

A Design Model for Automatic Vehicle Speed Controller

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ABSTRACT

This paper presents a new design to control the speed of the automobiles at remote places for fixed time. Generally, in automobiles throttle position is controlled by the Electronic Control Unit (ECU) mainly according to the one of the inputs received from the accelerator's Pedal position sensor. But in the proposed model, instead of ECU, another Microcontroller unit receives the pedal position from the sensor and then Microcontroller unit transfers to the ECU. The Microcontroller unit is also interfaced with the wireless module that is capable of detecting any other transceiver. Now, the automobile can be controlled at the desired places when we deploy the transmitters that send data frames with fields containing maximum speed and time for which this speed limitation is to be imposed.

General Terms

Electronic Control Unit (ECU), Throttle Valve, Global positioning System (GPS), Geographical Information System (GIS), Radio Frequency Transceiver

1. INTRODUCTION

It is known that road accidents are increasing day by day. Most of these road accidents are caused because the automobiles are driven at high speeds even in the places where sharp turnings and junctions exist [1]. Running the automobiles even at those places is the main cause for the accidents. Reduction of number of such accidents is the prime step needed to be taken. Many systems have been developed to prevent these road accidents. One of them is Cruise control system (CC) [2] that is capable of maintaining speed defined by the driver and its later evolution version Adaptive Cruise Control (ACC) [3] that keeps the automobile at safer distance from the preceding vehicle. But these systems have no capability to detect the curved roads where the speeds of the automobiles have to be lowered to avoid the accidents. Later curve warning systems (CWS) have been developed to detect the curved roads by using Global Positioning System (GPS) and the digital maps obtained from the Geographical Information Systems (GIS) [4] to assess threat levels for driver if approaching the curved road quickly. But these maps need to be updated regularly and are not useful if there are unexpected road diversions or extensions etc. Here we propose a dynamic model where the system controls the speed of the automobile according to the data in the frame that is transmitted by the RF transmitter fixed to the nearby poles as shown in figure 1. This is based on the work

done by Sato et al. [5] (describes an Advanced Driver Assistance System (ADAS)) and Joshué Pérez' team [6] (describes an RFID-Based Intelligent vehicle speed controller) where passive RF transceivers are arranged in the road close to the position of real traffic signals. This model can also be better utilized to improve the fuel efficiency by imposing the maximum speed limit on the automobiles at which the mileage will be more.

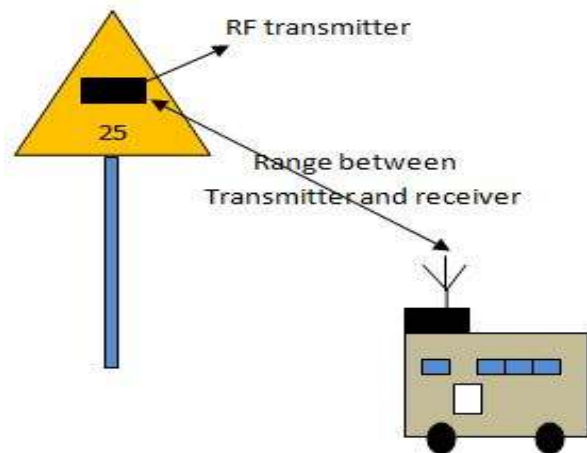


Figure 1: Traffic Signal posts equipped with RF transmitter (left side) Automobile equipped with the RF receiver (right side)

2. CONCEPT OF AUTOMATIC VEHICLE SPEED CONTROLLER

In general, the speed of the automobile is varied according to the accelerator's Pedal position. The variation in the Pedal position is fed to the Electronic Control Unit (ECU). ECU determines the position of the throttle based on the accelerators pedal position and the inputs received from the other sensors [9]. Adjustment of throttle position causes the change in the variation of automobiles speed. Such type of hardware scheme is shown in figure 2. Whereas in the proposed automatic vehicle speed controller model accelerator pedal position is given to the microcontroller unit and then it is fed to the Electronic Control Unit. If the automobile is in the active mode, microcontroller [7],[8] transfers the manipulated pedal position to the ECU that will not increase the automobile speed

greater than the maximum speed specified in the data packet. This model is shown in figure 3.

Proposed model of automatic speed controller comprises three core units.

2.1 Electronic Control Unit (ECU)

In the Automobile industry an electronic control unit (ECU) is an embedded electronic device [9]-[12], basically a digital computer, that read signals coming from sensors

An ECU is basically made up of hardware and software (firmware). The hardware is basically made up of various electronic components on a PCB. The most important of these components is a microcontroller chip that runs in the microcontroller. The ECU is characterized by:

- .Many analog and digital I/O lines (low and high power)
- . Power device interface/control
- . Different communication protocols (CAN, KWP-2000)
- .Large switching matrices for both low and high power signals
- High voltage tests
- Intelligent communication interface adapters (standard or custom)

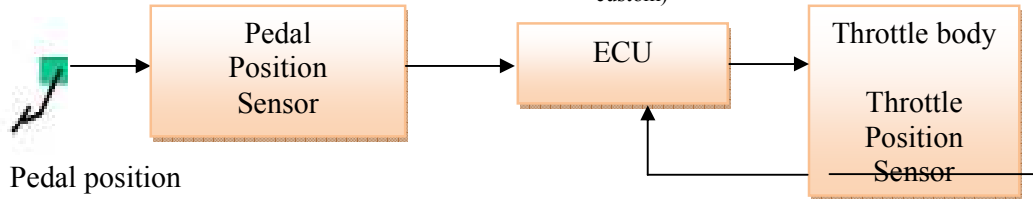


Figure 2: Hardware scheme in normal automobiles

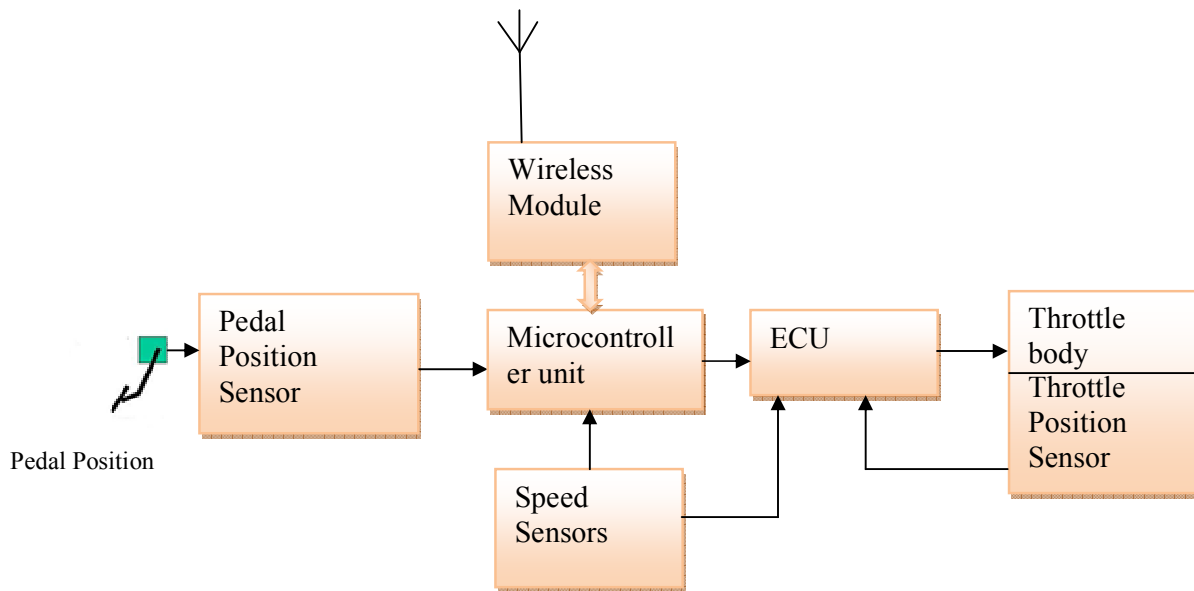


Figure 3: Hard scheme of automobile in our proposed design

placed at various parts and indifferent components of the car and depending on this information controls various important units e.g.. ECU controls the timing and duration of voltage pulses to the injectors, and the operation of the fuel pump relay (FPR).

It determines the timing and duration of the injection pulses by processing signals from the ignition start switch (Start), trigger contacts (TC) , manifold pressure sensor (MPS), temperature sensors (TS1 - air temp, and TS2 - cylinder head temp), and throttle position switch (TPS w/ idle switch IS).

- Automatic fixture recognition and software sequence enable
- Power simulation devices

Some of the most typical kind of sensors and actuators that are connected to an Engine control module are

2.1.1 Manifold Air temperature Sensor (MAT):

The sensor is a thermistor. It is normally mounted at the air duct housing of the manifold. Electrical resistance of the thermistor decreases in response to the temperature rise and

this can be measured using analog channel with some signal conditioning (excitation, amplification etc.)

2.1.2 Coolant Temperature Sensor (CTS):

The CTS too uses a thermistor to detect the temperature of the coolant in the engine and feeds the voltage signal to an analog input channel of the ECU.

2.1.3 Camshaft/Crankshaft Position Sensor (CPS):

The CPS is very important as it monitors the engine speed and the piston position in the engine. Traditionally variable reluctance sensors were used to measure this but nowadays various IR sensors and latest rotary encoders are used to do the same. These encoder signals are provided as frequency inputs to the ECU's.

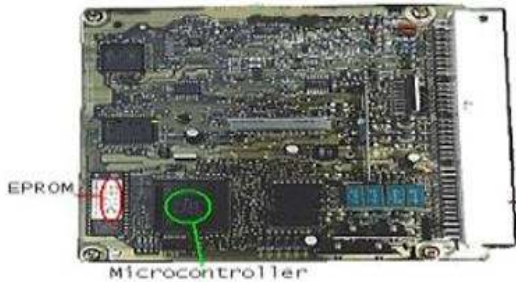


Figure 4: Snap shot of typical Electronic Control Unit

2.1.4 Knock Sensor (KS):

The KS is a typical piezoelectric sensor, it picks up the knocking vibration from the cylinder block where it is fixed and this complex/dynamic analog signal is fed to the ECU.

2.1.5 Heated Oxygen Sensor (HO2S):

The HO2S is an air quality measurement sensor. The sensor is basically made of ceramic zirconium which is placed in the exhaust manifold enclosed in a closed tube. The zirconium generates voltage from approximately 1V Max in richer conditions to 0V in leaner conditions. This analog signal is passed on to the ECU.

2.1.6 Throttle Position Sensor (TPS):

The TPS is a potentiometer that transforms the throttle position into output voltage which is fed to the ECU.

2.1.7 Vehicle Speed Sensor (VSS):

The VSS is placed on the transaxle. It is a pulse generator and provides a digital signal to the ECU.

2.1.8 Manifold Absolute Pressure (MAP):

The Manifold Absolute Pressure sensor measures changes in the intake manifold pressure resulting from engine load and speed changes. The ECU sends a 5-volt reference signal to the MAP sensor. As pressure changes in the intake manifold occurs, the electrical resistance of the MAP sensor also changes. By monitoring the sensor output voltage, the computer can determine the manifold absolute pressure. The higher the MAP voltage output the lower the engine vacuum, which requires more fuel. The lower the MAP voltage output the higher the engine vacuum, which requires less fuel. Under certain conditions, the MAP sensor is also used to measure barometric pressure. This allows the computer to automatically adjust for different altitudes. The computer uses the MAP sensor to control fuel delivery and ignition timing.

These are some of the most important signals that the ECU takes to control the fuel injection system in an efficient way for proper fuel management.

2.2. Microcontroller Unit

In the proposed design, microcontroller is interfaced with Pedal Position Sensor, Vehicle Speed Sensor, Electronic Control Unit and the wireless module. In transmitter section microcontroller loads the frames in to the wireless module and switches the wireless module periodically between the transmission state and sleep state. Microcontroller in the receiver section receives the frame from the wireless module. Later microcontroller processes this frame and imposes the speed limit on automobile. In order to implement this design in full fledge a separate microcontroller is very essential to handle the tasks like displaying maximum (MAX) speed allowed and other necessary information on Liquid Crystal Display (LCD), sounding an alarm when an attempt is made to exceed maximum speed limit and to implement any security mechanisms. Assigning all these tasks to the ECU is not at all recommended and the through put of the system will be decreased if it were done.

2.3 Wireless Module

A wireless module that is compatible with the microcontroller is embedded on the automobile. This module acts as a receiver. Similar wireless module is also interfaced with the Microcontroller which acts as the transmitter is shown in figure 5. The transmitter is to be fixed to the top of the pole at the locations where speed of the automobile needs to be controlled as shown in figure 1.

The job of the transmitter is to transmit the frames that specify the maximum speed and the time for which the speed limitation must be implemented. Whenever the vehicle passes nearby transmitter, receiver in the automobile detects the frame and gets ready to receive the frame. After completion of receiving the frame it generates interrupt to microcontroller.

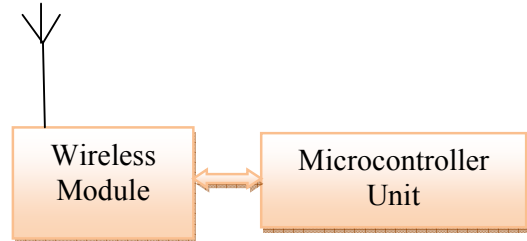


Figure 5: Hardware scheme of transmitter on remote place

Then the microcontroller process the frame received from the wireless module and then enters in to the active mode.

2.4 Frame Format

The structure of the frame contains typically speed limit and time to live values. Including this frame contains synchronization header and Frame length. This structure is shown in figure 6.

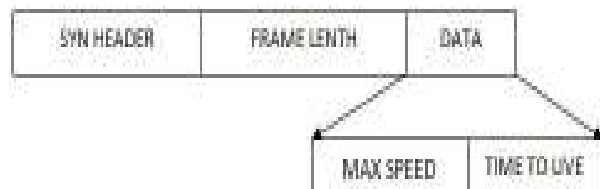


Figure6: Frame structure in automatic vehicle speed controller

2.4.1 SYN HEADER:

Synchronization header is used to synchronize between the transmitter and receiver. A typical size of synchronization header size is 4 bytes.

2.4.2 FRAME LENGH:

This field specifies the length of the frame in bytes. The size of this field is 1 byte.

2.4.3 DATA UNIT:

Data unit consists of two fields (2 bytes).

2.4.3.1 MAX SPEED

It is this field which contains the maximum speed above which the automobile should not be allowed to drive.

2.4.3.2 TIME TO LIVE

This field contains the value that specifies the time for which the speed limitation must be imposed on automobile.

Both “max speed” and “time to live” fields are to calculated appropriately in such a way that it suites to that particular place.

3. MODES OF OPERATIONS

In our proposed design automobile is always in either Normal mode or Active mode. An automobile operates in normal mode until wireless module receives any data packet from the transmitter.

3.1 Normal Mode

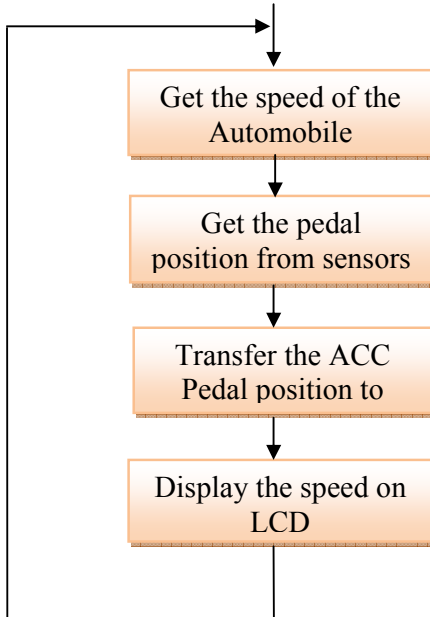


Figure 7: Flowchart scheme of operation in Normal Mode

During normal mode of operation microcontroller unit in the automobile receives the pedal position value from the sensors and transfers them to ECU. See Figure 7 for flow chart representation of Normal Mode.

3.2 Active Mode

In Active mode of operation microcontroller unit continuously studies the speed of the bike. To control the speed of the bike according to the limits we have developed the fuzzy logic [14],[15]. If the speed of the bike is above the Maximum speed

limit, then it sends the digital signal to the ECU such that speed of the automobile will be decreased. When the accelerator pedal is moved to increment the speed, microcontroller calculates the speed that would be reached on the new pedal position. If the speed is greater than the maximum speed limit then it denies excess speed and gives appropriate signal to the ECU. See figure 8 for Flow Chart in Active Model.

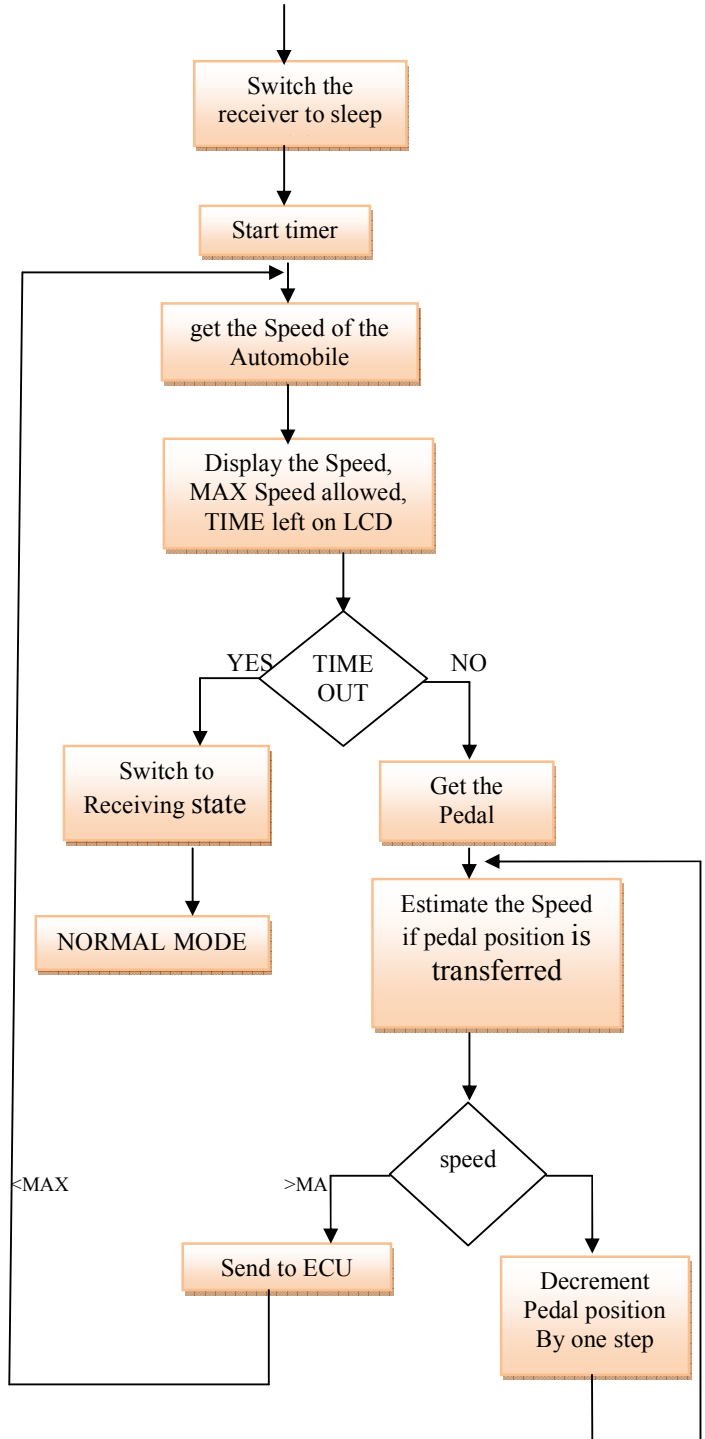


Figure 8: Flowchart schematic of operation in Active mode

4. THEORETICAL STUDY

To have a theoretical study on our design, we consider an Atmel's AVR microcontroller [16] with an operating frequency range of 16MHz and wireless module as AT86RF230. AT86RF230 [17] is a 2.45GHz radio transceiver. It can operate in the temperature range of -40 degree centigrade to 85 degree centigrade. AT86RF230 in the transmitter section will be either in the transmission state or sleep state and the AT86RF230 in receiver section will be in the Receiving state. Let the automobile equipped with our architecture is moving at 100 km/hr. Let the receiver can detect the frame at 30m away from the transmitter.

From the above considerations, the automobile will be in the range of transmitter for minimum time period of 1080 milliseconds. This can be deduced from the formula

$$\text{Distance} = \text{speed} * \text{time} \quad (1)$$

Figure 9 shows time (milliseconds) for which the automobile will be in the range of transmitter at two different speeds. Data sheets of AT86RF230 shows that transition time from transmission state to sleep state takes 1.1 milliseconds and from the sleep state to transmission state takes 48 micro seconds. It takes 224 micro seconds to transmit a frame of 1 byte. Since the frame size in the proposed design is 7 bytes it takes 1.792 milliseconds to transmit the frame. Now the time for which the transmitter can be in the sleep state is calculated by subtracting the sum of transmission time for the frame, transition times from transmission state to the sleep state and vice versa from the time for which automobile will be in the range of transmitter. Here,

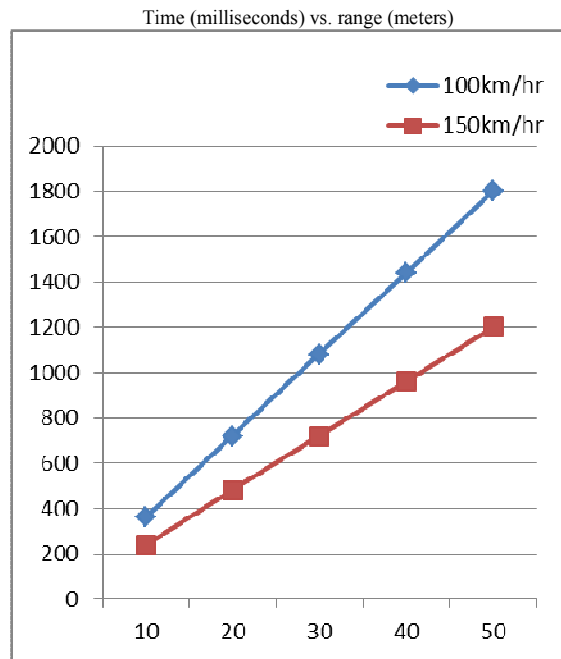


Figure 9: Time for which the automobile will in the range of transmitter for different ranges of Transmitter

$1080 * 10 \exp 3 - (1.1 + 1.792 + 0.048) = 1077.06$ milliseconds.

That is, the transmitter can be in the sleep state for minimum period of 1077.06 milliseconds. If the transmitter is in sleep state for more time then, there are more chances of optimizing the power.

Figure 10 shows the time (milliseconds) for which the transmitter can be in sleep state for different ranges of transmitter at two different speeds of automobile. Whenever the receiver receives the frame, it switches from receiving state to sleep state and the automobile enters in to active mode. During the Active mode, the receiver made to transit into sleep state so that the it does not receive the same multiple frames and at the same time power is also optimized.

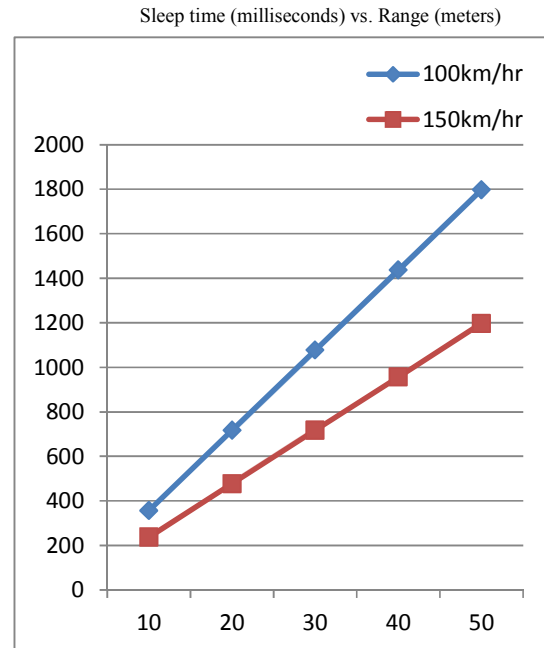


Figure10: Sleep times of the RF transmitter for its different ranges

5. CONCLUSIONS

In this paper we presented a new design to control the speed of the automobiles. We have presented a theoretical study on our proposed design. In our theoretical study, only one vehicle is considered. In normal driving situations, we can expect other vehicles circulating nearby and possibly blocking or attenuating RF signals. In this aspect, more study is needed.

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