Constant Current Driver for LED Backlights Improves Brightness Control

Background: LEDs are the most common type of backlight used on character and small graphic LCD modules. These backlight systems are current dependent, but they are often supplied by voltage sources, usually with a current limiting resistor. A constant current source is a much better match for a current dependent load. The forward current through the LED backlight array determines the brightness. Maintaining a constant, uniform brightness for the LCD display is often an important requirement for many applications. This paper presents a simple, low cost, efficient circuit to drive the LED backlight system, offering much greater accuracy, control, and repeatability. This circuit operates off the LCD logic supply voltage and delivers a constant current independent of both supply voltage variations and variations in the forward voltage drop of the LED backlight array.

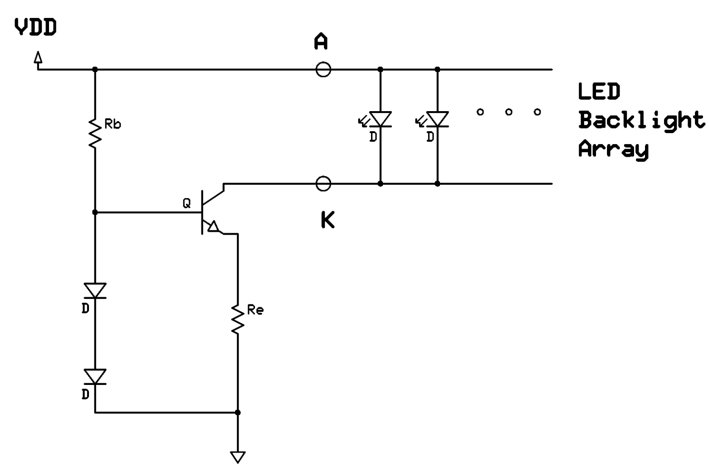

Figure 1: Basic Circuit

Figure 1 shows the basic constant current circuit. Here's how it works:
"A" and "K" are the external connections to the LCD module's LED backlight terminals. Depending on the manufacturer, these backlight connections may be part of the module's main data line connector, CN1, or they may be separate contacts on the PC board, usually solder pads.

1. Rb is selected so that the current through this resistor >> base current into the transistor. For example: Vdd = 5V, voltage across the two diodes = 1.4V, and the desired LED backlight current = 100 mA. For transistors with DC hfe = 100 min, base current = 1 mA max. So let current through Rb = 4 mA, and

then Rb = (5-1.4)/4 = 910 ohms. Decreasing this resistor value will make the circuit more stable, but overall efficiency will be reduced.

2. Re controls the constant current supplied to the LED backlight. The voltage across Re is simply the forward voltage of the second diode in the base circuit, 0.7V. To supply 100 mA, Re = 0.7/0.1 = 7 ohms. The forward voltage drop of this diode is a stable low voltage reference source that allows this circuit to operate from a low voltage power supply.
3. Note that once this emitter resistor is set, the current delivered to the load will be constant, independent of supply voltage variations, and independent of the forward voltage drop of the LED backlight array! This stable, repeatable constant current is the key feature of this circuit.

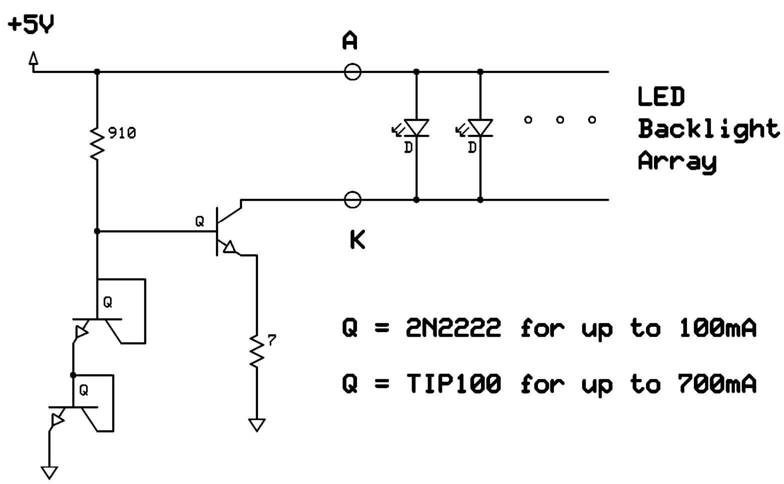

Figure 2: Practical Circuit

Figure 2 shows the practical constant current circuit, recommended for LCD applications:

1. Note the “trick” for thermal stability: Use the same transistor Q in place of the two diodes. Be sure to connect the collector to the base as shown to prevent oscillations.
2. This circuit will deliver a constant 100 mA with the resistor values shown, calculated from Figure 1 discussion above.
3. To achieve 700 mA, Re must be lowered to 1 ohm. In practice, this resistor value will have to be tailored if a precise current value is required.
4. Because of the high DC hfe of the TIP100, the base resistor can remain at 910 ohms in the high current model.
5. Total component BOM is low, < $0.50 for the low current version, < $1.50 for the high current version.

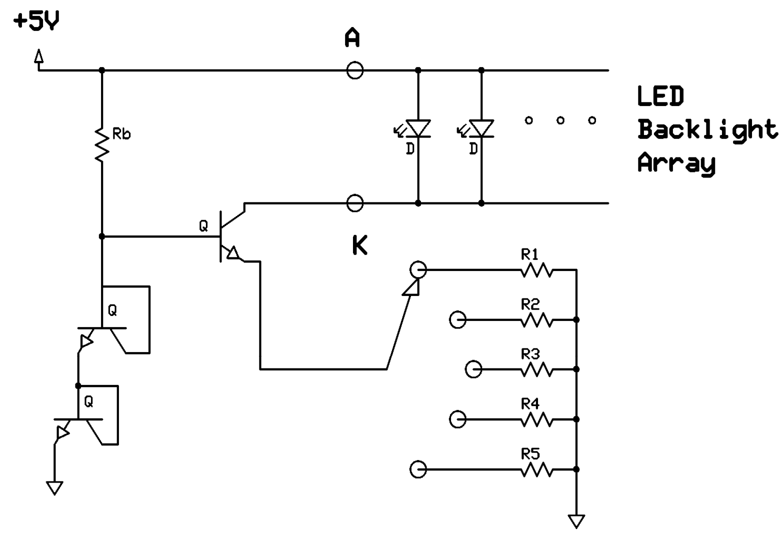

Figure 3: Switchable Constant Current Circuit

Figure 3 offers an adjustable constant current generator:

1. A multi-position switch with fixed resistors is recommended over a potentiometer. Under load conditions, the resistors can be adjusted to the desired current. Once adjusted, the current will remain stable, and the switch can be labeled with the correct current settings.
2. A potentiometer is not recommended for the following reasons:
   a. Using a potentiometer requires permanent insertion of a meter to monitor the current.
   b. Using a potentiometer will require adding a fixed current limiting resistor in the emitter circuit.
   c. The potentiometer will have some residual resistance when the wiper is fully adjusted to the "zero" ohms position, which must be measured and considered when selecting the fixed current limiting resistor.

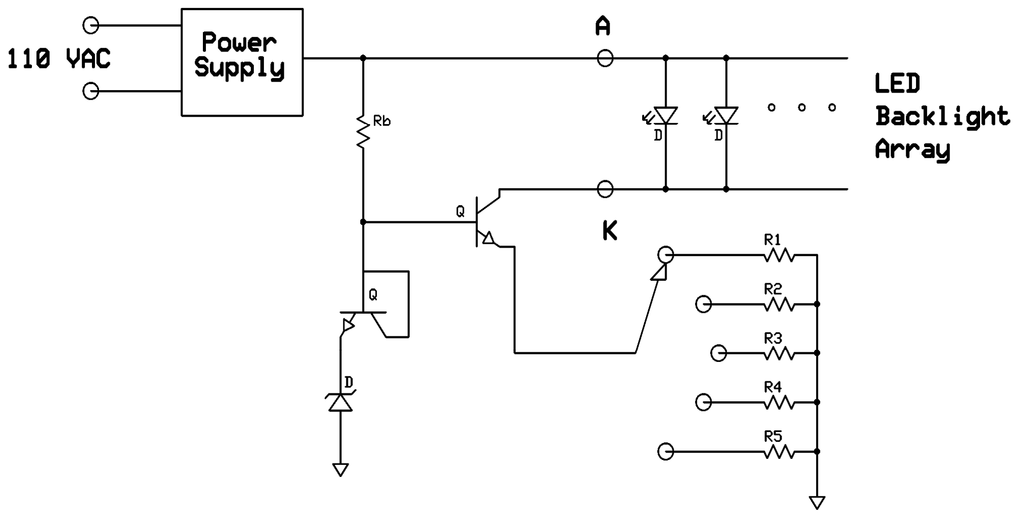

Figure 4: Constant Current Generator for the Lab

Figure 4 shows the recommended circuit for lab applications, where efficiency is not the primary concern. More precision can be achieved by switching to a separate power supply for this circuit, and raising the supply voltage to 12V – 15V. This will allow substituting a zener diode for one of the diodes used in the base circuit. The zener voltage now becomes the reference for the Re values to develop the current. Increasing this reference source value from 0.7V to a 5.1 V zener will allow for higher Re values and more circuit stability. For maximum thermal stability, use the same transistor in both locations shown in the circuit. A meter can be added in series with the load (not shown in Fig 4) to display the current at each switch position.