Three-phase power regulator

Tariq Iqbal's three-phase linear power regulator can control resistive loads or induction motors. Drive outputs are opto-isolated and regulation from zero to full load is via a single potentiometer so interfacing to a PC should be easy, assuming all mains isolation is properly implemented.

A three-phase optically-isolated power regulator with linear characteristics is shown in **Fig. 1**. It can be used to operate a three-phase heater load or an induction motor with, say, a fan load.

Load power is controlled from zero to maximum by a single potentiometer producing the control voltage $V_{control}$. If required, control voltage may be supplied from a PC using a d-to-a converter card.

In this power regulator, the power stage and signal stages are isolated via light-activated S21ME3G triacs. Linear transfer characteristics are achieved using the cosine-wave crossing method of triggering the triacs.

In **Fig. 2**, operation of one of the the power regulator's three sections is explained using various waveforms. Waveforms of the other two sections of the power regulator are similar to Fig. 2, but delayed by 120° and 240° respectively.

Figure **2a)** shows typical three-phase line waveforms. These line voltages are stepped down using three transformers. Full-wave rectified output of line the L_1

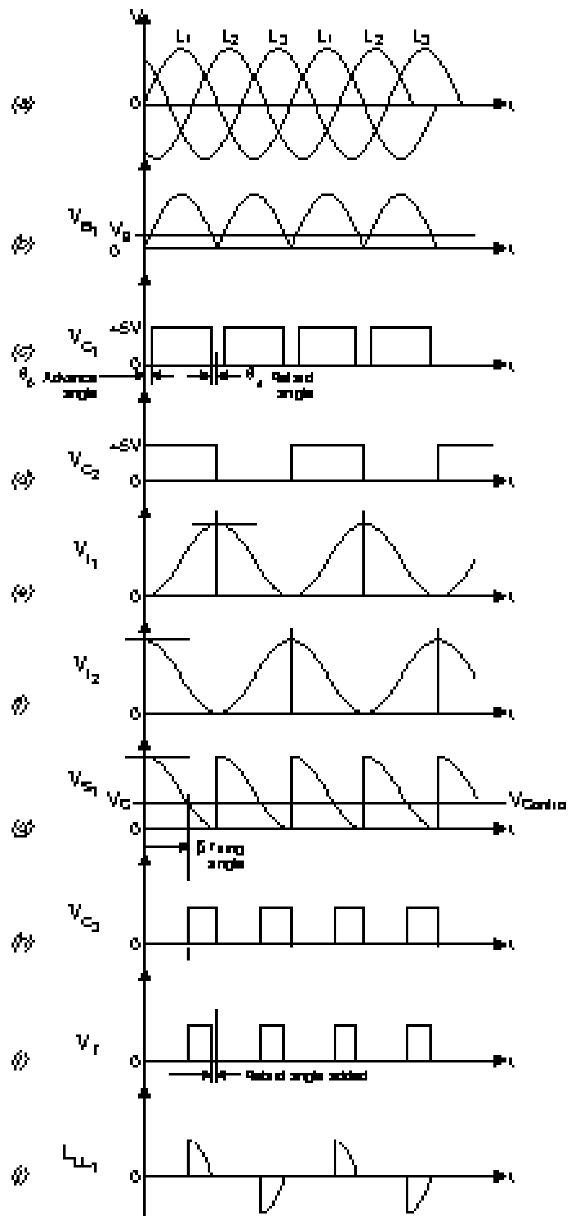
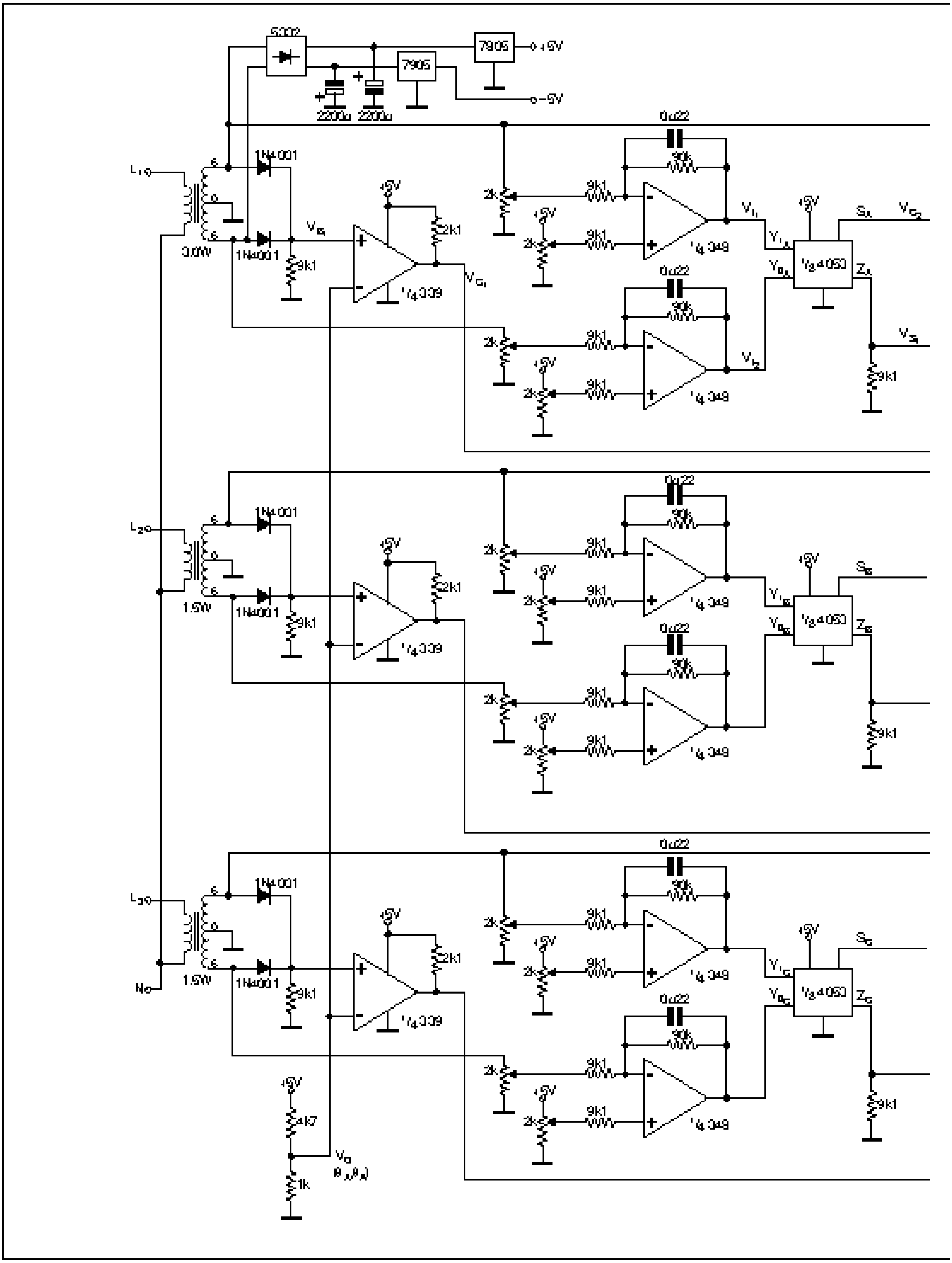


Fig. 2. Timings involved in the three-phase linear power regulator, with mains input at the top and power output at the bottom.



7905
+5V
-5V
2200µ
2200µ
0µ22
90k
9k1
2k
2k1
1N4001
3.0W
1.5W
1.5W
L_1
L_2
L_3
N
¼ 339
¼ 349
½ 4053
4k7
1k
S_A
S_B
S_C

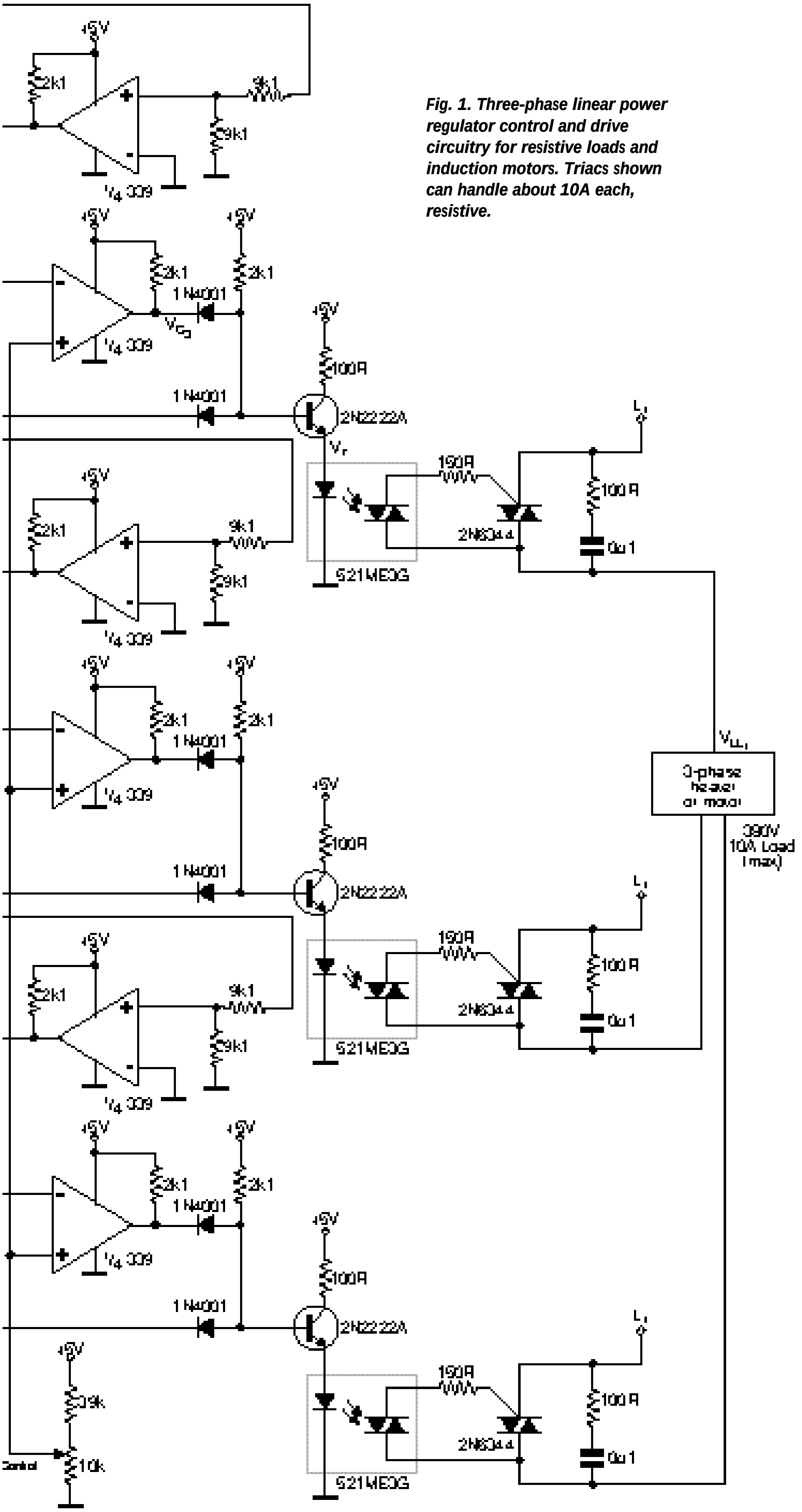


Fig. 1. Three-phase linear power regulator control and drive circuitry for resistive loads and induction motors. Triacs shown can handle about 10A each, resistive.

transformer is shown in Fig. **2b)**. This is compared with a small voltage V_θ to generate advance and retard angles. Advance and retard angles, θ_a and θ_d, are required to make sure that there is some voltage across the triac before it is triggered.

Figure **2c)** shows the advance and retard angle for phase L_1. A further comparator generates a reference waveform, V_{C2}, required for the isolation of two half cycles of cosine waves.

Two 180°-shifted biased cosine waves are generated using two integrators, Fig. 1. Both 2kΩ potentiometers of each integrator should be adjusted to obtain integrator outputs as in Figs **2e)** and **f)**.

Using reference voltage V_{C2} and a 4053 multiplexer, two cosine waveforms are combined to generate a reference cosine triggering waveform Fig. **2g)**. This is needed to achieve the power regulator's linear transfer characteristic.

Voltage V_c and the reference cosine waveform are compared to generate the respective firing angle, β, as in Fig. **2h)**. An AND function using two diodes and a transistor produces advance and retard angles.

The resulting waveform, Fig. **2i)**, is used for triggering the triac connected to phase L_1 of the supply. Three similar sections of the power regulator make sure that all three triacs are fired at exactly equal delay angle β.

I used a 2N6344 power triac in the original design. It is capable of carrying 10A load. If required, high current devices may be used. ■