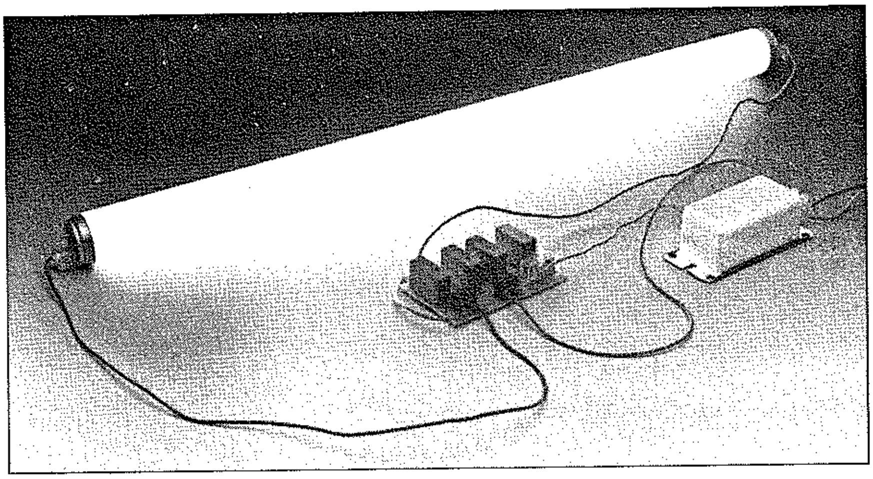
ELECTRONIC STARTER FOR FLUORESCENT TUBES

Design by L. Pijpers



Fluorescent tubes blink and flicker for a few seconds before they light properly. This deficiency is caused invariably by the traditional starter. The circuit described here may be used to replace the starter to obviate the blinking and flickering.

Low-pressure fluorescent tube lighting is justifiably popular because (1) it is 4–6 times as efficient as metal-filament lamps, (2) the life of a fluorescent lamp is about seven times that of a metal-filament lamp, (3) its light is spread much more evenly, and (4) it produces hardly any glare.

A low-pressure fluorescent lamp consists usually of a glass tube, 38 mm in diameter and from 600 mm to 2400 mm long. The tube is filled with an inert gas at a pressure of about $^1/_{250}$ of atmospheric pressure, and also with a drop of liquid mercury. The interior surface of the tube is coated with fluorescent material that converts the ultraviolet radiation from the mercury vapour into light of an acceptable colour.

There is an electrode at each end of the tube that serves as both cathode and anode, since the tube is invariably used in an a.c. circuit. The cathode, which is secured by nickel support wires, consists of a coiled filament coated with a barium-oxide thermionic emitter. The anode if formed by a metal strip attached to the support wires.

The cathodes are heated by passing a current through each filament. If the applied voltage is high enough, a glow discharge is set up through the gas, which excites or ionizes the mercury atoms throughout the tube and results in a mercury-arc discharge. As the arc current increases, the potential drop across the choke also increases, so that the voltage across the tube decreases, until a balance is reached.

Fluorescent tubes require some external components for satisfactory operation: a ballast, usually a choke, to limit the current through the tube, a starter for preheating the filaments, and a power factor correcting capacitor—see Fig. 1.

The simplest starter is a special switch (normally called the starter), which nowadays is invariably of the glow type (there used to be thermal types, but these have all but disappeared). The contacts of the switch are mounted on bimetallic strips that bend towards each other when they are heated. The switch is normally contained, together with a small radio interference suppression capacitor, in a sealed tubular case that is filled with an inert gas, usually argon or helium.

When the lamp switch is closed, the full mains voltage is applied across the starter, which causes a glow discharge through the gas across the open contacts. This discharge heats the bimetallic strips, whereupon the contacts close. As soon as this happens, current flows through the choke and the two series-connected filaments, whereupon the cathodes are heated. When the cathodes reach a certain temperature (called the 'emission temperature'), ionization begins and the ends of the tube start to glow. The voltage across the starter then decreases and the bimetallic strips begin to cool down. After a predetermined time, the contacts open quickly. This causes a high-voltage surge to be induced across the choke, which is applied to the tube, causing it to strike.

The choke causes a power factor (lag) that may be as low as 0.6, which is clearly very inefficient. To improve the power factor to a value closer to 1.0 (in practice 0.8–0.9), a suitably rated power factor compensating capacitor* is connected across the mains input terminals.

The reason for the blinking and flickering of the fluorescent tube is simply that the contacts of the starter switch open at any given moment. Invariably, the value of the current at that time is too low to induce a high enough voltage across the choke to make the tube strike. At the same time, the cathodes of the tubes often have not been sufficiently heated.

Electronic starter

There are several ways of using electronics to improve the striking of fluorescent tubes. The first is by simply replacing the starter by a thyristor circuit.

The second is using an h.f. amplifier and transformer to increase the frequency and the level of the operating voltage. This method, however, is feasible for low power (5–9 W) tubes only; the costs for higher power tubes are fairly high.

The third, proposed here, is based on the circuit in Fig. 2.

The choke is retained for limiting the current, but is no longer needed for inducing a high voltage.

At the instant the mains switch is closed, the fluorescent tube presents a high impedance and the four capacitors are not charged. For

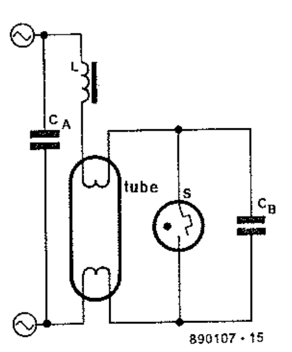


Fig. 1. Standard configuration of a fluorescent lamp circuit.

Table 1. Component values in Fig. 2. for various tube ratings.

	TUBE RATING		
	20 W	40 W	60 W
C_1	0.47 µF/1000 V	0.47 µF/1000 V	1 µF/1000 V
C_2	0.47 µF/1000 V	0.47 µF/1000 V	1 µF/1000 V
C_3	0.47 µF/1000 V	0.47 µF/1000 V	1 µF/1000 V
C_4	0.47 µF/1000 V	0.47 µF/1000 V	1 µF/1000 V
D_1	1N4007	1N5408	1N5408
D_2	1N4007	1N5408	1N5408
B_1	280 V/1.5 A	280 V/2.0 A	280 V/3.0 A
F_1	500 mA	1 A	3 A

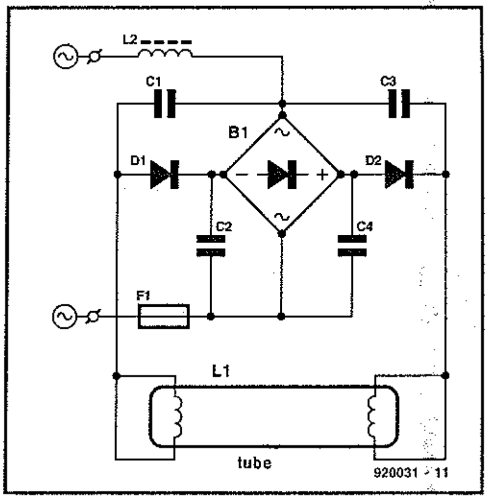


Fig. 2. Circuit of the electronic starter.

simplicity's sake, it will be assumed that the mains is going through a positive half cycle, that is, the voltage is high at L_2 and low at F_1. Capacitor C_1 is then charged via D_1 and the bridge rectifier, and C_4 via one of the diodes of the rectifier. The potential across these capacitors rises to about 340 V, the peak value of the mains. During the negative half cycle, C_2 is charged to about 340 V via the rectifier, and C_3 to just over 500 V via C_4 and D_2. This means that part of the charge on C_4 is transferred to C_3. During the next positive half cycle, part of the charge on C_2 is transferred to C_1 via D_1, while C_4 is recharged to about 340 V. In this way, capacitors C_2 and C_4 increase the voltage across C_1 and C_3 to twice the peak voltage of the mains, that is, 680 V. This means that the voltage at the right-hand side of the fluorescent tube is +680 V and that at the other side is –680 V, both with respect to neutral. That voltage remains across the tube until this strikes.

When the tube strikes, the potential across the capacitors instantly drops to 60–80 V, that is, the normal operating voltage of the tube. The capacitors cannot be recharged: from this moment on they serve no purpose as the tube is operated by the direct voltage produced by the rectifier.

Operating the tube from a direct-voltage source is the most obvious difference with normal practice. Another is that the filaments serve as anode or cathode only and no longer as pre-heating elements.

Although this method has the obvious advantage of the tube lighting immediately the mains is switched on, it also has a drawback. Since the ion current through the tube is now polarized, one of the filaments will become thinner and thinner and the other, thicker. Also, a black deposit may occur on the glass of the tube. These are long-term effects, however, and are no cause for immediate concern. It is nevertheless advisable to reverse the tube in its fitting from time to time, say, once every couple of months.

Construction

Since only seven components are used, the construction of the electronic starter is simplicity itself. Because of the high voltages present (well over 1000 V), good-quality board should be used. Also, keep reasonable distances between the soldering points. Furthermore, first class insulation is needed when the circuit is fitted in a suitable enclosure. Do not omit the (quick-blow) fuse under the impression that the choke will limit any peak currents.

Suitable values of components shown in Fig. 2 are given in Table 1. ■

* See 'Understanding power factor compensation' on page 43.

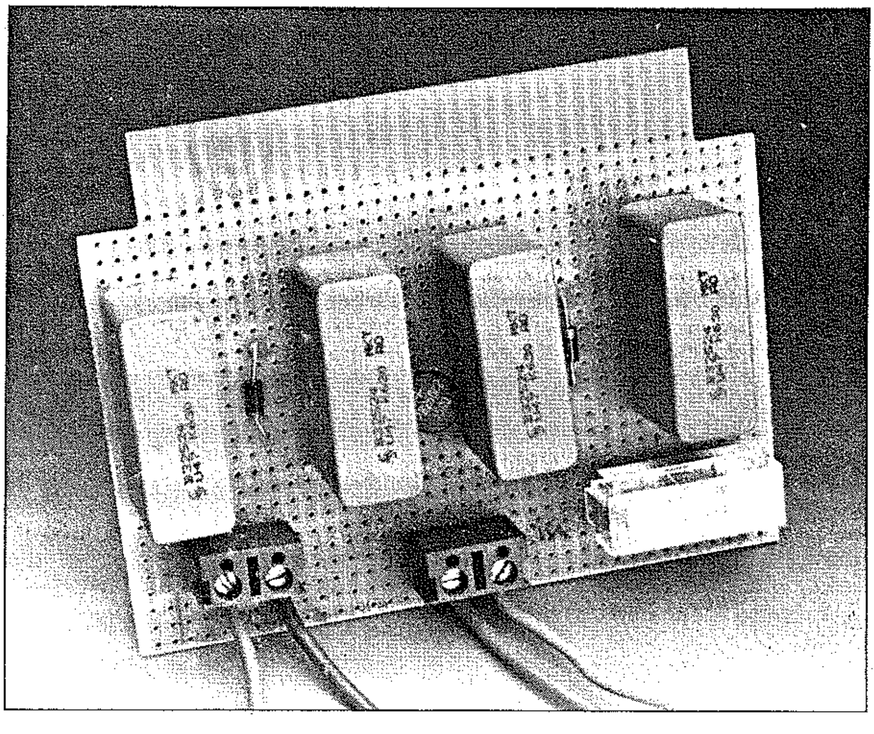


Fig. 3. Prototype of the electronic starter.