Be the light of the party:

The dazzling new "LED Head" lightchaser

LED chasers have been used in some weird and wonderful devices over the years but few have been as outrageous as this project. In our uncompromising quest for state-of-the-art electronic gimmickry we have designed an electronic headband utilising the LED chaser. The circuit is quite compact and simple and could, of course, just as easily be used to adorn a sun visor or any other likely item.

While he may look like a lunatic being restrained, this brave fellow is regarded as a leading light among his colleagues.

by COLIN DAWSON

We are assuming, however, that most constructors will opt for the LED chaser headband, and in honour of these innovators, we have christened the project "LED Head". Why LED Head? Well, there aren't many names suitable for a project that sets light emitting diodes chasing around the pre-frontal lobe and anyway, it seemed like a Bright Idea!

This project is quite similar in concept to the Boggle Goggles, presented in December '82. In fact, it would make a perfect accessory for the well dressed Boggle Goggler! It should prove very simple to construct, and in most cases will be one of the cheapest projects you can build. The actual chaser circuit, including a box, should not cost much over $10. The only additional expenses are a battery and suitable headband.

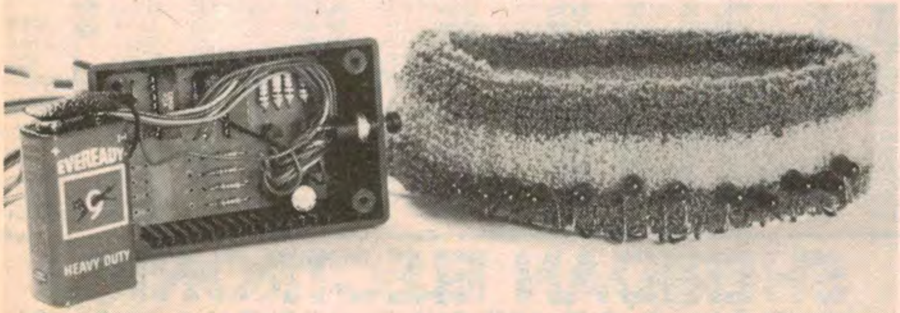
The LED Head has a big advantage over the Boggle Goggles in that the wearer is not significantly incapacitated whilst demonstrating them. You can go about your business as normal. For this reason we anticipate that the LED Head may be used for rather long continuous periods. This, of course, makes a fairly heavy demand on the power supply which may not be met by the 216 9V battery. This battery will give a useful life of about one hour of continuous use, and is the only battery which will fit in the small plastic utility box. If its capacity is inadequate, the solution is to use an external battery pack. An alternative would be to use a bench power supply but this may present a problem if you wish to lead a conga at a party!

Giving the impression of movement to a string of lights, chasers produce an appealing effect. Besides the well known commercial applications, they are almost mandatory on the control panel of science fiction space ships. To the technically uninitiated, such displays are synonymous with computers, death rays and other devices of unfathomable complexity. In fact, this circuit is quite simple, but only "Electronics Australia" readers need know this.

It is possible to impart the impression of movement to any number of lamps in a "string" by wiring them in groups of four. It is then only necessary to use a sequential four pole switch (or its electronic equivalent) to switch the lamps in sequence. At the first switch position, only the first lamp from each group is on and at the second position, only the second lamp should be on, and so on. By placing several groups of lamps end to end, movement appears continuous from one end of the array to the other.

The circuit employed in this project is almost identical to our Electronic Christmas Decoration of December 1981. The main difference is that the printed circuit board has been remodelled to fit into the smallest plastic utility box. Mounted on this printed circuit board are two ICs, four transistors and just a few other components. This part of the circuit can be considered as three parts: an oscillator (IC1); a divider (IC2), and a buffer/driver section (the four transistors).

IC1 is a 4011 quad two input CMOS NAND gate. This may sound rather daunting, but it simply means that the IC has



The LED chaser circuit and type 216 battery fit into the smallest size plastic utility box. The switch is wired between PCB and positive terminal of the battery.

four NAND (Not AND) gates, each gate having two inputs. In this circuit, only three of the gates are used, with the inputs to the fourth gate tied permanently low. By tying the inputs of a NAND gate together, the gate can be made to operate as an inverter ie, its input is in the opposite state to its output.

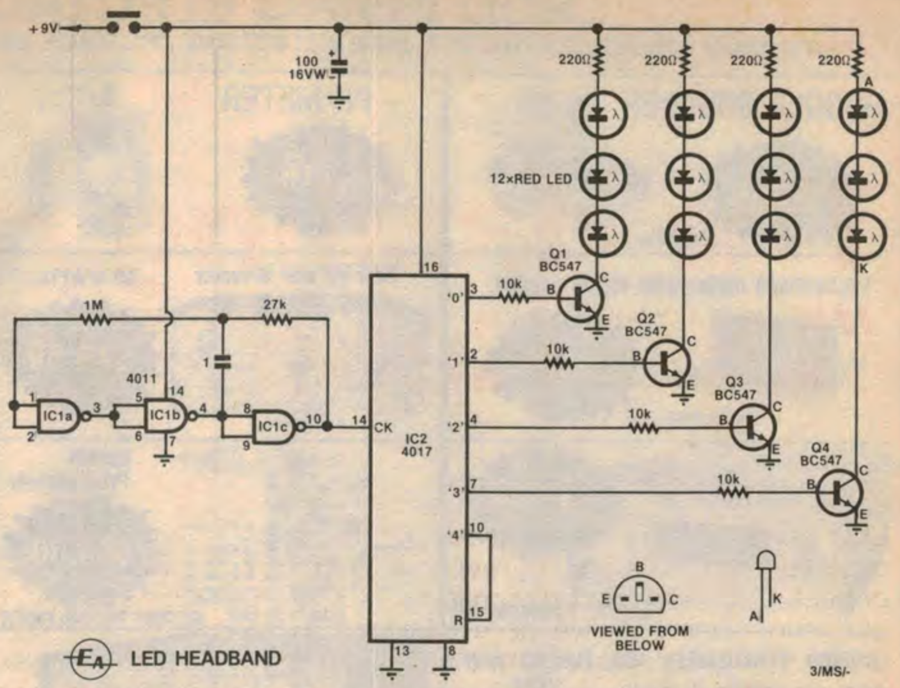
Referring to the circuit diagram, it can be seen that three such inverters, IC1a, 1b and 1c, are connected in series. A 1μF capacitor and a 27kΩ resistor are connected between the outputs of IC1b (pin 4) and IC1c (pin 10). Since these two outputs will always have opposite polarity (because IC1c is an inverter) the capacitor will be charged in one direction, or the other. The 27kΩ resistor provides a time of about 60 milliseconds for this charging. After this time has elapsed, the input of IC1a (pins 1 and 2) will be taken low (or high) and the gate output will change.

This will cause the other gates to change states and the 1μF capacitor now begins to charge in the opposite direction, again with the same charging time. The result of this continuing sequence is a square wave output at pin 10, which then provides clock pulses at a frequency of about 17Hz for the counter.

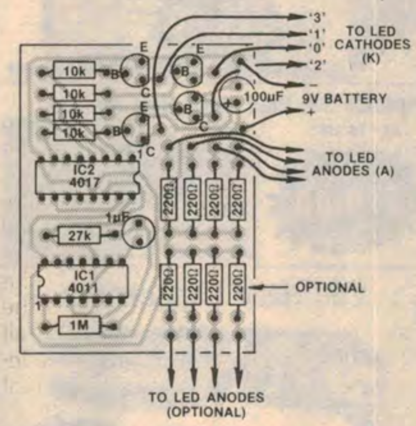
To give the desired sequential switching of the LED groups, a 4017 CMOS decade counter is used. This IC has 10 outputs, numbered 0-9, and normally each one goes high in turn for one clock cycle. Because we only require four different outputs, the fifth output is connected to the reset and the effective count is only four.

The 17Hz output of IC1c at pin 10 is connected to the clock input (pin 14) of IC2, the 4017 decade counter. On each positive transition of the square wave, the 4017 advances one count. The decoded "4" output (pin 5) is connected to the reset (pin 15). As soon as pin 5 goes high, the counter is reset with the decoded "0" (pin 3) going high. This last operation is independent of the clock input and, so far as this circuit is concerned, is instantaneous. Hence the 4017 is operating as a one-of-four counter.

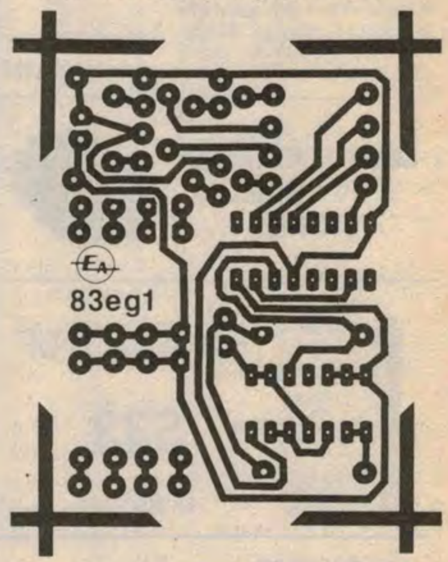
Four NPN transistors are used to buffer the outputs of the 4017. A 10kΩ resistor connects each output to the base of its respective transistor.



The chaser circuit consists of an oscillator, counter and LED driving transistors.



Above is the component overlay diagram. Parts marked "optional" can be added to produce a 24 LED chaser. The full size PCB pattern is at right.



LED combinations

Assuming that there are to be 12 LEDs in the array, the LEDs driven by the decoded zero (pin 3) will be 1, 5 and 9. Similarly, the decoded 1 (pin 2) will drive LEDs 2, 6 and 10; decoded 2 (pin 4) LEDs 3, 7 and 11; and decoded 3 (pin 7) LEDs 4, 8 and 12. If an additional 12 LEDs are included, they must be wired in the same manner as the first 12. The two displays are then mounted end to end (in the mechanical sense).

As we have presented it, the display has 12 LEDs arranged in four groups of three. One group is on at any given time, meaning that three LEDs at a time must be driven. In fact, the three LEDs are driven in series to minimise the current drain from the 216-type battery. The printed circuit board allows the option of adding another four groups of LEDs, the second group being driven in parallel with the first. Consequently, the current drain of the circuit is doubled. This virtually eliminates the 216 battery as a practical power source with a pack of four 1.5V "AA" cells becoming the smallest practical power supply.

We estimate that the current cost of components for this project is approximately

$12.00

This includes sales tax, but not a battery or headband.

A separate current limiting resistor is used for each group of LEDs so that the value of the resistor can be tailored to suit the LEDs used. Different value resistors are required to compensate for the differing operating characteristics of various LED types. For example, red LEDs will exhibit a forward voltage drop of typically 2V, whereas green LEDs will be nearer to 2.6V. Assuming that the chaser has homogeneous LED groups, the red LEDs will require a higher value limiting resistor than the green. In fact, the values suggested are 220Ω and 68Ω for red and green LEDs, respectively. Our prototype used red LEDs only, for minimum current drain.

Actually, the values of 220Ω and 68Ω do not precisely equalise the operating currents. The green LEDs are purposely operated at a slightly higher current than the red to compensate for their lower efficiency. Amber and yellow LEDs are also available and their operating characteristics can generally be expected to fall between red and green LEDs.

Irrespective of the current limiting resistor used, the battery can be expected to have a shorter useful life if green LEDs are used. With three LEDs in series, the total forward voltage drop is 3 × 2.6V, or 7.8V. Once the battery voltage falls below this level, the LEDs will not illuminate at all. Hence the useful life of the battery is the time it takes to discharge from a nominal 9V to 7.8V, which, for a 216 battery, will be somewhat less than one hour. By comparison, the circuit will continue to function down to about 6V with red LEDs.

Construction

If you are housing the electronics for the project in a "zippy" box, make sure that the printed circuit board, coded 83eg1, fits into the box. The board has nominal dimensions of 46mm × 60mm, but it may need to be filed down slightly to fit into some boxes. Once this has been taken care of you can begin assembly of the PCB components. Mount the ICs last and earth the barrel of the soldering iron to the earth track of the PCB when doing so. Solder the earth pins (7 for the 4011 and 8 for the 4017) first, followed by the positive supply pin (14 and 16). This protects the ICs from static damage.

The box needs to have two holes drilled in it. One of these is for the switch and the other is for the wires connecting to the LEDs. For a momentary contact pushbutton switch, a hole of 7mm is needed. Make sure you mount the switch high enough to clear the PCB. You can see from the photograph that the battery sits to one side of the box, so the hole for the wiring will have to be drilled with this in mind. This hole will most likely need to be about 4mm, depending on the type of hook-up wire used.

To prepare the LEDs for mounting, bend the leads so that they are perpendicular to the encapsulation. This allows the LEDs to face forward (rather than upward) after mounting. Make sure that you bend the leads the same way on each LED – for example, the anode always to the left.

Assembly will be simplified if the cloth is of the looped Terry-towelling type. The leads of the LEDS are pushed through the loops on the outside of the headband. If the leads are splayed by about 6 or 7mm, the LEDs will be less prone to movement after assembly. Once the wiring was completed, we found that no other means of securing the LEDs was necessary with the qualification that a periodic re-alignment may be needed.

The method of connecting the series strings are as follows: LED 1 to LED 5 to LED 9; 2 to 6 to 10; 3 to 7 to 11; 4 to 8 to 12. Connect the LEDs anode to cathode, using links of hook-up wire which are long enough to accommodate the full stretch of the headband. The anodes of the first four LEDs are connected to the current limiting resistors and the cathodes of the last four LEDs are connected to the driving transistors. The cathode connections will have to be in the correct sequence or the chasing effect will be lost.

The wiring is the major part of the construction for this project so it is well worthwhile re-checking it before switch on. The LEDs may be damaged by having a reverse bias applied to them and this would undoubtedly be a cause for disappointment amongst potential LED Headers. If the circuit is operating correctly, you will be greeted with a chain of LEDs which appear to chase rapidly around the head. The speed at which they chase can easily be altered by changing the value of the 27kΩ resistor.

Why not dazzle your friends with your LED-lit brilliance?

PARTS LIST

1 4017 CMOS decade counter
1 4011 CMOS quad two-input NAND gate
4 BC547 NPN transistors
12 LEDs (red)
1 100μF/16VW electrolytic capacitor
1 1μF non-polarised electrolytic
1 SPST momentary contact pushbutton switch
1 Plastic utility box, 28mm × 54mm × 83mm
1 printed circuit board, 46mm × 60mm, code 83eg1
1 9V battery, Eveready 216 or equivalent (see text)
1 snap connector to suit battery

RESISTORS
1 × 1MΩ, 1 × 27kΩ, 4 × 10kΩ, 4 × 220Ω (see text)

MISCELLANEOUS
Rainbow cable, headband, solder.