DESIGN AND CONSTRUCTION OF A TOUCH-ACTIVATED SWITCH

By

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DECLARATION

I Abubakar Yusuf, here-by declared that this work was done by me and has never been presented elsewhere for the award of a degree. I also relinquish the copyright to the Federal University of Technology, Minna.

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Surely, all praise is for Allah the Almighty. We praise him and seek his blessings.

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Finally, to my colleagues, I would like to say thank you all, for your assistance directly or indirectly.

ABSTRACT

A touch activated switch Is made up of several components interconnected to give the desired output. And the main task in constructing such an electronic device is the incorporation of the respective components together on a veroboard and making sure it functions properly. To realize this a bottom up approach was employed, i.e first understanding the basic principles governing the operation of electronic circuits, to the final/complete construction of the circuit. The application of transistors is not limited solely to the amplification of signals, it can be used as a switch. Thus, this project work undertook the design and construction of a simple transistorized switch that can be activated by the touch of the finger. It is adequate for controlling simple domestic appliances, such as lights, fans, etc.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 OVERVIEW

A switch is a digital device in that it may be either open or close. Simply put a switch is that part of an electrical/electronic device that start or stops the flow of electric current i.e. it's a device used for breaking, making or changing the connections in an electric circuit. Hence, a switching circuit is that circuit which can turn ON and OFF an electrical circuit, and it consists essentially of a switch and its associated circuitry.

Switches can be activated by having to press a button up or down etc, or by the use of a wireless remote control if so designed. Switches can also be made to be activated using light, sound or touch. The touch operated switch does not have the disadvantages of a wireless control, whereby the handy remote transmitter can be misplaced; neither does it have the disadvantage of restricted usage of a light operated switch; nor the disadvantage of a sound operated switch, where in background sounds sometimes can trigger a voice operated switch to do something not intended by the user. With touch operated switch the user is always in command and these switches may be used to control lights, fans etc.

Switch can be one of the two possible states – ON or OFF - at any particular time, hence, the need for some form of control to control the switching operation. Thus, this project work is aimed at designing and constructing a switch that can be operated by the touch of the finger or hand.

1.2 AIM

The objective of this project is to provide a practical knowledge on the fundamental principles of switching circuits. Thus, applying the theoretical concepts into real problem solving. Hence, this project brings to the fore the design and construction of a switch that can be operated by touch of the finger. A touch operated switch is made of several components interconnected to give desired output.

1.3 METHODOLOGY

For the realization of this project work a bottom – up approach was employed. The approach ranges from understanding the basic electronic principles governing the operation of electronic circuits to the final/complete construction of the circuit. The main task in designing such an electronic device involves the incorporation of the respective components arrived at the design and analysis together on a Vero – board and making sure that the device perform its prescribed duty without failure for a given time.

1.4 SCOPE

Though the primary concern of this project is a simple touch activated switch that can be used for the control of basic home appliances such as lights, fans, games, etc.

However, the principles and techniques are of basic importance and can find application in security system, alarm system, digital computer operations, telephone switching, etc

1.5 LIMITATION

The major constraints encountered during the course of this project work, were calculating the values of the various components used in this design, which must be practically transferred into construction, non-workable circuit design and ignorance about some basic knowledge of electrical circuit principles.

However, these limitations were countable, hence, necessary steps were taken leading to the final completion of the work.,

1.6 PROJECT OUTLINE

This project work is organized and grouped into five chapters. Chapter one is the introduction, initiating the topic and specifying the objectives, scope, encountered problems and as well methodology adopted.

Chapter two is the literature review, which gives in sight into the weakness of the existing circuits and the necessary improvement in the design.

Chapter three is on the circuit design and analysis, specifying the circuit requirements and design approach.

Chapter four is on the system construction and testing.

Chapter five being the last chapter summarizes the project work, in it also is the proffered suggestion for further improvement.

CHAPTER TWO

2.0 HISTORY

There's been lot of innovations, inventions and improvements in the field of electronics. And certainly switches has also undergone such innovative improvement from the mechanical switches to the sophisticated electronic switches that we now have. The development of solid state devices and semiconductor devices can be said to have aided the invention and development of electronic switching system. That is because virtually all electronic switches consist of semi – conductor device or integrated circuit (IC) in it.

The discovery of solid – state devices in the mid 19^{th} century led to the construction of a practical diode by I A Fleming. In addition to other uses diode tube is used as a switch; because it can allow current to flow or to be shut off. Semi-conductor diodes also were used for switching. The need to improve on the mechanical switched to the modification of the PN diode. This transistor was invented by a team of tree scientists at bell laboratory, USA in 1947. Electronic switches are made using the above mentioned devices and designed to have efficiency, reliability and speed.

2.1 OVERVIEW OF ELECTRONIC SWITCHES

The operation of electronic switches is based on the principle of conversion of non-electrical quantity into electrical signal by the use transducer. They use timing or latching circuit to control the duration of the – ON and OFF – states of the switch. The ON and OFF states of the system energizes or de-energizes a relay, pulling out or pushing in its contact.

2.2.1 SOUND –OPERATED SWITCH

The operational principle of this type of electronic switch is the conversion of sound energy into electrical signals. The sound, be it from a clap, music, voice, etc, is converted into electrical signal with the help of a transducer (e.g. microphone). It has different stages one of which is the amplifier stage responsible for amplifying the electrical signal. The rectifier stage converts the audio signal into DC voltage. This DC voltage is then filtered and moved to the switching unit, which drives the relay.

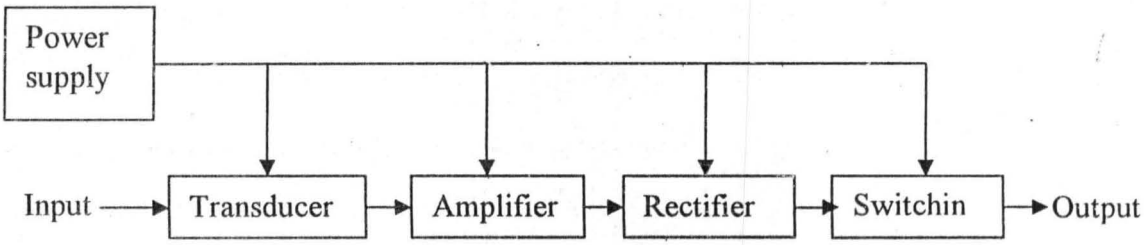

Fig 2.1: sound operated switch

2.2.2 CLAP – ACTIVATED SWITCH

In the year 1982, Joseph Pedoth invented the "clapper" which is one of the earliest known clap-activated switches on record. The "clapper" is a gadget that uses sound – activated switch sensitive to it.

These early versions clap – activated switches, particularly, the clapper were faced with problems of being activated by just any kind of sound. To solve these problems, we have improved clap activated switches, e.g. transistorized clap – activated switch and bistable -multivibrator clap-activated switch.

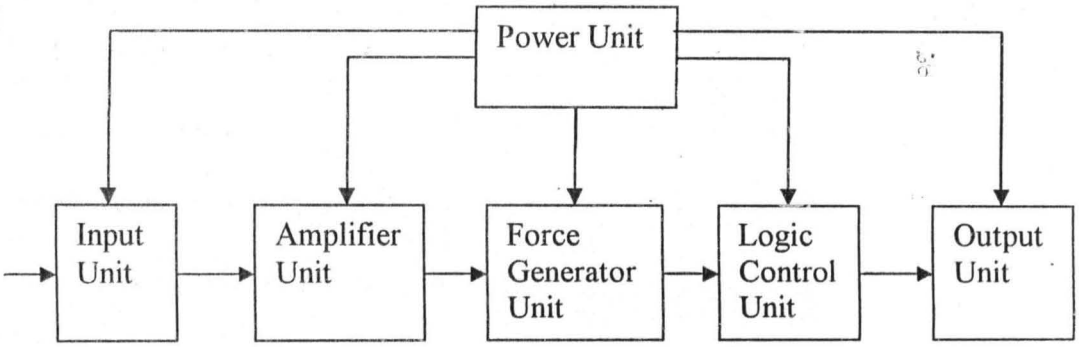

Fig. 2.2: block diagram of clap activated switch

2.2.3 LIGHT ACTIVATED SWITCH

Light activated switch operates on the principle of conversion of light energy into electrical signals. When light falls on the light dependent resistor (LDR) as shown in the figure below

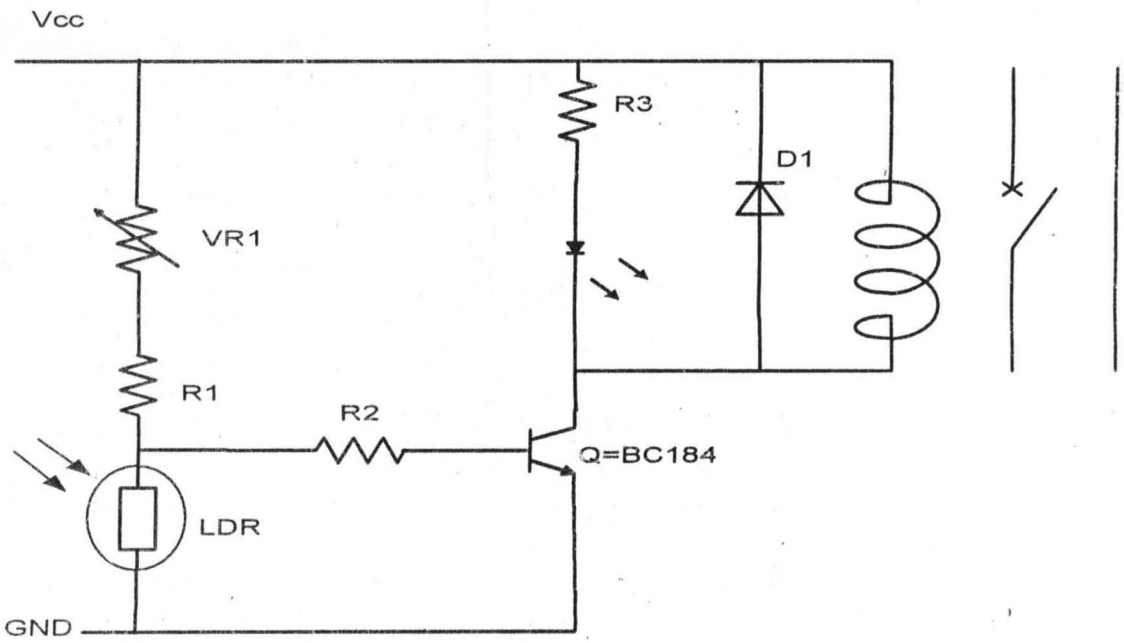

Fig.2.3: light activated switch

The light activated switch reacts to a different level of light intensity. This can be achieved by the variable (preset) resistor included in the circuit to allow for user control. Resistor R1 and variable resistor VR1 one connected in series so that the total resistance

cannot go below 150-, even if VR is set to zero. This is protecting the LDR from excessive current.

The transistor will switch ON only when the voltage at it base rises to about 0.6V thus, if the resistance of the LDR is low compared with VR1 and R1, less than 0.6V will be available at the transistor's base, and the transistor will not switch ON. When light falls on the LDR, its resistance increases and the voltage at the base of the transistor will arise, when it reaches 0.6V, the transistor will turn ON.

2.3 HISTORY OF TOUCH-ACTIVATED SWITCH

The touch activated switch operates on the principle of change in capacitance between the human body and the ground. Normally the capacitance of the touch to the ground is very small. So when the plate is touched the human body acts like a large capacitance to the ground allowing a small AC current to flow from the main through the small parasitic capacitance of the main transformer and the rectifier of the DC supply. This kind of touch activated switch uses two Schmitt trigger inverters, two resistors and one capacitor. It has the advantage of using only one touch plate which is used for ON and OFF. Another type of touch – activated switch is the one that uses two touch plates, one for ON and the other for OFF. It has a 555 timer as the timing circuit.

Emmanuel John (2005) designed and constructed a Touch – Activated switch. In his design only one touch plate was used and the 555 timer was replaced by a latching circuit. The latching circuit was made of a flip – flop which stays in on state until it is triggered by an applied signal. The duration of switching is not controlled by a capacitor and / or a resistor as in the case where a 555 timer is used.

2.3.1 TRANSISTORIZED TOUCH-ACTIVATED SWITCH

The concept of a transistorized touch operated switch is based on the use of 'high' and 'low' starter principle of a transistor as a switch. It is activated by the touch of a finger or hand. Very often, bipolar junction transistors are used as electronic switches. With the help of such a switch, a given load can be turned ON or OFF by a small signal. This control signal might be the appearing at the output of a digital logic or a microprocessor. The power level of the control signal is usually very small and hence, incapable of switching the load directly. However, such a control signal is certainly capable of providing enough base drive to switch a transistor ON or OFF and hence, the transistor is made to switch the load.

The application involves a small base current which enable current to flow in another circuit, designed on the basis of a transistorized touch operated switch. A transistorized touch operated switch is designed so as to operate at varying states. This is defined by calculation and selection of each circuit component for all the stages involved.

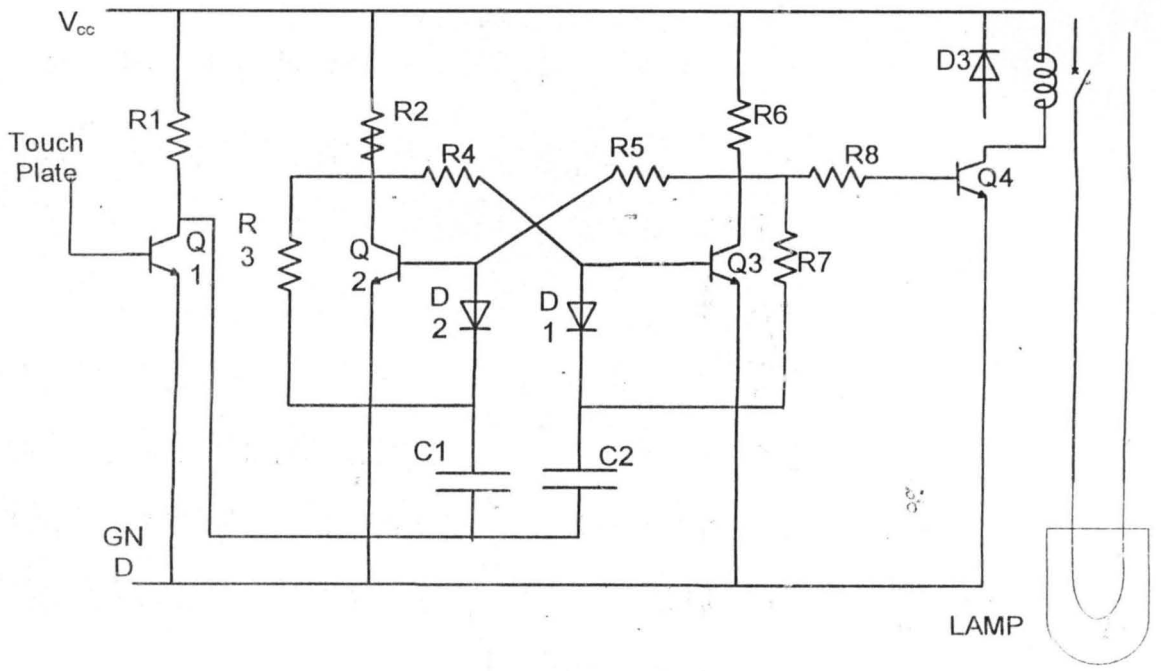

Fig. 2 4: TRANSISTORIZED TOUCH – ACTIVATED SWITCH

2.3.2 MONOSTABLE-BISTABLE MULTIVIBRATOR TOUCH-ACTIVATED SWITCH

With the circuit diagram shown below, one can effectively and efficiently control basic home appliances or industrial equipment with a simple touch of a finger or hand.

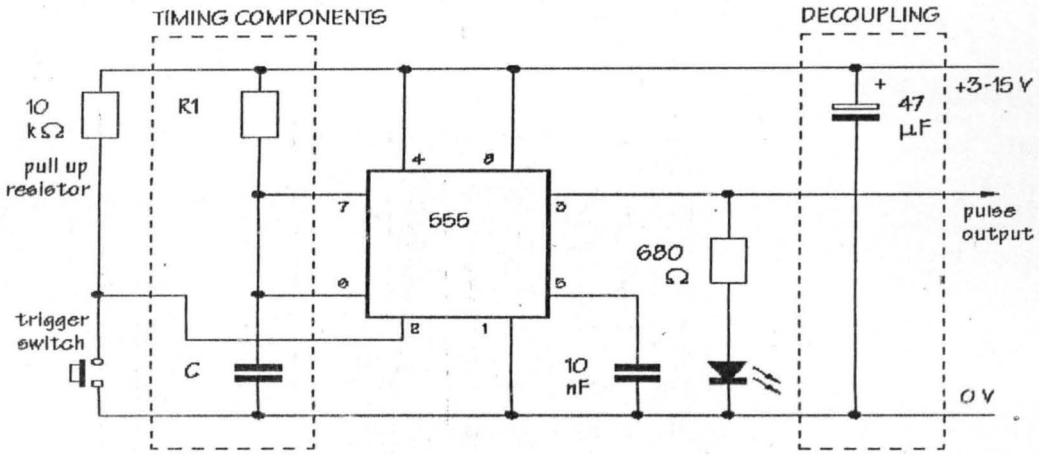

Fig. 2.5: MONOSTABLE/BISTABLE MULTIVIBRATOR TOUCH-ACTIVATED SWITCH

In this circuit a common – emitter configured BJT is used to amplifier signal from the touch – plate which is then fed to the input of a 555 timer (IC) in monostable mode. The 555 timer (IC) serves as the clock generator for the bistable mode (TC 4013) IC as shown in the circuit diagram above; this toggles the output with every input spikes.

2.3.3 CIRCUIT LIMITATION

- The circuit is not customize, i.e. is not made especially for a particular person(s) usage.
- The circuit is not triggered by a specific touch pattern.
- The circuit does not have an underlying logic operation, i.e. the circuit is not intelligent.

2.4 BLOCK DIAGRAM OF A TOUCH ACTIVATED SWITCH

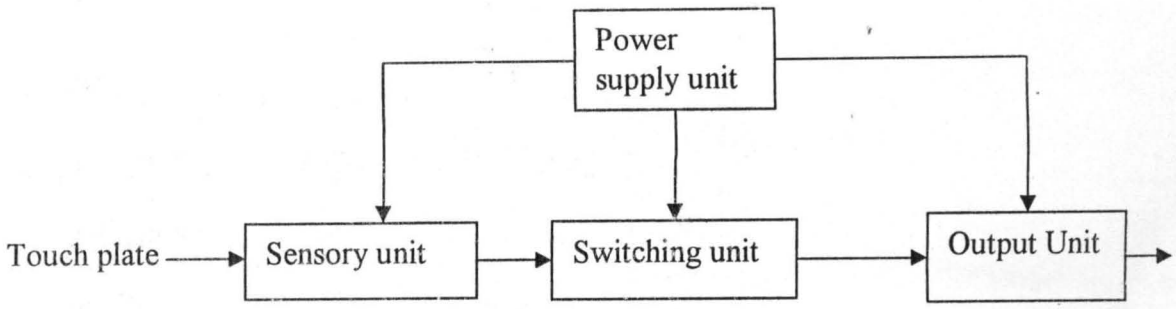

Fig. 2.6 Block diagram of a touch activated switch

The block diagram of a touch activated switch is made up of four units.

- Sensory unit
- Switching unit
- Output unit
- Power unit

2.4.1 SENSORY UNIT

The sensory unit is made up of the touch plate, a resistor and a transistor. When the touch plate is touched the system starts operation.

2.4.2 SWITCHING UNIT

The switching unit consist of 555 timer (IC) and /or a toggle flip – flop (TC 4013) IC, some resistor and capacitors. The system can operate in a timed function using the 555 timer (IC) or in an un-timed function using the 555 timer (IC) and the toggle flip-flop (TC 4013) IC.

2.4.3. OUTPUT UNIT

The output unit is made up of two transistor one each for the timed and the untimed functions, some resistors and an electromagnetic relay. The relay is connected across a protective diode. Output from either of the transistors energizes or de-energizes the relay. A small current applied to the base of either of the transistors produces a large collector current that energizes the coil of the relay and activates the device.

2.4.4 POWER UNIT

Most electronic device and circuits requires a dc source for their operation. In this design a 12V dc source obtained from the domestic ac supply through the process of rectification is used. This power unit regulates the voltage supply to the various units of the circuit.

CHAPTER THREE

DESIGN/ANALYSIS OF THE TOUCH ACTIVATED SWITCH

3.1 BLOCK DIAGRAM ANALYSIS

The circuits have been made as simple as possible; can be divided into four units, which include:

- Power supply unit
- Sensory unit
- Switching unit
- Output unit

3.2 DESIGN OF THE POWER UNIT

For an electrical and electronic device to work there must be power supply to the system. A regulated DC power consists of an ordinary power supply and voltage regulating device.

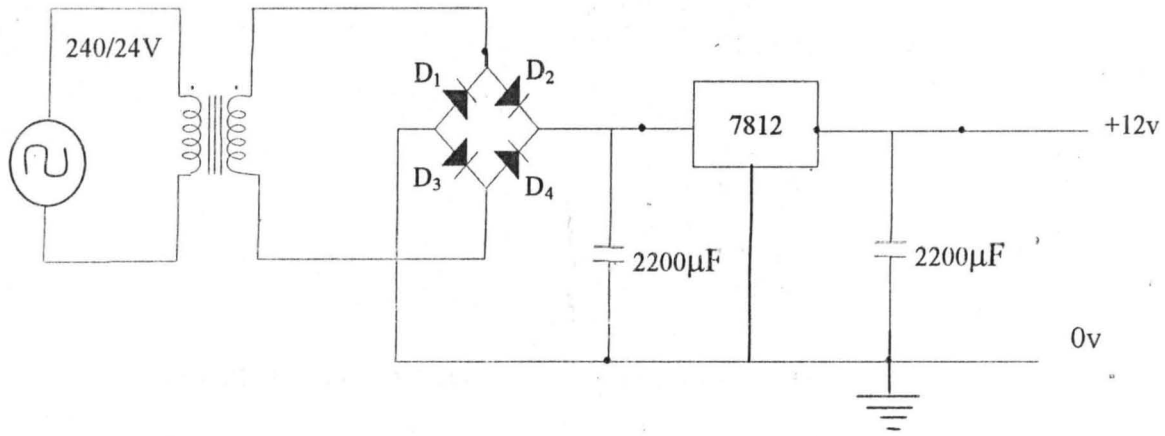

Fig. 3.1 Power supply unit

Most of electronic circuit uses DC supply for their operation and the conversion from AC to DC was achieved through the following procedures. The regulated

power supply consists of four parts.

- Transformer
- Bridge rectifier
- Capacitor filter
- Voltage regulator

3.2.1 TRANSFORMER

A 240 Vrms step – down transformer is used to reduce the 240V (Ac) from PHCN supply to 24V (ac), which is rectified to give the required to give the required DC output voltage, 12 V (dc).

3.2.2 BRIDGE RECTIFIER

The full wave bridge rectifier consists of inter-connected diodes with configuration as shown in fig 3.2 below. The IN4001 diodes are suitable for most low voltage circuit with current of less than 1A. Rectification being the process of changing pulsating AC voltage to DC voltage by eliminating the negative half – cycle of the alternating current. Hence, in this work a full wave bridge rectification is used is getting the reference voltage.

3.2.2 CALCULATION

The direct current voltage, Vdc is given by:

$$V_{dc} = \frac{2V_{max}}{\pi}$$

$$V_{max} = \pi \, x \, \frac{12}{2}$$

$$= 18.8$$

Allowing a safety margin of 1.5

Hence PIV = 1.5x18.8v

= 28.2V

This value of the PIV, 28.2V, prompted the choice of a 2A bridge rectifier (IC) with maximum peak inverse voltage of 100V

3.2.3 CAPACITOR FILTER

The capacitor serves as filter for the rectifier's output, i.e. it removes or minimizes the influence of the remaining ac component in the output. As it is known that output. As it is known that output of various rectifier circuits is pulsating, and so, not useful for driving electronic circuits or devices. Hence, in this work a suitable single capacitor C1 is connected across the rectifier to achieve filtering action, which is, minimizing the ripple content in the rectifier output.

3.2.5 VOLTAGE REGULATOR

The 7812 (IC) voltage regulator is incorporated into the circuit to achieve a more precise control over voltage levels, and provides regulated voltage of 12v. the regulator's output is connected with a capacitor C2, which further removes pulsation at the regulator's terminal.

3.3 SENSORY UNIT

The sensory unit, i.e. the input unit is made up of a touch plate, two resistors and an NPN Transistor, as shown in figure 3.3 below

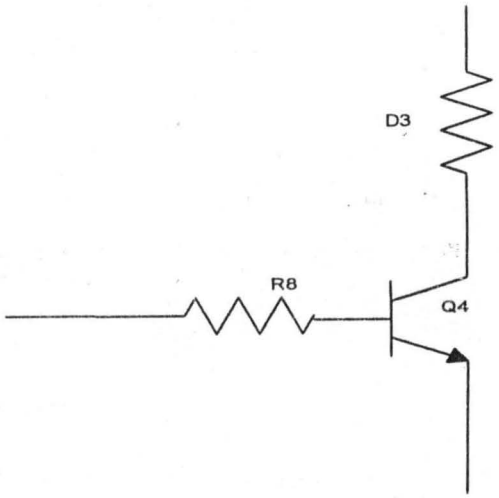

Fig. 3.2: Sensory unit

The base-emitter junction of a silicon transistor is assumed to a voltage of 0.7V.

$$Vin = Vbe + IbRb$$

Therefore, base resistance is given by:

$$Rb = \frac{(5 - 0.7)}{1.3}$$

$$= 3.3k$$

(a) Initially the system is yet to be activated by touch, therefore no current flows at the transistor Q1

(b) On touching the plate, base voltage changes are introduced at the base of the transistor pushing it to saturation mode.

$$Vbe(sat) = 0.7V, Vce(sat) = 0.3V$$

For the transistor to turn ON:

$$\beta Ib > Ic$$

Therefore,

$$\beta Ib > \frac{Vcc - Vce(sat)}{Rc}$$

A resistor of 100kΩ was used.

$$\beta Ib > \frac{(12 - 0.3)}{100}$$

$$\beta Ib > 0.117mA$$

$$Ib > \left(\frac{0.117}{200}\right)mA$$

$$Ib > 0.000585mA$$

Base current Ib must be greater than 0.000585mA which is very small, and so the transistor can turn ON.

Base current IB must be greater than 0.000585mA which is very small, and so the transistor can turn on. The touch plate delivers current from the power rail to the base of the transistor, via a finger. The finger acts as a very high vale resistor.

Touch – plate is classified as a high impedance device (or high impedance circuit) as the effect of a finger will be detected by the circuit connected to the plate.

3.4 SWITCHING UNIT

The switching unit is made up of a 555 timer in monostable mode and bistable multivibration (TC 4013) IC.

3.4.1 555 TIMER IC

555 Timer has three operating modes: monostable mode, astable mode and bistable mode. And one of the applications of a 555 in the monostable mode is as a touch switch. In this work it is also used as clock generator for the bistable multivibration (TC 4013) IC. The circuit diagram is as shown in figure 3.4 below.

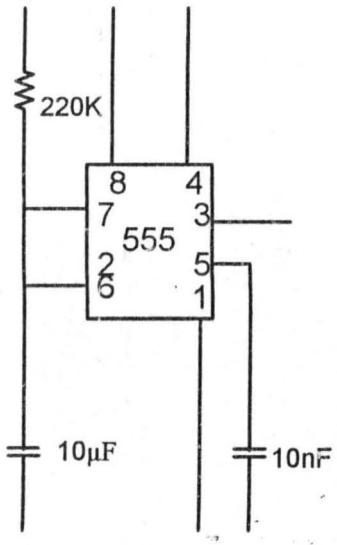

Fig. 3.3: 555 TIMER IC

Simply using a resistor and a capacitor as shown in the figure above, the timing interval was adjusted as required.

The interval time't' is given by:

$$P = 1.1RC$$

$$= 1.1x2.2k\Omega x10mF$$

$$= 2.42sec$$

3.5 OUTPUT UNIT

The output unit comprises of two NPN transistors, one each for the two different functions (time and untimed) of the system, one relay rated 12V, 400. the output is designed to respond to signals from the switching unit.

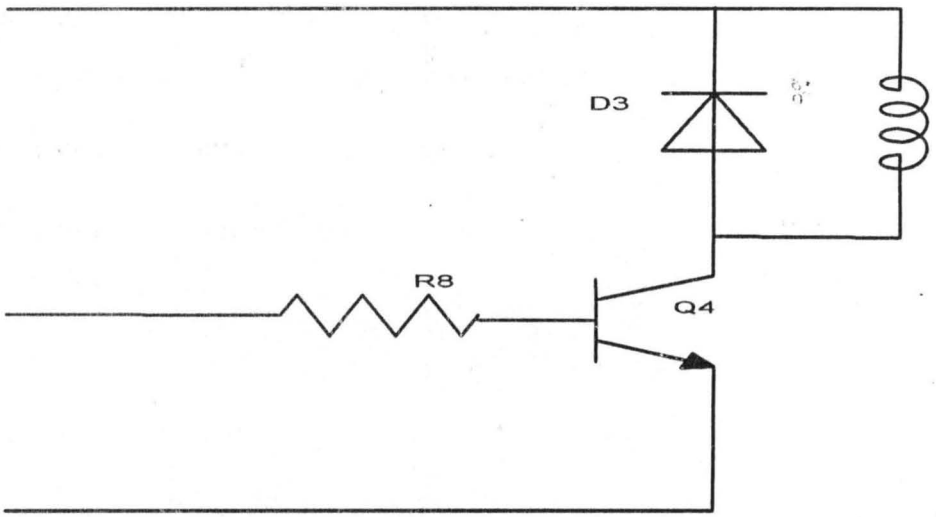

Fig. 3.4 Output unit

The typical hfe of the transistor is 100. The resistance of the load coil of the collector is 400Ω. Therefore, the collector's current of the transistor is expected to be:

$$Ic = \frac{12V}{400\Omega}$$

$$= 0.03A = 30mA$$

So that,

$$Ib = \frac{Ic}{hfe} = 30mA/100$$

3.5.1 BIPOLAR JUNCTION TRANSISTOR (BJT)

There are two types of transistor: The field – effect transistor (FET) and the Bipolar junction transistor which is of concern here – in.

The BJT is used in two broad areas of electronics; as a linear amplifier to boost an electrical signal and as an electronic switch. Basically the bipolar junction transistor consists of two P-N junctions made into a single piece of a semiconductor crystal, which give rise to three regions called emitter, base and collector.

3.5.2 RELAY

Relay is an electromagnetic switch. A movable armature is placed above the cone of an electromagnet, when the core is energized the armature is altered and the contact points open or closed in response to change in some physical quantities such as current, voltage, etc. relay allow one circuit to switch to switch another circuit which is completely isolated from each other.

A relay in a normally closed position opens when activated and a normally open relay closed when energized. When the energizing potential is removed, the spring action returns the armature to its original state.

3.5.3 PROTECTIVE DIODE

De – energizing a relay breaks the inductive circuit through the relay's coil, producing a hike (increase) in voltage that can damage the coil, hence the need for the protective diode. Transistors and ICs (chip) must also be protected from the brief high voltage 'spike' produced when the relay is switched off.

The diode is connected 'backwards' such that it will normally not conduct, conduction occurs only when the relay is switched off. At such moment current tends to continue flowing through the coil and is harmlessly diverted through the diode.

3.6 CIRCUIT OPERATION

The circuit operates in 'timed' and 'untimed' modes. When the switch (s) is depress the circuit will function in a timed mode, otherwise it will be in an untimed mode.

In the timed mode (function) of the circuit, amplified signal from the touch plate is fed into the input of a 555 timer, whose output is further amplified and then used in energizing the relay for a period of time.

In the untimed mode (function) amplified signal from the touch plate is used to trigger the 555 timer, which generate a clock pulse for the flip-flop (TC 4013) IC. For every consecutive touch of the touch plate, the output of the flip-flop (TC 4013) IC toggles, and there-by energizes the relay each time.

3.7 TC4013 IC

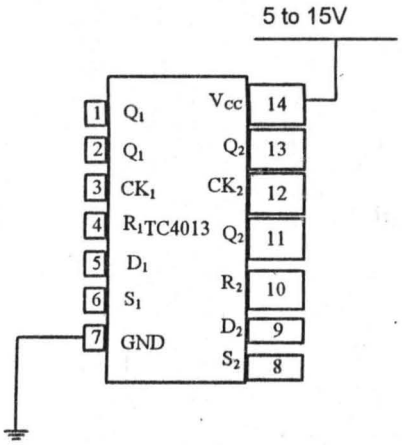

Fig. 3.5 TC 4013

The TC4013 dual D-Type flip-flop is a monolithic complementary MOS (CMOS) integrated circuit constructed with N- and P-channel enhancement mode transistors. Each flip-flop has independent data, set, rest, and clock inputs and Q and $\bar{Q}$ outputs. These devices can be used for shift register applications by connecting '$\bar{Q}$' output to the data input, for counter and toggle applications. The logic level present at the '$\bar{D}$' input is transferred to the Q input during the positive-going transition of the clock pulse.

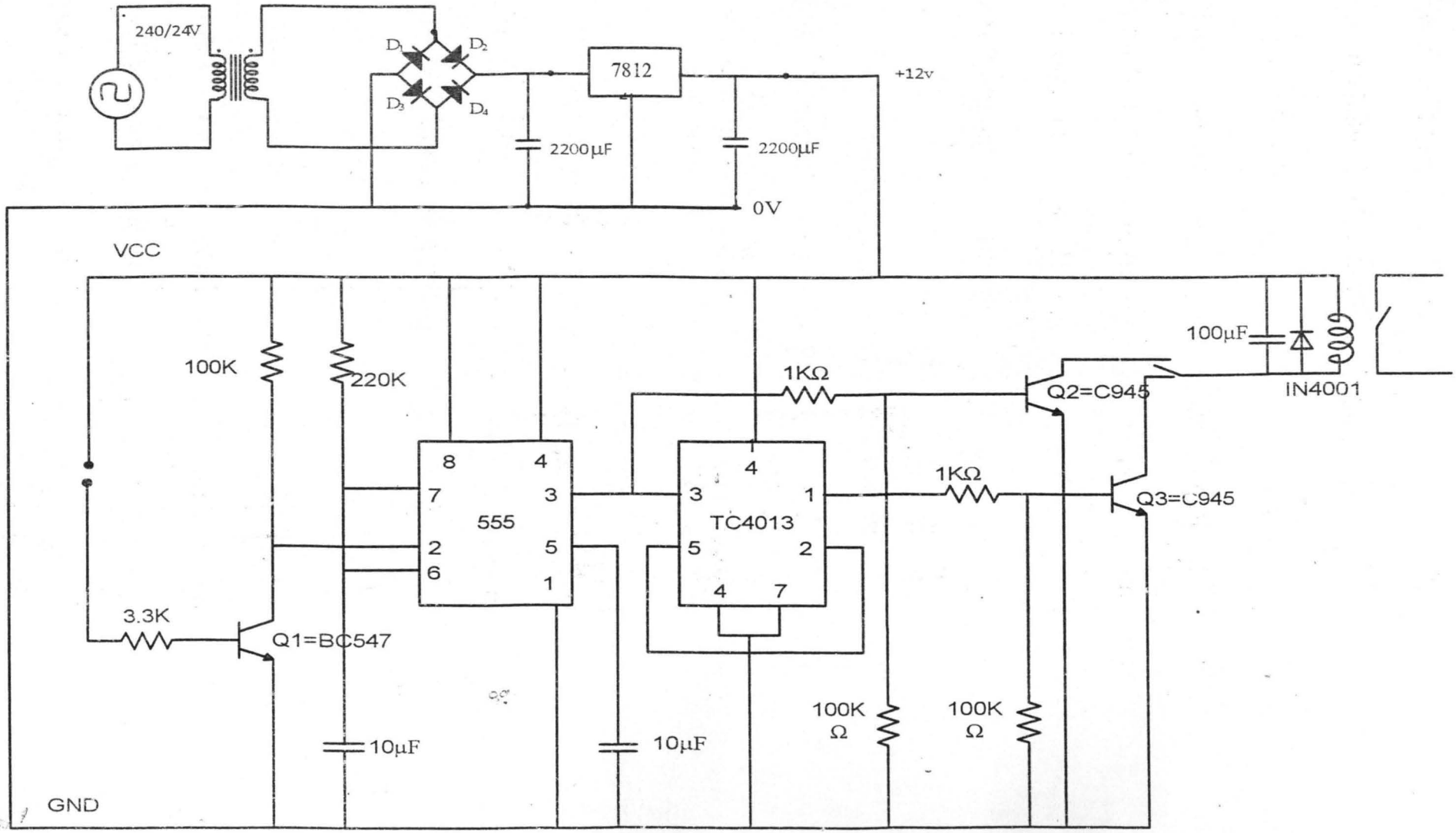

Fig. 3.6: Complete Circuit Diagram of a Touch Activated Switch

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULTS

4.1 CONSTRUCTION OF THE CIRCUIT

The touch activated switch circuit was designed and the dc analysis done to get the values of the different components. The touch – activate switch was then constructed in accordance with the circuit designed as illustrated in fig. 3.6. the circuit was first built and tested on a bread board before transferring it onto a strip type vero board, having ascertained it workability.

A bottom – up approach was used in this construction, i.e. the four separated units were incorporated on the Vero board unit, before connecting them node – to – node. The power unit was first constructed and powered. The subsequent units, such as the input, the switching unit and the output unit were constructed and tested at the completion of each stage to ensure there is an output before proceeding to the next.

The soldering on the vero board in such a way as to avoid bridging. And finally the completed circuit construction was tested for short circuit and open circuit faults which can pose a problem.

4.2 TESTS AND RESULTS

The completed work was test – run by powering it in order to ascertain its efficiency, workability, and reliability. At the initial stage of operation, the transistor Q1 at the sensory unit operate in cut off mode, and following result were obtained.

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4.3 DISCUSSION OF RESULTS

From the result obtained we can see that very small base current is needed to turn on the transistor and as such the sensitivity of the touch plate is very high. It is actually the pulse coming in from the sensory unit that triggers the monostable 555 coming in from the sensory unit that triggers the monostable 555timer on that changes the state of the bistable from one state to another. Pulse is sent in as touch is made on the touch plate.

4.4 TROUBLE SHOOTING

When the power LED fails to on in the stand – by mode. Possible causes

- Power plug not properly connected
- Power plug is bad
- Power LED is bad

SOLUTION

- Adjust the power plug
- Replace the LED

When there is general malfunction of the unit. Possible causes

- Component failure

SOLUTION

- Retrace the circuit and check for any fail component and replace it.

TABLE 4.5: LIST OF COMPONENTS USED

Components	Design specification
Transistor	BC547, C945
Diode	IN4001
Transformer	240/12V X 2
555 timer	IC
TC 4013 (IC)	IC
Relay	12V, 400Ω
Resistor	
Capacitor	
Vero board	STRIP E TYPE
7812 Regulator	IC
Rectifier (IC)	FULL WAVE BRIDGE RECTIFIER
Power cord	

CHAPTER FIVE

5.0 CONCLUSION

5.1 SUMMARY

A simple but efficient touch activated switch has been designed, constructed and tested. By simply placing a finger on the touch plate you control any appliance that is connected to the touch switch. This kind of give you a magic finger.

To prevent electric shock, the circuit was properly enclosed in a well insulated plastic casing.

5.2 PROBLEM ENCOUNTERED

Before arriving at this very design, several other non-workable designs were tried, leading to some components being damage and this poses a problem due to lack of money.

5.3 RECOMMENDATION

I will like to recommend that in constructing a switch using transistor, that switching transistors are particularly used as all the transistor available are not switching transistors. This is so as to get a better switch response.

I will also like to recommend that the transistor at the sensory unit should be very sensitive and must require very small base current to switch on.

Finally I'd like to recommend that for any project work, one should go for components that are easily available.

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