

# **TEST REPORT**

Test Report No.: UL-RPT-RP14002588-316A

Manufacturer : Cambium Networks Ltd

Model No. : 60 GHz cnWave V5000

**FCC ID** : QWP-60V5000

**Test Standard(s)** : FCC Parts 15.209, 15.215 & 15.255

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- 2. The results in this report apply only to the sample tested.
- 3. The sample tested is in compliance with the above standard(s).
- 4. The test results in this report are traceable to the national or international standards.

5. Version 3.0 supersedes all previous versions.

**Date of Issue:** 07 December 2023

Checked by:

Sarah Williams

RF Operations Leader, Radio Laboratory

**Company Signatory:** 

Ben Mercer

Lead Project Engineer, Radio Laboratory



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The tests reported herein have been performed in accordance with its terms of accreditation.

Telephone: +44 (0)1256 312000 Facsimile: +44 (0)1256 312001 TEST REPORT SERIAL NO: UL-RPT-RP14002588-316A

VERSION 3.0 ISSUE DATE: 07 DECEMBER 2023

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### **Table of Contents**

1. Customer Information	4
2. Summary of Testing	<b>5</b> 5 5 5 5 5
3. Equipment Under Test (EUT) 3.1. Identification of Equipment Under Test (EUT) 3.2. Description of EUT 3.3. Modifications Incorporated in the EUT 3.4. Additional Information Related to Testing 3.5. EUT Settings 3.6. Support Equipment	
4. Operation and Monitoring of the EUT during Testing  4.1. Operating Modes  4.2. Configuration and Peripherals	
5. Measurements, Examinations and Derived Results 5.1. General Comments 5.2. Test Results 5.2.1. Transmitter EIRP 5.2.2. Transmitter Peak Conducted Output Power 5.2.3. Transmitter 6 dB Bandwidth 5.2.4. Transmitter 20 dB Bandwidth 5.2.5. Transmitter Radiated Spurious Emissions	9 10 10 13 15 18 21
6 Measurement Uncertainty & Decision Rule	25
7. Report Revision History	26

# 1. Customer Information

Company Name:	Cambium Networks Ltd
Address:	Unit B2 Linhay Business Park Eastern Road Ashburton Devon TQ13 7UP United Kingdom

## 2. Summary of Testing

### 2.1. General Information

Specification Reference:	47CFR15.255
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Radio Frequency Devices) – Section 15.255
Specification Reference:	47CFR15.209 and 47CFR15.215
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.209 & 15.215
Site Registration:	685609
Lab. Designation No.:	UK2011
Location of Testing:	Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	12 April 2023 to 26 October 2023

### 2.2. Summary of Test Results

FCC Reference (47CFR) Measurement		Result
Part 15.255(c)(1)(i)	Transmitter EIRP	<b>②</b>
Part 15.255(e)	Transmitter Peak Output Power	<b>②</b>
Part 15.255(e)(1)	Transmitter 6 dB Bandwidth	<b>②</b>
Part 15.215(c)	Transmitter 20 dB Bandwidth	<b>②</b>
Part 15.255(d) / 15.209	Transmitter Spurious Emissions	<b>②</b>
Key to Results		

#### 2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

### 2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

### 3. Equipment Under Test (EUT)

### 3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Cambium Networks
Model Name or Number:	60 GHz cnWave V5000
Serial Number:	V5XM04KXS395
Hardware Version Number:	P9.3
Software Version Number:	1.2.2.1
FCC ID:	QWP-60V5000

#### 3.2. Description of EUT

The equipment under test was a point-to-multipoint distribution node operating in the 57-71 GHz band.

#### 3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

#### 3.4. Additional Information Related to Testing

Category of Equipment:	Transceiver		
Channel Spacing:	4.32 GHz		
Modulation Type:	BPSK, QPSK & 16QAM		
Antenna Type:	Integrated Patch		
Antenna Gain:	22.5 dBi		
Transmit Frequency Range:	57 GHz to 66 GHz		
Transmit Channels Tested:	Channel ID Channel No. Channel Frequency (GHz)		
	Bottom	9	59.400
	Middle	10	61.560
	Тор	11	63.720
Power Supply Requirement:	Nominal	56 VDC via 120 VAC	PoE

#### 3.5. EUT Settings

Channel	Sector	TPC	Tx LO GC	Notch
9	16	4	3	-
10	16	4	3	-
11	16	4	3	-

### 3.6. Support Equipment

The following support equipment was used to exercise the EUT during testing:

Description:	PoE
Brand Name:	Cambium Networks
Model Name or Number:	NET-P60-56IN (N000000L142A)
Serial Number:	2020000773

Description:	Test Laptop
Brand Name:	Dell
Model Name or Number:	Latitude E7440
Serial Number:	67QBV32

Description:	Ethernet Cables. Quantity 2. Length 1 m / 3 m	
Brand Name:	RS Pro	
Model Name or Number:	Not marked or stated	
Serial Number:	Not marked or stated	

### 4. Operation and Monitoring of the EUT during Testing

### 4.1. Operating Modes

The EUT was tested in the following operating mode(s):

- Transmitting with BPSK MCS5 modulation, which was found to be the worst-case mode after preliminary investigation.
- Operating on bottom, middle, and top channels with a 4.32 GHz channel bandwidth.
- Transmitting at maximum output power with beamforming locked to sector 16 (straight ahead), which was found to be the direction of highest EIRP during preliminary investigation.

#### 4.2. Configuration and Peripherals

The EUT was tested in the following configuration(s):

- A laptop PC with Qualcomm DMTools and QRCT software was used to configure the EUT during the testing. Telnet commands were used to set the notch filter. The laptop was connected to the EUT via Ethernet.
- The EUT was powered by a PoE supply connected to 120 VAC mains.
- The EUT has 2 pairs of identical patch antenna, two to the left and two to the right, with each pair independently serving different sectors. Only one patch of each pair can transmit at a time.
   Testing was performed on one patch only.

### 5. Measurements, Examinations and Derived Results

#### 5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to Section 6: Measurement Uncertainties for details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

Page 9 of 26

#### 5.2. Test Results

#### 5.2.1. Transmitter EIRP

#### **Test Summary:**

Test Engineers:	Shamraiz Ashiq & Ben Mercer	Test Date:	12 April 2023
Test Sample Serial Number:	V5XM04KXS395		

FCC Reference:	Part 15.255(c)(1)(i)
Test Method Used:	ANSI C63.10 Section 9.11

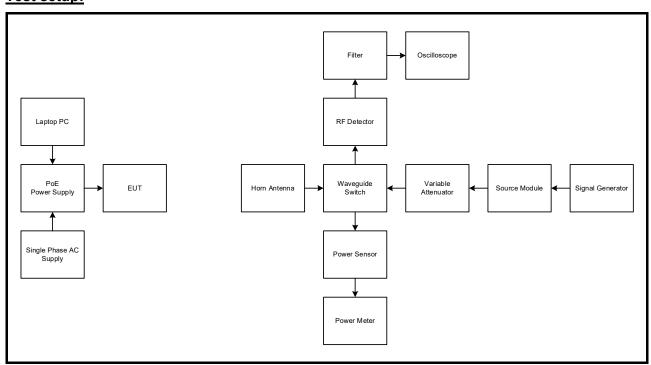
#### **Environmental Conditions:**

Temperature (°C):	19
Relative Humidity (%):	45

#### Note(s):

- The measurement antenna was connected to an RF detector via a 4-way waveguide switch. A CW signal generator and wideband thermocouple power sensor were connected to the remaining two ports.
- 2. The RF detector was connected to the 50  $\Omega$  input of a digital storage oscilloscope via a 10 MHz low pass filter.
- 3. The EUT peak and average voltages were measured on the oscilloscope. The waveguide switch was then rotated to connect the signal generator to the RF detector, and the signal generator output was adjusted to match the previously measured voltages. The waveguide switch was then rotated to connect the signal generator output to the thermocouple power sensor, and the signal generator output power was measured.
- 4. The substituted levels recorded below include the calibrated path loss of the waveguide switch.

#### **Test setup:**



ISSUE DATE: 07 DECEMBER 2023

### **Transmitter EIRP (continued)**

#### **Results: Bottom Channel / Peak**

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
59.400	4.85	35.9	43.0	7.1	Complied

#### Results: Bottom Channel / Average

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
59.400	4.15	35.5	40.0	4.5	Complied

#### **Results: Middle Channel / Peak**

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
61.560	5.60	36.4	43.0	6.6	Complied

#### Results: Middle Channel / Average

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
61.560	5.08	36.1	40.0	3.9	Complied

#### Results: Top Channel / Peak

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
63.720	6.42	37.3	43.0	5.7	Complied

### Results: Top Channel / Average

Frequency (GHz)	Level (V)	Substituted EIRP Level (dBm)	Limit (dBm)	Margin (dB)	Result
63.720	5.53	36.9	40.0	3.1	Complied

### **Transmitter EIRP (continued)**

### **Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0001	3m RSE Chamber	Rainford EMC	NA	NA	06 Sep 2024	12
M2040	Thermohygrometer	Testo	608-H1	45124934	09 Dec 2023	12
M2070	Oscilloscope	Keysight	DSOX2024A	MY59125508	22 Feb 2024	24
M281	Power Meter	Hewlett Packard	E4418A	GB37170210-01	18 May 2024	12
M1958	Waveguide Power Sensor	Keysight	E8486A	MY55050008	24 May 2024	12
G0640	Signal Generator	Keysight	E8257D	US00000055	10 Jan 2025	24
M1255	Source Module	Hewlett Packard	83557A	2948A00169	Calibrated before use	-
A2964	Horn Antenna	Link Microtek	AM15HA-ULV1	14930	24 Jun 2025	36
A3252	Low Pass Filter	Mini-Circuits	BLP-10.7+	YUU54901833	Calibrated before use	-

#### 5.2.2. Transmitter Peak Conducted Output Power

#### **Test Summary:**

Test Engineers:	Shamraiz Ashiq & Ben Mercer	Test Date:	12 April 2023
Test Sample Serial Number:	V5XM04KXS395		

FCC Reference:	Part 15.255(e)
Test Method Used:	ANSI C63.10 Section 9.11

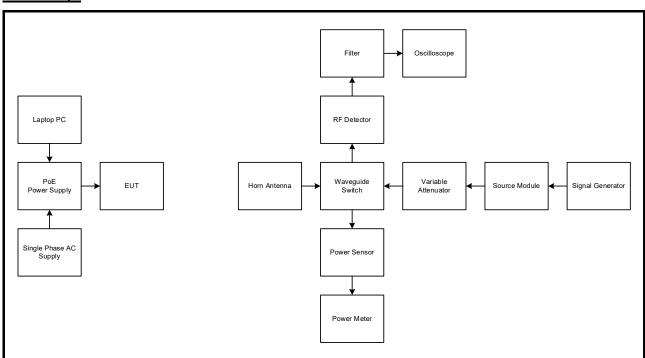
#### **Environmental Conditions:**

Temperature (°C):	19
Relative Humidity (%):	45

#### Note(s):

- The measurement antenna was connected to an RF detector via a 4-way waveguide switch. A CW signal generator and wideband thermocouple power sensor were connected to the remaining two ports.
- 2. The RF detector was connected to the 50  $\Omega$  input of a digital storage oscilloscope via a 10 MHz low pass filter.
- 3. The EUT peak and average voltages were measured on the oscilloscope. The waveguide switch was then rotated to connect the signal generator to the RF detector, and the signal generator output was adjusted to match the previously measured voltages. The waveguide switch was then rotated to connect the signal generator output to the thermocouple power sensor, and the signal generator output power was measured.
- 4. The stated antenna gain was subtracted from the measured EIRP to obtain the conducted power.
- 5. The substituted levels recorded below include the calibrated path loss of the waveguide switch.

#### Test setup:



VERSION 3.0

ISSUE DATE: 07 DECEMBER 2023

### **Transmitter Peak Conducted Output Power (continued)**

#### **Results: Bottom Channel**

EIRP Level (dBm)	Antenna Gain (dBi)	Conducted Level (dBm)	Conducted Level (mW)	Limit (mW)	Margin (mW)	Result
35.9	22.5	13.4	21.9	500	478.1	Complied

#### **Results: Middle Channel**

EIRP Level (dBm)	Antenna Gain (dBi)	Conducted Level (dBm)	Conducted Level (mW)	Limit (mW)	Margin (mW)	Result
36.4	22.5	13.9	24.5	500	475.5	Complied

### **Results: Top Channel**

EIRP Level (dBm)	Antenna Gain (dBi)	Conducted Level (dBm)	Conducted Level (mW)	Limit (mW)	Margin (mW)	Result
37.3	22.5	14.8	30.2	500	469.8	Complied

#### **Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0001	3m RSE Chamber	Rainford EMC	NA	NA	06 Sep 2024	12
M2040	Thermohygrometer	Testo	608-H1	45124934	09 Dec 2023	12
M2070	Oscilloscope	Keysight	DSOX2024A	MY59125508	22 Feb 2024	24
M281	Power Meter	Hewlett Packard	E4418A	GB37170210-01	18 May 2024	12
M1958	Waveguide Power Sensor	Keysight	E8486A	MY55050008	24 May 2024	12
G0640	Signal Generator	Keysight	E8257D	US00000055	10 Jan 2025	24
M1255	Source Module	Hewlett Packard	83557A	2948A00169	Calibrated before use	-
A2964	Horn Antenna	Link Microtek	AM15HA-ULV1	14930	24 Jun 2025	36
A3252	Low Pass Filter	Mini-Circuits	BLP-10.7+	YUU54901833	Calibrated before use	-

#### 5.2.3. Transmitter 6 dB Bandwidth

#### **Test Summary:**

Test Engineers:	Shamraiz Ashiq & Ben Mercer	Test Date:	19 October 2023
Test Sample Serial Number:	V5XM04KXS395		

FCC Reference:	Part 15.255(e)(1)
Test Method Used:	ANSI C63.10 Section 9.3

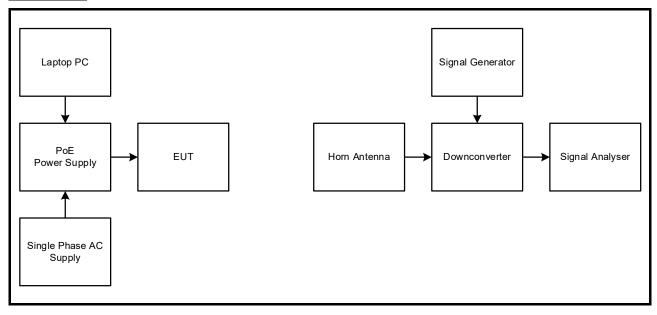
#### **Environmental Conditions:**

Temperature (°C):	21
Relative Humidity (%):	57

#### Note(s):

1. The analyser span was set to between two and three times the emission bandwidth. The RBW was set to 100 kHz, and the VBW was set to three times the RBW. The marker delta function was used to measure 6 dB down from the peak on both sides of the emission. The resulting frequency delta between the two markers was recorded as the emission bandwidth.

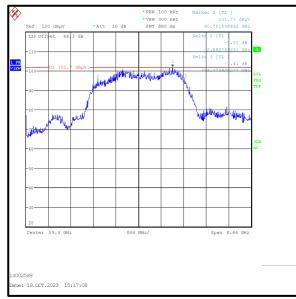
#### **Test setup:**

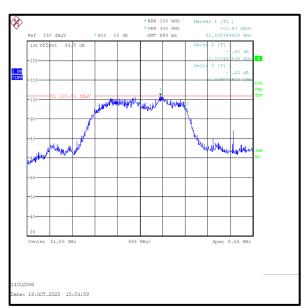


### **Transmitter 6 dB Bandwidth (continued)**

#### Results:

Channel	RBW (kHz)	VBW (kHz)	Emission Bandwidth (MHz)
Bottom	100	300	3361.846
Middle	100	300	3389.539
Тор	100	300	2988.231





#### **Bottom Channel**

**Top Channel** 

**Middle Channel** 

### **Transmitter 6 dB Bandwidth (continued)**

### **Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0010	3m RSE Chamber	Rainford EMC	N/A	N/A	11 Oct 2024	12
M2041	Thermohygrometer	Testo	608-H1	45119912	09 Dec 2023	12
M1886	Test Receiver	Rohde & Schwarz	ESU26	100554	02 Jul 2024	12
M2069	Downconverter	Virginia Diodes	WR15SAX	SAX 394	16 Oct 2025	24
G0640	Signal Generator	Keysight	E8257D	US00000055	10 Jan 2025	24
A2964	Horn Antenna	Link Microtek	AM15HA-ULV1	14930	24 Jun 2025	36

#### 5.2.4. Transmitter 20 dB Bandwidth

#### **Test Summary:**

Test Engineers:	Shamraiz Ashiq & Ben Mercer	Test Date:	19 October 2023
Test Sample Serial Number:	V5XM04KXS395		

FCC Reference:	Part 15.215(c)
Test Method Used:	ANSI C63.10 Section 6.9.2

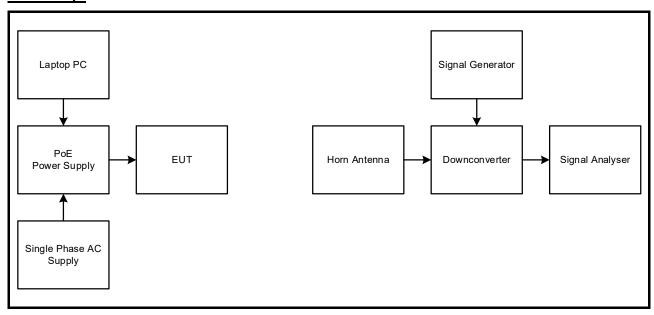
#### **Environmental Conditions:**

Temperature (°C):	21
Relative Humidity (%):	57

#### Note(s):

1. The signal analyser resolution bandwidth was set to 1 MHz and the video bandwidth to 3 MHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 8.64 GHz. The marker delta function was used to measure 20 dB down from the peak on both sides of the emission. The resulting frequency delta between the two markers was recorded as the 20 dB bandwidth.

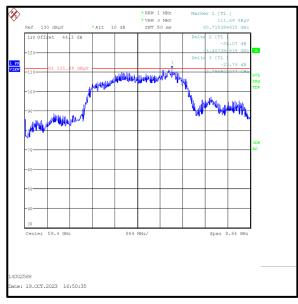
#### Test setup:



### **Transmitter 20 dB Bandwidth (continued)**

#### Results:

Channel	RBW (kHz)	VBW (kHz)	Emission Bandwidth (MHz)
Bottom	1000	3000	6204.308
Middle	1000	3000	5289.231
Тор	1000	3000	6948.616





#### **Bottom Channel**



**Top Channel** 

**Middle Channel** 

ISSUE DATE: 07 DECEMBER 2023

### **Transmitter 20 dB Bandwidth (continued)**

### **Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0010	3m RSE Chamber	Rainford EMC	N/A	N/A	11 Oct 2024	12
M2041	Thermohygrometer	Testo	608-H1	45119912	09 Dec 2023	12
M1886	Test Receiver	Rohde & Schwarz	ESU26	100554	02 Jul 2024	12
M2069	Downconverter	Virginia Diodes	WR15SAX	SAX 394	16 Oct 2025	24
G0640	Signal Generator	Keysight	E8257D	US00000055	10 Jan 2025	24
A2964	Horn Antenna	Link Microtek	AM15HA-ULV1	14930	24 Jun 2025	36

ISSUE DATE: 07 DECEMBER 2023

#### 5.2.5. Transmitter Radiated Spurious Emissions

#### **Test Summary:**

Test Engineers:	Shamraiz Ashiq & Ben Mercer	Test Dates:	19 October 2023 & 26 October 2023
Test Sample Serial Number:	V5XM04KXS395		

FCC Reference:	Part 15.255(d) / 15.209
Test Method Used:	ANSI C63.10 Sections 6.3, 6.6, 9.8, 9.9, 9.12 & 9.13
Frequency Range:	1 to 8 GHz, 110 to 140 GHz

#### **Environmental Conditions:**

Temperature (°C):	21 to 22
Relative Humidity (%):	50 to 57

#### Note(s):

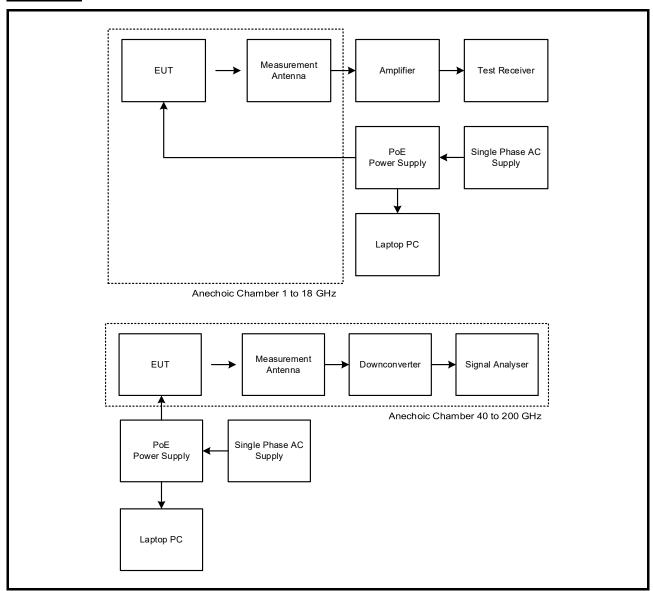
- 1. Full range spurious emissions testing was performed using a 2.16 GHz channel bandwidth under test report UL-RPT-RP13194254-3216A V2.0. Testing in this report has been reduced to known emission frequencies from the 2.16 GHz testing.
- 2. The final measured value, for the given emission in the field strength result tables, incorporates the calibrated antenna factor and cable loss.
- 3. Pre-scans were performed on middle channel. Final measurements were performed on bottom, middle and top channel.
- 4. All other emissions were greater than 20 dB below the applicable limit or below the noise floor of the measurement system.
- 5. Final measurements above 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
- 6. Part 15.255(d)(3) defines a power density limit of 90 pW/cm² at 3 metres for spurious emissions between 40 GHz and 200 GHz. This was converted to a field strength limit of 85.31 dBuV/m using the equations provided in section 9.6 of ANSI C63.10.
- 7. Measurements distances above 40 GHz were determined using the procedure defined in section 9.8 of ANSI C63.10. Measurements were made at the following distances:

#### 110 GHz to 140 GHz - 1 metre

8. Where measurements were performed at a distance other than that specified by the limit, a correction factor was calculated using the equation provided in section 9.4 of ANSI C63.10. This correction factor was included in the transducer factor entered on the signal analyser.

#### **Transmitter Radiated Spurious Emissions (continued)**

#### **Test Setup:**



#### **Transmitter Radiated Spurious Emissions (continued)**

#### Results: Bottom Channel / Peak

Frequency (MHz)	Antenna Polarity	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Margin (dB)	Result
1050.380	Horizontal	49.8	74.0	24.2	Complied
7425.033	Horizontal	52.5	74.0	21.5	Complied

#### Results: Bottom Channel / Average

Frequency (MHz)	Antenna Polarity	Average Level (dBμV/m)	Average Limit (dB <sub>μ</sub> V/m)	Margin (dB)	Result
1050.380	Horizontal	43.2	54.0	10.8	Complied
7425.054	Horizontal	49.2	54.0	4.8	Complied
117038.480	Vertical	80.4	85.3	4.9	Complied
120558.700	Vertical	81.8	85.3	3.5	Complied

### **Results: Middle Channel / Peak**

Frequency (MHz)	Antenna Polarity	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Margin (dB)	Result
1050.380	Horizontal	49.8	74.0	24.2	Complied
7694.909	Horizontal	55.3	74.0	18.7	Complied

#### Results: Middle Channel / Average

Frequency (MHz)	Antenna Polarity	Average Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
1050.380	Horizontal	43.2	54.0	10.8	Complied
7694.983	Horizontal	52.6	54.0	1.4	Complied
121358.430	Vertical	78.7	85.3	6.6	Complied
124878.400	Vertical	79.2	85.3	6.1	Complied

#### **Results: Top Channel / Peak**

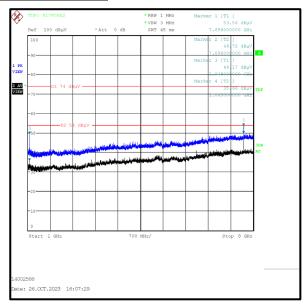
Frequency (MHz)	Antenna Polarity	Peak Level (dBμV/m)	Peak Limit (dBμV/m)	Margin (dB)	Result
1050.380	Horizontal	49.8	74.0	24.2	Complied
7964.969	Horizontal	55.9	74.0	18.1	Complied

### Results: Top Channel / Average

Frequency (MHz)	Antenna Polarity	Average Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
1050.380	Horizontal	43.2	54.0	10.8	Complied
7964.831	Horizontal	53.2	54.0	0.8	Complied
125678.474	Vertical	78.8	85.3	6.5	Complied
129198.579	Vertical	81.1	85.3	4.2	Complied

#### **Transmitter Radiated Spurious Emissions (continued)**

#### **Middle Channel:**





Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying table.

#### **Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0017	3m RSE Chamber	MVG Industries UK Ltd.	N/A	N/A	08 Nov 2023	12
M2003	Thermohygrometer	Testo	608-H1	45046641	09 Dec 2023	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	02 Nov 2023	12
A2889	Horn Antenna	Schwarzbeck	BBHA 9120 B	00653	06 Nov 2024	12
A2863	Pre-Amplifier	Keysight Technologies Inc	8449B	3008A02100	30 Oct 2024	12
M1832	Signal Analyser	Keysight Technologies Inc	N9010A	MY53470303	18 May 2024	24
A2968	Horn Antenna	Link Microtek Ltd.	AM7HA- ULV1	14934	06 Mar 2024	12
M2066	Downconverter	Virginia Diodes, Inc.	WR6.5SAX	SAX 392	31 May 2024	24

ISSUE DATE: 07 DECEMBER 2023

### 6 Measurement Uncertainty & Decision Rule

#### **Overview**

No measurement or test can ever be perfect, and the imperfections give rise to error of measurement in the results. Consequently, the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

#### **Decision Rule**

The decision rule applied is based upon the accuracy method criteria. The measurement uncertainty is met and the result is considered in conformance with the requirement criteria if the observed value is within the prescribed limit.

#### **Measurement Uncertainty**

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document "approximately" is interpreted as meaning "effectively" or "for most practical purposes".

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
Transmitter EIRP	57 to 71 GHz	95%	±2.70 dB
Transmitter Peak Output Power	57 to 71 GHz	95%	±2.70 dB
Transmitter 6 dB Bandwidth	57 to 71 GHz	95%	±4.59 %
Transmitter 20 dB Bandwidth	57 to 71 GHz	95%	±4.59 %
Transmitter Radiated Emissions	1 GHz to 40 GHz	95%	±3.16 dB
Transmitter Radiated Emissions	40 GHz to 200 GHz	95%	±5.12 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

# 7. Report Revision History

Version	Revision De	Revision Details		
Number	Page No(s)	Clause	Details	
1.0	-	-	Initial Version	
2.0	-	-	Testing repeated with new FW and no notch filter	
3.0	17	5.2.3	M2069 cal due date corrected	
	18	5.2.4	Span corrected in note 1	
	20	5.2.4	M2069 cal due date corrected	

--- END OF REPORT ---