Digital Speedometer using Arduino Board for Formula Student Cars

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Abstract—This paper outlines the design and implementation of Digital speedometer system using Arduino. The Arduino board senses the signals receiving from sensor as an input then do some Arithmetic calculations and showed the results on Liquid crystal display (LCD) as an output in kmph.

This article uses a GS101201 speed sensor to measure the speed of one of the cars wheels. The Arduino board receives signals from the sensor and calculates the rpm then converted into a speed, and send this information out to the LCD screen on the dashboard of the car. It is compatible with any kind of wheel, simply changing the radius of the wheel in the program in Arduino IDE software. Particularly it is very useful to monitor the speed of Formula student cars, motors, turbines using this Arduino system.

Keywords—Arduino Nano, Arduino IDE, speed sensor, microcontroller, hardware, software, LCD, buck converter, tachometer, etc.

I. INTRODUCTION

Pretty much all speedometers produced until the 1980s worked using the eddy current and cable mechanism much like Schulz’s original, patented design. But there are drawbacks. First, there are lots of mechanical parts to wear out (which makes them inaccurate) or fail suddenly. If the speedometer cable breaks, the whole contraption instantly becomes useless and it takes a mechanic to make a repair. Long speedometer cables are particularly impractical, which has always been something of a problem in large commercial vehicles such as trucks and buses. And it’s not just the cable that poses a problem, it can be difficult to read a conventional speedometer dial if you're racing down the freeway, especially at night. Do you really want to take your eyes off the road to figure out where the needle is on the dial? Some people prefer to see their speed as a simple number on a well-lit digital display.

Electronic devices can be analog or digital. Values on analog devices are (normally) infinitely variable. A speedometer that shows a car's speed by means of a dial is an analog device. The hand on that dial moves smoothly around the dial and can take any value that the car's engine can create. In a digital device, values are represented by numbers and therefore do not have the variability of analog devices.

II. BLOCK DIAGRAM OF THE SYSTEM

The system consists of hardware and software part. This fig. Shows the block diagram of the Digital speedometer. As for the software part plays biggest role in system. All the program is stored in Arduino nano using c language.
Flash memory is 16KB or 32KB that all depends on the Atmega board. Atmega168 comes with 16KB of flash memory while Atmega328 comes with a flash memory of 32KB. Flash memory is used for storing code. The 2KB of memory out of total flash memory is used for a bootloader.

The SRAM can vary from 1KB or 2KB and EEPROM is 512 bytes or 1KB for Atmega168 and Atmega328 respectively. It is programmed using Arduino IDE which is an Integrated Development Environment that runs both offline and online.

The sensor is paired with a gear of suitable dimensions as per the datasheet of the sensor. And is assembled as depicted in the figure. (sensing gap is 2-3 mm).

### Table I. Arduino Nano Specifications

<table>
<thead>
<tr>
<th>Spec</th>
<th>Atmega328p/Atmega 168</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>Atmega168</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>7 – 12 V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>14</td>
</tr>
<tr>
<td>PWM</td>
<td>6 out of 14 digital pins</td>
</tr>
<tr>
<td>Max. Current Rating</td>
<td>40mA</td>
</tr>
<tr>
<td>USB</td>
<td>Mini</td>
</tr>
<tr>
<td>Analog Pins</td>
<td>8</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>16KB or 32KB</td>
</tr>
<tr>
<td>SRAM</td>
<td>1KB or 2KB</td>
</tr>
<tr>
<td>Crystal Oscillator</td>
<td>16 MHz</td>
</tr>
<tr>
<td>EEPROM</td>
<td>512 bytes or 1KB</td>
</tr>
<tr>
<td>USART</td>
<td>Yes</td>
</tr>
</tbody>
</table>
It will have (16×2=32) 32 characters in total and each character will be made of 5×8 Pixel Dots. A single character with all its Pixels is shown in the above picture. The advantage of an I2C LCD is that the wiring is very simple. You only need two data pins to control the LCD.

D. I2C module

I2C is a serial communication protocol so you can connect multiple slaves to a single master (like SPI) and you can have multiple masters controlling single, or multiple slaves.

I2C only uses two wires to transmit data between devices as follows:

1) SDA (Serial Data): The line for the master and slave to send and receive data.

2) SCL (Serial Clock): The line that carries the clock signal A5 pin.

so, data is transferred bit by bit along a single wire (the SDA line) A4 pin.

With I2C, data is transferred in messages. Messages are broken up into frames of data. Each message has an address frame that contains the binary address of the slave, and one or more data frames that contain the data being transmitted. The message also includes start and stop conditions, read/write bits, and ACK/NACK bits between each data frame.

E. Buck converter (Step down converter)

A buck converter (step-down converter) is a DC-to-DC power converter which steps down the voltage (while stepping up current) from its input supply to its output load.

In this DC-DC Buck Converter Step Down Module LM2596 Power Supply is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. The LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

IV. SOFTWARE SYSTEM

The software that needs to be installed for programming the board and some important concept of programming is provided in this section.

A. Arduino IDE

Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

It is easily available for operating systems like MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment.
A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more. Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.

The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

B. Interrupts

Interrupts stop the current work of Arduino such that some other work can be done. The main program is running and performing some function in a circuit. However, when an interrupt occurs the main program halts while another routine is carried out. When this routine finishes, the processor goes back to the main routine again.

- The Arduino Mega has six hardware interrupts including the additional interrupts ("interrupt2" through "interrupt5") on pins 21, 20, 19, and 18.
- You can define a routine using a special function called as “Interrupt Service Routine” (usually known as ISR).
- You can define the routine and specify conditions at the rising edge, falling edge or both. At these specific conditions, the interrupt would be serviced.
- It is possible to have that function executed automatically, each time an event happens on an input pin.

There are two types of interrupts:

1. Hardware Interrupts – They occur in response to an external event, such as an external interrupt pin going high or low.
2. Software Interrupts – They occur in response to an instruction sent in software. The only type of interrupt that the “Arduino language” supports is the attachInterrupt() function.

V. PROPOSED SYSTEM

This part introduces our approach towards making of digital speedometer.

The sensor used in this setup is capable of detecting the presence of metal. This property can help in many applications, one of them being measuring speed with the help of a microcontroller analysing the data sent by the sensor to measure speed of shafts, in our case a hub. A gear of metallic material of compliant dimensions as per the datasheet of GS101201 sensor is to be made. A concept of such gear is depicted in the CAD figure 14.
The sensor is to be connected in a way such that when the gear rotates along with the wheel, the teeth point towards the flat surface of the sensor which detects the presence of metal. A concept of such arrangement is depicted in the CAD figure 15.

Fig. 15. Sensor and gear arrangement CAD.

The sensor is connected to Arduino Nano board to calculate wheel speed by a logical program saved on the board which is then displayed to the concerned authorities by means of a display (figure 16).

Fig. 16. 16x2 LCD.

VI. CIRCUIT INTERFACING

The electrical connections to be done are clearly depicted in the figure following.

The I2C is connected to the display to convert the 8bit data transfer capability of the display into I2C type of data transfer to reduce number of wires in the wiring harness. The 4 terminals of I2C module (5V, GND, SDA, SCL) are connected to the terminals on the Arduino Nano as shown. The sensor works on 5V DC currents hence is powered by connecting to 5V and GND terminals of the Arduino Nano. The output terminal of the sensor is connected to digital pin 2 of the Arduino as the pin supports hardware interrupt necessary for measuring speed with high precision. The Arduino Nano is powered by the 12V battery through a buck converter which supplies 5V constant DC supply free of voltage spikes and drops due to the 12V battery also being used by other components which could be a cause for the same. Connecting wires of suitable gauge and length are used for the connections and are then covered or tied together to avoid tangles.

VII. ACTUAL SETUP

The following section explains the current setup of the speedometer installed.

A mild steel billet is cut into the gear (shown in the figure above) by the process of laser cutting and is mounted on the front right hub (shown in the figure below) with a suitable coupling and hence rotates along with the wheel.

Fig. 18. Mild steel gear.

Fig. 19. Actual setup on vehicle.

The calculations are done by Arduino Nano to which the sensor is connected which sends a pulse to the Arduino Nano...
every time a tooth passes by the sensor. The time difference is calculated between two pulses by the built-in functions of Arduino Nano and with the help of a suitable code, false readings are identified and scrapped to get accurate time difference. The reciprocal of this time difference gives the frequency of the rotating gear. The frequency is then divided by the number of pulses per revolution i.e. the number of teeth on the gear gives number of revolutions per second which the multiplied by 60 gives number of revolutions per minute (RPM). The car wheel is 16 inches in diameter, the RPM is multiplied by a factor of 0.005911 to obtain the speed of vehicle in Kmph units. Arduino Nano’s digital pin number 2 is used as the signal input to the board from the sensor as it is one of the pins that supports interrupt service routine that helps to obtain readings with the highest speed possible for the board. The sensor is powered by getting 5-volt constant D.C. supply from Arduino Nano and is also grounded to the board itself. A pull up resistor of 1K Ohm is connected between the VCC and output terminals of the sensor. The Arduino Nano is powered by a buck converter that converts the 12-volt supply from the battery to 5-volt supply suitable for the board. The speed calculated is displayed to the driver through a suitable liquid crystal display in kmph (shown in the figures 20 and 21).

 VIII. PROCUREMENT OF MATERIALS

This section includes the necessary materials needed to build the project.

A list of parts is mentioned in the table below that were needed for our setup is mentioned below with their costs and quantity.

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Name of Part</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arduino Nano</td>
<td>1 pcs</td>
<td>₹ 220</td>
</tr>
<tr>
<td>2</td>
<td>GS101201 Sensor</td>
<td>1 pcs</td>
<td>₹59.42</td>
</tr>
<tr>
<td>3</td>
<td>16×2 LCD</td>
<td>1 pcs</td>
<td>₹ 125</td>
</tr>
<tr>
<td>4</td>
<td>I2C Module</td>
<td>1 pcs</td>
<td>₹ 79</td>
</tr>
<tr>
<td>5</td>
<td>Buck Converter</td>
<td>1 pcs</td>
<td>₹ 59</td>
</tr>
<tr>
<td>6</td>
<td>Arduino IDE</td>
<td>-</td>
<td>NIL</td>
</tr>
<tr>
<td>7</td>
<td>Gear</td>
<td>1 pcs</td>
<td>₹100</td>
</tr>
<tr>
<td>9</td>
<td>Rainbow wires</td>
<td>2 m</td>
<td>₹ 60</td>
</tr>
<tr>
<td>10</td>
<td>M6 Allen Nut, Bolt</td>
<td>1 pair</td>
<td>₹ 5</td>
</tr>
</tbody>
</table>

The costs mentioned in the above table are subject to change, as per market conditions and specific project requirements.

 IX. OTHER APPLICATIONS

This setup can also be used in many other places where the need of measuring the speed of shafts arises. Some examples are mentioned below but there are more applications of the setup than only the ones mentioned below:

1. Water and steam turbines speed measurement
2. Windmill speed measurement
3. Automobile industries
4. Motor speed measurement, etc.

An example for potential use of this setup is shown below.
X. CONCLUSION

This article proposed a new approach for low cost flexible setup for observing the precise speed of any kind of wheel and also any weather conditions. The results showed that the system works accurate and successfully.

Future research is Arduino based data logger which measures the speed using GPS module with the time stamp for monitoring the behavior of a car and stores that data into the SD card.

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REFERENCES


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