Circuit for measuring motor speed uses low-cost components

R García-Gil, J Castelló, and JM Espí,
Escola Tècnica Superior d'Enginyeria, University of Valencia, Spain

This Design Idea uses a microcontroller, a 16×2-key LCD, and a rotary encoder to measure and visualize the speed of a motor (**Figure 1**). You measure the rotor speed of the motor using an incremental encoder coupled to the motor shaft, which provides quadrature pulses with a frequency proportional to the rotor speed. The 1024-pulse rotary encoder is the RS-32-0/1024ER.11KB from Hengstler (www.hengstler.com). You can calculate the rotational speed of the motor, ω_R, by counting the number of revolutions that the encoder axis, n_V, makes during a certain time period, t_P. You calculate n_V by counting the number of pulses, n_P, that the encoder generates during this fixed period, t_P: $n_V=n_P/1024$ for this encoder. And the rotational speed is

$$\omega_R=\frac{60\times n_V}{t_P}=\frac{60\times n_P}{t_P\times 1024}=\delta\times n_P,$$

where $\delta=60/(t_P\times 1024)$ rpm represents the resolution of the measured speed. To obtain a resolution of 1 rpm for this application, the fixed period you use as a timebase is 60/1024=58.59 msec. In this Design Idea, a low-cost microcontroller, the PIC16F873, IC_1, from Microchip (www.microchip.com) performs these operations. This microcontroller also drives the LCD, IC_2, which shows the rotational speed in rotations per minute.

In a similar fashion to the circuit in **Reference 1**, you apply the quadrature pulses of the encoder to IC_1's RB0/INT input, which generates a high-priority interrupt at the rising edge of the pulse. These interruptions allow you to compute n_P by increasing a counter, which initializes after it reaches fixed period t_P. Moreover, the microcontroller's internal 8-bit timer, Timer 0, registers t_P, which generates a t_M (timer interruption) each 286 μsec for a clock frequency, f_{CLK}, of 14.3 MHz: $t_M=4\times 2^8/f_{CLK}/4=286$ μsec. This calculation means that fixing the timebase, t_P, requires 205 timer interruptions (t_P/t_M).

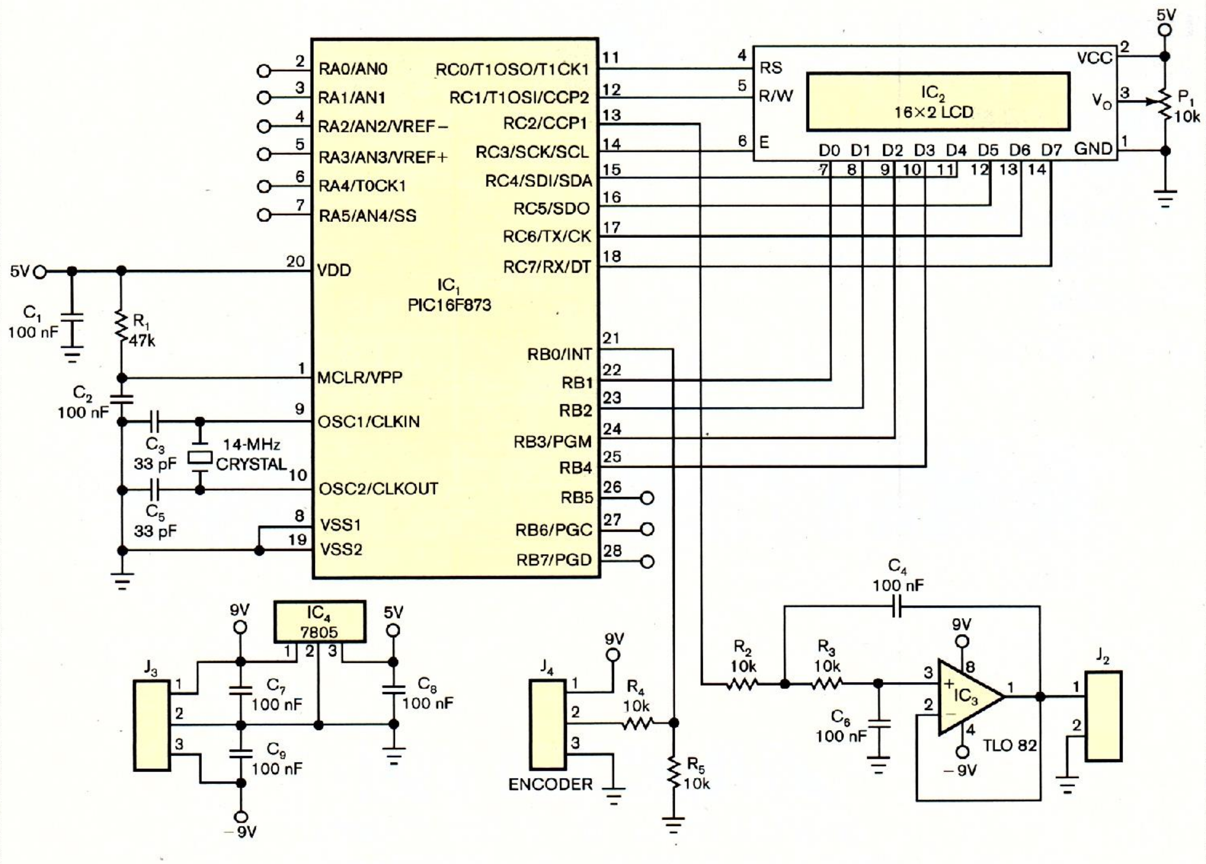

Figure 1 This circuit for measuring a motor's speed includes a PIC microcontroller and an LCD. It also provides an analog-to-digital conversion without an ADC.

When the counter reaches this time, the count, n_p, determines the rotational speed, according to the **equation**. Finally, this value appears on the screen of the LCD.

In addition, a digital-to-analog conversion is necessary if the control system must measure the rotational speed. You can do this conversion without adding an expensive DAC by applying a PWM (pulse-width-modulation) output of the microcontroller to a lowpass filter comprising R_2, R_3, C_4, C_6, and IC_3. The frequency of the PWM signal is 20 kHz, and the cutoff frequency of the lowpass filter is 160 Hz, which is much lower than the PWM frequency. In this design, the maximum duty cycle of the PWM signal corresponds to a rotational speed of 1500 rpm.

You can download the source code for IC_1's program from the online version of this Design Idea at www.edn.com/071108di1 and assemble the software with MPLab from www.microchip.com. You can alter constants within the software according to the encoder you use and your required resolution from the **equation**. EDN

REFERENCE

1 Jain, Abhishek, "Versatile digital speedometer uses few components," *EDN*, May 12, 2005, pg 95, www.edn.com/article/CA529384.