DESIGN AND CONSTRUCTION OF AN INTRUDER ALARM SYSTEM WITH MONITORING/INDICATOR UNIT

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIEMENT FOR THE AWARD OF B.ENG. DEGREE.

OCTOBER, 2006

DEDICATION

This Project is dedicated to the loving Memory of my late Dad, Surv. J. D. J Dashe.

May his gentle soul rest in perfect peace with the Lord, Amen.

CERTIFICATION

This is to certify that this project titled 'Design and Construction of an Intruder Alarm system with Monitoring/Indicator Unit', was carried out by Dashe T. Henry, under the supervision of Eng'r. M. S. Ahmed, for the award of bachelor of Engineering (B.Eng) degree in Electrical/Computer Engineering, Federal University of Technology, Minna, Niger state.

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The work will not be complete without mentioning and appreciating the tremendous support and encouragement from my friends and colleagues; Mozo, Ambas, Joe, Mairo, Vero, Enejor, Eddy, to mention a few, and the entire members of 'Penthouse'.

ABSTRACT

This project is concerned with the design and construction of an Intruder alarm system with a monitoring and indicator unit. The project is meant to provide a security alarm system which not only safe guards us from thieves and intruders, but also helps in pin-pointing the exact point(s) of intrusion (monitoring and indicator unit), hence reducing the time wasted in searching for point(s) of intrusion, which could give the intruder time to escape. The system comprises of six units; the input/sensor unit, the monitoring/indicator unit, the timing unit, the tone generation unit and the power supply unit (PSU). A prototype of a bungalow house is used to demonstrate the working principle of this project. Micro-switches are used as the intrusion detectors connected in electronic mats used at the doorsteps of each of the four entrances chosen and finally connected to the system. Light emitting diodes (LEDs) are used to act as the output of the monitoring and indicator unit. Each LED is labeled to correspond to a switching point and indicates which switch is tripped ON. The project was successfully implemented.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

In these times of increasing crime and theft, it has become imperative to safeguard our homes and properties with adequate safety devices. Installing a burglar alarm system can go a long way in providing us with protection against thieves and intruders. Burglar alarm systems commonly used today are electronic systems of sensors that detect intrusion and trigger off an alarm.

Intrusion detectors are generally of two classes: Point detectors and Area (or volume) detectors.[1]

Point detectors indicate an intrusion at a specific point, and types include mechanical or magnetic contacts on doors and windows to detect when they are opened or broken, photocell or microwave beams across pathways, pressure-sensitive mats, fiber-optic bend or stress sensors (e.g for wire fences), proximity switches that detect humans and vibration sensors among others.

Area detectors indicate an intruder's presence within the protected area and use such technologies as Ultrasonic transducers, passive infra-red (heat) detectors, and microwave transducers (sometimes in combination within one sensor). In general, area sensors detect a sudden change in the measurements being taken and trigger at some predetermined threshold. They are much more prone to false alarms than Point sensors, often because of improper aiming or other adjustments.[2]

1.2 OBJECTIVE

The main objective of this project is to design and construct an alarm system using micro-switches as sensor intrusion detectors, with a memory unit incorporated to help in indicating the exact point(s) of intrusion via indicators, and also store such information until it is reset.

The project is aimed at providing a security alarm system to protect us against thieves and intruders, and which helps in pin-pointing exact point(s) of intrusion hence reducing the time spent in searching for the point of intrusion which could give the intruder time to escape.

1.3 METHODOLGY

A prototype of a bungalow house is used to demonstrate the working principle of this project.

For convenience, only four door points were chosen to be secured (since the 4044 IC used for the monitoring and indicator unit has only four set/reset pins), to demonstrate the working principle of the system.

Micro-switches are used as the intrusion detectors connected in electronic mats used at the doorsteps of each of the four entrances chosen and finally connected to the system.

Light emitting diodes (LEDs) are used to act as the output of the monitoring and indicator unit. Each LED is labeled to correspond to a switching point and indicates which switch is tripped ON. These switches can also be connected to windows, such that any attempt to open any of the windows triggers the alarm.

1.4 BASIC WORKING PRINCIPLES OF THE INTRUDER ALARM SYSTEM

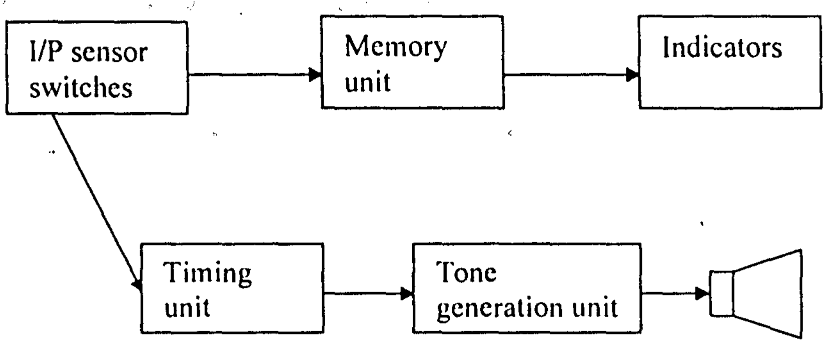

Fig.1 A simple block diagram of the Intruder Alarm System

When activated, with a little attempt at opening the window, door or on stepping on the doormat, the micro-switch which is normally in the open-mode gets closed, triggering the alarm.

The memory unit which is connected to each switch then indicates the point of intrusion via indicators. The pulse generated by the sensor switches will activate a two-tone generator built on 555 timer ICs connected in an astable mode, which makes up the Tone generation Unit. The timing unit controls the period at which the generated tone will last. The timing unit is also built on a 555 timer IC, but in a monostable mode. Hence the generated tone is gotten as the output.

The whole system is powered by a 9v d.c power supply, with a 6v d.c backup battery connected into the circuit as a standby power supply in the event of mains power source failure.

CHAPTER TWO

LITERATURE REVIEW

The need for security of lives and properties has been a basic and fundamental problem in human society for ages. Hence the emergence of electronic intruder alarm system to help detect/scare away intruders.

Most burglar alarm systems involve a circuit loop system that rings a bell or activates a siren when set off. A central control box monitors several motion detectors and perimeter guards and sounds an alarm when any of them are triggered.[3]

This project deals with the design and construction of an intruder alarm system which makes use of micro-switches as detectors. A memory unit is incorporated into the system which helps in indicating the exact point(s) of intrusion via indicators, which could be seven segment display or in this case LEDs.

The use of sensitive micro-switches in this project as the intrusion detectors is due to their soft touch nature, cost effectiveness in implementation and ruggedness to damage. The use of the memory unit also helps in indicating the exact point of intrusion, hence narrowing the searching perimeter for the intruder and reducing the time wastage which could give the intruder time to escape.

Prior to the research carried out, it is obvious to say that previous research work on design and construction of burglar alarm systems similar to this using different detectors have their own advantages and disadvantages (defects).

A security alarm system using the closed circuit television (CCTV) was considered [4]. Closed circuit television enables visual information of the intruder to be transmitted often in parallel with audio information. Since the use of the CCTV involve the use of many surveillance cameras as the input sensor and TV monitors connected by cables for the monitoring of the environment, this type of design is not only cost ineffective, but also prone to human error as the surveillance officer might sleep-off on duty. This means that at least two or more security guards must be on duty at any given time. Also the system will be visible to the intruder and needs a constant power supply which can not be guaranteed

Another design which is based on the principle of electromagnetism interconnected to the Earth Leakage Circuit Breaker (ELCB) which functions as a retaining contact [5] was considered. This type of project could not be feasible considering the unreliability of public mains supply, no back-up power supply and also the equipment used are visible to the intruder, which means that the intruder might have gotten access to the protected area.

Another detector considered was the light dependant resistor (LDR) [6]. The circuit operates with a fall of a shadow of any object on the LDR, i.e whenever the resistance of the LDR increases owing to decrease in level of light, the circuit actuate ON, making the output to be energized, thereby drawing the attention of the owner to the area of focus. The circuit used consists of a transistor, resistor and capacitor, which is the switching device and acts as a potential divider to bias the transistor as a switch. Once the transistor is ON it remains ON as long as the shadow falls on the surface of the LDR. This type of approach is not suitable because at night when the shadow of any object is not visible it becomes in-operative.

The use of infra-red beam as an intruder detector [4] was also considered. This security alarm uses the opaque nature and motion of the intruder to interrupt the reception of the infra-red beam energy transmitted towards a receiver which then triggers the alarm output. Again this method becomes discredited for outdoor use because of attenuation and eventual extinction of the beam in fog and heavy rain, which may cause false alarm. There is the real restriction of using infra-red beam because of the wavelength which is too short and excessive loss of beam strength in rain and fog may occur and if the wavelength is made too long, it will lose control of the shape of the beam.

Another sensor that could be used as an intrusion detector in security alarm system is the photoelectric cell, photoconductive cell or the audible sound detector.[7] If the audible sound detector as a sensor is used in a design like this, where a microphone is expected to be used to pick the sound of movement of an intruder. It obvious that the system is not practicable in highly populated environments such as schools, banks, office buildings etc since the population will make it impossible for the security man on duty to recognize the cause of most sounds that come from the speaker via the microphone. Hence this type of system is prone to false alarms.

Sophisticated computer-aided sensors [3, 10] include image-processing systems to detect and filter changes in a surveillance video picture (possibly using infra-red or other light sources for the image) and can be programmed to detect or ignore different types of motion in different parts of the scene, and can tell the difference between a person and other moving objects. This type of system though provides the much needed protection is complex in implementing and is not cost effective.

Another project which made use of micro-switches similar to that used in this project [11] was considered. This project uses micro-switches as input sensor detectors with a tone generator built on a 555 timer IC in the astable mode to generate the output tone. This design was both cost effective and easy to implement but lack an indicator unit to reduce time wastage in determining the exact point(s) of intrusion which could give time for the intruder to escape, especially when used in large environments.

Having measured all the pros and cons of these designs above, the option was to provide a security system with back-up power supply to counter power failure also one which is cost effective and less prone to false alarm. Hence this project design was chosen which uses micro-switches as sensor detectors, which are relatively cheap and less prone to false alarm, and which incorporates a memory unit which indicates the exact point of intrusion hence reducing the time of search of the intruder. A standby power supply is also used to power the system in the event of power failure.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 PREAMBLE:

This chapter deals with the design of the individual stages of the Intruder Alarm System, which consist of the following units:-

I. The power supply unit

II. Input/sensor micro-switches unit

III. Monitoring and indicator unit

IV. Timing unit

V. Tone generator unit

VI. Output unit

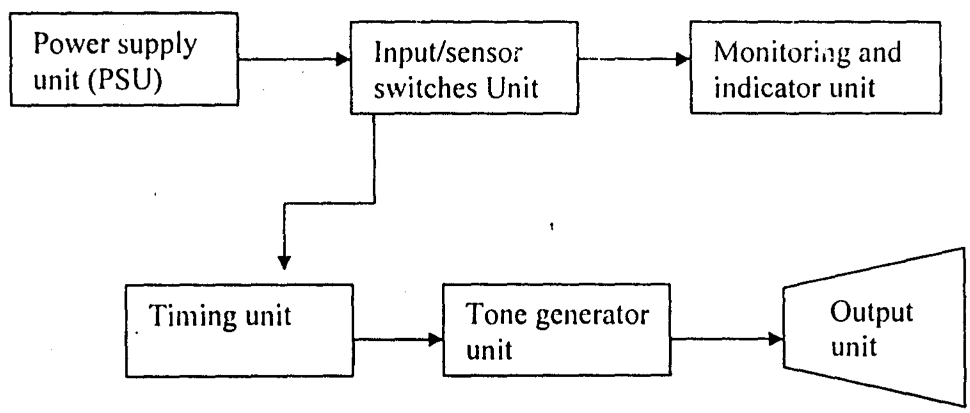

Fig. 3.1 A functional block diagram of the Intruder Alarm System

3.2 POWER SUPPLY UNIT (PSU)

The power supply unit (PSU) is meant to provide electrical power to every other unit of the system. The PSU comprises:-

- Transformer
- Rectifier
- Voltage regulator
- Battery and battery charger unit

3.2.1 Transformer

The transformer used in this circuit is a 220/9v center tap A.C step-down type with a current rating of 500mA.

3.2.2 Rectifier

Since every electronic unit in this project makes use of D.C voltage, the stepped down AC voltage from the transformer must be rectified to DC before it can be useful to the system. The rectifier is made up of two diodes, connected in the centre-tap full-wave rectifier configuration.

A filtering capacitor C_2, (see fig.3.2.2 below) is used to remove the pulsating DC output voltage of the bridge rectifier to a pure DC voltage. [13]

The peak output voltage of the supply transformer is V_p

Where $V_p = \sqrt{2}\, V_{rms}$ and $V_{rms} = 9v$

$V_p = 9\sqrt{2}$

$V_p = 12.728v$

The peak-to-peak current of the supply is given as $I_p = I_{dc} = 500mA$

3.2.3 Voltage Regulator

Due to variations in DC output voltage with changes in load or input voltage a regulator is connected between the filter and the load. A regulator is an electronic control circuit which is capable of providing a nearly constant DC output voltage even when there are variations in load or input voltage.

For this project a Zener diode of 6.2V rating connected in the charging system to prevent the rectified voltage charging the backup battery from supplying beyond the 6V when the battery is fully charged also served as the voltage regulator, keeping the output voltage at 9V. [13]

3.2.4 The Backup Battery and charger Unit

In the event of a failure in the mains power supply, a 6v backup battery is connected to prevent power failure in the system.

The battery charger unit is an automatic control circuit driven by 9v of the secondary windings of the transformer to charge the 6v DC battery. There are two thyristors used in the circuit, the first thyristor SCR_1 (BT152) is used to supply the charging current at charging while the second thyristor SCR_2 (BT151) is used as a monitoring component to either switch the thyristor SCR_1 OFF when the 6v DC battery is fully charged or ON when it is not fully charged.

A variable resistor with a range of 1KΩ was chosen to make sure the zener diode used 6.2v, does not go beyond the 6v when the battery is fully charged.

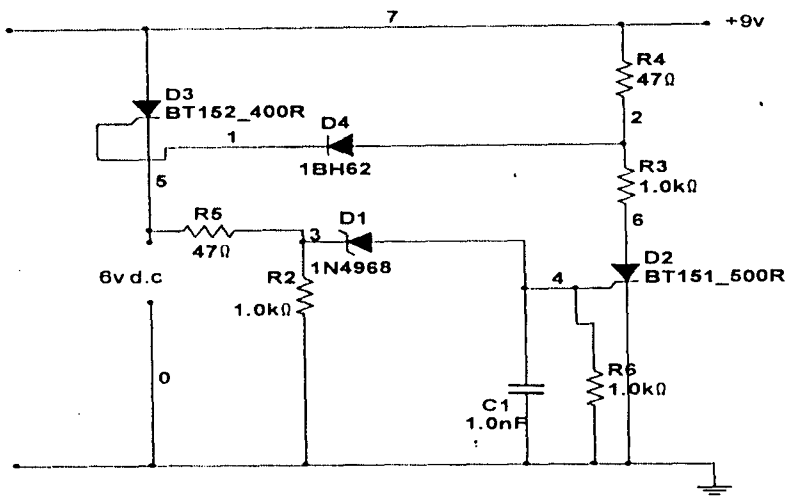

Fig.3.2.1 circuit diagram of the battery charger unit

CALCULATION

By the design of this project, for the charger, it can be seen from the diagram that R_1 and R_3 act as a voltage divider and if assumed maximum DC voltage across the fully charged battery and the voltage across the zener diode is chosen to be 6.2V, therefore using the formula;

$$V_r = V_z\left(\frac{R_1}{R_1 + R_3}\right) \quad \ldots\ldots\ldots\ldots\ldots (*)$$

Where V_z = voltage across the Zener diode = 6.2V

V_r = E.M.F of the battery under charge = 6V

$R_3 = 47\Omega$

Therefore from equation (*) above;

$$6 = 6.2\left(\frac{R_1}{R_1 + 47}\right)$$

$6(47 + R_1) = 6.2R_1$

$0.2R_1 = 6 \times 47$

$$R_1 = \frac{282}{0.2}$$

$$R_1 = 1410\ \Omega$$

The preferred value for R_1 was chosen to be 1kilo ohms.

Having calculated and found the value of the components to be used for the battery charger stage, a 50µF, 25V capacitor was chosen and connected in series with the zener diode to prevent any transient effect on the thyristor (SCR_2).

The complete circuit diagram of the Power Supply Unit (PSU) is shown below.

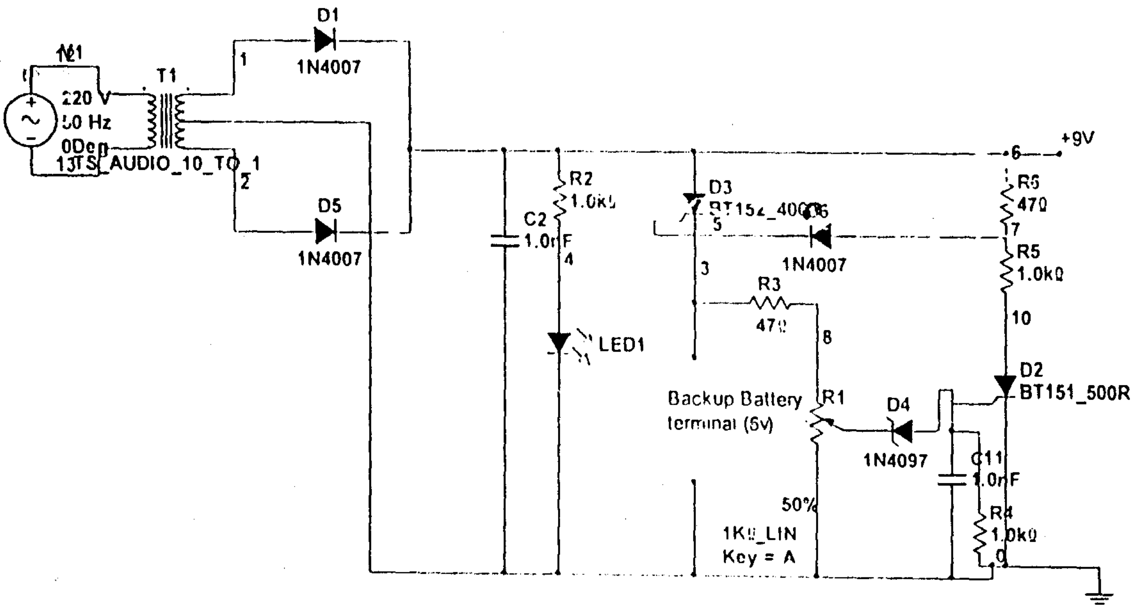

Fig.3.2.2 complete circuit diagram of the power supply unit (PSU)

3.3 INPUT/SENSOR MICROSWITCHES UNIT

The Intrusion sensor detectors used in this project are micro-switches in normally Open-mode. The switches are connected in an electronic mat which could be used as door mat at the entrance and exit to buildings or the switches could also be fixed to windows in a normally open-mode.

Any pressure of the heel or sole o a shoe as it steps on the mat or an attempt at opening the window causes the switches to close hence, triggering the alarm system.

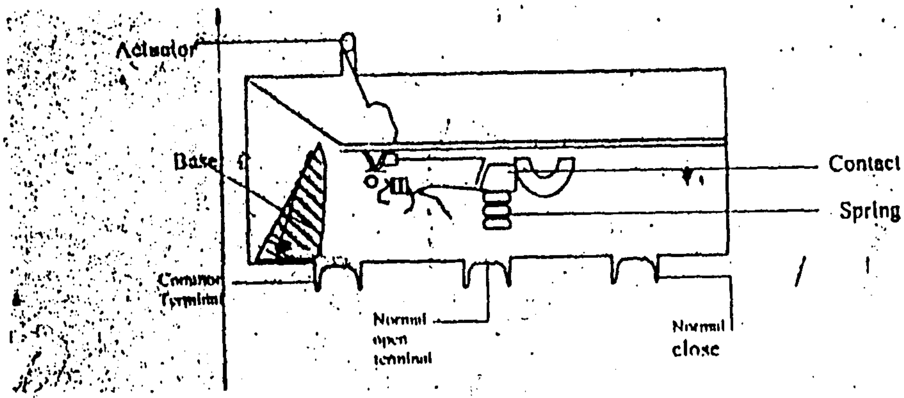

Fig. 3.3.1 schematic diagram of the micro-switch used as sensors

3.4 MONITORING AND INDICATOR UNIT

The monitoring and indicator unit is used in pin-pointing the exact point of intrusion hence, reducing the time wastage in locating the point of intrusion which could give the intruder the chance to escape.

The Unit is built on a 4044 (Quad R/S Flip-flop) IC. This package contains 4 independent Set/Reset flip-flops sharing a common output tristate enable control.

On any one flip-flop Set and Reset should normally be high. If Set (S) is made low, as when the input switch is triggered, the Q output goes and stays high. If Reset (R) is made low, the Q output goes and stays low, hence clearing the memory.

If both S and R go low, the output goes low. This is a normally disallowed state and the last input to go high determines the final state of the flip-flop.

The output Q can be seen via indicators such as seven segment display or in this case LEDs. Each LED is connected to a separate output pin, while the Set pins are triggered via the input switches separately so that the point of intrusion that is, the switch triggered can be determined by the LED indicator that comes on. The circuit diagram below shows the connection of the monitoring and indicator unit.

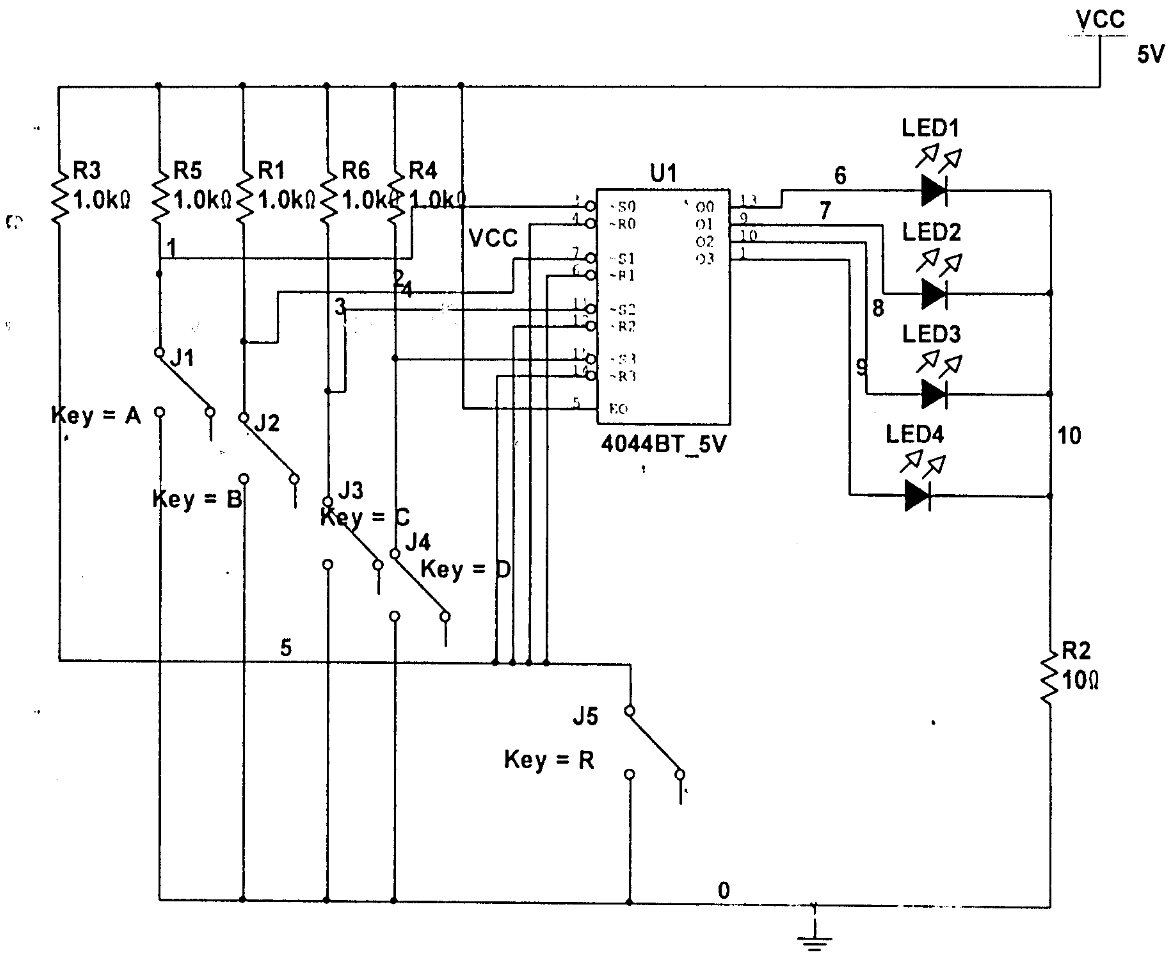

Fig. 3.4.1 circuit diagram of the monitoring and indicator unit

Keys A, B, C, and D serve as input switches with 10K pull-up resistors each, while key R is the reset switch with all reset pins looped together. The LEDs act as output (indicators) when any corresponding switch is triggered.

3.5 THE TIMING UNIT

The Timing Unit is built on a 555 timer IC in the monostable mode. The 555 timer IC has found wide acceptance in the design of timing units due to its reliable timing characteristics.

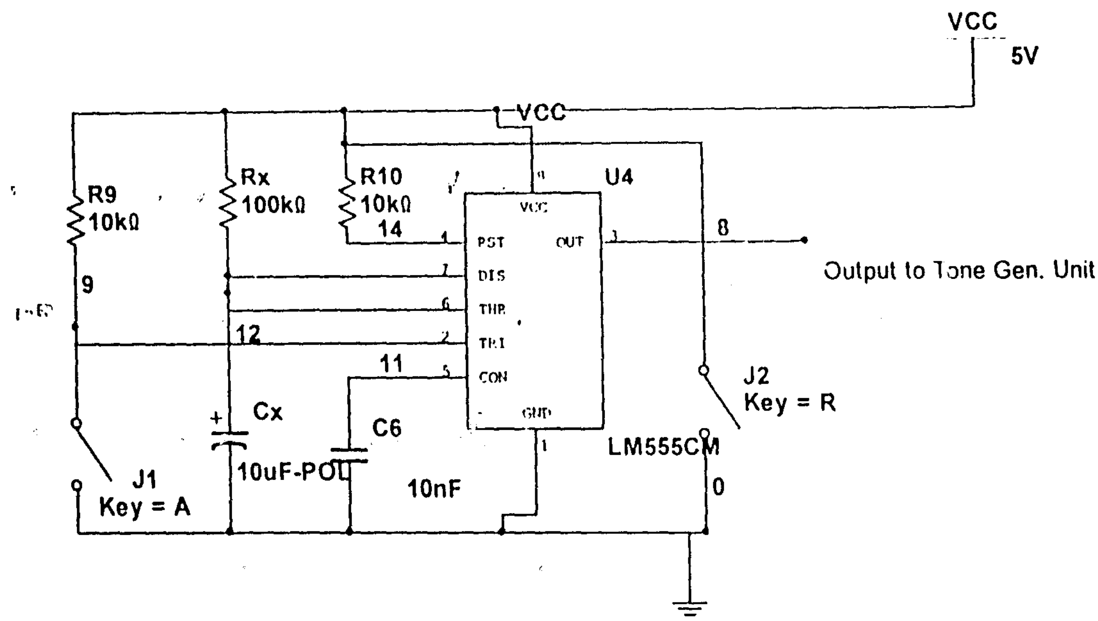

Fig. 3.5.1 circuit diagram of the Timing Unit

A monostable circuit produces a single output pulse when triggered. It is called a monostable because it is stable in just one state; "Output Low". It is only with the application of an external pulse that the circuit will interchange its state i.e to the "output high" state.

However after a certain time period, determined by the values of resistor R_x and capacitor C_x, the circuit will automatically switch back to the original stable state and remains there until another pulse is applied.

The timing period controls the period at which the generated tone will last.

3.5.1 Monostable Operation

The timing period is triggered (started) when the trigger input (pin2) is less than ⅓Vs, this makes the output high (+Vs) and the capacitor C_x starts to charge through resistor R_x. Once the time period has started further trigger pulses are ignored.

The threshold input (pin6) monitors the voltage across C_x and when this reaches ⅔Vs the time period is over and the output becomes low. At the same time discharge (pin7) is connected to 0V, discharging the capacitor ready for the next trigger.[12]

CALCULATION

The duration of the pulse is called the Time Period (T) and is determined by resistor R_x and capacitor C_x.

Time period, $T = 1.1 R_x C_x$

T = time period in seconds

R_x in Ohms and C_x in Farads

For a time period T = 2 seconds using a 10μF capacitor as C_x.

$$R_x = \frac{2}{(1.1 \times 10 \times 10^{-6})}$$

$R_x = 181{,}818.18\ \Omega$

Hence a 100k Ω resistor was chosen as R_x.

The Reset input (pin4) overrides all other inputs and the timing may be cancelled at anytime by connecting reset to Ground (0V), this instantly makes the output and discharges the capacitor. This is the way the tone generator may be disarmed.

3.6 THE TONE GENERATOR UNIT

The Tone Generator Unit is built on 555 timer IC, but in the Astable mode. Unlike in the monostable state, the astable mode has no stable state; the output is continually changing between 'low' and 'high'.

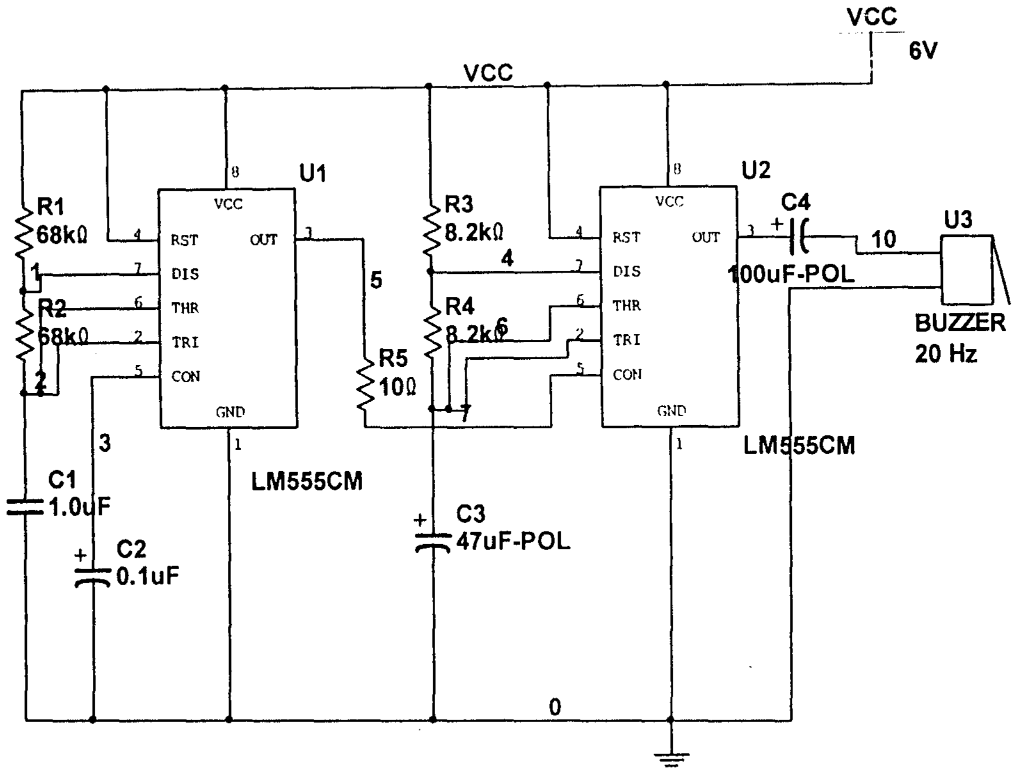

Fig.3.6 circuit diagram of the Tone generation Unit

3.6.1 Astable Operation

With the output high (+Vs), the capacitor C_1 is charged by current flowing through R_1 and R_2. The threshold and trigger inputs monitor the capacitor voltage and when it reaches ⅔Vs (threshold voltage), the output becomes low and the discharge pin (pin7) is connected to 0V.

The capacitor now discharges with current flowing through R_2 in the discharge pin. When the voltage falls to ⅓Vs (trigger voltage) the output becomes high again and the discharge pin is disconnected, allowing the capacitor to start charging again. This cycle repeats continuously unless the reset input is connected to 0V which forces the output low while reset is 0V. [12]

CALCULATION

$T_{ON} = 0.7 \times (R_1 + R_2) \times C_1$ .... (1)

And $T_{OFF} = 0.7 \times R_3 \times C_3$ .... (2)

Where, T = time period in seconds (s) = $T_{ON} + T_{OFF}$

With $R_1 = R_2 = 68K$ and $C_1 = 1\mu F$

$T_{ON} = 0.7 \times (2 \times 68 \times 10^3) \times 10^{-6}$

$T_{ON} = 0.0952$ sec.

With $R_3 = 8.2K$ and $C_3 = 47\ \mu F$

$T_{OFF} = 0.7 \times (8.2 \times 10^3) \times 47 * 10^{-6}$

$T_{OFF} = 0.26978$ sec.

$T_{OFF} \approx 0.27$sec.

Therefore,

T = 0.0952 + 0.27

T = 0.3652 sec.

Since frequency, $F = \frac{1}{T}$

$$F = \frac{1}{0.3652}$$

F = 2.74 Hz.

The tone generator unit is controlled by the timing unit via a transistor (BC 108), which acts as a switch to trigger the generator unit ON. Hence, once the timing period is elapsed the generated tone also ceases.

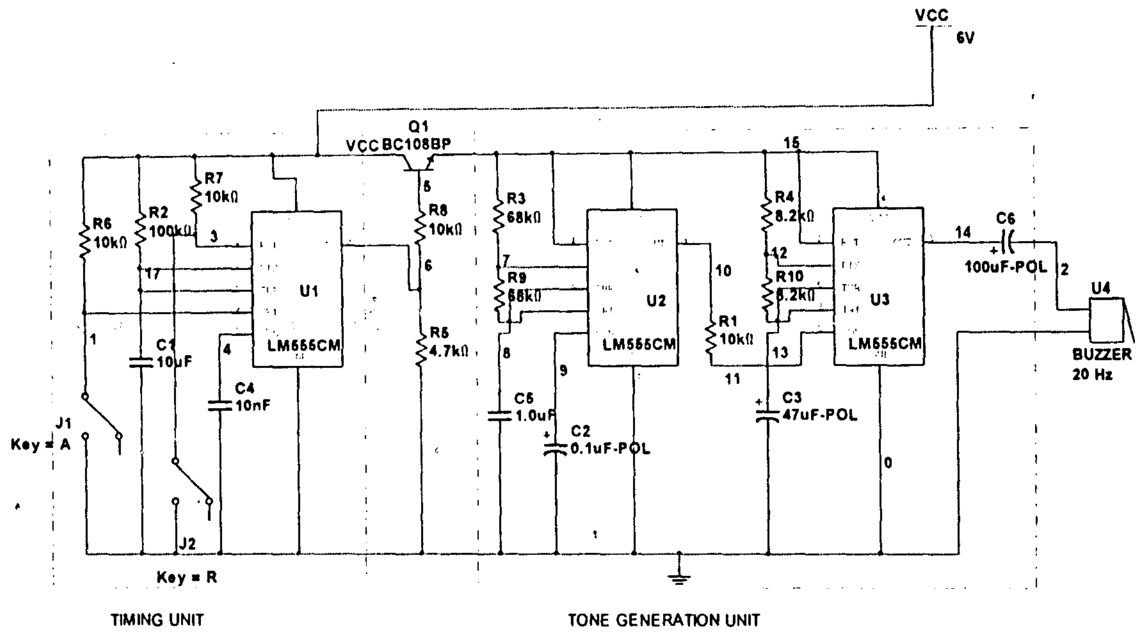

Fig 3.6.2 A circuit diagram of the timing unit and tone Gen. unit connected via a transistor (BC108BP).

3.7 OUTPUT UNIT

A buzzer was used as the output unit of the system, with the following specifications from data sheets:

Frequency = 15 Hz

Impedance = 300Ω

Voltage rating = 6v

A complete circuit diagram of the Intruder Alarm system without the Power Supply Unit (PSU) is shown in Appendix B.

CHAPTER FOUR

TESTING/ RESULTS AND ANALYSIS.

4.1 TESTING

The design and simulation of this project was carried out first using a Computer Aided Software known as Electronic Workbench,,with each block designed and tested, where upon getting the required output results, the test was carried out on a breadboard. The specified components were obtained and test was carried out stage by stage and it was found to be functional on the breadboard within the design specifications.

The entire components were then transferred on to a Vero board. Before soldering the components on the Vero board, the strip lines of the Vero board were cleaned with a methylated spirit in order to remove any form of conductor and dirt on the Vero board. IC bases were soldered on the Vero board instead of the ICs themselves directly to avoid over-heating them during soldering and for easy replacement when necessary. Great care should be taken in handling CMOS ICs because any form of static discharge or heat due to soldering could easily damage them.

Holes were then bore through the prototype base were the micro-switches were installed to protrude just for slight contact. The LEDs were also installed to serve as the indicators.

The project was assembled in a wooden case as shown in Appendix A.

4.2 RESULT ANALYSIS

Testing of this project was first carried out using a computer software (Electronic Workbench) and the required result gotten after simulation, as shown below.

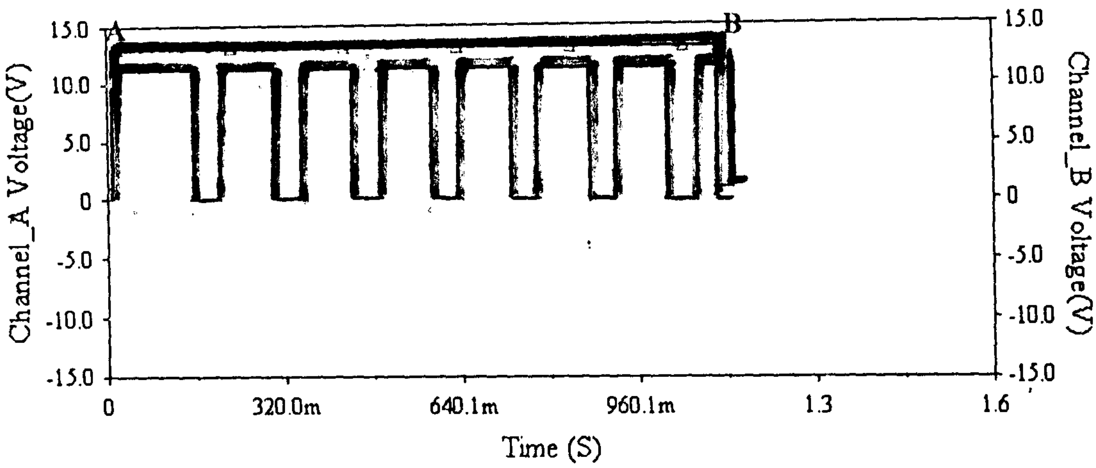

Fig 4.2.1 A graph of Voltage (V) against Time (S)

The above graph shows the simulated result gotten from the operation of the timing and tone generation unit. Where the blue line represents the timing unit output, while the red pluses represents the generated tone outputs. Point A is the point at which the system is triggered. Point B is the point at which the Timing Period (approx. 1.13sec.) has elapsed thereby cutting off the generated tone. Hence the result conformed to the stipulated output result.

The test was then carried out with the specified components on the breadboard, and found to have worked satisfactorily according the specifications of the design. Digital multimeter was also used to test for continuity at different stages on the veroboard to avoid any short-circuit or open circuit.

4.3 PACKAGING

The complete circuit constructed was housed in a wooden box casing which also serve as the base of the prototype bungalow house, with air holes for ventilation, as shown in Appendix A with the following dimensions.

Length:- 73.6cm

Width:- 52cm

Height:- 9cm

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The main aim of this project, which is to design and construct an intruder alarm system using micro-switches as intrusion sensors and which could incorporate a monitoring and indicator unit to reduce time spent in searching for point(s) of intrusion, was successfully achieved. it is worth mentioning how fascinating it is when one designs and constructs a system and see it function satisfactorily. This project has also improved on my knowledge and understanding on practical design and construction, especially on the use of integrated circuits (IC) in a digital system.

Although, during the construction, a lot of problems were encountered such as components malfunctioning, this was corrected after much trouble-shooting. The non-availability of some components in the market was also problems encountered, which led to the changing to their replacements. The project functioned correctly.

5.2 RECOMMEDATIONS

This design can be modified to perform better by replacing the LEDs used as indicators by seven-segment display or other forms of display, to display the door or window numbers on intrusion.

Considering the cost effectiveness of this design, it is worthy of note to recommend that this system be used in our homes and office buildings, airports, hotels, schools and other large environments.

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APPENDIX A

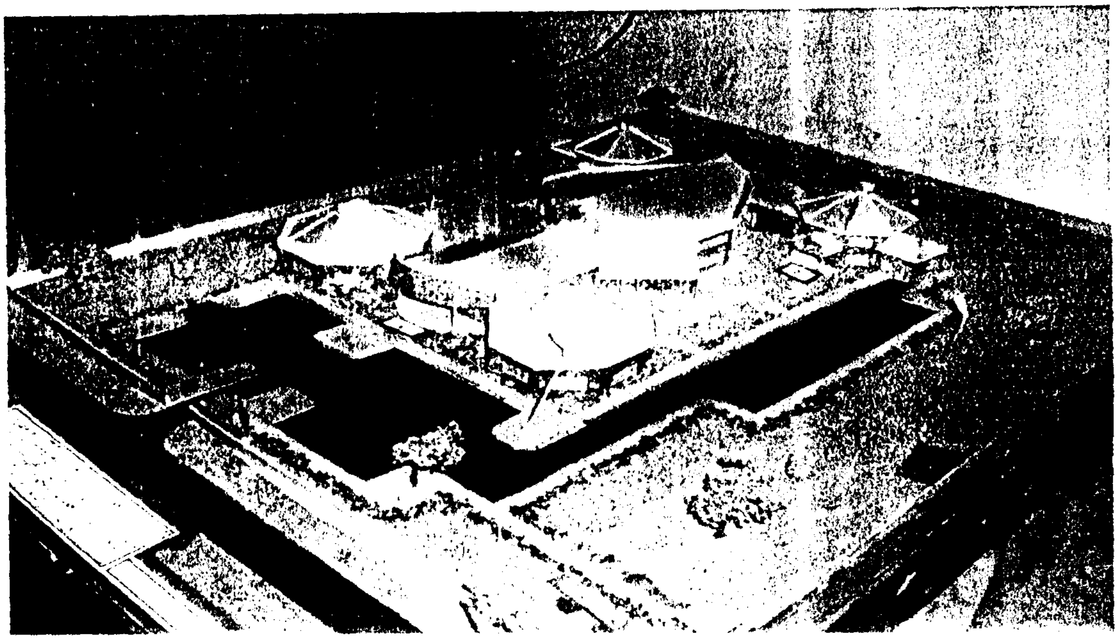

Fig. A1 Prototype of the Bungalow with the Alarm System.

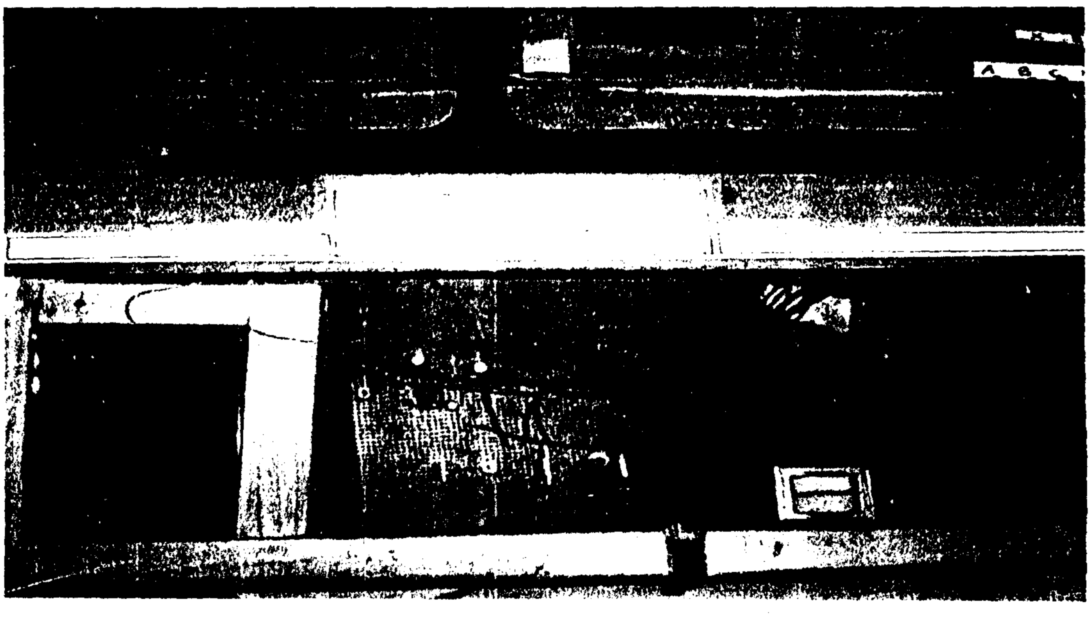

Fig. A2 Casing of the Intruder Alarm System.

APPENDIX B

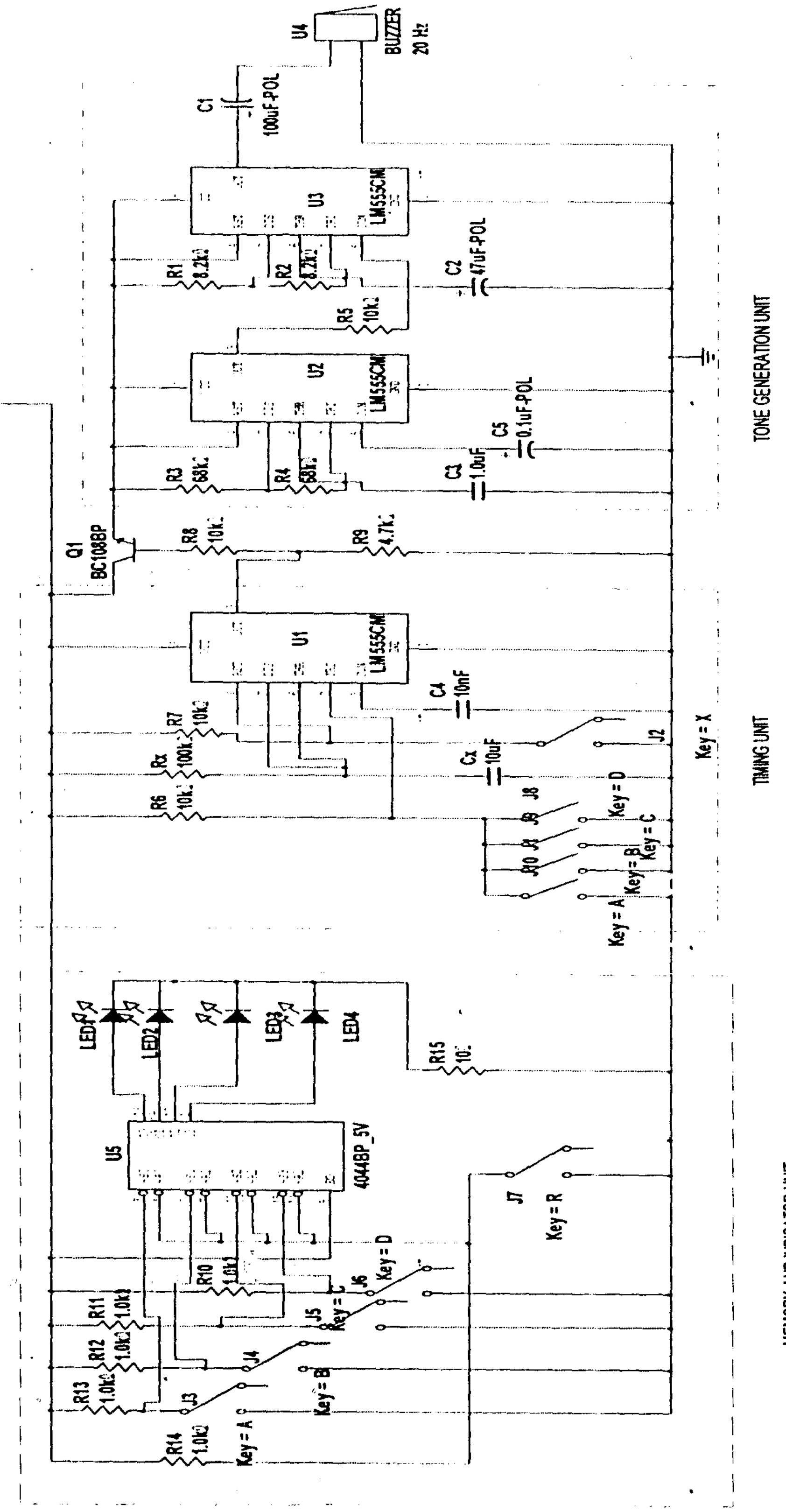

Fig. B complete schematic diagram of The Intruder Alarm System without the Power Supply Unit.

APPENDIX C

PARTS LIST

U1, U2 and U3	555 timer IC
U5	4044 (quad R/S flip-flop) IC
Keys (A, B, C, D)	Trigger Switches
Key R	Monitoring Unit Reset switch
Key X	Timing and tone Reset switch
R1, R2	Resistor 8.2KΩ each
R3, R4	Resistor 68KΩ each
Rx	Timing Resistor 100KΩ
R5, R6, R7, R8	Resistors 10KΩ each
R9	limiting Resistor 4.7KΩ
R10, R11, R12, R13, R14	Pull-up Resistors 1kΩ each
R15	Pull-down Resistor 10Ω
Q1	BC108BP NPN transistor
C1	Capacitor 100μF
C2	Capacitor 47μF
C3	Capacitor 1μF
C4	Capacitor 0.01μF
C5	Capacitor 0.1μF
Cx	Timing capacitor 10μF
LED (1, 2, 3, 4)	Indicators