Constructional Project

FOREVER FLASHER

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A novel flashing l.e.d. that could run for over 20 years on a 9V lithium battery or "forever'' using the "free energy'' from a TV aerial or similar.

THIS article describes how a simple micropower l.e.d. flasher circuit may be pulsed off less than 1µA power at 9V. It uses just under 10µW, which, in theory, will enable this circuit to run for many years off a small 9V lithium battery.

Although such a battery has a nominal shelf-life of ten years, it should without trouble be able to power this circuit for twenty or thirty years or more. In some cases, even zinc carbon batteries have been known to last this long.

The proof of the miniscule power consumption lies in resistor R3 (see Fig.1), which has a value of 10M, and is wired in series with the 9V power supply. A simple calculation of V/R shows that it therefore draws less than 1µA at 9V.

FREE ENERGY!

Another conspicuous feature of the Forever Flasher circuit (see Fig.1) is the provision for an aerial and an earth connection. Also, diodes D1, D2, and capacitor C1 should be instantly recognisable as a standard diode pump.

Such a "pump'' circuit is used when a higher d.c. output is required from a lower a.c. input. This is included in the circuit because, due to its miniscule power consumption, the flasher may in some cases be powered off a television aerial, in combination with a ground wire.

It is emphasised that this aspect of the circuit is purely experimental. However, the author found that he was able to power the flasher off various television aerials in various locations.

At first it was supposed that the aerials were picking up pure radio frequency energy. However, after extensive testing, it became clear that the real power source was not only electromagnetic waves at radio frequencies, but a wider range of electromagnetic radiations, including mains wiring and motorised equipment.

With such "free energy'' in mind, the Forever Flasher has in fact been designed to operate off a mere 2·5V at 2µA when an *aerial* and a *ground* wire are employed as the power source, battery operation being considered optional.

MINIMAL POWER

A CMOS 4016 quad bilateral switch i.c. (IC1) is employed at the heart of the circuit – see Fig.1. The reason for this is that CMOS devices have minimal power requirements, especially when quiescent. Their quiescent power consumption may not even register on the µA scale of a multimeter.

In addition, the 4016 in particular has no input protection circuitry, which enhances its input sensitivity. It was also found to be free from a problem which commonly affects CMOS i.c.'s in low power circuits. Current consumption frequently rises quite high when input terminals are held at levels close to triggering (typically 50µA to 200µA at 3V), and this would render such i.c.s useless in this application, where IC1 is used as a slow oscillator. This is not the case with the 4016 i.c.

Finally, whenever CMOS i.c.s are pushed to their limits, as is the case here, it is important to choose the i.c. from a specific manufacturer. In this case, the make of i.c. is absolutely critical. Only three specific makes were found to work at these extremes. However, other 4016s may work, but at a higher current consumption. The ones to use are the following:

The HEF4016BP (Philips); the CD4016BE (Texas Instruments), and the HCF4016BE (SGS-Thomson).

The Philips HEF4016BP proved to be the most suitable, and in this case, six individual i.c.s were tested, from two separate batches. Out of these, one failed – however, this may have been due to damage by static discharge.

The CD4016BE (*not* the CD4016BCN) should be the second resort. This uses very slightly more current, so that resistor R3 may be reduced to 4M7 accordingly. The HCF4016BE worked satisfactorily, although it pulsed a little erratically.

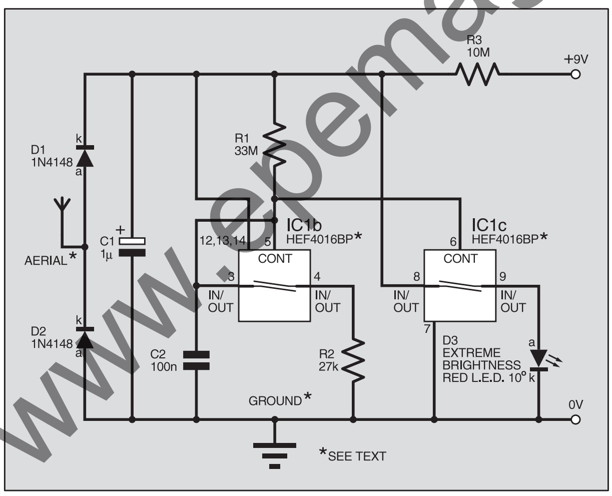

Fig.1. Complete circuit diagram for the Forever Flasher. Both sources of power supply are shown.

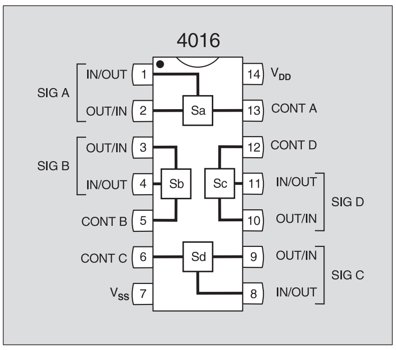

Fig.2. Pinout details for the 4016 quad bilateral switch i.c.

CIRCUIT DESCRIPTION

The full circuit diagram for the Forever Flasher is shown in Fig.1 together with the 4016 pinout details in Fig.2. Being a quad device, the internal "bilateral'' switches are labelled *a* to *d*, but we are only using switches *b* and *c* here as this fits into our printed circuit board (p.c.b.) layout. Hence, the annotations IC1b and IC1c on the circuit diagram. Note that the unused control pins (12 and 13) of switches *a* and *d* are tied to the positive supply (high), this does not affect the functioning of the circuit, but is considered good practice.

The Forever Flasher uses the 4016 (IC1) in an unorthodox manner, running it well below its minimum rated supply voltage. The main purpose of this is to draw as much power as possible from capacitor C1 to illuminate l.e.d. D3. While D3 draws all available current from C1, the voltage of the circuit plummets to about 1·7V – yet the circuit continues to function.

With most CMOS i.c.s, this would present an insurmountable problem. These may dip slightly below their minimum rated voltage (say 10%), but not much more before they fail. This does not apply, however, to the 4016. The only penalty here is that the 4016's "on" resistances gradually rise across the bilateral switches as voltage drops – to about 1kΩ (one kilohm) at 1·5V.

While it would be possible to run this circuit within its "legal" limits (at or above 3V), a theoretically perfect circuit would not make a good circuit in practice.

In this circuit, IC1 is wired as a slow oscillator. Capacitor C2 charges through resistor R1, causing pin 5 to go "high" (two-thirds of supply voltage). This closes switch IC1b, which causes C1 to be discharged through switch IC1b and resistor R2. When pin 5 goes "low" (one-third of supply voltage), switch IC1b opens again, and the charging of C1 begins over again.

At the same time as pin 5 goes "high", so also does pin 6. This causes switch IC1c to close, and so to pulse l.e.d. D3.

In order to conserve power, a very high value is chosen for R1, and a correspondingly low value for C2.

EXTREME BRIGHTNESS

An extreme brightness red l.e.d. (above 1000mcd – preferably around 3000mcd) is used for D3, with a narrow viewing angle (say 10º). Do not use any other l.e.d. in this circuit, as it is unlikely to work. D3 is chosen especially for its very high efficiency, with its extreme brightness converting to high efficiency at low power.

An extreme brightness red l.e.d. requires between 1·7V and 1·9V, depending on the make. It does not matter if D3 is momentarily powered by more than this, as happens in this circuit when capacitor C1 first discharges. L.E.D.s can be powered by far higher than their rated voltage – on condition that this is for a small percentage of their duty cycle.

POWER PUMP

When connected to a standard television aerial and earth, the diode pump (D1, D2 and C1) produces as much as 10V d.c. across capacitor C1 without load. Since all electromagnetic oscillations are a.c., the a.c. voltage for the pump is provided directly by the aerial.

A simple experiment may be performed with D1, D2, and C1. Allow C1 a few seconds to charge (assuming that aerial and ground wire are connected – see below). Then connect an l.e.d. across the terminals of C1, observing the correct polarity. The l.e.d. should flash brightly.

Although they are very common diodes, D1 and D2 have an extraordinarily low reverse current (25nA at 20V), which is essential in this application.

The aerial is a standard television aerial (a roof-top or attic television aerial, connected with coaxial cable), or about 7m of coaxial cable strung up in the air. The ground wire is securely connected to metal water pipes, or to a stake driven into the ground (but not the mains earth, although this does work).

Depending on various factors, the aerial may be shortened to as little as 3m of coaxial cable. In fact, the author found that he was able to power the flasher (under the right conditions – for instance when standing close to electrical equipment) off his own body!

CONSTRUCTION

The Forever Flasher is built on a small single-sided printed circuit board. The topside component layout, wiring and full-size underside copper foil master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 330.

Commence construction by first soldering in position the single link wire, the solder pins, and the 14-pin d.i.l. socket. This should be followed by resistors R1 to R3, then capacitors C1 and C2 and finally diodes D1 to D3. Make sure you observe the correct orientation of polarity-conscious components.

Once you have double-checked component positions, insert IC1 into the d.i.l. socket, being sure to observe anti-static precautions (ideally, do not touch the pins at all) – especially since the 4016 i.c. does not include static protection circuitry on its inputs. This is a very delicate i.c., and if any trouble-shooting is required on completion of the circuit, IC1 should be a prime suspect.

Note that it is possible that an extreme brightness red l.e.d. may have a large anode (instead of cathode) inside its plastic encapsulation, and may seemingly need to be inserted "the wrong way round".

IN USE

If a battery is used (9V), connect it to the supply solder pins provided (positive to the "+" pin, and 0V to the ground pin, being careful to select the right pins). The Forever Flasher should begin to flash at a rate of 0·5Hz to 1Hz.

If an aerial is to be used, connect this to the aerial pin provided (see "Power Pump" crosshead earlier for more details). Next, connect a ground wire. The unit will not work without a ground wire.

All being well, l.e.d. D3 should begin to flash within five seconds, at a slowish rate of about 0·5Hz. This rate may be increased by increasing the value of capacitor C1, or decreasing the value of C2 – although this may lead to a dimmer flash. The flash may also brighten when the aerial wire is touched by moist fingers.

You might wish to work more scientifically. In this case, wire up only diodes D1, D2, and capacitor C1, with the aerial and ground wires connected. Wire a 2M2 resistor across C1. Now use a high impedance voltmeter (a digital multimeter should do) to measure the voltage across C1. This should measure more than 3V, otherwise your aerial and/or ground is inadequate. □

Completed circuit board.

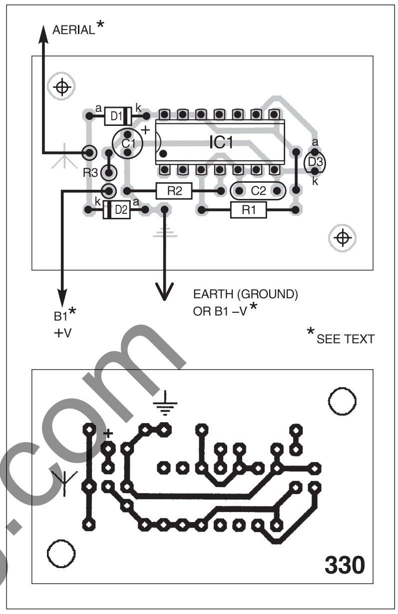

Fig.3. Component layout, wiring and full-size p.c.b. copper foil master.

COMPONENTS

Resistors
- R1 33M metal film, 0·5W 5%
- R2 27k carbon film } 0·25W 5%
- R3 10M carbon film } 0·25W 5%

Capacitors
- C1 1µ min. radial elect. 63V
- C2 100n disc ceramic

See SHOP TALK page

Semiconductors
- D1, D2 1N4148 signal diode (2 off)
- D3 extreme brightness 3mm red l.e.d. 3000mcd 10° viewing angle
- IC1 HEF4016BP CMOS quad bilateral switch (see text)

Miscellaneous
- B1 9V lithium battery (PP3), with clips (optional – see text)

Printed circuit board available from the *EPE PCB Service,* code 330; plastic case, type and size to choice; multistrand connecting wire; coaxial cable (see text); solder pins; solder, etc.

Approx. Cost Guidance Only **£6** ***excl. battery and case***