Our monthly "Surgeon" helps out with a boat owner's electrical woes.

Berserk Bargraph

Following on from last month with another troubleshooting story, I'm grateful to ***Mr. Eric Forrester*** of Hemlington, Cleveland who dropped a line as follows.

Your Circuit Surgery *September 1996 issue shows a Car/Boat Battery Monitor but this had me perplexed owing to your Dial Light arrangement. I constructed the circuit on stripboard but it is not dimming the l.e.d.s, and also the bargraph reads values different from those you indicate in your circuit diagram!*

This chip is new to me and I'd appreciate some help – enclosed is my Veroboard layout diagram which I designed, could you take a look? I can't quite figure out the calculations for the potential dividers, either.

No problem! After a few minutes of peeking through my magnifying glass, I spotted the cause of the l.e.d. problem, which I attributed to incorrectly identifying the pins of the LM3914 i.c. – Fig. 1 shows how to identify the pins of this dual in line chip. Notice that either a dimple or

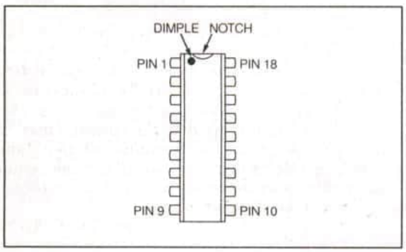

Fig. 1. An 18-pin d.i.l. integrated circuit package pin line-up.

a notch will identify one end of the device, and also the positive and negative supply pins 2 and 3 are (unfortunately) adjacent to each other; errors wiring them reversed to the supply will spell death to the chip!

You are not alone, Mr. Forrester, because the pin numbering sequence of a dual-in-line chip does often confuse newcomers. The other point in this respect concerns the circuit diagram shown on P.682 of the September issue. We always show the pin numbers on the outside of the i.c. symbol, and anything denoted *within* the rectangle represents the pin *function*, not number.

The Dial Light function worked well on test: the idea is that each resistor R5-R14 is connected to one of the l.e.d.s. in the display, and all the resistors are commoned to 0V via the switch. High value resistors are used and I tried 10k to 33k with success. They enable a small current to flow through each l.e.d. to 0V, so that each l.e.d. glows dimly. When its corresponding LM3914 output goes low, this permits a much greater current to flow through the l.e.d. which glows more brightly than the others. The effect is to create a "backlit" l.e.d. scale.

If you use high efficiency l.e.d.s., these require only a few milliamps to operate, and they offer a proportionately greater light output compared with vanilla-flavour devices. To enable the LM3914 to be cascaded to make larger displays, the

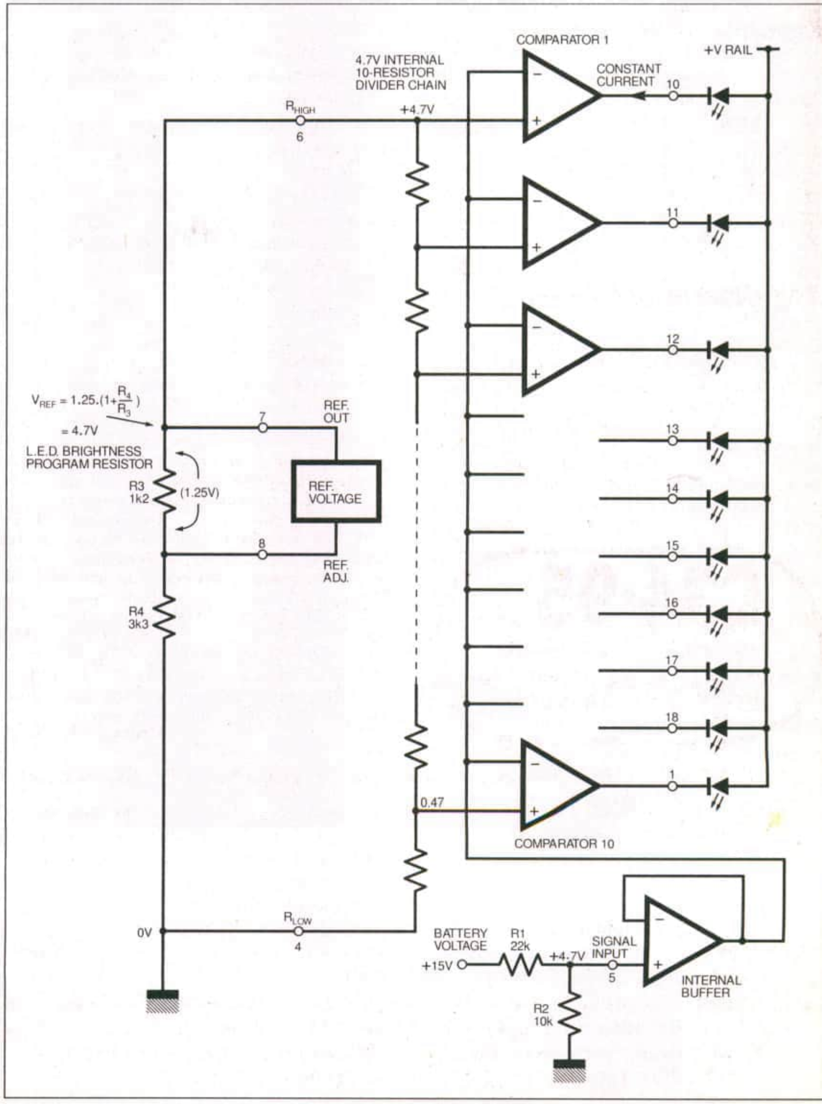

Fig. 2. Simplified block diagram for the LM3914 linear l.e.d. driver.

internal circuitry of the chip causes at least 100μA to flow through the l.e.d. connected to pin 1. So even if that l.e.d. should logically be switched off, this extra sink current may be adequate to cause D10 to glow faintly (assuming you use the l.e.d. at all in this design). The remedy is to shunt it with a parallel 10k resistor if this is a problem. Trying the circuit for myself with high efficiency l.e.d.s (before the Dial Light idea came about), I did indeed see D10 glowing continually because of the special circuitry at pin 1. A rummage through the Data Book revealed why!

Calculated Guess

Turning to the calculations behind the circuit, firstly I made use of the chip's adjustable reference voltage which is available at pin 7. Fig. 2 shows a simplified block diagram of the LM3914. It features a chain of resistors, each tapped and connected to a comparator, one per l.e.d. One end of the chain is labelled R_{HIGH} (pin 6), the other R_{LOW} (pin 4). The voltage applied across the resistor chain determines how sensitive the LM3914 will be to input voltages: apply 10V across the ends, for example, and each l.e.d. will represent 1V.

The internal reference voltage is preset at 1·25V, meaning that each l.e.d. represents 125mV. I wanted a full-scale deflection of 15V in 1·5V steps, so I increased the reference voltage with the resistors R3 and R4. (Note that the current drawn out of pin 7 also sets the l.e.d. brightness. Since 1·25V exists between pins 7 and 8, the l.e.d. current is actually ten times more than this, i.e. 10mA. I always tend to set R3 at 1·2k.) In fact when designing the circuit, I worked backwards from the input requirements, and set the reference voltage to suit, as follows.

If V_{IN} = 15V, therefore V_{SIG} = 4·7V roughly at pin 5. This means that the i.c. input signal sees about one third of the actual battery voltage measured, due to the potential divider action of R1 and R2. The i.c. reference is calculated by:-

$$V_{REF} = 1{\cdot}25\left(1 + \frac{R_4}{R_3}\right)$$

so the reference voltage applied across the resistor cascade was also set for 4·7V using the values of R3 and R4 shown. You'll see how this 4·7V reference voltage at pin 7 is connected to R_{HIGH} at pin 6, whilst R_{LOW} is grounded. Hence, each l.e.d. represents approximately 0·5V change in the input signal at pin 5, which scales up to approximately 1·5V battery voltage change. Ten light-emitting diodes therefore appear to read the battery voltage, up to 15V. Incidentally the input circuitry of the LM3914 is fully protected up to 35V in any case: but by scaling the bargraph with the reference voltage (and input dividers), you can obtain more suitable displays. I hope this helps.