AUTOMOTIVE ELECTRONICS SYSTEM WITH SENSORS

Mukesh Tiwari , Vaibhav Jagannathan and Jimit Gada

Abstract: The paper is dedicated to all mechanical engineers who are willing to make their own cars and get them on the road or participate in some event. The paoer deals with the simple electric and electronic circuitry of the automobile system. For a mechanical engineer, it's very easy to configure engines, clutch and gears but it's very difficult to put up the electronic system. It includes use of battery, sensors, switches and other electronic circuitry. For a mechanical engineer, it will be very simple to implement and test.

Keywords: **Battery, Dashboard, Kill switch, Gear ratio, Hall sensors, Piezoelectric sensors.**

I. INTRODUCTION

The electrical system of a vehicle comprises of mainly two parts, Outer wirings and circuitry inside the dashboard. Outer wirings include battery connections with recharging systems, lights, brake, sensors, horn, alarms, etc. Whereas the dashboard circuitry has the Microcontroller board to interface all the sensors output to the displays. Microcontroller can be any simple 8-bit general purpose which must have ADC present inside. ADC is required to convert the analog sensor output to the format (digital) which controller understands.

II. OUTER WIRINGS

It all starts up with the battery. First thing that is connected to it is the Kill switch at the ground terminal. Kill switch is something which is used to stop the engine in case of emergency. A wire comes out from the engine which when shorted to the ground stops the engine. Kill switch is very important part of the system and should be reliable. It can be placed anywhere on the Car body or in some cases on Dashboard also.

Fig. 1. Kill switch

Then the next thing is the Reverse alarm and light. We place a switch on the gear box. Whenever the gears are reversed the switch is closed and we get reverse alarm and lights also which are both connected in series. The brake light functions similar to this. The front lights are very easy to implement and can be connected in parallel with the battery via a switch.

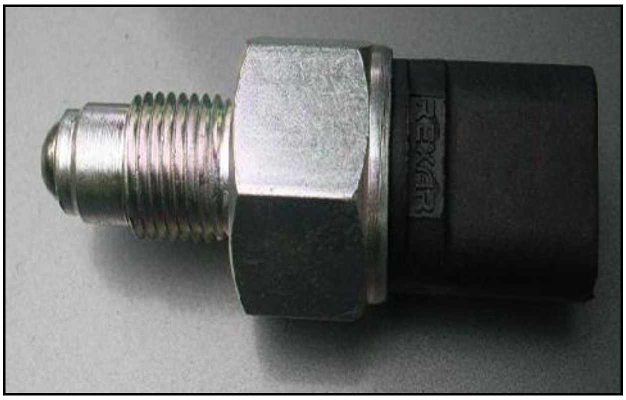

Fig. 2. Reverse Switch

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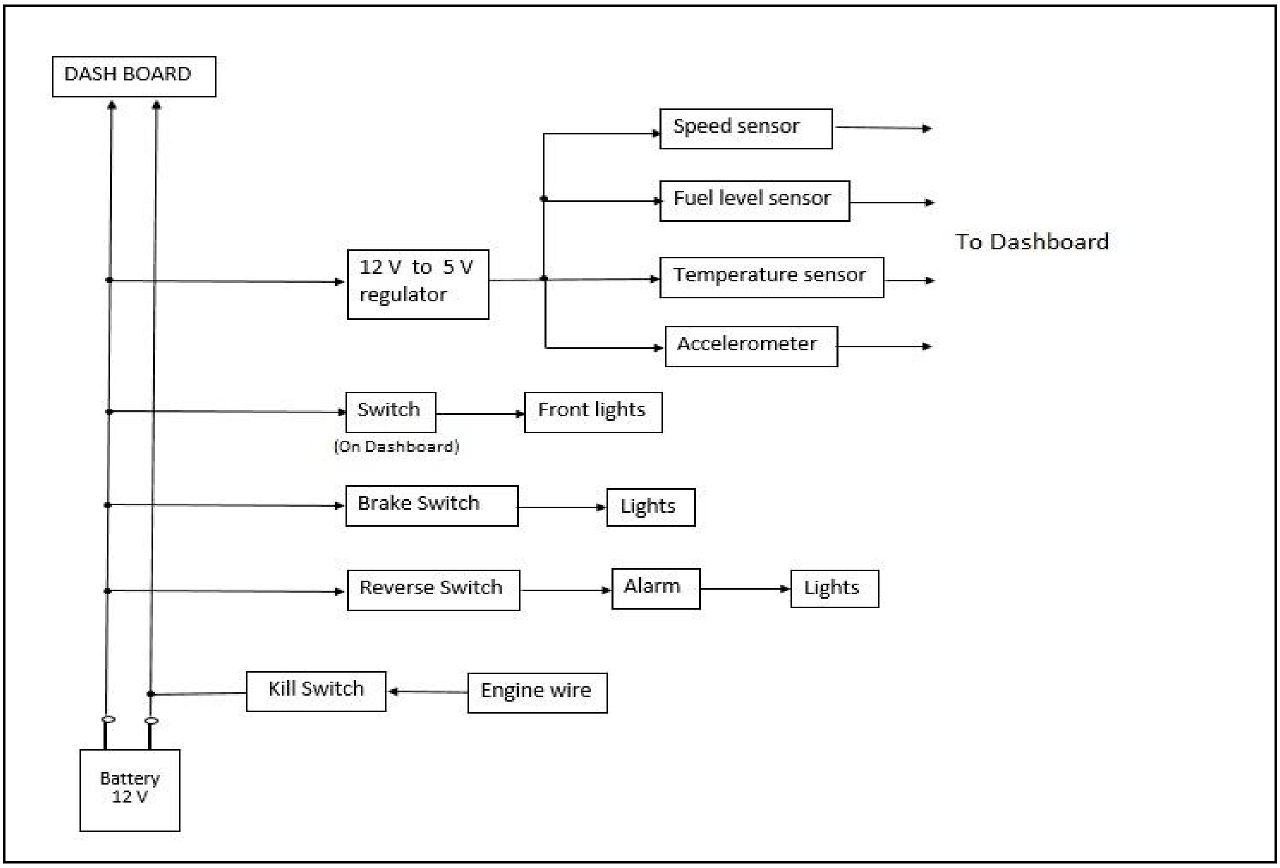

Fig. 3. Wiring diagram

Fig. 4. Brake light

Then comes the sensor system. As most of the sensor works on lower voltages than that of the Battery, A regulator is required to convert battery voltage to a lower value (5V). These regulated outputs are fed to the sensors as input, their outputs are passed on to the Microcontrollers present inside the Dashboard. The sensor can be speed sensor, fuel sensor, accelerometer, temperature sensor (thermistor) and so on. There can be many more according to the need and scope of the automobile system.

The battery wires are also passed on to the Dashboard internal circuitry which contains Microcontroller system and other functionalities.

We can also put a recharging system for the battery in an automobile system that charges battery when Car is running. It requires knowledge of **Alternators** as well. Alternators convert the AC voltage from engine output (Shaft rotation) to DC. For our scope of discussion, we will assume that battery is charged enough for its particular use.

III. Dash Board

Dashboard is the Drivers interface with the automobile system. The sensors outputs are to be shown on this. It should at least contain a fuel level indicator, speed indicator, tachometer (acceleration), Odometer (distance travelled), a key and few important lights for the remaining sensor outputs. All the sensor outputs are fed to the ADC of the Microcontroller as sensors provide analog signals. Then depending on the ADC value, data are shown on the interface.

The battery output when comes into the Dashboard, it first goes to the key. The key is the three terminal switch. One of them is always a ground, other two are a wire for Dashboard Microcontroller system and other is the engine wire. So when the Car is off then the engine wire should be connected to ground and in other case it should be passing the ground signal to the Microcontroller system

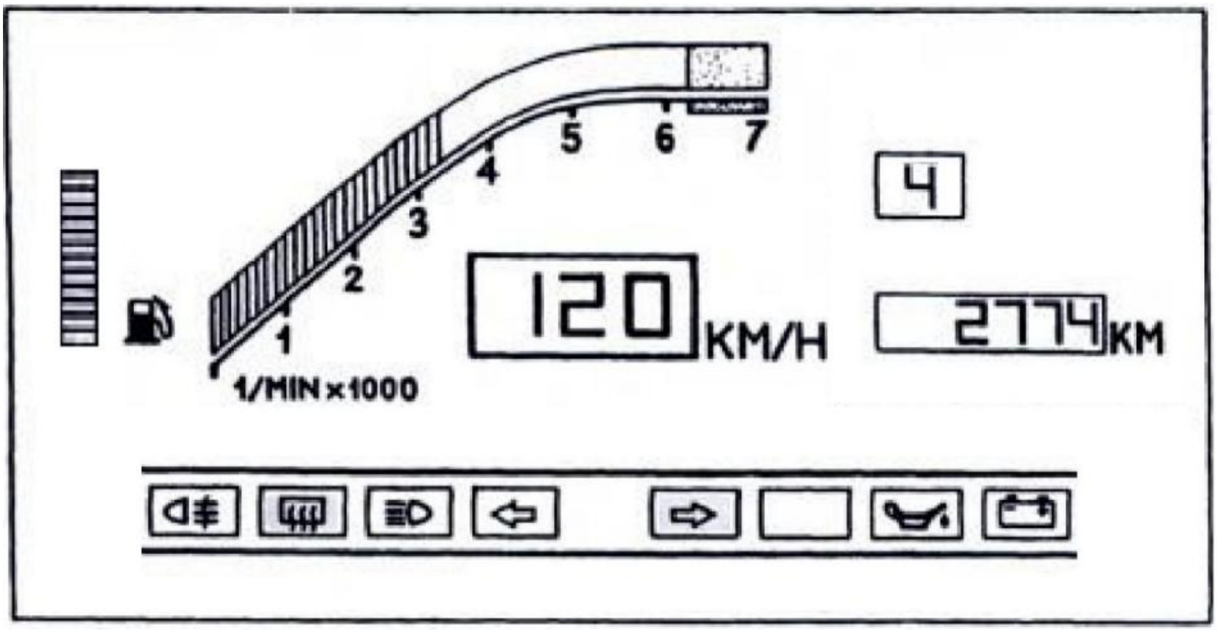

Fig. 5. A typical Dashboard

Fig. 6. Three terminal Keys

Distance travelled display on Dashboard is called as Odometer. The vehicle speed obtained here is used to measure the acceleration as it is rate of change of speed with respect to time. The display of acceleration is called as Tachometer.

Gear value can be indicated by making some potentiometer arrangement on the gear box and taking that as a sensor output for Microcontroller. The microcontroller will pass the data to the Gear display present on Dashboard depending on the sensor output. It is optional and generally not used because of the donkey work required to implement it and maintain the accuracy. Mainly used in racing cars.

As the speed sensor gives us the rotation speed of the engine and we need to calculate speed of vehicle and distance travelled, the GEAR RATIO comes into the picture. The term which Mechanical engineers are well aware of. The equations which can be used to calculate the vehicle speed and distance are,

$$d = \frac{C_t}{gr_t \times gr_d}$$

$$v_c = \frac{C_t \times v_e}{gr_t \times gr_d}$$

Where,

d = Distance travelled
C_t = Circumference of wheels
gr_t = Gear ratio of transmission
gr_d = Gear ratio of differential
V_e = Engine speed
V_c = Vehicle speed

IV. SENSORS

There can be number of sensors used in an automobile system depending upon our need and affordability. As we keep on installing the sensors, it's very difficult to maintain accuracy of all of them. Few of the important ones are mentioned here.

A. Thermistor (Temperature sensor)

The principle of measurement of temperature in thermistor is that the change in temperature will cause change in resistance of the thermistor and hence potential proportional to the temperature can be obtained. Most thermistors in Common use are of Negative Temperature Coefficient (NTC) type, which means that the resistance decreases when we increase the temperature. The thermistors are constructed by Semiconductor materials such as Cobalt or Nickel oxide [1].

Fig. 7. Thermistor

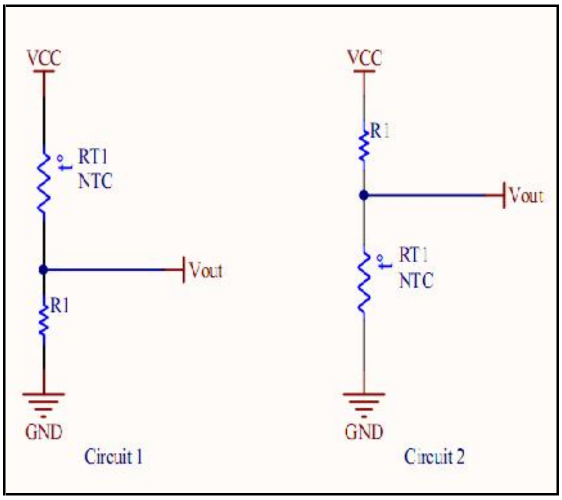

Fig. 8. Thermistor Circuit Diagram

In the two circuits shown above, the equations for output voltage is

$$V_o = \frac{R_1}{R_1 + RT_1} V_{CC}$$

$$V_o = \frac{RT_1}{R_1 + RT_1} V_{CC}$$

This Vo is fed to the Microcontroller as an input from sensor output.

B. Fuel Level Sensors

There are various kinds of fuel sensors available that work using different principles. Some of the more common fuel sensors used are,

Resistive

This is the most commonly used fuel level sensor in automobiles. The sensing unit usually uses a float connected to a potentiometer. As the tank empties, the float drops and slides a moving contact along the resistor, increasing its resistance. In addition, when the resistance is at a certain point, it will also turn on a "low fuel" light on some vehicles. Some drawbacks of this kind of apparatus is that since an electrical current flows through a wire located inside the tank which to lead to a spark causing an explosion if precautions are not taken. Also corrosion of the resistive element may lead to erroneous outputs.

Fig. 9. Resistive fuel level sensor

Capacitive

An automobile may use one or more low voltage tubular capacitor probes where the fuel becomes the dielectric. At different fuel levels, different values of capacitance are measured and therefore the level of fuel can be determined. The probes tend to be linear (capacitance proportional to fuel height) and the fuel computer works out how much fuel there is (slightly different on different manufacturers). This system can be more than 99% accurate. There are no hazards as no electrical current flows through the fuel.

Fig. 10. Capacitive fuel level sensor

Magneto-resistive

Magneto-resistive type of fuel sensors work similar to the resistive type, however a sealed detector at the float pivot determines the angular position of a magnet pair at the pivot end of the float arm. These are highly accurate, and the electronics are completely outside the fuel. The non-contact nature of these sensors address the fire and explosion hazard [2].

Fig. 11. Magneto-resistive type

C. Speed Sensors

The engine shaft rotation speed can be measured by speed sensors. The position of the rotation can also be found out. There are basically two types of sensors available for the speed measurement.

Inductive

This works on the very basic principle of electrical induction (A changing magnetic flux will induce an electromotive force in a winding). The output of most inductive type sensor approximates to a sine wave. The amplitude of the signal depends on rate of change of flux.

The most common way of converting output of an inductive sensor to a useful signal is to pass it through a Schmitt trigger circuit.

Fig. 12. Inductive type speed sensor

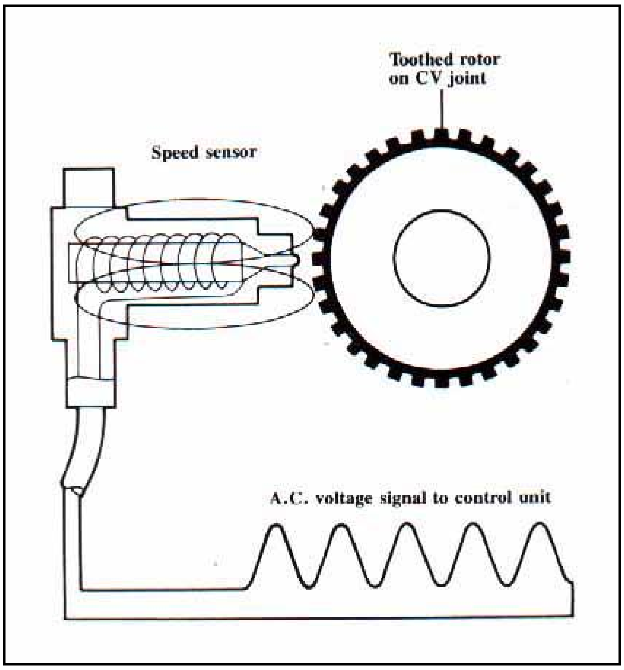

Fig. 13. Output

Hall effect Sensor

It is based on Hall effect given by Dr. E. H. Hall. The principle is very simple. If a certain type of crystal is carrying a current in a transverse magnetic field, then a voltage will be produced a right angles to the supply current. The magnitude of the voltage is proportional to the supply current and magnetic field strength. Hall effect sensors are becoming increasingly popular. This is partly due to their reliability but also the fact that they directly produce a constant amplitude square wave in speed measurement applications and a varying DC voltage for position sensing [3].

Fig. 14. Hall effect sensor

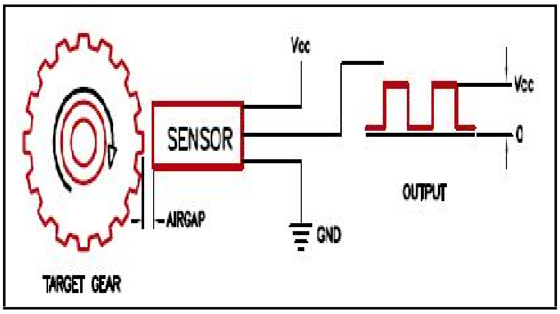

Fig. 15. Output

Accelerometer (Knock Sensor)

The piezoelectric crystal is used to convert the force on mass due to acceleration into an electrical output signal. The crystal not only acts as a transducer but as the suspension spring for the mass. The crystal is sandwiched between the body of the sensor and the seismic mass and is kept under compression by the bolt. Acceleration forces acting on seismic mass cause variation in the amount of crystal compression and hence generate the piezoelectric potential [4].

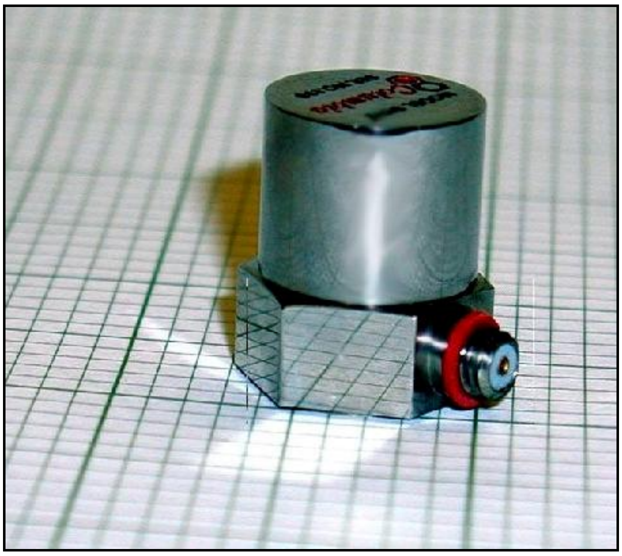

Fig. 16. Piezoelectric sensor

V. Conclusions

The automotive electronics field is growing very fast and is far beyond our scope of imagination. The major changes in the Cars during past few decades have been more in electronics than in the mechanical section. All this happened because of the growth of semiconductor industry. Now a days, we are able to play songs in our car, watch videos, get the news or weather on FM, we can even also lock our cars from 5 metres away. These advances in the technology are very much useful to us. If we have the basic idea of the whole system, we can always keep on adding new feature to make our car look better than others.

Acknowledgements

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