THE DESIGN AND IMPLEMENTATION OF AN AUTOMATED ENERGY SAVING BI-DIRECTIONAL VISITOR COUNTER

By

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING FACULTY OF ENGINEERING FEDERAL UNIVERSITY, OYE-EKITI, EKITI STATE.

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Being in partial fulfillment of the award of the Bachelor of Engineering (B.ENG) degree

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DEDICATION

This piece is first and foremost set apart to honouring God whose unceasing works here on earth has been effecting positive changes to our 'engineering world' at large. In this report, there are several of these positive changes (in terms of technological advancement) thereby attesting to the existence of an immortal God, because '*every good and perfect gift is from above, coming down from the Father of lights with whom there is no variation*........(Jas. 1:17)'.

Furthermore, I dedicate this report to Nigerians that are electronic hobbyist right from their childhood days.

DECLARATION OF ORIGINALITY

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CERTIFICATION

This is to certify that this project titled **An Automated Energy Saving Bi-Directional Visitor Counter,** by JOHN SAMUEL OLUWADAMILARE meets the minimum requirements governing the award of Bachelor Degree in Electrical and Electronics Engineering of Federal University Oye-Ekiti, Nigeria.

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ABSTRACT

This project, An Automated Energy Saving Bi-Directional Visitor Counter is a reliable circuit that automatically performs the task of controlling the lighting points of a room as well as counting the number of persons in the room very accurately. Its bi-directional feature means it can read both the incoming and outgoing traffic of persons.

The system consists of two parts. First is Visitor Counter and second is Automatic Room Light Controller (this gave rise to the energy saving name found in the project title). The Visitor Counter counts the visitors to a lecture theater, hall, offices, malls, etc and then displays the count on a cascade of four seven-segment displays. The Automatic Room Light Controller switches the lighting points in a room on/off based on the number of count provided by the first part mentioned above.

At the heart of this system is an AT89S51 microcontroller programmed to give the necessary control commands.

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ACKNOWLEGDEMENTS

To start with, I recognise the works of God's eternal love in me (which is made manifest in my passion for electronic circuits).

Secondly, the mild support that comes from my family (consisting of Mrs. Modupe John-mother, John Paul -brother and John Mary-sister) over the years in building my career in the world of electronic circuits is worthy to be mentioned.

In addition, kudos to the Federal Government of Nigeria (through the pact formed by two of its establishments which are; Nigerian Universities Commission and Federal University Oye-Ekiti) for giving me a career development boost by equipping me with the theoretical knowledge of electronic circuits and also by giving me the opportunity to practically demonstrate the knowledge acquired insofar in my course of study.

Lastly, my sincere appreciation goes to the loving team of lecturers in the department of Electrical/Electronics Engineering at Federal University Oye-Ekiti for their selfless service in impacting theoretical and practical knowledge (on electronic circuits) into me. They include: Engr. H.U. Ezea (Project Supervisor), Engr. G.K Ijemaru (Departmental Project Co-ordinator), Engr. (Dr.) J. Oricha (H.O.D) and all other member of staff in my department.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF PROJECT

Electricity is one of the most important resources, which plays a part and parcel of everyday life. With the growing human population, there is a much increase in the consumption of electrical energy. Thus, it is essential to conserve electricity. In general, electricity is wasted due to negligence of people to turn off lights, fans, air conditioner and other electrical devices when they leave the room. Automation system is a technology developed to meet the necessity for conserving electricity. It reduces the manual effort to control and operate on any equipment. The benefit of introducing an automation system is to save energy, labour and materials for improving quality, accuracy and precision. In general, humans are more prone to errors. However, an automated system can work with diligence, versatility and almost with zero error, thus are preferred over manual systems.

In the recent past, various automated systems have been employed to conserve electricity in working environments. Among them, conference hall automation system is used to control and integrate all electrical equipments inside the hall. Several conference hall automation systems have been developed based on various technologies which include RFID, Bluetooth, Wi-Fi, Zigbee and GSM (K. Gill, 2009).

The system designed in this paper is the visitor counter that is bidirectional in nature in that it can read both the incoming and outgoing traffic of persons.

In this system, up to 9999 incoming or outgoing visitors can be counted with the aid of an Atmel AT89S51 microcontroller having the below control operations stored in its ROM:

- The first filament bulb is switched ON at the entry of the first person.
- The second filament bulb is switched ON at the entry of the third person.
- The third filament bulb is switched ON at the entry of the seventh person.

NOTE: the above automatic operations effectively save electrical power by allowing power to be utilised ONLY when needed thereby preventing wastage which incurs a high cost in payment for power consumption.

- When the counter is decremented, the reverse of the aforementioned operations is implemented until no one is present in the room and all AC light bulbs go OFF.

1.2 STATEMENT OF THE PROBLEM

This design intends to effectively replace some manual operations (obtainable in a room) such as counting of room occupants, switching on/off of AC light bulbs. This project work intends to achieve the aforementioned purpose because of electrical power wastage inherent in the negligence of humans in turning off their lighting points when not in use.

1.3 MOTIVATION

The need for the automation of some daily mechanical activities (such as switching a room's lighting point on or off, etc) and efficient electrical power utilisation (called energy-saving in a simple term) gave rise to this project work.

1.4 SIGNIFICANCE OF THE STUDY

Automation plays a major role in the entire consumer needs of day to day life and energy saving is at the heart of technological advancement in our world today. To this effect, this project was developed in order to achieve the automation of a room's lighting point and to also conserve electrical power.

1.5 PROJECT AIM AND OBJECTIVES

The aim of this project is to design an Automated Energy Saving Bi-Directional Visitor Counter.

This system is designed to count and display the total number of people entering and leaving a room and in turn it switches the room's lighting points ON/OFF.

The objectives include:

i. To design a system that presents an on-the-spot number of persons present in a room.
ii. To design a system that saves electrical power effectively thus reducing cost incurred in power consumption.

1.6 SCOPE OF THE PROJECT

This project is mainly concerned with the design of a counter that will count visitors that enter or leave a particular room where it is installed. It helps in eradicating the use of human effort in counting the number of people in a room, switching AC light bulbs on/off. However, there are a few limitations of this design, they include:

i. The simultaneous entry/exit of two or more people is detected as just one obstruction of IR rays used for sensing the entry/exit of humans.
ii. This system cannot distinguish between a human and other obstacles (such as animals) interfering the sensor's emitted IR rays.
iii. Also this is a short range system since it cannot sense a far object owing to the short detection range limitation imposed by the IR sensors used.

CHAPTER TWO

2.0 LITERATURE REVIEW

Implementation of Automatic Room Light Controller with Visitor Counter Design is the visitor counter that is bidirectional in feature which can read both the incoming and outgoing traffic and agents at same time securely. In this system, up to 999 incoming or outgoing visitors can be counted using a microcontroller. Microcontroller is used here to make a secure count over a large number of visitors. The audacity of this project will not only give account of the person entering the room but will also light up the room according to the number of persons that entered. This system is basically required in many places where count for the visitors is needed by the administrator of that system (Shilpa, 2017). This cited project was implemented using homemade IR sensors, three single digit seven segment displays. My work takes after this cited project with some modifications such as: using four single digit seven segment displays for an increase in count capacity to be achieved, usage of industry-made IR sensors.

Automated Room Light Controller with Visitor Counter is a reliable circuit that takes over the task of controlling the room lights as well us counting the number of persons / visitors in the room very accurately. When somebody enters into the room then the counter is incremented by one and the light in the room will be switched ON and when any one leaves the room then the counter is decremented by one. The light will be only switched OFF until all the persons in the room go out. The total number of persons inside the room is also displayed on the seven segment displays. The microcontroller does the above job. It receives the signals from the sensors, and this signal is operated under the control of software which is stored in ROM. Microcontroller AT89S52 continuously monitor the Infrared Receivers. When any object pass through the IR Receiver's line of rays, the IR Rays falling on the receivers are obstructed. This obstruction is sensed by the Microcontroller. The work cited here designed the system using two DIY IR sensors, an 8052 microcontroller unit and two single seven segment displays (Sarath Pradeep, 2011) (Waradkar). In my work, I increased the seven segment display to four thereby increasing the count capacity and also industry-made IR sensors were used.

Bidirectional Visitor Counter with Automatic Room Light Controller with Arduino as master controller is a system to count the visitors of an auditorium, hall, offices, malls, sports venue, etc. The system counts both the entering and exiting visitor of the auditorium or hall or other place, where it is placed. Depending upon the sensors interruption, the system identifies the entry and exit of the visitor. On the successful implementation of the system, it displays the number of visitor present in the auditorium or hall. This is an economical cost reducing system when implemented in places where the visitors have to be counted and controlled. Counting the visitors can be time consuming so it helps to maximize the efficiency and effectiveness of employees, time saving and sales potential of an organization, etc. The cited work was implemented using an Arduino kit and LCD (Chattoraj, 2016), (Archana D, 2018). I used an 8051 microcontoller that is very much smaller than an Arduino Development Board and also I used segment displays in place of LCD which has small display outputs.

Automatic Room Light and Fan Controller with Bi-directional Visitor Counter has an automatic light and fan control for room to achieve these two objectives, which are, the design of a system wherein the number of persons entering or leaving a room is kept track of and displayed on a LCD and to turn on and turn off light and fan according to human presence in room with respect to light intensity & room temperature (Nikose, 2018), (R.R.Yuganandhine, 2017). I used segment displays in place of LCD which has small display outputs.

An author modeled and designed an automatic sliding door with a room light control system. This system works on the principle of breaking an infrared beam of light, sensed by a photodiode. It consists of two transmitting infrared diodes and two receiving photodiodes. The first one is for someone coming in and the second one is for someone going out of the room. The photodiodes are connected to comparators, which give a lower output when the beam is broken and high output when transmitting normally. The general operation of the work and performance is dependent on the presence of an intruder entering through the door and how close he/she is in closer to the door. The door is meant to open automatically but in a case where there is no power supply trying to force the door open would damage the mechanical control system of the unit (Adamu Murtala Zungeru). In place of the two segment displays used by the cited authors, I used four segment displays to increase the count capacity.

Arduino based Smart Light Control System is an advanced light control system that is capable of replacing the old generation light control system. The system is implemented on an embedded platform & is equipped with a photo sensitive detector (LDR) which gives the required input for operation. The working of our light control system is based on the amount of luminous energy in the environment at that moment of time. Depending upon the light intensity at that instant the lighting of the lighting system is adjusted. The embedded main board including the Microcontroller chip, memory (flash), and communication port are used as a processing module for the input that we get from peripheral devices (LDR) (Rath, 2016). The cited work was implemented using an Arduino Development Board which is quite costly. I used an 8051 microcontoller that is very much cheap than an Arduino Development Board.

Automatic Classroom Lighting Controller and Energy Saved based on a Microcontroller unit is a project based on the Campus Card System and automatic gadget control system respectively, which is mature and has been widely used, in combination with Ethernet, RF wireless communications technology, as well as the development of campus card to achieve a complete classroom energy saving system. System controls the master classroom power on and off by detecting the presence of the card, and effectively solve this problem. This system is characterized by simple-use and low-cost renovation (Jabeen, 2016), (AyyubKhan, 2018) .This cited work does not have a visitor counter unlike mine that merges both visitor counters and gadget controller together.

Some authors presented an Automatic Room Light Controller with Visitor Counter and GSM Messaging and room appliances controller based on Wi-Fi respectively. It automatically counts the number of persons that enter or exit the room and depend on counter value it automatically turns on or off the lights of room. To show the Count value, they use the 7-Segment display and the GSM is used to transmit the count value on allowed mobile number as a message "count=___" (Ghotre, 2018), (Adetiba, 2011), (Nangare, 2014). The striking difference between the cited work and mine is in the cost, the incorporation of a GSM and Wi-Fi module is cost effective.

An author presented a Congestion Control Bi-directional Digital visitor counter which is a consistent circuit mainly designed to monitor the room appliances as well as count number of people entering in the arena very accurately and also avoids congestions in the different areas of usage. When a person enters into the arena, a counter is maintained for presenting the number of people and is updated by one and the appliances in the arena will be turned ON and when a person leaves the arena, counter is maintained for presenting the number of people and is decreased by one. The appliances will be turned OFF when all the persons in the arena go out. The overall count of people inside the arena will be presented on Liquid crystal display. When a particle passed through the Infrared Receiver's rays then the Infrared Rays falling on the receivers are obstructed. This obstruction is sensed by the Ardunio Microcontroller. It also can manage fans based on relay provided, if the room reaches the maximum capacity, then, by using wifi module, message is sent to authorities to limit the person entering the room. Thereby congestion is avoided (S.LAKSHMI, 2016). The cited work here used cost-effective modules like Wi-FI and Arduino boards unlike my cheap work.

An author presented the design and construction of a digital bidirectional visitor counter (DBVC). The DBVC is a reliable circuit that takes over the task of counting number of persons / visitors in the room very accurately and beeps a warning alarm when the number of visitors exceeds the capacity limit of the auditorium/hall. When somebody enters the room then the counter is incremented by one (+1) and when any one leaves the room then the counter is decremented by one (-1). The total number of persons inside the room is also displayed on the LCD (Liquid Crystal Display). The microcontroller is used for detecting an entry or exit action and computing the figures (addition and subtraction) to acquire accurate results. It receives the signals from the sensors, and this signal is operated under the control of embedded programming code which is stored in ROM of the microcontroller. The microcontroller continuously monitors the Infrared Receivers. When any object pass through the IR Receiver's line of rays, and then the IR Rays falling on the receivers are obstructed. The obstruction occurs under two circumstances, either you obstruct sensor 1 (i.e. outside the building) before sensor 2 (i.e. which is inside the building) this shows that you are entering the building or you do it the other way round, which is obstructing sensor 2 before sensor 1 to indicates an exit movement. This obstruction is sensed by the Microcontroller, computed and displayed on a 16x2 LCD screen (Adjardjah, 2016). Instead of the homemade sensors used in the cited work, I used industry-made sensors.

An author presents the design of an occupancy detector circuit that automatically switch ON and OFF the light in a room based on room occupancy and display the number of persons in a room on LCD, design of Light dependent Resistor (LDR) based circuit that controls the light in a room depending upon the lighting condition (intensity of ambient light), design of Temperature indicator, design of smoke detector and design of capturing an image using webcam/canon camera (Bhushan, 2009). In place of LCD used in the cited report, I used seven segment displays for better display outputs.

A paper presents the design and development of PIC16F877A microcontroller based intelligent conference hall automation system, which is useful to control and integrate all electrical devices in a room automatically. The proposed system consists of an Infra-Red sensor, which acts as a bidirectional person counter to count the number of people inside the conference hall. Based on this count, the microcontroller automatically controls the electrical devices inside the hall. The system also provides a user interactive menu to set the required count value to turn on the devices, to meet the needs of the user (Hariprasath, 2016). The work cited here controls quite a number of appliances thus increasing the system's complexity and cost, whereas, my work controls few appliances making it considerably inexpensive in comparison to the cited work's cost.

Another paper contains the development of an ARM based controller or ARM 7 TDMI microcontroller i.e. LPC 2148 micro controller with automatic functioning of home appliances using IR sensors. This paper reports on a system which will save electricity, over and over whenever we have left the room and hall without switching/turn off lights and fans or any electrical appliance, therefore electricity is wasted. In this work we've developed a system during which energy are saved based on range of individuals coming in or going out of the area. If there's nobody within the area or in that particular room, then automatically the lights and fans are switched OFF. On the opposite hand, as a person enters the room, lights used in that room and fan are switched ON. On the idea of the intensity of daylight we will turn off lights in day time (Renuka, 2017). I substituted an 8051 microcontroller for the large ARM microcontroller used in the cited work.

In a paper, a system was designed to analyse the power usage in a Gathering Hall/Auditorium by deploying a visitor counter and automatic fan control system (Bagali, 2016). The system cited is expensive, whereas, my less expensive system achieves the basic purposes intended to be achieved by the cited work.

One paper has in it the design of a system in which every room will be monitored by a single CPLD that will keep the record of the number of persons in every room and when it finds the no of persons in a room to be zero then it automatically cut the power line for that room. We can also use a SEVEN SEGMENT, which will display the status of every room. The project can be subdivided into three main parts. First: - The one that will detect the entry or exit of a person in the room, this module will be applied at the door of each room. Second: - Which will further differentiate between entry and exit, and then accordingly increase or decrease the count of each room and display the count of each room on the timesharing bases on the seven segments which will be installed at a single central room. Third: - will be used to control the power line of each room which will work jointly with the second module to control the switching of power of each room (Ahmad, 2017). The complexity of the system proposed in the cited work is relatively high compared to my low cost system.

CHAPTER THREE

3.0 METHODOLOGY

The methodology of the design hinges on both software and hardware implementation.

The software implementation consists of:

i. Definition of tasks.
ii. Writing the control program in Keil uVision Integrated Design Environment.
iii. Testing and debugging the program for adaptation to Atmel AT89S51 microcontroller in Proteus virtual workbench.

The hardware implementation includes:

i. Adaptation of the power supply circuit.
ii. Adaptation of the infrared sensor modules.
iii. Design of the counter circuit.
iv. Interconnection of the above units.
v. Coupling of the whole design sub-units.

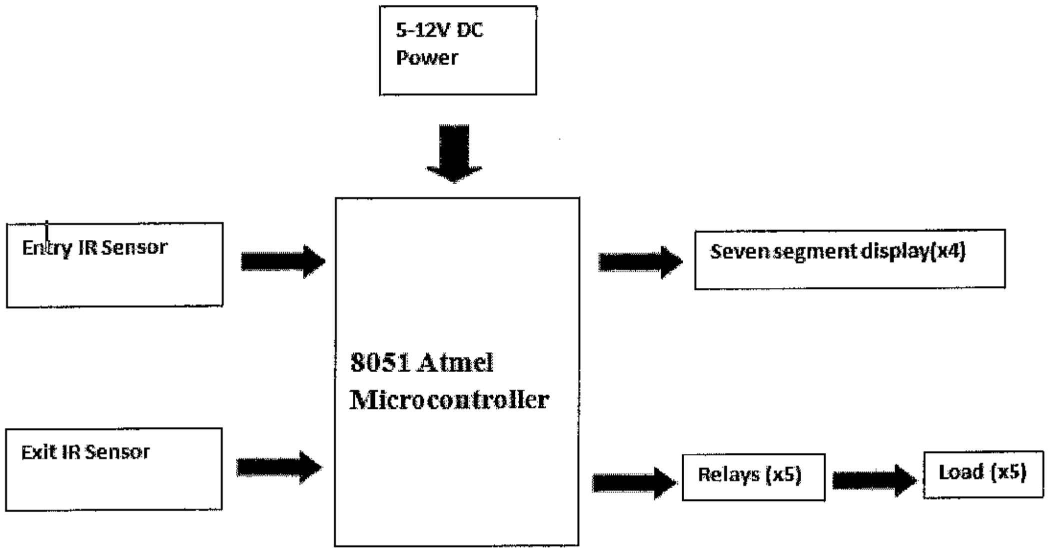


Fig. 1: Block diagram for a bi-directional visitor counter

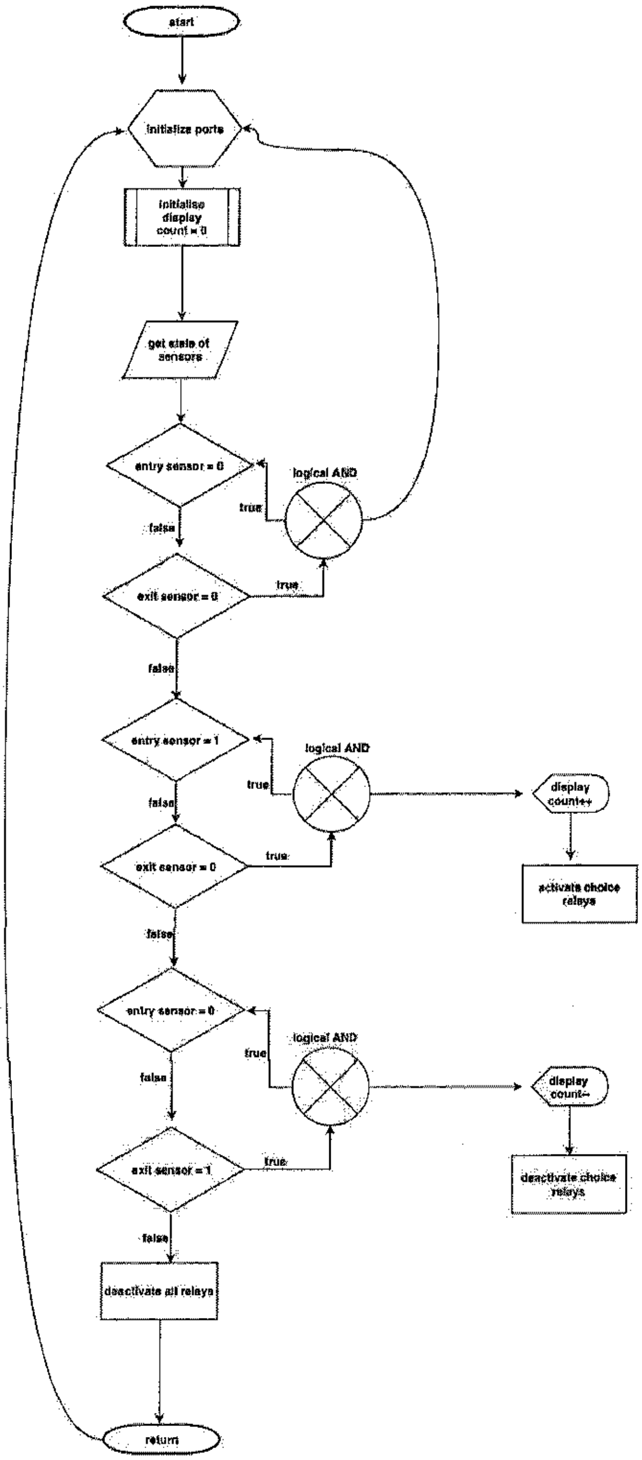


Fig. 2: Flow chart of an energy saving bi-directional visitor counter

3.1 REQUIREMENTS SPECIFICATIONS

Alleviating electrical power consumers' complaint of high cost incurred in billing (whereas a large chunk goes to power wastage i.e power not used but yet dissipated due to perhaps negligence on the part of the consumer) was taken into consideration for the design of this work. With this system in place, consumers of power would only pay for what they use.

For the system designed, two sensors placed strategically at the entry and exit point to a room detects visitors, a cascade of four seven segment displays gives a display of the total number of visitors present in a room.

In this system, up to 9999 incoming or outgoing visitors can be counted with the aid of an Atmel microcontroller having the below control operations stored in its ROM:

- The first filament bulb is switched ON at the entry of the first person.
- The second filament bulb is switched ON at the entry of the third person.
- The third filament bulb is switched ON at the entry of the seventh person.
  NOTE: the above automatic operations effectively save electrical power by allowing power to be utilised ONLY when needed thereby preventing wastage which incurs a high cost in payment for power consumption.
- When the counter is decremented, the reverse of the aforementioned operations is implemented until no one is present in the room and all AC lights go OFF.

3.2 DESIGN

3.2.1 INTRODUCTION

The design of BVCs can be quite simple for two door systems-where one door is dedicated for entry and the other for exit. One sensor monitors the visitors entering and the other one monitors the visitors leaving the room. This is the scenario for which many projects have been developed. But the design becomes more challenging for single door systems where all the visitors are entering and leaving through a single channel. The conventional systems employ IR Transmitter receiver pair, each installed on opposing sides of the door. In such systems, the sensor height, sensor alignment and power supply availability to both the devices offer many installation hurdles. The system can still fail to detect a kid if the installing height of sensors is higher than the kids' height. Similarly, some visitors may also pass through the channel without being detected if the height of the sensors is too low. Moreover, most of the existing systems are based on unreliable IR sensors with their limited range and poor detection of transparent or bright colour materials.

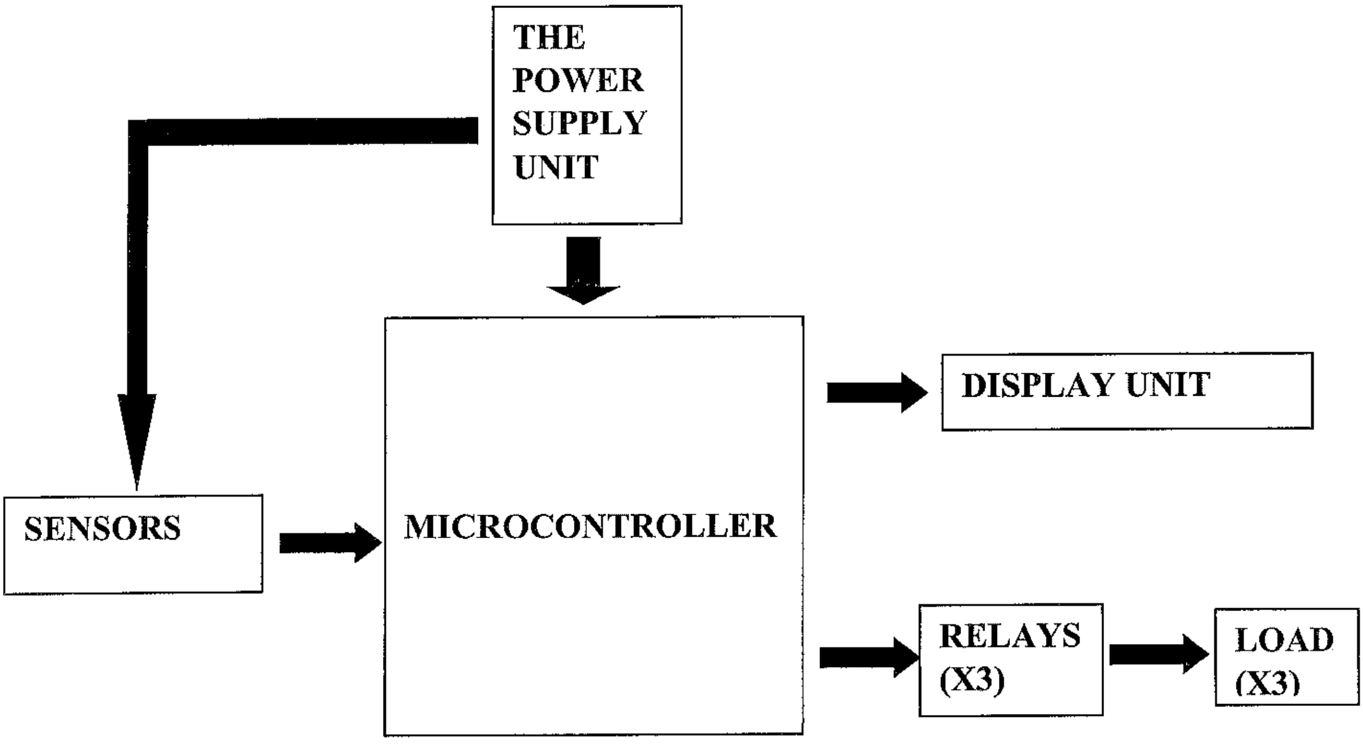


Fig. 3: System Architecture

The individual electronic components that makes up the system illustrated by the block diagram in Fig. 3 and the circuit diagram in Fig. 20 are highlighted below:

3.2.2 COMPONENTS

3.2.2.1 VOLTAGE REGULATOR

A voltage regulator is a system designed to automatically maintain a constant voltage level. A voltage regulator may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements (Regulator, 2019). I used a 7805 regulator to provide a 5V dc power source (for the sensors) from the 12V power adapter implemented.

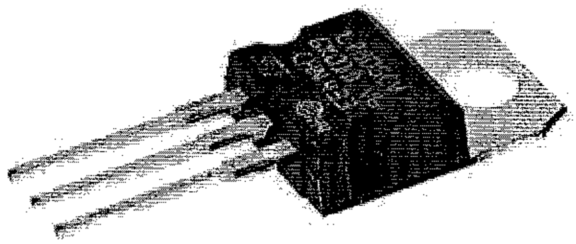


Fig. 4: 7805 Voltage Regulator

3.2.2.2 ELECTROLYTIC CAPACITOR

An electrolytic capacitor (abbreviated e-cap) is a polarized capacitor whose anode or positive plate is made of a metal that forms an insulating oxide layer through anodization. This oxide layer acts as the dielectric of the capacitor. A solid, liquid, or gel electrolyte covers the surface of this oxide layer, serving as the (cathode) or negative plate of the capacitor. Due to their very thin dielectric oxide layer and enlarged anode surface, electrolytic capacitors have a much higher capacitance-voltage (CV) product per unit volume than ceramic capacitors or film capacitors, and so can have large capacitance values. There are three families of electrolytic capacitor: aluminum electrolytic capacitors, tantalum electrolytic capacitors, and niobium electrolytic capacitors. The large capacitance of electrolytic capacitors makes them particularly suitable for passing or bypassing low-frequency signals, and for storing large amounts of energy. They are widely used for decoupling or noise filtering in power supplies and DC link circuits for variable-frequency drives, for coupling signals between amplifier stages, and storing energy as in a flashlamps (Capacitor, 2019)

Fig. 5: 3300uF Electrolytic Capacitor

3.2.2.3 CERAMIC CAPACITOR

A ceramic capacitor is a fixed-value capacitor where the ceramic material acts as the dielectric. It is constructed of two or more alternating layers of ceramic and a metal layer acting as the electrodes. The composition of the ceramic material defines the electrical behaviour and therefore applications. Ceramic capacitors are divided into two application classes:

- Class 1 ceramic capacitors offer high stability and low losses for resonant circuit applications.
- Class 2 ceramic capacitors offer high volumetric efficiency for buffer, by-pass, and coupling applications (capacitor, 2019). A pair of 33pF capacitor used in conjuction with a 12MHz crystal generates a signal with an approximate oscillating frequency required for stabilizing the microcontroller used.

Fig. 6: 33pF Ceramic Capacitor

3.2.2.4 TRANSISTOR

A transistor (e.g BC547) is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals controls the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits (Transistor, 2019). BC547 is a general purpose NPN transistor effective as a low power switch which was used to provide the necessary drive current for the anode of each seven-segment displays.

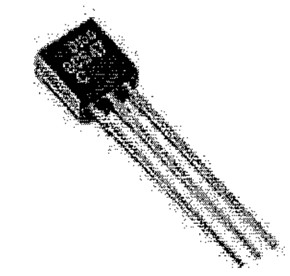


Fig. 7: BC547 Transistor

3.2.2.5 DARLINGTON TRANSISTOR ARRAY

The Darlington Transistor Array (e.g ULN2003A) is an array of seven NPN Darlington transistors capable of 500 mA, 50 V output. It features common-cathode flyback diodes for switching inductive loads (ULN2003, 2019). This ULN2003A transistor array used a relay driver has 7 output slots (out of which I used three for each of my relays).

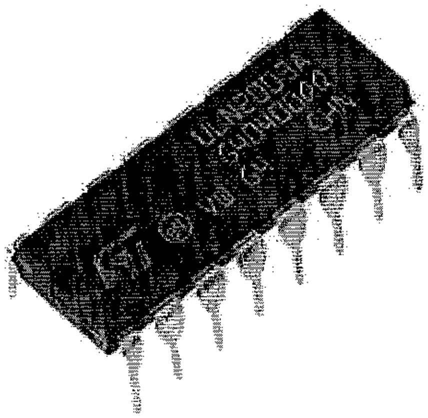


Fig. 8: ULN2003 Darlington Transistor Array

3.2.2.6 CRYSTAL OSCILLATOR

A crystal oscillator (e.g 12MHz crystal) is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. This frequency is often used to keep track of time, as in quartz wristwatches, to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits.

A crystal oscillator, particularly one made of quartz crystal, works by being distorted by an electric field when voltage is applied to an electrode near or on the crystal. This property is known as electrostriction or inverse piezoelectricity. When the field is removed, the quartz - which oscillates in a precise frequency - generates an electric field as it returns to its previous shape, and this can generate a voltage. The result is that a quartz crystal behaves like an RLC circuit (oscillator, 2019). The 12MHz crystal used generates the required signal for the stabilised operation of an AT89S51 microcontroller.

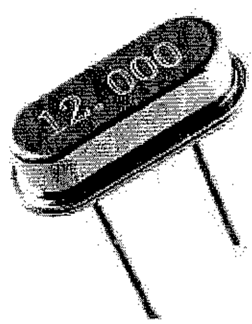


Fig. 9: 12MHz Crystal Oscillator

3.2.2.7 DIODE

A diode is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. A diode vacuum tube or thermionic diode is a vacuum tube with two electrodes, a heated cathode and a plate, in which electrons can flow in only one direction, from cathode to plate. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. Semiconductor diodes were the first semiconductor electronic devices (Diode, 2019).

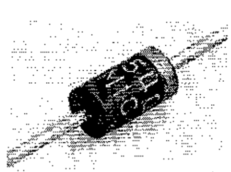


Fig. 10: Diode

3.2.2.8 SWITCH

A switch (e.g SPST push button momentary switch) is an electrical component that can "make" or "break" an electrical circuit, interrupting the current or diverting it from one conductor to another. The mechanism of a switch removes or restores the conducting path in a circuit when it is operated. It may be operated manually, for example, a light switch or a keyboard button, may be operated by a moving object such as a door, or may be operated by some sensing element for pressure, temperature or flow. A switch will have one or more sets of contacts, which may operate simultaneously, sequentially, or alternately (Switch, 2019).

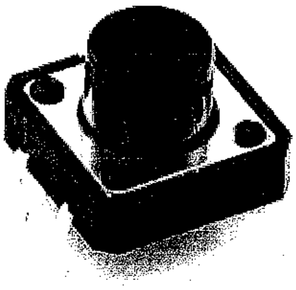


Fig. 11: SPST Momentary Push Button Switch

3.2.2.9 RESISTOR

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity. Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits. The electrical function of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance falls within the manufacturing tolerance, indicated on the component (Resistor, 2019). The four 10k resistors used provides the required drive current for each switching transistor base. A 10k resistor in the reset circuit pulls down the supply voltage, this is needed to provide the required signal for resetting the microcontroller. Seven 330 ohms resistors used serves as an effective current limiter in turning on the LEDs present in a seven segment display.

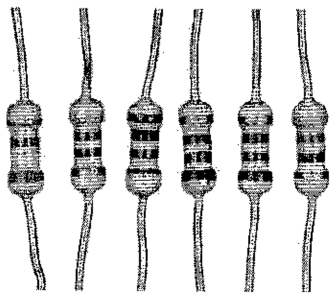


Fig. 12: Resistor

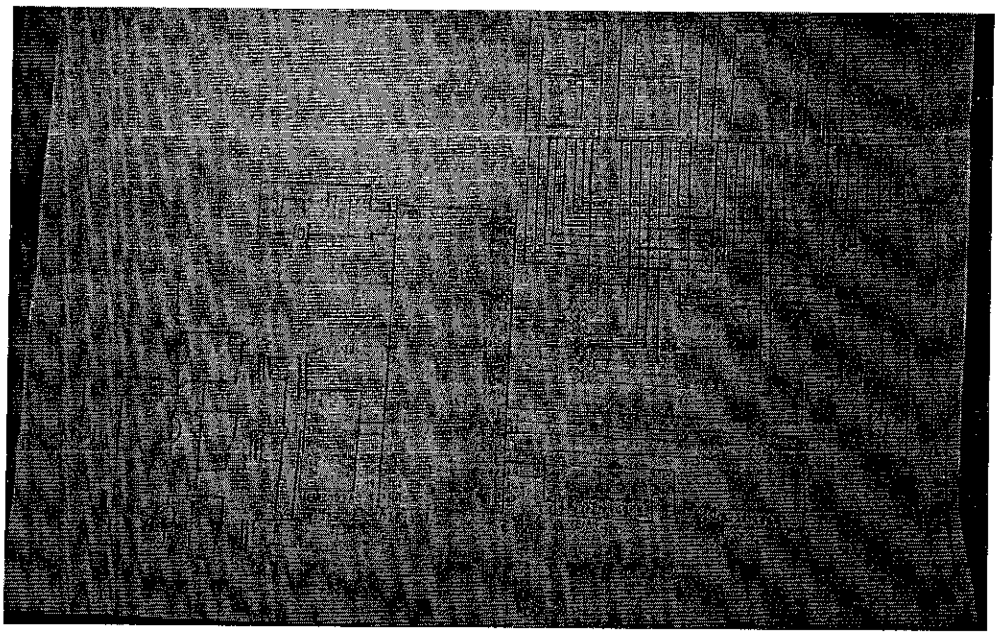


Fig. 20: Circuit diagram

3.2.3 THE POWER SUPPLY UNIT (PSU)

PSU is basically a circuit that converts an ac line voltage into dc for powering small loads with the aid of a bridge rectifier. Two supply voltages are required in this system design. They are 5Vdc (to power the microcontroller and sensors) and 12Vdc (to energise the relay coil).

A standalone (ready-made) 12Vdc power supply unit was incorporated for use in the design with the following ratings:

KE TAI AC ADAPTER

MODEL: KT-118C-52E

INPUT: 110-250V 50/60Hz 1A

OUTPUT: 12VDC 0-1.5A

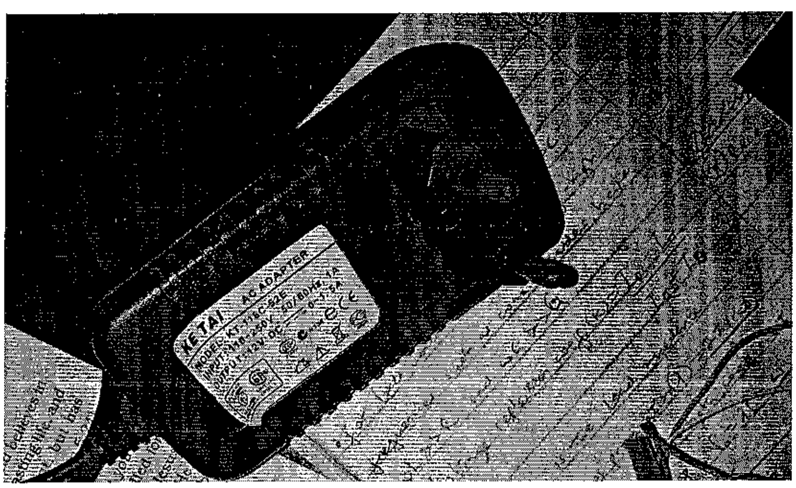


Fig. 13: Standalone 12V Power Supply

The 12V output of the power adapter was regulated to 5V by the use of LM7805 regulator to provide a 5V supply for the microcontroller and sensors.

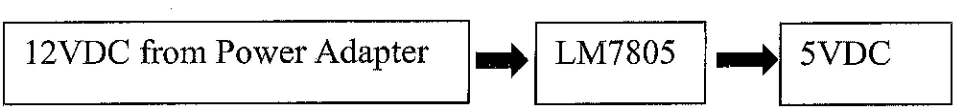


Fig. 14: 5V Power Supply Block Diagram

3.2.4 SENSORS

Two standalone infrared sensors were incorporated into the design. One for entry detection and the other for exit detection. An infrared sensor is an electronic device that emits IR rays in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors that measures only infrared radiation, rather than emitting it is called passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations that are invisible to our eyes can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and thus output voltages, change in proportion to the magnitude of the IR light received (Elprocus, 2015).

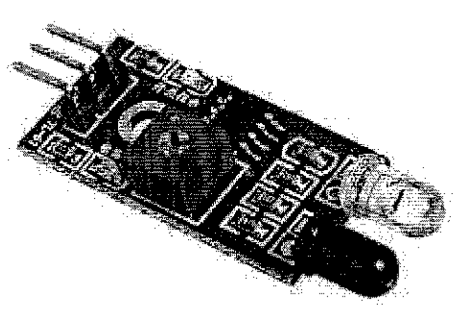


Fig. 15: Infrared Sensor

3.2.5 MICROCONTROLLER

This is the 'brain box' of the design in that all control operations are activated in it. ATMEL AT89S51 microcontroller was implemented in this work. The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on an monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications (culled from Atmel AT89S51 datasheet).

Fig. 16: AT89S51 Microcontroller

3.2.6 THE DISPLAY UNIT

This is the visual output section of the design. The present count is displayed here. A seven-segment display (SSD), or seven-segment indicator, is a form of electronic display device for displaying decimals , numerals that is an alternative to the more complex dot matrix displays.

Seven-segment displays are widely used in digital clocks, electronic meters, basic calculators, and other electronic devices that display numerical information (display, 2019).

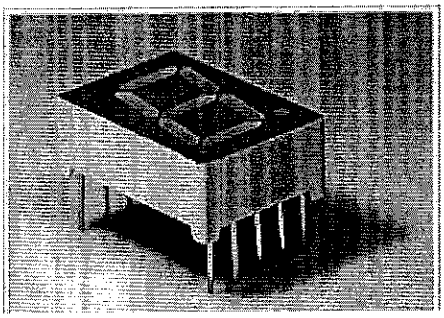


Fig. 17: Common anode seven segment display

A cascade of four single digit common anode seven segment displays was implemented so as to accommodate counts up to 9999.

3.2.7 LOAD DRIVER (RELAYS)

This is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

The specifications of the relay as provided in the device' datasheet are:

Current: 10A

No load voltage: 12VDC

Coil resistance: 400 ohms

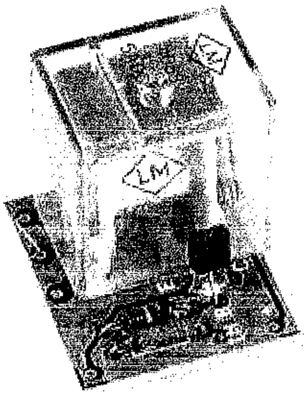


Fig. 18: 12Vdc Relay

Three 12Vdc relays were implemented in this design for the control of three filament bulbs.

3.2.8 LOADS

These are appliances (to be controlled) that are driven by the whole system designed. Here, three AC filament bulbs constitute the load.

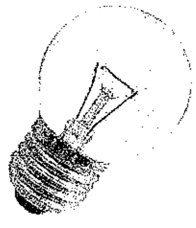


Fig. 19: Filament Bulb

CHAPTER FOUR

4.0 TESTING, ANALYSIS OF RESULTS AND DISCUSSION

Before the fabrication of this project work, the circuit was simulated on Proteus Design Workbench in order to have a priori, the behavioural pattern of the hardware when eventually deployed.

Proteus is an application software that provides a virtual design environment for the testing of various electronic circuits.

Not all physical devices (such as sensors) can be realised in Proteus but these unavailable devices can be modelled in Proteus. Below is the simulation snapshot of the project hardware (taking after the adopted circuit diagram) in Proteus

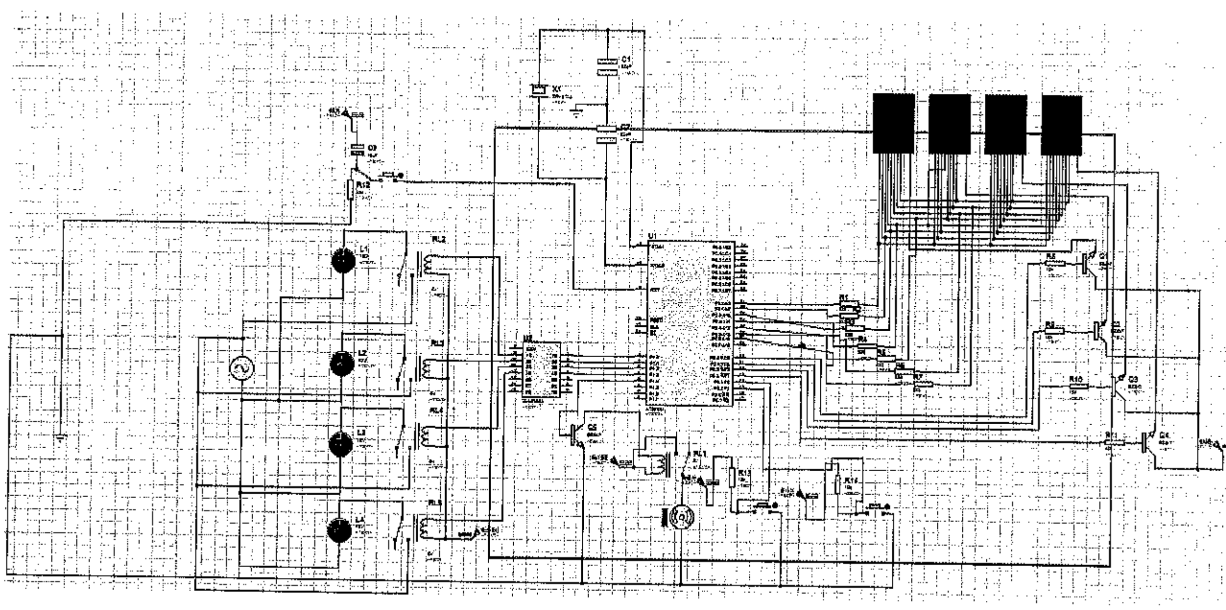


Fig. 21: Simulation of project work in Proteus

After the successful simulation of the work, hardware fabrication was next in line. The fabrication was kick-started by the production of a Printed Circuit Board (PCB) for the circuit. The production of the PCB was contracted to an engineer. Images of the PCB layout and board are shown below respectively.

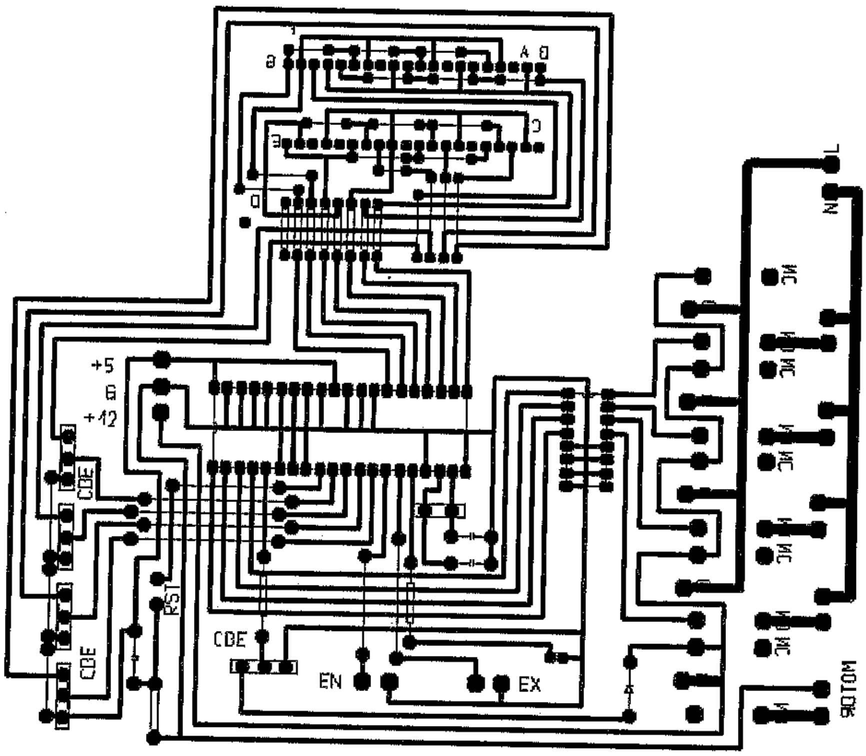
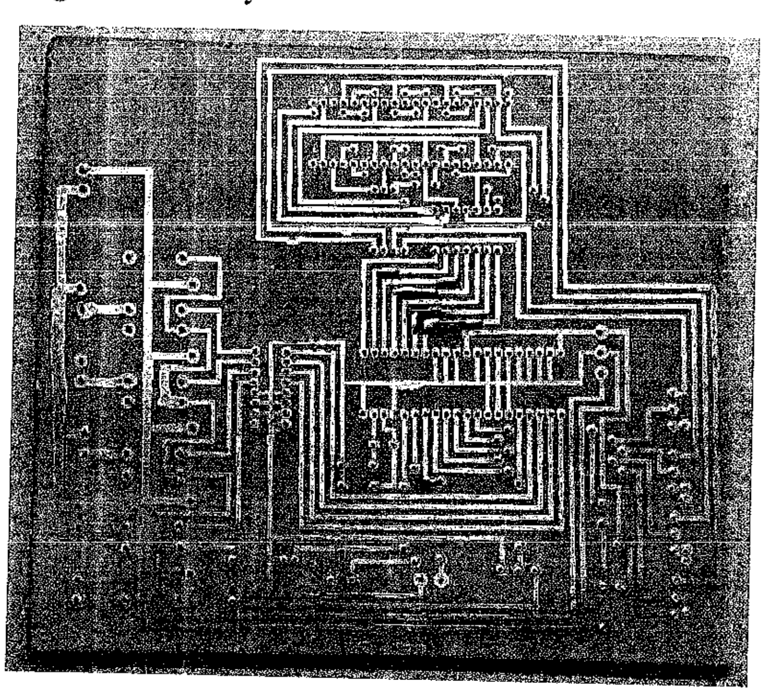


Fig. 22: PCB layout


'**Fig. 23:** PCB Board

Soldering of all components in accordance to the adopted circuit diagram was done after the production of a PCB. The image below shows the circuit's hardware.

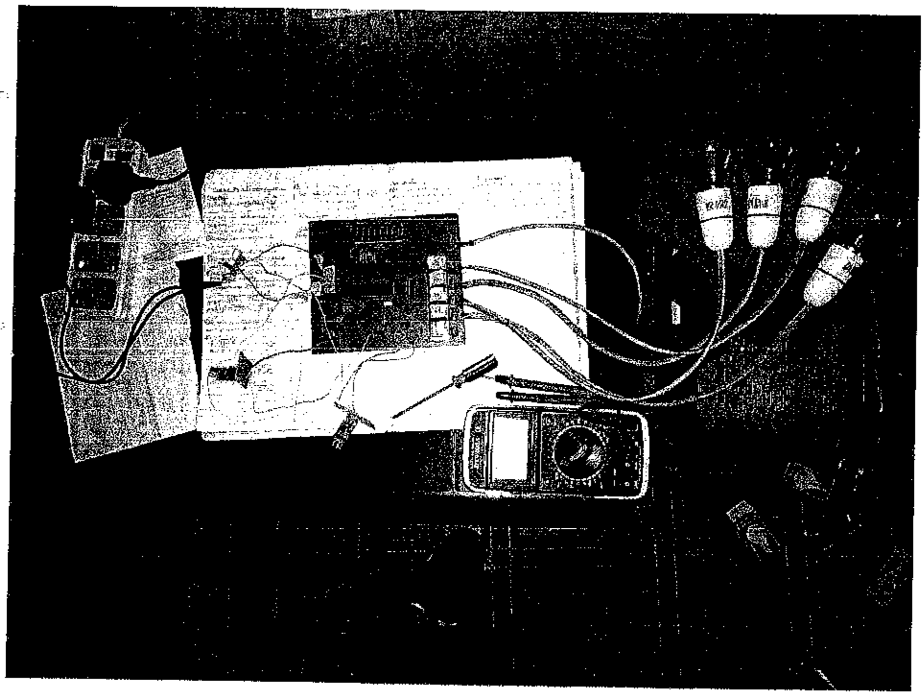


Fig. 24: Project hardware

Lastly, the implementation was completed by 'casing' the work appropriately for ease of mobility and setup.

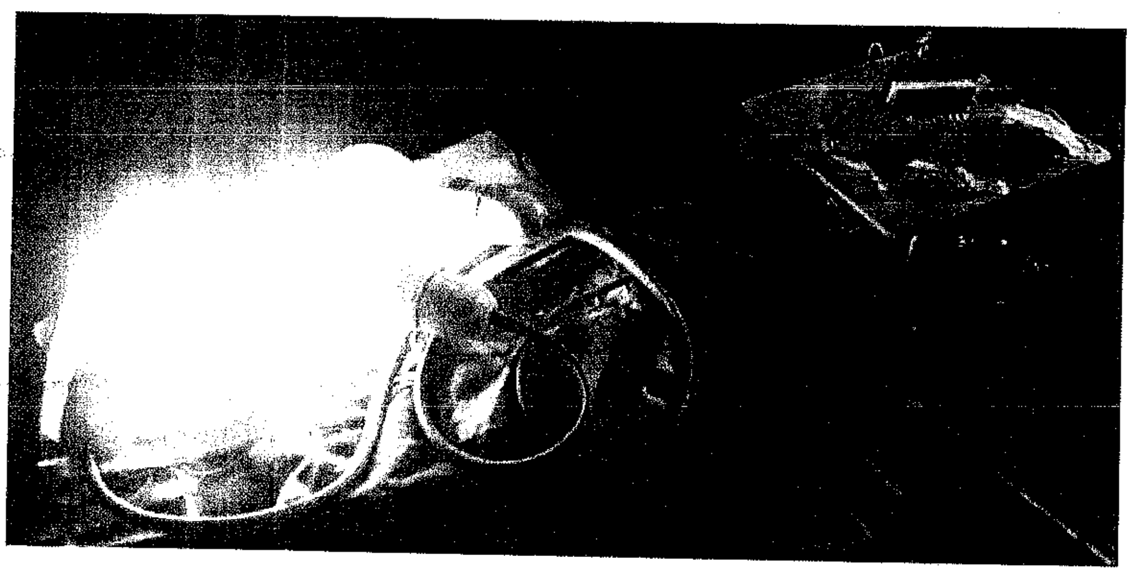


Fig. 25: Complete assembly of the design

4.1 TESTING

Since human error is quite inevitable, the hardware was painstakingly tested (even before powering it on) with the aid of a digital multimeter.

The 'continuity test' in particular was performed with the use of a multimeter. This test is basically done to confirm that circuit elements, connectors, nodes are all interconnected as expected in accordance to the circuit layout.

Also, various tests were performed on the infrared sensors. The tests include:

- Sensitivity range (in distance)-this is to determine the maximum and minimum horizontal distance between the sensor and the target outside which there would not be detection. The sensors detects within the range of (2-80) cm.
- Sensitivity to diverse colours-this depicts the behavioural detection pattern of the sensor to diverse colours.
- Effect of object's thickness on detection-this reveals the limitation imposed on the sensor's sentivity due to the thickness of the object.

Fig. 26 below contains a graph that summarises the last two test characteristics mentioned above.

4.2 ANALYSIS

The result of the tests on the IR sensor are summarised in the table below:

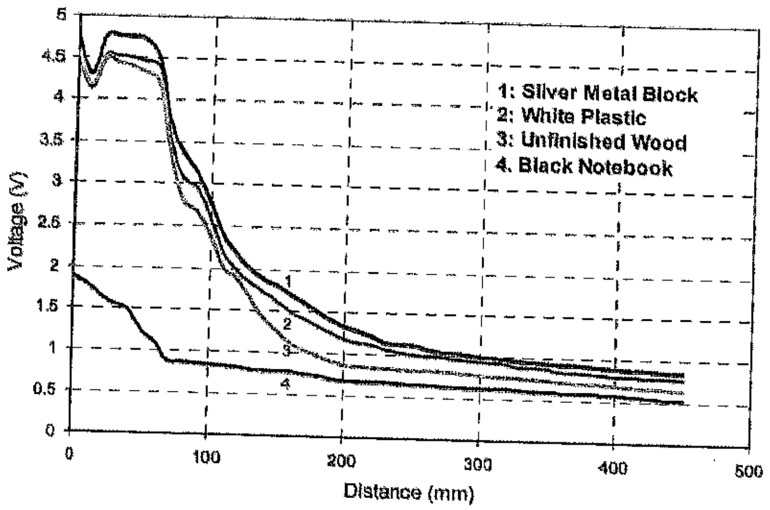


Fig. 26: Graph of IR output voltage to distance of object (Mohammad, 2009)

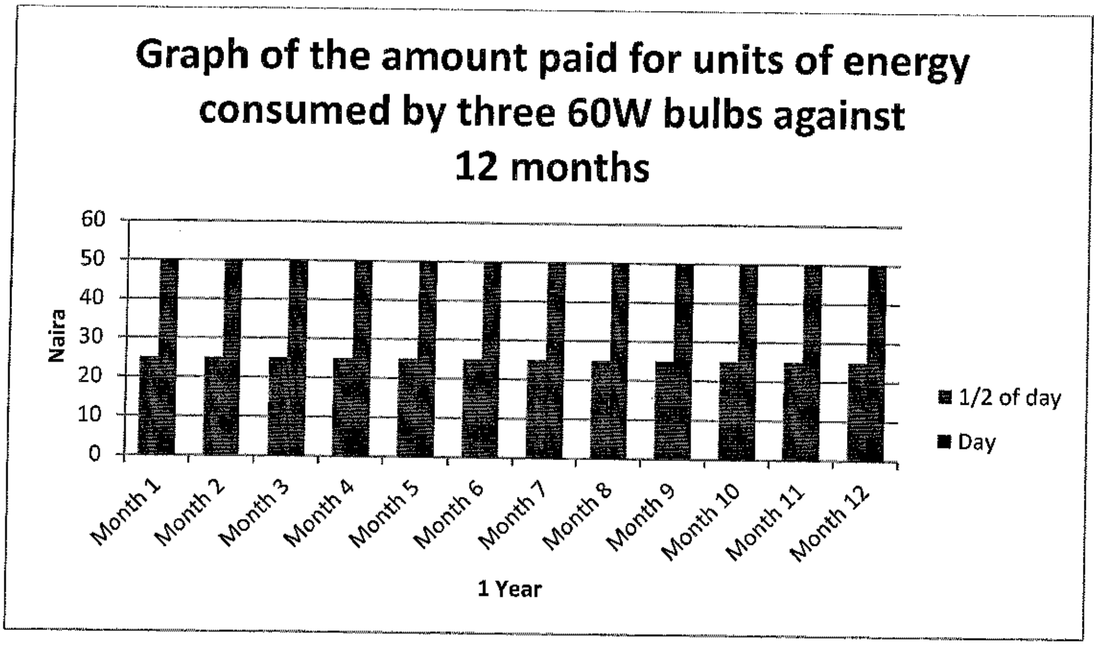
4.2.1 ENERGY SAVING CALCULATIONS

This work has three 60Watts light bulbs that comes on/off based on the count of visitors detected by a pair of IR sensors. Here, to establish the energy saving property of this project, two cases are presented thus:

Say the tariff rate is #1.16k for one unit of energy consumed per hour

1. <u>Three light bulbs ON for a day per year</u>
   Energy units consumed is (60Watts * 24 hours)/1000 =1.44kWh
   Energy charged is (#1.16k * 1.44kWh) = #1.67k
   In a month, energy charged is (30 days * #1.67k) = #50
   In a year, energy charged is (12 months * #50) = #600

2. <u>Three light bulbs ON for the half of a day per year</u>
   Energy units consumed is (60Watts * 12 hours)/1000 = 0.72kWh
   Energy charged is (#1.16k * 0.72kWh) = #0.84k
   In a month, energy charged is (30 days * #0.84k) = #25
   In a year, energy charged is (12 months * #25) = #300



Tariff rate is #1.16k for one unit of energy consumed per hour

Fig. 27: Graph of the amount paid for units of energy consumed by three 60W bulbs against 12 months

From the foregoing, we can see that the amount paid for electricity reduced by half as the number of energy units consumed in a day also reduced by half. This a 50 percent reduction in the cost incurred in electricity consumption.

Hence, when this automated system is deployed, the user can be rest assured of paying only for the energy units he uses, this also translates to reduction in the high cost incurred in electrical power generation by the Federal Government i.e the usually high amount allocated to power generation in the national budget of a country would witness a tangible reduction.

4.3 PROJECT MANAGEMENT

I chose the Gantt chart (as my project implementation analysis tool) to depict the schedule of implementation for the design work.

4.3.1 PROJECT SCHEDULE

TASK NAME	START DATE	DAY OF MONTH*	END DATE	DURATION* (WORK DAYS)	DAYS COMPLETE*	DAYS REMAINING*	PERCENT COMPLETE
Project Simulation							
Choice of circuit diagram	09/06/18	9	09/06/18	1	1	0	100%
Coding and Circuit layout on Proteus	13/06/18	13	27/06/18	15	15	0	100%
Simulation	27/06/18	27	27/06/18	1	1	0	100%
Modification of circuit diagram	28/06/18	28	28/06/18	1	1	0	100%
Simulation of modified circuit	28/06/18	28	29/06/18	2	2	0	100%
Hardware Fabrication							
Purchase of components	30/06/18	30	21/10/18	114	114	0	100%
Production of PCB	11/07/18	11	18/07/18	8	8	0	100%
Soldering							
Fixation of broken tracks	18/07/18	18	18/07/18	1	1	0	100%
Connection of jumpers	03/10/18	3	03/10/18	1	1	0	100%
Attachment of IC sockets	05/10/18	5	05/10/18	1	1	0	100%
Soldering of all components	09/10/18	9	09/10/18	1	1	0	100%
Connection of jumper blocks	09/10/18	9	09/10/18	1	1	0	100%
Casing							
Rough sketch of proposed casing	26/10/18	26	26/10/18	1	0.5	0.5	50%
Fabrication of hardware case	07/11/18	7	12/11/18	6	0	6	0%
Assembly of all hardware units	18/11/2018	18	18/11/2018	1	0	1	0%

Fig. 28: Table of Gantt chart

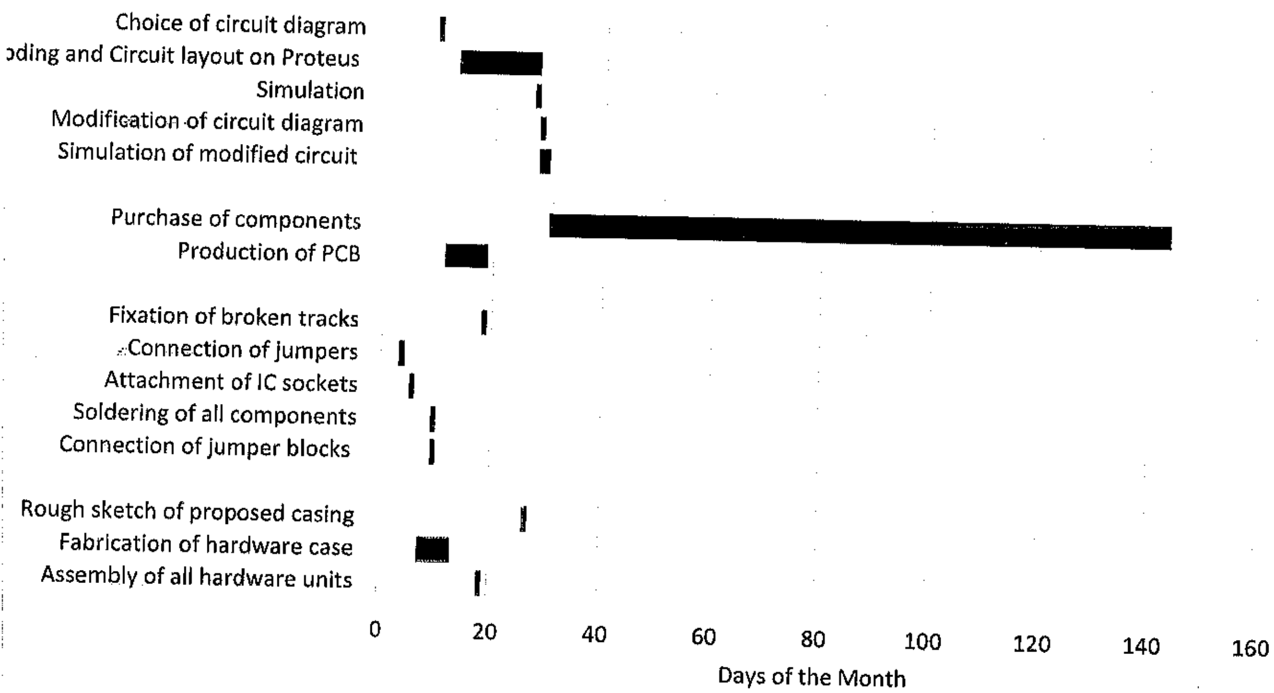


Fig. 29: Project Implementation Schedule shown on a Gantt chart

4.3.2 RISK MANAGEMENT

The major risk taken in the course of this project's execution was my compliance to fabricate this work all by myself despite my gross inexperience in developing electronic circuits practically.

This risk was well catered for by consulting volumes of resources on the design and fabrication of electronic circuits and also practical lessons learnt from skilful engineers in electronic circuit design was of immense help too.

That this work was a success attests to the fact that the risk was worth taking eventhough there were numerous challenging hurdles that had to be surmounted progressively.

4.3.3 SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL CONSIDERATIONS

In as much as this work was done as a requirement for obtaining a honorary degree, there are no associative considerations other than that which binds undergraduate students in tertiary institutions as stipulated by the educational sectorial arm of the federal government.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

Finally, the design of an Automated Energy Saving Bi-directional Visitor Counter has been successfully achieved. Bi-directional implies that it can read both the incoming and outgoing traffic of persons. The need to have an on-the-spot count of visitors present in a room, automatic control of a room's lighting points (for electrical power to be adequately saved) gave rise to this work.

This project titled Automated Energy Saving, Bi-Directional Visitor Counter is a reliable circuit that automatically performs the task of controlling a room's lighting points, as well as counting the number of persons in the room very accurately. When somebody enters into the room, the counter is incremented by one and the AC lights (filament bulbs) in the room will be switched ON and when any one leaves the room then the counter is decremented by one. The AC light will be only switched OFF when all the persons in the room go out. The total number of persons inside the room is also displayed on a cascade of four seven segment displays.

In this system, up to 9999 incoming or outgoing visitors can be counted with the aid of an Atmel microcontroller.

This design can be deployed for use in rooms of small capacity such as library, laboratory, garage, classrooms, engineering workshops, seminar halls, etc.

5.1 CONTRIBUTION TO KNOWLEDGE

My work increased the number of count capacity from 999 (the highest have seen insofar obtainable from systems that used segment displays) to 9999 by implementing four seven segment displays.

I would recommend that upcoming novel works taking after this design should incorporate real time imaging technology, long distance sensing laser technology, heat signature sensors such as ardafuit in order to overcome the limitations (which are highlighted below) imposed by this design.

5.2 LIMITATIONS

Firstly, the design cannot differentiate between an animal and a human being crossing the path of IR rays used for sensing.

Also, a young child whose height is less than the IR sensor's distance to the ground level cannot be detected.

Furthermore, two or more people concurrently crossing the path of IR rays would be detected as just one object obstructing the rays.

In addition, the system must be installed in such a way that the horizontal distance between the target and the sensors must be reasonably small for detection to be possible.

Lastly, the system can only be efficiently deployed in a small room capacity of ten to hundreds of people and not commercial centres where thousands upon thousands of people visit.

5.3 FUTURE WORKS

The design can be improved upon by incorporating the following features:

- Use of advanced sensors like long range laser sensors which have a wider and longer range of detection.
- Imaging systems such as face recognition that recognises the identities of a target object. This would differentiate between an animal and humans obstructing the sensor's rays.

5.4 CRITICAL APPRAISAL

The design effectively replaced manual operations of electrical load appliances in a room but if the fast rate at which we experience technological advancement in our age were to be considered, then this work is pretty less advanced because of the high grade features that most recent systems offer. Such systems include: Real Time Imaging systems, Zigbee technology, Raspberry Pi technology, Thermal sensors, etc.

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APPENDIX

APPENDIX I - GLOSSARY OF WORDS

- IR- infrared
- BVC- Bidirectional Visitor Counter
- SPST- Single Pole Single Throw
- a.c- alternating current
- d.c- direct current

APPENDIX II - LOOK-UP TABLES

THE SPECIFICATIONS OF AN IR SENSOR

Symbol	Quantity	Minimum	Typical	Maximum	Unit
o/p	Output Voltage	0	-	5	V
V_{CC}	Operating Voltage	4.5	5	5.5	V
GND	Ground Reference voltage	-	0	-	V

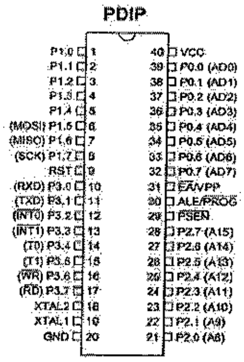
THE PIN CONFIGURATION OF AN IR SENSOR

Pin No.	Connection	Description
1	Output	Digital Output (High or Low)
2	VCC	Connected to circuit supply
3	Ground	Connected to circuit ground

THE FUNCTIONALITIES OF THE 40 PINS OF AN AT89S51 MICROCONTROLLER

Pin No	Function			Name
1	8 bit input/output port (P_1) pins			$P_1.0$
2				$P_1.1$
3				$P_1.2$
4				$P_1.3$
5				$P_1.4$
6				$P_1.5$
7				$P_1.6$
8				$P_1.7$
9	Reset pin; Active high			Reset
10	Input (receiver) for serial communication	RxD	8 bit input/output port (P_3) pins	$P_3.0$
11	Output (transmitter) for serial communication	TxD		$P_3.1$
12	External interrupt 1	Int0		$P_3.2$
13	External interrupt 2	Int1		$P_3.3$
14	Timer1 external input	T_0		$P_3.4$
15	Timer2 external input	T_1		$P_3.5$
16	Write to external data memory	Write		$P_3.6$
17	Read from external data memory	Read		$P_3.7$
18	Quartz crystal oscillator (up to 24 MHz)			Crystal 2
19				Crystal 1
20	Ground (0V)			Ground
21	8 bit input/output port (P_2) pins / High-order address bits when interfacing with external memory			$P_2.0/ A_8$
22				$P_2.1/ A_9$
23				$P_2.2/ A_{10}$
24				$P_2.3/ A_{11}$
25				$P_2.4/ A_{12}$
26				$P_2.5/ A_{13}$
27				$P_2.6/ A_{14}$
28				$P_2.7/ A_{15}$
29	Program store enable; Read from external program memory			PSEN
30	Address Latch Enable			ALE
	Program pulse input during Flash programming			Prog
31	External Access Enable; Vcc for internal program executions			EA
	Programming enable voltage; 12V (during Flash programming)			Vpp
32	8 bit input/output port (P_0) pins / Low-order address bits when interfacing with external memory			$P_0.7/ AD_7$
33				$P_0.6/ AD_6$
34				$P_0.5/ AD_5$
35				$P_0.4/ AD_4$
36				$P_0.3/ AD_3$
37				$P_0.2/ AD_2$
38				$P_0.1/ AD_1$
39				$P_0.0/ AD_0$
40	Supply voltage; 5V (up to 6.6V)			Vcc

PDIP



THE HEXADECIMAL ENCODINGS FOR THE DISPLAY OF 0-F ON A SEVEN SEGMENT DISPLAY

Digit	Display	gfedcba	abcdefg	a	b	c	d	e	f	g
0	0	0x3F	0x7E	on	on	on	on	on	on	off
1	1	0x06	0x30	off	on	on	off	off	off	off
2	2	0x5B	0x6D	on	on	off	on	on	off	on
3	3	0x4F	0x79	on	on	on	on	off	off	on
4	4	0x66	0x33	off	on	on	off	off	on	on
5	5	0x6D	0x5B	on	off	on	on	off	on	on
6	6	0x7D	0x5F	on	off	on	on	on	on	on
7	7	0x07	0x70	on	on	on	off	off	off	off
8	8	0x7F	0x7F	on	on	on	on	on	on	on
9	9	0x6F	0x7B	on	on	on	on	off	on	on
A	A	0x77	0x77	on	on	on	off	on	on	on
b	b	0x7C	0x1F	off	off	on	on	on	on	on
C	C	0x39	0x4E	on	off	off	on	on	on	off
d	d	0x5E	0x3D	off	on	on	on	on	off	on
E	E	0x79	0x4F	on	off	off	on	on	on	on
F	F	0x71	0x47	on	off	off	off	on	on	on

APPENDIX III – COMPONENTS CATALOGUE

S/N	Name	Value	Quantity
1	Microcontroller	AT89S51	1
2	Seven segment display	Common Anode	4
3	Relay	12V, 400 ohms	3
4	Darlington Transistor Array	ULN2003A	1
5	IR sensor module	N/A	2
6	Crystal Oscillator	12MHz	1
7	Resistor	330 ohms, 10k	7, 5
8	Ceramic capacitor	33pF	2
9	Electrolytic capacitor	10uF	1
10	Transistor	BC547	4
11	Switch	SPST Push Button Momentary	1

APPENDIX IV – PROGRAM CODE

```
// Program to make an energy saving bidirectional visitor counter using IR sensor

#include <reg51.h>

unsigned int num=0;

void msdelay(unsigned int t);

sbit relay1=P1^0;

sbit relay2=P1^1;

sbit relay3=P1^2;

sbit relay4=P1^3;

sbit dig_ctrl_4=P3^3; //declarations of the anodes of seven segments

sbit dig_ctrl_3=P3^2;

sbit dig_ctrl_2=P3^1;

sbit dig_ctrl_1=P3^0;

unsigned
digi_val[16]={0xc0,0xf9,0xa4,0xb0,0x99,0x92,0x82,0xf8,0x80,0x90,0x88,0x83,0xc6,0xa1,0x
86,0x8e}; //seven segement hexadecimal array for displaying digits

unsigned int dig_1,dig_2,dig_3,dig_4,test=0;

unsigned char dig_disp=0;

sbit up=P3^4; //entry sensor is connected to pin 4 of port 3

sbit down=P3^5; //exit sensor is connected to pin 5 of port 3

void init() // to initialize the output pins and Timer0

{

TMOD=0x01;

TL0=0xf6;

TH0=0xFf;

IE=0x82;

TR0=1;

}

void delay() //To provide a small time delay

{

 int count=0,sec;

       for(sec=0;sec<0.5;sec++)

       {

               count=0;

               while(count!=500)
```

```
                {
                        TMOD=0x01;
                        TL0=0x36;
                        TH0=0xF6;
                        TR0=1;
                        while(TF0==0);
                        TR0=0;
                        TF0=0;
                        count++;
                }
        }
}
void display() interrupt 1 // Function to display the digits on seven segment.
{
        P2=0xFF;
        dig_ctrl_1 = dig_ctrl_3 = dig_ctrl_2 = dig_ctrl_4 = 0;
        dig_disp++;
        dig_disp=dig_disp%4;
        switch(dig_disp)
        {
                case 0:
                        P2= digi_val[dig_1];
                        dig_ctrl_1 = 1;
                        break;
                        case 1:
                                P2= digi_val[dig_2];
                                dig_ctrl_2 = 1;
                                break;

                        case 2:
                                P2= digi_val[dig_3];
                                dig_ctrl_3 = 1;
                                break;
```

```
                case 3:
                        P2= digi_val[dig_4];
                        dig_ctrl_4 = 1;
                        break;
        }
}
void main()
{
        P1=0x00; // configures port 1 pins to be an input I/O line
        init();
        while(1)
                {
                up=down=1;
                if(up==0&&down==1) //checks if entry sensor's rays is broken
                        {
                                test++;
                                num=test;
                                dig_4=num%10;
                                num=num/10;
                                dig_3=num%10;
                                num=num/10;
                                dig_2=num%10;
                                dig_1=num/10;
                                msdelay(100);
                                while(up==0&&down==1);
                if(test>0&&test<=0)
                        {
                                relay1=0;
                        }

                else
                        {
                                relay1=1;
                        }
```

```
if(test>0&&test<=2)
        {
                relay2=0;
        }
else
        {
                relay2=1;
        }
if(test>0&&test<=4)
        {
                relay3=0;
        }
else
        {
                relay3=1;
        }
if(test>0&&test<=6)
        {
                relay4=0;
        }
else
        {
                relay4=1;
        }
if(test==9999)
while(test==9999);
}
```

```
                if(up==1&&down==0) //check if down pin is pressed
                    {
                        test--;
                        num=test;
                        dig_4=num%10;
                        num=num/10;
                        dig_3=num%10;
                        num=num/10;
                        dig_2=num%10;
                        dig_1=num/10;
                        msdelay(100);
                        while(up==1&&down==0);
                if(test==0)
                    {
                        relay1=0;
                    }
                if(test==2)
                    {
                        relay2=0;
                    }
                if(test==4)
                    {
                        relay3=0;
                    }
                if(test==6)
                    {
                        relay4=0;
                    }
                if(test==0)
                init();
            }
        }
}
```

```
void msdelay(unsigned int t)
{
	unsigned int i,j;
	for(i=0;i<t;i++)
	for(j=0;j<1275;j++);
}
```