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

Project Num	21E9185-4a
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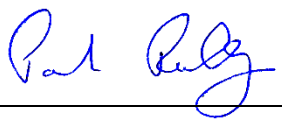
Prepared For	Alps Electric (Ireland) Limited
Company Address	Clara Road, Mountleader, Millstreet, Co. Cork , Ireland
Contact	Donal O'Shea
Contact Email	Donal.oshea-1@alps.ie
Contact Phone	+ 353(29)70677
Prepared By	Compliance Engineering Ireland
Test Lab Address	Clonross Lane, Derrockstown, Dunshaughlin, Co. Meath, Ireland
Tested By	Michael Kirby / Joy Dalayap
Test Report By	Michael Kirby
FCC Test Firm Registration	409640
ISED CAB identifier:	IE0001
Date	26th Aug 2021
EUT Description	Asset Tracker
FCC ID	2AT4VSKALLI1RM
IC ID	26629-SKALLIR2
Authorised by	**Paul Reilly**
Authorised Signature:	

TEST SUMMARY

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

FCC 15.247 Section	RSS-247 Section	TEST PARAMETERS	Test Result
15.205 15.209	RSS Gen 8.9 RSS Gen 8.10	Radiated Spurious Emissions	Pass

RSS 247-2 (Feb 2017)
RSS Gen Issue5 Amd 2 (Feb 2021)

RSS 247-2 (Feb 2017)
RSS Gen Issue5 Amd 2 (Feb 2021)

Exhibit A – Technical Report

Table of Contents

1.0 EUT Description

FCC ID	2AT4VSKALLI1RM
IC ID	26629-SKALLI1RM
Model:	2EE-2707AB
HVIN:	2EE-2707AB
PMN:	Skalli1RM
Type:	Asset Tracker
Type of radio:	Stand-alone

Sigfox

Transmitter Type:	D-BPSK
Classification:	DSS
Operating Frequency Range(s):	902.138MHz -904.663 MHz
Number of Channels:	Hopping on 54 channels (902.138 – 904.663 MHz)
Antenna:	Integral
Transmitter power configuration:	3.6 VDC Internal Battery (non-rechargeable)
Sigfox Antenna Type :	Folded metal antenna
Sigfox Antenna Gain Max:	3.86dBi
Sigfox Antenna Impedance:	50 ohms
Test Standards:	15.247 RSS-247
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013 KDB 558074 V5 R02

BLE

Type of radio:	Stand-alone
Transmitter Type:	BLE
Operating Frequency Range(s):	2.402 GHz - 2.480GHz
Number of Channels:	40
Power configuration:	3.7v Battery.
Ports:	None
Classification:	DTS
BLE Antenna Type :	Pcb printed antenna
BLE Antenna Gain Max:	0.9 dBi
Antenna Impedance:	50 ohms
Test Standards:	15.247 RSS-247
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013 KDB 558074 V5 R02

The EUT was an asset tracker reporting on the 915 MHz band over the Sigfox network

The EUT also contained a custom BLE radio.
This report details test carried out on the Sigfox and BLE transmitters transmitting simultaneously.
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1.1 EUT Operation

Operating Conditions during Test:

The EUT was operated in test mode where the channel and modulation was set via USB connection from the EUT to a laptop.
The EUT was powered from a bench PSU set to 3.6Vdc. for all conducted tests

Radiated measurements were performed on a sample (Sample #Z) with standard internal antennas with the EUT powered from its (new) internal battery with Sigfox and BLE transmitting simultaneously.

Environmental conditions

	Temperature	Relative Humidity
Test	°C	%
Conducted Emissions	21.2	49
Radiated Emissions <1GHz	18	42
Radiated Emissions >1GHz	19	47

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 7th 8th 27th Jul and 13th 16th Aug 2021.

1.4 Description of Test modes

Channel List

Channel	Channel	Freq MHz
Low	1	2402
	2	2404
Mid	19	2440
High	39	2480

All tests were performed with the EUT on the low mid and high channels.

2 Emissions Measurements

2.1 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.
The EUT was centred on a motorized turntable, which allows 360 degree rotation.

Emissions below 1GHz were measured using a test antenna positioned at a distance of 3 metres from the EUT (as measured from the closest point of the EUT). 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. In this case the resolution bandwidth was 100kHz.
Emissions in the 1GHz-3.6GHz range were measured using a horn antenna located at 3 metres distance from the EUT in a fully anechoic chamber.
The radiated emissions were maximised by configuring the EUT and by rotating the EUT, and by raising and lowering the test antenna from 1 to 4 metres.
Emissions above 3.6GHz were measured using a horn antenna located at 1 metre distance from the EUT in a fully anechoic chamber. The radiated emissions were maximised by configuring the EUT and by rotating the EUT and raising the test and antenna from 1 to 4 metres.
In this case the resolution bandwidth was 1MHz and video bandwidth was 3 MHz. for peak measurements. The Video bandwidth was changed to 10Hz for Average measurements (as per ANSI 63.10 2013 Section 4.1.4.2.3)

A pre-scan was performed to determine the worst case EUT orientation for the radiated measurements.
All radiated tests were performed with the EUT in orientation O3 for Horizontal polarization measurements and with the EUT in orientation O2 for Vertical polarisation measurements.
Ref Appendix D for orientations.

3

A number of co-location tests were performed, and the worst case are reported here.

For the restricted band at 2.4835GHz it was found that the worst case results were achieved with BLE at 2.48GHz and Sigfox transmitting at 902.138 MHz

For the restricted band below 2.39GHz it was found that the worst case results were achieved with BLE at 2.402 GHz and Sigfox at 902.138MHz

A full scan was performed with BLE operating at 2.402GHz and Sigfox operating at 902.138MHz

3.2. Spurious Emissions Measurements

3.2.1. Radiated Spurious Emissions in Restricted bands

3.2.1 Test Method
As per Ansi63.10 Section 11.12.1 and 6.10.5

Ansi63.10 Section **11.12.1 Radiated emission measurements**
Because the typical emission requirements are specified in terms of radiated field strength levels, measurements performed to determine compliance have traditionally relied on a radiated test configuration.92 Radiated measurements remain the principal method for determining compliance to the specified requirements; however antenna-port conducted measurements are also now acceptable to determine compliance (see 11.12.2 for details). When radiated measurements are utilized, test site requirements and procedures for maximizing and measuring radiated emissions that are described in 6.3, 6.5, and 6.6 shall be followed

6.10.5 Restricted-band band-edge measurements
These procedures are applicable for determining compliance at band edges of restricted bands.
6.10.5.1 Test setup
Restricted-band band-edge tests shall be performed as radiated measurements, on a test site meeting the specifications in 5.2 at the measurement distances specified in 5.3.57
The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2. Considering the requirements of 5.8, the antenna(s) shall be connected to the antenna ports. When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3, and the relevant procedure in 6.4, 6.5, or 6.6

As per Ansi 63.10 Section 11.12.2.5.2

11.12.2.5.2 Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction
If continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is constant (duty cycle variations are less than ±2%), then the following procedure shall be used:
a) The EUT shall be configured to operate at the maximum achievable duty cycle.
b) Measure the duty cycle *D* of the transmitter output signal as described in 11.6.
c) RBW = 1 MHz (unless otherwise specified).
d) VBW ≥ [3 *RBW].
e) Detector = RMS (power averaging), if span / (# of points in sweep) ≤ (RBW / 2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
f) Averaging type = power (i.e., rms):
1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
2) Some instruments require linear display mode to use linear voltage averaging. Log or dB averaging shall not be used.
g) Sweep time = auto.
h) Perform a trace average of at least 100 traces.
i) A correction factor shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:
1) If power averaging (rms) mode was used in step f), then the applicable correction factor is [10 log (1 / *D*)], where *D* is the duty cycle.
2) If linear voltage averaging mode was used in step f), then the applicable correction factor is [20 log (1 / *D*)], where *D* is the duty cycle.
3) If a specific emission is demonstrated to be continuous ($D \geq 98\%$) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.
Reduction of the measured emission amplitude levels to account for operational duty cycle is not permitted. Determining compliance is based on emission levels occurring during transmission; it is not based on an average across ON and OFF times of the transmitter

One Period uS	Pulse Width uS	Duty Cycle	10 log duty cycle for Power Averaging (dB)
626.09	95.65	0.153	-8.16

Duty cycle correction factor =8.16dB for average measurements

Frequency	Measured Peak Level	Antenna Factor	Preamp Gain	Cable Loss	Antenna Polarity	Duty Cycle Correction	Final Peak Level	Average Limit +20dB	Margin
4.804	46.6	32.4	37.1	5.2	Vertical	0.00	47.1	74	26.9
5.412	46.7	33.5	37.5	5.6	Vertical	0.00	48.3	74	25.7
4.804	46.7	32.4	37.1	5.2	Horizontal	0.00	47.2	74	26.9
5.412	46.7	33.5	37.5	5.6	Horizontal	0.00	48.3	74	25.7

Note the final average measurements include the duty cycle correction factor (which has been added to the measured result)
Test Result: - Pass

3.3 Radiated Band Edge / Restricted band Measurements

11.13.3.2 Peak detection

When using a peak detector to measure unwanted emissions at or near the band edge (within 2 MHz of the authorized band), the following integration procedure can be used:

a) Set instrument center frequency to the frequency of the emission to be measured (must be within 2 MHz of the authorized band edge).
b) Set span to 2 MHz.
c) RBW = 100 kHz.
d) VBW ≥ [3 × RBW].
e) Detector = peak.
f) Sweep time = auto.
g) Trace mode = max hold.
h) Allow sweep to continue until the trace stabilizes (required measurement time may increase for low-duty-cycle applications).
i) Compute the power by integrating the spectrum over 1 MHz using the analyzer's band power measurement function with band limits set equal to the emission frequency ($f_{emission}$) ± 0.5 MHz. If the instrument does not have a band power function, then sum the amplitude levels (in power units) at 100 kHz intervals extending across the 1 MHz spectrum defined by $f_{emission}$ ± 0.5 MHz.

11.13.3.4 Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction

If continuous transmission of the EUT (D ≥ 98%) cannot be achieved and the duty cycle is constant (duty cycle variations are less ±2%), then the following procedure may be used to measure the average power of unwanted emssions within 2 MHz of the authorized band edge:

a) The EUT shall be configured to operate at the maximum achievable duty cycle.
b) Measure the duty cycle D of the transmitter output signal as described in 11.6.
c) Set instrument center frequency to the frequency of the emission to be measured.
d) Set span to 2 MHz.
e) RBW = 100 kHz.
f) VBW ≥ 3 × RBW.
g) Detector = RMS (power averaging), if [span / (# of points in sweep)] ≤ (RBW / 2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
h) Averaging type = power (i.e., rms):
1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
2) Some instruments require linear display mode to use linear voltage averaging. Log or dB averaging shall not be used.
i) Sweep time = auto.
j) Perform a trace average of at least 100 traces.
k) Compute the power by integrating the spectrum over 1 MHz using the instrument's band power measurement function with band limits set equal to the emission frequency ($f_{emission}$) ± 0.5 MHz. If the spectrum analyzer does not have a band power function, then sum the amplitude levels (in power units) at 100 kHz intervals extending across the 1 MHz spectrum defined by $f_{emission}$ ± 0.5 MHz.
l) A correction factor shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:
1) If power averaging (rms) mode was used in step f), then the applicable correction factor is [10 log (1 / D)], where D is the duty cycle.
2) If linear voltage averaging mode was used in step f), then the applicable correction factor is [20 log (1 / D)], where D is the duty cycle.
3) If a specific emission is demonstrated to be continuous (D ≥ 98%) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Reduction of the measured emission amplitude levels to account for operational duty cycle is not permitted. Determining compliance is based on emission levels occurring during transmission—it is not based on an average across ON and OFF times of the transmitter.

3.3.1 Result Radiated Restricted Band and band edge near 2.4 GHz band

Frequency	Measured Peak Level	Antenna Factor	Preamp Gain	Cable Loss	Antenna Polarity	Duty Cycle Correction	Final Peak Level	Average Limit +20dB	Margin
GHz	dBuV/m	dB	dB	dB	V/H	dB	dBuV/m	dBuV/m	dB
2.310	53.6	27.4	39.2	3.4	Vertical	0.00	45.2	74	28.8
2.390	61.9	27.4	38.5	3.5	Vertical	0.00	54.3	74	19.7
2.400	80.2	27.4	38.5	3.5	Vertical	0.00	72.6	74	1.5
2.310	55.6	27.4	39.2	3.4	Horizontal	0.00	47.2	74	26.8
2.390	63.0	27.4	38.5	3.5	Horizontal	0.00	55.4	74	18.6
2.400	81.0	27.4	38.5	3.5	Horizontal	0.00	73.4	74	0.6

Frequency	Measured Average Level	Antenna Factor	Preamp Gain	Cable Loss	Antenna Polarity	Duty Cycle Correction	Final Average Level	Average Limit	Margin
GHz	dBuV/m	dB	dB	dB	V/H	dB	dBuV/m	dBuV/m	dB
2.310	39.1	27.4	39.2	3.4	Vertical	8.16	38.9	54	15.1
2.390	39.4	27.4	38.5	3.5	Vertical	8.16	40.0	54	14.0
2.400	51.6	27.4	38.5	3.5	Vertical	8.16	52.1	54	1.9
2.310	39.2	27.4	39.2	3.4	Horizontal	8.16	38.9	54	15.1
2.390	39.6	27.4	38.5	3.5	Horizontal	8.16	40.1	54	13.9
2.400	51.4	27.4	38.5	3.5	Horizontal	8.16	52.0	54	2.0

Frequency	Measured Peak Level	Antenna Factor	Preamp Gain	Cable Loss	Antenna Polarity	Duty Cycle Correction	Final Peak Level	Average Limit +20dB	Margin
GHz	dBuV/m	dB	dB	dB	V/H	dB	dBuV/m	dBuV/m	dB
2.4835	70.1	28.7	38.3	3.4	Vertical	0.00	63.9	74	10.1
2.500	55.7	28.7	38.3	3.4	Vertical	0.00	49.5	74	24.5
2.4835	66.9	28.7	38.3	3.4	Horizontal	0.00	60.7	74	13.3
2.500	54.4	28.7	38.3	3.4	Horizontal	0.00	48.2	74	25.8

Frequency	Measured Average Level	Antenna Factor	Preamp Gain	Cable Loss	Antenna Polarity	Duty Cycle Correction	Final Average Level	Average Limit	Margin
GHz	dBuV/m	dB	dB	dB	V/H	dB	dBuV/m	dBuV/m	dB
2.4835	43.9	28.7	38.3	3.4	Vertical	8.16	45.9	54	8.1
2.500	38.8	28.7	38.3	3.4	Vertical	8.16	40.7	54	13.3
2.4835	46.2	28.7	38.3	3.4	Horizontal	8.16	48.2	54	5.8
2.500	39.0	28.7	38.3	3.4	Horizontal	8.16	40.9	54	13.1

Note the final average measurements include the duty cycle correction factor (which has been added to the measured result)

Test Result: - Pass

Duty Cyckle
3.4
Test Method
As per Ansi 63.10 Section 11.6 KDB 558074 zero span measurement method

Ansi63.10 Section **11.6 Duty cycle (*D*), transmission duration (*T*), and maximum power control level**

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be used to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (*T*) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed *T* at any time that data are being acquired (i.e., no transmitter OFF-time is to be considered).

KDB 558074 D01 FAQ section

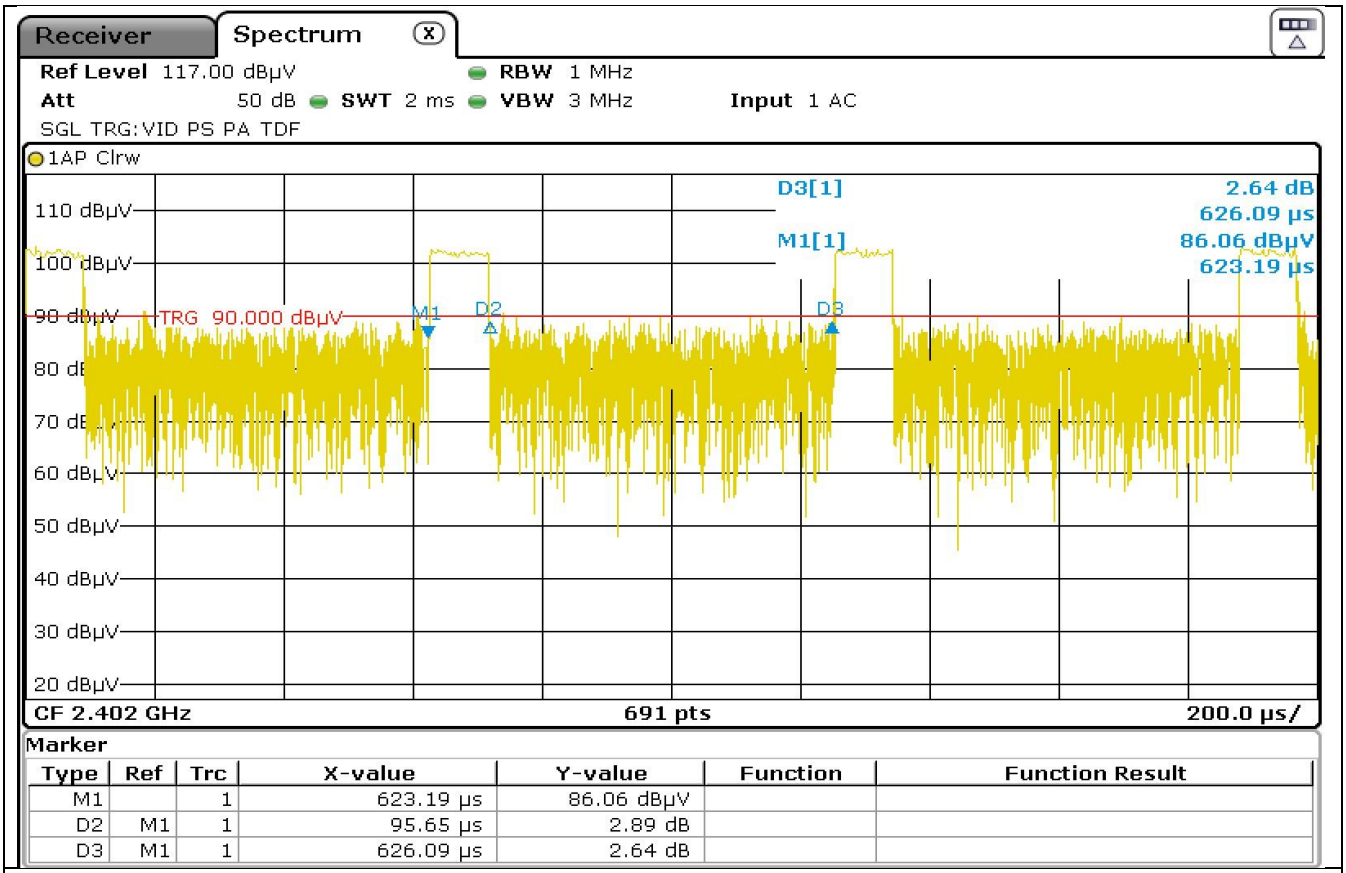


Fig 3 Duty Cycle

Duty Cycle =

Note the duty cycle results above shows how the sample operated during testing.

One Period uS	Pulse Width uS	Duty Cycle	10 log duty cycle for Power Averaging (dB)
626.09	**95.65**	**0.153**	**-8.16**

4 List of Test Equipment

Instrument	Manufacturer	Model	Serial Num	CEI Ref	Cal Due Date	Cal Interval Months
Spectrum Analyser 30Hz-40GHz	Rohde & Schwarz	FSP40	100053	850	11-Dec-21	36
Test Receiver 3.6GHz	Rohde & Schwarz	ESR	1316.3003k03-101625-s	869	28-May-23	36
Antenna Biconical	Schwarzbeck	VHBB 9124	9124 667	871	30-Sep-21	36
Antenna Horn	EMCO	3115	9905-5809	655	13-Dec-21	24
Anechoic Chamber	CEI	SAR 10M	845	845	16-May-22	36
Antenna Log Periodic	Chase	UPA6108	1072	609	03-Sep-21	36
Fully Anechoic Chamber	CEI	FAR 3M	906	906	23-Jul-22	36
Microwave Preamplifier	Hewlett Packard	83017A	3123A00175	805	30-Sep-21	12
Antenna Horn Standard Gain 18-26.5GHz	A-Info	LB-42-25-C-KF	J2021091103028	877	16-May-22	12

5 Measurement Uncertainties

Measurement	Uncertainty
Radio Frequency	+/- $5x10^{-7}$
Maximum Frequency Deviation	+/- 1.7 %
Conducted Emissions	+/- 1 dB
Radiated Emission 30MHz-100MHz	+/- 5.3 dB
Radiated Emission 100MHz-300MHz	+/- 4.7 dB
Radiated Emission 300MHz-1GHz	+/- 3.9 dB
Radiated Emission 1GHz-40GHz	+/- 3.8 dB
Modulation bandwidth	+/- $5x10^{-7}$
Duty Cycle	+/- 5 %
Power supply	±0.1 VDC
Temperature	±0.2 °C
Frequency	±0.01 ppm

The measurement uncertainties stated were calculated with a k=2 for a confidence level of over 95% as per ETS TR100 028.

The test data can be compared directly to the specification limit to determine compliance, as the calculated measurement uncertainty meets the requirements of the applicable specification.

Appendix A

Radiated Spurious Emissions

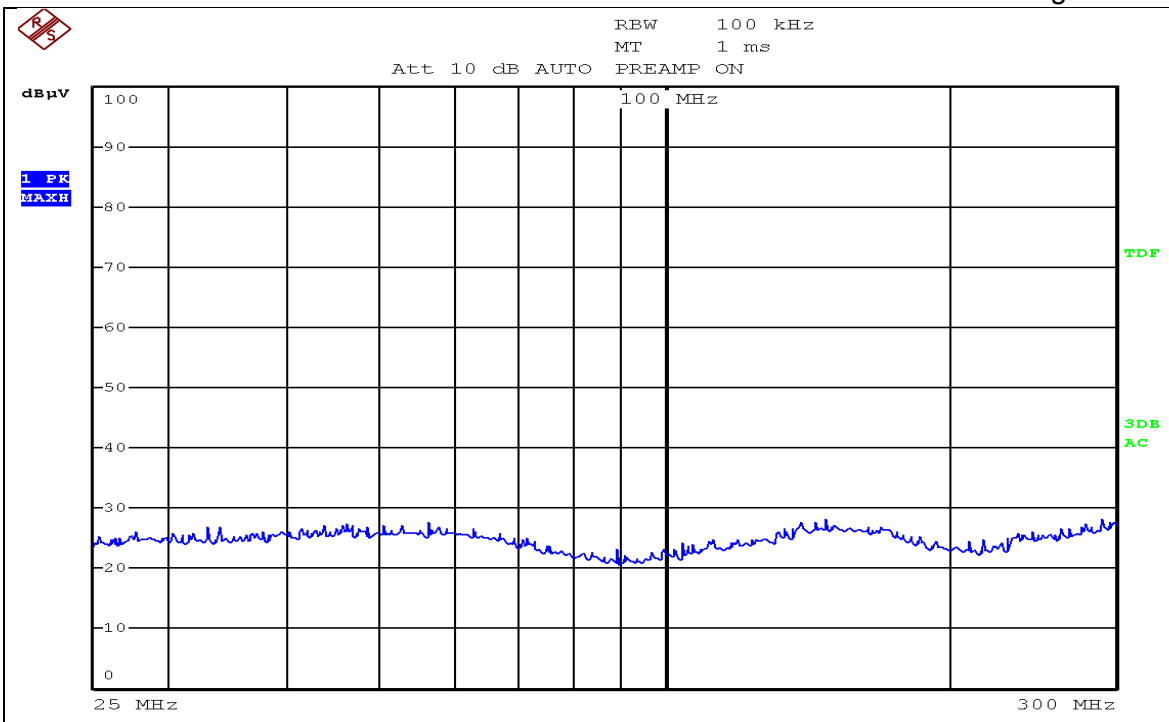


Fig A1 Radiated Emissions 30MHz -300MHz Vertical 3metres

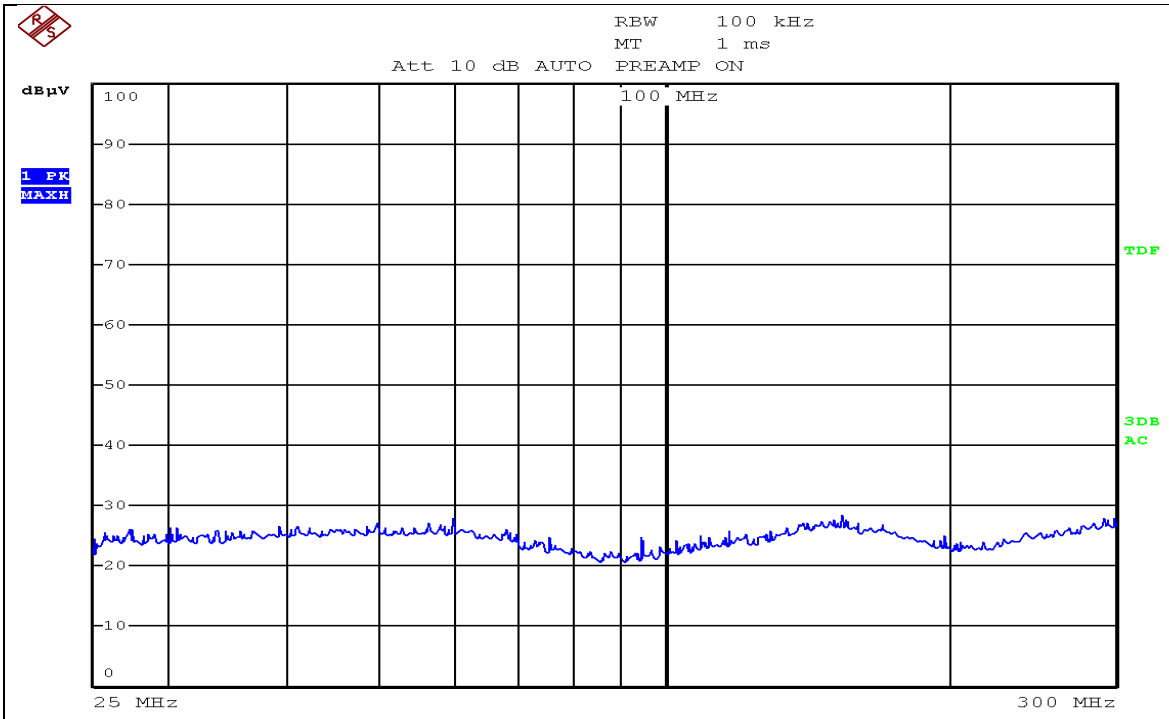


Fig A2 Radiated Emissions 30MHz -300MHz Horizontal 3metres

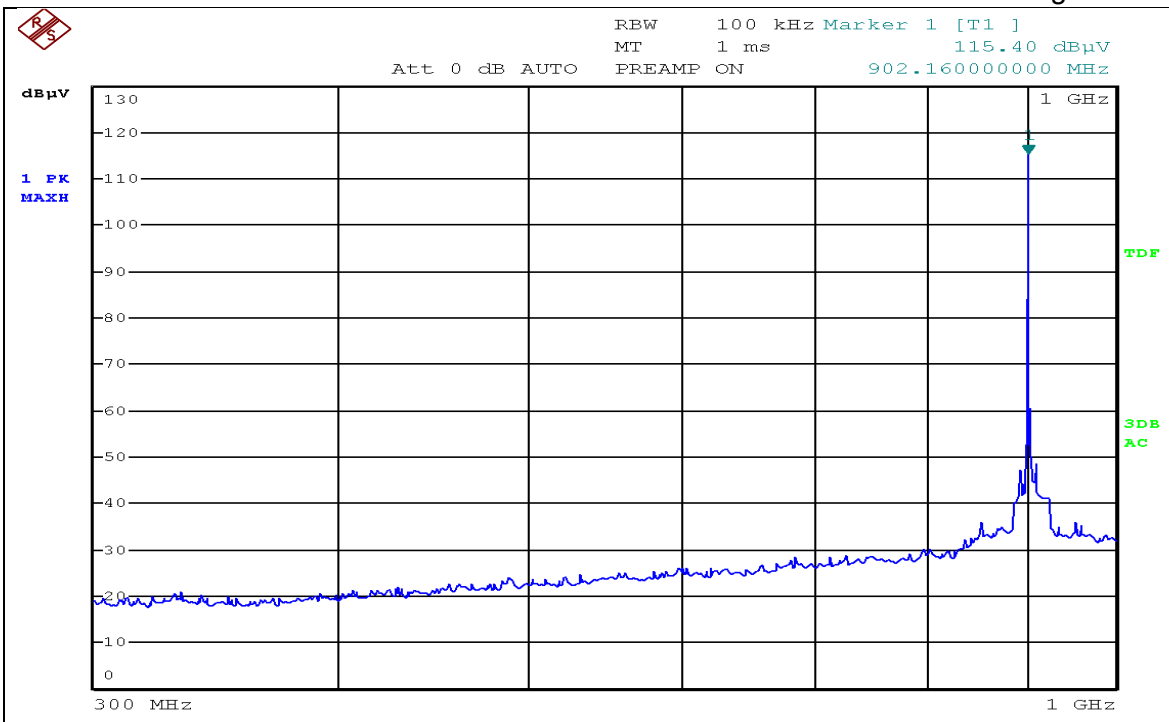


Fig A3 Radiated Emissions 300MHz -1GHz Vertical 3metres

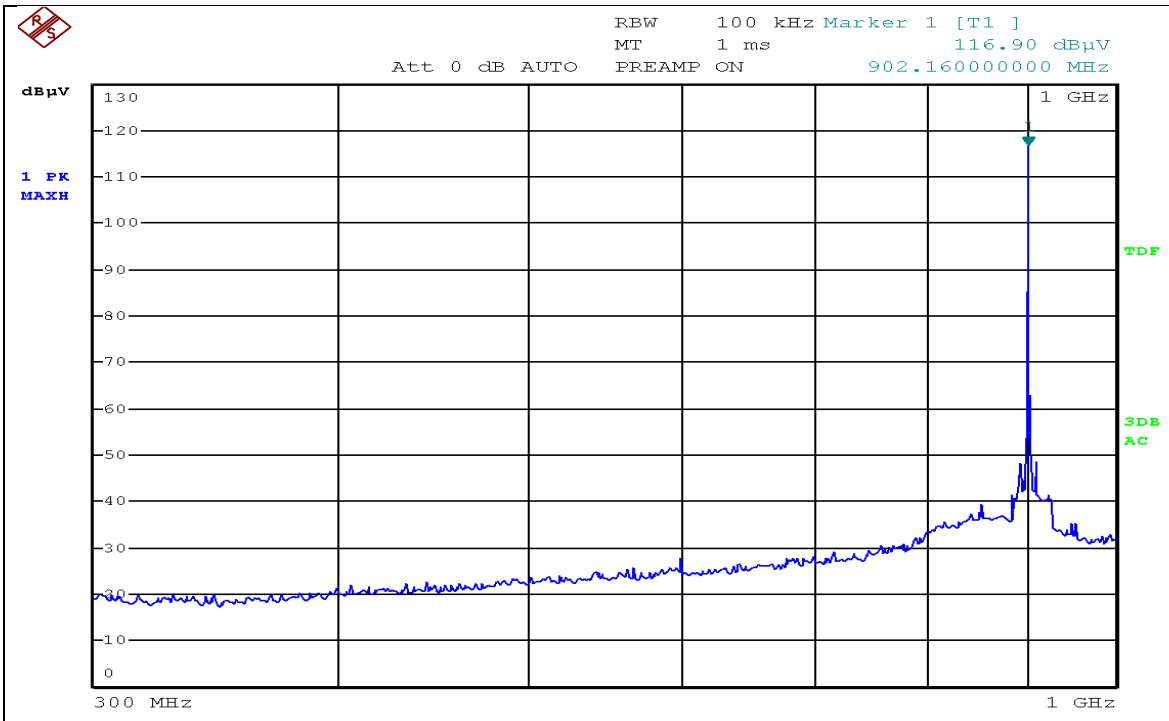


Fig A4 Radiated Emissions 300MHz -1GHz Horizontal 3metres

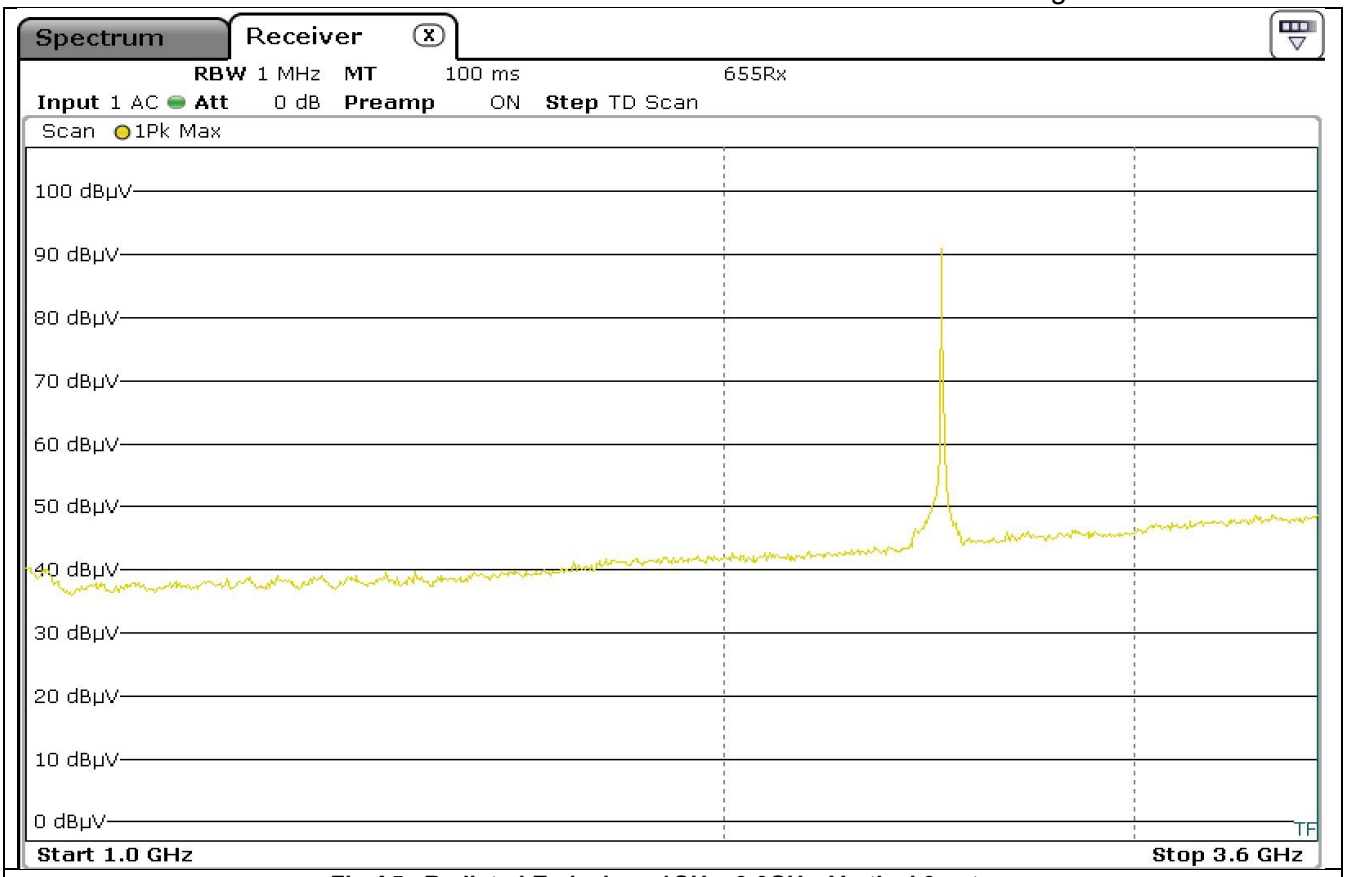


Fig A5 Radiated Emissions 1GHz -3.6GHz Vertical 3metres

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

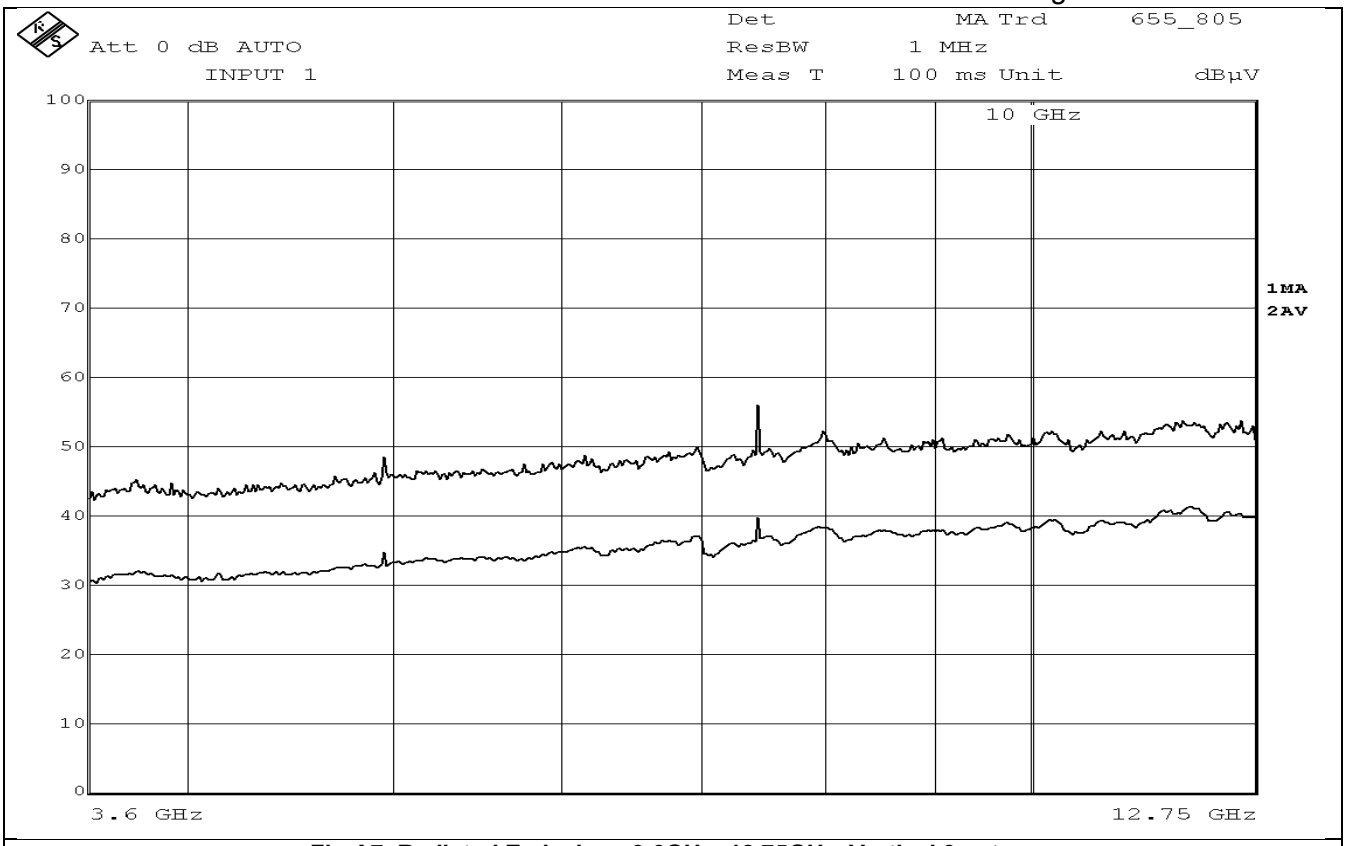


Fig A7 Radiated Emissions 3.6GHz -12.75GHz Vertical 3metres

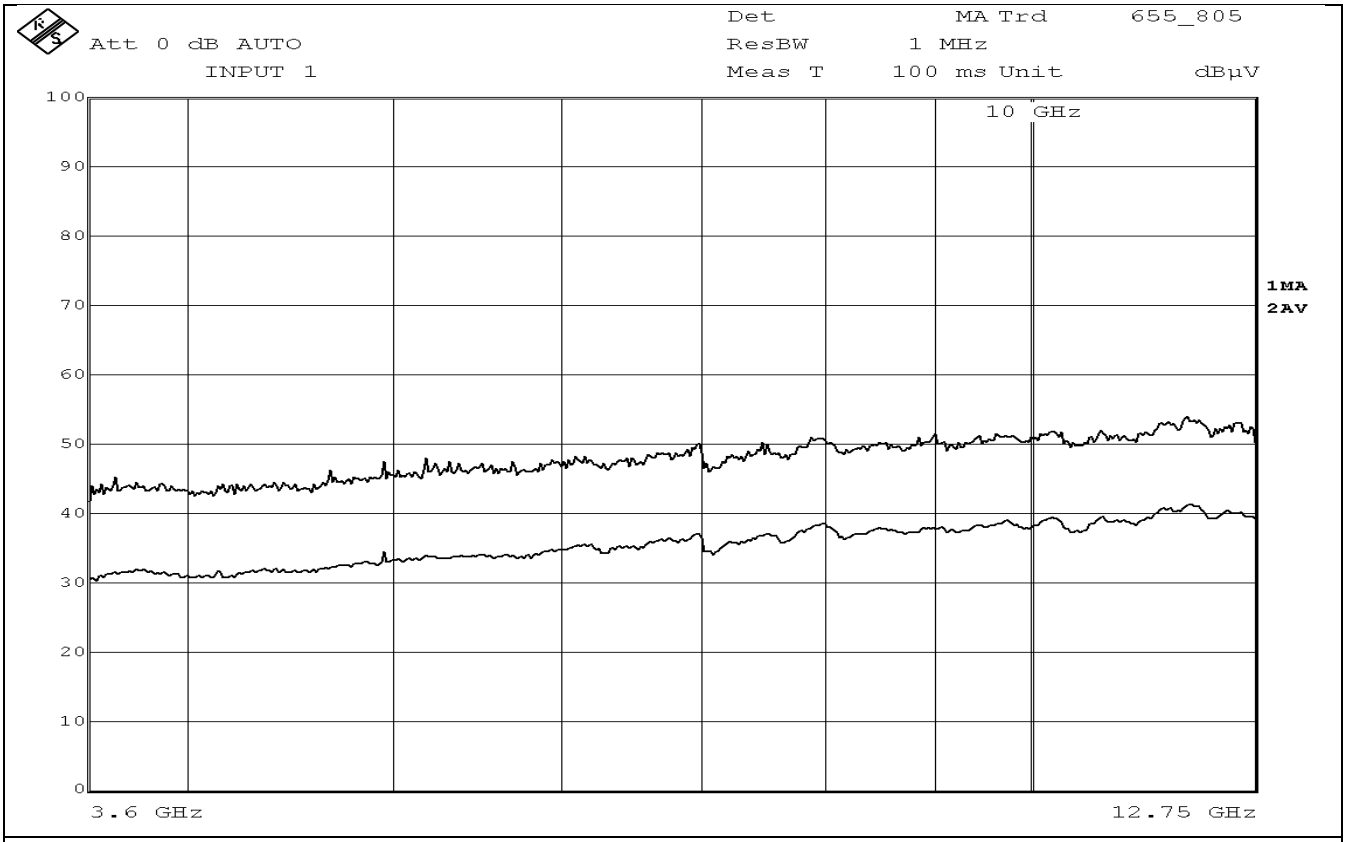


Fig A8 Radiated Emissions 7GHz -18GHz Horizontal 3metres

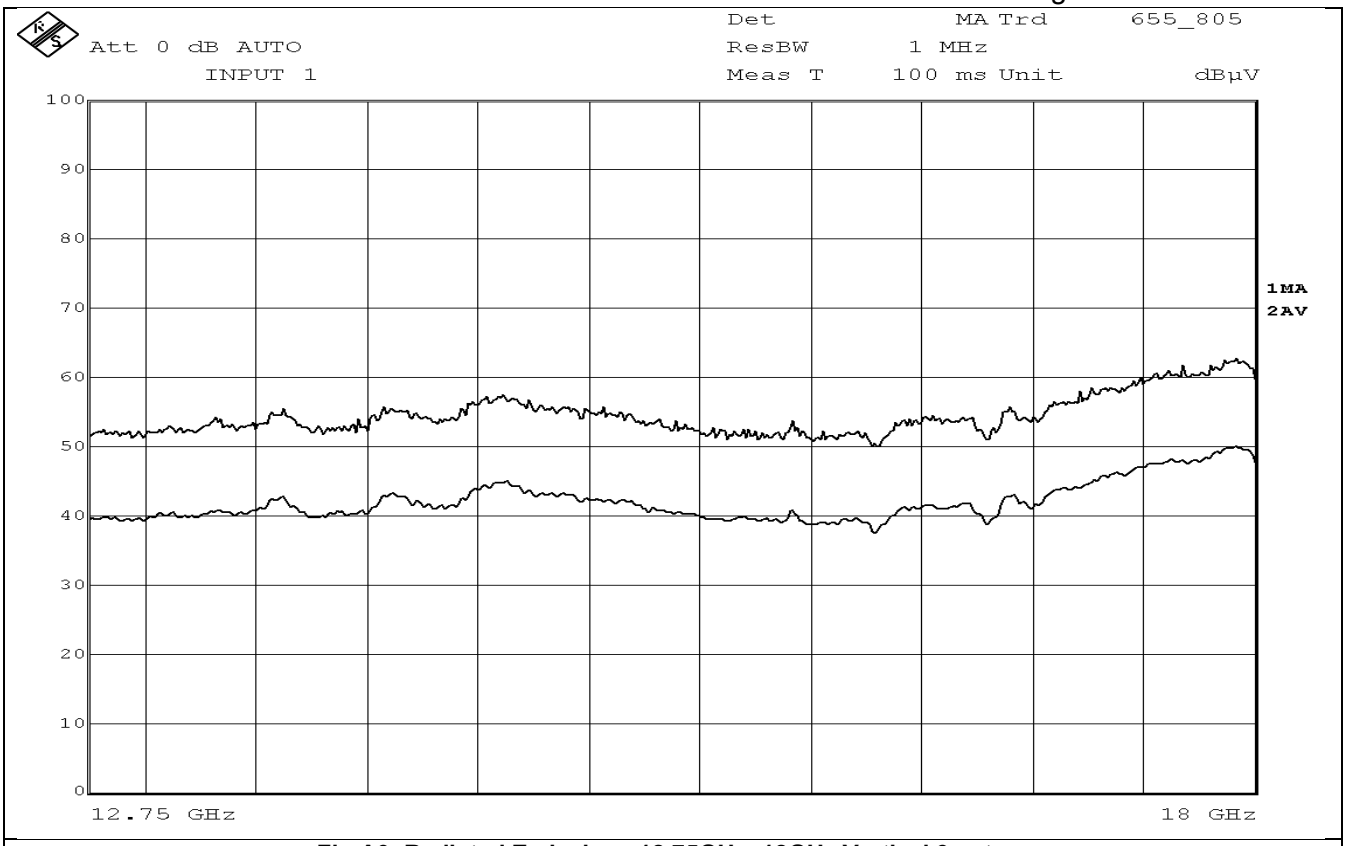


Fig A9 Radiated Emissions 12.75GHz -18GHz Vertical 3metres

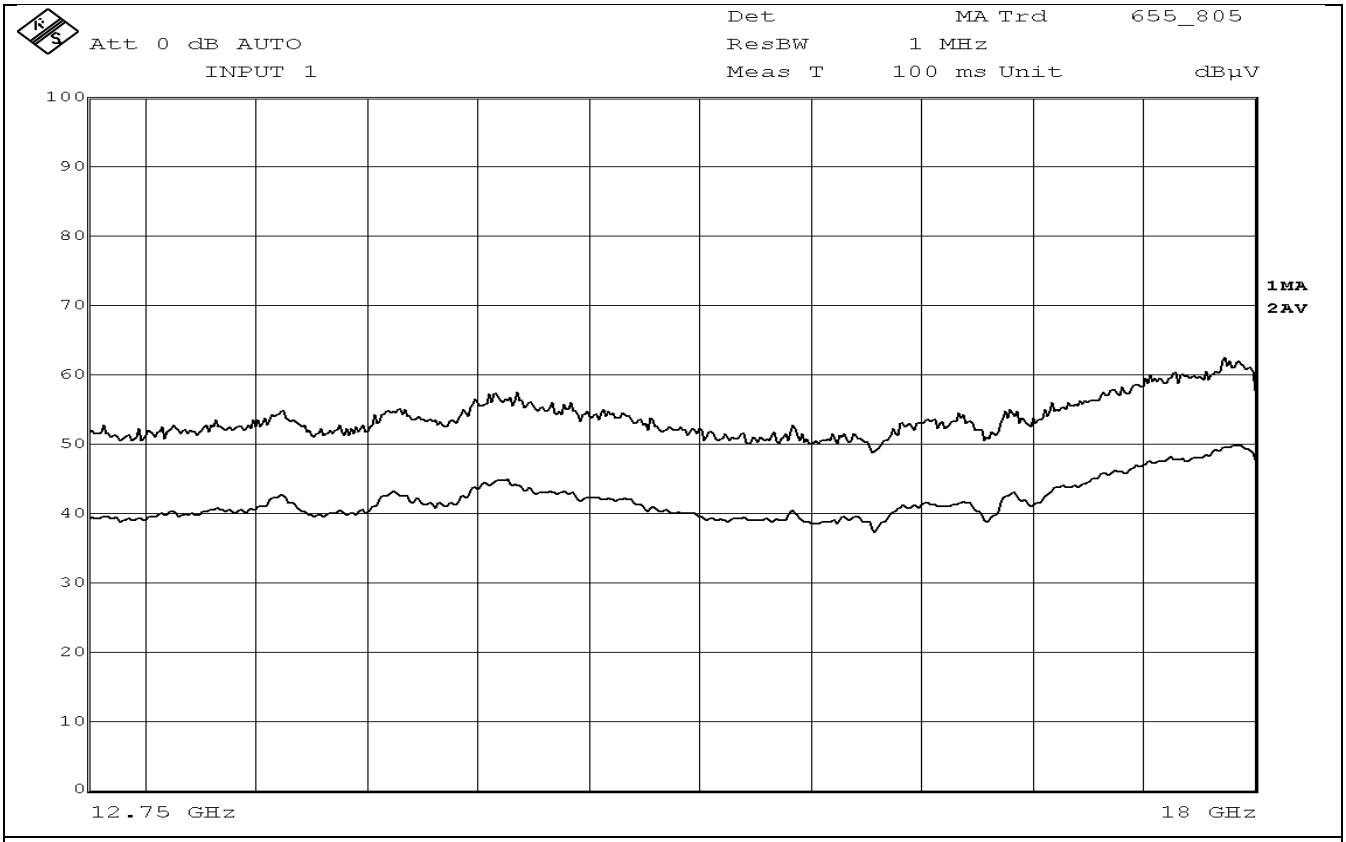


Fig A10 Radiated Emissions 12.75GHz -18GHz Horizontal 3metres

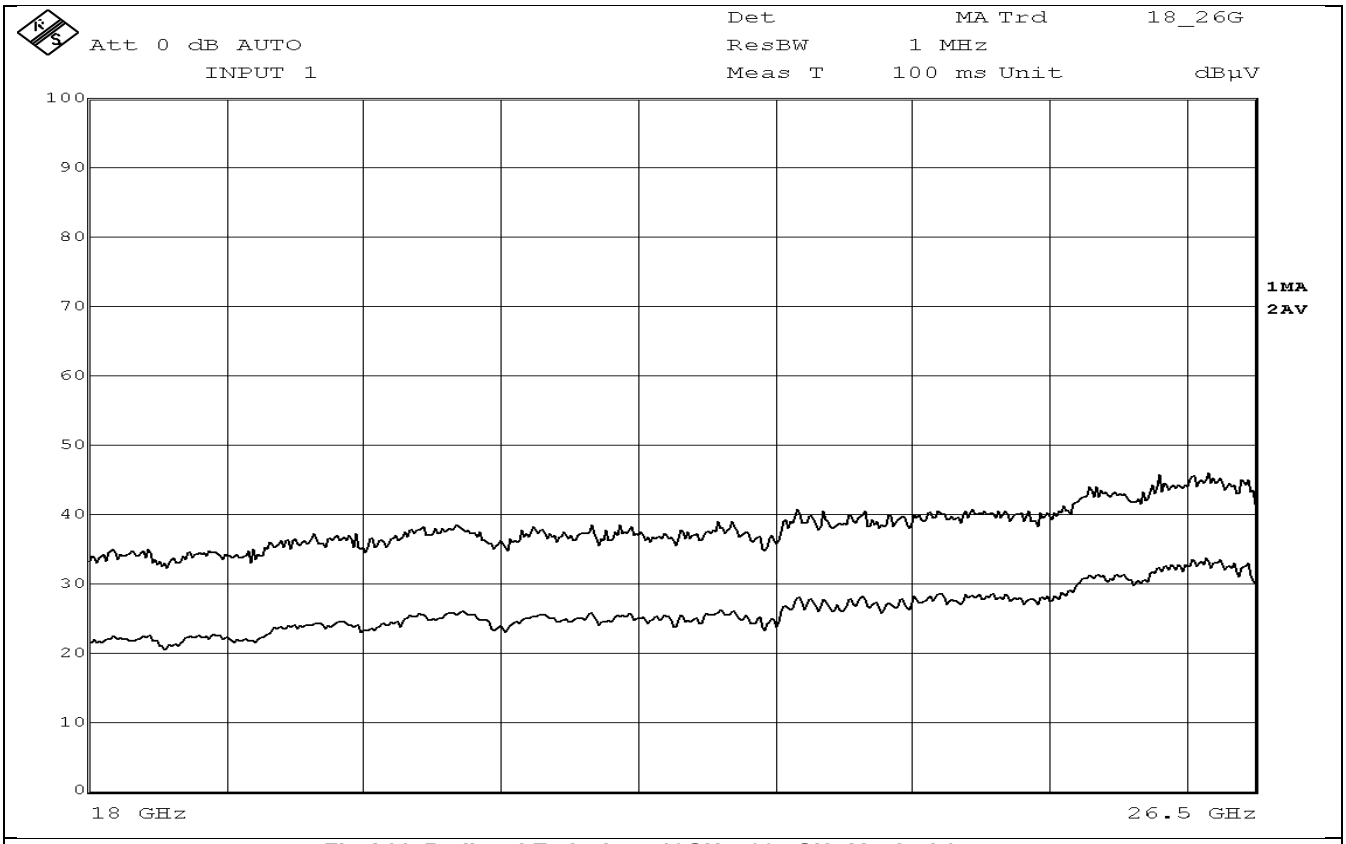


Fig A11 Radiated Emissions 18GHz -26.5GHz Vertical 1metre

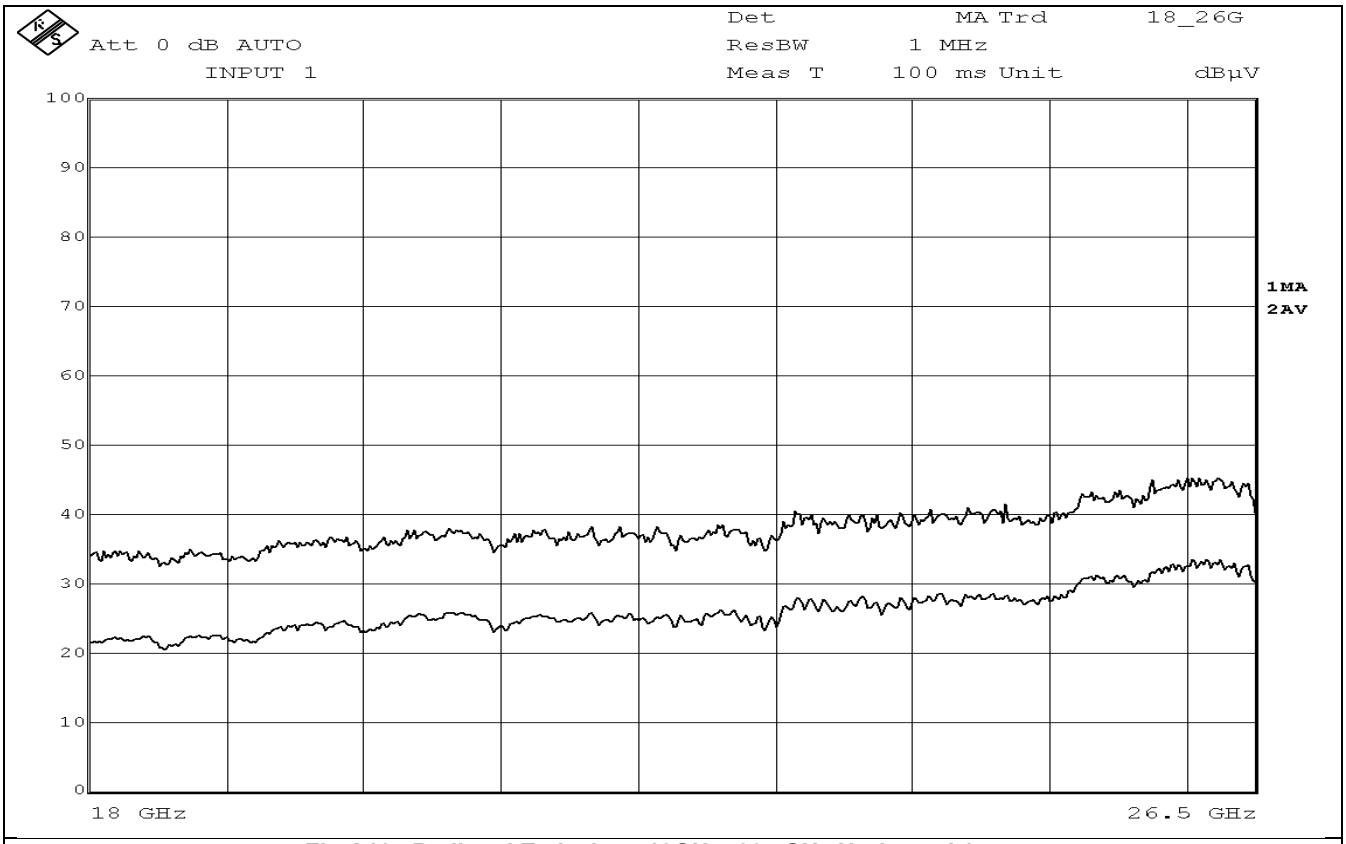


Fig A12 Radiated Emissions 18GHz -26.5GHz Horizontal 1metre

Appendix B

Radiated tests for Band Edges /Restricted band

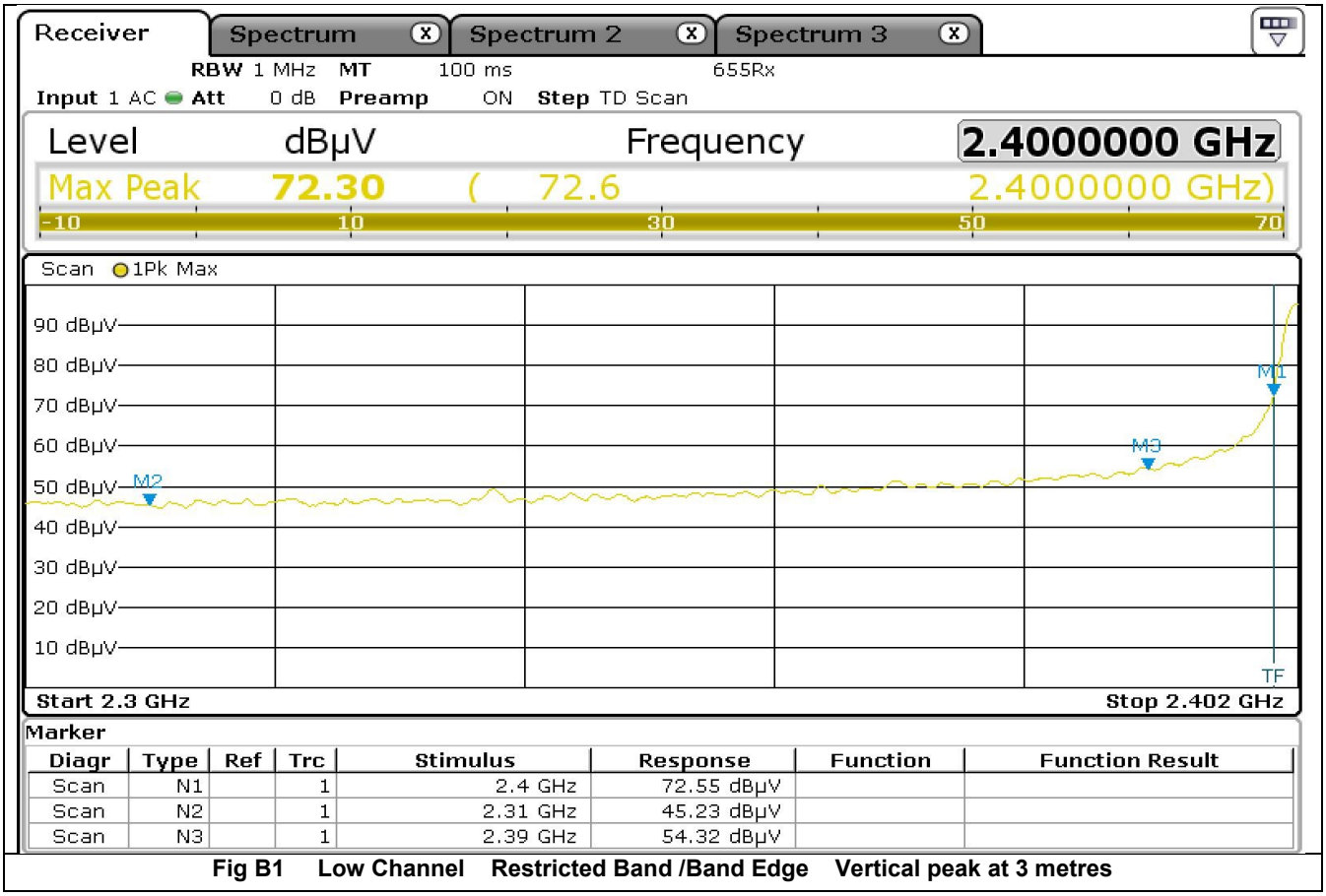


Fig B1 Low Channel Restricted Band /Band Edge Vertical peak at 3 metres

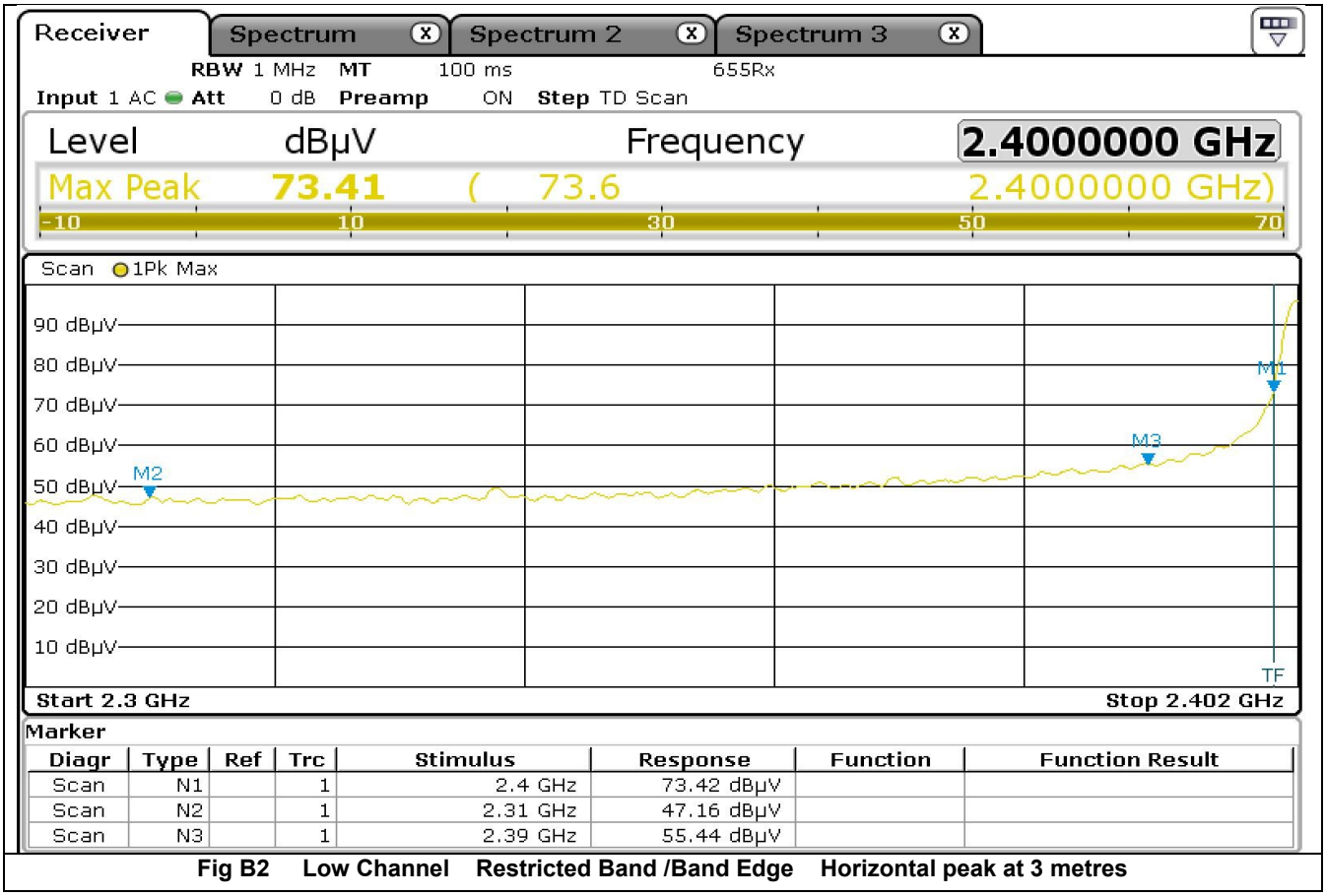
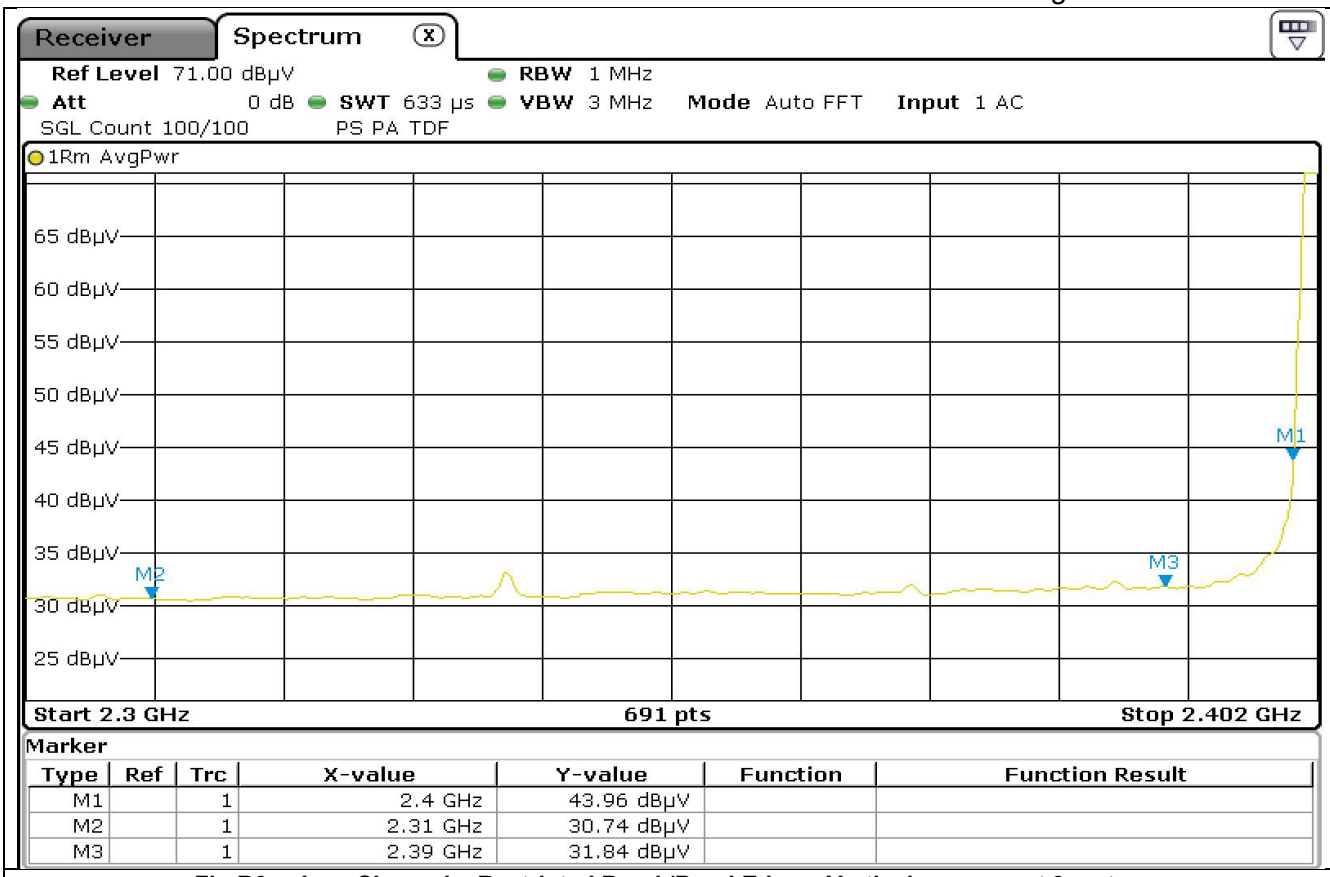


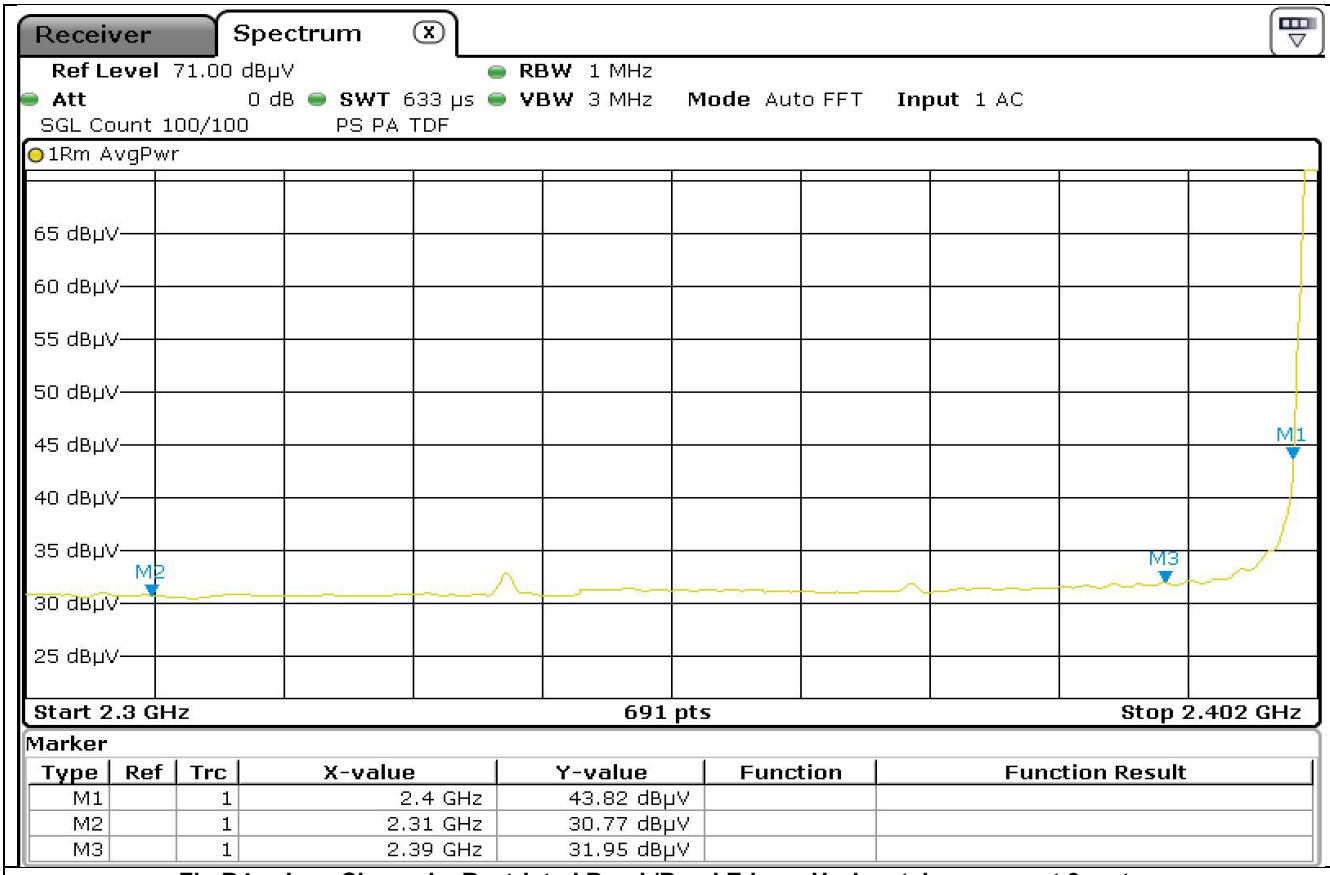
Fig B2 Low Channel Restricted Band /Band Edge Horizontal peak at 3 metres



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4 GHz	43.96 dBµV		
M2		1	2.31 GHz	30.74 dBµV		
M3		1	2.39 GHz	31.84 dBµV		

Fig B3 Low Channel Restricted Band /Band Edge Vertical average at 3 metres



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4 GHz	43.82 dBµV		
M2		1	2.31 GHz	30.77 dBµV		
M3		1	2.39 GHz	31.95 dBµV		

Fig B4 Low Channel Restricted Band /Band Edge Horizontal average at 3 metres

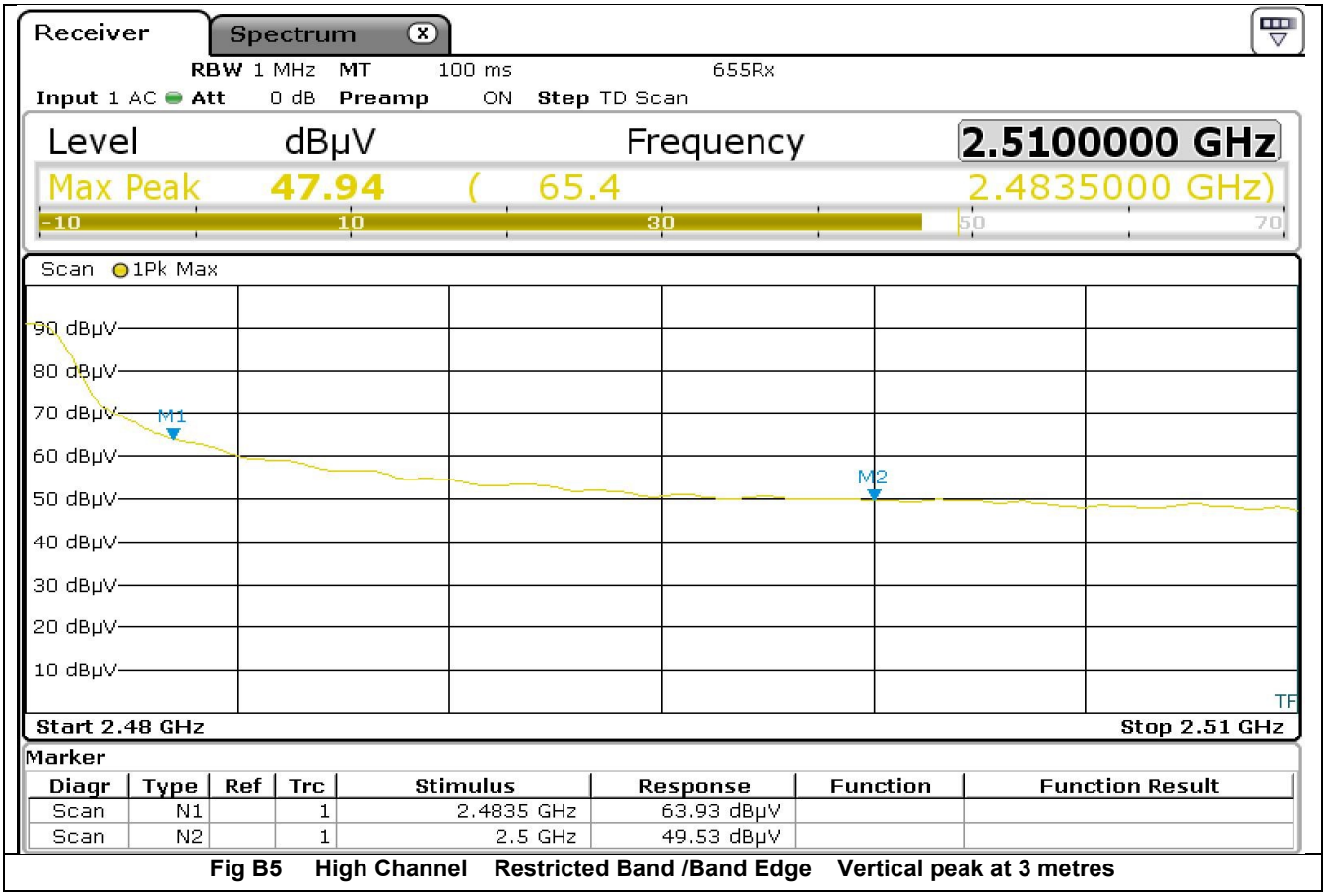


Fig B5 High Channel Restricted Band /Band Edge Vertical peak at 3 metres

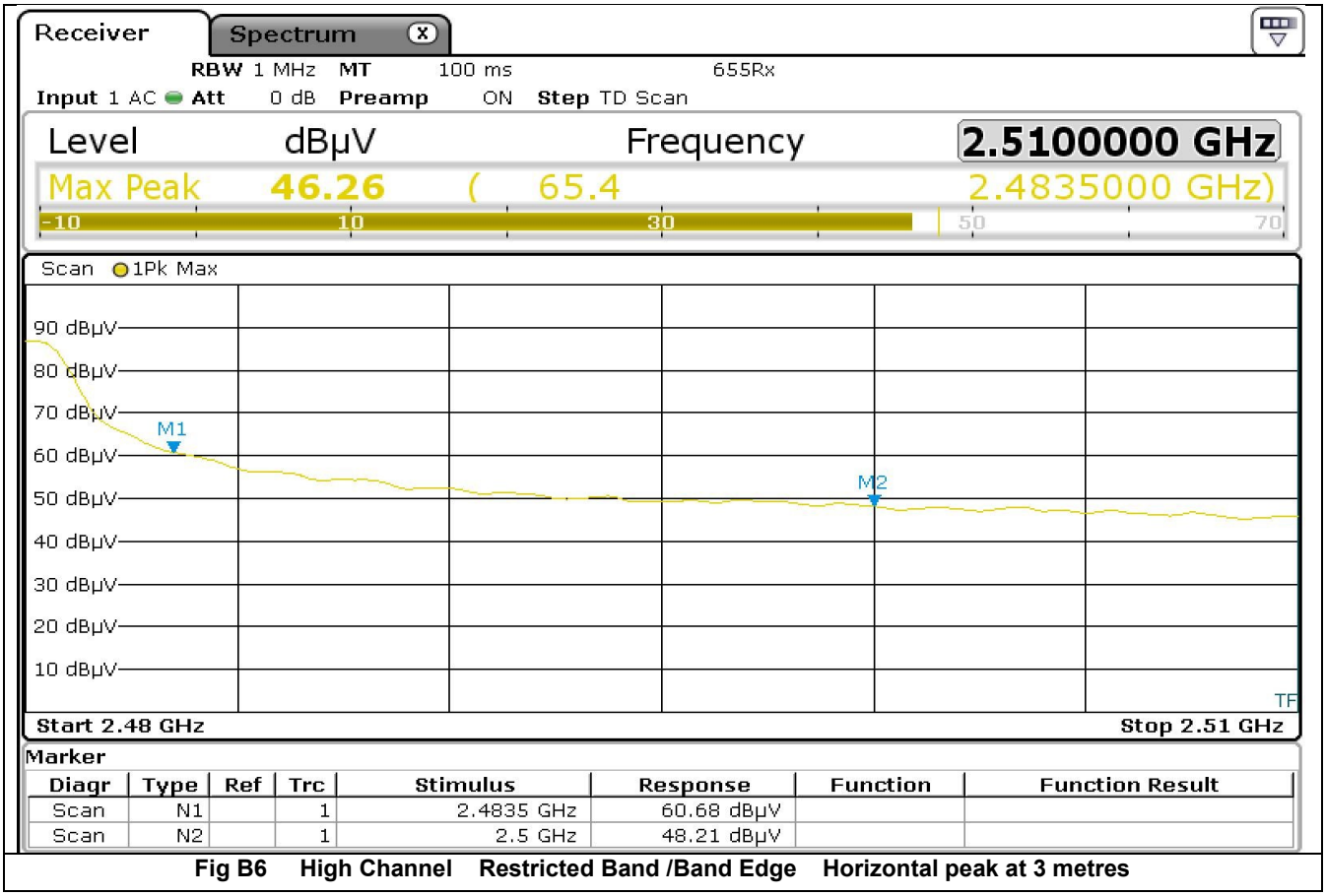


Fig B6 High Channel Restricted Band /Band Edge Horizontal peak at 3 metres

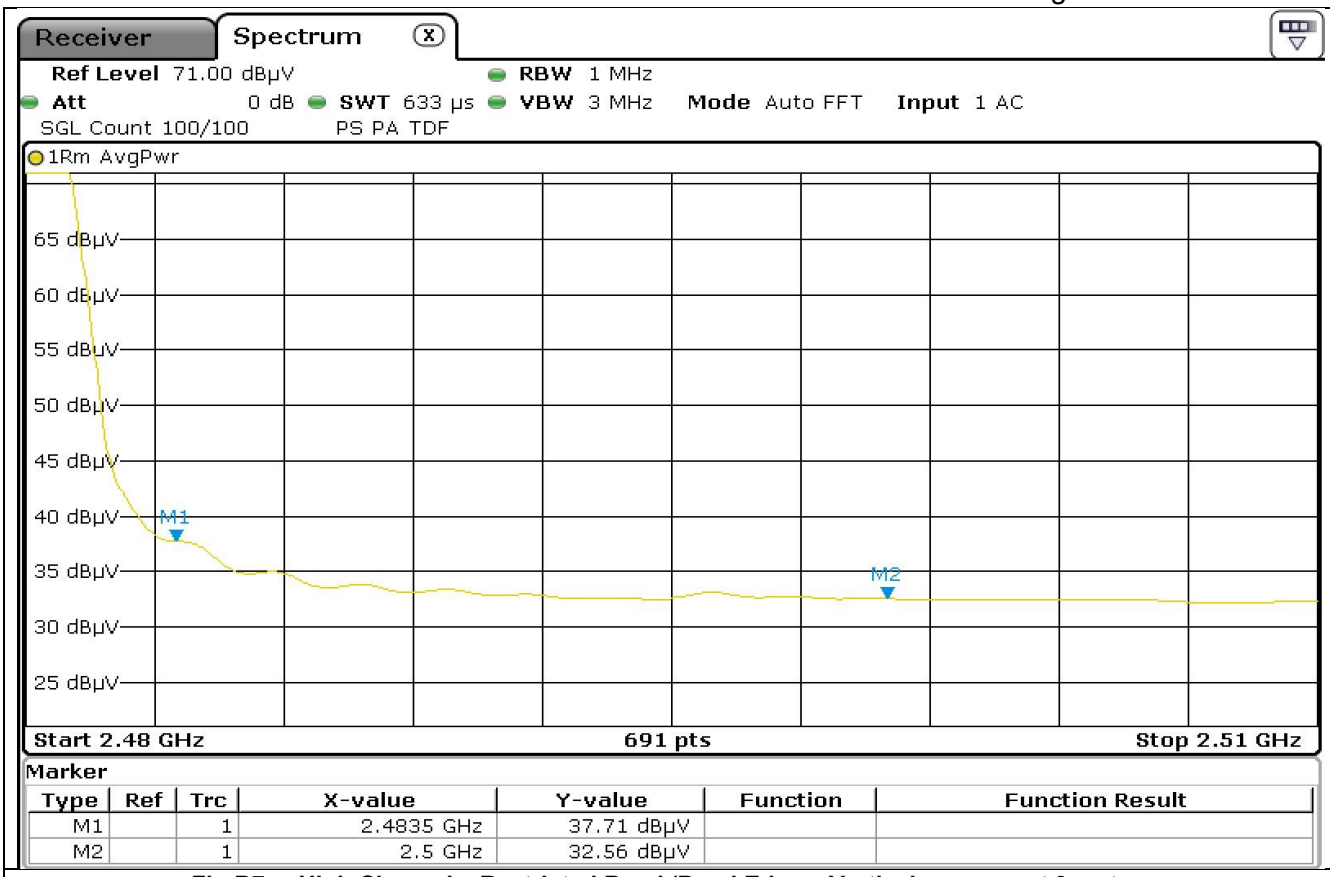


Fig B7 High Channel Restricted Band /Band Edge Vertical average at 3 metres

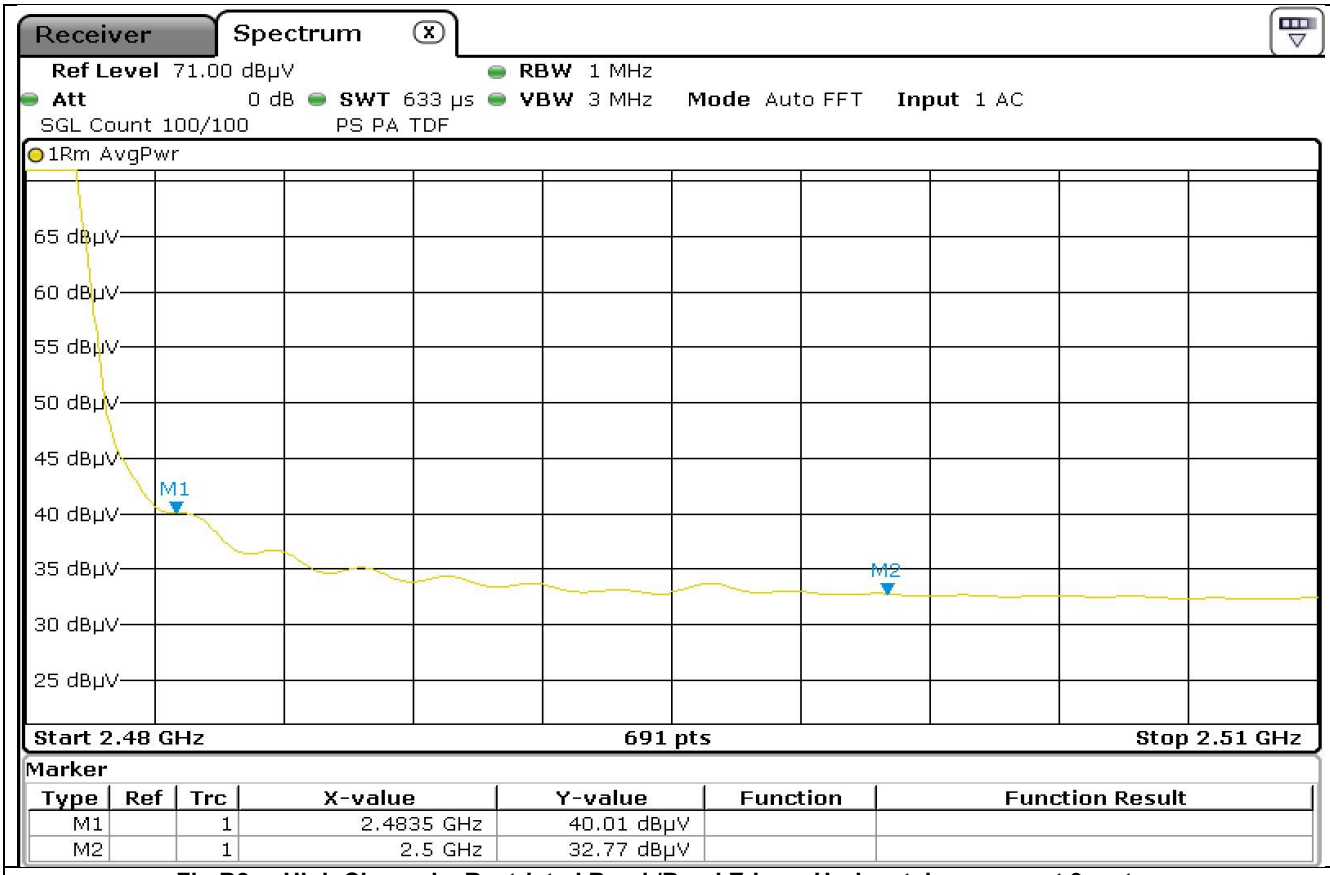


Fig B8 High Channel Restricted Band /Band Edge Horizontal average at 3 metres

Appendix C

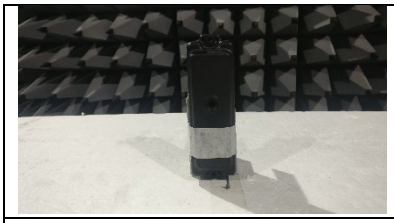
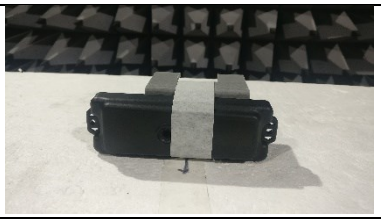
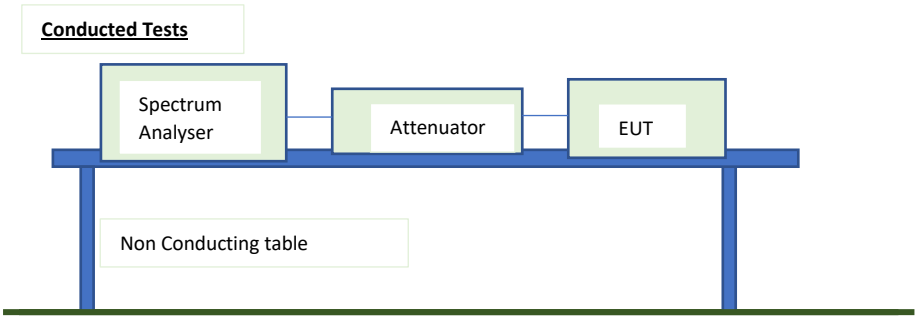
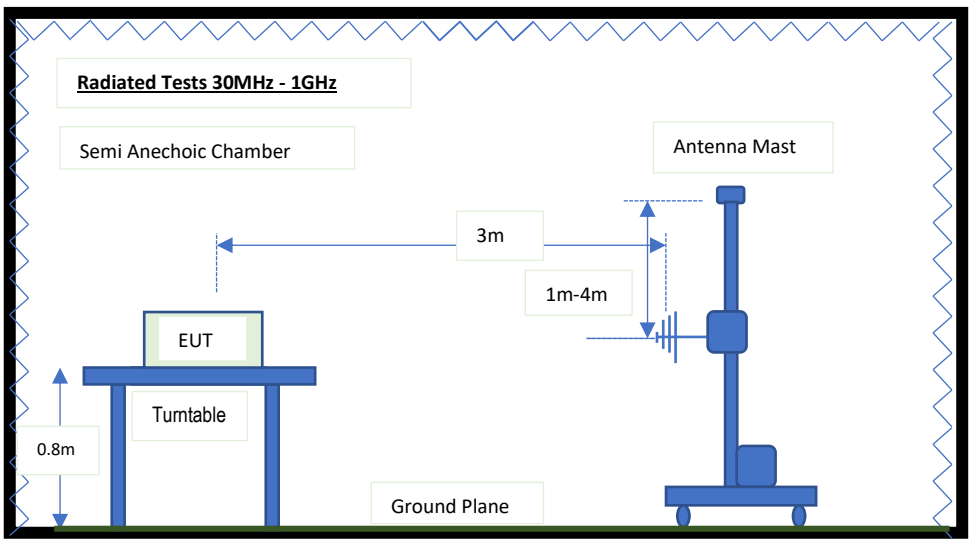
	

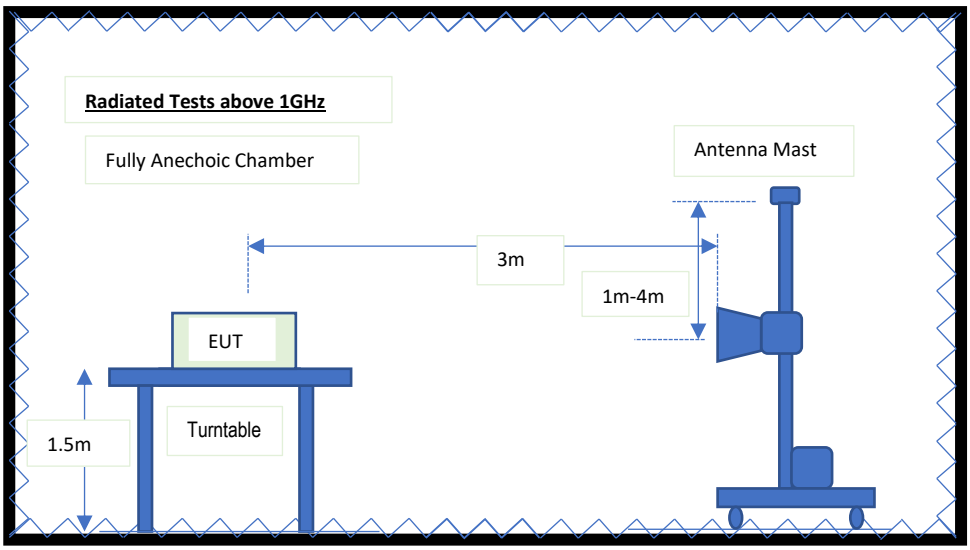
Fig C1 EUT orientation O1”	Fig C2 EUT orientation “O2”	Fig C3 EUT orientation “O3”

Orientations for Radiated Emissions

Appendix D
Block Diagrams of test set up







End of Report