Experiment # 3

HEART MEASUREMENT
(BIOFEEDBACK MEASUREMENT CIRCUIT)

INTRODUCTION:

Perhaps heart rate monitors are the most interesting type of biofeedback circuit for experimenting. There are numerous ways for detecting the heartbeat, but there are two normal electronic approaches to the problem. One of them is to use a photoelectric system. Because we use a light sensor of the type shown in Fig. 1, this method is known as photo-plethysmography.

The theory is very simple. With a light emitting diode (LED) shining a light beam through the finger tip, and a photocell on the opposite side of the finger then detecting the amount of light passing through, the heart rate can be measured. The blood-flow in the capillary bed of the finger causes variations in the amount of light received by the photocell, and these result in small changes in the resistance of the photocell. With suitable circuitry these resistance changes can be converted to small voltage pulses and then amplified to give a usable signal level.

In practice things are not quite as straightforward as this, and there are problems with such a simple set up. The first problem is getting a strong enough light source to transmit a significant amount of light through the finger-tip. Ultra-bright LEDs are now available and seem to give good results if they are operated at a reasonably high current. The main problem is that of getting consistent results, that is to produce a sensor that will operate reliably for a reasonable period of time. The first requirement is some form of finger rest to help keep the user's finger perfectly still, as any slight movement here can produce signals that are far stronger than those generated by the hearbeat. It is also important to have the smallest possible gap between the LED and the photocell, and this means a separation of only about 15 millimeters. The gap must not be so small that the finger-tip is wedged in place, as this would almost certainly prevent the unit from work at all. It is also important that the LED, photocell, and finger rest are all firmly fixed together so that these do not move significantly relative to one another. Finally, the light level received by the photocell is not likely to be very high, and as far as possible should be shielded from any ambient light.

As far as the circuit is concerned, basically all that is needed is an amplifier and a Schmitt Trigger circuit. Fig. 2 shows a suitable circuit diagram. PCC1 is the photocell and this is a CdS type. This is almost certainly the best type of cell for this application where a fast response time is not needed, but good sensitivity is a decided asset. D1 is the light source, and this must be an ultra-bright type if the unit is to operate well. IN FACT THE CIRCUITS IS UNLIKELY TO WORK AT ALL SUING AN ORDINARY LED IN THE D1 POSITION. The amplifier is a two stage type which has IC1 as an inverting amplifier and IC2 as a non-inverting type. The bandwidth is limited to only few Hz by the inclusion of C5 and C6, and this helps to give a low noise level while not attenuating any signal frequencies. BEAR IN MIND THAT THE HEART-RATE IS AT A FREQUENCY THAT WILL NORMALLY BE LITTLE MORE THAN 1 Hz. IC2b operates as a Schmitt Trigger which provides output pulses at the monitored heart rate. D2 flashes in sympathy with the user's heartbeat, but obviously the output pulses at pin 7 of IC2b can be fed to a pulse counter of some kind if preferred.

EXPERIMENTAL WORK:

Perform the experiment. Write a brief report including your observations. Comment, on the results obtained. Show how the performance of the circuit can be improved.

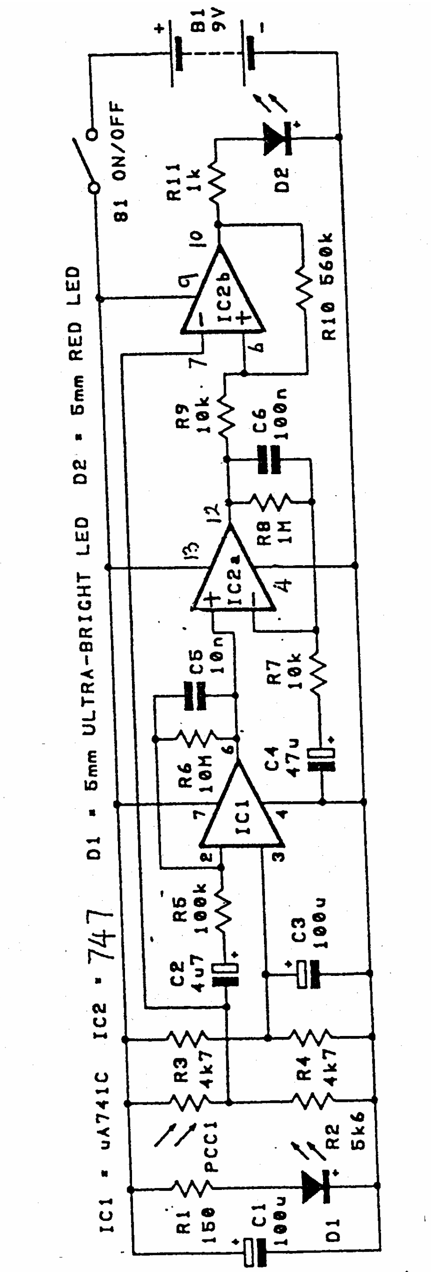

Fig.1: Heart Measurement Circuit

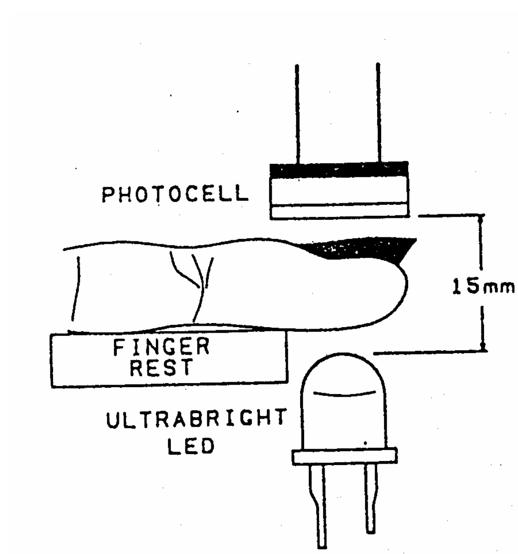

Fig.2: Schematic Diagram