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Electric Vehicle Control System by using Controller Area Network Communication

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Abstract

The Controller Area Network (CAN) communication protocol is designed by Bosch in the 1980s as a doubled wired, differential voltage-based serial communication system for control systems. Electric vehicles, like Gasoline vehicles, require controllers to regulate load operation, where conventional point-to-point communication system gets outcome of huge number of cables in the harness. CAN is used to minimize the amount of cables and enable various controllers to transfer data and accomplish complicated jobs simultaneously. This paper presents the design of a CAN-based control system to be used as a replacement for the existing system and shows the development of four modules as well as a proposed implementation for the complete system. Individual modules will be developed initially and later interfaced to the CAN network with CAN controller modules. All modules are connected with a twisted pair of cables for data transmission with CAN.

Keywords: Controller Area Network, Auxiliary load, Motor driver, Battery monitoring system

Nomenclature

EV	Electric Vehicle.
CAN	Controller Area Network.
MCU	Micro Controller Unit.
HMI	Human Machine Interface.
BMS	Battery Monitoring System.
OCV	Open Circuit Voltage.
CCM	Coulombs Counting Method.

1. Introduction

The growing use of electrical technology in automobiles has created a significant problem for the business. More cables are required to communicate and power around a vehicle as the number of electronics increases. The answer shortly emerged, to manage all data transfer with the minimum

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number of cables, the serial communication system can be implemented in automobiles by replicating computer systems. One or more main controllers monitor and control these networks, which typically consist of several autonomous nodes controlling specific tasks surrounding the vehicle [8]. This would eliminate point-to-point cables and replace them with a single connection that would allow data to be transferred throughout the vehicle.

CAN is now the most widely used and matured of all available automobile communication systems. Its capacity to send brief communication at a topmost rate of 1Mbps has earned it a reputation for its simplicity, robustness, and high level of reliability [7]. A Controller Area Network based system is developed and implemented to control and merge certain 12V dc loads. As stated previously, this would swap point-to-point cables with a singlecord linking various individual modules and operated by a single main module. It will reduce the amount of cables in the car, allow data to be communicated across various modules, and facilitate the development and integration of additional modules for a better and more reliable automobile [8].

In this paper, a control system based on CAN with four modules is developed. For data transmission following are the modules developed Auxiliary Lighting Module, Human-machine interface Module, Battery monitoring system Module and Motor controller Module. A fully functional tabletop prototype of a CAN-based system featuring one of each module has been created for test purposes.

2. Controller Area Network

CAN is a well-thought-out network architecture that allows for the reliable transmission and reception of brief real-time communication. It's developed to link multiple controllers. and it can communicate at a rate till 1Mbps, with robust fault recognition and treatment algorithms.

The highest communication speed of 1Mbps can be obtained with a cable span till 40 metresutilising a twisted cable. Figure 1 depicts the relationship between communication speed and cable span for CAN.

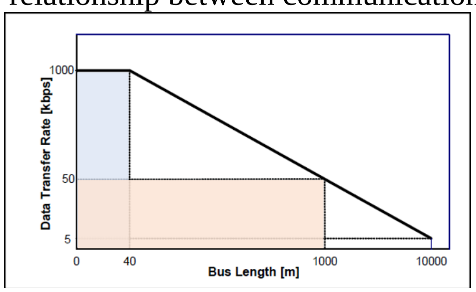

Figure 1: Data Transfer Rate vs. Bus length [8]

3. Proposed CAN control system

The Controller Area Network based system is developed for the EV to operate the specified 12Vdc loads. CAN modules should be built precisely to meet the requirements of the numerous loads in the EV, whereas the programmed software which satisfies the CAN standards operates each load. The system has been developed to work at a speed of 125kbps.

Figure 2 shows the proposed system, in block level representation. It contains the individual module information and the details about the electronic components used in the module construction. Table 1 gives details regarding message input and output from respective modules.

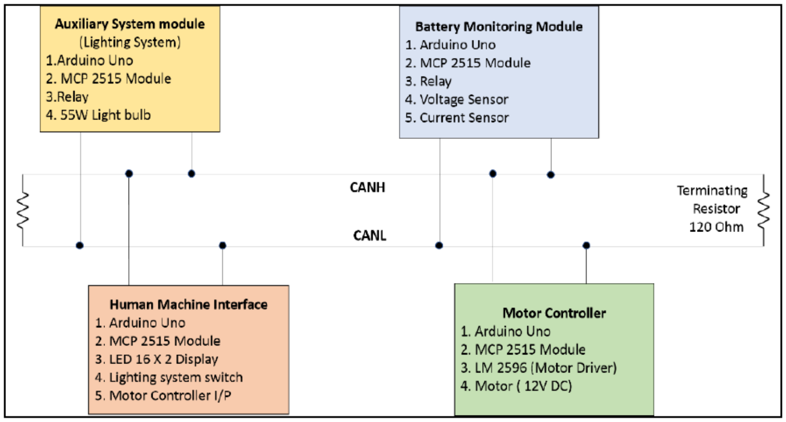

Figure 2 CAN module details

Table 1 Input/output mapping

Identifier	Transmitter Module	Receiver Module	CAN buffer Location	Message Content	Input Range	Active Range
7FE	Human Machine Interface Module	Lighting System Module	Canbuf[0]	Light Switch	0-255	0-255
		Motor Driver Module	Canbuf[1]	Potentiometer Reading	0-255	0-1
7FF	Battery Monitoring System Module	Human Machine Interface	Canbuf[0]	Battery SOC	0-255	0-100
			Canbuf[1]	Battery Voltage	0-255	0-13

4. CAN control system layout

The equipment should be able to activate and deactivate loads as needed and give strong and precise control over the Motor and Battery monitoring system to construct a reliable network in the control system. Figure 3 shows the general working flow of all the controller modules.

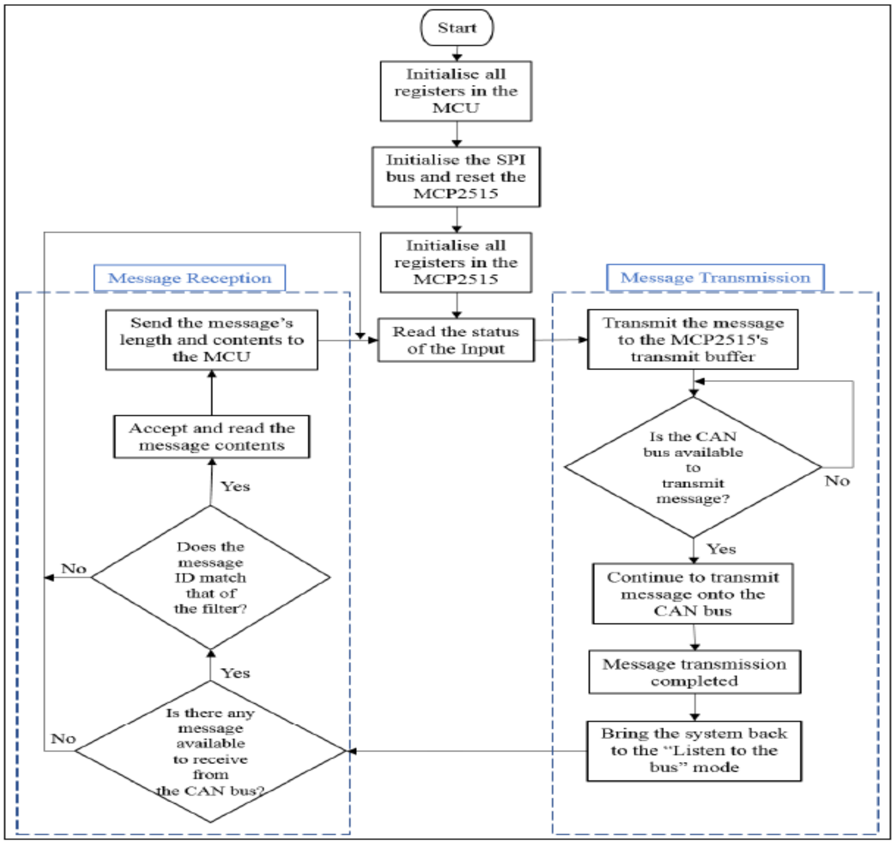

Figure 3 CAN Modules working flowchart [8]

4.1. Human Machine Interface module

The Human machine interface (HMI) module's function is for the reading, processing and transmission of human signals via the CAN bus. Input data is received through the CAN bus via the light module and the motor controller module. The connected loads are adjusted in a number of ways as per the programmed code. The HMI module can read digital inputs for simple on/off actions as well as analog inputs for devices that have changing speeds, such as motors. Figure 4 depicts the complete block schematic of the HMI controller. The linkage between the different elements of the HMI controller can be observed in it. The finished HMI module is shown in Figure 5 and Figure 6.

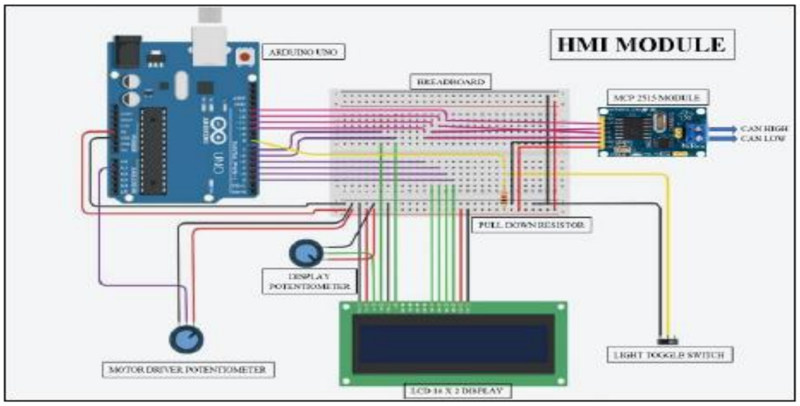

Figure 4 HMI module block diagram

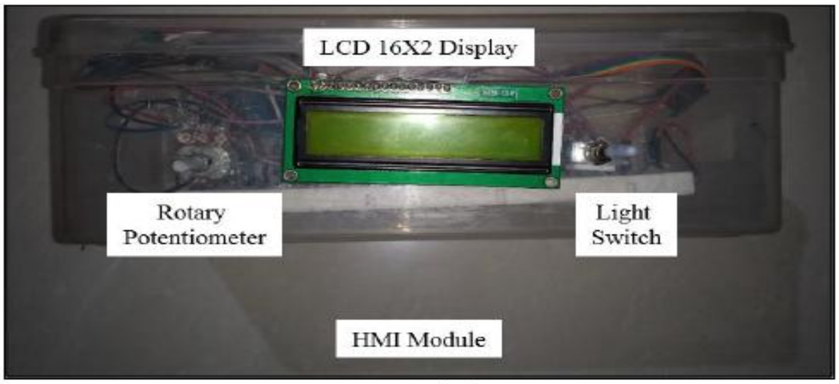

Figure 5 HMI module protype 1

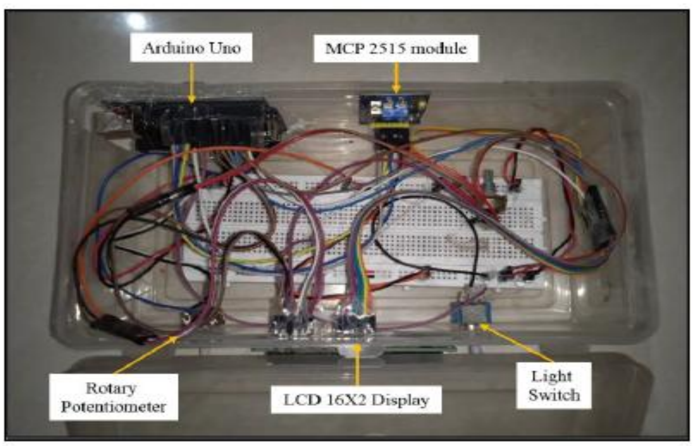

Figure 6 HMI module protype 2

4.2. Lighting system module

The Lighting system module is in charge of the front outside lighting. The lighting system module has CAN bus network connectivity, which allows modules to communicate with each other using only a single twisted pair connection. The ability to create smart features based on any of the various sensor or manual inputs in the system is also facilitated by network communication between modules. Digital load control using programmable microcontrollers allows for much simpler wiring with only one circuit connected to each load. Additional functionality can be simply added by changing the software code without changing the circuitry. Figure 7 depicts the complete block schematic of the Lighting system module. Figure 8 shows a photograph of the completed CAN lighting system module.

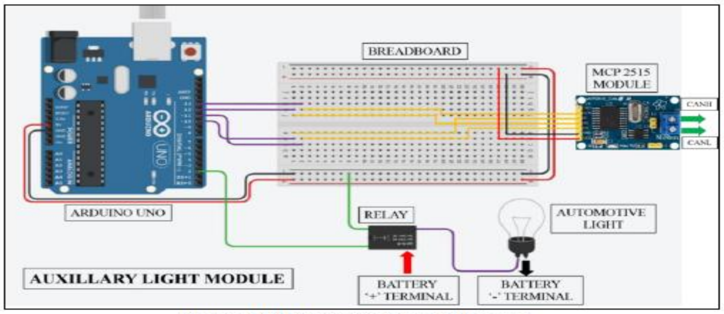

Figure 7 Lighting system block diagram

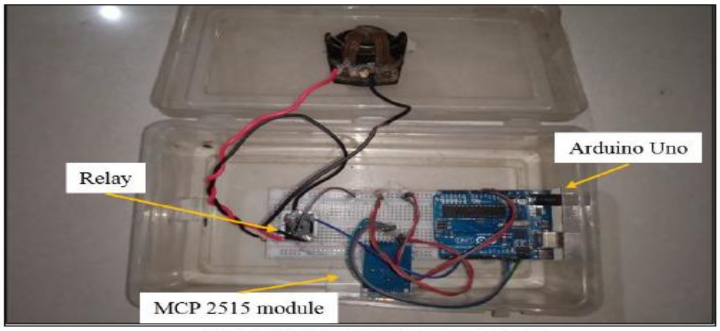

Figure 8 Lighting module prototype 2

4.3. Motor driver module

The Motor Driver module's job is to read rotary potentiometer data from the HMI module through the CAN bus network, where it is then used to drive the wheel's motor. This module was made separately from any other functions so that when coupled with motor drivers using CAN input for speed data, the module could be hooked either directly to the motor driver or through an existing CAN network. Due to the design and ability to upload different program codes, this module is capable of working with the existing accelerator pedal or standard drive-by-wire pedals in the event of an upgrade.

Figure 9 shows the block diagram of the development of the Motor driver module. Figure 10 shows a photograph of the completed motor controller module. HMI module consist of rotary potentiometer which is used as input to the motor driver for pulse width modulation

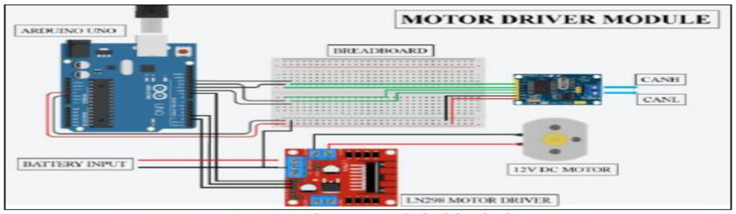

Figure 9 Motor driver module block diagram

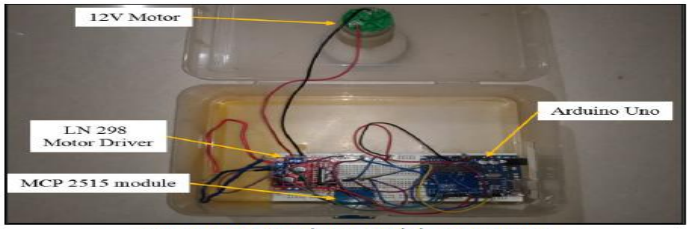

Figure 10 Motor driver module prototype 1

4.4. Battery Monitoring System module

The function of Battery monitoring system (BMS) module is to monitor the health of battery in terms of battery voltage and battery state of charge (SOC). We have used a combined strategy of Open Circuit Voltage (OCV) and Coulomb counting method. The OCV method uses the voltage of a battery cell as an indicator of a current battery SOC. Coulomb counting method (also called a Current integration method) is a simple process of summing of capacity taken out from the battery. The detailed block diagram of the Battery monitoring module construction is shown in Figure 11. Figure 12 shows a photograph of the completed Battery monitoring module. This module consists of Arduino UNO MCU, MCP 2515 module, 25V Voltage Sensor, 30A ACS 712 current sensor and Relay.

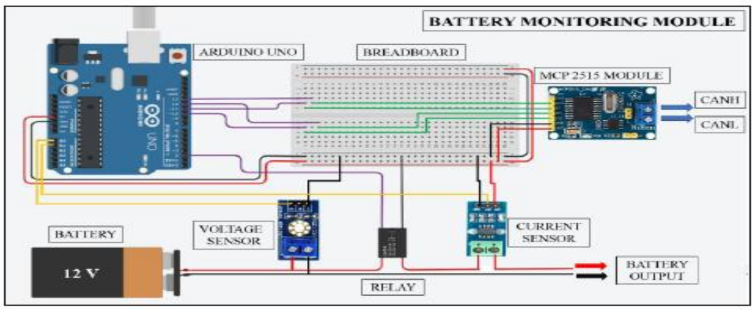

Figure 11 Battery monitoring module block diagram

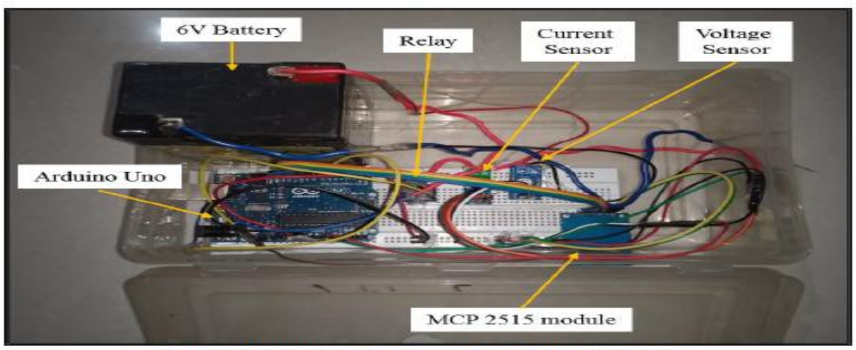

Figure 12 Battery monitoring module prototype

5. Working Four-node control system

Figure 13 and figure 14 shows working four-node CAN based control system with four individual modules

Figure 13 Working Prototype1

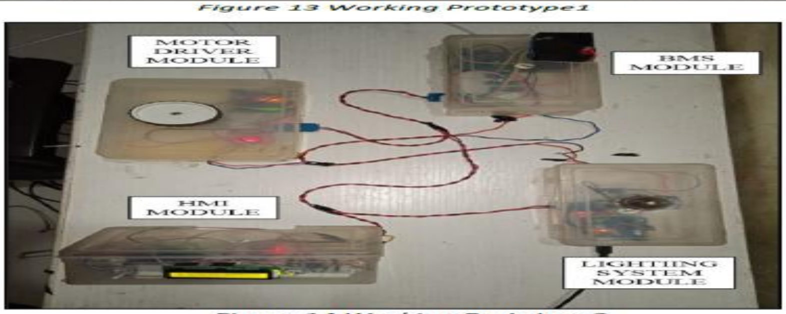

Figure 14 Working Prototype2

6. Conclusion

This paper details the design and construction of a control system using CAN communication system. One node of each kind was placed in a small experimental setup to display and illustrate entire system operation. Because the system is built to use a variety of nodes, it can be readily extended to function in a variety of automotive systems. Nodes can be introduced and removed from the system in any order, enabling the control system to be adapted as per each automobile. The flexibility to readily modify system functionality by merely reconfiguring individual nodes is additional advantage of this CAN-based system. Every linked node has access to data that is delivered through the CAN network, since CAN is a message-based communication system.

References

1. I.S.O. “Road Vehicles-Controller area network (CAN)-Part 1: Data link layer and physical signalling”, SC31, I. S. O. ISO 11898-1: 2015.
2. Di Natale, Marco, et al. “Understanding and using the controller area network communication protocol: theory and practice.” Springer Science & Business Media, 2012.
3. Vincent Stephen Andrew. “Development of a CAN Based Electric Vehicle Control System.” Diss. University of Kansas, 2014.
4. R. B. Gmbh, "CAN Specification," vol. Version 2.0, 1991.
5. Marsh David. "LIN simplifies and standardizes in-vehicle networks." EDN 50.9 (2005): 29-42.
6. Pazul Keith. "Controller area network (can) basics." Microchip Technology Inc 1, 1999.
7. Marsh David. "Network protocols compete for highway supremacy." EDN 48.16 (2003): 26-26.
8. Azzeh Abdel Rahman. "CAN Control System for an Electric Vehicle." Diss. University of Canterbury Christchurch, New Zealand, 2014.
9. Leen Gabriel and Donal Heffernan. "Expanding automotive electronic systems." Computer 35.1 (2002): 88-93.
10. Shweta S. Ashtekar, D. Patil Mukesh and B. Nade Jagdish. "Implementation of controller area network (CAN) bus (Building automation)." International Conference on Advances in Computing, Communication and Control. Springer, Berlin, Heidelberg, 2011.
11. Furmanski Piotr and ZiemowitStolarski. "Controller area network implementation in microwave systems." 14th International Conference on Microwaves, Radar and Wireless Communications. Conference Proceedings (IEEE Cat. No. 02EX562). Vol. 3. IEEE, 2002.
12. Nolte Thomas, Hans Hansson and Lucia Lo Bello. "Automotive communications-past, current and future." IEEE Conference on Emerging Technologies and Factory Automation. Vol. 1. IEEE, 2005.
13. De Campos, Marcio Folly and Lucia R. Franco R. Horta. “Analyzing SAE J1939 Messages Worst Case Response Time.” No. 2009-36-0242. SAE Technical Paper, 2009.
14. Microchip Semiconductor, “MCP2515 Datasheet”, June 2019.
15. Philips Semiconductors, “Arduino UNO Datasheet”, September 2014.
16. Samolyk Mateusz and Jakub Sobczak. "Development of an algorithm for estimating Lead- -Acid Battery State of Charge and State of Health." 2013. Acid Battery State of Charge and State of Health." 2013.