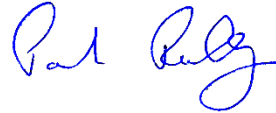


Confidential Report

Project No.	23E10780-1c
Quotation	Q23-2702-1
Prepared For	Sensata Schrader Electronics Ltd
Address	11 Technology Park Belfast Road, Antrim Northern Ireland BT41 1QS
Contact	Zoe Gourley
Contact (Phone)	+44 2894 482536
Contact (Email)	Gourley, Zoe [zgourley@sensata.com]
Prepared By	Compliance Engineering Ireland
Test Lab Address	Clonross Lane, Derrockstown Dunshaughlin, Co. Meath Ireland, A85XN59
Tested By	Joy Israel Dalayap
Test Report By	Michael Kirby
FCC Designation Number	IE0002
ISED CAB identifier	IE0001
Date Received	20th Nov 2023
Issue Date	11th Apr 2024
EUT Description	Sensor 433MHz, Tyre Pressure Monitor
FCC ID	MRXFTMS01
IC ID	2546A-FTMS01
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

All available operating modes except alarm mode meet the requirements of 15.231e.
Alarm mode meets 15.231a

15.231(a)4	RSS-210 A1.1d	Alarm mode	PASS
15.231(b)	RSS-210 A1.2a	Alarm mode field strength	PASS

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

All measurements were performed radiated and that therefore additional antenna gain information is not required.

This report should not be reproduced, except in full, without the written approval of Compliance Engineering Ireland Ltd.

Contents

1.	EUT DESCRIPTION	4
2.	EUT OPERATION	5
2.1	Modifications	5
2.2	Date of Test	5
2.3	Measurement Uncertainty	5
2.4	Special Test Software	5
3	EMISSIONS MEASUREMENTS	6
3.1	Conducted Emissions Measurements	6
3.2	Radiated Emissions Measurements	6
3.2.1	General.....	6
3.2.2	Measurements in Transmit mode	6
3.3	Antenna Requirements	7
3.4	Occupied Bandwidth.....	8
3.5	Maximum Modulation Percentage (M%)/Duty cycle	10
3.6	Field Strength of Radiated Emissions.....	12
3.6.1	Fundamental Measurements (30MHz to 1GHz)	13
3.6.2	Harmonics Spurious Emissions Measurements (30MHz to 1GHz).....	14
3.6.3	Harmonics Spurious Emissions Measurements (above 1GHz)	15
3.7	Duty cycle for other (non alarm) modes	17
3.8	Alarm mode	18
4	LIST OF TEST EQUIPMENT	19
	APPENDIX A: SCANS FOR RADIATED SPURIOUS EMISSIONS	20
	APPENDIX B: DUTY CYCLE FOR OTHER MODES	25
	APPENDIX C: TEST CONFIGURATIONS:	31
	APPENDIX D: BLOCK DIAGRAMS OF TEST SETUP	32

1. EUT Description

The EUT was monitor using a short range 433.92 MHz band transmitter for reporting of tyre pressure and temperature in automobiles.

Model:	FTMS01
Type:	Tyre Pressure Monitor
Type of radio:	Stand-alone
Transmitter Type:	FSK
Operating Frequency Range(s):	433.92 MHz
Number of Channels:	One
Antenna:	Integral
Transmitter power configuration:	3 VDC Internal Battery.
Operating. Temp Range:	-40° C to +85° C
Classification:	DSC
PMN:	FTMS01
HVIN:	FTMS01
FVIN:	Ver 1.0
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013

Table 1: Detailed Description of EUT

2. EUT Operation

Operating Conditions during Test:

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

A sample (Sample #1) of EUT which was programmed to operate in test mode (CW mode) was used for all tests except duty cycle and bandwidth.

A sample (Sample #2) of EUT which was programmed to operate in test mode (repeated modulated mode) was used for bandwidth test.

A sample (Sample #3) of EUT which was programmed to operate in test mode (modulated mode highest normal duty cycle) was used for duty cycle.

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

Environmental conditions:

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

	Temperature	Relative Humidity
Test	°C	%
Radiated Emissions SAR	23	49
Radiated Emissions FAR	20	50
Duty Cycle	22	51

2.1 Modifications

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

2.2 Date of Test

The tests were carried out on 21st, 22nd and 23rd Nov 2023 and 20th Mar 2024

2.3 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).

2.4 Special Test Software

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

3 Emissions Measurements

3.1 Conducted Emissions Measurements

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

3.2 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.

3.2.1 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.

3.2.2 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 polarisation was with the EUT vertical (orientation O1).

The EUT in a horizontal (orientation O2) gave the highest emissions for horizontal polarisation.

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.

3.3 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.

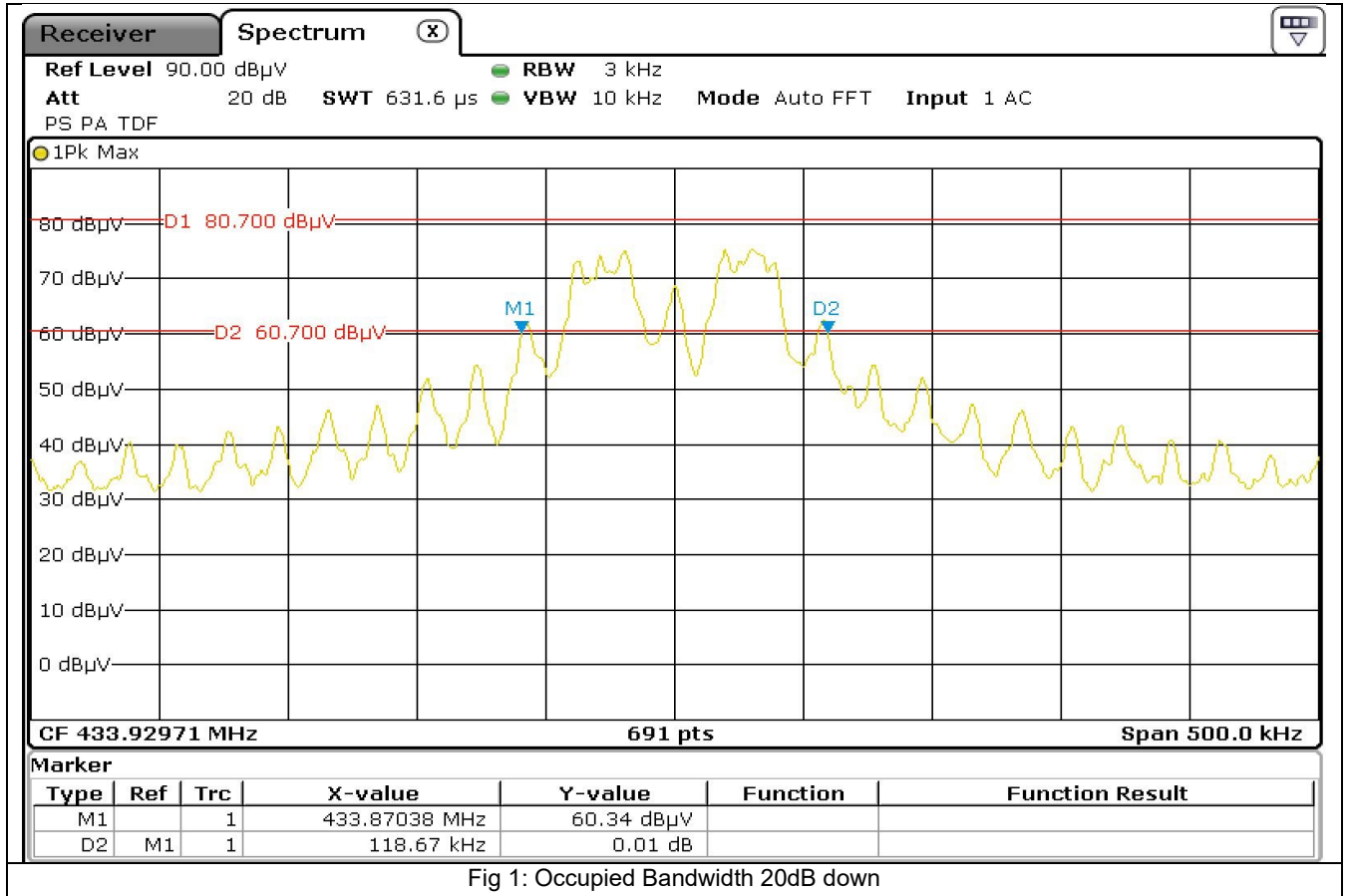
3.4 Occupied Bandwidth

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.

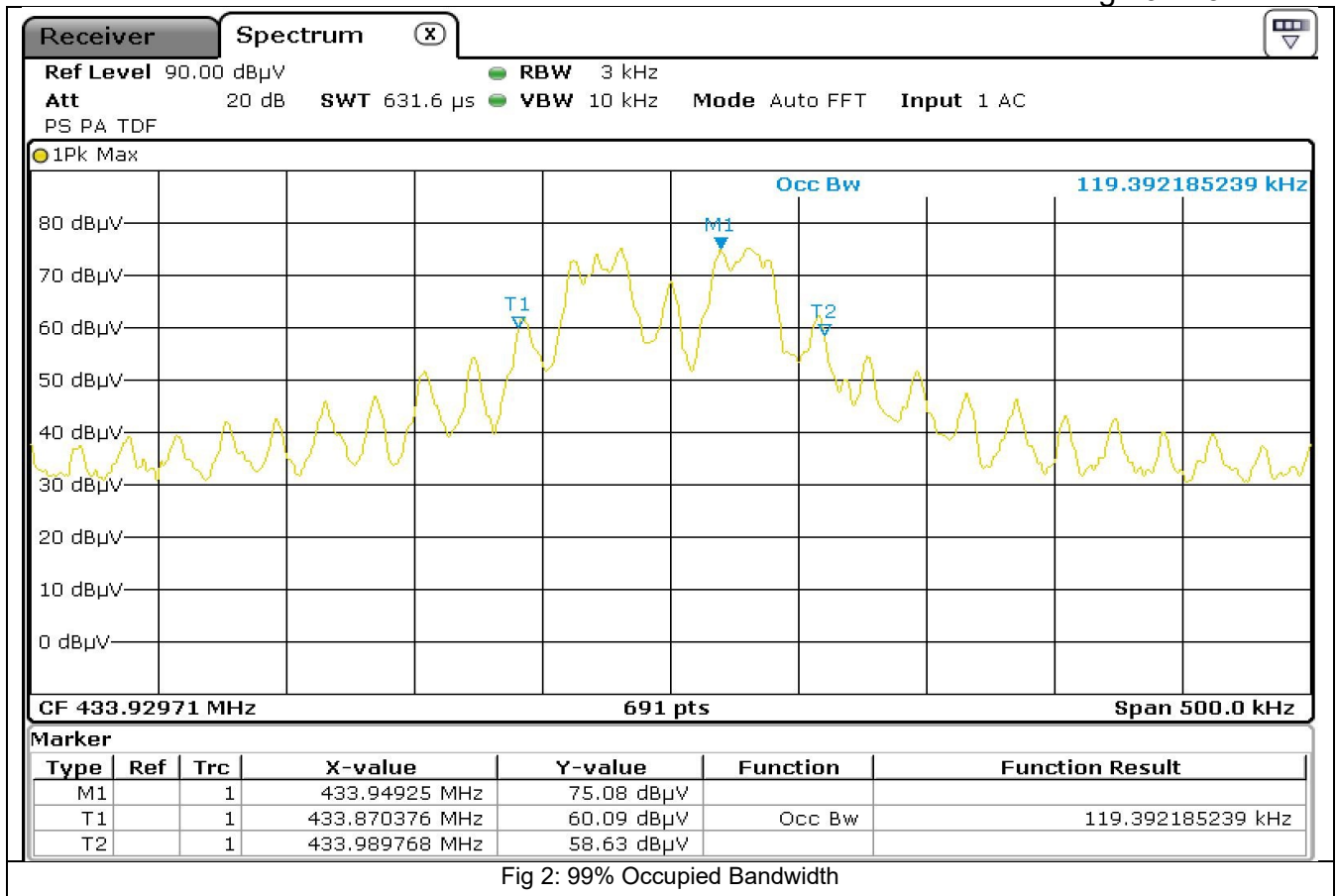
Test Procedure

RESULTS



Operating Frequency	20dB Bandwidth	Limit	Margin	Result
MHz	KHz	KHz	KHz	
433.929	118.67	1083.5	964.83	Pass

Test Result Pass



Operating Frequency	99% Bandwidth	Limit	Margin	Result
MHz	KHz	KHz	KHz	
433.929	119.39	1084.8225	965.4325	Pass

Test Result Pass

3.5 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 analyser 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	4.348	1	0.0435	-27.2	4.3	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)
-27.2

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 = 10.15mS	Limit <1sec	Comply
Silent period between transmissions 11.925Secs	Limit >10secs	Comply



Fig 3: Single Pulse Train

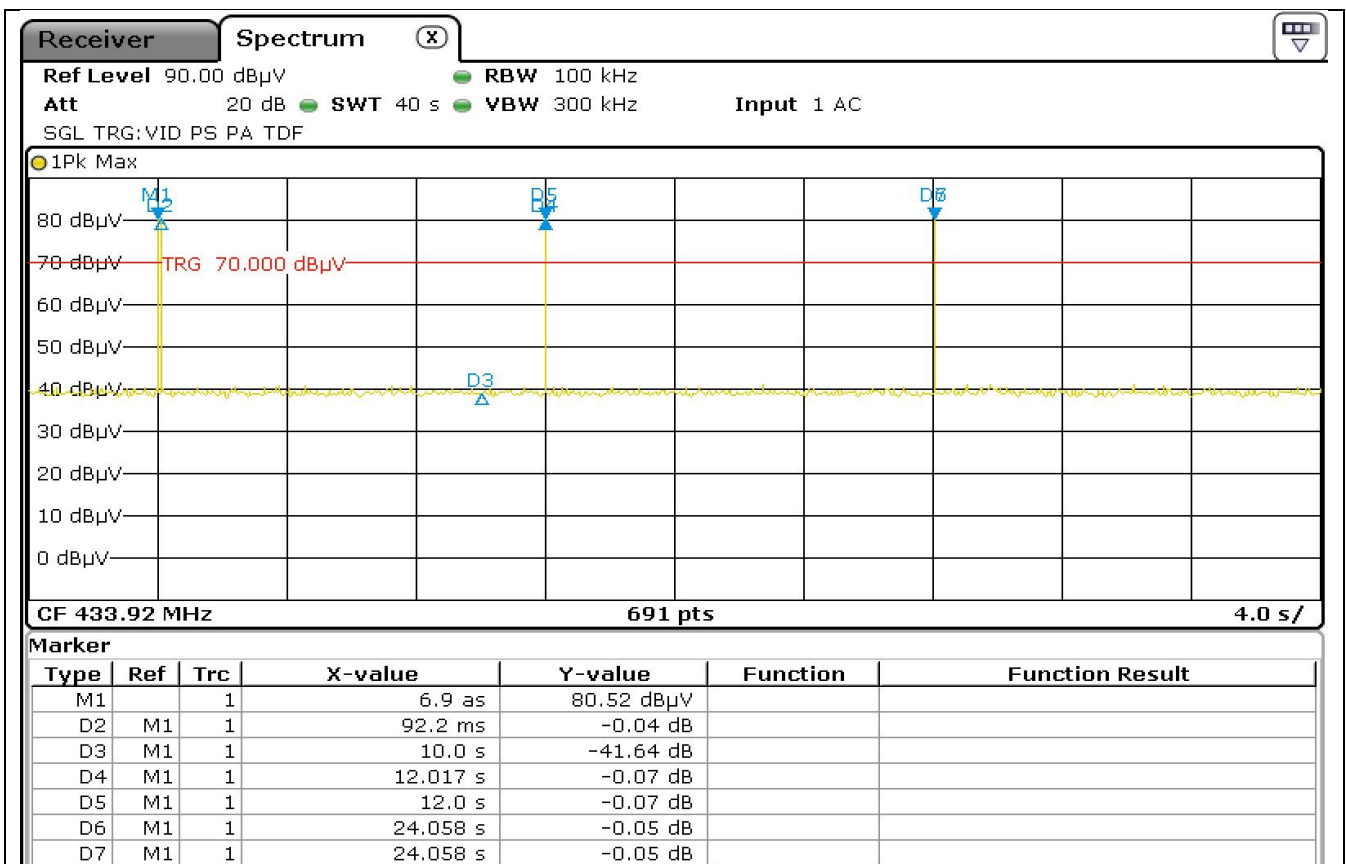


Fig 4: Pulse Repetition Rate Transmitted Pulses

3.6 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	1000	100
70 ~ 130	500	50
130 ~ 174	500-1500 **	50-150 **
174 ~ 260	1500	150
260 ~ 470	1500 to 5000 **	150 to 500 **
Above 470	5000	500

**** Linear interpolations**

Interpolation Formula = $16.67 \times \text{Freq MHz} - 2833.33$

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

Fundamental Frequency	Field Strength of fundamental	Field Strength of fundamental	Strength of Spurious Emissions	Strength of Spurious Emissions
MHz	μV/m	dBμV/m	μV/m	dBμV/m
433.920	4400	73	440	53

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 = $20\text{Log}(\text{duty cycle})$ dB

Duty Cycle correction for Average measurement of pulsed signal = Peak -27.2dB
as per ANSI C63.10 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.

3.6.1 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
433.960	59.5	O1	Vertical	16.9	0	3.3	79.7	72.9	13.2	Pass
433.960	60.5	O2	Horizontal	16.9	0	3.3	80.7	72.9	12.2	Pass

Calculation example

Final Field Strength Peak (dBuV/m) = Reading Peak (dBuV/m) + Antenna Factor (dB) - Pre-amp Gain (dB) + Cable Loss (dB)
 $80.7 = 60.5 + 16.9 - 0 + 3.3$

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 27.2dB Duty Cycle factor)	Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
433.960	79.7	O1	Vertical	52.4	72.9	20.5	Pass
433.960	80.7	O2	Horizontal	53.5	72.9	19.4	Pass

Calculation example

Average Level (dBuV/m) = Final Field Strength Peak (dBuV/m) + Duty cycle factor (dB)
 $53.5 = 80.7 - 27.2$

Test Result: Pass

3.6.2 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
867.900	0.8	O1	Vertical	23.4	0	5.3	29.5	52.9	43.4	Pass
866.800	1.4	O2	Horizontal	23.4	0	5.3	30.1	52.9	42.8	Pass

Calculation example

Final Field Strength Peak (dBuV/m) = Reading Peak (dBuV/m) + Antenna Factor (dB) - Pre-amp Gain (dB) + Cable Loss (dB)
 $30.1 = 1.4 + 23.4 - 0 + 5.3$

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

Test Result: Pass

3.6.3 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
1.302	12.1	O1	Vertical	25.3	0	3.5	40.9	52.9	32.0	Pass
1.736	12.2	O1	Vertical	26.8	0	4	43.0	52.9	29.9	Pass
2.169	14.9	O1	Vertical	27.9	0	4.6	47.4	52.9	25.5	Pass
2.604	18.4	O1	Vertical	29	0	5.1	52.5	52.9	20.4	Pass
3.038	19.3	O1	Vertical	30.3	0	5.4	55.0	52.9	17.9	Pass
3.472	18.4	O1	Vertical	31.3	0	6	55.7	52.9	17.2	Pass
3.906	51.1	O1	Vertical	32.9	38.3	6.1	51.8	52.9	21.1	Pass
4.339	52.7	O1	Vertical	32.2	38.3	6.6	53.2	52.9	19.7	Pass
4.773	46.6	O1	Vertical	32.7	39.3	7.8	47.8	52.9	25.1	Pass
5.207	48.0	O1	Vertical	33.8	38.7	8.1	51.2	52.9	21.7	Pass
5.641	43.9	O1	Vertical	34.4	39	8.2	47.5	52.9	25.4	Pass
1.302	12.5	O2	Horizontal	25.3	0	3.5	41.3	52.9	31.6	Pass
1.736	11.6	O2	Horizontal	26.8	0	4	42.4	52.9	30.5	Pass
2.169	12.9	O2	Horizontal	27.9	0	4.6	45.4	52.9	27.5	Pass
2.604	17.9	O2	Horizontal	29	0	5.1	52.0	52.9	20.9	Pass
3.038	18.8	O2	Horizontal	30.3	0	5.4	54.5	52.9	18.4	Pass
3.472	20.1	O2	Horizontal	31.3	0	6	57.4	52.9	15.5	Pass
3.906	51.1	O2	Horizontal	32.9	38.3	6.1	51.8	52.9	21.1	Pass
4.339	52.3	O2	Horizontal	32.2	38.3	6.6	52.8	52.9	20.1	Pass
4.773	47.0	O2	Horizontal	32.7	39.3	7.8	48.2	52.9	24.7	Pass
5.207	47.9	O2	Horizontal	33.8	38.7	8.1	51.1	52.9	21.8	Pass
5.641	44.6	O2	Horizontal	34.4	39	8.2	48.2	52.9	24.7	Pass

Calculation example

Final Field Strength Peak (dBuV/m) = Reading Peak (dBuV/m) + Antenna Factor (dB) - Pre-amp Gain (dB) + Cable Loss (dB)
40.9 = 12.1 + 25.3 - 0 + 3.5

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus - 27.2dB Duty Cycle factor)	Average Limit	Margin	Result
GHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
3.038	55.0	O1	Vertical	27.8	52.9	25.1	Pass
3.472	55.7	O1	Vertical	28.5	52.9	24.4	Pass
4.339	53.2	O1	Vertical	25.9	52.9	27	Pass
3.038	54.5	O2	Horizontal	27.3	52.9	25.6	Pass
3.472	57.4	O2	Horizontal	30.2	52.9	22.7	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)

27.8 = 55 - 27.2

Test Result: Pass

3.7 Duty cycle for other (non alarm) modes

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

Description of the non alarm modes

Mode Description	Frequency of RF transmission
Stationary Mode	-RF transmit every 60 seconds with 1 frame data.
Stationary Interim Mode	-RF transmit every 30 seconds with 1 frame data.
Tire Fill Assist Mode	-RF transmit every 30 seconds with 1 frame data.
Learn Interim Mode	-RF transmit every 30 seconds with 1 frame data.
Drive Interim Mode	-RF transmit every 30 seconds with 1 frame data.
Learn Mode	-Between 0s to 72s, the RF transmission rate shall be 24 seconds with 5 frames data. -Between 96s to 300s, the RF transmission rate shall be 12s with 2 frames data.
Drive Mode	-RF transmit every 12 seconds with 1 frame data. -An additional frame is added to the RF transmission every 36 seconds.

Duty cycle for all other modes in this section is less than worst case drive mode.
Note worst case drive mode reported in sections 3 to 3.6 of this report.

All modes in this section meet the 15.231e requirements.

Refer to appendix B for scans

Test Result Pass

3.8 Alarm mode

Test Specification: FCC 15.231(a)(4) (b) and RSS-210 A1.1d A1.2a

(4) Intentional radiators which are employed for radio control purposes during emergencies involving fire, security, and safety of life, when activated to signal an alarm, may operate during the pendency of the alarm condition

Field Strength Average limit

Fundamental Frequency	Field Strength of fundamental	Field Strength of fundamental	Strength of Spurious Emissions
MHz	μV/m	dBμV/m	μV/m
433.960	11000	80.8	1100

The EUT was placed in a pressure vessel at 30 psi and the pressure valve was released to simulate a sudden drop in pressure.

Mode Description	Frequency of RF transmission
Alarm Delta Pressure Mode	-RF transmit every 1 second with 1 frame data for 25 seconds duration.

Result

Duty Cycle

1 * 4 msec frame is transmitted every sec

Field Strength

Peak level taken from section 3.6.1

Frequency	Reading Peak	EUT Orientation	Antenna Polarity	Antenna Factor	Preamp Gain	Cable loss	Final Field Strength Peak	15.231b Average Limit	Margin for Peak v Average Limit	Result
MHz	dBuV/m		V/H	dB	dB	dB	dBuV/m	dBuV/m	dB	P/F
433.960	60.5	O2	Horizontal	16.9	0	3.3	80.7	80.8	20.1	Pass

Final Field Strength Peak (dBuV/m) = Reading Peak (dBuV/m) + Antenna Factor (dB) - Pre-amp Gain (dB) + Cable Loss (dB)
Calculation Example 80.7 = 60.5 + 16.9 - 0 + 3.3

Frequency	Final Field Strength Peak	EUT Orientation	Antenna Polarity	Average Level (Peak plus -27.6dB Duty Cycle factor)	15.231b Average Limit	Margin	Result
MHz	dBuV/m		V/H	dBuV/m	dBuV/m	dB	P/F
433.960	80.7	O2	Horizontal	53.1	80.8	27.7	Pass

Calculation example

Average Level (dBuV/m) = Final Field Strength Peak (dBuV/m) + Duty cycle factor (dB)

53.1 = 80.7 - 27.6

Duty cycle factor = 20*log(4.147mS / 100mS) = -27.6dB

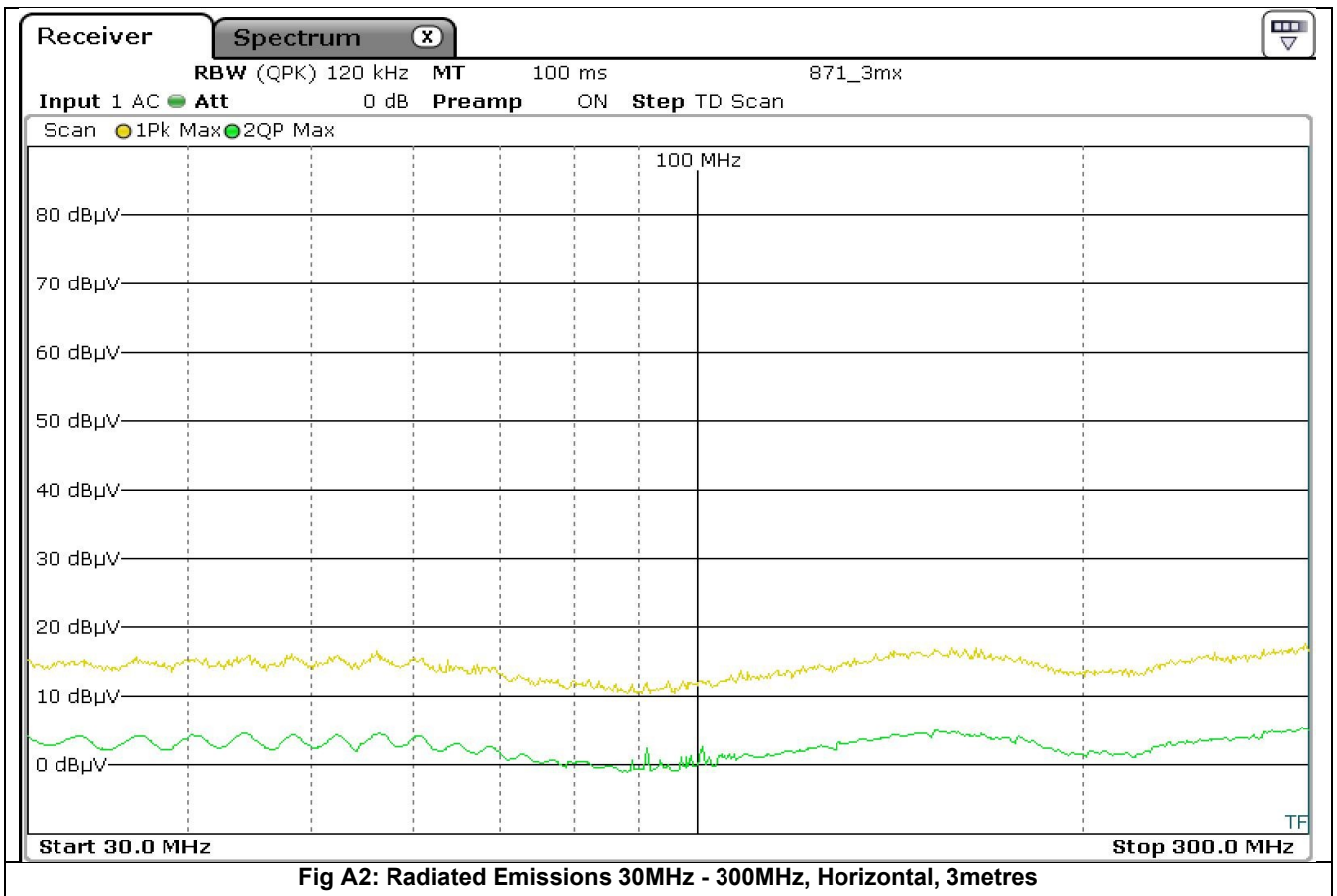
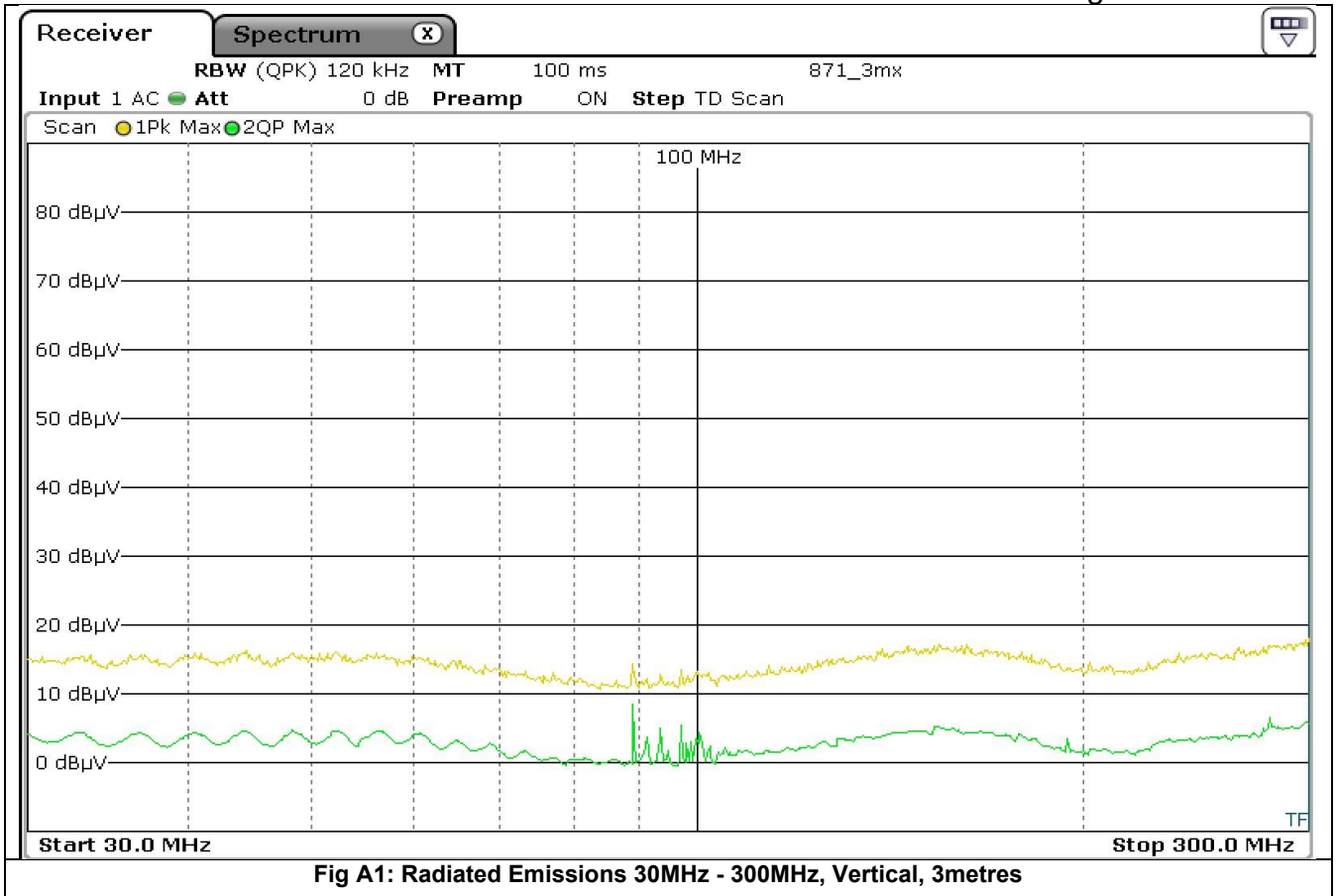
Refer to appendix B for scan

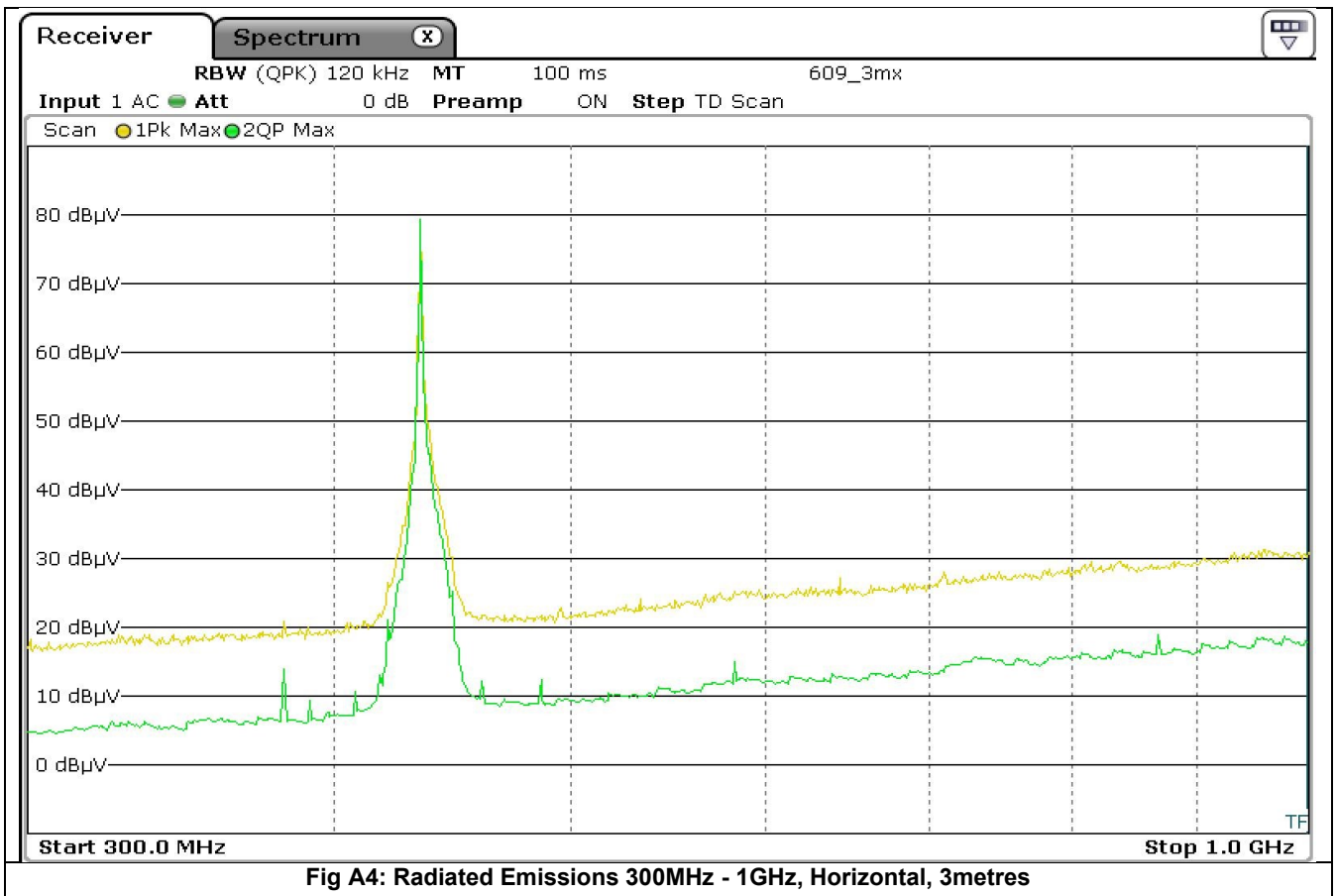
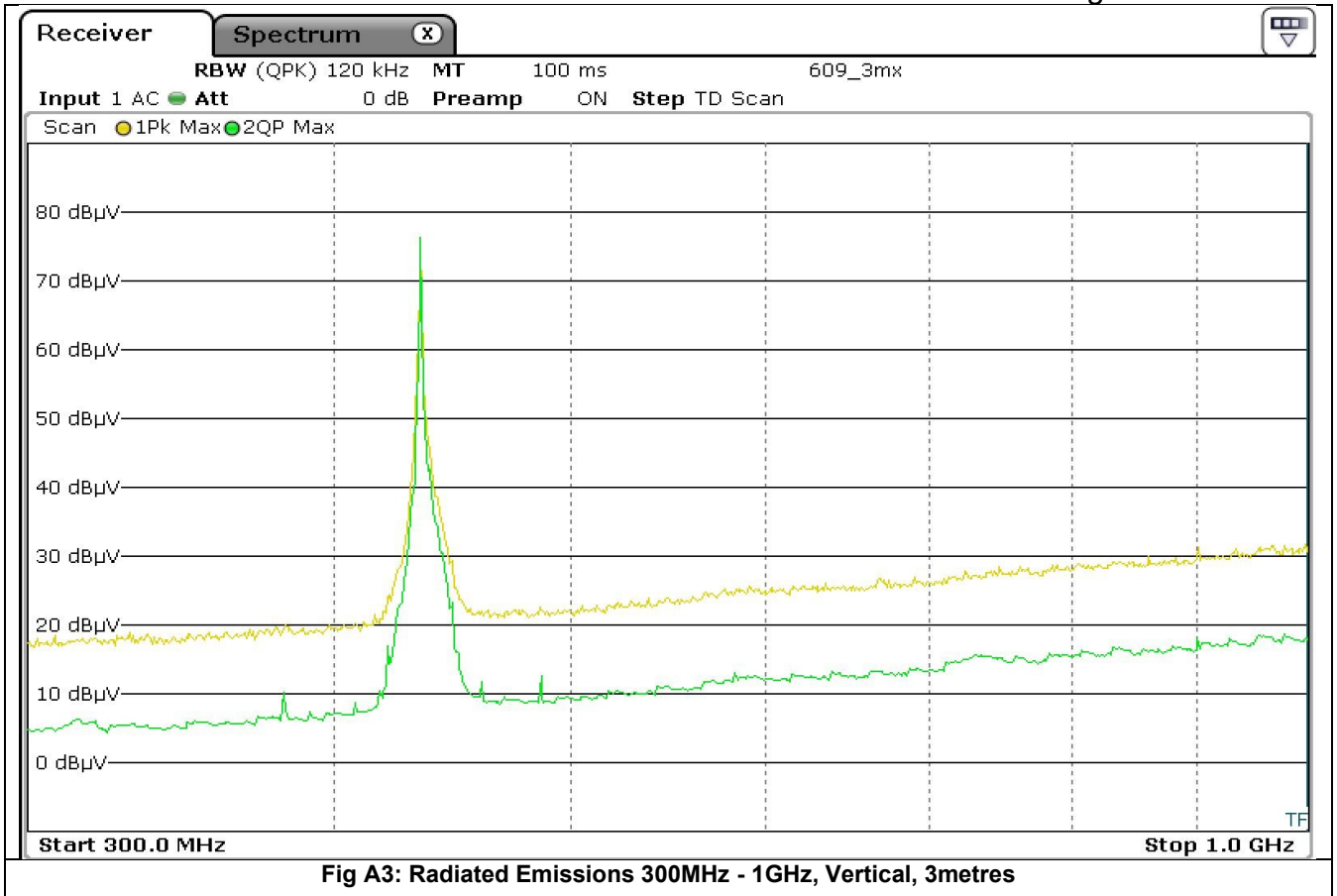
Test Result Pass

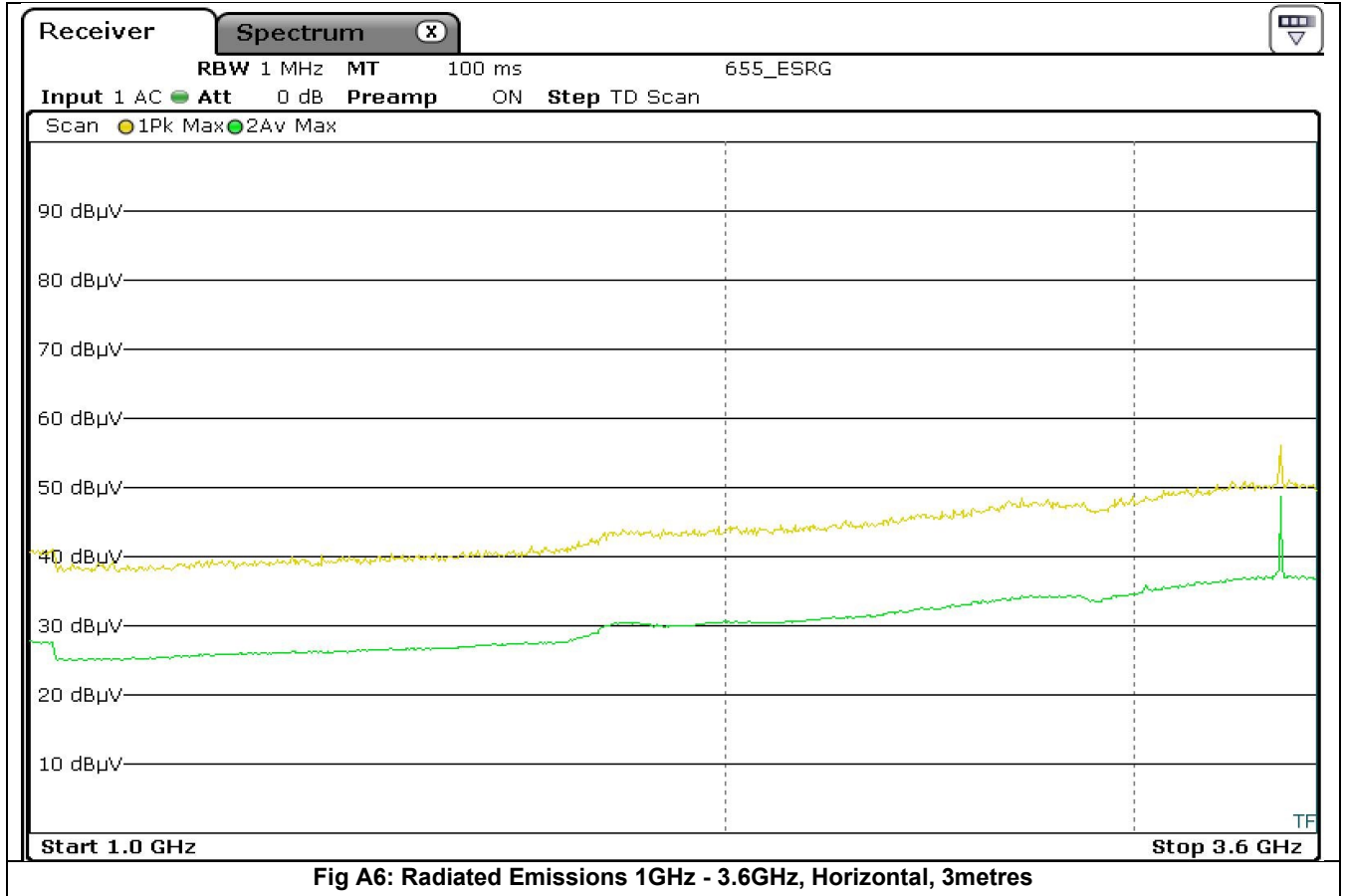
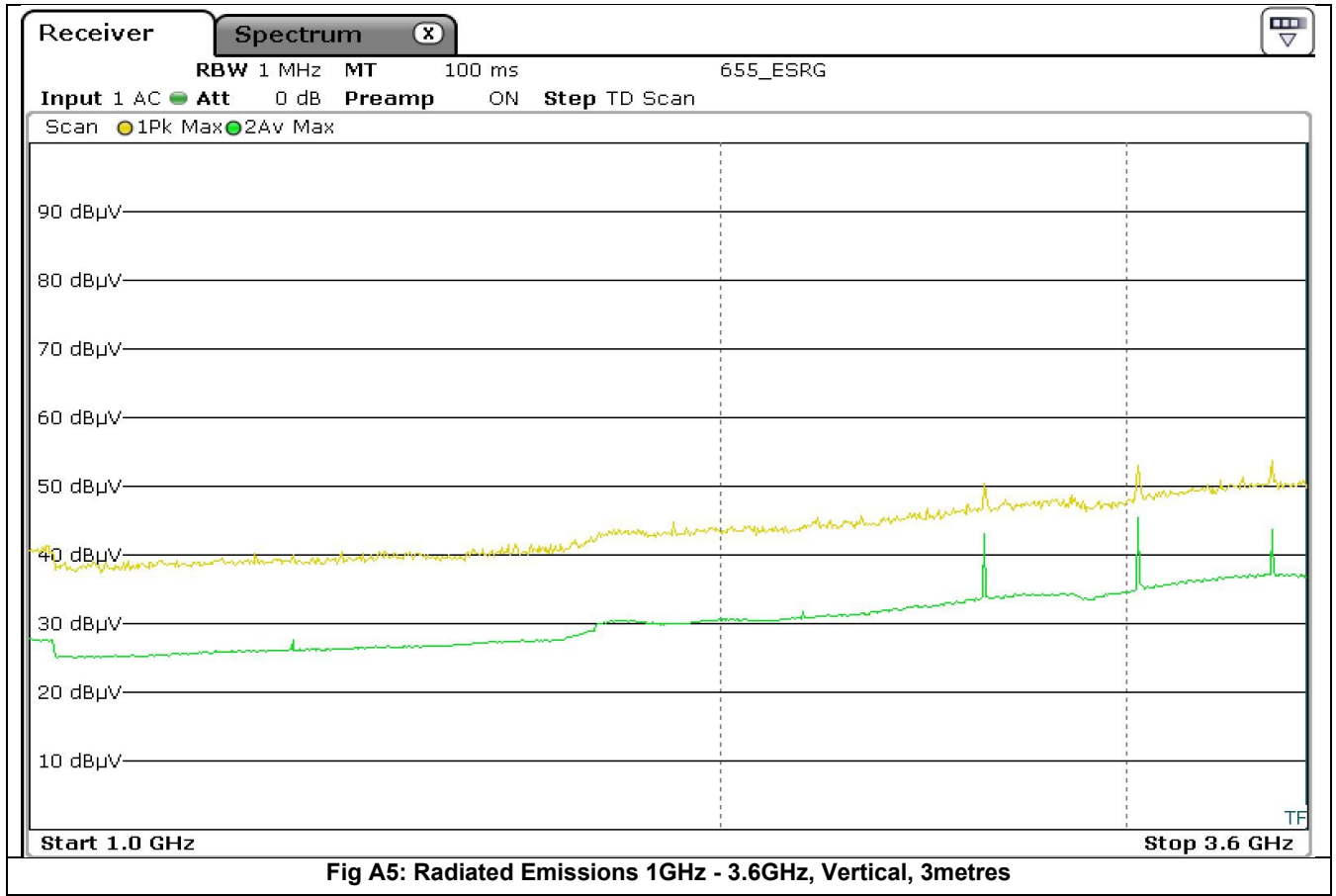
4 List of Test Equipment

Instrument	Manufacturer	Model	Serial Num	CEI Ref	Cal Date	Cal Interval Months
Microwave Preamplifier	Hewlett Packard	83017A	3123A00175	805	29-Sep-23	12
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	24-May-23	36
Receiver N9038A EMI 3Hz - 8.4 GHz	Keysight	MXE N9038A	MX60320104	1204	28-Feb-23	36
Antenna Horn	EMCO	3115	2363	1100	22-Feb-23	36
Fully Anechoic Chamber	CEI	FAR 3M	906	906	24-Jul-22	36
Anechoic Chamber	CEI	SAR 10M	845	845	22-Nov-22	36
Antenna Biconical	Schwarzbeck	VHBB 9124	9124 667	871	07-Oct-21	36
Antenna Log Periodic	Chase	UPA6108	1072	609	10-Sep-21	36
Antenna Horn Standard Gain 18-26.5GHz	A-Info	LB-42-25-C-KF	J2021091103028	877	30-Jul-23	12
Cable 20m				1213	16-May-23	12
Cable purple Ktype 1.8m				917	30-Jul-23	12
Cable HF Ktype 1.5m				705	30-Jul-23	12

Appendix A: Scans for Radiated Spurious Emissions







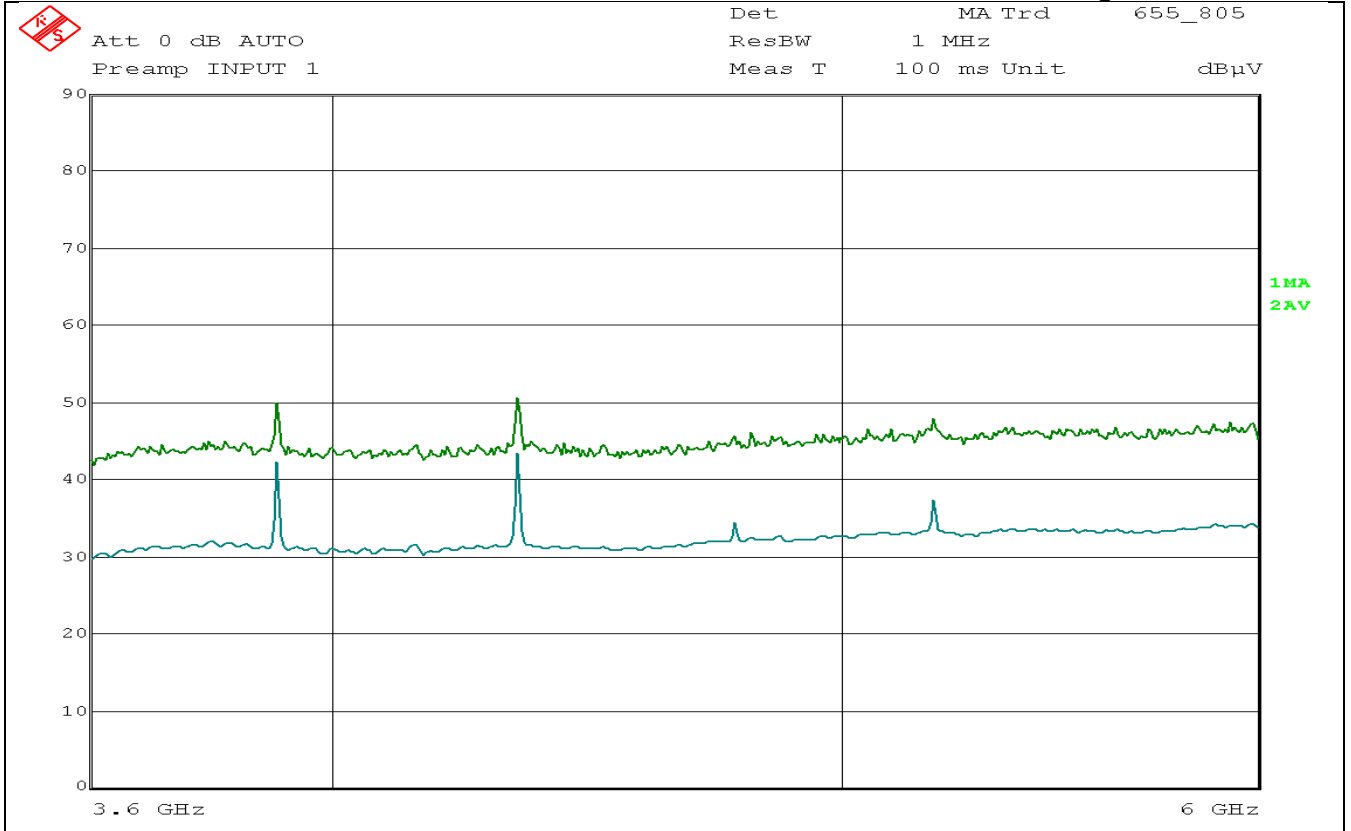


Fig A7: Radiated Emissions 3.6GHz - 6GHz, Vertical, 3metre

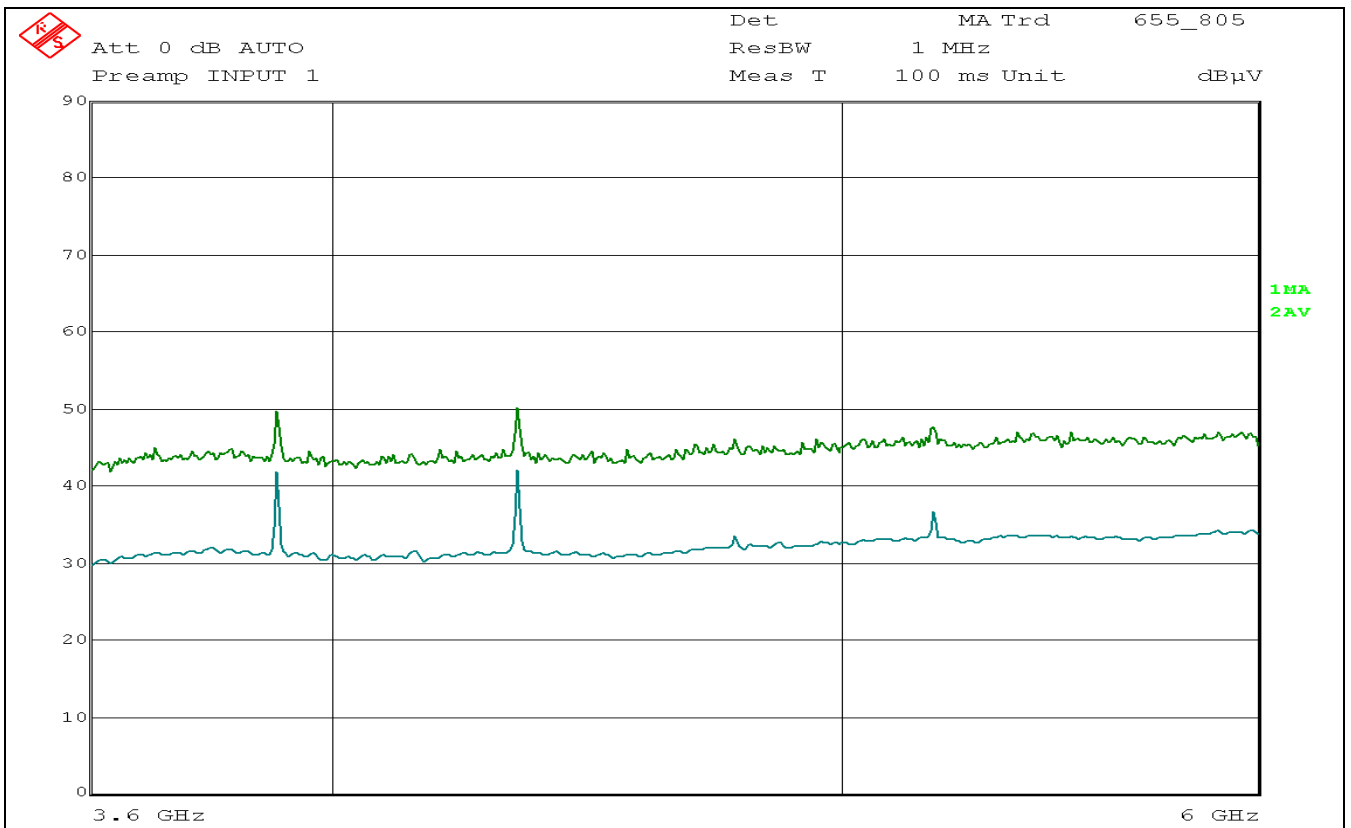
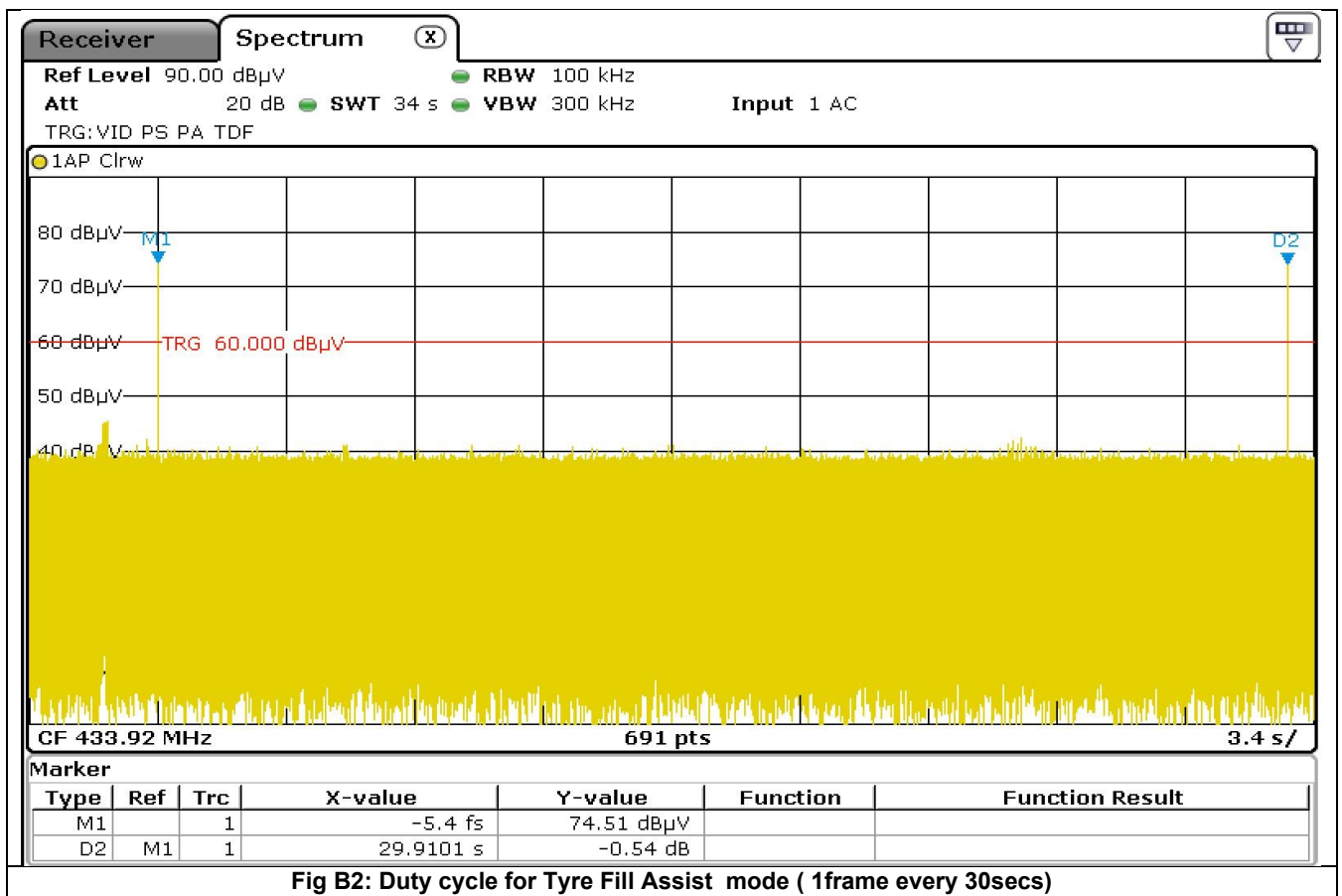
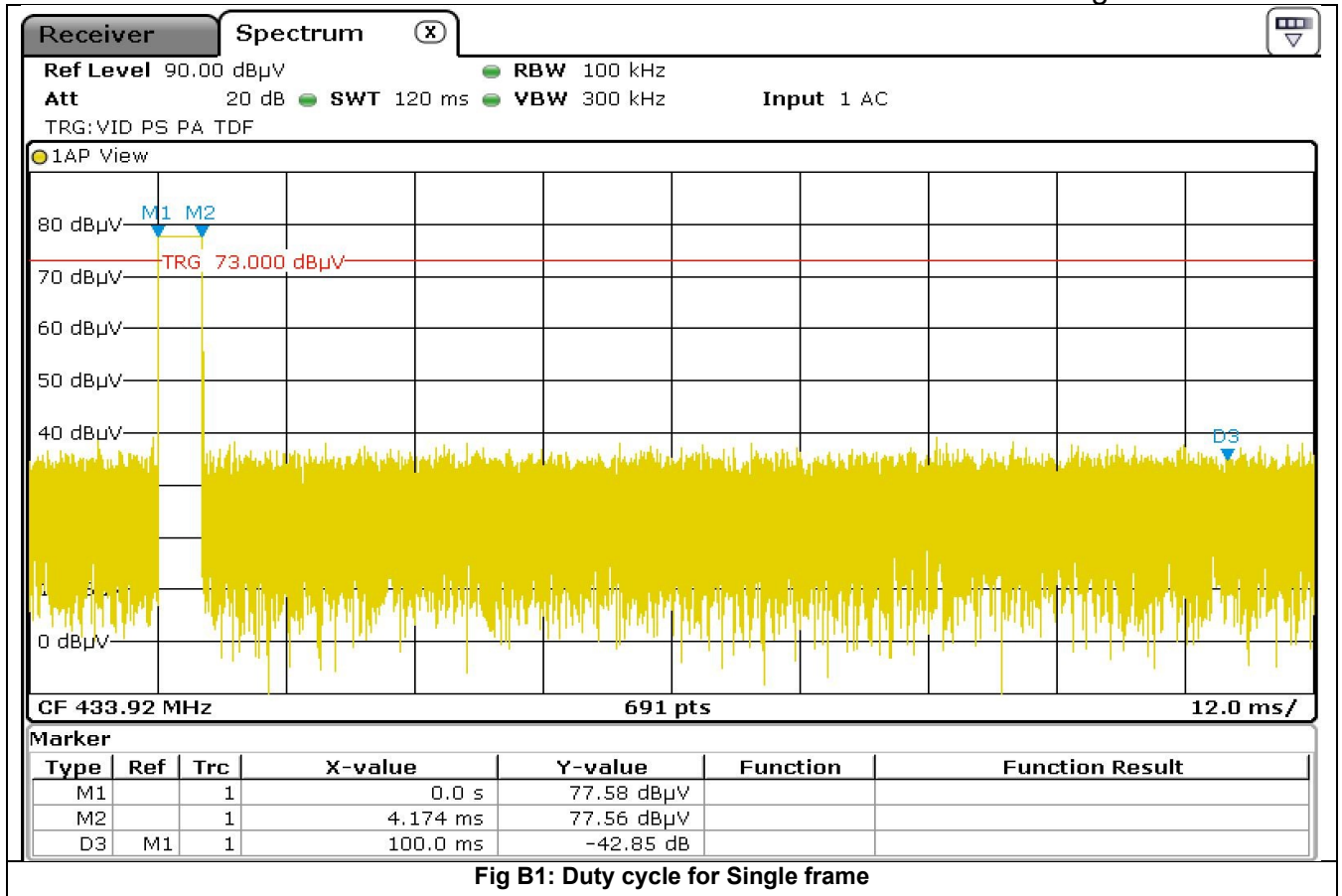
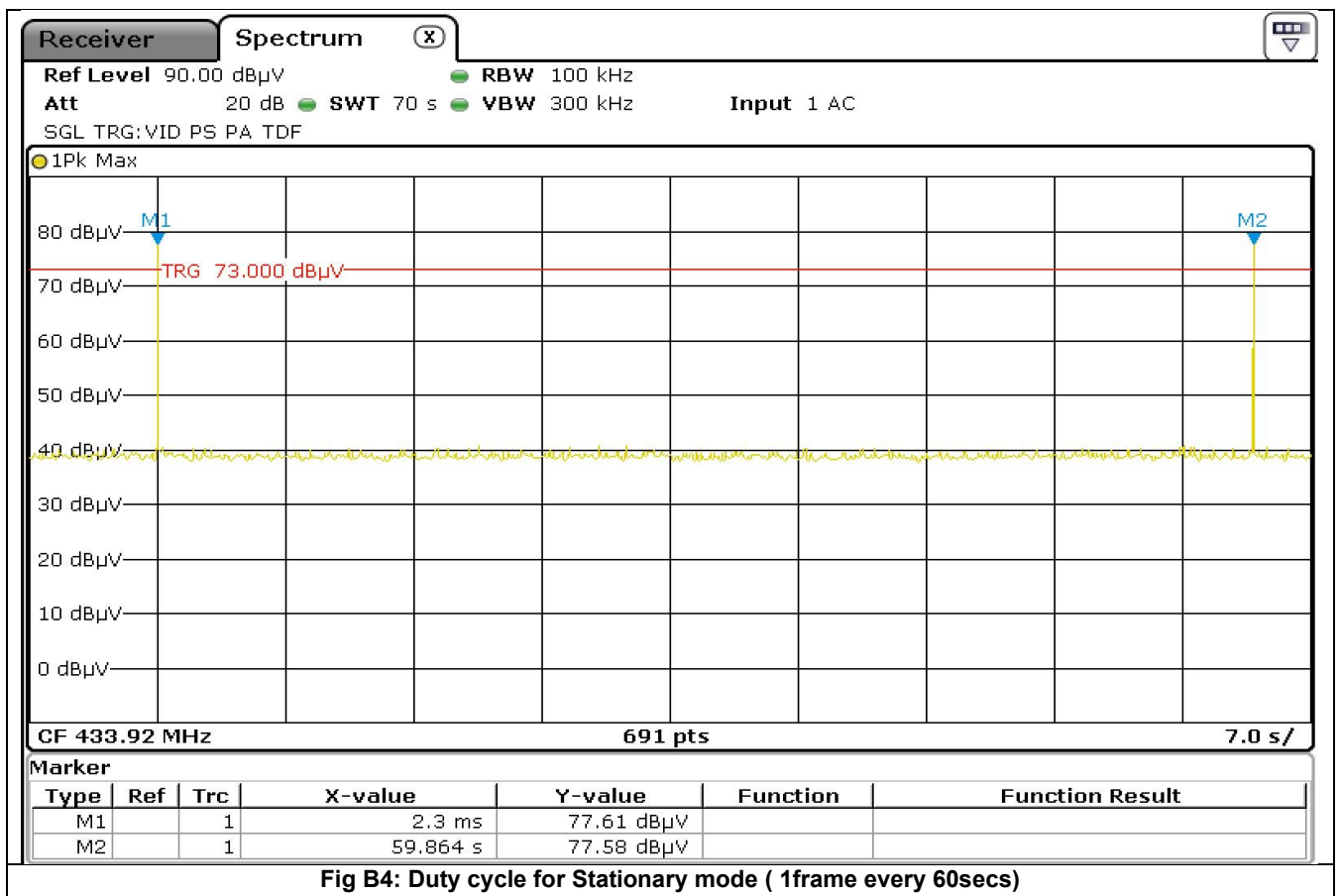
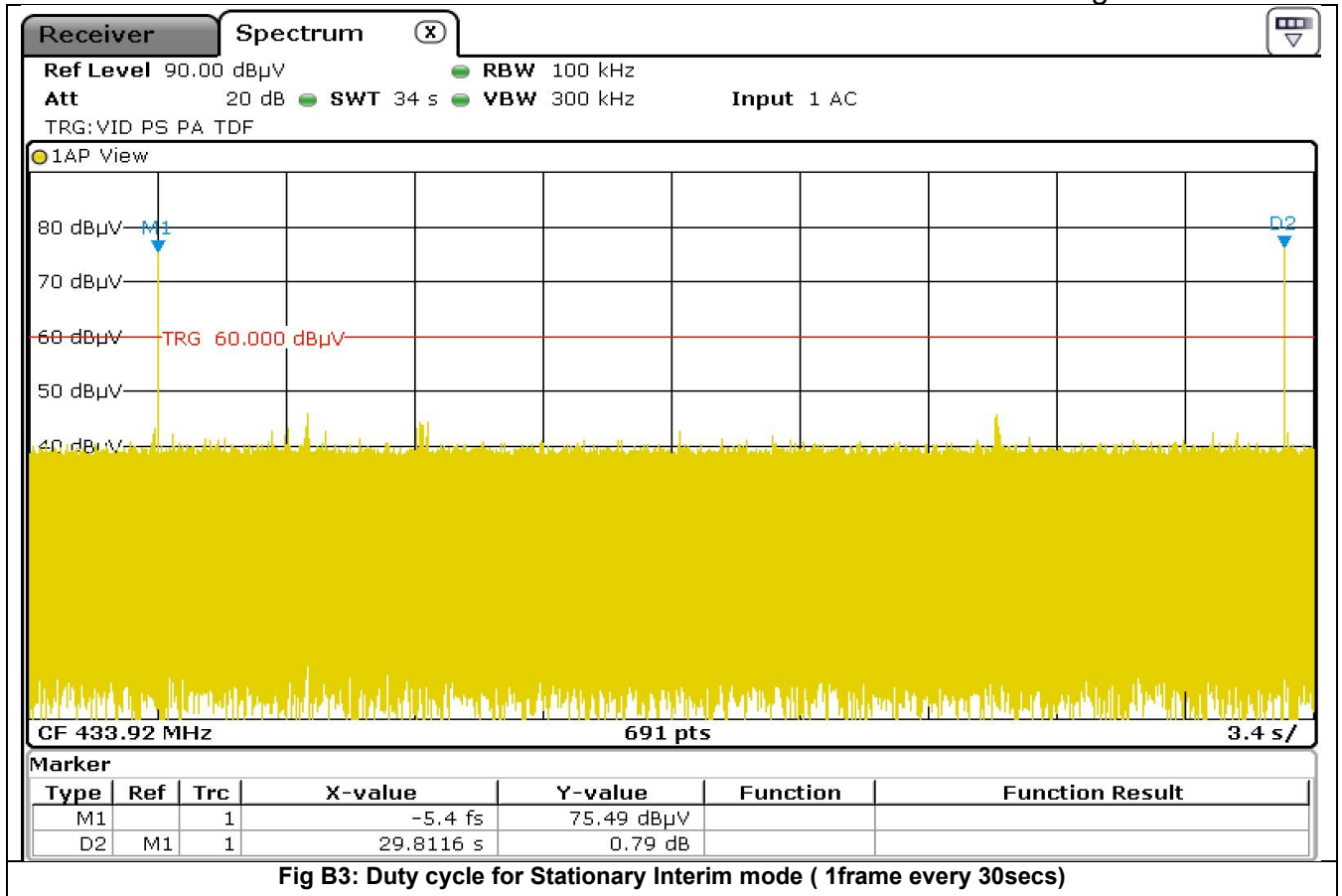
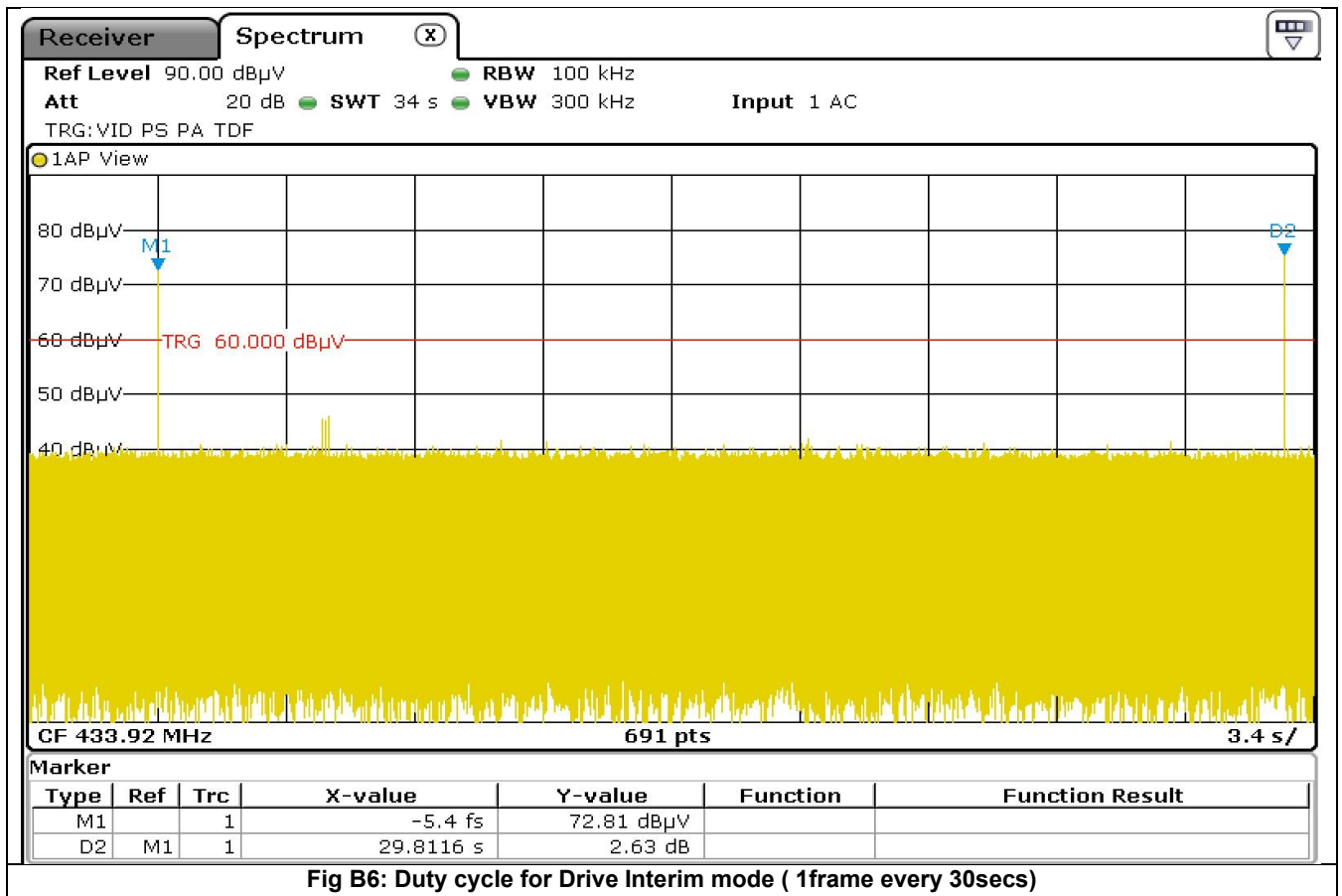
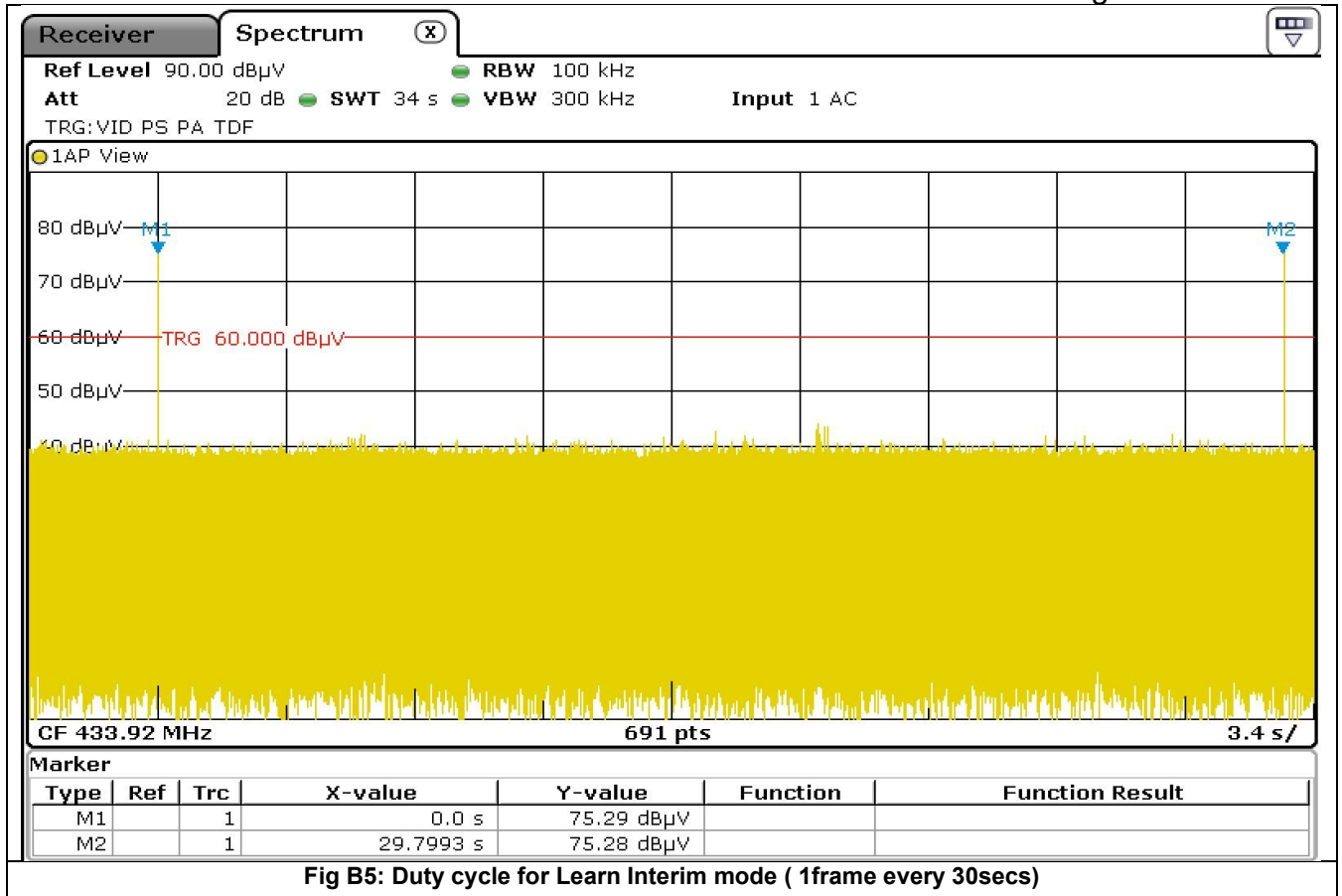


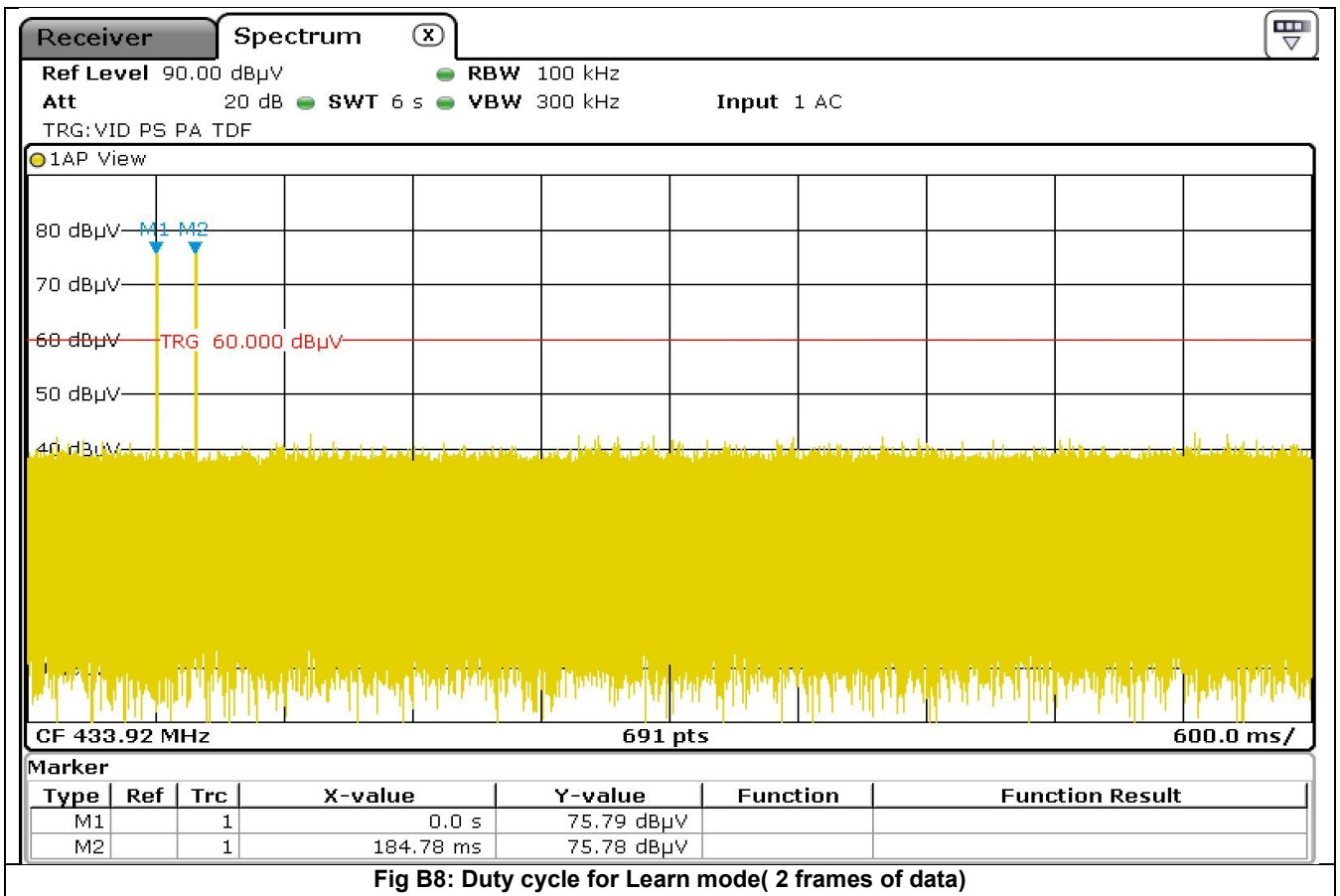
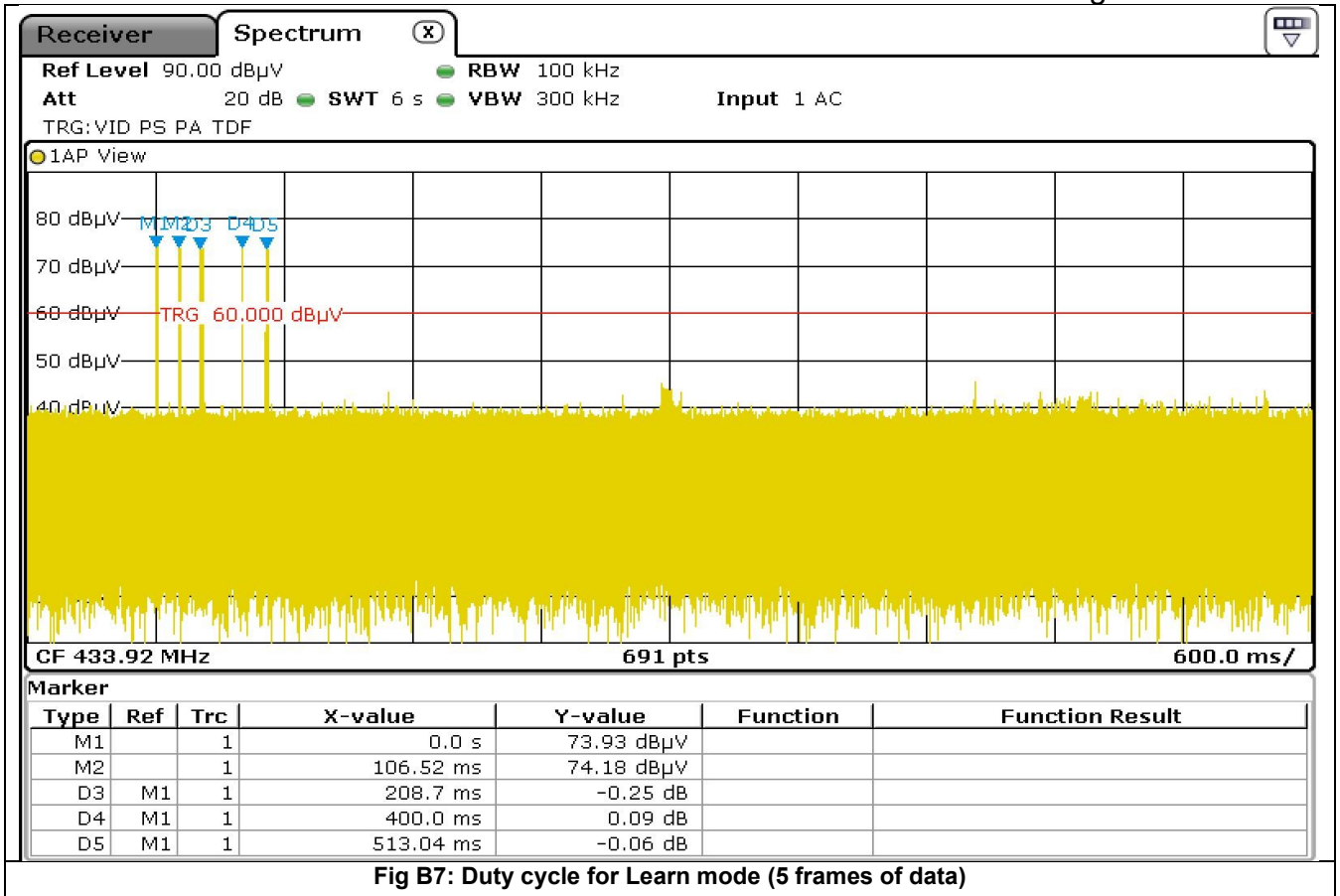
Fig A8: Radiated Emissions 3.6GHz - 6GHz, Horizontal, 3metre

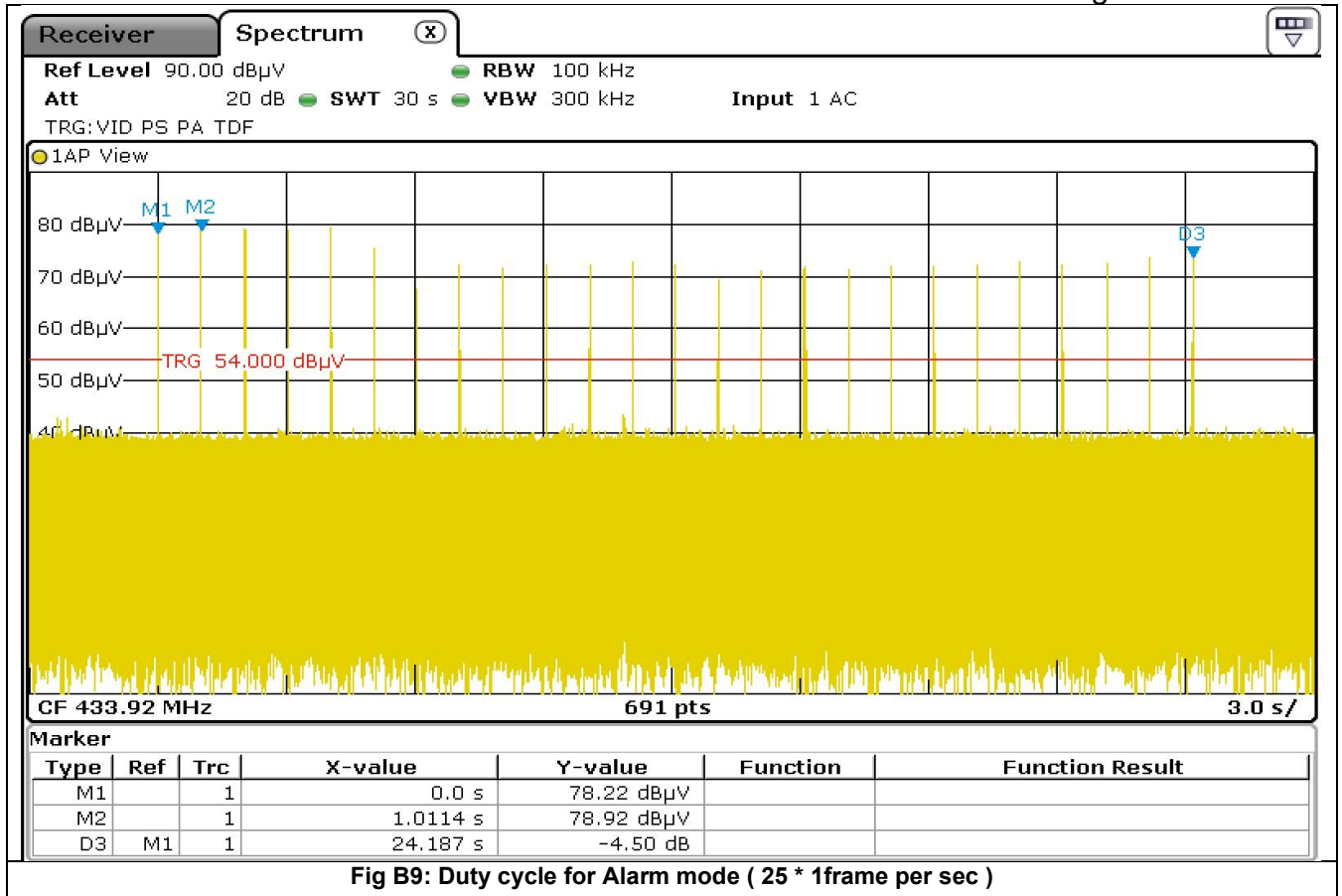
Appendix B: Duty Cycle for other modes





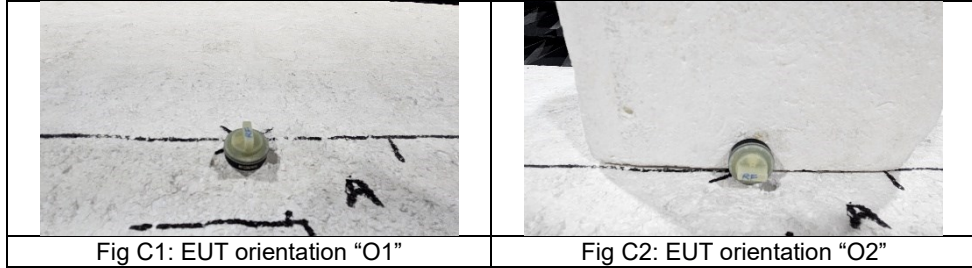






Appendix C: Test Configurations:

Orientations for Radiated Emissions



Appendix D: Block Diagrams of Test Setup

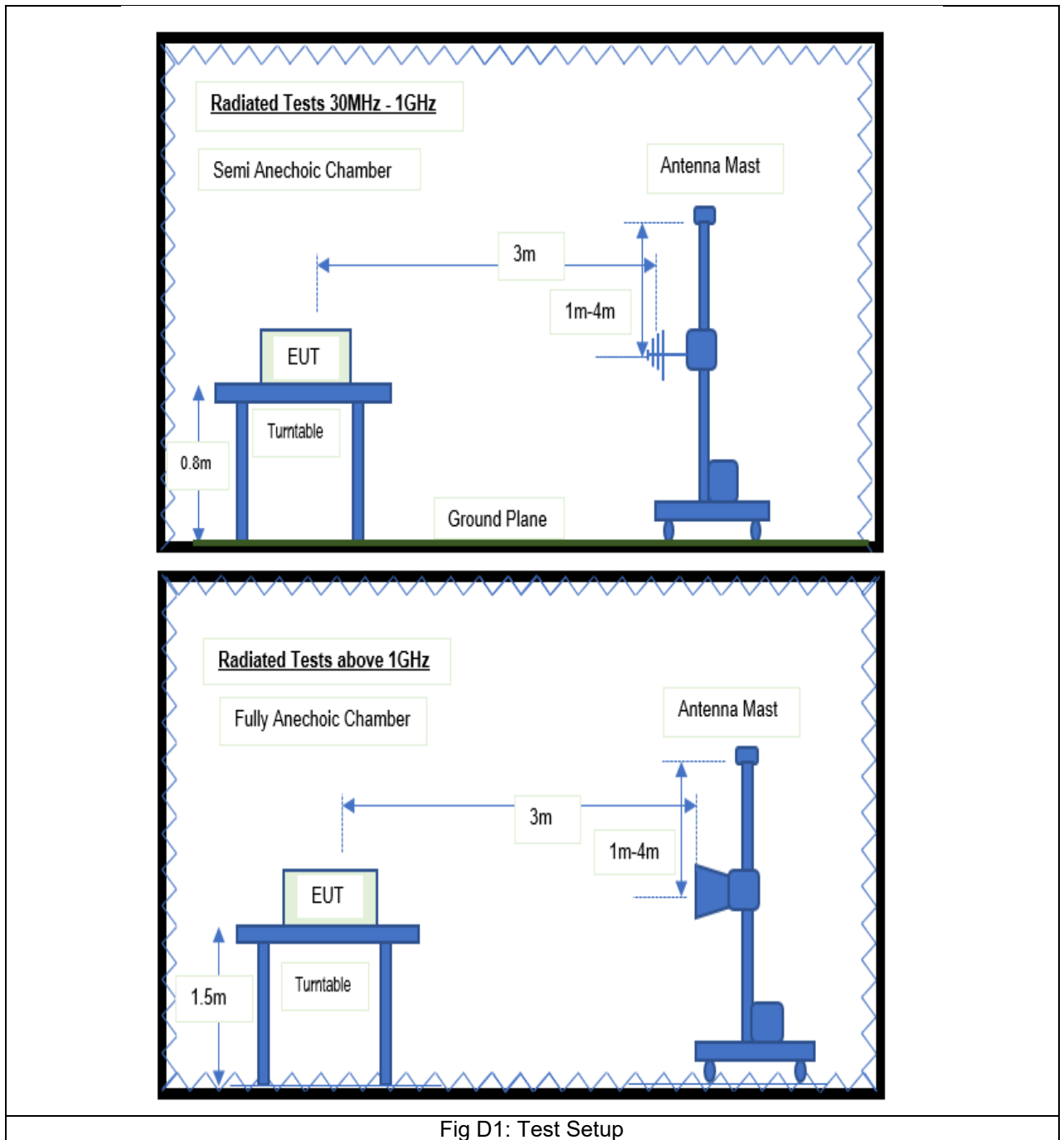


Fig D1: Test Setup

End of Report