No-ladder d-a converter works from one 5-V supply

by E. Insam
Chelsea College, University of London, London, England

An 8-bit digital-to-analog converter that operates from a single positive 5-volt supply can be built without the usual front-end ladder network. This is done by creating a pseudo-random binary generator that is driven by a free-running multivibrator at a nominal clock frequency of approximately 5 megahertz. The multivibrator also provides the -5-v supply line for the converter's operational amplifier.

The output from the binary generator is compared (by subtraction) with the 8 input data bits. These can be in either a normal format or a two's-complement format, depending on the control input M. The carry output from the full adders is a pulse train whose mean value is proportional to the input data and is clamped to about 0.6 v by diode D_1.

This pulse train is then fed to an active Butterworth low-pass filter formed by the op amp and its associated components. In the circuit given here, the gain of this stage is set at 1.59 to give the necessary filter-pole positions and to bring the peak-to-peak output amplitude of the converter to 1 v. Potentiometer R_1 controls the dc shift of the analog output.

The quantizing noise consists of harmonic multiples of the clock frequency divided by 255. In this case, the lowest harmonic occurs at around 20 kilohertz, which is beyond audibility. The cutoff frequency ($\omega = 1/RC$) of the Butterworth filter is around 7 kHz. The circuit's gain accuracy, which is not a major concern for audio work, depends only on diode D_1 and the closed-loop gain of the op amp.

The transistor-transistor-logic version of this d-a converter consumes around 300 milliamperes. If low power drain is an important design factor, complementary-MOS devices can readily be substituted, reducing the current consumption to around 40 mA. □

From digital to analog. Instead of the conventional ladder network followed by an op amp, this d-a converter employs a pseudo-random binary generator and an active low-pass filter. The generator's outputs and the 8 input data bits are subtracted in the full adders, resulting in a "carry" pulse train that drives the filter. Only one positive 5-volt supply is needed to power the entire circuit.