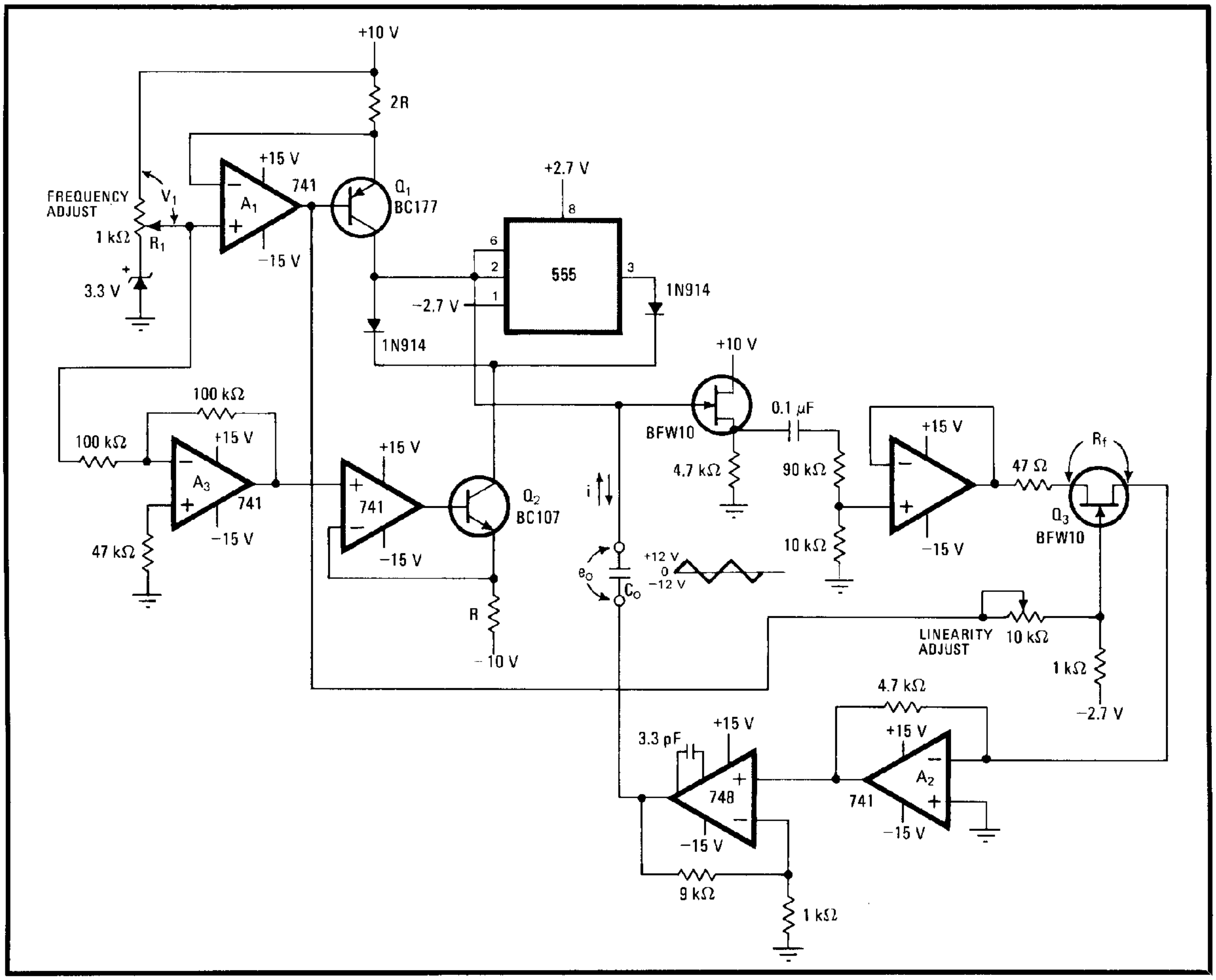
Capacitance multiplier extends generator's sweep ratio

by A. D. Teckchandani
Eastern Electronics Ltd., Faridibad, India

Most low-frequency function generators can produce triangular waves over a frequency range of 100 to 1 by using the standard method—constant-current charging and discharging of a fixed-value capacitor. But the sweep ratio, or the ratio of the maximum to the minimum output frequency, can be extended to 500 or more by varying the magnitude of the current from the generators and the capacitance simultaneously. Using one potentiometer both to control the current source directly and to adjust the capacitance by means of a capacitance-multiplier circuit allows a greater frequency range, because the ratio of current to capacitance is varied over a wider range.

The frequency, or rate, at which a capacitor charges or discharges is directly proportional to the magnitude of the current from the generators and inversely proportional to the capacitance; that is, $f = Ki/C$, where K is a constant. This circuit expands the sweep ratio by ensuring that an increase in i is accompanied by a decrease in C, and vice versa.

The circuit shown below is so configured that the current sources formed by stages A_1, Q_1, and Q_2 aid in determining both the oscillation rate of a 555 timer, wired as a double-ended comparator (Schmitt trigger), and the amplitude of the current through timing capacitor C_o. The frequency of oscillation is also determined by stages Q_3 and A_2 and is equal to:



Greater range. Simultaneous variation of current-source (A_1, Q_1, Q_2) magnitude and capacitance charged by source extends generator's sweep ratio. R_1 adjusts current source directly; capacitance is varied by means of capacitance multiplier (A_2, Q_3).

$$f = 1.5i/VC = i/3.6C$$

for $V = 5.4$, where:

V = supply voltage of 555

$C = C_o(1 + |A_v|)$

$A_v = 4{,}700/(47 + R_f)$ = voltage gain of A_2

R_f = on resistance of Q_2.

R_1 controls i, the current value being equal to $(10 - V_1)/2R$. R_f is controlled by the voltage appearing at the gate of Q_3, which in turn is controlled by A_1 and ultimately R_1. Therefore, when there is an amplification in the A_2–Q_3 loop, the effective capacitance at the output of Q_1 increases by A_vC_o. (The phenomenon of output capacitance increasing with active-device gain was first observed in the Miller effect). Capacitance multiplication is thereby achieved by varying R_1.

The frequency range of the triangular waves that can be produced by this circuit varies from about 10 cycles to approximately 5,000 cycles. □
