

## MONITORING AND CONTROLLING OF TEMPERATURE USING CAN ARCHITECTURE

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### ABSTRACT

CAN is a two-wire, half duplex, high-speed network system and is well suited for high-speed applications using short messages with the help of controller. The CAN transceiver is used to transmit and receive data. These Transceivers are specially designed for high-speed differential data transmission between the CAN controllers and the physical differential bus lines. This paper discuss in detail about temperature monitoring and control based on the CAN protocol. The temperature changes of LM135 sensor are measured by the inbuilt ADC and transmitted to the other node using the CAN Bus. Then other node will display the result on the LCD and based on the temperature control action is takes place in the temperature node.

**KEYWORDS:** Controller Area Network, Microcontroller, Nodes, Protocol, Transceiver

### INTRODUCTION

CAN (Controller Area Network) is a serial bus system, which was originally developed for automotive applications in the early 1980's. CAN is a serial communication protocol that may be used to transfer up to 8 data bytes within a single message.

Temperature is the often-measured environmental quantity since it affects many systems like physical, electronic, chemical, mechanical and biological systems. Narrow range of temperatures is needed for few processes to work well. But many systems perform to their best within limited temperature ranges. To optimize the processes within the specified temperature limits, control systems are often used. In these systems, reliability can be enhanced using temperature sensors. The implemented system is constituted of two CAN nodes, the CAN1 node that is located at the source of temperature and the other is located at where the temperature is to be monitored.

The CAN bus may be used in vehicles to connect engine control unit and transmission, or to connect the door locks, climate control, seat control, etc. Primarily due to the low cost of few CAN Controllers and processors, CAN bus is also used as a field bus in general automation environments;.

### OBJECTIVES OF THE STUDY

Reliable communication protocols require that all the intended recipients of a message receive the message intact. Automatic Repeat request (ARQ) techniques are used in unicast protocols, but they do not scale well to multicast protocols with large groups of receivers, since segment losses tend to become uncorrelated thus greatly reducing the effectiveness of

retransmissions. In such cases, Forward Error Correction (FEC) techniques can be used, consisting in the transmission of redundant packets (based on error correcting codes) to allow the receivers to recover from independent packet losses. Based on the above efficient protocols we can improve the communication standards.

## **METHODOLOGY**

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result. The system using temperature sensors with Microcontrollers is an exclusive work that can automatically monitor & control the temperature according to the user requirement. The system comprises of a) Temperature sensor to know the ambience temperature. b) CAN module c) Transceiver modules.

### **CAN Protocol**

CAN application tells communication controller to send/receive messages with a certain identifier (11 or 29 bits), the communication controller tries to send immediately, but can be delayed by current traffic, and by arbitrating against higher-priority messages currently transmitted by other nodes\_ Messages have a transmission latency that depends on the concurrent higher-priority messages; changing the message set/priority/transmit rate results in changes of the communication timing that are difficult to predict. Identifiers can be added to an existing network by only changing the sender and relevant receivers, but the message timing changes for all nodes. Arbitration between concurrent messages is non-destructive and therefore efficient, but limits the bit rate ( $< 1$  Mbit/s) and the topology (no star or ring, no repeaters) and has severe safety issues.

## **HARDWARE DESCRIPTION & OPERATION**

The block diagram and design aspect of independent modules are considered in this section. Block diagram is shown in figure 1. The implemented system is constituted of two CAN nodes, the CAN1 node that is located at the source of temperature and the other is located at where the temperature is to be monitored.

### **Hardware Requirements**

Since the main intension of this module is to design TEMPERATURE MONITORING AND CONTROL using CAN Bus. Designing the power supply for the entire circuitry and selection of microcontrollers that suits the application, selection of CAN controllers and CAN transceivers plays a major role in the module success. The basic ATMEGA16L micro controller is chosen for this application.

### **Selection of Can Controller**

The CAN Controller stores received bits (one by one) from the bus until an entire message is available, that can then be fetched by the host processor (usually after the CAN Controller has triggered an interrupt). The host-processor stores its transmit-messages into a CAN Controller, which transmits the bits serially onto the bus. In this work MCP2515 controller is chosen as shown figure 2.

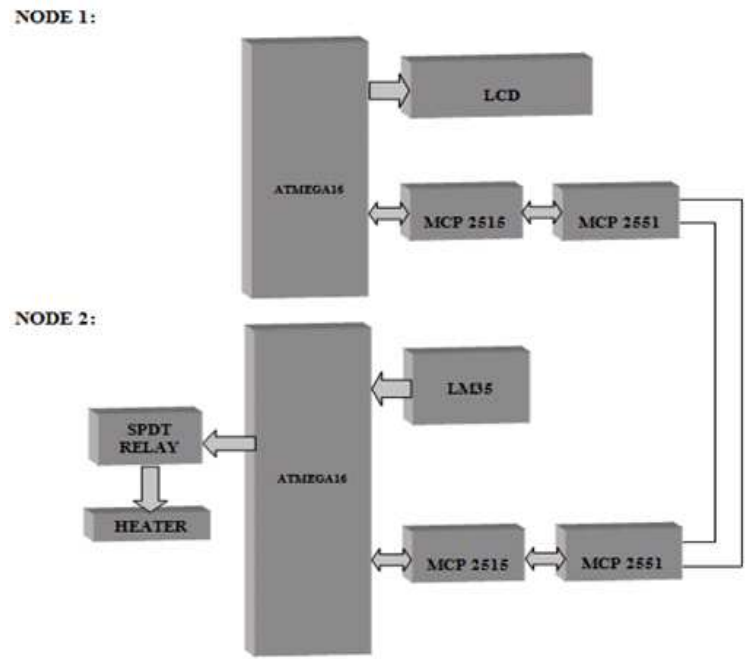


Figure 1: Block Diagram of Implemented System

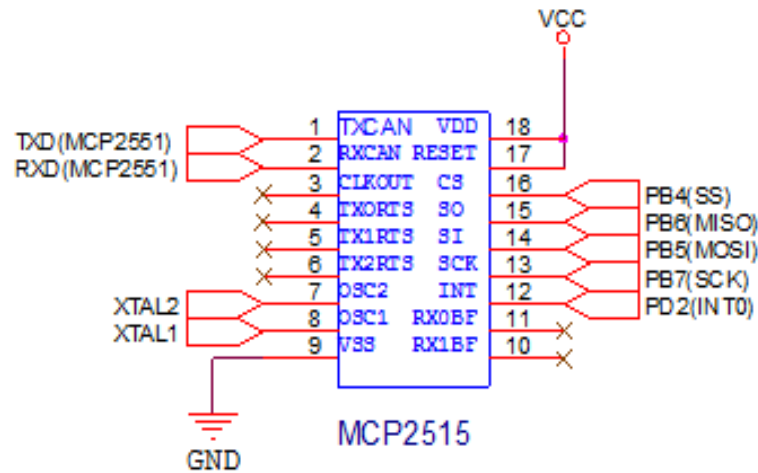


Figure 2: CAN Module

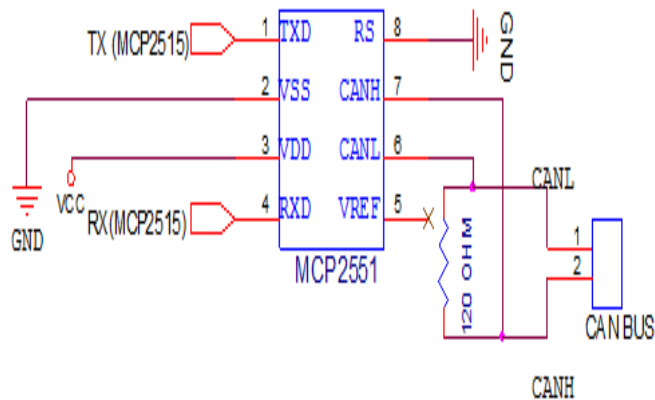


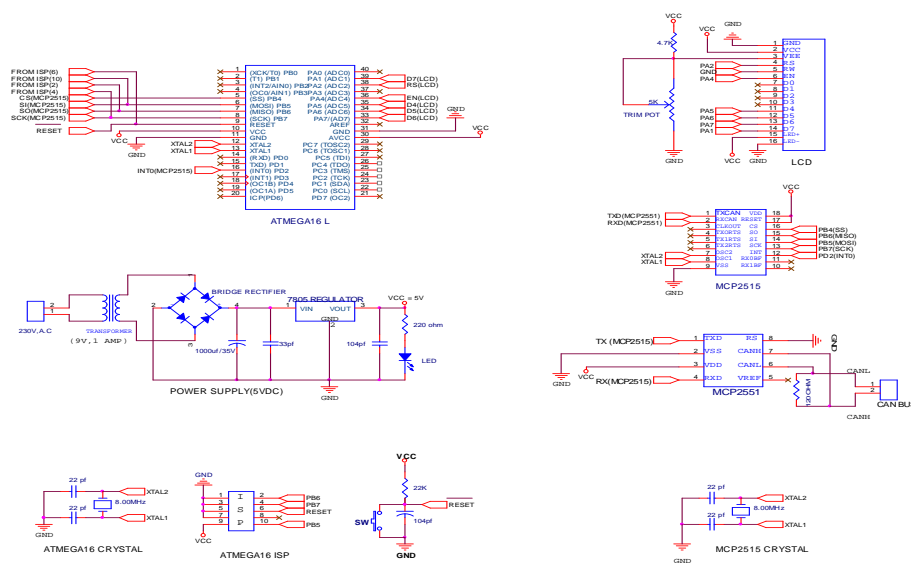
Figure 3: Transceiver

**Selection of Transceivers**

The Control Area Network (CAN) serial bus system with multi-master capabilities, originally developed for use in automobiles, operates at data rates of up to 1Mbaud, following the ISO 11898 international standard. Because of its ability to function in harsh environments at low costs, CAN has found its way into (almost) all applications within a vehicle (as Body, Safety and Power train). CAN is also widely used in industrial applications. Figure 3 shows a MCP 2551 transceivers.

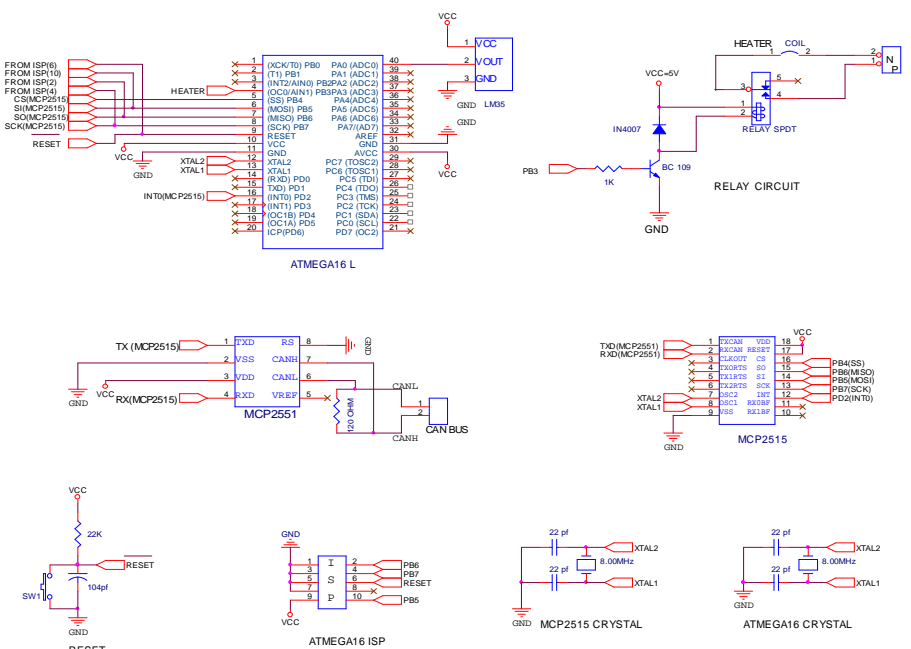
**Schematic Circuits at Node 1 & Node 2**

Figure 4 & 5 shows the complete schematic circuit at node 1 and node 2. Selection of microcontroller and Can controller and transceivers and their interfacing is shown in the following figures.



**Figure 4: Schematic Circuit at Node 1**

**NODE 2**

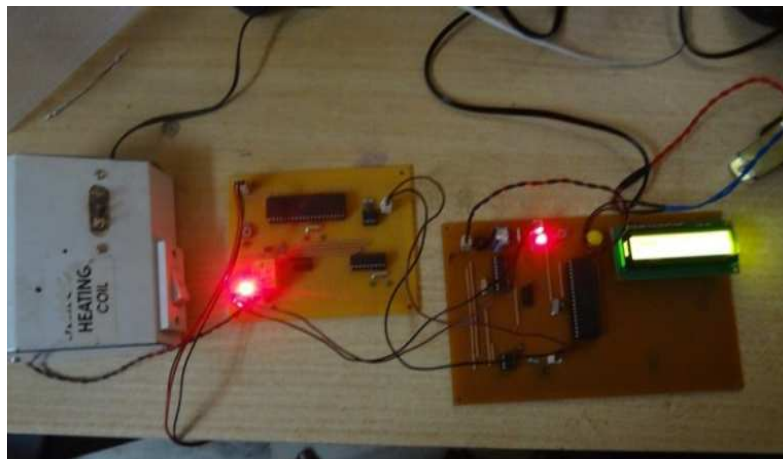


**Figure 5: Schematic Circuit at Node 2**

## CIRCUIT OPERATION

CAN is a message oriented broadcast mechanism. Using CAN we can make block to block connection or node to node connection. We can send the data from one node to other node using CAN bus. Using CAN we can send the data through frames. We are having data frame, extended data frame, remote frame, error frame etc.. If we want to send the data from one node to other we can use data frame, since CAN is an asynchronous communication so data must be put in start bit and stop bit. Data frame contains SOF, ARBITRATION (IDENTIFIER+RTR) FIELD, DLC, DATA (MAX 8 BYTES), CRC, ACK, EOF.

The module is designed for temperature monitoring and controlling based on the CAN protocol. It deals with the temperature changes that occur in any process in Industry. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The temperature changes are measured by the inbuilt ADC and transmitted to the other node using the CAN Bus. Then the other node will display the result on the LCD. And based on the temperature control action it takes place in the temperature node. Initially the main node sends request to all the nodes, after receiving the frame these sub nodes compare the identifier, if the identifier matches then, the corresponding sub node sends the data to the main node and then the main node will display data on LCD. Thus the communication between nodes will be done. The prototype circuit is shown in figure 6.



**Figure 6: Prototype Circuit**

## SOFTWARE DEVELOPMENT AND CODING

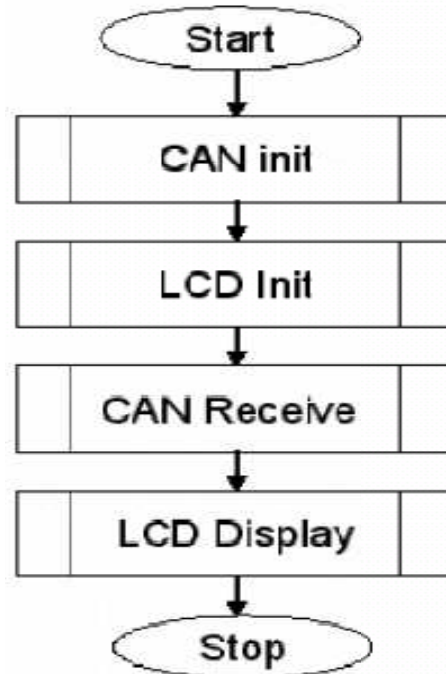
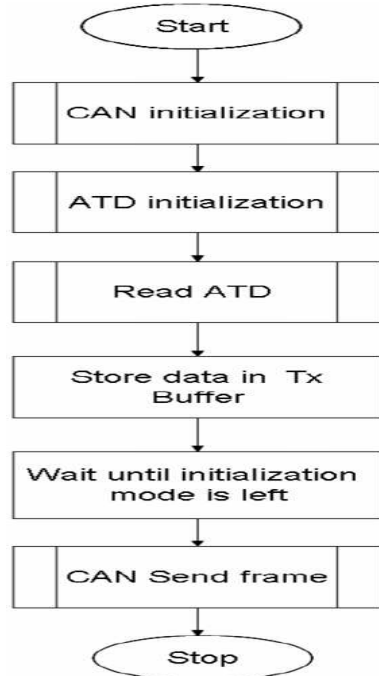
Assembly code is used for one or more of three reasons: speed, compactness or because some functions are easier to do in assembler than in a higher level language. It is well known that using a high level language always results in the faster program development but there are times when, for the reasons stated above, one wants to use assembly language. The Code Vision AVR C Compiler, like other compilers meant for microcontroller development, has an easy interface to assembly language. Assembler code may be embedded anywhere in a C program.

### Identifier

The arbitration field consists of the 11 bit Identifier for the basic CAN message, which determines the priority of the message. Lower the value of this identifier, higher the priority of the message. The following flow chart shown in figure 7 describes how to initialize and use the MSCAN module in conjunction with ATD converter. The flow chart implementation of CAN receiver is explained in figure 8.

**Identifier Extension (IDE)**

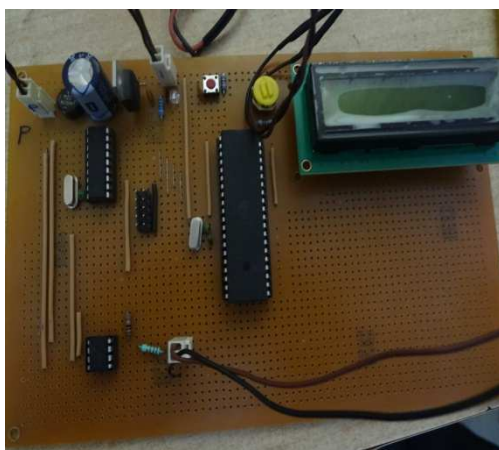
A dominant IDE bit means CAN base format and a recessive IDE bit means extended CAN format. AVR controller is having the in built PWM technique.



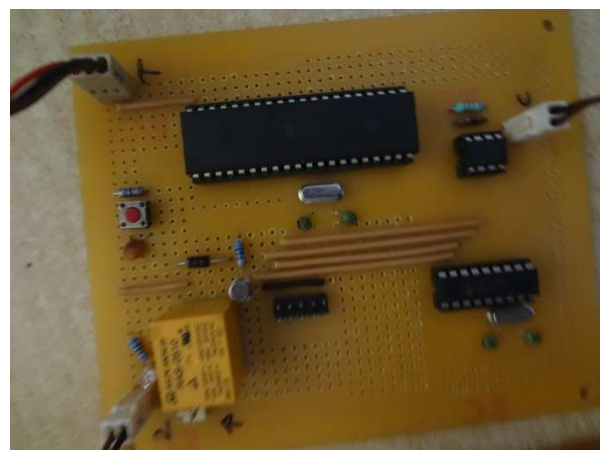
**Figure 7: Flow Chart For CAN Transmission Figure 8: CAN Receiver Flow Chart**

**RESULTS AND DISCUSSIONS**

The working model is embodied in this section. Figure 9 shows NODE 1 having a LCD display, ATMEGA16 Micro controller, CAN controller (MCP 2515) and transceiver (MCP 2551) and other circuit components. This NODE 1 is connected to NODE 2 through Two wire CAN cable. Figure 10 shows NODE 2 having an ATMEGA16 Micro controller, CAN controller (MCP 2515) and transceiver (MCP 2551) and Temperature sensor LM35 and a Relay circuit and other components. Figure 11 is a heating element. When the module is switched ON, the temperature sensor senses the surrounding temperature at node 2 and resultant temperature is displayed at the LCD of NODE 1. Initially the room temperature is displayed on the LCD as shown in the figure 12.



**Figure 9: Node 1**



**Figure 10: Node 2**

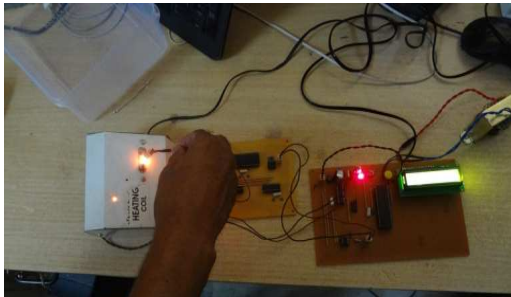


**Figure 11: Heating Element**



**Figure 12: Result 1**

When the heating element temperature increases, sensor sensing the temperature of the heater also increases. Figure 13 and 14 shows the temperature variations in heating element and sensor respectively. When the temperature sensed by the sensing element reaches a predefined cut off value (say 42 degrees), then the heating element gets switched off automatically as shown in figure 15.



**Figure 13: Sensing the Temperature of the Heater**



**Figure 14: Result 2**



**Figure 15: Result 3**

## CONCLUSIONS

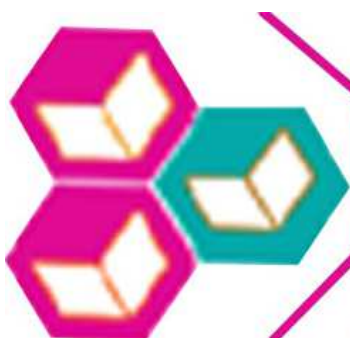
This paper is concerned with design techniques for implementation of CAN nodes for data monitoring and taking appropriate decision based on data in the control system. Implementation of CAN for temperature monitoring & controlling is successful and the same idea can be applicable to monitor tire pressure monitoring systems, adaptive cruise control, power window and Engine management systems in automobiles. This leads to decentralisation of control systems in vehicles. This can be extended to industrial control vertical. Mainly in decentralizing the PLC (programmable logic controllers) control mechanism.

There is potential future work implementing CAN for Industrial control systems like PLC's etc. This project is concerned to temperature monitoring, this can be extended to four nodes eight nodes and 16 nodes CAN network for different automotive applications. For further decentralization of control systems, sub-network for CAN called LIN (Local Interconnect Network) can be implemented. It is intended in future works, to increase the number of CAN nodes on the bus, using CAN IP's based on FPGA, Signal processors and other microcontrollers further develop . We can select

TCP/IP interface to design web based control system and the conversion algorithms to convert CAN data frames to TCP/IP format, for the successful design of Web based control system

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