# DESIGN AND CONSTRUCTION OF AN AUTOMATIC OCCUPANCY AND UTILITY CONTROL SYSTEM

BY

AWOBADE, AYODELE OLAOLU

(2003/15333EE)

DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.
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# DECLARATION

I AWOBADE AYODELE OLAOLU declared that this project work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna

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Sign & date

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Name of H.O.D

*Sign & date*

Name of External Examiner

Sign & date

# DEDICATION

This project is dedicated to my parent Most Snr Evang & Mrs Awobade for there undying love for me.

# ACKNOWLEDGEMENT

I appreciate God for his mercy and grace upon my life. I can not quantify God's blessings. I am also grateful to him for causing wonderful people to bless me both morally and financially. I cannot but adore his majesty for making my five years in school bunch of testimonies.

I thank my parents Most senior evang & Mrs Awobade for encouraging me and also for been there for me.

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Least I forgot my Big Daddy, Mr A.B.Oguntokun I also want to use this medium to thank him for been a friend to my family.

I wont forget my the following who has one way or the other been there for me. Mrs Oshungbohun, Engr Ojo, aunty Bola, papa stevo.

I also want to use this medium to acknowledge and also thank my best friend Taiwo Dada and my brothers and sisters, seun, ore, busayo, codex, Dr Ibukun and also the rest of my families.

And also I wont forget my friends at school, olaolu, feyi, seun, biola, kurusis, floro,jibike, kunle, funshy dada, Ralph, safam, and also my home boys at home nozman, saheed and also to my good friends seun keshinro, tolulope, morenike, love you all.

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## ABSTRACT

This project is all about the design and construction of an Automatic Occupancy and Utility Control System, embarked upon to enhance and control electrical power consumption and also detecting occupancy level in specific environments. The design is based on the principle of using a microcontroller to control and also helps in displaying of digits using the seven segments display mode. It entails writing of computer programs(C-Programming) which is written into the microcontroller as program codes. The design methods adopted in these project involves six stages; transmitting circuit, the sensor/receiver circuit, the microcontroller, the counter/display, the switching circuit and the power supply circuit. The project work was found working satisfactory.

# CHAPTER ONE

## INTRODUCTION

This project "Automatic Occupancy and Utility Control System" is a device that takes over the task of controlling the room lights as well as counting number of persons/visitors in a room. The project aims is to achieve the conservation of electrical power by automatically switching off the power supply when the room is empty of persons and the replacement of mechanical toggle switches with the sensitive auto switches. This is achieved through the design and construction of a simple, reliable, highly sensitive automatic room light using a microcontroller to achieve simplicity and reliability. The system is self operating, having the ability to reset itself automatically and thus need little or no human intervention.

When a person enters into the room then the counter is automatically incremented by one and the light in the room will be switched ON. When he leaves the room the counter is decremented by one. The light will be switched OFF only if all the persons in the room go out. The microcontroller receives the signals from the sensors, and this signal is operated under the control of software stored in the ROM. The microcontroller continuously monitors the infrared receiver. When any object passes through the IR receiver, the IR rays falling on the receiver are obstructed, this obstruction is sensed by the microcontroller and the lights turns ON and also its counts with the help of 555 timer present which acts as o counter.

### 1.1 Objectives of the Project

The objective of this project work will thereby include;

1. To design and construct a simple lighting control and counting device with the aid of a microcontroller.
2. To ease up digital counting devices through the aid of infrared beam.
3. To create awareness in electrical and electronic design in digital counting devices.

4. To stimulate students interest in the growing field of digital counter and microcontroller programming.
5. To conserve utility (electricity supply) system.

## 1.2 Methodology of the Project

The methods used in carrying out the project are as follows;

The project uses one power source; the regulated 5V from the main source (PHCN). This arrangement provides a steady power supply to the circuit. The seven segment display used are common -anode and are connected in parallel, multiplied to reduced the number of inputs and outputs.

The microcontroller does the above job and It also receives the signals from the sensors, and this signal is operated under the control of software which is stored in ROM. Microcontroller AT89C51 continuously monitor the Infrared Receivers, When any object pass through the IR Receiver's then the IR Rays falling on the receiver's are obstructed, this obstruction is sensed by the microcontroller.

The switches are connected to each seven segment display to switch current to each LED in other to display the number of persons coming in and also the number of persons leaving the room with the aid of the counter.

But if in daylight the lighting bulb will not glow but immediately its dark the lighting bulb will glow due to the present of a photo resistor present in the design of the project.

## 1.3 Scope of the Project and Limitations

The application of AOUCS cannot be over emphasized in the world of electronics because of its significance in electricity conservation. Such practical application includes the switching ON or OFF of electric light or bulb in a room.

The AOUCS is based on sensors, integrated circuits (ICs), and microcontrollers and also on the relay switches. It also has a counter that counts the numbers of persons that goes out and its shows this from its display using a seven segment display led.

The limitation of the AOUCS is that it can not detect two persons coming inside a building at a particular time; it will sense error of such occurrence, unavailability of some of the principal components especially in this locality and also high percentage of malfunctioning of faulty IC's being sold as new ones.

## 1.4 The Significance of the Project

The benefits of AOUCS are many, in terms of energy conservation and environmental impact are significant. The system's overall operation and benefits from reduced energy consumption, improved working environments. The production of electricity is the largest single source of air pollution from the burning of fossils fuels. A power plant used to generate electricity burns oil, coal or natural gas that emits gases such as carbon dioxide, sulphur dioxide. These gases, in turn cause acid rain, smog and global warning. Conserving energy reduces the amount of fuel that has to be consumed, thereby reducing the amount of pollution Generated.

## 1.5 SOURCE OF MATERIALS

Materials used for this project was sourced from several places, they include various textbooks, previous final year project, lecture notes and numerous websites on the internet with the internet yielding the most valuable references.

Components and working tools were sourced locally from minna.These include resistors, relay, capacitors, connecting wires, microcontroller and transistors to mention a few while the working tools include digital millimeter, soldering iron and screwdriver.

## 1.6 Project Layout

Chapter one; focus on the introduction, gives a brief overview of the topic and states project objectives, scope, problems and methodology adopted.

Chapter two; mainly on literature review bringing to light historical developments, advancement and limitations of other works, it's also contains the theoretical background of project.

Chapter three; contains circuit diagrams, design and analysis, it specification, circuit requirements and design approach and contains detailed notes on the components used defending their choice over contemporaries.

Chapter four; system construction and testing.

Chapter five; final chapter summarizes the project's area of application, problem encountered and limitations of the work as well as suggestion fro further improvement.

# CHAPTER TWO

## LITERATURE REVIEW

The idea of lighting and occupancy is familiar to everyone but it is a concept which is difficult to describe. The literature review of this project would be apparent if I failed to critically examine the historical and development of lighting.

### 2.1 History and Development of Lighting

In recent years researchers have been seeking a new economical solution of light systems. With the current increase in electricity demand, energy conservation has become a heavy consideration. Although it makes up 25% of all electricity consumed nationally, lighting is often overlooked as a potential source of conserving energy. An automatic light control device uses photoelectric beams to detect a person entering or leaving a room and a microcontroller is used to keep track of the number of occupants of a room, keeping the lights on until the last person leaves. This system could potentially reduce light usage of a room or occupancy by as much as 55%. [5]

In Nigeria, lighting accounts for approximately 30% of annual electricity consumption, while in UK its 20% of electricity consumption, therefore it is important to ensure that lighting installation are as energy efficient as practicable. The lighting device in use enable automatic switch-off of lighting when buildings are unoccupied and automatic dimming when sufficient daylight is available. The device can be set up quickly and easily and without the need to run cables.

### 2.2 First Generation Day Lighting Technology

Lighting as been in existence ever since the first day God created heaven and earth he said "Let there be light and there was light". But as changes started occurring to man, man knew it high time, for them to have light when there is darkness, so firewood was the first lighting system man used in lighting there environment when its dark. Man tried various modes of lighting but the day Faraday discovered electricity it solved man's problem at least 30% of the problem was solved, thereafter several scientist tried to apply electricity to lighting, which was successfully achieved through Rubinstein who invented the lighting bulb in 1890, from there various scientist has discovered lighting system which lead man to the second generation of lighting.

## 2.3 Second Generation Day Lighting Technology

The wireless lighting management solution that is been design today is the second generation of lighting, which include lighting sensor and control technology. The second generation which depends on a wired network is now in use all over the world after scientist first recognized the large potential for saving energy by taking advantage of day lighting.

Some various team's of researchers at Berkeley lab began developing an integrated building equipment system (IBECS) to allow facilities managers to automatically control devices such as lighting in commercial buildings, using a computer workstation and a wired network.

The team developed a set of prototypes, including a digital interface for dimmable lighting fixtures, a light sensor, switches, and a user interface for controlling the network from a personal computer. Their research demonstrated that automated network control of lighting system could be cost effective in new construction and major renovation project where it is relatively easy and inexpensive to run the necessary wiring.

The light is controlled wirelessly by the motes, which receive instruction from a single board computer that connects the entire network of motes to a PC running lighting control software. The research team has also developed a wireless environment sensor that measures the lighting level in a room. [5]

Energy may be saved by ensuring that lights are used when or to the extent when they are needed. The University of Michigan has implemented automatic lighting devices in offices, corridors, restrooms and classrooms.

## 2.4 Third Generation Day of Lighting Technology

The Third generation day lighting control system entails the design of an "Automatic Occupancy and Utility Control System". This device is a lighting and control system that light with the aid of infrared, microcontrollers, and photodiodes that measure the lighting level in a room, tells whether the room is occupied or empty i.e. transmit this information through the microcontroller. Light sensor control switches on/off automatically. Helpful for the elderly, disabled or children. It has the following features;

1) Turns on at dusk and off at dawn automatically
2) Emits bright and warm light
3) Modern design
4) Economical and long life LED technology which generates almost no heat
5) For use in rooms where background light is needed.

Since the device maybe left dormant for a long time and will be required to operate with fast response, there must be a reasonable guarantee that it will operate without human intervention; hence reliability is of utmost important. The system must be able to trigger immediately a person enters the room and power up the light bulbs; thus the systems response must be fast and accurate.

In Nigeria today, the need for electrical power conservation can no longer be ignored, considering the state of power generation, transmission and distribution in the country. It is obvious that this system has come of age and needs to be part of every home or office in present day Nigeria. However, importing such devices may be too expensive and out of reach of most Nigerians, but local manufacture of the device using readily available components would to a large extent resolve this problem of cost.

## 2.5 Theoretical Background of the Project

The theory of this project incorporates various theories and principle of electronics. These are drawn from topics such as optoelectronics, power electronics, integrated circuit electronics and electromechanical devices.

The "Automatic Occupancy and Utility Control System" can be divided or broken into different circuits segments namely;

1) The Transmitter circuit
2) The Sensor/Receiver circuit
3) The Microcontroller
4) The Counter/display
5) The Switching circuit
6) The Power supply unit

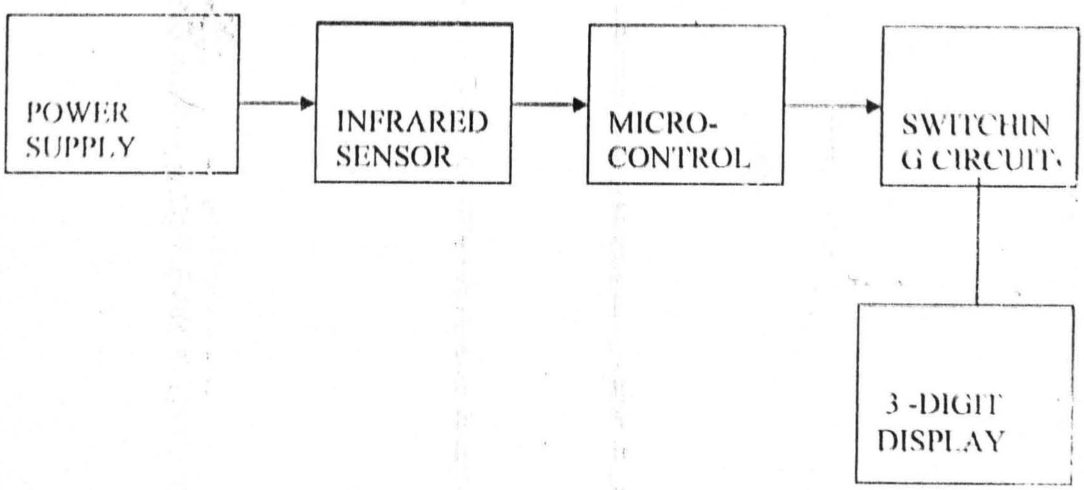


Fig 2.0 block diagram

### 2.5.1 The Transmitter Circuit

This is the portion of the system where the infrared beam originates. The transmitter is a light emitting diodes that emits light in the infrared region. It sends a continuous beam of signal with a beam angle of 40 degrees over a distance to the infrared sensor and maintains a constant link with the receivers. If this link is broken, the receiver which is always active LOW becomes active HIGH. The infrared diode operates at a frequency range of 32 KHz to 40 KHz. The infrared diode is combined with a 555 timer operated in a monostable mode to produce a single rectangular pulse, whose amplitude, pulse width and wave shape depends upon the values of circuit components. [7]

### 2.5.2 The Receiver Circuit

The receiver segment consists of infrared sensors which detect infrared signals especially in a waveform. The infrared sensors are on active LOW which means the microcontroller is presented with logic 0 when an infrared signal is detected. When no signal is received, the logic becomes 1 which is active HIGH. Once the link is intact or broken, the sensor sends a signal to the microcontroller for interpretation. [7]

### 2.5.3 The Microcontroller

The microcontroller serves as the "Brain" of the entire system. It processes the signal from the sensors and determines the action to be taken. The microcontroller is responsible for deciding if there is any person still left in the room or not. The ROM stores the software which the microcontroller uses to control the trigger or switch. Reset is used to put the microcontroller into a known state. Normally when a microcontroller is reset execution starts from address 0 of the program memory, this is where the first executable user program resides. The reset action also initializes various SFR registers inside the microcontroller. [8]

### 2.5.4 AT 89C51 Microcontroller

The 89C51 microcontroller used in this project is a member of 8051 microcontroller, which was introduced in the early 1980s by Intel. Despite its relatively old age, the 8951 is one of the most popular microcontrollers. It has three (3) general types of memory; (i) Codes memory (ii) Special Function Register (SFR) and (iii) External memory.

The 89C51 contains Flash Programmable and Erasable Memory (PEROM), where the codes (programs) memory can be reprogrammed. They are compatible with the 8051 family and offer reduced power consumption and high functionality.[8]

### 2.5.5 The Counter /Display

This segment of the system is under the direct control of the microcontroller, and is used to display the number of persons in the room. We can display a multi-digit number by connecting additional displays. The 8 LEDs inside each display can be arranged with a common cathode or common anode. With a common cathode display, the common cathode must be connected to the 0V rail and the LEDs are turned on with logic 1. Common anode displays must have the common anode to the +5V rail. The segments are turned on with logic 0. For the purpose of this project common cathode display is used. Displaying digits is carried out in multiplex mode which means that the microcontroller alternately prints ones digit and tens digit. The simplest way to drive a display is via a display driver, but alternatively displays can be driven by a microcontroller and if more than one display is required the method to drive it is called multiplexing. The main difference between the two methods is the number of drive lines.[6] [2] [1]

### 2.5.6 The Switching Circuit

The switching circuit is made up of a PNP transistors switch which is used to energize the relay. The transistor has two different states, the ON and OFF.[1]

### 2.5.7 The Power Supply

Power supply is a basic requirement of every electronics system; power must be available for the electronics system to perform its specified duties. Power supply can be in form of Alternating Currents (AC) power supply or a Direct Current (DC) power supply. The power supply unit for the system was built using a 240V/12V Step down transformer, full wave bridge rectifier, a 100uf Capacitor for smoothening of the signal output from the bridge rectifier and a 12V 7805 voltage regulator that makes sure the 12V voltage required for triggering the relay is produced. For the alternating current power supply to become a direct current power supply, it must undergo some processes which are transformation, rectification, filtering and regulation.

# CHAPTER THREE

## ANALYSIS AND HARDWARE DESIGN

The analysis of the AOUCS provides both theoretical and mathematical equations involved in the design. The hardware design (circuit's construction) is achieved based on the results obtained from this chapter. Figure 3.8 shows the complete circuit diagram of the Automatic Occupancy and Utility Control System. The values and types of all electrical components have been indicated neatly. For the sake of simplicity and accuracy, the circuit was divided into different units as shown below in fig. 1.0 and represented by the flow chart of figure 3.0. This chart elaborates how the calculation involved would be done.

The 'Automatic Occupancy and Utility Control System' comprises of the following subsystems;

(i) 5Volts Regulated system power supply

(ii) 3-digits 7 Segment display

(iii) 8-bit System controller

(iv) LDR Light sensor

(v) IR Generator

(vi) IR Receiver

### 3.1 System Power Supply

Power supply is a basic requirement of every electronics system; power must be available for the electronics system to perform its specified duties. Power supply can be in form of Alternating Currents (AC) power supply or a Direct Current (DC) power supply. The power supply unit for the system was built using a 240V/12V Step down transformer, full wave bridge rectifier, a 100µf Capacitor for smoothening of the signal output from the bridge rectifier and a 12V 7805 voltage regulator that makes sure the 12V voltage required for triggering the relay is produced. For the alternating current power supply to become a direct current power supply, it must undergo some processes which are transformation, rectification, filtering and regulation.

### 3.1.1 Transformation

This is the process of stepping the AC mains supply into smaller values through the use of a step down transformer.

### 3.1.2 Rectification

Rectification is the process where the AC voltage at the output of a transformer is converted into DC. The process is accomplished by using rectifier diodes which permit the flow of current in one direction only.

### 3.1.3 Filtration

This process involves the removal of AC ripples from the rectified voltage. It involves the use of a capacitor to filter off the ripples which are always embedded on the DC output.

### 3.1.4 Regulation

The process of filtering is not sufficient to completely eliminate AC ripples from the DC output of the rectifier due to the fact that the capacitors used has the ability to charge and discharge with time. Consequently voltage regulators are employed to stabilize the output voltage before it is made available to the load.

## 3.2 Generation Of The 5volts Power Supply

A +5V regulated system DC voltage (operational) is required for unit operation; this system supply was derived from a 12V- 0.5A stepdown transformer which is therefore connected to a fullwave bridge rectifier as shown below.

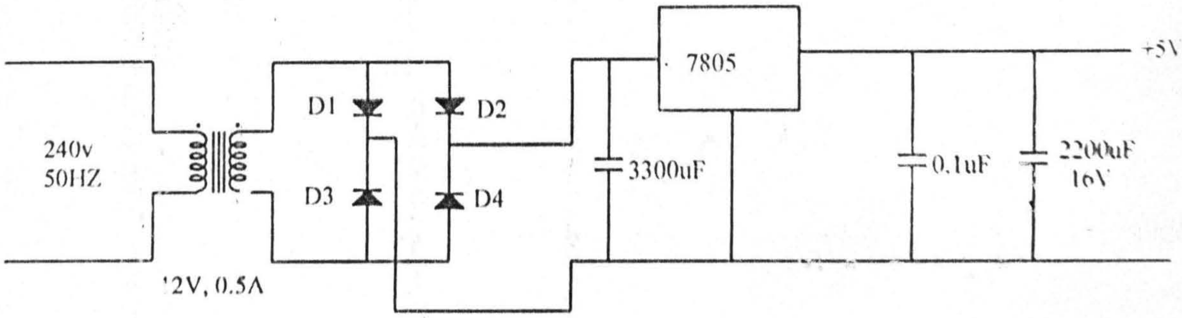


FIG 3.0 +5 POWER SUPPLY SYSTEM

The 12V AC voltage was connected to a pulsating DC of frequency of 100Hz and amplitude given by the expression

$$V_{dc\,(peak)} = \left[V_{rms}\sqrt{2} - 1.4\right] \text{ volts}$$

$V_{rms}$=RMS AC input voltage into rectifier

$\sqrt{2}$=RMS –to – Peak conversion factor

1.4= Forward voltage drop in two adjacent diodes of the rectifier.

For a 240V AC line condition

$V_{dc\,peak} = 12\sqrt{2} - 1.4 = 15.56$volts

This voltage was smoothened by a capacitance of value,

$C=\frac{It}{V}$, I= Maximum load current

t= ½ f =1/2 ×50Hz

V= Maximum AC ripple Voltage

It was deduced from the approximate summation of the current drawn by the different subsystem as totalized below:

$I_{RELAY}= V_{coil}/R_{coil} = \frac{6}{100} = 60mA$

AT89C51-15mA (12MHz)

3-Digit display -210mA peak

IR Sensor + LDR Sensor =20 ma

$\sum I = 305MA$

The maximum AC ripple voltage was calculated using the data supplied in the 7805 regulator spread sheet

For a 5volts regulated output, the input voltage is 7volts (2 volts overhead is needed to maintain the output regulated)

On a 15.5V peak input voltage, the minimum input voltage is 7V, corresponding to a peak AC ripple voltage of 15.5-7= 8.5V

Therefore,

$$C = 0.305 \times i/2 * 50/8.5 = 360\mu f$$

The above calculated value is the minimum value needed to maintain a regulated 5 volts output. It was increased by a factor of 9 for improved system performance.

The 5 volt DC output was stabilized by a 16V 2200μf

Capacitance, and filtered of HF noise by an 0.1μf capacitance as indicated in fig 3.0

### 3.3 System Controller

An 8-bit AT89C51 microcontroller was used for the system control. It was interfaced with other system components as shown below.

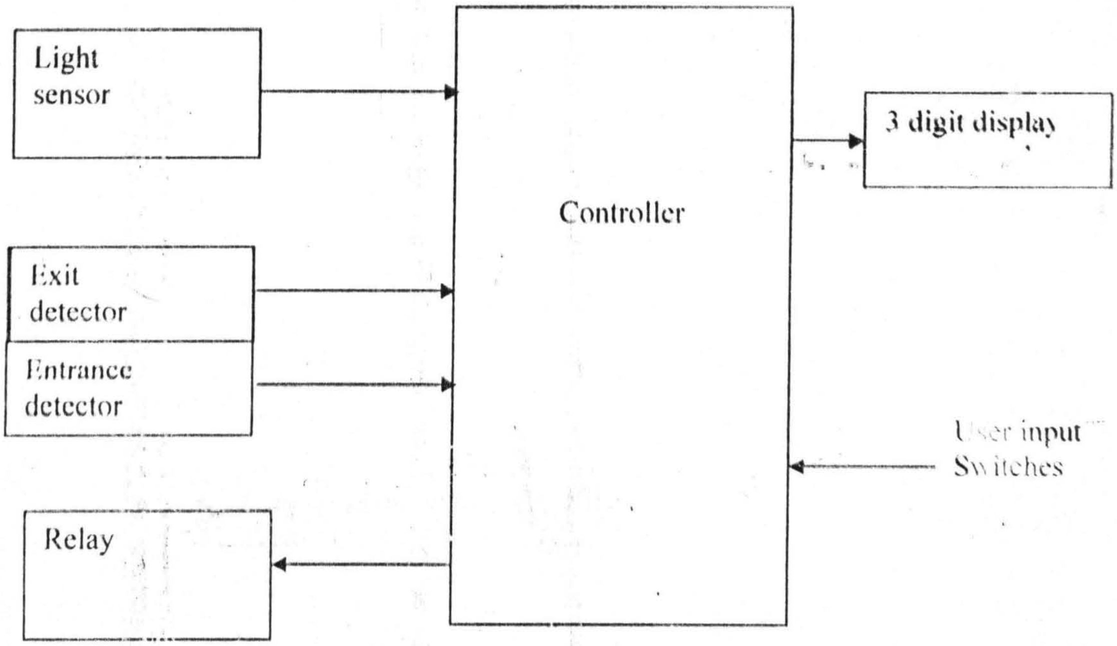


Fig 3.1 system component functional block diagram

The controller was programmed to execute the following system operation

(I) Refresh the 3-digit display depending on the accumulated value of the residual count.

(II) Detect the presence/ absence of ambient light over an input pin (P1.0)

(III) Control a connected lamp load via a relay.

(IV) Detect the exit and entrance motion from the IR sensors interfaced to the controller over P3.2, P3.3.

(V) Respond to user controlled input switches interfaced to P2.4, P2.5 and P2.6.

The controller was programmed to interrupt on the falling edge. Two interrupt special registers (ISRS) were written to handle the two cases which are entrance and exit. Three registers designated to hundred, tens and units were accordingly decremented or incremented on the ISR depending on whether it is an exit event or entrance event.

The controller was also programmed to respond to user preset of the display occupancy level by way of three keys interfaced to P2.4-P2.6.

The keys used in occupancy level are used where the counting are not zero based.

The controller was interfaced with the 3-digit display over P2.0, with P2.1-P2.3 providing digit position control via three PNP driver transistors. The controller was also programmed to automatically turn on/off a connected lamp load depending on the current occupancy level.

If occupancy is zero and ambient lighting is not detected, the lamp is turned off via a 6-volts relay.

If occupancy level is greater than zero and ambient light is detected, the lamp is turned off, otherwise it is turned ON.

### 3.4 3 Digit 7-Segment Display

A display was used to provide a running count of the occupancy level. A multiplexed display was used to reduce the number of I/O pins needed to address the segments. The display was controlled via three PNP digit driver as illustrated below

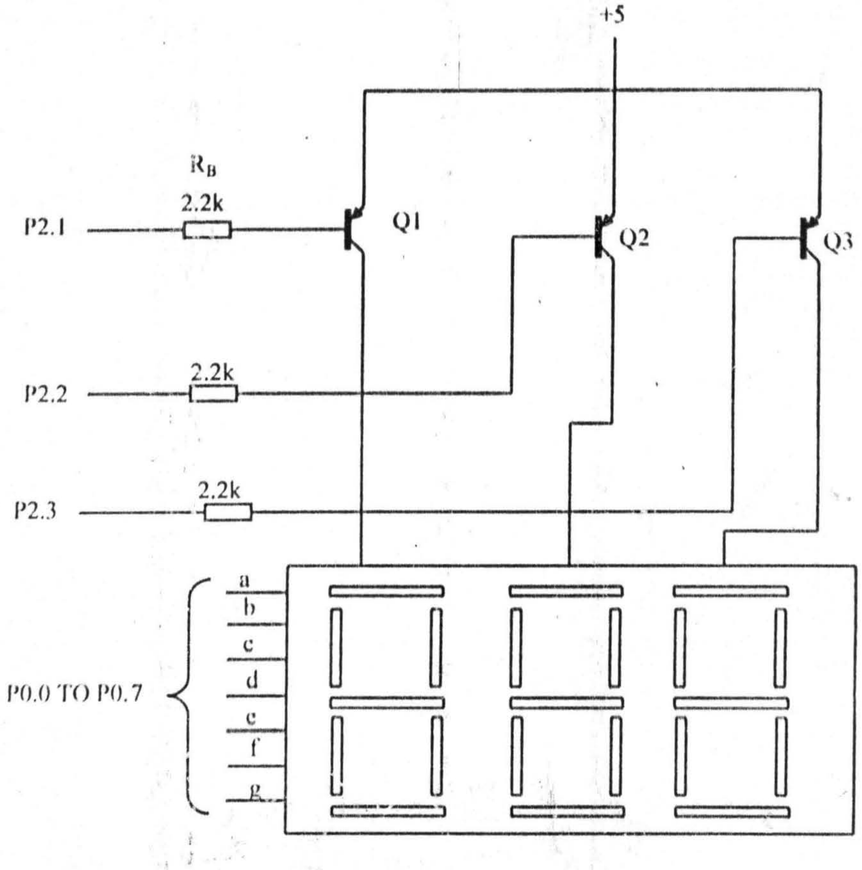


Fig 3.2 3 digit seven segment display

ф1- ф3 was 2SA1015GR PNP transistors. They were used to individually select the digit to be addressed. They were controlled over P2.1, P2.2 and P2.3 from software.

A multiplexed display works on the basis of time slice allocation of the common data path (P0). The time slicing was done in software via ϕ1- ϕ 2.

To address a multiplexed display, the digit drivers are first turned OFF; the data to be display on the display segment is written on the common data path. The digit driver for the display digit position is turned ON. The driver is turned ON for an interval depending on the system requirement. The digit driver is turned OFF and the other digit driver controlled as explained above.

For an n-digit multiplexed display, the current through each segment is equal to $I_{LED} \times N$.

$I_{LED}$= Condition LED forward event (5mA ~20mA) for standard RED LEDS.

n= no of digits in the display, for a 3-digit display and a $I_{LED}$ of 10mA, the current through each segments thus give

$3 \times 10mA = 30mA$

The total current through each digit with the 7 Segments ON is thus

$30mA \times 7 = 210mA$

The above value of digit current is therefore the collector current of each PNP digit driver transistor.

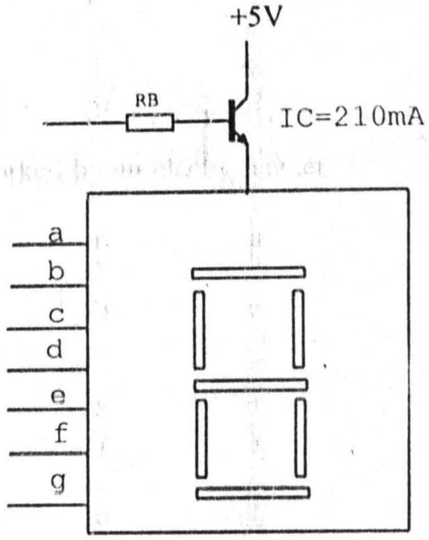


Fig 3.3 PNP digit driver transistor

The transistor used have an high frequency about 200Hz

Since $I_C = I_B \times \beta$

$I_B = I_C/\beta = 0.2/200 = 1mA$

$R_B = V_{CC} - V_{BE}/I_B$

$= 5 - 0.7/0.001 = 4.3K\Omega$

The value was halved to $2.2k\Omega$

### 3.5 Relay Driver

A relay is a switch worked by an electromagnet it is useful if a small current in one circuit is needed to control another circuit containing a device such as lamp or electric motor which requires large current, or if several different switch contacts are to be operated simultaneously.

When the controlling current flows through the coil, the soft iron core is magnetized and attracts the L-shaped soft iron armature. This rocks on its pivot and opens, closes or changes over, the electrical contacts in the circuit being controlled and it closes the contacts. The current needed to operate a relay is called the pull-in current and the dropout current is the current in the coil when the relay just stops working.

A PNP transistor was used to turn ON/OFF the relay controlling the lamp load.

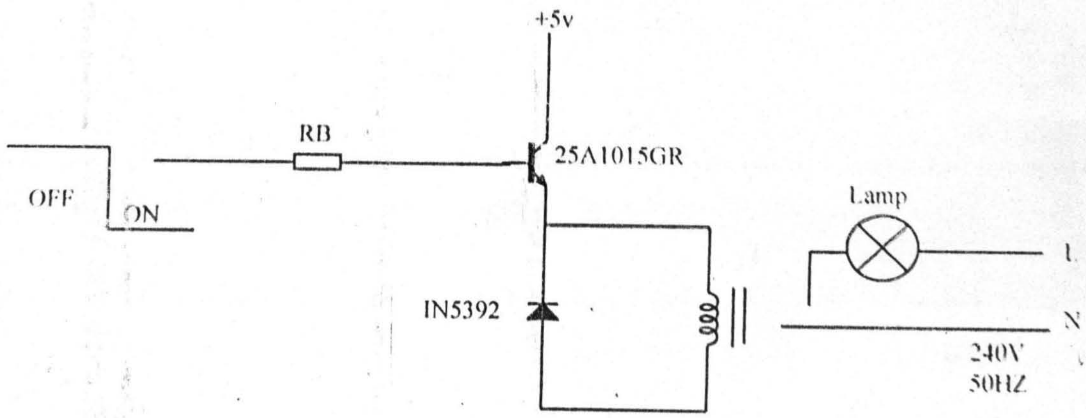


Fig 3.4 relay driver

The relay has a coil resistance of 100ohms, at a coil voltage of 6v

$$I_{RELAY} = \frac{Vr}{Rr} = \frac{6}{100} = 60mA$$

$I_c$ of the PNP transistor=60mA

$$I_B = \frac{0.06}{200} = 0.0003A$$

$$R_B = \frac{Vcc - VBE}{IB}$$

$$=\frac{5-0.7}{0.0003}=14Kohms$$

The value was reduced to 2.2kohms to guarantee switching under all possible circumstance.

### 3.6 Preset Key Inputs

This are normally open mechanical switches which are connected to P2.4, P2.5 and P2.6 as shown below

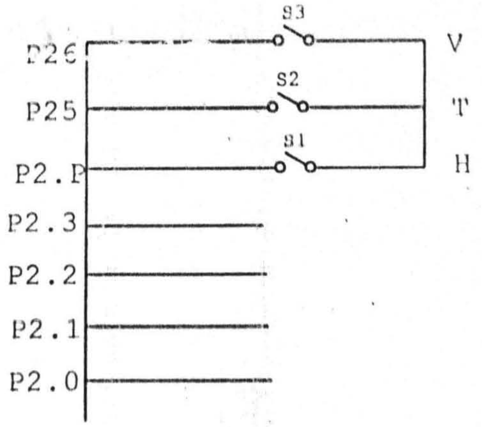


Fig 3.5 preset input switches

Key presses were detected by a closure to ground the three keys, which are used to adjust the occupancy level as desired .A key was dedicated to each RAM variable designated to hundreds, tens and units. In software the RAM variable were cognized as BCD up-counters incremented from 0 to 9 and then reset back to 0

### 3.7 LDR Light Sensor

To ensure detection of the presence and absence of ambient light, an LDR light sensor was used. An LDR exhibits a negative coefficient light dependent resistance. LDR IS only a resistance, it was wired in a potential divider network as shown below e

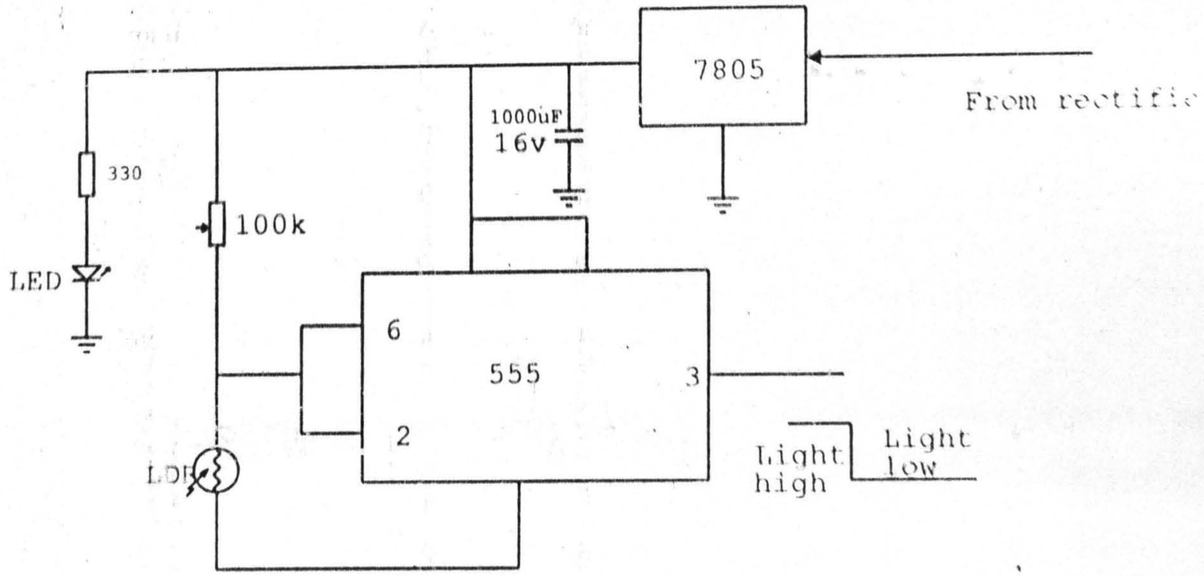


fig 3.6 LDR light sensor

The output voltage, Vx, of the divider does not posses the characteristics of a digital logic level. Therefore a waveform regenerator was used to provide a clear logic level compatible digital output.

An NS555 device was configured as a Schmitt trigger with an upper and lower switching thresholds.

As configured above, the output, pin 3of the device switches low when $Vx \geq \frac{2}{3}$ Vcc, that is at $\geq 3.3V$. Pin 3 remains low until $Vx \leq \frac{1}{3}$ Vcc that is 1.66V at which point pin 3 rises high.

Vx is high due to the very large value of the LDR resistance; The 555 output is then low. This detected in software as a low light level or total light absence. In the light .Vx is low, the 555 timer switches high. This is detected as a high ambient light level.

### 3.8 IR Generator

To enable entrance and exit motion detection two pairs of IR Generator and Receiver were needed.

The IR generators were required to produce a 30 KHz IR signal that is beamed across the monitored space in the direction of the IR sensors.

The IR Generators were based on the 555 device configured as an astable oscillators

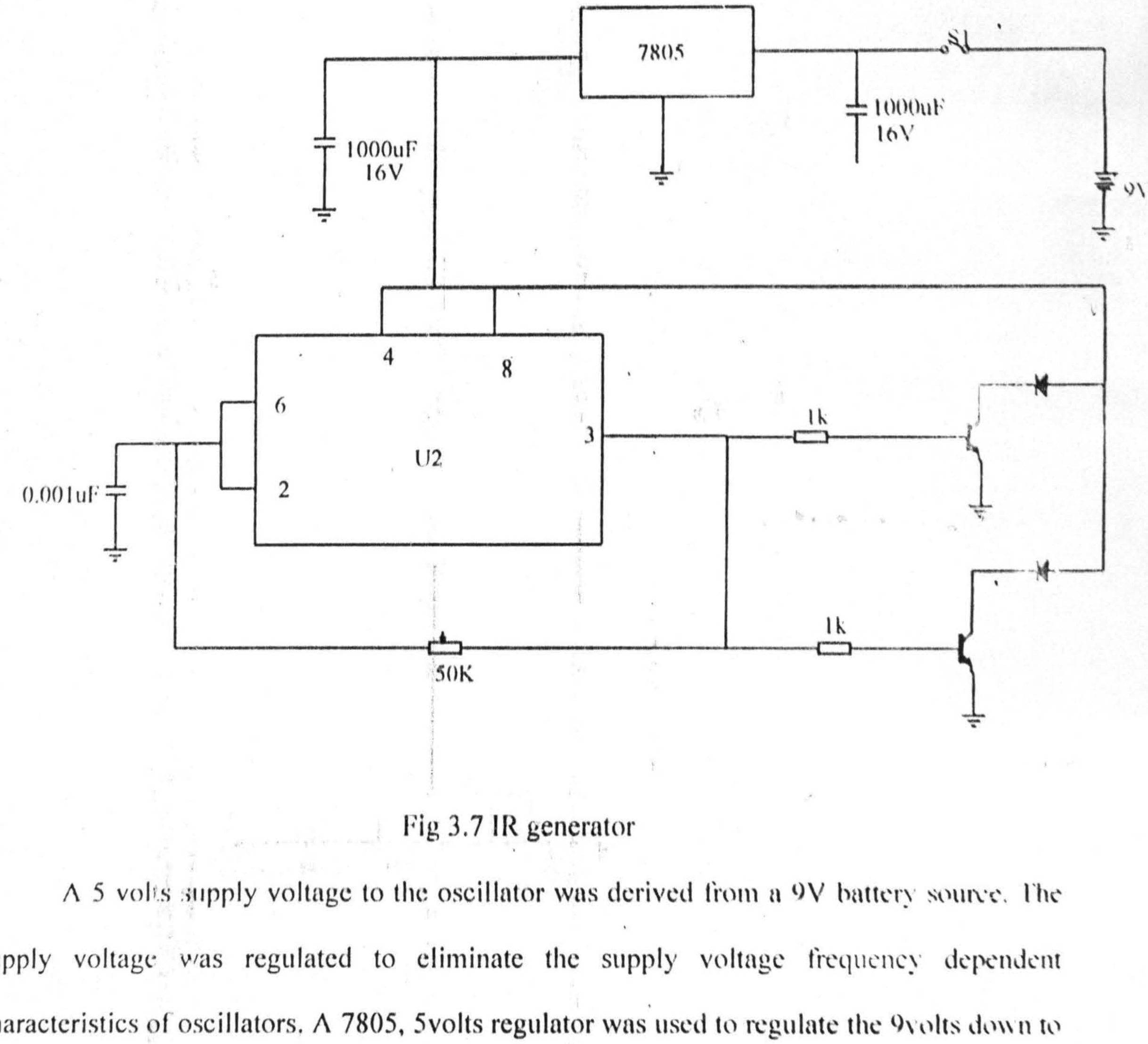


Fig 3.7 IR generator

A 5 volts supply voltage to the oscillator was derived from a 9V battery source. The supply voltage was regulated to eliminate the supply voltage frequency dependent characteristics of oscillators. A 7805, 5volts regulator was used to regulate the 9volts down to +5V.

A 555 device configured as a 50% duty cycle astable oscillator was used to generate an output frequency centered around 38KHz. The output frequency was derived by an $R_T$ $C_T$ combination g and given by the expression)

$F_{OS}=1/2\Pi R_T C_T$

$R_T$ was a 50kohms adjustable resistance while $C_T$ has a 0.009uf capacitance.

$R_T$ was adjusted to generate the required output frequency while the frequency was monitored on a frequency meter.

The 33 KHz high frequency drives signals was fed into the base emitter circuits of two C9014 transistor as shown in fig 3.7

In each transistor collector was a load comprising an LED (IR) and a series current limiting resistance. The value of the resistance were reduced from the expression

$$R_s = \frac{Vs - Vled}{Iled}$$

$V_s = 15v$, $V_{LED} = 9V$;

$I_{LED} \leq 0.5$ A (max)

On $I_{LED}$ current of 10mA was chosen for range

$$R_s = \frac{5-1}{0.01} = 400v$$

The value was reduced to 330Ω

The base current values of the transistors were calculated accordingly

Since $I_C = I_{LED} = 10mA$

Hfe=200

$$I_B = \frac{Ic}{Hfe} = \frac{0.01}{0.02} = 50mA$$

$$R_B = \frac{Vat(555) - VBE}{IB}$$

$$= \frac{2.5 - 0.7}{0.00005} = 36K\Omega$$

The value was reduced to 1KΩ to allow for overdrive.

### 3.8.1 IR Sensors

A pair of commercially produced TSOP1738 IR sensor was used to detect beam discontinuity between the IR generator and the detector units.

The TSOP1738 were interfaced with 555 monostables configured with for a 1-second pulse width.

The monostables were incorporated to prevent spurious noise on the supply coils to the sensor from supply coils to the sensor from falsely interrupting the microcontroller.

### 3.8.2 IR Detector

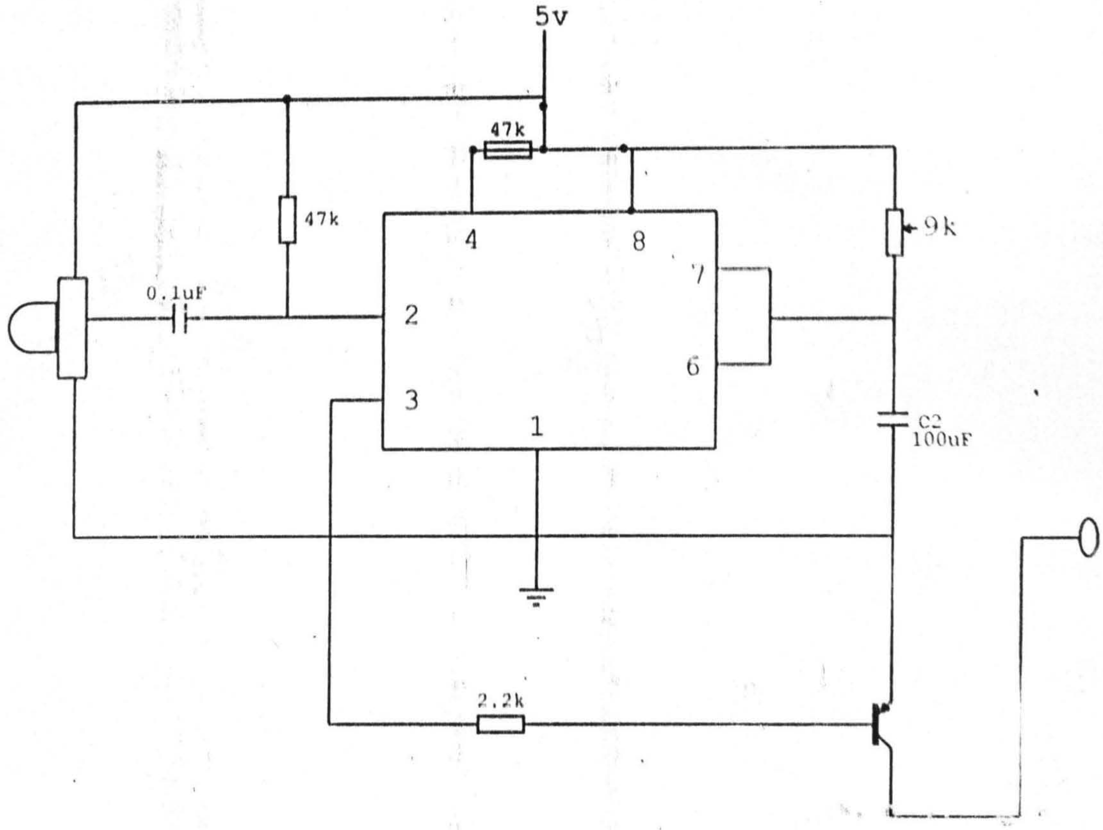


Fig 3.8 IR Sensor/detector

The value in parenthesis refers to the components in the second modular box. The TSOP's maintain their output wish when they receive an unmodulated high frequency beam. When a beam discontinuity is detected, their output s switch low, triggering the monostable and pulsing their outputs high, forcing a high to low transition on the interrupt inputs P3.2 and P3.3.

Interrupts were used to prevent the system missing exit and entrance events.

The three cascaded RAM registers (H,T,U) were run as a 3-digits up/down BCD counter incremented or decremented depending on whether the event that triggered an interrupts either an entrance or exit motion. The output pulse width of the 555 timer was computed from the expression T=RTCT

RT is the resistance between Vce and pin 7/6, CT is the capacitance between pin 7/6 and ground.

Since the controller requires a falling edge transition, its interrupt pins not gates derived from non transition were interposed between the 555 timer outputs and the interrupt inputs. With the TSOP's constantly radiated by the 38KHz IR signal, pin 2 on the monostable is high. However when beam discontinuity occurs, the TSOPS switch low , pulling the voltage on pin 2 of the 555 below $\frac{1}{3}$Vcc (≤1.66V),triggering the 555 timer and producing a 1 – second output pulse width which generates an interrupt condition in the system control software.

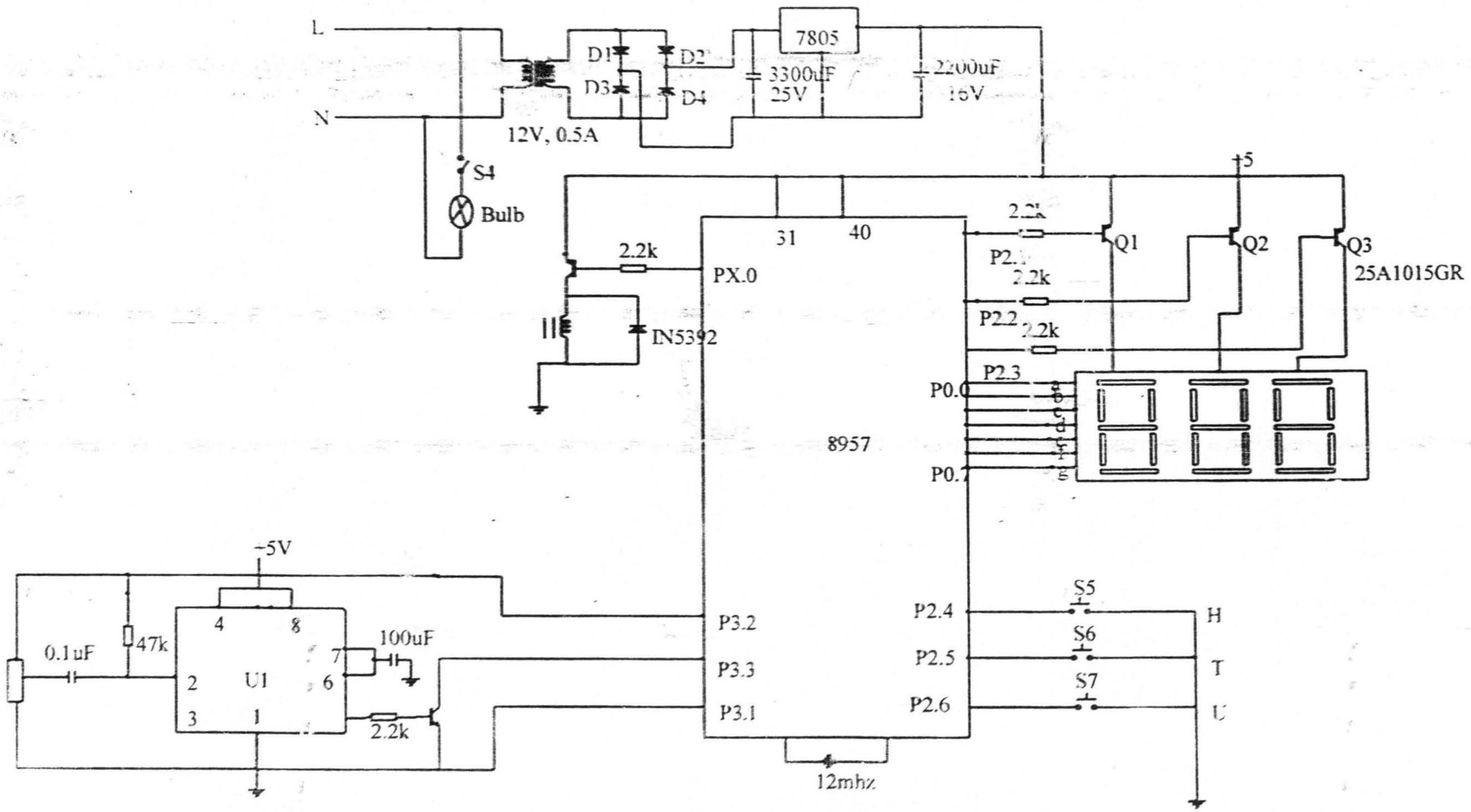


Fig 3.9 Complete circuit diagram of an Automatic Occupancy and Utility Control System

# CHAPTER FOUR

## CONSTRUCTION, TESTING AND DISCUSSION OF RESULTS.

### 4.1 Circuit Construction

Construction techniques involves a proper understanding of the design stages, acquiring adequate hardware components and minimizing the amount of components used. However, the most important aspect of construction is how to interface the different components to work effectively together. This brings about compatibility.

Compatibility is always a problem in electronic system design, but the ultimate aim of the construction is to ensure that the components work eventually so as to realize the objective of the project. The construction of the project started with a good understanding of how a microcontroller works and also programming it based on how other hardware components that would be connected to it. The programmed for the microcontroller was simulated to ensure that it was error free before the components were put together on a bread board to ensure effectiveness.

The construction of the project work was done in two different stages namely:

1. The soldering of the circuit to the board
2. The coupling of the entire project to the casing

The power supply unit was done with great care; it was derived from a bench power supply which supplied voltage to the various stages of the circuit.

The counter and receiver stages were constructed and tested on the bread board according to the block representation, before soldering of circuit commenced on the Vero board. The various stages and circuit were soldered in tandem to meet the desired workability of the project.

## 4.2 Casing Construction

The second phase of the project construction is the casing of the project work. The project was coupled to a plastic casing, the casing material was designed with special perforation and vents to ensure insulation and give ecstatic value.

## 4.3 Testing

Testing involves troubleshooting the hardware system to detect, isolate and correct internal or external fault such as malfunction in internal circuitry. It is expedient that the hardware system is properly tested because the software cannot work where there is a malfunction in the hardware. Testing of the design was carried out using various equipment which are:

1. **Bench Power Supply**: This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the project was soldered.
2. **Oscillloscope**: The oscilloscope was used to observe the ripples in the power supply waveform and also to observe the pulse generated at the monostable multivibrator circuit.
3. **Digital Multimeter**: the digital multimeter basically measures voltage, resistance, continuity, current, frequency, and temperature. The process of implementation on the board required the measurement of parameters like the voltage, continuity, current and resistance values of the components. The multimeter was also used to check the voltage level of the ray of light that was transmitted using the infrared in this project.

## 4.4 Result

The result obtained from testing the design showed that the design was able to recognize the presence of a person obstructing the infrared beam either entry or exit of the room bearing in mind that the room is empty of persons. A simulation was carried out using a prototype model and the result obtained are;

(1) The light bulb turned ON when an object representing a person entered the room and the seven segment display indicates a count to show the presence of a person.

(2) Repeating the process, the light remained ON and the indicator kept incrementing as more people entered the room.

(3) Reversing the process, the light bulb remained ON and the counter kept decrementing until no one was left in the room and the light bulb turned OFF.

On powering, the light bulb flashes ON and OF. This is due to the microcontroller resetting.

**4.5 Problems Encountered**

Like every other research and practical engineering work, diverse kinds of problems are often encountered. The problems encountered in this project and how they were solved and maneuvered are listed below;

(1) How to design a path that tells the microcontroller whether a person is coming in or coming out of the room

(2) Programming the microcontroller to monitor sensors as well as counting visit.

(3) Presence of external influence of light to the LDR which was affecting the current, this was solved by shielding the LDR with a black tape.

# CHAPTER FIVE

## CONCLUSIONS AND RECOMMENDATIONS

### 5.0 Conclusions

The design and construction of the Automatic Occupancy and Utility Control System was accomplished using electronic components that are readily available locally. This project was constructed bearing in mind the need to provide a cost effective way of conserving electrical energy or power through the turning ON or OFF of the light bulb when appropriate. The performance of project after testing showed that the system met these design specifications. The microcontroller made the realization and implementation of the project less stressful and relatively easy. The device is responsible for determining if the room was occupied and if the bulb should remain ON or be turned OFF.

### 5.1 Recommendations

Like most other systems in the world, this project had some limitations and therefore leaves room for improvement. The observed limitations and their respective recommendations are:

(1) The project assumes that the room is initially empty of person and will not operate as designed if for some reason this assumption is not met.

(2) The system might not sense extremely fast movement through the door. Using sensors with greater sensitivity could resolve this problem.

(3) A simple power switch could be incorporated into the system to serve as manual override when the light is not required in the room during a particular period of time

(4) Display could be made of liquid display crystal (LCD) in order to reduce power consumption

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# APPENDIX

```
INCLUDE 89c51.mc
load_dx BIT p2.0
digit_1_Dx BIT p2.1
digit_2_Dx BIT p2.2
digit_3_Dx BIT p2.3
display_port EQU p0
hundreds DATA 10h
tens DATA 11h
units DATA 12h
data_0 DATA 13h
data_1 DATA 14h
data_2 DATA 15h
dx_port EQU p2
update_buffer_flag BIT 05h
stack EQU 60
hundreds_key BIT p2.4
tens_key BIT p2.5
units_key BIT p2.6
light_in BIT p1.0

;*****************************************************************************
org 0000h
AJMP start_up
```

```
;**********************************************************************

org 0003h

aJMP go_plus

;**********************************************************************

org 0013h

aJMP go_minus

;**********************************************************************

start_up:      CLR ea
               MOV sp,#stack
               ACALL sys_init
               CLR load_dx

mainloop:      ACALL update_system
               ACALL scan_key
               ACALL write_display
               ACALL chk_occupancy
               SJMP mainloop

;************************************************************************
**

scan_key:

scan_hundreds:          JB hundreds_key, scan_tens
```

```
                    ACALL adjust_hundreds
scan_tens:          JB tens_key, scan_units
                    ACALL adjust_tens
scan_units:         JB units_key, exit_scan_key
                    ACALL adjust_units
exit_Scan_key:      RET
;***************************************************************************
**8

adjust_hundreds:    MOV R0, #hundreds
                    ACALL adjust_now
                    SJMP go_on_show

adjust_tens:   MOV R0,#tens
                    ACALL adjust_now
                    SJMP go_on_show

adjust_units:  MOV R0,#units
                    ACALL adjust_now
go_on_show:         SETB update_buffer_flag
                    MOV R4,#100

go_loop:            ACALL write_display
                    ACALL write_display
                    djnz r4, go_loop
```

```
rET
;***************************************************************************
***

adjust_now:         MOV A,@R0
                    INC A
                    CJNE A,#10, go_check
back_adjust:  MOV @R0,#0
                    MOV A,#0
                    RET

go_check:           JNC back_adjust
                    MOV @R0,A
skip_adjust:  RET

;***************************************************************************
***
xlate_Table:  DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,11111000
b,10000000b,10010000b

;**********************************************************************
sys_init:           ACALL reset_delay
                    MOV p0,#0ffh
```

```
        MOV p1,#0ffh
        MOV p2,#0ffh
        MOV p3,#0ffh
        MOV tcon,#00000101b        ; set up int0 ant int1 to interrupt on
falling edge
        MOV HUNDREDS,#0
        MOV TENS, #0
        MOV UNITS,#0
        CLR A
        MOV DPTR,#xlate_Table
        MOVC A,@a+dptr
        MOV data_0,A
        MOV data_1,A
        MOV data_2,A
        CLR update_buffer_flag
        MOV ie,#10000101b ; enable only into and int1 here
        RET
;*****************************************************************

go_plus:    PUSH acc
            push psw
            INC units
            MOV A, units
            CJNE A,#10, go_1
back_1:     MOV units,#0
```

```
            INC tens
            MOV A, tens
            CJNE A, #10, go_2
back_2:     MOV tens,#0
            INC hundreds
            MOV A, hundreds
            CJNE A,#10, go_3
back_3:     MOV hundreds,#0
common:     SETB update_buffer_flag
            pop psw
            POP acc
            RETI

go_1:       JNC back_1
            SJMP common


go_2:       JNC back_2
            SJMP common

go_3:       JNC back_3
            SJMP common

;***********************************************************************88
go_minus:
```

```
dec_value:    PUSH acc
              push psw
              MOV A, hundreds
              ORL A, tens
              ORL A, units
              JZ no_Dec
dec_units:    MOV A, units
              JZ dec_tens
              DEC units
              SJMP common2
dec_tens:     MOV units,#9
              MOV A, tens
              JZ dec_hundreds
              DEC tens
              SJMP common2
dec_hundreds:MOV tens,#9
              DEC hundreds
common2:      SETB update_buffer_flag
no_dec:       POP psw
              POP acc
              RETI

;**********************************************************************

write_display: ACALL update_buffer
```

```
write_2:        SETB digit_1_dx
                SETB digit_2_dx
                SETB digit_3_dx

;*******************************************************************

                MOV display_port,data_0
                CLR digit_1_dx
                ACALL delay_2_Show
                SETB digit_1_dx
                MOV display_port, data_1
                CLR digit_2_dx
                ACALL delay_2_Show
                SETB digit_2_dx
                MOV display_port,data_2
                CLR digit_3_dx
                ACALL delay_2_Show
                SETB digit_3_dx
                RET

;*******************************************************************8

update_system:
update_buffer:JNB update_buffer_flag, exit_update
                CLR update_buffer_flag
                MOV A,hundreds
                MOV DPTR,#xlate_Table
```

```
                MOVC A,@a+dptr
                MOV data_0, A
                MOV A, tens
                MOVC A,@a+dptr
                MOV data_1, A
                MOV A, units
                MOVC A,@a+dptr
                MOV data_2, A
exit_update:    RET

;*********************************************************************

delay_2_show:   MOV R5,#2
reload_r6:      MOV R6,#250
                DJNZ R6,$
                DJNZ R5, reload_r6
                RET
;*********************************************************************

chk_occupancy:  MOV A, hundreds
                ORL A, tens
                ORL A, units
                JNZ turn_on
                SETB load_dx
exit_chk:       RET
```

```
turn_on:            JB light_in, go_skip
                    CLR load_dx
                    RET


go_Skip:            SETB load_Dx
                    ret

;*****************************************************************

reset_Delay:   MOV R0,#0
reset_loop:         MOV R1,#0
loop_here:          NOP
                    NOP
                    NOP
                    NOP
                    NOP
                    DJNZ R1, loop_here
                    DJNZ R0, reset_loop
                    RET
```