A PROJECT REPORT ON DESIGN AND CONSTRUCTION OF DUAL CHANNEL DIGITAL VOLUME CONTROL

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CERTIFICATION

I hereby certified that this work was carried out by MR. ADEGBOYE MOSES ADEWALE of Department of Electrical/Computer Engineering, Federal University of Technology, Minna, Niger-State.

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SUPERVISOR DATE

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.... 6/4 ....

EXTERNAL EXAMINER DATE

DEDICATION

This project work is dedicated to the memory of my ever lovable Father who has been longing for today but went away to be with the Lord few months to the end of this project, May his gentle soul rest in peace. Amen.

DECLARATION

I hereby declare that this project work is my original work and has never to my knowledge being submitted elsewhere before.

MOSES ADEWALE ADEGBOYE DATE.

ACKNOWLEDGEMENT

My profound gratitude and appreciation goes to only HIM, the Lord Jehovah, who has kept me for the past years under his pavilion, to him be all the glory.

I wish to express my thanks and appreciation to my ever lovable father, although he went away to be with the lord few months to the end of this project work but the legacy he left behind for me and the spirit of diligence he instilled in me will always be living, may his gentle soul rest in peace, Amen.

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My deep appreciation goes to the H.O.D of the Department Dr.Y.A. Adediran and my Supervisor Mr. Paul Attah, and the entire staff of the department for their professional and academic support throughout, God shall reward them.

Thank to some friends,Biodun Oladunjoye,Biodun Olaniyi,Sola Adesanya,Amakiri Welekwes,God bless them all.

Thanks to a special family,Olojedes,that have made Minna home away from home,God bless them as well.

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I am indebted to my relations,Adenugas,Ayangunnas,Oladeles,my caring sister Funmi,Sakirat and my ever lovable younger brother Tope Adegboye, I pray his banner over us shall always be love.

All in all, there is a vessel that God used for me to be positioned in life and they have always been there for me morally, financially, spiritually etc, for me to achieve my goal, my living and loving parents MR.J.O TAIWO[of blessed memory],MRS.R.E. Taiwo and MR &MRS O. A.Adenuga, they shall always behold the glory of the lord God almighty in Jesus name, God bless them.

MOSES ADEWALE ADEGBOYE

ABSRACT

For this project,IC 555 timer is configured as an astable flip flops to provide low frequency pulses to ud/down clock inputs pins of presettable up/down conter 74LS193 via push to on switches s1 and s2.

Operation of switch s1[up] causes the binary output to increment ,the maximum count being 15[all output logic 1] and minimal volume repectively.

The active high output A,B.C.D of the conter are used for controlling two quad bipolar analogue switches in each of the two CD4066 ICS.

Each of the output bits,when high short a part of the ladder networks of the resistors comprising a series resistor R6 through R9 for one channel and R10 through R13 for the other channel and thereby control the output of the audio signals being fed to the inputs of a stereo power amplifiers.

Push to on switch S3 is used for resetting the output of conter to 0000 and thereby turning the volume of both channels to the minimum level.

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CHAPTER ONE

GENERAL INRODUCTION

The application of electronics to the world around us is nearly limitless. In the past 10 years, the world has seen electronics become a major influence in every aspect of daily life, it is impossible to think of doing daily tasks without relying on electronic.

In recent years significant progress has been made in discrete data and digital control system and these systems have gained popularity and importance in all industries due in part to the advances made in digital manipulation of numbers as well as the advantages found in working with digital signals.

Control of the electrical energy by electronic devices in essential to achieve the functions desired. Electronic systems are similar to many other physical systems, most electronic process except those related to computer electronics involves energy control and or conversion. We are familiar with such energy. Control process in our daily life.

Of major interest in any near electronic system is the manipulation or control of the available energy source. The energy source used in electronic system is a battery.

An information input in also provided, control is achieved by both active and passive devices in the circuit. The active accept this information input and impress a direct control over the energy supplied response to this information.

The conditioning devices in the circuit impress a constant level of control over energy flow whither to set maximum limits or to support the function of an active device.

Th output of the system, voltage variations and or current flow is a controlled response to the information input.

Active devices are transistors, diodes, vacuum tubes, op-amps etc and the passive devices are capacitors, inductors etc.

In control circuit, the output is not a cheat representation of the input unlike amplifier, the input to a control circuit may be a waveform, a pulse or on d.c level.

The output may be simply an on/off control of the current to a load. Often control devices are operated in a saturated or cut-off mode rather than being biased in a linear amplification mode.

1.0.0. INTROUCTION

The use of sampled data in control systems can be traced back to at least seventy years ago, some of these early applications of sampled data were for the purpose of improving the performance of the control system in one form or another.

The signal that is used to operate the control device can take one of three primary forms

- DC amplitude signals
- Pulsed control signals
- AC phase control signals

With the growing trend of applications in the electronics world, there is a challenge later not only to amplify the signals to produce a gain alone but also to create a special electronic special effect on the set e.g volume control in a more sizeable manner.

The basic volume control concept is to manipulate or control the available energy source thereof as shown in Fig 1.1 below.

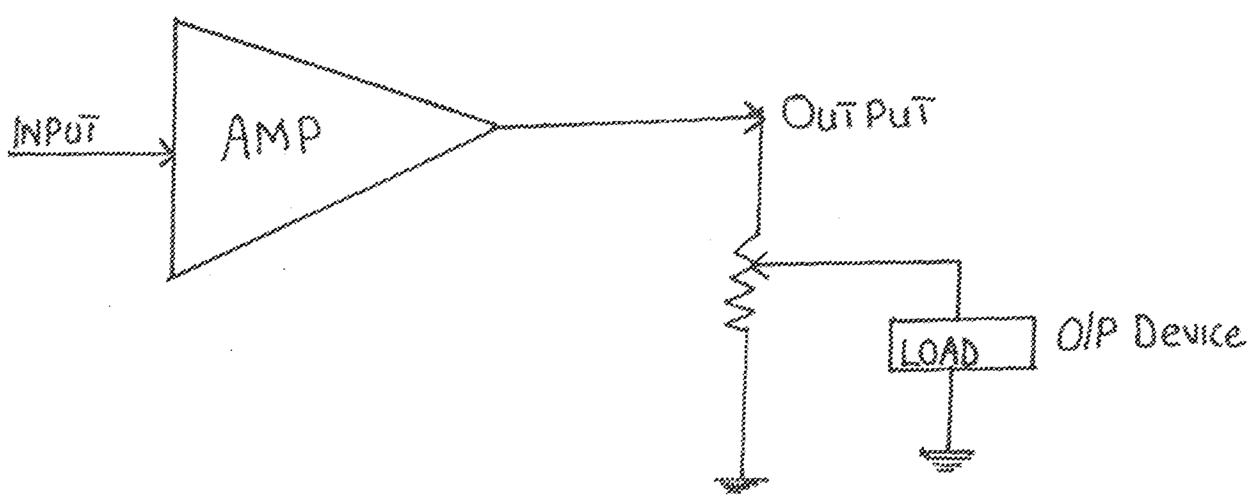

FIG 1.1 ONE FORM OF VOLUME CONTROL

The output level could simply be divided across a variable resistor prior to reaching the appropriat4e output device. If this were done, there would be a simple voltage divider circuit established by the potentiometer.

By adjusting the potentiometer, more or less voltage [and current] would be delivered to the output device, thus the power delivered to this device would be increased or decreased.

But there was a problem later, it was discovered such a circuit would be highly inefficient because all of the power that was not used the amplifier may simply be wasted in heating the variable resistor.

This would be similar using the brakes on a can to control its speed on the road while allowing the engine to run at full speed.

Now, if we use a circuit like the one shown in Fig 1.2 where the volume control [still a variable resistor] is now in control of the input to an amplifier, grater efficiency is achieved.

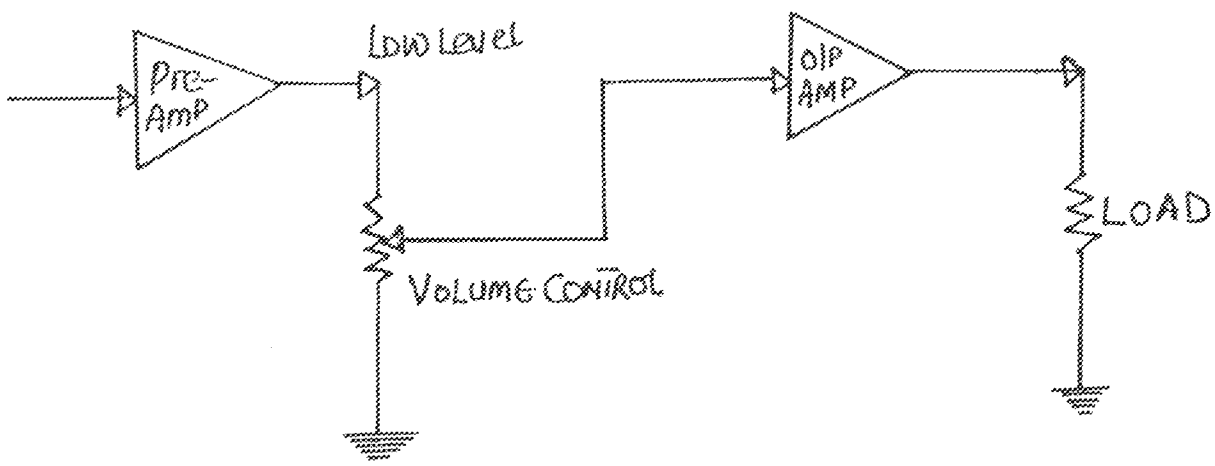

Fig 1.2 VOLUME CONTROL BETWEEN AMPLIFIER STATES.

This arrangement, where the control of volume is seen as a part of the amplifying process, waste far less energy than the previous circuit would.

Here there still is a voltage divider circuit but the actual energy losses are quite small compared to the losses seen when applying control at the final output.

The principle is about the same, reducing the voltage and current delivered to the following element, but in this case the amount of power lost in the control process is far less than when control is done at the output.

An interesting effect has occurred, the function of the volume control, its reduction in these low power levels, has been magnified by the next amplifier in line.

There is now this form of volume control that I work on in this project "DUAL CHANNEL DIGITAL VOLUME CONTROL". This requires the understanding of the internal working of the amplifier.

This type of volume control often uses even lesser power from the system than the other methods existing before her and this digitally control volume will be mostly preferred due to this following reasons which are more particular to sampled data and digitally control devices over manual or analogue one.

- Improved sensitivity
- Better reliability
- No drift
- Less effect due to noise and disturbance
- More compact and light weight.

These and other glaring comparisons are the main basics of this project.

1.2 PROJECT MOTIVATION AND OBJECTIVE

The essence of this project work is to replace a manual volume control with a digital one.

The motivation about this comes up when I discovered it is possible to manually tuned your knob and you over-tuned till it get spoilt, therefore an alternative way could be introduced to avoid us tuning but rather pressing which is more comfortable.

Furthermore, an instance could occurs that your hi-fi-set could be far away from you and you need to tune the volume by either increasing or decreasing, by incorporation of infra-red transmitter and receiver to this digital volume control, it could be possible.

As said before, the main essence of this project is to provide a control circuit that will be digitally controlled to vary the volume of our hi-fi-set and to replace the manual knob that was initially used for the volume control.

One of the many functions of electronic systems is to provide control over other electrical, mechanical or other functional circuits or machines.

The process of providing this control does not involving a standard amplification process. The input to a control system is typically not a varying a.c. signal but is an on/off type of signal mainly digital signals.

The objective of the control circuit is not to amplify the input in the classical sense by to control the function of a higher power electrical force as it acts on a load device, control functions deal primarily with 2 important circuit functions. One of the functions is how the actual control of supply voltage and current are to be metered out to a load elements (motor, light bulb etc), the other important functions is how the control signal, that which drives the controlling device is to be provided.

1.2 PROJECT LAYOUT

The basic principle behind this project is shown in Fig. 1.3. below

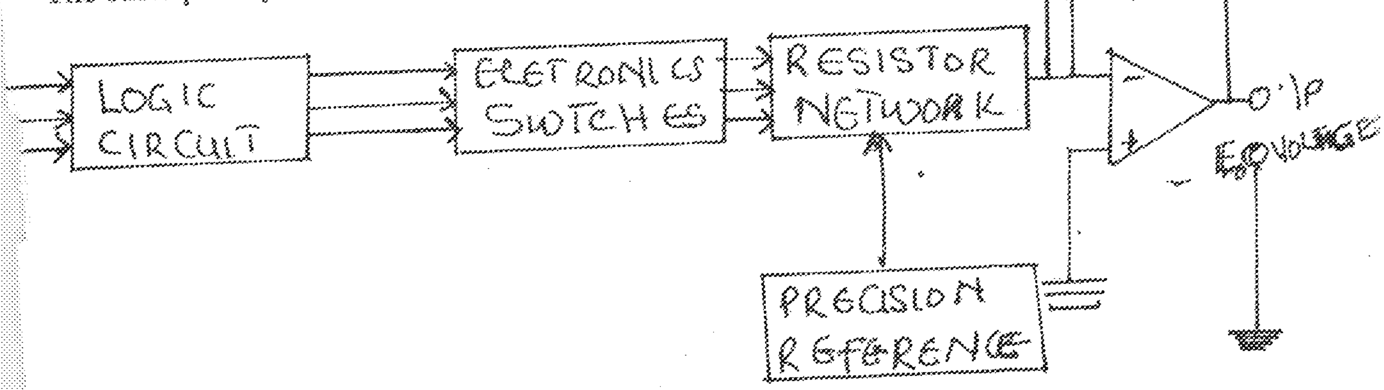

FIG.1.3 BASIC PRINCIPLE OF THIS PROJECT WORK

The function of the logic circuit is to control the switching of the precision reference voltage or audio pre-amplifier signals to the proper input terminals of the resistor network as function of the digital value of each digital input bit.

Each of these resistor is connected through an electronic switch to the pre-amplifier audio signals or to the ground. When a binary 1 appears at the control logic circuit of a switch, it closes the switch and connects the resistor to the reference pre-amplifier audio signals, on the other hand, a binary O connects the resistor to ground.

For this project, the block diagram is as shown in Fig.1.4 below.

5V power supply was constructed to power ICI, IC2, IC3 and IC4, the logic circuit used to control the switching of the precision reference voltage or audio pre amplifier signals comprises of IC1 and IC2.

IC1 is 555 timer that is configured in an astable mode and IC2 74LS193, a synchronous, 4 bit binary up/down counter with dual clocks.

IC3 and IC4 are quad digital switches that switch the precision reference voltage signals to the proper input terminals of the resistor network as function of the digital value of each digital input bit.

The output signals from the pre-amplifier stage of our hi-fi set serves as a precision reference voltage and the resistor network is R-ladder network in the range from 1k to 8k and each of these is resistor is connected through an electronic switch to the pre-amplifier audio signals or to ground.

The output signals from the electronic switches is invariably fed to the power amplifier and to the speaker to make the whole thing a complete.

Note that S1 and S2 from 555 timer to the 4 bit counter are respectively used to control up and down count of the electronic signals in natural counting.

FIG.1.4 BLOCK DIAGRAM OF A DUAL CHANNEL DIGITAL VOLUME CONTROL

CHAPTER TWO

ANALYSIS AND DESIGN OF COMPONENTS

2.1.0 POWER SUPPLY UNIT

Electronic systems invariably requires a source of power, the simplest being a dry battery, batteries have the advantage of complete absence of a.c. component in the output and low output impedance, but it suffers from a limited useful life and poor long term voltage stability. There is a danger of leakage if exhausted if batteries are accidentally allowed to stay too long in equipment, this may endanger the circuiting through corrosion damage.

Thus the a.c. main must be converted to the appropriate D.C. VOLTAGE.

In this project, a 5v, power supply is constructed as shown below in Fig. 3.1 and the stages in this 50 power supply are

- Rectifying
- Filtering (smoothing)
- Voltage regulation

2.1.1 RECTIFYING

This stage comprise of transformer and diode connected in bridge rectifying mode.

In this project, 240/12v, 500 mA, centre tapped transformer and a bridge rectifier diodes which usually has four diodes contained in one package is used in this project

2.1.2 **FILTERING:** At the output of the rectifier the voltage is unidirectional and it contains a high ripple content, the ripple can be largely filtered out, leaving a substantially smooth D.C. voltage.

The filtering circuit of this power supply of this project is a capacitor, since capacitor has a property of resisting changes of voltage across it and hence provides the desired smoothing action.

Therefore, to reduce the ripple voltage level of this supply, a large value of capacitance 2200PF, 160 electrolytic capacitor is used for this project.

2.1.3 VOLTAGE REGULATION

An unregulated D.C. power supply may be adequate for some application but there is often a need for the supply voltage to be constant as well as having a low amplitude of ripple.

In this project, a 7805 IC designed to give a stable 5v supply is used for voltage regulation.

2.1.4. LED SENSOR

Light emitting diode connected between the regulated power supply and the load serve as a sensor to really know if the regulated power supply unit is actually delivering.

This highly essential and very useful during the trouble shooting period i.e. if the LED refuse to lit up, the problem is actually coming from the power supply unit.

DIAGRAM FIG.2.1. 5V POWER SUPPLY

2.2.0 PULSE GENERATORS

The function of a pulse generator is to generate pulse at constant frequency, one integrated circuit that is exceptionally useful in square wave generation is the device universally known as the 555 timer. It is readily available in an 8-pin plastic dual-in-line package.

The 555 timer can be used with supply voltage in the range of +5V to 18V and can drive load up to 200mA. It is compatible with both TTL and CMOS logic circuits. When used in the astable mode, it produces up to frequencies of about 100khz, and its frequency can be accurately controlled with two external resistor and a capacitor.

This IC is used in this project in the astable mode to generate clock pulses at the desired frequency by selecting the appropriate timing resistor and capacitor.

2.2.1 ASTABLE CONNECTION OF 555 TIMER IN THIS PROJECT

The 555 timer is connected for astable operation as shown in Fig.2.2.(a) below, for the better understanding, the complete diagram of the circuit with detailed internal diagram of 555 timer is shown in Fig.2.2 (b) below.

The circuit operation is as follows, when the power supply Vcc is connected, the external timing capacitor C charges towards Vcc with a time constant (RA+RB)C. During this time, the output (pin3) is HIGH (equal Vcc) as RESET, R =O, SET, S=1 and this combination makes Q=0, when the capacitor voltage equals 2/3Vcc, upper comparator triggers the control flip flop so that Q=1, this is turn makes transistor Q1 ON and capacitor C starts discharging towards ground through Rb and transistor Q1, with a time constant RBC.

Current also flows into transistor Q1, through RA resistor RA and RB must be large enough to limits this current and prevent damage to the discharge transistor Q1.

During the discharge of the timing capacitor C, as it reaches 1/3 VCC, the lower comparator is triggered and at this stage A = 1, R=O, which turns Q =o, which undamps` the external timing capacitor C.

FIG.2.2. (a) Astable operation of 7555 timer

FIG.2.2 (b) Internal diagram of 7555 timer

The capacitor is thus periodically charged and discharged between 2/3VCC and 1/3VCC to 2/3VCC and it may be calculated as follows:

The capacitor voltage for a low pass RC circuit subjected to a step input of VCC volts is given by Vc =VCC (1-e^-t1/RC).

The time t1 taken by the circuit to change from 0 to 2/3 VCC is:-

2/3 = Vcc (1-e^-t2/RC) and this gives

t2 = 0.405RC

now, tHIGH=t1-t2=1.09RC-0.405RC

=0.69RC.

so for the circuit

tHIGH = 0.69 (RA+RB)C

Timing capacitor value can vary from a 400pf to 100uf

CALCULATION FOR C1,RA,AND RB

Frequency of the output pulses can be determined from the formula

F= 1.44/[RA+2RB]C.

OR

Form the chart in fig.2.2. © below and from the chart in fig.2.2. (c) below.

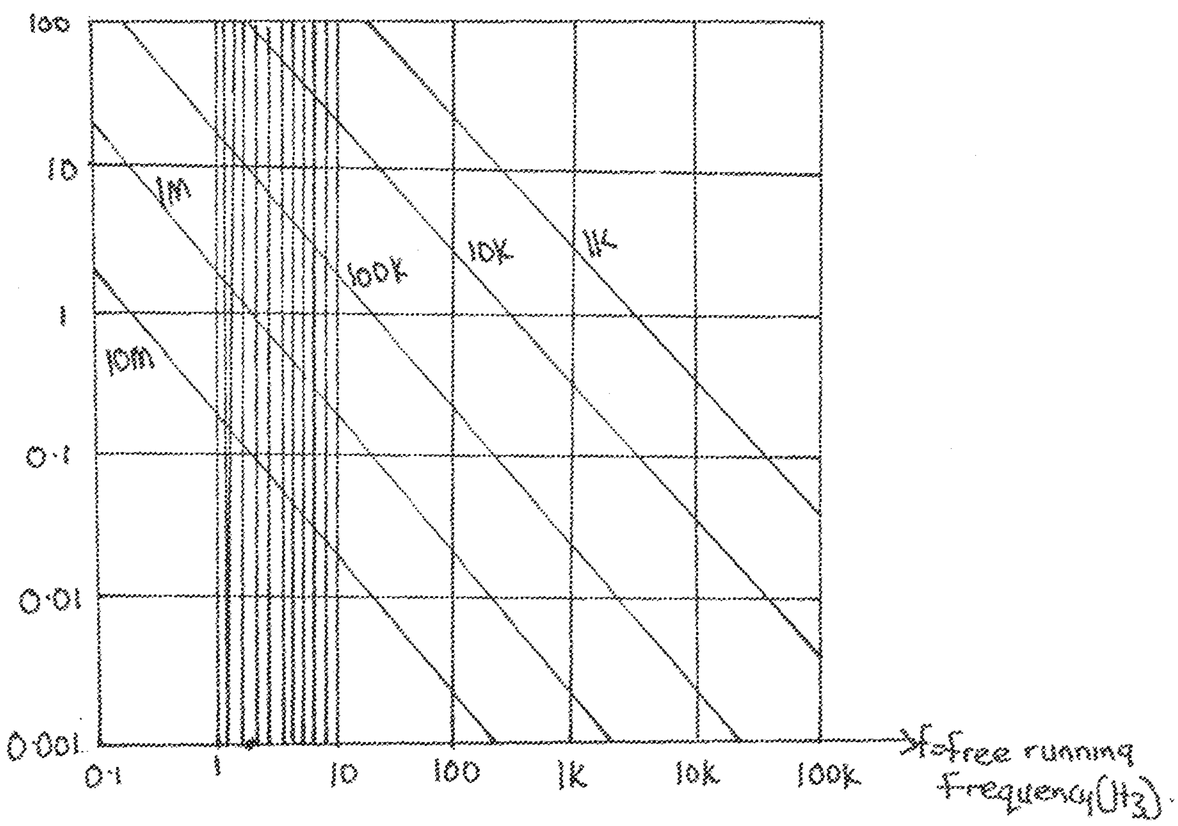

FIG. 2.2 (C) CHART FOR DETERMINING R AND C VALUES FOR ASTABLE.

$$F = I/T = \frac{1.44}{(RA+2RB)C}$$

$$\text{Duty cycle} = \frac{\text{Time Output High}}{T} = \frac{RA + RB}{RA + 2RB}$$

RA OR RB MINIMUM = 1KW

RA + RB MAXIMUM = 6.6MW

To use this chart, select the frequency you want on the horizontal axis, follow this frequency line upward until it intersects and available capacitor value and then read the value for RA + 2RB from the nearest diagonal line. If you want an approximately square wave output, then make RA much smaller than RB.

For this project, since we are in need of low frequency pulses to our up/down clock inputs, we choose our RA and RB to be very big but for

RA minimum is 1kw

RA + RB maximum is 6.6MW

And our C to be very small

RA = 150k, RB = 330k, C=IUF

F=1.44 = 1.44

(RA + 2RB)c(150x1000 + 2(330 x 1000) x 1x10-6

= 1.44

(150,000 x 660,000) x 1 x 10-6

= 6.7H3

Thus the timing components are

RA = 150kW

RB = 330KW

C = IUF

These are readily available in the market.

2.3.0 COUNTERS

A counter is a sequential circuit consisting of flip-flops which go through a sequence of states or the application of clock pulses, they are used for counting the occurrence of events, frequency division and generating timing sequence to control operations in a digital system.

In this project, a presettabloe synchronous 4-bit binary up/down counter with dual clocks (74LS193) is used, the logic diagram of a synchrnous, 4 bit up-down counter is shown below in Fig.2.3 (a)

2.3.1. 74LS193, 4-BIT, UP/DOWN SYNCHRONOUS COUNTER

As mentioned earlier, the counter used in this project is a synchronous, 4 bit, up-down counter 74LS193.

This is a pressettable, synchronous, 4-bit binary counter with dual clocks i.e. for either up or down counting mode.

The pin diagram for 74LS193 is shown below in Fig.2.3(b) below (a page should be left)

The internal circuiting diagram is shown below in Fig. 2.3.(c)

Fig.2.3 (b) Pin diagram for 74LS193

Fig.2.3.(c) internal circuiting of 74LS193

In Fig. 2.3. (d) below is a wave form representation for 74LS193 pressettable, 4 bit up-down synchronous counter.

This IC is called a pressettable due to a feature it possess for it to be able to preset to any desired state of logic.

The following sequences is being maintained when 74LS193 is in operation.

- when counting up, count down input must be high, when counting down, count up must be high.
- Clear output to zero
- Load preset to binary 13
- Count up to 14, 15, carry 0, 1 and 2
- Count down to 1,0 borrow 15,14,13

N/B: A clear overides load data and count inputs.

A page to be left for fig. 2.3d waveform for 74ls193

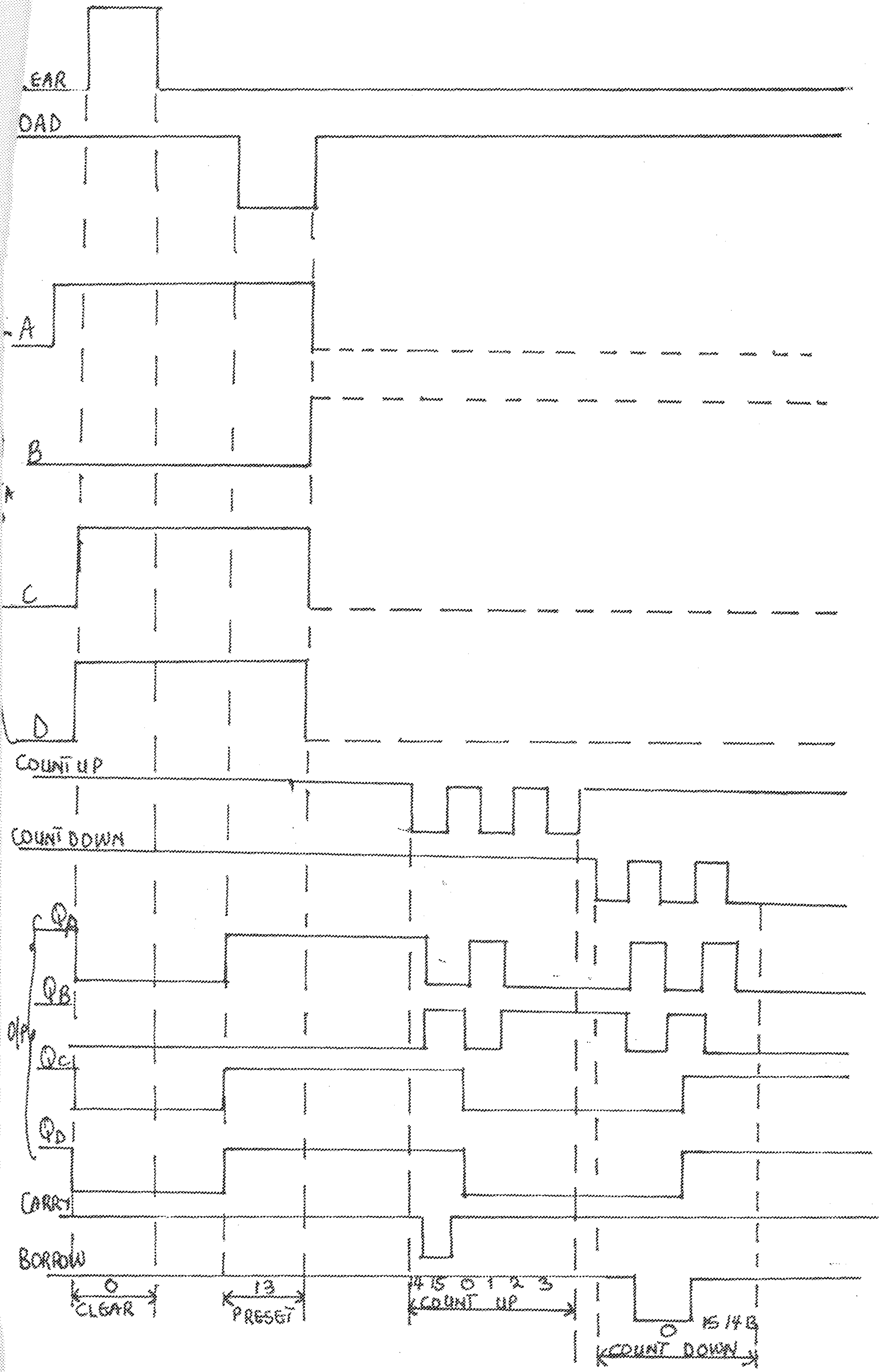

FIG. 2.3(d) WAVEFORM FOR 74LS193

It must be clearly noted that 74LS193 is a binary counter in the sense that the connection is such that the count advances in a natural binary sequence from 0000 to 1111 for count up mode and 1111 to 0000 in count down mode.

The wave form for count up and count down mode of 7415193, up-down counter is shown respectively in Fig. 2.3 (e) and 2.3 (f) blow

Fig 2.3(e) count up waveform

Fig 2.3(f) count down

The tabular representation of a count-up and count-down sequence of a 4 bit binary 74LS193 synchronous, resetable counter shown in Fig 2.3(g) below

D	C	B	A	COUNT
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

FIG 2.3 (G) COUNT-UP AND COUNT-DOWN SEQUENCE OF A

4 BIT SYNCHRONOUS BINARY COUNTER

2.4.0 SWITCH [CD4066]

The switching circuit in this project work is an electronic or digital type which is carefully embedded in an integrated circuit via medium scale integration technology. Inside is an array of 4 digital switching network contain in a single integrated circuit market as CD4066, the pin out and internal circuit is shown in Fig 2.4 below, the switching action of this device is being control by counter and this used to regulate the rate at which the audio preamplifier signals is passing through this resistor network for volume control of the device, the type of digital switching chosen for this work is to combat the problem mechanical switches introduce into a circuit design such as

-Time delay

- Introduction of glitches etc.

Fig 2.4, internal century of CD4066

Fig 2.5 the R ladder, resistor network

2.5.0 RESISTOR NETWORK

This is an R-ladder network of resistors, in the range of 1kw, 2kw, 4.7kw,and 8.2k, it is a major controlling passive devices which is arranged logically at the IN/OUT pin out of the CD4066.

The rate of the counting by the counters regulate the rate at which the preamplifier audio signals is passing through this resistor network to indicate up and down volume control respectively. The R-ladder resistor network is show in Fig 2.5 above

By interconnecting all these components as described thus far, the overall circuit of the dual channel digital volume control is shown at the back of this project work

2.5.0 CHOICE OF COMPONENTS

The first solid state circuit used discrete components, however by combining these circuit elements into one tiny semi conductor chip, all in a single package, the size and cost logic function was greatly reduced.

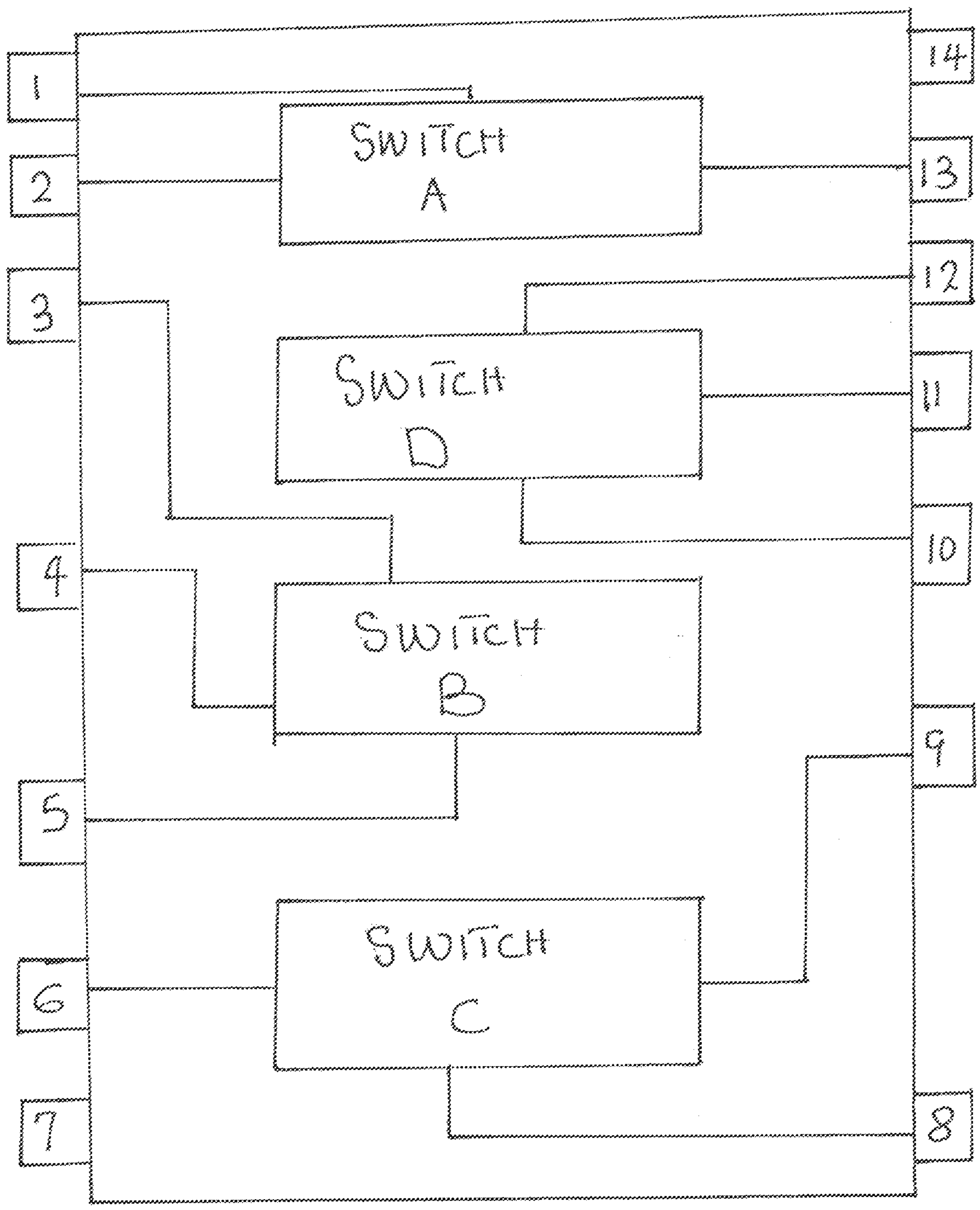

FIG. 2.5(d) QUAD BILATERAL DIGITAL SWITCH.

Such integrated circuit becomes available to logic designers in 1960. As technology advanced and manufacturing yield increased, the complexity and the number of element per package has grown and continue to grow seemingly without bound.

The more complex of these are referred to as MSI-medium scale integration.

2.6.1 DIGITAL DEVICES

Digital integrated circuits have been available for many years now, and most readers will be familiar with common family logic names like RTL (Resistor-Resistor Logic), DTL (Diode-Transistor Logic), and ECL (Emitter-Coupled Logic).

Each of these families offers its won particular advantages when compared tot he other type, but all of the families share a number of common disadvantages.

The chief disadvantages of the common logic families are

(1) High quiescent current requirements (typically 5MA per gate).

(2) Tight power supply requirement (power supplies typically have to be regulated to

+/- 10%)

(3) Poor noise immunity (meaning that gates can easily be triggered by spikes on the supply rail).

The introduction of the CD4000 series of digital integrated circuits, using both P-Channel and N-Channel MOSFET's on the same chip, marked the beginning of the latest phase in the evolution of IC logic.

The most widely used generic name for these is COMOS for complementary metal oxide semiconductor.

CMOS has the following advantages over other logic families.

- Ultra-low power consumption at low switching rate.
- Much grater tolerance to power supply voltage variation than other logic family.
- High noise immunity

- Stable characteristic over wide temperature rage.
- Extremely high CMOS to CMOS fan-out (about 50) and
- Has an excellent thermal characteristic, low cost commercial types are designed to operate over the temperature range –40°c to 85°c, while the more expensive military version can operate from 55° to +125°c.

Low power dissipation permits more logic function to be included per package than some other logic family since there is less heat to be dissipated.

The inclusion of a large number of logic function in package is called is LSI "Large Scale Integration". The result is low cost per function, reduced space and increased reliability CMOS characteristics approach those of an ideal logic family with respect to noise immunity, power-supply tolerant, temperature stability and static power consumption.

CMOS is therefore the best choice whenever its limitations do not prohibit its use. These limitations are in speed and output current, CMOS should be selected when a propagation delay of 20 to 30 nanoseconds is tolerable or where the maximum switching frequency is less than 3 to 5MHz.

For the reasons given above CMOS devices were used in this project.

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULT INTERPRETATION

3.1.0 CONSTRUCTION

The construction of the project was carried out by soldering the components and its IC's on the veroboard with the aid of the overall circuit diagram.

The soldering was done in modules, proceeding from one module to another after due testing.

3.1.1 POWER SUPPLY

The first module, which is the power supply unit, was constructed by soldering the bridge rectifier on the board, the appropriate connection to the transformer and the smoothing capacitor were then properly soldered, this was then followed by the soldering of the voltage regulator on the IC board.

A 270Ω limiting resistor was then soldered in series with the LED indicator across the positive nail and the ground.

3.1.2 PULSE GENERATOR

The next module, the pulse generator was soldered and all the necessary connections were made in accordance with the circuit diagram.

3.1.3 COUNTER

The next module is the counter circuit interconnected via the pulse generator through switch S_1 and S_2, the switch counting down mode. S_3, the reset switch.

3.1.4 SWITCHING CIRCUITS

The next module is the switching circuits which is interconnected from the four output terminals of the counter IC to the four input terminal of the switching IC.

3.1.5 RESISTOR NETWORK

The resistor network is arranged in a R-ladder network i.e. 1k, 2k, 4.7k and 8.2k, each resistor was connected to the in-between IN/OUT and OUT/IN of CD4066 and this is possible by checking the pin out of this IC in the ECG handout.

3.2.0 TESTING

As construction is being down in module, the testing is as well being carried out in module. Power supply unit after construction is being tested by observing the glowing of the LED as the power switch is on.

Pulse generator is connected to the output by a LED, this LED on testing by switching on the power indicating the presence of pulses by coming ON and OF at regular intervals.

Counter circuit has 4 output terminals which is connected to LED, respectively, this circuit is being tested by observing the glowing of this LED connected and soldered to the 4 respective outputs of each terminal.

The glowing of the LED is not enough, the rate of glowing of the LED must be responding to the natural counting number represented in the binary form by the ON and OFF of each terminals.The resistor network is connected by soldering iron on the respective O/P terminal of 4066The resulting instrument is then placed in plywoods casing and in order to protect the integrated circuit from being damaged by the soldering iron heat, IC socked were first placed and solder on the board, before inserting the IC on the socket.

3.3.0 RESULT INTERPRETATION

COUNT	8.2K	4.7K	2K	1K	
	D	C	B	A	Z
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	2
3	0	0	1	1	3
4	0	1	0	0	4.7
5	0	1	0	1	5.7
6	0	1	1	0	6.7
7	0	1	1	1	7.7
8	1	0	0	0	8.2
9	1	0	0	1	9.2
10	1	0	1	0	10.2
11	1	0	1	1	11.2
12	1	1	0	0	12.9
13	1	1	0	1	13.9
14	1	1	1	0	14.9
15	1	1	1	1	15.9

FIG. 3.0 TRUTH TABLE FOR RESULT INTERPRETATION OF DUAL CHANNEL DIGITAL VOLUME CONTROL

The active high output D,C,B,A of the counter are used for controlling bipolar switches in each of the CD 9066 ICS [IC3 and IC4].

Each of the resistor in the R-ladder network is connected through an electronic switch, input is Pre-amplifier audio signals and ground, when a binary 1 appears at the control logic circuit of a switch, it closes the switch and connects the resistor to the reference pre-amplifier audio signals, on the other hand, a binary 0 connects the resistor to ground.

Each of the output bits, when high, short a part of the resistor network comprising resistors R_6 through R_9 for one channel and R_{10} through R_{13} for the other channel, and thereby control the audio Pre-amplifier signals being fed to the input of the power amplifier to vary the volume as will be reproduced in the 8w speaker connected to the output of the power amplifier.

The shunting action of the resistor network for the volume control with respect to the switches by the high and low output of the counter is shown in the truth table fig. 3.0. above.

CHAPTER FOUR

4.1.0 CONCLUSION AND RECOMMENDATION

It can be conducted that most of the objective of the design work were achieved, the major objective is to replace the manual volume control in our hi-fi set and it has been dutifully carried out.

Although, the resulting instrument is a bit bigger than the pre-supposed commercially available digital volume control but this is expected because

(a) Inclusion of the power supply unit which if it is supposed to be commercial available one would have been taken care by the main power supply unit to the whole hi-fi set.

(b) In commercial production, LSI (large scale integration) integrated circuit would have been used, to be precise, a single IC that performs the function of digital volume control with some additional function incorporation existed, but this is not available for this project.

4.2.0 RECOMMENDATIONS

In future work of this type, for a better occupy, crystal oscillator can be employed instead of 555 time to generate the pulses.

Solar cells can be used for the power supply to achieve further reduction in size.

A digital display can as well be incorporated via LCD because of low power consumption.

And finally, Infra red transmitter and receiver can be incorporated to make it a remotely controlled digital volume control.

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