Digital Sine-Wave Generator Produces 0° To 360° Phase-Shifts

Contributing Author
ED Online ID #4995
December 4, 2000

Sine-wave generators with 0° to 360° phase-shifts are very important testing blocks in many systems involving DSP operations (i.e., I/Q modulator-demodulator communication, phase-angle measurements and up-down counter conversion in controls, and power electronics).

The popular approach to generating two sine waves with a 0° to 360° shift is via analog methods. These typically include a passive LC network, two transistors, or two op-amp stages (since each stage can provide only a 0° to 180° phase-shift).

Theoretically, analog phase-shift generators are easy to design. But they do have some important limitations. For example, they are frequency-dependent and the sine-wave outputs contain distortion. Above all, it's necessary to use an additional phase meter to measure the angle between the signals.

To eliminate these restrictions, the phase angle between the two signals is set digitally in this circuit (Fig. 1). The circuit provides two sine-wave outputs, each of which has a frequency that's 1/256th of a TTL clock source.

EPROM lookup tables combined with digital-to-analog converters (DACs) are used to generate the two sine waves. The outputs are available on channel V2 (the reference) and on channel V1 (with a 0° to 360° phase-shift).

For each channel, the 256-step resolution is achieved by controlling two 74LS193 up-down counters (U1 and U2), which are configured for count-up operation only (Fig. 1, again).

At the end of each cycle, these counters may be adjusted by the carry-output (CO) pulse provided by U4. They can be preset to any number in the range of 0 to 256, depending on the DIP-switch position. U3 and U4 always restart from 0.

The counter outputs are connected to the parallel address inputs of the 27128 EPROM. When the outputs from this EPROM are sent to the DAC0832, they're converted into a sine-wave signal.

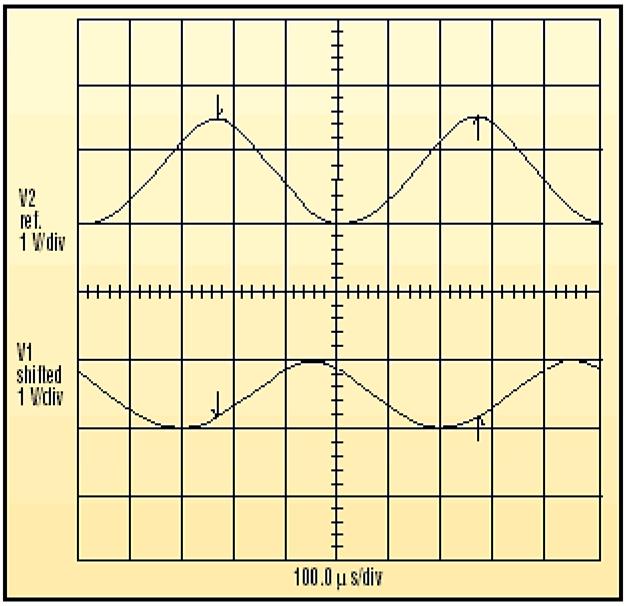
A CA3240, the first voltage follower, assures minimal loading on the DAC0832. The CA3240 feeds a variable attenuator-integrator that provides RF suppression and amplitude regulation to the signal. Each channel is completed with a unity-gain buffer (another CA3240) that has a 50-Ω output and a capacitor to remove the dc component of the signal. The HA-5002 has been added to supply the high output currents needed to drive a 50-Wcoaxial cable.

This circuit produces two excellent sine-wave outputs on channel V2 (stationary) and channel V1 (phaseshifted with respect to channel V2 at an angle in the range of 0° to 360° with a 360/256-degree resolution).

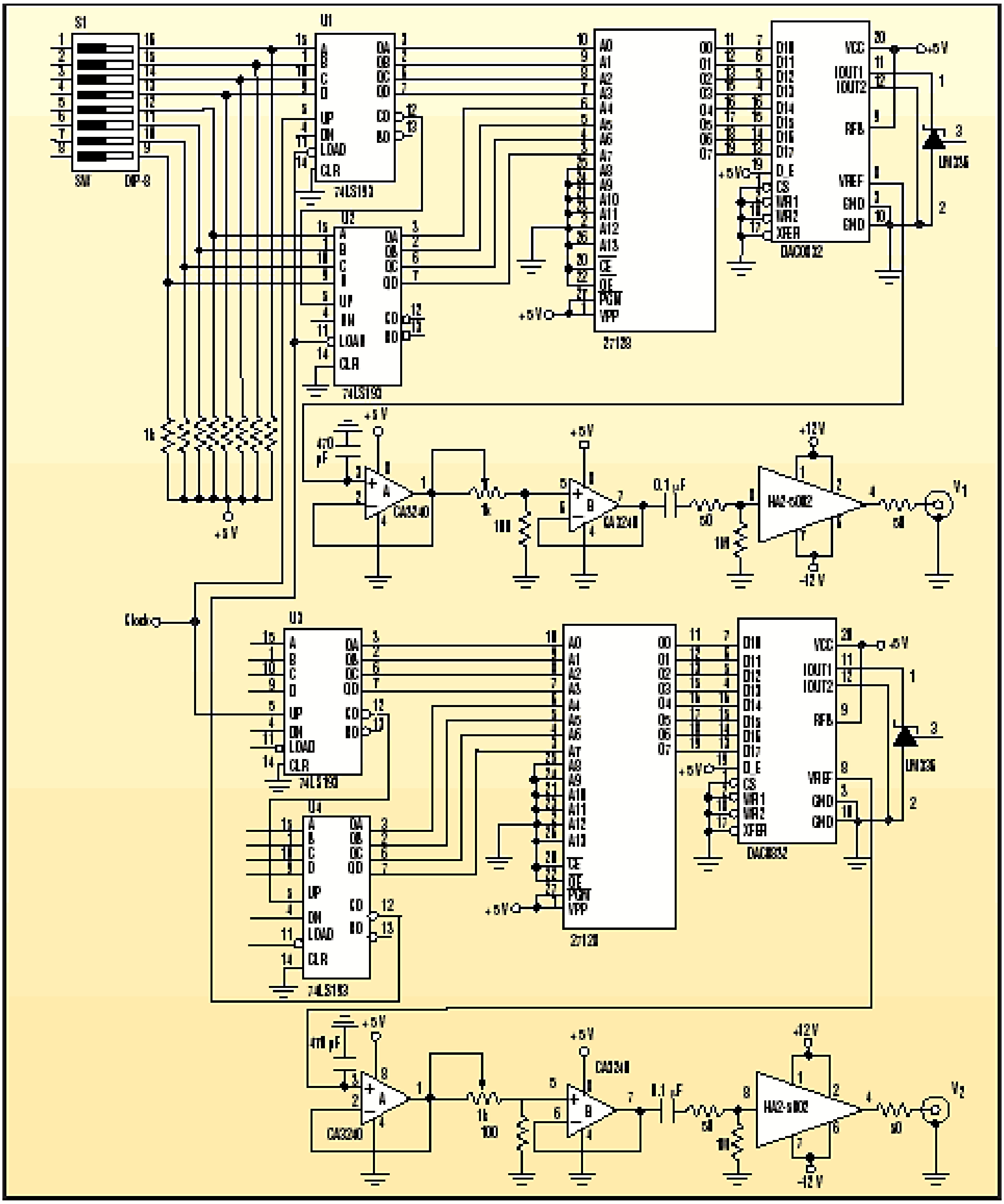
Variation of the phase-shift is achieved by changing the DIP switch settings. In Figure 2, the DIP switch is set to the number 160, resulting in an angle of 225° (160 × 360/256 = 225°).

The output frequency is $f_{CLOCK}/256$. Higher frequencies (up to about 1 MHz) are attainable by using only four bits. This proves detrimental to the waveshape accuracy, however.

One significant use of this circuit is for automatic testing of correlators over the entire 360° operating range. In this case, the DIP switches must be replaced by the outputs of an 8- bit counter that is clocked at a period equal to the desired correlation interval.



2. A 225° phase-shift is produced when the DIP switch is set to 160. The amplitude of each sine-wave output can be adjusted using the corresponding potentiometer.



1. This digital waveform generator produces a reference sine-wave output on channel V2 (the reference) and a shifted sine-wave output on channel V1 (with a 0° to 360° phase-shift). The phase shift of the V1 output can be controlled to a resolution of less than 1.5°.