Radio Test Report

Zinwave Ltd

Zinwave UNItivity 5000 Remote Unit

308-0007-2

47 CFR Part 24 Effective Date 1st October 2021
47 CFR Part 2 Effective Date 1st October 2021
Test Date: 7th to 18th November 2022
Report Number: 11-13927-1-22 Issue 01

R.N. Electronics Ltd.
Arnolds Court
Arnolds Farm Lane
Mountnessing
Essex
CM13 1UT
U.K.

www.RNelectronics.com

Telephone: +44 (0) 1277 352219
Email: sales@RNelectronics.com

Arnolds Court, Arnolds Farm Lane, Mountnessing, Brentwood Essex, CM13 1UT

Certificate of Test 13927-1

The equipment noted below has been fully tested by R.N. Electronics Limited and, where appropriate, conforms to the relevant subpart of FCC Part 24. This is a certificate of test only and should not be confused with an equipment authorisation. Other standards may also apply.

Equipment:	Zinwave UNItivity 5000 Remote Unit
Model Number:	308-0007-2
Unique Serial Number:	Sample #2 (T4237)
Applicant:	Zinwave Ltd Harston Mill, Royston Road Harston, Cambridge CB22 7GG
Proposed FCC ID	UPO308-0007-2
Full measurement results are detailed in Report Number:	11-13927-1-22 Issue 01
Test Standards:	47 CFR Part 24 Effective Date 1st October 2021 47 CFR Part 2 Effective Date 1st October 2021

NOTE:
Certain tests were not performed based upon manufacturer's declarations. Certain other requirements are subject to manufacturer declaration only and have not been tested/verified. For details refer to section 3 of this report.
This report only pertains to the operation of the equipment to 47 CFR part 24, for details of testing to other rule parts please see RN report: 11-13927-2-22 (Part 27).

DEVIATIONS: No deviations have been applied.

This certificate relates only to the unit tested as identified by a unique serial number and in the condition at the time it was tested. It does not relate to any other similar equipment and performance of the product before or after the test cannot be guaranteed. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of unit not meeting the intentions of the standard or the requirements of the Federal Regulations, particularly under different conditions to those during testing. Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Date Of Test:	7th to 18th November 2022
Test Engineer:	Charlie Blatt
Approved By: Radio Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2022.12.01 10:47:27 Z
Customer Representative:	

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File Name: Zinwave Ltd.13924-1 Issue 01

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Zinwave Ltd Harston Mill Royston Road Harston Cambridge CB22 7GG	
Manufacturer of EUT	Zinwave Ltd	
Full Name of EUT	Zinwave UNItivity 5000 Remote Unit	
Model Number of EUT	308-0007-2	
Serial Number of EUT	Sample #2 (T4237)	
Date Received	7th November 2022	
Date of Test:	7th to 18th November 2022	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	20th November 2022	
Main Function	Distributed Antenna remote unit	
Information Specification	Height	70 mm
	Width	440 mm
	Depth	270 mm
	Weight	9 kg
	Voltage	48 V DC
	Current	0.85 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Wall mounted
Choice of model(s) for type tests	Production unit
Antenna details	external max 8dBi
Antenna port	External: 2x TX; 2x RX (N-type ports)
Baseband Data port (yes/no)?	NO
Highest Signal generated in EUT	2690 MHz, but 1995MHz is maximum frequency for these rule parts
Lowest Signal generated in EUT	Not stated
Hardware Version	1.0
Software Version	Hub Software 5.21rc02
Firmware Version	5.61
Type of Equipment	Booster, Distributed Antenna System
Technology Type	Various – wideband distributed antenna system
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	150 - 2690 MHz
EUT Declared Modulation Parameters	Device supports Personal Communications Services under this rule part
EUT Declared Power level	+24dBm per TX port (27 dBm total power)
EUT Declared Signal Bandwidths	Device supports Personal Communications Services under this rule part
EUT Declared Channel Spacing's	Device supports Public Mobile Radio Services and personal Communications services under this rule part
EUT Declared Duty Cycle	up to 100%
Unmodulated carrier available?	Yes - EUT provides at its output whatever is presented to its input
Declared frequency stability	0ppm (DAS without frequency translation)
RX Parameters	
Alignment range – receiver	As per Transmitter range
EUT Declared RX Signal Bandwidth	As per Transmitter
Receiver Signal Level (RSL)	N/A
Method of Monitoring Receiver BER	N/A

2.3 Functional description

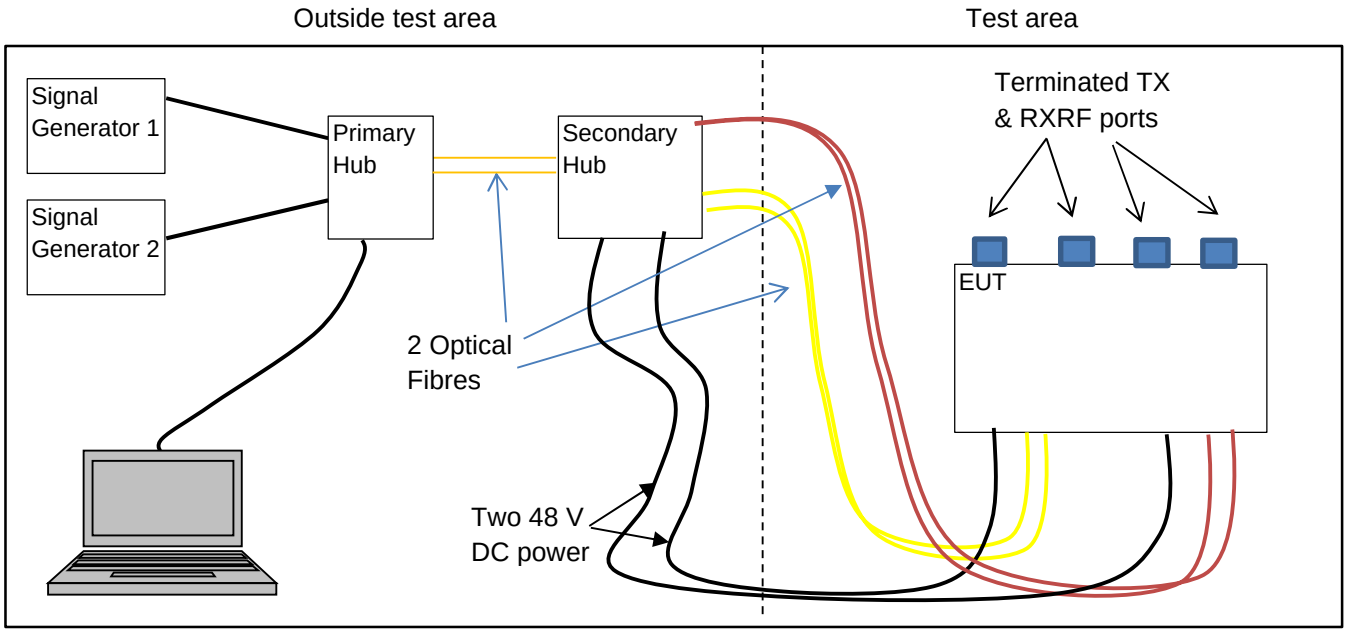
The Remote Unit is used as part of the Zinwave UNItivity 5000 system to provide cellular and private radio services within buildings, sports arenas and similar areas.
The system is wideband in nature and can support a wide range of radio services depending upon the system that is connected to the service module of the Primary Hub.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Mode 1	CW Sweep from 1930 – 1995 MHz to determine f0	Yes
Mode 2	Single mode Channel AWGN at f0 (1961.3MHz) in band 1930 – 1995 MHz	Yes
Mode 3	Single Low channel AWGN at 1932.5 MHz	Yes
Mode 4	Single Mid channel AWGN at 1960.0 MHz	Yes
Mode 5	Single High channel AWGN at 1992.5 MHz	Yes
Mode 6	Dual Low channel AWGN at 1932.5 MHz & 1937.5 MHz	Yes
Mode 7	Dual High channel AWGN at 1987.5 MHz & 1992.5 MHz	Yes

Note: Modes 3 to 7 were applied to both Optical inputs simultaneously for the Radiated field strength emissions test.
Note: This report only pertains to the operation of the equipment to 47 CFR part 24E, for details of testing to other rule parts please see RN report: 11-13927-2-22 (Part 27)

2.5 Emissions configuration



Each half of the unit was powered from the secondary hub at 48V DC. The unit was configured using the supplied network management software using the settings files prepared by Zinwave Ltd, this provided 29dB gain and +24dBm EUT output power at each TX port in conjunction with the signal generator settings of -5dBm. Any attenuation introduced by the Primary/secondary hub system was also accounted for in the set-up files provided by Zinwave Ltd. Test channels and required modulations were set using the signal generators connected to the primary hub. Single channel operation was provided by generator 1 and dual channel was using two signal generators. Output power of the signal generators was set to provide -5dBm at input to primary hub.
The transmit mode was 100% continuous with EUT output power maintained at +24dBm (29dB gain). Test channels and combinations used are stated in test modes section 2.4
The system supports operation with a number of wideband services, so testing was performed with AWGN modulation signal as per KDB 935210 D05, and a CW signal for determination of f0.

For conducted RF tests the RF ports were connected via suitable attenuation and filtering where required and connected directly to a spectrum analyser, with losses accounted for in the measurement results.
The system is designed for operation with antennas having a maximum gain of 8.0 dBi or 5.85 dBd. This is the value used for determining EIRP or ERP where required.

2.5.1 Signal leads

Port Name	Cable Type	Connected
DC power 1	2 cores	Yes
DC power 2	2 cores	Yes
Fibre TX 1	Fibre	Yes
Fibre RX 1	Fibre	Yes
Fibre TX 2	Fibre	Yes
Fibre RX 2	Fibre	Yes
Transmit port 1	N-type coaxial	Yes
Receive port 1	N-type coaxial	Yes
Transmit port 2	N-type coaxial	Yes
Receive port 2	N-type coaxial	Yes

3 Summary of test results

The Zinwave UNItivity 5000 Remote Unit, 308-0007-2 was tested for compliance to the following standard(s):

47 CFR Part 24 Effective Date 1st October 2021
47 CFR Part 2 Effective Date 1st October 2021

Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of equipment not meeting the intentions of the standard or the essential requirements of the directive, particularly under different conditions to those during testing. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Title	References	Results
Transmitter Tests		
1. Spurious emissions at antenna terminals	FCC Part 24 Clause 24.238 FCC Part 2 Clause 2.1051	PASSED[1]
2. RF Power Output	FCC Part 24 Clause 24.232(a) FCC Part 2 Clause 2.1046	PASSED
3. Frequency stability	FCC Part 2 Clause 2.1055	NOT APPLICABLE[2]
4. Occupied bandwidth	FCC Part 24 Clause 24.238 FCC Part 2 Clause 2.1049	PASSED
5. Field strength of spurious radiations	FCC Part 24 Clause 24.238 FCC Part 2 Clause 2.1053	PASSED[1]
6. Band edge emissions	FCC Part 24 Clause 24.238 FCC Part 2 Clause 2.1051	PASSED
7. Modulation characteristics	FCC Part 2 Clause 2.1047	PROVIDED[3]
8. Determination of f_0	KDB 935210 D05 Clause 3.3	PERFORMED

[1] Spectrum investigated started at a frequency of 30MHz up to a frequency of 20GHz based on 10 times the highest channel of 1992.5 MHz.
[2] EUT does not contain an oscillator and only reproduces what is provided at its input.
[3] Modulation characteristics information provided in section 2.2.

4 Specifications

The tests were performed and operated in accordance with R.N. Electronics Ltd procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	FCC Part 24	2021	Part 24 – Personal Communications Services
4.1.2	47CFR part 2J	2021	Part 2 – Frequency Allocations and radio treaty matters; General rules and regulations
4.1.3	KDB 971168 D01 v03r01	2018	Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement Guidance for Certification of Licensed Digital Transmitters
4.1.4	ANSI C63.26	2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
4.1.5	KDB 935210 D05 v01r04	2020	Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement guidance for Industrial and Non-consumer signal booster, repeater and amplifier devices
4.1.6	662911 D01 v02r01	2013	Federal Communications Commission Office of Engineering and Technology Laboratory Division; Emissions Testing of transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc)

4.2 Deviations

No deviations were applied.

5 Tests, methods and results

5.1 Spurious emissions at antenna terminals

5.1.1 Test methods

Test Requirements:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]
	FCC Part 2 Clause 2.1053 [Reference 4.1.2 of this report]
Test Method:	ANSI C63.26 2015 Clause 5.5 [Reference 4.1.4 of this report]
	KDB 935210 D05 Clause 3.6 / 4.7 [Reference 4.1.5 of this report]
Limits:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]

5.1.2 Configuration of EUT

EUT was tested on a bench. The EUT RF port under test was connected to a spectrum analyser via suitable attenuation. RX port was terminated into a 50 Ohm load. EUT was tested across Low, Middle and High channels within each applicable band in a single channel input mode and at bottom and top of the band in dual channel input mode modes, which are specified in section 2.4 of this report.

5.1.3 Test procedure

The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached per channel/band setting as required. Measurements were made and plots taken in the required Resolution bandwidths, where applicable results are referenced to EIRP limits by consideration of the antenna gain used with the EUT of 8dBi (5.85dBd) and indicated. Only results within 20dB of limits are reported.
Note: some emissions >1 MHz from band edge were measured using the spectrum analyser adjacent power function that integrated power from a lower resolution bandwidth into the 1MHz required by the rule part
Compliance with MIMO operation is demonstrated by following KDB 662911 D01 section E(3) and adding 10log(2), or 3dB, to the spurious emission measured from a single unit

Tests were performed in test site N.

5.1.4 Test equipment

F075, H071, H072, E602

See Section 8 for more details

5.1.5 Test results

Temperature of test environment	17-23°C
Humidity of test environment	35-58%
Pressure of test environment	100-103kPa

For band edge results please refer to section 5.6 within this report

Single channel results (SISO operation).

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channel	1932.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
1926.5	-29.75	-16.75
3864.8	-25.05	-12.05

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Mid channel	1960.0 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
3921.2	-29.42	-16.42

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
High channel	1992.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)
1998.0	-23.01	-10.01
3986.0	-31.27	-18.27

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Single channel results (MIMO operation).

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channel	1932.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Add 3dB	Difference to Limit (dB)
1926.5	-29.75	-26.75	-13.75
3864.8	-25.05	-22.05	-9.05

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Mid channel	1960.0 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Add 3dB	Difference to Limit (dB)
3921.2	-29.42	-26.42	-13.42

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
High channel	1992.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Add 3dB	Difference to Limit (dB)
1998.0	-23.01	-20.01	-7.01
3986.0	-31.27	-28.27	-15.27

Plots
1930-1995 CSE_low
1930-1995 CSE_high

Results are also presented graphically in section 6.

LIMITS:

24.238 (a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

In accordance with KDB 662911 D01 3dB has been added to measured results for two signal MIMO operation and then compared with the limits.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 2.8 dB

5.2 RF Power Output

5.2.1 Test methods

Test Requirements: FCC Part 24 Clause 24.232(a) [Reference 4.1.1 of this report]
FCC Part 2 Clause 2.1053 [Reference 4.1.2 of this report]
Test Method: ANSI C63.26 2015 Clause 5.2 [Reference 4.1.4 of this report]
KDB 935210 D05 Clause 3.5 / 4.5 [Reference 4.1.5 of this report]
Limits: FCC Part 24 Clause 24.232(a) [Reference 4.1.1 of this report]

5.2.2 Configuration of EUT

EUT was tested on a bench. The EUT RF port under test was connected to a spectrum analyser via suitable attenuation. RX port was terminated into a 50 Ohm load. EUT was tested centred on f0. Test mode was 2.

5.2.3 Test procedure

Tests were made in accordance with the test method noted above using the measuring equipment listed in the 'Test Equipment' Section. The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached per channel/band setting as required and the frequency under test was set to an appropriate channel to include f_0 as determined in section 5.8. An RMS detector was set and Channel power was measured using the channel power function.
The two optical to RF paths are identical, so total power to the antenna is determined by adding 10log(2), or 3dB, to the power measured from a single unit.

5.2.4 Test equipment

F075, H071, H072, E602

See Section 8 for more details

5.2.5 Test results

Temperature of test environment	18-22°C
Humidity of test environment	40-50%
Pressure of test environment	102kPa

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
f0 frequency	1961.3MHz

Test conditions		Average Power (SISO) (dBm)	TX power EIRP (dBm)	TX Power EIRP (W)	PK to Average Power ratio (dB)
Temp Ambient	Volts Nominal	24.37	32.37	1.73	7.89

Note: 8dBi Antenna gain used.

Test conditions		Average Power (MIMO) (dBm)	TX power EIRP (dBm)	TX Power EIRP (W)	PK to Average Power ratio (dB)
Temp Ambient	Volts Nominal	27.37	35.37	3.44	7.89

Note: 8dBi Antenna gain used. 3dB added to result for MIMO operation on single port.

Results are also presented graphically in section 6

LIMITS:
24.232(a) 1640 W ERP

File Name: Zinwave Ltd.13924-1 Issue 01

In accordance with KDB 662911 D01 3dB has been added to measured results for two signal MIMO operation and then compared with the limits.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows: < ±1 dB.

5.3 Frequency stability

NOT APPLICABLE: EUT does not contain an oscillator and only reproduces what is provided at its input.

5.4 Occupied bandwidth / Input versus output signal

5.4.1 Test methods

Test Requirements:	FCC Part 2 Clause 2.1053 [Reference 4.1.2 of this report]
Test Method:	ANSI C63.26 2015 Clause 5.4 [Reference 4.1.4 of this report]
	KDB 935210 D05 Clause 3.3 / 3.4, 4.3 / 4.4 [Reference 4.1.5 of this report]
Limits:	None

5.4.2 Configuration of EUT

EUT was tested on a bench. The EUT RF port under test was connected to a spectrum analyser via suitable attenuation. RX port was terminated into a 50 Ohm load. EUT was tested at f0. Test mode 2 was used

5.4.3 Test procedure

Tests were made in accordance with the test method noted above using the measuring equipment listed in the 'Test Equipment' Section. The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached per channel/band setting as required and the frequency under test was set to an appropriate channel to include f_0 as determined in section 5.8. The spectrum analyser was configured to measure 99% occupied bandwidth using peak detector and max hold.
The two radio cards in the unit are identical, so testing on one port is representative of both transmit ports.

5.4.4 Test equipment

F075, H071, H072, E602

See Section 8 for more details

5.4.5 Test results

Temperature of test environment	18-22°C
Humidity of test environment	45-58%
Pressure of test environment	102kPa

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
f0 frequency	1961.3MHz

	26dB BW (MHz)
Input measurement	4.07
Output measurement	4.11
Plot reference	1930-1995 Occupied Bandwidth

Results are also presented graphically in section 6

LIMITS:
Emissions to be contained within the applicable emissions mask/band edges.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
< ± 1.9%

5.5 Field strength of spurious radiations

5.5.1 Test methods

Test Requirements:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]
	FCC Part 2 Clause 2.1053 [Reference 4.1.2 of this report]
Test Method:	ANSI C63.26 2015 Clause 5.5 [Reference 4.1.4 of this report]
	KDB 935210 D05 Clause 3.6 / 4.7 [Reference 4.1.5 of this report]
Limits:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]

5.5.2 Configuration of EUT

The EUT was tested in an ALSE and ambient conditions were monitored. The EUT was examined in its declared normal use position. The transmit port was terminated into a 30dB Attenuator and a 50Ohm load. RX port was terminated into a 50 Ohm load. EUT was tested across all required modes as specified in section 2.4 of this report. Both optical fibre inputs had the same converted RF signals distributed to them from the Primary/secondary hub equipment.

5.5.3 Test procedure

Tests were made in accordance with the test method noted above using the measuring equipment listed in the 'Test Equipment' Section. The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached. Peak field strength pre-scans using the field strength method were performed. The EUT's emissions were maximised by rotating it 360 degrees. This method was used to determine any signals for substitution. An RMS detector was used for any final measurements.

30MHz - 1GHz.
The measuring antenna was scanned 1 - 4m in both Horizontal and Vertical polarisations. Where required a Substitution method was performed using tuned dipoles / a calibrated bi-conical antenna. Measurement distance of 3metres was used.

1GHz – 20GHz.
The measuring antenna was used in both Horizontal and Vertical polarisations. Where required a Substitution method was performed using standard gain horn antennas. Measurement distances used were: 1 – 6 GHz at 3metres, 6 – 18 GHz at 1.2metres and 18 – 20 GHz at 0.3metres.
Tests were performed in test sites B & M.

5.5.4 Test equipment

E534, E535, E914, E745, LPE261, LPE333, TMS78, TMS79, CAL08, E830, E007-2, E453, E330, E331, E853, E268, E428, E904, E296-2, E856, E642, E412, E777

See Section 8 for more details

5.5.5 Test results

Temperature of test environment	18-20°C
Humidity of test environment	50-55%
Pressure of test environment	102kPa

Single channel results.

Note: only results within 20dB of limits are shown.
Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channel	1932.5 MHz

File Name: Zinwave Ltd.13924-1 Issue 01

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)	Antenna Polarisation	EUT Polarisation
30.24	-27.29	-14.29	Vertical	Upright
39.1	-28.38	-15.38	Vertical	Upright
45.55	-33.04	-20.04	Vertical	Upright
51.63	-37.12	-24.12	Vertical	Upright
11036	-16.3	-3.3	Horizontal	Upright
11036	-17.97	-4.97	Vertical	Upright
11497	-17.14	-4.14	Horizontal	Upright
11497	-21.37	-8.37	Vertical	Upright

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Mid channel	1960.0 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)	Antenna Polarisation	EUT Polarisation
30.24	-27.29	-14.29	Vertical	Upright
39.1	-28.38	-15.38	Vertical	Upright
45.55	-33.04	-20.04	Vertical	Upright
51.63	-37.12	-24.12	Vertical	Upright
11036	-16.3	-3.3	Horizontal	Upright
11036	-17.97	-4.97	Vertical	Upright
11497	-17.14	-4.14	Horizontal	Upright
11497	-21.37	-8.37	Vertical	Upright

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
High channel	1992.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)	Antenna Polarisation	EUT Polarisation
30.24	-27.29	-14.29	Vertical	Upright
39.1	-28.38	-15.38	Vertical	Upright
45.55	-33.04	-20.04	Vertical	Upright
51.63	-37.12	-24.12	Vertical	Upright
11036	-16.3	-3.3	Horizontal	Upright
11036	-17.97	-4.97	Vertical	Upright
11497	-17.14	-4.14	Horizontal	Upright
11497	-21.37	-8.37	Vertical	Upright

DUAL CHANNEL RESULTS.

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channels	1932.5 MHz + 1937.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)	Antenna Polarisation	EUT Polarisation
30.24	-27.29	-14.29	Vertical	Upright
39.1	-28.38	-15.38	Vertical	Upright
45.55	-33.04	-20.04	Vertical	Upright
51.63	-37.12	-24.12	Vertical	Upright
11036	-16.3	-3.3	Horizontal	Upright
11036	-17.97	-4.97	Vertical	Upright
11497	-17.14	-4.14	Horizontal	Upright
11497	-21.37	-8.37	Vertical	Upright

Setup Table

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
High channels	1987.5 MHz + 1992.5 MHz

Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Difference to Limit (dB)	Antenna Polarisation	EUT Polarisation
30.24	-27.29	-14.29	Vertical	Upright
39.1	-28.38	-15.38	Vertical	Upright
45.55	-33.04	-20.04	Vertical	Upright
51.63	-37.12	-24.12	Vertical	Upright
11036	-16.3	-3.3	Horizontal	Upright
11036	-17.97	-4.97	Vertical	Upright
11497	-17.14	-4.14	Horizontal	Upright
11497	-21.37	-8.37	Vertical	Upright

Note: Emissions in above tables are generic emissions and are present regardless of channel settings.

LIMITS:

24.133(a)

1) For transmitters authorized a bandwidth greater than 10 kHz:

(i) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (fd in kHz) of up to and including 40 kHz: at least 116 Log10 ((fd + 10)/6.1) decibels or 50 plus 10 Log10 (P) decibels or 70 decibels, whichever is the lesser attenuation;

(ii) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 40 kHz: at least 43 + 10 Log10 (P) decibels or 80 decibels, whichever is the lesser attenuation.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows: 30MHz - 1GHz ± 3.9 dB, 1 – 18 GHz ±3.5dB, 18 – 27 GHz ±3.9dB

5.6 Band edge emissions

5.6.1 Test methods

Test Requirements:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]
	FCC Part 2 Clause 2.1053 [Reference 4.1.2 of this report]
Test Method:	ANSI C63.26 2015 Clause 5.5 [Reference 4.1.4 of this report]
	KDB 935210 D05 Clause 3.6 / 4.7 [Reference 4.1.5 of this report]
Limits:	FCC Part 24 Clause 24.238 [Reference 4.1.1 of this report]

5.6.2 Configuration of EUT

EUT was tested on a bench. The EUT RF port under test was connected to a spectrum analyser via suitable attenuation. RX port was terminated into a 50 Ohm load. EUT was tested across all required modes as specified in section 2.4 of this report.

5.6.3 Test procedure

The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached per channel/band setting as required. Measurements were made and plots taken in the required Resolution bandwidths, where applicable results are referenced to EIRP limits by consideration of the antenna gain used with the EUT of 8dBi (5.85dBd) and indicated.

Compliance with MIMO operation is demonstrated by following KDB 662911 D01 section E(3) and adding 10log(2), or 3dB, to the spurious emission measured from a single unit

Tests were performed in test site A.

5.6.4 Test equipment

F075, H071, H072, E602

See Section 8 for more details

5.6.5 Test results

Temperature of test environment	18-22°C
Humidity of test environment	40-50%
Pressure of test environment	102kPa

Single channel results – SISO operation

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channel	1932.5 MHz
High channel	1992.5 MHz

	Lower band edge (1930MHz)	Upper band edge (1995MHz)
(dBm)	-25.24	-24.89
Plot reference	930-1995 single_channel_low	930-1995 single_channel_high

Single channel results – MIMO operation

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channel	1932.5 MHz
High channel	1992.5 MHz

	Lower band edge (1930MHz)	Upper band edge (1995MHz)
Measured value (dBm)	-25.24	-24.89
Add 3dB	-22.24	-21.89
Plot reference	930-1995 single_channel_low	930-1995 single_channel_high

Dual channel results – SISO operation

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channels	1932.5 + 1937.5 MHz
High channels	1987.5 + 1992.5 MHz

	Lower band edge (1930MHz)	Upper band edge (1995MHz)
Measured value (dBm)	-24.81	-25.73
Plot reference	1930-1995 Dual_channel_low	1930-1995 Dual_channel_high

Dual channel results – MIMO operation

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	5 MHz
Mod Scheme	AWGN
Low channels	1932.5 + 1937.5 MHz
High channels	1987.5 + 1992.5 MHz

	Lower band edge (1930MHz)	Upper band edge (1995MHz)
Measured value (dBm)	-24.81	-25.73
Add 3dB	-21.81	-22.73
Plot reference	1930-1995 Dual_channel_low	1930-1995 Dual_channel_high

Results are also presented graphically in section 6

LIMITS:
24.238 (a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.
In accordance with KDB 662911 D01 3dB has been added to measured results for two signal MIMO operation and then compared with the limits.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
< ± 2.8 dB

5.7 Modulation characteristics

EUT uses digital modulation techniques. Modulation schemes and information is detailed in section 2.2 of this report.

5.8 Determination of f_0

5.8.1 Test methods

Test Requirements:	KDB 935210 D05 Clause 3.3 / 4.3 [Reference 4.1.5 of this report]
Test Method:	ANSI C63.26 2015 Clause 5.5 [Reference 4.1.4 of this report]
	KDB 935210 D05 Clause 3.3 / 4.3 [Reference 4.1.5 of this report]
Limits:	None.

5.8.2 Configuration of EUT

EUT was tested on a bench. The EUT RF port under test was connected to a spectrum analyser via suitable attenuation. RX port was terminated into a 50 Ohm load. EUT was swept across the operational band with a CW signal to determine the frequency of highest power in the band. Test performed in mode 1.

5.8.3 Test procedure

Tests were made in accordance with the test method noted above using the measuring equipment listed in the 'Test Equipment' Section. The EUT system was set up to maximum gain using the network management software provided. EUT signal level was raised until maximum output power was reached. The EUT input signal was then swept across the applicable service band frequency and plots taken showing the frequency of highest power in the band (f_0).

The two radio cards in the unit are identical, so testing on one port is representative of both transmit ports.

5.8.4 Test equipment

F075, H071, H072, E602

See Section 8 for more details

5.8.5 Test results

Temperature of test environment	18-22°C
Humidity of test environment	40-50%
Pressure of test environment	102kPa

Band	1930-1995 MHz
Power Level	24 dBm
Channel Spacing	N/A
Mod Scheme	CW

Band (MHz)	f_0 determined (MHz)
1930-1995	1961.3

Note: Measurement was performed over the service band frequency range only.

Results are also presented graphically in section 6.

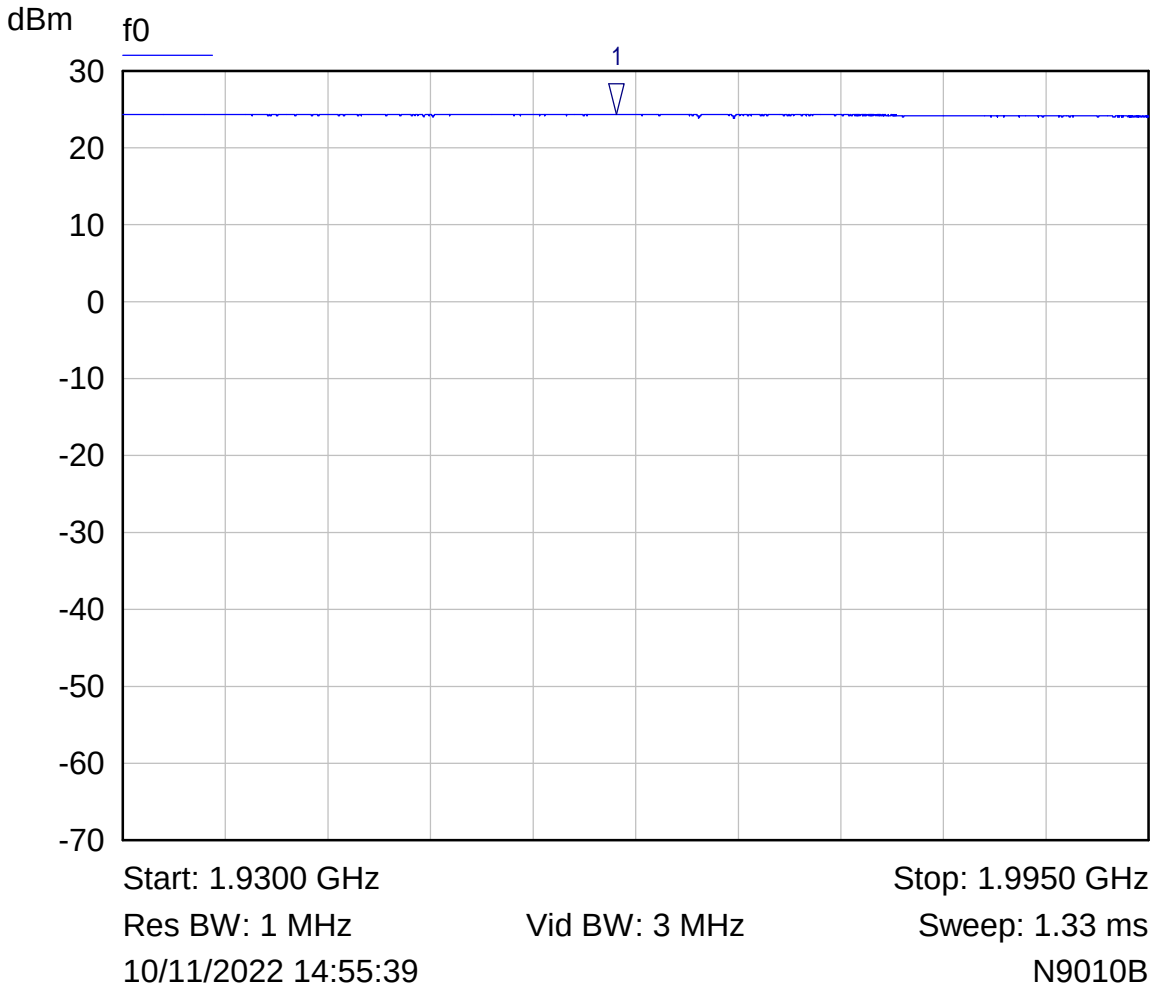
LIMITS:
None.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 1 dB

6 Plots/Graphical results

6.1 Determination of f_0

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Swept CW

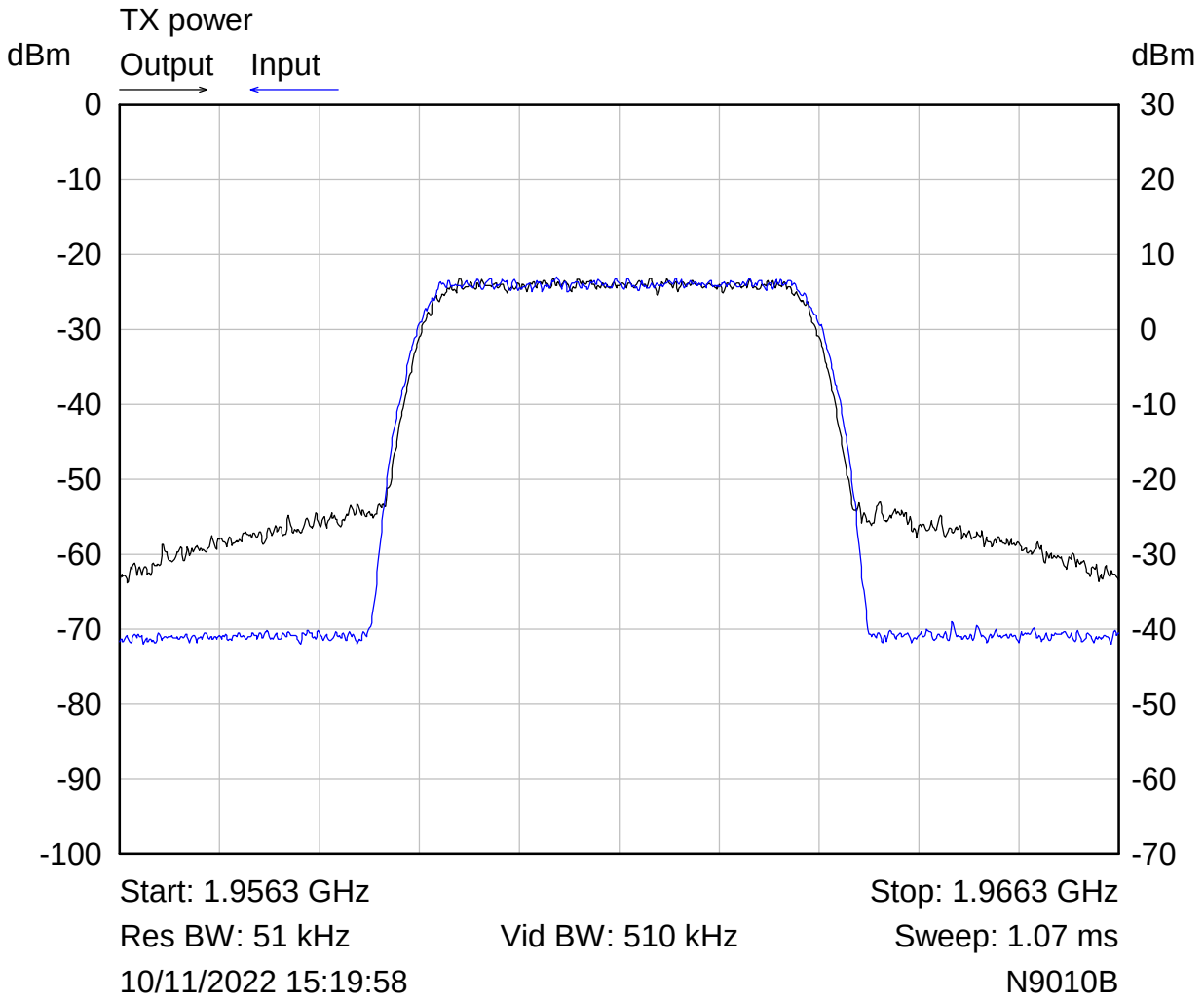


Mkr	Trace	X-Axis	Value	Notes
1 ▽	f0	1.9613 GHz	24.36 dBm	

Plot of f0 determined in band 1930-1995 MHz.

6.2 RF Power Output

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channel centre f0 of 1961.3 MHz.



Output

Measurement Parameter	Value
Total channel power	24.37 dBm

Input

Measurement Parameter	Value
Total channel power	-5.40 dBm

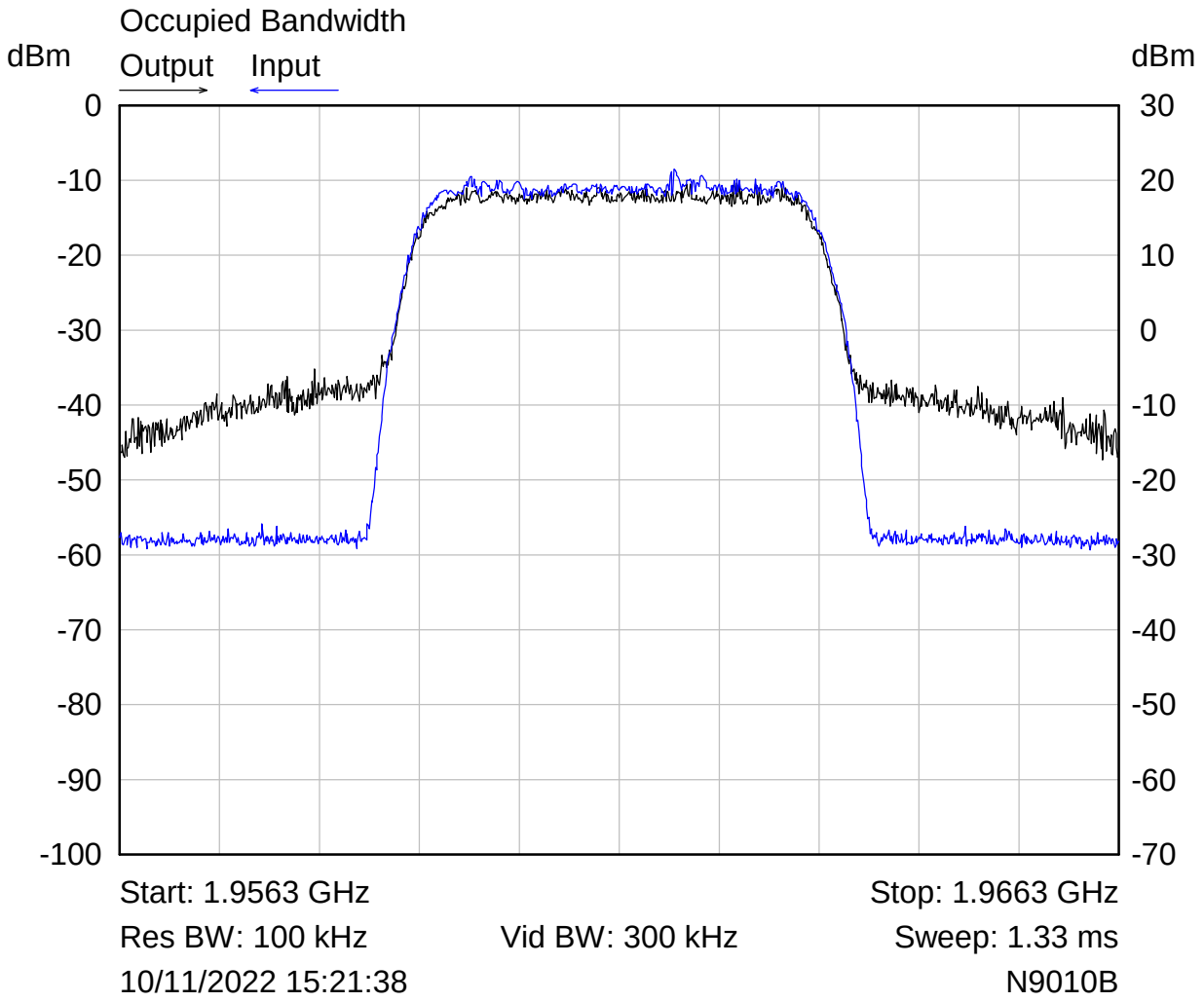
Plot of Channel power at determined f_0 in band 1930-1995 MHz (1930-1995 f0_1961.3MHz)

File Name: Zinwave Ltd.13924-1 Issue 01

Plot of Peak to Average power ratio at determined f_0 in band 1930-1995 MHz (1961.3 MHz)

6.3 Occupied bandwidth / Input versus output signal

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, f0 1961.3MHz



Output

Measurement Parameter	Value
Occupied Bandwidth	4.1142 MHz

Input

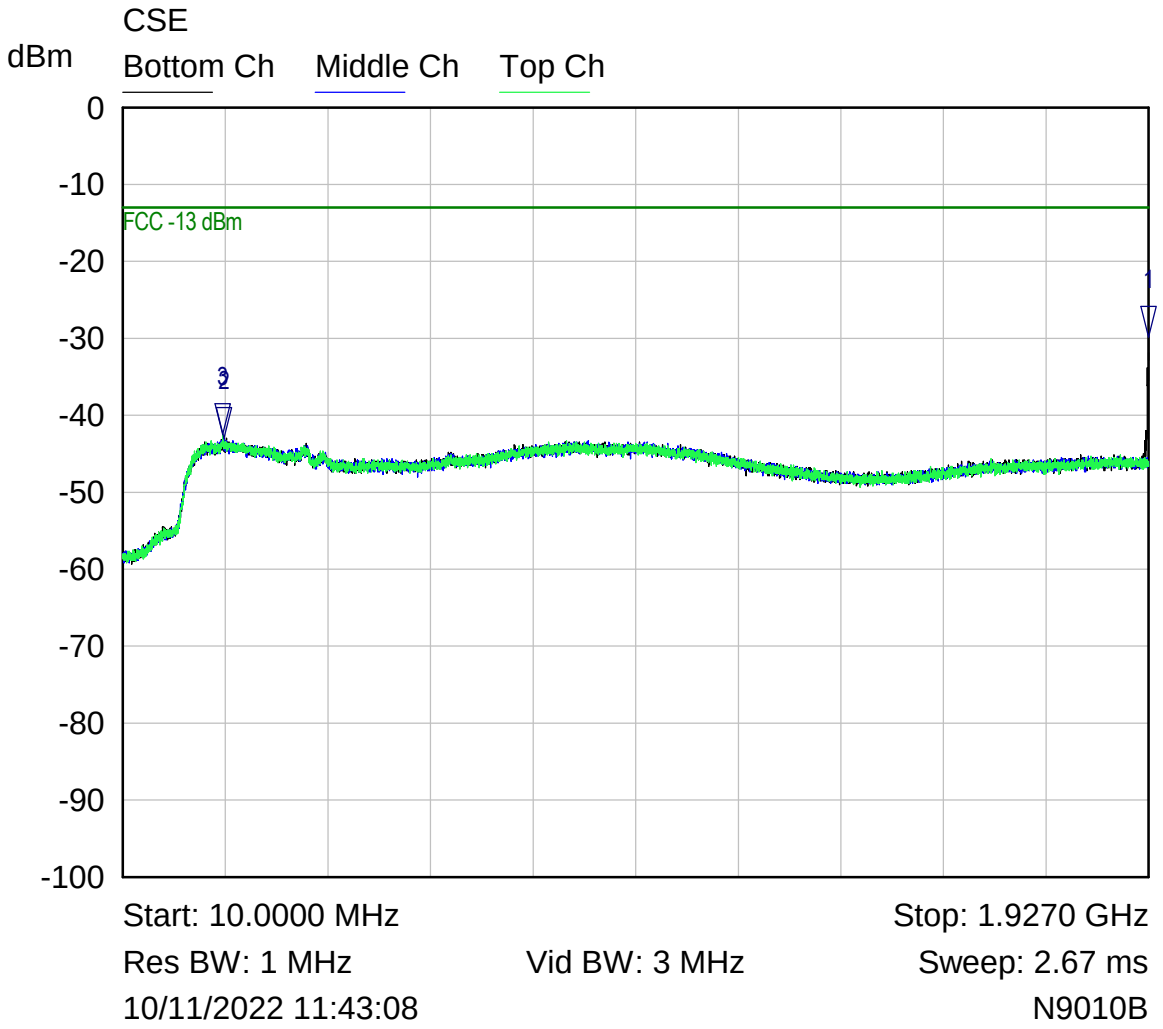
Measurement Parameter	Value
Occupied Bandwidth	4.0715 MHz

Occupied BW at f0, 1961.3MHz

File Name: Zinwave Ltd.13924-1 Issue 01

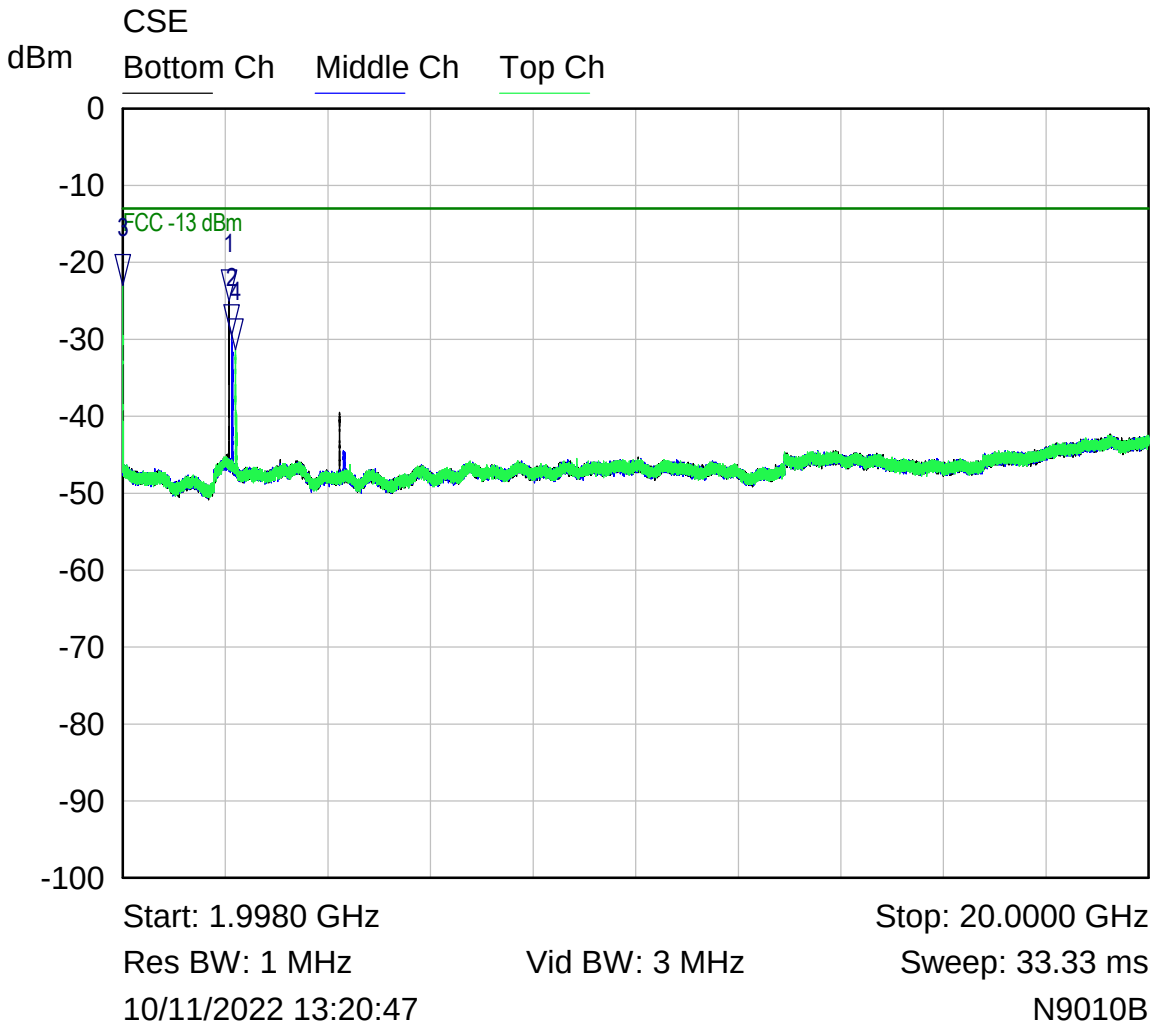
6.4 Spurious emissions at antenna terminals

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channels 1932.5 MHz, 1960 MHz, 1992.5 MHz, Single channel mode



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Bottom Ch	1.9265 GHz	-29.75 dBm	
2 ▽	Middle Ch	198.6422 MHz	-43.07 dBm	
3 ▽	Top Ch	197.2044 MHz	-42.56 dBm	

Plot of conducted emissions 10 MHz – 1.927 GHz range

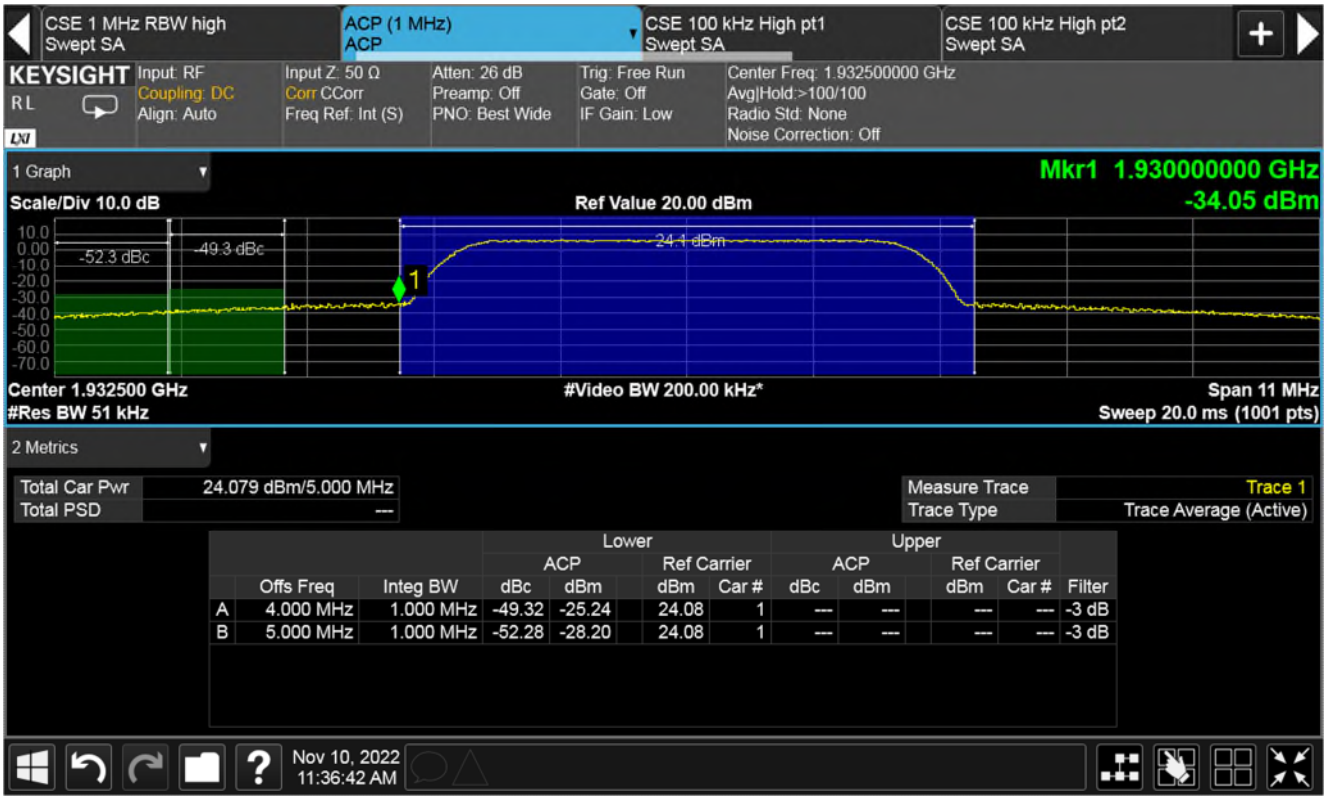


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Bottom Ch	3.8648 GHz	-25.05 dBm	
2 ▽	Middle Ch	3.9212 GHz	-29.42 dBm	
3 ▽	Top Ch	1.9980 GHz	-23.01 dBm	
4 ▽	Top Ch	3.9860 GHz	-31.27 dBm	

Plot of conducted emissions 2 GHz – 20 GHz range

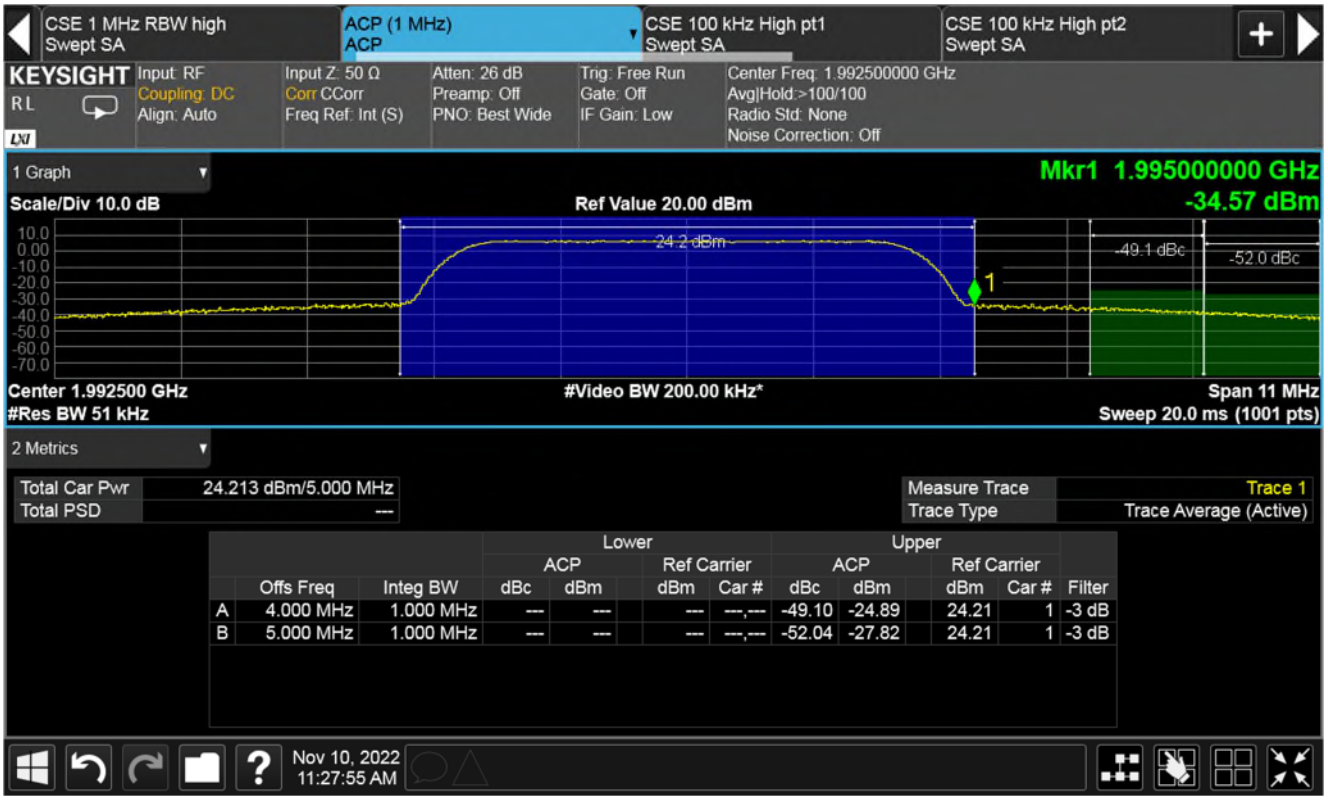
6.5 Band edge emissions

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channel 1932.5 MHz, Single channel mode



Plot of lower band edge for Low channel (1932.5 MHz)

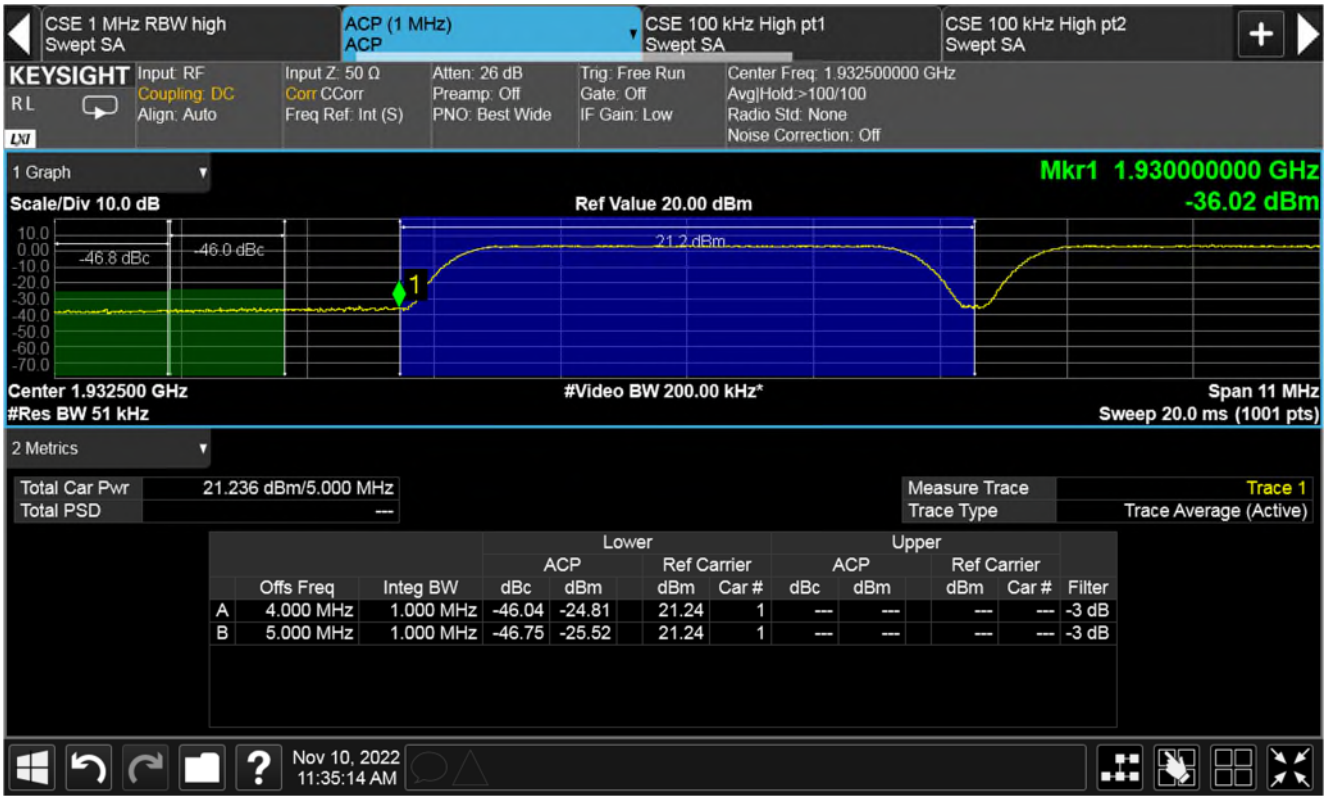
RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channel 1992.5 MHz, Single channel mode



			Lower				Upper				
			ACP		Ref Carrier		ACP		Ref Carrier		
	Offs Freq	Integ BW	dBc	dBm	dBm	Car #	dBc	dBm	dBm	Car #	Filter
A	4.000 MHz	1.000 MHz	---	---	---	---,---	-49.10	-24.89	24.21	1	-3 dB
B	5.000 MHz	1.000 MHz	---	---	---	---,---	-52.04	-27.82	24.21	1	-3 dB

Plot of upper band edge for High channel (1992.5 MHz)

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channels 1932.5 & 1937.5 MHz, Dual channel mode



Plot of lower band edge for Low channels (1932.5 & 1937.5 MHz)

RF Parameters: Band 1930-1995 MHz, Power +24 dBm, Channel Spacing 5MHz, Modulation AWGN, Channels 1987.5 & 1992.5 MHz, Dual channel mode

Plot of upper band edge for High channels (1987.5 & 1992.5 MHz)

7 Photographs

For confidentiality purposes, photographs are not included at client's request.

8 Test equipment calibration list

The following is a list of the test equipment used by R.N. Electronics Ltd to test the unit detailed within this report. In line with our procedures, the equipment was within calibration for the period during which testing was carried out.

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
CAL08	MWX221	Cable N Type to SMA Blue 2m	Junflon	12-Aug-2022	12 months
E007-2	VHA9103	Antenna Bi-con	Schwarzbeck	23-Apr-2021	36 months
E268	BHA 9118	Horn Antenna 1 - 18 GHz	Schaffner	02-Apr-2022	12 months
E330	2224-20	Horn Antenna 26.5-40GHz	Flann (FMI)	22-Apr-2022	12 months
E331	22093-KF20	Horn Antenna 26.5-40GHz	Flann (FMI)	22-Apr-2022	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	21-Jun-2022	24 months
E428	HF906	Horn Antenna 1 - 18 GHz	Rohde & Schwarz	02-Apr-2022	12 months
E453	20240-20-AA	Horn Std Gain 17.6 - 26.7 GHz	Flann (FMI)	25-May-2022	12 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	24-Jan-2022	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	25-Jan-2022	12 months
E602	MG3692A	Signal Generator 10 MHz - 20 GHz	Anritsu	21-Feb-2022	12 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	14-Dec-2021	24 months
E745	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	04-Feb-2022	12 months
E777	MG3695B	Signal Generator 8 MHz - 50 GHz	Anritsu	21-Jun-2022	12 months
E856	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	14-Dec-2021	12 months
E904	5086-7805	Pre-Amplifier 1GHz - 26.5GHz	Hewlett Packard	04-Mar-2022	12 months
E914	VULB 9163	Antenna BiLog 30MHz to 3GHz	Schwarzbeck	23-Apr-2022	12 months
F075	AA18-10H	Attenuator SMA 10dB 18GHz	AtlanTecRF	19-Aug-2022	12 months
H071	N9010B	EXA Signal Analyser 10 Hz to 44 GHz	Keysight Technologies	#09-Nov-2022	3 months
H072	N9000B	PXA Signal Analyser 9 kHz to 26.5 GHz	Keysight Technologies	09-Feb-2021	24 months
LPE261	3115	Horn Antenna 1 - 18 GHz	EMCO	02-Apr-2022	12 months
LPE333	8449B	Pre-Amplifier 1GHz - 26.5GHz	Hewlett Packard	27-May-2022	12 months
TMS78	3160-08	Horn Std Gain 12.4 - 18 GHz	ETS Systems	30-Sep-2022	12 months
TMS79	3160-09	Horn Std Gain 18 - 26.5 GHz	ETS Systems	25-May-2022	12 months

Equipment was within calibration dates for tests and has been re-calibrated since/during date of tests.

9 Auxiliary and peripheral equipment

9 .1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	N5172B	EXG signal generator	Agilent	MY53050810
2	N5172B	EXG signal generator	Keysight	MY53050728
3	15542	30 dB attenuator	Mini-Circuits	VUU78901032
4	15542	30 dB attenuator	Mini-Circuits	VUU72800911
5	UNAT-20+	20 dB attenuator	Mini-Circuits	42600852
6	UNAT-20+	20 dB attenuator	Mini-Circuits	42600852
7	306-0001	UNItivity 5000 Primary Hub	Zinwave Ltd	680102010400
8	305-0004	Zinwave Secondary Hub	Zinwave Ltd	620110000204
9	E4432B	ESG-D signal generator	Keysight	ZE000094
10	E4432B	ESG-D signal generator	Keysight	ZE000107
11	-	Dual long fibre optic cables	-	-
12	-	DC power cable	-	-
13	-	Male to Male N RF cables (x4)	-	-
14	306-0001	UNItivity 5000 primary hub	Zinwave Ltd	680102010401
15	308-0004	Zinwave Secondary Hub	Zinwave Ltd	830110000216
16	N5172B	EXG Signal Generator	Keysight	ZE0000007
17	N5172B	EXG Signal Generator	Keysight	ZE000107

9 .2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
E587	68217-02	Cable N-N	Rosenberger Micro Coax	Fa210b1015007070
E482	26-6-34	Attenuator 6dB 18GHz	Weinschel Corp	BC4907
E478	LQ2992/H	Filter Band Pass 1-3GHz	RACAL-MESL	006

10 Condition of the equipment tested

In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

10.1 Modifications before test

No modifications were made before test by RN Electronics Ltd.

10.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

11 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 293246, ISED Registration No. 5612A-4

Site C Transient Laboratory

Site D Screened Room (Conducted Immunity)

Site E Screened Room (Control Room for Site D)

Site F Screened Room (Conducted Emissions)

Site G Screened Room (Control Room for Site H)

Site H 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246, ISED Registration No. 5612A-2, VCCI Registration No. 4065

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246, ISED Registration No. 5612A-3

Site N Radio Laboratory

Site Q Fully-Anechoic Chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246, ISED Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

RN Electronics CAB identifier as issued by Innovation, Science and Economic Development Canada is UK0002
RN Electronics CAB identifier as issued by FCC is UK0015

12 Abbreviations and units

%	Percent	LBT	Listen Before Talk
µA/m	microAmps per metre	LO	Local Oscillator
µV	microVolts	mA	milliAmps
µW	microWatts	max	maximum
AC	Alternating Current	kPa	Kilopascal
ALSE	Absorber Lined Screened Enclosure	Mbit/s	MegaBits per second
AM	Amplitude Modulation	MHz	MegaHertz
Amb	Ambient	mic	Microphone
ATPC	Automatic Transmit Power Control	min	minimum
BER	Bit Error Rate	mm	milliMetres
ºC	Degrees Celsius	ms	milliSeconds
C/I	Carrier / Interferer	mW	milliWatts
CEPT	European Conference of Postal and Telecommunications Administrations	NA	Not Applicable
COFDM	Coherent OFDM	nom	Nominal
CS	Channel Spacing	nW	nanoWatt
CW	Continuous Wave	OATS	Open Area Test Site
dB	deciBels	OFDM	Orthogonal Frequency Division Multiplexing
dBµA/m	deciBels relative to 1µA/m	ppm	Parts per million
dBµV	deciBels relative to 1µV	PRBS	Pseudo Random Bit Sequence
dBc	deciBels relative to Carrier	QAM	Quadrature Amplitude Modulation
dBm	deciBels relative to 1mW	QPSK	Quadrature Phase Shift Keying
DC	Direct Current	R&TTE	Radio and Telecommunication Terminal Equipment
DTA	Digital Transmission Analyser	Ref	Reference
EIRP	Equivalent Isotropic Radiated Power	RF	Radio Frequency
ERP	Effective Radiated Power	RFC	Remote Frequency Control
EU	European Union	RSL	Received Signal Level
EUT	Equipment Under Test	RTP	Room Temperature and Pressure
FM	Frequency Modulation	RTPC	Remote Transmit Power Control
FSK	Frequency Shift Keying	Rx	Receiver
g	Grams	s	Seconds
GHz	GigaHertz	SINAD	Signal to Noise And Distortion
Hz	Hertz	Tx	Transmitter
IF	Intermediate Frequency	V	Volts
kHz	kiloHertz		