BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION AND ENGINEERING

DEPARTMENT OF PHYSICS AND ENGINEERING

Name	**Nyasha Dzorani**
Registration Number	**B192862B**
Course Narration	**Final Year Project (EEN5106)**
Faculty	**Science Education and Engineering**
Supervisor	**Engineer M Takawira**
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Abstract

The scope of the system is to design and implement an automated railway gate control system as a measure of improving safety at railways crossings points. The system incorporates a microcontroller which is the brain of the system and infrared sensors for detection of the train. Servo motors are used to control boom gates and traffic lights are installed for signaling. Through the automation of this system, the occurrence of accidents at railway level crossing points will be minimized.

LIST OF ABBREVIATIONS

LCD – LIQUID CRYSTAL DISPLAY

IR – INFRARED SENSOR

LHD – LOAD HAUL DUMP

RAM – RANDOM ACCESS MEMORY

MHz – MEGA HERTZ

LED – LIGHT EMMITTING DIODE

V – VOLTAGE

A – AMPERE

F – FARADS

R – RESISTANCE

GSM –GLOBAL SYSTEM FOR MOBILE COMMUNICATION

Table of Contents

Chapter 1: Introduction

1.1) Title

Automated Railway-level crossing gate control system

1.2) Background

The Zimbabwe railway network spans about 3000km across the country. Since its construction in the early 1900's, the number of railway related accidents has been on the increase as the use of automobiles and population growth is increasing as well. The National Railways of Zimbabwe has raised a concern over the high frequency of accidents at rail-level crossing points and on tracks. In Zimbabwe over 80% of railway related accidents have been noted to be occurring at rail-level crossing points. According to The Chronicle 2007, 34 people died in an accident which occurred when a commuter omnibus rammed onto a goods train travelling from Harare to Bindura. From 2007 to 2013, 167 deaths and 581 injuries were recorded from railway accidents across the country. According to statistics from 2019 to 2021, the country had 47 suspected suicide deaths while from January to August last year there were 38 suspected suicide deaths, a figure that was described as very disturbing by NRZ. Speaking during the launch of Railway Safety Week in Harare, Dube-Kaguru emphasized the need for increased safety measures and called for a comprehensive review of existing safety protocols to prevent further accidents. "So far this year, we have recorded 32 level crossing accidents in which six people were killed compared to 24 last year which resulted in two deaths, while in 2021 we had 10 accidents with one death", she said. The recorded number of accidents at railway crossings have been due to the lack of quickly operating gate systems, fewer safety measures at the railway level crossing points. Currently, there are few manually operated gate systems in some areas and traffic control lights which depend on the nation's power grid with the majority no longer functioning.[11][12]

1.3) **Problem Statement**

Too many accidents occurring at railway-level crossing points resulting in injuries and loss of lives as a result of poor safety measures at railway-level crossing points.

Figure 1.3 showing Headline on rail crossing accidents [11]

Figure 1.3.1 showing a car hit by a train at a railway level crossing point[2]

1.4) Aim

To design an automated railway-level crossing gate control system with signaling to road users.

1.5) Objectives

- To design a microcontroller based gate control system that
  - Detects an oncoming train using IR sensors and closes the gate instantly
  - Sound a buzzer/siren when a train is detected by IR sensor
  - Detects accident collision using vibration/piezoelectric sensor and send message via GSM to relevant authority
  - Detects an oncoming train using ultrasonic sensor and display its relative distance from the railway crossing line
- To design a traffic light system that gives signal to automobiles approaching railway level crossing

1.6) Justification

The proposed system will assist in minimizing the occurrence of railway-level accidents at unmanned and manned railway-level crossing points. Using an automated railway-level crossing gate control system will reduce the effects of human error as some existing systems are controlled manually and during the night it may be difficult and unsafe for manual operators. The system can be used in remote areas where there are no main line power lines by making use of solar power. By incorporating a GSM module train operators will be notified of unwanted objects in the path way and take necessary caution or change lanes before reaching the railway level crossing point.

Chapter 2: Literature Review

2.1) Introduction

This chapter is going to be focusing on the relevant theory and working principle of components that are to be used in the design of the Automated Railway-level crossing gate control system.

2.2) Background

The importance of rail safety needs to be over emphasized as rail system plays an important role in national development. The Zimbabwe rail network was constructed in the early 1900s (parts of it are part of the Cape Cairo railway) and has not been updated since. A number of parts are degrading as a result of 100 years of service, with the track splitting and the foundations collapsing. Defective points have caused multiple derailments due to the deficit of maintenance. The communications systems have been crippled by vandalism, only shunting with electric locomotives is possible in urban areas; two-way radios are utilized to ease train movements between towns. The network's global spread makes it nearly hard to fully protect and guard it. Signaling, telecommunication, and overhead electrification cabling. The Harare to Mutare is the only railway network in Zimbabwe that is using the Centralized Traffic Control (CTC) signaling system.

Old copper wire communications and electrification networks have been vandalized, and the microwave backbone radio network is obsolete and inoperative. CTC system is a digitalized communication link that coordinates the movement of trains at intersections and minimizes chances of collision. Due to a scarcity of replacement parts and the emigration of technical people responsible for equipment repair, the NRZ CTC system is alleged to have failed. The paper order system, in which some signal personnel must give a signal to train drivers, has resulted in accidents due to any negligence on the part of the signals controller.

Figure 2.1 showing current railway-level crossing in Zimbabwe [1]

Figure 2.1.1 showing railway level crossing point with no safety protocols for pedestrians and motorists

Existing Railway-level Control Systems

1] Route Relay Interlocking System

Route Relay Interlocking (RRI) Inside the Indian Railways, Panel Interlocking (PI) is normally used for small stations. Within this arrangement, the points and signals are determined by the switches on the panel. The control room handles the arrival and departure of trains and station master has set the point machine and signals which give a proper track to the train. The operator selects the desired train route using buttons on the control panel. The system checks if the chosen route is clear and there are no conflicting train movements. If the route is safe, the system performs the following actions.

- Activates level crossing barriers to block road traffic
- Switches railway points to the desired position
- Clears the train signal to green allowing the train to proceed

Drawbacks of Route Relay Interlocking System

- Complexity - involve a large number of relays and intricate wiring making them complex to maintain and troubleshoot
- Scalability – well suited for simpler level crossings and might become cumbersome for complex junctions with many tracks and signals
- Limited Automation – offer a level of automation but still require manual operation by a human operator at the control panel

2] **PLC-based Railway Level Crossing System**

A PLC (Programmable Logic Controller) based system is a modern and automated approach to controlling railway level crossings. It offers several advantages over older methods like Route Relay Interlocking (RRI).Trackside sensors like track circuits or axle detectors identify approaching trains. PLC Unit: A central Programmable Logic Controller receives signals from the sensors. Programmed Logic: The PLC is programmed with safety protocols that dictate actions based on sensor inputs. Outputs: Based on the program, the PLC controls various outputs like:

- Lowering level crossing barriers
- Activating warning lights and sirens
- displaying red signals for trains on approaching tracks [16]

Drawbacks of PLC-based Railway Level Crossing System

- Complexity: While simpler than RRI systems, programming a PLC requires technical expertise.
- Single Point of Failure: A malfunction in the PLC itself could disrupt the entire crossing operation.
- Security Concerns: PLCs can be vulnerable to cyber-attacks, potentially compromising safety protocols.
- Cost: The initial installation cost of a PLC system might be higher compared to simpler relay-based systems.

3] **Active Train Protection Systems (ATPS)**

Integrates train-borne and trackside equipment to prevent accidents. Trains automatically slow down or stop if a level crossing is not clear.[10]

Drawbacks of Active Train Protection System

- Requires significant investment in infrastructure and onboard systems
- Complexity might introduce new maintenance challenges
- Very costly to implement

4] **Automatic Level Crossing with warning lights**

Uses flashing lights and bells to warn approaching traffic without barriers

Drawbacks

- Relies solely on driver awareness and caution, prone to accidents due to inattention
- Not suitable for busy crossings with poor visibility

5] **Manned/Manually Operated Railway Level Crossing**

Uses a crossing guard or attendant to lower gates and activate warning signals when a train approaches.

Drawbacks

- Prone to human error or fatigue
- Not suitable for high traffic areas
- Requires manual presence increasing operational costs

6] M.D.Anil and colleagues suggest an "Advanced railway accidents prevention system employing sensor network," which includes a number of elements to prevent train collisions. The train speed is controlled by an electric braking system, which uses an IR sensor.[8]

7] Azrulnor Bin, proposed a “Development of a Traffic Light Control System Using PLC”. This project is divided into two parts which are hardware and software. First hardware part of this project is traffic light. Second one is software part with Omran PLC. It controls the traffic in railway track using plc. [4]

8] To give safety to human lives and reduce accidents, Naga Hema Kumari.V and China Appala Naidu.R developed a novel device combining UV sensor, IR sensor, and LPC2184 processor. To prevent railway accidents, they implemented sensor-based identification in this system.[6]

9] Traditional telecommunication systems, such as walkie-talkies or other communication devices, are used in some areas in developing countries

2.3) Components

1. Power Supply
2. Pic16F877A
3. IR sensor
4. GSM module
5. Servo motor
6. Ultrasonic Sensor
7. Vibration sensor
8. Crystal Oscillator
9. 16x2 LCD Display

2.3.1) Power Supply Theory

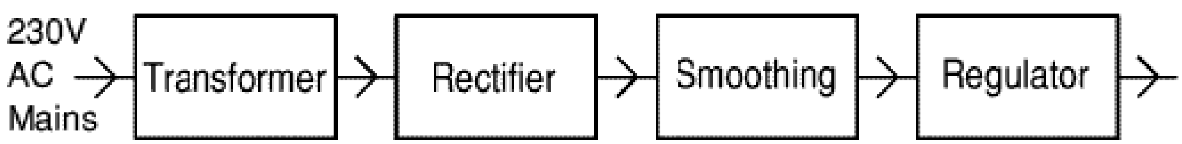


Figure 2.3.1 shows a block diagram of a power supply [14]

- A step-down transformer converts the 220V AC to 33V
- The bridge rectifier is used to change AC to DC
- A capacitor is used to filter the AC ripples and gives to the voltage regulator
- The voltage regulator regulates the voltage to the required output voltage

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low DC voltage supply for electronic circuits and other devices. There are three main types of power supply that can be used. Each has its own advantages and disadvantages and as a result each is used under slightly different circumstances.

The three main types are:

- Linear Regulated Power Supply – includes a step-down transformer, rectifier, filter circuit and voltage regulator. The main function is to first step-down the AC voltage and then change it to DC. It is a more reliable power supply which is less complex and gives a faster response. Its disadvantages include high loss of heat, size and low efficiency level.

- Switching Mode Power Supply- is a power supply that includes a switching regulator for converting electrical power. They offer high levels of efficiency and they can be contained in smaller packages as compared to linear equivalents.

- High efficiency resonant technology switching power supplies-These are an improvement of the Switching Mode power supplies. They are used in situations where lesser pace is required in addition to high efficiency. They are also known to produce little radio frequency (RF) interference. The major drawbacks to this technology is that it requires the greatest amount of engineering and are very expensive.

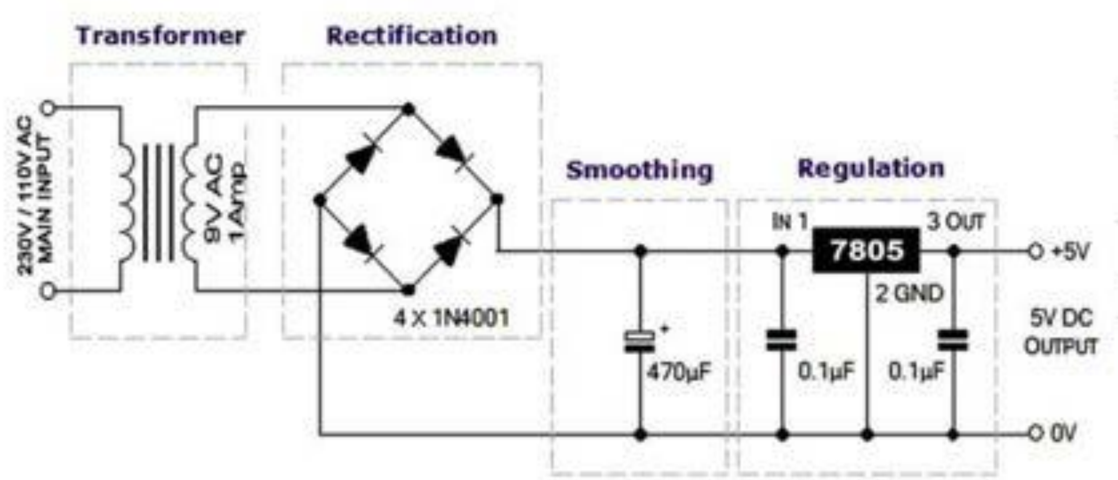


Figure 2.3.1.2 showing power supply circuit[14]

First, there is stepping down of 230V/110V AC supply to 12-Volt AC using a step-down transformer with a secondary rating of 12 Volt and 1 Amp. Then, using a diode bridge rectifier (full wave rectifier), the 12V AC is rectified to 12V DC. Following the rectifier, the ripple in the circuit is filtered using capacitors and fed to the input of the 7805 voltage regulator. We get a constant 5 Volt DC output from the 7805 after it regulates the 12 Volt DC to 5 Volt DC.

Step Down Transformer

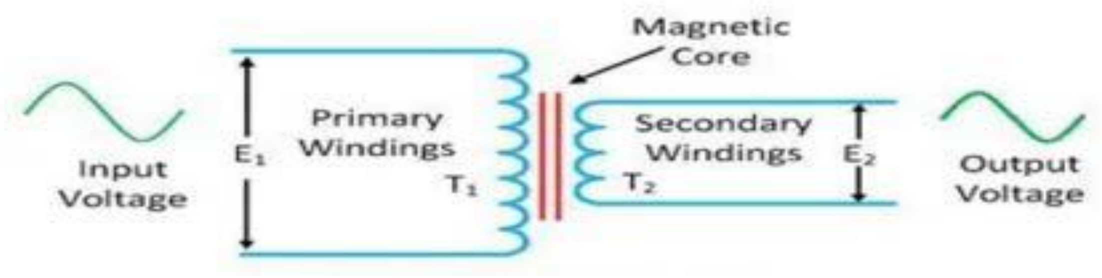


Figure 2.3.1.3 showing step-down transformer [3]

In a step-down transformer the number of turns in the primary coil is greater than the number of turns in the secondary coil. It converts the higher input voltage level to a lower voltage level.

Rectification

Rectification is the conversion of an alternating current AC which periodically reverses direction to a direct current DC which flows in one direction. High power semiconductor diodes are used as they allow flow of current in one direction. Rectifiers include Full wave rectifiers, half wave rectifiers and Bridge rectifiers.

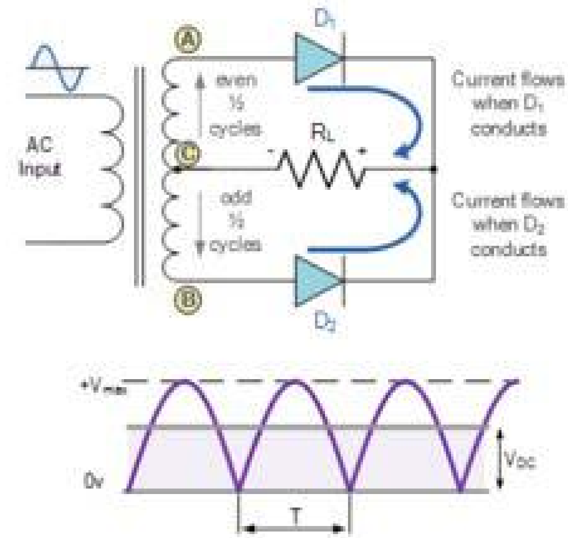


Figure 2.3.1.4 showing full-wave rectifier[14]

The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (R_L) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D_1 conducts in the forward direction as indicated by the arrows. When point B is positive (in the negative half of the cycle) with respect to point C, diode D2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles.

Diode Bridge Rectifier

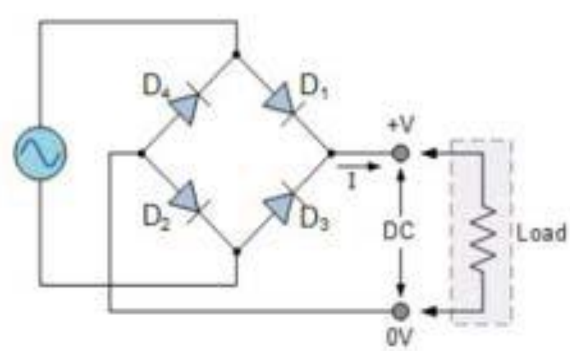


Figure 2.3.1.5 showing half wave bridge rectifier

The four diodes labelled D1 to D4 are arranged in series pairs with only two diodes conducting current during each half cycle. During the positive half cycle of the supply diodes D1 and D2 conduct in series while D3 and D4 are reverse biased. During the negative half cycle of the supply, diodes D3 and D4 conduct in series but diodes D1 and D2 switch off as they are now reverse biased. The current flowing through the load remains the same.

Smoothing

In rectification to produce a steady direct current or voltage from an alternating current or voltage, a smoothing capacitor is required. Smoothing is the variation of the output voltage or current. We can improve the average DC output of the rectifier while at the same time reducing the AC variation of the rectified output by using the capacitors to filter the output waveform. Smoothing capacitors are connected in parallel with the load across the output of the full wave bridge rectifier, increase the average DC output level even higher as the capacitor acts as a storage device.

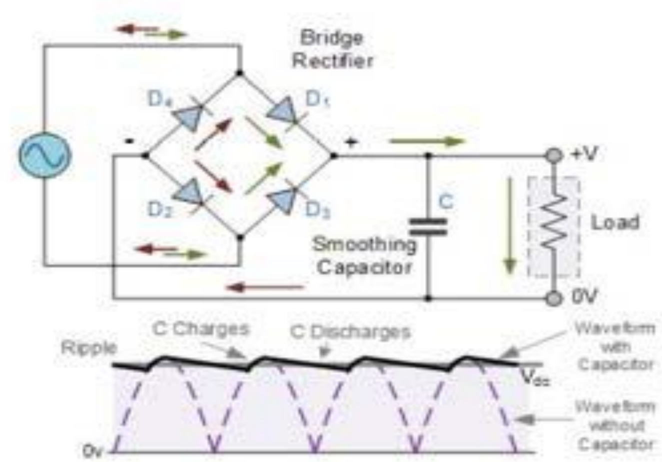


Figure 2.3.1.6 showing smoothing capacitor[3]

Regulator

A voltage regulator is a system designed to automatically maintain a constant voltage level. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage. The regulator will maintain a constant output even when there are changes in the input or any other changes occur.

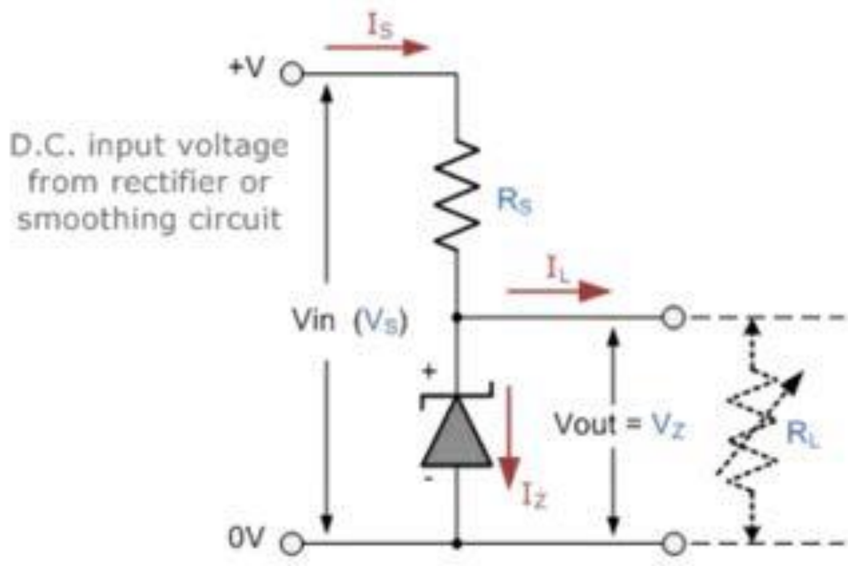


Figure 2.1.3.7 showing Zener diode regulator[3]

Resistor Rs is connected in series with the zener diode to limit the current flow through the diode with the voltage source Vs being connected across the combination. The stabilized output voltage Vout is taken from across the zener diode. The zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so its reverse biased and will be operating in breakdown condition. Resistor Rs is selected to limit the maximum current flowing through the circuit.

LM 78XX Series IC regulator

All voltage sources cannot provide stable output because of fluctuations within the circuit. The integrated circuits or ICs which are used for voltage regulation are known as voltage regulator ICs. The LM78xx series are fixed regulators. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For example 7805 IC, it is +5V DC regulated power supply. This regulator IC also adds a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 5V for any value of input less than or equal to 35V which is the threshold limit.

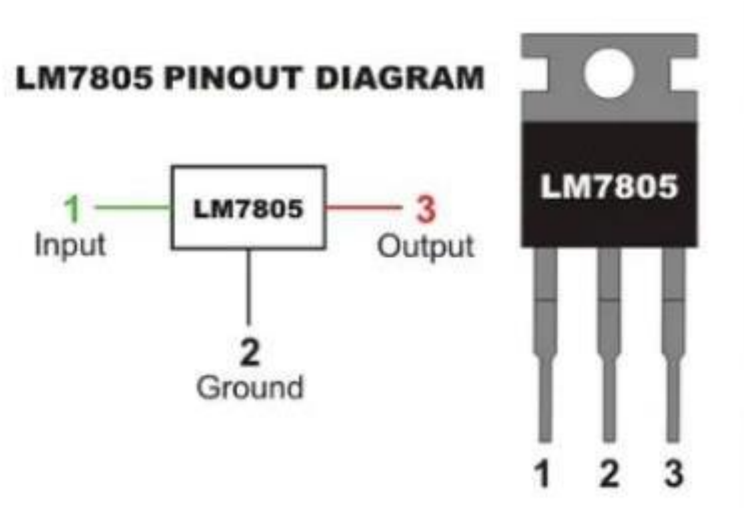


Figure 2.1.3.8 shows LM7805 regulator

2.3.2) PIC16F877A

PIC microcontroller PIC16f877A is a well-known microcontroller in the industry. The microcontroller is very convenient and very easy to program. One of the main advantages is that it uses flash memory, which makes it possible to write data to the controller and erase as many times you want. The controller consists of 40 pins with 33 input output pins. Additionally, PIC16F877A is mainly used in digital electronic circuits. Many gadgets use the pic16F877A microcontroller. The controller can be used in home automation systems, remote sensing and a lot of electronic gadgets. It also includes an EEPROM, which enables the permanent storage of some data like transmitter codes, receiver frequencies, and some other related data. This microcontroller is very cheap adding to the many advantages and also easy to work with.

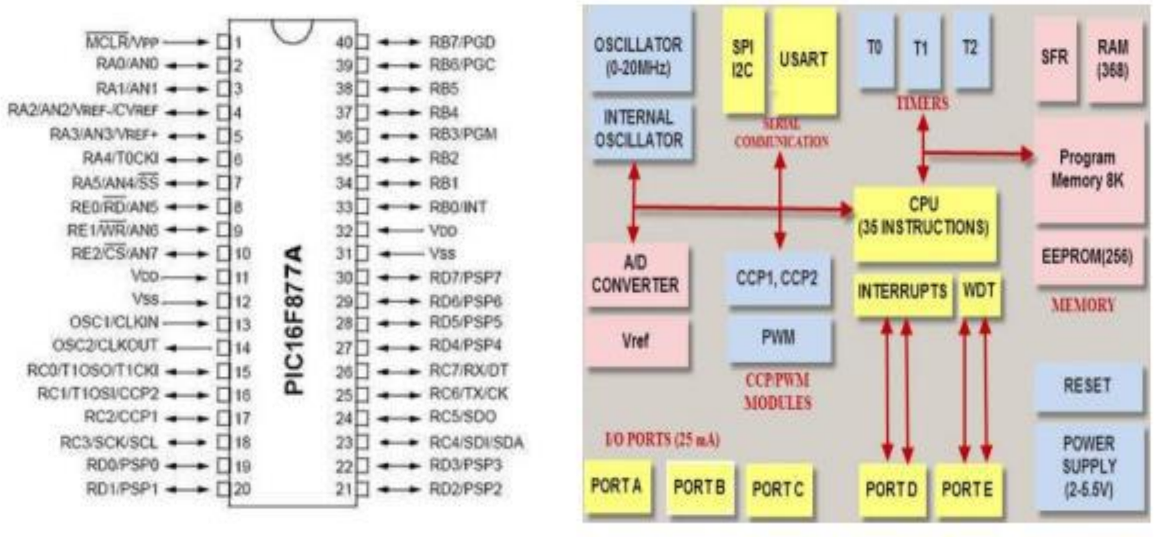


Figure 2.3.2 showing pin arrangement of Pic16F877A and internal structure[9]

PIC16F877A architecture

The Central processing unit, input output ports, memory layout, Analog to Digital converter, timers/counters, interrupts, serial communication, oscillator, and CCP module are all components of the PIC microcontroller architecture and are covered in more detail below.

Central Processing Unit (CPU)

The PIC microcontroller Central Processing Unit is similar to other microcontroller CPUs in that it includes the ALU, CU, MU, and accumulator, among other components. The primary functions of an arithmetic logic unit are arithmetic operations and making logical judgments. After processing, the memory stores the instructions. The external peripherals are controlled by the control unit which is connected to the CPU and an accumulator is used for storage of results and power subsequent processes.

Memory organization

Random Access Memory (RAM)

Data is temporarily stored in RAM's registers, which is an unstable memory. Each of the two banks in the RAM memory has a certain number of registers. There are two categories for RAM registers: General purpose registers (GPR) and special function registers (SFR). General Purpose Register (GPR): These are registers which are only used for general purposes. For example, the multiplication of two digits. The registers can be used to store the digits and the result of the multiplication. These registers are easily accessible by the CPU. Special Function Registers: These registers are only used in special cases. These registers are only utilized for the tasks given to them to them; they cannot be utilized as ordinary registers. These registers are used, for instance, to show the operation or status of the program if the STATUS register cannot be used to store the data. The special function registers are not user changeable since their operation is predetermined by the manufacturer.

Read Only Memory

This part of memory stores data permanently and that is why it's called a "read only memory." It is responsible for the storage of the instructions or program. The controller then operates in accordance with the program. It is also known as program memory, and is where the user writes the microcontroller program that is later permanently saved before being executed by the CPU. The CPU's execution of an instruction determines how well a microcontroller performs.

EEPROM

The microcontroller can only be used once per program; multiple uses of the microcontroller are not possible in a normal ROM. However, we can repeatedly program the read only memory in EEPROMs

Flash Memory

This is the part of the memory where we can read, write and erase programs. This can be done thousands of times.

Stack

The controller must first execute the interrupt and the active process address when an interrupt occurs. Following that, the execution is stored in the stack. The microcontroller calls the process using the address stored in the stack after completing the interrupt execution and starts the process.

2.3.3) IR Sensor

The IR sensor or infrared sensor is one kind of electronic component, used to detect specific characteristics in its surroundings through emitting or detecting IR radiation. These sensors can also be used to detect or measure the heat of a target and its motion. An infrared sensor includes two parts namely the emitter & the receiver (transmitter & receiver), so this is jointly called an opt-coupler or a photo-coupler. Here, IR LED is used as an emitter whereas the IR photodiode is used as a receiver. The photodiode used in this is very sensitive to the infrared light generated through an infrared LED. The resistance of photodiode & output voltage can be changed in proportion to the infrared light obtained. This is the fundamental IR sensor working principle.[13]

IR Sensor Module

- VCC Pin is power supply input
- GND Pin is power supply ground
- OUT is an active-high output pin

There are two types of Infrared Sensors

1. Active Infrared Sensor
2. **Passive Infrared Sensor**

Active Infrared Sensor

This type of sensor includes both the emitter & the receiver which are also known as transmitter & receiver. In most situations, a laser diode or LED is used as a source. For non-imaging infrared sensors, LED is used whereas laser diode is used for imaging infrared sensors. The working of an infrared sensor can be done through radiating energy, detected and received through the detector. Further, it is processed through a signal processor to fetch the required data.

Passive Infrared Sensor

Passive Infrared Sensor (PIR) includes detectors only and this kind of sensor uses targets like infrared transmitters or sources. Here, the object will radiate the energy & detects it through infrared receivers. After that, a signal processor is used to understand the signal to obtain the required data.

2.3.4) GSM Module

The Global System for Mobile Communication was developed by the European Telecommunications Standards Institute (ETSI). It established the protocols for second generation networks which is used by mobile cellphones. Protocols are set of rules that govern telecommunications. A GSM module establishes communication between a computer and cellphone with GSM system. The module is made up of computer communication interfaces such SD RS 232, USB 2.0. It can be a dedicated device or it might be a mobile.

A GSM module is an integrated circuit unlike the GSM modem, which is a complete external circuit. The processors on the GSM enable the user to connect to a GSM network. For communication to take place, the modem must produce, transmit data from a cellular network. The module just like the cellphones, needs a Subscriber Identity Module to establish communication. An International Mobile Equipment Identity is required for identification. In order to have serial communication with a processor, the module require AT commands. AT is an abbreviation for attention. Various AT commands can be used in order to perform various tasks using the GSM module. [18]

The GSM module can perform various tasks which include:

- Reading, writing and deleting messages
- Sending messages
- Monitoring of signal strength
- Monitoring charging status of battery

AT Command

Every GSM command begins with AT. The instructions which operate the modem are called AT commands. At prefix at the beginning of each command notifies the modem that a new command has begun.

Here are some of the tasks that can be done using AT commands with a GSM/GPRS modem or mobile phone:

- Get basic information about the mobile phone or GSM/GPRS modem. For example, the name of the manufacturer (AT+CGMI), model number (AT+CGMM), IMEI number (International Mobile Equipment Identity) (AT+CGSN), and software version (AT+CGMR).
- Getting information about the subscriber like name of service provider, SIM number.
- Connecting with remote modems
- Sending and receiving a fax

Figure 2.3.4 showing GSM SIM900

Difference between GSM/GPRS Modems, Modules, and Mobiles

A GSM module or GPRS modules are similar to modems, but there’s one difference: A GSM/GPRS Modem is external equipment, whereas the GSM/GPRS module is a module that can be integrated within the equipment. It is an embedded piece of hardware.

A GSM mobile, on the other hand, is a complete system in itself with embedded processors that are dedicated to providing an interface between the user and the mobile network.

2.3.5) Servo Motor

A servo motor is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. To rotate an object at some specific angles or distance, a servo motor is used. It is just made up of a simple motor which runs through a servo mechanism. If motor is powered by a DC power supply then it is called DC servo motor, and if it is AC-powered motor then it is called AC servo motor. Apart from these major classifications, there are many other types of servo motors based on the type of gear arrangement and operating characteristics. A servo motor usually comes with a gear arrangement that allows us to get a very high torque servo motor in small and lightweight packages.

Servo motors are governed by a servomechanism, a system that manages their operation. The motor's angular rotation and final position are guided by feedback mechanisms. The control line's input determines the desired position for the output shaft. This intricate interplay between input, feedback and control ensures that servo motors respond with remarkable accuracy to specific positional requirements.

Figure 2.3.5 showing SG90 servo motor

SG90 is a low-cost and high-output power servo motor. It can rotate up to 180 degrees and each step can be of maximum 90 degrees. Moreover, it is small enough that it can easily fit into any desired project.

Pin Configuration

Wire of motor	Possible colors of each wire
Vcc pin	Red
GND pin	Black, or brown
Control Signal / PWM pin	Yellow, orange, or white

Types of Servo Motors

Series servo motor

The series servo motors include high starting torque as well as draws huge current. The speed regulation of this motor is very less. Turnaround can be attained by overturning the field voltage polarity using split series field winding.

Split series servo motor

A split series motors can function as an individually energized field controlled motor. The motor armature supplies with a stable current supply. This motor has a common curve with torque speed. This specifies high stall torque & a fast decline in torque by amplifying in speed.

Shunt Control Motor

The shunt control motor includes two windings such as field windings and armature windings. Field windings are located on the stator whereas the armature windings are located on the rotor of machine. In a DC shunt motor, the two windings connect across the DC source in parallel.

Permanent Magnet Shunt Motor

It is a permanent excitation motor wherever a stable magnet supplies the field. The motor performance is same to armature controlled permanent field motor

2.3.6) Ultrasonic Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object’s proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.

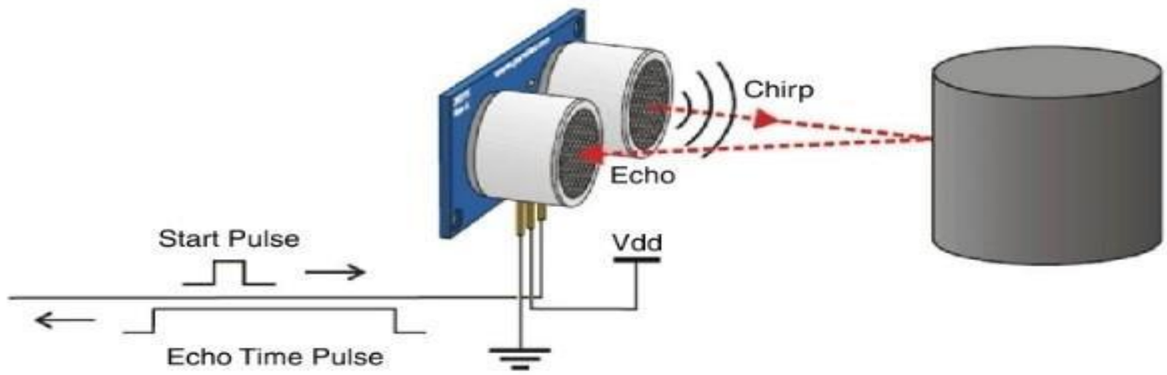


Figure 2.3.7 showing ultrasonic sensor

Working Principle

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.

<u>Types of Ultrasonic Sensors</u>

1. Ultrasonic Proximity Sensor
2. Ultrasonic 2 Point Proximity Switches
3. Ultrasonic Retro-reflective Sensors
4. Ultrasonic Through Beam Sensors

Ultrasonic Proximity Sensors

In this type of ultrasonic sensor, a special type of sonic transducer is used for alternate transmission and reception of the sound waves. It emits the sonic waves. These are reflected by an object. By this time, the sensor would have switched to the receive mode. The total time passed between the sending and receiving of the sound wave is inversely proportional to the distance of an object from the sensor. In order to change the range, one simply adjusts the sensor’s variable resistor (potentiometer).These are mainly used in distance detection.

Ultrasonic 2 Point Proximity Switches

This type of ultrasonic sensor consists of two points for switching, hence the name. It is quite similar to the standard ultrasonic sensor but differs from it in the sense that there is a 2-touch set up key. This function is referred to as the tech-in function. This switches SDE1 and SDE2 to allow them to be easily programmed within the sensing range with the assistance of the built in tech in button. This ultrasonic sensor type can be used in stack height management.

Ultrasonic Retro reflective sensors

This ultrasonic sensor type is also similar to the operation of the Ultrasonic Proximity Sensor. The sound propagation measurement determines the distance from the sensor to the reflector, or object in the measuring range. Any sound reflecting, stationary object can be used as the reflector. This ultrasonic sensor type is mainly used in sound absorbing materials such as cotton and foam rubber, with irregularly shaped and inclined objects and with sound deflecting target objects.

Ultrasonic Through Beam Sensors

These are ultrasonic sensor types that have short response times and have large ranges. The transmitter and receiver are in two separate housings. The transmitter continuously emits sound waves. It only transmits and does not receive. The receiver switches through the output stage when an object interrupts the sound waves.

2.3.8) Vibration Sensor

A vibration detector is a device that measures changes in the vibration levels of your equipment. Some vibration during operation is normal, and every piece of equipment has a certain vibration baseline or signature. However, changes to an equipment's normal vibration pattern is often the first indication of a problem. Even relatively small changes in vibration frequency can point to an imbalance, looseness, premature wear, or other fault. Vibration detectors are sensitive enough to pick up on changes that a human might miss.

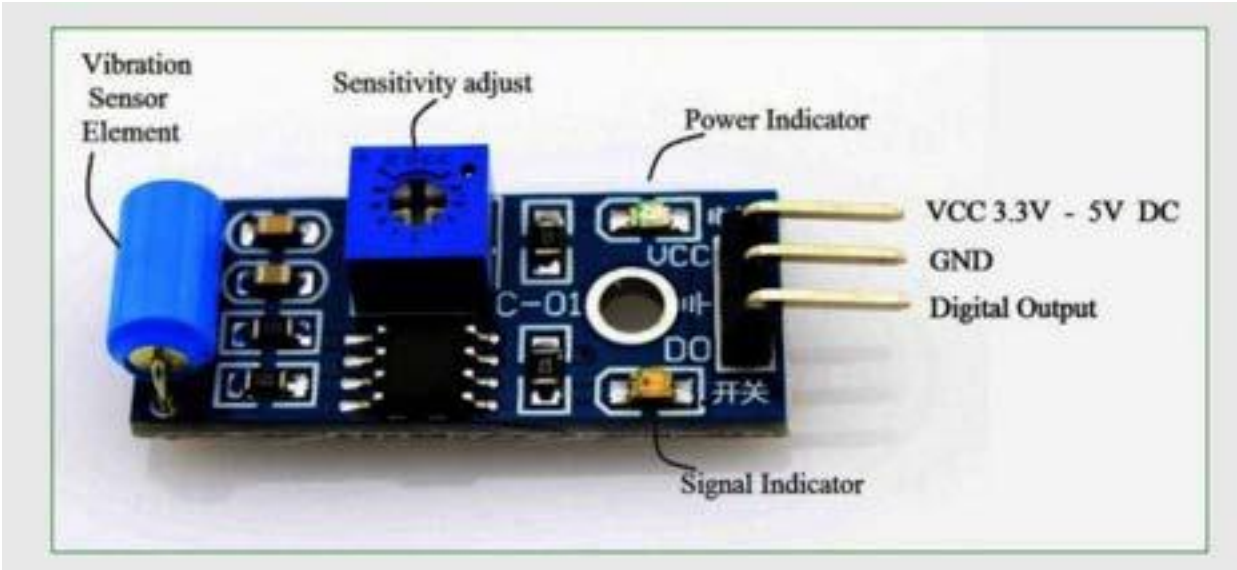


Figure 2.3.8 showing vibration sensor module[3]

Vibration Sensor Module comes with SW-420 vibration sensor, integrated with adjustable sensitivity via on board potentiometer. There are also LED indicators for power and the digital output status on board. It has a simple and straight forward 3-pin interface, VCC, GND and the DO (digital output). It supports 3.3V or 5V power. This vibration sensor module is compatible with any microcontroller that has a digital input. A direct interface is essential to using this sensor. The DO pin will be LOW when there is no vibration, and indicator LED will lit up.

2.3.9) Crystal Oscillator

Figure 2.3.9 showing Crystal Oscillator

The Crystal Oscillator is a circuit that produces a precise electrical signal by a piezoelectric crystal's mechanical resonance that is vibrating. Additionally, it has automatic amplitude control, and temperature-related frequency drift is very minimal. The only applications for crystal oscillators are high-frequency ones. Every microcontroller requires a crystal oscillator.

Crystal Oscillator According to the inverse piezoelectric effect, which governs how crystal oscillators operate, an applied electrical field will cause a mechanical distortion in a given piece of material. As a result, it makes use of the mechanical resonance of the vibrating crystal, which is created through the use of a piezoelectric material, to produce an electrical signal with a specific frequency. [10] Resistance, capacitance, and inductance values in RC and LC oscillators change with temperature, which has an impact on frequency. The use of piezoelectric crystals in oscillators helps to solve this issue.

The Piezoelectric effect

The crystal demonstrates the property whereby a potential difference develops across the opposing faces of the crystal when a mechanical stress is applied across one of its faces. In contrast, mechanical stress is created along the other faces when a potential difference is applied across one of the faces. The Piezoelectric Effect is this phenomenon. Piezoelectric crystals are crystalline substances that exhibit the piezoelectric effect, such as Rochelle salt, quartz, and tourmaline. Due to its low cost and easy availability in nature, quartz is the most popular piezoelectric crystal. A piezoelectric crystal mechanically vibrates when it is exposed to the right alternating potential. When the frequency of the alternating voltage is equal to the natural frequency of the crystal, the mechanical vibrations' amplitudes are at their highest. A capacitor is created by sandwiching a crystal between two metal plates so that it can function in an electronic circuit. Due to its affordability, strength, and availability, quartz is the most common type of crystal. The crystal receives a parallel application of the ac voltage.

2.3.9.1) 16 x 2 LCD Display

Liquid crystal display is normally called LCD. It is a particular type of electronic display module used in many circuits, including mobile phones, calculators, computers, TVs, and other electronics. These displays are very cheap and have less weight hence are mostly used in a lot of circuits.

Figure showing 2.3.9.1 16x2 LCD Display

Pin	Function
1	Is the ground pin and is connected to the ground.
2	The voltage supply pin
3	Used to adjust the LCD contrast
4	This toggles among command or data register
5	Toggles among read and write
6	Should be held hight to execute read or write operations
7-14	Used to send data to the display
15	Positive pin +5V
16	Negative pin 0V

Command register

The command register's task is to store the commands that are given to the display. In order to carry out predefined tasks like display control, cursor positioning, initializing screen, and clearing screen. This is where commands are processed.

Data register

This register's primary task is to store data that will be displayed on the screen. The information displayed on the LCD is the character's ASCII value. When data is sent to the screen, it is first processed by the data register. The data register will be chosen if register set = 1.

2.4) Summary

This chapter explained the theories of different components that are required in the design of an automated railway level gate control system and their significance in the designing of a reliable and efficient system. Therefore an automated railway level gate control system can be designed using relevant information.

Chapter 3: Design

3.1 Introduction

This chapter provides the basis of the project giving highlight to the structure and operation of the entire project. The proposed system is described and analyzed fully with the aid of block diagrams, system flow chart diagrams and schematic diagrams. Proteus simulation is used for circuit designing and simulations.

3.2) Block Diagram

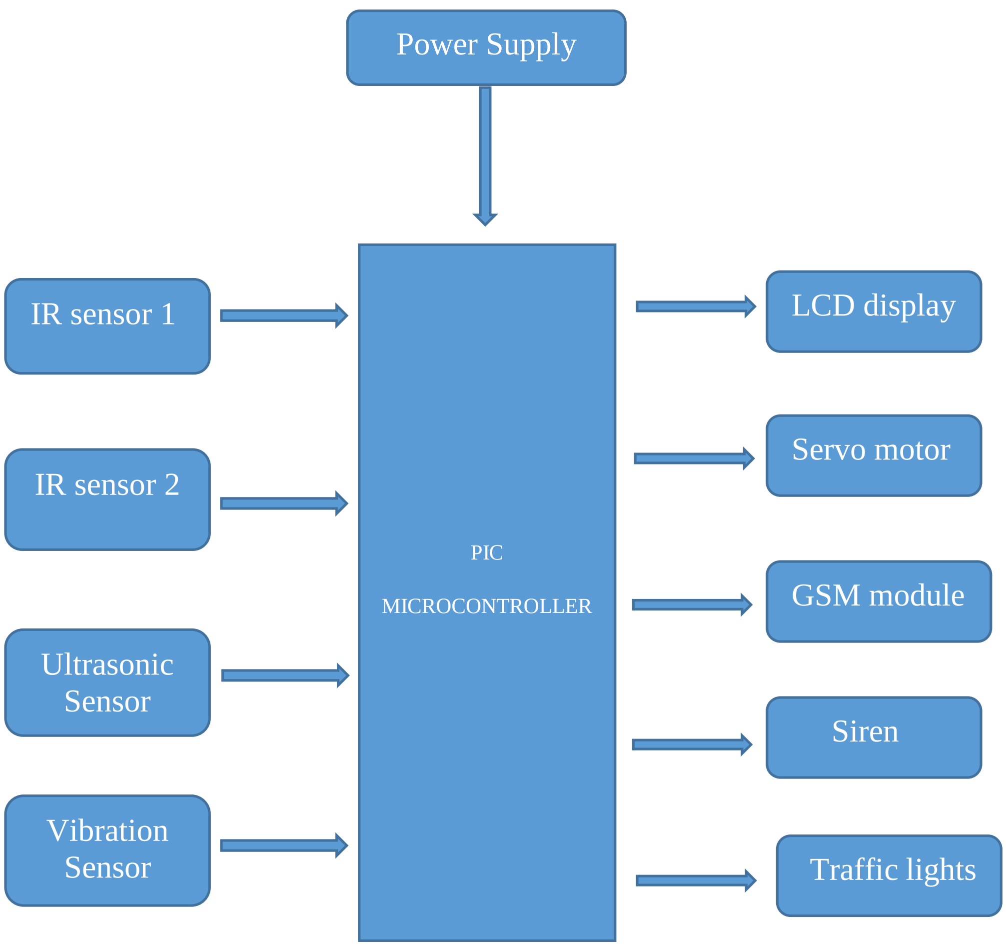


Figure 3.2 showing block diagram of Automated Gate Control System

The figure above shows all the sensors that are used in the system. The main control unit of the system is the PIC16F877A microcontroller which manages the control process of all inputs and outputs. The infrared sensors will be placed at a distance away from the rail-level crossing on both sides for train detection. The servo motor for controlling the gate to either open or close. The buzzer or alarm is to warn the road users of the approaching train. The traffic lights are for signaling the road users to stop or proceed on the railway crossing especially during the night, Red indicating Stop and Green indicating proceed.

3.3) Gate Control Flowchart

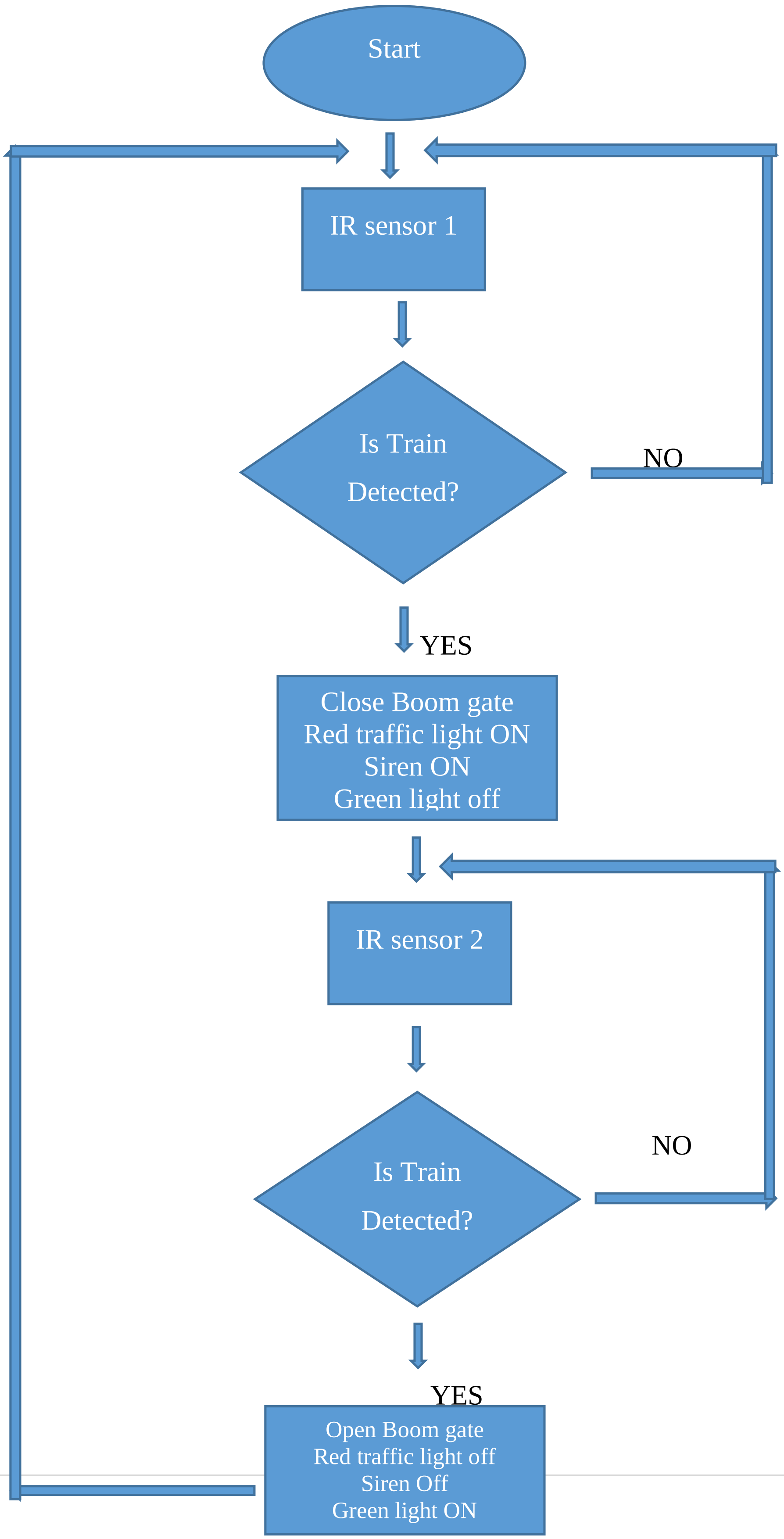


Figure 3.3 shows the automated boom gate flow chart

Figure 3.3 shows the control system of the boom gate. When IR Sensor 1 detects a train it will send a logic high signal to the Microcontroller which will respond by closing the boom gate through a 90 degree angle by the servo motor, switching off the green light and switching on the red traffic light and sounding the buzzer. When the second IR sensor detects the train, it will send a signal to the Microcontroller of logic high which will respond by switching off the red traffic light , sounding off the buzzer, rotating the servo motor a negative 90 degrees back to zero degrees thereby opening the gate and switching on the green traffic light.

3.3.1) System Communication Flowchart

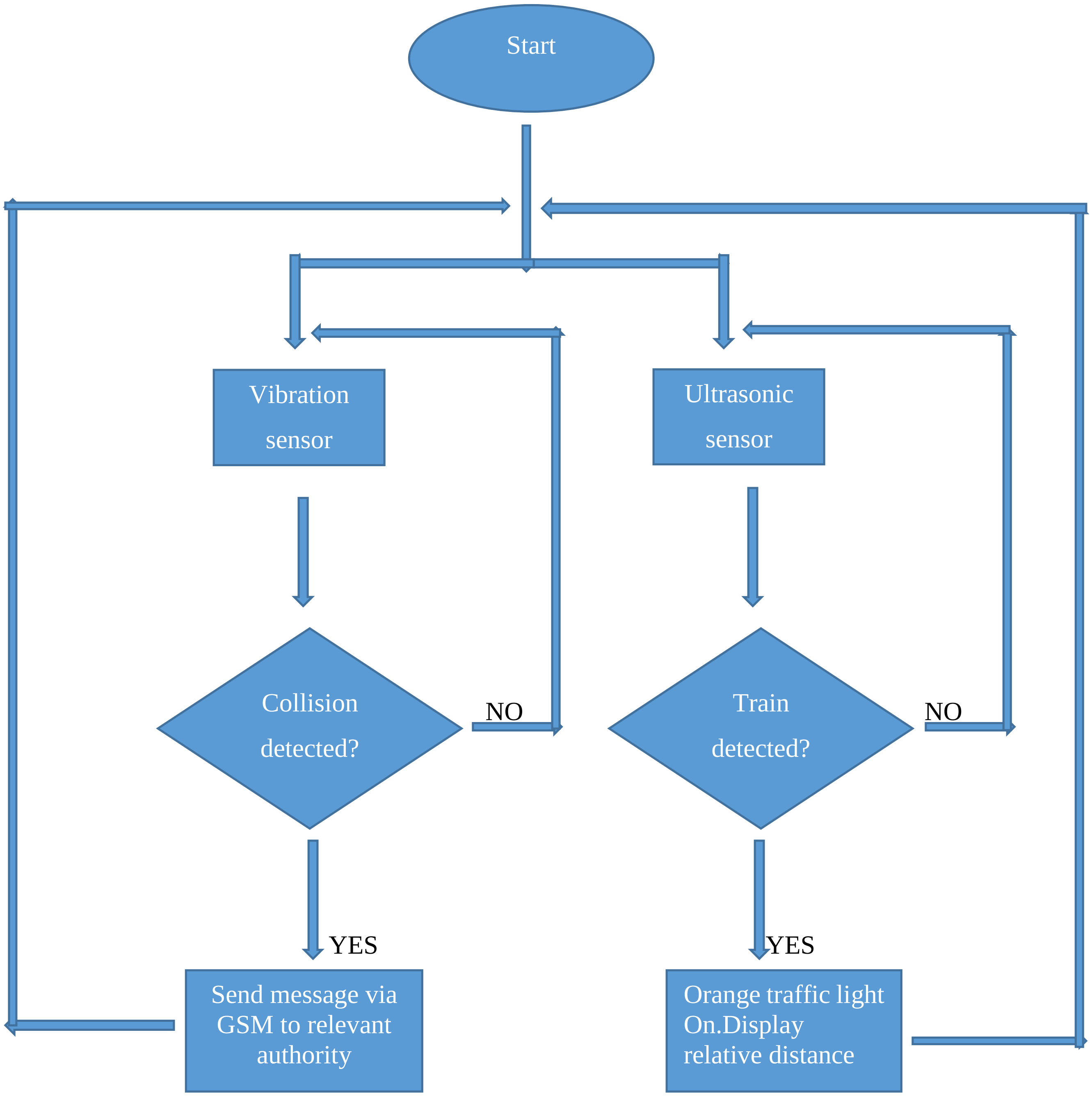


Figure 3.3.1 showing the communication flow chart

Figurers 3.3 and Figure 3.3.1 show the system flow chart of the automated railway level gate control system. The steps shown by the flow charts ensure that the system is working properly. Each condition must be met for the system to proceed to the next stage, if the condition is not met the system will check again till the condition is met.

3.4) Oscillator and Reset Pin Connection

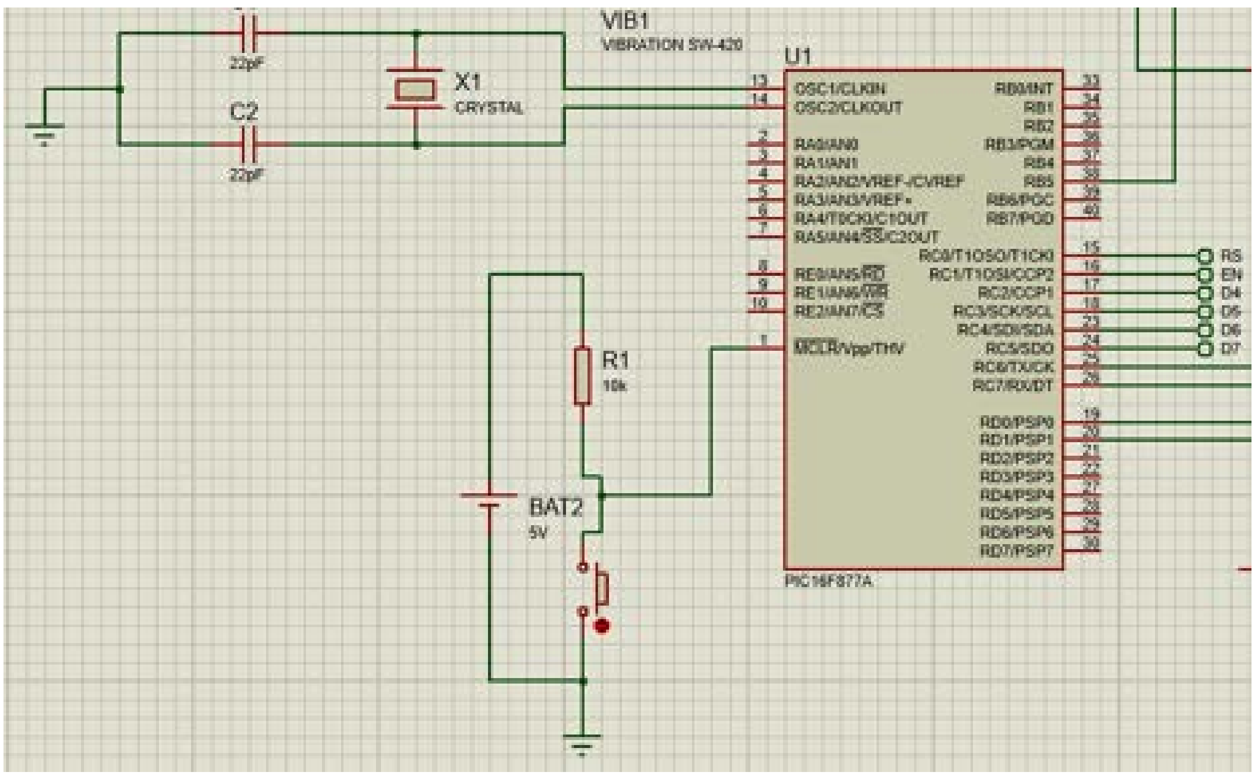


Figure 3.4 showing oscillator and reset button connection

The microcontroller has two pins (pin14 and pin13) that are used for oscillator connections. The oscillator provides an external clock the microcontroller. To ensure that there is smooth operation of the oscillator, two 22pF capacitors are connected to from the pins of the 8 MHz oscillator to the ground. A reset pin is also connected on the circuit in order to reset the microcontroller when the push button is pushed. Reset causes the microcontroller to stop its operation and go back to the first line of the code.

Oscillator Calculations

$CL = 12.5\,pF$. CL is given

(provided by oscillator manufacturer)

$$CL = (C1 * C2) / (C1 + C2) + C_{stray}$$

$$C1 = C2$$

$$C1 = 2\,(12.5\,pF - 2\,pF)$$

$$C = 21\,pF$$

The 22pF capacitor is selected since it is safe to operate with a slightly high capacitor than a small rated one.

3.5) <u>LCD Connection</u>

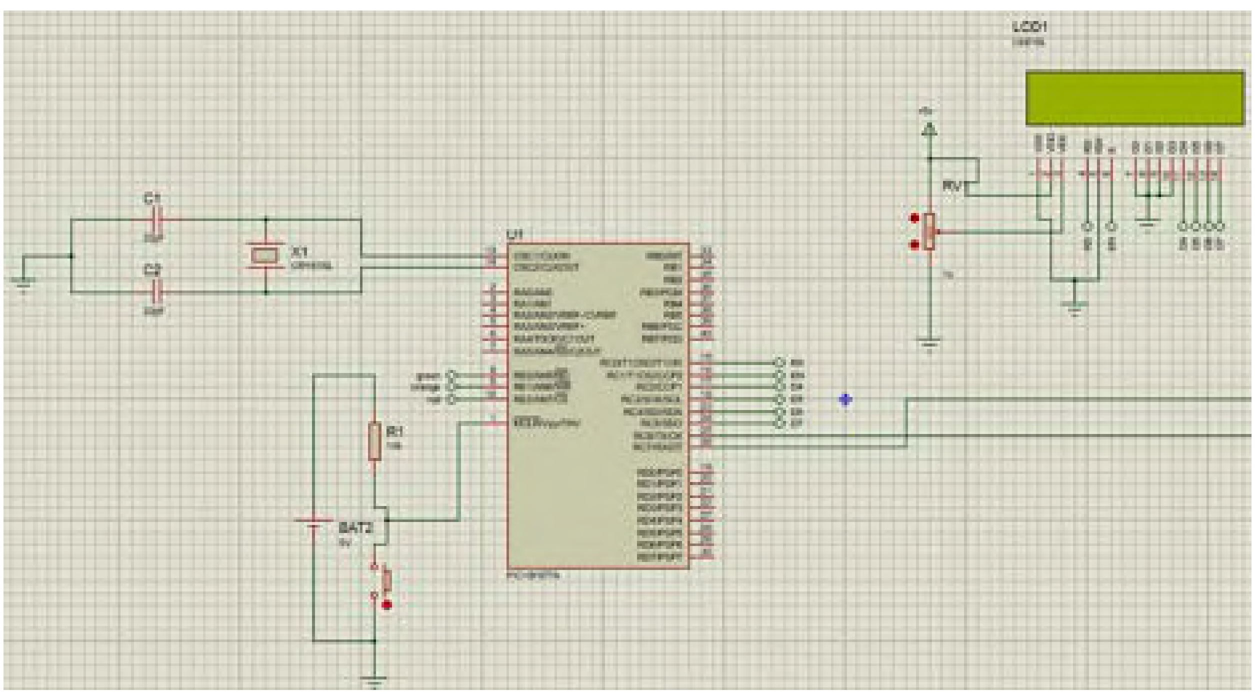


Figure 3.5 showing LCD connection to the microcontroller

In order to display various texts, a 16x2 LCD screen is used. It will display the following texts: Train Detected, SMS Sent, Proceed and Accident Slow Down. In order to display texts on an LCD, the port C to which the LCD is connected to must be configured as an output port. Below is the code for configuration of the LCD

```
// LCD module connections
sbit LCD_RS at RC0_bit;
sbit LCD_EN at RC1_bit;
sbit LCD_D4 at RC2_bit;
sbit LCD_D5 at RC3_bit;
sbit LCD_D6 at RC4_bit;
sbit LCD_D7 at RC5_bit;

sbit LCD_RS_Direction at TRISC0_bit;
sbit LCD_EN_Direction at TRISC1_bit;
sbit LCD_D4_Direction at TRISC2_bit;
sbit LCD_D5_Direction at TRISC3_bit;
sbit LCD_D6_Direction at TRISC4_bit;
sbit LCD_D7_Direction at TRISC5_bit;
// End LCD module connections
```

3.6) <u>GSM Module Connection</u>

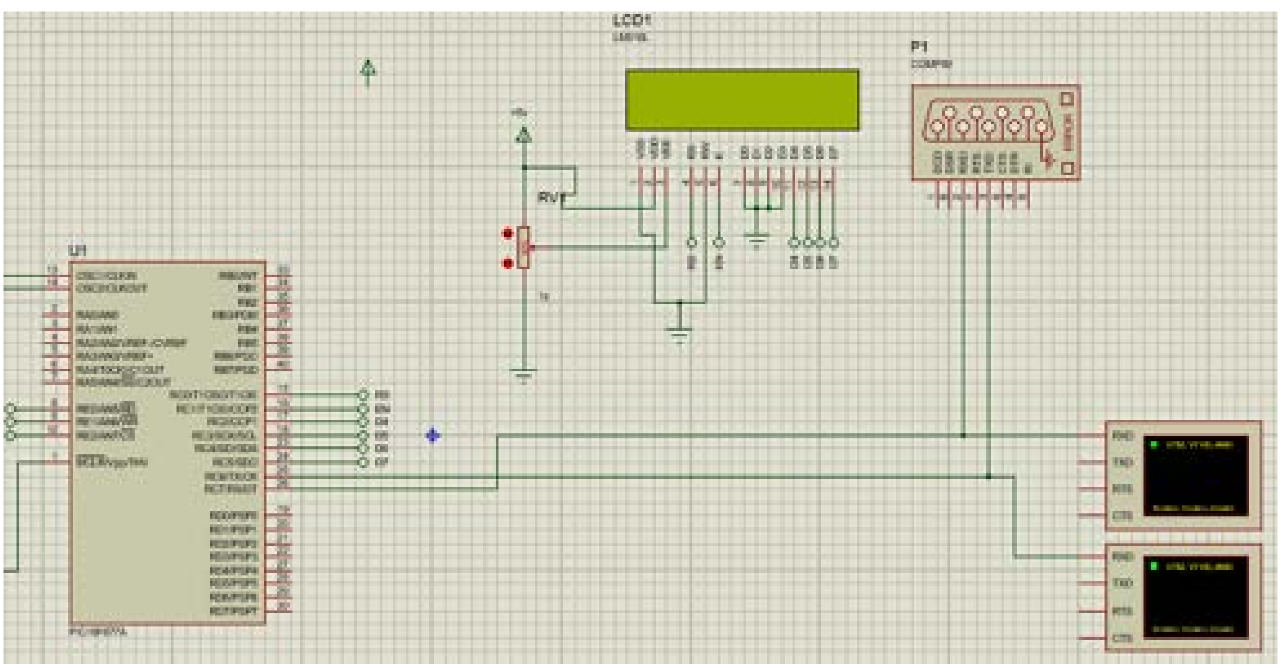


Figure 3.6 showing GSM connection to the microcontroller

In order to send messages to the train operator and relevant authority in case of emergencies, a GSM module is used in the system. The GSM module is connected to the receiver and transmitter pins of the microcontroller. Only two pins are used for connection to the GSM module from the microcontroller that is the receiver and transmitter pin. The code for the GSM module is shown the figure below.

```
char noecho[]="ATE0";
char mode_text[]="AT+CMGF=1";
char char_mode[]="AT+CSCS=\"GSM\"";
char param[]="AT+CSMP=17,167,0,0";
char mobile_number[]="AT+CMGS=\"+263776787906\"";
char message_3[]="Accident Occurred Bindura Railway level 1";
char terminator=0x1A;

void send_to_modem(char*s)

{
while(*s)
UART1_Write(*s++);
UART1_Write(0x0D);
}

void send_to_modem1(char*s)
{

while(*s)
UART1_WRITE(*s++);
```

```
PORTE.F0=0;


UART1_INIT(9615);
Send_to_modem(AT);
delay_ms(500);
send_to_modem(noecho);
delay_ms(500);
send_to_modem(mode_text);
delay_ms(500);
send_to_modem(mobile_number);
delay_ms(500);

Lcd_Init();
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
```

Figure 3.6.1 showing GSM code

Figure 3.6.1 shows the code for sending a message using the GSM module. There are various functions used in order to send a message. The first potion of the code is the setting up of the GSM. This includes setting the module to text mode, writing the phone number to which the module will send the text to and also putting module to character mode. The send to modem functions enables the GSM to send characters to the modem, so that they can be modulated for transmission over a distance. Void send sms is the function which consists the message that has to be sent. The baud rate for the module in this case is set to 9615. Baud rate is the number of characters that can be sent per second by the GSM Module.

3.7) Infrared Sensor Connection

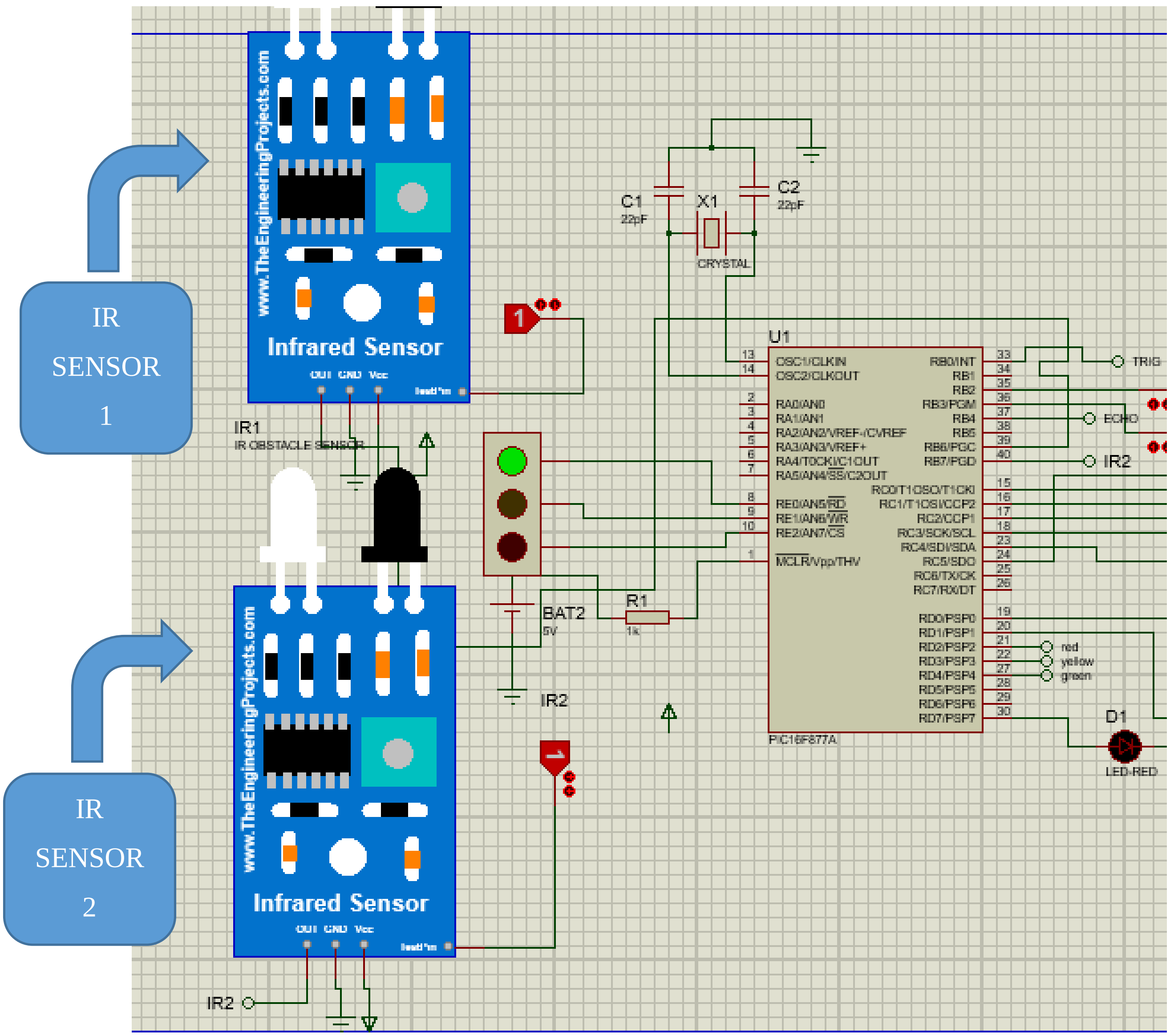


Figure 3.7 showing Infrared Sensors connection to the microcontroller

Figure 3.7 shows Infrared sensors connection. The infrared sensors are the sensors responsible for detecting the train and sending an input signal to the microcontroller to allow the servo motor open or close the gate for vehicles and allow the train to pass. The infrared sensors are digital sensors which are triggered by a logic state signal of either one or zero. If the sensor detects an object the signal sent to the microcontroller will be high or logic one. The sensors are connected to

PORT B at pin RB6 and RB7.

```
if (  IR1==1 && IR2==0 ) //1st direction
{
PORTE.F2=1;
PORTD.F2=1;
PORTD.F4=0;
PORTD.F3=0;
PORTD.RD7=1;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"Train Detected");

Rotation0(); //0 Degree
Rotation1();
Delay_ms(1000);

}
if ( IR3==1 && IR4==0)  // second direction
{
```

```
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");

Rotation90(); //0 Degree
Rotation_second();
Delay_ms(2000);

}
if ( IR3==0 && IR4==1 ) // second direction
{
PORTE.F0=1;
PORTD.F3=0;
PORTD.F4=1;
PORTD.F2=0;
PORTD.RD7=0;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");
```

Figure 3.7.1 showing code for Infrared Sensor

Figure 3.7.1 is showing the code for the infrared sensors when the train has been detected and when the train has left the railway level crossing point.

3.8) Servo Motor Connection

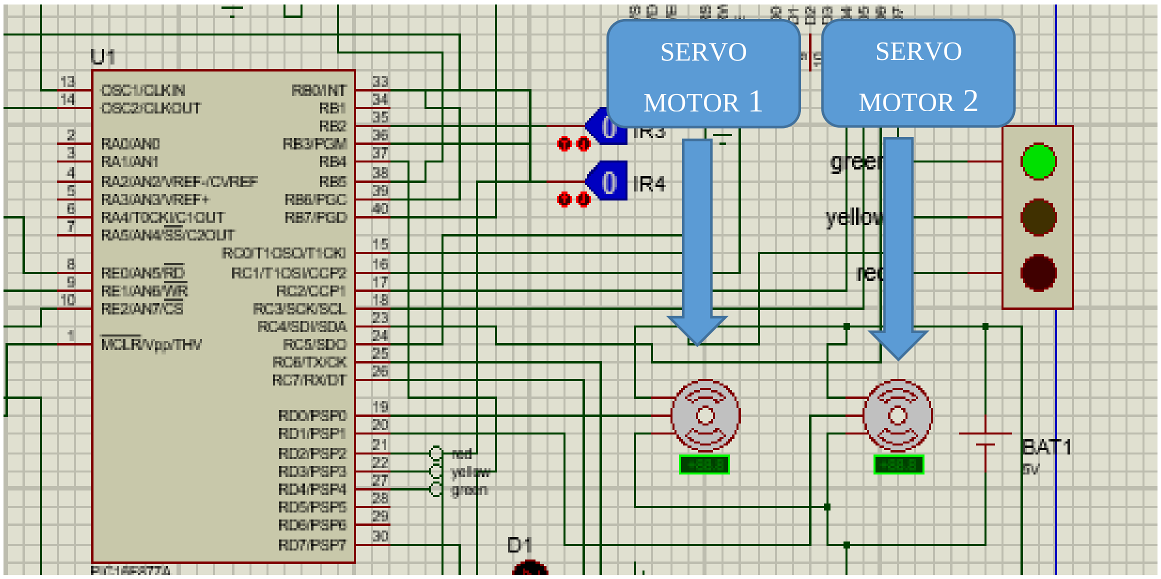


Figure 3.8 showing servo motor connection

The servo motor is a three pin device VCC, PWM pin and Ground pin. The signal from the microcontroller is connected to the PWM pin and the VCC will be connected to the 5V supply with the other pin grounded. The rotation angle of the servo motor is determined by the calculated pulse width modulation. The first servo motor is connected to pin RD0 of PORT D and the second is connected to pin RD1 of PORT D. When the infrared sensor detects the train it will send a signal of logic high to the controller which will in turn give a signal to the servo motors to rotate ninety degrees closing the boom gate.The code for the servo motor is shown below.

```
}

void Rotation1() //0 Degree rotation second servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F1 = 1;
Delay_us(800); // pulse of 800us
PORTD.F1 = 0;
Delay_us(1000);
}
 }
void Rotation90() //90 Degree first servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F0 = 1;
Delay_us(1500); // pulse of 1500us
PORTD.F0 = 0;
```

```
if ( IR3==0 && IR4==1 ) // second direction
{
PORTE.F0=1;
PORTD.F3=0;
PORTD.F4=1;
PORTD.F2=0;
PORTD.RD7=0;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");

Rotation_second(); //90 Degree
Rotation90();

Delay_ms(2000);
}


}
}
```

Figure 3.8.1 showing code for initializing and calling the servo motor

The servo motor will rotate to an angle of 90 degrees upon receiving a signal from the microcontroller and back to zero degrees.

3.9) **Ultrasonic Sensor Connection**

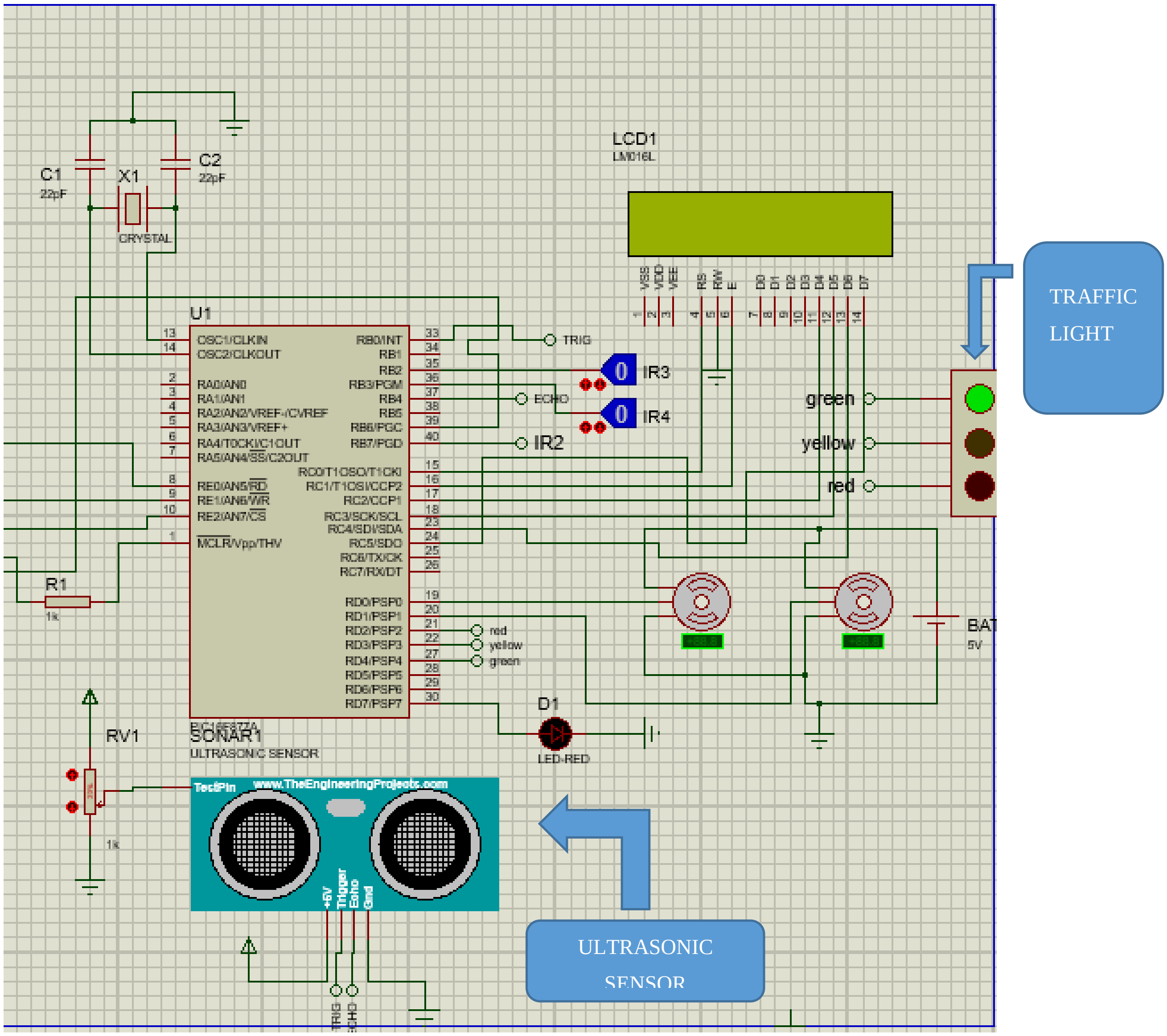


Figure 3.9 showing Ultrasonic connection to the microcontroller

The ultrasonic sensor will detect the distance of the train before it approaches the railway level crossing point, as it gets closer the traffic lights will signal amber to warn motorists to drive with caution. It has 4 pins Trigger pin, Echo pin, VCC and ground pin. The trigger pin is connected to pin RB0 of PORTB and the echo pin to RB4 of PORTB. For simulation purposes a variable resistor is connected to the test pin. Varying the resistance of the potentiometer will indicate the varying of distance measured by the sensor.

```
unsigned int duration;    // ultrasonic sensor declaration
float distance;
char text[15];
void interrupt(){
 if(RBIF_bit){
 RBIE_bit = 0; // disable the port change interrupt
 if(RB4_bit==1){
 TMR1L = 0;
 TMR1H = 0; // Clear the timer resistor
 T1CON.TMR1ON = 1; // Enable the Timer1
 }
 if(RB4_bit==0){
 duration = (TMR1H<<8) | (TMR1L) ;
 T1CON.TMR1ON = 0; // Disable the timer1
 }
 RBIF_bit = 0; // Clear the interrupt flag bit
 }
 RBIE_bit = 1; // Enable the port change interrupt
 }              // End of ultrasonic declaration
```


```
unsigned int duration;    // ultrasonic sensor declaration
float distance;
char text[15];
void interrupt(){
 if(RBIF_bit){
 RBIE_bit = 0; // disable the port change interrupt
 if(RB4_bit==1){
 TMR1L = 0;
 TMR1H = 0; // Clear the timer resistor
 T1CON.TMR1ON = 1; // Enable the Timer1
 }
 if(RB4_bit==0){
 duration = (TMR1H<<8) | (TMR1L) ;
 T1CON.TMR1ON = 0; // Disable the timer1
 }
 RBIF_bit = 0; // Clear the interrupt flag bit
 }
 RBIE_bit = 1; // Enable the port change interrupt
 }              // End of ultrasonic declaration
```


Figure 3.9 showing code for declaration and initialization of ultrasonic sensor

3.10) Automated Railway level crossing (circuit one) code

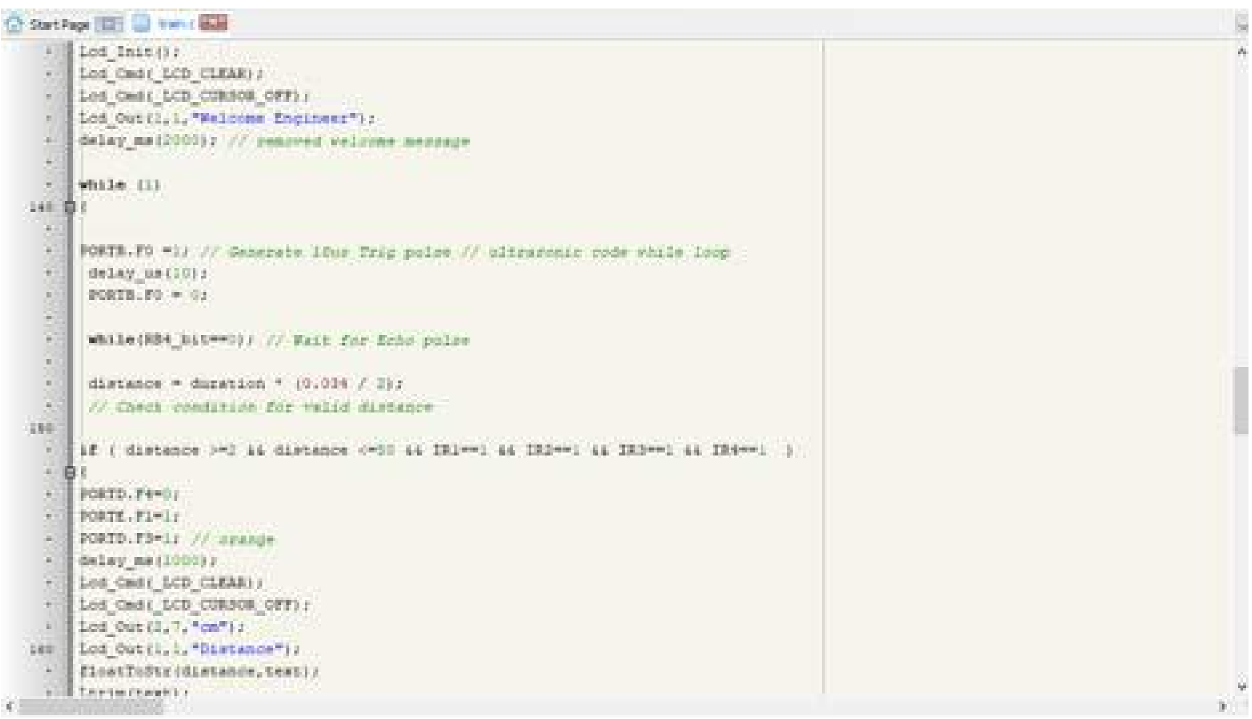
```c
// LCD module connections
sbit LCD_RS at RC0_bit;
sbit LCD_EN at RC1_bit;
sbit LCD_D4 at RC2_bit;
sbit LCD_D5 at RC3_bit;
sbit LCD_D6 at RC4_bit;
sbit LCD_D7 at RC5_bit;

sbit LCD_RS_Direction at TRISC0_bit;
sbit LCD_EN_Direction at TRISC1_bit;
sbit LCD_D4_Direction at TRISC2_bit;
sbit LCD_D5_Direction at TRISC3_bit;
sbit LCD_D6_Direction at TRISC4_bit;
sbit LCD_D7_Direction at TRISC5_bit;
// End LCD module connections

sbit green at RE0_bit;
sbit yellow at RE1_bit;
sbit red at RE2_bit;
sbit green2 at RD4_bit;
sbit yellow2 at RD3_bit;
sbit red2 at RD2_bit;
sbit IR3 at RB2_bit;
sbit IR4 at RB3_bit;
sbit Vibration at RB5_bit;
sbit Buzzer at  RD7_bit;
sbit servo1 at RD0_bit;
sbit servo2 at  RD1_bit;
sbit IR1 at RB6_bit;
sbit IR2 at RB7_bit;
```

```c
sbit IR2 at RB7_bit;


void Rotation0() //0 Degree rotation first servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F0 = 1;
Delay_us(800); // pulse of 800us
PORTD.F0 = 0;
Delay_us(1000);
}
}

void Rotation1() //0 Degree rotation second servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F1 = 1;
Delay_us(800); // pulse of 800us
PORTD.F1 = 0;
Delay_us(1000);
}
 }
void Rotation90() //90 Degree first servo
{
```

```
 }
void Rotation90() //90 Degree first servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F0 = 1;
Delay_us(1500); // pulse of 1500us
PORTD.F0 = 0;
Delay_us(18500);
}
}
void Rotation_second() //90 Degree second servo
{
unsigned int i;
for(i=0;i<50;i++)
{
PORTD.F1 = 1;
Delay_us(1500); // pulse of 1500us
PORTD.F1 = 0;
Delay_us(18500);
}
}
unsigned int duration;     // ultrasonic sensor declaration
float distance;
char text[15];
void interrupt(){
 if(RBIF_bit){
 RBIE_bit = 0; // disable the port change interrupt
 if(RB4_bit==1){
```

```
 if(RBIF_bit){
 RBIE_bit = 0; // disable the port change interrupt
 if(RB4_bit==1){
 TMR1L = 0;
 TMR1H = 0; // Clear the timer resistor
 T1CON.TMR1ON = 1; // Enable the Timer1
 }
 if(RB4_bit==0){
 duration = (TMR1H<<8) | (TMR1L) ;
 T1CON.TMR1ON = 0; // Disable the timer1
 }
 RBIF_bit = 0; // Clear the interrupt flag bit
 }
 RBIE_bit = 1; // Enable the port change interrupt
 }              // End of ultrasonic declaration



void main()
{
TRISE = 0x00;
TRISD = 0;
TRISB = 0xF0;
TRISC = 0x00;
Red==1;
Yellow==0;
Green==0;
PORTD.F2=0;
PORTD.F3=0;
```

```c
void main()
{
TRISE = 0x00;
TRISD = 0;
TRISB = 0xF0;
TRISC = 0x00;
Red==1;
Yellow==0;
Green==0;
PORTD.F2=0;
PORTD.F3=0;
PORTD.F4=0;
PORTD.RD7=0;


TRISB0_bit = 0; // Trig pin      // ultrasonic sensor
 PORTB.F0 = 0; // Set Trig pin low state
 TRISB4_bit = 1; // Echo pin
 PORTB.F4 = 0; // Clear Echo pin
 Lcd_Init(); // Initialize the Lcd module
 INTCON.GIE = 1; // Enable the global interrupt
 INTCON.RBIE = 1; // Enable the port change
 T1CON.TMR1ON = 0; // Disable timer1
 T1CON.TMR1CS = 0; // Timer1 internal clock source (Fosc/4)
 T1CON.T1CKPS1 = 0; // 1:2 Presclar value
 T1CON.T1CKPS0 = 1;
 duration = 0;
 distance = 0;
```



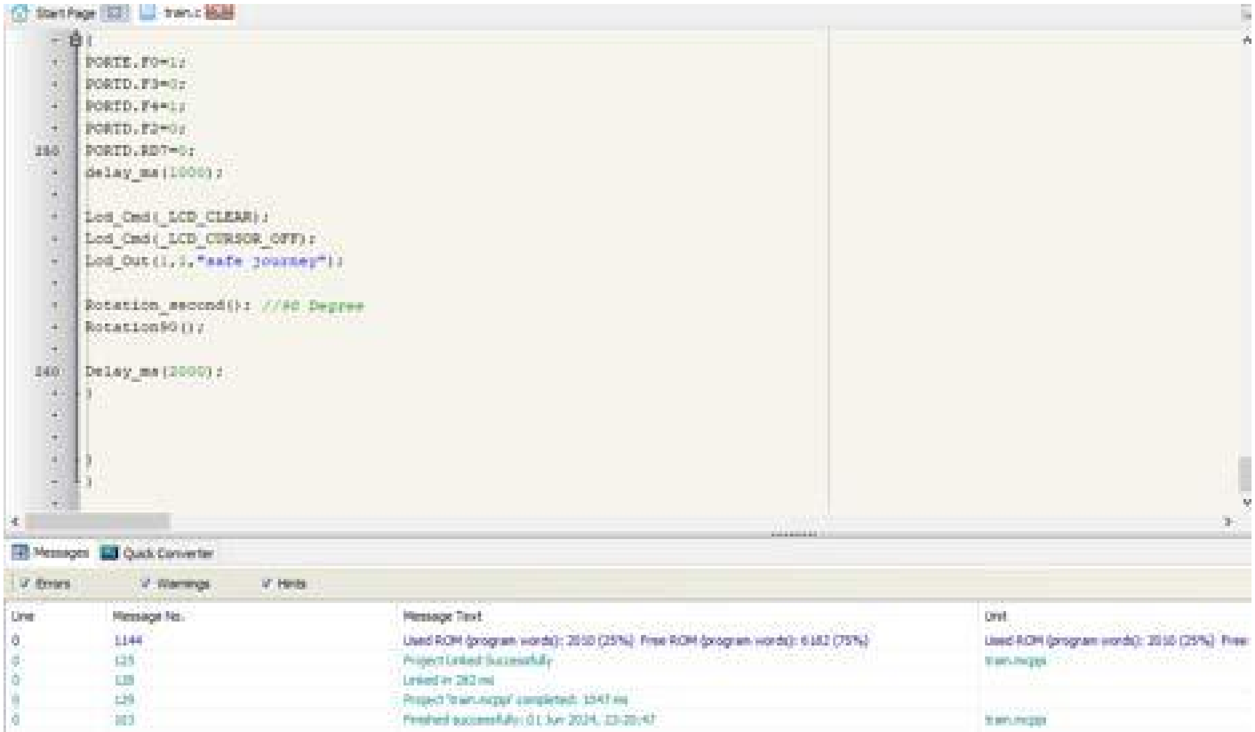
```c
Lcd_Init();
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"Welcome Engineer");
delay_ms(2000); // removed welcome message

while (1)
{

PORTB.F0 =1; // Generate 10us Trig pulse // ultrasonic code while loop
 delay_us(10);
 PORTB.F0 = 0;

 while(RB4_bit==0); // Wait for Echo pulse

 distance = duration * (0.034 / 2);
 // Check condition for valid distance

if ( distance >=2 && distance <=50 && IR1==1 && IR2==1 && IR3==1 && IR4==1  )
{
PORTD.F4=0;
PORTE.F1=1;
PORTD.F3=1; // orange
delay_ms(1000);
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(2,7,"cm");
Lcd_Out(1,1,"Distance");
FloatToStr(distance,text);
Ltrim(text);
```

```
Lcd_Out(1,1,"Distance");
floatToStr(distance,text);
Ltrim(text);
text[5]=0;
Lcd_Out(2,1,text);
delay_ms(1000);

}

if (IR1==1 && IR2==1 && IR3==1 && IR4==1 && distance >=50 )
{

Red==0;
PORTD.RD4=1;
Red2==0;
PORTD.F7=0;
PORTD.F3=0;
PORTE.F1=0;
PORTE.F0=1;

Lcd_Init();
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
LCD_Out(1,1,"Go On");
delay_ms(1000);

}


if (  IR1==0 && IR2==1 ) //1st direction
```

```


if (  IR1==0 && IR2==1 ) //1st direction
{
PORTE.F2=1;
PORTD.F2=1;
PORTD.F4=0;
PORTD.F3=0;
PORTD.RD7=1;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"Train Detected");

Rotation0(); //0 Degree
Rotation1();
Delay_ms(1000);

}
if ( IR3==0 && IR4==1)  // second direction
{
PORTE.F0=0;    //GREEN OFF
PORTE.F2=1;     // RED1 ON
PORTD.F3=0;     // ORANGE OFF
PORTD.F4=0;  //GREEN2 OFF
PORTD.F2=1;    //RED2 ON
PORTD.RD7=1;    // BUZZER ON
delay_ms(1000);
```

```
PORTD.F3=0;     // ORANGE OFF
PORTD.F4=0;  //GREEN1 OFF
PORTD.F2=1;   //RED1 ON
PORTD.RD7=1;    // BUZZER ON
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"Train Detected");

Rotation0(); //0 Degree
Rotation1();
Delay_ms(2000);

}
 if (IR1==1 && IR2==0 ) //1st direction
{
PORTE.F0=1;
PORTD.F3=0;
PORTD.F4=1;
PORTD.F2=0;
PORTD.RD7=0;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");

Rotation90(); //0 Degree
Rotation_second();
```

```
Lcd_Out(1,1,"safe journey");

Rotation90(); //0 Degree
Rotation_second();
Delay_ms(2000);

}
if ( IR3==1 && IR4==0 ) // second direction
{
PORTE.F0=1;
PORTD.F3=0;
PORTD.F4=1;
PORTD.F2=0;
PORTD.RD7=0;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");

Rotation_second(); //90 Degree
Rotation90();

Delay_ms(2000);
}


}
}
```



```
{
PORTE.F0=1;
PORTD.F3=0;
PORTD.F4=1;
PORTD.F2=0;
PORTD.RD7=0;
delay_ms(1000);

Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,1,"safe journey");

Rotation_second(); //90 Degree
Rotation90();

Delay_ms(2000);
}


}
}
```

Line	Message No.	Message Text	Unit
0	1144	Used ROM (program words): 2010 (25%) Free ROM (program words): 6182 (75%)	Used ROM (program words): 2010 (25%) Free
0	125	Project Linked Successfully	train.mcppi
0	128	Linked in 282 ms	
0	129	Project 'train.mcppi' completed: 1547 ms	
0	103	Finished successfully: 01 Jun 2024, 23:20:47	train.mcppi

Complete code for circuit one

3.11) <u>Circuit For Vibration sensor</u>

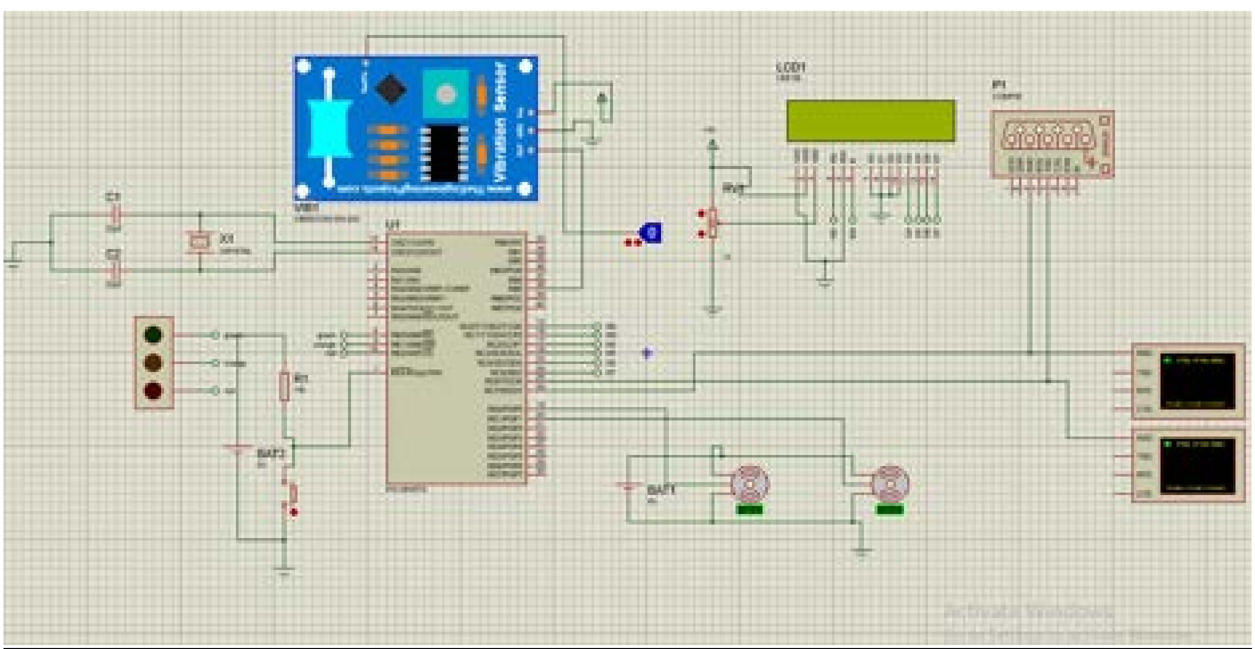


Figure 3.11 showing vibration sensor circuit

The vibration sensor is a digital sensor which is triggered by a logic state signal of either one or zero. If the sensor detects a change in vibration the signal sent to the microcontroller will be high or logic one. The sensor is connected to pin RB6 of PORTB. When the vibration sensor detects a change or variation of the normal train vibrations, a signal will be sent to the microcontroller indicating the occurrence of an accident. The Microcontroller will display a message on the LCD as well as send a text message via GSM indicating the occurrence of an accident along with the location of the accident.

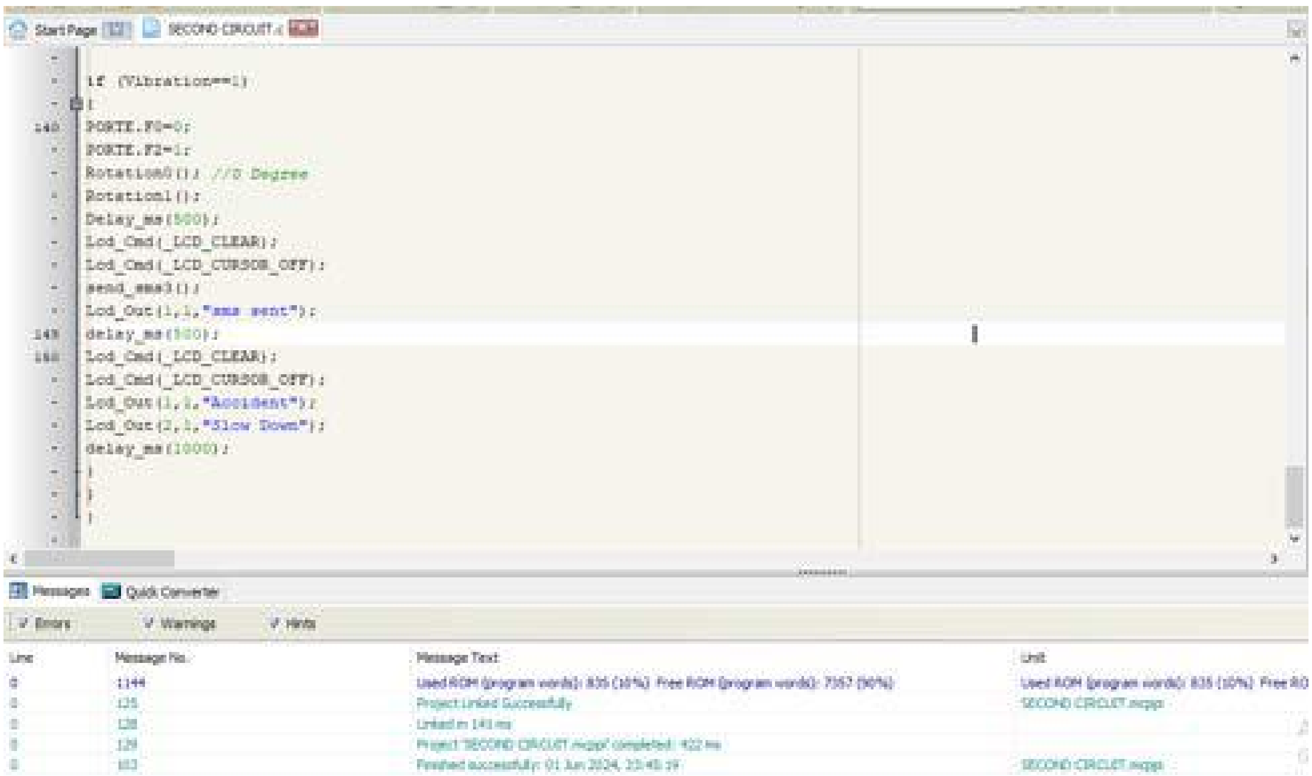


Figure 3.11.1 showing code for vibration sensor

3.12) Power Supply Circuit

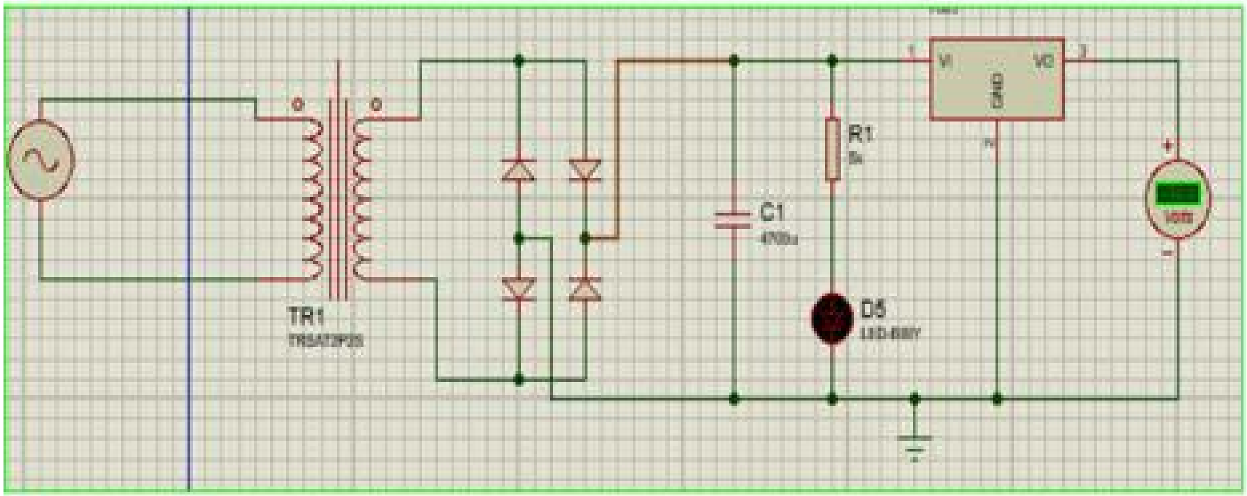


Figure 3.12 showing power supply circuit on Proteus

The transformer is a step down transformer. Its steps down 230 V 50Hz to 13V AC signal. The AC signal is rectified using the bridge rectifier. Output voltage of the bridge rectifier: 13V – 0.7*2 = 12.6V

The 12.6V is filtered off by a 4700uF capacitor. The 12.6V is fed into the input of the regulator which then gives an output constant 5V.

3.13) Summary

The system design included all the major components that are necessary to fully implement the project. The system intends to meet and satisfy the objectives of the project by incorporating input sensors which are Infrared Sensors for train detection and servo motors for controlling the closing and opening of the boom gate. Traffic lights were included for signaling as well as a buzzer which will sound as a siren. The LCD will be displaying messages and giving caution to road users.

Chapter 4: Simulations

4.1) Introduction

This chapter demonstrates the results of simulations of the designed system and outlines the interface of the software side of the project and the hardware part. It also analyses these results with reference to the proposed objectives of the project in chapter one.

4.2 Traffic Light Simulation

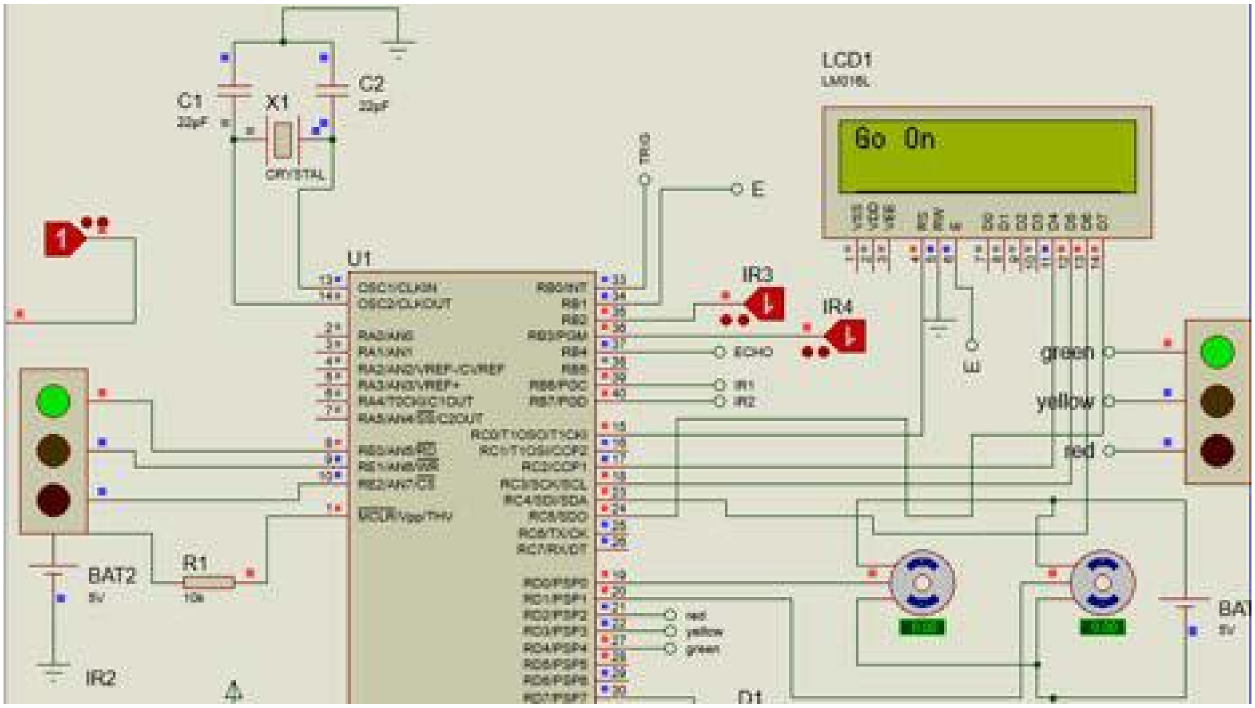


Figure 4.2(a) showing traffic light signal

Figure 4.2(a) shows the traffic light signal when there is no train that has been detected. Green indicates that motor vehicles can cross or proceed on the railway level crossing point as it is safe to do so.

Traffic Light Signal

Red = Stop

Amber = Slow Down Take Caution

Green = Proceed

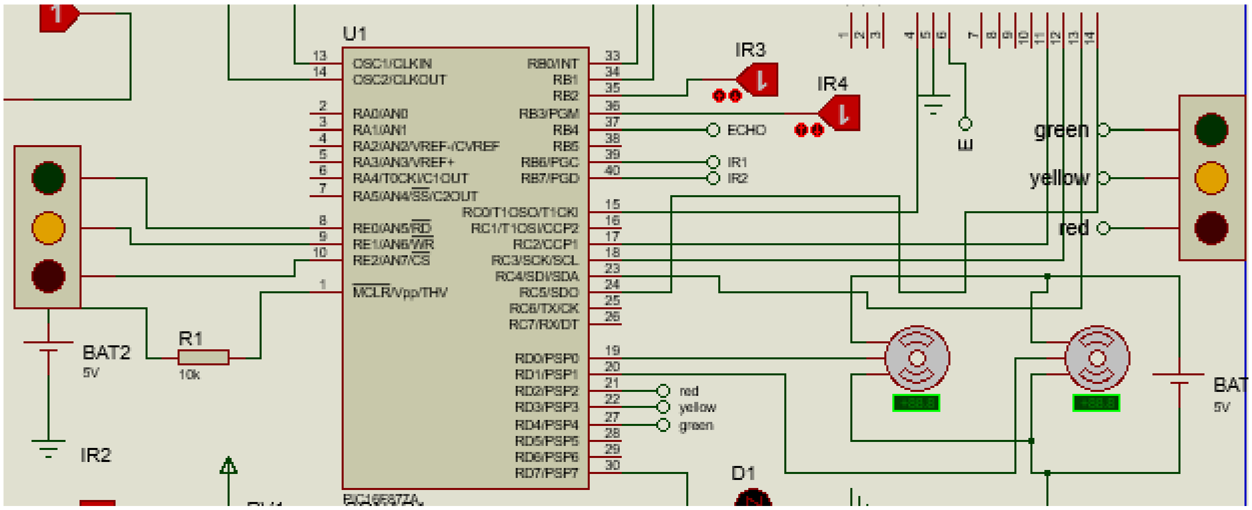


Figure 4.2(b) showing amber traffic lights

Figures 4.2(b) show amber traffic light indicating the train has been detected by the ultrasonic sensor and vehicle traffic should take caution as the train is getting closer to the railway level crossing point.

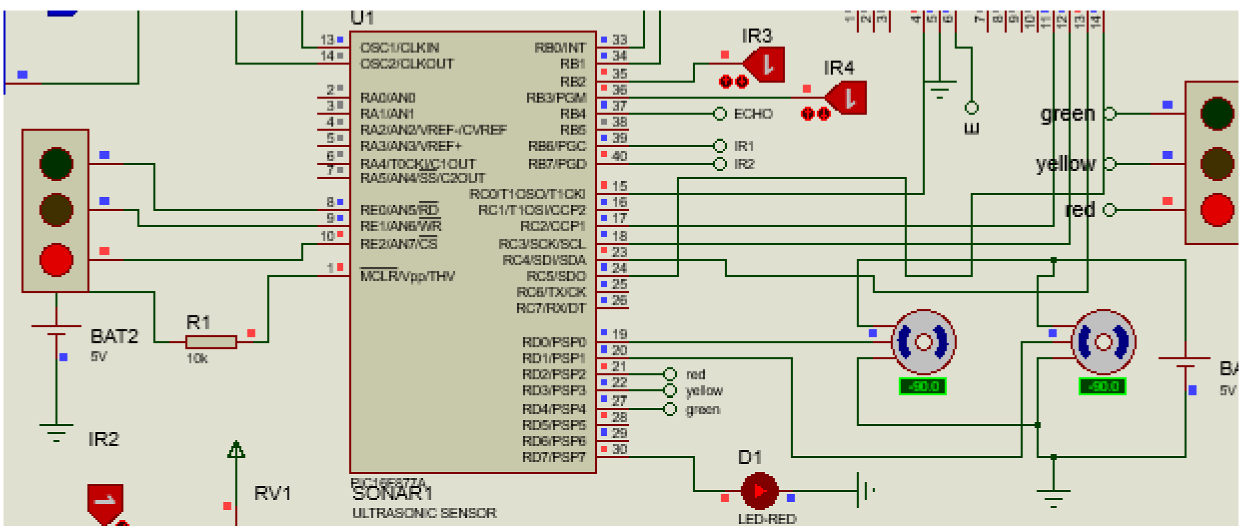


Figure 4.2(c) showing amber traffic lights

Figures 4.2(c) show red traffic light indicating the train has been detected by the first infrared sensor and vehicle traffic should stop as the train has arrived at the railway level crossing point.

4.3) **Infrared Sensor Simulation**

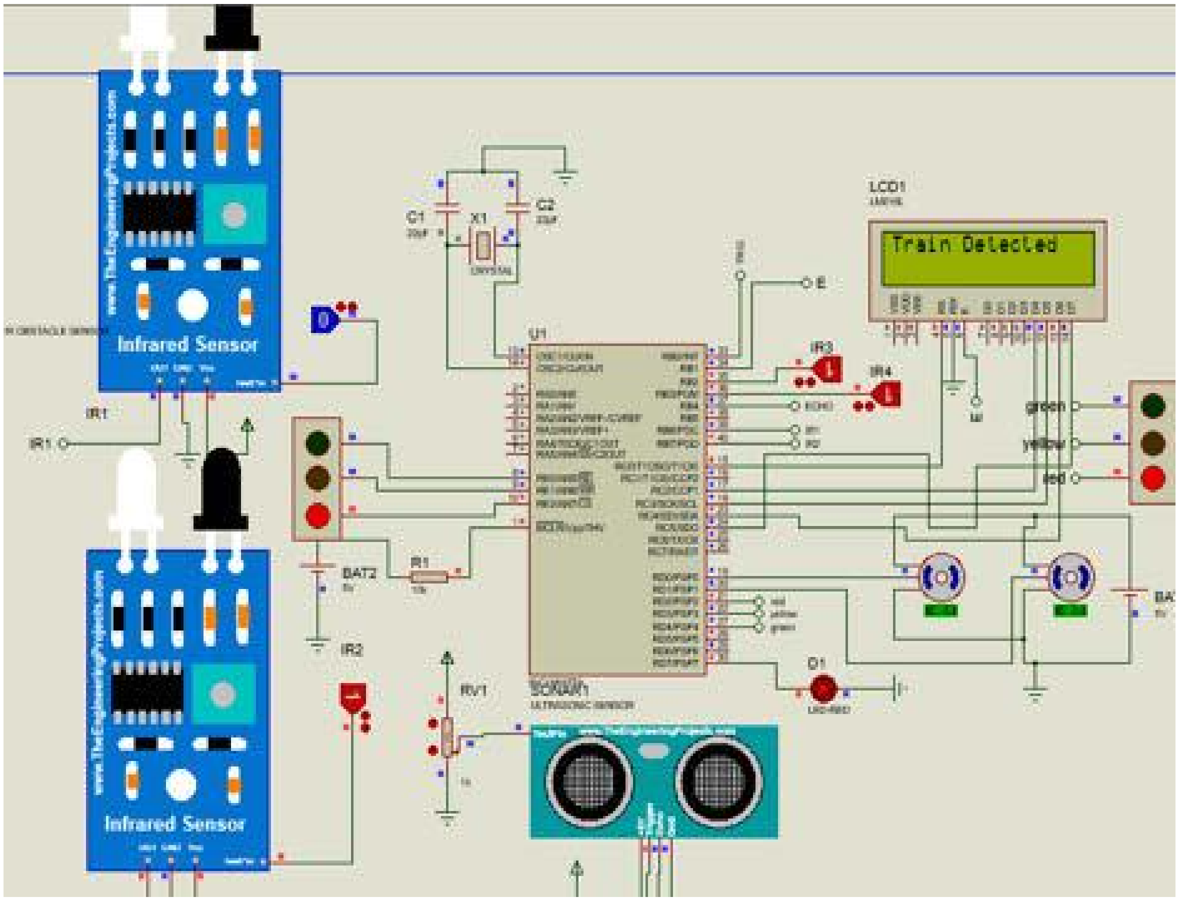


Figure 4.3(a) showing infrared simulation

Figure 4.3(a) shows when the first IR sensor has detected the train. Infrared sensors are logic low sensors. Therefore they give a signal when they are in the low state (logic 0) and no signal when they are in the logic 1 state.

Infrared Sensor Logic States

Logic level 0 = HIGH

Logic level 1 = LOW

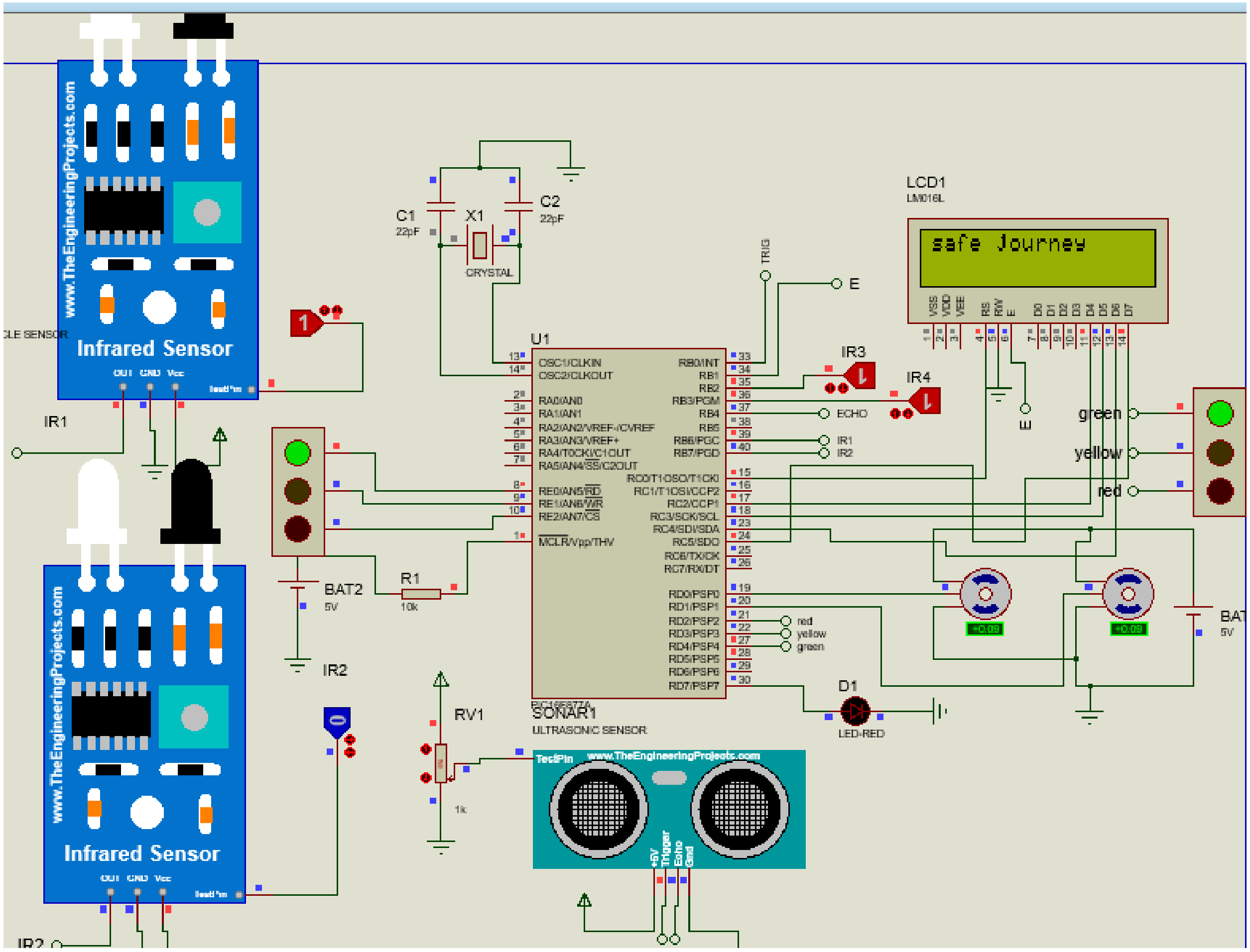


Figure 4.3(b) showing infrared simulation

Figure 4.3(b) shows when the second IR sensor has detected the train and the traffic light signal has turned from red to green indicating it is now safe to proceed.

4.4) Servo motor Simulation

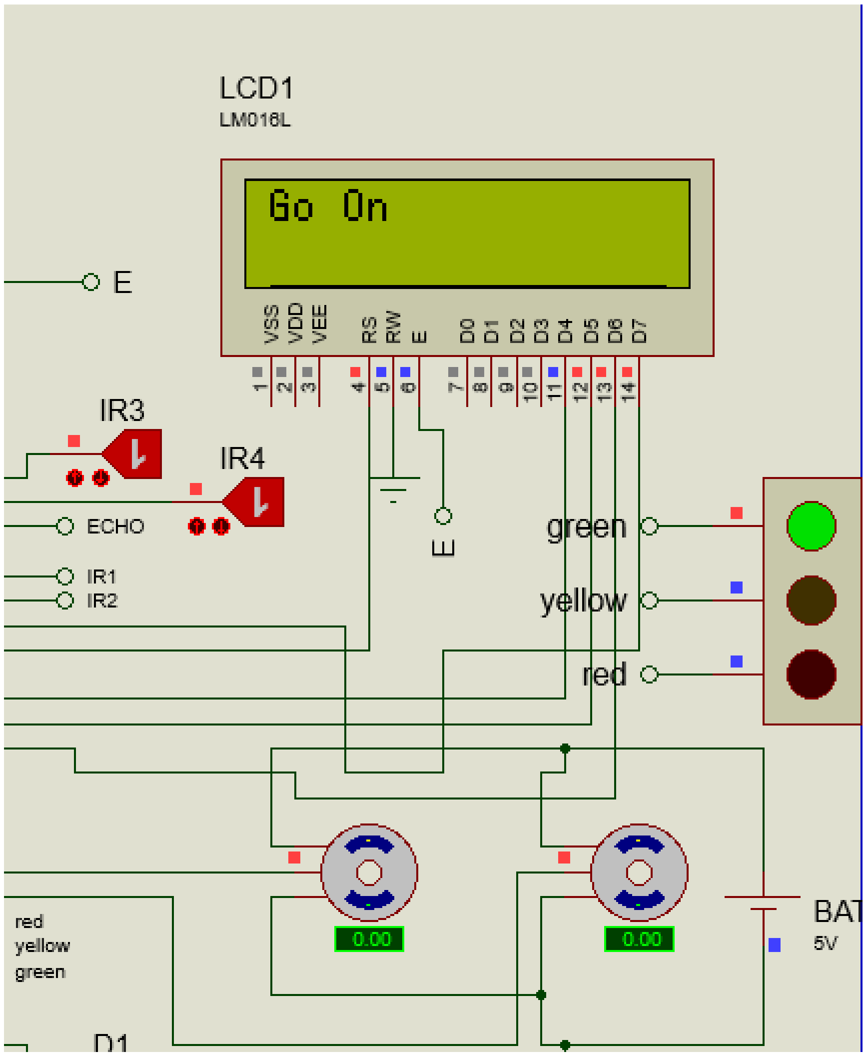


Figure 4.4 (a) showing servo motor simulation

Figure 4.4(a) shows the initial condition of the servo motor which control the rotation or movement of the boom gate. When no train is detected the boom gate is open and motor vehicles are free to go through. This angle is zero degrees showing gate is open.

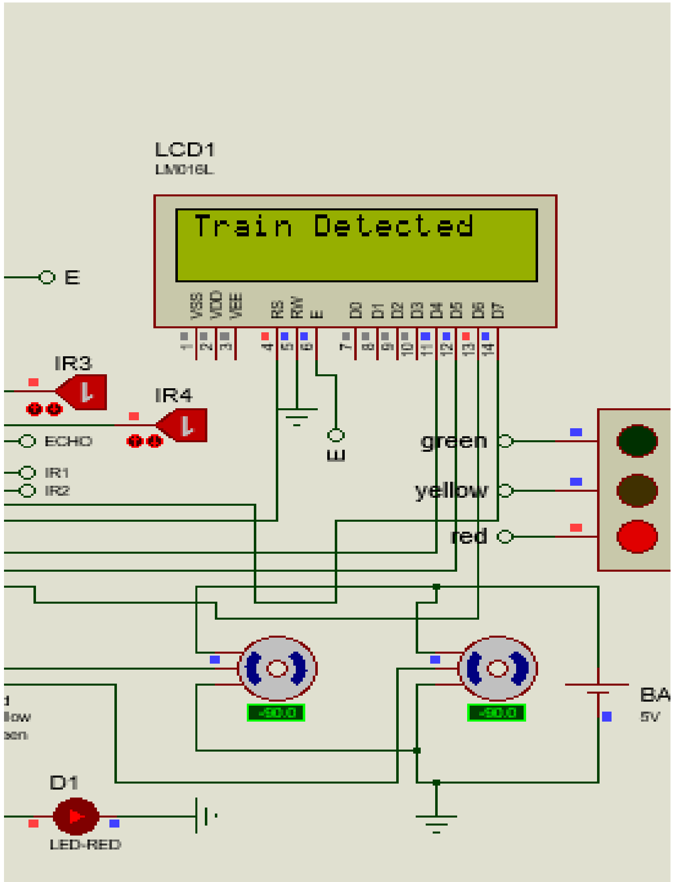


Figure 4.4 (b) showing servo motor simulation

Figure 4.4(a) shows the condition of the servo motor when a train is detected by the first IR sensor the boom gate is now closed at an angle of ninety degrees and motor vehicles are blocked giving preference to the train.

4.5) Ultrasonic Sensor Simulation

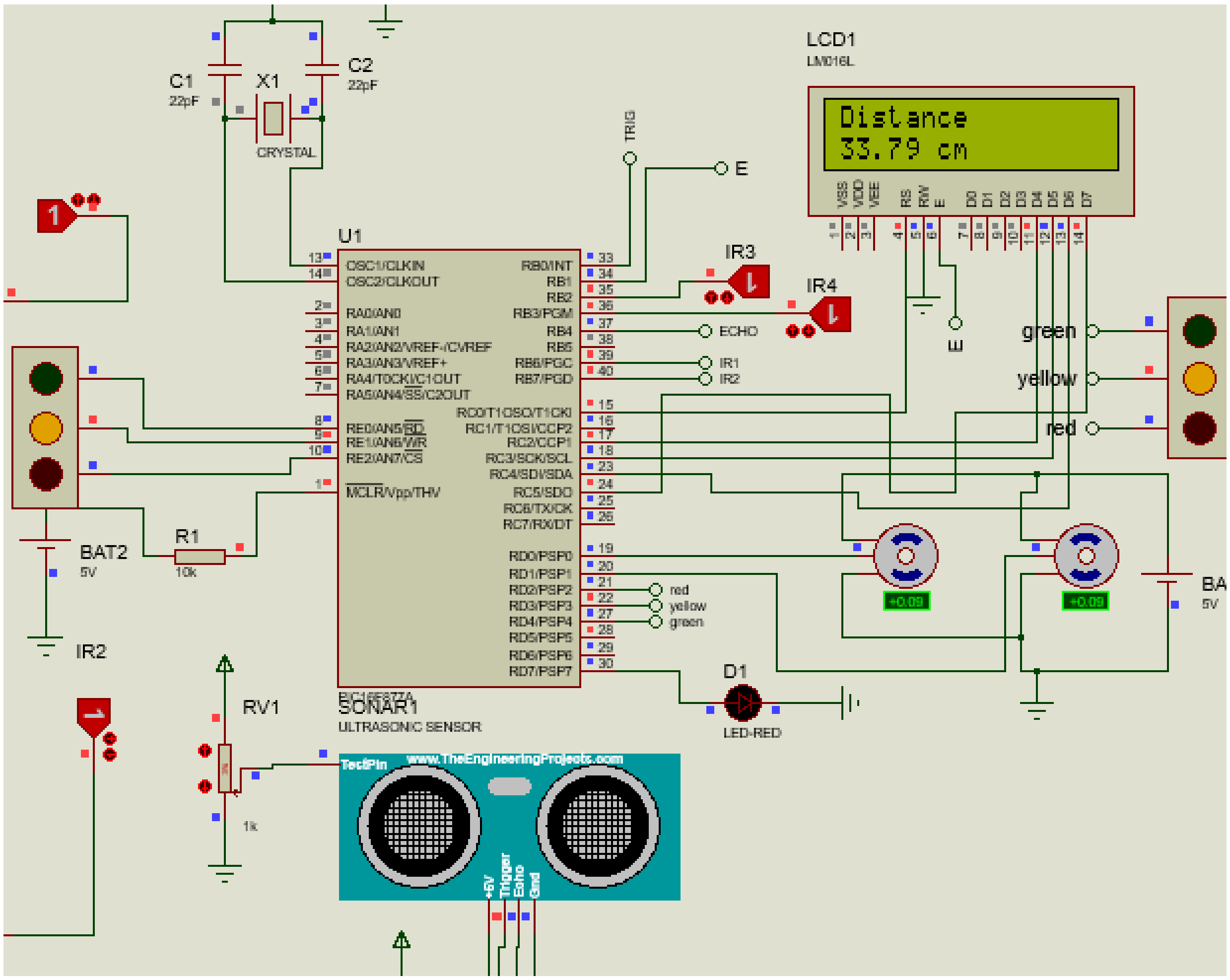


Figure 4.5 showing ultrasonic sensor

Figure 4.5 shows the ultrasonic sensor which is used to detect the train within a specified distance range. Once the train reaches that distance the traffic lights turns amber to warn road users that the train in now closer to the boom gate. The LCD will be displaying the distance of the train as it approaches.

4.6) Vibration Sensor and GSM Module Simulation

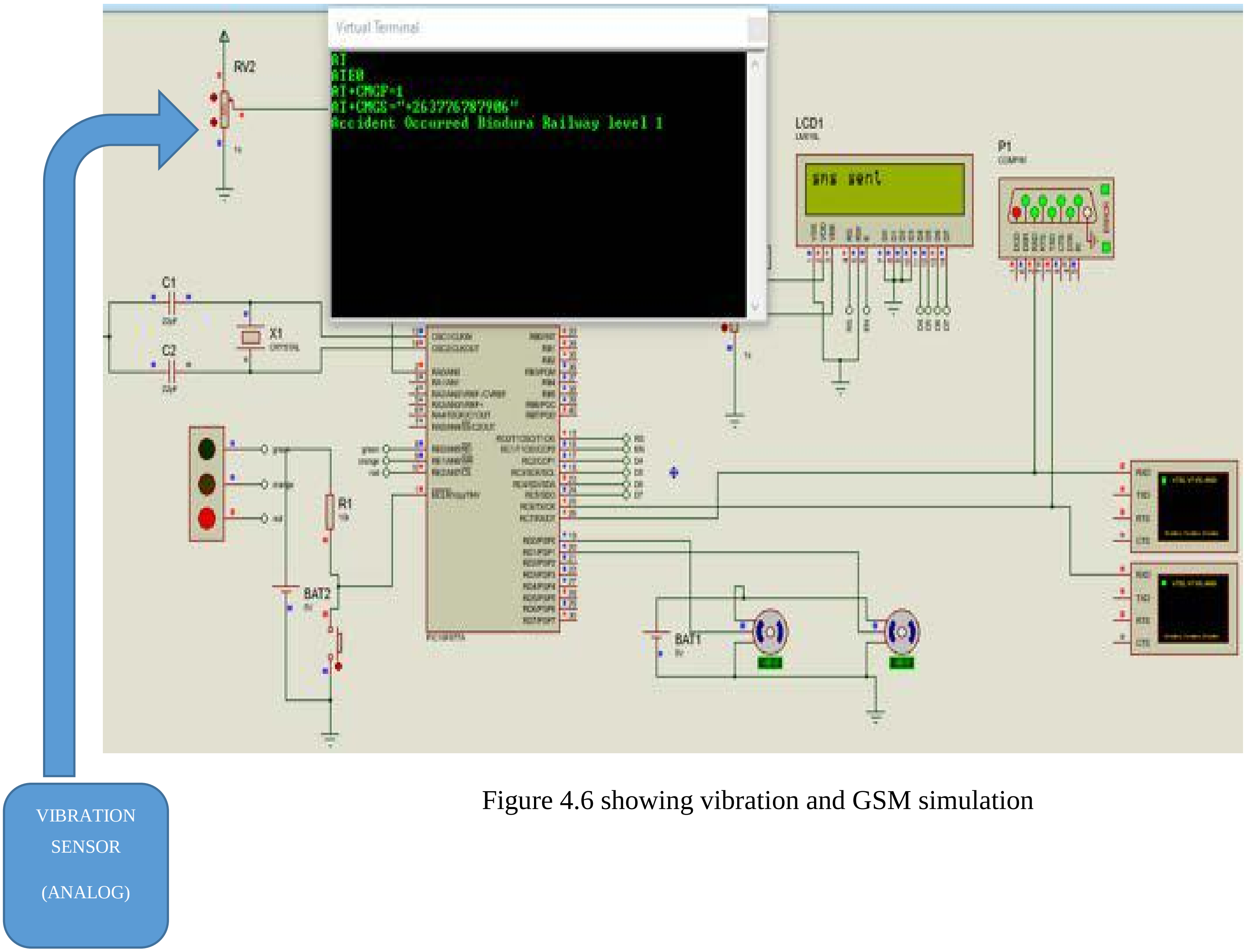


Figure 4.6 showing vibration and GSM simulation

Figure 4.6 shows the vibration sensor and GSM module. The vibration sensor used is analog hence the use of the variable resistor. As the resistance is varied to a certain level the signal will be translated to the microcontroller to an equivalent signal via the analog pins indicating a change in vibration. The microcontroller will send a message using the GSM to relevant authority alerting them of the accident.

4.7) Complete Circuit Simulation

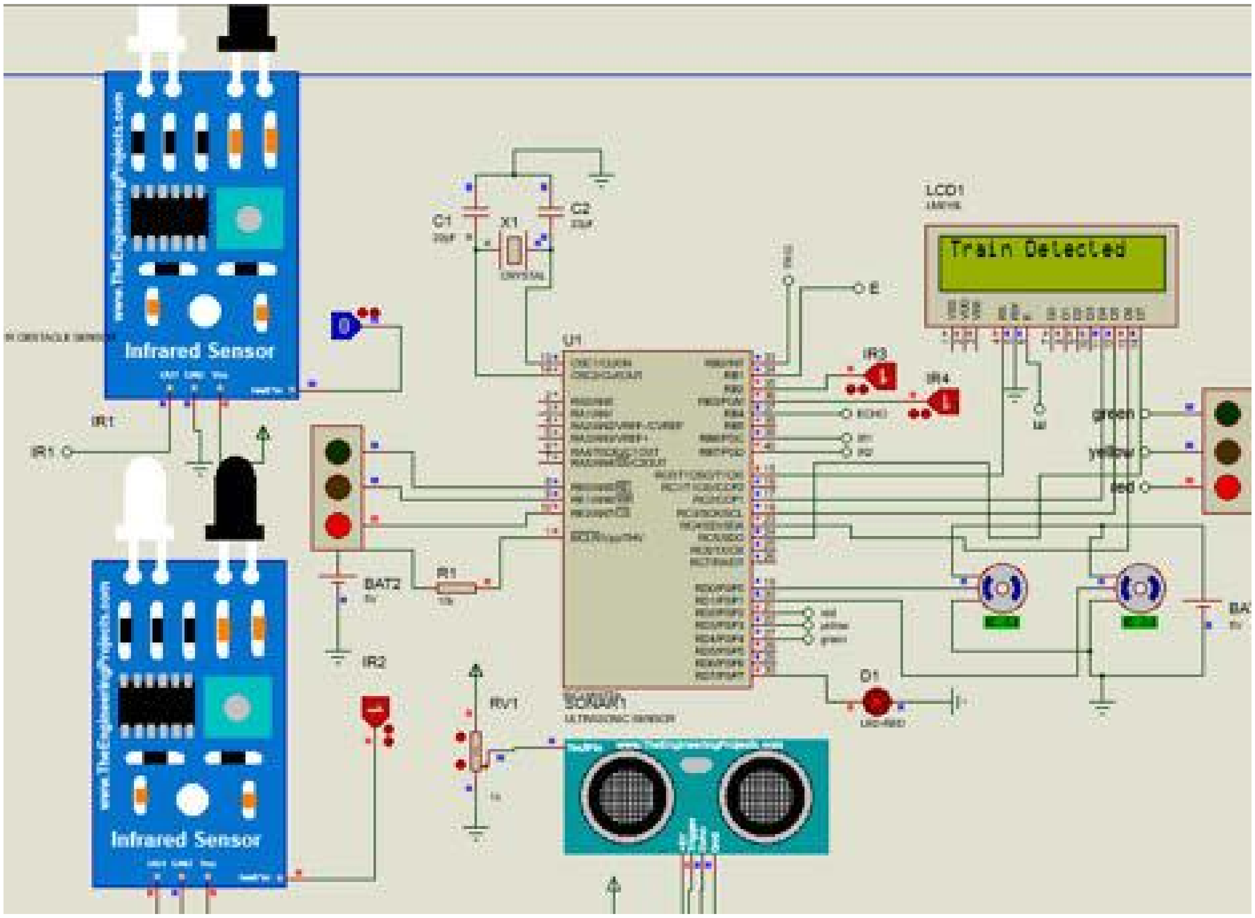


Figure 4.7 showing complete circuit simulation

Figure 4.7 shows the complete circuit simulation comprising of the IR sensors, servo motors, LCD, traffic lights as well as ultrasonic sensor.

4.8) Conclusion

The simulations were carried out successfully testing the response of each sensor individually as per the intended prototype requirements. The objectives were met successfully on the simulation,

Chapter 5: Implementation

5.1) Introduction

This chapter shows the practical implementation of the designed project to achieve the specified objectives of the project. The circuits were first implemented on the breadboard testing the sensors and adjusting them along with the code till they perform as desired. The functionality of the final designed prototype of the project is shown.

5.2) Breadboard Testing

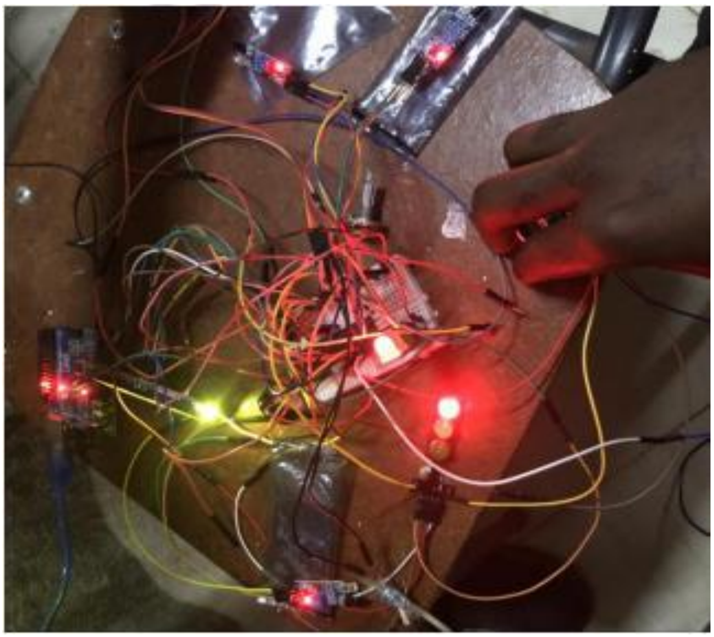


Figure 5.2 showing breadboard simulations

The simulations were first done on the breadboard for easy correction of errors and also to allow for the easy uploading of the code into the microcontroller in the case of changes.

5.3) Hardware Implementation

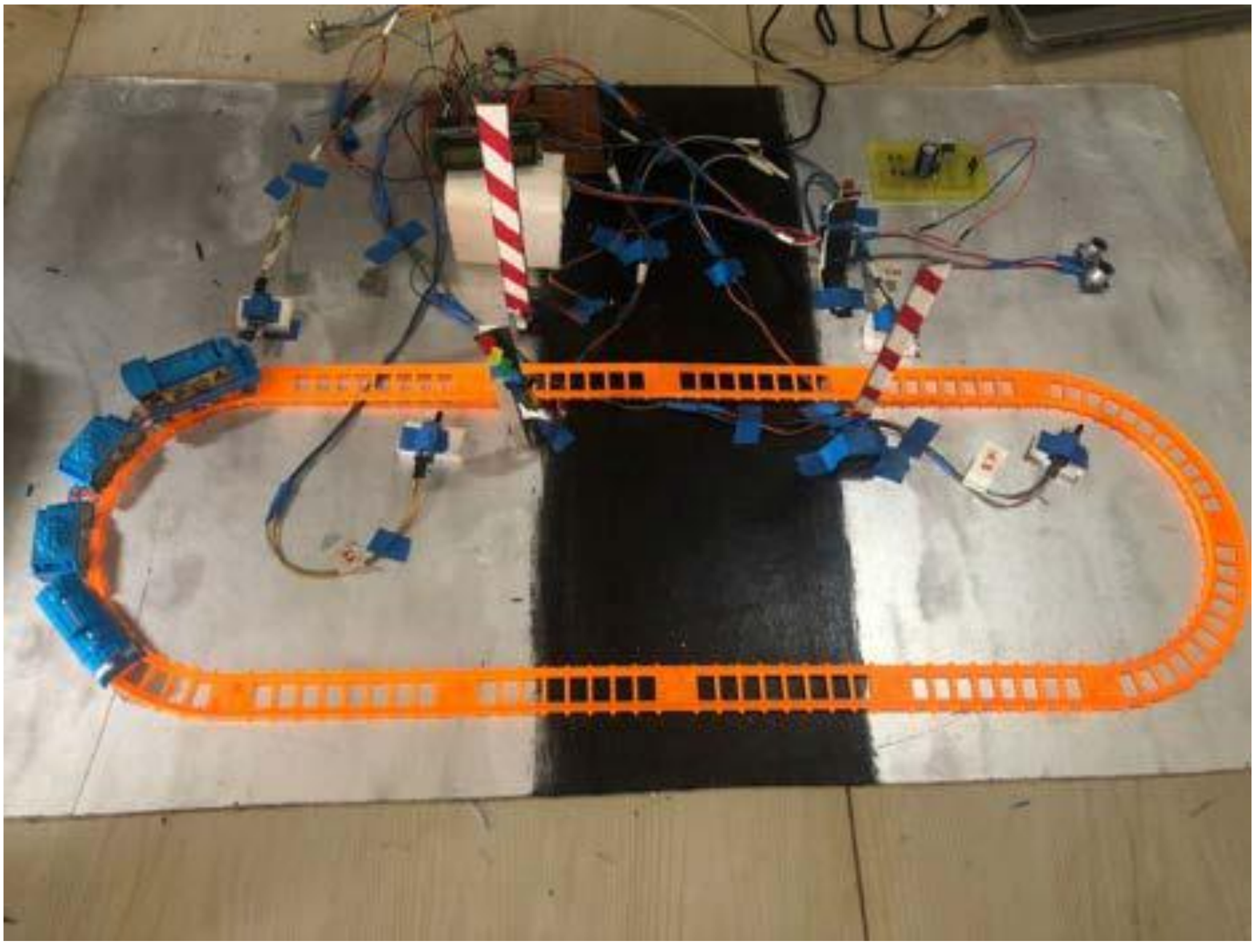


Figure 5.3 showing railway level crossing point

Figure 5.3 shows the railway level crossing point where the railway line crosses the road. Boom gates whose rotations are controlled by servo motors are erected at both sides of the roads as well as traffic lights for signaling to vehicle traffic. Four IR sensors are connected for detection. IR sensor 1 and IR sensor 2 detect the train from one direction, IR3 and IR4 detect the train when coming from the other direction.

5.4) Controller Circuit

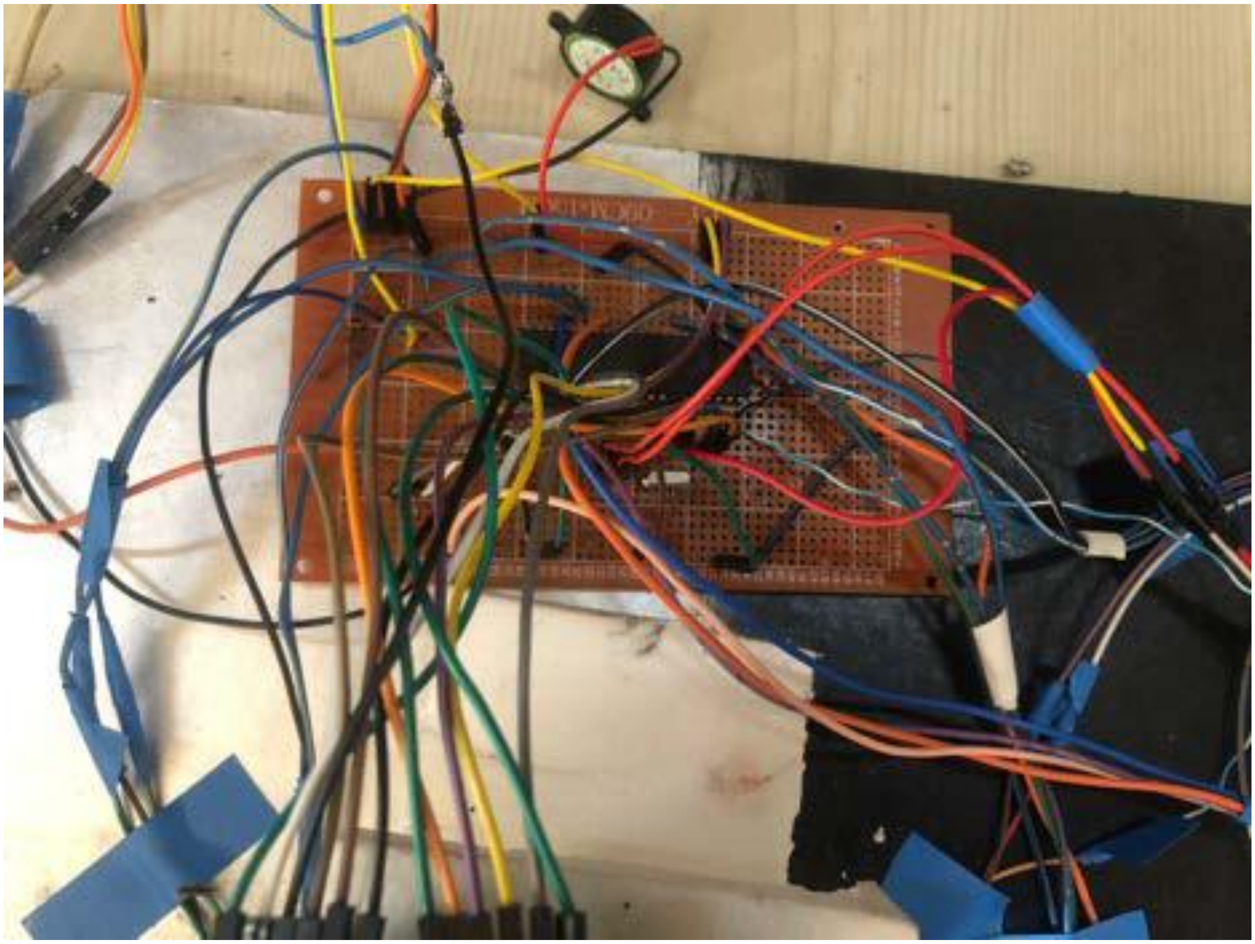


Figure 5.4 showing the controller circuit

Figure 5.4 shows the controller circuit comprising of the PIC16F877A microcontroller mounted on a Vero-board along with all the connections to the sensors and traffic lights. The microcontroller is the brain of the system which receives input signal and gives out signals for output sensors that include LCD and servo motors.

5.5) Initialization

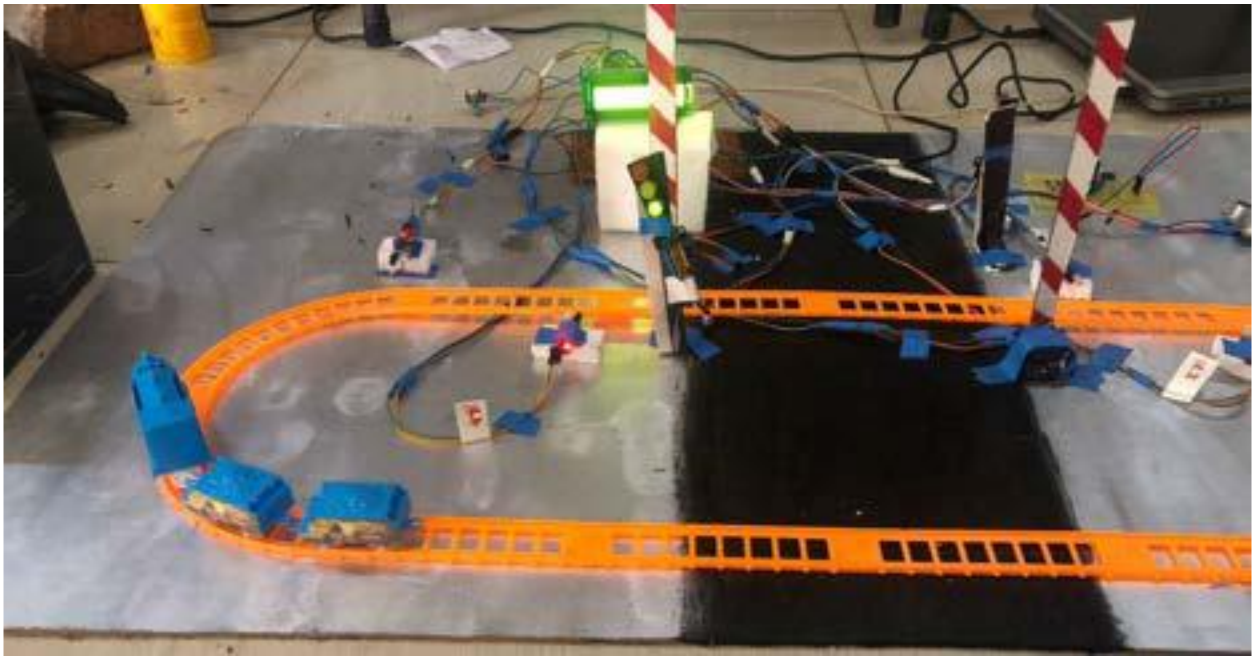


Figure 5.5 showing the initial condition of the system

Figure 5.5 shows the initial conditions of the system where the train has not been detected yet. The boom gate is initially open and the green traffic light is on.

5.6) IR Sensor 1 Triggered

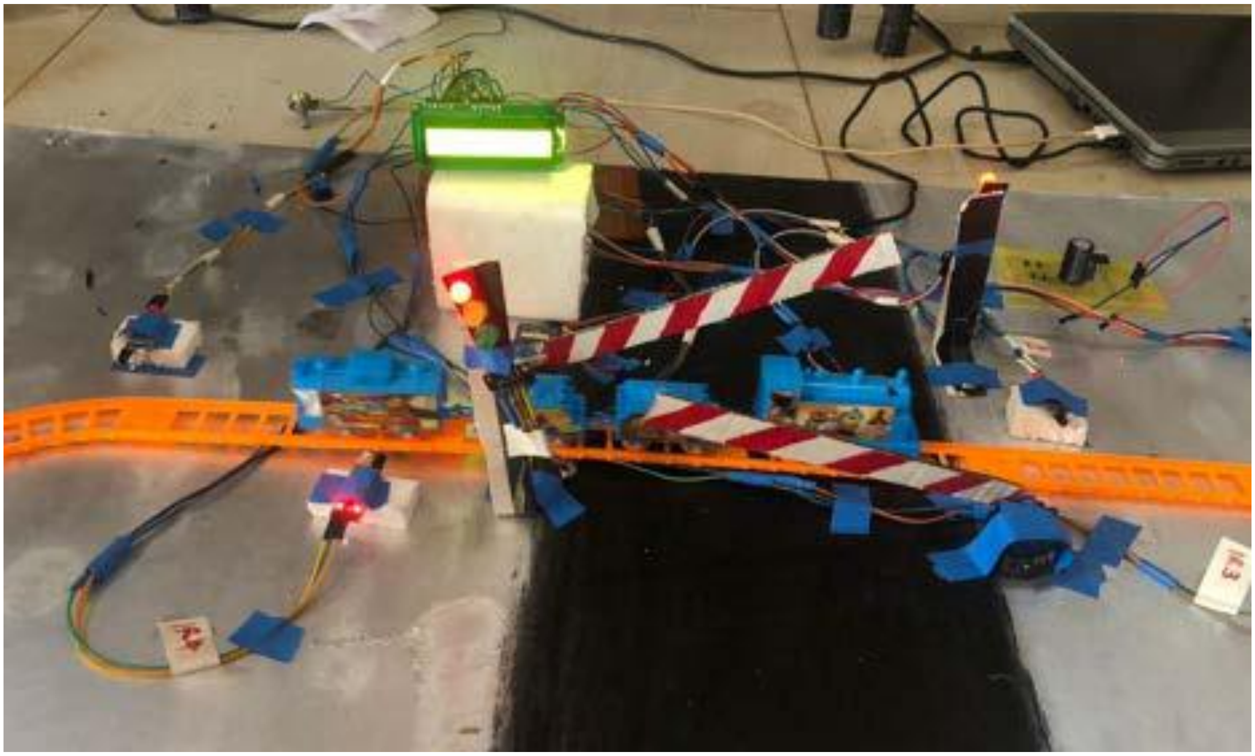


Figure 5.6 showing triggered IR sensor 1

Figure 5.6 shows when the train has passed IR sensor 1 and triggered it, immediately the red traffic light turns on and the boom gates close for road traffic giving preference to the train. The LCD displays Train Detected.

5.7) IR Sensor 2 Triggered

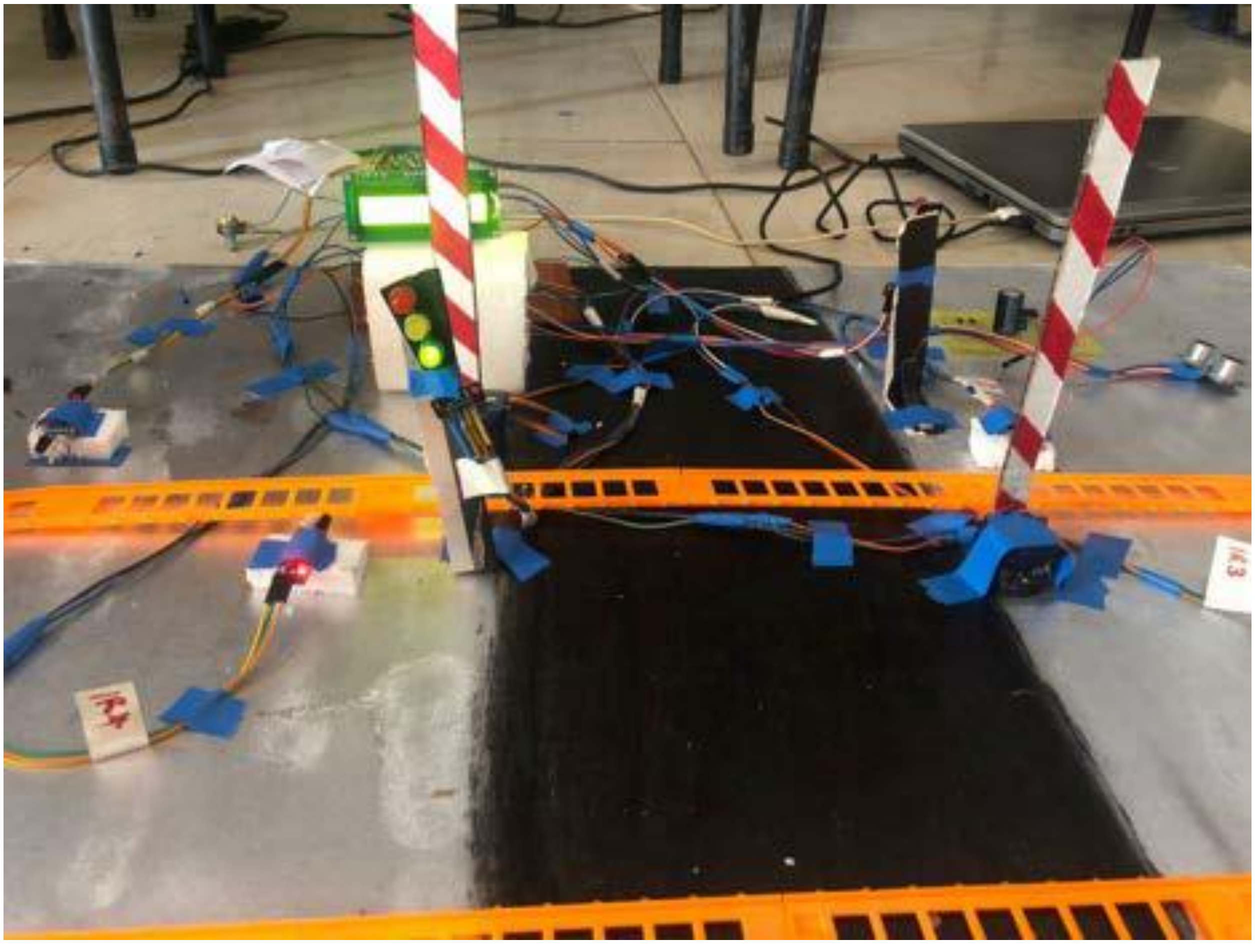


Figure 5.7 showing triggered IR sensor 2

Figure 5.7 shows when the train has reached IR sensor 2and triggered it, after a set delay period to allow for the carriage of the train to pass the green traffic light turns on and the boom gates open for road traffic. The LCD displays Go On indicating to traffic that it is now safe to proceed.

5.8) LCD Display

Figure 5.8(a) showing LCD display message when train is detected

Figure 5.8(b) showing LCD Display message after the train has passed the second IR sensor

5.9) Vibration Sensor and GSM module Circuit

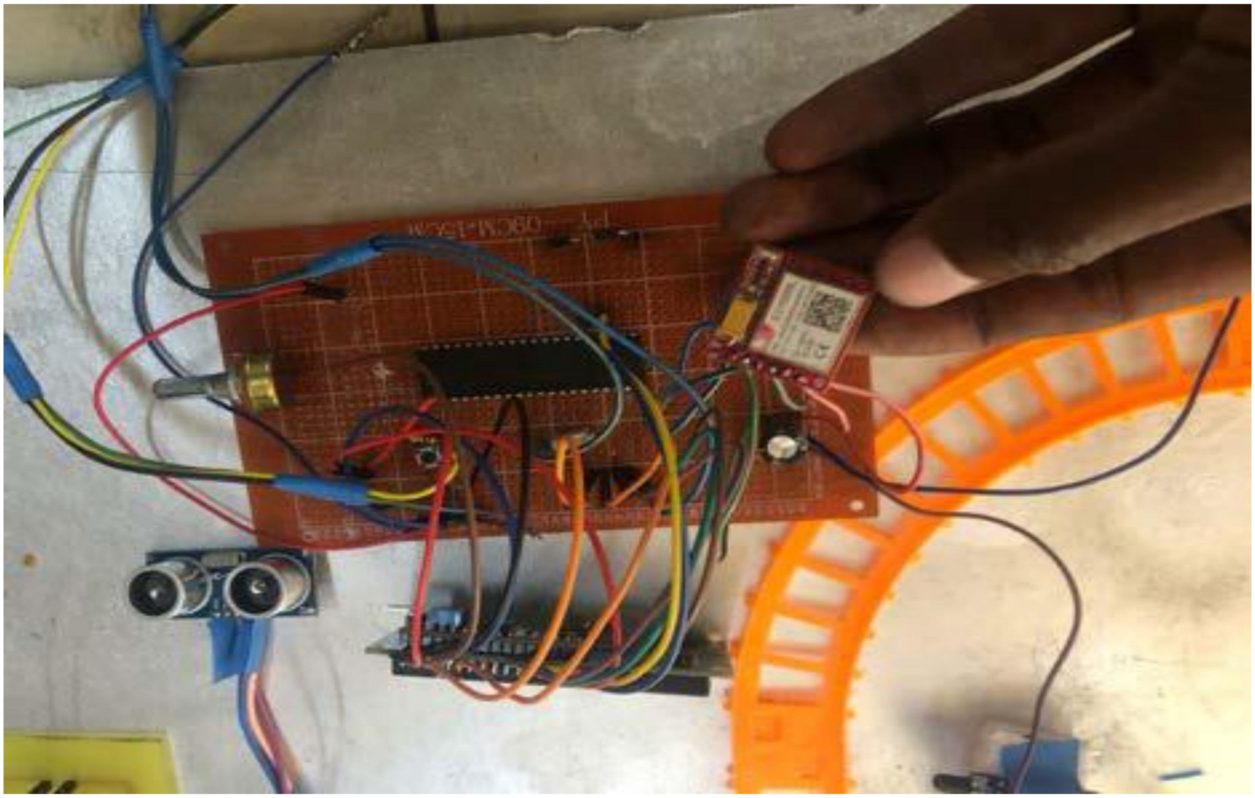


Figure 5.9 showing GSM and vibration sensor circuit

Figure 5.9 shows vibration sensor circuit with GSM module. When the vibration sensor detects a sudden change in the normal train vibrations, it sends an analog signal to the microcontroller to trigger the GSM to send a message to relevant authority informing them of an accident.

5.10) 5V Power Supply Circuit

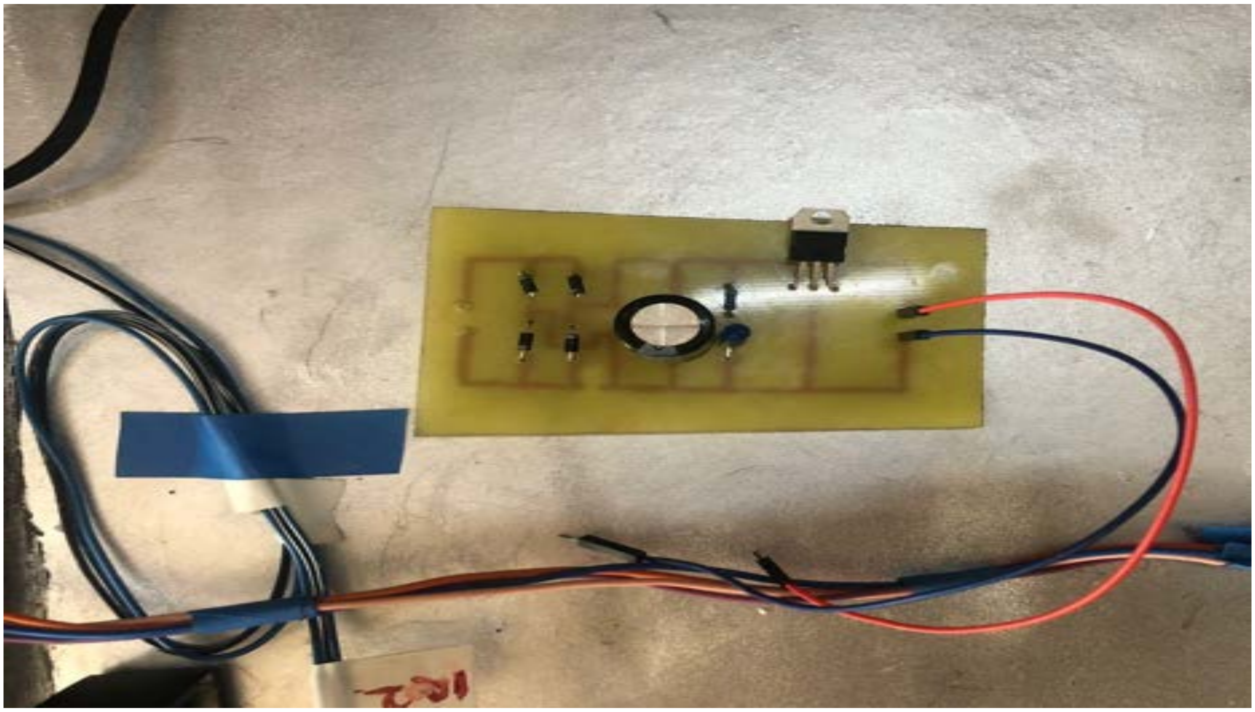


Figure 5.10 showing 5V power supply

Figure 5.10 shows a 5 volts power supply designed and implemented. The power supply was mounted on a PCB and it is giving out the required 5v output.

5.11) Table of Results

	EXPECTED RESULTS	ACQUIRED RESULTS	RATING
IR SENSORS	• Detect train at the railwaylevel crossing point • Send signal to the microcontroller	• Detected • Sent signals to the controller	100%
SERVO MOTOR	• Rotate 90 degrees • Rotate back to zero degrees	• Rotated • Rotated	100%
LCD	• Display relevant messages as per instruction from controller	• Displaying	100%
ULTRASONIC SENSOR	• Detect oncoming train and record distance	• Slow to detect	50%
TRAFFIC LIGHTS	• Respond correctly as per instruction from controller	• Responding	100%

PIC16F877A	• Receive signals from input sensors • Process signals • Send correct messages and signals to output sensors	• Responding correctly	100%
POWER SUPPLY	• Produce an output of 5 volts	• Produced 5volt	100%
VIBRATION SENSOR	• Detect change in vibration	• Detects with low accuracy	80%
GSM MODULE	• Send sms when triggered	• Not sending	0%
AVERAGE SUCCESS RATE			73%

Table 5.11 showing results obtained

Table 5.2 shows the results obtained in comparison to the expected results. The GSM module could not send a message, concluded it was faulty. The prototype was able to show and meet all the major objectives hence the project was a success

5.12) Conclusion

The prototype implementation was done successfully, the results obtained met the major objectives and fulfilled the aim of the project.

Chapter 6: Recommendations

6.1) Introduction

This chapter describes the relevance of the project, the strengths and weaknesses as well as recommendations made for future design projects of the same nature.

6.2) Strengths of the project

- The project was able to solve one of the major railway level crossing challenges in our country which is poor safety measures by automating the entire system.
- The automation of the project improves accuracy and convenience as it can be installed even in remote areas or highways where the railway level crossing point is unmanned
- Traffic lights and the boom get system ensure that road vehicle motorists give heed to the train thus protecting them from severe accidents
- The project is a low cost hence can be implemented anywhere and can be powered using solar energy

6.3) Weaknesses of the project

- The use of IR sensors only could hinder the effectiveness of the system as they could detect any other object other than the train
- Pic microcontrollers cannot handle as many sensors due to limited ROM
- Servo motors used to control the boom gate require individual 5volts power supplies therefore making the project to need more than one source of power
- GSM module only work where there is strong network coverage

6.4) Recommendations

The designed Automated Railway Level Gate Control System serves as an important system that can be implemented for better safety but it can also be improved. Here are potential improvements

- Advanced System Controller: An advanced controller would be required if the system is to be implemented in real time as pic controllers are now outdated. PLCs and SCADA systems would improve the efficiency and robustness of the system
- Communication Interface: A more sophisticated communication interface would improve the system, by implementing a control room and also GPRS which gives the real time location of the train as GSM modules are limited.

6.5) Conclusion

The aim of the project was to design an automated railway gate control system, the practical implementation managed to meet the aim and the major objectives by improving safety at railway level crossing points giving preference to trains and save human lives. The project as implemented successfully though there were some inconsistences in the sensors when reading or giving out signals.The student was able to learn valuable lessons from the project such as intense research, managing time and pressure and how to use a wide variety of components.

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