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RADIO COMPLIANCE REPORT

Certification Test Report

In accordance with:

CFR47 FCC Part 15, Subpart C, 15.247

Gallagher Group Ltd

eS1

eShepherd Neckband

FCC ID: M5V-G040804

REPORT: E2401-1734-1 Rev1

DATE: February, 2024

*This report replaces the previously issued report E2401-1734-1
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: E2401-1734-1 Rev1
Issue Date: February, 2024

Test Sample(s):	eShepherd Neckband	
Model No:	eS1	
Serial No:	2619268061, 2587181265	
FCC ID:	M5V-G040804	
Customer Details:	Mr Hayden Goble Gallagher Group Ltd 181 Kahikatea Drive, Melville, Hamilton 3206 New Zealand Phone No: +64 800 731 500 e-mail: Hayden.goble@gallagher.com	
Test Specification:	CFR47 FCC Part 15, Subpart C, 15.247	
Results Summary:	15.203 - Antenna requirement 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 15.247 (a)(1) - Channel Separation 15.247 (f) - Channel Occupancy Time 15.109 - Radiated Emissions (Receiver Mode) 15.207 – Conducted Emissions	<i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied</i> <i>Complied – Class B</i> <i>Not Applicable*</i>
	<i>*Internal battery powered device, does not connect to AC mains</i>	
Test Date(s):	24 th to 29 th of January, 2024	
Test House (Issued By):	EMC Bayswater Pty Ltd 18/88 Merrindale Drive Croydon South Victoria 3136 Australia	
	FCC Accredited Test Firm Registration number: 527798 FCC Accredited Test Firm Designation number: AU0004	
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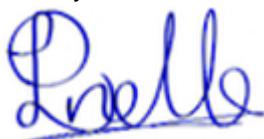
This is to certify that the necessary measurements were made by EMC Bayswater Pty Ltd, and that the modified Gallagher Group Ltd, eS1, eShepherd Neckband, has been tested in accordance with requirements contained in the appropriate commission regulations..

Prepared & tested by:



Adnan Zaman
(EMC Test Engineer)

Approved by:



Neville Liyanapatabendige
(Manager)

28/02/2024 16:56

Date



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Radio Compliance Report for Gallagher Group Ltd

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1. Introduction

Electromagnetic Compatibility (EMC) tests were performed on a modified Gallagher Group Ltd, eS1, eShepherd Neckband 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	SECTIONS AFFECTED	AUTHORISED BY
E2401-1734-1	13/02/24	Original	Neville Liyanapatabendige (Manager)
E2401-1734-1 Rev1	28/02/24	<ol style="list-style-type: none">As per customer request, FCC ID was updated.As per customer request, EUT internal LoRa module (without shield) photograph was included."Customer supplied the EUT with fully charged new battery for testing" statement was included in the 5.6 configuration section of the report.	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 modified EUT complied with applicable requirements of CFR47 FCC Part 15, Subpart C, 15.247. Worst-case results are tabled as follows:

FCC Part 15 sections	Test	Result
15.203	Antenna Requirement	Complied ^{#1}
15.247 (a)(1)	20dB Bandwidth	142kHz ^{#2}
15.247 (b)(3)	Maximum conducted output power	Complied by 14.2dB
15.247 (d)	Out-of-Band Emissions – 100kHz, -30dBc	Complied by at least > 6dB
15.247 (d)	Emissions on the Band edge	Complied by > 20dB
15.247 (d), 15.209	Radiated emissions in Restricted bands	Complied by 1.1dB ⁺
15.247 (e)	Power Spectral Density	Complied by 3.1dB ⁺
15.109	Radiated Emissions (Receiver Mode)	Complied with quasi-peak limit by 8.5dB
		Complied with peak limit by > 20dB
		Complied with average limit by > 20dB
15.247	Number of Hopping Frequencies	8 ^{#2}
15.247 (f)	Channel Occupancy Time	Complied
15.247 (a)(1)	Channel Separation	Complied
	Occupied Bandwidth (99% Emission Bandwidth)	125kHz ^{#2}

^{#1}Refer to relevant section for statement of Measurement Uncertainty

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

^{#2}Informative only. There is not limits defined for the Hybrid system

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:	eShepherd Neckband	
Model No:	eS1	
Part No:	G040804	
Serial No:	2619268061, 2587181265	
Firmware:	8.x.xxx	
Power Specifications:	Battery Powered LiFePO4, 3.2V, 12000mAH	
Dimensions:	Not supplied	
Weight:	Not supplied	
EUT Type:	Tested as table top.	
Transmitter Details:	Description:	IC MODULE LORA TRANSCEIVER 915MHz RFM95CW-915S2R
	Type:	RFM95CW-915S2R
	Modulation:	LoRa – Semtech proprietary chirp spread-spectrum digital modulation
	Modulation Technology:	Hybrid System
	Frequency Range:	902.4MHz to 903.8MHz
	Max power:	+14dBm
	Antenna:	PCB type
	Antenna Gain:	0dBi
	FCC ID:	2ASE0RFM95C

(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:

"Neckband is located around the neck of a farm animal, typically beef cattle. It determines its location by GPS/GNSS and compares it to programmed 'virtual fences'. If the animal attempts to cross a virtual fence the product first issues an audible warning. If the animal continues moving in the wrong direction the product applies an aversive electrical stimulus (series of HV pulses). It periodically transmits status to a base station and receives an acknowledgement and optional additional information.

The product contains FCC certified Wi-Fi module (FCC ID: 2AC7Z - ESPC3MINI1) is used by Gallagher authorised personnel only for testing and troubleshooting purposes. The LoRa and Wi-Fi module are not operated concurrently and is out of scope for this report."

(Customer supplied product description information)

The highest fundamental frequency generated or used within the EUT, or the highest frequency at which it operates as specified by the customer is 903.8MHz.

5.3. Support Equipment

Support Equipment 1:	Description:	Laptop
	Manufacturer:	DELL
	Model No:	Latitude 7420
	Serial No:	Not stated
Support Equipment 2:	Description:	Power supply
	Manufacturer:	TENMA
	Model No:	72-10480
	Serial No:	202108070789
Support Equipment 3:	Description:	1k Ohms Resistive Load
	Manufacturer:	NA
	Model No:	NA
	Serial No:	NA

5.4. Product operating modes

The customer described the product normal operation modes as the following:

“The animal is near a virtual fence, and the product remains active, monitors position and animal movement, and applies audio and aversive stimulus pulses as required. The product transmits status by LoRa packet (<0.4s) to the base station at >10min intervals (programmed time slots) typically every 10 minutes. The base station sends an acknowledgement and optionally additional information such as new virtual fence information or operating parameters.”

(Customer supplied product operating mode information)

5.5. Product operating mode for testing

“Radio transmitter testing – Product was put into test mode of continuous LoRa random-data transmission, or repeating LoRa packet transmissions with short separation. Nominal frequency 903MHz, US band-boundary channels at 902.4MHz and 903.8MHz.

Receiver Mode testing – Product was put into receive-only mode. A repeating sequence of audio and pulse events at approx. 2 second intervals represented accelerated normal operation for purpose of measurement position scanning (turntable etc). ”

5.6. Configuration

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

The product is battery powered and it does not normally have any cable connections. For testing a serial cable was connected from the product to a PC running a control program (Bandchat). The cable was fitted with numerous ferrites close to the product so as not to affect measurements. Customer supplied additional sample (serial no. 2587181265) with antenna port for Conducted method testing. Customer supplied the EUT with fully charged new battery for testing.

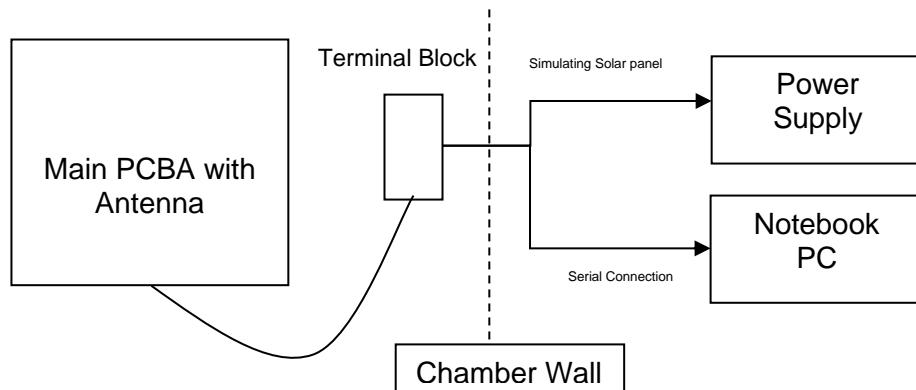


Figure 1: Customer supplied block diagram of EUT test configuration

Port	Cable type	Cable Brand	Cable Model	Length	Termination
Serial debug port (for test access only, not part of normal configuration)	Short 3-wire non shielded patch cable from PCB to outside of product.	Generic	Ribbon cable	50mm	2x8 pin 1.27mm pitch header
(As above)	DC extension cable from above patch cable to power supply simulating Solar input.	Generic	Shielded multi-core	9m	Power supply
	Serial extension cable from above patch cable to control PC – fitted with multiple ferrites				USB-to-Serial adapter at PC end

Table 2: List of ports and associated cables/terminations used for testing.

5.7. Modifications

The following modifications were made by the customer to the EUT to comply with Radiated emissions in Restricted bands testing:

- ① The EUT maximum transmit power was reduced from 18dBm to 15.8dBm to comply with Radiated emissions in Restricted bands.

Test	Modification
	①
20dB Bandwidth	✓
Maximum conducted output power	✓
Out-of-Band Emissions – 100kHz, -30dBc	✓
Emissions on the Band edge	✓
Radiated emissions in Restricted bands	✓
Power Spectral Density	✓
Radiated Emissions (Receiver Mode)	✗
Number of Hopping Frequencies	✗
Channel Occupancy Time	✗
Channel Separation	✗
Occupied Bandwidth (99% Emission Bandwidth)	✓

✓ Modification fitted ✗ Modification not fitted

Table 3: Summary of fitted modifications per test

EMC Bayswater takes no responsibility for any modifications made to the EUT specifically to achieve EMC compliance and hence these modifications may only be satisfactory for that purpose under the stated EUT test conditions. The customer must check that the proposed modifications meet all the product design, functional, safety or other compliance requirements. The customer elected not to re-test any of the previously completed tests (unless otherwise indicated in the table). EMC Bayswater takes no responsibility for any adverse EMC performance of the unpeated tests that may occur due to the modifications fitted.

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

None

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 PCB track Antenna. Therefore, the EUT complied with the antenna requirements of CFR47 FCC Part 15, Subpart C, 15.247 Section 15.203.

10.20dB Bandwidth – FCC 15.247 (a) (1)

10.1. Test Procedure

The 20dB Bandwidth measurement was performed in accordance with the section 6.9.2 of ANSI C63.10 - 2013.

20dB 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 3kHz RBW and 10kHz 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

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

10.3. Test Results

20dB Bandwidth measurements are tabulated below:

(Refer to graphs in Appendix C.1)

Transmit Operating Frequency (MHz)	-20dBc Lower Frequency (MHz)	-20dBc Upper Frequency (MHz)	Occupied Channel Bandwidth (kHz)
902.4 (Bottom Channel)	902.332	902.472	140
903 (Middle Channel)	902.929	903.070	141
903.8 (Top Channel)	903.728	903.870	142

Table 4: 20dB Bandwidth – Hybrid mode

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 5: Climatic conditions

Notes: The transmitter was continuously transmitting in Hybrid mode.

Assessment: The measured 20dB Bandwidth is 142 kHz (informative only).

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.

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)

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.5)

Transmit Operating Frequency (MHz)	99%BW Lower Frequency (MHz)	99%BW Upper Frequency (MHz)	Occupied Channel Bandwidth (kHz)
902.4 (Bottom Channel)	902.338	902.462	124
903 (Middle Channel)	902.938	903.063	125
903.8 (Top Channel)	903.738	903.863	125

Table 6: Occupied Bandwidth – Hybrid mode

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 7: Climatic conditions

Notes: The transmitter was continuously transmitting in Hybrid mode.

Assessment: The measured Occupied bandwidth (99% Emission Bandwidth) is 125 kHz (informative only).

12. Maximum conducted (average) output power– FCC 15.247 (b)(3)

12.1. Test Procedure

The Maximum conducted (average) output power measurements were performed in accordance with ANSI C63.10 - 2013.

The EUT was tested on the lowest, middle and highest channels using a fast power sensor (wideband RF power meter) with sample speed of 1 MS/s. The power sensor was directly connected the antenna port of the EUT via a suitable attenuator.. All the applicable correction factors such as attenuator loss were included into the RF power sensor correction factors. The RF power sensor was used with 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)

12.2. Limits

For systems using digital modulation techniques:

Transmit operating frequency (MHz)	Output Power (W)	Output Power (dBm)	e.i.r.p (W)	e.i.r.p (dBm)
902 – 928	1	30	4	36

Table 8: Limits – Transmitter maximum peak output power

12.3. Test Results

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

Channel	Frequency (MHz)	Measured Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	902.4	15.8	30	-14.2	Complied
Middle	903	15.8	30	-14.2	Complied
Top	903.8	15.8	30	-14.2	Complied

Table 9: Results for Maximum Conducted Output Power – Hybrid mode

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%.

Climatic Conditions	
Temperature:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 10: Climatic Conditions

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

The transmitter was continuously transmitting in Hybrid mode.

Assessment: The EUT complied with the Maximum conducted (average) 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 11: 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 3.6m 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.3)

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 12: 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	37.760	20.1	40.0	-19.9
	124.721	18.6	43.5	-24.9
	613.116	28.4	46.0	-17.6*
Vertical	37.615	20.2	40.0	-19.8
	125.157	18.5	43.5	-25.0
	610.060	28.3	46.0	-17.7

*Worst-case emissions

Table 13: Transmitter Spurious Emissions – 30MHz to 1GHz – Hybrid mode

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 >20dB below limit or no significant emissions above the noise floor observed			
Vertical	Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed			

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

Operating Channel: Bottom, (902.4MHz)								
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	5414.400	54.1	74.0	-19.9	2707.160	44.5	54.0	-9.5
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5414.640	51.0	54.0	-3.0 ⁺
					9023.734	47.9	54.0	-6.1
Vertical	5414.400	55.6	74.0	-18.4*	2707.420	43.9	54.0	-10.1
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5414.400	52.5	54.0	-1.5**
					9024.454	46.9	54.0	-7.1

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

Table 15: Transmitter Spurious Emissions – 1GHz to 10GHz – Hybrid mode

Operating Channel: Middle, (903MHz)								
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	5417.520	54.5	74.0	-19.5	2708.980	44.5	54.0	-9.5
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5417.760	51.4	54.0	-2.6 ⁺
					9029.494	45.1	54.0	-8.9
Vertical	5418.240	56.1	74.0	-17.9*	2708.980	43.8	54.0	-10.2
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5418.000	52.9	54.0	-1.1**
					9030.214	48.8	54.0	-5.2

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

Table 16: Transmitter Spurious Emissions – 1GHz to 10GHz – Hybrid mode

Operating Channel: Top, (903.8MHz)								
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	5422.320	55.0	74.0	-19.0	2711.580	43.7	54.0	-10.3
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5422.560	51.4	54.0	-2.6 ⁺
					9037.773	47.2	54.0	-6.8
Vertical	5422.560	55.9	74.0	-18.1*	2711.580	42.8	54.0	-11.2
	All other Peak preview emissions >20dB below limit or no significant emissions above the noise floor observed				5422.560	52.1	54.0	-1.9**
					9037.413	46.5	54.0	-7.5

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

Table 17: Transmitter Spurious Emissions – 1GHz to 10GHz – Hybrid mode

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:	22.5 to 24°C
Humidity:	50 to 56%
Atmospheric pressure:	1007.4 to 1011.5hPa

Table 18: Climatic conditions

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

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

Where:

- E = E-field in dB μ V/m
- $V_{QP/PK/A}$ = Measured Voltage (Quasi Peak, Peak or Average) in V dB μ V
- AF = Antenna Factor in dB(/m)
- L_c = Cable and attenuator Loss in dB
- G_{Amp} = Pre Amplifier Voltage Gain in dB

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 Hybrid 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, -30dBc) - 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.

Measurements were performed at the antenna port.

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)

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 +16.5dBm

Frequency Range (MHz)	Limits (dBm)
30MHz and 10GHz	-13.5

Table 19: Limits for Unwanted Emissions - -30dBc (Non-restricted bands)

14.3. Test Results

Unwanted emissions measurements are detailed as follows:

(Refer to graphs in Appendix C.3)

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 20: Transmitter Out of Band emissions - -30dBc/100kHz – Hybrid mode

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

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 (-30dBc).

Radiated measurements were made up to the 10th harmonic.

The transmitter was continuously transmitting in Hybrid mode.

Assessment: The EUT complied with the Out of Band emissions (100kHz, -30dBc) 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, -30dB from fc) was performed in accordance with the section 11.11 and 11.13 of ANSI C63.10 – 2013.

Conducted measurements were performed within 2 MHz of the authorised lower and higher 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 and higher 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 -30dB in a 100kHz bandwidth relative to the highest fundamental channel PSD in 100kHz, measurements were performed as per as section 6.10.4 of ANSI C63.10 - 2013.

(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 30 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 +16.5dBm

Band edge Frequencies	Limits (dBm)
Lower Edge (902MHz)	-13.5
Higher Edge (928MHz)	

Table 21: Limits for Band edge - -30dBc (Non-restricted bands)

15.3. Test Results

Band edge measurements are detailed as follows:

(Refer to graphs in Appendix C.2)

Operating Channel: Bottom (902.4MHz)			
Frequency (MHz)	Result Peak Power Spectral Density (dBm/100kHz)	Limit Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
901.953	-37.7	-13.5	-24.2*
901.999	-39.2	-13.5	-25.7

*Worst-case emissions

Table 22: Transmitter Emissions on the Band edge – Low end – Hybrid Mode (Hopping OFF)

Operating Channel: Top (903.8MHz)			
Frequency (MHz)	Result Peak Power Spectral Density (dBm/100kHz)	Limit Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
928.000	-41.5	-13.5	-28.0

Table 23: Transmitter Emissions on the Band edge – High end – Hybrid Mode (Hopping OFF)

Operating Channel: Bottom (902.4MHz)			
Frequency (MHz)	Result Peak Power Spectral Density (dBm/100kHz)	Limit Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
901.860	-37.1	-13.5	-23.6*
902.000	-40.6	-13.5	-27.1

*Worst-case emissions

Table 24: Transmitter Emissions on the Band edge – Low end – Hybrid Mode (Hopping ON)

Operating Channel: Top (903.8MHz)			
Frequency (MHz)	Result Peak Power Spectral Density (dBm/100kHz)	Limit Peak Power Spectral Density (dBm/100kHz)	Delta limit (dB)
928.000	-41.4	-13.5	-27.9

Table 25: Transmitter Emissions on the Band edge – High end – Hybrid Mode (Hopping ON)

The measurement uncertainty was calculated as follows:

Measurement frequency range	Calculated measurement uncertainty
30MHz to 10GHz	±1.4dB

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 26: Climatic conditions

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

The transmitter was continuously transmitting in Hybrid 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 11.10.3 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 power averaging (RMS) detector and a suitable span (at least 1.5 times of OBW) and number of measurement points ($\geq 2 \times$ span/RBW) to allow accurate measurements. Measurement was performed with trace averaging over (RMS) mode over a 100 traces and used the peak marker function to determine the maximum amplitude level.. An offset for the measurement path insertion loss (e.g. attenuators and cables) was used to get a true measurement.

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

16.2. Limits

As specified in Section 15.247(f), a hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off.

Transmit operating frequency (MHz)	Limit
902 – 928	8dBm/3kHz

Table 27: Power Spectral Density limits

16.3. Test Results

Power Spectral Density measurements are tabulated below:

(Refer to graphs in Appendix C.4)

Channel	Frequency (MHz)	Measured Power (dBm)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	902.403	+4.9	8.0	-3.1**	Complied
Middle	903.016	+4.8	8.0	-3.2+	Complied
Top	903.783	+4.4	8.0	-3.6+	Complied

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

Table 28: Results for Power Spectral Density – 3kHz RBW

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 29: Climatic conditions

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

The transmitter was continuously transmitting (the frequency hopping function was turned off).

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

17. Number of Hopping Frequencies

17.1. Limits

For a hybrid system, the number of hopping frequencies limits are not defined in CFR47 FCC Part 15, Subpart C, 15.247.

17.2. Test Procedure

The Number of Hopping Frequencies measurement was performed in accordance with the section 7.8.3 of ANSI C63.10 – 2013.

The Number of Hopping Frequencies 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 centre channel with 30kHz RBW and 100kHz VBW using the peak detector and a suitable span to allow accurate measurements.

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

17.3. Test Results

Number of hopping frequencies measured is tabulated below:

(Refer to graph in Appendix C.7)

Frequency (MHz)	Measured number of channels
902.4MHz to 903.8MHz	8

Table 30: Measurement results of the Number of Hopping channels

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 31: Climatic conditions

Notes: There is no minimum number of hopping channels requirements for hybrid system.

Assessment: Number of Hopping frequencies measured is 8 (Informative only).

18. Channel Occupancy Time

18.1. Limits

The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

18.2. Test Procedure

The Channel Occupancy Time measurement was performed in accordance with the section 7.8.4 of ANSI C63.10 – 2013.

The Channel Occupancy Time 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 channel with zero span, 100kHz RBW and 300kHz VBW using the peak detector. The marker delta function was used to measure the occupancy time.

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

18.3. Test Results

Channel occupancy time measurements are tabulated below:

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

Transmit frequency (MHz)	Measured duration (s)	Limit – Maximum duration (s)	Result
902.4	0.38	0.4*	Complied

*maximum 0.4 second average occupancy time in 3.2seconds (8 channels x 0.4second)

Tale 32: Measurement results of channel occupation time

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:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 33: Climatic conditions

Notes: The transmitter was continuously transmitting in Hybrid mode with the direct sequence or digital modulation operation turned-off.

Assessment: The EUT complied with the Channel Occupancy Time requirements of CFR47 FCC Part 15, Subpart C, 15.247 (f).

19. Channel Separation

19.1. Limits

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

19.2. Test Procedure

The Channel Separation measurement was performed in accordance with the section 7.8.2 of ANSI C63.10 – 2013.

The Channel Occupancy measurements were performed at the antenna port (Conducted method). The transmitter output was connected to a spectrum analyzer through a suitable attenuator. The marker delta function of the analyser was used to measure the frequency separation between two adjacent channels.

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

19.3. Test Results

Channel separation measurements are tabulated below:

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

Measured Separation (kHz)	Limit > 25kHz or 20dB BW (kHz)	Result
199	> 142 (20dB BW)	Complied

Table 34: Measurement results of channel occupation

Climatic Conditions	
Temperature:	22.5 to 24°C
Humidity:	50 to 51%
Atmospheric pressure:	1010.8 to 1011.5hPa

Table 35: Climatic conditions

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%.

Notes: The transmitter was continuously transmitting in Hybrid mode.

Assessment: The EUT complied with the Channel Separation requirements of CFR47 FCC Part 15, Subpart C, 15.247 (a)(1).

20. Radiated Emissions (Receiver Mode) – 15.109

20.1. Test Procedure

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 table, at a height of 0.8m above the ground plane.

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 120 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. 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 120 kHz.

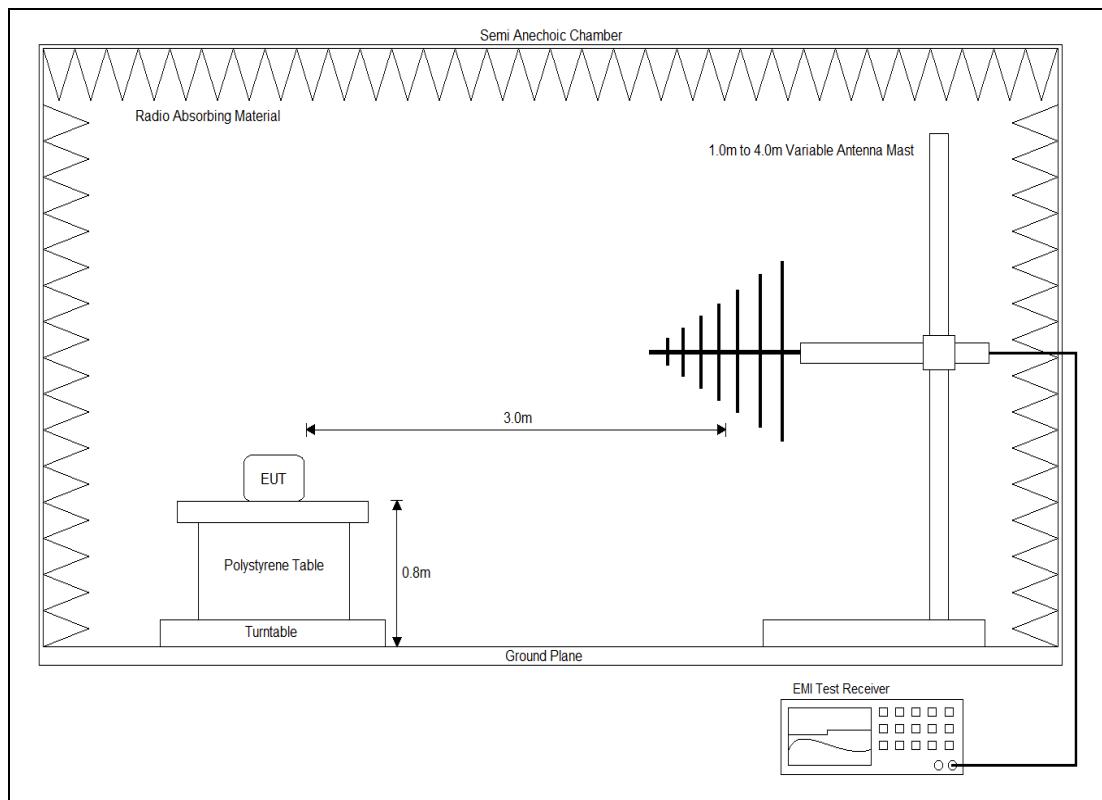


Figure 2: Test setup – 30MHz to 1GHz

In the frequency range 1GHz to 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 3 MHz. 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.

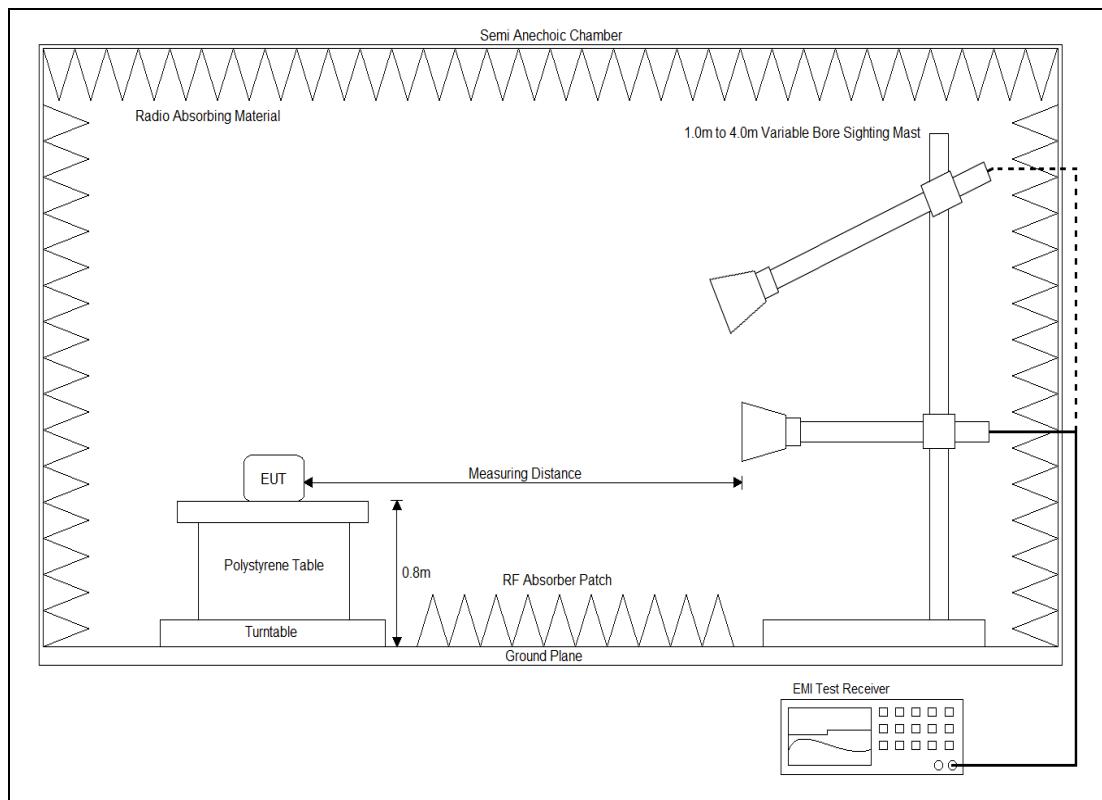


Figure 3: Test setup – above 1GHz

Horn	Frequency (GHz)	Degrees	Measuring Distance (m)	Illumination (m)	Measuring Distance (m)	Illumination (m)
EMCO 3115	1 to 2	55.00	3	3.12	1	1.04
	2 to 4	50.00	3	2.80	1	0.93
	4 to 6	34.00	3	1.83	1	0.61
AH SAS-584	5.8 to 8.2	30.00	3	1.61	1	0.54
AH SAS-585	8.2 to 12.4	30.00	3	1.61	1	0.54
AH SAS-586	12.4 to 18	30.00	3	1.61	1	0.54
AH SAS 587	18 to 26.5	30.00	3	1.61	1	0.54
AH SAS 588	26.5 to 40	31.00	3	1.66	1	0.55

Table 36: Worst case Maximum size of measuring envelope for Horn antennas

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)

20.2.Limits

20.2.1. CFR 47 FCC Part 15 Class B Limit

The EUT shall meet the limits in the following table:

Frequency Range (MHz)	Measuring distance	Limits (dB μ V/m)	
		Quasi-Peak	
30 to 88	3m	40.0	
88 to 216	3m	43.5	
216 to 960	3m	46.0	
960 to 1000	3m	54.0	
Frequency Range (GHz)	Measuring distance	Limits (dB μ V/m)	
		Average	Peak
1.0 to 26.5	3m	54.0	74.0
26.5 to 40.0	1m	64.0	84.0
26.5 to 40.0	0.5m	70.0	90.0

NOTE The lower limit shall apply at the transition frequency.

Table 37: Limits for Radiated Emissions of Class B equipment

20.3.Test Results

Radiated Emissions measurements are tabulated below. For below 1GHz measurements, Quasi-peak measurements were performed at spot frequencies where the peak emission was close to, or exceeded the applicable limit line. For above 1GHz measurements, 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.6)



Accreditation number: 18553. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports. This document may not be reproduced except in full without approval from EMC Bayswater, with the exception of the certificate on page 2.

Measurement Antenna Polarisation	Frequency (MHz)	Result peak (dB μ V/m)	Limit Quasi-peak (dB μ V/m)	Delta limit (dB)
Horizontal	30.631	26.1	40.0	-13.9
	32.328	24.6	40.0	-15.4
	485.512	25.1	46.0	-20.9
	630.915	28.9	46.0	-17.1
	794.894	31.0	46.0	-15.0
	858.720	31.5	46.0	-14.5
Vertical	30.340	31.5	40.0	-8.5*
	31.067	29.3	40.0	-10.7
	31.746	27.2	40.0	-12.8
	32.862	24.4	40.0	-15.6
	260.133	18.5	46.0	-27.5
	440.116	23.2	46.0	-22.8

*Worst-case emission

Table 38: Radiated Emissions – (30MHz to 1GHz)

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	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				Average emissions were not above the measurements system noise floor or at least 20dB below the limit			
Vertical	Peak emissions were not above the measurements system noise floor or at least 20dB below the limit				Average emissions were not above the measurements system noise floor or at least 20dB below the limit			

Table 39: Radiated Emissions – (1GHz to 5GHz)

The measurement uncertainty was calculated as follows:

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

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:	22.9 to 23°C
Humidity:	50%
Atmospheric pressure:	1008.6 to 1009.0hPa

Table 40: Climatic conditions

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

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

Where:

E	=	E-field in dB μ V/m
$V_{QP/PK/AV}$	=	Measured Voltage (Quasi Peak, Peak or Average) in dB μ V
AF	=	Antenna Factor in dB(/m)
L_c	=	Cable and attenuator Loss in dB
G_{Amp}	=	Pre Amplifier Voltage Gain in dB

Example calculation:

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

Notes: All Radiated Emissions measured were below the FCC Class B limits.

If the highest frequency generated or used within the device or on which the device operates or tunes is between 500MHz and 1000MHz, the upper frequency of measurement range should be 5000MHz.

The highest frequency of the EUT as specified by the customer is 903.8MHz as such measurements up to 5GHz were taken.

Assessment: The EUT complied with the Radiated Emissions (Receiver Mode) requirements of CFR47 FCC Part 15, Subpart B section 15.109.

21. Conclusion

The modified Gallagher Group Ltd, eS1, eShepherd Neckband complied with the applicable requirements of CFR47 FCC Part 15, Subpart C, 15.247 and CFR47 FCC Part 15, Subpart B section 15.109.

Appendix A – Test Equipment

Inv.	Equipment	Make	Model No.	Serial No.	Calibration		
					Interval	Due	Type
Power Spectral Density, Bandwidth, Non-Restricted Transmitter Spurious, Hopping Parameters and Band-edge							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	Jun-24	E
0715	ATTENUATOR, 20dB	JFW	50HF-020N		3 years	Dec-24	I
1155	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-25	I
Maximum Output Power							
1243	RF Power meter Sensor, USB	Dare!! Instruments	RPR3006W	17100015SN084	2 years	Jun-24	E
0715	ATTENUATOR, 20dB	JFW	50HF-020N		3 years	Dec-24	I
1155	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-25	I
SW027	Dare!! Instruments RadiPower Software	Dare!! Instruments	Radimation	Version 2017.2.9	N/A	N/A	N/A
Transmitter Spurious Emissions and Radiated Emissions (Receiver Mode)							
1217	ANALYSER, EMI Receiver	Rohde & Schwarz	ESU40	100182	1 year	Jun-24	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
0935	ANTENNA, Biconilog	Sunol Sciences	JB5	A071106	2 years	May-25	E
0718	ATTENUATOR, 6dB	JFW	50FPE-006	-	1 year	Jan-25	I
0989	CABLE, Coax, Sucoflex 104A	Huber+Suhner	44454/4A	C357	1 year	Jan-25	I
1145	CABLE, Coax, Sucoflex 104PA	Huber + Suhner	84279564	SN MY056/4PA	1 year	Jan-25	I
0024	ANTENNA, Active Loop	EMCO	6502	2620	2 years	Feb-25	I
0559	PRE-AMP, Microwave, 18GHz	Miteq	AFS8	605305	1 year	Apr-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-25	I
1193	Standard Gain Horn Antenna - 5.85GHz to 8.2GHz	A.H. Systems, inc	SAS-584	186	1 year	May-24	E
1194	Standard Gain Horn Antenna - 8.2GHz to 12.4GHz	A.H. Systems, inc	SAS-585	224	1 year	May-24	E
0711	ATTENUATOR, 10dB	JFW	50HF-010N		3 years	Dec-24	I
1250	FILTER, Hi-Pass	K&L Microwave, Inc	41H10-00033	3	2 years	Oct-24	V
1155	Hygrometer, Temp, Humidity	DigiTech	QM7312	-	2 years	Jul-25	I
0666	Enclosure, Semi-Anechoic, No 1	RFI Industries	S800 iOATS	1229	3 years	Aug-25	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

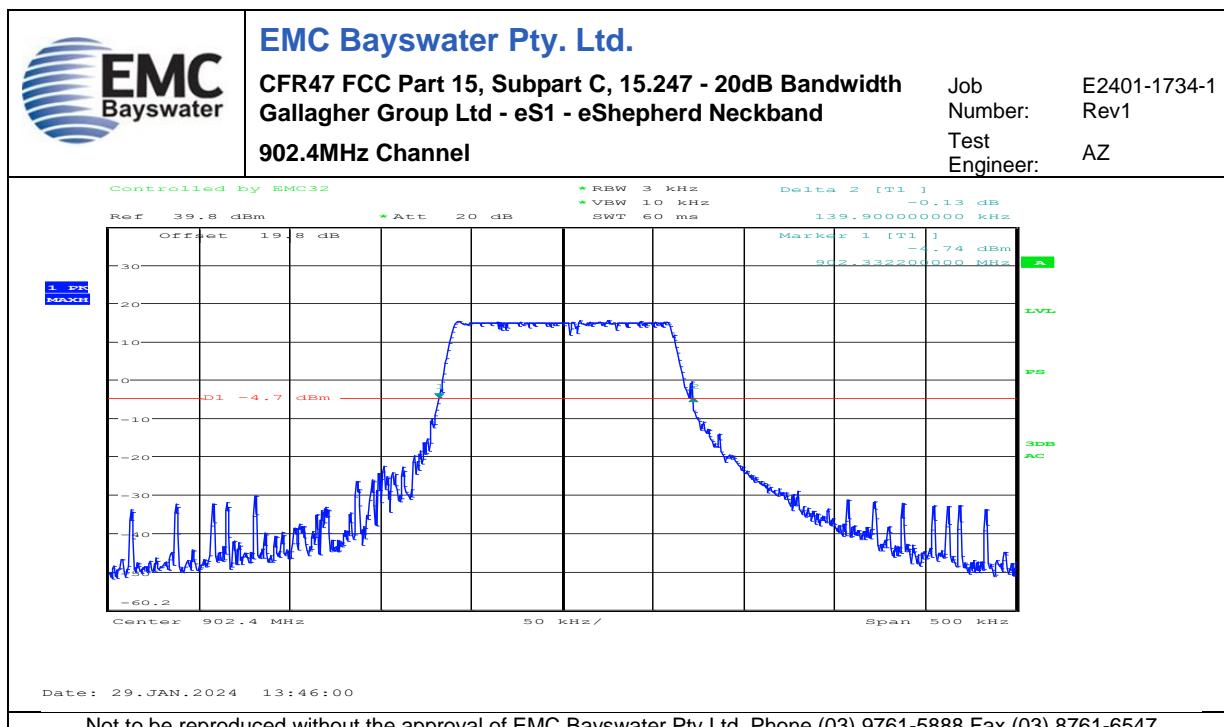
Appendix B – Photographs

Annex	Number	Photograph Description
A	1 to 10	EUT – External views
B	1 to 23	EUT – Internal views
B	24	EUT – View of the PCB trace antenna
B	25	
B	26	EUT – View of the sample with temporary SMA antenna port connector for Conducted method testing.
B	27	
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
C	9	
C	10	Receiver Mode – Test configuration
C	11	Conducted measurements
C	12	Conducted measurements – Power Meter Measurements

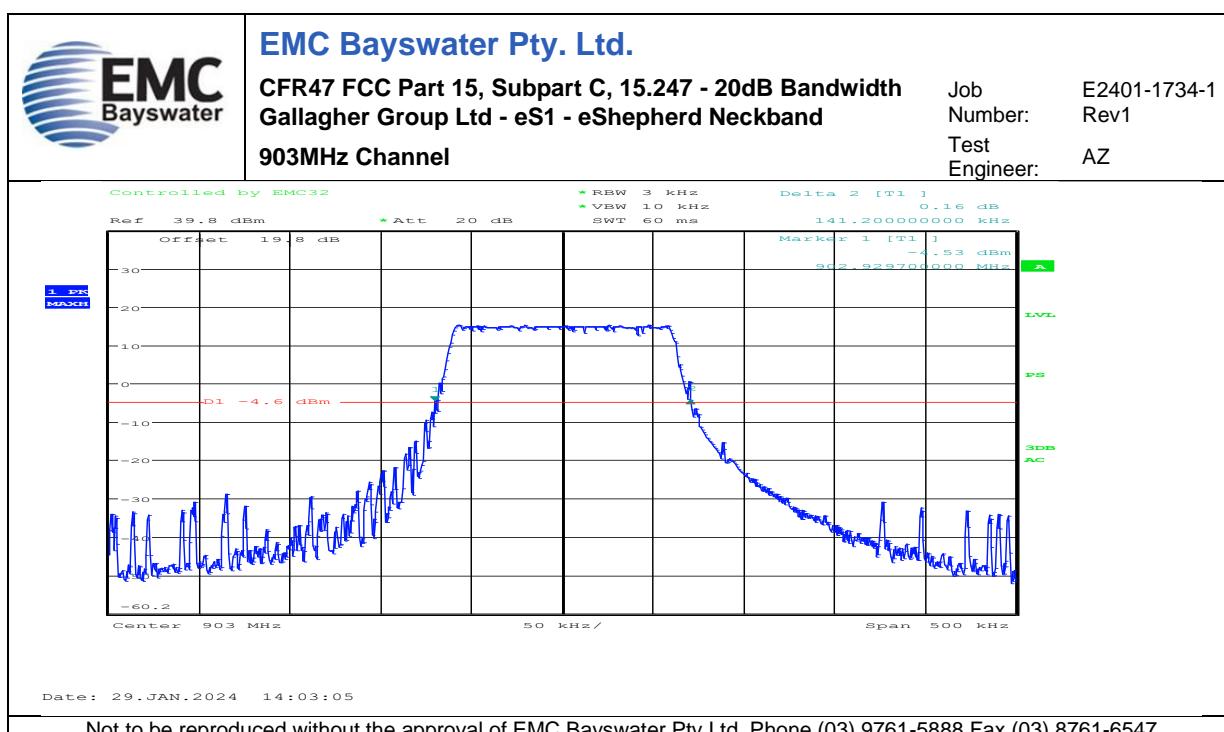
EUT External Photographs	EMC Bayswater Test Report E2401-1734-1 Rev1 Annex A
EUT Internal Photographs	EMC Bayswater Test Report E2401-1734-1 Rev1 Annex B
EUT Orientations & Test Configurations Photographs	EMC Bayswater Test Report E2401-1734-1 Rev1 Annex C

Appendix C.1 – Measurement Graphs – 20dB Bandwidth - 15.247 (a)(1)

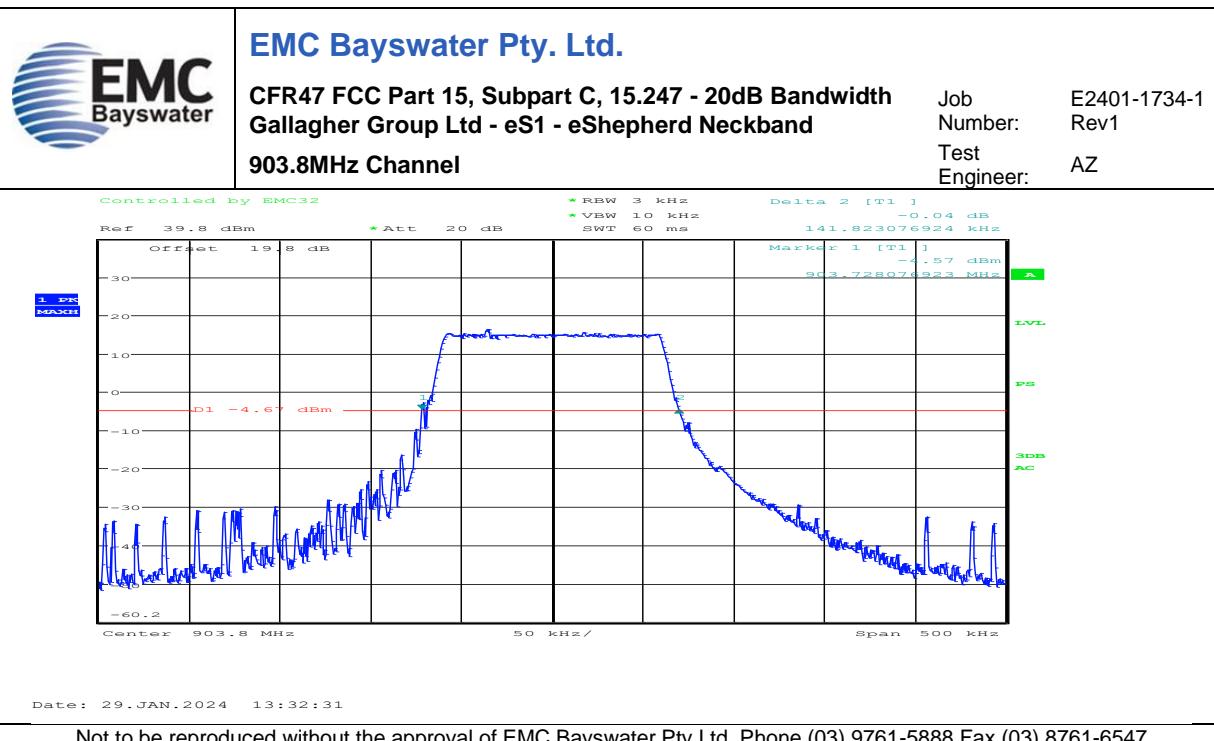
No.	Test	Graph Description
1	20dB Bandwidth	902.4MHz Channel
2		903MHz Channel
3		903.8MHz Channel



Graph 1



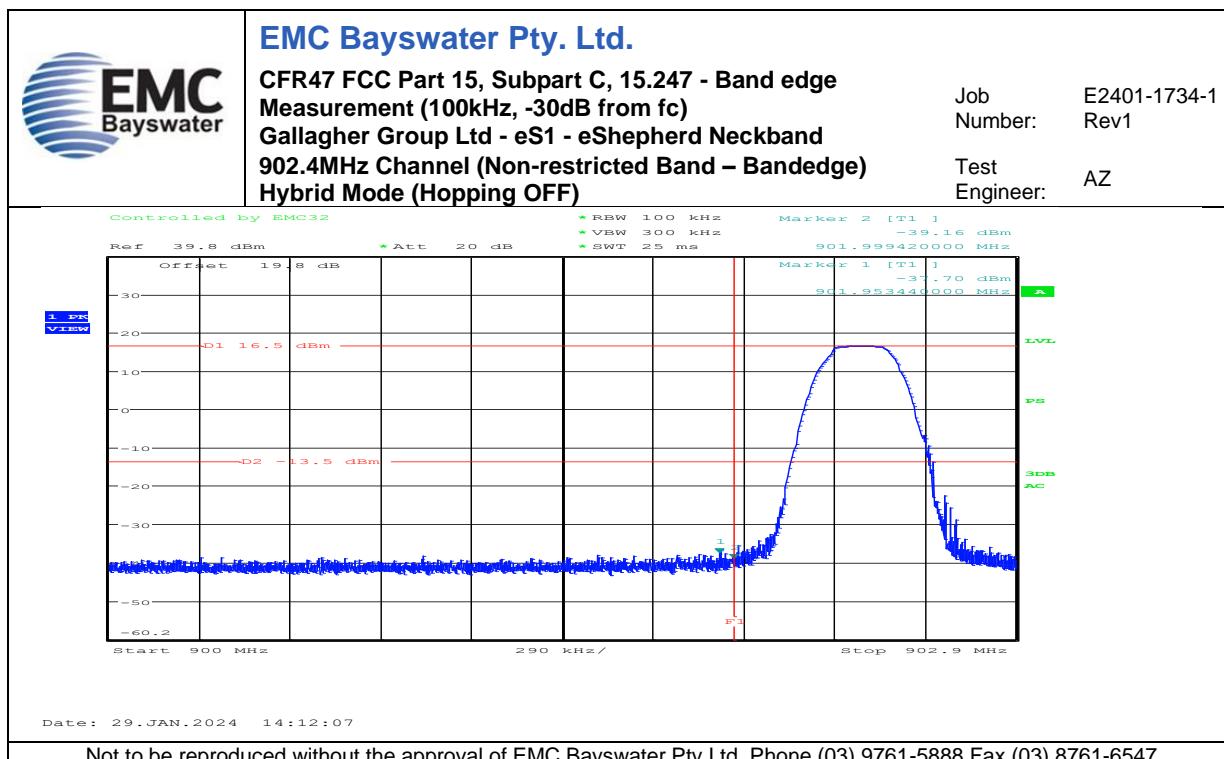
Graph 2



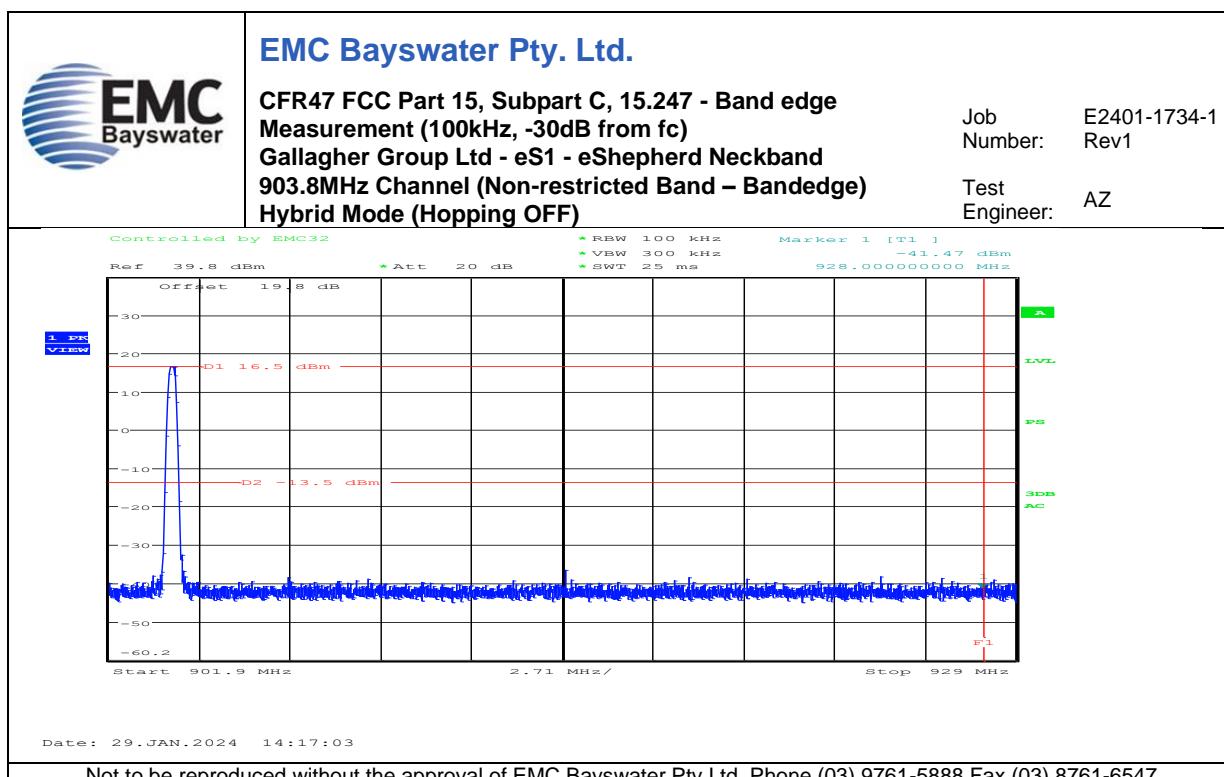
Graph 3

Appendix C.2 – Measurement Graphs – Band Edge - 15.247 (d)

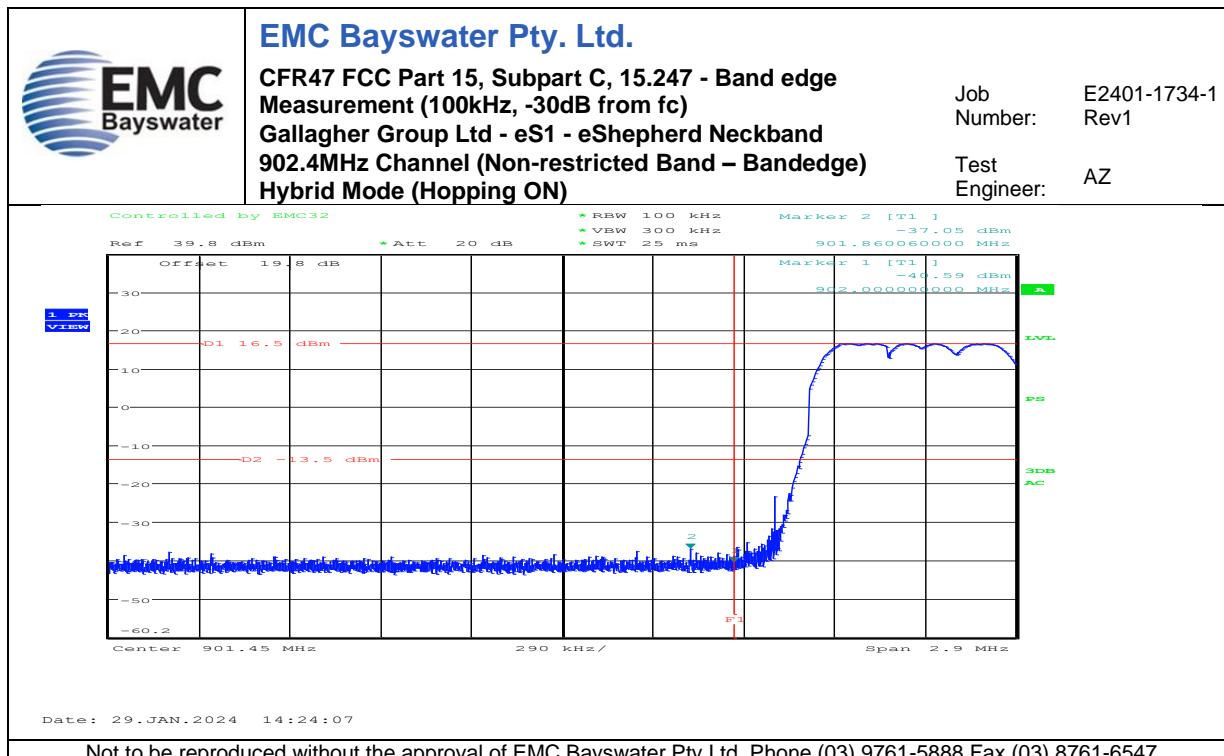
No.	Test	Graph Description
4	Band edge Measurement – Hybrid Mode (Hopping OFF)	902.4MHz Channel (Non-restricted Band – Bandedge)
5		903.8MHz Channel (Non-restricted Band – Bandedge)
6	Band edge Measurement – Hybrid Mode (Hopping ON)	902.4MHz Channel (Non-restricted Band – Bandedge)
7		903.8MHz Channel (Non-restricted Band – Bandedge)



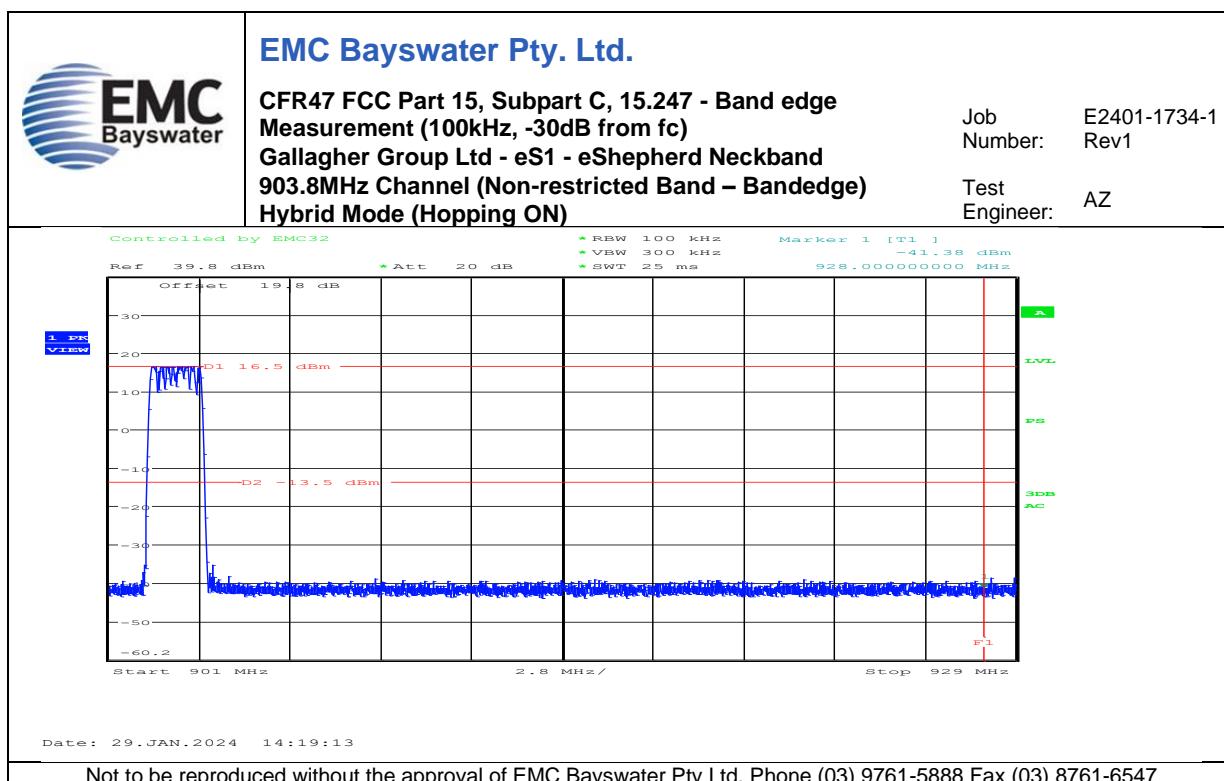
Graph 4



Graph 5



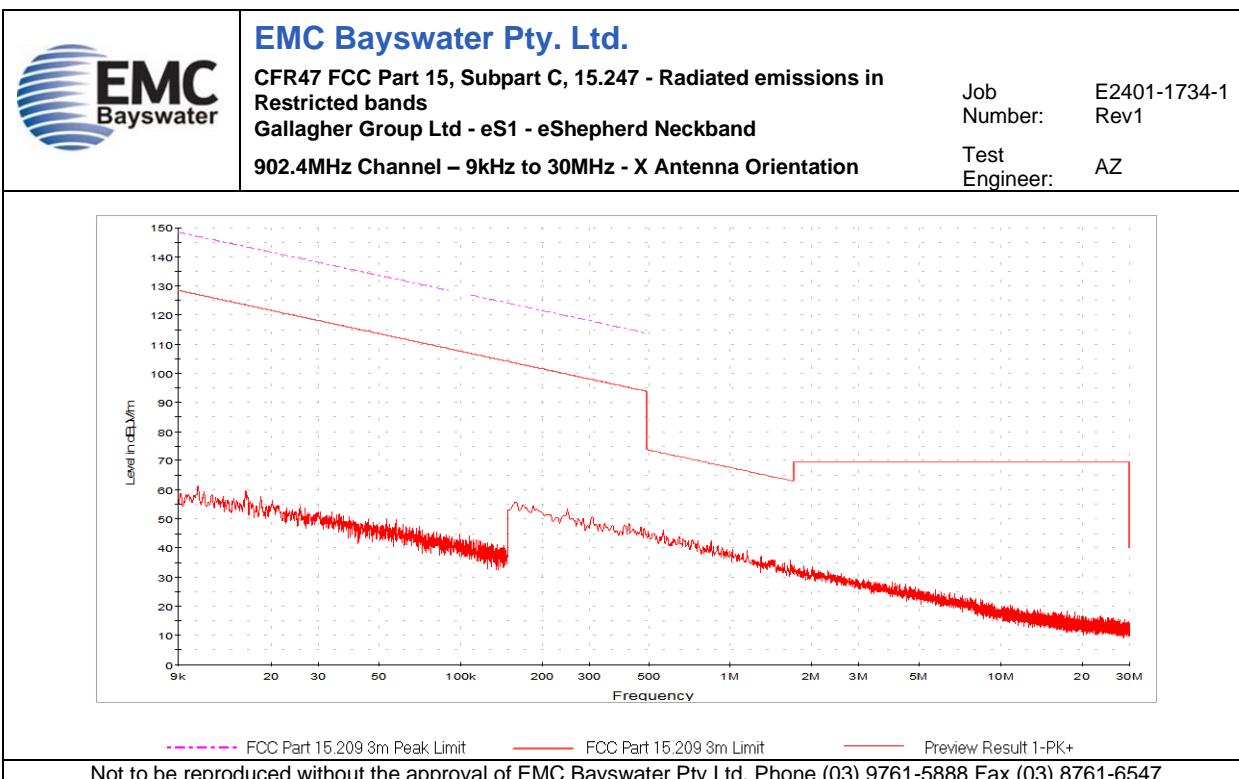
Graph 6



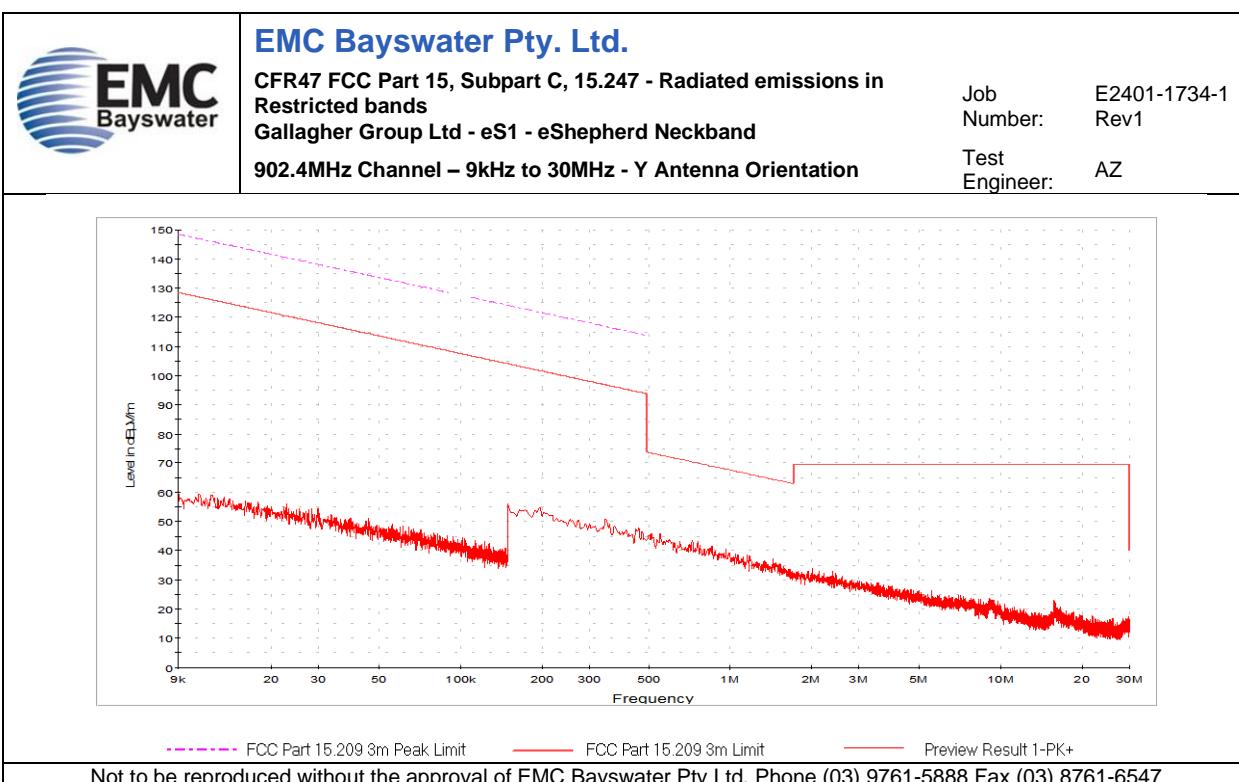
Graph 7

**Appendix C.3 – Measurement Graphs – Transmitter Spurious – FCC 15.247 (d),
15.209**

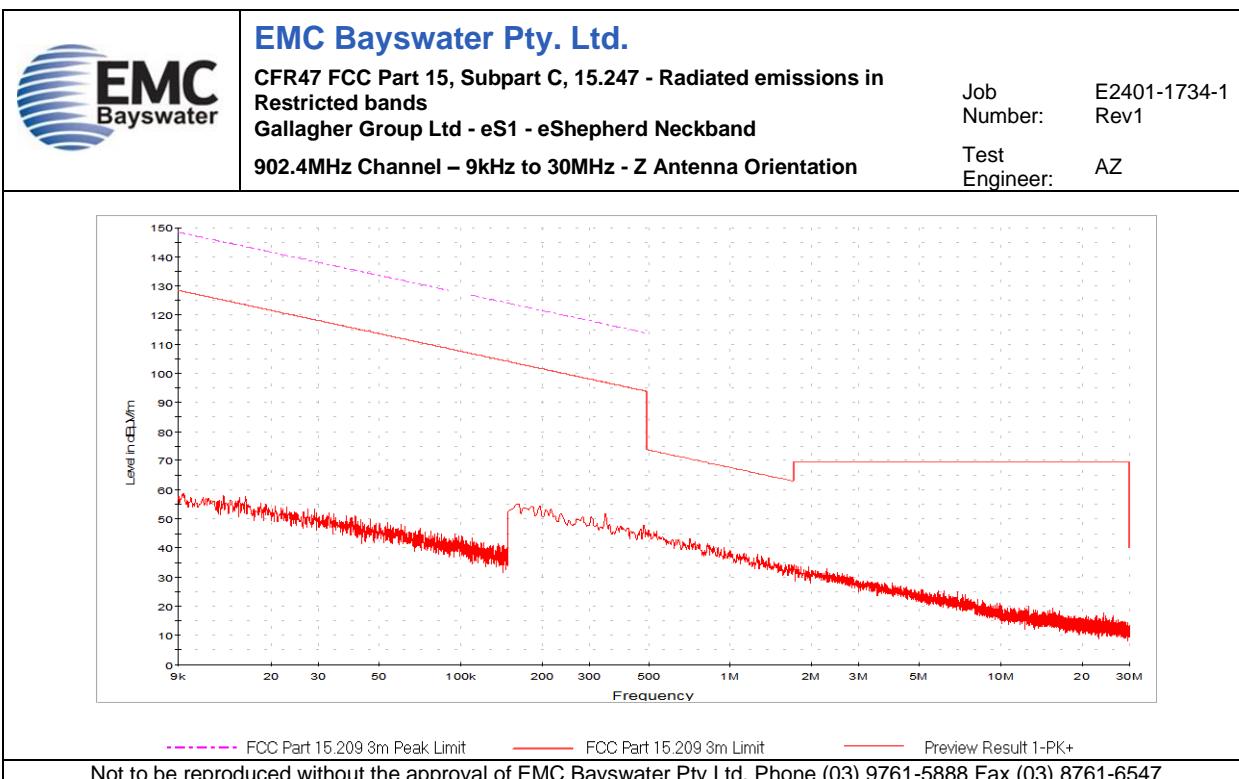
No.	Test	Graph Description
8	9kHz to 30MHz Restricted Bands	902.4MHz Channel, Antenna X
9		902.4MHz Channel, Antenna Y
10		902.4MHz Channel, Antenna Z
11		903MHz Channel, Antenna X
12		903MHz Channel, Antenna Y
13		903MHz Channel, Antenna Z
14		903.8MHz Channel, Antenna X
15		903.8MHz Channel, Antenna Y
16		903.8MHz Channel, Antenna Z
17	30MHz to 1GHz Restricted Bands	902.4MHz Channel, Antenna Horizontal
18		902.4MHz Channel, Antenna Vertical
19		903MHz Channel, Antenna Horizontal
20		903MHz Channel, Antenna Vertical
21		903.8MHz Channel, Antenna Horizontal
22		903.8MHz Channel, Antenna Vertical
23	1GHz to 1.3GHz Restricted Bands	902.4MHz Channel, Antenna Horizontal
24		902.4MHz Channel, Antenna Vertical
25		903MHz Channel, Antenna Horizontal
26		903MHz Channel, Antenna Vertical
27		903.8MHz Channel, Antenna Horizontal
28		903.8MHz Channel, Antenna Vertical
29	1.3GHz to 6GHz Restricted Bands	902.4MHz Channel, Antenna Horizontal
30		902.4MHz Channel, Antenna Vertical
31		903MHz Channel, Antenna Horizontal
32		903MHz Channel, Antenna Vertical
33		903.8MHz Channel, Antenna Horizontal
34		903.8MHz Channel, Antenna Vertical
35	5.8GHz to 8.2GHz Restricted Bands	902.4MHz Channel, Antenna Horizontal
36		902.4MHz Channel, Antenna Vertical
37		903MHz Channel, Antenna Horizontal
38		903MHz Channel, Antenna Vertical
39		903.8MHz Channel, Antenna Horizontal
40		903.8MHz Channel, Antenna Vertical
41	8.2GHz to 10GHz Restricted Bands	902.4MHz Channel, Antenna Horizontal
42		902.4MHz Channel, Antenna Vertical
43		903MHz Channel, Antenna Horizontal
44		903MHz Channel, Antenna Vertical
45		903.8MHz Channel, Antenna Horizontal
46		903.8MHz Channel, Antenna Vertical
47	30MHz to 1GHz Non-Restricted Bands	902.4MHz Channel
48		903MHz Channel
49		903.8MHz Channel
50	1GHz to 5GHz Non-Restricted Bands	902.4MHz Channel
51		903MHz Channel
52		903.8MHz Channel
53	5GHz to 10GHz Non-Restricted Bands	902.4MHz Channel
54		903MHz Channel
55		903.8MHz Channel



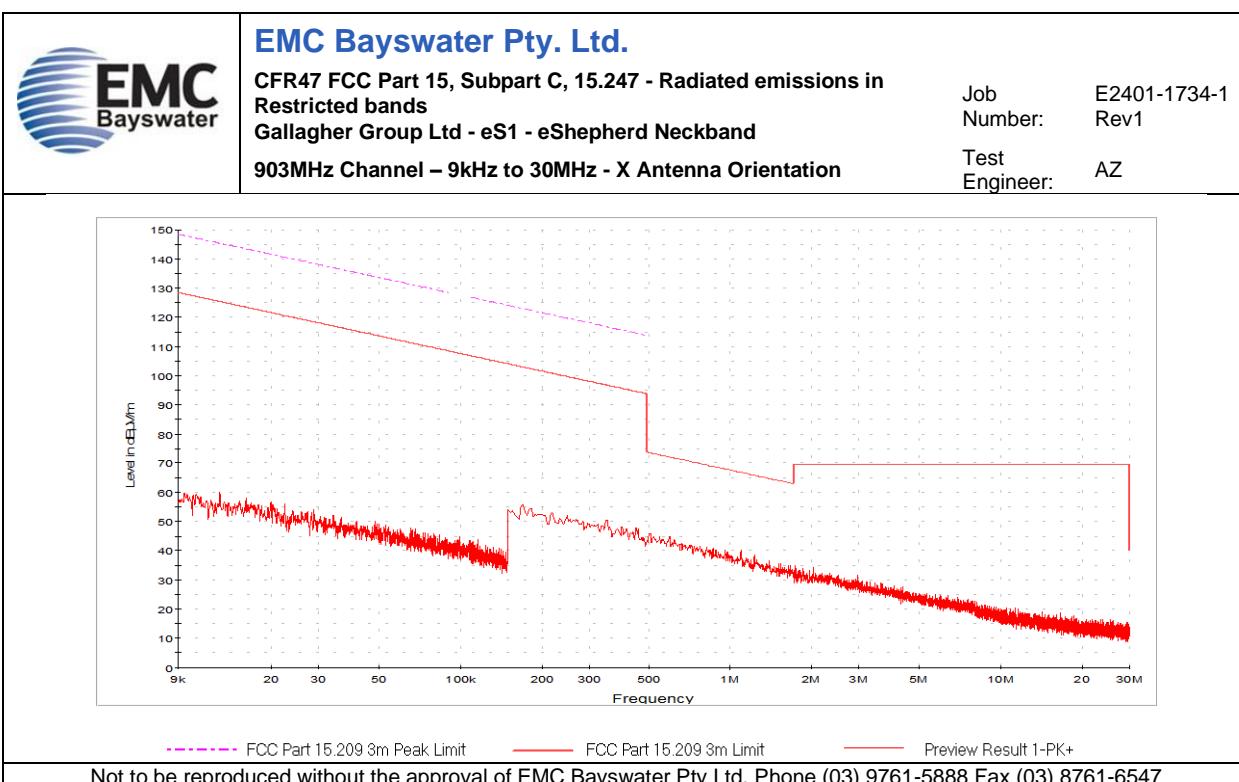
Graph 8



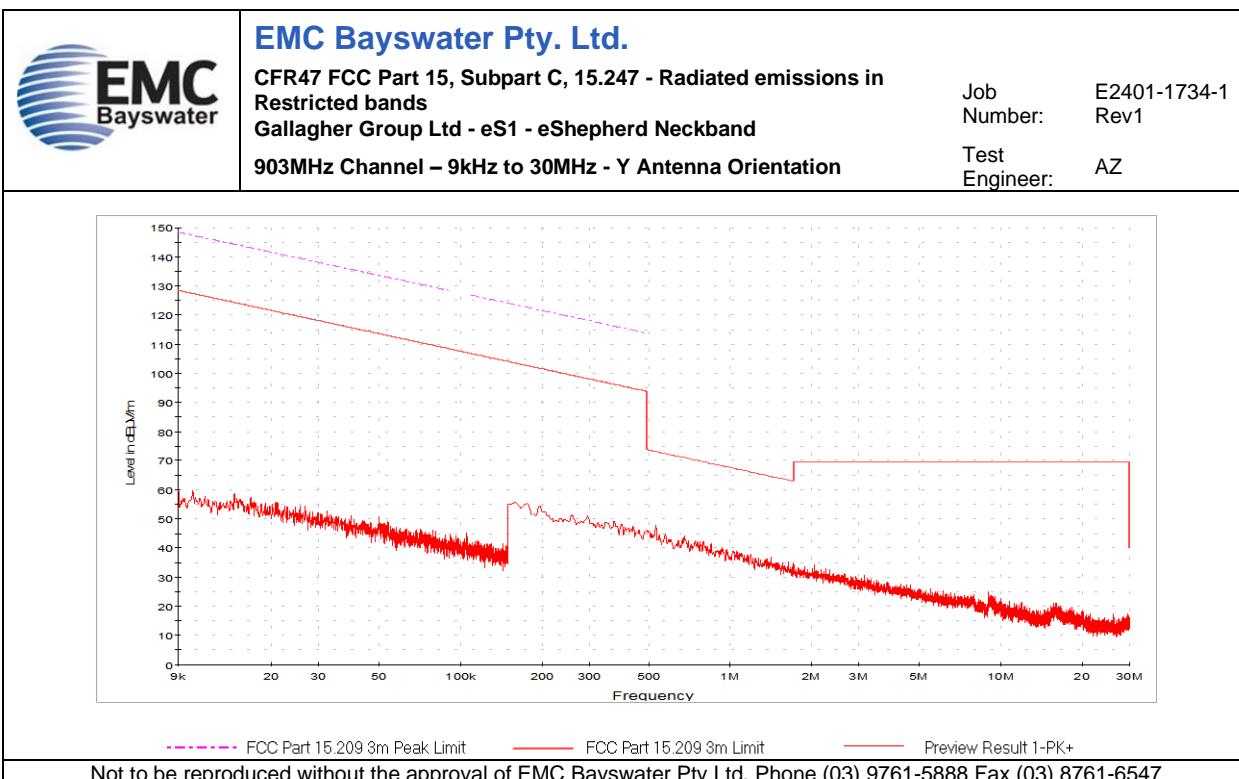
Graph 9



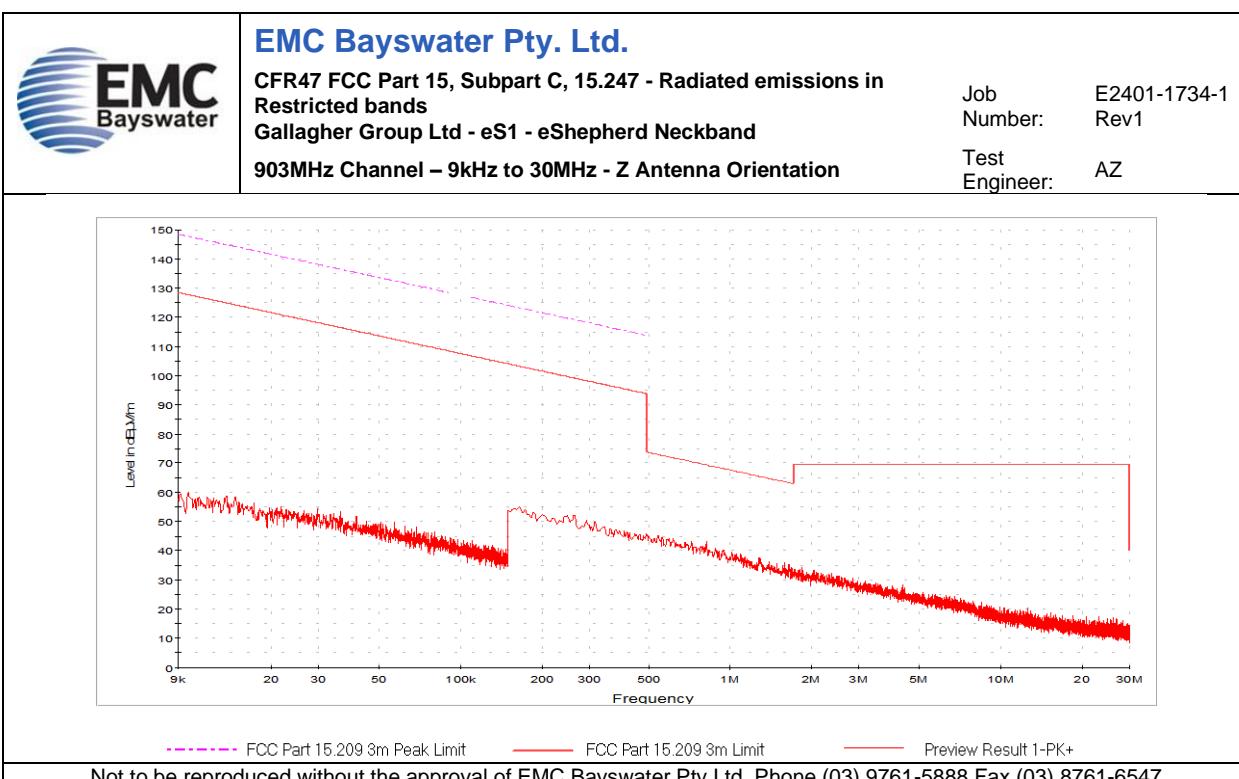
Graph 10



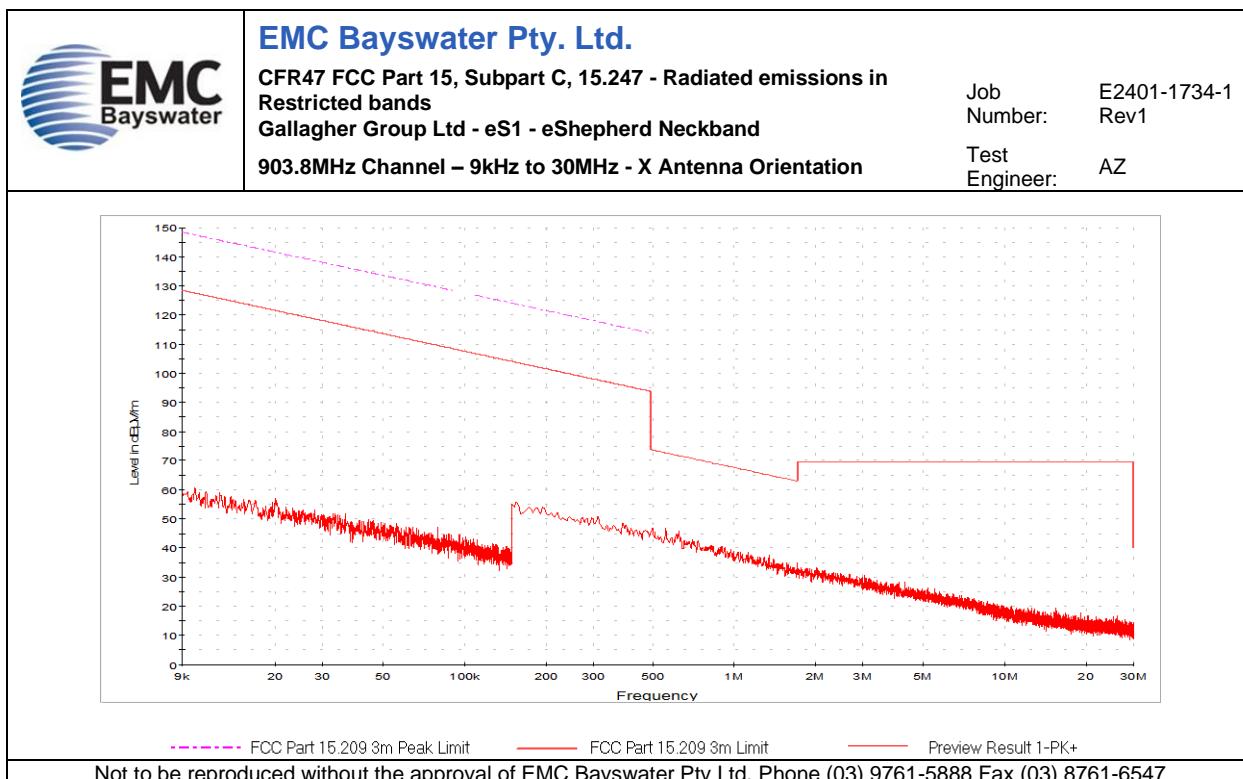
Graph 11



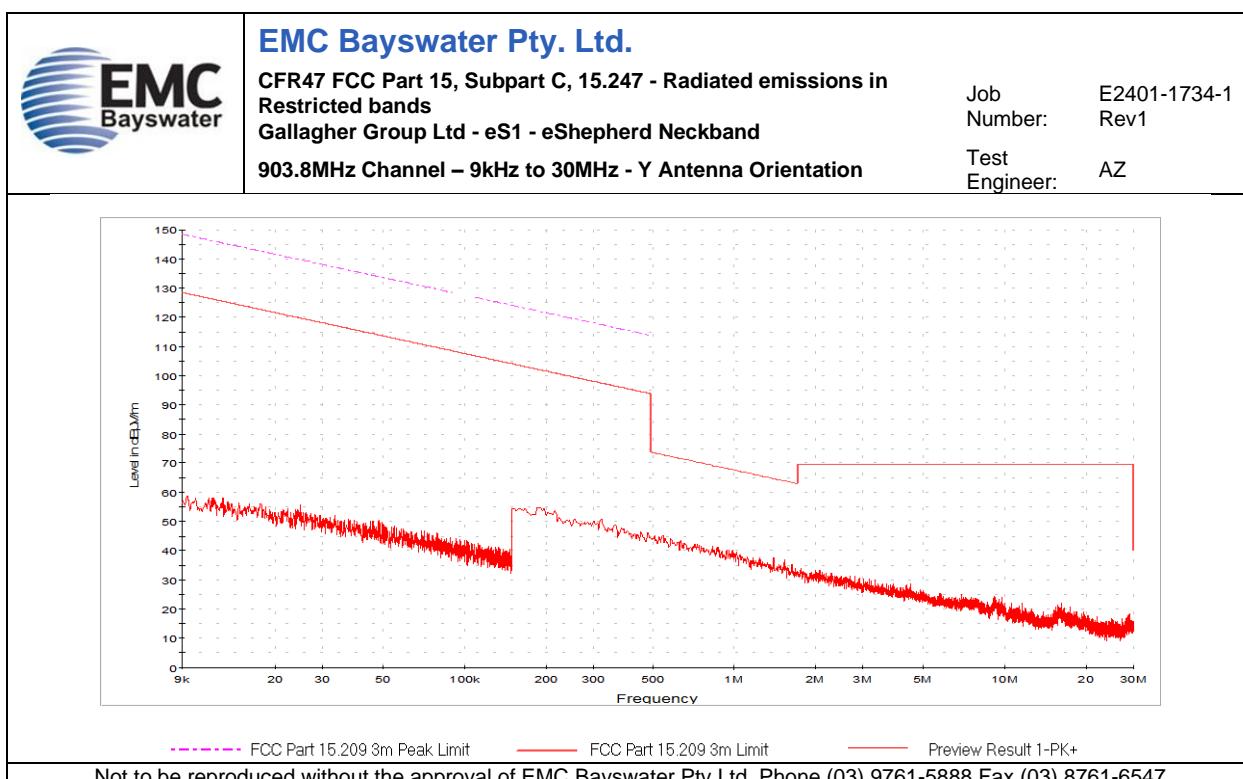
Graph 12



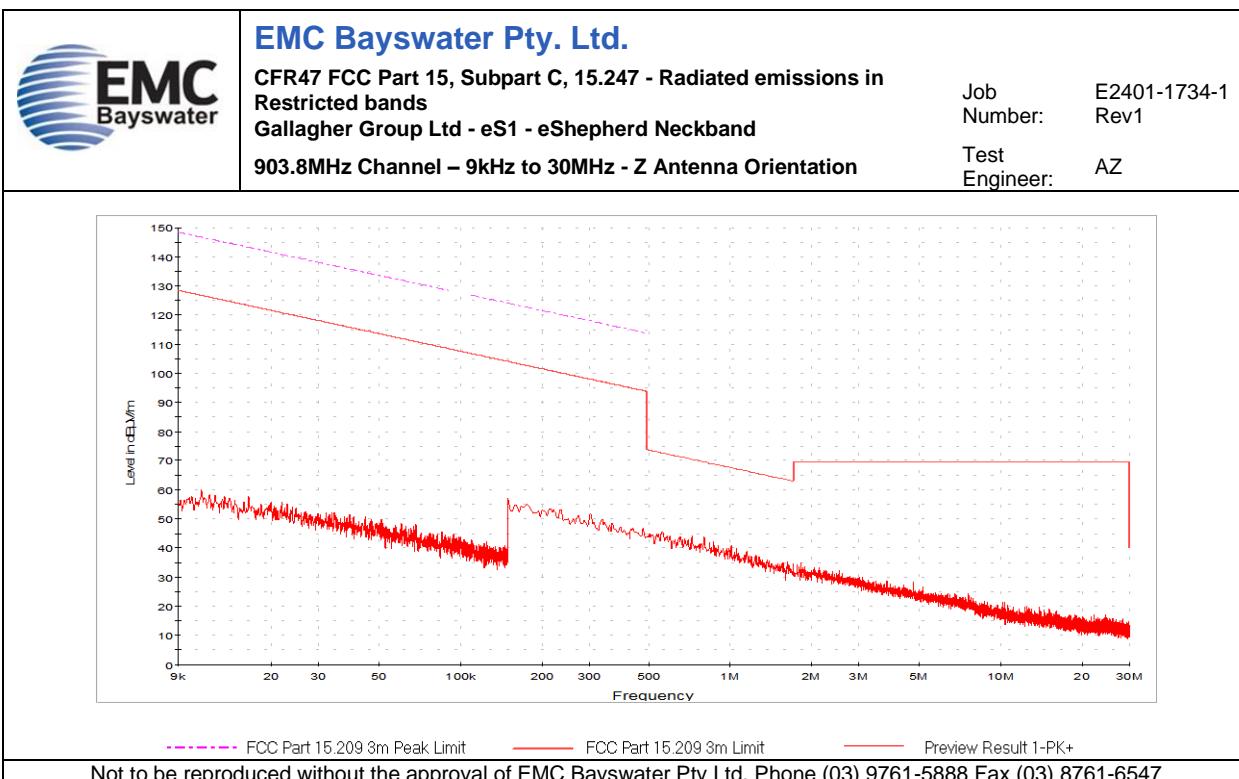
Graph 13



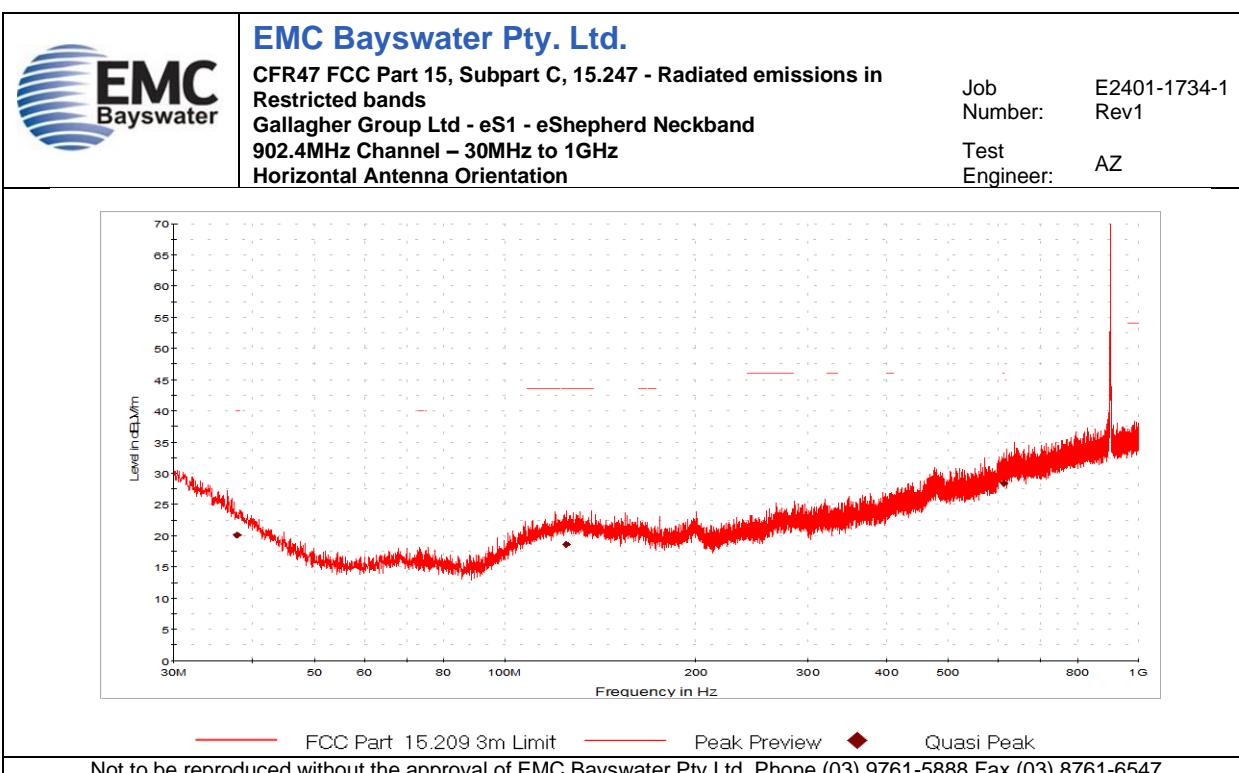
Graph 14



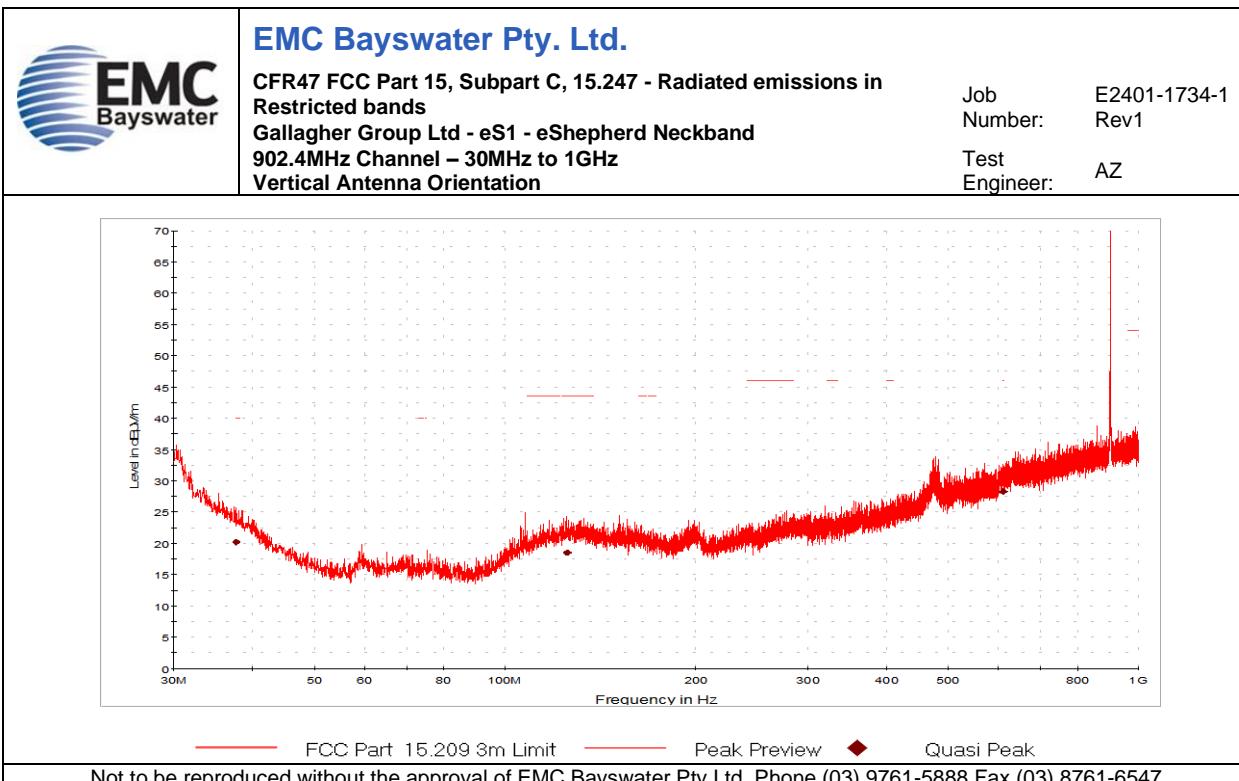
Graph 15



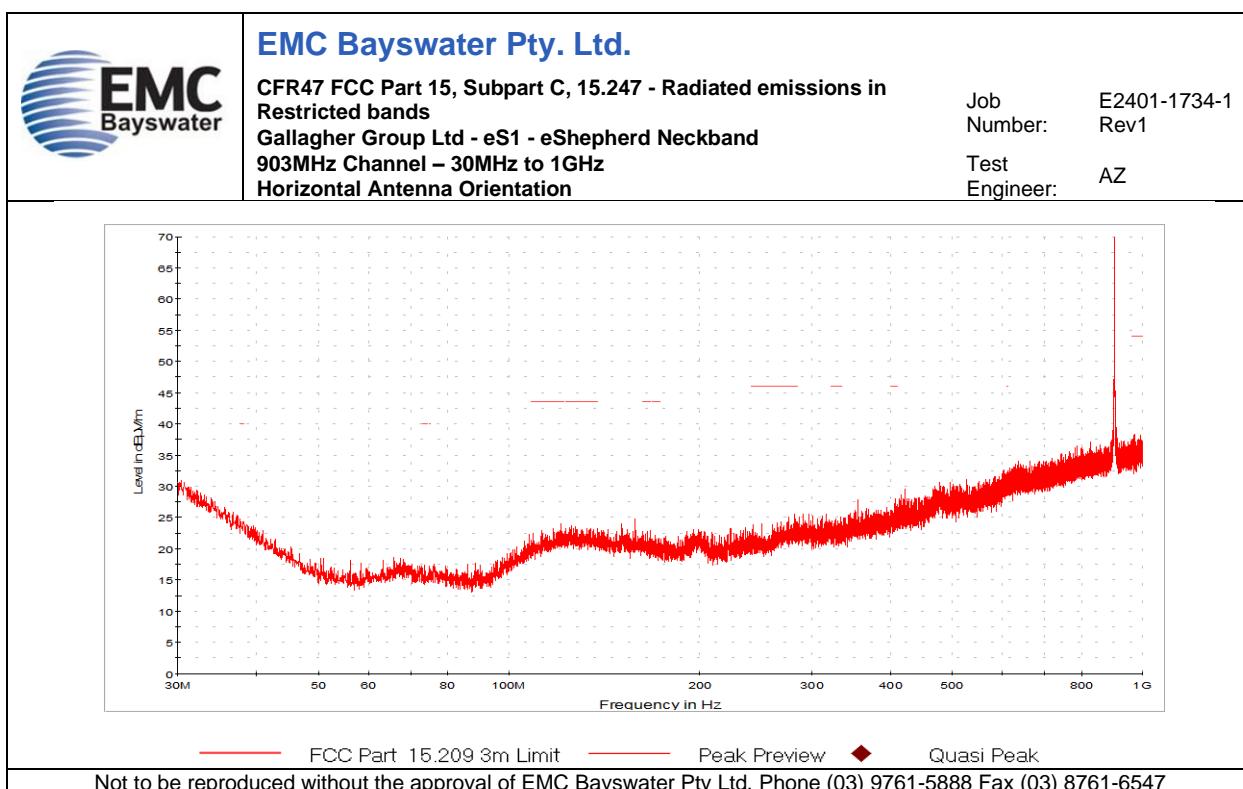
Graph 16



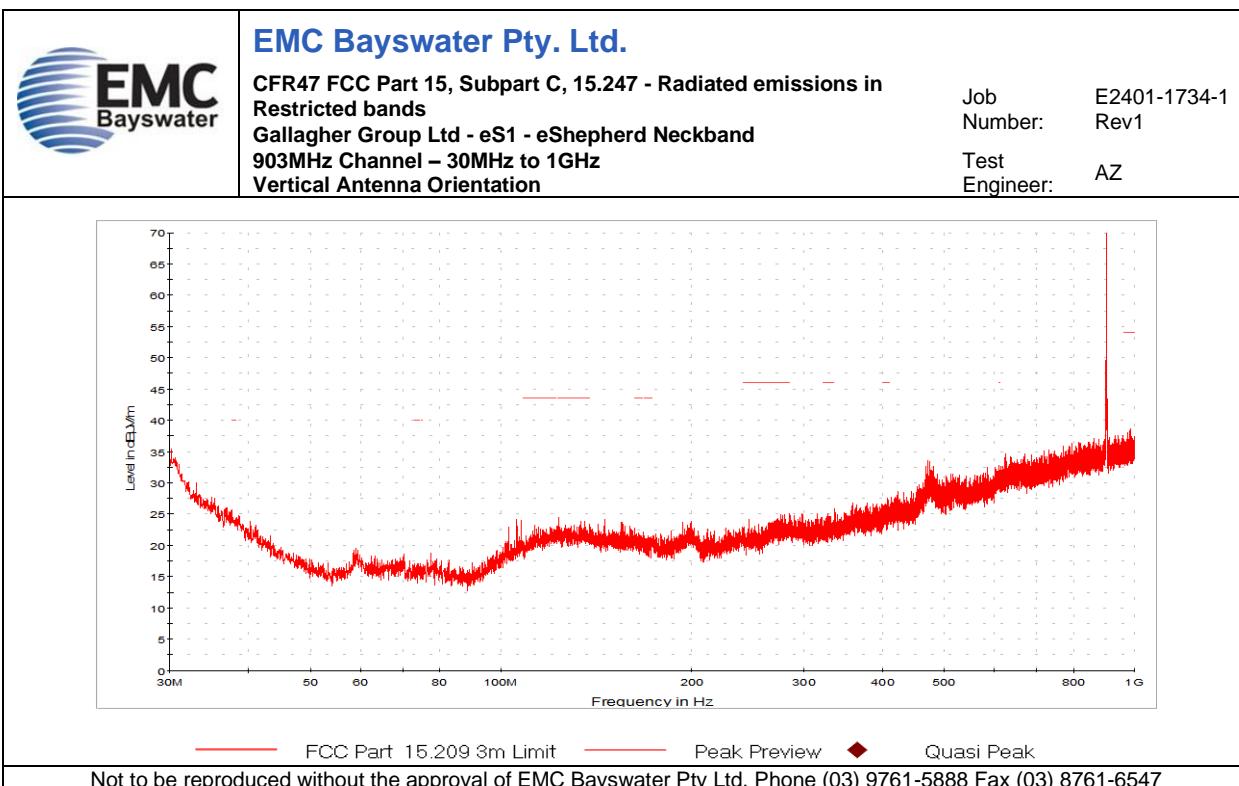
Graph 17



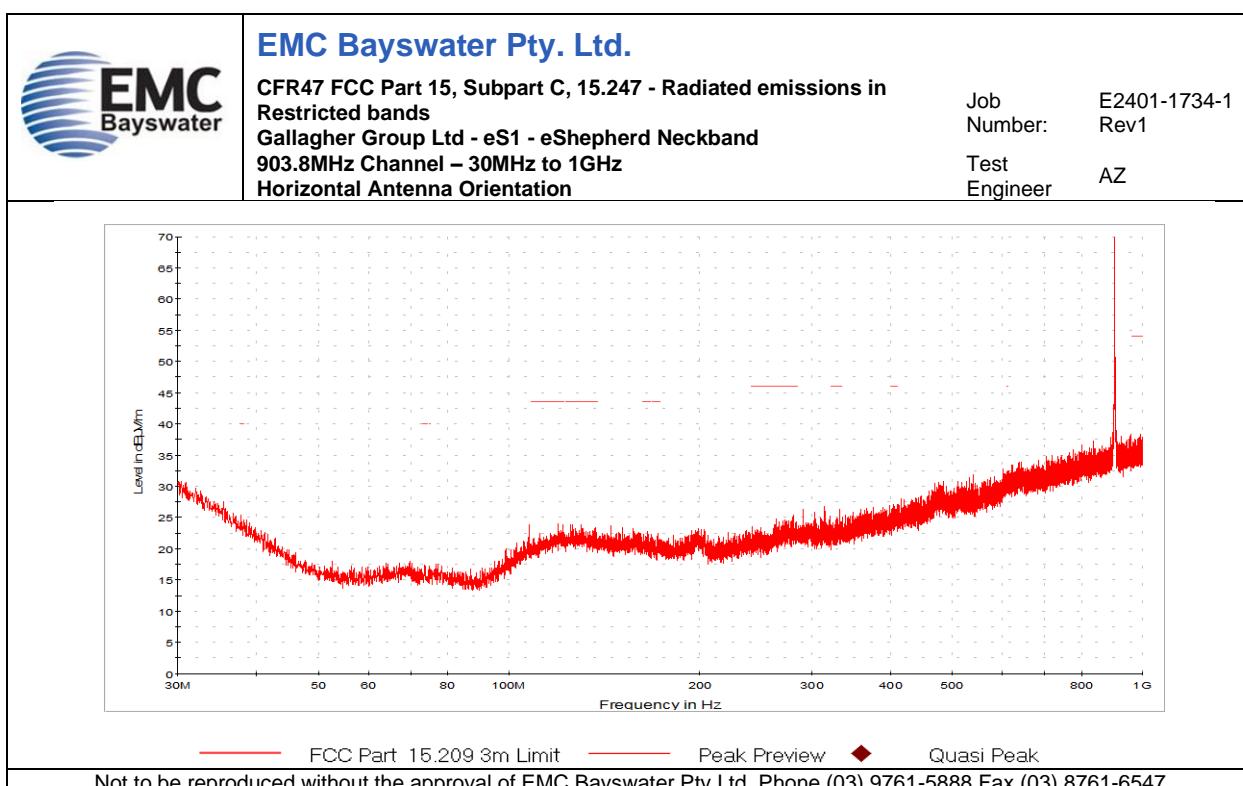
Graph 18



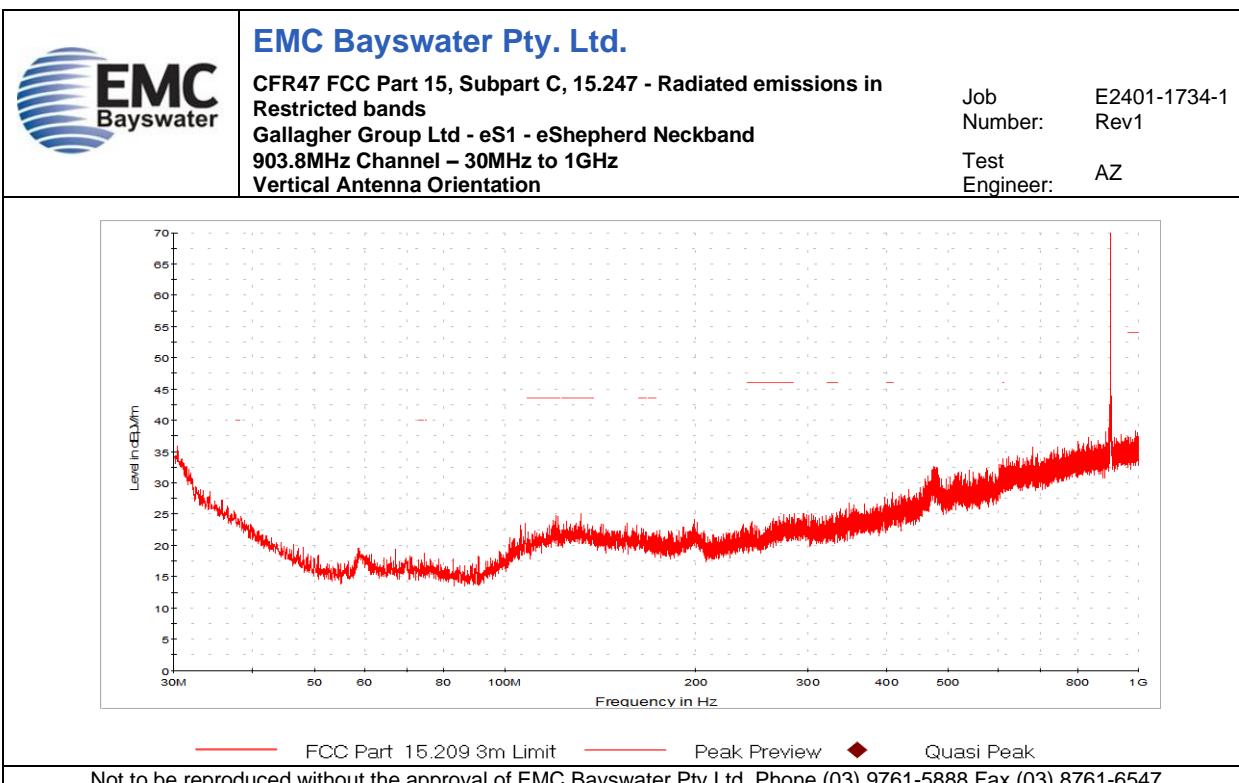
Graph 19



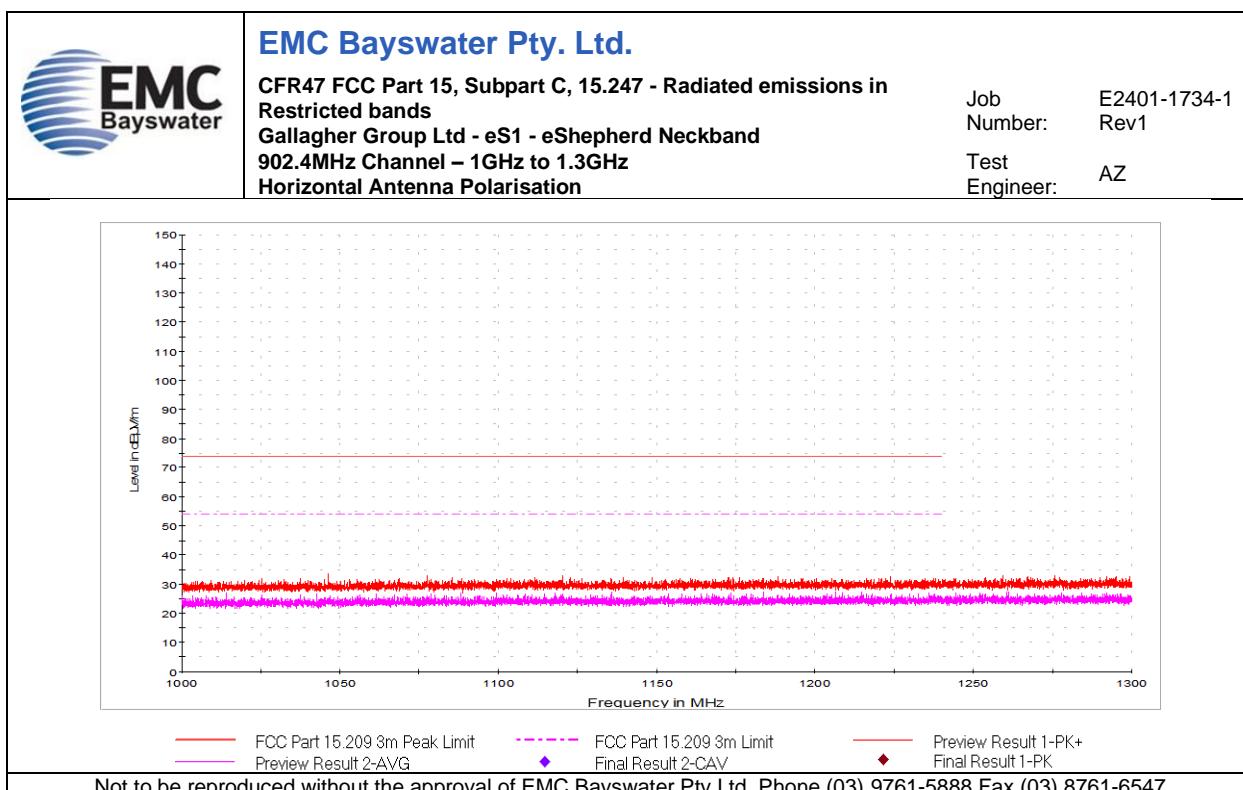
Graph 20



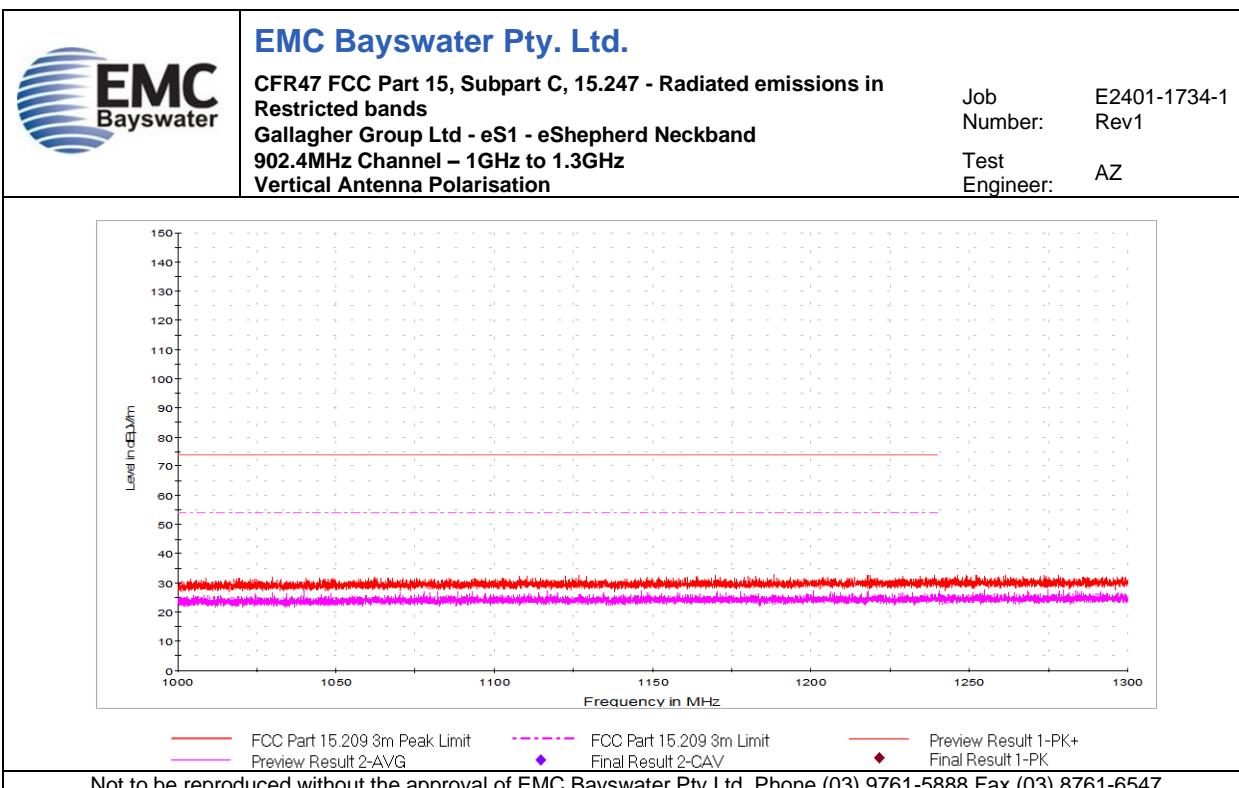
Graph 21



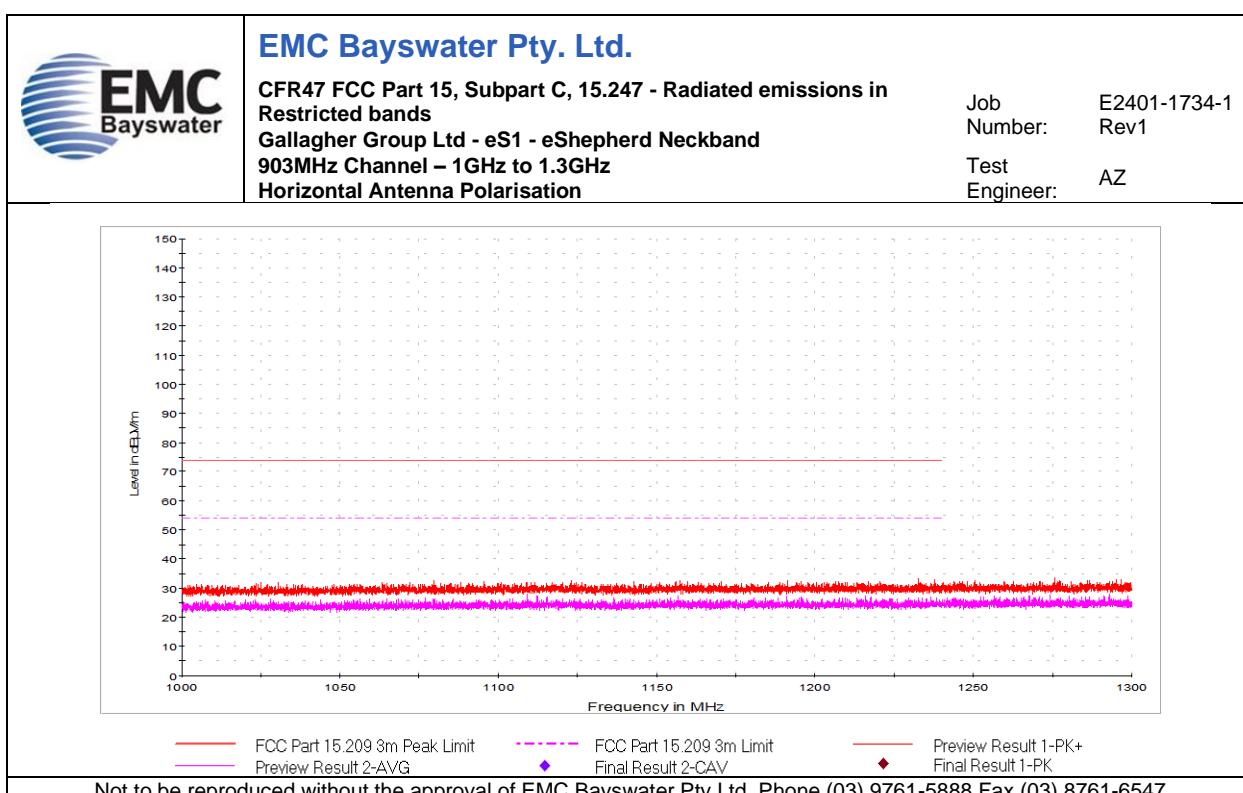
Graph 22



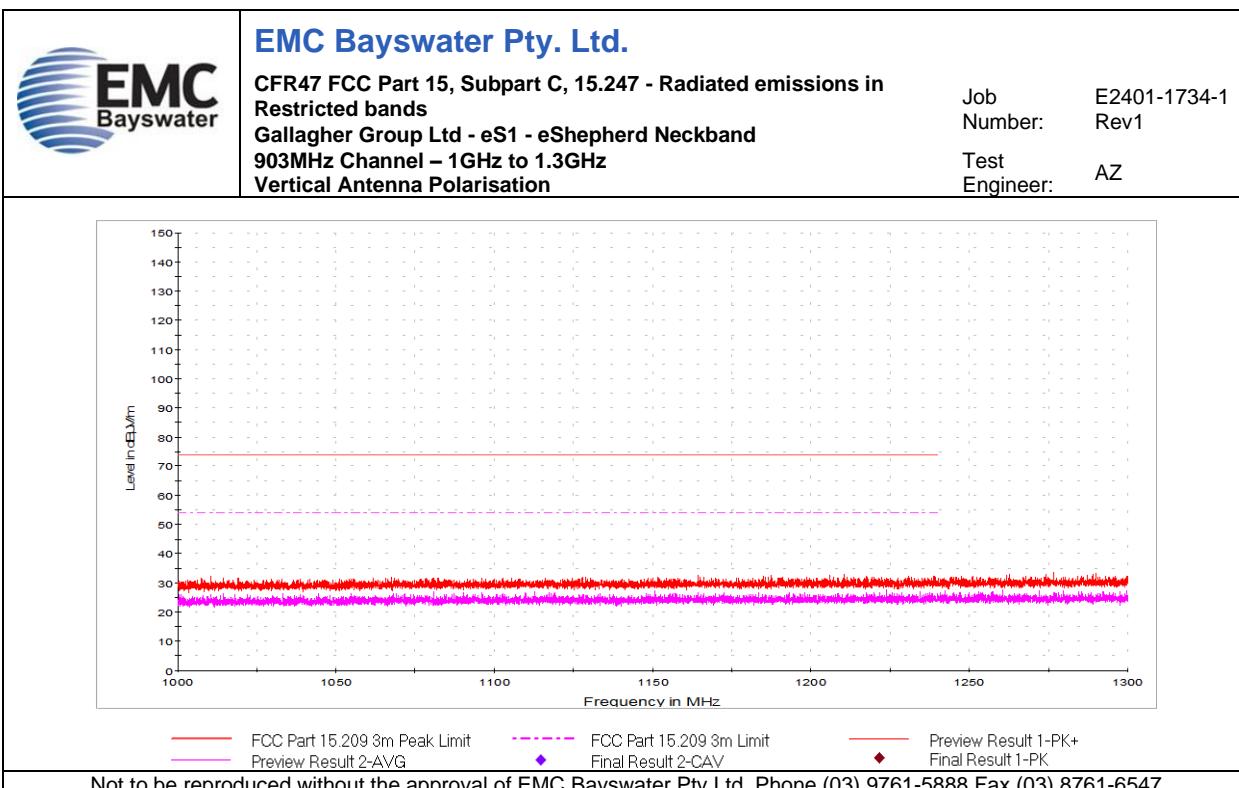
Graph 23



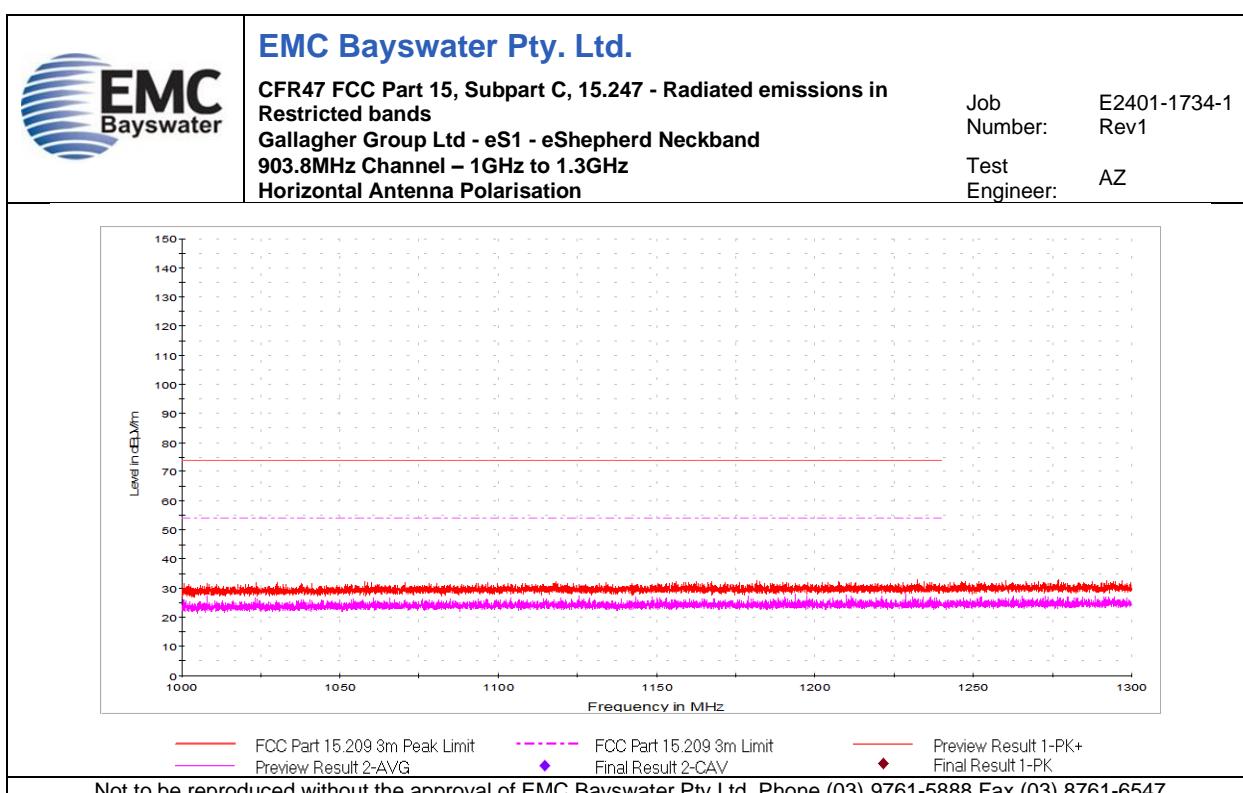
Graph 24



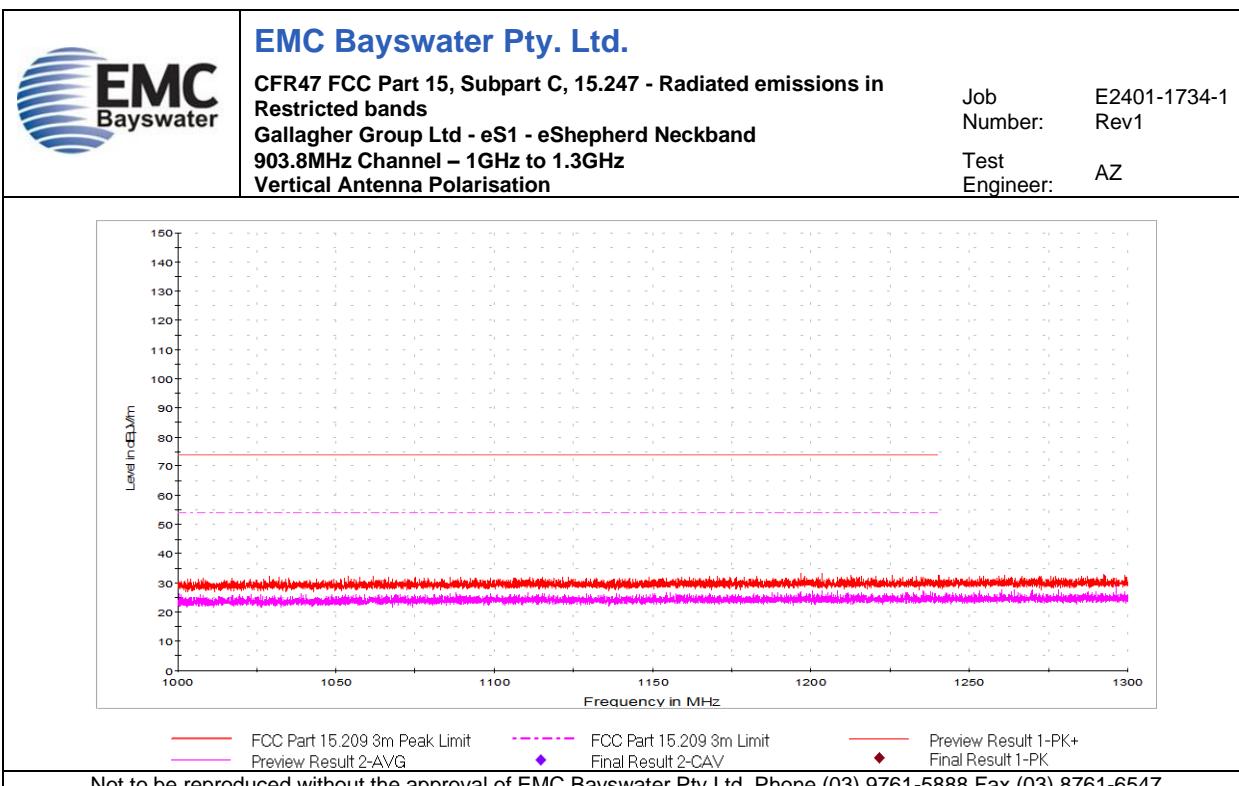
Graph 25



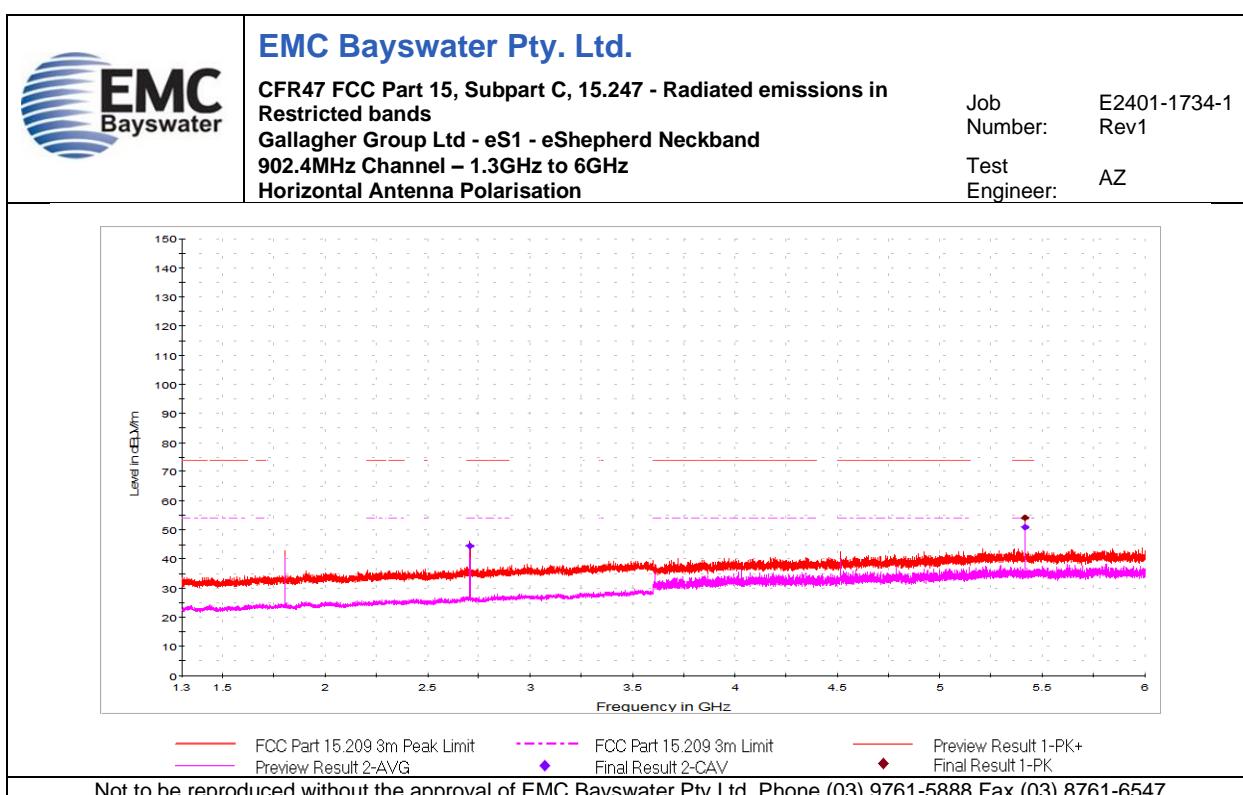
Graph 26



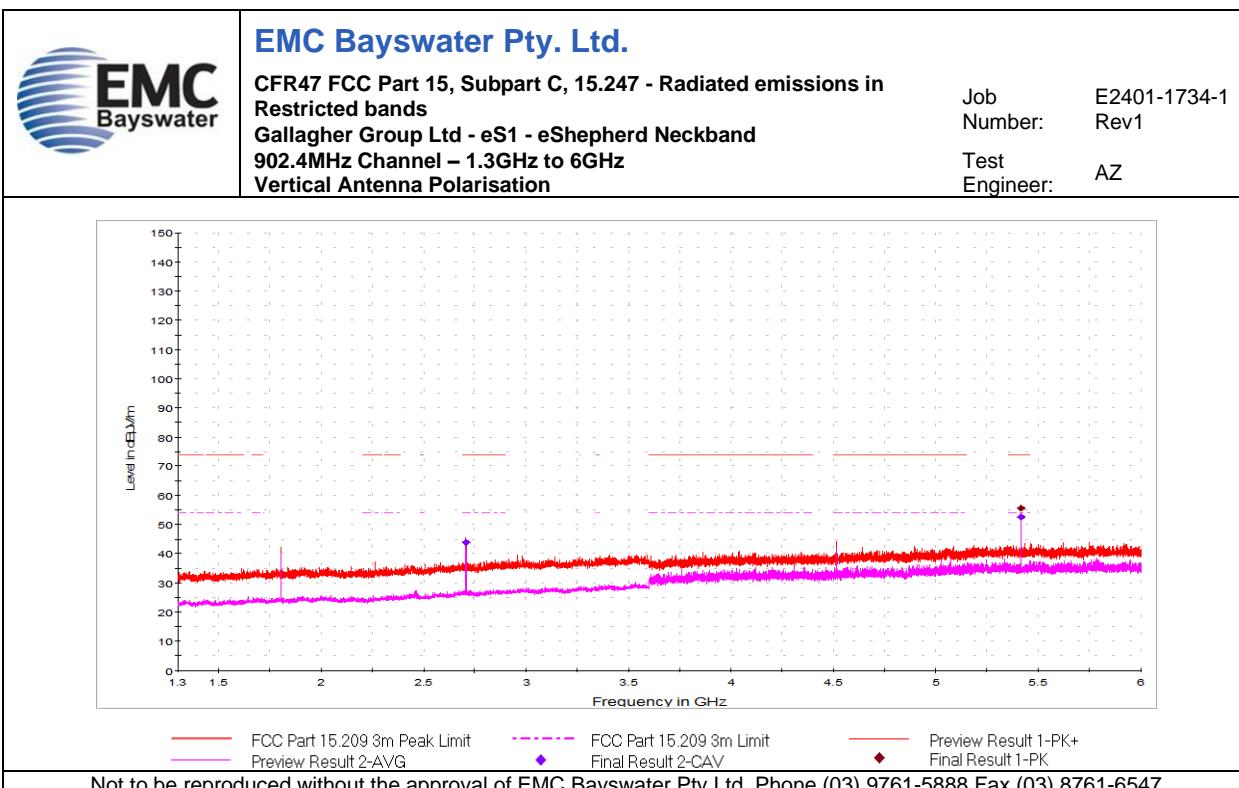
Graph 27



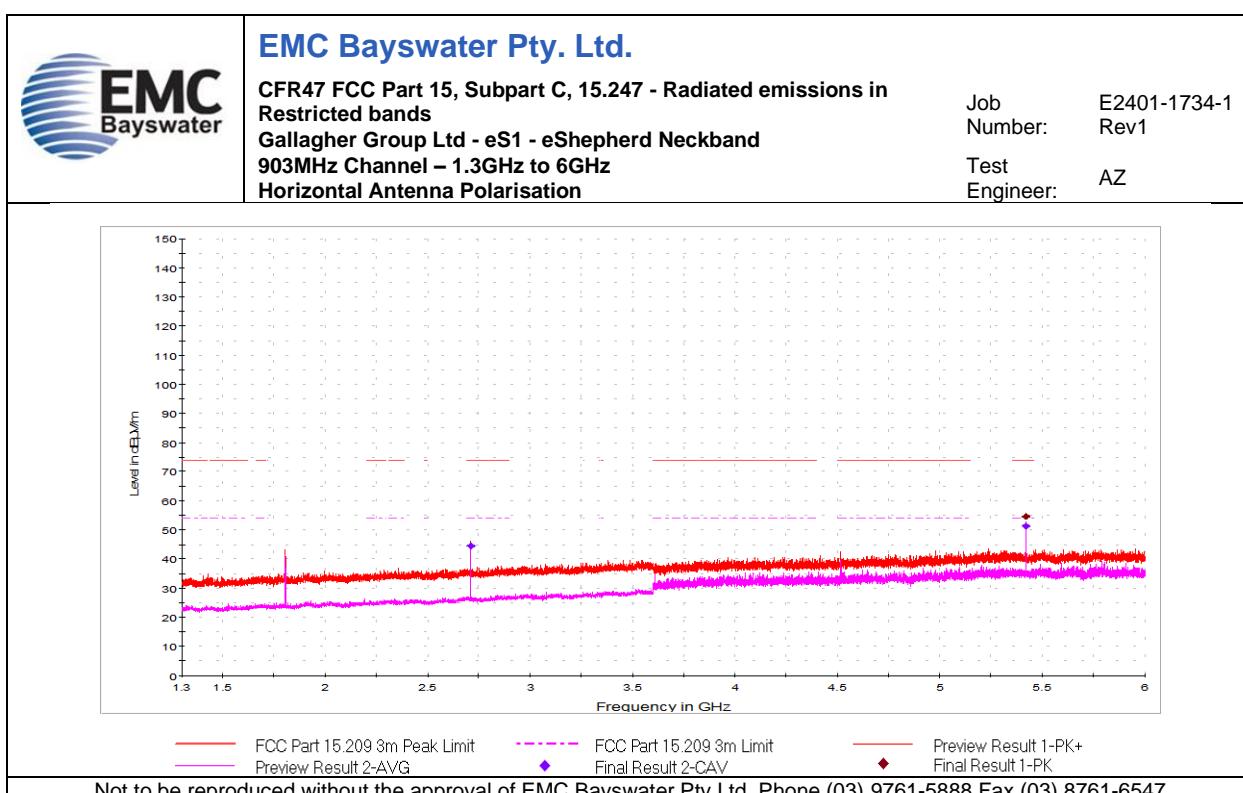
Graph 28



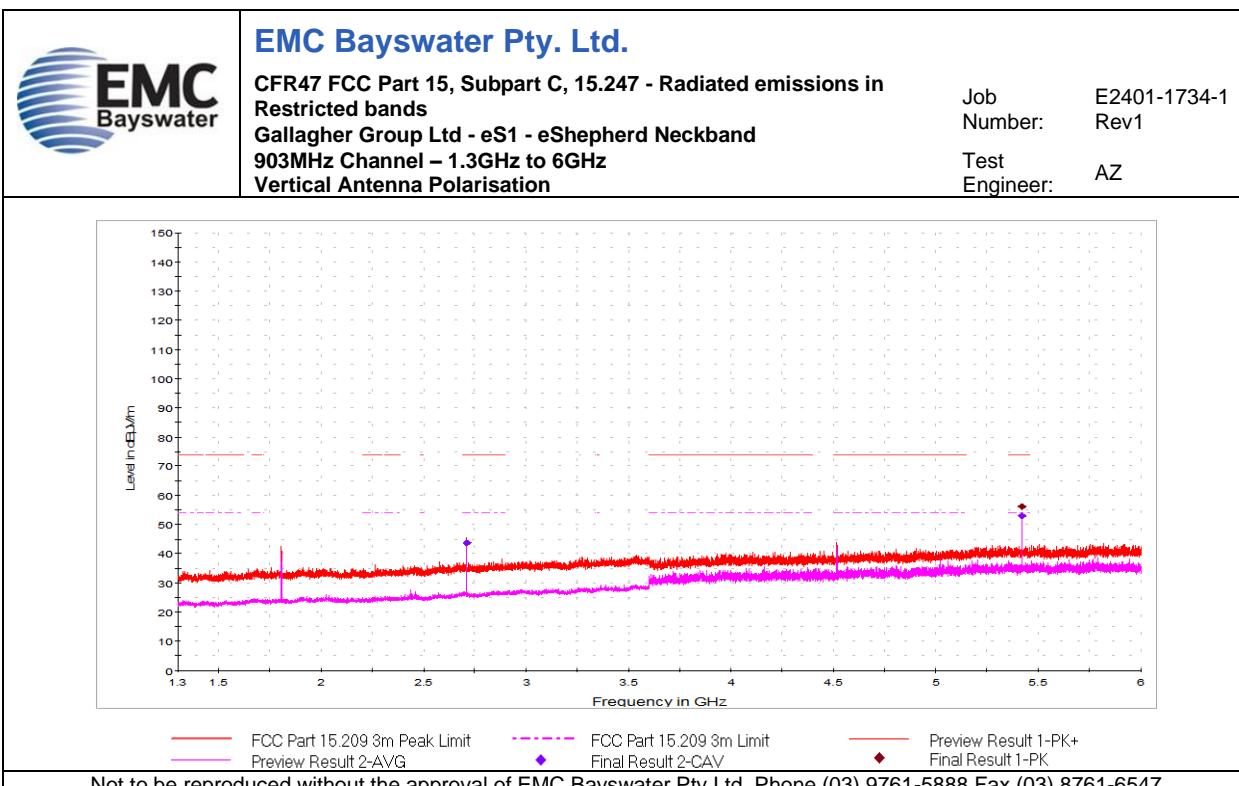
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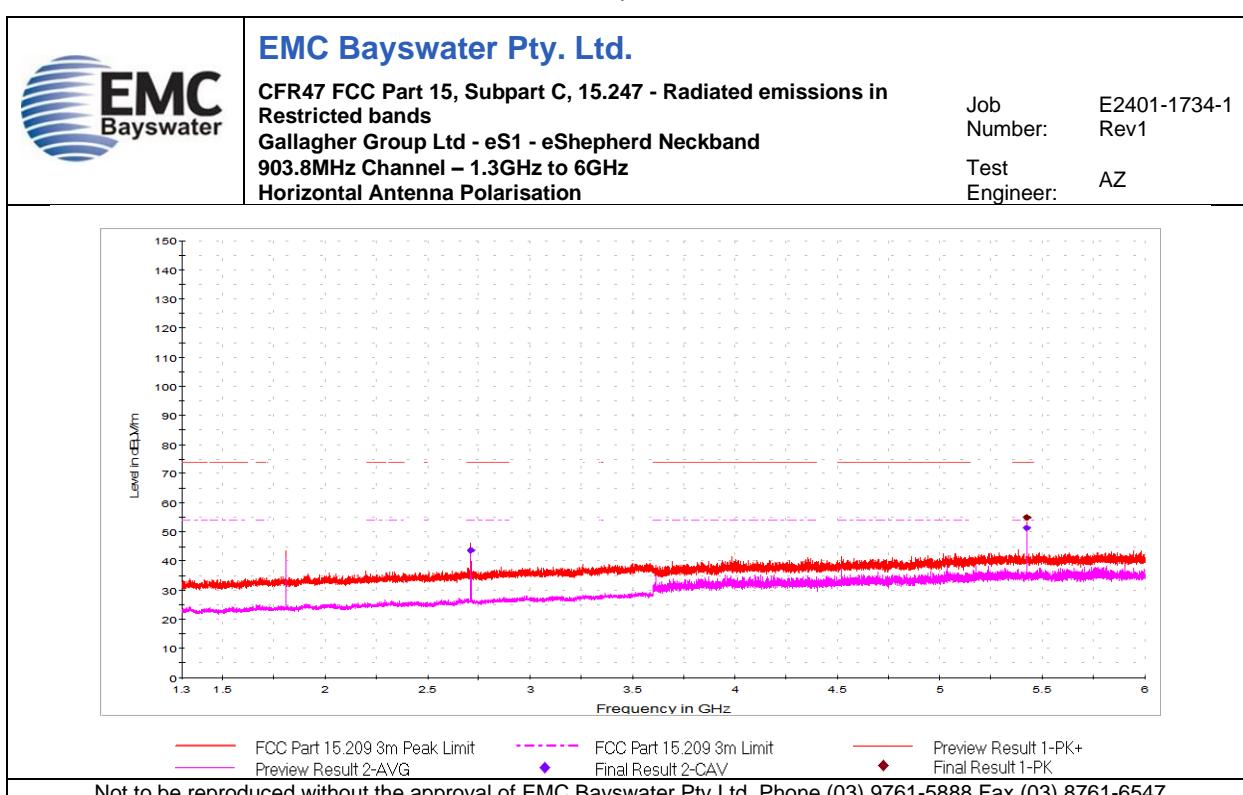
Graph 30



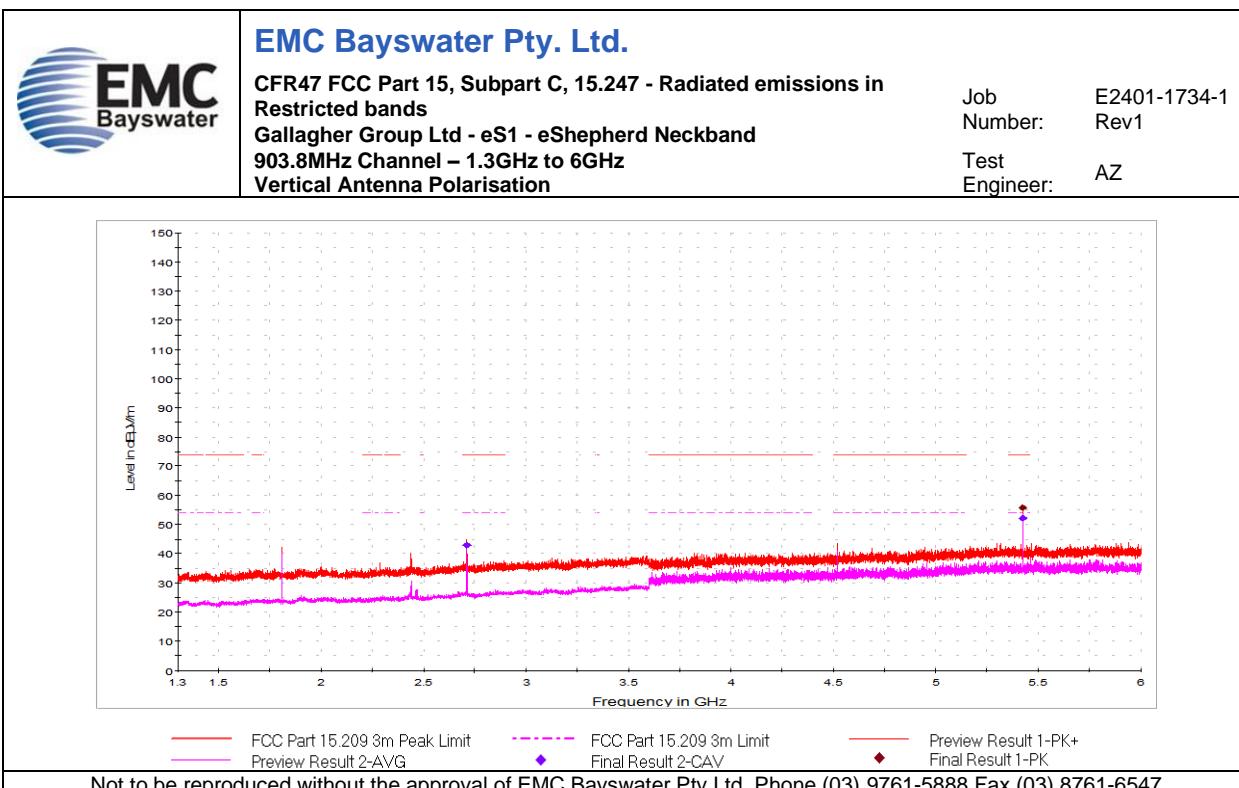
Graph 31



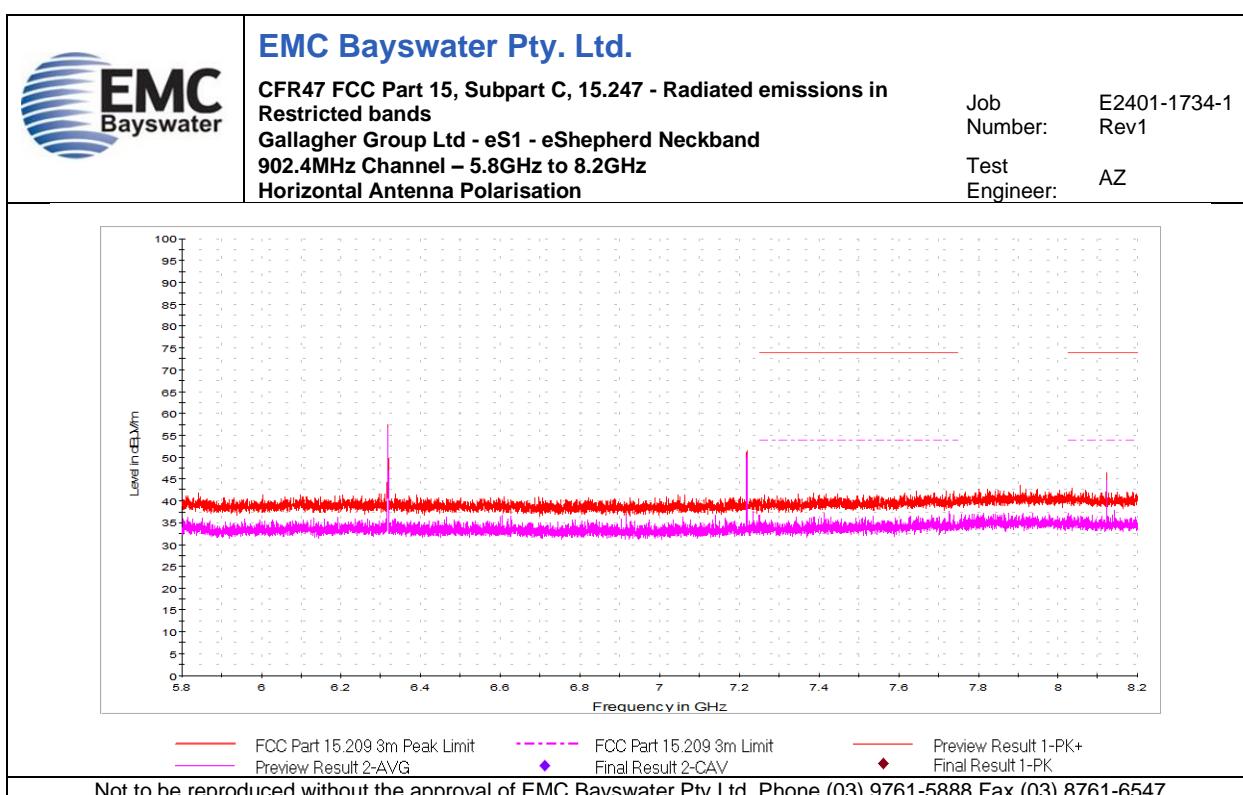
Graph 32



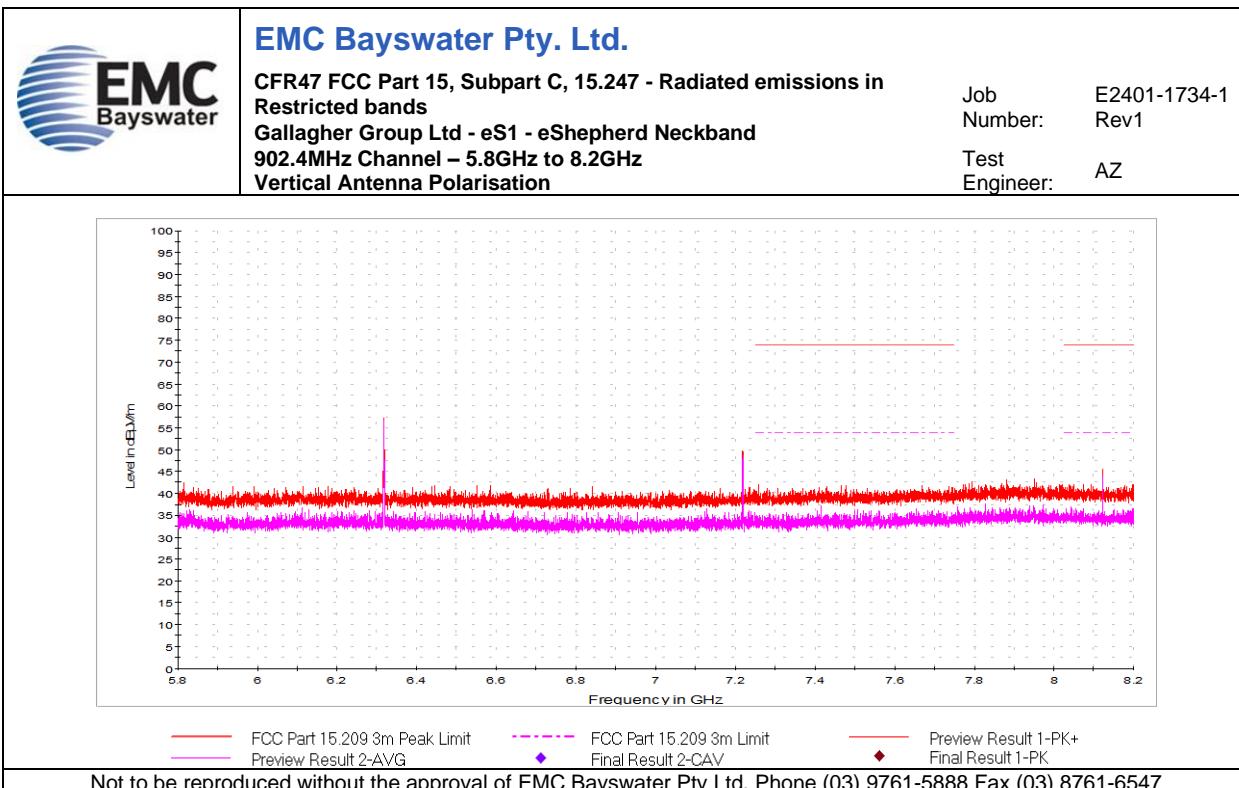
Graph 33



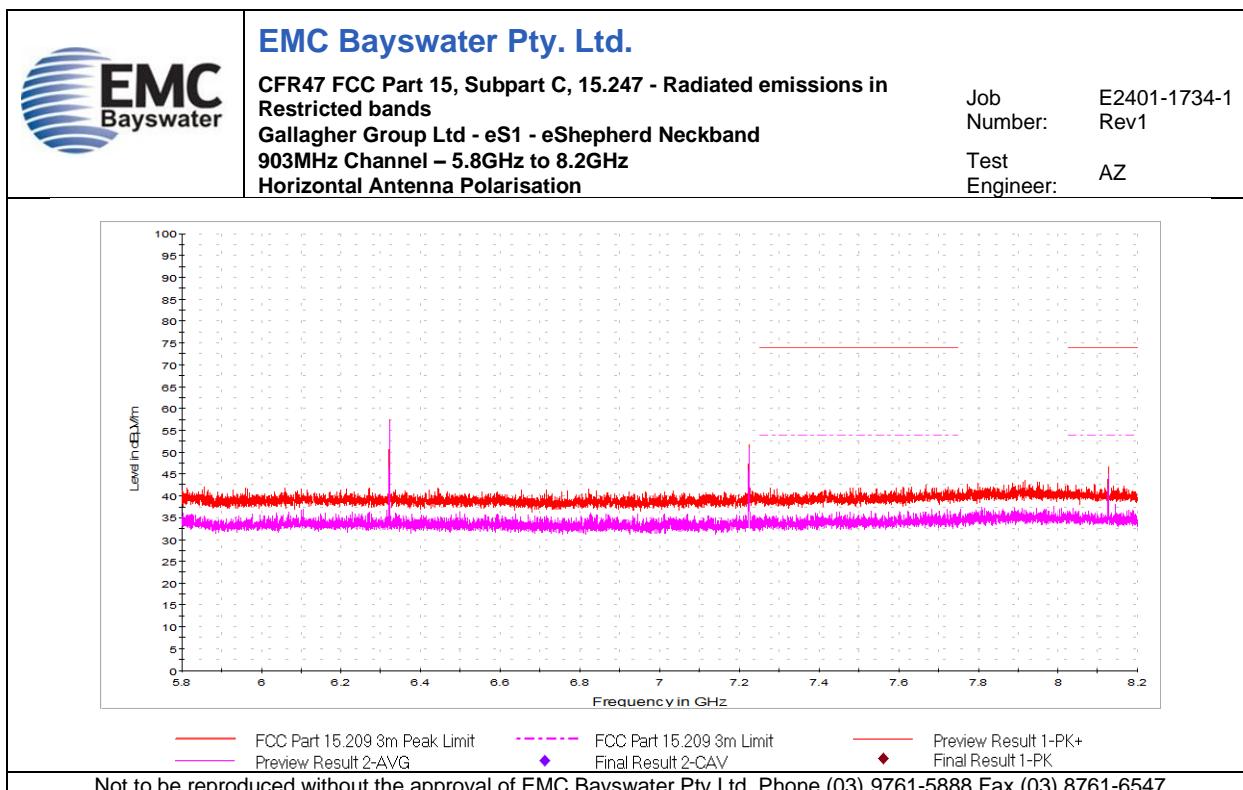
Graph 34



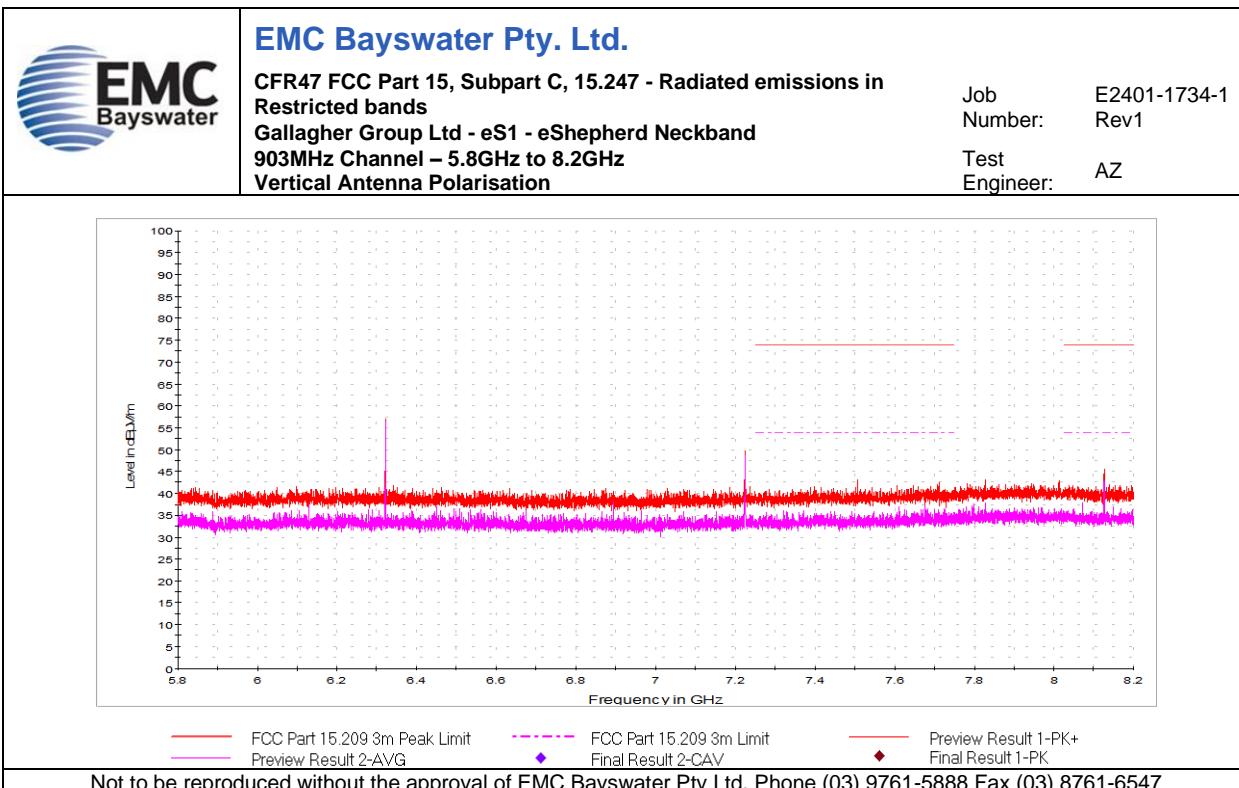
Graph 35



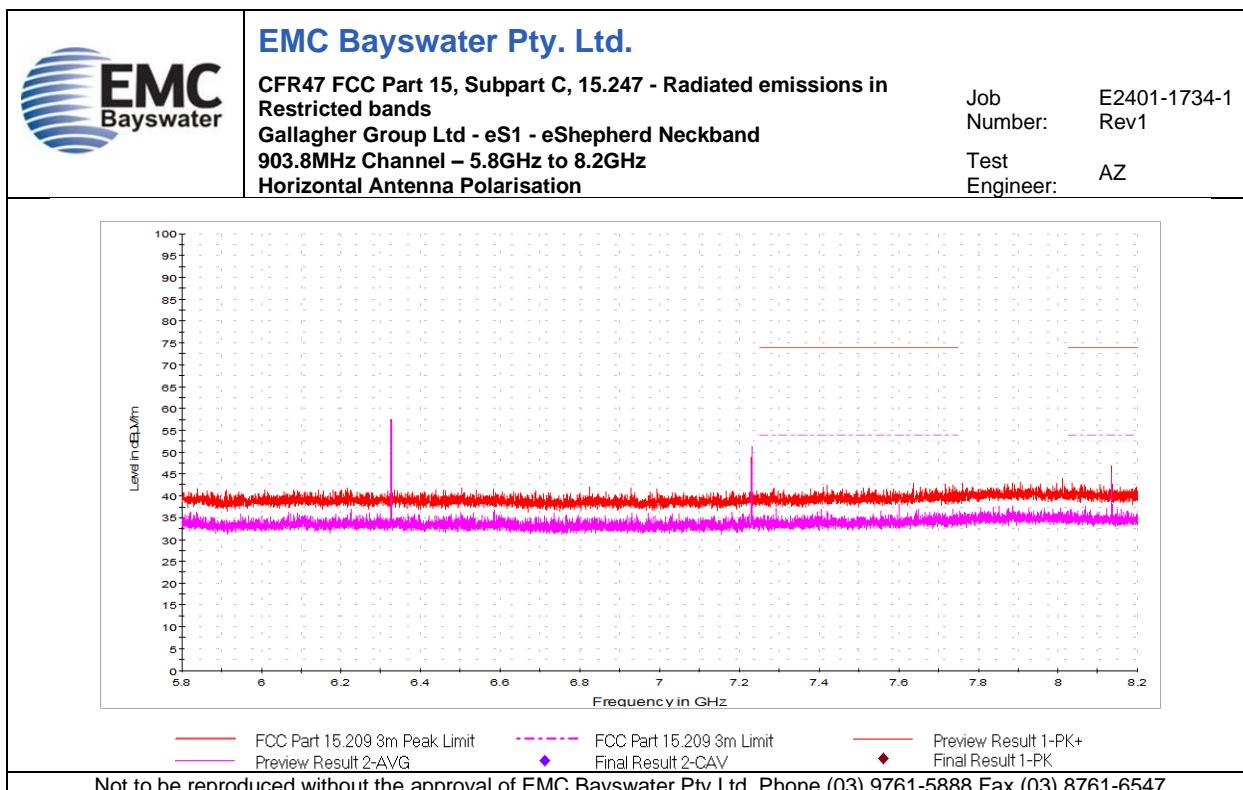
Graph 36



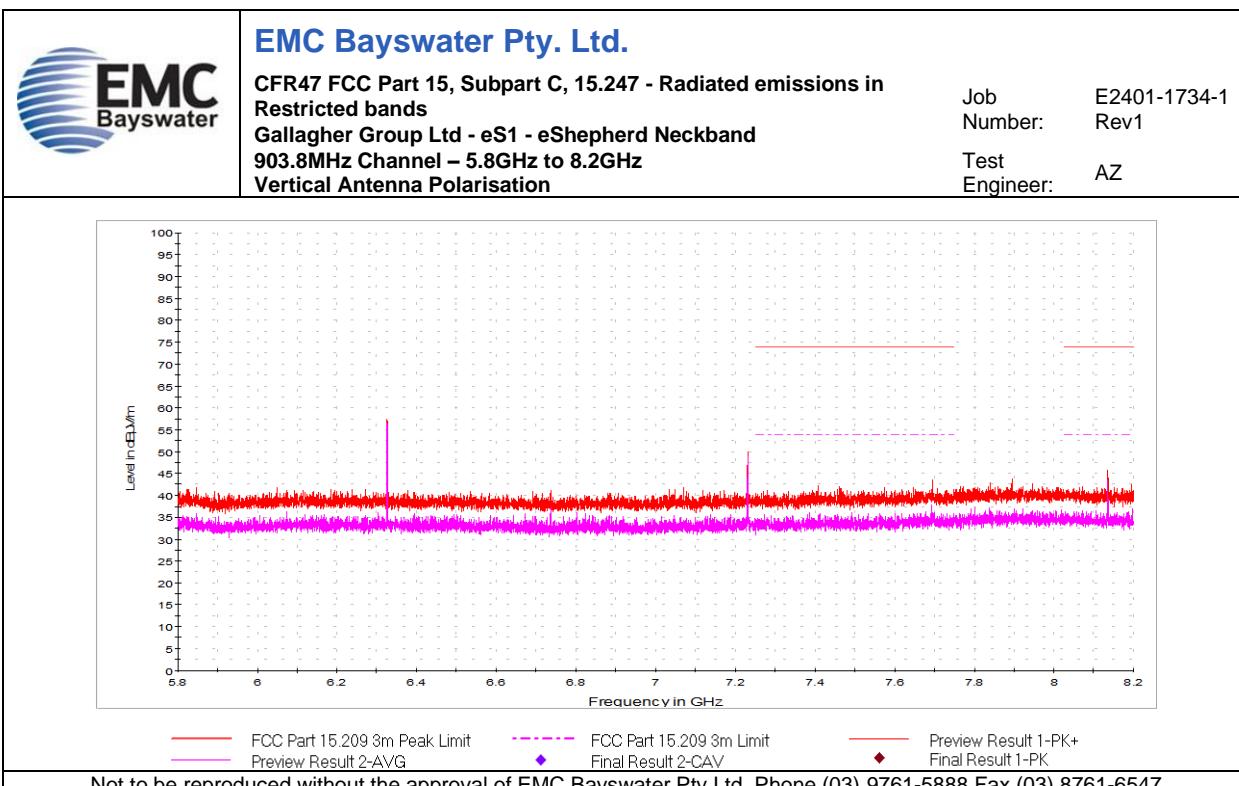
Graph 37



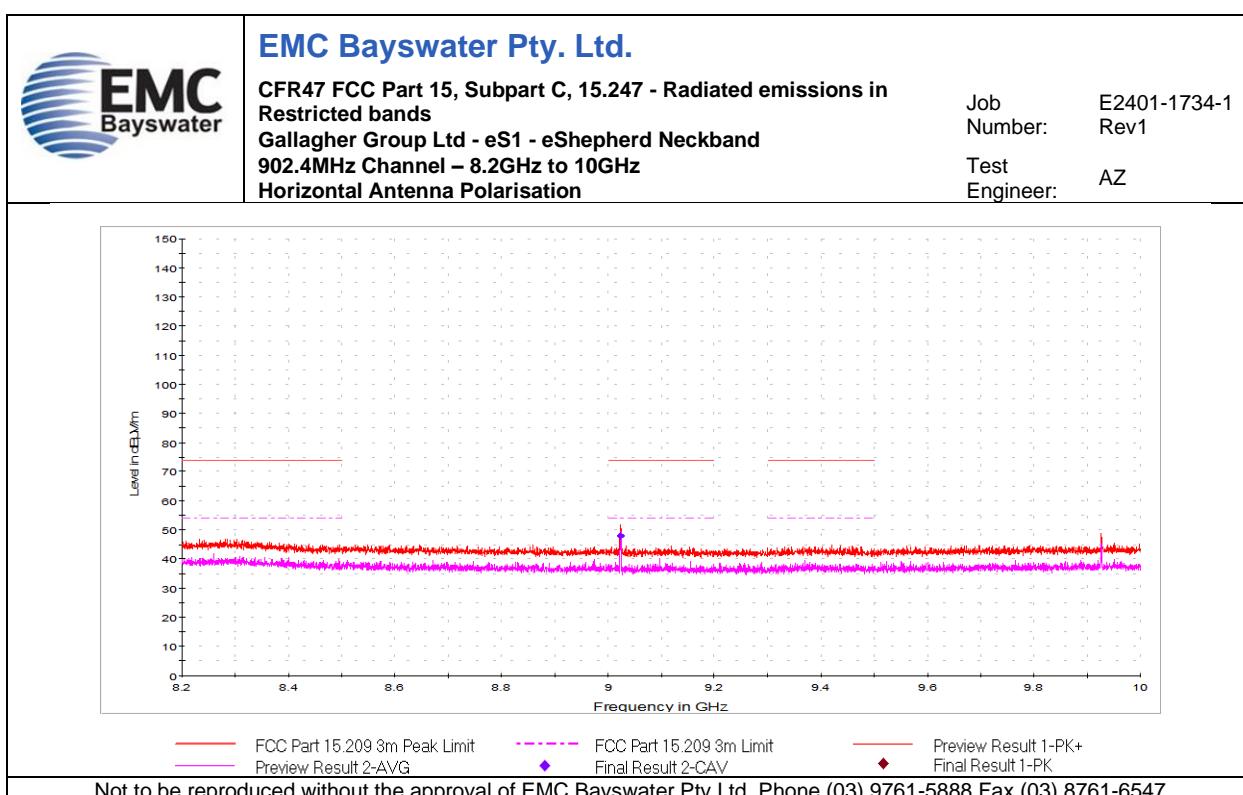
Graph 38



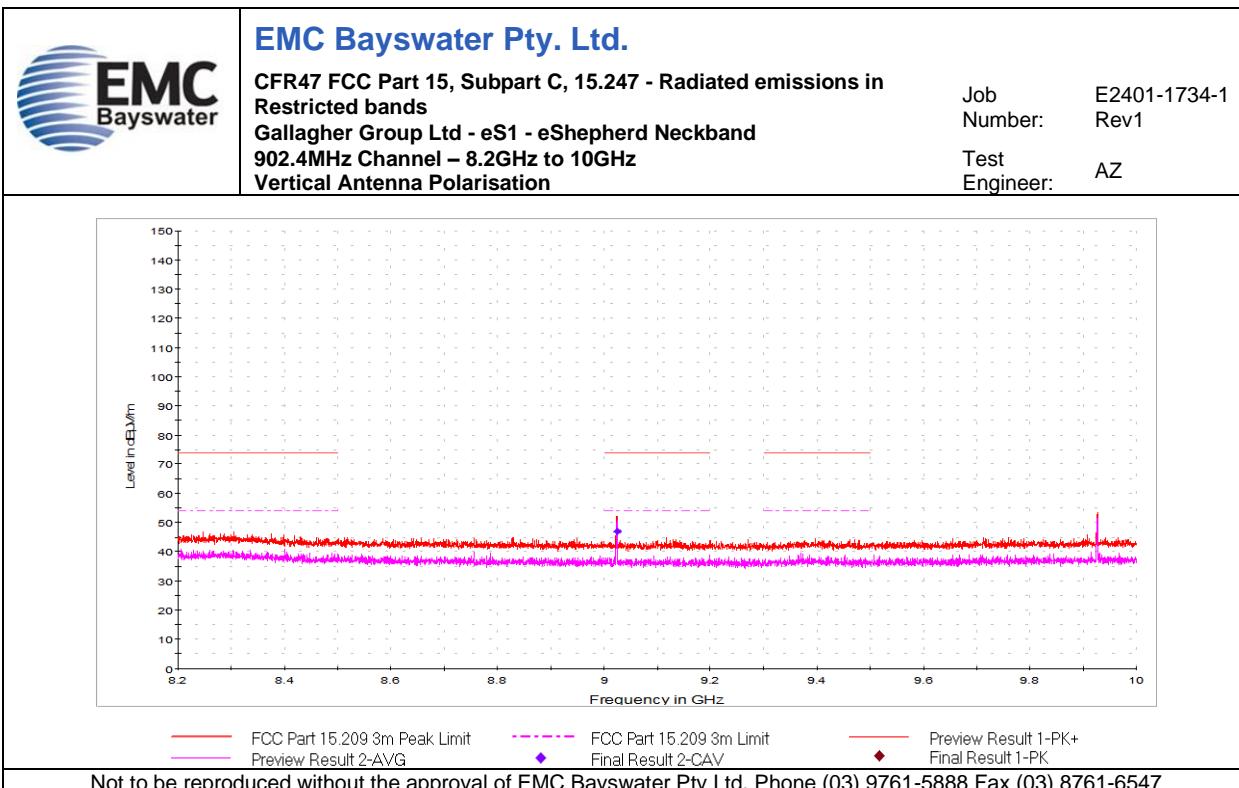
Graph 39



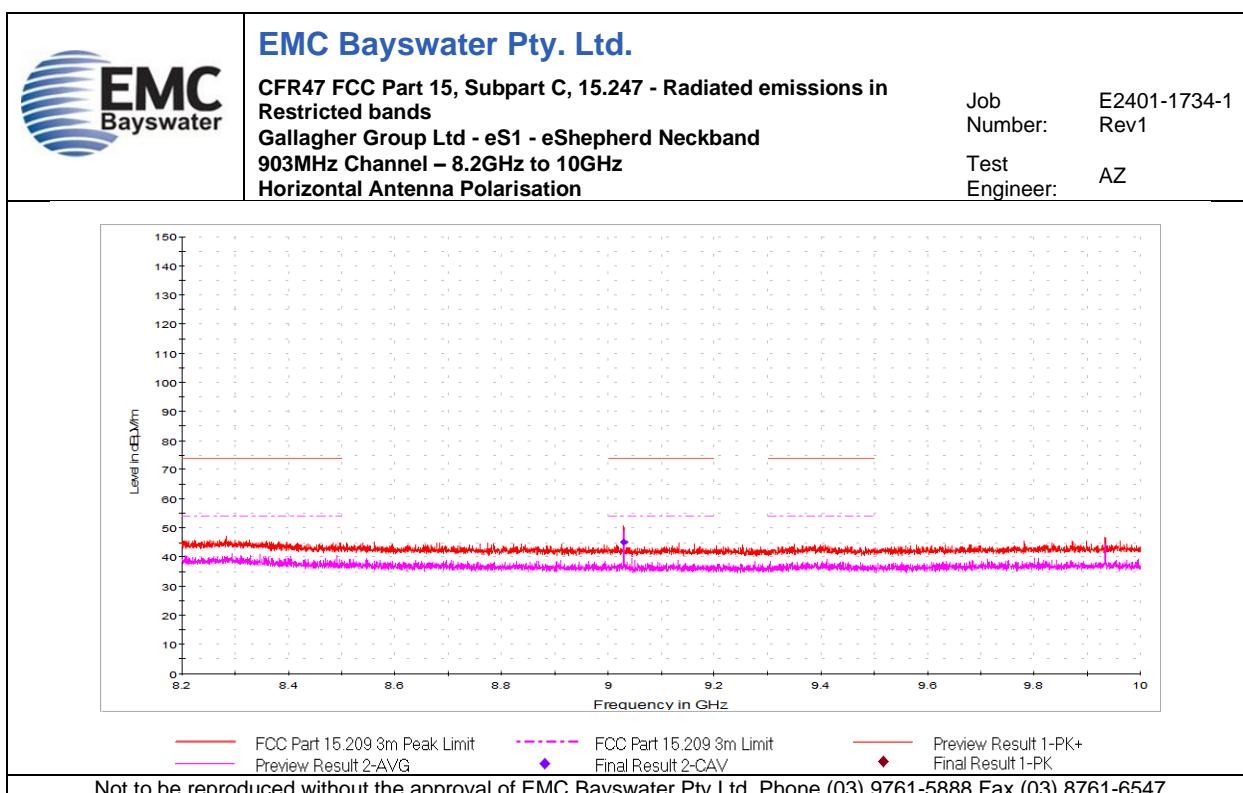
Graph 40



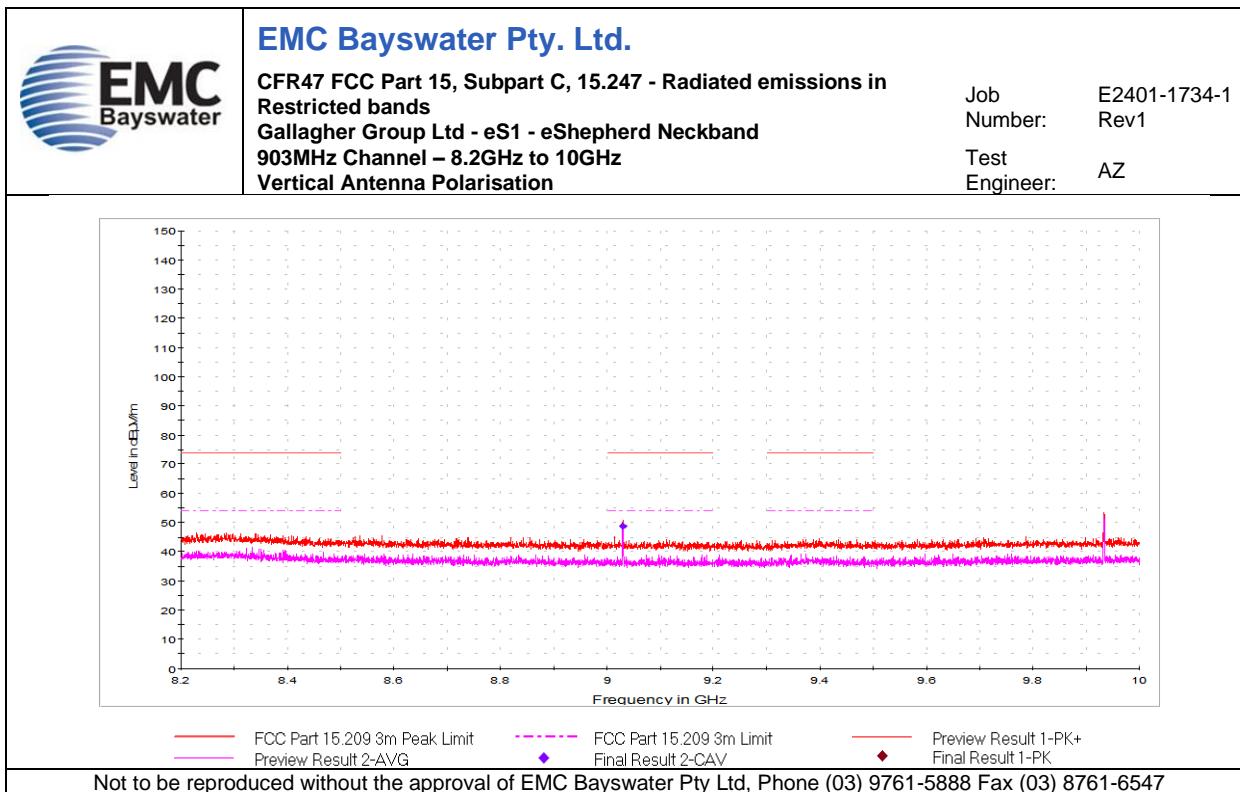
Graph 41



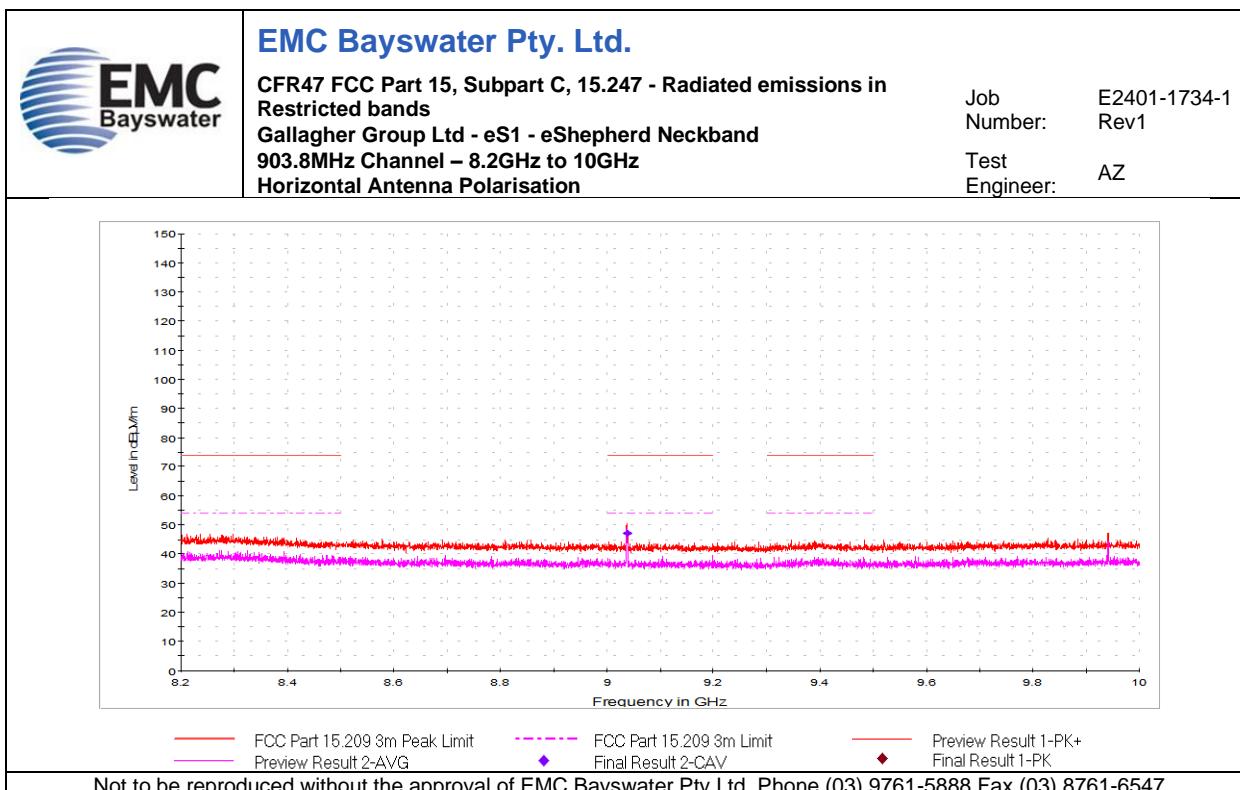
Graph 42



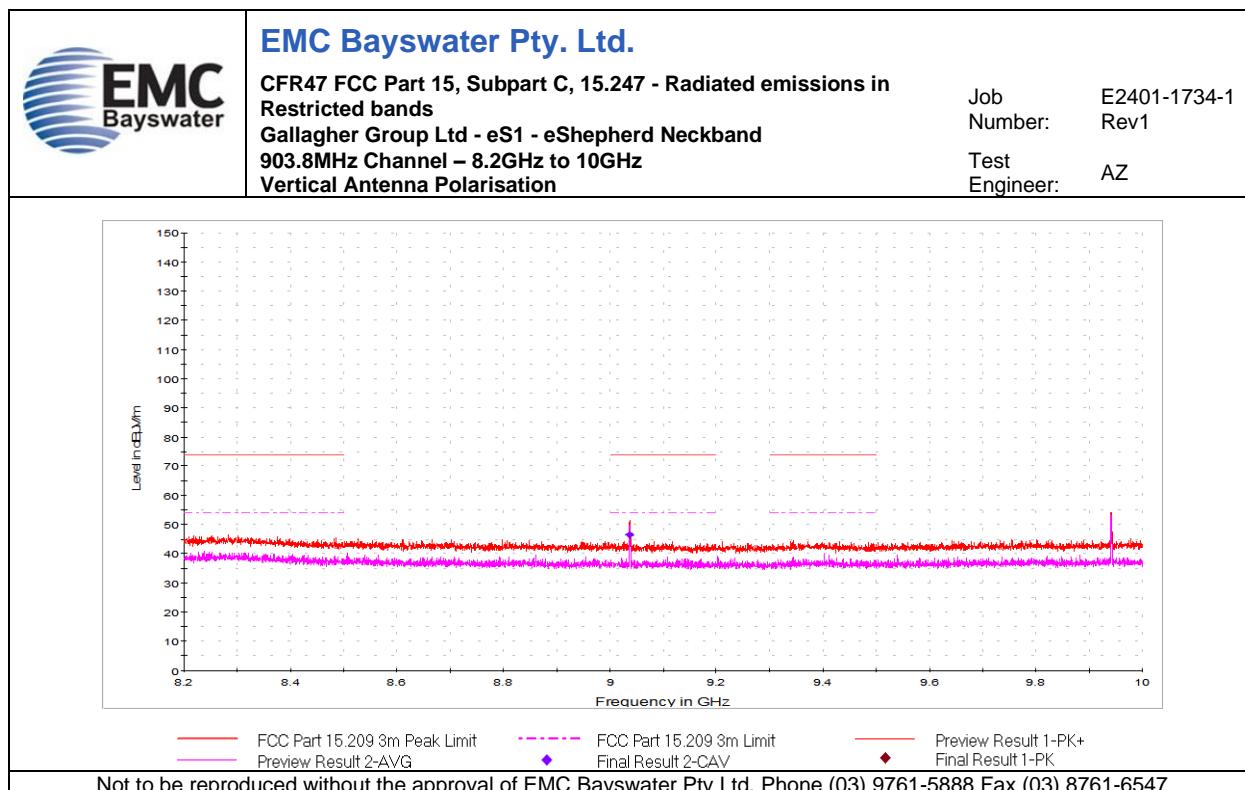
Graph 43



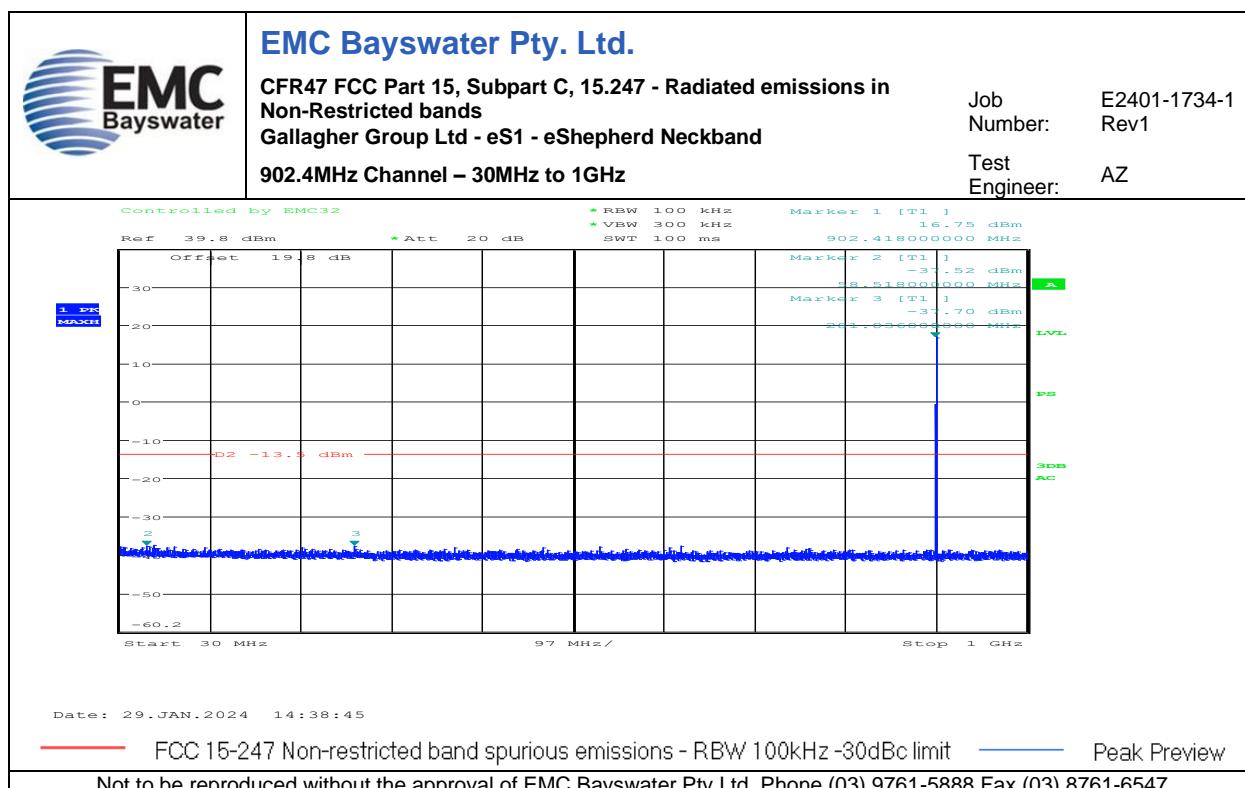
Graph 44



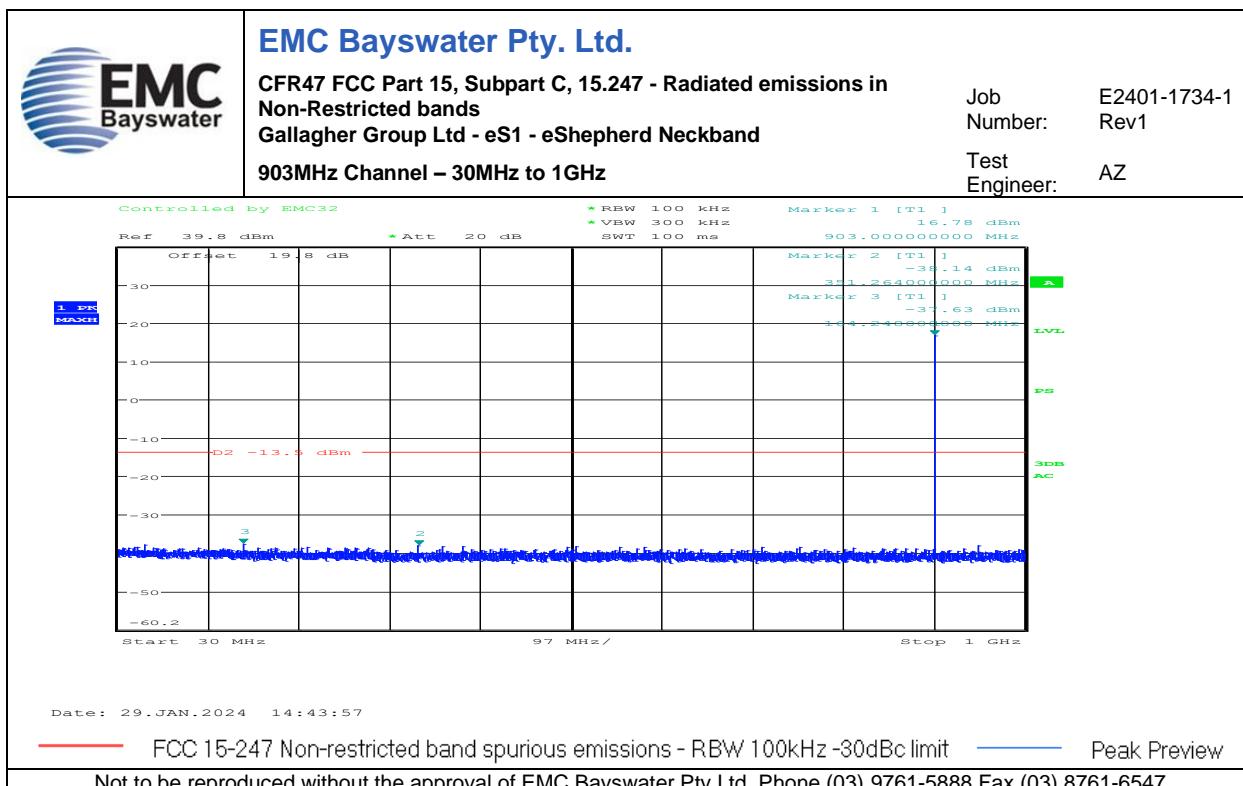
Graph 45



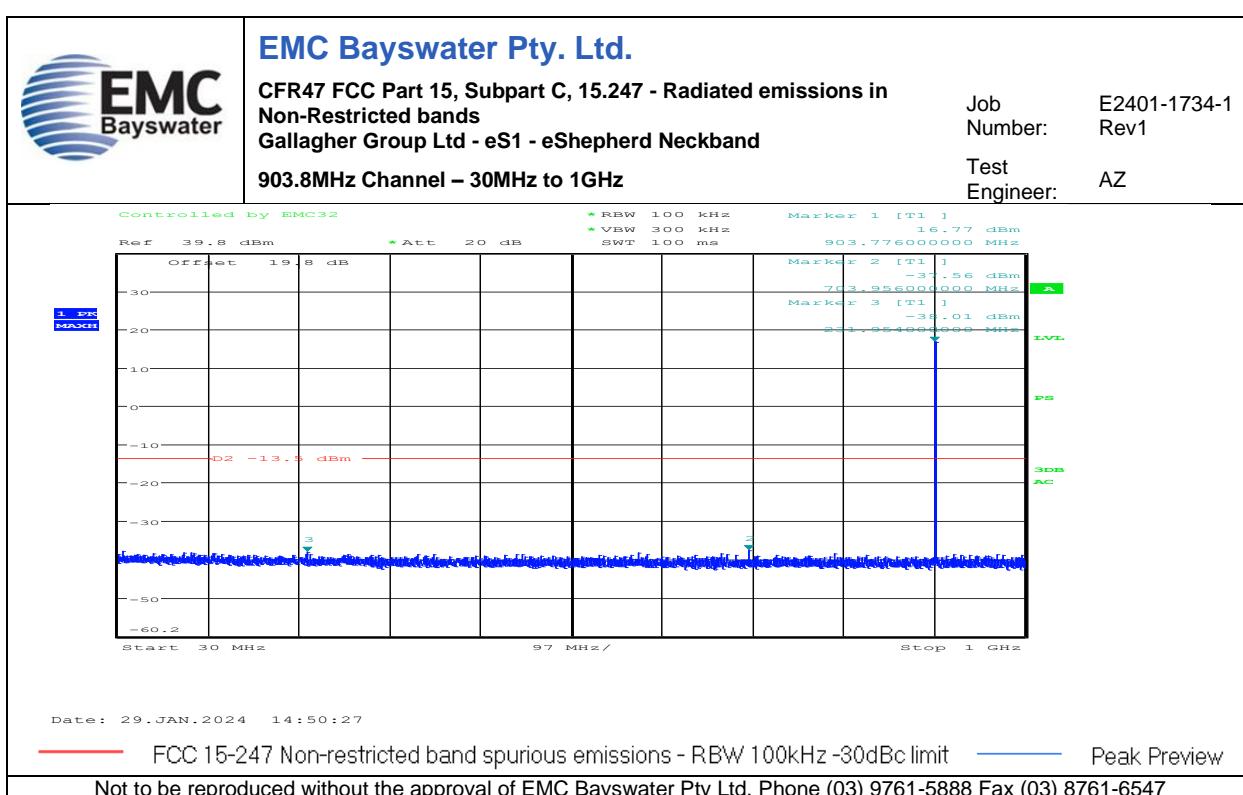
Graph 46



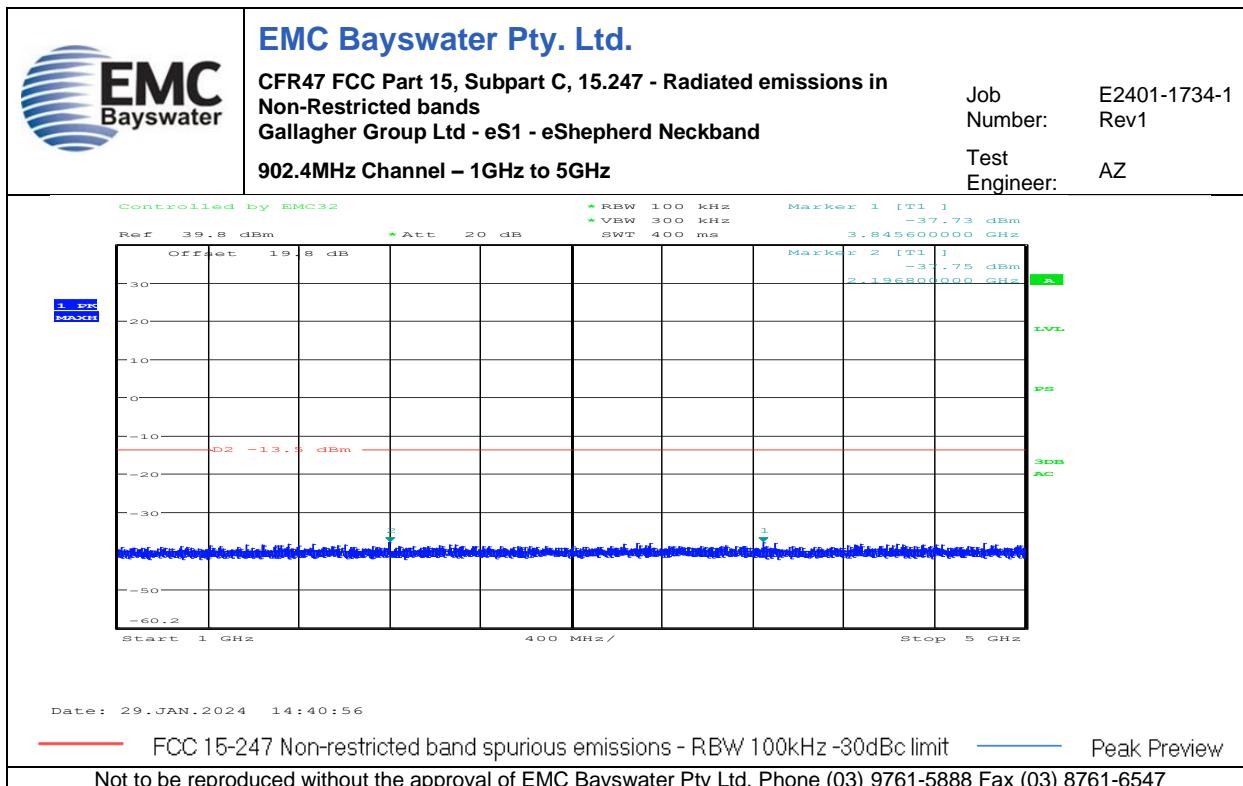
Graph 47



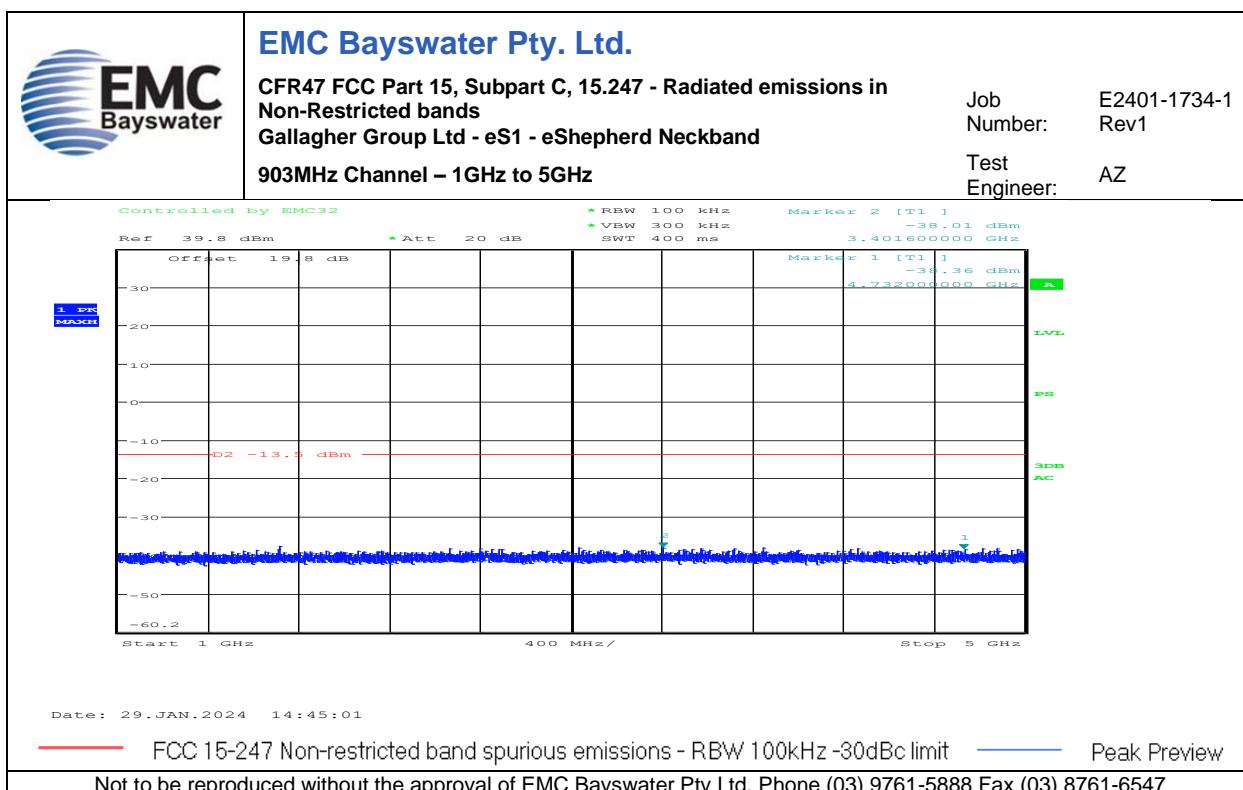
Graph 48



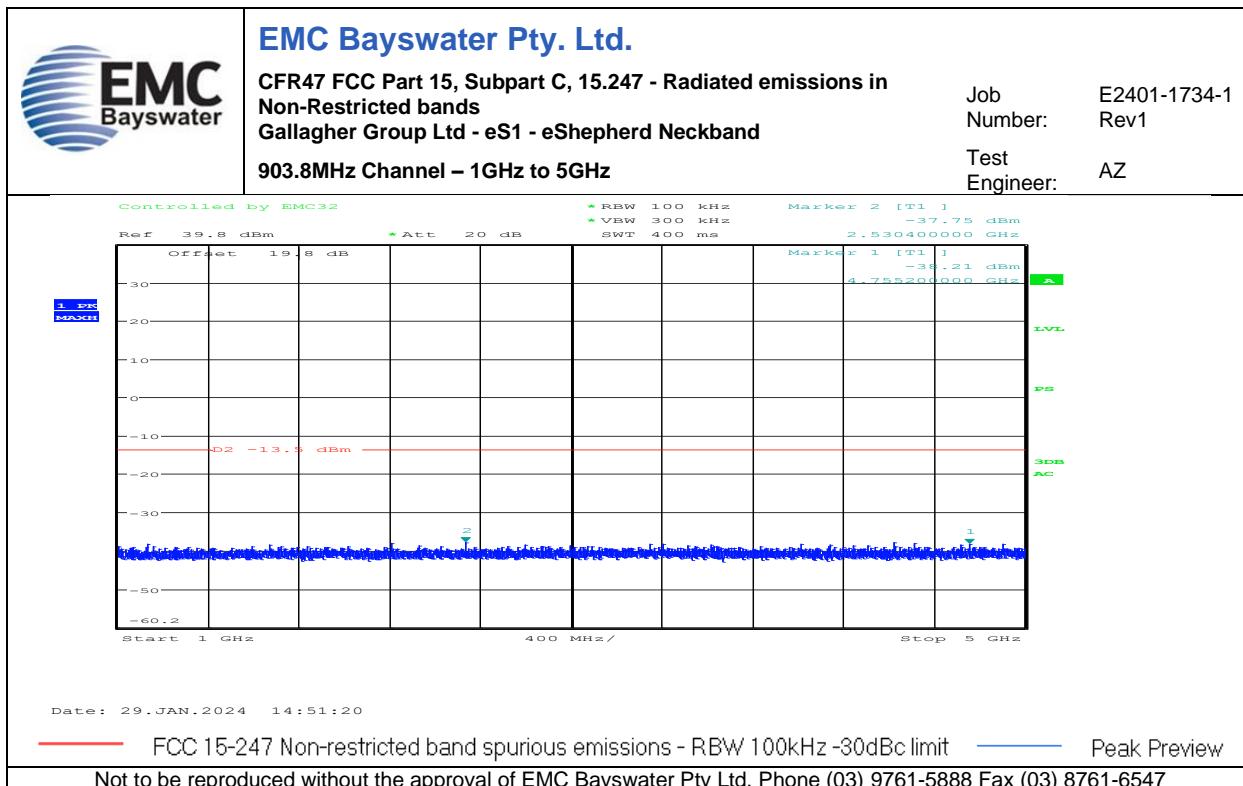
Graph 49



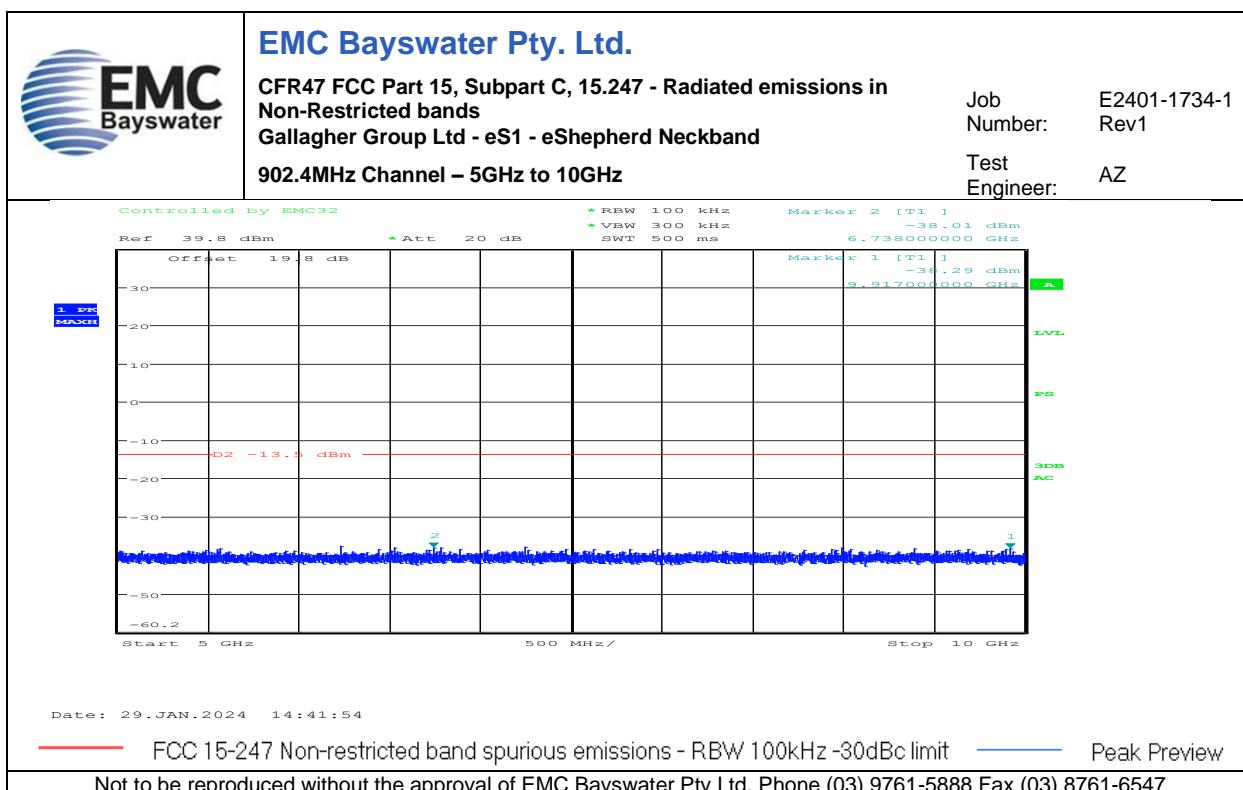
Graph 50



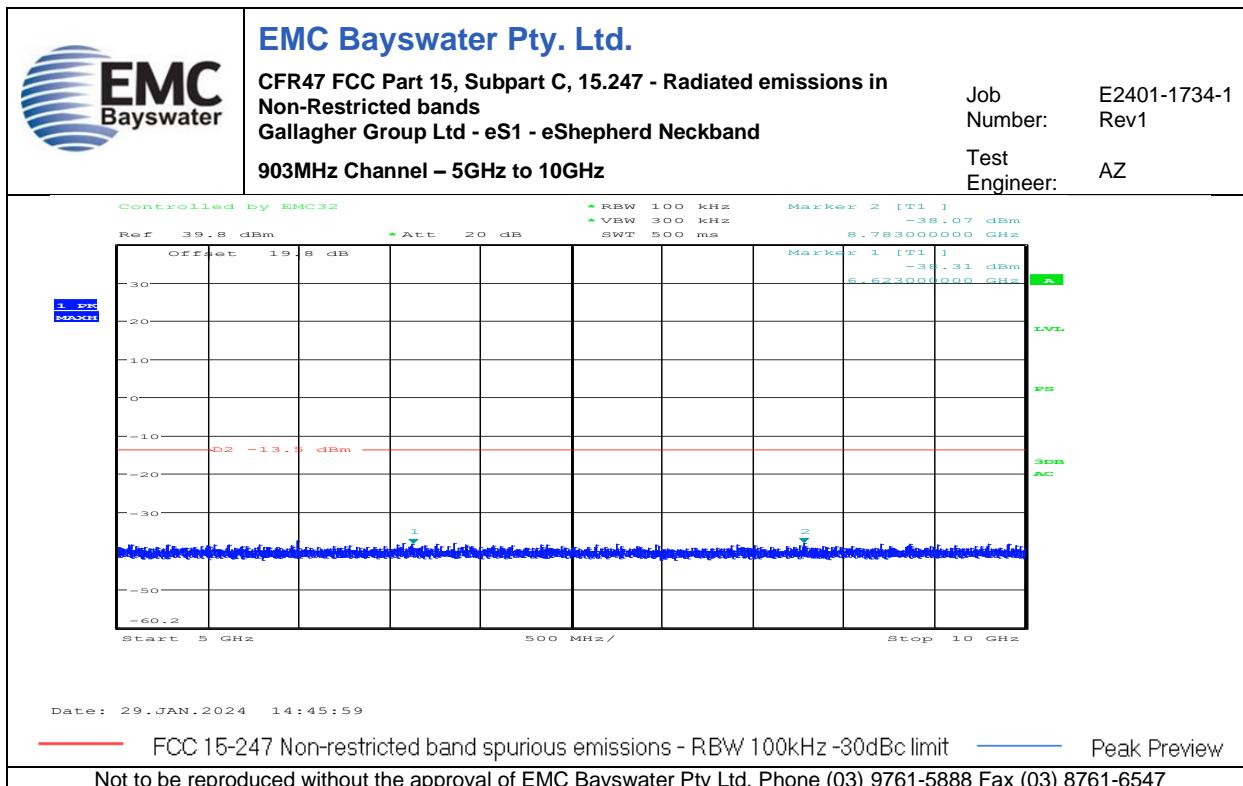
Graph 51



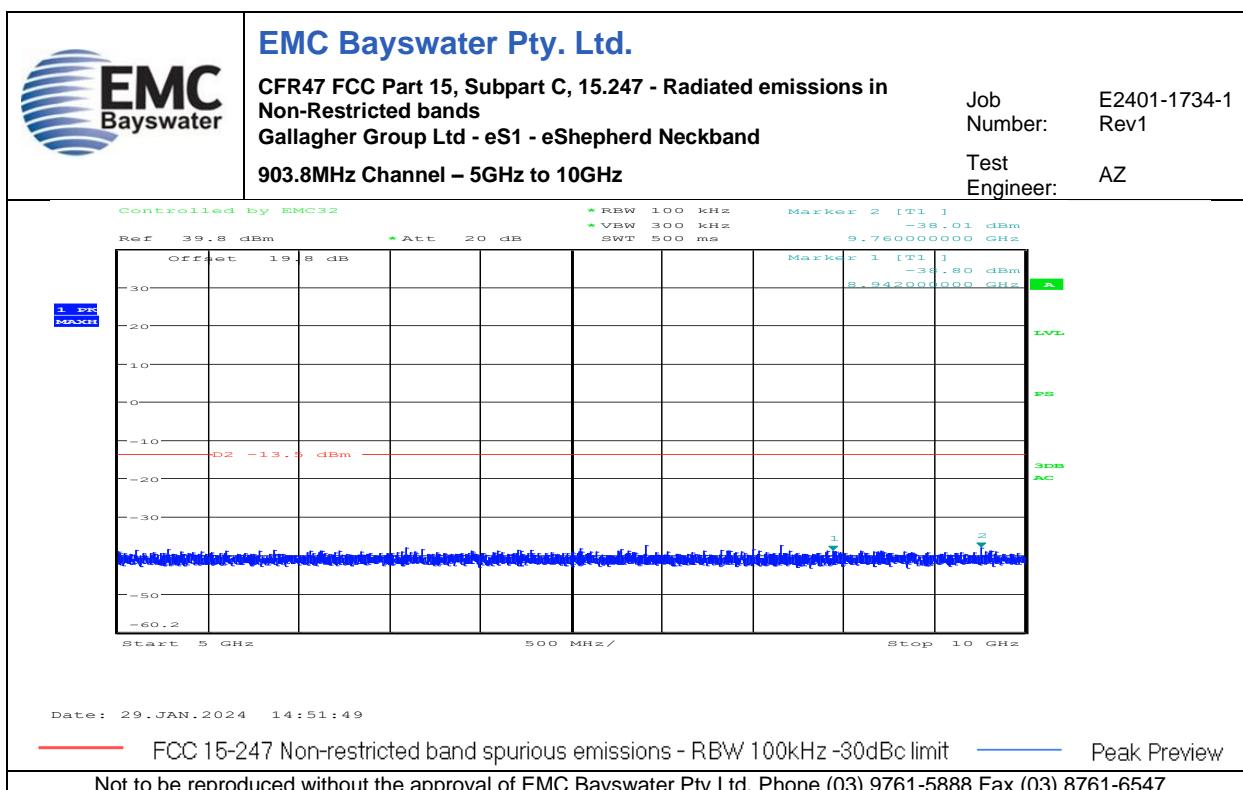
Graph 52



Graph 53



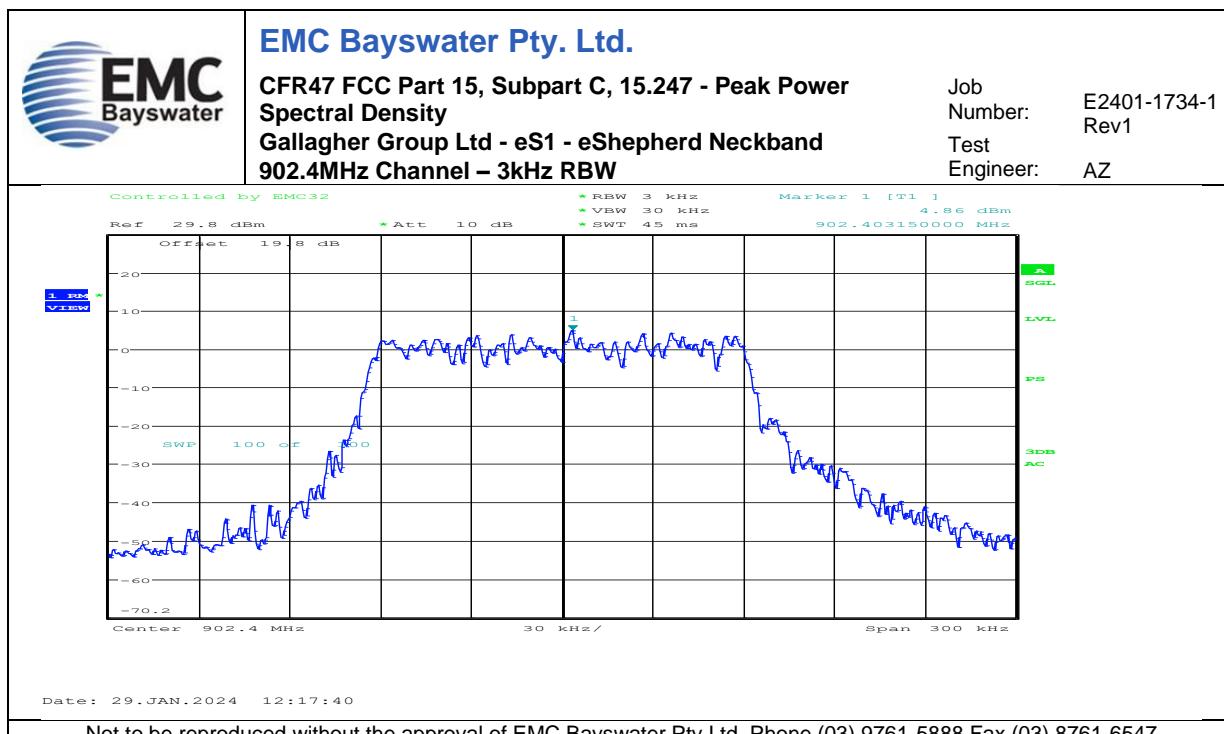
Graph 54



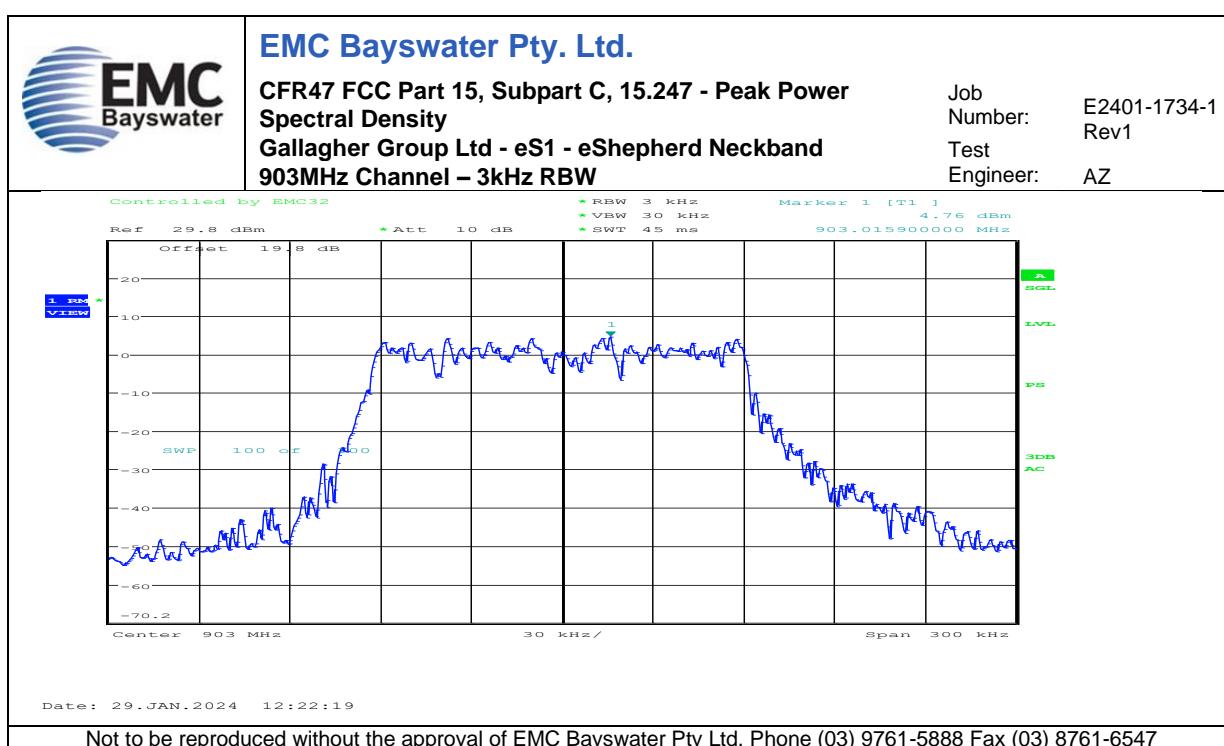
Graph 55

Appendix C.4 – Measurement Graphs – Power Spectral Density – FCC 15.247 (e)

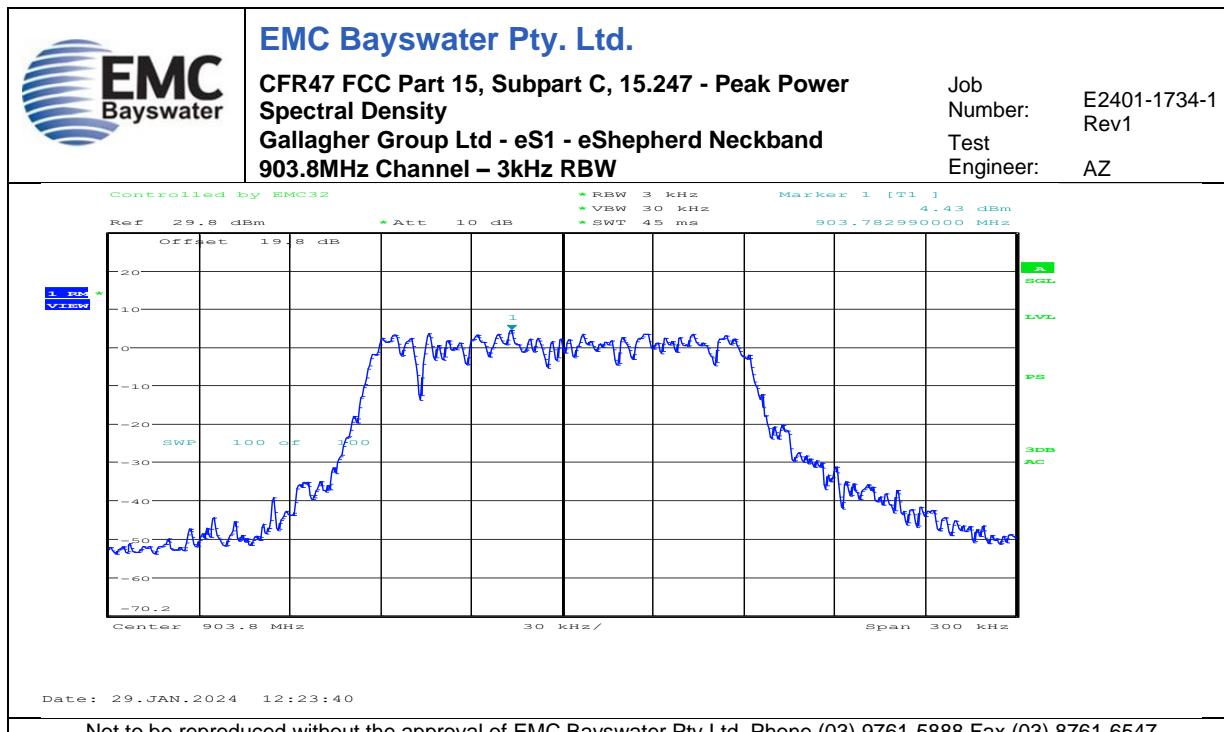
No.	Test	Graph Description
56	Power Spectral Density – 3kHz RBW	902.4MHz Channel
57		903MHz Channel
58		903.8MHz Channel
59	Power Spectral Density – 100kHz RBW (Informative only)	902.4MHz Channel
60		903MHz Channel
61		903.8MHz Channel



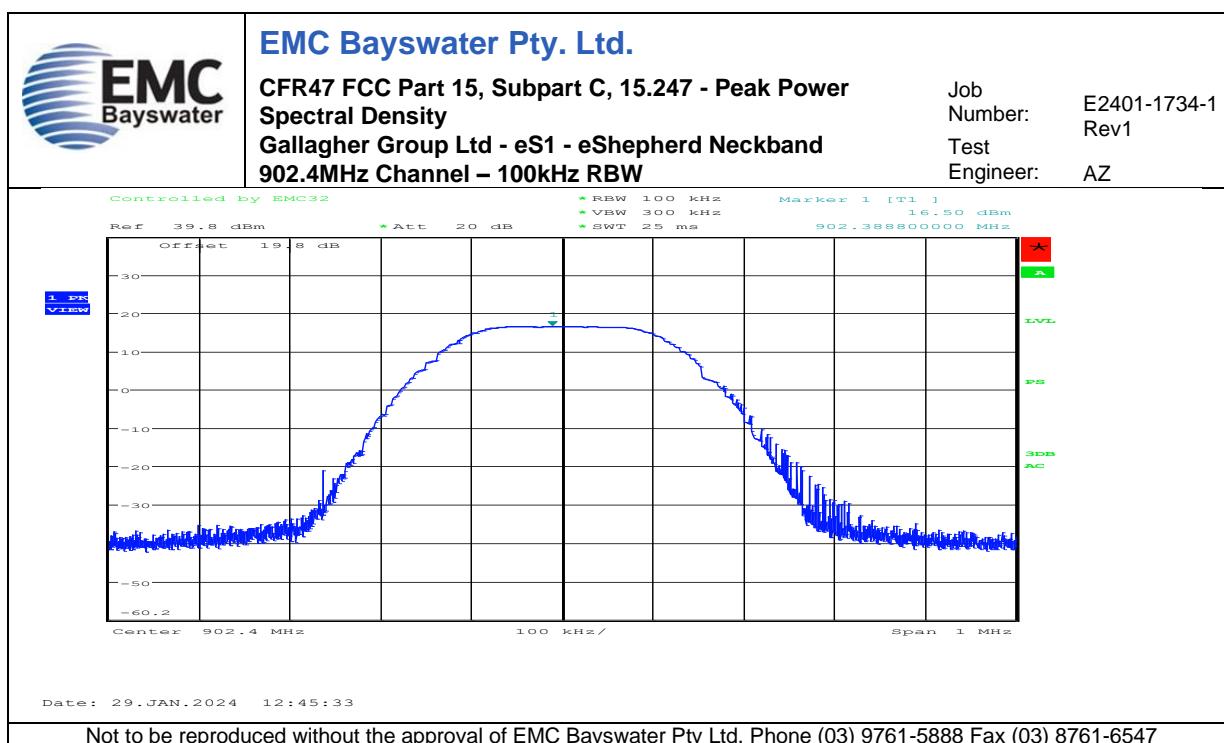
Graph 56



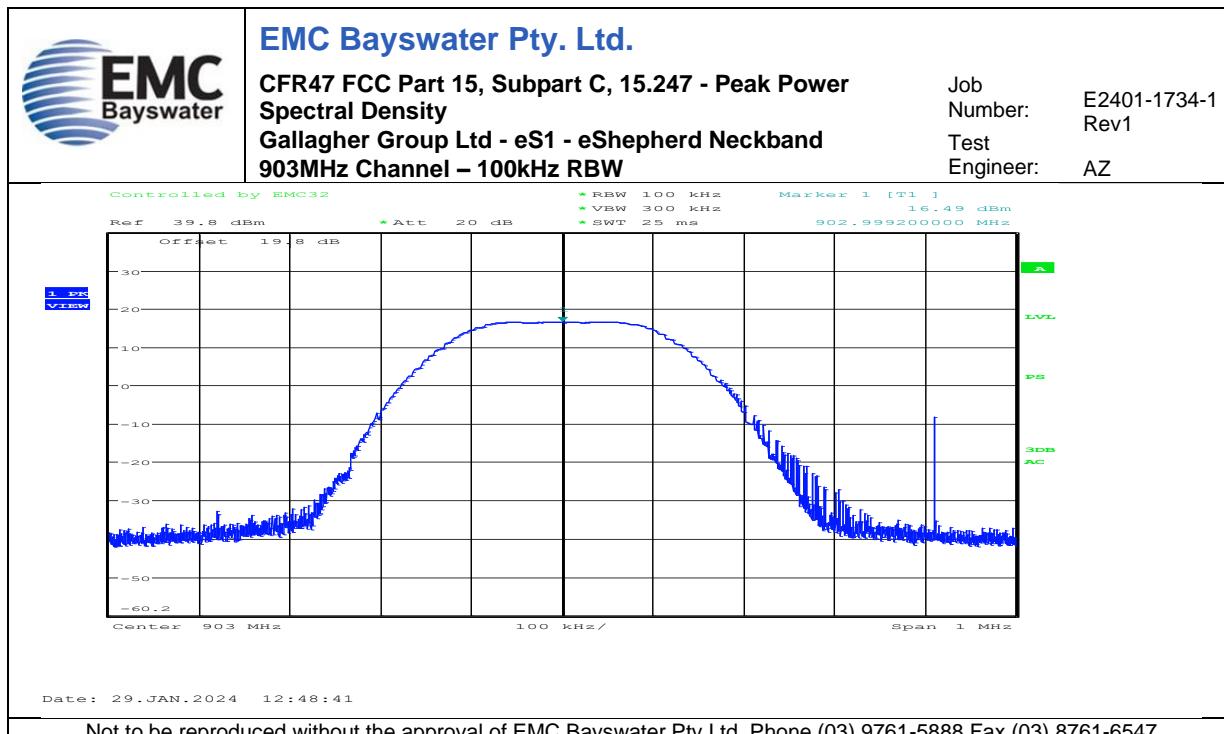
Graph 57



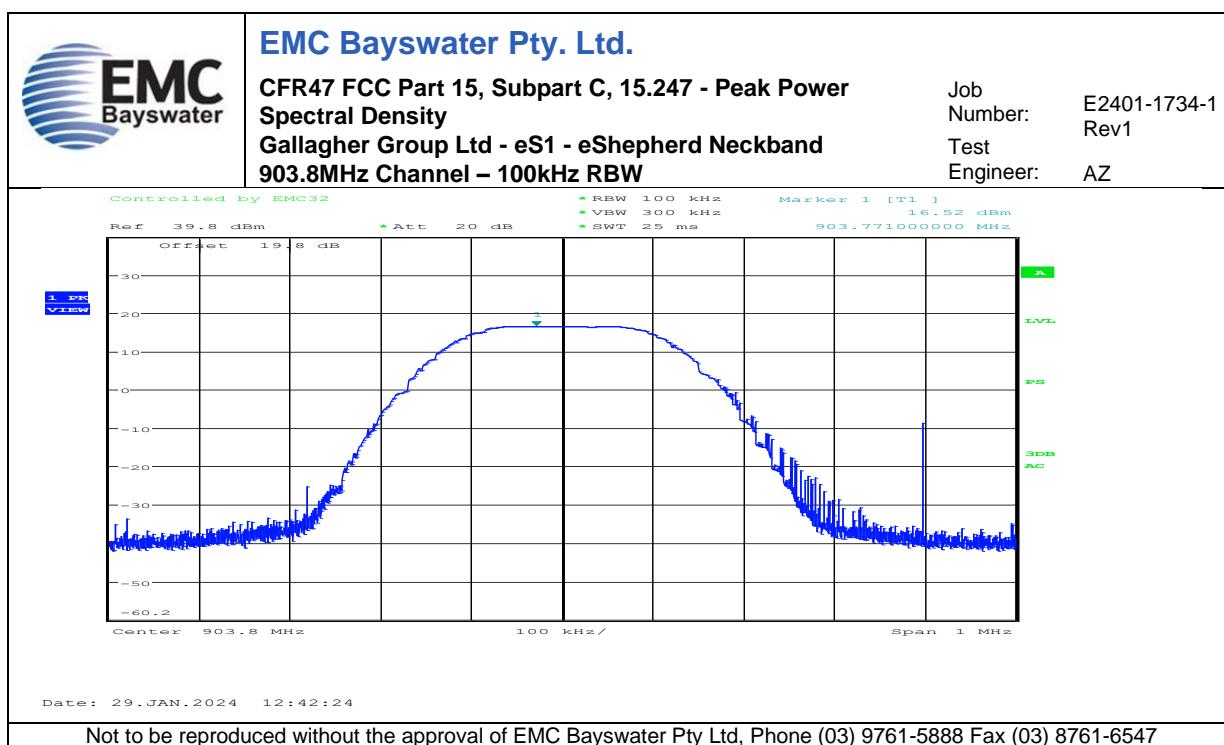
Graph 58



Graph 59



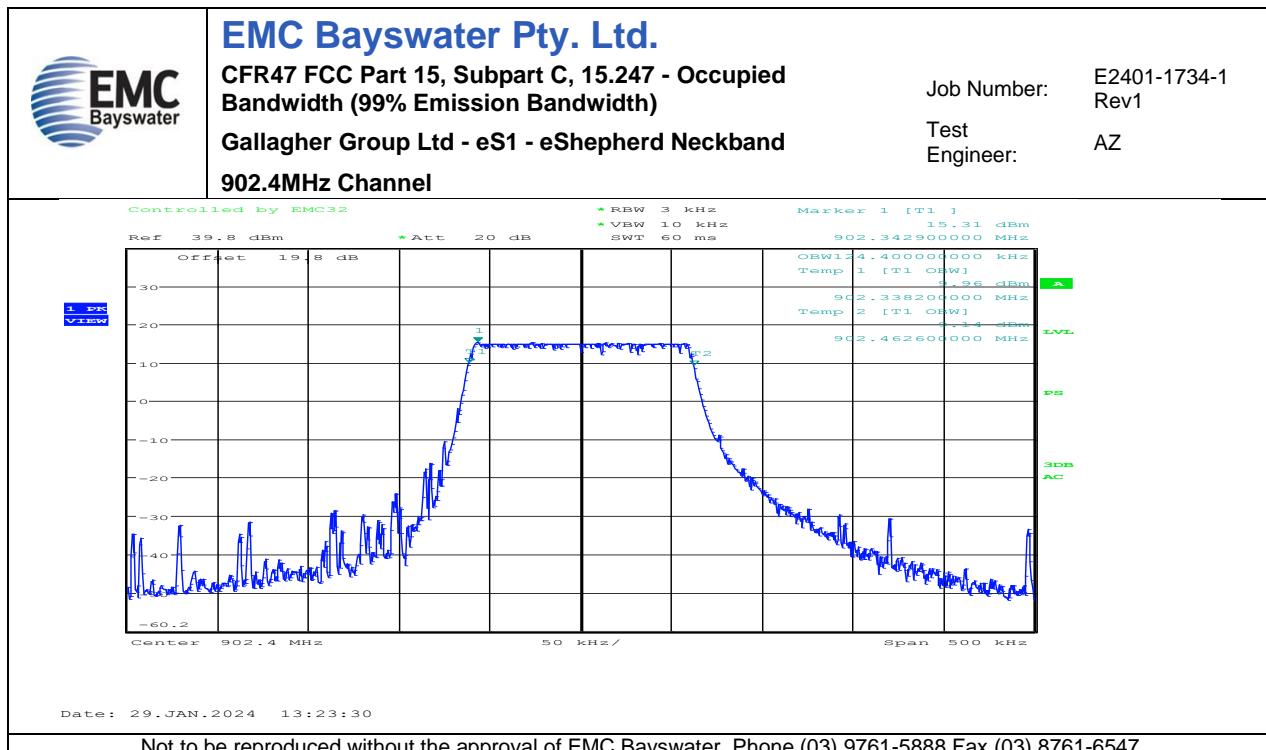
Graph 60



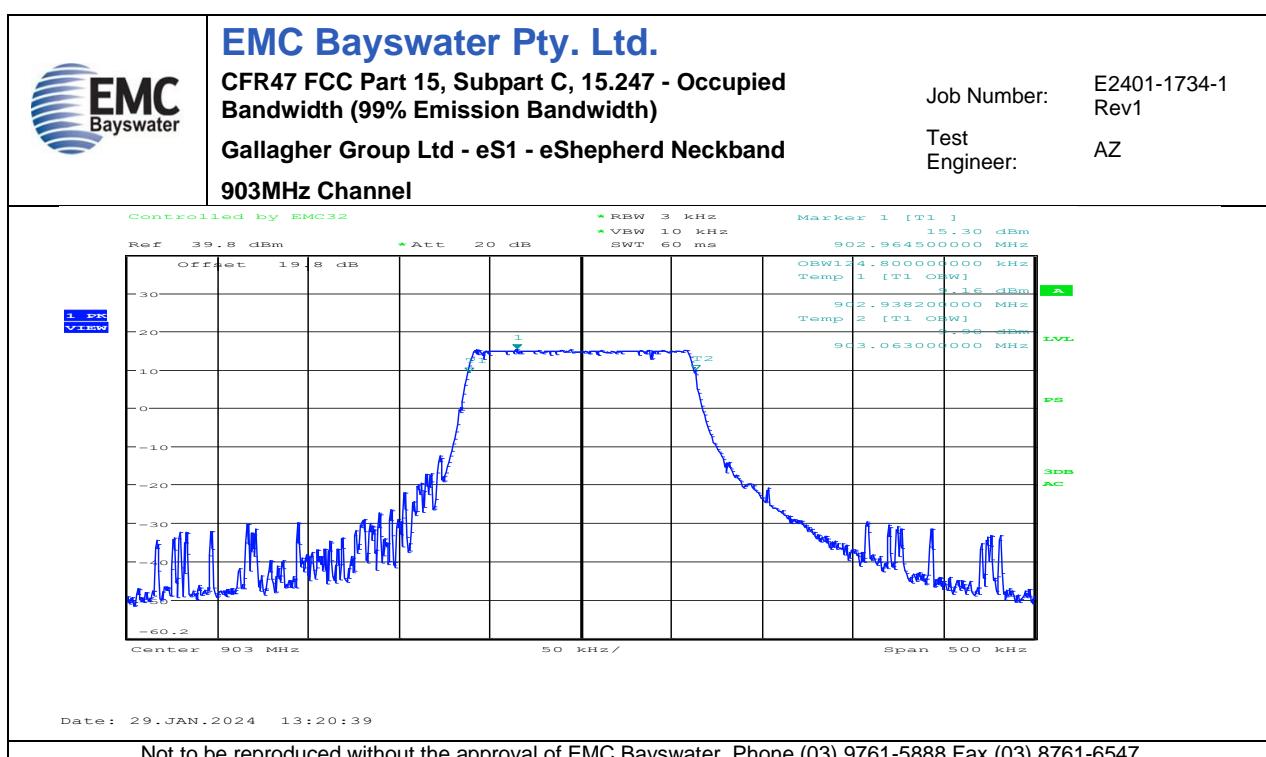
Graph 61

Appendix C.5 – Occupied Bandwidth (99% Emission Bandwidth)

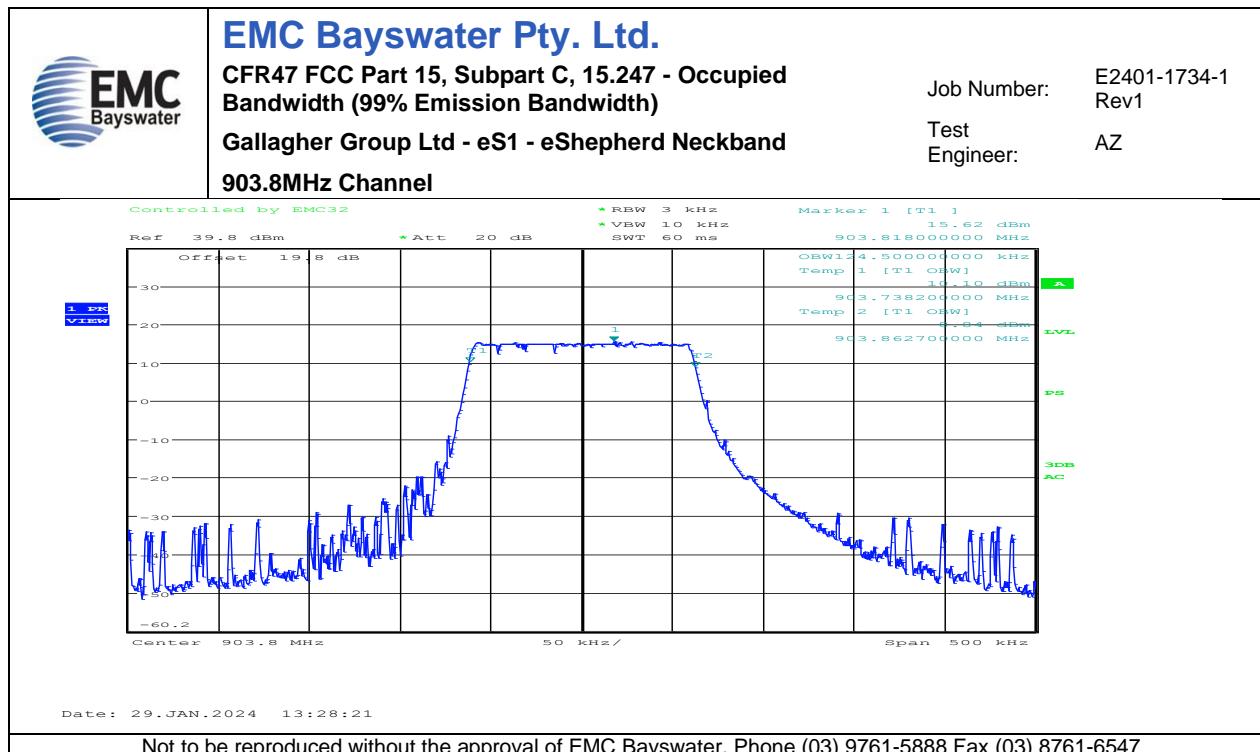
No.	Test	Graph Description
62	Occupied Bandwidth (99% Emission Bandwidth)	902.4MHz Channel
63		903MHz Channel
64		903.8MHz Channel



Graph 62



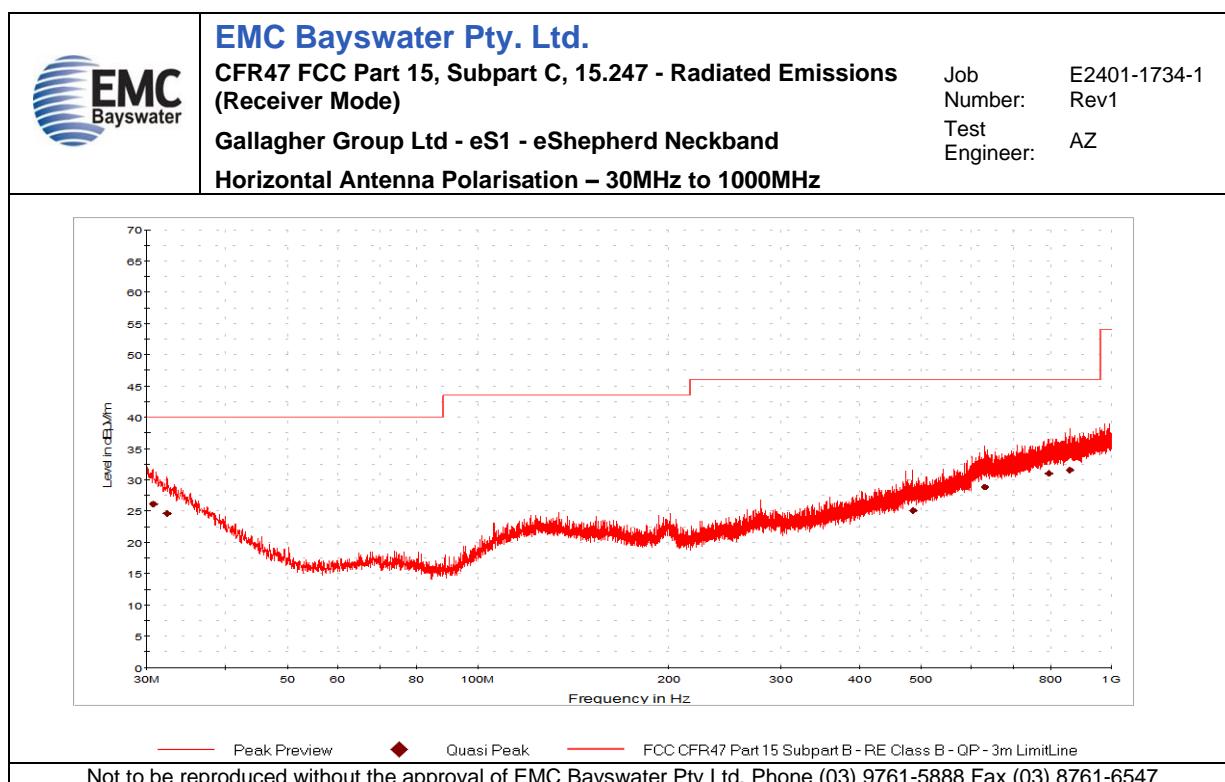
Graph 63



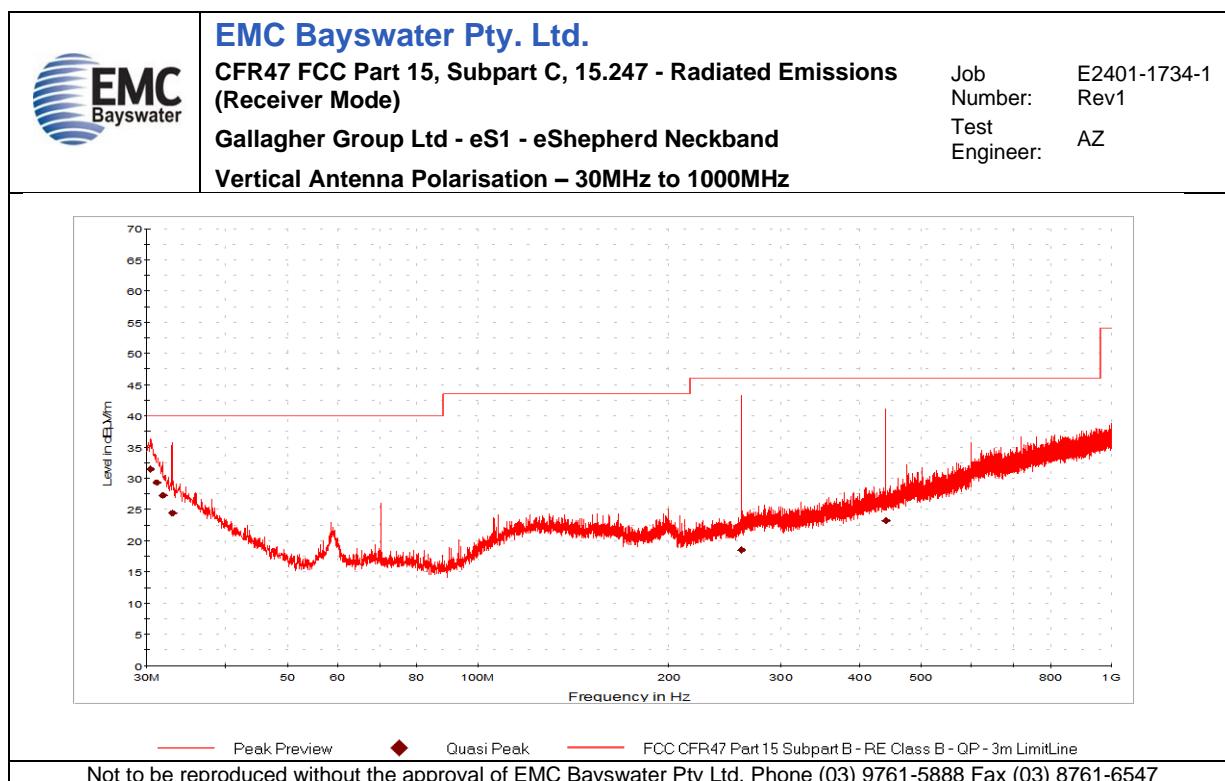
Graph 64

Appendix C.6 – Radiated Emissions (Receiver Mode)

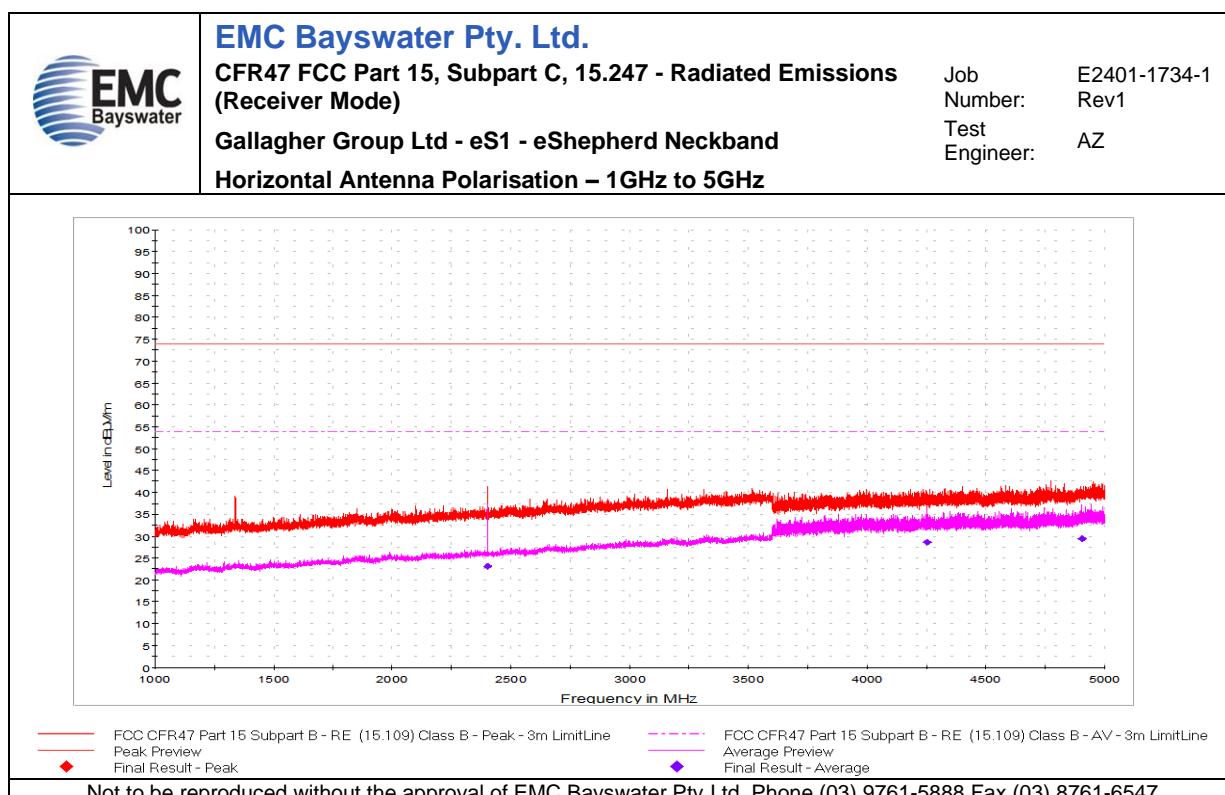
No.	Test	Graph Description
65	Radiated Emissions – 30MHz to 1000MHz	Horizontal Antenna Polarisation
66		Vertical Antenna Polarisation
67	Radiated Emissions – 1GHz to 5GHz	Horizontal Antenna Polarisation
68		Vertical Antenna Polarisation



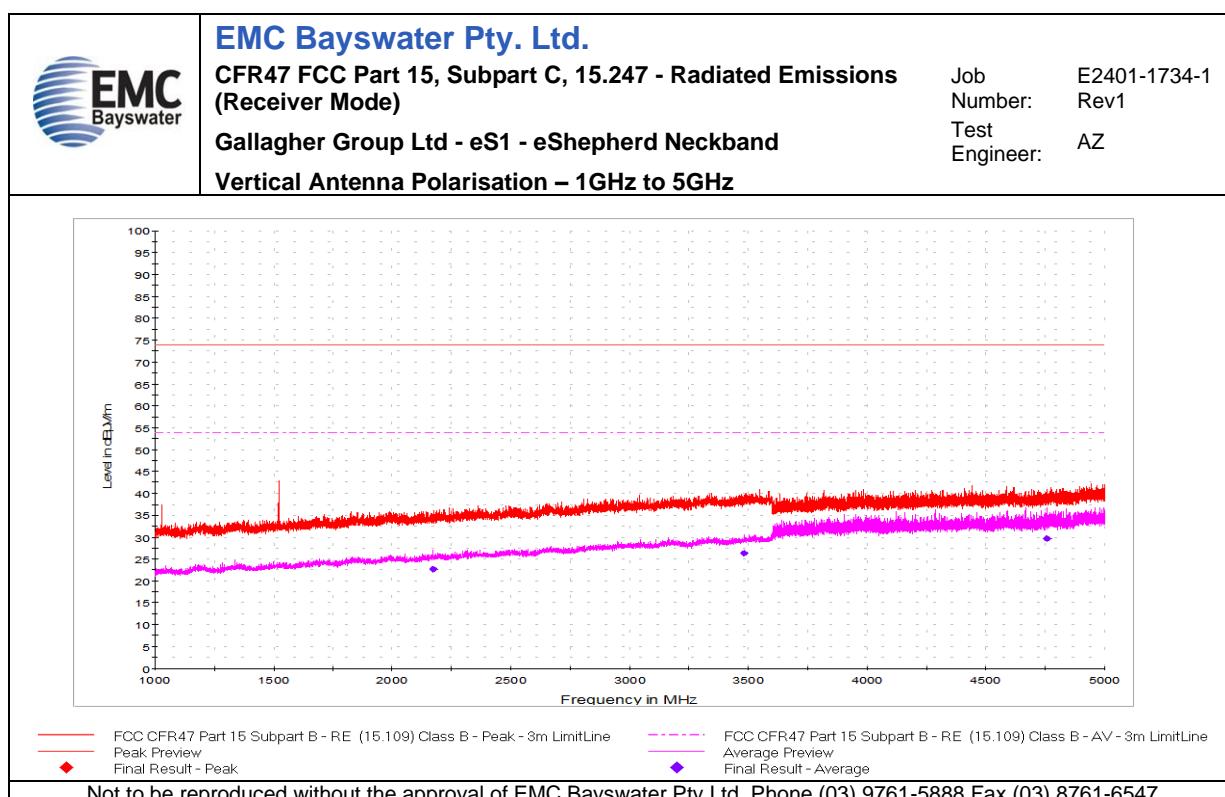
Graph 65



Graph 66



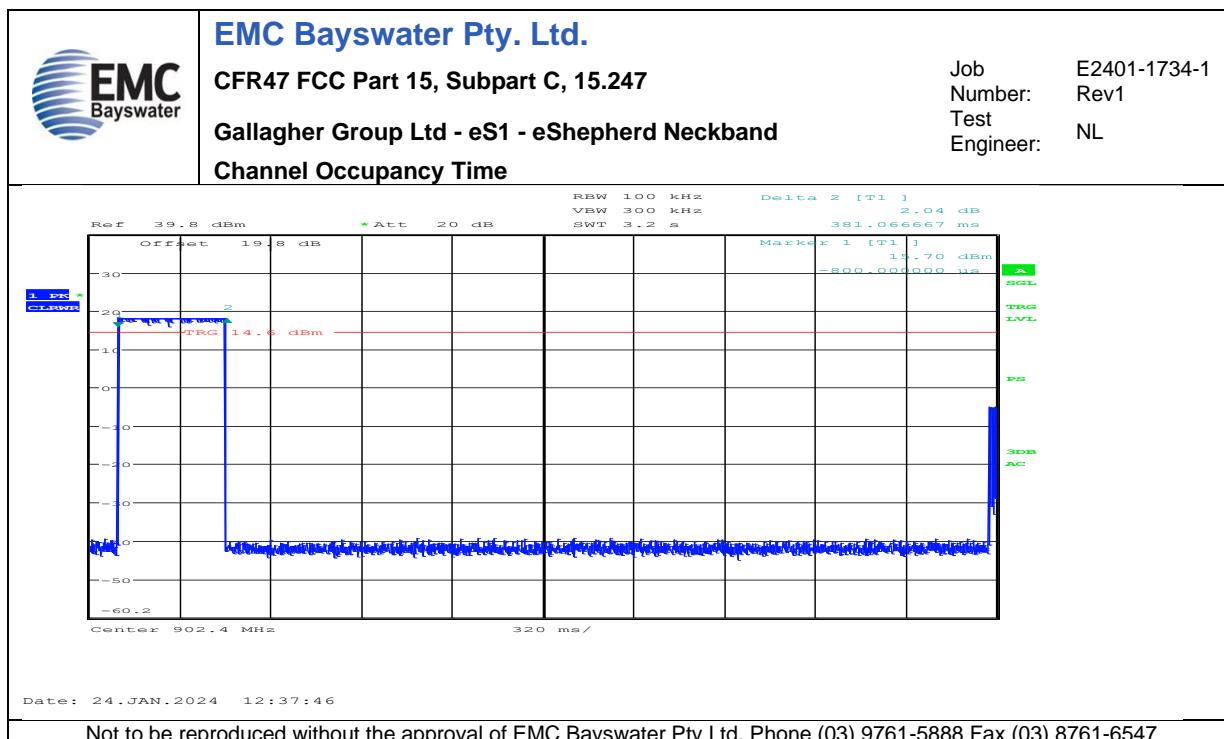
Graph 67



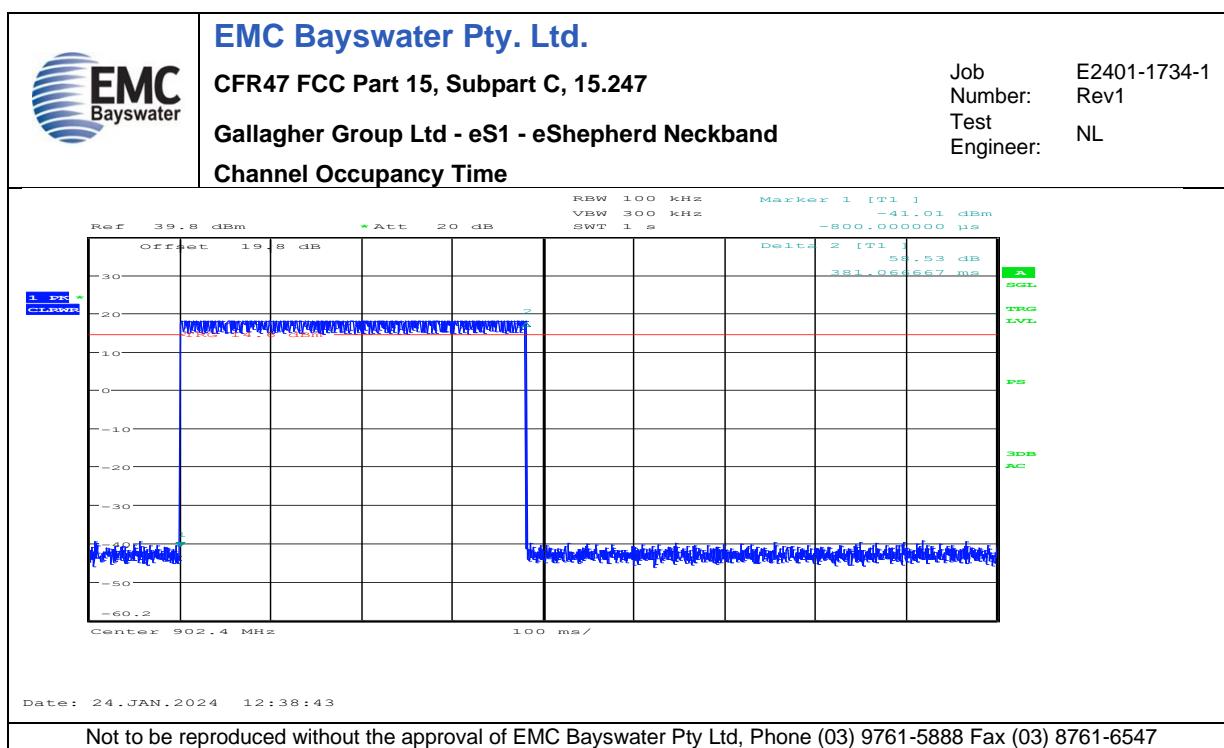
Graph 68

Appendix C.7 – Frequency Hopping Parameters

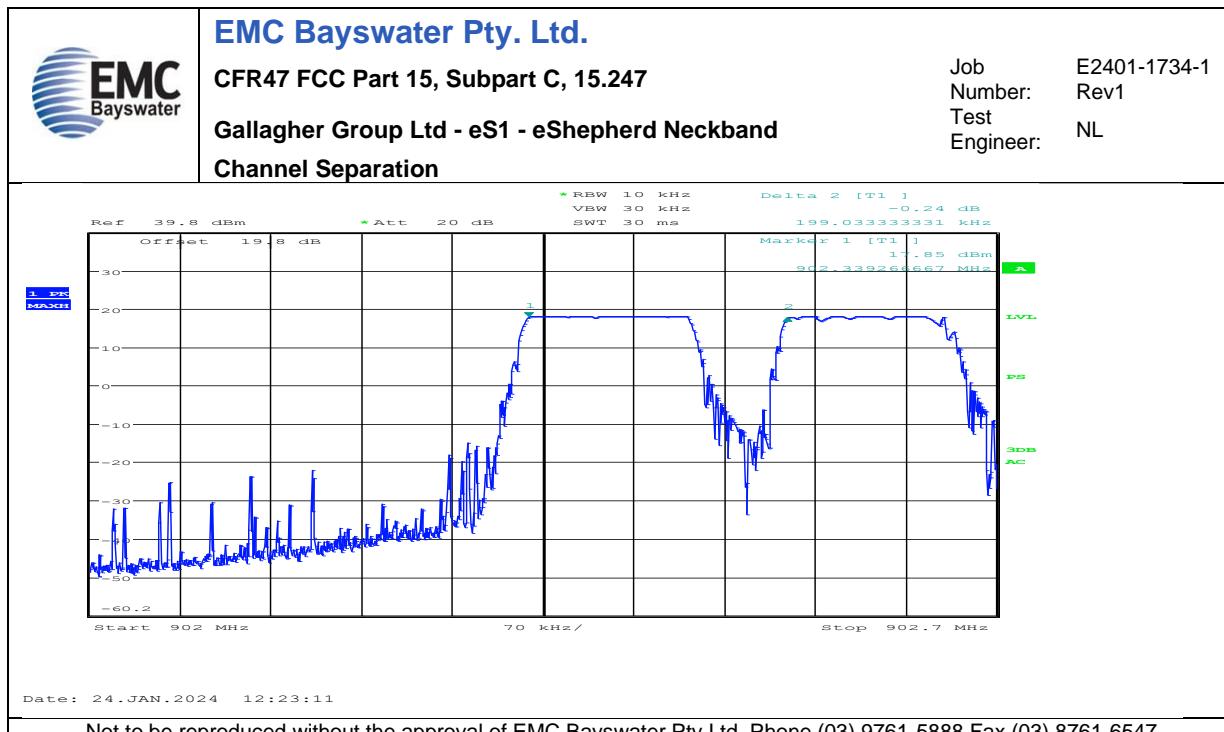
No.	Test / Graph Description
69	Chanel Occupancy Time
70	
71	Channel Separation
72	Number of Hopping Frequencies



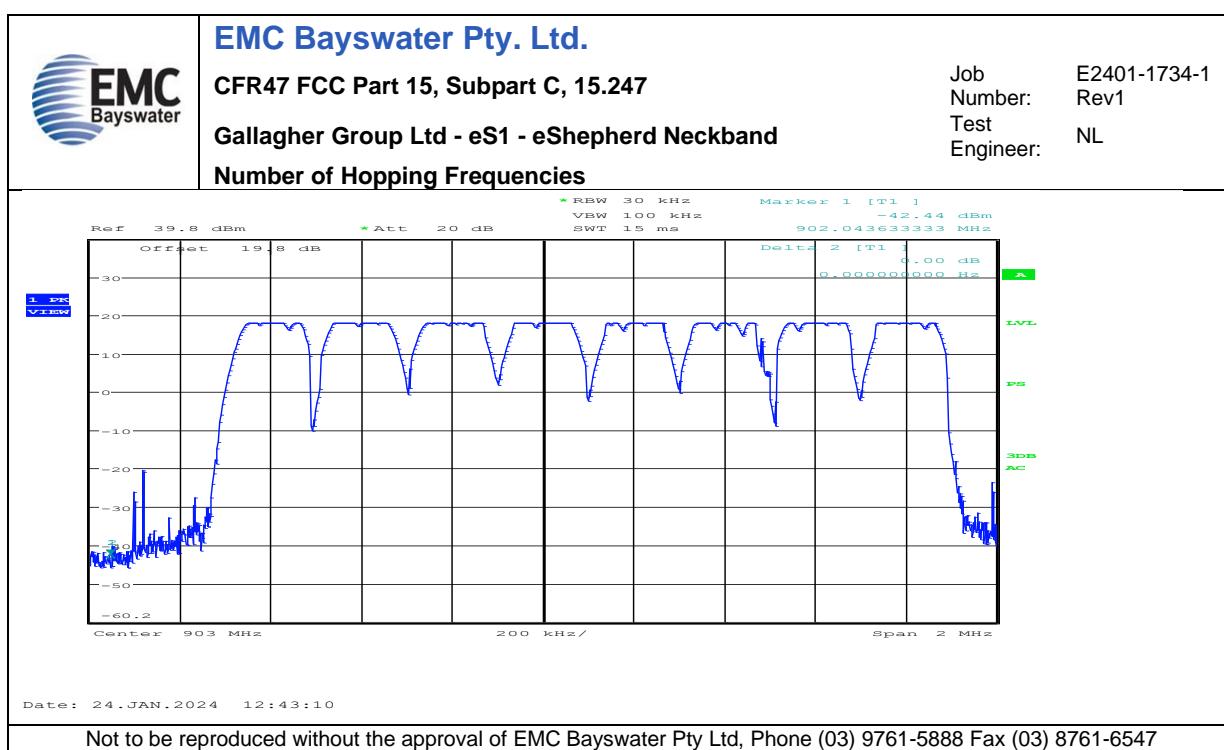
Graph 69



Graph 70



Graph 71



Graph 72