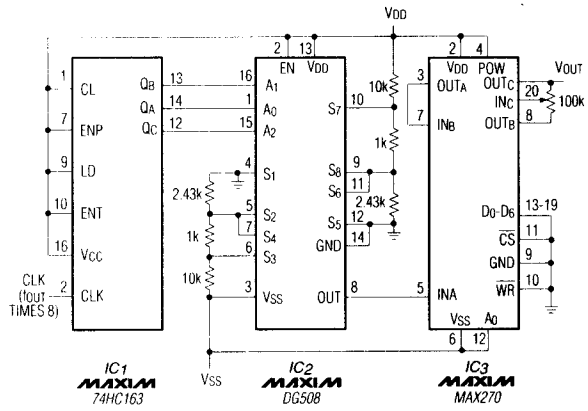
Three ICs Produce Pure Sine Waves

A TTL counter, an 8-channel analog multiplexer, and a fourth-order lowpass filter can generate 1- to 25-kHz sine waves with a THD better than -80dB (**Figure 1**). The circuit cascades the two second-order, continuous-time Sallen-Key filters within IC_3 to implement the fourth-order lowpass filter. Two resistive dividers connected from ground to V_{DD} and ground to V_{SS} provide bipolar dc inputs to the multiplexer.

To operate the circuit, you must first choose the filter's cutoff frequency, f_C, by tying IC_3's D_0 through D_6 inputs to 5V or ground. The cutoff frequency can be at 128 possible levels between 1 and 25kHz depending on those seven digital input levels. Because Figure 1 ties D_0 through D_6 to ground, f_C equals 1kHz. The 100kΩ potentiometer adjusts the output level between V_{DD} -1.5V and V_{SS} +1.5V.

The clock's input frequency must be eight times higher than the filter's f_C. The multiplexer then produces an eight-times oversampled staircase approximation of a sine wave. Eight-times oversampling greatly simplifies the smoothing requirements of the lowpass filter by pushing the first significant harmonic out to seven times the fundamental. All higher-order harmonics are removed by IC_3, which includes an uncommitted amplifier for setting the output level.

The frequency domain offers a view of the filter's operation. Smaller harmonics in the multiplexer's output spectrum (**Figure 2a**), caused by inaccuracies in the voltage dividers, are insignificant with respect to the larger-amplitude harmonics associated with the staircase approximation. In the filtered output (**Figure 2b**), all harmonics are lost in the noise floor of the spectrum analyzer.



NOTES:
V_{DD} TYPICALLY IS 5V
V_{SS} TYPICALLY IS -5V

Figure 1. This circuit produces a pure, -80dB THD sine wave whose frequency equals fC of the IC3 filter.

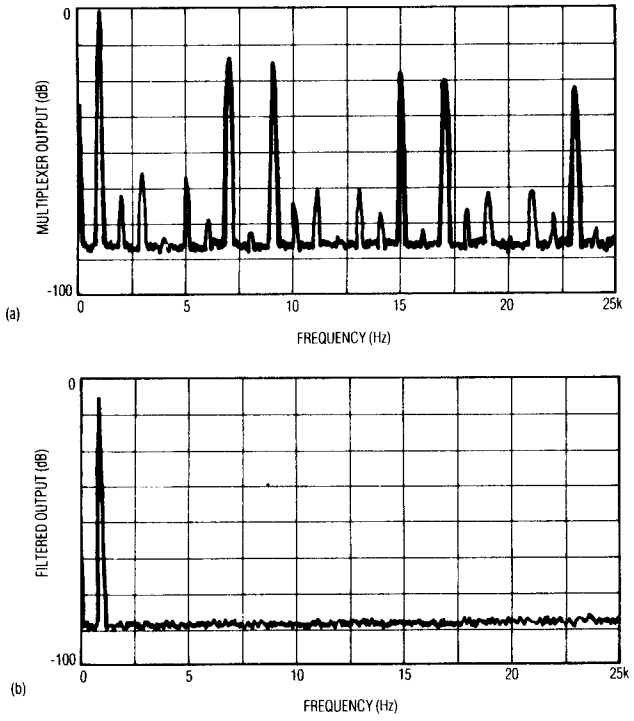


Figure 2. The circuit's approximation process generates large harmonics in the multiplexer's output spectrum (a), which the filter attenuates to a level below the spectrum analyzer's noise floor (b).

(Circle 7)