DESIGN AND CONSTRUCTION

OF A

NOISE BASED SWITCHING SYSTEM

BY

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DEDICATION

Dedicated to my beloved parents:

Mr. HAMMA M. ISSA and Mme nee HAOUA ABARCHI with humble love and respect.

May good fortune find your doorway, bringing you good health and happy things.

Declaration

I hereby declared that Hamma Ousmane carried out this work. It has never been presented elsewhere for the award of degree or diploma. This project work is based on information obtained from people of relevant experience in the field, from records and texts, all of which were acknowledged.

Signature:..........................

Date: 17-10-2003

CERTIFICATION

This is to certify that Hamma Ousmane carried out the project presented in this report under my supervision.

.... 20/4/04 ....

Signature of H.O.D Date

Eng. M. N. Nwohu

.... 28/10/03 ....

Signature of project supervisor Date

Eng. M. D. Abdullahi

....

Signature of external examiner Date

....

Signature of student Date

Hamma Ousmane

ACKNOWLEDGEMENTS

I sincerely express my profound gratitude and appreciation to my parents.

I am highly indebtedness to my immediate parents (father and mother) pere Hamma and mere Haoua, my entire family the Hamma's, Sal-ha, Fatima, Ramatou, Nouhou, Moussa, Aichatou.

My votes of thanks also go to my project supervisor Eng M. D. ABDULAHI, my friends and colleagues for their contribution, impacts and helps from one way or the other during the duration of my course of study and my project.

ABSTRACT

Over the years the use of a switching system has become widespread in industrial, commercial and private establishments. Its design and construction has also increased in sophistication and style.

This project work is based on the use of a transducer (electret microphone) whose input is converted into electrical signals. The output is the processed.

The processing of the output signals, which form the command unit, is made up of an input unit, an amplification unit, a comparator, a delay unit, a memory and then a protective and power unit.

The objective is to make it possible for the system to detect noise, and trigger the power unit to act like a single-pole single-throw (SPST) switch to be ON or OFF accordingly.

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CHAPTER ONE

1.0 INTRODUCTION

Engineering is to make life easier for mankind.

The advance in technology has reached the extent that engineers are making machines to obey human being.

An attempt to this is the design and construction of a noised based switching system.

In fact any noise perceived by a transducer is converted into signals capable of triggering a circuitry unit to allow the flow of current to a load connected to the output.

The input signal analogue in nature could be any perceptible noise or sound such as voice, steps movement, snap of fingers to mention only a few.

It is converted into electrical signal using a transducer, amplified, then compared with a desired level using a variable resistor.

To avoid any interference of foreign noise, which may trigger the circuit ON and OFF a delay unit allow the timing of the triggering effect. Then is followed a memory unit where the signal is memorized until a new one is applied.

The whole circuitry is protected against high voltage effect using an opto-isolator as it can be seen in figure 1.0.

A section with a.c. in to supply the circuit and the load constitutes the power unit.

The apparatus can be used for any a.c. application, which can operate on 220V/50HZ.

1.1 LITERATURE REVIEW

Man' s understanding of the physics of acoustics and his ability to use this knowledge to invent and develop useful mechanism has not evolved at a steady rate. Since prehistoric times man has relied on his five senses to keep him informed about his surroundings.

Of the five senses hearing was a relatively late arrival in the evolutionary process but has perhaps became the busiest.

Our sense of hearing seems always to be at work, and it has certainly evolved as a uniquely and finest tuned mechanism, which we are only now beginning to understand properly.

It is therefore hardly surprising that the sense of hearing and the nature of sounds that surround us, have interested scientists since the earliest times.

The term noise refers to a spurious signal generated in a system by any of the variety of environmental causes.

Sound, noise both means a sensation or effect produced by the stimulation of auditory receptors of the ear and the auditory center of the brain. Sound is in general applicable to anything that is heard.

Robert Boyle demonstrated in 1960 that sound needs a medium such as air through which it vibration can travel.

He hang a ringing alarm watch inside a glass jar and when most of the air had been pumped out of the jar the ringing become inaudible.

Other substances can transmit sound even more efficiently and faster than air notably water and metal.

As earlier as the middle of seventeenth century the French mathematician Mersenne measured the time it took for sound to reflect over a known distance and thus calculated the speed of sound as 450m/s.

The design of a model of Noise Based Switching System was carried out based on the principle of analogue to digital conversion of any perceptible sound by a transducer into signal susceptible to trigger switching circuitry.

The simplest switching device is the switch itself.

A switch is any mechanical device by means of which two (or more) electrical conductors may be conveniently connected or disconnected.

The simplest form of switch consists of two strips of spring metal on which are mounted electrical contacts. A lever or push-button controls whether the switch is open (contact separated) or closed (contacts touching).

Switch circuit topology has changed little over the years, but the constant demand for better precision, high tolerance has obliged engineers to persevere with development if only to achieve incremental improvement in performance.

The need for fault tolerant switching has brought a major exception.

Successful design calls for an understanding of parasitic and non-ideal characteristics in the basic switch architecture. Models for the ON&OFF states of a switch let one study both its static and dynamic effects on a system.

Static (steady state) errors include ON & OFF capacitance, voltage swing limits, leakage current, transmission loss, and cross talk.

Dynamic effects include ON & OFF switching times, settling time propagation delay. The desired level control allows one to control the switch with an applied logic level. Applied to one input of the comparator this external level establishes an internal logic state (high or low) with respect to the reference voltage connected to the comparator input. The comparator output then drives the complementary circuit.

1.2 OBJCTIVES

The objective of this project is to design and construct an original product not expensive, easy to be used, reliable, and having no negative effect when being used. In the design some aspect have been taken into consideration such as the background in the field of electronics, the cost, the reliability, the security, and the ease of use.

Real world physical quantities such as noise from voice, sound are analogue in form. Even though an analogue signal represents a real physical parameter with accuracy it is difficult to process and reproduce the analogue signal without introducing considerable errors due to superimposition of noise.
Therefore it is convenient to express it in digital form.
The conversion range from a fairly small noise from snaps of ones fingers to a bomb explosion sound brings out the need of sensitivity control to avoid interference of undesired noise.

In a nutshell the system is a sound controlled switch; when the microphone which sensibility is adjustable by a potentiometer receives a sensory excitation it is converted into electrical signals.

The signals are amplified using operational amplifiers (op.amp), compared with a reference voltage by means of a comparator and then it activates the next stage.

The later can be triggered ON or OFF when one snaps fingers within a well define period by a timer, then a flip-flop memorizes the signal instantaneously until a new one is applied.

The output of the memory unit is applied to a protective and power unit which is the interface between the command and the load, which depending on the situation switches the load ON or OFF as it can be seen in figure 1.0

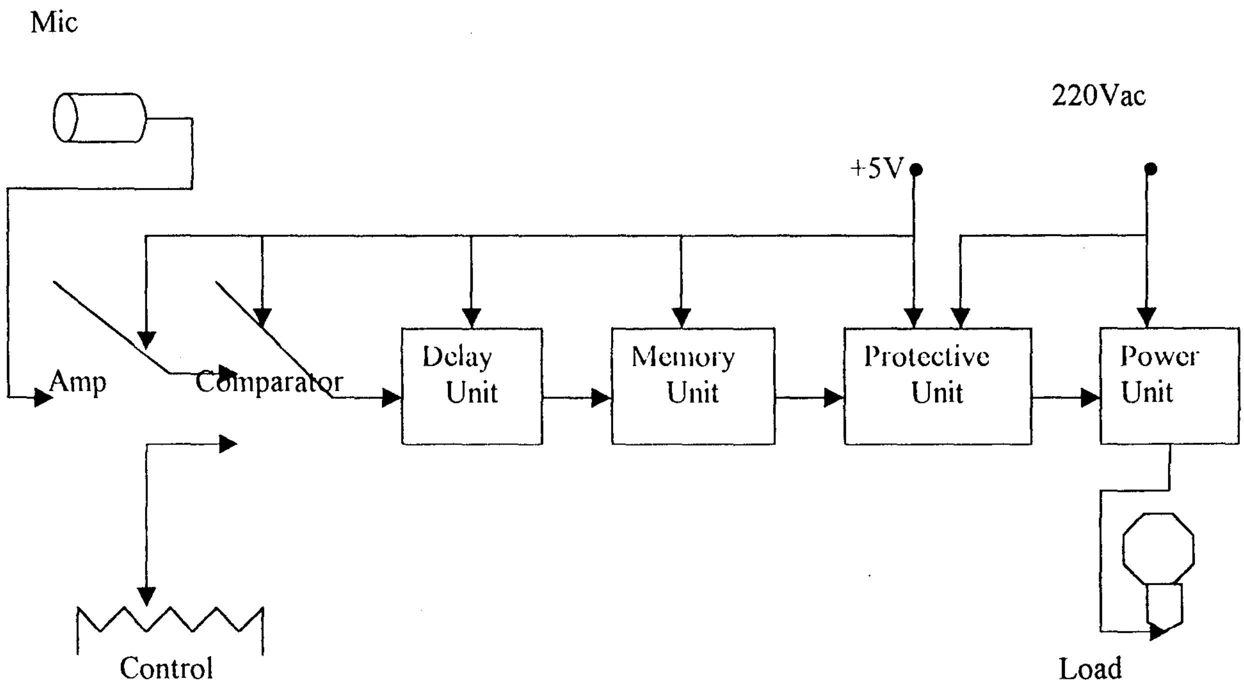


Figure 1.0: Block diagram

CHAPTER TWO

2.0 Introduction

For the ease of application and according to the block diagram of the figure 1.0, above, the components used can be classified into units.

The entire block is subdivided as follows:

1- the input unit,

2- the amplification unit,

3- the comparator unit,

4- the timing unit,

5- the memory unit, and

6- the power and protective unit.

2.1 Input unit

The major element of this unit is a transducer, here the microphone.

A basic electrical system needs a microphone to convert sound into electrical waveform, means for transmission, and reproduction of sound.

A microphone (mic) is a transducer that converts acoustical or mechanical energy into electrical energy. There are many types of mic, examples are:

- Carbon mic,
- Dynamic mic,
- Condenser mic,
- Electret mic.

The element in use for the purpose of the project is the electret mic. This uses a permanently polarized material (usually polytetrafluorethylen), which can be regarded as the electrostatic equivalent of the permanent magnet.

Contemporary electret mic may use either polarized diaphragm or neutral diaphragm with the fixed plate coated with electret material.

The latter arrangement avoids the problem that polarizing the diaphragm introduces a degree of compromise, a stable electret requiring a thick diaphragm while mechanical consideration demand a thin one made of selected material. As well as eliminating high D.C. Voltage supply. It can be very small and rugged.

2.2 Amplification unit

The signal is electrical quantity that is too small in its present form to be useable; it becomes usable because of the gain of the amplification.

Amplification is one of the most basic ideas in electronics. Amplifiers make signal levels greater; they must be provided two things:

i-D.C.power,

ii- input signal.

Gain is the basic function of all amplifiers. It is a comparison of the signal fed into the amp with the signal coming out of the amp.

Because of this gain we can expect the output to be greater than the input signal.

Any operational amplifier has two input terminals and one output terminal as shown in figure 2.1.0 below; it is also biased with both positive and negative voltage supply.

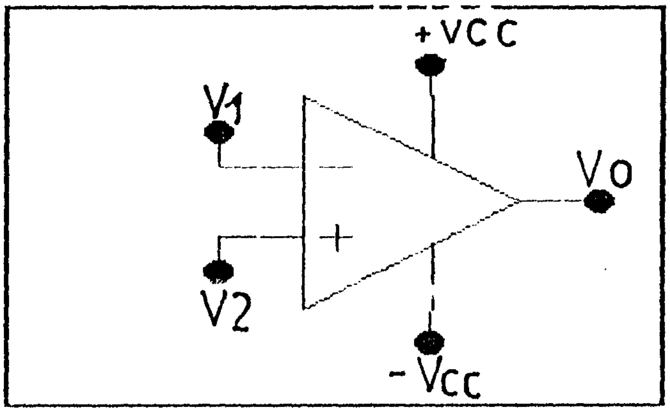


Fig.2.1.0 op-amp

The op-amp senses the difference between the two (2) input signals and amplifies this difference to produce an output signal.

Since ideal op-amp responds only to the difference between the two input signals V_1 and V_2 it maintains a zero output signal for:

$V_1 = V_2$.

There are many types of amplifiers (amp):

- Inverting amp,
- Non inverting amp,
- Differential amp,

To mention only a few.

For the purpose of the project an inverting amp is used, figure 2.1.1 shows a single stage-inverting amp with voltage gain defined as Av

$$Av = Vout/Vin \quad \text{----------------------------(1)}$$

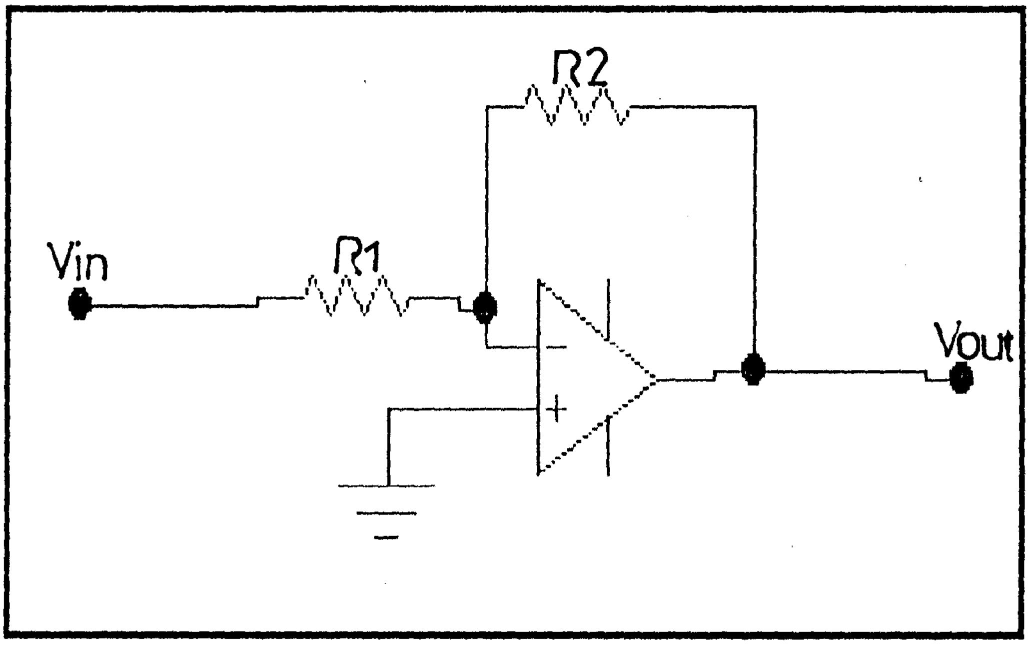


Fig 2.2.1 Single stage inverting amplifier.

The output voltage is given by:

$$Vout= Vin - i2R2 \text{ -----------------------------(2)}$$

Where i2 the current flowing through resistor R2.

The closed-loop voltage gain is:

$$A0 = Vout/Vin = -R2/R1 \text{ ---------------------(3)}$$

In order to obtain greater gain, amplifiers can be coupled in multistage configuration.

Coupling is the method used to transfer signal from one stage to next.

A two-stage amp is shown in figure 2.2.2 with overall gain being the product of the individual gain.

$$A_0 = A_{01} * A_{02} \quad \text{---(4)}$$

Which gives an output signal V_{Out},

$$V_{Out} = A_0 * V_{in}$$

$$V_{out} = (A_{01} * A_{02}) V_{in} \quad \text{----------------------(5)}$$

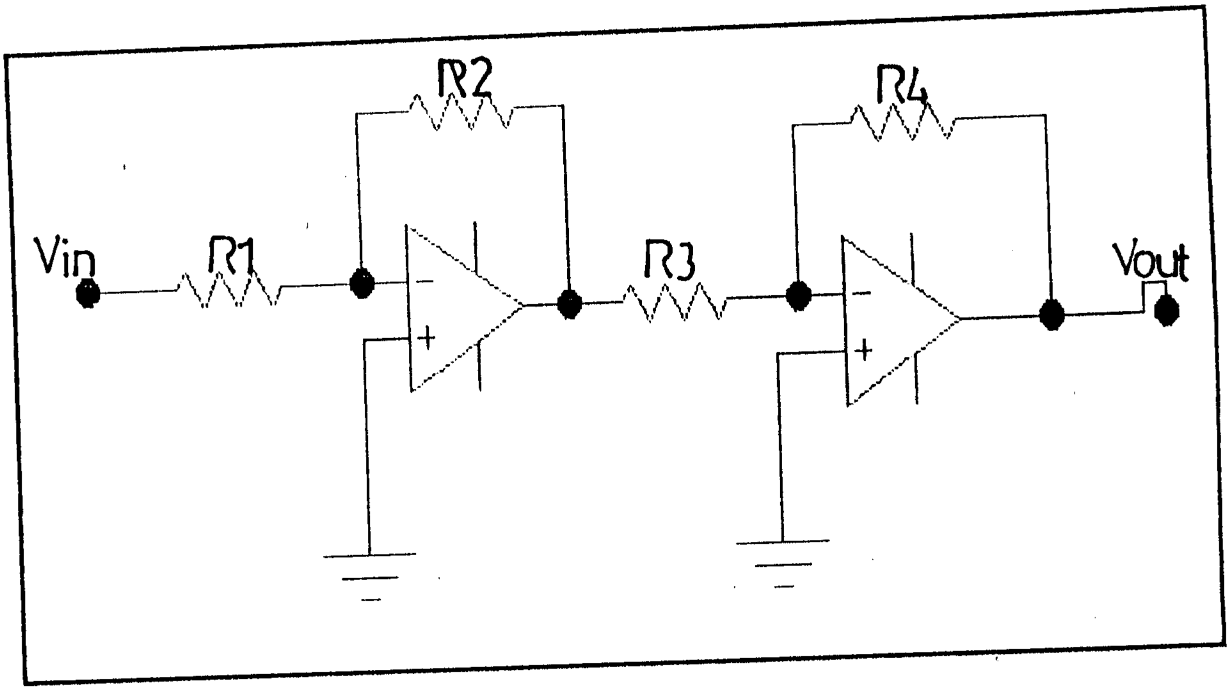


Fig: 2.2.2 two stages op.amp configuration

2.3 COMPARATOR

The comparator is essentially an op.amp operating in an open-loop configuration, as shown below.

As the name implies, a comparator compares two voltages to determine which is the larger .It is usually biased at voltages +Vcc and –Vcc, although other biases are possible.

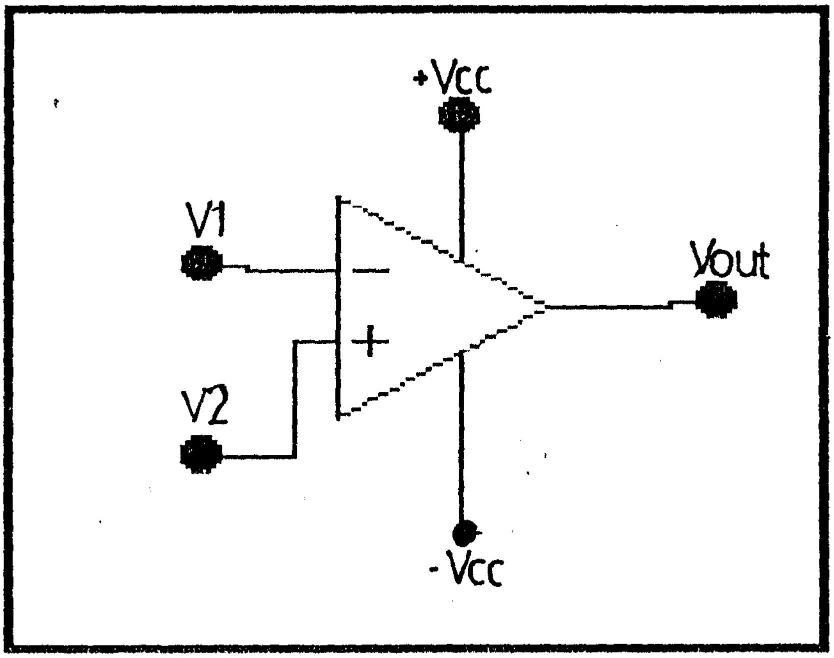


Fig: 2.3.0 (a) Open-loop comparator

When V2 is slightly higher than V1, the output is driven to a higher saturated state VH; when V2 is slightly less than V1 the output is driven to a low saturated state VL. The saturated output voltages VL and VH may be close to the supply voltages –Vcc and +Vcc respectively, which means that VL may be negative.

One major difference between a comparator and op.amp is that a comparator needs not be frequency compensated. Frequency stability is not a consideration since the comparator is being driven into one of the two states.

Since comparator does not contain frequency compensation capacitor, it is not slew rate limited by compensation capacitor as in the op.amp.

Typical response time for the comparator output to change states is in the range of 30 to 200 nanoseconds. Figure 2.3.1 shows two comparators configuration.

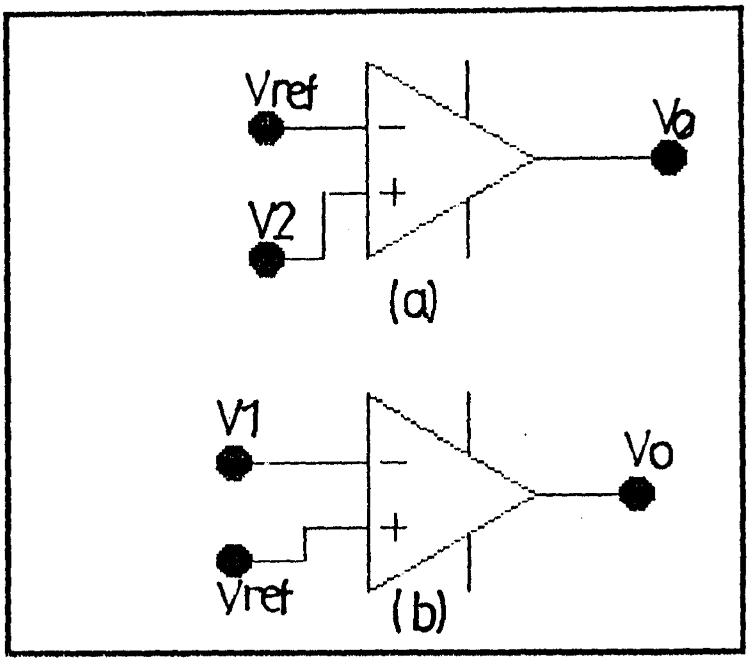


Fig: 2.3.1 (a) non inverting comparator and (b) inverting comparator

2.4 DELAY UNIT

Integrated time circuits represent one of the most interesting developments in integrated circuits (ic) design. The circuit consists of a number of high quality functional blocks that are combined in one ic but that are interconnected externally.

The 555 timer is the most common timer circuit in use; the circuit symbol is given below in figure 2.4.0.

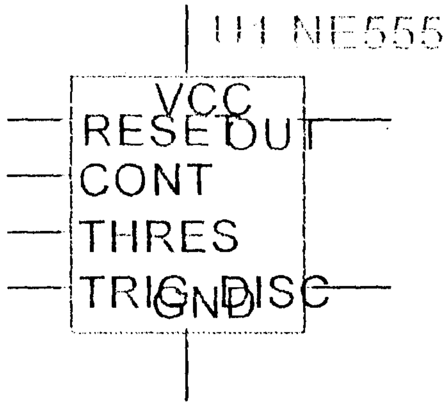


Fig: 2.4.0 timer symbol

However, since the components are not interconnected, they may be connected together to perform functions as monostable or astable multivibrator, linear voltage ramp generator, missing pulse detector, pulse width modulator.

To make the module more functional the 555 timer may be used with Vcc between +5 and +18 volts and the output can source or sink up to 200 milliamperes.

The timing circuit is a highly stable controller capable of producing accurate time delays or oscillations.

In the time delay mode of operation, one external resistor and capacitor precisely control the time. The circuit may be triggered and reset on falling waveforms and the main characteristics are stated as follows:

- Timing from microsecond to hour,
- Operates in both astable or monostable mode,
- Adjustable duty cycle,
- High current output can source or sink up to 200 mA,
- Output can drive M.T.T.L,
- Temperature stability of 0.005% per °C,
- Normally 'ON' or normally 'OFF' output.

The 555 timer provides stable time delays or free running oscillations.

This time delay is R-C controlled and is given for a monostable as

$$T = \ln 3\ (C_1 * R_1) = 1.1\ (C_1 * R_1) \quad \text{--------------------------(6)}$$

The major sections of a 555 timer ic:

1. Two voltage comparators
2. Bistable flip-flop,
3. Discharge transistor,
4. Resistor divider network,
5. Output amplifier (with up to 200mA current capability)

There are 3 divider resistors and each 15kΩ this divider network sets the threshold comparator trip point at 2/3 Vcc and the comparator at 1/3 Vcc.

Note that the output of the 555 timer is digital; it is either high or low. When it is high it is close to Vcc and when it is low it is near ground potential.

The control input pin 5 is not being used. This input is bypassed to ground to prevent erratic operation.

In order to make it functional as timing circuit it is to be designed as a monostable multivibrator as it can be seen in figure 3.3.0.

2.5 MEMORY UNIT

There are many types of storage or memory devices. In electronic sequential circuits or system the most common memory device is the Flip-Flop.

Flip- flop (or bistable multivibrator) is a switching circuit with two (2) stable states .The circuit can be triggered from either state to the other by applying an input voltage via a suitable trigger circuit; it thus can be used as a basic memory element for digital logic.

In the memorizing unit design the flip-flop parameters to be considered are:

1- The logic family being used,

Family	Designation	Propagation delay	F.F max. Frequency	Power consumption
Normal	74XX	9 nanoseconds	15MHZ	10 mW

2- The type of flip-flop needed,

3- The clocking type needed,

4- The signs of the data inputs needed,

5- How many auxiliary inputs are needed,

6- Timing constraint.

The drive used is the SN7476, and is a J-K flip-flop. The logic symbol for the commercial 7476 TTL J-K flip-flop is shown in figure 2.5.0(a) added to the symbol are two asynchronous inputs PRESET and CLEAR.

The synchronous inputs are the J and K data inputs .The customary normal (Q) and complementary ($\overline{Q}$) outputs are also shown. A detailed truth table for the commercial 7476 flip-flop is shown in figure 2.5.0(b).

Recall that asynchronous inputs override synchronous inputs. The asynchronous inputs are activated in the first three lines of the truth table. The synchronous inputs are irrelevant (overridden) in the first three lines. Therefore an "X" is placed under J-K and CLCK inputs for these rows. The prohibited state occurs when both asynchronous inputs are activated at the same time. This prohibited state is not useful and should be avoided. When both asynchronous inputs are disabled with 1 the synchronous input can be activated. The bottom 4 lines of the truth table detailed the HOLD, RESET, SET and the TOGGLE modes of operation for the 7476 J-K flip-flop.

Note that it uses the entire pulse to transfer data from the J and K data input to the Q and Q outputs.

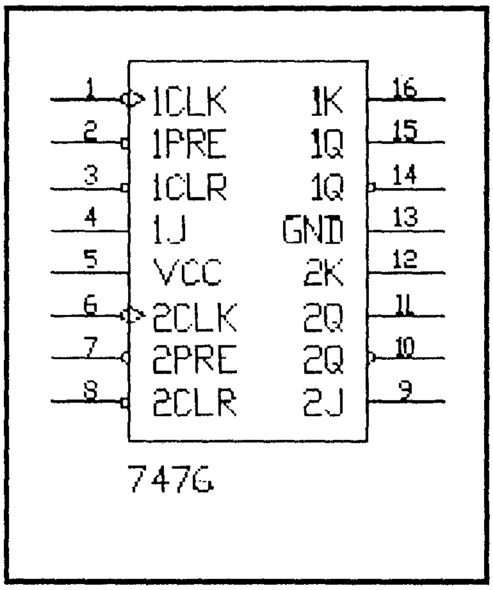


Fig: 2.5.0(a) flip-flop symbol

MODE OF OPERATION	INPUTS ASYNCHRONOUS		/SYNCHRONOUS			OUTPUTS	
	PS	CLR	/ CLCK	J	K	Q	$\bar{Q}$
Asynch. Set	0	1	X	X	X	1	0
Asynch. Reset	1	0	X	X	X	0	1
Prohibited	0	0	X	X	X	1	1
Hold	1	1	⎍	0	0	NO CHANGE	
Reset	1	1	⎍	0	1	0	1
Set	1	1	⎍	1	0	1	0
Toggle	1	1	⎍	1	1	OPPOSITE STATE	

Fig: 2.5.0(b) truth table

2.6 POWER AND PROTECTIVE UNIT

2.6.0 PROTECTIVE UNIT

The main element used is an opto-coupler.

The opto-coupler or opto-isolator is used primarily to provide isolation between the input and the output of a power supply, while at the same time providing a signal path for regulation control. The opto-coupler consists mainly of two elements:

i- the light source which can be an incandescent lamp or light emitting diode (LED),

ii- the detector, which could be a photovoltaic cell, photodiode, phototransistor or light sensitive semi conductor rectifier (S.C.R).

The only thing connecting the input circuit and the output circuit is light, so they are electrically isolated from each other. The circuit symbol is shown bellow.

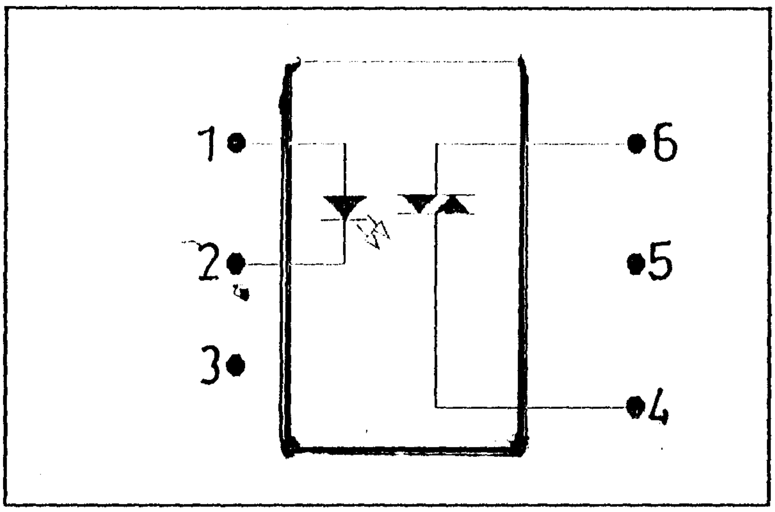


Fig: 2.6.0 circuit symbol of the opto-triac

The opto-triac provides a simple and electrically safe method of controlling d.c. and a.c. power equipment. The electrical isolation is the important factor.

Opto-isolators allow a.c-powered equipments to be controlled; they have a 400Volts rating suitable for direct main connection and a maximum current of 100mA. With high-powered loads the opto- triac may be used to provide the gate pulse to another triac via a current limiting resistor.

A brief pulse applied to the input terminal causes the opto-triac to be triggered. The triac then conduct until the end of the cycle of the mains at which point it automatically turns OFF or commutates. The triac is capable of conducting in both halves of the mains cycle.

To control the power supply to the a.c. load the opto-triac in a method known as integral cycle control involves turning the load "ON" and "OFF" for several complete cycles at a time as shown below.

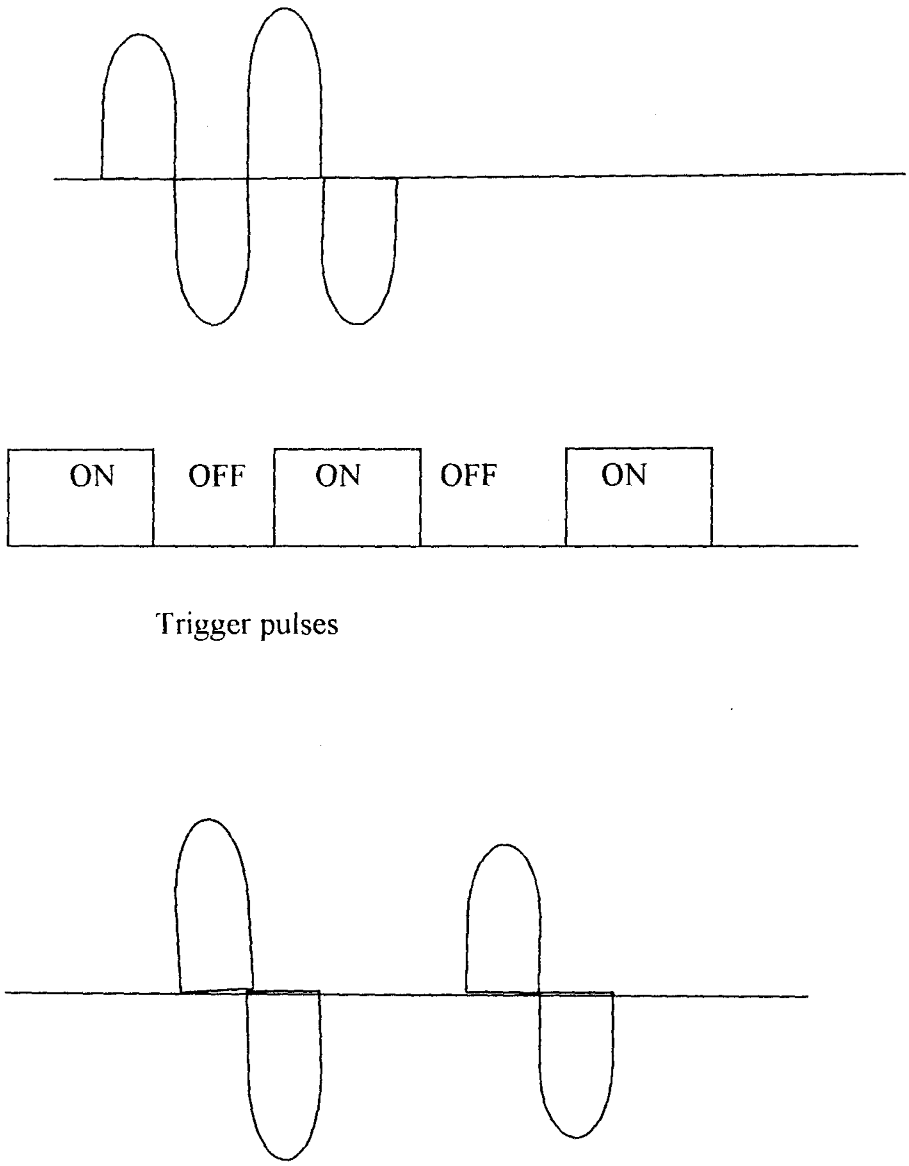


Fig: 2.6(b) integral cycle control waveforms

The power supplied is controlled by the ratio of cycles where the load is " ON" or " OFF".

2.6.1 POWER UNIT

The power unit consists mainly of a triac and a snubber network.

THE TRIAC

The triac may be considered as two-semiconductor rectifier (SCR) connected in inverse parallel. When one of the SCR is in its blocking mode the other will support the flow of current. Triacs are full-wave devices.

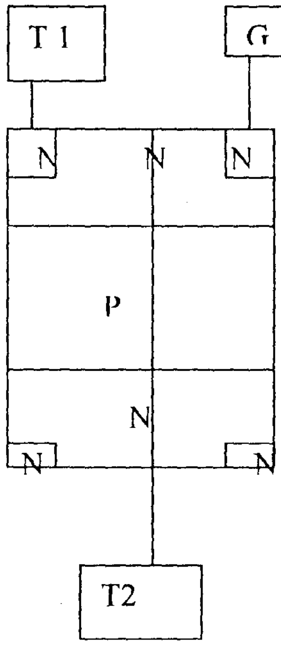
They are available with current rating up to about 40A and voltage ratings to about 600V.Triacs are more convenient for many low and medium power a.c. applications.

Figure (a) below shows that the three triac connections are called main terminal 1, main terminal 2, and the gate. The gate polarity usually is measured from gate to main terminal 1. A gate pulse that is either positive or negative with respect to main terminal 1 may trigger a triac. Also main terminal 2 can be either positive or negative with respect to main terminal 1 when triggering occurs.

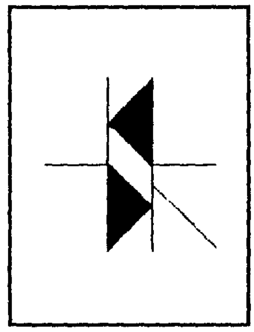
There are a total of four possible combinations of triggering modes for a triac. Table (b) summarizes the four modes for the triac triggering.

Note that mode 1is the most sensitive. Mode 1 compares with ordinary SCR triggering. The other three modes require more gate current.

Figure (c) shows the schematic symbol of a triac. The arrows show that the triac may is bi-directional (i.e. load current can flow in both direction). Triac are convenient for controlling or switching a.c. power.



(a) Structure of a triac



(C) Schematic symbol of a triac

Mode	Gate to terminal	Main terminal 2	Gate sensitivity
One	Positive	Positive	High
Two	Negative	Positive	Moderate
Three	Positive	Negative	Moderate
Four	Negative	Negative	Moderate

Table (b)

An R-C snubber network has been added, this network divert the charging current and help prevent unwanted turn ON. Triac gating circuit vary from application to application, it may simply be switched ON or OFF.

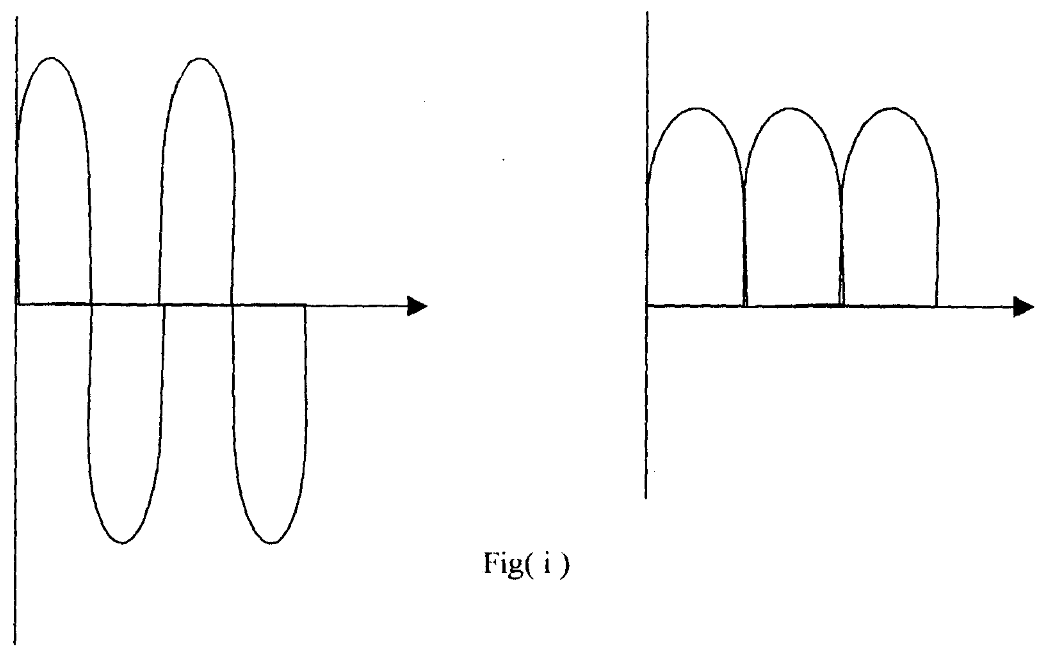
2.7 SUPLY UNIT

Electronics circuits need energy to work, in most cases this energy is provided by a circuit called the power supply. The supply is a key part of any electronic system because it energized the system, a failure in power supply will affect all the others circuits. Power supplies use rectifier diodes to convert a.c. to d.c.

1) BRIDGE RECTIFIER

A centered tapped transformer is necessary in this circuit to provide equal parts for the A.C. supply voltage through the secondary winding for diodes.

The process of deriving D.C. power from an A.C. source is called rectification. The power obtained from rectification is neat, cheap, and it provides and ensures continuous and regular supply of D.C. power. A.C. flows in both directions as shown in figure (i) below and D.C. flows in only one direction, since diodes conduct in only one direction they serve as rectifiers. The rectification circuit is depicted in figure (ii).



Fig(i)

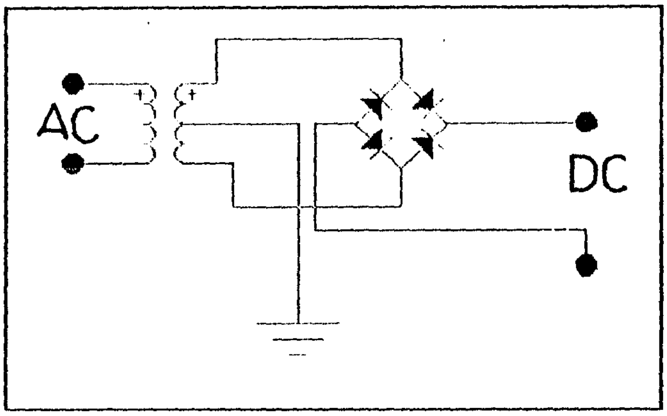


Fig: (ii) Bridge rectifier

2) SMOOTHING CIRCUIT

The output of a rectifier is not pure because it contains a.c. component. This a.c. component in a D.C. power supply is called ripple, something closer to pure d.c. is required. The circuit used to remove the ripple is called a filter; filter can produce a very smooth waveform.

The most common technique used for filtering is a capacitor connected across the output. The effectiveness of a capacitor filter is determined by three factors:

i. the size of the capacitor,

ii. the value of the load,

iii. the time between pulsations.

These 3 factors are related by the formula:

$$T = R*C \quad \text{-----------------------------(7)}$$

Where T is time in second (s)

R= resistance in Ohm (Ω)

C=capacitance in Farad (F)

The product RC is called the time constant of the circuit. A charged capacitor will lose 63.2% of its voltage in T seconds, it takes approximately 5*T seconds to completely discharge the capacitor.

The output waveform of the filter is shown in figure (iii).

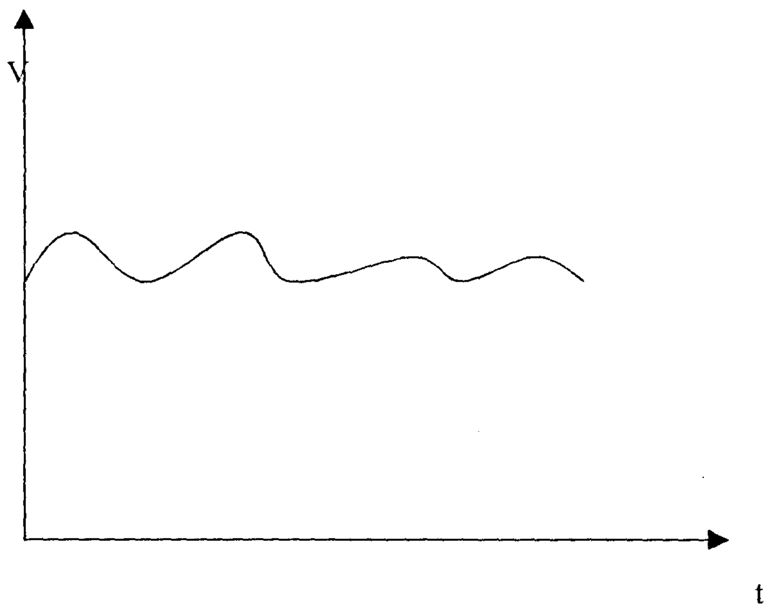


Fig (iii) output waveform of a filter.

A power supply filter reduces ripple to a low level. The actual effectiveness of the filter can be checked with measurement and then a simple calculation. The formula for calculating the percentage of ripple is:

$$Ripple = (a.c/d.c) * 100 \quad \text{------------------------}(8)$$

Ripple should be considered only when the supply is delivering its full rated output. At zero load current even a poor filter will reduce ripple to almost zero. One-way to get good filtering is to use large filter capacitor. This means that it will take longer for the capacitor to discharge. Electrolytic capacitors are available with very high value of capacitance.

3) REGULATION

Regulation is the most important power supply characteristics; it is the measure of supply's ability to maintain a constant output voltage. Regulation of a power supply is also its ability to hold the output steady under condition of changing input or changing load. As power supply is loaded the output voltage tends to drop to a lower value, the quality of the voltage regulation can be checked with the measurement and then a simple calculation.

The formula for calculating the percentage of voltage regulation is:

$$Regulation = (\Delta V/V_{FL})*100$$

Where ΔV= voltage change from no load to full load,

V_{FL} = output voltage at full load.

Fixed regulators in IC form such as the 78 or 79 series can supply 1.5A.

The output of a voltage regulator is shown in figure (iv)

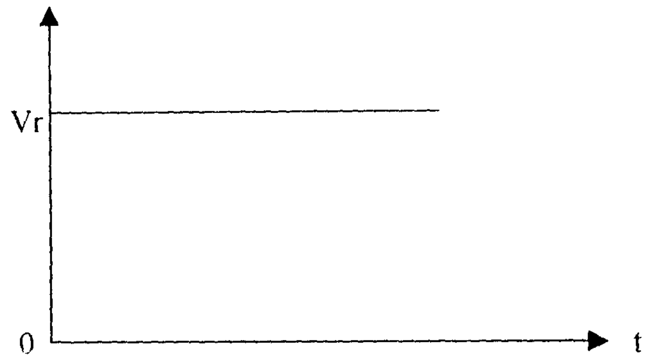


Fig (iv) Regulated output Vr

A capacitor can be used at the output of the regulator to improve the way the regulator responds to rapidly changing load current. The regulator ic operated at fixed output voltage.

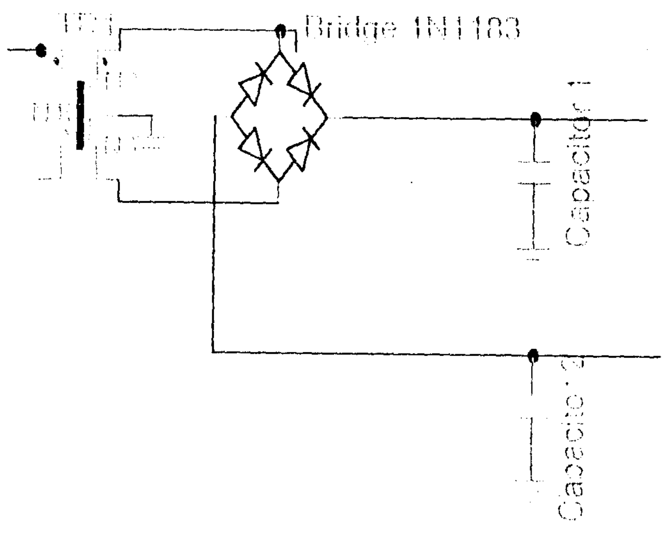


Fig (iii) filtering circuit

Chapter 3

SYSTEM DESIGN

3.0.0 Introduction

From the block diagram depicted in figure 1.0 the design procedure of the noise based switching system can be divided into stages.

This includes the design of:

1. The input unit
2. The amplification unit
3. The comparator unit
4. The time delay unit
5. The memory unit
6. The protective and power unit
7. And a suitable power supply unit

3.1 The input unit

The input unit is comprised of a transducer and a resistor –capacitor network (RC network) as shown in figure 3.0.0.

The transducer used is a microphone; the desirable features of any mic depend to some extent on the particular application for which it is intended.

Considering some characteristics, which distinguish one mic from another such as frequency response, sensitivity, directivity and requirements, which include availability, cost, size, weight, reliability and ease of use the electret mic selected.

The electret's type of mic is very small, rugged and eliminates the need of high dc voltage supply.

A condenser mic can also be used but with a polarizing resistor because it has to be polarized.

3.1.a THE RC NETWORK

Resistor R1 is used when a condenser mic is being used, when it is the electret type R1 is not necessary.

C1 is a coupling capacitor used to discard dc elements coming from R1 and M1 (mic), moreover it determines the frequency of the filter (high pass filter).

The suggested value for C1 is in the range of 10 nF to 1uF

i.e. 10nF < C < 1Uf

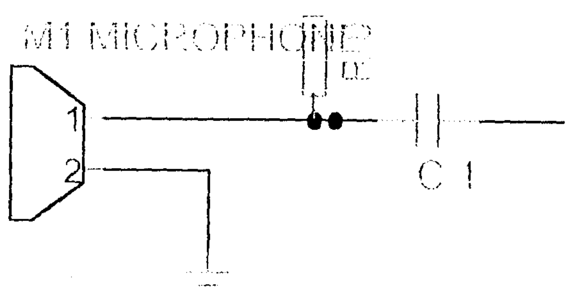


Figure 3.0.1 Input unit circuit diagrarn.

3.2 The amplification unit

A required design often starts with the need to amplify the level of a given signal while maintaining the form of the signal.

Amplification stage because the output of the mic is very small, in the order of few millivolts, for the electret mic the maximum output is about 5 mV. It has to be boosted to be usable.

The gain of an inverting amplification circuit as shown in figure 2.2.1 is function of the ratio R2/R1. Suppose that one desired R2/R1=10.There are many combinations of R2 and R1 that produce a ratio of 10, so how does one know which value to use?

The answer is that there is often a reasonable lea way on the part of the designer, and a number of different designs, all perfectly acceptable may be achieved.

The following general comments concerning the resistance ratio should be noted if a resistance level drops to low, the loading of the op. amplification and/or the source may become excessive and non-linear operation may result.

In contrast as the resistance level increases the thermal noise produced by the resistor increase, and dc offset due to bias current may pose potential difficulties.

While there are no optimum values for all case, a reasonable operating range of resistance for most operational amplification circuits in from around 1 KΩ to around 100KΩ or so with a large usage of resistance in the range of 10 to 100 KΩ.

However this is a rough guide rather than a restricting rule and many exceptions to the pattern will be found.

Considering two stages amplifier and a maximum input to be 5 mV, let the overall gain be about 150.

i.e. Ao =150.

Referring to equation (4):

$Ao = Ao1*Ao2$

With Ao = overall gain,

$Ao1$ = the 1st stage gain,

$Ao2$ = the 2nd stage gain.

Assuming $Ao1=10$

This desired gain is readily achieved by selecting $R3/R2=10$ and there many numbers of standard values in the given range that can achieve this ratio. For ease of computation let

$R2 = 3.3\ K\Omega$

$R3 = 10\ R2$

Thus $R3 = 10*3.3$

With $Ao=150$ and $Ao1=10$;

$Ao2=Ao/Ao1=150/10=15$

For the 2nd stage:

$Ao2 = R5/R4 = 15$

$R5 = 15R4$

Taking $R5 = R3 = 33K\Omega$

Viz $R4 = 33/15$

$R2=3.3K\Omega$

$R3=33\ K\Omega$

$R4=2.2K\Omega$

$R5=33K\Omega$

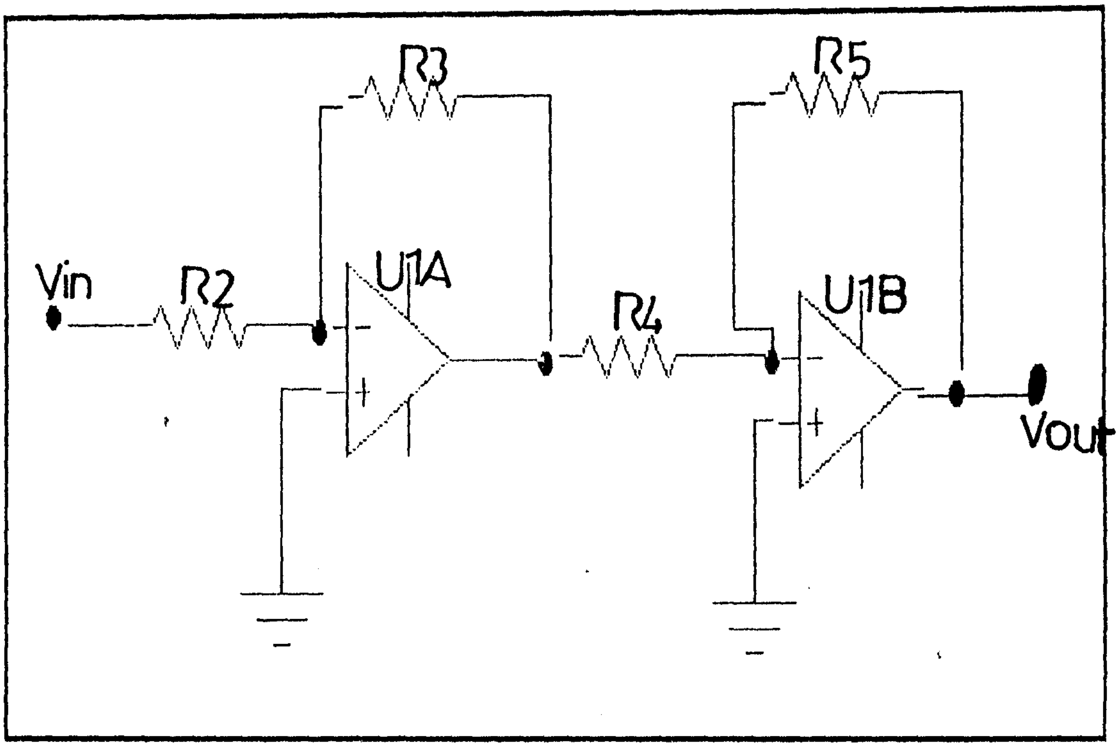


Fig: 3.1.0 amplifier circuit

3.3 Comparator

The best performance comparator functions are achieved with special IC chips designed and optimized for the comparator function. Here our focus is on utilizing general-purpose op.amp for comparator purposes.

A comparator is a circuit, which compares a signal voltage applied at one input of an op.amp. with a known reference voltage at the other input .It, is basically an open loop op.amp with output voltage Vsat.

Where Vsat = +Vcc or –Vcc.

A fixed reference voltage Vref is applied to the positive input and a varying signal is applied at the negative input.

In practical circuit Vref is obtained by using a 10kΩ variable potentiometer, which forms a voltage divider with the supply voltages +Vcc and -Vcc, thus a Vref of desired amplitude and polarity could be obtained by simply varying the 10kΩ potentiometer.
In order to protect the IC while operating at lower value of the potentiometer a fixed resistor is introduced.
In the selection of IC for amplification as well for the comparison the TL 074 is used because of its versatility and cost.

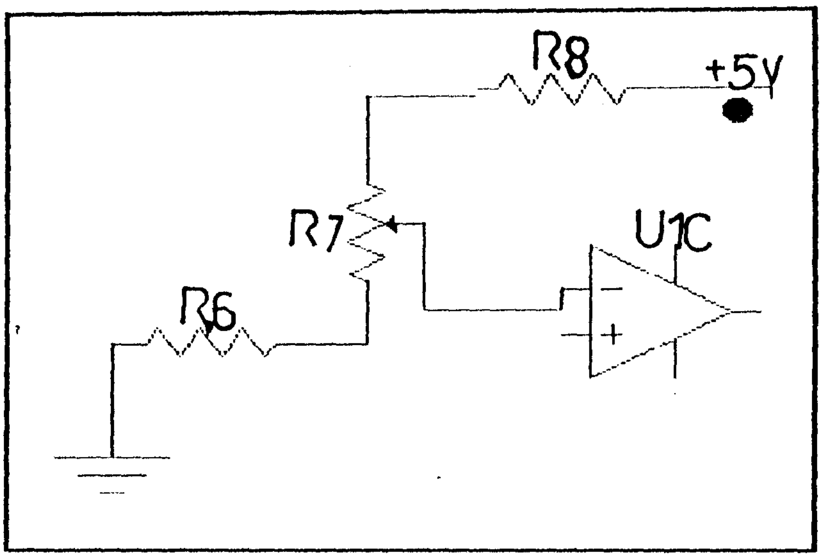


Fig 3.2.0comparator circuit

3.4 DELAY UNIT

In the design of the unit a timer is to be used because of its low cost, versatility and availability. The unit function is to avoid random effect of noise received at the mic level. The basic circuit for the monostable operation of the 555 timer is shown in figure 3.4.0.

The timing circuit consist of a resistor R and a capacitor C.

Threshold pin (6) and the discharge pin (7) terminals are connected to the timing capacitor. For the simplest form of monostable operation, the reset and control functions are not used, so pin (4) is connected to Vcc and pin (5) is bypassed to ground with $0.01\mu f$ capacitor.

Monostable operation requires an input trigger to initiate the output pulse.

Let T represents the pulse width produced by the timer, it is evident from equation (6) that the timing interval is independent of the supply voltage. It may be noted that once triggered, the output remain in the HIGH state until time T elapses, which depends only upon R&C. Any additional trigger pulse coming during this time will not change the output state.

$$T = 1.1(RC)$$

Let 5minutes be the maximum delay time

$$T = 5 \text{ min} = 300 \text{ seconds}$$

There are many choices of R and C that will satisfy this constraint. In the range of reasonable choice let R =2.2 kΩ

Thus: $T = 1.1\ RC$

$\therefore C = T/1.1*R$

$C = 300/1.1*2.2\ K\Omega$

$= 300/(1.1*2.2) = 123.9667$

$= 124\ \mu f$

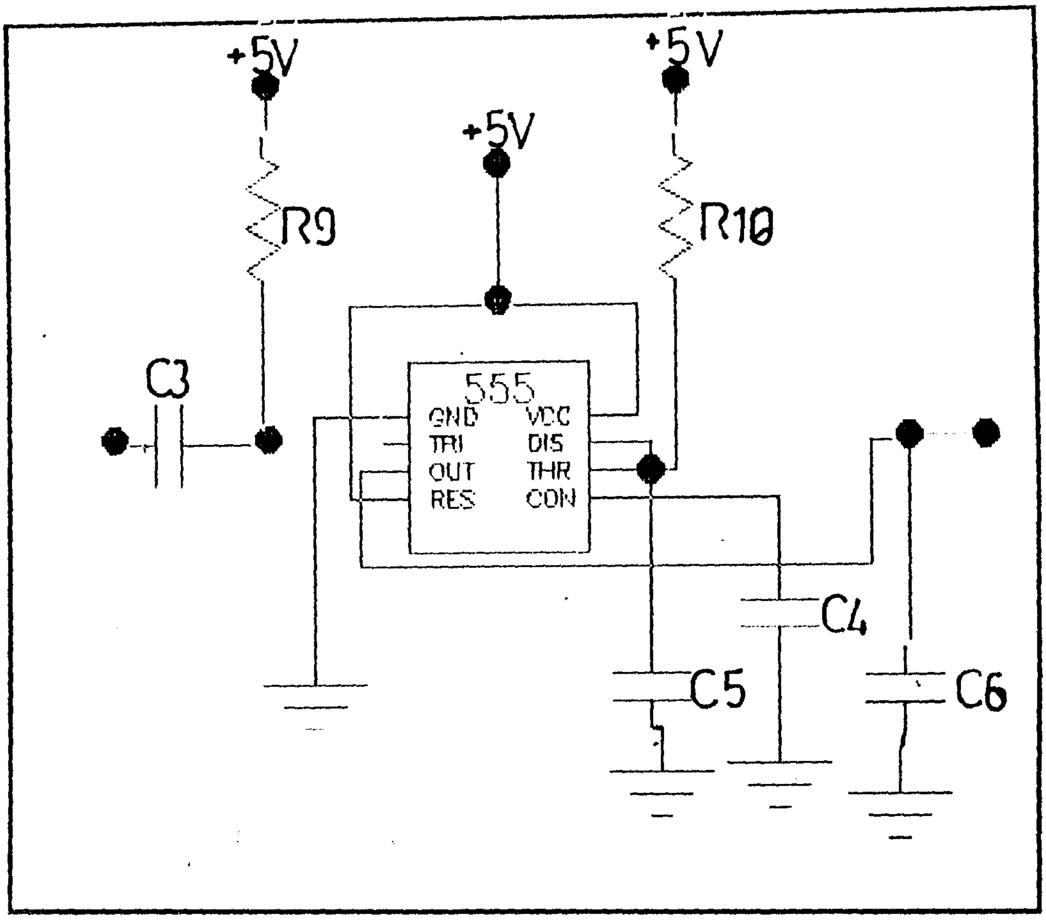


Fig: 3.3.0 time delay circuit

3.5 MEMORY UNIT

Its function is to memorize the impulsion detected by the comparator .a bistable multivibrator being a switching circuit with 2 stable states can be triggered from either state to the other by applying an input voltage via suitable trigger circuit, it thus can be used as a basic memory element in this project.

In order to obtain a bistable multivibrator a flip-flop cam be configured as shown bellow. The output of the flip-flop may not be sufficiently enough to operate the next stage where an opto-coupler is connected and also the light emitting diode used as the indicator for the operating state, so to provide a well operating state a transistor is connected in commutation as illustrated in figure 3.4.0 with an output current of about 40milliAmperes .The SN 7476 is the specific type of flip-flop selected for the purpose.

The output Q will change state each time the flip-flop received a signal at the input.

When Q = 1 the transistor Q1 will be activated and the LED also will be on then trigger the succeeding stage.

Resistors R11 and R12 are respectively used to protect the transistor and the LED (current limiting resistors).

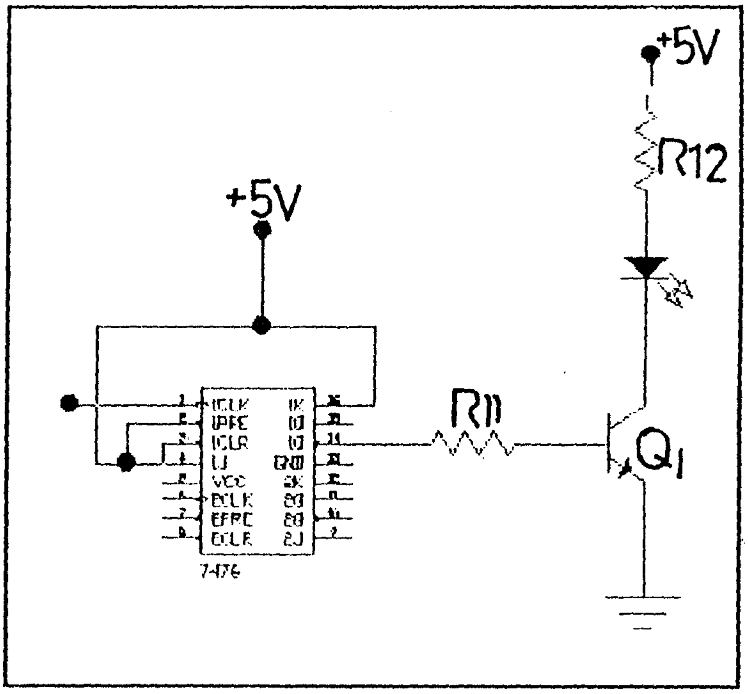


Fig 3.4.0 circuit diagram of the memory unit

3.6 PROTECTIVE UNIT

Being a switching system and it has to be connected to at least 220V ac the command unit has to be protected against high voltage.

in the conception of the protecting device the need of isolating the command unit arises, which brings out the use of an opto-isolator to separate electrically the two main units(command and power). In order to avoid any risk and the triggering of the succeeding elrement, which is a switching device, the opto-triac is the designated device. Based on its characteristic whereby the light is the only medium connecting the input circuit and the output circuit the MOC 3011 is the ic used. A current limiting resistor R_{13} is introduced to protect the opto-triac.

As a commanded switch the circuit has to be switched ON and OFF by power semiconductor device. To be on the safer side, a device that can be triggered with a small current and having high current rating and voltage is selected, a triac with specification TIC 226D having 40A and 600Vratings is an ideal power semiconductor switch. To protect the device against instantaneous voltage effect a snubber circuit is introduced also, as illustrated in figure 3.6.0.

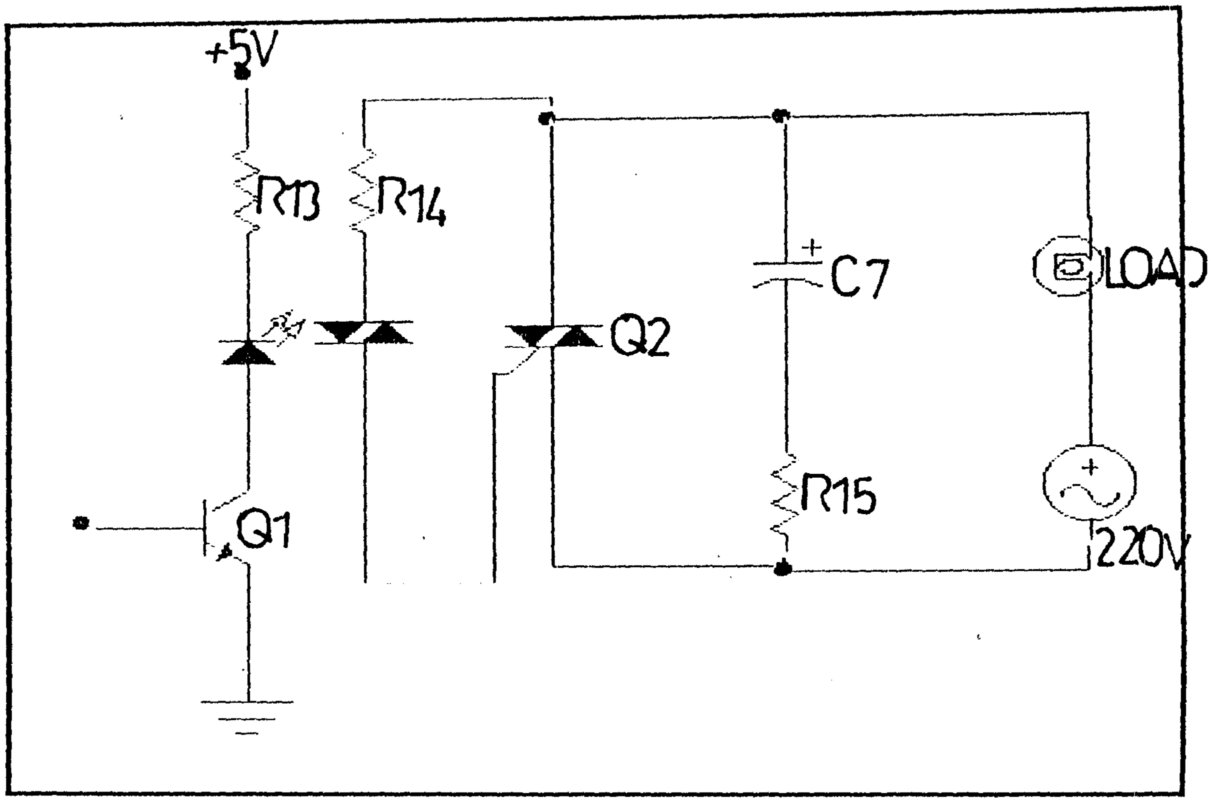


Fig 3.6.0 power unit circuit diagram.

3.7 POWER SUPLY

The arrangement requires a step down transformer, a bridge rectifier, a filter and regulators.

In the selection of the transformer the local standard voltage was first considered, then the requirement of the system, the input and output voltage values and the maximum current. A transformer rated:

Ac in 220/240V 50Hz

Ac out 12V*2/500mA

Will surely fulfill this requirement.

Stepped at 12V*2 ac the output of the transformer is to be rectified. The full bridge rectifier provides adequate rectification. The output of the rectifier is a pulsating dc , it has to be filtered . Figure 3.7.0 depicts the complete circuitry providing the necessary voltage supply requiring +5V and –5V dc to bias the ics , voltage regulators 7805 &7905 provide constant regulated dc to circuit.

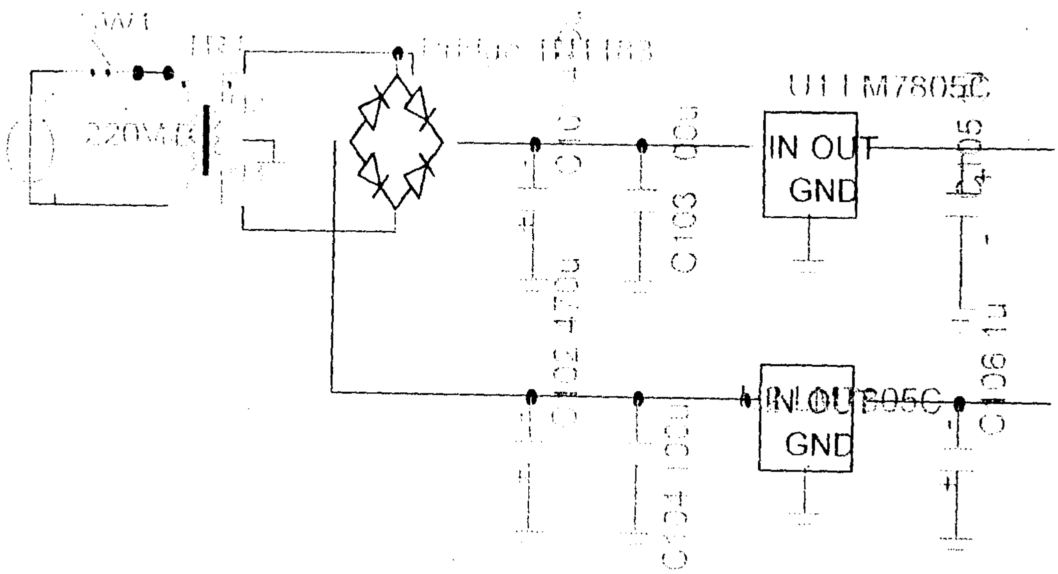
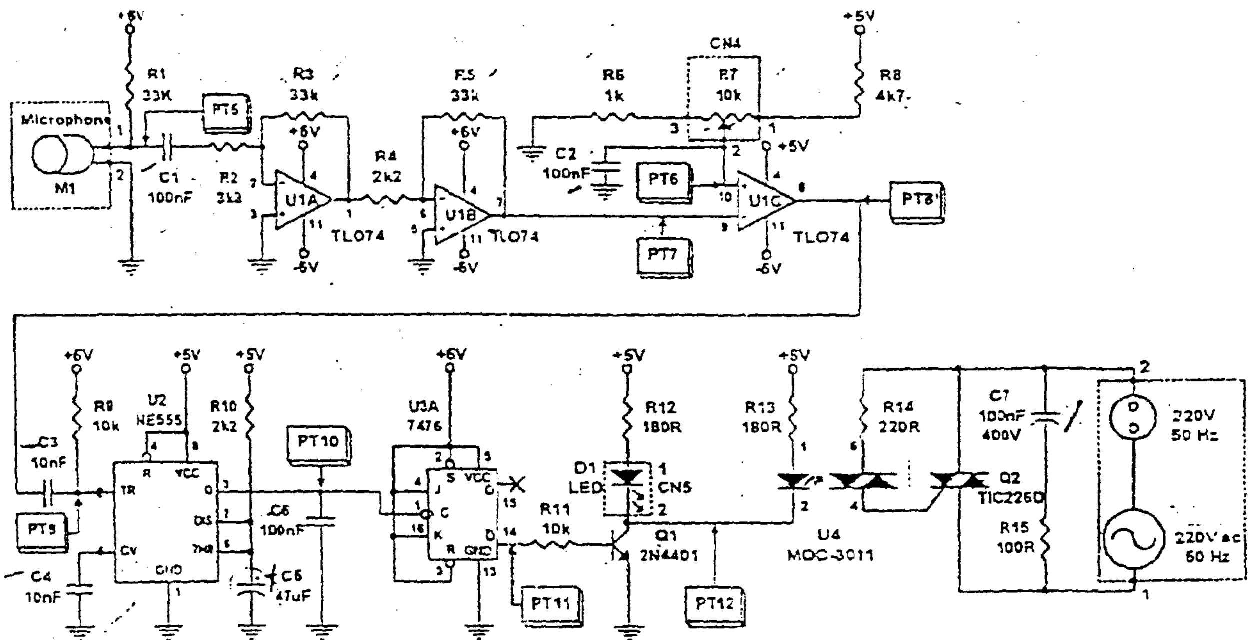


Fig: 3.7.0 the supply circuit diagram



CIRCUIT DIAGRAM

S/N	Name	Component	Specification/value
1	R1	Resistor	33K
2	R2	Resistor	3.3K
3	R3	Resistor	33K
4	R4	Resistor	2.2K
5	R5	Resistor	33K
6	R6	Resistor	1K
7	R7	Variable resistor	10K
.8	R8	Resistor	4.7k
9	R9	Resistor	10K
10	R10	Resistor	2.2k
11	R11	Resistor	10K
12	R12	Resistor	0.18k
13	R13	Resistor	0.18k
14	R14	Resistor	0.22k
15	R15	Resistor	0.1k
16	C1	Capacitor	100nF
17	C2	Capacitor	100nF
18	C3	Capacitor	10nF
19	C4	Capacitor	10nF
20	C5	Capacitor	100nF
21	C6	Capacitor	100nF
22	C7	Capacitor	100nF/400V
23	C101	Capacitor	470uF/16V
24	C102	Capacitor	100nF
25	C103	Capacitor	1uF/50V
26	C104	Capacitor	470uF/16V
27	C105	Capacitor	100nF
28	C106	Capacitor	1uF/50V
29	U1A	Amplifier	TL074
30	U1B	Amplifier	TL074
31	U1C	Amplifier	TL074
32	U2	Timer	NE555
33	U3	Flip-flop	SN7476
34	U4	Opto-triac	MOC3011
35	U1	Regulator	LM7805
36	U2	Regulator	CM7905
37	Q1	Transistor	2N4401
38	Q2	Triac	SCI146D orTIC226D
39	M1	Microphone	Electret microphone
40	D1	L.E.D.	L.E.D
41	TR1	Transformer	Center tape
42	SW1	Switch	Push button

List of the components used

Chapter 4

Analysis and construction

In the process of analysis the circuit the diagram depicted in figure 4 (b) is considered. Let consider the signal generated by one snap of finger.

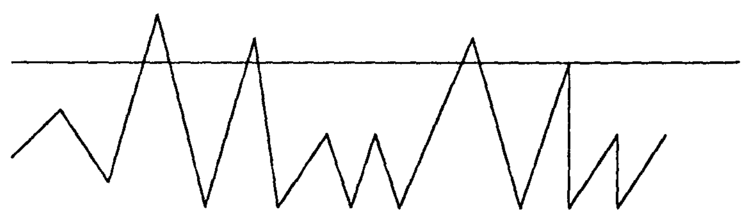


Fig. (a) wave generated by one snap of fingers.

The input unit M1 is just a transducer converting the incoming signal into electrical signals; it is a very small signal. Assuming that Vin is the output of M1.

$0 \leq Vin \leq 5$ mV

The overall amplification gain is Ao;

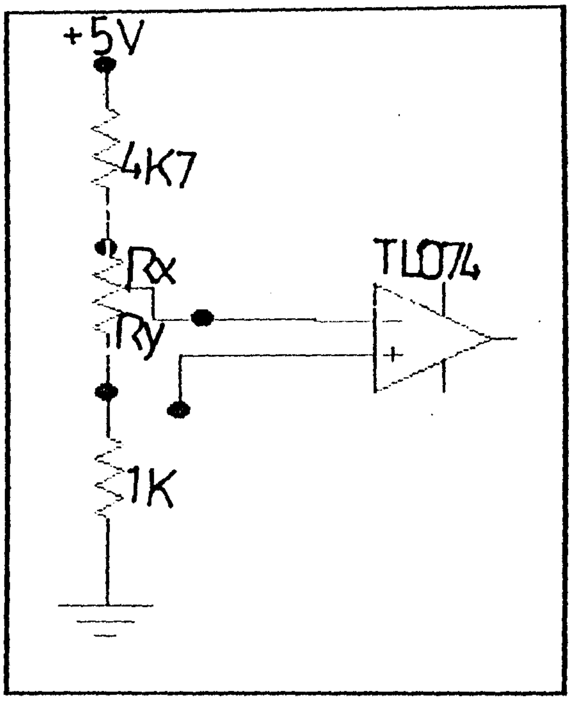
Ao = 150

The output of this amplification says V1 swings between 0*150 and 5mV*150

i.e. $0 \leq V1 \leq 750$mV

V1 is applied to the negative input of the comparator (UIC) while the positive input is determined by the selected level of potentiometer R7 (10KΩvariable resistor) and this value is user define.

Considering the diagram below:



Rx +Ry =10KΩ

Vref=[(1+Ry)/(Rx+Ry+4.7+1)]*5V

=[(1+Ry)/15.7]*5V

= 0.318*(1+Ry)

Vref depends on the level of Ry otherwise the adjustment of R7.

Having V1 and Vref being the inputs of UIC, there will be on output called V2 if V1 is greater than Vref.

V2 is in the form high or low.

V2 is high if V1 > Vref

V2 is low if V1< Vref

It can be noted that the response time for a comparator output to change states is in the range of 30 to 200 ns.

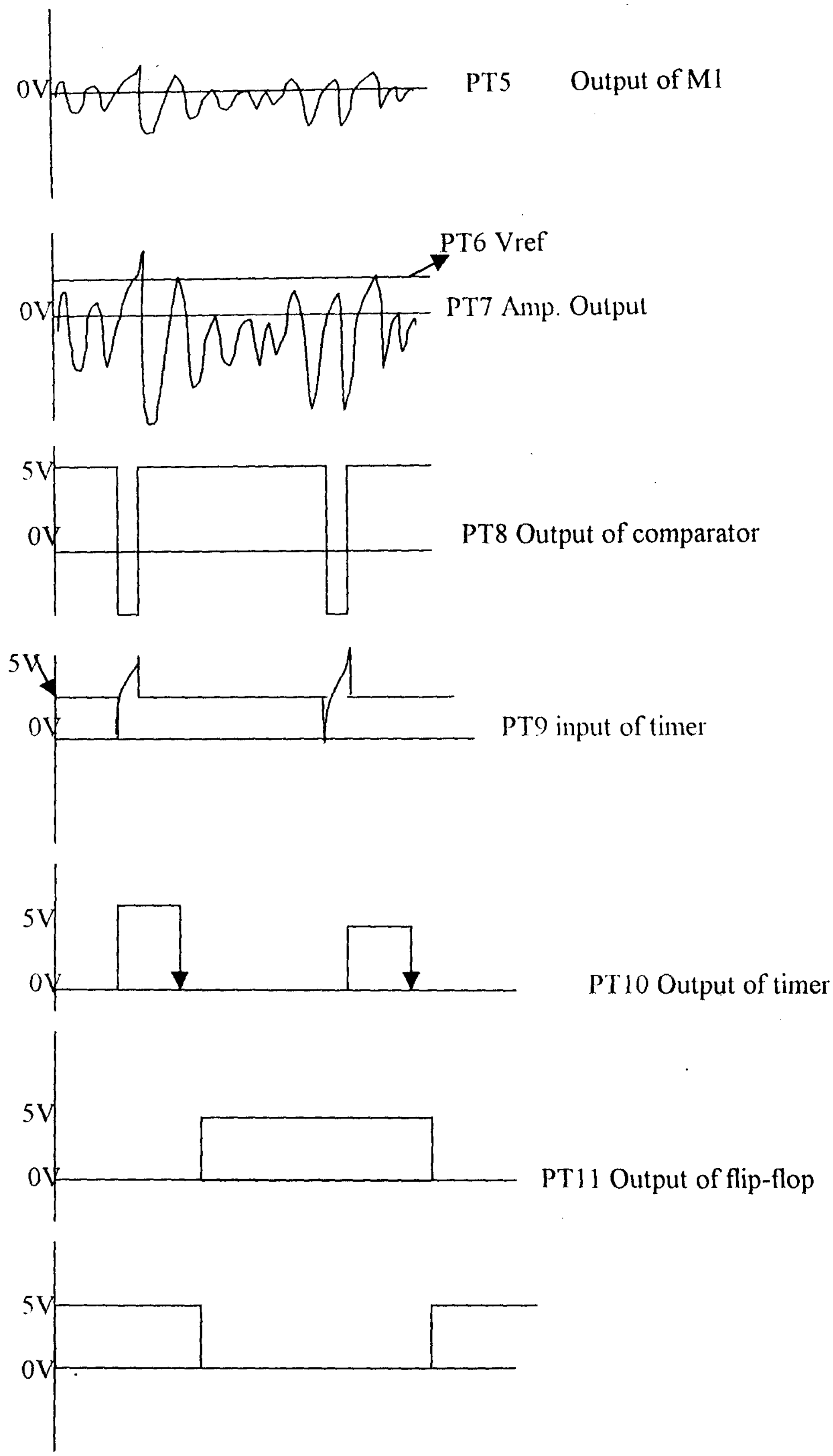
V2 is fed into a U2, which output is in the form high or low and the predefined time delay is 300 sec so within this period of time any incoming signal from UIC will be ignored.

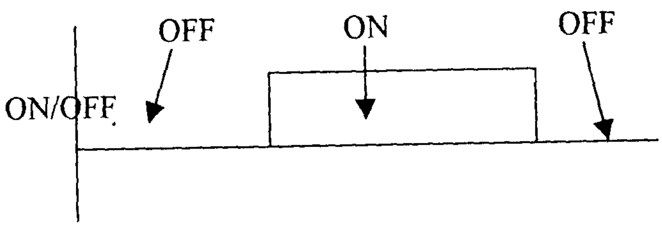
The output of U2 is applied to the input of U3, which memorizes the signal until a new one is applied.

When the output of U3 is low (i.e. Q=1) there will be a voltage across transistor Q1. Q1 is connected in commutation can provide the necessary current to drive the optocoupler U4 and the LED because the o/p of U3 may not be enough to drive them.

The last section is the one, which drives the power to the output (i.e. the load connected on the 220 V a.c), each time the output of U3 is high, Q1 will be polarized and U4 activated.

The current will then flow in the gate of Q2 and as a switch like the simple-pole-single-throw (SPST) the load will be ON or OFF. The provision of the snubber network protects Q2.


0V
PT5 Output of M1
PT6 Vref
0V
PT7 Amp. Output
5V
0V
PT8 Output of comparator
5V
0V
PT9 input of timer
5V
0V
PT10 Output of timer
5V
0V
PT11 Output of flip-flop
5V
0V



Output of triac the load is

Fig.4 (ii) signals at each point in the circuit

The circuit requires +5V as well –5V dc to operate and bias the ics.

The stop down transformer is giving an output of 12V*2 ac, which is fed into the full bridge rectifier.

The later output is Vdc,

The peak-to-peak voltage Vpp is:

$V_{pp}=\sqrt{2}*12V*2=33.94V$ ac

$V_{dc}=2V_{pp}/\pi$

$V_{dc}=(2*33.94)/\pi = 21.6V$

Or considering the peak voltage Vp

$V_p=\sqrt{2}*12V=16.97V$ ac

$V_{dc} = 2V_p/\pi = (2*16.97)/\pi = 10.8 V$

$V_{dc}= \pm 10.8V$

The rectified dc is filtered; requiring fixed voltages of +5V and –5V, the voltage regulator ics the 7805 and 7905give the expected voltages respectively and capacitor C5 and C6 enhance the response to rapidly changing load.

CONSTRUCTION

In the process of the construction the power unit was first built on the Vero-board in order to have suitable fixed supply. The main circuit was built first on the breadboard for testing and diagnostic which made it possible to make some changes as the need arise and it was made easier to locate bugs.

Being satisfied with the behavior of the circuit it was then transferred to Vero-board where the components were soldered. When soldering the components, each terminal was giving enough allowance in order to avoid bridging, which can create short-circuit. After fixing the whole components on the Vero-board, the interconnections were carefully checked.

The entire circuit was then housed in a wooden casing.

The switch (push button), the LED used as indicator when the system is powered on, the control selector knob and the mic were wired to the front side of the casing, making it easily accessible to the user.

The output, a fixed socket was wired at the back.

Testing

When the soldering was over, the complete circuit was traced and retraced carefully to ensure that there is no open or short circuit.

A digital millimeter was used to verify the base of each component and the continuity test was also made.

The transformer's output was measured 12V*2, then fed into the bridge rectifier where the output is also measured.

This output was fed in the filter and regulators where outputs of +4.97V and –5.03 were obtained after many measurements.

The percentage of error at the output of the regulators is:

(i) For the 7805

$\varepsilon_1 = [(5\text{-}4.97)/5]*100=(0.3/5)*100$

$= 0.6\%$

(ii) For the 7905

$\varepsilon_2 = [(-5-(-5.03))/-5]*100$

$= (-0.3/-5)*100$

$= 0.6\%$

The circuit was powered with the dc supply only and its behavior was observed.

Satisfied with this response it was finally powered with 220Vac.

The response of the system was tested while carrying the variable resistor.

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