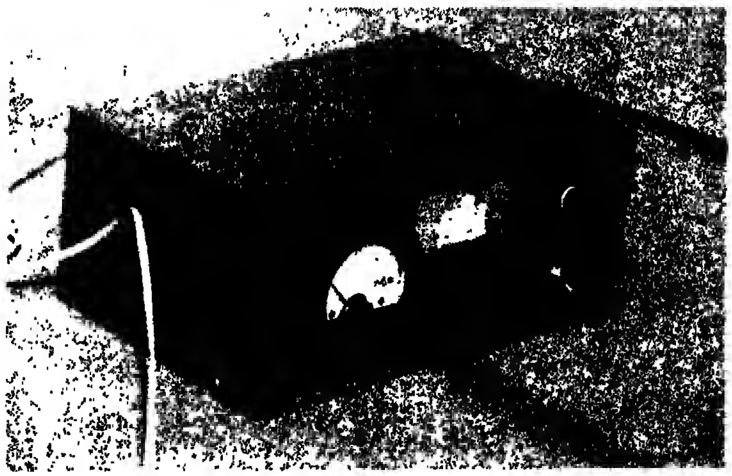
Solidstate Automatic AC Voltage Regulator



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Maintaining constant voltage is very difficult. This problem can be solved by using automatic voltage stabilisers. Although a number of automatic voltage regulators are available in the Indian market and are advertised as solidstate automatic voltage regulators, most of them cannot be said to be true solidstate devices.

Invariably, the voltage level sensing circuits in these automatic voltage regulators are of solidstate design but the controlling elements are usually relays or motor driven variacs which are actually mechanical devices. This article will describe how to design and fabricate a 'true' solidstate automatic voltage regulator, without a single moving element in its circuitry.

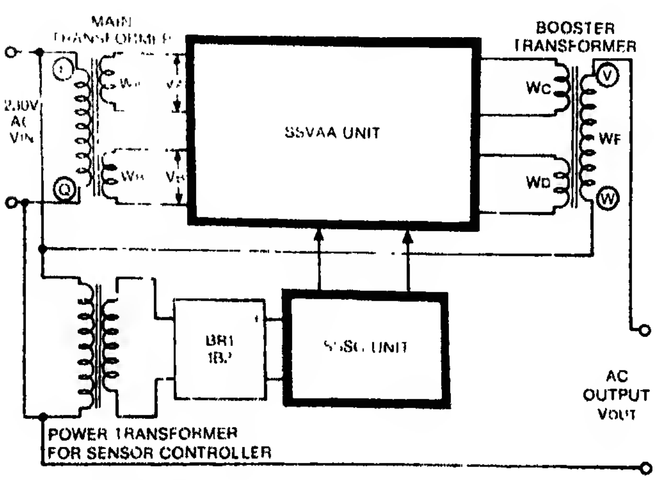

Fig. 1: Block diagram of the automatic voltage regulator.

Boosting principle

As shown in Fig. 1, the incoming line voltage, V_{IN}, is stepped down to voltages V_A and V_B at the secondary windings W_A and W_B respectively of the input transformer. The booster transformer has two primary windings, W_C and W_D, connected to the SSVAA (solidstate variable amplitude amplifier), which drives it in accordance with the control signals obtained from the SSSC (solidstate sensor and controller). One of the terminals of the secondary windings of the booster transformer is connected to the input and the other forms one of the output terminals. Another output terminal is taken from the input, to which the secondary of the booster transformer is not connected.

The input voltage is stepped down, rectified and the DC voltage is fed to the SSSC which detects the variations in the input voltage and provides the required correction control signal to the SSVAA.

Working of the SSVAA unit

This unit, as shown in Fig. 2, consists of two power transistors T1 and T2; four diodes D1, D2, D3 and D4; and three resistors VR1, R4 and R6. R4 is a light-dependent resistor

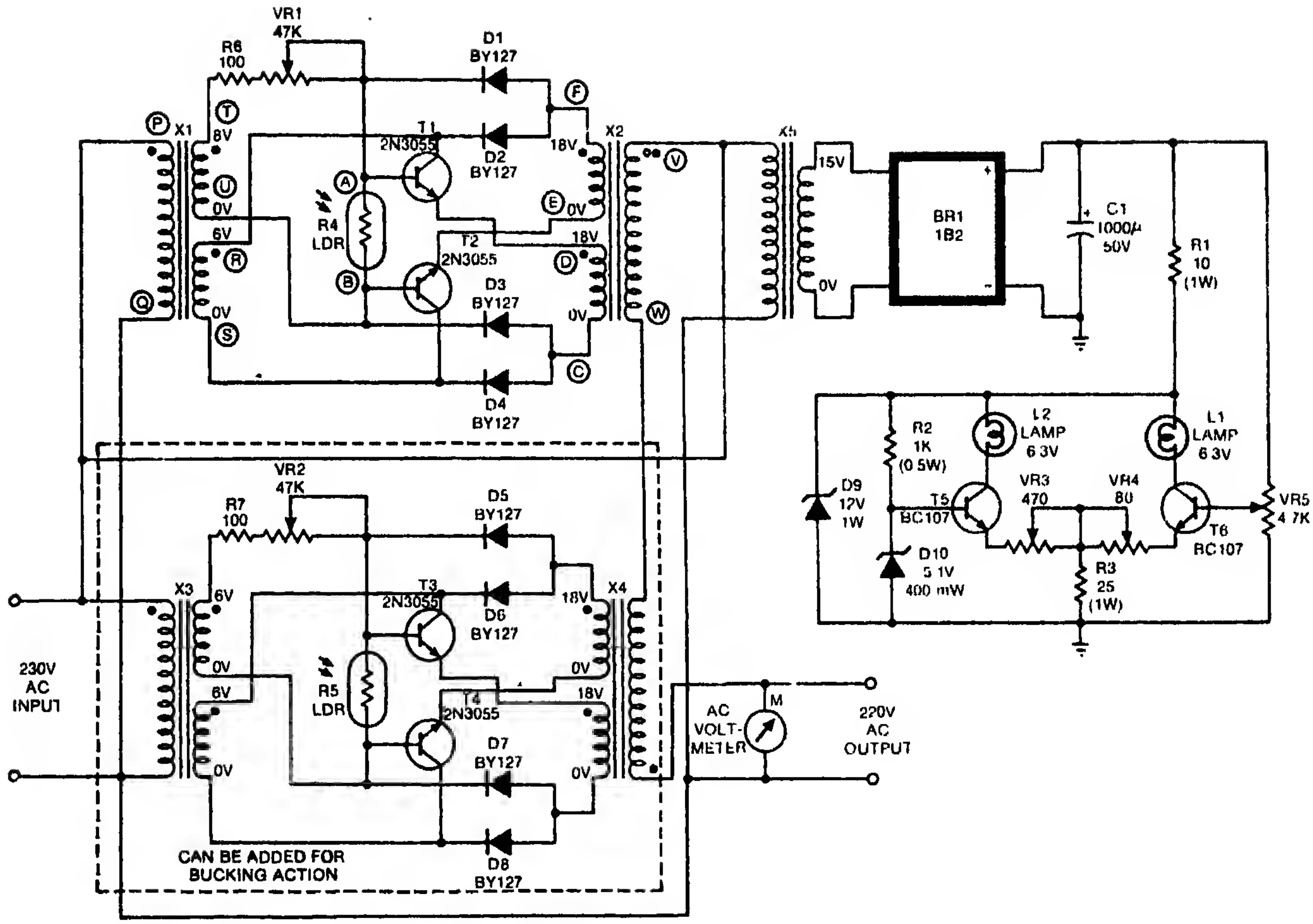

Fig. 2: Circuit diagram for solidstate automatic voltage regulator.

PARTS LIST

Semiconductors:

T1-T4	— 2N3055 npn power transistor
T5, T6	— BC107 npn transistor
D1-D8	— BY127 rectifier diode
D9	- 12V, 1-watt zener diode
D10	-- 5.1V, 400mW zener diode
BR1	— 1B2, 1-amp bridge rectifier diode

Resistors (all ¼watt ±5% carbon, unless stated otherwise):

R1	— 10-ohm, 1-watt
R2	- 1-kilohm, 0.5-watt
R3	— 25-ohm, 1-watt
R4, R5	— 100-ohm
R6, R7	— LDR (light dependent resistor)
VR1, VR2	— 47-kilohm potentiometer
VR3	— 470-ohm potentiometer
VR4	80-ohm potentiometer
VR5	— 4.7-kilohm potentiometer

Capacitor:

C1	— 1000µF, 50V electrolytic

Miscellaneous:

X1, X3	- 230V primary to two 0-6V, 1-amp secondary transformer
X2, X4	— Two 0-18V primary to 230V, 2-amp secondary transformer
X5	— 230V primary to 15V, 1-amp secondary transformer
L1, L2	— 6.3V, 0.3-amp lamp
	— PCB, heatsink for power transistor, AC voltmeter, 7/36 flexible wire, suitable enclosure, screws, nuts, washers etc.

(LDR). The resistance value of the LDR is inversely proportional to the incident light on its active surface.

The circuit is a special form of 'class B' emitter follower amplifier with the collector supply fed from an AC source instead of conventional DC supply. Since the various windings have to be connected in a particular phase relationship, at any instant when point P is positive with respect to point Q at the input of the mains transformer X1, points R, T and V will be positive with respect to points S, U and W in windings W_B, W_A and W_E as shown in the block diagram.

Considering such an instant, winding W_A drives a current through R6 and VR1. This current produces voltage V_C across the terminals A-B of the LDR. From the above assumption of polarity, point 'A' of this voltage will be positive with respect to 'B' and cause a base current to flow through the transistor T1, along the path A-D-C-B-A and on account of this base current drawn from winding W_B, along the path R-T1-D-C-S-R.

The above explanation covers half a cycle when point P is positive with respect to Q. At the end of this half cycle, during the period of zero crossing, the voltages V_C, V_A and V_B are all equal to zero after which the negative half cycle commences. During the negative half cycle, point 'B' becomes positive with respect to point 'A' and thus diode D3

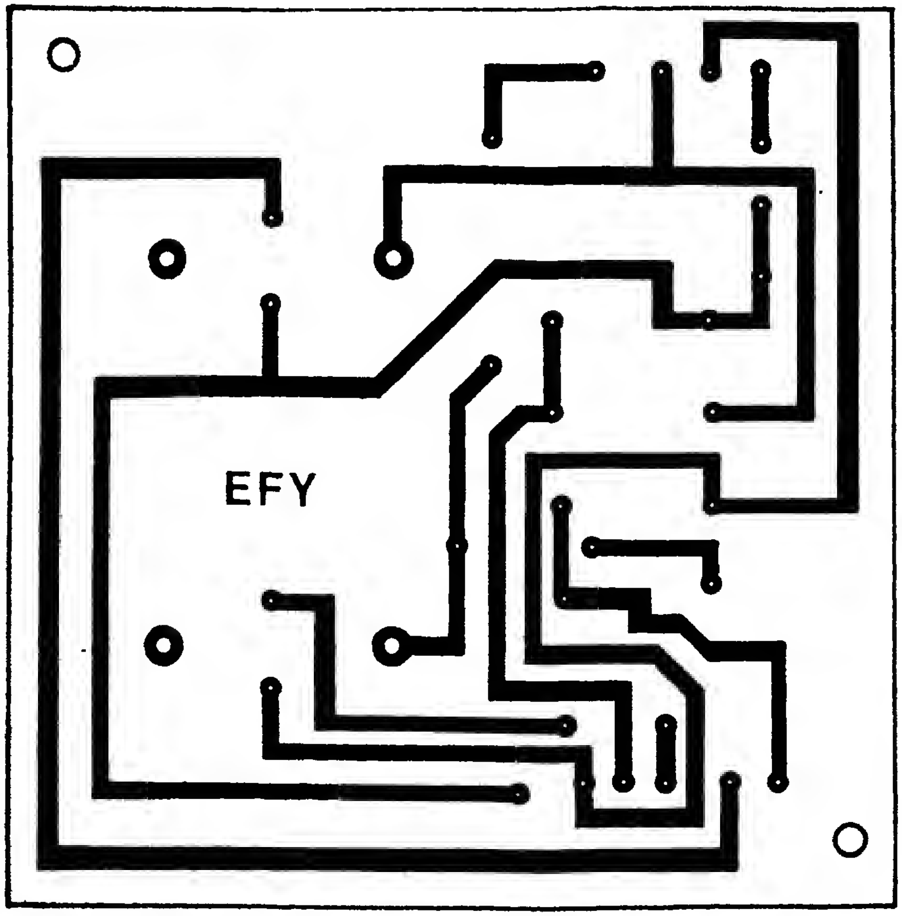

Fig. 3: Actual size PCB layout for variable amplitude amplifier.

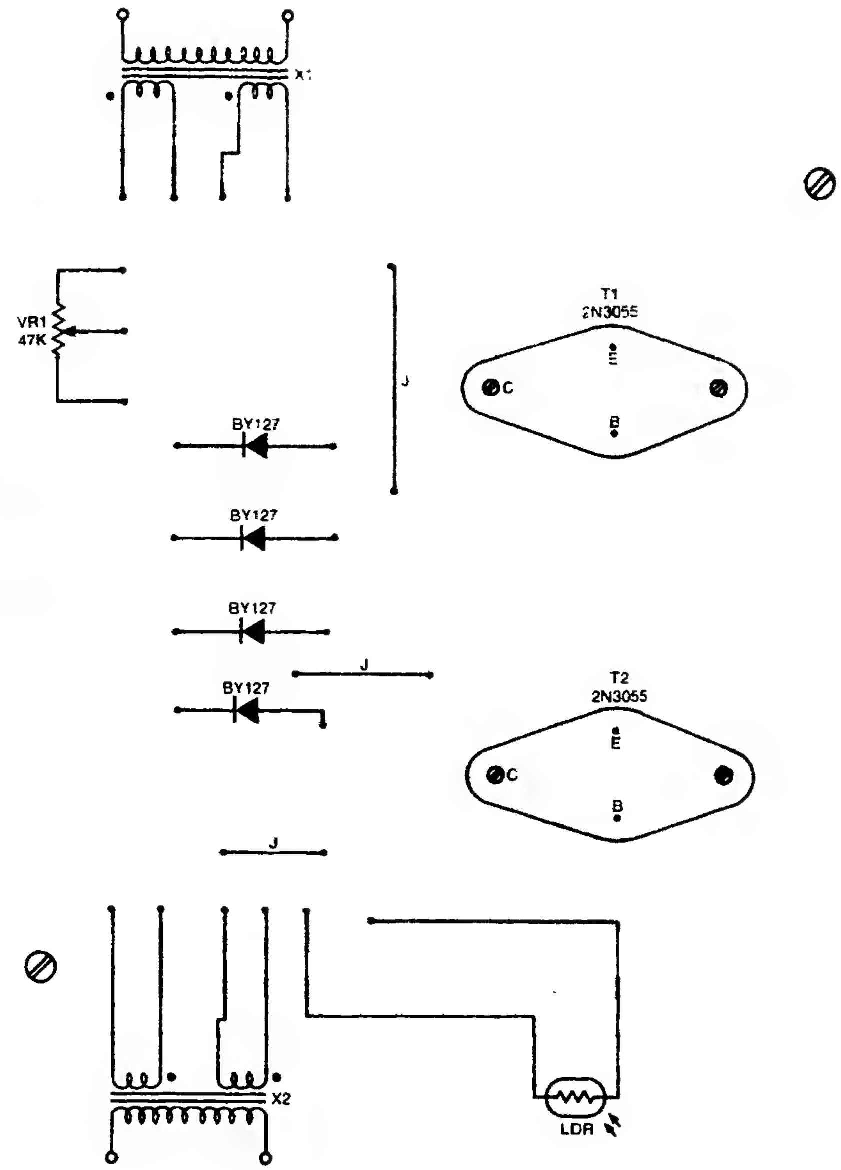

Fig. 4: Component layout for the PCB.

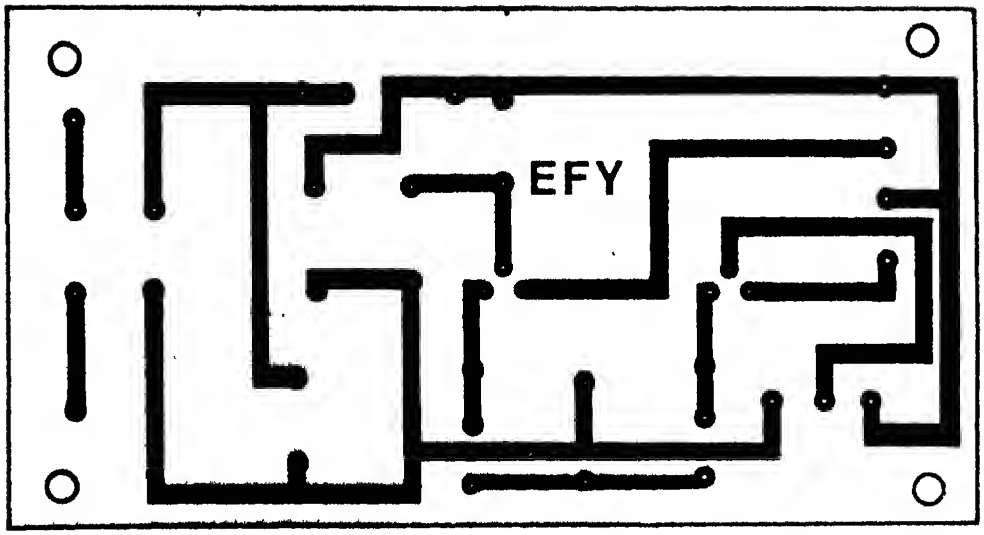

Fig. 5: Actual size PCB layout for the sensor and controller.

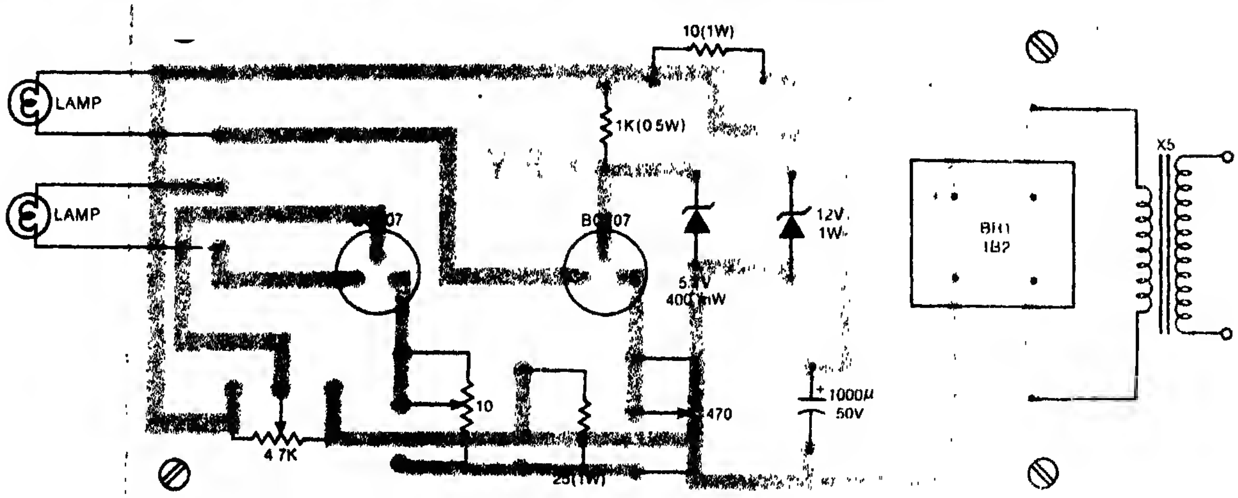

Fig. 6: Component layout for the PCB.

blocks any current through W_D. But a base current flows through transistor T2 and winding W_C causing a collector current along the path S-T2-E-F-R-S.

Solidstate sensor and controller

The input for the SSSC is obtained directly from the supply voltage through a stepdown transformer X5 and a bridge circuit used for sensing and controlling the variations in the supply is a differential amplifier.

Transistors T5 and T6 are connected (as shown in Fig. 2) so as to obtain a differential amplifier configuration at normal AC voltage of 230 volts. The potentiometer VR5 (4.7k) is adjusted to obtain maximum brightness of the lamp. When the input AC voltage decreases, the voltage applied to the base of T6 decreases. This causes a decrease in the collector current of T6 and thus a decrease in the brightness of the lamp. This will cause an increase in the resistance of the LDR which in turn increases the voltage applied to the primary of transformer of SSVAA whose secondary will 'boost' the output to the normal value. The LDR and the lamp must be enclosed in a light-impermeable capsule.

The circuit described boosts the voltage in case it goes below the normal value. But in case the voltage goes above normal, bucking action can also be incorporated.

The circuit for incorporating the bucking action using T3 and T4 is shown in Fig. 2. The secondary of output transformer of the boosting unit is in phase with the input, whereas the secondary of the output transformer of the bucking unit is connected in phase opposition. Both the secondaries are connected in series. The dots marked over the windings of transformer in Fig. 2 represent the polarity of the windings of transformers.

The voltage across the LDR (R4) of the boosting unit is controlled by lamp L1 whereas LDR (R5) is controlled by lamp L2. The output volt-amp, can be varied by varying the current rating of the secondary winding (W_E) of transformer X2.

The cost of prototype using a 2-amp transformer (X2) is about Rs 300 only. If bucking action is also incorporated, the cost will come to around Rs 400. ☐