PROF. K. PADMANABHAN

A tachometer is nothing but a simple electronic digital transducer. Normally, it is used for measuring the speed of a rotating shaft. The number of revolutions per minute (rpm) is valuable information for understanding any rotational system. For example, there is an optimum speed for drilling a particular-size hole in a particular metal piece; there is an ideal sanding disk speed that depends on the material being finished. You may also want to measure the speed of fans you use.

This easy-to-make photoelectric tachometer measures the rpm of most shop-floor tools and many household machines without any mechanical or electrical interface.

How it works?

Just point the light-sensitive probe tip atop the spinning shaft towards the spinning blade, disk or chuck and read the rpm. The only requirement is that you first place a contrasting colour mask. A strip of white adhesive tape is ideal on the spinning object. Position it such that the intensity of light reflected from the object’s surface changes as it rotates.

Each time the tape spins past the probe, the momentary increase in reflected light is detected by the phototransistor. The signal processor and microcontroller circuit counts the increase in the number of such light reflections sensed by it and thereby evaluates the rpm, which is displayed on the 4-digit, 7-segment display.

The phototransistor is kept inside a plastic tube, which has a convex lens fitted at one end. A convex lens of about 1cm diameter and 8-10cm focal length is a common item used by watch repairers and in cine film viewer toys. It can be obtained from them to set up the experiment. The phototransistor is fixed on a piece of cardboard such that it faces the lens at a distance of about 8 cm. The leads from the phototransistor are taken out through a small hole in the cardboard and then connected to the circuit with the help of short copper wires.

Fig. 1: Circuit of microcontroller-based tachometer

**PARTS LIST**

**Semiconductors:**
- IC1 - AT89C2051 microcontroller
- IC2 - ULN2003 current buffer
- IC3 - CA3140 operational amplifier
- T1-T4 - BC557 pnp transistors
- T5 - 2N2222 npn transistor
- T6 - L14F1 photo-transistor
- D1 - 1N4007 rectifier diode
- DIS1 - KLQ564 4-digit, 7-segment display

**Resistors (all ¼-watt, ±5% carbon):**
- R1-R4 - 1-kilo-ohm
- R5, R6 - 10-kilo-ohm
- R7-R11 - 1.2-kilo-ohm
- RNW1 - 10-kilo-ohm resistor network
- VR1 - 4.7-kilo-ohm preset

**Capacitors:**
- C1 - 10µF, 16V electrolytic
- C2, C5, C6 - 0.1µF ceramic disk
- C3, C4 - 22pF ceramic disk

**Miscellaneous:**
- S1 - Push-to-on switch
- S2 - On/Off Switch
- Xc, V - 12MHz
- BATT. - 6V battery
and connected in the circuit shown in Fig. 1. Fig. 2 shows the suitable arrangement of phototransistor.

The detected signal is amplified by transistor 2N2222 (T5) and further amplified by operational amplifier CA3140 (IC3). The reference voltage point for the operational amplifier is obtained by resistor divider network comprising R2 and R3. The output from pin 6 of IC3 is fed to pin 12 of microcontroller AT89C2051. Note that pins 12 and 13 of microcontroller AT89C2051 are the inputs (+ and -) of its internal analogue comparator. Pin 13 is adjusted to nearly half the supply voltage using a potential divider comprising resistor R7 and preset VR1 across the supply.

The pulses picked up by the phototransistor are sensed by the internal comparator of AT89C2051 and, through software, each pulse representing one rotation of the object is detected. By counting the number of such pulses, on an average per minute basis, the RPM is evaluated. It is displayed by a software routine to light up the LED segments of the 4-digit, 7-segment display.

Circuit description

Fig. 1 shows the circuit of the microcontroller-based tachometer. The tachometer comprises AT89C2051 microcontroller, ULN2003 high-current Darlington transistor array, CA3140 operational amplifier, common-anode 7-segment (4-digit multiplexed) display and its four anode-driving transistors.

The AT89C2051 is a 20-pin, 8-bit microcontroller of Intel’s 8051 family made by Atmel Corporation. Port-1 pins P1.7 through P1.2, and port-3 pin P3.7 are connected to input pins 1 through 7 of ULN2003. Port-1 pins are pulled up with 10-k ohm resistor network RNW1. They drive all the seven segments of the display with the help of internal inverters.

Port-3 pins P3.0 through P3.3 of the microcontroller are connected to the base of transistors T1 through T4, respectively, to select one digit out of the four at a time and to supply anode-drive currents to the common anode pin of respective digit. Pin configuration of transistor BC557 is shown in Fig. 3.

When pin P3.0 of microcontroller IC1 goes low, it drives transistor T1 into saturation, which provides the drive current to anode pin 6 of 4-digit, 7-segment, common-anode display DIS1. Similarly, transistors T2 through T4, respectively, provide supply to common-anode pins 8, 9 and 12 of DIS1. Thus microcontroller IC1 drives the segment in multiplexed manner using its port pins. This is time-division multiplexing process.

Segment data and display-enable pulse for display are refreshed every 5 ms. Thus, the display appears to be continuous even though it lights up one by one.

Switch S1 is used to manually reset the microcontroller, while the power-on-reset signal for the microcontroller is given by C1 and R6. A 12MHz crystal is connected to pins 4 and 5 of IC1 to
generate the basic clock frequency for the microcontroller. The circuit uses a 6V battery for power supply or alternatively a mains derived low voltage supply. An actual-size, single-side PCB layout for the tachometer (Fig. 1) is shown in Fig. 4 and its component layout in Fig. 5.

**Testing**

The source code of this article is available at [http://www.electronicsforu.com/efycodes/efy-codes.zip](http://www.electronicsforu.com/efycodes/efy-codes.zip) at code efycodes.zip and will also be included in EFY-CD of February 2008 issue.

**Software**

The software is written in Assembly language and assembled using 8051 cross-assembler. It is well commented and easy to understand. It uses AT89C2051’s internal timer for measuring the period of one cycle of the rotation in units of 100 microseconds.

Thus if the speed is 1500 rpm, it is 25 rpm, and the time taken for one cycle is 40 ms.

The timer uses an interrupt to count overflows every 100 microseconds and so the number counted by the timer program in this case will be ’400.’ This is divided by ’600,000’ (so many 100/µs present in a minute), giving a result of ’1500.’ This gives the rpm. These digits are displayed on the 4-digit, 7-segment display.

To perform the division, subroutine UDIV32 is employed, which is a standard subroutine available for 8051 family for 32-bit number by 16-bit number division. It has an accuracy of 5 rpm in a 6000rpm count.

**EFY note.** The source code of this article is available at [http://www.electronicsforu.com/efycodes/efy-codes.zip](http://www.electronicsforu.com/efycodes/efy-codes.zip) and was also included in EFY-CD of February 2008 issue.

Prof. K. Padmanabhan retired from Alagappa College of Technology, Guindy, Chennai
Let Us
Get Ahead Together

Tell Me More About Advertising Opportunities in EFY Magazine

I am aware that EFY Magazine presents unique advertising opportunities. I too would like to explore the various options available for my organisation, so that I can help it grow in terms of sales and brand presence.

My details are mentioned below:

Name_________________________________________Organisation_________________________________________Designation_________________________________________
Address_________________________________________City______________________________________________Pincode_________________________________________
Phone____________________Fax____________________E-mail________________________________________________

I would like to have a one-to-one meeting
☐ I would like to have a one-to-one meeting with someone from the EFY team.
☐ Please send me your marketing kit containing all necessary details.

Please mail/fax this form to:
EFY Enterprises Pvt Ltd
D-4/7/1, Okhla Industrial Area, Phase-5, New Delhi 110020
Tel: 011-26810601/2/3; Fax: 011-26817343
Email: efymkt@efyindia.com; Website: www.efyindia.com

EFY Sincerely Yours