BEE 525: EMBEDDED SYSTEMS - PROJECT

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Accident Avoidance System

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1. Introduction

1.1 Abstract

Road accidents have been a leading cause of many unwanted consequences. Ranging from drunk and distracted driving to fatigue and visual impairment, most road accidents occur because of some fault or the other of the driver or occupants of the vehicle. As per the report on "Road Accidents in India, 2011" by the Ministry of Transport and Highways, Government of India, approximately every 11th person out of 100,000 died in a road accident and further, every 37th person was injured in one, making it an alarming situation for a completely unnecessary cause of death. The above survey also concluded that in 77.5 percent of the cases, the driver of the vehicle was at fault. The situation makes it a necessity to target the root cause of road accidents in order to avoid them. While car manufacturers include a system for avoiding damages to the driver and the vehicle, no real steps have been taken to actually avoid accidents. "Road Accident Prevention Unit" is a step forward in this stead. **This design monitors the driver's state using multiple sensors and looks for triggers that can cause accidents, such as alcohol in the driver's breath and driver fatigue or distraction.** When an alert situation is detected, the system informs the driver and tries to alert him. Eye blink Sensor & Alcohol detection are the vital and of great importance from the perspective of passenger safety and traffic safety. **As the name indicates, this project is about advanced technologies in cars for making it more intelligent and interactive for avoiding accidents on roads. This paper shows the new fatigue detection algorithms & techniques using eye blink, alcohol, impact, gas, etc. sensors.** In this technique the fatigue will be detected immediately and regular traps the events driver and third party. Through this project, we propose an intelligent car system for accident prevention and making the world a much better and safe place to live.

1.2 Background and Motivation

"*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.

Automobiles are one of the primary sources of transportation around the world. When Henry Ford made Cars affordable to all people, it triggered the Industrial Revolution in the world. Such is the impact of Cars in the human society and economy. There are about 71.9 million cars sold every year all over the world.

Driving provides ease of access at your own convenience, offers flexibility, and a cheaper, fast alternative of transportation compared to biking, walking and grabbing a taxi on a daily basis. Despite these advantages, there are also considerations and responsibilities that comes with this luxury. Importantly, there are two major concerns.

1. **Pollution**
   Burning fossil fuels by cars causes pollution and degradation of natural resources. Car manufacturers have come up with less polluting cars with better engines. Technology, nowadays, are popularly incorporated in the car industries, such as electric and hybrid vehicles.

2. **Safety**
   Automotive safety is very important as far as humans are concerned. Both passenger and pedestrian safety have to be assured. Car manufacturers are spending millions to make the cars defect free. Every car is equipped with high tech safety systems like Air Bags, Collision Avoidance Steering, Rear view camera tracker, Automatic braking, Lane Change Detection etc.

Vehicle accidents are most common if the driving is inadequate. These happen on most factors if the driver is drowsy or if he is alcoholic. Driver's drowsiness is recognized as an important factor in the vehicle accidents. It was demonstrated that driving performance deteriorates with increased drowsiness with resulting crashes constituting more than 20% of all vehicle accidents. But the life lost once cannot be re-winded. Advanced technology offers some hope to avoid these up to some extent.

A driver who falls asleep at the wheel loses control of the vehicle, an action which often results in a crash with either another vehicle or stationary objects. In order to prevent these devastating accidents, the state of drowsiness of the driver should be monitored.
Studies say that, the major percentage of the Car accidents occur due to driver drowsiness. Monitoring the Driver Alertness, help in reducing minor as well as major accidents which occur because of the drowsiness of the driver. When driver is sleeping, his eyes would be closed for a few seconds, even while he is driving. The driver monitoring system senses this and alerts the driver in many ways, which can be through sound, voice or vibration of steering wheel.

Another factor which leads to accident is the addiction to alcoholism. Alcohol is one of the leading causes of accidents, leading to many injuries and deaths. Because alcohol is a depressant, it slows down the brain and affects the body's responses. People who have been drinking are more likely to take risks, further increasing the likelihood of accidents. Accident victims who have been drinking suffer more serious injuries than those who haven't. Alcohol may also hinder recovery from injury, as it affects a number of the body's responses, including circulation and the immune system.

1.3 Deliverables

Following the end of our project, we will be demonstrating a fully embedded system with a mini car, including sensors that will detect alcohol and sleep deprivation. Since the ARM microcontroller is the brain of the system, all code will be included in the appendix of this report upon completion of the project. They will be properly formatted, utilizing appropriate IDE, which in our case, is the IAR Workbench. For alcohol detection, should the driver have an alcohol reading above the programmed threshold, a notification will be sent to the driver and will therefore, lock the car to prevent further use and promote safety for the driver and all civilians. As for sleep detection, an IR sensor is utilized to measure the blinking rate of the driver. If the eyes have been closed for more than a certain time, this will indicate fatigue, and will immediately ping a notification (i.e., alarm).

1. Description of Project – Implementation Strategy

The Tier-1 level description consists of the overall block diagram of the expected system and flowcharts showing the control flow.

2.1 Top level diagrams and System Flowcharts

The Block Diagram of the Implementation criteria which we have followed for the Project is shown in the figure below.

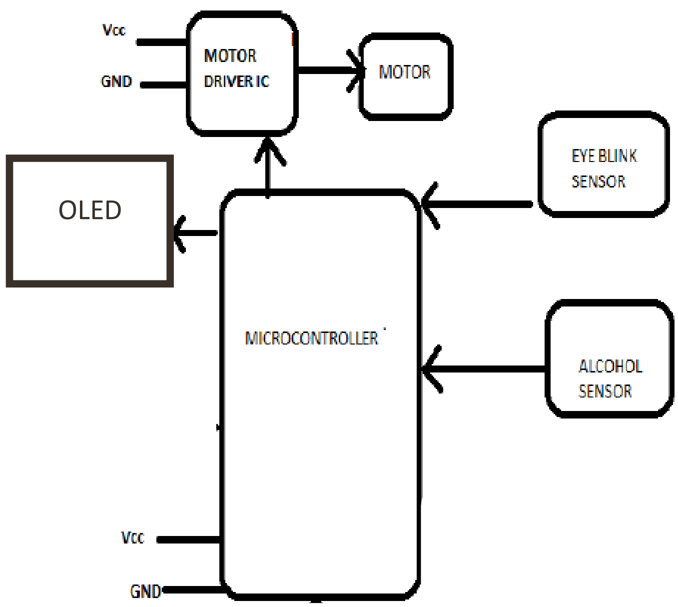


Figure 1: Block Diagram of the proposed system

The Flow chart showing the overall working of the expected system is shown in the figure below. The proposed system consists of three modules for the safety of the passengers: sleep detection system and alcohol detection system.

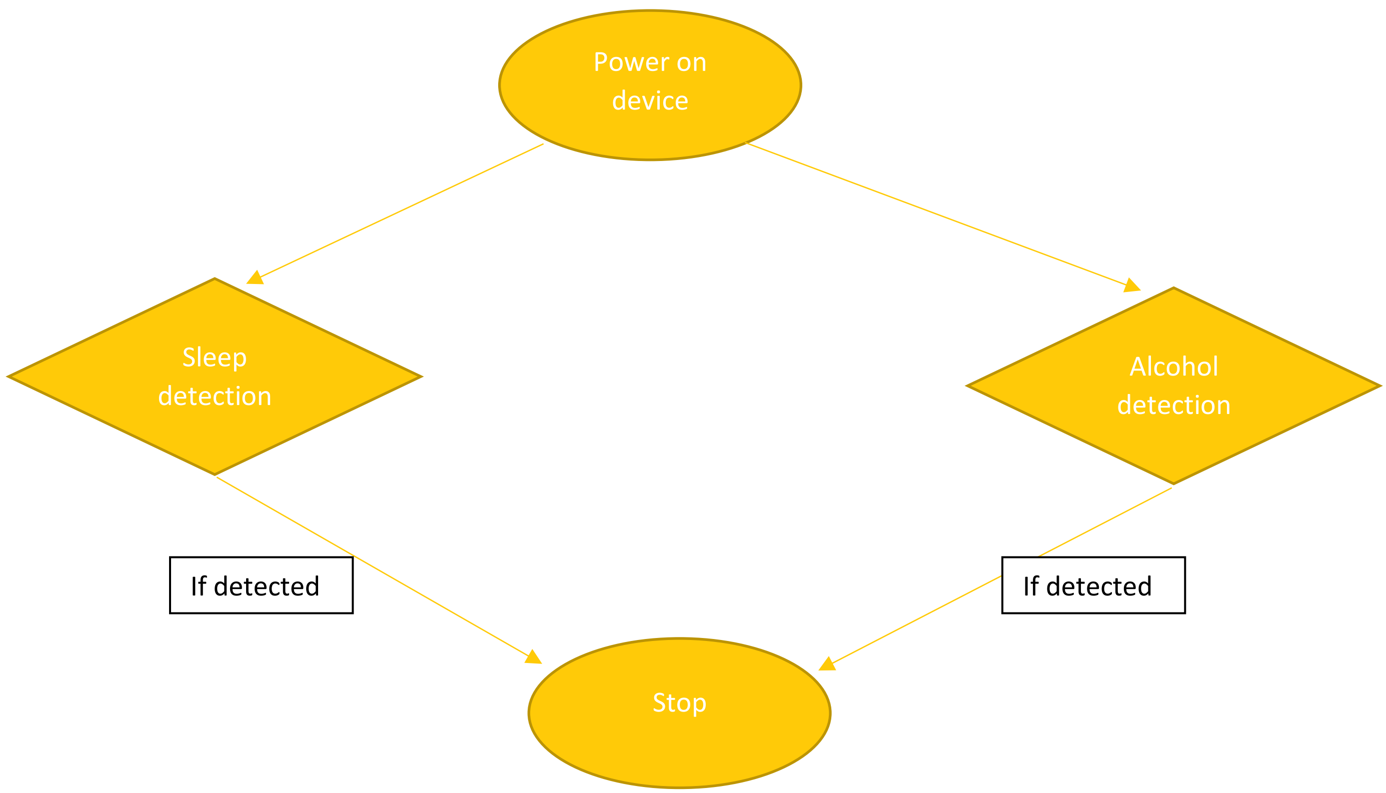


Figure 2: Flow chart indicating the working of the proposed system

3. List of Components Required

The components to be used for the proposed system includes the following.

- *Tiva C Series EK-TM4C123G LaunchPad*
- *LM 358 comparator*
- *L293D Motor driver IC*
- *IR Sensor, Photodiode*
- *Alcohol gas sensor MQ3*
- *Resistors*
- *OLED*

4. Alcohol Detection System

As per the US government of Federal laws, drinking and driving causes around 10,000 car accidents every year. To avoid these kinds of road accidents, the US Government have decided to implement a system called Driver Alcohol Detection System for Safety (DADSS). MQ-3 gas sensor (alcohol sensor) is suitable for detecting alcohol content from the breath. The surface of the sensor is sensitive to various alcoholic concentrations. It detects the alcohol from the rider's breath; the resistance value drops lead to change in voltage (Temperature variation occurs). Generally, the illegal consumption of alcohol during driving is 0.08mg/L as per the government act. Threshold can be adjusted using variable resistor.

This part of our project includes automatic sampling of exhaled air of the air from the surrounding and detecting the alcohol content in it to provide the result.

Figure 3: A method of alcohol detection from driver's exhalation

The alcohol gas sensor detects the concentration of alcohol gas in the air and outputs its reading as an analog voltage. The concentration sensing range of 0.04 mg/L to 4 mg/L is suitable for breathalyzers (the legal limit of breath alcohol concentration, or BrAC, in most US states is 0.08 grams per 210 liters, or 0.38 mg/L). The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V

4.1 Basic Design and Operation

The Alcohol Detector will analyze alcohol content in the air and then send an analog signal to the microprocessor for analysis. The Alcohol Detector will consist of three main areas:

- The alcohol detector sensor circuitry
- The PIC16F877A microcontroller
- OLED display circuitry

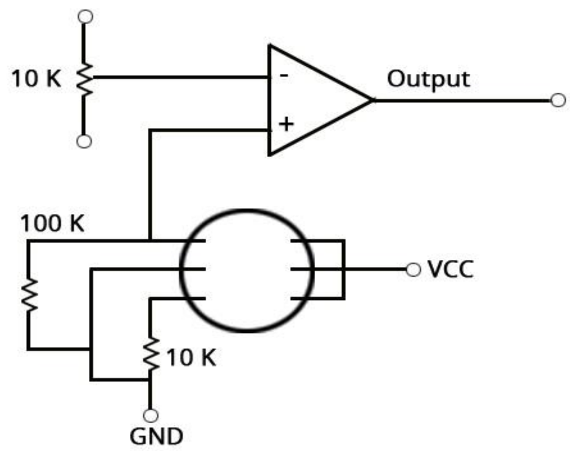


Figure 4: Circuit Diagram of Alcohol Detection system

The alcohol gas sensor detects the concentration of alcohol gas in the air and output its reading as an analog voltage. When a user exhales into the alcohol sensor, any ethanol present in their breath is oxidized to acetic acid, an organic acid. The resulting chemical reaction will produce an electrical current. The difference of potential produced by this reaction is measured, processed, and displayed as an approximation of overall blood alcohol content.

The alcohol detector circuitry consists of the MQ-3 alcohol sensor, one 10k ohm potentiometer, one 10k load resistor, two 1000 ohm resistors a 3300 ohm resister and a 100 ohm. The output of the MQ-3 alcohol sensor is regulated by the 10k potentiometer. The output of the MQ-3 sensor is connected to a voltage divider (Floyd), two 1000 ohm and a 3300 ohms resister in series; each section of the divider is connected to one of three inputs on the microcontroller.

4.2 Components Required

4.2.1 MQ3 Alcohol Gas Sensor

Description

The MQ-3 alcohol sensor, (Figure 5) is the sensor used for this project. It detects the concentration of alcohol gas in the surrounding air. It then output its reading as an analog voltage. The Sensor has a sensing range of 0.05 mg/L to 10 mg/L. The legal BAC in Canada is 0.08 grams per 210 litres, or 0.38 mg/L ("Blood Alcohol Levels"). The sensor is very sensitive to alcoholic content present and has an appropriate range of detection. The response time for measuring in alcohol content is quick and it can operate at temperatures from -10 to 50°C. The MQ-3 senor meets the criteria required to allow it to serve as the sensor for this project.

Figure 5: Alcohol Gas Sensor MQ 3

MQ-3 Sensor Operation

The MQ-3 has six contacts as shown in Figure 6. There is no polarization on the sensor so either contacts A or B could be used interchangeably as Vcc and Ground. The contacts labeled as H are the contacts for the internal heating system.

The internal heating system is a small tube made of aluminum oxide and tin dioxide. Inside this tube, there are heating coils which produce the heat. These coils can draw up to 150mA of current. The alumina tube is covered with the tin dioxide, SnO_2, embedded between the SnO_2 and the alumina tube is an Aurum electrode. When heated, the SnO_2 become a semiconductor and produces movable electrons. These movable electrons allow for the follow of more current. When alcohol molecules contact the electrode, the alcohol chemically changes into acetic acid and produces a flow of current within the tube. The more alcohol present the more current is produced.

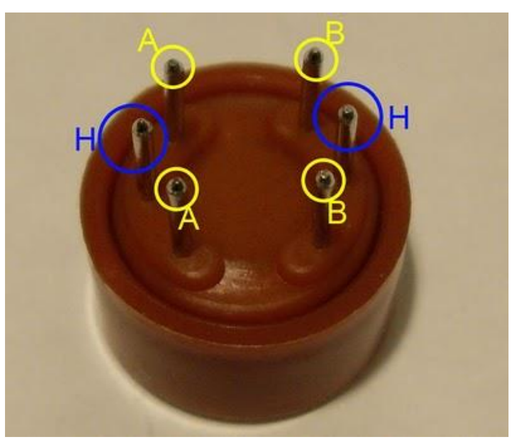


Figure 6: MQ-3 Contacts

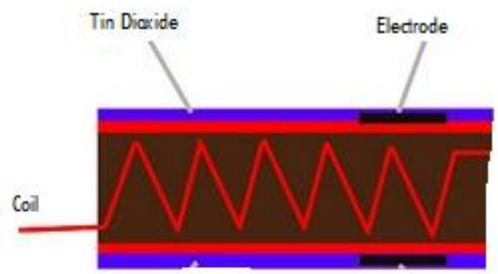


Figure 7: Heating Tube

The current however is not what is measured when measuring the output, what is measured is the voltage between the output of the sensor and the load resistor. Also inside the sensor there is a variable resistor across contacts A and B. The resistance between the contacts A and B will vary depending on the amount of alcohol present. As the amount of alcohol increase, the internal resistance will decrease and thus the voltage at the output will increase. This voltage is the analog signal transmitted to the microcontroller.

MQ Carrier Board

The MQ carrier board is a printed circuit board or PCB. This PCB is compatible with all MQ gas Sensor models and reduces the six contacts to an easier to manage layout of three pins. The three pins are Vcc, Ground and Output. Depending on your choice of positioning of the MQ sensor on the PCB, it will connect both A contacts to the Output pin and A side H contact to Ground, and both B contacts and B side H contact to Vcc.

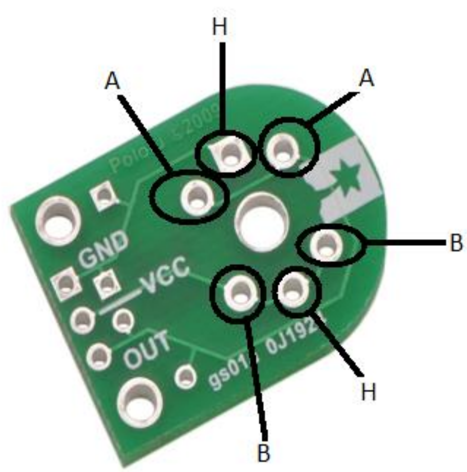


Figure 8: MQ3 Sensor Carrier Board

MQ3 Dimensions

- 16.8mm diameter
- 9.3 mm height without the pins

The details data sheet of MQ3 sensor is provided in the Appendix A.

4.2.2 LM358 Comparator

Description:

The LM358 consist of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltage. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifier, DC gain blocks and all the conventional OP-AMP circuits which now can be easily implemented in single power supply systems.

Features:

- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100dB
- Wide Power Supply Range: LM358 3V~32V (or ±1.5V~ 16V)
- Input Common Mode Voltage Range Includes Ground
- Large Output Voltage Swing: 0V DC to Vcc -1.5V DC
- Power Drain Suitable for Battery Operation.

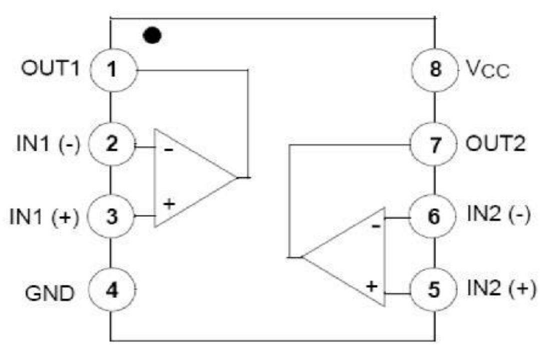


Figure 9: LM358 Pin Diagram

5. Sleep Alert System

The figure below shows the Sleep detection circuit used in the Project. This part of our project involves measure and control of the eye blink using IR sensor. The IR transmitter is used to transmit the infrared rays in our eyes. The IR receiver is used to receive the reflected infrared rays from our eyes. If the eyes are closed it means the output of IR receiver is high otherwise the IR receiver output is low. This to know the eye is closing or opening position of the eyes. This output is given to comparator to indicate the final output.

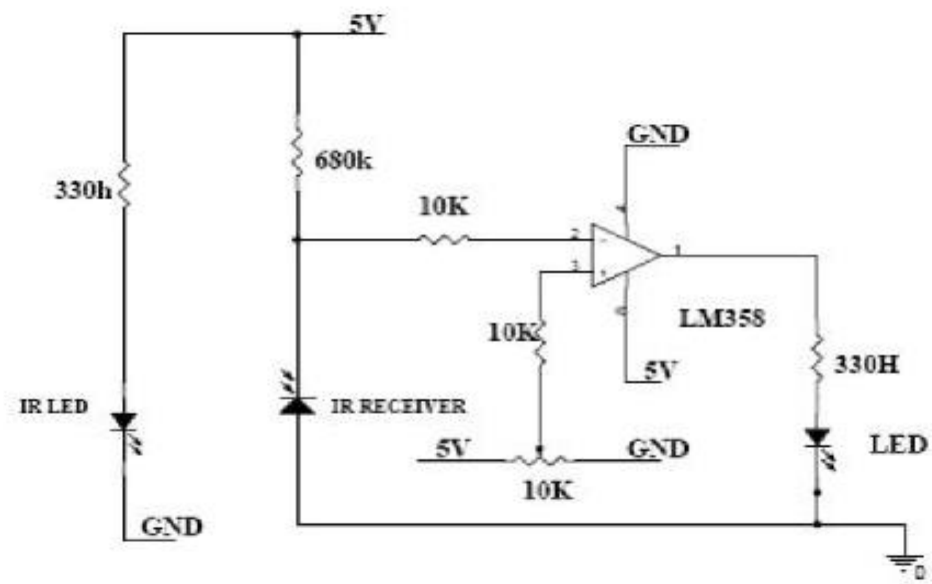


Figure 10: Circuit Diagram of the Sleep Detection System

5.1 Working

Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly, IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

The transmitted signal is given to IR transmitter whenever the signal is high, the IR transmitter LED is conducting it passes the IR rays to the receiver. The IR receiver is connected to the comparator. The comparator is constructed with LM 358 operational amplifier. In the comparator circuit the reference voltage is given to inverting input terminal. The non-inverting input terminal is connected to the IR receiver. When the IR rays are interrupted between the IR transmitter and receiver, the IR receiver is not conducting. So, the comparator's non inverting input terminal voltage is higher than inverting input. Now the comparator output is in the range of +5V. This voltage is given to microcontroller or PC.

When IR transmitter passes the rays to receiver, the IR receiver is conducting because, the non-inverting input voltage is lower than inverting input. Now the comparator output is GND so the output is given to microcontroller or PC. This circuit is mainly used to for counting application, intruder detector etc.

5.2 Components Required

5.2.1 Infrared Sensors

Description

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. It is also capable of measuring heat of an object and detecting motion. Infrared waves are not visible to the human eye.

In the electromagnetic spectrum, infrared radiation is the region having wavelengths longer than visible light wavelengths, but shorter than microwaves. The infrared region is approximately demarcated from 0.75 to 1000µm. The wavelength region from 0.75 to 3µm is termed as near infrared, the region from 3 to 6µm is termed mid-infrared, and the region higher than 6µm is termed as far infrared.

Infrared technology is found in many of our everyday products. For example, TV has an IR detector for interpreting the signal from the remote control. Key benefits of infrared sensors include low power requirements, simple circuitry, and their portable feature.

Types of Infra-Red Sensors

Infra-red sensors are broadly classified into two types:

- Thermal infrared sensors – These use infrared energy as heat. Their photo sensitivity is independent of wavelength. Thermal detectors do not require cooling; however, they have slow response times and low detection capability.
- Quantum infrared sensors – These provide higher detection performance and faster response speed. Their photo sensitivity is dependent on wavelength. Quantum detectors have to be cooled so as to obtain accurate measurements. The only exception is for detectors that are used in the near infrared region.

Principles of Operation

IR Sensors work by using a specific light sensor to detect a select light wavelength in the Infra-Red (IR) spectrum. By using an LED which produces light at the same wavelength as what the sensor is looking for, you can look at the intensity of the received light. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. This results in a large jump in the intensity, which we already know can be detected using a threshold. Figure 4 shows the visual description of the working of IR Sensor.

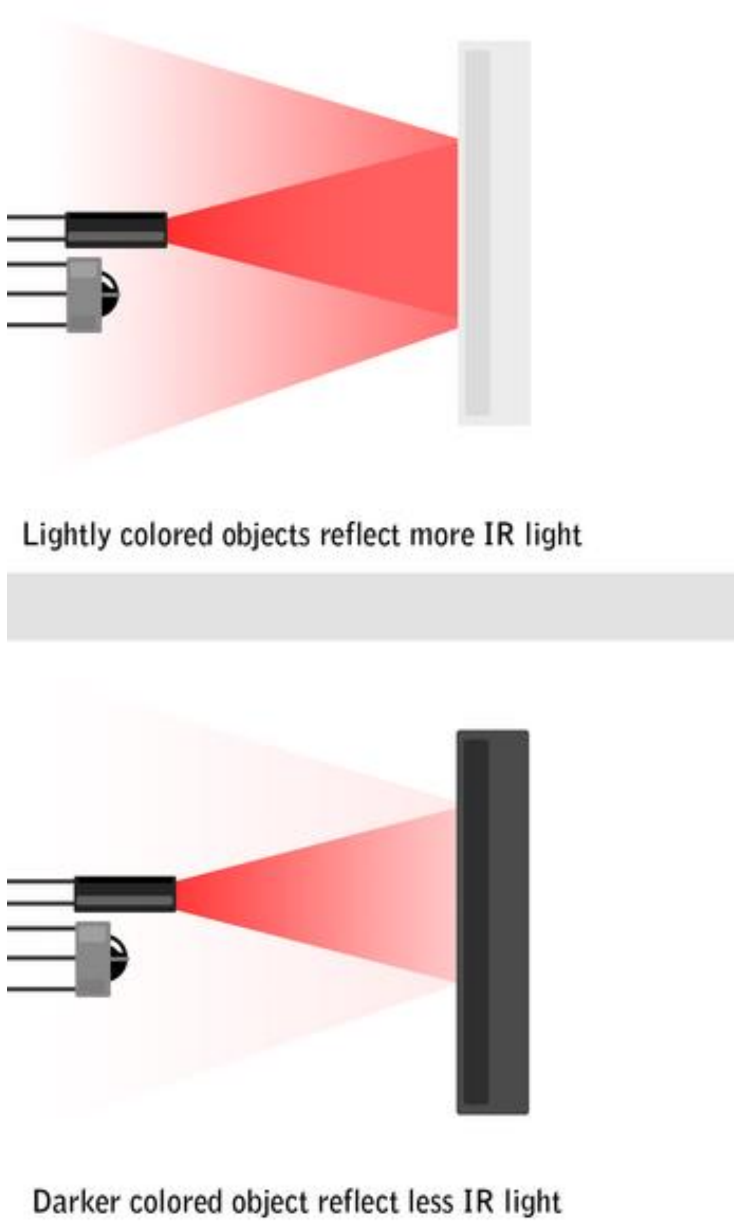


Figure 11: IR Sensor - Working

6. Description of Project – Control Strategy

6.1 Identification of Microcontroller that will be used

The selection of the controlling device solely depends on the speed and accuracy with which the instructions can be executed. As stated before, it needs to be versatile in nature and should be able to handle a whole cornucopia of functions. It is obvious that the job of a controlling device will be best performed by a suitable microcontroller. Owing to the welcomed simplicity in installation and exceptional veracity in performance, an ARM microcontroller proves to be a good choice.

Why choose an ARM?

Package, price and peripheral support are some of the most extremely important factors when choosing which controller to use for any design. However, the performance, power consumption and the overall development cost of the whole system will also have a large impact on the success of the project. Choosing an ARM provides designers with access to a huge range of third party development tools, operating systems and software. Furthermore, we will experience the power of a scalable architecture to ensure our investment in software development is protected should we wish to move to higher performance ARM controllers in future. The ARM controller provides designers with a range of solutions for applications across the full performance spectrum. Moreover there are many advantages for using ARM and they are explained in detail in the upcoming sections.

ARM is a family of modified Harvard architecture microcontrollers made by Texas Instruments. In the early days before its premiere, ARM stood for **Acorn RISC Machines**, where the type of microprocessor is designed based on Reduction Instruction Set Computer. As time progressed, ARM emerged as an independent company, replacing the ARM acronym with **Advanced RISC Machines**. Currently, it is the industry's leading provider of embedded RISC microcontrollers. We are utilizing Tiva C Series TM4C123G LaunchPad Evaluation Kit, which encompasses the ARM microcontroller, shown in Figure #. It is designed around an ARM Cortex-M processor core, providing a high-performance, low-cost platform. The overall development cost of the entire system is also an additional advantage compared to available microcontrollers in the market. Additionally, it delivers outstanding computational performance and exceptional system response to interrupts.

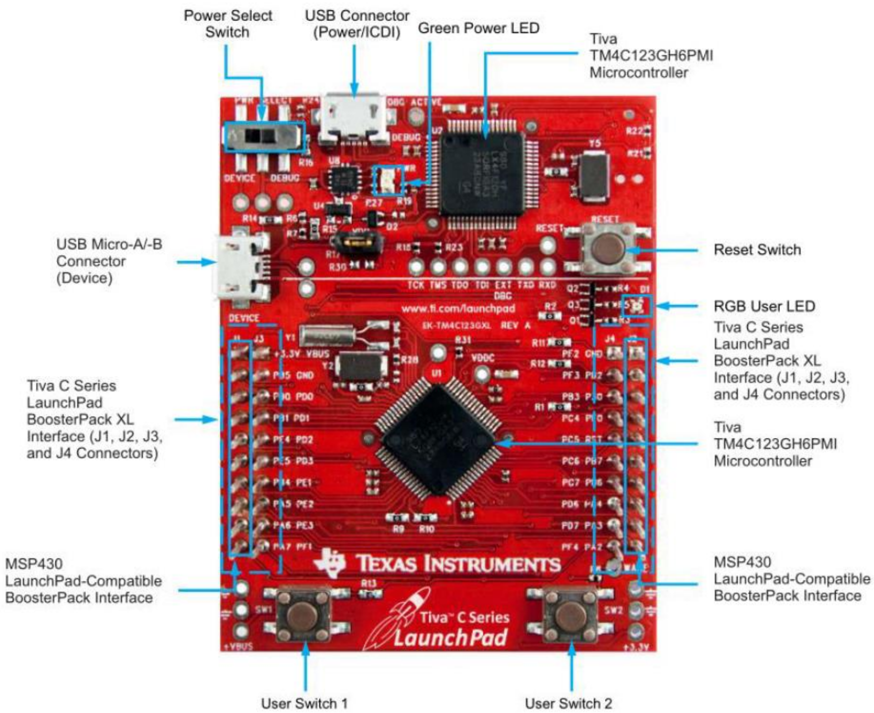


Figure 12: Tiva C Series EK-TM4C123G LaunchPad

The TM4C123GH6PM microcontroller pin diagram is shown in the Figure below.

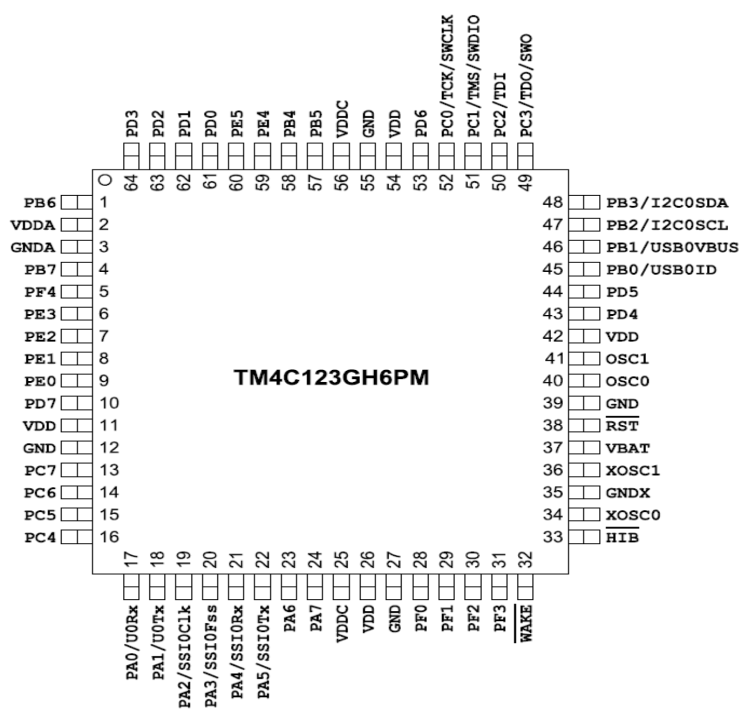


Figure 13: 64-Pin LQFP Package Pin Diagram of TM4C123GH6PM

ARM Core Architecture

The ARM architecture is characterized by its multiple attributes. These include the following:

- Separates instruction memory and data memory (Harvard Architecture)
- Outstanding processing performance combined with fast interrupt handling
- Enhanced system debug with extensive breakpoint and trace capabilities
- Deterministic, high performance interrupt handling for time-critical applications
- Ultra-low power consumption with integrated sleep modes
- Efficient processor core, system and memories
- Unaligned data access, enabling data to be efficiently packed into memory

ARM Controller Performance

RISC is implied in the name, where it stands for **Reduced Instruction Set Computer**, in comparison to its opposite, CISC (**Complex Instruction Set Computer**). The RISC design system is comprised of a simplified, yet highly-optimized instruction set, providing a much higher performance when combined with the microprocessor's architecture. This enables an efficient rate of cycles per instruction in terms of execution. Depending on its use, it can operate at a higher speed where it can perform more millions of instructions per second, or MIPS. When it comes to organization, RISC entails pipelined execution and possible single cycle execution.

Many of the advantages of RISC includes the following:

- Smaller set of instructions
- Smaller die sizes
- High clock rate with single cycle
- Freedom to choose how to use the space on a microprocessor

Advantages of ARM

The ARM architecture have the following advantages:

- Simple pipeline and instruction set
- RISC architecture
- Low power consumption
- Low cost
- High performance interrupt handling

6.2 System Requirements and Identification of Software

Considering the project entails an ARM microcontroller, which in our case is the EK-TM4C123GXL, the IDE that will be used is IAR Workbench. It is a Swedish computer software company that offers development tools for embedded systems. This type of IDE includes C and C++ compilers, debuggers, and other advanced tools to promote developing and debugging firmware. This suits well for our project since we will be using Embedded C Language. Another option to use is Keil Workbench. Regardless of which IDE is used, they are both compatible with the ARM microcontroller, requiring Embedded C Language. With the appropriate pin settings, and reading the manual, this will prepare us how to integrate the ARM microcontroller with the Workbench using C language.

7. Motor Driver IC

A motor driver IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver ICs act as an interface between microprocessors in robots and the motors in the robot. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge.

H-bridge is the simplest circuit for controlling a low current rated motor. For this tutorial we will be referring the motor driver IC as L293D only. L293D has 16 pins, they are comprised as follows:

- Ground Pins – 4
- Input Pins – 4
- Output Pins – 4
- Enable pins - 2
- Voltage Pins - 2

Motor Driver ICs are primarily used in autonomous robotics only. Also most microprocessors operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltages and current. Thus current cannot be supplied to the motors from the microprocessor. This is the primary need for the motor driver IC.

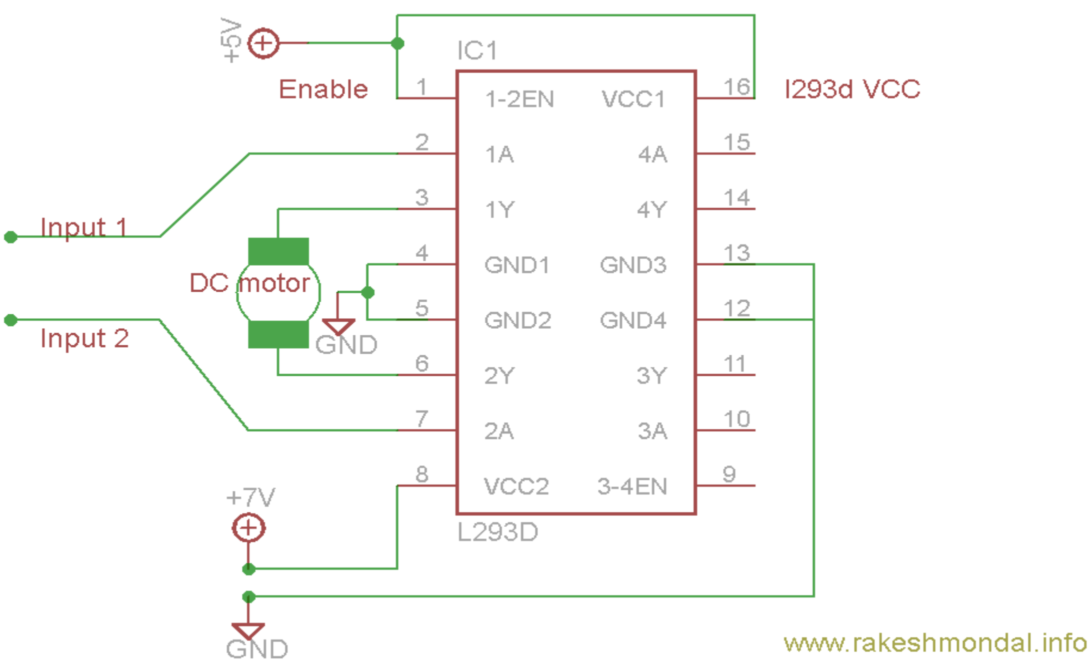


Figure 14: Motor Drive IC Circuit Diagram

7.1 Operation

The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D and the other is used to apply voltage to the motors. The L293D switches it output signal as per the input received from the microprocessor. For Example: If the microprocessor sends a 1(digital high) to the Input Pin of L293D, then the L293D transmits a 1(digital high) to the motor from its Output Pin. An important thing to note is that the L293D simply transmits the signal it receives. It does not change the signal in any case.

The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge.

H-bridge is the simplest circuit for controlling a low current rated motor. The Theory for working of a H-bridge is given below.

7.2 Working of H Bridge

H-bridge is given this name because it can be modelled as four switches on the corners of 'H'. The basic diagram of H-bridge is given below:

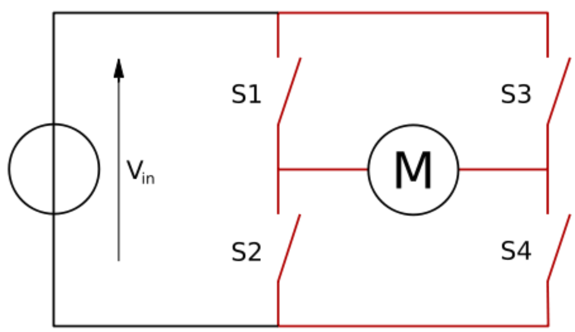


Figure 15: H-Bridge Basic Diagram

In the given diagram, the arrow on the left points to the higher potential side of the input voltage of the circuit. Now if the switches **S1** & **S4** are kept in a **closed** position while the switches **S2** & **S3** are kept in an **open** position meaning that the circuit gets shorted across the switches **S1** &**S4**. This creates a path for the current to flow, starting from the V input to switch **S1** to the **motor**, then to switch **S4** and then the exiting from the circuit. This flow of the current would make the motor turn in one direction. The direction of motion of the motor can be clockwise or anti-clockwise, this is because the rotation of the motor depends upon the connection of the terminals of the motor with the switches.

For simplicity, let's assume that in this condition the motor rotates in a clockwise direction. Now, when **S3** and **S2** are **closed** then and **S1** and **S4** are kept **open** then the current flows from the other direction and the motor will now definitely rotate in counter-clockwise direction.

When **S1** and **S3** are closed and **S2** and **S4** are **open** then the **'STALL'** condition will occur (The motor will break). When the motor is applied positive voltage on both sides then the voltage from both the sides brings the motor shaft to a halt. This is termed as ***Stall Condition.***

Pin No.	Pin Characteristics
1	Enable 1-2, when this is HIGH the left part of the IC will work and when it is low the left part won't work. So, this is the Master Control pin for the left part of IC
2	INPUT 1, when this pin is HIGH the current will flow though output 1
3	OUTPUT 1, this pin should be connected to one of the terminal of motor
4,5	GND, ground pins
6	OUTPUT 2, this pin should be connected to one of the terminal of motor
7	INPUT 2, when this pin is HIGH the current will flow though output 2
8	VC, this is the voltage which will be supplied to the motor. So, if you are driving 12 V DC motors then make sure that this pin is supplied with 12 V
16	VSS, this is the power source to the IC. So, this pin should be supplied with 5 V
15	INPUT 4, when this pin is HIGH the current will flow though output 4
14	OUTPUT 4, this pin should be connected to one of the terminal of motor
13,12	GND, ground pins
11	OUTPUT 3, this pin should be connected to one of the terminal of motor
10	INPUT 3, when this pin is HIGH the current will flow though output 3
9	Enable 3-4, when this is HIGH the right part of the IC will work and when it is low the right part won't work. So, this is the Master Control pin for the right part of IC

Table 3 : Pin characteristics of Motor Driver IC

Pin 1	Pin 2	Pin 7	Function
High	**High**	**Low**	**Turn Anti-clockwise (Reverse)**
High	**Low**	**High**	**Turn clockwise (Forward)**
High	**High**	**High**	**Stop**
High	**Low**	**Low**	**Stop**
Low	**X**	**X**	**Stop**

Table 4 : Truth Table of Motor Driver IC Operation States

8. OLED Display Board

An organic light-emitting diode (OLED) is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. This layer of organic semiconductor is situated between two electrodes; typically, at least one of these electrodes is transparent. OLEDs are used to create digital displays in devices such as television screens, computer monitors, portable systems such as mobile phones, handheld game consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications.[1][2][3]

There are two main families of OLED: those based on small molecules and those employing polymers. Adding mobile ions to an OLED creates a light-emitting electrochemical cell (LEC) which has a slightly different mode of operation. OLED displays can use either passive-matrix (PMOLED) or active-matrix (AMOLED) addressing schemes. Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes.

An OLED display works without a backlight; thus, it can display deep black levels and can be thinner and lighter than a liquid crystal display (LCD). In low ambient light conditions (such as a dark room), an OLED screen can achieve a higher contrast ratio than an LCD, regardless of whether the LCD uses cold cathode fluorescent lamps or an LED backlight.

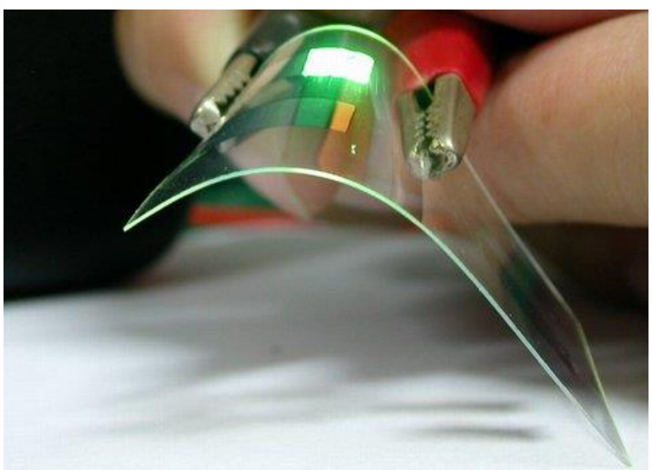


Figure 16: Demonstration of a Flexible OLED device

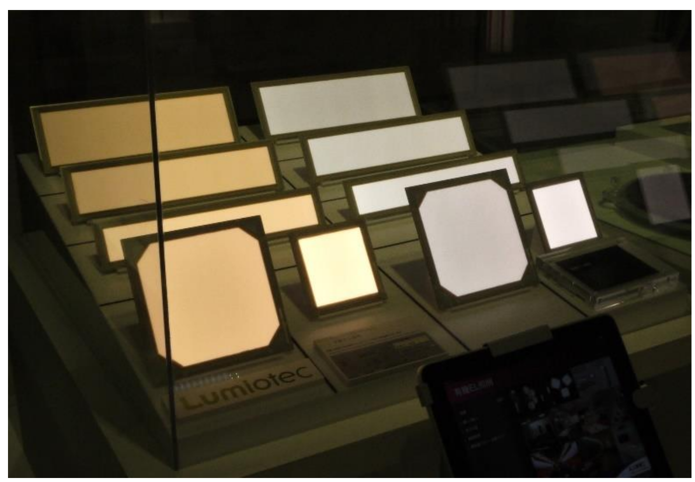


Figure 17: Prototype OLED lighting Panels

8.1 Working Principle

A typical OLED is composed of a layer of organic materials situated between two electrodes, the anode and cathode, all deposited on a substrate. The organic molecules are electrically conductive as a result of delocalization of pi electrons caused by conjugation over part or all of the molecule. These materials have conductivity levels ranging from insulators to conductors, and are therefore considered organic semiconductors. The highest occupied and lowest unoccupied molecular orbitals (HOMO and LUMO) of organic semiconductors are analogous to the valence and conduction bands of inorganic semiconductors.

Originally, the most basic polymer OLEDs consisted of a single organic layer. One example was the first light-emitting device synthesised by J. H. Burroughes *et al.*, which involved a single layer of poly(p-phenylene vinylene). However multilayer OLEDs can be fabricated with two or more layers in order to improve device efficiency. As well as conductive properties, different materials may be chosen to aid charge injection at electrodes by providing a more gradual electronic profile, or block a charge from reaching the opposite electrode and being wasted. Many modern OLEDs incorporate a simple bilayer structure, consisting of a conductive layer and an emissive layer. More recent developments in OLED architecture improves quantum efficiency (up to 19%) by using a graded heterojunction. In the graded heterojunction architecture, the composition of hole and electron-transport materials varies continuously within the emissive layer with a dopant emitter. The graded heterojunction architecture combines the benefits of both conventional architectures by improving charge injection while simultaneously balancing charge transport within the emissive region.

During operation, a voltage is applied across the OLED such that the anode is positive with respect to the cathode. Anodes are picked based upon the quality of their optical transparency, electrical conductivity, and chemical stability. A current of electrons flows through the device from cathode to anode, as electrons are injected into the LUMO of the organic layer at the cathode and withdrawn from the HOMO at the anode. This latter process may also be described as the injection of electron holes into the HOMO. Electrostatic forces bring the electrons and the holes towards each other and they recombine forming an exciton, a bound state of the electron and hole. This happens closer to the emissive layer, because in organic semiconductors holes are generally more mobile than electrons. The decay of this excited state results in a relaxation of the energy levels of the electron, accompanied by emission of radiation whose frequency is in the visible region. The frequency of this radiation depends on the band gap of the material, in this case the difference in energy between the HOMO and LUMO.

As electrons and holes are fermions with half integer spin, an exciton may either be in a singlet state or a triplet state depending on how the spins of the electron and hole have been combined. Statistically three triplet excitons will be formed for each singlet exciton. Decay from triplet states (phosphorescence) is spin forbidden, increasing the timescale of the transition and limiting the internal efficiency of fluorescent devices. Phosphorescent organic light-emitting diodes make use of spin–orbit interactions to facilitate intersystem crossing between singlet and triplet states, thus obtaining emission from both singlet and triplet states and improving the internal efficiency.

Indium tin oxide (ITO) is commonly used as the anode material. It is transparent to visible light and has a high work function which promotes injection of holes into the HOMO level of the organic layer. A typical conductive layer may consist of PEDOT:PSS as the HOMO level of this material generally lies between the work function of ITO and the HOMO of other commonly used polymers, reducing the energy barriers for hole injection. Metals such as barium and calcium are often used for the cathode as they have low work functions which promote injection of electrons into the LUMO of the organic layer. Such metals are reactive, so they require a capping layer of aluminum to avoid degradation.

Experimental research has proven that the properties of the anode, specifically the anode/hole transport layer (HTL) interface topography plays a major role in the efficiency, performance, and lifetime of organic light emitting diodes. Imperfections in the surface of the anode decrease anode-organic film interface adhesion, increase electrical resistance, and allow for more frequent formation of non-emissive dark spots in the OLED material adversely affecting lifetime. Mechanisms to decrease anode roughness for ITO/glass substrates include the use of thin films and self-assembled monolayers. Also, alternative substrates and anode materials are being considered to increase OLED performance and lifetime. Possible examples include single crystal sapphire substrates treated with gold (Au) film anodes yielding lower work functions, operating voltages, electrical resistance values, and increasing lifetime of OLEDs.

Single carrier devices are typically used to study the kinetics and charge transport mechanisms of an organic material and can be useful when trying to study energy transfer processes. As current through the device is composed of only one type of charge carrier, either electrons or holes, recombination does not occur and no light is emitted. For example, electron only devices can be obtained by replacing ITO with a lower work function metal which increases the energy barrier of hole injection. Similarly, hole only devices can be made by using a cathode made solely of aluminum, resulting in an energy barrier too large for efficient electron injection.

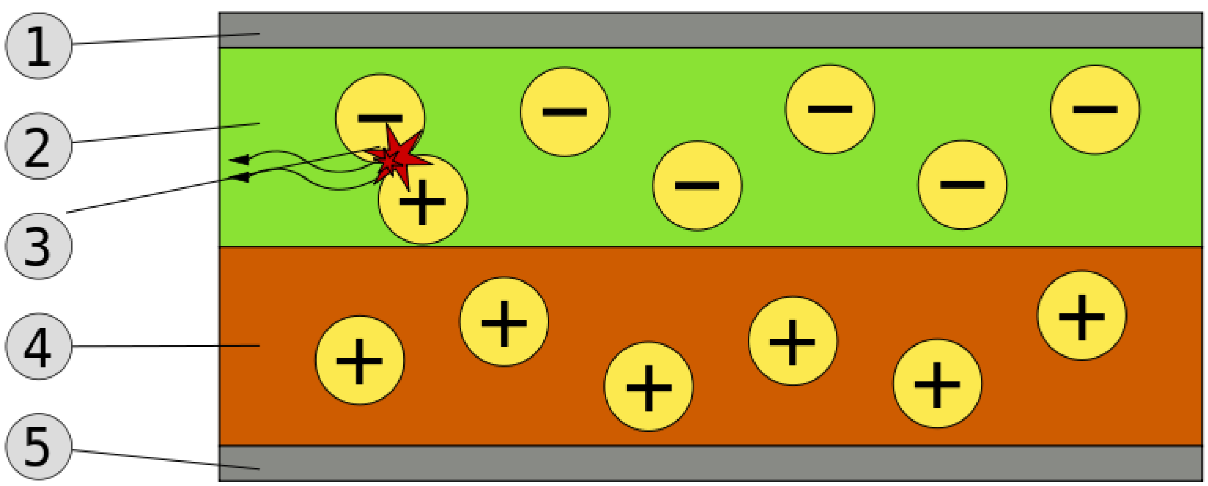


Figure 18: Schematic of a bilayer OLED:

1. Cathode (−)

2. Emissive Layer

3. Emission of radiation

4. Conductive Layer

5. Anode (+)

8.2 Advantages

The different manufacturing process of OLEDs lends itself to several advantages over flat panel displays made with LCD technology.

Lower cost in the future

OLEDs can be printed onto any suitable substrate by an inkjet printer or even by screen printing, theoretically making them cheaper to produce than LCD or plasma displays. However, fabrication of the OLED substrate is currently costlier than that of a TFT LCD, until mass production methods lower costs through scalability. Roll-to-roll vapor-deposition methods for organic devices do allow mass production of thousands of devices per minute for minimal cost; however, this technique also induces problems: devices with multiple layers can be challenging to make because of registration—lining up the different printed layers to the required degree of accuracy.

Lightweight and flexible plastic substrates

OLED displays can be fabricated on flexible plastic substrates, leading to the possible fabrication of flexible organic light-emitting diodes for other new applications, such as roll-up displays embedded in fabrics or clothing. If a substrate like polyethylene terephthalate (PET) can be used, the displays may be produced inexpensively. Furthermore, plastic substrates are shatter-resistant, unlike the glass displays used in LCD devices.

Better picture quality

OLEDs enable a greater artificial contrast ratio (both dynamic and static) and wider viewing angle compared to LCDs, because OLED pixels emit light directly. Furthermore, OLED pixel colors appear correct and unshifted, even as the viewing angle approaches 90° from the normal.

Better power efficiency and thickness

LCDs filter the light emitted from a backlight, allowing a small fraction of light through. Thus, they cannot show true black. However, an inactive OLED element does not produce light or consume power, allowing true blacks. Removing the backlight also makes OLEDs lighter because some substrates are not needed. When looking at top-emitting OLEDs, thickness also plays a role when talking about index match layers (IMLs). Emission intensity is enhanced when the IML thickness is 1.3–2.5 nm. The refractive value and the matching of the optical IMLs property, including the device structure parameters, also enhance the emission intensity at these thicknesses.

Response time

OLEDs also have a much faster response time than an LCD. Using response time compensation technologies, the fastest modern LCDs can reach response times as low as 1 ms for their fastest color transition, and are capable of refresh frequencies as high as 240Hz. According to LG, OLED response times are up to 1,000 times faster than LCD, putting conservative estimates at under 10 μs (0.01 ms), which could theoretically accommodate refresh frequencies approaching 100 kHz (100,000 Hz). Due to their extremely fast response time, OLED displays can also be easily designed to be strobed, creating an effect similar to CRT flicker in order to avoid the sample-and-hold behavior seen on both LCDs and some OLED displays, which creates the perception of motion blur.

9. Future Developments

The present system can be subjected to modifications so that its performance can be enhanced. New technologies which are on the pipeline to assure safety for vehicles are discussed below.

9.1 Alcohol Detection Technologies

TISSUE SPECTROMETRY (SKIN SENSORS)

Tissue Spectrometry (Skin Alcohol Sensors)

Skin sensors shine light through the skin to determine blood alcohol concentration (BAC). These devices estimate BAC by measuring how much light is absorbed at a particular wavelength from a beam of Near-Infrared (NIR) reflected from the subject's skin. Skin sensors are touch-based and as such require skin contact.. Future versions are expected to work with skin on the hand, such as a finger or hand scan. Lumidigm, a New Mexico-based firm, is developing a biometric fingerprint device capable of detecting alcohol levels. Toyota has begun developing a steering wheel that can detect alcohol thru the pores of our skin.

OFFSET/DISTANT SPECTROMETRY (ALCOHOL SNIFFERS)

Unlike skin sensors, sniffer systems do not require skin contact and can operate at a distance. Sniffers placed in the vicinity of a driver measure the driver's breath or tissue for alcohol. This technology is small enough to be placed into law enforcement flashlights that can determine if a driver has alcohol on his or her breath or if a drink has alcohol in it.

Nissan's Alcohol "Sniffer" Monitors Driver's Breath

TRANSDERMAL (SWEAT) SENSORS

Transdermal systems are touch-sensors that can continuously monitor drivers' (or non-drivers') BAC levels. When a person drinks alcohol, traces of alcohol are present in the person's sweat. These devices measure BAC based on how much alcohol is present in perspiration.

Currently, sweat sensors are body-worn perspiration monitors. One brand is the Secure Continuous Remote Alcohol Monitoring (SCRAM) device, prescribed by many U.S. courts for serious alcohol offenders. The SCRAM device is worn around the ankle.

Another transdermal alcohol detection device is the WrisTAS (Wrist Transdermal Alcohol Sensor).

While sweat sensors have primarily been used in body-worn devices, this technology can be transported to vehicles.Drivers would touch a part of the car with their hands, such as the steering wheel, gear shift or radio to detect

BAC. Nissan has already integrated a sweat sensor into the gear shift of a concept car.

9.2 Sleep Detection Technologies

Many researchers have worked in recent years on systems for driver inattention detection, focused mainly in drowsiness, with a broad range of technique. Several EU projects (AWAKE, PREVENT) and projects conducted by NHTSA are aimed at reducing accident tolls due to driver drowsiness and have had a significant contribution to understanding how drowsiness affects the driver performance and how these accidents can be prevented. Systems have been developed to predict the drowsiness level of drivers using a computer vision system to measure derived metric PERCLOS . There are also multisensory systems based on other driver inputs for predicting drowsiness.

Brain studies couple EEG with electrooculography (EOG), which detects eye movements, and electromyogram (EMG) that monitors muscular tone. These measurements provide the best data for detection of drowsiness, and as such have been used by several drowsiness detection systems, usually in conjunction with heart rate and breathing rate. The problem of these techniques is that theyare intrusive to the subject. They require electrodes and other sensors to be placed on the head, face and chest as in Figure which may annoy the driver. They also need to be carefully placed: installing the electrodes to obtain an EEG requires external help and takes a few minutes, and medical equipment is always expensive.

2. A driver wearing a helmet with electrodes for EEG.

A driver's state of attention can also be characterized using indirect measurements and contact-less sensors. Lateral position of the vehicle inside the lane, steering wheel movements and time-to-line crossing are commonly used, and some commercial systems have been developed. These systems do not monitor the driver's condition, but its driving.

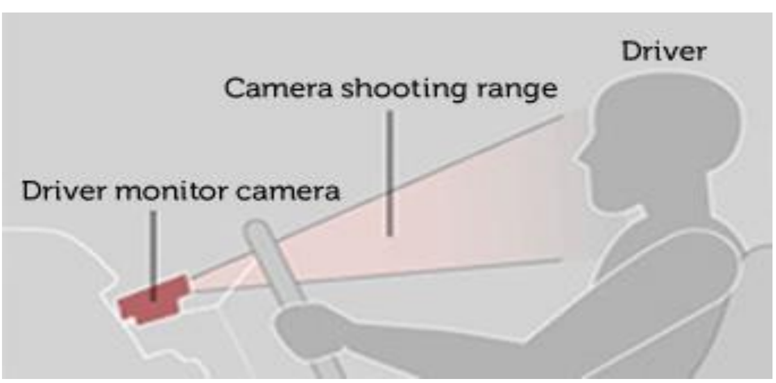
- Volvo Cars introduced its Driver Alert Control system which uses a camera, a number of sensors and a central unit to monitor the movements ofthe car within the road lane, to assess whether the driver is drowsy .
- Mercedes-Benz has introduced a similar system (ATTENTION ASSIST) in its newest E-Class vehicles.

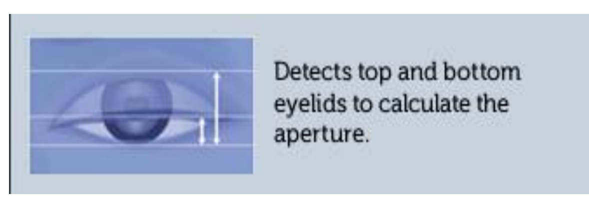
Fig. 4. Mercedes-benz's attention assist. *Images from emercedesbenz.com*

3. Volvo's driver alert control. *images from volvo cars*

A Drowsy Driver Detection System has been developed, using a non-intrusive machine vision based concepts. The system uses a small monochrome security camera that point directly towards the driver's face and monitors the driver's eyes in order to detect fatigue. In such a case when fatigue is detected, a warning signal is issued to alert the driver. This report describes how to find the eyes, and also how to determine if the eyes are open or closed. The algorithm developed is unique to any currently published papers, which was a primary objective of the project. The system deals with using information obtained for the binary version of the image to find the edges of the face, which narrows the area of where the eyes may exist.

Once the face area is found, the eyes are found by computing the horizontal averages in the area. Taking into account the knowledge that eye regions in the face present great intensity changes, the eyes are located by finding the significant intensity changes in the face. Once the eyes are located, measuring the distances between the intensity changes in the eye area determine whether the eyes are open or closed. A large distance corresponds to eye closure. If the eyes are found closed for 5 consecutive frames, the system draws the conclusion that the driver is falling asleep and issues a warning signal. The system is also able to detect when the eyes cannot be found, and works under reasonable lighting conditions.





10. Conclusion

A simple model of a driver friendly car was made incorporating two modules to avoid human triggered accidents and they are Alcohol Detection System and Sleep Alert System. Various sensors were used for the implementation such as the MQ3 alcohol gas sensor for alcohol detection and an Infrared sensor for sleep detection. The implementation of this project was done mainly using low cost methodologies. This simple model can be implemented in a large scale by improving the efficiency and reliability of the system in future.

11. References

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Appendix A– MQ3 Gas Sensor Data Sheet

TECHNICAL DATA MQ-3 GAS SENSOR

FEATURES

* High sensitivity to alcohol and small sensitivity to Benzine .
* Fast response and High sensitivity
* Stable and long life
* Simple drive circuit

APPLICATION

They are suitable for alcohol checker, Breathalyser.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
R_L	Load resistance	200KΩ	
R_H	Heater resistance	33Ω±5%	Room Tem
P_H	Heating consumption	less than 750mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-10℃-50℃	
Tas	Storage Tem	-20℃-70℃	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Remarks
Rs	Sensing Resistance	1MΩ - 8 MΩ (0.4mg/L alcohol)	Detecting concentration scope: 0.05mg/L—10mg/L Alcohol
α (0.4/1 mg/L)	Concentration slope rate	≤0.6	
Standard detecting condition	Temp: 20℃±2℃ Vc:5V±0.1 Humidity: 65%±5% Vh: 5V±0.1		
Preheat time	Over 24 hour		

D. Structure and configuration, basic measuring circuit

	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

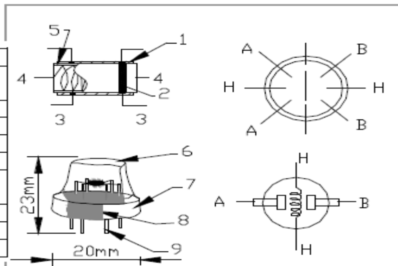


Fig. 1

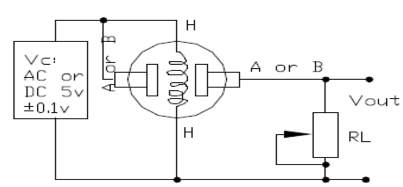
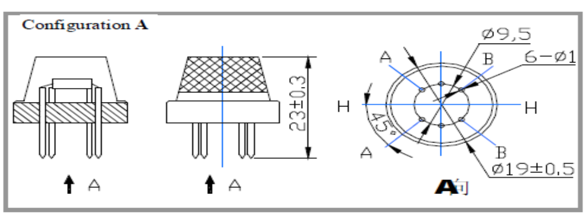
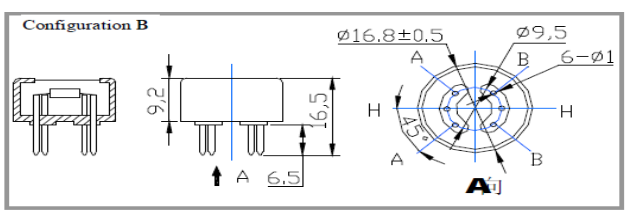


Fig.2





TEL: 86-371- 67169070 67169080 FAX: 86-371-67169090 E-mail: sales@hwsensor.com

Structure and configuration of MQ-3 gas sensor is shown as Fig. 1 (Configuration A or B), sensor composed by micro AL_2O_3 ceramic tube, Tin Dioxide (SnO_2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-3 have 6 pin ,4 of them are used to fetch signals, and other 2 are used for providing heating current.

Electric parameter measurement circuit is shown as Fig.2

E. Sensitivity characteristic curve

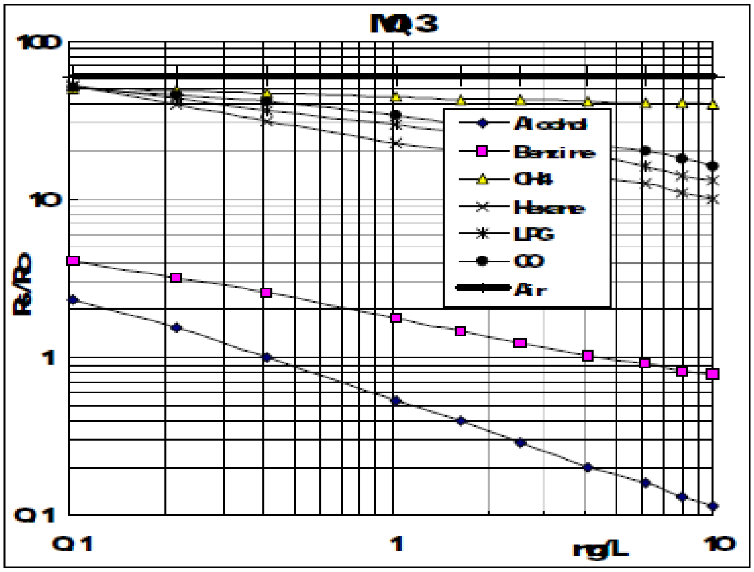


Fig.3 is shows the typical sensitivity characteristics of the MQ-3 for several gases.
in their: Temp: 20℃、
Humidity: 65%、
O_2 concentration 21%
RL=200k Ω
Ro: sensor resistance at 0.4mg/L of Alcohol in the clean air.
Rs:sensor resistance at various concentrations of gases.

Fig.2 sensitivity characteristics of the MQ-3

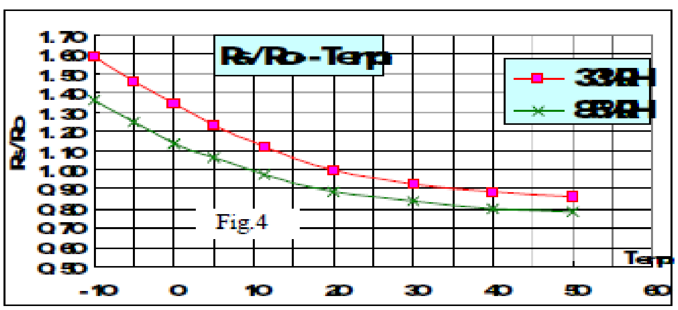


Fig.4 is shows the typical dependence of the MQ-3 on temperature and humidity.
Ro: sensor resistance at 0.4mg/L of Alcohol in air at 33%RH and 20 ℃
Rs: sensor resistance at 0.4mg/L of Alcohol at different temperatures and humidities.

SENSITVITY ADJUSTMENT

Resistance value of MQ-3 is difference to various kinds and various concentration gases. So,When using this components, sensitivity adjustment is very necessary. we recommend that you calibrate the detector for 0.4mg/L (approximately 200ppm) of Alcohol concentration in air and use value of Load resistancethat(R_L) about 200 KΩ (100KΩ to 470 KΩ).

When accurately measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence.

Appendix B – Motor Driver IC Data Sheet

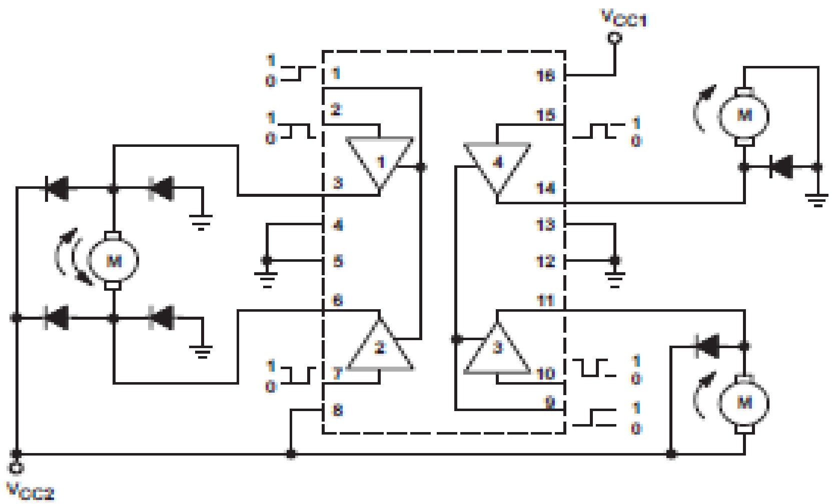
description/ordering information (continued)

On the L293, external high-speed output clamp diodes should be used for inductive transient suppression.

A V_{CC1} terminal, separate from V_{CC2}, is provided for the logic inputs to minimize device power dissipation.

The L293and L293D are characterized for operation from 0°C to 70°C.

block diagram



NOTE: Output diodes are internal in L293D.

FUNCTION TABLE
(each driver)

INPUTS†		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

H = high level, L = low level, X = irrelevant,
Z = high impedance (off)
† In the thermal shutdown mode, the output is in the high-impedance state, regardless of the input levels.