COMPLIANCE ENGINEERING
EMC - Shielding - Environmental

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EMC Compliance Test Report

EN IEC 61000-6-3:2021
Report Number: CE3310A
December 2021

Tru Blu Dog Wash
TRU-BLU K9000
Model: K9000 2.0

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COMPLIANCE CERTIFICATE

Client Contact: Phil Worrel
Tru Blu Dog Wash
36 Caramut Rd,
Warrnambool VIC 3280, Australia
Telephone: (03) 55629088
Email: office@trubludogwash.com.au

Device: TRU-BLU K9000
Model: K9000 2.0

Reference Standard: EN IEC 61000-6-3:2021
Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments.

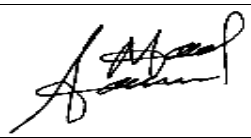
Summary Result:

Mains terminal disturbance voltage measurements	**Complied**
Radiated RF emission measurements	**Complied**
Voltage flicker emissions	**Complied**
Harmonic current emissions	**Complied**

Test Date: 6th & 7th December 2021

Tests Performed by: Abdi Shire
Compliance Engineering Pty Ltd
90 Indian Drive, Keysborough
Victoria, Australia 3173
Telephone: +61 3 9763 3079
Email: info@compeng.com.au

The **TRU-BLU K9000 (Model: K9000 2.0)** complies with the RF emission requirements detailed in EN IEC 61000-6-3: 2021 Electromagnetic compatibility of Part 6-3: Generic standards - Emission standard for equipment in residential environments.

		10th January 2022
Prepared By: Abdi Shire *Test Engineer* *Compliance Engineering Pty Ltd*	***Approved By:*** *Andrew Burden* *Technical Manager* *Compliance Engineering Pty Ltd*	***Date***

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Revision History			
Revision	**Issue Date**	**Remarks**	**Revised by**
1	10-12-2021	Initial release	

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EMC Compliance Test Report

1. INTRODUCTION

Electromagnetic compatibility (EMC) measurements were performed on a TRU-BLU K9000 (Model: K9000 2.0), in accordance with the emission requirements detailed in EN IEC 61000-6-3: 2021.

2. RESULTS SUMMARY

EN IEC 61000-6-3: 2021

Description	Result
Mains terminal disturbance voltage measurements	Pass
Radiated emissions measurements	Pass
Voltage flicker emissions (EN 61000-3-3:2013/A1:2019)	Pass
Harmonic current emissions (EN IEC 61000-3-2:2019/A1:2021)	Pass

3. TEST SAMPLE

The equipment under test (EUT) is described as follows:

Equipment Under Test (Information supplied by client):	
Product Name	TRU-BLU K9000
Model Number:	K9000 2.0
Weight:	285 kg
Serial Number:	1875V2H2
Electrical:	220/240 V 50/60 Hz
Maximum Load:	27AMP

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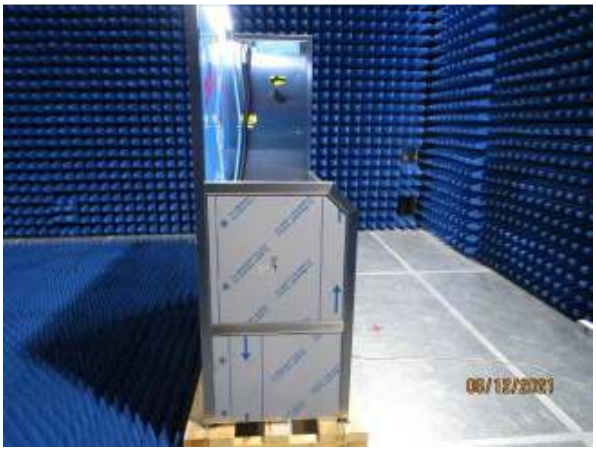

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4. CONFIGURATION

The TRU-BLU K9000 (Model: K9000 2.0) was powered from a 240 Volts, 50 Hz mains supply. The EUT was tested while in operation with the heated dryer drawing 15 A. The EUT is configured in to the operation mode after it is powers up. The EUT was configured to operate without a water supply.

The system also contains insert coins and notes sections, and water pressure gauge and LCD display that provides feedback on the status of the TRU-BLU K9000.

5. MODIFICATIONS

For the TRU-BLU K9000 (Model: K9000 2.0) to comply with the conducted emission requirements, a 20A WE-CLFS Line Filter was attached to the mains supply for all tests, except radiated emission test. The following photos depict the filter installation:

6. STANDARD DEVIATIONS

No deviation from the standard were made by Compliance Engineering Pty Ltd.

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7. TEST FACILITY

All measurements were performed inside Compliance Engineering's, 3m Semi-Anechoic (iOATS) enclosure located at 90 Indian Drive, Keysborough, Victoria, Australia.

A2LA (ISO 17025-2017) – Certificate No: 2829.01
Compliance Engineering Pty Ltd, is accredited to ISO 17025-2017 by American Association for Laboratory Accreditation (A2LA) which is an ILAC member and has mutual recognition agreements with the National Voluntary Laboratory Accreditation Program (NVLAP)

All tests within this report have been conducted in accordance with Compliance Engineering's scope of A2LA accreditation.

The current full scope of accreditation can be found on the A2LA website: www.a2la.org

FCC – Registration No: 982700
Compliance Engineering Pty Ltd, has been recognized and is listed as an FCC part 47 CFR 2.948 measurement facility to perform compliance testing on equipment under Parts 15 and 18. The Designation Number is AU0006 and the Test Firm Registration Number is 982700.

Innovation, Science & Economic Development Canada (ISED) - Registration No: 27266
Compliance Engineering's 3m indoor semi-anechoic chamber (iOATS) has been accepted by Innovation, Science & Economic Development Canada (ISED) for performing radiated measurements in accordance with RSS-102, RSS-GEN, RSS-210, RSS-247, RSS-248 – ISED Canada Registration No: 27266

8. FIELD STRENGTH CALCULATION

All emission measurements are automatically calculated via the dedicated EMC software using the pre-stored calibration factors. The following equation simplifies the actual calculation performed.

$$\textbf{Corr.Ampl} = V_{RAW} + AF - G + L$$

Where:

Corr.Ampl = Corrected amplitude in dBµV/m (for radiated) & dBµV (for conducted)
V_{RAW} = Raw voltage receiver/analyser reading in dBµV
AF = Antenna Factor in dB (stored as a data array of factor vs frequency)
G = Preamplifier Factor in dB (stored as a data array of gain vs frequency)
L = Cable Loss Factor in dB (stored as a data array of insertion loss vs frequency)

Margin:

This is the margin of compliance below the FCC limit. The units are given in dB. A negative margin indicates the emission was below the limit. A positive margin indicates that the emission exceeds the limit.

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Example Calculation:

A peak emission is observed at 100 MHz at 21.5 dBµV. An antenna factor for that frequency is 10 dB. The preamplifier gain factor is 30 dB and the cable loss at that same frequency 1.5 dB. Hence the overall Correction Amplitude is as follows;

V_{RAW} + AF - G + L : Corr.Amp - CISPR Limit = Margin

31.5 + 10 - 20 + 1.5 : 23 dBµV/m - 57.0 dBµV/m = - 34 dB

9. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2.

Measurement	Frequency / Range	Uncertainty (k=2)
Temperature	15.5°C to 24°C	0.5°C
Humidity	15% to 60%	2%
Conducted Emissions (using a 50Ω/50µH + 5µH LISN)	0.09 MHz to 30 MHz	± 4.79
Conducted Emissions (using a Voltage Probe)	0.15 MHz to 30 MHz	± 5.07
Conducted Emissions (using a 50Ω/50µH LISN)	0.15 MHz to 30 MHz	± 4.35
Conducted Emissions (using an ISN)	0.15 MHz to 30 MHz	± 4.35
Radiated Emissions (Horizontal Polarisation)	30 MHz to 200 MHz	± 4.98
Radiated Emissions (Vertical Polarisation)	30 MHz to 200 MHz	± 5.23
Radiated Emissions (Horizontal Polarisation)	200 MHz to 1000 MHz	± 5.24
Radiated Emissions (Vertical Polarisation)	200 MHz to 1000 MHz	± 5.92
Radiated Emissions (Log Periodic Antenna)	1 GHz to 6 GHz	± 5.14
Radiated Emissions (Log Periodic Antenna)	6 GHz to 18 GHz	± 6.11
Radiated Emissions (Horn Antenna)	18 GHz to 26 GHz	± 6.11
Radiated Emissions (Horn Antenna)	26 GHz to 40 GHz	± 6.11

Note 1: These uncertainties represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Note 2: The reference uncertainty standard specifies that although the measurement uncertainty shall be documented within the test report, the actual determination of compliance shall be based on measurements without taking into account the measurement uncertainty.

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10. MAINS TERMINAL RF EMISSION MEASUREMENTS

10.1 REQUIREMENTS

Frequency Range: 0.150 MHz to 30 MHz
Limit: EN IEC 61000-6-3:2021

10.2 TEST EQUIPMENT

Asset	Equipment	Model No	Serial No	Cal Due
644	EMI Receiver	ESIB	100338	Jul 22
34	LISN	3816/2AS	9605-1047	Dec 22
229	High Pass Filter	FEH0.15B	1247	Feb 22
230	Transient Limiter	TL250-10B	383	Feb 22
760	Semi-Anechoic Chamber iOATS (11m x 7m x 6m)	CE-iOATS	2021	Oct 23
TER-S004	Measurement Software	RadiMation	Rev: 2021.1.9	-

10.3 ENVIRONMENTAL CONDITIONS

Environment	Typical Range	Uncertainty (k=2)	Actual	Comment
Temperature	15.5°C to 24°C	0.5°C	22°C	Ok
Humidity	15% to 60%	2%	49%	Ok

10.4 PROCEDURE

In accordance with Compliance Engineering Test Procedure TP72.

Mains terminal disturbance voltage emission measurements are performed inside a semi-anechoic enclosure.

The EUT is placed on a non-conductive support 0.35 metres above the ground reference plane and any other metallic objects.

Measurement scans are performed over the specified (0.15 - 30 MHz) frequency band on both the active and neutral lines, via a 50 Ω Line Impedance Stabilization Network (LISN), located 0.8 metres away from the test sample. All other accessories are connected to another separate LISN as applicable.

The test receiver is set to Peak Detect with the specified bandwidth (IF Bandwidth of 9 kHz) whilst on Max Hold mode. Measurement scans are also repeated using the Average Detector and Quasi-Peak detector functions accordingly.

Plots of the accumulated measurement data, including all transducer correction factors are then produced and stored on file.

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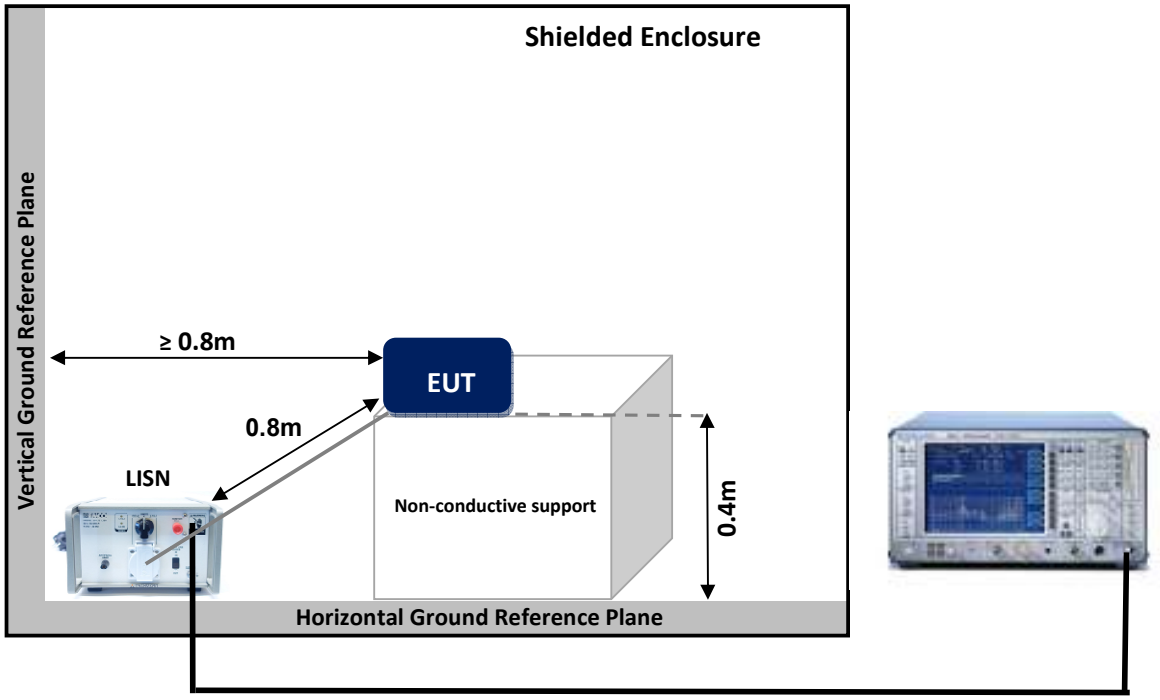

10.5 EMISSION TYPE

Mains terminal disturbance voltage emissions from the test sample are categorised as either continuous or discontinuous (clicks) – as per CISPR 14-1.

10.5.1 Continuous Emissions

Measurements are performed initially using a peak detector. Measurements using either a quasi-peak or average detector (as applicable) are then performed at spot frequencies where emissions approach or exceed the quasi-peak or average limits.

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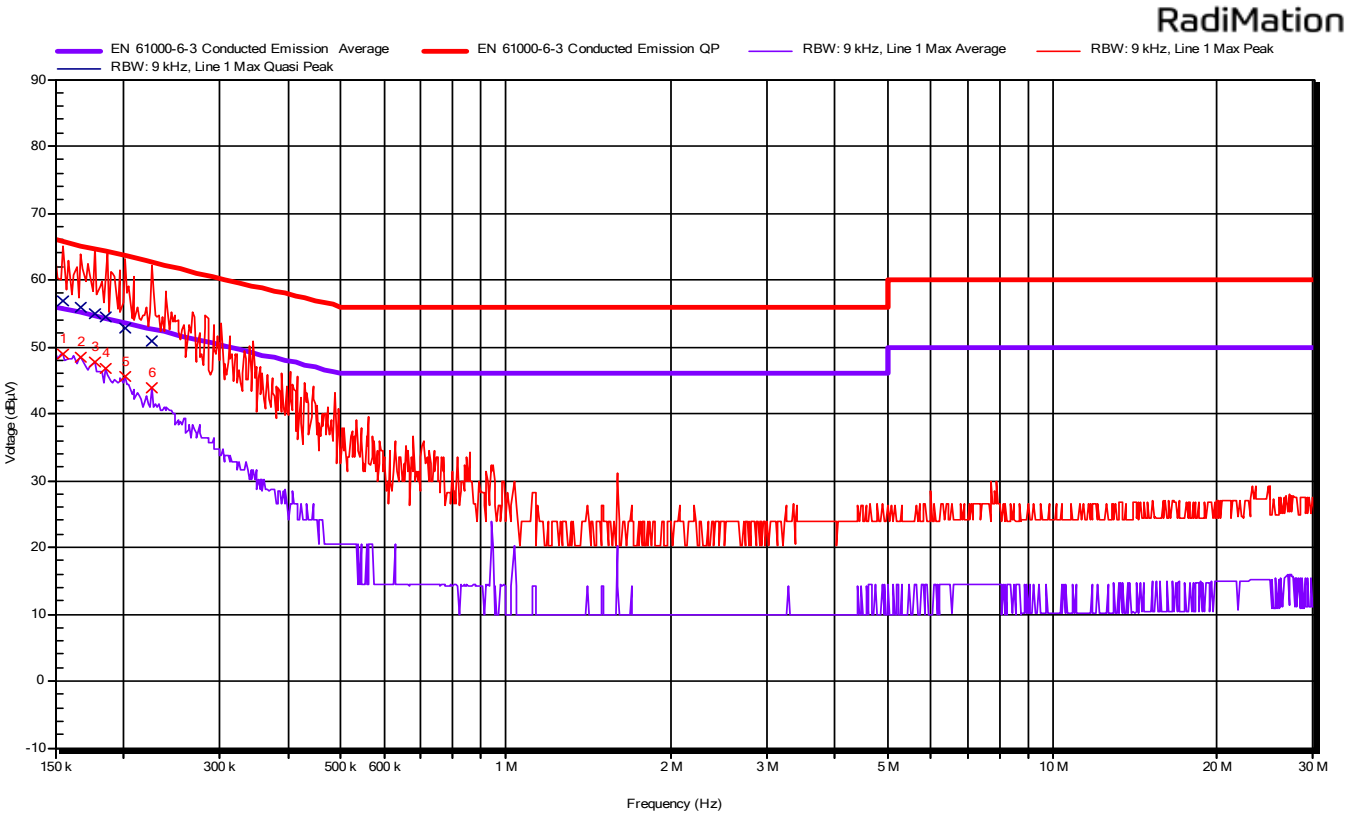
10.5.2 Discontinuous Emissions

Measurements of discontinuous disturbances (or "clicks") require the assessment of the disturbance amplitude, duration and repetition rate, in order to determine compliance with the disturbance limit.

$N = n_1/T$ Where **N** is the click rate, **T** is the time taken in minutes to register 40 clicks or switching operations and **n_1** = 40 clicks.

10.6 CONTINUOUS EMISSION RESULTS

Mains Terminal Emission Measurements – Active Line							
Frequency (MHz)	**Quasi-peak (dBµV)**	**Quasi-peak Limit (dBµV)**	**Delta QP Limit (dB)**	**Average (dBµV)**	**Average Limit (dBµV)**	**Delta AVG Limit (dB)**	**Result**
0.150	57.2	66	**-8.8**	49.6	56	**-6.4**	**Pass**
0.195	53.1	63.8	**-10.7**	47.8	53.8	**-6**	**Pass**
0.223	50.7	62.7	**-12**	44.3	52.7	**-8.4**	**Pass**
0.269	46.4	61.6	**-14.7**	41.1	51.6	**-10**	**Pass**
0. 494	31.3	56.1	**-24.8**	22.6	46.1	**-23.5**	**Pass**



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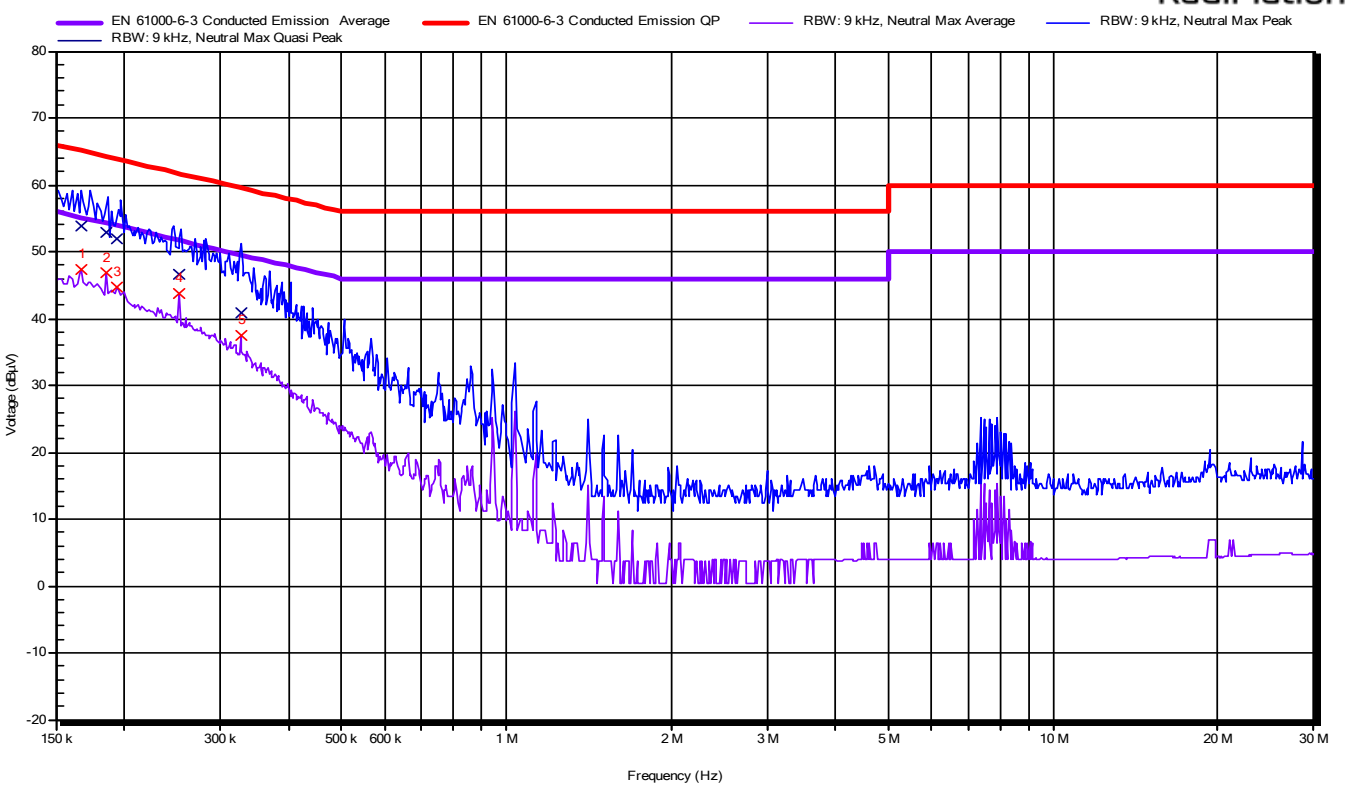
Mains Terminal Emission Measurements – Neutral Line							
Frequency (MHz)	**Quasi-peak (dBµV)**	**Quasi-peak Limit (dBµV)**	**Delta QP Limit (dB)**	**Average (dBµV)**	**Average Limit (dBµV)**	**Delta AVG Limit (dB)**	**Result**
0.167	53.9	65.1	**-11.2**	47.4	55.1	**-7.7**	**Pass**
0.185	52.9	64.2	**-11.3**	46.8	54.2	**-7.4**	**Pass**
0.194	52	63.9	**-11.9**	44.7	53.9	**-9.1**	**Pass**
0.252	46.6	61.7	**-15.1**	43.7	51.7	**-8**	**Pass**
0.327	41	59.5	**-18.6**	37.5	49.5	**-12**	**Pass**



10.7 DISCONTINUOUS EMISSION RESULTS

The test sample did not produce discontinuous emissions.

Frequency (MHz)	Clicks < 10 ms	N ≤ 5	Result
0.15	Not Applicable	Not Applicable	Not Applicable
0.5	Not Applicable	Not Applicable	Not Applicable
1.4	Not Applicable	Not Applicable	Not Applicable
30	Not Applicable	Not Applicable	Not Applicable

10.8 ASSESSMENT

The TRU-BLU K9000 (Model: K9000 2.0) complied with the mains terminal disturbance voltage emission requirements detailed in EN IEC 61000-6-3:2021, and the EUT did not produce discontinuous emissions as per CISPR 14-1.

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11. RADIATED RF EMISSION MEASUREMENTS

11.1 REQUIREMENTS

Frequency Range: 30 MHz to 6 GHz
Measurement Distance: 3 metres
Limit: EN IEC 61000-6-3:2021

11.2 TEST EQUIPMENT

Asset	Equipment	Model No	Serial No	Cal Due
644	EMI Receiver 7 GHz	ESIB7	100338	Jul 22
731	Biconical 0.03-0.2 GHz	VHBB 9124+BBA 9106	9124-1461	Aug 22
733	Log Periodic 0.2-6 GHz	USLP 9143 B	USLP 9143B 136	Aug 22
466	Preamplifier 0.03-6 GHz	ABL0600-01-3440	35401	Sep 23
734	Log Periodic 1-18 GHz	STLP 9148	176	Aug 22
760	Semi Anechoic Chamber iOATS (11 x 7 x 6 m)	CE-iOATS	2021	Oct 23
TER-S004	Measurement Software	RadiMation	Rev:2021.1.7	-

11.3 ENVIRONMENTAL CONDITIONS

Environment	Range	Uncertainty (k=2)	Actual	Comment
Temperature	15.5°C to 24°C	0.5°C	23°C	Ok
Humidity	15% to 60%	2%	49%	Ok

11.4 PROCEDURE

Radiated RF emission measurements were performed at distance of 3 metres, inside a semi-anechoic chamber in the frequency range of 30 MHz to 6 GHz and the metal ground plane was covered by absorbing material when measuring above 1 GHz.

The measuring antenna height was varied between 1 and 4 metres using both horizontal and vertical polarisations in turn.

Plots of the accumulated measurement data, including all transducer correction factors are then produced and stored on file.

Measurements below 1 GHz:

RWB = 120 kHz, VBW = 3 x RBW

Measurements above 1 GHz:

RF absorber is placed on the ground reference plane between the EUT and the measuring antenna and its location size should allow the test site area to comply with the CISPR 16-1-4 requirements.

RWB = 1 MHz (minimum), VBW = 3 x RBW

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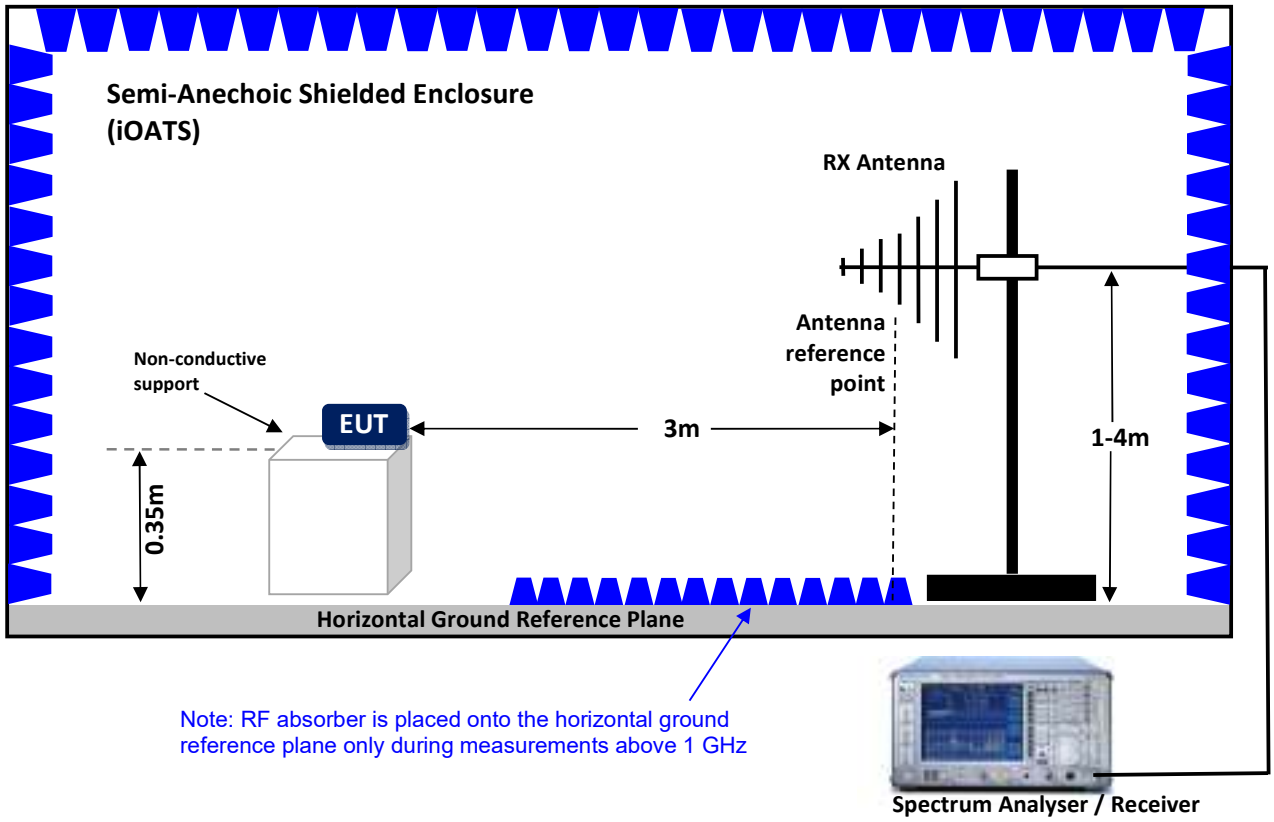

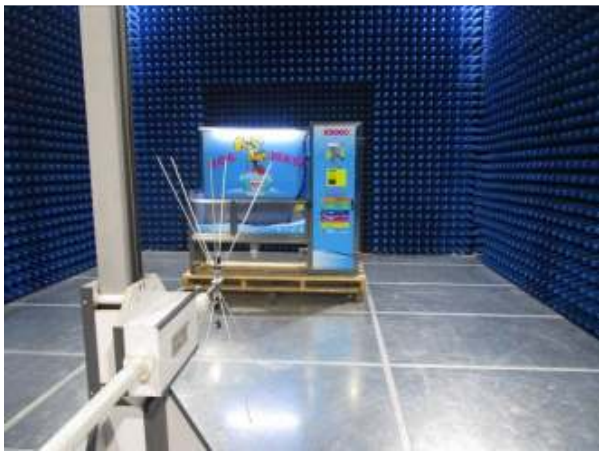

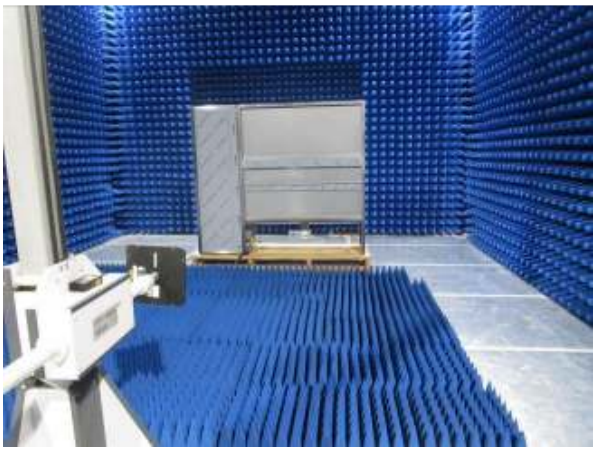

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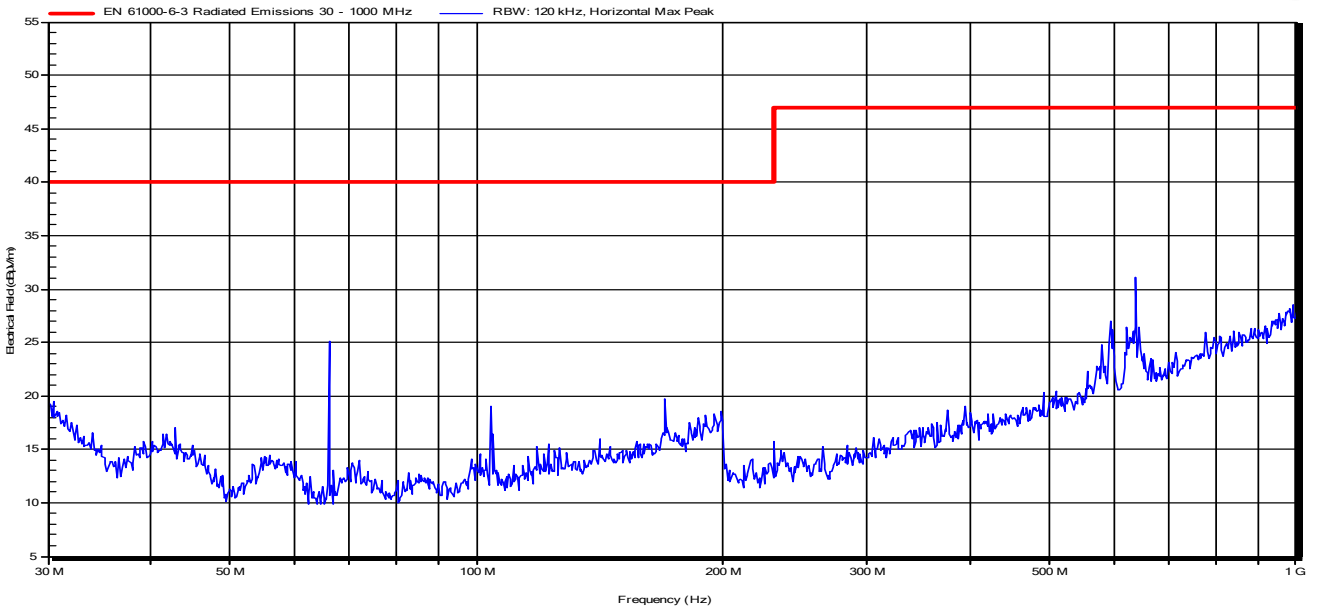
11.5 RESULTS

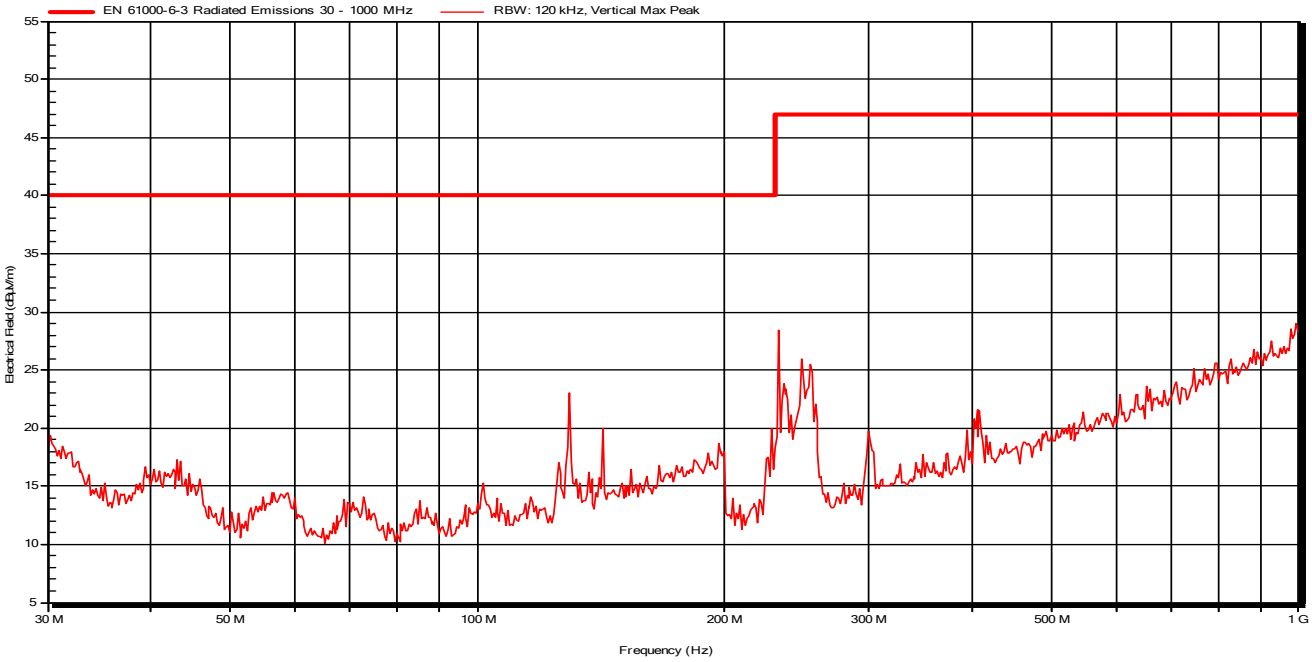
Radiated RF Emission Measurements – Horizontal Polarisation – 30 MHz to 1000 MHz – Front Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



Radiated RF Emission Measurements – Vertical Polarisation – 30 MHz to 1000 MHz – Front Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



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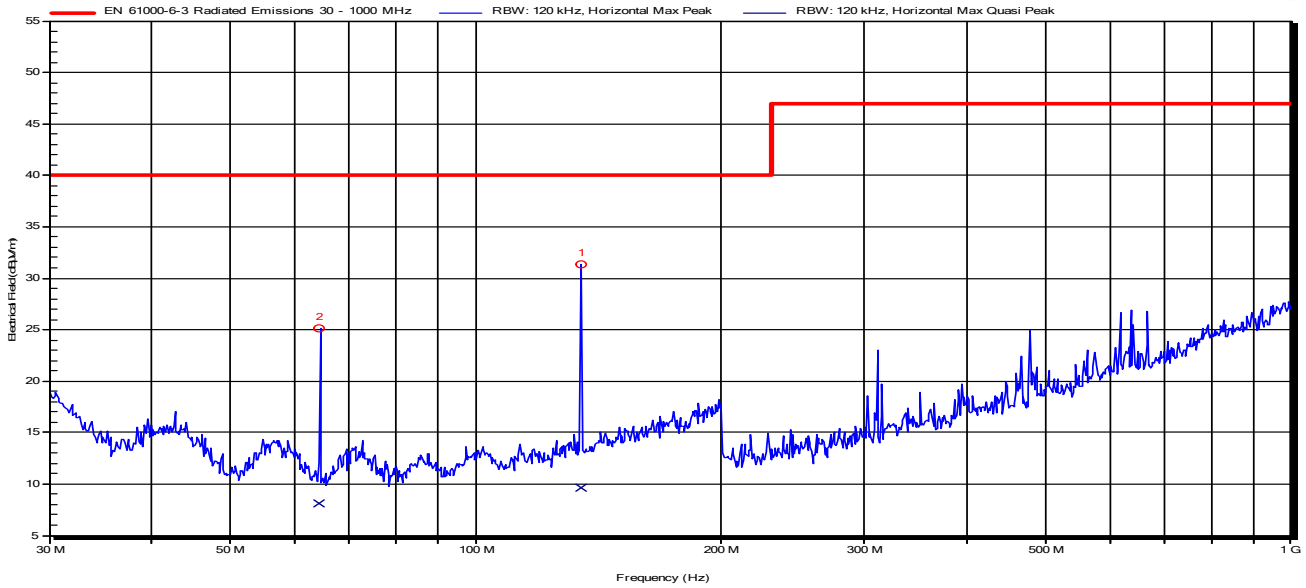
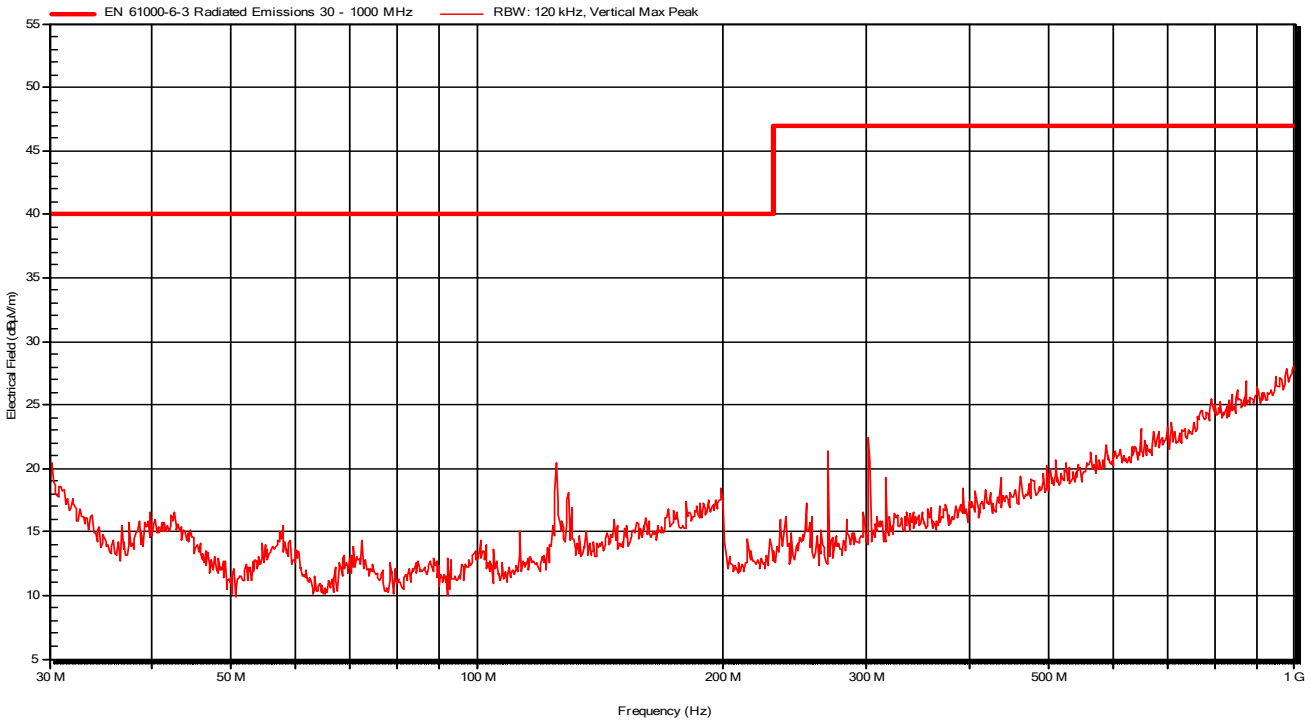
Radiated RF Emission Measurements – Horizontal Polarisation – 30 MHz to 1000 MHz – Back Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
64.369	5.2	40	**-34.8**	**Pass**
134.669	8.3	40	**-31.7**	**Pass**

RadiMation



Radiated RF Emission Measurements – Vertical Polarisation – 30 MHz to 1000 MHz – Back Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



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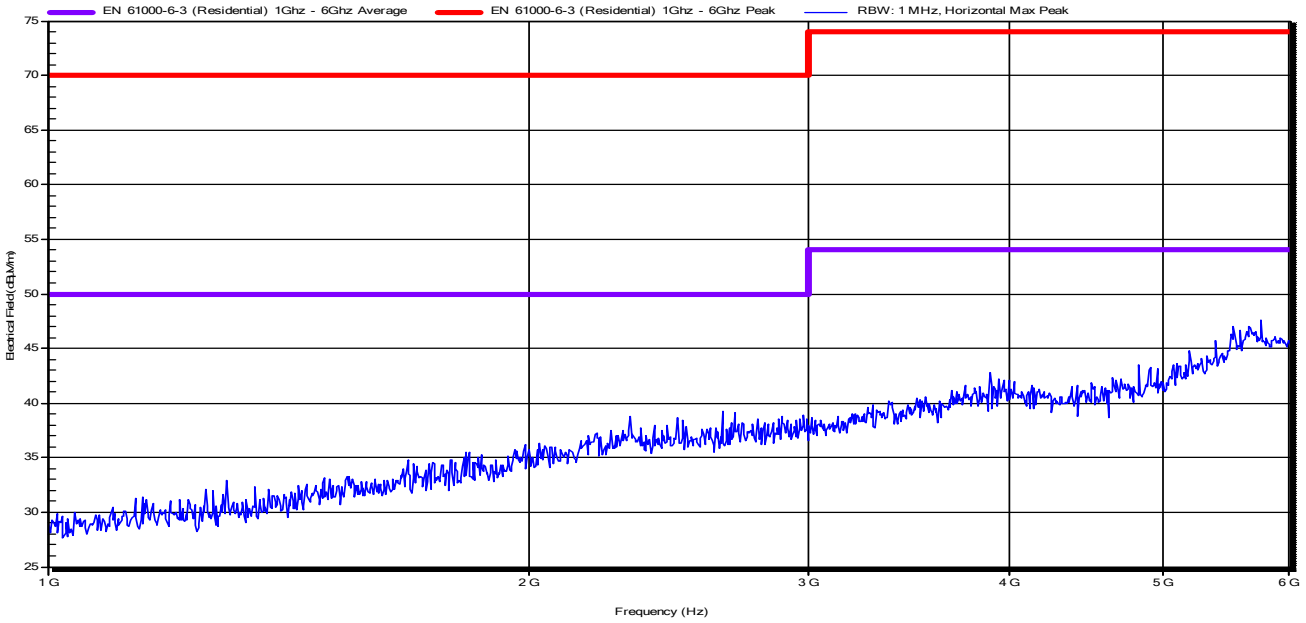
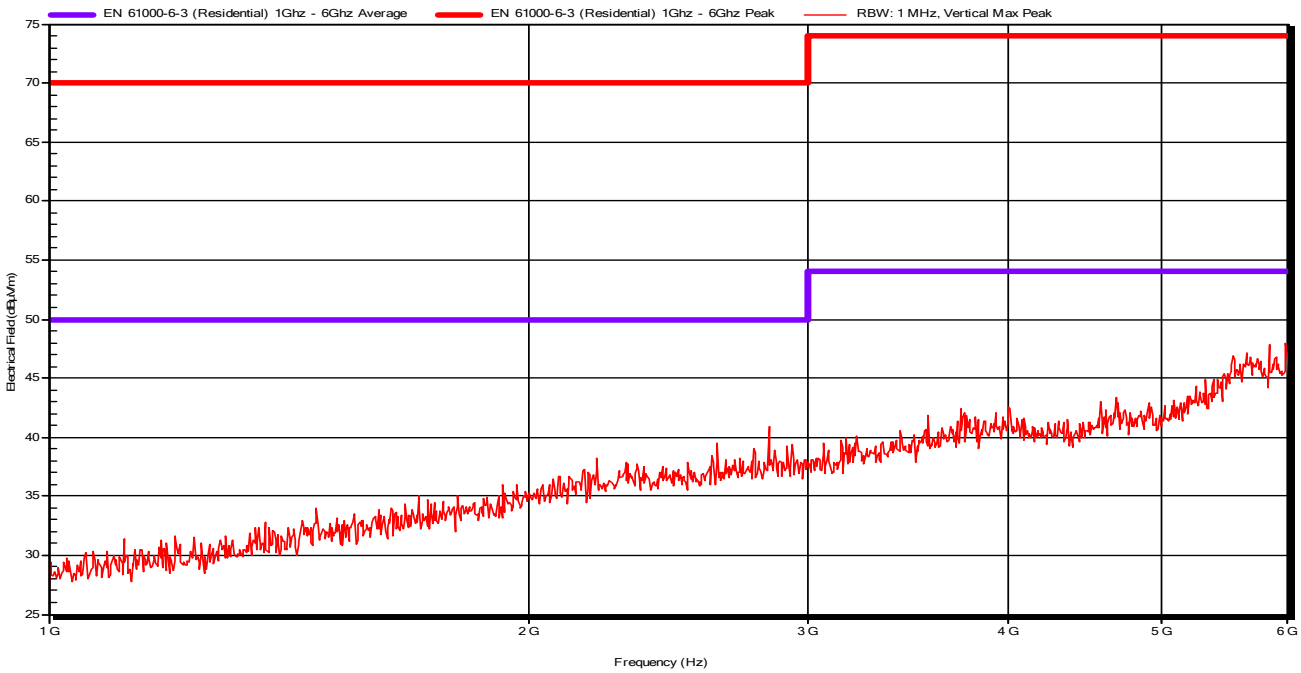
Radiated RF Emission Measurements – Horizontal Polarisation – 1000 MHz to 6000 MHz – Front Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



Radiated RF Emission Measurements – Vertical Polarisation – 1000 MHz to 6000 MHz – Front Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



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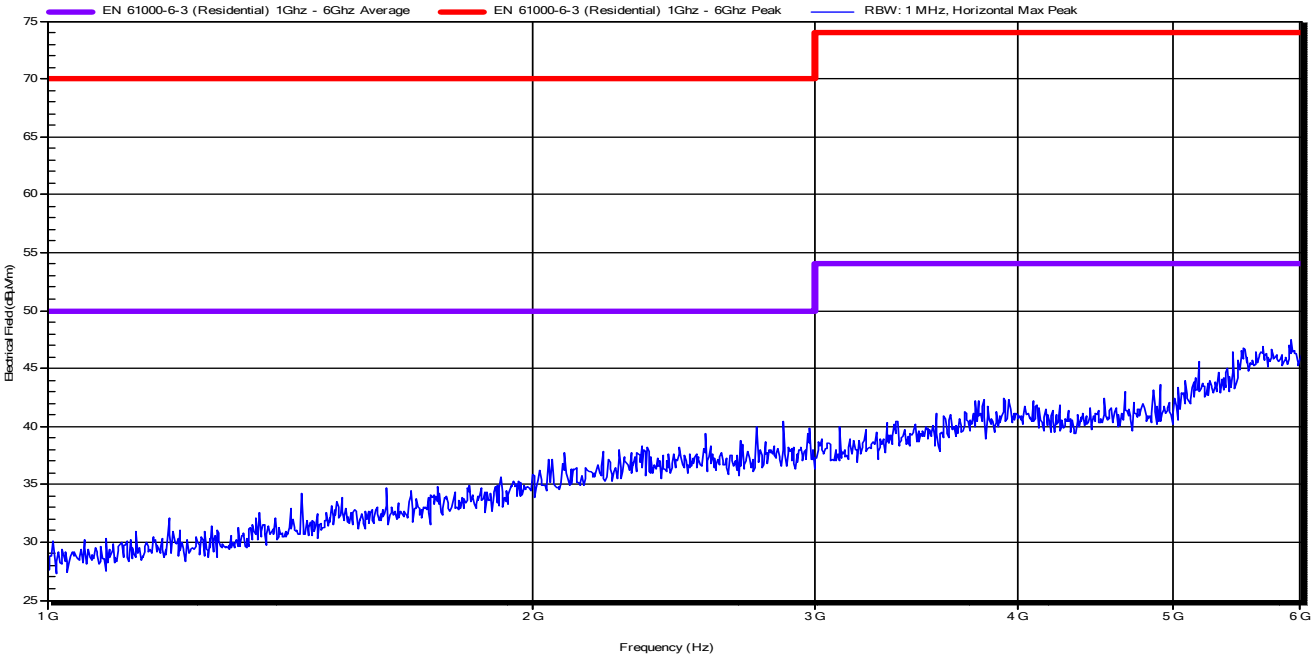
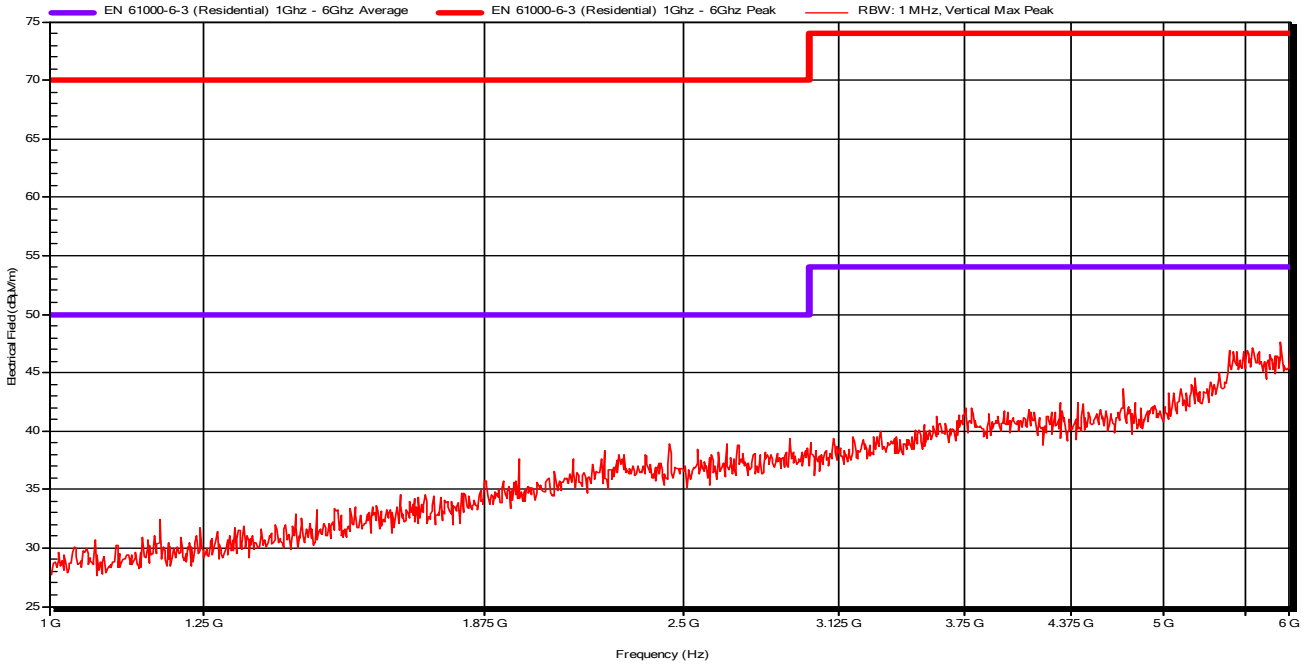
Radiated RF Emission Measurements – Horizontal Polarisation – 1000 MHz to 6000 MHz – Back Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions more than 10 dB under the limit				**Pass**

RadiMation



Radiated RF Emission Measurements – Vertical Polarisation – 1000 MHz to 6000 MHz – Back Side				
Frequency (MHz)	**Quasi-Peak (dBµV/m)**	**Quasi-Peak Limit (dBµV/m)**	**Delta Limit (dB)**	**Result**
Peak emissions are more than 10 dB under the limit				**Pass**

RadiMation



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11.6 ASSESSMENT

The TRU-BLU K9000 (Model: K9000 2.0) complied with the radiated RF emission requirements detailed in EN IEC 61000-6-3:2021.

12. MAINS TERMINAL VOLTAGE FLUCTUATION MEASUREMENTS

12.1 REQUIREMENTS

Refer EN 61000-3-3:2013/A1:2019

12.2 TEST EQUIPMENT

Asset No	Equipment	Model No	Serial No	Cal Due Date
188	Flicker Analyser	Harcs1000-1P	168	Feb 22
760	Semi Anechoic Chamber iOATS (11 x 7 x 6 m)	CE-iOATS	2021	Oct 23

12.3 ENVIRONMENTAL CONDITIONS

Environment	Range	Uncertainty (k=2)	Actual	Comment
Temperature	15.5°C to 24°C	0.5°C	22.5°C	Ok
Humidity	15% to 60%	2%	51%	Ok

12.4 PROCEDURE

Measurements were performed with the test sample plugged into and powered from a voltage fluctuation analyser in accordance with the requirements of EN 61000-3-3.

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EMC - Shielding - Environmental

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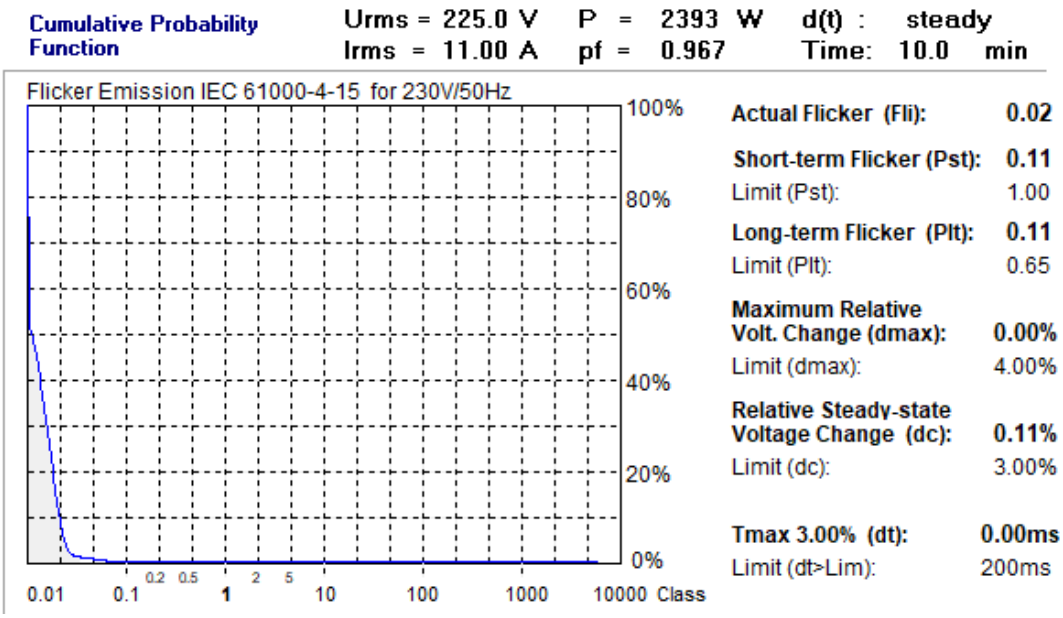
12.5 RESULTS




```
Full Bar: Actual Values
Empty Bar: Maximum Values
Circles: Average Values
Blue: Current, Green: Voltage, Red: Failed
```

Urms = 225.0V Freq = 50.039 Range: 25 A
Irms = 11.00A Ipk = 19.34A cf = 1.758
P = 2393W S = 2475VApf = 0.967

Test - Time : 12 x 10min = 120min (10000 %)

LIN (Line Impedance Network) : L: 0.24ohm +j0.15ohm N: 0.16ohm +j0.10ohm

Limits : Plt : 0.65 Pst : 1.00
dmax : 4.00 % dc : 3.00 %
dtLim: 3.00 % dt>Lim: 200ms

Test completed, Result: PASSED

	dmax [%]
1	0.000
2	0.000
3	0.000
4	0.000
5	0.000
6	0.000
7	0.000
8	0.000
9	0.000
10	0.000
11	0.000
12	0.000

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12.6 ASSESSMENT

The TRU-BLU K9000 (Model: K9000 2.0) complied with Mains Terminal Voltage Flicker requirements detailed in EN 61000-3-3:2013/A1:2019.

13. POWER FREQUENCY HARMONIC EMISSIONS

13.1 REQUIREMENTS

Refer EN IEC 61000-3-2:2019/A1:2021

13.2 TEST EQUIPMENT

Asset No	Equipment	Model No	Serial No	Cal Due Date
188	Harmonics Analyser	Harcs1000-1P	168	Feb 22
760	Semi Anechoic Chamber iOATS (11 x 7 x 6 m)	CE-iOATS	2021	Oct 23

11.3 ENVIRONMENTAL CONDITIONS

Environment	Range	Uncertainty (k=2)	Actual	Comment
Temperature	15.5°C to 24°C	0.5°C	22.5°C	Ok
Humidity	15% to 60%	2%	50%	Ok

13.4 PROCEDURE

Measurements were performed with the test sample plugged into and powered from a harmonic analyser in accordance with the requirements of EN 61000-3-2.

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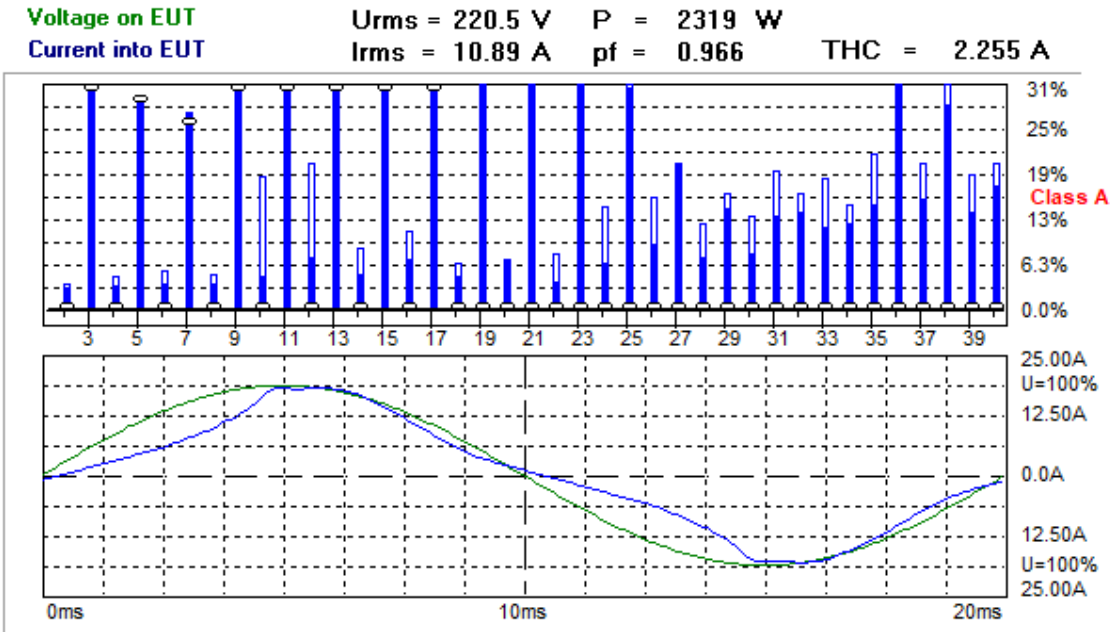
13.5 RESULTS



Full Bar: Actual Values
Empty Bar: Maximum Values
Blue: Current, Green: Voltage, Red: Failed

TRU-BLU K9000 (Model: K9000 2.0) Date : 7/12/2021 2:37:15 PM

Urms =	220.5V	Freq =	50.000	Range:	25 A
Irms =	10.89A	Ipk =	18.73A	cf =	1.720
P = 2319W	S =	2401VA	pf =	0.966	
THDi =	21.2 %	THDu =	0.20 %	Class A	

Test - Time : 5min (100 %)

Test completed, Result: PASSED

Order	Freq. [Hz]	Iavg [A]	Irms [A]	Imax [A]	Limit [A]	Status
1	50	10.624	10.654	10.706		
2	100	0.0000	0.0305	0.0351	1.0800	
3	150	2.1989	2.2064	2.2095	2.3000	
4	200	0.0000	0.0122	0.0183	0.4300	
5	250	0.3284	0.3311	0.3342	1.1400	
6	300	0.0000	0.0092	0.0153	0.3000	
7	350	0.1979	0.2060	0.2075	0.7700	
8	400	0.0000	0.0076	0.0107	0.2300	
9	450	0.1250	0.1343	0.1343	0.4000	
10	500	0.0000	0.0076	0.0336	0.1840	
11	550	0.1099	0.1175	0.1175	0.3300	
12	600	0.0000	0.0107	0.0305	0.1533	
13	650	0.0993	0.1053	0.1068	0.2100	
14	700	0.0000	0.0061	0.0107	0.1314	
15	750	0.0669	0.0824	0.0839	0.1500	
16	800	0.0000	0.0076	0.0122	0.1150	
17	850	0.0415	0.0671	0.0671	0.1324	
18	900	0.0000	0.0046	0.0061	0.1022	

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19	950	0.0000	0.0534	0.0534	0.1184
20	1000	0.0000	0.0061	0.0061	0.0920
21	1050	0.0000	0.0443	0.0443	0.1071
22	1100	0.0000	0.0031	0.0061	0.0836
23	1150	0.0000	0.0366	0.0381	0.0978
24	1200	0.0000	0.0046	0.0107	0.0767
25	1250	0.0000	0.0275	0.0290	0.0900
26	1300	0.0000	0.0061	0.0107	0.0708
27	1350	0.0000	0.0168	0.0168	0.0833
28	1400	0.0000	0.0046	0.0076	0.0657
29	1450	0.0000	0.0107	0.0122	0.0776
30	1500	0.0000	0.0046	0.0076	0.0613
31	1550	0.0000	0.0092	0.0137	0.0726
32	1600	0.0000	0.0076	0.0092	0.0575
33	1650	0.0000	0.0076	0.0122	0.0682
34	1700	0.0000	0.0061	0.0076	0.0541
35	1750	0.0000	0.0092	0.0137	0.0643
36	1800	0.0000	0.0214	0.0290	0.0511
37	1850	0.0000	0.0092	0.0122	0.0608
38	1900	0.0000	0.0137	0.0229	0.0484
39	1950	0.0000	0.0076	0.0107	0.0577
40	2000	0.0000	0.0076	0.0092	0.0460

13.6 ASSESSMENT

The TRU-BLU K9000 (Model: K9000 2.0) complied with Mains Terminal Voltage Flicker requirements detailed in EN 61000-3-3:2013/A1:2019.

14. CONCLUSION

The **TRU-BLU K9000 (Model: K9000 2.0)** complies with the RF emission requirements detailed in EN IEC 61000-6-3: 2021 Electromagnetic compatibility of Part 6-3: Generic standards - Emission standard for equipment in residential environments.