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An Analysis of Network-Based Control System Using Controller Area Network (CAN) Protocol

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Abstract: Active safety is an important feature of a modern vehicle to provide precaution warning or compensatory control before the pre-crash stage of vehicle safety. All vehicle signals and information are acquired by several in-vehicle sensors on ECUs or surrounding vehicles, and integrated in vehicle gateway through in- safely with the cooperative driving mechanism. The demonstration system consists of a vehicle gateway, which is based on a PIC processor. After reaching within the communication limit, the vehicles set up time synchronization and then exchange vehicle information. The cooperative driving is fulfilled by sharing the vehicle information and emergency warning through wireless communication, so a driver can be aware of the dangerous situation. vehicle or vehicle-to-vehicle communications. The information exchanged among the host and surrounding vehicles provides comprehensive vehicle and driving status of each vehicle, so the driver can drive more

I. INTRODUCTION

A. Historical Background

In the automotive industry, embedded control has grown from stand-alone systems to highly integrated and networked control systems. By networking electro-mechanical subsystems, it becomes possible to modularize functionalities and hardware, which facilitates reuse and adds capabilities. The ECU handles the control of engine, turbofan, etc. Combining networks and mechatronic modules makes it possible to reduce both the cabling and the number

In many of these applications, the two or more ECUs are used and they need to communicate between them by some means. But existing protocols (I2C, D2B) didn't support multi-masters communication. They have low baud-rates and poor error detection & management. So these protocols are not useful for such applications. So the Control Area Network (CAN) protocol was developed for such application. It is a Multi-master type protocol which uses broadcasting techniques. CAN is an asynchronous serial communication protocol. It has System wide message consistency because of efficient error detection & management mechanism. It uses CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance) technology and the communication is Object-oriented communication. The Controller Area Network (CAN) is a serial bus communications protocol developed by Bosch in the early 1980s. It defines a standard for efficient and reliable communication between sensor, actuator, controller, and other nodes in real-time applications. Bit-arbitration is used for avoiding Cross-connections. It can be implemented by using advanced micro-controllers which support the CAN protocol.

Bosch originally developed the Controller Area Network (CAN) in 1985 for in-vehicle networks. In the past, automotive manufacturers connected electronic devices in vehicles using point-to-point wiring systems. Manufacturers began using more and more electronics in vehicles, which resulted in bulky wire harnesses that were very heavy and expensive. They then replaced dedicated wiring with in-vehicle networks, which reduce wiring cost, complexity, and weight. CAN, a high-integrity serial bus system for networking intelligent devices, emerged as the standard in-vehicle network. The automotive industry quickly adopted CAN and, in 1993, it became the international standard known as ISO 11898.

In this project, we are using CAN protocol to communicate between micro-controllers which will analyze the parameters like temperature, fuel level, Hand brake system and communicate with other micro-controller which is interfaced to Dash-board which indicates these parameters to the driver. Certain microcontrollers, like some models of the TriCore family, C166/XC166/XE166/XC2000 family, and XC800 family by Infineon Technologies, PIC microcontroller family by Microchip Technology.

B. Problem Definition

An analysis of network-based control system using CAN (Controller Area Network) protocol. In this project our basic focus is the communication between two cars in V.I.P.s and V.V.I.P.s convoy. By using the CAN protocol few parameters such as temperature, fuel, acceleration, door open-close condition, braking key etc. can be measured & monitored by the other cars in the convoy. It is

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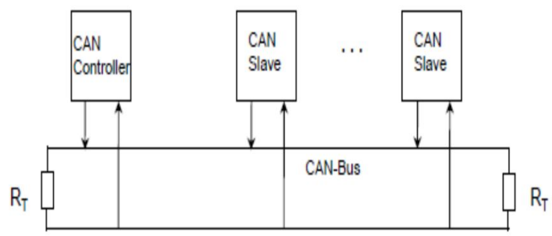
extremely useful for security and safety purpose for the important persons.

C. Proposed Work

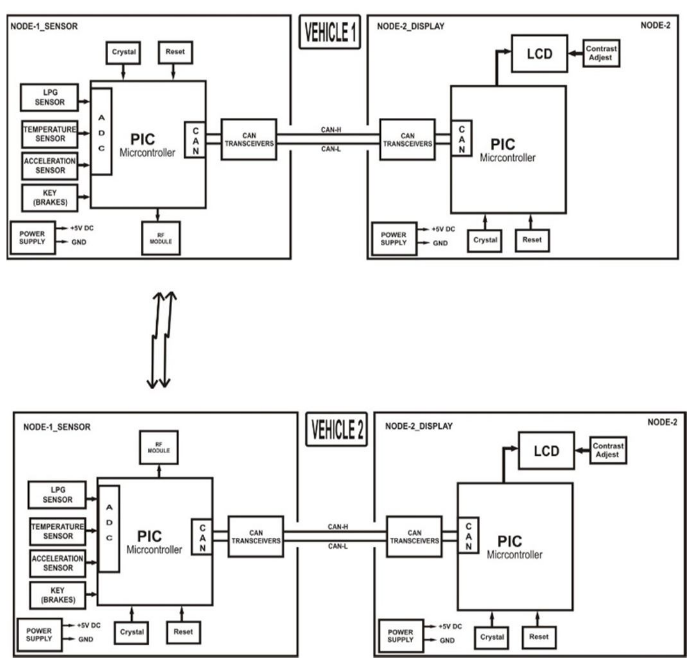
In this project there is the wireless sensor node and CAN node. The sensor like LPG and temperature sensor would be connected to the microcontroller PIC. The sensor gives the analog output which is further given to the ADC which is in-built in the microcontroller. This data is processed and further given to the RF wireless module which will convert the digital data in RF waves. The RF module used is CC2500 from Cipcon company. Further the data is transmitted to the RF receiver which will receive the data and processed in the PIC microcontroller. The PIC microcontroller used is IC18F458 which is has in-built CAN support. The PIC microcontroller process the data further passed the data on the CAN bus through CAN transceiver. The data is received at the CAN display node where the LCD 128 X 64 is connected to the Microcontroller.

In this there are two nodes. The one node is connected to the RF modules which receives the wireless data transmitted by the sensor network. The PIC microcontroller would be used for the node 1 and node two. The MCP2551 transceiver would be used as CAN transceiver. The two nodes would be connected on the CAN bus.



The node 2 would be connected to the graphics LCD which displays the sensor data.

The crystal would be used for the clock generation. In modern automotive there are around 20-50 ECU (Electronic Control Units) connected on CAN network.



1) *Complexity*: Our project is based on communication which is of medium complexity. ARM is high end processor which we do not require for our project.
2) *Memory:* The different compilers generate a HEX file that can be downloaded into the ROM of microcontroller. The size of

HEX file is the main reason of worry for the microcon-troller programmers. This is because on-chip ROM of the microcontroller is limited & the code space for the PIC18F458 is limited to 32KB. The executable code (HEX) file for project would of maximum 25KB to 30KB. PIC18F458 has 32KB of ROM which is sufficient for our project on other hand ARM has 512KB of ROM which is not needed for our project.

3) *Cost:* It is the major factor while selecting the controller of any project. Cost of PIC controller is less than ARM processor. PIC controller can fulfill all the requirements and its cost is also less than ARM processor. We are using IC18F458 because it is cheaper and it has in-built CAN support than other controllers in the PIC family. We are using RF module (Chipcon2500) for the communication between two cars. It is used for short distance wireless communication.
4) CAN: To satisfy customer requirements for greater safety, comfort, and convenience, and to comply with increasingly stringent government legislation for improved pollution control and reduced fuel consumption, the car industry has developed many electronic systems. Anti-lock Braking, Engine Management, Traction Control, Air Conditioning Control, central door locking, and powered seat and mirror controls are just some examples. The complexity of these control systems, and the need to exchange data between them meant that more and more hard-wired, dedicated signal lines had to be provided. Sensors had to be duplicated if measured parameters were needed by different controllers. Apart from the cost of the wiring looms needed to connect all these components together, the physical size of the wiring looms sometimes made it impossible to thread them around the vehicle (to control panels in the doors, for example). In addition to the cost, the increased number of connections posed serious reliability, fault diagnosis, and repair problems during both manufacture and in service. A new solution was needed and, in the mid 1980s, the Robert Bosch company (a highly regarded supplier of components and sub systems to the automotive industry) provided the answer by specifying the Controller Area Network (CAN). Many of the world's chip manufacturers now offer a wide range of semiconductor devices that implement the protocol in small low-cost controllers and interface devices and most modern cars (certainly in Europe - and increasingly in the rest of the world) now use CAN.
5) RF MODULE: This is an FSK transceiver module, which is designed using the chipcon IC(CC2500). It is a true single-chip transceiver,. It is based on 3 wire digital serial interface and an entire phase-locked loop (PLL) for precise local oscillator generation .so the frequency could be setting. It can use in UART / NRZ / manchester encoding / decoding. It is a high performance and low cost module. It provides extensive hardware support for packet handling, data buffering, burst transmissions clear channel assessment, link quality indication and wake on radio. It can be used in 2400-2483.5 MHz ISM/SRD band systems. (eg. RKE-two way Remote Keyless Entry, wireless alarm and security systems, AMR-automatic Meter Reading, Consumer Electronics. Industrial monitoring and control, Wireless Game Controllers, Wireless Audio/Keyboard/Mouse

SENSOR 1:
MQ6CO Gas Sensor

This is a simple-to-use liquefied petroleum gas (LPG) sensor, suitable for sensing LPG (composed of mostly propane and butane) concentrations in the air. The MQ-6 can detect gas concentrations anywhere from 200 to 10000ppm.

This sensor has a high sensitivity and fast response time. The sensor’s output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC.

SENSOR 2:
LM35

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35’s low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-

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lead surface mount small outline package and a plastic TO-220 package.

SENSOR 3:
ADXL355
The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tiltsensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.
The user selects the bandwidth of the accelerometer using the C_X, C_Y, and C_Z capacitors at the X_{OUT}, Y_{OUT}, and Z_{OUT} pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.
The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package.

SENSOR 4:
IR Sensor
An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion.These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor.The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, The resistances and these output voltages, change in proportion to the magnitude of the IR light received.

II. CONCLUSION

CAN based vehicle communication have been designed with transmitter nodes and receiver node. The transmitter nodes are designed as sensor nodes and the receiver node as the control node with display, which accepts messages from the sensor nodes and uses the information to detect the fuel level, obstacle ahead condition, temperature and vibrations in the car. The small size of the CAN transceiver IC and the micro controller with integrated CAN solution reduces the size and cost of the node considerably. With the use of high speed CAN transceiver the data is transmitted and received in faster rates with high level of integrity.

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