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DESIGN AND DEVELOPMENT OF A MICROCONTROLLER BASED SYSTEM FOR MEASURMENT OF RPM

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ABSTRACT

RPM measurement meters used in different applications need to meet the high performance, accuracy and reliability to achieve the desired output. But RPM meters have always been expensive tools for the average hobbyists. This paper deals with the design of a microcontroller based system for RPM measurement using proximity sensor and measured RPM is displayed on LCD display which is interfaced with 89C2051 microcontroller in 4-bit mode.

KEYWORDS: LCD, Microcontroller, Proximity Sensor, RPM

INTRODUCTION

This paper deals with the design of a microcontroller based system for acquiring the rpm and to display it on LCD. An Inductive proximity sensor is used to measure the RPM and the measured values are displayed on LCD which is interfaced to microcontroller in 4 bit mode [1]. In such a scenario this paper describes an inexpensive, small scale microcontroller based system for measuring the frequency and rpm of any rotating device. Proximity sensor is used to sense the metal strip stickled on the rotating disc in the present study. It can send a pulse while a metal object reached the detection field of view of the sensor.

This paper describes a new way for the processing of the pulses. The processing takes advantage of new single chip low cost programmable microcontroller, LCD and proximity sensor. The design of the measuring system differs fromtechniques described in the literature [2]. The special feature of this instrument is very simple and portable to carry. When any rotating metal device is placed within the detection field of view of the proximity sensor, it can directly send the measured RPM values to LCD. Software is developed in Embedded C and RIDE is the software used in the present work.

PRINCIPLE OF THE EXPERIMENT

There are many known principles are available for measuring rotation speed [3]. The output frequency generated by rotation speed sensors is proportional to the measured parameter. The rotating disc (wheel) connected with the angle of rotation and can be determined by the instantaneous frequency in any moment of time is proportional to the instantaneous angular speed.

The general formula for rotation speed is given by the following equation:

$$\text{Rotation speed (RPM)} = \text{frequency X } 60/n$$

Where 'n' is the number of encoder's gradations.

There are several methods which can provide a frequency measurement in order to derive the rate of rotation from pulse signals. But all the methods have their disadvantage in all specified measuring range of frequencies [4, 5]. The present system gives a simple counting method for measuring frequency and rotation speed. The present system measures the frequency of pulses range from 0 to 65,535 Hz.

The general formula for calculating frequency is given by the following equation:

$$\text{Frequency, } f = \text{number of pulses/ sec}$$

$$\text{RPM} = [\text{No. of rotations/sec}] \times 60/n$$

$$= \text{Frequency} \times 60/n$$

If number of encoders on the rotating disc (wheel) is one (n= 1), the rotation speed is:

$$\text{RPM} = \text{Frequency} \times 60$$

EXPERIMENTAL SETUP

Fig. 1 shows the proposed block diagram of the hardware developed in the present work. It requires the following:

- Proximity sensor
- 89C2051 microcontroller
- LCD Module

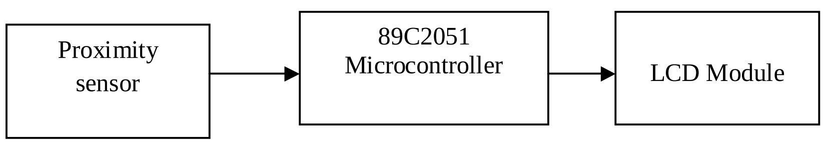

Fig. 1: Block Diagram of LCD Based RPM Measurement System

Proximity Sensor

Inductive proximity sensors operate under the electrical principle of inductance. Inductance is the phenomenon where a fluctuating current, which by definition has a magnetic component, induces an electromotive force (emf) in a target object.

An Inductive proximity sensor has four components, the coil, Oscillator, detection circuit and output circuit. The oscillator generates a fluctuating magnetic field the shape of the doughnut around the winding of the coil that locates in the device's sensing face [6]. The Photograph of inductive Proximity sensor used in this present work is shown in Fig. 2.

Fig.2. Inductive Proximity Sensor

The detection distance of an inductive proximity sensor depends on the target materials capacity for conducting electricity. Also, the target's thickness will have an influence of its detection. Generally thin materials are easier for an inductive proximity sensor to detect than thick materials. The material conduction and thickness factor to detection distance depends on technology of the inductive proximity sensor.

When a metal object moves into the inductive proximity sensor's field of detection, eddy circuits build up in the metallic object, magnetically push back, and finally dampen the inductive sensor's own oscillation field. The sensor's detection circuit monitors the oscillator's strength and triggers an output from the output circuitry when the oscillator becomes dampened to a sufficient level. For every detection of metal object by the sensor produces a pulse from the output circuitry of sensor.

An output circuitry is connected to a 16 bit counter, which counts the number of pulses produced by sensor. 16-bit counter is used to count the number of clock pulses within an input signal period [7]. The counter content is cleared after this information is fed to the microcontroller. So that the system is ready for a new measurement.

89C2051 Microcontroller

The microcontroller used in the present work is a low-cost and popular Atmel's 89C2051 [8]. This microcontroller is selected for the following reasons:

1. It is a 20-pin IC having the architecture and instruction set compatibility with 8051 microcontroller series.
2. It has a on-chip precision analog comparator
3. Interrupt control, timer and serial transmission facilities
4. Only disadvantage with this IC is that there are only two ports available (one 8-bit port and the other 5-bit port).

Cost-effectiveness and low-pin count have attracted us to use this microcontroller. Selection of 11.0592 MHz crystal across pins 4 and 5 of 89C2051 used to provide stable frequency without any phase difference.

LCD Module

The LCD module used in the present work is of type 16X2, which displays 16 alphanumeric characters and two lines. Pin details of this module are given in Table 1. The LCD module contains 3 control lines and 8 data lines. Control lines are used to control the internal operations of the LCD module. Data lines are used to transmit the data to microcontroller or receive the data from microcontroller. The LCD module used here is, in the 4-bit data interface mode, wherein only data pins for DB4-DB7 are used for data transfer [9]. In this paper the LCD module is connected to higher nibble MSB of port1 of the microcontroller. Three control lines of LCD are connected to LSB of port1 of microcontroller. A functional diagram is shown in Fig. 3. The 10k potentiometer is used to control the contrast of the LCD module.

Table 1: Pin Description for LCD

Pin No.	Symbol	Description
1	Vss	Ground
2	Vcc	+5V Power supply
3	Vee	Power supply to control contrast
4	RS	RS=0 to select command register, RS=1 to select data register
5	R/W	R/W=0 for write
6	E	Enable
7-14	DB0-DB7	8-bit data bus

Pins of LCD	14	13	12	11	X	6	5(GND)	4
	DB7	DB6	DB5	DB4	NC	E	NC	RS
Pins of 89C2051	P1.7	P1.6	P1.5	P1.4	P1.3	P1.2	P1.1	P1.0
	19	18	17	16	15	14	13	12

Fig. 3: Functional diagram of LCD used in the present work

HARDWARE DESCRIPTION

Fig. 4 shows the circuit diagram of the measuring system designed in the present study. The photograph of the present system is shown in Fig.5. Regulated Power Supply is used as an External Power supply to provide sufficient voltage to the circuit. Another 9V battery source is internally mounted in the case to provide sufficient voltage to the circuit when power is OFF. For this a toggle switch S2 is provided here to choose internal (9V)/External (12V) power supply voltages. Further the External power supply voltage is regulated to provide sufficient voltage (+5V) required for the circuit. In this paper Timer0 is accessed as counter by initializing TMOD register of microcontroller.

The circuit is powered up by pressing the RESET (S1) button provided on the top view of the photograph shown. Then the microcontroller start to activate Counter (Timer0) and is ready to take count of pulses received from the proximity sensor. Software is developed for calculating the RPM value and is displayed on LCD module which is interfaced to 89C2051 Microcontroller in four bit mode. Counter is cleared after sending first value of RPM and it is ready to take another count and send it to LCD through software. The entire circuit is battery backed up [10]

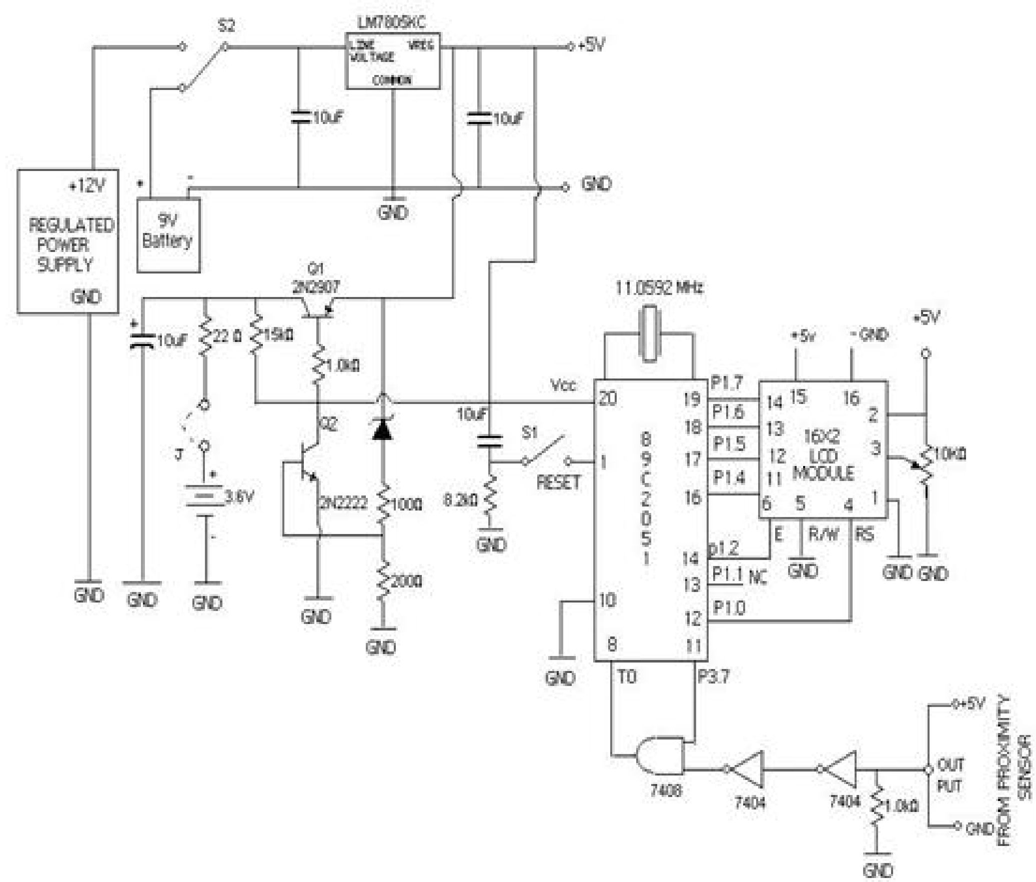

Fig. 4: Circuit Diagram of RPM Measuring System

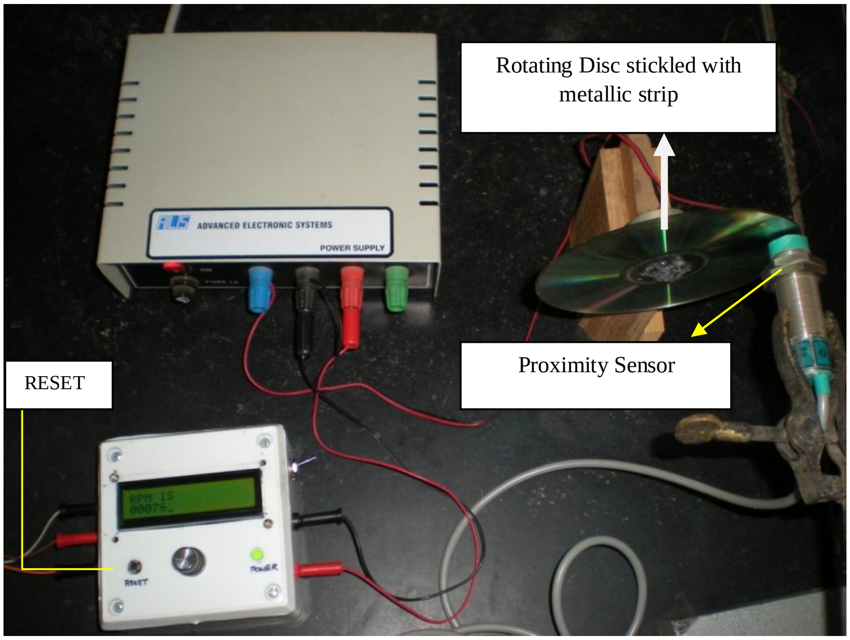

Fig. 5: Photograph of RPM Measurement System

SOFTWARE DESCRIPTION

Code is developed using **R**aisonance **I**ntegrated **D**evelopment **E**nvironment software for the microcontroller in C language [11]. The developed Code can be compiled and run for creating a hex file. The created Hex file can be dumped on to the flash memory of a microcontroller using a special Atmel programmer. The flow chart of the code developed in the present work is shown in Figure 5.

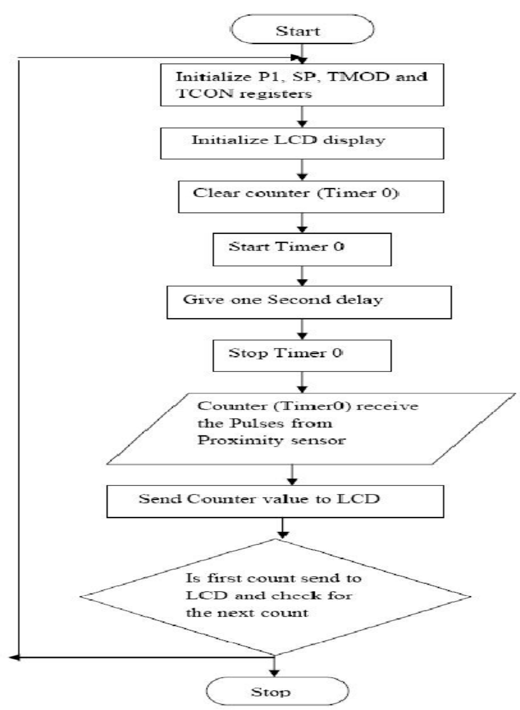

Fig. 5: Flowchart of the Embedded C Program Developed in the Present Work

EXPERIMENTAL RESULTS

The RPM value of a rotating disc in the laboratory has been checked using the instrument developed in the present work. This instrument can also be used in the automobile industry for checking the balance of the rotating wheel by calculating its rotating speed. This is useful in the field also by placing a sensor at a point near to the rotating shaft of the wheel. The present system shows good results in both the cases. And the measured RPM value is displayed on LCD module by using this small system developed in the present study.

CONCLUSIONS

A Simple hard ware and software are developed for measuring the RPM of a rotating disc (wheel). The circuit can easily be constructed on a PCB using cost-effective ICs and readily available components. The constructed PCB enclosed in a small case, which looks very simple and easy to carry it anywhere.

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