

FCC Testing of the
Crane Electronics Ltd
RF Transceiver, Model: RF Module (101 – 482)
In accordance with FCC 47 CFR Part 15C

Prepared for: Crane Electronics Ltd
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FCC ID: TA6RFM01

COMMERCIAL-IN-CONFIDENCE

Date: November 2017
Document Number: 75938430-04 | Issue: 01



Product Service

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Steven White	01 November 2017	
Authorised Signatory	Matthew Russell	01 November 2017	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Graeme Lawler	01 November 2017	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2016 for the tests detailed in section 1.3.



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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	01 November 2017

Table 1

1.2 Introduction

Applicant	Crane Electronics Ltd
Manufacturer	Crane Electronics Ltd
Model Number(s)	RF Module (101 – 482)
Serial Number(s)	Not Serialised (75938430-TSR0001)
Hardware Version(s)	B
Software Version(s)	5.0
Number of Samples Tested	1
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2016
Order Number	049562
Date	17-March-2017
Date of Receipt of EUT	06-April-2017
Start of Test	25-September-2017
Finish of Test	10-October-2017
Name of Engineer(s)	Graeme Lawler
Related Document(s)	ANSI C63.10 (2013)



Product Service

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C is shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: 2.4 GHz SRD Transmitting				
2.1	15.249 (a)	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.2	15.249 (a) and 15.35 (b)	Field Strength of Fundamental	Pass	ANSI C63.10 (2013)
2.3	15.249 (a)(d)	Field Strength of Emissions	Pass	ANSI C63.10 (2013)

Table 2



1.1 Application Form

EQUIPMENT DESCRIPTION									
Model Name/Number			RF Module						
Part Number			101-482						
Hardware Version			A						
Software Version			5.0						
FCC ID (if applicable)				TA6RFM01					
Industry Canada ID (if applicable)				N/A					
Technical Description (Please provide a brief description of the intended use of the equipment)				Transmits and receives digital information primarily for torque measurement systems.					

INTENTIONAL RADIATORS									
Technology	Frequency Band (MHz)	Conducted Declared Output Power (dBm)	Antenna Gain (dBi)	Supported Bandwidth (s) (MHz)	Modulation Scheme(s)	ITU Emission Designator	Test Channels (MHz)		
							Bottom	Middle	Top
use Nordic nRF24LE1	2400-2480	0	3	1MHz	GFSK	1M00F1D	2400	2440	2480

UN-INTENTIONAL RADIATOR	
Highest frequency generated or used in the device or on which the device operates or tunes	16 MHz

Power Source			
AC	Single Phase	Three Phase	Nominal Voltage
External DC	Nominal Voltage		Maximum Current
	3.3V		20mA
Battery	Nominal Voltage		Battery Operating End Point Voltage
Can EUT transmit whilst being charged?			Yes ☐ No ☐

EXTREME CONDITIONS			
Maximum temperature	+55	°C	Minimum temperature
			-20
			°C

Ancillaries	
Please list all ancillaries which will be used with the device.	
External Dipole Antenna W5E-WO-03	



Product Service

ANTENNA CHARACTERISTICS			
☒	Antenna connector		State impedance 50 Ohm
☐	Temporary antenna connector		State impedance Ohm
☒	Integral antenna	Type	ANT3216A063R 2400 A CERAMIC CHIP ANTENNA YAGEO
☒	External antenna	Type	50Ohm External Dipole Antenna W5E-WO-03 WINIZEN

I hereby declare that the information supplied is correct and complete.

Name: NEIL MCDONALD
Position held: TECHNICAL DIRECTOR Date: 31/03/2017

1.2 Product Information

1.2.1 Technical Description

Transmits and receives digital information primarily for torque measuring systems.

1.3 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.4 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Serial Number: Not Serialised (75938430-TSR0001)			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 3

1.5 Test Location

TÜV SÜD Product Service conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz SRD Transmitting		
Authorised Band Edges	Graeme Lawler	UKAS
Field Strength of Fundamental	Graeme Lawler	UKAS
Field Strength of Emissions	Graeme Lawler	UKAS

Table 4

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Authorised Band Edges

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.249 (d)

2.1.2 Equipment Under Test and Modification State

RF Module (101 – 482), S/N: Not Serialised (75938430-TSR0001) - Modification State 0

2.1.3 Date of Test

09-October-2017

2.1.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.10.4

Average measurements have been performed in accordance with ANSI C63.10 clause 4.1.4.2.2.

Measurements were made using a 1 MHz RBW in order to also demonstrate compliance with the restricted bands at 2390 MHz and 2483.5 MHz.

2.1.5 Environmental Conditions

Ambient Temperature 19.2 °C

Relative Humidity 53.0 %

2.1.6 Test Results

2.4 GHz SRD Transmitting

Frequency (MHz)	Measured Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
2402.5	2400.0	71.42	45.13
2480.5	2483.5	68.10	45.30

Table 5 - Authorised Band Edge Results



Product Service

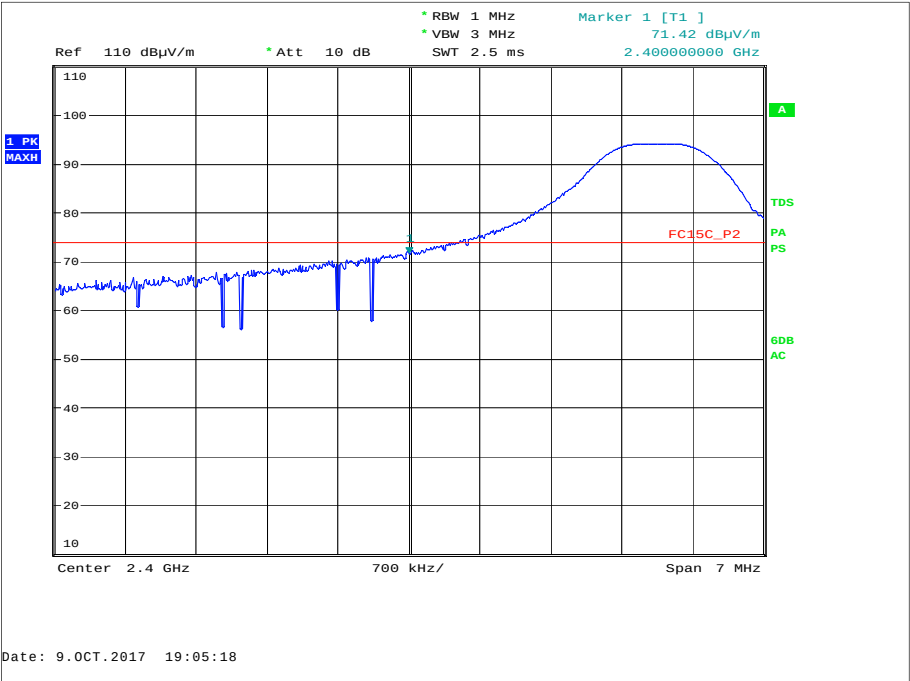


Figure 1 - 2402.5 MHz, Measured Frequency: 2400.0 MHz

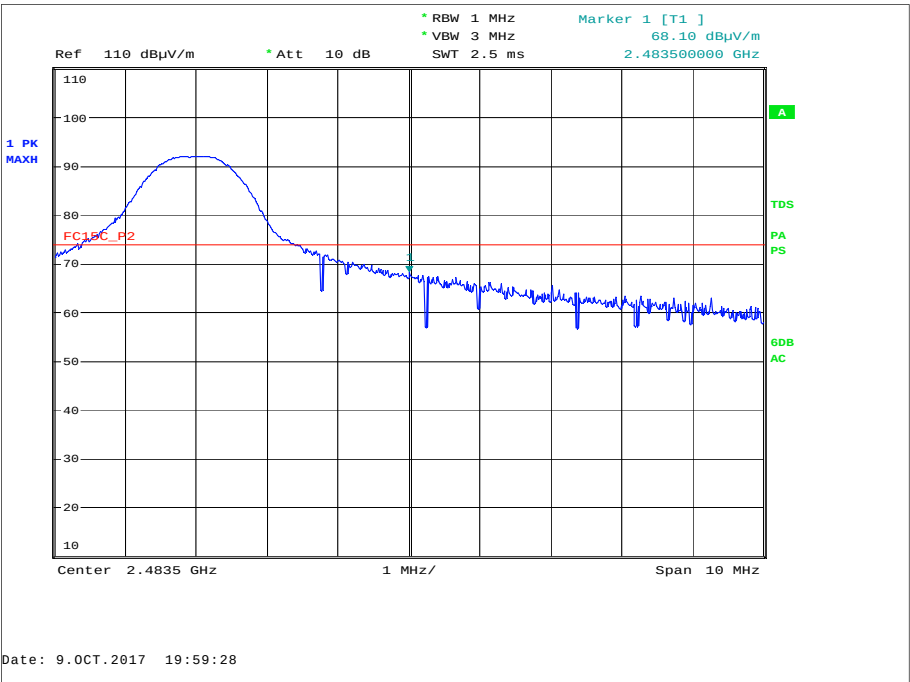


Figure 2 - 2480 MHz, Measured Frequency: 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.249 (d)

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in 15.209, whichever is the lesser attenuation.

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (metres)
0.009 to 0.490	2400/F(kHz)	300
0.490 to 1.705	24000/F(kHz)	30
1.705 to 30	30	30
30 to 88	100	3
88 to 216	150	3
216 to 960	200	3
Above 960	500	3

Table 6 - FCC Limit Table - 15.209

2.1.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	mature GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	mature GmbH	NCD	3917	-	TU
Digital thermo Hygrometer	Radio Spares	1260	4300	12	30-Aug-2018
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	04-Nov-2017
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 7

TU - Traceability Unscheduled



2.2 Field Strength of Fundamental

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.249 (a) and 15.35 (b)

2.2.2 Equipment Under Test and Modification State

RF Module (101 – 482), S/N: Not Serialised (75938430-TSR0001) - Modification State 0

2.2.3 Date of Test

10-October-2017

2.2.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.3 and 6.6.

Average measurements have been performed in accordance with ANSI C63.10 clause 4.1.4.2.2.

2.2.5 Environmental Conditions

Ambient Temperature 19.5 °C

Relative Humidity 53.0 %

2.2.6 Test Results

2.4 GHz SRD Transmitting

Frequency	Field Strength (dBµV/m)
2402.5	94.71
2440.5	94.49
2480.5	93.10

Table 8 - Peak Level



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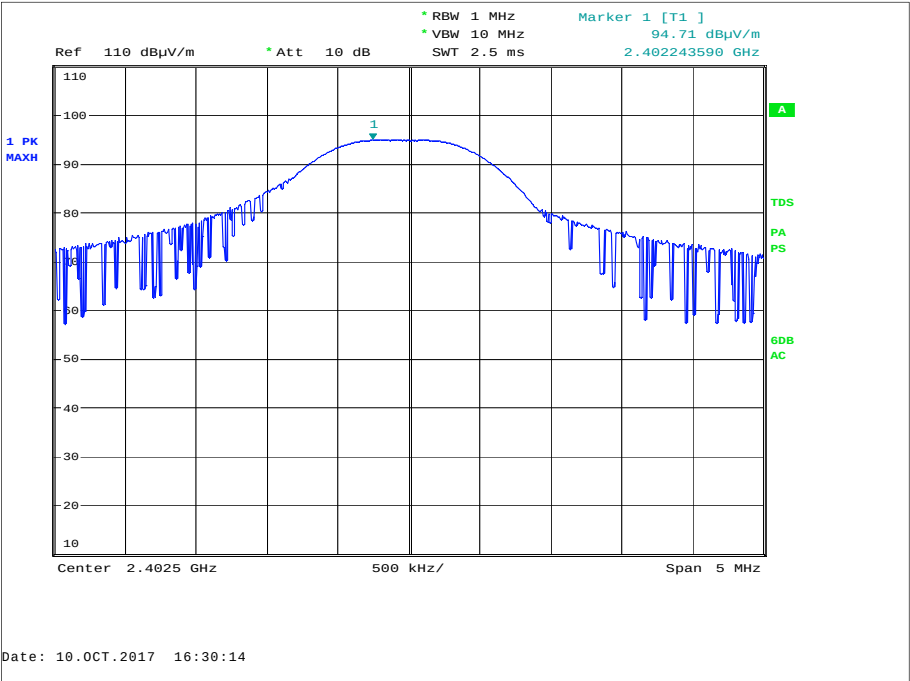


Figure 3 - 2402.5 MHz, Peak Level

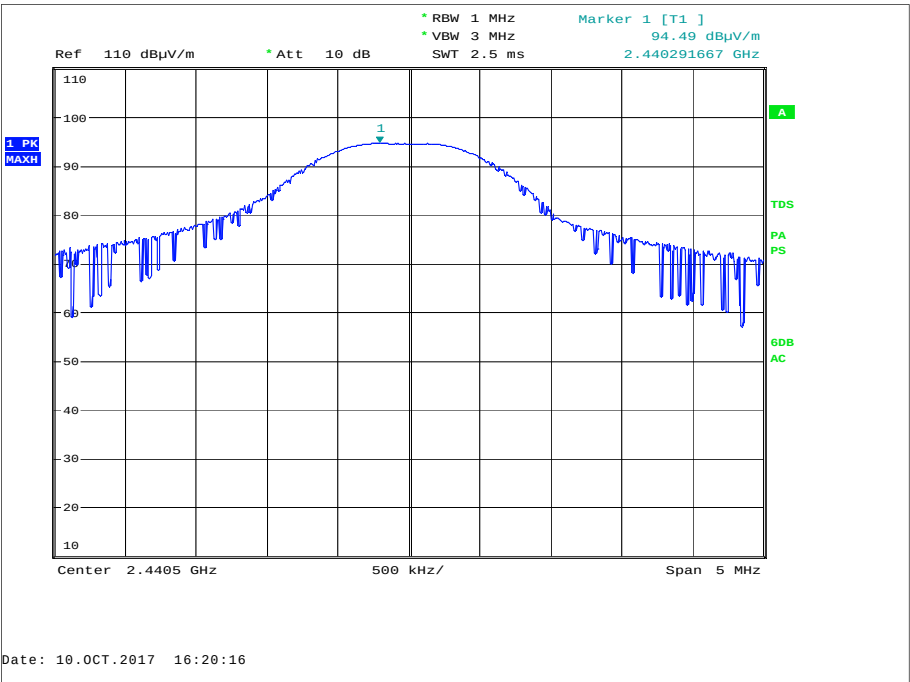


Figure 4 - 2440.5 MHz, Peak Level



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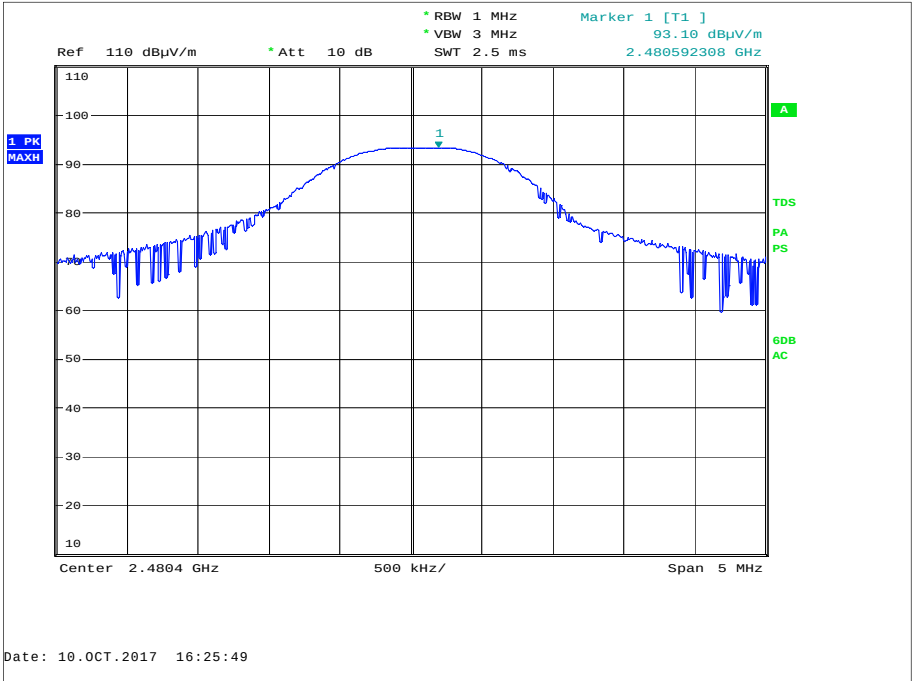


Figure 5 - 2480.5 MHz, Peak Level



Frequency	Field Strength (dBµV/m)
2402.5	76.47
2440.5	76.26
2480	75.00

Table 9 - Average Level

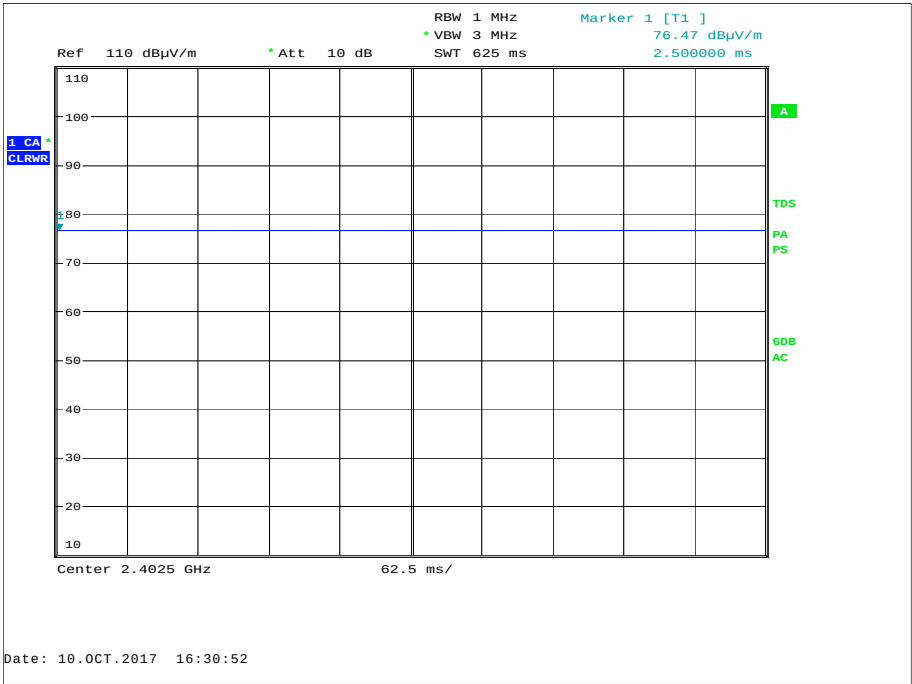


Figure 6 - 2402.5 MHz, Average Level

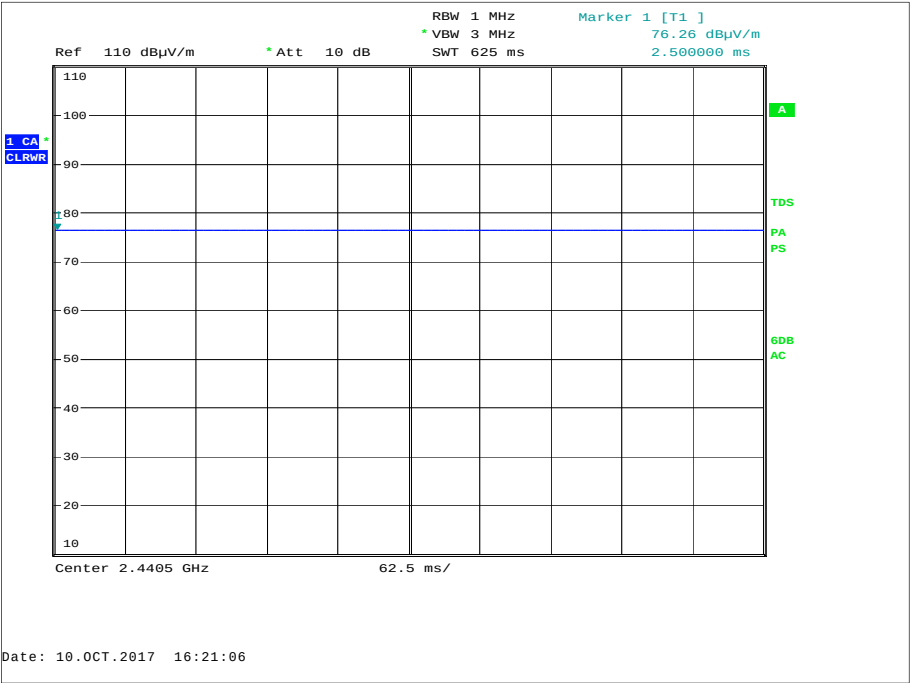


Figure 7 - 2440.5 MHz, Average Level

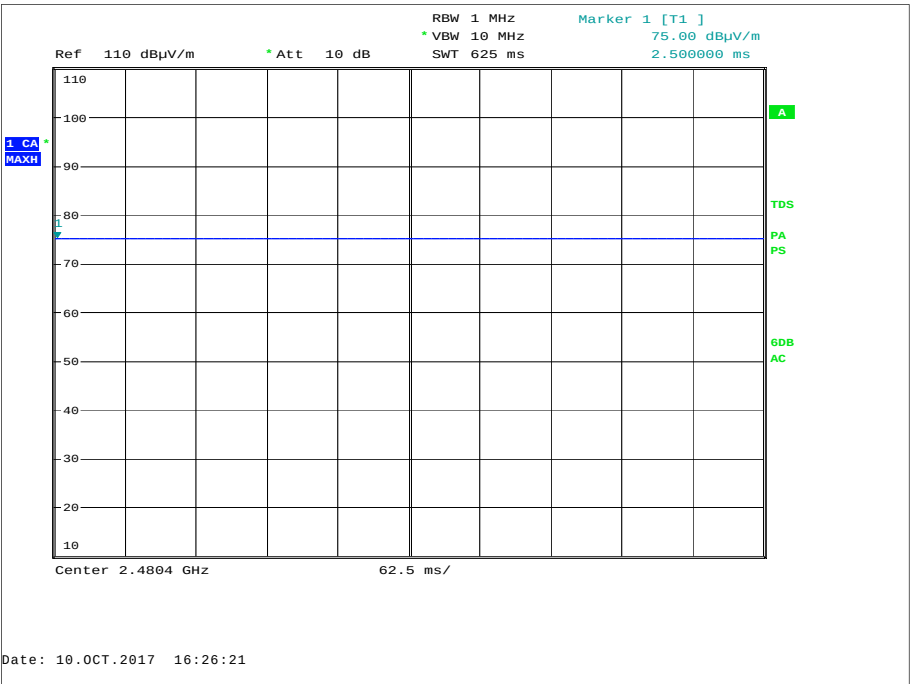


Figure 8 - 2480.5 MHz, Average Level

FCC 47 CFR Part 15, Limit Clause 15.249 (a)

Fundamental Frequency (MHz)	Average Field Strength of Fundamental (millivolts/meter)
902 to 928	50
2400 to 2483.5	50
5725 to 5875	50
24000 to 24250	250

Table 10

FCC 47 CFR Part 15, Limit Clause 15.35 (b)

The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device.

2.2.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	maturo GmbH	NCD	3917	-	TU
Digital thermo Hygrometer	Radio Spares	1260	4300	12	30-Aug-2018
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	04-Nov-2017
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 11

TU - Traceability Unscheduled

2.3 Field Strength of Emissions

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.249 (a)(d)

2.3.2 Equipment Under Test and Modification State

RF Module (101 – 482), S/N: Not Serialised (75938430-TSR0001) - Modification State 0

2.3.3 Date of Test

25-September-2017 to 09-October-2017

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.3, 6.5 and 6.6.

Plots for average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.3 to characterize the EUT. Where emissions were detected within 10dB of the average limit, final average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.2.

The following expression was used to convert dBuV/m to uV/m: $10^{(\text{Field Strength in dBuV/m}/20)}$.

2.3.5 Environmental Conditions

Ambient Temperature 19.2 °C

Relative Humidity 53.0 %

2.3.6 Test Results

2.4 GHz SRD Transmitting

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.353	31.6	40.0	-8.4	159	3.97	Vertical
80.005	30.5	40.0	-9.5	38	1.48	Vertical
127.971	27.6	43.5	-15.9	95	1.00	Vertical
143.998	33.3	43.5	-10.2	126	1.00	Vertical
191.996	30.9	43.5	-12.6	360	1.00	Vertical
200.018	33.9	43.5	-9.6	177	1.00	Vertical

Table 12 - 2402.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

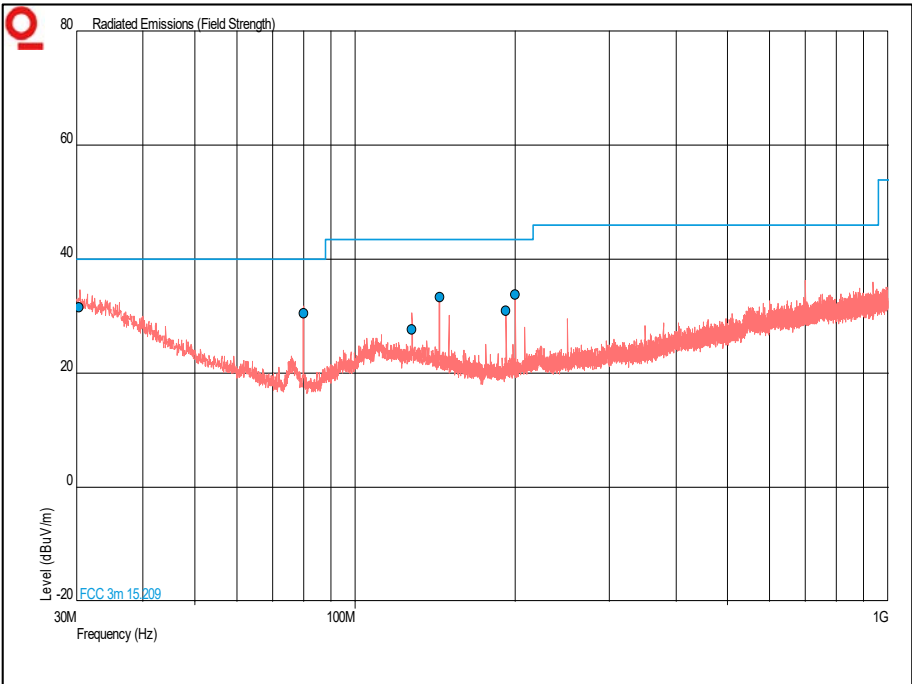


Figure 9 - 2402.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

Frequency (MHz)	Final Peak (dBµV/m)	Final Average (dBµV/m)	Final Peak (µV/m)	Final Average (µV/m)	Angle (°)	Height (m)	Polarisation
*							

Table 13 - 2402.5 MHz, 1 GHz to 25 GHz, Horizontal and Vertical

* No emissions were detected within 10 dB of the limit.

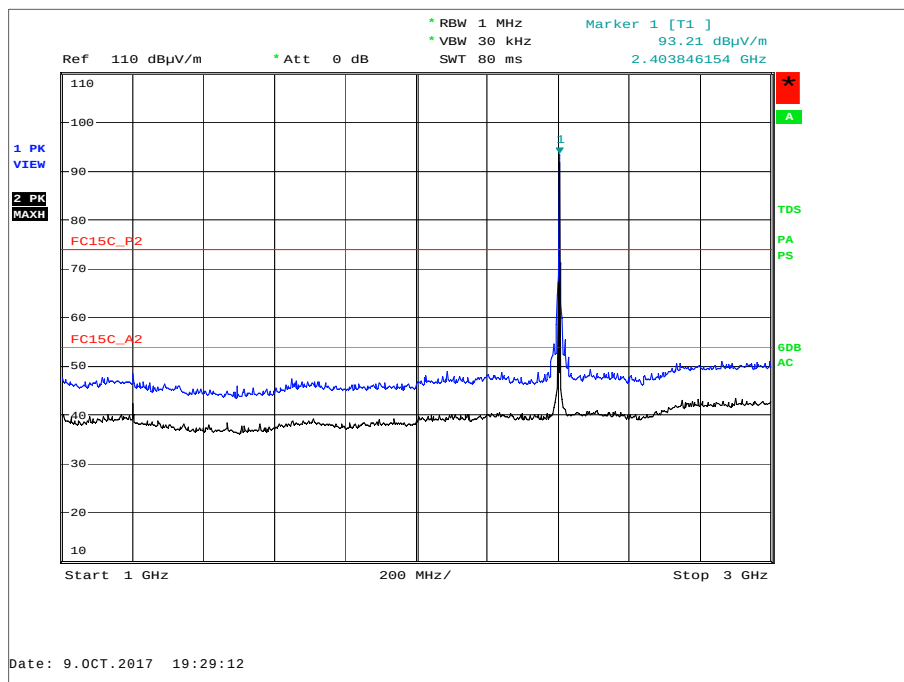


Figure 10 - 2402.5 MHz, 1 GHz to 3 GHz, Horizontal and Vertical

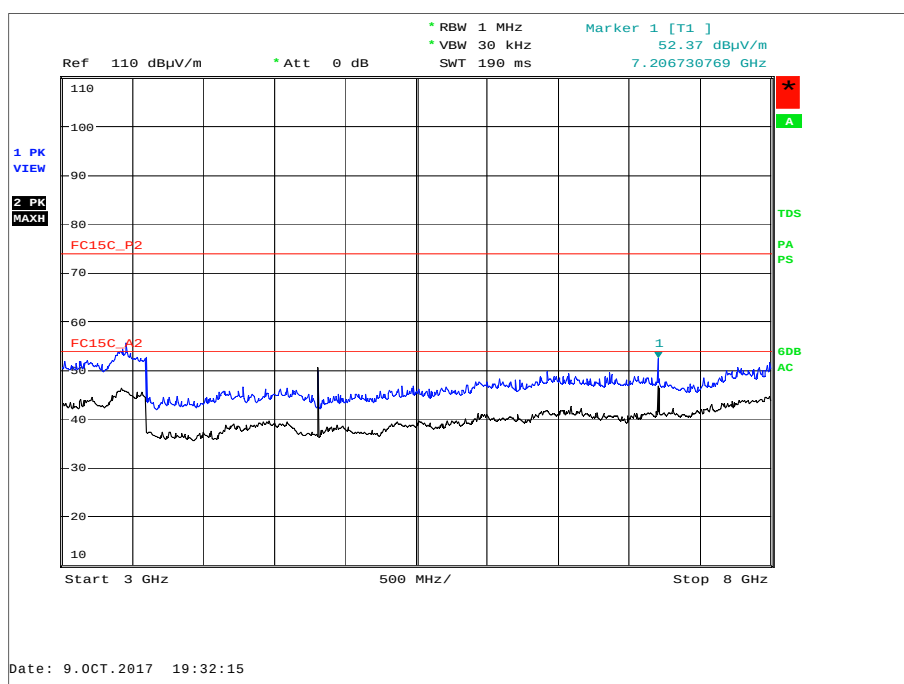


Figure 11 - 2402.5 MHz, 3 GHz to 8 GHz, Horizontal and Vertical

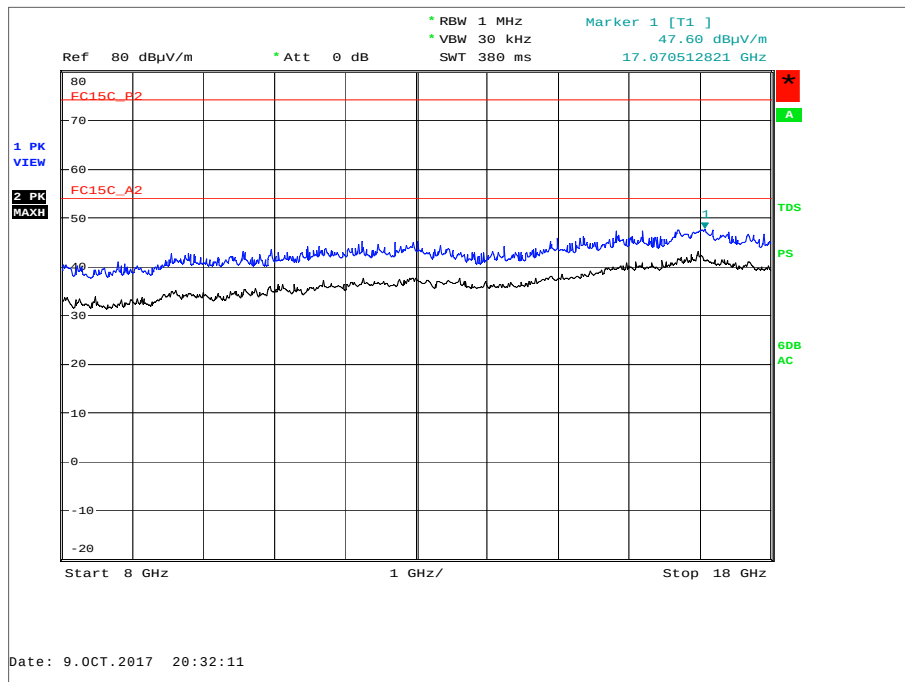


Figure 12 - 2402.5 MHz, 8 GHz to 18 GHz, Horizontal and Vertical

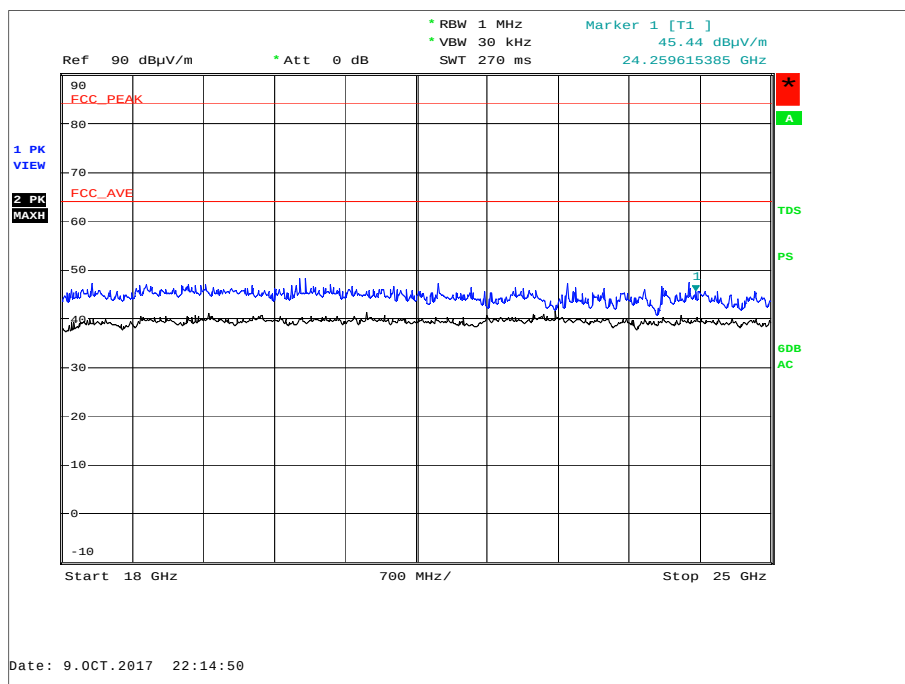


Figure 13 - 2402.5 MHz, 18 GHz to 25 GHz, Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.019	30.3	40.0	-9.7	301	1.00	Vertical
80.000	29.1	40.0	-10.9	87	1.00	Vertical
128.011	28.3	43.5	-15.2	116	1.00	Vertical
144.007	31.0	43.5	-12.5	118	1.00	Vertical
200.018	32.4	43.5	-11.1	360	1.00	Vertical
700.042	37.7	46.0	-8.3	92	1.00	Vertical

Table 14 - 2440.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

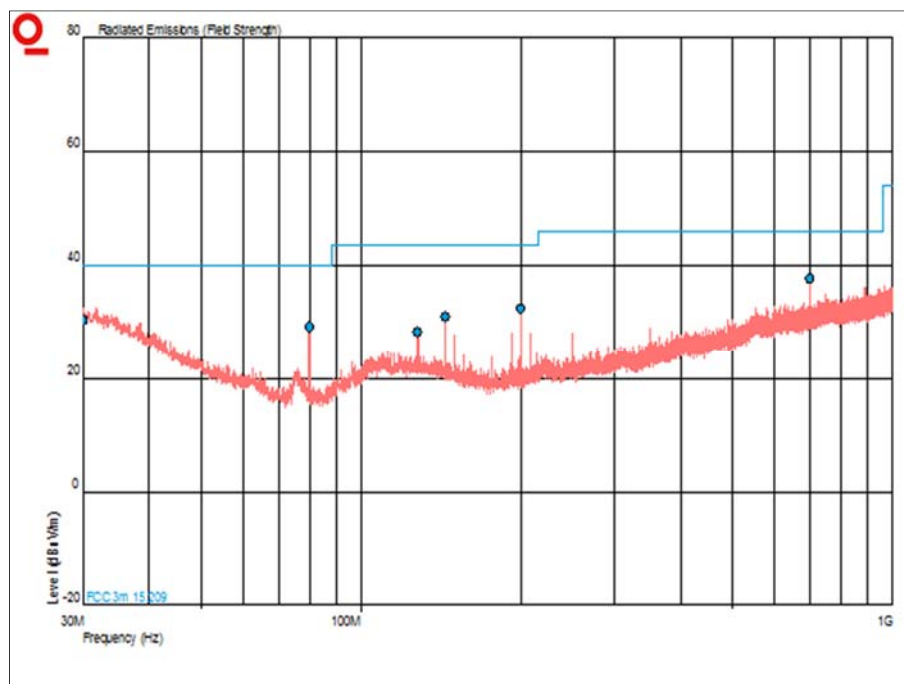


Figure 14 - 2440.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

Frequency (MHz)	Final Peak (dBµV/m)	Final Average (dBµV/m)	Final Peak (µV/m)	Final Average (µV/m)	Angle (°)	Height (m)	Polarisation
4880.920	59.07	45.84	898.46	195.88	217	1.49	Vertical

Table 15 - 2440.5 MHz, 1 GHz to 25 GHz, Horizontal and Vertical

No other emissions were detected within 10 dB of the limit.

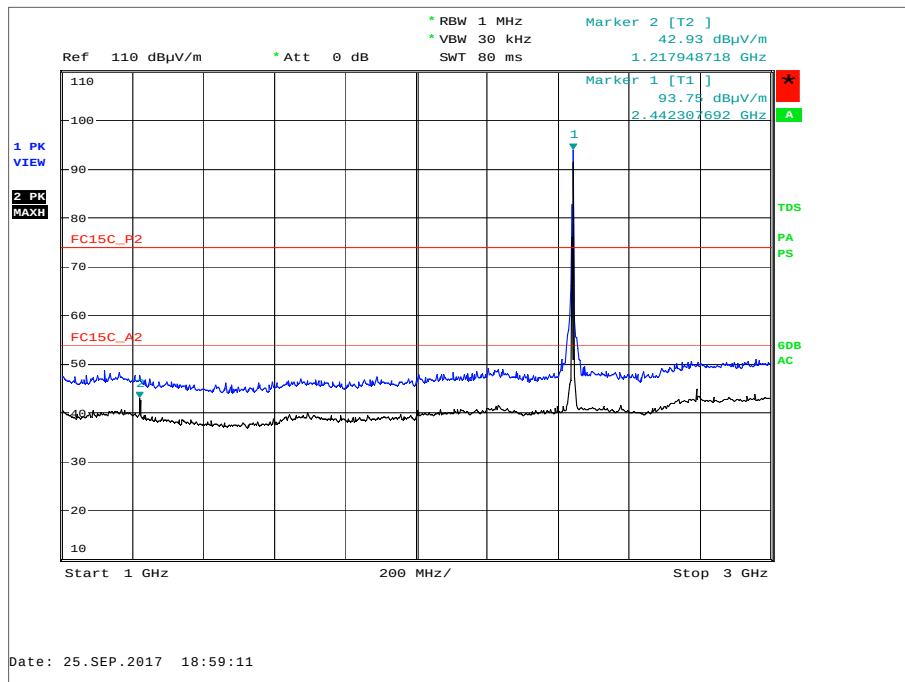


Figure 15 - 2440.5 MHz, 1 GHz to 3 GHz, Horizontal and Vertical

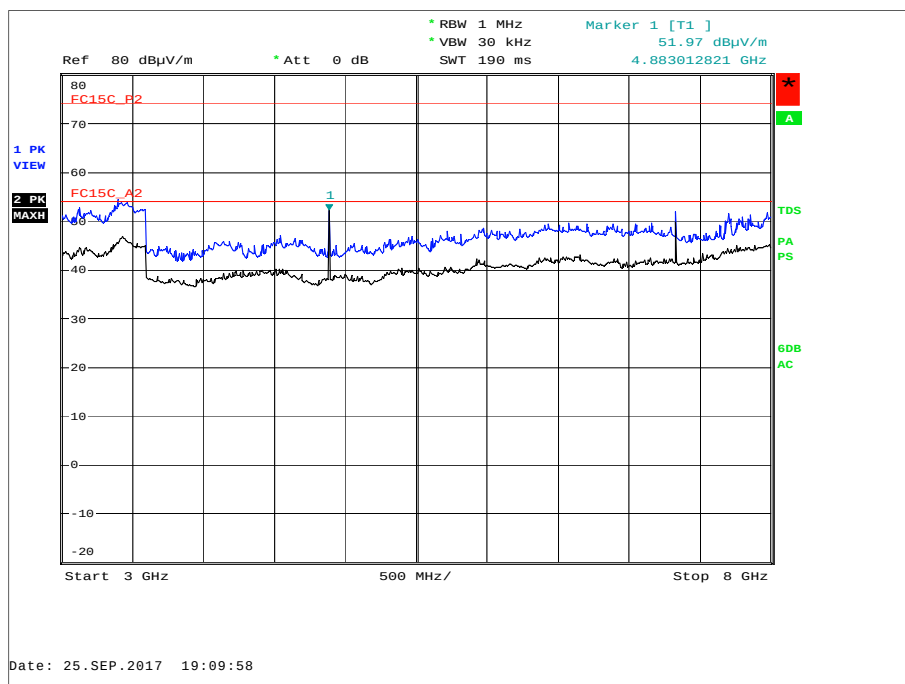


Figure 16 - 2440.5 MHz, 3 GHz to 8 GHz, Horizontal and Vertical



Product Service

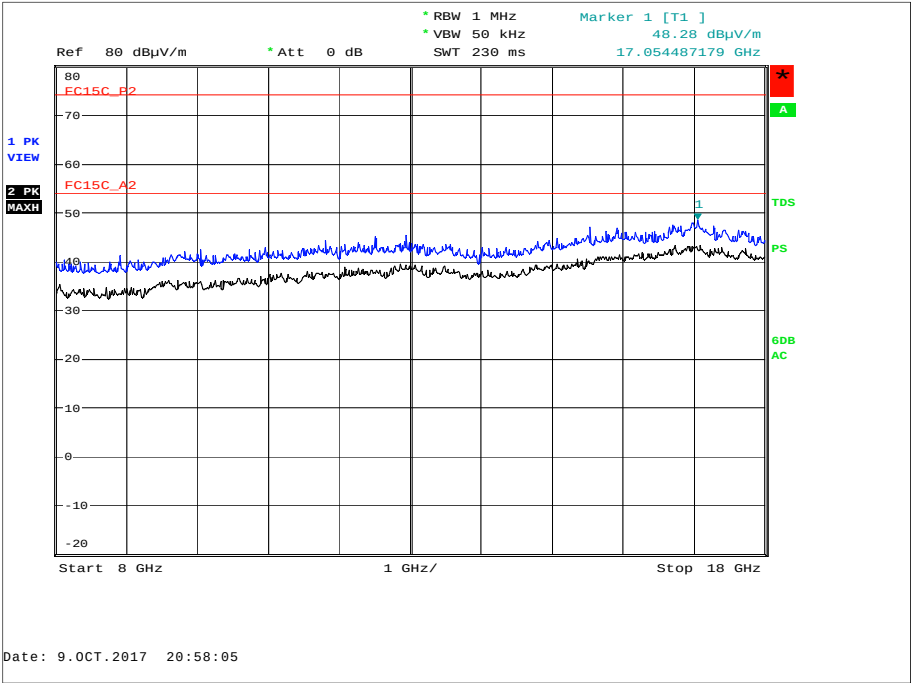


Figure 17 - 2440.5 MHz, 8 GHz to 18 GHz, Horizontal and Vertical

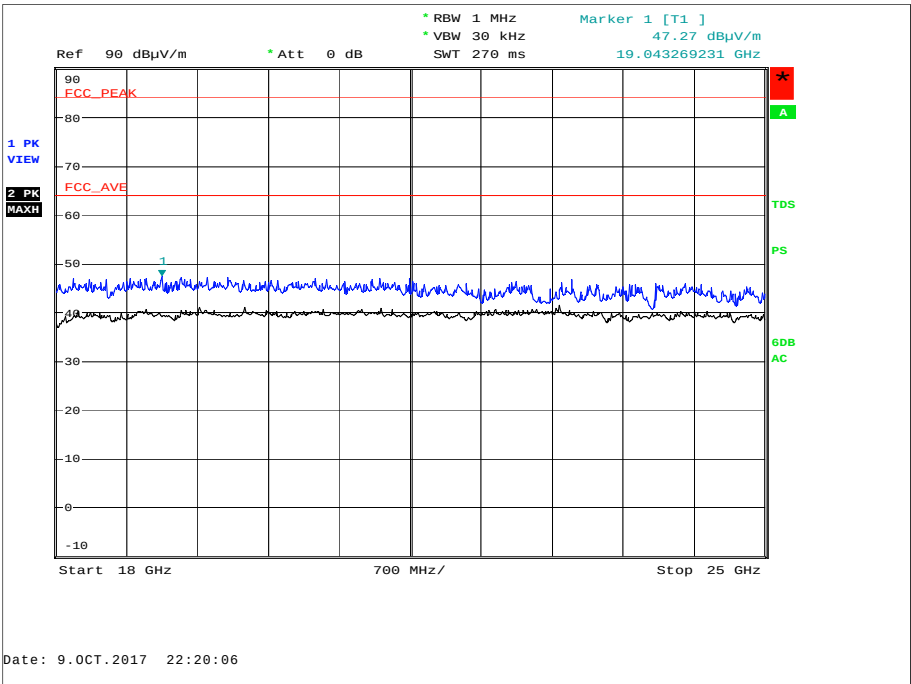


Figure 18 - 2440.5 MHz, 18 GHz to 25 GHz, Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.914	30.0	40.0	-10.0	52	1.00	Vertical
80.006	29.6	40.0	-10.4	81	1.00	Vertical
128.007	28.0	43.5	-15.5	127	1.00	Vertical
143.996	28.8	43.5	-14.7	76	1.00	Vertical
200.021	32.8	43.5	-10.7	349	1.00	Vertical
699.896	31.3	46.0	-14.7	137	1.00	Vertical

Table 16 - 2480.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

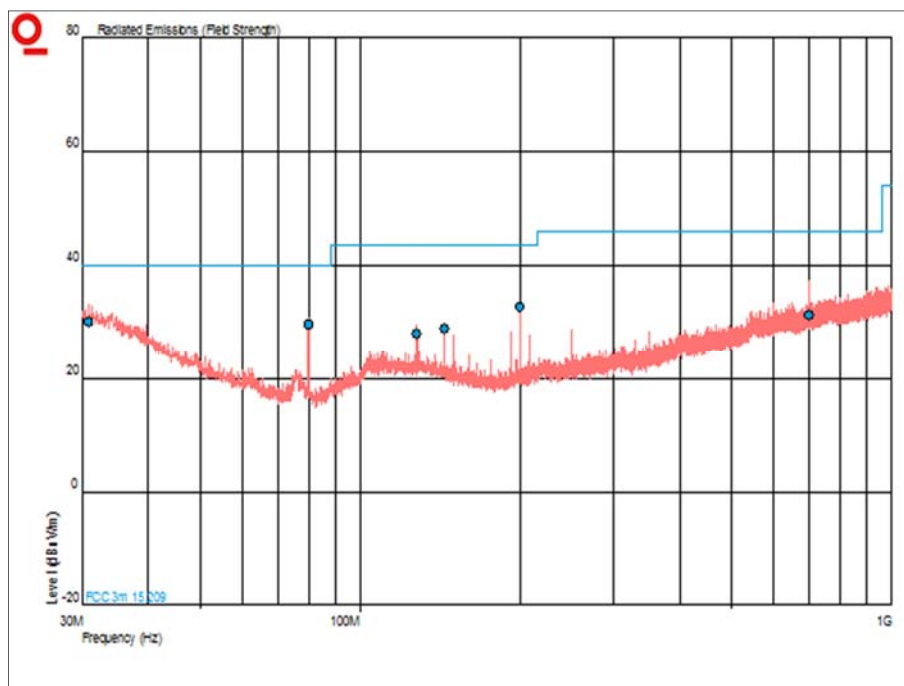


Figure 19 - 2480.5 MHz, 30 MHz to 1 GHz, Horizontal and Vertical

Frequency (MHz)	Final Peak (dBuV/m)	Final Average (dBuV/m)	Final Peak (uV/m)	Final Average (uV/m)	Angle (°)	Height (m)	Polarisation
4960.897	63.17	50.40	1440.45	331.13	216	1.81	Vertical

Table 17 - 2480.5 MHz, 1 GHz to 25 GHz, Horizontal and Vertical

No other emissions were detected within 10 dB of the limit.



Product Service

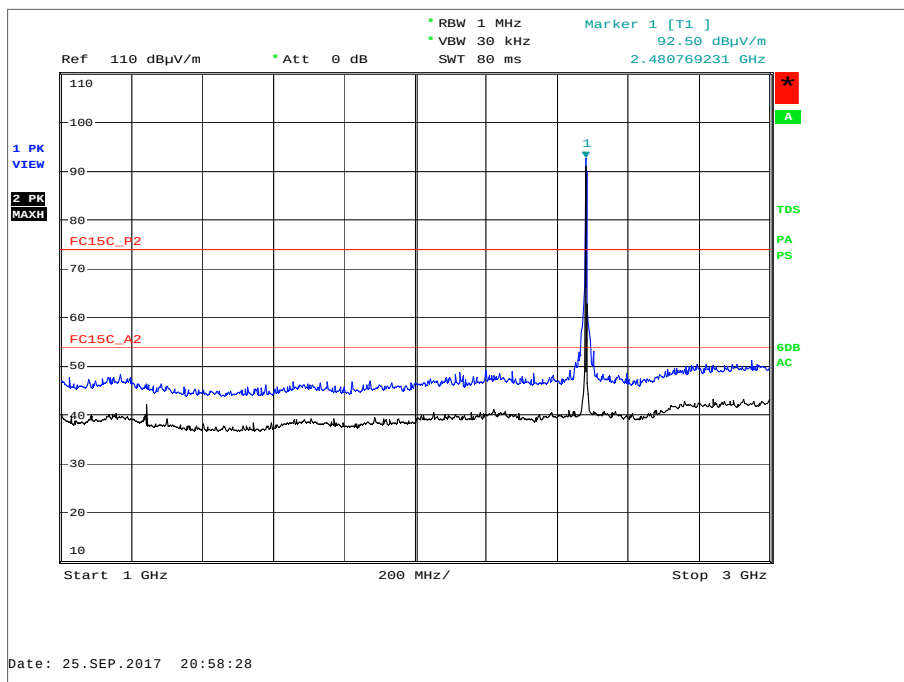


Figure 20 - 2480.5 MHz, 1 GHz to 3 GHz, Horizontal and Vertical

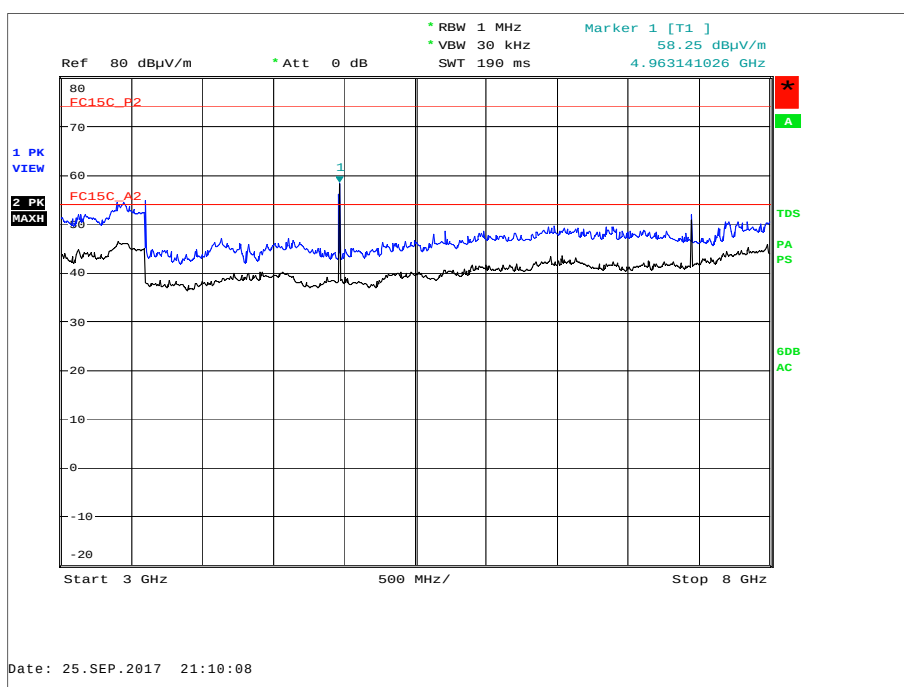


Figure 21 - 2480.5 MHz, 3 GHz to 8 GHz, Horizontal and Vertical

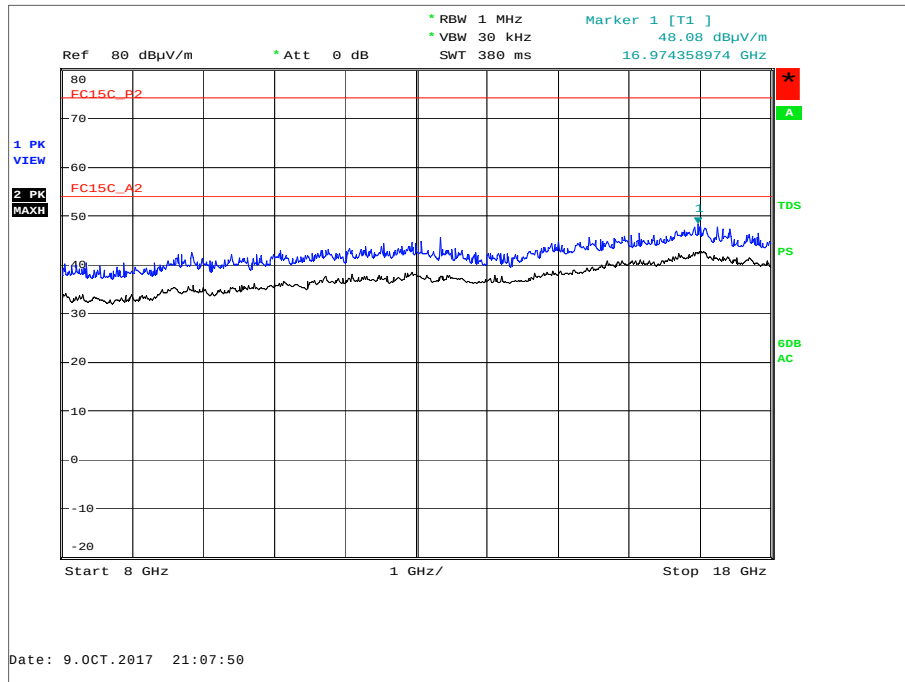


Figure 22 - 2480.5 MHz, 8 GHz to 18 GHz, Horizontal and Vertical

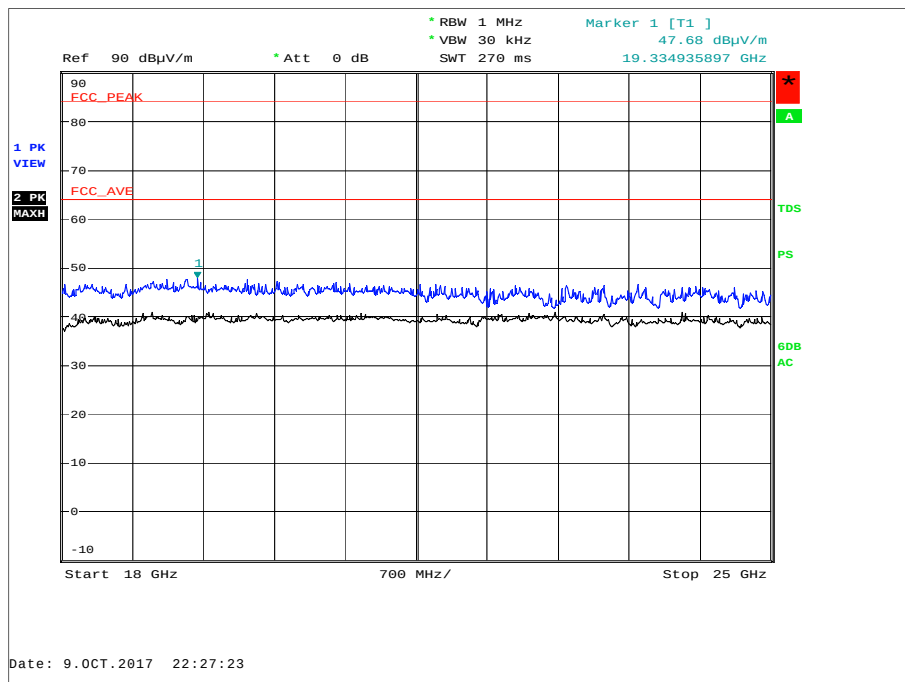


Figure 23 - 2480.5 MHz, 18 GHz to 25 GHz, Horizontal and Vertical

FCC 47 CFR Part 15. Limit Clause 15.249 (a)

Fundamental Frequency (MHz)	Field Strength of Harmonics (microvolts/meter)
902 to 928	500
2400 to 2483.5	500
5725 to 5875	500
24000 to 24250	2500

Table 18 - FCC Limit Table, 15.249

FCC 47 CFR Part 15. Limit Clause 15.249 (d) and 15.209

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in 15.209, whichever is the lesser attenuation.

Frequency (MHz)	Field Strength (microvolts/meter)
0.009 to 0.490	2400/F (kHz)
0.490 to 1.705	24000/F (kHz)
1.705 to 30.0	30
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 19 - FCC Limit Table, 15.209

2.3.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	12-Feb-2018
Antenna (Bilog)	Schaffner	CBL6143	287	24	18-Apr-2018
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
Signal Generator: 10MHz to 20GHz	Rohde & Schwarz	SMR20	3475	12	05-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	maturo GmbH	NCD	3917	-	TU
Digital thermo Hygrometer	Radio Spares	1260	4300	12	30-Aug-2018
Suspended Substrate Highpass Filter	Advance Power Components	11SH10-3000/X18000-O/O	4412	12	03-Apr-2018
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	04-Nov-2017
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	17-Feb-2018
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 20

TU - Traceability Unscheduled



3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Authorised Band Edges	Conducted: ± 3.08 dB Radiated: 30 MHz to 1 GHz: ± 5.2 dB Radiated: 1 GHz to 40 GHz: ± 6.3 dB
Field Strength of Fundamental	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Field Strength of Emissions	30 MHz to 1 GHz: ± 5.1 dB 1 GHz to 40 GHz: ± 6.3 dB

Table 21