Circuit efficiently switches bipolar LED

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The circuit in Figure 1 represents one method to switch a bipolar, two-color LED using an SPDT mechanical switch or relay. This circuit wastes power and does not work properly if the power-supply voltage is not substantially more than the sum of the LEDs' forward voltages. The circuit is, therefore, marginal, to the point of being unusable, with a 5V supply and a red or green LED, which typically has a total forward voltage of 4V. You can use a circuit resembling a flip-flop (Figure 2) that doesn't suffer the disadvantages of the circuit in Figure 1. It adds only one V_{CE(SAT)} voltage to the V_F of each LED, so plenty of headroom exists with a 5V supply and a series resistor to control the LEDs' current. The circuit in Figure 2 costs less than a dime for the parts, which include three resistors and two inexpensive, general-purpose npn transistors, such as the 2N4401 or the C8050. In this example, D_1 is red (V_{F1}=1.6V), and D_2 is green (V_{F2}=2.4V). Based on D_2, the green LED, you can calculate that \( R_S = (5V - 2.4V - 0.1V)/0.02A = 125\Omega \) (use 130\Omega for 19 mA).

As a result, using a single resistor, D_1 has a current of 25 mA. If it is desirable to have equal or arbitrarily different currents, you can insert an additional resistor in one leg of the switch to increase the effective \( R_S \) for that switch position. The base drive is a function of the \( V_F \) of the driven LED, so you can calculate the base resistors, using a forced beta of 20, as follows:

\[
R_1 = \frac{20(V_{F1} - 0.7V)}{I_{LED1}} = 720\Omega \text{ (use } 750\Omega). \\
R_2 = \frac{20(V_{F2} - 0.7V)}{I_{LED2}} = 1.8 \text{ k}\Omega.
\]

The base drive reduces the actual LED current by 5\%, which is visually negligible. As a bonus, the circuit does not introduce any switching glitches into the power supply. The circuit requires only two connections, rendering it ideal for front-panel use. Because the 130\Omega resistor is in series with the power supply, any part of the circuit beyond \( R_S \) can short to ground without causing damage.