

Department of Electrical & Computer Engineering

*COEN 6711*

*MICROPROCESSOR AND ITS APPLICATIONS.*

Project Report on

**“Automatic Braking System”.**

Submitted to:

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**Abstract**

This project work presents an ultrasonic automatic braking system for forward collision avoidance with accelerator pedal disengagement mechanism. In our present world, safety has become important aspects of automobile design. Automation is the key, which keep the safety at our fingers. Accidents happen with the automobile vehicles which cause serious injury or even death. One common cause is the failure to apply the brakes is such critical situation or some inefficient braking system.

An automobile braking system is an important innovation to the automobile domain that can assist drivers to brake a car while avoiding imminent obstacle that could cause collision and other fatal condition. The system is based on an ultrasonic emitter and receiver that helps in producing and receiving the ultrasonic waves to determine the distance between a car and an obstacle. This can be used to provide some level of safety in an automobile system. This project will focus on a design that can help stop the automobile by disabling the acceleration and optionally turning away from the direction of the obstacle.

There are ultrasonic sensors that will be mounted on the vehicle and the signals are transmitted constantly from it and the reflected signals are received back from the obstacles if any. A decoder module in the firmware converts the received signals into relative distance between the obstacle and vehicle. A safety module monitors the calculated distance and if the distance measured crosses above defined safety limit, with the help of a Motor driver which is integrated to the FRDM-KL25Z to drive the vehicle, the FRDM-KL25Z firmware will stop the motor driving function and disable acceleration.

The core component and the brain is the Microprocessor Arm Cortex M0+ KL25Z from Arm, which interfaces with other part of the system to provide the desired functionality. Design, procedures and implementation details are discussed and further improvement are suggested.

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**Introduction**

The automobiles of today are much more intelligent than it used to be years back. The early automobiles worked based on timing the ignition of the spark using mechanical distributors. This method of coordinating the timing of the spark delivery when the fuel and air mixture were compressed in the engine cylinders are not efficient enough. Due to the fixed nature of the mechanical setup, it was very difficult to get optimum fuel combustion resulting in the most efficient power output.

Fortunately, the use of real time software in the automobile industries have brought about new innovation and features that have several benefits to all stakeholders. An example is the ability of an automobile to adapt to environmental conditions such as air density in order to increase the combustion efficiently subsequently improving fuel economy.

Based on the current fast development in the areas of real time embedded systems, there has been a tremendous increase in the number of intelligent Automobiles, as they have become a major tool of transportation in the current society. Automobile safety system becomes very important as its number soars nowadays.

The act of driving requires a high level of co-ordinations and sometimes human error do occur, for example, reversing accidents are very common. This can be avoided if there the system has a braking system that alerts the driver about the distance from obstacles in the reversing vehicle pathway.

There are three (3) common kinds of system used in the Automobile system for detecting the distance, ultrasonic system, infrared system and radar system. These three systems have their individual pros and cons.

Ultrasonic systems are widely used in many applications, whose strength lies in its wide range of detection and anti-interference. Besides, the component is cheap with low production cost, making its price more widely acceptable. Its weakness lies in the valid radius of detection that is rather limited and in its accuracy in obstacle detection that is the lowest among the three. Ultrasonic systems are generally used in middle and low-end cars.

The infrared system can have long-distance detection and accuracy that is better to that of ultrasonic. However, they have very high manufacturing cost and underperformance in detection before mirror obstacles. Therefore, this one is used with the ultrasonic system in high-end cars.

The radar system outperforms the other two distance-detecting tool. This radar system has a more advantage in terms of detection radius, range and anti-interference. However, manufacturers for home-use and commercial automobiles do not prefer its high manufacturing cost. Thus the radar type of system is more commonly used in military vehicles. One of the prevalent use of the ultrasonic system was in ultrasonic reversing warning system which help to ensure a safety distance of vehicles, it continuously monitor the distance between the source car and obstacle, if the distance is less than the safety distance, it will activate an alarm to alert the driver.

For this project, the Automatic braking system is based on the Ultrasonic systems. The main target of the ultrasonic braking system is that an automobile should automatically brake when the sensors sense the obstacle.

**Aim and Objectives.**

The aim of this project is to implement an Automatic Braking system based on the Arm cortex m0+ FRDM-KL25Z, as the core of the system, this microcontroller will receive a signal about an obstacle detected by an ultrasonic Sensor, stop motor driving function, and disable acceleration through the integrated motor Driver IC. The system is required to stop the vehicle in a smallest possible distance. It should not slip or skid during the braking of the automobile. Of importance is that, there is little or no effort on the part of the driver to achieve this functionality. Specific objective in the project includes.

1. To explore in detailed all the features and functionality of FRDM-KL25Z,
2. Understanding of the interfacing of FRDM-KL25Z, with other important component
3. To develop a safety car braking system using ultrasonic sensor system interfacing with the microcontroller of cortex M0+
4. To develop an automobile braking system which will improve the safety of transportation even with less human attention
5. Top present a Final report and Demonstration of the working prototype

Important features and benefits of the system are highlighted below

Avoid road accident

Safety of Drivers

stop the vehicle in the shortest distance

prevent the damage of vehicle body

quickly sense of obstruction

Act instantaneously in case of emergency

operates with the least effort from the drivers.

**Motivation**

The use of various types of automobile has become an integral part of human activity. The movement of people from one location to another is a typical scenario of the daily use of automobile. Thus the number of automobiles is increasing day by day. However, some uncertain and unpredictable situations such as accidents do occur from time to time in an increasing manner. Accidents do occur every time and everywhere and can result into severe damages, serious injury or even cause death. These accidents are usually cause by several factors but of important is the influence caused by delay of the driver to hit the brake or a failure in the part of the braking system. This project is designed to develop a new system that can solve this problem where drivers may not brake manually but the vehicles can stop automatically when detecting obstacles.

Presently, some automobile has a reverse alarm system where when the car gets too close to an object an alarm is triggered which warns the driver about an object close behind. But this feature has produced lot of problems and is prone to human error. This project will have enhanced the feature by using similar sensors but with the advantage that we have a mechanism that the car brakes automatically when an obstacle is close.

This project is about a system that can control braking system for safety. The system is required to stop the vehicle in a smallest possible distance Using ultrasonic as a ranging sensor, its function based on ultrasonic wave. After transmitting by transmitter, the wave can reflect when obstacle is detected and then received by receiver. The braking circuit’s function is to slow down or stop the car automatically after receiving signal from the sensor

**Scope of Project**

This project focus on the implementation of an ultrasonic automatic braking system for forward collision avoidance with accelerator pedal disengagement mechanism. The Arm cortex M0+ is the core of the system design and interfacing with other important component such as the sensor, Motor IC and others. Thus the project will aim at developing an ultrasonic sensor to detect the obstacle. Furthermore, the output from the ultrasonic sensor is used to drive the motor as an actuator.

**Review of literatures on Braking systems**

The Reverse Alert System was first developed by Surveillance Guard Corporation (SVG). It was the world first aftermarket automatic braking system that can be fitted to any vehicle. This system firstly fitted in Australian vehicles and has been taken extensively trialed across the passenger vehicle market, road transportation and taxi industries. This system begins with ultrasonic sensors that were fitted at rear of the vehicle. These sensors detect an object at 1.6m and a signal is sent to a solenoid located at the front of the vehicle. The solenoid is attached to a flexible cable that runs through the firewall and is attached to a universal brake pedal clamp that is fitted on the brake pedal. Subsequently, when the solenoid is activated this pulls the brake pedal -stopping the vehicle automatically.

Another important innovation in automobile system was the ABS (Anti-lock Braking System) which helps the rider gets a hassle free braking experience in muddy and watery surfaces. It applies a distributed braking and prevents skidding and wheel locking. In 1988 BMW sold for the first time electronic-hydraulic motorcycles. The first Japanese maker selling motorcycles with ABS was Honda ST1100 equipped optionally with electro-hydraulic ABS module in 1992. [9]

With the ABS, if the rider only brakes with the front or rear wheel, the braked wheels tends to lock up faster as if both brakes would have been applied. A [Combined Braking System](http://en.wikipedia.org/wiki/Combined_braking_system) (CBS) distributes the brake force also to the non-braked wheel to lower the possibility of a lock up, increase deceleration and reduce [suspension](http://en.wikipedia.org/wiki/Suspension_(motorcycle)) pitch. [10]

**Working Principles of Brake System**

A brake is a device used either to bring to rest a body which is in motion or to hold a body in the state of rest or of uniform motion against the action of eternal force or couple. Current brake systems fall into two types: drum brakes and disk brake [13]. Both have distinctive strengths and weaknesses.

**Drum brake:**

Drum brake has been used in automobiles for a long time. Its reliability and excellent braking performance have accounted for the popularity today. In drum brake, two semi-circular brake pads are inserted onto the inner wheel ring and slow or stop the car via friction between pads and wheels following the principle of leverage theory. Drum brake is mostly applied to big-tonnage cars (and mostly used in the rear wheels). Here’s the working principle: with two semi-circular brake pads in the inner ring of wheels, the drive stomps on the brake, hydraulic piston rods connected to the brake pad will put the motionless pads in contact with wheels in speedy motion and create a tremendous amount of friction force, thus reducing wheels’ rotation speed or stopping the car. Its strengths include great force of braking force and the function of automatic tightening-braking. The processing and composition of parts are relatively simple and easy to handle. Another strength is its low production cost. Its weaknesses: in the case of successive brake, the pads will be overheated by the inner wheel ring and heat-fade if such case lasts long. This will compromise the brake effect. It’s also plagued by slow response of the brake system and not suitable for high frequency braking actions. The large number of parts in drum brake system makes it a big trouble to debut and maintain the brake system.

Disk brake:

As the disk brake has its pads exposed to air in the outer ring of the wheel, heat can be well dissipated and pads won’t heat-fade with successive braking actions. So, the disk brake has a

higher level of safety and becomes the major trend (mostly used in front-wheel-driven cars).

Many disk brakes also have ABS(Anti-lock Braking System)[14] to improve its level of safety ( refers to that an air sac inside the valve body, creates friction between the wheel and

brake pad owing to its instant pressure on brake oil. The air sac then retracts and continues to

apply pressure on the brake oil. The process will go on and on. Each second may see 8-30

Hai Wang & Ronghong Xiao Automatic Car Braking System 18 occurrences of such process. This system can prevent instant wheel locking in braking and cars sideslipping or turning over caused by inertia.) Disk brake works via two brake pads located on both sides of a wheel. When the driver stomps on the brake, two pads will get closer, clamp the moving wheels and apply friction to stall the car. Strengths of this brake system include: its dissipation effect is better than that of the drum brake; in the case of successive brakes, there won’t be heat-fading; it lasts long; brake response speed is fast and suitable for high-frequency braking cases. The structure of the disk brake system is easier than that of the drum disk, thus facilitating debugging and maintenance. The weaknesses of the disk brake include: its braking force isn’t as strong as that of the drum brake; it’s hard to

mount a disk brake; moreover, the cost of disk brake is higher than that of drum brake.

1. **System Design:**

This section describes Automatic Braking System design which aims to emulate the real-world scenario of automobile collision prevention concept. To demonstrate its sophisticated and safety feature to the Target Industry, this project makes use of robot chassis Vehicle as Target Application. The Automatic Braking System comprises of three functional modules which enables it to achieve its goal. The Modules are

1. Steering Module – conducts the driver module through user interface
2. Motor Driver Module – drives the RC vehicle
3. Obstruction detection Module – detects the obstacle

All the above modules work in parallel to emulate the target scenario automatic collision prevention.

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**Steering Module:**

The primary functionality of this module is to provide user a way to control the RC vehicle. It realizes it through employing wireless technology Bluetooth. From the above figure, Steering Module encompasses below

* FRDM KL25Z (Arm Cortex M0+ Microcontroller)
* Direct software
* Bluetooth Module HC 05
* Android app

The Microcontroller controls driving Module based on the inputs from the Bluetooth module.

Direct software is a software program which works between the Bluetooth device and the

microcontroller and process the inputs from HC 05. It sits inside the motor driver software component, suitable location to direct driving software. It stops directing the motor if it receives interrupt from Obstruction detection module and disable the acceleration control from the user towards the obstacle. It prevents the acceleration until the interrupt is removed.

The Bluetooth Module is interfaced as serial device with the Microcontroller. Detailed information of interfacing Bluetooth module HC05 with microcontroller and its pin configuration is available in the Hardware interface section.

Android app, the primary user interface which gets inputs from the user and displays current condition to user. It has a glossy graphical interface with forward, left, right, reverse and stop button to get inputs of steering as shown in the figure. It also has buttons and interfaces to connect Bluetooth device and display the status. It performs so by establish wireless connection with the Bluetooth module HC 05.

**Motor Driver Module:**

This module implements the driving functionality of the Automatic Braking system. It achieves the requirements by combining software and hardware components listed below

* FRDM KL25Z (Arm Cortex M0+ Microcontroller)
* Motor driver Software
* Dual Bridge Motor Driver IC L293DNE
* Robot Chassis Vehicle

The Kl 25Z Microcontroller generates PWM signal to drive Motor Drive IC and in turn Robot Chassis Vehicle.

Motor Driver software is a software Program which manipulates the PWM signal for driving Moto driver IC in Forward, Left, Right, Reverse and Stop directions.

Motor Driver IC L293DNE takes PWM signal from KL 25Z and sends electrical signals to dc motors. It can drive two motors at the same time. Its interface to Microcontroller and the DC motors of RC vehicle can be found at Hardware interface section.

Robot chassis Vehicle emulates the automobiles from target scenario. Which is the target application here. The project concept is show cased in its motional experiments. It is powered with two dc motors to drive two wheels of the vehicle. This vehicle hosts entire components of the project components in it. The top rack of the vehicle carries the Microcontroller, Bluetooth module and Ultrasonic sensor. The bottom one contains the power supplies to motor and Microcontroller such as AA batteries and Power banks.

**Obstruction Detection Module:**

This is the core module of ABS which senses the obstacles to RC vehicle and feedbacks the obstacle detect data to Microcontroller. The Module It achieves the objective by combining software and hardware components listed below

* FRDM KL25Z (Arm Cortex M0+ Microcontroller)
* Decoder Module
* Ultrasonic Sensor HC SR04

The Microcontroller plays an important role in this module by generating trigger signals to and receiving echoed signals from Ultrasonic sensor.

Decoder Module is a software Program which reads the feedback data from Ultrasonic sensor and converts the data in seconds to meaningful distance units. It also tracks the distance data for safety minimum value. If the distance happens to be below safety minimum value it interrupts Motor driver software to brake the RC Vehicle.

Ultrasonic Sensor works on generating ultrasonic waves to detect the obstacle in front of it. As mentioned above it gets trigger signal from microcontroller to perform its operation. The generated waves travel in front till it finds an obstacle and the waves are reflected to sensor. The sensor captures the time of this process and feedback to Kl 25Z.

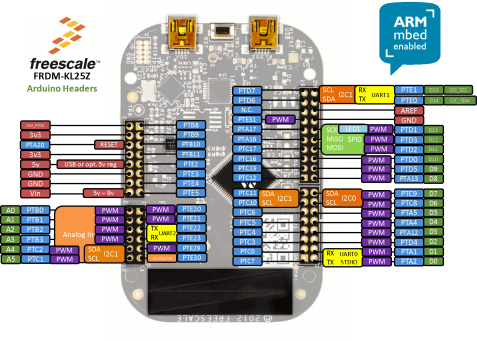
**Software Description:**

**Software Tools**

For the software, we used MBED online compiler.

Benefits of using MBED Compiler:

* USB drag and drop programming interface
* Entry-level online Compiler
* High-level peripheral abstraction
* Easy to use C/C++ SDK
* Lots of published libraries and projects

**Hardware Description:**

Some of the important activities of our implementation includes the understanding of functional behavior of the component and how they are to interface with our Microcontrollers. The implementation of the hardware and interfacing design were also crucial. Other activities were carried out in relation to testing to ensure that we are able to achieve the implementation

* **FRDM KL25Z Processor:**

The Freedom KL25Z is an ultra-low-cost development platform built on ARM® Cortex®-M0+ processor.it has very easy access to MCU I/O, battery-ready, low-power operation, a standard-based form factor with expansion board options and a built-in debug interface for flash programming and run-controller

The key Features of the Processor includes:-

* MKL25Z128VLK4 MCU – 48 MHz, 128 KB flash, 16 KB SRAM, USB OTG (FS), 80LQFP
* Capacitive touch “slider,” MMA8451Q accelerometer, tri-color LED
* Easy access to MCU I/O
* Sophisticated OpenSDA debug interface
* Mass storage device flash programming interface (default) – no tool installation required to evaluate demo apps
* P&E Multilink interface provides run-control debugging and compatibility with IDE tools
* Open-source data logging application provides an example for customer, partner and enthusiast development on the OpenSDA circuit
* mbed enabled

**HC-SR04 Ultrasonic Sensor**

The [HC-SR04](http://elecfreaks.com/store/download/HC-SR04.pdf) sensor is an ultrasonic sensor with 4 pin and generally used because of its incredible price point. Its pins are as follows:

1. Vcc (+5V DC supply)
2. Trig (TTL input, to trigger a measurement)
3. Echo (TTL output, pulse proportional to distance)
4. GND (ground)

Ultrasonic se[nsors](http://en.wikipedia.org/wiki/Alternating_current) [(also kn](http://en.wikipedia.org/wiki/Alternating_current)own as transceivers when they both send and receive, but more generally called transducers) work on a principle similar to ra[dar or](http://en.wikipedia.org/wiki/Voltage)sonar  which evaluate attributes of a target by interpreting the echo[es from radio or sound waves respectively. Ultras](http://en.wikipedia.org/wiki/Piezoelectricity)onic sensors generate high frequency sound waves and evalu[ate the echo which is received back by the sensor.](http://en.wikipedia.org/wiki/Piezoelectricity) Sensors calculate the time interval between sending the signal and rece[iving the e](http://en.wikipedia.org/wiki/Dog_whistle)cho to determine the distance to an object[.](http://en.wikipedia.org/wiki/File:Soundfield_Water_4MHz_TransducerRadius5mm.png)

Product features:

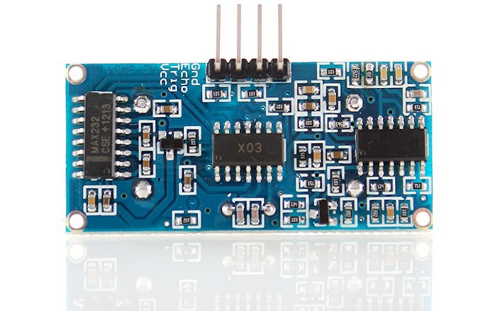
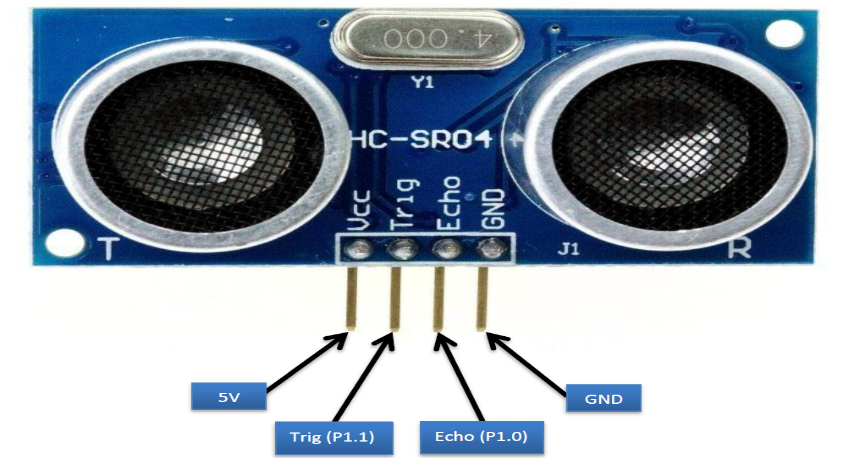
Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal,

(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.

(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

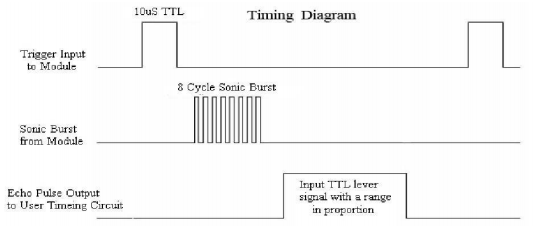
Test distance = (high level time × velocity of sound (340M/S) / 2, λ



Timing diagram:

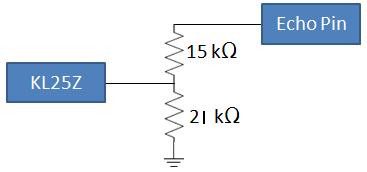
The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion.

You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time \* velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



**VOLTAGE DIVIDER**

The HC-SR04 uses TTL (5V) supply voltage and logic levels. The FRDM-KL25Z processor has a 3.3V voltage, but the board provides 5V on the header. The HC-SR04 can use 3.3V levels on the Trig signal, but provides a 5V signal on the Echo pin. To get the signal to the 3.3V level, simple voltage divider with a 21k Ohm and 15k Ohm resistor is used.



* **Robot Car Chassis kit:**

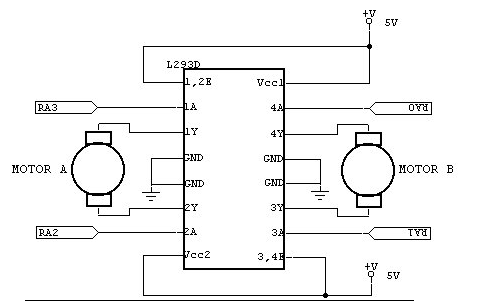
This chassis is a versatile robot platform featuring two gear motors with 65mm wheels and a rear caster for differential movements. The chassis plates are cut from acrylic with a wide variety of mounting holes for sensors, controllers, power, etc. Simply bolt the two pre-cut platforms together, attach the motors and caster and add your favorite robotics controller. This kit includes all of the parts needed to assemble the chassis as well as a 4xAA battery holder with barrel jack termination.

Functions and Features of the Car Chassis kit:-

* The Mechanical structure is simple, it is easy to install
* This car is the tachometer encoder
* With a 4 AA battery box (batteries not included)
* Can be used for distance measurement, velocity
* Can use with other devices to realize function of tracing, obstacle avoidance, distance testing, speed testing, wireless remote control , Size: 20 x 14cm (L x W) Wheel size: 6.5 x 2.7cm (Dia. x H)

Motor Driver - L293DNE

This IC Run four solenoids, two DC motors or one bi-polar or uni-polar stepper with up to 600mA per channel using the L293D. It is a high current Motor driver IC with dual H-bridge for controlling up to two motors at a time. Best for Inductive load de coupling from the main/control unit and the wide voltage range allows for an adaptive voltage range control.



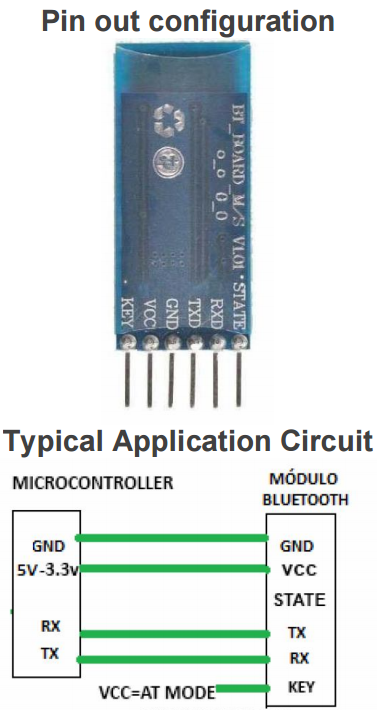


* Wide Supply-Voltage Range: **4.5 V to 36 V**.
* Separate Input-Logic Supply.
* Internal ESD Protection.
* Thermal Shutdown.
* High-Noise-Immunity Inputs.
* Output Current 1 A Per Channel (**600 mA for L293D**).
* Peak Output Current 2 A per Channel (**1.2 A for L293D**).
* Output Clamp Diodes for Inductive Transient Suppression (L293D).

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* **Bluetooth Module** :

#### HC-05- Bluetooth Module –

Operates from 3.6v to 6v, which means you can use interface this simple device to any micro controllers.  The added simplicity of the four pre-soldered connectors results in a very easy n' quick plug and play for any future projects. This device can work up to 10 meters, the voltage supplied must not exceed 6v and it is not reverse polarity protected. Comes preheat-shrink with clear coating to protect the device from anti-static discharge, dust protection and accidental shortage while maintaining an elegant look. Use this 3.6cm x 1.5cm device for any project you may have in mind and rest assure with this Bluetooth based device will consume less power than a traditional WiFi Module will! No Firmware = No Fuss, pairing code 1234 (default) and Logic Levels of RX & TX are 3.3V.

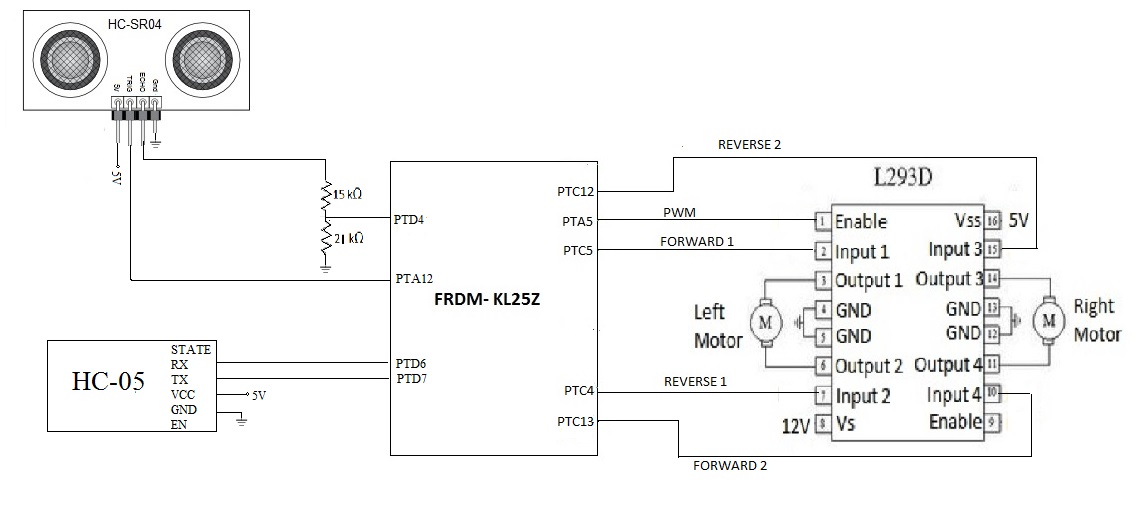
**Power Supply Units**

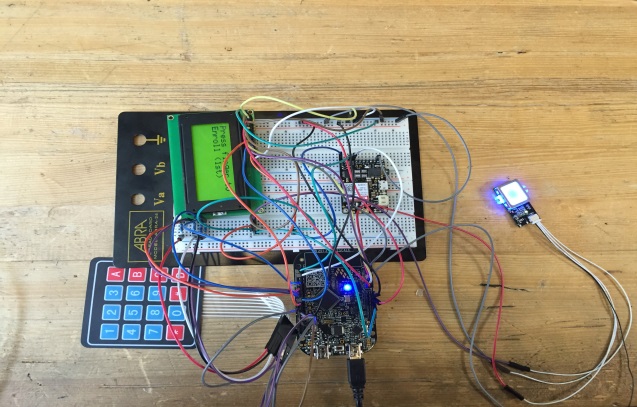
There are two main power supply sources to our automatic braking system

The a 4 -AA finger batteries which powers the Robot Car Chassis kit

The power bank, which provided power supply to Microcontroller FRDM KL25Z

**Hardware Interfacing:**

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Fingerprint sensor, GSM module, Keypad and LCD are connected to FRDM KL25Z processor. All the digital pins of LCD are connected to digital pins of the FRDM KL25Z processor. Transmitter pin of fingerprint sensor and GSM module is connected to UART receiver pin of the processor. Receiver pin of both the components is connected to UART transmitter pin of the FRDM KL25Z. All pins of the keypad are connected to digital pins of the processor. FPS, LCD display and Keypad act as user system. Fingerprints are already stored in the database of the FPS. Every time we give fingerprint as input comparison takes place with the stored fingerprints. After LCD displays valid user, a code is sent to the authorized user’s mobile number through GSM. User gets the access to the safe only after entering the valid code received from the GSM.

During the project implementation, first thing we realized was that working with fingerprint sensor and GSM module was quite challenging. As GSM itself is a project on its own and implementing in our project increased the complexity of our application. But with the positive attitude and hard work we completed the project on time.

As a team if we had researched enough on the project, components used and the software we would have been able to complete our implementation with ease and in a more efficient way.

|  |  |  |
| --- | --- | --- |
| **QUANTITY** | **DESCRIPTION** | **TOTAL AMOUNT** |
| 1 | FRDM KL25Z | $38 |
| 1 | HC-SR04 Sensor | $6 |
| 1 | Robot Car Chassis kit | $28 |
| 1 | Motor Driver - L293DNE | $7 |
| 1 | HC-05, 3.6V - 6V Bluetooth Module | $6 |
| 2 | BREADBOARD | $6 |
| 1 | Finger BATTERY | $18 |
| 50 | Wires | $9 |
| 2 | Resistors | $1 |
| 1 | Power Bank | $24 |

**Budget:**

**Testing:**

Testing is a disciplined process that consists of evaluating the application (including its components) behavior, performance, and robustness -- usually against expected criteria. Expected behavior, performance, and robustness should therefore be both formally described and measurable. Verification and Validation (V&V) activities focus on both the quality of the software/Hardware product and of the engineering process. Testing is most often regarded as a detective measure of quality, it is closely related to corrective measures such as debugging. In practice, embedded system engineers usually find it more productive to enact testing and debugging together, usually as an interactive process. Debugging literally means removing defects ("bugs").”

In our project we performed:

* Unit Testing: where we ensure that the individual parts are working correctly.
* Functional Testing: where the testing of the functions of component or system was done and the question “Can the user perform this “ was answered.
* Regression Testing: was to verify that modifications in the software or the environment have not caused any unintended adverse side effects and that the system still meets its requirements.

Hardware Testing involved testing of individual components by making use of the IEEE Labs:

* Processor: tested if it drew or delivered enough Voltage, Current, Power.
* Sensor: Connected the Ground and Vcc to the Oscilloscope and observed if a square wave was generated when the fingerprint was given as an input.

Developing simple Test cases/runs/plans helped in the Software testing which was further enhanced to perform Hardware Testing.

Bugs Found in Hardware Testing:

* Due to the misconnection of the sensor to the FRDM board, which further damaged the sensor circuit led to the Malfunctioning of the sensor leading to incorrect results. Bug reported when the sensor chip was getting overheated very quickly. Bug Fixed by replacing with a new sensor.
* Missed on testing the compatibility of the components which led to a lot of challenges and was overcome by replacing or by following an alternate method.

Bugs Found in Software Testing:

* Incorrect libraries imported on mbed led to the compilation failure. Bug fixed by importing/updating the right libraries and by modifying the code.
* Errors while declaring the functions leading to major exceptions caused the program to fail. Attention to detail fixed the bugs.
* Failed to install the PED Drivers led to the unrecognition of the COM ports on the system which held up the project for a while, as we were unable to test the program and the working of the sensor using the SDK\_DEMO test Software which needed the details of the COM ports. Installation of the necessary drivers made the work easy.

**Development Process:**

This section explains the process used in the development of software for the embedded system. The project was developed with most widely used SDLC model, Waterfall Model.

Waterfall approach was first SDLC Model used widely in Software Engineering to ensure success of the project. In "The Waterfall" approach, the whole process of software development divided into separate phases. In Waterfall model, typically, the outcome of one phase acts as the input for the next phase sequentially.

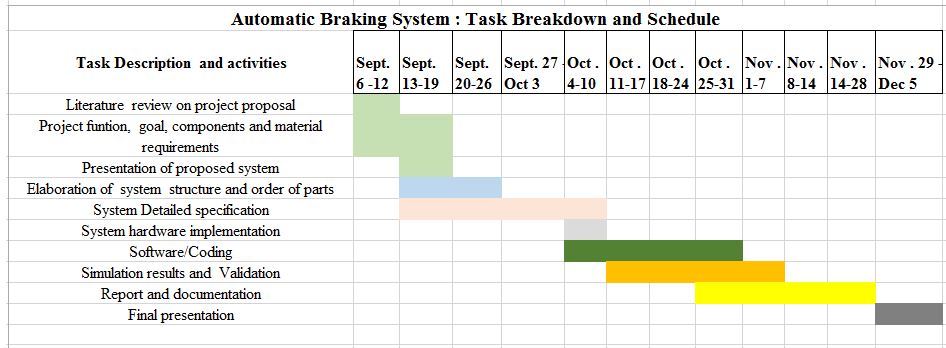
Following is a diagrammatic representation of different phases of waterfall model.



* **Requirement Gathering and analysis:** All possible requirements of the system to be developed captured in this phase and documented in a requirement specification doc.
* **System Design:** The requirement specifications from first phase studied in this phase and system design is prepared. System Design helps in specifying hardware and system requirements and helps in defining overall system architecture.
* **Implementation:** With inputs from system design, the system first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.
* **Integration and Testing:** All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
* **Deployment of system:** Once the functional and non-functional testing executed, the product is deployed in the customer environment.
* **Maintenance:** There are some issues, which come up in the client environment. To fix those issues patches are released. In addition, to enhance the product some better versions are released. Maintenance performed to deliver these changes in the customer environment.

**Project Schedule:**

The below table shows the proposed schedule that is being used to achieve the deliverables required for our Automatic Braking System. All major tasks were identified and executed on time as a Team.

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**Project Repository:**

As a requirement for the project, we decided to use a collaborative and tracking technique too so that we can easily monitor and manage the progress we were making on our project at a specific time. We are using the Github open source as our collaborative tool that gives every member an opportunity to update on the deliverables in a flexible manner. It was very helpful in achieving our goals**.**

[**https://github.com/gsanthar/Automatic-Braking-System**](https://github.com/gsanthar/Automatic-Braking-System)

**Conclusion:**

The Primary goal of this project is to design and develop Automatic Braking System, which prevents automobile mishaps. As a Final Point, this report demonstrates successful analysis, design and implementation of the Automatic Braking System with proposed requirements. It is believed that the system created will be an important safety feature in automobile industry.

This Project utilizes various innovative technologies in hardware and software design of the embedded system. This document represents project accomplishments adhering to stringent embedded system requirements such as Cost, Power and Size.

The author is satisfied that the criteria set down at the outset of the project has been fulfilled and ultimately the project has been a success.

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