Oltronix Labpac
B60-1T

Service Manual

SECTION 1

GENERAL DESCRIPTION

A. GENERAL

Oltronix LABPAC B60-1T is a low voltage regulated DC triple power supply. Its 6V range, intended for use with e.g. integrated circuits incorporates an overvoltage protection circuit.

The model number B60-1T is a code for the performance of the power supply. The first letter "B" indicates the approximate stability for ± 10% line voltage change, which is 0,01 - 0,03%.
The figures in the model number state the maximum output voltage 60V at which a maximum output current of 1A can be maintained. "T" after the model number stands for triple range power supply.

B. FEATURES

LABPAC B60-1T is equipped with volt-and ammeter for simultaneous reading of output voltage and current.
LABPAC B60-1T has an adjustable current limit control for protecting the load and the power supply from excessive current. The terminals for operating the power supply are available from the binding posts on the front panel.
If higher voltage or current is desired, two or more units can be connected in series respectively in parallel.

C. INCOMING INSPECTION

a. Mechanical check

When the power supply is received, verify that the package contents are complete and as ordered. Inspect the instrument for any physical damage such as a scratched panel surface, broken knobs or connectors etc. incurred in shipping. Visually check inside the instrument for loose or damaged components. To facilitate possible reshipment, keep the original packing.
If damage is found, file a claim with the responsible carrier or insurance company and refer to the warranty, last page in this manual.

b. Performance check

The power supply may be checked for electrical operation within the specifications of section 2 by following the procedures of section 5. If the instrument does not operate as specified refer to the warranty page of this manual.

SECTION 2

SPECIFICATIONS

Model	DC output			Stability 10 % line voltage change %	Stability 100 % load change mV	Noise mV RMS	Recovery time (0–100 % load) μsec	Environmental temperature range °C	Dimensions height x width x depth mm	Weight kg
	Voltage range	Amperes								
		Short circuit current	Max current							
B60-1T	0–6 0–30 0–60	2.6 1.4 0.7	4.0 2.0 1.0	0.005 % (or 1 mV)	10 mV (or 0.03 %)	0.05	50	0–50	167x132x242	5.0

Input: 110, 117, 220 and 235 VAC ± 10%, 50-60 Hz.
Temperature coefficient is less than ± 100 ppm/°C.
Long term stability is ± 0.02% for 8 hours.
Storage temperature range is -40°C to +70°C.
Output totally floating; positive or negative may be grounded.
Output voltage is adjustable from zero.

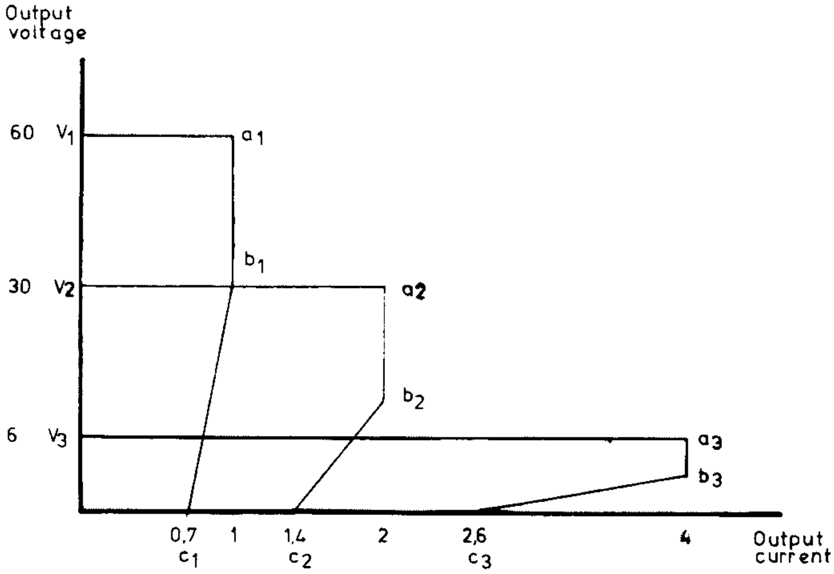


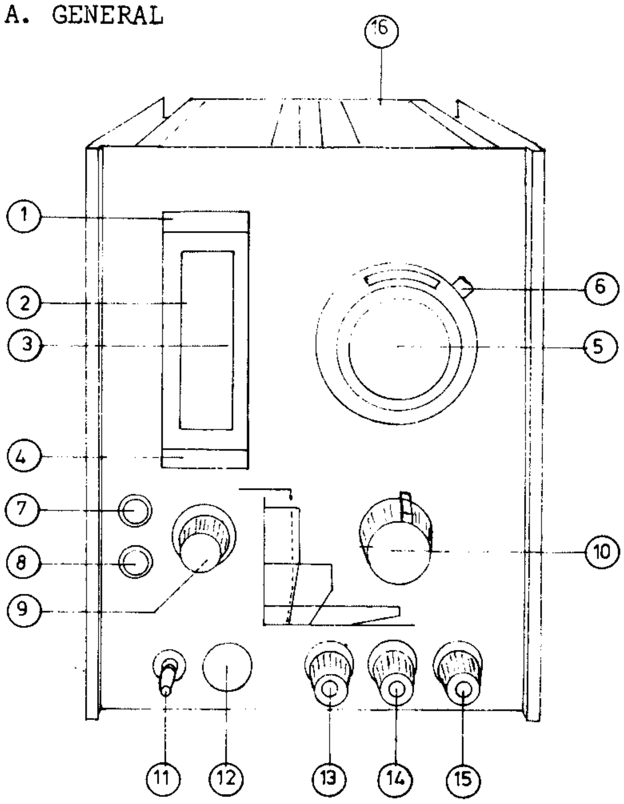
Figure 1. Voltage-current characteristic.

LABPAC B60-1T can deliver any current and voltage within the area limited by the curve V1-a1-b1-c1 in the upper range, or by V2-a2-b2-c2 in the middle range or by V3-a3-b3-c3 in the lower range.
Maximum output current is limited by the factory preset "fold back" current limits b1-c1, b2-c2, and b3-c3.
When increasing the load from a low value, the output voltage remains constant, until the current limit curve is reached.
Then, both output voltage and current fall along the curves b1-c1, b2-c2, or b3-c3, which are factory preset to 10% above the specified values.
Important to note is that maximum available current is decreasing with decreasing output voltage.

SECTION 3

OPERATION

A. GENERAL



Presentation

Figure 2.
Front side of LABPAC B60-1T

1. "Hot" indicating lamp
2. Output DC ammeter
3. Output DC voltmeter
4. Constant voltage -current limit indicator
5. Output voltage control
6. Voltage control lock
7. 7V full scale expansion
8. 0,5 A full scale expansion
9. Current limit control
10. Voltage range selector
11. Line switch, AC only
12. AC fuse
13. DC power "-" terminal
14. Power supply ground terminal
15. DC power "+" terminal
16. Overvoltage protection fuse

Line

Unless otherwise specified, this model is wired for 220 VAC ± 10%, 50-60 Hz. For other line voltages, connect the transformer as indicated on it.

Fuses

The line fuse is mounted on the front panel (pos. 12). For 110 or 117 V lines replace the line fuse for 2 A. Use slow blow type.

The overvoltage protection fuse is located at the rear. (pos. 16) For 110 or 117V lines replace the fuse for 4 A. Use fast blow type.

Power

The power supply is switched on with the toggle switch (pos.11). Either the current limit or the constant voltage indicator is lit.

Voltage

The instrument has three output voltage ranges : 0 - 6V, 0 - 30V and 0 - 60V, which are selected by the four-position switch (pos. 10). The fourth position is an "off" position, to protect the load in case of accidentally switching from 0-6 V to higher range. A specific setting of the voltage control (pos. 5) at middle and upper range (e.g. 25 V) gives the same output voltage at both ranges (25V) and is divided by a factor 10 on the 0-6V range (2,5V).

A specific setting of the voltage in the lower range, e.g. 3V is multiplied by a factor 10 for the middle and upper range, that is 30 V.

Push button marked 7V (pos. 7) is intended for expansion of the monitoring voltmeter range to 7V full scale when selected 0-30V and 0-60V range.

Overvoltage protection

The 0-6 V range includes an overvoltage protection circuit. If for any reason the voltage at the output terminals rises above the selected voltage, the power supply will clamp the voltage to 7 V. As soon as the overvoltage disappears, the output voltage automatically returns to the selected value. For longer transient overvoltages, a thermal sensor turns off the supply and turns on a "HOT" indicating lamp, located over the output meters (pos. 1).

Current limits

Set "Current limit" control (pos. 9) at a value well above the expected peak current, but below the value which could damage the load. Read output current from the ammeter (pos. 2). The characteristics of the current limit are shown in figure 1.
The current limit function is the following: If the load is increased above the value giving maximum output current (upper knee current), both output voltage and output current will decrease. This means that if the instrument is adjusted for 60V in the upper range, it maintains a constant voltage as long as the output current is less than 1 A. If the load resistance decreases from its value down to zero ohms, the voltage decreases naturally to zero and the output current decreases to 0,7 A (upper short circuit current). Figure 1 also shows that, when the power supply is adjusted to 30 V in the middle range, it has an upper knee current of 2 A.

Decreasing the output voltage to zero results finally in an upper short circuit current of 1,4 A. Adjusted to 5 V in the lower range gives an upper knee current of 4 A and when decreasing the output voltage to zero in this range, the upper short circuit decreases to 2,6 A.

Push button marked 0,5 A (pos. 8) is intended for expansion of the monitoring ammeter range to 0,5 A full scale in each range.

Meters

The left part of the combined panel meter is intended for output current indication and the right part for output voltage. Note that the latter has two scale divisions, depending on the range in use.

B. NORMAL OPERATION

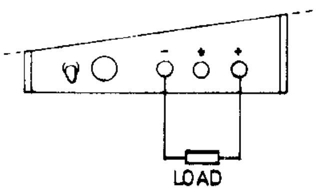


Figure 3.

The output may be positive, negative or floating, depending on how the jumper is connected, i.e. respectively between ground and "-", or between ground and "+" or removed.
The maximum voltage to ground is limited to 500 V.

C. SERIAL OPERATION

If higher output voltage is desired, two or more units can be connected in series, provided the maximum voltage to ground does not exceed 500 V. The output may be positive, negative or floating, depending on how jumpers A and B (figure 4) are connected. Jumper A to ground gives positive output; jumper B to ground gives negative output.

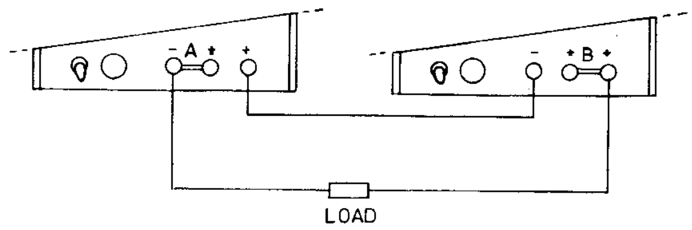


Figure 4.

Set current limit on both units well above the expected peak output current, but below the value that can damage the load.

D. PARALLEL OPERATION

If higher output current is required, two or more units can be connected in parallel.

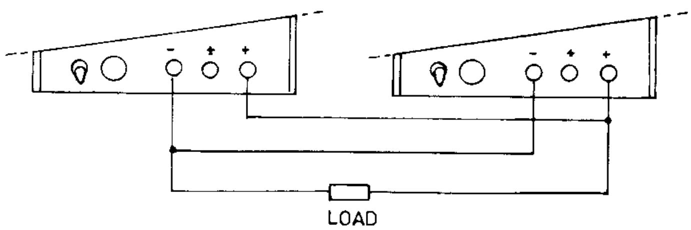


Figure 5.

Adjustment:

1. Set all voltage controls at one desired voltage.
2. Set all current limit controls to approximately the same percentage of maximum and so, that the sum of them is the desired current limit. As there will likely be a small difference between the adjusted voltages the power supplies are adjusted to, the following will happen: as long as the load current is less than the capability of the power supply adjusted to the highest output voltage, this unit will carry the whole load current. When the current limit of this power supply is reached, the next highest adjusted power supply takes over the part of the load current, which power supply no 1 cannot carry. When switching from power supply no 1 to no 2 the output voltage will drop by an amount corresponding to the voltage difference between the settings of these two power supplies. The same thing happens when the third, fourth and so on power supply takes over. Thus a slightly stepwise output voltage will result from any difference between the output voltages of the parallel connected power supplies. It is thus necessary to adjust the power supplies sufficiently accurate so that the incremental voltage steps become negligible.

SECTION 4

CIRCUIT DESCRIPTION

A. GENERAL

This section describes the electrical operation of the circuit.
First the principal operation is described by means of a block diagram.
A detailed description of the block follows. Also refer to the complete diagram, section 6 in this manual.

B. BLOCK DIAGRAM

The complete block diagram of the power supply is shown in figure 6.

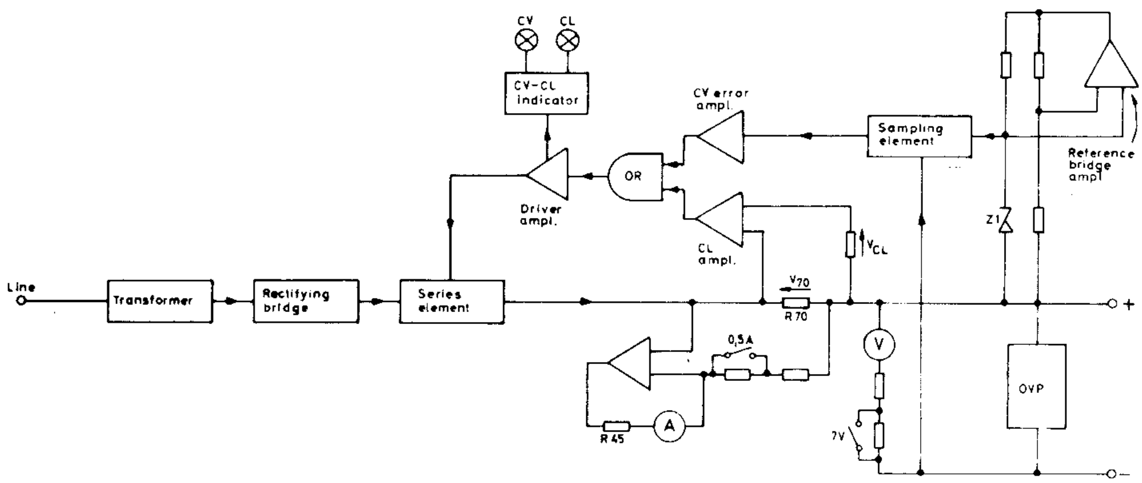


Figure 6. Block diagram

The line delivers power to the transformer, where it is transformed to a suitable voltage. In the block "Rectifying bridge" the voltage from the transformer is rectified. The "Sampling element" is designed so, that the input voltage to the "CV error amplifier" is zero if the output voltage is correct.
If for example the output voltage is lower, the error is amplified in the "CV error amplifier", the "OR-gate" and the "Driver amplifier". The phase angle of this chain is such that the "Series element" is controlled to decrease the voltage across itself. As this happens, the output voltage returns to its correct value.
To make sure that the output current will never be excessive, the instrument is equipped with a current limit system. The output current is monitored through the resistor R 70. (see also circuit diagram, section 6)
When the voltage across R 70 is higher than the voltage at the wiper arm of P93, the "CL amplifier" comes in through the "OR-gate" and the "Driver amplifier" and controls the "Series element" in such a way that the voltage across R70 does not exceed a predetermined value.
The "Reference bridge" together with the "Reference bridge amplifier" supplies an extremely constant reference voltage across Z1. This circuit also supplies voltages for the other amplifiers in the instrument.

The "CV-CL indicator" monitors in the "OR-gate" if the "CV error amplifier" is controlling output voltage or current.
If the "CV error amplifier" controls the output it implies that the power supply is under constant voltage operating condition and the "CV-CL indicator" lights the CV lamp. Under the other condition the CL lamp is lit.
The OVP circuit senses the 6V output voltage with respect to an internal reference. If this output is above the value, the OVP is set for, it is switched on and the output is shortcircuited. This is made to protect the load in case the panel voltage control is accidentally set to a too high value.

The "Sampling element" consisting of the voltage divider R1 + P1 and P90 is designed so, that the voltage over R1 + P1 becomes exactly identical to the reference voltage if the output voltage has the correct value. This implies that the voltage between the inputs of the "CV error amplifier" T1 + T2 is zero. Should the output voltage e.g. decrease, a positive voltage is applied at the input of the "CV error amplifier". This increases the base current of the series regulator through the "OR-gate" and "Driver amplifier", resulting in a lower voltage drop over the series regulator and the output voltage returns to the correct value.

The "Driver amplifier" increases the voltage and current gains to a sufficient level to control the series regulator. T1 + T2 is a temperature compensated pair and hence should be matched.
P1 is the programming constant (K_p) adjustment. P90 is the output voltage control.
Referring to the circuit diagram (section 6), D1, D2 and R2 form a protection circuit for the "CV error amplifier".
C91 is an AC feed-back, reducing ripple and noise.
T6 together with T7 form the "OR-gate" where T7 is the CV input.
Under CV conditions the CC input of the "OR-gate" is not active as the base of T6 is reversed biased.

C. RECTIFYING CIRCUIT

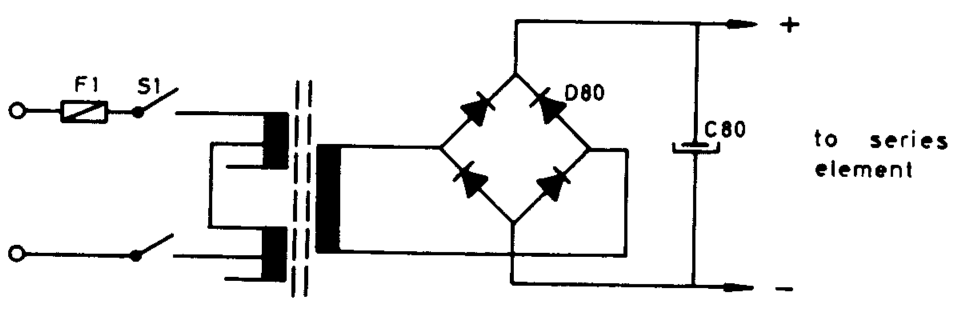


Figure 7.

The rectifying circuit supplies a rectified voltage to the series regulator.

D. REFERENCE CIRCUIT

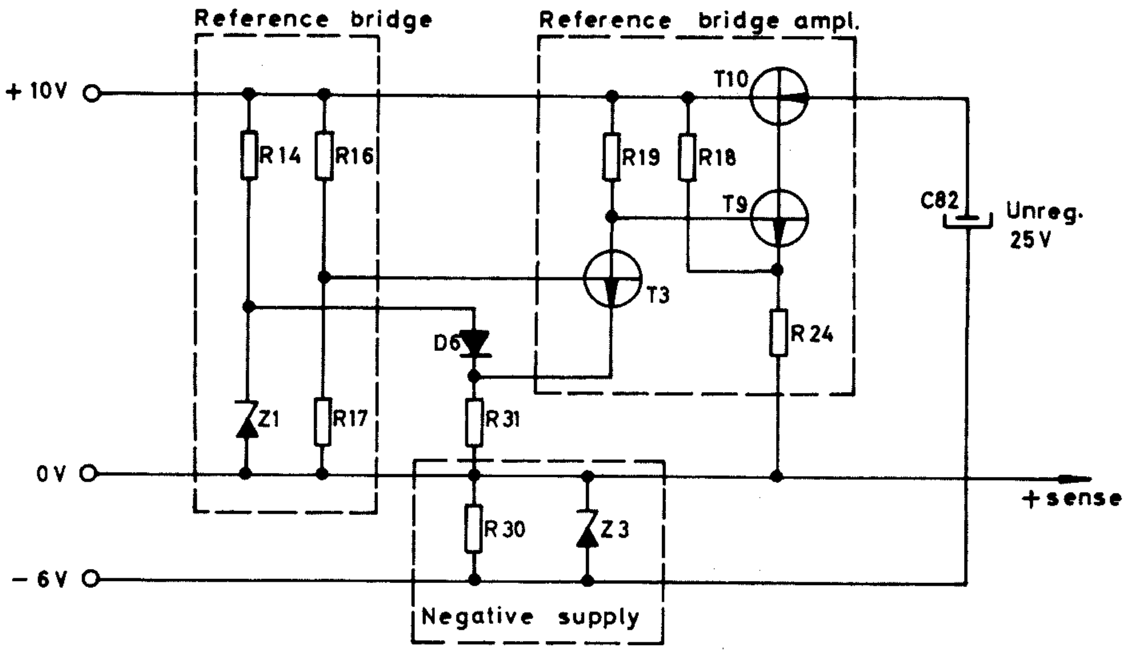


Figure 8. Stabilizer for reference and internal supply voltages

Z1 is a temperature compensated zener diode, which supplies a highly stable reference voltage for the instrument. The "Reference bridge" is stabilized by the "Reference bridge amplifier". This serves two purposes:

1. To supply a stable current to the reference zener diode Z1.
2. To supply a stable voltage (+10V) to other amplifiers.

The "Reference bridge amplifier" consists of a temperature compensated input stage T3 + D6, a driver stage T9 and an output stage T10.
The zener diode Z3 is inserted in the reference supply in order to achieve a negative (-6V) power supply to other amplifiers.

E. VOLTAGE STABILIZING

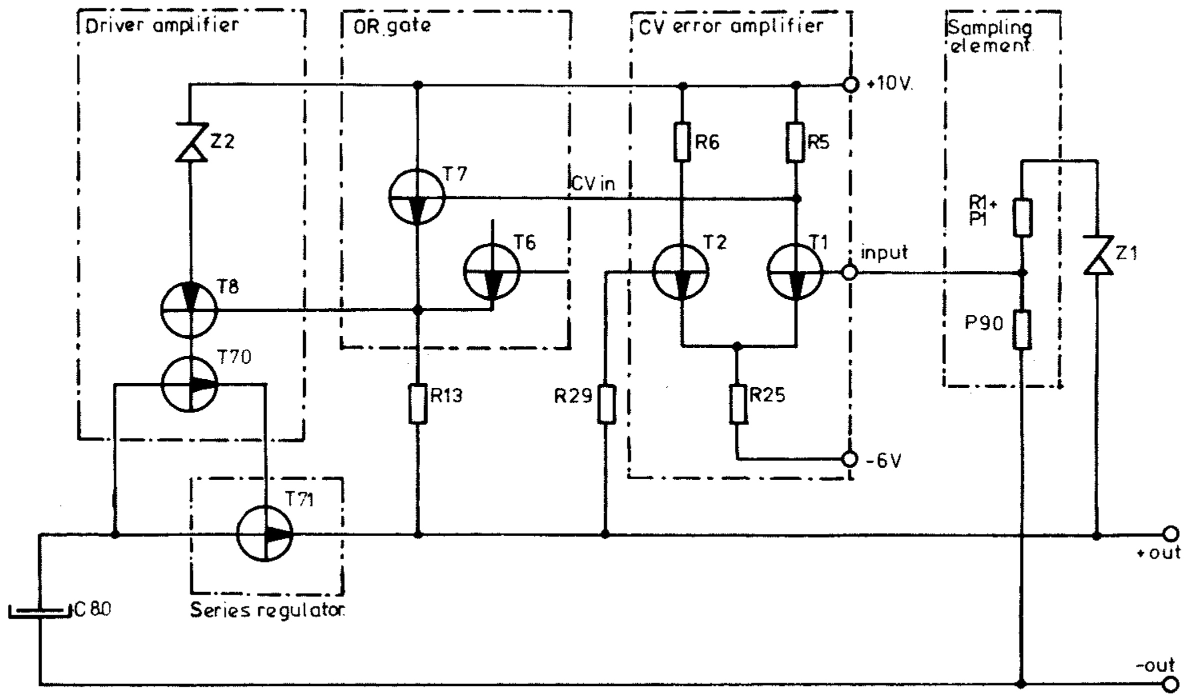


Figure 9. Principle drawing of voltage stabilizing

The "Sampling element" consisting of the voltage divider R1 + P1 and P90 is designed so, that the voltage over R1 + P1 becomes exactly identical to the reference voltage if the output voltage has the correct value. This implies that the voltage between the inputs of the "CV error amplifier" T1 + T2 is zero.

Should the output voltage e.g. decrease, a positive voltage is applied at the input of the "CV error amplifier". This increases the base current of the series regulator through the "OR-gate" and "Driver amplifier", resulting in a lower voltage drop over the series regulator and the output voltage returns to the correct value.

F. CURRENT LIMITING

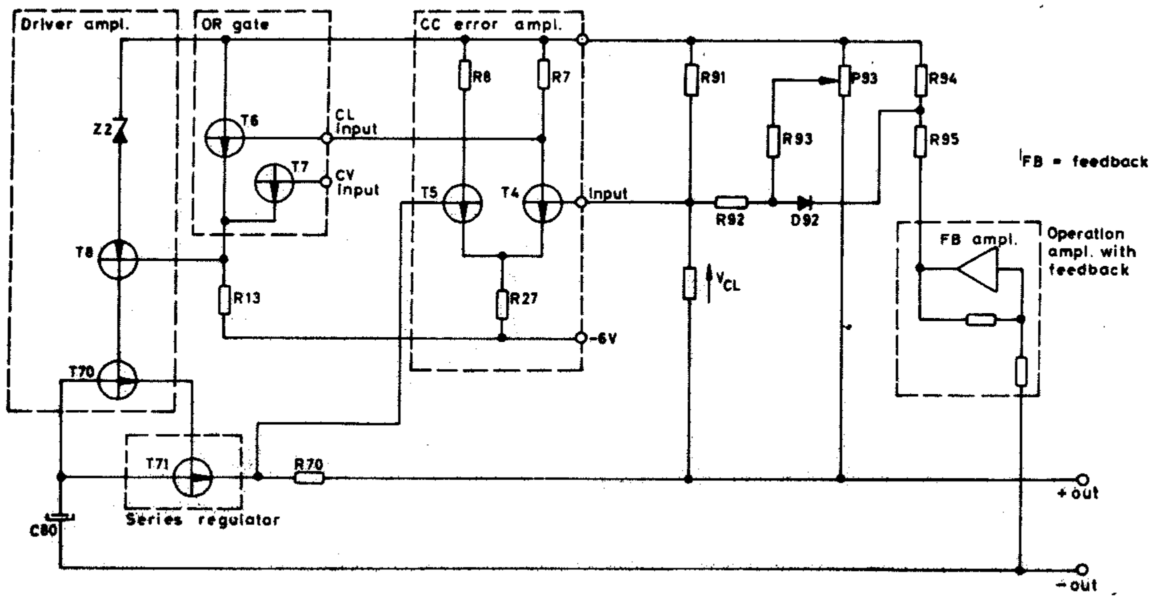


Figure 10. Principle drawing current limiting

The output current passes through the emitter resistors of T 71 a and b where they give voltages proportional to the current through each transistor.
With the resistors R47 and R48 the average of the currents through T 71 a and b is taken. Thus the voltage is proportional to the output current.
R70 is changed with the output range so that 100% current corresponds to an average of 0,5V over the R70's.

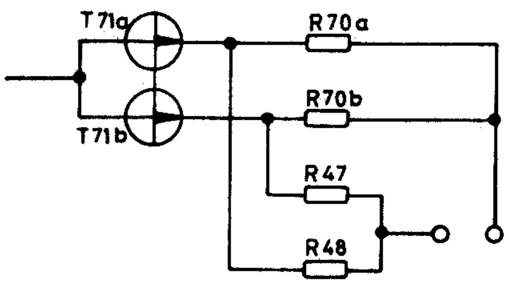


Figure 11

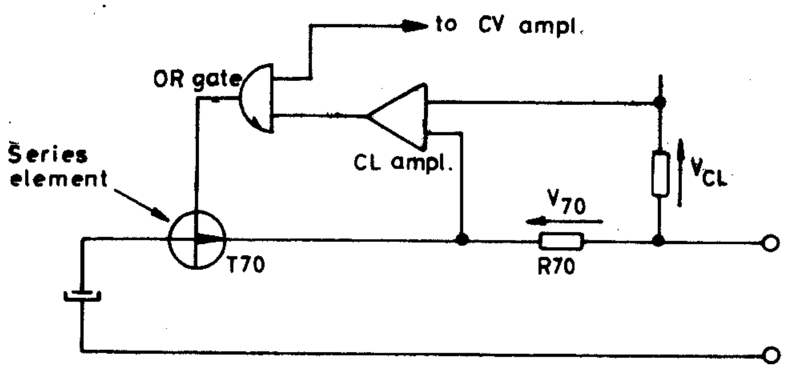


Figure 12

When the output current is low, V_{CL} is greater than V70. The "CL amplifier" is then disconnected by the "OR-gate". If the output current increases, V70 becomes greater than V_{CL}, causing the input to the "CL amplifier" to change polarity. The "CL amplifier" overpowers the "CV amplifier" in the "OR-gate" and controls the series transistors so that the output current is limited to a value resulting in V70 = V_{CL}.
To obtain partly constant current and partly foldback, the desired characteristic would be as shown in figure 13.

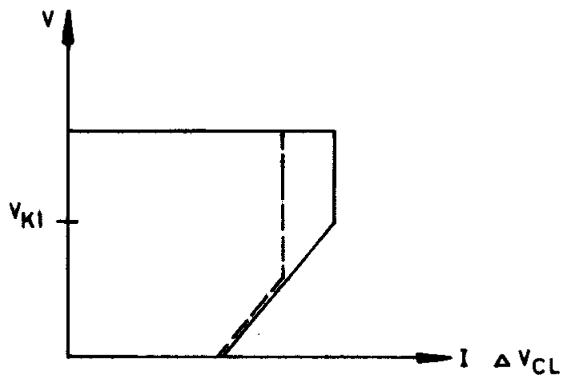


Figure 13.

V_{CL} will be proportional to the output voltage below V_{K1} and constant above it, When the CL control is set below 100% the dotted characteristic is followed.

V_{CL} is composed by two components, one fixed giving the minimum CL determined by R91 and one variable determined by R92, R93 and P93.

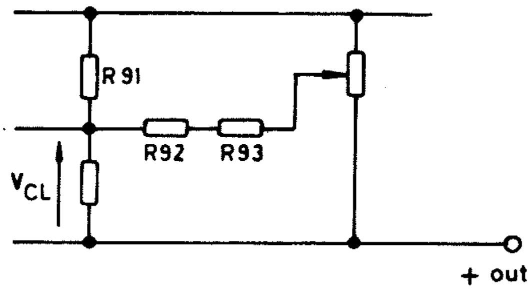


Figure 14.

For output voltages below V_{K1} the variable component must be limited so that the output current cannot exceed the desired characteristic. This is done with an "Operational amplifier" type circuit with feedback in inverting configuration.

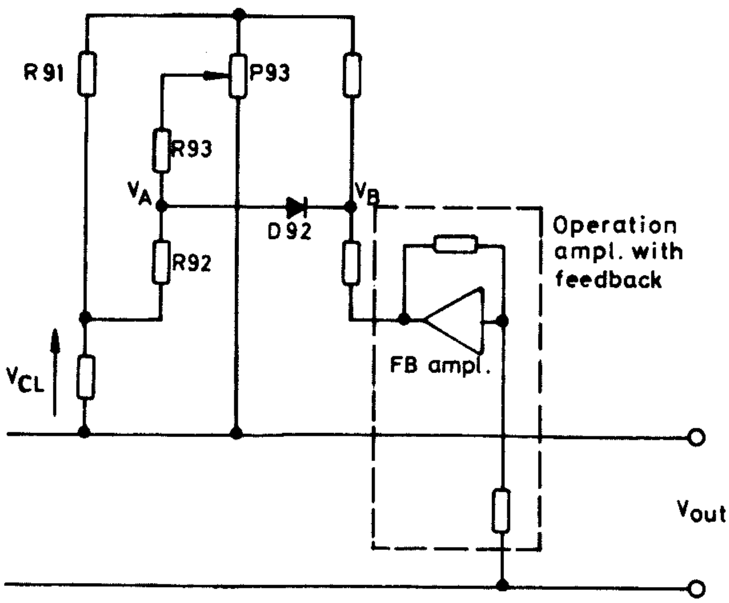


Figure 15.

For high output voltages the "FB amplifier" is overcontrolled so that the output is in positive saturation. Then the "FB amplifier" is disconnected by D92.

At an output voltage above V_{K1}, V_A and V_B have the same voltage if the CL potentiometer P93 is set to maximum. At voltages below V_{K1} the component to V_{CL} from the CL control P93 is limited by the "FB amplifier" to lower values as is shown in figure 15.
The "Operational amplifier" consists of T90 and D93 where D93 is temperature compensation for T90.

G. CV-CL INDICATOR

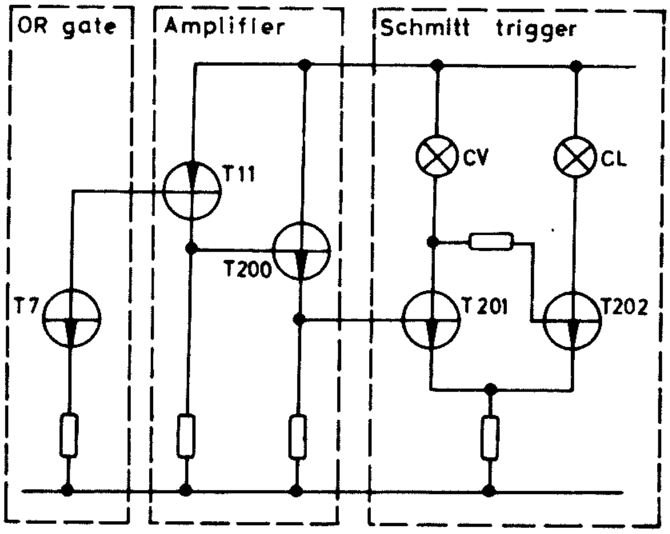


Figure 16. CV-CL indicator

Under CV conditions the transistor T7 in the "OR-gate" is conducting. The collector current of T7 is amplified in the amplifier T11 + T200, giving a positive voltage to the base of T201.
Then the "Schmitt-trigger" switches to the state where the CV lamp is lit. Under CL conditions T7 is not conducting, T201 is switched off and T202 on through the amplifier. The CL lamp is then lit.

H. OVERVOLTAGE PROTECTION

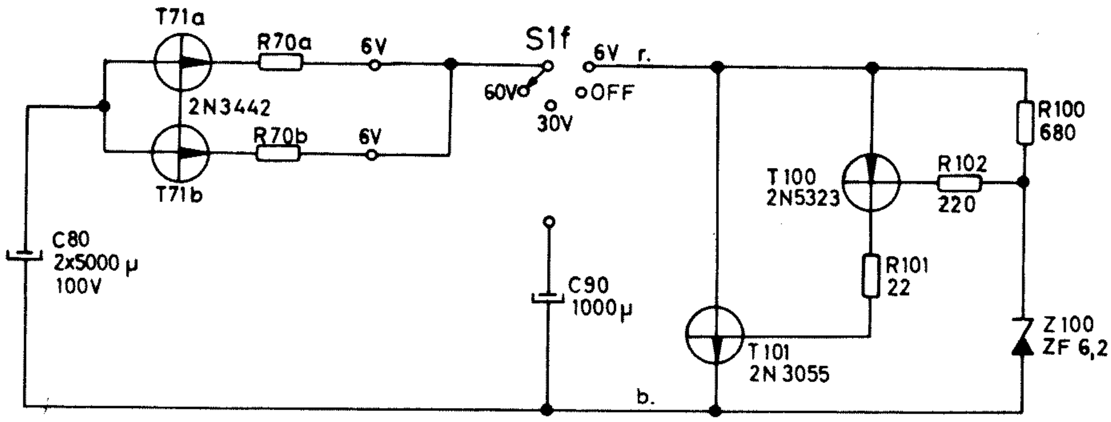


Figure 17. O.V.P.

The "Overvoltage protection" circuit is operative in the 6V range of the power supply. The circuit is designed so that the voltage at the output terminals is limited to 7 volts under an overvoltage condition. When the overvoltage disappears, the output voltage returns to the previously adjusted value.
For longer transients, a thermal sensor turns off the instrument and switches on a "HOT" indicating lamp, located over the output meter on the front panel.

SECTION 5

MAINTENANCE AND CALIBRATION

A. GENERAL

This section contains information on maintenance and adjustment of the Oltronix power supply, LABPAC B60-1T.

This power supply is fully equipped with semi-conductors and under normal operating conditions requires little or no maintenance throughout its life. If any doubt about the function of this power supply arises during maintenance or adjustment, please refer to section 4 for complete circuit description. Switch off the power supply before any component replacement is made.

B. COVER REMOVAL

The cover of this power supply is removed as follows:
1. Turn the instrument upside down.
2. Unscrew the 2 screws which are placed at the power supply bottom near the rear panel.
3. Pull the cover upwards.

C. VISUAL INSPECTION

Inspect the power supply once a year for possible circuit defects. These defects may include e.g. loose or broken connections, broken PC board, or burned components. The cure for most of these faults is obvious but special care must be taken when a burned component is found. This kind of fault often indicates that there is another fault in the circuit as well. It is therefore essential to find out what has caused the actual component to overheat before it is replaced.

D. ALIGNMENT PROCEDURE

All power supplies are completely aligned when delivered from the factory. Though it is unlikely that the power supply will fall out of trim when used under normal operating conditions, the power supply may need re-adjustment in case of component replacement. Information on these tests is given in the following paragraphs a - c. Always perform the alignment in this order.

a. Voltage control adjustment

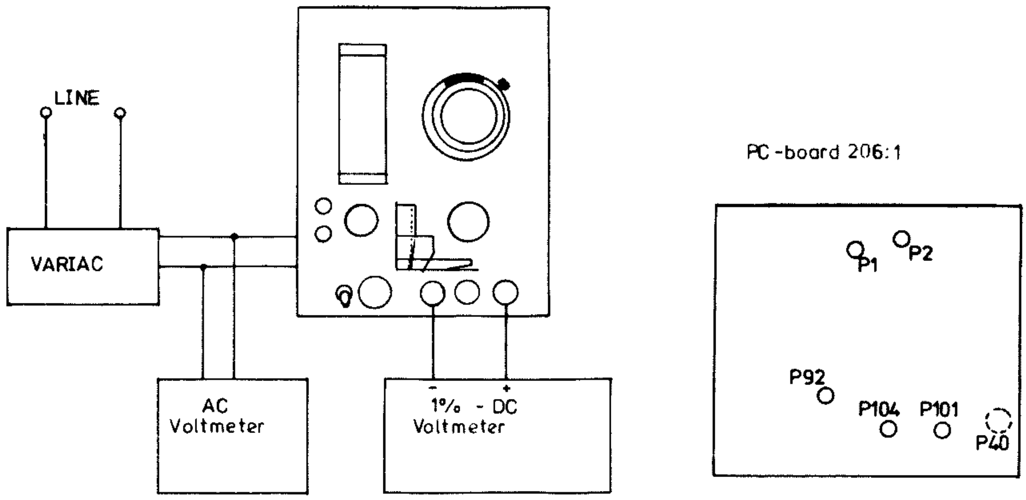


Figure 18.

1. Set variac to 220V.
   Set "Voltage control" P90 (front panel) to 0 and switch S1 (front panel) to range 6V - 4A.
   Measure voltage, which is approx. ± 0,01V. Note polarity! Set voltage control scale to the value measured.

2. Set voltage control scale to 6,0V and adjust voltage with P2 (10K)- PC board to 5,995 - 6,005V.

3. Check that voltmeter indicates 6,0V. If not adjust R98 (6,9K)- PC board. Please note: Current limit is in min. position. Check that OVP stabilizes at approx. 7V. by increasing the voltage (P90) to 7 - 7,5 min. 6,5V and that ammeter indicates a current.

4. Measure the voltage over the whole range 0 - 6,0V in 1V steps. So set voltage control scale to 1,0V and measure the voltage, and so on. Accuracy: ± 25mV.

5. Set switch S1 to 60V - 1A range. Set voltage control scale to 60,0V and adjust voltage with P1 (250) - PC board to 59,95 - 60,05 V.

6. Check that voltmeter indicates 60,0V. If not adjust R89 (63k)- PC board.

7. Measure the voltage over the whole range 0 - 60,0V in 10V steps. So, set voltage control scale to 10,0V and measure the voltage, and so on. Accuracy: ± 250 mV.

8. Set voltage control to 30,0V and set switch S1 to 30V - 2A range. Check that voltmeter indicates 30,0V. If not, adjust R99 (20K)- PC board.

9. Set P92 (10K)- PC board in mid position. Set voltage control to 6,0V.

b. Current limit adjustment

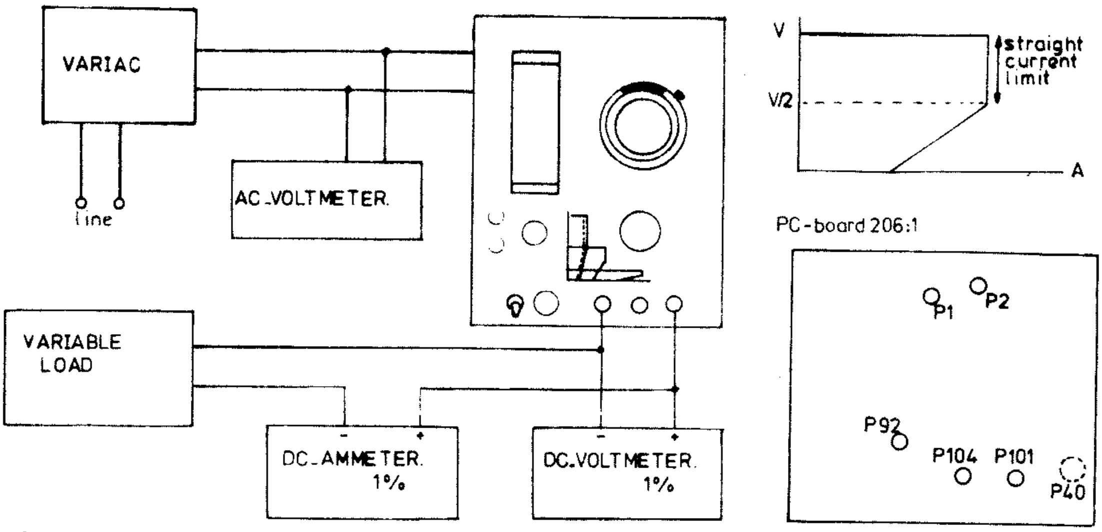


Figure 19.

1. Adjust the variac for 220V. Set "Current limit control" P93 (front panel) to max. position. Set P101 (250) and P104 (100) on PC board to mid position. Make set-up according to above drawing. Adjust R70a and R70b (the pleated resitances) to max. current 4,2 - 4,3 A.

2. Switch off the power supply and calibrate ammeter for zero. Switch on and press 0,5A push button.
Adjust to 0A with P40 (100K)- PC board.
Connect the load (0,5A), press 0,5A and adjust ammeter to 0,5A with P104 (100).
Connect load (4A) and adjust ammeter to 4A with P101 (250).

3. The knee of the current limit is adjusted with P92 (10K)- PC board. Please note: Common for the 3 ranges, switch S1 in pos. 6V-4A. Current limit in max. pos. voltage control at 6,0V. Connect load so that current limit is actuated (max. current 4,2 - 4,3A) and that the voltage falls to 3V. Adjust the current to 4,2A with P92 (10K).

4. Decrease load resistance until the power supply is short-circuited and check that I_K is 2,6 - 2,8A.

5. Set voltage control to 30,0V. Switch S1 in position 30V - 2A. Connect the load.
Adjust R70c and R70d (the pleated resistances) to max. current 2,2 - 2,4A. (Straight current limit to 15V). Check the knee. Load the power supply so that the voltage falls to 15V. Increase the load until shortcircuit and check that I_K = 1,3 - 1,5A.

6. Switch S1 in position 60V - 1A. Set voltage control to 60,0V. Connect the load. Adjust R70e and R70f (the pleated resistances) to max. current 1,1 - 1,2A (Straight current limit to 30V.) Check the knee. Load the power supply so that the voltage falls to 30V. Increase the load until short circuit and check that I_K is 0,65 - 0,75A.

7. Check that current limit P93 is at:
6 V range in min. pos. 0,4A
30V range in min. pos. 0,2A
60V range in min. pos. 0,1A

c. Performance check

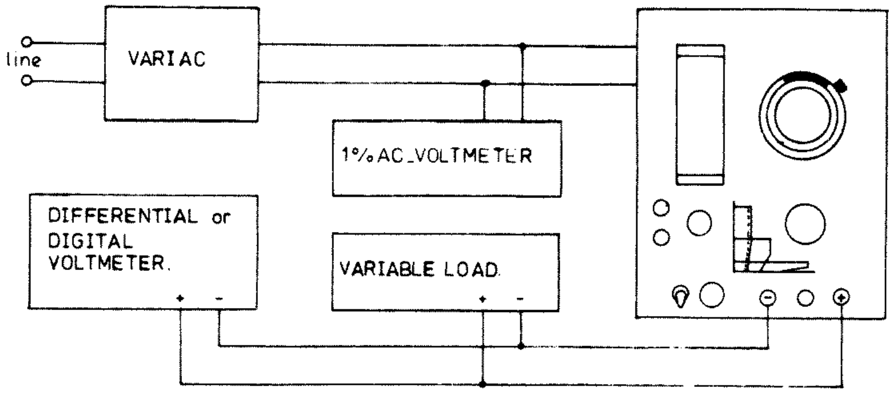


Figure 20.

Prior to all short term performance checks

1. Connect the power supply as shown.
2. Adjust the variac for 220V power. Switch on.
3. Adjust the power supply for a 100% output voltage in the upper voltage range and the load for maximum current of this range.

Load regulation

1. Adjust the variac for 220V power. Read the differential voltmeter.
2. Disconnect the load. Read the differential voltmeter.
3. The difference between these two readings is the load regulation.

Line voltage regulation

1. Adjust the variac for 240V power input. Read the differential voltmeter.
2. Adjust the variac for 200V power input. Read the differential voltmeter.
3. The difference between these two readings divided by a factor 1,8, is the power supply regulation for 10% line voltage variation. (The factor 1,8 is because 200 - 240V is an 18% voltage variation.)

Ripple

1. Connect the load resistor for 100% output current.
2. Measure the output ripple by means of an AC RMS voltmeter connected across the output.

Repeat all performance checks for the middle and lower output voltage ranges.

d. Test points

Test points	Correct value	Remarks
+T70c (BSW 66) to -output terminal +C82 (500 uF) to -C82	2,2V 3,55V	S1 in pos. 6V - 4A. P90 in pos. 3,0V Increase variac slowly 0 to 50VAC
+T70c to -output terminal +C82 to -C82	8,6V 3,55V	S1 in pos. 30V - 2A
+T70c to -output terminal +C82 to -C82	16,0V 3,55V	S1 in pos. 60V - 1A
+T10c (BC1788) to +output terminal +Z1 (1N823) to -output terminal -C82 to -output terminal	10V 6,2V -5,6V	Increase variac to 175VAC
+T10c to +output terminal	To be trimmed to 10,00V with resistor over R16 (4,7K).	Increase variac to 220VAC. (without load) Check that output voltage stabilizes to 60V.

SECTION 6

SPARE PARTS AND CIRCUIT DIAGRAM

A. GENERAL

Replacement parts are available from the Oltronix factory. All standard parts can also be ordered through most well-equipped component distributors. Note that some transistors have an Oltronix letter-number combination e.g. H90 in the spare parts list in addition to the part number. This combination indicates the quality of the transistor expressed in current gain and maximum voltage. This description should always accompany the transistor when a replacement is ordered. For further information on the classification refer to the "Oltronix transistor identification code" which is found after the spare parts list. When a pair of matched transistors is needed, add "Matched" to the description. When ordering parts listed below, state the following information for each part:

a. Model and serial number of the instrument
b. Circuit reference
c. Type and value

B. ABBREVIATIONS

AB = AB Metal Products Ltd.
Cer = ceramic
Dav = Davall Electronics
Elec = Electrosil
EMC = electrolytical metal case
Fra = Frako
Heli = Helipot
Int = Intermetall
Iso = Isotan
K = Kilo or 10^3
Kons = konstantan
M = Mega or 10^6
MF = metal film
Mfr = manufacturer
Mot = Motorola
MP = metalized polyester
Nis = Nissei
nF = nano Farad or 10^{-9}
pF = pico Farad or 10^{-12}
PF = polyester film
Ph = Philips
Ples = Plessey
Pos = position
Roe = Roederstein
Si = silicon
Tan = tantalum
TI = Texas Instruments
Trim = trimpotentiometer
uF = micro Farad or 10^{-6}
V = Volt
Vitr = Vitrohm
W = Watt
WW = wire wound
WIC = Wicon KG

C. SPARE PARTS

Pos		Value		Part no	Type	Mfr
Capacitors						
C1	4,7 uF	25 V		1415	Tan	Ero
C2	4,7 uF	25 V		1415	Tan	Ero
C3	2200 pF	100 V		2875	PF	Nis
C4	470 pF	500 V		1422	Cer	Erie
C5	47 pF	500 V		2873	Cer	Erie
C6	47 pF	500 V		2873	Cer	Erie
C7	1500 pF	100 V		2874	PF	Nis
C80	5000 uF	100 V		3565	EMC	Wic
C82	500 uF	35 V		1517	EMC	Roe
C90	1000 uF	100 V		3566	EMC	Fra
C91	0,68 uF	250 V		1405	MP	Ero
C92	470 pF	500 V		1422	Cer	Erie
C103	15 uF	12 V		2870	EMC	Ples
C104	10 uF	100 V		1397	PF	Nis
Diodes						
D1 - D7, D91 - D93		1S921		1667	Si	TI
D70, D82 - D85		1N4003		1668	Si	TI
D90		409D		2954	Si	Ph
Potentiometers						
P1	250	1,5 W		2877	Trim	AB
P2	10K	1,5 W		2879	Trim	AB
P40	100K	0,25W		2881	Trim	Dav
P90	20K	2 W	5%	3024	WW	Heli
P92	10K	1,5 W		2879	Trim	AB
P93	5K	2 W	10%	1328	WW	Clar
P101	250	1,5 W		2877	Trim	AB
P104	100	1,5 W		2876	Trim	AB

Unless otherwise specified, all resistors are 10%, 0,25W carbon

R1	1,1K	0,125W	1%	3499		Vitr
R2	1K			1016		
R5	100K			1040		
R6	100K			1040		
R7	100K			1040		
R8	100K			1040		
R9	15K			1030		
R10	5,6K	0,25 W	2%	3552	MF	Elec
R11	100			1004		
R12	1K			1016		
R13	10K			1028		
R14	330			1010		
	390			1011		
	470			1012		

Pos		Value		Part no	Type	Mfr
R16	4,7K	0,25 W	2%	3551	MF	Elec
R17	6,8K	0,25 W	2%	3553	MF	Elec
R18	1,5K			1018		
R19	39K			1035		
R21	10K	0,125W	1%	3086	MF	Vitr
R23	1M			1052		
R24	4,7K			1024		
R26	1K			1016		
R27	47K			1036		
R28	47K			1036		
R29	2,7K			1021		
R30	680			1014		
R31	22K			1032		
R40	68K			1038		
R41	82K			1039		
R42	470			1012		
R43	470			1012		
R44	10K			1028		
R45	1K			1016		
R46	27K	0,25 W	2%	3548	MF	Elec
R51	27			2949		
R52	27			2949		
R70 a,c,e	3 X 0,08			3547	Kons	Iso
R70 b,d,f	3 X 0,08			3547	Kons	Iso
R71	470			1012		
R72	27			2949		
R74	91K	0,25W	2%	3561	MF	Elec
R80	5	12 W	5%	3564	MF	Vitr
R89	63K	0,25W	2%	3560	MF	Elec
R90	1K	0,25W	2%	3550	MF	Elec
R91	200K	0,25W	2%	3563	MF	Elec
R92	10K	0,25W	2%	3556	MF	Elec
R93	10K	0,25W	2%	3556	MF	Elec
R94	2,2K	0,25W	2%	3555	MF	Elec
R95	300	0,25W	2%	3549	MF	Elec
R96	15K	0,25W	2%	3557	MF	Elec
R97	18K	0,25W	2%	3558	MF	Elec
R98	6,9K	0,25W	2%	3554	MF	Elec
R99	28K	0,25W	2%	3559	MF	Elec
R100	680			1014		
R101	20	4 W	10%	1214	WW	Vitr
R102	220			1008		
R103	180K	0,25W	2%	3562	MF	Elec
R110	8,2K			1027		
R111	5,6K			1025		
R112	22K			1032		
R113	10K			1028		
R114	270			1009		
R115	15K			1030		
R116	270			1009		
R118	10K			1028		

Pos	Value	Part no	Type	Mfr
Transistors				
T1-T2	BC 109C	2363	matched	Ph
T3	BC 108B	2861	Si	Ph
T4-T5	BC 109C	2363	matched	Ph
T6	BC 108B	2861	Si	Ph
T7	BC 108B	2861	Si	Ph
T8	BC 178B	2862	Si	Ph
T9	BC 108B	2861	Si	Ph
T10	BC 178B	2862	Si	Ph
T11	BC 178B	2862	Si	Ph
T20-T21	BC 109C	2363	matched	Ph
T22	BC 109C	2930	Si	Ph
T70	BSW 66	3546	H90	Ph
T71a-b	2N 3442	1653	Si	RCA
T90	BC 109C	2930	Si	Ph
T100	2N 5323	2927	Si	RCA
T101	2N 3055	1533	Si	RCA
T200	BC 108B	2861	Si	Ph
T201	BC 108B	2861	Si	Ph
T202	BC 108B	2861	Si	Ph
Zener diodes				
Z1	1N 823	1677	unclass.	Mot
Z2	ZF 5,6	1686	unclass.	Int
Z3	ZF 5,6	1686	unclass.	Int
Z100	Zf 6,2	2758	1N753A	Int

D. OLTRONIX TRANSISTOR IDENTIFICATION CODE

To assure that the transistors in the Oltronix power supplies have good enough data for their actual application, all transistors are tested with a Tektronix Curve Tracer before they are mounted in any instrument. Certain transistors e.g. power transistors and transistors for high voltage use pass a more complete test after which a classification mark is applied. This mark is a letter-number combination on the power transistors and a colour dot on the smaller transistors.
The letter indicates high "H" or low "L" current gain. The number shows the maximum working voltage.
The test conditions are:

Test	Power transistors TO-3 and TO-36	Other transistors TO-5 and similar
Current gain	I_C = 2A V_{CE} = 10V High if $h_{FE} \geqslant 50$ Low if $h_{FE} < 50$	I_C = 1 mA V_{CE} = 10V High if $h_{FE} \geqslant 50$ Low if $h_{FE} < 50$
	Transistors with extremely high or extremely low h_{FE} are rejected.	
Voltage	I_C = 400 mA R_{BE} = 100 ohms	I_C = 1 mA R_{BE} = 1,5k

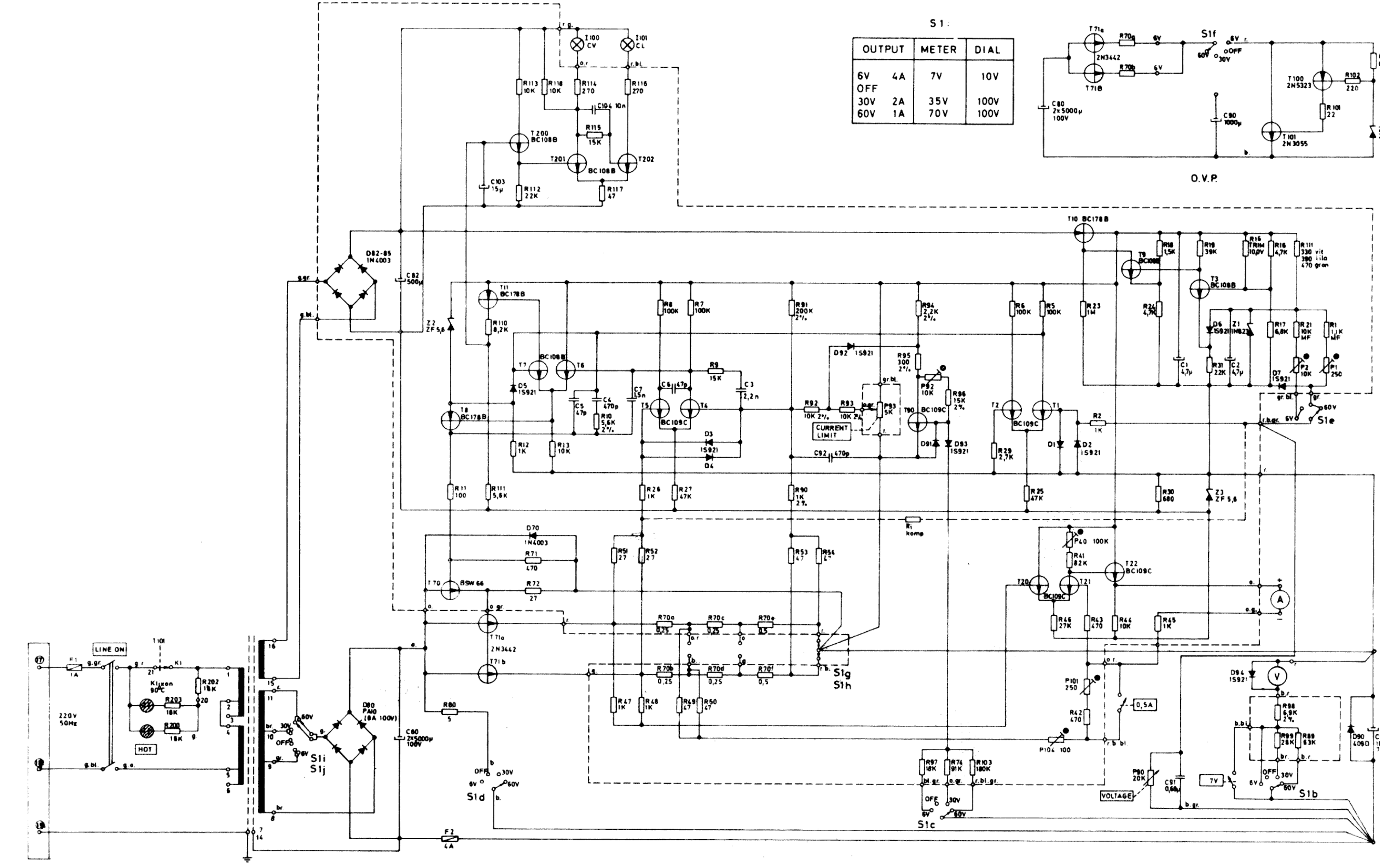
The colour code is:

Class	Colour	Class	Colour
L25	Brown	L100	Silver
H25	Red	H100	Black
L50	Yellow	L125	Silver and brown
H50	Green	H125	Black and red
H65	Blue	L150	Silver and yellow
L75	White	H150	Black and green
H75	Violet	L175	Silver and white
		H175	Black and violet

Colour code for wiring is:

b = blue
bl = black
br = brown
g = green
gr = grey
l = violet
o = orange
r = red
w = white
y = yellow

E.g. an orange-black wire is indicated as o-bl.



S1

OUTPUT		METER	DIAL
6V	4A	7V	10V
OFF			
30V	2A	35V	100V
60V	1A	70V	100V

OLTRONIX

REGULATED POWER SUPPLY
LABPAC B60-1T
0-6V 4A, 0-30V 2A, 0-60V 1A

12.5.70 AK | 8.6.70 Sc

206 - 72 - 1

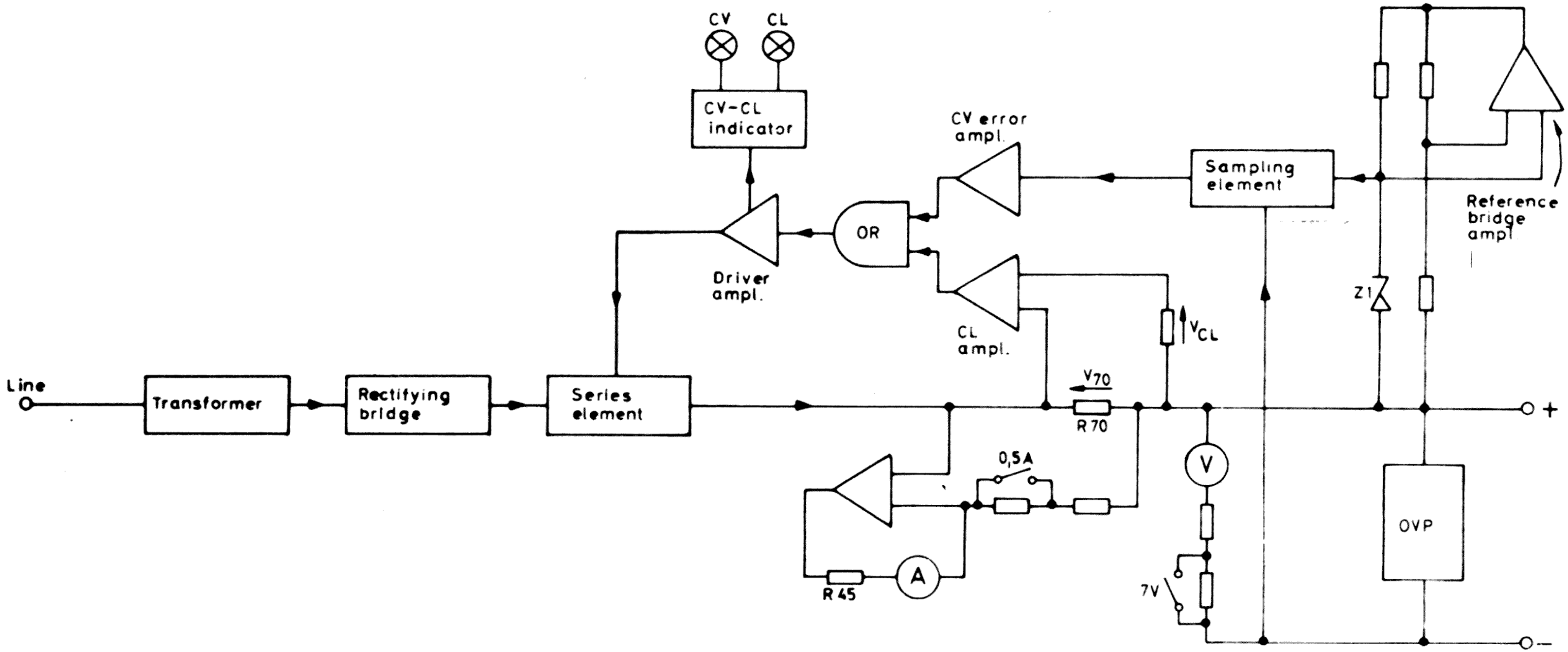


Figure 6. Block diagram