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EMC COMPLIANCE REPORT

Certification Test Report

In accordance with:
CFR47 FCC Part 15, Subpart C, 15.247

Powerpal Pty Limited

PPL-002

Powerpal

FCC ID: 2A5SI-PPL002

REPORT: E2111-1481-4
DATE: May, 2022



Accreditation Number: 18553
Accredited for compliance with ISO/IEC 17025 - Testing

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Certificate of Compliance
Certification Compliance Report
EMC Bayswater Test Report: E2111-1481-4
Issue Date: May, 2022

Test Sample(s): Powerpal
Model No: PPL-002
Serial No: 0000d218
FCC ID: 2A5SI-PPL002

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Test Specification: CFR47 FCC Part 15, Subpart C, 15.247

Results Summary: 15.203 - Antenna requirement
15.247 (a) (2) - 6dB Bandwidth
15.247 (b)(3) - Maximum Output Power
15.247 (d) - Out-of-Band Emissions - - 100kHz, -20dBc
15.247 (d) - Emissions on the Band edge
15.247 (d), 15.209 - Radiated emissions in Restricted bands
15.247 (e) - Power Spectral Density
15.247 (i) - Radio frequency hazard

Complied
Complied
Complied
Complied
Complied
Complied
Complied

Test Date(s): 25th of March, 2022 to 7th of April, 2022

Test House
(Issued By): EMC Bayswater Pty Ltd
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FCC Accredited Test Firm Registration number: 527798
FCC Accredited Test Firm Designation number: AU0004

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This is to certify that the necessary measurements were made by EMC Bayswater Pty Ltd, and that the Powerpal Pty Limited, PPL-002, Powerpal, has been tested in accordance with requirements contained in the appropriate commission regulations..

Prepared & tested by:



Adnan Zaman
(EMC Test Engineer)

Approved by:



Neville Liyanapatabendige
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30/05/2022 16:46

Date

EMC Compliance Report for Powerpal Pty Limited

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1. Introduction

Electromagnetic Compatibility (EMC) tests were performed on a Powerpal Pty Limited, PPL-002, Powerpal in accordance with the requirements of Title 47 of the standard CFR47 FCC Part 15, Subpart C, 15.247.

2. Test Report Revision History

None

3. Report Information

EMC Bayswater Pty Ltd reports apply only to the specific samples tested under the stated test conditions. All samples tested were in good operating condition throughout the entire test program unless otherwise stated. EMC Bayswater Pty Ltd does not in any way guarantee the later performance of the product/equipment. It is the manufacturer's responsibility to ensure that additional production units of the tested model are manufactured with identical electrical and mechanical components. EMC Bayswater Pty Ltd shall have no liability for any deductions, inference or generalisations drawn by the clients or others from EMC Bayswater Pty Ltd issued reports. This report shall not be used to claim, constitute or imply product endorsement by EMC Bayswater Pty Ltd. This report shall not be reproduced except in full (with the exception of the certificate on page 2) without the written approval of EMC Bayswater Pty Ltd. This document may be altered or revised by EMC Bayswater Pty Ltd personnel only, and shall be noted in the revision section of the document. Any alteration of this document not carried out by EMC Bayswater Pty Ltd will nullify the document.

4. Summary of Results

The EUT complied with applicable requirements of CFR47 FCC Part 15, Subpart C, 15.247. Worst-case results are tabled as follows:

FCC Part 15C sections	Test	Result
15.203	Antenna Requirement	Complied ^{#1}
15.247 (a) (2)	6dB Bandwidth	Complied by 194kHz
15.247 (b)(3)	Maximum Peak Output Power	Complied by 14.7dB
15.247 (d)	Out-of-Band Emissions – 100kHz, -20dBc	Complied by at least >20dB
15.247 (d)	Emissions on the Band edge	Complied by 1.1dB ⁺
15.247 (d), 15.209	Radiated emissions in Restricted bands	Complied by 0.5dB ⁺
15.247 (e)	Power Spectral Density	Complied by 4.0dB ⁺
	Occupied Bandwidth (99% Emission Bandwidth)	1054kHz

⁺Refer to relevant section for statement of measurement uncertainty.

^{#1}The Antenna is permanently attached, internal to the device

Table 1: Summary of test results

5. Product Sample Details

5.1. EUT Description

The EUT (Equipment Under Test), as supplied by the client, is described as follows:

Product:	Powerpal	
Model No:	PPL-002	
Serial No:	0000d218	
Firmware:	1.0.0	
Software:	N/A	
Power Specifications:	3 VDC (2x1.5V AA Alkaline batteries)	
Dimensions:	80mm x 55mm x 18mm (Length x Width x Height)	
Weight:	100g	
EUT Type:	Portable, tested as table-top	
Transmitter details:	Description:	Powerpal
	Type:	Bluetooth Low Energy
	Modulation:	GFSK
	Channels:	40
	Max power:	20dBm
	Antenna:	PCB Trace
	FCC ID:	2A5SI-PPL002
	IC:	28339-PPL002
	CE mark	Yes
	RCM Logo	Yes

(Customer supplied product information)

(Refer to photographs in Annex A & B for views of the EUT)

5.2. Product description

The EUT (Equipment Under Test) has been described by the customer as follows:

“Powerpal is a home energy monitoring product.

The product logs optical pulse outputs from digital electricity meters (typically generated by a flashing LED on the face of the meter) where each pulse represents a unit of energy consumed. This data is then exposed over a wireless BLE connection for receipt by a companion mobile phone app.

The sensor end of the product is attached to the front of the electricity meter (over the optical pulse output) using adhesive brackets and is magnetically attached to the top of the meter cabinet that contains the meter being monitored.”

(Customer supplied product description information)

The highest frequency generated or used in the device or on which the device operates or tunes as specified by the customer is 2.483GHz.

5.3. Support Equipment

None

5.4. Product operating modes

“Powerpal has two operating modes, advertising where it transmits its availability for connection and peripheral mode where it is in a connection with a companion mobile device.

The product can transmit at two power modes, standard power (max transmit power 10dBm), and high power (max transmit power 20dBm). The product can be switched from standard to high power mode wirelessly based on the region in which the product is installed to ensure compliance with regional PSD requirements.”

(Customer supplied product operating mode information)

5.5. Product operating mode for testing

The product was tested in high power mode for FCC testing. The EUT transmits constantly with modulation at the lowest, middle, and highest channels.

5.6. Configuration

The EUT was either configured by the customer or configured using the customer's instructions.

The product was tested in high power mode for FCC testing. The device was connected to an external power supply as the internal battery cannot sustain extended periods of high current draw.



Figure 1: Block diagram of EUT test configuration

5.7. Modifications

EMC Bayswater Pty Ltd did not modify the EUT.

6. Test Facility & Equipment

6.1. Test Facility

Tests were performed at the indoor Open Area Test Site (iOATS) at EMC Bayswater Pty Ltd, located at 18/88 Merrindale Drive, Croydon South, Victoria, 3136, Australia.

EMC Bayswater Pty Ltd FCC Test Firm registration number is 527798.

EMC Bayswater Pty Ltd FCC Test Firm Designation number is AU0004.

6.2. Test Equipment

Refer to Appendix A for the measurement instrument list.

7. Referenced Standards

CFR47 FCC Part 15, Subpart C, 15.247

CFR47 FCC Part 15, Subpart B

ANSI C63.10 - 2013

American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

ANSI C63.4 - 2014

American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

FCC KDB - 558074 D01 15.247 Meas Guidance v05r02

8. Referenced Documents

Test Plan

Not supplied

9. Antenna Requirement – FCC Part 15.203

9.1. Requirements

As per section 15.203 of CFR47 FCC Part 15, Subpart C, 15.247:

- An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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.

9.2. Result

The EUT uses permanent, internally attached antenna which is etched into the PCB. Therefore, the EUT complied with the antenna requirements of CFR47 FCC Part 15, Subpart C, 15.247 Section 15.203.

10.6dB Bandwidth – FCC 15.247 (a) (2)

10.1.Test Procedure

The 6dB Bandwidth was performed in accordance with the section 11.8 of ANSI C63.10 - 2013.

6dB Bandwidth measurements were performed at a distance of 3m from the EUT, using the spectrum analyser. The worst-case transmitter orientation, measurement antenna height and polarization were used for each measurement. The spectrum analyser was tuned to the fundamental (transmit frequency) of the transmitter bottom, centre and top channels with 100kHz RBW and 300kHz VBW using the peak detector and a suitable span to allow accurate measurements whilst capturing the full intentional transmission including side lobes. The resultant bandwidth measurement was recorded.

(Refer to photographs in Annex C for views of the test configuration)

10.2.Limits

Applicable only to systems using digital modulation techniques:

Transmit operating frequency (MHz)	Minimum 6dB Bandwidth (kHz)
2400 – 2483.5	500

Table 2: 6dB Bandwidth

10.3.Test Results

6dB Bandwidth measurements are tabulated below:

(Refer to graphs in Appendix C.1)

Transmit operating frequency (MHz)	Measured 6dB Bandwidth (kHz)	Minimum 6dB Bandwidth (kHz)	Margin (kHz)	Comment
2402 (Bottom)	714	500	+214	Complied
2440 (Middle)	703	500	+203	Complied
2480 (Top)	694	500	+194	Complied

Table 3: Results for 6dB Bandwidth

The measurement uncertainty was calculated as follows:

Measurement Parameter	Calculated measurement uncertainty
Operating Frequency	±10.5kHz
Bandwidth	±14.96kHz

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of $k=2$ which gives a level of confidence of approximately 95%.

Climatic Conditions	
Temperature:	24°C
Humidity:	41%
Atmospheric pressure:	1021.0hPa

Table 4: Climatic conditions

Notes: The minimum required 500kHz 6dB Bandwidth requirements were satisfied by at least 194kHz.

The transmitter was continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the 6dB Bandwidth requirements of CFR47 FCC Part 15, Subpart C, 15.247 (a)(2).

11. Occupied Channel Bandwidth (99% Emission Bandwidth)

11.1. Test Procedure

The 99% emission Bandwidth was performed in accordance with the section 6.9.3 of ANSI C63.10 - 2013.

The EUT was placed on a polystyrene support at a height of 1.5m above the ground reference plane. The measuring antenna was located at a distance of 3m from the EUT, using the spectrum analyser. The transmitter was operated at its maximum carrier power. The worst-case transmitter orientation, measurement antenna polarization were used for each measurement. The spectrum analyzer centre frequency was tuned to the fundamental (transmit frequency) of the transmitter with the span of the analyzer was set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth (RBW) was set to 1% to 5% of the occupied bandwidth and video bandwidth (VBW) was set to three times the RBW.

A peak detector, maxhold function (worst case) was used to measure the occupied bandwidth, using the built-in 99% occupied bandwidth measurement function of the receiver. The resultant bandwidth measurement was recorded.

(Refer to photographs in Annex C for views of the test configuration)

11.2. Requirements

No limits are defined in CFR47 FCC Part 15, Subpart C, 15.247.

11.3. Test Results

Occupied Bandwidth measurements are tabulated below:

(Refer to graph in Appendix C.6)

Transmit Operating Frequency (MHz)	99%BW Lower Frequency (MHz)	99%BW Upper Frequency (MHz)	Occupied Channel Bandwidth (kHz)
2402 (Lowest Channel)	2401.478	2402.527	1049
2440 (Middle Channel)	2439.480	2440.530	1050
2480 (Highest Channel)	2479.475	2480.529	1054

Table 5: Occupied Bandwidth

The measurement uncertainty was calculated as follows:

Measurement Parameter	Calculated measurement uncertainty
Operating Frequency	$\pm 10.5\text{kHz}$
Bandwidth	$\pm 14.96\text{kHz}$

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of $k=2$ which gives a level of confidence of approximately 95%.

Climatic Conditions	
Temperature:	24°C
Humidity:	41%
Atmospheric pressure:	1021.0hPa

Table 6: Climatic conditions

Notes: The transmitter was tested with modulation applied.

Assessment: The measured Occupied bandwidth (99% Emission Bandwidth) is 1054 kHz (informative only).

12. Maximum Peak Output Power – FCC 15.247 (b)(3)

12.1. Test Procedure

The Maximum Peak Output Power measurements were performed in accordance with ANSI C63.10 - 2013.

Radiated Emissions were measured 3 metres away from the EUT in the iOATS (indoor Open Area Test Site) facility, which is an ANSI C63.4 compliant semi-anechoic chamber with ground plane. The EUT was placed on a non-conductive support at a height of 1.5m above the ground plane.

A Horn antenna was used and an area of 3m x 3m was covered between the antenna and the EUT using RF absorbing material with a rated attenuation more than 20dB over the frequency range.

For both horizontal and vertical antenna polarizations, the peak detector was set to MAX-HOLD and the range selected continuously scanned with 1MHz RBW and 3MHz VBW. The antenna height was varied from 1 to 4 metres using the antenna bore-sighting technique and the turntable slowly rotated. The EUT was orientated in each of the X, Y and Z-axis, in-turn, to find the worst case emissions. The maximum emissions were recorded.

Plots of the accumulated measurement data for both horizontal and vertical antenna polarizations, including all transducer and other measuring system correction factors were produced using commercially available compliant software (as listed in the test equipment list of this report)

The EUT was tested on the top, middle and bottom channels.

(Refer to photographs in Annex C for views of the test configuration)

12.2. Limits

For systems using digital modulation techniques:

Transmit operating frequency (MHz)	Peak Power (W)	Peak Power (dBm)	e.i.r.p (W)	e.i.r.p (dBm)
2400 – 2483.5	1	30	4	36

Table 7: Limits – Transmitter maximum peak output power

12.3. Test Results

The worst-case maximum output power measurements are tabulated below:

(Refer to graphs in Appendix C.2)

Channel	Frequency (MHz)	Measured E-Field Peak (dB μ V/m)	Peak Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	2402	115.736	20.5	36.0	-15.5	Complied
Middle	2440	116.175	20.9	36.0	-15.1	Complied
Top	2480	116.486	21.3	36.0	-14.7*	Complied

**Worst-case emissions*

Table 8: Results for Maximum Peak Output Power

The measurement uncertainty was calculated at ± 4.83 dB. The reported uncertainty is an expanded uncertainty calculated using a coverage factor of approximately $k=2$ which gives a level of confidence of approximately 95%.

Climatic Conditions	
Temperature:	24°C
Humidity:	43%
Atmospheric pressure:	1011.5hPa

Table 9: Climatic Conditions

Notes: The transmitter maximum output power was below the specified limit for the specified operating frequency.

The transmitter was continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the Transmitter Maximum Peak output power requirements of CFR47 FCC Part 15, Subpart C, 15.247 (b)(3).

13. Radiated emissions in Restricted bands – 15.247 (d), 15.209

13.1. Requirements

As per section 15.247(d) of 47 CFR Part 15 Subpart C:

- Radiated emissions which fall in the restricted bands, as defined in section 15.205(a) of 47 CFR Part 15 Subpart C, must also comply with the radiated emission limits specified in section 15.209(a) of 47 CFR Part 15 Subpart C (see §15.205(c) of 47 CFR Part 15 Subpart C)..

As per section 47 CFR Part 15 Subpart C section 15.209 (Radiated emissions, general requirements) the EUT is required to meet the limits that permit the highest field strength of the following table for the radiated emissions which fall in the restricted bands, as defined in section 15.205(a) of 47 CFR Part 15 Subpart C:

Frequency Range (MHz)	Limits at 3m (dB μ V/m)
0.009 to 0.490	128.5 to 93.8
0.490 to 1.705	73.8 to 62.9
1.705 to 30.0	69.5
30.0 to 88	40.0
88.0 to 216.0	43.5
216.0 to 960.0	46.0
Above 960	54.0
NOTE: The lower limit shall apply at the transition frequency.	

Note 1: as per CFR FCC Part 15 section 15.209 (d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector

Note 2: as per CFR FCC Part 15.35 (b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g., see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519 of this part, 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, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

Table 10: Limits for Radiated Spurious Emissions at distance of 3m – Restricted Bands

13.2. Test Procedure

The Radiated Emissions were performed in accordance with the section 11.12 of ANSI C63.10 - 2013.

Radiated Emissions were measured 3 metres (from 9kHz to 25GHz) away from the EUT in the iOATS (indoor Open Area Test Site) facility, which is an ANSI C63.4 compliant semi-anechoic chamber with ground plane. The EUT was placed on a non-conductive support at a height of 0.8m (9kHz to 1GHz) and 1.5m (1GHz to 25GHz) above the ground plane.

In the frequency range of 9kHz to 30MHz, an Active loop antenna was used. For X (Parallel), Y (Perpendicular) and Z (Ground-Parallel) antenna polarizations, the peak detector was set to MAX-HOLD and the range selected continuously scanned. The measuring antenna was positioned at 1m fixed height, and the turntable slowly rotated. The peak preview measurements were performed with a resolution bandwidth of 200Hz (9kHz to 150kHz), 9kHz (150kHz to 30MHz) and a video bandwidth of 30kHz. Peak emissions that exceeded the limit or were close to the applicable limit were investigated further. The frequency of each emission was then accurately determined. Each emission of interest was then in-turn maximised by using the turntable to rotate the EUT through 360 degrees to find the worst-case emission arrangement. Quasi peak measurements were then performed using a measuring time of no less than 15 seconds. The final quasi-peak measurements were performed using a receiver bandwidth of 6dB and a resolution bandwidth of 200Hz (9kHz to 150kHz) and 9kHz (150kHz to 30MHz).

In the frequency range of 30MHz to 1GHz, a Biconilog antenna was used. For both horizontal and vertical antenna polarizations, the peak detector was set to MAX-HOLD and the range selected continuously scanned. The measuring antenna was positioned at 4 different fixed height positions and the turntable slowly rotated. The peak preview measurements were performed with a resolution bandwidth of 120kHz and a video bandwidth of 300kHz. Peak emissions that exceeded the limit or were close to the applicable limit were investigated further. The frequency of each emission was then accurately determined. Each emission of interest was then in-turn maximised by using the turntable to rotate the EUT through 360 degrees and varying the height of the antenna between 1 and 4 metres to find the worst-case emission arrangement. Quasi peak measurements were then performed using a measuring time of no less than 15 seconds. The final quasi-peak measurements were performed using a receiver bandwidth of 6dB and a resolution bandwidth of 120kHz.

In the frequency range 1.0GHz to 26.5GHz a Horn antenna was used and an area of 3m x 3m was covered between the antenna and the EUT using RF absorbing material with a rated attenuation more than 20dB over the frequency range. The height of the horn antenna was varied using the antenna bore-sighting technique and the turntable slowly rotated to maximise the emissions. For both horizontal and vertical antenna polarizations, the Peak and Average preview measurements were performed with a resolution bandwidth of 1 MHz and a video bandwidth of 3MHz. Peak and average emissions that exceeded the applicable limit or were close to the applicable limit were investigated further. Each emission of interest was then in-turn maximised by using the turntable to rotate the EUT through 360 degrees and the antenna height varied (if applicable, using the antenna bore-sighting technique) to find the worst-case emission arrangement. Peak and CISPR Average measurements were then performed using a

measuring time of no less than 15 seconds, the maximum emission level in the observed duration was recorded as the final result. The final peak and CISPR Average measurements were performed using a receiver bandwidth of 6dB and a resolution bandwidth of 1 MHz. Peak and Average measurements were performed at spot frequencies where the peak or average emission was close to, or exceeded the applicable limit line with the EUT rotation and antenna height varied (if applicable, using the antenna bore-sighting technique) to produce the highest emission.

Plots of the accumulated measurement data for both horizontal and vertical antenna polarizations, including all transducer and other measuring system correction factors were produced using commercially available compliant software (as listed in the test equipment list of this report).

(Refer to photographs in Annex C for views of the test configuration)

13.3. Test Results

Transmitter Spurious Emissions measurements are detailed as follows:

(Refer to graphs in Appendix C.4)

Operating Channel: Bottom, Middle and Top				
Measurement Antenna Polarisation	Frequency (MHz)	Result peak (dB μ V/m)	Limit Quasi-peak/ Average (dB μ V/m)	Delta limit (dB)
X	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			
Y	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			
Z	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			

Table 11: Transmitter Spurious Emissions – 9kHz to 30MHz

Operating Channel: Bottom, Middle and Top				
Measurement Antenna Polarisation	Frequency (MHz)	Result Quasi-peak (dB μ V/m)	Limit Quasi-peak (dB μ V/m)	Delta limit (dB)
Horizontal	37.906	20.2	40.0	-19.8
	114.051	17.5	43.5	-26.0
	613.601	28.4	46.0	-17.6*
Vertical	73.747	12.8	40.0	-27.2
	269.784	19.4	46.0	-26.6
	406.651	22.4	46.0	-23.6

Table 12: Transmitter Spurious Emissions – 30MHz to 1GHz

Operating Channel: Bottom, (2402MHz)								
Measurement Antenna Polarisation	Peak Measurements				Average Measurements			
	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)
Horizontal	4803.600	56.0	74.0	-18.0	2224.080	39.9	54.0	-14.1
	19214.000	57.9	74.0	-16.1	2274.000	40.3	54.0	-13.7
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				2323.660	42.3	54.0	-11.7
					2337.960	40.8	54.0	-13.2
					2373.580	41.8	54.0	-12.2
					2210.040	43.2	54.0	-10.8
					2352.260	42.8	54.0	-11.2
					4803.600	44.5	54.0	-9.5
					12008.800	41.4	54.0	-12.6
					19214.000	42.7	54.0	-11.3
Vertical	4804.320	53.6	74.0	-20.4	2210.040	43.2	54.0	-10.8
	19214.000	59.0	74.0	-15.0	2274.000	41.2	54.0	-12.8
	19216.000	62.9	74.0	-11.1*	2288.300	38.1	54.0	-15.9
	19218.000	59.0	74.0	-15.0	2323.660	41.3	54.0	-12.7
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				2338.220	41.5	54.0	-12.5
					2352.260	44.2	54.0	-9.8
					2369.680	40.9	54.0	-13.1
					2494.480	39.2	54.0	-14.8
					4804.080	41.9	54.0	-12.1
					12010.240	48.0	54.0	-6.0*
					19213.600	41.8	54.0	-12.2
					19215.600	40.4	54.0	-13.6
					19217.600	42.6	54.0	-11.4

**Worst-case emissions*

Table 13: Transmitter Spurious Emissions – 1GHz to 26.5GHz

Operating Channel: Middle, (2440MHz)								
Measurement Antenna Polarisation	Peak Measurements				Average Measurements			
	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)
Horizontal	2247.740	54.9	74.0	-19.1	2219.400	38.8	54.0	-15.2
	2489.800	54.7	74.0	-19.3	2233.700	41.4	54.0	-12.6
	4879.920	58.3	74.0	-15.7	2248.000	44.2	54.0	-9.8
	7319.200	65.8	74.0	-8.2*	2262.300	40.7	54.0	-13.3
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				2276.600	37.8	54.0	-16.2
					2489.800	42.3	54.0	-11.7
					4879.920	48.1	54.0	-5.9
					7319.440	51.4	54.0	-2.6**
					12198.880	39.6	54.0	-14.4
					19520.000	38.9	54.0	-15.1
Vertical	2489.800	55.4	74.0	-18.6	2233.700	40.4	54.0	-13.6
	4879.680	56.1	74.0	-17.9	2248.000	42.1	54.0	-11.9
	7320.160	64.3	74.0	-9.7	2262.040	39.1	54.0	-14.9
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				2297.920	38.3	54.0	-15.7
					2361.880	40.8	54.0	-13.2
					2375.920	42.6	54.0	-11.4
					2489.800	44.6	54.0	-9.4
					4879.920	43.3	54.0	-10.7
					7320.160	48.1	54.0	-5.9
					12198.880	41.3	54.0	-12.7
					19522.000	39.8	54.0	-14.2

*Worst-case emission, *Refer to measurement uncertainty statement

Table 14: Transmitter Spurious Emissions – 1GHz to 26.5GHz

Operating Channel: Middle, (2480MHz)								
Measurement Antenna Polarisation	Peak Measurements				Average Measurements			
	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)
Horizontal	2288.040	54.9	74.0	-19.1	2273.740	43.6	54.0	-10.4
	4959.600	61.6	74.0	-12.4	2288.040	44.5	54.0	-9.5
	7439.200	60.0	74.0	-14.0	2337.700	41.0	54.0	-13.0
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				2486.420	40.8	54.0	-13.2
					4959.840	49.2	54.0	-4.8 ⁺
					7440.640	46.3	54.0	-7.7
					12399.040	40.8	54.0	-13.2
					19840.000	38.7	54.0	-15.3
Vertical	4960.080	60.8	74.0	-13.2	2288.040	40.4	54.0	-13.6
	7439.440	66.4	74.0	-7.6 [*]	2485.640	41.8	54.0	-12.2
	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				4960.080	48.2	54.0	-5.8
					7439.200	53.5	54.0	-0.5 ^{**}
					12399.040	41.3	54.0	-12.7
					19838.000	41.4	54.0	-12.6

**Worst-case emissions, *Refer to measurement uncertainty statement*

Table 15: Transmitter Spurious Emissions – 1GHz to 26.5GHz

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
30MHz to 1GHz	±4.65dB
1GHz to 6GHz	±4.83dB
6GHz to 18GHz	±4.49dB
18GHz to 26.5GHz	±4.46dB

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of $k=2$ which gives a level of confidence of approximately 95%.

Climatic Conditions	
Temperature:	19.2 to 24°C
Humidity:	41 to 55%
Atmospheric pressure:	1016.0 to 1024.0hPa

Table 16: Climatic conditions

Calculation: The above results are based upon the following calculation:

$$E = V_{QP/PK/AV} + AF - G_{Amp} + L_C$$

Where:

$$\begin{aligned} E &= \text{E-field in dB}\mu\text{V/m} \\ V_{QP/PK/A} &= \text{Measured Voltage (Quasi Peak, Peak or Average) in dB}\mu\text{V} \\ AF &= \text{Antenna Factor in dB(/m)} \\ L_C &= \text{Cable and attenuator Loss in dB} \\ G_{Amp} &= \text{Pre Amplifier Voltage Gain in dB} \end{aligned}$$

Example calculation:

$$\begin{aligned} E &= V_{PK} + AF - G_{Amp} + L_C \\ E &= 30\text{dB}\mu\text{V} + 12\text{dB/m} - 0\text{dB} + 2.3\text{dB} \\ E &= 44.3 \text{ dB}\mu\text{V/m} \end{aligned}$$

Notes: All Transmitter Radiated spurious emissions in restricted bands measurements were below the specified limits.

Radiated Emissions measurements were made up to the 10th harmonic.

The transmitter was continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the Radiated emissions in Restricted bands requirements of CFR47 FCC Part 15, Subpart C, 15.247 (d).

14. Out of Band emissions (100kHz, -20dBc) - FCC 15.247 (d)

14.1. Test Procedure

The Out of band emissions in non-restricted bands were performed in accordance with the section 11.11 of ANSI C63.10 – 2013.

Radiated Emissions were measured 3 metres (from 30MHz to 25GHz) away from the EUT in the iOATS (indoor Open Area Test Site) facility, which is an ANSI C63.4 compliant semi-anechoic chamber with ground plane. The EUT was placed on a non-conductive support at a height of 0.8m above the ground plane.

Reference and emission level measurements were performed as per section 11.11.2 and 11.11.3 of ANSI C63.10 - 2013.

In the frequency range of 30MHz to 1GHz, a Biconilog antenna was used. For both horizontal and vertical antenna polarizations, the peak detector was set to MAX-HOLD and the range selected continuously scanned. The measuring antenna was positioned at 4 different fixed height positions and the turntable slowly rotated. The peak preview measurements were performed with a resolution bandwidth of 100 kHz and a video bandwidth of 300 kHz. Peak emissions that exceeded the limit or were close to the applicable limit were investigated further. The frequency of each emissions was then accurately determined. Each emission of interest was then in-turn maximised by using the turntable to rotate the EUT through 360 degrees and varying the height of the antenna between 1 and 4 metres to find the worst-case emission arrangement. Peak measurements were then performed using a measuring time of no less than 15 seconds.

In the frequency range 1.0GHz to 26.5GHz a Horn antenna was used and an area of 3m x 3m was covered between the antenna and the EUT using RF absorbing material with a rated attenuation more than 20dB over the frequency range. The height of the horn antenna was varied using the antenna bore-sighting technique and the turntable slowly rotated to maximise the emissions. For both horizontal and vertical antenna polarizations, the Peak preview measurements were performed with a resolution bandwidth of 100 Hz and a video bandwidth of 300 kHz. Peak emissions that exceeded the applicable limit or were close to the applicable limit were investigated further. Each emission of interest was then in-turn maximised by using the turntable to rotate the EUT through 360 degrees and the antenna height varied (if applicable, using the antenna bore-sighting technique) to find the worst-case emission arrangement. Peak measurements were then performed using a measuring time of no less than 15 seconds, the maximum emission level in the observed duration was recorded as the final result.

Plots of the accumulated measurement data for both horizontal and vertical antenna polarizations, including all transducer and other measuring system correction factors were produced using commercially available compliant software (as listed in the test equipment list of this report).

(Refer to photographs in Annex C for views of the test configuration)

14.2.Limits

As per section 15.247(d) of 47 CFR Part 15 Subpart C:

- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of section 15.247 of 47 CFR Part 15 Subpart C, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section 15.209(a) of 47 CFR Part 15 Subpart C is not required. In addition, radiated emissions which fall in the restricted bands, as defined in section 15.205(a) of 47 CFR Part 15 Subpart C, must also comply with the radiated emission limits specified in section 15.209(a) of 47 CFR Part 15 Subpart C (see §15.205(c) of 47 CFR Part 15 Subpart C).

The measured highest fundamental channel PSD in 100kHz was +19.4dBm

Frequency Range (MHz)	Limits (dBm)
30MHz and 26.5GHz	-0.6

Table 17: Limits for Unwanted Emissions - -20dBc (Non-restricted bands)

14.3.Test Results

Unwanted emissions measurements are detailed as follows:

(Refer to graphs in Appendix C.4)

Channel	Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Delta limit (dB)
Bottom	Peak emissions >20dB below limit or no significant emissions above the noise floor observed			
Middle	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			
Top	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			

Table 18: Transmitter Out of Band emissions - -20dBc/100kHz

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
30MHz to 1GHz	±4.65dB
1GHz to 6GHz	±4.83dB
6GHz to 18GHz	±4.49dB
18GHz to 26.5GHz	±4.46dB
26.5GHz to 30GHz	±4.44dB

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of $k=2$ which gives a level of confidence of approximately 95%. The referenced uncertainty standard specifies that determination of compliance shall be based on measurements without taking into account measurement uncertainty. However, the measurement uncertainty shall appear in the test report.

Notes: All Transmitter Out of Band emissions measurements were below the specified limits (-20dBc).

Radiated measurements were made up to the 10th harmonic.

The transmitter was continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the Out of Band emissions (100kHz, -20dBc) requirements of CFR47 FCC Part 15, Subpart C, 15.247 (d).

15. Emissions on the Band edge – FCC 15.247 (d)

15.1. Test Procedure

The Band edge Measurement (100kHz, -20dB from fc & Restricted bands) was performed in accordance with the section 11.11, 11.12 and 11.13 of ANSI C63.10 – 2013.

Radiated measurements were performed within 2 MHz of the authorised band-edge.

At the lowest channel, 99% Occupied Band Width of the fundamental channel emission was within 2 MHz of the authorised Lower band edge therefore Marker-delta method was used. Unwanted emission at the lower band-edge were performed as per section 6.10.4 of ANSI C63.10 - 2013. At authorised-band band edge where the requiring band-edge emission attenuation is -20dB in a 100kHz bandwidth relative to the highest fundamental channel PSD in 100kHz. Radiated peak measurements were performed as per as section 6.10.4 of ANSI C63.10 - 2013.

The higher end of the authorised band-edge was in restricted-band therefore measurements were performed as per section 6.10.5 of ANSI C63.10 - 2013. The RSS-Gen general field strength limits are applicable to emission in restricted-band band-edge.

For highest channel, 99% Occupied bandwidth of the fundamental channel emission was not within 2MHz of the authorised High band edge (2483.5MHz).

(Refer to photographs in Annex C for views of the test configuration)

15.2. Limits

Band edge in Non-restricted Bands

As per CFR47 FCC Part 15, Subpart C, 15.247 (d) the EUT shall meet the requirements that in any given 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

The measured highest fundamental channel PSD in 100kHz was +19.4dBm

Band edge Frequencies	Limits (dBm)
Lower Edge (2402MHz)	-0.6

Table 19: Limits for Band edge - -20dBc (Non-restricted bands)

Band edge in Restricted Bands

As per CFR47 FCC Part 15, Subpart C, 15.247 (d) and 15.209 (Transmitter emission limits) the EUT is required to meet the limits that permit the highest field strength of the

following table for the radiated emissions which fall in the restricted bands, as defined in section 15.205(a) of 47 CFR Part 15 Subpart C :

Band edge Frequencies	Limits at 3m (dB μ V/m)	
	Peak	Average
2483.5MHz to 2485.5	74.0	54.0

Table 20: Limits for Radiated Spurious Emissions at distance of 3m – Restricted Bands.

15.3.Test Results

Band edge measurements are detailed as follows:

(Refer to graphs in Appendix C.3)

Operating Channel: Bottom (2402MHz)				
Measurement Antenna Polarisation	Frequency (MHz)	Result Radiated Peak Power Spectral Density (dBm/100kHz)	Limit Radiated Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
Horizontal	2399.543	-32.0	-0.6	-31.4
	2399.983	-29.2	-0.6	-28.6
Vertical	2399.534	-30.2	-0.6	-29.6
	2399.968	-27.0	-0.6	-26.4*

**Worst-case emissions*

Table 21: Transmitter Emissions on the Band edge - Low end

Operating Channel: Top (2480MHz)								
Measurement Antenna Polarisation	Peak Measurements				Average Measurements			
	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)	Frequency (MHz)	Result (dB μ V/m)	Limit (dB μ V/m)	Delta Limit (dB)
Horizontal	2484.080	68.5	74.0	-5.5	2483.560	45.1	54.0	-8.9
	2484.600	64.9	74.0	-9.1	2484.080	43.8	54.0	-10.2
	2485.120	61.8	74.0	-12.2	2484.600	42.7	54.0	-11.3
					2485.120	42.1	54.0	-11.9
Vertical	2483.560	72.9	74.0	-1.1*	2483.560	46.1	54.0	-7.9*
	2483.820	71.4	74.0	-2.6	2483.820	45.4	54.0	-8.6
	2484.600	65.9	74.0	-8.1	2484.340	44.1	54.0	-9.9
					2485.120	42.7	54.0	-11.3

**Worst-case emissions*

Table 22: Transmitter Emissions on the Band edge - High end

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
Radiated (1GHz to 6GHz)	± 4.83 dB

The reported uncertainty is an expanded uncertainty calculated using a coverage factor of $k=2$ which gives a level of confidence of approximately 95%.

Climatic Conditions	
Temperature:	24°C
Humidity:	41%
Atmospheric pressure:	1021.0hPa

Table 23: Climatic conditions

Calculation: The above results are based upon the following calculation:

$$E = V_{QP/PK/AV} + AF - G_{Amp} + L_C$$

Where:

$$E = \text{E-field in dB}\mu\text{V/m}$$

$$V_{QP/PK/AV} = \text{Measured Voltage (Quasi Peak, Peak or Average) in dB}\mu\text{V}$$

$$AF = \text{Antenna Factor in dB/(m)}$$

$$L_C = \text{Cable and attenuator Loss in dB}$$

$$G_{Amp} = \text{Pre Amplifier Voltage Gain in dB}$$

Example calculation:

$$E = V_{PK} + AF - G_{Amp} + L_C$$

$$E = 30\text{dB}\mu\text{V} + 12\text{dB/m} - 0\text{dB} + 2.3\text{dB}$$

$$E = 44.3 \text{ dB}\mu\text{V/m}$$

Notes: All Band edge measurements were below the specified limits.

The transmitter was continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the Transmitter Emissions on the Band edge requirements of CFR47 FCC Part 15, Subpart C, 15.247 (d).

16. Power Spectral Density – FCC 15.247 (e)

16.1. Test Procedure

The Power Spectral Density was performed in accordance with the section 11.10 of ANSI C63.10 - 2013.

The radiated peak power spectral density was measured 3 metres away from the EUT in the iOATS (indoor Open Area Test Site) facility, which is an ANSI C63.4 compliant semi-anechoic chamber with ground plane.

The EUT was placed on a polystyrene support at a height of 1.5m above the ground plane. For both horizontal and vertical antenna polarizations, peak detector was set to MAX-HOLD and the range selected continuously scanned. The antenna height was varied from 1 to 4 metres using the antenna bore-sighting technique and the turntable slowly rotated with X, Y and Z EUT orientations, in order to find the worst-case emission arrangement.

A 3m x 3m ground plane area (between antenna and the EUT) was covered using RF absorbing material (rated attenuation more than 20dB).

The EUT was tested on the lowest, middle and highest channels measured using a spectrum analyser with 3kHz RBW and 30kHz VBW using the peak detector and a suitable span to allow accurate measurement whilst capturing the full intentional transmission. The maximum emissions were recorded.

Plots of the accumulated measurement data including all transducer correction factors were produced using commercially available compliant software (as listed in the test equipment list of this report).

(Refer to photographs in Annex C for views of the test configuration)

16.2. Limits

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of CFR47 FCC Part 15, Subpart C, 15.247 (e). The same method of determining the conducted output power shall be used to determine the power spectral density.

Applicable only to systems using digital modulation techniques:

Transmit operating frequency (MHz)	Limit
2400 – 2483.5	8dBm/3kHz

Table 24: Power Spectral Density limits

16.3. Test Results

Power Spectral Density measurements are tabulated below:

(Refer to graphs in Appendix C.5)

Channel	Frequency (MHz)	Measured Power (dBm)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	2401.896	3.8	8.00	-4.2	Complied
Middle	2439.980	4.0	8.00	-4.0*	Complied
Top	2479.895	3.7	8.00	-4.3	Complied

Table 25: Results for Power Spectral Density

The measurement uncertainty was calculated at $\pm 4.83\text{dB}$. The reported uncertainty is an expanded uncertainty calculated using a coverage factor of approximately $k=2$ which gives a level of confidence of approximately 95%. The referenced uncertainty standard specifies that determination of compliance shall be based on measurements without taking into account measurement uncertainty. However, the measurement uncertainty shall appear in the test report.

Climatic Conditions	
Temperature:	24°C
Humidity:	41%
Atmospheric pressure:	1021.0hPa

Table 26: Climatic conditions

Notes: All Power Spectral Density measurements were below the specified limits.

The transmitter was supplied by the customer to be continuously transmitting in modulated transmit mode.

Assessment: The EUT complied with the Power Spectral Density requirements of CFR47 FCC Part 15, Subpart C, 15.247 (e).

17. Conclusion

The Powerpal Pty Limited, PPL-002, Powerpal complied with the applicable requirements of CFR47 FCC Part 15, Subpart C, 15.247.

Appendix A – Test Equipment

Inv.	Equipment	Make	Model No.	Serial No.	Calibration		
					Interval	Due	Type
Transmitter Maximum EIRP, Power Spectral Density, 6dB Bandwidth and Band-edge							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	May-22*	E
0633	ANTENNA, Double Ridge Horn	EMCO	3115	9712-5369	3 years	Aug-24	I
0559	PRE-AMP, Microwave, 18GHz	Miteq	AFS8	605305	1 year	Apr-23	I
0932	CONTROLLER, Position	Sunol Sciences	SC104V-3	081006-1	N/A	N/A	V
0933	TURNTABLE	Sunol Sciences	SM46C	081006-2	N/A	N/A	V
0934	MAST, Antenna	Sunol Sciences	TLT2	081006-5	N/A	N/A	V
1143	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84287041	SN MY058/4PA	1 year	Jan-23	I
1145	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84279564	SN MY056/4PA	1 year	Jan-23	I
1238	CABLE, Coax, Sucoflex 126 E	Huber + Suhner	10422876	SN 8000495/126E	1 year	Jan-23	I
0715	ATTENUATOR, 20dB	JFW	50HF-020N	-	3 years	Dec-24	I
1155	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-23	I
0666	Enclosure, Semi-Anechoic, No 1	RFI Industries	S800 iOATS	1229	2.5 years	Jul-22	I
SW007	EMC Measurement Software	Rohde & Schwarz	EMC 32	Version 8.53.0	N/A	N/A	N/A
Transmitter Spurious Emissions							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	May-22*	E
0935	ANTENNA, Biconilog	Sunol Sciences	JB5	A071106	2 years	Feb-23	E
0718	ATTENUATOR, 6dB	JFW	50FPE-006	-	3 years	Jan-23	I
0633	ANTENNA, Double Ridge Horn	EMCO	3115	9712-5369	3 years	Aug-24	I
0559	PRE-AMP, Microwave, 18GHz	Miteq	AFS8	605305	1 year	Apr-23	I
1193	Standard Gain Horn Antenna - 5.85GHz to 8.2GHz	A.H. Systems, inc	SAS-584	186	1 year	May-23	E
1194	Standard Gain Horn Antenna - 8.2GHz to 12.4GHz	A.H. Systems, inc	SAS-585	224	1 year	May-23	E
1195	Standard Gain Horn Antenna - 12.4GHz to 18.0GHz	A.H. Systems, inc	SAS-586	195	1 year	May-23	E
1196	Standard Gain Horn Antenna - 18.0GHz to 26.5GHz	A.H. Systems, inc	SAS-587	181	1 year	Apr-23	E
0932	CONTROLLER, Position	Sunol Sciences	SC104V-3	081006-1	N/A	N/A	V
0933	TURNTABLE	Sunol Sciences	SM46C	081006-2	N/A	N/A	V
0934	MAST, Antenna	Sunol Sciences	TLT2	081006-5	N/A	N/A	V
1143	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84287041	SN MY058/4PA	1 year	Jan-23	I
1145	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84279564	SN MY056/4PA	1 year	Jan-23	I
1238	CABLE, Coax, Sucoflex 126 E	Huber + Suhner	10422876	SN 8000495/126E	1 year	Jan-23	I
0711	ATTENUATOR, 10dB	JFW	50HF-010N	-	3 years	Dec-24	I
0715	ATTENUATOR, 20dB	JFW	50HF-020N	-	3 years	Dec-24	I
1157	High Pass filter	Microwave Circuits	H3G213G1	476071	2 years	Aug-22	I
1155	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-23	I
0666	Enclosure, Semi-Anechoic, No 1	RFI Industries	S800 iOATS	1229	2.5 years	Jul-22	I
SW007	EMC Measurement Software	Rohde & Schwarz	EMC 32	Version 8.53.0	N/A	N/A	N/A

V: Verification of operation against an internal reference

I: Internal calibration against a traceable standard

E: External calibration by a NATA or MRA equivalent endorsed facility

N/A: Not Applicable

** Calibration current at the time of testing*

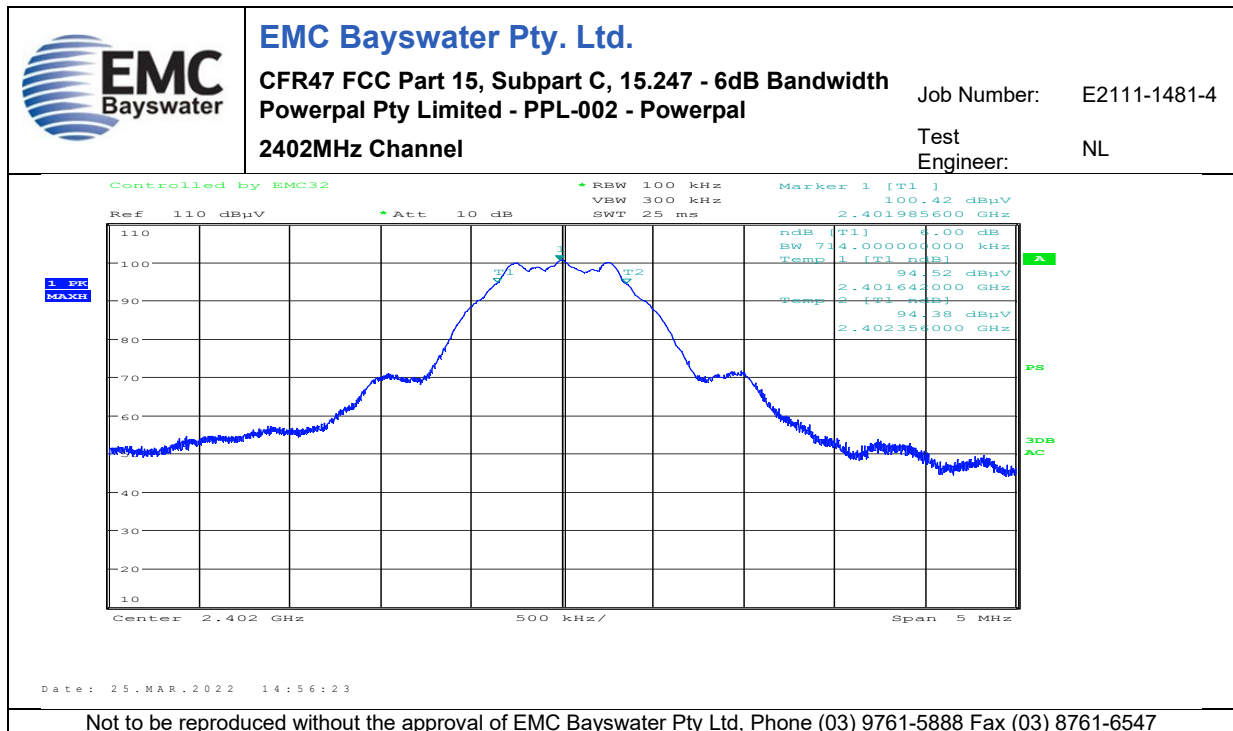
Appendix B – Photographs

Annex	Number	Photograph Description
A	1	EUT – External views
A	2	
A	3	
A	4	
A	5	
A	6	
A	7	
A	8	
A	9	EUT – View of sample with temporary DC power supply connection – Radiated method testing
B	1	EUT – Internal views
B	2	
B	3	
B	4	EUT – View of sample with temporary DC power supply connector – Radiated method testing
B	5	
B	6	
B	7	
B	8	
B	9	
B	10	EUT – View of the PCB trace antenna
C	1	Radiated measurements – EUT X Orientation
C	2	Radiated measurements – EUT Y Orientation
C	3	Radiated measurements – EUT Z Orientation
C	4	Radiated measurements – 9kHz to 30MHz – X Antenna orientation
C	5	Radiated measurements – 9kHz to 30MHz – Y Antenna orientation
C	6	Radiated measurements – 9kHz to 30MHz – Z Antenna orientation
C	7	Radiated measurements – below 1GHz
C	8	Radiated measurements – above 1GHz

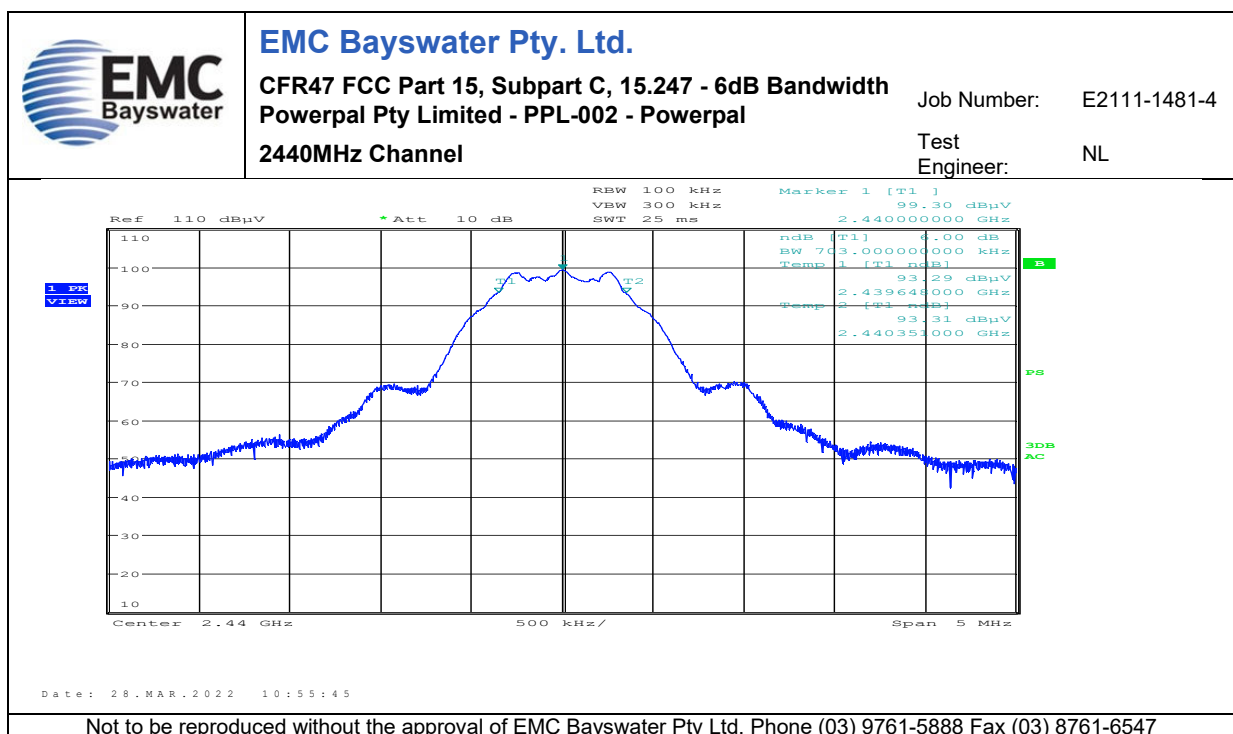
EUT External Photographs	EMC Bayswater Test Report E2111-1481-4 Annex A
EUT Internal Photographs	EMC Bayswater Test Report E2111-1481-4 Annex B
EUT Orientations & Test Configurations Photographs	EMC Bayswater Test Report E2111-1481-4 Annex C

Appendix C.1 – Measurement Graphs – 6dB Bandwidth - 15.247 (a) (2)

No.	Test	Graph Description
1	6dB Bandwidth	2402MHz Channel
2		2440MHz Channel
3		2480MHz Channel



Graph 1



Graph 2

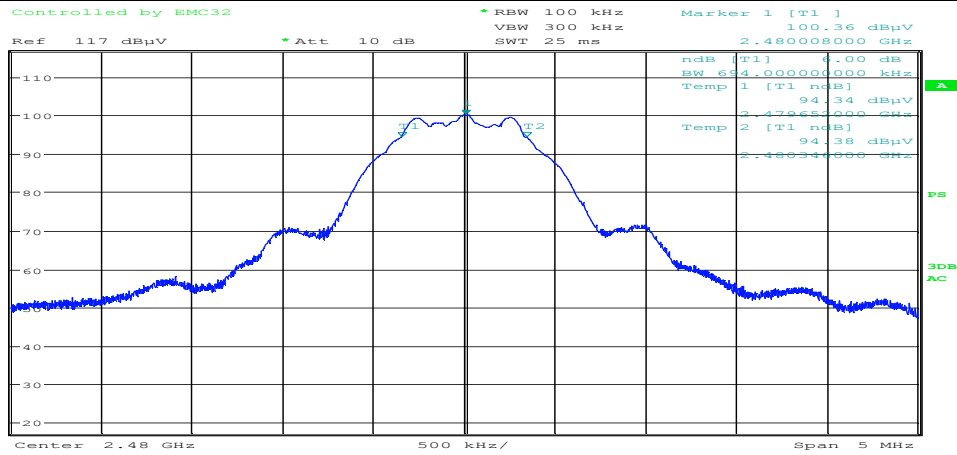


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - 6dB Bandwidth
Powerpal Pty Limited - PPL-002 - Powerpal
2480MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL



Date: 28.MAR.2022 15:52:27

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Graph 3

**Appendix C.2 – Measurement Graphs – Maximum Peak Output Power - 15.247
(b)(3)**

No.	Test	Graph Description
4	Maximum Peak Output Power	2402MHz Channel
5		2440MHz Channel
6		2480MHz Channel

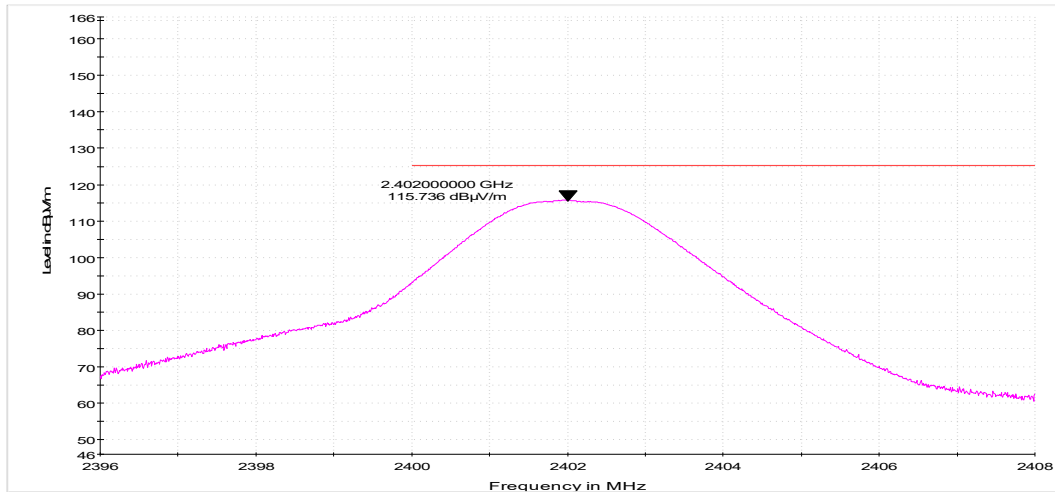


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Maximum
Peak Output Power
Powerpal Pty Limited - PPL-002 - Powerpal
2402MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL



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Graph 4

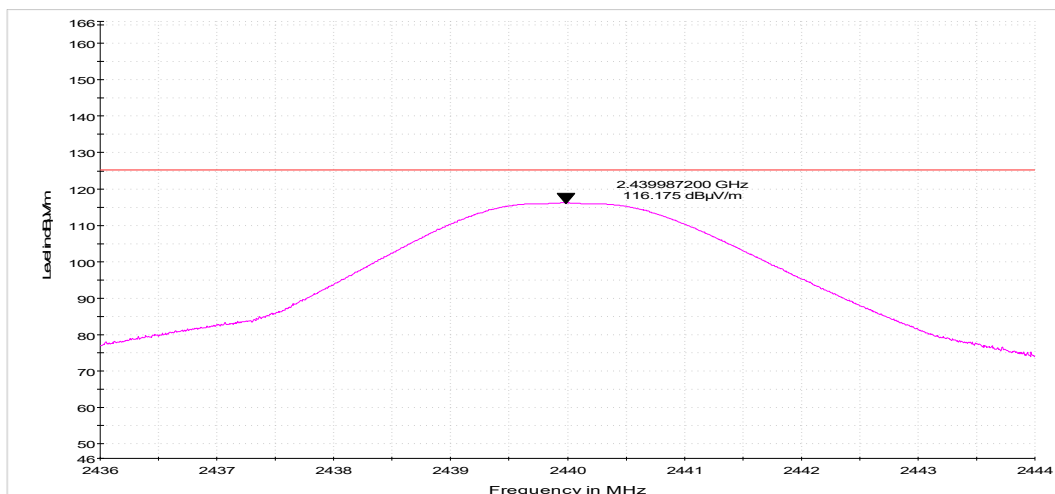


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Maximum
Peak Output Power
Powerpal Pty Limited - PPL-002 - Powerpal
2440MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL



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Graph 5

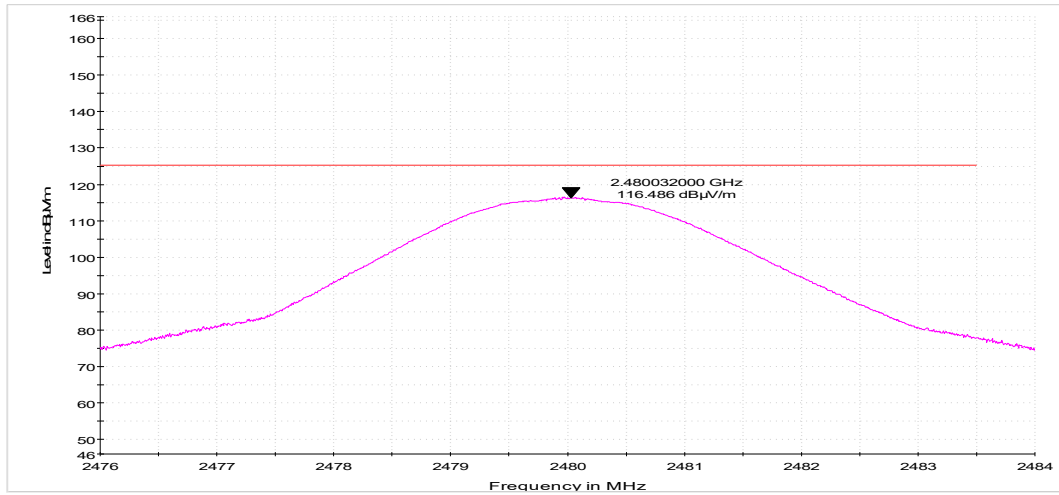


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Maximum
Peak Output Power
Powerpal Pty Limited - PPL-002 - Powerpal
2480MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL

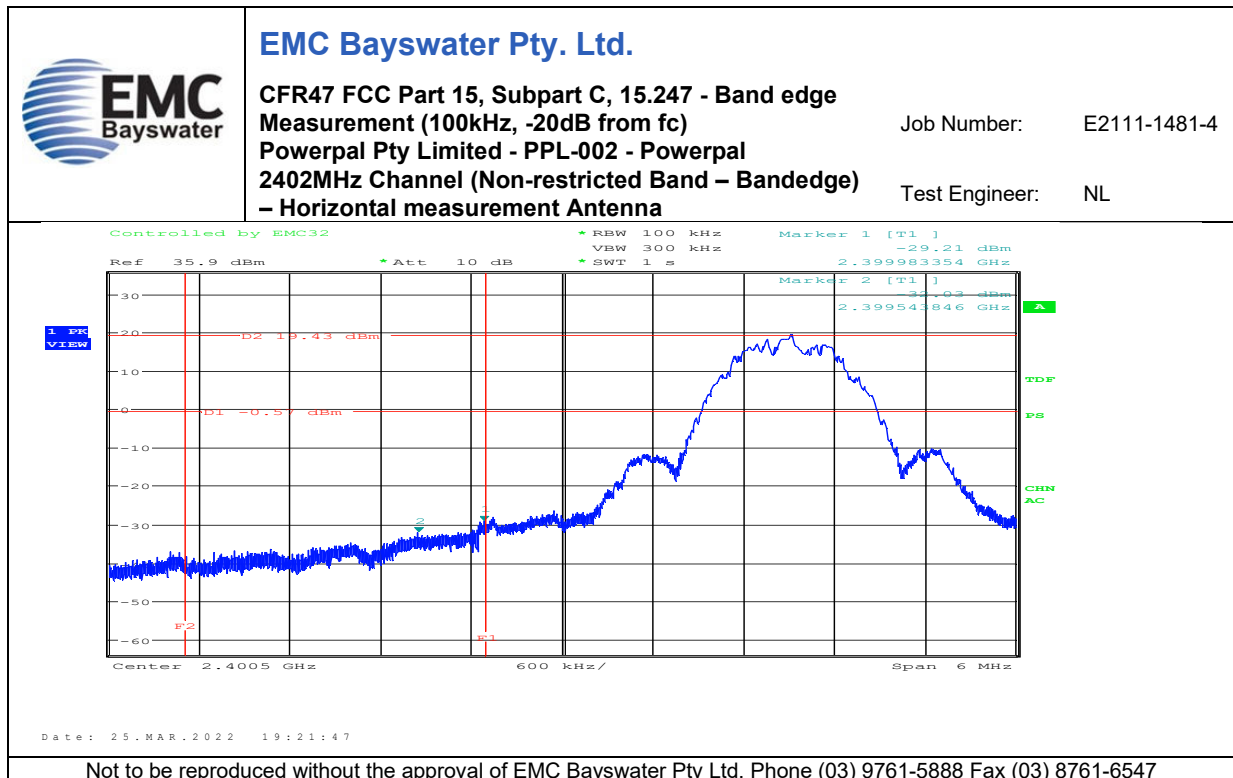


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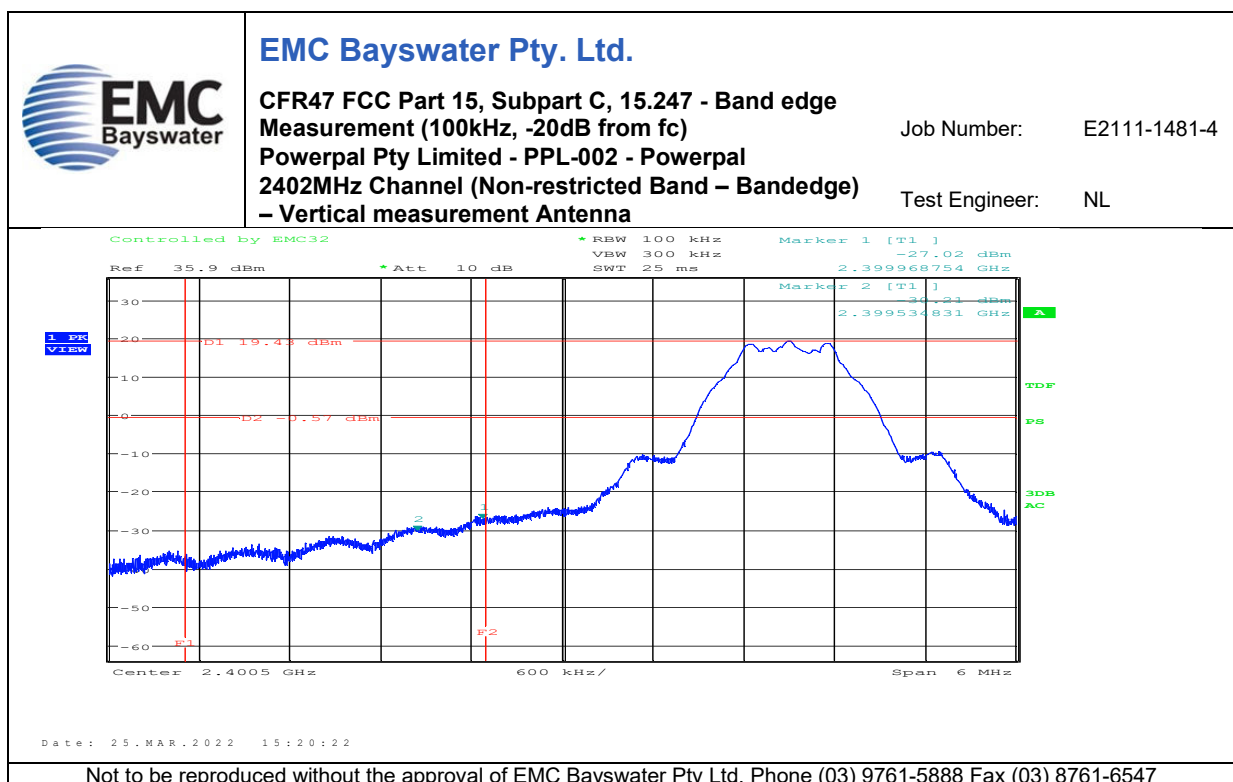
Graph 6

Appendix C.3 – Measurement Graphs – Band Edge - 15.247 (d)

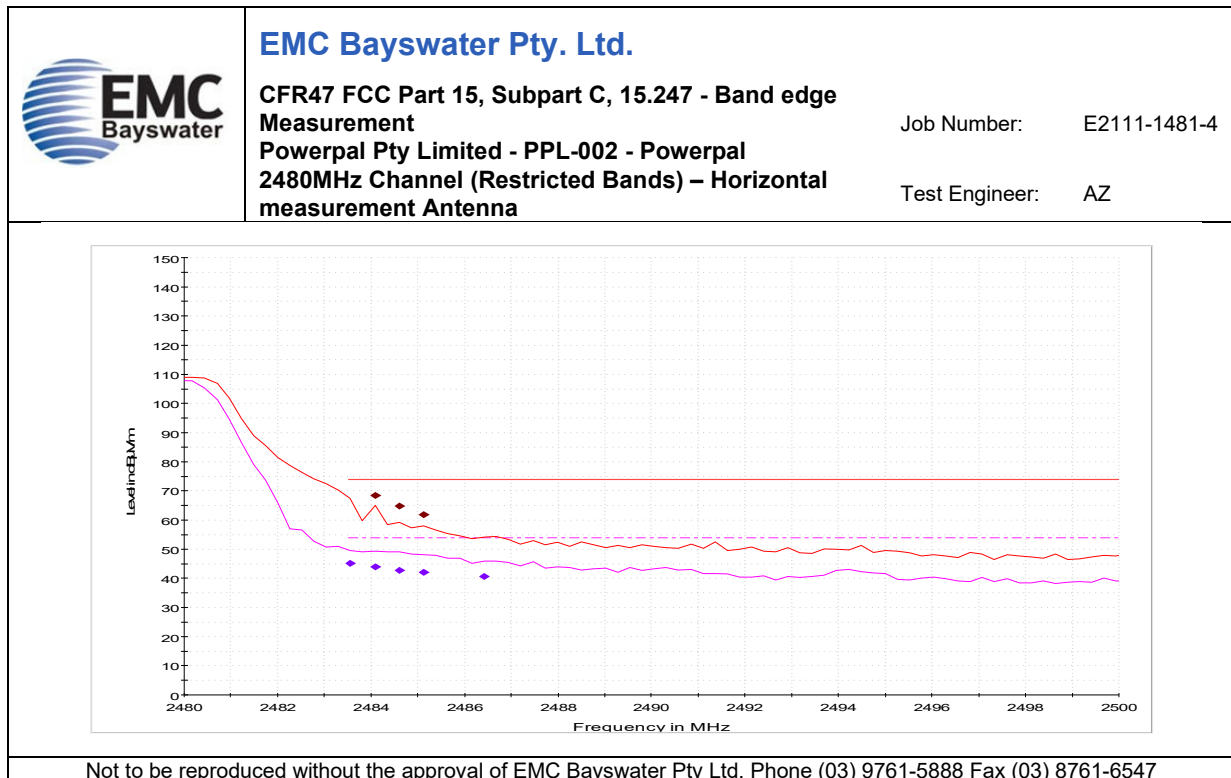
No.	Test	Graph Description
7	Band edge Measurement	2402MHz Channel (Non-restricted Band – Bandedge) – Horizontal measurement Antenna
8		2402MHz Channel (Non-restricted Band – Bandedge) – Vertical measurement Antenna
9	Band edge Measurement	2480MHz Channel (Restricted Bands) – Horizontal measurement Antenna
10		2480MHz Channel (Restricted Bands) – Vertical measurement Antenna



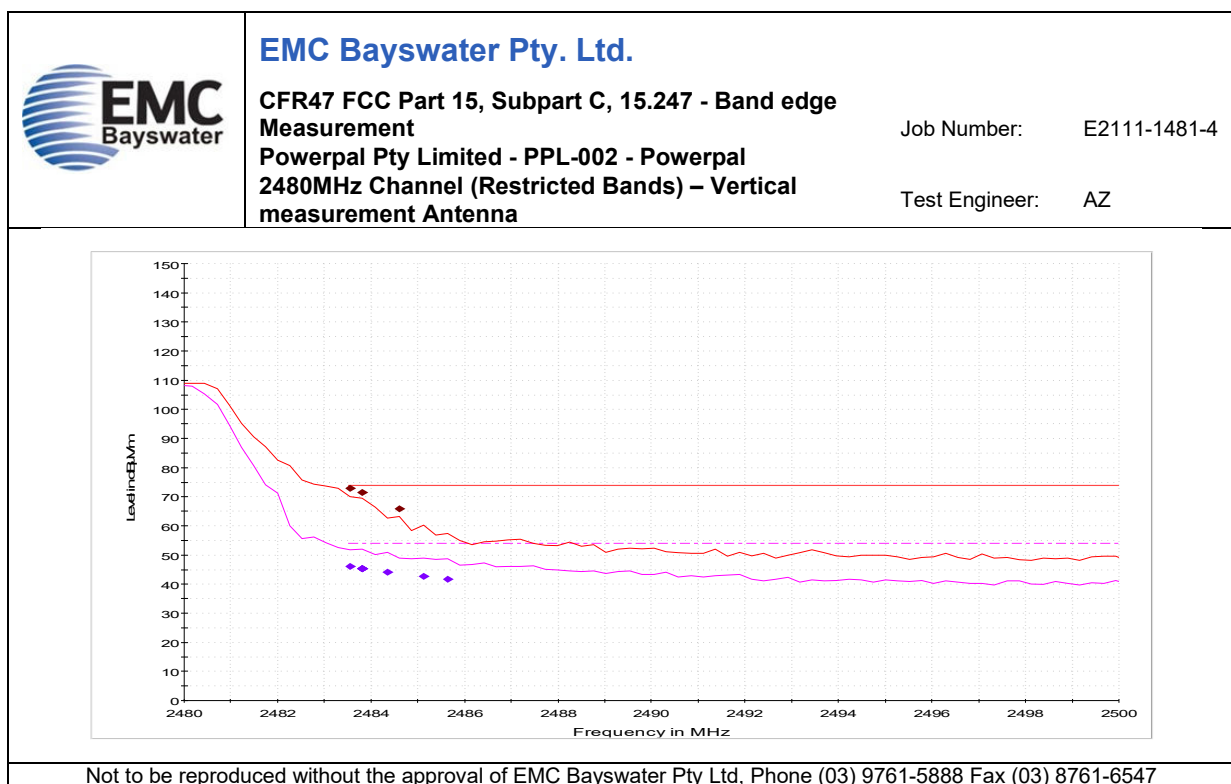
Graph 7



Graph 8



Graph 9

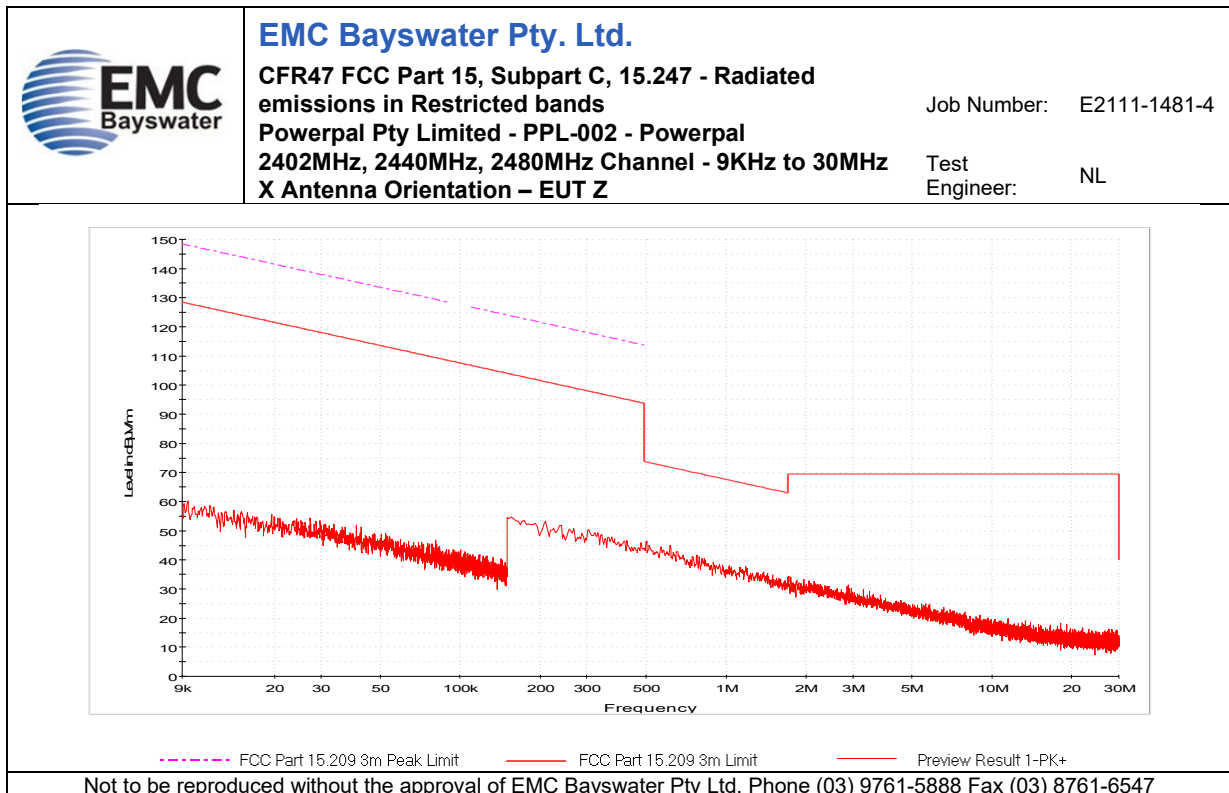


Graph 10

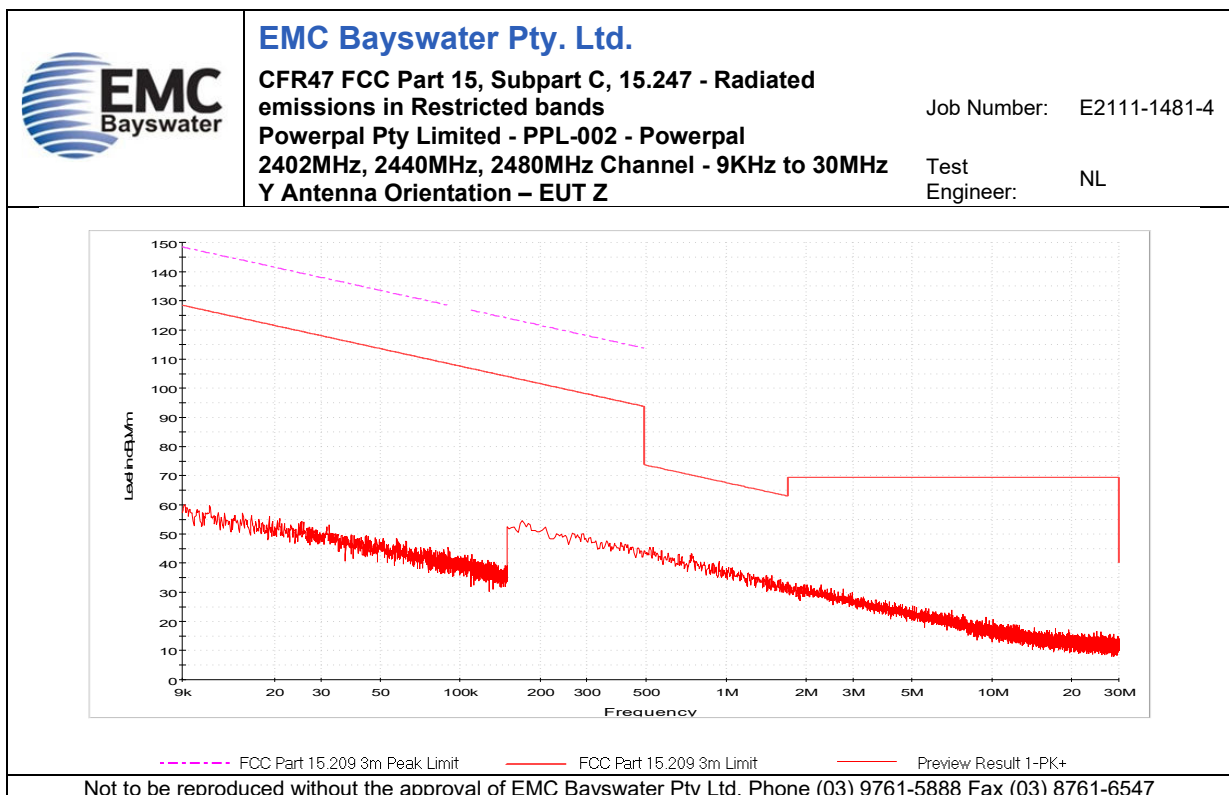
Appendix C.4 – Measurement Graphs – Transmitter Spurious – FCC 15.247 (d), 15.209

No.	Test	Graph Description
11	9kHz to 30MHz EUT Z, Antenna X	2402MHz, 2440MHz, 2480MHz Channels – Restricted Bands
12	9kHz to 30MHz EUT Z, Antenna Y	2402MHz, 2440MHz, 2480MHz Channels – Restricted Bands
13	9kHz to 30MHz EUT Z, Antenna Z	2402MHz, 2440MHz, 2480MHz Channels – Restricted Bands
14	30MHz to 1GHz EUT Y, Antenna Horizontal	2402MHz, 2440MHz, 2480MHz Channels – Restricted and Non-Restricted Bands
15	30MHz to 1GHz EUT Z, Antenna Vertical	2402MHz, 2440MHz, 2480MHz Channels – Restricted and Non-Restricted Bands
16	1GHz to 3.6GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
17		2402MHz Channel, EUT Z, Antenna Vertical
18		2440MHz Channel, EUT Y, Antenna Horizontal
19		2440MHz Channel, EUT Z, Antenna Vertical
20		2480MHz Channel, EUT Y, Antenna Horizontal
21		2480MHz Channel, EUT Z, Antenna Vertical
22	3.6GHz to 6GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
23		2402MHz Channel, EUT Z, Antenna Vertical
24		2440MHz Channel, EUT Y, Antenna Horizontal
25		2440MHz Channel, EUT Z, Antenna Vertical
26		2480MHz Channel, EUT Y, Antenna Horizontal
27		2480MHz Channel, EUT Z, Antenna Vertical
28	1GHz to 6GHz Non-Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
29		2402MHz Channel, EUT Z, Antenna Vertical
30		2440MHz Channel, EUT Y, Antenna Horizontal
31		2440MHz Channel, EUT Z, Antenna Vertical
32		2480MHz Channel, EUT Y, Antenna Horizontal
33		2480MHz Channel, EUT Z, Antenna Vertical
34	5.8GHz to 8.2GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
35		2402MHz Channel, EUT Z, Antenna Vertical
36		2440MHz Channel, EUT Y, Antenna Horizontal
37		2440MHz Channel, EUT Z, Antenna Vertical
38		2480MHz Channel, EUT Y, Antenna Horizontal
39		2480MHz Channel, EUT Z, Antenna Vertical
40	5.8GHz to 8.2GHz Non-Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
41		2402MHz Channel, EUT Z, Antenna Vertical
42		2440MHz Channel, EUT Y, Antenna Horizontal
43		2440MHz Channel, EUT Z, Antenna Vertical
44		2480MHz Channel, EUT Y, Antenna Horizontal
45		2480MHz Channel, EUT Z, Antenna Vertical
46	8.2GHz to 12.4GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
47		2402MHz Channel, EUT Z, Antenna Vertical
48		2440MHz Channel, EUT Y, Antenna Horizontal
49		2440MHz Channel, EUT Z, Antenna Vertical
50		2480MHz Channel, EUT Y, Antenna Horizontal
51		2480MHz Channel, EUT Z, Antenna Vertical

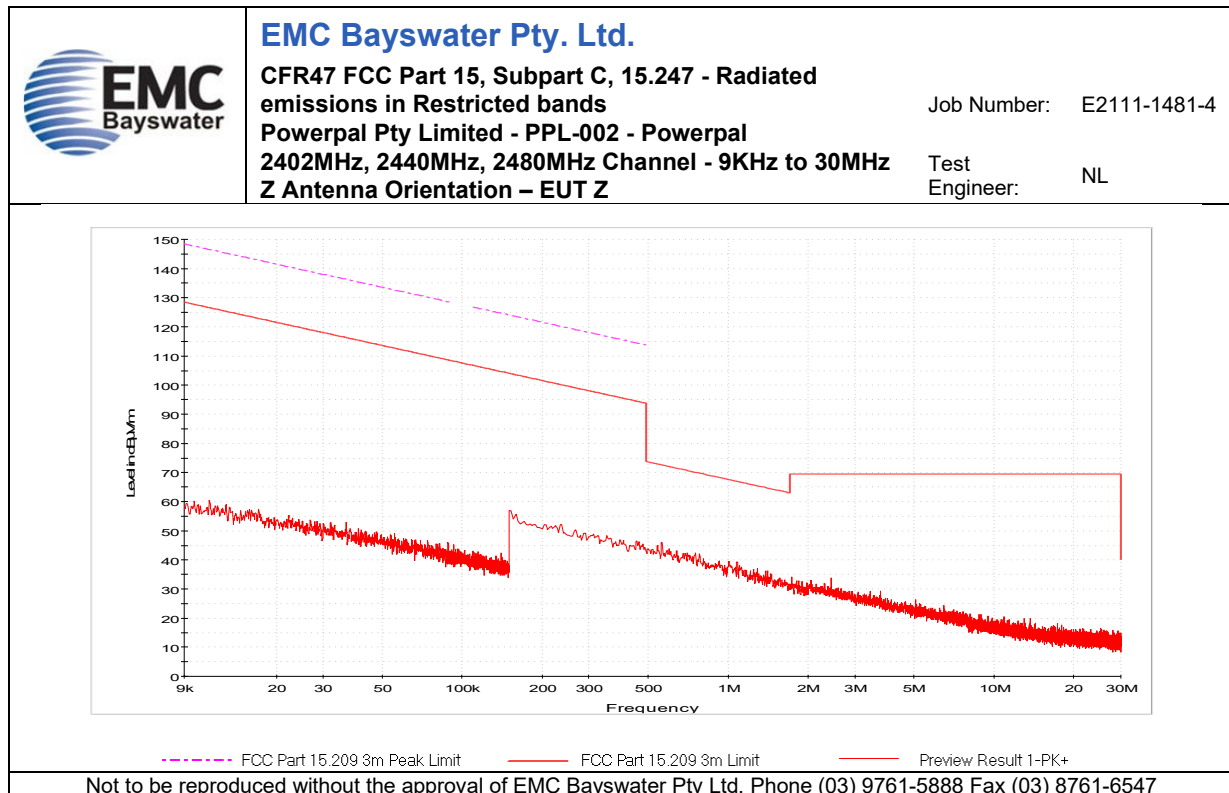
No.	Test	Graph Description
52	8.2GHz to 12.4GHz Non-Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
53		2402MHz Channel, EUT Z, Antenna Vertical
54		2440MHz Channel, EUT Y, Antenna Horizontal
55		2440MHz Channel, EUT Z, Antenna Vertical
56		2480MHz Channel, EUT Y, Antenna Horizontal
57		2480MHz Channel, EUT Z, Antenna Vertical
58	12.4GHz to 18GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
59		2402MHz Channel, EUT Z, Antenna Vertical
60		2440MHz Channel, EUT Y, Antenna Horizontal
61		2440MHz Channel, EUT Z, Antenna Vertical
62		2480MHz Channel, EUT Y, Antenna Horizontal
63		2480MHz Channel, EUT Z, Antenna Vertical
64	12.4GHz to 18GHz Non-Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
65		2402MHz Channel, EUT Z, Antenna Vertical
66		2440MHz Channel, EUT Y, Antenna Horizontal
67		2440MHz Channel, EUT Z, Antenna Vertical
68		2480MHz Channel, EUT Y, Antenna Horizontal
69		2480MHz Channel, EUT Z, Antenna Vertical
70	18GHz to 26.5GHz Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
71		2402MHz Channel, EUT Z, Antenna Vertical
72		2440MHz Channel, EUT Y, Antenna Horizontal
73		2440MHz Channel, EUT Z, Antenna Vertical
74		2480MHz Channel, EUT Y, Antenna Horizontal
75		2480MHz Channel, EUT Z, Antenna Vertical
76	18GHz to 26.5GHz Non-Restricted Bands	2402MHz Channel, EUT Y, Antenna Horizontal
77		2402MHz Channel, EUT Z, Antenna Vertical
78		2440MHz Channel, EUT Y, Antenna Horizontal
79		2440MHz Channel, EUT Z, Antenna Vertical
80		2480MHz Channel, EUT Y, Antenna Horizontal
81		2480MHz Channel, EUT Z, Antenna Vertical



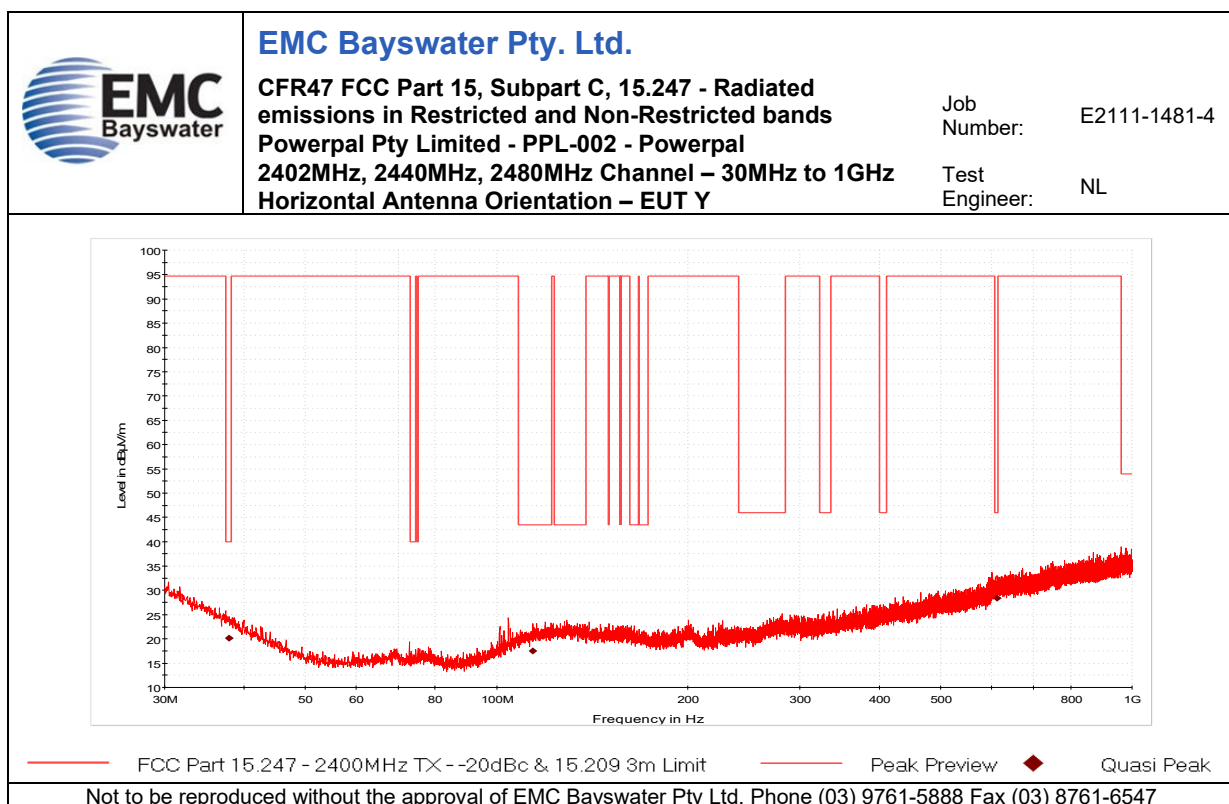
Graph 11



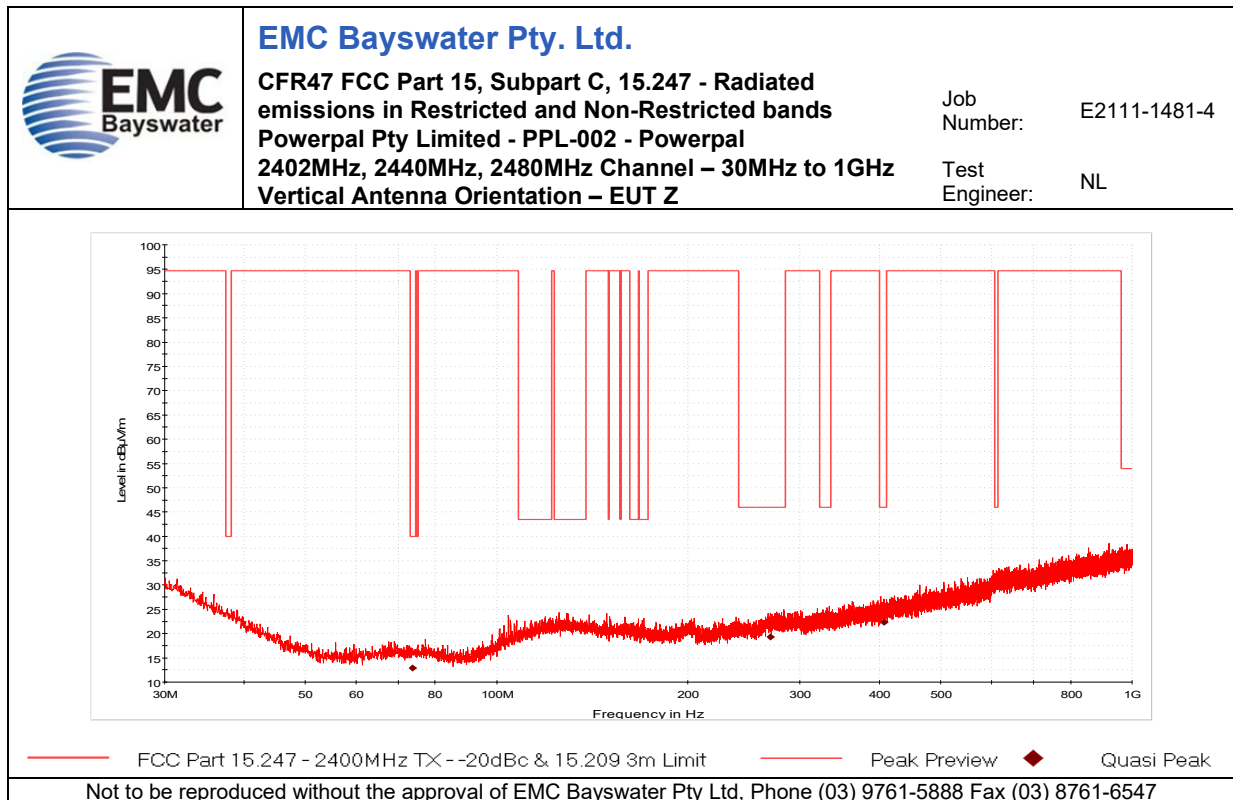
Graph 12



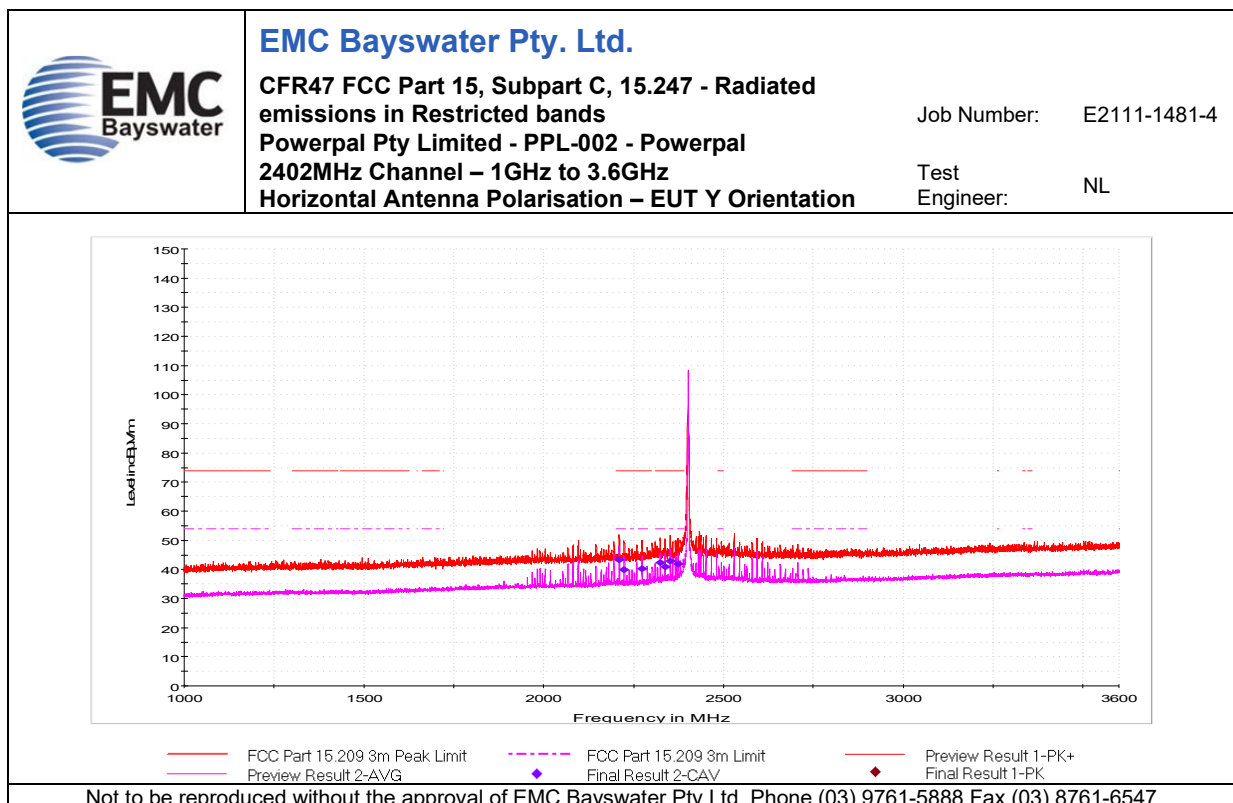
Graph 13



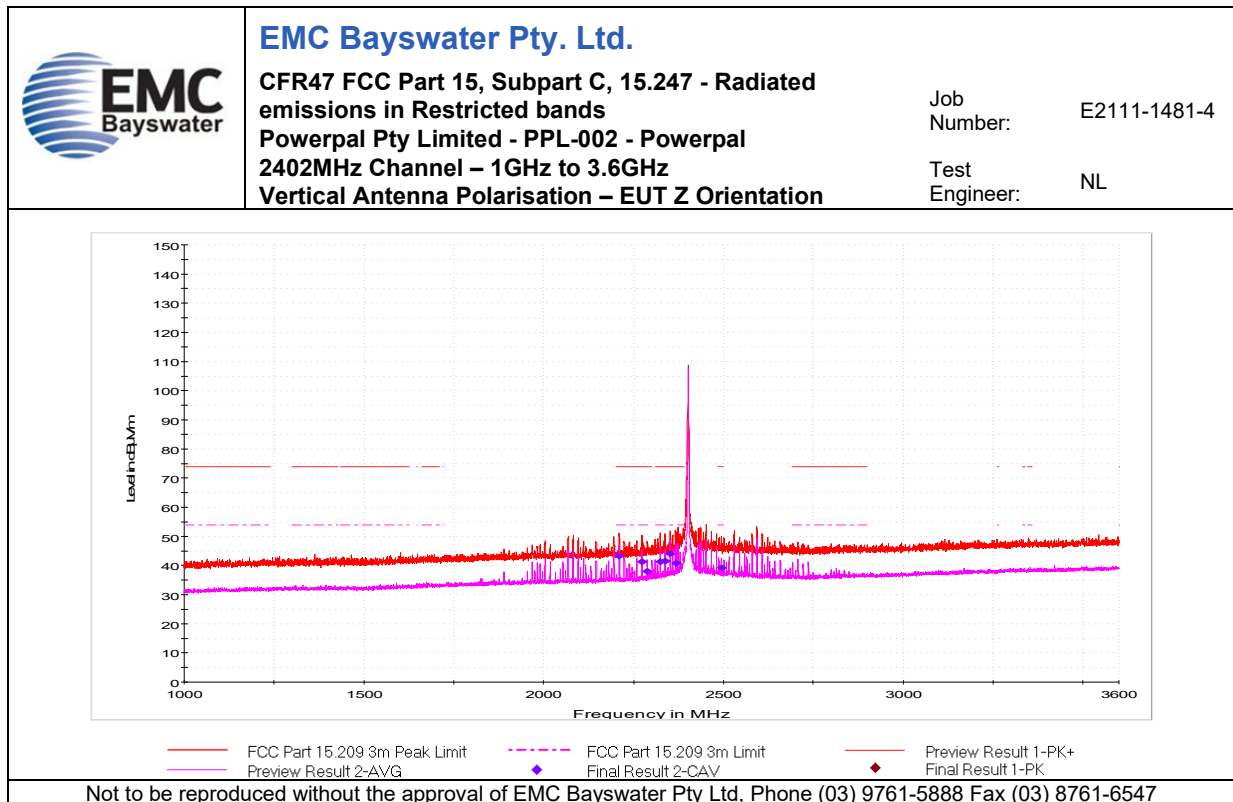
Graph 14



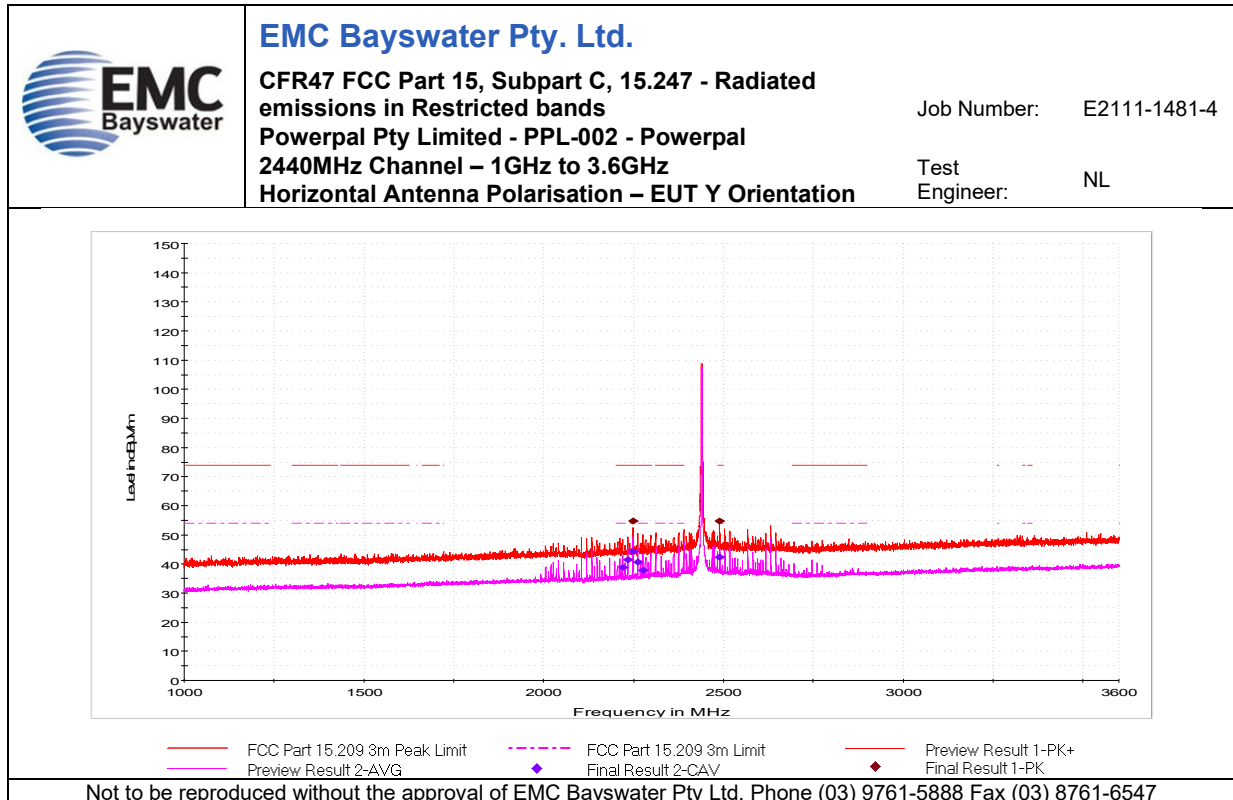
Graph 15



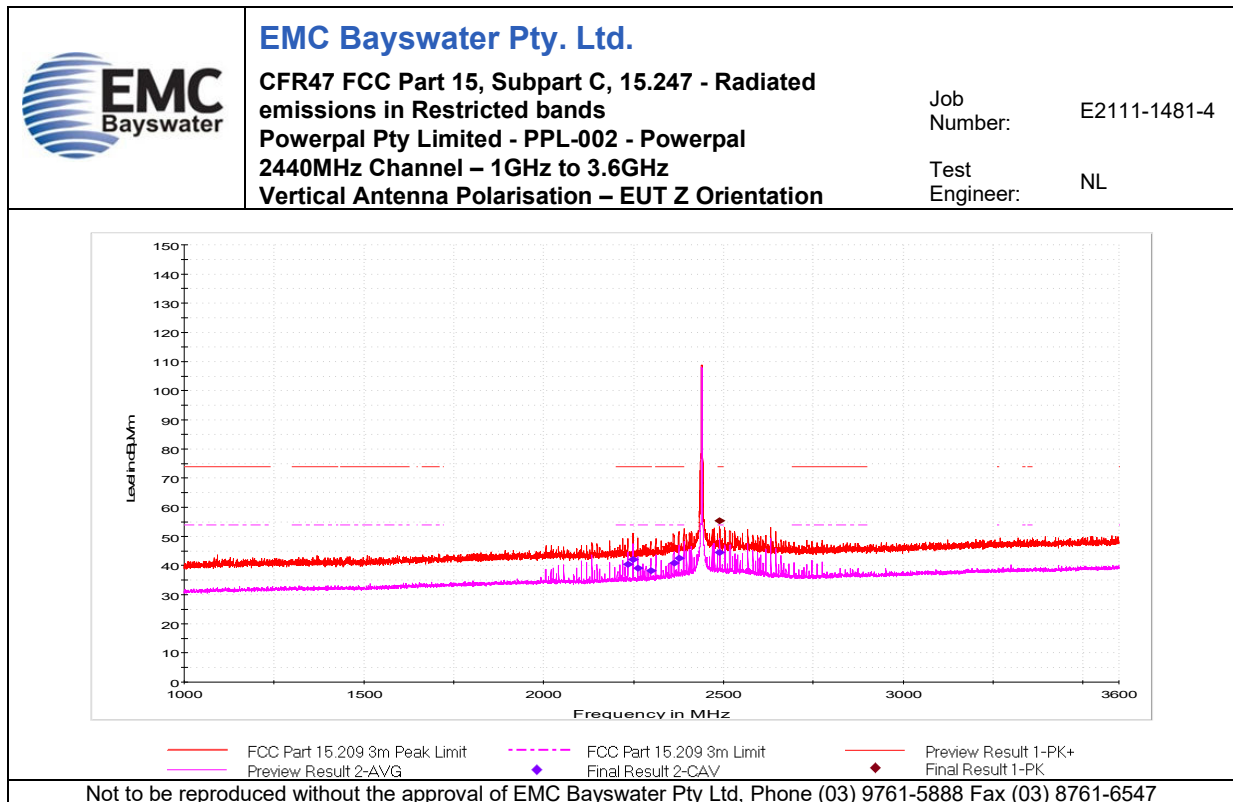
Graph 16



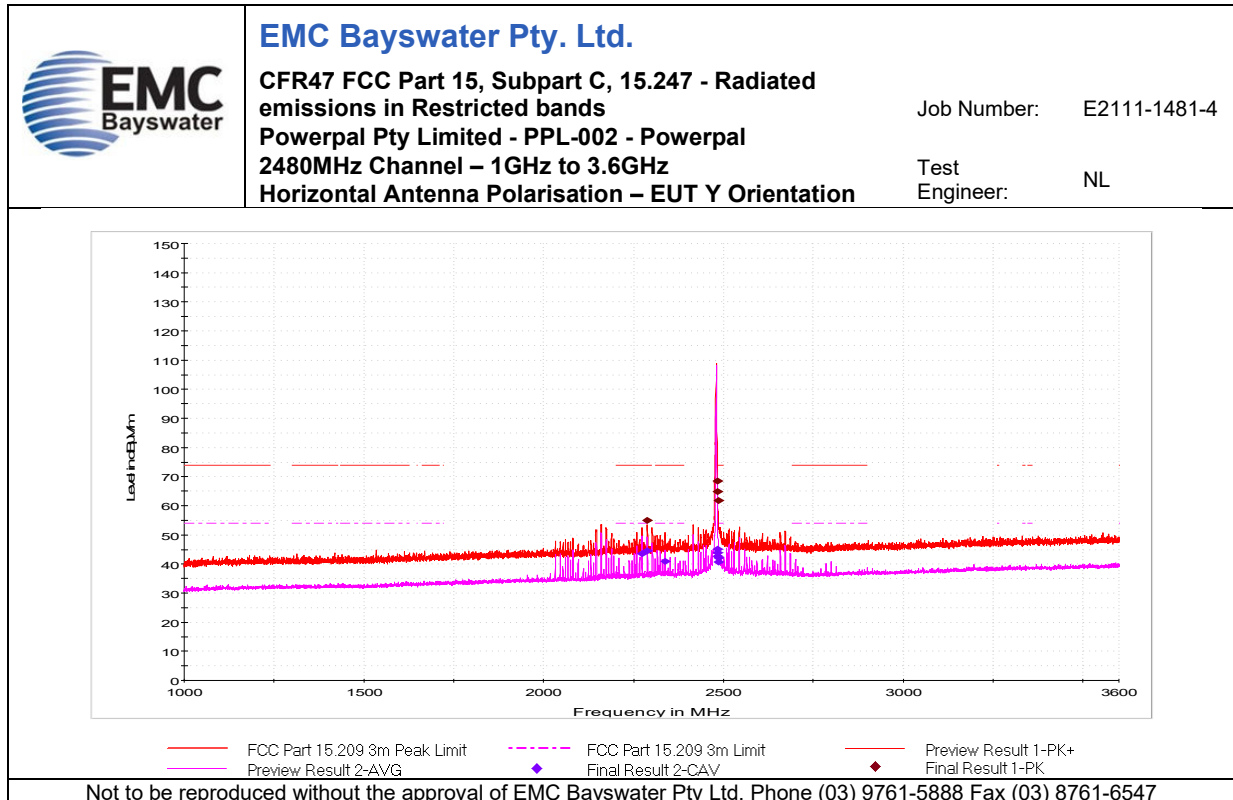
Graph 17



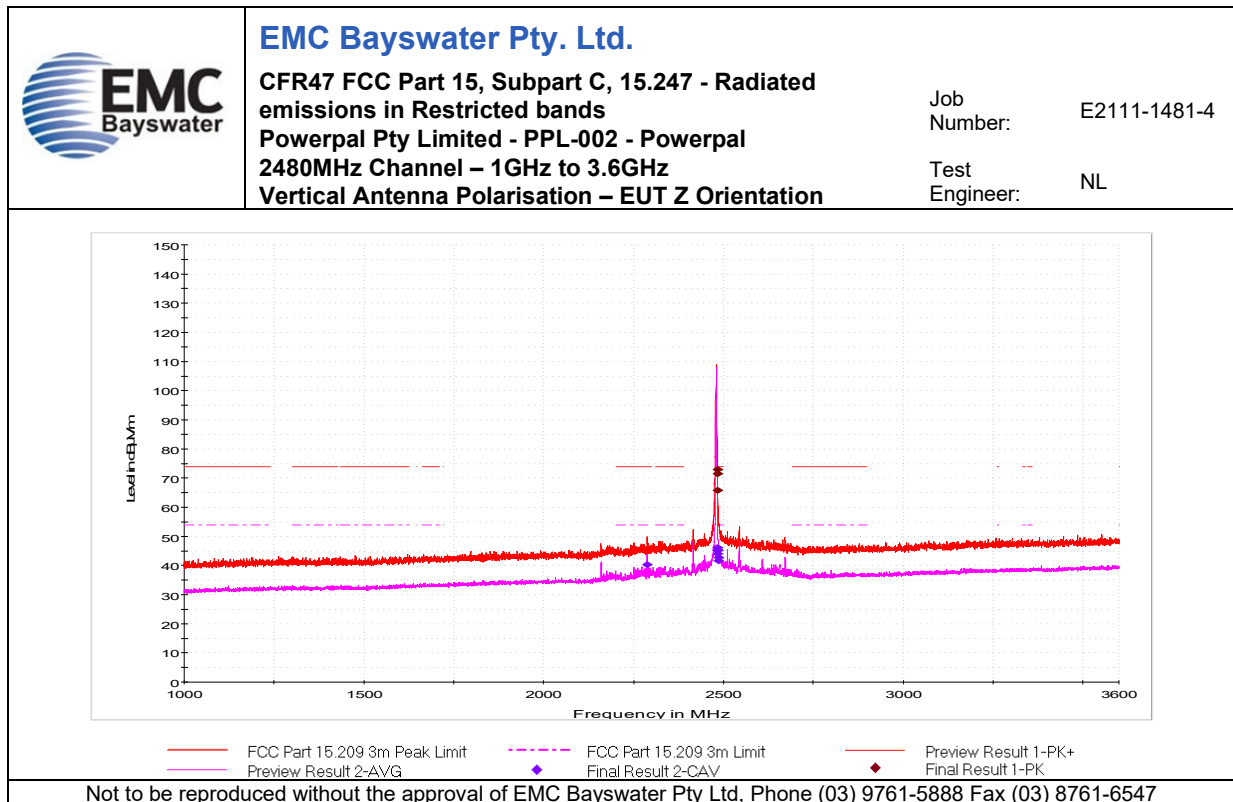
Graph 18



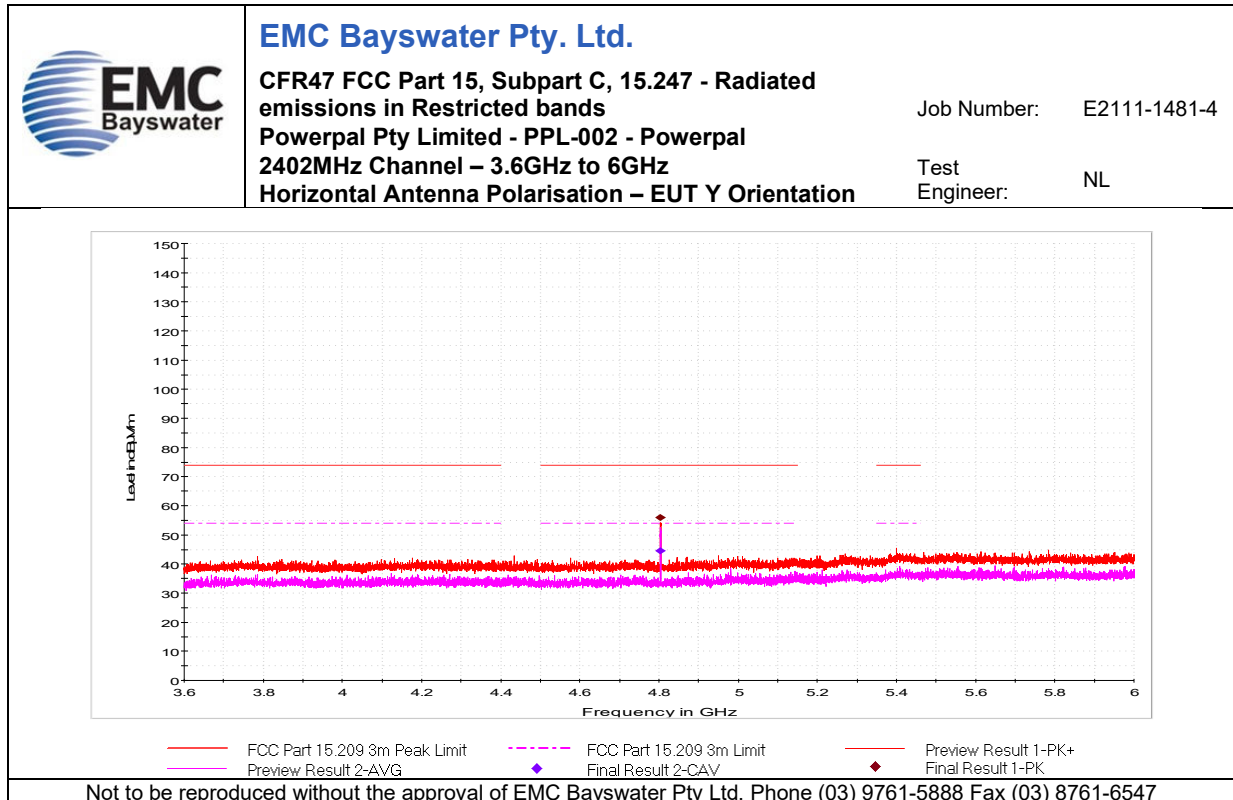
Graph 19



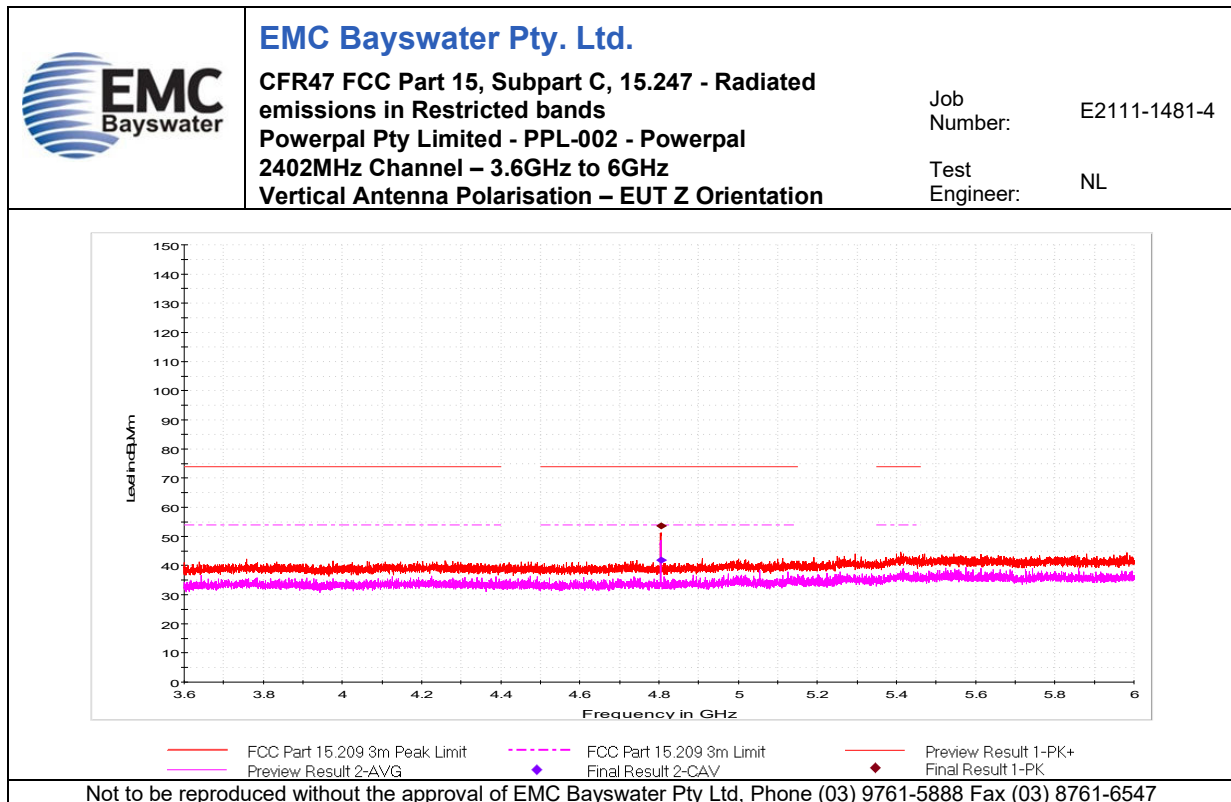
Graph 20



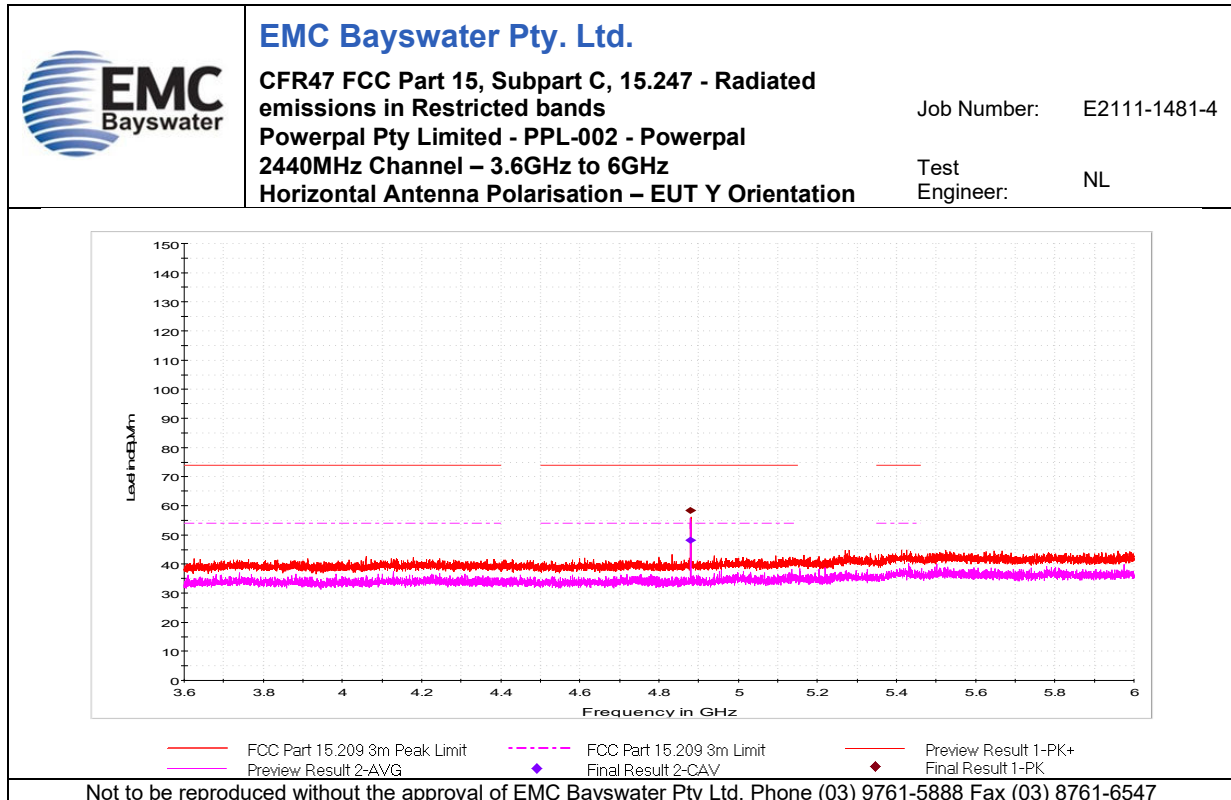
Graph 21



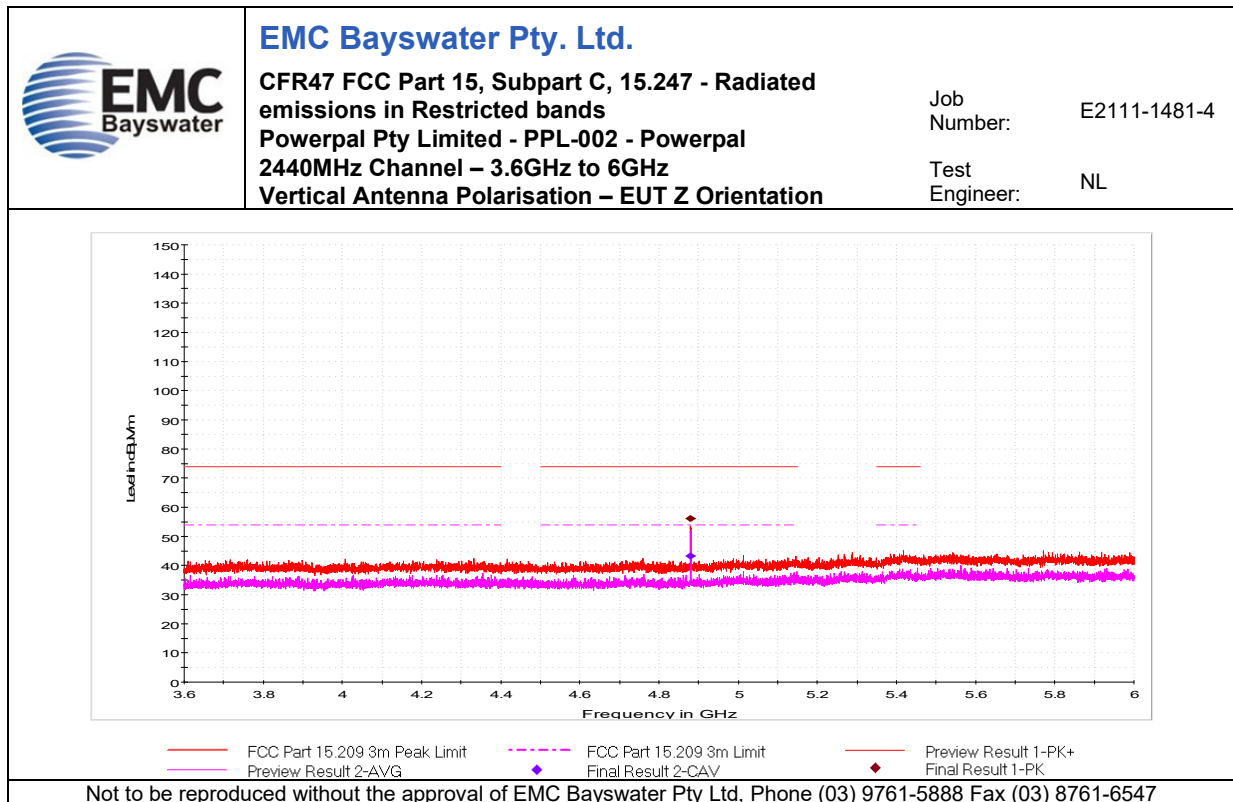
Graph 22



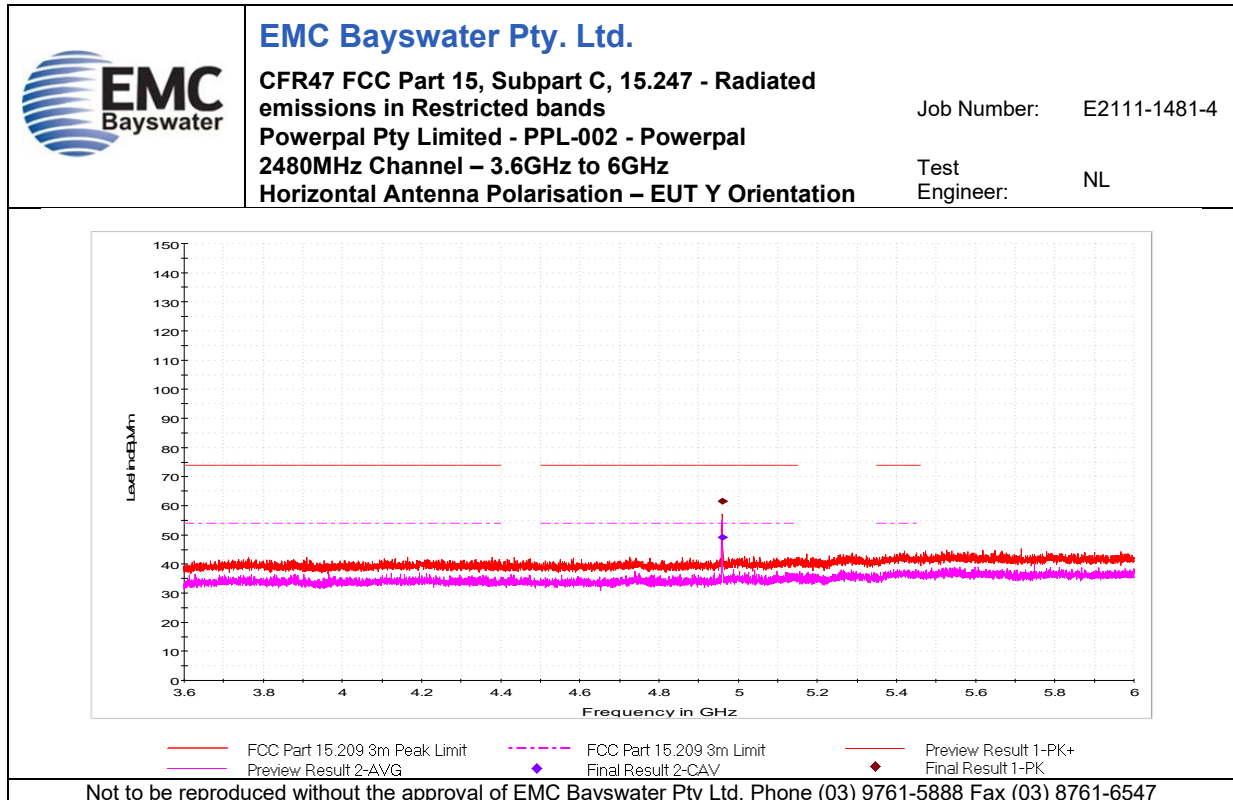
Graph 23



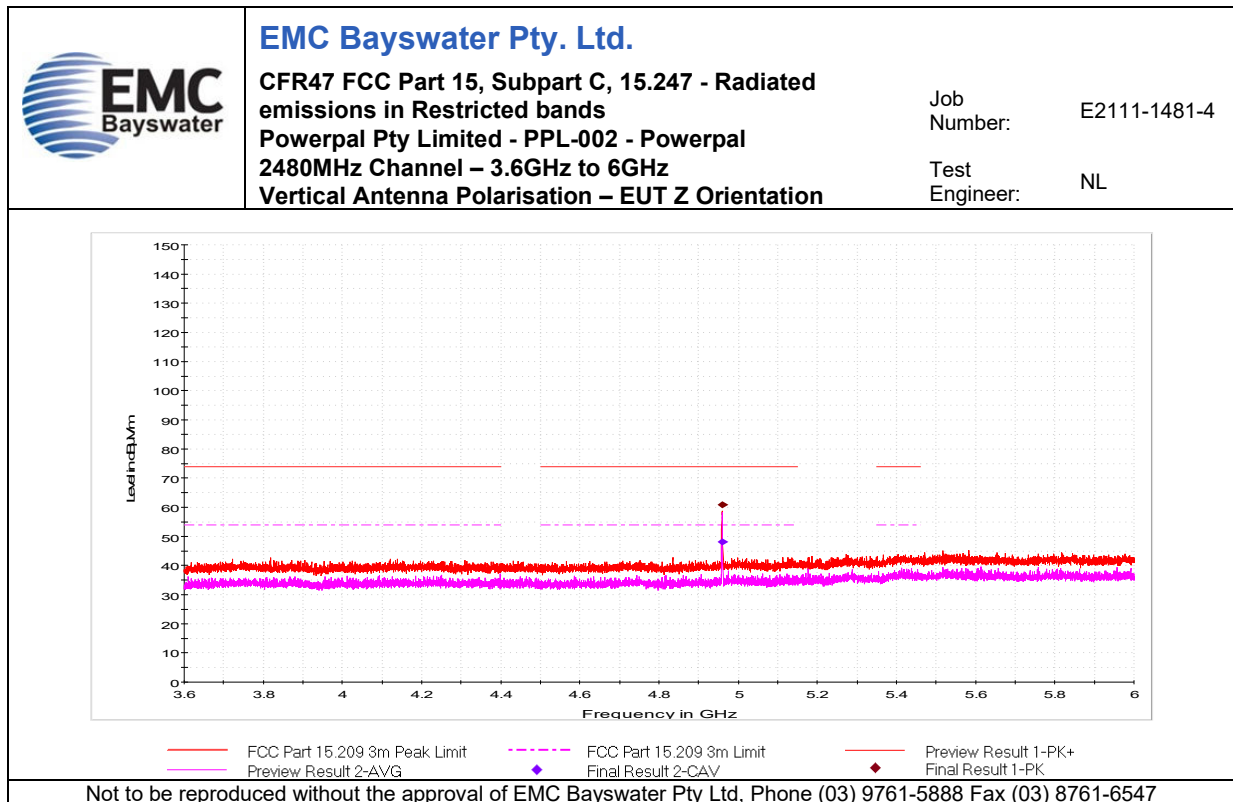
Graph 24



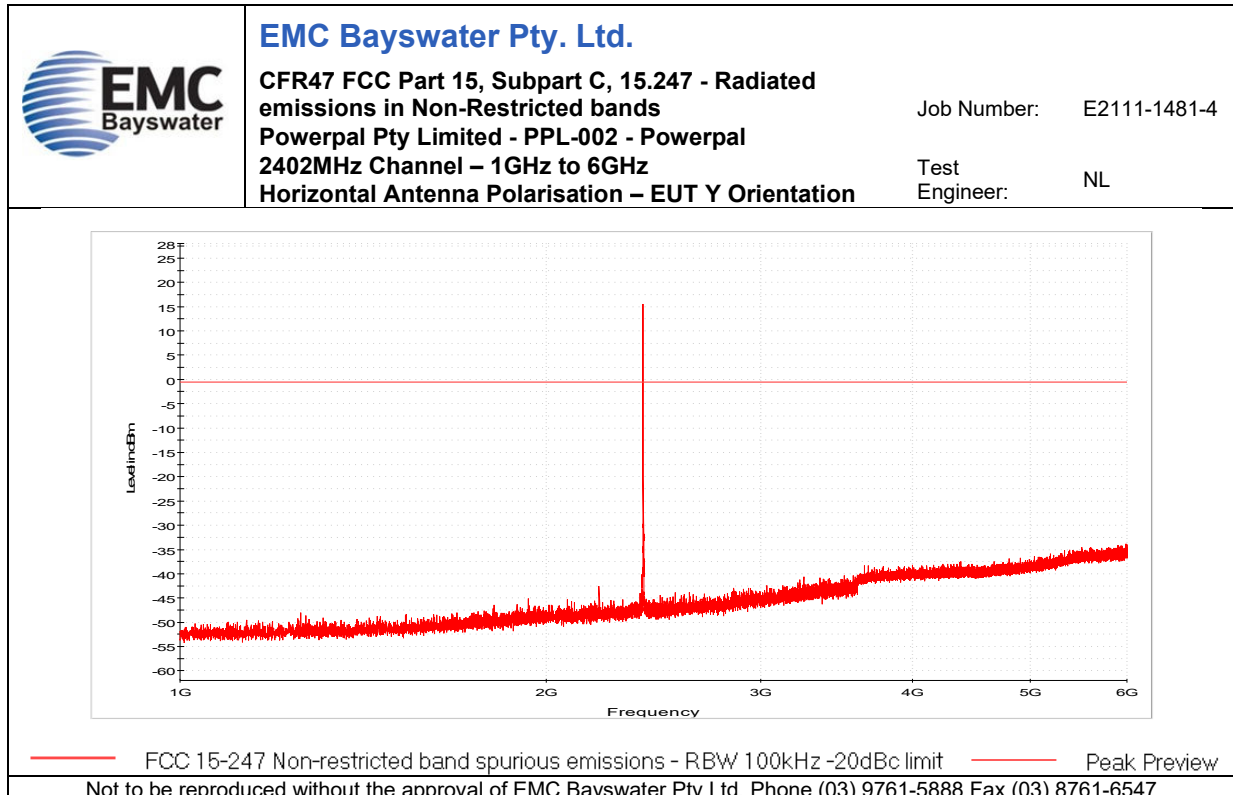
Graph 25



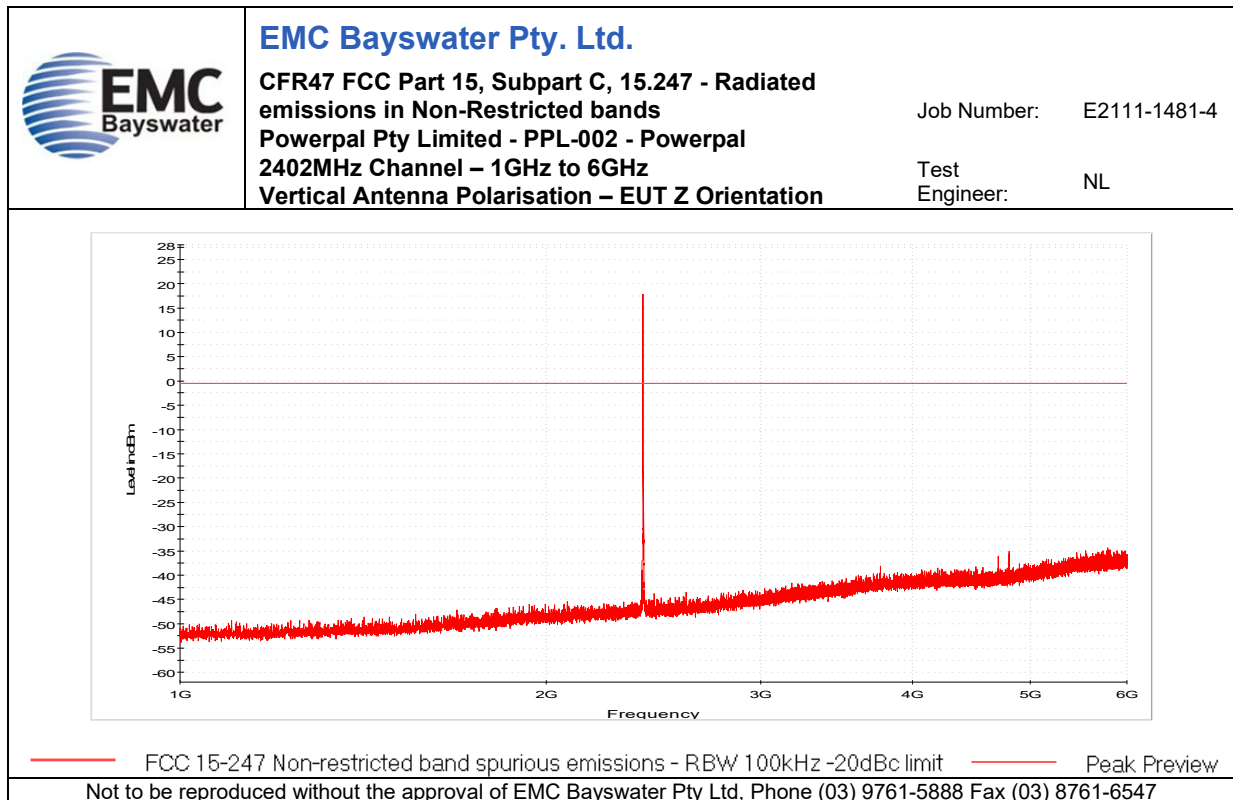
Graph 26



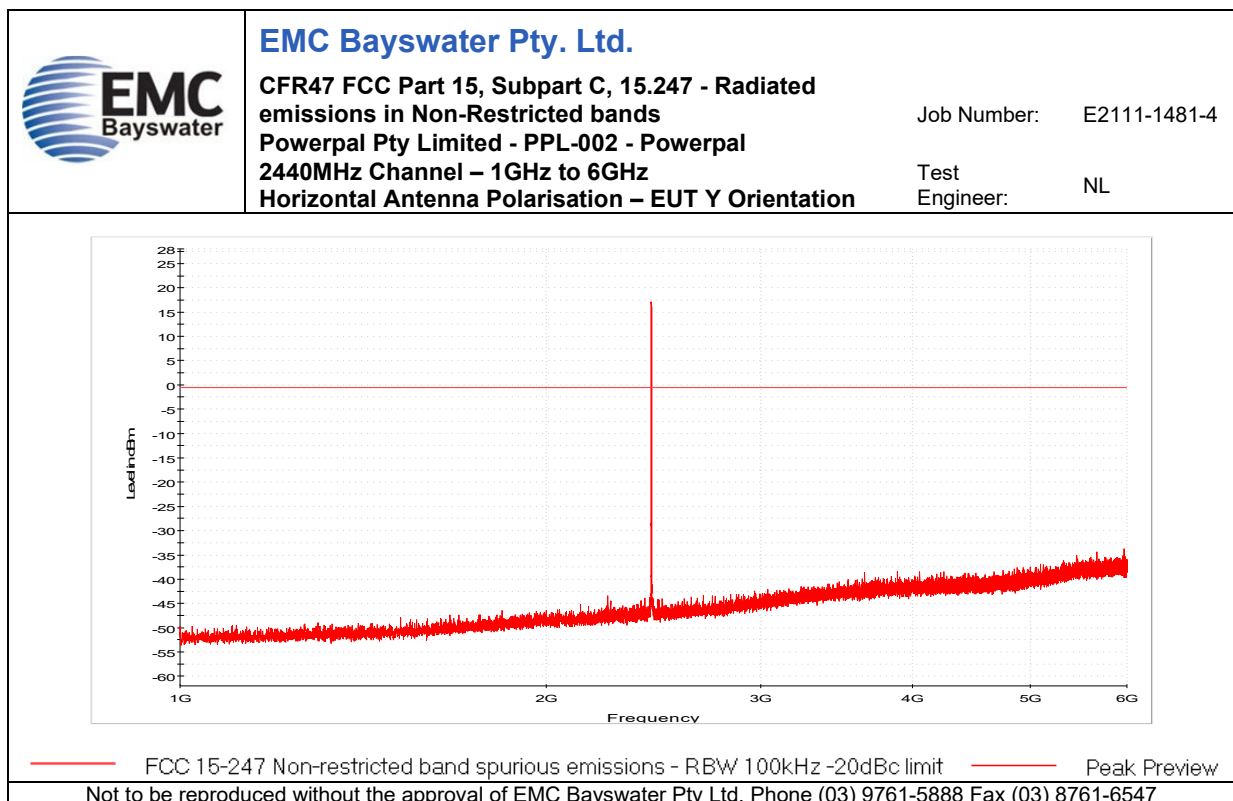
Graph 27



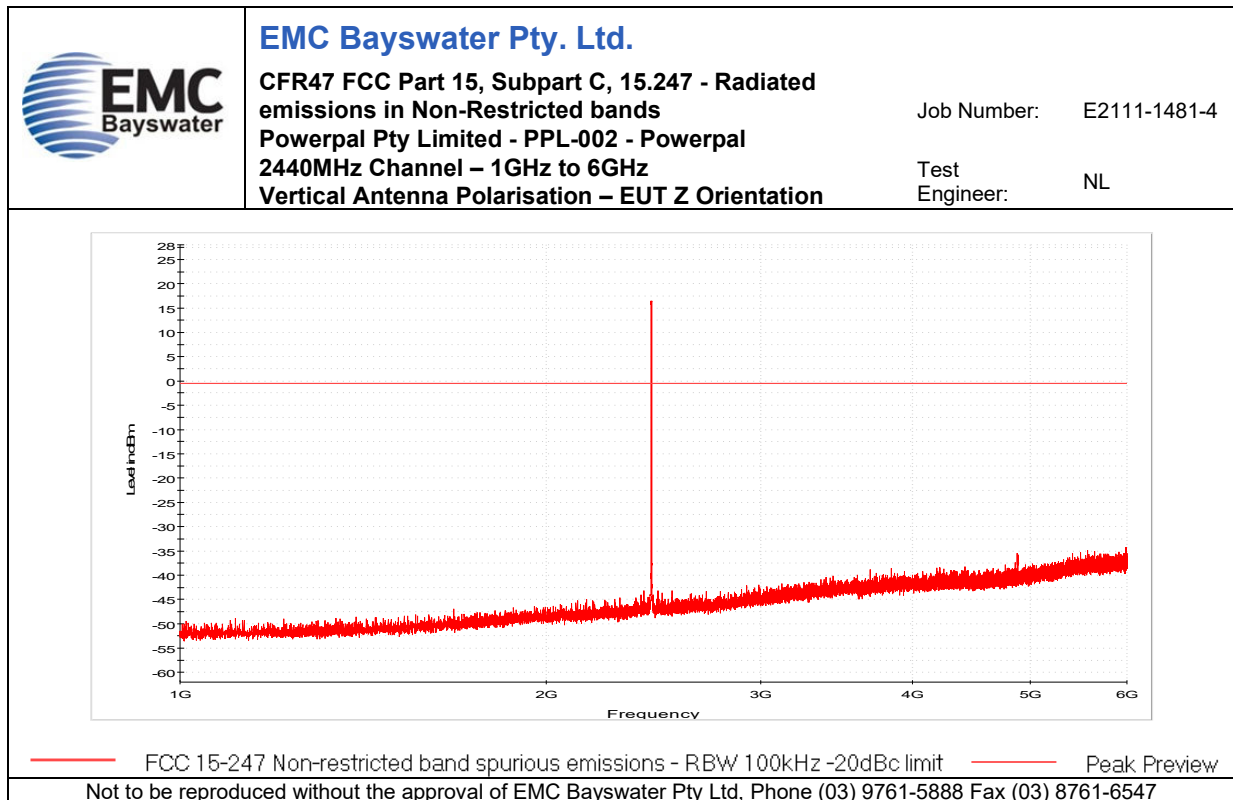
Graph 28



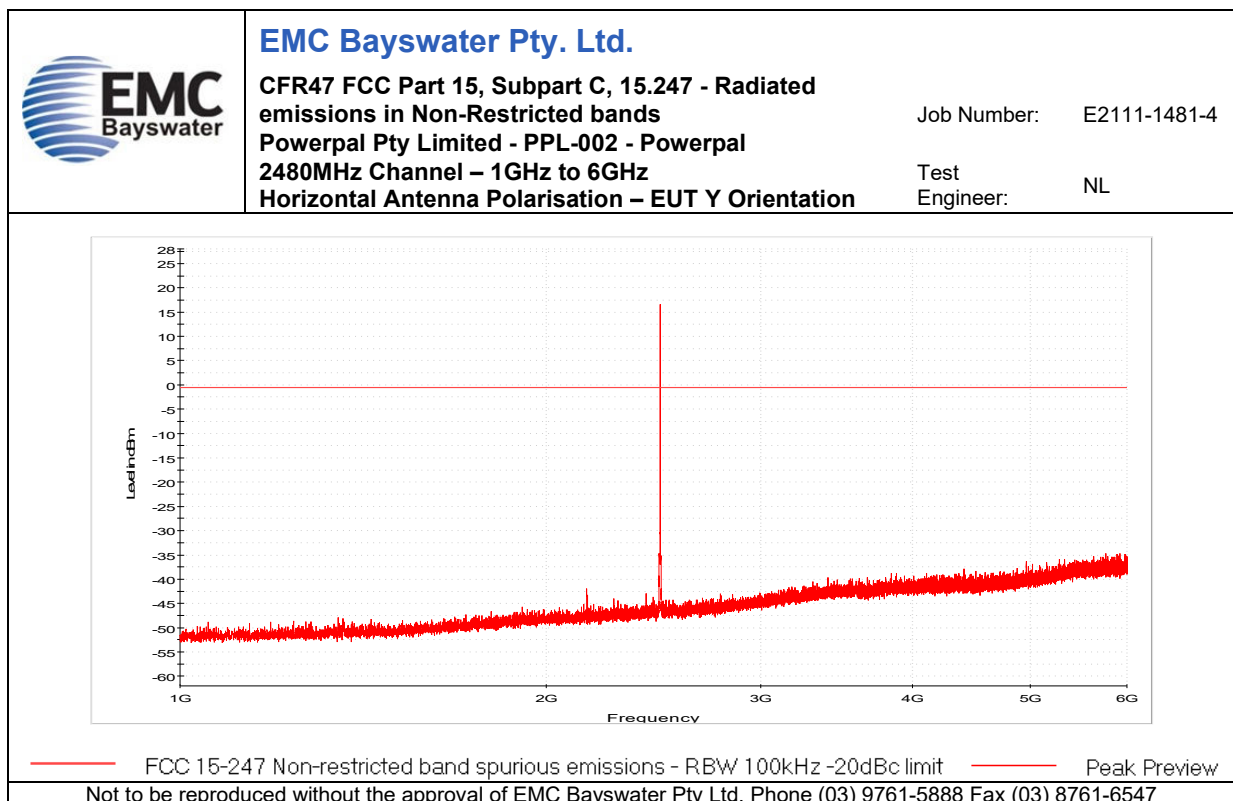
Graph 29



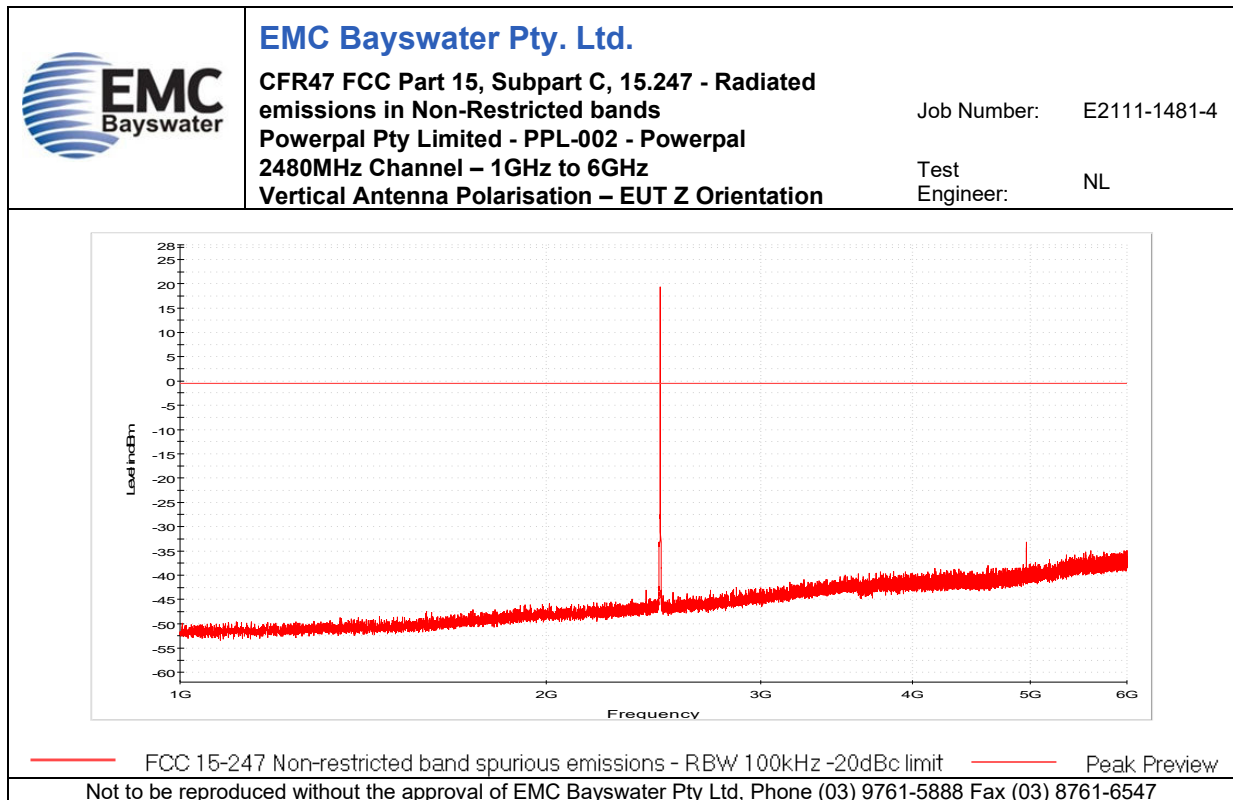
Graph 30



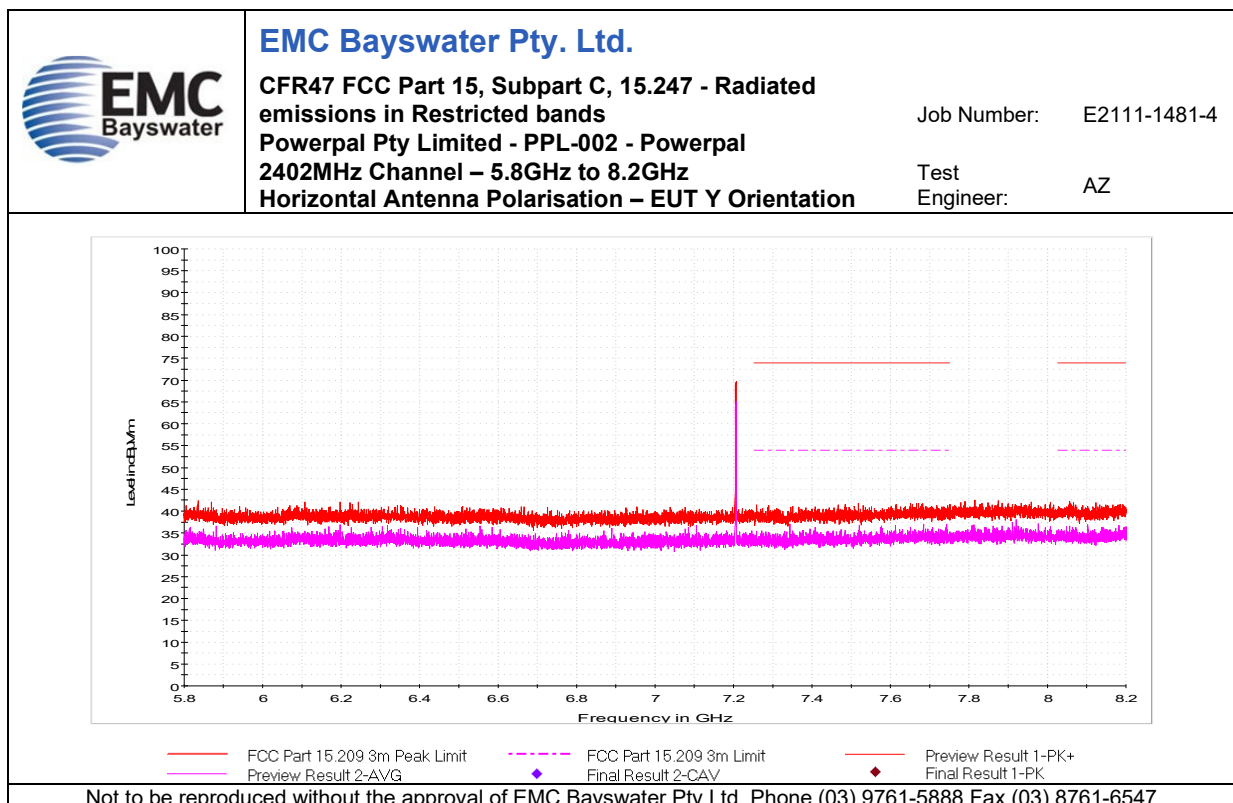
Graph 31



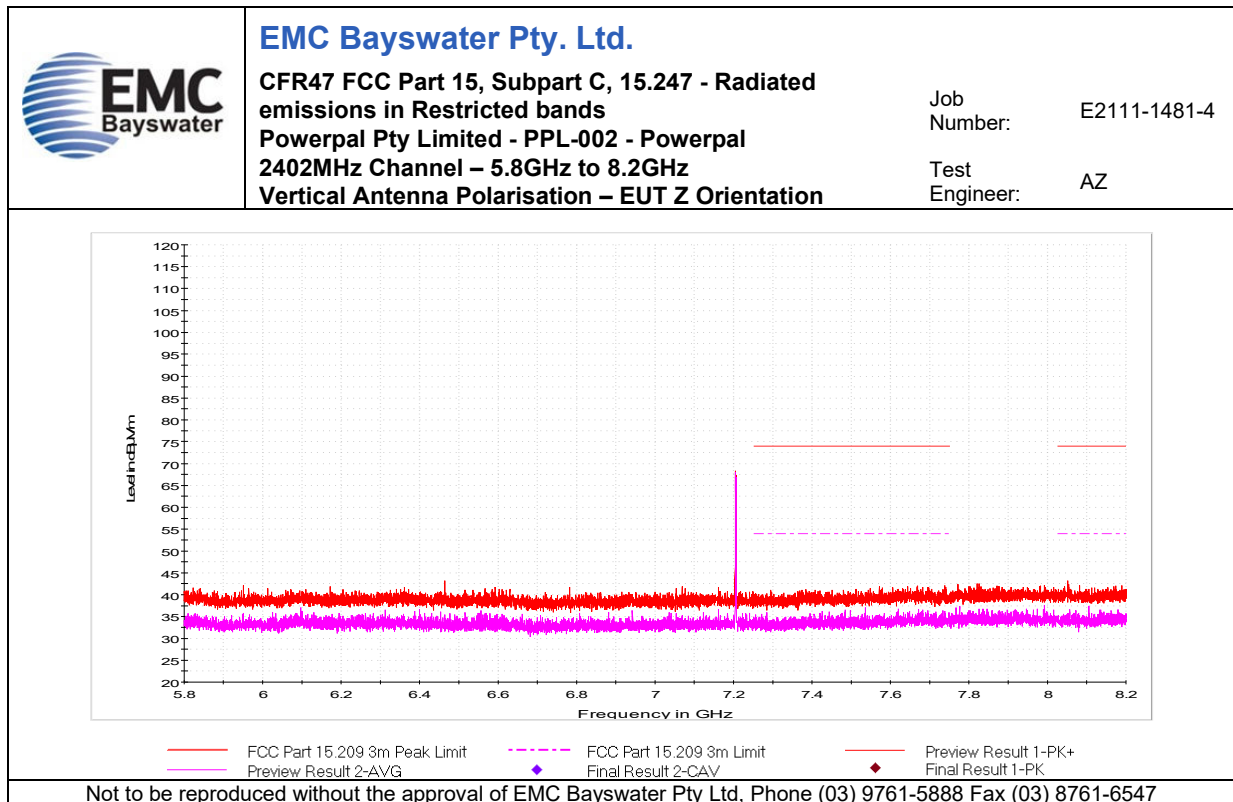
Graph 32



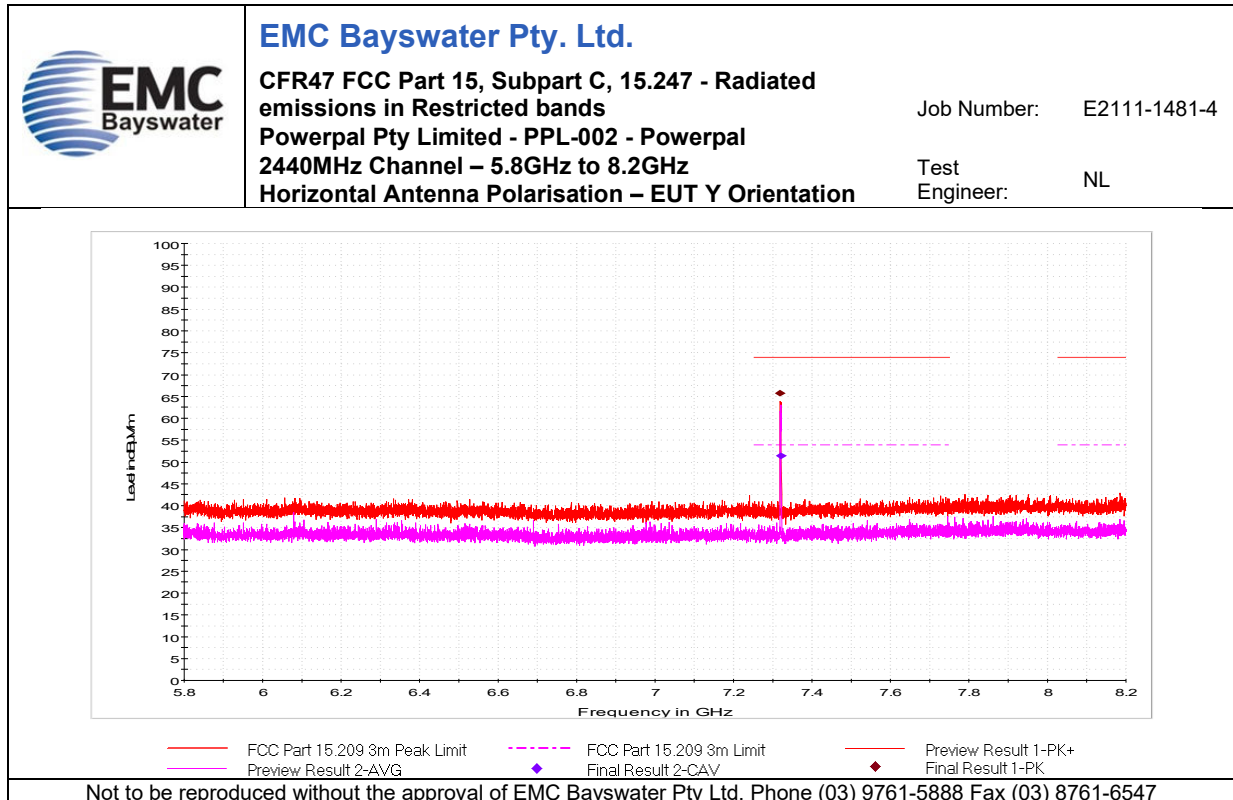
Graph 33



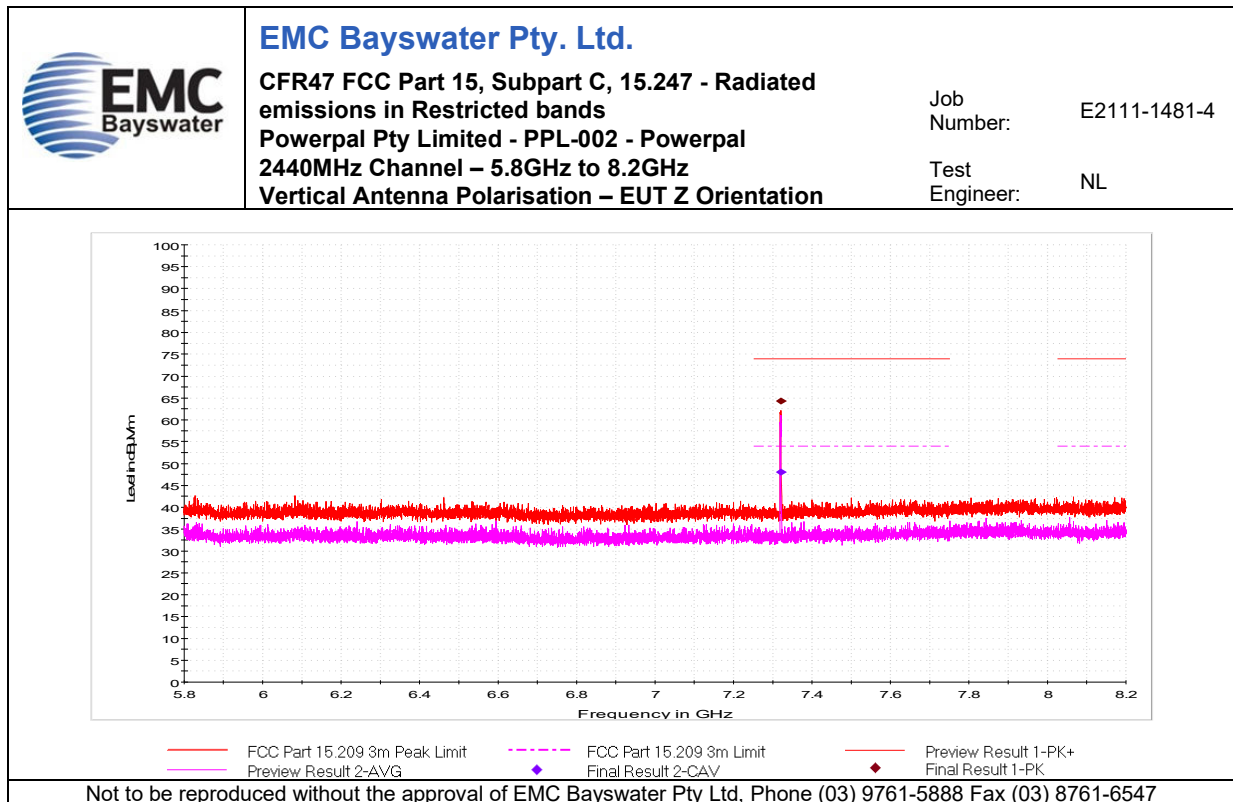
Graph 34



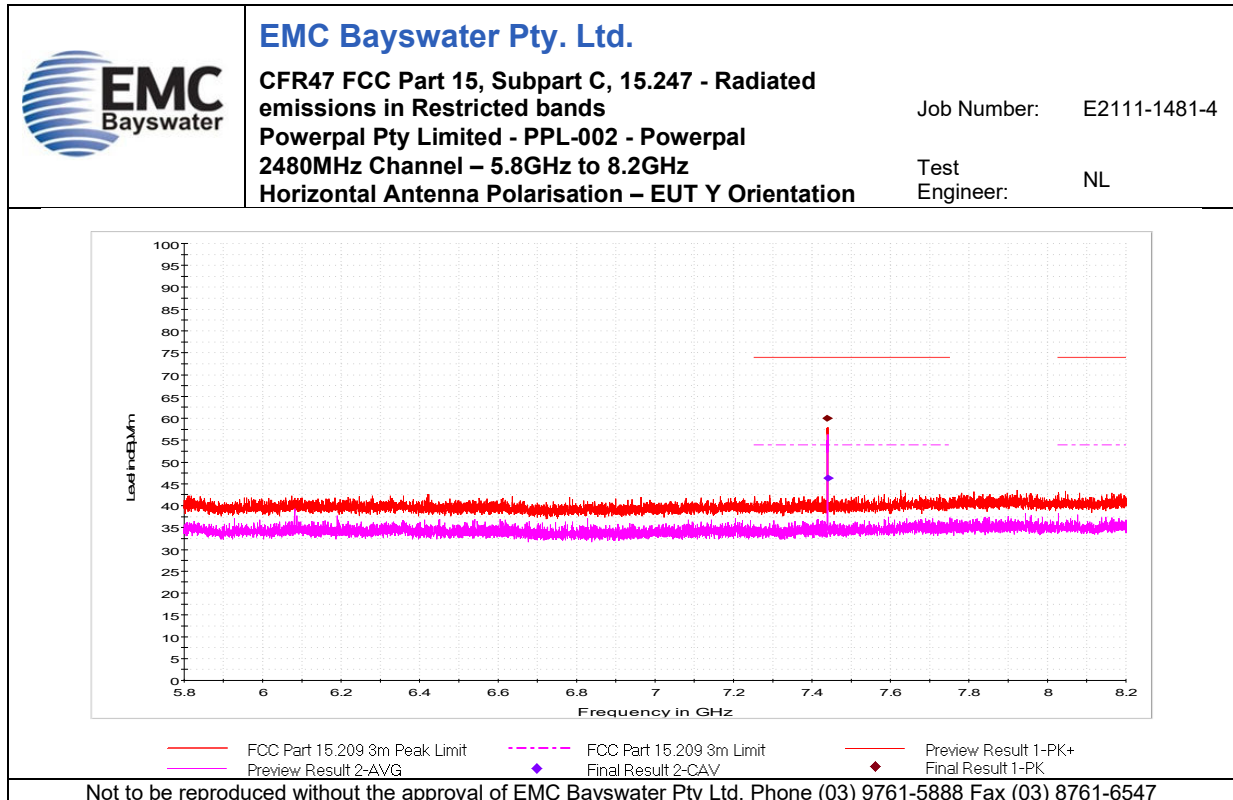
Graph 35



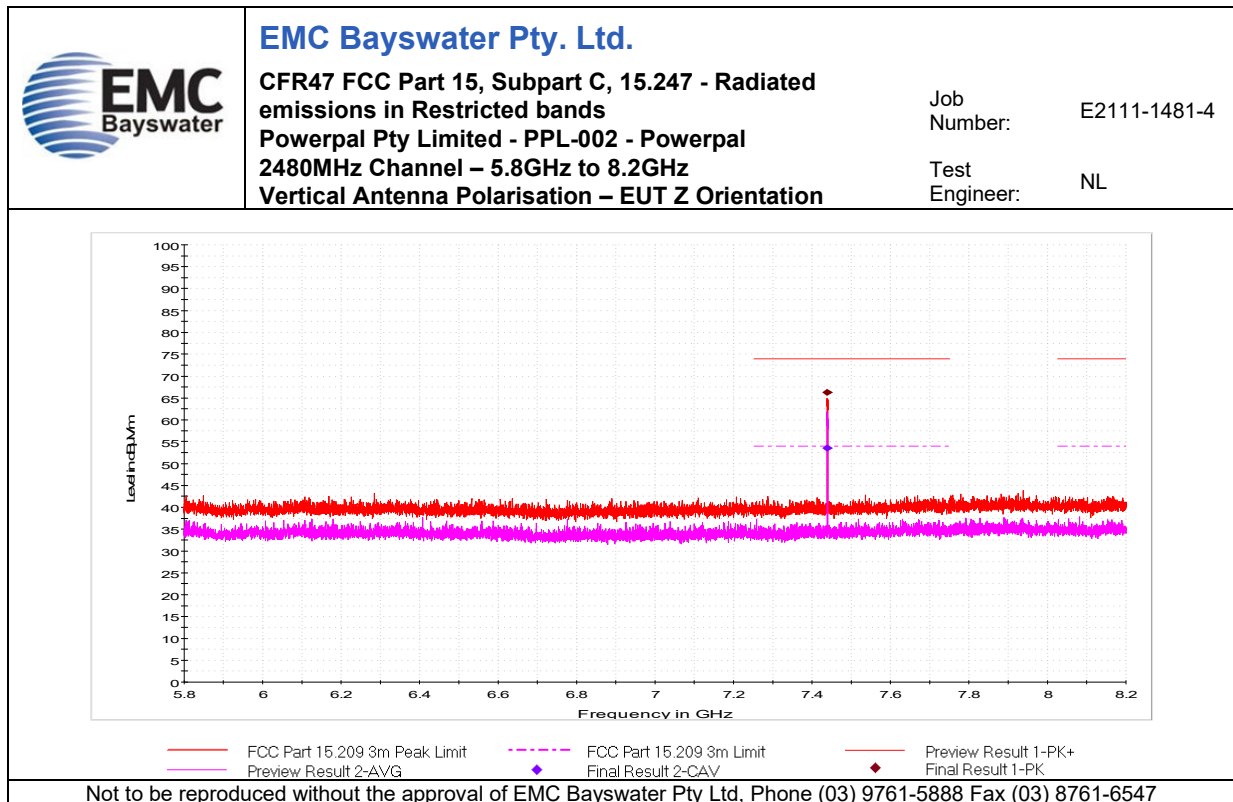
Graph 36



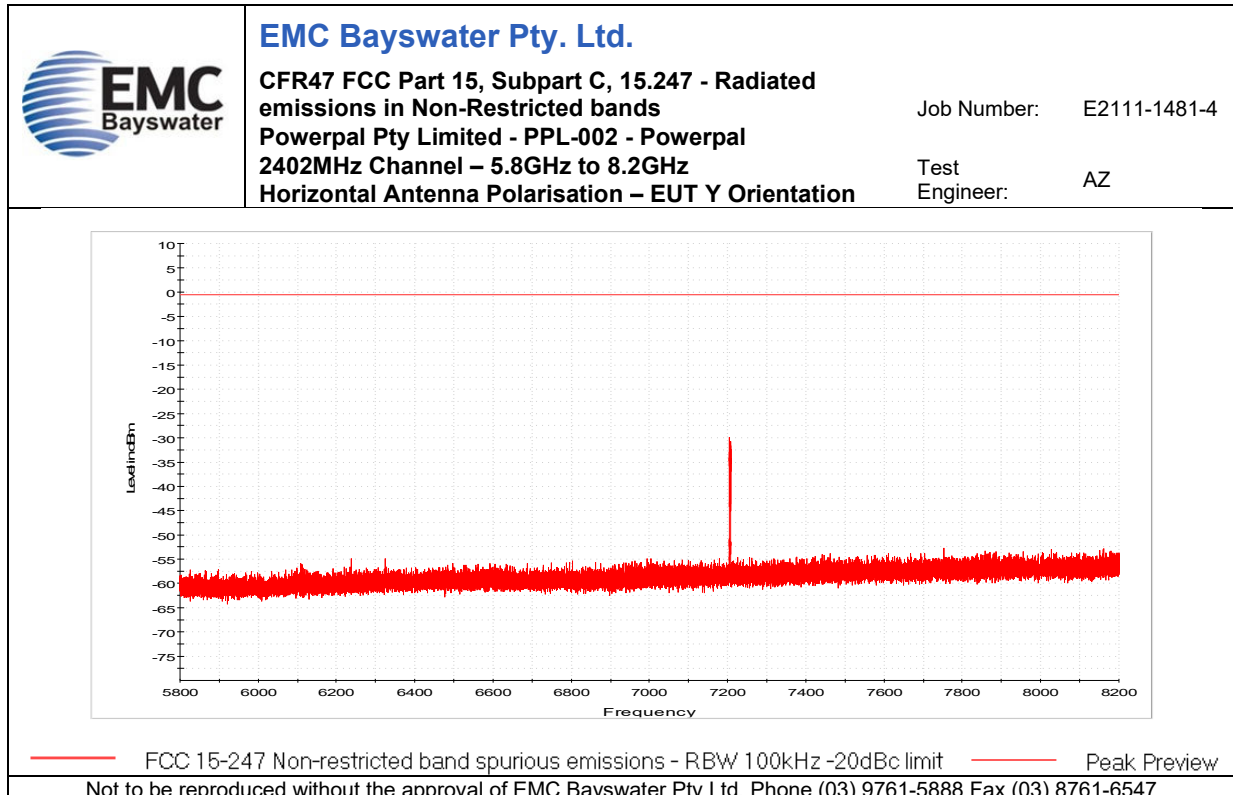
Graph 37



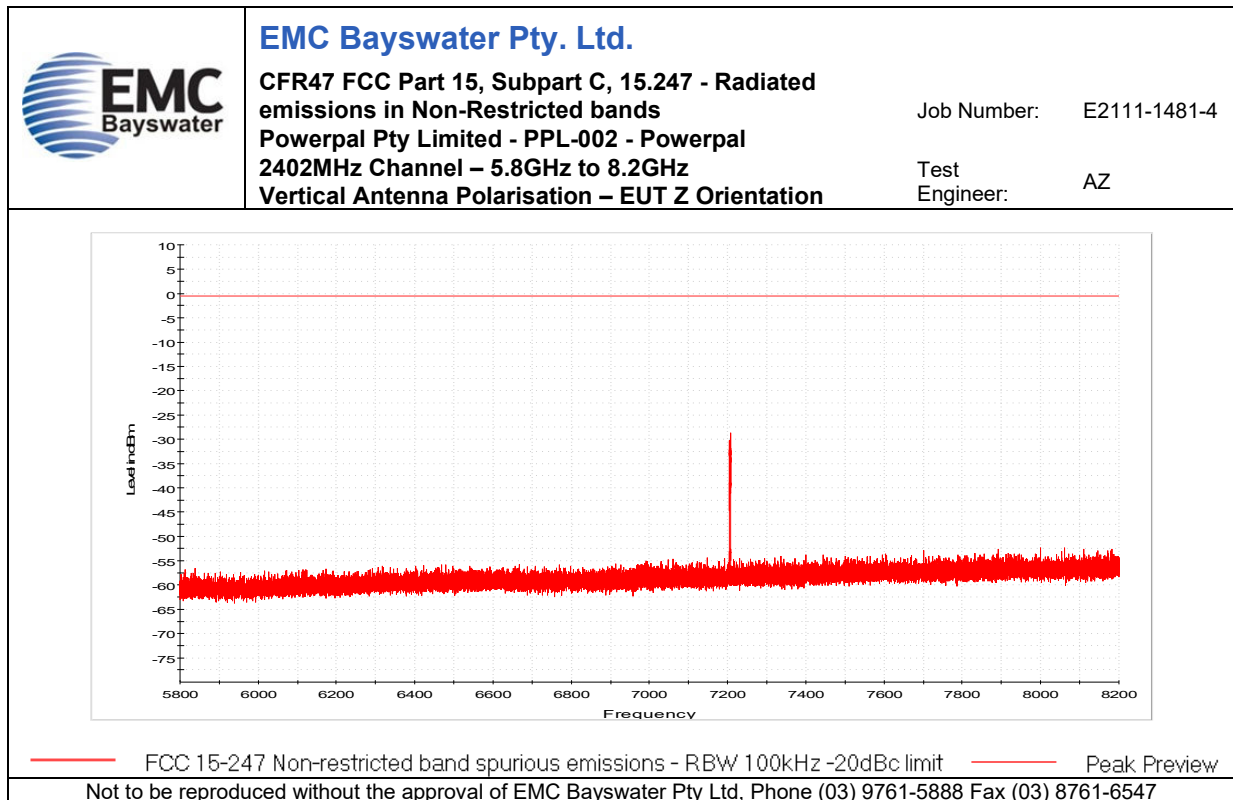
Graph 38



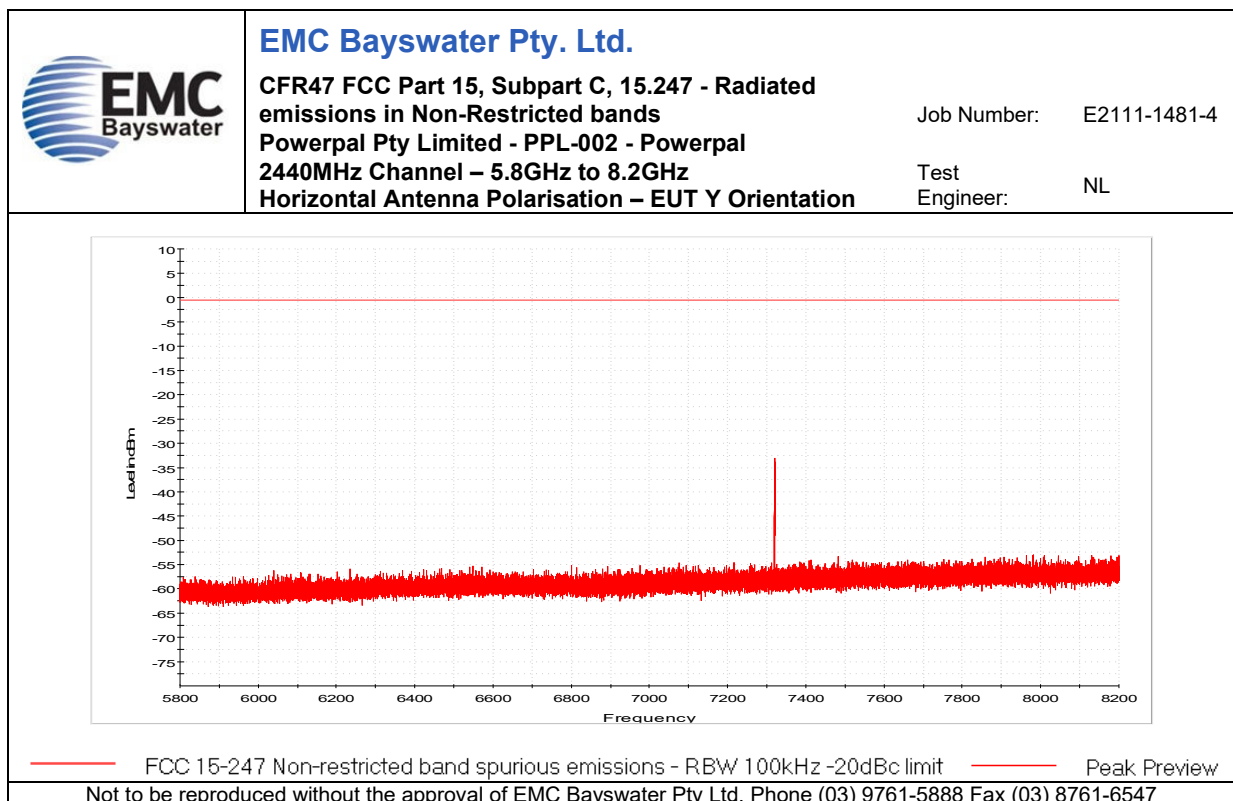
Graph 39



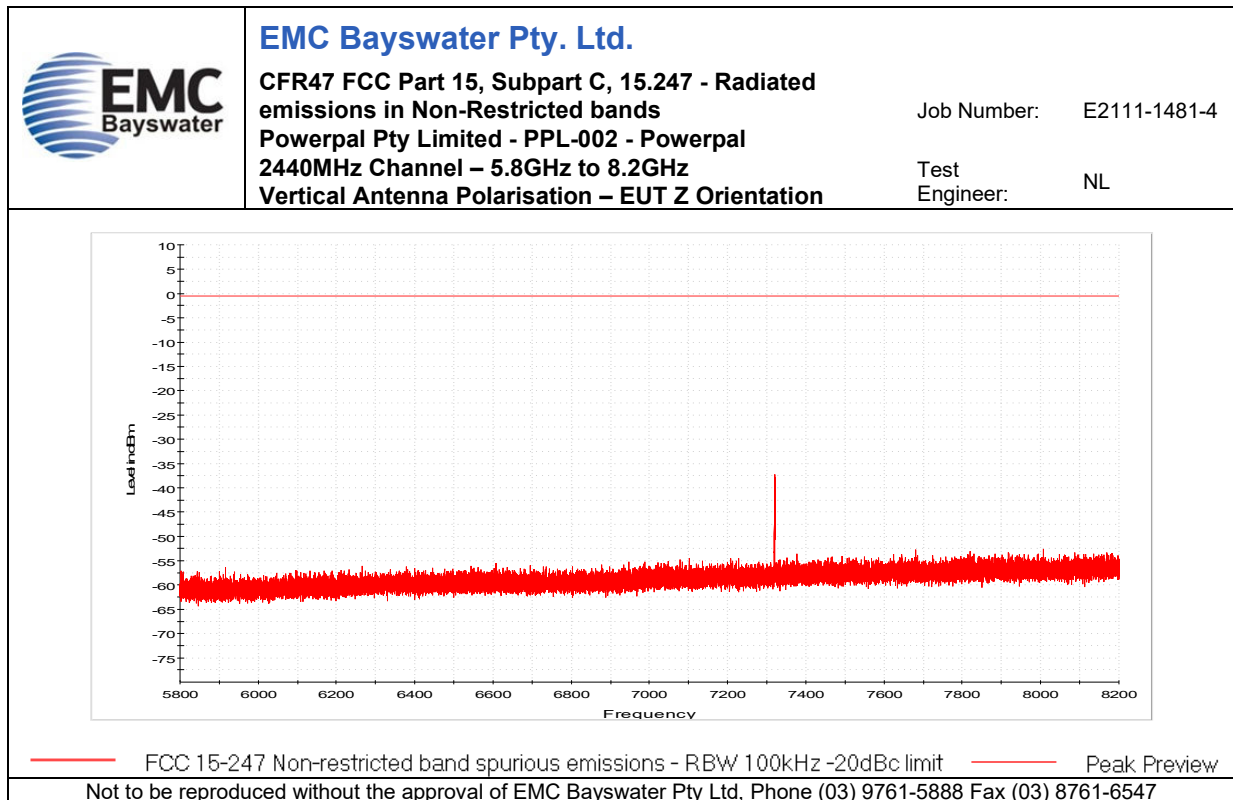
Graph 40



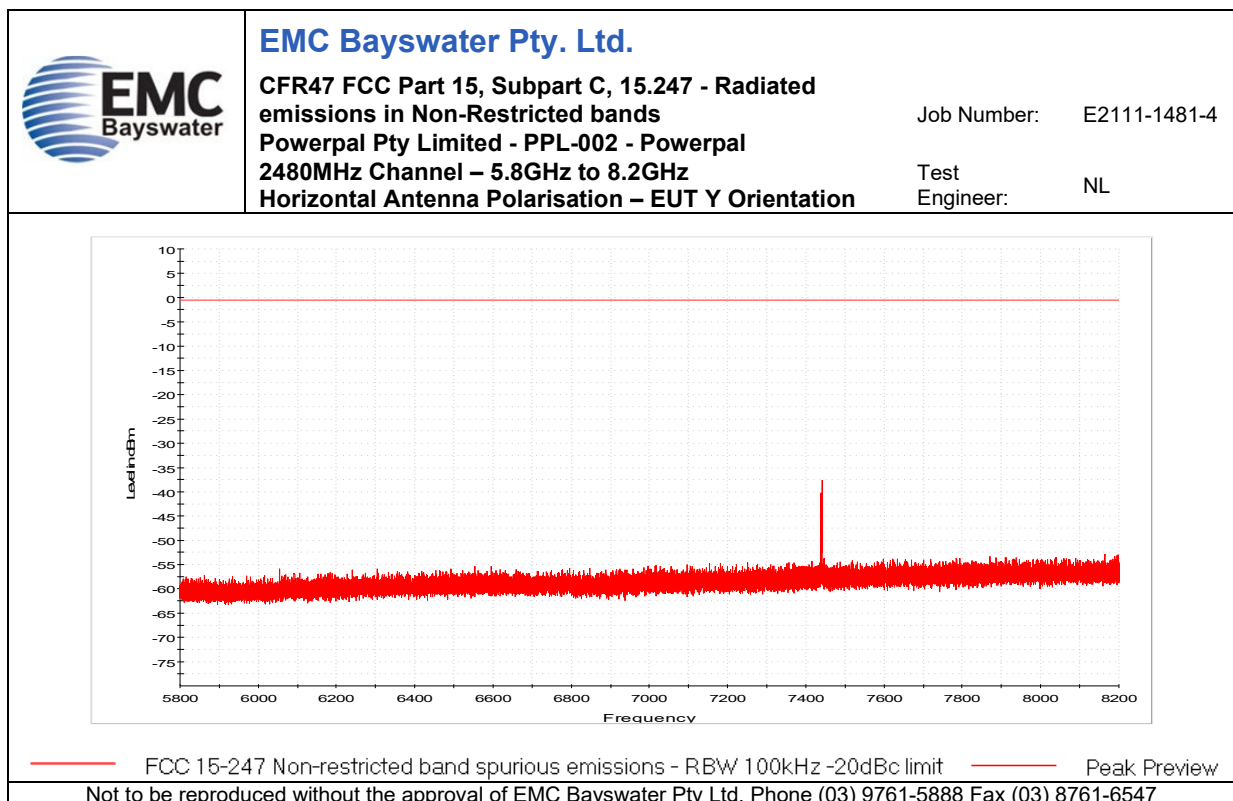
Graph 41



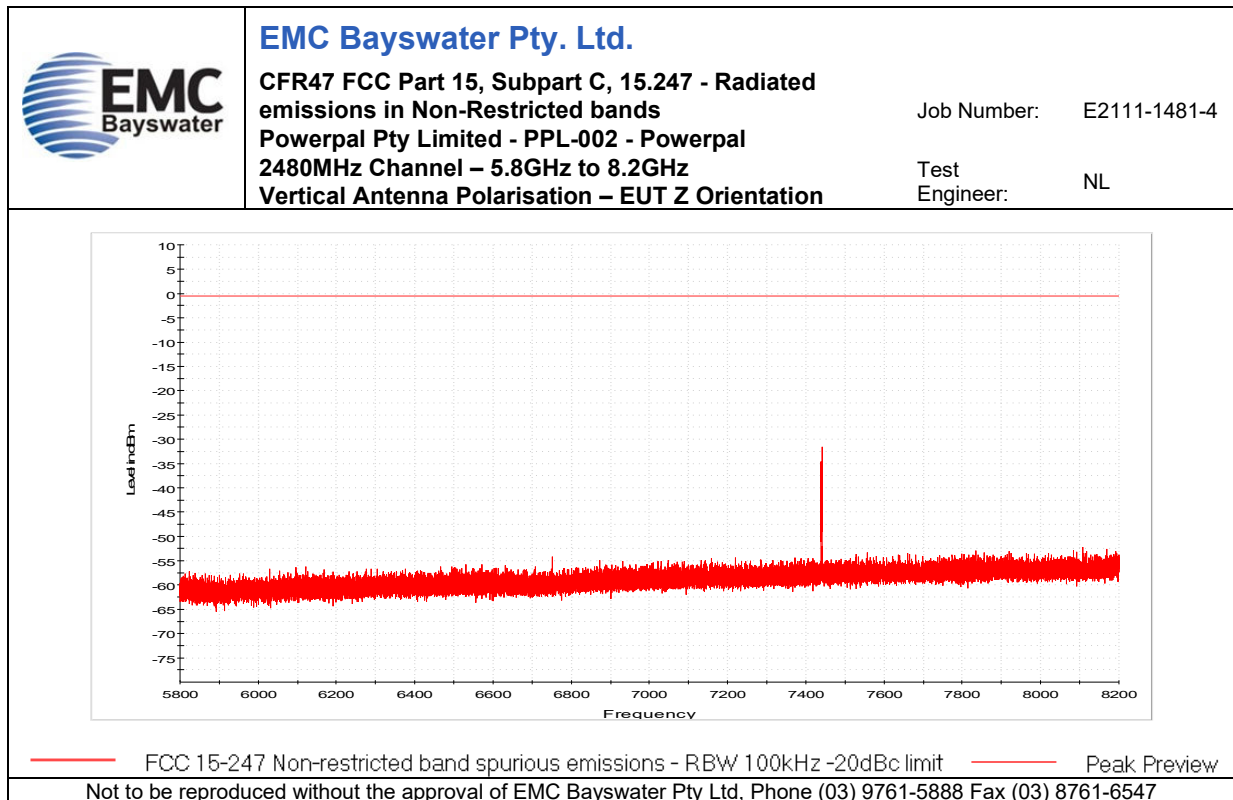
Graph 42



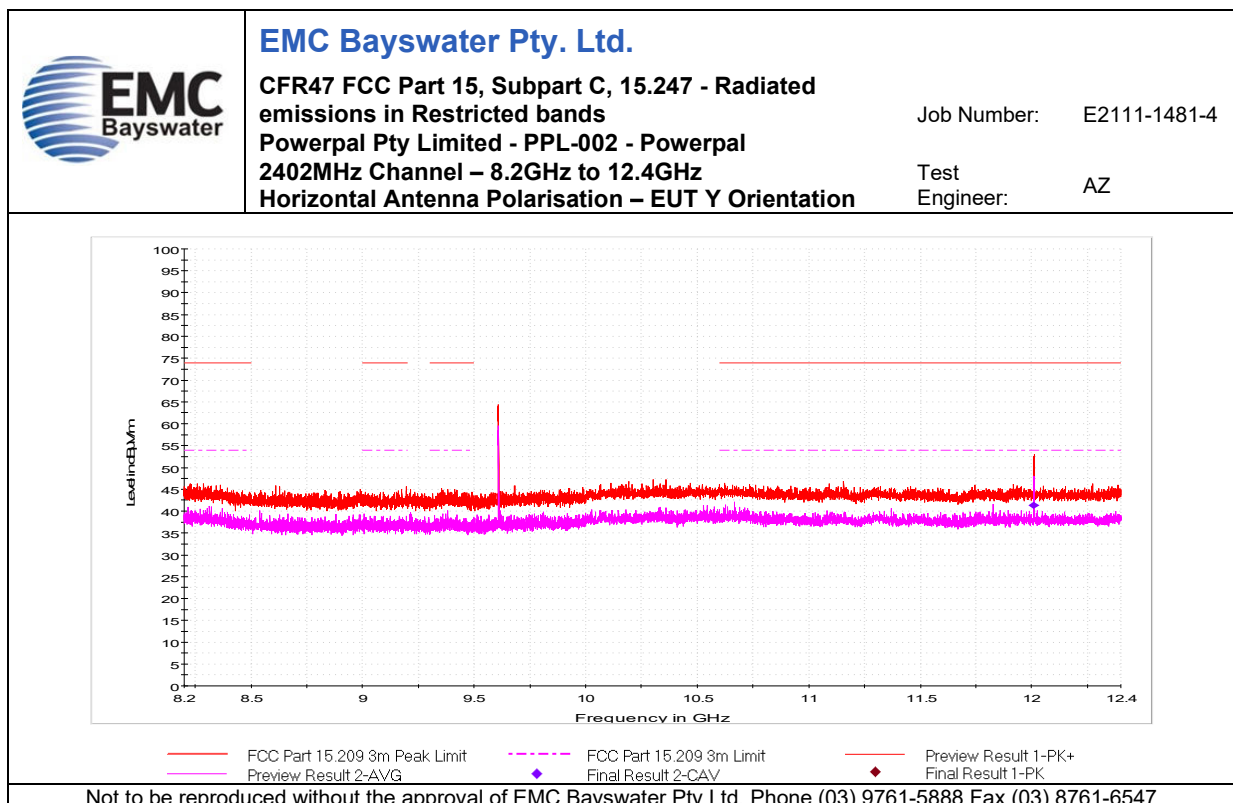
Graph 43



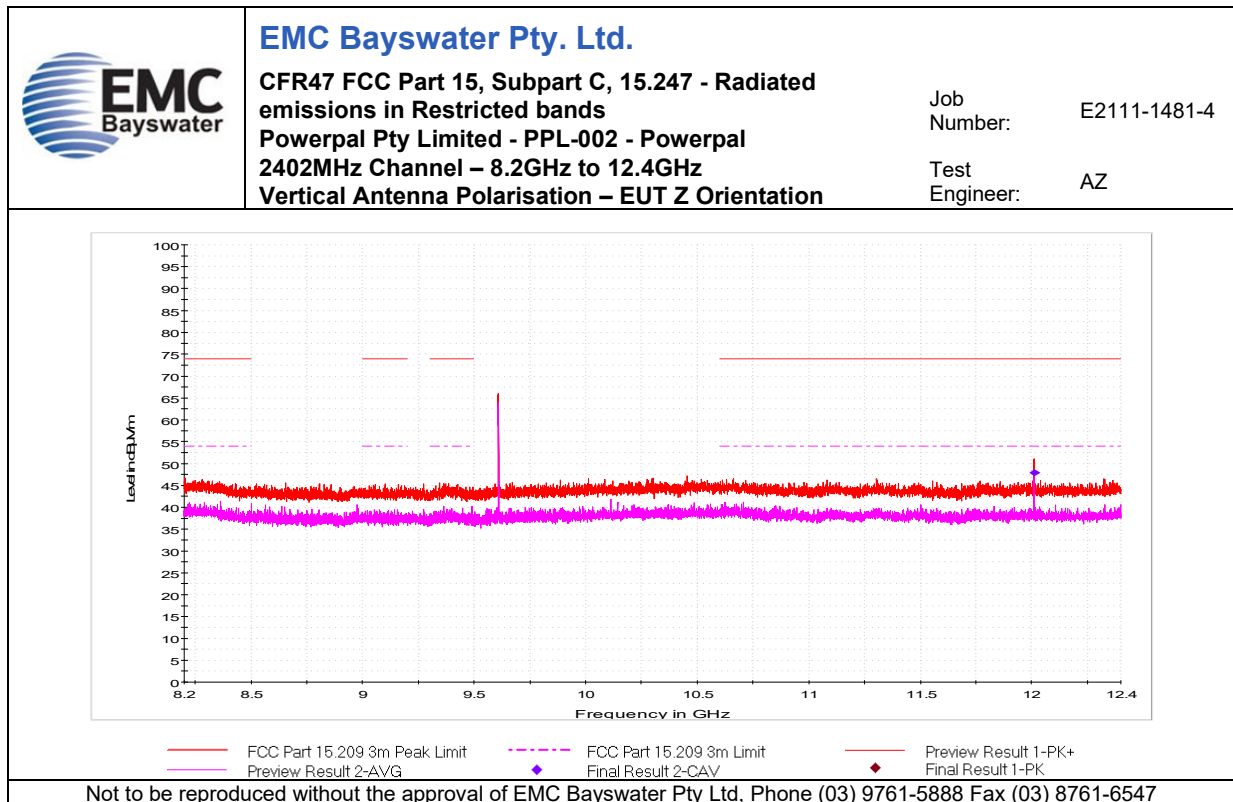
Graph 44



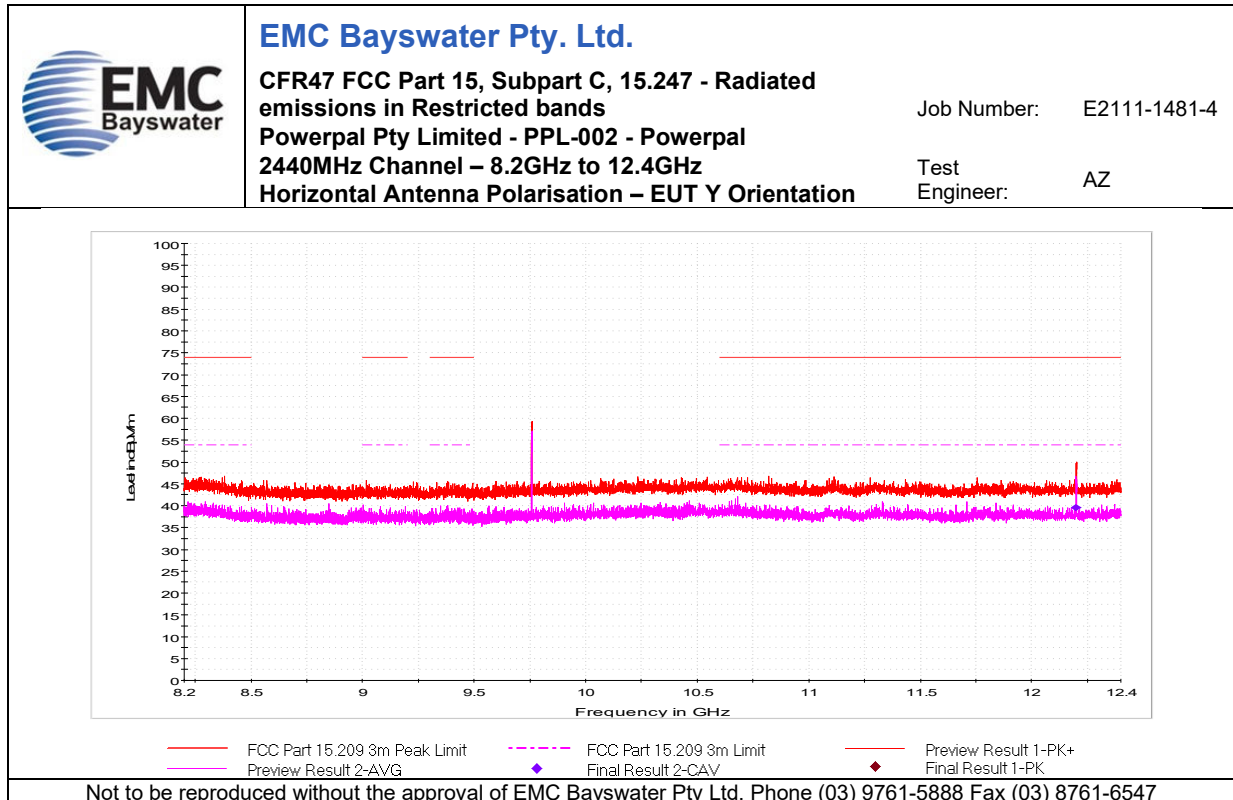
Graph 45



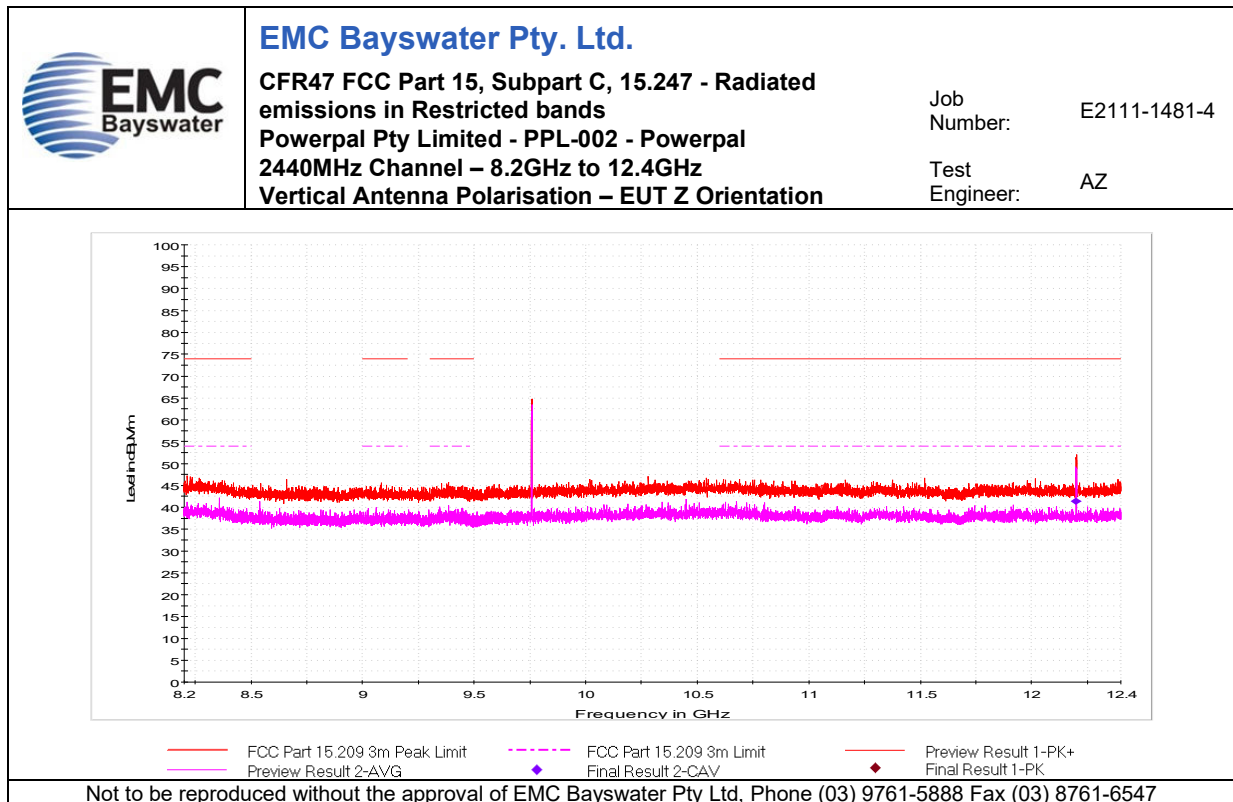
Graph 46



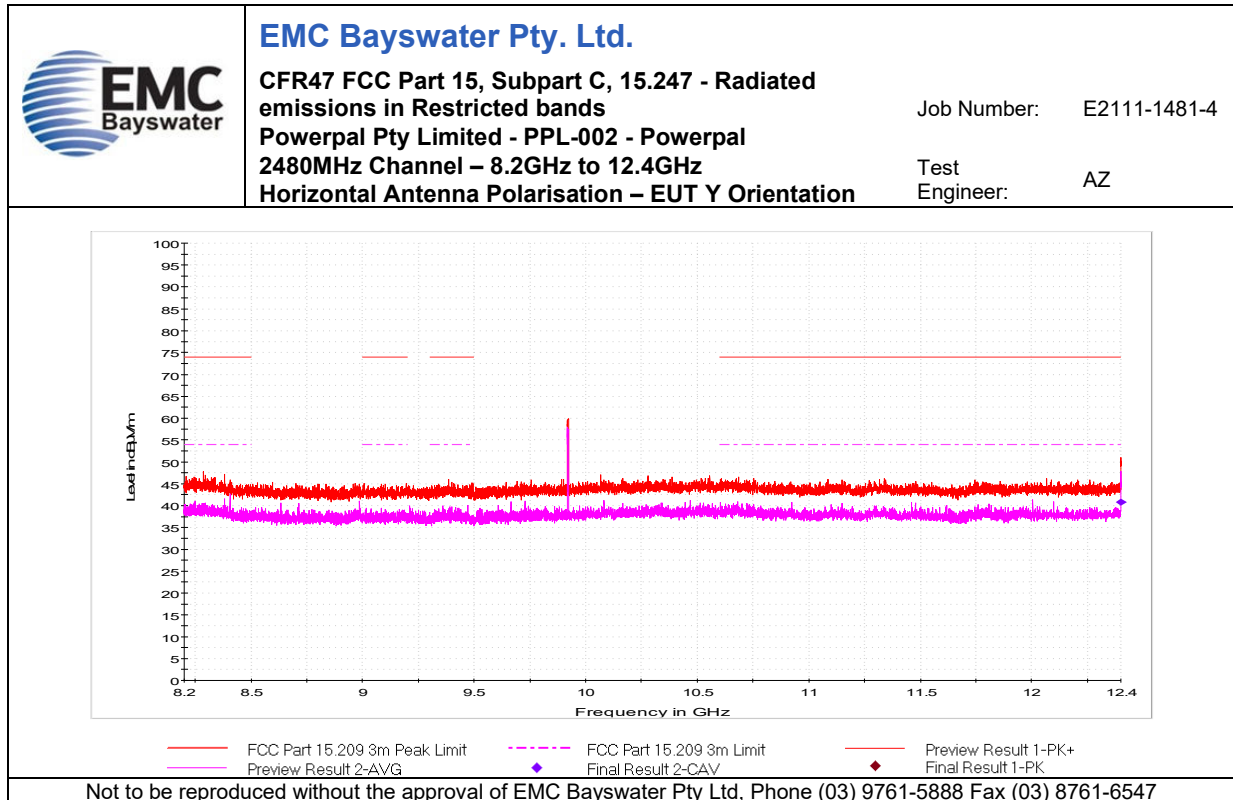
Graph 47



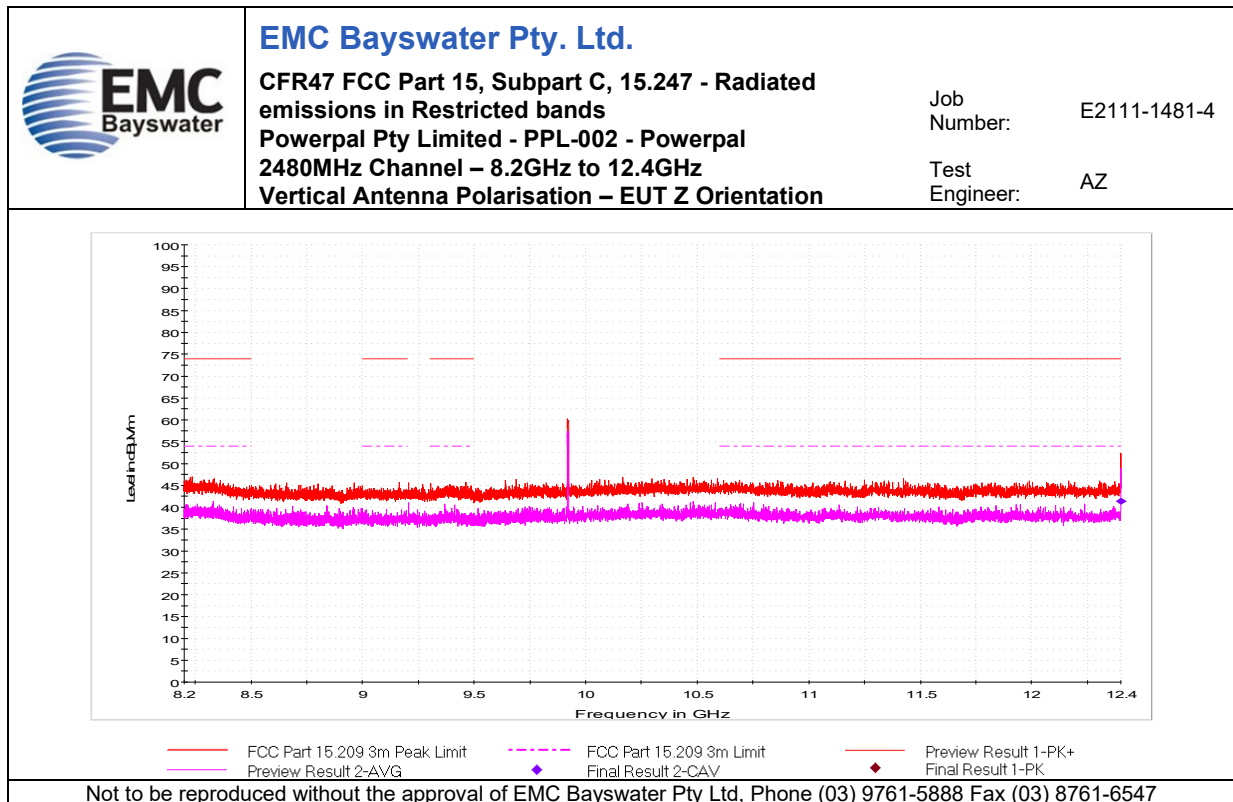
Graph 48



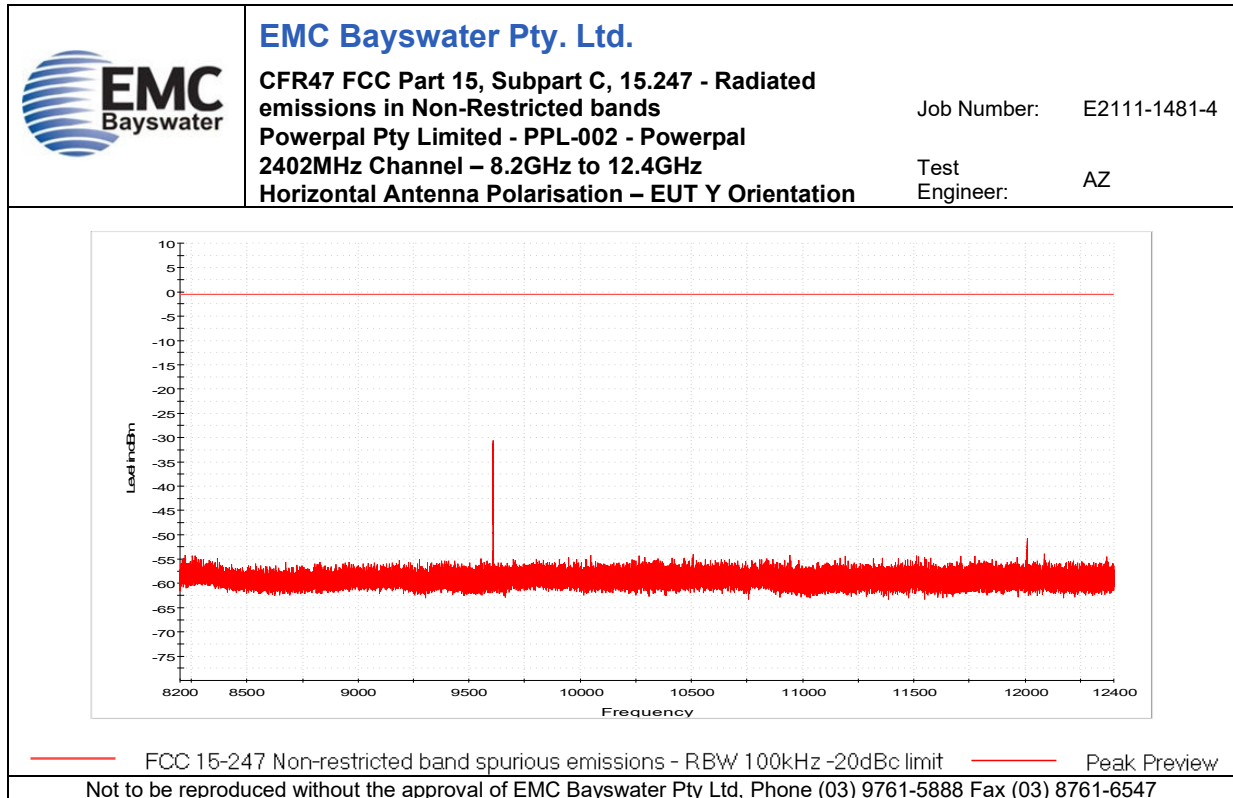
Graph 49



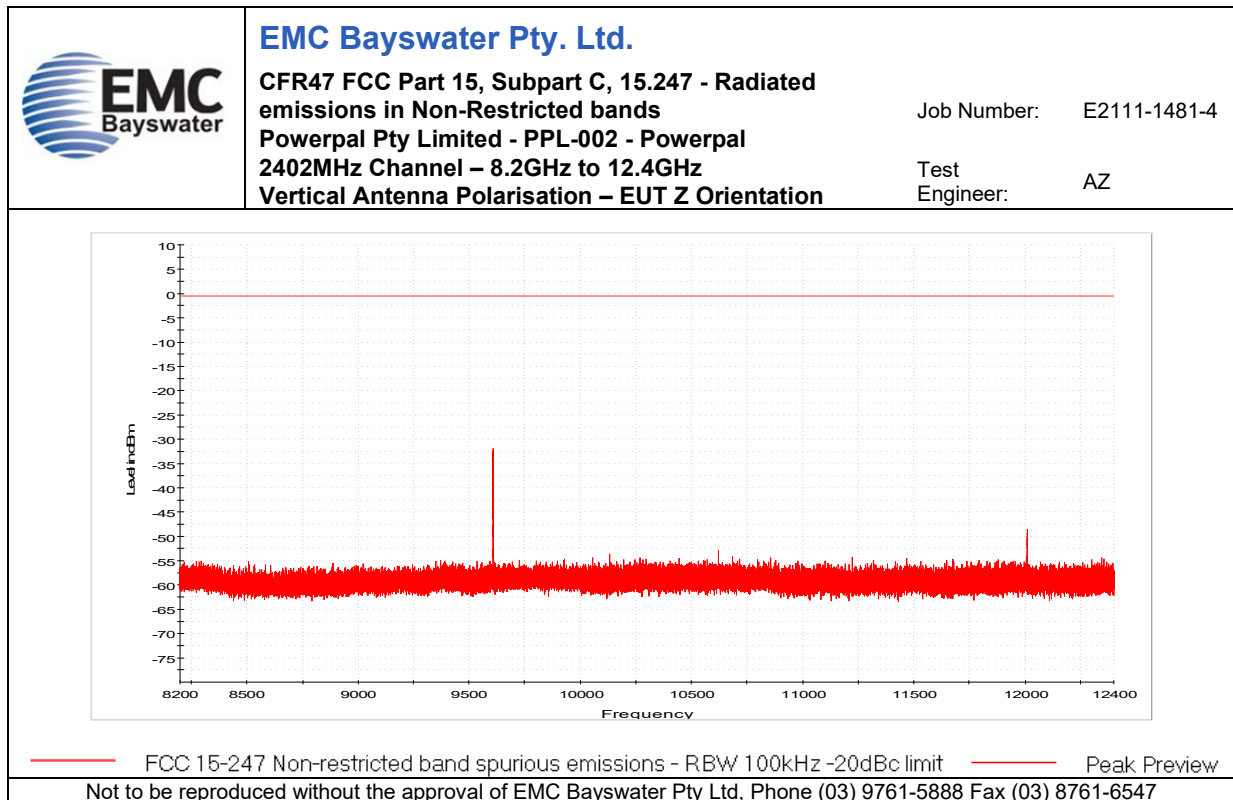
Graph 50



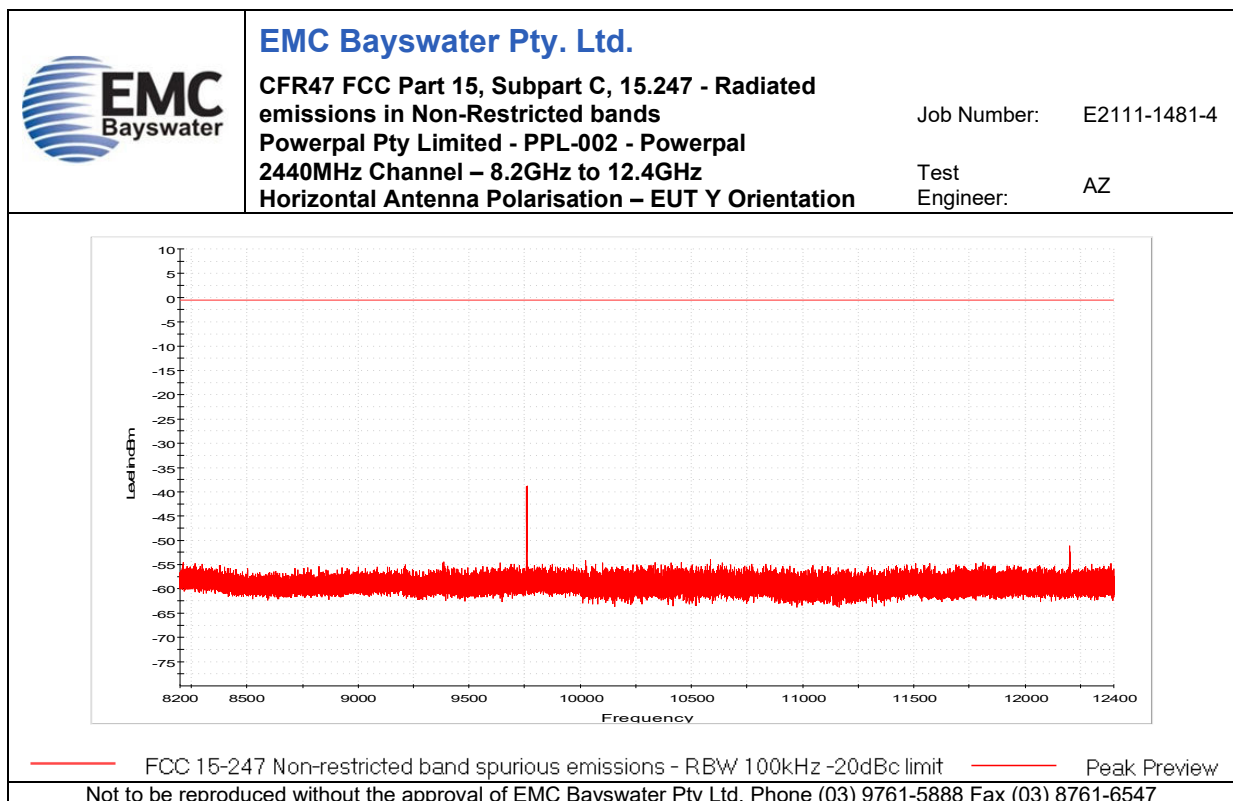
Graph 51



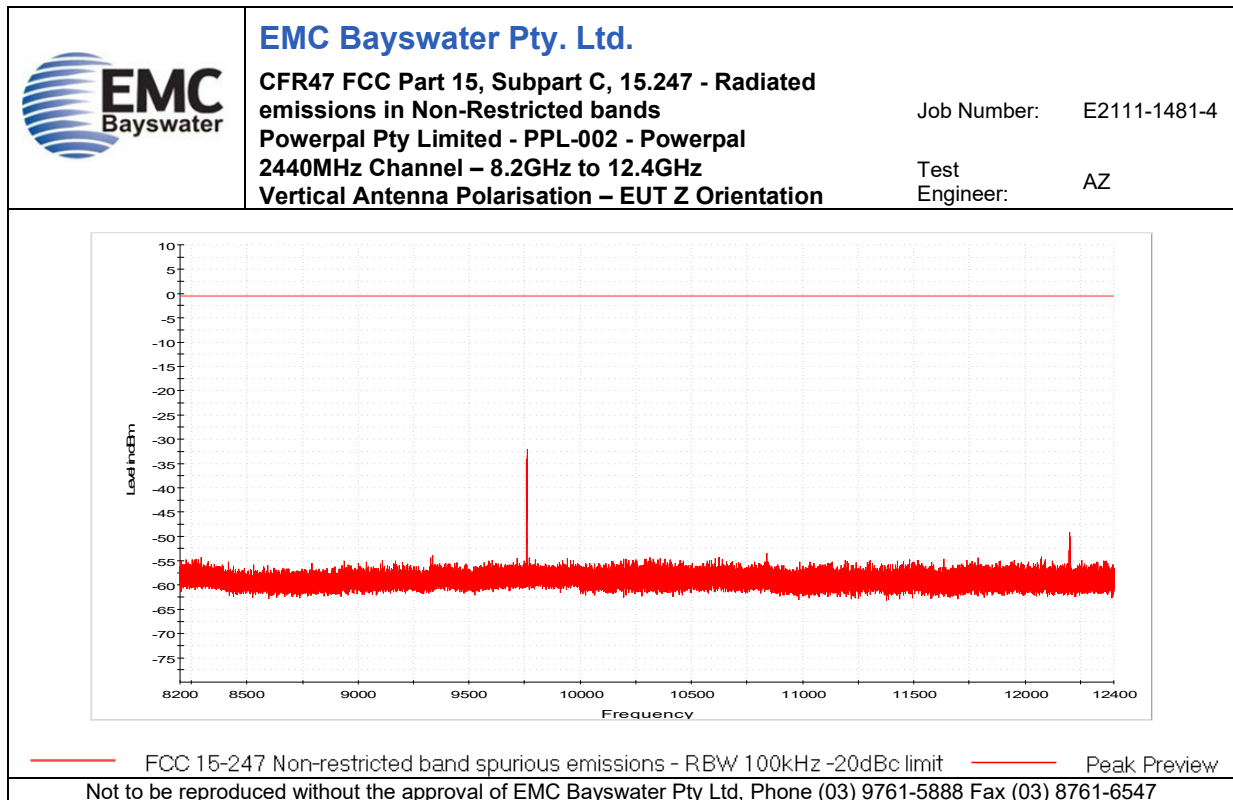
Graph 52



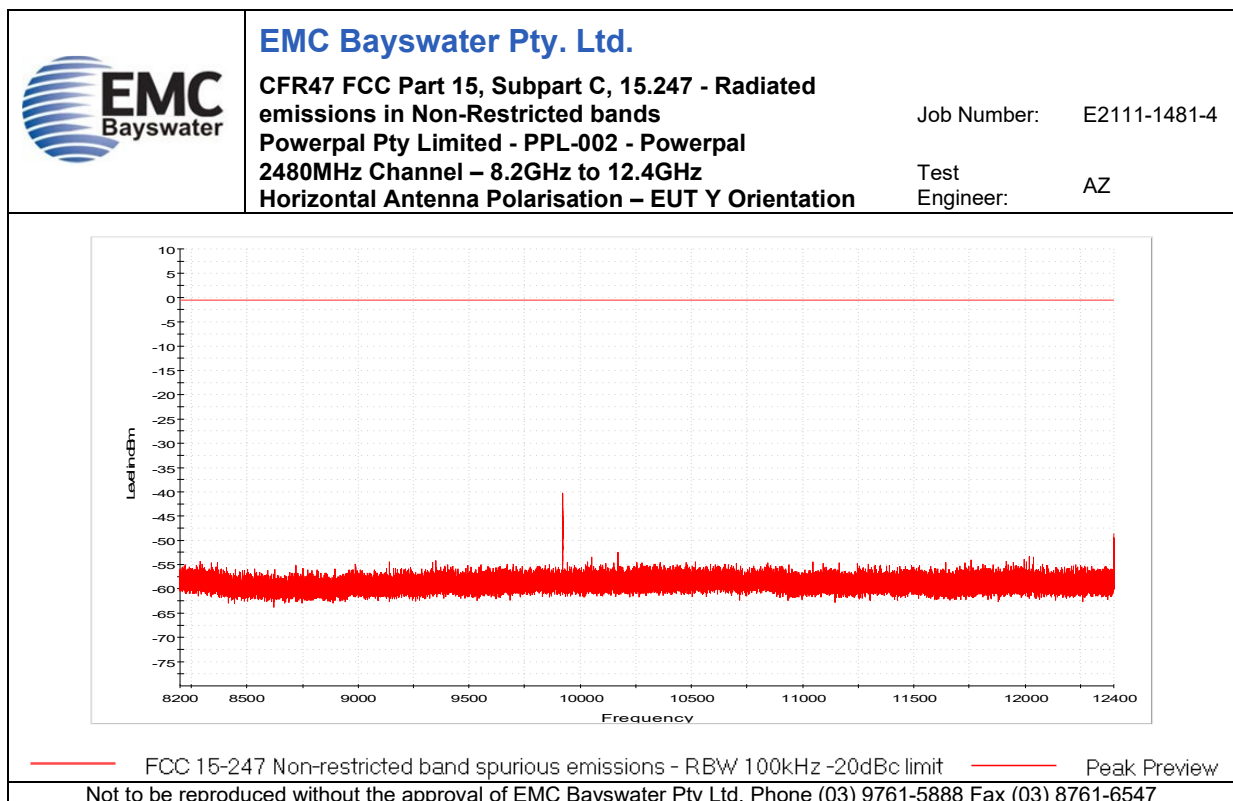
Graph 53



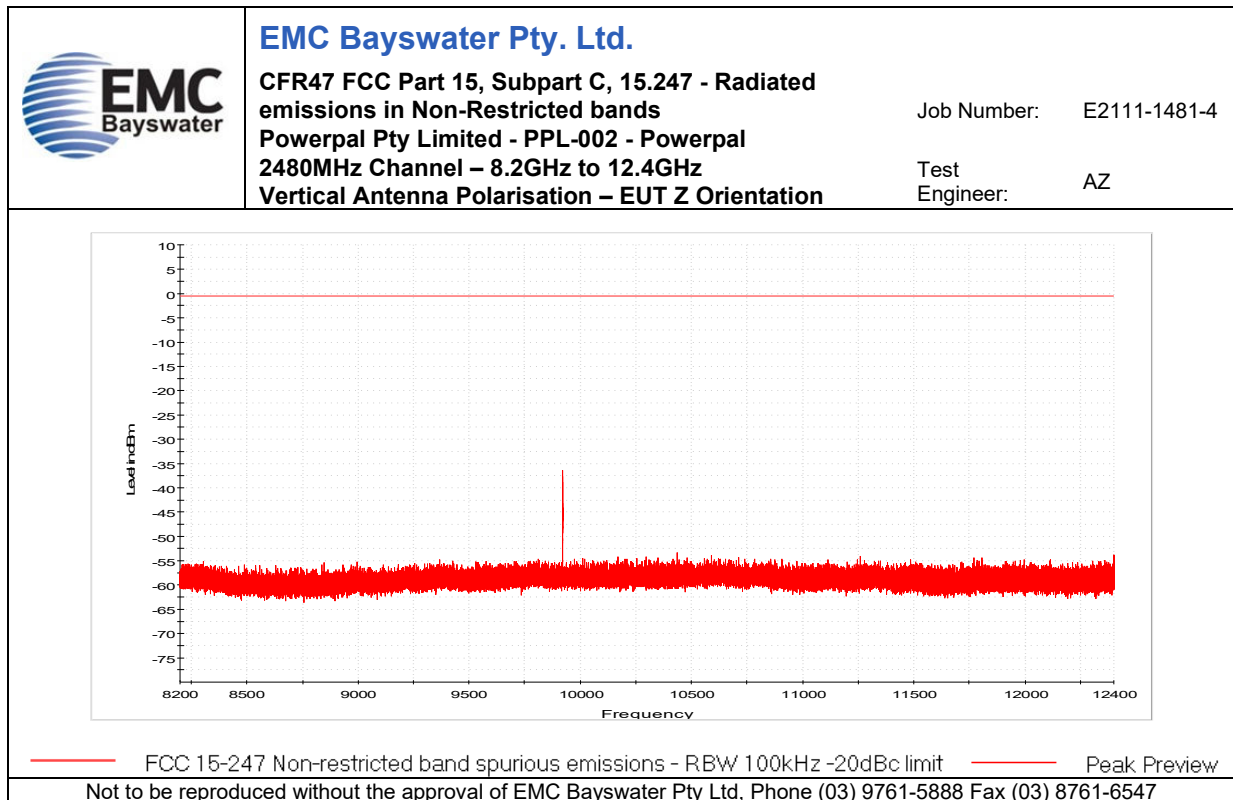
Graph 54



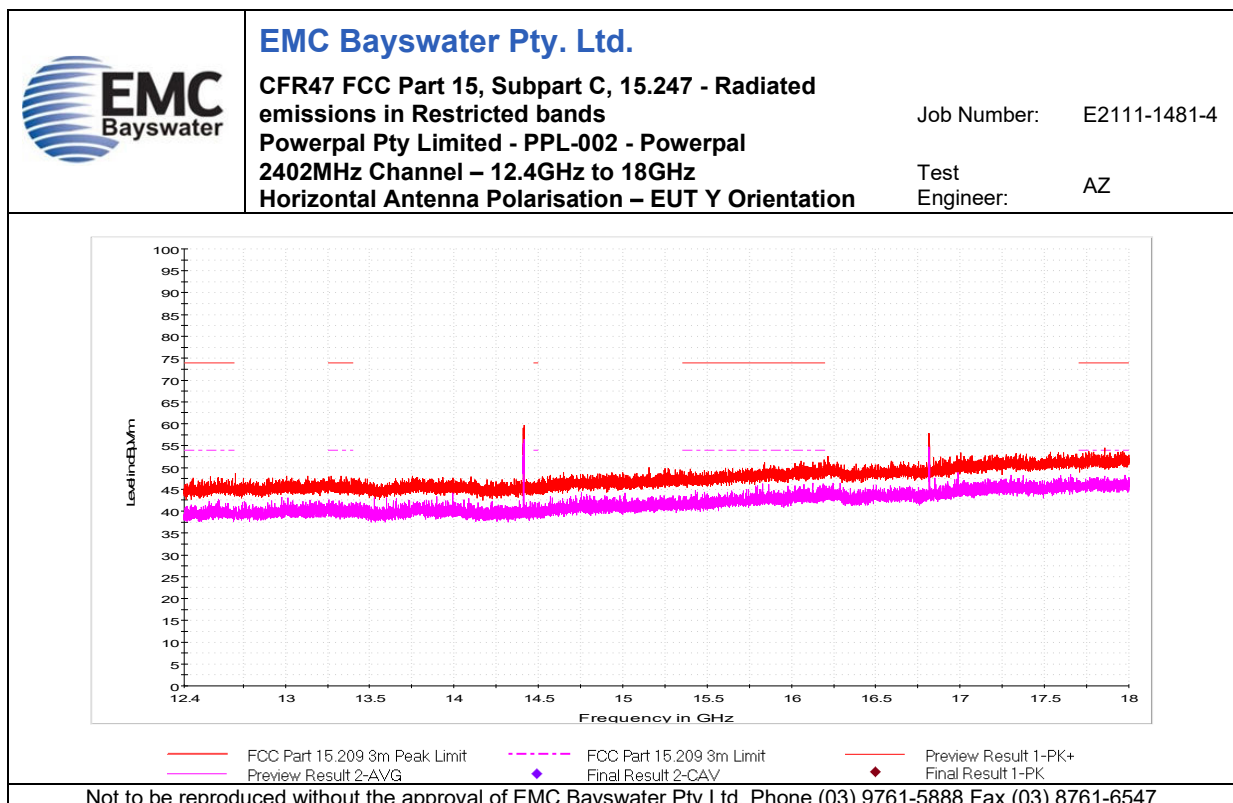
Graph 55



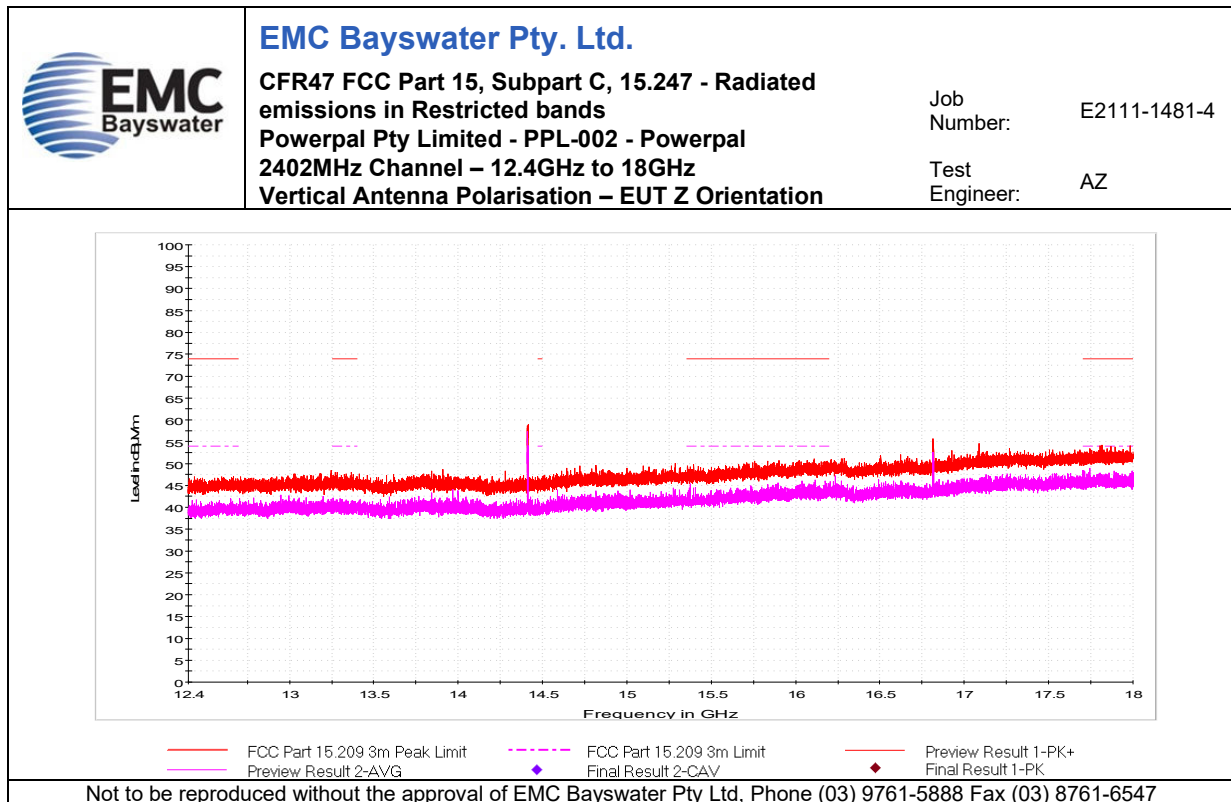
Graph 56



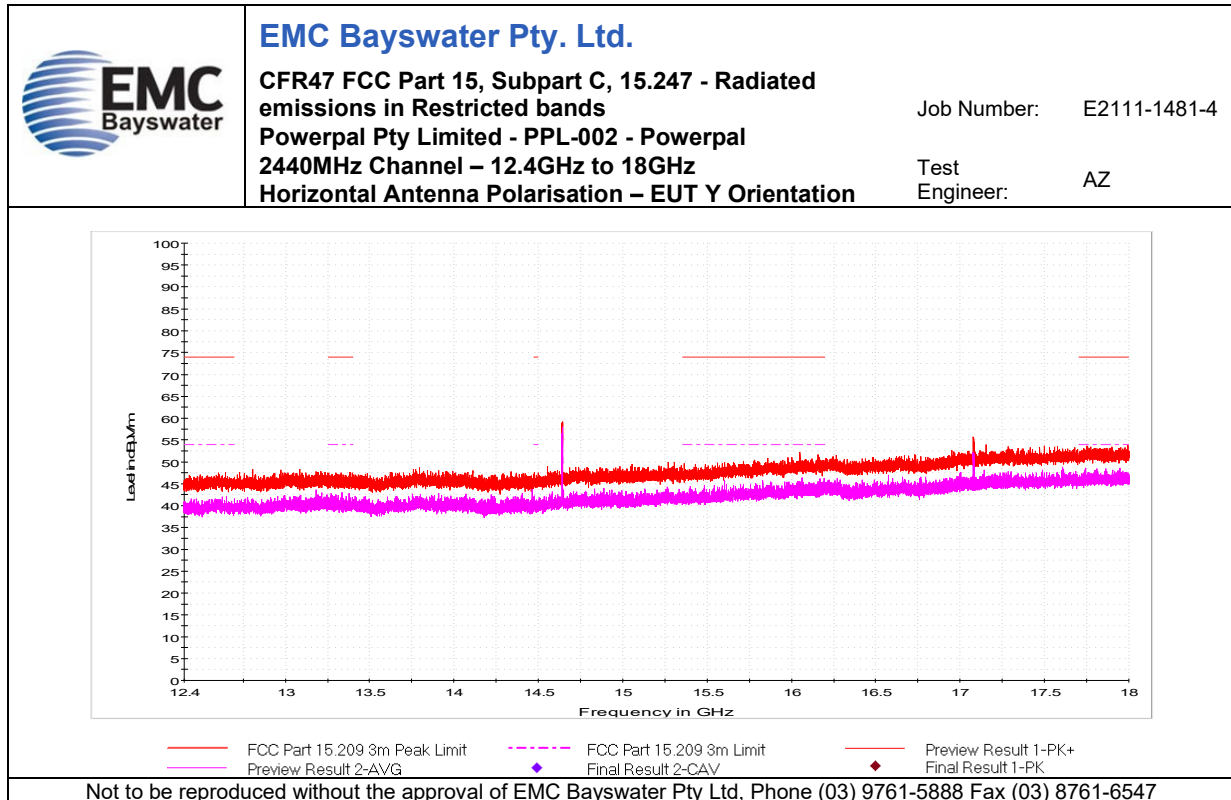
Graph 57



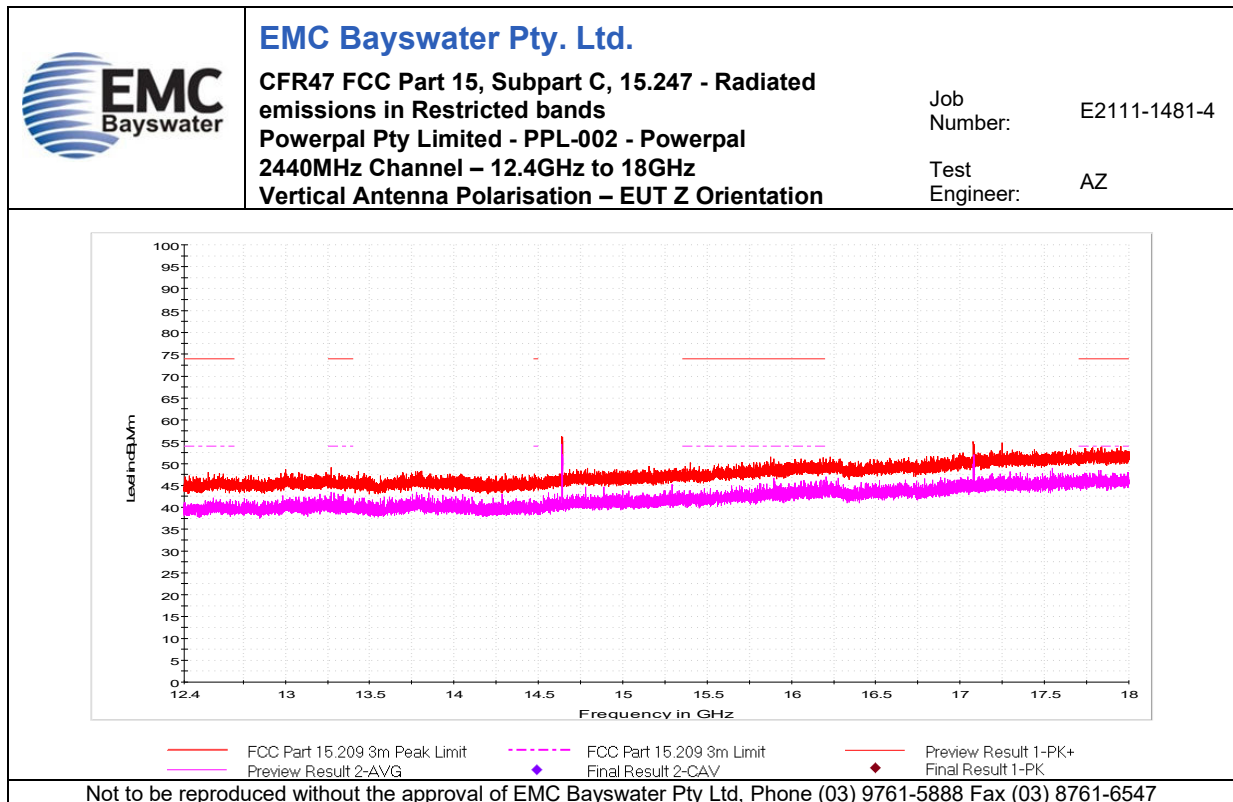
Graph 58



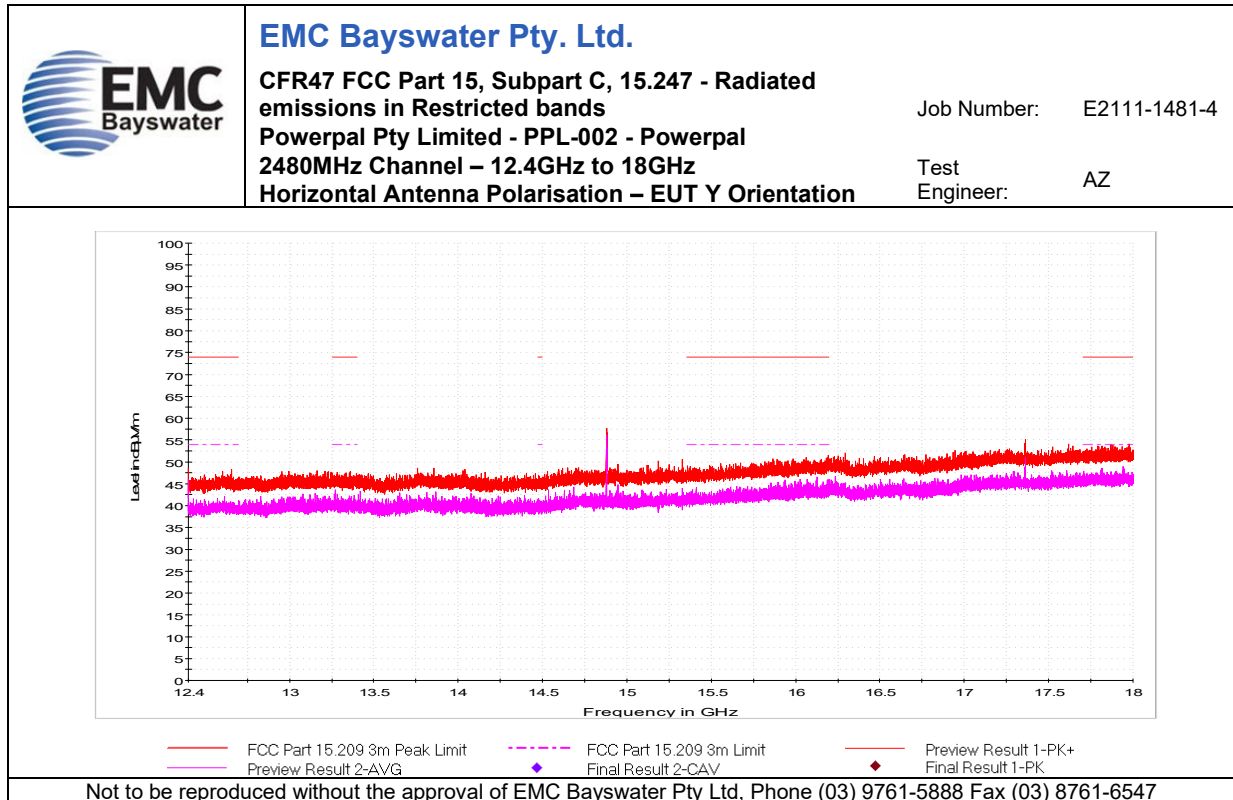
Graph 59



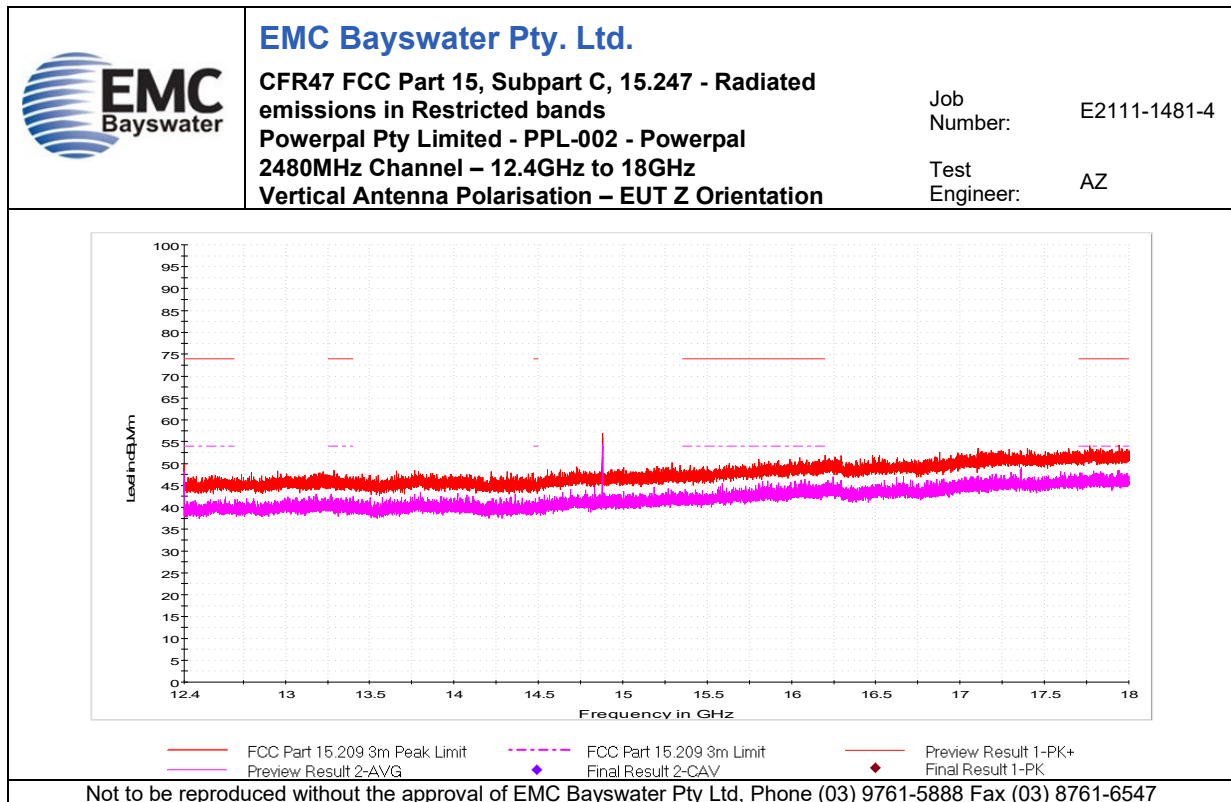
Graph 60



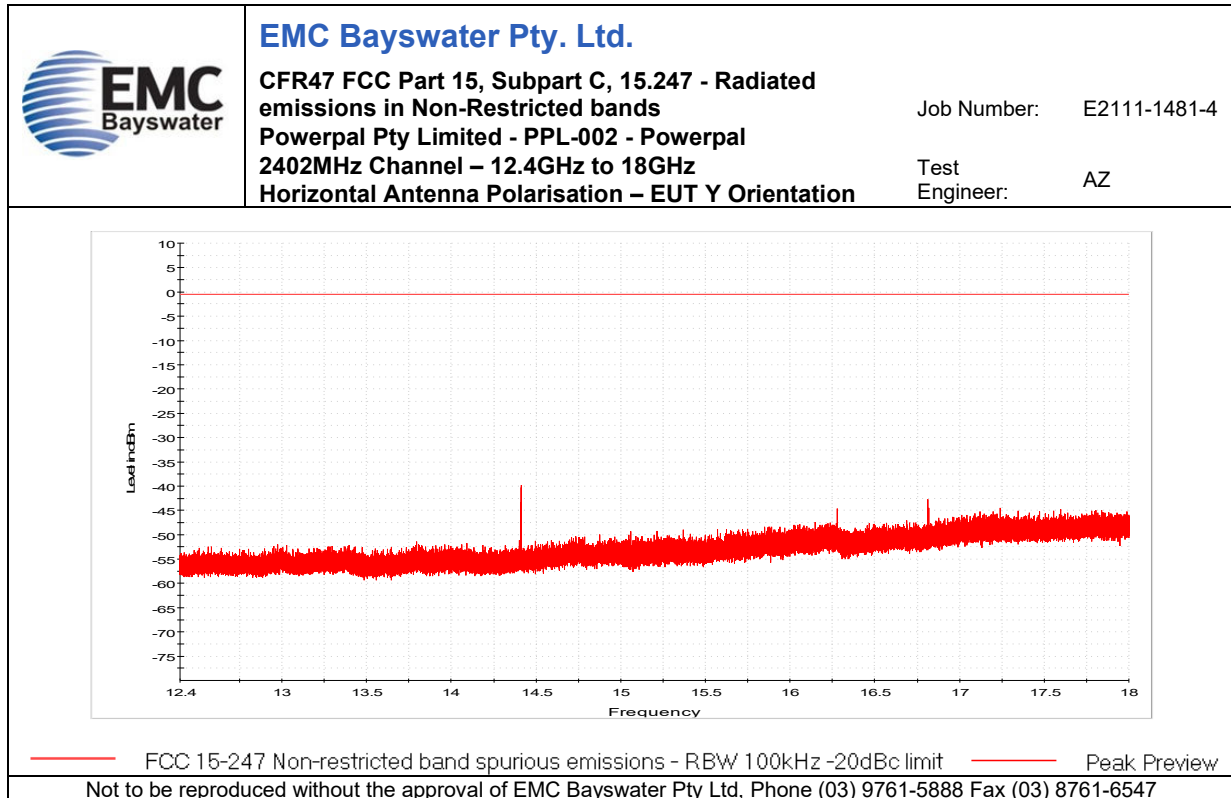
Graph 61



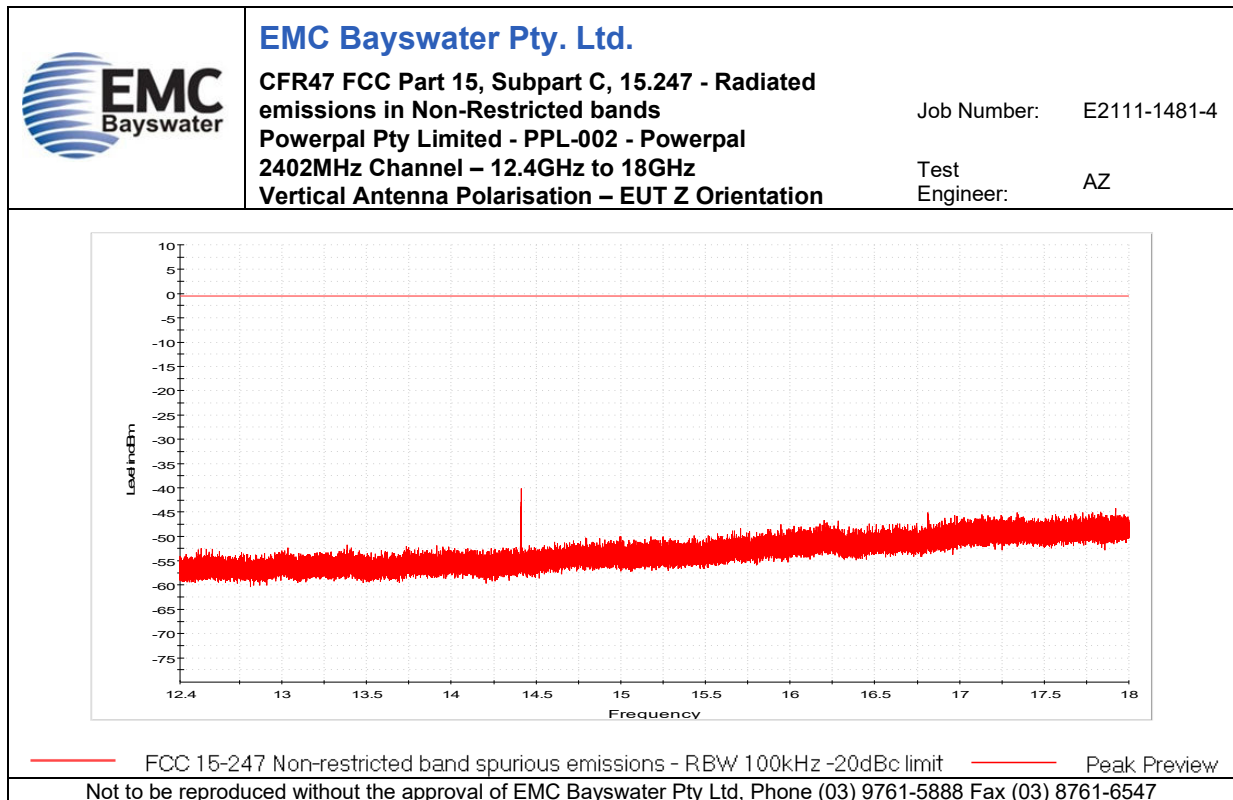
Graph 62



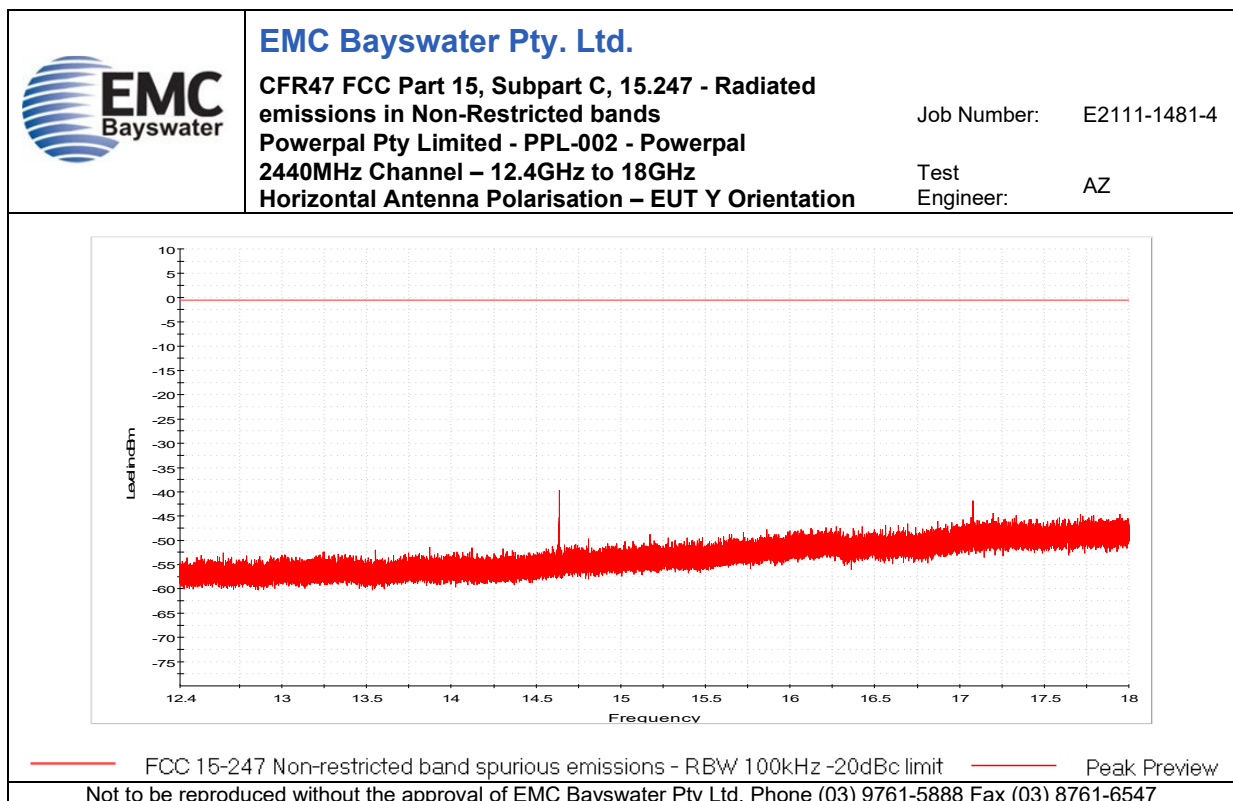
Graph 63



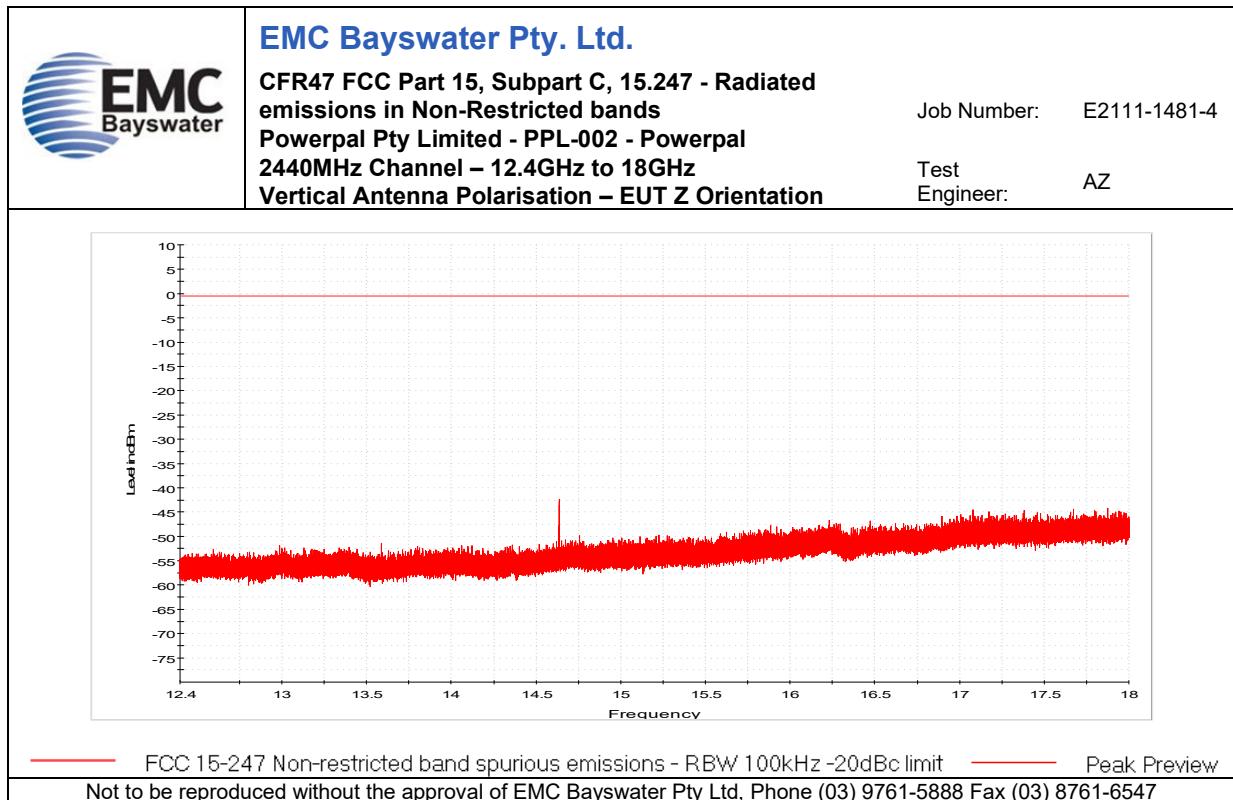
Graph 64



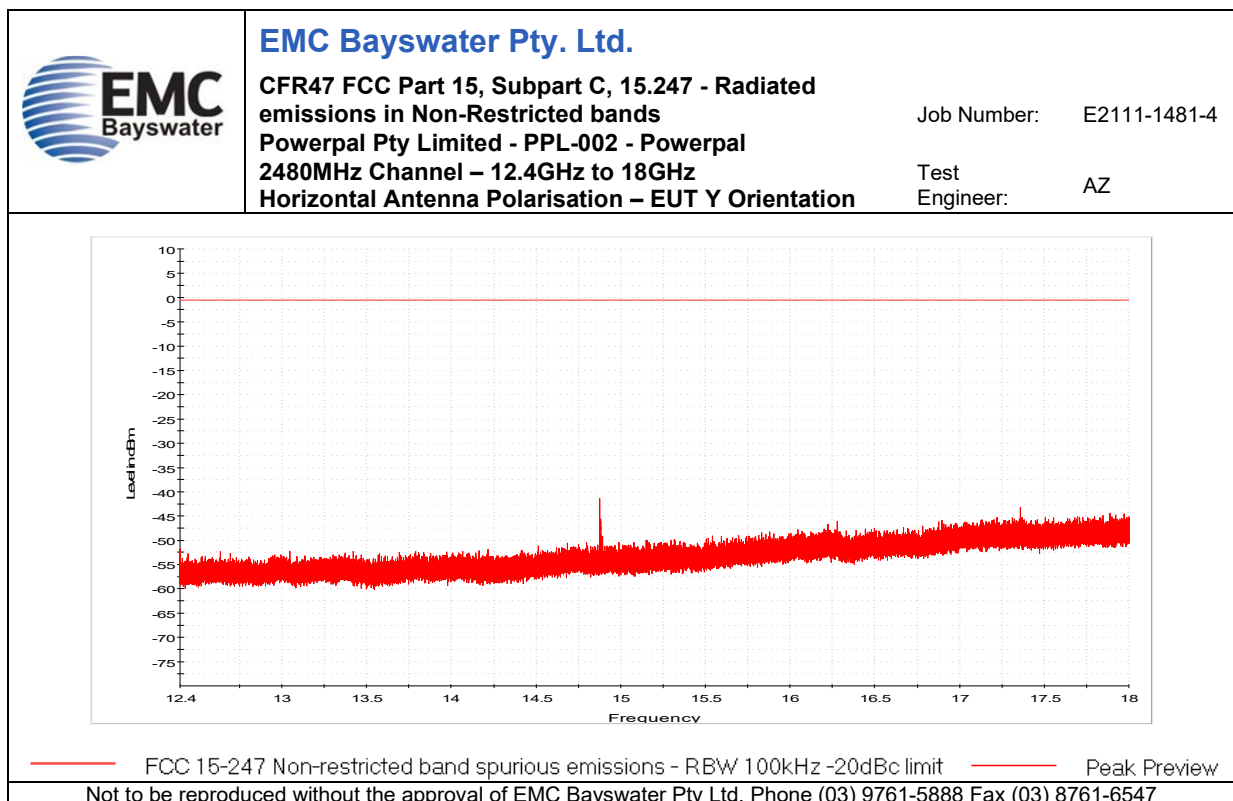
Graph 65



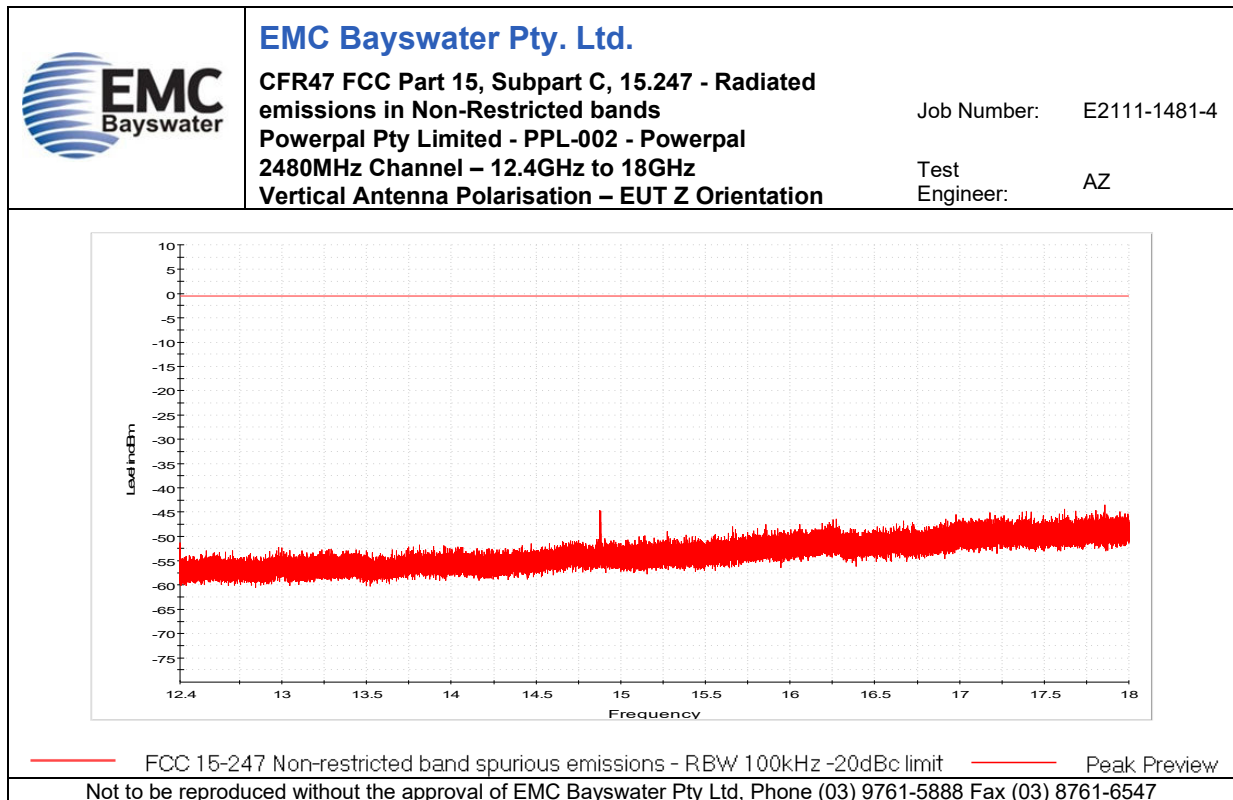
Graph 66



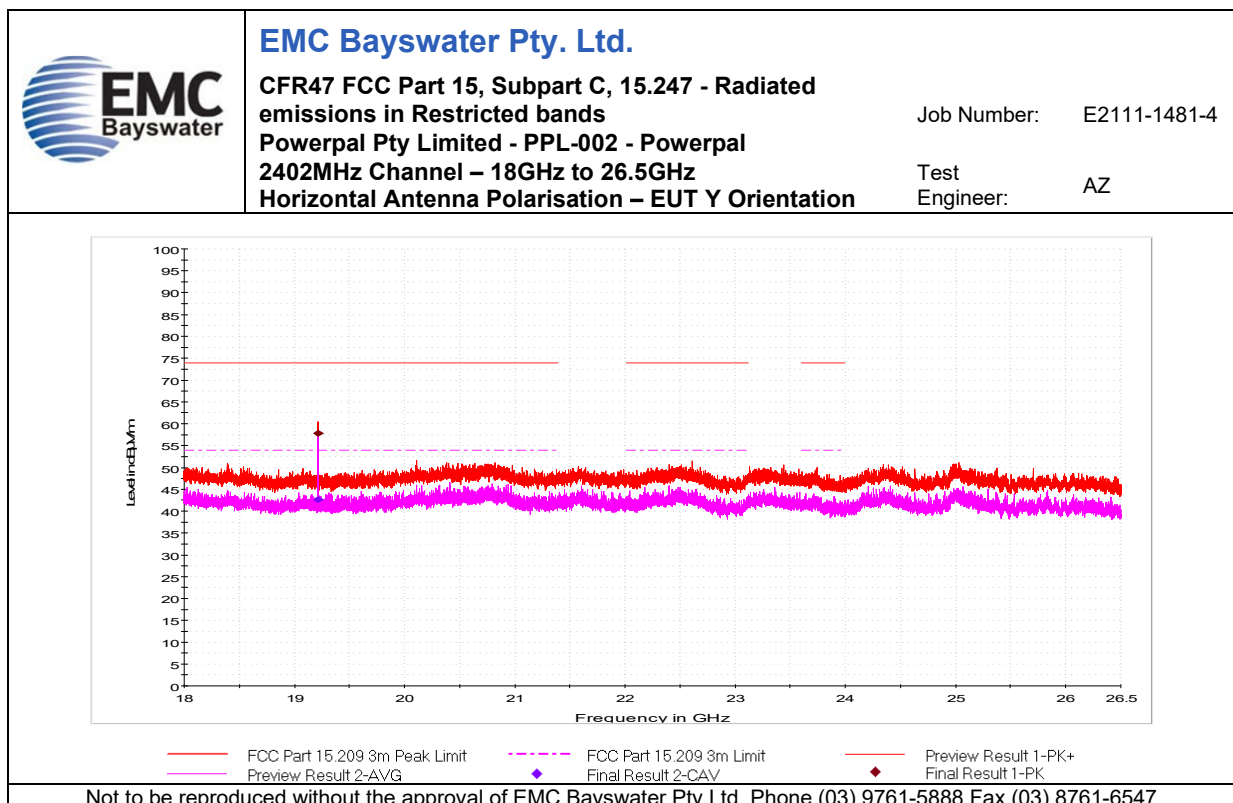
Graph 67



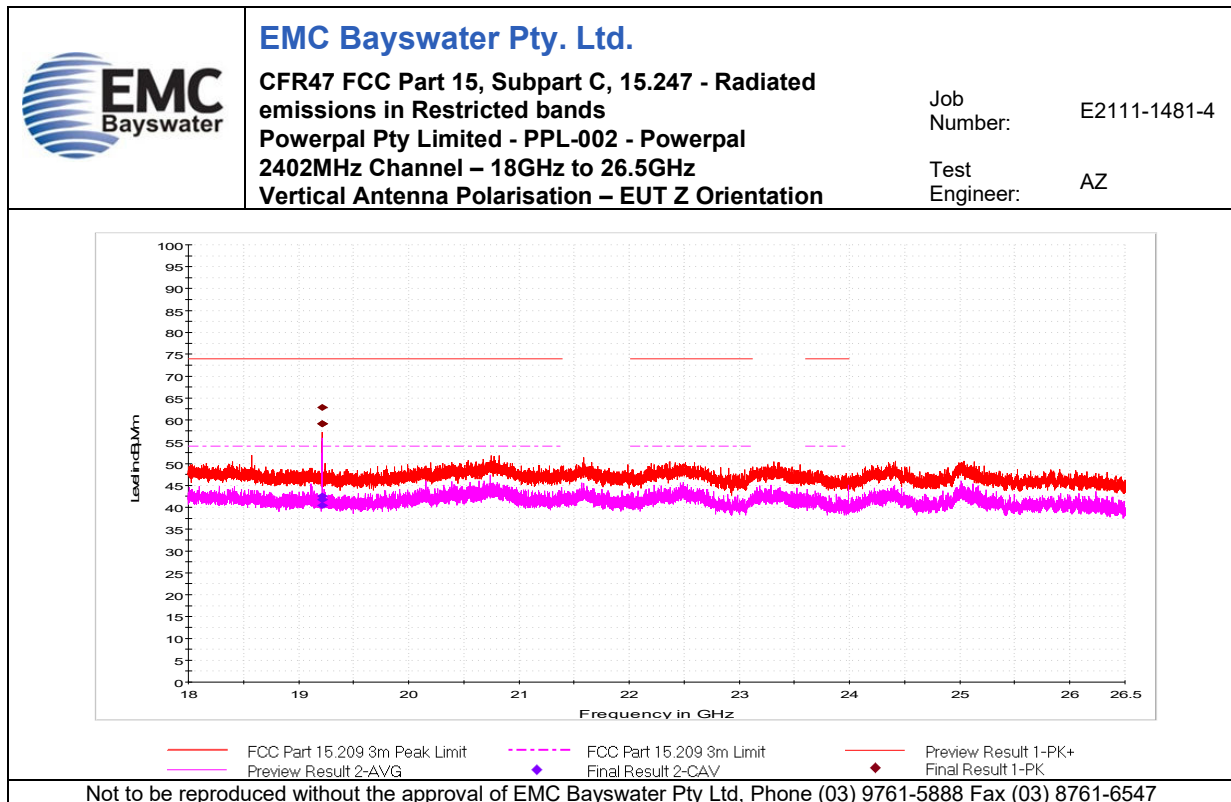
Graph 68



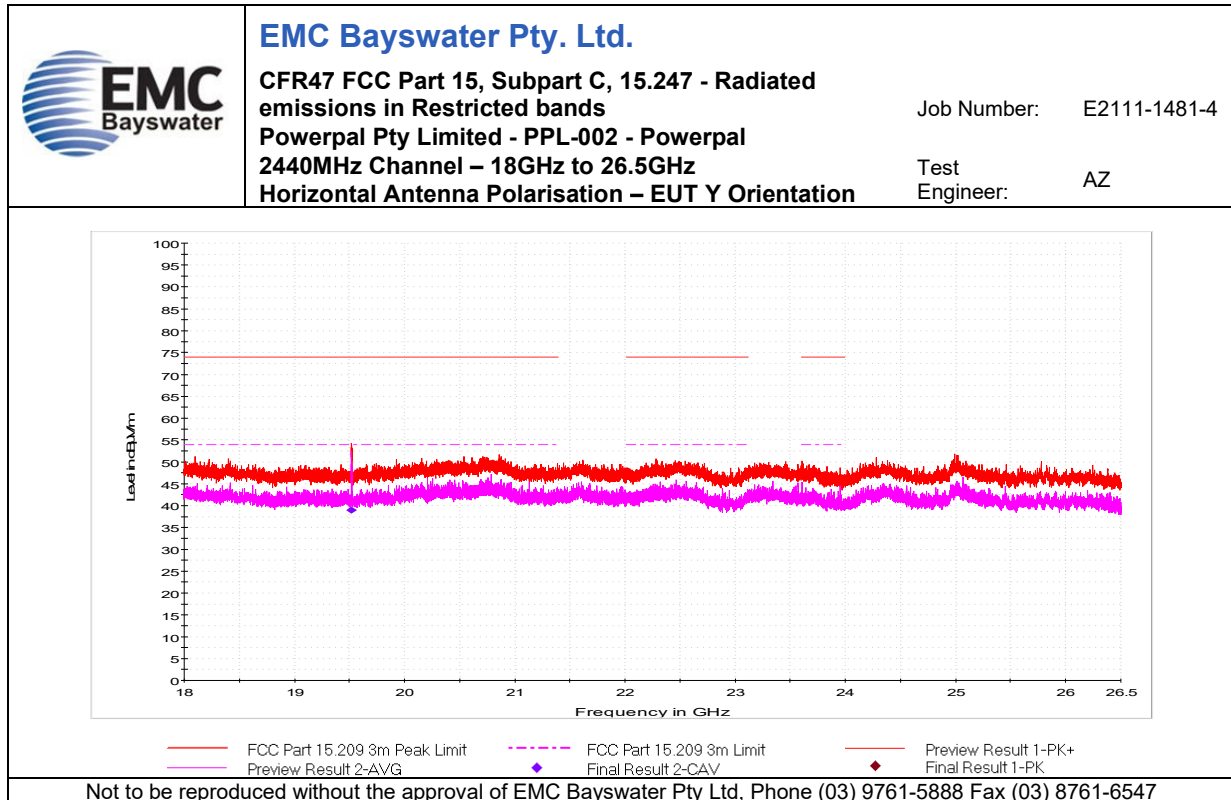
Graph 69



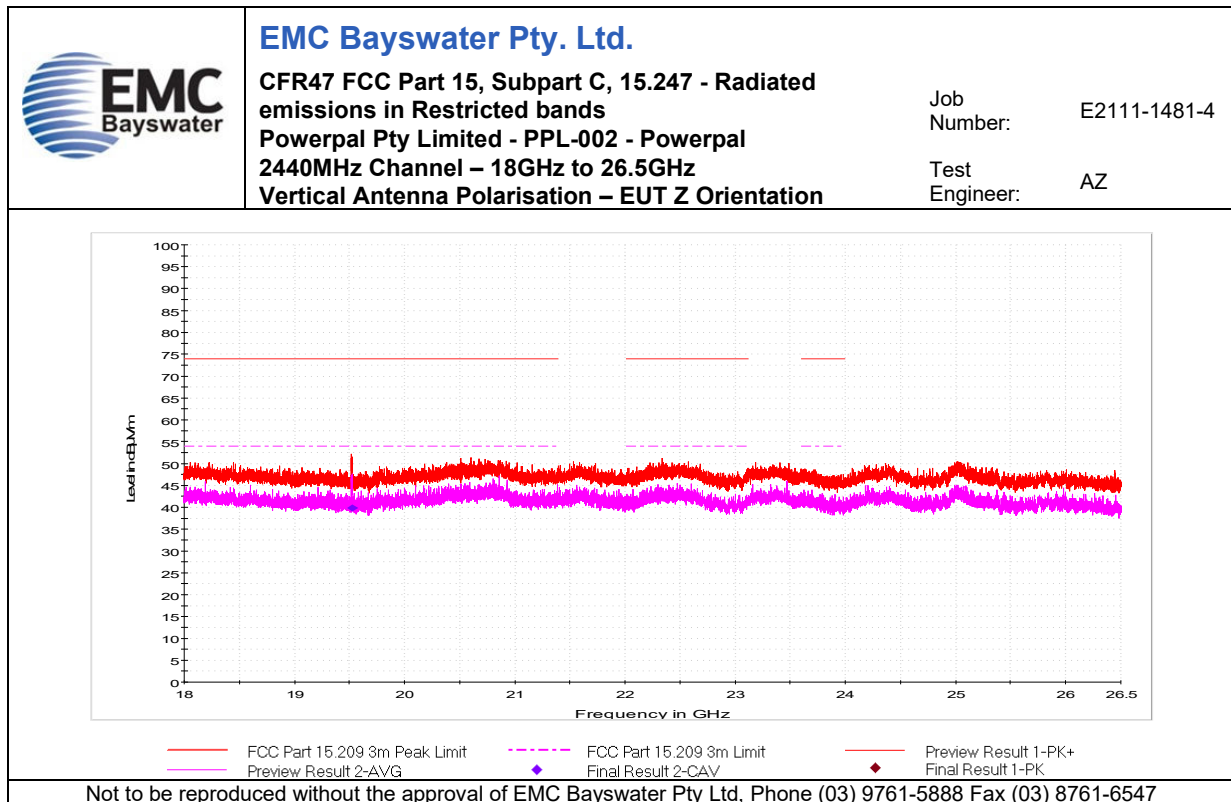
Graph 70



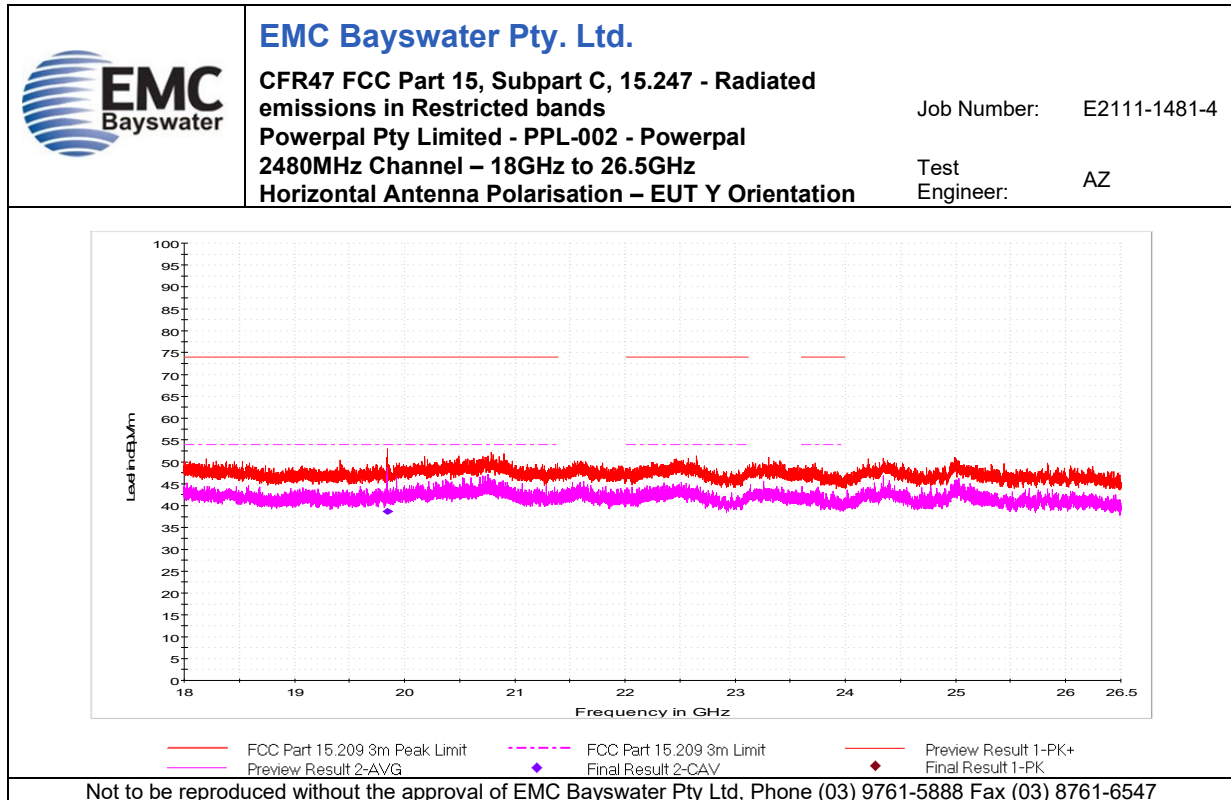
Graph 71



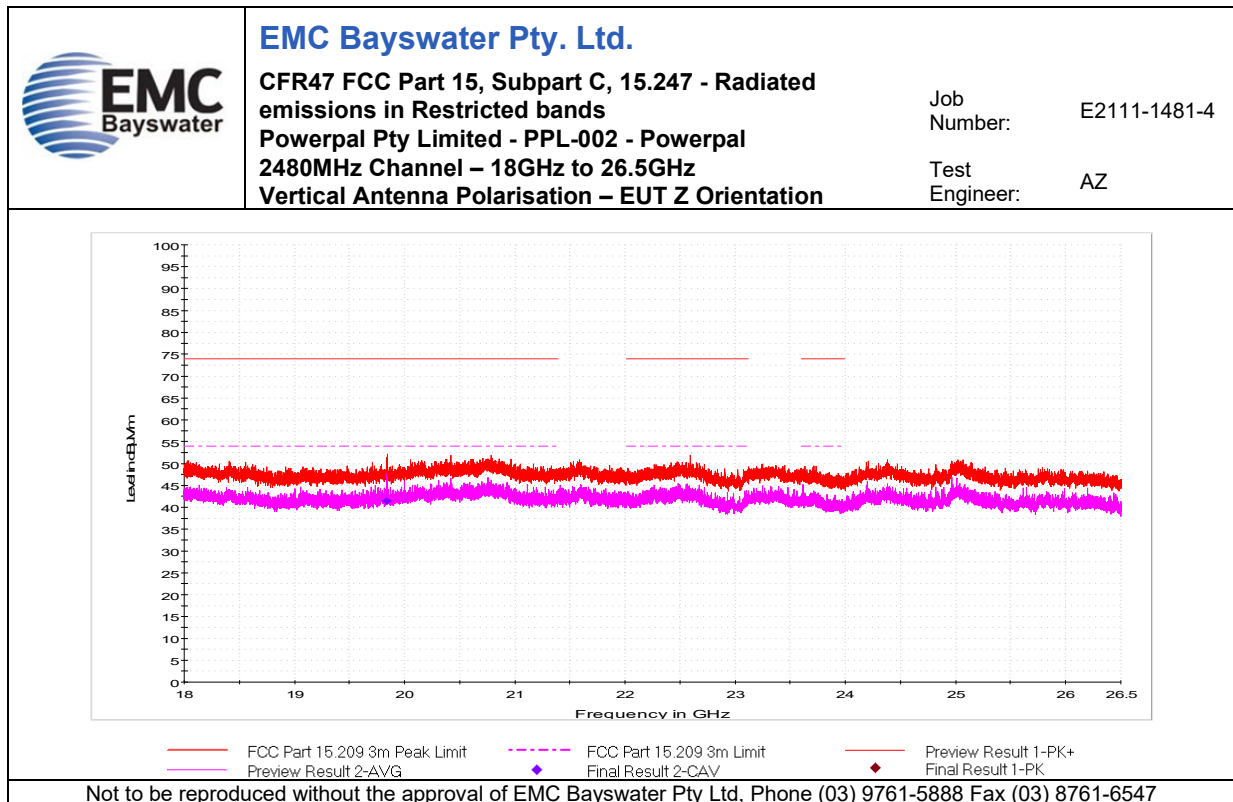
Graph 72



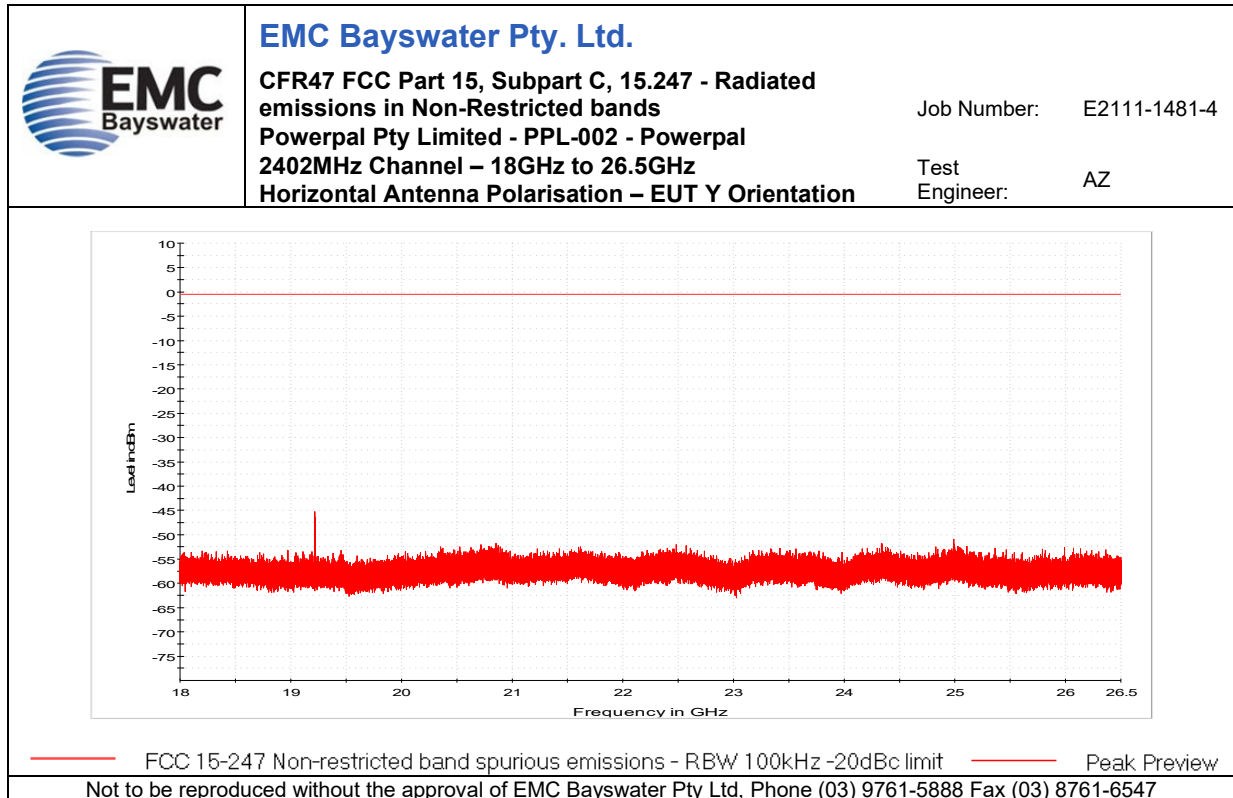
Graph 73



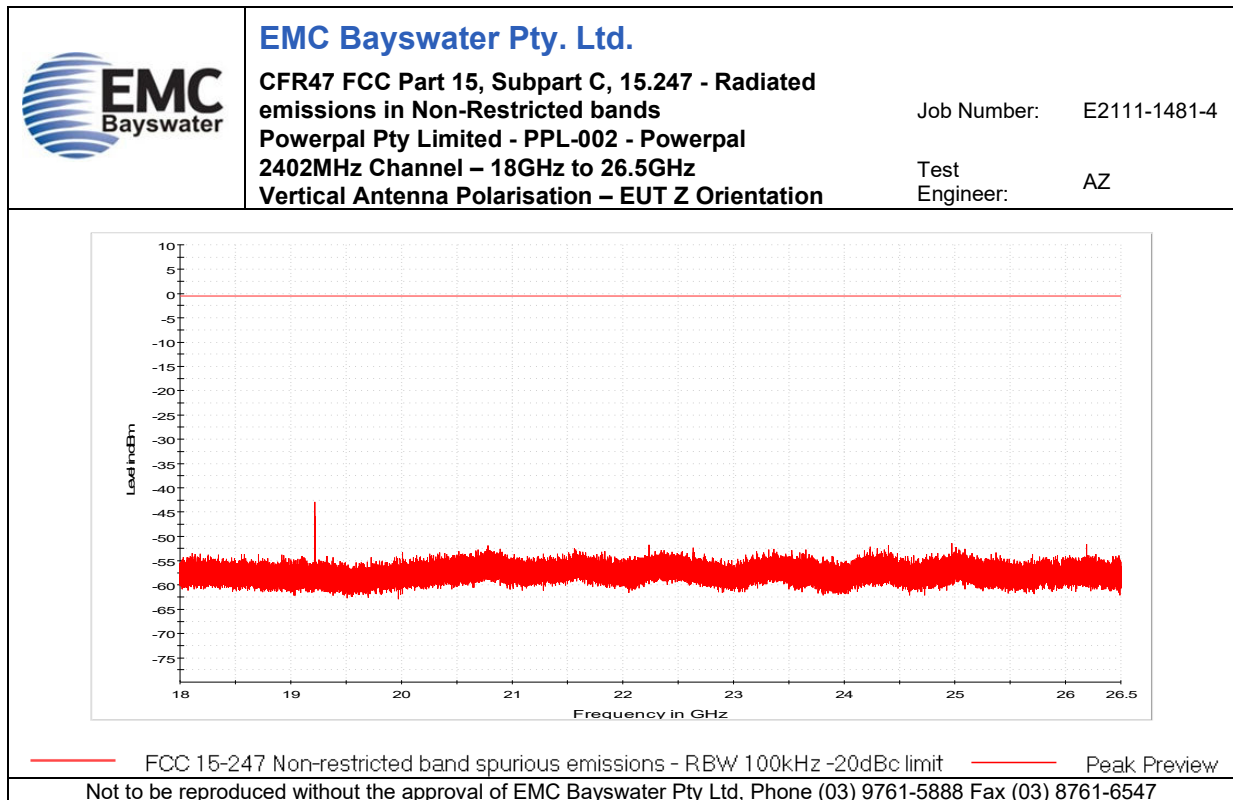
Graph 74



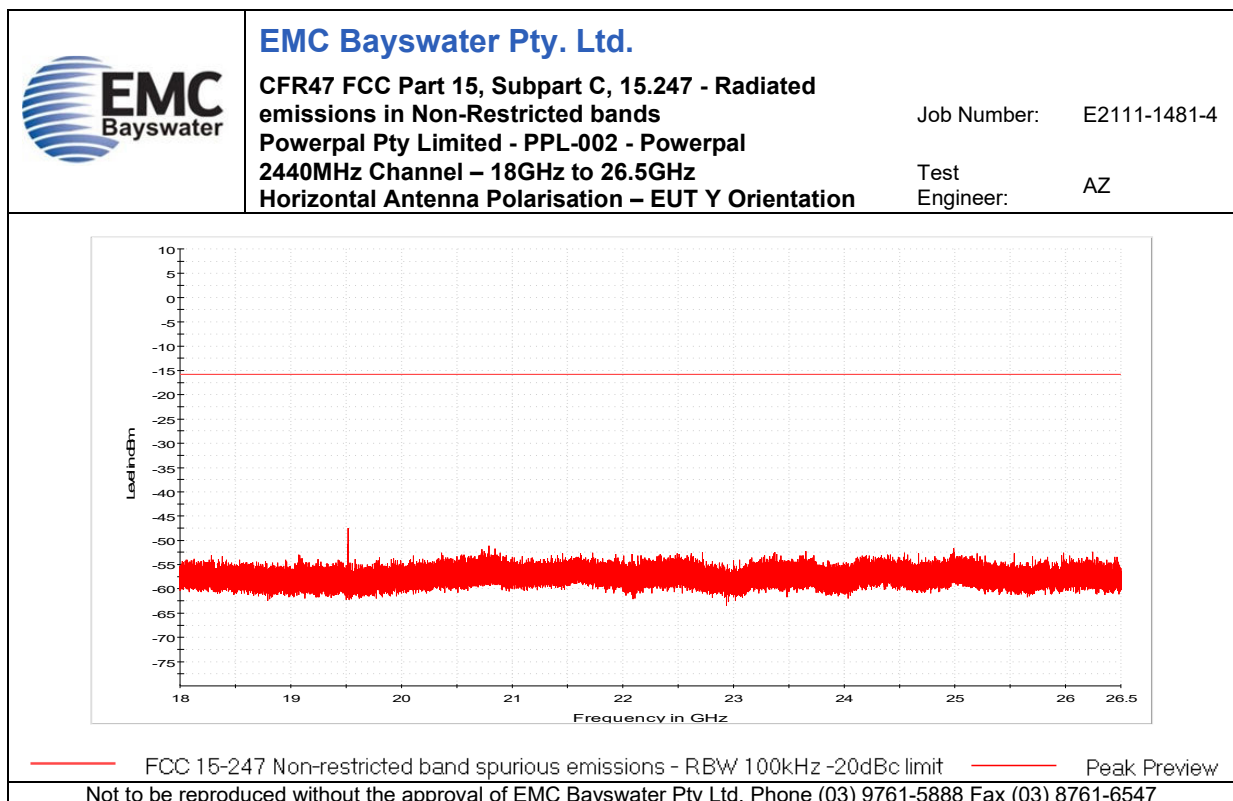
Graph 75



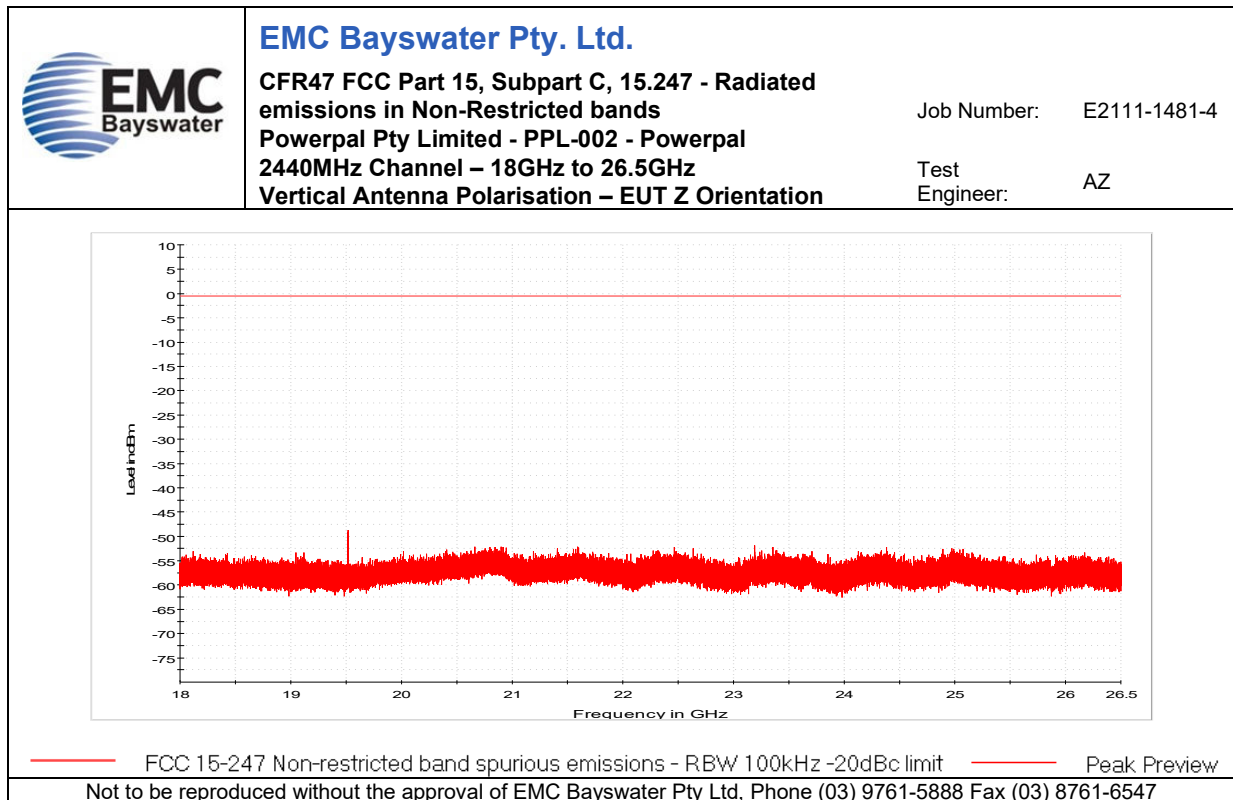
Graph 76



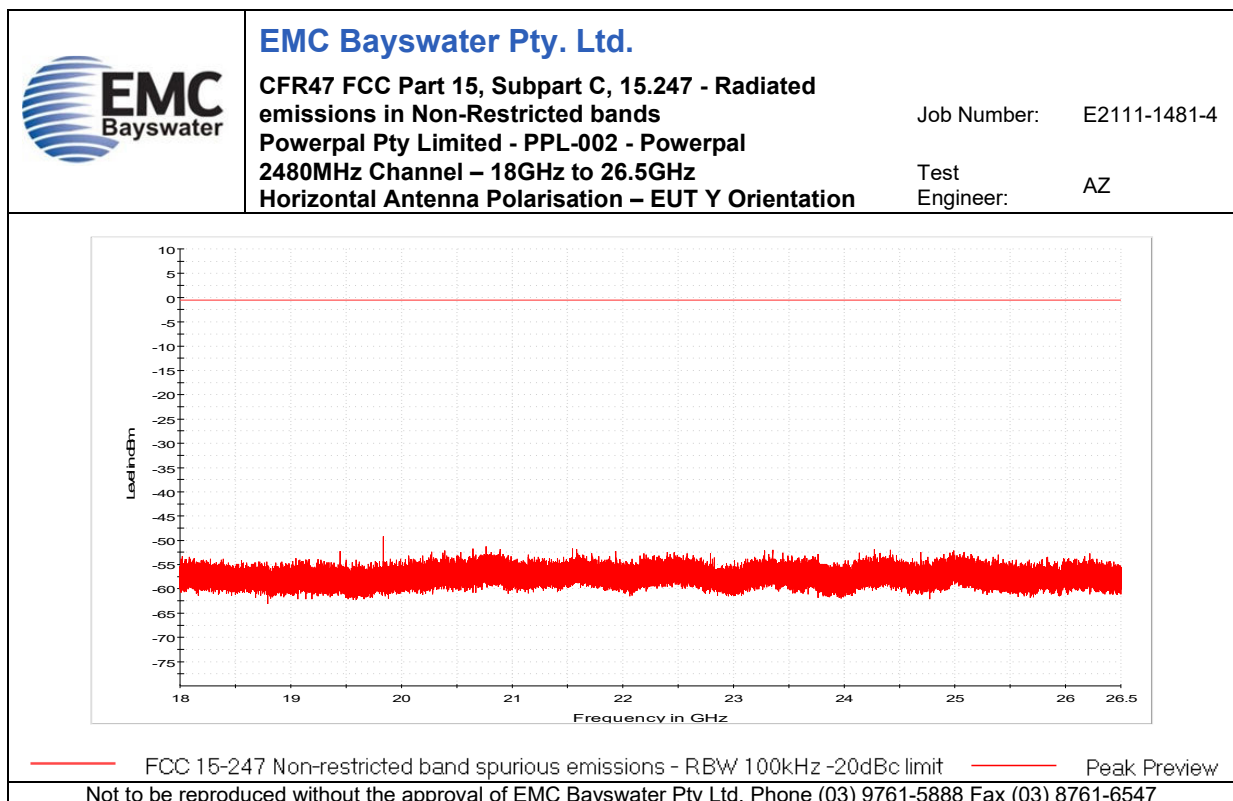
Graph 77



Graph 78



Graph 79



Graph 80

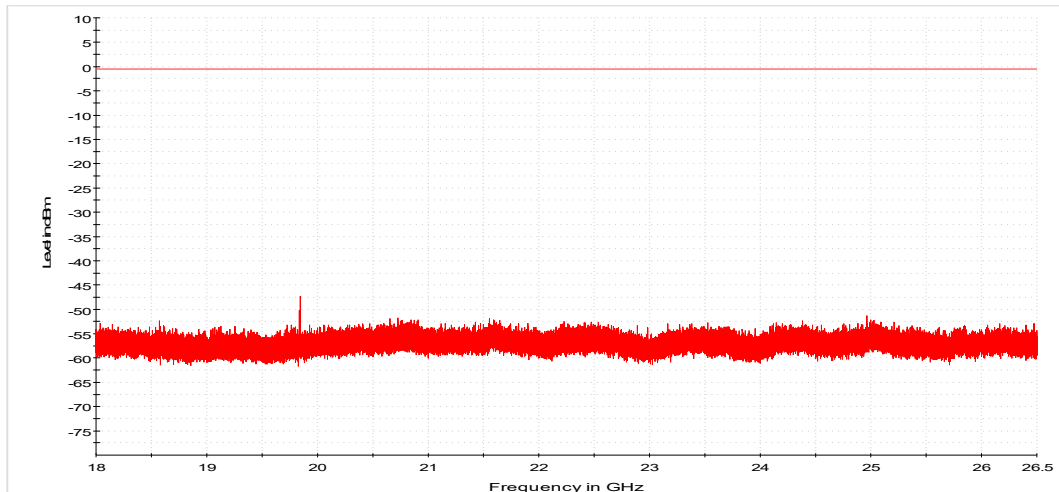


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Radiated emissions in Non-Restricted bands
Powerpal Pty Limited - PPL-002 - Powerpal
2480MHz Channel – 18GHz to 26.5GHz
Vertical Antenna Polarisation – EUT Z Orientation

Job Number: E2111-1481-4

Test Engineer: AZ



— FCC 15-247 Non-restricted band spurious emissions - RBW 100kHz -20dBc limit — Peak Preview

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Graph 81

Appendix C.5 – Measurement Graphs – Power Spectral Density – FCC 15.247 (e)

No.	Test	Graph Description
82	Power Spectral Density	2402MHz Channel
83		2440MHz Channel
84		2480MHz Channel

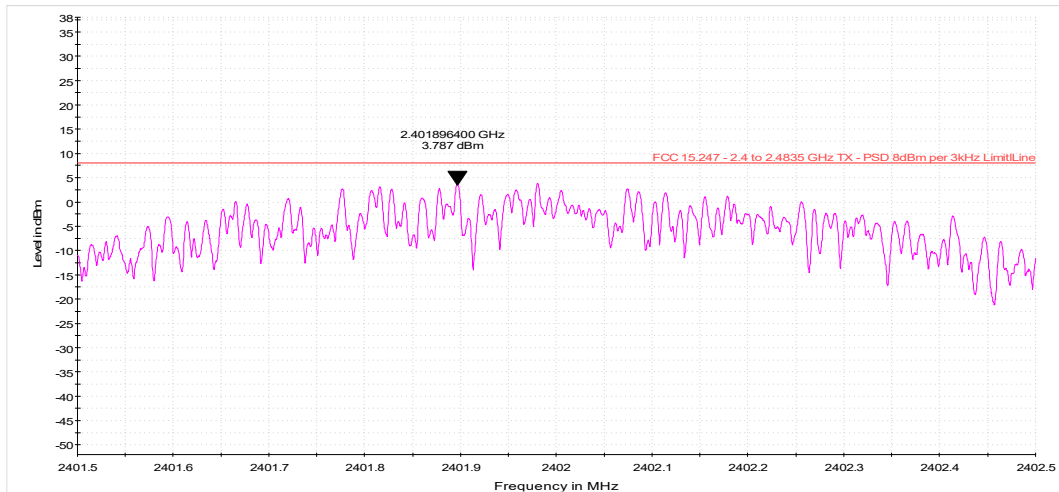


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Peak Power
Spectral Density
Powerpal Pty Limited - PPL-002 - Powerpal
2402MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL



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Graph 82

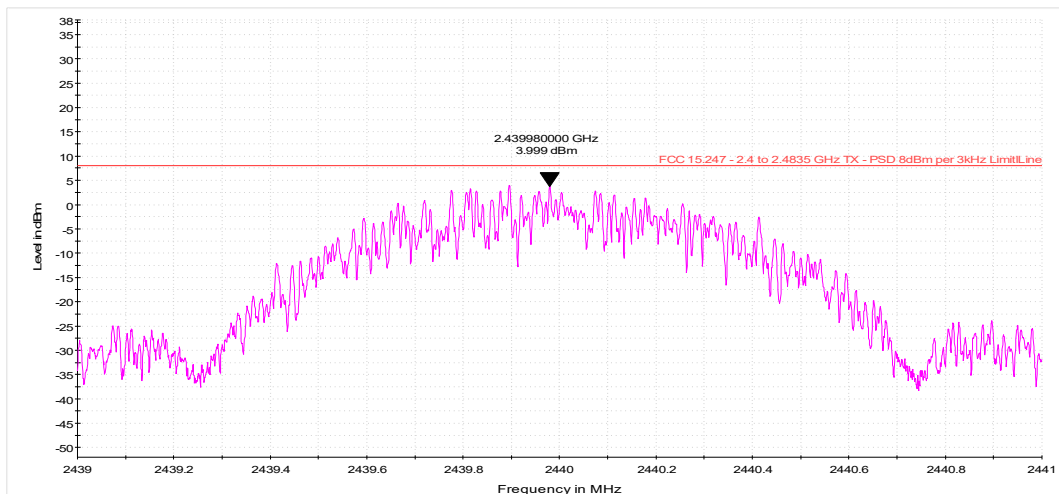


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Peak Power
Spectral Density
Powerpal Pty Limited - PPL-002 - Powerpal
2440MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL



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Graph 83

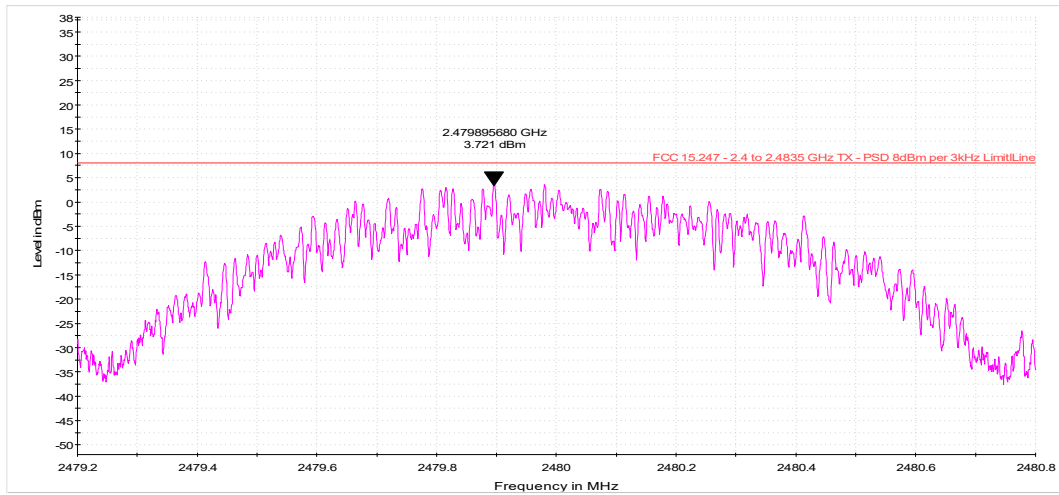


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Peak Power
Spectral Density
Powerpal Pty Limited - PPL-002 - Powerpal
2480MHz Channel

Job Number: E2111-1481-4

Test Engineer: NL

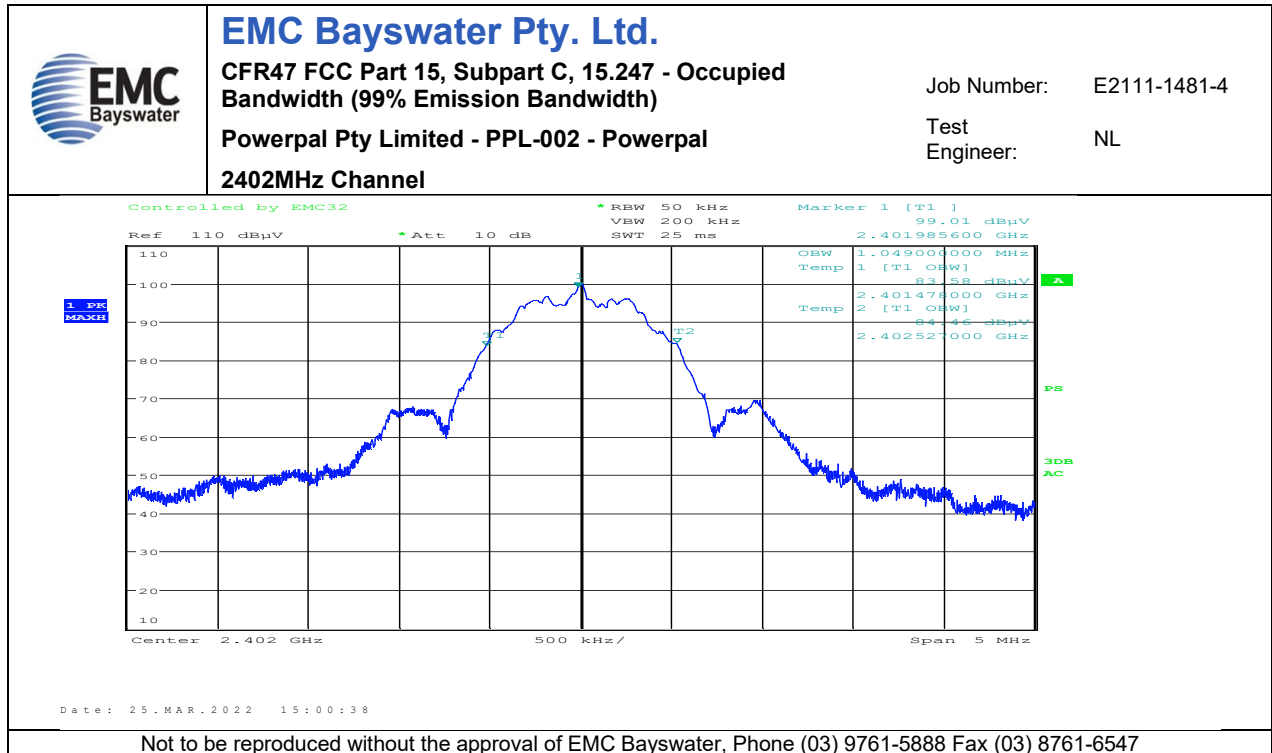


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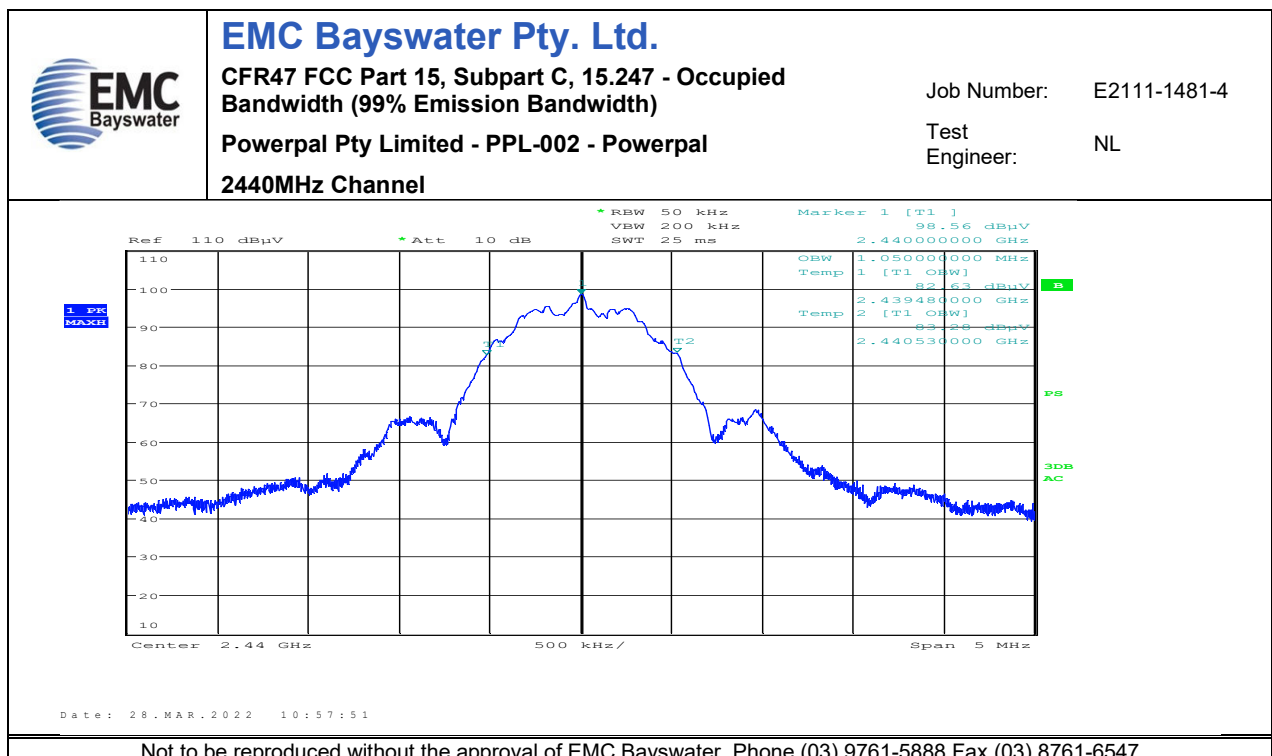
Graph 84

Appendix C.6 – Occupied Bandwidth (99% Emission Bandwidth)

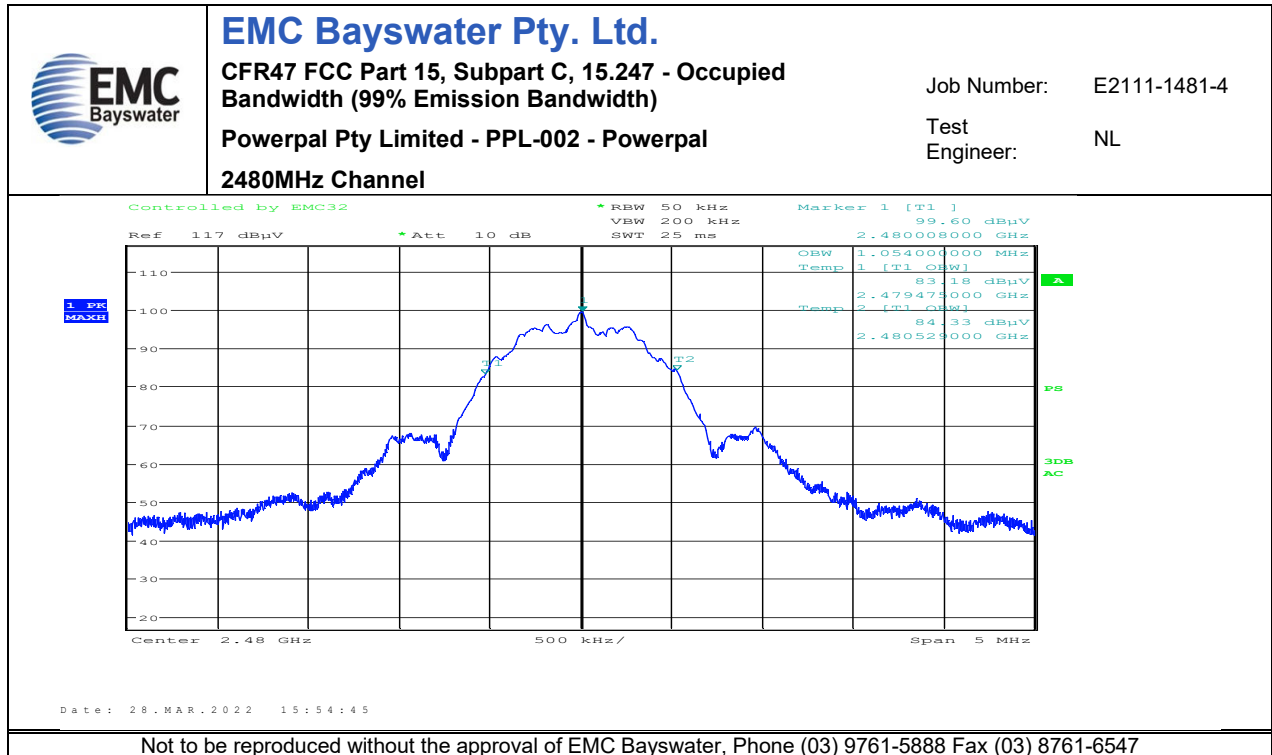
No.	Test	Graph Description
85	Occupied Bandwidth (99% Emission Bandwidth)	2402MHz Channel
86		2440MHz Channel
87		2480MHz Channel



Graph 85



Graph 86



Graph 87