Keywords: LED drivers, linear brightness controllers, digital potentiometers

APPLICATION NOTE 4561

Linear Brightness Controller for LEDs Has 64 Taps

By: Ahmad Ayar
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Abstract: In this circuit, a digital potentiometer (DS1869) aids an LED-driver IC (MAX16800) in providing manual control of the LED brightness. The circuit also provides thermal protection against excessive heat and overload conditions.

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Applications that include LEDs but no microcontroller (or other form of control intelligence) can benefit from a simple circuit that provides manual control of the LED's light intensity. Among the devices suitable for this purpose are mechanical (analog) and electronic (digital) potentiometers. The digital pot with two pushbuttons (UP/DOWN), an alternative to the mechanical potentiometer, is smaller, more reliable, and usually less expensive (**Figure 1**).
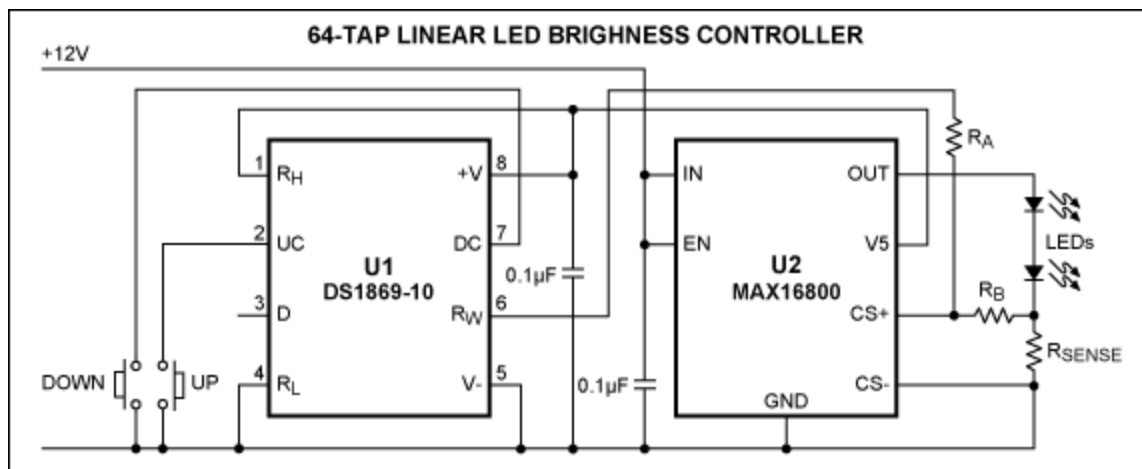

Figure 1. This brightness-control circuit lets you adjust the LED brightness manually, using the UP and DOWN buttons.

U2 is a current regulator (MAX16800) designed to drive a chain of LEDs with current as high as 200mA. In a standard application circuit, U2's internal regulator senses the drop across current-sense resistor R_{SENSE}, in series with the LED chain. Thus, U2 controls current through the chain by regulating voltage at the differential inputs CS- and CS+, to the set value of 204mV. Resistors R_A and R_B allow the current level to be adjusted by the output voltage at U1, pin 6.

U1 is a 64-tap linear digital potentiometer (DS1869-10) whose resistance is connected between ground and V5, a well-regulated voltage internally generated by U2. The RW control voltage (pin 6), defined as a fraction of V5, is adjusted manually by the two pushbuttons UP and DOWN. A few assumptions allow a quick and simplified calculation of the resistor values needed. Initially you fix R_A, then calculate R_B and R_{SENSE}. The assumptions are:

- Error induced by the bias current at CS+ (6.93µA maximum) can be neglected.
- The value chosen for R_A is much higher than U1's equivalent resistance, for which the worse-case value at position 32 (top and bottom resistances plus the wiper series resistance) is 2.9kΩ.
- $R_{SENSE} \ll R_B$

After setting R_A = 25.5kΩ, V_{WIPER} = (5V/63) × N, where N is the wiper setting (0 to 63). (V_{WIPER} - 0.204V)/R_A = (0.204V - I_{LED} × R_{SENSE})/R_B.

Solve the above equation for R_B under the conditions for which I_{LED} = 0, which are N = 63 and V_{WIPER} = 5V (top position):

$$R_B = 25.5kΩ × 0.204V/(5V - 0.204V) = 1.085kΩ$$

You can choose R_B from the standard values 1.07kΩ (1% series) or 1.1kΩ (5% series).

At the bottom position, where VWIPER = 0 and LED current is maximum (200mA), brightness should be the maximum available. Solving for R_{SENSE}:

$$R_{SENSE} = [0.204V +(0.204V × (1.085/25.5))]/0.2A = 1.063Ω$$

1.07Ω is a standard value in the 1% series.

A graph of LED current versus tap position (**Figure 2**) shows a slight nonlinearity due to the variation in resistance seen looking into the wiper at different tap positions. At extreme ends of the pot, only the 400Ω wiper resistance is seen. As the wiper moves towards mid-point, the resistance increases toward a maximum of ¼ of the end-to-end resistance value. Because U1 is a 10kΩ potentiometer, the resistance seen by the wiper at mid-point is about 2.5kΩ in series with R_{WIPER}. This variation introduces a maximum linearity error of 8%, which is negligible in most LED applications.
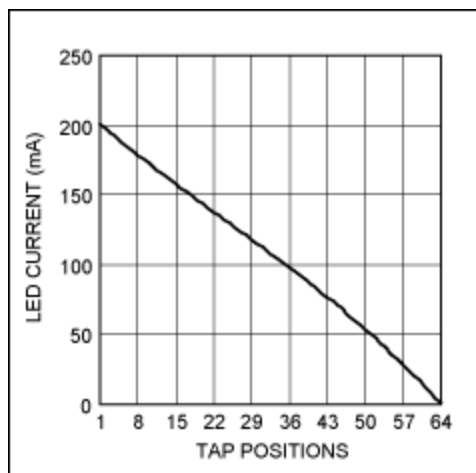

Figure 2. LED current vs. tap position in Figure 1 exhibits only a slight nonlinearity.

U2 offers thermal protection against excessive heat and overload conditions. For effective power

dissipation and to avoid thermal cycling, the exposed pad of the package must be connected to a large-area ground plane.

Related Parts		
DS1869	3V Dallastat Electronic Digital Rheostat	
MAX16800	High-Voltage, 350mA, Adjustable Linear High-Brightness LED (HB LED) Driver	Free Samples

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