

# **Design & Developing of a Microcontroller Based Smart Home Appliance Control System**

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## DECLARATION

We hereby declare that this Project is our original work. We also declare that no part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged. Requisite references are quoted to support my work.

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## **APPROVAL**

The Project titled as “Design and developing of a microcontroller based Smart Home Appliance Control System” has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering for partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics & Telecommunications Engineering by the following students and has been accepted as satisfactory.

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## **ABSTRACT**

The price of electricity is gradually increasing all over the world. In Bangladesh the price is also increasing day by day. In these circumstances, the users will try to minimize the wastage of electricity. In this project, a smart control system for home appliances has been developed to minimize the electricity wastage. The systems will automatically shutdown the electrical loads when the last person leaves the room. When the first person enters the room the loads will get power and can be run by their switches. If a person enters the room the system will increase its count by one and when a person leaves the room it will decrement its count. When the value of count is zero the power will be cut off. To count the number of persons in the room optical sensors have been used. An Arduino Uno board has been used to count the persons and control the power to the load. A program has been developed using Arduino software. The system has been constructed and tested. It is found that the system works properly.

# Chapter 1

## INTRODUCTION

### 1.1 Energy

Energy is a very important issue in our world. According to physics, energy is a property of objects, transferable among them via fundamental interactions, which can be converted in form but not created or destroyed. Energy is two types (potential energy and kinetic energy). World energy consumption refers to the total energy used by all of human civilization. Typically measured per year, it involves from every energy source applied towards humanity's endeavors across every industrial and technological sector, across every country.

### 1.2 Electrical Energy

Electrical energy is the energy carried by moving electron sin an electric conductor. It cannot be seen, but it is one of our most useful forms of energy because it is relatively easy to transmit and use. All matter consists of atoms, and every atom contains one or more electrons, which are always moving. The movement of these electrons depends on how much energy it has. This means every object has potential energy, even though some have more than others. When electrons are forced along a path in a conducting substance such as a wire, the result is energy called electricity. Electrical generating plants do not create energy. They change other forms of energy into electricity. Lightning is one good example of electrical energy in nature, so powerful that it is not confined to a wire. Thunderclouds build up large amounts of electrical energy. This is called static electricity.

### **1.3 Misuse of Electricity**

From morning to late night, we use a lot of electricity. Possibly everyone, living in the city, is well aware of the fact that there is power crisis, but still many buildings, decorated with thousands of electric bulbs hanging from the roof top for wedding ceremony, are found in the city even until late night. This type of programmes even lasts for several days. While a group suffers due to load shedding, other groups waste a high amount of electricity just for entertainment and luxury. Many people not turn off lights and fans or other home appliances when not in the room or home. It is a big reason of loss of electricity. Many people, especially in the rural areas, pass their night without electricity. There's never enough energy to waste. It is everyone's duty to turn off the TV when no one is watching it, to turn off light and fans when we not in the room. The same goes for computers and stereos.

### **1.4 Purpose of the project**

Now a day's electricity is an important part of our life. Lack of electricity creates load shedding. To solve this problem we must stop the misuse of electricity or minimize the wastage of electricity. In this project, we describe how to solve this problem and designing a smart home appliance control system. In our project, we design automatic electric load turn on and off without using any switch. In home, a big office, a shop or in a university class room we forget the turn off lights and fan after finished the work. For this project we use laser, photodiode and Arduino. It works automatically without any switch. It also used for secured our home or work place. So this control system gives safe secured environment and save the electrical energy.

### **1.5 Aim of the Project**

- To design a smart home appliance control system
- To construct a smart home controller circuit in the breadboard
- Test for its functionality
- Product commercialization
- To design the control system with low cost components

## Chapter 2

# AN OVERVIEW OF MICROCONTROLLERS

### 2.1 Introduction

In this project we use Arduino. Using an Arduino simplifies the amount of hardware and software development you need to do in order to get a system running. The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB. In addition, the I/O pins of the microcontroller are typically already fed out to sockets/headers for easy access (This may vary a bit with the specific model). On the software side, Arduino provides a number of libraries to make programming the microcontroller easier. The simplest of these are functions to control and read the I/O pins rather than having to fiddle with the bus/bit masks normally used to interface with the At mega I/O.

### 2.2 Microcontroller

A highly integrated chip that contains all the components comprising a controller. Typically this includes a CPU, RAM, some form of ROM, I/O ports, and timers. Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task to control a particular system. As a result, the parts can be simplified and reduced, which cuts down on production costs.

### **2.1.1 Advantages of Microcontroller**

1. The simplest computer processor is used as the "brain" of the future system.
2. Depending on the taste of the manufacturer, a bit of memory, a few A/D converters, timers, input/output lines etc. are added.
3. All that is placed in some of the standard packages.
4. Simple software able to control it all and which everyone can easily learn about has been developed.

## **2.2 Arduino**

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It intended for artists, designers, hobbyists and anyone interested in creating interactive objects and environment. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware in order to load new code onto the board – simply use a USB cable. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. The Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a huge variety of Arduino-based projects.

### **2.2.1 History of Arduino**

The Arduino is developed in 2005. The Arduino microcontroller was initially created as an educational platform for a class project at the Interaction Design Institute Ivrea in Milan (Italy) in 2005. It derived from a previous work of the Wiring microcontroller designed by Hernando Barragan in 2004. From the beginning, the Arduino board was developed to attract artists and designers. The Wiring microcontroller was created by Hernando Barragan to be used for parsing data to electronic devices. His aim was that it could be used by non-technical people who only had basic experience with using computers. He first of all wanted it to be used as a prototyping tool. Since he needed help to create an easy software tool to programmed the board he engaged Casey Reas and Massimo Banzi as his assistants. Reas created the visual programming language for the prototyping tool.

### **2.2.2 Development**

The computer, commonly defined as a tool for processing, storing, and displaying information, arose from a long line of analog devices used for effective counting and calculation, ranging from the simple abacus (first invented in Sumeria around 2300 BC), to Napier's Bones (conceived in 1617, and the precursor to the slide rule), to BlaisePascal's gear-based mechanical calculator (1645).The development of the computer accelerated during the 1940's, spurred on largely by the highly industrialized nature of military production in World War II.The 1960's marked a significant evolutionary leap for computing, due to the development of solid state computers (such as the IBM 1401), which used transistors for processing operations, and magnetic core memory for storage. The invention of integrated circuits in 1959 by Jack Kilby, which enabled transistors and circuits to be fused onto small chips of semiconducting materials (such as silicon), allowed further miniaturization of computer components. Another important development during this decade was the advent of high-level computer programming languages that were written in symbolic language, making computer code somewhat easier to read and learn than previous machine languages. COBOL and FORTRAN were the main languages introduced during this period. The microprocessor was introduced in 1970. The microprocessor essentially miniaturized all hardware components of a computers central processing unit to fit onto a single, tiny integrated circuit, now more popularly known as a microchip. The microchip



also became the main driving component of microcontrollers (such as the Arduino), which generally consist of a microchip, memory storage hardware, and input/ output hardware for sensors. The 1970's and 1980's also saw the development of a new generation of more powerful programming languages (such as C, C++, and later Java) for applications in business and science.

### **2.2.3 Evaluation**

The PIC microcontroller board, introduced in 1985 by General Instruments, became one of the most popular tools for electronics enthusiasts (before the Arduino) for several reasons. Other popular boards for hobbyists include the BASIC Stamp (Parallax Inc., 1990), and Wiring both of which share the benefits of simplicity of programming, and a resulting ease of rapid-prototyping. The Arduino project grew largely out of the “DIY” climate created by the burgeoning popularity of rapid- prototyping boards like PIC. In fact, the immediate precursor to the Arduino was a custom-made Wiring microcontroller created by the artist/ designer Hernando Barragan in 2004. In 2005, the Arduino team was formed in Ivrea, Italy, consisting of Barragan, Massimo Banzi, David Cuartielles, Dave Mellis, Gianluca Marino, and Nicholas Zambetti. As a result, the Arduino incorporated the following characteristic, a programming environment based on Processing language (a programming language conceived by Ben Fry and Casey Reas, also conceived for artists/ designers), the ability to program the board via a standard USB connection, and a low price point. The Arduino achieved rapid success even within its first two years of existence, selling in a quantity of more than 50,000 boards. By 2009, it had spawned over 13 different incarnations, each specialized for different applications. Today, the Arduino microcontroller has become one of the most popular prototyping platforms in the world, and is a prime example of how hardware and software technologies originally created for military, business, and scientific applications can be repurposed to serve the needs of individuals creating projects in the realms of new media art and design.

# Chapter 3

## THEORY BEHIND THE PROJECT

### 3.1 Introduction

This project include with Arduino Uno board, Op-Amp LM324N, photodiode. We want to connect the photodiode to an Arduino .We understand that photodiode produce current, and it produces more current the more intensive the light that falls on it. Others connect it to an "Op-Amp" And We need to amplify the current.

### 3.2 Architecture Arduino Uno board

There are many varieties of Arduino boards that can be used for different purposes. The Arduino UNO components are:



Figure 3.1: Arduino UNO R3 Board

### 3.2.1 Power -USB / Barrel Jack

Our Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply that is terminated in a barrel jack. In the picture above the USB connection is labeled and the barrel jack is labeled. The USB connection is also how you will load code onto your Arduino board.

### 3.2.2 Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

The pins of Arduino are the places where connect wires to construct a circuit. The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.

- **5V:** The 5V pin supplies 5 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.
- **GND:** Full name is Ground. There are several GND pins on the Arduino, any of which can be used to ground circuit.
- **Analog:** The area of pins under the ‘Analog In’ label (A0 through A5 on the UNO) is Analog In pins. These pins can read the signal from an analog sensor and convert it into a digital value that we can read.
- **Digital:** Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input and digital output (like powering an LED).
- **PWM:** The digital pins (3, 5, 6, 9, 10, and 11) on the UNO are the PWM(~) pins. These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM).
- **AREF:** Stands for Analog Reference. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

### 3.2.3 Power LED Indicator

Just beneath and to the right of the word “UNO” on circuit board, there’s a tiny LED next to the word ‘ON’. This LED should light up whenever plug Arduino into a power source. If this light doesn’t turn on, there’s a good chance something is wrong.

### **3.2.4 Reset Button**

The Arduino has a reset button. Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if code doesn't repeat, but we want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn't usually fix any problems.

### **3.2.5 TX RX LEDs**

TX is short for transmit, RX is short for receive. In our case, there are two places on the Arduino UNO where TX and RX appear once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These LEDs will give us some nice visual indications whenever Arduino is receiving or transmitting data.

### **3.2.6 Main IC**

The black thing with all the metal legs is an IC, or Integrated Circuit. . The main IC on the Arduino is slightly different from board type to board type, but is usually from the ATmega line of IC's from the ATMEL Company. This can be important, as may need to know the IC type before loading up a new program from the Arduino software. This information can usually be found in writing on the top side of the IC.

### **3.2.7 Voltage Regulator**

The voltage regulator is not actually something interacting with on the Arduino. But it is potentially useful to know that it is there and what it's for. It controls the amount of voltage that is let into the Arduino board. It will turn away an extra voltage that might harm the circuit.

### 3.2.8 Schematic Diagram

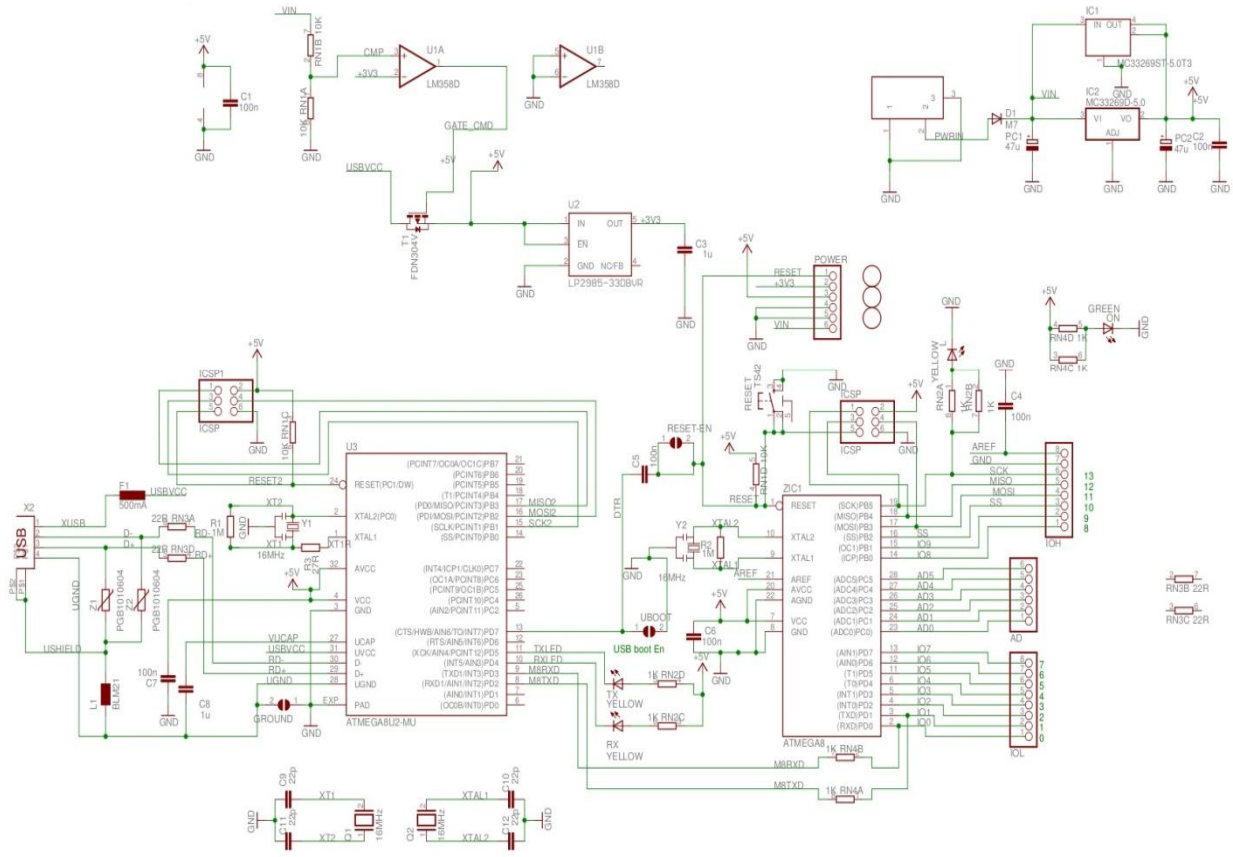


Figure 3.2: Schematic diagram for Arduino Uno Board

### 3.3 Getting started with Arduino Software

First download and install the Arduino IDE for Mac, Linux or Windows from [arduino.cc](http://arduino.cc). Windows users also need to install a driver. Connect your board via USB, launch the Arduino application and select Arduino Uno from the tools to board menu. Open the sketch File. Open Examples: 01.Basics: Blink. Click the toolbar button to upload it to your board.

### **3.3.1 The Integrated Development Environment (IDE)**

Every microcontroller needs software to be programmed. The Arduino board is not a case apart. It has its own integrated development environment (IDE). It is free and everyone can download it from its official website using either the Windows, Mac OS X or Linux platform. That allows Arduino Board to gain more users and it also helps it to grow.

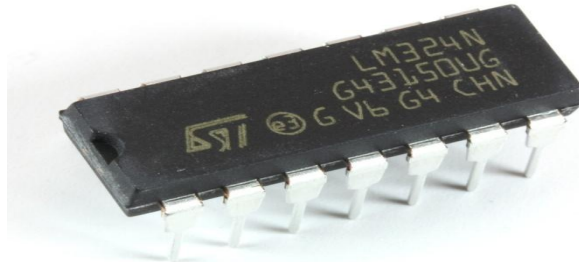
### **3.3.2 IDE Parts**

- Compile: Before program “code” can be sent to the board, it needs to be converted into instructions that the board understands. This process is called Compiling.
- Stop: This stops the compilation process.
- Create new Sketch: This opens a new window to create news ketch.
- Open Existing Sketch: This loads a sketch from a file on our computer.
- Save Sketch: This saves the changes to the sketch.
- Upload to Board: This compiles and then transmits over the USB cable to our board.
- Serial Monitor: Until this point when our programs (sketches) didn’t work, we just pulled out our hair and tried harder.
- Tab Button: This lets you create multiple files in your sketch. This is for more advanced programming than we will do in this class.
- Sketch Editor: This is where write or edit sketches
- Text Console: This shows you what the IDE is currently doing and is also where error messages display if make a mistake in typing program.
- Line Number: This shows what line number your cursor is on.

## **3.4 LM324N OP-AMP**

Conventional operational amplifier applications can be easily implemented with the LM324N. The LM324 consist of four in dependent, high gains, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range. Operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts. Application areas include transducer

amplifier, DC gain blocks and all the conventional OP Amp circuits which now can be easily implemented in single power supply systems.



**Figure 3.3: OP-AMP LM324N**

In the linear mode, the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage. The unity gain crossover frequency and the input bias current are temperature-compensated.

### 3.4.1 Specifications

- IC type: General purpose quad Op-Amp
- Number of circuits: 4
- Slew rate: 0.5 V/ $\mu$ s
- Gain bandwidth: 1.2 MHz
- Current - Input bias: 20 nA
- Voltage - In out offset: 3000  $\mu$ V
- Current supply: 1.4 mA
- Current - Output channel: 60 mA
- Voltage - Supply, Single/Dual: 3 V ~ 32 V,  $\pm$ 1.5 V ~ 16 V
- Package: DIP-14 (0.1"  $\times$  0.3" pin spacing)
- Lead-free (RoHS compliant)
- Manufacturer: Texas Instruments
- Manufacturer part number: LM324N

### 3.4.2 Pin Diagram

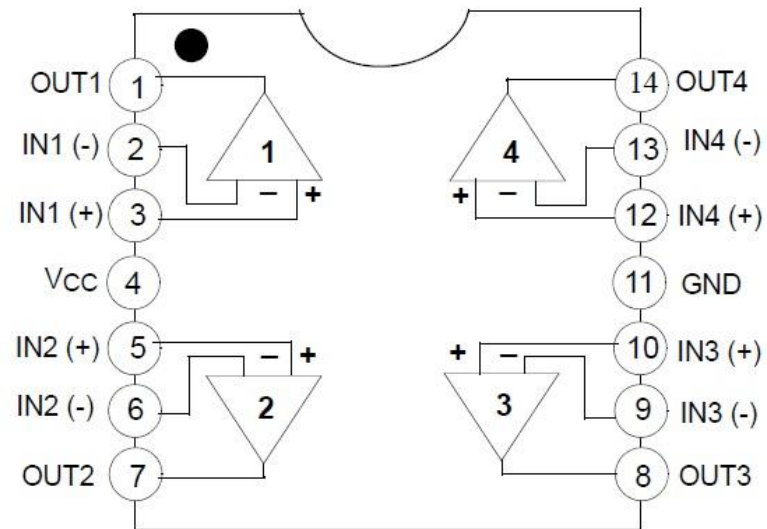


Figure 3.4: Pin diagram of LM324N

### 3.4.3 Features

- Internally frequency-compensated for unity gain
- Large DC voltage gain: 100dB
- Wide bandwidth (unity gain): 1MHz (temperature-compensated)
- Wide power supply range Single supply: 3VDC to 30VDC or dual Supplies:  $\pm 1.5$ VDC to  $\pm 15$ VDC
- Very low supply current drain: essentially independent of supply Voltage (1mW/op amp at +5VDC)
- Low input biasing current: 45nADC (temperature-compensated)
- Low input offset voltage: 2mVDC and offset current: 5nADC
- Differential input voltage range equal to the power supply voltage
- Large output voltage: 0VDC to VCC-1.5VDC swing



### 3.4.4 Schematic Diagram

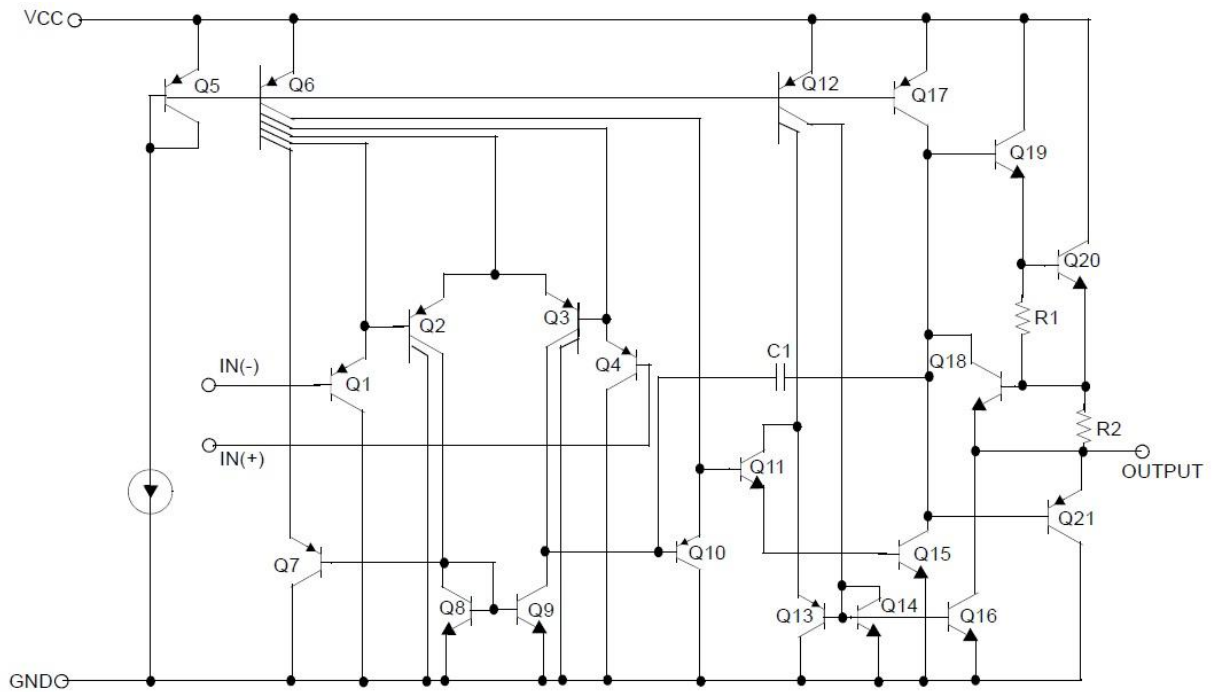


Figure 3.5: Schematic Diagram of LM324N (One Section Only)

### 3.4.5 Absolute Maximum Rating

Parameter	Symbol	LM324	Unit
Power Supply Voltage	$V_{CC}$	$\pm 16$ or 32	V
Differential Input Voltage	$V_{I(DIFF)}$	32	V
Input Voltage	$V_I$	-0.3 to +32	V
Output Short Circuit to GND $V_{CC} \leq 15V, T_A = 25^\circ C$ (one Amp)		Continuous	
Power Dissipation, $T_A = 25^\circ C$	$P_D$		mW
14-DIP		1310	
14-SOP		640	
Operating Temperature Range	$T_{OPR}$	0 ~ +70	$^\circ C$
Storage Temperature Range	$T_{STG}$	-65 ~ +150	$^\circ C$

Table 3.1: Absolute Maximum Rating of LM324N

### 3.5 C828 Transistor

NPN Silicon Epitaxial Planar Transistor for switching and AF amplifier applications. These transistors are subdivided into three groups Q, R and S according to their DC current gain.



Figure3.6: Transistor

#### 3.5.1 Absolute Maximum Ratings ( $T_a = 25^{\circ}\text{C}$ )

	Symbol	Value	Unit
Collector Base Voltage	$V_{\text{CBO}}$	30	V
Collector Base Voltage	$V_{\text{CBO}}$	25	V
Emitter Base Voltage	$V_{\text{EBO}}$	7	V
Peak Collector Current	$I_{\text{CM}}$	100	mA
Collector Current	$I_{\text{C}}$	50	mA
Power Dissipation	$P_{\text{tot}}$	400	mW
Junction Temperature	$T_{\text{j}}$	150	$^{\circ}\text{C}$
Storage Temperature Range	$T_{\text{s}}$	-55 to +150	$^{\circ}\text{C}$

Table 3.2: Absolute Maximum Ratings of C828 Transistor

### 3.5.2 Characteristics

	Symbol	Min.	Max.
DC Current Gain at $I_C=2\text{mA}$ , $V_{CE}=5\text{V}$ Current Gain Group			
Q	$h_{FE}$	130	280
R	$h_{FE}$	180	360
S	$h_{FE}$	260	520
Collector Base Breakdown Voltage at $I_C=10\mu\text{A}$	$V_{(BR)CBO}$	30	
Collector Emitter Breakdown Voltage at $I_C=2\text{mA}$	$V_{(BR)CEO}$	25	
Emitter Base Breakdown Voltage at $I_E=10\mu\text{A}$	$V_{(BR)EBO}$	7	
Collector Saturation Voltage at $I_C=50\text{mA}$ , $I_B=5\text{mA}$	$V_{CE(sat)}$		
Base Emitter Voltage at $I_C=10\text{mA}$ , $V_{CE}=5\text{V}$	$V_{BE}$		0.8
Gain Bandwidth Product at $I_C=2\text{mA}$ , $V_{CE}=10\text{V}$	$f_T$		
Noise Figure at $V_{CE}=5\text{V}$ , $I_E=0.2\text{mA}$ , $R_G=2\text{k}\Omega$ , $f=1\text{kHz}$	NF		

**Table 3.3: Characteristics of C828**

### 3.6 Photodiode

A photodiode is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present. Photodiodes may contain optical filters, built-in lenses, and may have large or small surface areas. Photodiodes usually have a slower response time as its surface area

increases. Photodiodes are similar to regular semiconductor diodes except that they may be either exposed (to detect vacuum UV or X-rays) or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device. Many diodes designed for use specifically as a photodiode use a PIN junction rather than a p–n junction, to increase the speed of response. A photodiode is designed to operate in reverse bias.



**Figure 3.7: Photodiode**

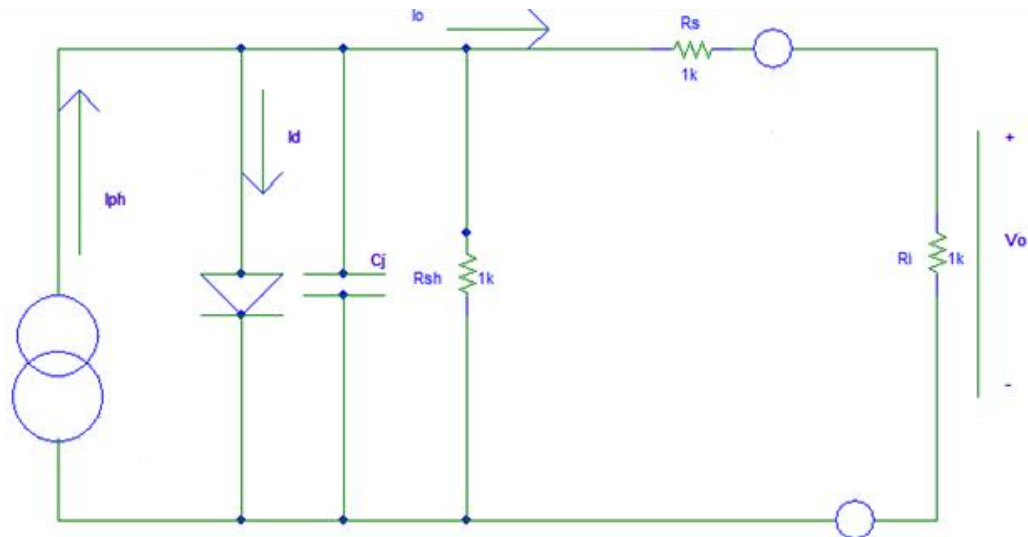
### 3.6.1 Materials of Photodiode

Material	Electromagnetic spectrum wavelength range (nm)
Silicon	190–1100
Germanium	400–1700
Indium gallium arsenide	800–2600
Lead(II) sulfide	<1000–3500
Mercury cadmium telluride	400–14000

**Table 3.4: Materials of photodiode**

### 3.6.2 Electrical Characteristics

A silicon photodiode can be represented by a current source in parallel with an ideal diode (Figure. 3). The current source represents the current generated by the incident radiation, and the diode represents the p-n junction. In addition, a junction capacitance ( $C_j$ ) and a shunt resistance ( $R_{SH}$ ) are in parallel with the other components. Series resistance ( $R_S$ ) is connected in series with all components in this model.



**Figure 3.8: Equivalent Circuit for the silicon photodiode**

#### **Shunt Resistance ( $R_{SH}$ )**

Shunt resistance is the slope of the current-voltage curve of the photodiode at the origin, i.e.  $V=0$ . Although an ideal photodiode should have an infinite shunt resistance, actual values range from 10's to 1000's of Mega ohms. Experimentally it is obtained by applying  $\pm 10$  mV, measuring the current and calculating the resistance. Shunt resistance is used to determine the noise current in the photodiode with no bias (photovoltaic mode). For best photodiode performance the highest shunt resistance is desired.

#### **Series Resistance ( $R_S$ )**

Series resistance of a photodiode arises from the resistance of the contacts and the resistance of the undepleted silicon. It is given by:

$$R_s = ((W_s - W_d)p/A) + R_c$$

Where  $W_s$  is the thickness of the substrate,  $W_d$  is the width of the depleted region,  $A$  is the diffused area of the junction,  $p$  is the resistivity of the substrate and  $R_c$  is the contact resistance. Series resistance is used to determine the linearity of the photodiode in photovoltaic mode (no bias,  $V=0$ ). Although an ideal photodiode should have no series resistance, typical values ranging from 10 to 1000  $\Omega$ 's are measured.

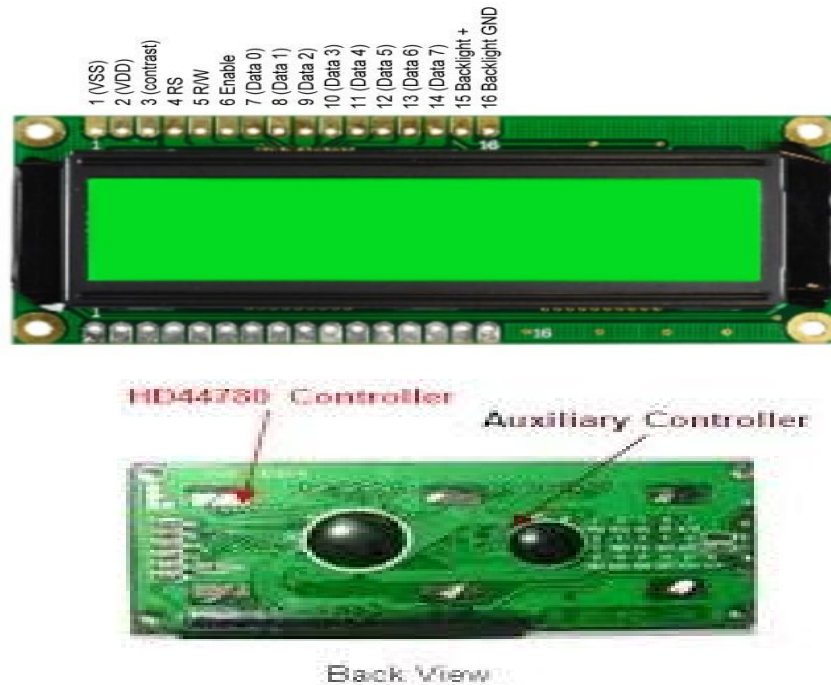
### **Junction Capacitance (C<sub>J</sub>)**

The boundaries of the depletion region act as the plates of a parallel plate capacitor. The junction capacitance is directly proportional to the diffused area and inversely proportional to the width of the depletion region. In addition, higher resistivity substrates have lower junction capacitance. Furthermore, the capacitance is dependent on the reverse bias as follows:

$$C_j = \epsilon_{si} \epsilon_0 A / W_d$$

## **3.7 Liquid Crystal Display (LCD)**

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.



**Figure 3.9: 16 x 2 Liquid Crystal Display (front side & back side)**

### 3.7.1 Features

- 5 x 8 dots with cursor
- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED)
- N.V. optional for + 3V power supply

### 3.8 Relay

A relay is an electrically operated switch. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.



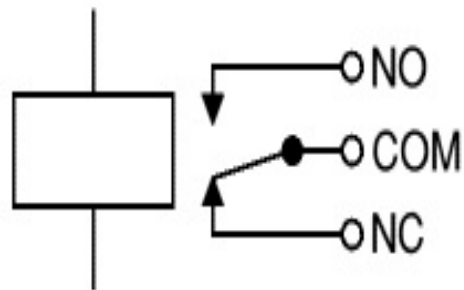
**Figure 3.10: 12V Relay**

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification. 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 low-power signal or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and retransmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contractor. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays". Most relays are



designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

### 3.8.1 Circuit Diagram



**Figure 3.11: Circuit symbol for a relay**

# Chapter 4

## SYSTEM DESIGN AND ANALYSIS

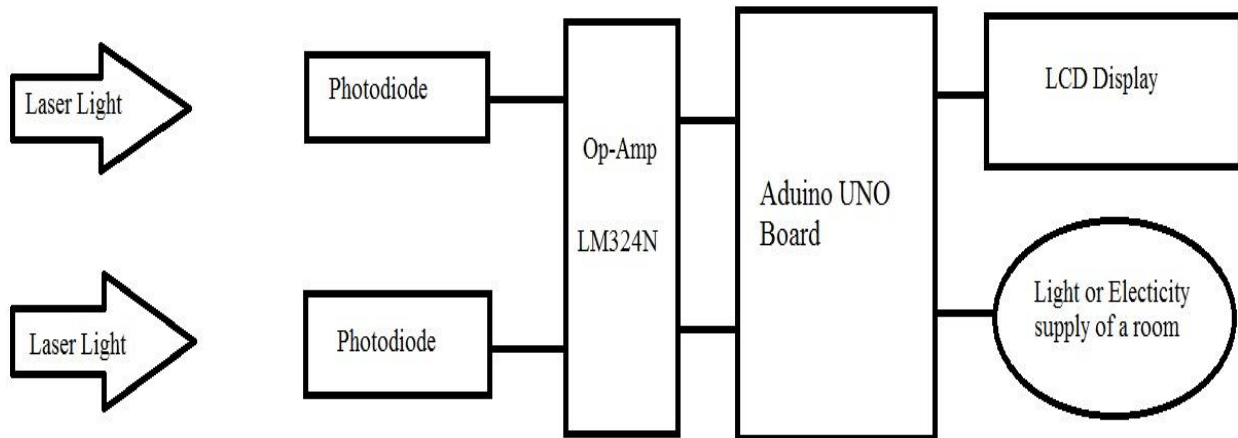
### 4.1 Introduction

In this project helps those people who interested to build something with Arduino. To Design a project include into two parts, one is hardware design and another part is software design. We use laser, Op-Amp, photo diode for the hardware design and we connected these components with microcontroller. Arduino microcontroller is more suitable for establishing a new project including robotics. Arduino software is downloaded from [www.arduino.cc](http://www.arduino.cc) and C/C++ programmable language is used. Many examples are given in the [ardiono.cc](http://ardiono.cc) and this software is easy to usage.

### 4.2 Hardware design

The whole system design is divided into two parts to design a smart home appliance control system. One is the design the smart system in the breadboard and controls the designed system. Another part is the display part design to count the value in smart system. Finally, the smart home appliance control system is formed a complete integrated system. In this project Arduino development board is more efficient.

## 4.2.1 Full Circuit Design



**Figure 4.1: Full View of Control System**

Mainly we use three major components for designing a full control system. The photodiode is receiving signal from laser light and it is connected to Op-amp to amplify the signal. This Op-Amp is connected to Arduino and the LCD display is connected to the Arduino UNO board. The output of this circuit is connected to Light or electric load of a room.

## 4.2.2 Components Used in the System

To design the project we use following component:

- One Arduino Uno Board
- Two bread board
- OP-Amp LM 324N

- Two photo diode
- Two C828 Transmitter
- Zener diode
- One LCD display
- 1k Resistance
- Variable resistance
- Two Laser light

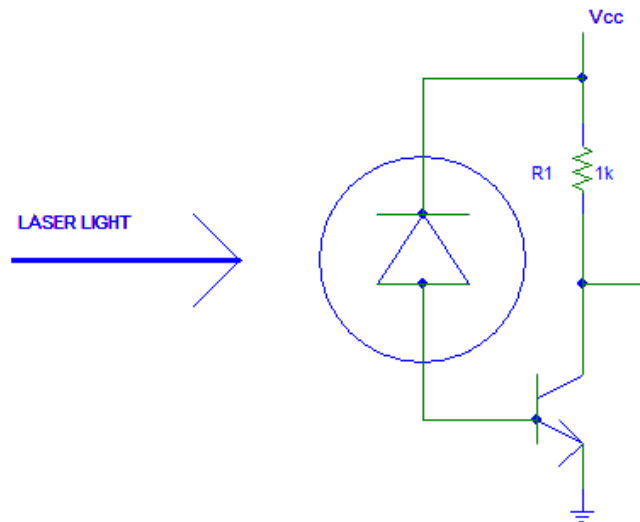
### **4.2.3 Sensing Unit**

We use photodiode for receiving the laser light. It converts the light signal into current. When light falls on the junction, a reverse current flow which is proportional to the illuminance. The linear response to light makes it an element in useful photo detectors for some applications.

The photodiode is operated under a moderate reverse bias. This keeps the depletion layer free of any carriers and normally no current will flow. However when the light photon enters the intrinsic region it can strike an atom in the crystal lattice and dislodge an electron. In this way a hole-electron pair is generated. The hole and electron will then migrate in opposite directions under the action of the electric field across the intrinsic region and a small current can be seen to flow. It is found that the size of the current is proportional to the amount of light entering the intrinsic region. The more light, the greater the numbers of hole electron pairs that are generated and the greater the current flowing.

Photodiodes are just exposed PN or PIN junctions. Reverse biasing means there is an electric field over the junction. When a photon of sufficient energy hits the junction and is absorbed, this creates a free electron-hole pair which is accelerated towards the anode/cathode by the electric field, thus creating current.

Visible light is coincidentally well-suited to this kind of operation, because the absorptive of most semiconductors is fairly high in the visible region, while the required energy to excite an electron beyond the band gap voltage is 0.6-1eV, which is exactly the amount of energy contained in a just-infrared photon (1200-1400nm).

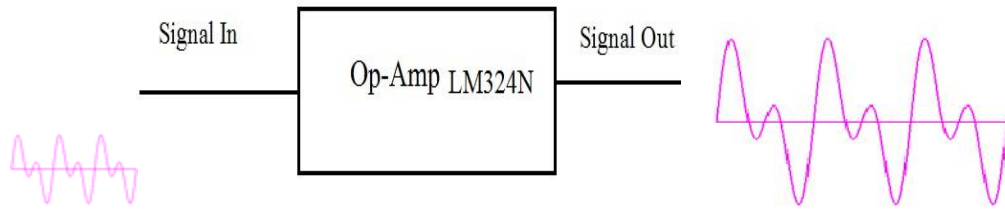


**Figure 4.2: Circuit diagram of the photodiode and amplifier**

The negative pin of the photo diode is connected to base of the C828 transistor. The positive pin of the photodiode is connected to 5V and connected to collector of the transistor. The Emitter is connected to the ground. The output of this circuit is out from the collector. Then the output is connected to OP-AMP LM324N.

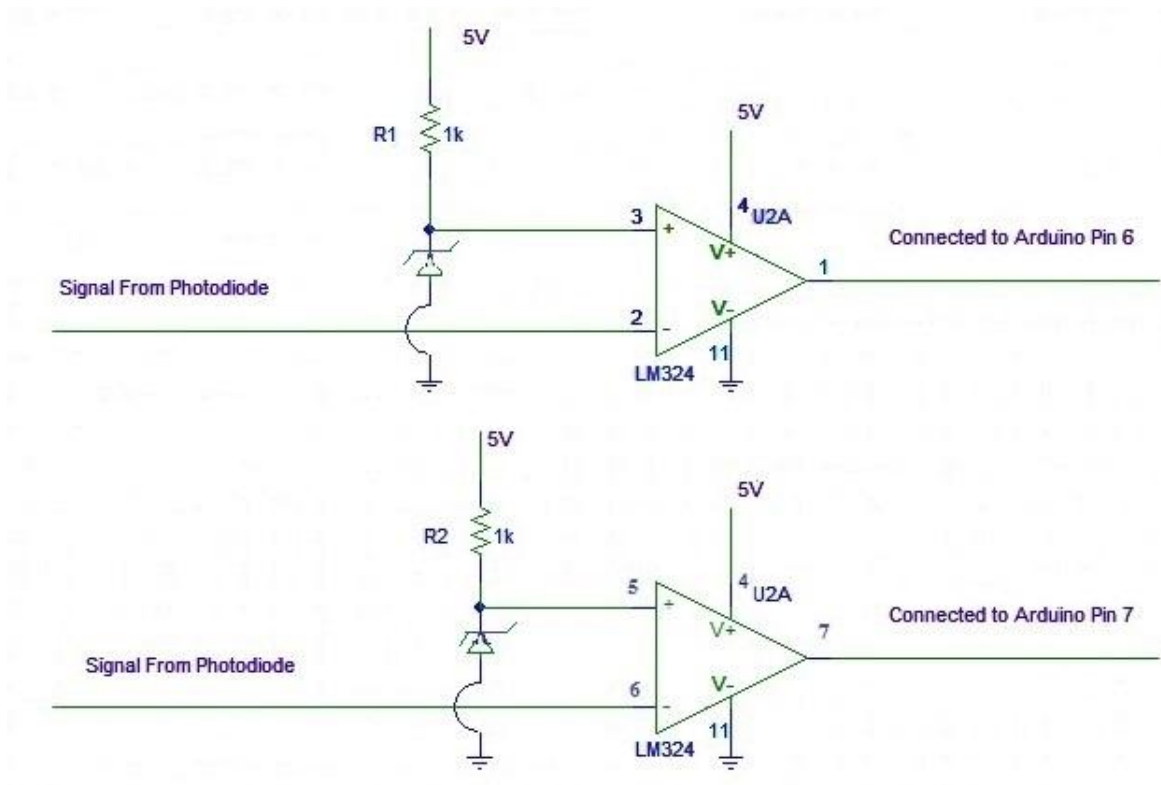
#### **4.2.4 Comparators Unit**

Its main purpose is to increase a weak signal to strong signal. We have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.



**Figure 4.3: Amplifier Operation**

Op amps amplify tiny signals from sensors so analog-to-digital converters (ADCs) can digitize them. We also make it possible to craft active filters with better characteristics than filters built of just coils and capacitors. Although an IC op amp’s circuitry tends to be subtle and complex, its application principles—at least to a first approximation are relatively simple.



**Figure 4.4: Comparators using Op-Amp**

In this circuit signal from photodiode is connected with Op-Amp’s pin 2 and pin 6. One side of the pin 3 and pin 5 is connected to Vcc (5V). Other side of pin is connected to ground via diode. The pin 4 of the Op-Amp LM324N is connected to 5V and the pin 11 is connected with ground

pin of Arduino Uno. The output pin 1 and 7 are connected with Arduino pin 6 and 7. We get the signal from photodiode is 0.17V and the Op-Amp is convert this signal to 3.67V.

#### 4.2.5 16 x 2 LCD Display Connections with Arduino

We use 16 x 2 LCD and that have a parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. We can select the data register, which holds what goes on the screen. A Read/ Write (R/W) pin that selects reading mode or writing mode. The Enable pin that enables writing to the registers. The 8 data pins (D0 -D7). The states of these pins (high or low) are the bits that we writing to a register. There's also a display contrast pin (Vo), power supply pins (+5V and Ground) and LED Backlight (Bklt+ and BKlt-) pins that we use to power the LCD, control the display contrast, and turn on and off the LED backlight, respectively.

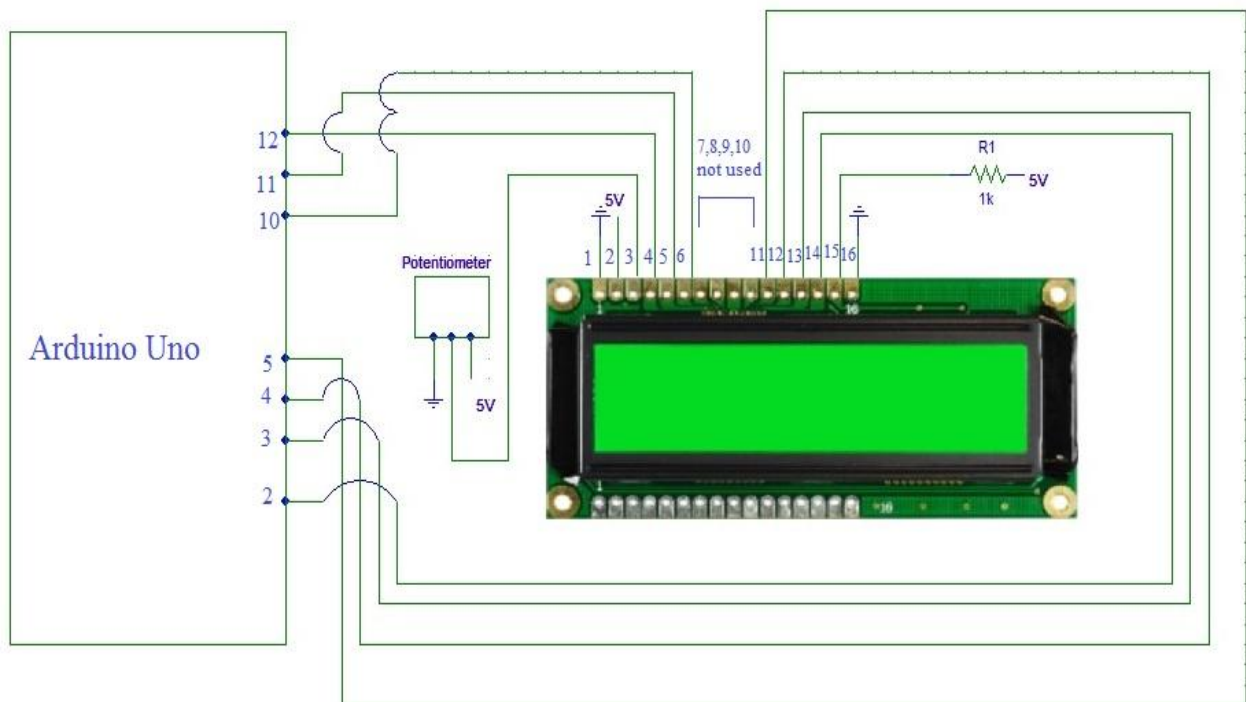


Figure 4.5: Display Connection with Arduino

We connect the LCD pins with Arduino in following steps:

Pin 1 is connected to Arduino GND

Pin 2 is connected to Arduino 5V

Pin 3 is connected to wiper ( this is the middle pin of the 10k potentiometer )

Pin 4 is connected to Arduino pin 12

Pin 5 is connected to Arduino GND

Pin 6 is connected to Arduino pin 11

Pin 11 is connected to Arduino pin 5

Pin 12 is connected to Arduino pin 4

Pin 13 is connected to Arduino pin 3

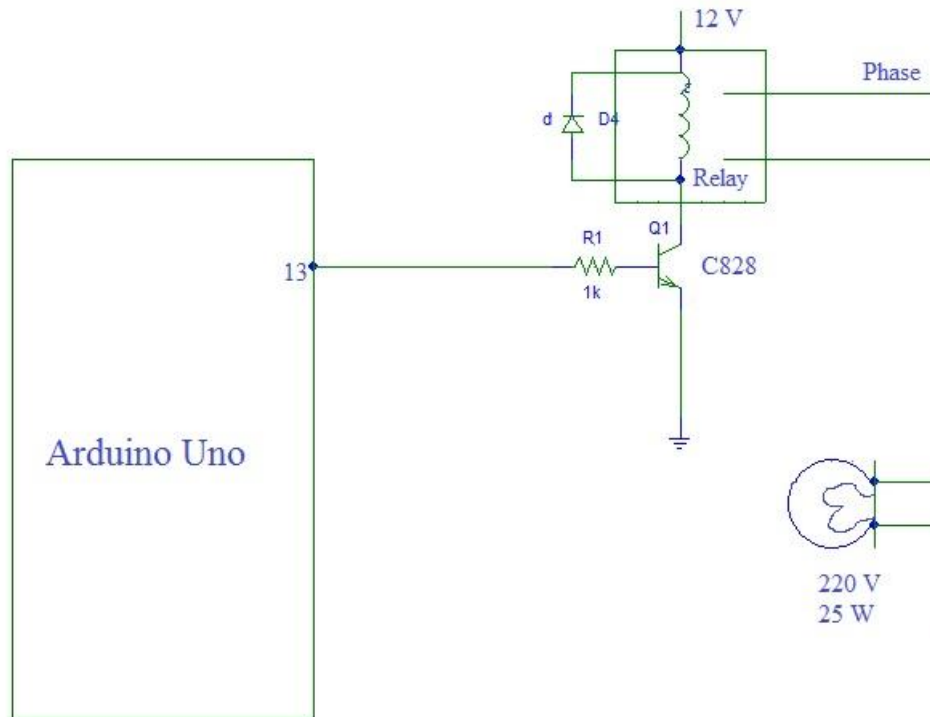
Pin 14 is connected to Arduino pin 2

Because we will only be writing, pin 5 will be dropped to ground to show that there will be no reading. For we use the backlight, connect LCD pin 16 to GND and LCD pin 15 to +4.2V. Connect one side of the potentiometer to Arduino GND, the opposite to Arduino 5v, and the center to LCD pin 3. The pin 7, 8,9,10 are not used in the Arduino.

#### **4.2.5 Connection to Load with Power Source**

We use 12V Relay for connect a light or electricity supply of a room. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The high end applications of relays require high power to be driven by electric motors. Relays are called contactors.





**Figure 4.6: Connection of Load and Relay**

We connect Arduino pin 13 with transistor's base. The emitter is connected to ground and the collector is connected to relay and diode. The relay and diode are connected parallelly. The two terminals of a relay operate as a switch. When the contacts are 'in contact' then the current flows from Terminal to Terminal. There are two types of contacts, the NO and the NC. NO stands for Normal Open contact, while NC stands for Normal Closed contact. The Normal Open is a contact like the one showed in the previous illustration. When the contacts is still, then no current flows through it (because it is an OPEN circuit). On the other hand, a Normal Closed contact allows the current to flow when the contact is still. The NC contact is turned upside-down compared to the NO contact. This way, both contacts (NO and NC) will change state if a force is applied to the left metal heading from UP to DOWN. The device that forces the terminal to move is actually an electromagnet. A coil is placed right under the contact. When current is flown through this coil, magnetism is created. This magnetism can overcome the force of the spring and can pull the contact towards it, thus it changes its position. And due to the fact that the

contact is usually a small piece of metal not capable to be pulled by the electromagnet, another piece of metal is attached to the common. The other side of relay is connected to bulb or electricity supply of a room. We need 12V power supply for relay.

## **4.3 Software design**

Software design is divided into two parts. First we write the Arduino program in Arduino software. Then we compile it to the Arduino hardware. This Arduino command is control the Arduino hardware and other circuit and display connection.

### **4.3.1 Installing Arduino**

Arduino runs on Windows. Go to the Arduino software web site at <http://arduino.cc/en/Main/Software> and download the version of the software compatible with our system. We use Arduino 1.0.5 version.

### **4.3.2 Verifying the Hardware**

Now that we have the Arduino IDE software installed, let's connect the computer to the mc board, load a small program, and verify that all components are working together. First, need to connect the USB cable to our mc board and then plug the other end of the USB cable into our computer.

### **4.3.3 Arduino Language**

The Arduino language is implemented in C/C++ and based in Wiring. When we write an Arduino sketch, we are implicitly making use of the Wiring library, which is included with the Arduino IDE. This allows us to make run able programs by using only two functions: `setup ()` and `loop ()`. As mentioned, the Wiring language is inspired by Processing, and the Arduino language structure is inherited from the Processing language, where the equivalent functions are called `setup ()`. We need to include both functions in every Arduino program, even if we don't need one of them. Let's analyze the structure of a simple Arduino sketch using again the Blink example.

### 4.3.4 Logical Diagram

We have two logical diagrams for this project. First when enters the room and 2<sup>nd</sup> for exits the room.

#### 4.3.4.1 Flow chart when enters the Room

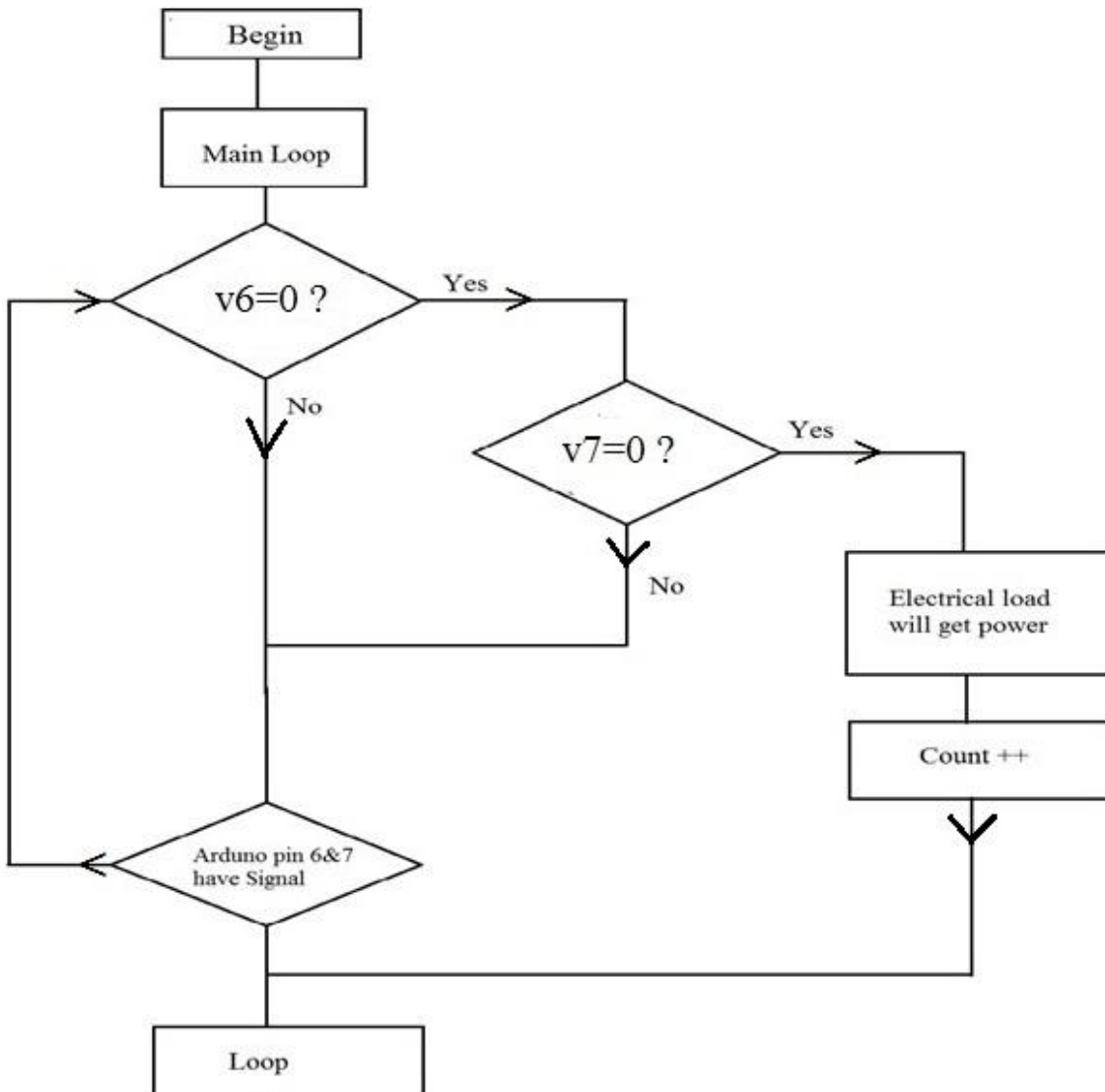


Figure 4.7: Logical Diagram (Entering the room)

#### 4.3.4.2 Flow chart when exits the Room

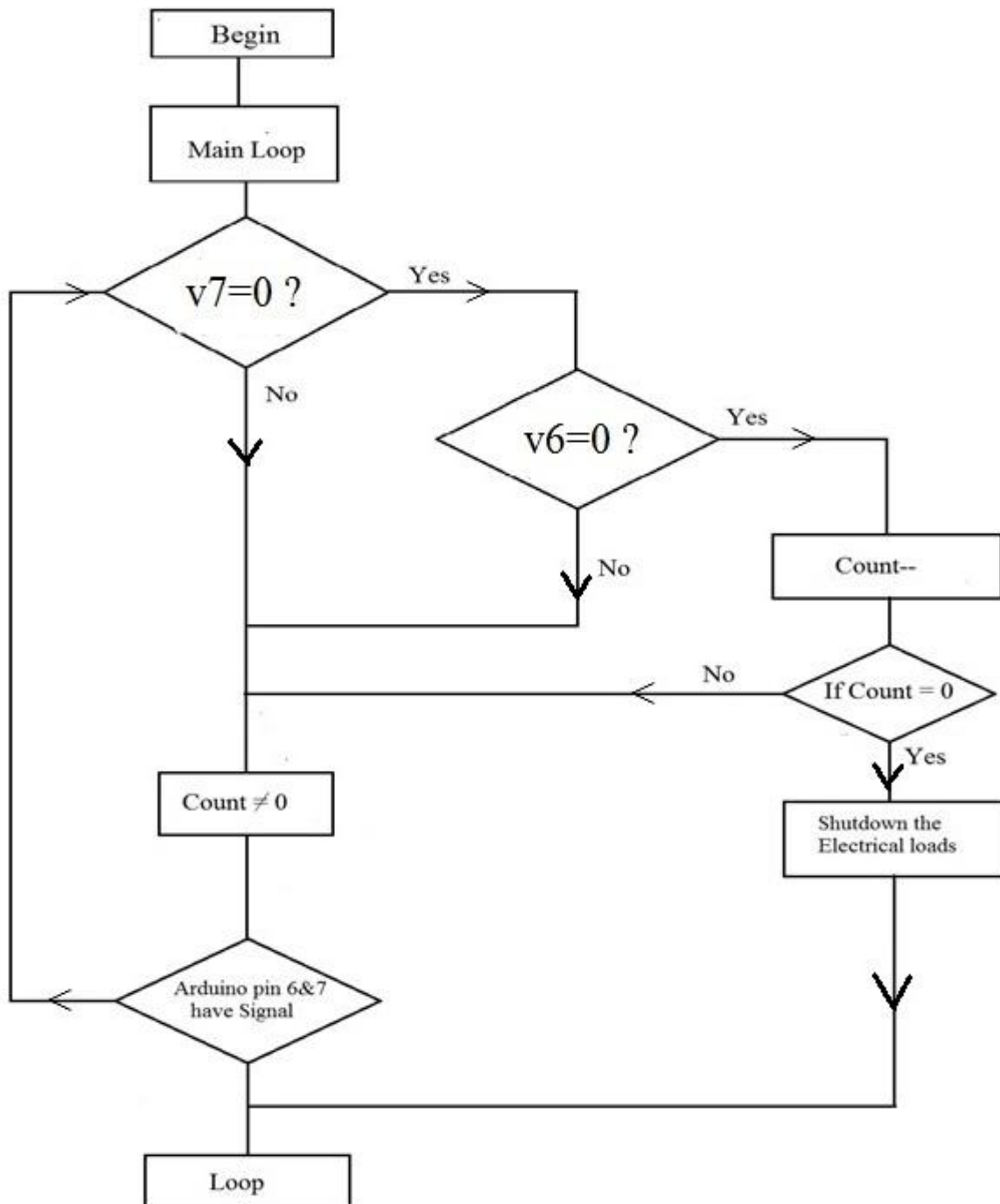


Figure 4.8: Logical Diagram (Exiting the room)

# Chapter 5

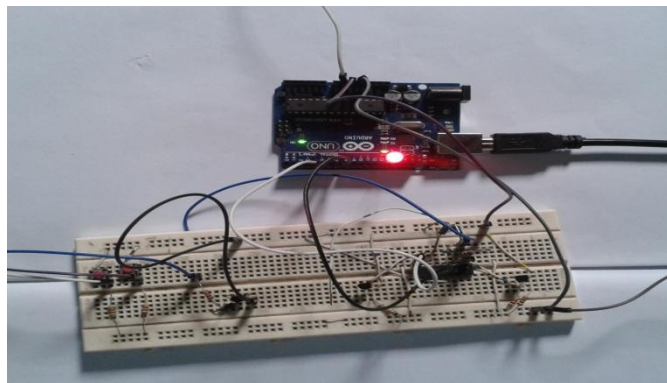
## IMPLEMENTATION AND TESTING

### 5.1 Implementation

All the parts are connected as circuit design. Then we upload the programming code in the Arduino and we get positive result. It works properly according to our design.

#### 5.1.1 Count Testing

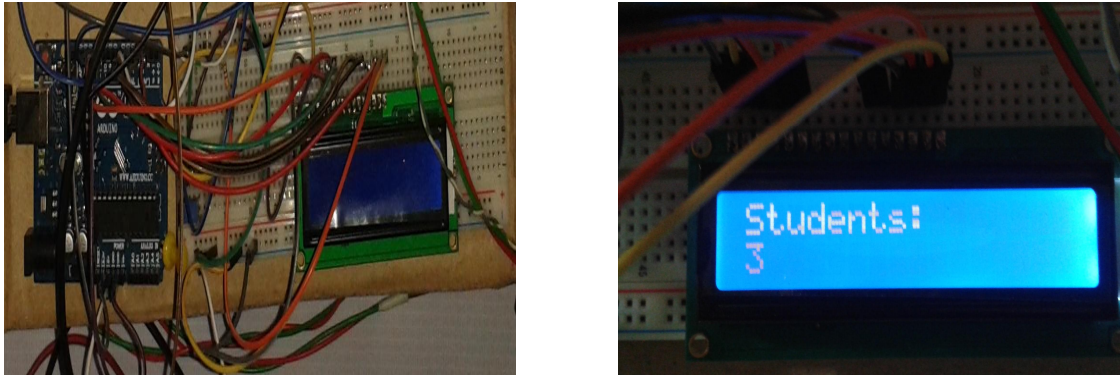
After finishing our person counting unit we found that it worked properly. First, we write the program for one laser light and this light signal is received by photodiode and connected to Arduino pin 6 and test. At first, some problem was found but finally it worked properly. Then we combined all parts for properly counting. We use LED light for testing.



**Figure 5.1: Test the Count value**

### 5.1.2 Display Testing

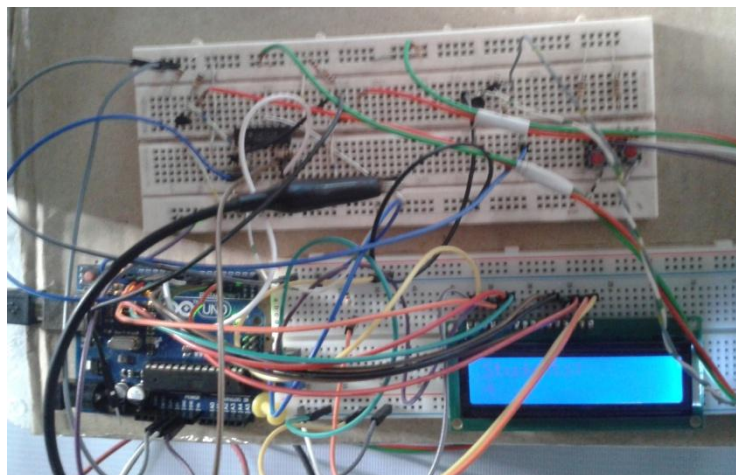
We connect the entire pin with the right place in Arduino board like circuit design. This pin connection is described in 4.2.5. Then we found it works properly. When a person enters room, the display shows 1 and when exits from room, the display show 0.



**Figure 5.2: Display Testing**

### 5.1.3 Development of the Whole System

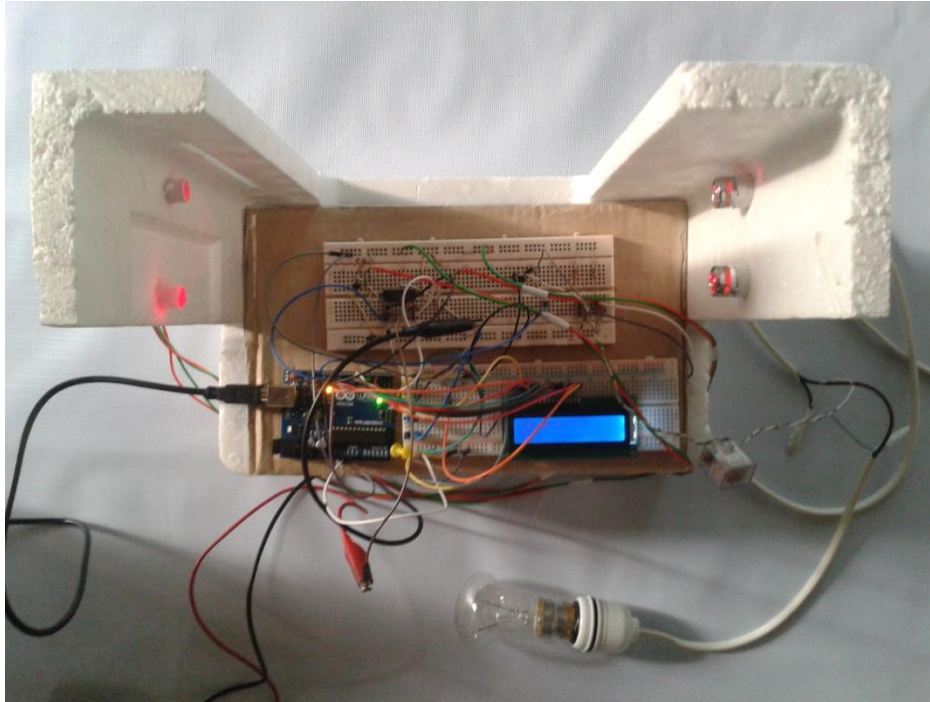
After testing, we combined display circuit and count circuit. Then, we develop the full circuit. It works correctly. When person enters the room, electrical load get power and display show the count values. When last person exits from room, the system automatically shut down the electrical load and display show the value 0.



**Figure 5.3: Final Development of Circuit**

## 5.2 Product Commercialization

After completing all the circuit and developing the Control system, we connected this control system in a room and saw that it works properly. Therefore, we can say that the smart home appliance control system is ready for commercial use. Our commercially based smart home appliance control system is like this figure.



**Figure 5.4: Sample figure of Complete Smart home appliance control system.**

# Chapter 6

## CONCLUSION

### 6.1 Future Work Scope

This project gives us an opportunity to do a big project in future. The applications stated above are some demo applications that are absolutely possible with its future development. Initially for the limitation of time and required fund we were able to develop just a home appliance control system. The system will also work using IR sensor. It will be more efficient than Laser light and Photodiode. So, we have a big work scope in this sector. We hope that, we will be able to complete all the features needed for its ultimate applications.

### 6.2 Conclusion

The smart home appliance control system was designed and developed for minimizing the wastage of electricity. We use 5V from Arduino board and use 12V DC power supply for relay connection. We use the photodiode for receiving laser light because it is low cost, low noise, excellent linearity in output photocurrent over 7 to 9 decades of light intensity and fast response times. We use Op-Amp.

Finally, we design and develop a microcontroller base smart home appliance control system. We fix the entire problem that we have. Finally, we successfully achieve our primary goals.

In this study, the application of microcontroller with improved algorithm of extended specifications has reduced the misuse of electricity and improves the security system. We see that our smart home appliance control system is efficient and the production cost is low. So, our smart home appliance control system is suitable for commercial use.



# APPENDIX

## Programming code of count for Testing

We write the code for count in the Arduino software. While light will be ON or OFF thus kind of matter is written in this code. The count code is:

```
// constants won't change. Used here to
```

```
// set pin numbers:
```

```
const int ledPin = 13;
```

```
    // the number of the LED pin
```

```
    // Variables will change:
```

```
int ledState = LOW;
```

```
    // ledState used to set the LED
```

```
long previousMillis = 0;
```

```
    // will store last time LED was updated
```

```
int i,j,v6,v7;
```

```
int En=1,Ex=1,Enp=1,Exp=1;
```

```
int count=0;
```

```
    // will quickly become a bigger number than can be stored in an int.
```

```
long interval = 1000;
```

```
    // interval at which to blink (milliseconds)
```

```

void setup()
{
    // set the digital pin as output:

pinMode(ledPin, OUTPUT);

pinMode(6,INPUT);

pinMode(7,INPUT);

}

void loop()
{
v6 = digitalRead(6);

if (v6==0)
    {if (Exp!=0)

Enp=0; En=0;}

        if((v6==1)

& (En==0)

& (Ex ==0)

& (Exp==0))
            {

count--;

Ex=En=Exp=1;

```

```

}

v7=digitalRead(7);

if(v7==0)

    {if(Enp!=0)

        Exp=0;Ex=0;}

        if((v7==1)

& (En==0)

& (Ex==0)

& (Enp==0))

            {

count++;

Ex=En=Enp=1;

}

if(count>0)

digitalWrite(12,HIGH);

else

digitalWrite(12,LOW);

delay(50);

}

```

## Programming code of LCD Display for Testing

We connected the LCD display with Arduino and write a program for operates that display. The LCD code is:

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(12, 11,10, 5, 4, 3, 2);

int backLight = 13;

// pin 13 will control the backlight

void setup()

{

pinMode(backLight, OUTPUT);

digitalWrite(backLight, HIGH);

// turn backlight on. Replace 'HIGH' with 'LOW' to turn it off.

lcd.begin(16,2);

// columns, rows. use 16,2 for a 16x2 LCD, etc.

lcd.clear();

// start with a blank screen

lcd.setCursor(0,0);

// set cursor to column 0, row 0 (the first row)

lcd.print("Students:");

// change this text to whatever we like. keep it clean.
```

```
lcd.setCursor(0,1);  
  
// set cursor to column 0, row 1  
  
lcd.print("3");  
  
// if have a 4 row LCD, uncomment these lines to write to the bottom rows  
  
// and change the lcd.begin() statement above.  
  
//lcd.setCursor(0,2);  
  
// set cursor to column 0, row 2  
  
//lcd.print("Row 3");  
  
//lcd.setCursor(0,3);  
  
// set cursor to column 0, row 3  
  
//lcd.print("Row 4");  
  
}
```

## Combination of all Programming code

```
#include<LiquidCrystal.h>

const int ledPin = 13;

    // the number of the LED pin

LiquidCrystal lcd(12,11,10,5,4,3,2);

int backlight=8;

    // pin 8 will control the backlight

    // Variables will change:

int ledState = LOW;

    // ledState used to set the LED

long previousMillis = 0;

    // will store last time LED was updated

int i,j,v6,v7;

int En=1,Ex=1,Enp=1,Exp=1;

int count=0;

    // will quickly become a bigger number than can be stored in an int.

long interval = 1000;

    // interval at which to blink (milliseconds)

void setup()
```

```

{

    // set the digital pin as output:

pinMode(ledPin, OUTPUT);

pinMode(6,INPUT);

pinMode(7,INPUT);

lcd.begin(16,2);

pinMode(backlight,OUTPUT);

}

void loop()

{

v6 = digitalRead(6);

if (v6==0)

    {if (Exp!=0)

Enp=0; En=0;}

if((v6==1)

& (En==0)

& (Ex ==0)

& (Exp==0))

    {

```

```
count--;  
  
Ex=En=Exp=1;  
  
}  
  
v7=digitalRead(7);  
  
if(v7==0)  
  
    {if(Enp!=0)  
  
        Exp=0;Ex=0;}  
  
if((v7==1)  
  
    & (En==0)  
  
    & (Ex==0)  
  
    & (Enp==0))  
  
    {  
  
        count++;  
  
        Ex=En=Enp=1;  
  
    }  
  
    if(count>0)  
  
        digitalWrite(13,HIGH);  
  
    else  
  
        digitalWrite(13,LOW);  
  
        digitalWrite(backlight,HIGH);
```



**// turn backlight on. Replace 'HIGH' with 'LOW' to turn it off.**

**lcd.clear();**

**// start with a blank screen**

**lcd.setCursor(0,0);**

**// set cursor to column 0, row 0 (the first row)**

**lcd.print("Students:");**

**lcd.setCursor(0,1);**

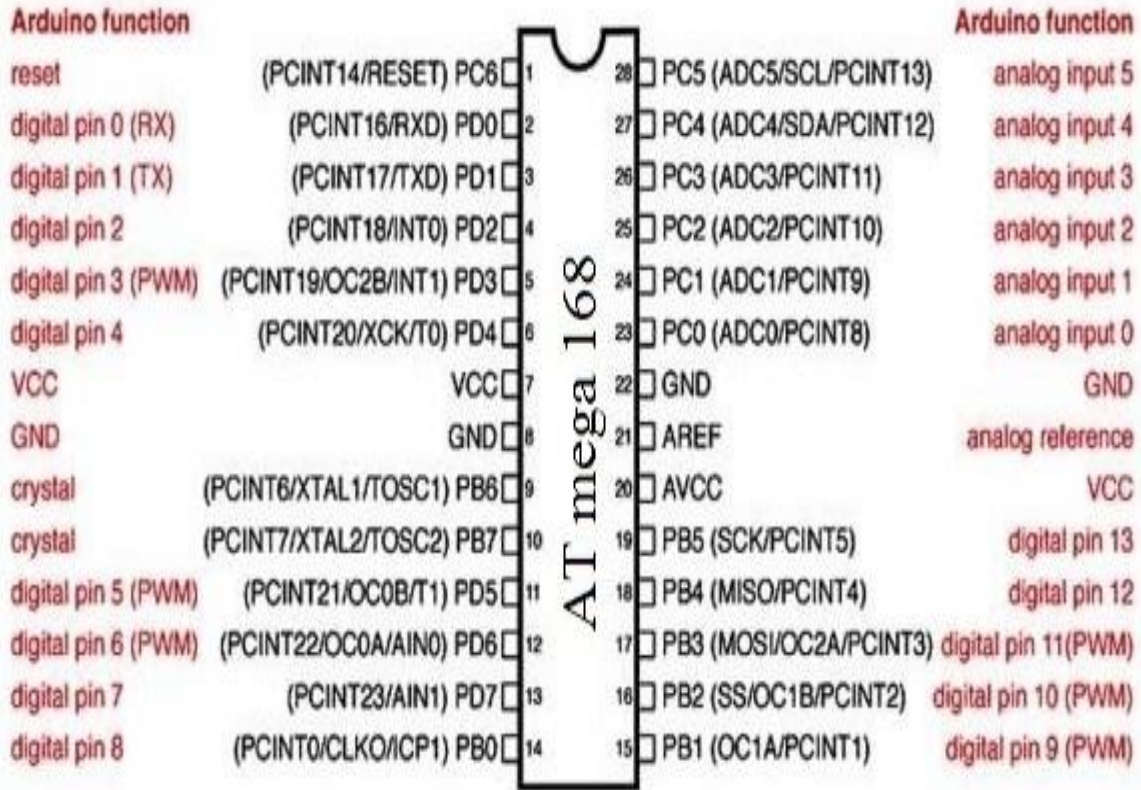
**// set cursor to column 0, row 1**

**lcd.print(count);**

**delay(50);**

**}**

## Pin diagram of AT mega 168



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