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Confidential Report

Project No.	**23E10540-2a**
Quotation	**Q23-1805-1**
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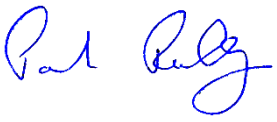
FCC Test Firm Registration	**IE0002**
ISED CAB identifier:	**IE0001**
Date	**25th Aug 2023**
EUT Description	**Sensor**
FCC ID	**2ANL3SPR433TA**
IC ID	**23633-SPR433TA**
Authorised by	**Paul Reilly**
Authorised Signature:	

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) 15.209 15.247	RSS-210 A1.4 RSS-210 8.9 RSS-247	Radiated Emissions	PASS
15.247	RSS-247	Carrier Power BLE	PASS

RSS 210 Issue 10 Dec 2019
RSS-Gen Issue 5 Mar 2019
RSS-247 Issue 2 Amd 1 Mar 2017

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1. EUT Description

Ref report 23E10540-1a.

1.0 EUT Operation

Operating Conditions during Test:

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

A sample of EUT which was programmed to operate in test mode (CW mode for 433MHz) and BLE on.

Environmental conditions:

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

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

1.1. Modifications

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

1.2. Date of Test

The tests were carried out on one sample of the EUT on the 11th, 28th of March & the 5th of April 2022.

1.3. Electromagnetic Emissions Testing

The guidelines of CISPR 16-4 were used for all uncertainty calculations, estimates and expressions thereof for EMC testing. A copy of Compliance Engineering Ireland Ltd.'s policy for EMC Measurement Uncertainty is available on request.
RF Requirements: Spurious emissions in accordance with FCC CFR 15.107, 15.109 and 15.209. Tests were carried out to the requirements of CISPR 16-4 and ANSI C63.4-2014 and C63.10-2013.

1.3.1. 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).

1.4. 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, 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 flat orientation (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

The EUT was operated where BLE and 433MHz transmitters were both on. Spurious emissions for 433MHz and harmonics were compared to limits of 15.231e.
BLE and 433MHz above 4GHz were compared to 15.247 limits as BLE is for commissioning only.

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.

3. Field Strength of Radiated Emissions

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

Fundamental Frequency (MHz)	Field Strength of fundamental (µV/m)	Strength of Spurious Emissions (µV/m).
40.66 ~ 40.70	22.50	225
70 ~ 130	1250	125
130 ~ 174	1250 to 3750 **	125 to 375 **
174 ~ 260	3750	375
260 ~ 470	3750 to 12500 **	375 to 1250 **
Above 470	12500	1250

**** 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

3.1. Results for Radiated Emissions

3.1.1. Fundamental Measurements 433.4 MHz
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
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

3.1.2. Fundamental Measurements BLE

Test Specification: FCC 15.247 and RSS-247

Frequency	Reading Average	EUT Orientation	Antenna Polarity	Antenna Factor	Preamp Gain	Cable loss	Final Field Strength Average	Transmitted Power	Limit	Margin	Result
GHz	dBuV/m		V/H	dB	dB	dB	dBuV/m	dBm	dBm	dB	P/F
2.402	49.6	O2	Vertical	28.6	0	4.8	83.0	-12.2	36.0	48.2	Pass
2.426	49.9	O2	Vertical	28.6	0	4.8	83.3	-11.9	36.0	47.9	Pass
2.480	50.0	O2	Vertical	28.6	0	4.9	83.5	-11.7	36.0	47.7	Pass
2.402	48.2	O1	Horizontal	28.6	0	4.8	81.6	-13.6	36.0	49.6	Pass
2.426	47.6	O1	Horizontal	28.6	0	4.8	81.0	-14.2	36.0	50.2	Pass
2.480	46.1	O1	Horizontal	28.6	0	4.9	79.6	-15.6	36.0	51.6	Pass

Calculation example
Final Field Strength Peak (dBuV/m) =Reading Peak (dBuV/m) + Antenna Factor (dB)- Pre-amp Gain (dB) +Cable Loss (dB)
79.6 = 46.1 + 28.6 - 0 + 4.9

Test Result: Pass

3.1.3. Spurious Emissions Measurements

Test Specification: FCC 15.247 and RSS-247

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	12.3	O1	Vertical	25.3	0	3.5	41.1	54.0	32.9	Pass
3.900	45.9	O1	Vertical	32.9	38.3	6.1	46.6	54.0	27.4	Pass
4.334	46.1	O1	Vertical	32.2	38.3	6.6	46.6	54.0	27.4	Pass
4.767	48.0	O1	Vertical	32.7	39.3	7.8	49.2	54.0	24.8	Pass
4.804	44.3	O2	Vertical	33.1	39.3	7.8	45.9	54.0	28.1	Pass
1.300	13.1	O2	Horizontal	25.3	0	3.5	41.9	54.0	32.1	Pass
3.900	45.3	O2	Horizontal	32.9	38.3	6.1	46.0	54.0	28.0	Pass
4.334	45.2	O2	Horizontal	32.2	38.3	6.6	45.7	54.0	28.3	Pass
4.767	48.7	O2	Horizontal	32.7	39.3	7.8	49.9	54.0	24.1	Pass
4.804	44.0	O1	Horizontal	33.1	39.3	7.8	45.6	54.0	28.4	Pass

Calculation example
Final Field Strength Peak (dBuV/m) =Reading Peak (dBuV/m) + Antenna Factor (dB)- Pre-amp Gain (dB) +Cable Loss (dB)
45.6 = 44 + 33.1 - 39.3 + 7.8

Test Result : Pass

3.1.4. Band Edge Test

Test Specification: FCC 15.247 and RSS-247

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
2.4835	13.1	O2	Vertical	28.6	0	4.9	46.6	54.0	27.4	Pass
2.5000	12.8	O2	Vertical	28.8	0	4.9	46.5	54.0	27.5	Pass
2.4835	13.1	O1	Horizontal	28.6	0	4.9	46.6	54.0	27.4	Pass
2.5000	12.8	O1	Horizontal	28.8	0	4.9	46.5	54.0	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)
46.5 = 12.8 + 28.8 - 0 + 4.9

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
2.3500	13.0	O2	Vertical	28.4	0	4.8	46.2	54.0	27.8	Pass
2.3950	12.7	O2	Vertical	28.4	0	4.8	45.9	54.0	28.1	Pass
2.3500	12.3	O1	Horizontal	28.4	0	4.8	45.5	54.0	28.5	Pass
2.3950	12.2	O1	Horizontal	28.4	0	4.8	45.4	54.0	28.6	Pass

Test Result: Pass

4. 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
Antenna Horn Standard Gain 18-26.5GHz	A-Info	LB-42-25-C-KF	J2021091103028	877	21-Jun-23	12
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 and BLE active

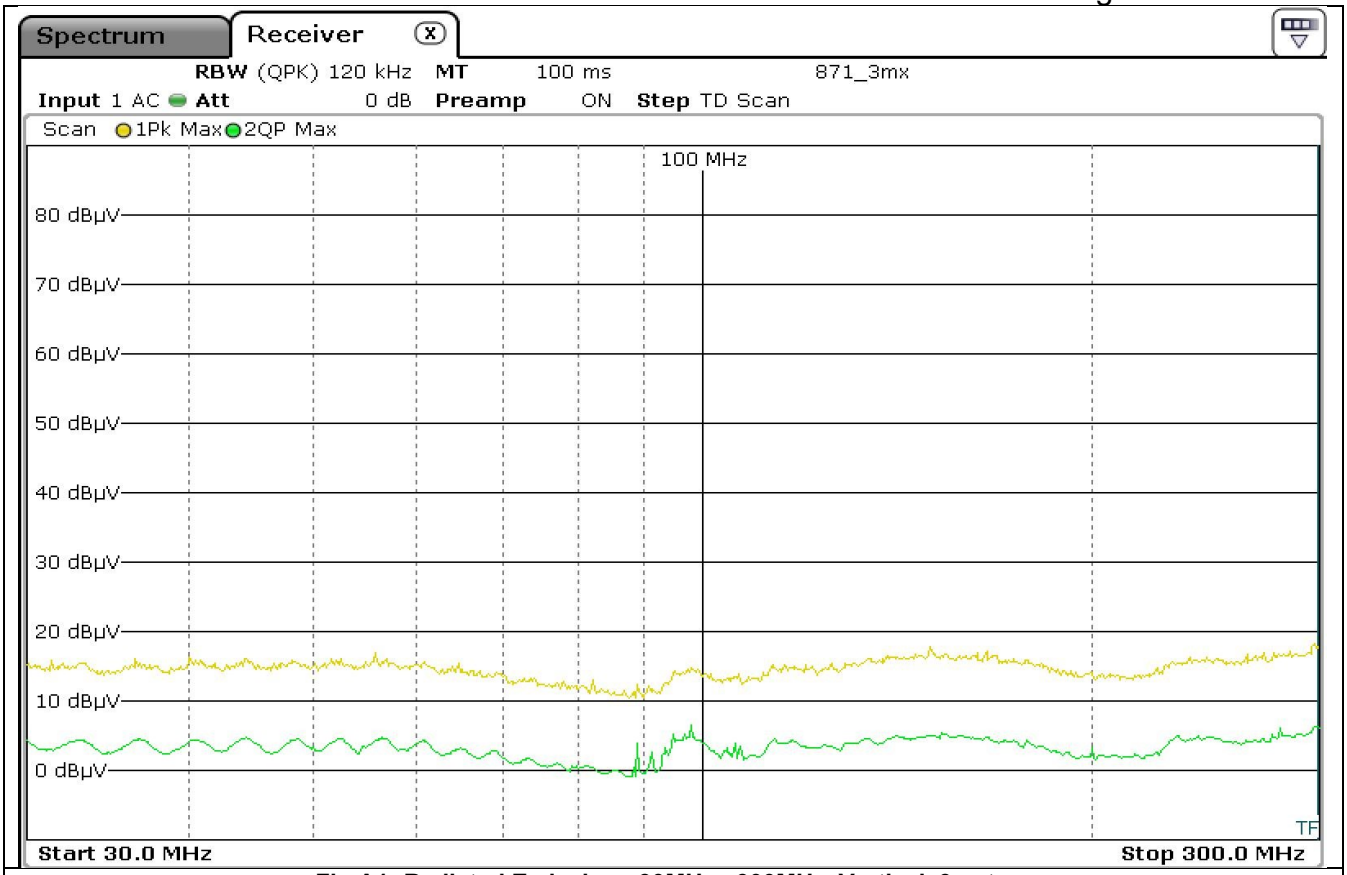


Fig A1: Radiated Emissions 30MHz - 300MHz, Vertical, 3metres

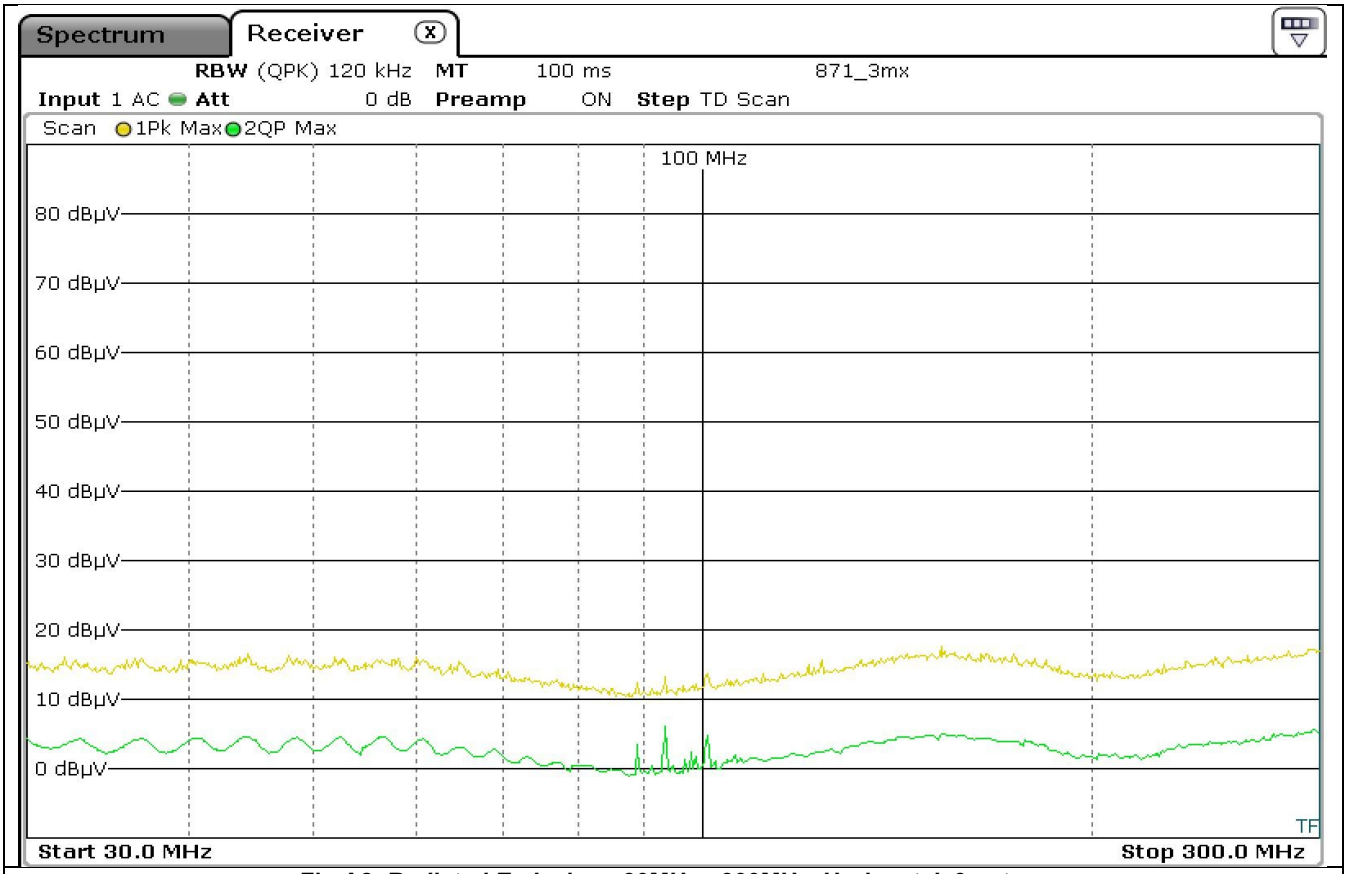


Fig A2: Radiated Emissions 30MHz - 300MHz, Horizontal, 3metres

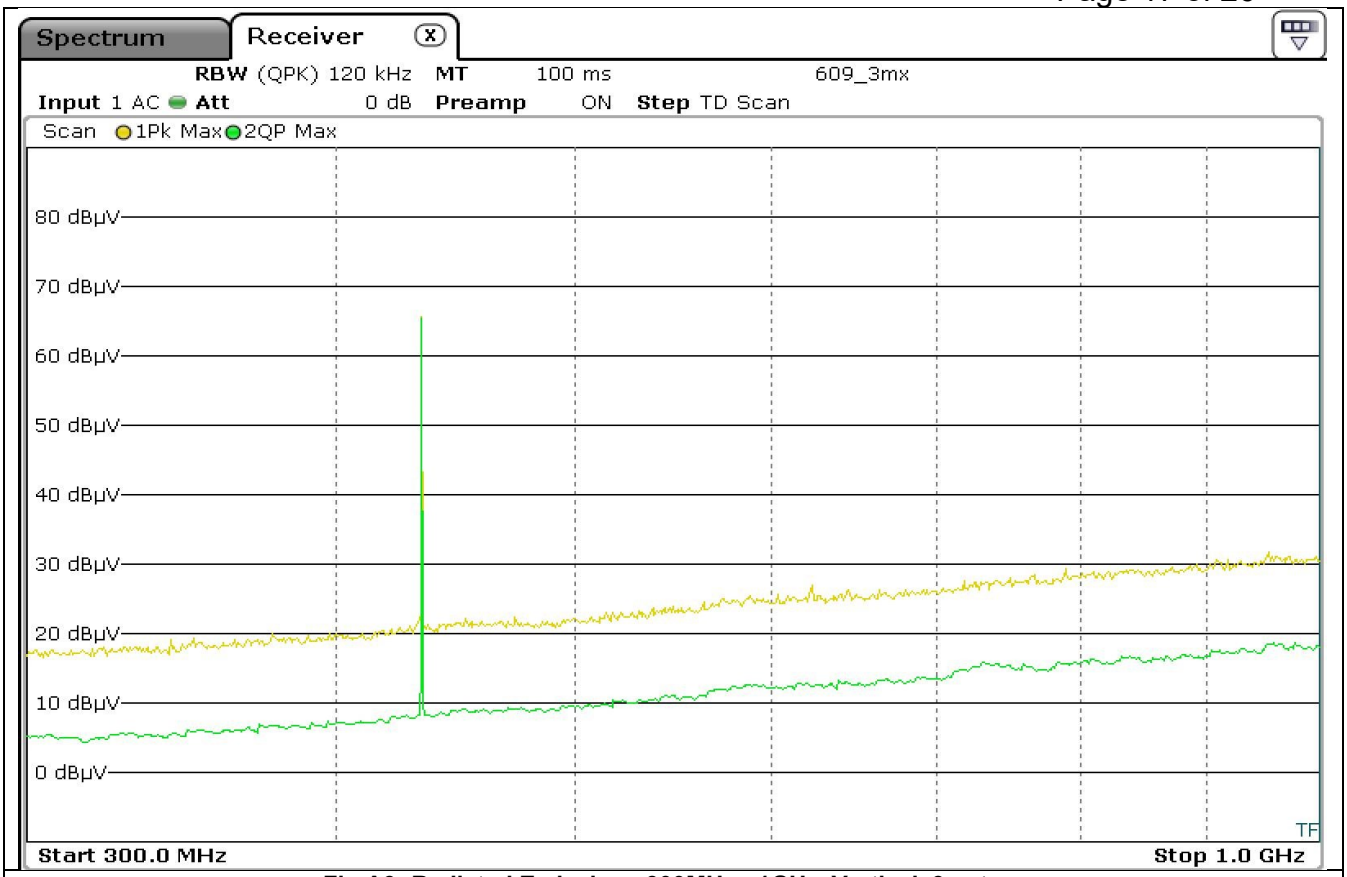


Fig A3: Radiated Emissions 300MHz - 1GHz, Vertical, 3metres

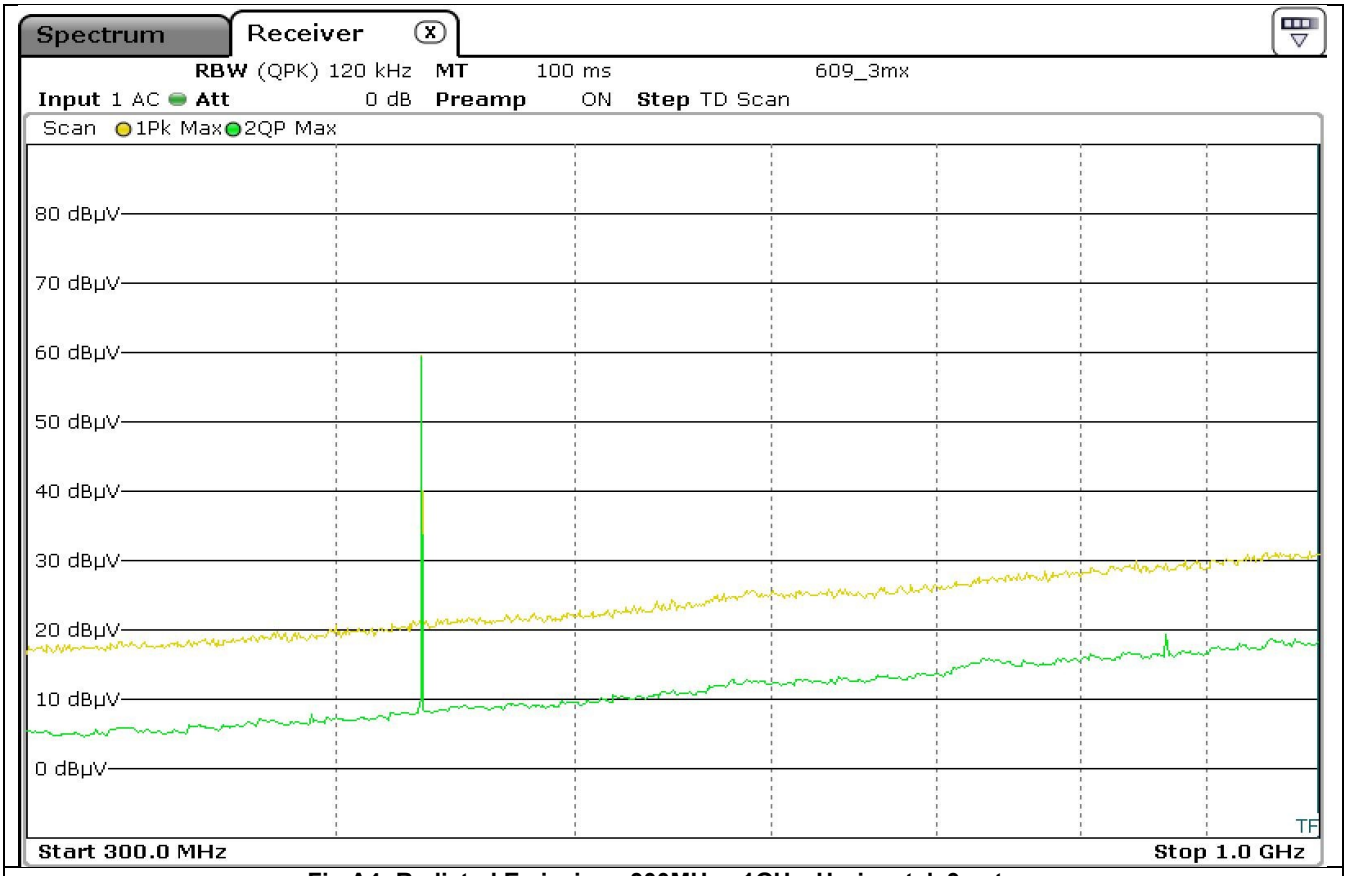


Fig A4: Radiated Emissions 300MHz - 1GHz, Horizontal, 3metres

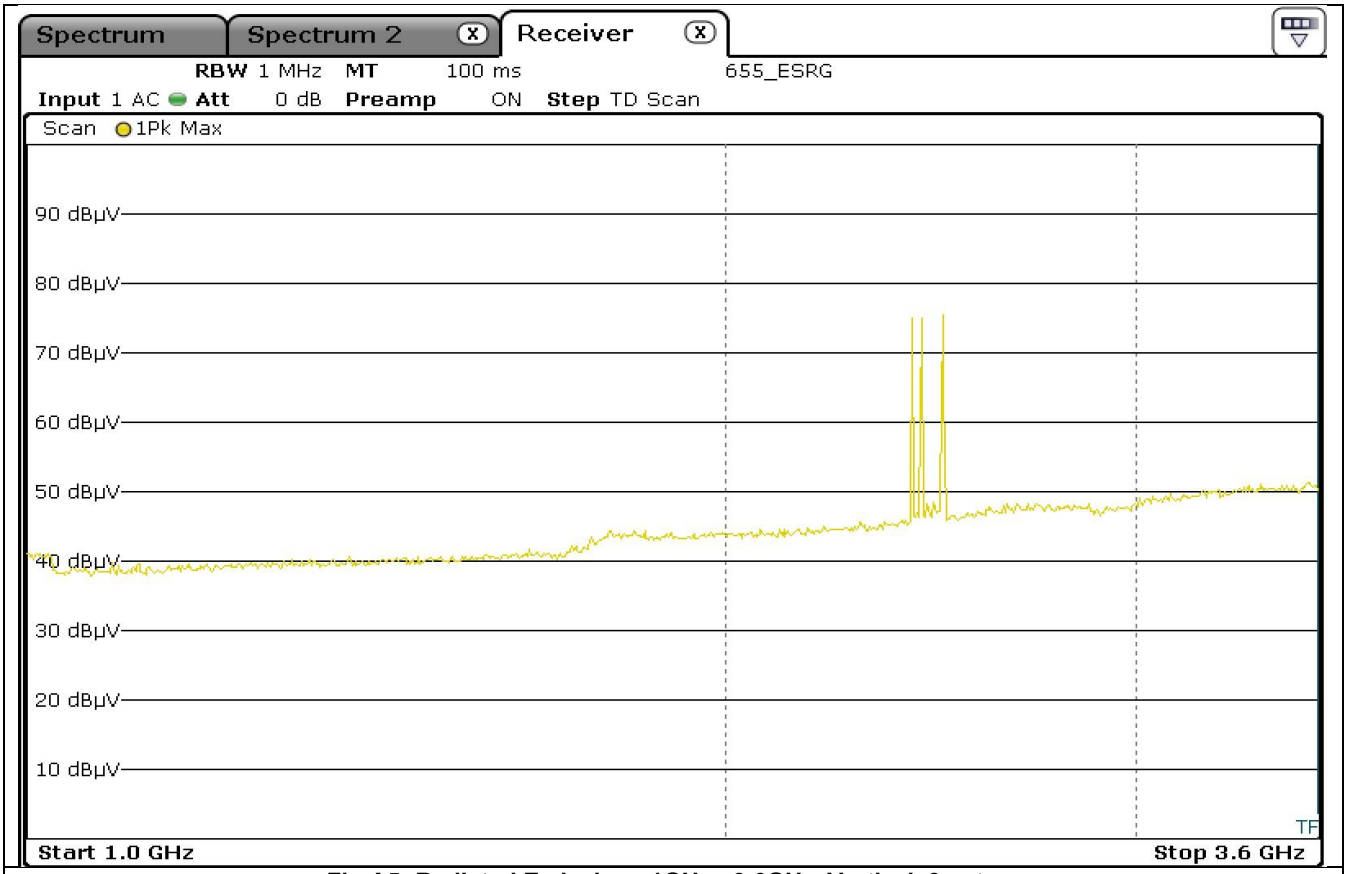


Fig A5: Radiated Emissions 1GHz - 3.6GHz, Vertical, 3metres

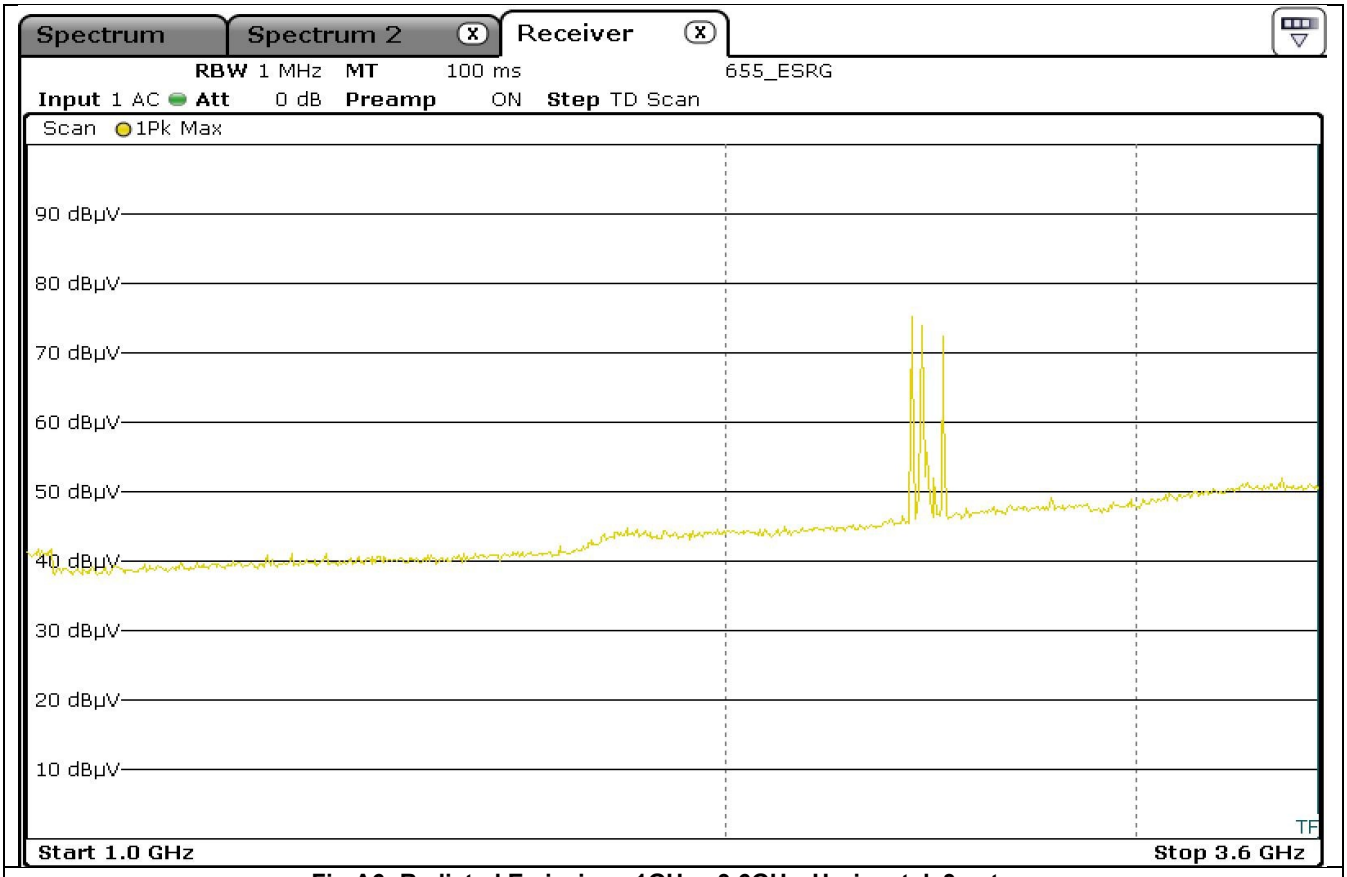


Fig A6: Radiated Emissions 1GHz - 3.6GHz, Horizontal, 3metres

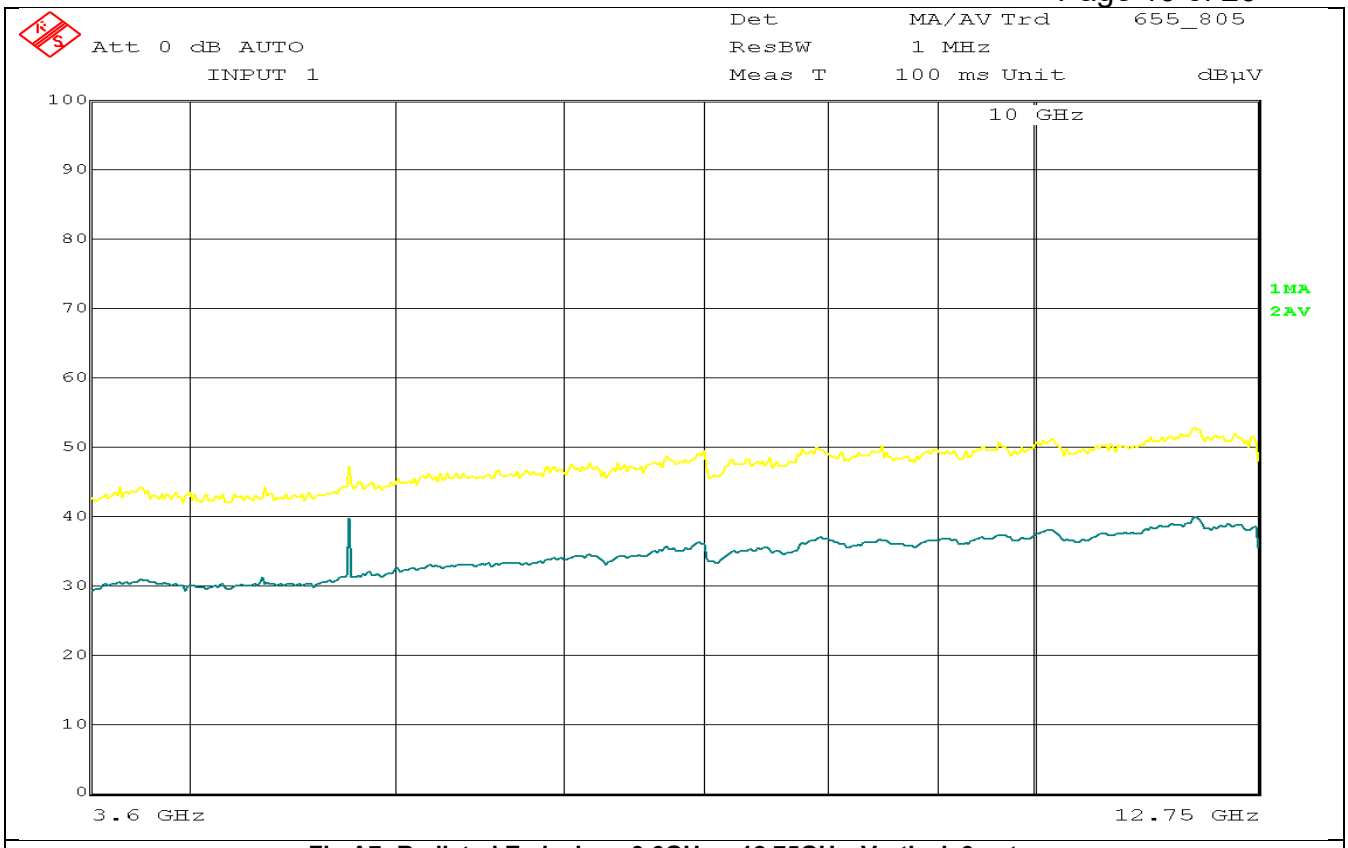


Fig A7: Radiated Emissions 3.6GHz – 12.75GHz, Vertical, 3metre

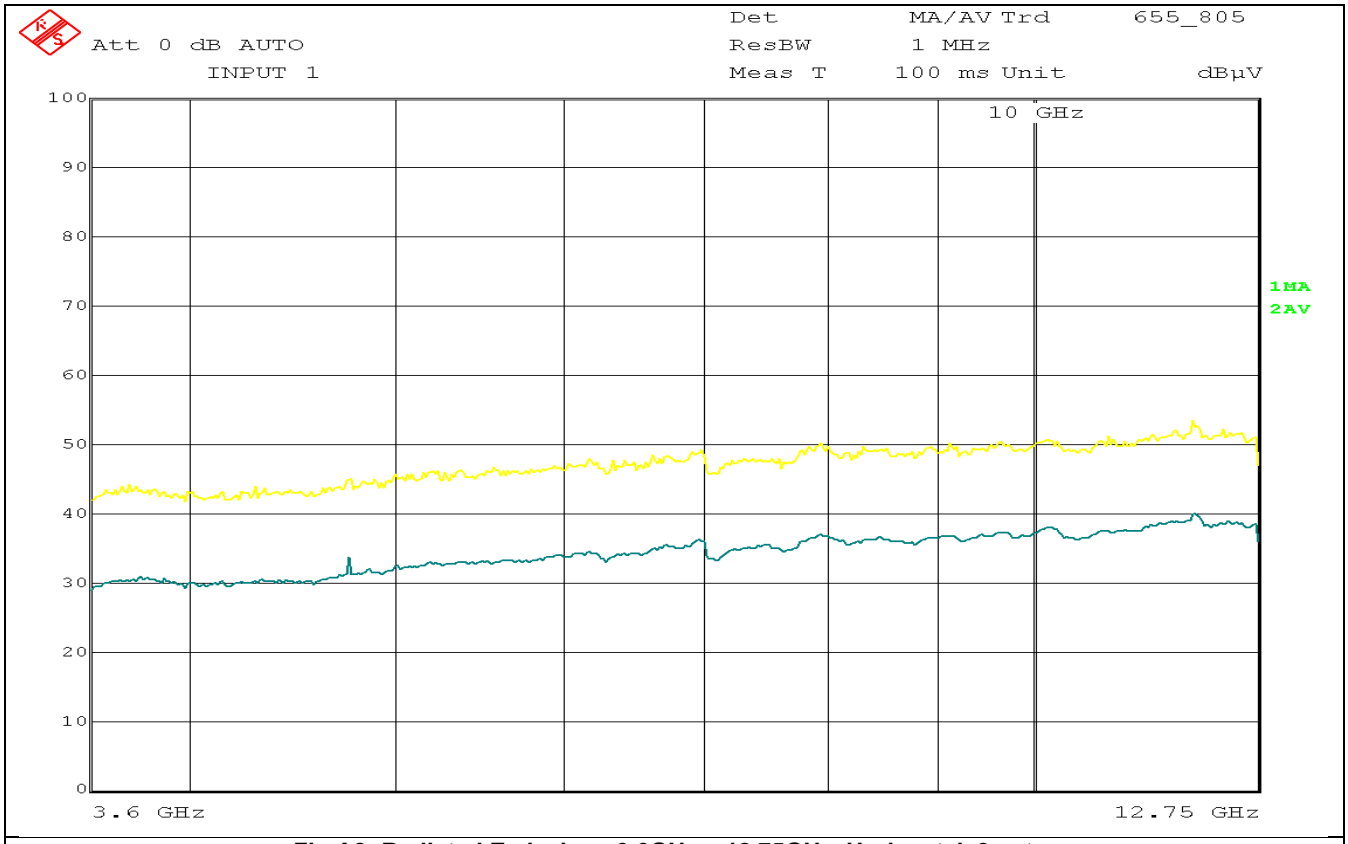


Fig A8: Radiated Emissions 3.6GHz – 12.75GHz, Horizontal, 3metre

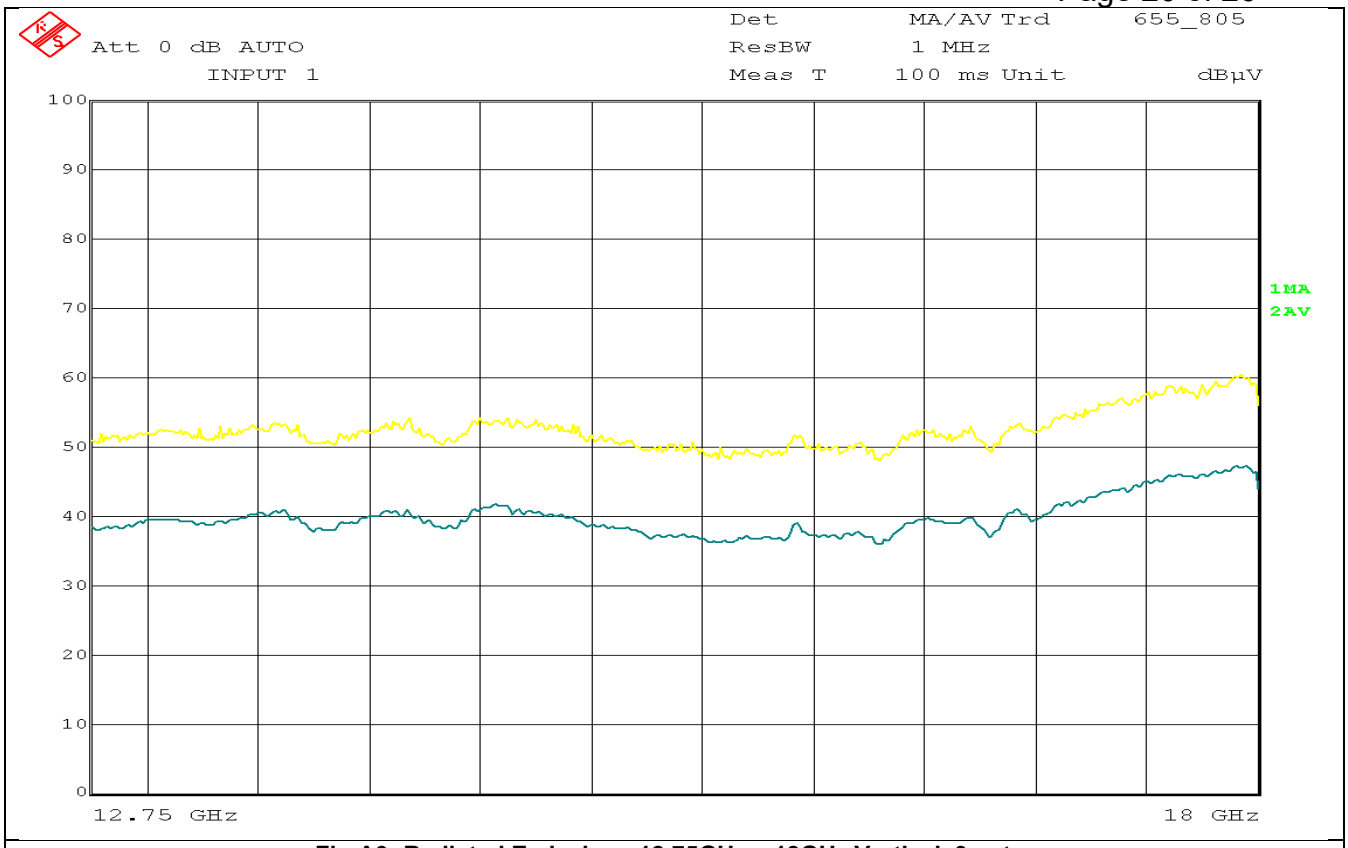


Fig A9: Radiated Emissions 12.75GHz – 18GHz Vertical, 3metre

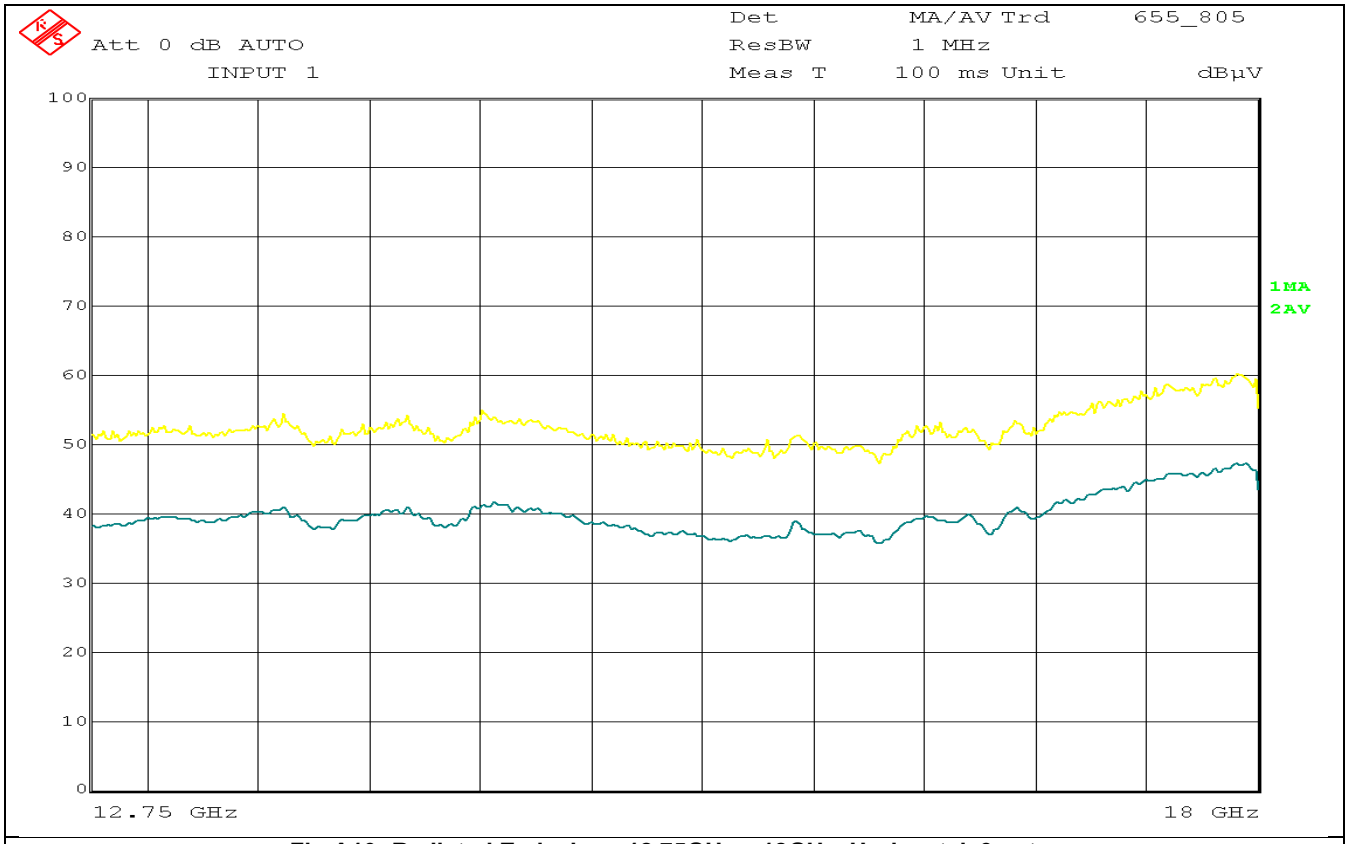


Fig A10: Radiated Emissions 12.75GHz – 18GHz, Horizontal, 3metre

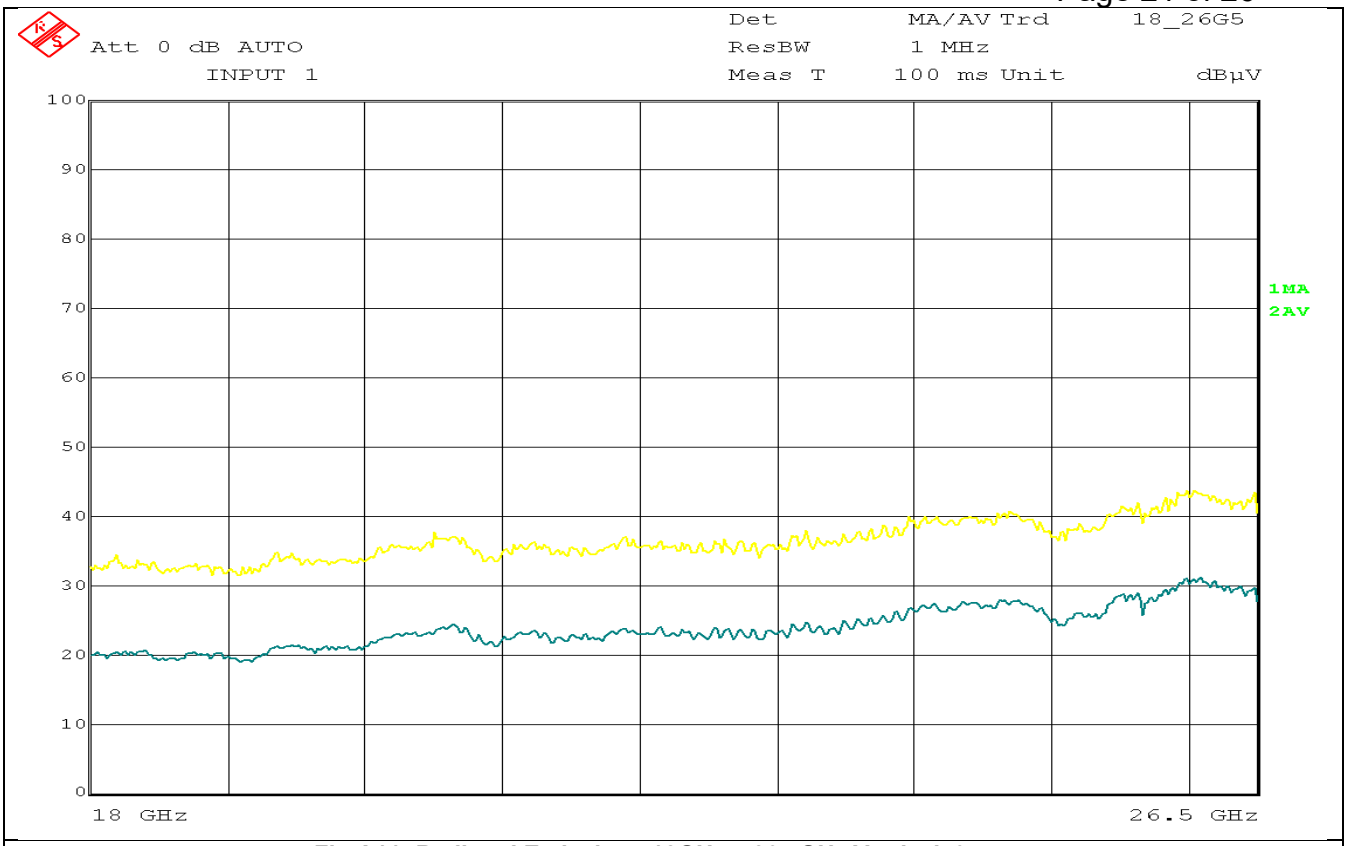


Fig A11: Radiated Emissions 18GHz – 26.5GHz Vertical, 3metre

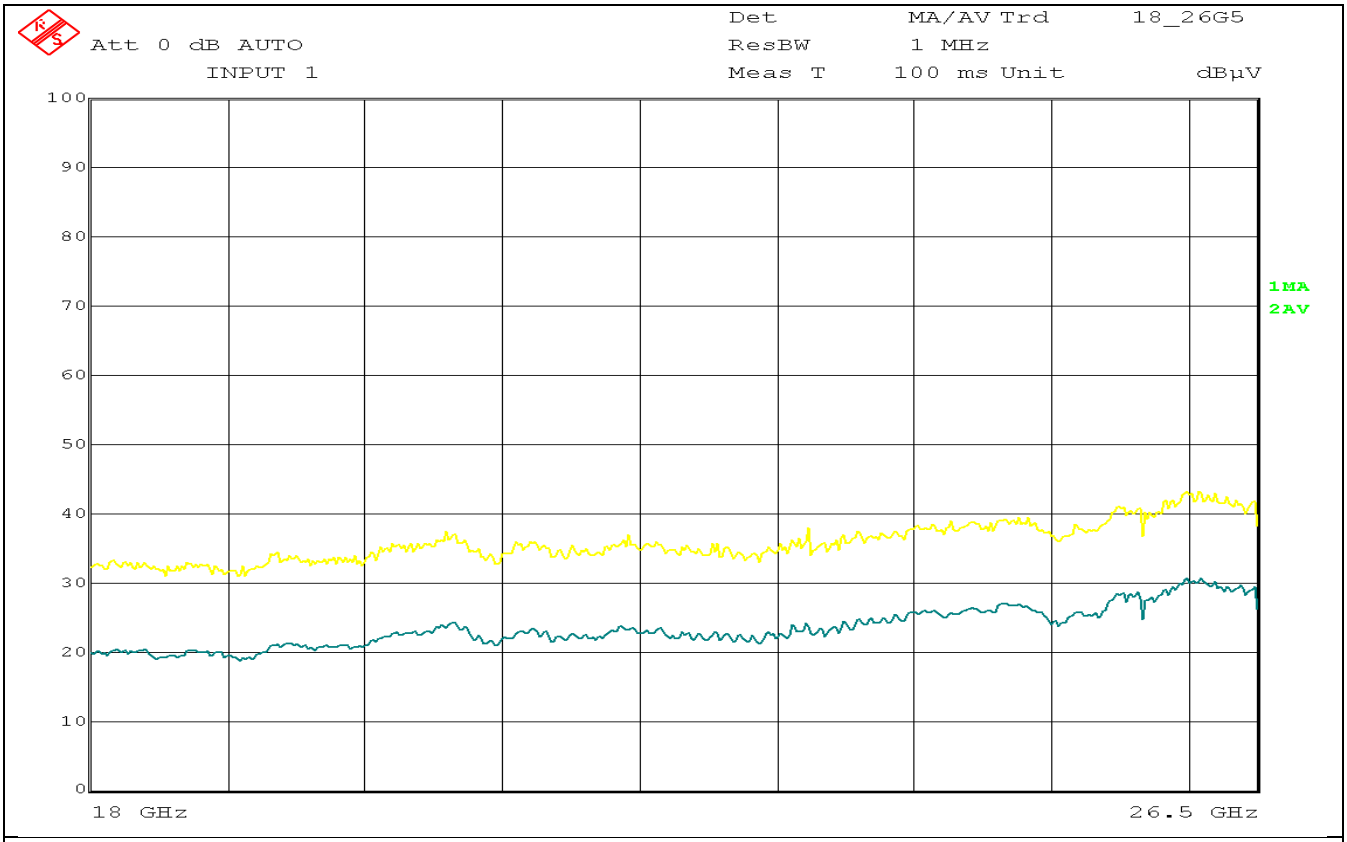
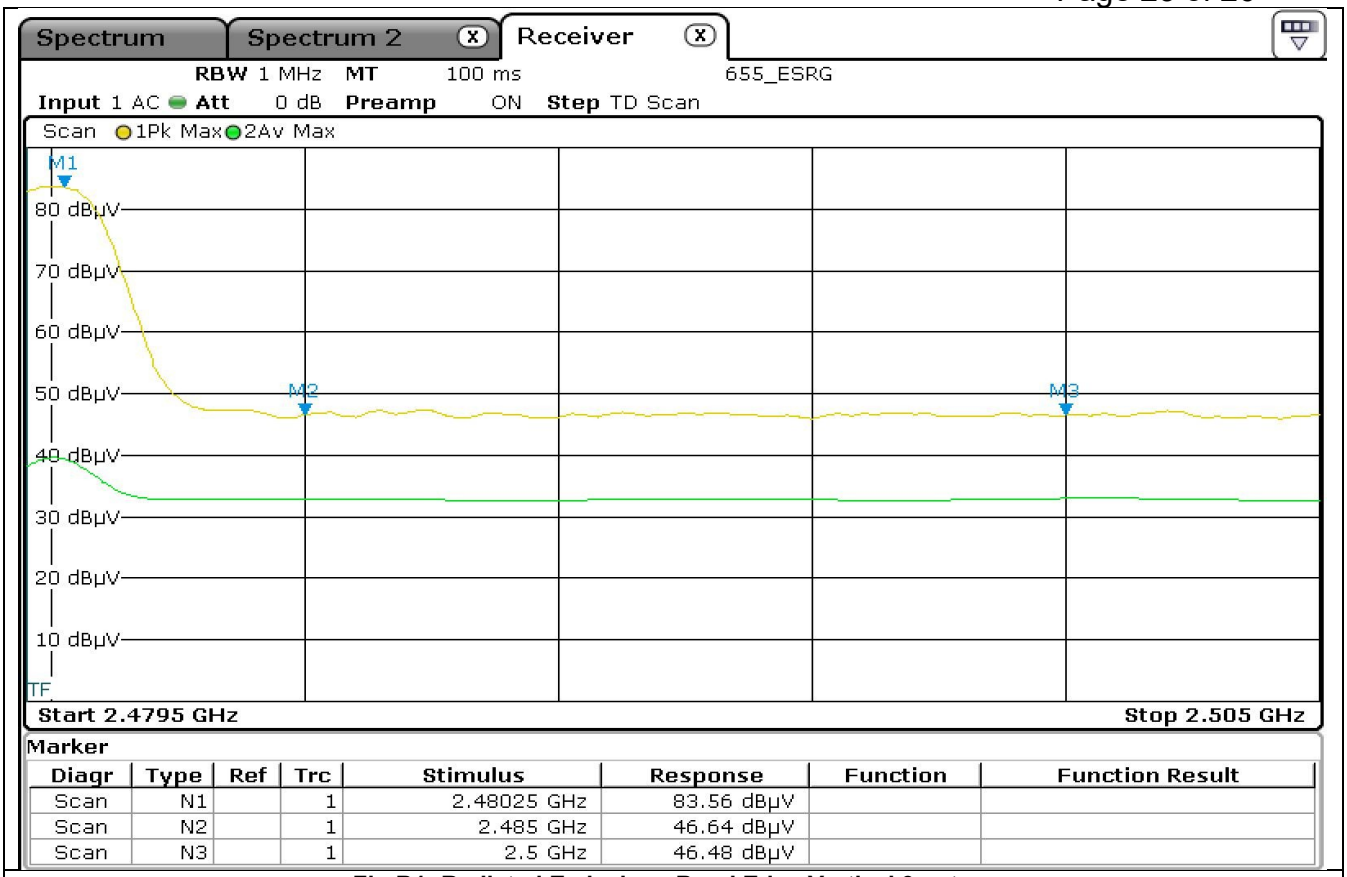


Fig A12: Radiated Emissions 18GHz – 26.5GHz Horizontal, 3metre

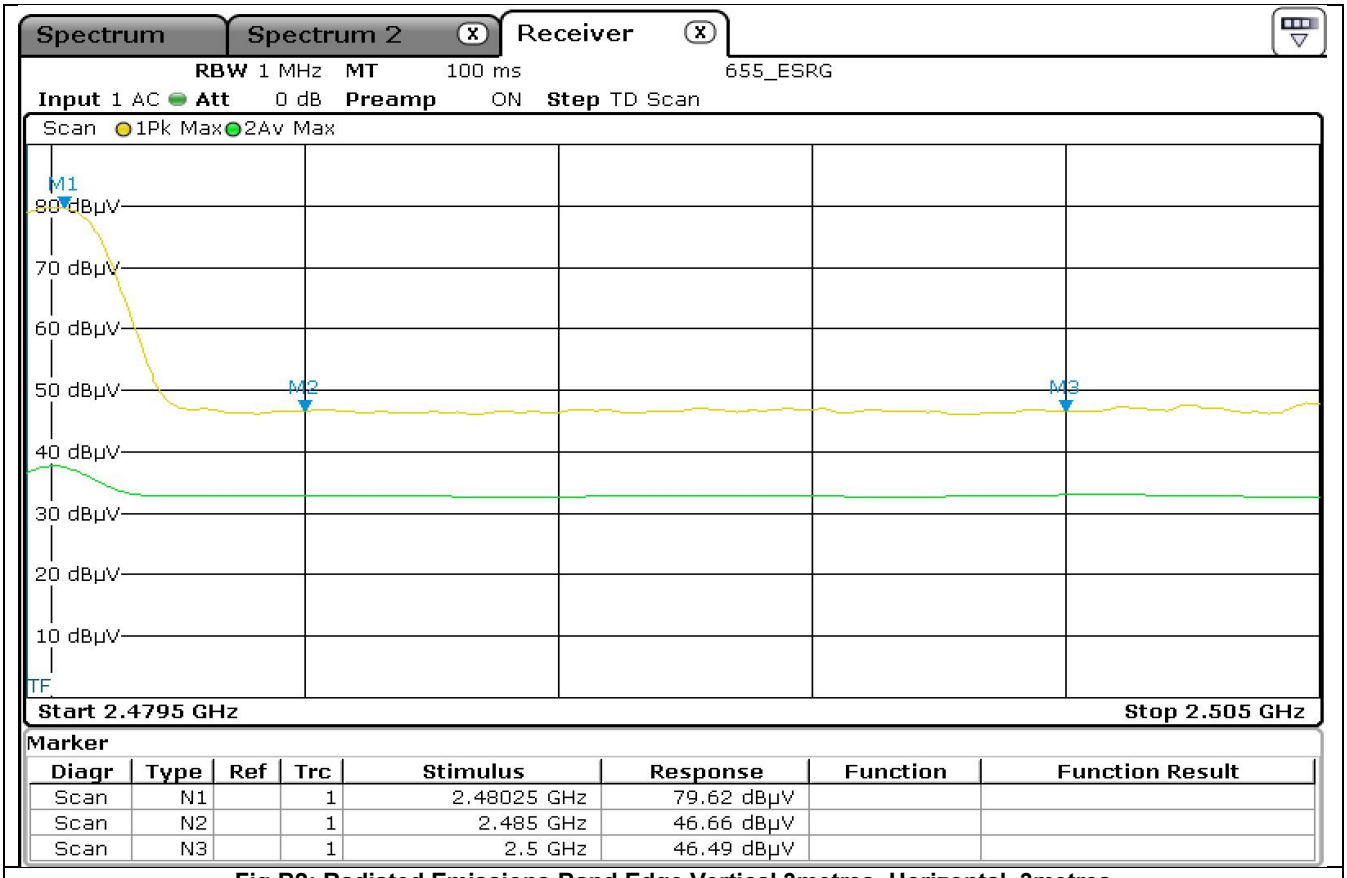
Appendix B: Scans for Restricted band Edge



Marker

Diagr	Type	Ref	Trc	Stimulus	Response	Function	Function Result
Scan	N1		1	2.48025 GHz	83.56 dBµV		
Scan	N2		1	2.485 GHz	46.64 dBµV		
Scan	N3		1	2.5 GHz	46.48 dBµV		

Fig B1: Radiated Emissions Band Edge Vertical 3metres



Marker

Diagr	Type	Ref	Trc	Stimulus	Response	Function	Function Result
Scan	N1		1	2.48025 GHz	79.62 dBµV		
Scan	N2		1	2.485 GHz	46.66 dBµV		
Scan	N3		1	2.5 GHz	46.49 dBµV		

Fig B2: Radiated Emissions Band Edge Vertical 3metres, Horizontal, 3metres

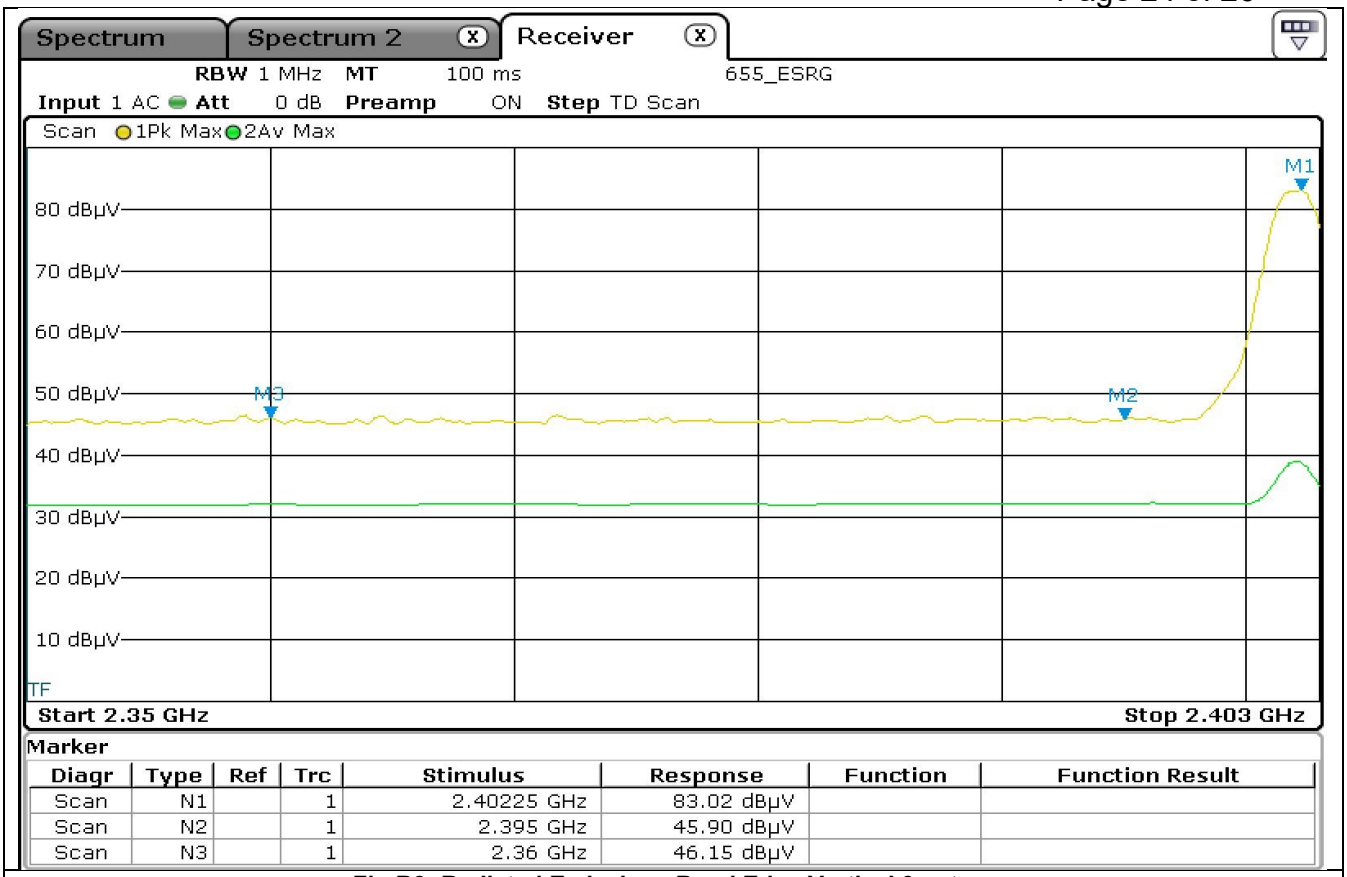


Fig B3: Radiated Emissions Band Edge Vertical 3metres

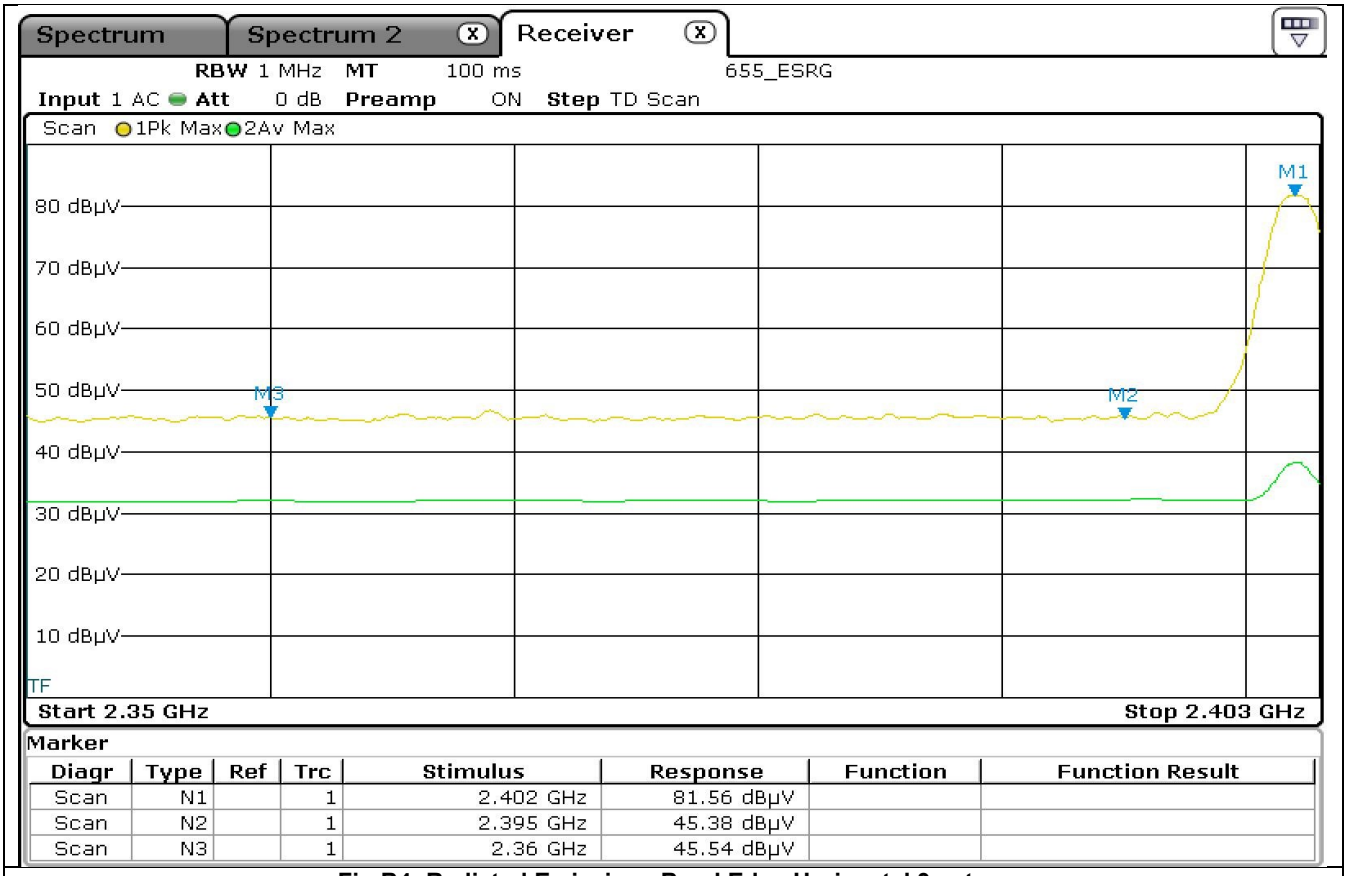


Fig B4: Radiated Emissions Band Edge Horizontal 3metres

Appendix C: Test set up configurations

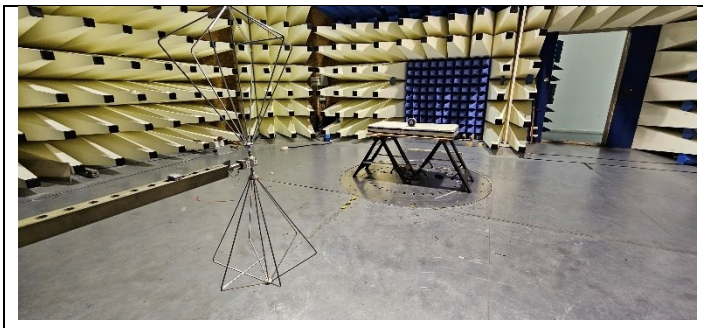


Fig C1: Spurious Emissions 30MHz-300GHz 3 metres

Fig C2: Radiated Emissions 300MHz-1GHz 3metres

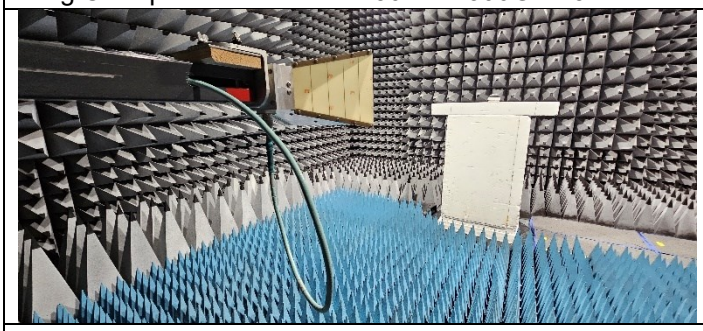


Fig C3: Radiated Emissions 1GHz-18GHz 3metres

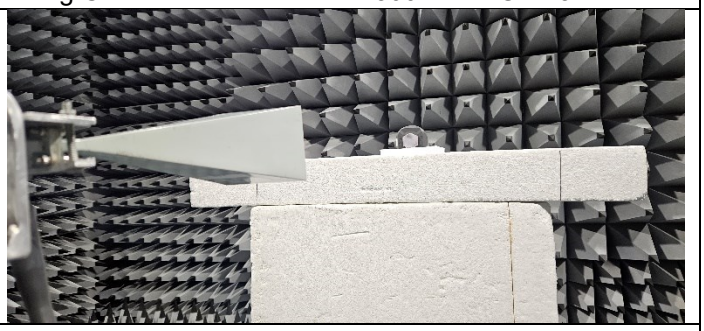


Fig C4: Radiated Emissions 18GHz-26.5GHz 1metre

Fig C5: EUT Orientation O1

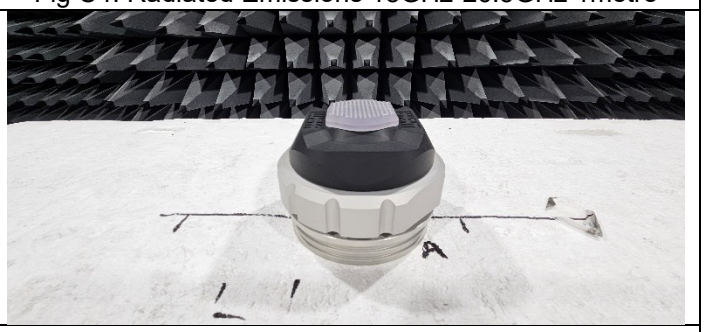


Fig C6: EUT Orientation O2

Appendix D: Block Diagrams of test set up

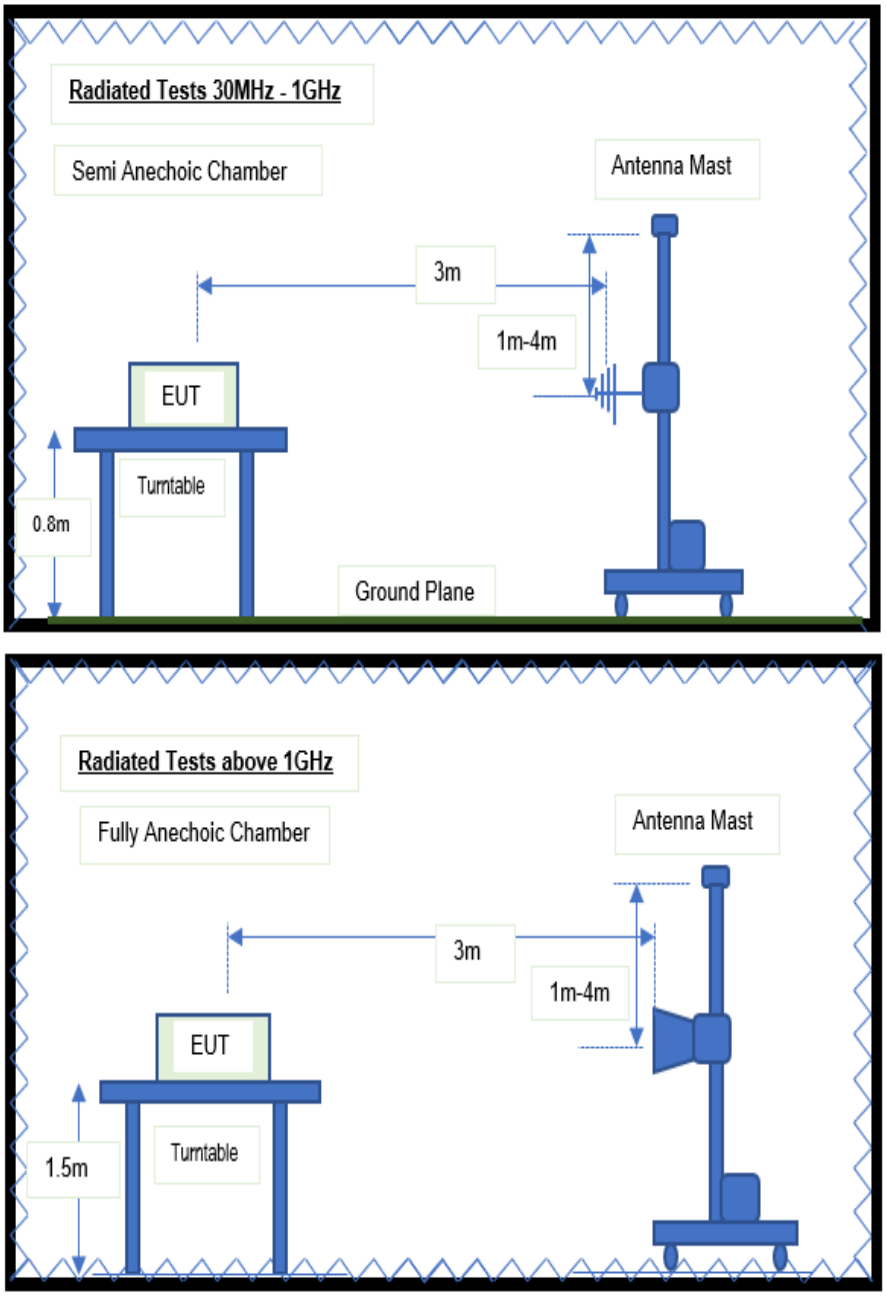


Fig D1: Test Setup

End of Report