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Results, Findings, and Oddities from the Solid State Lighting Proficiency Testing for the NVLAP Energy Efficient Lighting Program

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Proficiency Testing – HB150-1 (2010 Draft)

- **3.4.2** Laboratories applying for initial accreditation for solid-state test methods shall participate satisfactorily in a bilateral proficiency testing with NIST before accreditation will be granted.
- **3.4.5** Laboratories renewing accreditation shall have satisfactorily participated in all required proficiency testing during their previous accreditation period.

Bilateral Test Items

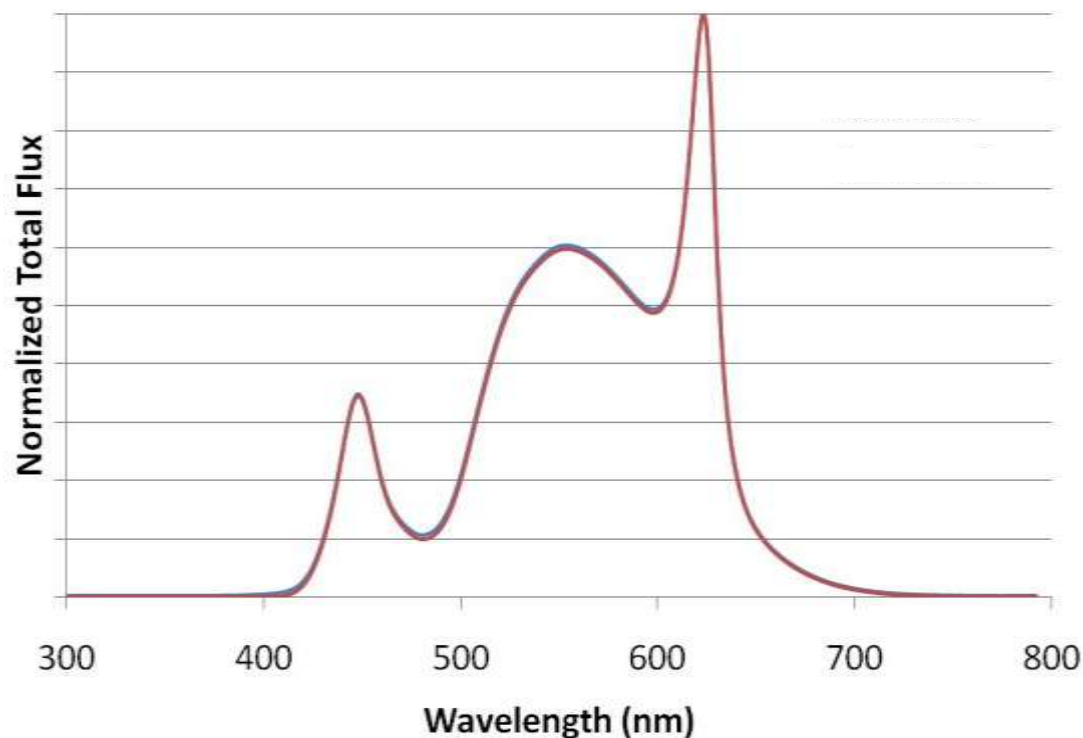
- Six items
 - Incandescent lamp (120 V AC)
 - Under cabinet SSL luminaire
 - (12 V DC, DC current controlled)
 - Four different white SSL luminaires (120 V AC)



Incandescent lamp and SSL-1

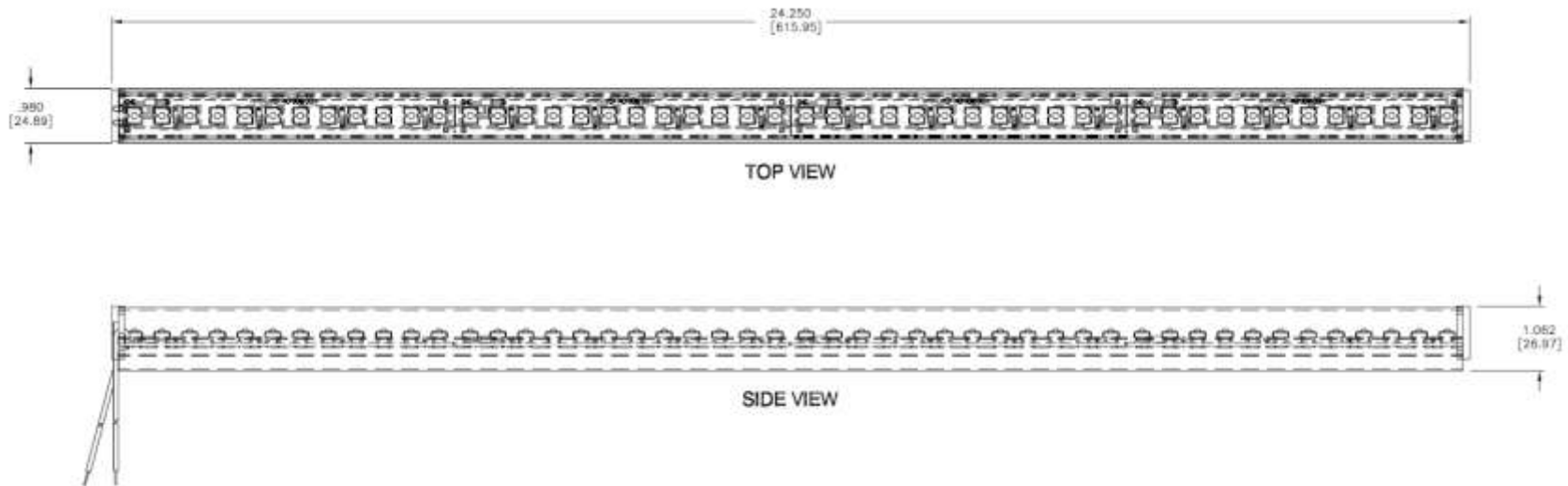
Primary purpose

- Check lumen scale
- Check stabilization time



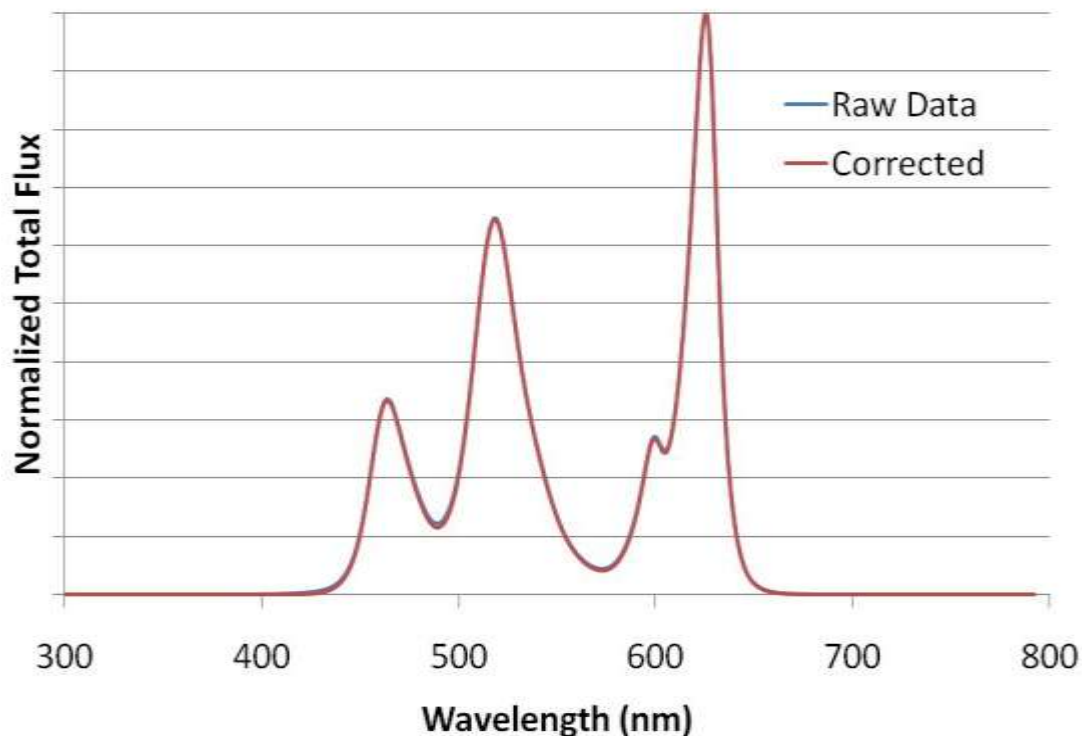
Under Cabinet SSL Luminaire

- Older technology
- Ambient temperature insensitive
- DC current controlled
- Spatial distribution is different
- Very high CCT

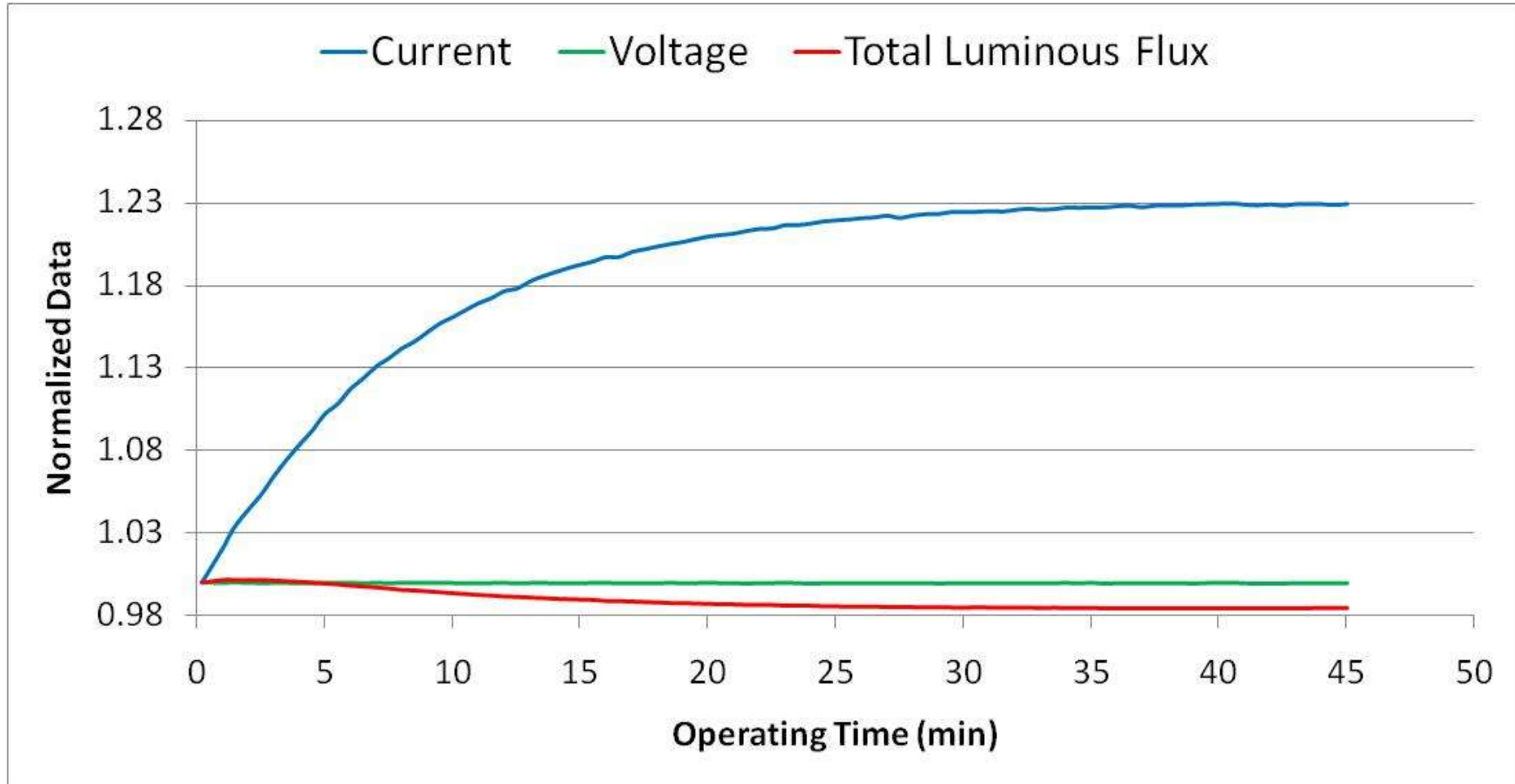


SSL-2, SSL-3, and SSL-4

- Various whites and spatial properties



Stabilization Time



NIST Characterization

	Incandescent	SSL-1	SSL-2	SSL-3	SSL-4	Under Cabinet
Voltage	0.01 %	0.00 %	0.02 %	0.01 %	0.03 %	0.00 %
Current	0.01 %	0.01 %	0.19 %	0.13 %	0.14 %	0.00 %
Power	0.02 %	0.00 %	0.16 %	0.05 %	0.20 %	0.00 %
Flux	0.08 %	0.02 %	0.18 %	0.05 %	0.12 %	0.21 %
Efficacy	0.06 %	0.02 %	0.16 %	0.10 %	0.11 %	0.21 %
CCT	2 K	1 K	5 K	3 K	7 K	7 K
CRI	0.02	0.01	0.02	0.04	0.20	0.05

Total Flux Comparison

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
SSL 1	0.9%	0.8%	-1.7%	-1.2%	-2.8%
SSL 2	10.5%	36.9%	7.1%	12.7%	9.1%
SSL 3	0.5%	0.1%	-0.9%	-0.6%	0.2%
SSL 4	9.6%	28.1%	5.8%	10.9%	6.2%
Under Cabinet	0.5%	-0.3%	-5.4%	-0.8%	-2.3%
Incandescent	-0.6%	-1.5%		0.0%	-0.1%

Luminous Efficacy

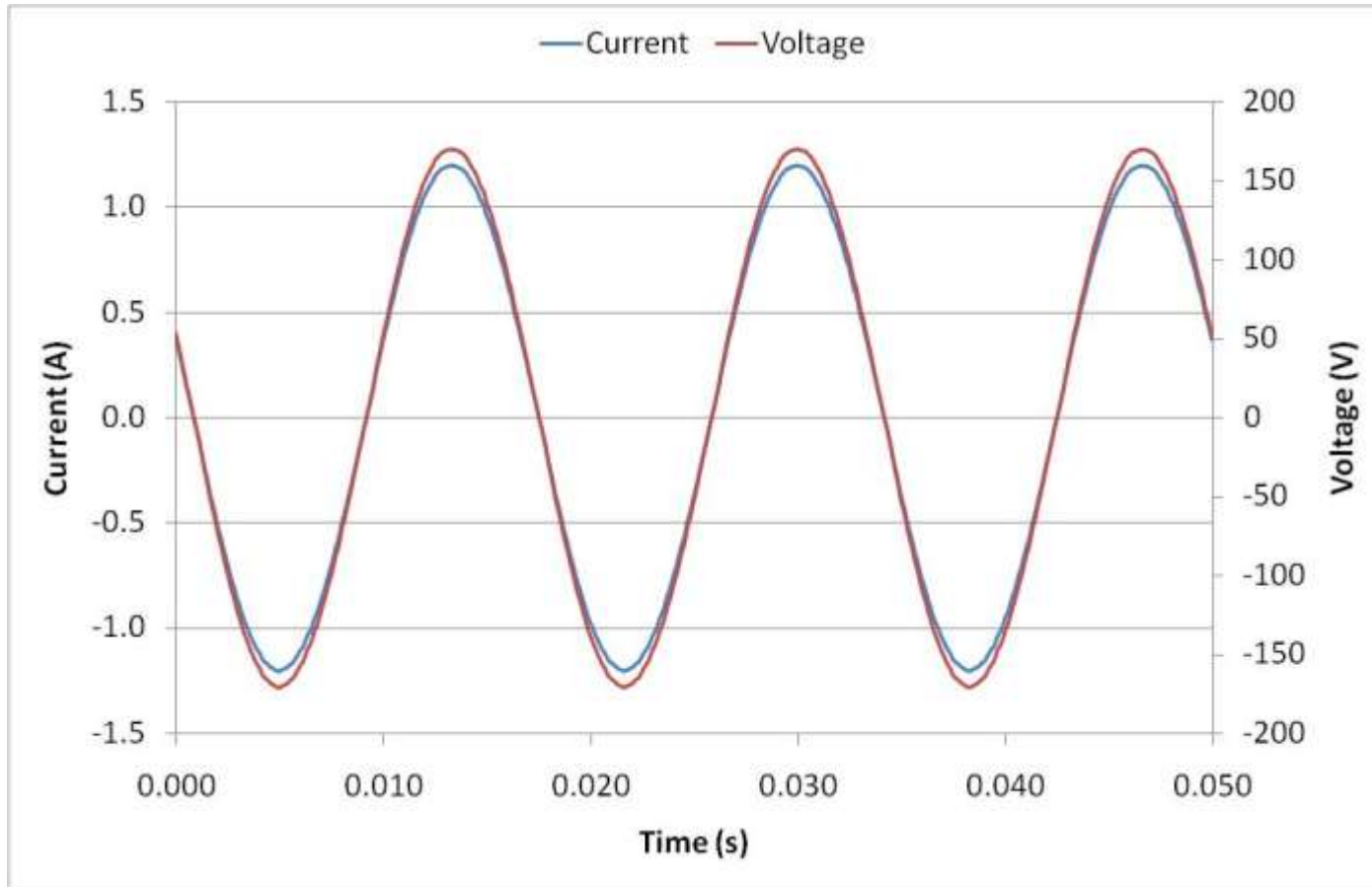
	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
SSL 1	1.9%	0.5%	0.0%	0.4%	-1.6%
SSL 2	-3.5%	-17.1%	-5.6%	-2.7%	-7.6%
SSL 3	0.5%	0.3%	-0.4%	0.2%	0.8%
SSL 4	-3.2%	-20.0%	-16.4%	-4.2%	-7.9%
Under Cabinet	0.9%	0.4%	-4.3%	-0.8%	-2.3%
Incandescent	-0.9%	-1.9%		-0.1%	-0.5%

Power

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
SSL 1	0.5%	0.4%	-1.7%	-1.6%	-1.2%
SSL 2	13.5%	47.0%	12.0%	15.0%	15.5%
SSL 3	0.0%	-0.2%	-0.5%	-0.8%	-0.6%
SSL 4	12.4%	40.1%	19.0%	14.5%	13.1%
Under Cabinet	0.2%	0.4%	-1.0%	0.1%	0.3%
Incandescent	0.0%	-0.7%		0.1%	0.1%

Oscilloscope Measurements

Incandescent lamp – AC power supply



Power Meter
120.0 V rms
0.845 A rms
101.8 W true

Oscilloscope
120.0 V rms
0.845 A rms
101.4 W true

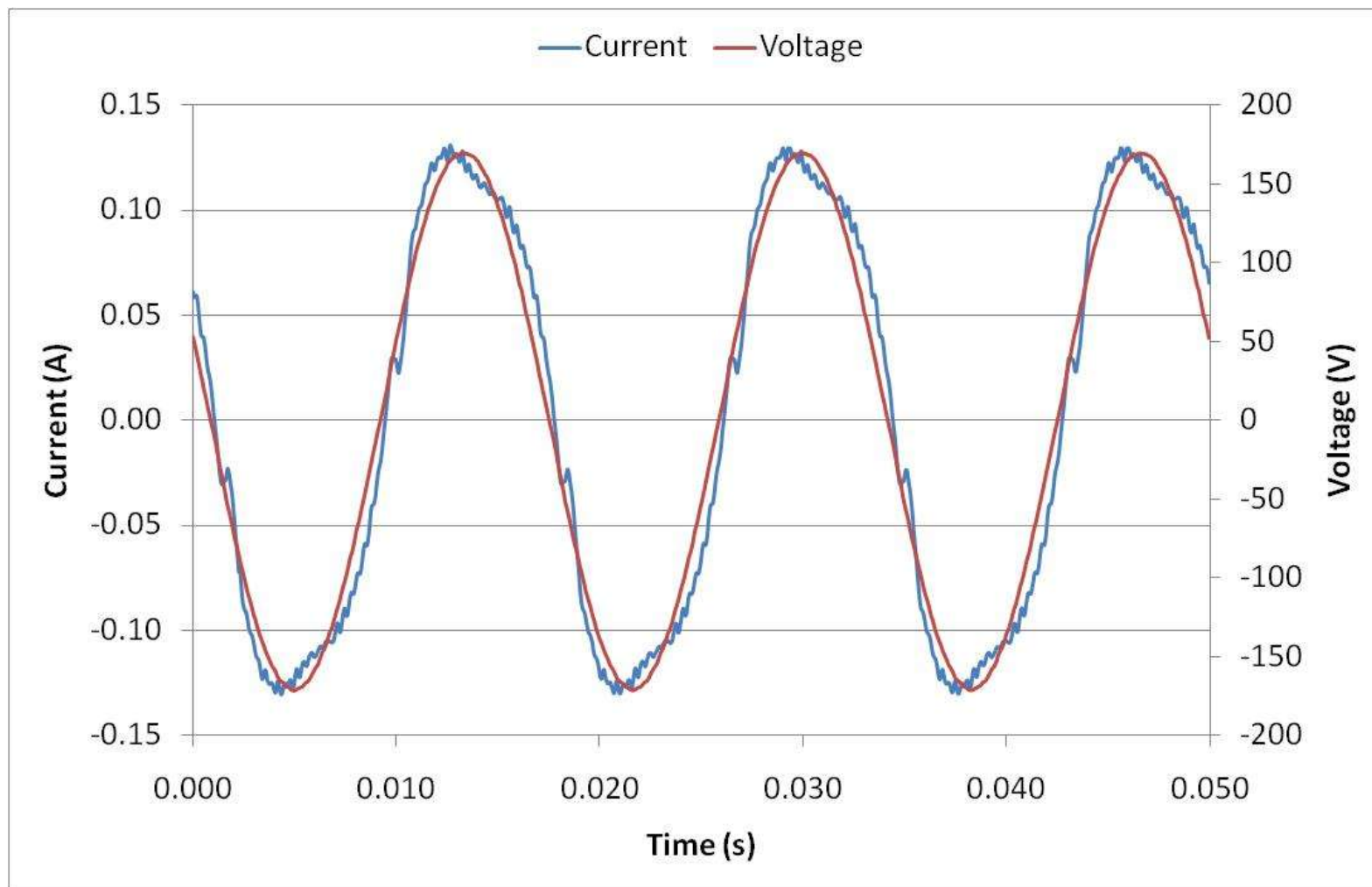
Crest Factor
1.417

Sine wave
1.414

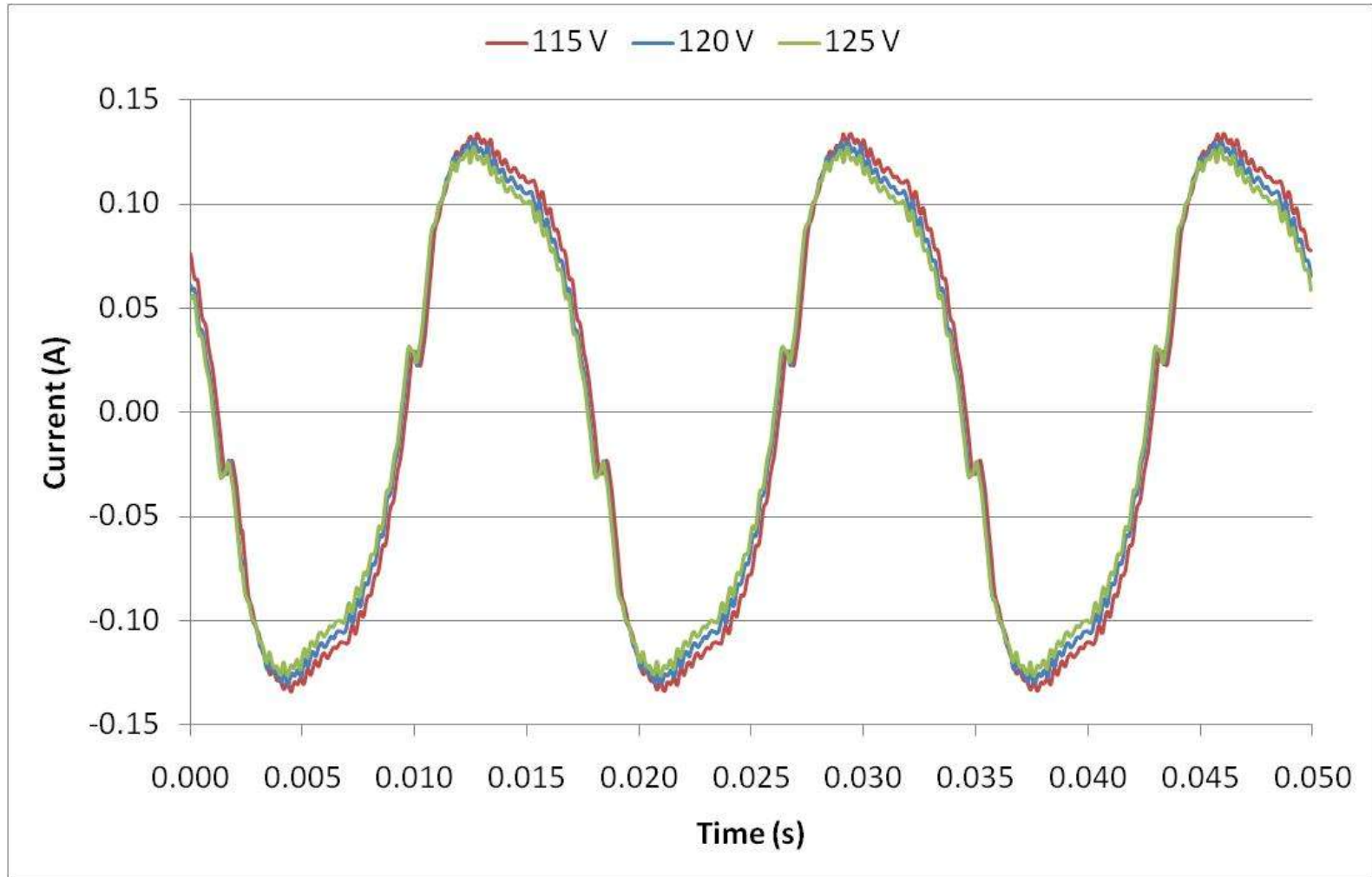
rms - root mean square

true – integration of $V \cdot A$

SSL-1 Measurements



SSL-1 Voltage Dependence

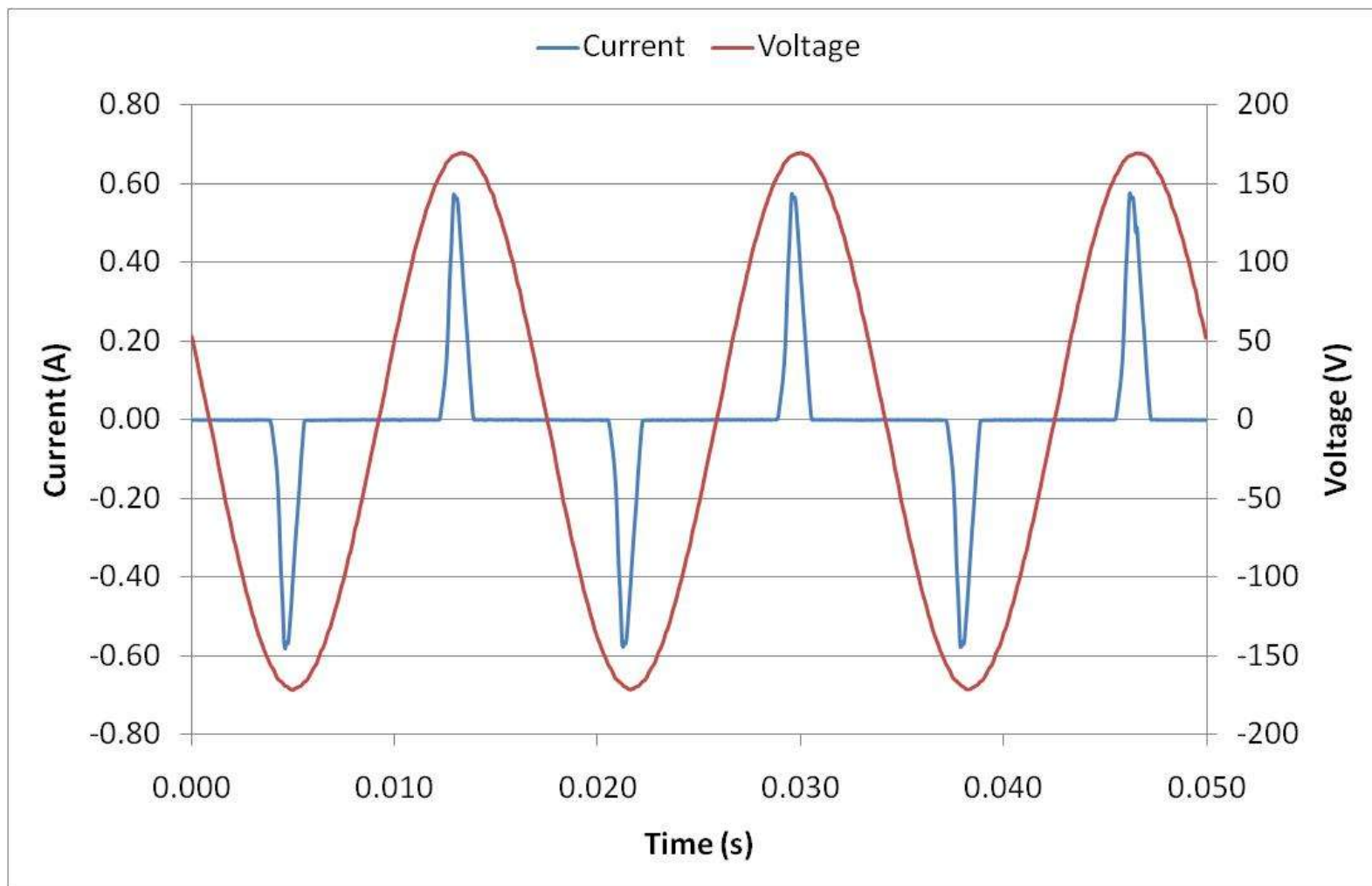


SSL-1 Electrical Time Dependence

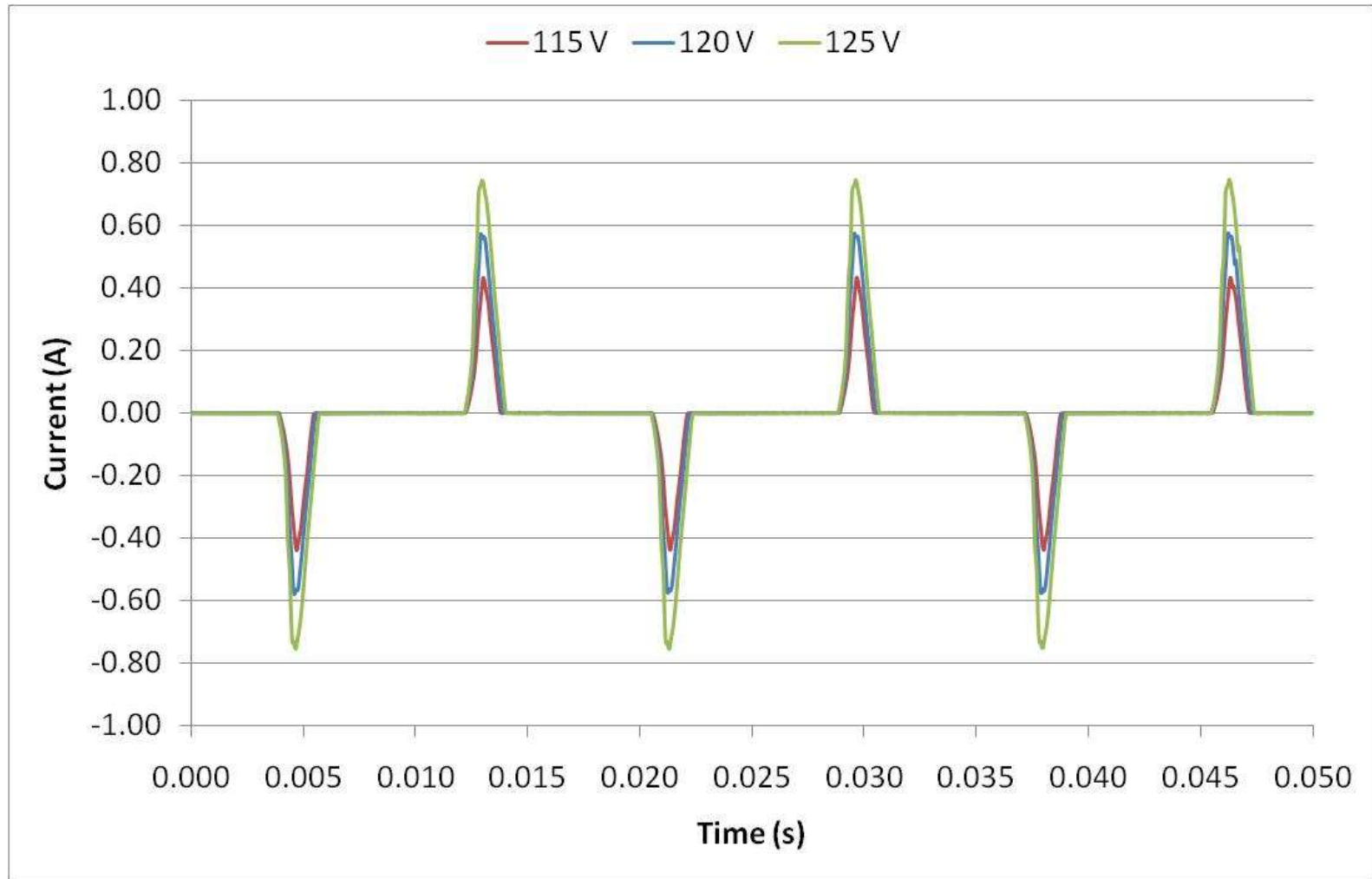
Time	AC [Ω]	Real [Ω]	Imag. [Ω]	PF	THD i	THD v	Voltage	Current	Wattage
0	1370	1320	-378	0.961	12.0	0.08	120	0.0872	10.05
13	1340	1290	-366	0.962	13.8	0.08	120	0.0895	10.33
25	1330	1280	-363	0.962	14.2	0.09	120	0.0903	10.43
40	1325	1270	-362	0.962	14.6	0.09	120	0.0906	10.47
55	1322	1270	-361	0.962	14.8	0.09	120	0.0908	10.48
75	1320	1270	-361	0.962	14.8	0.09	120	0.0909	10.50

	AC [Ω]	Real [Ω]	Imag. [Ω]	PF	THD i	THD v	Voltage	Current	Wattage
1 ohm	1320	1270	-361	0.962	14.8	0.09	120	0.0909	10.50
10 ohm	1320	1270	-361	0.962	14.8	0.16	120	0.0909	10.50

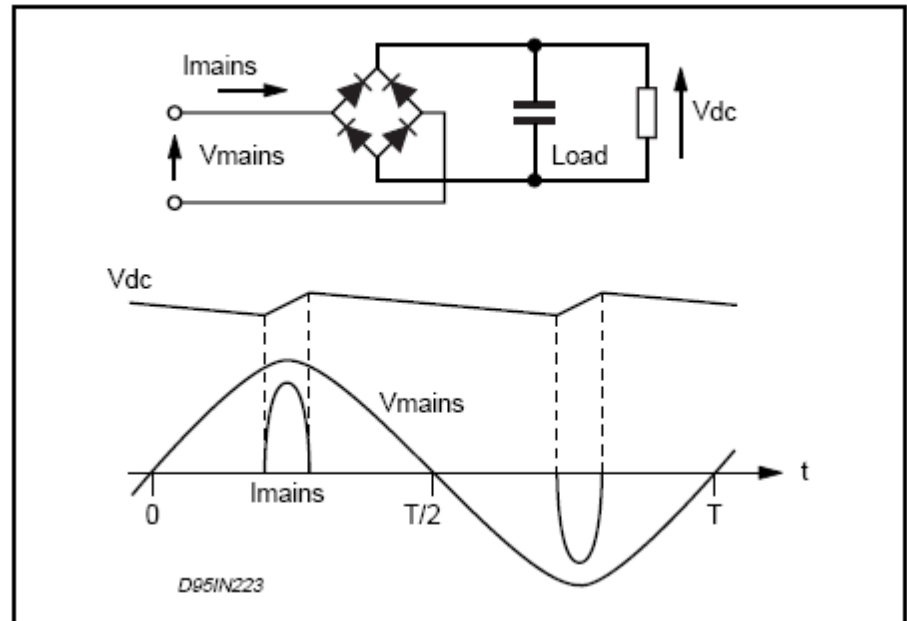
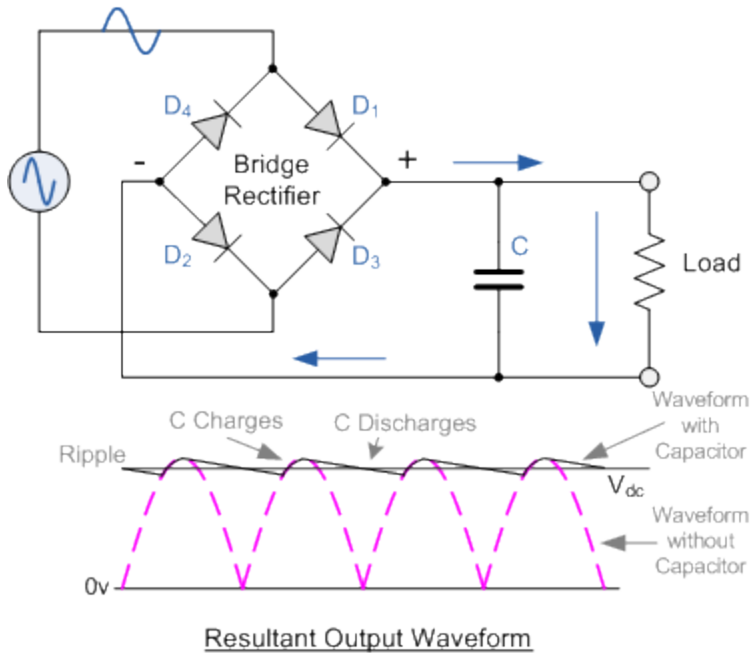
SSL-2 Oscilloscope Measurements



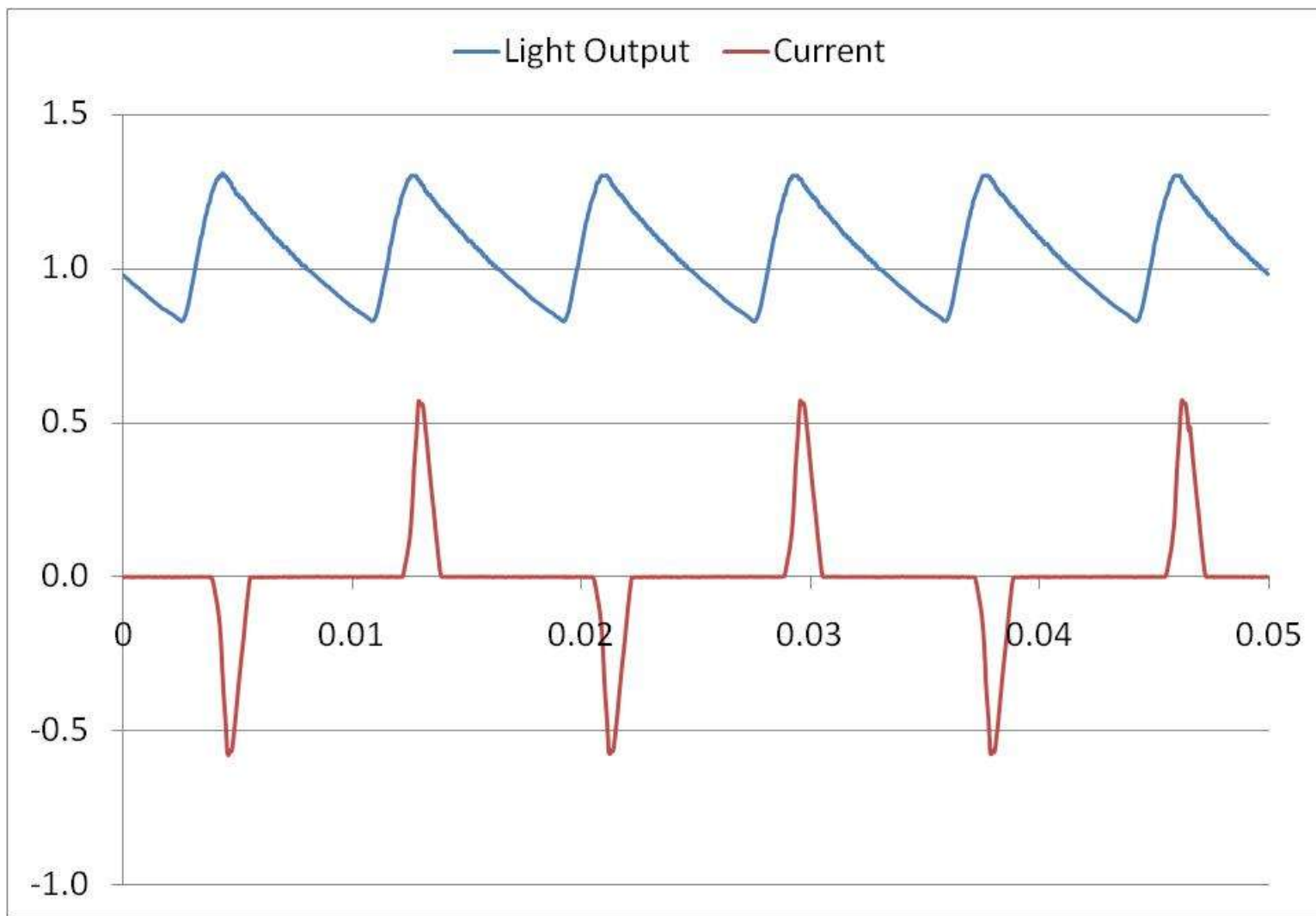
SSL-2 Voltage Dependence



Literature Search



SSL-2 Light Output



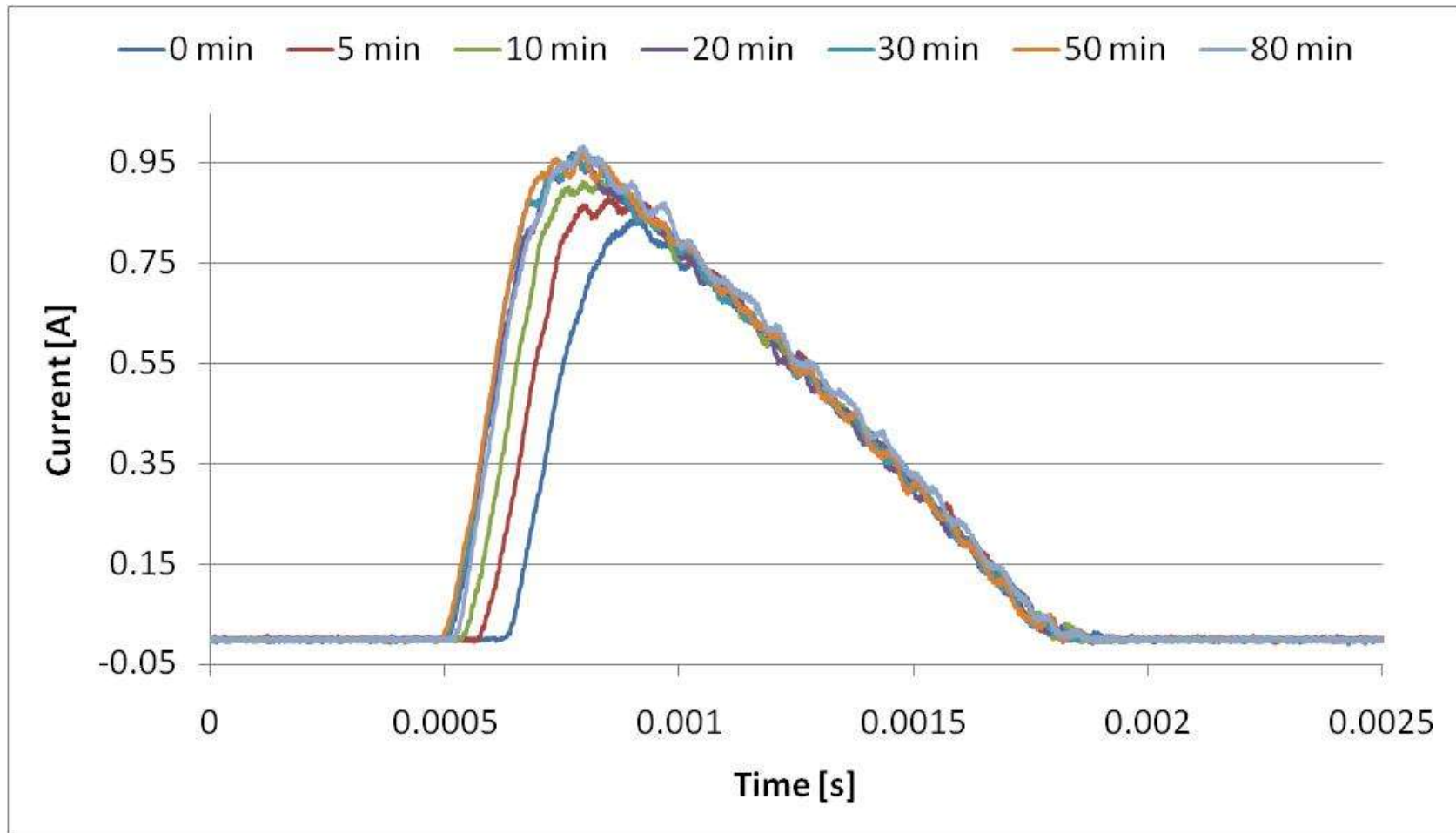
Time constant

Integration time

SSL-2 Electrical Time Dependence

Time	AC [Ω]	Real [Ω]	Imag. [Ω]	PF	THD i	THD v	Voltage	Current	Wattage	Efficacy
0	600	273	-536	0.456	190	0.30	120	0.198	10.86	30.5
5	556	258	-493	0.463	185	0.32	120	0.214	11.93	28.4
10	527	247	-465	0.468	183	0.38	120	0.226	12.76	26.8
20	510	240	-452	0.471	181	0.42	120	0.235	13.29	25.8
30	503	237	-444	0.472	180	0.40	120	0.237	13.52	25.4
50	499	236	-439	0.473	180	0.34	120	0.239	13.65	25.2
80	498	236	-438	0.473	179	0.34	120	0.241	13.70	25.1

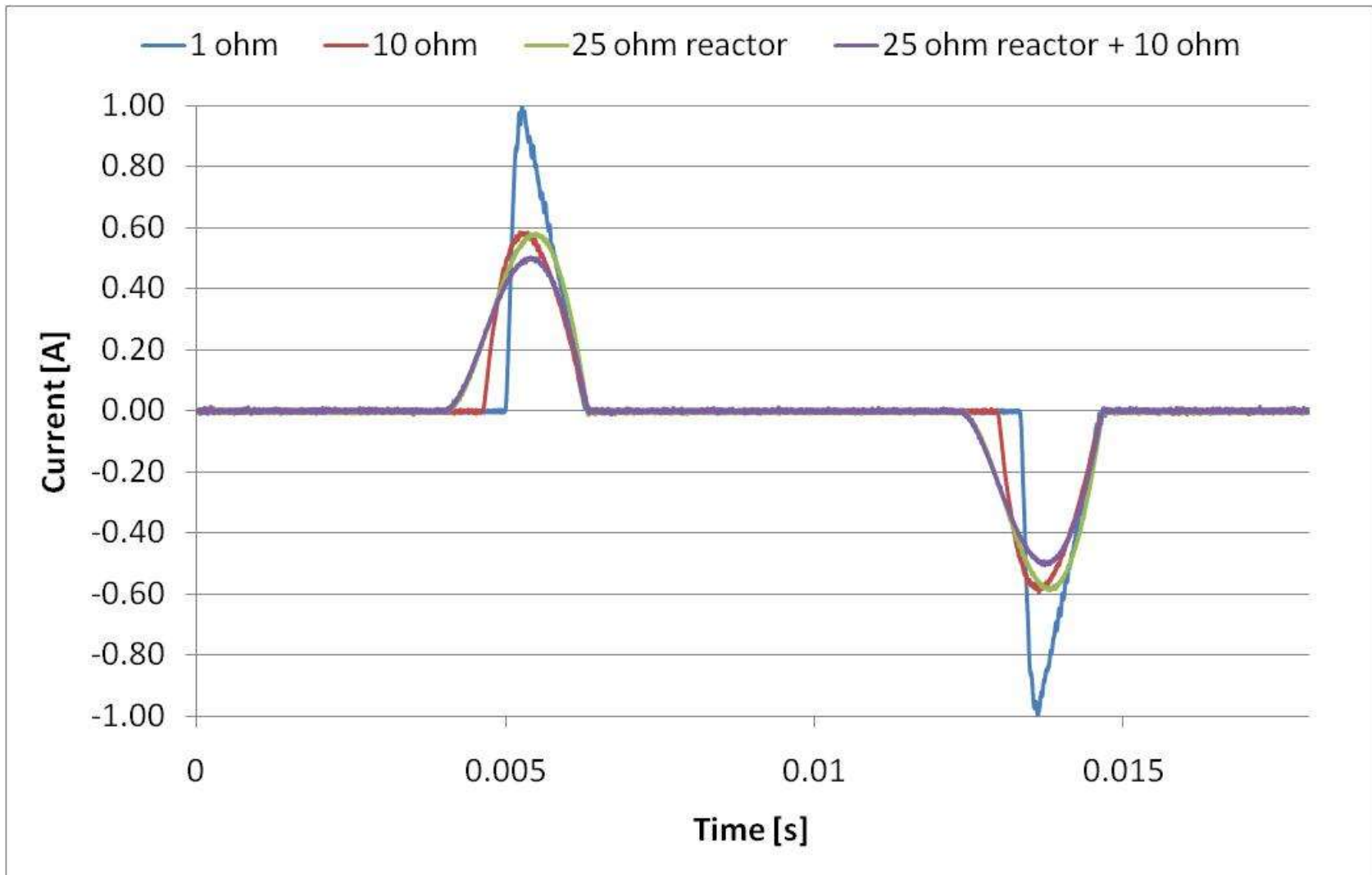
SSL-2 Current Waveshape



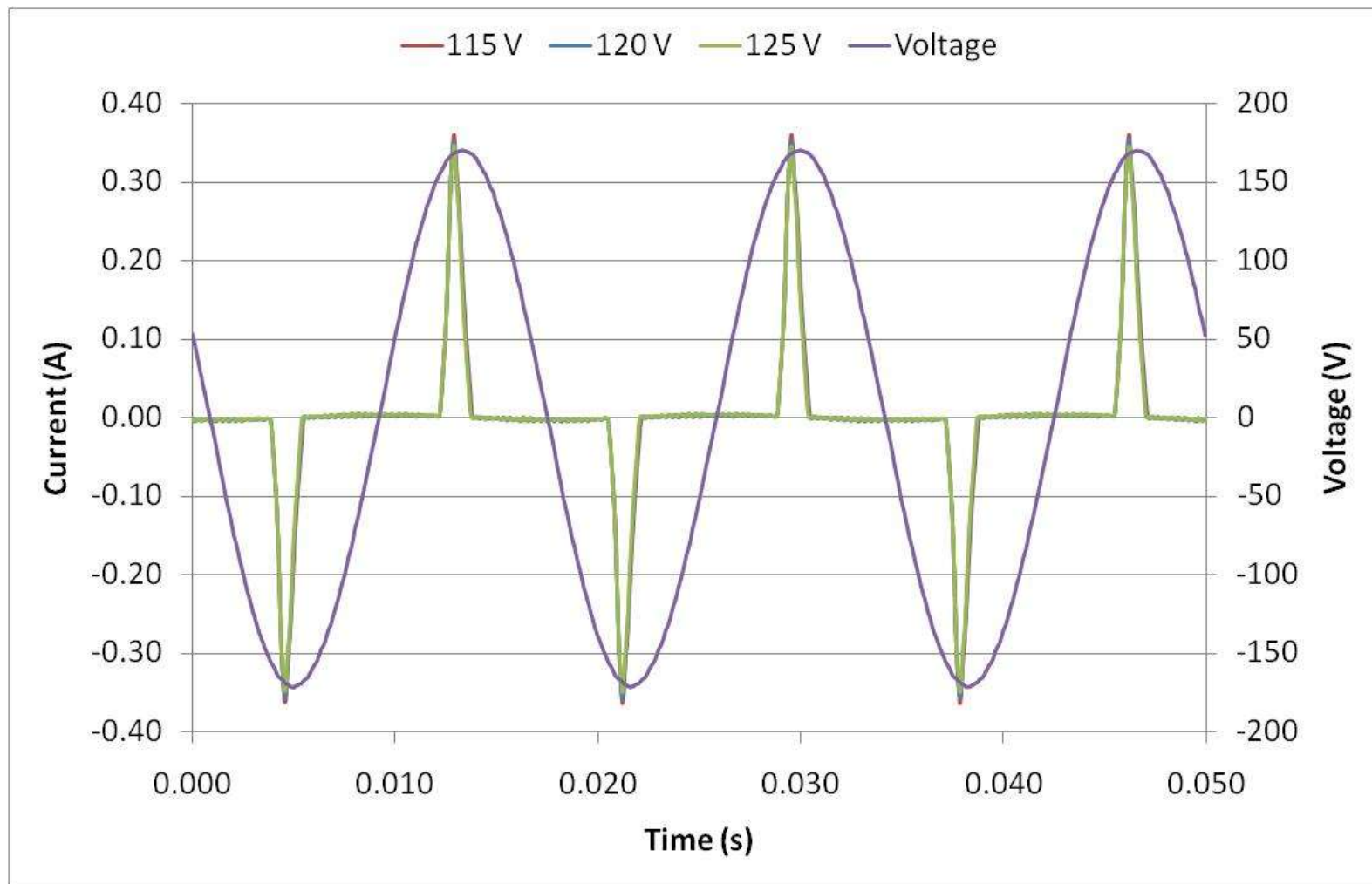
SSL-2 Supply Impedance Dependence

	AC [Ω]	Real [Ω]	Imag. [Ω]	PF	THD i [%]	THD v [%]	Volt	Current	Wattage	Efficacy
No resistor	477	218	-424	0.458	186	0.18	120	0.252	13.86	25.0
1 Ω	496	234	-438	0.472	179	0.32	120	0.242	13.70	25.1
10 Ω	641	355	-534	0.554	144	1.5	120	0.187	12.45	26.1
25 Ω reactor	594	369	465	0.621	124	3.9	120	0.202	15.00	24.1
25 Ω reactor + 10 Ω (27 Ω)	678	423	530	0.623	121	3.6	120	0.177	13.30	25.4

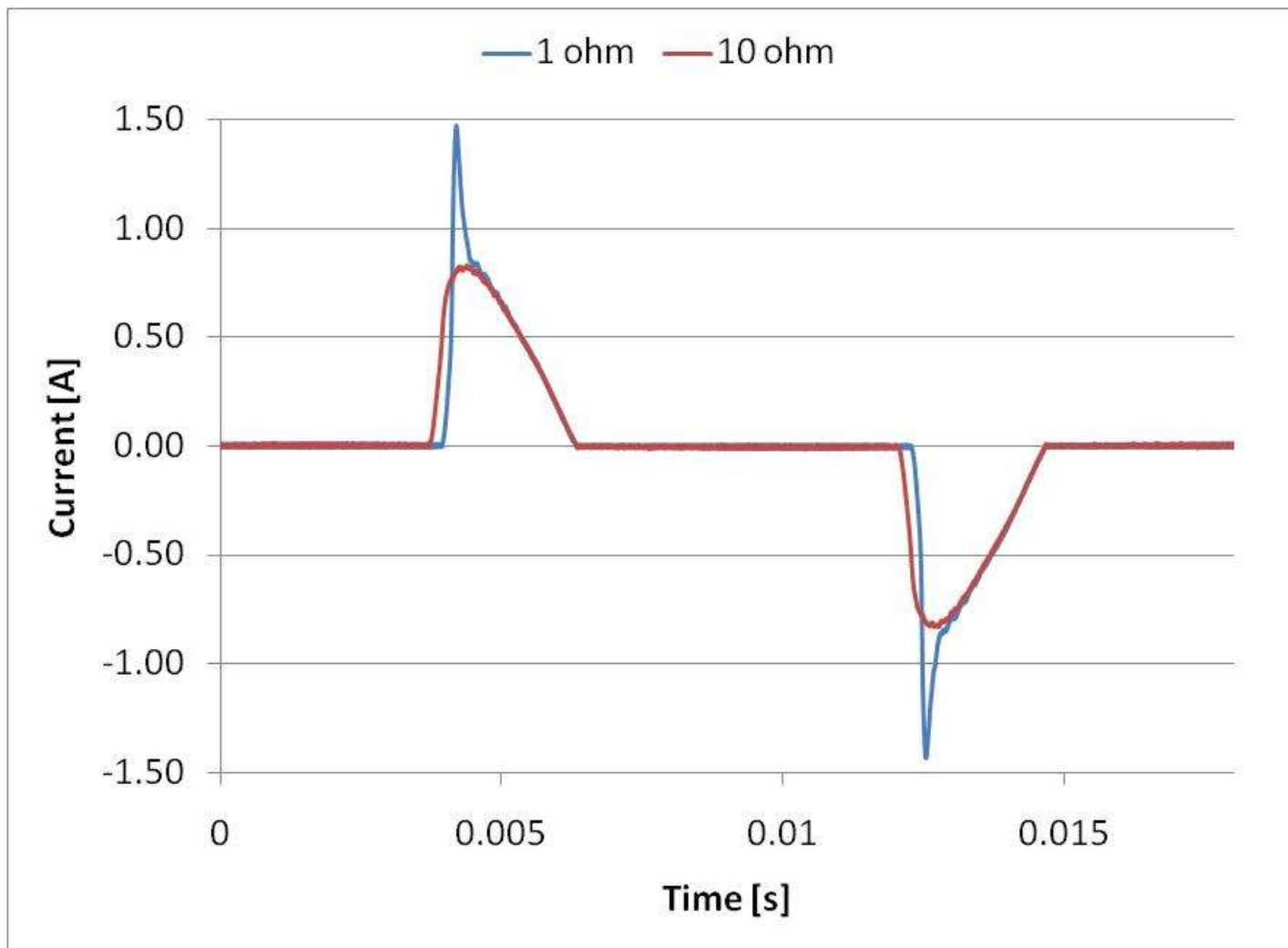
SSL-2 Impedance Waveshape Dependence



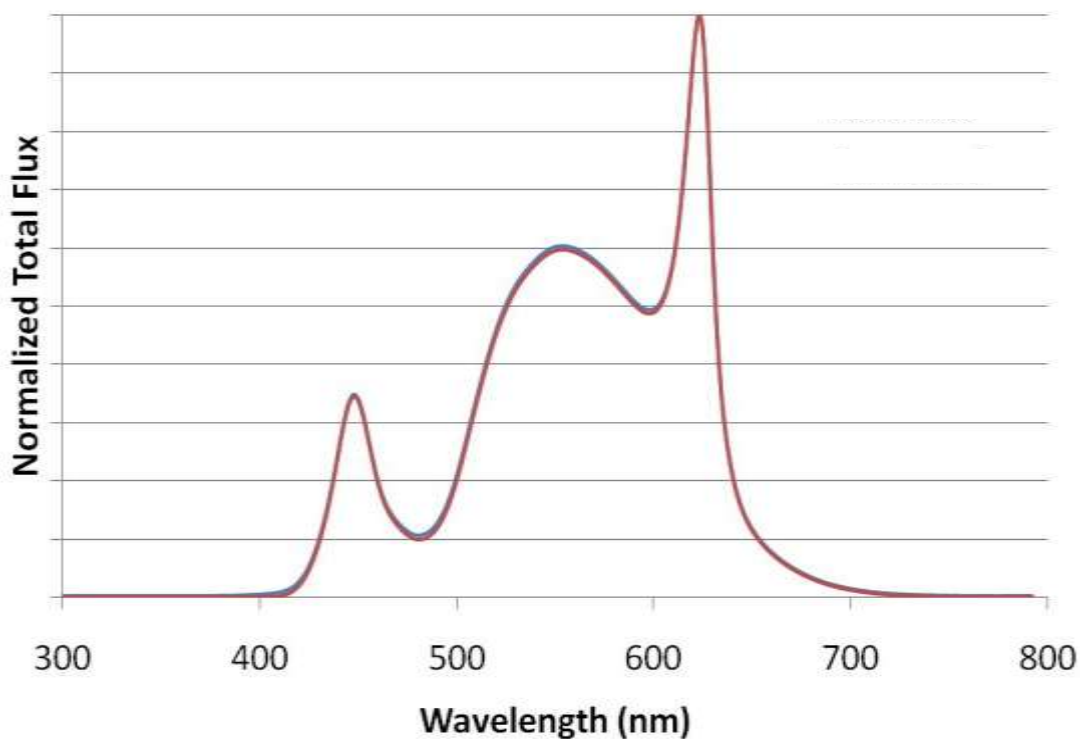
SSL-3 Voltage Dependence



Compact Fluorescent Lamp



Feedback Oddities



	Voltage [volts]	Current [amps]	Power [watts]	Flux [lumens]	Efficacy [lpw]	Color [x]	Color [y]	CCT [K]	Color Rend [Ra]
Aux on	120	0.0974	11.33	680.6	60.06	0.4120	0.3924	3371	92.4
Aux off	120	0.0957	11.12	678.5	61.02	0.4058	0.3927	3505	90.8

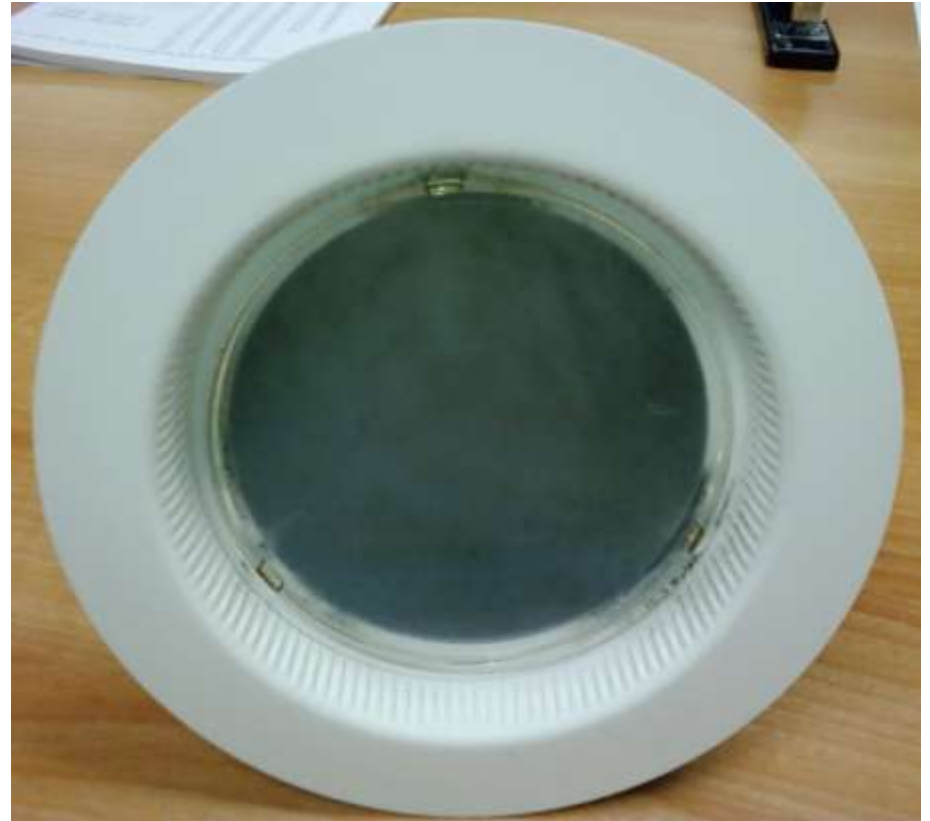
Inrush Oddities



17 A peak current draw

Zero phase power supply

More Oddities



Thank you for your time and questions