Low-cost timers govern switched-mode regulator

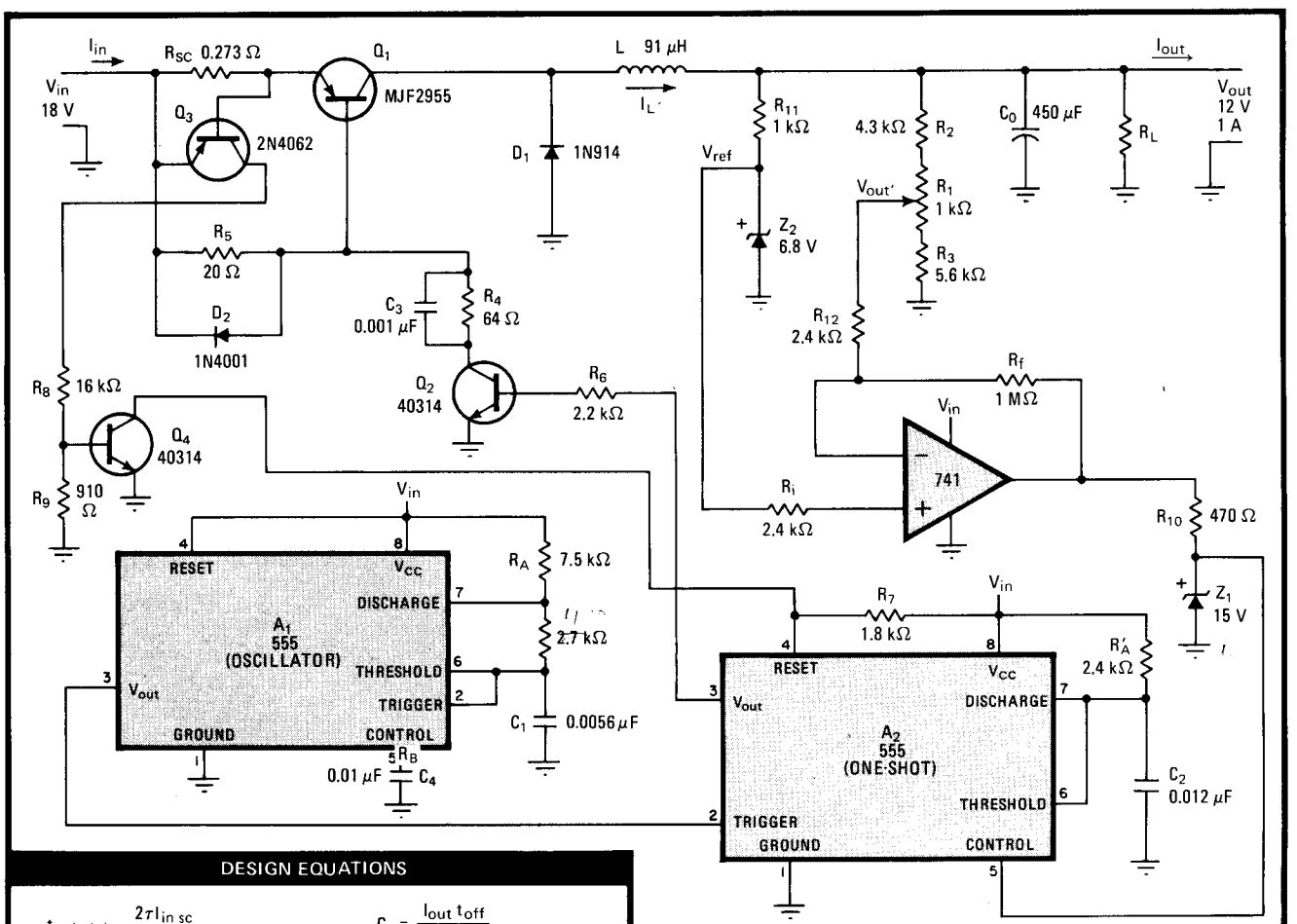
by Luces M. Faulkenberry
Texas State Technical Institute, Waco, Texas

This step-down switching power supply, which uses 555 timers for pulse-width modulation, combines good performance with very reasonable cost. Providing an output of 12 volts at 1 ampere for an 18-V input, the unit offers input-current limiting, 0.1%/V line regulation, 0.5% load regulation, and an output ripple of only 20 mV. However, the design equations given here enable the user to specify his own requirements. The supply can be built for less than $15.

Operating as an astable multivibrator at 20 kilohertz, timer A_1 generates the trigger pulses needed to switch the output of monostable multivibrator A_2 to logic 1 during each cycle. Modulating the control pin of one-shot A_2 with the output of the 741 operational amplifier controls the width.

The op amp compares a preset fraction of the supply voltage, V_{out}', with the 6.8-V reference, V_{ref}. When $V_{ref} > V_{out}'$, the control pin of the one-shot moves high and each pulse from the output of A_2 is lengthened accordingly until the reference and supply voltages are virtually equal. Similarly, if $V_{ref} < V_{out}'$, the output pulses are shortened.

As seen, transistors Q_1 and Q_2 in the simple feedback loop perform the switching function. Monitoring transistors Q_3 and Q_4 limit the current by bringing A_2's reset pin low when the design-maximum peak current through the inductor is reached, thereby shortening the width of the output pulses until the cause of the trouble is removed. Q_3 can also serve in a dual capacity as a switch to turn off the supply during overload conditions. For example, should automatic shutdown of the supply be necessary, Q_3 could be used to fire a silicon controlled rectifier in order to hold the reset pin of oscillator A_1 low permanently. In these cases, a simple circuit would also be needed to reset the supply manually. □



DESIGN EQUATIONS

$$t_{on(min)} = \frac{2\tau I_{in\,sc}}{I_{L(max)}}$$

$$t_{on}/t_{off} = \frac{V_{out} + 0.7}{V_{in} - (V_{out} + V_{ce\,sat_{Q_1}})}$$

$$L = \frac{(V_{out} + 0.7)\,t_{off}}{I_P}$$

$$C_O = \frac{I_{out}\,t_{off}}{4\,V_{ripple}}$$

$$R_{sc} = \frac{V_{BE_{Q3}}}{1.1\,I_P}$$

τ = OSCILLATION PERIOD
$I_{in\,sc}$ = SHORT-CIRCUIT INPUT CURRENT
$I_P = 2\,I_{out}$

Rudimentary. Dc-dc switching regulator, using 555 timers, is simple and low-cost yet provides good performance. Typical specs of 18-V-in–to–12-V-out unit include 0.1%/V line regulation, 0.5% load regulation, and output ripple of 20 mV. User can design supply to meet his own requirements with aid of given equation set.