Four ICs make a modulator with linear phase shift

by Gregg Butler,
Analog Devices Inc., Norwood, Mass.

Phase modulation is a common technique used in analog communications, data storage, and data transmission. The phase modulator circuit in Fig. 1 uses four integrated circuits to accomplish the function. It produces a reference frequency, F_0, and a phase-shifted signal, F'. The phase difference between F_0 and F' is proportional to input voltage V_{in}.

The AD581 precision 10-V reference (IC1), AD630 balanced modulator-demodulator (IC2), and ½ AD644 dual field-effect-transistor-input operational amplifier (IC3) form an oscillator with a frequency equal to ¼ R_C. The output of the comparator in IC2 is used as the reference frequency of the phase modulator.

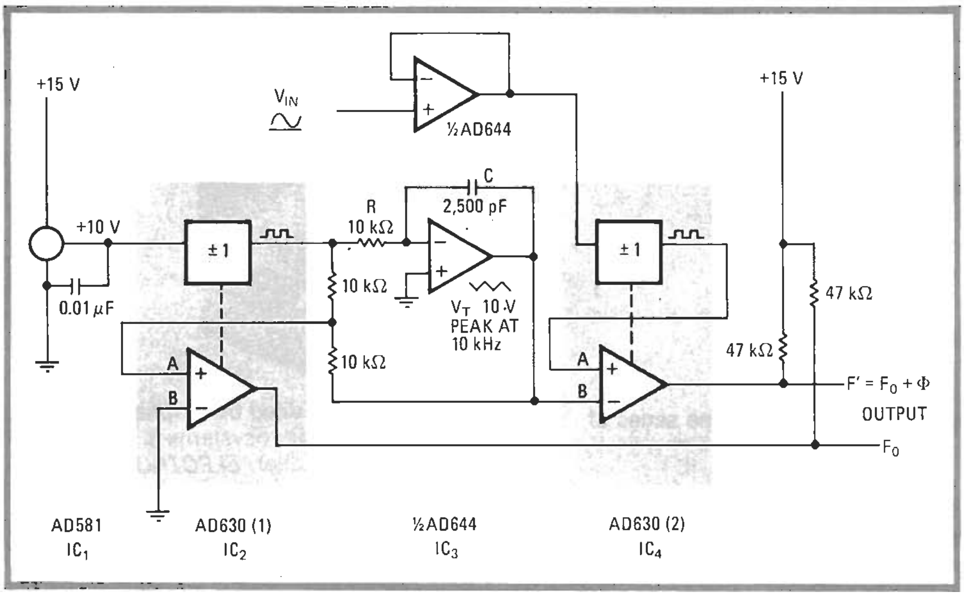
The triangle-wave output from one half of IC3, configured as an integrator, drives IC4, which is wired as a linearly variable hysteresis comparator. The unity-gain buffer, the second half of IC3, provides a high impedance to the input. The comparator in IC4 switches states when the triangle-wave voltage V_t equals $\pm V_{in}$. Zero hysteresis is exhibited when V_{in} is equal to zero. In this case, IC4 switches states at the triangle-wave zero crossing.

When V_{in} increases, the transition levels shift symmetrically toward $\pm V_t$ peak. This shift produces a corresponding phase shift in the IC4 comparator output, F' (Fig. 2).

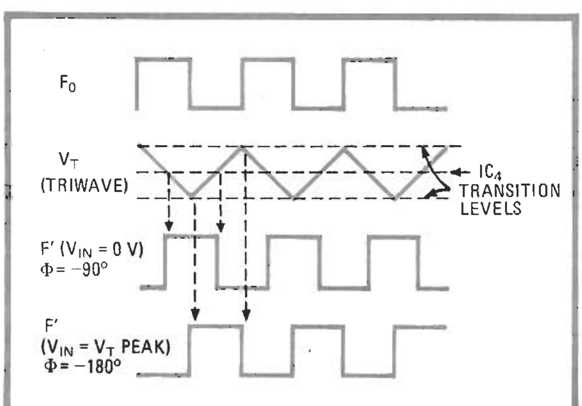
V_{in} can be varied dynamically from 0 V to $+V_t$ peak full scale. The phase output is linear and varies over a range from –90° to –180°.

Several IC4 hysteresis blocks can be ganged to a single reference oscillator if the user desires. This allows the user to transmit a number of independent signals with respect to only one reference.

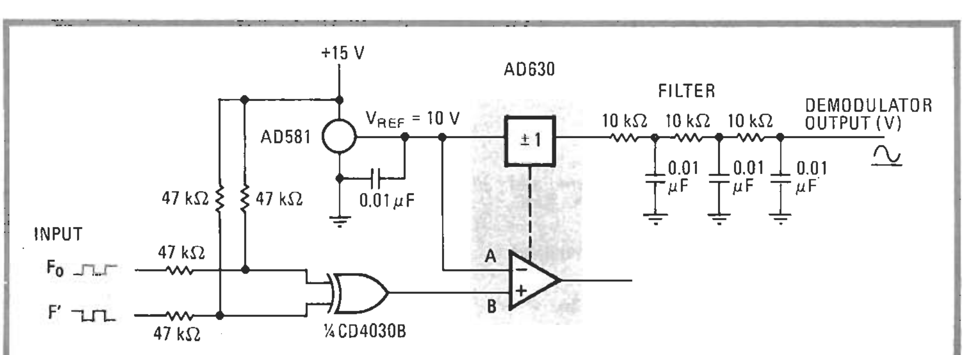
Phase demodulation is easily achieved by feeding F_0 and F' into an exclusive-OR gate, in this case a CD4030B. The logic output drives an AD630 comparator input, causing the gain channel output to alternate between $\pm V_{ref}$ at a rate proportional to the phase difference between F_0 and F' (Fig 3). This output is then low-pass filtered, and the circuit extracts the original signal, V_{in}.



1. Modulator in four. Wired as switched gain channels, IC2 provides the reference frequency and integrator input to IC3. IC4 functions as a hysteresis block, enabling the input voltage to symmetrically change the comparator's transition levels.



2. Linear shift. The linearly variable hysteresis comparator in IC4 switches states when the triangle-wave voltage equals the input voltage. When the input voltage equals zero, the phase shift is –90° and increases linearly to –180° when V_{in} equals V_t peak.



3. Demodulator circuit. By feeding the modulator outputs into a logic gate that directly drives a comparator, a phase-demodulator can be realized. The output alternates at a rate proportional to the phase difference between F_0 and F. The output is then filtered.