PS-40A-1 AC Bench Power Supply

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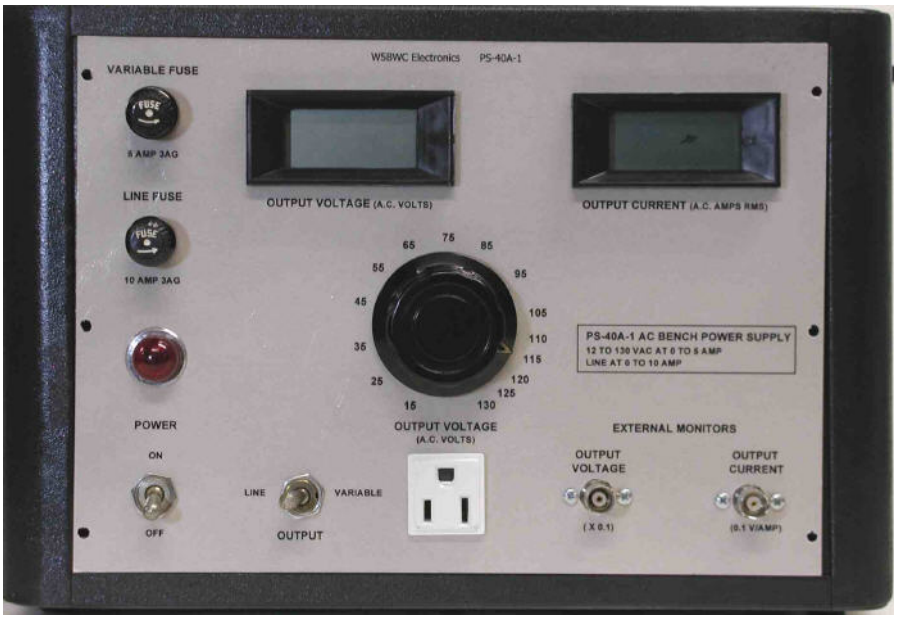


PS-40A-1

Bench power supply capable of direct line or 12 to 130 VAC variable output. Fused output at 10 A for line and 5 A for variable output. Includes voltage and current displays and external monitor outputs.

PS-40A-1 AC Bench Power Supply

Applications

- Intended for bench testing AC powered equipment.
- Variable transformer allows voltage to equipment under test to be brought up slowly.
- Excellent for testing input voltage range over which equipment operates correctly.
- True RMS current meter dedicated to measuring output current.
- With external BNC monitors, the shape of non-RMS current can be measured.
- External monitors are phased correlated for power factor calculations.

Features

- Selection of straight line voltage or variable 12 to 130 VAC output.
- Voltage monitored with high Voltage rectifier and averaged for RMS display.
- Current monitored with true RMS converter for up to 5:1 crest factor.
- External BNC monitors for voltage and current.
- All modes fused with front panel fuses.
- Front panel NEMA 5-15R receptacle

Characteristics

Parameter	Conditions	Value	Notes
Input Voltage	60 Hz	120 VAC	1
Input Current	120 VAC line voltage	10 A maximum	2
Output Voltage	0 to 5 A load current	12 to 130 VAC	1
	0 to 10 A load current	Input line voltage	
Output Current	Variable Voltage Selected	0 to 5 A	1,3
	Line Voltage Selected	0 to 10 A	
Output Voltage	Display	3 ½ Digits	4,5
	Type	Hi-Voltage Rectifier averaged for RMS	
	Accuracy	±0.5%	
	Monitor Point, 50 Ω BNC	± 2%, 1 MΩ Load	
Output Current	Display	3 ½ Digits	
	Type	True RMS Detector	
	Accuracy	± 2% (1.5 to 10 Amps) ± 30 mA (0 to 1.5 Amps)	
	Monitor Point, 50 Ω BNC	± 2% (1.5 to 10 Amps) ± 30 mA (0 to 1.5 Amps)	

Calibration

First, calibrate the Voltage Display . Set the output voltage to 120.0 VAC using an accurate external meter and adjust the calibrate potentiometer on Assy PS40A102. **Use Caution** while performing this step as the adjustment is near T2's slider ring that exposes the output voltage.

Second, calibrate the Voltage Monitor Point using an accurate meter connected to BNC connector J2. Adjust R118 on the PS40A101 printed circuit board assembly for 12.00 VAC with the Output voltage adjusted to 120.0 VAC.

Third, calibrate the Current Display. Ensure the Output Voltage switch, S2 is in the "Variable" position and the Output Voltage is adjusted to 12 VAC. Connect a load to the output that consumes 600 to 1200 Watts at nominal line voltage. Use either an accurate clamp-on or series connected Amp-meter capable of 10 Amps.

Adjust the Output voltage to obtain 2.00 Amp load current. Adjust the calibrate potentiometer on U2 for a display of 2.00. Connect an accurate AC Voltmeter to BNC J3 and adjust R117 on the PS40A101 assembly for 0.200 Volts AC.

Operation

Warning: This line operated AC power supply has internal connections that expose Voltages capable of severe or lethal shock. In this age of low Voltage miniature electronics, do not forget to use **Caution** while working inside this unit.

Normal operation, with the unit enclosed, should pose no risk to the user, other than the fact its' output can be lethal if exposed by external connections.

The Power Switch, S1, applies and removes power to the entire unit including the output connector, J1. The Output Voltage selector switch, S2, selects either straight line Voltage or variable Voltage.

The Output Voltage adjustment is accomplished by the variac, T2, which has approximate Voltage settings on the front panel. The Output is connected to the equipment under test by way of J1, a NEMA 5-15R panel mounted receptacle.

Power-on indicator, I1, will light when S1 is on. If F1 is blown or removed it will not light. I1 is not effected by F2, the Variable Output fuse.

Output Voltage and current are independently monitored by U1 and U2. The Voltage display is an averaged high Voltage rectifier while the current display is a true RMS reading for peak to RMS ratios under 5. This feature is included to improve the current measurement accuracy for poor power factor loads such as rectifier or SCR equipment.

Phase correlated Monitor Points are included for both Voltage and current. Using an oscilloscope, peak amplitudes and phase alignment can be determined.

Theory of operation

The primary use for the PS-40A-1 is to provide either line or variable AC power to equipment under test.

Incoming power is protected by F1, a 10A 3 AG panel mounted fuse and controlled by on/off switch, S1. Output selection is done by S2 for fixed line or variable AC output.

Variac, T2, provides an adjustable Voltage from 0 to 120 VAC (or nominal line Voltage), which is boosted by T1 to 12 to 130 VAC. Note, for low line Voltage the full 130 VAC may not be available under full load conditions. The variable output is protected by F2.

Output Voltage is displayed on U1. D201 and R201 form a high Voltage rectifier with a 33 mS charge time constant. R202 and R203 isolate the DPM from the AC line and along with R204 and R205 scales the nominal 169 VDC rectifier output to 0.1200 VDC for U1, resulting in a displayed reading of 120.0. R205 calibrates the display only.

T3 provides isolation from the AC output for the monitor at J2. R118 is used to calibrate the Monitor Point output.

Output current is displayed on U2. U102 is an RMS to DC converter which along with C105 and C106 provides a DC voltage that is equivalent to the AC Voltage at it's input.

Transformers T3 and T4 are orthogonally mounted to minimize magnetic coupling. C108 removes a residual 1 MHz from the relatively low level at J3's output. This provides a cleaner appearance for scope monitoring. The 1 MHz artifact is from the DC to DC conversion process in U101 and U104.

These micro-current power supplies are required to provide isolated operating power to U1 and U2 which are LCD DPM that cannot monitor their own supply Voltage source.

Power to operate U101 and U104 as well as the remaining circuitry is provided by T101 and the +5.6 and -5.6 VDC zener regulated power supply.

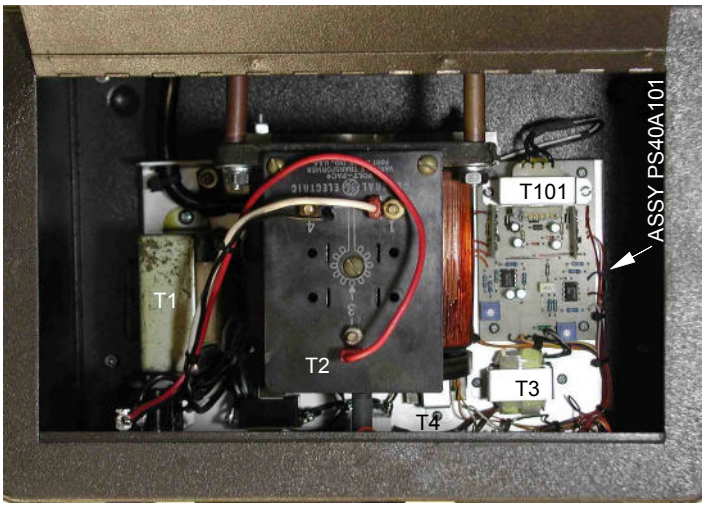


Figure 1. Top view, looking down into steel enclosure. Front panel is at the bottom and the variac, T2, is in the center and assembly PS40A101 is to the right.

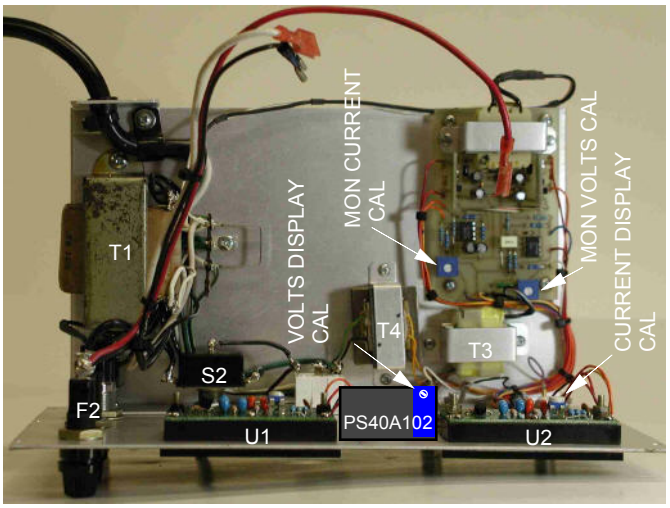


Figure 2. Top view of chassis - removed from the steel enclosure. Note locations of key components and calibration points.

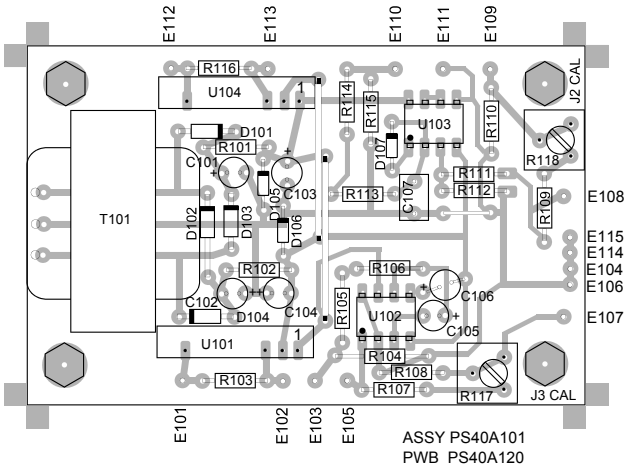


Figure 3. Component locator for assembly PS40A101.

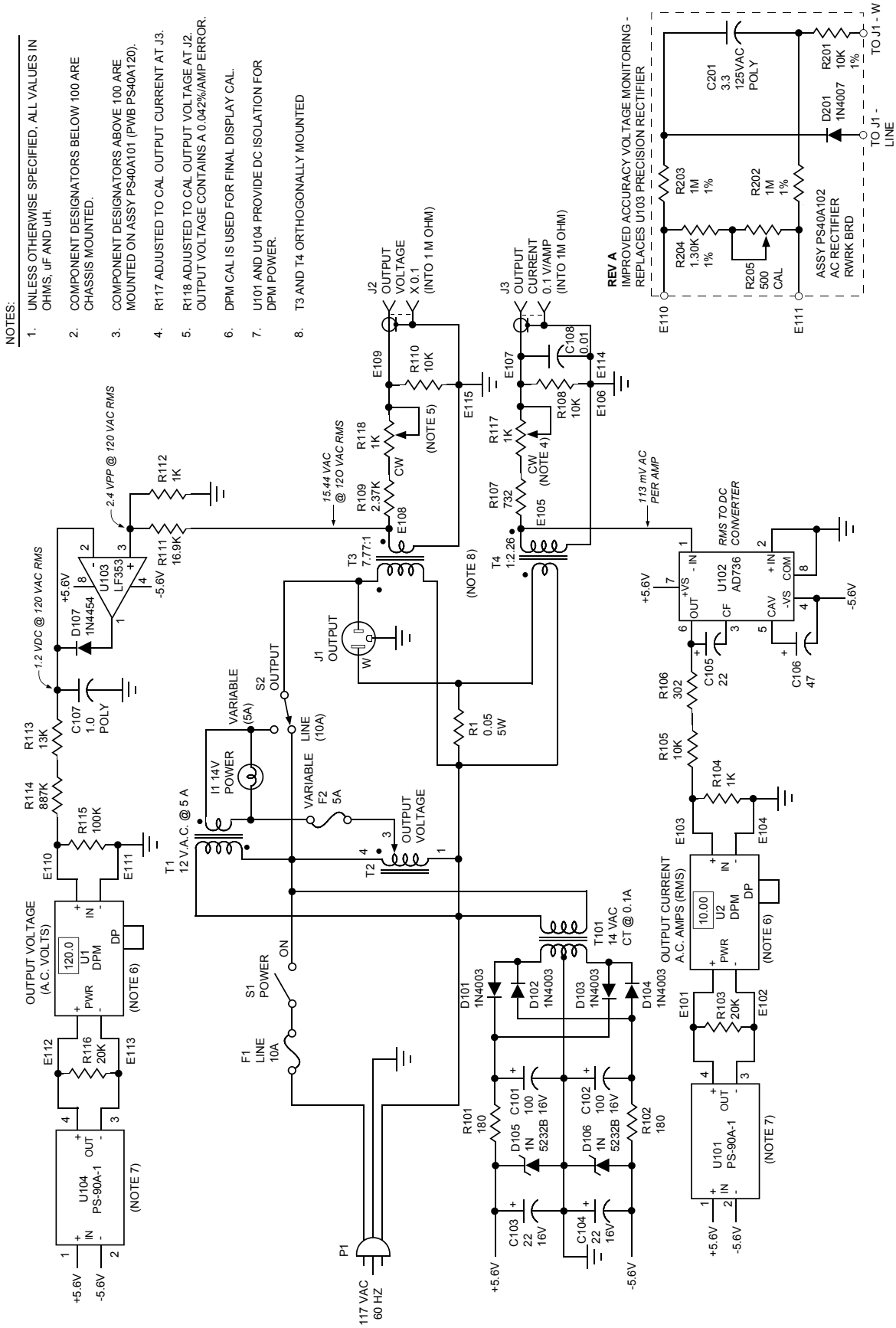


Figure 4. Complete schematic for PS-40A-1.

Material List - PS40A100 Chassis Assembly

Qty	Designator	Value/Type	Description	Part Number*	Supplier
1	C1	0.01 µF, 50V	Disc Ceramic		
1	F1	10A, 250V 3AG	0.25 X 1.25 Fuse		
1	F2	5A, 250V 3AG	0.25 X 1.25 Fuse		
1	I1	14V, 0.33A Bayonet	Type 1815	606-CM1815	MOU
1	J1	Receptacle, 3 prong	NEMA 5-15R		
2	J2, J3	BNC Female, 50 Ω	Bulk-head		
1	P1	SJT Pwr Cord	14 AWG, NEMA 5-15P		
1	R1	0.05 Ω, 5%, 5W	Lo Ind Curr Sense, IRC OAR	66-OAR5R050JLF	MOU
1	S1	SPST 15A, 250V	Toggle Switch		
1	S2	SPDT 15A, 250V	Toggle Switch		
1	T1	12 VAC @ 5A	117 VAC Transformer		
1	T2	5A Variac	117 VAC Variable		
1	T3	7.77:1 Ratio 60 Hz	Isolation Transformer		
1	T4	1:2.26 Ratio 60 Hz	Isolation Transformer		
2	U1, U2	3½ Digit Panel Meter	199.9 mV LCD PM-128		
2	XF1, XF2	¼ X 1 ¼ Fuse Holder	Panel Mount		
1	XI1	T-3 ¼ Min. Bayonet	Panel Mount		
1		Cable Clamp	0.40” I.D. Nylon		
1		Panel Bushing	0.40” I. D. Snap Nylon		
1		1.9” Knob 0.375” Shaft	Black w/ White Pointer		
4		0.625” Rubber Foot	Heavy Duty	534--721	MOU
1		Main Chassis	Shop Built		
1		Pwr Cord Bracket	Shop Built		
1		T2 Bracket	0.25” Al Rt Angle		
1		Front Panel 0.050 Al	Shop Built		
4		0.25” X 0.375” #4 Screw	Hex Standoff		
1		Enclosure	Steel 8X8X12		

* Items without a part number came from Shop stock. Most items are available from Mouser Electronics.

Material List - PS40A101 PWB Assembly

Qty	Designator	Value/Type	Description	Part Number*	Supplier**
2	C101, C102	100 µF, 16 VDC	Radial Aluminum	647-UVZ1C101MDD	
3	C103, C104, C105	22 µF, 16 VDC	Radial Aluminum	647-UVR1C220MDD	
1	C106	47 µF, 16 VDC	Radial Aluminum	647-UVR1C470MDD	
1	C107	1.0 µF, 63 V	Polyester Film	80-R82DC4100DQ60J	
2	D101 - D104	1N4003	1A, 150 V Si Rectifier		
2	D105, D106	1N5232B	5.6 V, 0.5 W Zener	78-1N5232B	
1	D107	1N4454	Si Switching Diode	512-1N4454	
2	R101, R102	180 Ω, 0.25W, 5%	Carbon Film	291-180-RC	
2	R103, R116	20 KΩ, 0.25W, 5%	Carbon Film	291-20K-RC	
2	R104, R112	1 KΩ, 0.25W, 1%	Metal Film	271-1K-RC	
3	R105, R108, R110	10 KΩ, 0.25W, 1%	Metal Film	271-10K-RC	
1	R106	302 Ω, 0.25W, 1%	Metal Film	271-302-RC	
1	R107	732 Ω, 0.25W, 1%	Metal Film	271-732-RC	
1	R109	2.37 KΩ, 0.25W, 1%	Metal Film	271-2.37K-RC	
1	R111	16.9 KΩ, 0.25W, 1%	Metal Film	271-16.9K-RC	
1	R113	13 KΩ, 0.25W, 1%	Metal Film	271-13K-RC	
1	R114	887 KΩ, 0.25W, 1%	Metal Film	271-887K-RC	
1	R115	100 KΩ, 0.25W, 1%	Metal Film	271-100K-RC	
2	R117, R118	1 KΩ, Variable	Cermet Trimmer	625-3386F-1-102LF	
1	T101	14VAC C.T. @ 0.1 A	117 VAC PRI		
2	U101, U104	DC Isolation	Micro Current Supply	PS-90A-1	W5BWC
1	U102	AD736 Analog Devices	RMS to DC Converter		
1	U103	LF353	Dual JFET Op Amp		
		PWB		PS40A120	W5BWC

Material List - PS40A102 Rework Assembly

Qty	Designator	Value/Type	Description	Part Number*	Supplier**
1	C201	3.3µF, 125VAC	Polyester Film		
1	D201	1N4007	1 KV, 1A Si Rectifier		
1	R201	10 KΩ, 0.25W, 1%	Metal Film		
2	R202, R203	1 MΩ, 0.25W, 1%	Metal Film		
1	R204	1.3 KΩ, 0.25W, 1%	Metal Film		
1	R205	500Ω, 0.5W	10 Turn Trimmer		

* Items without a part number came from Shop stock. Most items are available from Mouser Electronics.
** Part numbers are Mouser Electronics unless otherwise noted in Supplier column.

Prototype tests and notes

Voltage Display and Monitor Accuracy				
Output (Volts)	**Display**	**Error** (%)	**Monitor** (Volts)	**Error** (%)
100.0	100.0	0	10.08	+0.80
105.1	105.1	0	10.57	+0.57
110.5	110.5	0	11.09	+0.36
115.5	115.5	0	11.56	+0.09
120.5	120.6	+0.08	12.05	0
125.1	125.2	+0.08	12.48	-0.24
130.3	130.3	0	12.95	-0.61
Error Range	± 0.1 % (tracking) ± 2 % (Composite)		± 1% (tracking) ± 2 % (Composite)	

Current Display and Monitor Accuracy				
Output (Amps)	**Display**	**Error** (%)	**Monitor** (Volts)	**Error** (%)
9.06	9.07	+0.11	0.917	+1.21
4.51	4.51	0	0.453	+0.44
3.48	3.52	+1.15	0.353	+1.44
3.02	3.07	+1.66	0.308	+1.99
2.49	2.53	+1.61	0.253	+1.61
2.00	2.01	+0.50	0.200	0
1.51	1.49	-1.34	0.149	-1.32
1.01	0.98	-3.00	0.098	-2.97
0.50	0.48	-4.00	0.049	-2.00
Error Range	± 2 % (1.5-10 Amps) ± 30 mA (0.5-1.5Amps)		± 2 % (1.5-10Amps) ± 30 mA (0.5-1.5 Amps)	

Voltage and Current monitor points are phase aligned to 0.2 mS out of 16.67 mS for 1.2% which appears to hold within ± 1.5% (± 5 Degrees).

Voltage Display Accuracy During warm-up				
Output (Volts)	**Display**	**Error** (Volts)	**Elapsed Time** (Hrs:Mins)	**Error** (%)
121.2	123.1	+1.9	0	+1.6
122.8	124.5	+1.7	0:42	+1.4
122.3	123.6	+1.3	1:00	+1.1
122.0	123.4	+1.4	1:24	+1.1
121.6	122.3	+0.7	2:13	+0.6
120.4	120.8	+0.4	2:20	+0.3
121.6	121.4	-0.2	2:50	-0.2
120.4	120.4	0	3:18	0
120.4	120.1	-0.3	3:35	-0.2
121.3	120.7	-0.6	4:13	-0.5
119.7	119.1	-0.6	4:29	-0.5
119.3	118.6	-0.7	4:48	-0.6
118.9	118.2	-0.7	5:08	-0.6
120.0	119.0	-1.0	8:09	-0.8
121.5	120.6	-0.9	9:10	-0.7
119.3	118.5	-0.8	10:00	-0.7

Note: T3 and T4 have a voltage non-linearity that contributes to the error at the monitor points. T3 actually improves a slight non-linearity in the precision rectifier, but imposes an error on the Voltage Monitor point. Notice the Current Monitor point tracks the Current display within a fraction of a percent, but the error contribution of T4 can be seen when the Current Monitor reading is compared to the actual output current.

T3 also has a considerable warm-up time that effects the Voltage Display and Monitor Point as can be seen from the above data.

After one hour warm-up the contribution of T3 stablizes and supports ± 2 % when the initial calibration is done at 3 hours operation.

T3 and T4 provide isolation for voltage and current measurements, but at the expense of accuracy. The transformers contribute significant inaccuracies in the PS-40A-1. A Triad CSE current transformer might improve T4, but the data sheet is too vague to be sure. T3 may need to be 1:1 115 VAC 2.5 VA type with a 10:1 resistive divider on its primary side. Or 600 Ohm transformers could be used with the line Voltage divided by 100. Also, an RMS converter in place of the precision rectifier would improve harmonic induced errors in Voltage display.

Prototype tests and notes

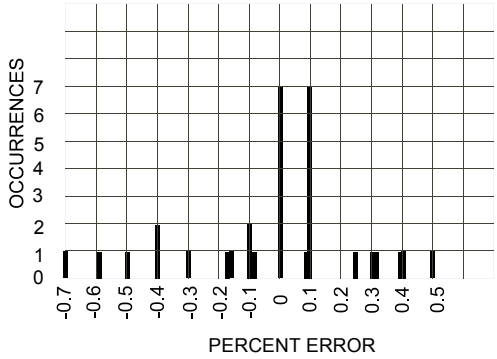
Data for Rev A modification that replaces the precision rectifier with a high Voltage rectifier and isolation resistors for the Voltage Display. The original transformer coupled circuit caused inconsistencies up to ± 2%. As seen by the following data the high voltage rectifier is within ± 0.5% over 90% of the instances that it was checked.

Time	Rdg	Volts	Error	%
9-12-09				
9:40	121.8	120.8	1.0	+0.83
9:56	122.8	121.8	1.0	+0.82
11:00	123.7	122.7	1.0	+0.81
11:17	124.0	123.0	1.0	+0.81
11:18	122.8	122.8	Re-Cal	Re-Cal
11:52	123.3	123.1	-0.2	-0.16
1:27	122.6	122.6	0	0
2:13	122.6	122.6	0	0
3:03	120.7	120.9	-0.2	-0.17
3:15	121.8	121.8	0	0
6:36	122.3	122.3	0	0
7:21	121.7	121.6	+0.1	+0.09
8:28	121.2	120.9	-0.7	-0.58
9-13				
8:50	122.7	122.2	+0.5	+0.41
9:00	122.9	122.5	+0.4	+0.33
9:12	121.8	121.5	+0.3	+0.25
9:37	122.7	122.1	+0.6	+0.49
10:44	120.8	120.5	+0.3	+0.25
11:55	119.9	120.0	-0.1	-0.08
1:15	121.5	121.5	0	0

Time	Rdg	Volts	Error	%
9-14-09				
10:12	122.0	121.9	+0.1	+0.08
11:00	121.8	121.7	+0.1	+0.08
11:48	122.4	122.3	+0.1	+0.08
1:24	121.5	121.4	+0.1	+0.08
9-15-09				
9:55	123.4	123.1	+0.3	+0.24
11:11	122.2	122.1	+0.1	+0.08
3:45	122.3	122.8	-0.5	-0.41
5:08	120.9	121.6	-0.7	-0.58
6:31	121.6	122.0	-0.4	-0.33
6:55	121.6	122.0	-0.4	-0.33
7:37	119.8	119.9	-0.1	-0.08
7:53	121.8	121.7	+0.1	+0.08
9-16-09				
8:24	123.4	123.0	+0.4	+0.33
2:03	122.8	122.8	0	0
6:40	120.7	121.0	-0.3	-0.25
9-17-09				
8:51	123.2	122.8	+0.4	+0.33
9:04	123.2	122.8	+0.4	+0.33
9-18-09				
9:45	123.2	123.2	0	0
10:50	123.8	123.9	-0.1	-0.08
11:50	122.9	122.8	+0.1	+0.08

The distribution of readings taken over several days reveals the following:

Range	Occurrences	% In Range
0 ± 0.1 %	18	51 %
0 ± 0.25 %	21	60 %
0 ± 0.5 %	33	94%



Dynamic Range Accuracy			
Rdg	Volts	Error	%
138.2	138.1	0.1	+0.07
130.1	130.1	0	0
125.2	125.2	0	0
120.2	120.2	0	0
114.9	114.9	0	0
109.1	109.1	0	0
104.8	104.8	0	0
99.4	99.4	0	0
89.9	89.9	0	0
80.1	80.1	0	0
69.3	69.3	0	0
50.3	50.4	-0.1	-0.20
39.5	39.6	-01	-0.25
20.0	20.1	-0.1	-0.50
14.0	14.2	-0.2	-1.43

Notes: For Characteristics (page 2).

1. Input voltage below 120 VAC may not provide 130 VAC output under 5 Amp load.

2. Input current for the PS-40A-1 control circuitry is a fraction of an Amp.

3. Fuses are 5 Amp and 10 Amp. Extended periods at maximum current may cause one or the other to open. Also, R1 is at full rated dissipation at 10 amp.

4. Output Voltage display accuracy based on initial calibration after 3 hours operation.