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Analysis of Digital Tachometer using 8051 Microcontroller

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Abstract:
A digital tachometer is a digital device that measures and displays the rotational speed of an object. A rotating object could be a bicycle tyre, a car tyre, a ceiling fan, or any other motor, for example. A digital tachometer circuit includes an LCD or LED readout as well as a memory for storage. Digital tachometers, which provide numerical readings rather than dials and needles, are becoming more common. An optical encoder that determines the angular velocity of a rotating shaft or motor is a digital tachometer. Digital tachometers are used in a variety of applications, including automobiles, aeroplanes, and medical and instrumentation. It is expressed in RPS or RPM, and the model counts the RPM pulses using a set of infrared transducer receivers. The project is implemented using the Arduino microcontroller. The microcontroller counts the individual pulses to produce the RPM output.
Keywords: *Digital Device, Digital tachometer, Memory unit, Microcontroller, Transmitter and receiver LED, 8051, 8051 microcontroller.*

I. Introduction:

A tachometer is a device that measures the rotational speed of a rotating object, such as an electric motor or the crank shaft of a vehicle engine. The number of revolutions made by an electric motor in one minute determines its speed. In other words, RPM (Revolutions per Minute) is the unit of measurement for speed. In this project, we created a simple non-contact or contactless digital tachometer with an 8051 microcontroller that can measure speed with a resolution of 1 rev/sec.

A tachometer is primarily used to determine the angular speed of a motor. It can be a mechanical device with a warm gear and spindle arrangement, or it can be an electrical device that converts angular speed into an electrical signal. The electrical tachometer, in turn, can be either an AC or a DC tachometer.

A contact tachometer, which can produce erroneous results due to changes in contact parameters, is preferred over a contactless digital tachometer, which does not require any contact with the device whose speed is to be measured. [1]

It operates on the retro reflective scanning principle, in which a light source device, such as an LED, transmits a light signal to a retro reflective target device, which reflects the light, which is then received by the light detector.

Based on data acquisition and measurement techniques, digital tachometers are classified into four types.

- Tachometers are classified into the following types based on the data acquisition technique:

1. Contact type
2. Non Contact type

- Tachometers are classified into the following types based on measurement technique:

1. Time measurement
2. Frequency measurement

Principle of Circuit

The Digital Tachometer works on the basis of a simple implant system that includes a sensor, a controller, and an actuator. The sensor used here is an infrared transmitter and receiver pair, the controller is an 8051 Microcontroller loaded with assemble code, and the actuator is a display component that displays the motor's speed.

By using the principle of light transmission and reflection, the sensor detects the speed of the motor without actually coming into contact with it and sends a signal. This signal is converted into an electric signal and fed into the microcontroller, which is programmed to measure the speed in terms of the number of motor rotations per minute. On the seven-segment display, this speed is displayed. [2]

Contactless digital tachometer using 8051.

This project introduces a three-digit contactless digital tachometer built with an 8051 microcontroller that can be used to measure the revolutions per second of a rotating wheel, disc, shaft, or anything else. The tachometer can measure up to 255 rev/sec with a 1 rev/sec accuracy. Simply align the sensor near the reflective strip (aluminium foil, white paper or something similar) glued to the rotating surface, and the metre displays the rev/sec on the display. The digital tachometer circuit diagram is shown below.

Components Required

- 8051 Microcontroller
- 8051 Development Board
- 8051 Microcontroller Programmer
- IR Sensor Module (Reflective Type)
- 4 – Digit 7 – Segment Display
- 4 x 2N2222 NPN Transistors
- 4 x 470Ω Resistors (1/4 Watt)
- 8 x 100Ω Resistors (1/4 Watt)
- If Development Board is not used, then you need
  - 11.0592 MHz Quartz Crystal
  - 2 x 33pF Ceramic Capacitors
  - 2 x 10 KΩ Resistor (1/4 Watt)
  - 10 µF Capacitor (Polarized)
  - Push Button
  - 1 KΩ x 8 Resistor Pack

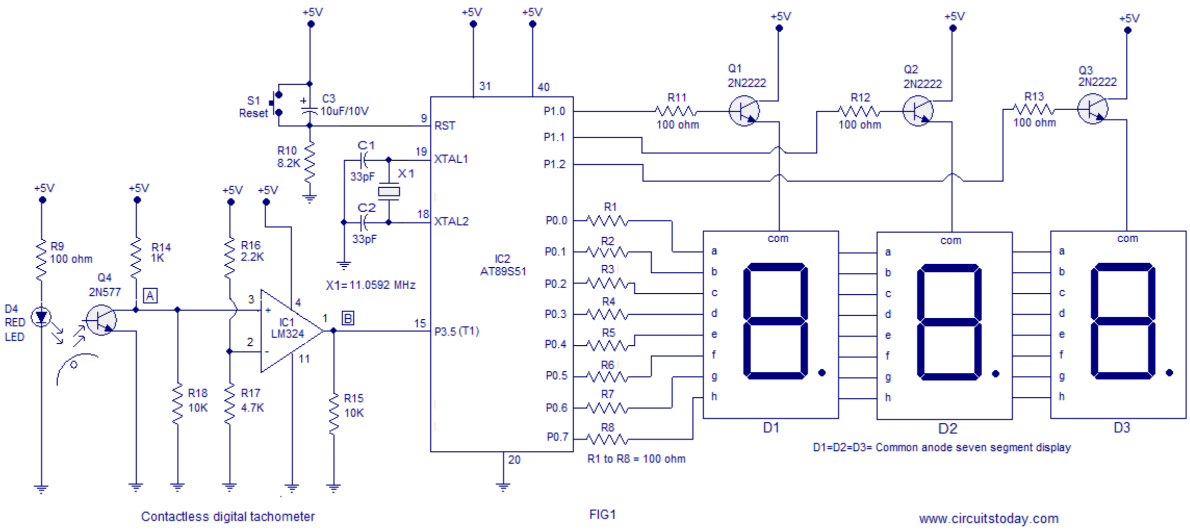

Figure 1: Digital tachometer using 8051.

A microcontroller, phototransistors, op-amps, a seven-segment LED display, and other miscellaneous components are used in this circuit. In addition, a sensor is placed near the reflective strip, such as an aluminium foil fixed to the rotating surface. As the phototransistor detects the strip, the LED directed from this device is reflected. [3]

As a comparator, the op-amp LM 324 compares the voltage on the transistor collector to the fixed voltage. As a result, it generates continuous pulses for the shaft's rotation. These pulse trains are fed into the microcontroller, which counts them and converts them into RPM as programmed. They are also shown on a seven-segment display that is connected in a transistor-driven common anode configuration.

The optical pickup, which is based on photo transistor Q4 and red LED D4, is the first section of the circuit. When the reflective stripe on the rotating object passes in front of the sensor assembly, the reflected light falls on the photo transistor, causing it to conduct more and lowering the collector voltage to zero. The collector waveform of the photo transistor Q4 (2N5777) would look like this when viewed through an oscilloscope:

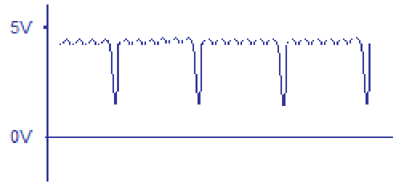

Figure 2

The signal conditioning unit based on the opamp LM324 (IC1) is the next component. The quad LM324 contains only one opamp, which is wired as a comparator with a reference voltage of 3.5V (via resistors R16 and R17).

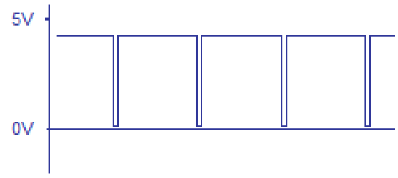

Figure 3

The negative going edge of the waveform in the above two graphs indicates the passage of the reflective patch across the sensor, which equals one revolution.
The 8051 microcontroller here performs two functions:
1. Determine the number of negative going pulses available at its T1 pin (15).
2. Perform the necessary maths and display the count on the three-digit seven-segment display.

Both of the 8051 timers (Timer0 and Timer1) are used for counting. Timer 1 is set up as an 8-bit auto-reload counter to register the number of incoming zero-going pulses, and Timer 0 is set up as a 16-bit timer to generate the required one-second time span for Timer 1 to count. [4]

LCD version of the tachometer using 8051.

This is simply an 8051-based modification of the previous digital tachometer. The output is displayed using a 162 LCD module. The output is given in rpm (revolutions per minute), with the digits increasing from 3 to 5. This circuit is more accurate than the LED version and can display up to 10200 rpm. There is also a change in the sensor circuit. Instead of the discrete photo transistor/LED combination, a photo transistor/IR diode pair (LTH-1550) is used to sense the rpm. The use of the LTH-1550 photo interrupter module increases its ruggedness and stability. Because the LTH-1550 only detects infrared light, visual light interference is minimised. The operating principle is nearly identical to that of the previous version, but the programme has been heavily modified. The LCD tachometer circuit diagram using the 8051 is shown below. [5]

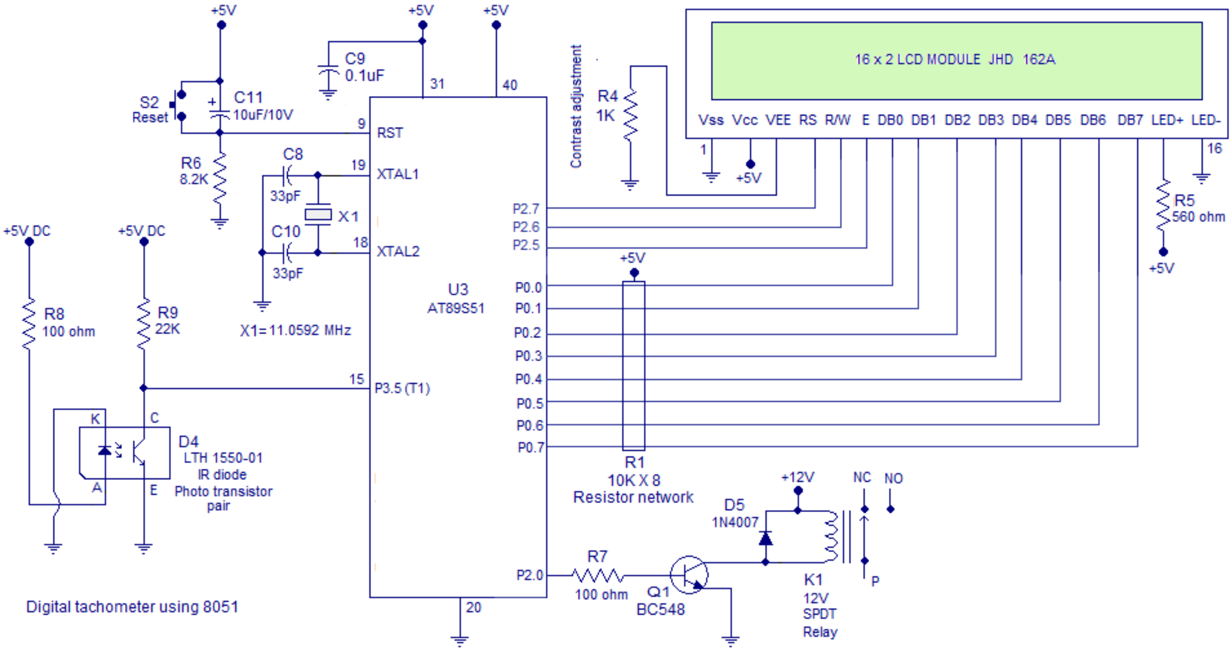

Figure 4: LCD version of the tachometer using 8051

Objectives:

1. Analysis of Digital Tachometer using 8051 Microcontroller
2. LCD version of the tachometer using 8051
3. Initialized circuit for RPM measurement
4. LCD displaying final RPM output
5. Operate the Contactless Digital Tachometer Circuit

Proposed System Concept

The basic concept includes an Arduino with a background in c programming from embedded systems, an IR sensor, an Arduino microcontroller, an LCD output screen, and a source from which the output to be measured is generated, as illustrated in Figure 1. The IR sensor module consists of an IR transmitter LED and an IR photoreceiver, the microcontroller is programmed in C and stored in its memory until reset, and the actuator is an LCD display device that displays the real-time speed measured from the motor surface. [6]

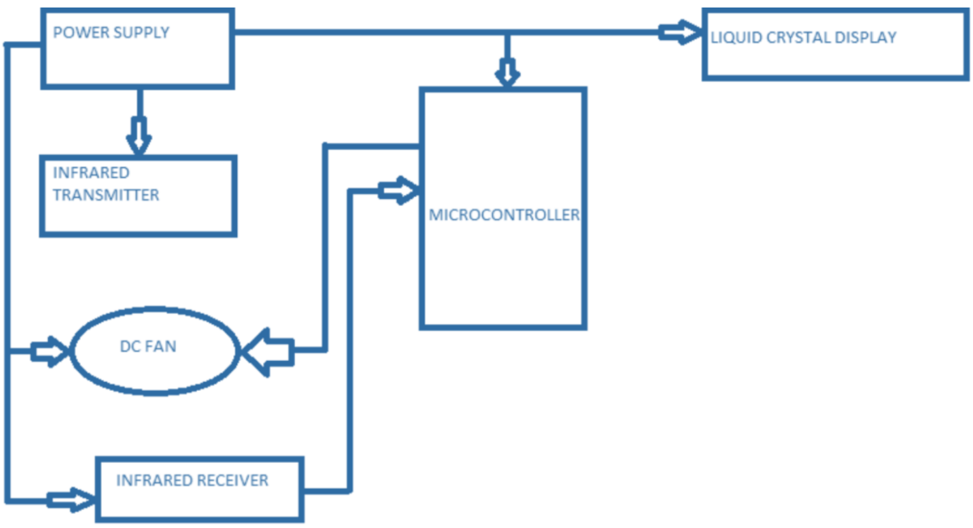

Figure 4 : Block diagram of the proposed system

The IR sensor detects high pulses caused by reflection from the motor's surface, and the controller is used to calculate the speed of the motor without actually connecting to it; a result is generated from the signals using the reflection principle, as shown in Figure 1. This calculated output signal is sent as an electrical signal and fed into the actuator, which is an LCD panel programmed to display the speed in revolutions per minute. This is the finished product. [7]

II. Result and Discussion:

This can also be used to measure the speed of motors that are in inaccessible locations. This device is built around an Atmega328 microcontroller, speed is detected using an IR transmitter and receiver pair, readings are displayed on an LCD display, and speed is controlled by aipot. It works on the principle that the number of rotations per second is determined by the number of times the IR receiver-transmitter circuit is cut and reestablished in a second. The value is shown on the LCD screen. The image depicts the tachometer circuit that was used as our test model for tracking the RPM of an independent-powered dc motor. Figure 6 depicts the circuit's initialization when there is no movement and the LCD reads 0 RPM. Figure 7 depicts an RPM of 273 that the IR module tracks from the motor rotational circuit that we are testing. Figure 8 shows the LCD displaying the final RPM output. [8-9]

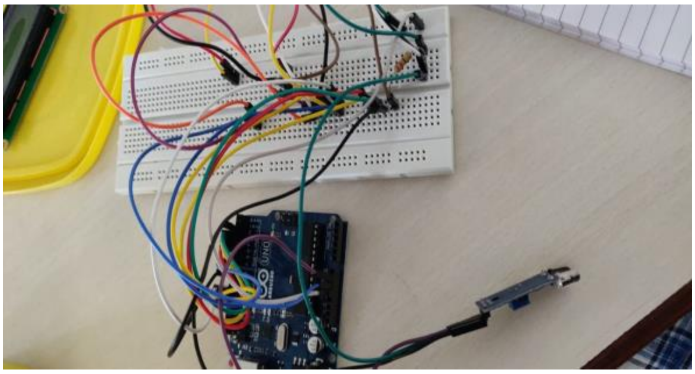

Figure 6. Experimental setup

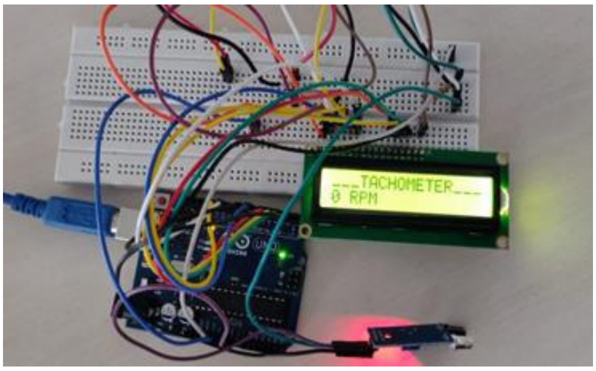

Figure 7. Initialized circuit for RPM measurement

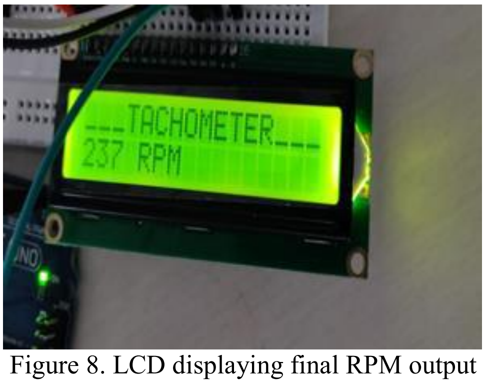

Figure 8. LCD displaying final RPM output

Operate the Contactless Digital Tachometer Circuit [10]
When the IR sensor is turned on, the IR transmitter begins to emit IR rays. A motor with a white dot on its shaft is placed in front of the IR sensor.
The IR rays are reflected by the dot and fall on the IR receiver as the motor shaft rotates and the white spots come into contact with the sensor. When the IR rays are reflected, the photo diode, which serves as the IR receiver, begins to conduct.
At this point, the output of the IR sensor is fed into the comparator, and the comparator output is HIGH when the IR rays are reflected, and LOW when there are no reflections. As a result, the comparator's output takes the form of an ON-OFF pulse.
This pulse is fed into the microcontroller as a timer input, and the microcontroller is programmed to count how many times the motor rotates in one second.
The motor's speed is calculated by multiplying the value of the final count by 60 to get the revolutions per minute. The 4-digit 7-segment display then displays this value.

Applications
1. The Contactless Digital Tachometer circuit is capable of calculating the speed of rotating wheels, discs, and motor shafts.
2. This circuit can be used in situations where direct contact with motor shafts or wheels is not possible, such as in vehicles and industrial machines.
3. This circuit can be used in the home to test the speed of small battery-powered fans and other motor-powered devices.

Limitations of the Circuit
1. The CMOS devices used in this circuit are highly static, making it impossible to touch them with bare hands.
2. It has a limited lifespan due to the use of a battery to power the circuit.
3. The varying duty cycle of the timer may have an effect on speed calculation.

III. Conclusion:

Motors and generators are essential parts of the industrial enterprise in this fast-growing world of technologies. For a specific application in industry, the speed must be fixed, and thus the speed in revolutions per minute (RPM) must be known. Tachometers are used to measure the revolutions per minute (RPM) of a rotating machine. In our project (contact less digital tachometer), we achieved satisfactory results in accordance with our goal of developing an experimental setup that can be used to calculate the RPM of the machine.

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