Energy Saving Automatic Street Lighting System

Abstract

Energy saving is one of the most important aspects in our life trying to achieve because different forms of energy including electricity, gas and oil cost a lot of money. Large percent of this cost is spent on wasted energy through the use of applications. This leads to search for new technologies and systems that save energy.

In our project, we will design and implement an automatic street lighting system. The main goal of this system is to reduce the energy consumed in the high road ways by using traffic density based control system. The system works based on the traffic density. This control is done by switching lights ON or OFF.

The main function of the system is monitoring the amount of traffic in this road, and it will control lighting function of the road. In order to demonstrate this function, we build a model that simulates the idea of lighting control system.

الملخص

على الرغم من أن الحفاظ على الطاقة ليست قضية نفكر بها في حياتنا اليومية , إلا أنها وبدون أدنى شك قضية بالغة الأهمية. جميعنا نستخدم الطاقة على مدار اليوم ولكننا للأسف نقوم بذلك بشكل بديهي دون التفكير بالعواقب. والأمر الذي ينساه معظم الناس هو أن الطاقة ليست متوفرة الى الأبد , وأننا للحفاظ على نوعية حياتنا يجب ان نستخدم مصادر الطاقة بحكمة. ومن هنا ظهرت الحاجة للبحث والتفكير في طرق تهدف للعمل على توفير استهلاك الطاقة.

يهدف مشروع "energy saving street lighting system" الى توفير الطاقة من خلال بناء نظام يتحكم بإنارة الشوارع على الطرق السريعة وذلك اعتمادا على سرعة السيارات , مع العلم أن هذا النظام يعمل فقط في الليل ويقوم مبدأ عمله على التحكم واختيار المصابيح الكهربائية المنوي تشغيلها بالاعتماد على سرعة السيارة . ولصعوبة تطبيق هذا المشروع حاليا على أرض الواقع تم بناء نموذج يوضح الية العمل.

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Chapter One

Introduction

1.1 Problem overview

The use of energy has been a key in the development of the human society by helping it to control and adapt to the environment. Managing the use of energy is important in any functional society. In the industrialized world, the development of energy resources has become essential for transportation, waste collection, information technology, communications that have become prerequisites of a developed society.

However the increasing demand and the limited availability of energy sources requires "efficient energy use" that aims to reduce the amount of energy required to provide products and services.

Lighting is a major source of energy consumption. It accounts about five to ten percent of total energy use; it is an area that offers many energy efficiency opportunities in almost any field like buildings and roadways. While energy efficiency is an attractive goal for many reasons, lighting designers must also consider a host of other factors, including the effect of quality of light on the visual comfort and performance. The right quality and quantity of light can be provided efficiently with less energy by using the right technology and its effective integration with daylight [21].

In this project, it has proposed to build a cost effective automatic street lighting system that has the capability to solve the problem of having lights switched on without the need for it. The system turns lights on only when it needed and this reduces the amount of energy consumed. The system works based on the traffic density that varies from maximums at peak morning and afternoon " rush hours " to minimums during the late evening and early morning hours. Traffic is normally significantly lighter between 11:00 pm to 6:00 am. (Based on a discussion with the staff of Hebron municipality).

In this project, we will study and analyze different ways and technologies to design a system that solves the problem mentioned earlier. However, due to difficulties in implement such a system in real life. We will simulate it and test our design using a model.

1.2 Project Objectives

The main objectives of the project are:

1. Study and analyze energy street lighting systems.

2. To design energy saving and cost effective street lighting system, that saves electrical energy based on traffic density

3. To implement a model that simulates the street lighting system simulates and tests, and provide the least possible cost to run the system.

1.3 Literature Review

The following related projects were researched:

1. Desing and Fabrication of Automatic Street Lighting Control System.

This paper has highlighted the importance of designing and fabrication circuits that can control distribution line based on the intensity of the daylight. It is observed that the circuit is working reliably, and it is possible to improve the power management system. Streetlights have a great demand of energy of the Bangladesh country. Any loss of power by streetlights has significant effect on load management. The main objective of this paper is to design an automated control system for streetlights to avoid power loss when lights remain switched on all the day. The system has designed and fabricated a circuit that can control on\off distribution line based on the intensity of the daylight, if the light intensity varies with seasons or some other factors it is adjustable [1].

The control system consists of light sensor, operational amplifier switching element, 220v (AC) street line distribution system and protection circuit and alert system for faults. The results showed that the system is reliable and thereby could reduce the loss of energy by maintaining the appropriate timing for ON\OFF the system.

In this project, the system mainly works based on the traffic density, which means if there is a traffic the system will be switched on, also the system controlled by a microcontroller compared with this project.

2. Led Street Lighting

This paper summarize an assessment project conducted to study the performance of light emitting diode(LED) luminaries in a street lighting application, the project include installation of four manufacture's led street lights on public roadways in San Francisco.

It studied the applicability of light emitting diode luminaries as replacement for existing streetlights. The results showed that using led lights will save 280 to 400 kWh per year and both technical and economic performance of the led lights continue to increase, the project acknowledges that LED technology is rapidly becoming competitive with HID light sources for outdoor area lighting.

In our project, we try to design a model that use led lights, Led Street Lighting project encouraged the use of these lights by explaining the advantages of it [2].

3. Energy Saving Project for Street Lighting of Provincial Electricity Authority (PEA)

This project perform study on saving energy consumption by installing power reducer equipments using transformer for reducing the amplitude of power, it showed that energy saving is about 25-30% or 52,300kWh per year by using the appropriate dimming circuits, the system consist of dimmers, and a communication system but the costly equipments including an integration of power reducer technology with metering and telecommunication system tends to add a higher investment cost [3].

In our project, the process of dimming is related to this project but without using specific component, a microcontroller will be responsible for process of controlling.

4. Intillegent Road and Street Lighting in Europe

In this paper, a study of adaptive street lighting system defined five subsystems performed: roadside equipments, power system, local control system and center control system. The street lighting control system receives information about traffic volume from traffic center TM and a sensor system provides information about precipitation, snow, etc. They use PLC, RF, optical link, internet, SMS, GMS technologies. About 80000 luminaries controlled in different countries using intelligent technologies. The results showed energy saving between 20% and 50% [4].

Our project, use infrared transmitters, photo detector sensors and a microcontroller to control the lights. It is related to this project by providing information about the traffic volume.

In this project will be designed and implemented an automatic street lighting system controlled based on the traffic density, we manage to reduce the amount of energy consumed by enabling the system when there is a traffic only and the system will works only at night.

1.4 Project Importance.

The project importance appears in the ability to manage street lighting system, and so reduce the amount of energy consumed. By doing that, it is clear that the proper implementation will have the following benefits:

- Reduce energy consumptions and costs.
- Increase lighting performance using LED lights.
- Control the street lighting system based on traffic density.
- Provide new control capabilities for current lighting systems.

- Permit people to travel at night with good visibility, in safety and comfort.

1.5 Project Scheduling

The project plan follows the following time schedule, which includes the relation between the tasks of the study and the analysis system:

1.5.1 First and Second Semesters Tasks

Table 1.1 Tasks Description

Task ID	Task Description
T1.1	Research problem parameters.
T1.2	Collect data, information, and previous projects research.
T1.3	Looking for possible solutions for current lighting system.
T1.4	System analysis and design
T1.5	Financial visibility and business plan research.
T1.6	Documentation
T2.1	Determine hardware and software design
T2.2	High-speed road design.
T2.3	Test the circuits and obtaining results.
T2.4	Modification pre-project and documentation.

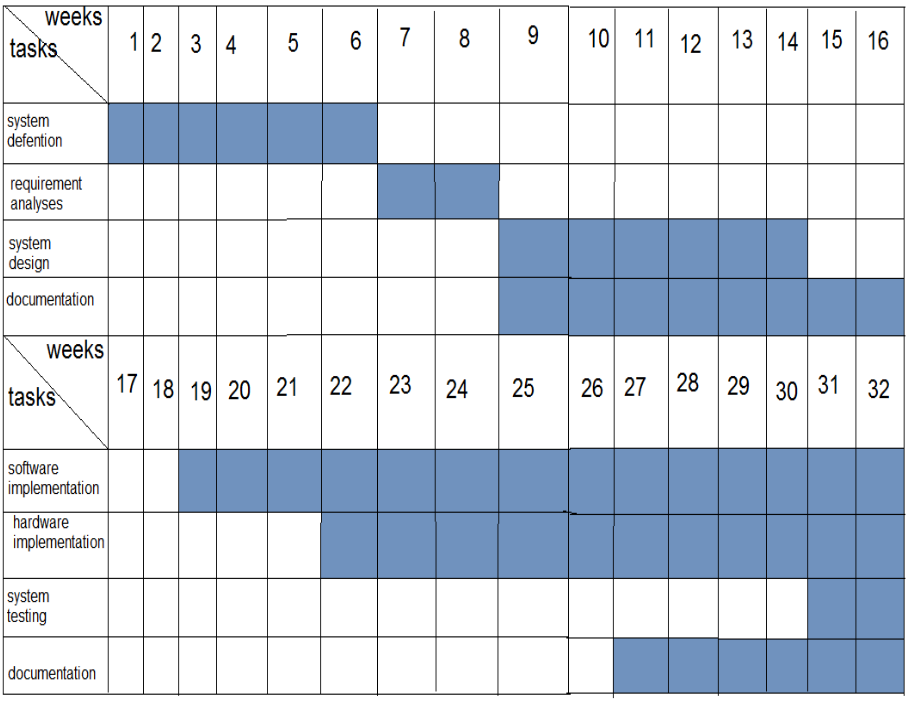
1.5.2 Project Timing Plan

Table 1.2 Project Timing Plan

System definition	6 weeks
Requirement analyses	2 weeks
System design and documentation	6 weeks
Documentation	8 weeks
Software implementation	14 weeks
Hardware implementation	11 weeks
System testing	2 weeks
Documentation	6 weeks
Total	32 weeks

1.5.3 Schedule Table

Table 1.3 Schedule Table



1.6 Project Estimated Costs

As mentioned before, we will simulate our design using a model. The following table shows the hardware estimated cost for establishing the model.

Table 1.3 Hardware Cost

Component	Price (NIS)	Quantity
PIC 16f877a	60	1
Timer 555	5	1
MT8870	20	1
Crystal	5	2
TSOP1738	15	2
Lm016L	50	1
IR led	5	2
LDR	5	1
LM324	5	1
Relay	12	8
Led light	10	8
Transistor 2N222A		8
Boards	100	1
Other electronics		
Model	200	
	Total	800 NIS

1.7 Risk Identification and Planning

Risks are a major factor to consider while going through any project, so it's important to anticipate the risks that might affect the project schedule progress and to take action to avoid these risks is very important for the success of the project.

The following table lists the types of risks that may affect development of the project, showing the risk and its type and strategy to handle the risk.

Table 1.4 Risk Identification

Type of risk	Possible risk	Strategy
Technology	Hardware may not be delivered on schedule.	Identify the hardware needed as fast as possible.
Tools	The code of software may be deleted or damaged.	Always save backup copies of the software.
Estimations	The size of software and hardware is underestimated, budget not sufficient	Understand the exact size of software and hardware

1.8 Chapter Overview

The following chapters will be included:

Chapter One –Introduction: an introduction to the project, describing the problem, project idea, and its objectives, benefits. It give readers a general view about the project.

Chapter Two –Theoretical Background: A theoretical background study on the components and technologies needed for this project.

Chapter Three –System Analysis and Design: presents the general system design concepts. It includes system objectives, general system block diagram, and description of system operation.

Chapter Four –Hardware and software Implementation: discusses a detailed description about subsystem and overall hardware and software system design, with showing components pins and feat, and software requirements to perform the required function of the system.

Chapter Five –Testing and Results: shows the results of the project.

Chapter Six – Conclusion and Recommendation: shows challenges faced in this project and recommendation for the development of the project.

Chapter Two

Theoretical Background

2.1 Introduction

In this chapter, we will talk about the basic overall architecture for a street lighting system and the hardware components that used to build the model.

2.2 Lighting Basics

In this section, you will be introduced to lighting equipment as related to roadway lighting design.

2.2.1 Lighting Equipment

- **Lamps**: The most important element of the lighting system is the light source. It is the principal determinant of the visual quality, economy, efficiency, and energy conservation aspects of the lighting system. An electric light source is a device, which transforms electrical energy, or power (in watts), into light. The most currently lamps used is the high intensity discharge (HID), and sodium lamps.
- **Service Cabinets**: The electrical service point consists of a lighting service cabinet complete with circuit breakers and photoelectrical control, a concrete foundation, electrical connections connected to the power company.
- **Light Bases** (foundations): The foundation must be designed to support the weight of the structure as well as resist wind loads and vibrations. The base could be concrete or steel.
- **Poles**: A long cylinder, rounded piece of wood or metal, designers must determine the pole height, which affects the lighting intensity, area covered, and relative glare of the unit. Pole placement also an important issue determined by engineers.

2.3 Overall Architecture

The street lighting system consists of the following subsystems:

1. **Road side equipment**: includes lamps, luminaries, gears, light poles.

2. **Power system:** consists of transformer stations, power cabinets and power lines.

3. **Control system:** can be considered in terms of function as luminaries with dimmable electronic ballast with power line modem.

4. **Communication system:** performs information exchange between the different subsystems.

2.4 Hardware Components

In this section, you will be introduced to the basic hardware components used to build the suggested energy saving street lighting system.

2.4.1 Microchip Microcontrollers.

Microcontrollers are a small and low cost computers existing on a single integrated circuit. More specifically, a microcontroller contains a central processing unit (CPU) Random Access Memory (RAM), Read Only Memory (ROM), input / output lines, serial and parallel ports, timers and other peripherals such as digital to analog (A /D) and (D /A) converters.

In this project the PIC16F877A 8 –bit microcontroller is chosen as the main controller unit and is based on instruction set architecture, usually it is used for (nano watt) low power applications, and interfacing applications.

PIC16F877A has 14.3 KB flash memory, the chip's most widely available form factor is a 40 pin silicon chip consisting of 5 I/O ports (Port A, Port B, Port C, Port D, Port E) [5][6] .

The main features of PIC16F877A

- 368 Bytes RAM.
- 14.3 KB flash memory
- 265 Bytes EEPROM
- CPU speed (5MIPS)
- 2 Comparators
- 3 Timers
- 5 Digital I/O ports , 40 pin in total
- 8 analog channels
- Digital communication peripherals _USART, MSSP.

We use the PIC16F877A microcontroller as a control unit to control the lighting system automatically by programming it to do specific commands.

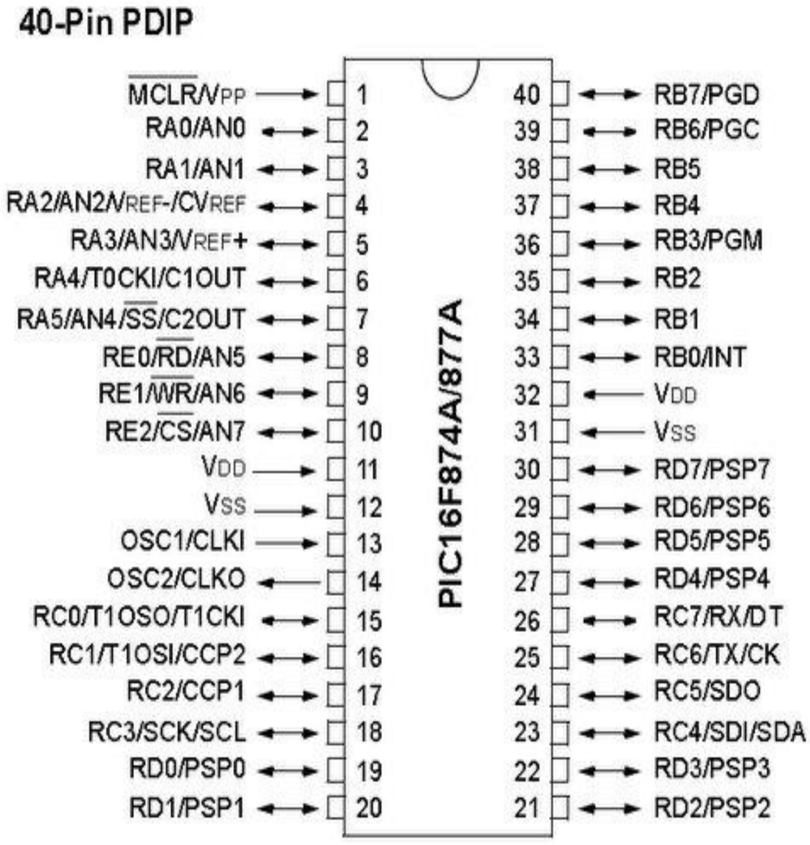


Fig 2.1 PIC16F877A Pin Layout

2.4.2 NE 555 Timer Astable Multivibrator.

NE 555 is a very commonly used IC for generating accurate timing pulses. It is an 8-pin timer IC and has mainly tow modes of operation: monostable and astable. In monostable mode time an external resistor and a capacitor can precisely control delay of the pulses whereas in astable module frequency and duty cycle are generating time delays and pulses [7].

In this project the NE timer 555 used to generate 38 KHz signal to modulate IR transmitters.

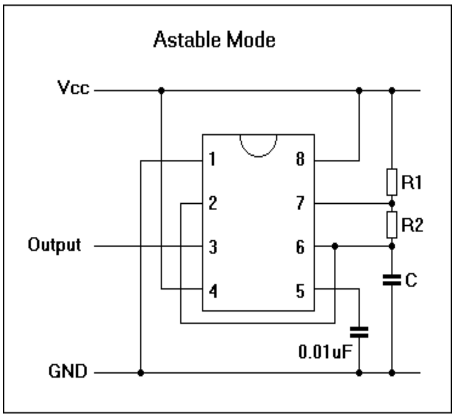


Figure 2.2 Pin Diagram

Table 2.1 Pin Description

Pin	Name	Purpose
1	GND	Ground ,low level (0V)
2	TRIG	Out rises , and interval stats when this input falls below 1\3Vcc
3	OUT	This output is driven to Vcc or GND
4	RESET	Timing interval may be interrupted by driving this input to GND
5	CTRL	Control access to the internal voltage divider
6	THR	The interval ends when the voltage at THR is greater than at CTRL
7	DIS	Open collector output , may discharge a capacitor between intervals
8	V+, Vcc	Positive supply voltage between 3 and 15V

2.4.3 Liquid Crystal Display

Liquid Crystal Display is a flat panel display, electronic visual display video display that uses the light modulating properties of liquid, and is the technology used for displays in notebook and other smaller computers. Like light emitting diode and gas plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (LRT) technology. LCDs consume much less power than LED and gas displays because they work on the principle of blocking light rather than emitting it.

An LCD is made with either a passive matrix or active matrix display grid. The active matrix LCD is also known as thin film transistor (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. An active matrix has transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, improving the screen refresh time [8].

2.4.4 Dual Tone Multi Frequency CMD8870.

DTMF is a signaling system for identifying the keys or better say the number dialed on a pushbutton or DTMF keypad. The early telephone systems used pulse dialing or loop disconnect signaling this was replaced by multi frequency (MF) dialing. DTMF is a multi frequency tone dialing system used by the pushbutton keypads in telephones and mobile sets to convey the number or key dialed by the caller, DTMF has enabled the long distance signaling of dialed numbers in voice frequency range over telephone lines. This has eliminated the need of telecom operator between the caller and callee and evolved automated dialing in the telephone switching centers [9].

Our project use this component as a DTMF decoder is connected to mobile headset if you call the mobile and the mobile answers your call, any key you press will produce a tone at the headset wires. The DTMF decoder reads the received tone and converts it to a digital representation. For example press 1, output is 0001, etc.

2.4.5 Photo Detectors.

2.4.5.1 TSOP 1738

Is a member of IR remote control receiver's series. This IR sensor module consists of a PIN diode and a pre amplifier, which are embedded into single package. The output of TSOP is active low and it gives +5V in off state. When IR waves, from source, with a center frequency of 38 kHz incident on it, its output goes lower.

Lights coming from sunlight, fluorescent lamps etc. May cause disturbance to it and result in undesirable output even when the source is not transmitting IR signals. A band pass filter, an integrator stage and an automatic gain control are used to suppress such disturbances.

TSOP module has an inbuilt control circuit for amplifying the coded pulses from the IR transmitter. A signal is generated when PIN photodiode receives the signal. The input signal is received by an automatic gain control (AGC). For a range of inputs, the output is fed back to AGC in order to adjust the gain to a suitable level. The signal from AGC is passed to a band pass filter-to-filter undesired frequencies. After this, the signal goes to a demodulator and this demodulated output drives an NPN transistor. The collector output of the transistor is obtained at pin 3 of TSOP module.

Members of TSOP17xx series are sensitive to different centre frequencies of the IR spectrum, for example, TSOP1738 is sensitive to 38 kHz whereas TSOP1740 to 40 kHz centre frequency [10].

In this project, a TSOP1738 receiver is used which detects only 38 KHz modulated IR light.

2.4.5.2 Infrared Leds

Also known as, IR transmitter is a special purpose LED that transmits infrared rays in the range of 760 nm wavelength.

The appearance is same as common LED. Since the human eye cannot see the infrared radiations, it is not possible for a person to identify whether the IR LED is working or not, unlike a common LED. To overcome this problem, the camera on cell phone can be used. The camera can show us the IR rays being emanated from the IR LED in a circuit [12].

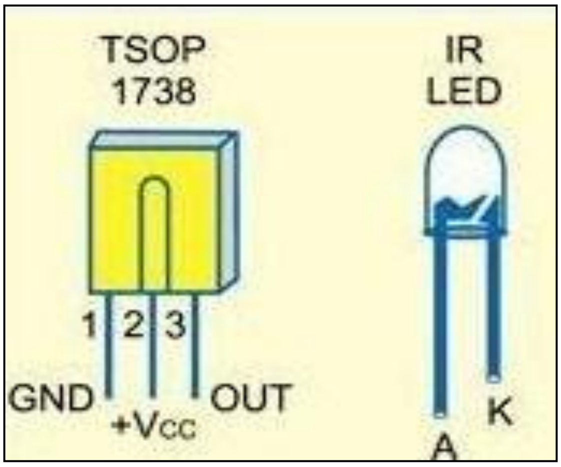


Fig 2.4 IR receiver / transmitter

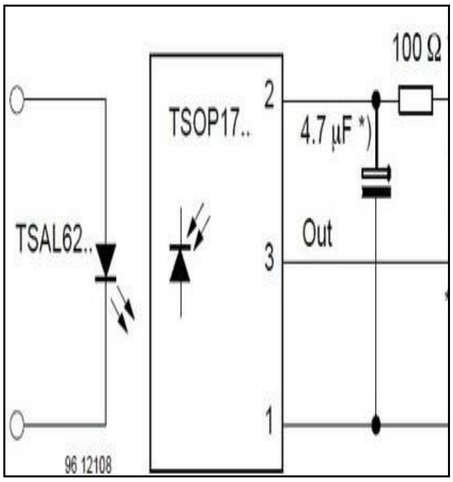


Fig 2.5 IR receiver/ transmitter circuit

2.4.6 LDR Sensors

Light dependent resistor offers resistance in response to the ambient light, the resistance decreases as the intensity of incident light increases, and vise versa. In the absence of light, LDR exhibits a resistance of the order of mega-ohms, which decreases to few hundred ohms in the presence of light. It can act as a sensor, since a varying voltage drop can be obtained in accordance with the varying light. It is made up of cadmium supplied. An LDR has a zigzag cadmium supplied track. It is a bilateral device i.e. conducts in both directions in same fashion. It is used as daylight/night sensor to sense darkness/night [11].

2.4.7 Crystals

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is used to keep track of time to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers.

Also used other electronics like capacitors, resistors, LEDs.

Chapter Three

System Analysis and Design

3.1 System Analysis

In this section, you will be introduced to main characteristics of the current street lighting system applied in Hebron city.

We make a study about the current lighting system to understand the main function of the system, how it works, and how can we improve it.

Depending on Hebron Municipality:"In streets of Hebron there are about 140 lighting panel, each one covers about 30 electric lamp. By multiplying the number of panels with the number of lamps we get 4200 lamp distributed in Hebron streets. Almost in all streets are used High-pressure Sodium lamps and partially Halide lamps. The distance between each two electric lamps is about 28 meters and the height of the pole is 10 meters".

These lamps are controlled by using the technology of photo detectors and timers. Where photo detectors are small electric components sensitive to light. One of the most common types of photo detector is a photo resistor. Photo resistors resist the flow of electricity, but resistance drops when light hits them. The more resistance in a circuit, the less electric current flows through. In a photo resistor powered streetlight, a small current runs through the resistor. When it becomes dark, the resistance increases and the current drops. This tells the circuit to switch the lights on until daylight comes and the current increases again. [22]

Timers are used to control many street lamp systems. Usually an electronic clock is built into the entire system. The clock turns the streetlights on the evening and off in the morning automatically. [22]

The figure below show a control panel placed on a pole of streetlight in Hebron city. A timer and a photocell are provided in this service cabinet.

Fig 3.1 Control panel

However using photo detectors and timers only is not efficient. Although the use of timers was expected to give a good percentage of energy savings but the percentage was not good as enough. We all must know that the street lighting system in Hebron city only cost 250 000 to 270

000 NIS per month and this is a very big number especially for a country that lives under bad economic conditions.

Our project comes to solve the problem of wasted energy due to having lights switched on without the need for it. The project will improve the control system of street lighting by adding new features to it such as activating the lighting system only when there is traffic at night. This leads to save energy and money.

3.2 System Design

3.2.1 Factors Affecting Street Lighting System

The street lighting system in anywhere is affected by several factors that should be considered when we try to design a reliable system:

- Luminaries' age, the light output of a luminaire decreases with age and use. We have to select the proper streetlights with a long lifetime.

- Light loss factors
  * Lamp and ballast failure
  * Lamp lumen depreciation
  * Luminaire dirt depreciation

- Light loss gradually decreases system efficiency over time.

- Safety
  The primary objective of road lighting is to ensure safe passage for vehicles and pedestrians. We must have effective system that minimis traffic accident.

- System reliability and focused on future development, achieving this by using advanced technology to ensure that lighting systems used on the roads are reliable and have an extended lifespan, this effectively cuts down maintenance time[16].

In order to design a street lighting system, these factors must be taken. The system aims to save energy by controlling lights based on the traffic density. The figure below shows a simple drawing of a street where lights controlled by traffic density.

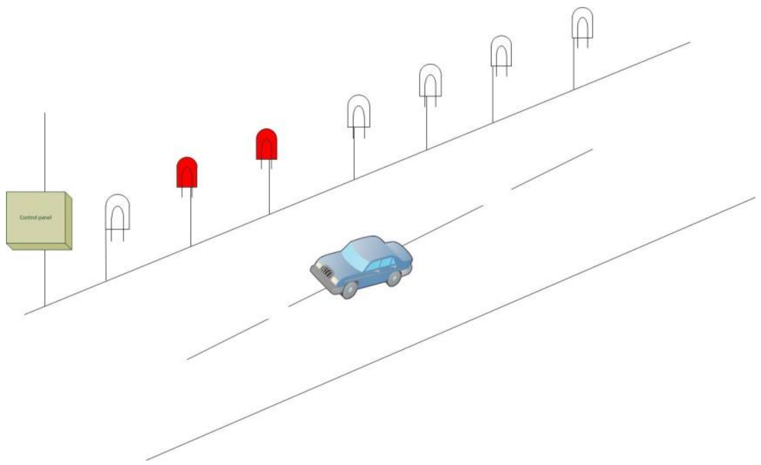


Fig 3.2 Street lighting system controlled by traffic density

3.2.2 Street Lighting System Design

The system we want to design has the ability to save energy; it is designed to work only when there is traffic. In this section, we describe the system inputs, outputs, and the communication mechanism between the lighting scouts. First, let us talk about the traffic density, which is a major factor in implementing our system. We have information about the traffic density from Mr. Ismael Abu Moqdam who is working in the National Electricity Company, He give us some information about the traffic density in highways, he said that the current system on highways works on photo sensors, each scout have two lamps.

The photo detector detects if there is normal light or not, the system turns on the lamps when there is no light. After 12 am, one of the two lamps is turned off due to the decrease of the traffic density. This means that the system works on with one lamp all the night regardless there is traffic or not. Moreover, this in our view is waste of energy.

Our system designed to work only when there is traffic and it selects specific lights to be turned on based on the traffic speed. The following calculations show how our system will save energy.

If we say that the current system stays on for 10 hours (from 8 pm to 6 am), even that after 12 am one of lamps will be off. It does not provide a good amount of saving.

Based on the principle of our system, the lights will be on for nearly 4 hours and this means 40% of the time, which means our system will consume 40% of the energy and save the energy consumed in the six hours in the current lighting system.

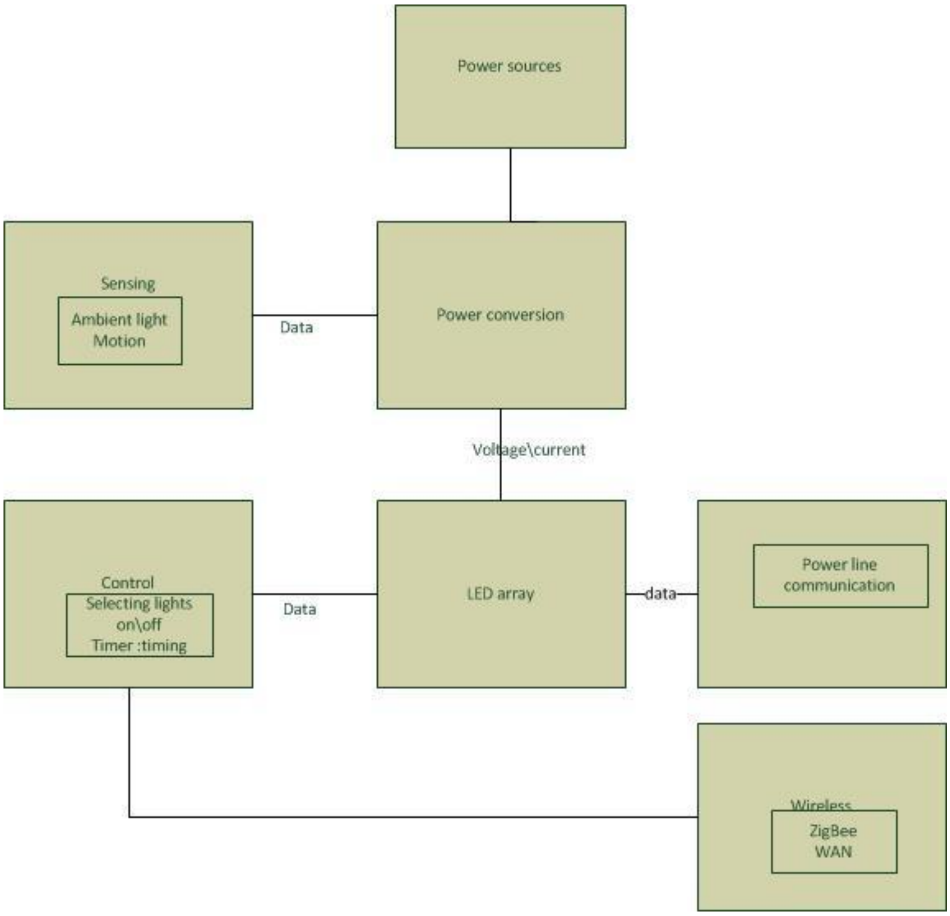
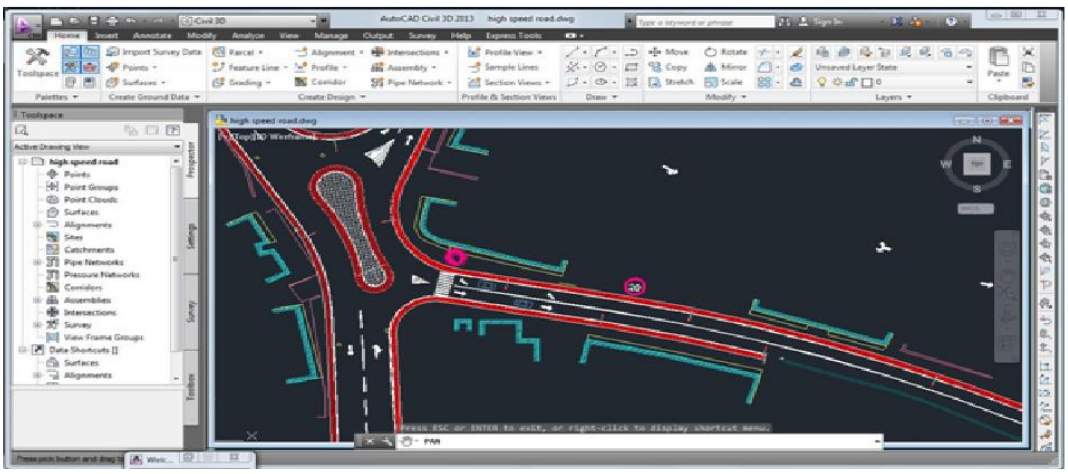


Fig 3.3 General block diagram for lighting system

3.2.3 Highway System Design

The following figures show a high-speed road that designed on AutoCAD_Civil3D program, which used to design roads on real world.

This design is abstract one, to view distances between scouts on high-speed road, and where to place energy saving system on a highway.



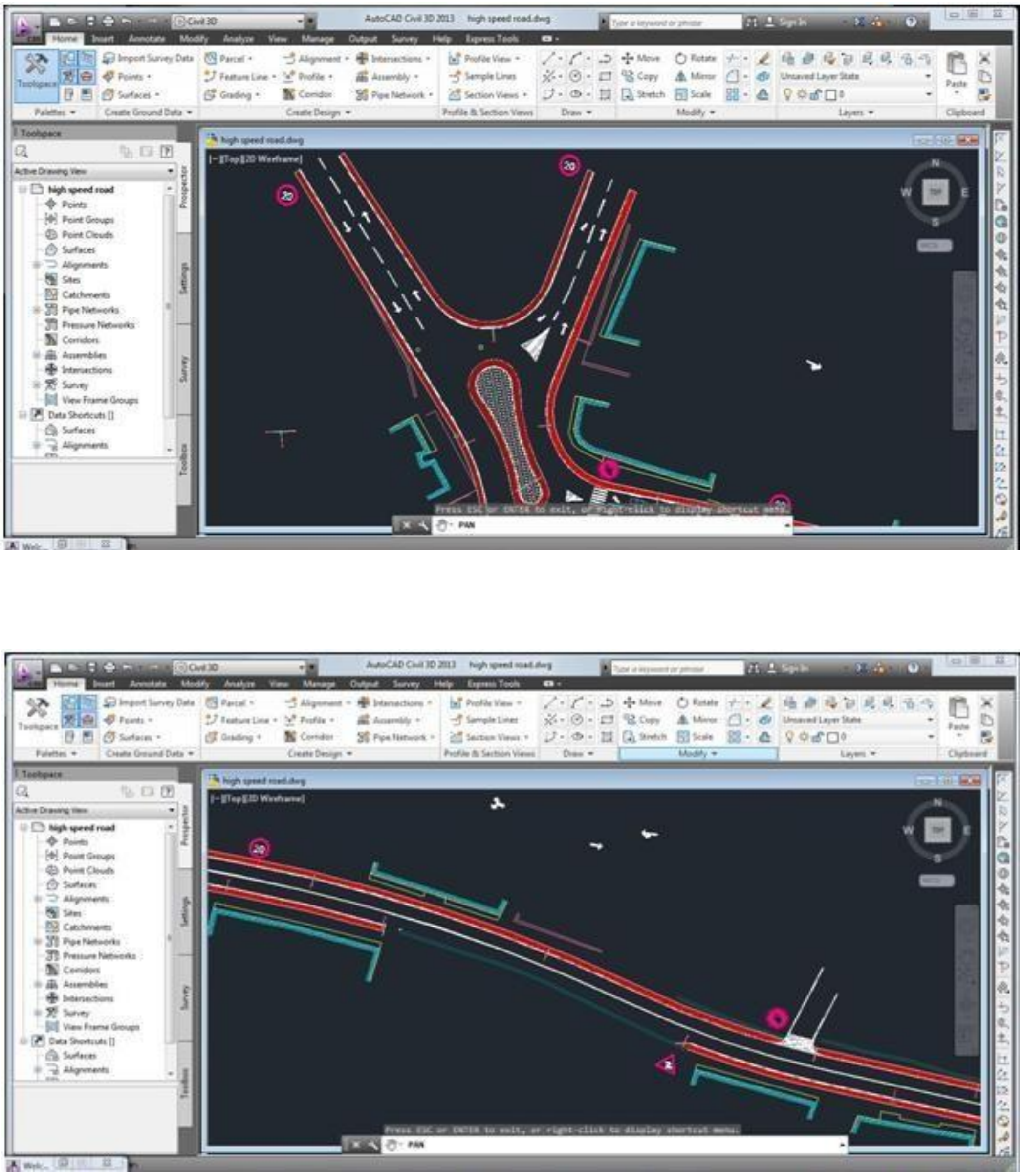


Fig 3.4 Highway design

This design shows the lights distribution on the road, with nearly 45 meters between each light. Because it is, a highway the distance between the lights is larger than if it is in a city.

AutoCAD_Civil3D program is not our specialty; we did the design of the street with the help of civil engineers [17].

The following figure explains the abstract work for street lighting system, and shows where to place the system. As shown in figure, photo detectors are placed under the ground using special base .Also IR LEDs placed under the ground on the opposite side of the road. IR light is not visible by naked eye, so they will never affect negatively on the traffic.

In addition, IR LEDs does not affected by normal lighting from sun, vehicles lights, so the IR signal that the photo detector receives is completely pure.

Therefore, the street lighting criteria will be completely depending on IR signal and photo detector output.

Fig 3.5 Abstract street lighting system

3.3 Model Simulation

By looking at the most basic understanding of the system, and by addressing the design from a purely non-technical user's point of view, it is clear that the system must have the following components to achieve the required requirements, summarized in figure 3.1 below

Fig 3.6 Basic System Abstraction

To achieve a good understanding of the proposed system from technical point of view, the system must be characterized in different levels of abstraction and structure, thus the system is to be presented as two interacting systems, one deal with the microcontroller software and the other one with hardware.

3.3.1 System Hardware Design

This section deals with hardware, on a very basic level.

3.3.2 Functional Requirements

The functional requirements expected from the hardware system are the following:

1. The system must automatically works at night.
2. The system must interface with IR sensors in order to detect traffic.
3. The system must interface with mobile (this is an additional feature of the system in emergency cases.
4. The system control streetlights based on the traffic speed.
5. The system must interface an LCD screen.

3.3.3 Non-Functional Requirements

The non-functional requirements expected from the hardware system are listed as following:

1. It should consume very little power and be able to withstand all long hours of operation.
2. The system must provide flexibility in terms of required functionalities.
3. The system should not have any negative effect on the traffic movement.
4. The system must be relatively easy to integrate with Palestinian street lighting systems.

3.3.4 Hardware System Design Abstraction

The system can be modeled as a set of subsystems and the relationships between them, each subsystem must have the least amount of dependency, so in general it can be present as illustrated in fig 3.2 below:

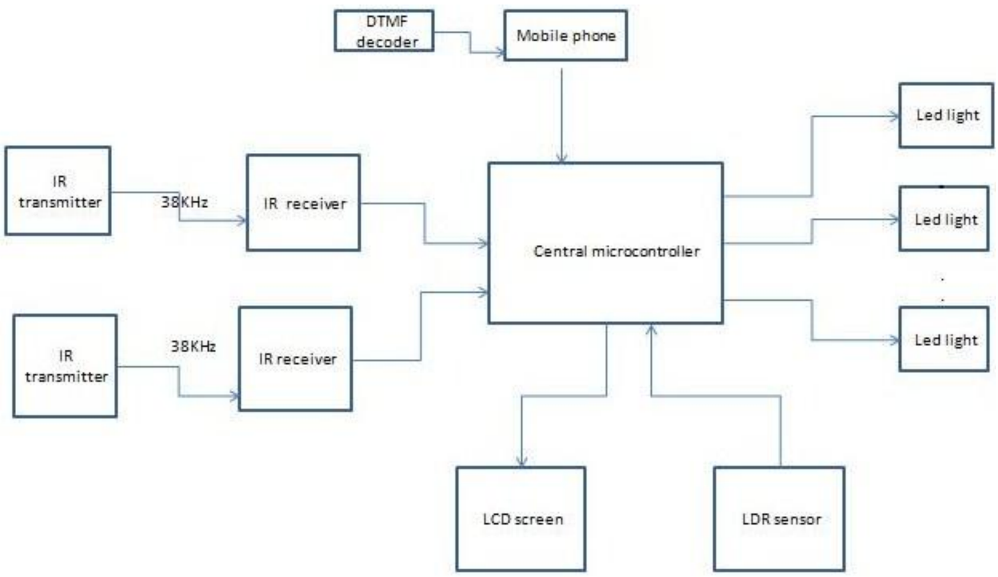


Fig 3.7 Hardware System Block Diagram

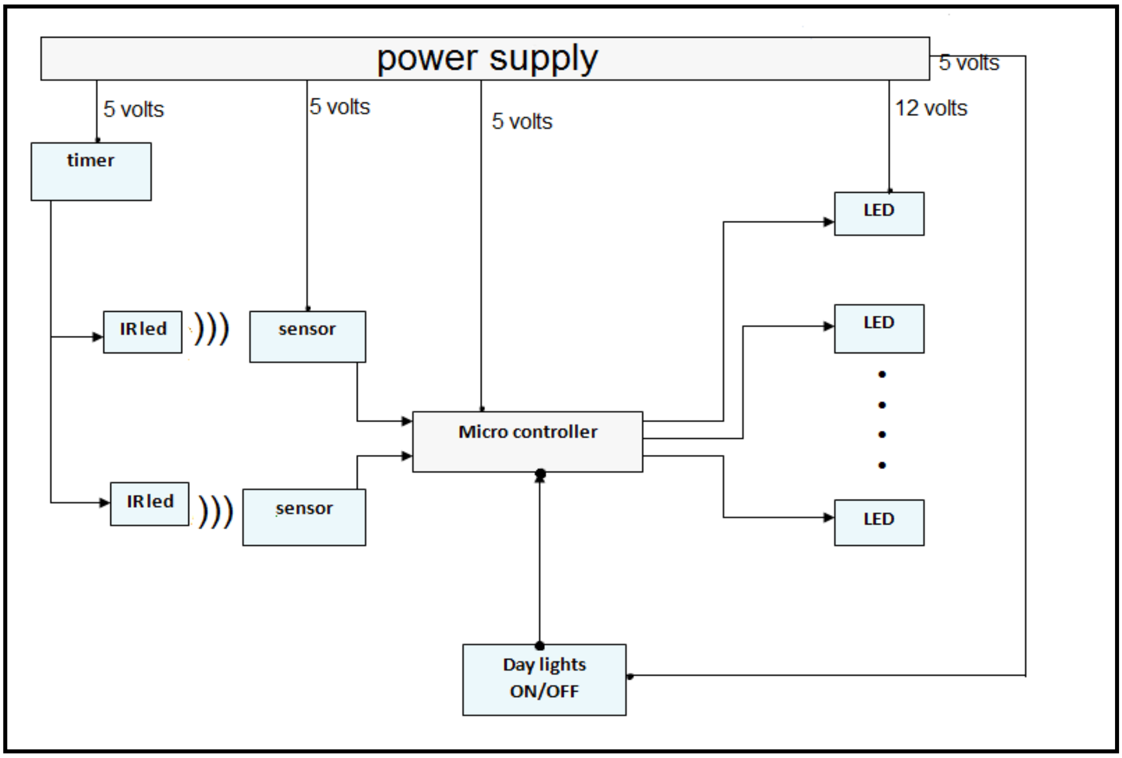


Fig 3.8 Hardware System Diagram

Decisions and commands made in microcontroller, produce using the software as a response to the traffic needs, and then sent via the corresponding connection to the wanted module. The system designed to control streetlights based on the traffic speed to achieve the main objective of the project, which is energy saving.

The hardware is designed in a way that conserves flexibility and the ability to change any component for upgrading and maintenance purposes, somewhat similar to object oriented design, each component has its specific requirements, inputs and outputs with disregard to implementation.

3.4 System Software Design

This section explains the expected design of the software components, classified and characterized according to their function.

3.4.1 Functional Requirements

The software within the project has the following functional requirements:

1. The software must be able to communicate with the microcontroller.
2. The software must be able to process data taken from the hardware, and convert it to suitable understandable data.
3. The software must provide an event driven architecture (event, condition, action) as a set of rules for dealing with the port values.
4. The set of rules should be dynamically set and can differ depending on the state of the system.
5. The software must be able to display specific data on the LCD screen.

3.4.2 Non-Functional Requirements

The software also has the following nonfunctional requirements:
1. The software should be as reliable, as robust as possible.
2. The software must hold object oriented design principles, so that the components can be independently built.

3.4.3 Software System Design Abstraction

The software can be modeled as a set of objects each performing a specific task with disregard to the main logic. It is taken in regards that each subsystem must have the least amount of dependency. The software controller takes control of the interfacing requirements of the system, and is the main front to handle all commands, tasks, and data transactions.

3.4.4 Software Components and Design

The following components and subcomponents represent the individual functionalities required from the software:

3.4.4.1 Hardware Modules

The following components and subcomponents represent the individual functionalities required from the software:

3.4.4.2 PIC (peripheral interface control)

Microcontrollers are a small and low cost computers existing on a single integrated circuit. In this system, the microcontroller is chosen as the main controller unit and it based on instruction set architecture, usually used for low power application, and interfacing applications.

Using a UML diagram, this component can be represented as shown in fig 3.9

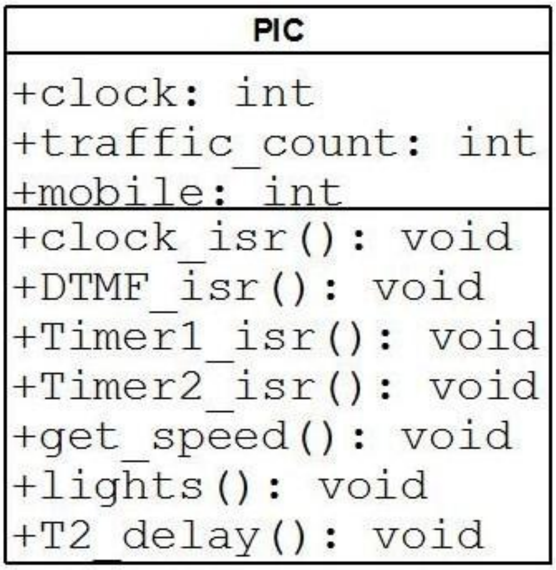


Fig 3.9 PIC UML Class Diagram

The PIC performs the following functions:

- clock_isr ( ): this function used to count numbers of vehicles that crossing the street by setting timer 1.
- dtmf_isr ( ): this function used to enable external interrupt for the DTMF decoder.
- Timer2_isr ( ): function for traffic speed calculation, by setting timer2 in the PIC we get the time needed for a vehicle to pass through sensors.
- get_speed ( ): for speed calculation of a vehicle, called when there is traffic, the speed will be classified into low, medium and high speed.
- Lights ( ): for controlling streetlights based on the traffic speed.
- T2_delay ( ): delay function for Timer2.

3.4.4.3 Graphical user interface (LCD) module

In our project, we use the LCD as an interface that display the speed state
if it is low, medium or high speed.
The UML is shown in fig 3.5

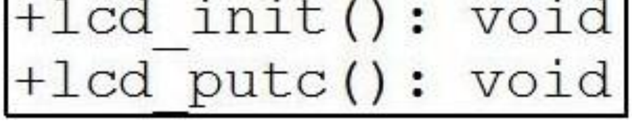


Fig 3.10 LCD UML Class Diagram

Mainly the LCD has a function for initializing and the lcd_putc ( ) to print a specific output on the LCD. In our project, it is used to display the traffic speed status.

3.4.4.4 Timers

Two timers used in our software implementation, Timer 1 and Timer 2 are a built in devices in the microcontroller.

Timer 1 used as traffic counter, it counts the number of vehicles that cross the first sensor.

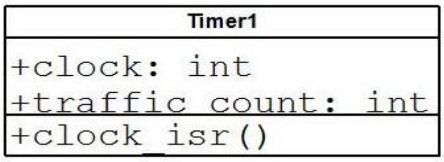


Fig 3.11 Timer1 UML Class Diagram

Timer2 used for speed calculation, the timer is enabled when the vehicle cross the second sensor, the time duration that the vehicle take to pass through the two sensors is then used to find the speed. The following diagram shows the Timer2 function

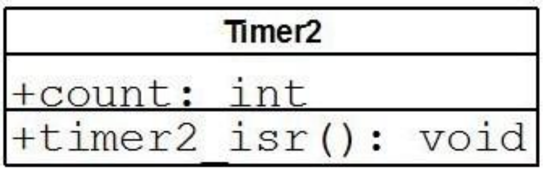


Fig 3.12 Timer2 UML Class Diagram

3.4.4.5 LED Lights

Lights used on the roads are controlled based on the traffic speed, the following diagram shows light diagram, the function lights ( ) used to control which light is selected to turn on or off.

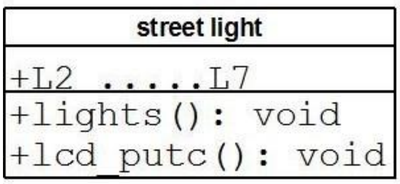


Fig 3.13 Street light UML Class Diagram

3.4.4.6 DTMF interface

The DTMF connected to mobile headset used for mobile control when there is override
or an accident, the traffic department calls the system automatically to control lights without the need to wait until there is traffic. The function input_a ( ) used to insert the number we want to call (reserved system number).

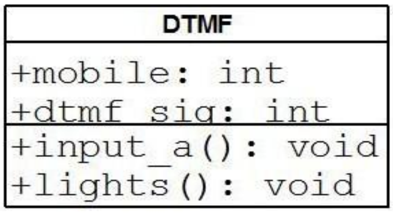


Fig 3.14 DTMF UML Class Diagram

3.5 Events System Data

The software implements an event system for independent operation; the presence of such events allows the system to specify the operation of the hardware as set of rules that is saved and executed should their conditions be meeting. Figure 3.15 shows the sequence diagram that explains the expected functionality of the event system.

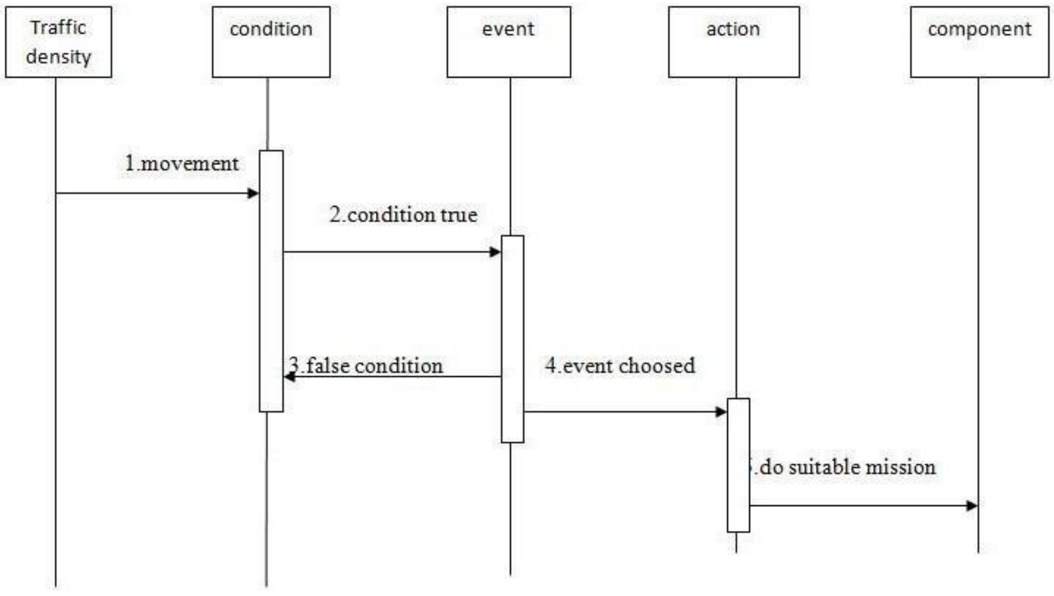


Fig 3.15 Event Sequence Diagram

3.5.1 Events

Events occur through the runtime of the system; these events must be identified, characterized, and used to implement certain actions under certain conditions. For this design, the following events are available:

- The output voltage of the sensor is checked to verify if there is traffic or not.
- The system is activated only at night.
- The mechanism of controlling lights on the road depends on the speed of the vehicle, group of conditions will be checked then a specific function will perform.

Each event has an automatically generated identifier, a type, a condition and an action. Moreover, an event is inherited by other events that have customized information about regarding that event.

3.5.2 Actions

The system must be able to implement a set of actions; these actions are listed below:

- Count traffic: to determine whether there is traffic density or not, depending on number of vehicles are moving through high-speed road. If there is traffic density then microcontroller will turn on lights sequentially, but if there is no traffic so no action to be hold.
- Set timers (internal timer): is an action that used to calculate the time for a vehicle take to cross the sensors.

- Turn ON the first and the last led light without any exceptions.
- Control lights based on the traffic speed.
- Display on the LCD the status of speed (low, medium or high speed).
- Reset timers, if the timer has been send the estimated time to system, then system will reset timers, to continue its mission in serving next traffic.

3.6 System Flowchart

Flow charts are used in designing and documenting complex processes. Like other types of diagram, they help visualize what is going on and thereby help the viewer to understand a process or system.

Figure 3.16 shows the flowchart of automatic street lighting system.

From the flowchart, it is visible that the first condition to be checked is whether the output voltage on sensor port equals zero, if it is zero that means that there is no traffic in street, on the other hand, if output voltage equals +5 volt this means that there are some vehicles.

At this moment, the controller send a command to timer to start counting after the vehicle cross the second sensor, another timer is enabled to find the speed of the vehicle. According to the speed, lights will be controlled. The speed status is also display on the LCD.

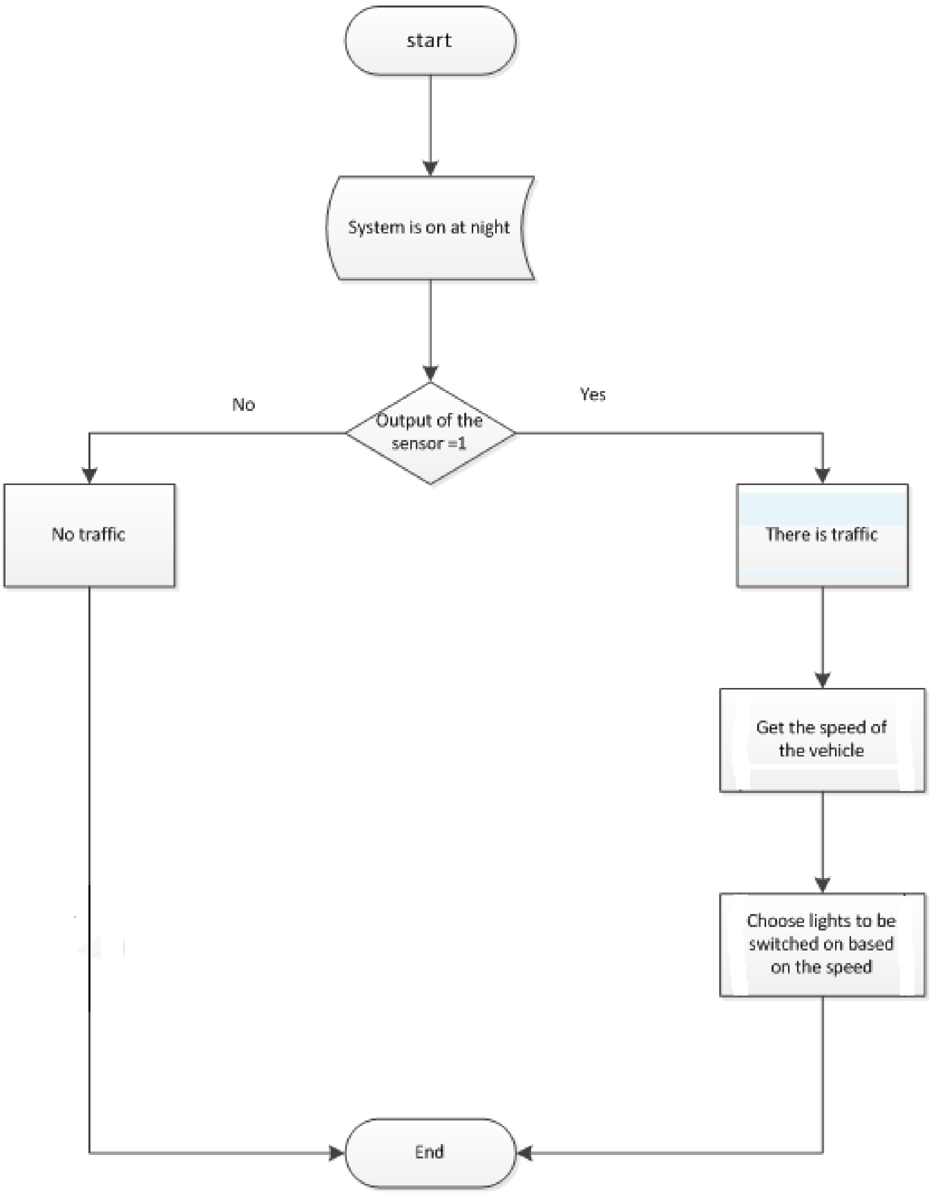


Fig 3.16 General Flow Chart of the System

Chapter Four

System Software and Hardware Implementation

4.1 Introduction

In the previous chapter, we presented the conceptual design. In this chapter we will discuss the detailed software and hardware and interfacing connection between each component in this project.

4.2 Hardware Design

This chapter provides a description about project details which can be summarized by understanding the way microcontroller works and implementing the connection between the microcontroller, sensors and led lights.

The following figure determines the general connection of every circuit that will be designed in details in this chapter.

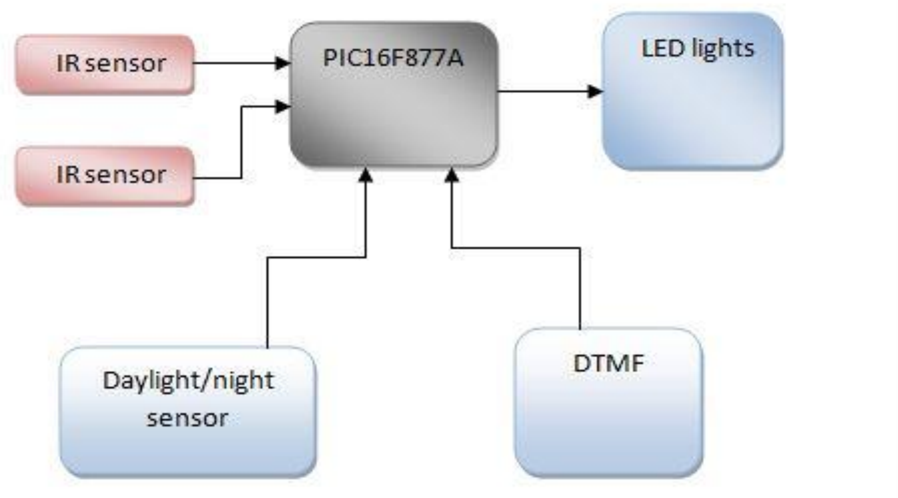


Fig 4.1general connection of circuits with PIC

4.2.1 PIC 16F877A Microcontroller

PIC (Peripheral Interface Controller) is the IC, which was developed to control peripheral devices. Microcontrollers are computers that are created to perform one particular task. PIC16F877A will be used because of its nano Watt technology which incorporate a range of features that can significantly reduce power consumption during operation .

This PIC has 40 pin divided to 5 I/O ports (PORT A, PORT B, PORTC, PORT D and PORT E). PORT B and PORT D have 8 pins to receive / transmit 8 bit I/O data. The remaining ports have numbers of pins for I/O data communications. The PIC has some pins just to get power, typically +5 volts and 0 volts or ground. Additionally there are two pins where a quartz crystal is attached to provide a basic "pulse" or clock for the PIC [5].

To program this device in this project, some pins of the PIC16F877A can be used in different description as the following:

*** Pin 1 can be used as:**

1 .MCLR (master clear reset input): an input pin, which is an low active pin used to reset the device.

2. Vpp: power pin that is a programming voltage input.

*** Pin 2 can be used as:**

1. RA0: used for an input/output I/O digital data.
2. RN0: this pin is used only for analog input**.**

*** Pin 3 can be used as:**

1. RA1: used for an I/O digital data.
2. RN1: used only for analog input.

*** Pin 4 can be used as:**

1. RA2: used for an I/O digital data.
2. AN2: used only for analog input.
3. Vref: is an analog input pin that used for A/D reference voltage.
4. CVref: Analog comparator reference output.

*** Pin 5 can be used as:**

1. RA3: used for an I/O digital data.
2. RN3: used only for analog input.
3. Vref: is an analog input pin for A/D reference voltage.

*** Pin 13, 14 can be used as:**
1. OSC1 / CLKIN and OSC2 /CLKO: clock oscillator pin attached to quartz crystal to provide pulse or clock.

*** Pin 8 can be used as:**
1. RE0: used for I/O digital data.
2. RN5: used only for analog input.

*** Pin 9 can be used as:**
1. RE1: used for I/O digital data.
2. RN6: used only for analog input.

*** Pin 33 can be used as:**
1. RB0: used for I/O digital data.
2. INT: used for external interrupt.

*** Pin 34 can be used as:**
1. RB1: used for I/O digital data.

*** Pin 35 can be used as:**
1. RB2: used for I/O digital data.

*** Pin 36 can be used as:**
1. RB3: used for I/O digital data.
2. PGM: used for low voltage programming enable pin.

*** Pin 37 can be used as:**
1. RB4: used for I/O digital data.

*** Pin 38 can be used as:**
1. RB5: used for I/O digital data.

*** Pin 39 can be used as:**
1. RB6: used for I/O digital data.
2. PGC: In-circuit debugger and ICSP programming clock.

*** Pin 40 can be used as:**

1. RB7: used for I/O digital data.
2. PGD: In-circuit debugger and ICSP programming data.

*** Pin 24 can be used as:**

1. RC5: used for I/O digital data.
2. SDO: SPI data out.

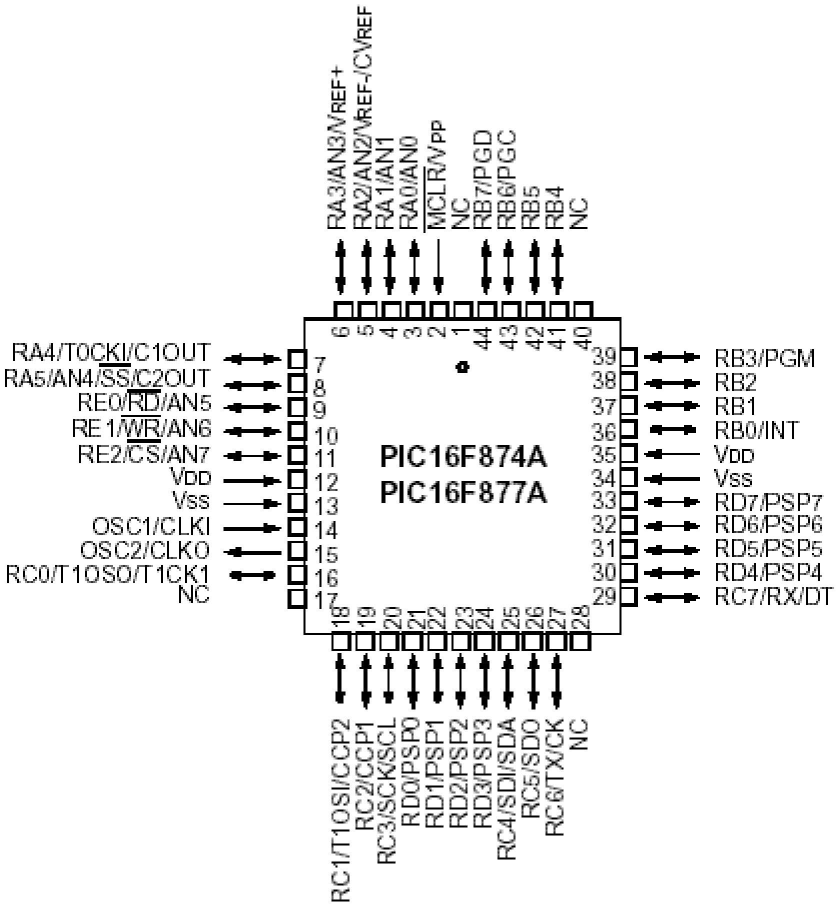


Fig 4.2 PIC16F877A A/D inputs

4.2.2 Sensors Interfacing

TSOP1738 Sensor

Is the standard IR remote control receiver, the output signal can directly be decoded by a microprocessor. The supply voltage of TSOP1738 must be in the range of -0.3 – 6 V.

Table 4.1 TSOP pin description

Pin	Name	Comment
1	GND	Ground
2	Vs	Source voltage
3	OUT	Output voltage

In this project, the applied supply voltage on the sensor is 5 V, used pull up resistor with 100 ohm.

Two sensors connected to the microcontroller, as show in the figure pin 3 (output) in the sensor was connected to RE0, and this is the same for the second sensor that connected to RE1 in the microcontroller.

IR Sensor

Is special purpose led that transmit infrared rays. Known as IR transmitter.
In the project the IR transmitter is built around LMC555 timer, which is wired as an astable multivibrator, the multivibrator produces 38 KHz pulses at low duty cycle that drive an infrared led. A 50-ohm series resistor connected to the IR led ensures that the current consumption of the IR transmitter is not out of arrangement.

The IR receiver which is a TSOP1738 module, is placed in a location to face the IR led, as mentioned previously TSOP1738 is optical receiver which responds to IR light switching at a frequency of 38KHz. it's output is 0 V when receiving signal from the IR led and 5 V when the signal is not available[13].

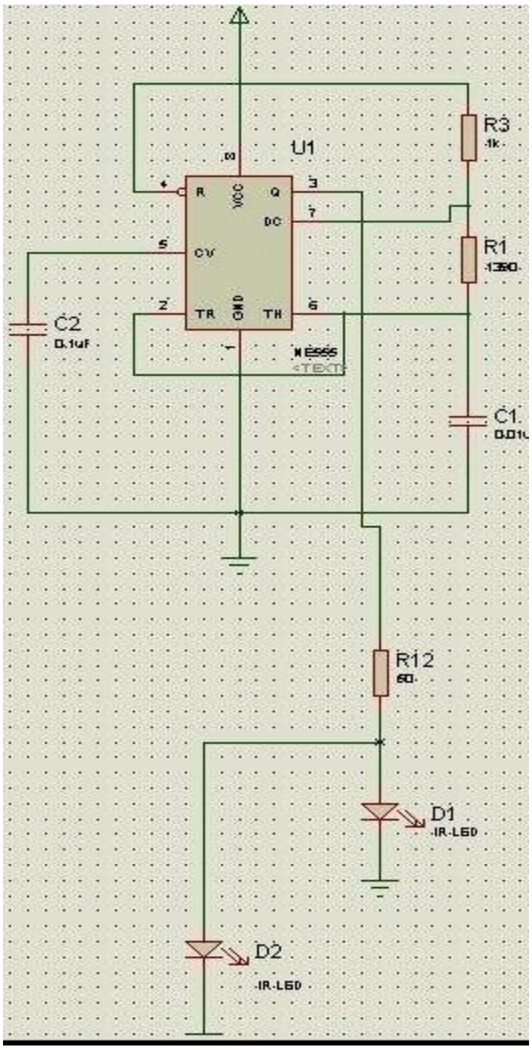


Fig 4.3 IR transmitter circuit

These figures shows that TSOP1738 detects only 38KHz modulated IR light, it means while 38KHz modulated IR signal falls over the TSOP1738 its output will be low and that's indicate there is nothing cross the signal, i.e. there is no traffic in the street by considering that when the output of the TSOP1738 goes high there is a traffic since pin 3 of the two sensors connected to RE0 and RE1 (as shown in the figure 4.6) will be active to do specific function described later.

4.2.3 Lighting Interfacing

Led lighting technology is rapidly growing, with significant potential for energy savings.
In this project, led lights have been used instead of incandescent and sodium bulbs. Experiments show that led lights can be three to four times more energy efficient than sodium bulbs. In addition, LEDs have a long rated life.

In this project, the light emitting diode is used as a street light. We built a control system for controlling the lights in the highways, the system consist of eight led lights. The figure below shows the lighting circuit:

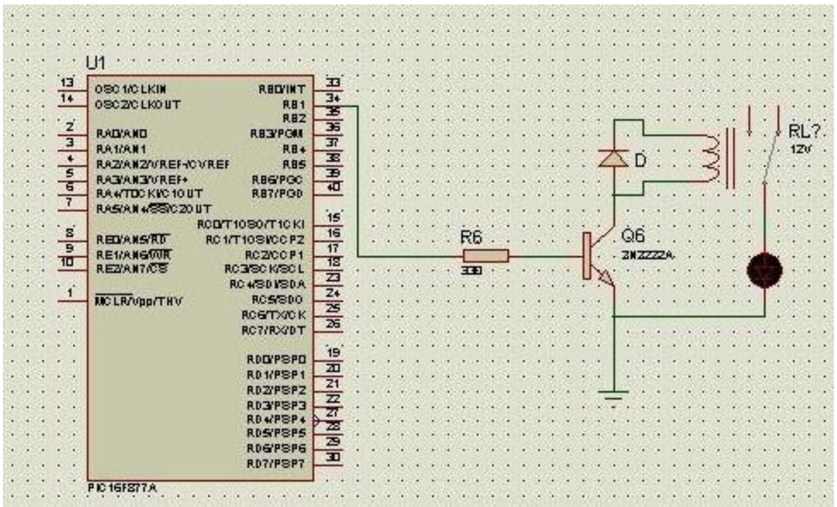


Fig 4.4 LED light circuit

From the figure 4.6 the led light is connected to a contactor (RELAY) which is an electromagnetic switch, it is used to switch on and off the light bulb; it is obvious that the PIC microcontroller send logic 0 or 1 to the circuit. If RB1=zero, there is no current flow over the circuit so the relay switch will be open and the led light is off.

Else if RB1=1 means that there is voltage, and the current flow in the circuit, the circuit energized closing the switch and turn on the light.

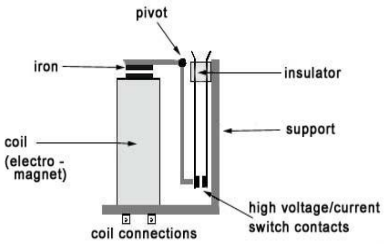


Fig 4.5 Contactor circuit

4.2.4 DTMF Interfacing

A DTMF (dual tone multi frequency) is used for telecommunication signaling over analog telephone lines in the voice – frequency band between telephone handsets and other communication devices. With DTMF, each key you press on your phone generates two tones of specific frequencies. So that a voice cannot imitate the tones, one tone is generated from a high-frequency group of tones and the other from a low frequency group as shown in the table below [14]:

Table 4.1 DTMF frequencies

Table of DTMF frequencies (CCITT)

Symbol		Tone B [Hz]			
		1209	1336	1477	1633
Tone A [Hz]	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

In this project, DTMF decoder (CMD8870) is connected to mobile headset, and the decoder is implemented to answer automatically means that if you call the mobile and the mobile answers your call, any key you press will produce a tone at the headset wires.

The DTMF decoder reads the received tone and converts it to a digital representation. Press 1 >> output is 0001, etc.

As shown in the figure below (fig4.9), a wire of the headset is connected to the input of DTMF decoder. The decoder gives a pulse every time produced a tone, this pulse (STD / INT) is connected to pin 33 in the microcontroller that gives an interrupt, when RB0 is active, and the microcontroller reads the output of the decoder and perform a function based on the code.

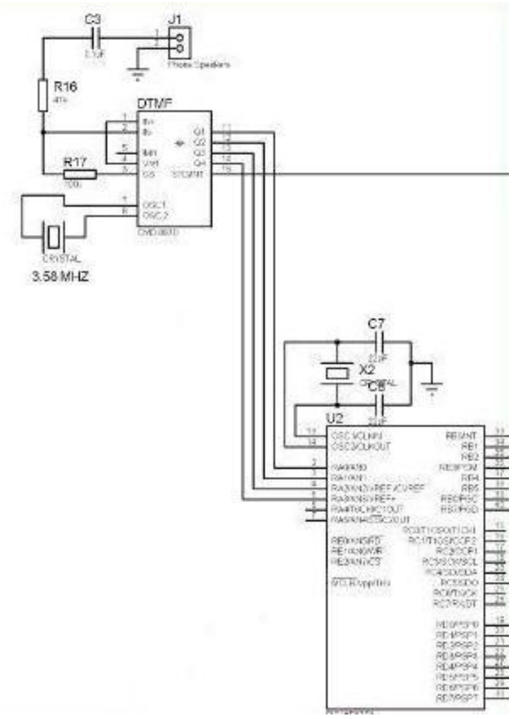


Fig 4.6 DTMF circuit

4.2.5 Daylight / night sensor interfacing

LDR (light dependent resistor) used to sense darkness / light.

This sensor consist of LDR, variable resistance and comparator, the following figure describe the LDR circuit.

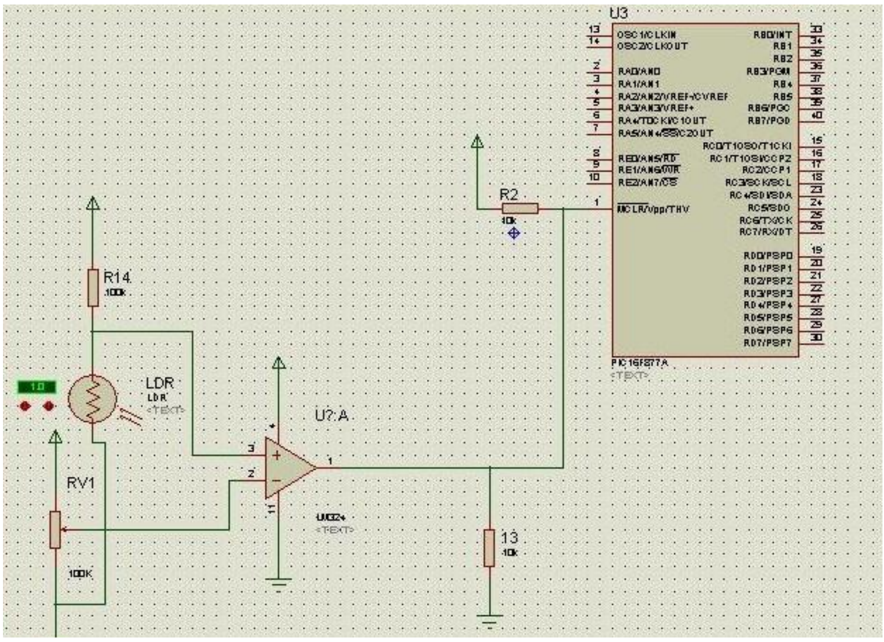


Fig 4.7 Daylight /night sensor circuit

As known, LDR resistance decreases with light; in dark, the resistance is very high sometimes up to 1M ohm. However, when light falls over its surface, the resistance decreases. It is connected with op amp IC works as comparator.

The comparator has two input values, input (+) and input (-). These positive and negative inputs are called as non – inverting and inverting inputs respectively. The comparator is used to compare the output voltage of the LDR to an adjustable reference voltage (provided by the variable resistance).

In this circuit, the sensor gives an out zero as output when it senses the absence of light, which means that pin 1 in the microcontroller, equals 0 and that make the system active (reset the PIC). The control system works only at night.

4.3 Software Design Implementation

In this section, the detailed description for the project software, in the previous section we talked about hardware interface with the microcontroller, in this section we will describe software used to perform hardware functions.

For software implementation, PIC C compiler and MPLAP IDE are used to program the microcontroller in C language.

4.3.1 Sensors and PIC programming

The microcontroller acts as the basic unit of the system. It receives data from the sensors that interface with it, an algorithm is developed to make the microcontroller able to read the input and respond accordingly. Therefore, the algorithm is established and represented by a flowchart in chapter three. These flowcharts translated into C language and compiled using PIC C compiler. The flowchart is shown on fig4.11

PIC code analysis

The PIC code is the code that is downloaded on the PIC in order to control the whole operation of the system.

In our system the PIC perform these functions:

1. Count the number of cars that cross the sensors (traffic counter).

2. Traffic speed calculations.

3. Control lights (relays) based on the speed state (low, medium and high speed).

4. Mobile control override.

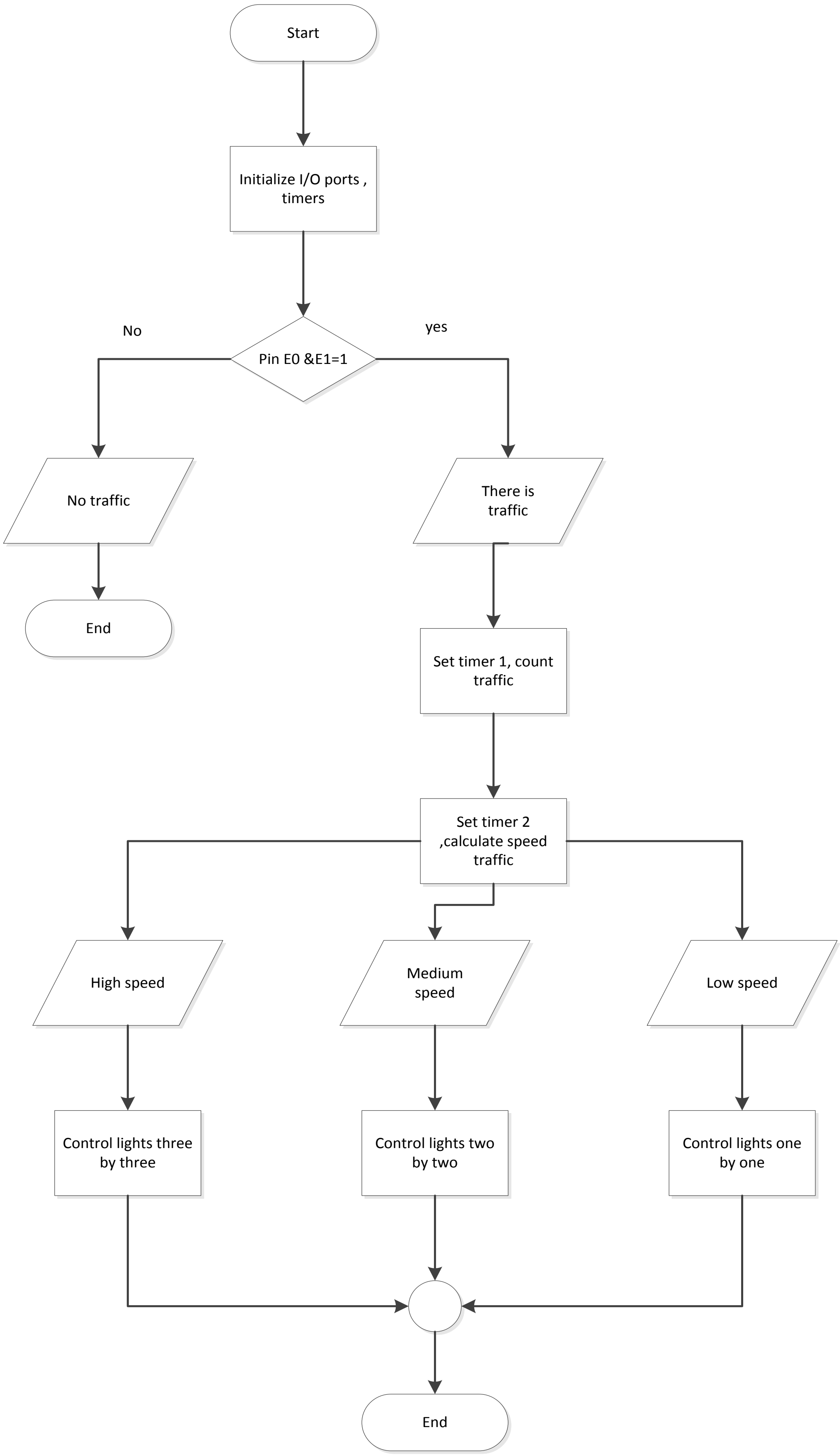


Fig 4.8 Control system flow chart

The algorithm shown in fig 4.8 describes the basic concept of the control system. The microcontroller communicates with the TSOP 1738 sensors via direct-wired connection. The out pins of the sensors act as input to the microcontroller. When pin E0 and E1 have logic of 1 this indicates that, there is traffic. When a vehicle crosses the first sensor, the control system enables timer1. Timer1counts up until the vehicle crosses the second sensor. The control system calculates the speed of the vehicle by using the time (the period of time that the car takes to pass through the two sensors) measured by timer1. The calculated speed is classified into low, medium and high. The lights that need to be turned on and off are selected based on the speed of the vehicle.

4.3.2 Light programming

The lights used in streets will be controlled based on the traffic speed as mentioned before, the table below shows how it will be controlled

Table 4.2 Low speed control

	Light2	Light3	Light2	Light4	Light3	Light5	Light4	Light6	Light5	Light7	Light6	Light7
Low speed	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF

Table 4.3 Medium speed control

	Light2	Light3	Light4	Light5	Light2	Light3	Light6	Light7	Light5	Light4	Light7	Light6
Medium speed	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF

Table 4.4 High-speed control

	Light2	Light3	Light4	Light5	Light6	Light7	Light6	Light7	Light2	Light3	Light4	Light5,6,7
High speed	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF

As seen in the tables the lights that need to turn on and off are selected based on the traffic speed.

```
Case 1

lcd_putc ("\f   Low Speed");

output_high (L2);

T2_delay (500);
```

f

Fig 4.9 Lights control

4.3.3 DTMF Programming

The algorithm used to describe the operation of the DTMF in this project is shown in figure 4.13, traffic department calls the system on the number 9999, the system designed to answer the call automatically. After responding to this call, the system control lights without the need to have traffic.

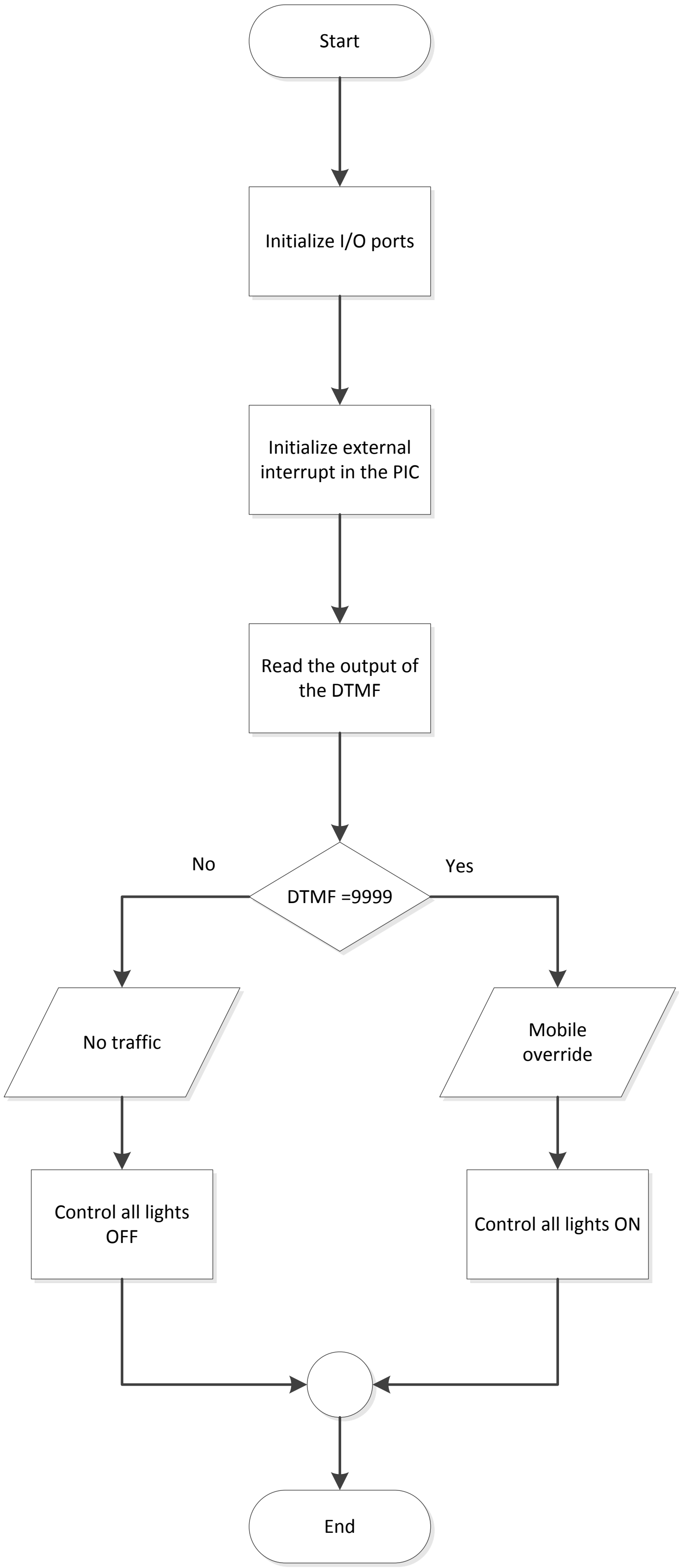


Fig 4.10 DTMF flow chart

CCS C compiler

CCS provides a complete integrated tool suite for developing and debugging embedded applications running on Microchip PIC. This suit an IDE for project management, a context sensitive c aware editor, build tools and real time debugger. Helping developers create, analyze, debug and document project code.

The CCS IDE allows developers to manage every aspect of their embedded software development, from code creation through device programming. External programs can be invoked from the IDE, simplifying integration with programmers and debuggers [15].

The heart of this development tool suit is the CCS code optimizing C compiler, which used in implementing the software of this project because of its reliability and the direct access to the hardware features from the C.

PCW C compiler

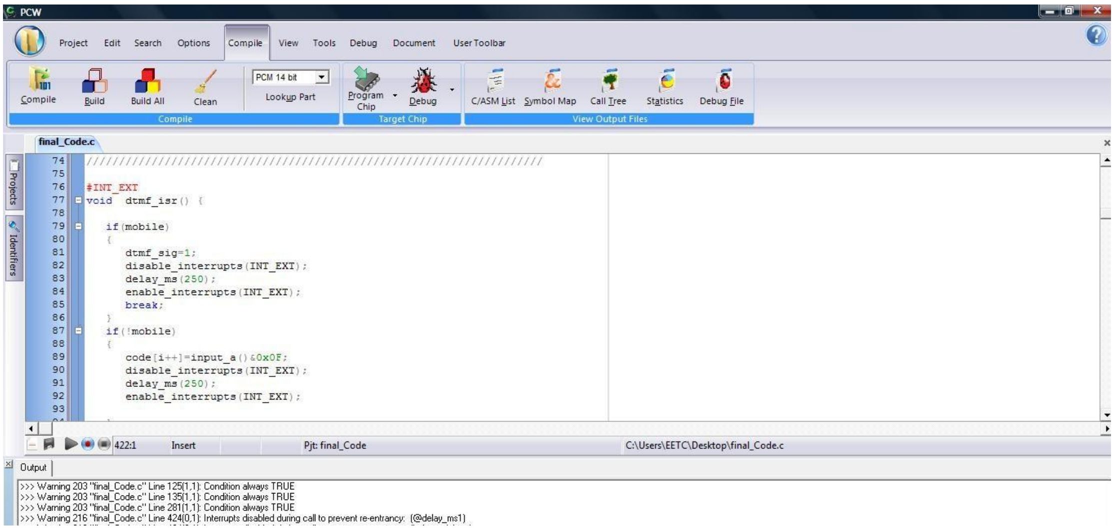


Fig 4.11 PCW editor

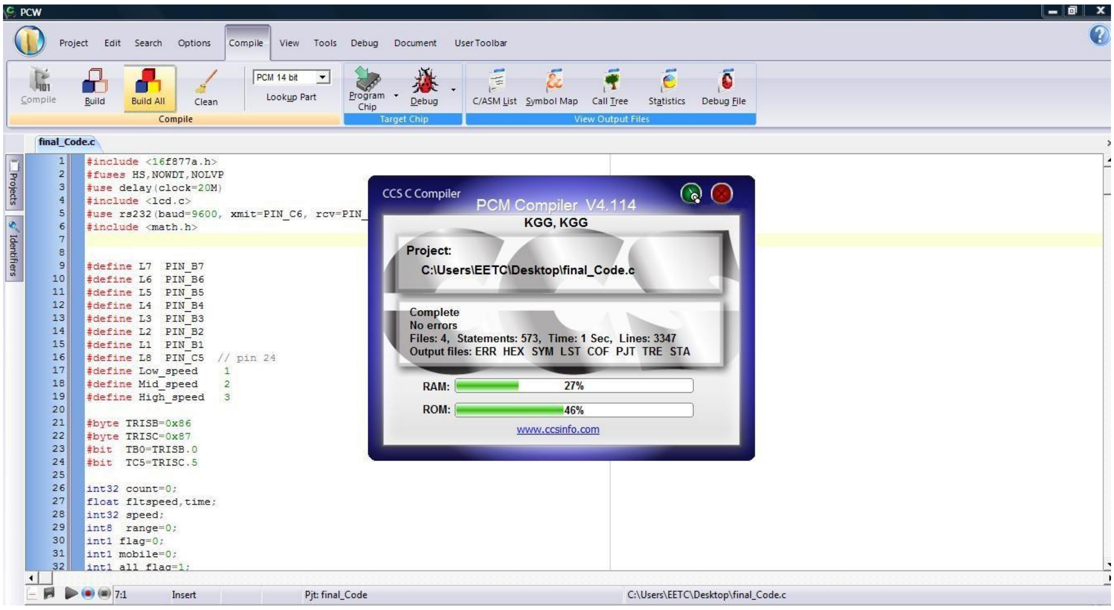


Fig 4.12 CCS C compiler

Programmer

Traditionally, embedded systems engineers use in circuit emulators (ICE) to develop and debug their designs and then programmers transfer the code to the device. The in-circuit debugging logic when implemented is part of the actual microcontroller silicon and provides a low cost alternative to more expensive ICE.

Features

. USB (full speed 2 Mbit /sec) and RS232 interface to host PC.

. Real time execution.

. Read / Write program and data memory of microcontroller.

. Erase of program memory space with verification.

Chapter Five

Testing and Results

5.1 Introduction

The final stage to complete the project is to test the system to get results and measure the performance of our system. This chapter shows all measurements needed to evaluate the performance of this system.

5.2 Testing and Results

The system consists of group of circuits, each circuit is implemented to do specific function .The figure below shows the practical circuit of the system

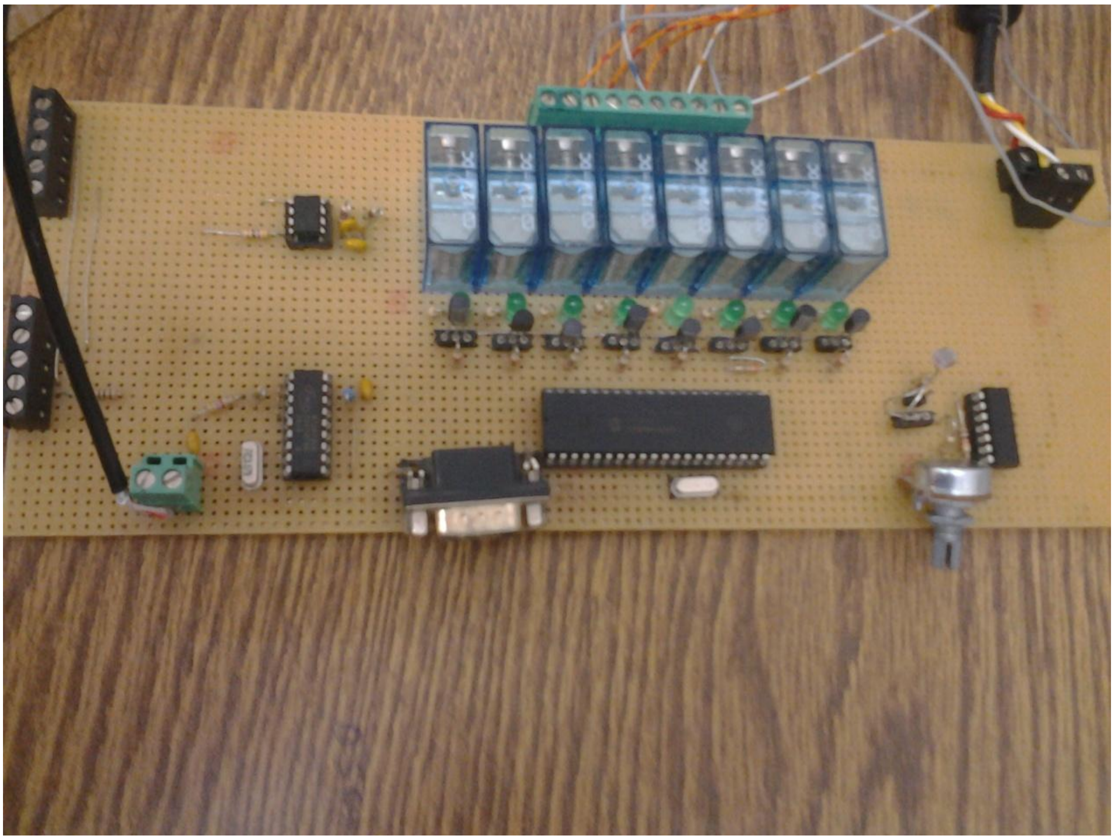


Fig 5.1 Total practical circuit

To make our idea more clear, we build a model for simulating a street in the real life.

Fig 5.2 street lighting system model

In this figure, all lights are off, because the system works only at night and here it is considered to be in daylight. This is controlled by the LDR circuit, its determine when it is night or daylight. LDR circuit is shown below:

Fig 5.3 LDR circuit

The system will be activated when the LDR sense it is night, and this means that the first and last led light will be turned on. That is the first case of traffic testing

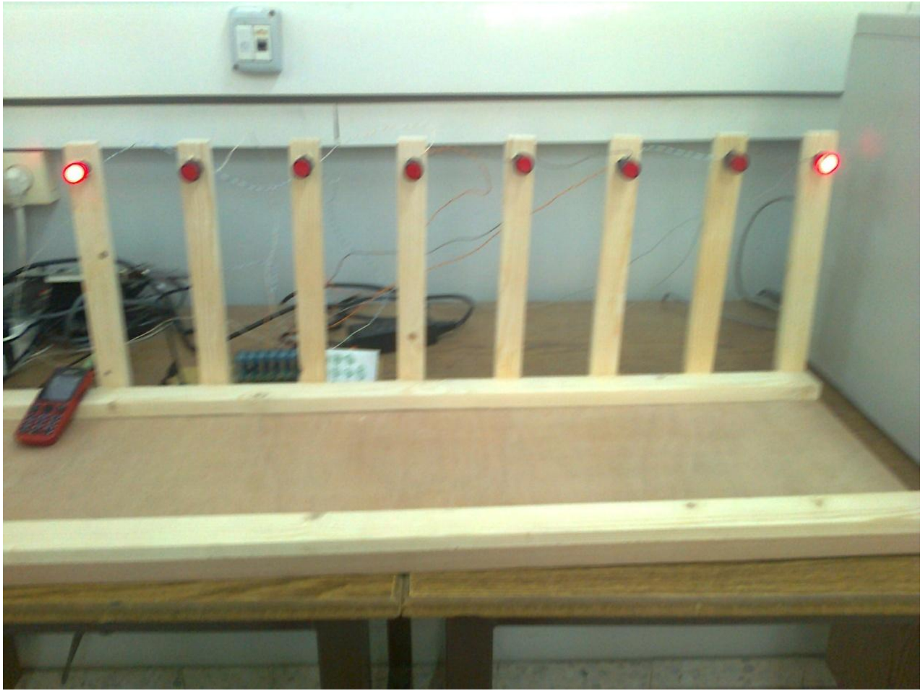


Fig 5.4 No traffic case

If the system detect that there is traffic, a speed calculations will be done to get the speed of the vehicle and turn on the lights based on the traffic speed.

Take the first case of having a vehicle moving with low speed, the lights start worked sequentially as determined in the figures:

Fig 5.5 low speed case (1)

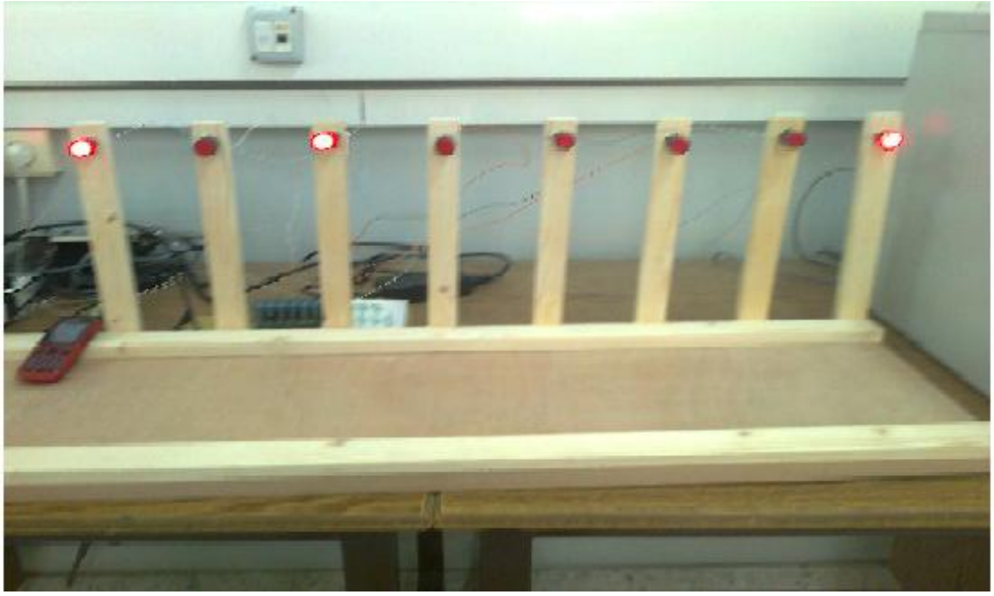


Fig 5.6 Low speed case (2)

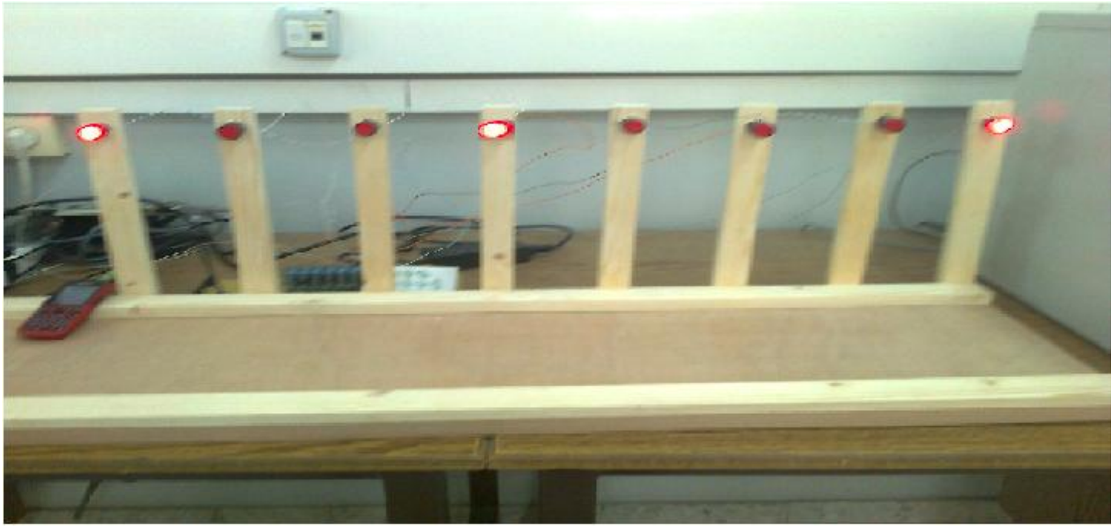


Fig 5.7 Low speed case (3)

Moreover, it continues turn on leds one by one until the vehicle pass the street and lights will back to be off.

If the speed of a vehicle is medium, the system turns lights on two by two sequentially as shown in the figures below:

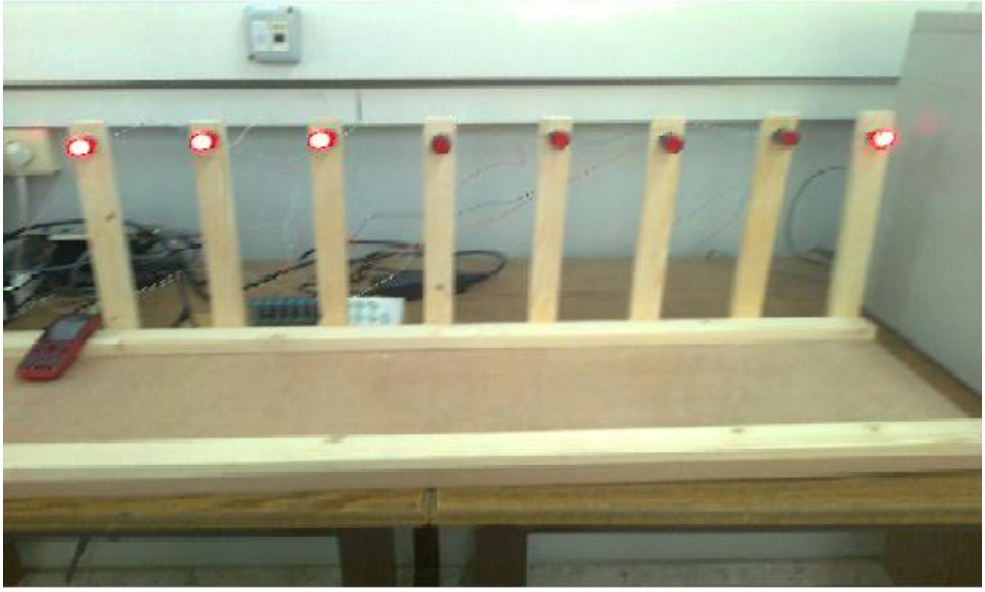


Fig 5.8 Medium speed case (1)

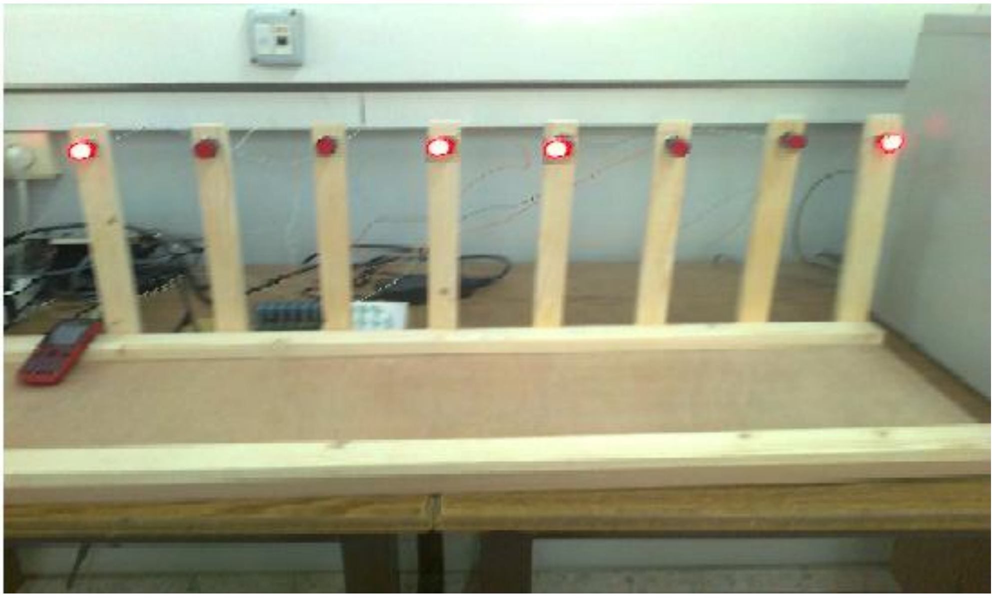


Fig 5.9 Medium speed case (2)

Fig 5.9 Medium speed case (3)

Remember that lights will turn off after the vehicle passes.

The last case of traffic testing is when the system detects high-speed case; the lights will be turned on three by three sequentially as shown below:

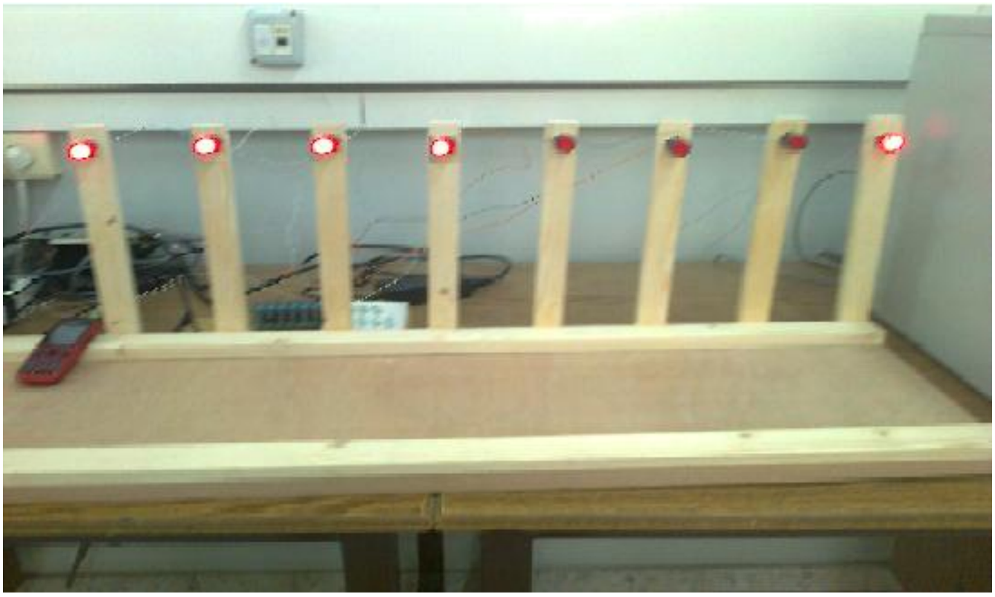


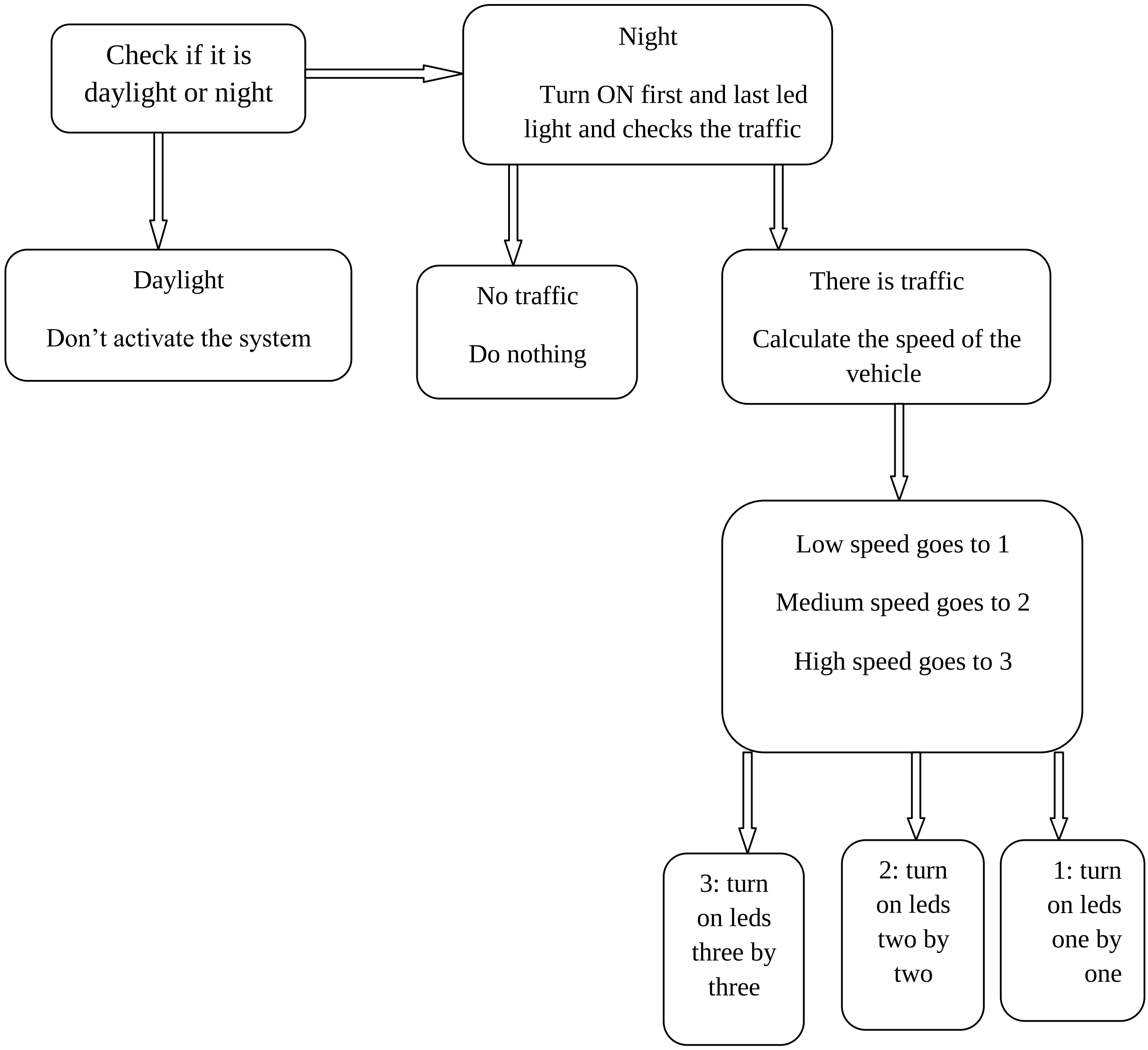
Fig 5.10 High-speed case (1)

Fig 5.11 High-speed case (2)

Fig 5.12 High traffic and mobile override

Fig 5.12 shows that the system turn on all the lights when there is high traffic, more than four vehicles on the road. In addition, this is executed too when the traffic department calls the system for override or emergency.

This general block diagram shows how the system works:



Chapter Six

Conclusions and Recommendations

6.1 Introduction

The project that has been done was a step for developing and finding new techniques to save energy. In addition, the project was a good step for implementing a system for controlling lights in highways. Meanwhile we have some recommendations and suggestions for the future work. Discussed in the following sections.

6.2 System Achievements

Almost all the goals of our system have been achieved. In this point, the main achievements of the system are discussed.

1. We build a control system capable of controlling lights in highways based on the traffic speed.

2. Reduce energy consumption by using lights when we need it only.

3. Improve the use of LED lights.

6.3 Real Learning Outcomes

After the implementation of the project, we have an expert in the following points:

- Learn how to use and program 16F877A microcontroller.
- Learn how to program DTMF.
- Learn how to interface photo detector sensors.

6.4 Recommendation

After our work in this project and after facing many problems during the implementation, we as a project team, see that the following points may be a good improvement for this project to make it more sense and more reliable :

- The system could be improved by making the communication between street lights wireless using GSM modem.
- An improvement to the system could be applied by using video monitoring, monitor and control the street in real time.
- Smart street system, transform the street lights into intelligent, energy-efficient, remotely managed networks [19].
- Improve the system by using pre –programmed sunrise and sunset time calculation algorithm (enhancement on the daylight /night sensor).

- Use Light Tools, which is a new tool developed to help optical designers working in street lighting [18].