Designer's casebook

Voltage-controlled amplifier phase-adjusts wave generator

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When added to a generator that produces two triangular and two square waves in quadrature, a voltage-controlled, gain-switching amplifier makes it easy to adjust the phase difference of each pair of signals. The entire circuit—that is, the generator and the controller—requires only two chips and one field-effect transistor for providing phase differences from 0° to 180°.

In the arrangement shown, a quad operational amplifier (A_1–A_4) serves as the quadrature oscillator, and a dual op amp (A_5–A_6) is the control section. Amps A_1 and A_2 form an integrator and comparator, needed for generating the triangular and square waves. A_3 is a zero-crossing detector, used to produce a square wave from the triangular input of A_1. A_4 produces a second triangular wave from A_3's output. Note that the feedback resistor R_3 in the A_1–A_4 loop will prevent A_4 from drifting into saturation, even if offset voltages from the op amps are high.

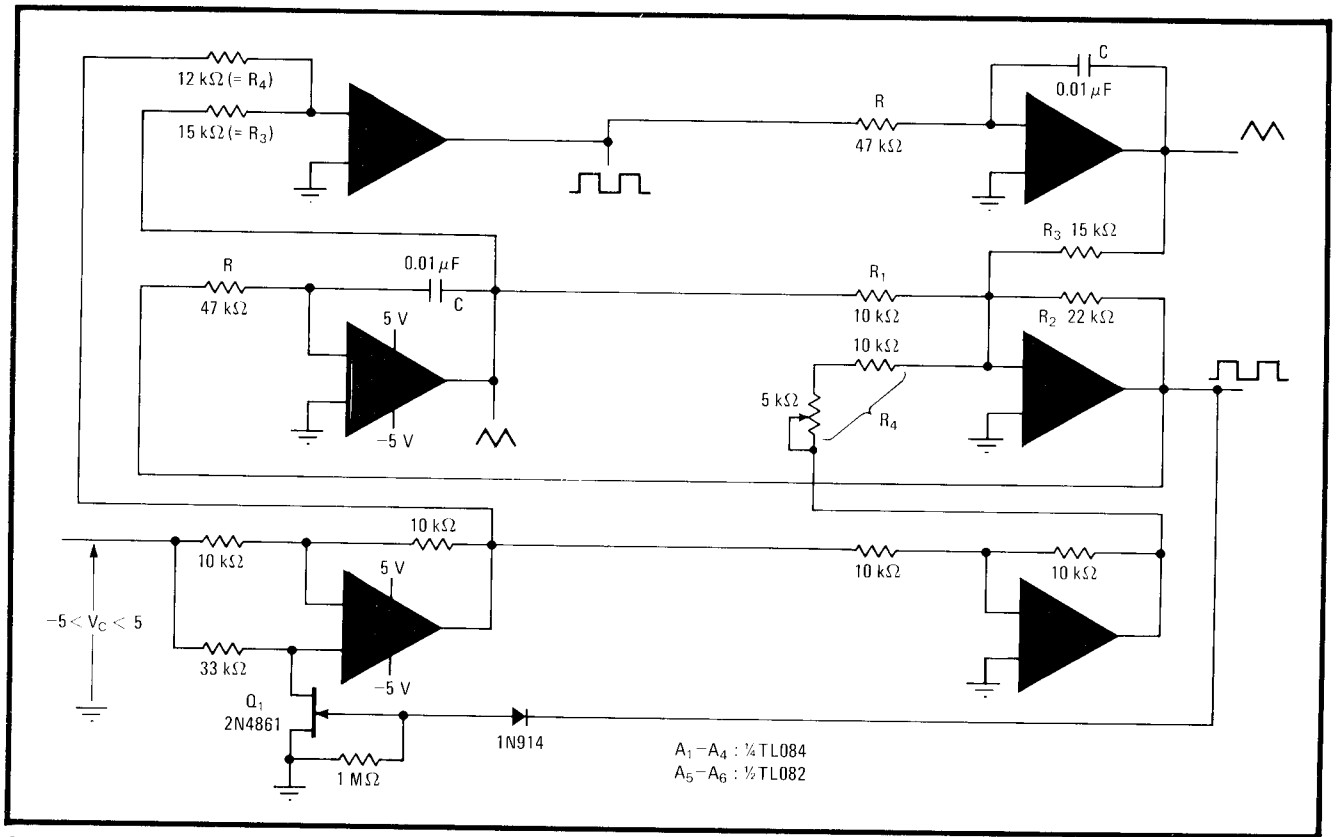
In the phase-control section, A_5 acts as the switched-gain element. A_2 and Q_1 control the gain of A_5. When Q_1 turns on, A_5 has a gain of -1; otherwise, its gain is $+1$. This element, appropriately biased at its input with a control voltage, V_c, thus turns on and off sooner or later than usual, depending on the magnitude of the control voltage. This acts to advance or retard A_3's on-off transitions on both the rising and the falling edge of A_2's square-wave signal. As a result, the signals from A_3 and A_4 lead their respective counterparts at A_2 and A_1 by a value almost linearly proportional to V_c.

A_5's output is inverted by A_6, which is in turn connected to potentiometer R_4 and A_2. R_4, included to overcome the effects of component mismatch, is placed strategically, so that it will not interfere with the generation of waves produced by A_1 and A_2.

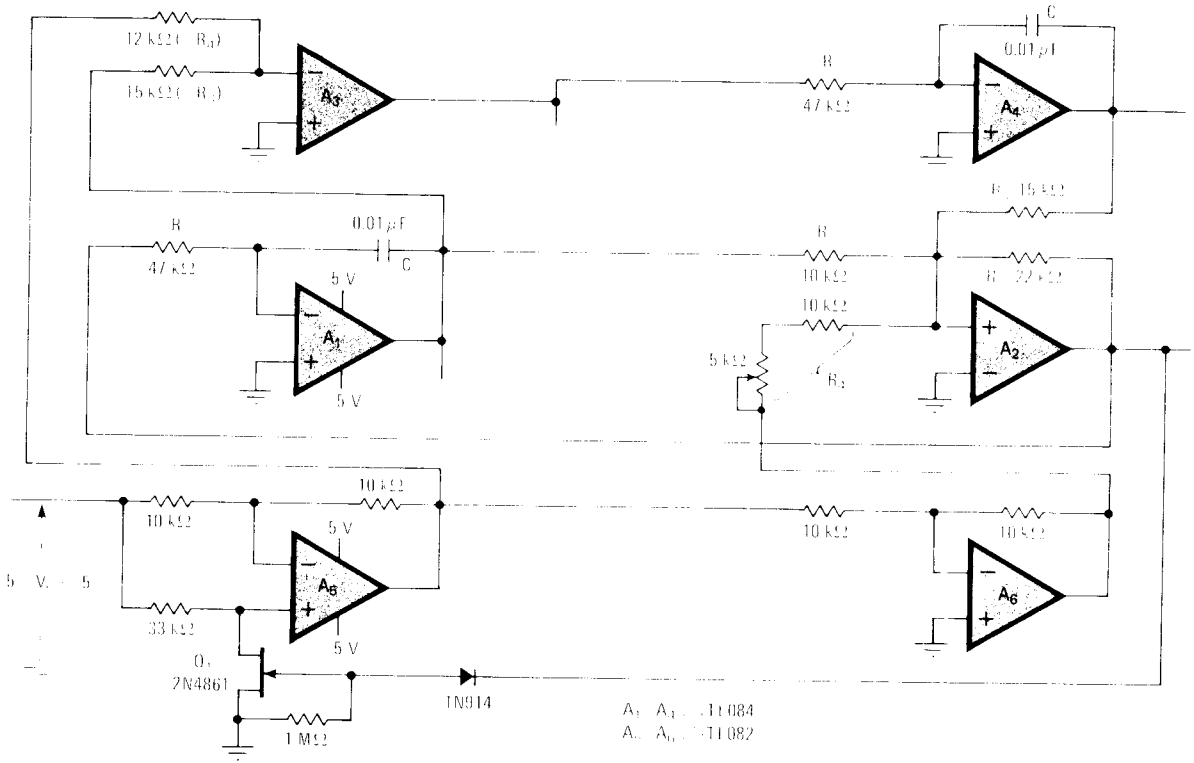
If the components and amplifiers are matched, the frequency of oscillation for all waveforms will be $f = R_2/4R_1CR$. The relation between control voltage, resistor R_4's value, and phase shift is given by:

$$\theta = 90^\circ[(V_cR_2R_3/V_{o\,sat}R_1R_4) - 1]$$

where $V_{o\,sat}$ is 0.7 v below the supply voltage. □



Quadrature variance. Waveform generator that normally produces in-quadrature (90° departure) triangular or square waves is converted into variable phase-delay circuit when gain-switching amps A_5–A_6 are added. A_5–A_6 act to advance A_3's turn-on transition, so that signals at A_3 and A_4 lead those at A_1 and A_2. Phase shift between both sets of waves is controlled by V_c.



Quadrature variance. Waveform generator that normally produces in-quadrature (90° departure) triangular or square waves is converted into variable phase-delay circuit when gain-switching amps A_4–A_6 are added. A_4–A_6 act to advance A_2's turn-on transition, so that signals at A_2 and A_1 lead those at A_5 and A_6. Phase shift between both sets of waves is controlled by V_S.