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Control of Lighting System

Group No: D13

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Abstract

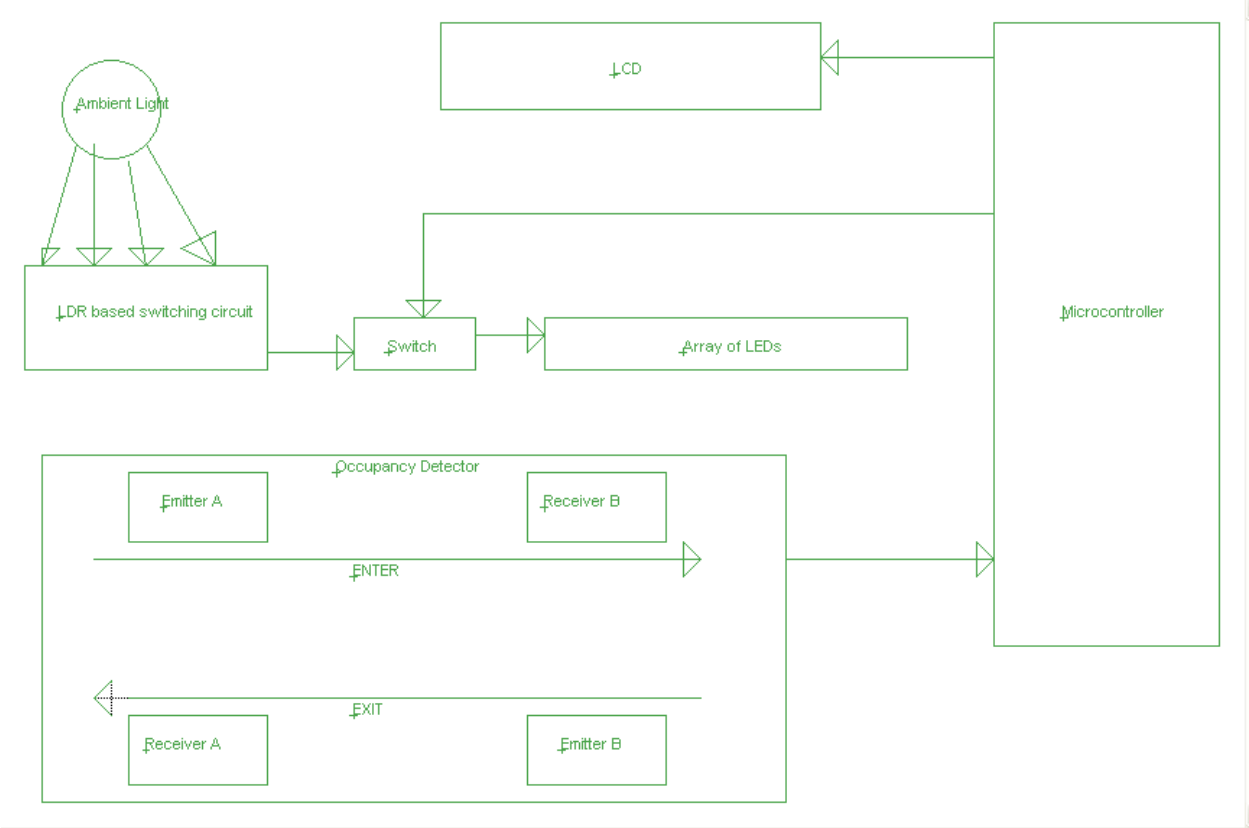
In this report we are discussing the design of an energy efficient array of Light emitting diodes(LEDs) having good intensity of light, an occupancy detector circuit that automatically switch ON and OFF the light in a room based on room occupancy and display the number of persons in a room on LCD and also a Light dependent Resistor(LDR) based circuit that controls the light in a room depending upon the lighting condition(intensity of ambient light) and user objective i.e. the user has to define a desired level of illumination.

1 Introduction

The motivation behind this project is "Energy Saving"; we tried our level best in designing an energy efficient electronic circuit to prevent the wastage of energy after looking at hostel rooms, toilets, Central Library e.t.c. of IIT Bombay. The major parts of this project are:

- Design of LEDs: Designing of circuit of LED array, AC to DC conversion, current driver, switching of circuit by Microcontroller
- Occupancy Detector: An occupancy detector circuit was built using a pair of infrared transceivers (5mm Transmitter and Receiver). When an opaque object is put in between the aligned transceivers, the receiver gets toggled. Putting one transceiver on a door could be used to determine whether someone crossed the door, however, two are needed to determine the direction of the person crossing the door. This is the circuit which saves the electricity to great extent, this circuit saves approximately around the 57.8% of the energy which otherwise has been wasted.
- LCD Display: In this part we are displaying the information about room occupancy (i.e number of persons) in the room detected by an occupancy detector circuit on LCD.
- LDR based switching circuit: This circuit is basically a light sensor circuit which senses the light and accordingly switches on and off the light automatically. This is the circuit which saves the electricity to great extent, this circuit saves approximately around the 49.5% of the energy which otherwise has been wasted. This circuit contains basically a comparator (Schmitt trigger) which compares the light intensity with the normal intensity and if required triggers the light on or off.

1.1 Block Diagram:



1.2 Conditions for LEDs to switch ON and OFF

- If an occupancy of room is zero, i.e. room is empty then LEDs will be switched off automatically
- If an occupancy of room is not equal to zero then
  - if an ambient light is sufficient then LEDs will be switched OFF
  - otherwise LEDs will be switched ON

2 Design of LEDs

2.1 Circuit Implementation:

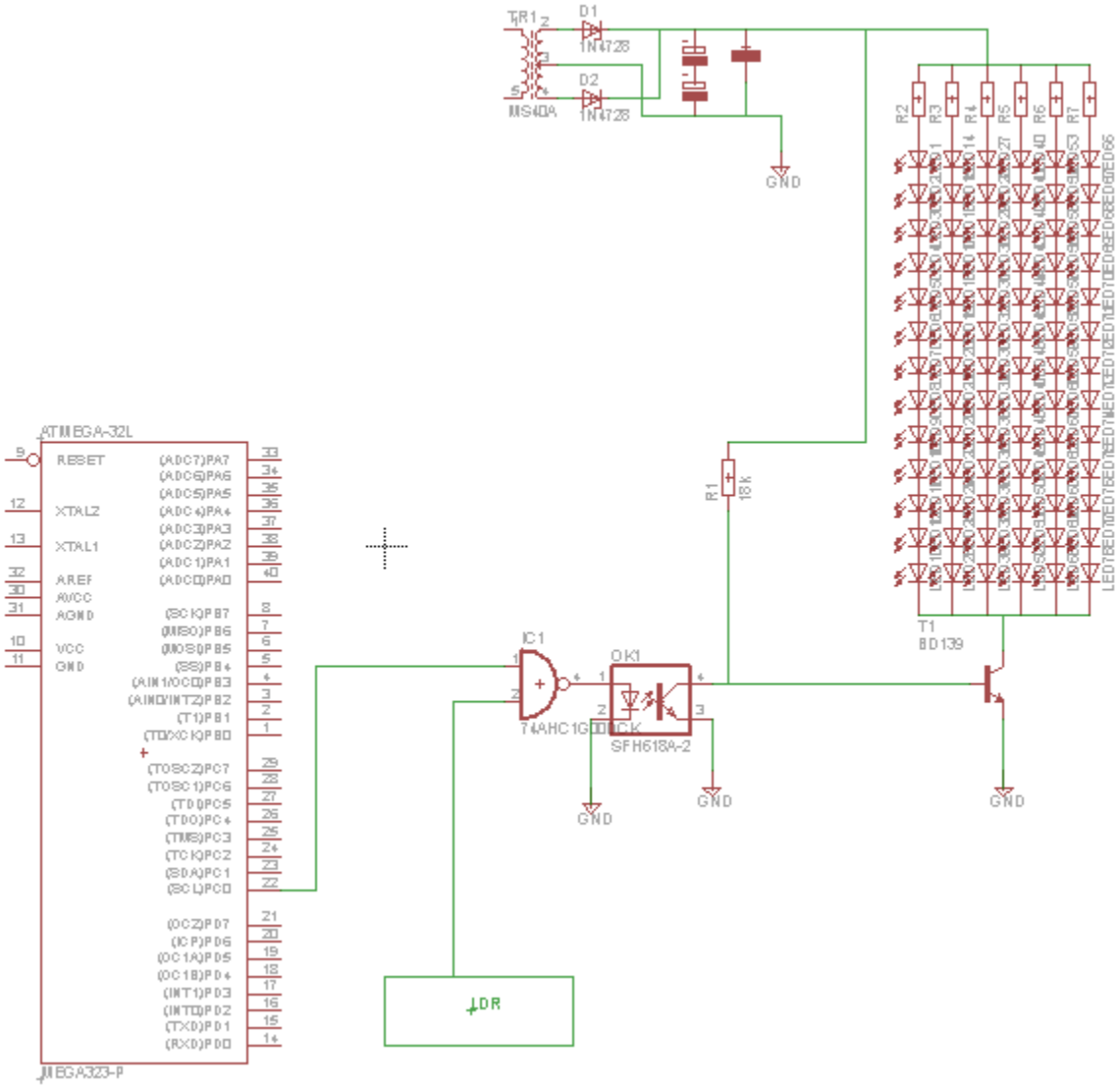
LED design circuit can be divided into following sub parts:

- Transformer: A transformer of value 36 – 0 – 36 V is used to down convert 230 ac voltage into 36 ac voltage.
- Rectifier Circuit: A rectifier circuit is used to convert ac value of voltage into dc. A circuit contains 2 diodes (1N4007), two electrolyte capacitors (470 uF) and a capacitor (0.1uF) as shown in schematic circuit diagram. This rectifier gives a RMS value of 36 V ($36\sqrt{2} = 51$ V). This voltage is used to drive LED arrays.
- LED array: 78 LEDs are used in parallel-series combination. (13X6, i.e. 6 parallel rows each are containing 13 LEDs. Each row contains a resistor (220Ω) to drive constant

current through LEDs, for each LED, the rated voltage and current are 3.5V and 30mA respectively.

- Switch: An n-p-n transistor (BD139) is used as switch for a circuit.
- Opto-coupler: An opto-coupler (MCT2E) is used between uC and circuit to avoid damage to uC. For logic 1 opto-coupler switch off the circuit and vice versa. Therefore a logic inverter 7404 is used to invert the logic.

2.2 Circuit Diagram:



2.3 Power Calculation :

For one LED :

Rating Voltage = 3.5 V

Rating Current = 0.030 Amp

Power = 3.5 * .030

=0.105 Watt

For 78 LEDs, Total power = 78 * 0.105

= 8.19 watt.

We assume 2 arrays of 78 LEDs have almost same intensity as Tube light

For one day :

For array of LEDs : 24hours X 2 X 8.19 watts = 393.12 watt-hours = 0.39312 Kwhrs

For Tube Light: 24hours X 40watts = 960 watt-hours = 0.960Kwhrs

Net saving: 0.960Kwhrs - 0.39312 Kwhrs = 0.567 Kwhrs

In percentage this power saving is approximately 59%

So, we can **SAVE 59% POWER**

3 Occupancy Detector

3.1 Circuit Implementation:

The voltage that develops across the receiver is dependent on the opaqueness of the object and the distance between the transmitter and receiver. To deal with this, an inverting Schmitt Trigger (IC40106B) was used. This design permits easy interfacing with the microcontroller as it provides an active-low signal to indicate a specific sensor has toggled. The transmitter/receiver Pair has an active range of detection of about 10° and was tested for acceptable operation of 0.25m, 0.5m, 0.75m, 1m.

3.2 Algorithm:

The circuit feeds information to the microcontroller, so an appropriate algorithm needed to be developed. Conceptually, when a person walks into the room through a door with the sensors, Sensor A is toggled first followed by Sensor B. Similarly, when a person leaves the room, Sensor B is toggled before Sensor A. In order to account for cases when a person walks half-way through the door (toggling only Sensor A) and decides to reverse direction and leave never entering the room, the following algorithm was implemented.

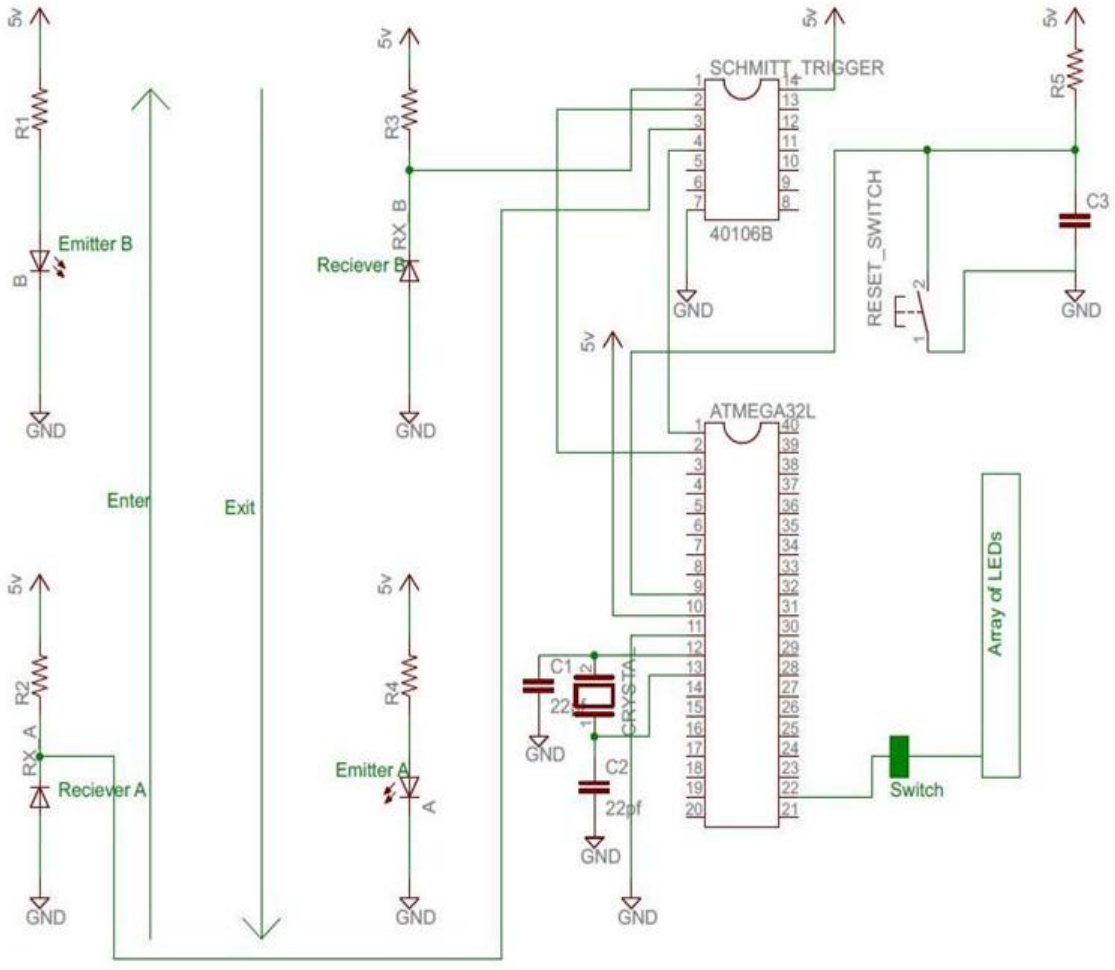
The number of people in the room will only be increased if the sensors are toggled in the following specific order:

1. Sensor A
2. Sensor A and Sensor B

3. Sensor B

In an analogous manner, the number of people will only be decreased if the following sensors are toggled in order:
1. Sensor B
2. Sensor B and Sensor A
3. Sensor A
All other combinations are ignored.

3.3 Circuit Diagram:



3.4 Power Calculation:

This Occupancy detection circuit is for general purpose i.e. it can be used to switch ON and OFF any type of lighting system(Array of LEDs, Tube Light, Bulbs), fans e.t.c Moreover,

we made this circuit from “Array of LEDs” point of view but the same circuit can be used for switching other devices with a little modification if desired.

1) Suppose a light in absence of circuit is on for whole day (i.e. 24hours)
   So, the power consumption for whole day will be = 0.39312 Kwhrs
2) Now let the circuit is connected so light will on for 10hours at max
   So, the power consumption of LEDs light will be = 10hours X 2 X 8.19 watts
   = 163.8 watt-hours
   = 0.1638 Kwhrs
3) And power consumption of circuit will be = 24hours X (5V X 16mA) watts
   = 24hours X 0.08 watts
   = 1.92 watt-hours
   = 1.92E-3 Kwhrs
4) So the total power consumption with circuit will be = Power consumption of circuit + power Consumption of LEDs light = 1.92E-3 Kwhrs + 0.1638 Kwhrs
   = 0.16572Kwhrs
   = 165.72 watt-hours

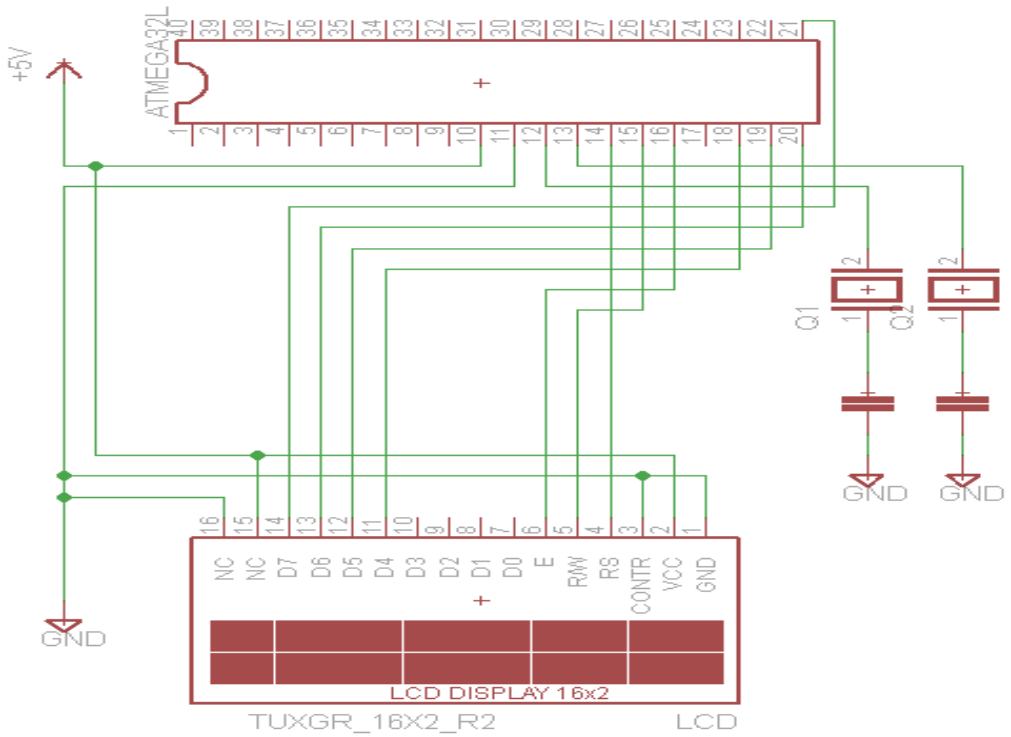
   So, the net power saving = 0.39312 Kwhrs – 0.16572Kwhrs
   = 0.2274Kwhrs

   In percentage this power saving is approximately 57.8%
   So, we can **SAVE 57.8% POWER**

4 LCD Display

Numbers of persons present in the room are displayed on LCD

4.1 Circuit Diagram:



4.2 Circuit Implementation:

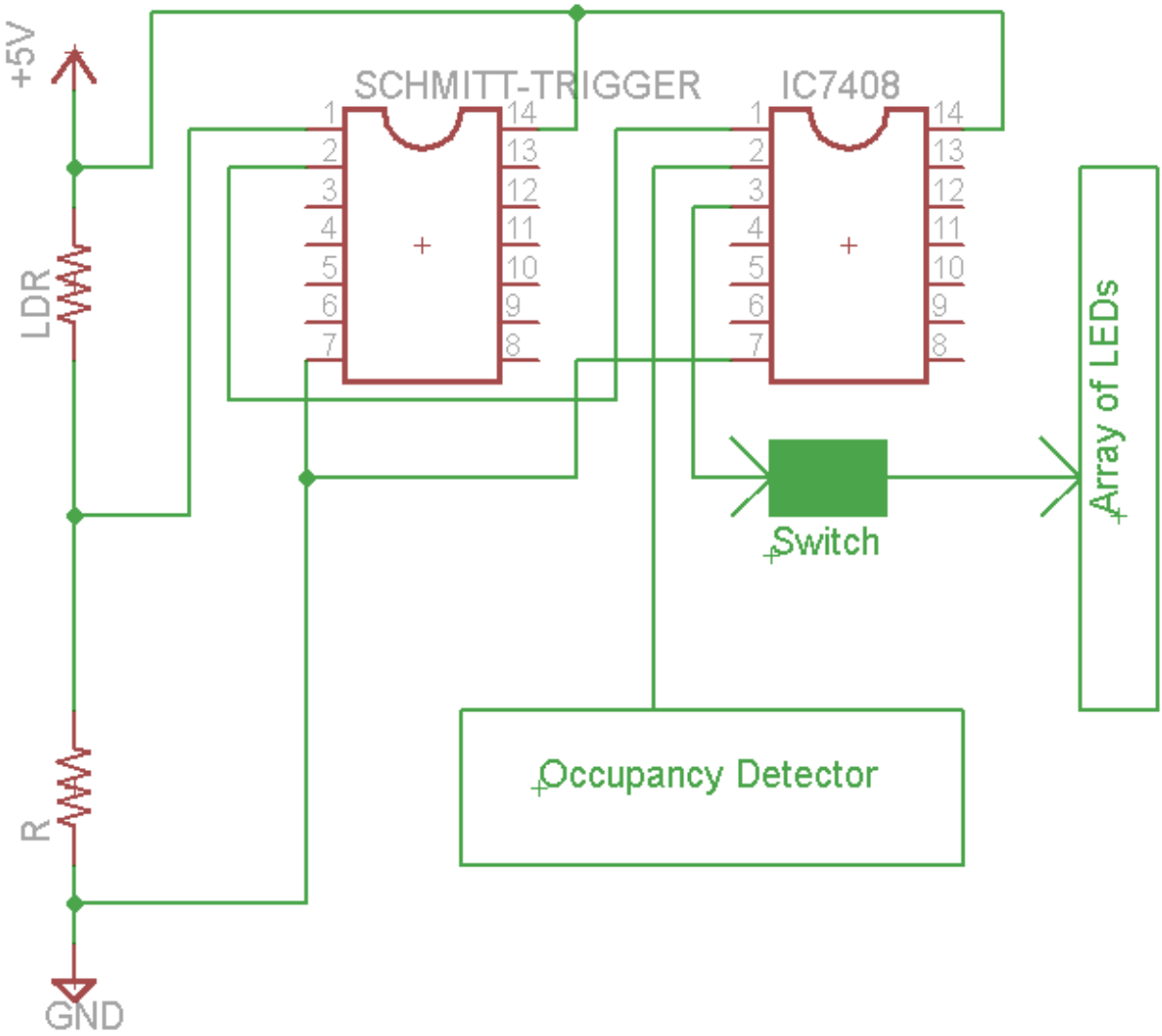
We are using only four pins D4, D5, D6 and D7 of LCD to interface with microcontroller.

5 LDR based switching circuit

5.1 Circuit Implementation:

This circuit is made using Light dependent Resistor (LDR) of dark resistance equal to 51kohms, the voltage developed across the resistance R is given to Schmitt Trigger, output of Schmitt Trigger is one of the input of AND gate, the other input of AND gate is an output of occupancy detector, when both are at logic 1 then they turn ON the switch and the LEDs will glow.

5.2 Circuit Diagram:



5.3 Power Calculation:

1) Suppose a light in absence of circuit is on for whole day (i.e 24hours)
   So, the power consumption for whole day will be = 0.39312 Kwhrs
2) Now let the circuit is connected so light will on for 12hours at max
   So, the power consumption of LEDs light will be = 12hours X 2 X 8.19 watts
   = 196.56 whrs
   = 0.19656Kwhrs
3) And power consumption of circuit will be = 24hours X (5V X 16mA) watts
   = 24hours X 0.08 watts
   = 1.92 watt-hours
   = 1.92E-3 Kwhrs
4) So the total power consumption with circuit will be = Power consumption of circuit + power Consumption of LEDs light = 1.92E-3 Kwhrs + 0.19656Kwhrs
   = 0.19848Kwhrs
   = 198.48 watt-hours

   So, the net power saving = 0.39312 Kwhrs - 0.19848Kwhrs
   = 0.19464Kwhrs

   In percentage this power saving is approximately 49.5%
   So, we can **SAVE 49.5% POWER**

6 Conclusion and suggestions for further improvement

- Just imagine after connecting this circuit on the door of one room we are saving 58 % energy, so after connecting all the Hostel rooms and Toilets of IIT Bombay we can save innumerable amount of energy. Hence the energy saved can be used in some or other way and we can easily come out of the energy crisis
- If we use this circuit on the doors of Lecture Halls, then LCD will display the occupancy of hall(i.e. Number of persons), this will save the last five minutes of Profs which are usually spend in taking head count and hence this circuit is also helping in preventing Proxies
- The occupancy detector is a good circuit but it has a limitation that is if two persons enter or leave a room simultaneously then this circuit treats these two persons as a one persons
- This circuit is good for Saving of light in a room, but if we want to save the light of corridors then in that case we need to use Passive infrared(PIR) sensor based circuit
- Since sky is the limit, we can add many things to this lighting system for eg. we can control the intensity of LEDs light by using RF based Remote control

7 Acknowledgement and References

- Prof. Girish Kumar, he had shown us the direction and had tried to solve our problems at each level, we did experiments on different combinations of various LEDs under his presence and he had cleared most of our concepts related to selection of an array of LEDs
- Prof.C S. Solanki, he helped us in the designing of an LDR based switching circuit

- Mr. Sudip Nag (RA), he helped us in choosing the right kind of sensors for occupancy detector, we tested two different kinds of sensors (IR Transceivers and PIR) and finally selected IR Transceivers because it is cheap and shows good result

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