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Research Article

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Design and Construction of a Home Security System with Alarm and Flashing Outdoor Light

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Abstract A home security system with alarm and flashing outdoor light was constructed using infrared red sensor, operational amplifier (LM358 as a voltage comparator), NE555 timer, DC battery and relays. The design was carried out using Proteus software. For proper operation, the system is divided into four units; the power supply unit which consists of both the DC battery and main power supply to ensure constant power supply to the circuit; the sensor unit to detect the presence of an intruder and to send a signal to the trigger unit; the trigger unit which is responsible for activating the alarm unit, and the alarm unit that produces an audible sound through a 1 Watt 8 Ω loud speaker, and equally switches ON through a relay a flashing light that can alert the neighborhood. The time out period for the trigger unit was 25 seconds, after which the system returns to its initial operating stage. This security system could be placed in major entrance of a house. It is cheap, reliable (since it uses both DC and AC sources) and effective. It can be used in both rural and urban homes where there are challenges of power supply.

Keywords Sensor, Security System, Operational Amplifier, NE555 Timer, Alarm Unit

1. Introduction

Security of lives and properties world over is so paramount in recent times. From neighbourhood thieves, well "armed" armed robbers, hired assassins and more recently to terrorism are on the increased. Any research work on security system should therefore be given the attention it deserves. Security system can be literally defined as a means or method by which something is secure through a system of networking components and devices.Security is defined as the state of being free from danger or injury. All home security systems work on the same basic principle of securing entry points, like doors and windows, as well as interior space containing valuables objects like art, computer, jewellery, guns and coin collections.Insecurity can be defined as the state of being subject to danger or injury. Crime constitutes some of the major problems facing our immediate society today. People live with the fear of being attacked by burglars, vandals and thieves. Despite all the effort, resources and time that has been devoted to the development of tools that will reduce crime rates and make the world a safer place to live, these problems still increase. These gave rise to the need for an increasing development in the technology of alarm systems which utilizes various principles such as infrared motion detector, light (photo) sensitive electronic devices and so on.

The importance of home security system has greatly increased in the recent years. Many houses are burgled by means of illegal entry force, such as breaking a window or slashing a screen or by entering through an unlocked door or an open door. Consequently, we have seen a trend in the increasing need for home security systems. Early studies have shown that burglaries seldom occur in places where an efficient, secure home security system has been installed. There are electronic alarm systems that operate without any human effort. Once it senses a particular signal, it gives an indication in the form of loud sound or noise depending on its design [1].

This modified home alarm system constructed has an automatic power change over switch that can switch between the mains supply and DC battery using a relay. The system uses a sensor (place at the door or main gate) to detect any intruder or unwanted visitor. The output of the alarm system ranges from siren sound to flashing outdoor lights. These serve as an alarm and alert the neighbours about the possibility of an intruder in the house concerned.

The term operational amplifier refers to a high gain dc amplifier with a differential input. It is a complete pre-packaged amplifier whose operating characteristics and behaviour depend almost entirely of the few components connected to its terminals [2]. Its internal circuit consists of many transistors, FETs and resistors. The term Op-amp is used to denote an amplifier which can be configured to perform various operations like amplification, subtraction, differentiation, addition, integration and so on. Op - amps could be employ to solve simultaneous linear equations as demonstrated by [3]. They can also be used in audio mixer amplifiers [4]. An op-amp has two input voltage supply terminals and one output terminal. The negative input terminal is known as the inverting terminal while the other input terminal that is positive is the non-inverting terminal.

2. Block Diagram and Circuit Description of Various Units of the Home Security System

This section presents the block diagram of the entire home security system and the circuit description of the various units.

2.1. Block Diagram of the Home Security System

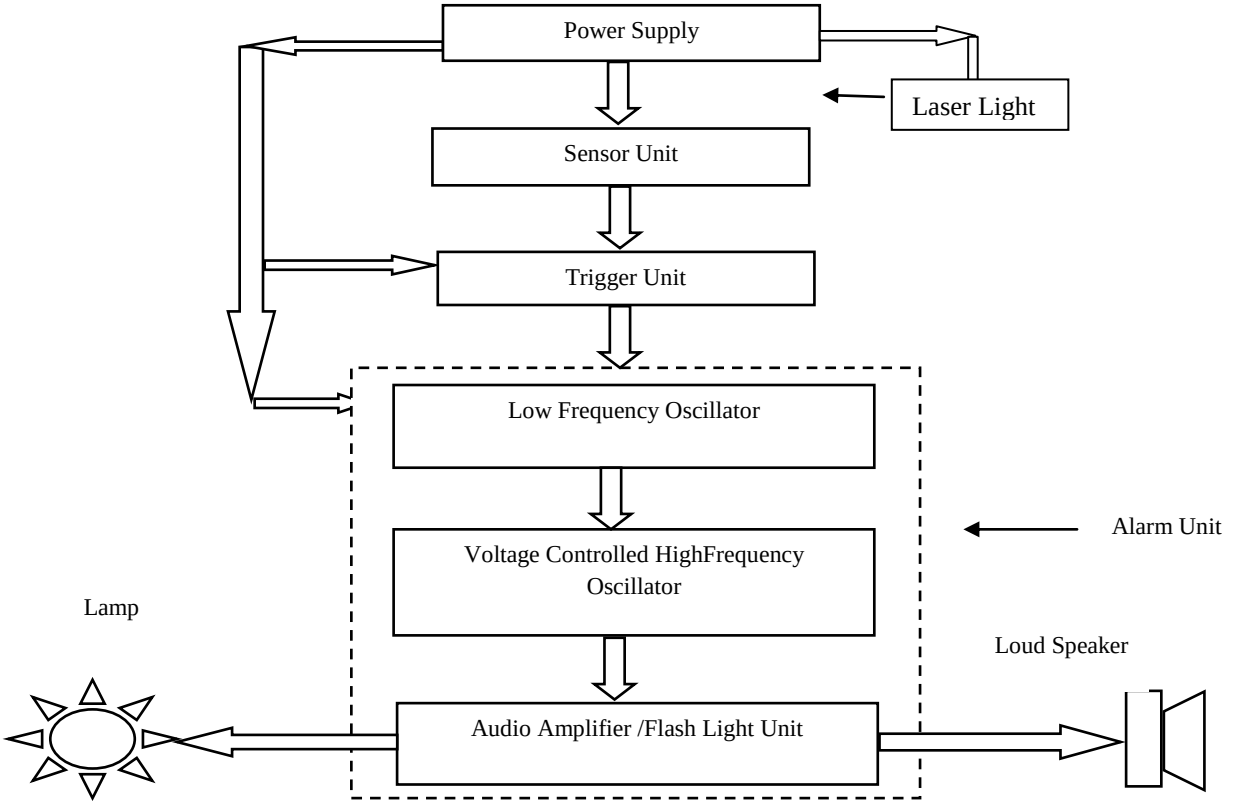

Figure 1: Block Diagram of a Home security System

The block diagram shown in Fig.1 also represents the flow chart of the home security system.

2.2. Circuit Description of the Various Units

2.2.1. The Power Supply Unit

The unit consists of the power supply AC (which is rectified to produce a DC voltage) and a DC battery. An automatic power change over switch was used to switch between the mains supply and DC battery using a relay that feeds other components of the circuit.

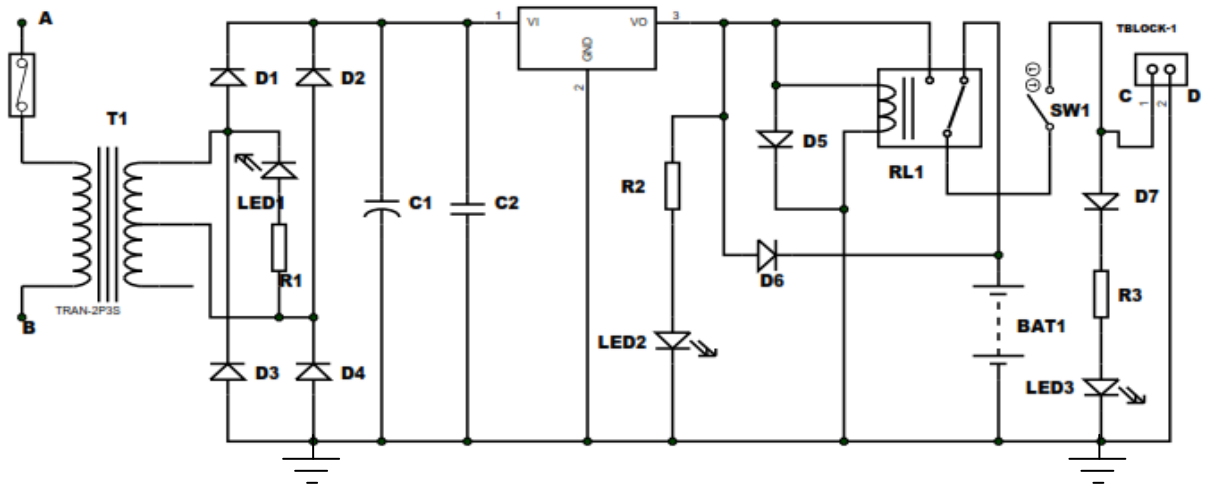

Figure 2: Circuit Diagram of Power Supply unit

The power supply unit consists of a 2-way automatic power supply system. It consists of a transformer, diodes, resistors, capacitors, relay, rechargeable battery (DC) and a light emitting diode (LED). The AC source is rectified by the diodes, filtered by the capacitor and regulated constant output voltage. A DC source is connected as the alternative source, with arelay that serves as an automatic switch. This passes through a switch that turns ON/OFF the system. The power supply unit provides power supply to the other three units of the circuit.

2.2.2. The Sensor Unit

The sensor unit detects the presence of an intruder whenever the latter blocks the laser beam falling on the light dependent resistor (LDR), and automatically sends out a signal to the trigger unit.

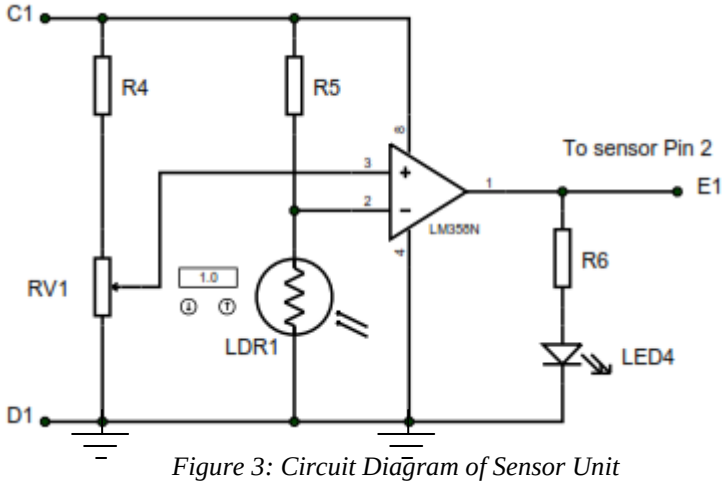

Figure 3: Circuit Diagram of Sensor Unit

The operational amplifier (LM358N) in the sensor unit compares the analog input from reference voltage and gives the output signal to the trigger unit at pin2 of IC_3. It is a low power dual operational amplifier integrated circuit that can be used in detector circuits.

2.2.3. The Trigger Unit

The trigger unit receives the signal sent from the sensor unit and produces an output that switches ON the alarm and the flashing light stage to the power supply for a time duration determined by the time out period of the NE555 timer.

The trigger unit consists basically of three major components; the NE555 timer; Transistor (TR3) and a relay (RL2). The NE555 timer produces a trigger current which comes out through its pin 3 whenever pin 2 is activated through the sensor. Resistor R_7 and capacitor C_4 determine the time out period of the NE555 timer (i.e. the period at which the alarm will produce sound).

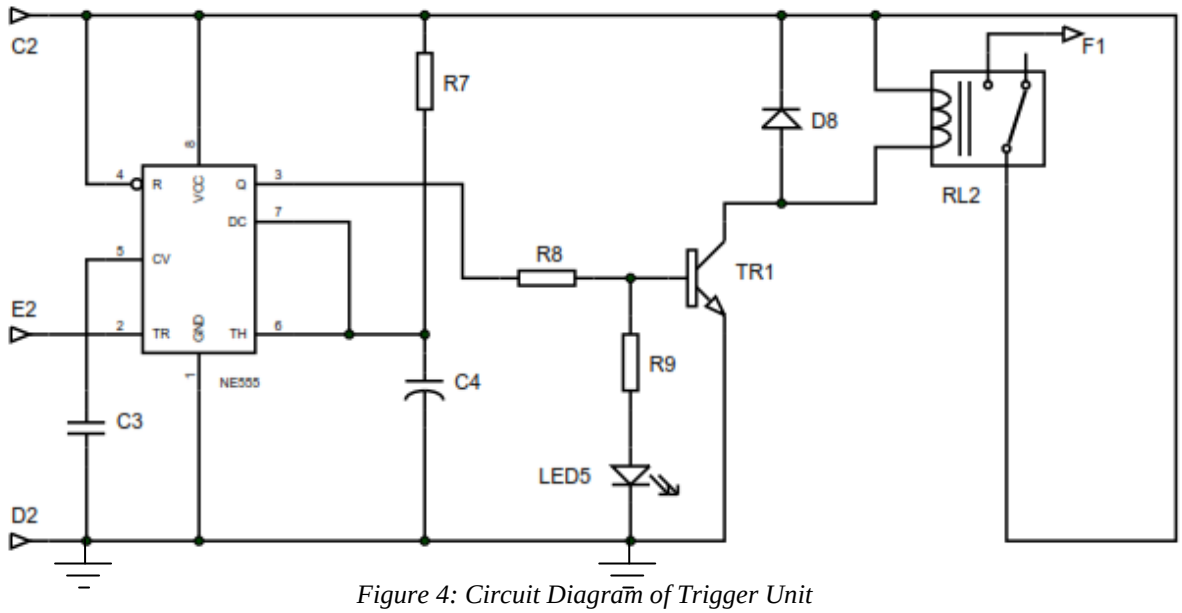

Figure 4: Circuit Diagram of Trigger Unit

The output from pin3 (trigger current) is amplified by transistor (TR_1). R_8 act as base resistor to TR_1 which is operating in common emitter mode. The output current from transistor (TR_1) causes the relay (RL_2) to operate thereby switching on the alarm and flashing light. The NE555 timer in this unit that produces the time out period for the alarm operates in a mono stable mode.

2.2.4. The Alarm Unit

The alarm unit consists of low frequency oscillator (LFO), voltage controlled high frequency oscillator (VCHFO), and the alarm unit, which also contains the speaker and flashing outdoor light. The alarm unit also has two NE555 timers (IC_3 and IC_4) and a relay RL_3. The NE555 timers IC_3 and IC_4 operate in a stable mode. They produce the siren sound in the speaker and trigger the coil of the relay (RL_3) that produces the flashing outdoor light. The power transistor (TR_2) is used to further amplify the audio and light outputs. Timer IC_4 operates at a frequency of about 320 Hz, and acts as a voltage controlled oscillator. This forms the basic tone of the siren sound system. Timer IC_3 produces a much lower frequency of about 2 Hz that alters the rhythm of the steady tone from IC_4 to the desired siren sound. The output of IC_4 (i.e. pin3) is coupled through resistor R_{12} to control the voltage terminal of IC_4. The low frequency 2Hz output from IC_3 is used to modulate the high frequency 320 Hz produced by IC_4 thereby alternating the frequency of operation of IC_3 to produce a siren sound instead of a continuous 320 Hz tone.

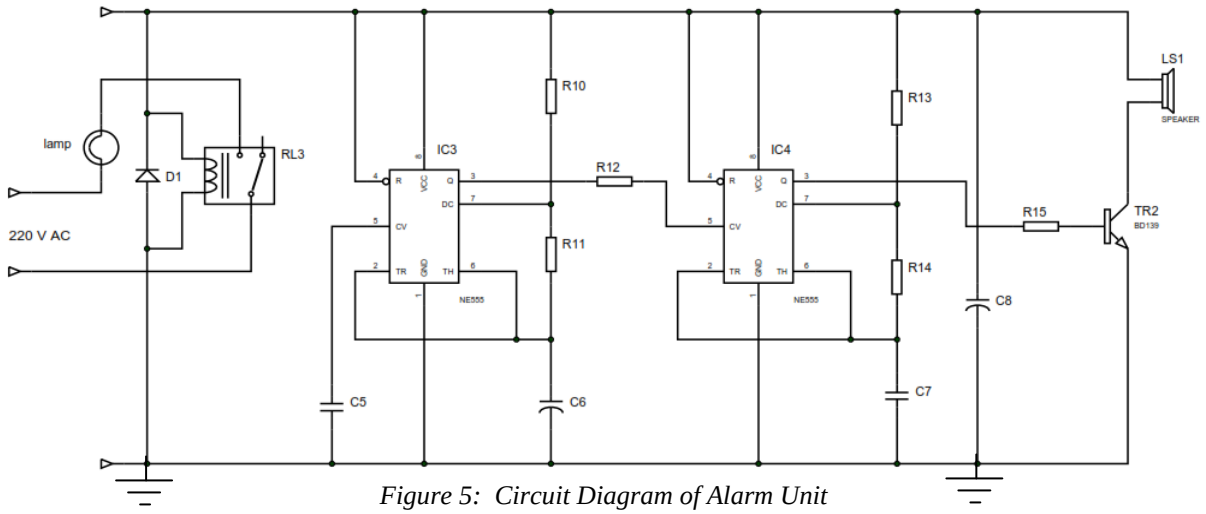

Figure 5: Circuit Diagram of Alarm Unit

The final siren note is available at pin3 of IC_4. The pin3 output of IC_4 is fed to the transistor TR_2 for further amplification enabling it to power the speaker thereby producing a very loud audible siren sound.

3. Design Parameters of Each Circuit Unit

The values of the components used in each of the unit were obtained based on relevant equations.

3.1. The Power Supply Unit

A 220/24V transformer was chosen because the rating is capable of meeting the current demand of the circuit. This is protected by the 1A fuse against excess current. The limiting resistor (R_1) for the LED1 was obtained using equation (1) below

$$R_1 = \frac{voltage\ \ drop}{LED\ current} = \frac{V_s - V_{LED}}{I_{LED}} \quad (1)$$

where, V_s is the supply voltage (= 24 V), V_{LED}= 2 V, I_{LED} = maximum allowable current across the LED= 0.02 mA. The value of R_1obtained from equation (1) was 1100 Ω. However, a preferred resistor value of 1KΩ was chosen and used in this work. The peak inverse voltage (PIV) obtainable at the secondary terminal transformer was picked as twice the terminal voltage V_s. Therefore,

$$PIV = 2 \times V_s = 2 \times 24 = 48V \quad (2)$$

At the full bridge rectifier circuit IN4001 diode was used because its PIV of 50 V is higher than the PIV of the secondary terminal of 24V. This is done to protect the diodes in case reverse operation occurs. The value of the filter capacitor C_1 was obtained using equation (3) below expressed by [5] as

$$C_1 = \frac{1}{2\sqrt{3}\,\omega R_1 \gamma} \quad (3)$$

For a full wave rectifier circuits in Nigeria, ω = 628.32 rads^{-1} , and γ is the ripple factor = 5% = 0.05. For a constant output voltage of 12 V, and output current of 1 A from the regulator, and using ohms law, R_1 was obtained as 12 Ω. The value of capacitor C_1 from equation (3) is 76.67 µF. A closest and standard value of 64 µF was used in the design. The current limiting resistors R_2 and R_3 for LED_2 and LED_3 respectively were calculated using equation (1). For V_{CC} voltage of 12V, V_{LED} voltage of 2 V, and I (LED) = 0.02A, the values of R_2 and R_3 are

$$R_2 = R_3 = 500\Omega \quad (4)$$

The preferred resistor value closest to 500 Ω chosen for this work was 560Ω.

3.2. The Sensor unit

The output voltage, V_o of an op-amp is given by the equation (5)

$$V_o = V_1 - V_2 \quad (5)$$

Where V_1 is the voltage at the non inverting terminal, while V_2 is the voltage at the inverting input of the op – amp. However, V_o can take any of the values given in equation (6) below

$$V_o = \begin{cases} -V_{cc} = -12\ V \\ +V_{cc} = +12V \\ 0 \end{cases} \quad (6)$$

3.3. The Trigger unit

The timeout period (T) (i.ethe period at which the alarm produces soundand the flash light outdoor is ON) is determined by the values of resistor $R_7$and capacitor C_4. This time out period is given as:

$$T = 1.1(R_7 \times C_4) \quad (7)$$

Preferred values of R_7 = 47 kΩ and C_4 = 470 µF were chosen to give a time out period of 25 seconds. The value of resistor R_{10} for transistor TR_1 was determined using equation (8) below

$$R_{10} = \frac{V_{CC} - V_{BE}}{I_B} \quad (8)$$

whereV_{cc} is the supply voltage (= 12 V), V_{BE} is the base emitter voltage (=0.7 V), I_B is the base current, and is expressed as

$$I_B = \frac{I_C}{h_{FE}} \quad (9)$$

h_{FE} is the supply voltage gain (= 100), while I_C is the collector current defined as

$$I_C = \frac{\text{sup}\, ply \quad voltage}{coil \quad resis\,\text{tan}\, ce} = \frac{12}{400} = 0.03A \quad (10)$$

From equations (9) and (10), the value of I_B is 0.0003 A. To ensure that the current is sufficient to drive the transistor into saturation, the quantity of the current was tripled, so that the value of R_{10} was 12.6 kΩ. However, astandard preferred value of 12 KΩ resistor was chosen to serve as the base resistor to the transistor.

3.4. The Alarm Unit

The calculation of the designed parameters for this unit was performed in three stages.

Stage 1: This is the high frequency oscillator stage. The period (T_H) and frequency (F_H) for this stage were calculated using equations(11) to (14) below as demonstrated by [6]

$$T_H = t_1 + t_2 \quad (11)$$

where

$$t_1 = 0.693 \times C_5 (R_{12} + R_{13}) \quad (12)$$

$$t_2 = 0.693 \times R_{13} \times C_5 \quad (13)$$

and

$$F_H = \frac{1}{T_H} \quad (14)$$

The duty cycle was obtained using equation (15) below

$$Duty \quad cylcle = \frac{t_1}{T_H} \times 100\% \quad (15)$$

For a high frequency value of 320 Hz, the corresponding period T_H is $3.125 \times 10^{-3}\, s$. The corresponding values of C_5, R_{12} and R_{13} chosen to produce the value of 320 Hz were 1 µF, 1 kΩ and 2.5 kΩ (though 2 kΩ was used) respectively. These values produced the required high frequency tune for this stage. The corresponding duty cycle was 77.62 %

Stage 2: This is the low frequency oscillator stage. The period (T_L) and frequency (F_L) for this stage were calculated using the same procedure as in stage 1. For a low frequency value of 2 Hz, the corresponding period $T_L$is $0.5\, s$. The resistors and the capacitors used were C_7, R_{16} and R_{17}. The values of C_7, R_{16} and R_{17} chosen to produce the value of 2 Hz were 47 µF, 10 kΩ and 2.7 kΩ (though 2 kΩ was used) respectively. These values produced the required low frequency tune for this stage. The corresponding duty cycle was 8.3 %

Stage 3: This is the audio amplifier stage that produces the power output at the speaker. The actual power output by the transistor (TR_2) was calculated using equation (16) below [7,8]

$$P_{OUT} = I_E \times V_{CC} \quad (16)$$

where V_{CC} is the supply voltage (= 12 V), I_E is the emitter current defined as

$$I_E = (1 + h_{FE}) \times I_B \qquad (17)$$

where

$$I_B = \frac{V_{CC} - V_{BE}}{R_{16}} \quad (18)$$

From equations (17), (18) and (19), the value of P_{OUT} was 1.4 W.A 1 Watts, 8Ω speaker was used at the output stage for maximum power transfer.

4. The Complete Circuit Diagram of the Home Security System

The complete circuit diagram of the alarm system is shown in Fig 6. The design was carried out using Proteus software .The NE555 timer in the trigger unit gets activated whenever pin 2 senses a smaller potential that is less than 1/3 the supply voltage. When activated it sounds for duration of time determined by R7 and C4, this also determines how long the alarm will sound before going off. In reality the sensor will be mounted at each door, whenever an intruder block the laser beam falling on the light dependent resistor (LDR), the trigger unit get activated through a signal sent by the sensor unit and the alarm sounds as well as the flashing outdoor light gets ON. This signal is less than 1/3 the supply voltage thereby causing the trigger unit to operate for a period of time determined by C_4 and R_7.

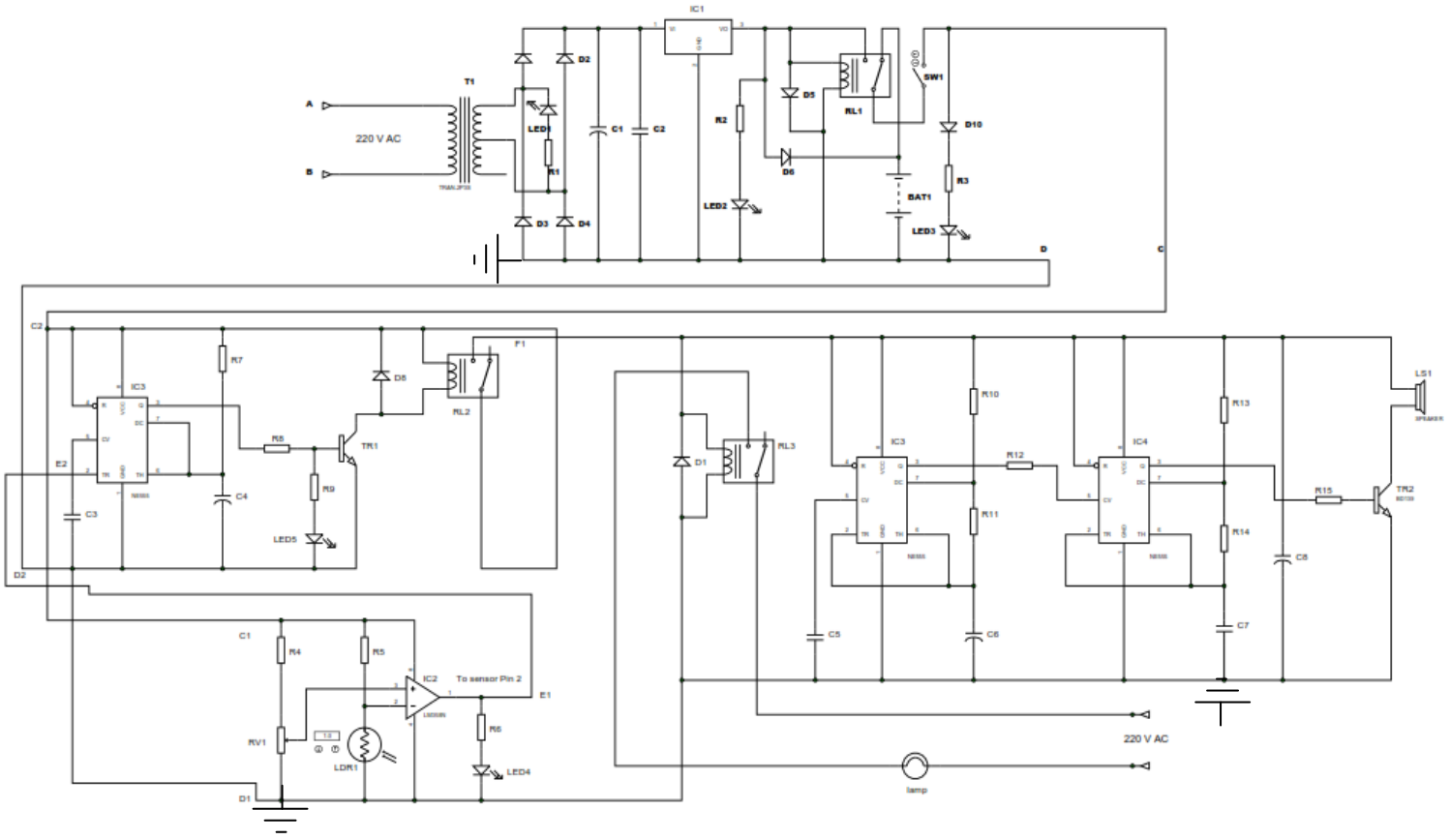

Figure 6: Complete Circuit Diagram of the Home Security System

5. Construction of the Home Security System

The construction of the home security system followed the normal circuitry construction processes.

- The tools used to carry out the construction are: print circuit board (PCB), veroboard, soldering iron, lead sucker, long nose pliers, cutting pliers, screw driver, drilling machine, digital multi-meter,

and chemical product (mixture of hydrogen peroxide "H_2O_2", hydrochloric acid "HCl" and distilled water).

- All the different components were tested via the use of a digital multimeter in order to dismiss any faulty one. it was discovered that each circuit was in a perfect working condition to ensure continuity.
- The casing was made of PVC sheets of about 2mm in thickness. It consists of different parts which were fitted into each other to form an enclosure for the step-down transformer, power supply circuit board and the trigger and alarm circuit. The dimensions of the case were: length (15cm), the breadth (15cm) and the height (6cm).
- Assembling was done by fixing the circuit board into the casing and screwing properly to prevent vibration. The rechargeable battery was also properly placed to avoid shaking. Finally, proper and tight connections were made between the components.
- Proper safety precautions were taken to avoid unnecessary damage to the components

6. Conclusion

We have designed and constructed a home security system with the aid of Proteus software. The system is cheap, reliable, and efficient, and could be used in both rural and urban areas, since it has both the dc and the ac power sources. The various components and the technicalities involved are within the reach of a technician in the rural community. The time out period for the trigger unit was 25 seconds. This security system could be placed in major entrance of a house for proper tracking. The use of both flash light and loud speaker is to show that even the blind and the deaf can detect the presence of an intruder.

References

[1]. Petruzzelis, T (1994). The Alarm Sensor and Security Circuit Book. TAB books. Imprint of McGrawl-Hill San Francisco, U.S.A.

[2]. Maloney, J. T. (1986). Industrial Solid – State Electronics Devices andSystems. Second Edition, Prentice – Hall, Inc. Englewood Cliffs, New Jersey, U.S.A.

[3]. Tyona, M. D; Tsor, O. J. and Njinga, R. L (2007). Application of a Balanced Adder – Subtractor in the Solution of Simultaneous Linear Equations.Nigerian Journal of Physics. 19; 115 - 119

[4]. Kwaha, B. J; Amalu, P. and Mafai, B. U. (2009). An Op – Amp Based 100 W Triple input Complementary Audio Mixer Amplifier with Independent Tone Control. International Journal of Research and Reviews in Applied Sciences. 1 (3); 254 – 264.

[5]. Nwosu, I. E. and Ezike, M. F (2006). Basic Electrical and Electronic Systems. Megasoft Publishers, Owerri, Nigeria.

[6]. Olusola, O. I. and Olusola, O. O. (2012). Development of a Microcontroller – Based Protective Circuit for a Direct Current – to – Alternating Current Converter System. Nigerian Journal of Physics. 23; 70 - 82

[7]. Theraja, B.L. and Theraja, A.K. (1999). A Textbook of Electrical Technology. 21st Edition. S. Chand and company, New Delhi, India

[8]. Udezue, C.N; Eneh, J; Unachukwu, A; Onyemelukwe, I. and Onyeka, H (2016). 12 V Portable Battery Charging System. The Pacific Journal of Science and Technology. 17 (1); 6–11.