Electro Magnetic Compatibility Test Report

Regarding the CE Mark Compliance of the

Aleph Objects – LulzBot TAZ 5 – 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	23 February 2015	Initial Release

Description of Equipment Under Test (EUT)

Test Item	:	LulzBot TAZ 5 – 3D Printer
Manufacturer	:	Aleph Objects, Inc.
Receipt date	:	28 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	:	4 Feb 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	:	23 February 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 TAZ 5 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

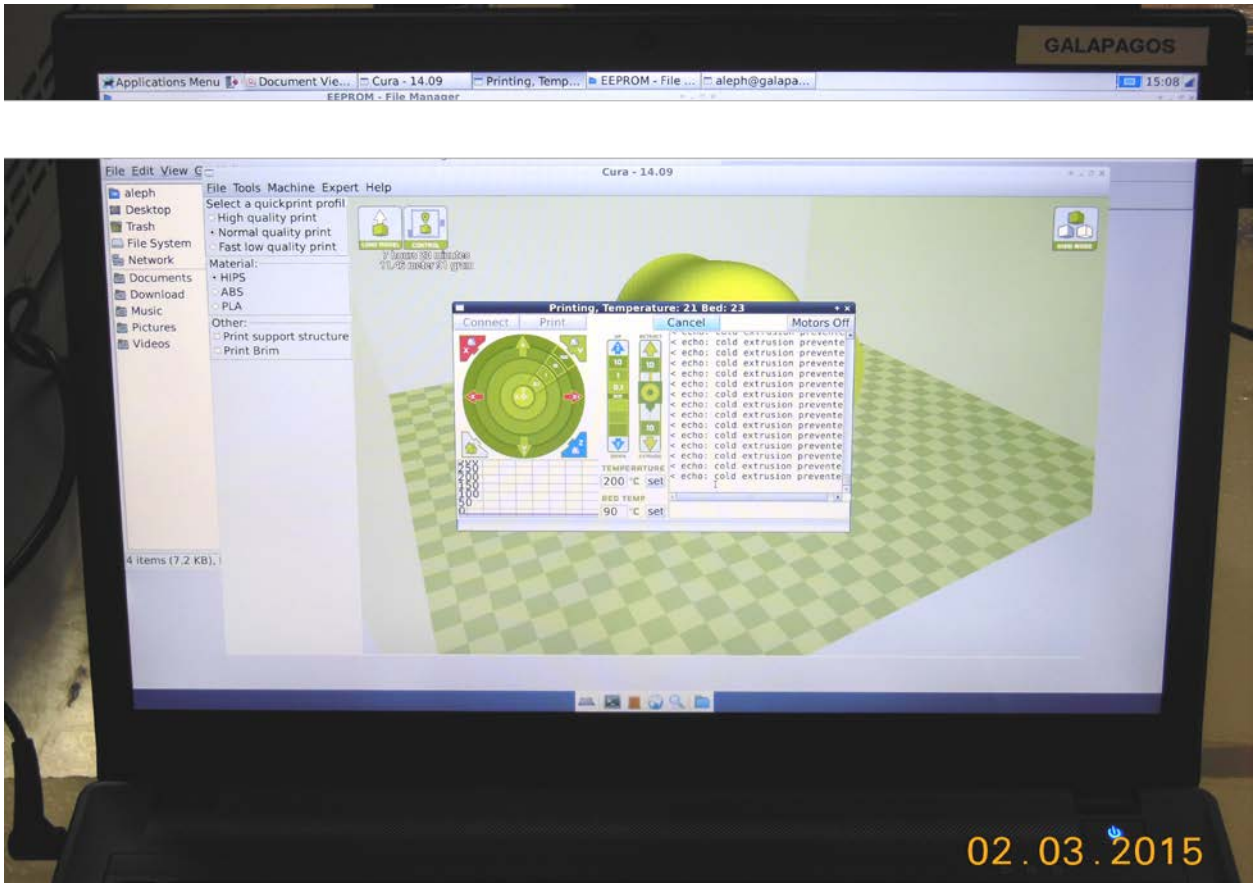
The 3D Printer was tested while printing a 3D "Rocktopuss". The printer was connected to a laptop through the usb port on the printer. The software was installed on the laptop by Aleph Objects and represents typical software currently used by the end user.

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 TAZ 5 Software:

The default software for the LulzBot TAZ 5 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.

Firmware loaded on the TAZ 5 was Marlin 2014Q4



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

1.2.1 Description of test configuration

EUT	:	LulzBot TAZ 5 3D Printer
Manufacturer	:	Aleph Objects, Inc.
System model name	:	TAZ 5
Serial Number	:	KT-PR0016-8075
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 TAZ5	Yes	Typical 6 ft. usb cable, no ferrites

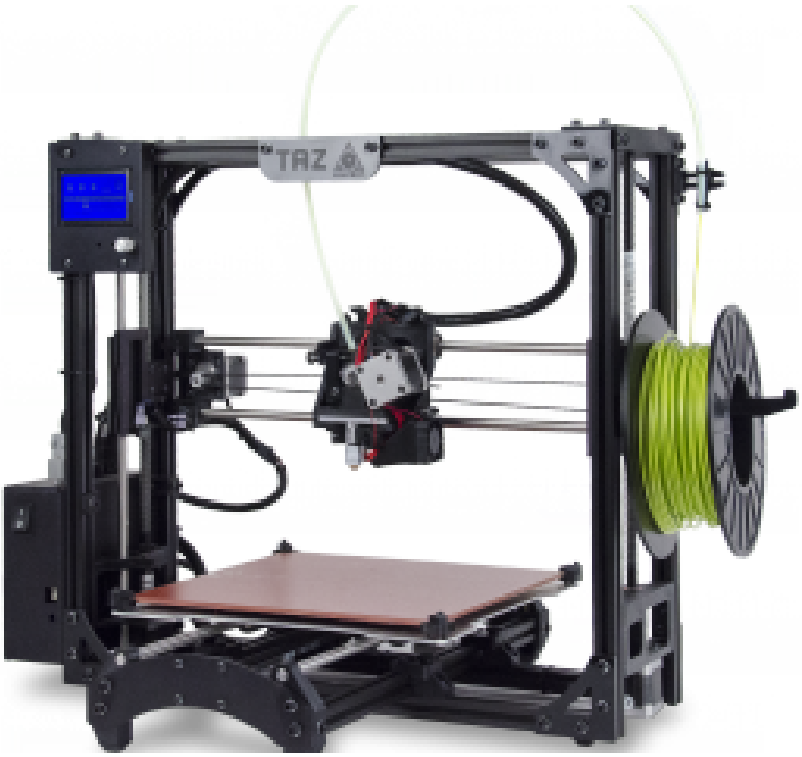
Power supply location	Manufacturer	Model	Serial number	Shielded	Remarks
External AC supply	N/A	PC-240167	PC-1412200510	Plastic enclosure	CE and FCC marks – Output; 24V 16.7A

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 TAZ 5 – 3D Printer

https://www.lulzbot.com/products/lulzbot-taz-5-3d-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.

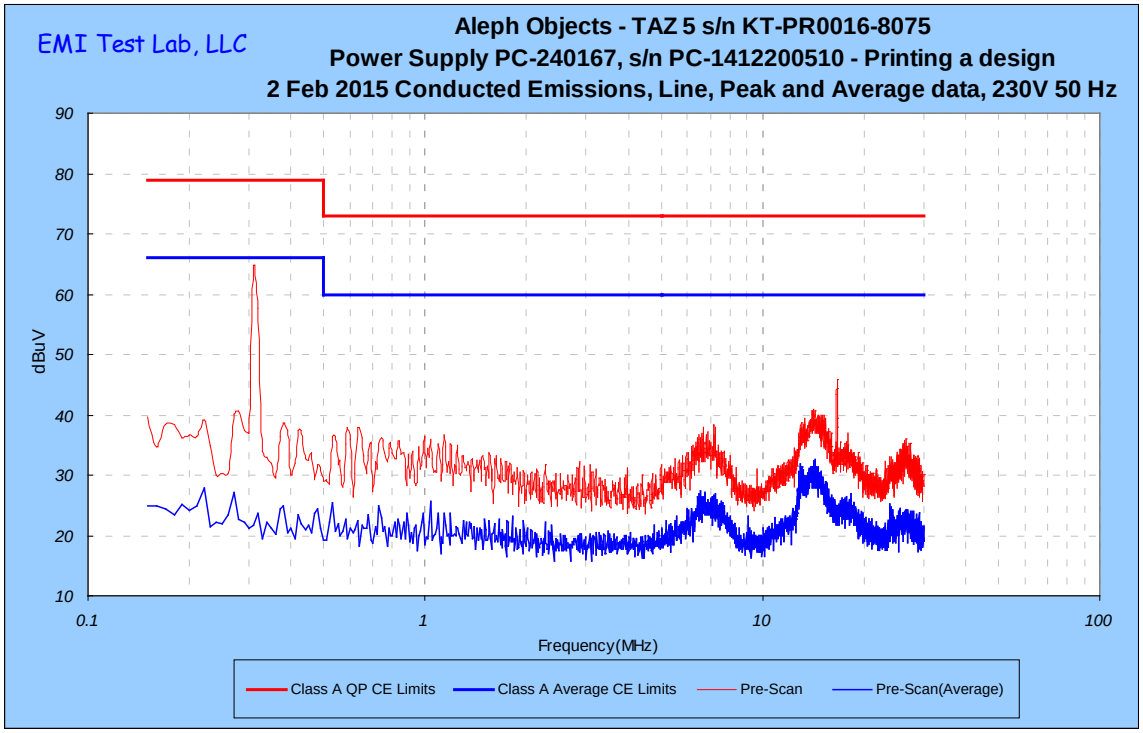
Basic standard	:	CISPR 22:2008
Test setup	:	EN 55022:2010
Frequency range 1	:	0.15 – 0.5 MHz
Limit	:	79.0 dBuV quasi peak, 66 dBuV average
Frequency range 2	:	0.5 – 30 MHz
Limit	:	73 dBuV quasi peak, 60 dBuV average

Results of the measurements concerning the emissions of voltage levels at the AC mains input port of the EUT.	**PASS Class A**
Name of Test Engineer: Signature: Date:	Dennis King  2 February 2015

Remarks: The configuration was tested at 230VAC 50Hz.
Conducted Emission Summary:

Peak data was over the Quasi Peak limit but when measured Quasi Peak, those frequencies are passing. All Average scans passed Average limits.

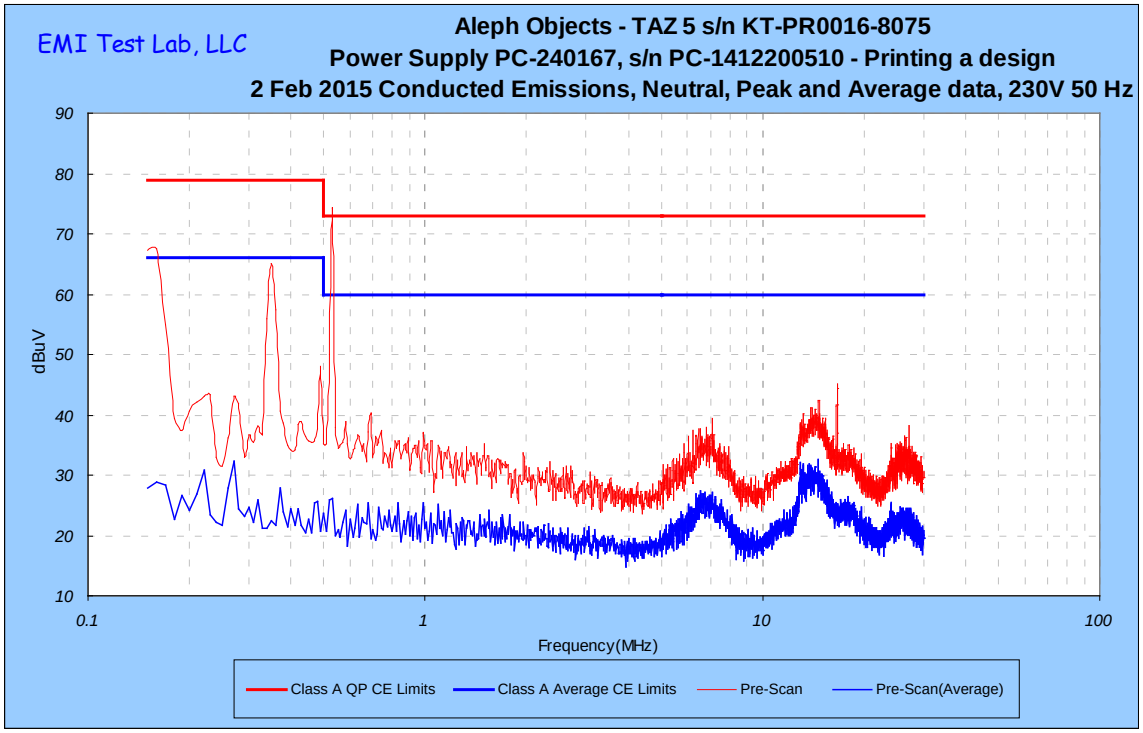
The unit was printing during all conducted emissions tests.



230 VAC 50 Hz Line

Peak passes the Quasi Peak (upper) and Average (lower) limits

Red is peak and blue is average

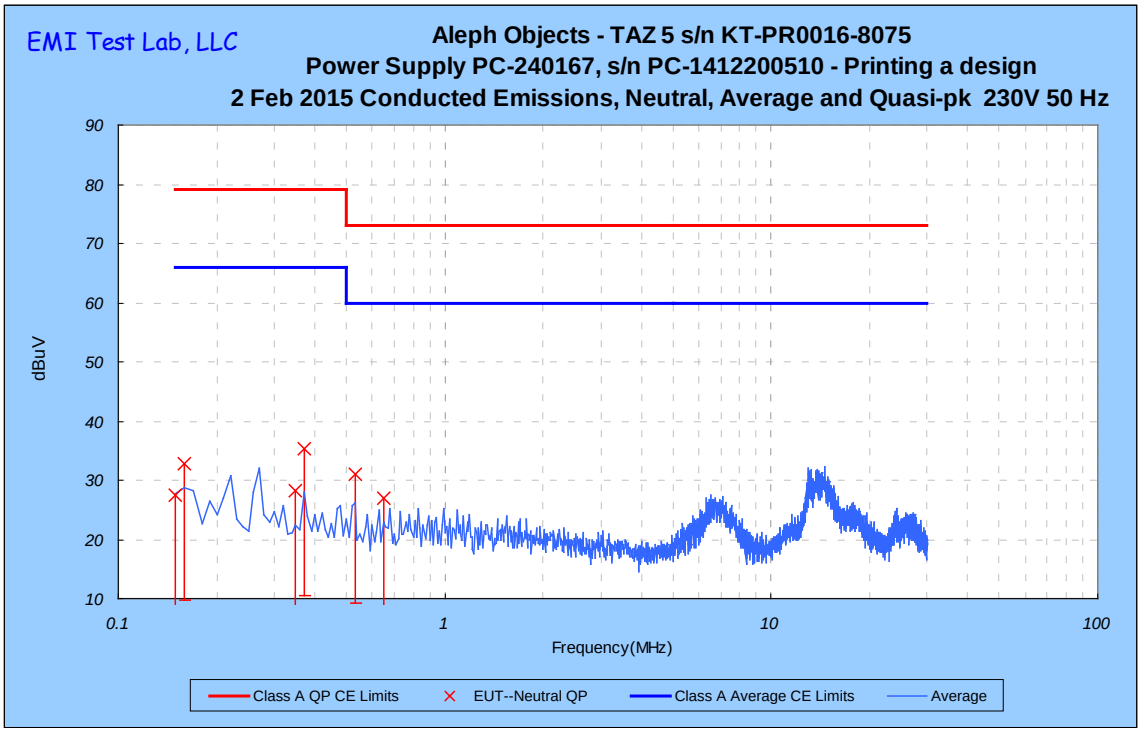


230 VAC 50 Hz Neutral

Peak is over the Quasi Peak (upper)limit so Quasi Peak readings were taken – see the next chart

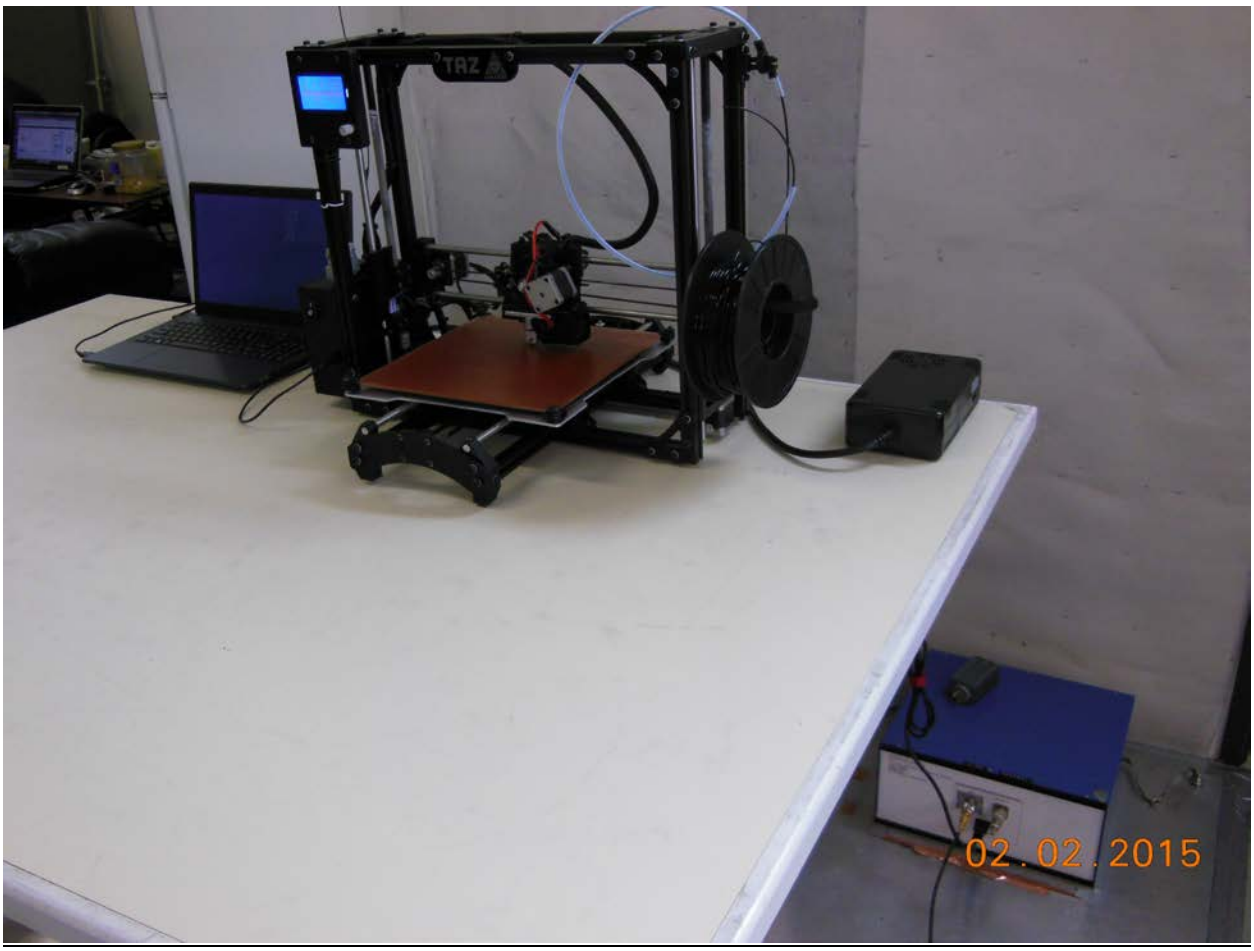
Average (lower) limit passes

Red is peak and blue is average



Frequency(MHz)	*QP Disturbance (dBuV)*	*QP Limit*	*Margin QP (dB)*	*Transducer Connection*	*Correction Factor (dB)*
0.150	27.50	79.00	51.50	AMN	0.20
0.370	35.36	79.00	43.64	AMN	0.26
0.650	26.92	73.00	46.08	AMN	0.48
0.160	32.70	79.00	46.30	AMN	0.20
0.351	28.26	79.00	50.74	AMN	0.26
0.530	31.14	73.00	41.86	AMN	0.34

Quasi Peak passes the Quasi Peak limit



Conducted Emissions test setup

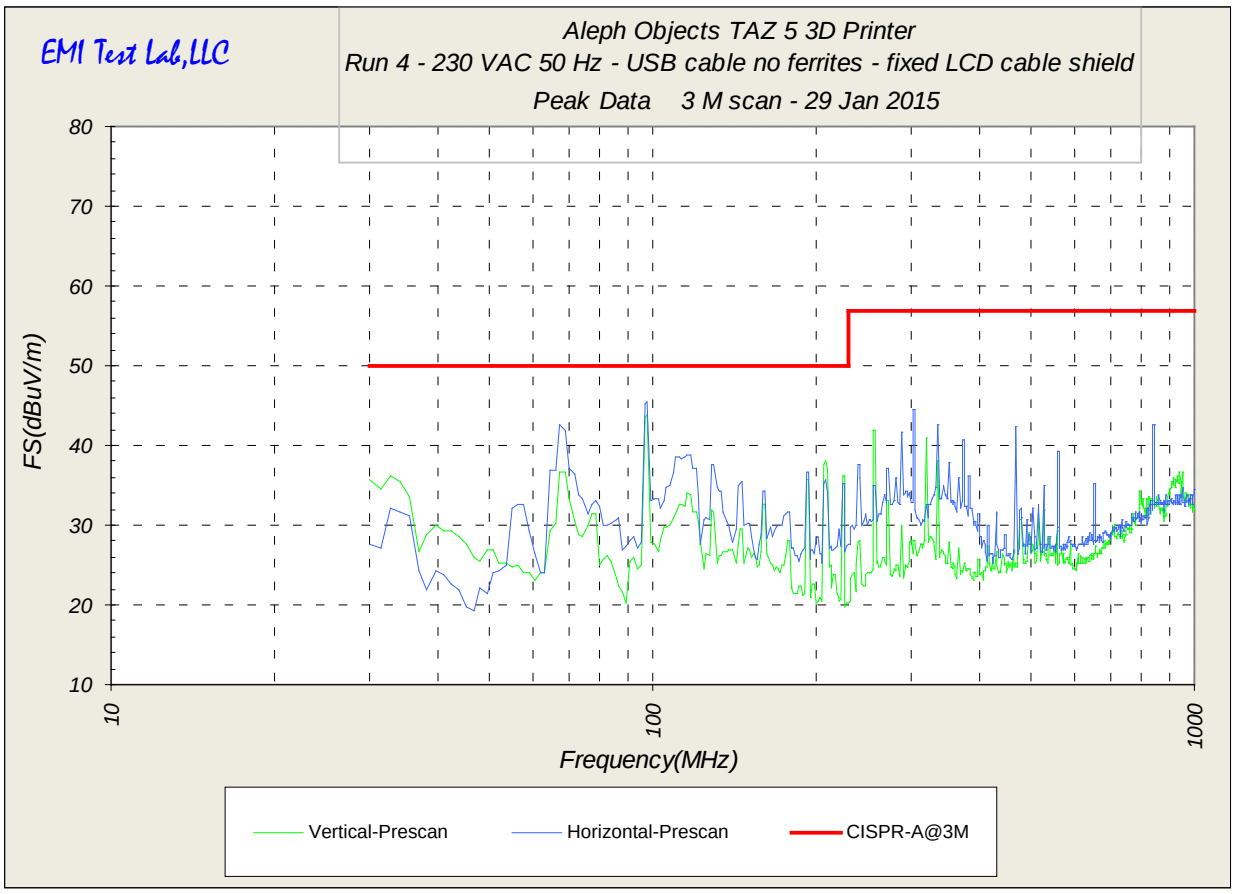
2.2 Enclosure

2.2.1 30-1,000 MHz

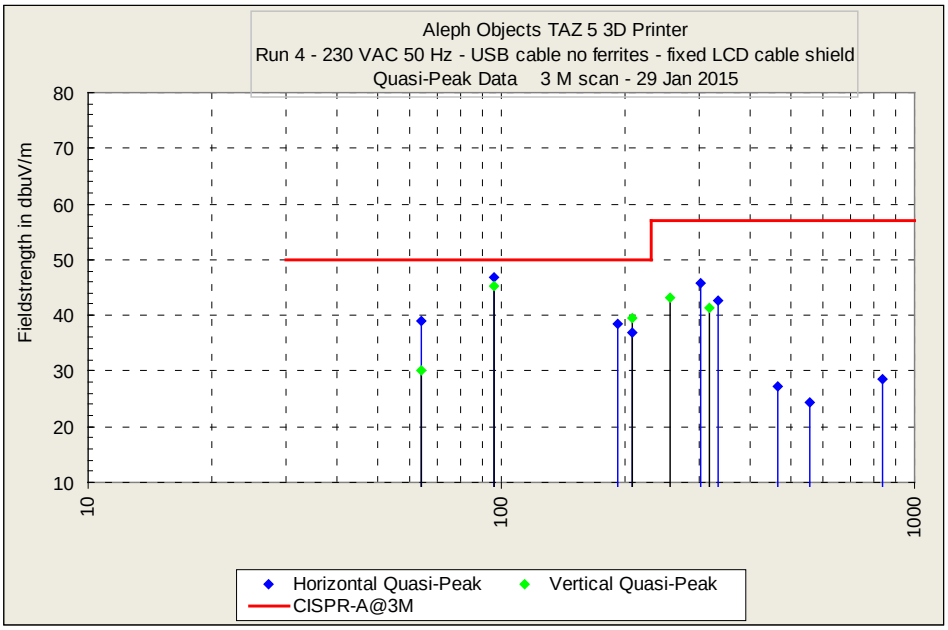
The radiated field strength levels (electric component) have been measured in conformity with and according to the criteria as stated below.

Basic standard	:	CISPR 22:2008
Test setup	:	EN 55022:2010
Limit distance	:	3 meters
Frequency range 1	:	30 -230 MHz
Limits	:	50 dBuV/m
Frequency range 2	:	230 – 1,000 MHz
Limits	:	57 dBuV/m

Results of the measurements concerning radiated electromagnetic fields (electric component) emitted by the EUT, enclosure, as a tested system	**PASS Class A**
Name of Test Engineer: Signature: Date:	Dennis King  2 February 2015
Remarks: The configuration was tested at 230VAC 50Hz **Radiated Emissions Summary:** Passing Class A. The unit was re-tested and passed with a new LCD ribbon cable connector. The grounding of the LCD cable shield was also improved to pass emissions. See modifications section for details.	



Peak Data passing the Quasi peak Limit



EMI Test Lab Sheet4

1822 Skyway Drive, Unit J, Longmont Co Dennis
King dennis@emitestlab.com , Cell 303-746-0611

Frequency	F.S. EUT	Limit	Azimuth	Height	Antenna Polarization	Limit delta
(MHz)	*(dBuV/m)*	*(dBuV/m)*	*Degrees*	*Meters*	*H or V*	*dBuV*
256.00	43.2	57	0.0	1	V	-13.8
208.01	39.45	50	183.0	1	V	-10.6
64.00	30.22	50	189.0	1	V	-19.8
319.99	41.37	57	267.0	1	V	-15.6
96.00	45.20	50	336.0	1	V	-4.8
834.94	28.60	57	0.0	1	H	-28.4
335.99	42.75	57	9.0	1	H	-14.3
192.00	38.50	50	48.0	1	H	-11.5
64.00	39.12	50	141.0	1	H	-10.9
303.98	45.75	57	156.0	1	H	-11.3
208.00	36.92	50	183.0	1	H	-13.1
557.70	24.45	57	216.0	1	H	-32.6
468.01	27.15	57	240.0	1	H	-29.9
96.00	46.72	50	336.0	1	H	-3.3

Quasi Peak Data

Radiated emissions test setup

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 56 dBuV/m, Peak 76 dBuV/m
Frequency range 2	:	3-6 GHz
Limits	:	Average 60 dBuV/m, Peak 80 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  22 February 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: Signature: Date:	Dennis King  3 February 2015
Remarks: The unit was tested at 230VAC 50Hz. The 3D printer was printing during the entire test.	

Data – the EUT is printing

HA-PC Link Plus. Software v2.02. Firmware v2.81
Report Number : 52
Tested On : 03 February 2015 11:20 for 150 Seconds.
Equipment Under Test : TAZ 5
Serial Number : KT-PR0016-8075
Tested by : Dennis King

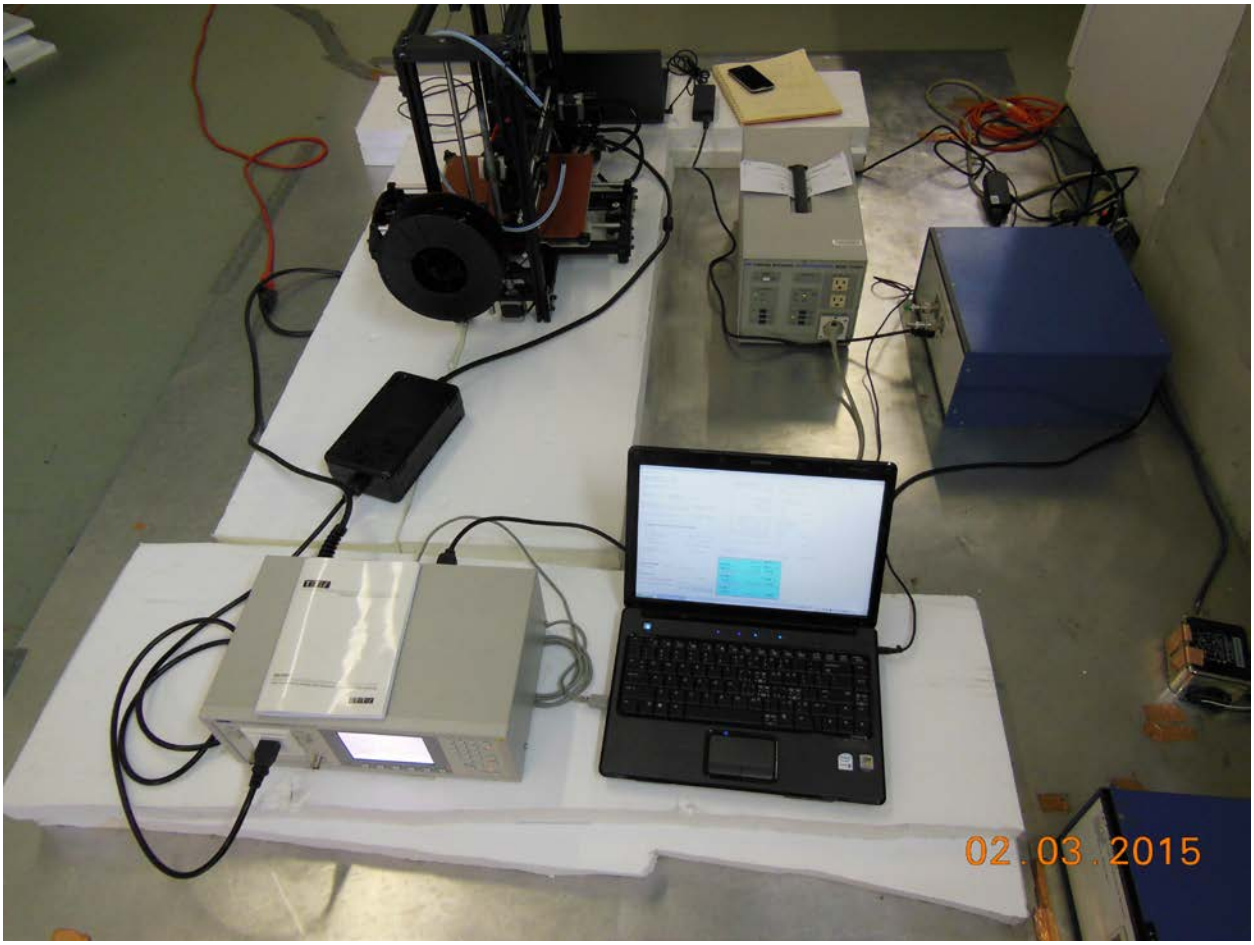
Supply Voltage : 229.1 to 230.7 Vrms 327.9 Vpk Frequency : 59.98 to 60.10 Hz
Supply Fails : Harmonic Requirements Frequency Limits.

Load Power : 48.80 to 50.60 W 111.8 VA Power Factor 0.450
Load Current : 476.8 to 489.2 mArms 1813.2 to 1973.6 mApk Crest Factor: 3.877

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
19 :	118.4	37.8	31.9	53.1	44.8	Pass
Fundamental :		240.8				
2 :	-	3.7	-	0.0	-	-
3 :	-	209.6	-	0.0	-	-
4 :	-	3.7	-	0.0	-	-
5 :	-	194.2	-	0.0	-	-
6 :	-	3.4	-	0.0	-	-
7 :	-	176.5	-	0.0	-	-
8 :	-	3.5	-	0.0	-	-
9 :	-	154.5	-	0.0	-	-
10 :	-	2.9	-	0.0	-	-
11 :	-	127.8	-	0.0	-	-
12 :	-	2.8	-	0.0	-	-

13 :	-	103.0	-	0.0	-	-
14 :	-	2.4	-	0.0	-	-
15 :	-	76.0	-	0.0	-	-
16 :	-	2.0	-	0.0	-	-
17 :	-	50.5	-	0.0	-	-
18 :	-	1.6	-	0.0	-	-
19 :	-	30.6	-	0.0	-	-
20 :	-	1.3	-	0.0	-	-
21 :	-	14.9	-	0.0	-	-
22 :	-	1.1	-	0.0	-	-
23 :	-	9.1	-	0.0	-	-
24 :	-	0.9	-	0.0	-	-
25 :	-	14.6	-	0.0	-	-
26 :	-	0.9	-	0.0	-	-
27 :	-	18.5	-	0.0	-	-
28 :	-	0.9	-	0.0	-	-
29 :	-	19.8	-	0.0	-	-
30 :	-	0.9	-	0.0	-	-
31 :	-	18.0	-	0.0	-	-
32 :	-	0.8	-	0.0	-	-
33 :	-	14.7	-	0.0	-	-
34 :	-	0.7	-	0.0	-	-
35 :	-	9.9	-	0.0	-	-
36 :	-	0.6	-	0.0	-	-
37 :	-	6.2	-	0.0	-	-
38 :	-	0.5	-	0.0	-	-
39 :	-	2.1	-	0.0	-	-
40 :	-	0.5	-	0.0	-	-
21 - 39 :	-	44.0	-	0.0	-	-



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  3 February 2015
Remarks: The unit was tested at 230VAC 50Hz. The 3D printer was printing during the entire test.	

LulzBot Mini 3D printer – data - Flicker

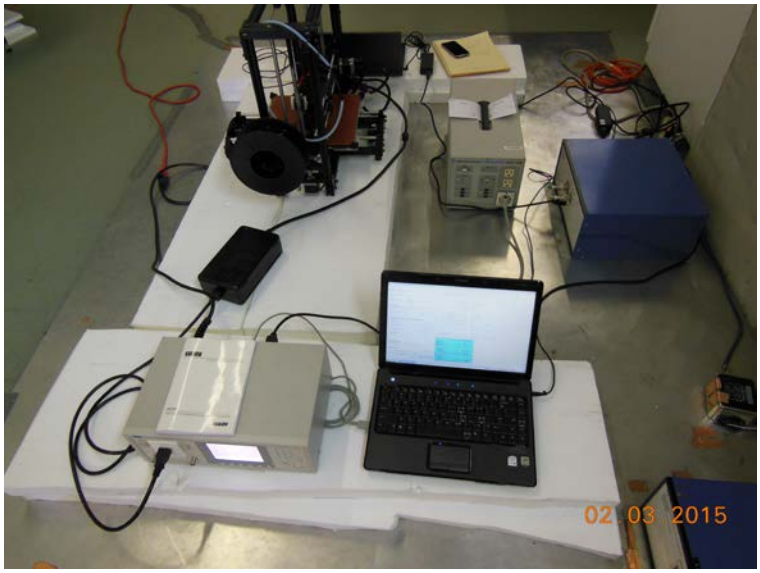
HA-PC Link Plus. Software v2.02. Firmware v2.81
Report Number : 53
Tested On : 03 February 2015 11:24 for 600 Seconds.
Equipment Under Test : TAZ 5
Serial Number : KT-PR0016-8075
Tested by : Dennis King
Supply Voltage : 230.1 to 230.7 Vrms 328.4 Vpk Frequency : 59.99 to 60.16 Hz
Load Current : 0.5 Arms 2.0 Apk Crest Factor: 3.941
Test Method: EN61000-3-3:2008
Voltage Variations :

Highest Level:	+0.59%	
Lowest Level:	-0.51%	
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:	+0.32%	
Lowest Steady State:	-0.42%	
Max d(c) Between Adjacent:	0.62%	PASS
Max d(c) Between Any:	0.74%	
Short Term Flicker Pst:	0.19	PASS
Longest d(t) over 3.33%:	0.00 Seconds	
Highest Steady State:	+0.28%	
Lowest Steady State:	+0.28%	
Max d(c) Between Adjacent:	0.00%	PASS
Max d(c) Between Any:	0.00%	

Flicker Results :

Pst Classifier Duration	Flicker	Plt Calculation Interval	Pst
0.1%	0.84		
0.7%	0.14		
1.0%	0.09		

1.5%	0.06
2.2%	0.05
3%	0.03
4%	0.02
6%	0.02
8%	0.02
10%	0.00
13%	0.00
17%	0.00
30%	0.00
50%	0.00
80%	0.00
6%	1.00



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

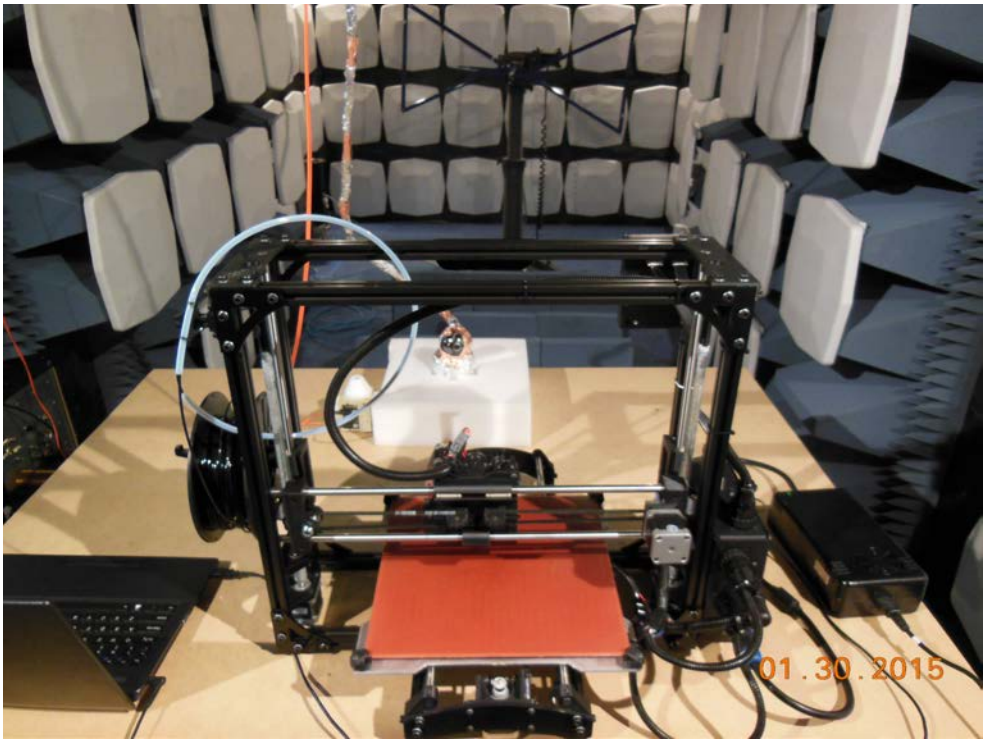
3.2.1 Radio-frequency electromagnetic field. Amplitude modulated.

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:	30 January 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

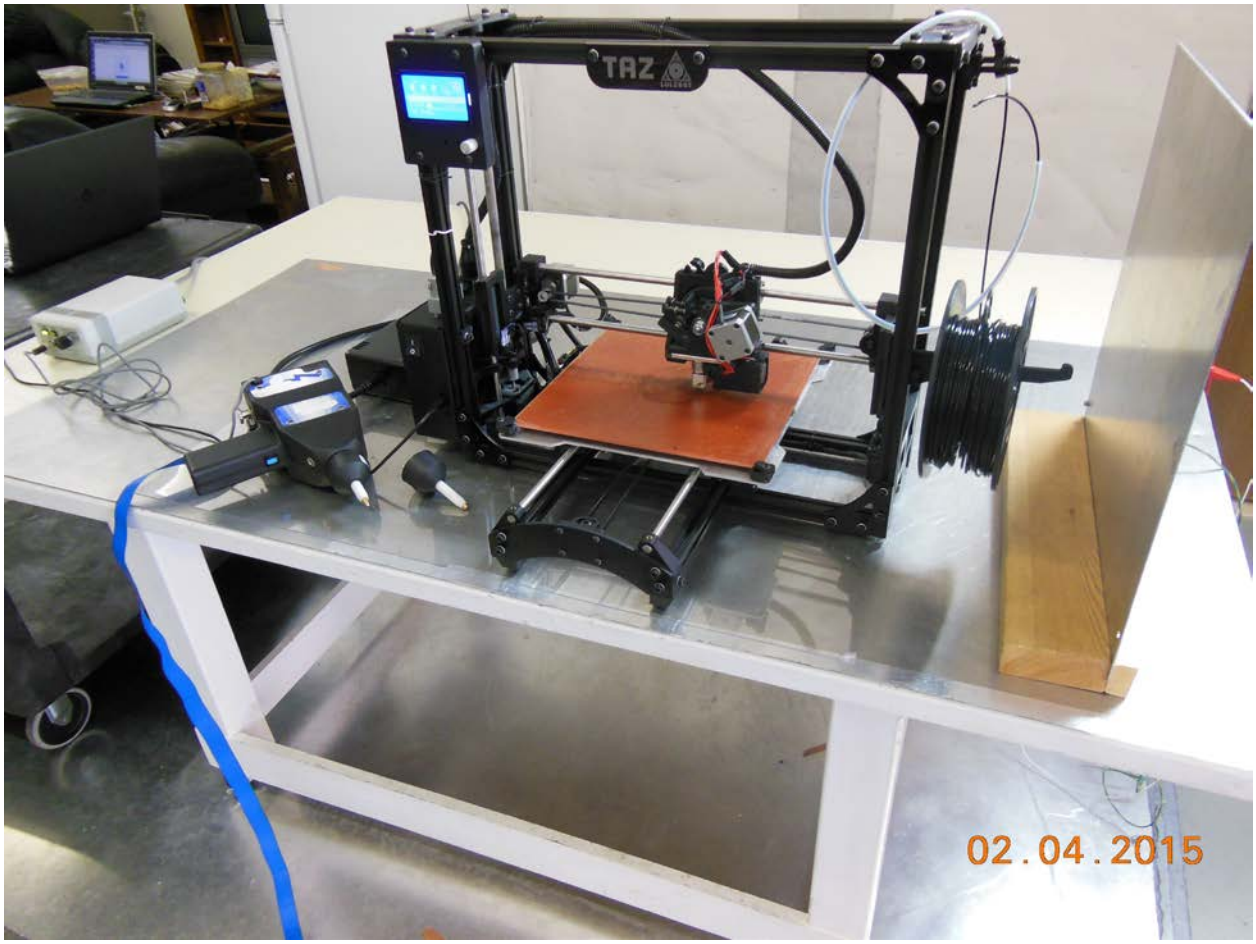
All 4 sides, Vertical and Horizontal were checked at 3 V/M
No errors were detected - passing Criteria A.

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 B (with conditions)**
Name of Test Engineer: Signature: Date:	Dennis King  4 February 2015
Remarks: The printer had problems when the discharge was made to the box around the electronics or the LCD display. **Conditions of Acceptability:** A statement will be made in the user guide to use esd precautions when touching the unit, either discharging to an earth ground or wearing an esd strap. Per the Manufacturer, this is acceptable operation of the EUT.	



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

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.

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  23 February 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: Signature: Date:	Dennis King  23 February 2015
Remarks: There are no interconnecting cables on the unit that exceed 3 meters. See the test plan.	

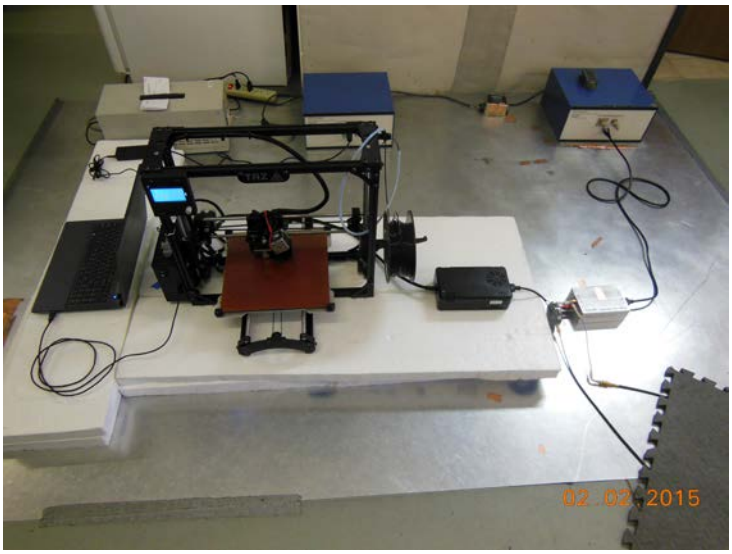
3.3 AC input and AC output power ports

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.

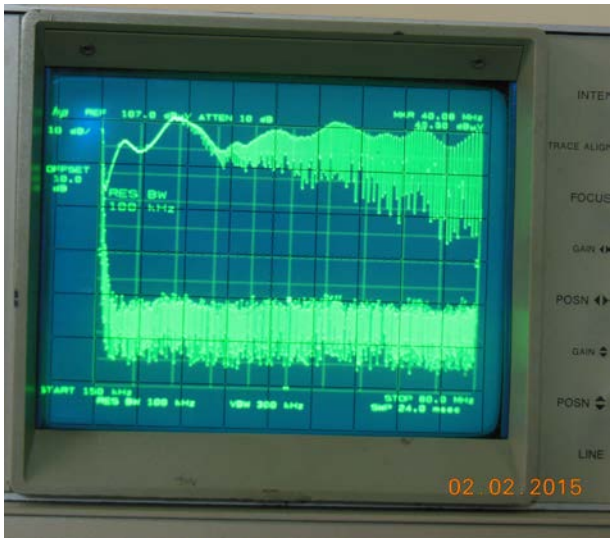
Basic standard	:	EN 55024:2010
Test setup	:	EN61000-4-6
Frequency range	:	0.15 – 80 MHz
Test level	:	3 Vrms
Source impedance	:	150 Ohms
Performance criteria	:	Criteria A

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  2 February 2015
Remarks: Tested at 230 VAC 50 Hz – the EUT continued to operate as intended with no loss of data or function. **The TAZ 5 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:	3 February 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 03 February 2015

==========

REMOTE/TESTER RUN

Versions: SW v3.00 FW v3.01 Str v3.00 CEMASTER

Operator: Dennis King

Sequence File: CISPR 24 - ITE Equipment - 1kV Diff 2kV CM.SEQ

EUT: TAZ 5 – re-checking passing results from power supply manufacturer

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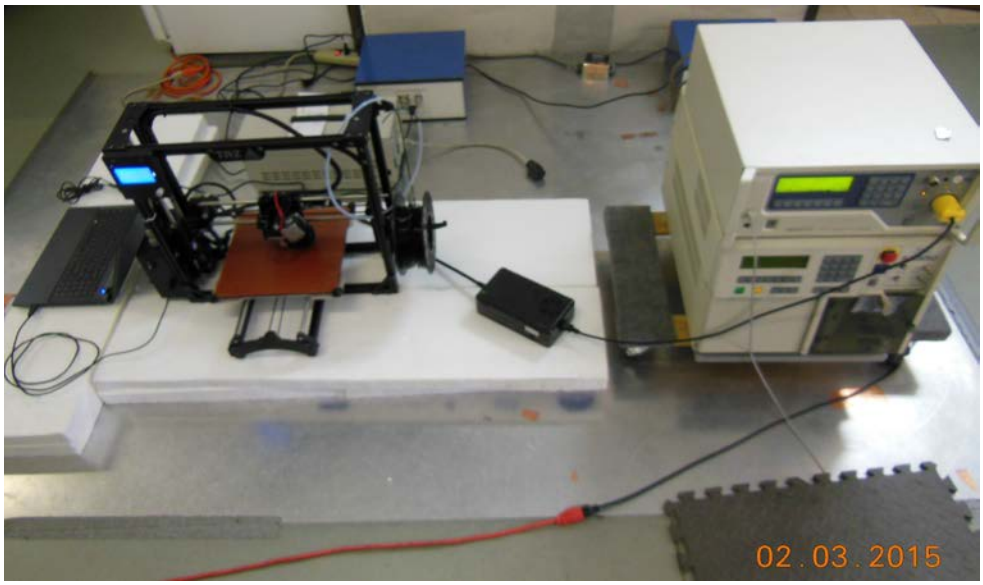
230 VAC

03:22:00P 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
03:22:00P	2 Ohm	1000V	MAINS:L1/L2	L1	0 deg.	5	60 sec.
03:27:06P	2 Ohm	1000V	MAINS:L1/L2	L1	90 deg.	5	60 sec.
03:32:12P	2 Ohm	1000V	MAINS:L1/L2	L1	270 deg.	5	60 sec.
03:37:17P	2 Ohm	-1000V	MAINS:L1/L2	L1	0 deg.	5	60 sec.
03:42:23P	2 Ohm	-1000V	MAINS:L1/L2	L1	90 deg.	5	60 sec.
03:47:28P	2 Ohm	-1000V	MAINS:L1/L2	L1	270 deg.	5	60 sec.
03:52:34P	12 Ohm	2000V	MAINS:L1/PE	L1	0 deg.	5	60 sec.
03:57:40P	12 Ohm	2000V	MAINS:L1/PE	L1	90 deg.	5	60 sec.
04:02:45P	12 Ohm	2000V	MAINS:L1/PE	L1	270 deg.	5	60 sec.
04:07:51P	12 Ohm	-2000V	MAINS:L2/PE	L1	0 deg.	5	60 sec.
04:12:57P	12 Ohm	-2000V	MAINS:L2/PE	L1	90 deg.	5	60 sec.
04:18:03P	12 Ohm	-2000V	MAINS:L2/PE	L1	270 deg.	5	60 sec.

04:21:17P SEQUENCE COMPLETE

Unit continues to operate as intended. Passing Criteria A



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.***

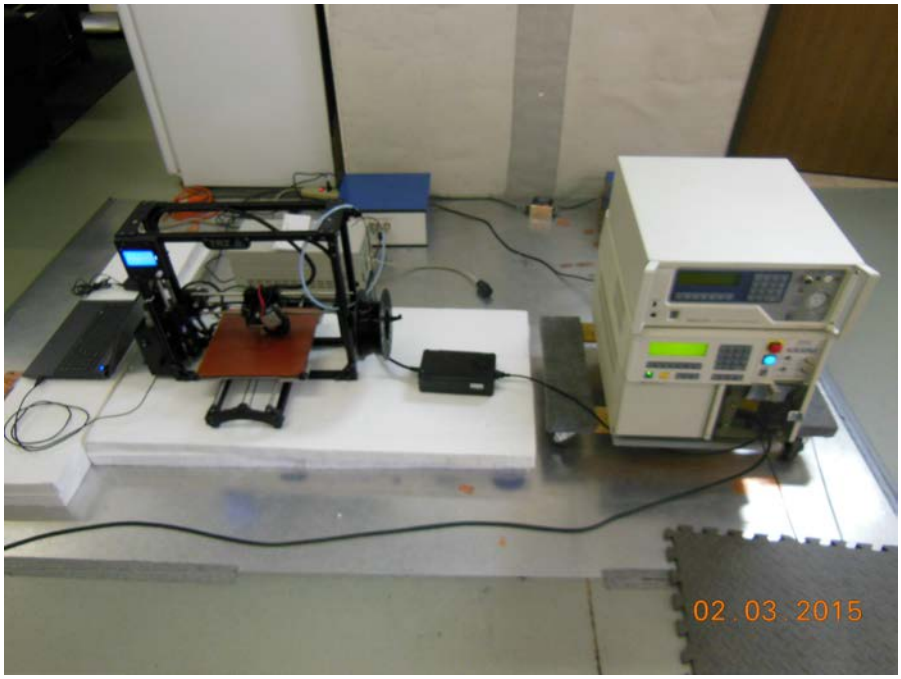
Results of the test concerning the susceptibility of the EUT to fast transients (common mode, AC input and AC output ports)	**Pass Criteria A**
Name of Test Engineer:	Dennis King
Signature:	
Date:	3 February 2015
Remarks: Tested at 230 VAC 50 Hz while printing. The unit continued to function as intended.	

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 11:51.07 on FEB 3,2015
Test File:C:\KEYTEK\ECAT\EFT\ITE_1KV.EFT
Operator :dennis king
EUT:TAZ 5
Comments: 230VAC printing
E400:Name:TAZ 5
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
11:51.16:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1
11:53.17:	EFT Step Ended											
11:53.30:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2
11:55.29:	EFT Step Ended											
11:55.40:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1,PE
11:57.40:	EFT Step Ended											

11:57.51:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2,PE
11:59.51:	EFT Step Ended										
12:00.03:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L2
12:02.02:	EFT Step Ended										
12:02.13:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	L2,PE
12:04.13:	EFT Step Ended										
12:04.24:	Burst	1000	5000	Hz	15	mS	300	RND	E412	E412	PE
12:06.24:	EFT Step Ended										
12:06.35:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1
12:08.35:	EFT Step Ended										
12:08.46:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2
12:10.46:	EFT Step Ended										
12:10.57:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1,PE
12:12.57:	EFT Step Ended										
12:13.08:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L1,L2,PE
12:15.08:	EFT Step Ended										
12:15.19:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L2
12:17.19:	EFT Step Ended										
12:17.30:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	L2,PE
12:19.29:	EFT Step Ended										
12:19.41:	Burst	-1000	5000	Hz	15	mS	300	RND	E412	E412	PE
12:21.40:	EFT Step Ended										
12:21.41:	Test Complete										
12:21.41:	Log Closed										



Test Setup per EN 61000-4-4

3.3.4 Voltage Dips and Interruptions

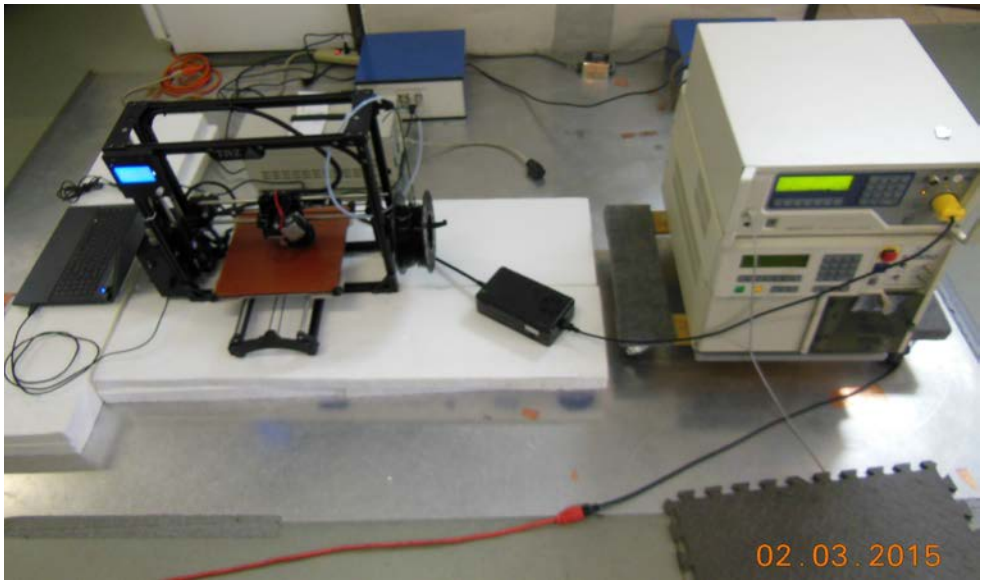
The susceptibility of the EUT to voltage dips and interruptions has been tested in conformity with and according to the criteria as stated below.

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  3 February 2015
Remarks: Tested at 230 VAC 50 Hz while printing. The unit continued to function as intended.	

Test Data

```
================================================================================
Aleph objects                                  03 February 2015
================================================================================
REMOTE/TESTER RUN
Versions:     SW v3.00  FW v3.01  Str v3.00  CEMASTER
Operator:     Dennis King
Sequence File: ITE AC Dips EN 61000-4-11.SEQ
EUT:          TAZ 5
================================================================================

--------------------------------------------------------------------------------
230 VAC - Printing
--------------------------------------------------------------------------------

03:06:25P SEQUENCE START

SEQUENCE          TYPE             SEQUENCE DESCRIPTION
PQF               User Defined     ITE Equipment

          Test Level    Phs Ang   Dur. Value   Duration   Tests    Delay
03:06:25P    0% Open     0 deg.      0.50        cyc      3     10 sec.
03:07:01P    0% Open     90 deg.     0.50        cyc      3     10 sec.
03:07:36P    0% Open     180 deg.    0.50        cyc      3     10 sec.
03:08:11P    0% Open     270 deg.    0.50        cyc      3     10 sec.
03:08:47P    70% Dip     0 deg.      25.00       cyc      3     10 sec.
03:09:23P    70% Dip     90 deg.     25.00       cyc      3     10 sec.
03:09:59P    70% Dip     180 deg.    25.00       cyc      3     10 sec.
03:10:35P    70% Dip     270 deg.    25.00       cyc      3     10 sec.
03:11:12P    0% Open     0 deg.      250.00      cyc      3     10 sec.
03:11:59P    0% Open     180 deg.    250.00      cyc      3     10 sec.

03:12:47P   SEQUENCE COMPLETE
--------------------------------------------------------------------------------
Unit continues to operate as intended.
Passing.
--------------------------------------------------------------------------------
```



Test setup according to EN 61000-4-11

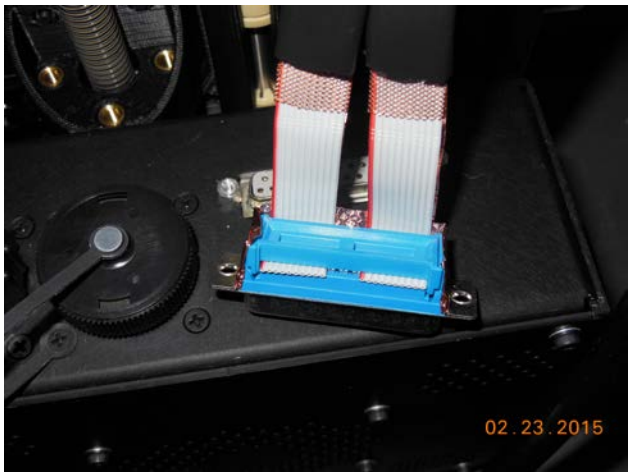
3.3.5 Power Frequency Magnetic Fields

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:	23 February 2015
Remarks: There are no magnetically sensitive components in this product.	

4.0 Modifications



A blue LCD cable connector was used during emissions testing, changing from a more expensive version of the same connector. The results were the same or better using the less expensive connector.

Copper tape was added to the ribbon cable shielding to connect the shield to the metal of the connector in order to get a chassis ground connection.

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 70-72 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 TAZ 5 3D Printer will be tested for Class A Emissions per EN 55022 and all applicable Immunity tests per EN 55024 for immunity as required for the EMC portion of the CE Mark.

Test Setup

The LulzBot TAZ 5 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.

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 TAZ 5 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