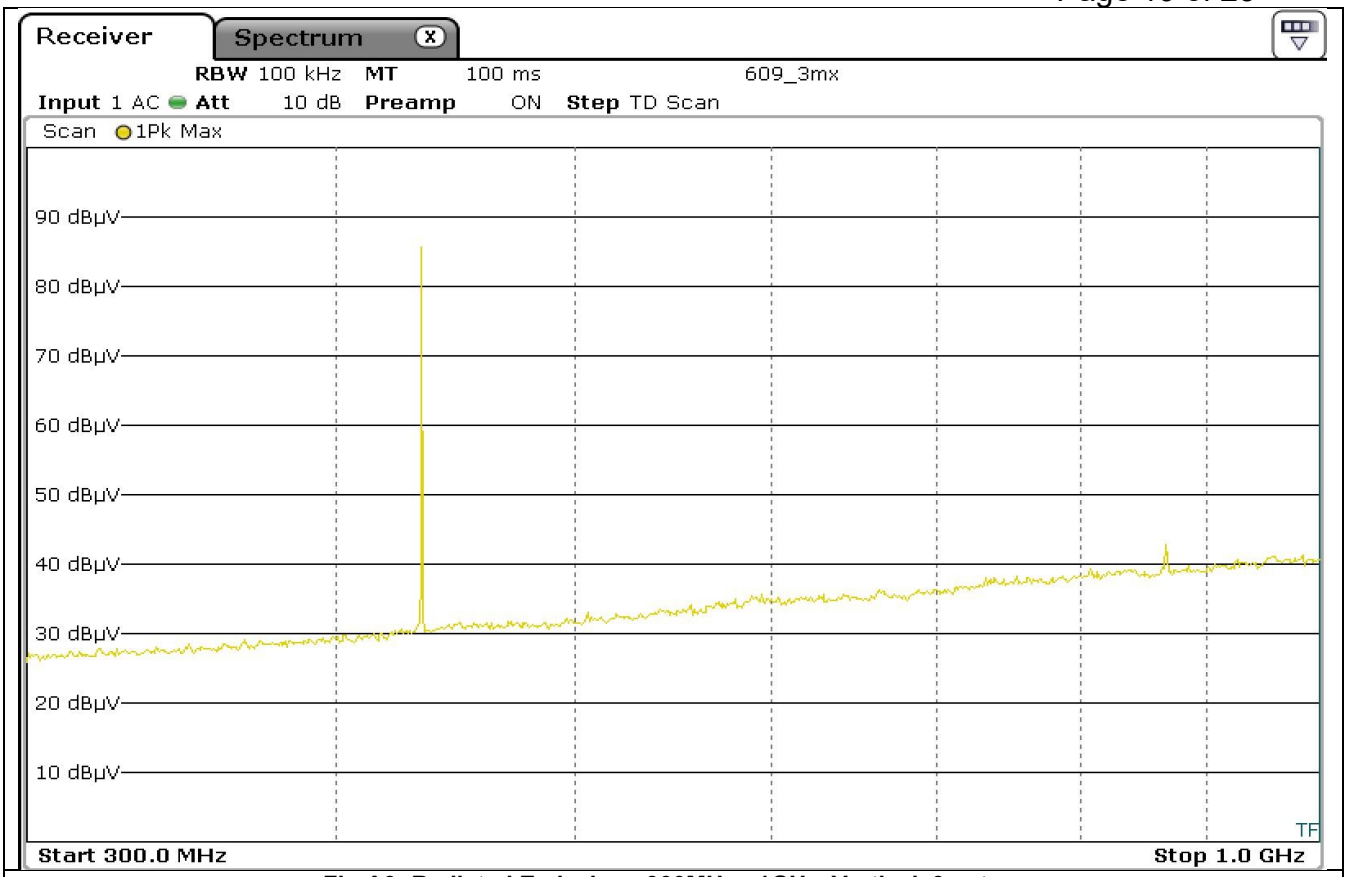


Fig A3: Radiated Emissions 300MHz - 1GHz, Vertical, 3metres

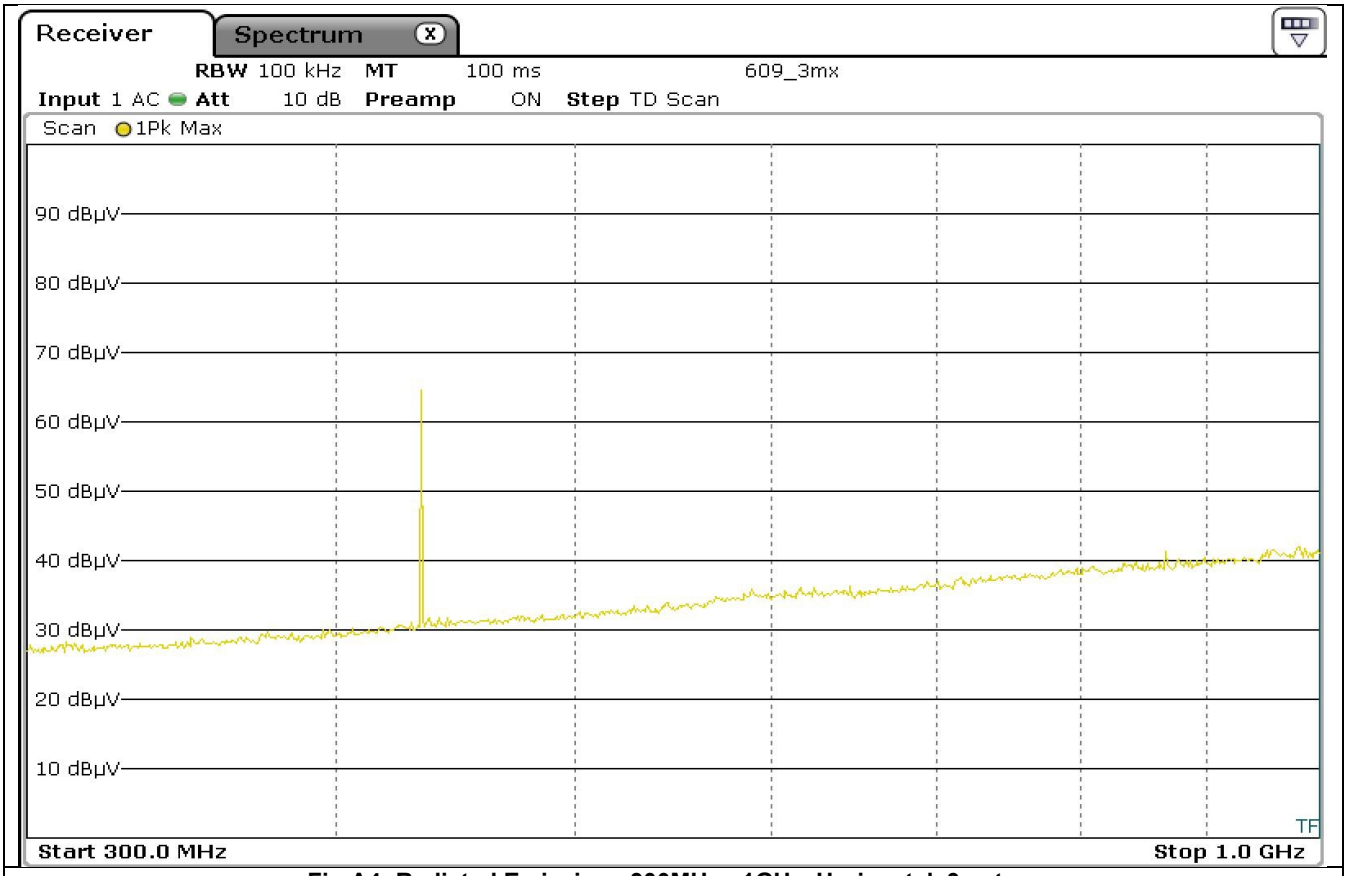


Fig A4: Radiated Emissions 300MHz - 1GHz, Horizontal, 3metres

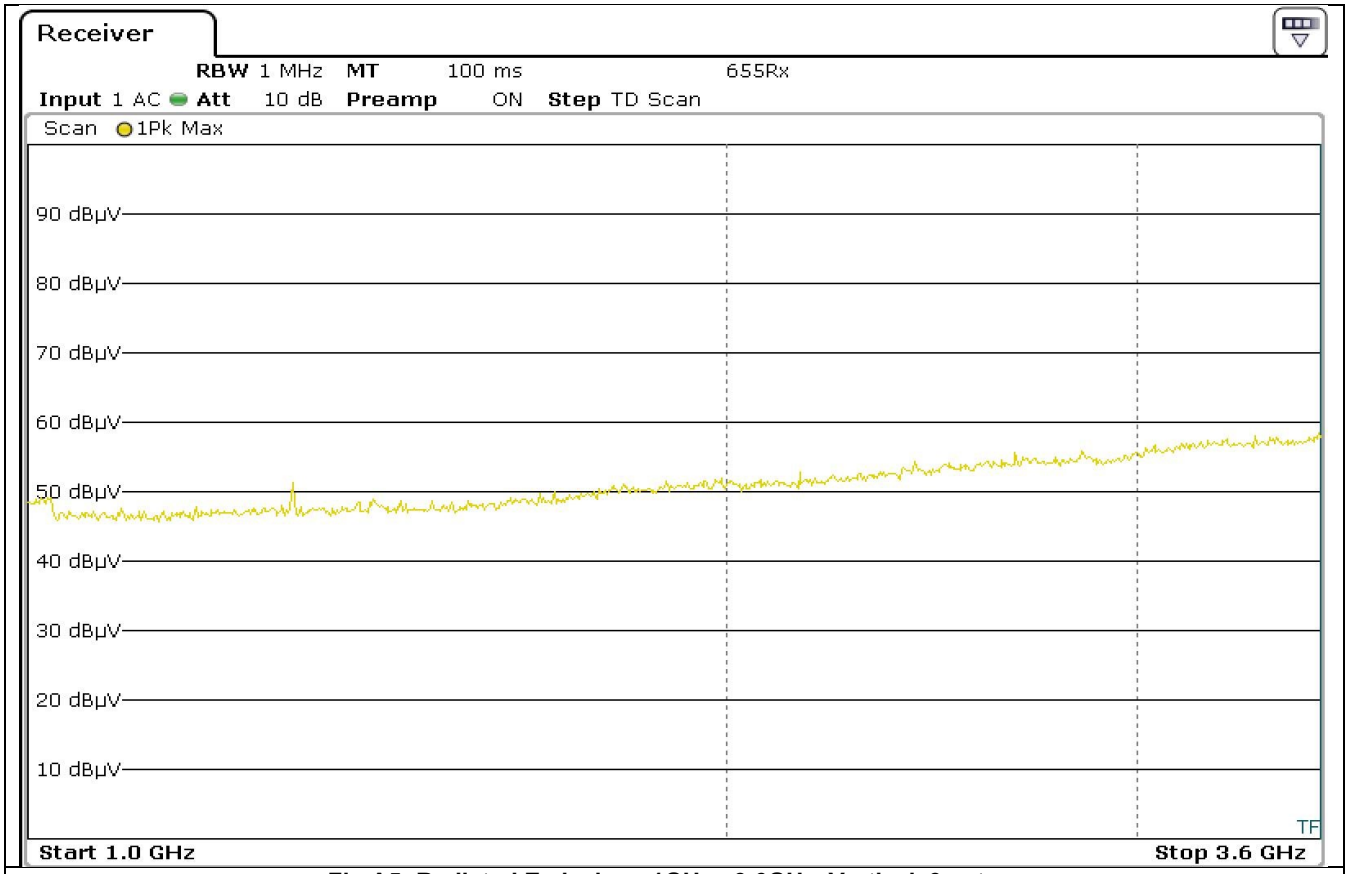


Fig A5: Radiated Emissions 1GHz - 3.6GHz, Vertical, 3metres

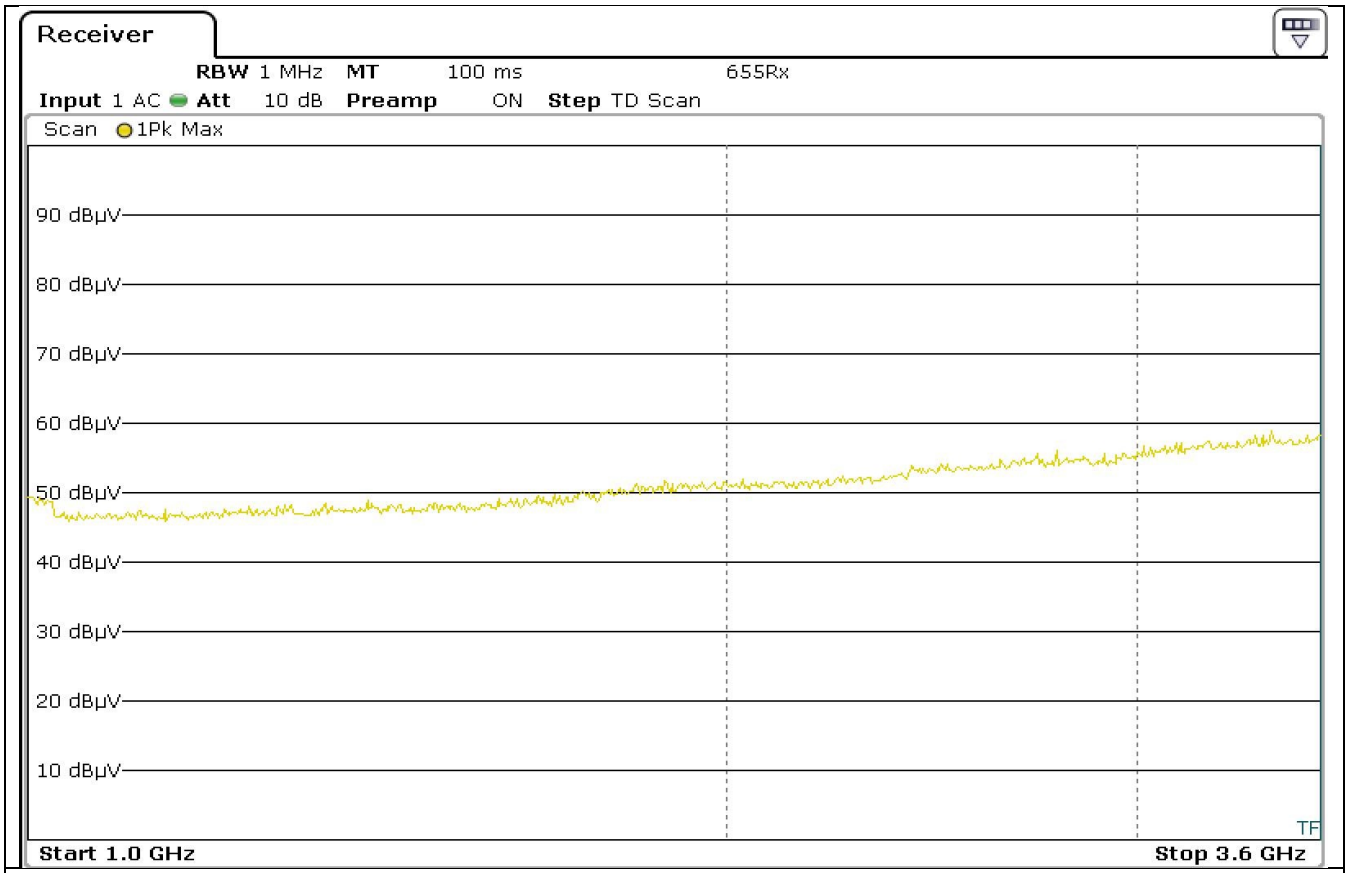


Fig A6: Radiated Emissions 1GHz - 3.6GHz, Horizontal, 3metres

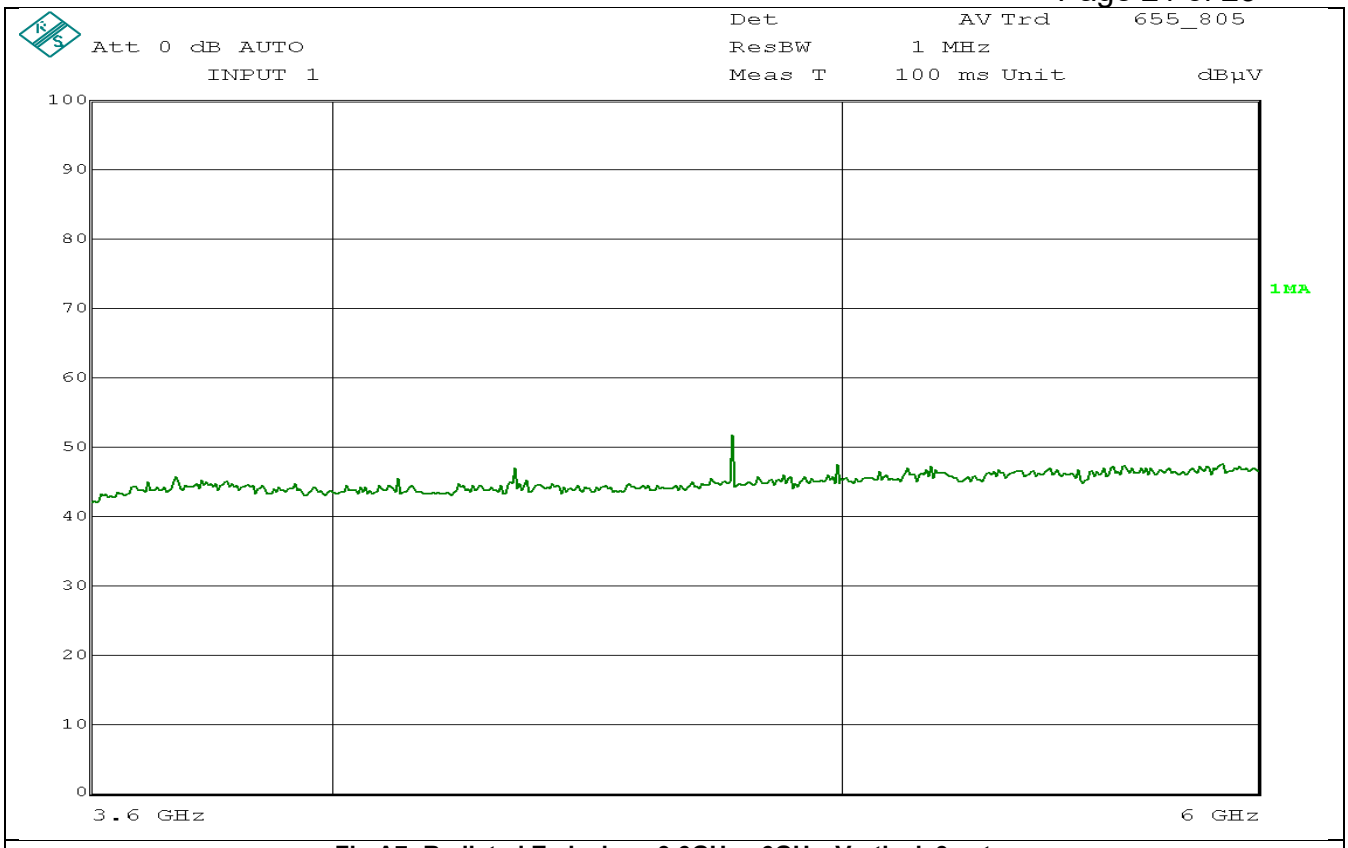


Fig A7: Radiated Emissions 3.6GHz - 6GHz, Vertical, 3metre

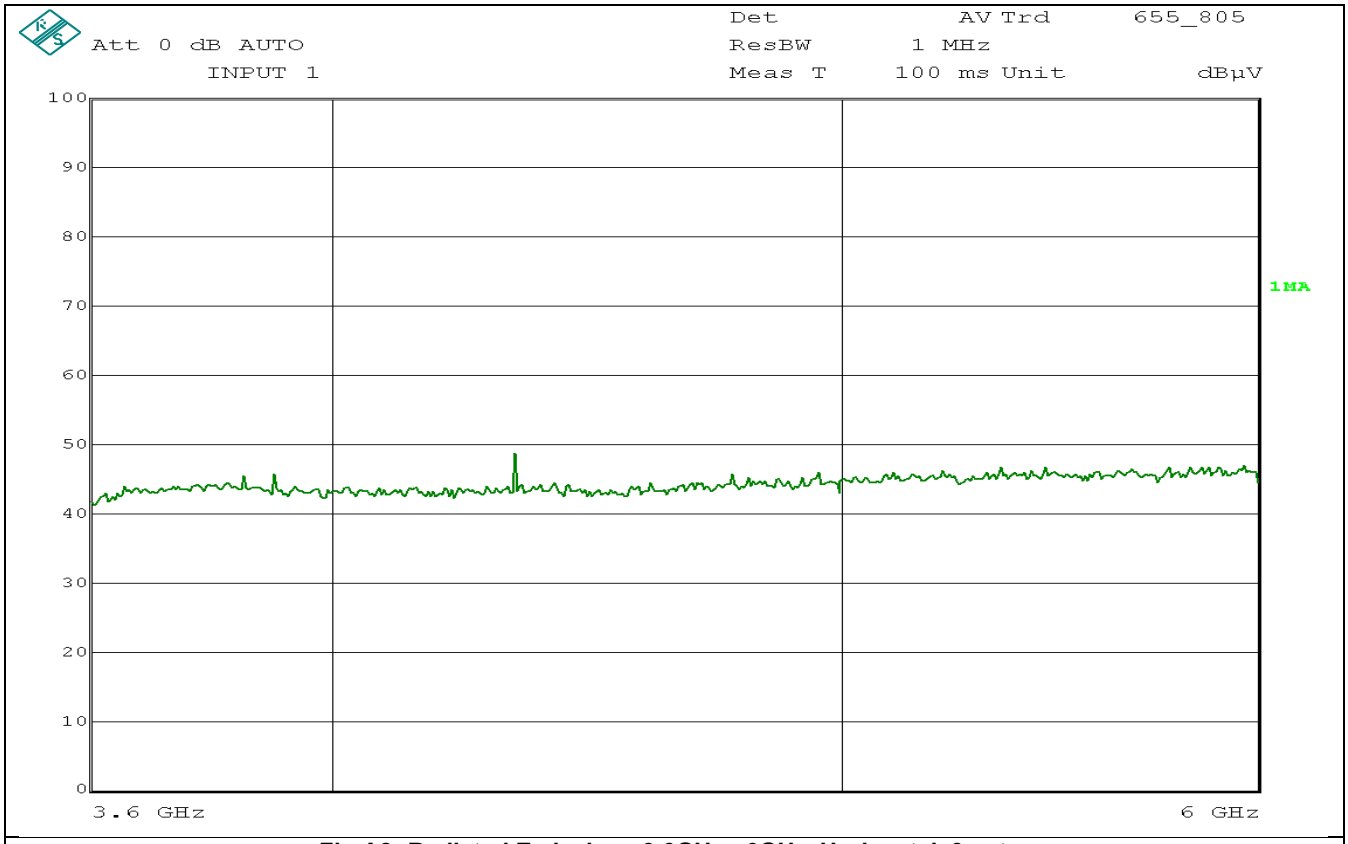


Fig A8: Radiated Emissions 3.6GHz - 6GHz, Horizontal, 3metre

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

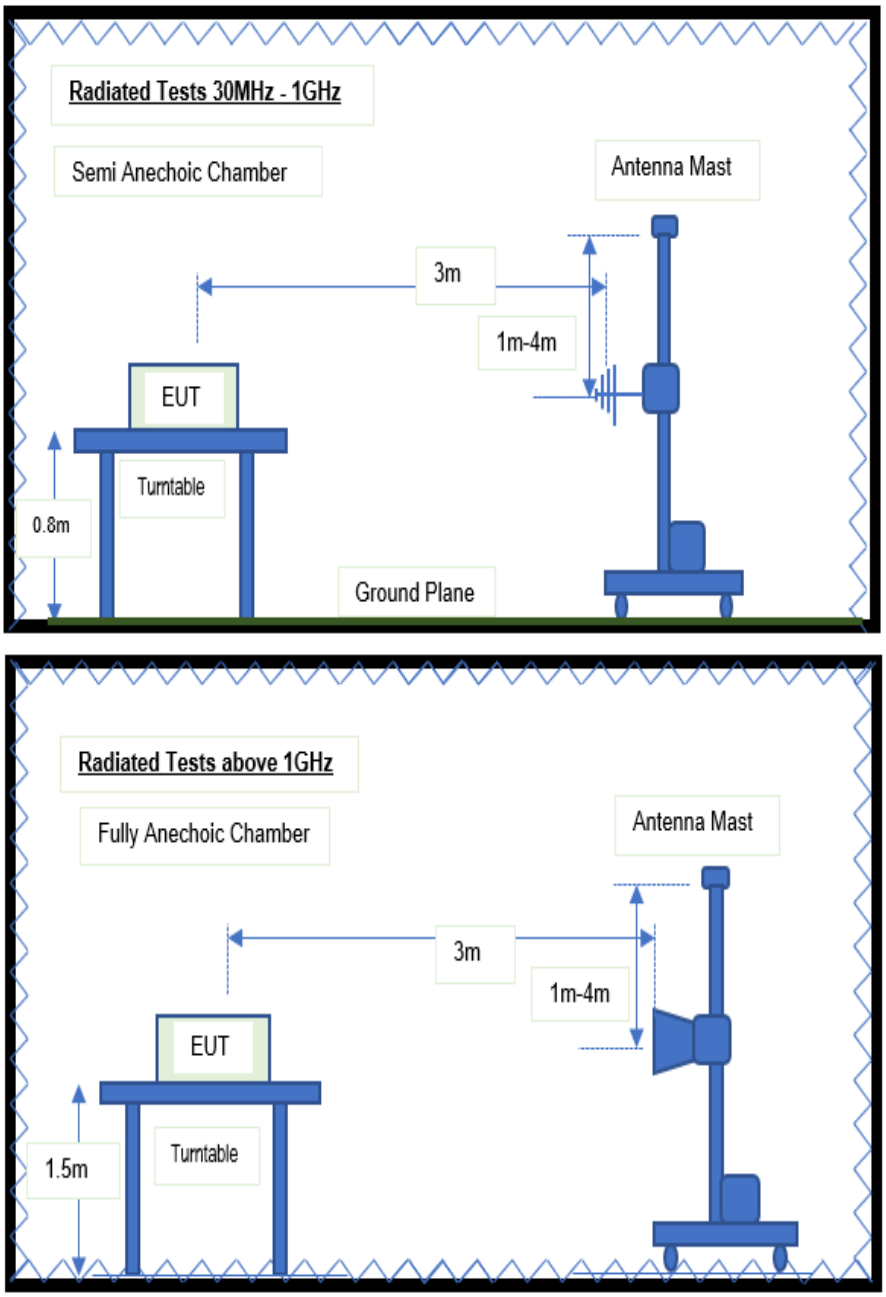


Fig C1: Test Setup

End of Report