

# Enhanced Modified model for safe driving using Embedded Automotive control systems

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**Abstract**—The population of our country has been increasing rapidly, which indirectly has increased the vehicle density and lead to many road accidents. The main causes of accidents include drowsiness of driver, health conditions, drunk and drive, collision of vehicles etc. The main aim of this project is to minimize the road accidents occurring due to driving fatigue which cause the loss of invaluable human life and other valuable things, till now we saw many ways to reduce causes for accidents,[1] we now implement a new concept of monitoring the driver's health condition, by that we can avoid the accidents up to some extent, if the person met with any health issues the vehicle will get slow down/stopped and then the message will be sent to doctor for medical services using GSM, then by using GPS receiver the vehicle will be tracked to serve emergency medical services to the victim present inside the vehicle.

**Keywords**—ARM7TDMI-S, CAN Protocol, Heartbeat Sensor, Eye blink Sensor, Alcohol Sensor, GSM SIM900, GPS.

## I. INTRODUCTION

“Driving to save lives, time, and money in spite of the conditions around you and the actions of others” -This is the slogan for Defensive Driving. As per the study conducted by the Ministry of transport and highways, only 9 percent of accidents observed were attributed to material causes due to faults in the road, whether conditions, vehicular effects etc. To reduce such accidents especially caused by driver distractions we are implementing this project using different sensors. Increasing stress levels in drivers cause the drivers to deviate their attention levels from the primary task of driving. Modern vehicles are equipped with multiple sensors and ECUs.

Doctors measure the heart rate manually by holding patient/victim's hand they feel the pulse in the nerve and look at the timer/wrist watch to count the heart beats per minute. Heart rate indicates the soundness of our heart and helps assess the condition of the cardiovascular system. So in order to detect the pulse we will pass light from one side of the finger and measure the intensity of light received on the other side, this can be done using Heartbeat sensor.

Driver's drowsiness is as an important factor in the vehicle accidents. This Project involves measuring and control of an eye blink using the IR sensor. The basic principle of IR sensor is based on an IR emitter and an IR receiver. The eye blink sensor continuously monitors the movement of the eye, and calculates the closing time of eyelid, and those values are compared with the original values. If the blinking rate is less, then the engine will get slowed down.

Driving in either intoxicated or drunken state is very dangerous, at present several accidents are taking place mainly due to drunken drivers. High BAC of the drunken driver will lead to unconsciousness this intends to vehicle accidents, here we are using Alcohol sensor which detects the alcohol based on the human breath. In such case if the driver has consumed alcohol the vehicle won't start at all.

The communication module used is embedded networking by CAN which has efficient data transfer and is intended as a communication network between the control units in the vehicle. Additionally, this unit is equipped with GSM in order to have communication with the owner for further medical services it allows transmission of SMS in TEXT mode and PDU mode and further the vehicle detection can be done using GPS which is a space-based satellite navigation that provides location and time information anywhere on or near the Earth.

## II. MODULES DESCRIPTION

The block diagram depicts the total essence and the functioning of the project. The block diagram consists of 6 parts mainly. This includes:

- i. Heartbeat Sensor
- ii. Eye blink sensor
- iii. Alcohol Sensor
- iv. Vibration sensor
- v. ARM7 LPC2148
- vi. Can protocol

measure heart rate is a pair of LED and LDR which are placed parallel to each other.

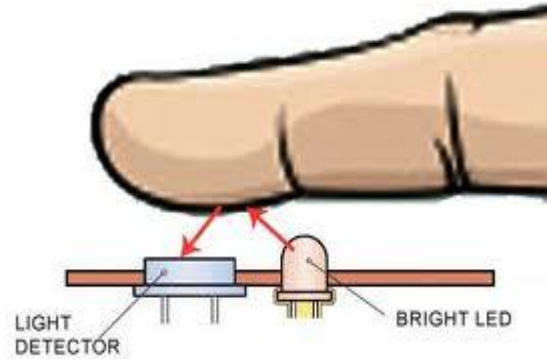


Figure2.2: Heart rate measurement system

The LED emits IR rays, so that when the finger is placed in between LED and LDR there exists some systolic pressure. Whenever systolic pressure is applied, normal pressure of blood flow is disturbed at finger tip which is high and IR rays penetrate through the blood and are received by LDR. The intensity of the reflected light depends upon the blood volume inside the fingertip. So, each heartbeat slightly alters the amount of reflected infrared light that can be detected by the photodiode. With a proper signal conditioning, this little change in the amplitude of the reflected light can be converted into a pulse [2]. The pulses can be later counted by the microcontroller to determine the heart rate. The signals are in analog form which is converted into digital by ADC suitable for the MCU. If the driver met with a heart stroke, then the buzzer is rangd and the message is sent to the monitoring station for further medical services.

### B. Eye Blink sensor module

Driver drowsiness resulting in reduced vehicle control is one of the major causes of road accidents. This project involves measuring and control of the eye blink using an IR sensor. By monitoring the eye blink rate of a human being, we can easily determine whether he/she is sleeping or awake.

The technique of monitoring eye blink rate is by measuring IR light reflected from the surface of the eye. Here the eye is illuminated by an infrared LED and the reflected light is recorded by an IR photodiode, but here the IR LED and IR photo diode should be placed in a straight line with each other. The module starts counting as soon as an object obstructs the line of sight.

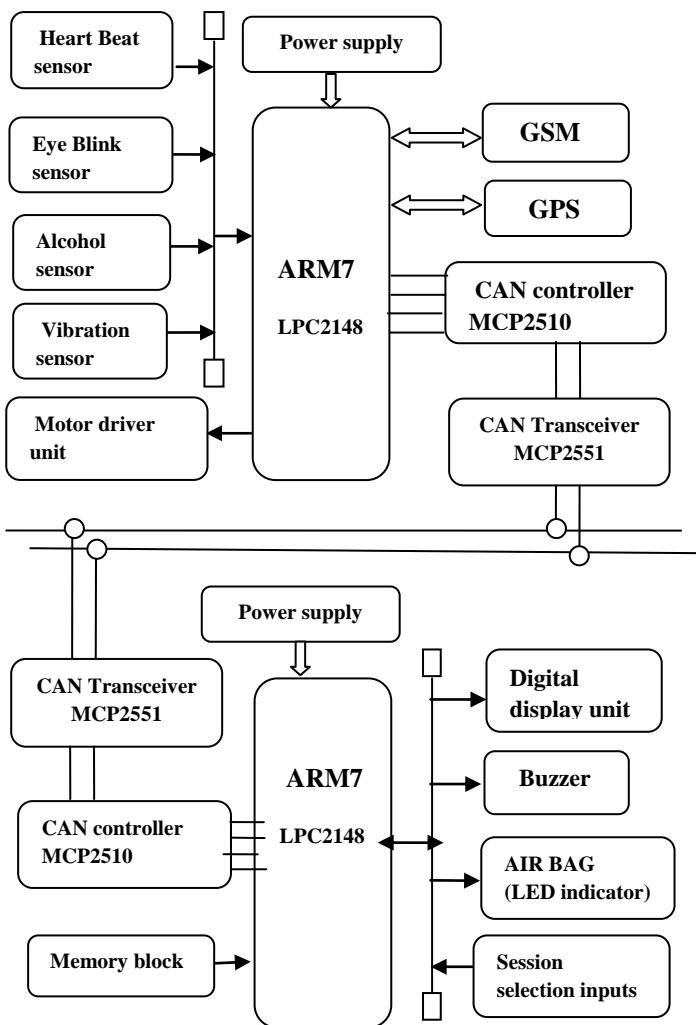


Figure 2.1: Block diagram

### A. Heartbeat sensor module

Heart rate indicates the soundness of our heart and helps to assess the condition of the cardiovascular system. The pulse is felt due to the expansion and contraction of blood vessel when blood enters and leaves it. To measure the heart rate, first we will detect the heartbeat and counts the pulses for one minute to get the BPM. Sensor works on a very basic principle of optoelectronics. All it takes to

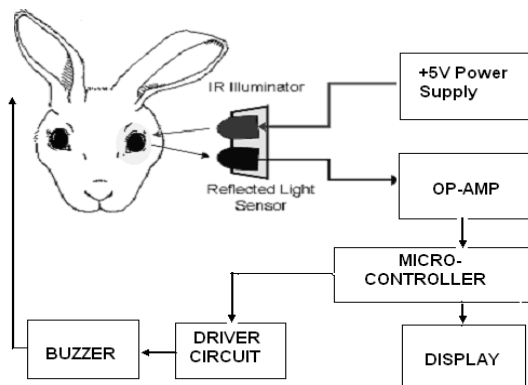


Figure 2.3: Logic block for Eye Blink module

The IR photo diode converts the reflected light into electrical signals, and sends those signals to Op-Amp. The output of Op-Amp depends on the intensity of light received by the IR photo diode. The micro-controller drives the buzzer according to the output of Op-Amp [3]. When the eyelid is open, maximum amount of light will be reflected from the eye because our eyeball is transparent, while minimum of light will be reflected from the eye, when it is closed as skin part of the eye is opaque. In that case if the driver feels drowsy the sensor senses it automatically, alerts the driver with the buzzer sound.

### C. Alcohol sensor module

Now-a-days drunk and driving accidents are becoming far too common. This sensor detects the concentration of alcohol gas in the air and outputs its reading as an analog voltage. The sensing range of 0.04 mg/L to 4 mg/L is suitable for breathalyzers. The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V. The sensor connects to the ignition system of the car, and prevents the car from starting if the driver BAC is greater than 0.08mg. It accomplishes this by taking various inputs and determines whether the driver is sober enough to drive, if the range exceeds the value then vehicle won't start. Here we are using MQ-10 alcohol gas sensor, [4] it detects ethanol in the air. Basically it has 6 pins, but here we will use only 4 of them. Two of them are used for the heating system, and another 2 are for connecting power and ground, we can find one little tube inside the sensor, in which it is used for heating system this is usually made up of aluminum oxide and tin dioxide inside it there are heating coils, which practically produce the heat.

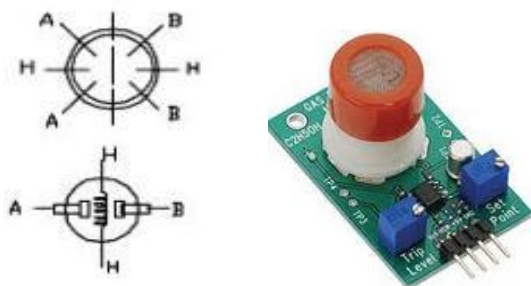


Figure 2.4: Alcohol breath analyzer

Whenever the alcohol molecules in the air meet the electrode then ethanol burns into acetic acid then more current is produced. So, just because of more alcohol molecules more current we will get for this change in current, we get the different values from the sensor. Once the sensor senses the alcohol level then the data will be sent to the microcontroller. If the BAC content exceeds the range 0.08 mg, the vehicle won't get started at all.

### D. Vibration sensor module

Here we are using the accelerometer based sensor as vibrator in which, acceleration is a measure of how quickly speed changes. They measure in  $m/s^2$  or in G-forces (g). It is used to measure static or dynamic acceleration in all three axes, forward/backward, left/right and up/down. The output of accelerometer provides 1.65V to 3.3V in the positive direction and in negative direction the voltage drop from 1.65V to 0V.

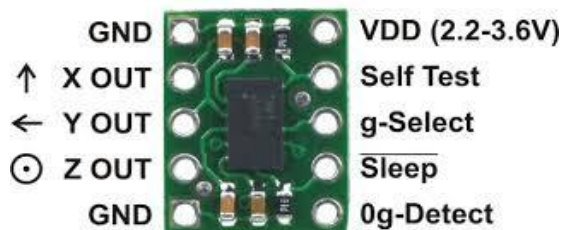


Figure 2.5: MMA7361L accelerometer

The output of the accelerometer is in analogue form with three different output voltages each representing in the X, Y and Z direction of motion. These voltage signals are processed through ADC0 on three different Channels available on ARM. ADC0 is configured at 4.5MHz clock from system peripheral clock. The 8 bit digital output from ADC0 is fed to UART1 of ARM [5]. Accelerometer is used in this design for the collision detection. The maximum output voltage of accelerator module is 3.3V that is a CMOS voltage of the processor. This helps the driver to stay awake whenever he feels drowsy due to the vibration.

### E. GSM Module

GSM is the acronym for Global System for Mobile Communication, which is a wireless modem that transmits data using radio waves. GSM module allows transmission of Short message service (SMS) in TEXT mode and PDU mode. The proposed design uses SIM 900 GSM module in text mode. The design uses GSM/GPRS RS232 Modem built with SIMCOM Make SIM900 Quad-band GSM and works on frequencies 850/900/1800 and 1900 MHz; it is very compact in size and easy to use as a plug in the GSM Modem. The baud rate is configurable from 9600-11520 through AT command. AT is used to start a command line to be sent from TE (Terminal Equipment) to TA (Terminal



Adaptor).The information contains position (longitude, latitude), identity and temperature of a vehicle that is transmitted to the monitoring station by the SMS through the GSM network.

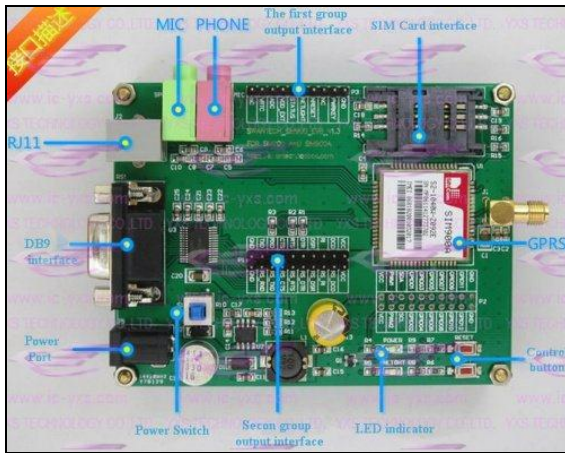


Figure 2.6: GSM SIM900 Module

The GSM Module interfaces with ARM Processor where the TxD pin of ARM processor is connected to RxD pin of GSM module and vice versa. The transmitted data from ARM processor using UART1 module generally contains information about Vehicle Identity that may be checked and displayed on Hyper-Terminal, then the Same data is sent to a specific mobile number and GPRS to the monitoring station for further medical services to the victim inside the vehicle.

**F. GPS Module**

GPS is the acronym for Global positioning system; it is a spaced-based satellite navigation system which provides information about the vehicle location and timely information in all weather conditions anywhere on or near the earth. The GPS receiver broadcast signals from space in which it provides data in three dimensions (longitude, latitude and altitude). GPS receiver can acquire GPS signals from 65 channels of satellites and output position data with high accuracy in extremely challenging environments and under poor signal conditions due to its active antenna and high sensitivity. The GPS has become a widely used aid to navigate worldwide, became a useful tool for map-making, land surveying, scientific researches, tracking and surveillance [6]. GPS receiver calculates its position by timing the signals sent by the constellation of GPS satellites high above the Earth. Here each satellite transmits the messages continually containing the time information.

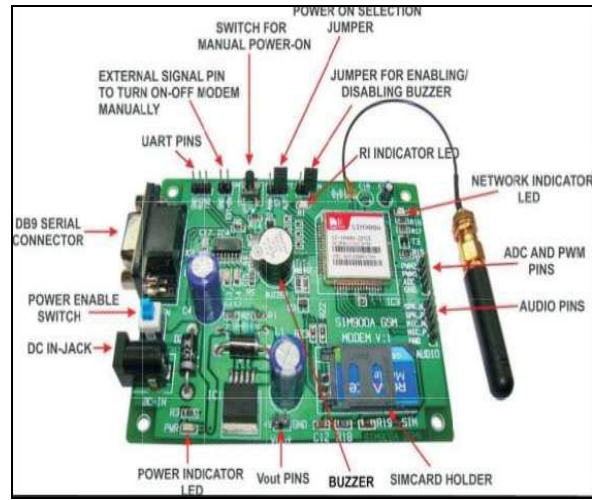


Figure 2.7: GPS Module

Once the GSM sent the message to the monitoring station about the driver’s condition then, the GPS receiver tracks for the vehicle location by that, we can take driver for further medical services, here the output is in standard National marine electronics association (NMEA) format.

**III. HARDWARE RESOURCES**

**A. ARM7TDMI core**

ARM is the acronym for “Advanced Risc Machines”, it is one of the most licensed and thus widespread processor cores in the world.

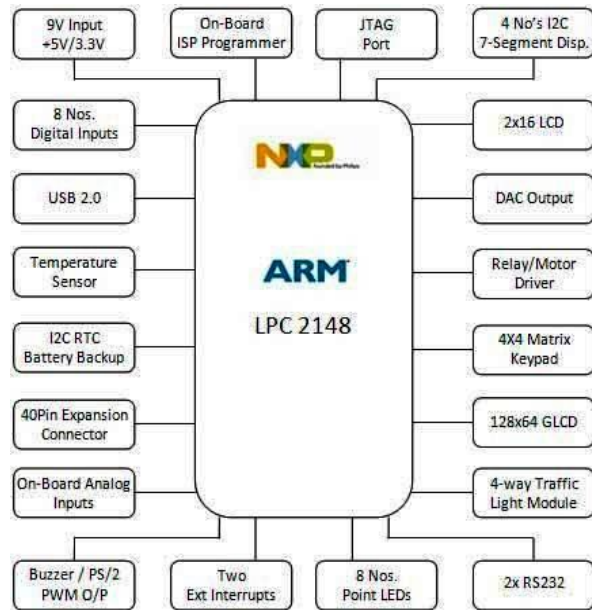


Figure 3.1: Block diagram of ARM7TDMI-S

The ARM processor is used especially in portable devices due to low power consumption, small size and high performance needed in portable embedded applications. ARM7 family includes the ARM7TDMI, ARM7TDMI-S, and ARM7EJ-S processors. This is the industry’s most widely used 32-bit embedded RISC microprocessor with real-time emulation and embedded trace support, which combine the microcontroller with embedded high speed

flash memory ranging from 32 KB to 512 KB. This memory is used for both data and code storage.

### 1. ARM7TDMI features

In this project we have used LPC2148 microcontroller which is based on a 16-bit/32-bit ARM7 is one of the most used ARM-version for low end systems. LPC2148 is the widely used IC from ARM-7 family. The ARM7TDMI processor has two operating states, one is ARM-32bit, in this word aligned instructions are executed the other is Thumb-16bit; in this state half word aligned thumb instructions are executed [7].

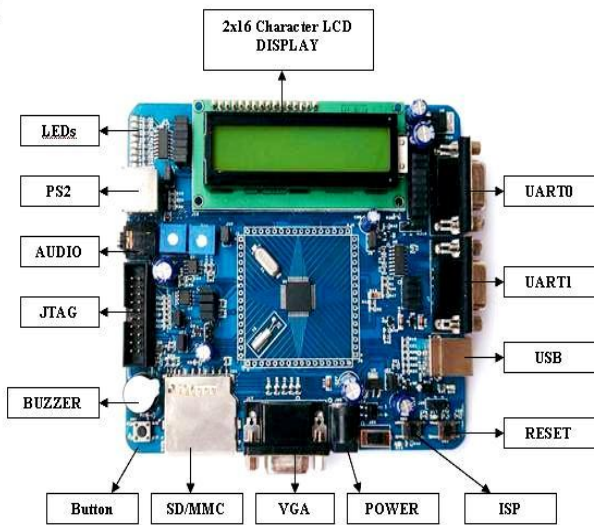


Figure 3.2: ARM7TDMI-S Module.

The operating state of the ARM7TDMI core can be switched ARM state and Thumb state using the branch and exchange instructions. The features of ARM7 are In-System Programming (ISP), Two 10bit ADCs with 14 channels, USB 2.0 Full Speed Device Controller, one with full modem interface. Two SPI serial interfaces Two 32-bit timers.

### 2. ARM7TDMI working

In this project we are using various sensors, for monitoring the driver behavior. To measure the BAC we have used alcohol sensor, but the output of this sensor is in analog form, so to convert the output of the sensor into electrical form we will use signal conditioning (transducer). As controller operates only on digital data, the analog output that we get from all the sensors has to be converted into digital form by using ADC. The ADC is inbuilt in ARM processor, so by using that we can convert all the outputs to digital form. So the output of the signal conditioner circuit is directly connected to the ARM processor. Here we are using two ARM processors one is used as master port and the other is for slave, all the outputs are displayed on the LCD which is present in the master port.

## B. CAN bus overview

### 1. CAN History

The CAN is an ISO standard (ISO 11898) for serial communication that was originally designed for the automotive industry but has also become a popular bus in industrial automation as well as other applications.

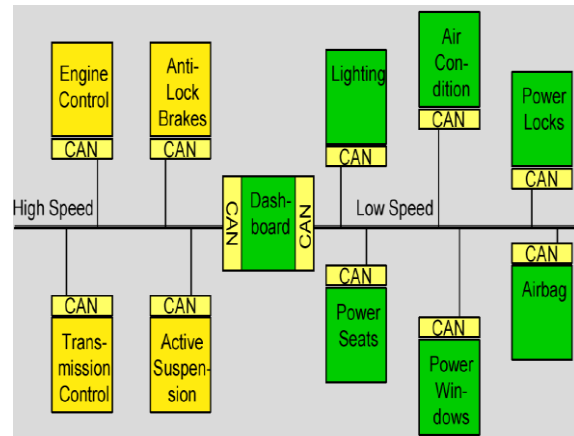


Figure 3.3: CAN in passenger car

At first the CAN bus is primarily used in embedded systems, and as its name implies, it is the network established among microcontrollers. The protocol was developed in February 1980 by Robert Bosch GmbH at the Society of Automotive Engineers (SAE) congress [8]. Today CAN have gained widespread use in automotive, industrial automation, military, and other environment network applications. CAN was introduced for the reduction of wiring harness.

### 2. CAN Terminology

The CAN protocol uses the Data Link Layer and the Physical Layer in the ISO - OSI model. CAN is usually a two-wire bus consists of CAN-High and CAN-low operated in differential mode, half duplex, high-speed network system and is well suited for high speed applications using short messages. The benefits of CAN include its robustness, compatibility, reliability and the large following from the semiconductor industry [5]. The CAN bus is a broadcast type of bus, it means all nodes can hear all types of transmissions. CAN protocol is a message-based protocol, not an address based protocol. In the CAN protocol, all messages are transmitted in a predetermined format. When the bus is unoccupied, all units connected to the bus can start sending a new message. If two or more units start sending a message at the same time, their priority is resolved by an identifier (hereafter the ID). The unit that won the arbitration (i.e., the one that has the highest priority) can continue to send, while the units that lost in arbitration immediately stop sending and go to a receive operation.

### 3. CAN mechanism and working

The CAN physical layer supports two states termed, dominant ('0') and recessive ('1'). If two or more CAN controllers are transmitting at the same time and at least one of them transmits a '0' then the value of the bus will be a '0'. This mechanism is used to control access to the bus and also to signal errors. The main goal of the design is to distribute the control over the CAN bus, where many I/O ports are used for interfacing devices to the microcontroller, which increases the interconnections (wires) and makes the hardware look clumsy. All the sensor's values can be sent to microcontroller by using CAN protocol. The CAN protocol use Non-Return-to-Zero (NRZ) encoding (with "bit-stuffing") for data communication on a "differential two wire bus" as transmission method. This means that the bit level is placed on the bus for the entire bit time. The use of NRZ encoding ensures compact messages with a minimum number of transitions and high resilience to external disturbance.

#### 4. CAN transceiver:

The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 provides differential transmit and receive capability for the CAN protocol controller and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s.

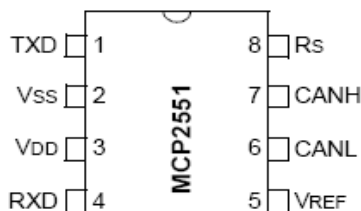


Figure 3.4: MCP2551 pin diagram

## IV. SOFTWARE DESCRIPTION

### A. Embedded C overview

Everything around us is surrounded by various types of embedded systems, like digital cameras, mobile phone, and washing machine all of this has some kind of processor functioning inside it. The hardware forms the body of an embedded system, processor acts as the brain, and software forms its soul, here embedded software which governs the functioning of the embedded systems rule's the

entire system. An embedded system is mainly designed to perform one specific task.

As time progressed, automatically use of microprocessor assembly language reduced and the same moved onto C as the embedded programming language of choice. The C language is perhaps the most popular programming language for programming embedded systems. Assembly is also used, but C is used specifically for the portions where we require high timing accuracy, efficiency, code size, etc. We can find many advantages in C over assembly language in which it is small and simple to learn C, easily understandable and it is processor-independence and not specified to one particular microcontroller, this makes it convenient in developing programs for all microcontrollers. It has two salient features one is code size, which is governed by available program memory and the other is code speed governed by the timing constraints. The very important goal of embedded system programming is to get maximum features in minimum space and time.

### B. Keil Compiler

The use of C language to program microcontrollers is becoming too common, most of the time it's not easy to build an application in assembly, but it makes easy if we implement the same using c. Here we are using KeilµVision4 IDE which is a Windows based front end for the C Compiler and assembler.

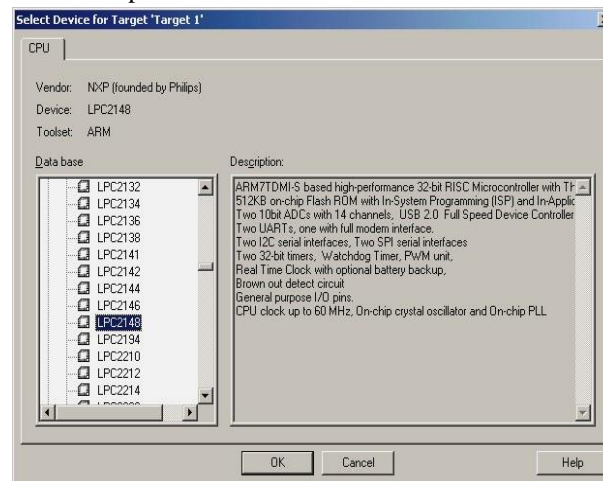


Figure 4.1: Selecting the ARM LPC2148.

Keil is used for writing embedded C programs. Embedded C is a high level programming language, in which many aspects of the ANSI C programming language are included in it. Here the Standard libraries are enhanced to address the peculiarities of an embedded target processor. At first we have to create a source file in C or assembler, after that we have to compile it, and then the linker is used to create an absolute object module suitable for the in-circuit



emulator. Then add the hex file to the microcontroller for output.

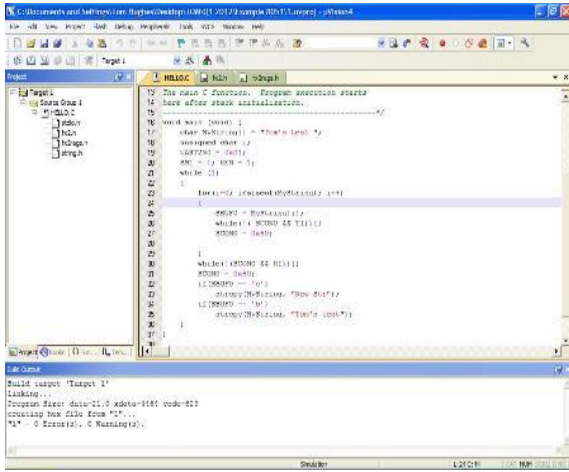


Figure 4.2: Compiling the code

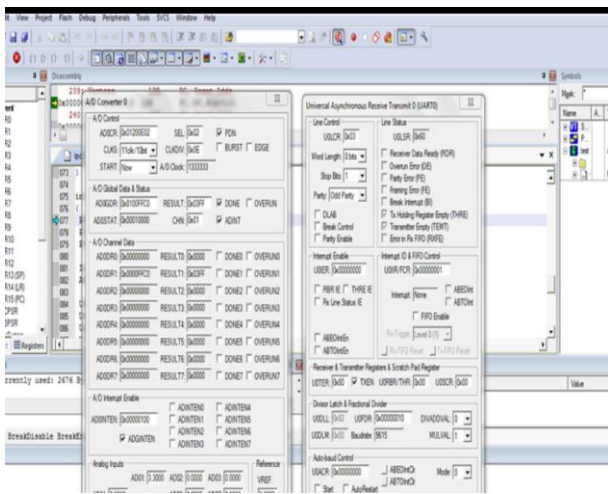


Figure 4.3: Simulation result of configured ADC0 using keilµVision4 of LPC2148.

**V. PROJECT IMPLEMENTATION**

An embedded controller is implemented by using four sets of modules, i.e. the heartbeat sensing module, eye blink, alcohol and vibration sensing module. To measure the heart rate, first we will detect the heart beat and counts the pulses for one minute to get the BPM. Sensor works on a very basic principle of optoelectronics. All it takes to measure heart rate is a pair of LED and LDR which are placed parallel to each other. It then sends the corresponding signals to the master port such that an alarm is provoked by the microcontroller and further the vehicle will get slow down if the driver gets any heart stroke.

The eye blinks sensor involves measuring and controls the eye blink using an IR sensor. By monitoring the eye of a human being, we can easily determine whether he is sleeping or awake. If the driver’s eye blinking rate is less than normal, then the buzzer will be ranged in order to alert the driver. The alcohol sensor detects the concentration of

alcohol gas in the air and outputs its reading as an analog voltage.

The sensor connects to the ignition system of the car, usually prevents the car from starting, if the driver BAC is greater than 0.08mg. It accomplishes this by taking various inputs and determines whether the driver is sober enough to drive, if the range exceeds the value then vehicle won’t start at all.



Figure 5.1: Hardware design model

The vibration sensor is used for collision detection, the output of the accelerometer is in analogue form with three different output voltages each representing in the X, Y and Z direction of motion, then the corresponding signals are sent to the microcontroller and in turn commands the GSM module to send an SMS to the authorized user about the situation in the vehicle. All these data can be sent to microcontroller by using CAN protocol.

The GSM module which is connected to the microcontroller transmits the data about the driver’s health condition through SMS, and further GPS receiver is used to detect to vehicle location. All the data values can be shown on the LCD, which displays all the values of the sensors.

**VI.CONCLUSION**

This project is implemented in two sections. First one runs with ARM as master node and another as normal ARM data acquisition node to which sensors are connected. Communications between two nodes are accomplished through High Speed CAN communication. Sensors connected are Heartbeat, Eye blink, Alcohol sensor and Vibration sensors. The master node collects all this information through CAN network and stores in three sessions. To acquire the results, respective session switches are provided in the master node. These results can be monitored on display.

**VII.FUTURE ENHANCEMENT**

There is always a chance to improve any system as research & development, it is an endless process. The following implementations can be done in future.

1. Can be implemented in Robotic Applications.
2. Can be used in large vehicles like Trucks and buses.
3. Can be implemented in Aircraft and aerospace electronics.

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