Staircase generator resists output drift

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Tracking capacitors that mutually cancel temperature drift make a simple analog staircase generator, which is as accurate and stable as expensive circuits that employ precision digital-to-analog converters. Additionally, the strictly analog circuit is easier to adjust for any number of steps and to any step amplitude.

The generator essentially consists of two sections, a one-shot and an integrate-and-hold circuit. The one-shot, which drives the integrate-and-hold circuit, is triggered by an oscillator or system clock that determines the generator's stepping rate. During the high period (T) of the one-shot's output pulse, integrating capacitor C_1 is charged to produce an output voltage step:

$$\Delta V_o = V_{REF}T/R_1C_1$$

Between one-shot output pulses, transistor Q_1 is off, and the integrator becomes a hold circuit and maintains the output constant.

Capacitors C_1 and C_2 are the two components with the greatest effect on step height stability. If the same type of capacitor is used in both the one-shot and the integrator sections of the circuit, the temperature coefficients of C_1 and C_2 will cancel. Staircase risetime is proportional to capacitor C_2, while integrator slope is proportional to capacitor C_1, so that step height is unaffected by a similar percentage change in both capacitors. The period of the one-shot's output pulse is directly proportional to the ratio of C_2/C_1.

As for the output voltage droop that occurs during the integrator's hold mode, the value of C_1 must be large enough to keep it negligible over the staircase cycle. For the components shown, output droop is only about 1 millivolt in 10 seconds, and step amplitude is stable within ±0.2% from 0°C to 50°C. □

Stepping up. Staircase generator employs one-shot to drive integrate-and-hold circuit. During one-shot period, capacitor C_1 charges and steps up output voltage. When one-shot is off, integrator section holds step height constant. Output voltage droop is kept to 1 millivolt in 10 seconds. Step amplitude drift is held to ±0.2% because temperature coefficients of same-type capacitors C_1 and C_2 cancel.