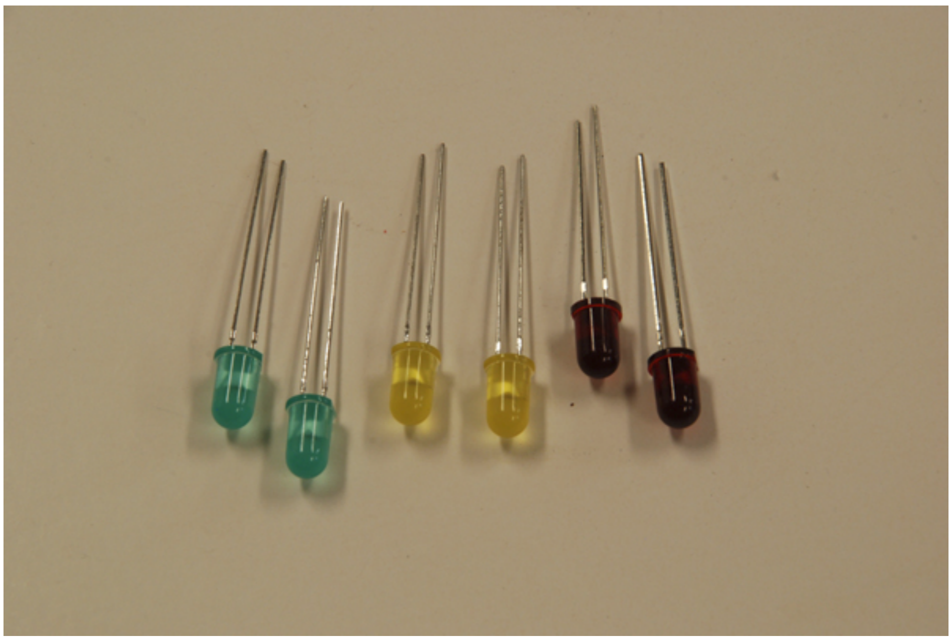
A **light emitting diode** (LED) emits light when an electric current passes through it. LEDs have polarity, meaning current must pass from anode to cathode to activate. The anode is labelled **a** or **+** , and cathode is labelled **k** or **-**. The cathode is the short lead and there may be a slight flat spot on the body of round LEDs. Thus, the anode is the longer lead.



These are single-color LEDs. The color is determined by the physics of the material used to construct the LED. Notice that each LED has one long lead and one shorter lead.

The brightness of an LED depends on the applied electrical power (*P=I*V*). Since the LED voltage is approximately constant in the active region (see left side of Figure 8.5), we can establish the desired brightness by setting the current.

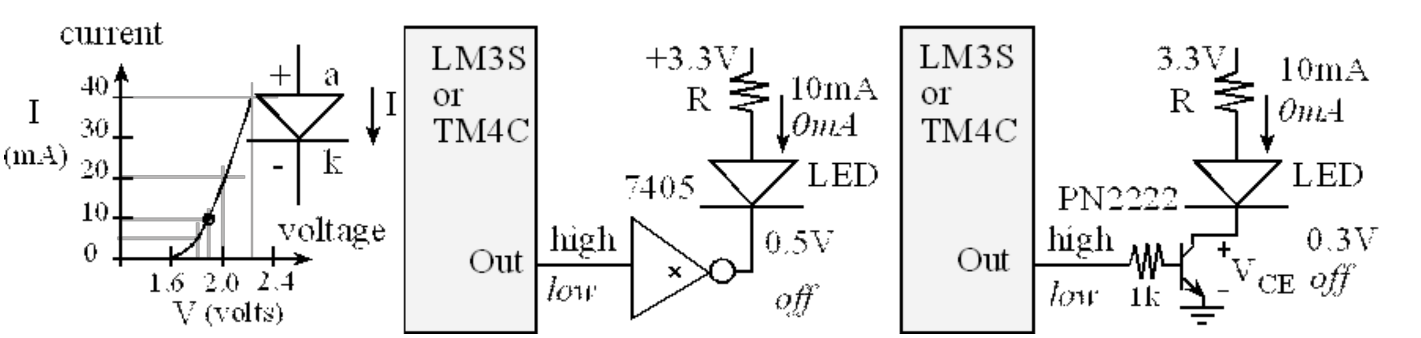


Figure 8.5. Positive logic LED interface (Lite-On LTL-10223W).

If the LED current is above 8 mA, we cannot connect it directly to the microcontroller because the high currents may damage the chip. Figure 8.5 shows two possible interface circuits we could use. In both circuits if the software makes its output high the LED will be on. If the software makes its output low the LED will be off (shown in Figure 8.5 with *italics*). When the software writes a logic 1 to the output port, the input to the 7405/PN2222 becomes high, output from the 7405/PN2222 becomes low, 10 mA travels through the LED, and the LED is on. When the software writes a logic 0 to the output port, the input to the 7405/PN2222 becomes low, output from the 7405/PN2222 floats (neither high nor low), no current travels through the LED, and the LED is dark. The value of the resistor is selected to establish the proper LED current. When active, the LED voltage will be about 2 V, and the power delivered to the LED will be controlled by its current. If the desired brightness requires an operating point of 1.9 V at 10 mA, then the resistor value should be

$$R = \frac{3.3 - V_d - V_{OL}}{I_d} = \frac{3.3 - 1.9 - 0.5}{0.01} = 90\Omega$$

where V_d, I_d is the desired LED operating point, and V_{OL} is the output low voltage of the LED driver. If we use a standard resistor value of 100Ω in place of the 90Ω, then the current will be (3.3-1.9-0.5V)/100Ω, which is about 9 mA. This slightly lower current is usually acceptable.

Help

CHECKPOINT 8.1

What resistor value in the 7405 circuit of Figure 8.5 is needed if the desired LED operating point is 1.8V and 10 mA?

Hide Answer

We represent voltages in V, current in A, and resistances in ohms. For this LED, we have 3.3 - 1.8 - 0.010*R - 0.5 = 0 => R = 100Ω