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RADIO COMPLIANCE REPORT

Certification Test Report

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

Sealite Pty Ltd

PCA-2201

2.4GHz Radio Module

FCC ID: 2A7Y2AV-RFM-01

REPORT: E2206-1543-1 Rev1

DATE: September, 2022

*This report replaces the previously issued report E2206-1543-1.
Please refer to section 2 of this report for details of any previously issued reports.*



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: E2206-1543-1 Rev1
Issue Date: September, 2022

Test Sample(s): 2.4GHz Radio Module
Model No: PCA-2201
Serial No: None stated
FCC ID: 2A7Y2AV-RFM-01

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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
15.207 - Conducted Emissions

Complied
Complied
Complied
Complied
Complied
Complied
Complied
Complied

Test Date(s): 16th to 23rd of June and 9th of September 2022

**Test House
(Issued By):** EMC Bayswater Pty Ltd
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Croydon South
Victoria 3136
Australia

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 Sealite Pty Ltd, PCA-2201, 2.4GHz Radio Module, has been tested in accordance with requirements contained in the appropriate commission regulations.

Prepared & tested by:

Approved by:



12/09/2022 12:52

Adnan Zaman
(EMC Test Engineer)

Neville Liyanapatabendige
(Manager)

Date

Radio Compliance Report for Sealite Pty Ltd

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1. Introduction

Electromagnetic Compatibility (EMC) tests were performed on a Sealite Pty Ltd, PCA-2201, 2.4GHz Radio Module in accordance with the requirements of Title 47 of the standard CFR47 FCC Part 15, Subpart C, 15.247.

2. Test Report Revision History

ISSUE	DATE	PAGES AFFECTED	AUTHORISED BY
E2206-1543-1	27/07/22	Original	Neville Liyanapatabendige (Manager)
E2206-1543-1 Rev1	12/09/22	Added Conducted Emissions test data.	Neville Liyanapatabendige (Manager)

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 and 15.207 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 1044kHz
15.247 (b)(3)	Maximum Peak Output Power	Complied by 10.0dB
15.247 (d)	Out-of-Band Emissions – 100kHz, -20dBc	Complied by at least >20dB
15.247 (d)	Emissions on the Band edge	Complied by 4.8dB ⁺
15.247 (d), 15.209	Radiated emissions in Restricted bands	Complied by 1.4dB ⁺
15.247 (e)	Power Spectral Density	Complied by 2.6dB
	Occupied Bandwidth (99% Emission Bandwidth)	2242kHz
15.207	Conducted Emissions (Active Line)	Complied with quasi-peak limit by 22.5dB
		Complied with average limit by 22.0dB
	Conducted Emissions (Neutral Line)	Complied with quasi-peak limit by 25.0dB
		Complied with average limit by 25.0dB

⁺Refer to relevant section for statement of measurement uncertainty.

^{#1}The Antenna is attached to a dedicated connector, 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:	2.4GHz Radio Module	
Model No:	PCA-2201	
Serial No:	None stated	
Firmware:	Not supplied	
Software:	N/A	
Power Specifications:	3.3VDC	
Dimensions:	28.25mm x 27.50mm x 7.5mm (Length x Width x Height)	
Weight:	4 gm	
EUT Type:	Tested as table-top	
Transmitter details:	Description:	nRF52833
	Type:	Bluetooth ® 5.1, IEEE 802.15.4-2006, 2.4 GHz transceiver
	Max power:	<+20dBm
	Antenna:	Part number: TE Connectivity 2118059-1 Frequency Range (MHz): 2300 – 3800 MHz Peak Gain +4dBi
AC/DC Charger details:	Description:	Dual Power Balance Charger/Discharger
	Manufacturer:	G.T.POWER
	Model:	C607D
	Serial No.:	250812

(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:

“2.4GHz Radio Module to be embedded in aviation lanterns for communication using proprietary protocol 802.15.4.”

(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

“Receiving and transmitting.”

(Customer supplied product operating mode information)

5.5. Product operating mode for testing

“The module will be configured to operate in a test mode which continuously transmits data once power is applied or in a continuous receive mode. The mode of operation is selectable via an externally mounted rotary switch on the test fixture. The channel frequency in transmit mode can be selected between lowest, middle, and highest channel. An additional external switch on the test fixture activates the power to the unit.”

(Customer supplied product operating mode for testing information)

5.6. Configuration

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

The EUT was battery powered and transmitting constantly with modulation.



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.

Conducted Emissions measurements were performed inside an anechoic chamber or a standard shielded enclosure, where applicable, 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 internal antenna with dedicated connector. Therefore, the EUT complied with the antenna requirements of CFR47 FCC Part 15, Subpart C, 15.247 Section 15.203.

10. Duty cycle correction factor

As per section 7.5 of ANSI C63.10 - 2013 & FCC Part 15.35(c):

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in following equation:

$$\delta(\text{dB}) = 20\log(\Delta)$$

where

δ = The duty cycle correction factor (dB)

Δ = The duty cycle (dimension less)

$$\text{Duty Cycle} = \text{Total on time (ms)} / \text{Period (ms)}$$

10.1. Test Procedure

The Duty cycle correction factor determination was performed in accordance with the section 7.5 of ANSI C63.10 - 2013.

10.2. Test Results

(Refer to graphs in Appendix C.8)

Duty Cycle calculation:

Pulse	Pulse time	Number of Pulses in a period	Time
Pulse	2.65ms	23	60.95ms
Total ON time			60.95ms
Pulse Period			100ms

$$\text{Duty Cycle} = (60.95/100) = 0.6095$$

$$\text{Duty Cycle Correction Factor} = 20 * \log(0.6095) = -4.3\text{dB}$$

Measured Duty Cycle	Correction Factor (dB)
0.6095	-4.3

Table 2: Measured Duty Cycle

10.3. Customer Specified Duty Cycle

Customer Specified Duty Cycle	Correction Factor (dB)
0.05	-20dB (maximum)*

*Duty cycle factor for 0.05 duty cycle is 26dB but maximum allowed 20dB

Table 3: Customer specified Typical Duty Cycle

The measurement uncertainty was calculated as follows:

Measurement Parameter	Calculated measurement uncertainty
Time	±0.2%

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

Notes: The measured duty cycle for customer supplied sample is 0.6095 (60.95%).

The duty cycle correction factor for 0.6095 duty cycle is -4.3dB.

Customer declared typical duty cycle as below:

“For the purpose of compliance testing only, the transmit duty cycle has been greatly increased to facilitate measurement to approximately 61%. However, in application the nominal transmit duty cycle will be <1% with an estimated maximum duty cycle of 5%. This should be accounted for when measurement requires an average measurement and a duty cycle correction factor is to be applied.”

The duty cycle correction factor for 0.05 duty cycle is 26dB but maximum allowed is 20dB. Therefore, customer declared duty cycle correction factor is 20dB (maximum allowed).

Assessment: All Peak measurements of the transmission fundamental and associated harmonics can be reduced by 20dB.

11.6dB Bandwidth – FCC 15.247 (a)(2)

11.1.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 the antenna port (Conducted method). The transmitter output was connected to a spectrum analyzer through a suitable attenuator. 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)

11.2.Limits

Applicable only to systems using digital modulation techniques:

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

Table 4: 6dB Bandwidth

11.3.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
2410 (Bottom)	1556	500	+1056	Complied
2440 (Middle)	1569	500	+1069	Complied
2465 (Top)	1544	500	+1044	Complied

Table 5: 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 6: Climatic conditions

Notes: The minimum required 500kHz 6dB Bandwidth requirements were satisfied by at least 1044kHz.

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).

12. Occupied Channel Bandwidth (99% Emission Bandwidth)

12.1. Test Procedure

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

99% Emission Bandwidth measurements were performed at the antenna port (Conducted method). The transmitter output was connected to a spectrum analyzer through a suitable attenuator. 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)

12.2. Requirements

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

12.3. Test Results

Occupied Bandwidth measurements are tabulated below:

(Refer to graphs in Appendix C.7)

Transmit Operating Frequency (MHz)	99%BW Lower Frequency (MHz)	99%BW Upper Frequency (MHz)	Occupied Channel Bandwidth (kHz)
2410 (Lowest Channel)	2408.869	2411.106	2237
2440 (Middle Channel)	2438.869	2441.104	2235
2465 (Highest Channel)	2463.862	2466.104	2242

Table 7: 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 8: Climatic conditions

Notes: The transmitter was tested with modulation applied.

Assessment: The measured Occupied bandwidth (99% Emission Bandwidth) is 2242 kHz (informative only).

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

13.1. Test Procedure

Conducted Method:

The conducted output power measurements were performed in accordance with the section 11.9.1 of ANSI C63.10 - 2013.

The transmitter output was connected to a spectrum analyzer through a suitable attenuator. The Maximum Peak Conducted Output Power of the fundamental transmit frequency was measured using a spectrum analyzer with 1MHz RBW and 3MHz VBW using the peak detector and a suitable span to allow accurate measurement whilst capturing the full intentional transmission including side lobes. An offset for the measurement path insertion loss (attenuators and cables) was used to get a true measurement.

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

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

13.2. 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 9: Limits – Transmitter maximum peak output power

13.3. Test Results

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

(Refer to graphs in Appendix C.2)

Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	2410	+20.0	30.0	-10.0*	Complied
Middle	2440	+19.4	30.0	-10.6	Complied
Top	2465	+18.7	30.0	-11.3	Complied

**Worst-case emissions*

Table 10: Results for Maximum Peak Conducted Output Power – Conducted Method

The measurement uncertainty was calculated at ± 1.4 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 11: 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).

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

14.1. 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 12: Limits for Radiated Spurious Emissions at distance of 3m – Restricted Bands

14.2. 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)

14.3. 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 13: Transmitter Spurious Emissions – 9kHz to 30MHz

Operating Channel: Bottom				
Measurement Antenna Polarisation	Frequency (MHz)	Result Quasi-peak (dB μ V/m)	Limit Quasi-peak (dB μ V/m)	Delta limit (dB)
Horizontal	123.654	18.2	43.5	-25.3
	407.233	23.0	46.0	-23.0
	610.594	27.7	46.0	-18.3*
Vertical	119.871	17.9	43.5	-25.6
	271.045	20.0	46.0	-26.0
	611.030	27.6	46.0	-18.4

**Worst-case emissions*

Table 14: Transmitter Spurious Emissions – 30MHz to 1GHz

Operating Channel: 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	Peak preview emissions >10dB below limit or no significant emissions above the noise floor observed			
Vertical	Peak preview emissions >10dB below limit or no significant emissions above the noise floor observed			

Table 15: Transmitter Spurious Emissions – 30MHz to 1GHz

Operating Channel: Bottom, (2410MHz)								
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	2266.720	63.2	74.0	-10.8	2217.840	37.5	54.0	-16.5
	2281.540	66.0	74.0	-8.0	2269.320	36.5	54.0	-17.5
	2346.020	64.1	74.0	-9.9	2281.800	42.4	54.0	-11.6
	2389.960	69.0	74.0	-5.0*	2346.020	41.0	54.0	-13.0
	4818.960	69.0	74.0	-5.0*	2386.320	40.1	54.0	-13.9
	12047.680	59.1	74.0	-14.9	2491.620	37.2	54.0	-16.8
					12047.680	47.0	54.0	-7.0
Vertical	2255.020	62.0	74.0	-12.0	2218.100	37.5	54.0	-16.5
	2281.540	66.0	74.0	-8.0	2255.020	36.2	54.0	-17.8
	2345.760	63.7	74.0	-10.3	2281.540	41.4	54.0	-12.6
	2390.480	68.4	74.0	-5.6	2299.480	37.0	54.0	-17.0
	2483.820	59.4	74.0	-14.6	2345.760	40.4	54.0	-13.6
	4820.880	67.7	74.0	-6.3	2378.260	44.2	54.0	-9.8
	12052.480	57.4	74.0	-16.6	2485.120	36.9	54.0	-17.1
					4820.160	52.6	54.0	-1.4**
					12052.480	45.5	54.0	-8.5

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

Table 16: Transmitter Spurious Emissions – 1GHz to 25GHz

Operating Channel: Bottom, (2410MHz)								
Measurement Antenna Polarisation	Frequency (MHz)	Peak Result (dB μ V/m)	Duty Cycle Correction Factor (dB)	Average Result (dB μ V/m)	Peak Limit (dB μ V/m)	Average Limit (dB μ V/m)	Peak Delta Limit (dB)	Average Delta Limit (dB)
Horizontal	4818.960	69.0	20 [#]	49.0	74.0	54.0	-5.0*	-5.0*

*Worst-case emissions, [#]Customer specified Duty Cycle correction factor.

Note: Average Result (dB μ V/m) = Peak Result (dB μ V/m) – Duty Cycle correction factor (dB)

Table 17: Transmitter Unwanted Emissions for Harmonics with Duty Cycle correction factor – 1GHz to 25GHz

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	2311.960	67.7	74.0	-6.3*	2312.220	43.7	54.0	-10.3
	2375.660	65.7	74.0	-8.3	2337.700	38.2	54.0	-15.8
	2489.540	58.6	74.0	-15.4	2375.920	42.1	54.0	-11.9
	4880.880	62.6	74.0	-11.4	2489.540	37.5	54.0	-16.5
	7318.480	60.7	74.0	-13.3	4880.880	48.0	54.0	-6.0
	12197.440	57.9	74.0	-16.1	7318.480	49.3	54.0	-4.7*
					12197.440	45.8	54.0	-8.2
Vertical	2248.000	60.0	74.0	-14.0	2248.260	38.0	54.0	-16.0
	2312.220	67.3	74.0	-6.7	2289.080	36.8	54.0	-17.2
	2343.420	63.5	74.0	-10.5	2298.440	37.3	54.0	-16.7
	2375.920	65.1	74.0	-8.9	2311.960	43.5	54.0	-10.5
	2485.120	58.9	74.0	-15.1	2328.600	39.0	54.0	-15.0
	4878.720	61.8	74.0	-12.2	2349.400	38.2	54.0	-15.8
	7318.496	58.6	74.0	-15.4	2375.920	42.2	54.0	-11.8
	12197.920	54.3	74.0	-19.7	2486.680	37.6	54.0	-16.4
					4881.120	48.0	54.0	-6.0
					7318.496	47.2	54.0	-6.8
					12197.920	42.0	54.0	-12.0

*Worst-case emissions

Table 18: Transmitter Spurious Emissions – 1GHz to 25GHz

Operating Channel: Top, (2465MHz)								
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	2324.440	64.2	74.0	-9.8	2310.920	37.4	54.0	-16.6
	2337.180	69.4	74.0	-4.6**	2315.080	37.7	54.0	-16.3
	2352.000	64.7	74.0	-9.3	2324.440	38.2	54.0	-15.8
	2389.700	63.0	74.0	-11.0	2336.660	45.8	54.0	-8.2
	2483.581	69.2	74.0	-4.8	2337.440	45.3	54.0	-8.7
					2349.920	38.3	54.0	-15.7
	2485.120	67.3	74.0	-6.7	2354.080	39.4	54.0	-14.6
					2389.700	39.1	54.0	-14.9
	4930.560	64.6	74.0	-9.4	2483.581	40.4	54.0	-13.6
					2489.800	39.0	54.0	-15.0
	7393.600	61.4	74.0	-12.6	2497.080	43.7	54.0	-10.3
					4929.120	44.6	54.0	-9.4
Vertical	12327.520	58.1	74.0	-15.9	7393.600	49.4	54.0	-4.6*
					12327.520	45.7	54.0	-8.3
	2272.700	59.7	74.0	-14.3	2272.440	37.8	54.0	-16.2
					2293.760	36.1	54.0	-17.9
	2337.180	69.1	74.0	-4.9	2318.460	37.8	54.0	-16.2
					2324.700	38.0	54.0	-16.0
	2484.080	68.7	74.0	-5.3	2337.180	46.1	54.0	-7.9
					2352.780	40.1	54.0	-13.9
	4930.560	64.9	74.0	-9.1	2360.320	40.0	54.0	-14.0
					2375.400	38.6	54.0	-15.4
	7393.535	58.0	74.0	-16.0	2484.080	39.2	54.0	-14.8
					2496.820	44.3	54.0	-9.7
	12322.720	53.9	74.0	-20.1	4930.800	46.6	54.0	-7.4
					7393.535	46.5	54.0	-7.5
					12322.720	41.1	54.0	-12.9

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

Table 19: Transmitter Spurious Emissions – 1GHz to 25GHz

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
30MHz to 1GHz	± 4.65 dB
1GHz to 6GHz	± 4.83 dB
6GHz to 18GHz	± 4.49 dB
18GHz to 26.5GHz	± 4.46 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 20: Climatic conditions

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

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

Where:

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

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: The customer specified duty cycle correction factor was applied to one of the harmonic emissions in the restricted bands in order to comply with Average limit as per the customer request.

All other transmitter unwanted emission 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).

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

15.1. 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.

Measurements were performed at the antenna port.

The EUT was placed inside a shielded chamber. The transmitter output was connected to a spectrum analyzer through a suitable attenuator (Conducted method). The out of band emissions were measured by spectrum analyzer with 100kHz RBW and 300kHz VBW using the peak detector. All measuring system correction factors (attenuators and cables) were used to get a true measurement.

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

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

15.2. 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 +19.2dBm

Frequency Range (MHz)	Limits (dBm)
30MHz and 26.5GHz	-0.8

Table 21: Limits for Unwanted Emissions - -20dBc (Non-restricted bands)

15.3. Test Results

Unwanted emissions measurements are detailed as follows:

(Refer to graphs in Appendix C.5)

Channel	Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Delta limit (dB)
Bottom	Peak preview 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 22: Transmitter Out of Band emissions - -20dBc/100kHz

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
30MHz to 25GHz	$\pm 1.4\text{dB}$

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

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

Conducted 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).

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

16.1. 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.

Conducted measurements were performed within 2 MHz of the authorised lower 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 band-edge was in restricted-band therefore measurements were performed as per section 6.10.5 of ANSI C63.10 - 2013. The FCC 15.209 limits are applicable to emission in restricted-band band-edge.

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

16.2. 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 +19.2dBm

Band edge Frequencies	Limits (dBm)
Lower Edge (2410MHz)	-0.8

Table 23: 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 24: Limits for Radiated Spurious Emissions at distance of 3m – Restricted Bands.

16.3. Test Results

Band edge measurements are detailed as follows:

(Refer to graphs in Appendix C.3)

Operating Channel: Bottom (2410MHz)			
Frequency (MHz)	Result Radiated Peak Power Spectral Density (dBm/100kHz)	Limit Radiated Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
2399.290	-36.6	-0.8	-35.8*
2399.988	-36.6	-0.8	-35.8*

*Worst-case emissions

Table 25: Transmitter Emissions on the Band edge - Low end

Operating Channel: Top (2465MHz)								
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	2483.581	69.2	74.0	-4.8**	2483.581	40.4	54.0	-13.6
	2485.120	67.3	74.0	-6.7				
Vertical	2484.080	68.7	74.0	-5.3	2484.080	39.2	54.0	-14.8

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

Table 26: 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
Conducted (1GHz to 6GHz)	± 1.4 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 27: 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).

17. Power Spectral Density – FCC 15.247 (e)

17.1. Test Procedure

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

The transmitter output was connected to a spectrum analyzer through a suitable attenuator (Conducted method). The Power Spectral density was measured in a 3kHz bandwidth of the fundamental frequency by spectrum analyzer with 3kHz RBW and 30kHz VBW using the peak detector and a suitable span to allow accurate measurements whilst capturing the full intentional transmission including side lobes.

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

17.2. 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 28: Power Spectral Density limits

17.3. Test Results

Power Spectral Density measurements are tabulated below:

(Refer to graphs in Appendix C.6)

Channel	Frequency (MHz)	Measured Power (dBm)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	2410.050	+5.4	8.00	-2.6*	Complied
Middle	2439.558	+5.1	8.00	-2.9	Complied
Top	2465.049	+4.3	8.00	-3.7	Complied

**Worst-case emissions*

Table 29: Results for Power Spectral Density

The measurement uncertainty was calculated at ± 1.4 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:	16°C
Humidity:	59%
Atmospheric pressure:	1017.0hPa

Table 30: 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).

18. Conducted Emissions – FCC 15.207

18.1. Test Procedure

The EUT was positioned 0.4m from the vertical ground reference plane (chamber wall) and 0.8m above a horizontal ground reference plane (chamber floor) with the mains cable connected to the power port of an AMN located 0.8m away. The measuring port of the AMN was connected to the measuring receiver. In order to avoid unwanted ambient signals, power to the AMN was supplied via power line filters fitted to the shielded enclosure wall.

The mains flexible cord provided by the manufacturer is required to be 1m long for these measurements. If the manufacturer supplies a non-removable power lead, in excess of 1m, the cable in excess of 1m is folded at the centre into a bundle no longer than 0.4m in length.

Preview scan measurements were performed using a peak and an average detector of the EMI receiver with a resolution bandwidth of 9 kHz. The scan measurements frequency step size of the EMI receiver was set to less than half of the resolution bandwidth. The final quasi-peak and CISPR average measurements were performed at spot frequencies where the preview peak or average emission was close to, or exceeded the applicable limit line with a receiver bandwidth of 6dB and a resolution bandwidth of 9 kHz. The final measurements were performed using a measuring time of no less than 15 seconds.

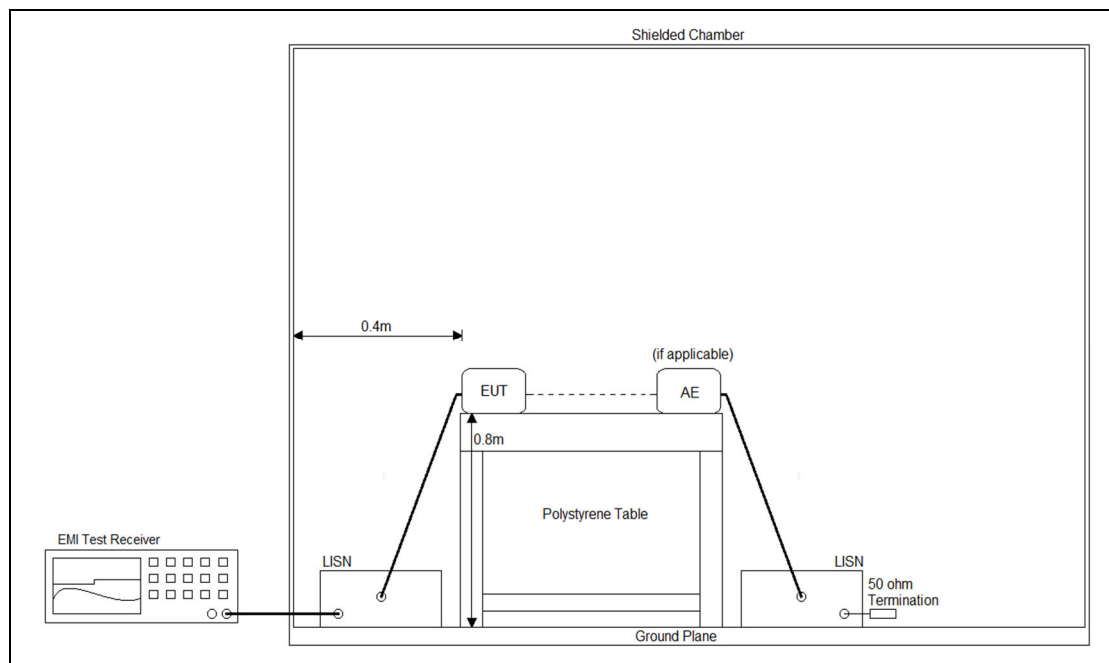


Figure 2: Test setup

Both the active and neutral lines were measured, in turn. Plots of the accumulated measurement data for both active and neutral terminals, 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 photograph in Annex C for views of the test configuration)

18.2.Limits

18.2.1. CFR 47 FCC Part 15 Subpart C, 15.207 Limit

The EUT shall meet the limits in the following table:

Frequency Range (MHz)	Limits (dBµV)	
	Quasi-Peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.5 to 5	56	46
5 to 30	60	50
NOTE 1 The lower limit shall apply at the transition frequencies. NOTE 2 The limit decreases linearly with the logarithm of the frequency in the range 0,15 MHz to 0,50 MHz.		

Table 31: Limits for Conducted Emissions at the mains ports

18.3.Test Results

Conducted Emissions measurements are tabulated below. Quasi-peak or CISPR Average measurements were performed at spot frequencies where the peak or average emission was close to, or exceeded the applicable limit line.

(Refer to graphs in Appendix C.9)

Quasi - Peak Measurements				Average Measurements			
Frequency (MHz)	Result (dBµV)	Limit (dBµV)	Delta Limit (dB)	Frequency (MHz)	Result (dBµV)	Limit (dBµV)	Delta Limit (dB)
0.162	42.0	65.4	-23.4	0.422	25.4	47.4	-22.0*
0.218	34.2	62.9	-28.7	0.438	23.8	47.1	-23.3
0.294	30.5	60.4	-30.0	1.238	16.8	46.0	-29.2
0.314	30.5	59.9	-29.3	1.974	16.4	46.0	-29.6
0.354	29.0	58.9	-29.9	3.386	17.1	46.0	-28.9
0.422	34.9	57.4	-22.5*	3.766	17.5	46.0	-28.5

* Worst-case emissions

Table 32: Conducted Emissions – Active Line

Quasi - Peak Measurements				Average Measurements			
Frequency (MHz)	Result (dBμV)	Limit (dBμV)	Delta Limit (dB)	Frequency (MHz)	Result (dBμV)	Limit (dBμV)	Delta Limit (dB)
0.166	40.2	65.2	-25.0*	0.426	21.8	47.3	-25.6
0.286	28.4	60.6	-32.3	0.438	22.1	47.1	-25.0*
0.422	31.7	57.4	-25.8	0.746	17.6	46.0	-28.4
0.434	31.7	57.2	-25.4	1.626	17.2	46.0	-28.8
1.846	19.9	56.0	-36.1	2.154	16.5	46.0	-29.5
20.690	19.8	60.0	-40.2	3.770	16.2	46.0	-29.8

*Worst-case emissions

Table 33: Conducted Emissions – Neutral Line

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
0.15MHz to 30MHz	±2.88dB

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.

Climatic Conditions	
Temperature:	20.5 to 21.9°C
Humidity:	46 to 49%
Atmospheric pressure:	1008.0 to 1008.2hPa

Table 34: Climatic conditions

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

$$V = V_{QP/AV} + VLISN + L_C + L_T$$

Where:

V = Corrected Voltage Amplitude in dBμV

$V_{QP/AV}$ = Measured Voltage (Quasi Peak or Average) in dBμV

$VLISN$ = Line Impedance Stabilization Network Factor in dB

L_C = Cable/attenuator Loss in dB

L_T = Transient Protection Network Loss in dB

Example calculation:

$$V = V_{QP} + VLISN + L_C + L_T$$

$$V = 15 \text{ dBμV} + 10.1\text{dB} + 11.5\text{dB} + 10.1\text{dB}$$

$$V = 46.7 \text{ dBμV}$$

Notes: Conducted Emissions measurements were below the specified limit.

The customer supplied AC/DC power supply was connected in parallel to the EUT battery (charging). The EUT was continuously transmitting with modulation during testing.

The AC/DC power supply was supplied with 120VAC, 60Hz.

Assessment: The EUT complied with the Conducted Emissions requirements of CFR47 FCC Part 15, Subpart C, section 15.207.

19. Conclusion

The Sealite Pty Ltd, PCA-2201, 2.4GHz Radio Module complied with the applicable requirements of CFR47 FCC Part 15, Subpart C, 15.247 and 15.207.

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 – Conducted Method							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	Jun-23	E
0715	ATTENUATOR, 20dB	JFW	50HF-020N	-	3 years	Dec-24	I
0843	ATTENUATOR, 10dB	JFW	50HF-010N	-	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	Jan-23	I
Transmitter Spurious Emissions							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	Jun-23	E
0935	ANTENNA, Biconilog	Sunol Sciences	JB5	A071106	2 years	Feb-23	E
0718	ATTENUATOR, 6dB	JFW	50FPE-006	-	1 year	Jan-23	I
0024	ANTENNA, Active Loop	EMCO	6502	2620	2 years	Aug-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
0559	PRE-AMP, Microwave, 18GHz	Miteq	AFS8	605305	1 year	Apr-23	I
0715	ATTENUATOR, 20dB	JFW	50HF-020N	-	3 years	Dec-24	I
0843	ATTENUATOR, 10dB	JFW	50HF-010N	-	3 years	Dec-24	I
0633	ANTENNA, Double Ridge Horn	EMCO	3115	9712-5369	3 years	Aug-24	I
1238	CABLE, Coax, Sucoflex 126 E	Huber + Suhner	10422876	SN 8000495/126E	1 year	Jan-23	I
1145	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84279564	SN MY056/4PA	1 year	Jan-23	I
0989	CABLE, Coax, Sucoflex 104A	Huber+Suhner	44454/4A	C357	1 year	Jan-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
1010	CABLE, Coax, Sucoflex 104B	Huber+Suhner	00078/4B	C406	2 years	Aug-24	E
1009	CABLE, Coax, Sucoflex 104B	Huber+Suhner	00065/4B	C405	2 years	Aug-24	E
1064	PRE-AMP, Microwave, 26GHz	Miteq	AFS33	1696371	1 year	Aug-23	V
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	Jan-23	I
SW007	EMC Measurement Software	Rohde & Schwarz	EMC 32	Version 8.53.0	N/A	N/A	N/A
Conducted Emissions							
0954	ANALYSER, EMI Receiver	Rohde+Schwarz	ESCI 3	100196	1 year	Aug-23	E
1244	LISN, Single Phase, 50uH/50 Ohm	AMETEK CTS Europe GmbH (Teseq)	NNB 51	47414	2 years	Apr-24	I
1148	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84287047	SN MY059/4PA	1 year	Jan-23	I
1149	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84287049	SN MY053/4PA	1 year	Dec-22	I
0044	LIMITER, Transient, 9k-200M	Hewlett Packard	11947A	2820A00132	3 years	May-23	I
1154	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-23	I
0441	Enclosure, Shielded, No 5	RFI Industries	TC800-20	933	N/A	N/A	V
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

Appendix B – Photographs

Annex	Number	Photograph Description
A	1	EUT – Host – External views
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	AC/DC Charger – External views
	13	
	14	
	15	
	16	
	17	
	18	
	19	
	20	
	21	
B	1	EUT – Host – Internal views
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	13	
	14	
	15	
	16	
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	20	
	21	EUT – Module with RF Shield – Views
	22	
	23	
	24	
	25	
	26	
	27	
	28	

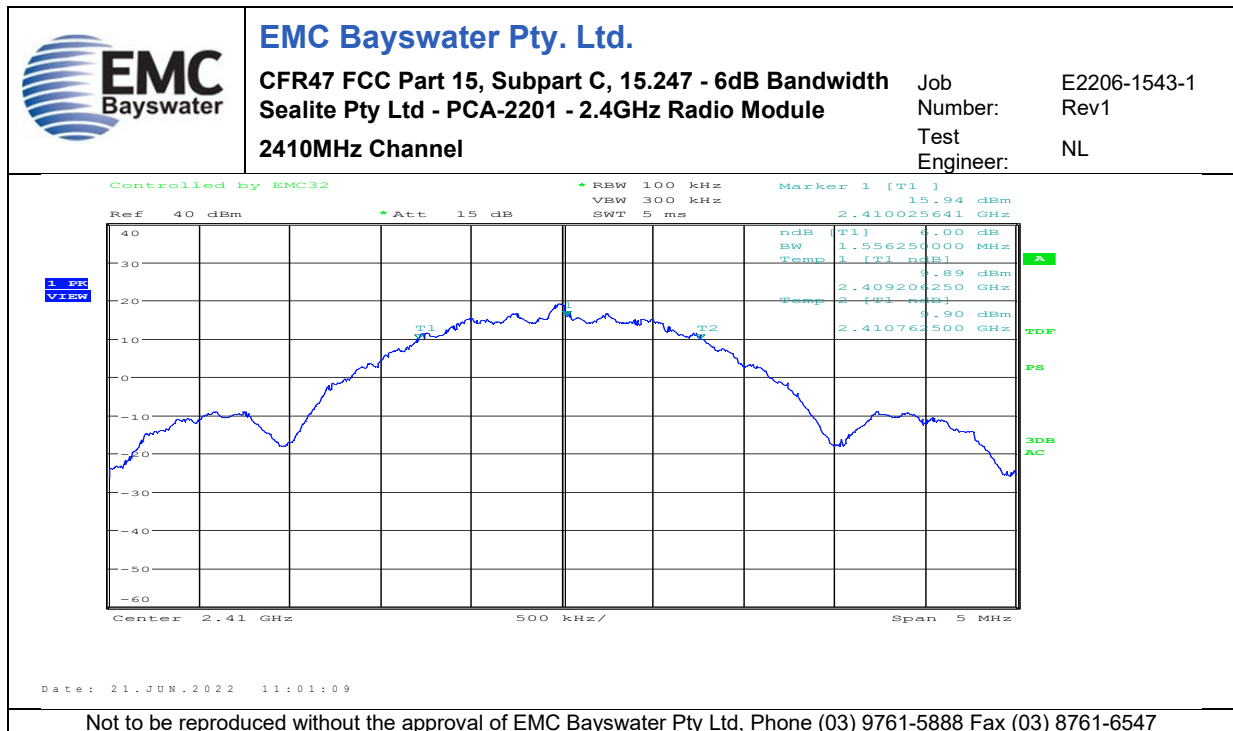
Photographs list continued on the next page

Annex	Number	Photograph Description
B	29	EUT – Module without RF Shield – Views
	30	
	31	
	32	AC/DC Charger – Internal views
	33	
	34	
	35	
C	1	Radiated measurements – Test configuration – EUT X Orientation
	2	Radiated measurements – Test configuration – EUT Y Orientation
	3	Radiated measurements – Test configuration – EUT Z Orientation
	4	Radiated measurements – 9kHz to 30MHz – X Antenna orientation
	5	Radiated measurements – 9kHz to 30MHz – Y Antenna orientation
	6	Radiated measurements – 9kHz to 30MHz – Z Antenna orientation
	7	Radiated measurements – below 1GHz
	8	Radiated measurements – above 1GHz
	9	Conducted measurements
	10	Conducted Emissions – Test configuration

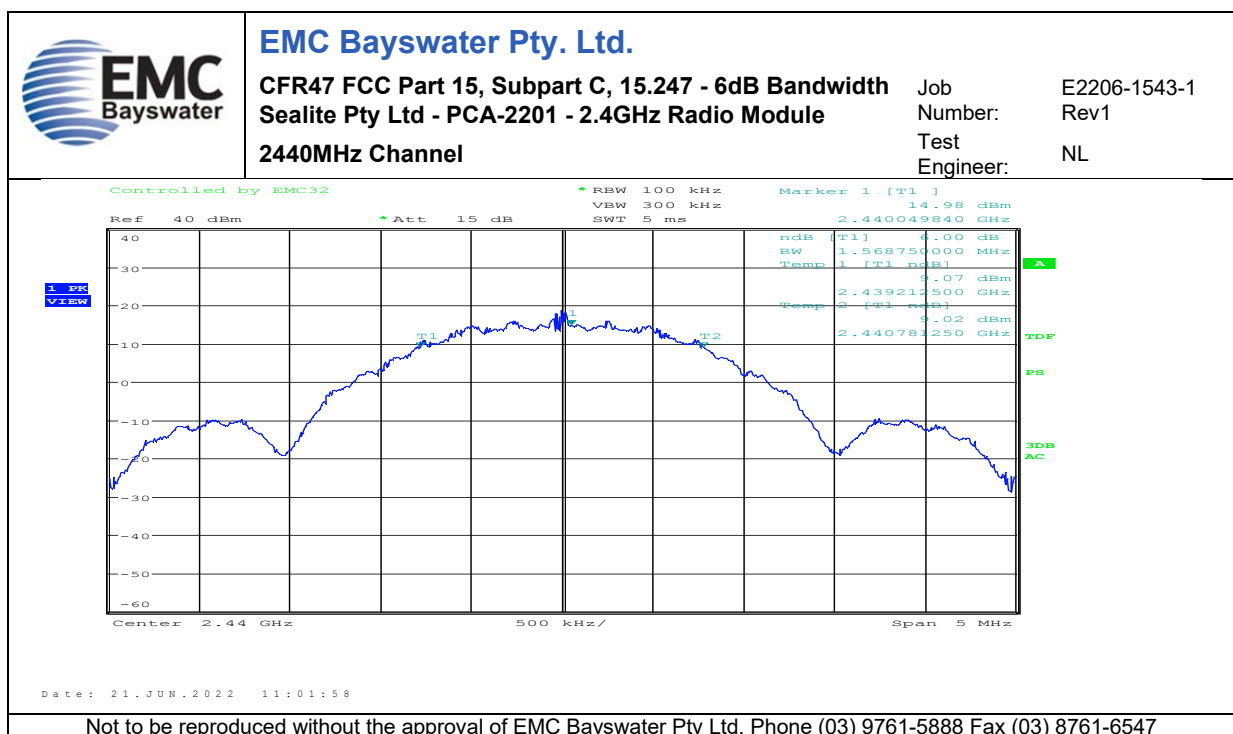
EUT External Photographs	EMC Bayswater Test Report E2206-1543-1 Rev1 Annex A
EUT Internal Photographs	EMC Bayswater Test Report E2206-1543-1 Rev1 Annex B
EUT Orientations & Test Configurations Photographs	EMC Bayswater Test Report E2206-1543-1 Rev1 Annex C

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

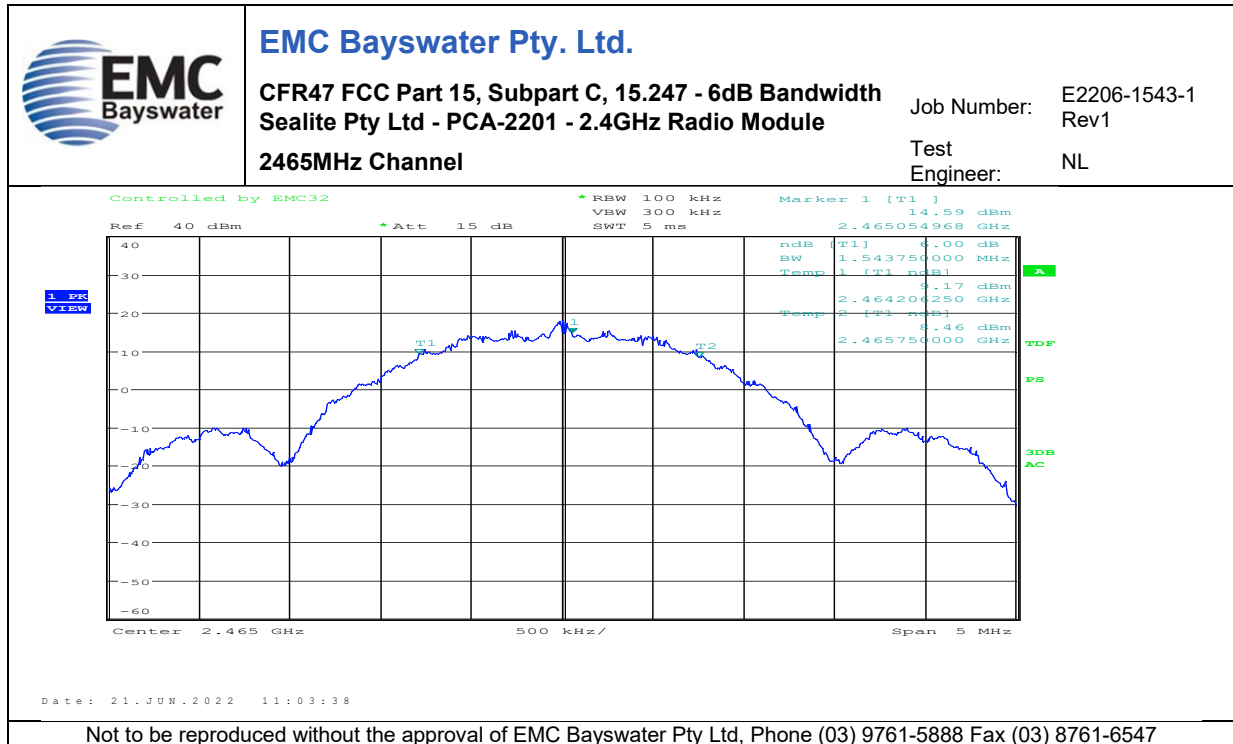
No.	Test	Graph Description
1	6dB Bandwidth	2410MHz Channel
2		2440MHz Channel
3		2465MHz Channel



Graph 1



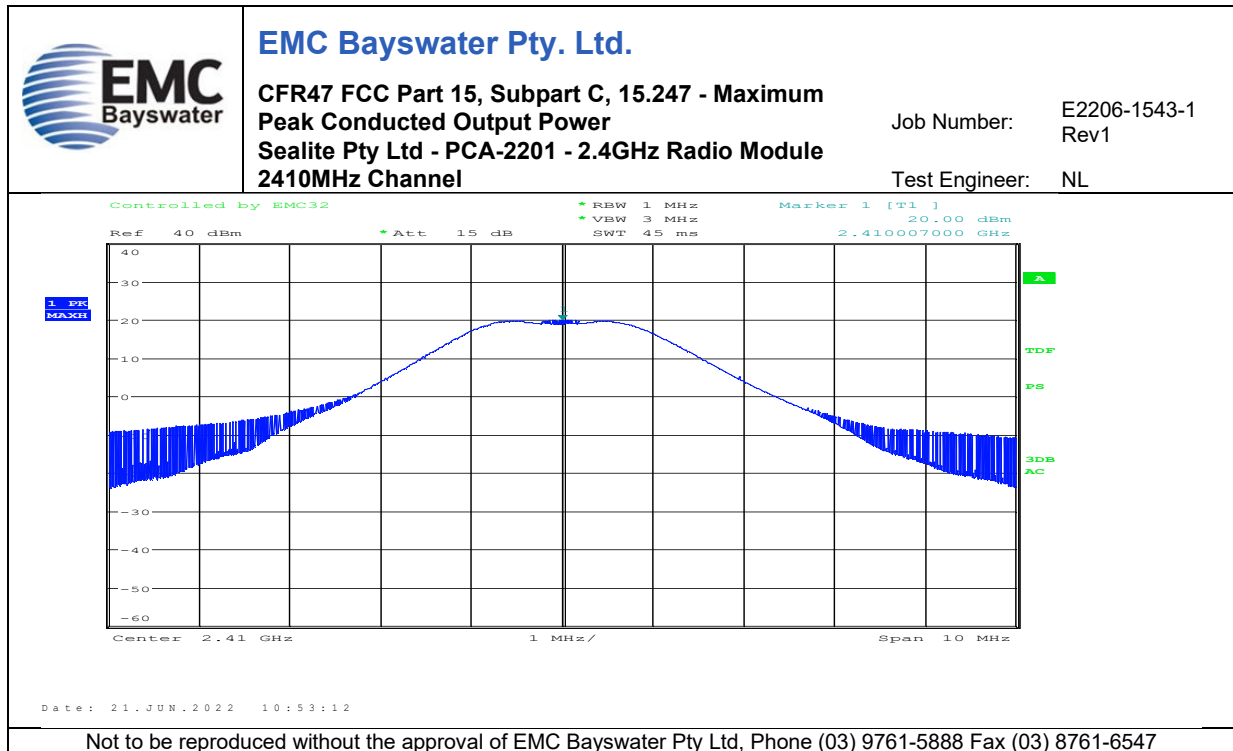
Graph 2



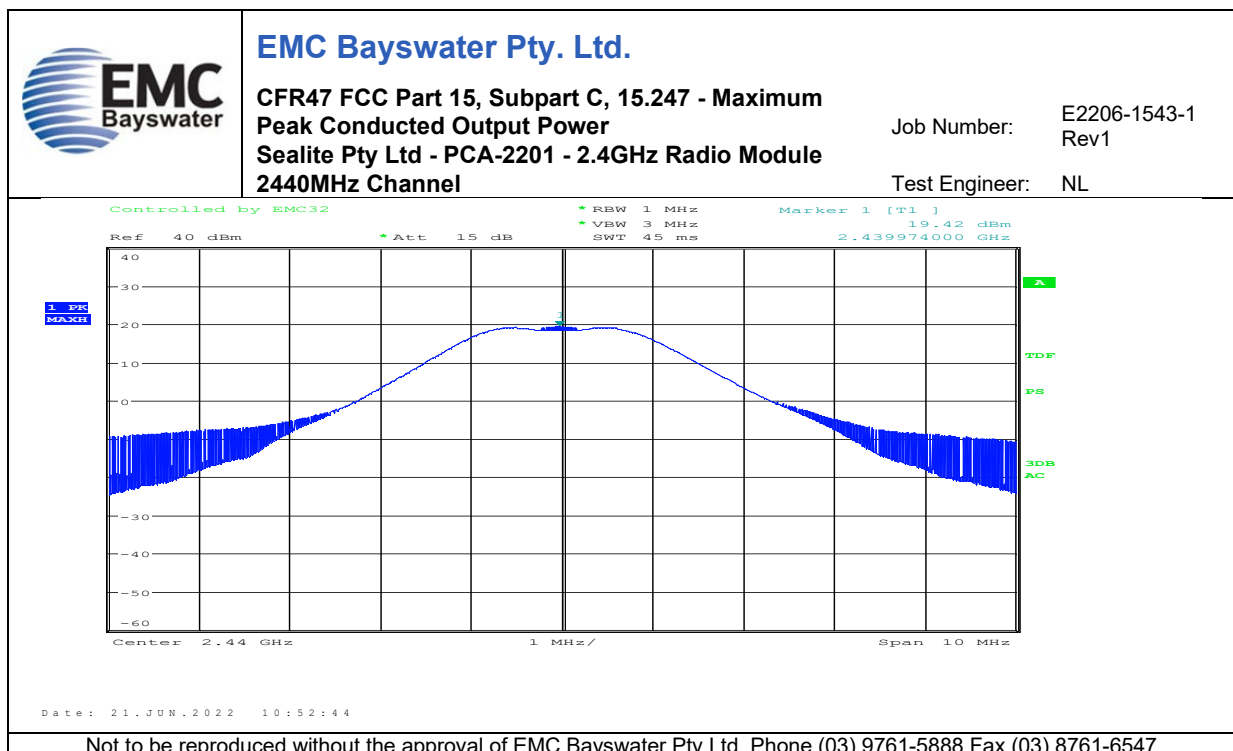
Graph 3

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

No.	Test	Graph Description
4	Maximum Peak Conducted Output Power	2410MHz Channel
5		2440MHz Channel
6		2465MHz Channel



Graph 4



Graph 5

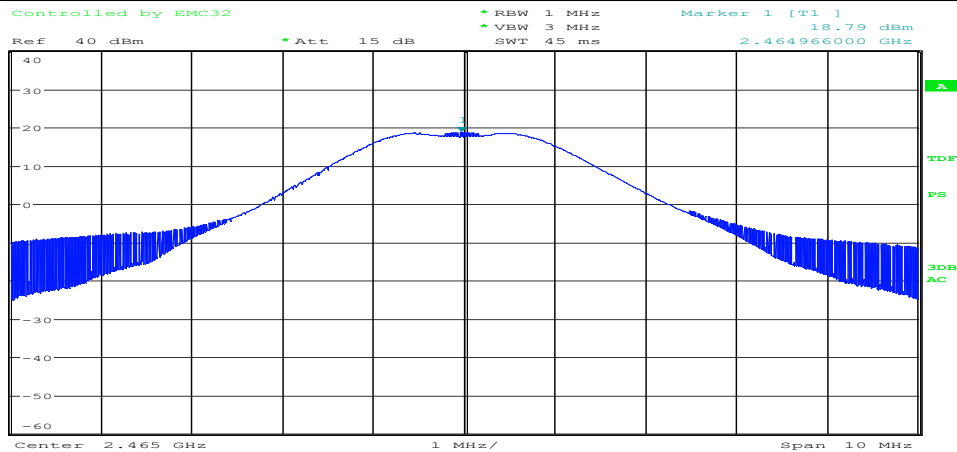


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Maximum
Peak Conducted Output Power
Sealite Pty Ltd - PCA-2201 - 2.4GHz Radio Module
2465MHz Channel

Job Number: E2206-1543-1
Rev1

Test Engineer: NL



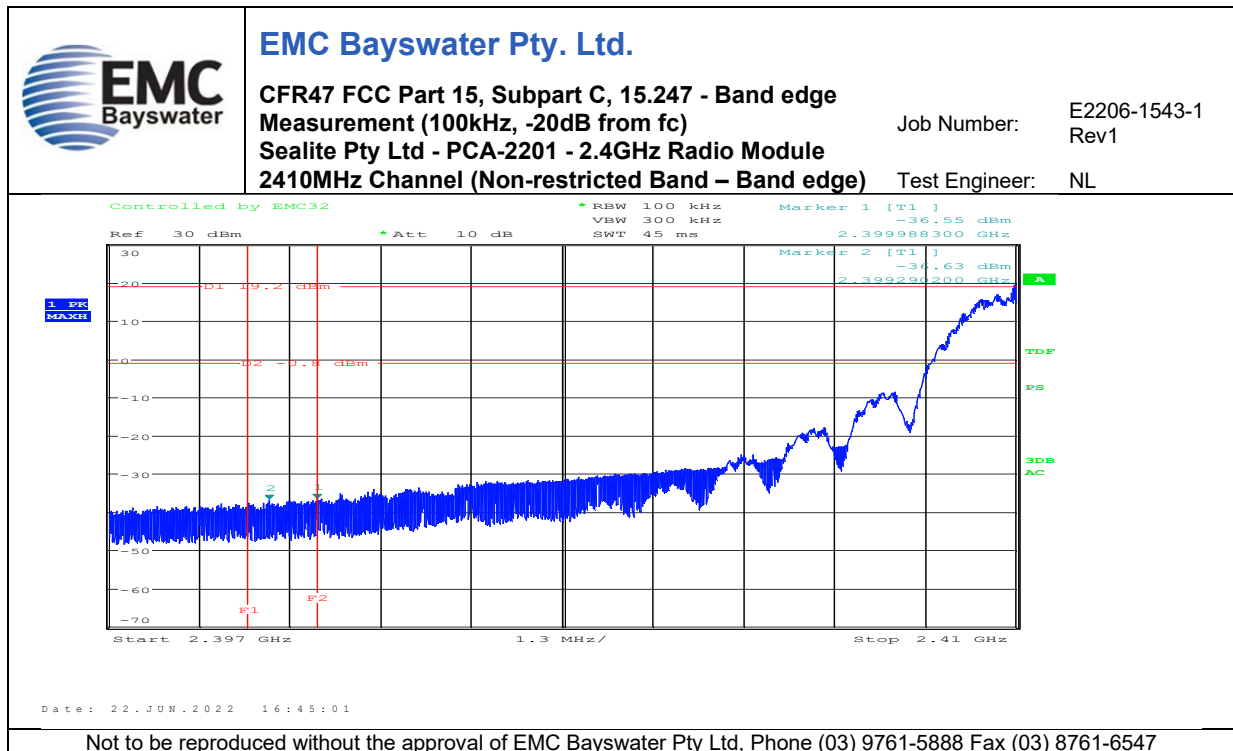
Date: 21 JUN 2022 10:52:16

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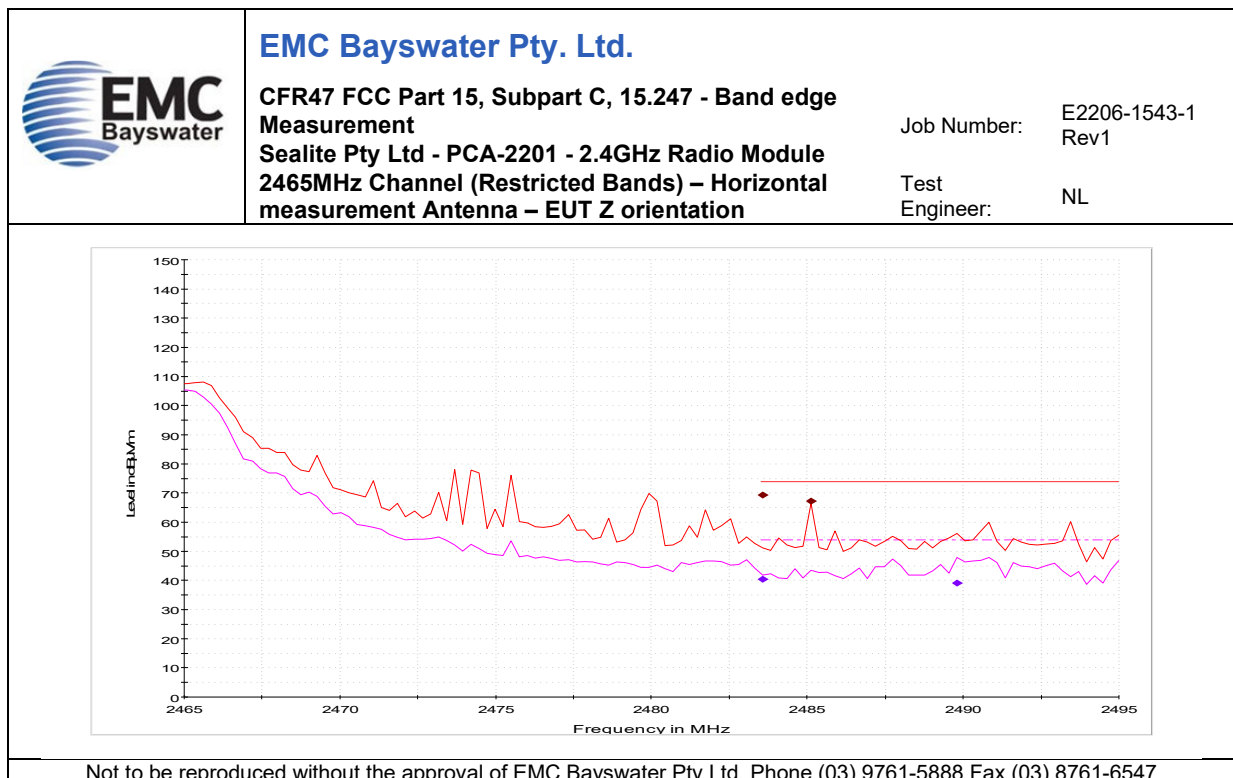
Graph 6

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

No.	Test	Graph Description
7	Band edge Measurement	2410MHz Channel (Non-restricted Band – Band edge)
8	Band edge Measurement	2465MHz Channel (Restricted Bands) – Horizontal measurement Antenna – EUT Z orientation
9		2465MHz Channel (Restricted Bands) – Vertical measurement Antenna – EUT X orientation



Graph 7



Graph 8

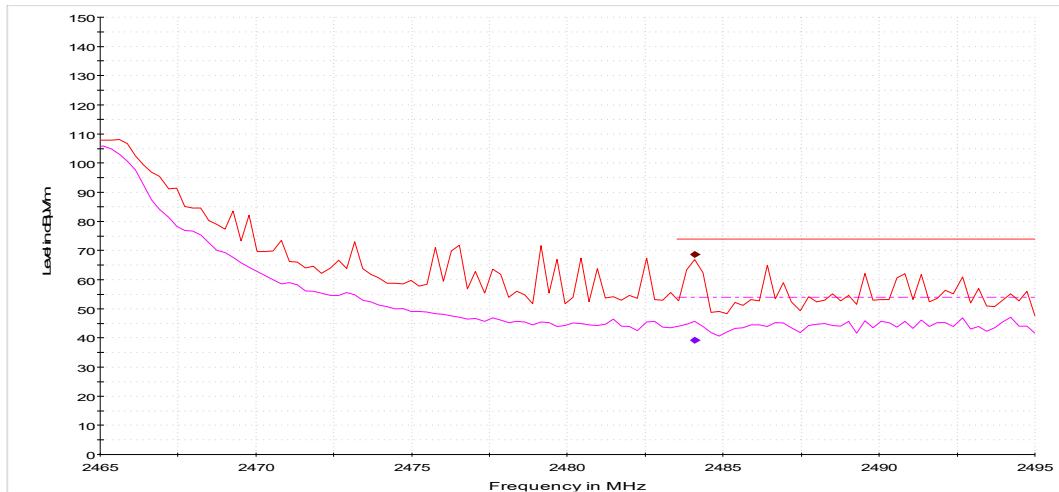


EMC Bayswater Pty. Ltd.

**CFR47 FCC Part 15, Subpart C, 15.247 - Band edge
Measurement**
Sealite Pty Ltd - PCA-2201 - 2.4GHz Radio Module
2465MHz Channel (Restricted Bands) – Vertical
measurement Antenna – EUT X orientation

Job Number: E2206-1543-1
Rev1

Test
Engineer: NL

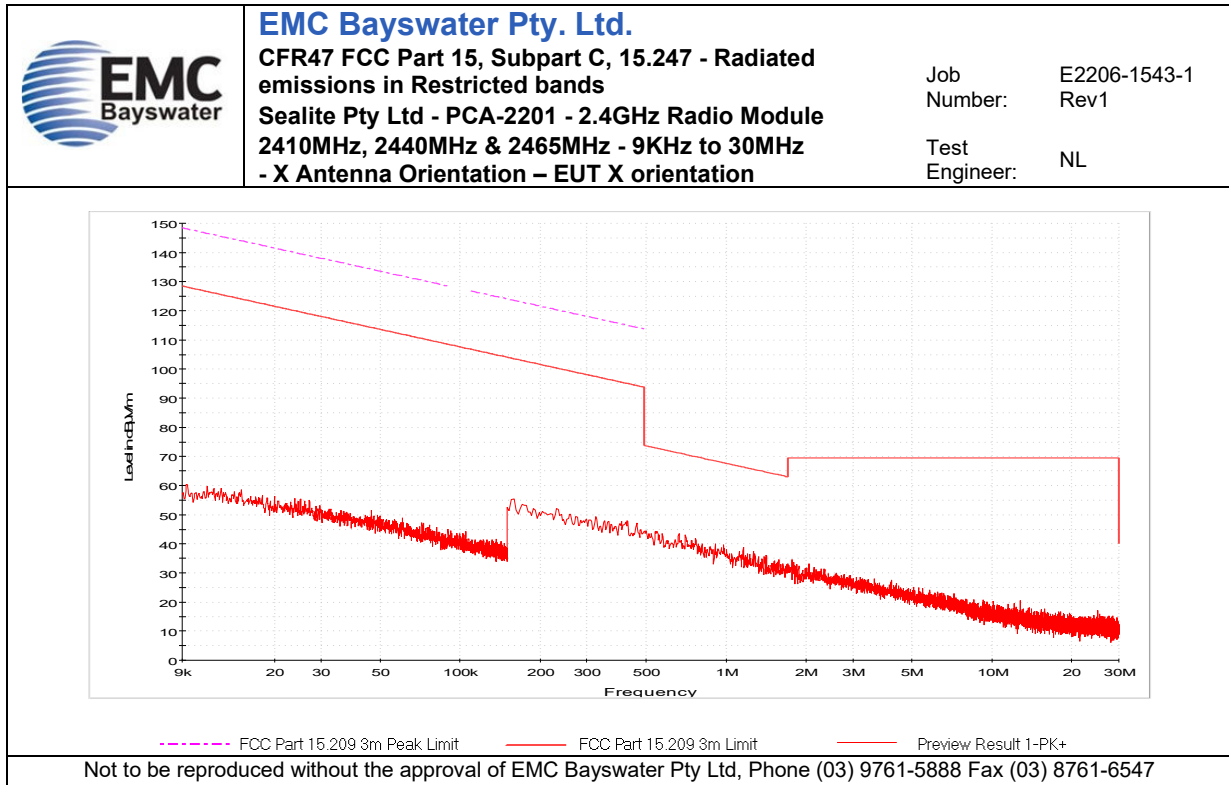


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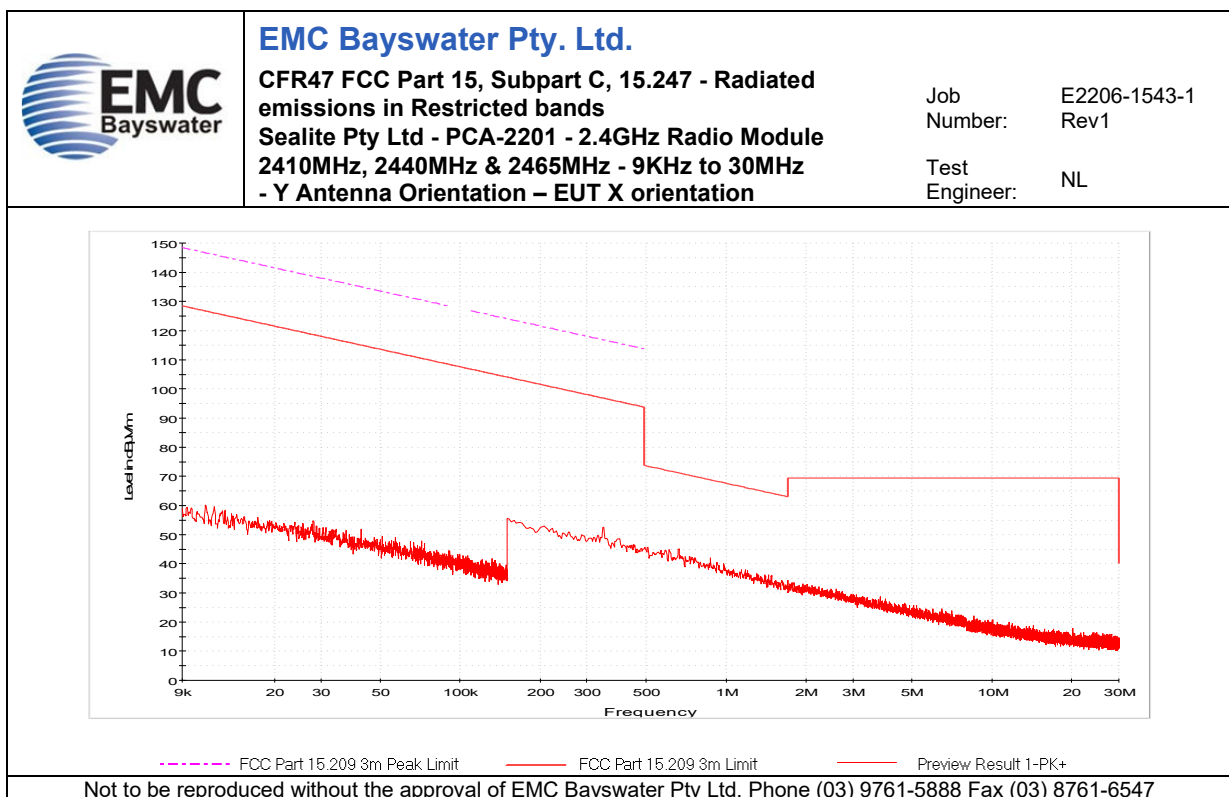
Graph 9

Appendix C.4 – Measurement Graphs – Radiated emissions in Restricted bands – FCC 15.247 (d), 15.209

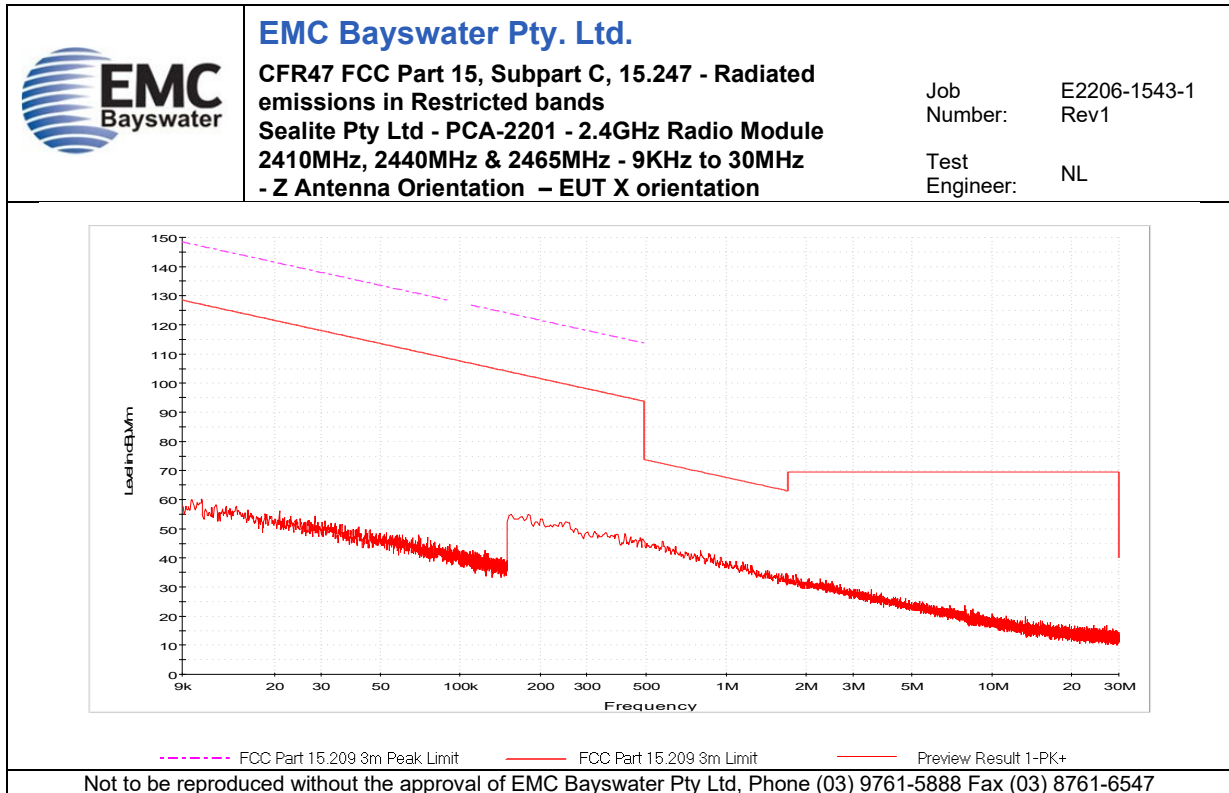
No.	Test	Graph Description
10	Radiated emissions in Restricted bands 2410MHz, 2440MHz & 2465MHz Channel	9kHz to 30MHz – Antenna X – EUT X orientation
11		9kHz to 30MHz – Antenna Y – EUT X orientation
12		9kHz to 30MHz – Antenna Z – EUT X orientation
13	Radiated emissions in Restricted bands 2410MHz Channel	30MHz to 1GHz – Horizontal Antenna – EUT Z orientation
14		30MHz to 1GHz – Vertical Antenna – EUT X orientation
15		1GHz to 3.6GHz – Horizontal Antenna – EUT Z orientation
16		1GHz to 3.6GHz – Vertical Antenna – EUT X orientation
17		3.6GHz to 6GHz – Horizontal Antenna – EUT Z orientation
18		3.6GHz to 6GHz – Vertical Antenna – EUT X orientation
19		5.8GHz to 8.2GHz – Horizontal Antenna – EUT Z orientation
20		5.8GHz to 8.2GHz – Vertical Antenna – EUT X orientation
21		8.2GHz to 12.4GHz – Horizontal Antenna – EUT Z orientation
22		8.2GHz to 12.4GHz – Vertical Antenna – EUT X orientation
23		12.4GHz to 18GHz – Horizontal Antenna – EUT Z orientation
24		12.4GHz to 18GHz – Vertical Antenna – EUT X orientation
25		18GHz to 25GHz – Horizontal Antenna – EUT Z orientation
26		18GHz to 25GHz – Vertical Antenna – EUT X orientation
27	Radiated emissions in Restricted bands 2440MHz Channel	30MHz to 1GHz – Horizontal Antenna – EUT Z orientation
28		30MHz to 1GHz – Vertical Antenna – EUT X orientation
29		1GHz to 3.6GHz – Horizontal Antenna – EUT Z orientation
30		1GHz to 3.6GHz – Vertical Antenna – EUT X orientation
31		3.6GHz to 6GHz – Horizontal Antenna – EUT Z orientation
32		3.6GHz to 6GHz – Vertical Antenna – EUT X orientation
33		5.8GHz to 8.2GHz – Horizontal Antenna – EUT Z orientation
34		5.8GHz to 8.2GHz – Vertical Antenna – EUT X orientation
35		8.2GHz to 12.4GHz – Horizontal Antenna – EUT Z orientation
36		8.2GHz to 12.4GHz – Vertical Antenna – EUT X orientation
37		12.4GHz to 18GHz – Horizontal Antenna – EUT Z orientation
38		12.4GHz to 18GHz – Vertical Antenna – EUT X orientation
39		18GHz to 25GHz – Horizontal Antenna – EUT Z orientation
40		18GHz to 25GHz – Vertical Antenna – EUT X orientation
41	Radiated emissions in Restricted bands 2465MHz Channel	30MHz to 1GHz – Horizontal Antenna – EUT Z orientation
42		30MHz to 1GHz – Vertical Antenna – EUT X orientation
43		1GHz to 3.6GHz – Horizontal Antenna – EUT Z orientation
44		1GHz to 3.6GHz – Vertical Antenna – EUT X orientation
45		3.6GHz to 6GHz – Horizontal Antenna – EUT Z orientation
46		3.6GHz to 6GHz – Vertical Antenna – EUT X orientation
47		5.8GHz to 8.2GHz – Horizontal Antenna – EUT Z orientation
48		5.8GHz to 8.2GHz – Vertical Antenna – EUT X orientation
49		8.2GHz to 12.4GHz – Horizontal Antenna – EUT Z orientation
50		8.2GHz to 12.4GHz – Vertical Antenna – EUT X orientation
51		12.4GHz to 18GHz – Horizontal Antenna – EUT Z orientation
52		12.4GHz to 18GHz – Vertical Antenna – EUT X orientation
53		18GHz to 25GHz – Horizontal Antenna – EUT Z orientation
54		18GHz to 25GHz – Vertical Antenna – EUT X orientation



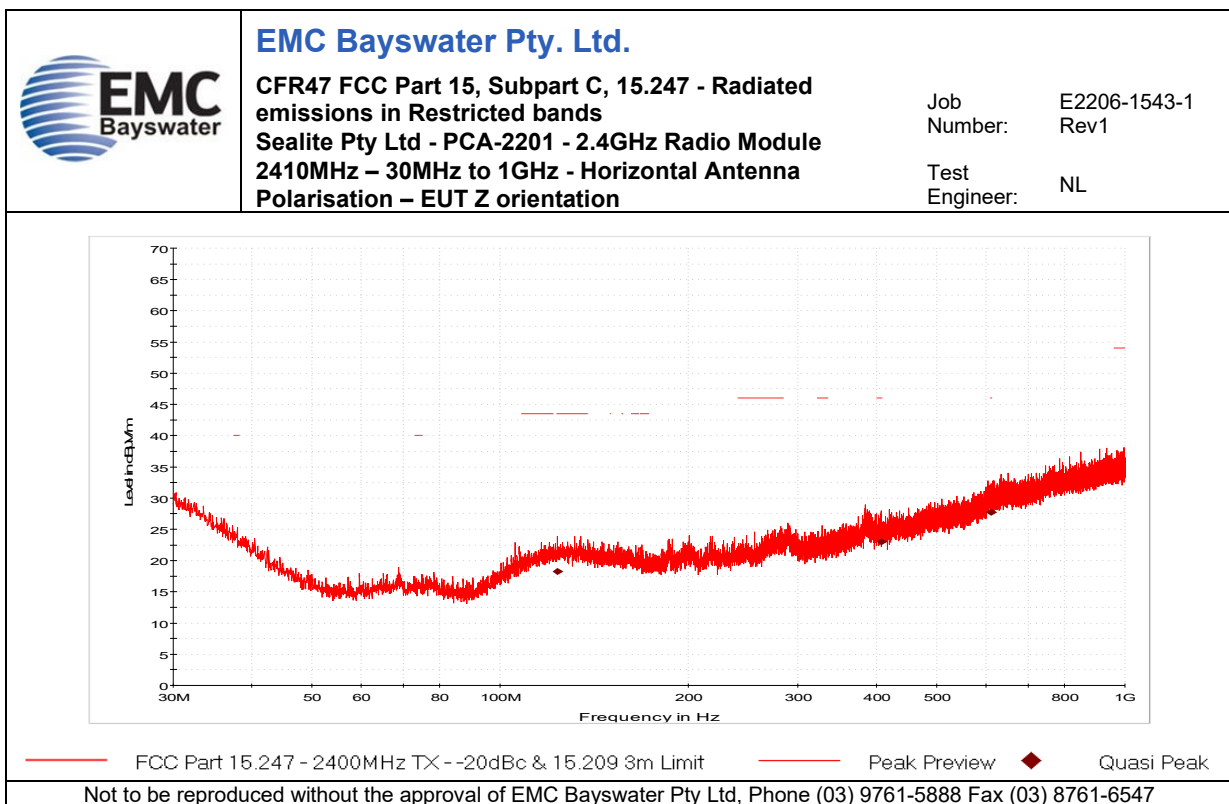
Graph 10



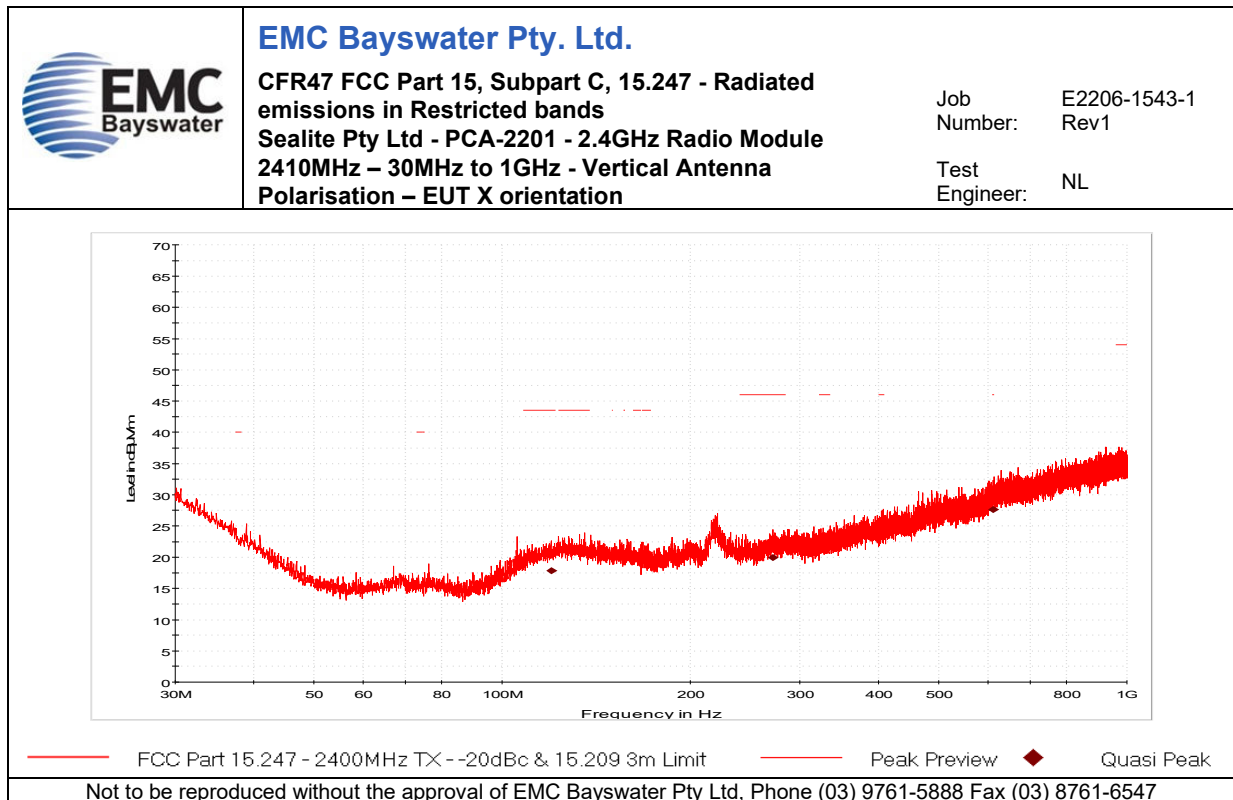
Graph 11



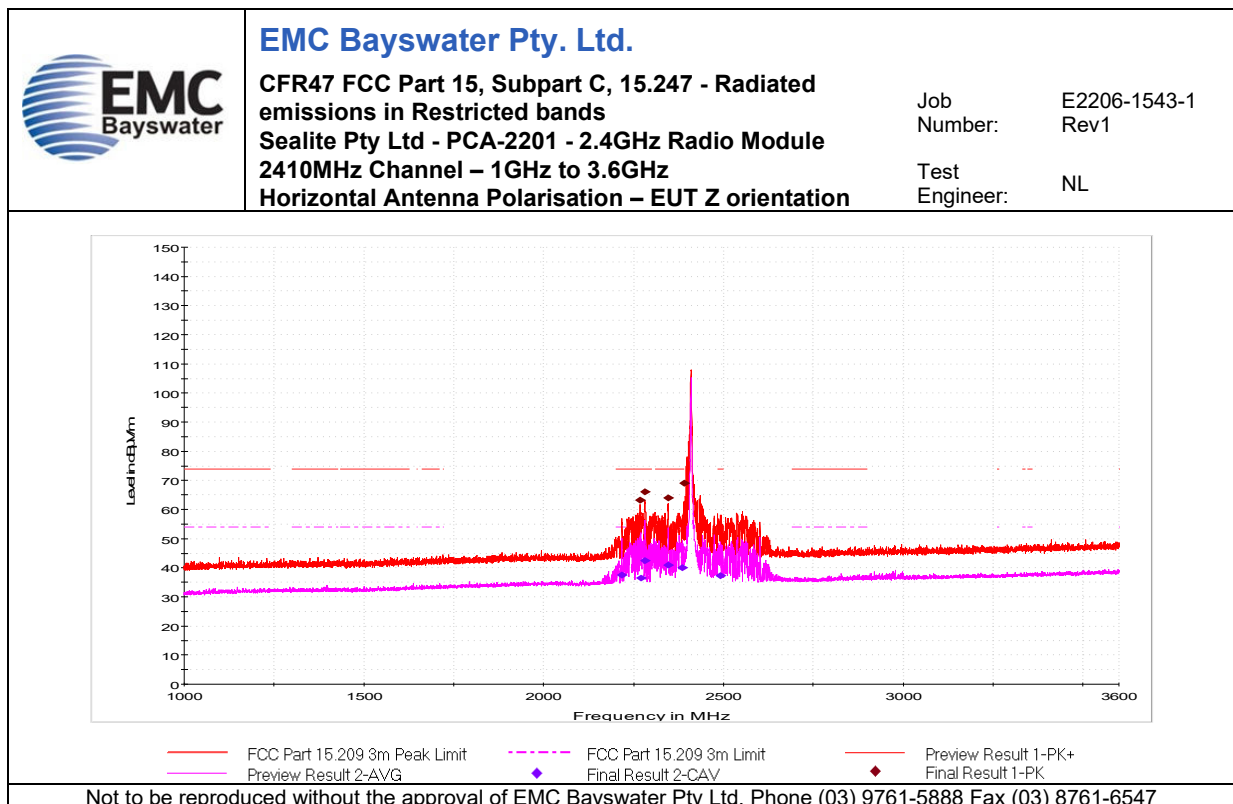
Graph 12



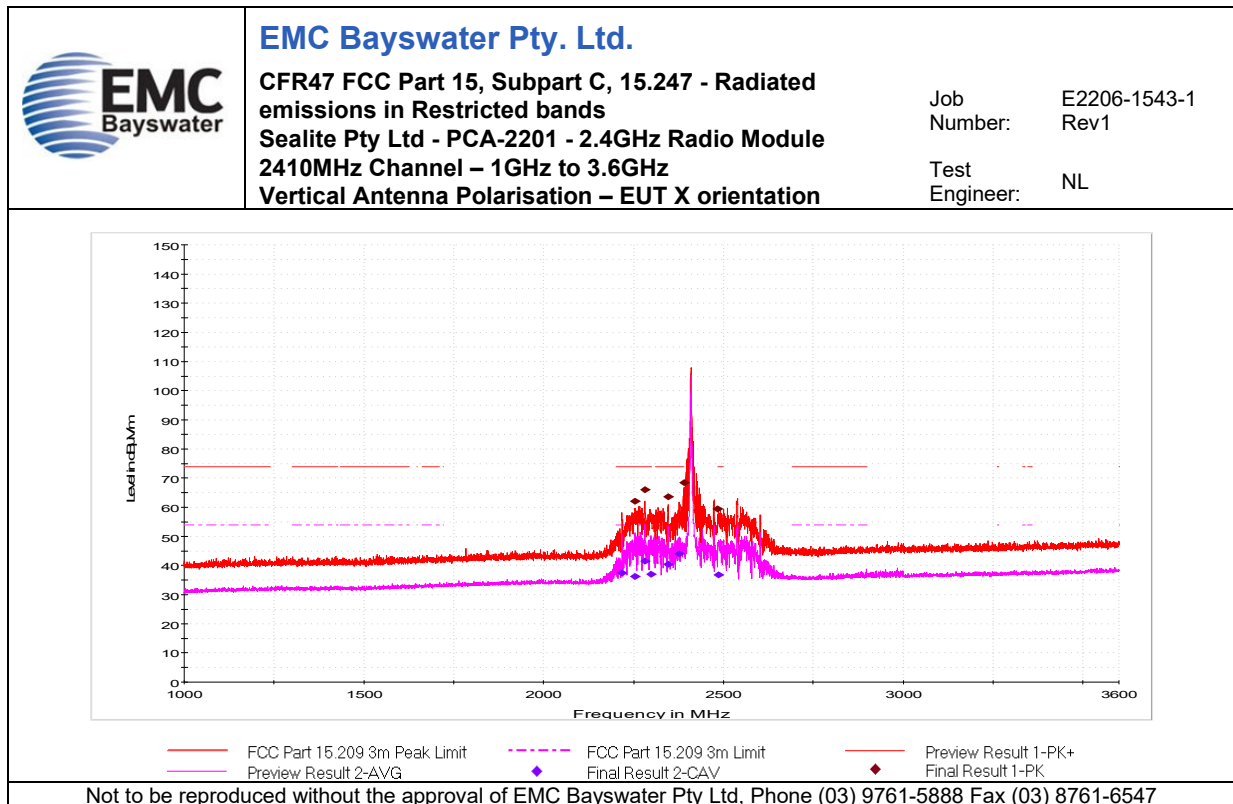
Graph 13



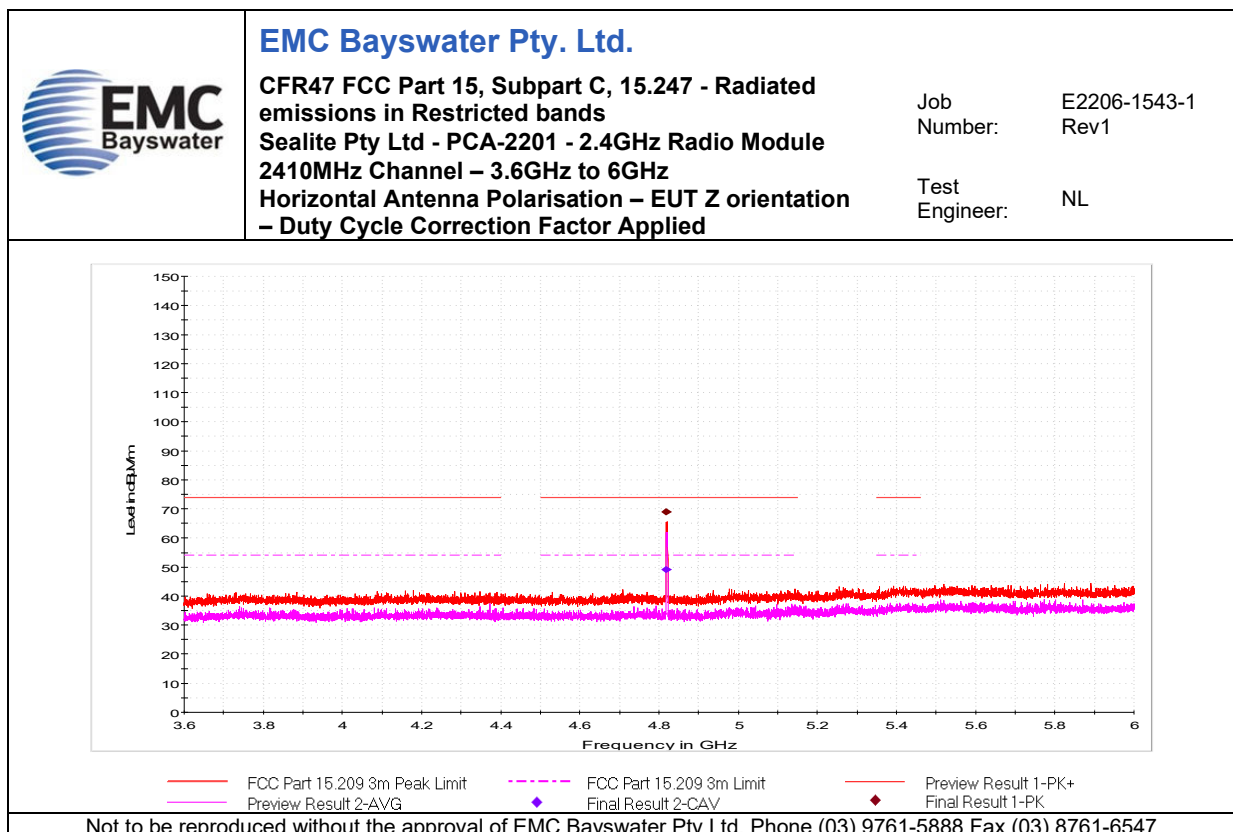
Graph 14



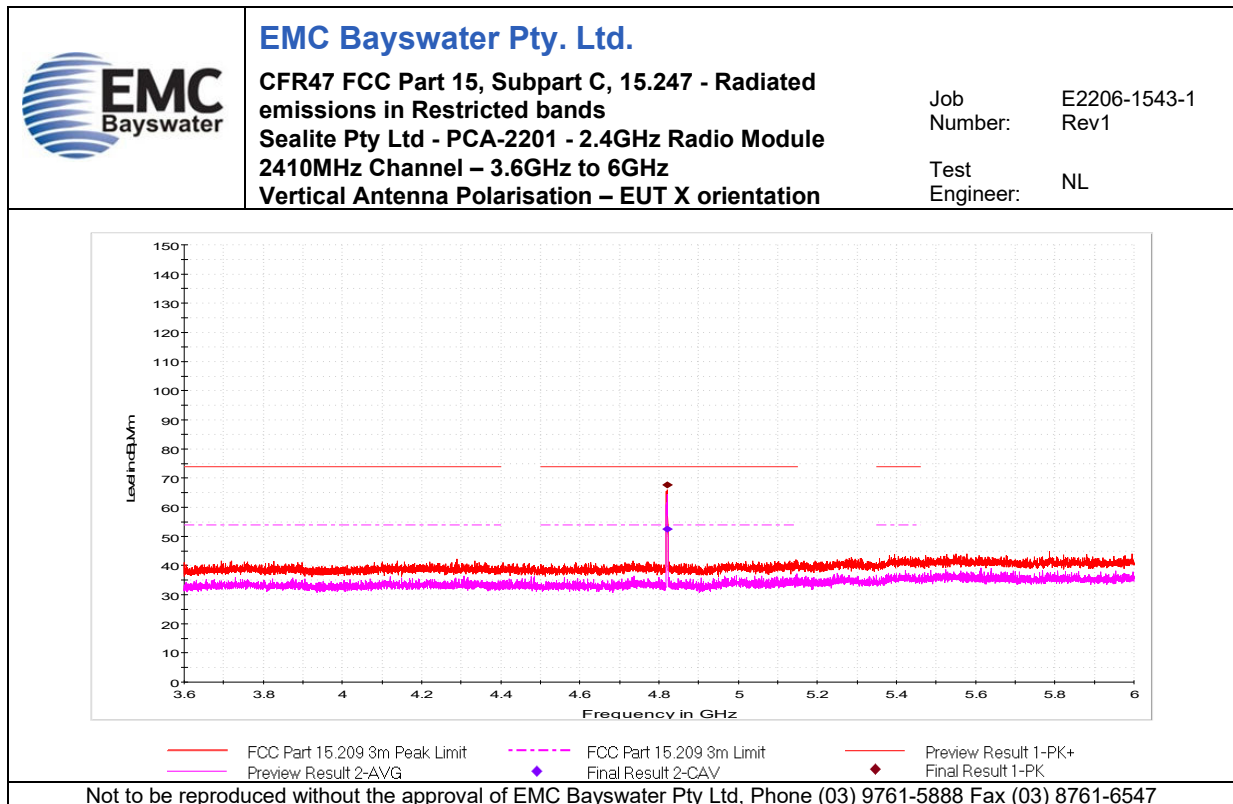
Graph 15



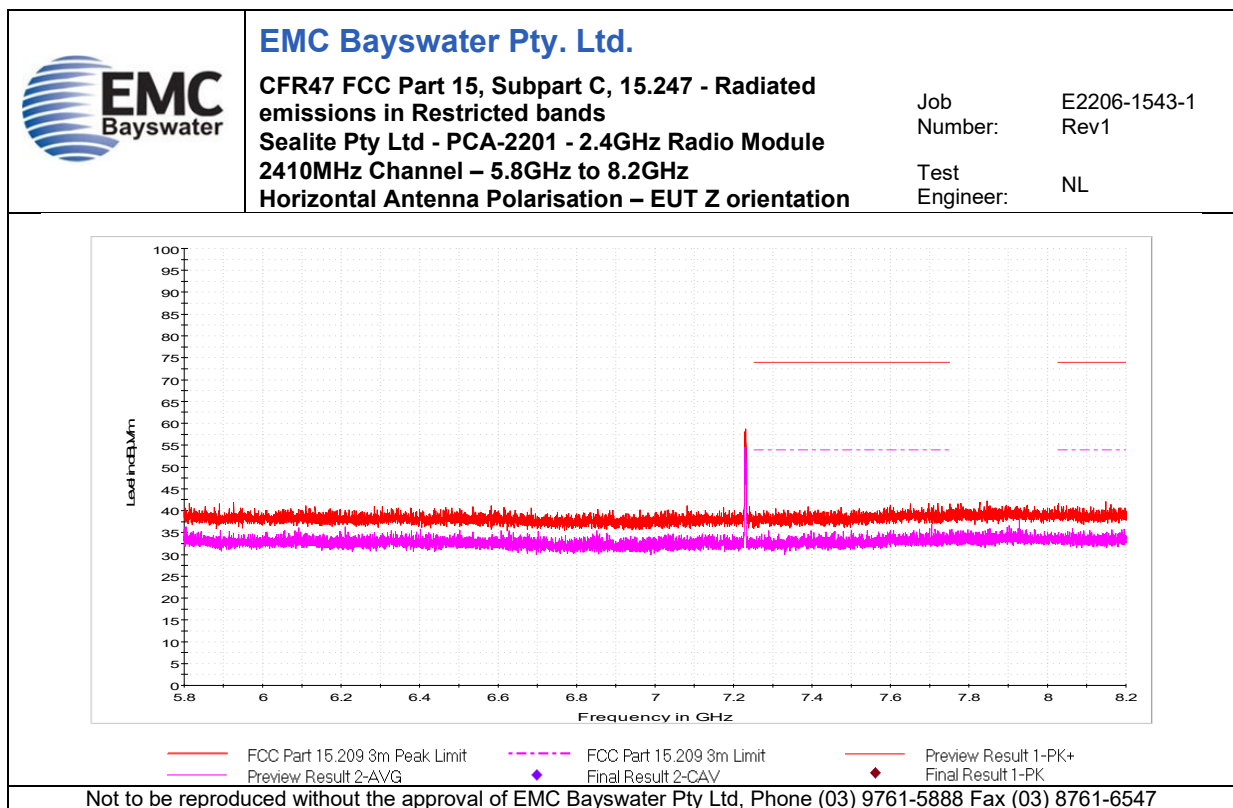
Graph 16



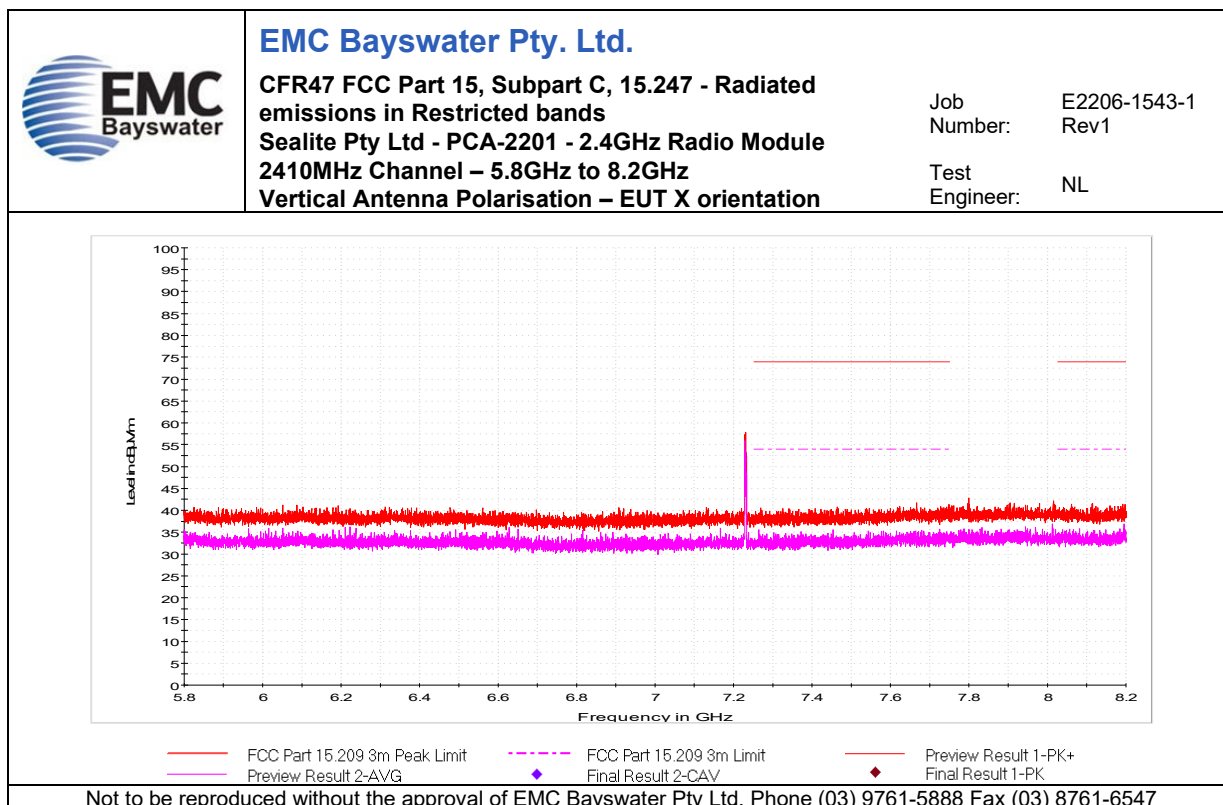
Graph 17



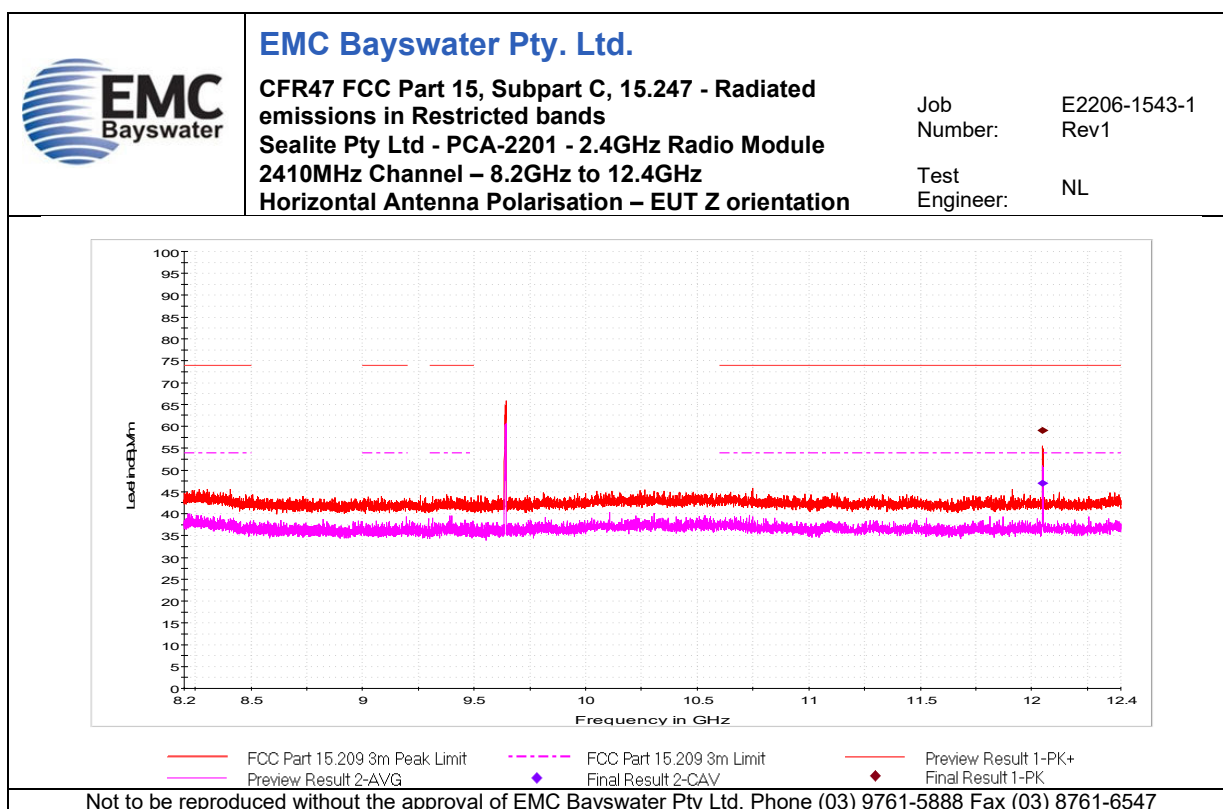
Graph 18



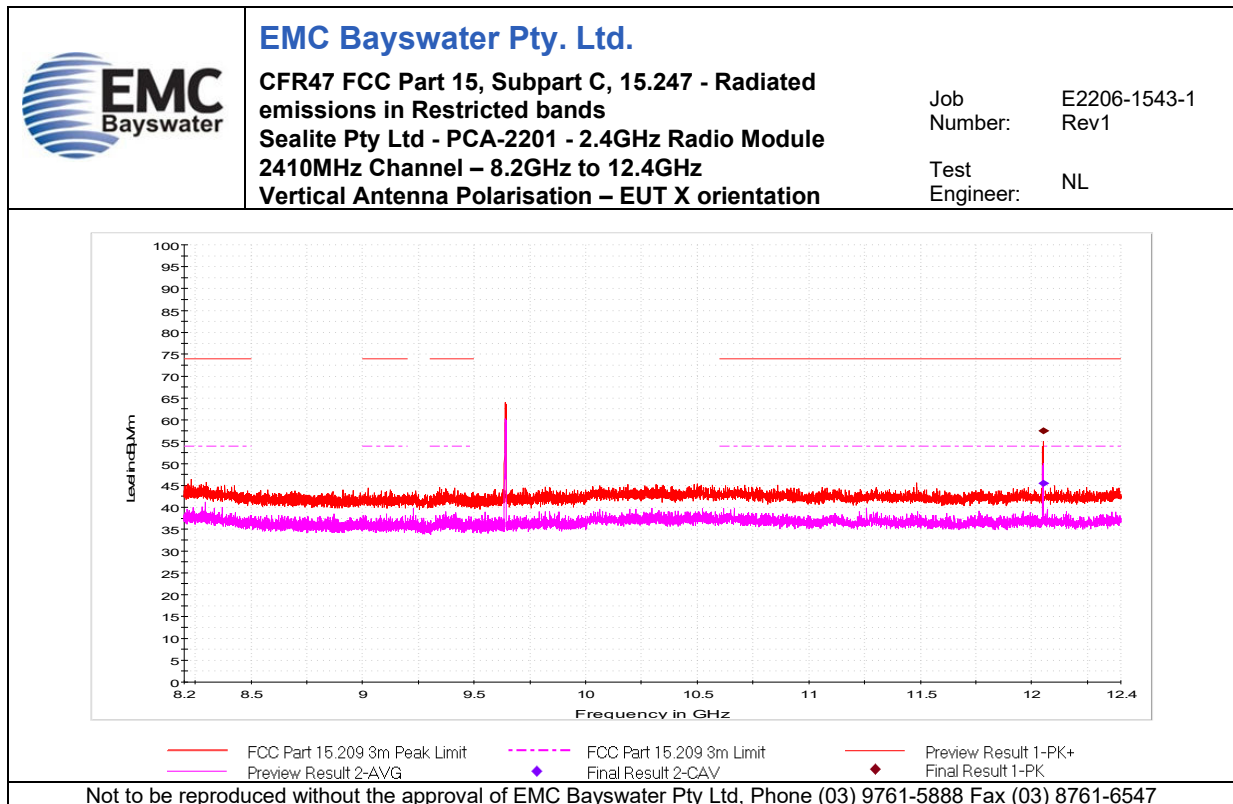
Graph 19



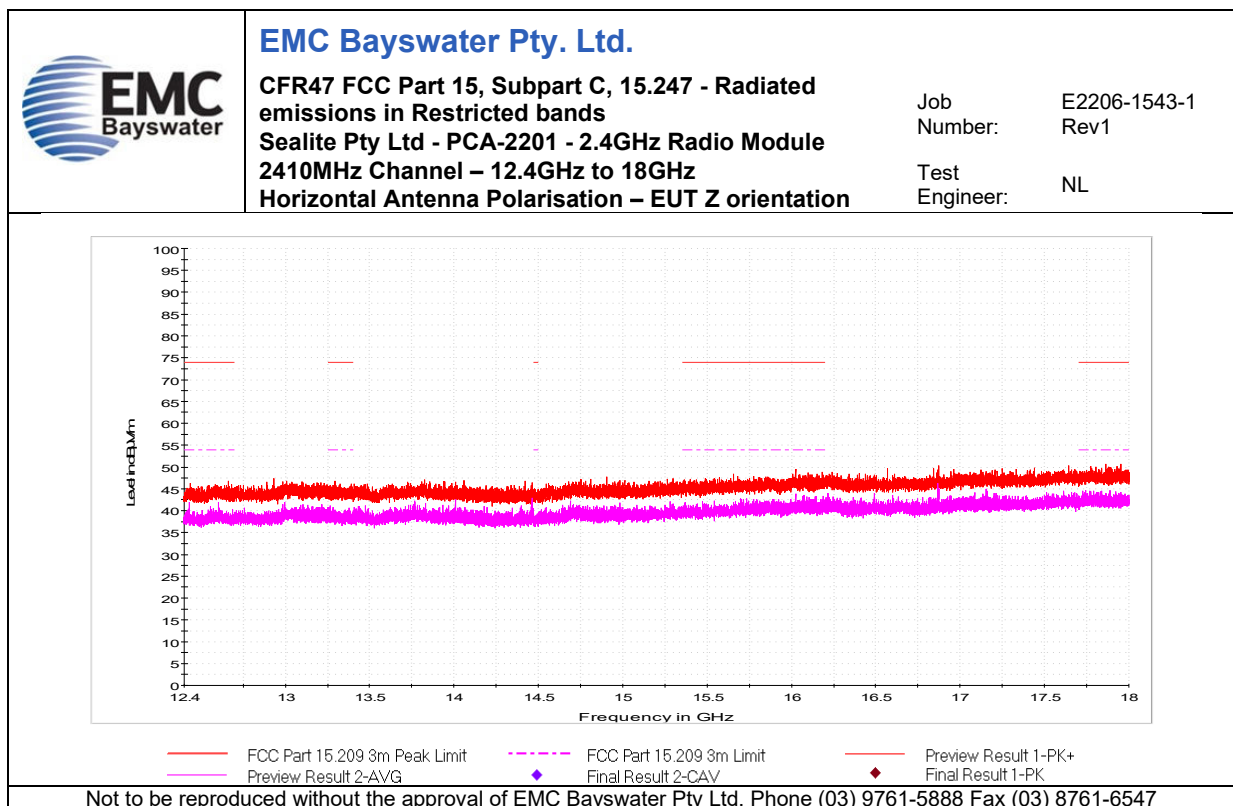
Graph 20



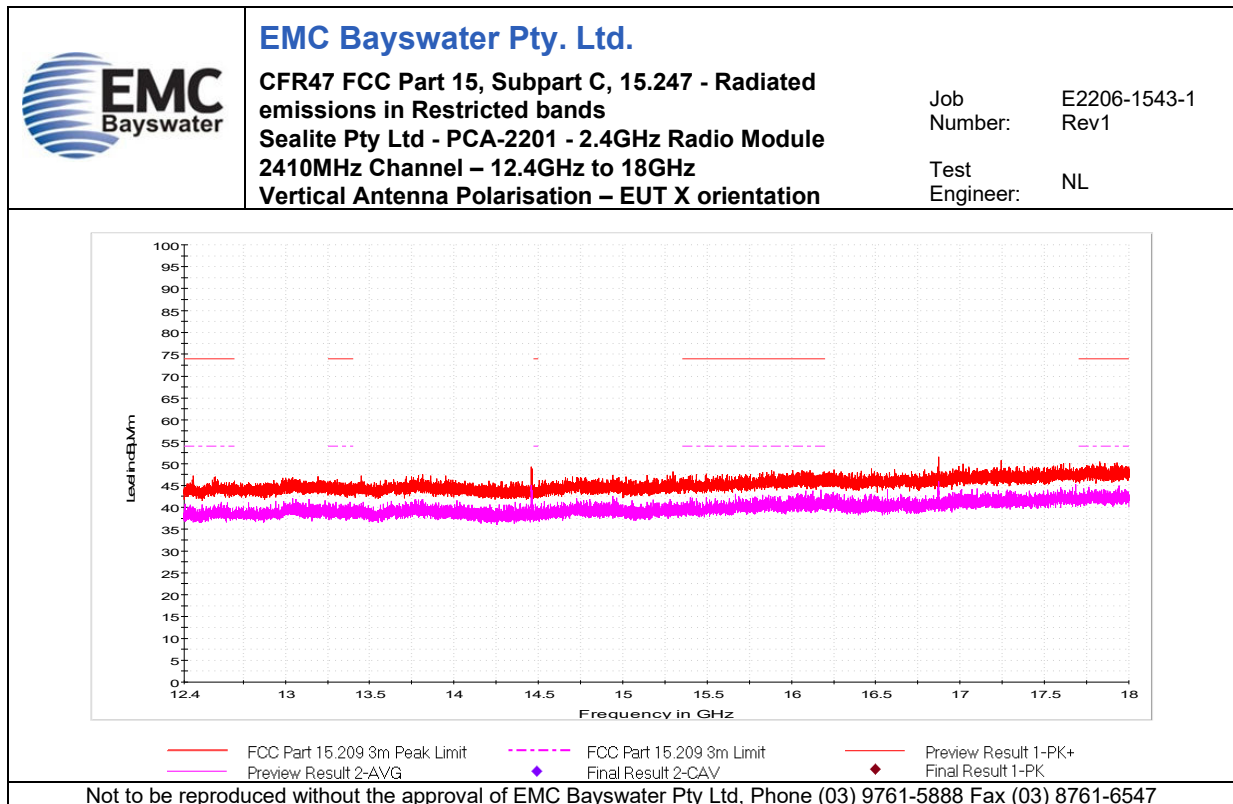
Graph 21



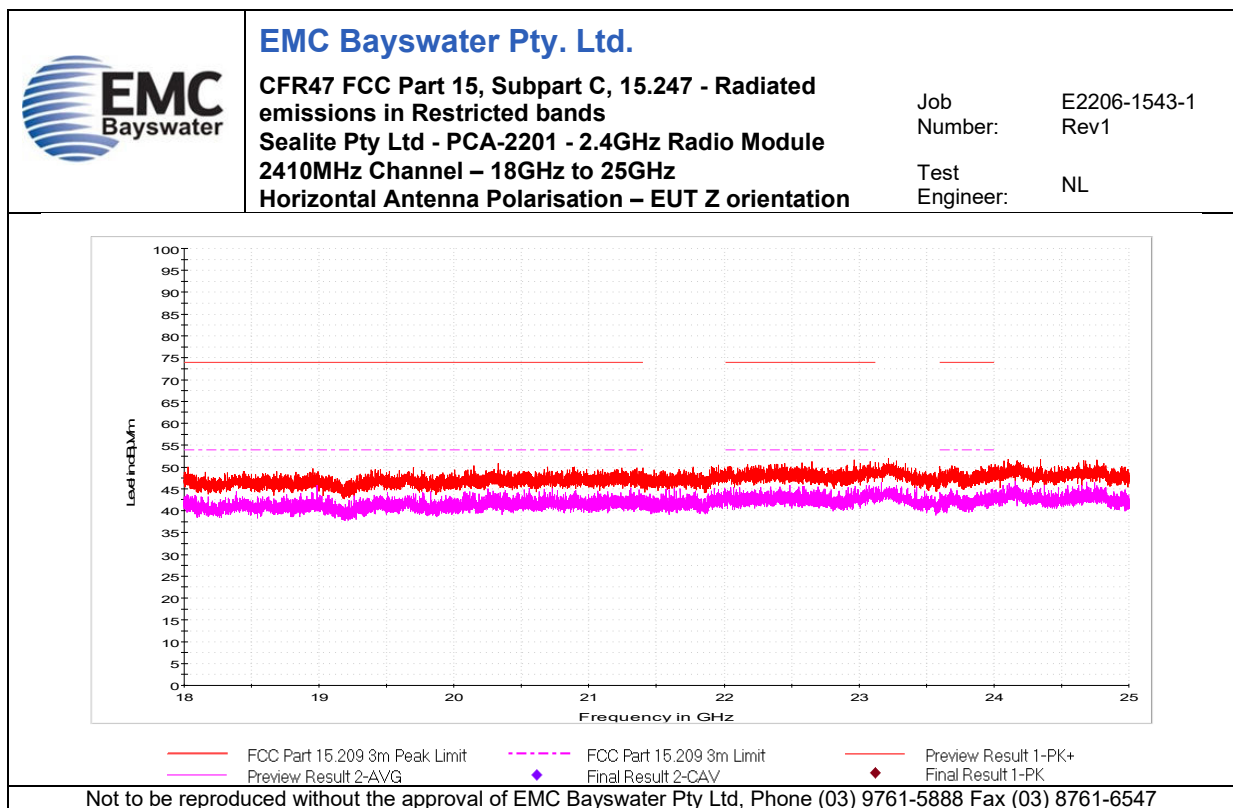
Graph 22



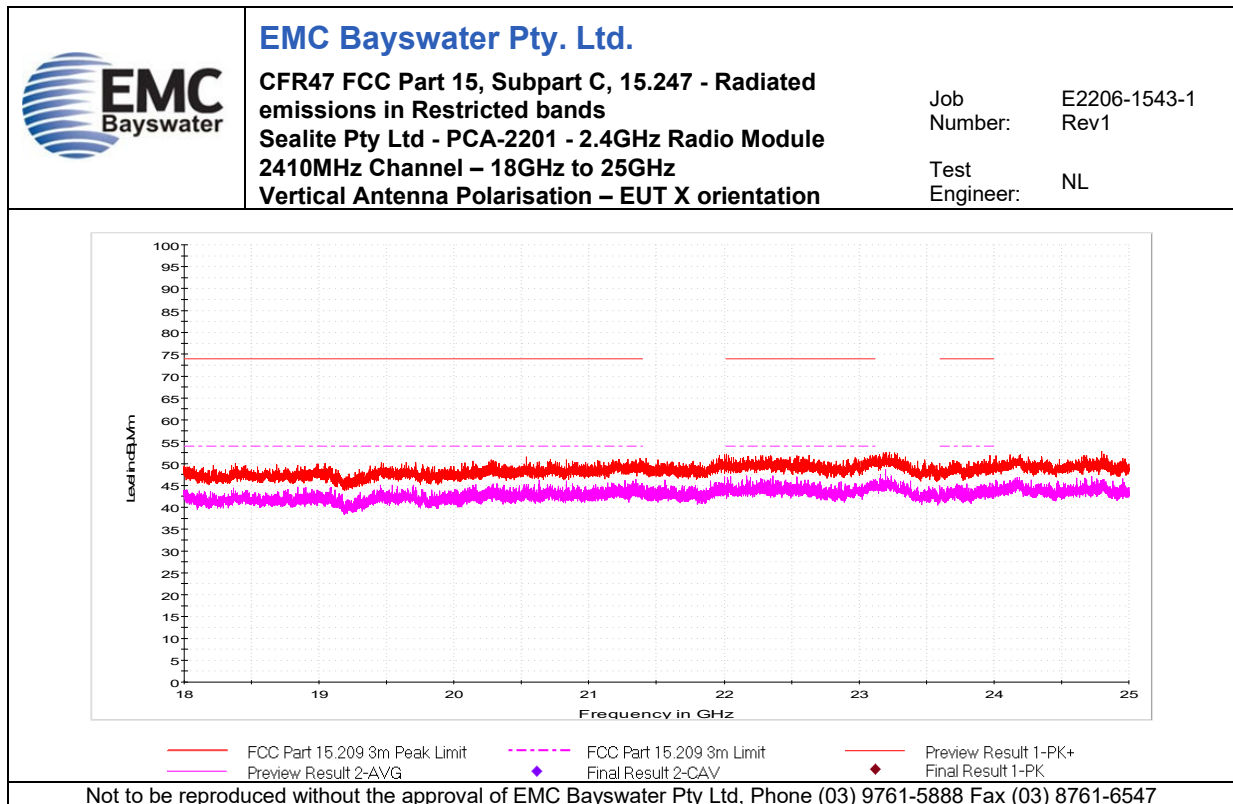
Graph 23



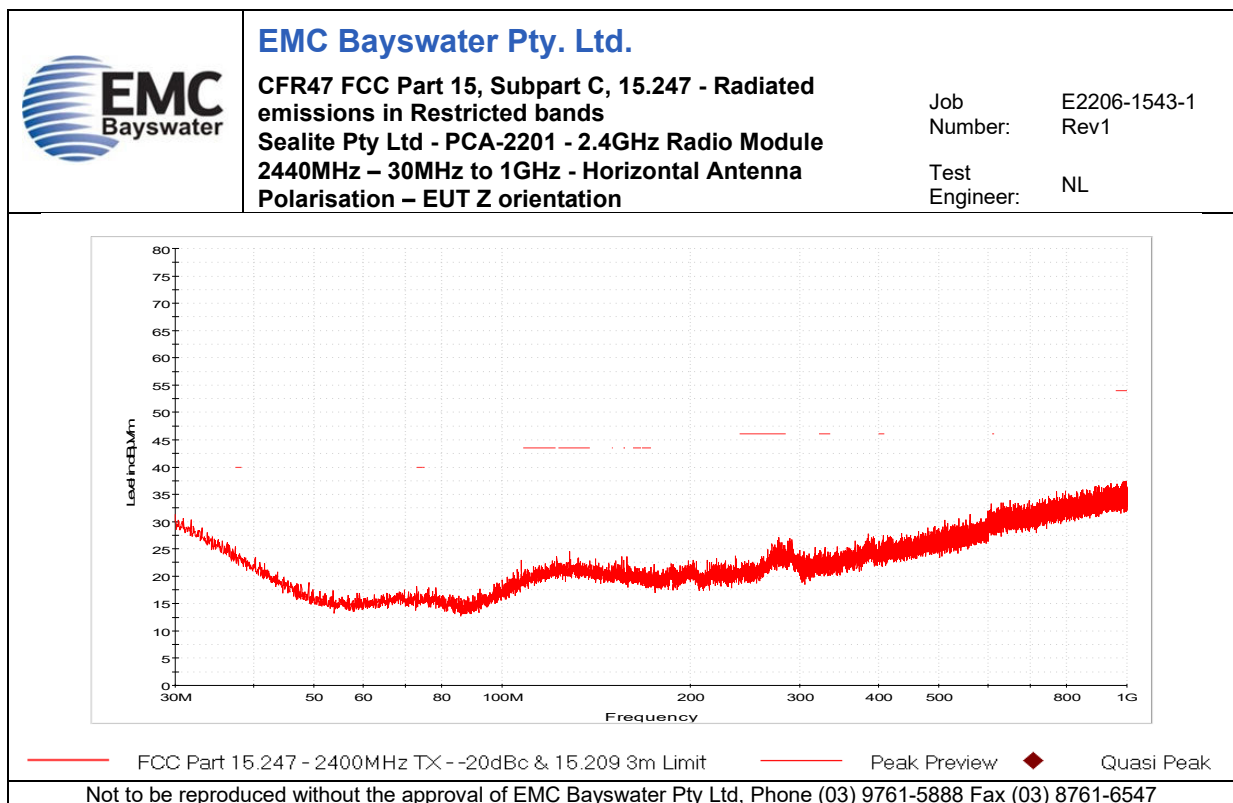
Graph 24



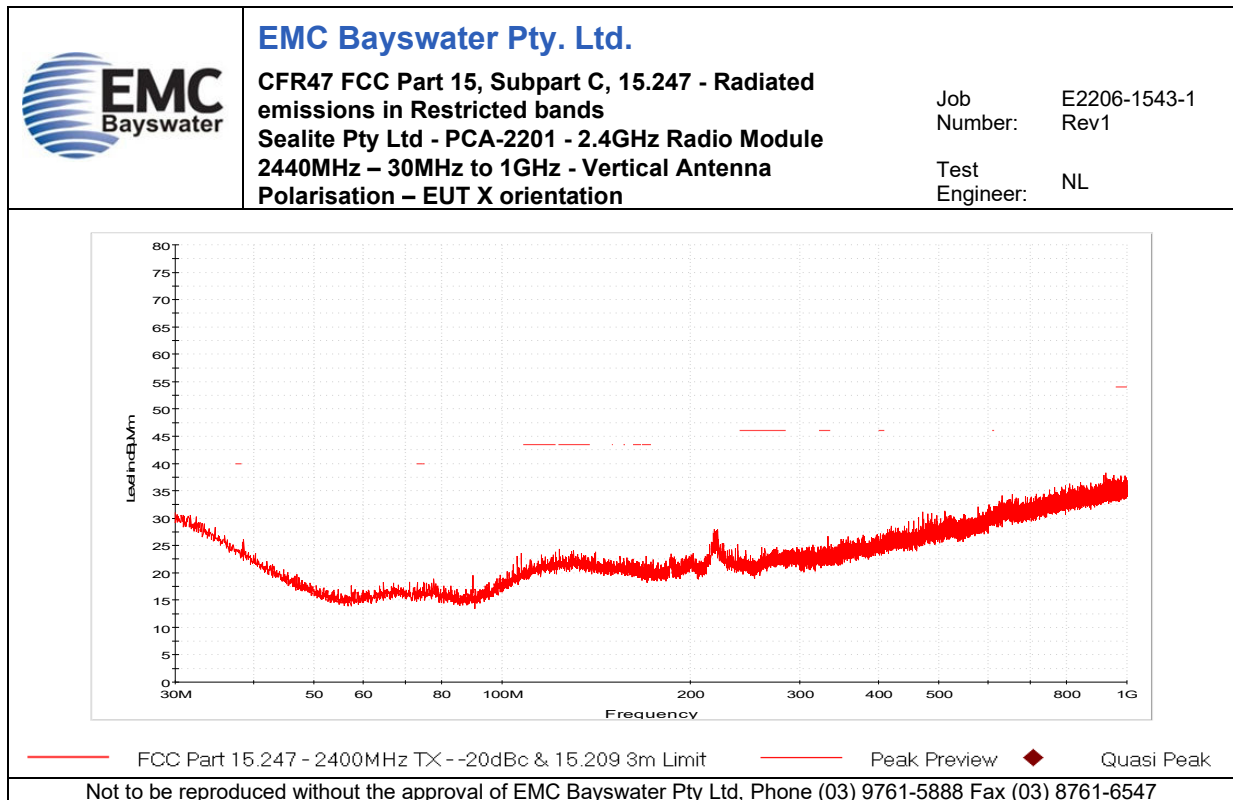
Graph 25



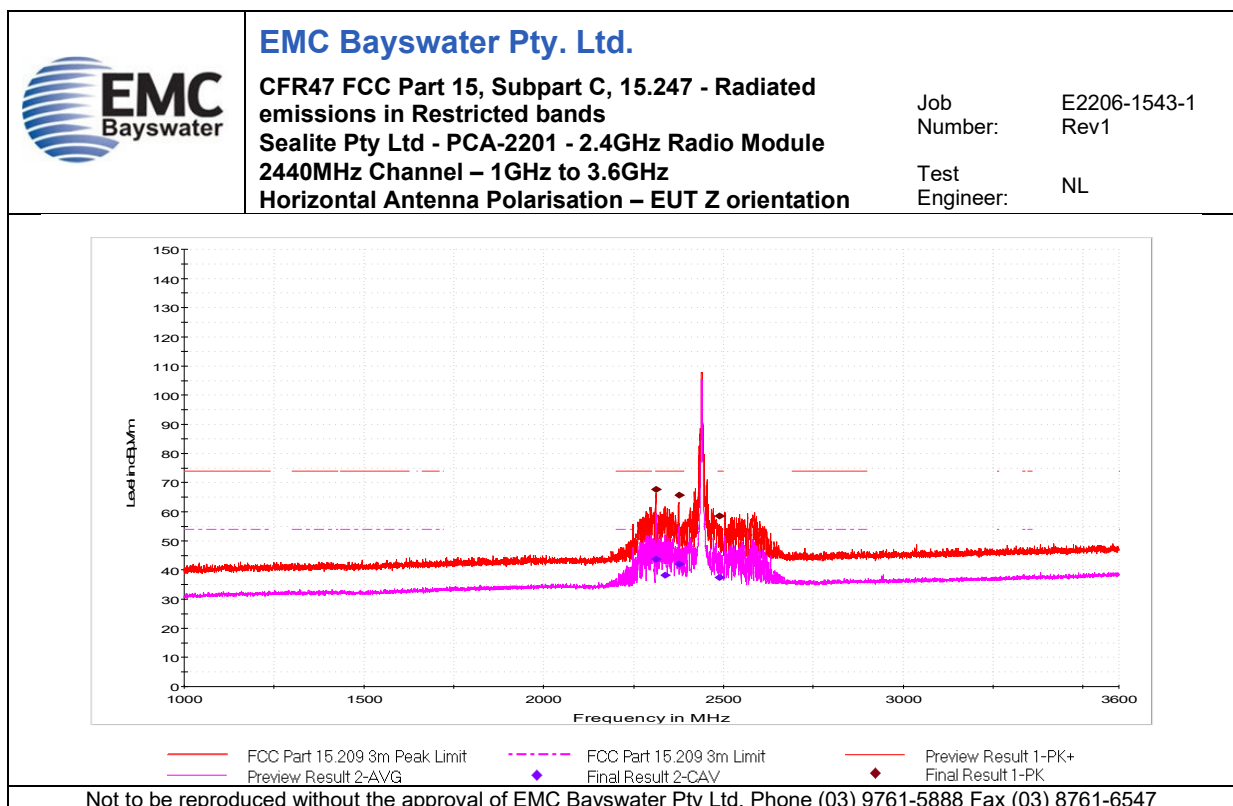
Graph 26



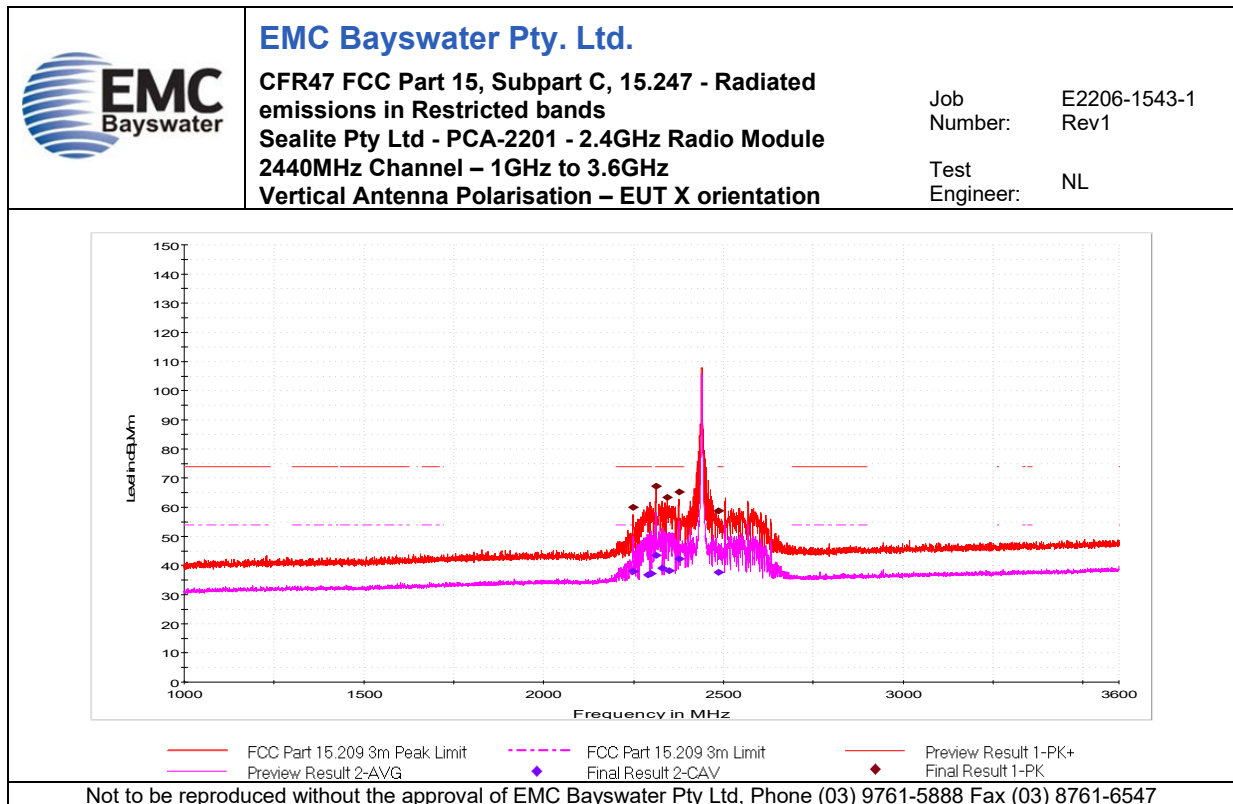
Graph 27



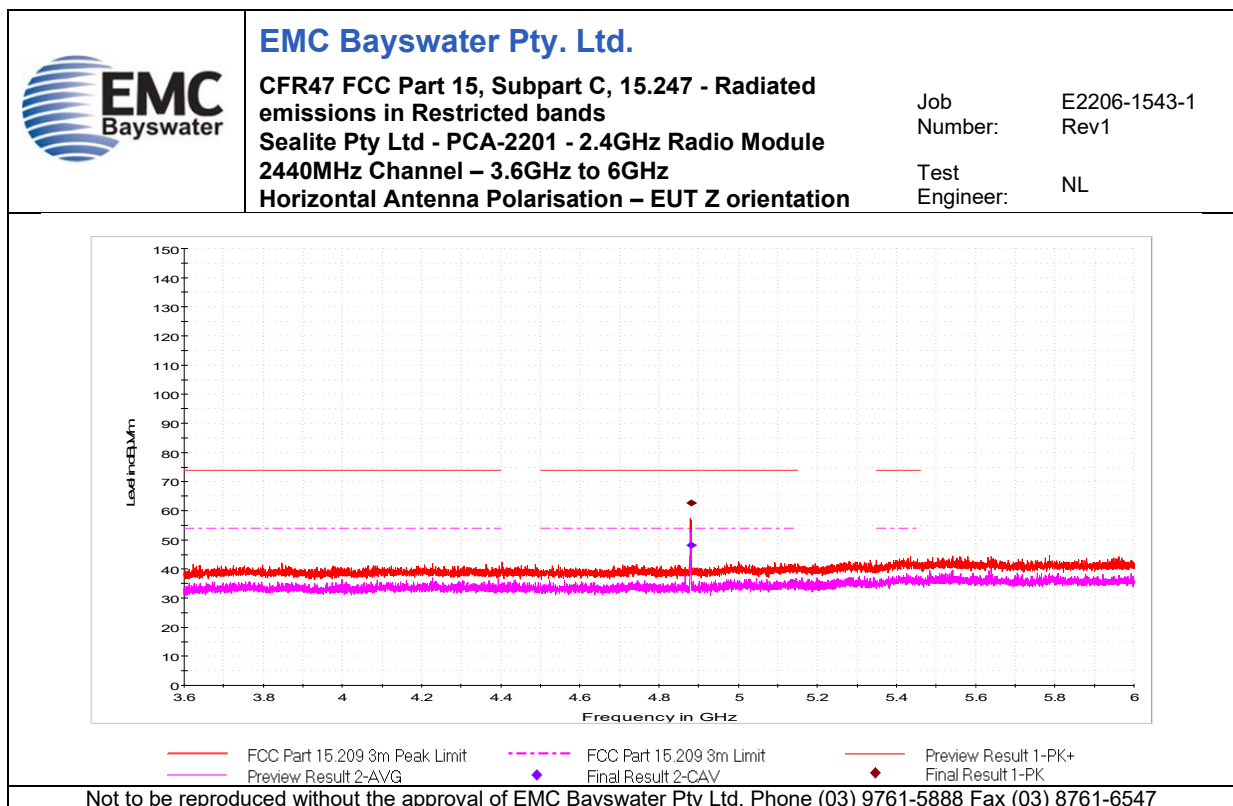
Graph 28



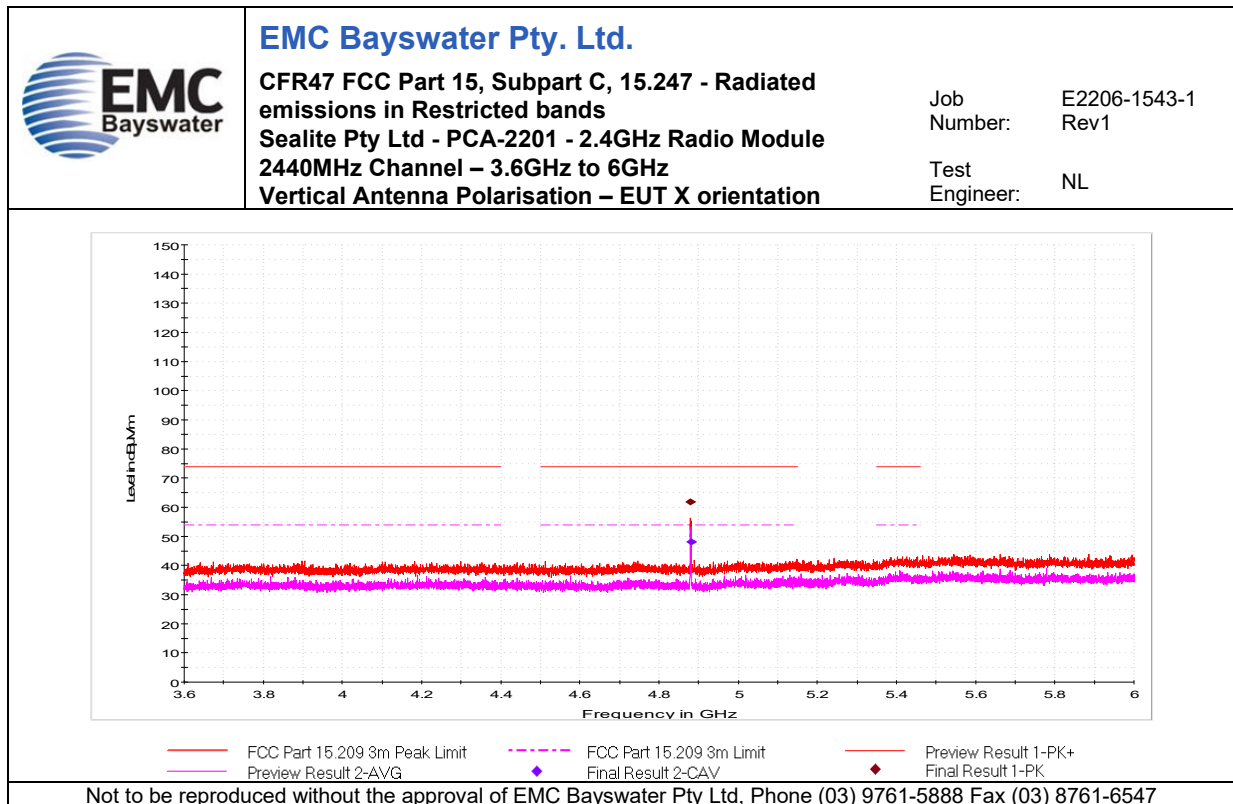
Graph 29



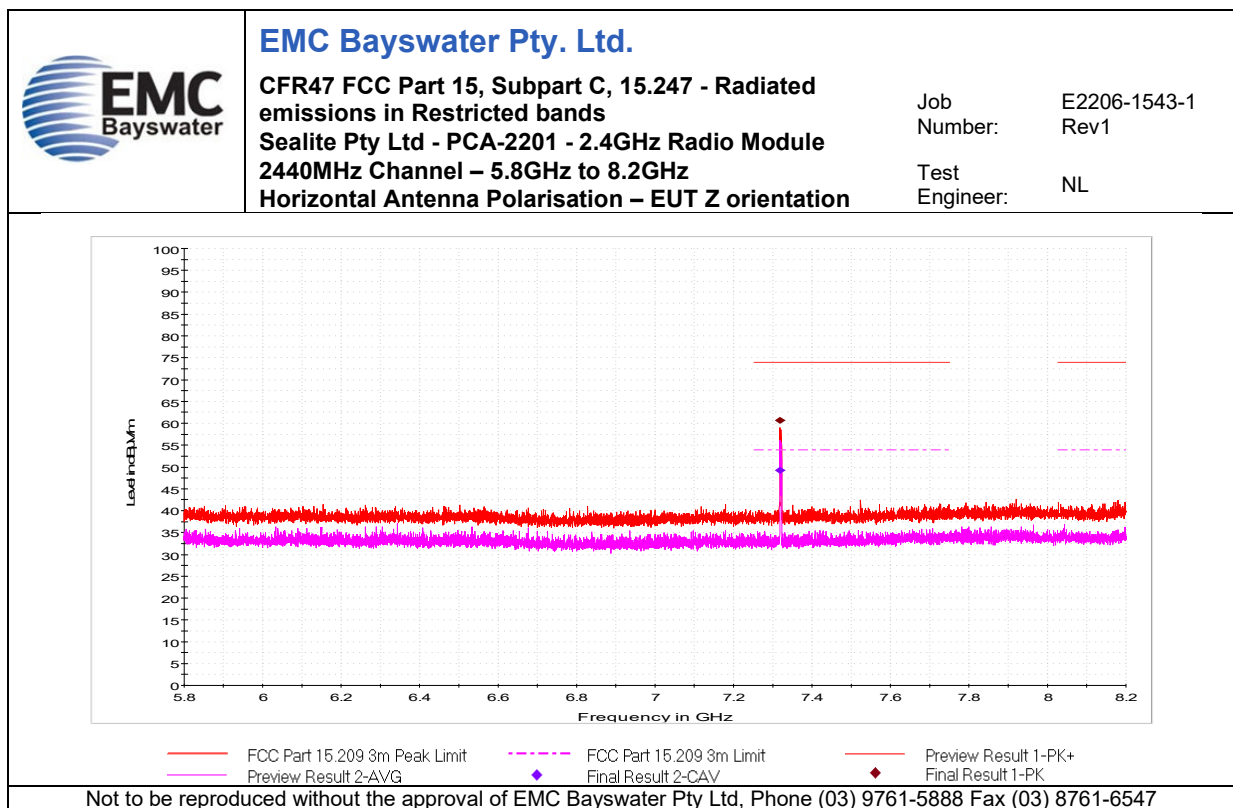
Graph 30



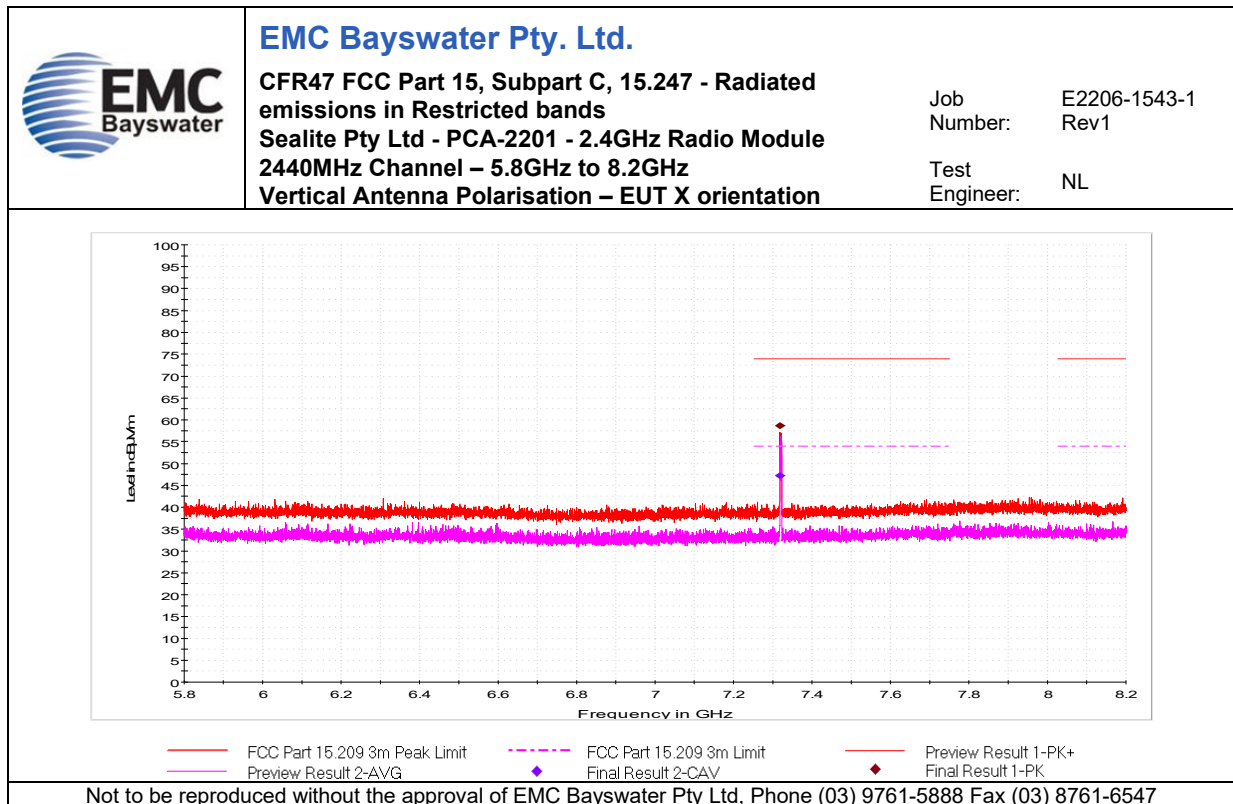
Graph 31



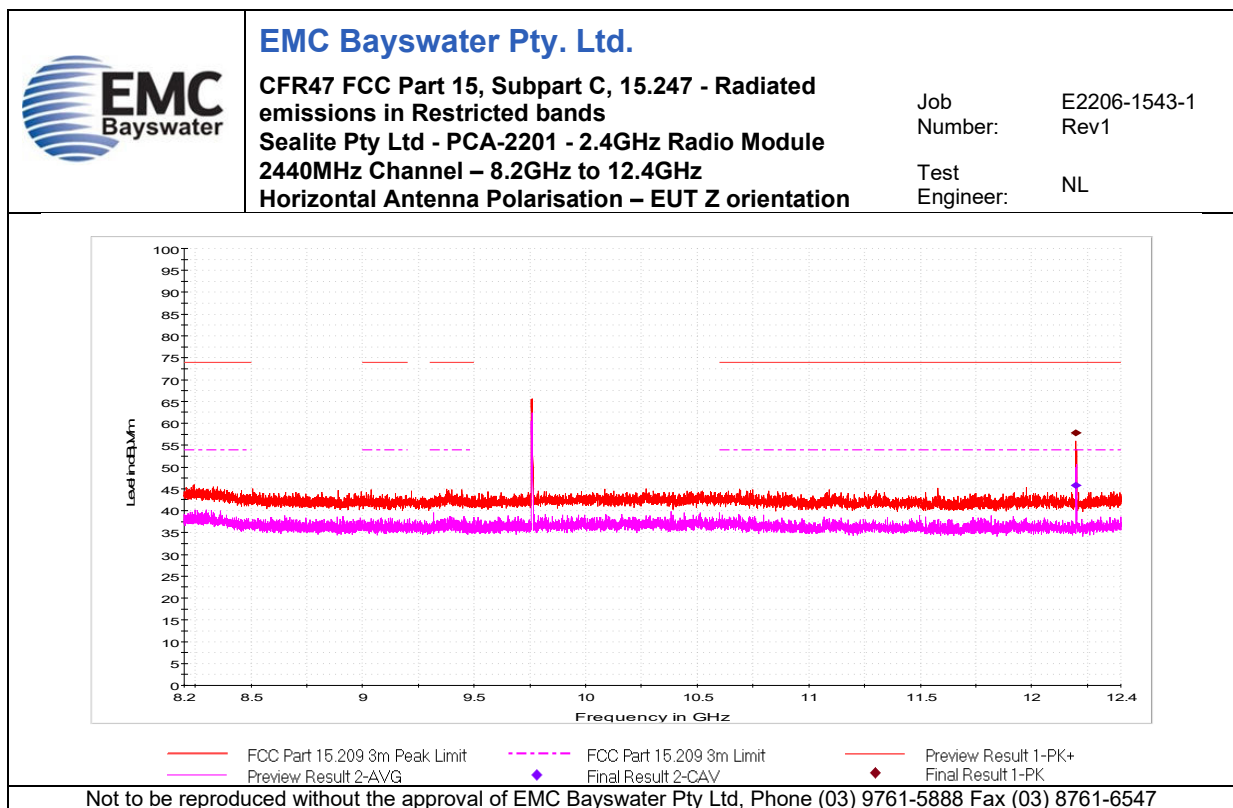
Graph 32



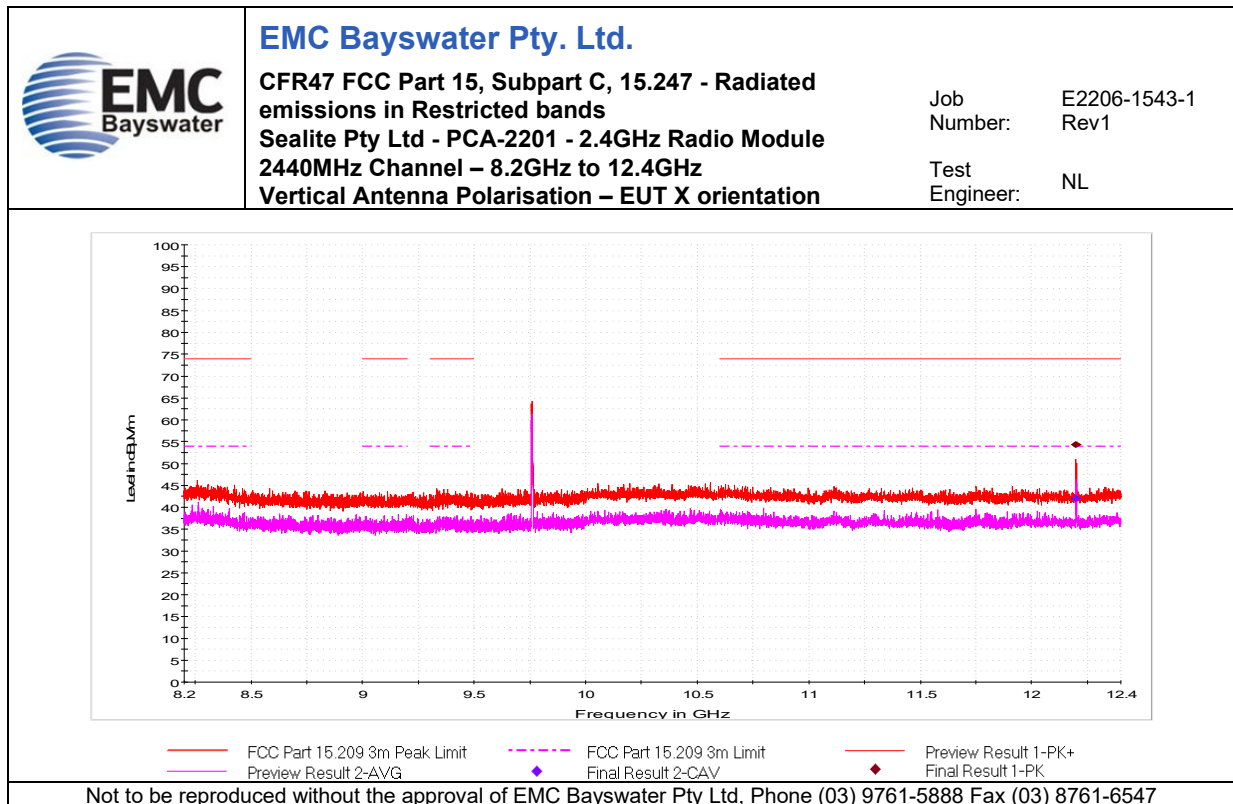
Graph 33



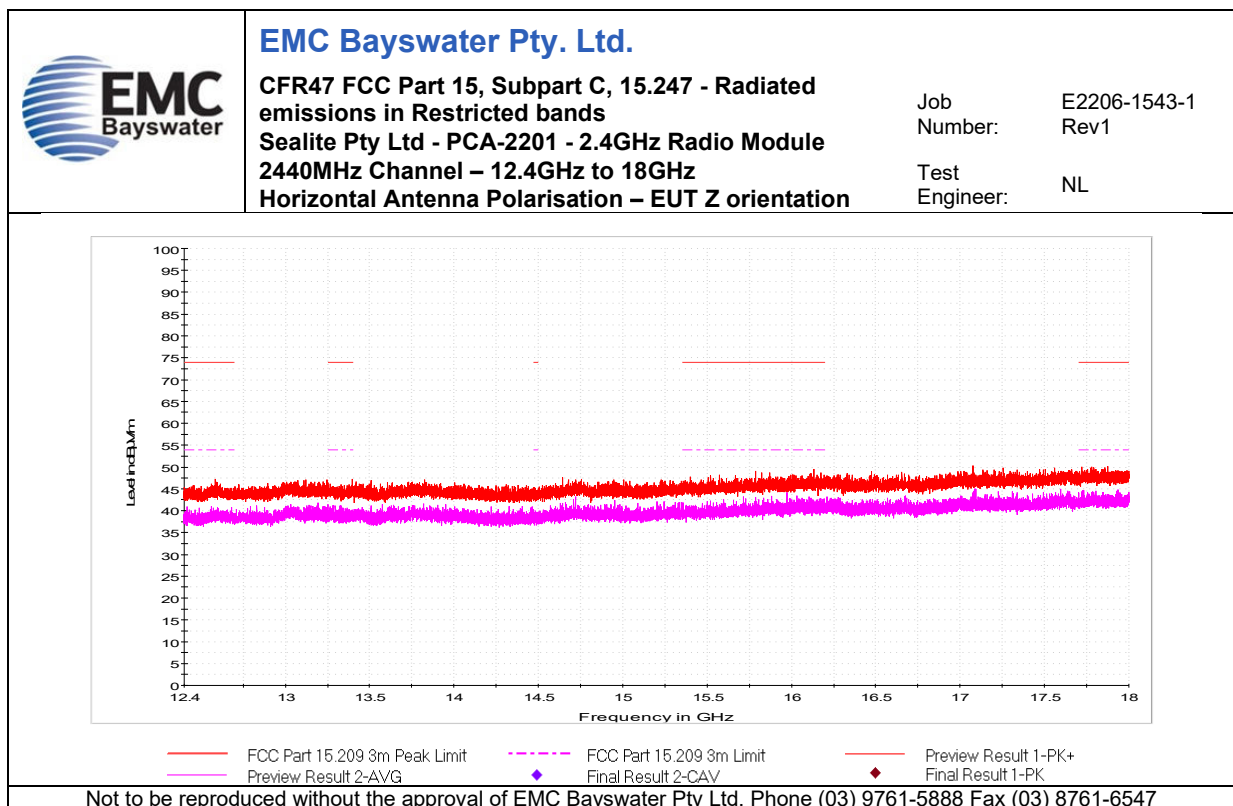
Graph 34



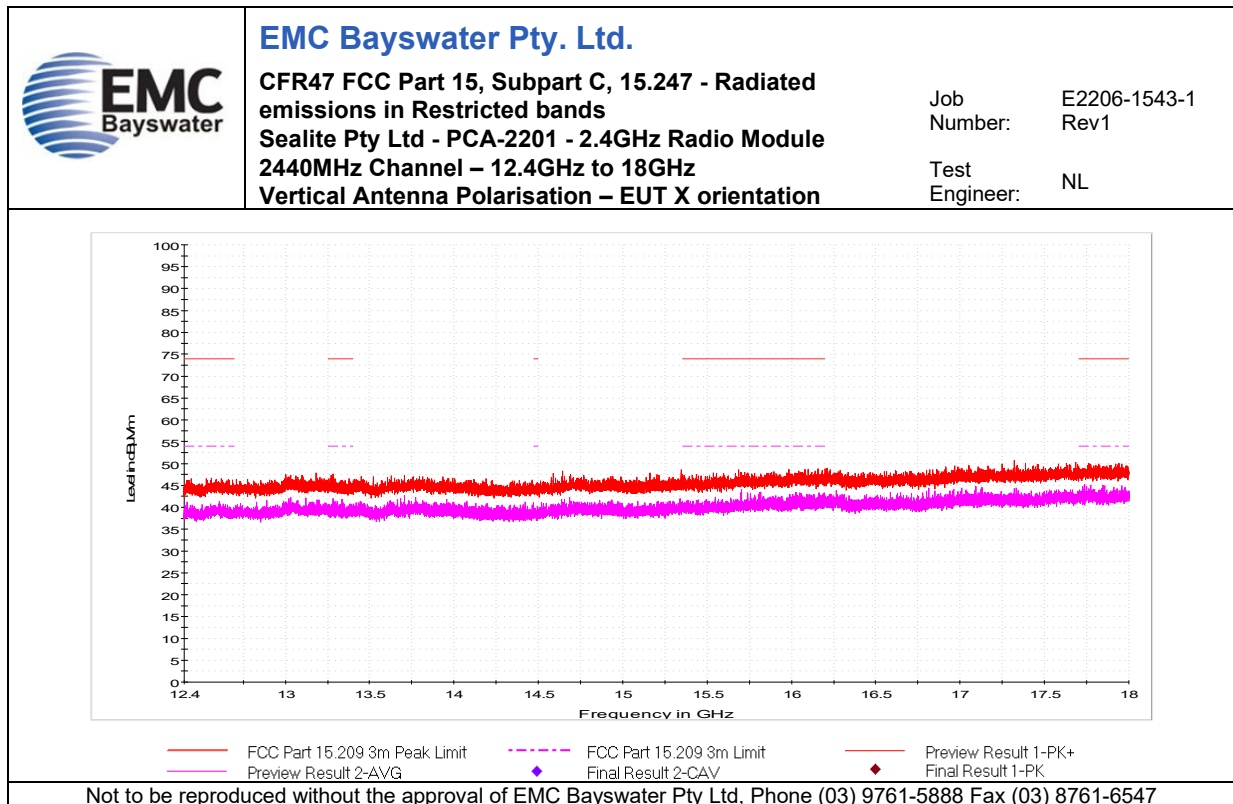
Graph 35



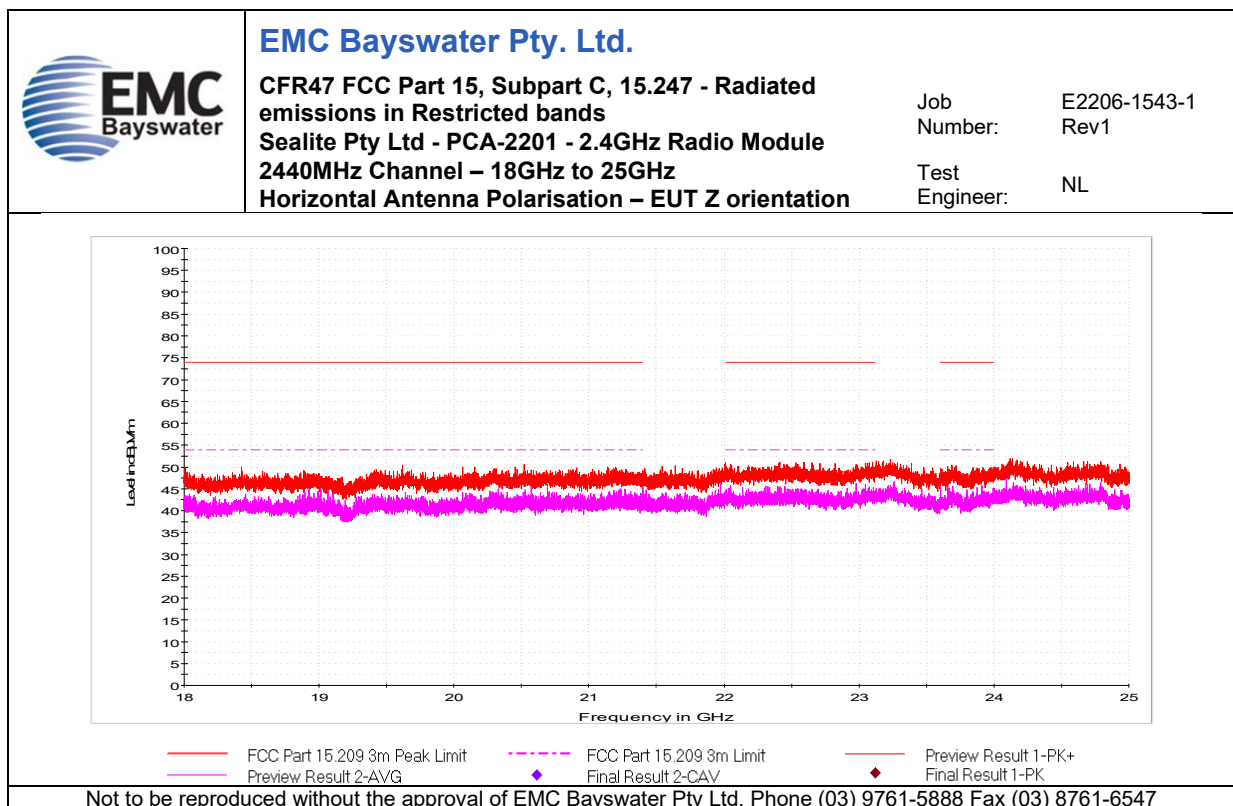
Graph 36



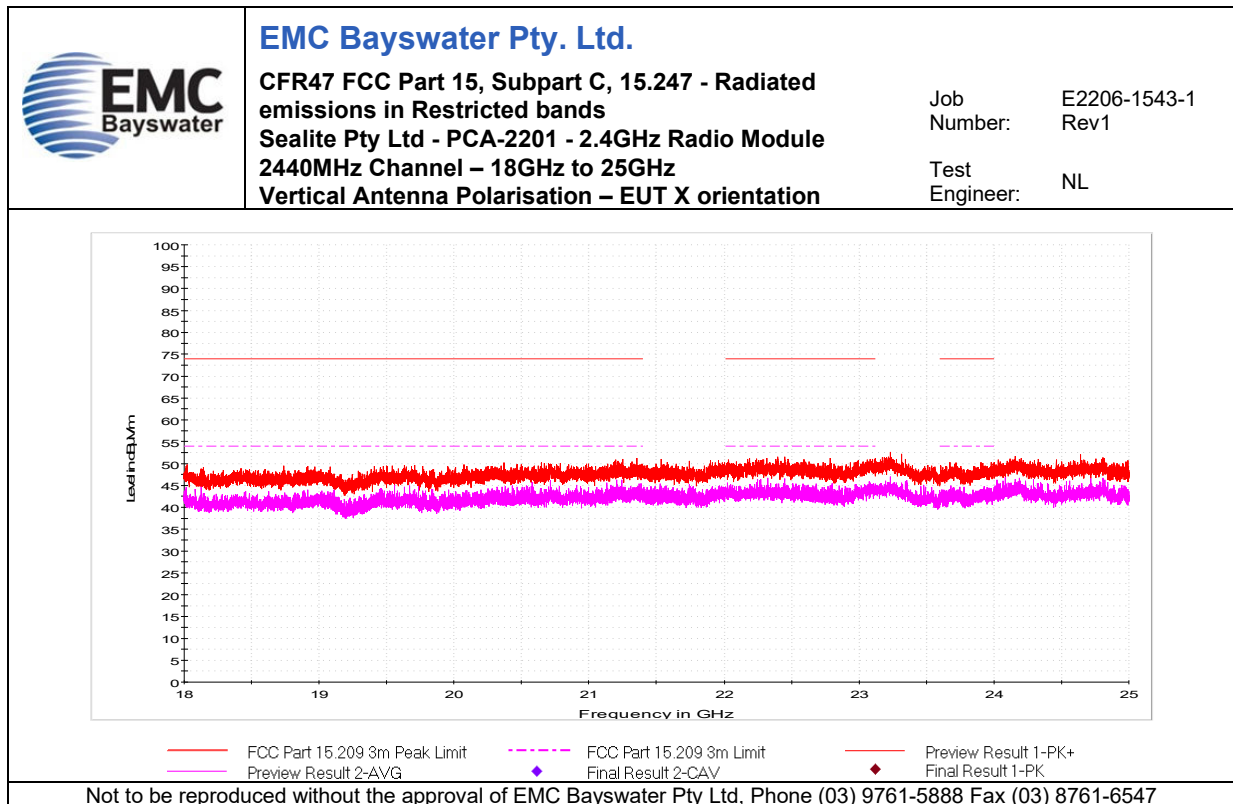
Graph 37



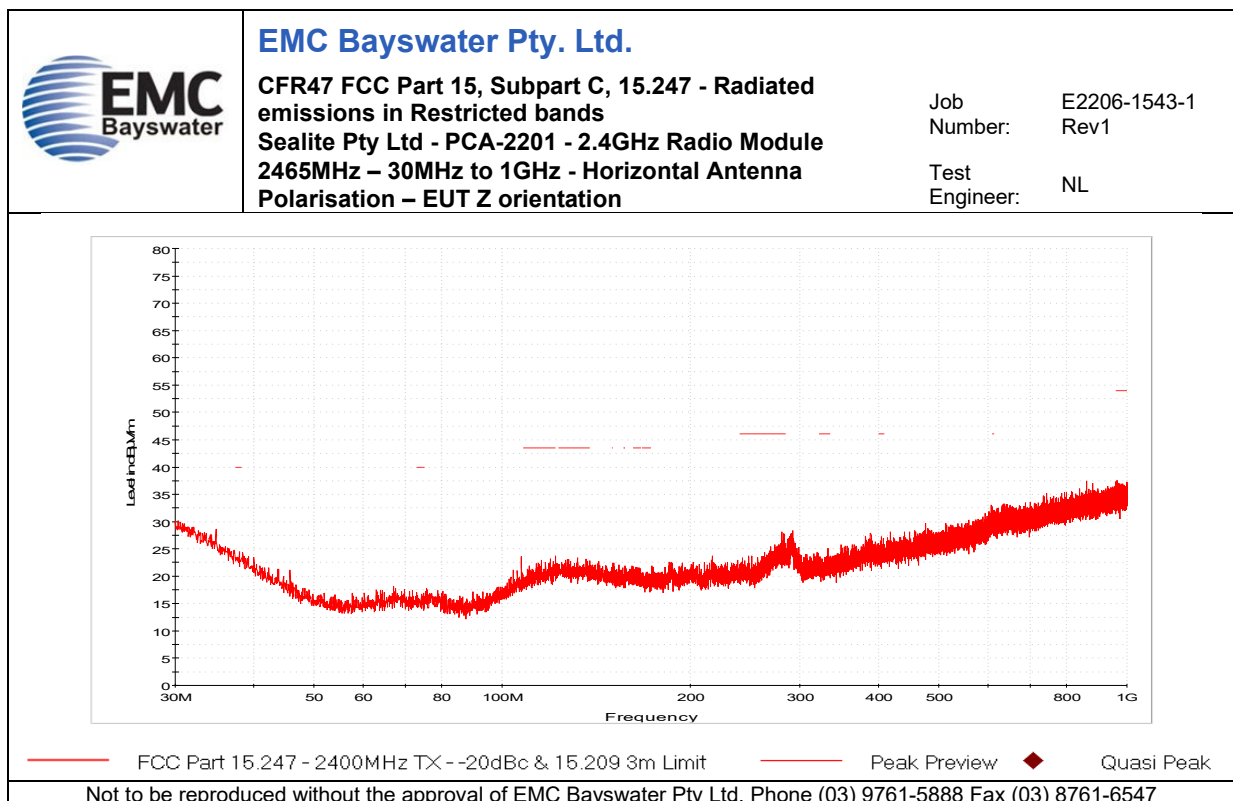
Graph 38



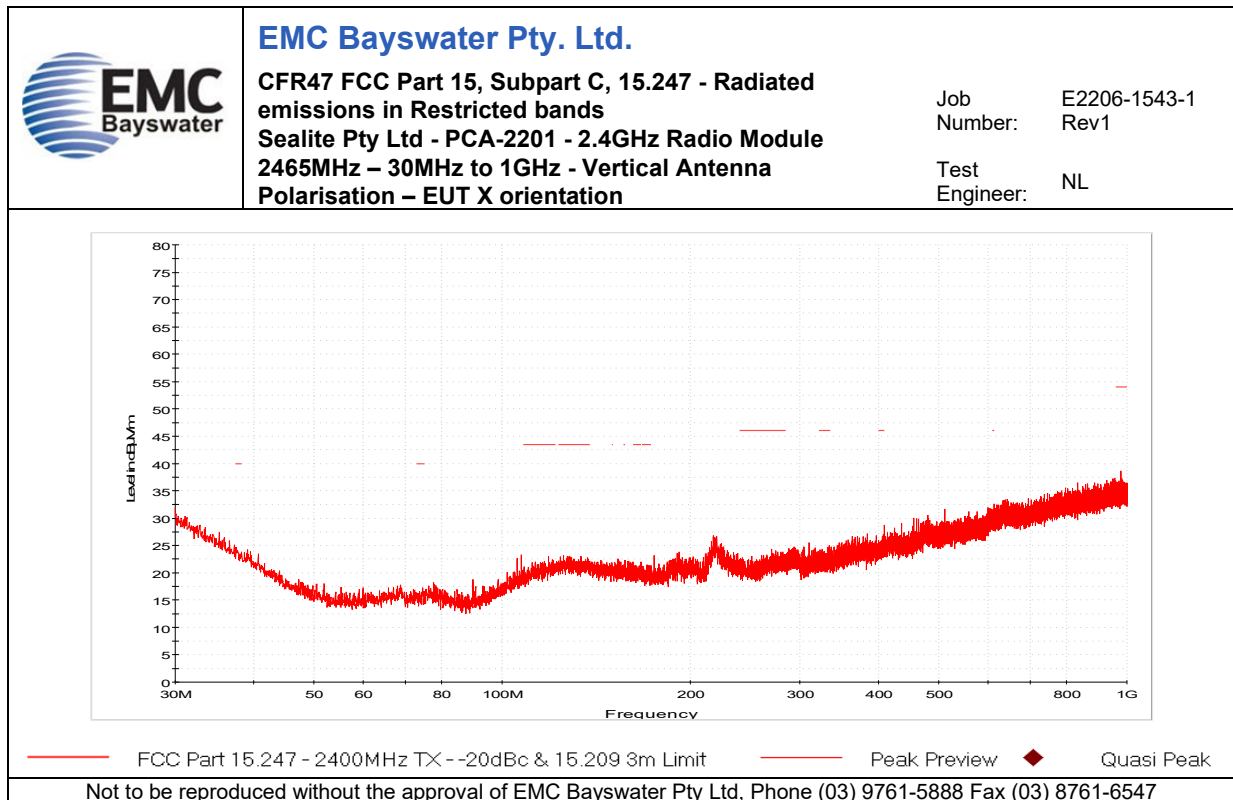
Graph 39



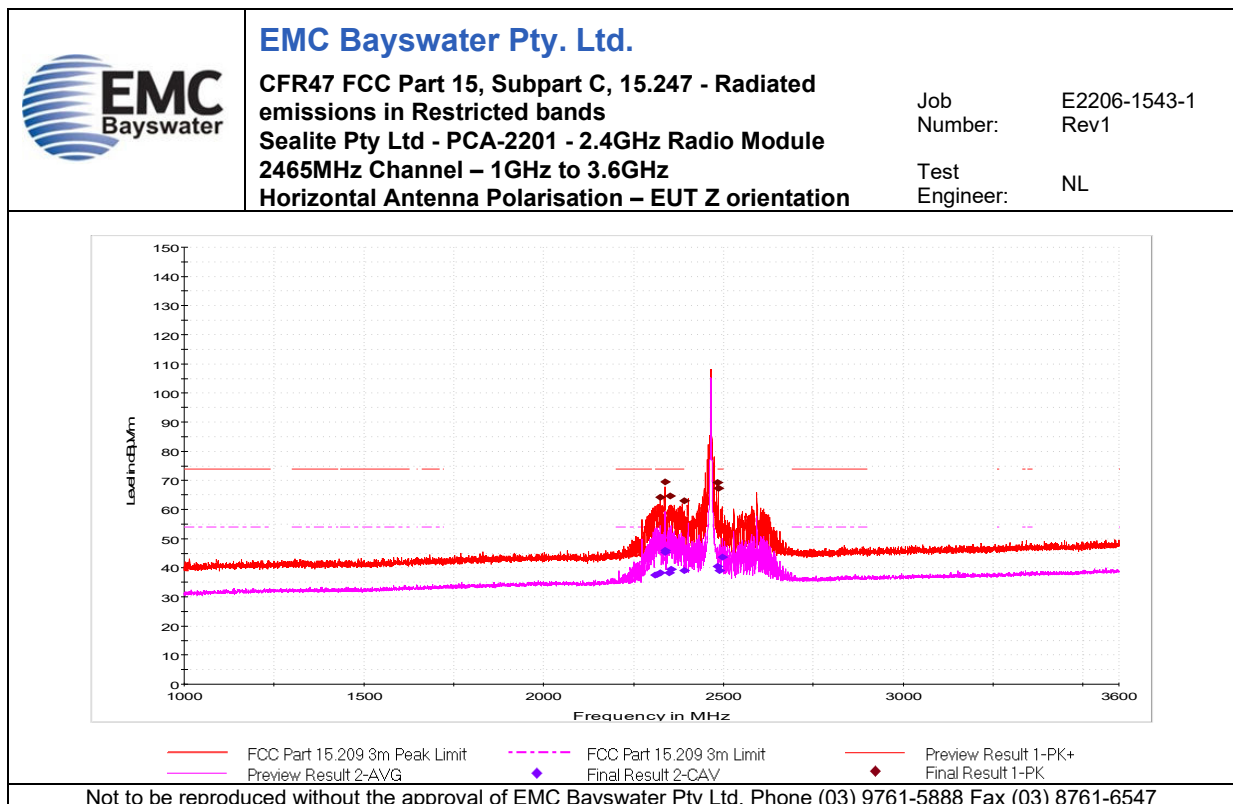
Graph 40



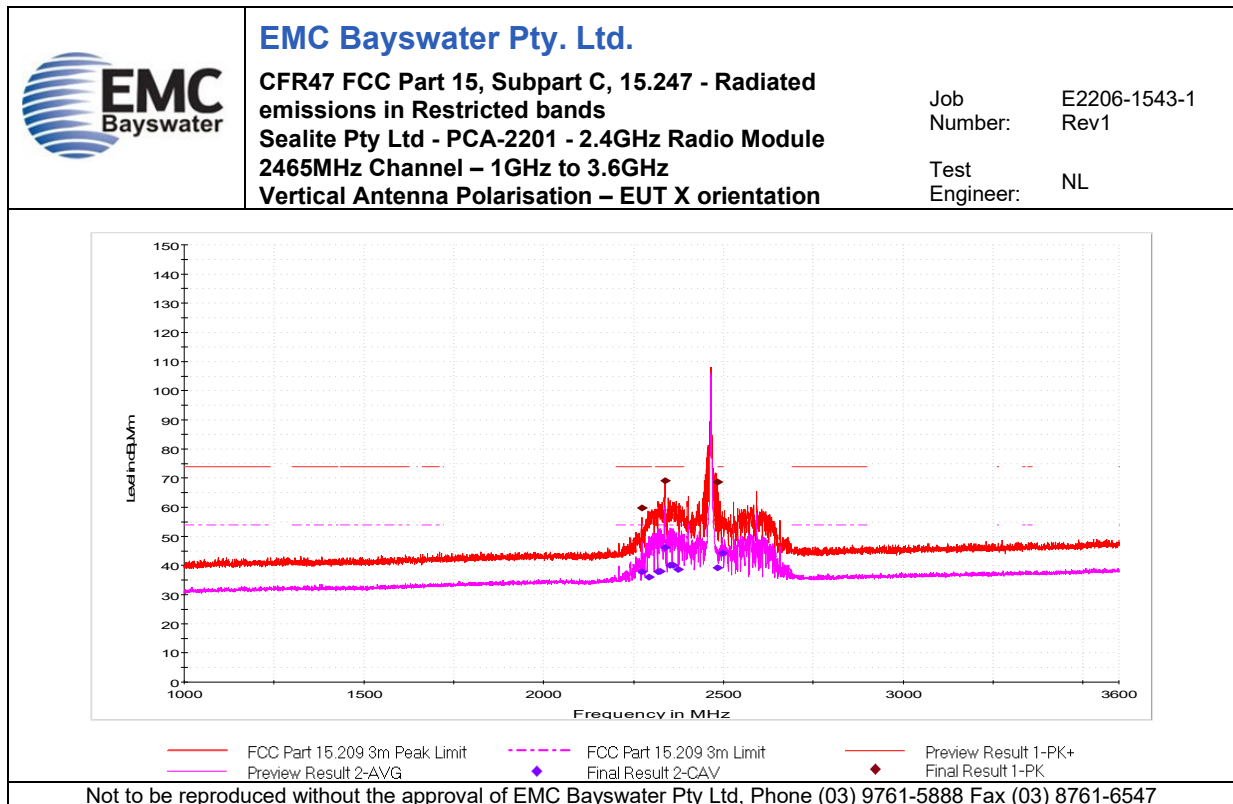
Graph 41



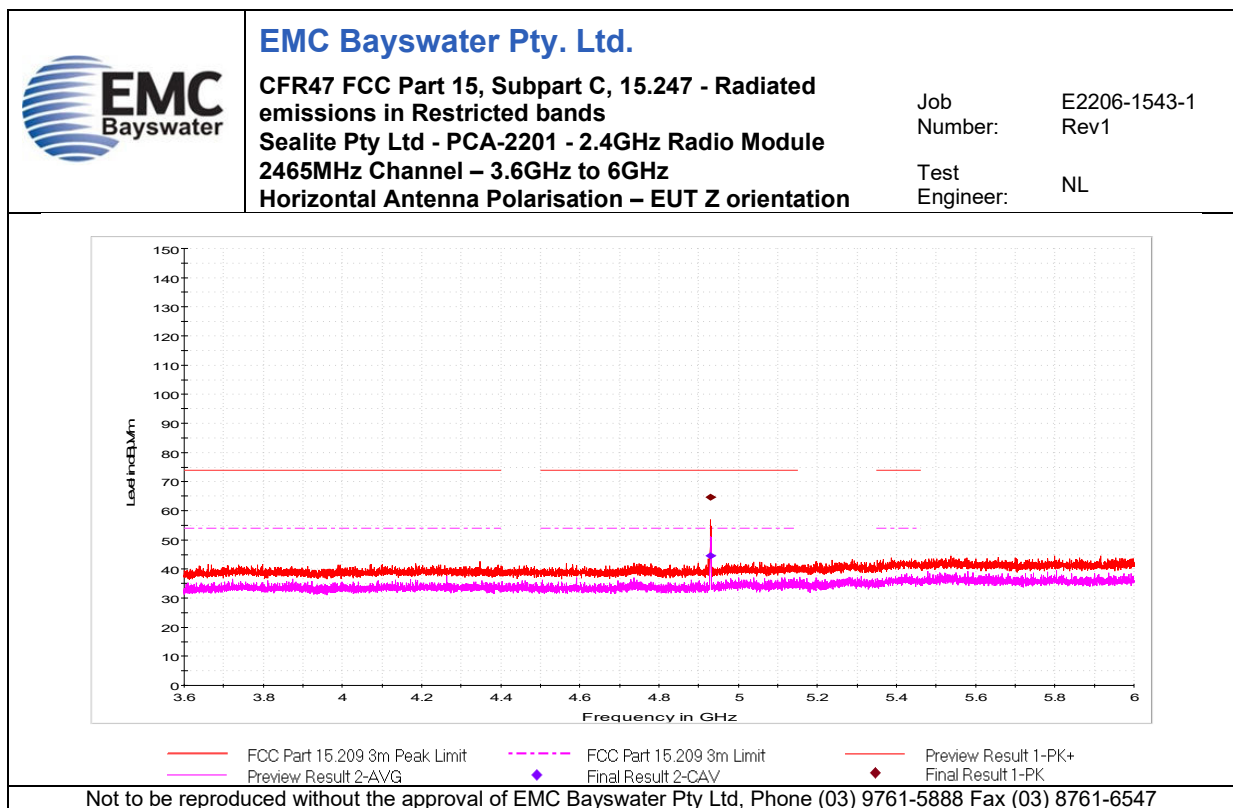
Graph 42



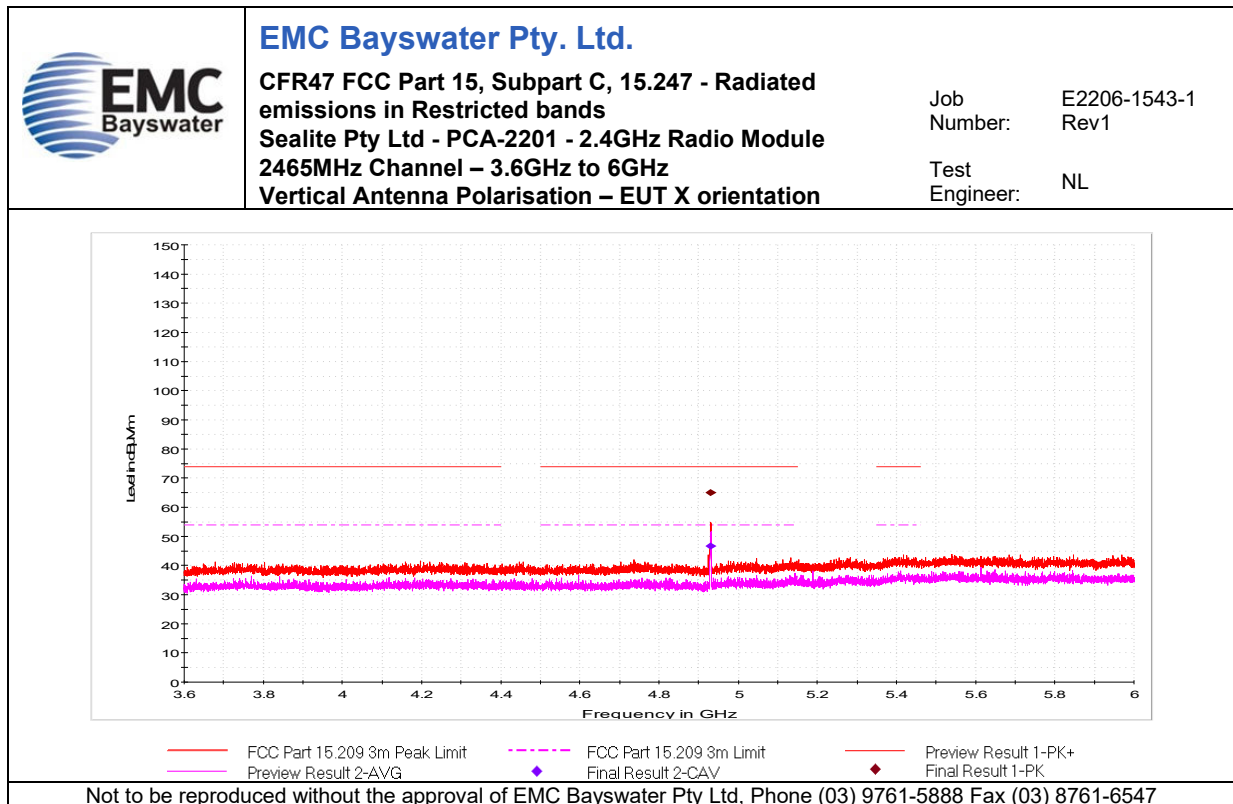
Graph 43



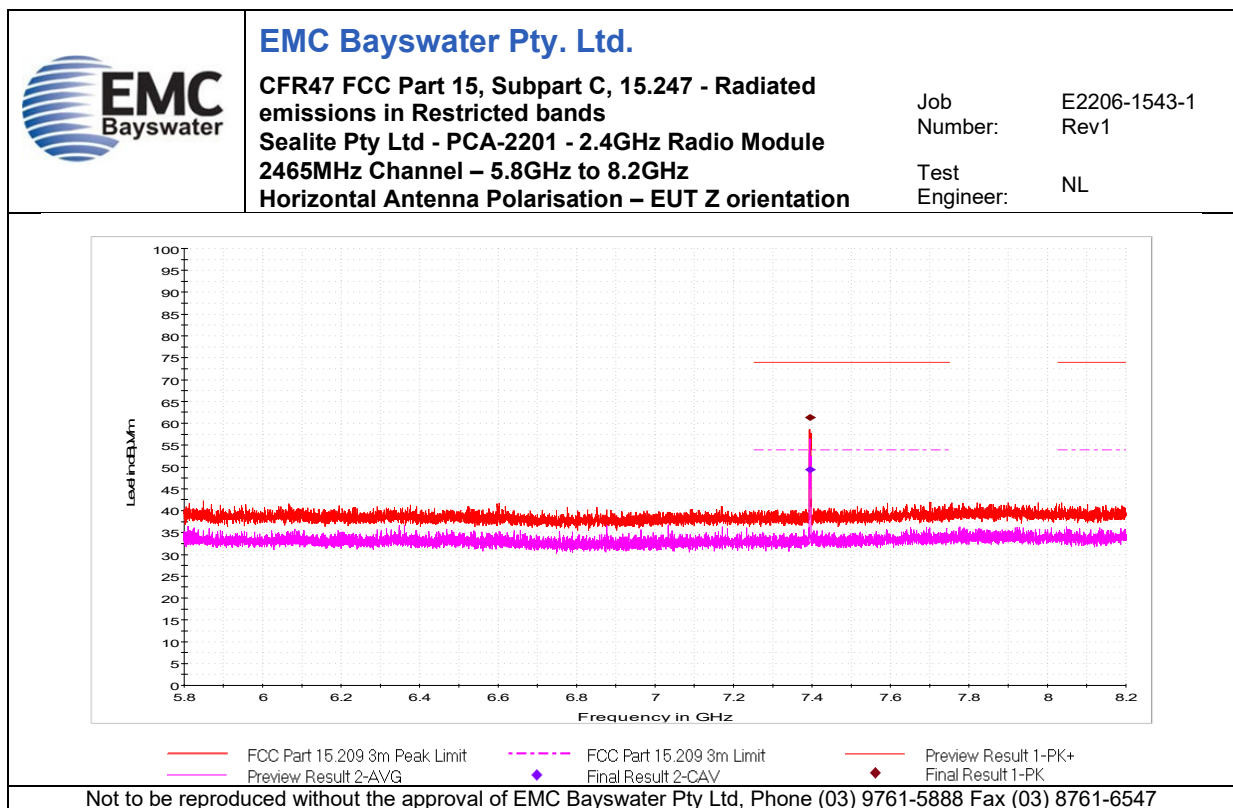
Graph 44



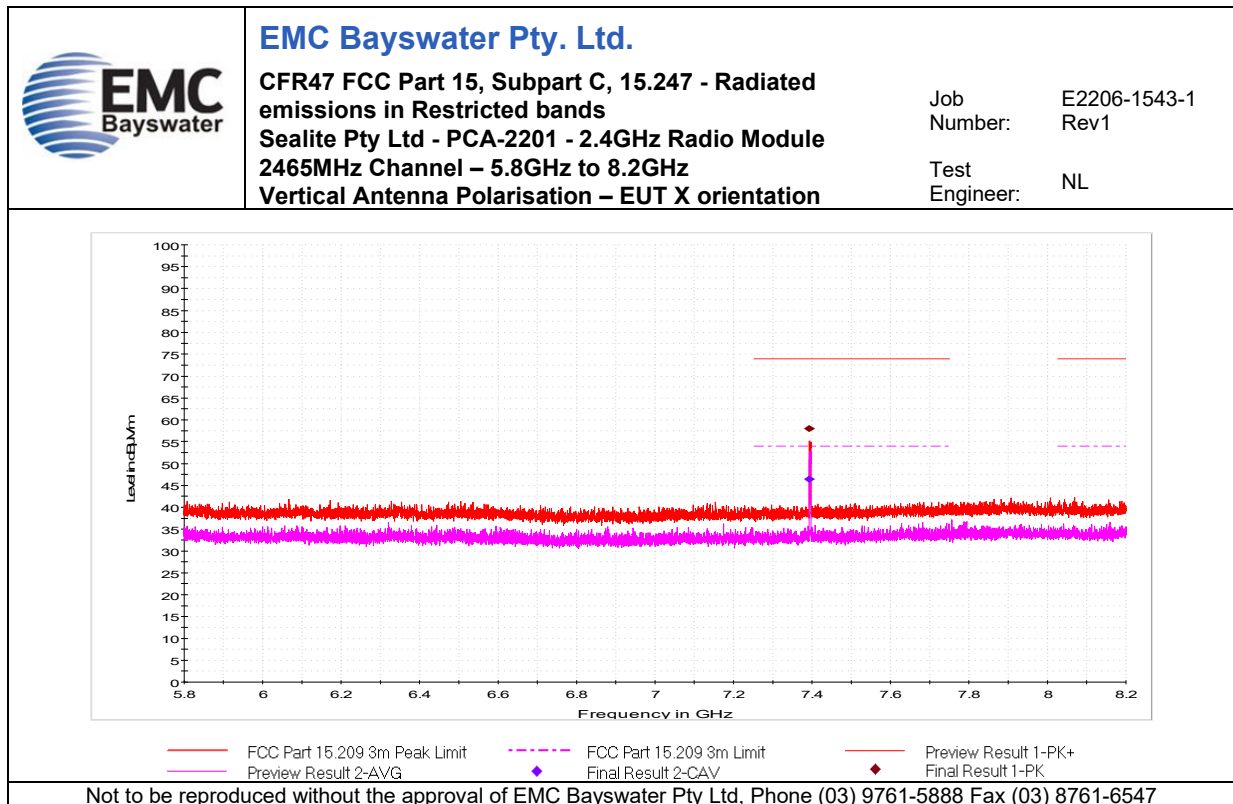
Graph 45



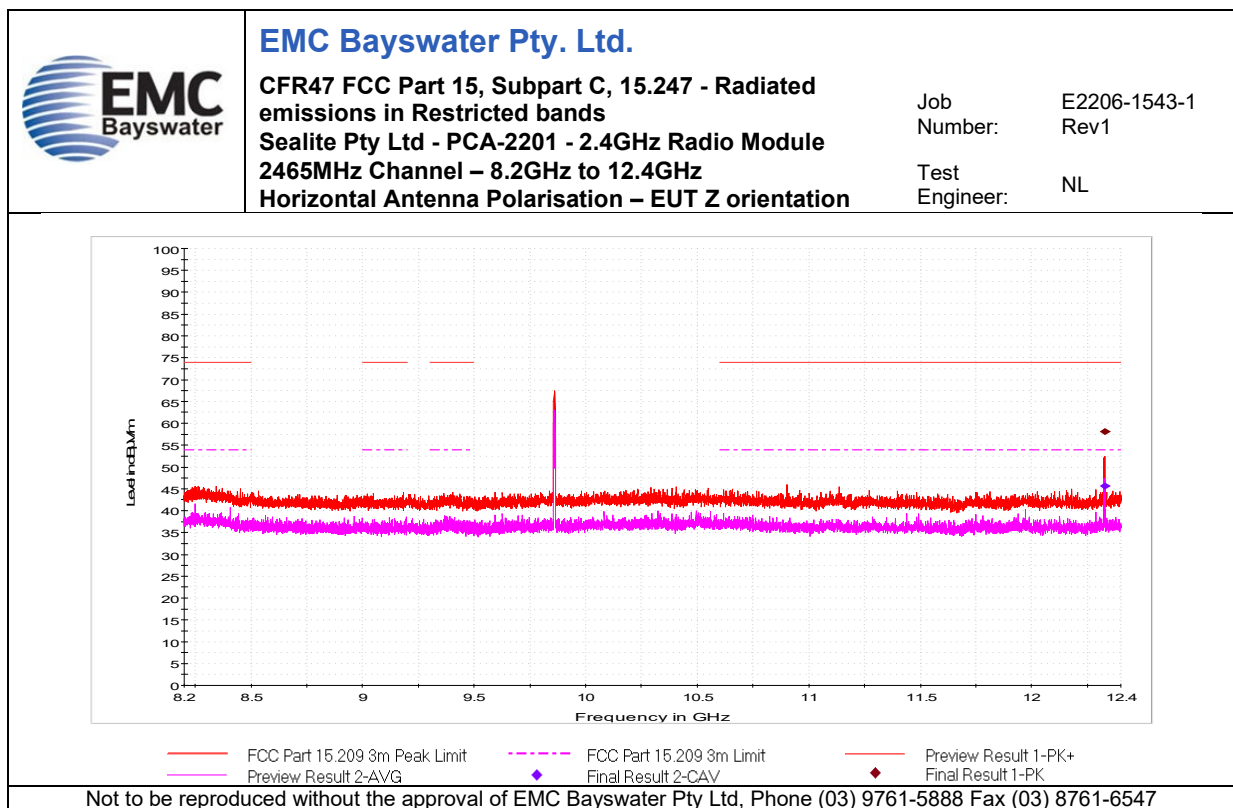
Graph 46



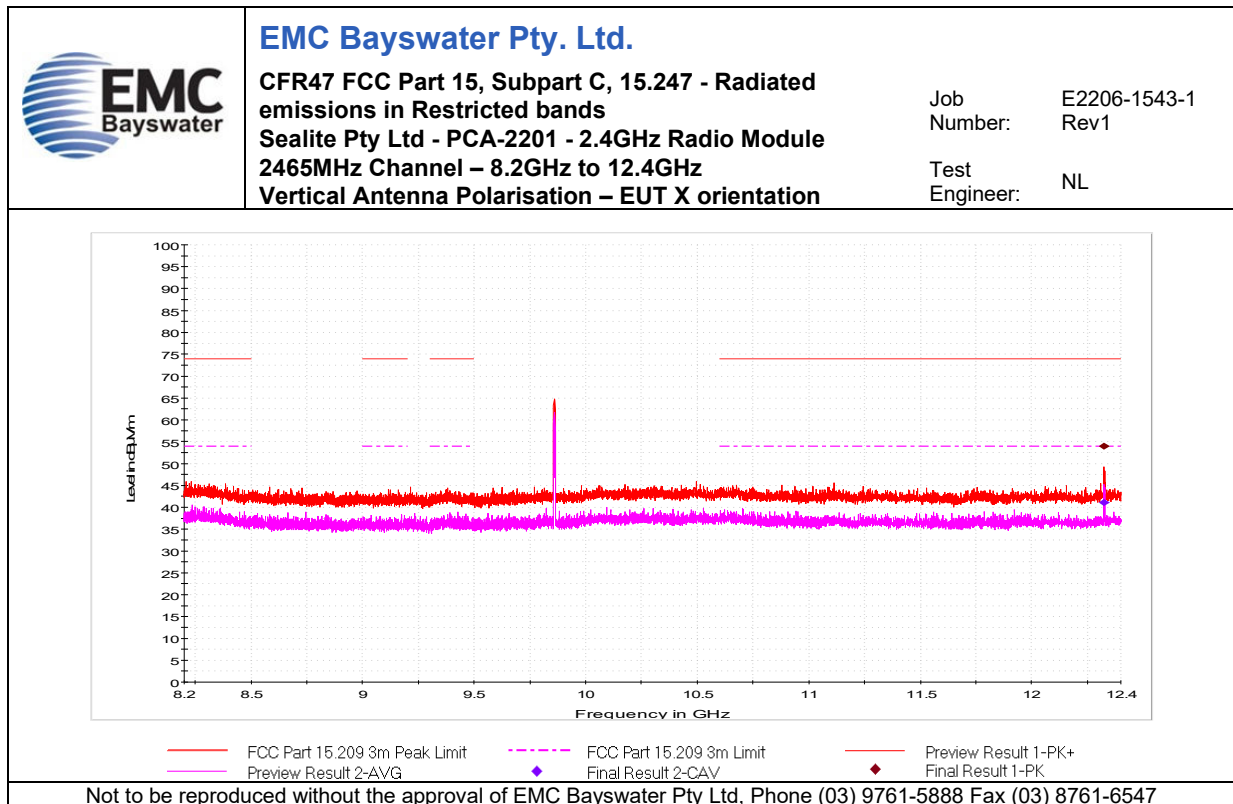
Graph 47



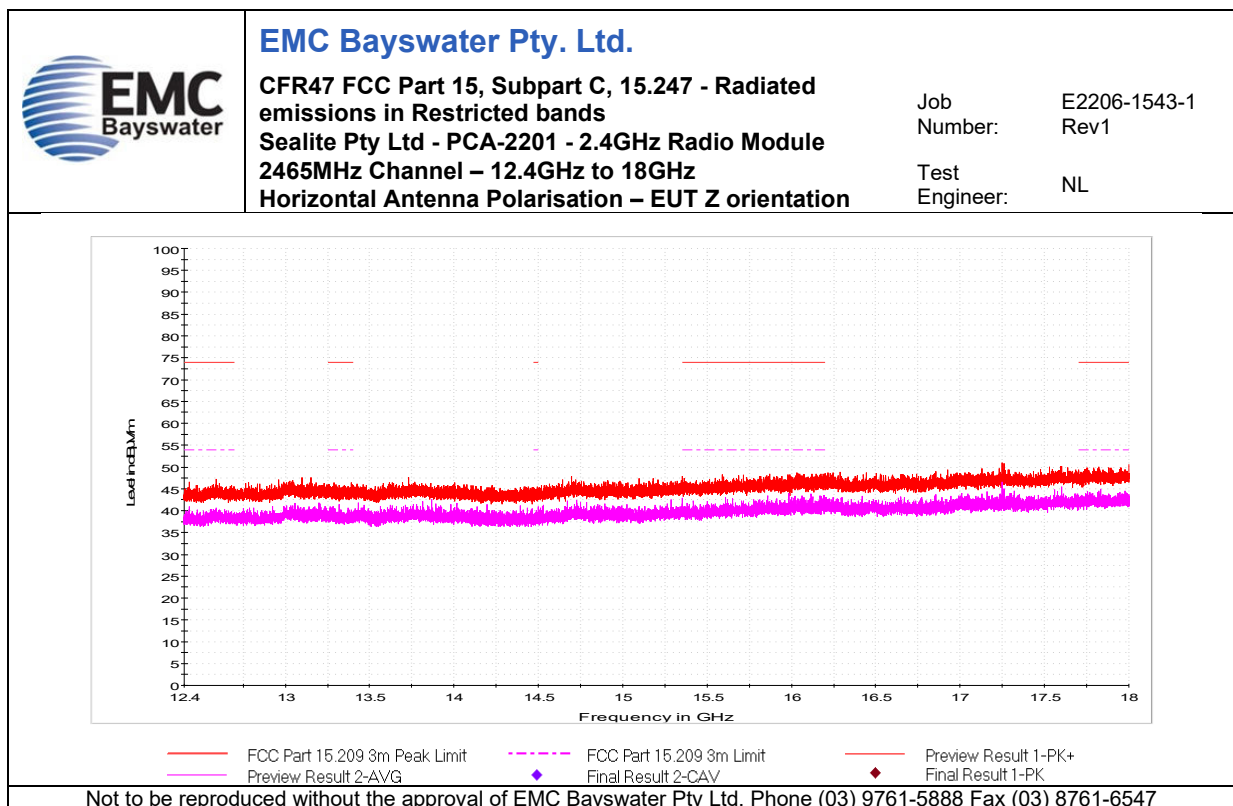
Graph 48



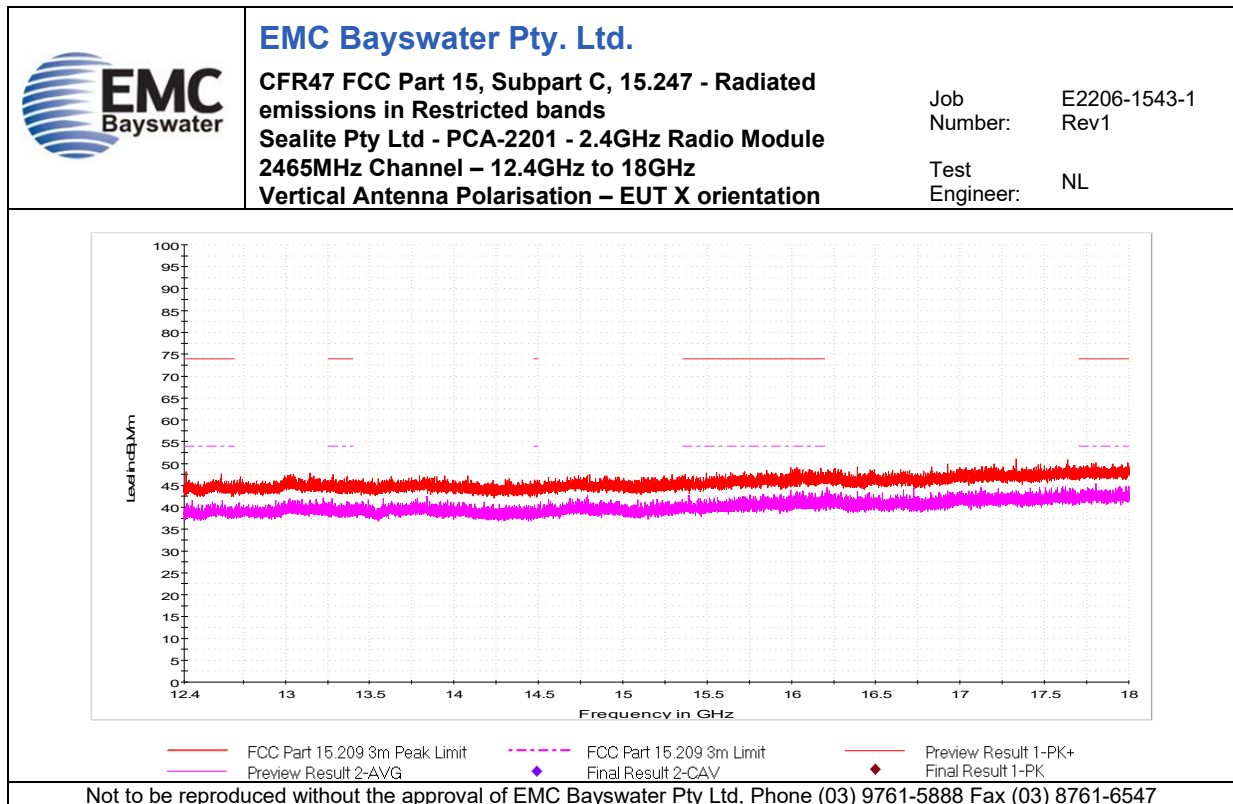
Graph 49



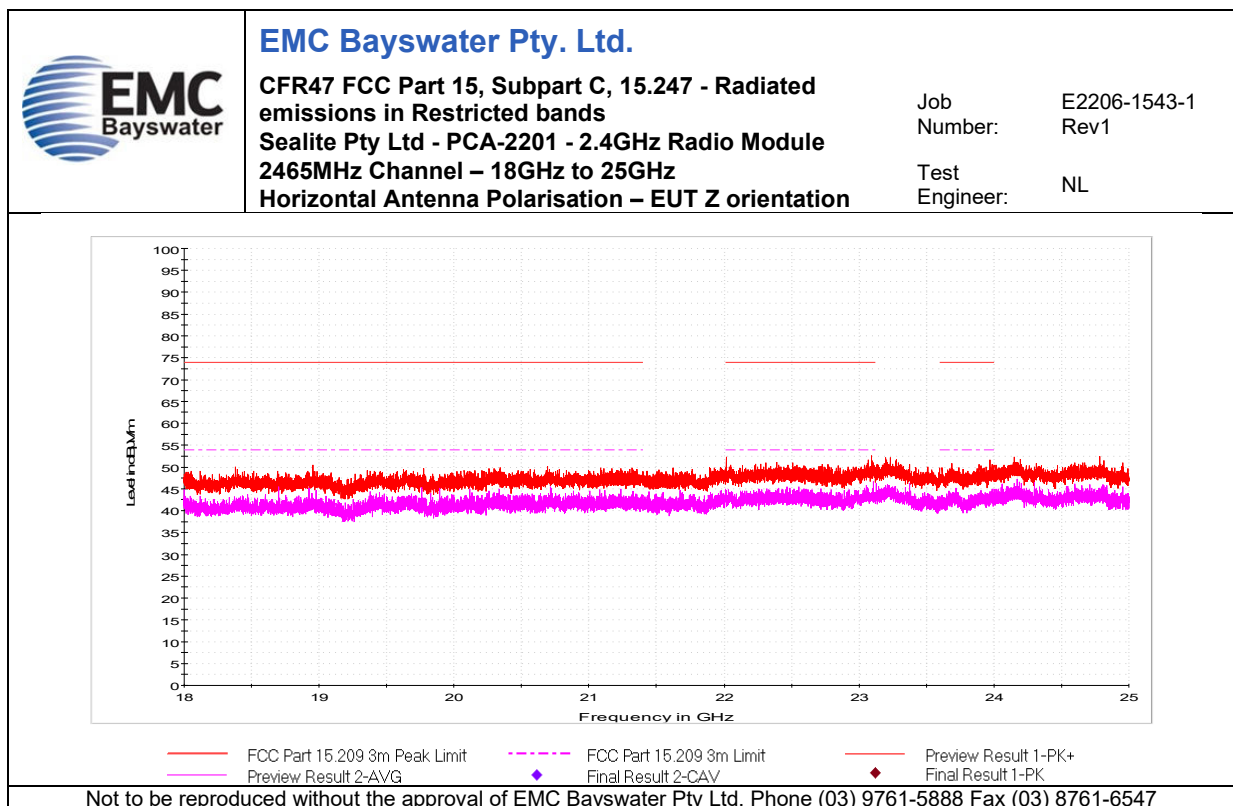
Graph 50



Graph 51



Graph 52



Graph 53

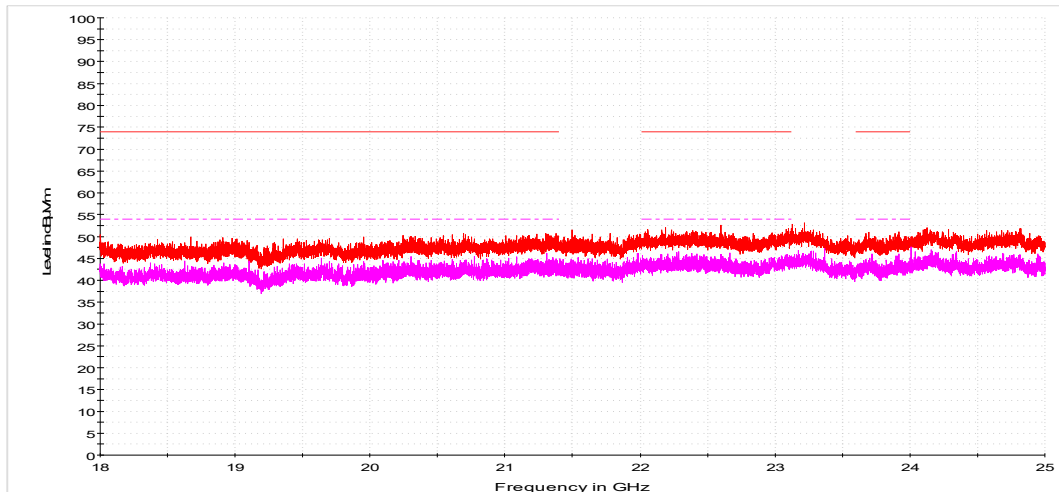


EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Radiated emissions in Restricted bands
Sealite Pty Ltd - PCA-2201 - 2.4GHz Radio Module
2465MHz Channel – 18GHz to 25GHz
Vertical Antenna Polarisation – EUT X orientation

Job Number: E2206-1543-1 Rev1

Test Engineer: NL



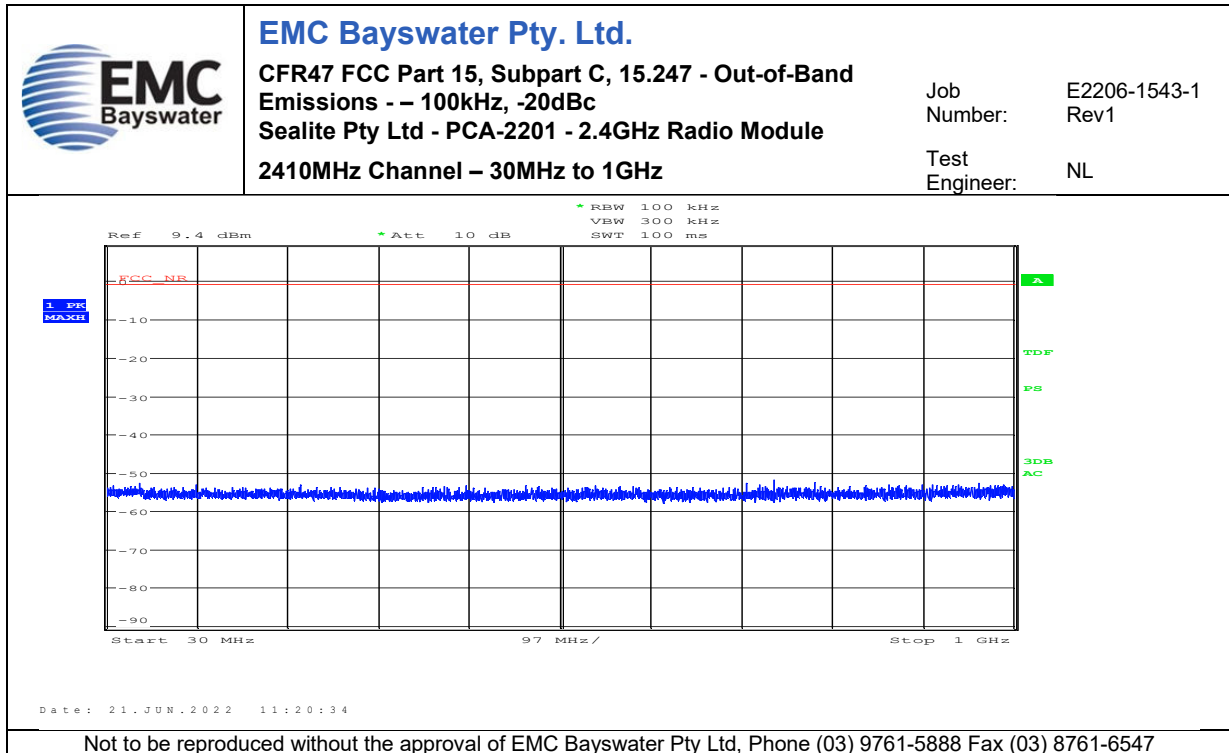
— FCC Part 15 209 3m Peak Limit - - - FCC Part 15 209 3m Limit — Preview Result 1-PK+
 — Preview Result 2-AVG ◆ Final Result 2-CAV ◆ Final Result 1-PK

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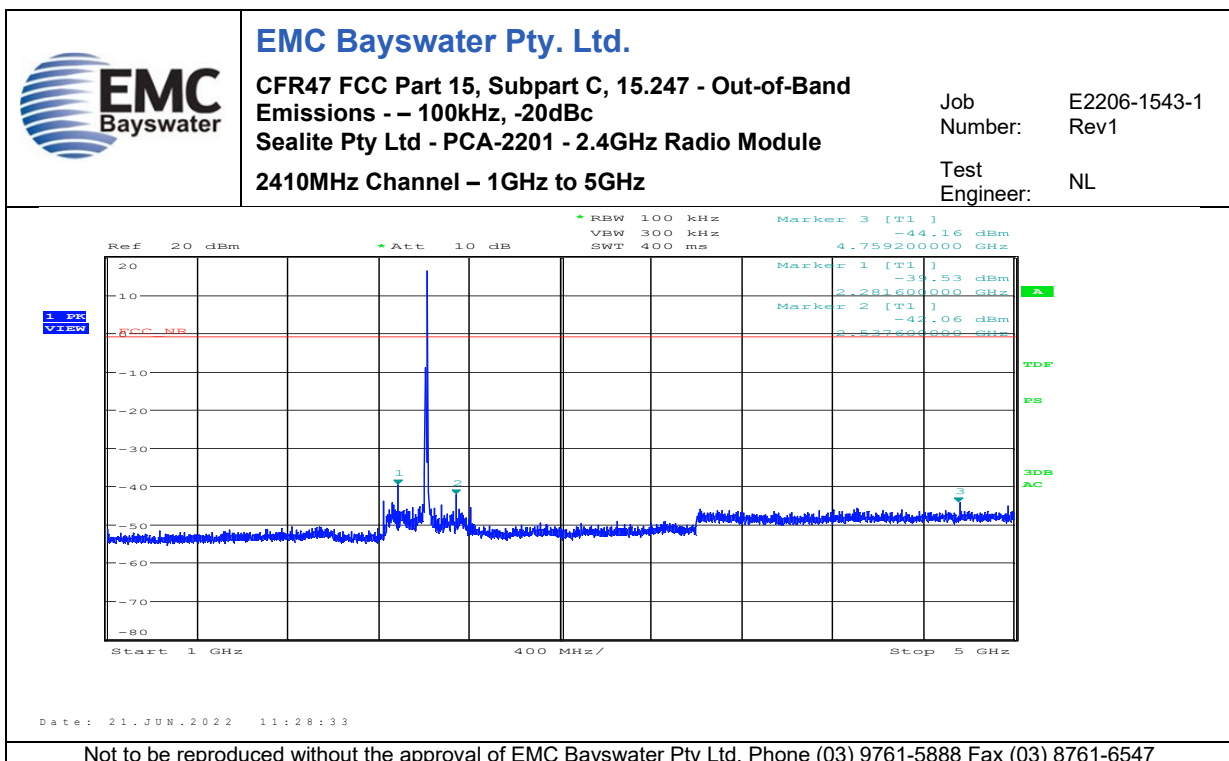
Graph 54

Appendix C.5 – Out-of-Band Emissions – 100kHz, -20dBc – FCC 15.247(d)

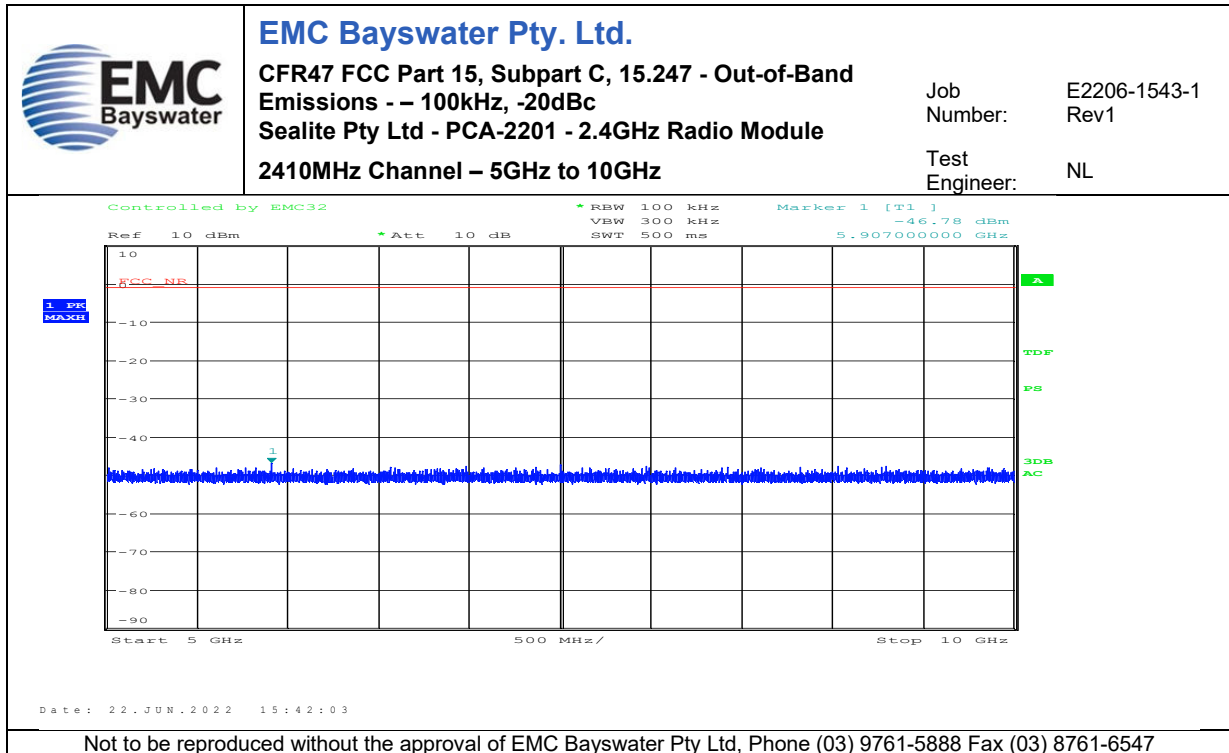
No.	Test	Graph Description
55	Out-of-Band Emissions 100kHz, -20dBc 2410MHz Channel	30MHz to 1GHz
56		1GHz to 5GHz
57		5GHz to 10GHz
58		10GHz to 15GHz
59		15GHz to 25GHz
60	Out-of-Band Emissions 100kHz, -20dBc 2440MHz Channel	30MHz to 1GHz
61		1GHz to 5GHz
62		5GHz to 10GHz
63		10GHz to 15GHz
64		15GHz to 25GHz
65	Out-of-Band Emissions 100kHz, -20dBc 2465MHz Channel	30MHz to 1GHz
66		1GHz to 5GHz
67		5GHz to 10GHz
68		10GHz to 15GHz
69		15GHz to 25GHz



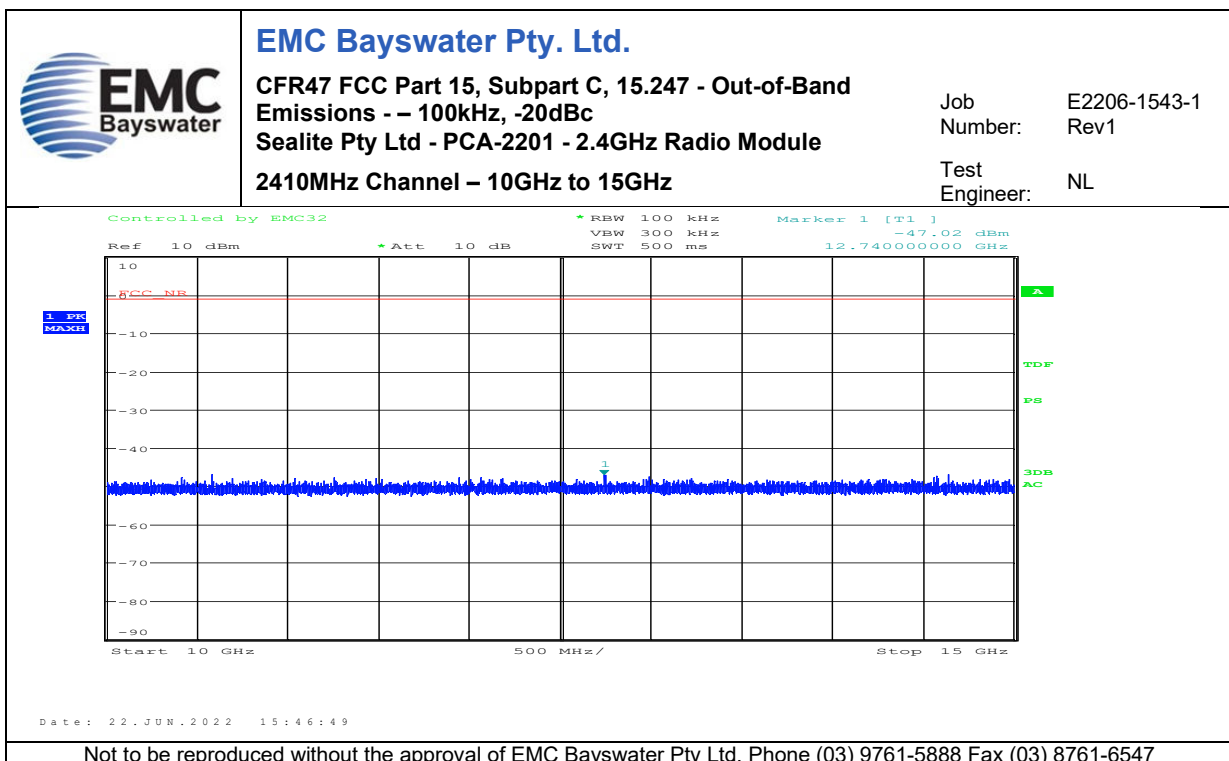
Graph 55



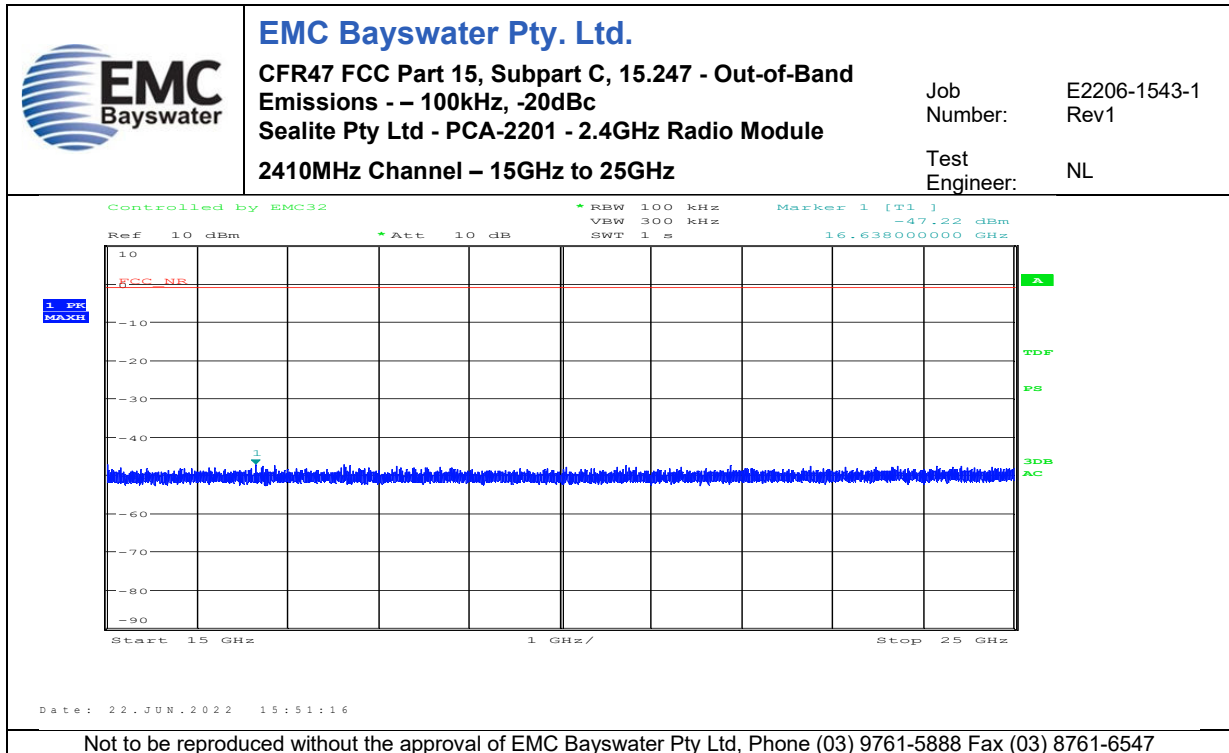
Graph 56



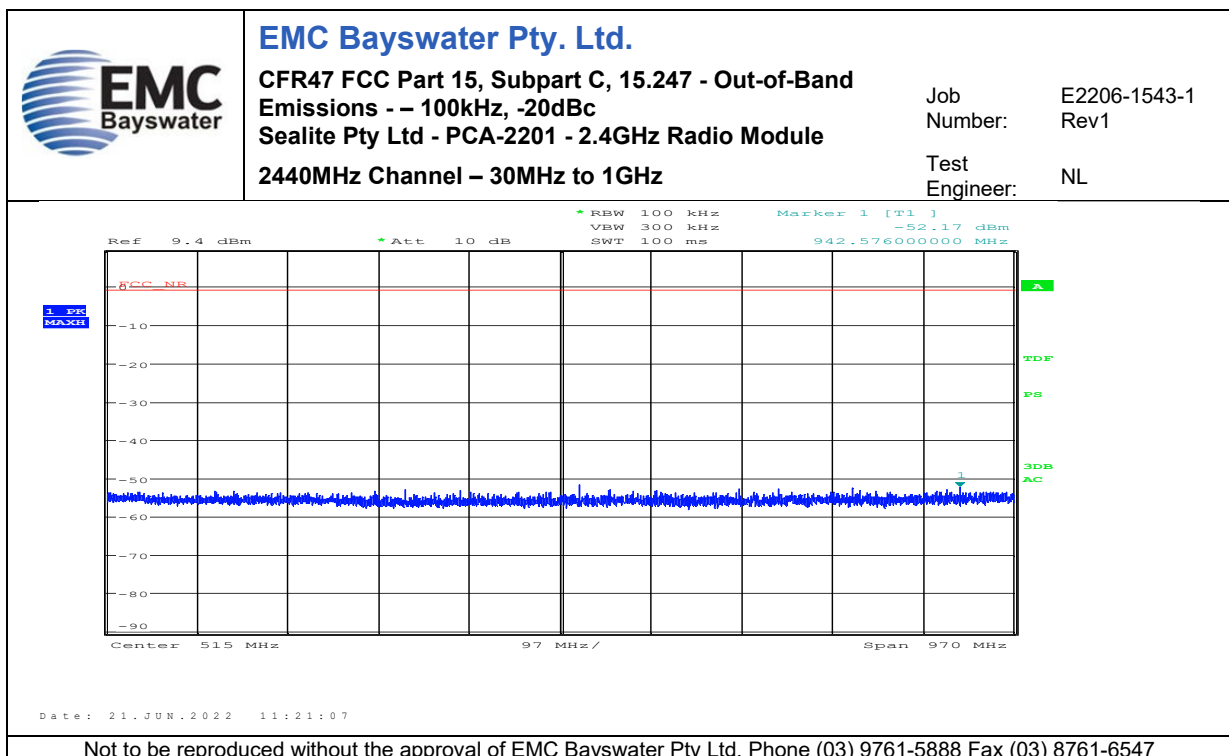
Graph 57



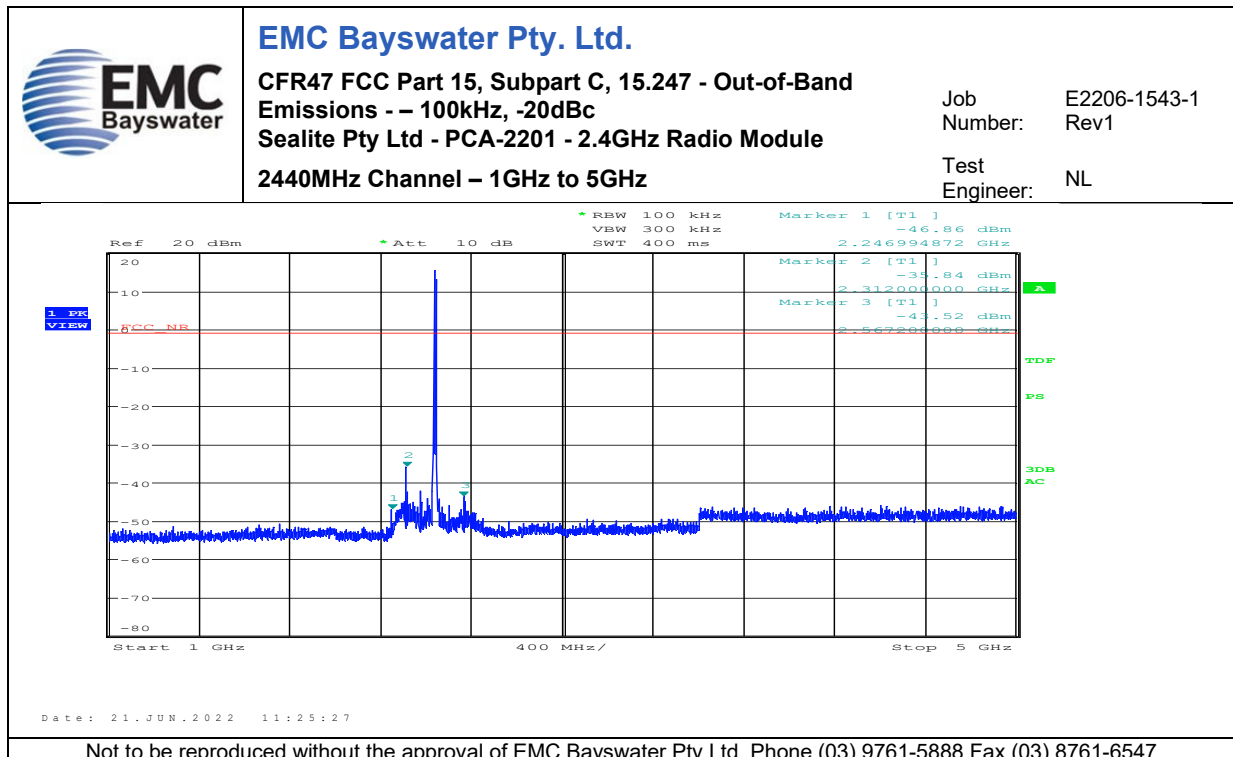
Graph 58



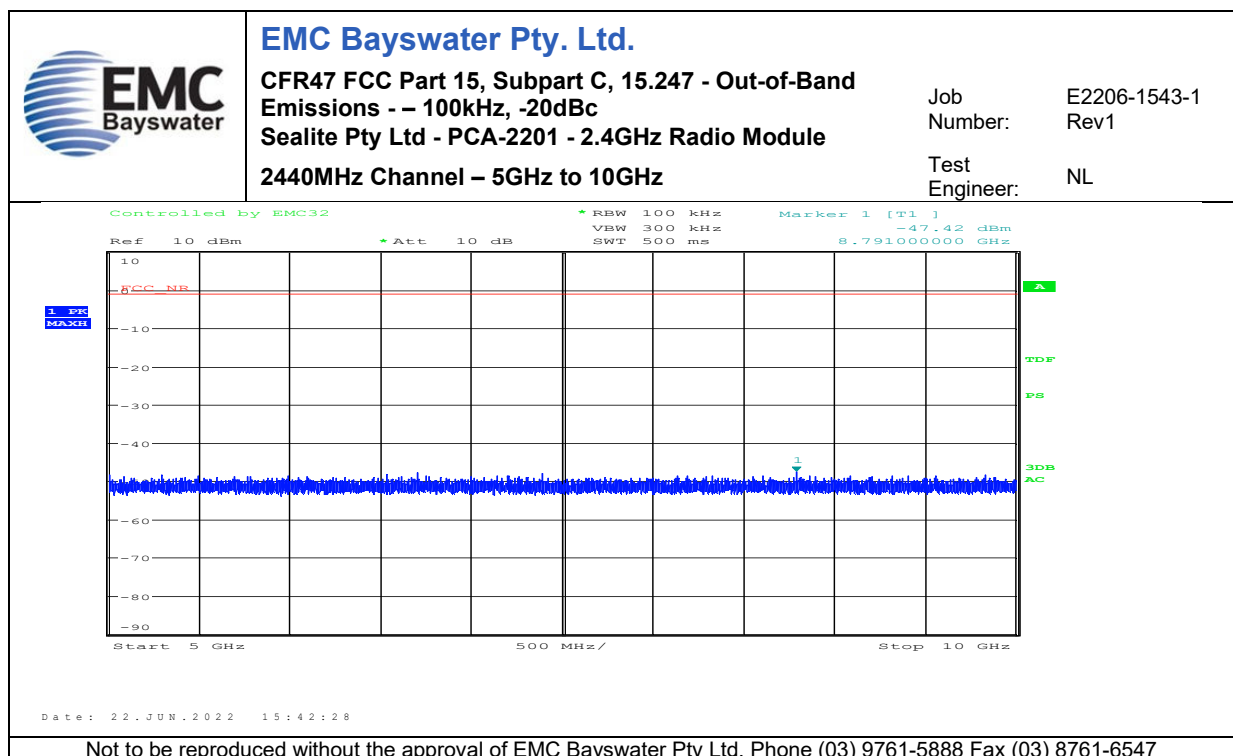
Graph 59



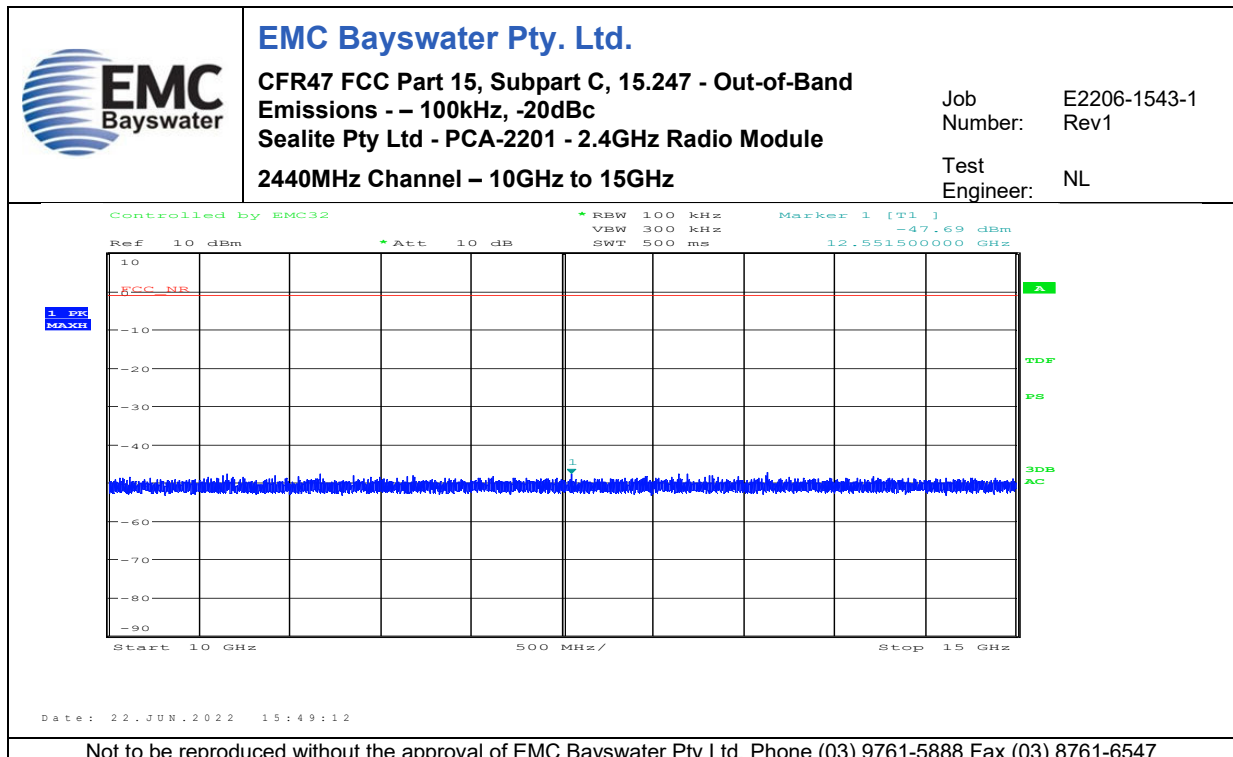
Graph 60



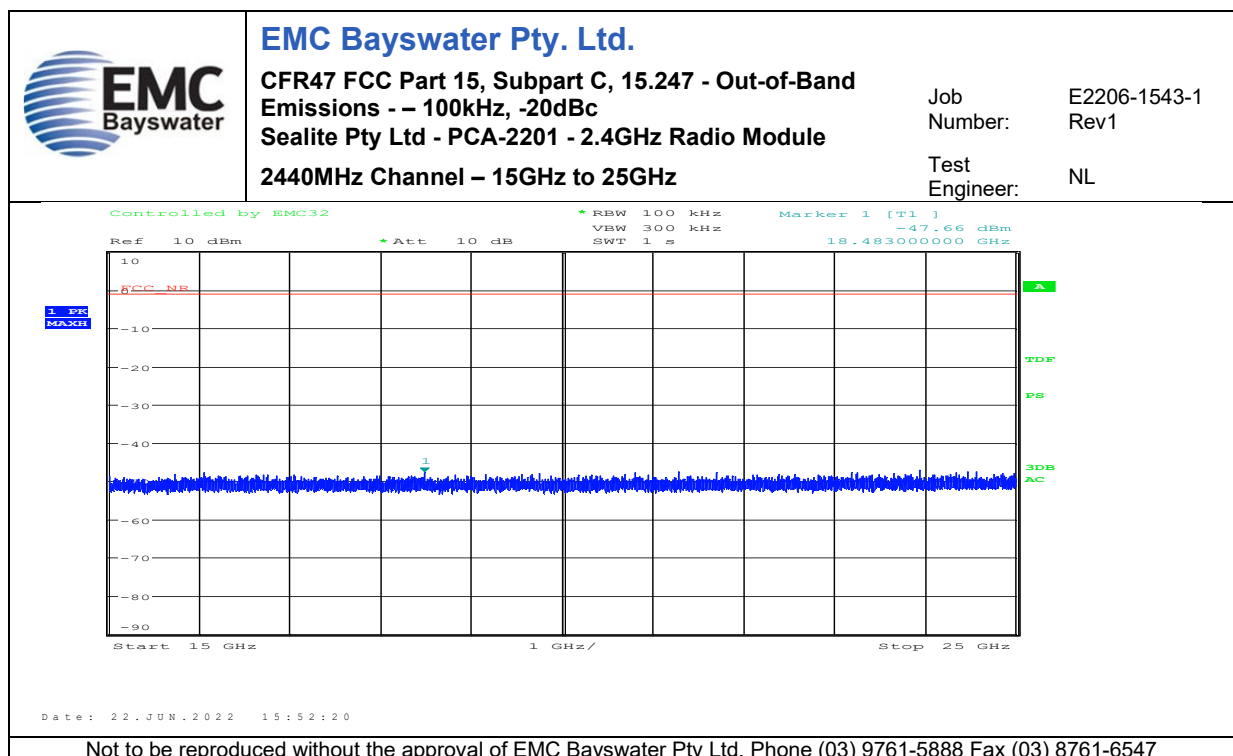
Graph 61



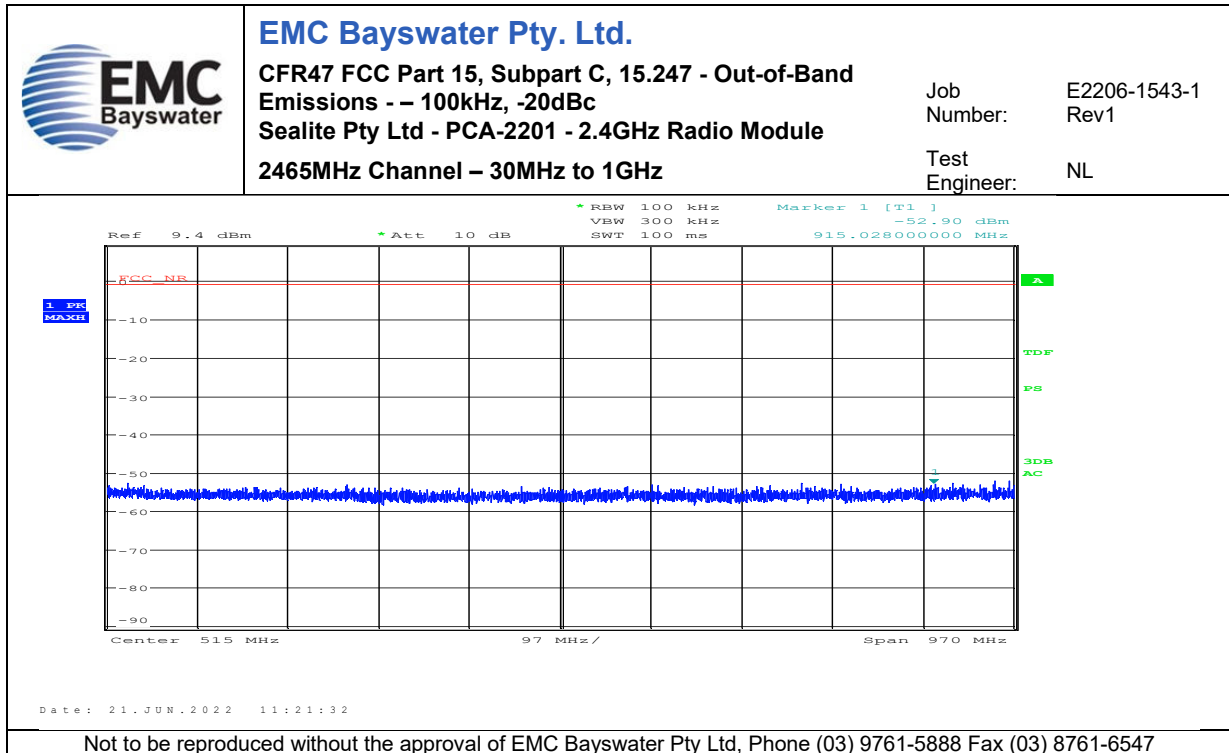
Graph 62



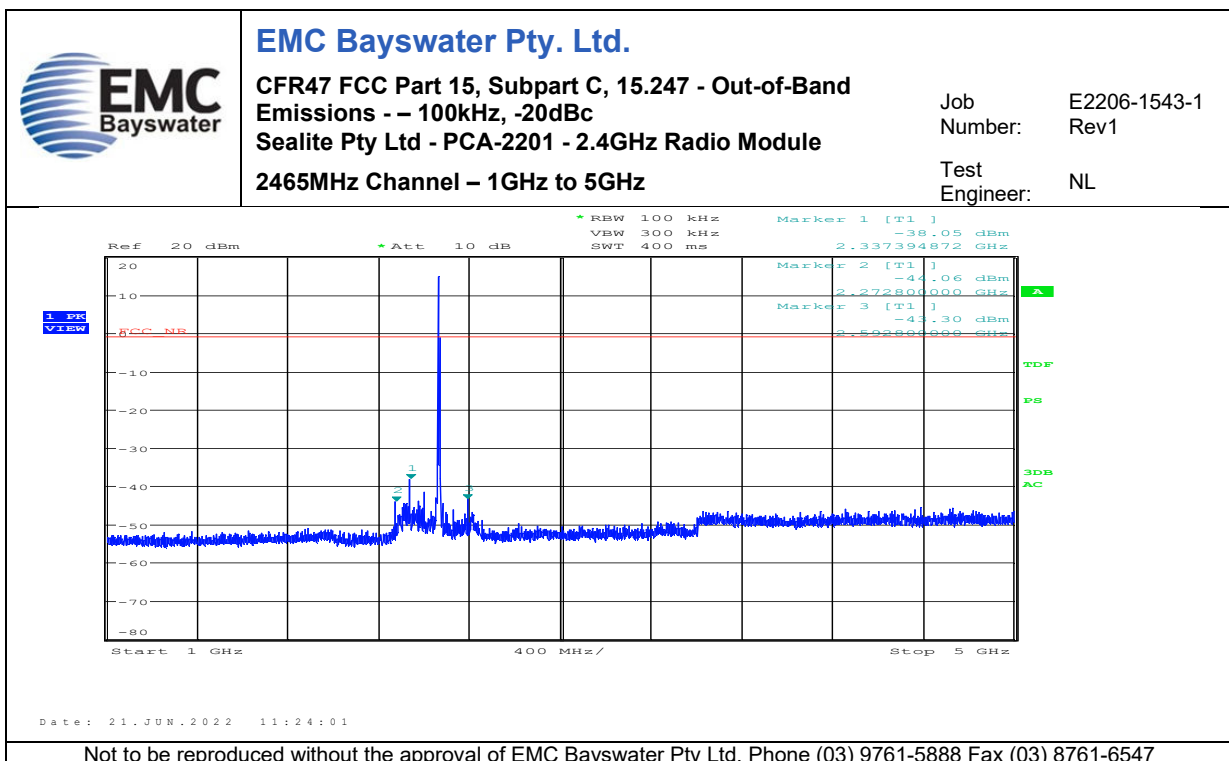
Graph 63



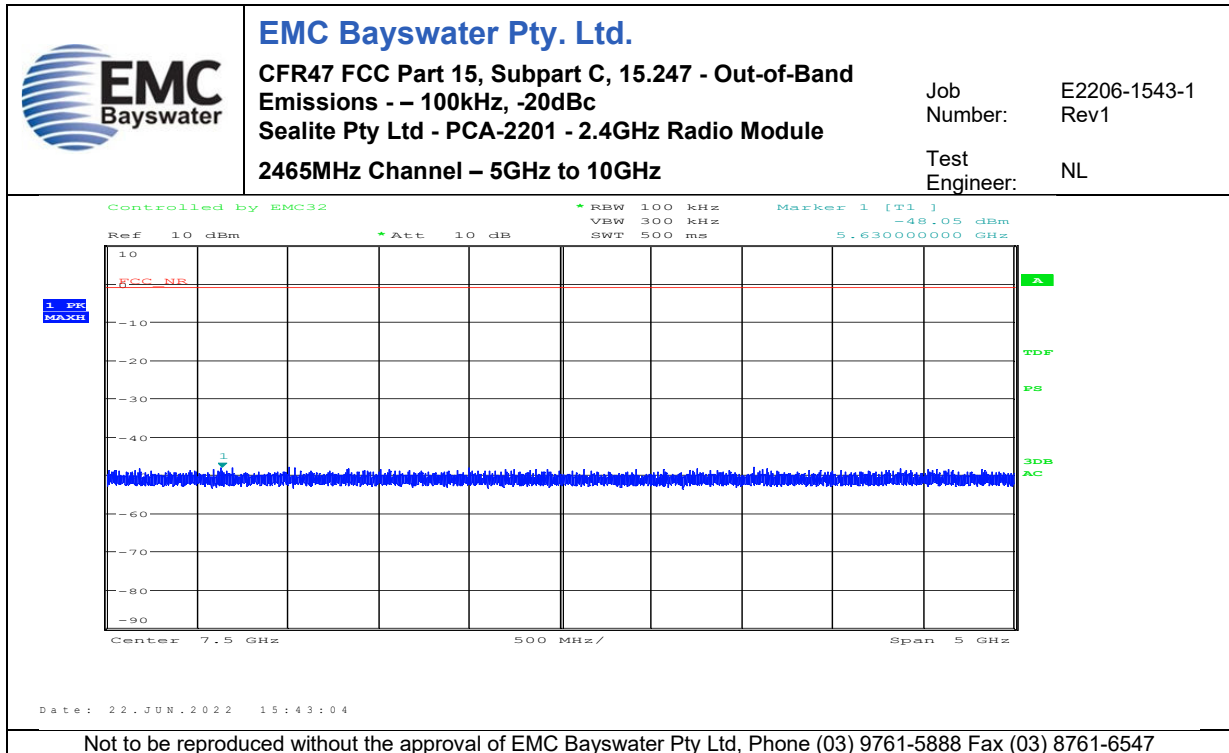
Graph 64



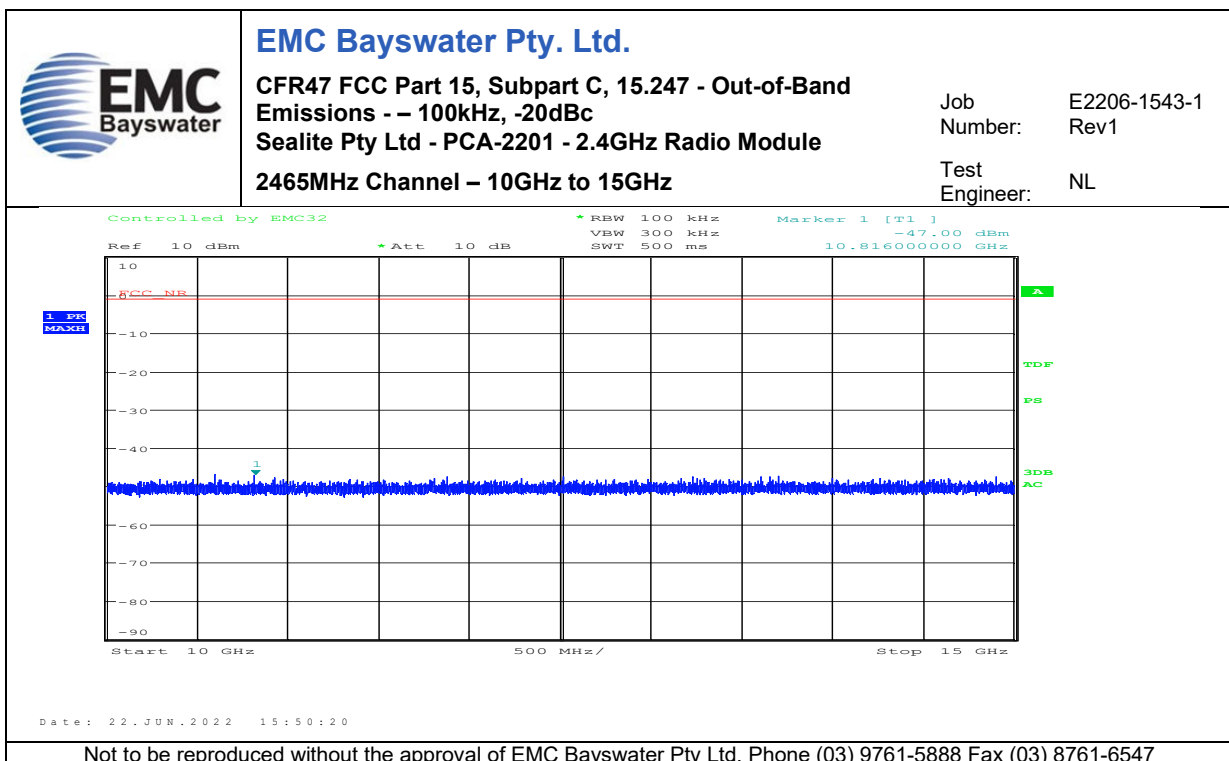
Graph 65



Graph 66



Graph 67



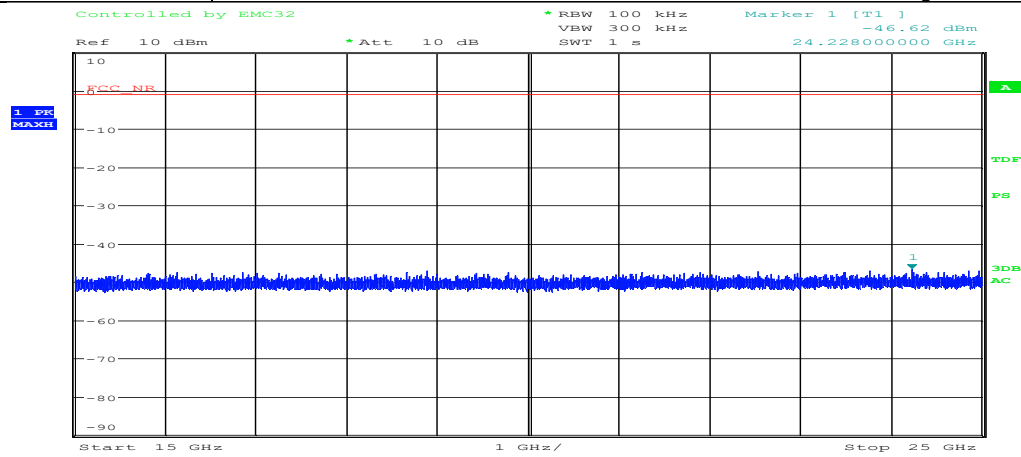
Graph 68



EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Out-of-Band
Emissions - - 100kHz, -20dBc
Sealite Pty Ltd - PCA-2201 - 2.4GHz Radio Module
2465MHz Channel - 15GHz to 25GHz

Job Number: E2206-1543-1 Rev1
Test Engineer: NL



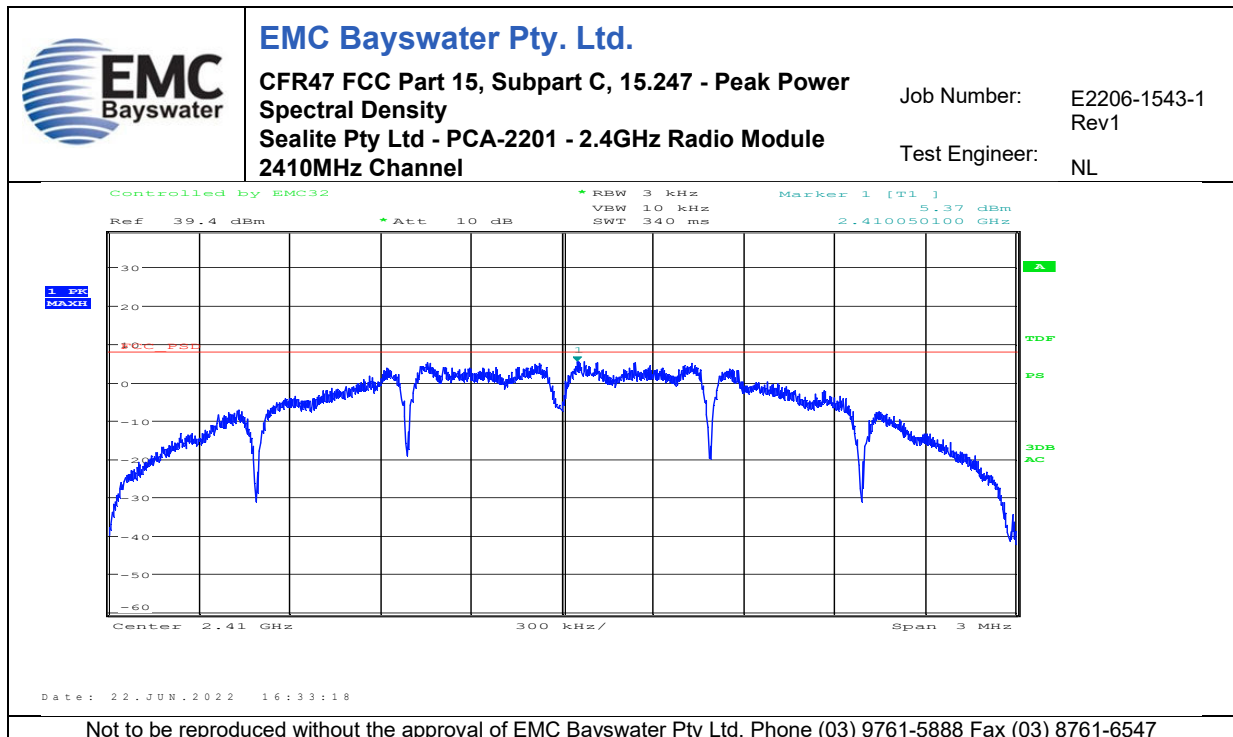
Date: 22 JUN 2022 15:53:22

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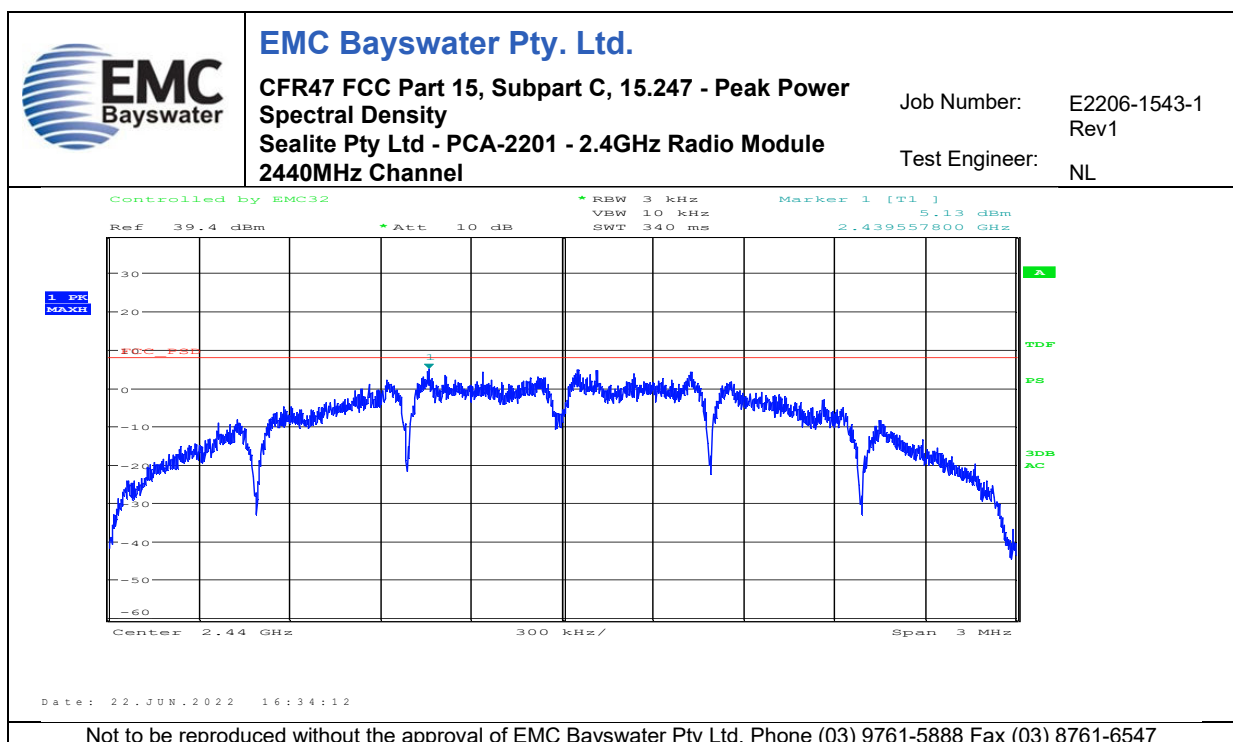
Graph 69

Appendix C.6 – Measurement Graphs – Power Spectral Density – FCC 15.247 (e)

No.	Test	Graph Description
70	Power Spectral Density	2410MHz Channel
71		2440MHz Channel
72		2465MHz Channel



Graph 70



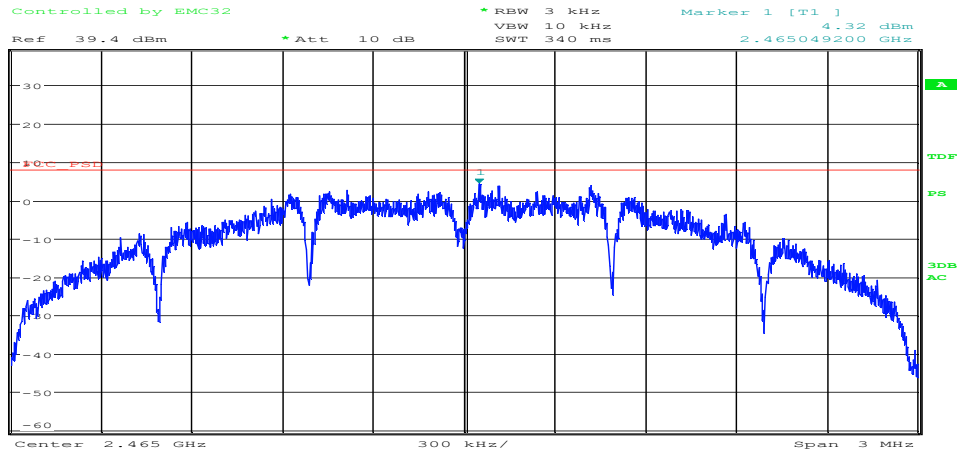
Graph 71



EMC Bayswater Pty. Ltd.

CFR47 FCC Part 15, Subpart C, 15.247 - Peak Power
Spectral Density
Sealite Pty Ltd - PCA-2201 - 2.4GHz Radio Module
2465MHz Channel

Job Number: E2206-1543-1
Rev1
Test Engineer: NL



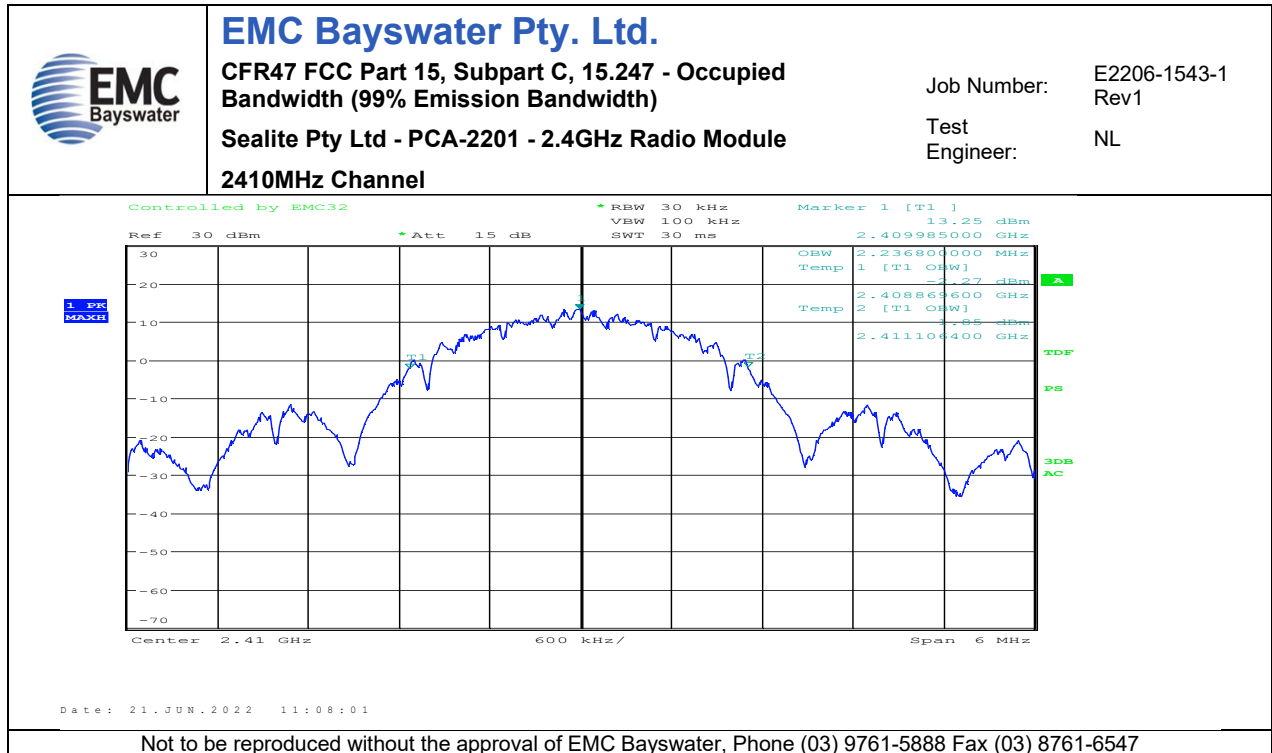
Date: 22. JUN. 2022 16:34:49

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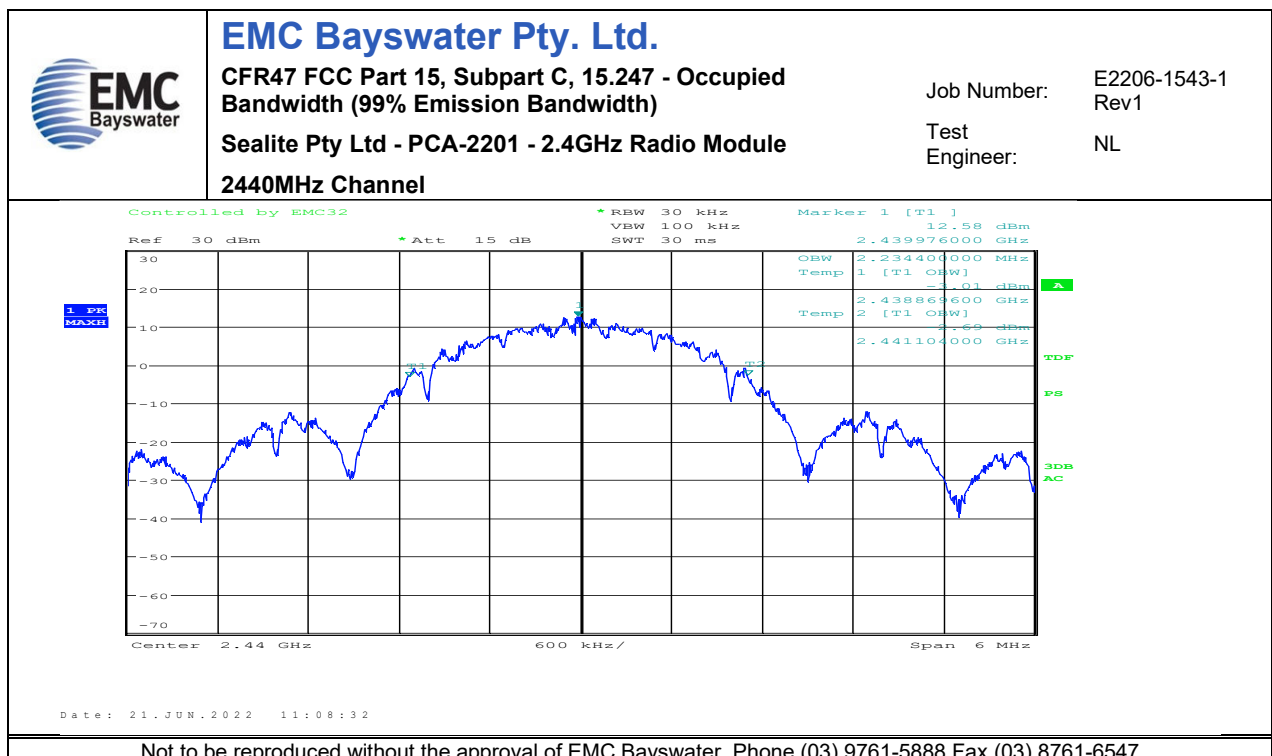
Graph 72

Appendix C.7 – Occupied Bandwidth (99% Emission Bandwidth)

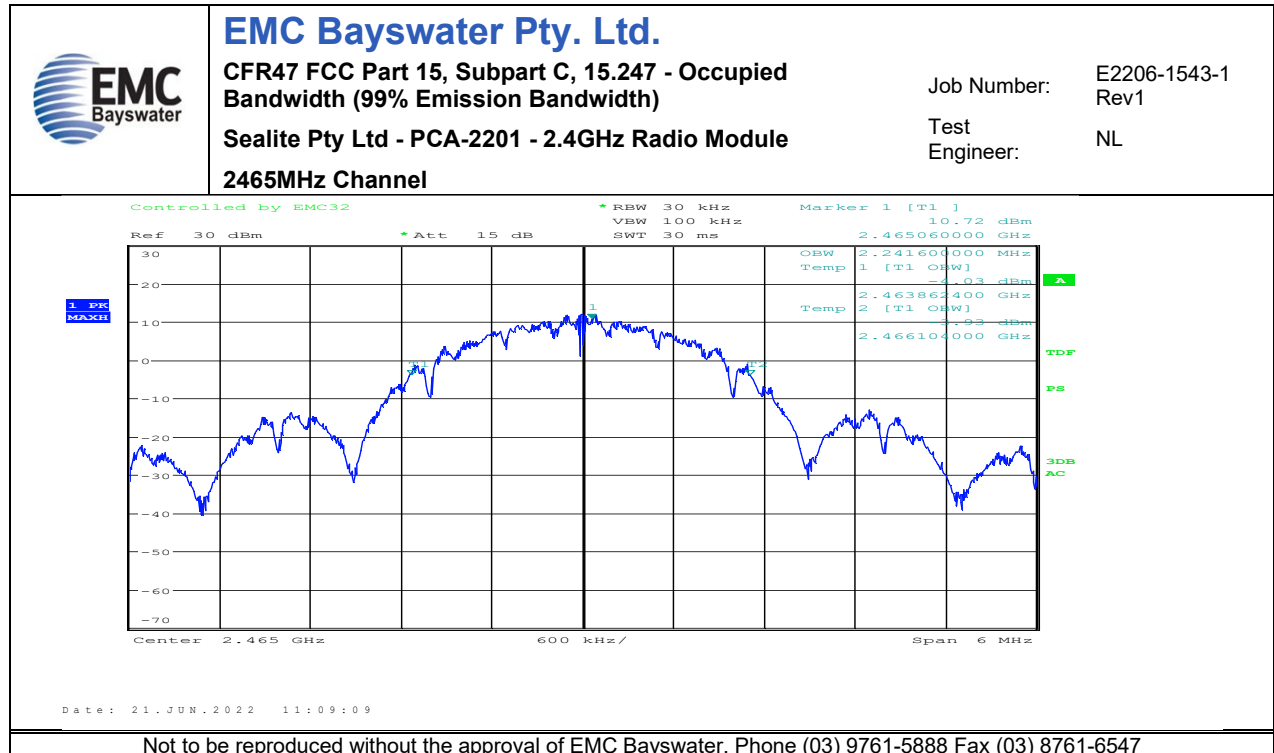
No.	Test	Graph Description
73	Occupied Bandwidth (99% Emission Bandwidth)	2410MHz Channel
74		2440MHz Channel
75		2465MHz Channel



Graph 73



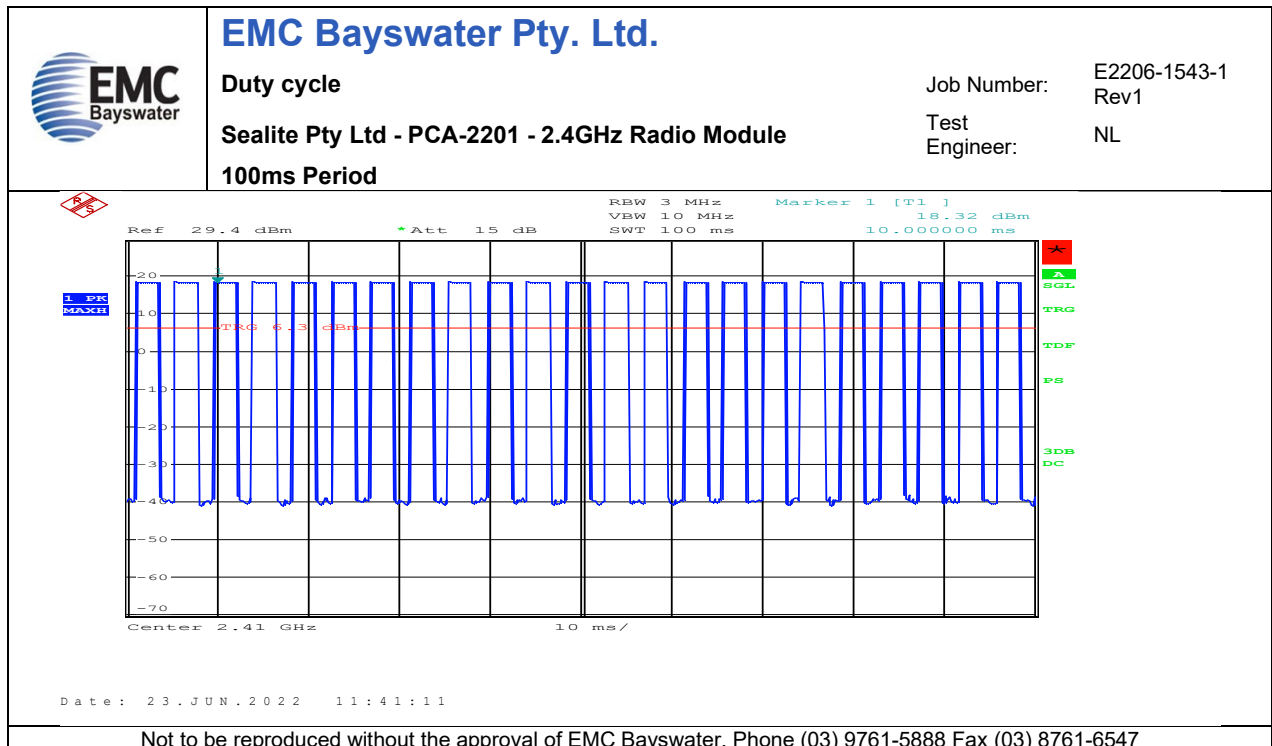
Graph 74



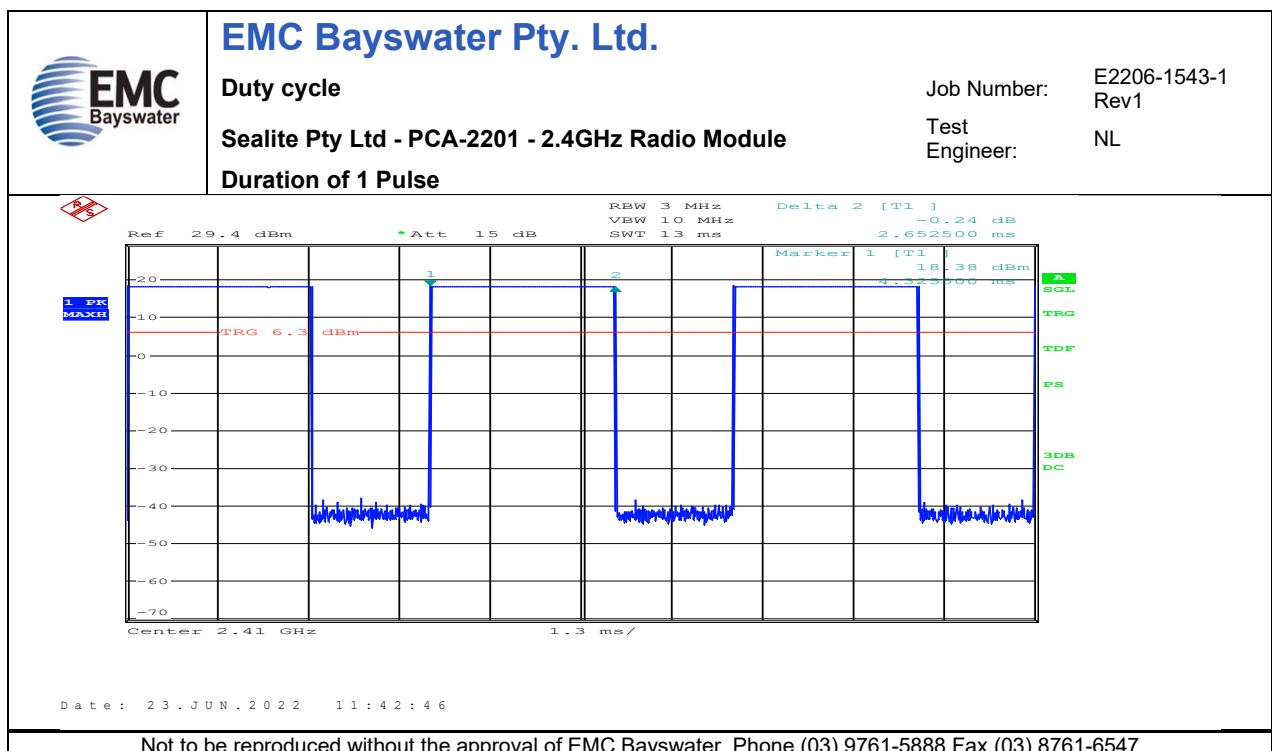
Graph 75

Appendix C.8 – Duty Cycle

No.	Test	Graph Description
76	Duty Cycle	100ms Period
77		Duration of One Pulse



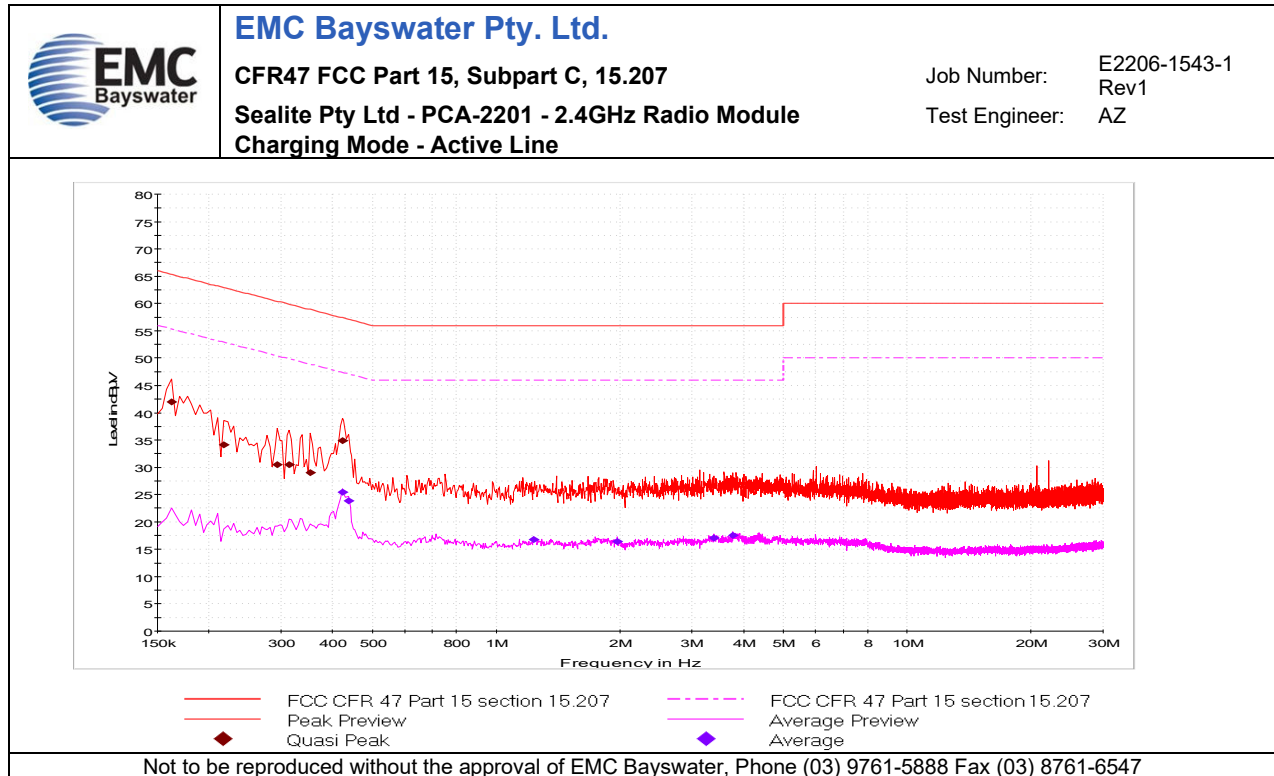
Graph 76



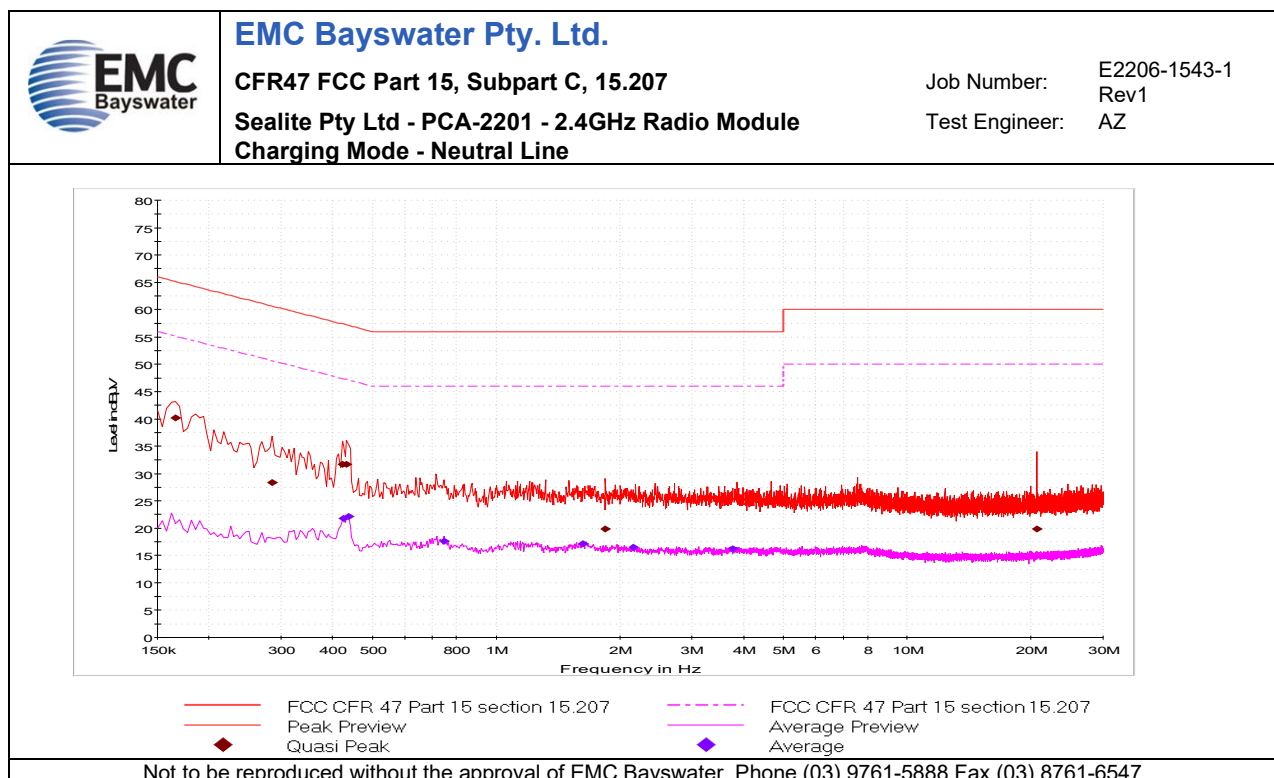
Graph 77

Appendix C.9 – Measurement Graphs – Conducted Emissions – 15.207

No.	Test	Graph Description
78	Conducted Emissions	Active Line – Charging Mode
79	CFR47 FCC Part 15, Subpart C, 15.207	Neutral Line – Charging Mode



Graph 78



Graph 79