PWM Sets Output of LCD/LED Driver

The digital, pulse-width-modulation (PWM) output available from many microprocessors is based on an internal 8- or 16-bit counter and features a programmable duty cycle. It is suitable for adjusting the output of an LCD driver, a negative-voltage LED driver, or a current-controlled LED driver.

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The circuit consists simply of a PWM source, capacitor C, and resistors R_D and R_W. For CMOS outputs, you calculate the open-circuit output voltage as:

$$V_{CONT} = D \times V_{DD}$$

where D is the PWM duty cycle and V_{DD} is the logic supply voltage. The control circuit's output impedance is the sum of resistor values R_W and R_D:

$$R_{CONT} = R_D + R_W$$

For the circuit of Figure 1, the output voltage (V_{OUT}) is a function of the PWM average voltage (V_{CONT}):

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_1}{R_2}\right) + \frac{(V_{REF} - V_{CONT}) \times R_1}{R_{CONT}}$$

where V_{REF} is the reference voltage at the feedback input.

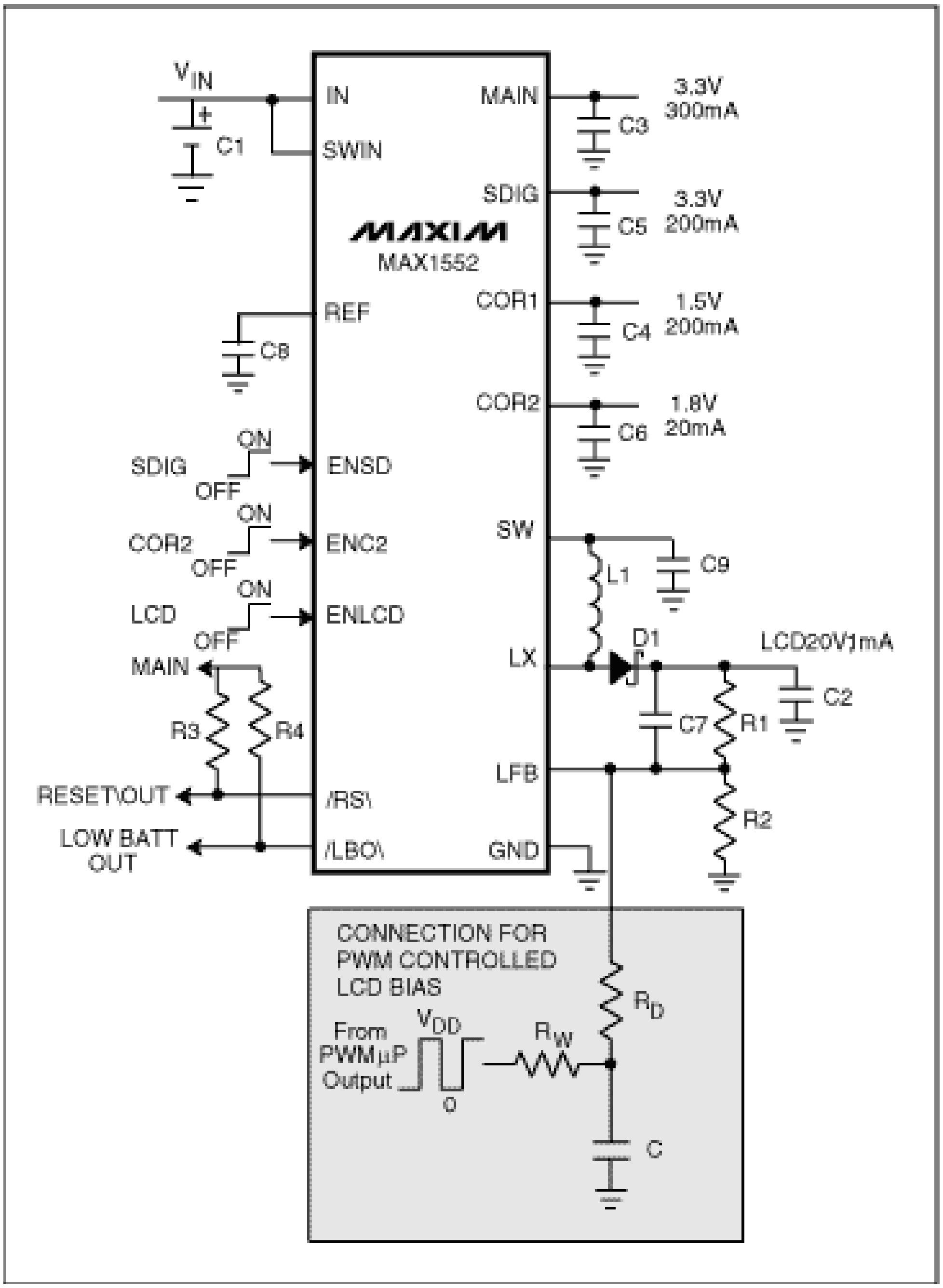

Figure 1. LCD Driver with positive output voltage.

Bear in mind that the initial charge on filter capacitor C produces a turn-on transient. The capacitor forms a time constant with R_{CONT}, which causes the output to initialize at a voltage higher than that intended. You can minimize this overshoot by scaling the value of R_D as high as possible with respect to R1 and R2. As an alternative, the µP can disable the LCD until the PWM voltage stabilizes.

For Figure 2, the output voltage (V_{OUT}) is a function of the PWM average voltage (V_{CONT}):

$$V_{OUT} = V_{REF} + \frac{(V_{REF} - V_{CONT}) \times R_{FB}}{R_{CONT}}$$

where V_{REF} is the reference voltage at the feedback input.

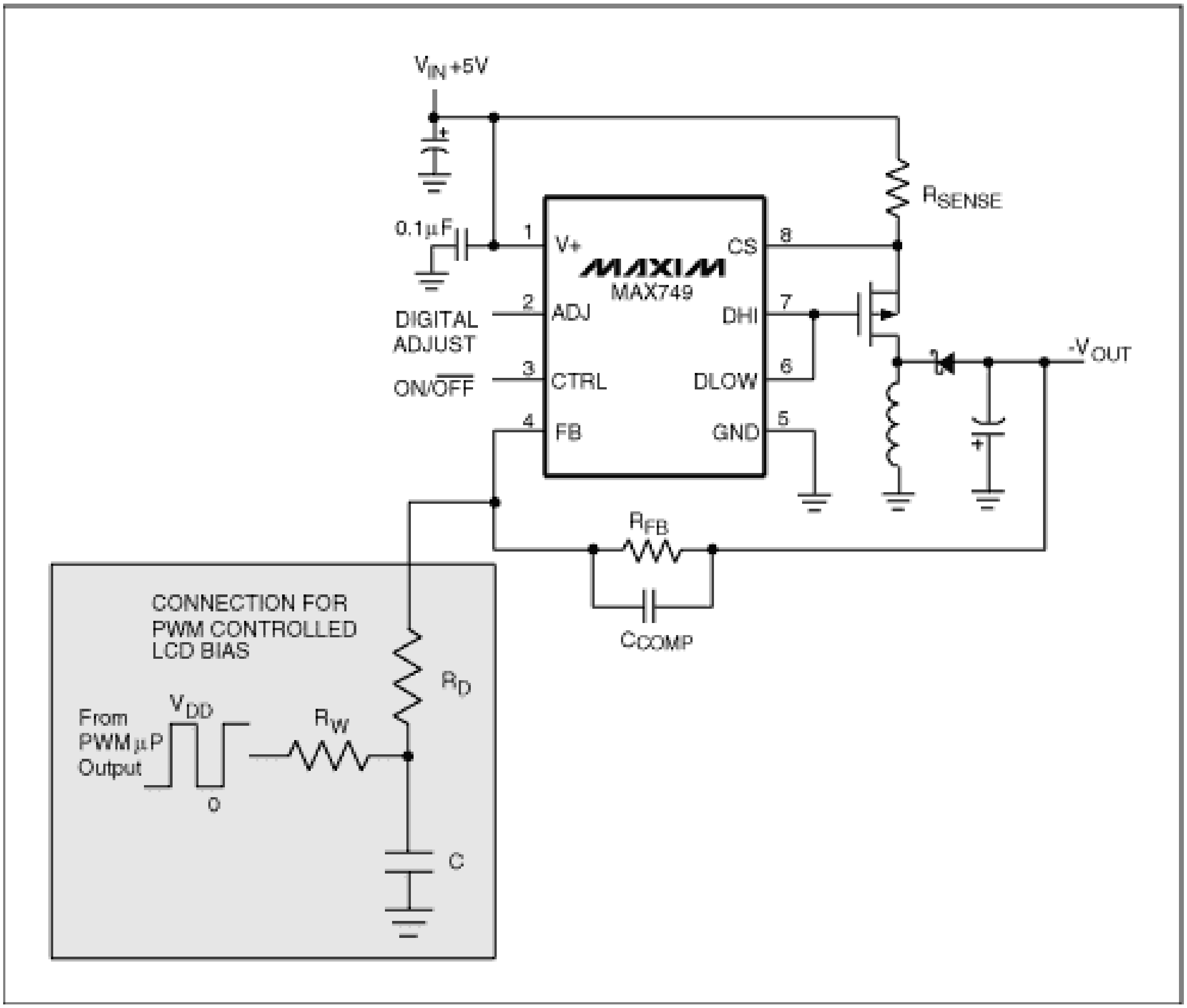

Figure 2. LCD driver with negative output voltage.

For Figure 3, the output current (I_{OUT}) is a function of the PWM average voltage (V_{CONT}):

$$I_{OUT} = \left[\frac{V_{REF} + \frac{(V_{REF} - V_{CONT}) \times R_{SET}}{R_{CONT}}}{R_{SET}} \right] \times K$$

where V_{REF} is the reference voltage at the SET output and K is the current-scaling factor.

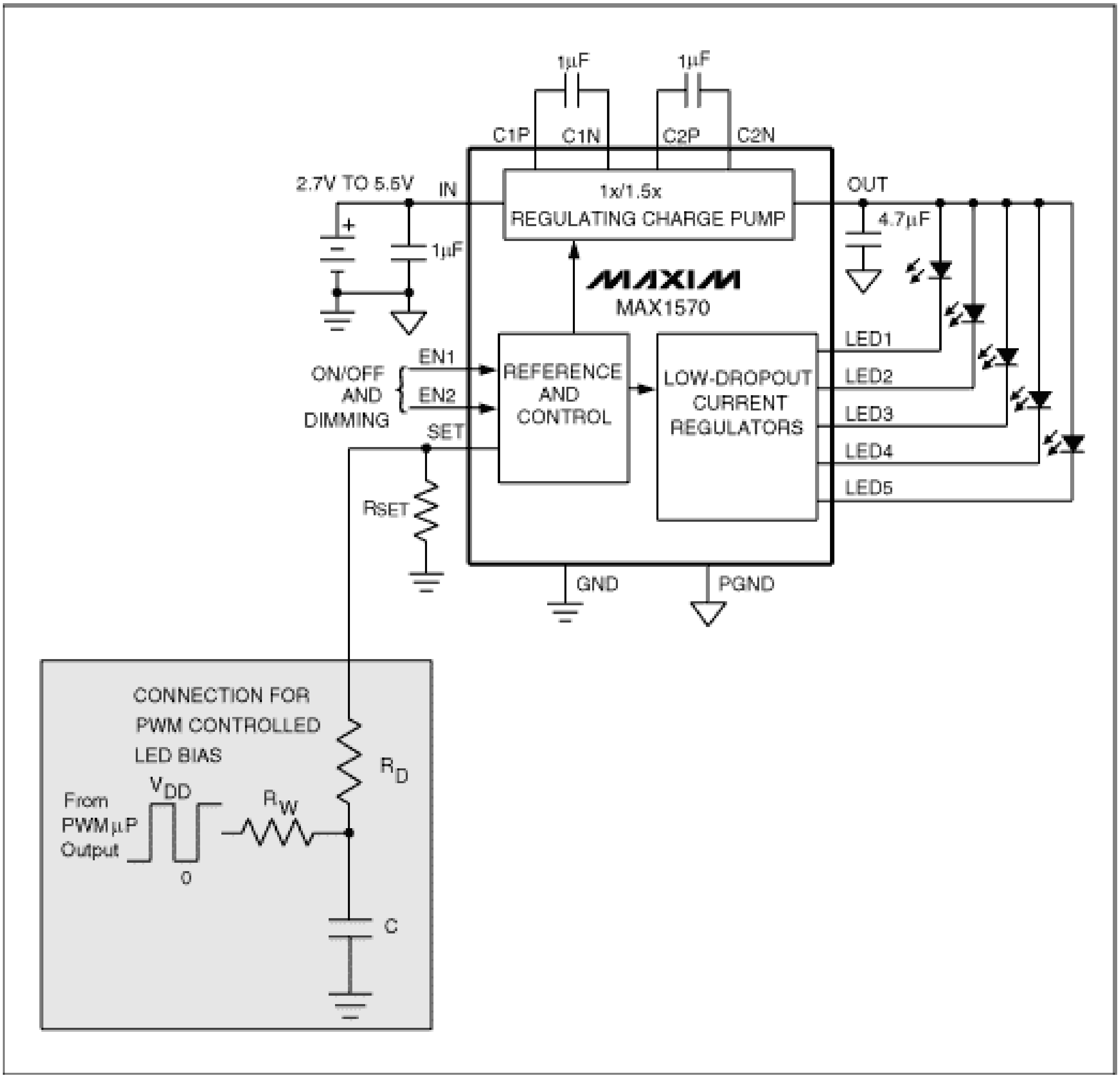

Figure 3. Current-controlled LED driver.

R_D isolates the capacitor from the feedback loop in these PWM-adjustment methods. Assuming a stable voltage at the feedback point, the following equation defines the lowpass filter's cutoff frequency:

$$f_C = \frac{1}{2 \times \pi \times R \times C}$$

where $R = R_W || R_D$. If $R_D >> R_W$, $R \approx R_W$. To minimize ripple voltage at the output, you should set the cutoff frequency at least two decades below the PWM frequency.

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