Up-down ramp quickens servo system response

by R. E. Kelly
Southwest Research Institute, San Antonio, Texas

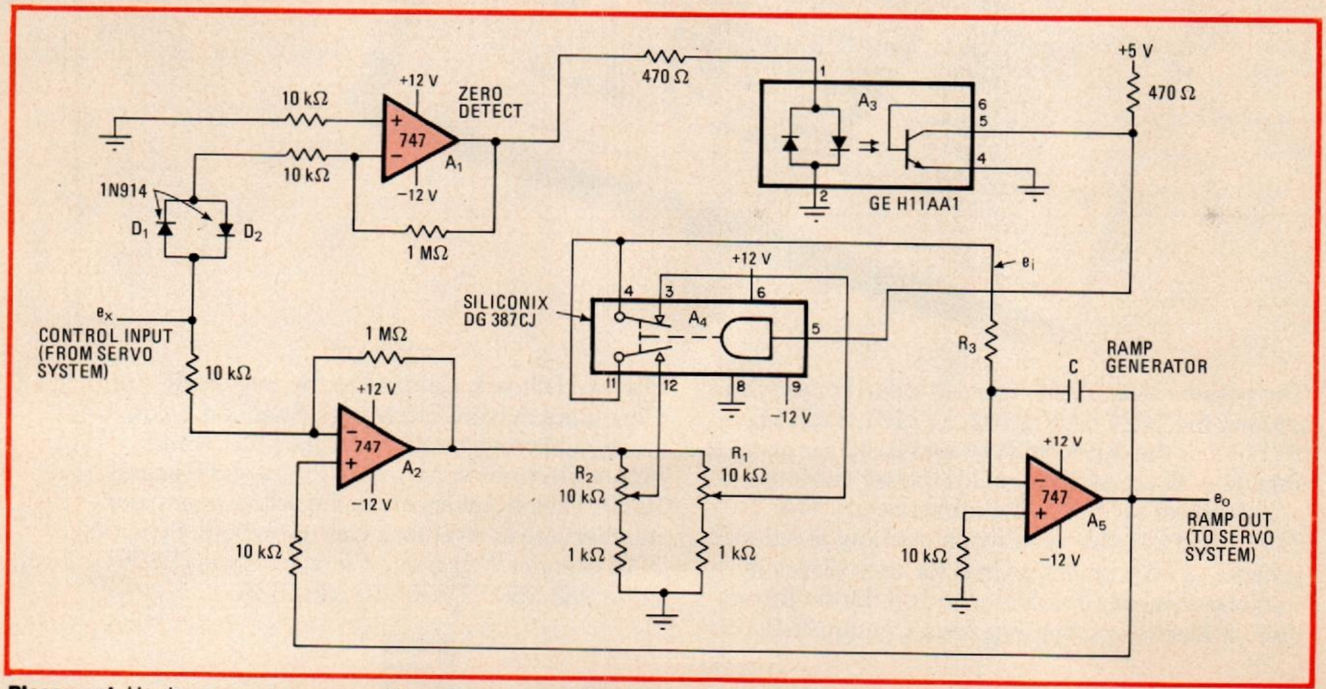
Servo systems often require a ramp waveform to control both the acceleration and deceleration rates of heavy loads, but all too often system complexity and reaction time are increased because only a positive-going, fixed-slope ramp is available for performing the dual function. Using a dual-polarity ramp generator that allows individual selection of both the up- and down-ramp rates, such as that shown in the figure, ensures optimum servo system response at low cost.

Command-input voltage derived from the servo system's joy-stick (control) position is applied to operational amplifiers A_1 and A_2, as shown. Diodes D_1 and D_2 provide a 0.7-volt drop of the input signal before it is introduced to A_1.

When the control-input voltage is above or below zero by more than 0.7 v, the system load must be accelerated to a position corresponding to that control voltage. A_1 detects that the input voltage is other than zero and switches phototransistor A_3 on, which in turn switches A_4. Meanwhile, A_2 will switch from a positive voltage to −12 v if the control voltage is equal to or greater than the ramp's output voltage. A_3 provides a high-impedance input for A_1 and an output signal suitable for driving transistor-transistor or similar logic. A_4 is a solid-state, single-pole, double-throw relay that initiates an up-ramp waveform whose slope is partially controlled by the value of R_1.

The positive-going ramp emanating from A_5 will move the system load toward its desired position, and as that occurs, the servo system's feedback voltage will act to reduce the control-input voltage. When the input voltage moves within 0.7 v of ground, A_1 moves low and A_3 turns off. A_4 now initiates a down-ramp waveform to decelerate the system to a stop at a rate determined partially by R_2.

The ramp generator, A_5, is an op-amp integrator that produces waveforms whose rate is proportional to the input voltage, e_i. This voltage, in turn, is set by R_1 or R_2. The time-dependent voltage output from the ramp generator is approximately equal to the voltage across C. C is charged by a steady current $I = e_i/R_3$, so that:



Placement. Up-down ramp generator with selectable-slope capability can efficiently position heavy servo-system loads. Key to operation is solid-state relay A_4, which switches from up ramp to down ramp to decelerate load when it zeros in on terminating position.

$$e_o = e_i t/R_3C \qquad (1)$$

because $e_o = e_c = It/C$.

Equation 1 is useful for setting the values of R_3 and C needed for a given ramp slope. For example, assume that the maximum positive-going or negative-going ramp rate ust be 20 v/second and that e_i is 12 v maximum. Then, 1 $20 = 12/R_3C$ and therefore $R_3C = 0.6$. Assuming a nominal value of 0.33 microfarad for C, R_3 is then equal to 1.81 megohms.

Using the component values shown in the circuit allows a linear ramp to be generated over a 10 : 1 frequency range. Note that once the component values for the maximum ramp rate are determined, the actual ramp rate may be selected by setting R_1 and R_2 for the corresponding value of e_i. □