# Linear potentiometer provides nonlinear light-intensity control

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THE HUMAN EYE's highly nonlinear response to light levels poses problems for designers of adjustable lighting. Simple hardware or software linear-control methods compress most of the apparent intensity variation into a relatively small portion of the adjustment range. A strongly nonlinear control characteristic is necessary. Such a characteristic spreads the intensity adjustment over a wider range and offers a more natural feel. This Design Idea shows how to use an inexpensive linear potentiometer to develop a satisfactory hardware technique. In an experiment in a darkroom, one of the room's corners was too dark because a fixed barrier shielded safe light. Using spare parts from a junk box, you could assemble a simple red LED-based auxiliary safe light, but if the light level were adjustable, you could balance the light levels and minimize the risk of fogging the printing paper. However, the experimenters in this case lacked an audio-taper intensity-control potentiometer and wanted to avoid paying for one.

**Figure 1** shows a simplified version of the technique. Diode-connected transistor $Q_1$ and an AD589 1.235V reference, $IC_1$, produce a reference voltage of $1.235V+V_{BE}(Q_1)$ at Node A. Connected between Node A and $Q_2$'s emitter, linear potentiometer $R_2$ and resistor $R_3$ cause $Q_2$'s emitter and collector current to vary as $1.235V/(R_2+R_3)$. The relationship isn't exact because the $V_{BE}$ voltages of $Q_1$ and $Q_2$ vary slightly as you adjust the potentiometer, but, in practice, this nonlinear—if not logarithmic—characteristic works well.

Transistor $Q_2$'s collector current generates the control voltage across $R_4$, and, whereas $Q_2$ always operates close to saturation, the components limit $Q_2$'s collector-base forward bias to an acceptable 200 mV. When you set $R_2$ to its minimum resistance for maximum light intensity, resistor $R_3$ limits LED current, and, when you set $R_2$ to its maximum resistance for minimum intensity, $R_1$ limits the current through $IC_1$.

The reference voltage produced at $Q_2$'s collector drives a standard integrating servoamplifier comprising an AD8031 rail-to-rail op amp, $IC_2$; an IRFD010 low-power MOSFET, $Q_3$; $R_5$ ;$R_6$; and $C_2$. The servo sets the current through $R_5$ to $R_4/R_5$ times the current through $R_4$. Resistor $R_7$ isolates $Q_3$'s gate capacitance to prevent load-induced instability in $IC_2$. A 12V-dc module supplies power to the circuit and allows the use of four LEDs per string, for a total voltage drop of approximately 8V across each string. To prevent current hogging and provide a maximum of approximately 20 mA for each series-connected LED string, resistors $R_8$ through $R_{11}$ divide $Q_3$'s drain current into four. Voltage drop across each resistor is 1V, leaving $Q_3$ to support a 3V drain-source voltage and an approximately 250-mW power dissipation. If you increase the number of LEDs or the power-supply voltage, you may need to replace $Q_3$ with a higher dissipation MOSFET.□

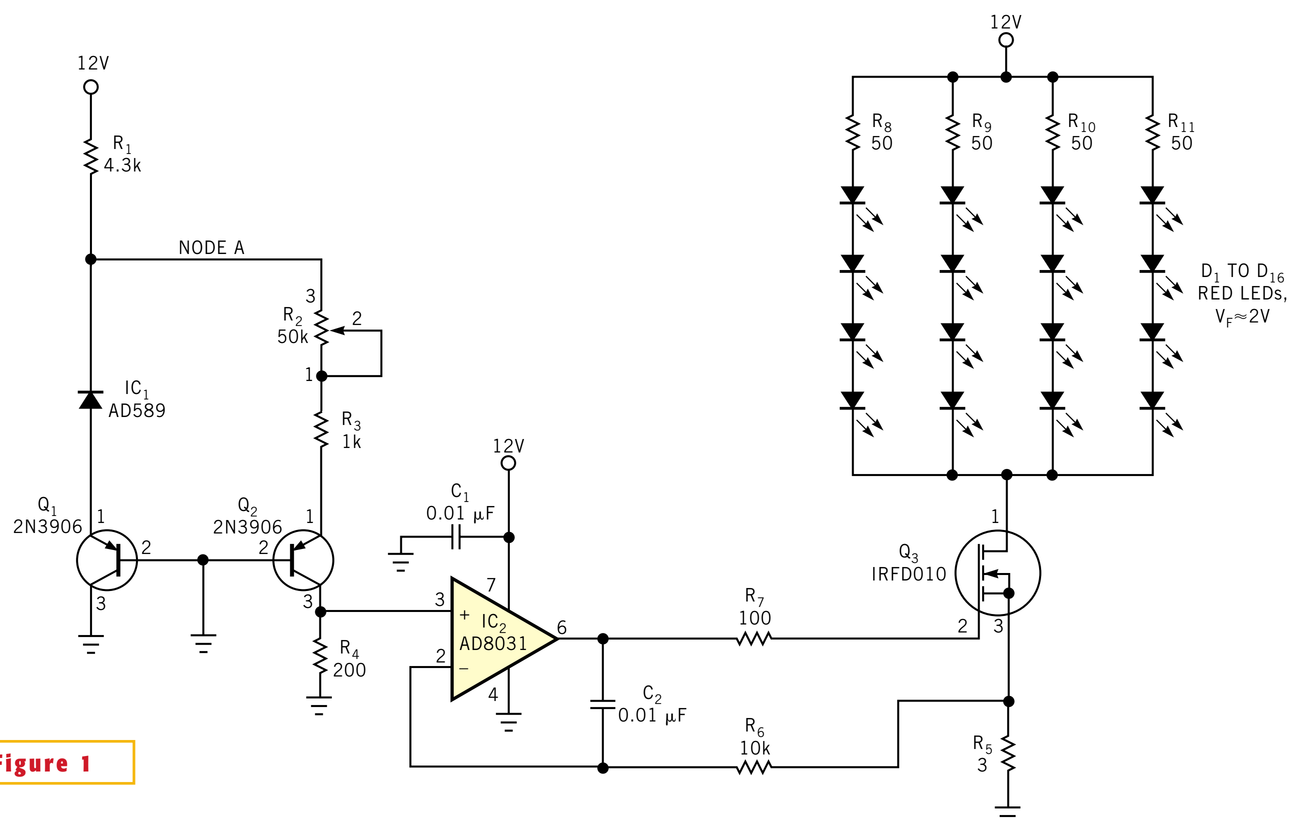


Figure 1

**A handful of components provides linear adjustment of a darkroom's safe light.**