Pushbutton or logic controls nonvolatile DAC

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For manual control of analog signals, it's hard to beat the venerable precision multiturn potentiometer's simplicity, resolution, and power-off nonvolatility. When digital control of an analog parameter is the design objective, a universe of DACs is available to the designer. The circuit in **Figure 1**, however, has manual-pushbutton and CMOS/TTL-compatible digital interfaces to a 10-bit, nonvolatile, two- or four-quadrant multiplying DAC. The heart of the circuit is the Xicor (Milpitas, CA) X9511 PushPot series of digitally controlled potentiometers. These devices implement a convenient up/down response to either ground-referenced contact closures (with built-in debounce and pullup provisions) or open-collector/drain digital pulses.

Other useful features of these digital potentiometers include a ±5V analog-signal range and automatic storage and retrieval of settings with power-on/off cycles via an on-chip EEPROM. The potentiometer's only shortcoming in this context that its resolution is inadequate for precision applications (only 32 distinct settings, equivalent to a mere five bits). To overcome this limitation, the circuit combines two PushPots with a summing op-amp buffer to achieve nearly 10-bit resolution. IC_1 provides a weighted sum of the wiper voltages of P_2 (coarse input) and P_1 (fine input) in the ratio of 25.5-to-1. This operation provides a composite resolution of $32\cdot(25.5+1)=848$ distinct settings, equivalent to 9.7 bits.

The missing 0.3 bits are lost to the good-but-still-only-finite differential linearity of the X9511 (Xicor specifies ±0.2 LSBs) and the consequent need to give a less-than-ideal weight (32×0.8 instead of 32) to P_2 to guarantee overall DAC monotonicity. The resultant two-quadrant (R_2=10 kV, R_3 omitted) gain equation is $V_{OUT}/V_{IN}=(25.5\times P_2+P_1-31)/761$. Thus, two-quadrant gain runs from –0.04 to 1.04 in steps of 0.0013, as P_1 and P_2 settings vary from (0,0) to (31,31).

Optionally, you can obtain four-quadrant multiplication by adding one resistor to the circuit, with the value $R_3=R_2$=20 kV. Gain then becomes $V_{OUT}/V_{IN}=(25.5\times P_2+P_1-410)/380$ and ranges from –1.08 to 1.08 in steps of 0.0026, as P_1 and P_2 vary from 0 to 31. The loading of P_1 by R_1 is light enough to produce a negligible effect on linearity. Connecting Pin 7 (automatic store enable) of P_1 and Pin 7 of P_2 to ground enables automatic storage of potentiometer settings to internal EEPROM upon power-down. The circuit then automatically retrieves the settings on power-up. (DI #2269).

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Use a pushbutton or provide a digital signal to choose a nonvolatile analog output with nearly 10-bit resolution.

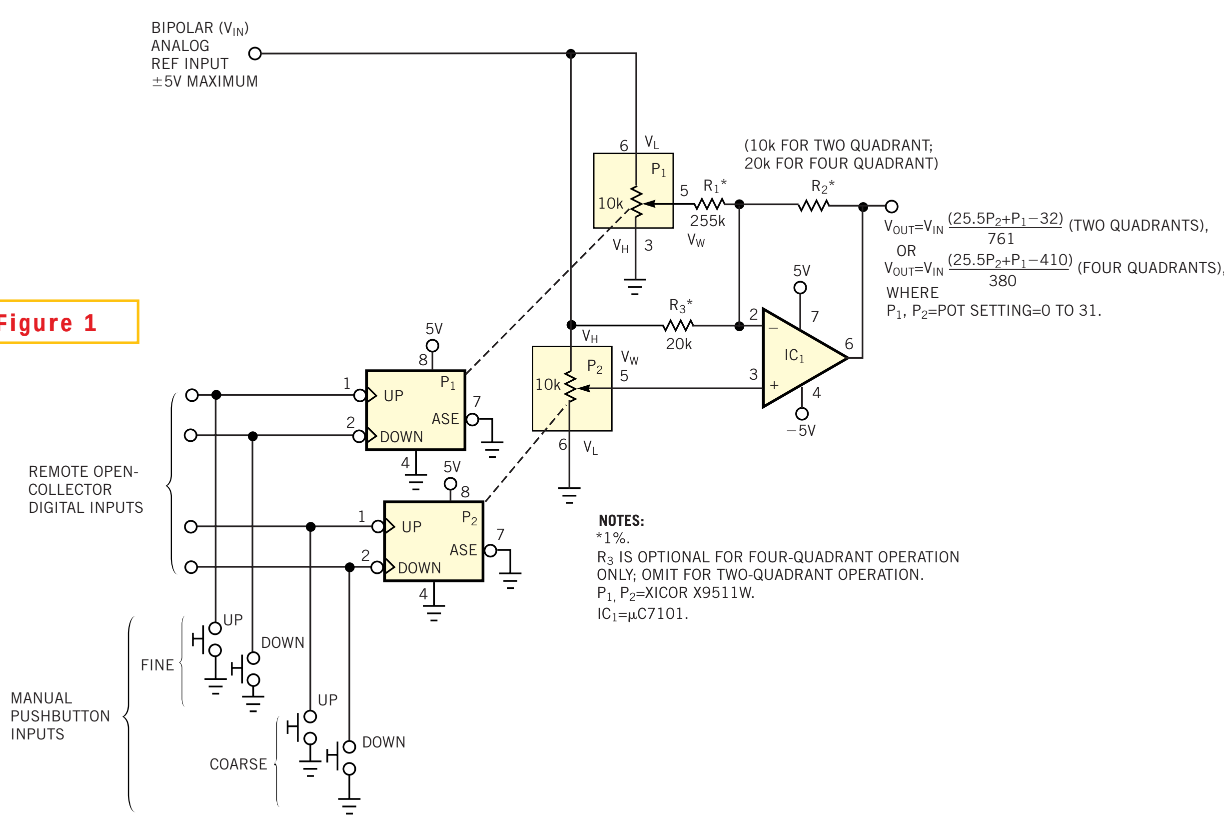

Figure 1