Design and Construction of a Clap-Activated Switch

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2000/9881EE

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A Thesis submitted to the department of Electrical and Computer Engineering, Federal University of Technology, Minna.

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Dedication

I would like to dedicate this entire work to God who saw me through and my parents, Sir & Lady E.O Nwaocha, who ardently supported and encouraged me through out my years in the university. They made me believe that I could achieve anything I set my mind to, with hard work, perseverance and God on my side.

Declaration

I, Nwaocha Chika Monique, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

NWAOCHA CHIKA M. (Name of Student)	MRS. C. ALENOGHENA (Name of Supervisor)
.... (Signature and date)	.... (Signature and date)
ENGR. MUSA D. ABDULLAHI (Name of H.O.D)	.... (Name of External Examiner)
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These reviews and contributions played a key role in the improvement of this work.

Abstract

This project design is based on the clap activated switch. This project presents the design, construction and testing of a simple clap-activated switch.

The principle of operation is simple and it employs the use of a relay, an electrically operated switch, which remains dormant until the operational amplifier is activated upon sound through the transducer. The microphone converts the acoustical energy in the received input sound wave, into the electrical energy for the required switching operation. It's adequate for switching on and off, simple domestic applications such as lights and fans.

The Clap-Activated switch has been designed, constructed and tested and found to be in good working condition.

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Chapter One
Introduction

1.1Overview

A Clap-activated switch, which operates on the principle of a sound-activated switch, is sensitive to hand clapping and is used to turn OFF and ON any appliance connected to it. This switch has the advantage that the transmitter is always with you thus eliminating the possibility of losing it if it were a hand-held device.

Sound activated switches are increasingly being used in private homes, offices, stores and other businesses due to their simplicity, low cost of implementation and functionality.

The basic concept in any switching circuit is that a definite change of state, usually a voltage change, causes operation of the switching device [2]. Much of the switching, sequencing and interlocking used in industrial control systems and digital computers employ switching–type control. Switching-type control functions in a binary manner; that is, the devices used are permitted to exist only in two possible states [2].

A circuit which can turn ON and OFF an electrical circuit is known as a switching circuit and it consists essentially of a switch and its associated circuitry [5]. A switch is a digital device, in that it may be either open or closed [2].

A sound activated switch is one which operates upon the incidence of a pre-defined sound pattern which it has been designed to respond to, thus undergoing a definite change of state. Switches assume one of the two possible states – ON or OFF at any given time and as such need some form of control which may be mechanical, electro-mechanical or electronic.

1.2Aim

The purpose of this project is to provide a working knowledge on the fundamental principles of switching circuits, applying the abstract concepts to solving real problems.

This project presents the design, construction and testing of a simple clap activated switch. Its principle of operation is simple and it employs the use of a relay, an electrically operated switch, which remains dormant until the operational amplifier is activated upon sound via the transducer. The transducer is a device that converts energy or information from one form to another. In this case, a microphone converts the acoustical energy in the received input sound wave into the electrical energy of the output current.

The ultimate goal is to realize the design of a simple circuit built around the basic principles of electronics, with the ability to perform interesting and useful functions.

1.3 Methodology

A bottom-up approach was employed in the realization of this project ranging from the understanding of basic electronic principles which govern the operation of all electronic circuits to the complete construction of the final circuit.

The main task in designing such an electronic device involves getting a set of transmiting and receiving units to work in accord. The transmitter generates the required sound energy and on the other side, the receiver converts the sound energy into corresponding electric energy which is used for the required switching operation. The transmitter is merely any suitable sound signal source which includes voice, pre-recorded messages, human hands used in generating a pattern of clap or other forms of forced sound generation. The intensity of the sound must attain a specific level for altogether response and result.

The favorable results obtained were due to useful input from various sources which include textbooks, journals, previous related works done, and people which have been cited in the course of the report.

1.4 Scope

Although this project is primarily concerned with clap-activated switches, many of the principles, techniques and approaches discussed are of basic importance and they find application in alarm systems, security systems, telephone switching, satellite transmissions, digital computer operations and more.

This project examines the simple clap-activated switch which is used for control of basic home appliances such as lights, fans, games and other suitably rated devices.

1.5 Limitations

In the course of the project, setbacks and constraints encountered were mainly due to unavailability of required components, non-workable circuit design, and ignorance of knowledge of electrical circuit principles.

These were however within containable limits as necessary remedies were sought and implemented leading to the final completion of the desired project.

1.6 Project Outline

This work is organized in five chapters. Chapter one which is the introduction, initiates the topic specifying the objectives, scope, problems encountered as well as methodology adopted.

Chapter two deals with the literature review. It looks into the weaknesses of the existing circuits and improvements in the design.

The third chapter focuses on the circuit design and analysis. It specifies the circuit requirements and design approach. The modules and sub modules are equally analyzed and designed.

The fourth chapter treats the system construction and testing. The performance of the system is evaluated using the expected and actual results.

Chapter five which is the last chapter summarizes the project work. It looks at the achievements, problems encountered, as well as suggestions for further improvement.

Chapter Two
Literature Review

2.1 History

From the very beginning, man has sought to improve the quality of his life and existence. This ever-increasing quest has been necessitated and propelled by the simple need to address the challenges posed by his environment. Borne out of this need, a number of inventions have been made in virtually every field of human endeavor.

2.1.1 History of Remote Control

Remote control which dates back to the early eighteenth century may be defined as the control of a system, device or activity from a distance [7].

Nikola Tesla (1856–1943), Serbian-born American physicist, electrical engineer, and inventor was also very interested in the possibility of radio communication. As early as 1897, he demonstrated remote control of two model boats on the lake in Madison Square Garden in New York City. In 1900 he began to construct a broadcasting station on Long Island in the hope of developing a project called "World Wireless." [8]

Zenith Electronics Corporation, one of the world's leading manufacturers of consumer electronics components and a top innovator of television, radio, and digital technology based in Glenview, Illinois, blazed new trails in the early years of electronics. It introduced industry firsts that included a wireless remote control for television in 1956. The remote, unofficially called "Lazy Boner" – used a wire to connect to the television set. This unattractive setup was improved by the development of another wireless remote control in 1957 called the "flash matic". It worked by shining beam of light on to a photoelectric cell but the problem it faced was that the cells could not distinguish between light from the remote and light from other sources. The "flash matic" also required that the remote control be pointed accurately at the receiver.[6,7]

2.1.2 Sound-Activated switches

The sound-activated switch is a form of remote control in that the generated sound is used to control a system/device, some distance away.

Sound-activated switches emerged over the years as technology forged ahead in trying to make life easier for man. This form of switch is one which responds to a pre-defined pattern of sound which the device has been designed to respond to. Such sound patterns include voice, pre-recorded commands, hand-clapping, snapping of the fingers, music and many others. However, some of these have posed more problems in its operation than the others which lie mainly in the quest to minimize false trigger.

The voice-activated switch is closely related to the sound activated switch but for the reasons outlined below, the clap-activated switch poses fewer problems.

- Put simply, a voice-activated switch does not always "hear" commands correctly, given the current state of voice recognition technology and the inevitable errors in systems.
- Sometimes the user of a voice-activated switch may say one thing but the unit hears something else and does something unintended - or does nothing at all.
- A voice-activated switch doesn't just hear the user's voice and no other sound. On the contrary, it hears all sounds within range. So background sounds - including other peoples' voices, sometimes can trigger a voice-activated switch to do something when no command was given by the user.
- Similarly, ambient background noise – including desired "noise" such as music or sound from a television set, can sometimes interfere with the switch's ability to hear what the user is saying.

- Also, a person's voice sometimes has different characteristics when the person is lying down versus sitting upright (in a wheelchair), or the voice quality may change during the course of the day or when the person is sick (perhaps with a respiratory problem).

These different voice patterns may confuse a voice-activated switch. All of which is to say, the voice-activated switch, though useful, is not very reliable.

2.1.3 History of the Clap-Activated Switch

One of the earliest recordings of the clap-activated switches is the 'Clapper'. It was invented in the early 80's (1982) by Joseph Pedott, owner of Joseph Enterprises Inc, who also invented the Chia Pet [6]. The clapper is a gadget that uses a sound-activated switch sensitive to hand clapping, to turn off and on any two appliances that are plugged into it depending on the number of times you clap. At one time two types of the 'Clapper' existed, 'Clapper I' with one outlet and 'Clapper II' with two outlets. Clapper II features two outlets that are activated separately by two or three claps.

At the tail end of the 80's, both types of Clapper were available (the two-outlet version and the one-outlet version) until the first version was discontinued due to incessant reports of malfunction. They were faced with the problem of being activated by just about any sound [6].

In recent years, a lot of improvement has been made and to ascertain this, specific circuits illustrate this.

2.1.3.1 The Transistorized Clap-activated switch

This circuit makes use of a combination of transistors in an amplifying circuit to power on a light bulb for visual indication of produced sound or to energize a relay for other functions. A microphone is used in the circuit as a transducer of sound waves into electrical signals prior to their amplification.

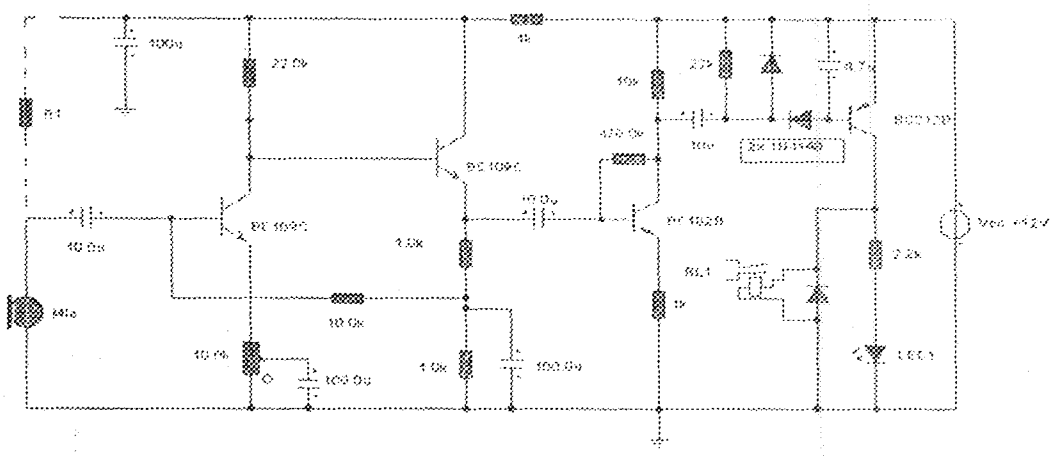


Fig 2.1 a transistorized clap-switch circuit

The circuit above may be seen in two stages. In the first stage, the output from the amplifier operates the two-transistor switch in the second stage. In the second stage, when the speaker receives sound waves, the resultant signal across the output of the first stage consists of voltage changes which are the amplified electrical signals corresponding to the sound waves. This sensitive sound operated switch can be used with a dynamic microphone insert as above, or be used with an electret (ECM) microphone. If an ECM is used then R1 (shown dotted) will need to be included. A suitable value would be between 2.2kΩ and 10kΩ. The two BC109C transistors form an audio preamp, the gain of which is controlled by the 10k Ω preset. The output is further amplified by a BC182B transistor. To prevent instability the preamp is decoupled with a 100uf capacitor and 1kΩ resistor. The audio voltage at the collector of the BC182B is rectified by the two 1N4148 diodes and 4.7uf capacitor. This dc voltage will directly drive the BC212B transistor and operate the relay and LED.

It should be noted that this circuit does not "latch". The relay and LED operate momentarily in response to audio peaks [9, 10].This circuit performs the desired action but not entirely. It turns on the light/device but 'turn-off' is effected manually. This does not quite save time and energy if one still has to manually operate the switch.

2.1.3.2 Bistable-Multivibrator Clap-Activated Switch

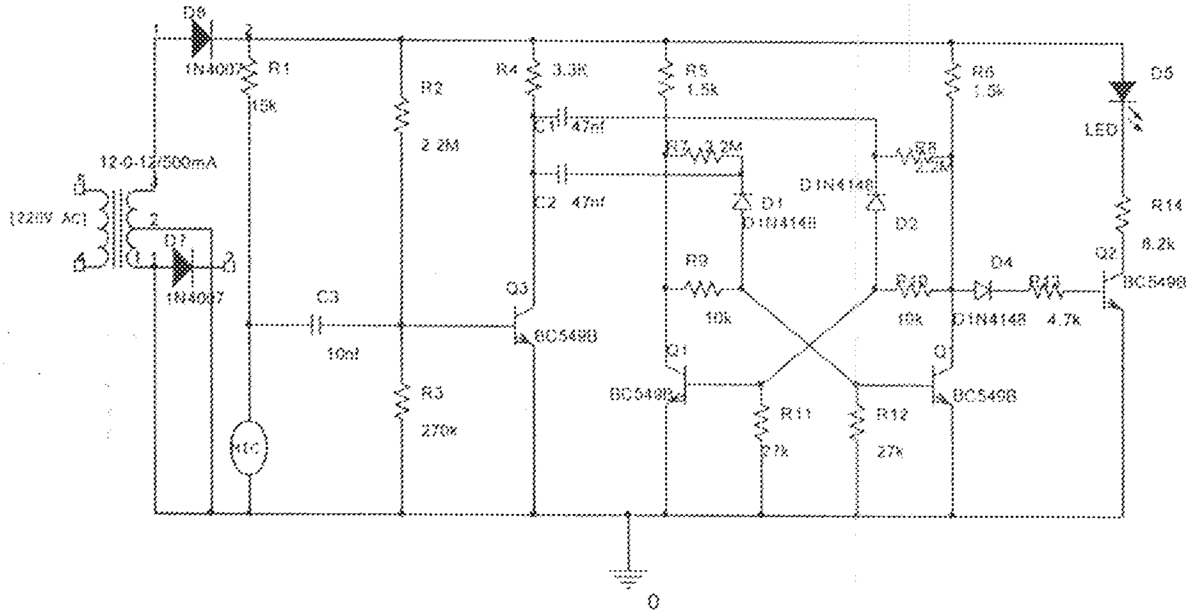


Fig 2.2 a monostable multivibrator clap circuit

A simple Switch triggered by a clap. One can control different home appliances with claps.

A simple bistable multivibrator with a LED driver illustrates this. The microphone input is amplified with a Common Emitter BJT amplifier and fed to the bistable multivibrator. This toggles the output with every input spikes. A led driver transistor is switched on and off and hence the LED glows [11].

2.1.3.3 Circuit limitations

- It is not triggered by a specific clap pattern
- It is not intelligible since it has no underlying logic operation
- It is more prone to false trigger

A digital version can be constructed on similar lines using a Toggle flip flop.

2.1.3.4 Two-clap activated switch

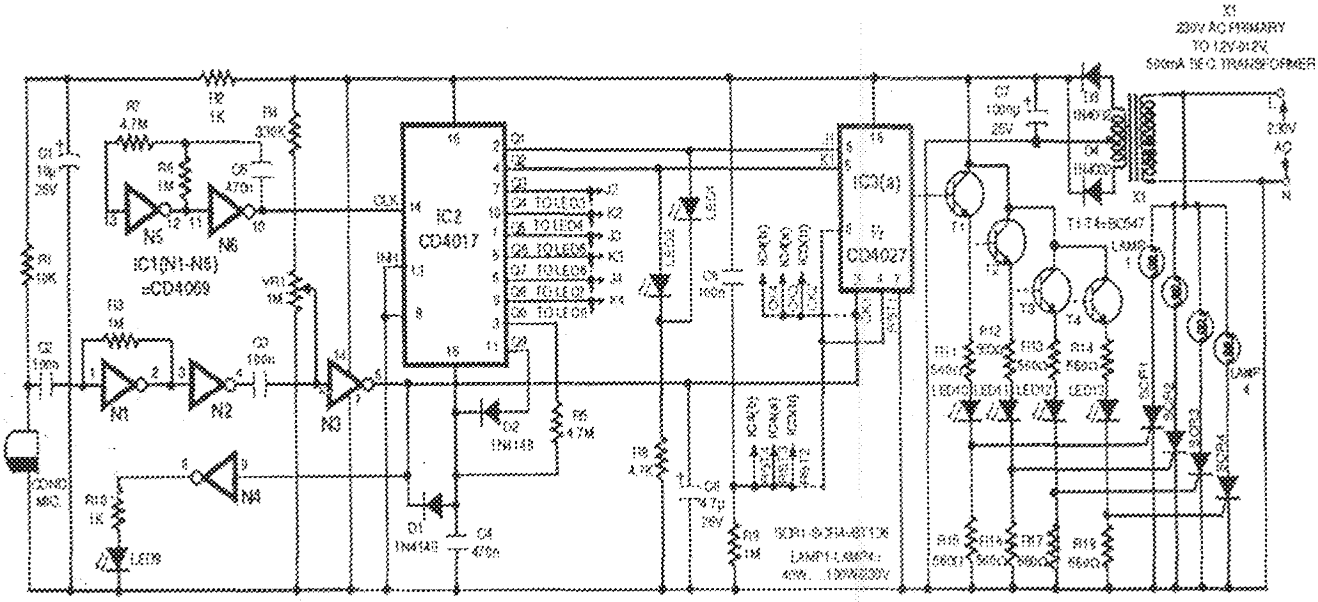


Fig 2.3 clap-activated switch that responds to 2 claps

Figure2.3 shows the diagram of a clap-activated Switch which responds to two claps. It consists of a transistor amplifier, a transistor switch and two types of digital circuits, a one-shot multivibrator and a flip-flop. A waveform is created when hands are clapped together. The microphone senses this waveform and couples it to the base the capacitor. The transistor is configured as a common emitter amplifier since the AC signal is bypassed to ground by capacitor C4.

2.1.3.5 Circuit Limitations

- The circuit though digital, is not free from false trigger.
- It is complex.
- It employs the use of many components, thus higher unit cost.

2.2 The Three-Clap-Activated Switch

This project offers a way to control up to four latching switches with two claps of your hand. These switches may be used to control lights or fans – or anything else that does not produce too loud a sound. To prevent an occasional loud sound from causing malfunction, the circuit is normally quiescent. The first clap takes it out of standby state and the third clap effects a definite change of state. If this circuit is to be active, i.e. scanning all the time, some components around CD4017 B could be omitted and some connections changed. But then it would no longer be immune to an occasional, spurious loud sound. The electrect microphone usually available in the market has two terminals. It has to be supplied with power for it to function. Any interference on this supply line will be passed on to the output. So the supply for the microphone is smoothed by resistor-capacitor combination of R2, C1 and fed to it via resistor R1. The project embodies numerous interesting features which make it an improvement on past related works. The main evident feature is the use of complementary metal oxide semiconductor (CMOS) ICs throughout the circuit. These ICs have the following advantages;

- low cost
- simplicity of design
- low heat dissipation
- good fan-out and wide logic swings
- good noise-margin performance

In the course of the project design, error was considered. Thus error-limiting techniques were incorporated to yield a better overall response.

Past related works were mostly concerned with unidirectional operation, but this design makes an attempt to counter that by providing bi-directional switching of the circuit.

2.2.1 Circuit advantages

- It is less prone to false trigger since it requires three claps.
- Its operation is simple.
- Its sensitivity to sound can be adjusted.

2.3 Block Diagram of the Clap-Activated Switch

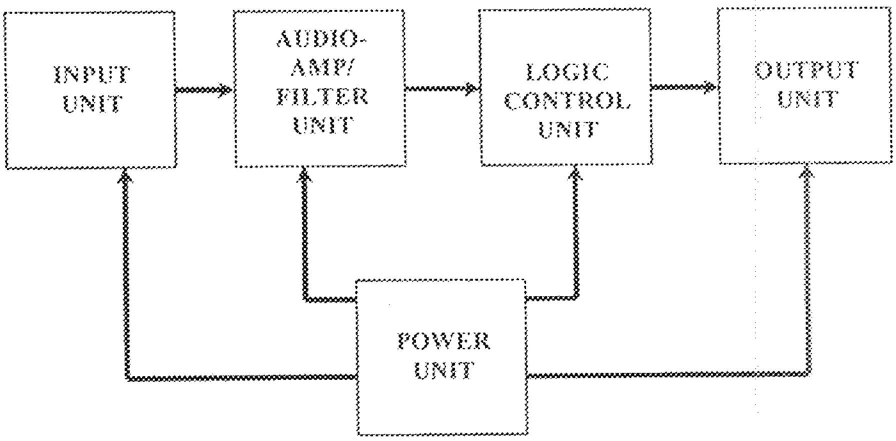


Fig 2.4 Block diagram of the clap-activated switching unit

The block diagram of the sound activated switch involved four main units which include;

- Input Unit (transducer)
- Audio Amplifier/ Filter Unit
- Logic Control Unit
- Output Unit (load switching)
- Power Unit

2.3.1 Input Unit (transducer)

The input transducer is merely a normal microphone. It converts sound energy into corresponding electrical signal. The signal is weak and usually requires amplification for reasonable use. The input transducer feeds in signal which the other part of the circuit works upon.

2.3.2 Audio amplifier/ Filter unit

The audio amplifier was incorporated to amplify or strengthen the weak signal from the input transducer to an appreciable level. The amplifier is the LM386 and it provides signal gain of up to 200. An RC filter unit is connected to the output of the amplifier for removing noise or adjusting level of response. It is important for removing input error.

2.3.3 The logic control unit

The logic control unit is designed to digitally respond to the input signal. This unit has six sub-units which are all integrated circuits. The logic control unit is attributed to a timing technique in removing error, responding to three wanted inputs and switching on and off the output load in a toggling manner. This unit is the heart of the entire system.

2.3.4 The Output unit

The output unit involves the load switching. Its main component is a relay switch which supplies electric current to the load in accord with the logic control unit. In other words, the output unit is controlled by the logic control unit.

The design of the sound activated switch involves an input transducer (a microphone) that feeds in audio signal into an audio amplifier. The audio amplifier strengthens the audio signal to a working level with the logic control unit. This last unit works upon three signals in switching on or off the electric current or power to a given load.

2.3.5 The Power Unit

The power unit supplies regulated voltage required by the various units of the circuit for its operation. This is as a result of the presence of the 12V and 5V regulators. The power unit has a direct connection to the a.c. mains but uses a step-down transformer to obtain the wanted voltage. This unit must be functional before the other parts of the circuit can operate.

Chapter Three

Design of the Clap-activated Switching Unit

3.1 Block Diagram Analysis

The circuit is made as simple as possible. Therefore, limited number of components is involved in the design. The circuit can be divided into four groups, namely

- Power supply unit
- Input unit
- Logic Control unit
- Output unit

3.1.1 The Power supply unit

Most electronic circuits require a D.C. power source which remains at a fairly constant value irrespective of changes in A.C. mains or load.

The power supply unit deals with both 12v and 5v D.C. It is better described as a dual power supply unit with its input from a 500mA, 24V AC step-down transformer which produces the required regulated D.C. power supply. A regulated D.C. power supply consists of an ordinary power supply and voltage regulating device.

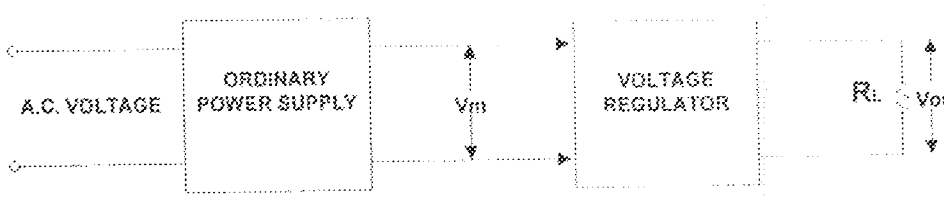


Fig 3.1 a regulated power supply

The regulated power supply is a combination of three parts which include;

- The bridge rectifier
- The capacitor filter, C1

- The voltage regulators, 7812 and 7805

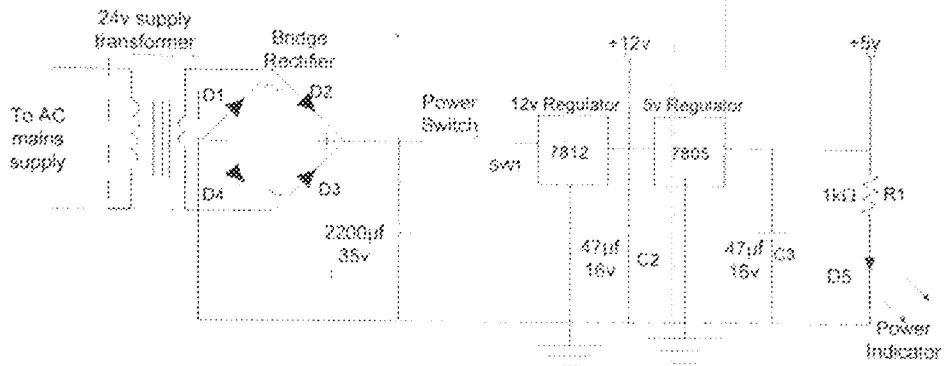


Fig 3.2 operation of a bridge rectifier as it converts A.C. to D.C.

The rectifier is made up of the four-diode configuration. The 1N4001 is suitable for most low voltage circuits with a current of less than 1A. Two of the four diodes work at forward bias during half cycle of the input A.C. voltage from the transformer. The resulting low output from the bridge rectifier is polarized. One is positive and the other, negative. A 2200µf capacitor (C1) serves as filter for the rectifier's output. This component removes or minimizes the influence of remaining A.C component in the expected D.C output from the bridge rectifier. The value is usually within 1000- 3300µf range. The voltage rating of the capacitor is 35V which is reasonably above the 24V rating of the power supply.

The 7812 and 7805 regulators are incorporated into the circuit so as provide regulated voltages of 12V and 5V respectively. Each regulator's output is connected with a 47µf 16V capacitor. The device further removes pulsations at the particular terminals.

A power indicator circuit, comprising of a 1kΩ resistor and a light Emitting diode (LED), is used for defining the presence of electric current at sensitive point of the current.

An LED must have a resistor connected in series to limit the current through the LED; otherwise it will burn out almost instantly [12]. The resistor value, R is given by:

R = (VS - VL) /I

Vs = Supply voltage

V_L = LED voltage (about 2.3V)

I = LED current (e.g. 3mA), this must be less than the maximum permitted current.

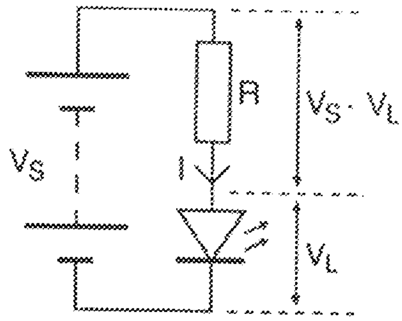


Fig 3.3 the power indicator circuit

If the calculated value is not available, the nearest standard resistor value which is greater is chosen, so that the current will be a little less than the maximum value [12, 13]. The resistor allows a suitable voltage of about 2.7V to be supply across the LED.

3.1.2 The power indicator current

A 5v power supply is expected across the entire circuit. Assuming a typical current of 3mA in such a circuit;

Therefore $R_1 = (5V - 2.3V)/(3x\ 10^{-3})\Omega$

$= 900\Omega$

$1k\Omega$ is used in the circuit for practical allowance.

3.2 The input unit

This project offers a way to control up to four latching switches with three claps of your hand. These switches may be used to control lights or fans – or anything else that does not produce too loud a sound. To prevent an occasional loud sound from causing malfunction, the circuit is normally quiescent. The first clap takes it out of standby state and the third effects the definite state change.

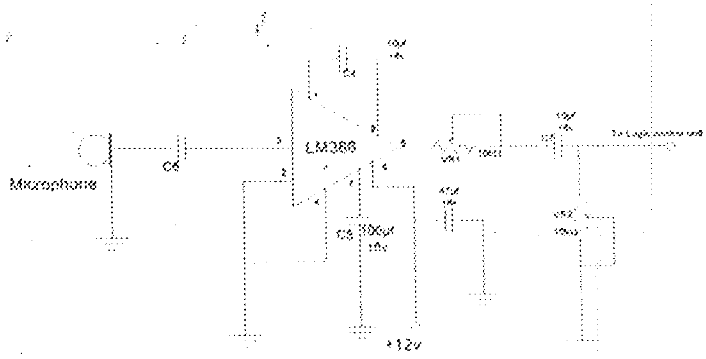


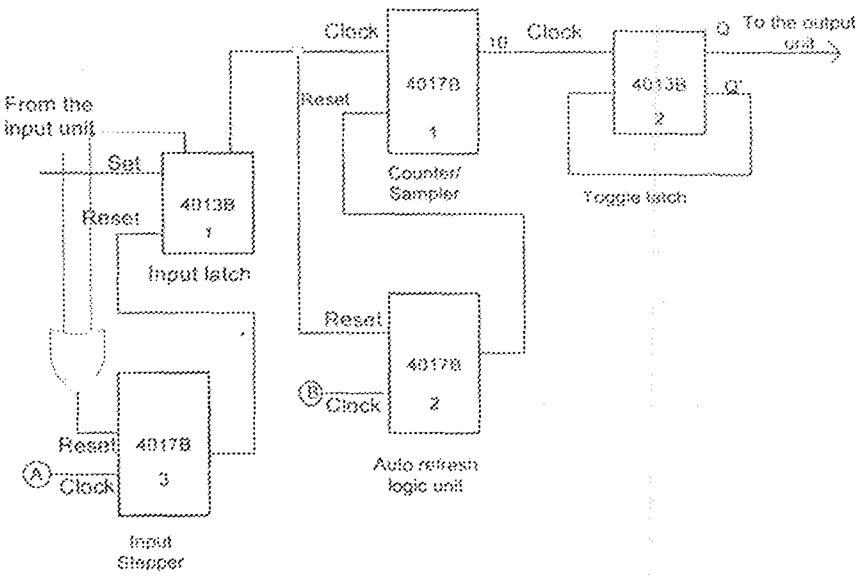
Fig 3.4 Input unit of the clap-activated switch

The microphone converts the involved sound to electric energy. The corresponding electric current is quite weak but it is amplified by the LM 386 amplifier. Based on data sheet of the device, the gain of such a configuration having a 10μf 16Vcapacitor across Pins 1 and 8 is 200 [6]. Therefore, any signal from the microphone results in 200 times its strength at Pin 5. Designing a circuit for the required gain is achievable if noise is minimized or prevented. An electrical current is not a smooth continuous flow. It is made up of individual electrons and even when there is no net current in a particular direction, say in a resistor, the electrons are in a continuous state of agitation. Their random movements remain stationary and equivalent to tiny random currents which give rise to small voltages across the resistor. It is such a moderate effect but can be heard as a HISSING sound after 3 or 4 stages in the circuit [3]. Some noise is picked up from external electrical components as well. The condenser microphone usually available in the market has two terminals and it has to be supplied with power for it to function. Any interference on this supply line will be passed on to the output. So the supply for the microphone is smoothed by resistor-capacitor combination of R2, C1 and fed to it via resistor R1. Of these two terminals, one is connected to its body. This terminal has to be connected to circuit ground, and the other to the junction of resistor R2 and capacitor C2. These wires are preferably kept short (one or two centimeters) to avoid noise pickup [14].

On other hand, Vr1, C7 and Vr2 are incorporated to filter and define the level of signal going to the logic control unit. The level must be at the edge of response, therefore it involves a careful and time consuming process to obtain the exact midpoint between the ON and OFF state.

3.3 The Logic Control Unit

The logic control unit is designed to co-ordinate the whole operation of the circuit. Its aim is to harmonize the operation of the input with the output so that they work in accord thereby yielding the target function or operation. The unit comprises of the two 4013B latches, three 4017B steppers and an oscillator (4060B).



3.5 The logic control unit showing only the important terminals.

Although, the 4060B is designed to generate ten frequency outputs, only two are incorporated into the design. They clock the operations of the 4017B stepper in the circuit. The two frequencies are generated from pins 1 and 3 of the 4060B.

3.3.1 The 4060B IC

The choice of the 4060B IC was due to

- Its ability to perform logic operations required by the circuit

- Its being a CMOS circuit, thus lower power consumption
- Its wide range of frequencies within which it can function.

The 555 timer, its close alternative, was not adopted due to the following reasons

- It usually requires a specific pulse time duration
- It operates with a specific operation frequency
- It usually requires a specific duty-cycle

The 4060B integrated circuit is designed to generate ten different frequencies. It can be configured in both RC and crystal oscillator modes. It passes an active low reset/enabling input (PIN 12) for activating or deactivating the altogether integrated circuit. The frequency outputs from the device result from the 14-stage internal division of a main frequency. All the outputs are buffered to allow wide out drive [12, 15].

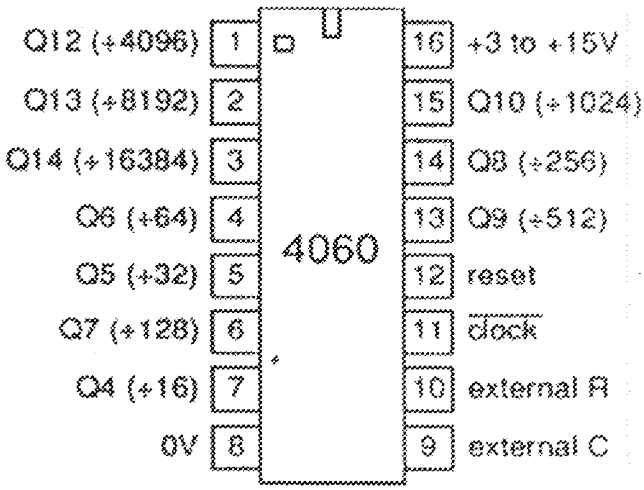


Fig 3.6 4060B 14-bit (÷16,384) ripple counter with internal oscillator

The frequency output from a particular output pin is based on its Q number: involved.

The formula is given below;

$F_{pinx} = F_m / 2x$

For instance assuming F_m =256Hz, the frequency input from pin 3(while x =14) is given below:-

Fpin3 = 256 / 2^14 =0.0156Hz.The information is from the data sheet of the integrated circuit

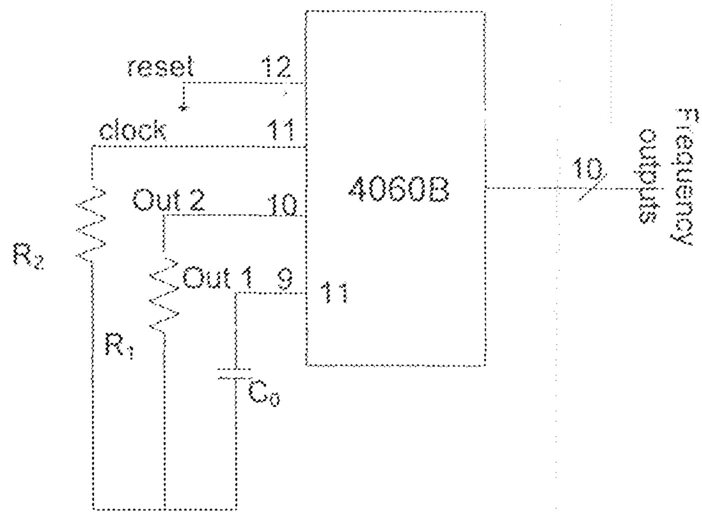


Fig 3.7 functional diagram of 4060B

The data sheet of the integrated circuit also provides:-

$F_m = f / 2.3RC$

While R=33kΩ and C=0.001uf. They are typical valves for the RC configuration of the 4060B

Therefore = $F_m = 1/2.3x33x10^3 x0.001x10^{-6} = 13.2KH_z$

Therefore, $F_{pin3} = F_m / 2^{14} = 13.2x10^3/2^{14} = 0.806Hz$

For terminal (B) = $F_{pin3} = 0.806Hz$ $T_{pin3} = 1/0.806 = 1.155$ Secs

For terminal (A) $F_{pin1} = F_m / 2^{12} = 13.2x10^3/2^{12} = 3.22Hz$ $T_{pin1} = 1/3.22 = 0.31$ Secs

The oscillator is the heart of the circuit. It provides the necessary timing technique for the execution of the logic duty.

3.3.2 The 4017B IC

The 4017B IC is a 5-stage Johnson counter with ten decoded outputs. Its close alternative, the 4022BC was not employed since it is able to produce just 8-decoded outputs.

The 4017B has three control inputs; CLOCK, CLOCK ENABLE, and RESET. Also, there is a carry out terminal (Pin 12) for the purpose of cascading. The output responds to positive-going trigger or pulse. Whenever the reset input is at a high logical level, the outputs are clear. The IC is functional when the clock enable terminal is low thus the input is active low.

3.3.3 The 4013B IC

The 4013B and the 4027B are similar and perform basically the same function but due to the relative scarcity of the latter, the use of 4013B was employed.

The 4013B is a dual D-type flip flop integrated circuit with SET and RESET functions i.e. the IC holds two independent flip flops. The logical level of data of each flip-flop is transferred into the Q output whenever there is a positive trigger at the clock input. The other functions are indicated in the devices truth table. The device is mostly used for logic control applications

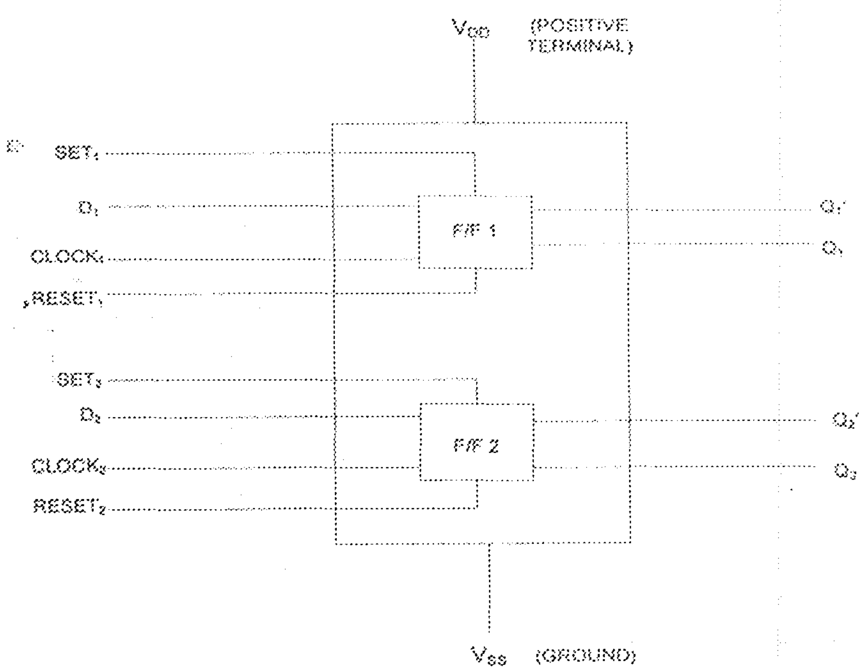


Fig 3.8 functional diagram of 4013B

4013B-1 (input latch) receives a high logical level from the input unit whenever a loud sound is applied to the microphone. This sound resulting from the hand clap causes the latch to respond with its Q output changing from logic 1 to 0 and Q (bar) doing the opposite. The Q output clocks 4017B-1 by incrementing its step by one. Pin 3 of 4017B-2 goes low from its high state while pin2 acquires a high logical level. 4017B-3 is disabled at that moment through a high logical level from the set input of 4013B-1 through OR-gate 1. 4017B-2 is disabled at the same time as 4017B-3. Three pulses or high level signal must be sent from the input unit within a given time interval before 4017B-2 is triggered to reset the summer/sampler.

Set	Reset	Q	$\bar{Q}$
0	1	0	1
1	0	1	0
1	1	1	1

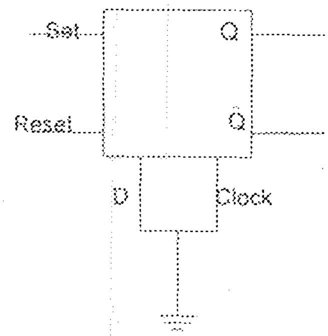


Fig 3.9 truth table and SR configuration of 4013B flip-flop

Whenever the three signals gets to 4017B, its pin 10 goes to a high logical level in order to clock the toggle latch. The logical level of the toggle latch's Q output interchanges in response to the input i.e. from logic 1 to 0 or logic 0 to 1. Another set of 3-pulse signal is required to interchange the earlier state.

The time at which the three wanted signals must to be sent is the period of F_{pin3}, which is 1.155 seconds. This is a mere theoretical value, the practical or real time is approximately 4seconds. The time that must be between the signals is the period of F_{pin1}, which is 0.31 seconds. This is also a mere theoretical value, the practical or real time is approximately 1.5seconds.

4017B-3 is aimed at resetting the output (4013B-1) at a particular time so as cut multiple input responses, thereby functioning as a timer as well. It responds to signals from the input unit. The logic device co-relates the responses of 4013B-1 to the signal level from the input unit.

4013B-2 is designed to refresh or reset 4017B-1. The resetting operation allows a fresh counting or sampling of the input signals. It uses the pulse pin 3 of the oscillator to perform its time-based duty.

4013B-1 is incorporated into the design to sample and count the number of pulses coming out of the input unit through hand claps. 4017B-2 controls 4017B-1 at the reset terminal.

The toggle latch is used for 2-way switching of the output unit or load. It receives command from pin 10 of 4017B-1.

3.4 The Output Unit

The output unit is designed to respond to control signals or logic levels from the logic control unit. It comprises of an NPN transistor – 12v relay configuration.

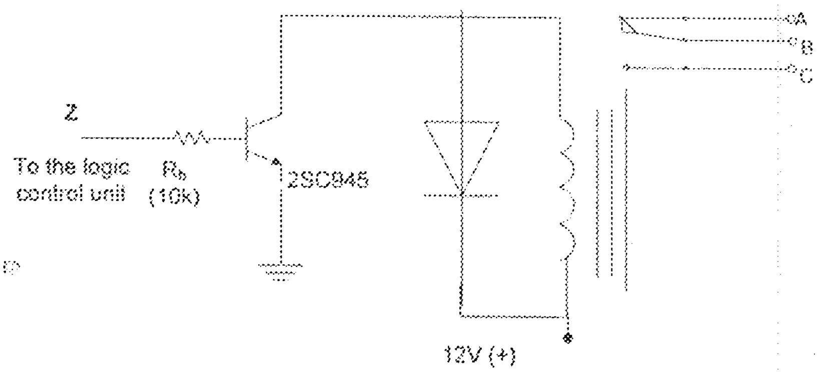


Fig 3.9 the output unit

The unit is designed to switch ON and OFF a particular load below the power rating of the relay. This is in response to signals from the logic control unit through the toggle latch or flip-flop. The NPN transistor (2SC945) switches on the relay by applying a voltage across it whenever Z is at a high logical level. The situation is reversed whenever the transistor receives a low logical level.

The typical hfe of the transistor is 100. The resistance of the load coil of the collector of the transistor is 400Ω.

The collector's current is expected to be: -

$I_C = 12V / 400\Omega$

$= 0.03A = 30mA$

So that,

$I_B = I_C / hfe = 30mA / 100$

$= 0.3mA$

The base-emitter junction of a silicon transistor is assumed to have a voltage of 0.7V. In an NPN transistor, base is 0.7V higher than the emitter terminal [12, 16]

Therefore base resistance is given by:

R_B = (change in V_{BE}) / (change in I_B)

= (5 – 0.7) / 0.3mA

= 14.33kΩ

OR Using

$V_{IN} = V_{BE} + I_B R_B$

5V = 0.7V + (0.3mA)R_B

R_B = (5 – 0.7) / 0.3mA = 14.33kΩ

10kΩ is used instead because of the drop in voltage at the toggle output is not considered in the calculation above.

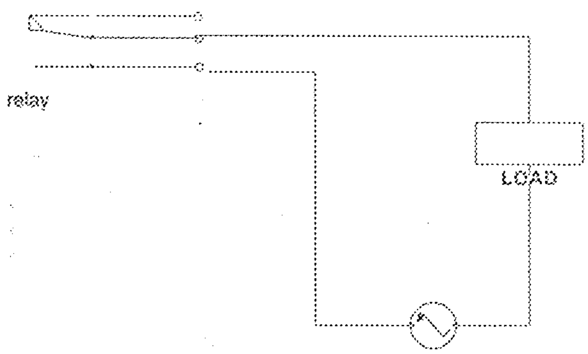


Fig 3.10 Normal output configuration of a relay

The above diagram shows a simple way of connecting the relay for switching application. The device's response to a well-timed three-clap pattern is to switch the load OFF and ON.

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions [12]. Relays allow one circuit to switch a second circuit which can be completely separate from the first. There is no electrical connection inside the relay between the two circuits the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay as seen in the one the circuit uses. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil.

3.4.1 Protection diode

Transistors and ICs (chips) must be protected from the brief high voltage 'spike' produced when the relay coil is switched off. The diode is connected 'backwards' so that it will normally not conduct. Conduction only occurs when the relay coil is switched off, at this moment current tries to continue flowing through the coil and it is harmlessly diverted through the diode. Without the diode no current could flow and the coil would produce a damaging high voltage 'spike' in its attempt to keep the current flowing.

3.4.2 Comparing the relay and transistor

Like relays, transistor can be used as an electrically operated switch. For switching small DC currents (< 1A) at low voltage they are usually a better choice than a relay. However transistors cannot switch AC or high voltages (such as mains electricity) and they are not usually a good choice for switching large currents (> 5A). In these cases a relay will be needed, but a low power transistor may still be needed to switch the current for the relay's coil.

In the circuit, the relay has been used instead of the transistor for the following reasons

- Relays can switch AC and DC, transistors can only switch DC.
- Relays can switch high voltages, transistors cannot.
- Relays are a better choice for switching large currents (> 5A).
- Relays can switch more than one contact at once.

Also, the transistor has been used instead of the relay for the following reasons

- Relays are bulkier than transistors for switching small currents.

- Relays cannot switch rapidly (except reed relays), transistors can switch many times per second.
- Relays use more power due to the current flowing through their coil.

Relays require more power than many chips can provide, so a low power transistor may be needed to switch the current for the relay's coil [12, 13].

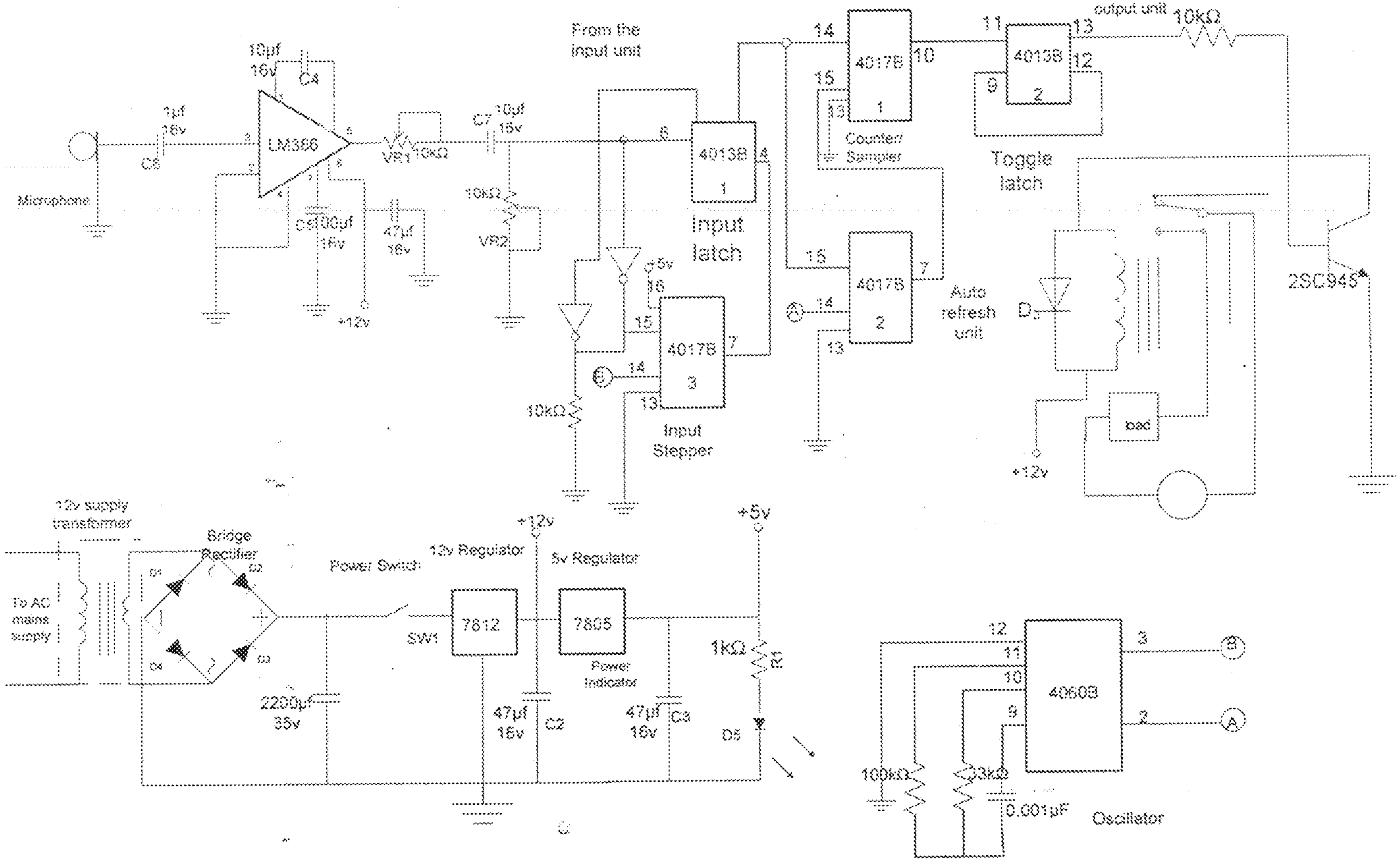
3.5 Circuit operation

The input signal from a microphone connected to the input of the LM386 amplifier through a coupling capacitor, has a gain of 200. This amplified signal is fed to an RC filter to remove pulsations due to noise or any other form of interference. An input latch holds the logical level of the register high in the presence of a high current input at Q. This circuit was designed to respond only to three hand claps which occur in (relatively) quick succession, and to ignore one hand clap or even continuous clapping, as well as most other sounds which normally have lower frequency contents than a hand clap. The signal further moves on to the logic control unit which removes error due to multiple input as a result of the un-uniform nature of the signal which is passed on by the amplifier.

A sampler recognizes the three useful inputs which the circuit was designed to respond to. An automatic logic refresh unit provides a timing sequence for the sample. The time-based control automatically resets the sampler for a fresh input. This sampler triggers on a toggle latch for the circuit's output control.

The toggle latch responds to the sample interchangeably through logic levels 1 and 0. These logic levels operate a relay switch which controls the flow of electric current to the desired load.

3.5 Circuit Diagram of the clap-activated switch



Chapter four

Construction, Test and Results

4.1 Circuit Construction

The clap-activated switch was constructed in accordance with the circuit designed as illustrated Figure 3.11. The design was simulated on electronics work bench [11]. The testing followed the modular pattern used in the design with each functional block being tested as described as follows.

Employing a bottom-up approach, the first step was to section the complete circuit into several sub-units after which each unit was treated separately i.e. the power unit was first constructed and powered up. Subsequent stages such as the input unit, logic control unit and the output unit were tested at the completion of each stage to ensure there was an output before proceeding to the next.

At the input stage, the amplifier was tested for the output voltage level, using the digital meter. It was coupled to the speaker via a 47μF, 16V capacitor.

The entire circuit was tested for short circuit and open circuit faults that could result into problems. The following items were involved during the major construction:

1. Soldering iron
2. Soldering lead
3. Connecting wires
4. Glue
5. Vero board
6. Pliers
7. Scissors
8. Cutting knife
9. File

10. Lead sucker (desoldering pump)

4.1.1 Casing Construction

The use of plastic material for the circuit was borne out of the need for safety, durability and aesthetics. The casing comprised of a plastic platform on which the microphone was mounted with the switch attached to it. This casing houses the internal circuitry of the switching device. The size of the casing was chosen putting into consideration the size and the number of components involved. Necessary holes for the switch, power unit light indicator, and the device's light indicator were bored on the complete casing.

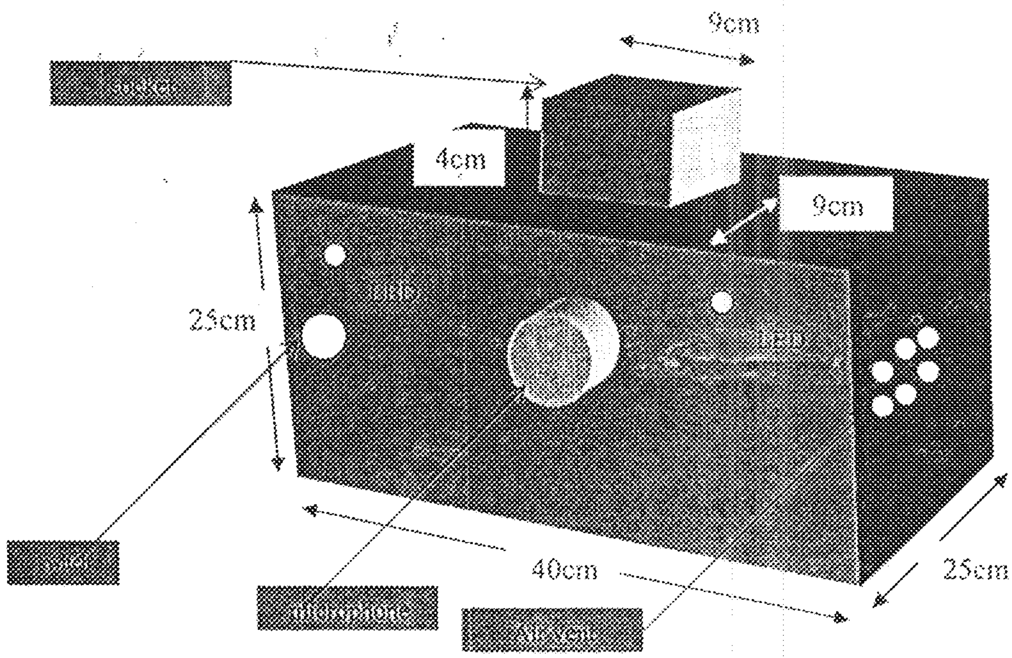


Fig 4.1 cased model of the clap-activated switch

4.2 Tests and Results

The following results were obtained for distances at which the switch was triggered. When the microphone was also tapped the circuit was triggered. The testing of the complete circuit was quite direct. Before anything, the circuit was checked for short circuit or any form of

Chapter Five
Conclusion

5.1 Summary

A simple clap-activated switch has been designed, constructed and tested. It is suitable for homes, hospitals, alarm systems, control of devices which do not produce too loud a sound. This circuit has been designed to make life easy, no need to bend down to turn on awkwardly positioned switches, just clap your hands and the controlled appliance will be turned on for you.

The major objective of the project revolves around providing a simple and cost-effective means of controlling the operation of suitably rated load in the home. This was achieved in the course of this project.

5.2 Problems Encountered

Setting the sensitivity of the device was very difficult since the exact value had to be set manually by varying the variable resistor. In practice, the "exact value" actually lies within a range of values separated by a *forbidden region [19]*.

The model had to be tested far away from devices that generate sound as it would affect the operation of the circuit. The noise in the model circuit was at a harmful level so this was rectified by adding variable resistors to the output of the signal amplifier.

5.3 Recommendations

Like every other work, this work is not without its limitations and can be improved upon. On this basis recommendations have been made for improvement.

References

[1] Paul E. Gray and Campbell L. Searle, Electronic Principles, physics, models and circuits, John Wiley and Sons Inc., New York, 1969. pp 245-247

[2] Eugene C. Lister, Electric Circuits and machines, fifth Edition, McGraw Hill, New York, 1960. pp 369-381

[3] M. G. Scroggie, Foundation of Wireless Communication and Electronics, tenth Edition, 1975. pp 354-356

[4] Ralph J. Smith and Richard C. Dorf, Circuits, devices and Systems, fifth Edition, Wiley and Sons Inc., New York, 1966. pp 385-399

[5] V. K. Mehta and Shalu Mehta, Principles of Electronics, S. Chand & Company LTD, New Delhi, 2003.

[6] http://en.wikipedia.org/wiki/switch. Wikipedia, The free Encyclopaedia

[7] microsoft®Encarta®2006©1993-2005. Microsoft Corporation

[8] http://www.pbs.org/tesla/

[9] Keith Gibbs, Advanced Physics, second edition, Cambridge University Press 1988. pp368-395

[10] Malcolm Plant, Basic Electronics Transistors in circuit, Transistors in action post transistion project, Hodder and Stoughton Schools Council, 1976. pp156-178.

[11] www.vinode.150m.com

[12] http://www.kpsec.freeuk.com/ohmslaw

[13] www.rapidonline.com

[14] www.electronicsforu.com

[15] Walter J Jang, IC timer cook book, Howard w. Sans & Co. Inc.,

[16] B.L. Theraja, A.K. Theraja, A textbook of electrical technology twenty second edition S.Chand & Co. Ltd. pp 1760-1762

[17] Tolcheum Roger L., Digital Electronics Principles and Application, Fifth edition,

[18] Paul Horowitz, The art of electronics, Second edition, Winfield hill. Pp55-58

[19] D.C. Green, Transmission systems, Second edition, Great Britain. 1982 pp399

[20] http://www.howstuffworks.com

[21] National Semiconductor Company, "Datasheet on LM386 low signal audio amplifier", Available at: http://www.national.com, 2000.

[22] Fair Child Semiconductor Company, "Datasheet on CD4013B Dual D-Type Flip-flop", revised Ed., Available at: http://www.fairchildsemi.com, 2002.

[23] Warnes L., Electronics and Electrical Engineering: principles and practice, 2nd Ed., Macmillan Press Ltd. London, pp. 136-157, 1998.

[24] Fair Child Semiconductor Company, "Datasheet on CD4060B 14 stage ripple carry binary counter", revised Ed., Available at: http://www.fairchildsemi.com, 2004.

Appendix1: