PROJECT OF THE MONTH

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TRI-STATE LED DEMONSTRATOR

THE TRI-STATE LED is one of the most interesting optoelectronic components available to the experimenter. The most common version incorporates separate red and green LED chips mounted very close to one another in a clear or milky-white epoxy package. The two chips are connected as shown in Fig. 1 in what is called an inverse parallel configuration. This ensures that one of the two diodes is forward-biased regardless of the polarity of the applied voltage.

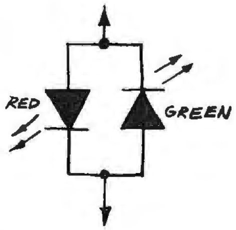

Fig. 1. Schematic symbol for a tri-state LED.

The three states of a tri-state LED usually are defined as red, green and off. Actually, a total of seven optical states is available: off, steady, or flashing red, green, or yellow. Yellow radiation is obtained by rapidly switching the polarity of the applied voltage. The pulsed red and green radiation from the two chips visually merge. Although the color the eye perceives is not a true yellow, it is distinctly recognizable as being neither red nor green.

The schematic diagram of a circuit that has been adapted from one given in the data sheet of Monsanto's MV5491 tri-state LED is shown in Fig. 2. The circuit incorporates two series resistors to provide an optimized current to each LED to balance their brightness. The 1N914 diode (*D1*) bypasses *R2* when the green LED is selected. This compensates for the green LED's higher barrier potential so that the same forward current flows through each diode.

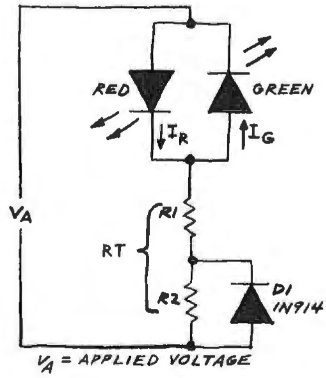

Fig. 2. Circuit used to calculate needed resistances.

The formulas employed to calculate the values of *R1* and *R2* for specific red and green LED forward currents are: $R1 = (V_A - 3.3)/I_G$; $R_T = (V_A - 1.63)/I_R$; $R2 = R_T - R1$; where I_G and I_R are the forward current through the green and red LEDs, respectively, and V_A is the applied voltage. For example, to bias both diodes at 20 mA when V_A is 5 volts, *R1* and *R2* should be 102 and 68 ohms, respectively. The MV5491 data sheet includes a table that gives resistance for *R1* and *R2* for a range of forward currents.

Incidentally, don't be concerned if the exact resistor values the equations dictate are unavailable. Just try to obtain the closest standard value. If you're not concerned with matching brightnesses, simply insert a single 270-ohm resistor in series with the LED when powering it from a 5-volt supply.

Figure 3 is a simple astable multivibrator that demonstrates six of the seven states of a tri-state LED. You can assemble the entire circuit on a miniature solderless breadboard in several minutes. When the wiper of *R1* is at the midpoint of its travel, the LED will alternately flash red and green. The effect is visually striking, particularly if you are used to viewing monochromatic (single-color) LEDs.

Rotating the wiper of *R1* will increase or decrease the red-green flash rate. At one extreme, the red and green flashes will merge into a washed-out orange or yellow color. Both diodes are still flashing, but the flash rate is faster than the flicker response of the eye. (You can hear the flash rate as a series of clicks by connecting the input of a small audio amplifier to ground and through a 0.1-microfarad capacitor to either pin 3 or 6 of the 7400.) At the other extreme, the LED will stop flashing and glow a steady red or green depending on the direction it is connected.

So far, we've accounted for five of the seven states. The sixth state occurs when the circuit is turned off and the LED is extinguished. The seventh state, which this circuit does not provide, is flashing yellow. It can be obtained by gating the pulse train applied to the LED with a low-frequency pulse train at the cost of somewhat increased circuit complexity.

I've seen only a few commercial applications for tri-state LEDs. One is the indicator lamp on the power switch of the Realistic STA-2100 AM/FM stereo receiver. The LED glows red when the switch is pressed.

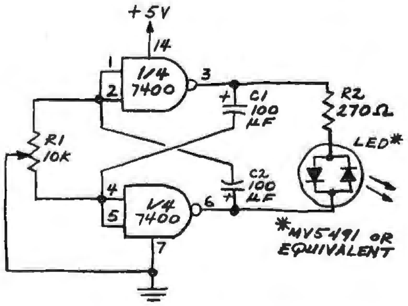

Fig. 3. Tri-state demonstration circuit.

After a few seconds, it glows green as the unit begins operation.

Building and experimenting with the simple project in Fig. 3 will give you some ideas about the novel display and indicator possibilities for tri-state LEDs. (Model railroaders will find these devices to be ideally suited for use in block signals.) You can buy tri-state LEDs from some of the companies that advertise in the Electronic Market Place in this magazine. Keep in mind that you can simulate some of the functions of a tri-state LED by connecting a pair of standard red and green LEDs in inverse parallel. ◇