National Semiconductor

VOLTAGE REGULATOR CONTROLS SCANNER LAMP BRIGHTNESS

APPLICATION

Best possible performance in an image scanning device can only be obtained when the scanner IC is able to control the brightness of the image reflected into the light sensors. The best way to do this is to adjust the intensity (light output) of the fluorescent lamp which shines light onto the item being scanned.

Traditionally, adjustable brightness has not been economically feasible in most scanners due to the cost of implementing a high-current voltage source which is software programmable. This paper describes a simple, low-cost circuit which can be used with National Semiconductor's LM9830 "scanner-on-a-chip" IC to implement full-range lamp brightness control.

DESCRIPTION OF BRIGHTNESS CONTROL REGULATOR

The fluorescent lamp in most low-cost scanners is typically run from a fixed +12V source, which operates the lamp at maximum brightness. If the 12V used to power the lamp is reduced to a lower voltage, the brightness of the lamp can be adjusted to virtually any level. To accomplish this, a circuit is used which takes 12V in and produces a regulated DC output voltage which varies between 0 and 12V, depending on the brightness control signal coming from the LM9830 IC (see Figure 1). This control signal is a 5V pulse train, whose duty cycle is set by the LM9830.

The lamp brightness controller circuit (Figure 2) takes in +12V and regulates it down to any voltage between 0 and 12V. Since the ON-resistance of the NDP6020P FET is only about 50 mΩ, the maximum regulated output voltage the circuit can provide is within about 25mV of the input voltage at the typical lamp current of 0.5A.

The regulated output voltage is generated by the error amplifier U1B, resistive divider R8 and R9, and the reference voltage produced by averaging the square wave pulse train. The square waves are filtered into a DC voltage by R4, C3, R6, and C4. The voltage across C4 is the average value of the pulse train, which is directly proportional to the duty cycle:

$$V_{C4} = 5V \times (\text{Duty cycle})$$

This shows that the reference voltage applied to pin 6 of U1B can be varied linearly between 0 and 5V by adjusting the duty cycle of the 5V pulse train. When used with the LM9830, a maximum of 4095 different values of duty cycle can be programmed (which yields 4095 different brightness levels).

The error amplifier U1B compares the C4 voltage to the voltage at the center of resistive divider R8 and R9 (which is derived from the regulated output voltage Vout). The regulating action of U1B is such that it constantly adjusts the gate drive voltage to the FET Q1 to cause Vout to be the value required to keep the voltages at the inputs of U1B equal. In this way, the voltage at C4 (which is proportional to the duty cycle of the pulse train) controls the regulated voltage Vout. Vout can be calculated from:

$$\text{Vout} = V_{C4} \times (R8 + R9) / R9 = \text{Vpk} \times (\text{duty cycle}) \times (R8 + R9) / R9$$

Where **Vpk** is the peak amplitude of the pulse train (5V in this application) and **duty cycle** is the pulse ON time divided by the total period (see Figure 2).

Components C2, R5, R7, C1, and C5 are required for compensation and stability. For component values shown, best performance is obtained with the frequency of the pulse train between 10 kHz and 50 kHz.

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FIGURE 1. TYPICAL IMAGE SCANNER

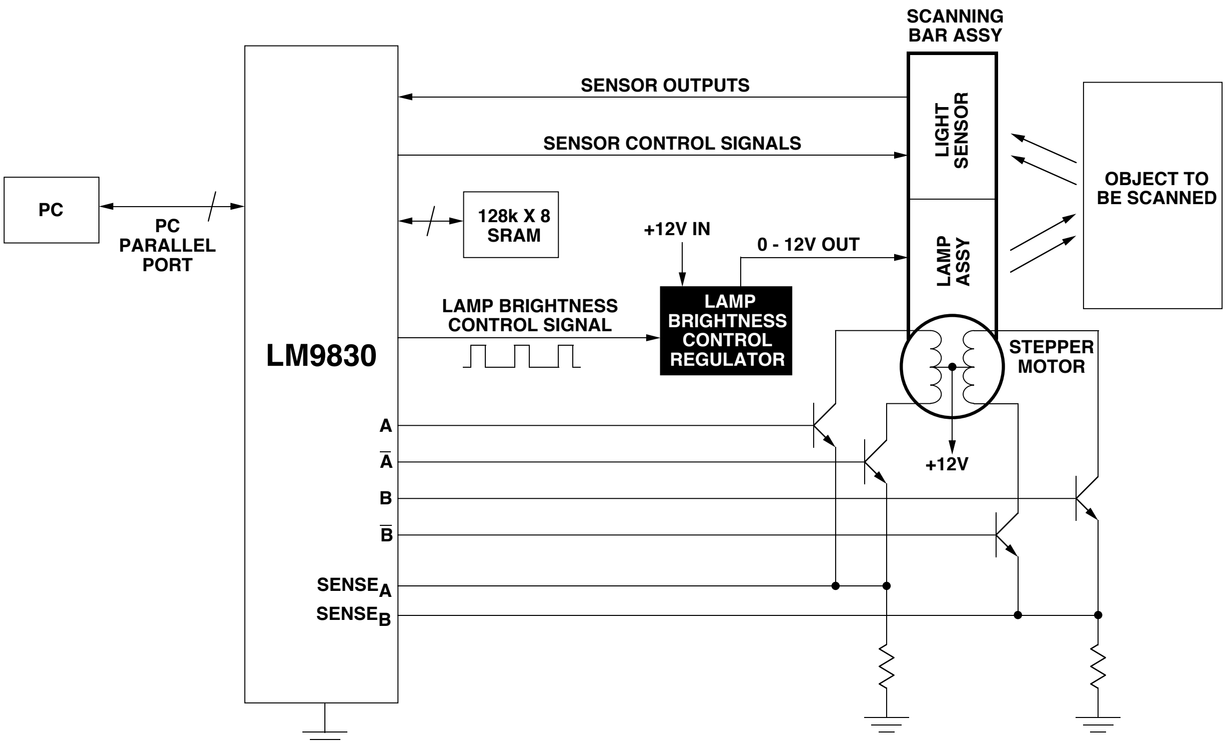
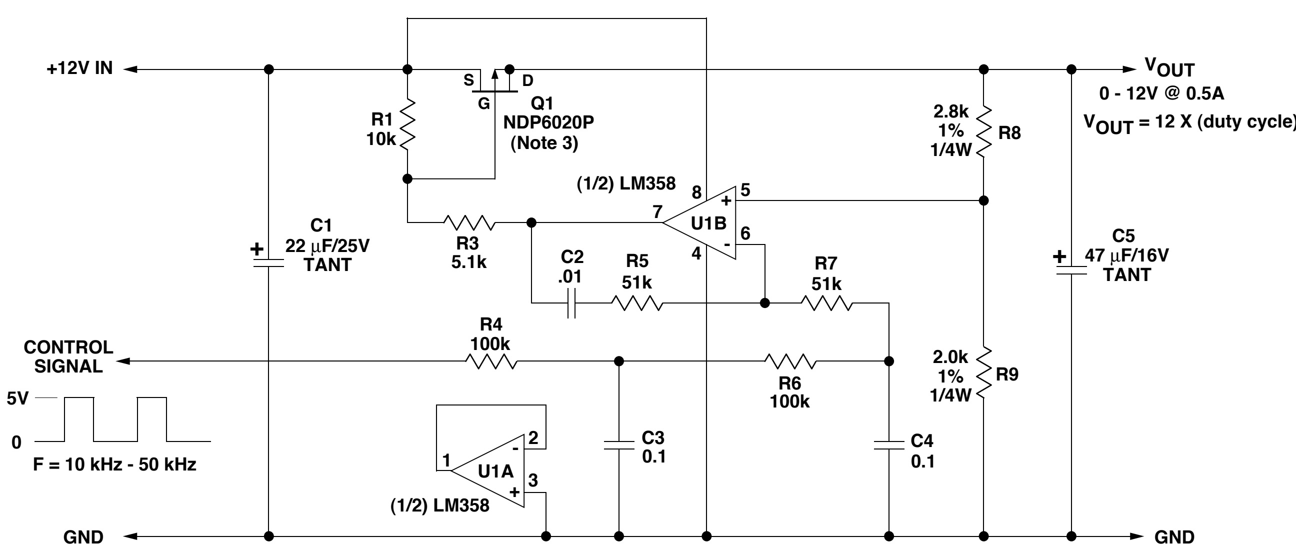


FIGURE 2. LAMP BRIGHTNESS CONTROL REGULATOR



NOTES (UNLESS OTHERWISE SHOWN):

1) All resistors are 5% tolerance, 1/8W.

2) TANT capacitors are solid Tantalum. All other capacitors are ceramic.

3) Solder to PC board with copper area ≥ 1 in^2 for heatsinking.