Automotive Automation and Remote Access using GSM Technology

L. Jayaraju,
Assistant Professor, Department of ECE,
Hyderabad Institute of Technology and Management (HITAM),
Hyderabad, Andhra Pradesh, India.

I. Manjula Rani,
Lecturer, Computer Engineering Department,
Smt. Durgabai Deshmukh Government Women's Technical Training Institute,
Department of Technical Education,
Hyderabad, Andhra Pradesh, India.

***Abstract* - In this paper we present Controller Area Network (CAN), it's architecture, protocol, and standards i.e. an overview of the Controller Area Network. We also propose the application of CAN extended to automation in automotive field like heavy earth moving vehicles. The proposed system is stand-alone single-chip embedded system equipped with 8 CAN ports to monitor and control vehicle locally. The authorized person who is at outside of vehicle can monitor the condition of the vehicle and also remotely controls the vehicle via a mobile phone through GSM technique.**

Keywords: Controller Area Network (CAN), Automation in Automotive field, GSM.

I. INTRODUCTION

Nowadays, many communication networks, like wired and wireless exists. Common application of all these networks is to carry out transfer of text, audio and video content. Some of these networks have been used in industrial automation to monitor and control industrial plants[2-3].
One of the popular communication networks among these is Controller Area Network [6]. CAN is intended as a communication network between the control units in vehicles. The backbone of CAN is a fast serial bus that is designed to provide a reliable and efficient link between sensor and actuators [4-5]. CAN uses a twisted-pair cable to communicate at speed of 1Mbps, with 40 devices [4]. This paper presents a comprehensive overview of controller area network, their layered architecture, protocol and standards. Also, this paper gives an overview of CAN application in automotive fields.

II . CAN Architecture, Standards and Protocol

CAN was initially developed by Robert Bosch (Germany,1986)between three electronic control units in vehicle. Bus system plays vital role in industrial automation. Due to reliable and efficient CAN bus, it's applications were enhanced drastically compared to point-to-point communication network.
Similar to OSI-ISO layers, CAN has a 4-layered protocol: Physical layer, Transfer layer, Object layer, and Application layer as in the figure 1. [5]

Application Layer
Object Layer -Message Filtering -Message and Status Handling
Transfer Layer -Fault Confinement -Error Detection and Signalling -Message Validation -Acknowledgement -Arbitration -Message Framing -Transfer Rate and Timing
Physical Layer -Signal Level and Bit Representation -Transmission Medium

Fig.1. Layered Architecture of a CAN

The Physical layer defines how the signals are transmitted. The Transfer layer is responsible for presenting and accepting the received/transmitted message to/from the upper layer. These messages are sent and received using the properties Bit timing, Message framing and Arbitration, acknowledge, Error detection and Signaling, in addition to Fault confinement. The Object layer is responsible for message filtering and handling. The Application layer is the upper layer through which the user interfaces.

CAN2.0 has two different standards: CAN 2.0 A, standard CAN using 11 bits for node identification, and CAN 2.0 B or extended CAN using 29 bits for node identification. The 29-Bit format of CAN as shown in fig. 6.
The classification of these two CANs is shown in Table 1.
There are two ISO standards classifying the CAN's Physical layer in terms of data rate; ISO 11898 which can handled speed up to 1Mbps and ISO 11519 that can handle speed up to 125Kbps.

Table.1. CAN versions

	Standard	Signal Rate	Identifier
Low-Speed CAN	ISO 11519	125kbps	11-bit
CAN2.0A	ISO11898(1993)	1Mbps	11-bit
CAN2.0B	ISO11898(1995)	1Mbps	29-bit

Bits in a CAN protocol can be one of the following:

- "0": Dominant bit
- "1": Recessive bit

CAN protocol has been designed using four different frame types, namely: Data frame, Remote frame, Overload frame, and Error frames

A. Data Frame.

The Data frame is used whenever the transmitter sends data to the receiver, with its own identifier. The Data frame structure as shown in fig.2 [5]

SOF	**11-Bit Identifier**	**RTR**	**r1**	**r0**	**DLC**	**0…8 Bytes Data**	**CRC**	**ACK**	**EOF**

Fig.2. 11-Bit Identifier CAN Data frame

- **SOF** (Start Of Frame) :
  This bit indicates the beginning of the Data frame/Remote frame.
- **Identification Field** (either 11 or 29 bits):
  11Bit identifier is used in CAN2.0A and 29 bit identifier is used in CAN 2.0B versions.
- **RTR** (Remote Transmission Request) :
  This bit is used to differentiate between a Remote and Date frames. When RTR=0 then it indicates Data frame and when RTR=1 then it indicated Remote frame.
- **r0 and r1:**
  These two dominant bits are left for future enhancement.
- **DLC** (Data length code, 4bits):
  It indicates the number of bytes in the Data field.
- **Data Field:**
  It contains the data sent. It contain s 0-8 bytes maximum.
- **CRC Field:**
  It contains two fields.
  CRC sequence is used for error checking in the sent message.
  CRC Delimiter:
  This is a recessive delimiter bit.
- **ACK Field**:
  It contains two fields.
  ACK Slot bit: After reading the error free message it gives acknowledgement message i.e., a successfully received message.
  ACK Delimiter: This is a recessive delimiter bit.
- **EOF Field:**
  This consists of 7 recessive bits, delimiting the end of a Data frame/Remote frame.

B .Remote Frame:

The remote frame is used whenever a receiver node requests data from any other source. The frame structure [5] of remote fame is shown in fig.3.

SOF	**Arbitration Field**	**Control Field**	**CRC**	**ACK**	**EOF**

Fig.3. 11-Bit Identifier CAN Remote frame

This differs from the Data frame as follows.

- It does not contain any data field.
- The RTR field should be a recessive bit.
- The data length is the value of the corresponding Data frame.
- The Identifier is the one representing the node from which data is requested.

C. Overload Frame:

An Overload frame is sent whenever a delay is needed in the network. The frame structure of a Overload frame [5] is as shown in Fig.4.

Overload Flag	**Overload Delimiter**

Fig.4. 11-Bit Identifier CAN Overload frame

- Overload flag consists 6 dominant bits.
- Overload delimiter consists of 8 recessive bits.

D. Error Frame:

An Error frame consists of 2 fields. i.e. Error flag and Error delimiter as shown in Fig.5.

Error Flag	Error Delimiter

Fig.5. 11-Bit Identifier CAN Error frame

- Error flag consists of 6 consecutive dominant bits in Active error flag and 6 consecutive recessive bits in Passive error flag.
- Error delimiter consists of 8 recessive bits.

SOF	11-Bit Identifier	SRR	IDE	18-Bit Identifier	RTR	r1	r0	DLC	0..8 Bytes Data	CRC	ACK	EOF	IFS

Fig.6. 29-Bit Format of CAN protocol

The difference between 11-Bit Identifier and 29-Bit Identifier is only in the no. of bit identifiers. Remaining operation and instructions are same for both the Bit formats.

The Physical connection of CAN as shown Fig.7.

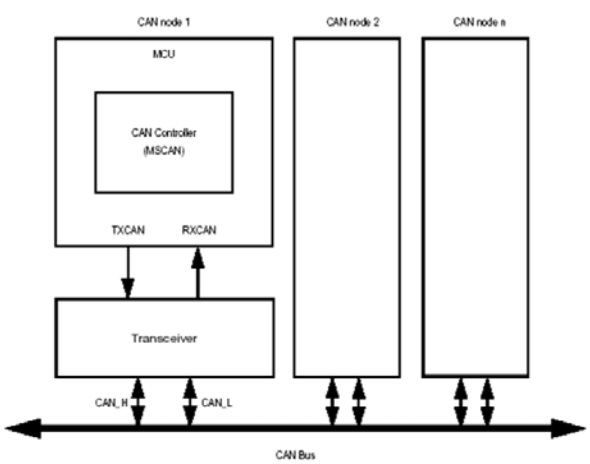

Fig. 7. Physical Connection of CAN

III . CAN Applications

The CAN has many applications in both industrial and non-industrial fields [6]. The main CAN application fields include industrial machine control, air craft and aerospace, medical equipment and devices, marine electronics, off-highway cargo and passenger trucks and busses, passengers cars, factory automation, lifts and escalators, building automation, ATM machines, office automation, vending machines, packaging machines, textile production, network machines and process control units, office equipments, ship automation systems, vehicle engine management systems, etc.,

IV. Proposed Automation System in Automotives

Automation in automotives has been implemented using CAN protocol and GSM-network [7] and many others. In this work, we propose a stand-alone embedded system equipped with 8 CAN ports to monitor and control heavy earth moving vehicle locally as shown in fig. 8. An advantage of using CAN is that, it works on Master-Slave configuration (In contrast to some protocols earlier, where devices may only receive message from a master).

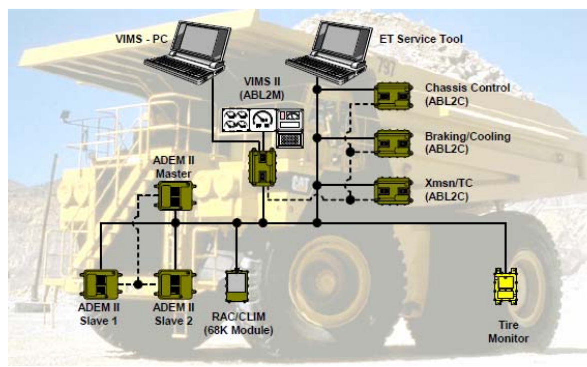

Fig.8. Heavy Earth Moving Vehicle

The vehicle owner or authorized person can remotely access their vehicle via a GSM modem to control and monitor their vehicle.

The proposed system consists of two parts. One part is installed at vehicle, hereafter called as *vehicle-controller*. The other part is the *remote-access* part. The *vehicle-controller* is a stand-alone single-chip microcontroller equipped with 8 CAN ports and a GSM modem. The *remote-access* part consists of a mobile phone. The proposed system of CAN-GSM based automation system [7] on a Heavy Earth Moving Vehicle is as shown in Fig.9.

- For demonstration purpose, only some sensors are displayed in the proposed system as in Fig.9. We can enhance the sensors as per application needed.
- *The vehicle-controller* is developed by using the embedded system's native language which can control the vehicle through CAN ports, checking the vehicle status and transmitting them to the *remote-access point* i.e. the mobile phone through a GSM modem. The ports connected through CAN are vehicle speed sensor, oil sensor, fire sensor, alcoholic sensor [8], engine temperature sensor, power lock, lighting sensor and active suspension sensor.
- The control methodology of the selected sensor of the vehicle is translated into a control driver written in the microcontroller native language. The status of the vehicle is displayed on the Liquid Crystal Display (LCD) and also there is a buzzer for hazardous indications.
- The speed of the vehicle is sensed by speed sensor and is displayed on the LCD. Oil level sensor measures the level of the oil in tank of the vehicle and is displays on the LCD. Fire sensor sense the fire and gives the buzzer. Alcoholic sensor sense if the driver was drunk, and it gives the information to the owner or authorized persons of the vehicle. Engine temperature sensor sense the temperature of the engine and gives the condition of the engine through the LCD display. Power lock sensor gives the condition of the power lock system on the LCD. Lighting sensor gives the status of all the lights to avoid the lighting in the day time. Active suspension sensor gives the suspension status .
- The status of all the above sensors can be accessed by the mobile phone at *access-point* through GSM. By selecting particular key on the mobile phone, we can get the status of the corresponding sensor as well as control the vehicle, based on the condition of the vehicle through the mobile phone.
- The Level shifter gives compatibility between micro-controller and GSM module. The needed voltages +5v and +/-12v are supplied by the power supply block. The LCD displays the parametric values of the sensors and buzzer gives the signal in hazardous conditions.

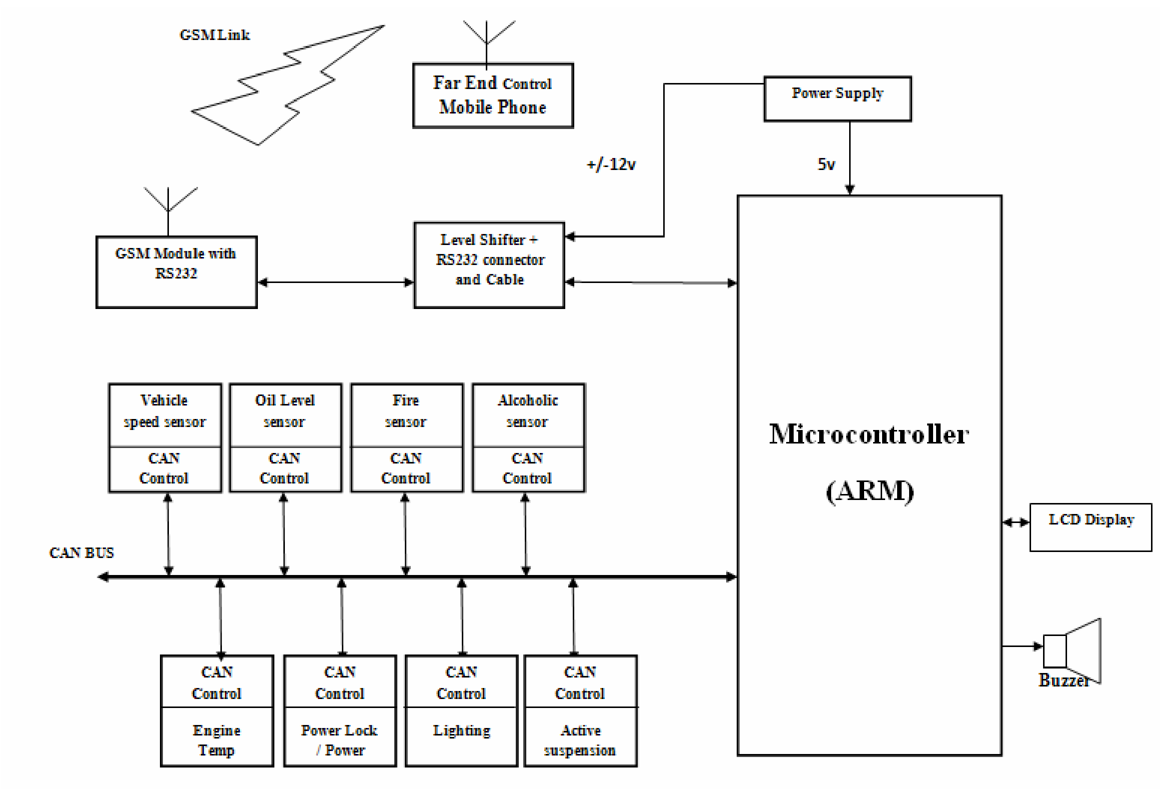

Fig. 9. CAN-GSM based automation system in automotives

V . Conclusion

Controller Area Network applications are emerging and gaining a high ground in many applications from automobile industry to automation of factory industries. To mention a few, we can cite passenger cars, trucks and buses, marine electronics, factory automation, industrial machine control, and non-industrial control. In this paper, Controller Area Network's architecture, protocol and standards are presented. It also stressed on the key features of CAN systems that enabled the proposal of extending CAN application towards vehicle automation and control. The proposed system proves the ability of CAN to accommodate vehicle automation into its scope.

REFERENCES

[1] H. F. Othman, Y. R. Aji, F. T. Fakhreddin, A. R. Al-Ali, "*Controller Area Networks: Evolution and Applications" IEEE*, 2006.

[2] I. Lin, H. Broberg, "*Internet-based monitoring and controls for HVAC applications*", Industry Aplication Magazine, IEEE , Vol. 8, No.1, Jan-Feb.2002 PP.49-54.

[3] A. Z. Alkar, U. Buhur, "*An internet based wireless home automation system for multifunctional devices*", IEEE Transactions on Consumer Electronics, Vol. 51, No.4, Nov.2005 pp.1169-1174.

[4] "Controller Area Network – CAN Information," http://www.algonet.se/~staffann/developer/CAN.html,3Nov 2005

[5] Bosch, R. "CAN SPECIFICATION (Version2.0)," Germany: Stuttgart,1991.

[6] "CAN Application Fields," http://www.can-cia.org/applications/,Dec.2005

[7] A. Alheraish, "*Design and Implementation of Home Automation System*," IEEE July 10, 2004

[8] Federic Baronti, Francesco Lenzi, Roberto Roncella, Roberto Saletti, "*Distributed Sensor for Steering Wheel Grip Force Measurement in Driver Fatigue Detection*" IEEE, 2009.

L.Jayaraju was born in Guntur, Andhra Pradesh, India. He has received his B.Tech degree in Electronics and Communication Engineering from Jawaharlal Nehru Technological University, Hyderabad, India and M.Tech degree in VLSI System Design from Jawaharlal Nehru Technological University, Hyderabad, India. Currently he is working as an Assistant Professor in ECE Dept. in Hyderabad Institute of Technology and Management, Hyderabad, Andhra Pradesh, India. He has 10 years of industrial experience from various electronic industries and 4 years of teaching experience from various Engineering Colleges. His current research interests include VLSI full custom design, Low Power VLSI design, Embedded system design and communications. He guided many projects for B.Tech and M.Tech students. He has published 2 papers in International Journals and presented 3 papers in various International Conferences on VLSI and Embedded Systems.

Manjula Rani Indupalli is native of Vijayawada, Andhra Pradesh, India. She has done her B.Tech. degree in the year 2004 and her M. Tech. degree in the year 2008, both the degrees in Computer Science and Engineering and also from JNTU (Jawaharlal Nehru Technological University), Hyderabad, India. She has been working as Lecturer, Dept of Computer Engineering in the Department of Technical Education, Government of Andhra Pradesh state, India. At present she is working in Smt. Durgabai Deshmukh Government Women's Technical Training Institute, Hyderabad, Andhra Pradesh, India. She has 8 years of teaching experience. She is interested in design of software, digital circuits and networking.