1. Report Detail

Objective	To undertake measurements to determine the EUT's compliance with the specifications.	
Equipment under test	Switched Mode Power Supply	
Manufacturer	TDK-Lambda UK Limited.	
Models	DRB480-24-1 and DRB480-48-1	
Units Tested[1]	See Appendix D – Equipment Under Test	
Test Engineers	Tim Broxholme Paul Dyer Phil Mantle (Kiwa Blackwood)	Nick Heighington Glen Moore Charlie White (ETC)

Figure 1 - Product Photograph

[1] Not all tests were carried out on every unit, details are given on the relevant pages within the document as to which units were subjected to each test regime.

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2. Results Summary Table DRB480-24-1

Specification[2]	Title	Result	Comments
EN 61000-6-1	Generic standards – Immunity for residential, commercial and light-industrial environments	Compliant	
EN 61000-6-2	Generic Standards – Immunity for industrial environments	Compliant	
EN 61000-6-3	Generic standards – Emission standard for residential, commercial and light industrial environments	Compliant	
EN 61000-6-4	Generic standards – Emission standard for industrial environments	Compliant	
CISPR 16-2-3 EN 55011 FCC 47.1.15.109 FCC 47.1.18.305	Radiated Electric Field Emissions 30MHz - 1000MHz	Class B	Simulating Customer use.
		Class B	Stand-alone
CISPR 16-2-1 EN 55011 FCC 47.1.15.107 FCC 47.1.18.307	Conducted Emissions On Power Lines (AC Power Port) 150kHz – 30MHz	Class B	.
EN 61000-3-2 EN 61000-4-7	Limits for harmonic current emissions (equipment input current <= 16 A per phase)	Class A	230V @ 50Hz and 110V @ 60Hz
EN 61000-3-3	Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <= 16 A	Pass	d_{max} = 2.13%
EN 61000-4-2	Electrostatic discharge immunity test	Level 3	Criteria A
EN61000-4-3	Radiated, radio frequency, electromagnetic field immunity test	Level 3	Criteria A
EN 61000-4-4	Electrical fast transient burst immunity test	Level 3 AC Level 3 DC	Criteria A
EN 61000-4-5	Surge Immunity test	Level 3	Criteria A
EN 61000-4-6	Immunity to conducted disturbances, induced by radio frequency fields	Level 3	Criteria A
EN 61000-4-8	Power frequency magnetic field immunity test	Level 4	Criteria A
EN 61000-4-11	Voltage dips, short interruptions and voltage variations immunity test	Class 3	Criteria A / B
EN 61000-4-12	Ring wave immunity test	Level 3	Criteria A

[2] See Appendix B – References for dates of standards used.

3. Results Summary Table DRB480-48-1

Specification[3]	Title	Result	Comments
EN 61000-6-1	Generic standards – Immunity for residential, commercial and light-industrial environments	Compliant	
EN 61000-6-2	Generic Standards – Immunity for industrial environments	Compliant	
EN 61000-6-3	Generic standards – Emission standard for residential, commercial and light industrial environments	Compliant	
EN 61000-6-4	Generic standards – Emission standard for industrial environments	Compliant	
CISPR 16-2-3 EN 55011 FCC 47.1.15.109 FCC 47.1.18.305	Radiated Electric Field Emissions 30MHz - 1000MHz	Class B	Simulating Customer use.
		Class B	Stand-alone
CISPR 16-2-1 EN 55011 FCC 47.1.15.107 FCC 47.1.18.307	Conducted Emissions On Power Lines (AC Power Port) 150kHz – 30MHz	Class B	.
EN 61000-3-2 EN 61000-4-7	Limits for harmonic current emissions (equipment input current <= 16 A per phase)	Class A	230V @ 50Hz and 110V @ 60Hz
EN 61000-3-3	Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <= 16 A	Pass	d_{max} = 2.13%
EN 61000-4-2	Electrostatic discharge immunity test	Level 3	Criteria A
EN61000-4-3	Radiated, radio frequency, electromagnetic field immunity test	Level 3	Criteria A
EN 61000-4-4	Electrical fast transient burst immunity test	Level 3 AC Level 3 DC	Criteria A
EN 61000-4-5	Surge Immunity test	Level 3	Criteria A
EN 61000-4-6	Immunity to conducted disturbances, induced by radio frequency fields	Level 3	Criteria A
EN 61000-4-8	Power frequency magnetic field immunity test	Level 4	Criteria A
EN 61000-4-11	Voltage dips, short interruptions and voltage variations immunity test	Class 3	Criteria A / B
EN 61000-4-12	Ring wave immunity test	Level 3	Criteria A

[3] See Appendix B – References for dates of standards used.

4. Table of Contents

5. System Configuration During EMC Testing

The equipment under test (EUT) was configured for all testing as described below, details of test specific setup is given on the relevant pages.

5.1. Emission Testing

The EUT consisted of a switched mode power supply producing one output. The power supply output was connected via 30 cm lengths of cable to load resistors, an LED was connected across each load to give a visual indication that the output was operational. For emissions the unit was tested as both stand-alone and with EUT and load resistors mounted in an enclosure.

5.2. Immunity Testing

The EUT was functioning correctly prior to each test and was configured as for stand-alone emission testing. The correct operation of the EUT was monitored throughout the test by a glitch detector circuit attached to each output port and signal port. This is configured to detect changes in output as defined in Appendix A,Table 63. This also has analogue voltage meters to provide a visual indication. For some testing that injects noise into the output ports the glitch detectors cannot be used. For these tests viewing an analogue meter connected to the load resistors is used. Additionally for some tests an oscilloscope is also used to monitor the output voltages. This was done continuously by using a closed circuit television camera and monitor where necessary. Variation in output voltage or loss of output or activation of any latch circuits was indicated by the meters, as well as giving an additional indication of the EUT's performance. The EUT is tested to conform to performance criteria A or B dependant on test and level, see Appendix A for a full description of performance criteria.

5.3. EMC Performance

The EMC performance of a power supply can be affected by the final installation, for guidance with respect to test conditions please see the application note or contact your local TDK-Lambda sales office.

6. Collateral, Generic and Product Standards

6.1. EN 61000-6-1 Generic standards – Immunity for residential, commercial and light-industrial environments

Table 1 – Immunity – Enclosure port

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
1.1	Power-frequency magnetic field	50, 60 Hz 3 A/m	A	50, 60 Hz 30 A/m	A
1.2	Radio-frequency electromagnetic field amplitude modulated	80 to 1000 MHz 3 V/m 80 % AM (1 kHz)	A	80 to 1000 MHz 10 V/m 80 % AM (1 kHz)	A
1.3	Radio-frequency electromagnetic field amplitude modulated	1.4 to 2.0 GHz 3 V/m 80 % AM (1 kHz)	A	1.4 to 2.0 GHz 10 V/m 80 % AM (1 kHz)	A
1.4	Radio-frequency electromagnetic field amplitude modulated	2.0 to 2.7 GHz 1 V/m 80 % AM (1 kHz)	A	2.0 to 2.7 GHz 10 V/m 80 % AM (1 kHz)	A
1.5	Electrostatic discharge	Contact ± 4 kV Air ± 8 kV	B B	Contact ± 6 kV Air: ± 6 kV	A A

Table 3 – Immunity – DC input and DC output power ports

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
3.1	Radio-frequency common mode	0.15 – 80 MHz 3 V 80 % AM (1kHz)	A	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A
3.2	Surges Line- to-earth Line-to-line	1.2/50 (8/20) µs ± 0.5 kV ± 0.5 kV	B	Output lines are not intended to connect directly to outdoor cables, so are excluded. Where this is required additional system level protection shall be used.	
3.3	Fast transients	± 0.5 kV 5/50 ns 5 kHz	B	± 2 kV 5/50 ns 5 kHz	A

Table 4 – Immunity – Input and output AC power ports

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
4.1	Radio-frequency common mode	0.15 – 80 MHz 3 V 80 % AM (1kHz)	A	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A
4.2	Voltage dips	0% residual voltage 0.5 cycles	B	0% residual voltage 0.5 cycles	A
		0% residual voltage 1 cycles	B	0% residual voltage 1 cycles	A

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
		70% residual voltage 25/30 cycles at 50/60Hz	C	70% residual voltage 25/30 cycles at 50/60Hz	B
4.3	Voltage interruptions	0% residual voltage 250/300 cycles at 50/60Hz	C	0% residual voltage 250/300 cycles at 50/60Hz	B
4.4	Surges Line- to-earth Line-to-line	1.2/50 (8/20) µs ± 2 kV ± 1 kV	B	1.2/50 (8/20) µs ± 2 kV ± 1 kV	A
4.5	Fast transients	± 1 kV 5/50 ns 5 kHz	B	± 2 kV 5/50 ns 5 kHz	A

6.2. EN 61000-6-2 Generic Standards – Immunity for industrial environments

Table 1 – Immunity – Enclosure Ports

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
1.1	Power-frequency magnetic field	50, 60 Hz 30 A/m	A	50, 60 Hz 30 A/m	A
1.2	Radio-frequency electromagnetic field amplitude modulated	80 to 1000 MHz 10 V/m 80 % AM (1 kHz)	A	80 to 1000 MHz 10 V/m 80 % AM (1 kHz)	A
1.3	Radio-frequency electromagnetic field amplitude modulated	1.4 to 2.0 GHz 3 V/m 80 % AM (1 kHz)	A	1.4 to 2.0 GHz 10 V/m 80 % AM (1 kHz)	A
1.4	Radio-frequency electromagnetic field amplitude modulated	2.0 to 2.7 GHz 1 V/m 80 % AM (1 kHz)	A	2.0 to 2.7 GHz 10 V/m 80 % AM (1 kHz)	A
1.5	Electrostatic discharge	Contact ± 4 kV Air ± 8 kV	B B	Contact ± 6 kV Air ± 8 kV	A A

Table 3 – Immunity – Input and Output DC power ports

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
3.1	Radio-frequency common mode	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A
3.2	Surges Line- to-earth Line-to-line	1.2/50 (8/20) µs ± 0.5 kV ± 0.5 kV	B	Output lines are not intended to connect directly to outdoor cables, so are excluded. Where this is required additional system level protection shall be used.	
3.3	Fast transients	± 2 kV 5/50 ns 5 kHz	B	± 2 kV 5/50 ns 5 kHz	A

Table 4 – Immunity – Input and output AC power ports

Section	Environmental Phenomenon	Test specification	Performance Criteria	Level Achieved	Criteria Achieved
4.1	Radio-frequency common mode	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A	0.15 – 80 MHz 10 V 80 % AM (1kHz)	A
4.2	Voltage dips	0% residual voltage 1 cycles	B	0% residual voltage 1 cycles	A
		40% residual voltage 10/12 cycles at 50/60Hz	C	40% residual voltage 10/12 cycles at 50/60Hz	B
		70% residual voltage 25/30 cycles at 50/60Hz	C	70% residual voltage 25/30 cycles at 50/60Hz	B
4.3	Voltage Interruptions	0% residual voltage 250/300 cycles at 50/60Hz	C	0% residual voltage 250/300 cycles at 50/60Hz	B
4.4	Surges Line- to-earth Line-to-line	1.2/50 (8/20) µs ± 2 kV ± 1 kV	B	1.2/50 (8/20) µs ± 2 kV ± 1 kV	A
4.5	Fast transients	± 2 kV 5/50 ns 5 kHz	B	± 2 kV 5/50 ns 5 kHz	A

6.3. EN 61000-6-3 Generic standards – Emission standard for residential, commercial and light-industrial environments

Clause	Port	Frequency Range	Limits	Requirement	Level Achieved
1.1	Enclosure port	30 MHz – 230 MHz 230 MHz – 1000 MHz	30 dBµV/m Quasi-peak at 10m 37 dBµV/m Quasi-peak at 10m	CISPR 16-2-3	Compliant
2.1	Low voltage AC mains port	See Basic Standards	IEC 61000-3-2 IEC 61000-3-3	IEC 61000-3-2 IEC 61000-3-3	Class A d_{max} <4% Other aspects to be tested at system level.
		0.15 MHz – 0.5 MHz	66 dBµV to 56 dBµV quasi-peak 56 dBµV to 46 dBµV average	CISPR 16-2-1, 7.4.1 CISPR 16-1-2, 4.3	Compliant
		0.5 MHz – 5 MHz	56 dBµV quasi-peak 46 dBµV average		
		0.5 MHz – 5 MHz	60 dBµV quasi-peak 50 dBµV average		
3.1	DC power	Not applicable			
4.1	Telecommunications / network	Not applicable			

6.4. EN 61000-6-4 Generic standards – Emission standard for industrial environments

Clause	Port	Frequency Range	Limits	Requirement	Level Achieved
1.1	Enclosure port	30 MHz – 230 MHz 230 MHz – 1000 MHz	40 dBµV/m Quasi-peak at 10m 47 dBµV/m Quasi-peak at 10m	CISPR 16-2-3	Compliant
2.1	Low voltage AC mains port	0.15 MHz – 0.5 MHz	79 dBµV quasi-peak 66 dBµV average	CISPR 16-2-1, 7.4.1 CISPR 16-1-2, 4.3	Compliant
		0.5 MHz – 30 MHz	73 dBµV quasi-peak 60 dBµV average		
3.1	Telecommunications / network	Not applicable			

7. Radiated Electric Field Emissions 30MHz - 1000MHz to EN55011

7.1. Enclosure Port - Test Procedure.

The EUT was set up in the Semi Anechoic Chamber (SAC), being placed on the table. Measurements were taken at a distance of 3m and were obtained with the antenna in horizontal and vertical polarisations. A scan was taken from 30 MHz to 1000MHz this giving a list of highest emissions, these emissions were then confirmed to be coming from the EUT. Then formally measured using a Quasi-Peak detector on a 10m OATS. Details of the highest emissions are presented below; see also Appendix B – Additional Emissions Results.

Table 1 - Radiated Emissions, Class B Limits

Standard	Frequency (MHz)	Field Strength in Standard	Field Strength, 3m (dBµV/m)	Field Strength, 10m (dBµV/m)
EN55011	30MHz – 230MHz	40dBµV/m	40.00	30.00
	230MHz – 1000MHz	47dBµV/m	47.00	37.00
FCC Title 47, Part 15, Subpart B, §15.109	30MHz - 88MHz	100µV/m	40.00	30.00
	88MHz – 216MHz	150µV/m	43.52	33.52
	216MHz - 960MHz	200µV/m	46.02	36.02
	Above 960MHz	500µV/m	53.98	43.98

Figure 2 - Test Setup, Radiated Emissions (SAC)

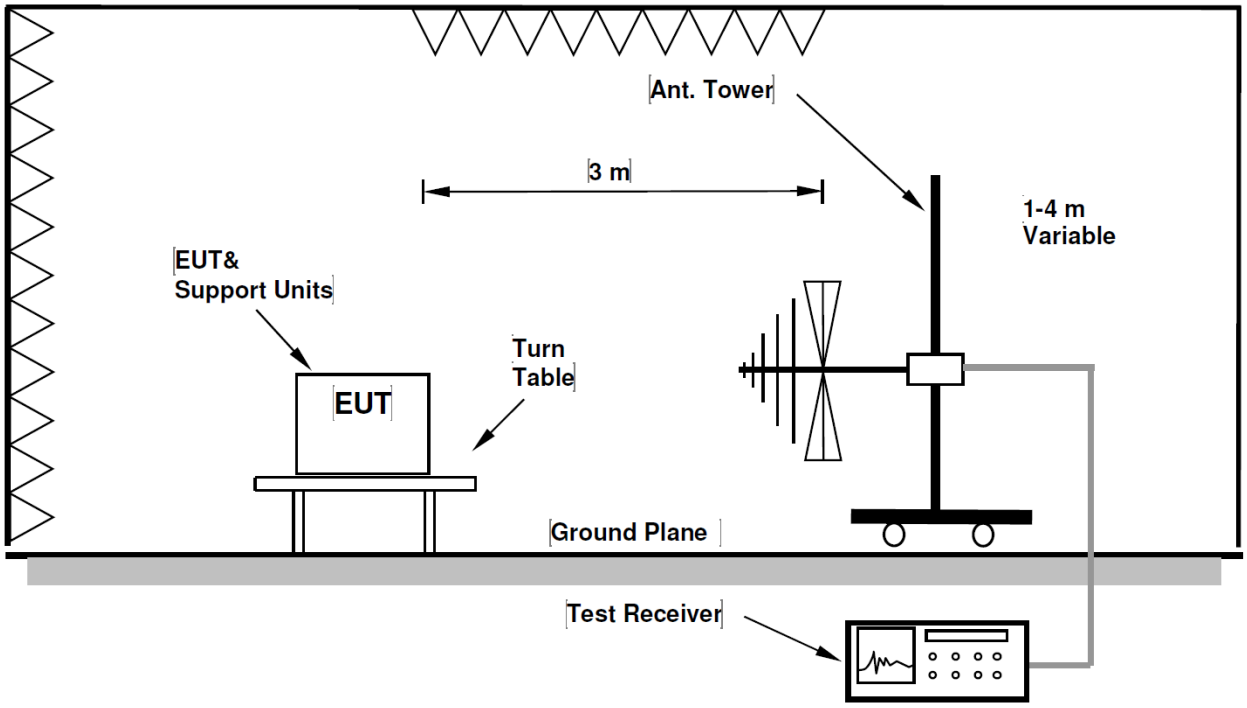
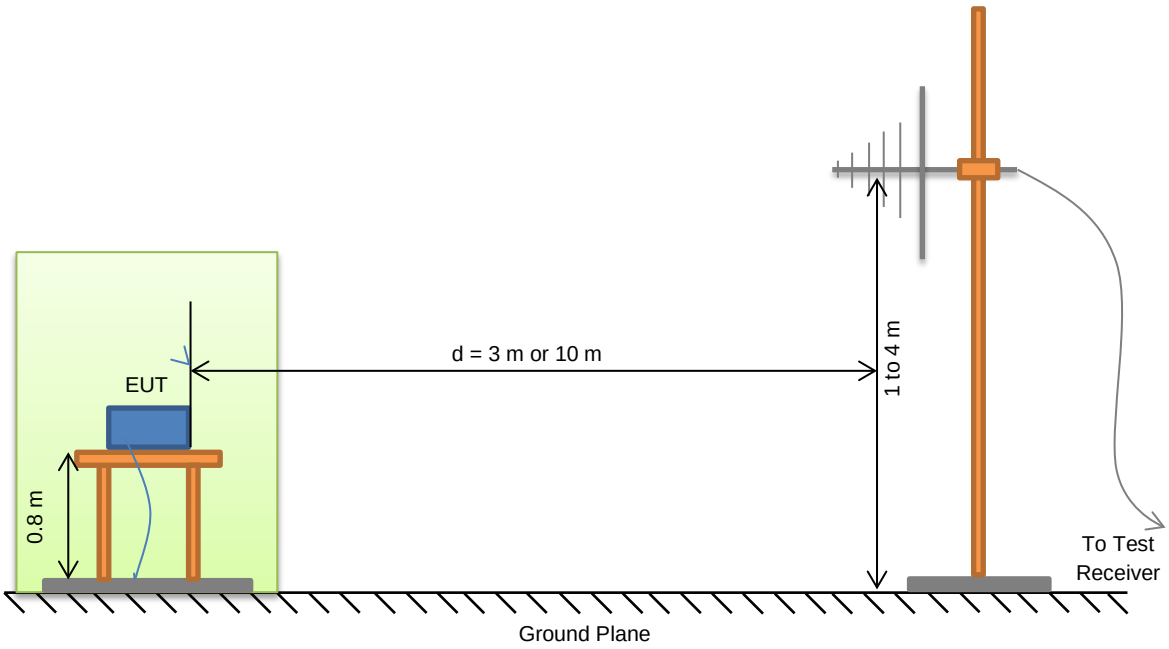


Figure 3 - Test Setup, Radiated Emissions (OATS)



The EUT was tested in two configurations, stand-alone and in a cabinet:

Figure 4 - Test Configuration, Radiated Emissions – Stand-Alone

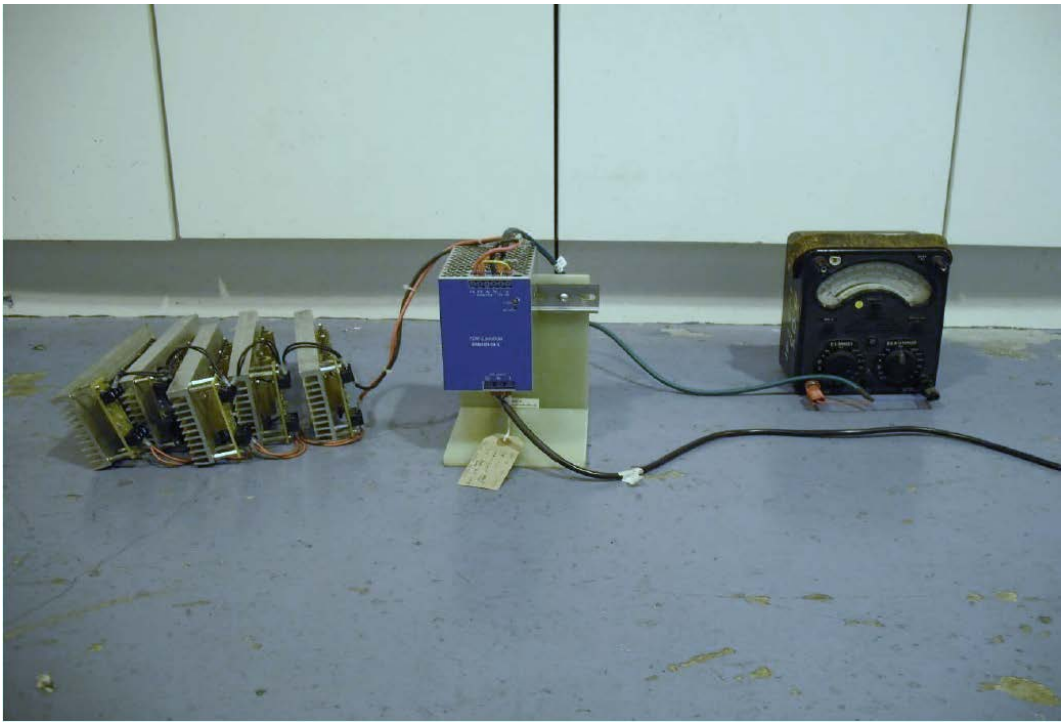
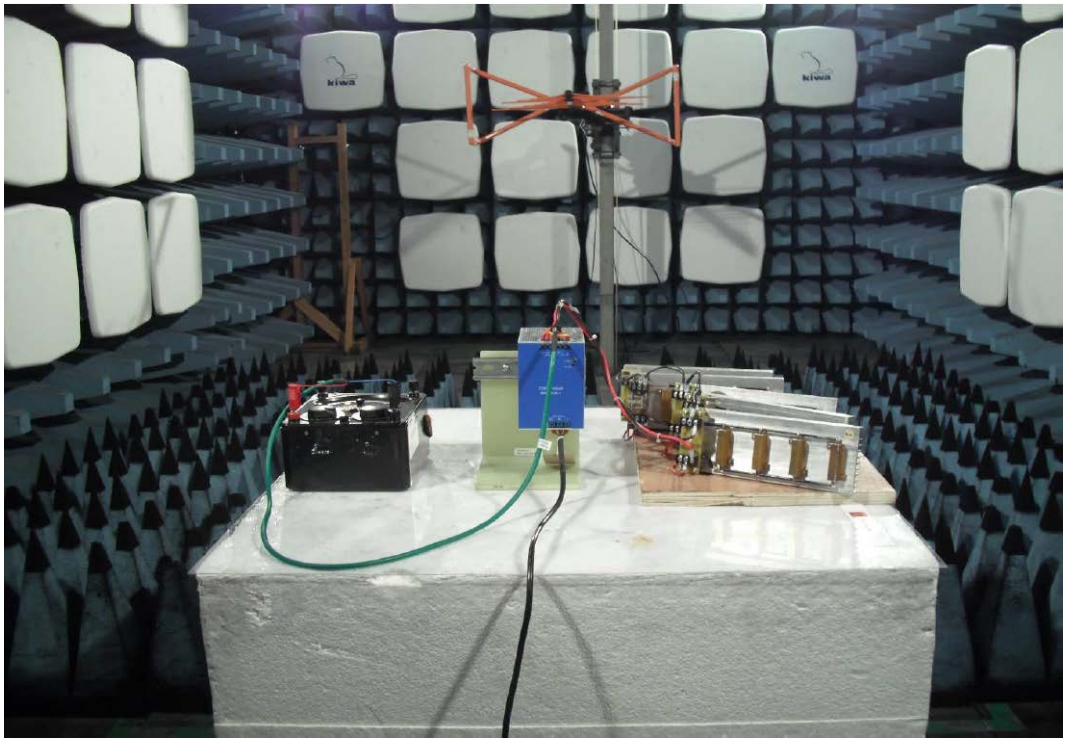


Figure 5 - Test Configuration, Radiated Emissions – In Cabinet

Figure 6 – Radiated Emissions Test Setup



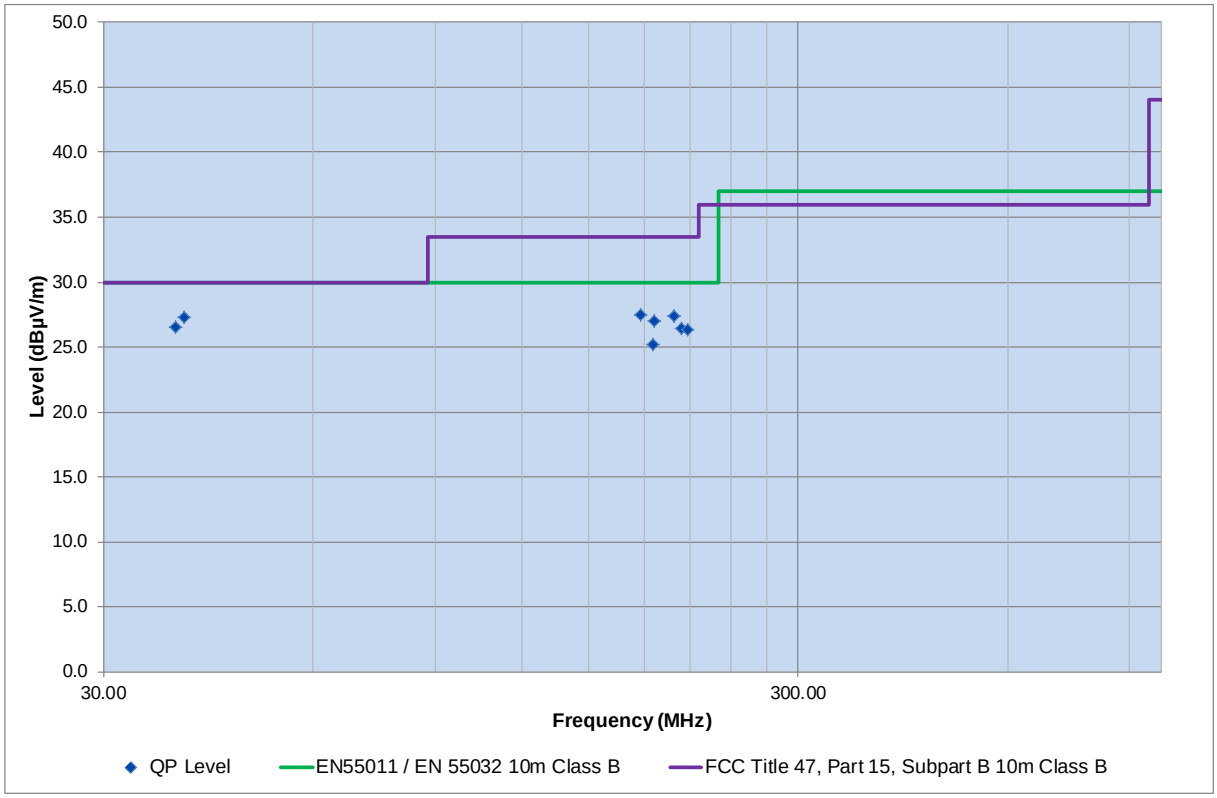
7.2. Test Results

The levels of the highest emissions measured in accordance with the specification are presented below. The unit was measured as a stand-alone supply and in a cabinet to simulate a typical customer use. The emissions with the least margin are highlighted. Graphs of radiated emissions are held in engineering if necessary.

Table 2 - Radiated Electric Field Emissions, DRB480-24-1 UNIT #04, Stand alone Supply

Frequency (MHz)	QuasiPeak (dBµV/m)	Polarisation	Limit EN55011 Class B (dBµV/m)	Margin EN55011 Class B (dB)	Limit FCC Class B (dBµV/m)	Margin FCC Class B (dBµV/m)
38.16	26.56	V	30.0	3.4	30.0	3.4
39.27	27.28	V	30.0	2.7	30.0	2.7
178.03	27.51	H	30.0	2.5	33.5	6.0
185.74	25.20	V	30.0	4.8	33.5	8.3
185.84	27.03	H	30.0	3.0	33.5	6.5
199.03	27.38	H	30.0	2.6	33.5	6.1
203.83	26.47	V	30.0	3.5	33.5	7.0
207.68	26.33	H	30.0	3.7	33.5	7.2

Figure 7 - Radiated Emissions 230Vac, DRB480-24-1 UNIT #04, Stand alone Supply Graph



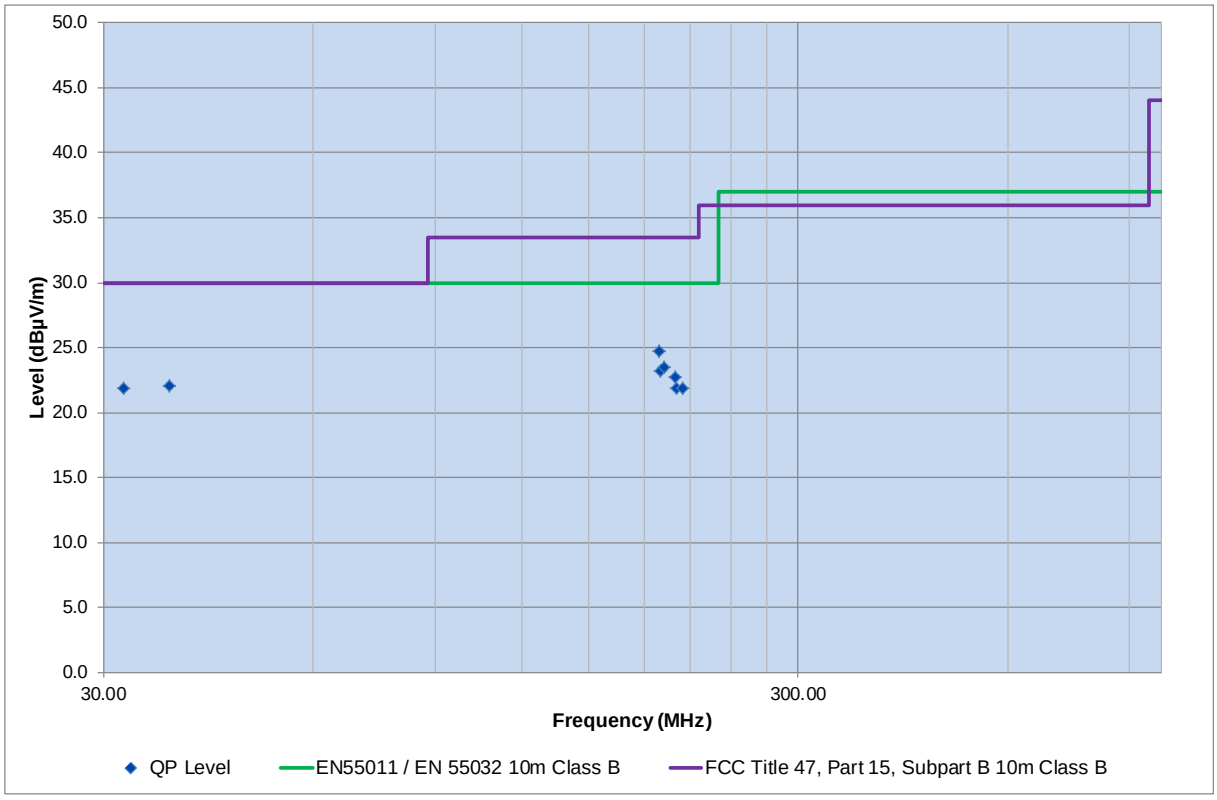
Unit Tested: DRB480-24-1 UNIT #04, the EUT met the requirements of EN 55011:2009 +A1:2010 (Class B [Enclosure Port]) for radiated disturbances when measured as a stand alone supply. In addition the requirements of FCC Title 47, Part 15, Subpart B, §15.109, Class B were met.

Procedure	CISPR16-2-3: 2006 / EN 55011:2009 + A1:2010 FCC Title 47, Part 15, Subpart B, §15.109	**Date**	16/09/2016
		Location	Kiwa Blackwood
Environment	20°C	**Test Engineer**	Phil Mantle

Table 3 - Radiated Electric Field Emissions, DRB480-24-1 UNIT #04, In Cabinet

Frequency (MHz)	QuasiPeak (dBµV/m)	Polarisation	Limit EN55011 Class B (dBµV/m)	Margin EN55011 Class B (dB)	Limit FCC Class B (dBµV/m)	Margin FCC Class B (dBµV/m)
32.07	21.87	V	30.00	8.13	30.00	8.13
37.30	22.07	V	30.00	7.93	30.00	7.93
189.35	24.70	V	30.00	5.30	33.52	8.82
190.01	23.23	H	30.00	6.77	33.52	10.29
192.47	23.48	H	30.00	6.52	33.52	10.04
199.57	22.71	V	30.00	7.29	33.52	10.81
200.04	21.83	H	30.00	8.17	33.52	11.69
204.69	21.83	H	30.00	8.17	33.52	11.69

Figure 8 - Radiated Emissions 230Vac, DRB480-24-1 UNIT #04, In Cabinet Graph



Unit Tested: DRB480-24-1 UNIT #04, the EUT met the requirements of EN 55011:2009 +A1:2010 (Class B [Enclosure Port]) for radiated disturbances when measured in the cabinet. In addition the requirements of FCC Title 47, Part 15, Subpart B, §15.109, Class B were met.

Procedure	CISPR16-2-3: 2006 / EN 55011:2009 + A1:2010 FCC Title 47, Part 15, Subpart B, §15.109	**Date**	16/09/2016
		Location	Kiwa Blackwood
Environment	20°C	**Test Engineer**	Phil Mantle

Table 4 - Radiated Emissions Test Equipment DRB480-24-1

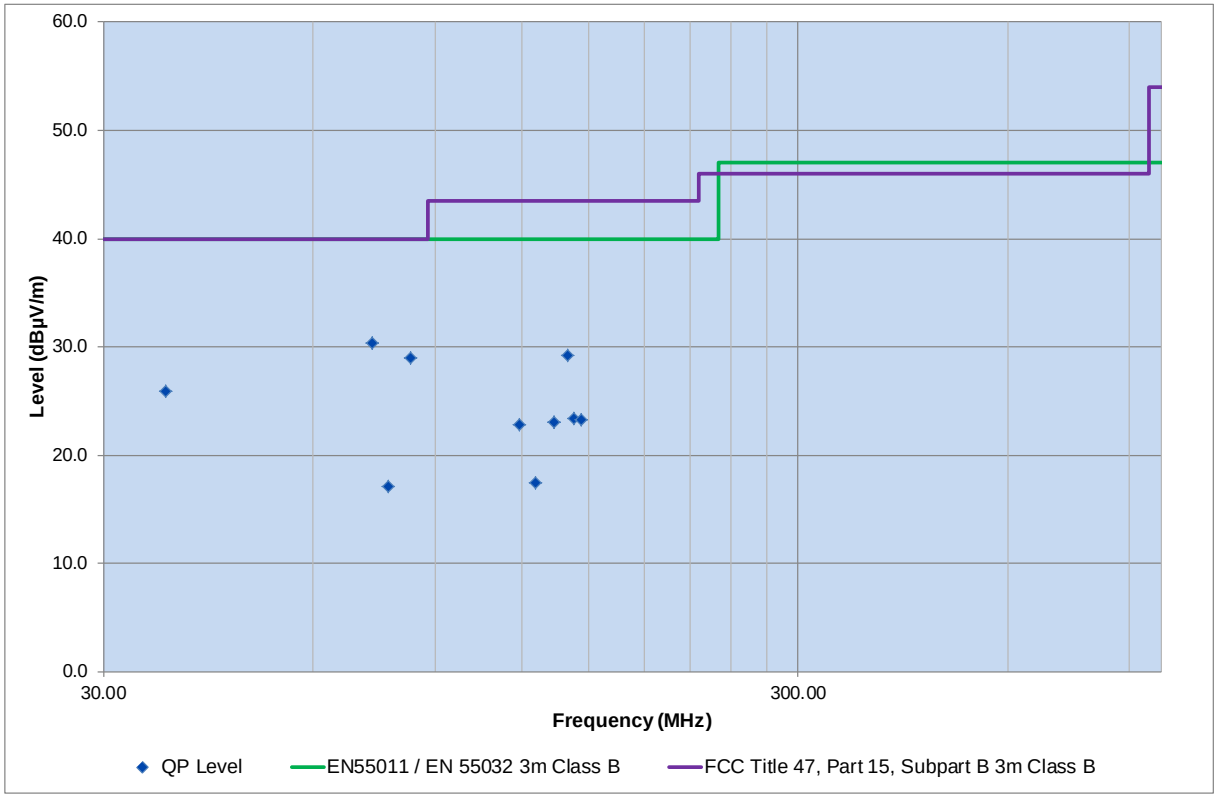
Equipment	Manufacturer	Kiwa Blackwood Reference
Anechoic Chamber	Rainford	8551
CBL6143 Bilog Antenna	Schaffner	8623
Antenna Cables	N/A	N/A
HP 8568B Spectrum Analyser System	HP	8512
HP 8566B Spectrum Analyser System	HP	8513
Radiated Emissions Pre-Scan Software	HP	8637
10m Open Area Test Site (OATS)	N/A	8516
CBL6111 Bilog Antenna	Chase	8515
1051 Mast	EMCO	8660
N-Type 20m OATS Cable	N/A	8511
Radiated Emissions OATS Software	HP	8647

All test equipment was traceably calibrated at the time of testing.

Table 5 - Radiated Electric Field Emissions, DRB480-48-1 UNIT #06, In Cabinet

Frequency (MHz)	QuasiPeak (dBµV/m)	Polarisation	Limit EN55011 Class B (dBµV/m)	Margin EN55011 Class B (dB)	Limit FCC Class B (dBµV/m)	Margin FCC Class B (dBµV/m)
36.80	25.90	V	40.0	14.1	40.0	14.1
73.20	30.30	V	40.0	9.7	40.0	9.7
77.12	17.10	H	40.0	22.9	40.0	22.9
83.00	29.00	V	40.0	11.0	40.0	11.0
118.96	22.80	V	40.0	17.2	43.5	20.7
125.40	17.50	H	40.0	22.5	43.5	26.0
133.52	23.00	H	40.0	17.0	43.5	20.5
139.76	29.20	H	40.0	10.8	43.5	14.3
142.64	23.40	V	40.0	16.6	43.5	20.1
146.44	23.30	H	40.0	16.7	43.5	20.2

Figure 9 - Radiated Emissions 230Vac, DRB480-48-1 UNIT #06, In Cabinet Graph



Unit Tested: DRB480-48-1 UNIT #06, the EUT met the requirements of EN 55011:2016 (Class B [Enclosure Port]) for radiated disturbances when measured in the cabinet. In addition the requirements of FCC Title 47, Part 15, Subpart B, §15.109, Class B were met.

Procedure	EN 55011:2016 FCC Title 47, Part 15, Subpart B, §15.109	**Date**	06/07/2018
		Location	TDK Lambda UK Ltd.
Environment	22°C; 34%rh; 1009mB	**Test Engineer**	Tim Broxholme

8. Conducted Emissions, Mains Disturbance 0.15MHz to 30MHz to EN55011

8.1. AC Power Port - Test Procedure

The emissions were measured using an Average and a Quasi-Peak detector. A scan was taken from 0.15 MHz to 30MHz thus giving a list of highest emissions, these emissions were then formally measured using an average and quasi-peak detector, measuring both L1 and N lines. The emissions were measured under the following test conditions, according to TDK-Lambda documents 72500 and 69896.

Figure 10 - Conducted Emissions Test Setup

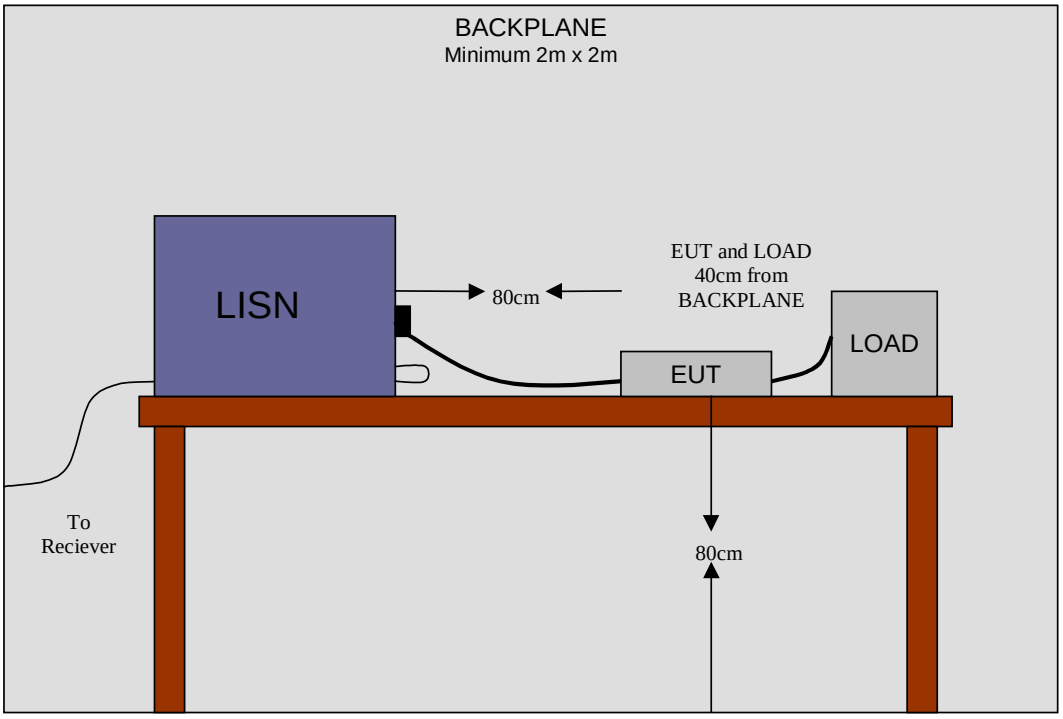


Table 6 - Conducted Emissions Test Equipment

Equipment	Manufacturer	Kiwa Blackwood Reference
3825/2 Line Impedance Stabilisation Network.	EMCO	8501
25-A-MFB-10 10dB Attenuator	Bird	8770
J01006A0836 10dB Attenuator	Telegartner	8627
10m BNC Cable	N/A	8761
50Ω Termination	N/A	8659
HP8566B Spectrum Analyser System	HP	8513
Conducted Emissions Software	HP	8636
BAA898HG Environmental Monitor	Oregon Scientific	8648

All test equipment was traceably calibrated at the time of testing.

8.2. AC Power Port - Test Results

Figure 11 - Conducted Emissions, DRB480-24-1 Unit #04, Stand-Alone, Graphs

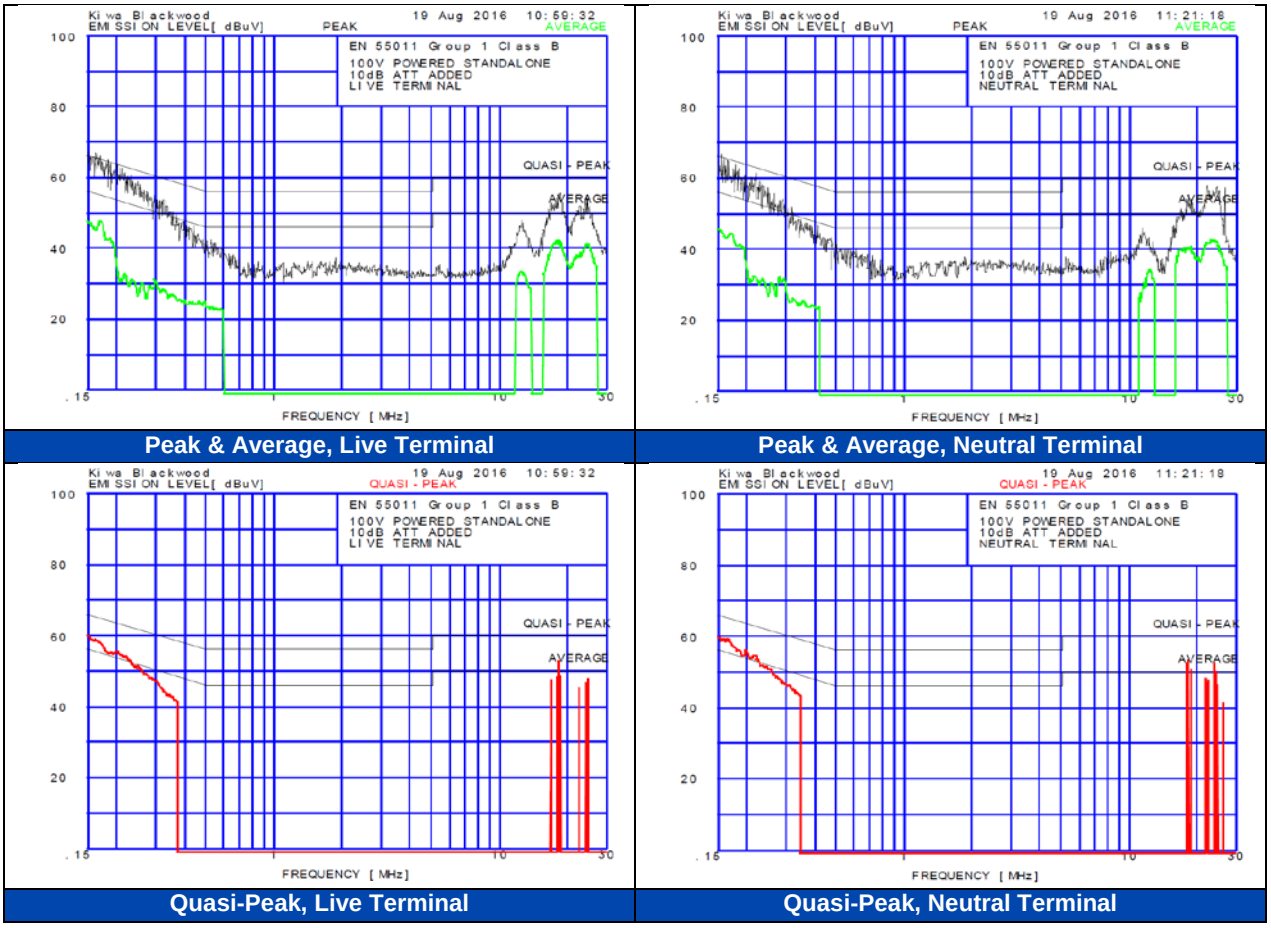


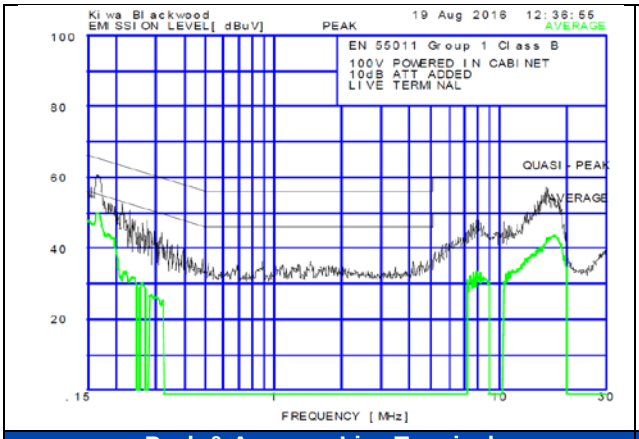
Table 7 - Conducted Emissions, DRB480-24-1 Unit #04, Stand-Alone, Quasi-Peak

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.158	59.4	N	6.1	65.5
0.163	58.8	L	6.4	65.2
0.167	59.3	N	5.8	65.1
18.05	52.8	N	7.2	60.0
18.43	53.1	L	6.9	60.0

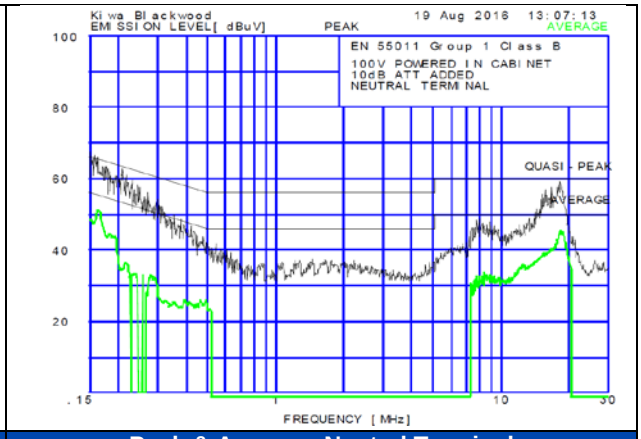
Table 8 - Conducted Emissions, DRB480-24-1 Unit #04, Stand-Alone, Average

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.171	47.6	L	7.3	54.9
17.95	42.3	L	7.7	50.0
18.14	42.3	L	7.7	50.0
18.34	42.4	L	7.6	50.0
22.90	42.9	N	7.1	50.0
23.15	42.7	N	7.3	50.0

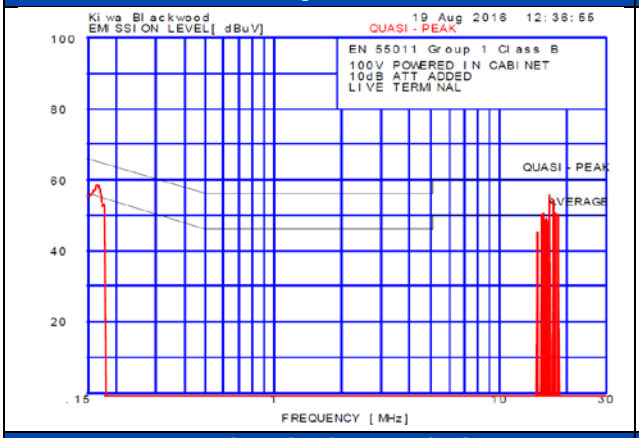
Figure 12 - Conducted Emissions, DRB480-24-1 Unit #04, In Cabinet, Graphs



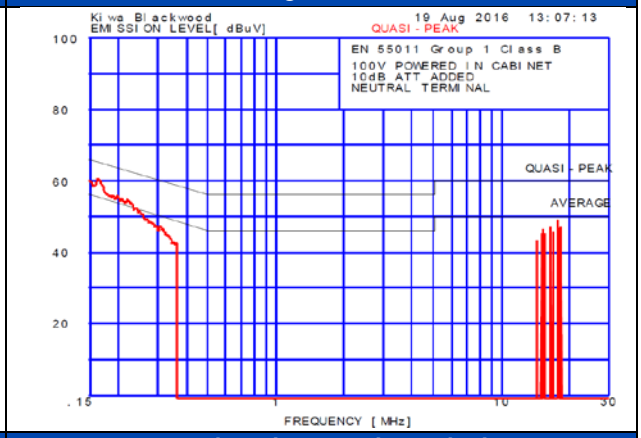
Peak & Average, Live Terminal



Peak & Average, Neutral Terminal



Quasi-Peak, Live Terminal



Quasi-Peak, Neutral Terminal

Table 9 - Conducted Emissions, DRB480-24-1 Unit #04, In Cabinet, Quasi-Peak

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.164	60.4	N	4.8	65.2
0.200	55.9	N	7.7	63.6
16.85	55.8	L	4.2	60.0
17.39	54.1	L	5.9	60.0

Table 10 - Conducted Emissions, DRB480-24-1 Unit #04, In Cabinet, Average

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.152	48.5	N	7.3	55.8
0.167	51.2	N	3.9	55.1
17.03	43.4	L	6.6	50.0
17.39	43.6	L	6.4	50.0
17.67	43.6	L	6.4	50.0
18.43	45.3	N	4.7	50.0
18.73	45.0	N	5.0	50.0

Unit Tested: DRB480-24-1 UNIT #04, the EUT met the requirements of EN 55011:2009 +A1:2010 (Class B [Enclosure Port]) for conducted disturbances when measured Stand-Alone and in a Cabinet.

Procedure	CISPR16-2-1: 2005 / EN 55011:2009 + A1:2010	**Date**	19/08/2016
		Test Location	Kiwa Blackwood
Environment	20°C	**Test Engineer**	Phil Mantle

See Appendix B – Additional Emissions Results for further results.

Figure 13 – Conducted Emissions Test Setup

Figure 14 - Conducted Emissions 230Vac, DRB480-48-1 UNIT #06, Graph

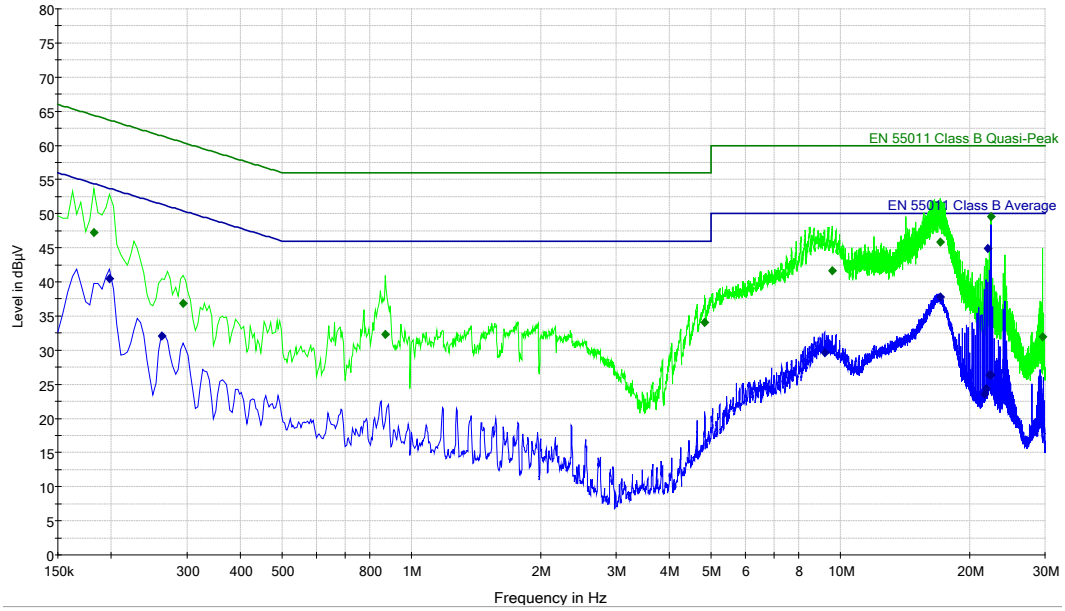


Table 11 - Conducted Emissions 230Vac, DRB480-48-1 UNIT #06, Quasi-Peak

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.182	47.3	N	17.1	64.4
0.294	36.9	N	23.6	60.4
0.870	32.4	L1	23.6	56.0
4.830	34.1	L1	21.9	56.0
9.578	41.6	L1	18.4	60.0
17.062	45.8	L1	14.2	60.0
22.418	49.6	L1	10.4	60.0
29.562	31.9	L1	28.1	60.0

Table 12 - Conducted Emissions 230Vac, DRB480-48-1 UNIT #06, Average

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.198	40.4	N	13.3	53.7
0.262	32.1	N	19.3	51.4
9.182	29.6	L1	20.4	50.0
17.074	37.8	L1	12.2	50.0
21.630	23.6	L1	26.4	50.0
21.830	24.4	L1	25.6	50.0
22.026	44.9	L1	5.1	50.0
22.222	26.4	L1	23.6	50.0
22.418	26.3	L1	23.7	50.0

Figure 15 - Conducted Emissions 100Vac, DRB480-48-1 UNIT #06, Graph

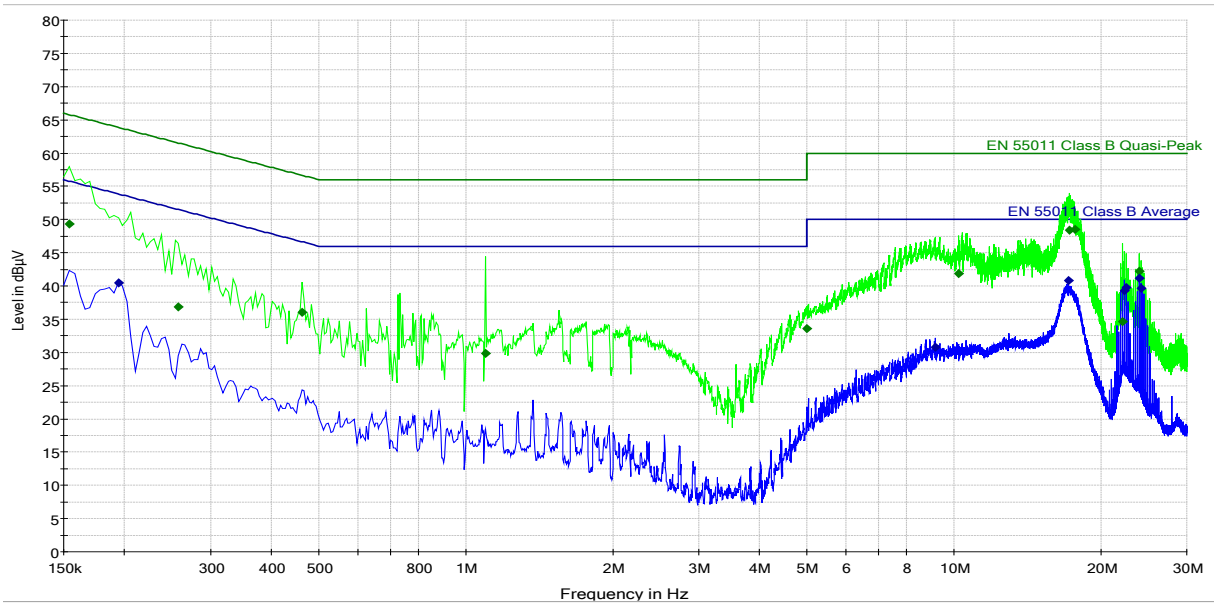


Table 13 - Conducted Emissions 100Vac, DRB480-48-1 UNIT #06, Quasi-Peak

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.154	49.3	N	16.5	65.8
0.258	36.9	L1	24.6	61.5
0.462	36.0	N	20.6	56.7
1.098	29.8	N	26.2	56.0
4.986	33.6	L1	22.4	56.0
10.238	41.9	L1	18.1	60.0
17.210	48.4	L1	11.6	60.0
17.698	48.6	L1	11.4	60.0
22.182	34.6	N	25.4	60.0
23.946	42.2	L1	17.8	60.0

Table 14 - Conducted Emissions 100Vac, DRB480-48-1 UNIT #06, Average

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.194	40.5	L1	13.4	53.9
9.162	30.8	L1	19.2	50.0
17.202	40.8	L1	9.2	50.0
22.378	39.3	L1	10.7	50.0
22.574	39.8	L1	10.2	50.0
23.946	41.2	L1	8.8	50.0
24.142	39.6	L1	10.4	50.0

Unit Tested: DRB480-48-1 UNIT #06, the EUT met the requirements of EN 55011:2016 (Class B [Enclosure Port]) for conducted disturbances.

Procedure	EN 55011:2016	**Date**	21-25/05/2018
		Test Location	TDK-Lambda UK Ltd
Environment	22°C; 40%rh; 1011mB	**Test Engineer**	Nick Heighington

9. Conducted Emissions On Power Lines (Harmonics) to EN61000-3-2

9.1. AC Power Port - Test Procedure

The test was performed in accordance with TDK-Lambda UK document 60802. The mains supply was generated by an AC Power Source, this provides a 230V 50 Hz supply whose harmonic content is very low over the frequency range of the test. The odd and even harmonics were then measured from the fundamental, 50 Hz, to the 40th harmonic, with the EUT on and functioning correctly. The harmonic emission profile emanating from the EUT was measured and this was then compared to the requirements of the specification.

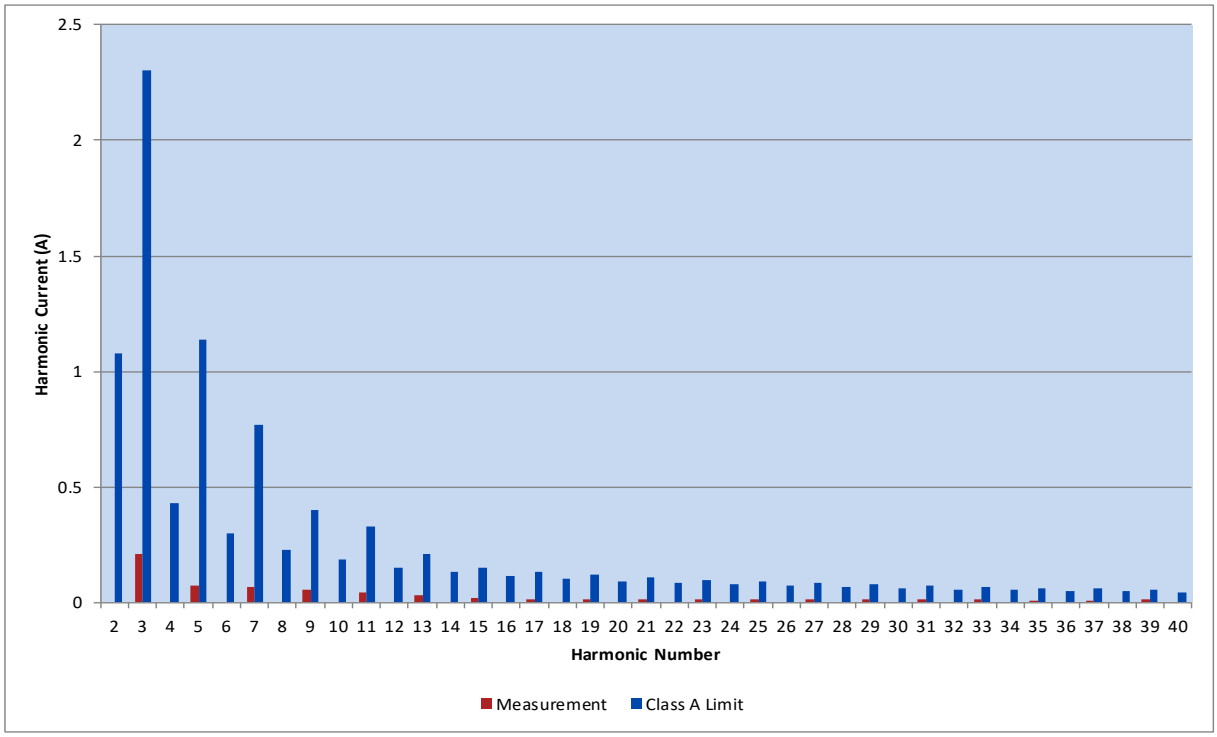
9.2. AC Power Port - Test Results

The details of the test results are given on the following pages.

Table 15 – Harmonics , DRB480-24-01 Unit #02, Class A

Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit
1	2.276	-	11	0.041	0.330	21	0.012	0.107	31	0.012	0.073
2	0.000	1.080	12	0.000	0.153	22	0.000	0.084	32	0.000	0.058
3	0.213	2.300	13	0.030	0.210	23	0.012	0.098	33	0.011	0.068
4	0.000	0.430	14	0.000	0.131	24	0.000	0.077	34	0.000	0.054
5	0.076	1.140	15	0.022	0.150	25	0.014	0.090	35	0.010	0.064
6	0.000	0.300	16	0.000	0.115	26	0.000	0.071	36	0.000	0.051
7	0.066	0.770	17	0.016	0.132	27	0.014	0.083	37	0.010	0.061
8	0.000	0.230	18	0.000	0.102	28	0.000	0.066	38	0.000	0.048
9	0.053	0.400	19	0.012	0.118	29	0.013	0.078	39	0.011	0.058
10	0.000	0.184	20	0.000	0.092	30	0.000	0.061	40	0.000	0.046

Figure 16 - Harmonics, DRB480-24-01 Unit #02, Class A Graph



EUT: DRB480-24-01 Unit #02, met the requirements of EN 61000-3-2:2014, for Class A Harmonic current emissions.

Procedure	EN61000-3-2:2014	**Date**	12/07/2015
		Test Loacation	TDK-Lambda UK Ltd.
Environment	25°C	**Test Engineer**	Tim Broxholme

Table 16 - Conducted Harmonics, Test Equipment

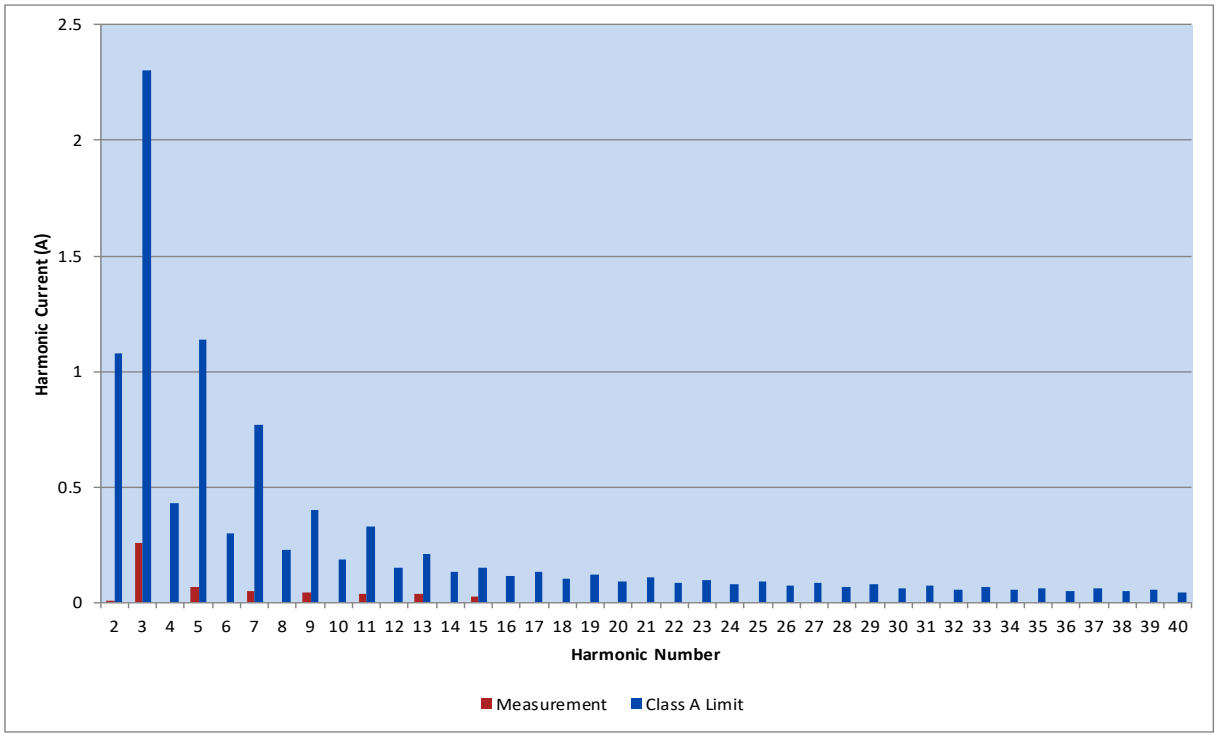
Equipment	Serial	Calibration
TTI HA1600A Power Analyser	414206	4/11/16
Chroma AC Source	N/A	N/A
Kikusui Load	14010613	13/10/16

The test equipment was verified to meet the requirements for Repeatability as defined in EN61000-3-2:2014.

Table 17 – Harmonics , DRB480-48-01 Unit #07, Class A

Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit	Harmonic No.	Measurement	Class A Limit
1	2.276	-	11	0.039	0.330	21	0.000	0.107	31	0.000	0.073
2	0.001	1.080	12	0.000	0.153	22	0.000	0.084	32	0.000	0.058
3	0.258	2.300	13	0.036	0.210	23	0.000	0.098	33	0.000	0.068
4	0.000	0.430	14	0.000	0.131	24	0.000	0.077	34	0.000	0.054
5	0.067	1.140	15	0.026	0.150	25	0.000	0.090	35	0.000	0.064
6	0.000	0.300	16	0.000	0.115	26	0.000	0.071	36	0.000	0.051
7	0.051	0.770	17	0.000	0.132	27	0.000	0.083	37	0.000	0.061
8	0.000	0.230	18	0.000	0.102	28	0.000	0.066	38	0.000	0.048
9	0.044	0.400	19	0.000	0.118	29	0.000	0.078	39	0.000	0.058
10	0.000	0.184	20	0.000	0.092	30	0.000	0.061	40	0.000	0.046

Figure 17 - Harmonics, DRB480-48-01 Unit #07, Class A Graph



EUT: DRB480-48-01 Unit #07, met the requirements of EN 61000-3-2:2014, for Class A Harmonic current emissions.

Procedure	EN61000-3-2:2014	**Date**	28/06/2018
		Test Loacation	TDK-Lambda UK Ltd.
Environment	25°C	**Test Engineer**	Kai Chappell

Table 18 - Conducted Harmonics, Test Equipment

Equipment	Serial	Calibration
Vitrec Power Analyser PA900	24702	30/10/2018
LeCroy WaveRunner Oscilloscope LT354M	541585	16/01/2019
Chroma Electronic Load (Module) 63303A	63306A000472	17/01/2019
Chroma AC Source 61504	615050001002	12/07/2018
Keysight Current Probe	1146B	15/06/2018
LeCroy Differential Probe	D28489	15/10/2018

The test equipment was verified to meet the requirements for Repeatability as defined in EN61000-3-2:2014.

10. Limitation of Voltage Changes, Fluctuations & Flicker to EN61000-3-3

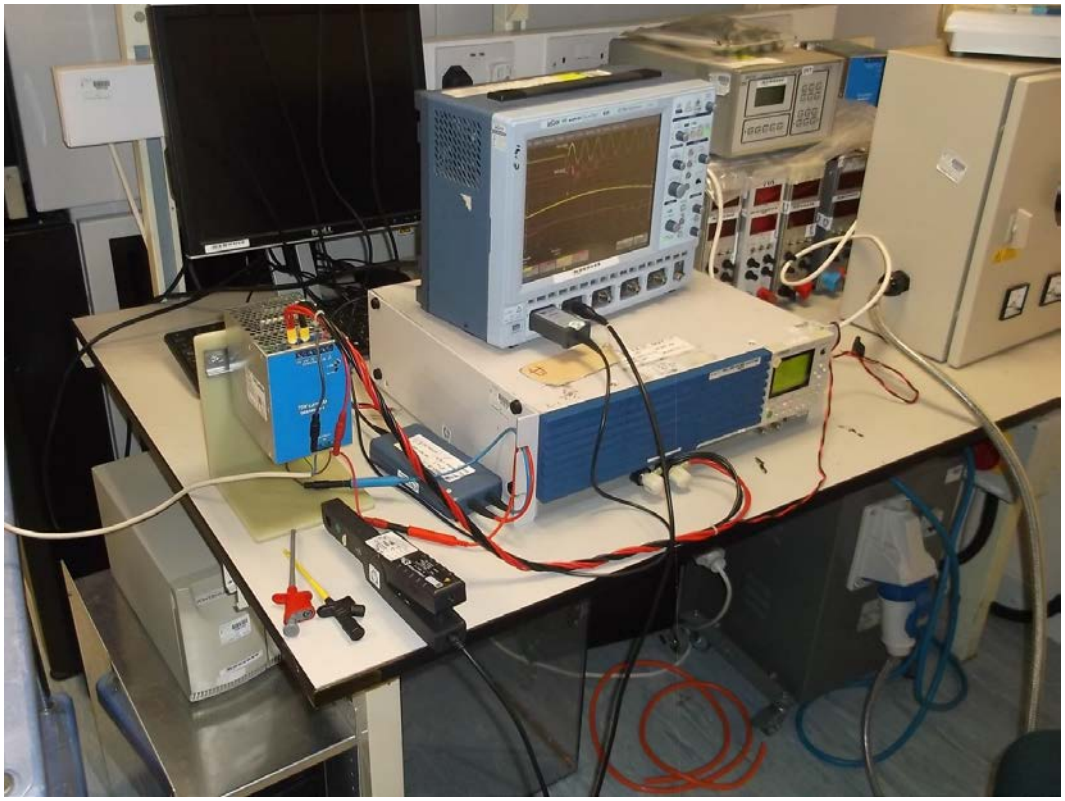
10.1. AC Power Port - Test Procedure

The main part of the Flicker test, is not performed as it is only relevant in the end application, so is the responsibility of the manufacturer of the end equipment to test P_{st} and P_{lt}. The part of the standard that is applicable to a power supply is the measurement of d_{max} in Annex B. The test was performed in accordance with TDK Lambda procedure 72502. The 50 Hz mains supply was generated by an AC Power Source. The EUT is set up and operated under full loading to give maximum input current, an oscilloscope is connected to measure input current and voltage waveforms. Twenty-four (24) measurements of inrush current are taken at one-minute intervals, measuring the maximum r.m.s. input current evaluated over each 10ms half-period between zero voltage crossings. The minimum and maximum values are discarded and the arithmetical average of the remainder is taken. The voltage deviation is calculated as follows:

$$dV = I_{rms} \times (R_a + jX_a + R_n + jX_n)$$

The limit is 4% voltage change, which at 230Vac is 9.2V which corresponds to an average inrush current of 19.47A, from a standard impedance AC source.

Figure 18 - Flicker Test Setup



10.2. Test Results

Table 19 - Flicker Test Results, DRB480-24-1 Unit #04

Number	Voltage (V)	Min / Max	Number	Voltage (V)	Min / Max
1	5.52	Max	13	4.94	
2	5.40		14	4.13	Min
3	5.12		15	4.18	
4	5.17		16	4.67	
5	5.50		17	5.31	
6	4.85		18	5.03	
7	4.67		19	4.48	
8	4.43		20	4.79	
9	4.68		21	4.72	
10	5.26		22	4.56	
11	4.86		23	5.06	
12	4.67		24	5.26	

Average voltage change d_{max} = 4.89 Volts, or 2.13%.

EUT: DRB480-24-1 Unit #04, met the requirements of EN 61000-3-3:2008, for Voltage Changes, Fluctuations & Flicker for d_{max} <4%.

Procedure	EN 61000-3-3:2008	**Date**	05/09/2016
		Test Loacation	TDK-Lambda UK Ltd.
Environment	24°C; 36%rh; 1009mB	**Test Engineer**	Tim Broxholme

Table 20 - Flicker Test Equipment

Name	Manufacturer	Serial Number / Cal Ref	Calibration Expires
Oscilloscope WaveSurfer 434	LeCroy	E191	18/01/2017
PLZ1004W Load	Kikusui	E188	13/04/2017
Current Probe E3n	Chauvin Arnoux	A186	12/04/2017
Differential Probe ADP305	LeCroy	A343	10/05/2017
AC Source 61605	Chroma	616050000361	N/A

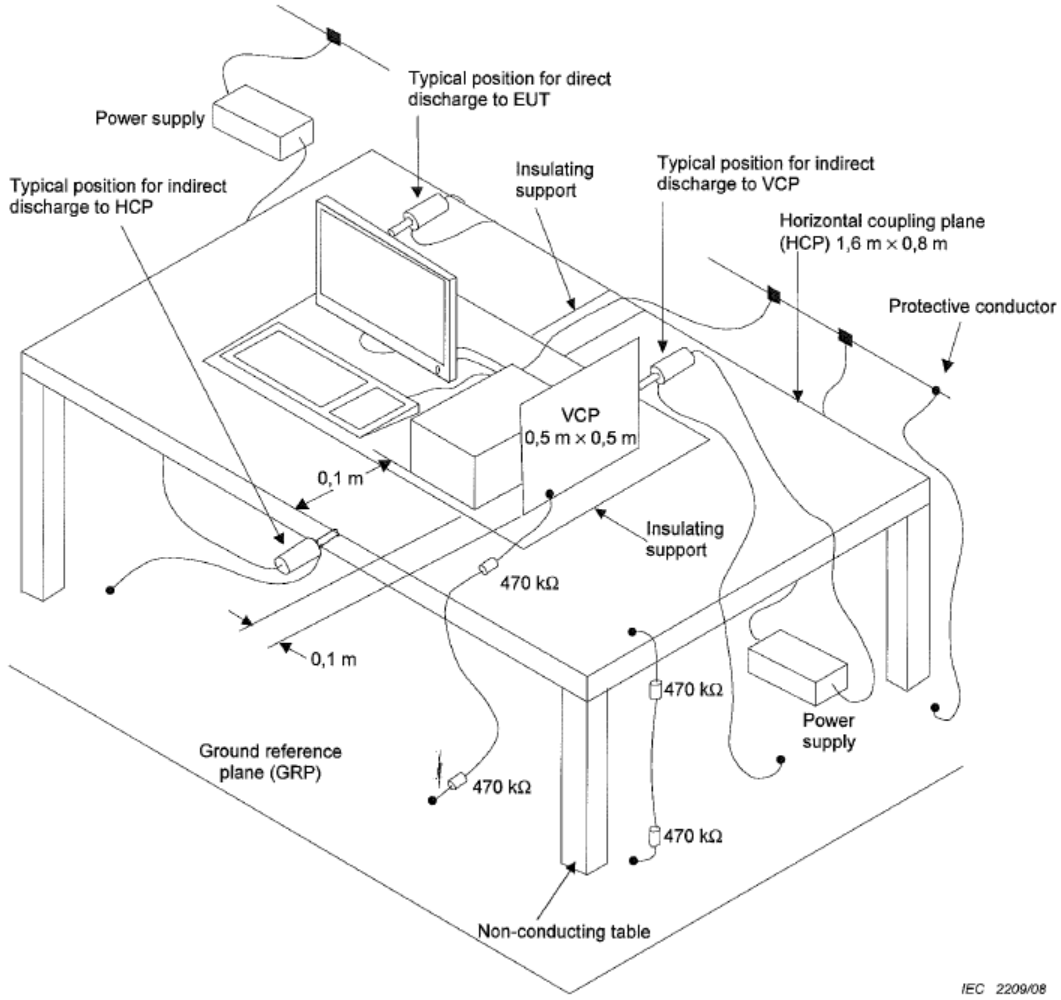
The DRB480-48-1 has the same primary circuit to the DRB480-24-1, so the flicker result for the 24V unit is representative of the 48V.

11. Immunity to Electrostatic Discharge to EN61000-4-2

11.1. Test Procedure

The EUT was set up on insulators 0.5 mm above the Horizontal coupling plane and tested in accordance with the specification. According to TDK Lambda procedure 72503 and 69896, the unit was tested while operational (R10.1) at 230Vac, full load, and when non-operational (R10.2).

Figure 19 - ESD Test Setup Diagram



11.2. Air Discharge

A potential was applied to each applicable test point, the levels are given in Table 21 below. Where the discharges occurred the potential was then applied a total of 20 times to each test point, ten positive and ten negative discharges.

Table 21 - ESD, Test Levels, Air Discharge

Level	Voltage	Test Voltage
1	2 kV	2.2 kV
2	4 kV	4.2 kV
3	8 kV	8.8 kV
4	15 kV	16.5 kV

Table 22 - ESD, Test Points, Air Discharge

Air Discharge	Specification Level
None Applicable	N/A

11.3. Contact Discharge

All user accessible conductive surfaces (Test Points) were subjected to contact discharges, the levels are given in Table 23 below, ten positive and ten negative discharges were applied to each test point. The side of the EUT was subjected to Vertical Coupled Plane (VCP) discharges and the base of the EUT was subjected to Horizontal Coupled Plane (HCP) discharges, ten positive and ten negative. Correct functioning of the EUT throughout the test was checked by using the procedures described in Section 5.2.

Table 23 - ESD, Test Levels, Contact Discharge

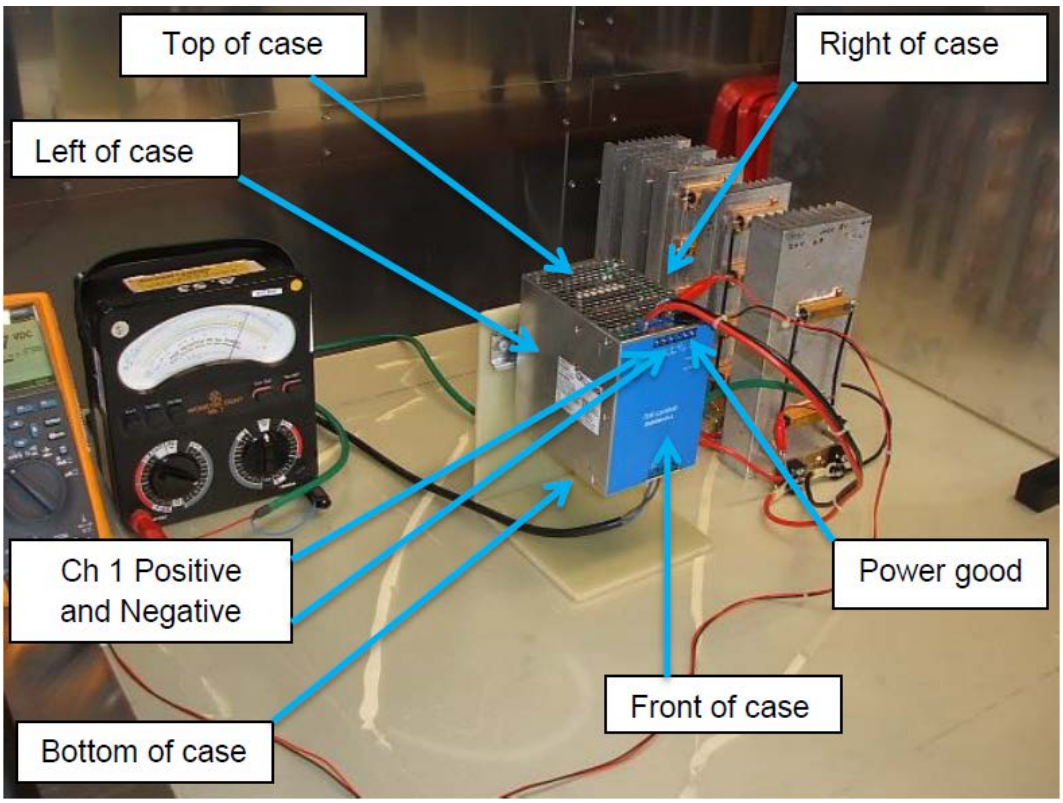
Level	Voltage	Test Voltage
1	2 kV	2.2 kV
2	4 kV	4.2 kV
3	6 kV	6.6 kV
4	8 kV	8.8 kV

Table 24 - ESD, Test Points, Contact Discharge

Contact Discharge	Specification Level
Horizontal Coupling Plane	3
Vertical Coupling Plane	3
Bottom of Case	3
Left of Case	3
Right of Case	3
Top of Case	3
Front of Case	3
Output Ch1 Positive	3
Output Ch1 Negative	3
DC Good Positive	3
DC Good Negative	3
Mains Input Connector[4]	3

[4] Input connections are only tested with the unit switched off.

Figure 20 - ESD, Test Setup Photograph



11.4. ESD, Enclosure Port, Test Results

Table 25 - ESD Test Results, DRB480-24-1 Unit #02, 230Vac, Full Load

Discharge	Voltage	Level	Test Point	Spec Criteria	Result Criteria	Pass / Fail
Contact	6600V	3+10%	Horizontal Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Vertical Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Top of Case	A	A	PASS
Contact	6600V	3+10%	Bottom of Case	A	A	PASS
Contact	6600V	3+10%	Left of Case	A	A	PASS
Contact	6600V	3+10%	Right of Case	A	A	PASS
Contact	6600V	3+10%	Front of Case	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Positive	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Negative	A	A	PASS
Contact	6600V	3+10%	DC Good Positive	A	A	PASS
Contact	6600V	3+10%	DC Good Negative	A	A	PASS

Table 26 - ESD Test Results, DRB480-24-1 Unit #02, Unit Off

Discharge	Voltage	Level	Test Point	Spec Criteria	Result Criteria	Pass / Fail
Contact	6600V	3+10%	Horizontal Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Vertical Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Top of Case	A	A	PASS
Contact	6600V	3+10%	Bottom of Case	A	A	PASS
Contact	6600V	3+10%	Left of Case	A	A	PASS
Contact	6600V	3+10%	Right of Case	A	A	PASS
Contact	6600V	3+10%	Front of Case	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Positive	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Negative	A	A	PASS
Contact	6600V	3+10%	DC Good Positive	A	A	PASS
Contact	6600V	3+10%	DC Good Negative	A	A	PASS
Contact	6600V	3+10%	Input Connector L	A	A	PASS
Contact	6600V	3+10%	Input Connector N	A	A	PASS
Contact	6600V	3+10%	Input Connector PE	A	A	PASS

Unit tested: DRB480-24-1 Unit #02, the EUT met the requirements of EN 61000-4-2:2009 (level 3, [Enclosure Port]) for immunity to electrostatic discharge. The EUT's performance level met Criteria A, as defined in Appendix A. Details of points tested are presented above.

Procedure	EN 61000-4.2:2009	**Date**	27/07/2016
		Test Loacation	TDK-Lambda UK Ltd.
Environment	19°C; 41%rh; 1010mB	**Test Engineer**	Paul Dyer

Table 27 - ESD Test Equipment

Name	Manufacturer	Serial Number	Calibration
ESD Simulation System, NSG435	Schaffner	165	02/02/2017
AVO Meter	AVO	B53	N/A
DMM	Fluke	A236	12/10/2016

The ESD test equipment was verified according to the standard prior to the testing.

Table 28 - ESD Test Results, DRB480-48-1 Unit #06, 230Vac, Full Load

Discharge	Voltage	Level	Test Point	Spec Criteria	Result Criteria	Pass / Fail
Contact	6600V	3+10%	Horizontal Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Vertical Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Top of Case	A	A	PASS
Contact	6600V	3+10%	Bottom of Case	A	A	PASS
Contact	6600V	3+10%	Left of Case	A	A	PASS
Contact	6600V	3+10%	Right of Case	A	A	PASS
Contact	6600V	3+10%	Front of Case	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Positive	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Negative	A	A	PASS
Contact	6600V	3+10%	DC Good Positive	A	A	PASS
Contact	6600V	3+10%	DC Good Negative	A	A	PASS

Table 29 - ESD Test Results, DRB480-48-1 Unit #06, Unit Off

Discharge	Voltage	Level	Test Point	Spec Criteria	Result Criteria	Pass / Fail
Contact	6600V	3+10%	Horizontal Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Vertical Coupling Plane	A	A	PASS
Contact	6600V	3+10%	Top of Case	A	A	PASS
Contact	6600V	3+10%	Bottom of Case	A	A	PASS
Contact	6600V	3+10%	Left of Case	A	A	PASS
Contact	6600V	3+10%	Right of Case	A	A	PASS
Contact	6600V	3+10%	Front of Case	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Positive	A	A	PASS
Contact	6600V	3+10%	Output Ch1 Negative	A	A	PASS
Contact	6600V	3+10%	DC Good Positive	A	A	PASS
Contact	6600V	3+10%	DC Good Negative	A	A	PASS
Contact	6600V	3+10%	Input Connector L	A	A	PASS
Contact	6600V	3+10%	Input Connector N	A	A	PASS
Contact	6600V	3+10%	Input Connector PE	A	A	PASS

Unit tested: DRB480-48-1 Unit #06, the EUT met the requirements of EN 61000-4-2:2009 (level 3, [Enclosure Port]) for immunity to electrostatic discharge. The EUT's performance level met Criteria A, as defined in Appendix A. Details of points tested are presented above.

Procedure	EN 61000-4.2:2009	**Date**	23/05/2018
		Test Loacation	TDK-Lambda UK Ltd.
Environment	22°C; 42%rh; 1010mB	**Test Engineer**	Nick Heighington

Table 30 - ESD Test Equipment

Name	Manufacturer	Serial Number	Calibration Expires
ESD Simulation System, NSG435	Schaffner	165	13/04/2018
AMM	Kyoritsu	W8215795	N/A
AMM	Kyoritsu	W8224452	N/A

The ESD test equipment was verified according to the standard prior to the testing.

12. Immunity to Radiated Electric Fields to EN61000-4-3

12.1. Enclosure Port Continuous Swept Field

The EUT was tested in accordance with TDK Lambda procedure 72504 and 69896, all testing was conducted within a Shielded Enclosure. The test levels are given below.

Table 31 - Radiated Electric Field Immunity, Test levels

Level	Field Strength
1	$1Vm^{-1}$
2	$3Vm^{-1}$
3	$10Vm^{-1}$
4	$30Vm^{-1}$

The EUT was subjected to the specified field strength over the frequency ranges 80 MHz to 2.7 GHz in both horizontal and vertical polarisation. The frequency was stepped by increasing the present frequency by 1%, and the dwell time at each frequency step was 0.5 seconds. The carrier frequency was amplitude modulated with a 1kHz sine wave at a modulation depth of 80%. The field strength level given is of the unmodulated carrier signal. Correct functioning of the EUT throughout the test was checked using the procedures described in section 5.2.

Figure 21 - Radiated Electric Field Immunity, Test Setup Diagram

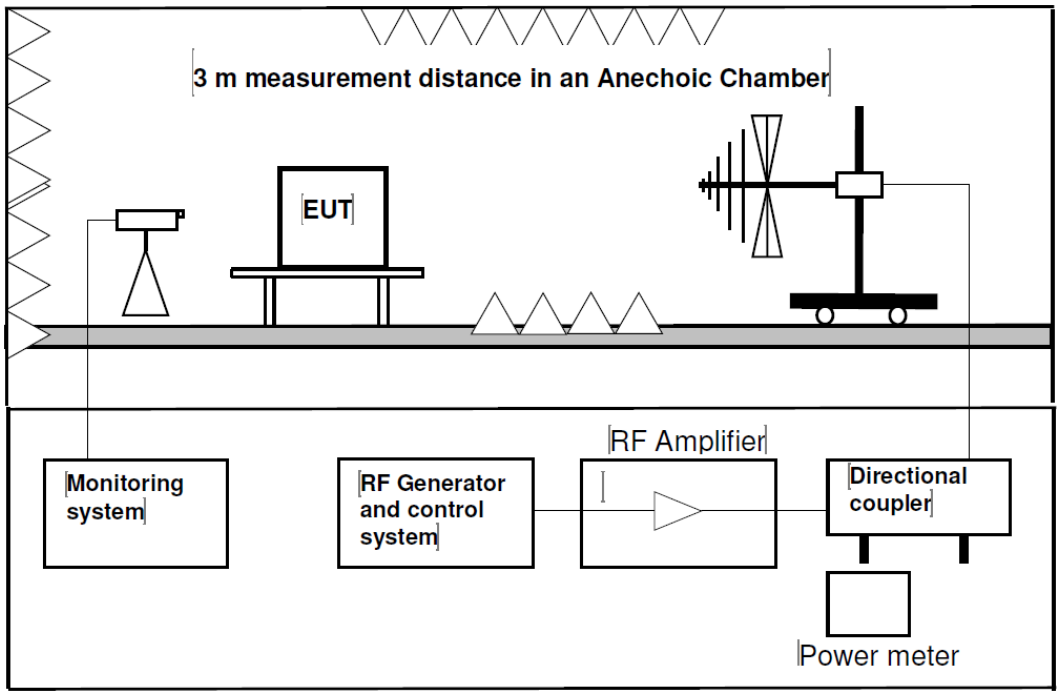


Figure 22 - Radiated Electric Field Immunity, Test Face Definition DRB

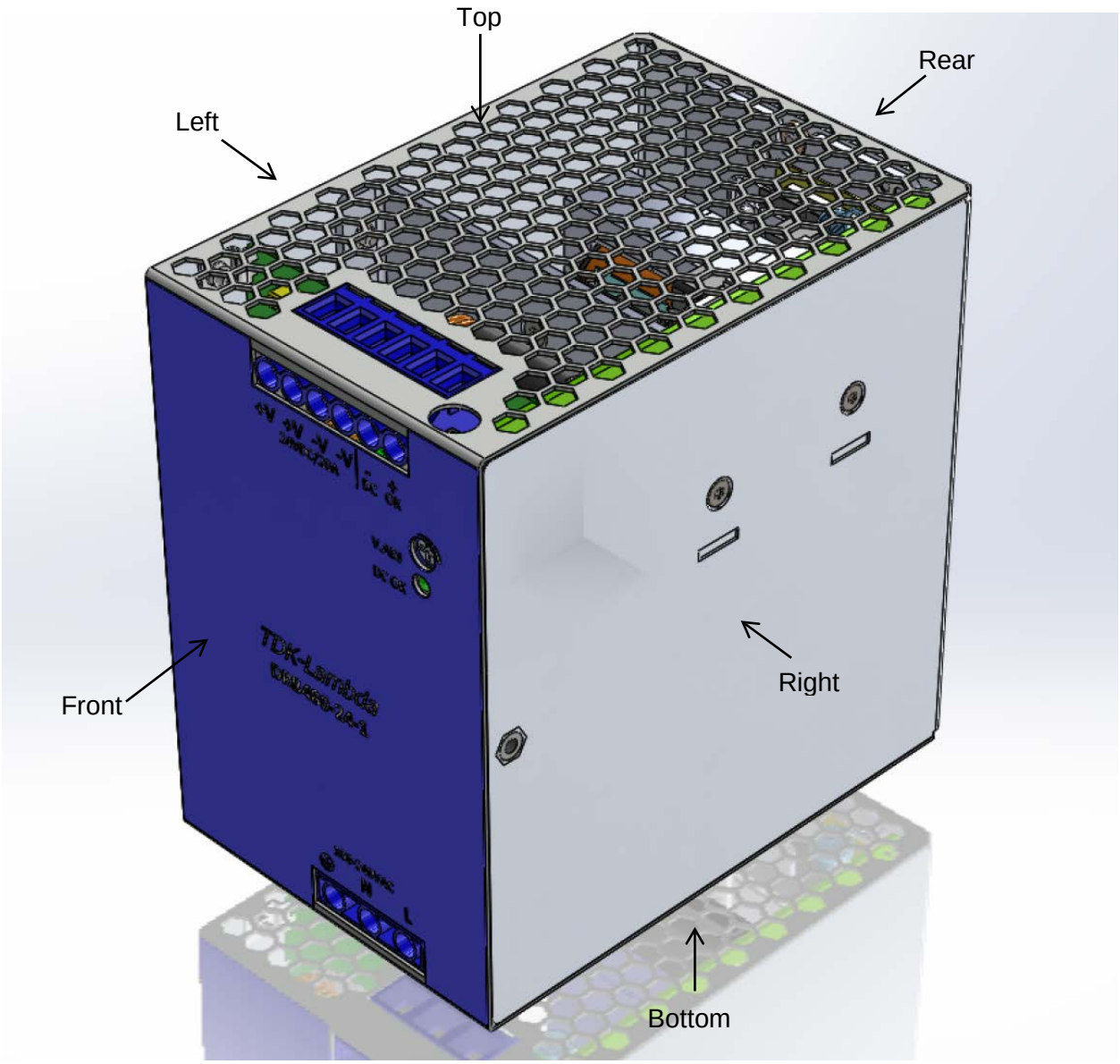
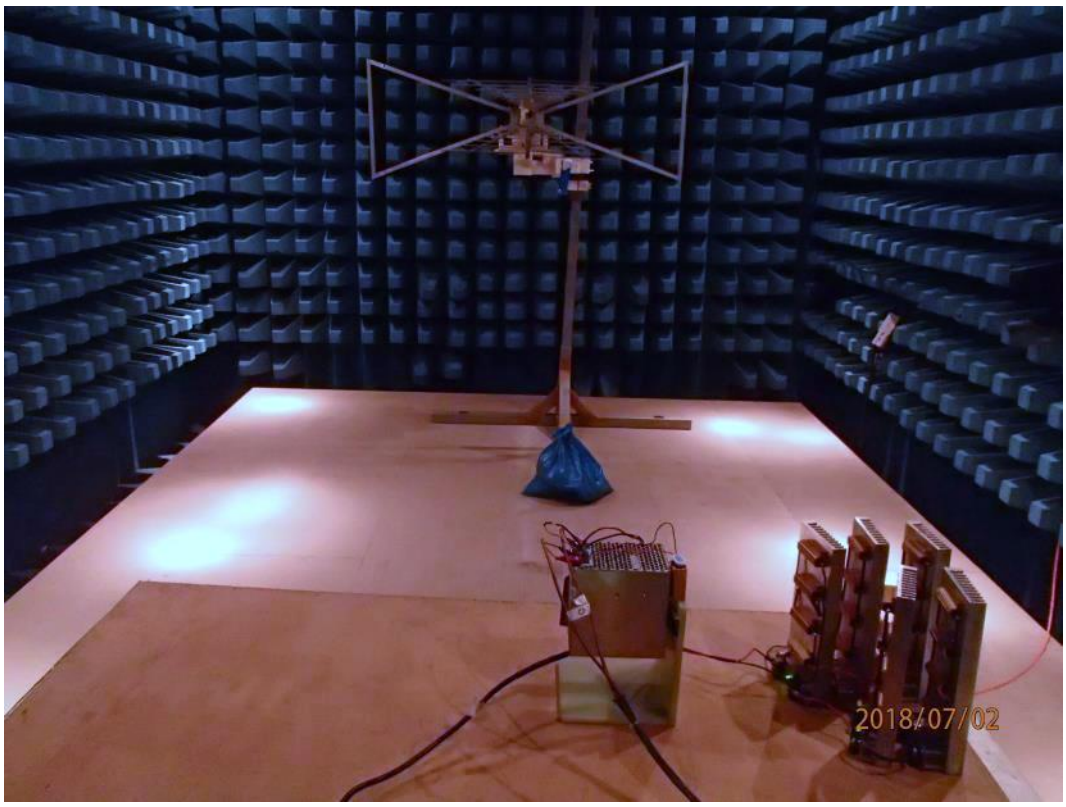
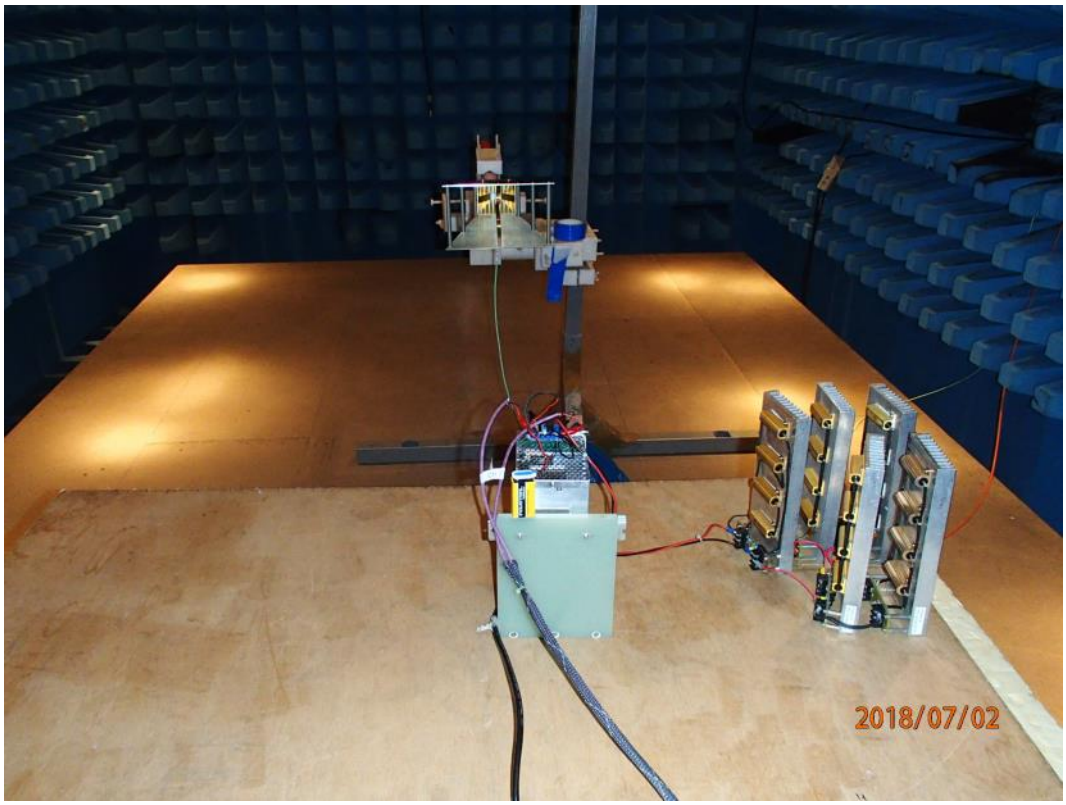


Figure 23 - Radiated Electric Field Immunity, Test Setup Photographs





12.1. Enclosure Port - Test Results

Table 32 - Radiated Electric Field Immunity, Test Results, DRB-480-24-1 Unit #04

EUT Face	Antenna Polarisation	Observed effect on EUT	Pass Criteria
Front	V	No change observed in output voltage, or DC good signal.	A
	H	No change observed in output voltage, or DC good signal.	A
Back	V	No change observed in output voltage, or DC good signal.	A
	H	No change observed in output voltage, or DC good signal.	A
Left	V	No change observed in output voltage, or DC good signal.	A
	H	No change observed in output voltage, or DC good signal.	A
Right	V	No change observed in output voltage, or DC good signal.	A
	H	No change observed in output voltage, or DC good signal.	A

EUT Tested: DRB-480-24-1 Unit #04. The EUT met the requirements of EN 61000-4-3:2006 + A2:2010 (level 3, [Enclosure Port]) for Immunity to Radiated Electric Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4.3:2006 + A2:2010	**Date**	19/08/2016
		Test Location	Kiwa Blackwood
Environment	19.9°C; 58% rh	**Test Engineer**	Phil Mantle

Table 33 - Radiated Electric Field Immunity, DRB480-48-1 Unit #06

Frequency	Level	Face	Result
80 MHz – 1.0 GHz	10V/m	Left	Criteria A Pass
		Front	Criteria A Pass
1.0 GHz – 2.7 GHz	10V/m	Left	Criteria A Pass
		Front	Criteria A Pass
2.7 GHz – 6.0 GHz	10V/m	Left	Criteria A Pass
		Front	Criteria A Pass

EUT's Tested: DRB480-48-1 Unit #06. The EUT's met the requirements of EN 61000-4-3:2006 + A2:2010 (level 3, [Enclosure Port]) for Immunity to Radiated Electric Fields. For all tests the EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4.3:2006 + A2:2010	**Date**	02/07/2018
		Test Location	ETC
Environment	22°C; 44% rh; 1014mB	**Test Engineers**	Charlie White

Table 34 - Radiated Electric Field Immunity, Test Equipment, Kiwa Blackwood

Name	Manufacturer	Kiwa Blackwood Reference
HP8648C Signal generator	HP	8695
E4419B Power meter	Agilent	8766
Power Sensor and cable	Agilent	8766A
CBL6143 Bilog Antenna	Schaffner	8623
6M25W 20dB Attenuator	Inmet	8545
AR150L RF Amplifier	AR	8529
AR25W1000 RF Amplifier	AR	8530
80MHz – 1GHz Directonal Coupler	Schaffner	8544
Anechoic Chamber	Rainford	8551
Cables	N/A	N/A
Radiated Immunity Software	EMC Hire	8634
BAA898HG Environmental Monitor	Oregon Scientific	8648

All test equipment was traceably calibrated at the time of testing.

Table 35 - Radiated Electric Field Immunity, Test Equipment, ETC

Manufacturer & Description	ID No.	Calibration Expires
Anechoic Chamber	ETC1272	21/02/2019
Hewlett Packard 8648D Signal Generator	ETC725	05/03/2019
Ophir RF Power Amplifier	ETC774	27/03/2019
Werlatone Dual Directional Coupler	ETC806	25/09/2018
Rohde & Schwarz NRVS Power Meter	ETC805	05/07/2018
Rohde & Schwarz NRVS Power Meter	ETC808	05/07/2018
Rohde & Schwarz NRV-Z51 Power Sensor	ETC1065	23/10/2018
Rohde & Schwarz NRV-Z51 Power Sensor	ETC719	14/08/2018
Rohde & Schwarz Bilog Antenna	ETC1312	09/07/2019
Attenuator 20dB 10W	ETC718	23/01/2019
Rohde & Schwarz Signal Generator 1GHz - 20GHz	ETC1163	31/03/2019
ARA Horn Antenna	ETC724	22/11/2018
Ophir RF Power Amplifier	ETC733	12/10/2018
Thompson TWT Amplifier	ETC732	18/10/2018
Thompson TWT Amplifier	ETC747	19/07/2018
Hewlett Packard 11692D Dual Directional Coupler	ETC746	18/07/2018
Hewlett Packard 778D Dual Directional Coupler	ETC950	10/04/2019
N Type Cable	ETC957	21/06/2019
N Type Cable	ETC941	19/09/2018
N Type Cable	ETC948	15/05/2019
N Type Cable	ETC1588	05/07/2019
SMA Cable	ETC1721	03/08/2018
SMA Cable	ETC1145	23/08/2018

13. Immunity to Electrical Fast Transient Bursts to EN61000-4-4

13.1. AC Power Port - Test Procedure

The EUT was set up and functioning correctly, as described in Section 5.2. A series of Fast Transient Bursts meeting the specification were applied for a period of 60 seconds. The unit was tested with both 5kHz and 100kHz burst frequencies. The Transient Bursts were applied for both positive and negative burst trains, to both PE and L+N+PE. The Test levels are given below in Table 36. The test was performed under the conditions specified in TDK-Lambda UK documents 72505 and 69896.

Table 36 - EFT, AC Power Port, Test levels

Level	Voltage	Test Voltage
1	0.5 kV	0.55 kV
2	1 kV	1.1 kV
3	2 kV	2.2 kV
4	4 kV	4.4 kV

Figure 24 - EFT, Test Setup DRB480-24-1

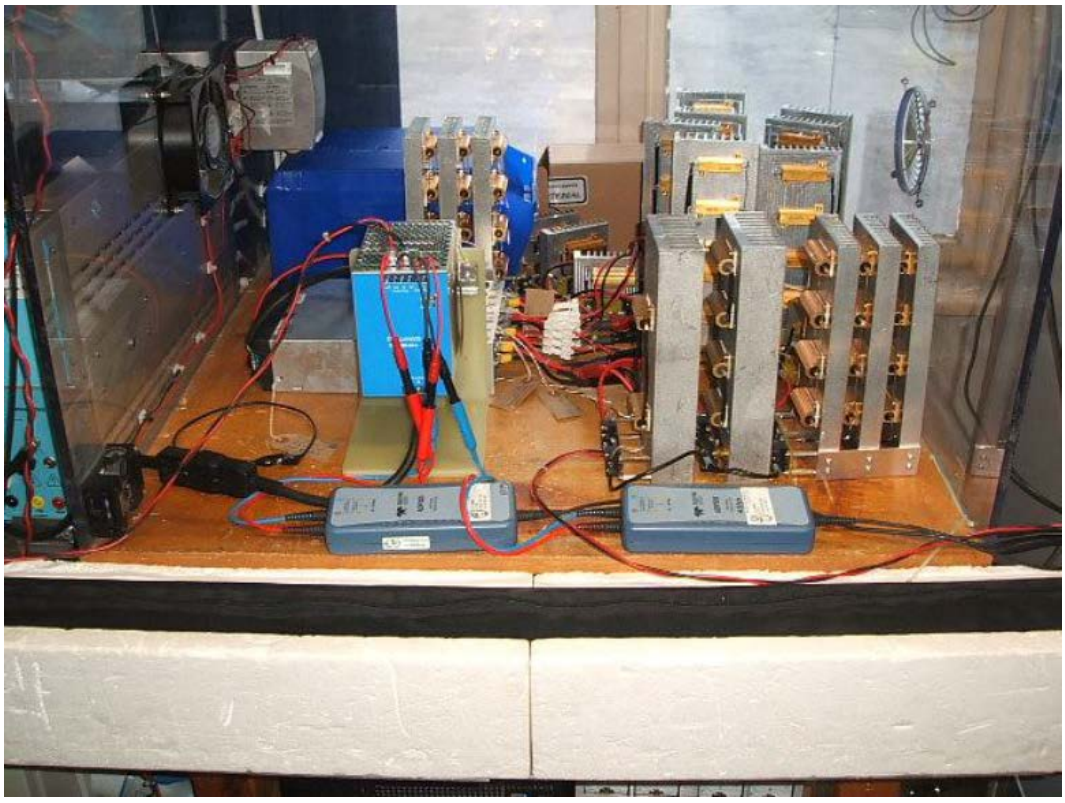


Figure 25 - EFT, Test Setup DRB480-48-1

13.2. AC Power Port - Test Results

Unit tested: DRB480-24-1 Unit #04, the EUT met the requirements of EN 61000-4-4: 2004 + A1:2010 (level 3, [AC Power Ports]) for Immunity to Fast Transient Bursts. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-4:2004 + A1:2010	**Date**	19/07/2016
		Test Location	TDK-Lambda UK Ltd.
Environment	20°C; 41%rh; 1016mB	**Test Engineer**	Paul Dyer

Unit tested: DRB480-48-1 Unit #06, the EUT met the requirements of EN 61000-4-4: 2004 + A1:2010 (level 3, [AC Power Ports]) for Immunity to Fast Transient Bursts. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-4:2012	**Date**	30/05/2018
		Test Location	TDK-Lambda UK Ltd.
Environment	20°C; 38%rh; 1011mB	**Test Engineer**	Tim Broxholme

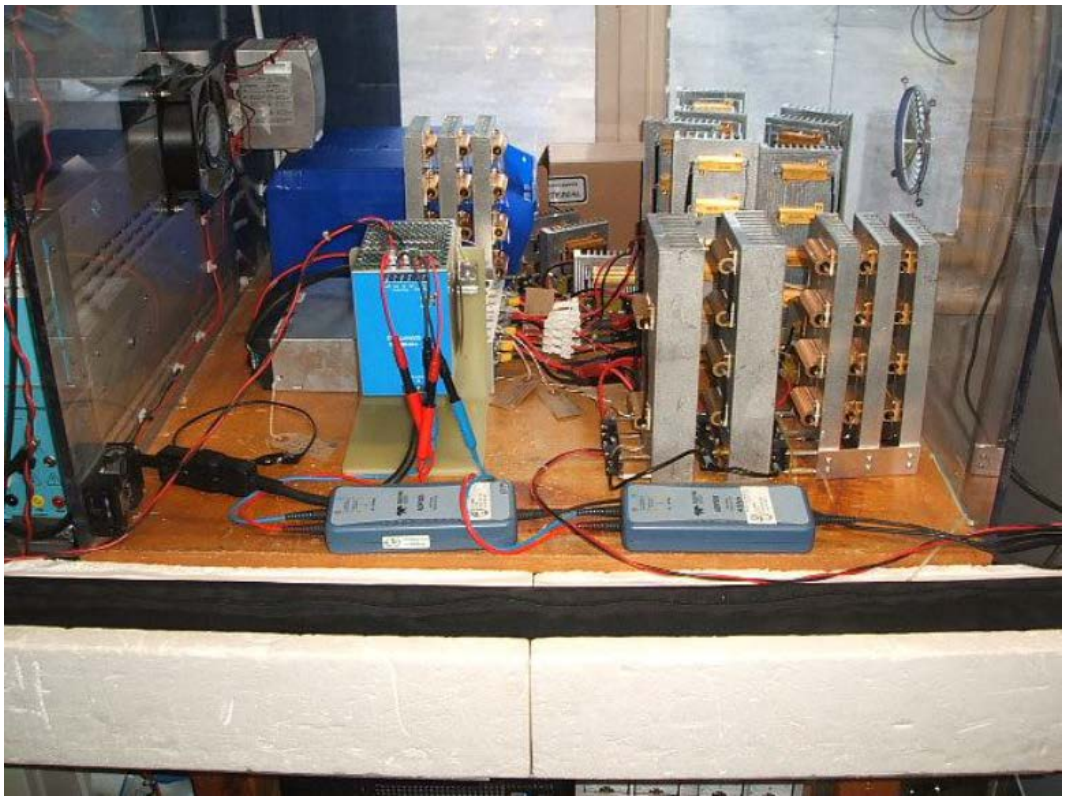
13.3. DC Output Port- Test Procedure

The EUT was set up and functioning correctly, as described in Section 5.2. The main DC output port was subjected to a series of Fast Transient Bursts meeting the specification using a capacitive coupling clamp for a period of greater than 60 seconds. The test was applied with both 5kHz and 100kHz burst frequencies. The Transient Bursts were applied for both positive and negative burst trains. The fan output was not tested as this output is not intended to be connected to a cable longer than 3m. The test was performed under the conditions specified in TDK-Lambda UK documents 72505 and 69896.

Table 37 - EFT, DC Power Port, Test Levels

Level	Voltage	Test Voltage
1	0.5 kV	0.55 kV
2	1 kV	1.1 kV
3	2 kV	2.2 kV
4	4 kV	4.4 kV

Figure 26 - EFT, DC Output port, Test Setup, DRB480-24-1



13.4. DC Output Port - Test Results

Unit tested: DRB480-24-1 Unit #04, the EUT met the requirements of EN 61000-4-4: 2004 + A1:2010 (level 3, [DC Output Ports]) for Immunity to Fast Transient Bursts. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-4: 2004 + A1:2010	**Date**	19/07/2016
		Test Location	TDK-Lambda UK Ltd.
Environment	20°C; 41%rh; 1016mB	**Test Engineer**	Paul Dyer

Unit tested: DRB480-48-1 Unit #06, the EUT met the requirements of EN 61000-4-4: 2004 + A1:2010 (level 3, [DC Output Ports]) for Immunity to Fast Transient Bursts. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-4:2012	**Date**	30/05/2018
		Test Location	TDK-Lambda UK Ltd.
Environment	20°C; 38%rh; 1011mB	**Test Engineer**	Tim Broxholme

Table 38 - EFT Test Equipment, DRB480-24-1

Name	Manufacturer	Serial Number	Calibration
TRA2000IN6	EMC Partner	789	01/02/2017
AVO	AVO	B53	N/A
Coupling clamp	Schaffner	N/A	N/A
DMM	Fluke	A236	12/10/2016

The test equipment was verified in accordance with the specification on 18/07/2016 by Paul Dyer.

Table 39 - EFT Test Equipment, DRB480-48-1

Name	Manufacturer	Serial Number	Calibration
TRA2000IN6	EMC Partner	1162	05/12/2018
WaveSurfer 434	LeCroy	P71	17/01/2019

The test equipment was verified in accordance with the specification on 18/07/2016 by Paul Dyer.

14. Combination Wave Surge Immunity to EN61000-4-5

14.1. AC Power Port - Test Procedure

The EUT was set up and functioned correctly, as described in section 5.2. A series of high energy surges were applied as shown in Table 40 below.

Table 40 - Surge, Test levels

Installation Class	Coupling	Level	Voltage	Test Voltage
1	Line to Neutral (2 Ohm)	1	N/A	N/A
	Line or Neutral to Ground (12 Ohm)		0.5kV	0.55kV
2	Line to Neutral (2 Ohm)	2	0.5kV	0.55kV
	Line or Neutral to Ground (12 Ohm)		1kV	1.1kV
3	Line to Neutral (2 Ohm)	3	1kV	1.1kV
	Line or Neutral to Ground (12 Ohm)		2kV	2.2kV
4	Line to Neutral (2 Ohm)	4	2kV	2.2kV
	Line or Neutral to Ground (12 Ohm)		4kV	4.4kV

For each of the above applicable test conditions, five positive and five negative pulses were applied, each applied at intervals of 30 seconds. Correct functioning of the EUT throughout the test was checked using the procedures described in Section 5.2. The test was performed under the conditions specified in TDK-Lambda UK document 72506 and 69896.

Figure 27 - Surge Immunity, Test Setup, DRB480-24-1

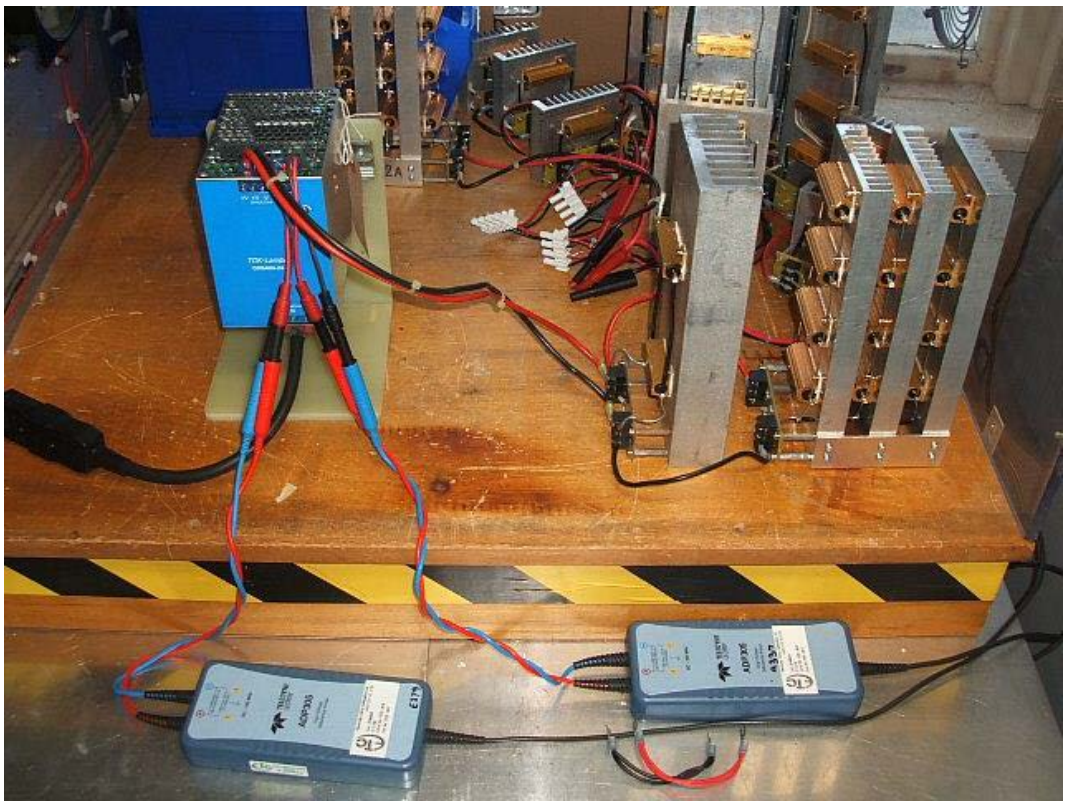


Figure 28 - Surge Immunity, Test Setup, DRB480-48-1

14.2. AC Input Port - Test Results

Table 41 - Surge, Test Results

Unit	Line	Load	Output Voltage	Level	Pass Criteria
DRB480-24-1 UNIT #04	240Vac	Full	Nominal	3	A
DRB480-24-1 UNIT #04	240Vac	Full	Maximum	3	A
DRB480-24-1 UNIT #04	100Vac	Full	Maximum	3	A
DRB480-24-1 UNIT #04	240Vac	Zero	Maximum	3	A
DRB480-48-1 UNIT #06	240Vac	Full	Nominal	3	A
DRB480-48-1 UNIT #06	240Vac	Full	Maximum	3	A
DRB480-48-1 UNIT #06	100Vac	Full	Maximum	3	A
DRB480-48-1 UNIT #06	240Vac	Zero	Maximum	3	A

Unit tested: DRB480-24-1 UNIT #04, the EUT met the requirements of EN 61000-4-5: 2014 (Installation Class 3, [AC Power Ports]) for Immunity to Combination Wave Surges. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-5:2014	**Date**	14/07/2016
		Test Location	TDK-Lambda UK Ltd.
Environment	22°C; 42%rh; 1000mB	**Test Engineer**	Paul Dyer

Unit tested: DRB480-48-1 UNIT #06, the EUT met the requirements of EN 61000-4-5: 2014 (Installation Class 3, [AC Power Ports]) for Immunity to Combination Wave Surges. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-5:2014	**Date**	31/05/2018
		Test Location	TDK-Lambda UK Ltd.
Environment	21°C; 36%rh; 1008mB	**Test Engineer**	Tim Broxholme

Table 42 - Surge Test Equipment, DRB480-24-1

Name	Manufacturer	Serial Number	Calibration Expires
TRA2000IN6	EMC Partner	789	01/02/2017
Oscilloscope	LeCroy	E190	12/04/2017
Differential Probe	LeCroy	A337	08/02/2017
Differential Probe	LeCroy	E279	05/02/2017

The test equipment was verified in accordance with the specification on 30/06/2016.

Table 43 - Surge Test Equipment, DRB480-48-1

Name	Manufacturer	Serial Number	Calibration Expires
TRA2000IN6	EMC Partner	1162	05/12/2018
WaveSurfer 434	LeCroy	P71	17/01/2019

The test equipment was verified in accordance with the specification on 21/05/2018.

15. Immunity to Conducted RF Disturbances to EN61000-4-6

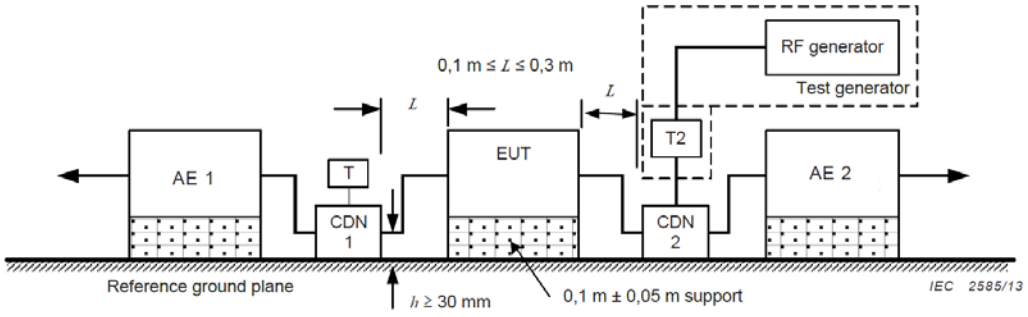
15.1. Test Procedure

The EUT was set up and functioning correctly. The input mains was connected through a coupling decoupling network and functioned correctly. The EUT was subjected to Radio-Frequency fields injected into the AC input. The DC output is also subjected to Radio-Frequency fields injected into it via a coupling clamp. The fan supply is not tested as it is not intended to be connected to cables longer than 3m. The frequency was swept from 150 kHz to 80 MHz, amplitude modulated with a 1 kHz sine wave to a depth of 80%. The test levels are detailed in Table 44 below. The test was performed at 240Vac and 100Vac under the conditions specified in TDK-Lambda UK document 72506 and 69896. Correct functioning of the EUT was checked throughout the test by using the procedure described in Section 5.2.

Table 44 - Conducted RF Immunity, Test Levels

Level	Voltage
1	1
2	3
3	10
x	special

Figure 29 - Conducted RF Immunity, Test Setup Diagram



Schematic setup for immunity test used for CDN

Figure 30 - Conducted RF Immunity, Test Setup Photograph, AC Port, DRB480-24-1

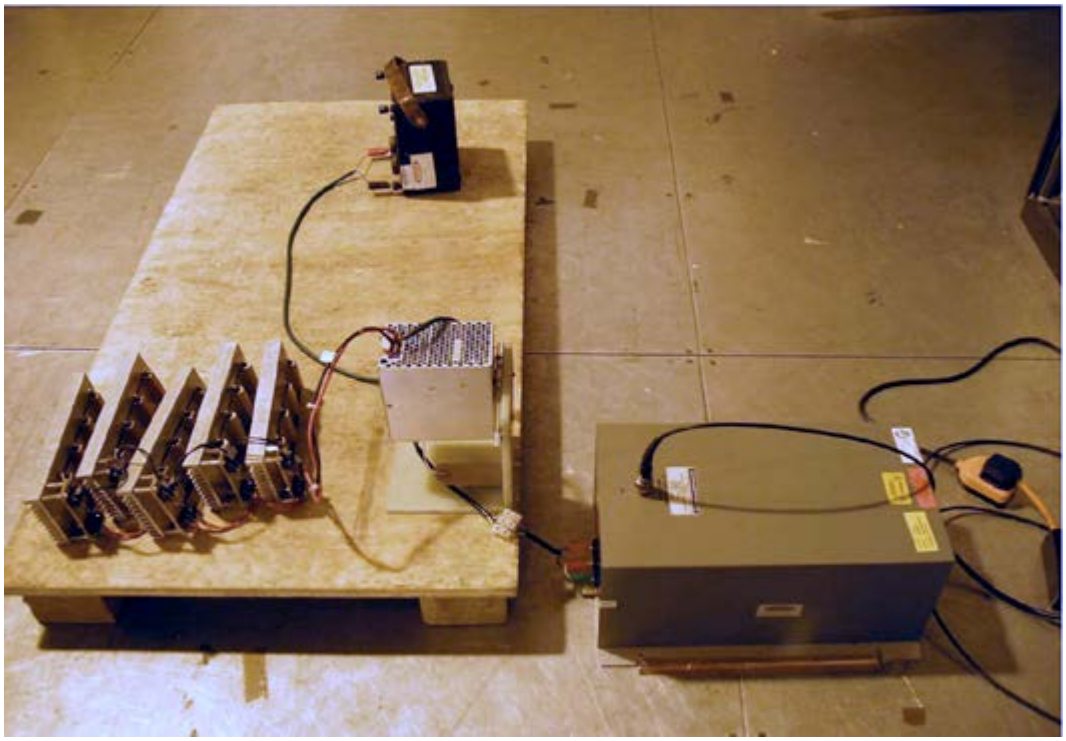


Figure 31 - Conducted RF Immunity, Test Setup Photograph, AC Port, DRB480-48-1

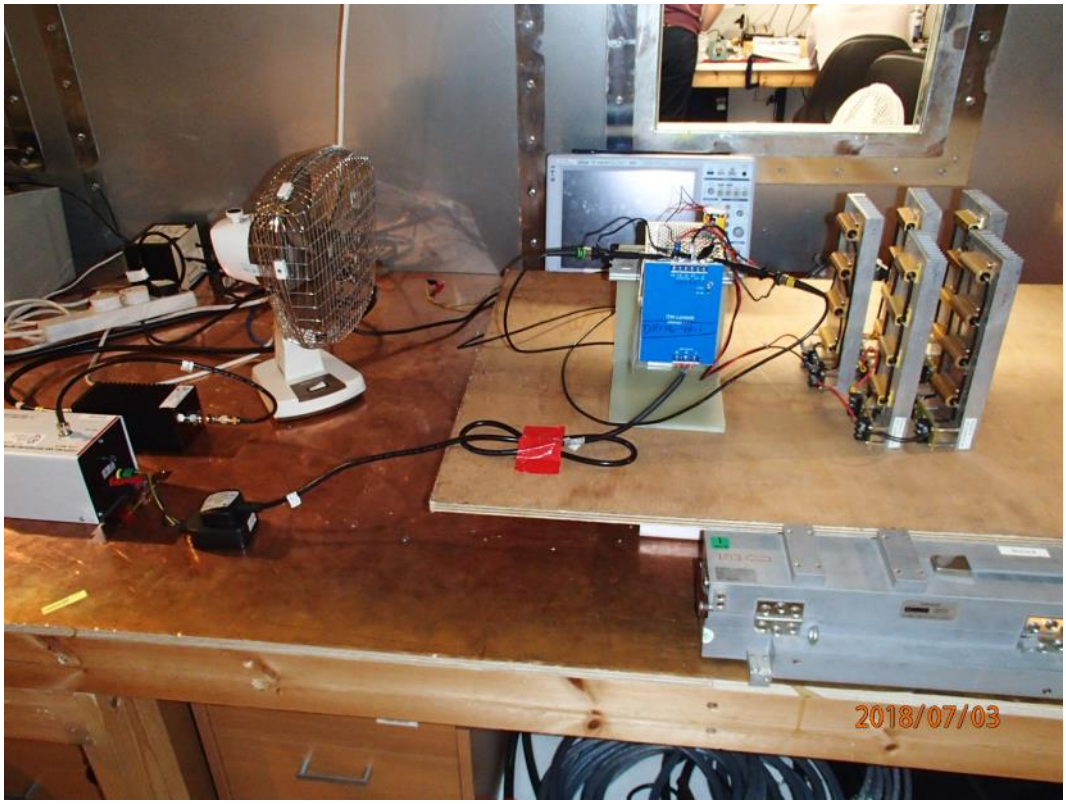
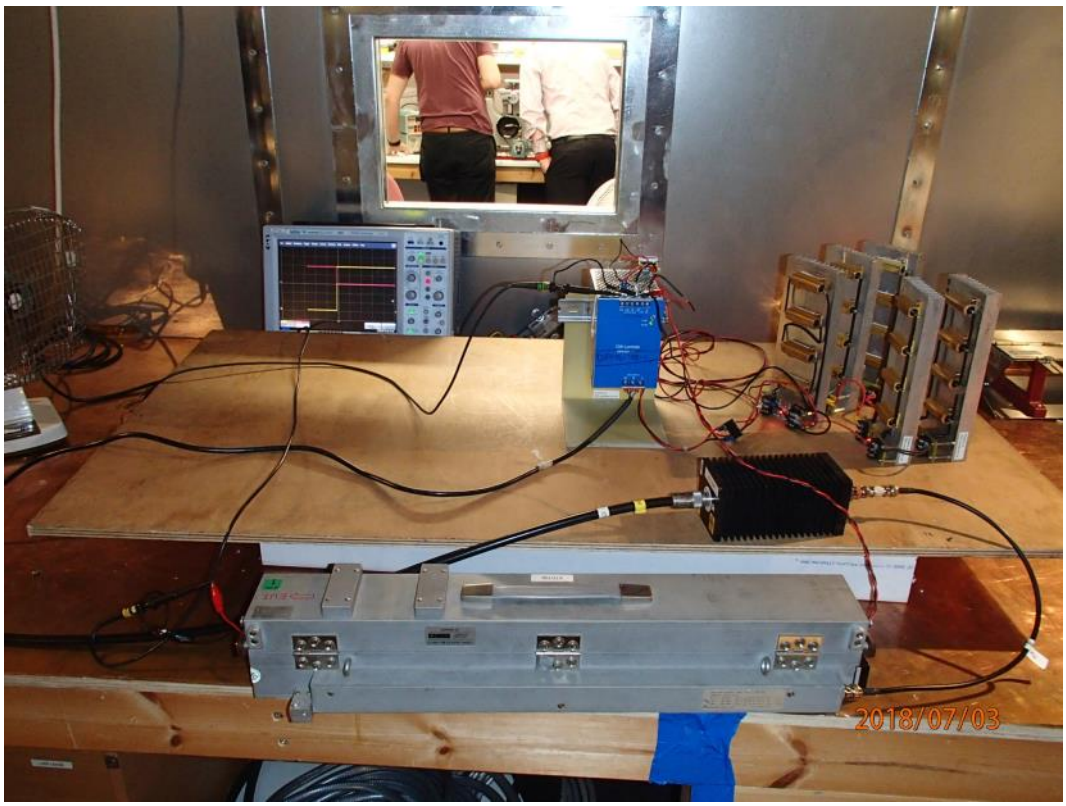


Figure 32 - Conducted RF Immunity, Test Setup Photograph, DC Ports, DRB480-48-1



15.2. Test Results

Table 45 - Conducted RF, Test Results

Unit	Output	Input	Port	Level	Pass Criteria
DRB480-24-1 Unit #01	Nominal	230V AC	AC Port	3	A
DRB480-24-1 Unit #01	Nominal	230V AC	DC Port	3	A
DRB480-24-1 Unit #04	Nominal	230V AC	AC Port	3	A
DRB480-48-1 Unit #06	Nominal	230V AC	AC Port	3	A
DRB480-48-1 Unit #06	Nominal	230V AC	DC Port	3	A

EUT Tested: DRB480-24-1 Unit #01. The EUT's passed the requirements of EN 61000-4-6: 2009 (Level 3, [AC Input port and DC Output Ports]) for Immunity to Conducted disturbances, induced by Radio-Frequency Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-6:2009	**Date**	16/11/2015
		Test Location	TDK Lambda UK Ltd.
Environment	19°C; 44% rh; 1011mB	**Test Engineer**	Nick Heighington

EUT Tested: DRB480-24-1 Unit #04. The EUT's passed the requirements of EN 61000-4-6: 2014 (Level 3, [AC Input port]) for Immunity to Conducted disturbances, induced by Radio-Frequency Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-6:2014	**Date**	19/08/2016
		Test Location	Kiwa Blackwood
Environment	20.3°C; 51% rh	**Test Engineer**	Phil Mantle

EUT Tested: DRB480-48-1 Unit #06. The EUT's passed the requirements of EN 61000-4-6: 2014 (Level 3, [AC Input port and DC Output Ports]) for Immunity to Conducted disturbances, induced by Radio-Frequency Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-6:2014	**Date**	02-03/07/2018
		Test Location	ETC Ltd.
Environment	19-22°C; 44-54% rh; 1014-1016mB	**Test Engineer**	Charlie White

Table 46 - Conducted RF Immunity, Test Equipment DRB480-24-1 Unit #1

Equipment	Calibration ID	Serial Number	Calibration Date Expires
Signal Generator	ETC826	203001/396	01/04/2016
Amp	ETC724	1004	19/11/2016
Power sensor	ETC893	836400/027	03/06/2016
CDN	ETC824	2291	27/04/2016
Coupler	ETC774	23101	28/04/2016
Power meter	ETC894	842856/006	03/06/2016
Oscilloscope	C209	-	14/10/2016

Table 47 - Conducted RF Immunity, Test Equipment DRB480-24-1 Unit #4

Name	Manufacturer	Kiwa Blackwood Reference
HP8567A Signal generator	HP	8527
25A250 RF Amplifier	AR	8531
25-A-MFB-10 10dB Attenuator	Bird	8770
CDN-M3-50 Couling / Decoupling Network	Schaffner	8678
Cables	N/A	N/A
Conducted Immunity Software	EMC Hire	8635
BAA898HG Environmental Monitor	Oregon Scientific	8648

All test equipment was traceably calibrated at the time of testing.

Table 48 - Conducted RF Immunity, Test Equipment DRB480-48-1 Unit #6

Equipment	Calibration ID	Calibration Date Expires
Hewlett Packard 8648B Signal Generator	ETC1485	07/03/2019
Rohde & Schwarz NRVS Power Meter	ETC806	25/09/2018
Rohde & Schwarz NRVS Power Meter	ETC805	05/07/2018
Rohde & Schwarz NRV-Z51 Power Sensor	ETC808	05/07/2018
Rohde & Schwarz NRV-Z51 Power Sensor	ETC1065	23/10/2018
Bonn Power Amplifier 9 kHz to 100 MHz	ETC1713	20/06/2018
Werlatone Dual Directional Coupler	ETC774	27/03/2019
Schaffner CDN	ETC1481	20/11/2018
Bird Attenuator 100W 6dB	ETC1000	16/11/2018
N Type Cable	ETC948	15/05/2019
N Type Cable	ETC947	15/05/2019
N Type Cable	ETC950	10/04/2019
N Type Cable	ETC1129	06/11/2018

16. Power Frequency Magnetic Field Immunity to EN61000-4-8

16.1. Enclosure Port - Test Procedure

The test was performed under the conditions specified in TDK-Lambda UK document 72508 and 69896. The EUT was set up on a table within the field coils and checked to be functioning correctly. A 50Hz and a 60Hz Magnetic field was applied in accordance with the specification at the levels detailed in Table 49 below. The EUT was tested in three orthogonal orientations for greater than 1 minute in each. Correct functioning of the EUT throughout the test was checked by using the procedures described in Section 5.2.

Table 49 - PF Magnetic Field, Test Levels

Level	Continuous Magnetic Field Strength (A/m)	Short Term Magnetic Field Strength (A/m)
1	1	N/A
2	3	N/A
3	10	N/A
4	30	300
5	100	1000

Figure 33 - PF Magnetic Field, Setup Photograph, X

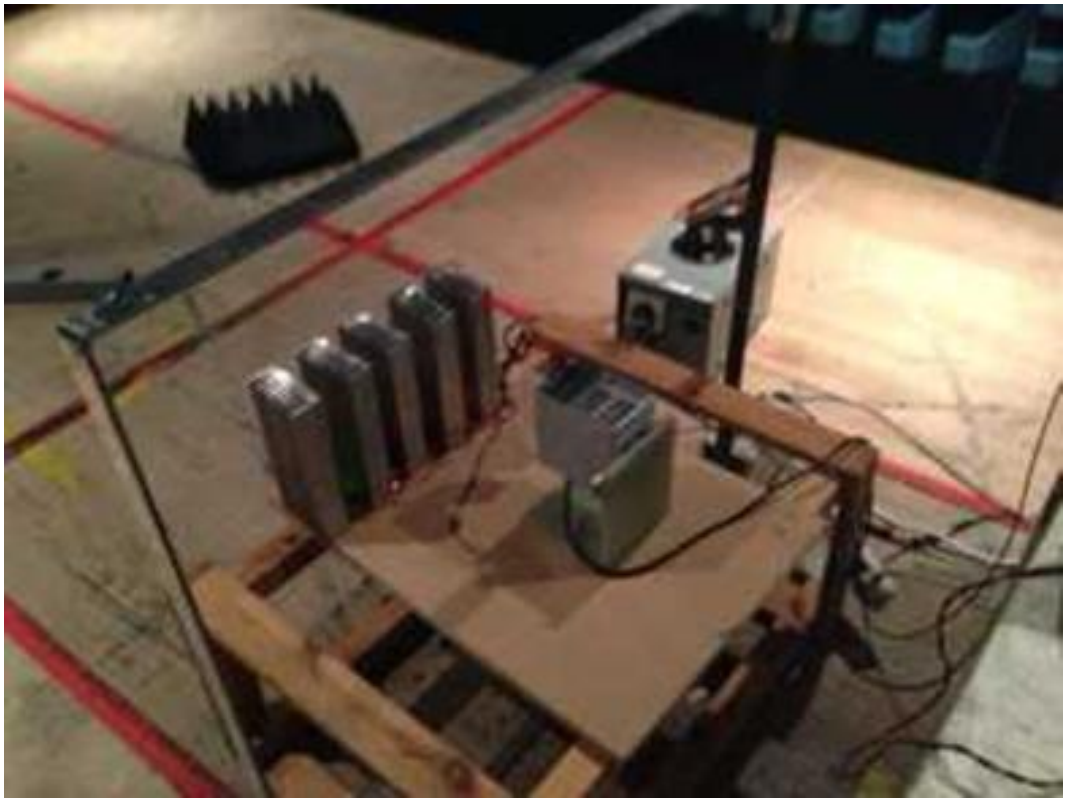


Figure 34 - PF Magnetic Field Setup Photograph, Y

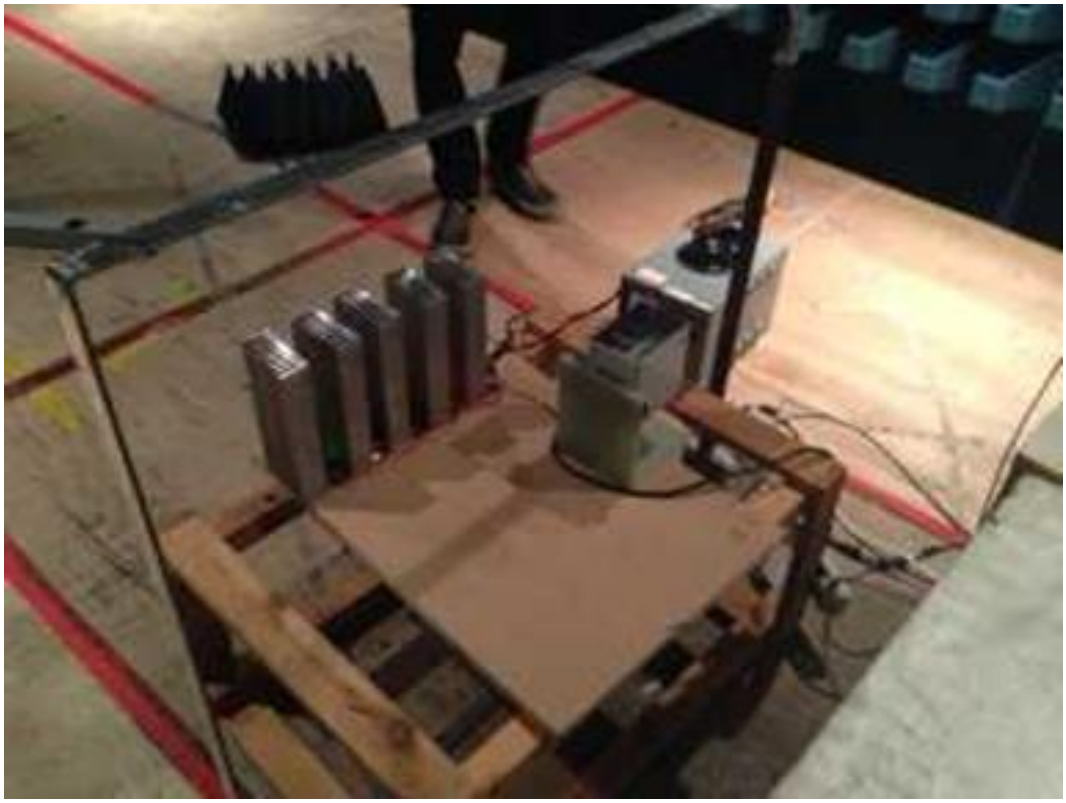
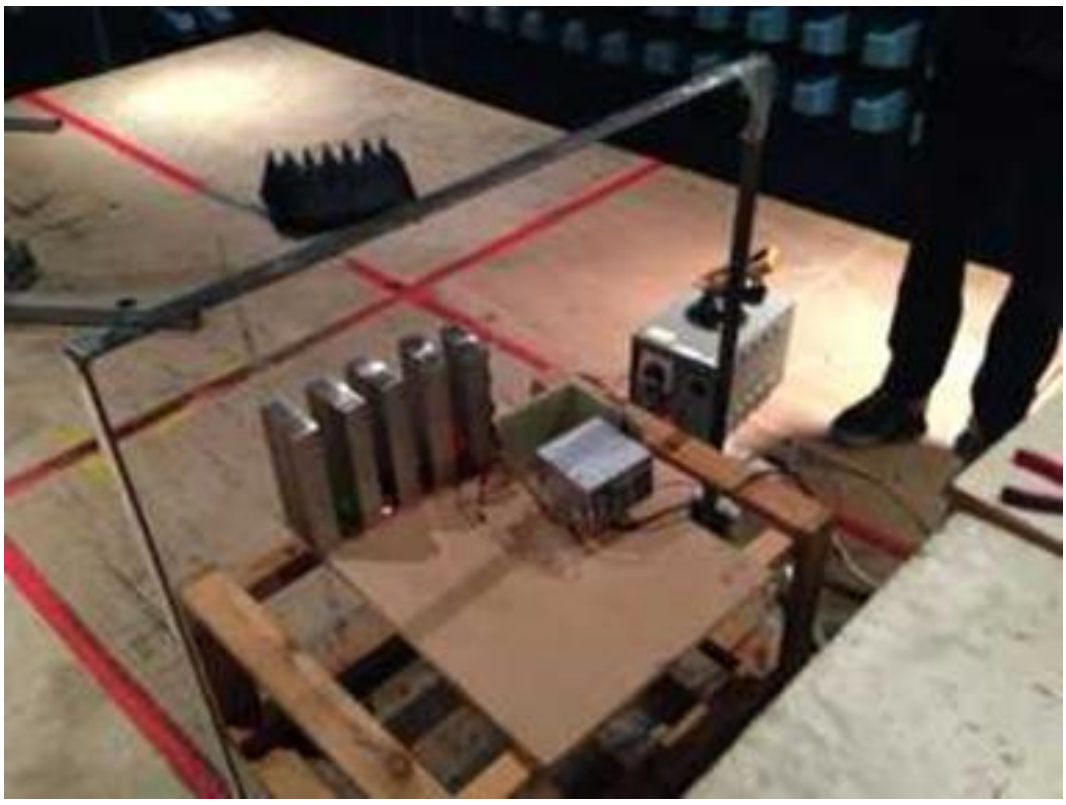


Figure 35 - PF Magnetic Field Setup Photograph, Z



16.2. Enclosure Port - Test Results

Table 50 - PF Magnetic Field, Test Results

Unit	Type	Level	Field	Spec Criteria	Result Criteria	Pass / Fail
DRB480-24-1 Unit #01	Continuous	4	30Am^{-1} 50Hz	A	A	PASS
DRB480-24-1 Unit #01	Short duration	4	300Am^{-1} 50Hz	A	A	PASS
DRB480-24-1 Unit #01	Continuous	4	30Am^{-1} 60Hz	A	A	PASS
DRB480-24-1 Unit #01	Short duration	4	300Am^{-1} 60Hz	A	A	PASS
DRB480-48-1 Unit #08	Continuous	4	30Am^{-1} 50Hz	A	A	PASS
DRB480-48-1 Unit #08	Short duration	4	300Am^{-1} 50Hz	A	A	PASS
DRB480-48-1 Unit #08	Continuous	4	30Am^{-1} 60Hz	A	A	PASS
DRB480-48-1 Unit #08	Short duration	4	300Am^{-1} 60Hz	A	A	PASS

Unit Tested: DRB480-24-1 Unit #01. The EUT passed the requirements of EN 61000-4-8: 2010 (Level 4, [Enclosure port]) for Immunity to Power Frequency Magnetic Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-8:2010	**Date**	07/12/2015
		Test Location	ETC Ltd.
Environment	19°C; 44% rh; 1011mB	**Test Engineer**	Nick Heighington

Unit Tested: DRB480-48-1 Unit #08. The EUT passed the requirements of EN 61000-4-8: 2010 (Level 4, [Enclosure port]) for Immunity to Power Frequency Magnetic Fields. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-8:2010	**Date**	19/07/2018
		Test Location	TDK Lambda UK Ltd.
Environment	21°C; 36% rh; 1008mB	**Test Engineer**	Glen Moore

Table 51 - PF Magnetic Field, Test Equipment, DRB480-24-1

Equipment	Manufacturer	Calibration ID	Calibration
AC Power Supply	Kikusui	ETC1506	05/11/2016
Digital Multimeter	Tenma	ETC928	05/03/2016
Mains Variac	Cooke International	ETC227	10/03/2016
Helmholtz Coil	EMC Partner	ETC923	27/06/2016
Oscilloscope	LeCroy	C209	14/10/2016

Table 52 - PF Magnetic Field, Test Equipment, DRB480-48-1

Equipment	Manufacturer	Calibration ID	Calibration
Analogue multimeter	Kyoritsu	W8224450	-
Analogue multimeter	Kyoritsu	W8215794	-
Helmholtz coil	TDK Lambda UK	N/A	-
Programmable AC source	Chroma	P96	11/04/2019
Digital multimeter	Fluke	J214	16/01/2019
Shunt	-	D04	30/07/2019

17. Immunity to Voltage Dips, Interruptions and Variations to EN61000-4-11

17.1. AC Power Port - Test Procedure

The EUT was set up and functioned correctly. A series of voltage dips, interruptions and variations were applied to the input as specified in TDK-Lambda UK document 72509 and 69896. The test was performed for 240Vac 50Hz nominal, and 100Vac 50Hz nominal. Correct functioning of the EUT throughout the test was checked by using the procedures described in Section 5.2, and with the use of an oscilloscope.

Figure 36 – Dips & Interruptions, Setup Photograph

17.2. AC Power Port - Test Results

Table 53 – Voltage Dips & Interruptions, DRB480-24-1 Unit #04, 100V ac Test Results

Standard	Test	Required Pass Criteria	Result Criteria	Verdict
EN 61000-4-11 Class 3	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	40% 10/12 cycles	B	B	
	70% 25/30 cycles	B	A	
	80% 250/300 cycles	B	A	
	0% 250/300 cycles	B	B	
EN 61000-6-1	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	
EN 61000-6-2	0% 1 cycle	B	A	PASS
	40% 10/12 cycles	C	B	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	

Table 54 – Voltage Dips & Interruptions, DRB480-24-1 Unit #04, 240V ac Test Results

Standard	Test	Required Pass Criteria	Result Criteria	Verdict
EN 61000-4-11 Class 3	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	40% 10/12 cycles	B	A	
	70% 25/30 cycles	B	A	
	80% 250/300 cycles	B	A	
	0% 250/300 cycles	B	B	
EN 61000-6-1	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	
EN 61000-6-2	0% 1 cycle	B	A	PASS
	40% 10/12 cycles	C	A	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	

Unit Tested: DRB480-24-1 Unit #04. The unit passed the Class 3 requirements of EN 61000-4-11; 2004 [Power Ports] for Immunity to Voltage Dips and Interruptions. The Criteria for each test is given in the tables above, see Appendix A for details. In addition, the requirements of EN 61000-6-2:2005; EN 61204-3:2000 and EN 60601-1-2:2015 were met.

Procedure	EN 61000-4-11:2004; EN 61000-6-1: 2007; EN 61000-6-2:2005	**Date**	15/08/2016
		Test Location	TDK-Lambda UK Ltd.
Environment	22°C; 37% rh; 1010mB	**Test Engineer**	Tim Broxholme

Table 55 – Voltage Dips & Interruptions, DRB480-48-1 Unit #06, 100V ac Test Results

Standard	Test	Required Pass Criteria	Result Criteria	Verdict
EN 61000-4-11 Class 3	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	40% 10/12 cycles	B	B	
	70% 25/30 cycles	B	B	
	80% 250/300 cycles	B	A	
	0% 250/300 cycles	B	B	
EN 61000-6-1	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	70% 25/30 cycles	C	B	
	0% 250/300 cycles	C	B	
EN 61000-6-2	0% 1 cycle	B	A	PASS
	40% 10/12 cycles	C	B	
	70% 25/30 cycles	C	B	
	0% 250/300 cycles	C	B	

Table 56 – Voltage Dips & Interruptions, DRB480-48-1 Unit #06, 240V ac Test Results

Standard	Test	Required Pass Criteria	Result Criteria	Verdict
EN 61000-4-11 Class 3	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	40% 10/12 cycles	B	A	
	70% 25/30 cycles	B	A	
	80% 250/300 cycles	B	A	
	0% 250/300 cycles	B	B	
EN 61000-6-1	0% ½ cycle	B	A	PASS
	0% 1 cycle	B	A	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	
EN 61000-6-2	0% 1 cycle	B	A	PASS
	40% 10/12 cycles	C	A	
	70% 25/30 cycles	C	A	
	0% 250/300 cycles	C	B	

Unit Tested: DRB480-48-1 Unit #06. The unit passed the Class 3 requirements of EN 61000-4-11; 2004 [Power Ports] for Immunity to Voltage Dips and Interruptions. The Criteria for each test is given in the tables above, see Appendix A for details. In addition, the requirements of EN 61000-6-2:2005; EN 61204-3:2000 and EN 60601-1-2:2015 were met.

Procedure	EN 61000-4-11:2004; EN 61000-6-1: 2007; EN 61000-6-2:2005	**Date**	30/07/2018
		Test Location	TDK-Lambda UK Ltd.
Environment	20°C; 38% rh; 1010mB	**Test Engineer**	Glen Moore

Table 57 – Voltage Dips & Interruptions, Test Equipment, DRB480-24-1

Equipment	Manufacturer	Serial / Cal Ref	Calibration
TRA-2000-IN6	EMC Partner	789	02/02/2017
Oscilloscope,	LeCroy	A362	08/06/2017
ADP305 Differential Probe	LeCroy	A569	25/02/2017
Differential Probe	Metrix	E146	N/A

Table 58 – Voltage Dips & Interruptions, Test Equipment, DRB480-48-1

Equipment	Manufacturer	Serial / Cal Ref	Calibration
TRA-2000-IN6	EMC Partner	1162	05/12/2018
Oscilloscope,	LeCroy	P71	16/01/2019

18. Ring Wave Surge Immunity to EN61000-4-12

18.1. AC Power Port - Test Procedure

The EUT was set up and functioned correctly, as described in section 5.2. A series of high energy surges were applied as shown in Table 59 below. The testing was carried out at a 10 second repetition rate with a 30Ω generator impedance.

Table 59 - Ring Wave Surge, Test levels.

Level	Coupling	Voltage	Test Voltage
1	Line to Neutral	0.25kV	0.275kV
	Line or Neutral to Ground	0.5kV	0.55kV
2	Line to Neutral	0.5kV	0.55kV
	Line or Neutral to Ground	1kV	1.1kV
3	Line to Neutral	1kV	1.1kV
	Line or Neutral to Ground	2kV	2.2kV
4	Line to Neutral	2kV	2.2kV
	Line or Neutral to Ground	4kV	4.4kV

For each of the above test conditions, five positive and five negative pulses were applied, each at 0°, 90°, 180° and 270° phase angle. Correct functioning of the EUT throughout the test was checked using the procedures described in Section 5.2. The test was performed under the conditions specified in TDK-Lambda UK document 72509 and 69896.

Figure 37 - Ring Wave, Test Setup, DRB480-24-1

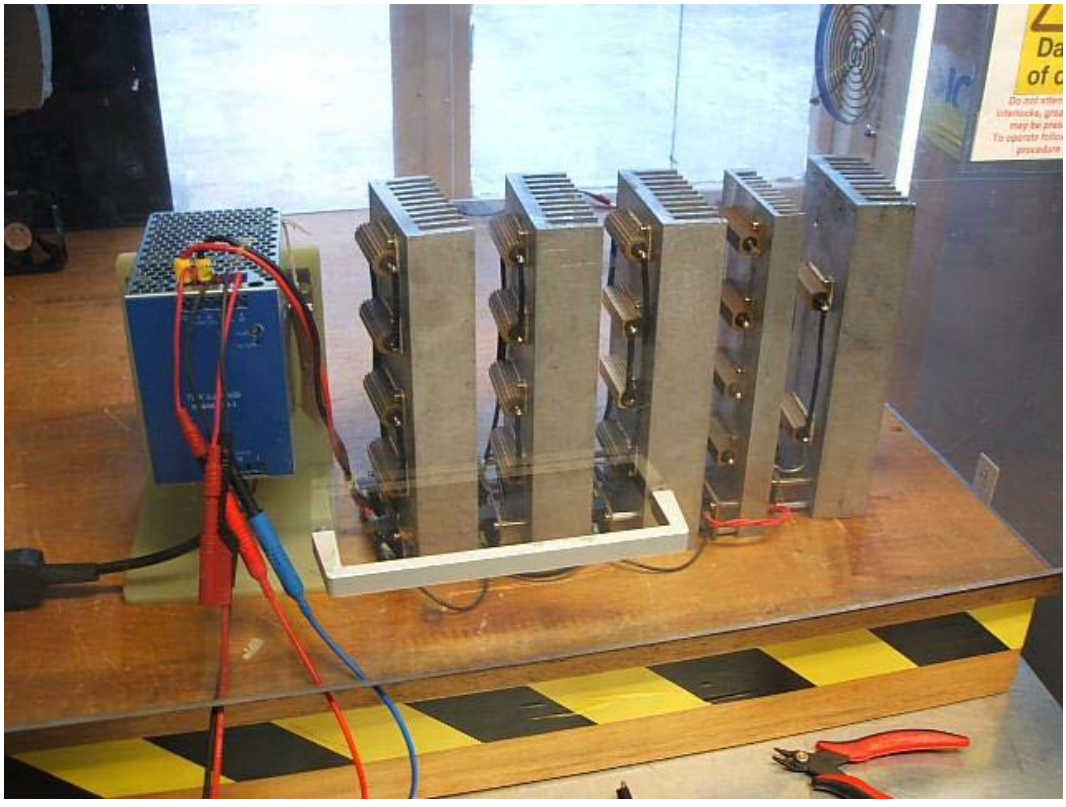


Figure 38 - Ring Wave, Test Setup, DRB480-48-1

18.2. Test Results

Table 60 - Ring Wave Surge, AC Power Port Test Results

Unit	Line	Load	Output Voltage	Level	Pass Criteria
DRB480-24-1 Unit #04	240Vac	Full	Nominal	3	A
DRB480-24-1 Unit #04	240Vac	Full	Maximum	3	A
DRB480-24-1 Unit #04	100Vac	Full	Maximum	3	A
DRB480-24-1 Unit #04	240Vac	Zero	Maximum	3	A
DRB480-48-1 Unit #06	240Vac	Full	Nominal	3	A
DRB480-48-1 Unit #06	240Vac	Full	Maximum	3	A
DRB480-48-1 Unit #06	100Vac	Full	Maximum	3	A
DRB480-48-1 Unit #06	240Vac	Zero	Maximum	3	A

Unit tested: DRB480-24-1 Unit #04. The EUT met the requirements of EN 61000-4-12: 2006 (Level 3, [AC Power Ports]) for Immunity to Ring Wave Surges. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-12:2006	**Date**	10/08/2016
		Test Location	TDK-Lambda UK
Environment	20°C; 36%rh; 1011mB	**Test Engineer**	Tim Broxholme

Unit tested: DRB480-48-1 Unit #06. The EUT met the requirements of EN 61000-4-12: 2006 (Level 3, [AC Power Ports]) for Immunity to Ring Wave Surges. The EUT's performance level met criteria A, as defined in accordance with the specification, see Appendix A.

Procedure	EN 61000-4-12:2006	**Date**	24/05/2018
		Test Location	TDK-Lambda UK
Environment	22°C; 37%rh; 1009mB	**Test Engineer**	Tim Broxholme

Table 61 - Ring Wave Surge Test Equipment, DRB480-24-1

Name	Manufacturer	Serial Number	Calibration
TRA2000IN6	EMC Partner	789	01/02/2017
Oscilloscope	LeCroy	LCRY3703N15806	08/06/2017
ADP305 Diff Probe	LeCroy	A569	25/05/2017
Differential probe		E146	N/A

The test equipment was verified in accordance with the specification on 02/08/2016.

Table 62 - Ring Wave Surge Test Equipment, DRB480-48-1

Name	Manufacturer	Serial Number	Calibration
TRA2000IN6	EMC Partner	1162	05/12/2018
WaveSurfer 434	LeCroy	P71	17/01/2019

The test equipment was verified in accordance with the specification on 21/05/2018.

Appendix A – Immunity Performance Criteria

Performance Criterion A

The unit remains within the performance level specified in Table 63 below throughout the testing.

Table 63 - Immunity performance level for Criteria A

Parameter	Performance level during immunity tests
Output Voltage set point	Within ±5% of set point
DC good signal	Continue to show DC good correctly
AC Fail signal	Continue to operate correctly

Performance Criterion B

The unit's performance drops below the levels in Table 63 above during the test, but recovers to within this performance level after the test has completed without user intervention.

Performance Criterion C

The unit's performance drops below the levels in Table 63 above during the test, but after user intervention[5] recovers to within this performance level after the test has completed.

Performance Criterion D

The unit's performance drops below the levels in Table 63 above during the test, and cannot be made to recover to within this performance level after the test has completed, without replacement of components. Alternatively, if evidence of physical damage can be seen[6] even if performance levels are acceptable.

Pre and Post Performance Checks

Additionally before and after each immunity test the input and output Y capacitors are measured and the values compared to ensure there is no damage to the Y capacitors during the test. After each immunity test the DC good and AC fail signals are checked to operate correctly and the inhibit function(s) are checked for correct operation. Only after these checks is a pass at Criteria A, B or C given. If these checks fail the result is Criteria D.

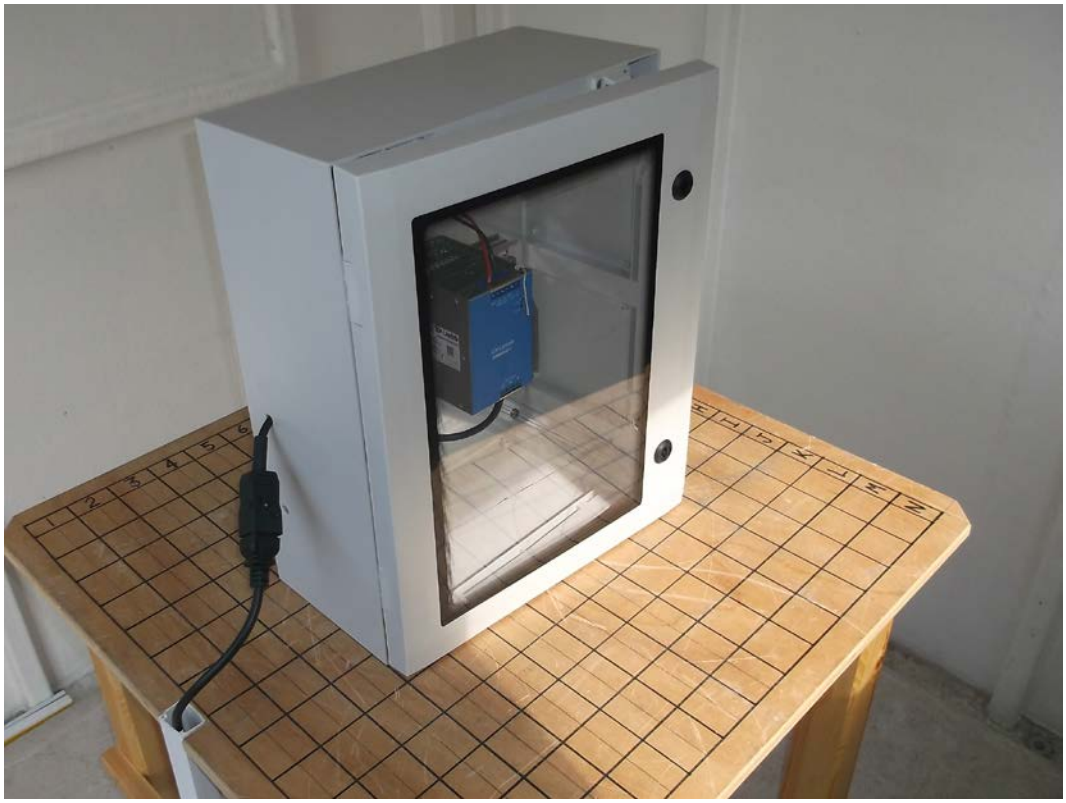
[5] Usually recycling the input power, or operating the Inhibit / Enable function.
[6] Damaged components, or smoke, fire etc.

Appendix B – Additional Emissions Results

From thermal shock testing of DRB480-24-1, a problem was found with the PFC current sense resistors. As a result of this a change was implemented (TLU CS 68905) to change the four current sense resistors to a single metal strip resistor, Vishay SR3R0500FE14, and to add a 1µF cap in parallel, Murata GRM21BR71E105KA99L or Samsung CL21B105KAFNNNF. As part of the validation of this change, radiated emissions and conducted emissions were tested, the results of which are presented below.

Radiated Emissions

Figure 39 – Radiated Emissions Test Setup in Cabinet



Test Results

The levels of the highest emissions measured in accordance with the specification are presented below. The unit was measured as a stand-alone supply and in a cabinet to simulate a typical customer use at an antenna distance of 3m. The emissions with the least margin are highlighted. Graphs of radiated emissions are held in engineering if necessary.

Table 64 - Radiated Electric Field Emissions, UNIT #05, In Cabinet 230Vac

Frequency (MHz)	QuasiPeak (dBµV/m)	Polarisation	Limit EN55011 Class B (dBµV/m)	Margin EN55011 Class B (dB)	Limit FCC Class B (dBµV/m)	Margin FCC Class B (dBµV/m)
37.20	22.4	V	40.00	17.6	40.00	17.6
45.76	24.3	V	40.00	15.7	40.00	15.7
45.84	10.8	H	40.00	29.2	40.00	29.2
92.64	16.2	H	40.00	23.8	43.52	27.3
92.80	27.7	V	40.00	12.3	43.52	15.8
141.08	26.6	H	40.00	13.4	43.52	16.9
183.16	18.2	H	40.00	21.8	43.52	25.3
184.80	19.4	V	40.00	20.6	43.52	24.1

Table 65 - Radiated Electric Field Emissions, UNIT #05, In Cabinet 100Vac

Frequency (MHz)	QuasiPeak (dBµV/m)	Polarisation	Limit EN55011 Class B (dBµV/m)	Margin EN55011 Class B (dB)	Limit FCC Class B (dBµV/m)	Margin FCC Class B (dBµV/m)
37.08	25.7	V	40.00	14.3	40.00	14.3
47.00	24.5	V	40.00	15.5	40.00	15.5
83.72	28.2	V	40.00	11.9	40.00	11.9
88.76	29.7	V	40.00	10.3	43.52	13.8
90.84	22.3	H	40.00	17.7	43.52	21.2
92.44	24.9	V	40.00	15.1	43.52	18.6
140.64	30.0	H	40.00	10.0	43.52	13.5
182.96	26.6	V	40.00	13.4	43.52	16.9
183.00	24.6	H	40.00	15.4	43.52	18.9
189.76	23.5	V	40.00	16.5	43.52	20.0

Unit Tested: UNIT #05, the EUT met the requirements of EN 55011:2009 +A1:2010 (Class B [Enclosure Port]) for radiated disturbances when measured in a cabinet. In addition the requirements of FCC Title 47, Part 15, Subpart B, §15.109, Class B were met.

Procedure	CISPR16-2-3: 2006 / EN 55011:2009 + A1:2010 FCC Title 47, Part 15, Subpart B, §15.109	**Date**	04/11/2016
		Location	TDK-Lambda UK
Environment	15°C; 91% rh; 1022mB	**Test Engineer**	Paul Dyer

Conducted Emissions

Figure 40 - Conducted Emissions, Unit #05, In Cabinet, Graph 230Vac

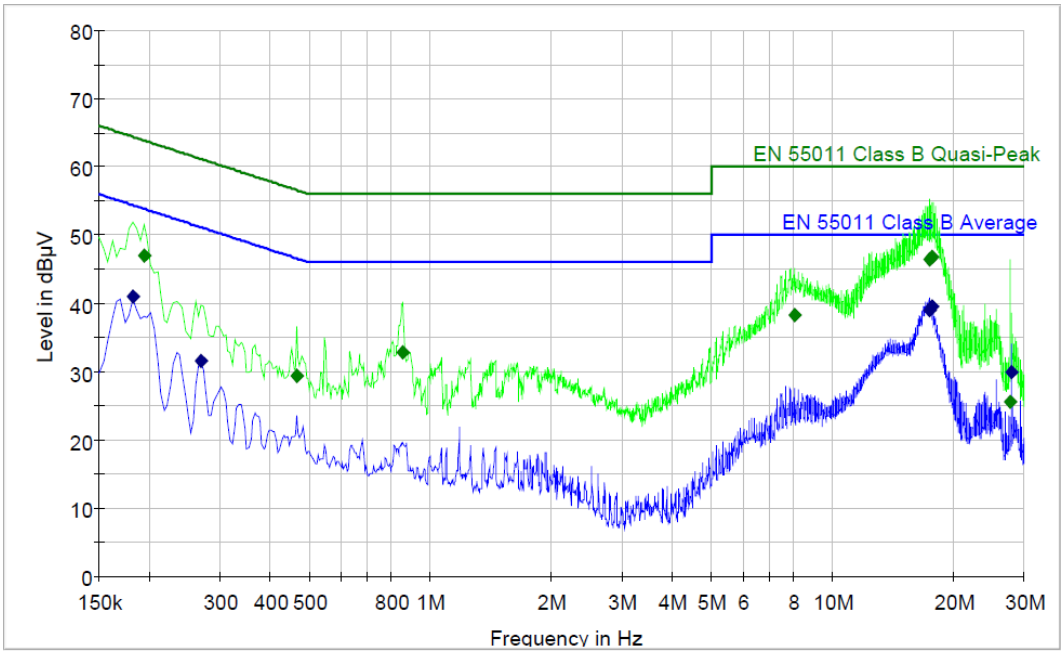


Table 66 - Conducted Emissions, Unit #05, In Cabinet, Quasi-Peak 230Vac

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.194	46.9	L1	16.9	63.9
0.466	29.3	N	27.2	56.6
0.854	32.8	N	23.2	56.0
8.070	38.2	L1	21.8	60.0
17.486	46.5	L1	13.5	60.0
17.678	46.8	L1	13.2	60.0
27.738	25.5	L1	35.4	60.0

Table 67 - Conducted Emissions, Unit #05, In Cabinet, Average 230Vac

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.182	40.9	L1	13.5	54.4
0.270	31.5	L1	19.6	51.1
17.478	39.0	L1	11.0	50.0
17.662	39.5	L1	10.5	50.0
28.002	29.9	L1	20.1	50.0

Figure 41 - Conducted Emissions, Unit #05, In Cabinet, Graph 100Vac

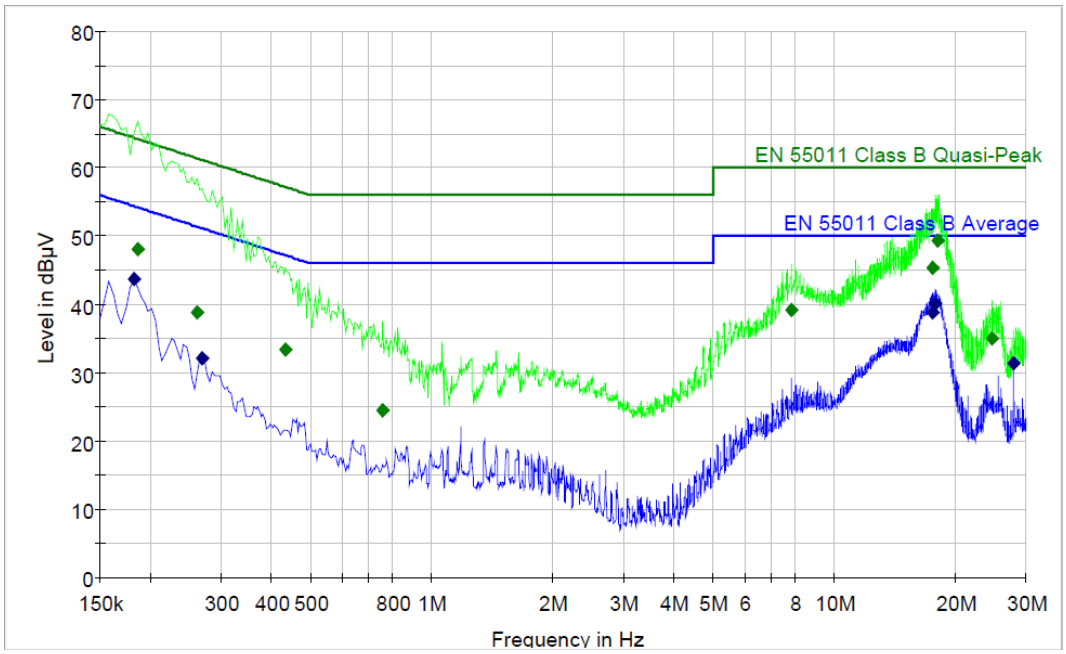


Table 68 - Conducted Emissions, Unit #05, In Cabinet, Quasi-Peak 100Vac

Frequency (MHz)	QuasiPeak (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.186	48.0	N	16.2	64.2
0.262	38.8	N	22.6	61.4
0.434	33.3	N	23.9	57.2
0.758	24.5	N	31.5	56.0
7.838	39.3	L1	20.7	60.0
17.614	45.3	N	14.7	60.0
18.042	49.3	L1	10.7	60.0
24.738	35.0	N	25.0	60.0

Table 69 - Conducted Emissions, Unit #05, In Cabinet, Average 100Vac

Frequency (MHz)	Average (dBµV)	Line	Margin (dB)	Limit (dBµV)
0.182	43.6	L1	10.8	54.4
0.270	32.2	L1	19.0	51.1
17.610	38.9	L1	11.1	50.0
17.822	40.2	L1	9.8	50.0
28.002	31.4	L1	18.6	50.0

Unit Tested: UNIT #05, the EUT met the requirements of EN 55011:2009 +A1:2010 (Class B [Enclosure Port]) for conducted disturbances when measured in a Cabinet.

Procedure	CISPR16-2-1: 2005 / EN 55011:2009 + A1:2010	**Date**	03/11/2016
		Test Location	TDK-Lambda UK Ltd.
Environment	21°C; 35%rh; 1018mB	**Test Engineer**	Paul Dyer

Appendix C – Measurement Instrument Uncertainty

For emissions measurements the uncertainty is measured in accordance with CISPR 16-4-2. This standard defines limits for the values of U_{cispr} as follows:

Measurement	U_{cispr}
Conducted Disturbance (mains port) 150 kHz – 30 MHz	3.60 dB
Radiated disturbance (electric field strength on an open area test site) 30 MHz – 1000 MHz	5.20 dB

Calculations of U_{lab} for the conducted emissions test facility at TDK-Lambda UK

Input Quantity		Uncertainty of Xi		u(Xi)	ci	ci u(xi)
Description	Xi	±dB	Probability Distribution Function	dB		dB
Receiver Reading	Vr	0.1	k=1	0.10	1	0.10
Attenuation: AMN-receiver	Lc	0.2	k=2	0.10	1	0.10
Attenuation: Pulse limiter	Lpl	0.2	k=2	0.10	1	0.10
AMN Voltage division factor	Lamn	0.2	k=2	0.10	1	0.10
Receiver, Measurement Uncertainty	∂Vmu	1.5	Rectangular	0.87	1	0.87
Receiver, Noise floor proximity	∂Vnf	0.0	Rectangular	0.00	1	0.00
Mismatch: AMN-receiver	∂M	0.8	U-shaped	0.53	1	0.53
AMN Impedance	∂Z	3.6	Triangular	1.44	1	1.44
					2 uc(V) =	3.55

Calculations of U_{lab} for the radiated emissions test facility at TDK-Lambda UK

Input Quantity		Uncertainty of Xi		u(Xi)	ci	ci u(xi)
Description	Xi	±dB	Probability Distribution Function	dB		dB
Receiver Reading	Vr	0.1	k=1	0.10	1	0.10
Attenuation: Antenna-receiver	Lc	0.2	k=2	0.10	1	0.10
Attenuation: Pre-Amplifier	Lpa	0.2	k=2	0.10	1	0.10
Receiver, Measurement Uncertainty	∂Vmu	1.5	Rectangular	0.87	1	0.87
Receiver, Noise floor proximity	∂Vnf	1.0	k=2	0.50	1	0.50
Mismatch: Antenna-receiver	∂M	1.5	U-shaped	1.00	1	1.00
Antenna factor	AF	2.0	k=2	1.00	1	1.00
Antenna directivity (3m)	∂Adir	0.3	Rectangular	0.17	1	0.17
AF height deviations	∂Afh	0.5	Rectangular	0.29	1	0.29
Antenna Balance	∂Abal	0.3	Rectangular	0.17	1	0.17
Site Imperfections	∂SA	3.0	Triangular	1.20	1	1.20
Separation Distance (3m)	∂d	0.3	Rectangular	0.17	1	0.17
Table Height	∂h	0.1	k=2	0.05	1	0.05
					2 uc(V) =	4.31

2 uc(V) is the calculation of U_{lab}, as for both conducted emissions and radiated emissions this is less than U_{cispr}, the unmodified limit lines can be used to determine compliance or non-compliance.

Uncertainty of Radiated Immunity Field 80 MHz to 2.7 GHz at ETC Ltd.

Uncertainty of generated field level is 1.6 dB. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=1.67, providing a level of confidence of approximately 95%. Calculated in accordance with UKAS LAB34.

Uncertainty of Radiated Immunity Field at spot frequencies up to 5.785 GHz at ETC Ltd.

Uncertainty of generated field level is 3.2 dB. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=1.67, providing a level of confidence of approximately 95%. Calculated in accordance with UKAS LAB34.

Uncertainty of Conducted Immunity Voltage 150 kHz to 80 MHz at ETC Ltd.

Uncertainty of generated field level using the Coupling Decoupling Network is 1.2 dB and using the Electromagnetic Clamp is 2.7 dB. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=1.67, providing a level of confidence of approximately 95%. Calculated in accordance with EN 61000-4-6.

Measurement Uncertainty at Kiwa Blackwood.

ISO/IEC 17025:2005 “General requirements for the competence of testing and calibration laboratories” requires measurement uncertainty to be estimated for all testing done.

Measurements Uncertainty for conducted and radiated emissions has been calculated and applied in accordance with CISPR 16-4-2:2003. Measurement Uncertainty has been calculated for all other tests in accordance with UKAS document LAB 34 Edition 1:2002.

With regard to emissions testing Ulab meets Ucispr meaning that a simple pass or fail is reported.

With regard to Radiated Field Immunity and Conducted RF Immunity testing the test level generation uncertainty has not been added to the test level. This is in line with current Cenelec interpretation sheets on the two basic standards EN 61000-4-3 and EN 61000-4-6.

Appendix D – Equipment Under Test

The following units were used for the testing in this report, details of which unit(s) were subjected to which tests are given on the relevant pages of the test report and a summary in Table 71 – Test Matrix below. Not all tests were carried out on every unit, details are given on the relevant pages within the document as to which units were subjected to each test regime. The testing performed is sufficient to give a representative result for all tests to cover the range of models available.

Table 70 – DRB480 Test Sample List

Unit	Full Name
Unit #01	DRB480-24-1 B1-M1; SU01
Unit #02	DRB480-24-1 C1-M5; SN: 10015168001100021
Unit #03	DRB480-24-1 D1-M2; SN: TRG1870014
Unit #04	DRB480-24-1 D1-M3; SN: TRG1870014
Unit #05	DRB480-24-1 SN: TRG3000005
Unit #06	DRB480-48-1 A1-M4; SN: 7JD1903481
Unit #07	DRB480-48-1 A1-M4; SN: 7JD1903469
Unit #08	DRB480-48-1 A1-M4; SN: W8215794

Table 71 – Test Matrix

Unit	Radiated Emissions	Conducted Emissions	Harmonics	Flicker	ESD	Radiated Immunity	EFT	Surge	Conducted Immunity	PF Magnetic Field	Dips & Interruptions	Ring Wave
DRB480-24-1 Unit #01									X	X		
DRB480-24-1 Unit #02			X		X							
DRB480-24-1 Unit #03												
DRB480-24-1 Unit #04	X	X		X		X	X	X	X		X	X
DRB480-24-1 Unit #05	X	X										
DRB480-48-1 Unit #06	X	X			X	X	X	X	X		X	X
DRB480-48-1 Unit #07			X									
DRB480-48-1 Unit #08										X		

Appendix E – References

Table 72 - National & International Standards

Document Number	Title
Directive 2014/30/EU	Directive 2014/30/EU of the European Parliament and the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast)
BS EN 60601-1-2:2015	Medical electrical equipment. General requirements for basic safety and essential performance. Collateral Standard. Electromagnetic disturbances. Requirements and tests
BS EN 61000-3-2: 2014	Electromagnetic compatibility (EMC) – Part 3-2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
BS EN 61000-3-3: 2013	Electromagnetic compatibility (EMC) – Part 3-3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤ 16 A
BS EN 61000-4-2: 2009	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
BS EN 61000-4-3: 2006 + A2:2010	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio frequency, electromagnetic field immunity test
BS EN 61000-4-4: 2012	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient burst immunity test
BS EN 61000-4-5: 2014	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test
BS EN 61000-4-6: 2014	Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques –Immunity to conducted disturbances, induced by radio frequency fields
BS EN 61000-4-7: 2002 +A1: 2009	Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected hitherto
BS EN 61000-4-8: 2010	Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test
BS EN 61000-4-11: 2004	Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity test
BS EN 61000-4-12: 2006	Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test
BS EN 61000-4-14:1999+A2:2009	Electromagnetic compatibility (EMC). Testing and measurement techniques. Voltage fluctuation immunity test for equipment with input current not exceeding 16 A per phase
BS EN 61000-6-1: 2007	Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments
BS EN 61000-6-2: 2005	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
BS EN 61000-6-3: 2007 + A1:2011	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for residential, commercial and light-industrial environments
BS EN 61000-6-4: 2007 + A1:2011	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
BS EN 55011: 2016	Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement
BS EN 55024: 2010 + A1:2015	Information technology equipment. Immunity characteristics. Limits and methods of measurement
BS EN 55032:2015	Electromagnetic compatibility of multimedia equipment. Emission Requirements
CISPR 16-1-2: 2014	Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances

Document Number	Title
CISPR 16-2-1: 2014	Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements
CISPR 16-2-3 2016	Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3:Methods of measurement of disturbances and immunity – Radiated disturbance measurements
CISPR 16-4-2: 2011 + AMD:2014	Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty
FCC Title 47, Chapter 1, Part 15.107 – 2016	Federal Communications Commission, Title 47, Part 15- Radio Frequency Devices, 107, Conducted limits.
FCC Title 47, Chapter 1, Part 15.109 – 2016	Federal Communications Commission, Title 47, Part 15- Radio Frequency Devices, 109, Radiated Emissions limits.

Table 73 - TDK-Lambda UK Procedures

Document Number	Title
69896 iss 4, 2017	EMC Design Verification Tests
72500 iss 2, 2013	EMC Procedures: C16 - Conducted Emissions
72501 iss 3, 2012	EMC Procedures: C17 - Radiated Emissions
72502 iss 1, 2010	EMC Procedures: C11.2 - Voltage Flicker
72503 iss 2, 2014	EMC Procedures: R10 - Electrostatic Discharge (ESD) Immunity
72504 iss 2, 2014	EMC Procedures: R11 - Radio Frequency, Electromagnetic Field Immunity.
72505 iss 5, 2016	EMC Procedures: R12 - Electrical Fast Transient Burst Immunity
72506 iss 5, 2016	EMC Procedures: R13 - Surge Immunity and Ring Wave Surge Immunity
72507 iss 2, 2014	EMC Procedures: R14 - Conducted Disturbances, Induced By Radio-frequency Fields Immunity
72508 iss 2, 2014	EMC Procedures: R15 - Power Frequency Magnetic Field Immunity
72509 iss 4, 2016	EMC Procedures: R16 - Voltage Dips, Short Interruptions and Voltage Variations Immunity
60802 iss 4, 2015	EMC Procedures: C-12 - Harmonic Current Emissions
260016 iss 7, 2016	DRB480-24-1 Design Specification
260442 iss 1, 2018	DRB480-48-1 Design Specification

Appendix F – Testing Locations

Where the report states the test location at *TDK-Lambda UK* this is:

TDK-Lambda UK Limited
Kingsley Avenue
Ilfracombe
Devon
EX34 8ES
United Kingdom

Where the report states the test location as *Kiwa Blackwood* this is:

Kiwa Blackwood Compliance Laboratories
Unit 8 Woodfieldside Business Park
Pontllanfraith
Blackwood
NP12 2DG
United Kingdom

Where the report states the test location as *ETC Ltd.* this is:

Electronic Test & Calibration Ltd.
Caddsdown Industrial Park
Clovelly Road
Bideford
EX39 3DX
United Kingdom

Appendix G – Revision History

Revision	ECR	Changes	Issued By	Date
1	N/A	Initial Version	Stuart Nottage	28/09/2016
2	CSF 69393	Added Appendix with emission results for Unit #05	Stuart Nottage	21/11/2016
3	002974	Added results for DRB480-48-1 and changed titles to DRB-480, migrated to template v2.0	Stuart Nottage	06/09/2018