Eurofins York Castleford
Unit 5, Speedwell Road
Castleford, WF10 5PY
United Kingdom
+44 (0) 1977 731173
enquiryyork@eurofins.com
eurofins.co.uk/york

Test Report for the EMC Testing of Raspberry Pi Pico W for Raspberry Pi Ltd

Test Report number 14531TR2

Project number B5190_1

Author: .....
M Dyster Test Technician

Checked: .....
S Seller BSc Senior EMC Engineer

Approved: .....
S Seller BSc Senior EMC Engineer

Issue	Description						Issue by	Date
2	*Copy 1*		*Copy 2*		*PDF*		*MD*	*05 May 2022*

Registered Address:
Eurofins York
i54 Business Park, Valiant Way
Wolverhampton, WV9 5GB, UK

Registered in England and Wales
Company Reg. No. 6048589
VAT Reg. No. GB 887 1276 83

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Test Report Change History

Issue	Date	Modification Details
1	08/03/2022	Original issue of test report
2	05/05/2022	Company name updated
3		
4		
5		
6		
7		
8		
9		
10		

Section 1Test Location

All testing was performed at;

Eurofins York Ltd	Unit 5
	Speedwell Road
	Castleford
	WF10 5PY
Tel:	01977 731173
Website	https://www.yorkemc.com
UKAS Testing No.	1574

1.1 UKAS Accreditation

Tests marked "Not UKAS Accredited" in this report are not included in the UKAS Accreditation Schedule for our laboratory.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

Eurofins York, Castleford latest accreditation schedule can be found at:

http://www.ukas.org/testing/lab_detail.asp?lab_id=989&location_id=&vMenuOption=3

Eurofins York, is a recognised test facility with the Federal Communications Commission (FCC). The appropriate FCC recognition number is UK2013, recognition date 5th September 2017.

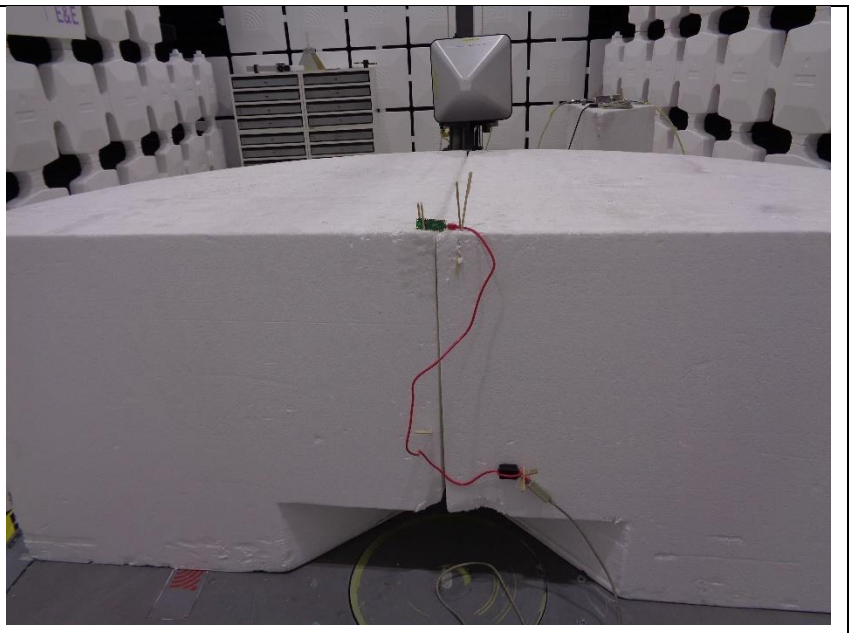
Section 2 Customer Information

Company name	Raspberry Pi Ltd
Address	Maurice Wilkes Building
	St. John's Innovation Park
	Cowley Road
	Cambridge
	CB4 0DS
Tel:	07969 247 428
Contact	Tom Westcott
Email	tom.westcott@raspberrypi.com
Customer Representative(s) present during testing	N\A

Section 3 Equipment Details

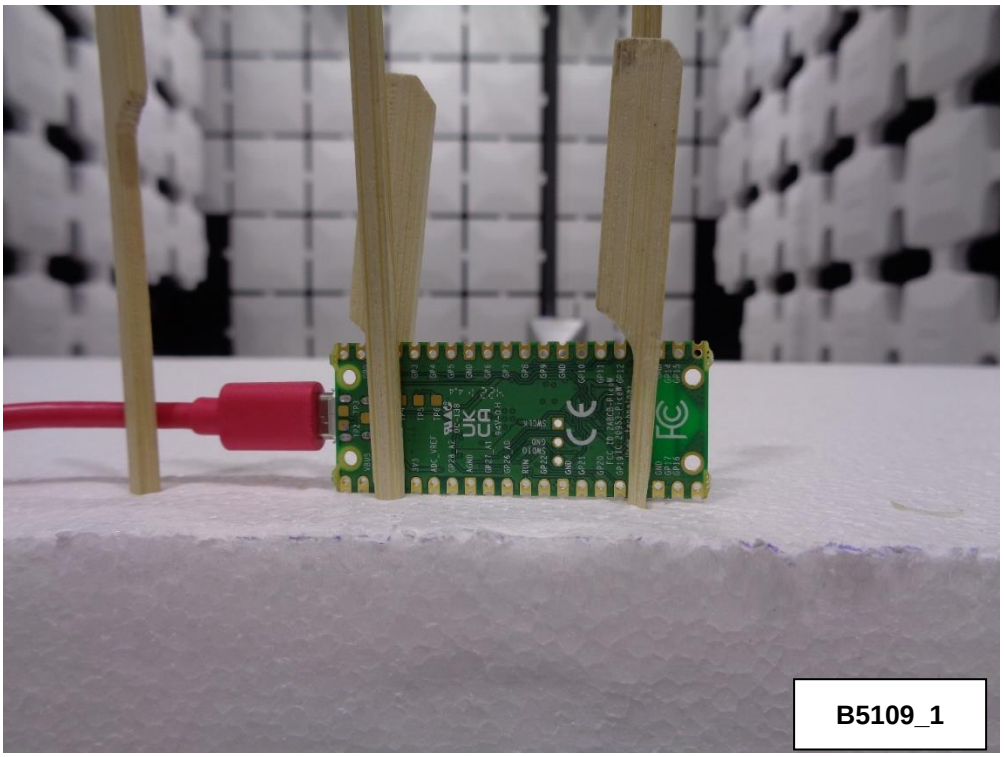
3.1 Equipment Under Test (EUT)

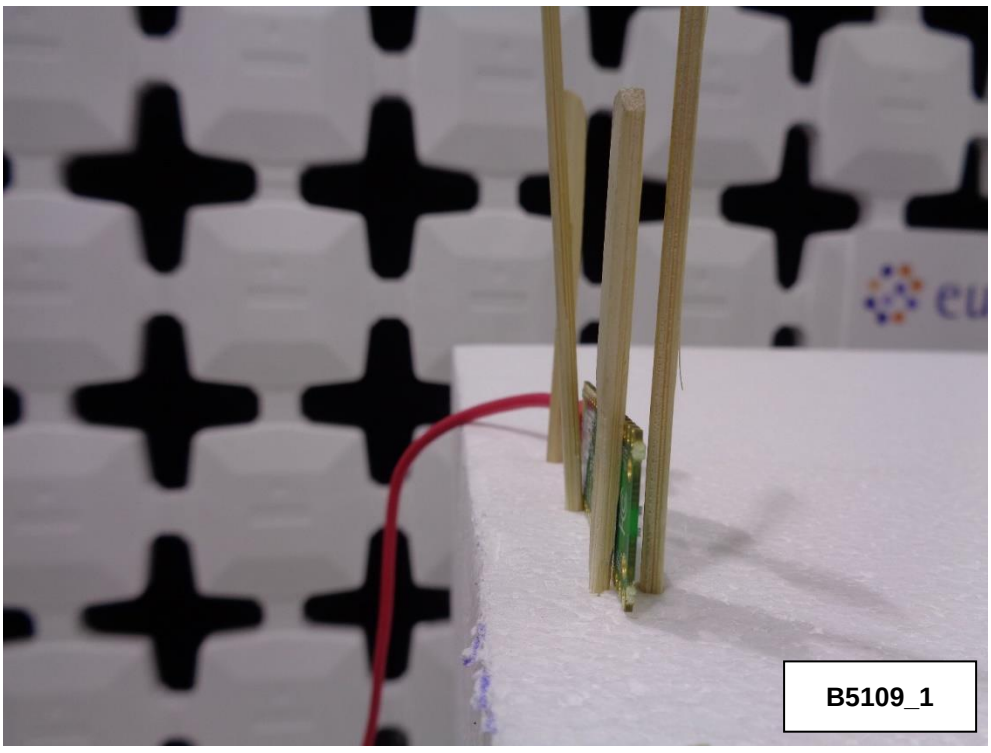
Date received:	08/02/2022						
EUT name:	Raspberry Pi Pico W						
Type/Part no:	Raspberry Pi Pico W						
Serial no/s:	Rad 1 & Rad 2						
EUT description:	The Raspberry Pi Pico W is a small single board microprocessor board. The user connects the board to a host via a micro USB connector. This connection provides power and operation functionality. The product is supplied with an operating system. The board has a CYW43439 Bluetooth and Wi-Fi combo chip which allows the user to connect to a 2.4GHz Wi-Fi networks, BT Classic 5 compliant devices and BT-LE devices. The system uses a single PCB Niche single band antenna with a centre frequency of 2450 MHz.						
No of units tested:	One						
EUT power:							
	3.3	V	Battery operation (Via USB)				
Highest internal frequency:	2.4GHz (Wifi/Bluetooth)						
Cables: USB	Cable 1		5	m	Unscreened	Terminated	
Size of EUT (mm)	L: -	55	W: -		23	H: -	4
Tested as	Table top						
Mode/s of operation	Test software simulates normal Wi-Fi operation.						
Firmware Version	N\A						
Software Version	Pico Wifi Scan Emc						
Client modification statement:	N\A						
Modifications incorporated during testing:	For radiated measurements a Wurth 742 711 31 S ferrite was placed on the USB cable between the EUT and the Auxiliary PC. This encompassed 2 turns of the USB cable and was positioned approximately 1m from the EUT.						

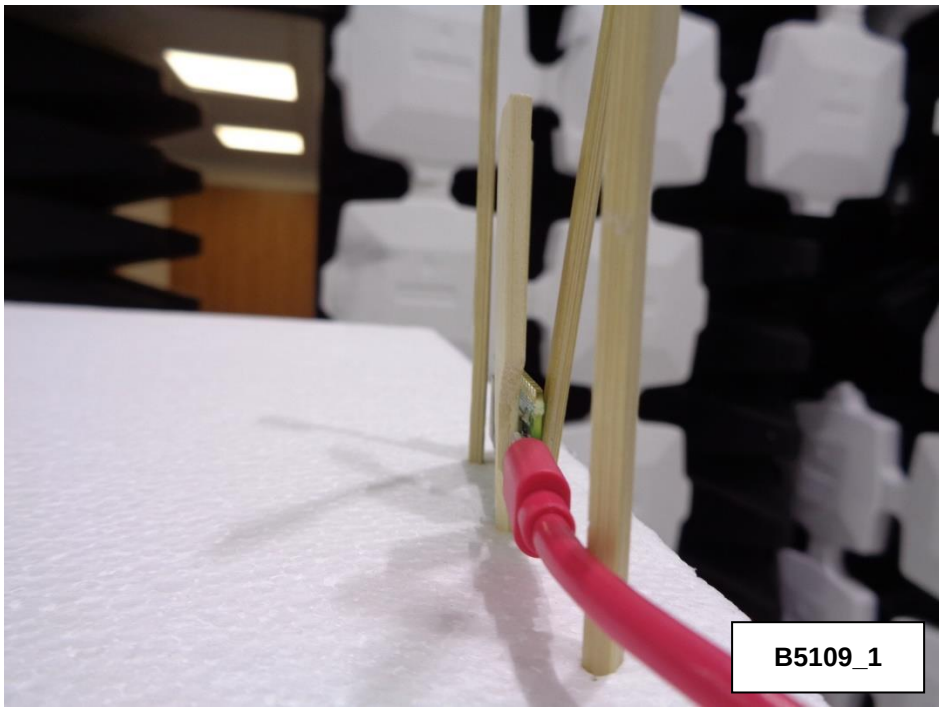
	

Radio Module(s)	CYW43439 Bluetooth and Wi-Fi combo

3.2 EUT Photos



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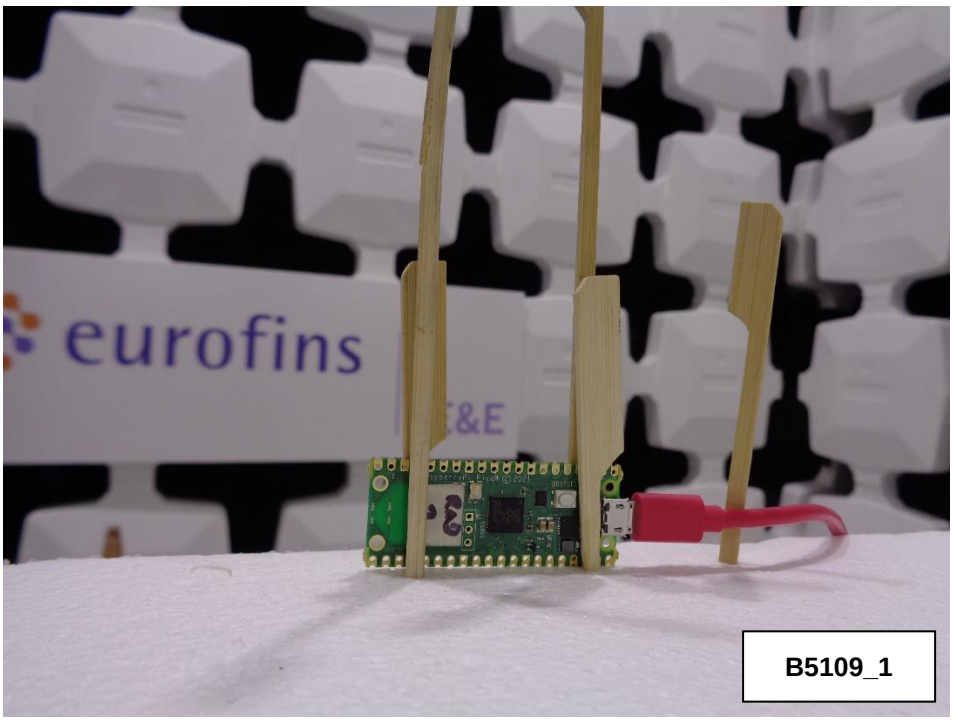

eurofins
B5109_1

3.3 Configuration of EUT

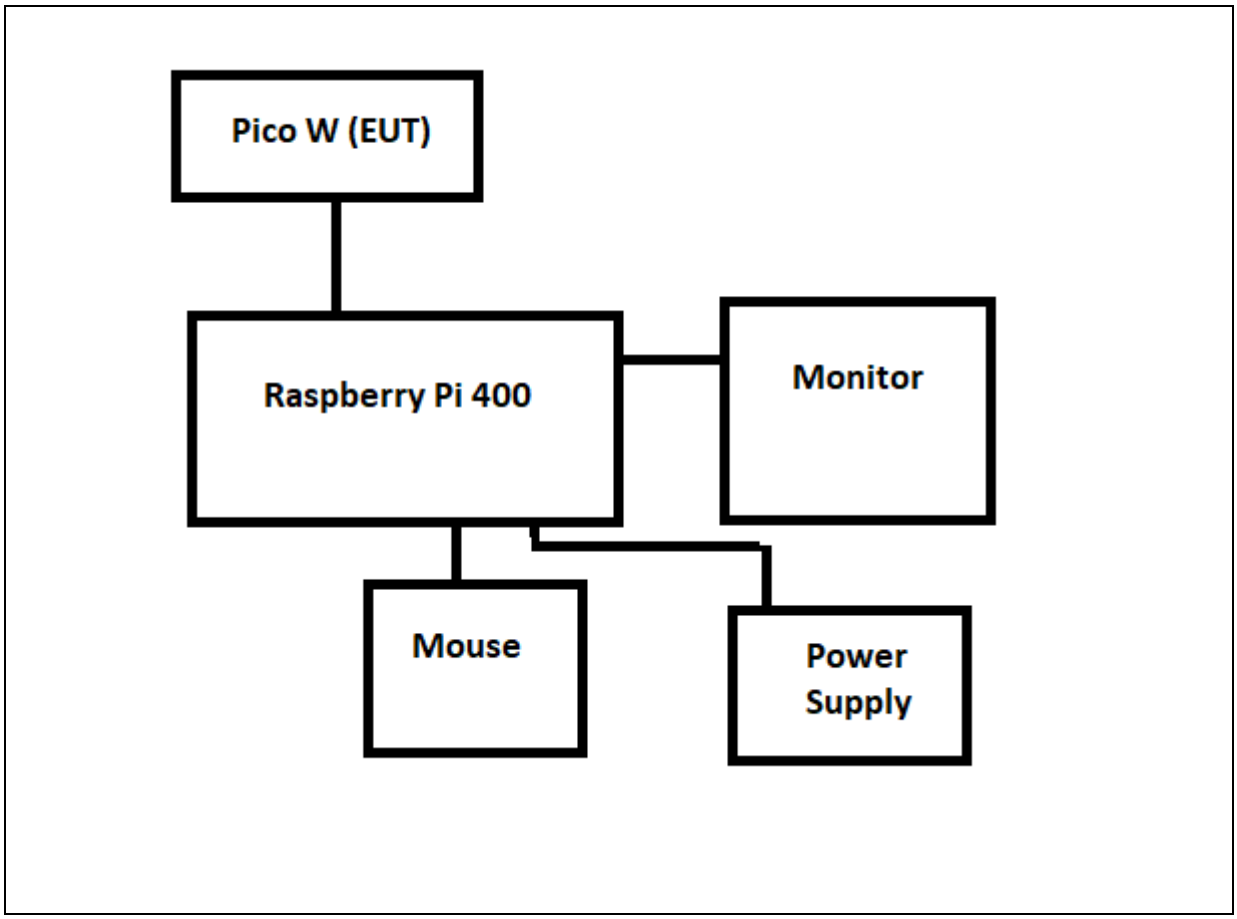


Figure 1: Diagram of EUT

3.4 EUT Monitoring/Auxiliary Equipment

Equipment Name	Type No.	Serial No.
Raspberry Pi 400	RPI-400	80000290807
Monitor	Asus VC279	J1LMRS035002
Raspberry Pi Mouse	RPI-Mouse	N\A
Raspberry Pi Power Supply	KSA-15E-051300HK	N\A

3.5 Monitoring Software

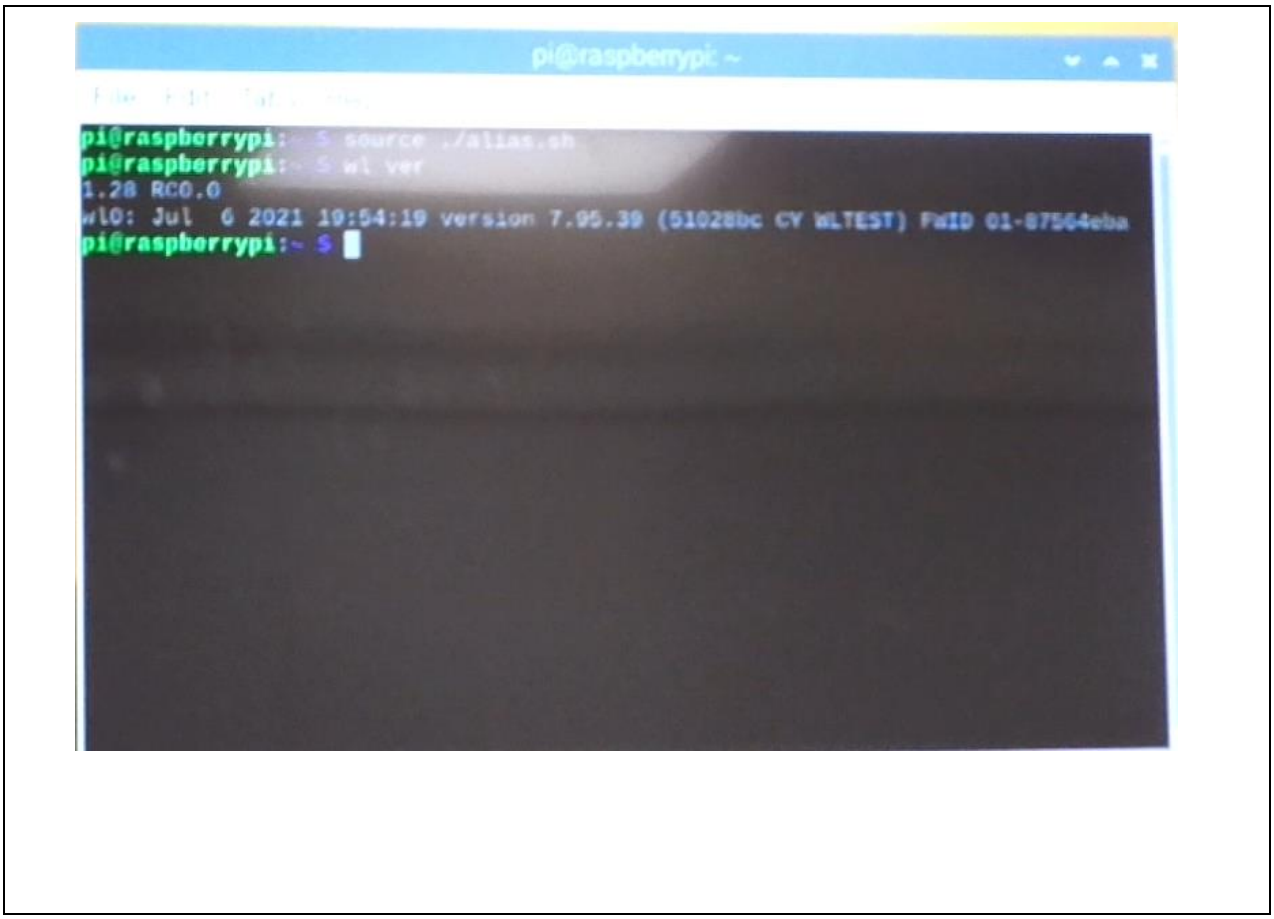


Figure 2: Screenshot – Monitoring Software

Section 4 Test Specifications

The tests were performed in accordance with Eurofins York Ltd Quotation B5190_1

47CFR Part 15, Sub Part B Unintentional Radiators			
Which references the following specification: -			
ANSI C63-4: 2014 Methods of Measurements of Radio Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range 9kHz to 40GHz.			
Test	**Method**	**Levels**	**Result**
Radiated Emissions Electric Field Measurements (30 – 18000MHz)	ANSI C63.4: 2014 Section 8	Part 15 Clause 15.109 Class B & ICES-003 Clause 6.2 Class B	Pass See Note 1

Note 1 :All testing was carried out at a test distance of 3m and the limits adjusted accordingly. This is a deviation from the standard as Class A limits are specified at 10m test distance.

Note 2 :Applies to carrier current systems see reference 47CFR Part 15Clause 15.109(e).

The Decision Rule is applied on the basis of the following:

As the decision is generally inherent in the standard for Commercial EMC a simple acceptance rule can be applied. The following statement will be added to EMC quotes and reports.

“The Decision Rule is applied on the basis of CISPR16-4-2 and/or EN61000-4-x (TR61000-1-6)

These standards provide guidance on how to calculate and apply measurement uncertainty whilst providing maximum uncertainties allowance. Due consideration will also be given to JCGM 106:2012, ILAC-G8:09/2019 and LAB 48.

This laboratory has demonstrated by calibrating its equipment and facilities, and calculating its own uncertainties, that it complies with the above requirements and therefore no allowance of uncertainties has been given to the tolerances.”

Where a result is considered marginal in respect of its proximity to the limit line, for example, the customer would be made aware of situation so that they can make an informed decision on how to proceed.

4.1 Knowledge Database References

The following KDBs were referenced during the testing of the Raspberry Pi Pico W:

The latest knowledge database references are available via the FCC KDB website at:

https://apps.fcc.gov/kdb

4.1.1 Radiated Emissions (30MHz to 1000MHz)

Publication Number	Keyword	Publication Date
746324	CE Mark and use of CISPR 22 limits	06/12/2015
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017

4.1.2 Radiated Emissions (1GHz to 40GHz)

Publication Number	Keyword	Publication Date
746324	CE Mark and use of CISPR 22 limits	12/06/2015
714737	15B, Average Detector for Unintentional Radiator	30/11/2010
704992	Test Site Validation Requirements above 1 GHZ.	12/06/2015
149045	Comparison Noise Emitter (CNE), reference noise source, .pdf	05/04/2007
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017
934285	Comparison Noise Emitters (CNE), test equipment, Broadband.pdf	05/04/2007

4.1.3 Radiated Emissions - Apparatus Containing a Modular Transmitter

Publication Number	Keyword	Publication Date
996369	Modular Transmitter Integration Guide – Guidance for Host Product Manufacturers, Frequency Spectrum to be Investigated	01/02/2019

4.2 Compliance Statement

The Raspberry Pi Pico W, as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

Section 5 Radiated Emission Results

5.1 Test Specification

Standard	ANSI C63.4:2014
Measurement Uncertainty	The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95% is +/- 5.01dB for the frequency range from 9kHz to 30MHz +/- 6.23dB for the frequency range 30MHz to 1GHz +/- 5.04dB for the frequency range from 1GHz to 6GHz +/- 5.35dB for the frequency range from 6GHz to 18GHz +/- 4.81dB for the frequency range from 18GHz to 40GHz

5.2 Procedure and Test Software Version

Eurofins York test procedure (9kHz to 30MHz)	CEP22 Issue 8
Eurofins York test procedure (30MHz to 1GHz)	CEP23 Issue 9
Eurofins York test procedure (1GHz to 40GHz)	CEP64 Issue 9
Test software	RadiMation Version 2016.2.8

5.2.1 Sample Data

5.3 Radiated Emissions (30MHz to 1GHz)

5.3.1 Limits at 3m

Frequency (MHz)	Class A (dBµV/m)	Class B (dBµV/m)
	Quasi Peak	Quasi Peak
30 - 88	49.5	40.0
88 -216	53.5	43.5
216 - 960	56.4	46.0
960- 1000	59.5	54.0

Note: FCC 47 CFR Part 15 Section 15.109 specifies test limits at 10m for Class A and 3m for Class B.
Please note that for Class A, limits have adjusted by 10dB to correct for the measurement distance of 3m.

5.3.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Quasi Peak
Start Frequency	30MHz
Stop Frequency	1000MHz
Resolution Bandwidth	120kHz
Video Bandwidth	Auto

5.3.3 Emissions measurements

5.3.4 Date of Test

18th February 2022

5.3.5 Test Area

LAB 1 (SAC)

5.3.6 Tested by

M Dyster

5.3.7 Test Setup

The EUT was configured in the SAC on an 80cm high table the measurement was performed with an antenna to EUT separation distance of 3m. The Quasi peak limits are therefore increased by 10dB (from the 10m values), to allow for the reduction in the measurement distance.

The results were maximised in orientation 0-360 degrees and height 1-4m.

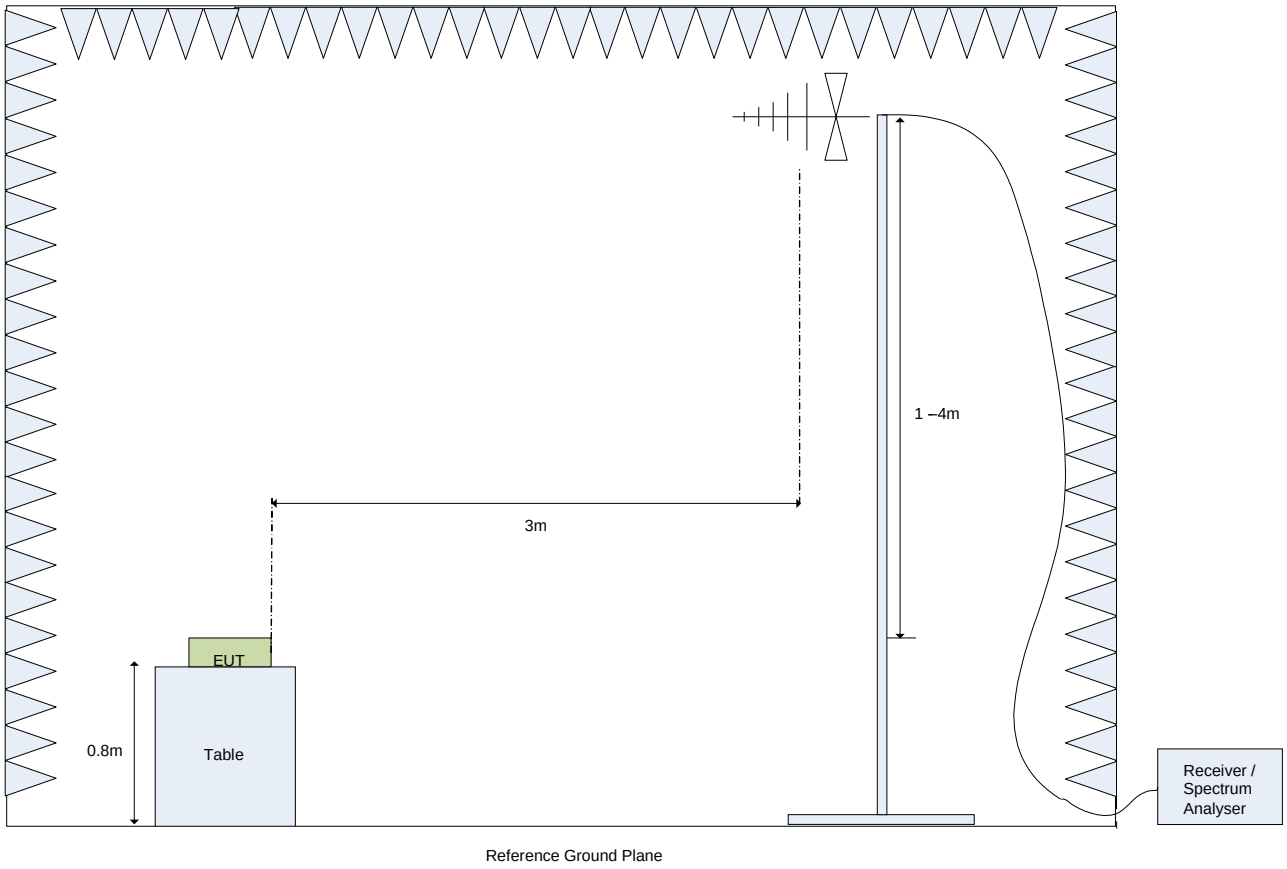


Figure 3: Test Setup for E-Field Measurements from 30MHz to 1GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.4-2014 Clause 5.1.3.

Note 2 : There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

5.3.8 Electric field emissions, 30MHz to 1GHz

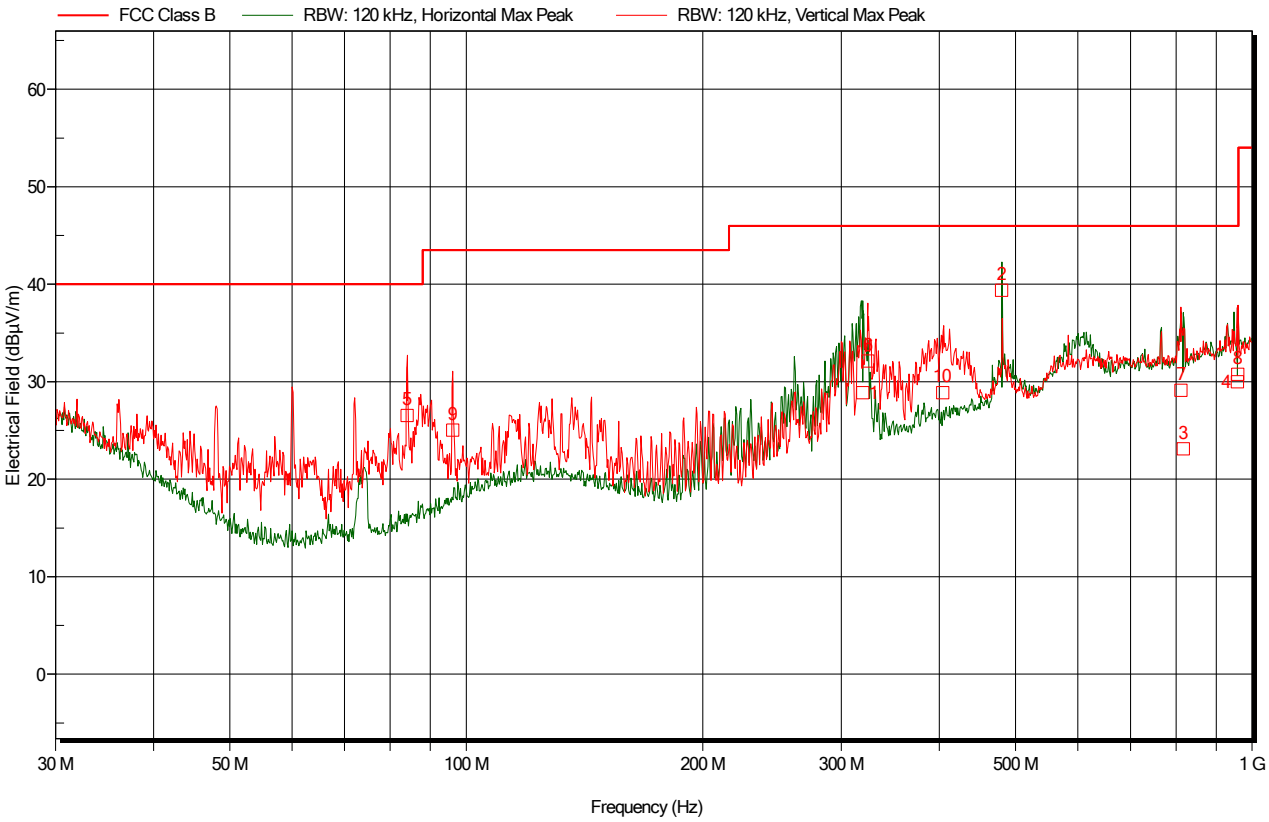


Figure 4: Electric field emissions Plot, 30MHz to 1GHz

Peak Number	Frequency	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference	Quasi-Peak Correction	Quasi-Peak Status	Status	Angle	Height	Polarization
1	319.596 MHz	28.9 dBµV/m	46 dBµV/m	-17.1 dB	21.2 dB	Pass	Pass	5 degrees	1.1 m	Horizontal
2	480.066 MHz	39.4 dBµV/m	46 dBµV/m	-6.6 dB	25.2 dB	Pass	Pass	360 degrees	1.9 m	Horizontal
3	816.882 MHz	23.1 dBµV/m	46 dBµV/m	-22.9 dB	28.4 dB	Pass	Pass	195 degrees	3.6 m	Horizontal
4	957.354 MHz	30 dBµV/m	46 dBµV/m	-16.0 dB	29.5 dB	Pass	Pass	300 degrees	2.4 m	Horizontal
5	84.048 MHz	26.5 dBµV/m	40 dBµV/m	-13.5 dB	14.7 dB	Pass	Pass	185 degrees	1.1 m	Vertical
6	324.18 MHz	32.1 dBµV/m	46 dBµV/m	-13.9 dB	21.2 dB	Pass	Pass	270 degrees	1.7 m	Vertical
7	811.56 MHz	29.1 dBµV/m	46 dBµV/m	-16.9 dB	28.4 dB	Pass	Pass	200 degrees	3 m	Vertical
8	958.05 MHz	30.8 dBµV/m	46 dBµV/m	-15.2 dB	29.6 dB	Pass	Pass	125 degrees	1.6 m	Vertical
9	96.042 MHz	25 dBµV/m	43.5 dBµV/m	-18.5 dB	16.9 dB	Pass	Pass	240 degrees	1 m	Vertical
10	403.74 MHz	28.9 dBµV/m	46 dBµV/m	-17.1 dB	23.5 dB	Pass	Pass	305 degrees	1.3 m	Vertical

Table 1: Electric Field Emissions Peaks, 30MHz to 1GHz

5.3.9 Quasi Peak correction factors

The quasi peak correction is shown in the above table. This correction figure consists of Antenna factor (AF); and Cable loss (CL).

Field strength (FS) is calculated as follows:

FS (dBµV/m) = Indicated Signal Level (dBµV) + AF (dB) + CL (dB)

5.3.10 Sample Data

The Quasi-Peak level at 319.596MHz

FS (dBµV/m) = 28.9dB = 7.7dBµV + 19.5dB + 1.7dB

5.4 Radiated Emissions (1GHz to 40GHz)

5.4.1 Limits

Frequency (GHz)	Class A (dBµV/m)	Class B (dBµV/m)
	Average	Average
1-40	59.5	54.0

5.4.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average
Start Frequency	1GHz
Stop Frequency	40GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.4.3 Emissions measurements

5.4.4 Date of Test

24th February 2022

5.4.5 Test Area

LAB 1 (SAC)

5.4.6 Tested by

Mark Dyster

5.4.7 Test Setup

The EUT was configured in the SAC on an 80cm high table Exploratory measurements on the EUT were carried out to identify suspect frequencies and worst case orientations, see Section 5.4.8.

The measurement was then performed with an antenna to EUT separation distance of 3m.

The antenna was kept in the “cone of radiation” from the EUT and pointed at the area both in azimuth and elevation using the tilt mechanism on the antenna mast.

The results were maximised in orientation 0-360 degrees and height 1-4m.

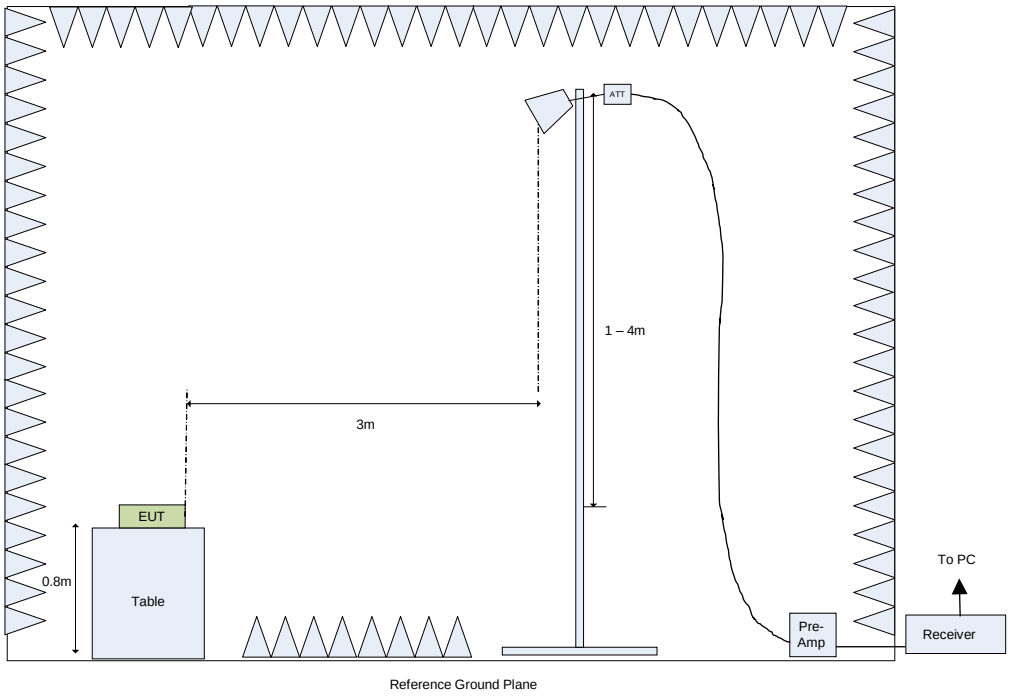


Figure 5: Test Setup for Final E-Field Measurements from 1GHz to 18GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.4-2014 Clause 5.1.3.

Note 2 : There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

5.4.8 Exploratory Radiated Emission Maximization

During exploratory testing, suspect emissions from the EUT were identified both in terms of the frequency and directionality. This was achieved by manually positioning the antenna close to the EUT and also by scanning it over all sides of the EUT whilst observing a spectral display. The typical distance between the surface of the EUT and the scanning antenna was circa 30cm.

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height (m)	Polarization
2.4150	Mode 1	0	0	0.8	Vertical
1.037	Mode 1	0	0	0.8	Vertical
3.645	Mode 1	0	0	0.8	Vertical
4.924	Mode 1	0	0	0.8	Vertical
2.095	Mode 1	0	0	0.8	Horizontal
1.037	Mode 1	0	0	0.8	Horizontal
3.669	Mode 1	0	0	0.8	Horizontal

No Emissions above 18GHz were found.

Table 2: Frequencies identified during Exploratory Radiated Emission maximization

Note 1 : The front face of the EUT is deemed to be 0°, which is then turned in a clockwise direction through 360°.

Note 2 : The method for the exploratory radiated emission maximisation is as detailed in Annex E of ANSI C63.4-2014.

5.4.9 Electric field emissions, 1GHz to 18GHz

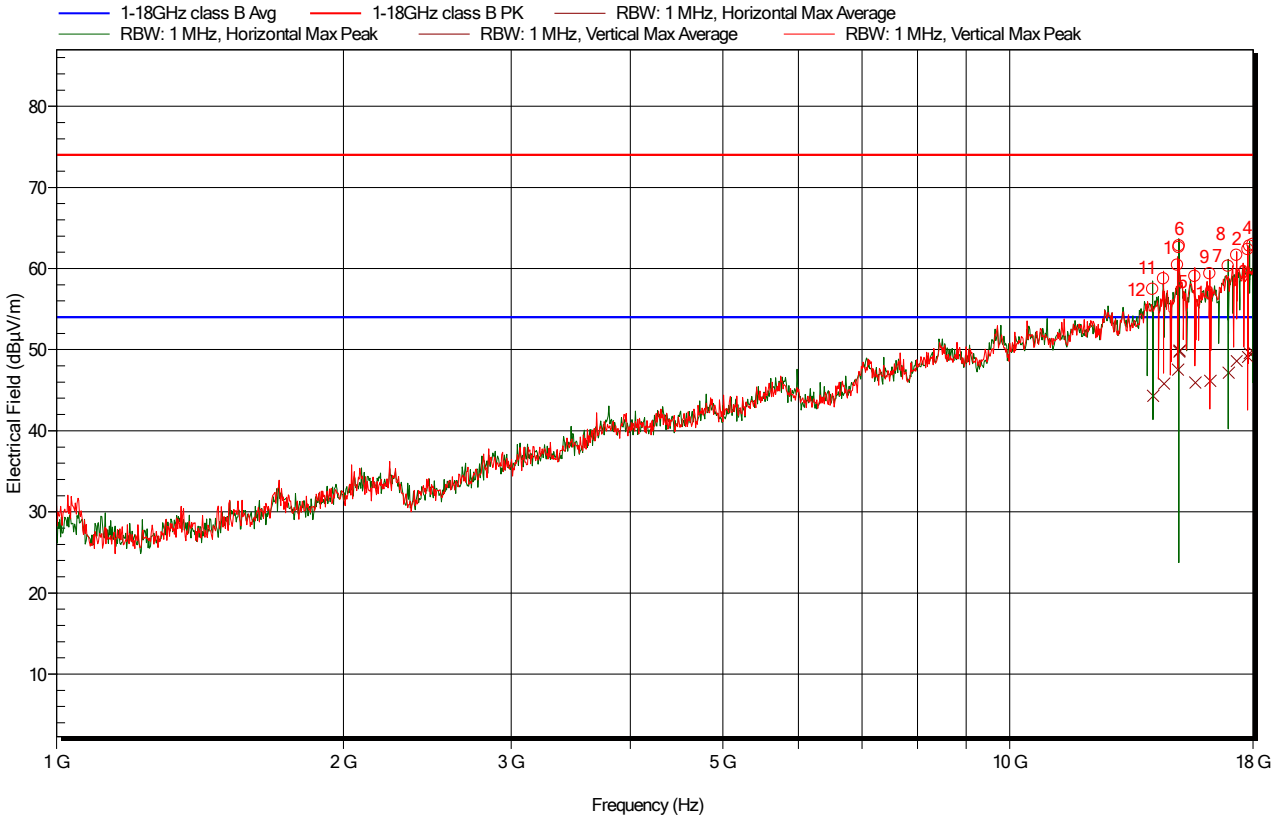


Figure 6: Electric field emissions Plot, 1GHz to 18GHz – 3m Distance

Peak Number	Frequency	Peak	Peak Limit	Peak Difference	Peak Correction	Peak Status	Average	Average Limit	Average Difference	Average Correction	Average Status	Status	Angle	Height	Polarization
1	15.043 GHz	62.6 dBµV/m	74 dBµV/m	-11.4 dB	5.8 dB	Pass	49.83 dBµV/m	54 dBµV/m	-4.17 dB	5.8 dB	Pass	Pass	75 degrees	3.9 m	Horizontal
2	17.773 GHz	62.34 dBµV/m	74 dBµV/m	-11.66 dB	6.9 dB	Pass	49.11 dBµV/m	54 dBµV/m	-4.89 dB	6.9 dB	Pass	Pass	180 degrees	3.3 m	Vertical
3	17.847 GHz	62.76 dBµV/m	74 dBµV/m	-11.24 dB	7.1 dB	Pass	49.56 dBµV/m	54 dBµV/m	-4.44 dB	7.1 dB	Pass	Pass	220 degrees	4 m	Horizontal
4	18 GHz	62.97 dBµV/m	74 dBµV/m	-11.03 dB	7.8 dB	Pass	49.69 dBµV/m	54 dBµV/m	-4.31 dB	7.8 dB	Pass	Pass	225 degrees	2.3 m	Horizontal
5	14.992 GHz	60.41 dBµV/m	74 dBµV/m	-13.59 dB	3.7 dB	Pass	47.59 dBµV/m	54 dBµV/m	-6.41 dB	3.7 dB	Pass	Pass	250 degrees	3.3 m	Vertical
6	15.055 GHz	62.8 dBµV/m	74 dBµV/m	-11.2 dB	5.9 dB	Pass	49.95 dBµV/m	54 dBµV/m	-4.05 dB	5.9 dB	Pass	Pass	260 degrees	4 m	Horizontal
7	16.943 GHz	60.28 dBµV/m	74 dBµV/m	-13.72 dB	5.1 dB	Pass	47.21 dBµV/m	54 dBµV/m	-6.79 dB	5.1 dB	Pass	Pass	35 degrees	3.6 m	Horizontal
8	17.303 GHz	61.66 dBµV/m	74 dBµV/m	-12.34 dB	6.4 dB	Pass	48.6 dBµV/m	54 dBµV/m	-5.4 dB	6.4 dB	Pass	Pass	245 degrees	3.6 m	Vertical
9	16.204 GHz	59.38 dBµV/m	74 dBµV/m	-14.62 dB	3.2 dB	Pass	46.2 dBµV/m	54 dBµV/m	-7.8 dB	3.2 dB	Pass	Pass	235 degrees	1.3 m	Vertical
10	15.63 GHz	59.03 dBµV/m	74 dBµV/m	-14.97 dB	3.1 dB	Pass	45.98 dBµV/m	54 dBµV/m	-8.02 dB	3.1 dB	Pass	Pass	320 degrees	2.6 m	Vertical
11	14.493 GHz	58.73 dBµV/m	74 dBµV/m	-15.27 dB	2.7 dB	Pass	45.85 dBµV/m	54 dBµV/m	-8.15 dB	2.7 dB	Pass	Pass	315 degrees	3 m	Vertical
12	14.118 GHz	57.43 dBµV/m	74 dBµV/m	-16.57 dB	0.6 dB	Pass	44.37 dBµV/m	54 dBµV/m	-9.63 dB	0.6 dB	Pass	Pass	210 degrees	3.5 m	Horizontal

Table 3: Electric Field Emissions Peaks, 1GHz to 18GHz – 3m Distance

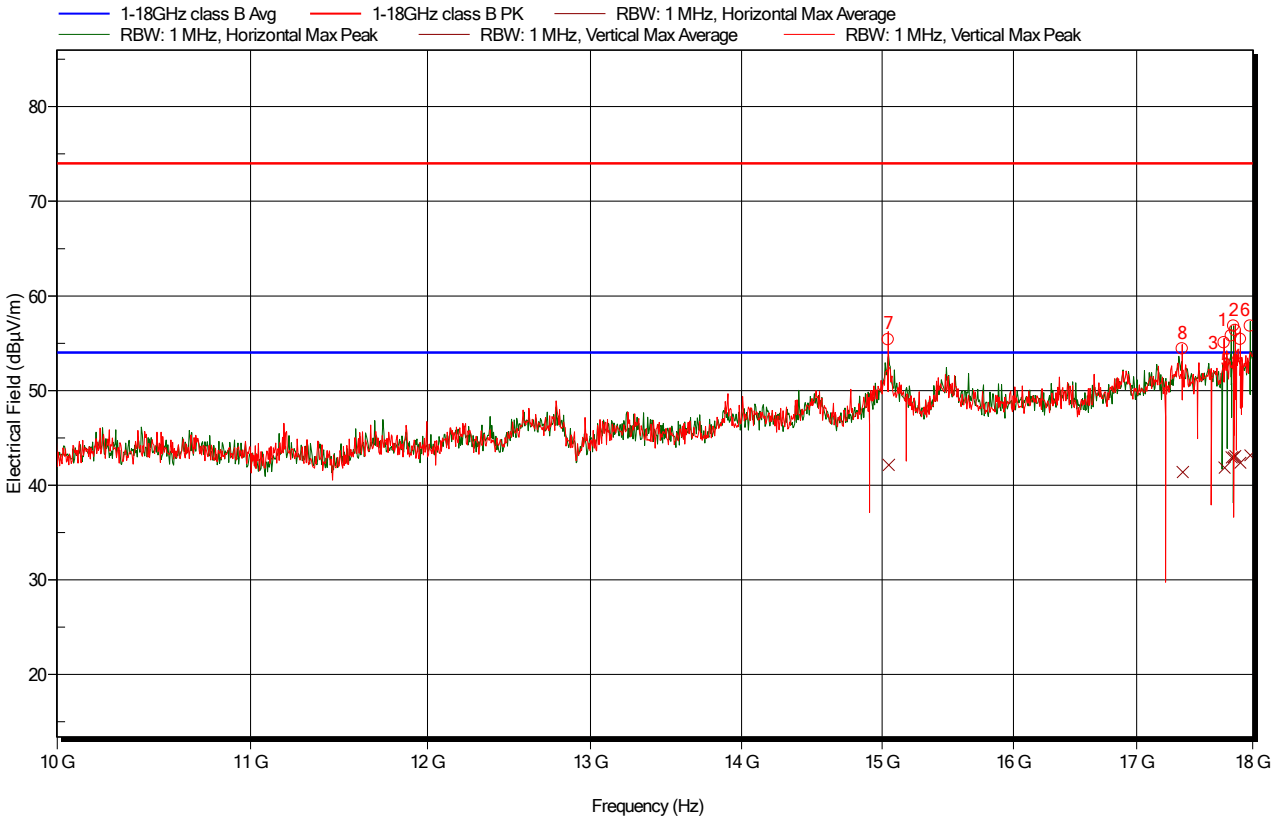


Figure 7: Electric field emissions Plot, 10GHz to 18GHz – 1m Distance

Peak Number	Frequency	Peak	Peak Limit	Peak Difference	Peak Correction	Peak Status	Average	Average Limit	Average Difference	Average Correction	Average Status	Status	Angle	Height	Polarization
1	17.843 GHz	56.34 dBµV/m	74 dBµV/m	-17.66 dB	0.3 dB	Pass	43.08 dBµV/m	54 dBµV/m	-10.92 dB	0.3 dB	Pass	Pass	85 degrees	2.9 m	Vertical
2	17.828 GHz	56.82 dBµV/m	74 dBµV/m	-17.18 dB	0.3 dB	Pass	42.94 dBµV/m	54 dBµV/m	-11.06 dB	0.3 dB	Pass	Pass	120 degrees	2.2 m	Horizontal
3	17.745 GHz	55.07 dBµV/m	74 dBµV/m	-18.93 dB	-0.7 dB	Pass	41.88 dBµV/m	54 dBµV/m	-12.12 dB	-0.7 dB	Pass	Pass	160 degrees	3.9 m	Vertical
4	17.807 GHz	55.79 dBµV/m	74 dBµV/m	-18.21 dB	0.3 dB	Pass	42.97 dBµV/m	54 dBµV/m	-11.03 dB	0.3 dB	Pass	Pass	125 degrees	1.9 m	Horizontal
5	17.886 GHz	55.4 dBµV/m	74 dBµV/m	-18.6 dB	-0.2 dB	Pass	42.36 dBµV/m	54 dBµV/m	-11.64 dB	-0.2 dB	Pass	Pass	280 degrees	3.8 m	Vertical
6	17.974 GHz	56.83 dBµV/m	74 dBµV/m	-17.17 dB	0.8 dB	Pass	43.14 dBµV/m	54 dBµV/m	-10.86 dB	0.8 dB	Pass	Pass	280 degrees	3.8 m	Horizontal
7	15.046 GHz	55.38 dBµV/m	74 dBµV/m	-18.62 dB	-2 dB	Pass	42.19 dBµV/m	54 dBµV/m	-11.81 dB	-2 dB	Pass	Pass	100 degrees	1.9 m	Vertical
8	17.383 GHz	54.4 dBµV/m	74 dBµV/m	-19.6 dB	-0.9 dB	Pass	41.41 dBµV/m	54 dBµV/m	-12.59 dB	-0.9 dB	Pass	Pass	270 degrees	3.8 m	Vertical

Table 4: Electric Field Emissions Peaks, 10GHz to 18GHz – 1m Distance

5.4.10 Average correction factors

The total average corrections are shown in the above table. This correction figure consists of Preamplifier gain (PG), Antenna factor (AF); Attenuator loss (AL) and Cable loss (CL).

Field strength (FS) is calculated as follows:

FS (dBµV/m) = Indicated Signal Level (dBµV) - PG (dB) + AF (dB) + AL (dB) + CL (dB)

5.4.11 Sample Data

The Average level at 15.043GHz

FS (dBµV/m) = 49.83dBµV/m = 43.98dBµV – 54.68dB + 49.21dB + 11.32dB

Appendix A EUT Test Photos

Radiated Emissions

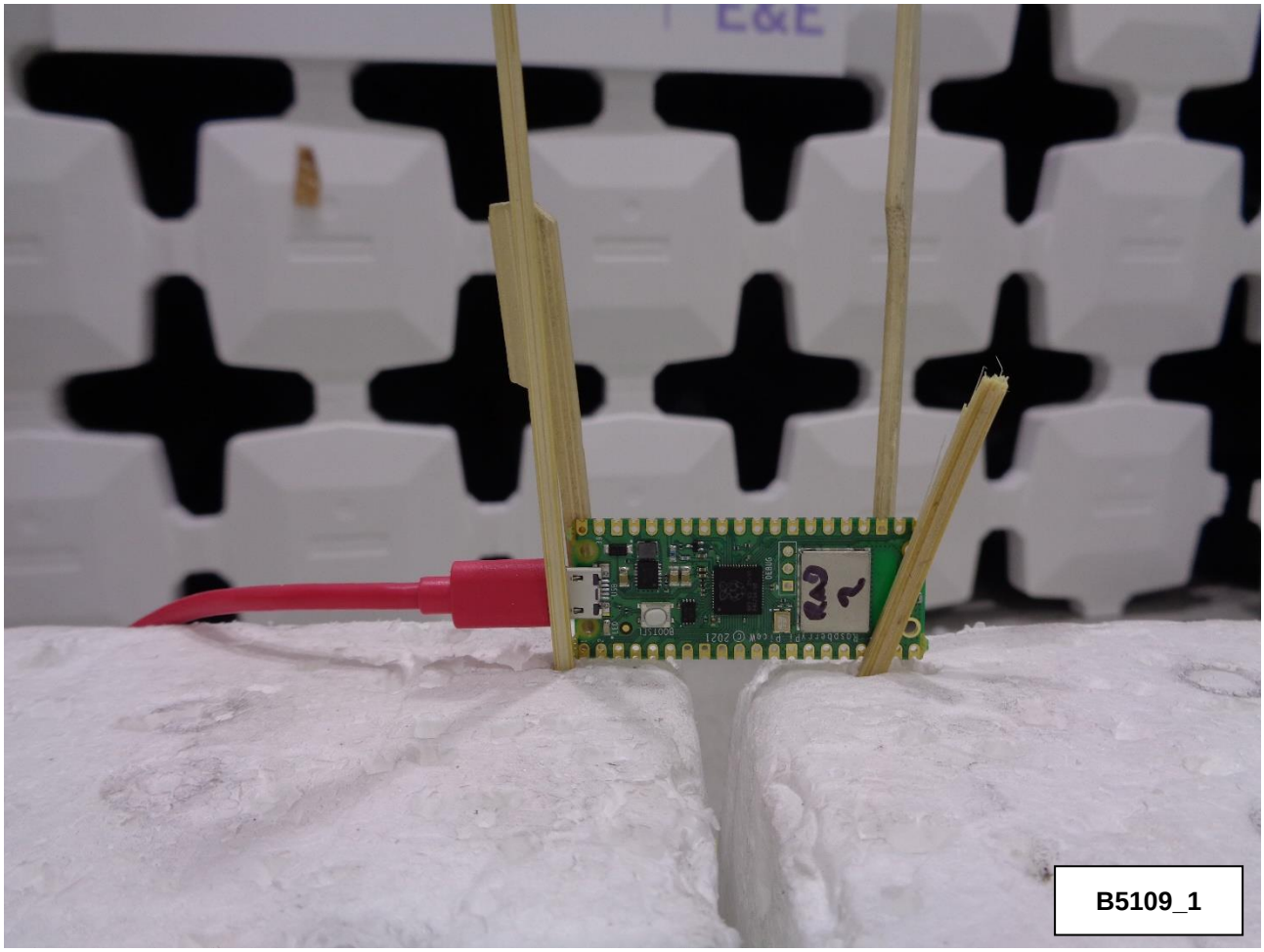


Photo 1: Radiated Emissions, close-up shot

The cable/wire placement on the test site was setup to produce the highest radiated emissions. The above photograph(s) illustrates the setup tested.

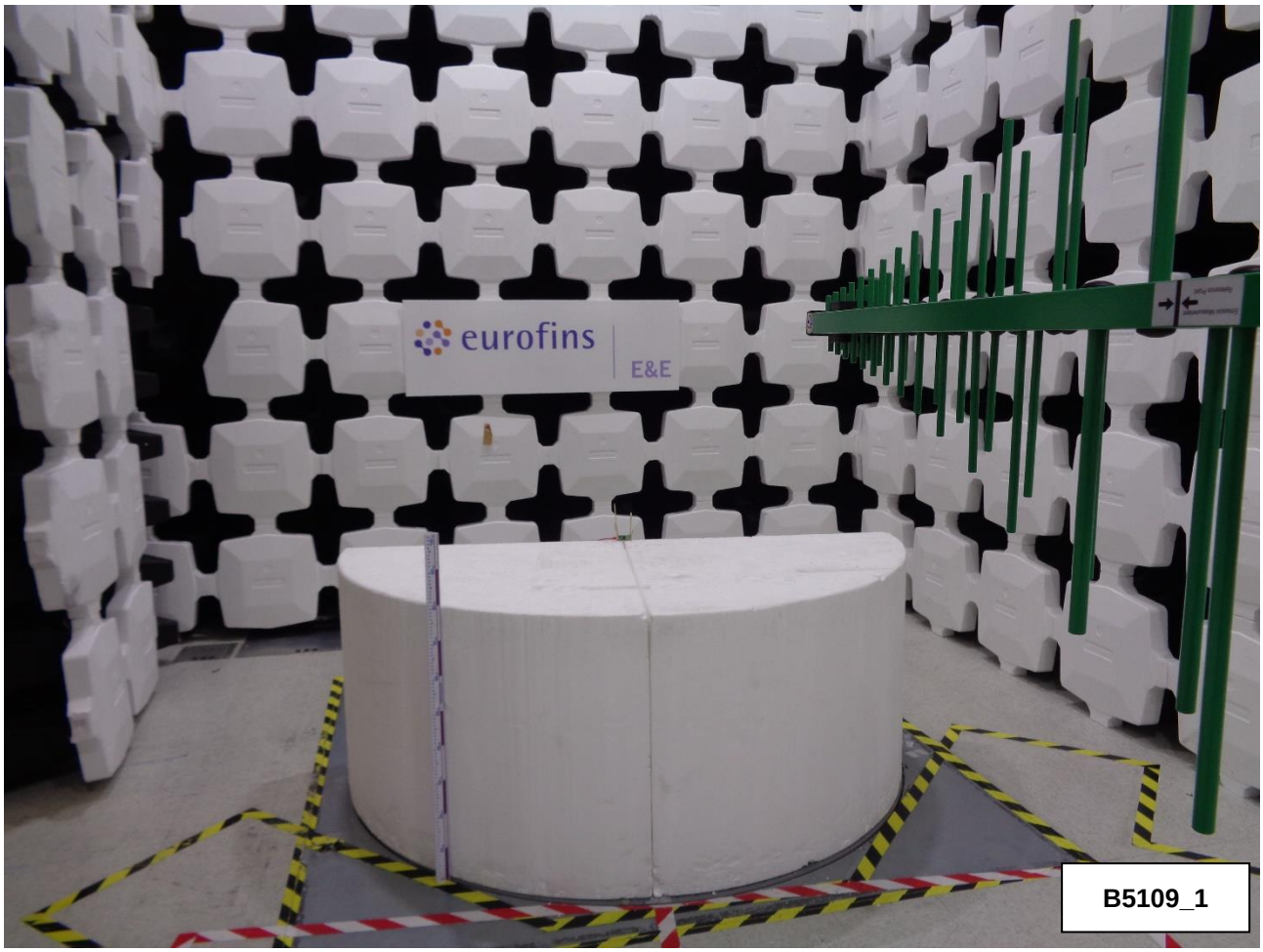


Photo 2: Radiated Emissions, 30MHz to 1GHz

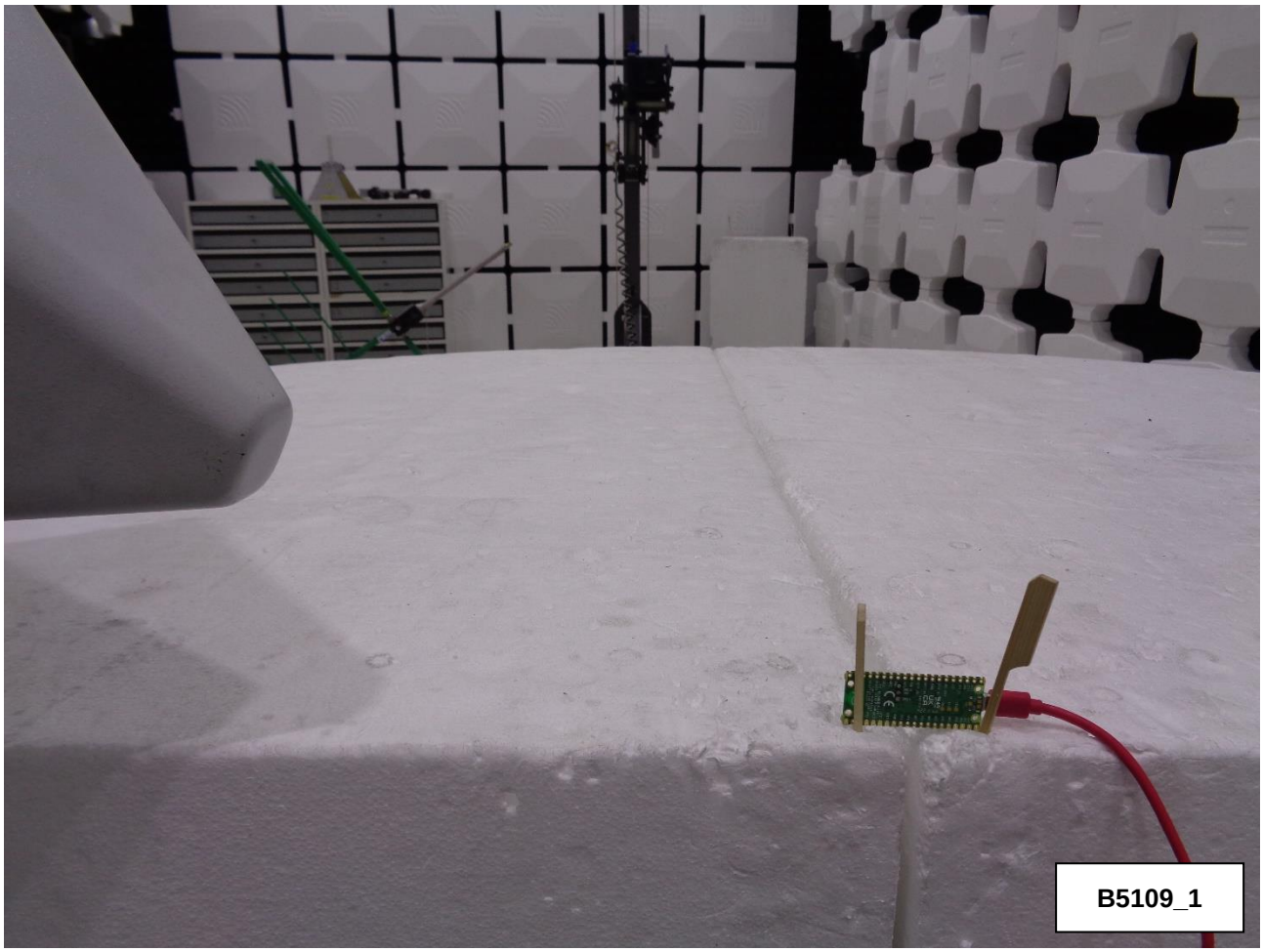
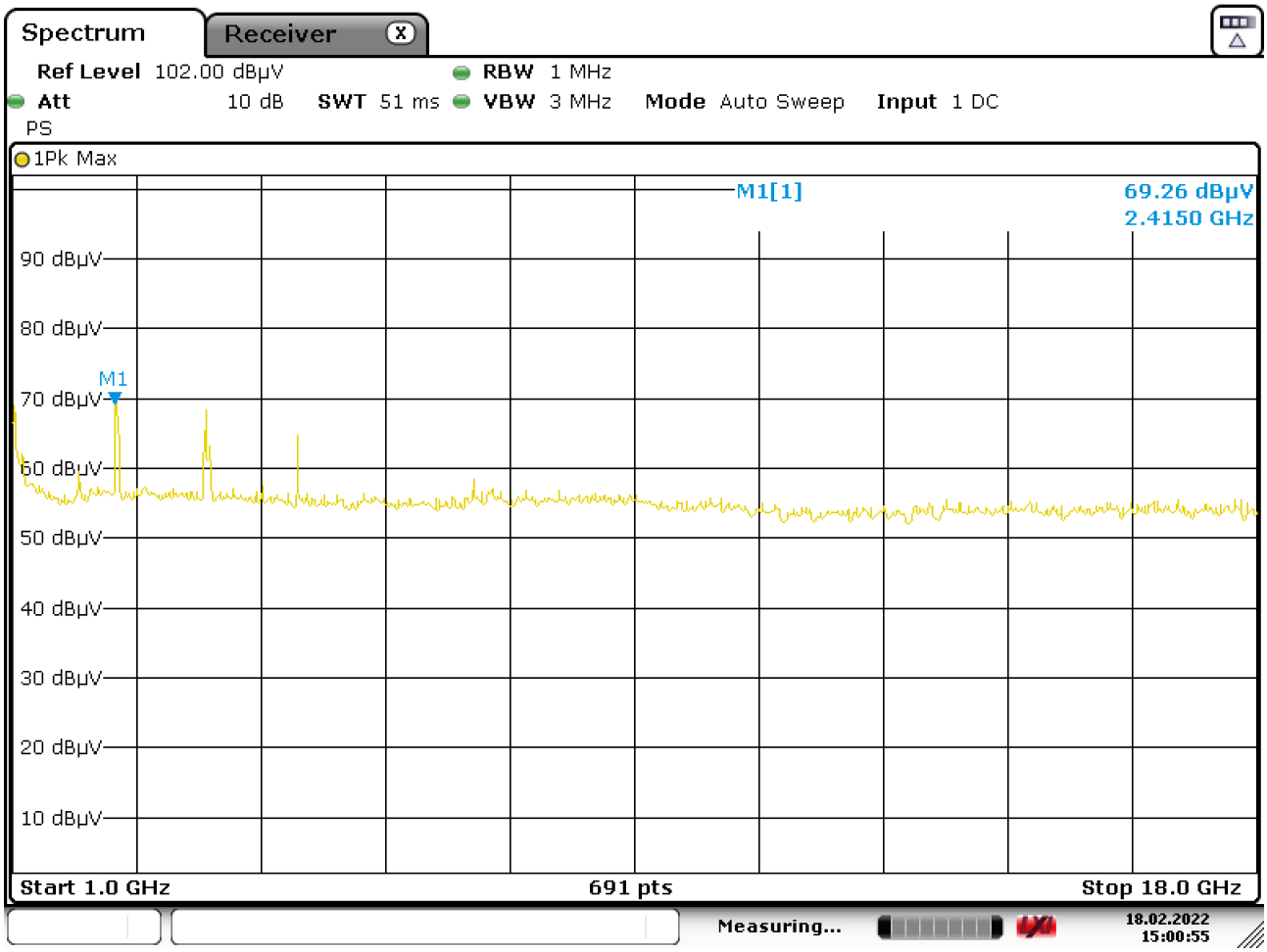
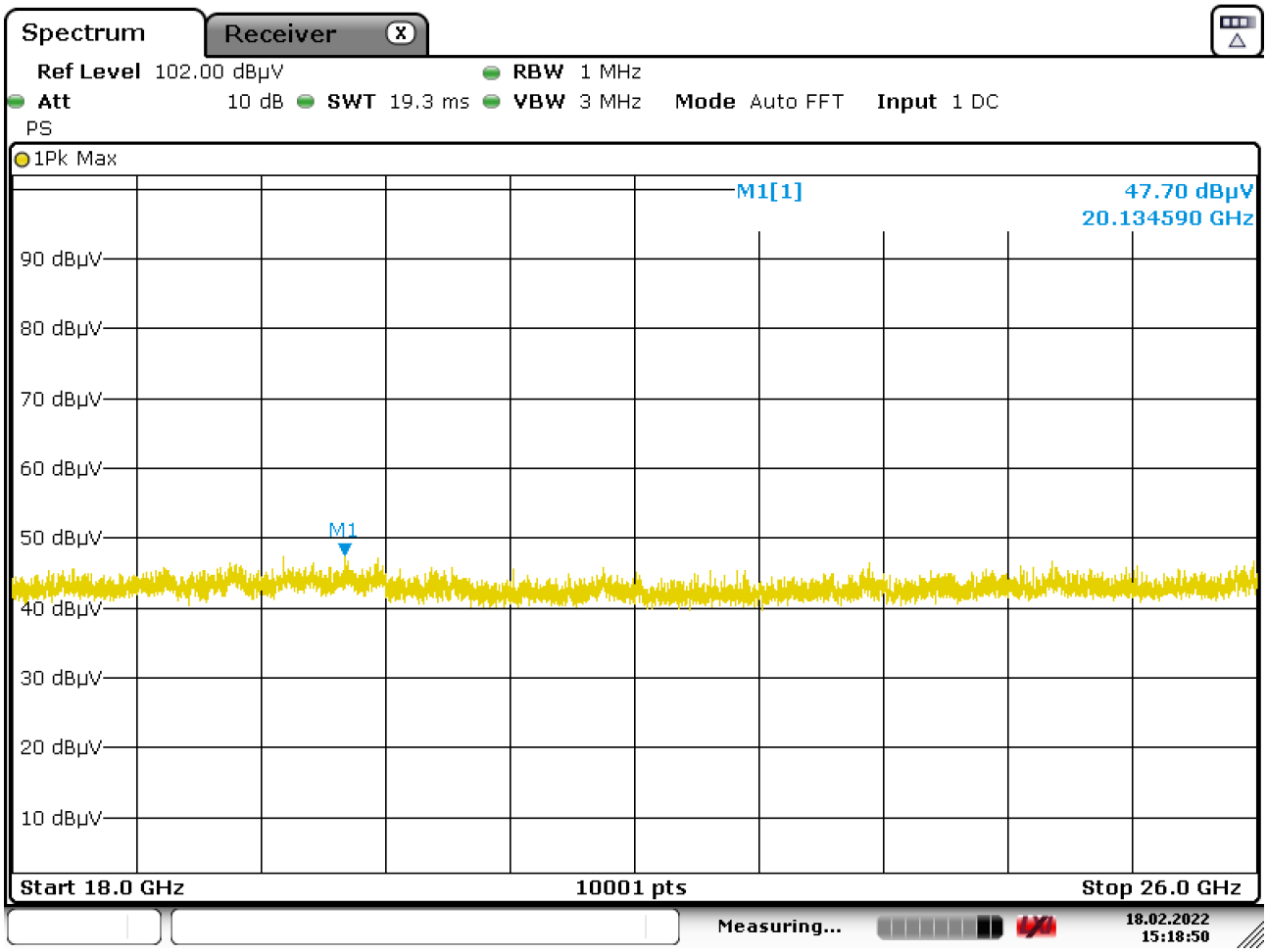


Photo 3: Exploratory Radiated Emissions Maximization, 1GHz to 40GHz



Date: 18.FEB.2022 15:00:56

Photo 4: Exploratory Radiated Emissions Maximization, 1GHz to 18GHz



Date: 18.FEB.2022 15:18:50

Photo 5: Exploratory Radiated Emissions Maximization, 18GHz to 26GHz

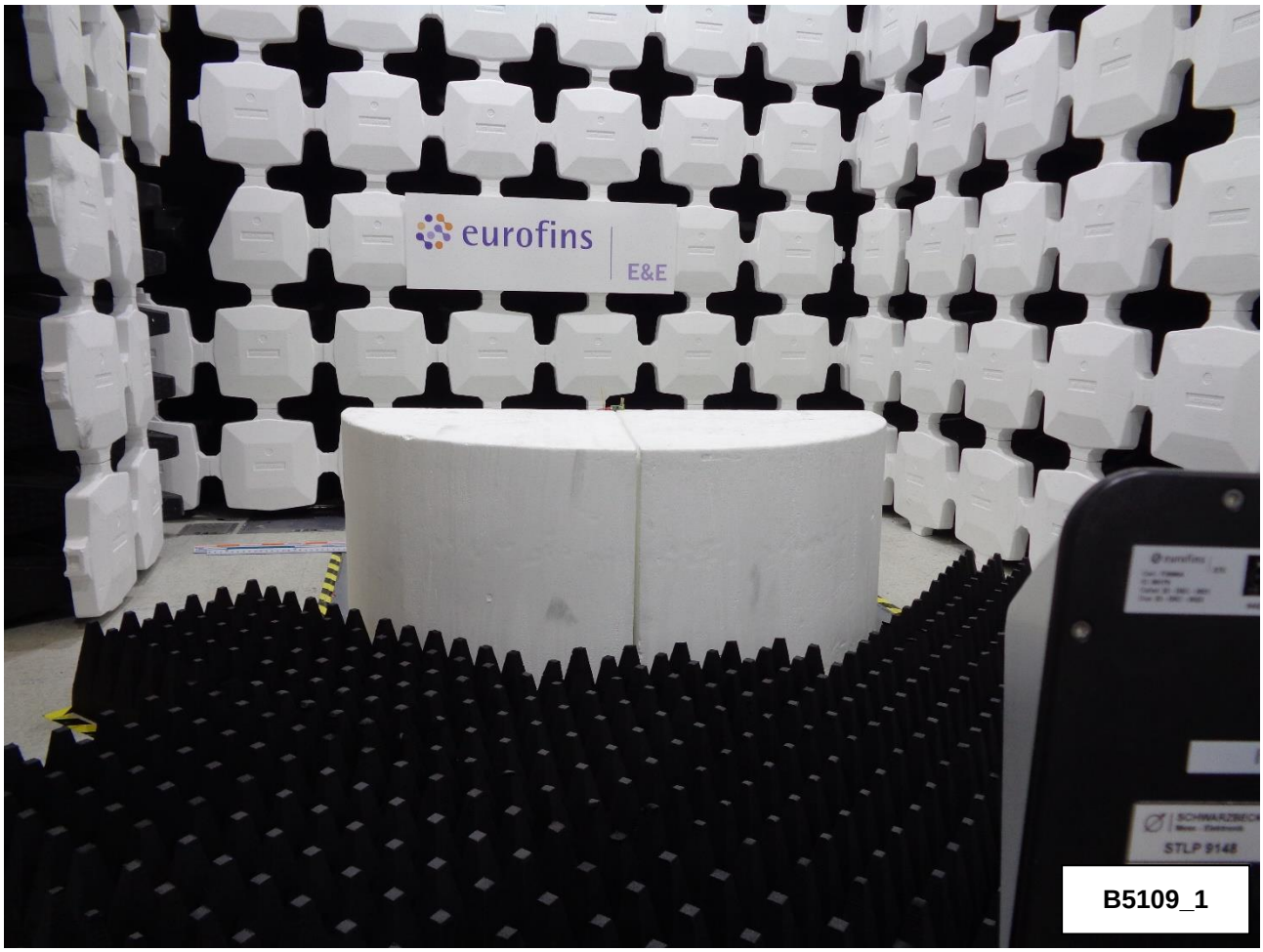


Photo 6: Radiated Emissions, 1GHz to 18GHz – 3m Distance

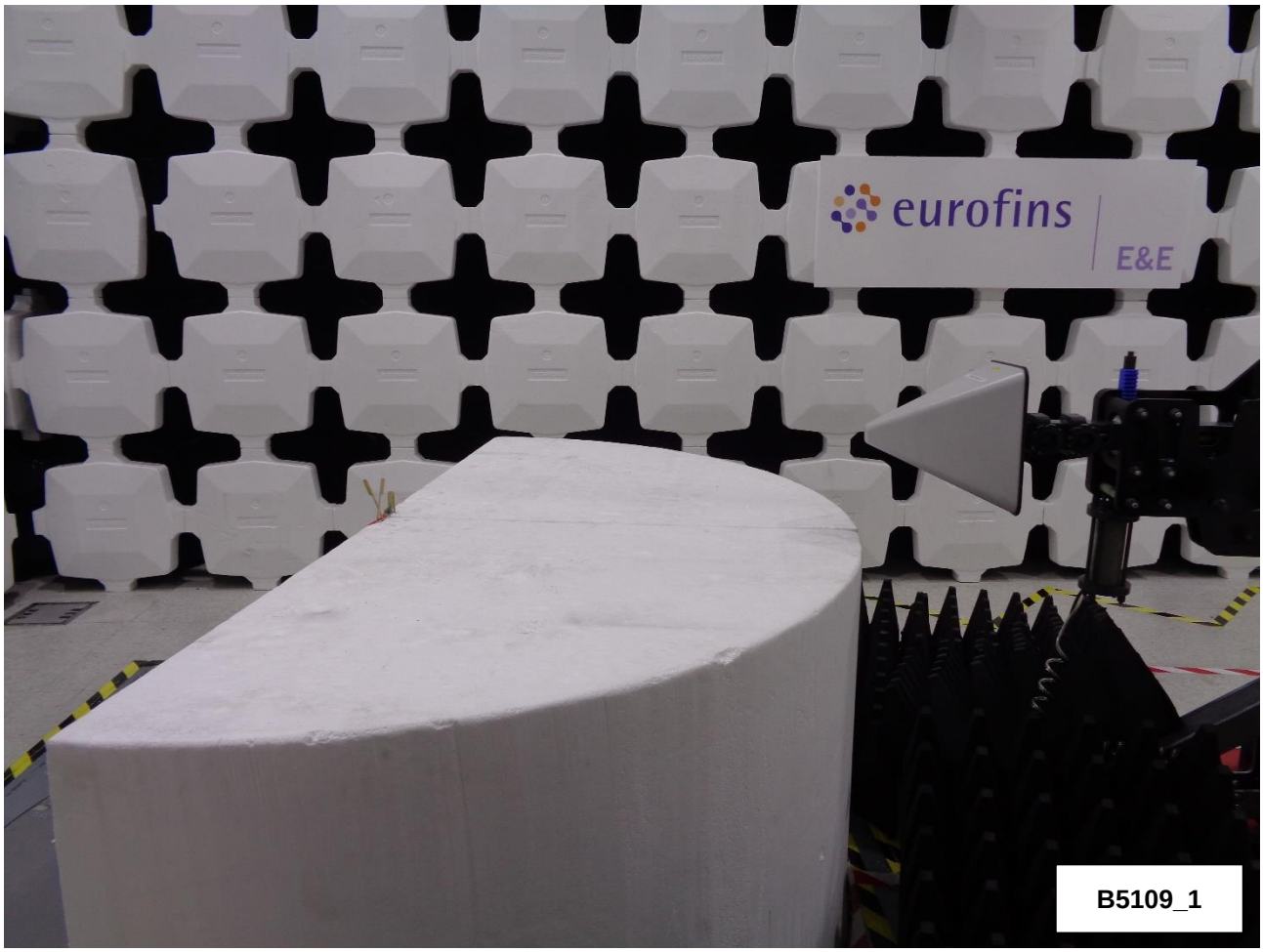


Photo 7: Radiated Emissions, 10GHz to 18GHz – 1m Distance

Appendix B Test Equipment List

Radiated Emissions Equipment

Item	Serial No.	Last Calibration Date	Calibration Interval
Laboratory 1 Semi-Anechoic Chamber	Lab 1	28th January 2020	36 Months
ETS Lindgren 2017B Mast (1 – 4m) with tilting mechanism	--	N/A	N/A
Rohde & Schwartz ESR26	C0502	10th November 2021	12 Months
Teseq CBL6112D Bilog Antenna	C0506	15th July 2021	36 Months
6dB Attenuator (For use with Bilog Antenna)	C0506B	15th July 2021	36 Months
HF26 Cable	HF26	17th January 2022	12 Months
HF35 Cable	HF35	17th January 2022	12 Months
HF27 Cable	HF27	17th January 2022	12 Months
Schwarzbeck D-69250 Antenna 1-18GHz	C0626	23rd December 2021	24 Months
2.4GHz Microtronics BRM50702 notch filter	C0473	11th January 2022	12 Months
BONN BLMA 0118-M Preamplifier	G0327	6th January 2022	12 Months
ETS Lingren 3116C-PA Horn Antenna 18-40GHz	C0433	17th October 2019	36 Months