EMI Test Lab LLC
Electro Magnetic Interference Testing
EmiTestLab.com

Electro Magnetic Compatibility Test Report

Regarding the CE Mark Compliance of the

Aleph Objects – LulzBot Mini – 3D Printer

In Accordance with the Information Technology Standards

EN 55022:2010 for Emissions

And

EN 55024:2010 for Immunity

Report Revision History

Revision	Date	Reason
1.0	27 January 2015	Initial Release

Description of Equipment Under Test (EUT)

Test Item	:	LulzBot Mini – 3D Printer
Manufacturer	:	Aleph Objects, Inc.
Receipt date	:	8 January 2015

Manufacturer's information

Manufacturers Representative	:	Chris Wagner
Company	:	Aleph Objects, Inc.
Address	:	626 West 66th Street Loveland, Colorado 80538 U.S.A.
Website	:	https://www.alephobjects.com/index.html

Tests Performed at

Address	:	EMI Test Lab LLC 1822 Skyway Drive Unit J Longmont, Colorado 80504 U.S.A
Website	:	http://www.emitestlab.com/

Test Specifications	:	EN 55022:2010 and EN 55024:2010
Tests completed	:	12 January 2015
Result of Testing	:	**The EUT is in Compliance with EN 55022:2010 and EN 55024:2010**
Senior EMC Engineer	:	Dennis King
Report written by	:	Dennis King – EMI Test Lab
Test Plan	:	Dennis King for Aleph Objects
Report date	:	27 January 2015

These test results relate only to the specific unit that was tested. A periodic production audit to verify continued compliance is recommended.

Table of Contents

1 General

1.1 Applied Standards

The LulzBot Mini 3D Printer was evaluated for emissions using EN 55022:2010 and for immunity using EN 55024:2010.

EN 55022:2010 is the European Union's version of the international CISPR standard CISPR 22:2008.

EN 55024:2010 is the European Union's version of the international CISPR standard CISPR 24:2010.

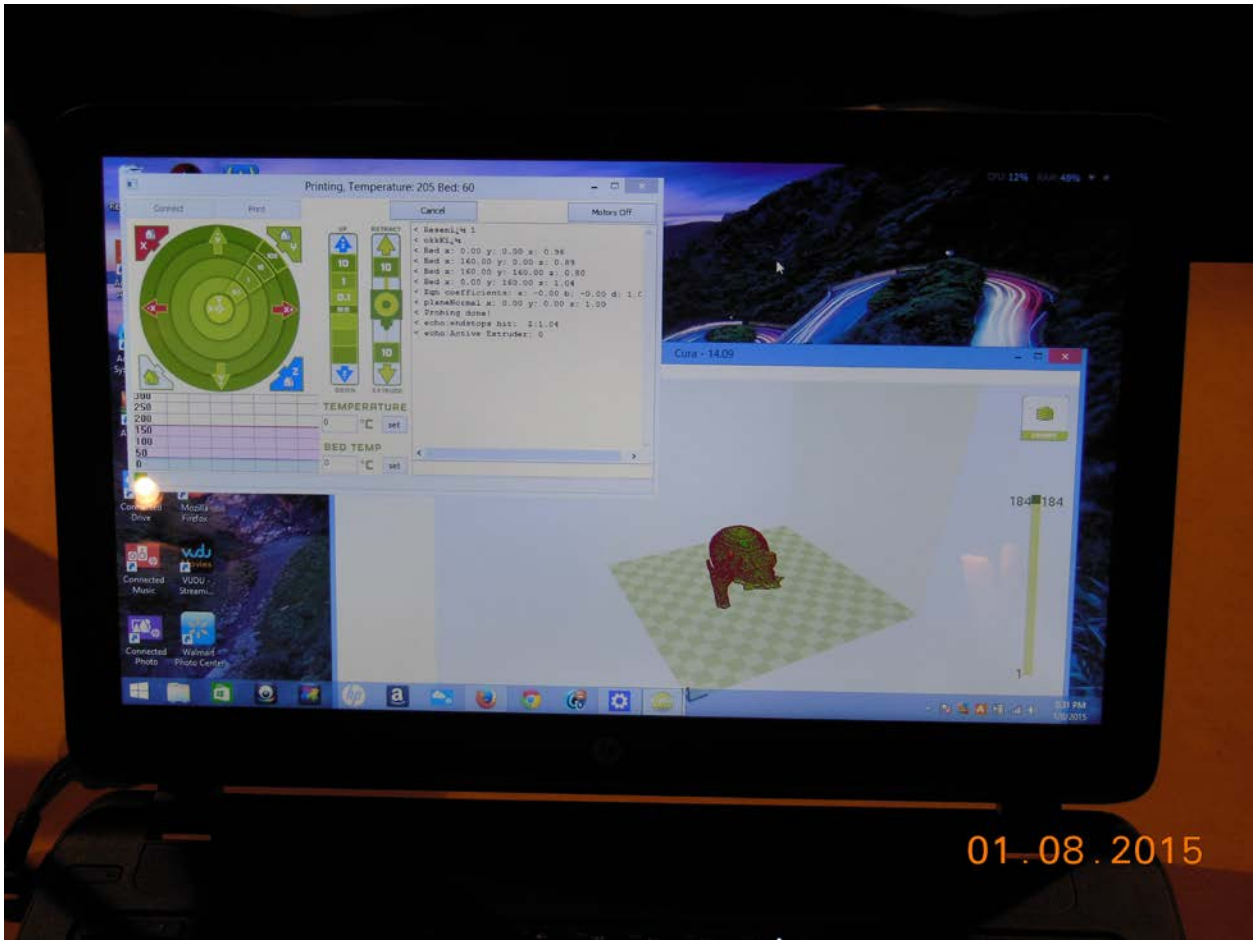
1.2 Detailed description of the test configuration, input and output ports

The 3D Printer was tested while printing a 3D "Rocktopuss". The printer was connected to a laptop through the usb port on the printer. The software was installed on the laptop by Aleph Objects and represents typical software currently used by the end user.

For all test configurations the equipment under test (EUT) is powered by European AC power: 230VAC/50Hz. All I/O cables are less than 3 meters.

LulzBot Mini Software:

The default software for the LulzBot Mini 3D printer is called Cura LulzBot Edition. Cura is a Free Software program that both prepares your files for printing (by converting your model into GCODE), and also allows you to control the operation of your LulzBot 3D printer. The revision used during the testing was 14.09.



Typical screen shot of software used during emissions and immunity testing.

1.2.1 Description of test configuration

EUT	:	LulzBot Mini 3D Printer
Manufacturer	:	Aleph Objects, Inc.
System model name	:	Mini
Serial Number	:	KT-PR0035-0051
Test Voltage	:	230 VAC 50 Hz

1.2.2. Description of tested input and output ports and power supply information

Number of cable type	Type of Cable	From	To	Shielded?	Remarks - length
1	USB	Test Laptop	LulzBot Mini	Yes	6 ft. Tripp Lite model: U023-006 – ferrites on both ends

Power supply location	Manufacturer	Model	Serial number	Shielded	Remarks
Internal AC supply	Delta Electronics, Inc.	PMC-24V150W1AA	P241501AA3L140818691	Shielded enclosure	TUV Rheinland Certified – Output; 24V 6.25A

1.2.2 Operation modes

During preliminary testing for emissions it was determined that the following configurations are worst case for emissions and immunity. All further testing was done in these modes.

The system is operating in a typical mode as used by the end user.

The 3D Printer was tested while printing a 3D “Rocktopuss”. The printer was connected to a laptop through the usb port on the printer. The software was installed on the laptop by Aleph Objects and represents typical software currently used by the end user.

The LulzBot Mini – 3D Printer

https://www.lulzbot.com/blog/lulzbot-mini-3d-printer

2 Emissions

The EUT (equipment under test) has been tested to determine conformity with the relevant emissions parts of the EN 55022:2010 standard.

AC Power line conducted and radiated field strength measurements concerning the emission of radiated and conducted electromagnetic disturbances were made.

Harmonic currents at the AC mains connection terminals of the EUT were measured in conformance with and according to EN 61000-3-2.

Voltage fluctuations and flicker at the AC mains connection terminals of the EUT were measured in conformance with and according to EN 61000-3-3.

2.1 AC Mains Power Input Ports

The disturbance voltage emissions levels at the AC mains power port of the EUT were measured in conformity with and according to the criteria as stated below.

Basic standard	:	CISPR 22:2008
Test setup	:	EN 55022:2010
Frequency range 1	:	0.15 – 0.5 MHz
Limit	:	66 dBuV quasi peak, 56 dBuV average Decreasing with the log of frequency to range 2
Frequency range 2	:	0.5 – 5 MHz
Limit	:	56 dBuV quasi peak, 46 dBuV average
Frequency range 3	:	5 – 30 MHz
Limit	:	60 dBuV quasi peak, 50 dBuV average

Results of the measurements concerning the emissions of voltage levels at the AC mains input port of the EUT.	**PASS Class B per testing at Intertek**
Name of Test Engineer: Signature: Date:	Not available – see Intertek test report
Remarks: The configuration was tested at 230VAC 50Hz. **Conducted Emission Summary:** Please see Intertek test report for conducted emissions test data.	

2.2 Enclosure

2.2.1 30-1,000 MHz

The radiated field strength levels (electric component) have been measured in conformity with and according to the criteria as stated below.

Basic standard	:	CISPR 22:2008
Test setup	:	EN 55022:2010
Limit distance	:	10 meters
Frequency range 1	:	30 -230 MHz
Limits	:	30 dBuV/m
Frequency range 2	:	230 – 1,000 MHz
Limits	:	37 dBuV/m

Results of the measurements concerning radiated electromagnetic fields (electric component) emitted by the EUT, enclosure, as a tested system	**PASS Class B per testing at Intertek**
Name of Test Engineer: Signature: Date:	See Intertek test report
Remarks: **Radiated Emissions Summary:** Please see Intertek test report for radiated emissions test data.	

2.2.2 1-6 GHz

The radiated field strength levels (electric component) have been measured in conformity with and according to the criteria as stated below.

Basic standard	:	CISPR 22:2008
Test setup	:	EN 55022:2010
Limit distance	:	3 meters
Frequency range 1	:	1-3 GHz
Limits	:	Average 50 dBuV/m, Peak 70 dBuV/m
Frequency range 2	:	3-6 GHz
Limits	:	Average 54 dBuV/m, Peak 74 dBuV/m

Results of the measurements concerning radiated electromagnetic fields (electric component) emitted by the EUT, enclosure, as a tested system	**Not applicable**
Name of Test Engineer: Signature: Date:	Dennis King  26 Jan 2015
Remarks: All clocks are below 108 MHz.	

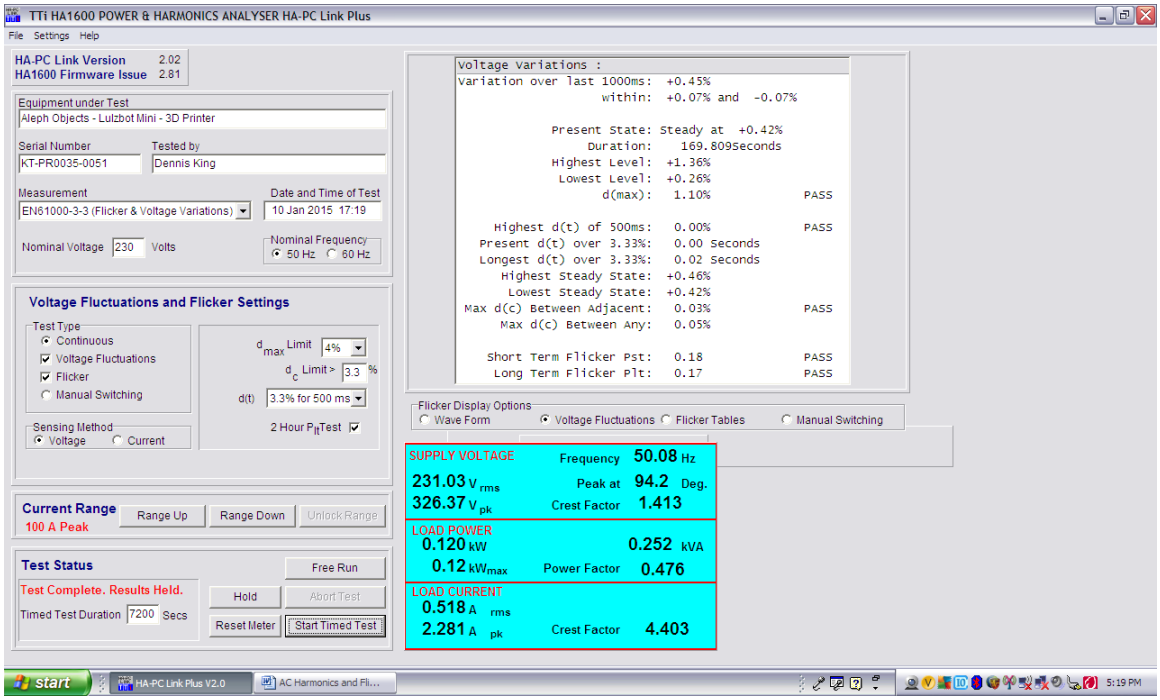
2.3 Harmonic current emissions

The emissions of harmonic currents at the AC mains connection terminals of the EUT were measured in conformance with and according to the criteria as stated below.

Basic standard : EN 61000-3-2
Test setup : EN 61000-3-2
Frequency range : 100 Hz – 2000 Hz

Results of the measurements concerning the emission of harmonic currents at the AC mains connection terminals of the EUT	**PASS**
Name of Test Engineer:	Dennis King
Signature:	
Date:	10 Jan 2015
Remarks: The unit was tested at 230VAC 50Hz. The 3D printer was printing during the entire test.	

Data – the EUT is printing



Data – the EUT is printing

```
HA-PC Link Plus. Software v2.02. Firmware v2.81
Report Number        : 50
Tested On            : 10 January 2015 14:18 for 150 Seconds.
Equipment Under Test : LulzBot Mini
Serial Number        : KT-PR0035-0051
Tested by            : Dennis King

Supply Voltage : 0.0 to 287.8 Vrms  444.4 Vpk   Frequency : 33.11 to 68.70 Hz

Load Power     : -2.66 to 222.70 W  199.3 VA Power Factor 0.466
Load Current   : 0.0 to 1066.7 Arms    0.0 to 3206.2 Apk Crest Factor: 4.465

Measurement Standard : EN61000-4-7:2002
Limits Applied       : EN61000-3-2 Class A  Limits Apply.
```

Harmonic Number	Limit Current mA	Average (filtered) mA	% Limit	max. Value (Filtered) mA	% Limit	Assessment
Fundamental :		357.6				
2 :	1080.0	60.6	5.6	90.6	8.4	Pass
3 :	2300.0	339.2	14.7	488.7	21.2	Pass
4 :	430.0	56.8	13.2	84.5	19.7	Pass
5 :	1140.0	311.5	27.3	444.5	39.0	Pass
6 :	300.0	51.0	17.0	74.8	24.9	Pass
7 :	770.0	274.0	35.6	385.1	50.0	Pass
8 :	230.0	43.7	19.0	62.9	27.3	Pass
9 :	400.0	230.0	57.5	316.1	79.0	Pass
10 :	184.0	35.8	19.5	53.2	28.9	Pass
11 :	330.0	183.9	55.7	244.9	74.2	Pass
12 :	153.3	27.9	18.2	43.8	28.6	Pass

13	:	210.0	139.3	66.3	176.9	84.2
Pass						
14	:	131.4	20.8	15.8	35.6	27.1
Pass						
15	:	150.0	99.8	66.5	118.6	79.1
Pass						
16	:	115.0	15.1	13.1	28.7	25.0
Pass						
17	:	132.3	67.8	51.2	74.8	56.5
Pass						
18	:	102.2	11.1	10.9	23.3	22.8
Pass						
19	:	118.4	44.7	37.8	47.4	40.0
Pass						
20	:	92.0	9.1	9.9	19.4	21.1
Pass						
21	:	107.1	30.1	28.1	33.8	31.6
Pass						
22	:	83.6	8.1	9.7	16.1	19.3
Pass						
23	:	97.8	21.7	22.2	27.3	27.9
Pass						
24	:	76.7	7.2	9.4	13.6	17.7
Pass						
25	:	90.0	17.3	19.2	21.2	23.6
Pass						
26	:	70.8	6.2	8.8	11.5	16.2
Pass						
27	:	83.3	15.2	18.2	18.3	22.0
Pass						
28	:	65.7	5.4	8.2	10.4	15.8
Pass						
29	:	77.6	14.3	18.4	18.3	23.6
Pass						
30	:	61.3	5.0	8.2	10.0	16.3
Pass						
31	:	72.6	14.1	19.4	17.6	24.2
Pass						
32	:	57.5	4.9	8.5	10.0	17.4
Pass						
33	:	68.2	13.3	19.5	16.5	24.2
Pass						
34	:	54.1	4.9	9.1	10.4	19.2
Pass						
35	:	64.3	11.7	18.2	15.4	24.0
Pass						

36 :	51.1	4.9	9.6	10.4	20.4	Pass
37 :	60.8	9.6	15.8	13.6	22.4	Pass
38 :	48.4	4.9	10.1	10.0	20.7	Pass
39 :	57.7	7.9	13.7	11.8	20.5	Pass
40 :	46.0	4.7	10.2	9.7	21.1	Pass
21 - 39 :	251.4	53.0	21.1	61.8	24.6	-

Test setup for AC power line harmonics

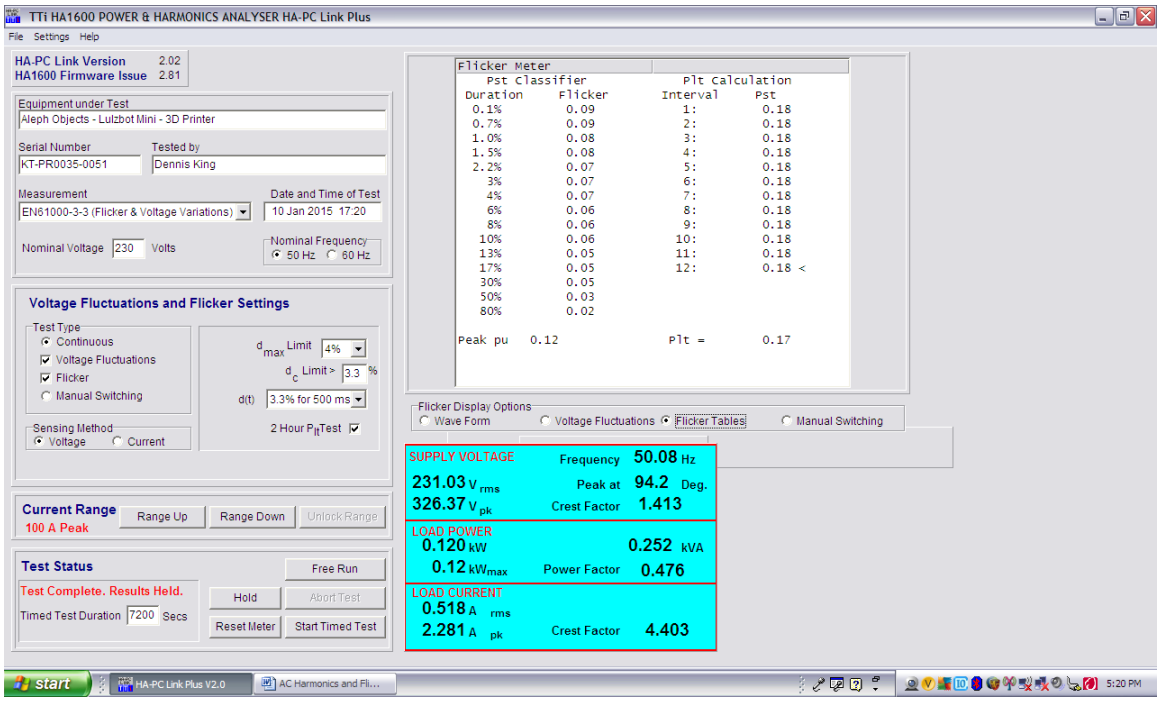
2.4 Voltage fluctuations and flicker

Voltage fluctuations and flicker at the AC mains connection terminals of the EUT were measured in conformance with and according to the criteria as stated below.

Basic standard : EN 61000-3-3
Test setup : EN 61000-3-3

Results of the measurements concerning voltage fluctuations and flicker at the AC mains connection terminals of the EUT	**PASS**
Name of Test Engineer: Signature: Date:	Dennis King  10 Jan 2015
Remarks: The unit was tested at 230VAC 50Hz. The 3D printer was printing during the entire test.	

LulzBot Mini 3D printer – data - Flicker



HA-PC Link Plus. Software v2.02. Firmware v2.81
Report Number : 51
Tested On : 10 January 2015 15:06 for 7200 Seconds.
Equipment Under Test : Aleph Objects - Lulzbot Mini - 3D Printer
Serial Number : KT-PR0035-0051
Tested by : Dennis King
Supply Voltage : 231.1 Vrms 328.4 Vpk Frequency : 50.07 to 50.19 Hz
Load Current : 0.5 to 1.4 Arms 2.4 to 5.9 Apk Crest Factor: 4.540

Test Method: EN61000-3-3:2008

Voltage Variations :

Highest Level: +1.36%
Lowest Level: +0.26%
d(max): 1.10% PASS

Highest d(t) of 500ms: 0.00% PASS
Present d(t) over 3.33%: 0.00 Seconds
Longest d(t) over 3.33%: 0.02 Seconds
Highest Steady State: +0.46%
Lowest Steady State: +0.42%
Max d(c) Between Adjacent: 0.03% PASS
Max d(c) Between Any: 0.05%

Short Term Flicker Pst: 0.18 PASS
Long Term Flicker Plt: 0.17 PASS

Flicker Results :

Pst Classifier		Plt Calculation	
Duration	Flicker	Interval	Pst
0.1%	0.09		
0.7%	0.09	1:	0.18
1.0%	0.08	2:	0.18
1.5%	0.08	3:	0.18
2.2%	0.07	4:	0.18
3%	0.07	5:	0.18
4%	0.07	6:	0.18
6%	0.06	7:	0.18
8%	0.06	8:	0.18
10%	0.06	9:	0.18
13%	0.05	10:	0.18
17%	0.05	11:	0.18
30%	0.05	12:	0.18
50%	0.03	Plt =	0.17
80%	0.02		

Test setup for Voltage fluctuations and flicker EN 61000-3-3

3 Immunity

The EUT has been tested in conformity with parts of the standard EN 55024:2010 (immunity) concerning susceptibility and transient, conducted and radiated disturbances including electrostatic discharges.

3.1 Performance criteria

The general principles (performance criteria) for the evaluation of the immunity test results are given below. The details are in EN 55024:2010

Performance Criterion A: The apparatus shall continue to operate as intended during the test. No degradation of performance or loss of function is allowed below a performance level (or permissible loss of performance) specified by the manufacturer, when the apparatus is used as intended.

Performance Criterion B: The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level (or permissible loss of function) specified by the manufacturer, when the apparatus is used as intended. During the test, degradation of performance is allowed, however, no change of actual operating state or stored data is allowed.

Performance Criterion C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls, or by any operation specified in the instructions for use.

3.2 Enclosure Port

3.2.1 Radio-frequency electromagnetic field. Amplitude modulated.

The susceptibility of the EUT to radio-frequency electromagnetic fields has been tested in conformity with and according to the criteria as stated below.

Basic standard	:	EN55024:2010
Test setup	:	EN61000-4-3
Frequency range	:	80 MHz to 1000 MHz
Field strength level	:	3 V/m (selected w/o modulation, applied w/mod.)
Modulation	:	1 kHz AM modulation, 80% depth
Performance criteria	:	Criteria A

Results of the measurements concerning the susceptibility of the EUT to radio-frequency electromagnetic fields	**PASS Criteria A**
Name of Test Engineer:	Dennis King
Signature:	
Date:	8 Jan 2015

Remarks:
No loss of performance was observed during and after the test, all sides and both antenna polarizations meet Performance Criteria A.
Radiated Immunity Summary:
Configuration **:The printer was printing during the entire test: PASS 3 V/M**

Radiated immunity test setup – 80-1,000 MHz

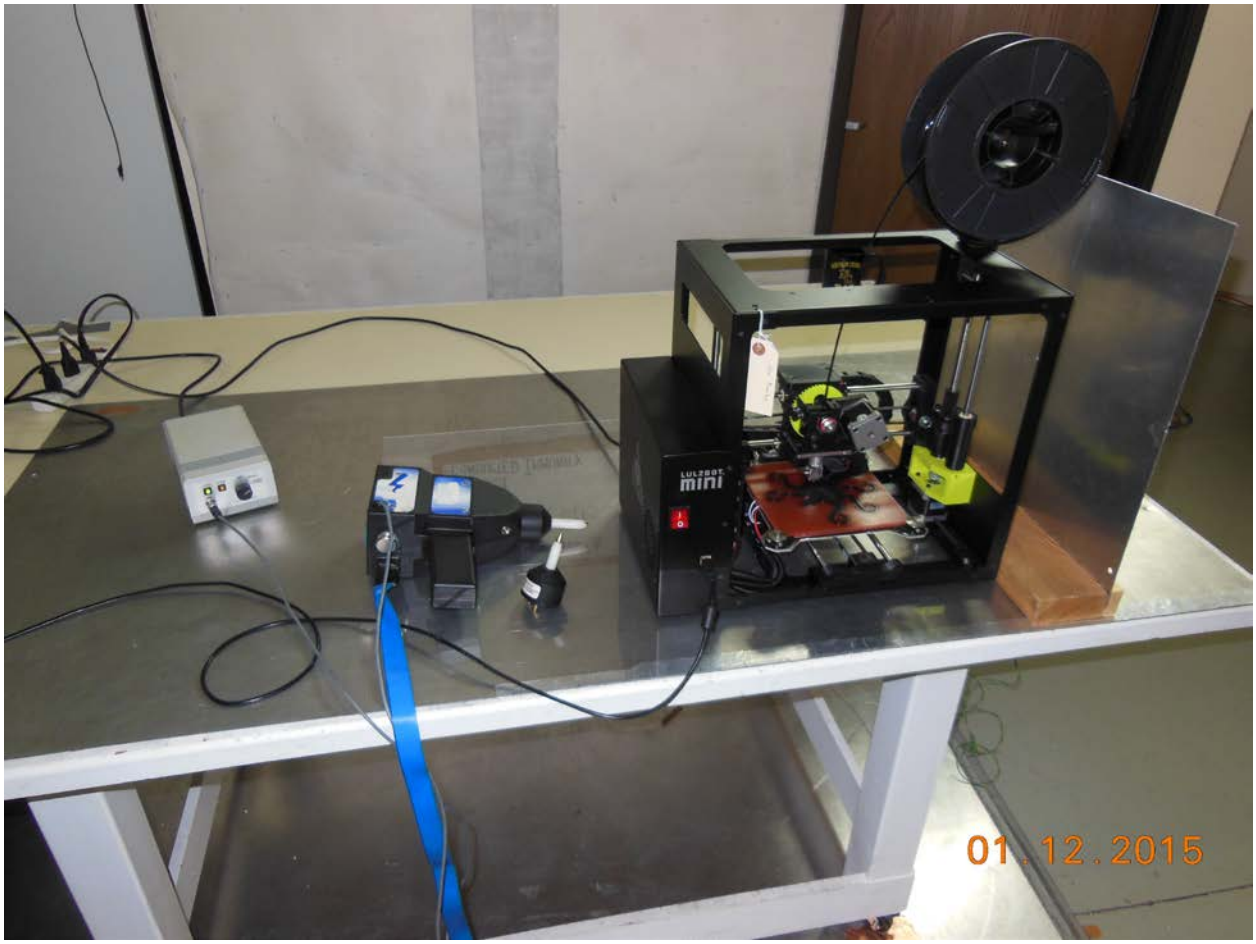
All 4 sides, Vertical and Horizontal were checked at 3 V/M
No errors were detected - passing Criteria A.

3.2.2 Electrostatic discharge

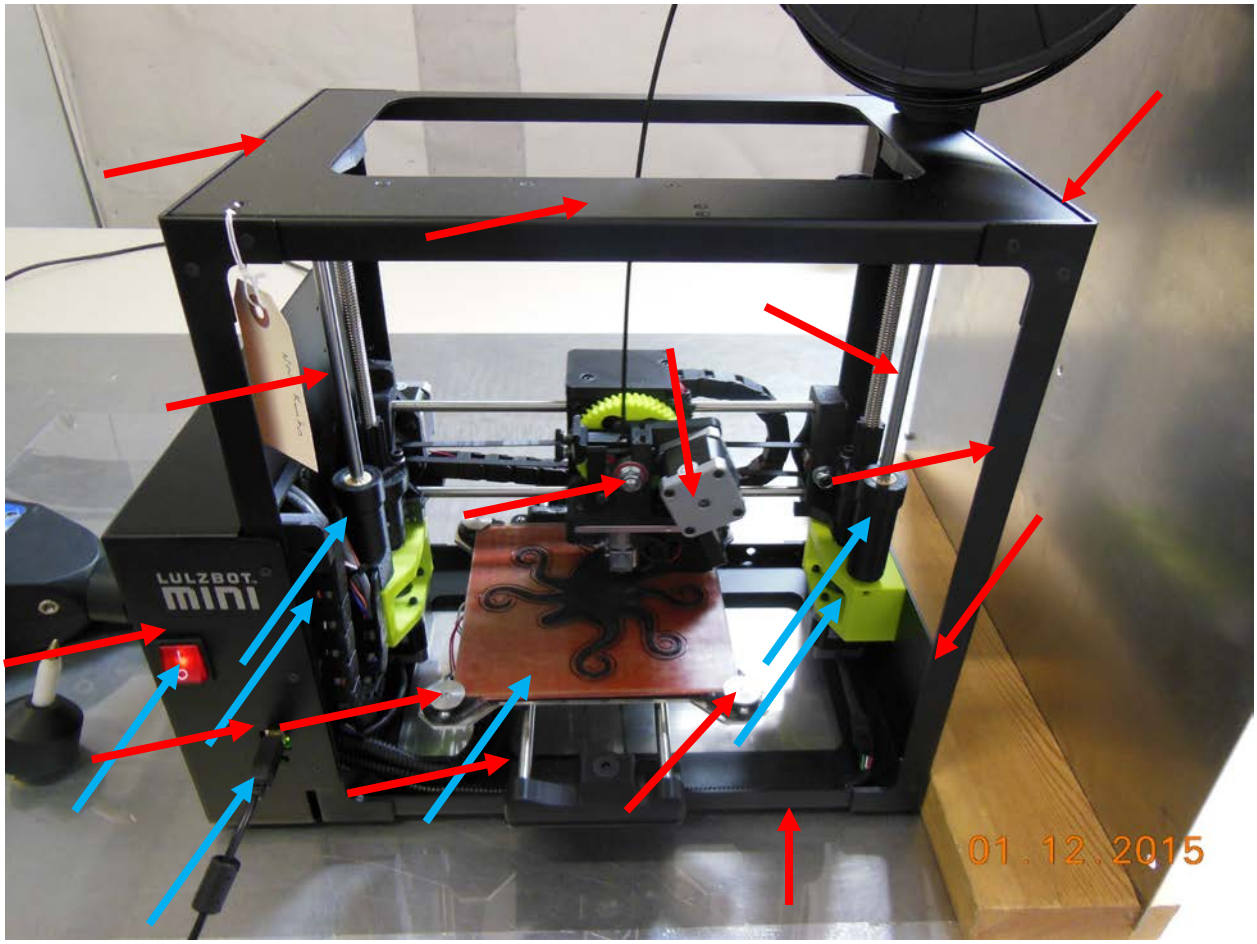
The susceptibility of the EUT to electrostatic discharge was tested.

Basic standard	:	EN 55024:2010
Test setup	:	EN 61000-4-2
Test levels	:	+- 2,4kV and +- 8 kV air discharge +- 2kV and +- 4 kV contact discharge +- 2kV and +- 4 kV, indirect, horizontal and vertical coupling plane.
Performance criteria	:	B

Results of the test concerning the susceptibility of the EUT to electrostatic discharges (enclosure port)	**Pass Criteria A**
Name of Test Engineer: Signature: Date:	Dennis King  12 Jan 2015
Remarks: The printer continued to function as intended during the testing with no loss of data or function.	



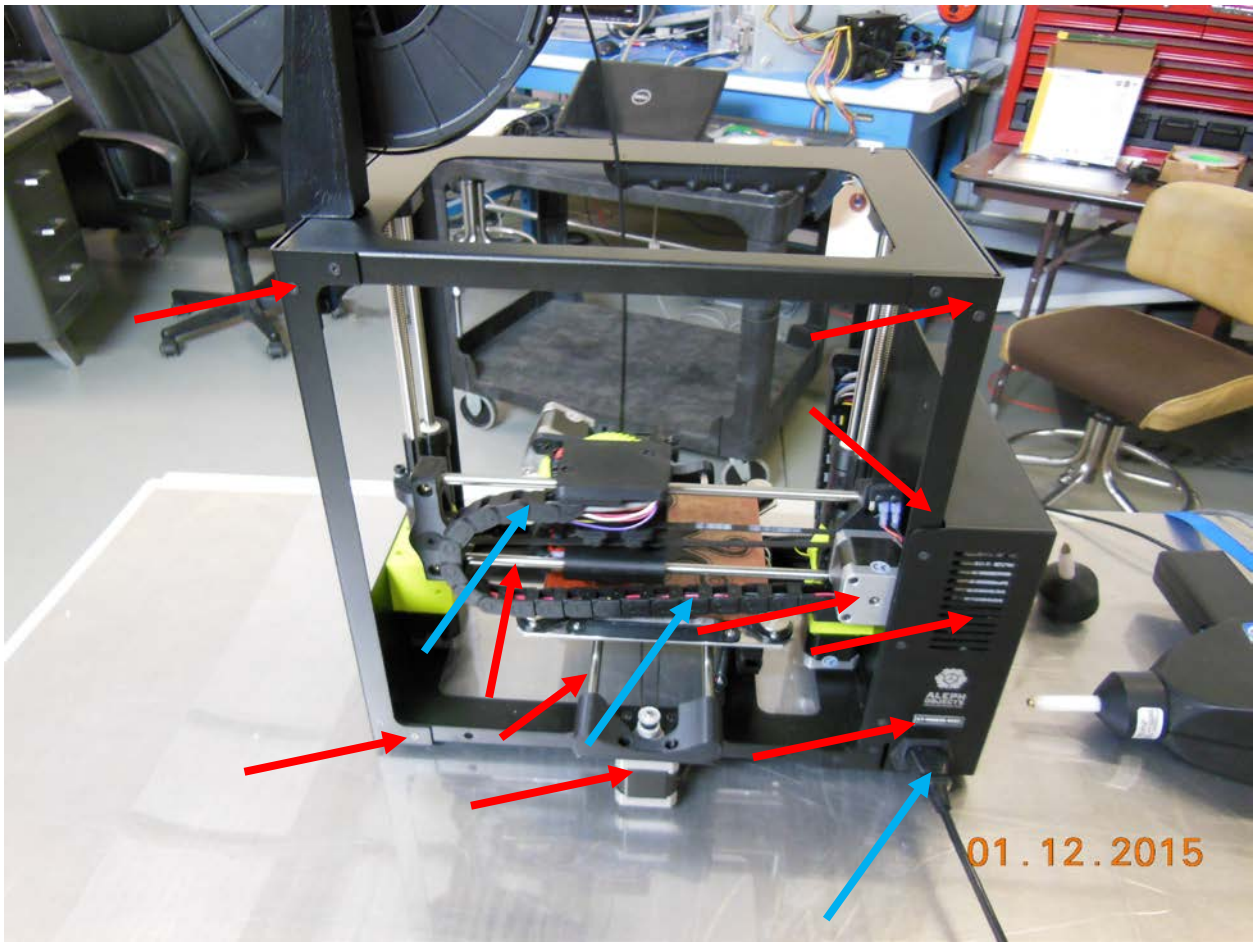
ESD test setup per EN 61000-4-2
Horizontal and Vertical coupling planes were checked



ESD Test Setup per EN 61000-4-2:2009

Blue arrows are places that were checked for Air Discharge
Red arrows are places that were checked for Contact Discharge

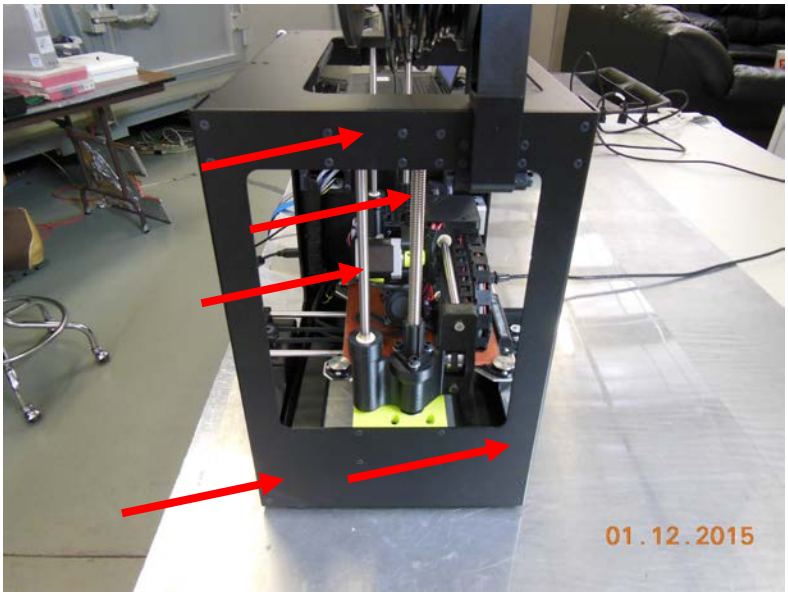
All metal parts that the user might touch were tested for contact discharge. All plastic areas that the user might touch were tested for air discharge.

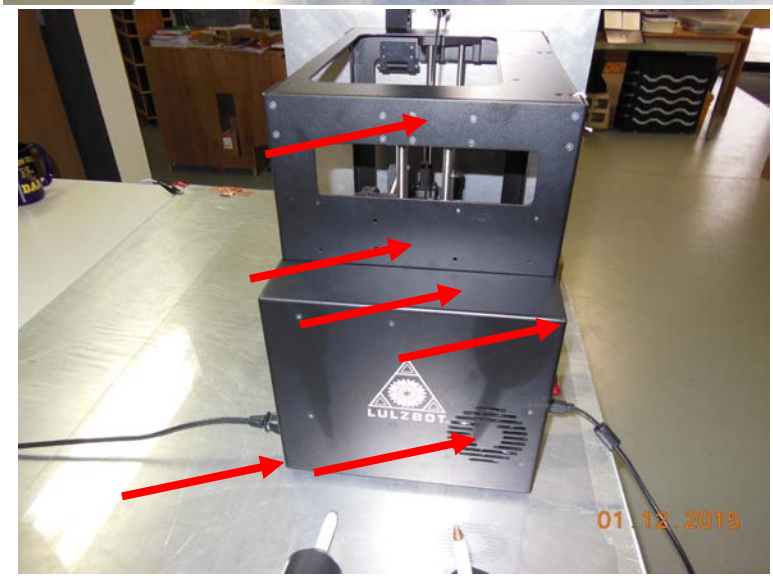


ESD Test Setup per EN 61000-4-2:2009

Blue arrows are places that were checked for Air Discharge
Red arrows are places that were checked for Contact Discharge

All metal parts that the user might touch were tested for contact discharge. All plastic areas that the user might touch were tested for air discharge.





ESD Test Setup per EN 61000-4-2:2009

Blue arrows are places that were checked for Air Discharge
Red arrows are places that were checked for Contact Discharge

Signal ports including telecommunication ports

3.2.3 Radio-frequency (common mode). Amplitude modulated

The susceptibility of the EUT to radio-frequency (common mode, amplitude modulated) signals to be tested in conformity with and according to the criteria as stated below

Basic Standard	:	EN 55024:2010
Test setup	:	EN 61000-4-6
Frequency range	:	0.15 – 80 MHz
Test level	:	3 Vrms
Modulation	:	1 kHz AM to a depth of 80%
Source impedance	:	150 Ohms
Performance criteria	:	Criteria A

Note: Conducted only on ports interfacing with cables whose total length, according to the manufacturer's functional specification, may exceed 3 meters.

Results of the test concerning the susceptibility of the EUT to radio-frequency signals (common mode, AM modulated applied to signal and telecom ports)	**Not Applicable**
Name of Test Engineer: Signature: Date:	Dennis King  26 January 2015
Remarks: There are no interconnecting cables on the unit that exceed 3 meters. See the test plan.	

3.2.4 Fast Transients

The susceptibility of the EUT to fast transients has been tested in conformity with and according to the criteria as stated below.

Basic standard	:	EN 55024:2010
Test setup	:	EN 61000-4-4
Test level	:	+- 0.5 KV
Tr/Th	:	5/50 nSec
Repetition frequency	:	5 kHz
Performance criteria	:	Criteria B

Note: Conducted only on ports interfacing with cables whose total length, according to the manufacturer's functional specification, may exceed 3 meters.

Results of the test concerning the susceptibility of the EUT to fast transients	**Not Applicable**
Name of Test Engineer:	Dennis King
Signature:	
Date:	26 January 2015
Remarks: There are no interconnecting cables on the unit that exceed 3 meters. See the test plan.	

3.3 AC input and AC output power ports

3.3.1 Radio-frequency (common mode, amplitude modulated)

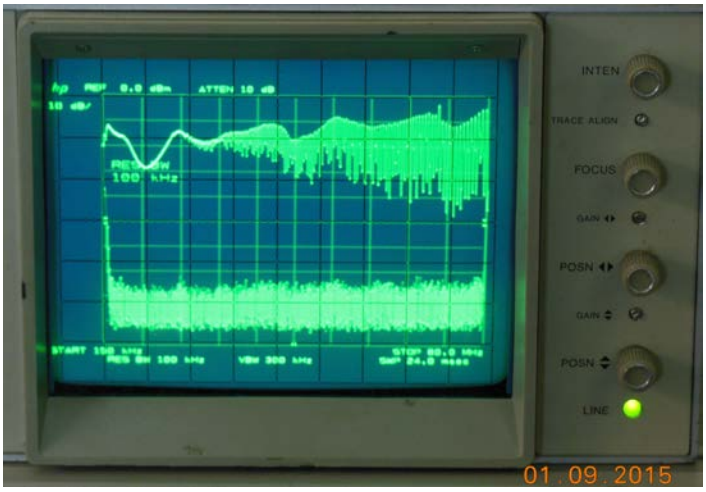
The susceptibility of the EUT to radio-frequency signals (common mode, amplitude modulated, has been tested in conformity with and according to the criteria as stated below.

Basic standard	:	EN 55024:2010
Test setup	:	EN61000-4-6
Frequency range	:	0.15 – 80 MHz
Test level	:	3 Vrms
Source impedance	:	150 Ohms
Performance criteria	:	Criteria A

Results of the test concerning the susceptibility of the EUT to radio-frequency signals (common mode, amplitude modulated) – AC input and AC output power ports	**Pass Criteria A – 3 Vrms**
Name of Test Engineer: Signature: Date:	Dennis King  9 January 2015
Remarks: Tested at 230 VAC 50 Hz – the EUT continued to operate as intended with no loss of data or function. **The Mini passed Criteria A, 3 Vrms** **PASS**	

AC power line conducted immunity setup per EN 61000-4-6
The injected signal is monitored with the current clamp

The spectrum analyzer display is recorded below



3.3.2 Surges

The susceptibility of the EUT to surges has been tested in conformity with and according to the criteria as stated below

Basic Standard	:	EN 55024:2010
Test setup	:	EN 61000-4-5
Test level 1	:	+- 0.5 kV, +- 1.0 kV, Differential mode
Test level 2	:	+- 0.5 kV, +- 1.0 kV, +- 2 kV Common Mode
Tr/Th	:	1.2/50(8/20) micro Seconds
Number of pulses		
Per phase angle/voltage	:	5
Performance criteria	:	Criteria B
Note	:	***Applicable only to input AC ports***

Results of the test concerning the susceptibility of the EUT to surges (AC input and AC output power ports	**Pass Criteria A**
Name of Test Engineer:	Dennis King
Signature:	
Date:	9 Jan 2015
Remarks: Tested at the highest voltage levels since this is a confirmation of the original passing data from the power supply manufacturer. **PASS**	

Surge Test Data

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Aleph objects 09 January 2015

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REMOTE/TESTER RUN
Versions: SW v3.00 FW v3.01 Str v3.00 CEMASTER
Operator: Uriah Higgins
Sequence File: CISPR 24 - ITE Equipment - 1kV Diff 2kV CM.SEQ
EUT: Lulzbot Mini

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230 VAC
Printing Rocktopuss

11:13:05A SEQUENCE START

SEQUENCE	TYPE	SEQUENCE DESCRIPTION					
Srg 1.2/50	User Defined	EN 61000-4-5 Surge - Diff 1kV - CM 2kV					
	Waveform	Voltage	Output:LC	Phs Ref	Phs Ang	Tests	Delay
11:13:05A	2 Ohm	1000V	MAINS:L1/L2	L1	0 deg.	5	60 sec.
11:18:11A	2 Ohm	1000V	MAINS:L1/L2	L1	90 deg.	5	60 sec.
11:23:16A	2 Ohm	1000V	MAINS:L1/L2	L1	270 deg.	5	60 sec.
11:28:22A	2 Ohm	-1000V	MAINS:L1/L2	L1	0 deg.	5	60 sec.
11:33:27A	2 Ohm	-1000V	MAINS:L1/L2	L1	90 deg.	5	60 sec.
11:38:33A	2 Ohm	-1000V	MAINS:L1/L2	L1	270 deg.	5	60 sec.
11:43:38A	12 Ohm	2000V	MAINS:L1/PE	L1	0 deg.	5	60 sec.
11:48:44A	12 Ohm	2000V	MAINS:L1/PE	L1	90 deg.	5	60 sec.
11:53:50A	12 Ohm	2000V	MAINS:L1/PE	L1	270 deg.	5	60 sec.
11:58:56A	12 Ohm	-2000V	MAINS:L1/PE	L1	0 deg.	5	60 sec.
12:04:02P	12 Ohm	-2000V	MAINS:L2/PE	L1	90 deg.	5	60 sec.
12:09:08P	12 Ohm	-2000V	MAINS:L2/PE	L1	270 deg.	5	60 sec.

12:14:14P SEQUENCE COMPLETE

Equipment continued to function as intended.

Test setup according to EN 61000-4-5, Surge

3.2.4 Fast Transients

The susceptibility of the EUT to fast transients (common mode) has been tested in conformity with and according to the criteria as stated below.

Basic standard	:	IEC/EN 60601-1-2:2007
Test setup	:	EN 61000-4-4
Test level	:	+- 1 KV
Tr/Th	:	5/50 nSec
Repetition frequency	:	5 kHz
Performance criteria	:	Criteria B
Note	:	***Conducted on the AC input.***

Results of the test concerning the susceptibility of the EUT to fast transients (common mode, AC input and AC output ports)	**Pass Criteria A**
Name of Test Engineer: Signature: Date:	Dennis King  9 Jan 2015
Remarks: Tested at 230 VAC 50 Hz while printing. The unit continued to function as intended.	

Test Data

KeyTek Instrument Co. ECAT Log File
Software:E400 Burstware V4.15 (c)1996
Firmware:: 5.11.v
Modules:
Row 1 Right:E412 SN:-32612
Test Started at 14:22.00 on JAN 9,2015
Test File:C:\KEYTEK\ECAT\EFT\ITE_1KV.EFT
Operator :Uriah Higgins
EUT:Aleph Objects Lulzbot Mini
Comments: 230 VAC
Coupling:Coupler:AC
Coupling:All
Voltage:Fixed 1000 V
Polarity:Alternate 1 each
Units:mSec
Frequency:Fixed 5000 Hz
Period:Fixed 300 ms
Phase:Fixed 0 dg
Duration:Fixed 15 mS
Repeat:0
E400:Wait time 10 Seconds
E400:Duration time 2 Minutes
E400:EUT power:ON
E400:Phase Mode Period
E400:Order:Repeat,Polarity,Coupling

Time	Action	Volts(V)		Freq		Dur.		Period	Phase	Source	
At	Cpl										
14:22.03:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1
14:22.08:	14:22.08:	Burst	1000	5000	Hz	15	mS	300	RND	E412	
14:24.19:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2
14:26.19:	EFT Step Ended										
14:26.29:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1,PE
14:28.29:	EFT Step Ended										
14:28.39:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	
L1,L2,PE											
14:30.39:	EFT Step Ended										
14:30.49:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L2

14:32.49:	EFT Step Ended									
14:32.59:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L2,PE
14:34.59:	EFT Step Ended									
14:35.09:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	PE
14:37.09:	EFT Step Ended									
14:37.19:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1
14:39.19:	EFT Step Ended									
14:39.29:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2
14:41.29:	EFT Step Ended									
14:41.39:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1,PE
14:43.39:	EFT Step Ended									
14:43.49:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	
L1,L2,PE										
14:45.49:	EFT Step Ended									
14:45.59:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L2
14:47.59:	EFT Step Ended									
14:48.09:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L2,PE
14:50.09:	EFT Step Ended									
14:50.19:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	PE
14:52.19:	EFT Step Ended									
14:52.19:	Test Complete									
14:52.19:	Log Closed									

Test Setup per EN 61000-4-4

3.3.4 Voltage Dips and Interruptions

The susceptibility of the EUT to voltage dips and interruptions has been tested in conformity with and according to the criteria as stated below.

Basic Standard	:	EN 55024:2010
Test setup	:	EN61000-4-11
Test level (a)	:	Line at <5% of nominal for 0 .5 cycles
Test level (b)	:	Line at 70% of nominal for 25 cycles
Test level (c)	:	Line at <5% of nominal for 250 cycles

Results of the test concerning the susceptibility of the EUT to voltage dips and interruptions – AC input and AC output ports	**Pass**
Name of Test Engineer: Signature: Date:	Dennis King  9 Jan 2015
Remarks: Tested at 230 VAC 50 Hz while printing. The unit continued to function as intended.	

Test Data

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Aleph objects 09 January 2015

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REMOTE/TESTER RUN
Versions: SW v3.00 FW v3.01 Str v3.00 CEMASTER
Operator: Uriah Higgins
Sequence File: ITE AC Dips EN 61000-4-11.SEQ
EUT: Lulzbot Mini

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230 VAC - making a Rocktopuss

12:56:27P SEQUENCE START

SEQUENCE	TYPE	SEQUENCE DESCRIPTION
PQF	User Defined	ITE Equipment

	Test Level	Phs Ang	Dur. Value	Duration	Tests	Delay
12:56:27P	0% Open	0 deg.	0.50	cyc	3	10 sec.
12:57:03P	0% Open	90 deg.	0.50	cyc	3	10 sec.
12:57:38P	0% Open	180 deg.	0.50	cyc	3	10 sec.
12:58:13P	0% Open	270 deg.	0.50	cyc	3	10 sec.
12:58:48P	70% Dip	0 deg.	25.00	cyc	3	10 sec.
12:59:25P	70% Dip	90 deg.	25.00	cyc	3	10 sec.
01:00:01P	70% Dip	180 deg.	25.00	cyc	3	10 sec.
01:00:37P	70% Dip	270 deg.	25.00	cyc	3	10 sec.
01:01:13P	0% Open	0 deg.	250.00	cyc	3	10 sec.
01:02:01P	0% Open	180 deg.	250.00	cyc	3	10 sec.

01:02:48P SEQUENCE COMPLETE

Test setup according to EN 61000-4-11

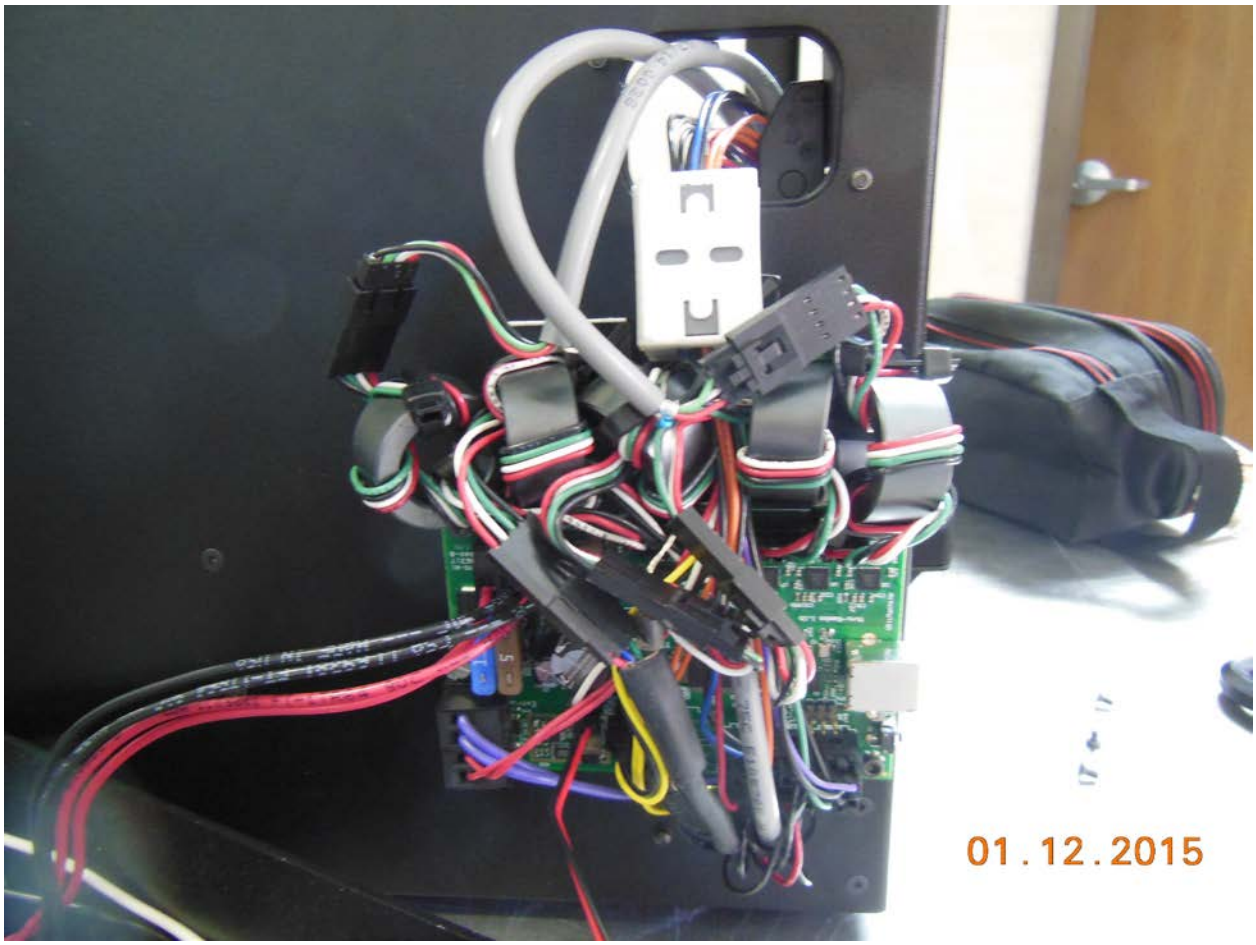
3.3.5 Power Frequency Magnetic Fields

The susceptibility of the EUT to power frequency magnetic fields has been tested in conformity with and according to the criteria as stated below.

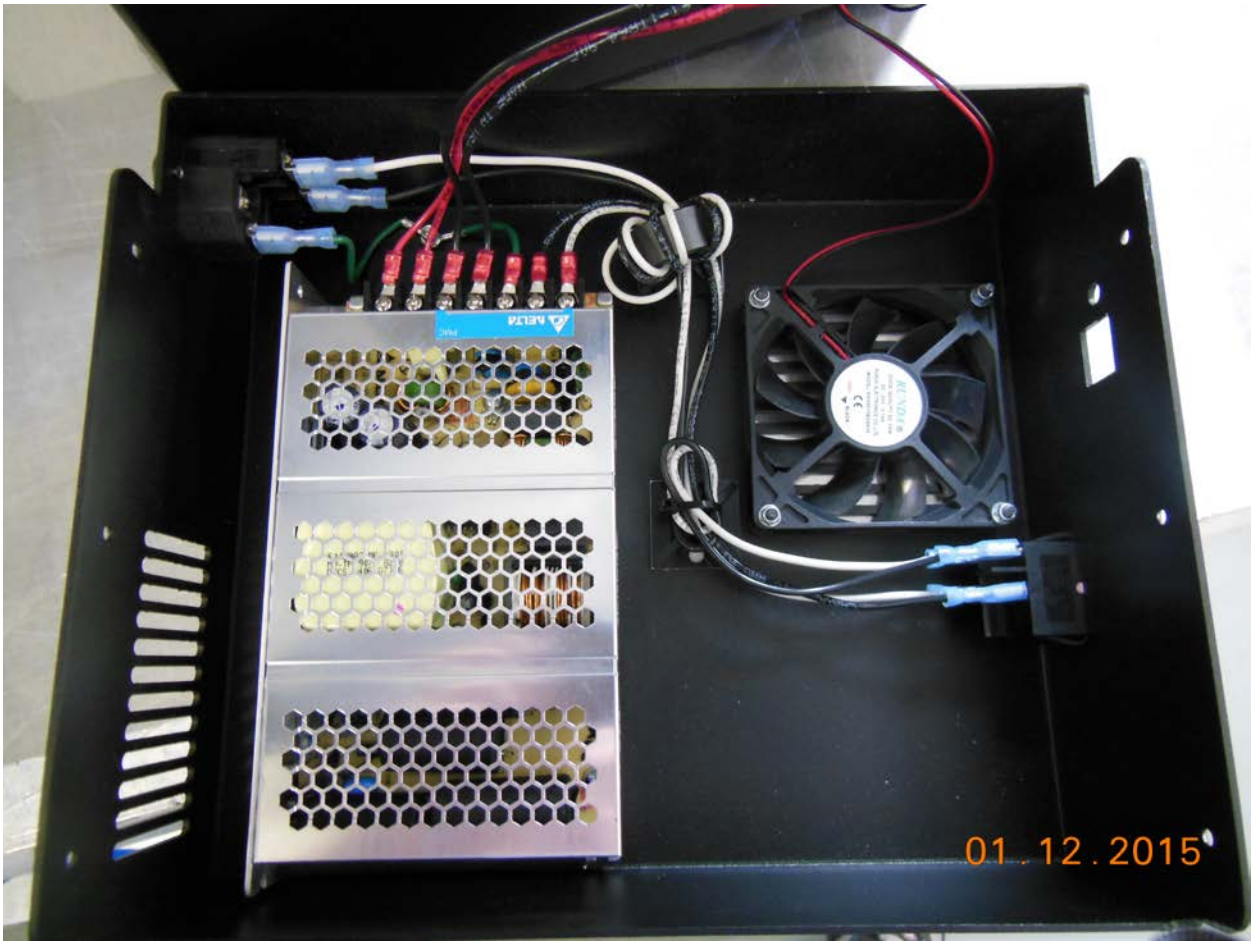
Basic Standard	:	EN 55024:2010
Test setup	:	EN61000-4-8
Test level	:	1 Amp per meter, X,Y and Z axis

Results of the test concerning the susceptibility of the EUT to	**Not Applicable**
Name of Test Engineer:	Dennis King
Signature:	
Date:	27 January 2015
Remarks: There are no magnetically sensitive components in this product.	

4.0 Modifications



Ferrites were added to all the wiring as shown in the above picture.



A ferrite was also added to Line and Neutral of the incoming AC power wiring as shown above.

5.0 Test equipment and Environmental Conditions

All tests were conducted within parameters specified for each test, for example >30% humidity for ESD.
The lab temperature during all testing was between 72-74 degrees F.
All equipment used for testing has been calibrated or verified for cal using NIST traceable standards.
Each piece of test equipment has a cal verification procedure that is conducted before and after each test.

Table of Test Equipment

Equipment	Description and Test	Model number	Serial number	Next cal due
HP Spectrum Analyzer	Used for Radiated and Conducted Emissions	8566B	2607A02760	3 June 2015
HP Quasi-Peak Adapter	Used for Radiated and Conducted Emissions	85650A	8574A00233	3 June 2015
Advantest Spectrum Analyzer	Used for Radiated and Conducted Emissions	R3361A	01730556	20 October 2015
Com-Power transient Limiter	Conducted Emissions	HZ560	001	3 June 2015
Miteq Pre-Amp	Radiated Emissions	1381	544407	20 October 2015
RF Bay Pre-Amp	Radiated emissions – 100kHz to 10 GHz	LPA-10-20	0643	2 Dec 2015
GTEM	Radiated Emissions and Radiated Immunity	5317	9703-1209	26 April 2015 – Field Uniformity Cal per IEC 61000-4-20
3 Meter FAR – Fully Anechoic Room	Radiated Immunity and Emissions	N/A	FAR #1	15 October 2015 Field Uniformity per IEC/EN 61000-4-3 and Correlation data to GTEM
ComPower Horn Antenna	1-18 GHz – Radiated Immunity and Emissions	AH 118	071040	20 March 2016
Chase BiLog Antenna	Radiated Emissions and Immunity	CBL6111	1121	20 March 2016
Marconi Instruments – Signal Generator 10kHz – 2.7 GHz	Radiated Immunity	2031	1196061031	20 October 2015

HP Signal Generator	Radiated Immunity	8657A	STD0578	3 May 2015
HP Synthesized Sweep Generator .01-20 GHz	Radiated Immunity 1 GHz to 2.7 GHz	83752B	34462	3 May 2015
Amplifier Research .800 – 4.2 GHz Amp	Radiated Immunity – 1 GHz to 2.7 GHz	10S1G4	34516	4 May 2015
Antenna Research Associates – 100 Watt amplifier w/controller	Radiated Immunity – 80-1000 MHz in the FAR	ARAPS/PC757LC ARA757LC-CE	587V7 587V7	20 October 2015
Kalmus Power Amplifier	Radiated Immunity 150kHz – 1 GHz – in the GTEM	747LC-CE	7894-1	10 May 2015
Amplifier Research E- Field Probe	Radiated Immunity	FP 2000	12845	10 May 2015
Com-Power LISN	Conducted emissions	LI-115	241010	17 May 2015
Com-Power LISN	Conducted emissions	LI-115	241011	11 September 2015
California Instruments 1000 VA Power Source	Emissions and Immunity - used as a 100/120/230/240-VAC 50/60 Hz AC source	1001WP	L04788	4 June 2015
EMI Labs CDN	Conducted Immunity	EMICDN	001	9 Dec 2015
Schaffner ESD Gun	Electro Static Discharge	NSG435	54711	11 Dec 2015
KeyTek ECAT	Fast transients / Burst	E412	32612	5 June 2015
FCC Inc. RF Current Probe	Monitor Conducted Immunity signal	F-33-1	423	9 Dec 2015
EMI Labs Mag Loop	Magnetic Loop Antenna	Mag100	80162	12 Dec 2015
Thermo Keytek CE Master	Surge/ AC Dips and Interrupts	CE Master	0405277	15 Dec 2015

6.0 *Measurement Uncertainty* - Radiated Emissions example;

Table of Uncertainty Calculation					
√	Contribution	Designation	Probability Distribution	k	Uncertainty (dB)
	Equipment Under Test Uncertainties	U_{EUT}			Note 1
√	Measuring Receiver Amplitude Accuracy	$U_{RXaccuracy}$	rectangular	$\sqrt{3}$	± 0.9
√	GTEM Uniformity	$U_{Uniformity}$	rectangular	$\sqrt{3}$	± 4.0
√	Secondary Field Components	$U_{Secondary}$			Excluded by Test Method
√	Mismatch Uncertainty-GTEM to Pre-Amplifier	$U_{Mismatch}$	U-shaped	$\sqrt{2}$	+0.63 and -0.65
√	Mismatch Uncertainty-Pre-Amplifier to Spectrum Analyzer	$U_{Mismatch}$	U-shaped	$\sqrt{2}$	+0.92 and -1.03
√	System Sensitivity Error	$U_{Sensitivity}$	rectangular	$\sqrt{3}$	0.28
√	GTEM Electric-Field Frequency Response	$U_{E-Field}$	rectangular	$\sqrt{3}$	± 1.6
	Ambient Signal Uncertainty	U_{Abient}			Not Significant
√	GTEM to OATS Correlation	U_{Corr}	rectangular	$\sqrt{3}$	±1.2
√	Septum Height Variation	U_{Septum}	normal	2	+0.72 and -0.82
	Coaxial Cable Temperature Variations	$U_{CableTemperature}$			Not Significant
√	Coaxial Cable Calibration	$U_{CableCalibration}$	rectangular	$\sqrt{3}$	±0.05
√	Pre-amplifier Calibration Uncertainty	$U_{Pre-Amp}$	rectangular	$\sqrt{3}$	±0.05
	Combined Uncertainty(dB) Positive Terms				2.77
	Combined Uncertainty(dB) Negative Terms				-2.75
	Expanded Uncertainty Positive Terms		Normal	2	5.54
	Expanded Uncertainty Negative Terms		Normal	2	-5.50

Typical Measurement Uncertainty for the following Tests:

The estimated combined standard uncertainty for ESD testing, EN 61000-4-2 is ± 4%
The estimated combined standard uncertainty for Radiated Immunity, EN 61000-4-3 is ± 2.7dB
The estimated combined standard uncertainty for EFT/Burst, EN 61000-4-4 is ± 5.8%
The estimated combined standard uncertainty for Surge, EN 61000-4-5 is ± 8%
The estimated combined standard uncertainty for Conducted Immunity, EN 61000-4-6 is ± 1.5 dB
The estimated combined standard uncertainty for Magnetic Fields, EN 61000-4-8 is ± 0.6%
The estimated combined standard uncertainty for Voltage Dips and Interrupts, EN 61000-4-11 is ± 4.3%
The estimated combined standard uncertainty for Conducted Emissions, CISPR 11 is ± 1.2dB
The estimated combined standard uncertainty for Harmonic current and flicker is ± 11.6%

7.0 Test Plan

Testing required

The LulzBot Mini 3D Printer will be tested for AC Harmonics and Flicker and all applicable Immunity tests per EN 55024 for immunity as required for the EMC portion of the CE Mark.

The radiated and conducted emissions tests were done by Intertek. The test results showed that the LulzBot Mini passes Class B radiated and conducted emissions. The same unit that passed at Intertek is being used for this testing to show Immunity compliance with regards to the CE Mark.

Test Setup

The LulzBot Mini will be operating in a typical use mode, printing an object during all the testing. The user software is installed on a laptop and is controlling the 3D printer. There are no other I/O cables on the 3D Printer.

The ferrites that were used to pass radiated emissions will be in place during all the testing. Also, the USB cable with ferrites on both ends, used to pass radiated emissions, will be used during the entire test. Typical software that the end user would use will be used during the testing.

Failure Criteria

If the unit stops working or the printing process is altered by the injected noise, this would be considered a failure.

I/O cables

The unit has only one I/O cable, the USB cable that is used to control the printer from software installed on the host computer. There are no I/O cables on the unit 3 meters or longer.

Status of the test unit

Production level.

8.0 Conclusion

The Aleph Objects – LulzBot Mini 3D Printer
complies with the emissions standard EN 55022:2010
and the immunity standard EN 55024:2010
in the configurations and operating modes as stated in this test report.

End of Report