CHAPTER ONE

INTRODUCTION

1.1 Overview

Now-a-days, it became essential for people work during nights and returning back to homes late nights; also increasing crime rate during night times. This can be best achieved by implementing proper solar based lighting system on streets. The efficient monitoring and controlling of this lighting system must be taken into account. We will get more power consumption and saving money through solar panel. Also saving precious time and decrease the huge human power through from the LDR and IR Sensors [1]. In recent years, environmental issues have gained widespread international attention, resulting in the development of energy-efficient technologies aimed at reducing energy consumption. One aspect of this evolving situation is an increasing demand for a reduction in the amount of electricity used for illumination. In particular, energy conservation for large scale illumination tasks such as street lighting is gaining considerable importance [2].

The lifecycle of an LED can be more than three times as long as an HID light. LED illumination could reduce the amount of time needed to exchange defective fixtures, and it is expected that an LED system would be comparatively maintenance free [2]. Lighting systems, particularly within the public sector, are still designed per the previous standards of reliability and that they don't usually profit of latest technological developments. Recently, the increasing pressure associated with the raw material prices and also the increasing social sensitivity to CO_2 emissions are leading to develop new techniques and technologies which permit significant cost savings and larger respect for the environment [3].

Solar Photovoltaic panel based street lighting systems are used. But the limitation with these ordinary street light systems is that it lacks intelligent performance. It is very essential to automate the system so that we can conserve energy as well as to maximize the efficiency of the system [4].

1.2 Problem Statement

Due to the huge cost of energy, especially electricity, efficiency can be one of the main ways to save energy in the world. Lighting consumes for around 20% of the world's total electrical energy. Therefore, the efficient lighting can save lots of energy. As a result of the increasing traffic congestion, high population density and increase the proportion of cars and engines led to the use of a new type of technology, such as solar cell technology to reduce energy waste and environmental conservation.

1.3 Objectives

The main objective of this research is to:

Realize a smart street lighting system based on ZIGBEE and LED. So that to reduce the traffic congestion. Use a new technique that reduces the energy consumption by using solar photovoltaic panel street lighting system, so as to take care of environment.

The proposal aims energy saving, high luminous efficacy and high useful life when replacing traditional lighting systems such as incandescent or compact fluorescent lamps by light emitting diodes (LEDs) lights without any change in electrical system installation:

- Enhance the power consumption in the street by utilizing the LEDs as the lighting components.
- Reduce the cost of installing wired connection for sensors by using Zigbee technology in lighting street system technology instead of using and maintain cable that need to be installed at the lamp posts.

1.4 Methodology

The thesis methodology is undertaken according to these steps:

1. Study the pervious works.
2. Study and understand solar photovoltaic.
3. Study and understand microcontroller and sensors.
4. Build complete system using proteus software.
5. Evaluate system performance based on simulation result.

1.5 Thesis Outline

This thesis is presented in five chapters. Chapter one gives an introduction to the research, including overview, problem statement, objective and methodology. Chapter two present backgrounds and literature review of smart street light system, wireless sensor, light emitting diode and solar energy. Chapter three simulation model of system. Chapter four presents the simulation result and discussion. Finally Chapter five provides the conclusion and recommendations.

CHAPTER TWO

BACKGROUND AND LITREATUR REVIEW

2.1 Smart Street Lighting System

Intelligent street lighting refers to public street lighting that adapts to movement by pedestrians, cyclists and cars. Intelligent street lighting also referred to as adaptive street lighting, dims when no activity is detected, but brightens when movement is detected. This type of lighting is different from traditional, stationary illumination, or dimmable street lighting that dims at pre-determined times [5].

Lighting is often the largest electrical load in offices, but the cost of lighting energy consumption is low when compared to the personnel costs. Thus its energy saving potential is often neglected. According to study global grid based electricity consumption for lighting was about 2650 TW in 2005, which was an equivalent of 19% of total global electricity consumption. European office buildings dedicate about 50% of their electricity for lighting, whereas the share of electricity for lighting is around 20-30% in hospitals, 15% in factories, 10-15% in schools and 10% in residential buildings. Intelligent lighting control and energy management system is a perfect solution for energy saving, especially in public lighting management, it realizes remote on/off and dimming of lights, which can save energy by 40%, save lights maintenance costs by 50%, and prolong lamp life by 25%. The system application in streetlight control for each lamp will reduce in streetlight electricity and maintenance cost, and increase availability of street light [5].

2.2 Wireless Sensor Network

A wireless sensor network consists of a large number of low-cost sensor nodes which can be self-organized to establish an ad hoc network via the wireless communication module equipped on the nodes each sensor node is also equipped with various kinds of sensors, computation units, and storage devices. These functional parts enable sensor nodes to be easily and rapidly deployed to cooperatively collect process and transmit information [6]. As sensor nodes, WSN are designed to operate on extremely low power, they usually run on battery power, which makes wireless sensor networks especially useful in monitoring applications where AC electricity is not available [7].

2.3 Wireless Sensor Network Architecture

Generally, the wireless sensor network consists of nodes and sinks /gateways. The sensor node is considered the simplest component in the network. Sinks or gateways are considered to be more complex than sensor nodes due to their complex functionality. In many applications the number of nodes is much higher than the number of sinks or gateways, thus their cost and size must be kept low [8].

2.3.1 Node architecture

Architecture of node focuses to reduce cost, increase flexibility, provide fault-tolerance, improve development process and conserve energy. The sensor node consists of sensing unit, processing unit (MCU- microcontroller unit), communication unit and power supply as shown in Figure 2.1.

- Sensing unit: Composed of collection of sensor which produces the signal then relay to microcontroller for further processing. The type of sensor being used in a sensor node will depend on the application.
- Processing unit: Microcontroller is general purpose processor; it forms the core part of the sensor node to tackle many aspects including the operating system, networking and power management. It is responsible for collecting data from various sources then processes it and stores it. The microcontroller is not only consists of memory and processor but also non-volatile memory

and interfaces. It helps to reduce the requirement of wiring, extra hardware, circuit board space and energy. For saving of power, microcontroller should have three states-active, sleeps, idle.

- Power supply unit: Which responsible for providing energy to the sensor node for monitoring the environment at low-cost and time. It takes energy from power generator and pass to other component of node. Life of sensor node depends upon battery. So battery is the important component that must be distribute properly. Power unit are required due to the following reasons provide long life, provide stability of voltage, capacity under load, ability to recharge under low current and low self-discharge.
- Communication or Transceiver Unit: A transceiver is a unit in which transmitter as well as receiver is sharing same circuitry on single board. It receives command from processing unit and passes it to the other node of the network. Communication is performed through communication channels. This phase provide some network protocol in order to perform communication. Using communication channel such as radio, laser, optical and infrared or Zigbee [8].

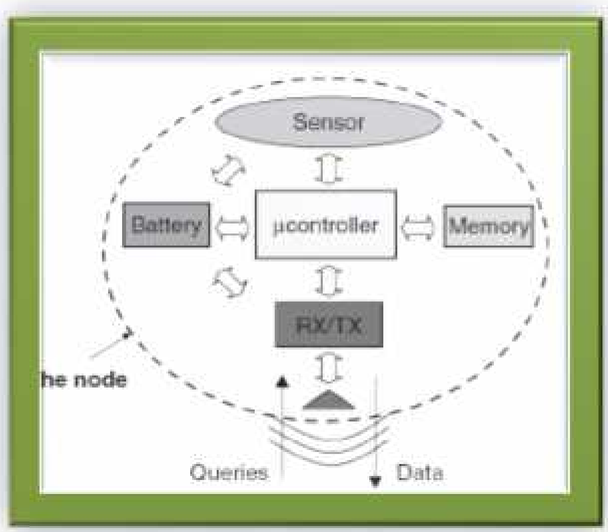

Figure 2.1: Architecture of a sensor node

2.3.2 Sink or gateway architecture

It provides four services such as sensor manager which provide access to sensors and manage the delivery of sensor data. It is responsible for providing the persistent storage for data streams, query manager performs query processing and manages active queries, integrity services is used for access control [8].

2.4 Light-Emitting Diodes

Light-emitting diodes are semiconductor devices that convert electricity to light. LED lighting is also called solid state lighting; because the light is emitted from a solid object a block of semiconductor material rather than from a vacuum or gas tube, as in traditional incandescent or fluorescent lights. LED technology has existed in specialized applications since the 1960s. Unlike incandescent or fluorescent lights, LEDs are not inherently white. White light is actually a mix of wavelengths in the visible spectrum, whereas LEDs emit light in a very narrow range of wavelengths, and so are ideal for producing colored light [9].

Today LEDs have been used widely to create the highly efficient red, green, and blue lights in devices including digital clocks, watches, televisions, dashboards, and traffic lights. In 1993 Japan’s Nichia Corporation devised a way to create white light from a single diode. This discovery initiated the ongoing quest to develop an LED-based technology that can produce a high-quality, warm white light suitable for general illumination. LED lighting technology has its own terminology distinct from traditional lighting. The light emitting part of an LED lighting product, the chip is a very small square of semiconductor material (also called a die). This chip is packaged with several components within an epoxy dome. Unlike traditional lighting products, LED lighting does not involve a bulb. Instead, a number of LED packages are clustered in a housing to form an LED lamp. An LED lamp cannot simply be screwed into a traditional lighting fixture like an incandescent or fluorescent bulb; instead, it must be integrated into a specially designed lighting fixture, or luminaries although the installation skills needed to install an LED luminary are the same as for traditional lighting fixtures [9, 10].

Luminaries are now a viable alternative to conventional technologies in the applications under discussion, and in many cases offer improved efficacy, color quality, and luminous intensity distributions. Notably, LEDs can be dimmed much more easily and to lower levels than HID (~10% versus ~50%) without sacrificing lifetime. In fact, operating LEDs at lower drive currents tends to reduce lumen depreciation while simultaneously increasing efficacy. The favorable dimming capabilities of LEDs can substantially improve the cost-effectiveness of sensing technology, and in fact are strongly correlated with the emerging development of advanced control systems for exterior lighting applications. However, there are still technical issues, such as visible flicker, with the use of dimming equipment in many situations that require resolution before these systems can achieve widespread implementation [11].

2.5 Solar Energy

Solar energy deployment contained in the word energy outlook, energy technology perspectives and several IEA technology roadmaps. It aims at offering an updated picture of current technology trends and markets, as well as new analyses on how solar energy technologies for electricity, heat and fuels can be used in the various energy consuming sectors, now and in the future.

If effective support policies are put in place in a wide number of countries during this decade, solar energy in its various forms solar heat, solar photovoltaic, solar thermal electricity, and solar fuels can make considerable contributions to solving some of the most urgent problems the world now faces: climate change, energy security, and universal access to modern energy services [12].

Solar energy offers a clean, climate-friendly, very abundant and inexhaustible energy resource to mankind, relatively well-spread over the globe. Its availability is greater in warm and sunny countries – those countries that will experience most of the world's population and economic growth over the next decades. They will likely contain about 7 billion inhabitants by 2050 versus 2 billion in cold and temperate countries (including most of Europe, Russia, and parts of China and the United States of America) [12].

The costs of solar energy have been falling rapidly and are entering new areas of competitiveness. Solar Thermal Electricity (STE) and solar Photovoltaic electricity (PV) are competitive against oil-fuelled electricity generation in sunny countries, usually to cover demand peaks, and in many islands. Roof-top PV in sunny countries can compete with high retail electricity prices. In most markets, however, solar electricity is not yet able to compete without specific incentives [12].

2.6 Previous Works

Fabio Leccese and Zbigniew Leonowicz [2] have proposed intelligent wireless street lighting system with optimized management and efficiency. Wireless communication uses ZigBee-based wireless devices which allow more efficient street lamp system management. It uses many sensors to control and guarantee the optimal system parameters; the information is transferred point-by-point using ZigBee transmitters and receivers and is sent to a control terminal used to check the state of the street lamps and to take appropriate measures in case of failure. The system allows substantial energy savings with increased performance and maintainability [2].

Archana.M and Mahalahshmi.R [1] have proposed E – Street: LED Powered Intelligent Street Lighting System with Automatic Brightness Adjustment Based On Climatic Conditions and Vehicle Movements. Presents a remote streetlight monitoring and controlling system based on LED and wireless sensor network. The system can be set to run in automatic mode, which control streetlight. This control can make a reasonable adjustment according to the seasonal variation. Also this system can run in controlled mode. This street light system also includes a time cut-out function, and an automatic control pattern for even more electricity conserving, namely when vehicles pass by, the light will turn on automatically, later turn off. This design can save a great amount of electricity compared to streetlamps that keep a light during nights. This system has auto-alarm function which will set off if any light is damaged and will show the serial number of the damaged light, thus it is easy to be found and repaired the damaged light. In addition, the system integrates a digital temperature and humidity sensor, not only monitoring the streetlight but also temperature and humidity [1].

Richu Sam Alex and R Narciss Starbell [13] have a proposed Energy Efficient Intelligent Street Lighting System Using ZIGBEE and Sensors. They used a new method is suggested so as to maximize the efficiency of the street lighting system and to conserve the energy usage by the system with the help of ZIGBEE and sensors. Sensors sense the intensity of light and presence sensor is used to detect the presence of humans or cars and then it gets turned on automatically. Yet another advantage with this system is that it allows the control terminal to identify the current status of each lamp, whether they are working properly or not and can even analyze the power consumed by each lamp. The microcontroller used here is ATMEGA. This controller is used because of the simplicity in programming [13].

Pilar Elejoste, Asier Perallos, Aitor Chertudi, Ignacio Angulo, Asier Moreno, Leire Azpilicueta, José Javier Astráin, Francisco Falcone and Jesús Villadangos [14] have proposed Easily Deployable Streetlight Intelligent Control System based on Wireless Communication. Which will provide tangible solutions to improve energy efficiency by adapting to the changes in the contextual needs. The proposed solution is said to be intelligent since light dimming is fixed based on the analysis of the data provided by the deployed sensors. The designed system includes some sensors (those which measure key environmental factors) and long range communication devices (such as a GPRS modems) in the fewest number of points of light. The rest would include the minimum device needed to configure the mesh network between streetlights in the same geographical or electrical region and PIR sensors that will detect the presence of people. Using collaborative techniques their single behavior would be coordinated by the smartest ones which would gather data from the environment and communicate with the control management on their behalf. The main challenge to be achieved in our work is to perform a set of streetlights smart enough to work in an autonomous way, as well as to be able to be remotely managed (for diagnostic, action and other energy optimization services). These two capabilities can decisively contribute to improve the global efficiency of the lighting systems, both in energy consumption as in maintenance costs. On one hand, the autonomous operation provides that the streetlights´ behavior can be changed according to the environment conditions, because they perceive some relevant characteristics of the environment, such as ambient lighting, presence of vehicles or people, or their own performing (if they are working properly or not). This way according to the information obtained from the environment they will regulate the lighting intensity, being able to perform different levels appropriate to instant requirements. On the other hand, the smart working of every streetlight also requires some knowledge about what is happening in the nearest ones, as well as what happened in the past and what the consequences of previous actions in similar conditions were [14].

Samir A. Elsagheer Mohamed [15] has a proposed Smart Street Lighting Control and Monitoring System for Electrical Power Saving by Using VANET. Propose a system that automatically switches off the light for the parts of the streets having no vehicles and turns on the light for these parts once there are some vehicles that are going to come. Logically, this system may save a large amount of the electrical power. In addition, it may increase the lifetime of the lamps and reduce the pollutions. This system automatically controls and monitors the light of the streets. It can light only the parts that have vehicles and help on the maintenance of the lighting equipments. Vehicular Ad-Hoc Networks (VANET) makes it possible to propose such sys- tem. VANET enables the possibility to know the presence of vehicles, their locations, their directions and their speeds in real time. These quantities are what are needed to develop this system. An advantage of using VANET is that there is no need to use specific network and equipments to design the system, but VANET infrastructure will be used. This de- creases the cost and speed up the deployment of such system. Results show that the saved energy may reach up to 65% and an increase of the lifetime of the lamps of 53% [15].

Chaitanya Amin, Ashutosh Nerkar, Paridhi Holani, Rahul Kaul [3] has proposed GSM Based Autonomous Street Illumination System for Efficient Power Management. The system compromises of server, GUI to display and nodes which are micro-controlled processed with embedded sensors measuring different parameters. Each node in the network is linked to the main server via a protocol. This system defines the control of street lightning system and thereby saving electricity which is a major concern worldwide. It also describes the use of wireless sensor networks using GSM for streetlight monitoring and control. This system would provide a remote access for streetlight maintenance and control. It also discusses an intelligent system that takes automatic decisions for luminous control (ON/OFF/DIMMING) considering surrounding light intensity and time of the day both at the same moment. The system also senses various parameters like surrounding temperature, fog, carbon emissions, and noise intensities and suggests corrective measures. Power theft control is also integrated in the same system. The system application in streetlight control for each lamp will reduce in streetlight Electricity and maintenance cost, and increase availability of street light [3].

B. K. Subramanyam, K. Bhaskar Reddy and P. Ajay Kumar Reddy [4] have proposed Design and Development of Intelligent Wireless Street Light Control and Monitoring System Along With GUI. The Street lights are controlled through a specially designed Graphical User Interface (GUI) in the PC. The Zigbee technology can be used for the street lights monitoring and controlling at the PC end. In this system there are two modes of operations: AUTO & MANUAL Operations.

AUTO: In this automatic mode operation we are using LDR Sensor (Light Dependent Resistor) for measuring light intensity for switched ON or OFF the street light using relays. The main principle of LDR is when the light intensity is low; light is going to be ON otherwise it’s going to be OFF. For the efficient reduction of power wastage IR (Infrared) Sensor is integrated. If any vehicle or obstacle is detected using IR sensor at that time it will check the light intensity level using LDR sensor then light will go ON or OFF.

MANUAL: In this manual mode, the street lights are controlled through a specially designed Graphical User Interface (GUI) in the PC. The Zigbee technology can be used for the street lights monitoring and controlling at the PC end [4].

Lakshmiprasad and Keerthana [16] have proposed Smart Street Lights. This system explains how the energy can be saved from the street lights through effective management using GSM technology. The key objective is to design an intelligent system that takes decisions for luminous control (ON/OFF/DIM) considering the light intensity during day and night simultaneously. System enables anti-thefting of power and it is easily adoptable to the present street lights using single computer module. The intelligent system is suitable for solar cell installations. This system resolves the faulty street lamps issue, where people are rarely taking the initiative to report faulty street lamps in their locality. With this device, it able to track whenever there is faulty lamps and sends the data to the control centre. Thus, technician will be able to acknowledge the faulty street lamps at the first moment and head for the repair. Another benefit of this system is the cost saving in terms of wiring. The Xbee module will allow the streets lamps communicate to the control system via wireless. Results show that the detection/Alarm of date Management (energy consumption report), 24-hours online Monitoring and Reduce energy use by up to 40 autonomous devices embedded along with sensors which monitor the environmental parameters like sound, fog, temperature, carbonmonoxide emission [16].

Dr. D.V.Pushpa Latha, Dr. K.R.Sudha and Swati Devabhaktuni [17] have purposed PLC based Smart Street Lighting Control. In this system describe the Smart Street Lighting system, an approach to accomplish the demand for flexible public lighting systems using a Programmable Logic controller (PLC). The main difference from other computers is that PLCs are armored for severe conditions such as dust, moisture, heat, cold etc., and have the facility for extensive input/output (I/O) arrangements. Street lights are controlled using millennium 3 PLC taking the seasonal variations into consideration.

Different control techniques have been proposed for street lighting controller during seasonal variation. It is common to use relays to make simple logical control decisions. The relays allow power to be switched on and off without a mechanical switch. The development of low cost computer has brought the most recent revolution. The simulated results are verified experimentally by using a light dependent resistor (LDR) which senses the light. LDR is used as the replacement for the seasonal variation. This system confirms that the proposed

PLC based street lighting control system has great potential to revolutionize street lighting which in turn saves large amount of power [17].

CHAPTER THREE

SIMULATION MODEL

3.1 Introduction

This system resolves the faulty street lamps issue, where people are rarely taking the initiative to report faulty street lamps in their locality. With this device, it able to track whenever there is faulty lamps and sends the data to the control centre. Thus, technician will be able to acknowledge the faulty street lamps at the first moment and head for the repair. Another benefit of this system is the cost saving in terms of wiring. The Xbee module (Zigbee) will allow the streets lamps communicate to the control system via wireless. With the wiring method, the high cost of the construction and material makes the system uneconomical; moreover, the reliability of the system will reduce too. Although this system monitors the health of the street lamp status, it did not have other smart feature whereby controlling the street lamps by automatically turning ON or OFF the lamps. If this feature is apply to this system, this allow another great energy saving. Then main ideas for this thesis is the problem of congestion of cars and their accumulation in the streets has become one of the problems that concern organizations the competent authorities in this area.

With this in mind many of the bodies and individuals began to formulate possible solutions. Which alleviate congestion and overcrowding cars and was among this Trka solutions and street smart, which have proven effective in solutions at high rates? In this thesis, the basic idea is based on the control in road lighting so nagy color lighting in the way of one color to several colors and each color has a specific meaning. For example, the first color symbolizes the road congestion in this case a busy street allows the driver identify on that one occasion and change course to a distance alternative path. And vice versa in the case of the lighting is congestion Yemen for the driver to continue his way, helping to reduce congestion on the roads. The proposed scheme is characterized by employing MCU to manage the whole street lots through wireless communication. Uses IR sensors to detect the motion of the vehicle in the street which connected to the processing unit. System technology also contain a LCD display, LED, wireless communication and solar photocell as shown in Figure 3.1.

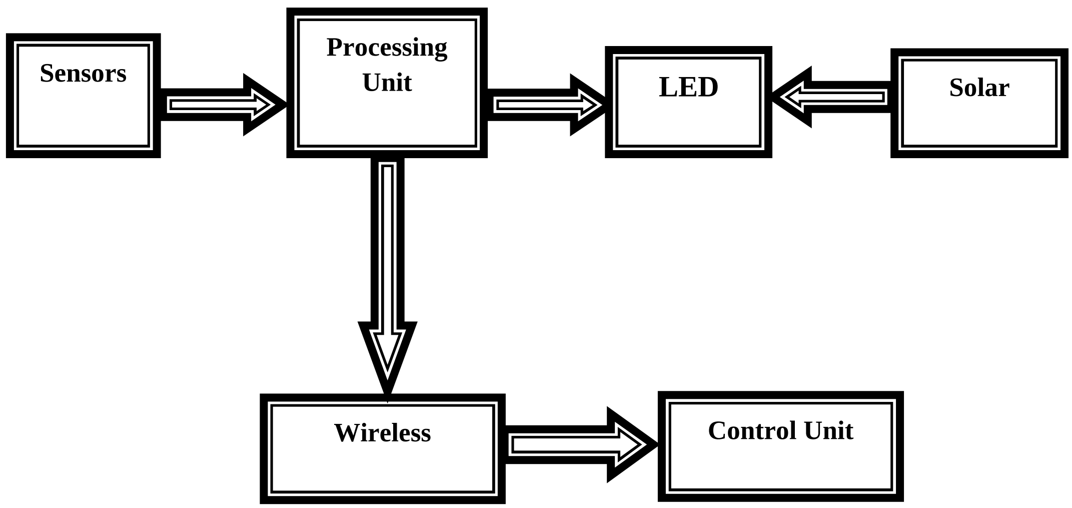

Figure 3.1: Block diagram of the system

3.2 IR Sensor Modules

All objects emit some form of thermal radiation, usually in the infrared spectrum. This radiation is invisible to our eyes, but can be detected by an infrared sensor that accepts and interprets it. In a typical infrared sensor like a motion detector, radiation enters the front and reaches the sensor itself at the center of the device [18]. This part may be composed of more than one individual sensor, each of them being made from pyroelectric materials, whether natural or artificial. These are materials that generate an electrical voltage when heated or cooled. These pyroelectric materials are integrated into a small circuit board. They are wired in such a way so that when the sensor detects an increase in the heat of a small part of its field of view, it will trigger the motion detector's alarm. It is very common for an infrared sensor to be integrated into motion detectors like those used as part of a residential or commercial security system. An infrared sensor can be thought of as a camera that briefly remembers how an area's infrared radiation appears. A sudden change in one area of the field of view, especially one that moves, will change the way electricity goes from the pyroelectric materials through the rest of the circuit. This will trigger the motion detector to activate an alarm. If the whole field of view changes temperature, this will not trigger the device. This makes it so that sudden flashes of light and natural changes in temperature do not activate the sensor and cause false alarms [18].

3.3 Object Detection Using IR Sensor

The object detection of IR sensor that shown in Figure 3.2. It is the same principle in all Infra-Red proximity sensors. The basic idea is to send infra red light through IR-LEDs, which is then reflected by any object in front of the sensor. From the electronic circuit of IR sensor that shown in Figure 3.3.As the name implies, the sensor is always ON, meaning that the IR led is constantly emitting light. This design of the circuit is suitable for counting objects, or counting revolutions of a rotating object, that may be of the order of 15,000 rpm or much more. However, this design is more power consuming and is not optimized for high ranges. In this design, range can be from 1 to 10 cm, depending on the ambient light conditions [18].

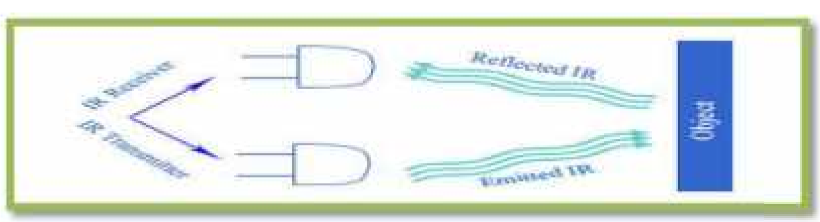

Figure 3.2: Object detection using IR sensor

The sender is composed of an IR LED (D2) in series with a 470 ohm resistor, yielding a forward current of 7.5 MA. The receiver part is more complicated, the two resistors R2 and R3 form a voltage divider which provides 2.5V at the anode of the IR LED (here, this led will be used as a sensor). When IR light falls on the LED (D1), the voltage drop increases, the cathode's voltage of D1 may go as low as 1.7V or more, depending on the light intensity. This voltage drop can be detected using an Operational Amplifier (Op-Amp). The voltage after operational amplifier must be 5V *i.e.* logic 1 [18].

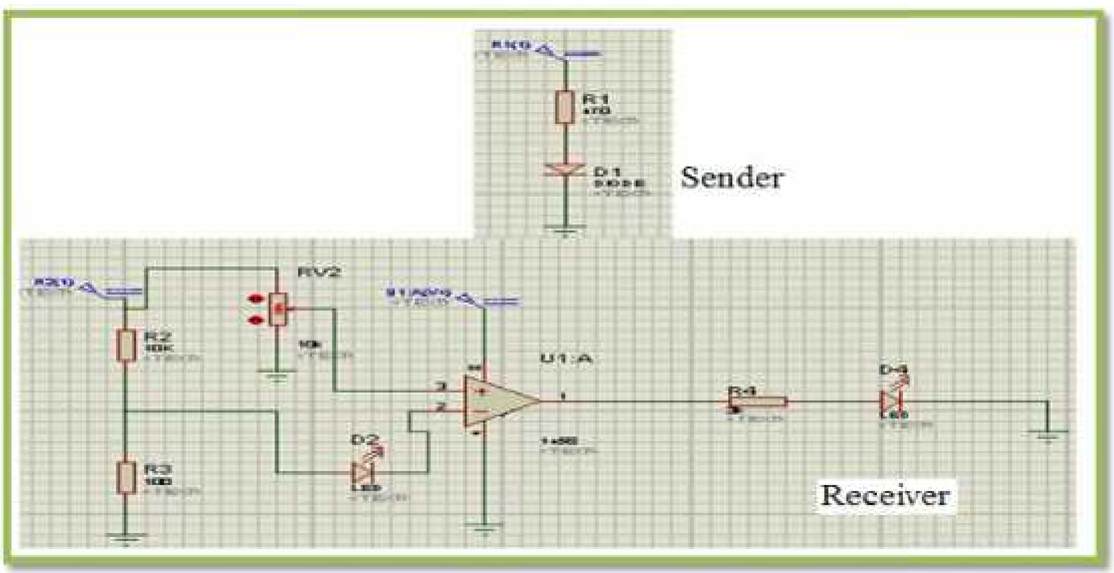

Figure 3.3: Design of sender and receiver IR sensor

3.4 Processing and Storing Unit

The microcontroller performs a task, controls the functionality of other components and processes data. Advanced virtual RISC controller is the main control unit of the smart street system. It controls all the IR sensor nodes, PSDU and the whole system. It receives the signal from the IR sensors and also sends the information to them in order to manage the street system.

The selected microcontroller is ATmega16 and ATmega8. ATmega16 is 8 bit MCU working with low power supply voltage range 2.7V to 5.5V. It consists of advanced RISC architecture with 32KB self-programming flash program memory, 1KB Static Random Memory (SRAM), 512bytes Electrically Erasable Programmable Read Only Memory (EEPROM) and 32bit programmable I/O lines, with 16MHz max operating frequency. The power consumption at 1MHz is 3VA. Active mode: 1.1mA, idle mode: 0.35mA, and power down mode :< 1µA (see Appendix A). ATmega8 is low power supply voltage range 2.7V to 5.5V. It consists of advanced RISC architecture with 8 KB self-programming flash program memory, 1KB Static Random Memory (SRAM), 512Bytes Electrically Erasable Programmable Read Only Memory (EEPROM) and 23 programmable I/O lines, with 16MHz max operating frequency. The power consumption at 4MHz is active mode: 3.6mA, idle mode: 1.0mA, and power down mode: 0.5µA (see Appendix B). Microcontroller was programmed by code vision AVR compiler (for more information about programming code please refers to Appendix C and D), and tested in Proteus program with virtual program.

3.5 Wireless Communication Unit (Based on ZigBee)

ZigBee is a typical wireless communication technology, which is widely used in wireless sensing networks, and it is a specification for a suite of high level communication protocols**.** ZigBee uses low rate, low-power digital radios based on an Institute of Electrical and Electronic Engineering (IEEE) 802 standard for personal area networks. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other Wireless Personal Area Networks (WPANs), such as Bluetooth. ZigBee is targeted at RF applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250Kbps best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. It is open standard protocol with no or negligible licensing fees, chipsets available from multiple sources, remotely upgraded firmware, fully wireless and low power, mesh networking to operate on batteries, low maintenance and larger network size with standard based high security [19].

3.5.1 IEEE 802.15.4/ZigBee standard overview

The ZigBee alliance selected the IEEE 802.15.4 standard, released in May 2003, as the wheels and chassis upon which ZigBee networking and applications have to be constructed. IEEE 802.15.4/ZigBee is a standard protocol for Low-Rate Wireless Personal Area Networks (LR-WPAN). Its main features are network flexibility, low data rate, low cost and very low power consumption, which make it suitable for an ad-hoc network between inexpensive fixed, portable and moving devices [20].

3.5.2 ZigBee specifications

The basic specifications of the ZigBee802.15.4 standard are present in Table 3.1.

Table 3.1: Basic ZigBee specifications

Parameters	**Zigbee Value**
Transmission rang (meters)	1 -100
Battery life (days)	100 -1,000
Network size (of node)	>64,000
Throuhput	20 -250

3.5.3 Network components

IEEE 802.15.4 protocol generally defines three types of nodes or three kinds of devices that incorporate ZigBee radios, with all three found in a typical ZigBee network as in Figure 3.4.

- Coordinator (ZC): Organizes the network and maintains routing Tables.
- Routers (ZR): Can talk to the coordinator, to other routers and to reduced-function end devices.
- End devices (ZED): Can talk to routers and the coordinator, but not to each other [18].

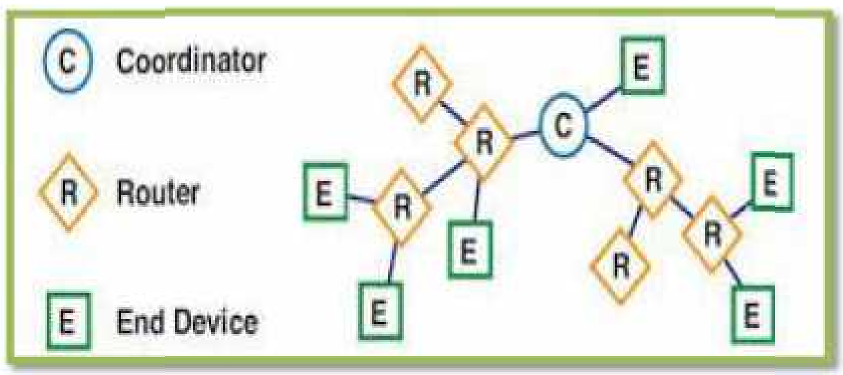

Figure 3.4: ZigBee network topologies

3.5.4 ZigBee topologies

IEEE 802.15.4 supports three types of topologies: star, mesh and tree that can be considered as a special case of mesh topology.

- Star topology: In this simple topology, a coordinator is surrounded by a group of either end devices or routers. This type of topology is attractive because of its simplicity, but at the same time presents some key disadvantages. In the moment when the coordinator stops functioning, the entire network is functionless because all traffic must travel through the center of the star. For the same reason, the coordinator could easily be a bottleneck to traffic within the network, especially since a ZigBee network can have more than 60000 nodes.

- Tree topology: In a tree network, a coordinator initializes the network, and is the top (root) of the tree. The coordinator can now have either routers or end devices connected to it. For every router connected, there is a possibility for connection of more child nodes to each router. Child nodes cannot connect to end devices because it does not have the ability to relay messages. This type of topology is not the most reliable topology. If a router fails, then all of that router's children are cut off from communicating with the rest of the network [20].
- Mesh topology: It is the most flexible topology of the three. Flexibility is present because a message can take multiple paths from source to destination. If a particular router fails, then ZigBee's self-healing mechanism will allow the network to search for an alternate path for the message to be passed [20].

As related works studied, different technology has been explored to implement intelligent lighting systems. A comparison between these kinds of communication approaches are shown in Table 3.2.

The available PLC modules in Iran's market suffer from some disadvantages such high cost and no networking capabilities. Opposed of ZigBee technology, Z-wave technology has lower data rates and supporting limited nods. The reason of why ZigBee media are used mainly is its easiness of installation and maintenance. There are no needs to install additional transmission line and it is more economical than other media's case [21].

Table 3.2: Comparison available communications technologies

	Power Line Communcation	Z-Wave	ZigBee
Data rate (kbps)	0.625 - 50	40	250
Power consumption	Very Good	Good	Very Good
Implementation	Good	Good	Best
Installation cost	Good	Very Good	Very Good
Maintenance cost	Good	Good	Very Good
Max number of nodes	-	232	2^16
Frequency	-	900MHz	900 and 2.4GHz
Range	-	30m	10m-1.6km

3.6 RGB Light-Emitting Diodes

A single LED die can only emit monochromatic light which could be one of the three primary colors red, green and blue, known as RGB. To realize more colors, three LED dies need to be used together for RGB color mixing. Commonly 7 colors can be produced by controlling the switch of the channel for each primary color. To produce more than 7 colors, each color channel should be able to change in brightness, not just switched on or off. A popular control method is PWM, of which the cycle duty range determines the available brightness levels. The more the levels are available, the more colors can be produced. Apart from the popularity in applications like outdoor decoration lighting in cities, stage lighting designs, home decoration lighting and LED display matrix, RGB color mixing technology can also be found recently in LCD backlighting and projectors [22].

To implement different patterns of RGB color mixing, each LED die needs a dedicated signal for dimming. One method is using a single driver that has three or more channels and is capable of controlling each channel separately for dimming. The other is using three drivers to provide power and implement dimming function respectively on three channels. Obviously, the former method uses fewer drivers and is suitable for the applications such as backlighting and display matrix that work on lower current and a large number of LEDs. The latter one can be used in high power applications such as decoration lighting.

LEDs used in RGB color mixing are totally depends on application requirement, either high brightness or high power LEDs can be used in these applications .To form a color with RGB, three light beams (one red, one green, and one blue) must be superimposed (for example by emission from a black screen). Each of the three beams is called component of that color, and each of them can have an arbitrary intensity, from fully off to fully on, in the mixture. The RGB color model is additive in the sense that the three light beams are their light spectra add, wavelength for wavelength, to make the final color’s spectrum.

Zero intensity for each component gives the darkest color (no light, considered the black), and full intensity of each gives a white, the quality of this white depends on the nature of the primary light sources, but if they are properly balanced, the result is a neutral white matching the systems white point. When the intensities for the entire component are the same, the result is a shade of gray, darker or lighter depending in the intensity. When the intensities are different, the result is a colorized hue, more or less saturated [23].

Depending on the difference of the strongest and weakest of the intensities of the primary colors employed. When one of the component has the strongest intensity, the color is a hue near this primary color (red, green, or blue), and when two component have the same strongest intensity, then the color is hue of a secondary color (a shade of cyan, magenta or yellow). A secondary color is formed by the sum of two primary colors of equal intensity: cyan is green+blue, magenta is red+blue, and yellow is red+green. Every secondary color is the complement of one primary color, when a primary and its complementary secondary color added together, the result is white, cyan complements red, and magenta complements green and yellow complements blue. The RGB color model itself does not define what is meant by red, green and blue. Colorimetrically, and so the result of mixing them are not specified as absolute, but relative to the primary colors [23] .

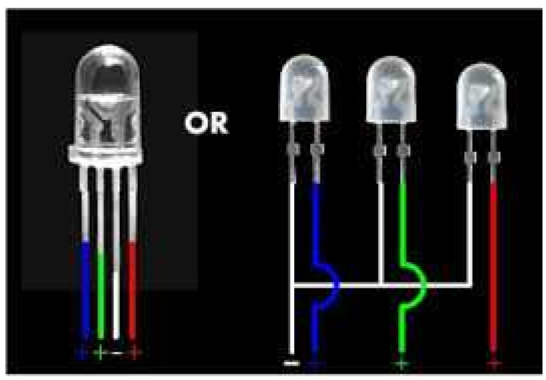

Figure 3.5: RGB Led

3.7 Solar Street Lighting System

The solar street lights work on the principle of the photovoltaic cell or solar cell. The solar cell converts solar energy to the electrical energy which stored in the battery. The solar lamp draws the current from this battery and it requires no other wiring [24].

Figure 3.6: Solar Street Lighting System

3.7.1 Working of solar street lights

The solar street lights use solar energy, a form of the renewable energy. These days it is common to see the solar street lamps along the side of roads. The solar street lights comprise of the photovoltaic cells, which absorb the solar energy during day time. The photovoltaic cells convert solar energy into electrical energy, which is stored in the battery. At the night time the lamp start automatically and it consumes electricity already stored in the battery. During the day time the battery gets recharged and the process keeps on repeating every day [24].

3.7.2 Solar led lights

LED stand of Light Emitting Diode. LED comprises of the chemical compound that gives of the light when Direct Current (DC) from the battery passes through it. Solar LEDs are available from number of companies in different size, shapes and style. The life of LED is usually very high extending up 50,000 hours. The LED requires very little current hence the solar panels of smaller size are required for the solar light with LED lamps.

3.7.3 Centralized solar systems

In centralized solar system. The solar system is separated from each street light to provide power to a cluster of street lights, although this system has problem of its own, it is considered a more viable option for converting existing street lights to solar power for the following reasons [24].

- The existing infrastructure such as poles and wiring does not have to be replaced to accommodate the solar system.
- The system does not have the same limitation as the stand –alone system. The result is that the solar system can be designed to be as big as required with enough batteries and panels to provide power to the lights.
- The solar panels can be placed away from any shade to optimize power generation.
- The batteries will be housed in an ip65, well-ventilated battery cabinet which can be insulated to provide maximum protection against heat.
- The system can easily be equipment with monitoring device to alert authorizes of any tampering or removal of equipment. This will not eliminate the threat of theft but will reduce the response times so the culprits could be caught red handed.
- The monitoring device can keep control on one or many systems. most large inverters are equipped to facilitate monitoring software which will not only alert the relevant people of any maintenance issues, but also to send alert if the system is over-heating or if moisture is detected in the system. This will assist the municipalities to better understand the system and to avoid major replacement of equipment.
- The maintenance will be done at one point for several lights and combined with the monitoring system; maintenance could simply be done on the system from a central computer.

The main drawback of the centralized solar system is that cables must be laid to each pole. Where a standalone system does not require cabling. It is the author opinion that the additional cost related to stand-alone system such as stronger poles, battery boxes, and solar panels and the risk of additional maintenance will outweigh the cost of installing a centralized system [24].

3.7.4 Type of solar street lighting system

The main types of solar street lighting system are:

1. Centralized street light PCU

The range of this type is 500VA, 1KVA, 2KVA, 3KVA, 4KVA, 5KVA, 6KVA. The existing street light so far powered from grid supply is powered from centralized solar power plant in clusters of 10 with provision for grid backup. The existing street light with 40w tube light or equivalent &filament lamps are replaced with 20w LED lights. The smart power conditioning unit in the system allows chagrining of battery from grid, only in rainy or cloudy days, when solar power is not sufficient to charge the battery in full during 10 am-6pm only.

2. Standalone (built in batteries) street light system-sunway

The range of this type is 4Wp, 8Wp, 15W LED based. The newly designed solar street light systems have the in-built lithium in batteries. This reduces the issue of maintenance of batteries. Lithium batteries also have the capacity of fast charging compared to normal lead acid batteries.

These solar lighting systems offer an environment friendly and economical option to light up streets, boulevards, highways, yards, park, car parking areas, airports and any public space. Table 3.3 shows the selection matrix for standalone (built in batteries) street light system-sunway.

1. Standalone (external battery) street light system-sunway

The rang of this type are 30Wp, 60Wp, 80Wp LED based. These are lenses backed LED based solar powered street lighting system. It has the advantage of configuring as per the back-up and individual requirement of the customer. The high efficiency LED based street lighting system has more LUX and at the same time reduces the size of panels [24]. Table 3.4 shows the selection matrix for standalone (external battery) street light system-sunway.

Table 3.3: Selection Matrix for Standalone (built in batteries) street light system-sunway

Model	**Lumens**	**Height(m)**	**Lux**	**Distance between light(meter)**	**Charge controller**	**Battery**	**Battery Type**
4W	400	3	21	5m-7m	Internal	3.7V,10.2Ah	Li Integrated
8W	700	4	21	6m-8m	Internal	14.8V,5.2Ah	Li Integrated
15W	1100	4	28	8m-10m	Internal	14.8V,5.2Ah	Li Integrated

Table 3.4: selection matrix for standalone (external battery) street light system-sunway

Model	**Lumens(m)**	**Height**	**Lux**	**Distance between light**	**Charge controller**	**Battery**	**Battery Type**
30W	2900	5	34	18m-20m	External,12V,10V	12V,130Ah	LA
60W	5800	7	34	20m-25m	External,12V,20V	12V,100Ah	LA
60W	5800	7	34	20m-25m	External,12V,20V	12V,160Ah	LA
60W	5800	7	34	20m-25m	External,12V,20V	12V,240Ah	LA
80W	7700	8	35	25m-30m	External,12V,20V	12V,120Ah	LA
80W	7700	8	35	25m-30m	External,12V,20V	12V,240Ah	LA
80W	7700	8	35	25m-30m	External,12V,20V	12V,320Ah	LA

3.8 Control Unit

Basic function of the control unit is the signal coming forth from microcontroller through zigbee. Saluting tell her about the road condition do you busy or otherwise and the number of cars on the road. And generally receive the console on the state of the road and retains the information until it is used in cases of decoding congestion and traffic cases VIPs.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The program that controls the system is designed primarily to avoid wasting energy. Firstly, as a result that the system works solely in the darkness, avoiding waste of energy throughout sunlight hours when the sole active device is the solar panel that recharges battery. Secondly, the sensors enable the system to operate solely when necessary. Thirdly, the system employs highly economical LEDs to ensure correct illumination and assure energy savings. Finally, when the system is disabled, all devices (wireless module and microcontrollers) are in the sleep mode. The prototype has been tested in variable real-life conditions to verify the general functionality and determine points for improvement and optimization. The measurements collected throughout the testing permit to calculate energy savings and economic benefits. It was found the applied ZigBee modules are appropriate for this application. Every lamppost being placed at the distance of 25 meters from one another, since modules have a range of 100 m outdoors. In this system we work simulation process control in road crowded by LED model, as well as solar energy is used for lighting LED. Through this system we can also control the distribution of energy and reduce the waste of energy used.

4.2 Flowchart

In normal position of road lighting be in the stopped state. Once the oncoming car to the road, LED lighting works. There are sensors in the first way, sensors in the road last and sensors in all lamppost. When the arrival of a car to the road gives a reference to the delicate lighting in order to work and show the way.

Upon the arrival a car to the road gives another indication of delicate lighting to stop working.

In the street number S, N, W or E. If the first sensor sense seven or more cars and the last sensor did not give a signal the exit of vehicles from the road, its means busy road, All vehicles coming in will know that a busy road and change direction in Figure 4:1.

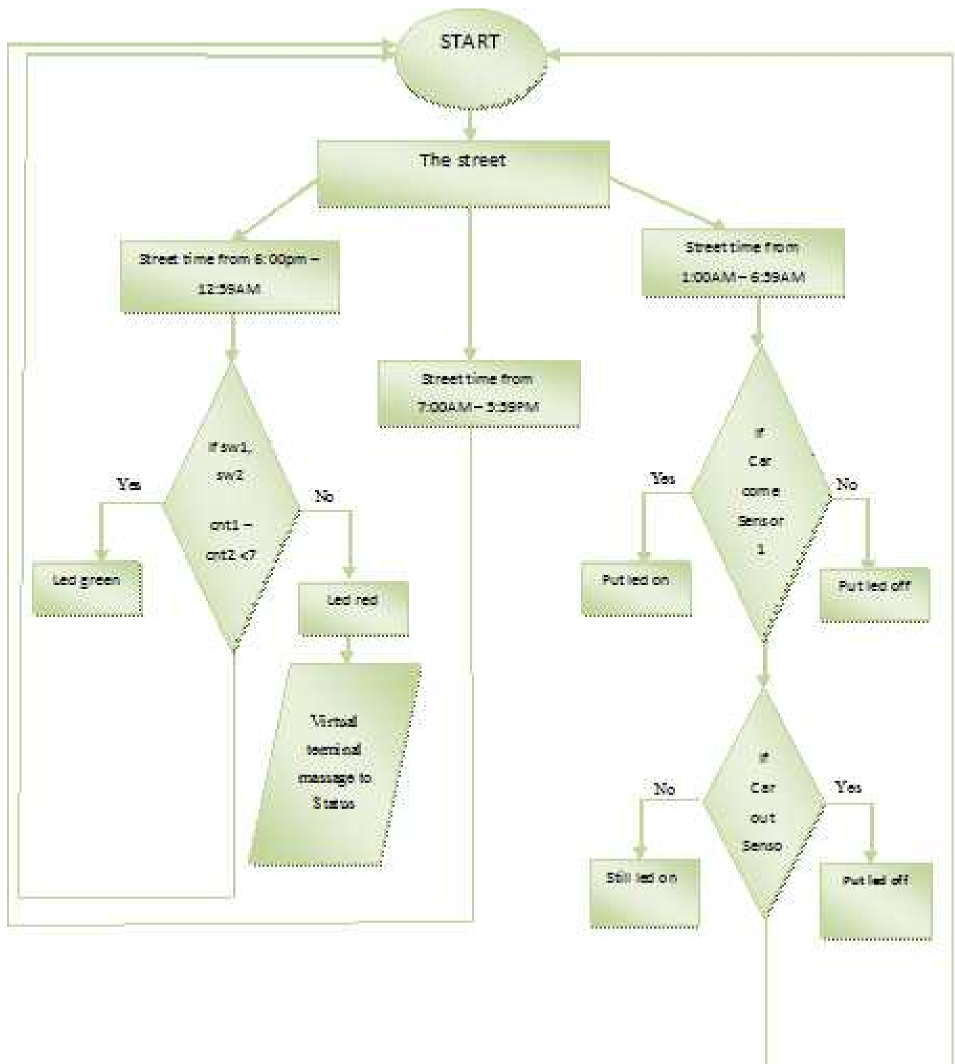

Figure 4.1: The flow chart

4.3 Operation of System

There are three cases in this system:

4.3.1 Case one (sleep case)

From 1:00AM to 6:59AM at this time the road is not busy or barely empty of vehicle. In this case it lights the way to be static and not working as shown in Figure 4.2.

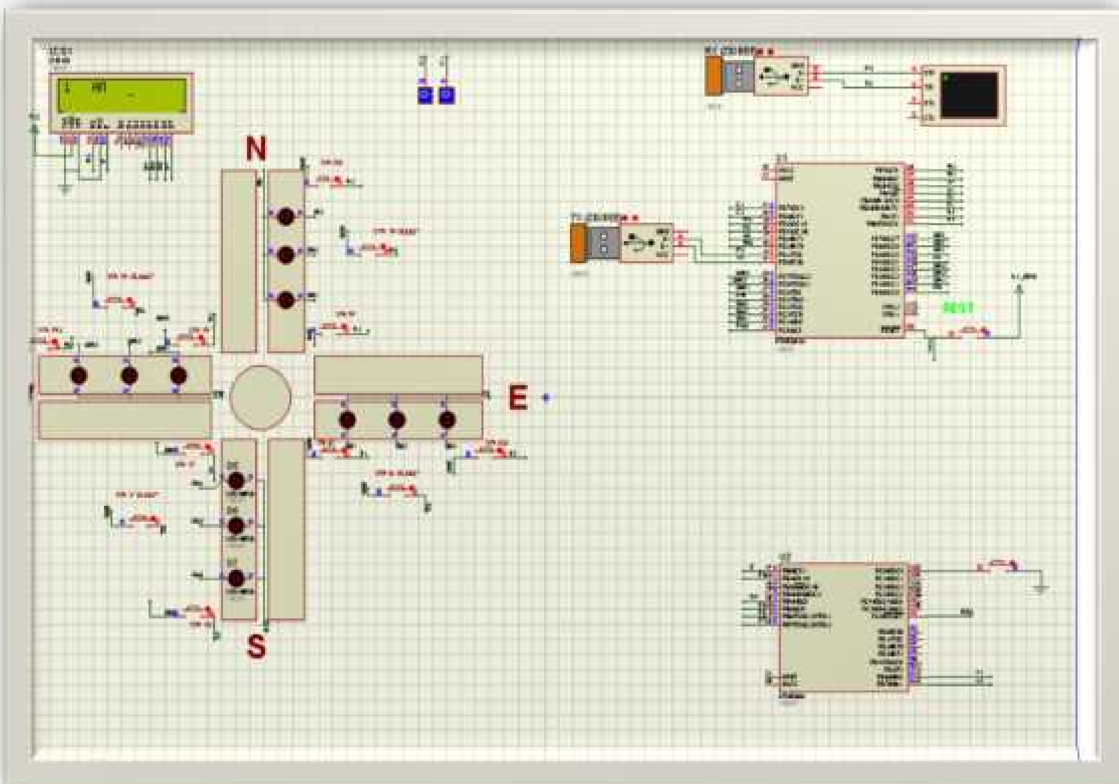

Figure 4.2: LED off (sleep case)

If we use the road in case S the IR sensor (SW: S1) sense inter the vehicle to the road and sends signal to the MCU of the transmission unit .The MCU send this signal to the receiving unit through the zigbee module. Start lighting in the work gradually, the purpose of the road lighting is to gradually reduce the energy used in lighting and preserved used when needed. This situation applies to the rest of the streets N, W and E as shown in Figure 4.3.

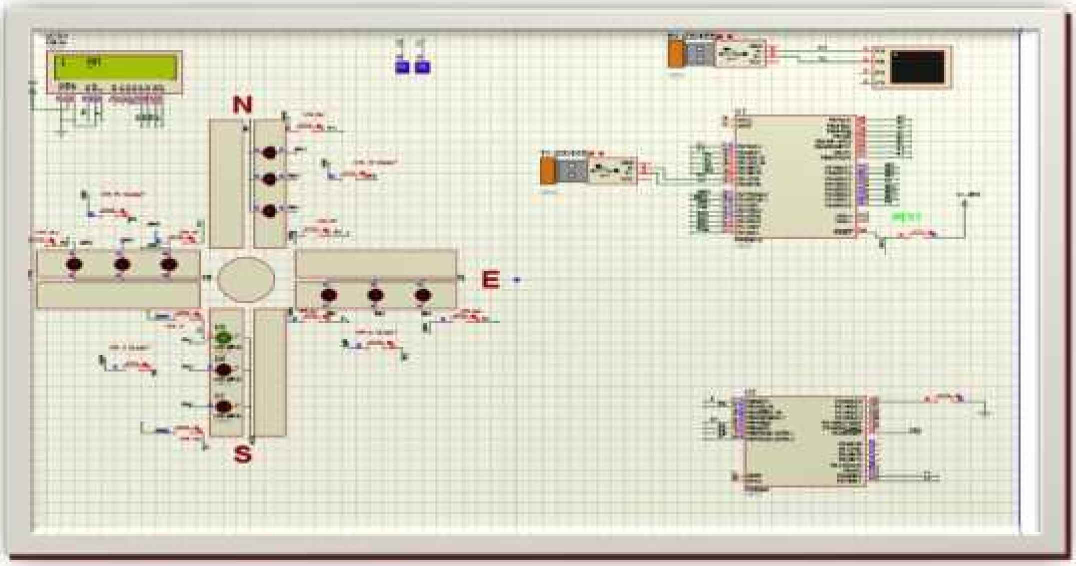

Figure 4.3: LED ON gradually 1

When IR sensor (SW: S) sense the vehicle, then the LED (GN2) lighting as shown in Figure 4.4.

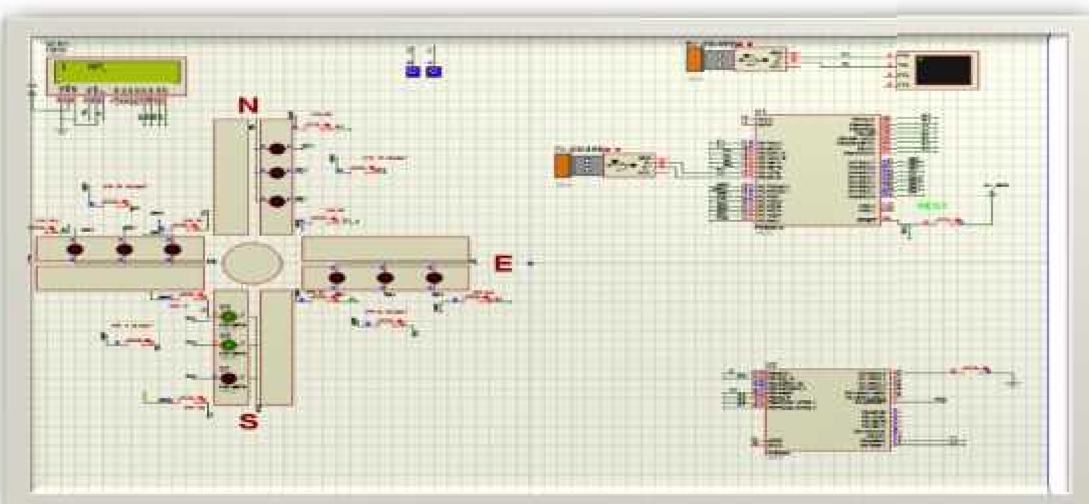

Figure 4.4: LED ON gradually 2

When sensor (SW: S2) sense the vehicle then the LED (GN3) lighting and after moment the all lighting in this road stop the working as shown in Figure 4.5.

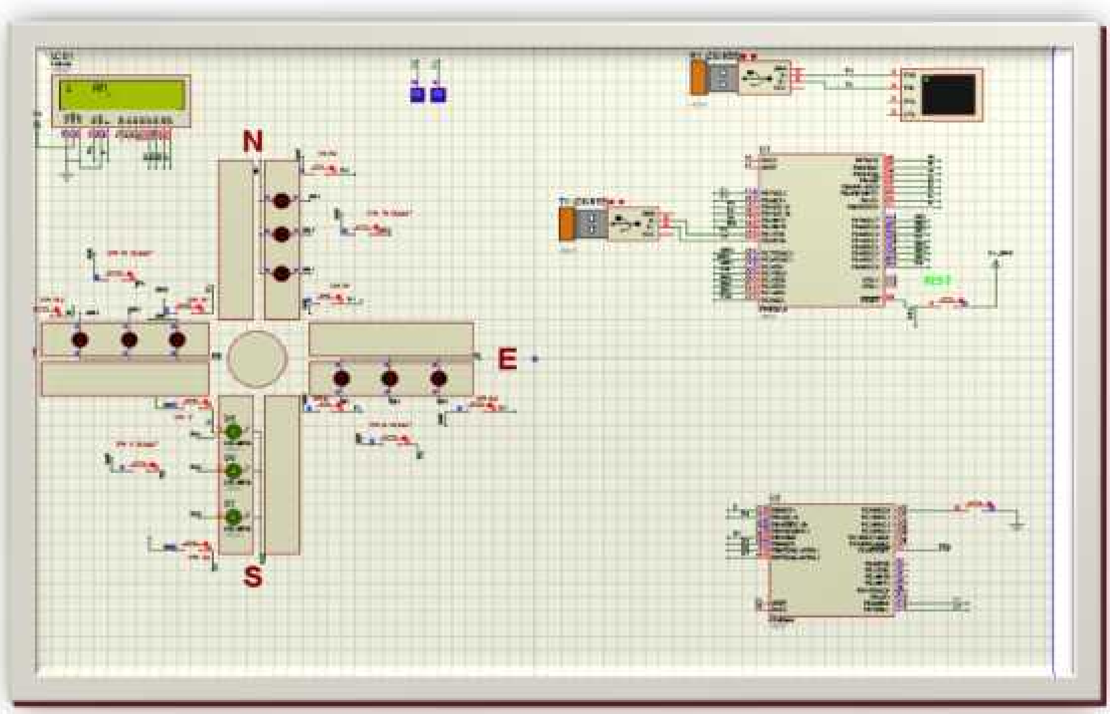

Figure 4.5: LED ON gradually 3

4.3.2 Case two (stop case)

From 7:00AM to 5:59PM, in this case the system is not active and as shown in Figure 4.6.

4.3.3 Case three (normal case)

In time of 6:00PM to 12:59AM in this case if the road is not crowded which means that the number of cars less than seven cars, LED the way lighting is green as shown in Figure 4.7.

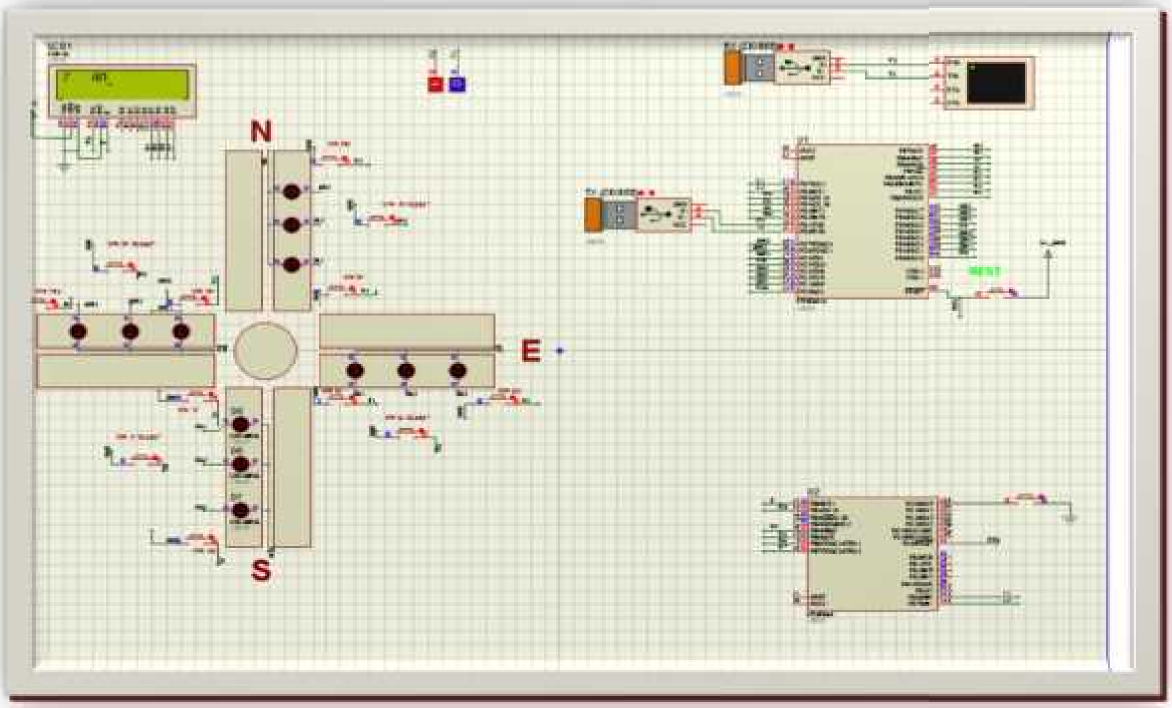

Figure 4.6: System off (stop case)

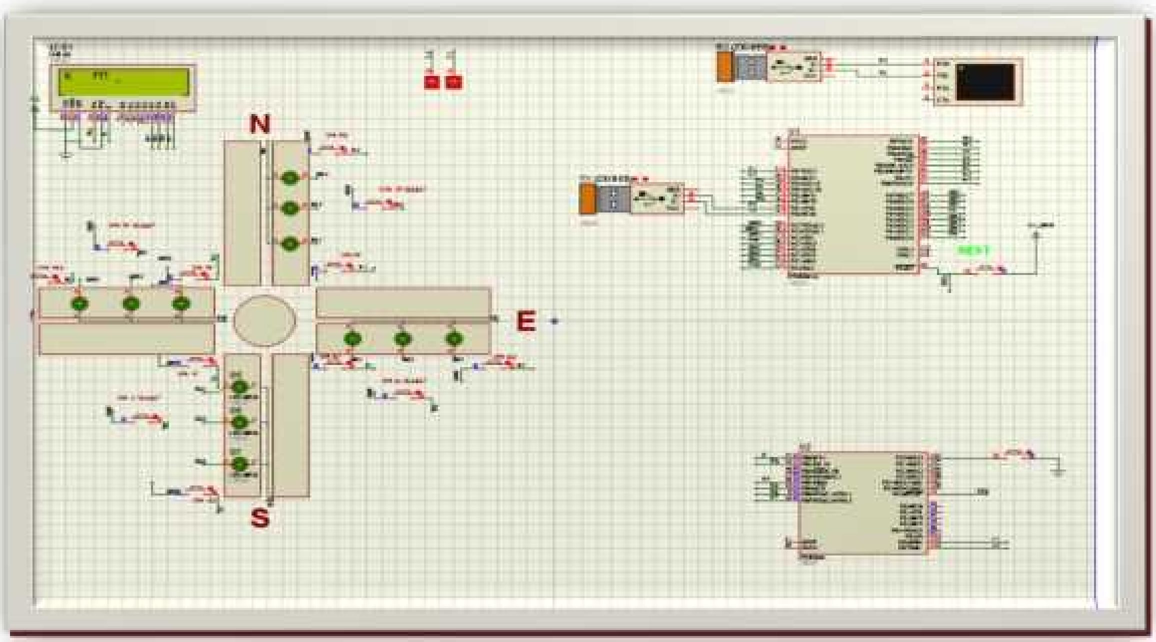

Figure 4.7: normal case

When the sensors (SW: S1, SW:N1, SW:E1, SW:E1) sense inter the cars in roads, are sends massage to the MCU of the transmission unit. The MCU send this massage to the receiving unit through the zigbee module. Then the virtual terminal displays the number of the car in the street as shown in the Figure 4.8.

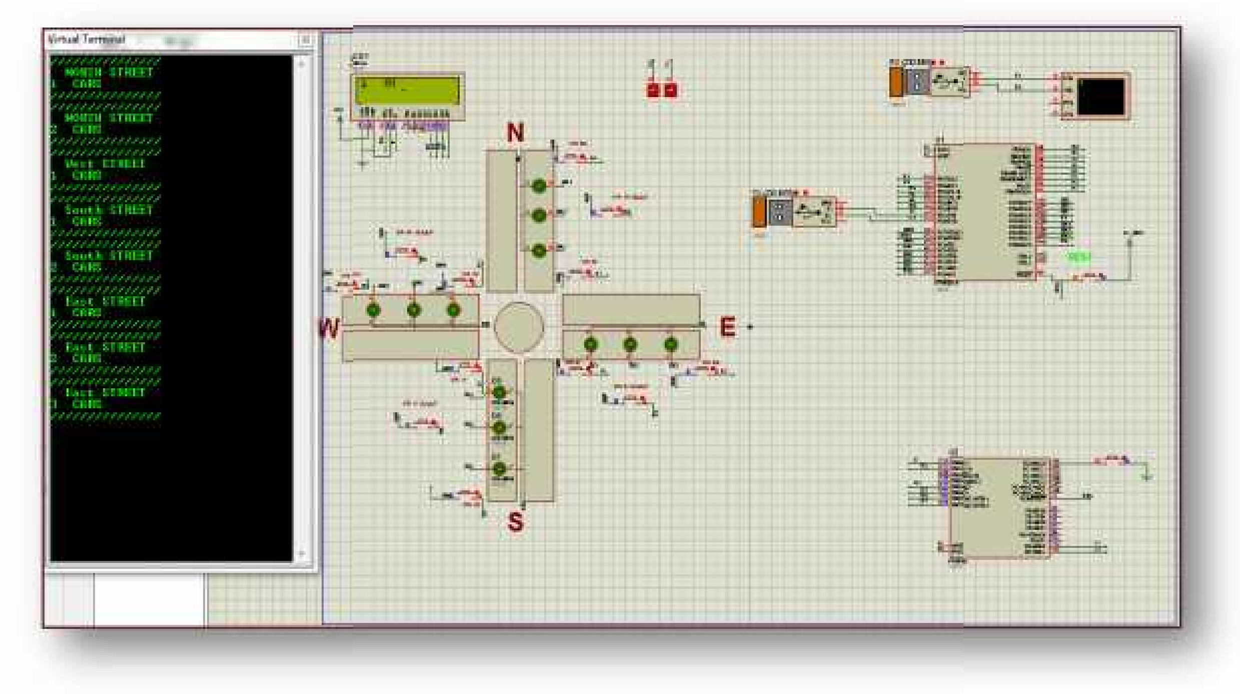

Figure 4.8: Normal case1

If we use the road in case N, the IR sensor senses seven cars or more in the road it sends signal to the MCU of the transmission unit. The MCU send this signal to the receiving unit through the zigbee module. Then change the LED lighting from green to red and send a report contains street status to MCU of the transmission unit and the MCU repeater sends the same report to control unit through zigbee receiver as shown in Figure 4.9.

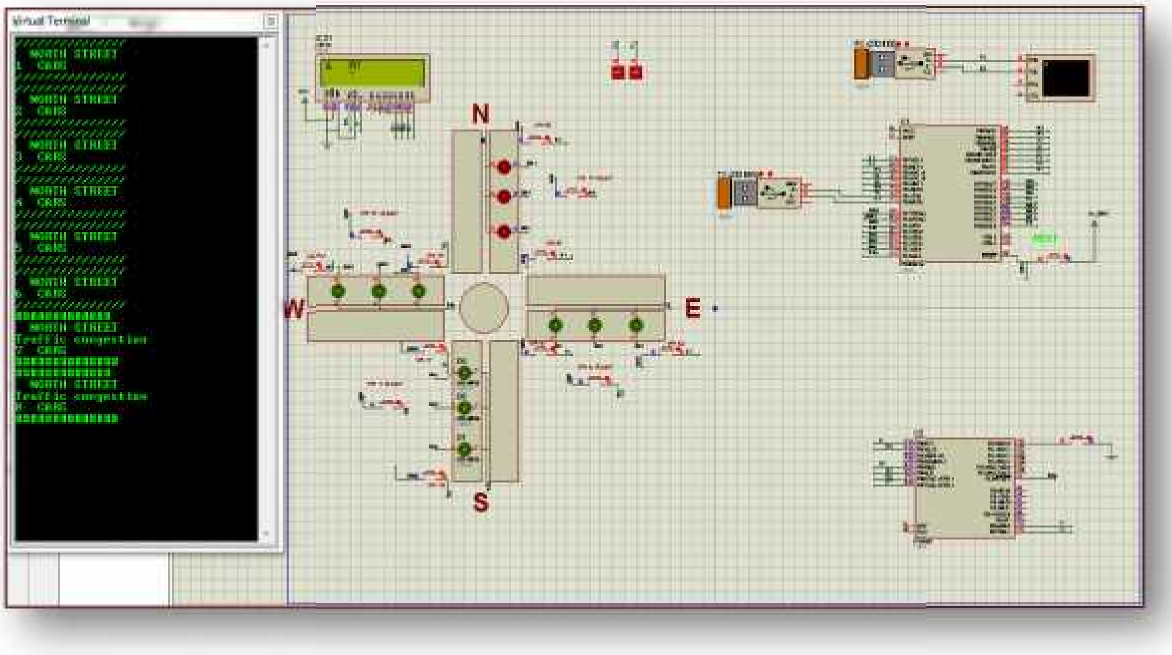

Figure 4.9: Crowded road (normal case)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Control of street lighting based on wireless sensor network and light emitting diode has been successfully designed and tested. Control of street lighting system is described that integrates new technologies, offering ease of energy savings and reduce the power consumption of the street lighting system about 20-35% compared to conventional design . This is obtained by using the highly economical LED technology supplied by renewable energy provided by the solar panels and by using the intelligent management of the lampposts. The proposed system is especially appropriate for street lighting in remote urban and rural areas where the traffic is low at times. Independence of the power network permits to implement it in remote areas where the classical systems are prohibitively expensive. The system is versatile, extendable and totally adjustable to user needs. Resolve the problem of crowded the road by controlling the RGB LED. This system is fully automated and is using ZIGBEE so that the control station can analyze all the performance of the system.

5.2 Recommendation and Future Work

The simulation result of this thesis opens some interesting and chanllenging problems of great importance. In what follows, we point out some of the possible future works.

1. Control the traffic signal lights depending on the amount of traffic in a particular direction, necessary controlling action could be taken also emergency vehicles and VIP convoys can be passed efficiently.

2. Attempts can be made to ensure that the complete system is self-sufficient on nonconventional energy resources like windmills, Piezo-electric crystals, etc.
3. Use of remote management system based mostly on intelligent lampposts that send info to a central management system, simplifying the management and maintenance.

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APPENDIX A

ATMEGA 16 DATA SHEET

Features

• High-performance, low-power Atmel® AVR® 8-bit microcontroller.

• Advanced RISC architecture.

– 131 powerful instructions – most single-clock cycle execution.

– 32 × 8 general purpose working registers.

– Fully static operation.

– Up to 16 MIPS throughput at 16 MHz.

– On-chip 2-cycle multiplier.

• High endurance non-volatile memory segments.

– 16 Kbytes of in-system self-programmable flash program memory.

– 512 Bytes EEPROM.

– 1 Kbyte internal SRAM.

– Write/Erase cycles: 10,000 flash/100,000 EEPROM.

– Data retention: 20 years at 85°C/100 years at 25°C (1).

– Optional boot code section with independent lock bits in-system. Programming by on-chip boot program true read-while-write operation.

– Programming locks for software security.

• JTAG (IEEE std. 1149.1 compliant) interface.

– Boundary-scan capabilities according to the JTAG standard.

– Extensive on-chip debugs support.

– Programming of flash, EEPROM, fuses, and locks bits through the JTAG interface.

• Peripheral features.

– Two 8-bit Timer/counters with separate prescalers and compare modes.

– One 16-bit timer/counter with separate prescaler, compare mode, and capture mode.

– Real time counters with separate oscillator.

– Four PWM channels.

– 8-channel, 10-bit ADC.

8 Single-ended channels.

7 Differential channels in TQFP package only.

2 Differential channels with programmable gain at 1x, 10 xs, or 200 xs.

– Byte-oriented two-wire serial interface.

– Programmable serial USART.

– Master/slave SPI serial interface.

– Programmable watchdog timer with separate on-chip oscillator.

– On-chip analog comparator.

• Special microcontroller features.

– Power-on reset and programmable brown-out detection.

– Internal calibrated RC oscillator.

– External and Internal interrupt sources.

– Six sleep modes: Idle, ADC noise reduction, power-save, power-down, standby and extended standby.

• I/O and packages.

– 32 programmable I/O lines.

– 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF

• Operating voltages.

– 2.7V - 5.5V for ATmega16L

– 4.5V - 5.5V for ATmega16

• Speed grades.

– 0 - 8 MHz for ATmega16L

– 0 - 16 MHz for ATmega16

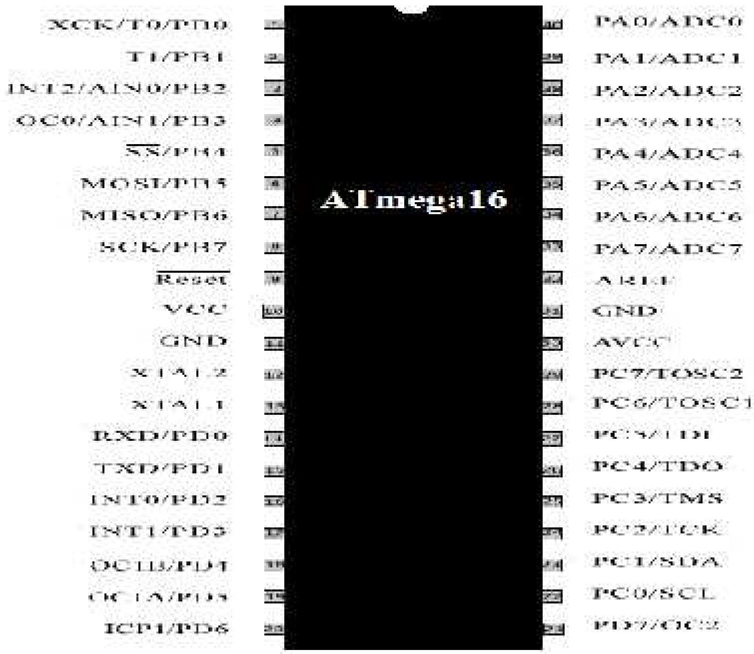
• Power consumption @ 1 MHz, 3V, and 25°C for ATmega16L

– Active: 1.1 mA

– Idle mode: 0.35 mA

– Power-down Mode: < 1 µA

Pin configurations



Pin descriptions

VCC: Digital supply voltage.

GND: Ground.

Port A (PA7..PA0): Port A serves as the analog inputs to the A/D converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The port a output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0): Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active,
Even if the clock is not running.

Port C (PC7..PC0) Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port C pins that are externally pulled low will source current if the pull-up resistors are activated. The port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs.

Port D (PD7..PD0): Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

RESET Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset.

XTAL1: Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

XTAL2: Output from the inverting oscillator amplifier.

AVCC: AVCC is the supply voltage pin for Port A and the A/D converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF:AREF is the analog reference pin for the A/D converter.

APPENDIX B

ATMEGA 8 DATA SHEET

Features

• High-performance, iow-Power Atmel®AVR® 8-bit microcontroller.

• Advanced RISC architecture.

– 130 powerful instructions – most single-clock cycle execution

– 32 × 8 general purpose working registers

– Fully static operation

– Up to 16MIPS throughput at 16MHz

– On-chip 2-cycle multiplier

• High endurance non-volatile memory segments

– 8Kbytes of in-system self-programmable flash program memory

– 512Bytes EEPROM

– 1Kbyte internal SRAM

– Write/erase cycles: 10,000 flash/100,000 EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C(1)

– Optional boot code section with independent lock bits in-system Programming by on-chip boot program true Read-While-Write operation

– Programming Lock for Software Security

• Peripheral features

– Two 8-bit timer/counters with separate prescaler, one compare mode

– One 16-bit timer/counter with separate prescaler, compare mode, and capture mode

– Real time counters with separate oscillator

– Three PWM channels

– 8-channel ADC in TQFP and QFN/MLF package eight channels 10-bit accuracy

– 6-channel ADC in PDIP package six channels 10-bit accuracy

– Byte-oriented two-wire serial interface

– Programmable serial USART

– Master/slave SPI serial interface

– Programmable watchdog timer with separate on-chip oscillator

– On-chip analog comparator

• Special microcontroller features

– Power-on reset and programmable brown-out detection

– Internal calibrated RC oscillator

– External and internal interrupt sources

– Five sleep modes: Idle, ADC noise reduction, power-save, power-down, and Standby

• I/O and packages

– 23 Programmable I/O lines

– 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF

• Operating voltages

– 2.7V - 5.5V (ATmega8L)

– 4.5V - 5.5V (ATmega8)

• Speed grades

– 0 - 8MHz (ATmega8L)

– 0 - 16MHz (ATmega8)

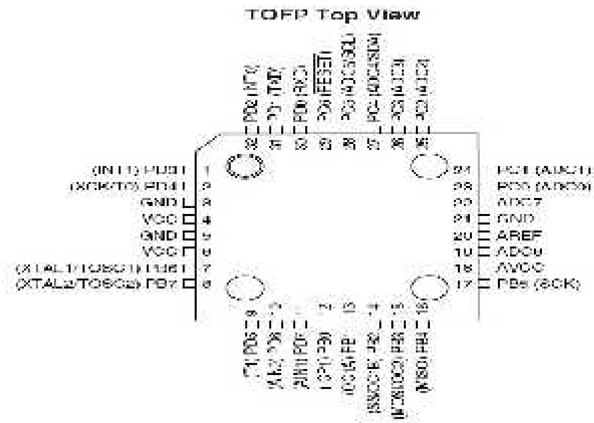
• Power Consumption at 4 MHz, 3V, 25□C

– Active: 3.6mA

– Idle Mode: 1.0mA

– Power-down mode: 0.5µA

Pin configurations



Pin descriptions

VCC: Digital supply voltage.

GND: Ground.

Port B (PB7..PB0) XTAL1/XTAL2/TOSC1/ TOSC2: Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port B pins that are externally pulled low will source current if the pull-up resistors are activated. The port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal calibrated RC oscillator is used as chip clock source, PB7..6 is used as TOSC2..1 input for the asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC5..PC0) Port C is an 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port C pins that are externally pulled low will source current if the pull-up resistors are activated. The port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET: If the RSTDISBL fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of port C. If the RSTDISBL fuse is unprogrammed, PC6 is used as a reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running.

Port D (PD7..PD0) : Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port D pins that are externally pulled low will source current if the pull-up resistors are activated. The port D pins are tri-stated when a reset condition becomes active, even if the clock is not running

RESET: A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running shorter pulses are not guaranteed to generate a reset.

APPENDIX C

```
$regfile = "m16def.dat"
$crystal = 1000000
$baud = 2400
'==============================
'==============================
Config Porta = Output
Config Portb = Input
Config Portd = Input
'Config Pind.6 = Input
Config Portc = Output
Config Debounce = 30
Portb = 255
Portd.5 = 1 : Portd.4 = 1 : Portd.3 = 1 : Portd.2 = 1
'==============================
Dim Swn1 As Byte : Swn1 = 0
Dim Swn2 As Byte : Swn2 = 0
Dim Swe1 As Byte : Swe1 = 0
Dim Swe2 As Byte : Swe2 = 0
Dim Sws1 As Byte : Sws1 = 0
Dim Sws2 As Byte : Sws2 = 0
Dim Sww1 As Byte : Sww1 = 0
Dim Sww2 As Byte : Sww2 = 0
Dim N As Integer
Dim S As Integer
Dim E As Integer
Dim W As Integer
Dim Ns As Integer
Dim Ss As Integer
Dim Es As Integer
Dim Ws As Integer
Dim Count As Double
Dim Y As Byte
Dim B As Byte
Dim H As Byte
Dim T As Byte
'==============================
Count = 0
Do
```

```
If Pind.7 = 0 Then                                'c1
  If Pind.6 = 0 Then                              '##### SLEEP #### c2
    Debounce Pinb.0 , 0 , Ns1 , Sub
    Debounce Pinb.1 , 0 , Ns2 , Sub
    Debounce Pinb.2 , 0 , Es1 , Sub
    Debounce Pinb.3 , 0 , Es2 , Sub
    Debounce Pinb.4 , 0 , Ss1 , Sub
    Debounce Pinb.5 , 0 , Ss2 , Sub
    Debounce Pinb.6 , 0 , Ws1 , Sub
    Debounce Pinb.7 , 0 , Ws2 , Sub
    Debounce Pind.5 , 0 , Ns3 , Sub
    Debounce Pind.4 , 0 , Es3 , Sub
    Debounce Pind.3 , 0 , Ss3 , Sub
    Debounce Pind.2 , 0 , Ws3 , Sub
    If Count > 0 Then
      Porta = 0
      Portc = 0
      Count = 0
      End If
      If Ns <= 0 Then
        Ns = 0
          Swn1 = 0
          Swn2 = 0
       End If
       If Es <= 0 Then
          Es = 0
          Swe1 = 0
          Swe2 = 0
        End If
        If Ss <= 0 Then
           Ss = 0
           Sws1 = 0
           Sws2 = 0
        End If
          If Ws <= 0 Then
           Ws = 0
           Sww1 = 0
           Sww2 = 0
          End If
  End If
  If Pind.6 = 1 Then                              'STOPE
```

```
        Porta = 0
        Portc = 0
        Count = 0
   End If
End If
If Pind.7 = 1 Then                                          '$$$$$  NORMAUL $$$$$
    If Pind.6 = 1 Then
      '/////////////////////////////////////////
        Incr Count
          If Count = 1 Then
          Porta = 238
          Portc = 238
          End If
       '/////////////////////////////////////////

'&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
&&&&&&&&&&&&&&&
         If N <= 0 Then
            N = 0
              Swn1 = 0
              Swn2 = 0
          End If

          If E <= 0 Then
              E = 0
              Swe1 = 0
              Swe2 = 0
           End If

           If S <= 0 Then
                S = 0
                Sws1 = 0
                Sws2 = 0
           End If

             If W <= 0 Then
                W = 0
                Sww1 = 0
                Sww2 = 0
             End If
```

```
'&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
&&&&&&&&&&&&&&&

   Debounce Pinb.0 , 0 , N1 , Sub
   Debounce Pinb.1 , 0 , N2 , Sub
   Debounce Pinb.2 , 0 , E1 , Sub
   Debounce Pinb.3 , 0 , E2 , Sub
   Debounce Pinb.4 , 0 , S1 , Sub
   Debounce Pinb.5 , 0 , S2 , Sub
   Debounce Pinb.6 , 0 , W1 , Sub
   Debounce Pinb.7 , 0 , W2 , Sub
   End If
End If
Loop
End                                          'end program
'===================================================
N1:
 Swn1 = Swn1 + 1
  N = Swn1 - Swn2
 If N => 7 Then                                   'RED LENE  NOURTH
  Porta.0 = 1
  Porta.1 = 0
  Porta.2 = 0
  Porta.3 = 0
  '******* ZIGBEE TX ********
    Print "#############"
   Print "  NORTH STREET"
   Print "Traffic congestion"
   Print N ;
   Print "  CARS"
   Print "##############"
  '*************************
  End If
  If N < 7 Then
   Print "//////////////"
   Print "  NORTH STREET"
   Print N ;
   Print "  CARS"
   Print "//////////////"
   End If
```

```
Return
'=======================================================
N2:
Swn2 = Swn2 + 1
 N = Swn1 - Swn2
 If N < 0 Then
    N = 0
    End If
 If N < 7 Then                                     'GREEN LENE NOURTH
 Porta.0 = 0
 Porta.1 = 1
 Porta.2 = 1
 Porta.3 = 1
    Print "///////////////"
    Print "  NORTH STREET"
    Print N ;
    Print "  CARS"
    Print "///////////////"
 End If
 If N => 7 Then
   Print "#############"
    Print "  NORTH STREET"
    Print "Traffic congestion"
    Print N ;
    Print "  CARS"
    Print "##############"
  End If
Return
'=======================================================
E1:
Swe1 = Swe1 + 1
E = Swe1 - Swe2
If E => 7 Then                                     'RED LENE EAST
   Porta.4 = 1
   Porta.5 = 0
   Porta.6 = 0
   Porta.7 = 0
   '******* ZIGBEE TX ********
     Print "#############"
    Print "  East STREET"
    Print "Traffic congestion"
```

```
   Print E ;
   Print "  CARS"
   Print "##############"
  '***************************
  End If
  If E < 7 Then
   Print "///////////////"
   Print "  East STREET"
   Print E ;
   Print "  CARS"
   Print "///////////////"
   End If
Return
'==============================================================
E2:
Swe2 = Swe2 + 1
E = Swe1 - Swe2
 If E < 0 Then
   E = 0
   End If
If E < 7 Then                                        'GREEN LENE EAST
  Porta.4 = 0
  Porta.5 = 1
  Porta.6 = 1
  Porta.7 = 1

    Print "///////////////"
   Print "  East STREET"
   Print E ;
   Print "  CARS"
   Print "///////////////"
 End If
 If E => 7 Then
   Print "#############"
   Print "  East STREET"
   Print "Traffic congestion"
   Print E ;
   Print "  CARS"
   Print "##############"
 End If
Return
```

```
'==================================================
S1:
Sws1 = Sws1 + 1
S = Sws1 - Sws2
If S => 7 Then                                'RED LENE S
   Portc.0 = 1
   Portc.1 = 0
   Portc.2 = 0
   Portc.3 = 0
   '******* ZIGBEE TX ********
     Print "#############"
     Print "  South STREET"
     Print "Traffic congestion"
     Print S ;
     Print "  CARS"
     Print "##############"
 End If
   If S < 7 Then
    Print "///////////////"
    Print "  South STREET"
    Print S ;
    Print "  CARS"
    Print "///////////////"
    End If
Return
'==================================================
S2:
Sws2 = Sws2 + 1
S = Sws1 - Sws2
If S < 0 Then
    S = 0
End If
If S < 7 Then                                 'GREEN LENE S
   Portc.0 = 0
   Portc.1 = 1
   Portc.2 = 1
   Portc.3 = 1
    Print "///////////////"
    Print "  South STREET"
    Print S ;
    Print "  CARS"
```

```
    Print "///////////////"
 End If
 If S => 7 Then
    '******* ZIGBEE TX ********
     Print "#############"
     Print "  South STREET"
     Print "Traffic congestion"
     Print S ;
     Print "  CARS"
     Print "##############"
 End If
Return
'==================================================
W1:
Sww1 = Sww1 + 1
W = Sww1 - Sww2
If W => 7 Then                                    'RED LENE W
   Portc.4 = 1
   Portc.5 = 0
   Portc.6 = 0
   Portc.7 = 0
   '******* ZIGBEE TX ********
     Print "#############"
     Print "  West STREET"
     Print "Traffic congestion"
     Print W ;
     Print "  CARS"
     Print "##############"
 End If
   If W < 7 Then
    Print "///////////////"
    Print "  West STREET"
    Print W ;
    Print "  CARS"
    Print "///////////////"
    End If
Return
'==================================================
W2:
Sww2 = Sww2 + 1
W = Sww1 - Sww2
```

```
If W < 0 Then
    W = 0
    End If
If W < 7 Then                                        'GREEN LENE W
   Portc.4 = 0
   Portc.5 = 1
   Portc.6 = 1
   Portc.7 = 1
    Print "///////////////"
    Print "  West STREET"
    Print W ;
    Print "  CARS"
    Print "///////////////"
 End If

   If W => 7 Then
     Print "#############"
     Print "  West STREET"
     Print "Traffic congestion"
     Print W ;
     Print "  CARS"
     Print "##############"
   End If
Return
'==================================================          sleep
sw
Ns1:
Swn1 = Swn1 + 1
Ns = Swn1 - Swn2
 If Ns = 1 Then
  Porta.0 = 0
  Porta.1 = 1
 End If
Return
'==================================================
Ns2:
 Swn2 = Swn2 + 1
 Ns = Swn1 - Swn2
 If Ns => 1 Then
  If Y => 1 Then
    Porta.3 = 1
```

```
    Y = 0
  End If
 End If
If Ns = 0 Then
   Porta.3 = 1
   Waitms 500
   Porta.0 = 0
   Porta.1 = 0
   Porta.2 = 0
   Porta.3 = 0
End If
Return
'=================================================
Ns3:
If Ns => 1 Then
Porta.0 = 0
Porta.2 = 1
Incr Y
End If
Return
'=================================================
Es1:
Swe1 = Swe1 + 1
Es = Swe1 - Swe2
 If Es = 1 Then
   Porta.4 = 0
   Porta.5 = 1
 End If
Return
'=================================================

Es2:
 Swe2 = Swe2 + 1
 Es = Swe1 - Swe2
If Es => 1 Then
  If H => 1 Then
    Porta.7 = 1
    H = 0
  End If
 End If
If Es = 0 Then
```

```
   Porta.7 = 1
   Waitms 500
   Porta.4 = 0
   Porta.5 = 0
   Porta.6 = 0
   Porta.7 = 0
End If
Return
'===================================================
Es3:
If Es => 1 Then
Porta.4 = 0
Porta.6 = 1
Incr H
End If
Return
'===================================================

Ss1:
Sws1 = Sws1 + 1
Ss = Sws1 - Sws2
  If Ss = 1 Then
   Portc.0 = 0
   Portc.1 = 1
 End If
Return
'===================================================
Ss2:
 Sws2 = Sws2 + 1
 Ss = Sws1 - Sws2
If Es => 1 Then
  If B => 1 Then
    Porta.7 = 1
    B = 0
  End If
 End If
If Es = 0 Then
   Portc.3 = 1
   Waitms 500
   Portc.0 = 0
   Portc.1 = 0
```

```
  Portc.2 = 0
  Portc.3 = 0
End If


Return
'=====================================================
Ss3:
If Ss => 1 Then
Portc.0 = 0
Portc.2 = 1
Incr B
End If
Return
'=====================================================
Ws1:
Sww1 = Sww1 + 1
Ws = Sww1 - Sww2
 If Ws = 1 Then
  Portc.4 = 0
  Portc.5 = 1
 End If
Return
'=====================================================
Ws2:
Sww2 = Sww2 + 1
 Ws = Sww1 - Sww2
If Ws => 1 Then
 If T => 1 Then
  Portc.7 = 1
  T = 0
 End If
 End If

If Ws = 0 Then
  Portc.7 = 1
  Waitms 500
  Portc.4 = 0
  Portc.5 = 0
  Portc.6 = 0
  Portc.7 = 0
```

```
End If
Return
'=============================================
Ws3:
If Ws => 1 Then
Portc.4 = 0
Portc.6 = 1
Incr T
End If
Return
```

APPENDIX D

```
$regfile = "m8def.dat"
$crystal = 1000000
Config Lcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 , Db7 =
Portb.7 , E = Portb.0 , Rs = Portb.1
Config Lcd = 16 * 2
Config Portb = Output
Config Pinc.0 = Input
Config Portd = Output
Portc.0 = 1
Dim Count As Byte
Dim Count_1 As Byte
Dim A As Byte
Dim Am As String * 3
Dim Pm As String * 3
Count = 1
Cls
A = 1
Locate 1 , 1
Lcd A
' Lcd ":00:00"
'Locate 1 , 3 :
Am = "AM"
Pm = "PM"
Count = 1
'A = 7
Do
If Count = 2 Then
'Cls
      Locate 1 , 5
    Lcd Pm ; "   "
       If A <= 5 Then
       Portd.6 = 0
       Portd.7 = 1
       End If
       If A >= 6 Then
       'Portd.5 = 1
       Portd.6 = 1
```

```
        Portd.7 = 1
       ' Waitms 100
       ' Portd.5 = 0
        End If
     'Count = 0
    End If
   If Count = 1 Then
   'Cls
     Locate 1 , 5
     Lcd Am ; "   "
     If A <= 6 Then
      Portd.6 = 0
      Portd.7 = 0
      End If
      If A >= 7 Then
      Portd.6 = 0
      Portd.7 = 1
      End If
     End If
 If Pinc.0 = 0 Then
  Cls
  Incr A
  Locate 1 , 1                                       ': Lcd ":00:00"
   Lcd A
  'Incr Count
   Waitms 200
  ' Gosub H
   If A = 12 Then
    'Cls
     A = 0
     Count = Count + 1
     If Count = 3 Then
     Count = 1
     End If
    End If
    End If
 Loop
 End                                               'end program
```