LED Indicator Draws Only 20mW

One of the most significant developments in solid state technology in recent years has been the evolution of light emitting diodes and displays. This article discusses their principle of operation, mentions various applications and describes a very low current drain indicator lamp circuit for battery operated equipment.

by LEO SIMPSON

Until recently, only two common light sources were available for application in electronic circuitry: the incandescent lamp and the neon lamp. One generates light by raising the temperature of its metal filament to incandescence, and the other by ionising a gas mixture containing neon. The first process is inefficient as it requires considerable power and the second requires relatively high voltages to ionise the gas.

But now a third light source is available which is not wasteful of power and does not require high voltages to drive it. It is the light-emitting diode or LED.

A light-emitting diode, also known as solid-state lamp, is a PN junction diode which emits light when biased in the forward direction. The light emitted can be visible or infra-red. Semiconductor light sources are now available in a wide range of wavelengths, extending from the near ultra-violet region of the electromagnetic spectrum to the far infra-red region.

Light emitting diodes produce light by a phenomenon known as PN junction luminescence. When a PN junction is forward biased, electrons move towards the P-type material from the N-type material, and holes move from the P-type material towards the N-type material. In the region of the junction, recombination occurs, i.e., electrons neutralise holes. When this occurs, energy is released in the form of heat and light.

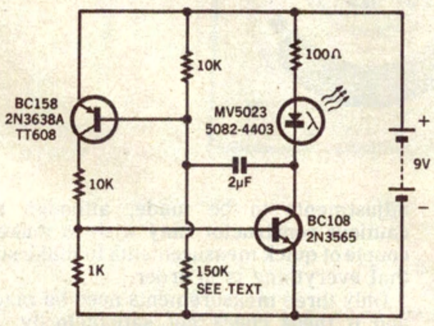
From this general statement, it may be appreciated that light is emitted from the junctions of conventional diodes, but the amount of light is small compared to the heat produced and is not evident since the silicon (or germanium) semiconductor material is not transparent. Gallium arsenide and Gallium phosphide are the materials used for light-emitting diodes.

There are several inherent advantages of light-emitting diodes over conventional lamps. Since an LED has no filament, there is no thermal inertia, so it has very fast response times — typically to 10MHz. Again, because it has no fragile filament and is merely a semiconductor chip mounted in a solid encapsulation, it has very long life and is mechanically rugged leading to much improved reliability. In many cases where an "infinite life" light source or indicator is required, an LED comes closest to fitting the specification. Lifetimes of tens of thousands of hours are possible.

LEDs have low impedance and are compatible with low voltage power supplies and semiconductor circuitry. Their forward bias characteristics are very similar to the silicon diodes but their reverse voltage breakdown characteristic is very much lower — in the order of a few volts.

Other advantageous characteristics of LEDs are: Nearly monochromatic light output; miniature size; freedom from microphony and low power consumtpion.

The stimulus for this article came when Hawker Siddeley Electronics Ltd recently released a range of Monsanto light emitting diodes and seven-segment numeric displays onto the Australian market. While there are dozens of applications for LEDs, mostly in combination with phototransistors, in digital electronics, industrial control and in the communications field, such circuitry is rather esoteric as far as the average hobbyist is concerned.



This flashing indicator circuit draws only 2mA but has high visibility, and is ideal for battery-operated equipment where other indicators cannot be used. The 2uF capacitor must be a low-leakage polyester or tantalum dielectric type.

With these facts in mind, we cast about for a simple circuit which could take advantage of the properties of the LED but would utilise one of the cheaper units in the range. The more powerful LEDs are quite expensive at this stage, ruling the possibility of a light-beam communicator.

As it happened, the circuit we finally decided upon for presentation in this article is the ideal solution to a problem which confronted us some time ago. When developing the Solid-state Volt-Ohm Meter featured in the December 1968 issue of "Electronics Australia" we desired a low consumption pilot light which would enable the user to conserve the batteries by switching the meter off when not required. At the time, there appeared to be no simple solution.

The circuit featured here is ideal for this and any other application where a low drain pilot light is required for use in battery operated equipment. It runs from a nine-volt battery and has an average current drain of only 2 milliamps or less. It has high visibility since it pulses the light-emitting diode at a rate of approximately 10 pps. This takes advantage of the fact that LEDs give higher light output under pulse conditions, and also that the eye is more sensitive to flashing light.

Using a silicon NPN transistor and a silicon PNP transistor, the circuit is an unusual form of multivibrator which has a single RC time-constant. It is unusual in that instead of the two transistors alternately switching into the conducting or blocking state as they do in a conventional cross-coupled multivibrator, both transistors are either conducting or blocking at the same time.

When power is initially applied to the circuit, the 2uF capacitor is slowly charged via the 150K resistor so that its LED end becomes positive. At some point in the charge curve, the PNP transistor becomes forward biased so that it turns on and forward biases the NPN transistor into conduction. Since the 2uF capacitor is connected between the base and collector of these two transistors a regenerative action takes place so that the 2uF is very rapidly charged in the opposite direction.

This rapid charging action of the 2uF capacitor also allows the NPN transistor to apply a brief pulse of current to the light-emitting diode so that it flashes. Once the capacitor is fully charged the voltage across the 150K resistor is almost equal to the supply voltage so that the PNP transistor is biased "off". This switches off the NPN transistor so that the charging cycle via the LED and 150K resistor, recommences and repeats the whole sequence, ad infinitum.

The LED used is the Monsanto MV5023. This is supplied with a clip-in bezel surround for panel mounting and is an economy device. An alternative to this device is the Hewlett-Packard 5082-4403 which is slightly more efficient as it has a better lens.

Apart from use as a power indicator in battery operated equipment such as test equipment and tape recorders, the circuit could also be used as an end-of-life battery indicator, although its sensitivity to voltage will depend mainly on the beta of the transistors. A similar circuit function could be performed by a relaxation oscillator based on a unijunction transistor but we opted for the economy of the bipolar transistor circuit.

Two components in the circuit are critical. The 2uF capacitor must be a low leakage type such as polyester or metallised polyester. Voltage rating is unimportant. The 150K resistor may have to be adjusted to obtain correct operation. If it is too low the circuit will not oscillate and the LED will not light. If the 150K resistor is too high, both transistors will tend to remain conducting and the LED will be lit continuously.