FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 6 No. 6, December, 2022, pp 214 - 223
DOI: https://doi.org/10.33003/fjs-2022-0606-1150

DESIGN AND IMPLEMENTATION OF AUTOMATIC LIGHT CONTROL WITH BIDIRECTIONAL COUNTING SENSOR

***Engr. Muhammad Nura Idris, Muhammad Yahaya Abdullahi, Murtala Nasiru**

Department of Electrical & Electronics Engineering, Federal University, Dutsin-Ma. Katsina State, Nigeria

*Corresponding authors' email: mnura@fudutsinma.edu.ng

ABSTRACT

This paper present design and Implementation Automatic Light Control with Bidirectional counting Sensor. In the design, Light Control with Bidirectional Counting Sensor is proposed to be used so that controller-based model is adopt to count the number of persons entering or leaving a particular building and accordingly turn on or turn off lighting in the building. A sensor is used with counters to count the number of people entering or leaving a particular building. The logic behind the design is that whenever a person enters, it counts up and when a person leaves its count down. The light control of the system is actualized when an individual enter and remains off when left. The designed is achieved using infrared light sensor and combination of array counter. When implemented, the design can be used in public places like malls or library to restrict the flow of people.

Keywords: Astable, Common cathode, Electrical energy, Flip-flop, Infrared

INTRODUCTION

Sometime in the past, energy scarcity has become crucial in this planet. The power usage in public places like Library, Hotels, and Domestics takes the highest percentage of the energy consumed in the world (Bai & Ku, 2008). Currently, the area of technologies focuses on; automation, energy consumption and cost optimization (Sudhakar, Anil, Ashok, & Bhaskar, 2013). Automation in the public places guarantees efficiency as well as increase in the lifespan of electrical components (Tadimeti & Pulipati, 2013).

Gazis et al. (2022) proposed monitoring and tracking visitors within a building. The authors used python, protocols communication and sensors. Specific location operation might be the negative part of the design.

Owing to the rapid increase in population, it is also important to know the number of people in the public places by counting the inflow and outflow, this will enable the organization or administrators to satisfy the visitors, feasibility studies and future expansion (Dey *et al*., 2016).

Human beings especially old and disable find it difficult to put-off light when is not required, this results into energy wastage and increase in the cost of electricity (Ranjit, Ibrahim, Salim, & Wong, 2009). As a result of increase in cost of electrical energy and short comings in our power generation, it become necessary to make good use of the available electrical energy (Priya & Vijayan, 2017). In (Monder, Chen, & Tomoaki, 2022), the author presented an array sensor and low resolution infrared sensor is his designed to identify the location of indoor, outdoor peoples were not discussed in the paper. Therefore, energy conservation has become a priority for efficient utilization of electrical energy (Wazed, Nafis, Islam, & Sayem, 2010). Knowing the exact number of people at a particular time can be used to analyze the progress an organization is making and also guide it in policy and decision making (Ashkanani, Roza, & Naghavipour, 2015). (Manoj, & Thingom, (2022) designed and implemented Visitor counter using FPGA and Bluetooth, though the goal was achieved, but the design worked in one direction only. Infrared ray sensor was used to design visitor counter with automatic light control but absolute count would not be determine by the design.

This research work designed and presented an approach that combines both automatic light control with bidirectional counting sensor. The system is developed using readily available discrete components. The article is structured to begin with the architecture of the system which include block diagram, various circuit designs of the system, working principle, simulation of some parts of the designed circuit, results, conclusion and finally the reference.

METHODOLOGY

This work proposed design and implementation of Automatic Light controller with bidirectional sensor. Figure 1 below shows the complete circuit block diagram of the project. The circuit comprises of three sections with numerous electrical components; transmitting circuit, receiving circuit, switching & counting unit

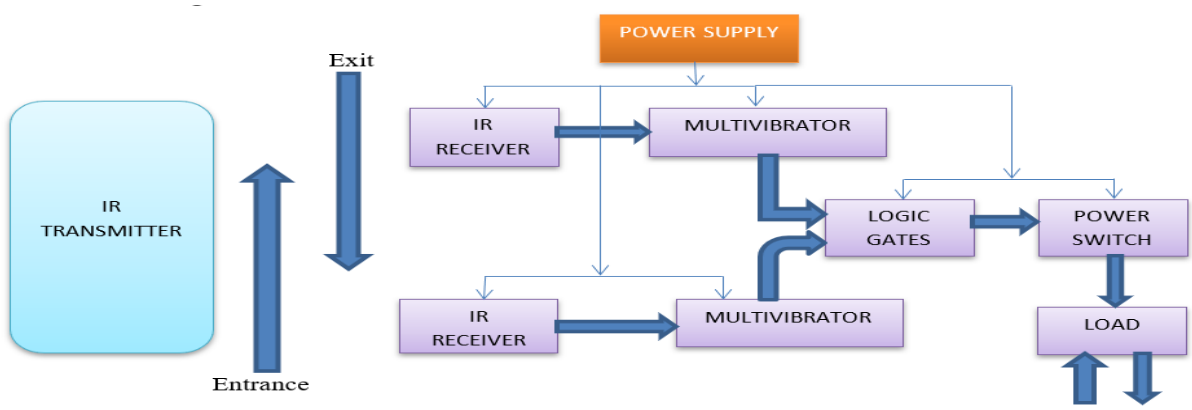


Figure 1: Block diagram of the system

List of components
1. 555 Timer
2. TSOP sensor
3. Transistor
4. Solid state relay
5. Three inputs OR-gate
6. Dual J & K flip-flop
7. Infrared and LEDs
8. Resistors and Capacitors
9. 74LS192 Decade counter
10. Seven segment display and BCD to 7- segments decoders

Circuit Design
The three parts of the design block diagram was design separately. Circuit transmitter was initially design, followed by other block diagram components to complete the whole circuit diagram. TSOP 1730SEI was used as an infrared signal receiver to receive a signal at 35 KHz. Identical frequency of 35 KHz was used for the transmitter.

Infrared Transmitter
In this design, 555 timer is used to design the infrared transmitter. The circuit has the ability to generate signal at the frequency of a range $1 - 500kHz$ (Diodes Incorporates, 2012). This timer is choosen because it can be configured as either Astable or Monostable depending on the application of the project. For this work, it's configured to operate as Astable mode as shown in the figure below

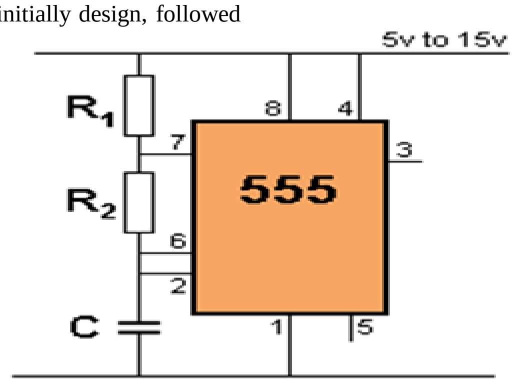


Figure 2: Astable Mode of Configuration (Mitchell, 2011)

The unknown in the above circuit is proportional to the design frequency and can be found using the formula below:

$t_{High} = 0.693(R_1 + R_2)C$ (1)

$t_{Low} = 0.693R_2C$ (2)

$T = Period = t_{High} + t_{Low} = 0.693(R_1 + 2R_2)C$ (3)

$Frequency = 1.44/(R_1 + 2R_2)C$ (Diodes Incorporates, 2012) (4)

The design frequency is identical between receiver and transmitter, thus, Substituting appropriately the values of the frequency and the period in the equations above, define the values of R_1, R_2 & C. For better result, concept of frequency shift key is applied. In addition, the working 555 timer is set to be at $12k\ Hz$. Figure 3 shows the overall transmitting circuit.

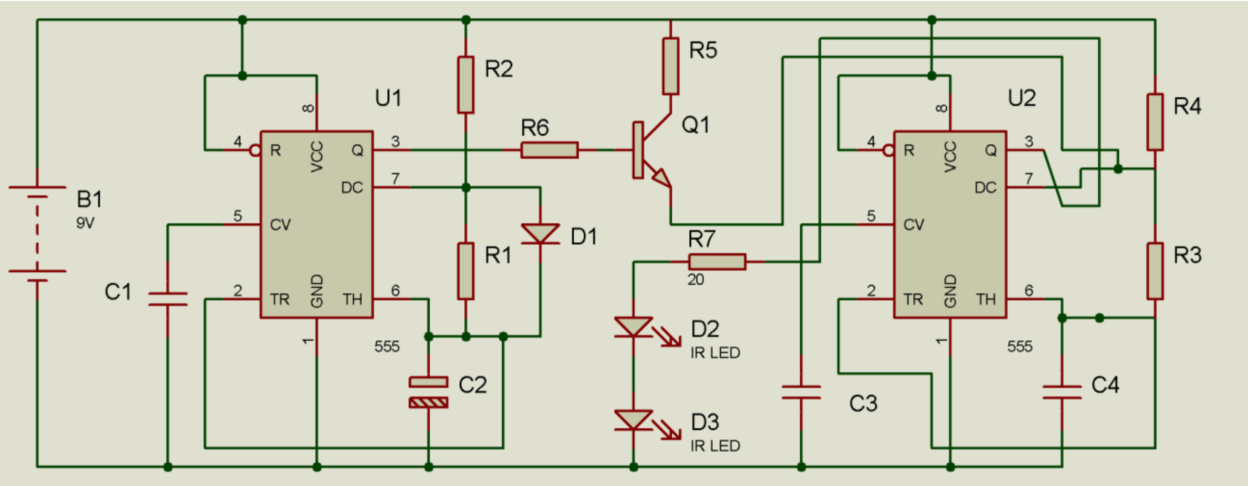


Figure: 3. Infrared Transmitting Circuit

Infrared Receiver

TSOP 17 series was preferred as a receiving sensor at $35k\ Hz$ with preamplifier cascaded in the epoxy package (Telefunken, 2001). The internal configuration of the sensor as well as the application circuit is shown in figure 4 & 5 respectively.

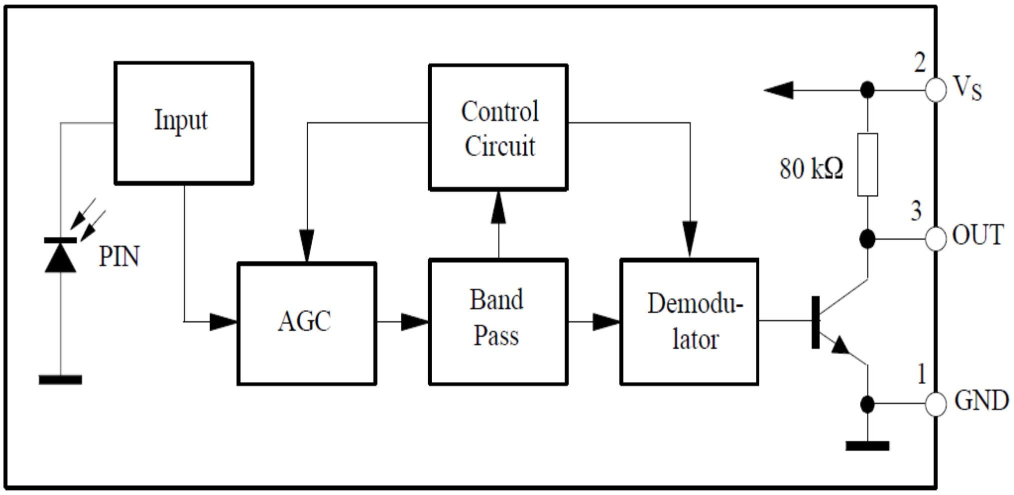


Figure 4: internal configuration of TSOP Sensor (Telefunken, 2001)

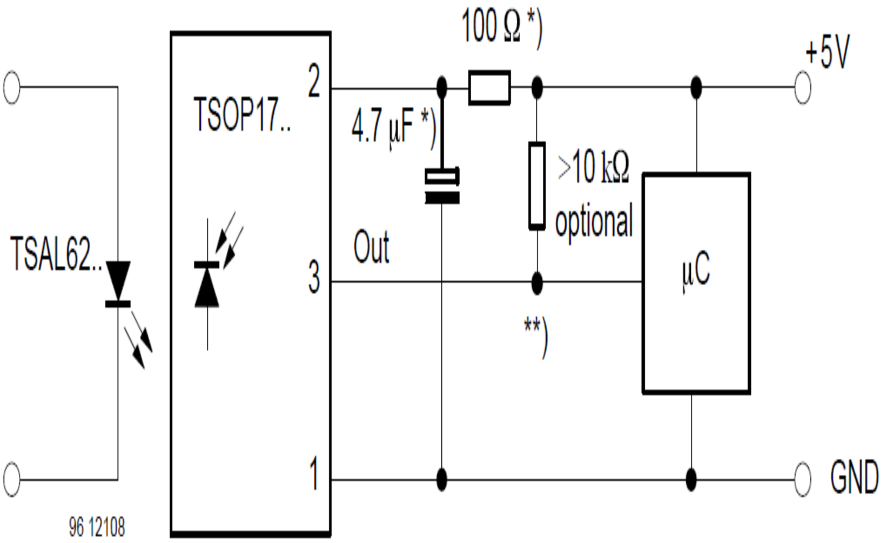


Figure 5: Application circuit of the Sensor (Telefunken, 2001)

Figure 5 present receiving part of the application sensor. Appropriate operation of the sensor can be achieved by getting actual limiting resistor and capacitor value.

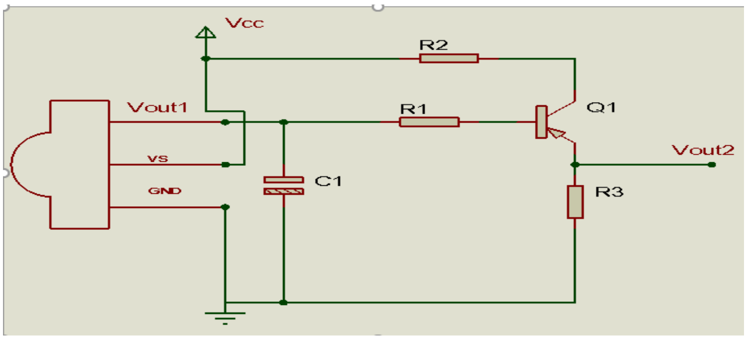


Figure: 6. Infrared receiver circuit

Specifications of the above circuit are;
$V_{CC} = 5V$
$Voltage\ drop\ across\ the\ sensor V_D = 0.7V$
$V_{out2} = V_{CC}/3 = 1.7V$
From figure 6
$V_{CC} = V_{out1} + V_D$
$V_{out1} = 5 - 0.7 = 4.3V$
General- purpose BC 557 is selected to function as a switch labelled as Q_1. It has the following specifications from its data sheets;
$I_{C(max)} = 100mA, \quad V_{CC(max)} = 65V\ and\ \beta = 125\ to\ 800$
But $V_{CC} = 5V$
Let $\beta = 130\ and\ I_C = 56mA$

$I_C = \beta I_B,\ I_B = I_C/\beta = (56 \times 10^{-3})/130 = 0.43mA$
$I_B = 0.43mA$
$R_1 = V_{out1}/I_B = 4.3/(0.43 \times 10^{-3}) = 10K\Omega$
$R_2 = V_{CC}/I_C = 5/(56 \times 10^{-3}) = 89.82\Omega \approx 90\Omega$
$V_{out2} = \{R_2/(R_2 + R_3)\} \times V_{cc}$
$1.7 = \{90/(90 + R_3)\} \times 5$
$R_3 = 174.70\Omega \approx 180\Omega$

Multivibrator Design
Figure 7. Showed the configuration of 555 timer in monostable mode. This mode is gained when the trigger voltage is below threshold value.

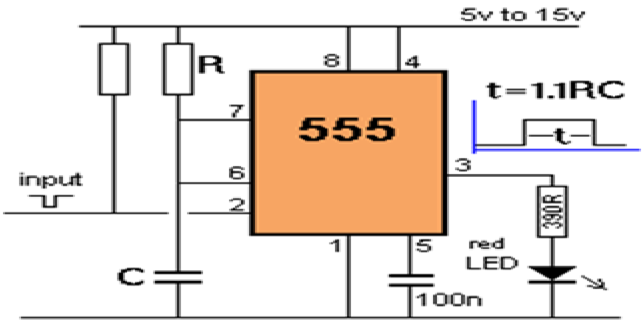


Figure 7: Monostable Mode of Configuration (Mitchell, 2011)

The time it takes to bridge between the two sensors is approximately 0.5 seconds, then
$T = 1.1RC$ (5)
$T = 0.5s\ \ and\ \ $ Let $C = 100\mu F$
$R = T/(1.1 \times C) = 0.5/(1.1 \times 100 \times 10^{-6}) = 4545.45\Omega \approx 4.5K\Omega$

Counter and Combinational logic Design
Two JK flop flips can be used for direct bidirectional flow. The flip flop has the following excitation table;

Table 1. Excitation table of dual J-K Flip Flop (ST, 2001)

INPUTS				OUTPUTS		FUNCTION
$\overline{CLR}$	J	K	$\overline{CK}$	Q	$\overline{Q}$	
L	X	X	X	L	H	CLEAR
H	L	L	$\downarrow$	Q_n	$\overline{Q}_n$	NO CHANGE
H	L	H	$\downarrow$	L	H	----
H	H	L	$\downarrow$	H	L	----
H	H	H	$\downarrow$	$\overline{Q}_n$	Q_n	TOGGLE
H	X	X	$\uparrow$	Q_n	$\overline{Q}_n$	NO CHANGE

Single input (J) is used for this purpose only. In this application, operation of the flip flop function properly when clear (CLR) is set to high. However, clock transition also is set to high, and J = Q^1 . These concepts are used to realize bidirectional flow, two NOT gates are connected in order to smoothen the pluses, the combinational circuit diagram is shown in figure 8.

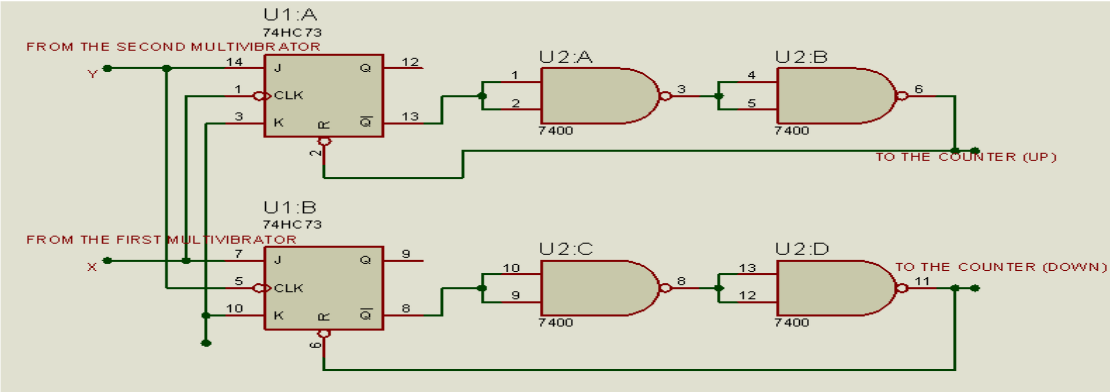


Figure 8: Bidirectional combinational circuit

The circuit count from 0 to 999, thus, three seven segment display (Common Cathode or Common Anode) and three decade up/down counters are required with their drivers. The counter (74LS192) has borrow and carry, which allow one to cascade the circuit as shown in the figure 9.

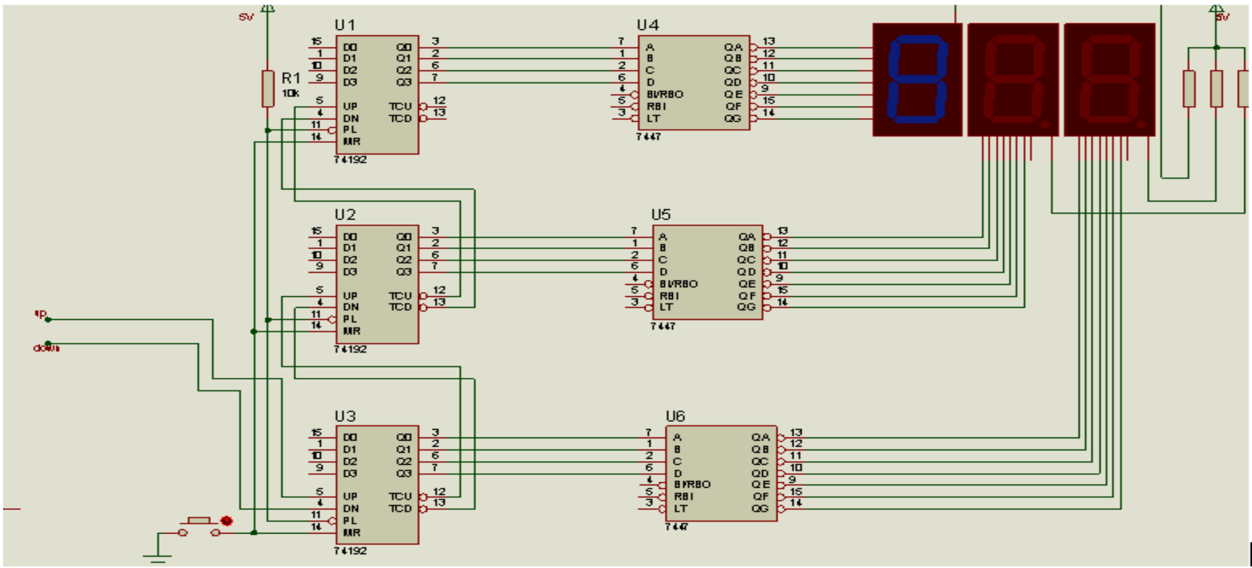


Figure 9: Counting circuit

Switching circuit Design
This circuit is required to have a low signal at the base of the switching transistor whenever the counter is reading ‘000’ and the High signal when otherwise. This is necessary for the correct functionality of the system. From figure 10, when all the outputs of the three-decade counters are at low signal level, the counters read 000. Then let $P_1 = A_1^{\iota}+A_2^{\iota}+A_3^{\iota}+A_4^{\iota}$, $P_2 = B_5^{\iota}+B_6^{\iota}+B_7^{\iota} + B_8^{\iota}$ and $P_3 = C_9^{\iota} + C_{10}^{\iota} + C_{11}^{\iota} + C_{12}^{\iota}$ be the output of the three decade counter respectively Where $A^{\iota} = B^{\iota} = C^{\iota} = 0$ and $A = B = C = 1$.
Then the total output will be
$P_T = A_1^{\iota} + A_2^{\iota} + A_3^{\iota} + A_4^{\iota} + B_5^{\iota} + B_6^{\iota} + B_7^{\iota} + B_8^{\iota} + C_9^{\iota} + C_{10}^{\iota} + C_{11}^{\iota} + C_{12}^{\iota}$ Which can be implemented using OR gates as shown in figure 10 below;

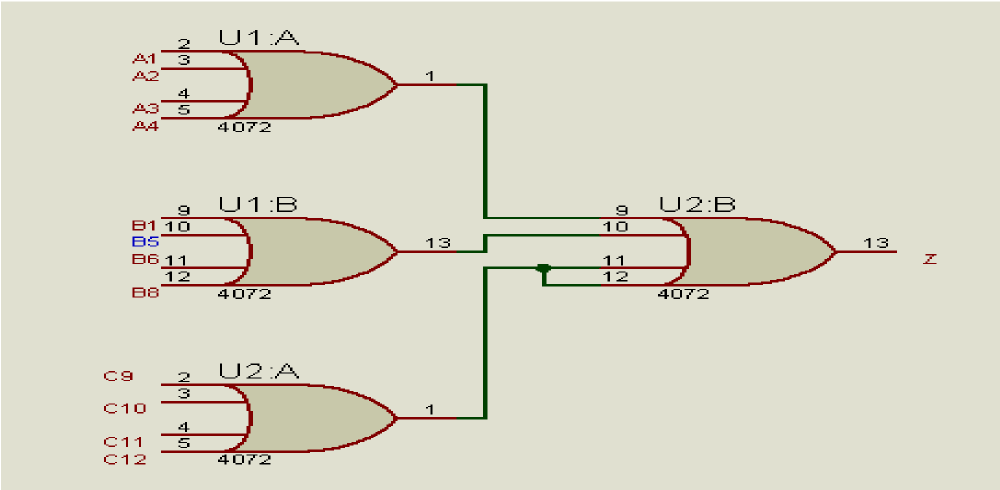


Figure: 10 Logic circuit

The output of the logic circuit from figure 10 is connected to a transistor through a resistor. The general-purpose transistor (BC108) is used for switching a solid-state relay, as shown in figure 11 below;

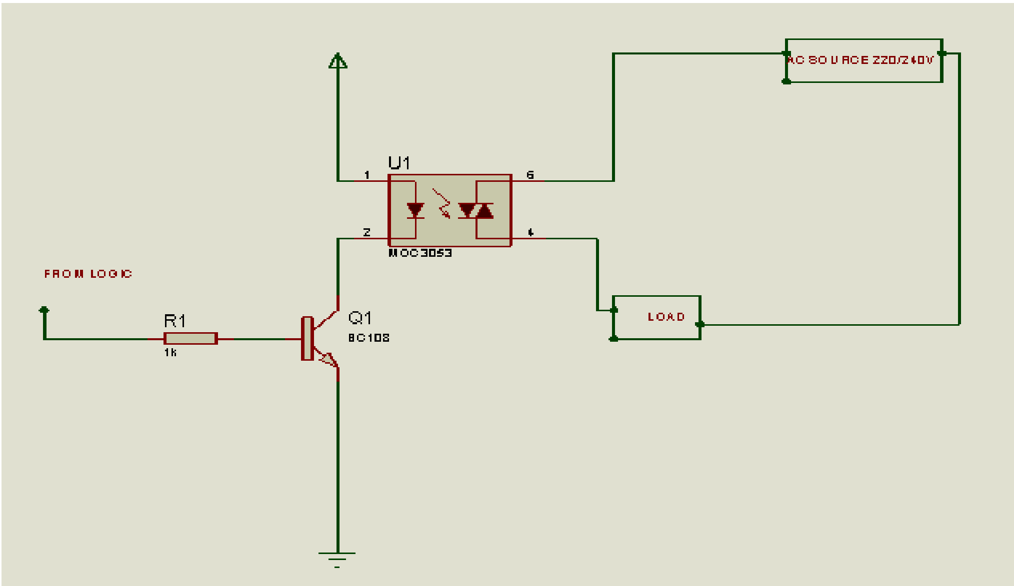


Figure: 11. Switching circuit

Design of power supply

The power supply unit consists of a 240V/12V step down transformer, rectifier, filter and a voltage regulator. A full wave bridge rectifier IN4001diode is used and the current of 2A is chosen, as in shown in figure 12 below;

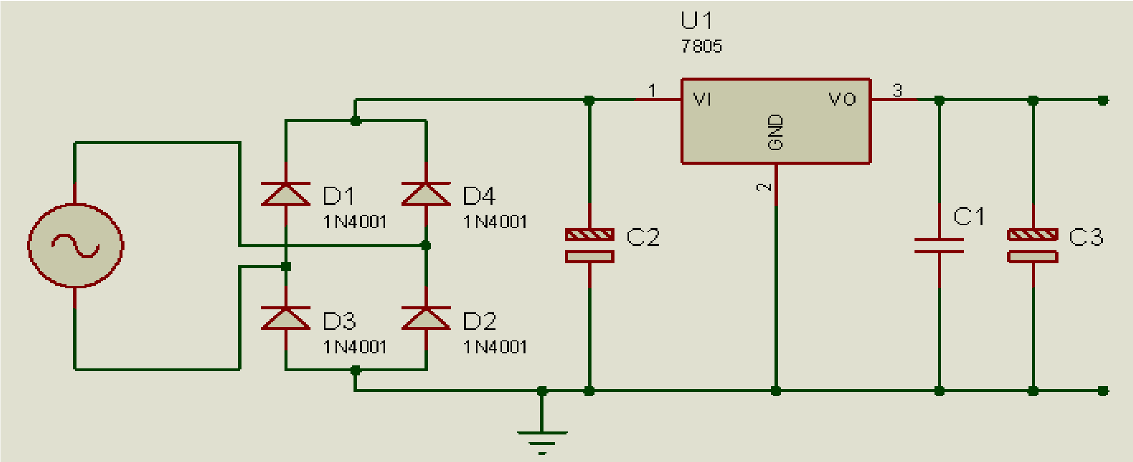
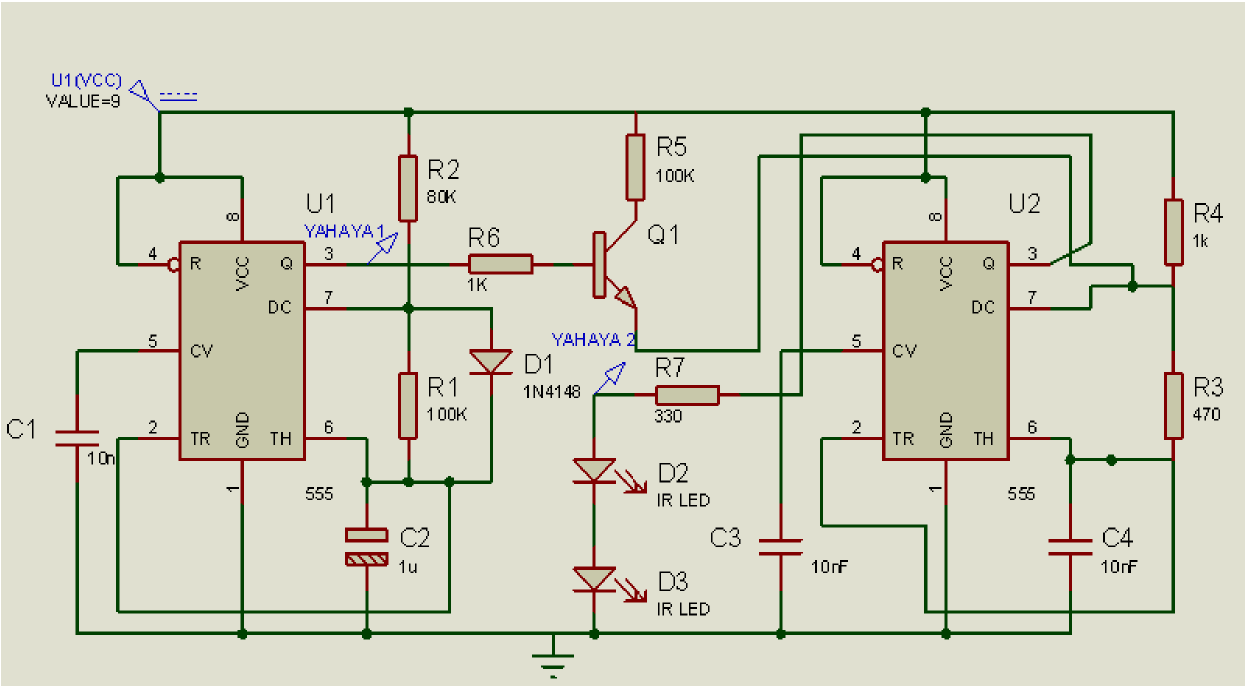
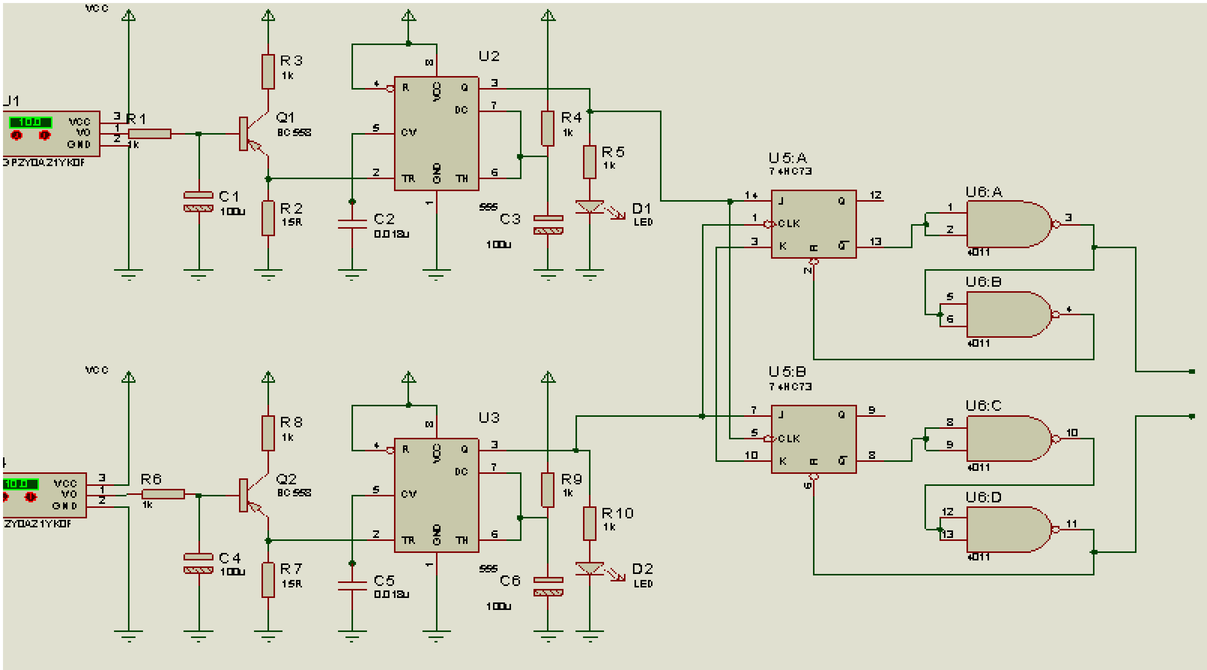


Figure: 12. Power supply unit

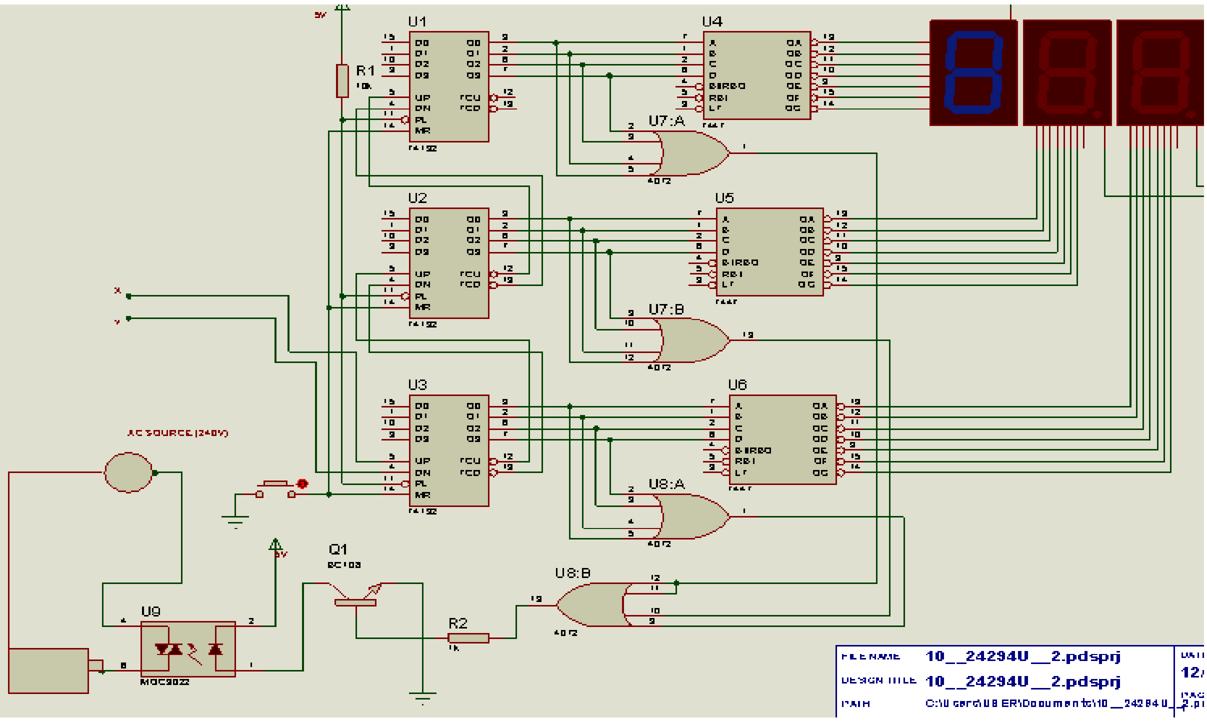
The overall circuit diagram is shown



(a)



(b)



(c)

Figure: 13. Overall circuit diagram: (a) Infrared transmitter, (c) Infrared receiver with bidirectional circuit, (c) Counting and switching circuit

SIMULATION RESULTS AND DISCUSSION

Figure 13 present complete circuit diagram of the project. The digital part of the circuit was analyzed using light emitting diode (LED) which can be either Low or High, ON or OFF. Proteus 8.0 and National Instrument (version 11) was used for the check the transmission, sensing and power supply sections.

Transmitter

The circuit transmitter is designed to operate Infrared signal at $33-38kHz$. Simulation result of the designed transmitter is shown in figure 14. From figure, it has been observed that, the output of the two 555timers is square wave at different frequencies. This correlate the aim of the transmitter design which is based on the frequency shift keying. Fig 14 (a) of 555 timer transmitter generate about 100 Hz, while figure 14 (b) generate a frequency of 35 kHz which is the target design frequency.

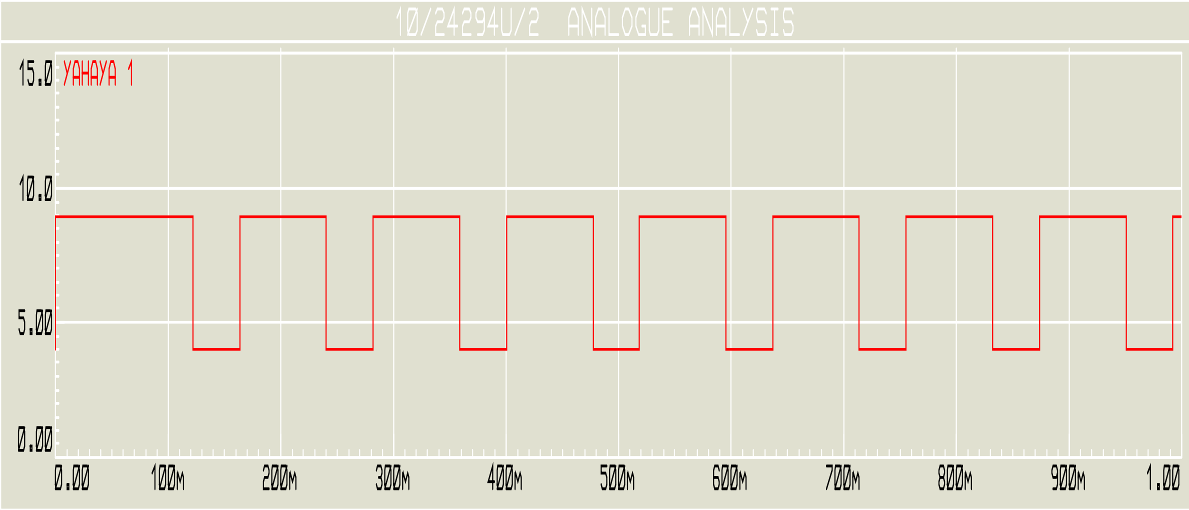
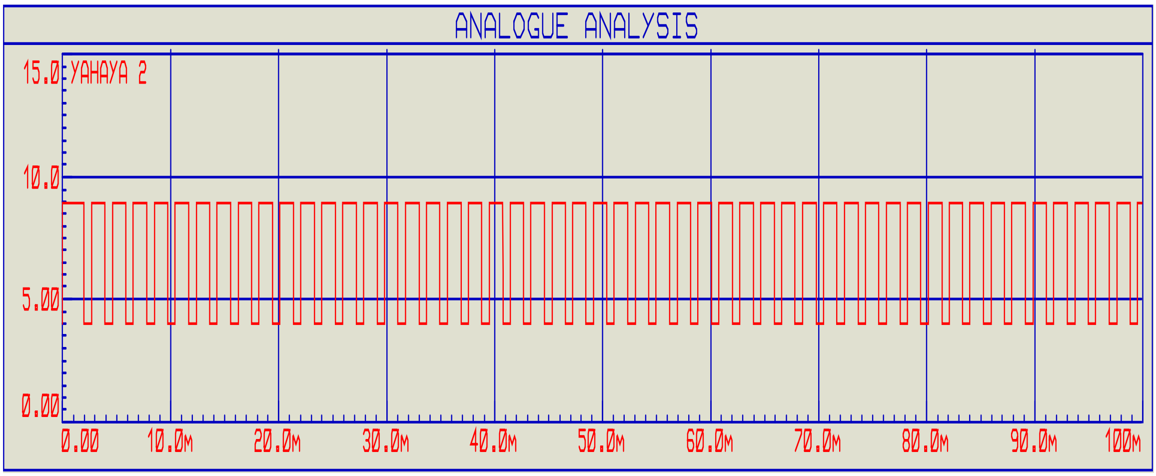


Figure: 14 Output signals: (a) Output from U_1,



(b) Output from U_2

Time between the two sensors

As person enters or exits the entrance, the time it takes to bridge from one sensor to another was designed using monostable multivibrator. If the time is not accurately designed, the count up and count down cannot be achieved.

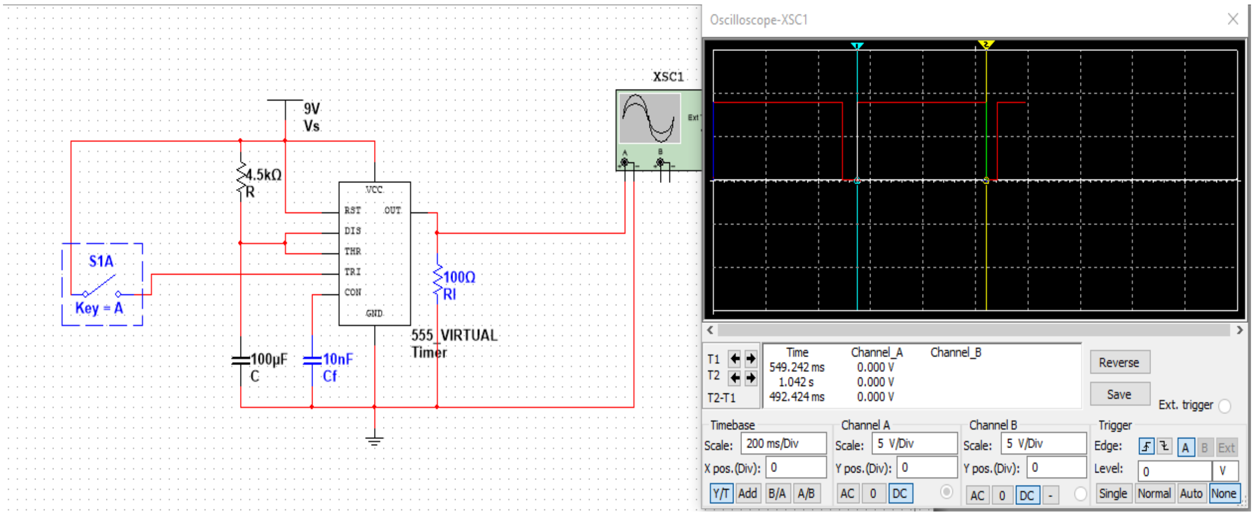


Figure: 15. Simulation of the Sensor unit

CONCLUSION

This work present design and implementation of automatic light control with bidirectional counting sensor. The design goal is to minimize the cost of electrical energy and also know the number of people present in the public domain like library, Hotel. The circuits were designed and constructed using various electronics component. The infrared transmitter was mounted on the door frame with the receiver, four hundred watts of bulbs were connected to the main circuit. As the circuit was switch-on the counter reads '000', an individual pass through the door frame the bulbs turned on and the counter reads '001'.

The number on the counter kept incrementing as people pass through the entering point, when individuals passed through the exit point the counter was counting down, as the last person left the bulbs turned-off and the counter read '000'. The whole circuits were tested and was found to be both switching the light and counting.

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