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Design of an automobile instrument cluster using CAN protocol

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Abstract - *The instrument cluster or the dashboard is one of the important components in an automobile. The function of an instrument cluster is to display the vital information to the driver, such as fuel indicator, speed, distance travelled, engine state, temperature and many other information is to be displayed on the instrument cluster, with this information the driver can determine whether he can reach the destination. Modern automobiles use state of art LCD screens to display the information. The goal of this paper is to discuss how to efficiently display vital information to the driver. The information or the data from various sensors is sent to the central control unit or the ECU (Electronic Control Unit) and from here, the ECU displays the vital information based on the urgency or the priority of the information. The communication between the sensors and ECU is achieved using the standard CAN Protocol. CAN Protocol is a message based protocol which is defined by ISO 11898-2/3 Medium Access Unit [MAU] standards.*

Key Words: **Instrument Cluster, Controller Area Network (CAN) Protocol, Electronic Control Unit (ECU), Sensors.**

1. INTRODUCTION

An Instrument Cluster is a device which is used to display all the information which can either be critical or not. The information is usually displayed onto a LCD screen which is easily visible to the driver. The information is gathered from various sensors of the vehicle and this information is received by a central control unit or the ECU (Electronic Control Unit). The control unit prioritizes the data gathered by all the sensors and displays it to the driver.

- The sensors must send the signals to the central control unit.
- The central control unit must prioritize which information must be displayed to the driver.
- By using CAN protocol, the information sent to the central control unit is prioritized through the unique 'Identifier' bit of the CAN Protocol.
- The central control unit uses the identifier bit and displays the data which has high priority to the driver, for example, if the fuel is low the fuel indicator blinks on the display screen.

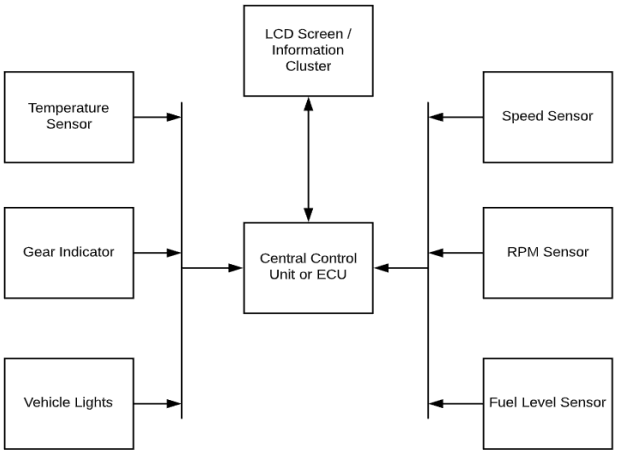

Fig-1: CAN Protocol

By using the CAN Bus, it is possible to send the data from all the sensors to the central control unit or the ECU through a single bus and then from the central control unit or the ECU the data such as speed, RPM, fuel level and etc, are displayed to the driver. For CAN protocol to be implemented and for the communication to take place in the network, each node requires a microcontroller, CAN controller, and CAN transmitter.

This approach has the following significant characteristics:

(i)Robustness: The CAN protocol enables the system to detect and resolve errors easily.

(ii)Speed: The high speed CAN offers signal transfer rates of between 40 kbps and 1 Mbps, depending on the length of the cable, and the low speed CAN offers lower signal transfer rates that may start at 40kbps but are often capped at or near 125 kbps.

(iii)Flexibility: Since the CAN protocol is a message-based communication protocol. In this method of protocol, nodes on the bus do not have identifying information associated with it. As a result, the nodes can be easily added or removed without performing any software or hardware updates.

The above mentioned characteristics can make sure that the driver is receiving the correct data on the information cluster.

2. PROBLEM STATEMENT

Improving the instrument cluster in an automobile by providing accurate real time information to the LCD display screen by using the CAN protocol which has properties like high speed and high accuracy.

To be able to add and remove additional sensors without having to make much changes in the hardware and software components.

To be able to prioritize critical information which is to be presented first to the driver rather than presenting the information which is of less significance.

3. LITERATURE SURVEY

According to Surekha P. Gaikwad et.al [1], various developments have been done and today's automobile has more electronic components. The CAN protocol is used for efficient and reliable communication between the sensor, actuator, controller, other nodes and the ECU in real-time applications. To provide correct information by various sensors to the ECU and then display the relevant data to the driver a CAN bus can be used.

According to Rakesh Ranjan et.al [2], to implement safer, efficient and reliable automated system for vehicles with decreased complexity and reduced wiring. In this paper they discuss about a system to connect a group of sensors to a pair of microcontrollers acting as slaves which in turn send the collected data to a master microcontroller through CAN bus technology. The implemented system is using many sensors for data acquisition and CAN bus is the communication medium for data transmission.

According to A. A. Salunke [3], the CAN bus protocol is implemented using a single board computer to access the vehicle parameters remotely. This paper concentrates on the communication between the nodes using a CAN bus and how to access modern vehicle ECU parameters.

According to Y. Tao et.al [7], the digital industrial dashboards are developing rapidly. But only to display numbers in dashboards has not met industrial demands, more text information is added into them. In addition, some errors would be caused by fatigue, carelessness and other uncertain factors during human observation. In order to improve the efficiency of instruments reading and recording, this paper proposes an end-to-end real-time instruments information location and recognition.

4. EXISTING SYSTEM

Currently many automobiles use both analog gauges and an LCD screen to display the information to the driver, due to the bigger sized dials of both speed and RPM gauges, the LCD screen will usually be small and it will display less information, such as odometer reading, fuel levels and the time. The vital information such as oil levels, engine errors, ABS, Traction Control and many other such information lights up as tiny symbols on the instrument cluster. These tiny static symbols only light up if there is an error or the sensor is active.

The information is gathered from various sensors from different parts of the automobile by using the standard CAN protocol. The information gathered is sent either to the ECU (Electronic Control Unit) or to a central control unit. The ECU then processes the sensor data and then sends it to the analog gauges and digital display, which is the information cluster.

5. METHODOLOGY

The various sensors will send data to the CAN bus, here the CAN bus is used as a medium of communication between the sensors and the central control unit or the ECU. Once the ECU receives the data from the sensors, the ECU identifies the sensor from which the data has been received; the data is then processed by the ECU and the information is then sent to the information cluster to be displayed to the driver. If the data consists of both critical and non critical data, the ECU must identify the critical data and display that information before any other information is displayed to the driver, for example the ECU receives the data that Traction Control System is active and the ECU also receives the data that the engine has an issue; here, the engine issue has to be shown to the driver first rather than showing that the Traction Control System is active.

The prioritization of the data which is received by the ECU is done with the help of the 'Identifier' bit of the

CAN protocol. If a higher priority data arrives then this data is processed first by the ECU, and consequently displayed to the driver.

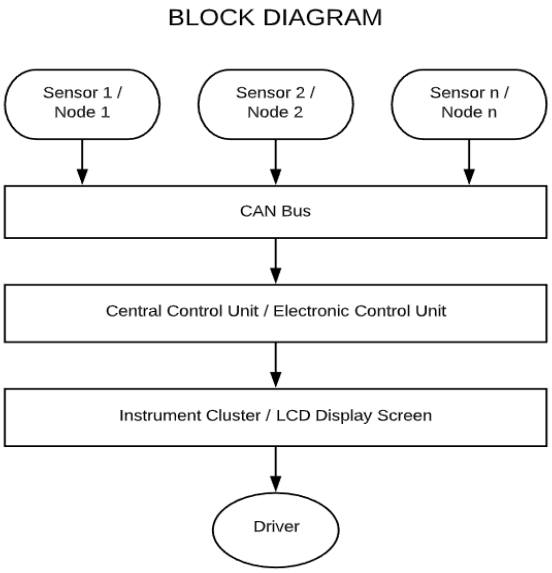

Fig-2: Methodology

6. SYSTEM DESIGN

The two major parts addressed in this paper is the instrument cluster and the CAN Protocol, firstly for the instrument cluster to display the important information, the ECU should have a sorting algorithm to sort the information which has the highest priority and then send that information to the instrument cluster. The instrument cluster will always display the basic information such as speed, RPM, fuel level, distance covered and temperature, for example, in case of an error in the Anti-lock Braking System and this data will be sent to the ECU that there is an error, and the ECU will compare the priority level of the data against the priority levels of other sensor data and then display the information with the highest priority in the queue, in this case, a message is shown to the driver on the instrument cluster stating that there is an error in the Anti-lock Braking System.

Secondly, the CAN protocol is used to achieve communication between the sensors and the central control unit or the Electronic Control Unit (ECU). In CAN protocol the messages are sent in a format called frames. A frame is defined structure, carrying meaningful sequence of bit or bytes of data within the network. Framing of message is done by MAC sub layer of Data Link Layer. There are two types of frames standard and extended. These frames can be differentiated on the basis of identifier fields. A CAN frame with 11 bit identifier fields called Standard CAN and with 29 bit identifier field is called extended frame. The identifier field is used for two purposes one is to determine which node has access to the bus and second to identify the type of message. The messages are sent to the ECU or the central control unit through the CAN Bus.

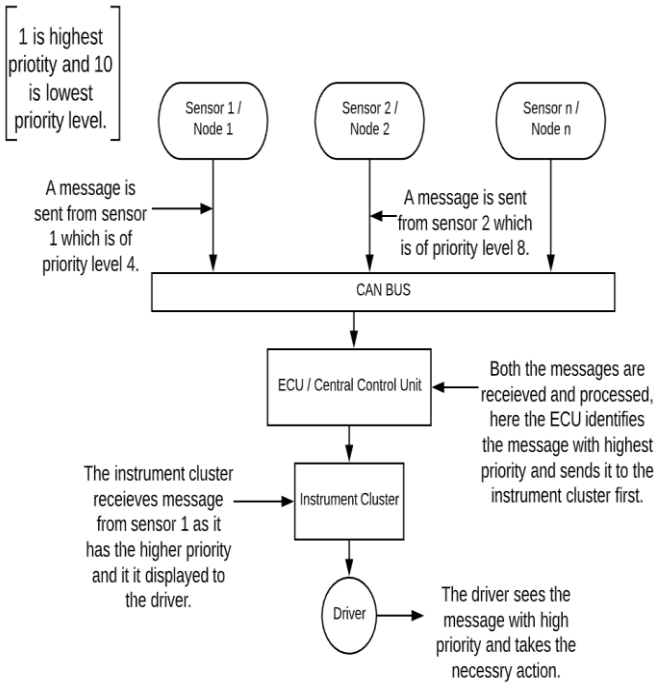

Fig-3: System Design

7. EXPECTED OUTCOMES

An instrument cluster which is accurate, fast and easy to understand which uses CAN protocol has the following features;

- By displaying messages instead of warning lights, the driver can quickly understand the issue.
- Reduced wiring costs due to CAN bus.
- Easily add and remove sensors.
- Easier to understand which component malfunctioned.
- To display critical information first.

By displaying error messages in the instrument cluster along with the component symbol lighting up which indicates that a component has malfunctioned, it enables the driver to easily understand the issue in the automobile. Quick and accurate passing of data from the sensors to the ECU or the central control unit is achieved by using the CAN protocol.

8. CONCLUSIONS

Implementing an easy to understand instrument cluster will reduce the accidents caused due to the malfunction of electronic components by helping the driver to know that the vehicle is not fit for driving. The sooner the driver knows that an electronic component has malfunctioned the sooner the driver will get the automobile repaired or serviced before another component malfunctions, thereby reducing additional service costs.

The use of CAN protocol to obtain all the sensor data is speedy and simple. Using the CAN bus to connect all the wires to a single bus cable is cheaper, quicker and simplifies the process of either adding or removing an electronic component in an automobile.

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