Adding a Sign Bit to a Unipolar ADC

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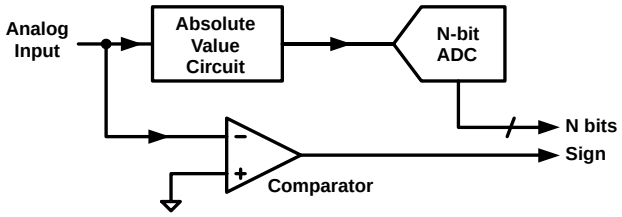
Many inexpensive Analog-to-Digital converters (ADCs), such as those embedded in microcontrollers offer only unipolar operation. In many applications, however, bipolar (+/-) signals need to be measured.

Signed conversion capability can be added to a unipolar ADC with the use of a small amount of simple external circuitry. To do so requires that one detect the sign of the incoming signal, and feed the absolute value of that signal to a unipolar ADC, as illustrated in the block diagram of Figure 1. An absolute value circuit provides the magnitude of the input signal to the ADC. The comparator compares the incoming signal to ground (0V) and produces the sign bit. In addition to allowing the unipolar ADC to measure a bipolar signal, it also effectively doubles the ADC's dynamic range because the sign bit provides an additional bit of resolution.

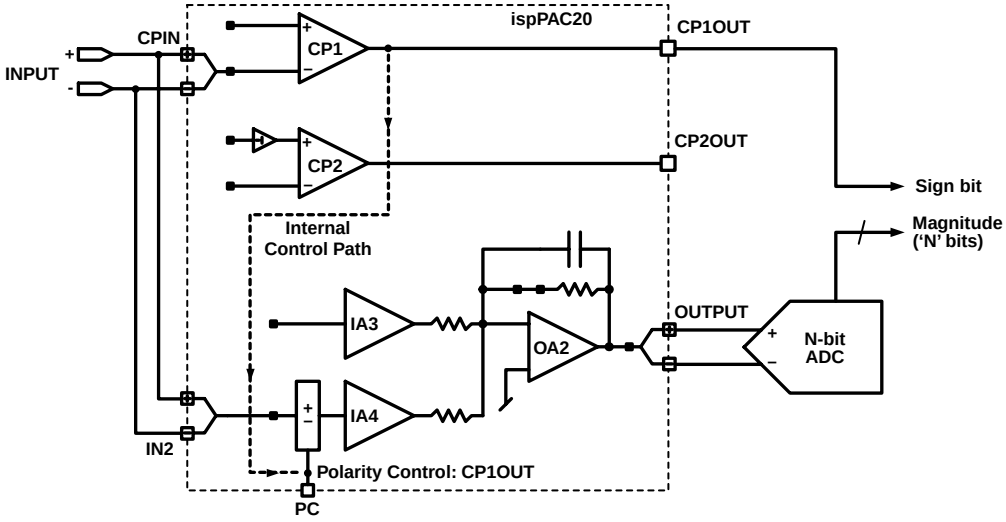
Figure 1. Sign-magnitude A-D Conversion



This signed-conversion scheme can be readily implemented with an ispPAC®20 device and a differential-input ADC, as shown in Figure 2. The CP1 comparator is used to identify the sign of the incoming signal, and its output is used both to indicate the sign and to switch the gain of the IA4 input amplifier to perform the absolute value function.

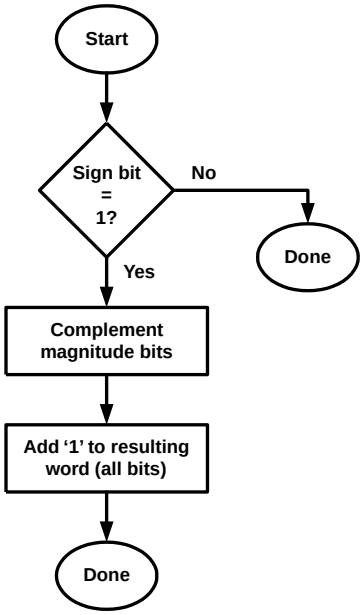
When implementing this technique, one should be aware of the effect of the comparator's input offset voltage. Comparator offset limits the accuracy with which 'zero' can be detected. This in turn sets an upper limit to the number of bits with which the technique can be used. Because the signal range of the ispPAC20 is +/-3V, and the comparator's maximum input offset voltage is 5mV, the ispPAC20 can be effectively used with unipolar ADCs of up to eight or nine bits.

Figure 2. Signed-magnitude Conversion Using ispPAC20



Because the sign and the magnitude of the binary output are represented separately, the resulting binary output format is in a signed-magnitude format, where a negative sign bit indicates a negative signal value. The flowchart shown in Figure 3 shows the steps needed to convert this signed-magnitude format into a more traditional two's complement format.

Figure 3. Signed-magnitude to Two's Complement Conversion



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