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Advance Security Interface for Vehicle with IoT and inter ECU Communication using CAN Protocol

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Abstract: **Main driving forces for the development of vehicle network technology have been the advances made in the electronics industry in general and government regulations imposed. These electronics systems are demanding for a better and secure system for communication between each other and between their respective subsystems and also to the user. In this paper, we present an advanced security interface for automobiles by using Internet of Things (IoT) and inter Electronic Control Unit (ECU) communication using CAN protocol using ARM Cortex M3 for implementation of the ECU's. It mainly consists of in-built CAN controller besides with the ARM Cortex M3. The sensor data is collected, processed and displayed on the user display module. The data is continuously sent on to the internet using ESP8266 Wi-Fi module which can be used for further monitoring, controlling and warning. The data which is been collected can be preserved and can be used in the future for comparison and to generate an early warning. This system can be used in automobiles, aircrafts, industries etc.**

Keywords: **ARM Cortex M3, CAN Protocol, Electronic Control Units, Internet of Things, ESP8266 Wi-Fi module, LM35 temperature sensor, HC-SR04 ultrasonic sensor, SIM300 GSM module, SIM28ML GPS module, LCD.**

I. INTRODUCTION

With rapid advancement in computer and information technology much of the technology finding its way into automobiles. Automobiles are undergoing noticeable changes in their capabilities and the way they interact with the drivers. Although some vehicles are provided to decide either to generate warnings for the driver or controlling the vehicle autonomously but in real they should make these decisions in real time with incomplete information. So, it is important that driver should have some control over the vehicle. The introduction of in-vehicle information system into the vehicle design has allowed almost symbiotic relation between the driver and vehicle by providing an advanced & intelligent driver-vehicle interface through an intellectual information network. This provides such a control framework for the vehicle which consists of a mechanism between the driver and vehicle which provides perception, decision making and control. New applications demand more complex and intelligent ECUs (Electronic Control Units) and urgent need for communication between them as these devices exceeded 100 units in some high-end vehicles. Currently x-by-wire applications are being developed (e.g. Brake-by-wire, Steer-by-wire, Throttle-by-wire, etc…) where heavy mechanical systems are being replaced by electronic modules in order to reduce the overall weight of the vehicle and to reduce the fuel consumption. In this paper we use CAN Bus Protocol for the in-vehicle communication between the Electronic Control Units (ECU) as it offers higher data rates of 1Mbps and high extensibility with message arbitration, error detection and cost effective.

Further the wireless communication of data from the vehicles to a unified data analysis system will provide more efficiency, performance, safety to the user and also provides with early warning capabilities. In this paper we use Internet of Things (IoT) for the wireless communication of the data to the analysis server. The rest of this paper is organized as following.

II. SYSTEM IMPLEMENTATION

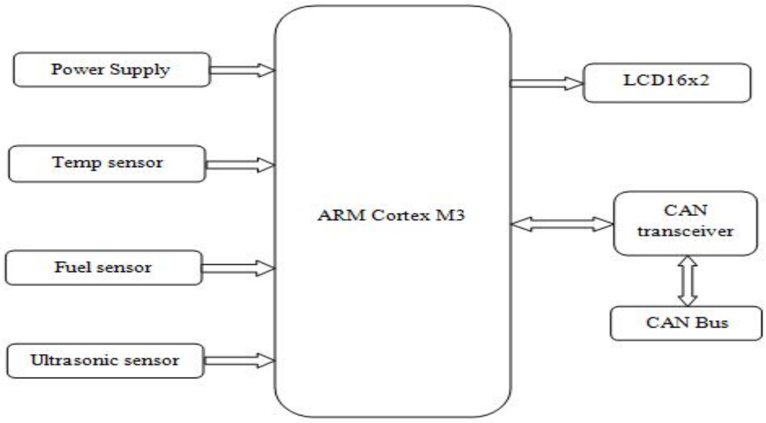

Fig. 1: Transmitter Section

The proposed system consists of a transmitter section and a receiver section. The Fig 1 gives an architectural overview of the transmitter section. The processor used in both the transmitter and receiver sections is ARM Cortex M3. The transmitter section will collect the data from different sensors and the collected data is transmitted to the receiver section through the CAN Bus. The transmitter section consists of ARM Cortex M3 processor, temperature sensor (LM35), fuel level sensor (HC-SR04), ultrasonic sensor (HC-SR04), LCD. Here we use temperature sensor for the monitoring of the temperature of the engine, ultrasonic sensor is used for the detection of any obstacle, and fuel level sensor is typically another ultrasonic sensor used to measure the fuel level. The obstacle detection sensor will display a message when the signal is back; ECHO output of the sensor will be in HIGH state (5V). Another ultrasonic sensor i.e. fuel level sensor is set to detect in term of range. Here three different ranges (5, 10, 20) kept for three different levels (full, half, empty). The LCD on the transmitter side is used to display the sensor data to check whether the data is generating or not. The generated sensor data is transmitted to the receiver on CAN Bus. The Fig 2 gives an architectural overview of the receiver section.

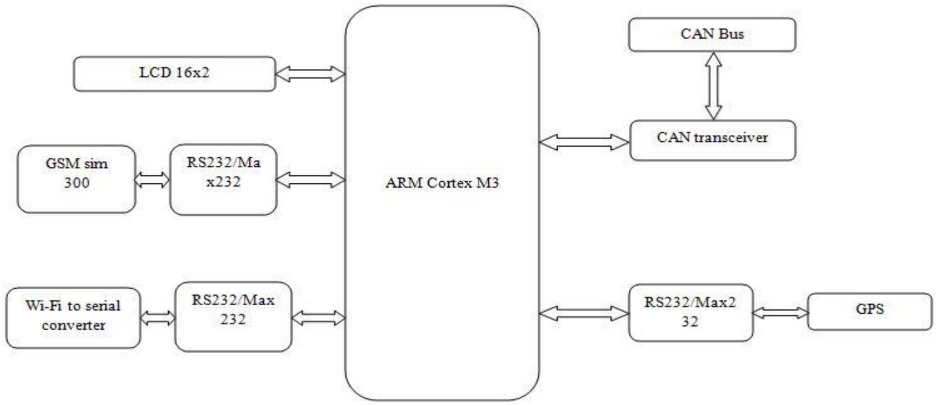

Fig. 2: Receiver section

The receiver section consists of GSM (SIM300), GPS modules (SIM28ML), LCD, and Wi-Fi module (ESP8266). The generated sensor data is received through CAN Bus and the data is processed to generate the message that should be shown to the user. The LCD on receiver side will show the message generated according to the sensor data. The GPS will generate the location co-ordinates of the vehicle. The GSM will send a message consist of the location co-ordinates of the vehicle with the message like temperature, fuel level to the given number. The same message is sent to the user webpage using Wi-Fi module.

III. HARDWARE DESCRIPTION

A. Cortex M3

The Cortex - M3 is a 32-bit microprocessor. It has a 32-bit data path, a 32-bit register bank, and 32-bit memory interfaces. The processor has a Harvard architecture, which means that it has a separate instruction bus and data bus. This allows instructions and data accesses to take place at the same time, and as a result of this, the performance of the processor increases because data accesses do not affect the instruction pipeline. This feature results in multiple bus interfaces on Cortex-M3, each with optimized usage and the ability to be used simultaneously. However, the instruction and data buses share the same memory space (a unified memory system). In other words, you cannot get 8GB of memory space just because you have separate bus interfaces. For complex applications that require more memory system features, the Cortex-M3 processor has an optional Memory Protection Unit (MPU), and it is possible to use an external cache if it's required. Both little endian and big endian memory systems are supported. The Cortex-M3 processor includes a number of fixed internal debugging components. These Components provide debugging operation supports and features, such as breakpoints and watch points.

B. LM35

LM35 a precision IC temperature sensor with its output proportional to the temperature (in ^{o}C). With **LM35**, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 ^{o}C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ^{o}C rise/fall in ambient temperature, *i.e.,* its scale factor is 0.01V/ ^{o}C.

C. Ultrasonic Sensor

Ultrasonic transducers are transducers that convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit. Systems typically use a transducer which generates sound waves in the ultrasonic range, above 40 kHz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed. The technology is limited by the shapes of surfaces and the density or consistency of the material. Foam, in particular, can distort surface level readings.

D. SIM28ML GPS Module

SIM28ML is a stand-alone or A-GPS receiver. With built-in LNA, SIM28ML can relax antenna requirement and don't need for external LNA. SIM28ML can track as low as -165dBm signal even without network assistance. The SIM28ML has excellent low power consumption characteristic (acquisition 16mA, tracking 15mA). SIM28ML supports various location and navigation applications, including autonomous GPS, QZSS, SBAS ranging (WAAS, EGNOS, GAGAN, MSAS), RTCM and A-GPS.

E. SIM300 GSM Module

Global System for Mobile Communication (GSM) is a second generation cellular standard developed to cater voice services and data delivery using digital modulation. SIM 300 is designed for global market and it is a tri-band GSM engine. It works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz. SIM300 features GPRS multi-slot class 10/ class 8 (optional) and supports the GPRS coding schemes. This GSM modem is a highly flexible plug and play quad band GSM modem, interface to RS232, it supports features like voice, data, SMS, GPRS and integrated TCP/IP stack. It is controlled via AT commands (GSM 07.07, 07.05 and enhanced AT commands). It uses AC – DC power adaptor with following ratings DC Voltage: 12V/1A.

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F. ESP8266 Wi-Fi Module

This is a serial module with a built-in TCP/IP stack, so it can be used as standalone. The AT commands are used to connect to Wi-Fi networks and open TCP connections without need to have TCP/IP stack running in your own microcontroller, it can simply connect any microcontroller to ESP module and start pushing data up to internet. There are several module designs called ESP-x where x is 1 to 12, so far. I am using the ESP-1 module. The new firmware is set at 9600 baud provides the same 2×4 connector, Tx, Rx, RST, CH_DP(chip enable), and two GPIO's. The current consumption of the module is 80mA at idle state it can draw as much as 300mA during operation. Supply voltage is 3.3V, up to 300 mA.

IV. EXPERIMENTAL RESULTS

For the demonstration of CAN and IOT communication, it has been proposed a practical exercise Hands-on Laboratory model which it consists in small-scale recreation of the real bus inside of a vehicle with IoT . In this case, multiple sensors and actuators similar to those that exist in conventional vehicle have been selected. All these devices are connected through the nodes using a CAN communication line and the messages related to the data collected by the sensors is transmitted to the IoT user webpage for the monitoring. The laboratory model of the proposed system is illustrated in below figures: Fig 3, Fig 4, and Fig 5.

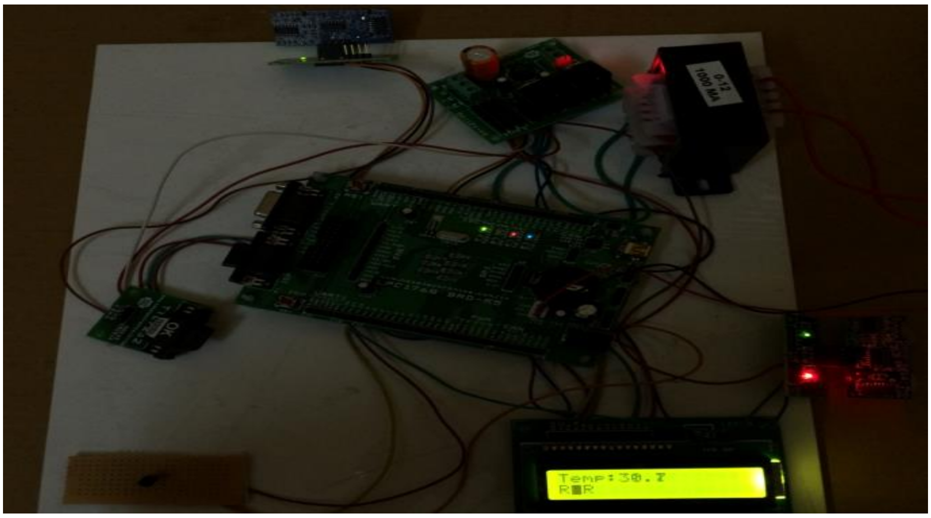

Fig. 3: Transmitter Section

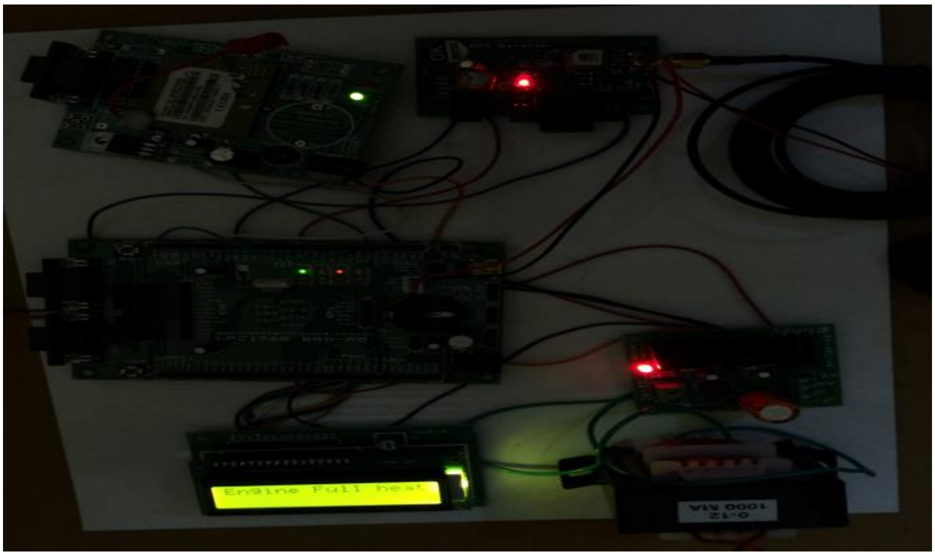

Fig. 4: Receiver Section

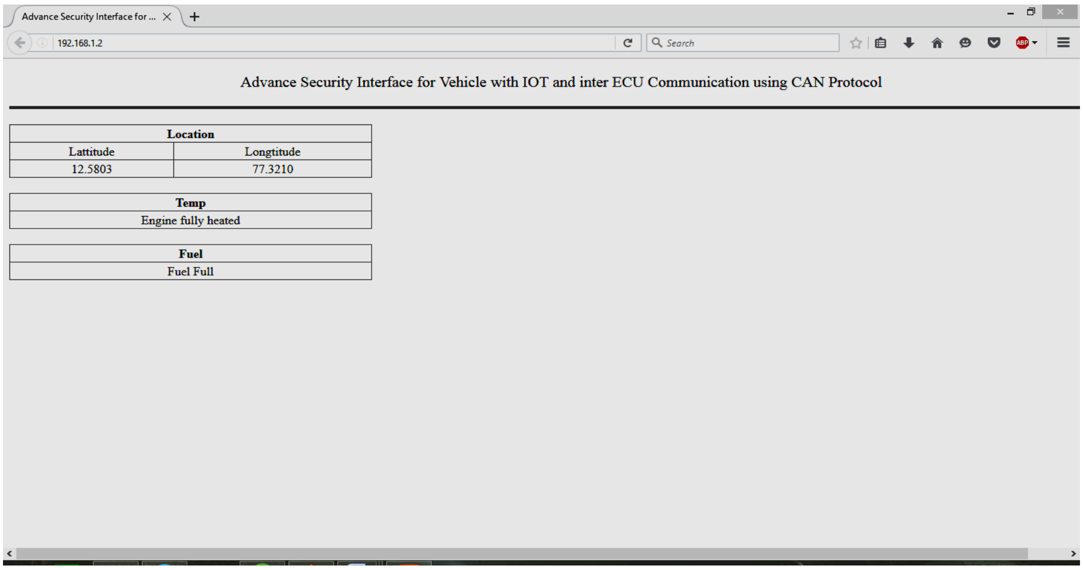

Fig. 5: IOT Webpage

V. CONCLUSION

This paper demonstrates a laboratory model for creating a secure interface to the electronic control units in an automobile vehicle using the CAN Bus Protocol and Internet of Things (IoT) for the user monitoring. The LIN is a low cost Protocol but it will give low data rates where the MOST and Flex-Ray will give higher data rates but at the moment they are of high cost but the CAN Bus Protocol is a low cost efficient bus Protocol which will give good data rates. By using CAN Bus we can achieve more performance and error free message transmission. IoT is the new trend in interconnecting different devices wirelessly and making communication between them. The implemented system has helped to understand the working of CAN Bus and IoT which will not only improves the in-vehicle performance and efficiency but also improves the safety of the user and also the vehicle.

VI. FUTURE WORK

The system implemented in this paper demonstrates the communication of the data between electronic control units using CAN Bus Protocol and monitoring of the data transmitted by the IoT to user in webpage. This system can be further developed by adding of controlling to the present proposed system using IoT and also can make two systems interconnected to each other and communicate with each other using IoT.

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