DESIGN AND CONSTRUCTION OF A SATELLITE DISH ACTUATOR

BY

JOHN HABILA ANDREW

(97/6045EE)

OF

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR IN ENGINEERING (ELECTRICAL AND COMPUTER ENGINEERING) FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

SEPTEMBER 2003

CERTIFICATION

I hereby certify that this work was carried out by JOHN HABILA ANDREW of the electrical and computer engineering department federal university of technology minna, Niger State, Nigeria.

....

Student signature

Date 20th Oct, 2003

....

SUPERVISOR

ENGr. M.D. ABDULLAHI

DATE 28/10/03

....

HEAD OF DEPARTMENT

ENGr. M.N. NWOHU.

DATE 26/4/04

....

EXTERNAL EXAMINER

DATE..........................

DEDICATION

I dedicate this project to the

BLESSED VIRGIN MARY:

Mediatrix of all graces.

AKNOWLEDGMENT

My sincere and honest gratitude goes to my creator, the almighty God, the infinite wisdom. His son, Jesus Christ, the word incarnate. For the special grace to live and be loved, protected and cared for, and for special guidance through the cause of my sturdy. May honour, glory and power be his forever and ever.

In a special way I wish to express my profound gratitude to my project supervisor ENGR MUSA DAJI ABDULLAHI (the man of the century). For the special attention, fatherly and faithful contribution and guidance he accorded me in the cause of this project. Above all his ardent love for the younger generation.

I also wish to appreciate the patience and generosity of ENGr EMMANUEL ARONU who made special inputs in this project. Same goes to all lecturers and staff of electrical and computer engineering department.

My deep appreciation goes to my parent Mr. and Mrs. John Audu, and to my late grand mother for their care, love and inspiration. For all the support given me in this wild search for knowledge may God reward them?

My indebtedness goes to my special friends and brothers, Bro Sam Mary Nwalozie and Bro Alphonsus Marie Ukwu, to whom I owe a greater part of my stay in this school. These were hands that never got tired. In them I saw true love may our lord Jesus Christ whom they imitate never turn his face away from them.

I am also highly indebted to Mr. And Mrs. Daniel Madibo of the federal university of technology Minna, for their concern especially my health and upkeep. And not to forget my late friend Elisha Usman may his gentle soul rest in perfect peace.

My profound gratitude also goes to my uncle Mr. Michael Gberhe of KRPC Kaduna, and his wife Sarah for all their financial and moral support.

My heart felt gratitude also goes to my cousin brother Emmanuel Yusuf, my friend Godwin kukah for all their financial support.

I sincerely wish to thank Miss Gloria Osagie and her family for they were my source of courage.

With all the love of my heart, I wish to appreciate all my younger ones, especially Helen and Mathew whose chain of prayers and novenas have sustained the whole family and me. May God give them the grace to remain in his love. Daniel I also appreciate you.

Finally I wish to acknowledge the overbearing tolerance and generosity of Emmanuel Akut who made his computer available for my use.

A.J. HABILA

ABSTRACT

This project is an intensive exploit into the great but hidden potentials of **stepper motors**. It aims at introducing anew approach to the control and actuation of satellite dish for both domestic and commercial use.

The technique employed was that of using discrete component, LSI and MSI technology to carry out functions meant for intelligent IC's and microprocessors this is seen in the translator circuit, where a flip flop and an XOR gate were use to generate a stepping sequence for the stepper motor control. In this report a complete chapter is specially for stepper motors.

An astable multivibrator circuit with NAND gate produces square waves, which are used to trigger the translator circuit. This generates a special sequence of four different output pulses to drive the four-phase stepper motor.

To meet up with the high current demand of the stepper motor and other component the 7105 was used in the increased current mode employing a TIP32 PNP transistor. Where as the regulator regulates the voltage, current up to 2.5 A can be drawn from the power supply

The satellite dish will conveniently move from 0 to 360in 48 step pulses. Two stepper motors control both AZIMUTH and HORIZONTAL. The stepping sequence of the stepper motor is displayed by LED each representing a phase.

To add glamour a melody generator based on three NAND gate oscillates, oscillating at different frequencies is added to alert the user that the dish is in motion. The angular displacement of the dish is also displayed on a three and half digit seven-segment display.

A provision is also made for control via RS232 port for IBM compatible personal computers(PC 's), the 74 LS 245 bi-directional buffers are used. Parallel data is fed directly into the output of the translator circuit. This is also the input to the transistor bases that drives the stepper motor.

This finally accomplished by the construction of a prototype 300mm dish with a table stand.

TABLE OF CONTENTS

Contents *Page*

CHAPTER ONE

1.10 INTRODUCTION

A satellite is a relatively small object moving in an orbit around a planet. It may be natural or artificial, manned or unmanned, passive or active.

From the launching of the first commercial satellite in 1965, the INTELSAT, satellite communication has continued to develop to its present state, where it has found use in military and marine technology weather and space research, communication industries, direct TV broadcasting, to mention but a few. It is also worth noting that the global communication network solely depends on satellite technology.

One of the most important devices used in sending (uplink) and receiving (downlink) signals is the satellite dish, technically called, REFLECTOR ANTENNA. This is found in the earth stations where signals are sent or received.

With the compression of satellite dishes, from the 30m and 25m diameter dishes to 3m, 2.4m, 1.2m and presently the 0.45m diameter (DSTV) dish and VSAT for internet services. The dish has been domesticated, hence, the need for more attention

An important factor in the design of a satellite dish is the optimization of reflected signals through tracking accuracy. This is of high priority especially in domestic satellite direct TV broadcasting, which is made to receive narrow beam signals.

The aim of this project is to provide a more precise method of tracking, using *stepper motor*. Though in big earth stations the wheel and track mount are used whereas small and medium ones use electric motors. In most domestic applications, a system of jack and gears and other inefficient mechanical system are used for tracking.

In mechanical method of control, where more than one person is employed to track as well as monitor signal on the receiver, efficiency is very low. The motorized system of controlling the actuator is limited in terms of accuracy. There is no stopping torque except friction, which is transient (i.e. the motor gradually ground to a stop when it has been de-energized). Position sensing is done through feed back control, this can have defect due to hash weather like the rusting of transducer.

In this design stepper motors are used. This is a technology that has been used and is being used in position control of computer peripherals, textile industries, integrated circuit fabrication, robotics etc. They are used to control position without need for position feedback rather, by keeping count of the number of electrical pulse input.

The architecture of this project is in two major parts viz **electrical** and **mechanical.**

ELECTRICAL

This part has eight basic building blocks, the oscillators, translator circuit, display circuit, melody generator, power supply, interface and enhancement circuit.

There are two oscillators OSC 1 and OSC 2. OSC 1 generates pulses at a frequency of between 1 and 100Hz, which is used in the stepper motor drive to trigger its control. OSC 2 operates at frequency of 7.5 times the frequency of oscillator 1. their two variable resistors are ***ganged*** where as they have capacitors of different values this give out pulses equivalent to the step angle.

The display circuit uses three presettable up-down counters, to count the pulses from oscillator 1 and display the exact position, of the dish on seven segment display using seven segment decoder/ drivers/latch to the display. The position of the dish is given in three digits from 0-360°.

The stepper motor driver circuit uses two flip-flops and four exclusively OR gates to generate step pulse in the two phase step mode and the out put is used to switch the transistors that drive the stepper motor. Four outputs are used to drive the motor, two at a time.

The stepper motors are four phase, 12V variable reluctance stepper motors connected in parallel with 1N4004 diode for freewheeling operation i.e. providing a path for the emf which arises as a result of induced current in the coil.

The PC interface unit is provided to enable interfacing with a personal computer. A program can be written in Q basic or VISUAL and used to control the stepper motor with angular position of the dish visually displayed on screen. The unit is interfaced through a buffered RS232 serial port.

The logic control block selects position control for horizontal and azimuth, forward or reversed directions. It controls the operations of the counter and dictates missing pulses. It also enables the melody generator and sequence indicator to indicate dish movement

MECHANICAL

This aspect deals with the fabrication of a prototype 30cm dish .The dish comprises of the stand, which is made of steel and a table stand. Coupling of the joints is done using bearings. The surface of the dish is made up of wire gauze.

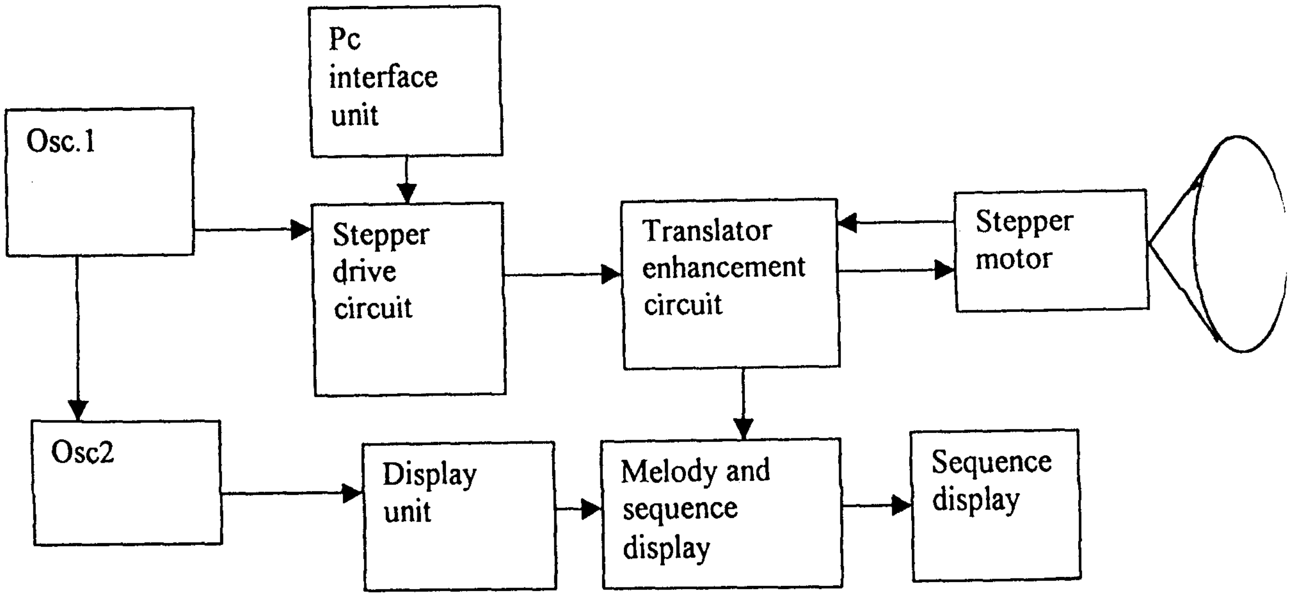


Fig 1.1 Block diagram of the complete project design

1.20: LITERATURE REVIEW

A British science fiction writer Arthur C. Clarke, is given the credit of originating the idea of satellite technology, when in his book in October 1945, "Extraterrestrial Relays" wireless world, proffered the idea of asynchronous communication satellite.

In 1968, in another of his books, "Space Odyssey" noted that a satellite in a circular equatorial orbit with a radius of about 42242 km would have an angular velocity that matches the earths. Thus it will always remain above the same sport on with respect to the ground, and it could receive and relay signals from most of a hemisphere. Three satellites spaced 120 degrees apart could cover the whole world (with some over lap). Provided that message could be relayed between satellites, reliable communication between any two points in the earth could be possible.

With Clarke's idea, there was no rocket launcher till 1957 when USSR launched SPUTNIK 1 on October 4th. But asynchronous orbit was not achieved till 1963.

Being triggered by USSR, there was a space race, with USA trying to catch up with USSR. This they did by launching the SCORE (signal communication by orbit relay equipment) launched by US air force on 18th December 1958. This was used to air president Eisenhower's taped message. It had a lot of limitations and failed after 35 days as it batteries ran down.

On august12th, 1960 and January 25th, 1964 ECHO 1&2 were launched by AT&T. This attracted widespread attention because they served as passive reflectors and could be seen. They had no battery to run down either but its limitations were many such as high power consumption and large antenna etc. TELSTAR 1&2 were launched on July 10th, 1962 and may 7th, 1963 respectively by BELL COMMUNICATIONS. Their choice of frequencies resulted in interference with other terrestrial links sharing these bands, hence the US Congress passed a Bill banning them from operation and establishing thecommunication cooperation (comsat).

In 1965 SYNCOM SERIES were launched. One failed during launching but two were successful. Being a joint effort by the National Aeronautics and Space Administration and the US Defense Department, hence it used military frequencies.

The first commercial geo-synchronous satellite was INTELSAT 1 (first called early birth) developed in by Comsat and launched in1965 April 6th. This was active till 1969. Routine operations between the United States and Europe began on June 28th 1965. This date is recognized as the birthday commercial satellite communication.

Today over a hundred satellite systems worldwide are in space. The ***reflector antenna gives access to multiple access of this satellite.***

The use of stepper motors could be traced back to Robotics, where they are widely used and were first made for. Though industrial robots have been in existence for quite a number of years, it is only in the 70`s that research effort into sophisticated computer-controlled devices began due to the advent of microprocessors.

The word robot was first used in 1921 by a Czech play-write, novelist and essayist Karel Capekor as "slave laborer", in his satirical drama, entitled RUR (rossum`s universal robot) derived from a Czech word meaning "forced laborer". The word robotics was carved by Isaac Asimove in his short story "runaround" published in 1942 where he gave the three rules of robotics. Robots continue to grow and were powered by hydraulics, and pneumatics.

In 1970 Victor Scheinman, while at Stanford University, demonstrated computer-controlled manipulator that was powered by servomotors rather than hydraulics.
Later it was discovered that for precise position control, arm azimuth and other functions, a drive other than the servomotor is needed hence the introduction of ***stepper motors***.

CHAPTER TWO

THEORY OF DESIGN

2.10 POWER SUPPLY

2.11 introduction

The power supply is built to supply voltages of 12V, 5V and 3V.

The 12V supply is from the 7812 fixed regulator output. While the 5V supply, which requires 1.5A is the sum of Io and Ic from the increased current regulation of 7805 and TIP 32. The 3V is from the zener diode connected across the 121v output.

2.12 Design procedure.

The total current consumption of the circuit is about 1.5A; the transformer used is rated 20V and 1A. This is to ensure that there is enough power even at low voltages.

For the increase current regulator connection it is to give a maximum of 2A. The current increases as the load increase.

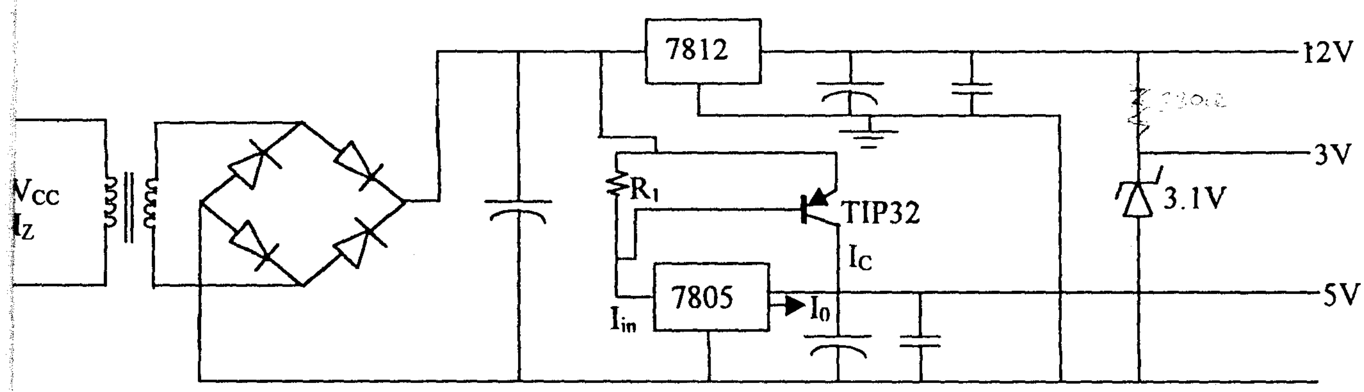


Fig 2.12: *power supply circuit*

For a low current, voltage drop across R1 is insufficient to turn on Tr1 and the Regulator supplies the load current as I_L, increase V_{R1} increase, when it is up to 0.7V the transistor turns on. Hence excess current comes from Tr 1 after amplification by β, the regulator adjust so that.

$I_L = Ic + Io$, we know that $I_C = \beta I_B$, $Io = I_i - I_Q$, where I_Q is quiescent current

$$I_B = I_i - I_{R1} \qquad I_{R1} = \frac{V_i}{R}$$

$$= \frac{I_i - V_{EB\,(ON)}}{R_1}$$

$$I_L = (\beta+1)\, I_O - \frac{\beta V_{EB\,(ON)}}{R_1}$$

Required output $I_L = 2.0A$, $I_Q = 4.2mA$, $Io = 1A$, $\beta = 25$

$Ic = \beta I_B$, $10 = 25I_B$.

$\frac{10}{25} = I_B = 0.04 = 40mA$

$I_O = I_i - I_Q$.

$1.0 = I_i - 4.2mA$.

$2.0\ I_i = 1,0042A$

$.I\beta = I_i - I_{R1}$

$0.04 = Ii - IRI,$.

$0.04 = 1,0042 - I_{RI}$.

$I_{RI} = 0.9642$.

$R_1 = Vi/I_{R1} = 5/(1.9642) = 5.1856 = 5\Omega$.

To get V_{EB} (ON) the equation

$$I_L = (\beta+1)\, I_O - \beta V_{EB\,(ON)}$$

$$2 = (25+1)\, 1 - 25V_{EB}\,(\text{ON})/5.1856$$

$$2x5.1856 = 26x5.1856\text{-}25V_{EB}(\text{ON})/R1.$$

$$(26\text{-}2)\ X5.1856 = 25\ V_{EB}\ (\text{on})$$

$$\frac{24x5.1856 = 25\ V_{EB}\ (\text{on})}{25}$$

$$V_{EB}\ (\text{ON}) = \underline{4.978176V}$$

This means that once there is any drop in voltage of about 5-4.978176 = **021824V** the transistor will supply more current.

2.13 bridge full wave rectification

The diode used is an IC rectifier, it still work on the same principle as if they were four discrete diodes. The process of rectification is explained below.

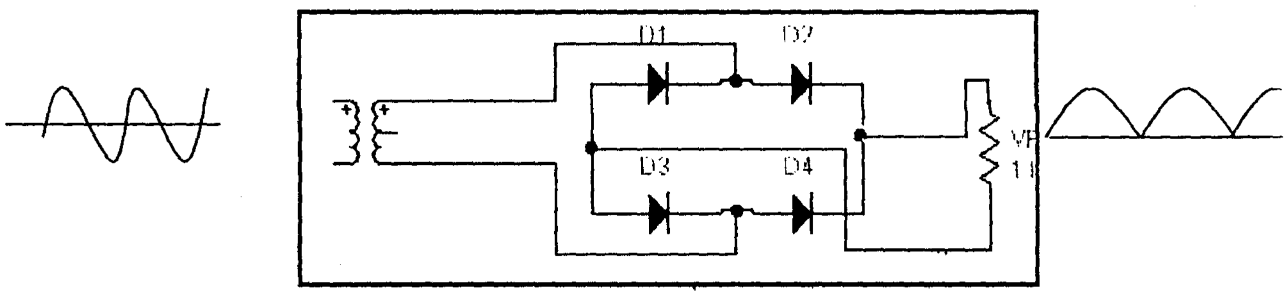


Fig 2.13: Rectification circuit

Full wave rectification is meant to increase the output voltage from VR/π to 2VR/π. This is preferred for higher voltage application. During the positive half of the input voltage D1 and D2 conduct while during the negative half cycle D4 and D3 conducts thereby producing the above output waveform.

2.14: Voltage smoothing.

A capacitor called the tank capacitor is used to filter the output voltage, reducing ripples. The smoothing action of the capacitor is due to the large value of the time constant CxR_L compared to the time for one cycle of the a.c voltage i.e. 1/50 seconds 0.2 seconds.

The capacitor valve used in this design is given by the manufacturer of the IC regulator as 50V/2200uf. The ripple voltage is calculated thus

Output current I_{dc}= 1.5A, F=50Hz C=2200uF

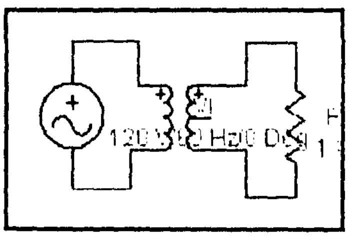
$V_r = Idc/2C$

$= I_{dc}/2FC$

$= 1.5/(2x50x2200x10^{-6})$

=0.682V, which is very small, compared to 12V.

2.15 transformer



This is an electromagnetic device used in transferring power from one circuit to another, at different voltages and different current; while power transmitted is the same neglecting loses.

There are different types of transformers step up and step down. The voltage ratio is given by $V_1 : V_2$ where V1 z input voltage and V2 is output voltage.

If V1 > V2 it is a step down transformer. If V1 < V2 it is a step up transformer.

2.16: diode (wol) bridge rectifier.

The diode used is an IC bridge rectifier i.e. has about four diode incorporated.

It has with the following specifications.

PIV = 100, If (av) = 1.5A, more input V = 70V more load capacitance, more V_f per diode, 1.1at 1A, maximum reverse current at PIV per diode 10μA.

Choice of diode.

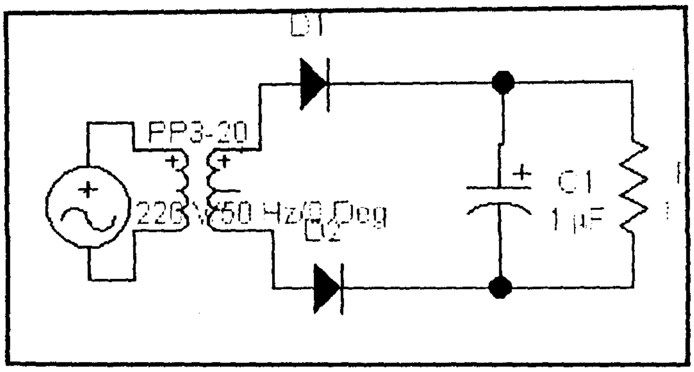


fig 2.16 bridge rectification

When the diode is conducting in the positive half cycle, voltage across the diode is 20V. i.e. the voltage across the transformer. During the negative half cycle the voltage across the diode is voltage across the transformer and voltage across the capacitor. I.e.

$V_T + V_C = V_D$

$V_D = 20V + 20V = 40V.$

Hence it is advisable to choose diodes with V_{RR} not less than 4 times the transformer voltage. V_{RR} = 4Vrms. For thus application the diode chosen has V_{RR} = 100V = PIV. (peak inverse voltage)

2.17 IC regulators.

There different types of IC regulators. Ranging from the LM series e.g. LM317, the 78 series, AN series, e.t.c. the 78 series used in the project are fixed regulators.

2.171 Fixed regulators (78xx)

These regulators produce a fixed output voltage depending on which number of the series is used. The 7812 produce 12V and the 7805 produce 5V.

The input voltage must be at least 2V greater than the output voltage. The maximum current is rated from the manufacturers, 7805 $ 7812 produce 1000mA each.

They have thermal shunt down temperatures sensors which cut off when temperature of the regulator rise to between 120°C to 150°C

The 7805 have an input range from 7 to 18V, output of voltage of 5.0V and 4.98 typical and a quincent current of 4.2mA and output current of 1A.

The 7812 have its input voltage from 15-30V-output current of 1A, quincent current of 4.3mA output voltage 12V rated and 11.98 typical.

2.18: Zener diode

The zener diode is used for voltage regulation this is made to be used in the breakdown region and is connected in reverse bias.

The voltage across it stays almost constant for a wide range of reverse current.

$$V_i = V_R + V_O$$

$$12V = V_R + 3V$$

The melody generator needs 20mA; to carter for eventualities 30mA is provided. Hence.

$V_R = I_R$, $R = V_R/I_D$ = 9v/30mA = 0.3x103Ω = 300Ω = 330K

Then at 330Ω I_D = 9/330 = 27mA.

2.19 TIP32

This is a PNP transistor mostly used as operational amplifier, in this application it is used as a regulator. This transistor complement the popular NPN TIP31, it has V_{CEO} of 60V, V_{CBo}=60,

V_{EB} = -5, I_C = 3A P_D = 40w and hfe 25@3A unit typical F_T = 3MHz. It was use becau8se of its high collector current.

2.30 DISPLAY CIRCUIT

2.31 :Introduction.

This circuit uses three up/down counters 74HC190 this counters are presettable and enable the reading of dish position on both directions. When data is fed into the clock input of the counter and the direction pin pull high the counter is on the down mode and count from nine to zero. If in the other hand the direction pin is pulled low the counter count up from zero to nine. When a maximum/minimum count is reached, the max/min pin of the counter set the next counter. The same apply when the second counter has reached its max/min count.

The binary data from the counter are .fed into the bcd-seven segment latch /decoder driver CD4511this is a tri- purpose chip. it contain bcd to binary decoder, binary to seven segment decoder and a latch. Its compact nature informs it choice for this project.

The results of the counter and decoder action are displayed in a three and half digit seven-segment display. Each of the segments is driven by the output of the CD4511through current limiting resistors. Each also display a digit between 0 and 9 hence the three displays the angular position of the dish between 0 and 360.

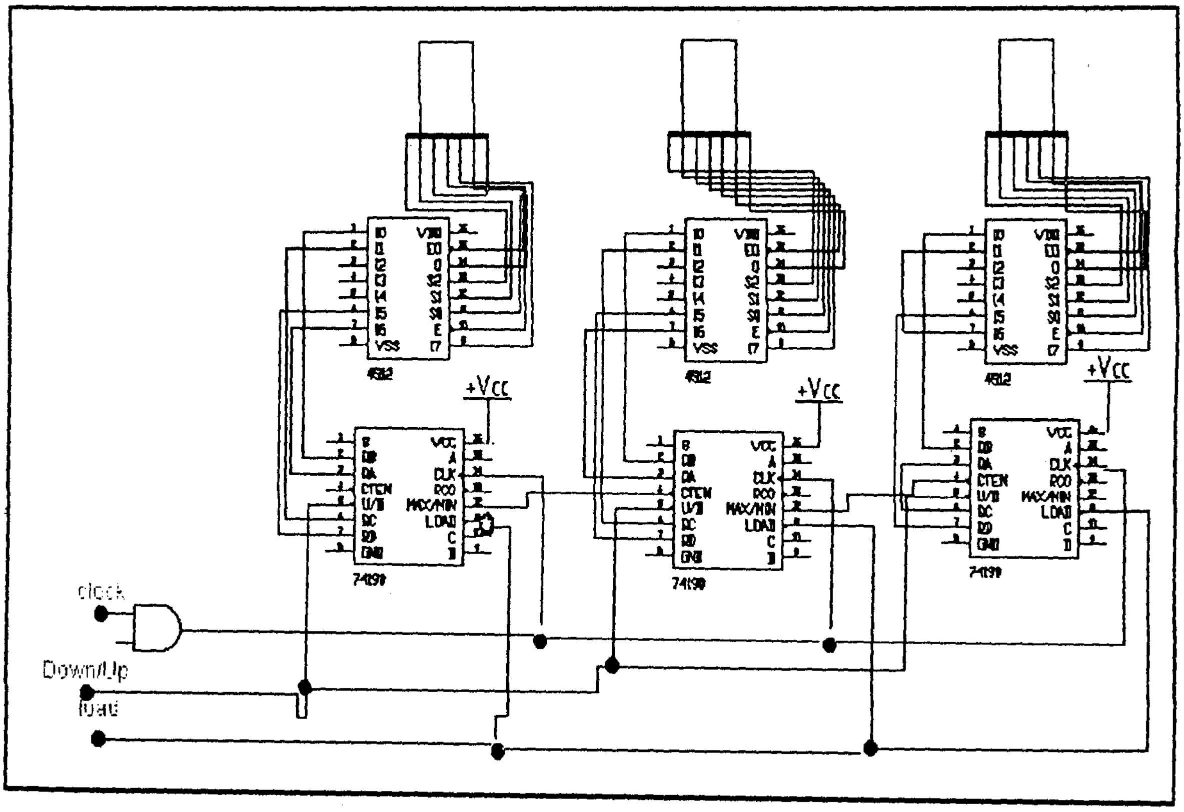


fig 2.30 display circuit

2.32: 74HC190 UP/DOWN counter

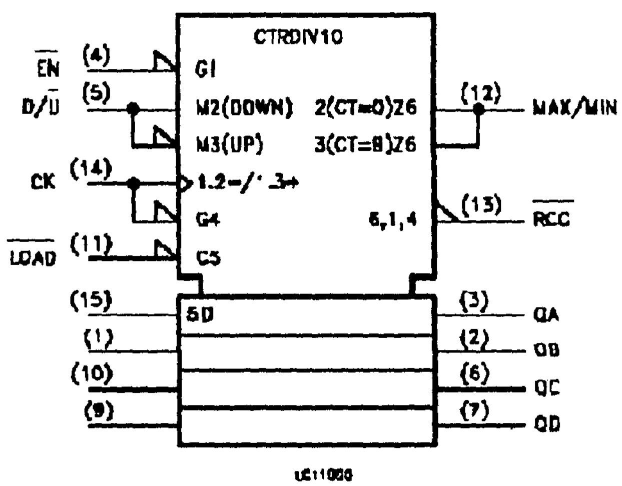
The 74HC190 is a high speed CMOS 4-bit synchronous up/down counter fabricated in silicon gate C^2MOS technology.

It has the same speed performance of LSTTL combine with true CMOS low power consumption.

State changes of the counter are synchronous with the LOW to HIGH transition of the clock pulse input.

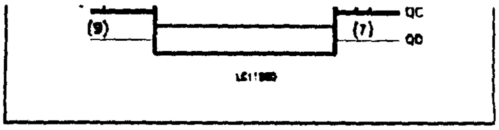
An asynchronous parallel load input override counting and load s the data present on the data input into the flip-flops, which make s it possible to use the circuit as programmable counters.

Fig 2.321 logic diagram



A counter enable input serve as the carry /borrow input in multistage counter s. control input down/up, determines whether a circuit count up or down. AMAX/MIN output and a ripple clock output provide overflow/underflow indicator and make possible a variety of method for generating carry /borrow signals in multi stage counter applications.

All inputs are equipped with protection circuit against static discharge and transient excess voltage. The logic symbol, truth table and internal circuitry of the counter are shown below.



TRUTH TABLE

INPUTS				OUTPUS				FUNCTION
$\overline{LOAD}$	$\overline{ENABLE}$	D/$\overline{U}$	CLOCK	QA	QB	QC	QD	
L	X	X	X	a	b	c	d	PRESET DATA
H	L	L	_⌐	UP COUNT				UP COUNT
H	L	H	_⌐	DOWN COUNT				DOWN COUNT
H	H	X	_⌐	NO CHANGE				NO COUNT

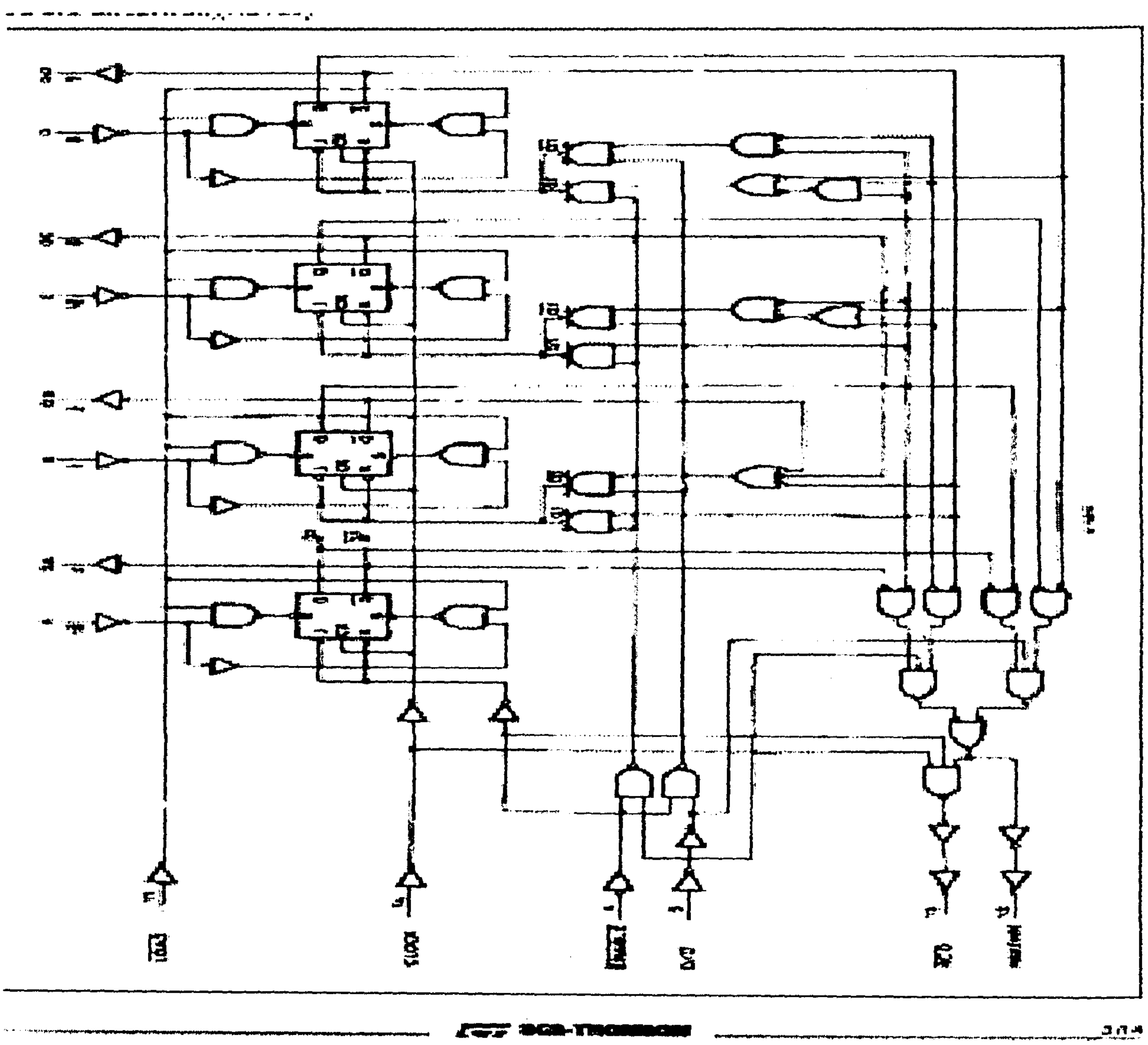


fig2.322 block diagram of74HC190 and truth table.

2.33 : CD4511 bcd-seven segment latch / decoder

The 4511 BCD 7-segment latched decoder/driver is constructed with complimentary MOS (CMOS) enhancement mode and devices NPN bipolar output drivers in a monolithic structure.

The circuit provides the functions of a 4-bit storage latch an 8421 BCD to seven segment decoder and an output drive capability lamp test (LT) blanking BC, and latch enable (LE) input are used to test the display to turn off or pulse modulate the brightness of the display, and to store a BCD code respectively.

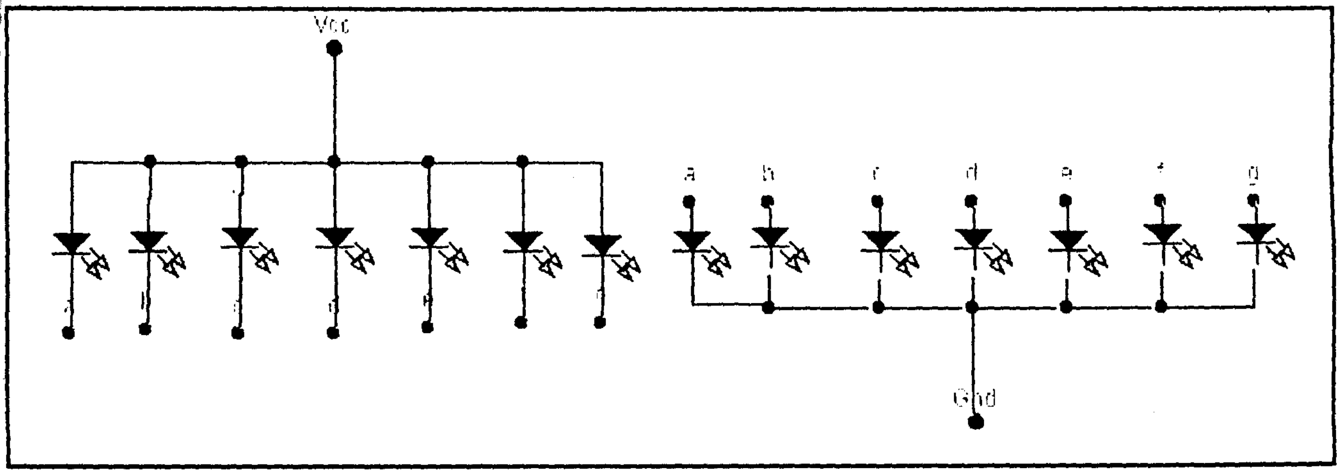
It can be used with seven-segment light emitting diodes (LED) incandescent, fluorescent, gas discharge, or liquid crystal readouts, either directly or indirectly. Applications include instrument (e.g. Counter, DVM, etc) display driver, computed calculator display driver, cockpit display driver and various clock watch and timer uses.

2.33: seven segment display

The seven-segment display is a very popular arrangement, and can be obtained using light emitting diodes (LED) elements, gas discharge or liquid crystal display (LCD) elements. The figure above shows the arrangement and usually labeled a to g, with the decimal point labeled Dp.

Each segment is an individual LED and has an anode and cathode lead. There are two types; the common anode and the common cathode.

In the common anode all the anodes are connected together, as shown below in the same way all the cathode are connected together for the common cathode type. In TTL circuits the common anode display is usually preferred.



For this arrangements the out puts of the logic circuit, or driver, must go low to provide segment illumination. For a particular number to be indicated the correct segment leads must be connected to ground.

The current through each segment diode must be limited to 20mA(though presently there are low current types consume as low as 5mA).

One of the advantages of the LED seven segment display is that it is rugged and the fact that it can operate at more lower voltages than the cold cathode tube. There are also multi digit displays such as the two-digit type, the three and half digit type etc

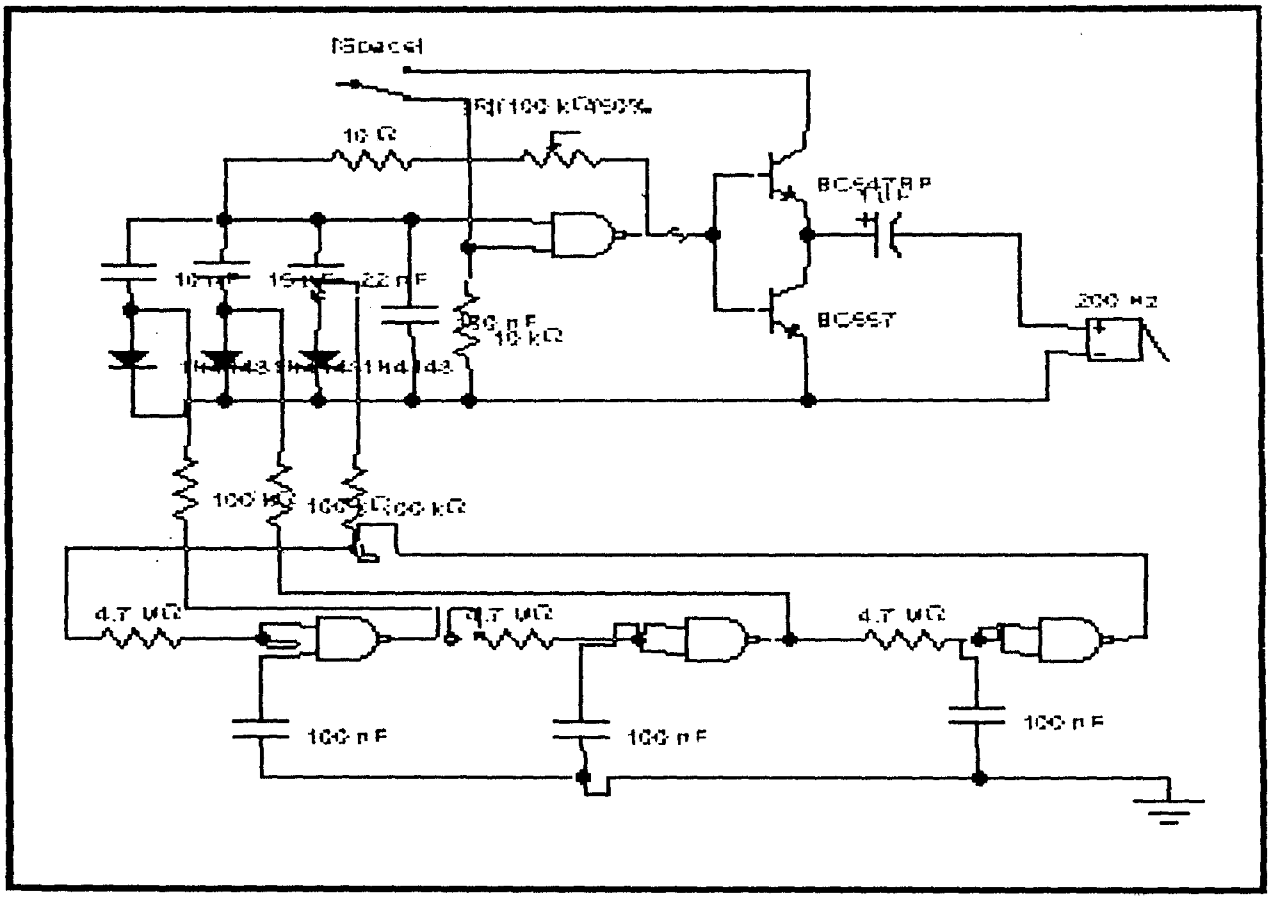
In this project the three and half digit type is used and also the common cathode type.

2.40 MELODY GENERATOR

2.41:introduction

This melody generator is based on type 4093 CMOS Schmitt trigger. Three NAND gates are connected in series by an RC networks. An oscillation is effected by feed back of the output signal of NAND gate N4 to input N2.

The logic high level produced by the gates in the oscillator circuit are used for biasing one of associated diode D1, D2, D3.the relevant diode connect one of frequency determining capacitors C1, C2, C3 tone oscillator N1. The audio signal is applied to complementary transistor T1&T2 that drives the loudspeaker .The frequency of emitted tones can be varied by Vr.



2.42: CD4093 CMOS quad 2-input Schmitt trigger NAND gate

The 4093 consist of four Schmitt trigger circuits. Each circuit function as a two input NAND gate with Schmitt trigger action in both inputs. The gate switches at different points for positive going and negative going signals. The difference between the positive

(V+) and negative (V+) voltage is defined as hysterises voltage (V_H). All outputs have equal source and sink currents and conform to standard B-series output drive.

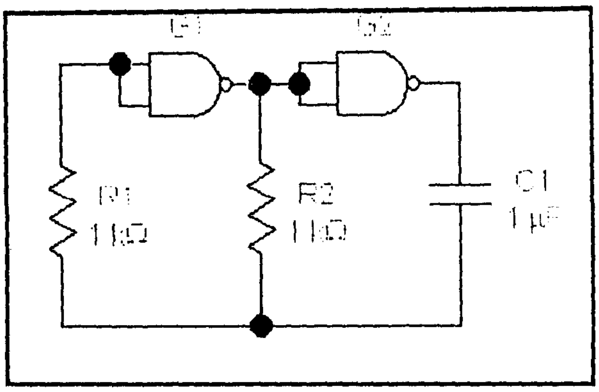
The supply voltage range is 3V to 15V with a noise immunity of over 50% and hysterises voltage at TA = 25oC, at any input.

Typical at VDD = 5V V_H = 1.5V

VDD = 10V V_H = 2.2V

VDD = 15V V_H = 2.7V

2.50: OSCILLATORS



2.51 Introduction

Resistor R1 is meant to protect the input diode of the gate.

The positive feed back from the output of G2 to input of G1 via C1 causes the astable to rapidly change state. Assume that the output of G2 has just gone high. The input to G2 must there fore be low at approximately 0 volt, as will be the output of G1. The input to G1 must be at threshold voltage. When G2 output goes high the rise of almost 3.6 volt is passed via C1 to the input of G1, taken G1 input voltage to 5.6 volt C1 charges at a rate determine by the time constant C1, R2,.

$T = 2.2\ C1\ R2$ sec. $F = 1/T$ Hz.

2.52 Oscillator 1.

The frequency of the oscillator is not fixed rather it ranges between 1 Hz and 100 Hz this is to enable the user choose the rate at which he moves the dish.

FL= 1Hz and FH = 100Hz, C1 is chosen to be 680nf.

$FL = 1\ 1 = 1/(2.2x680x10^{-9})xR.$

$R = 1/(1.496x10^{-6}).$

$= 6.68449x10^{5}.$

= 668.449KΩ.

Hence 680KΩ was chosen for FH = 100Hz.

100 = 1/(2.2x680x10-9RH).

RH = 1/(2.2x680x10-9x100).

= 668 4.49Ω.

Hence RH = 6800Ω was chosen.

= 6.8KΩ.

2.53 Oscillator 2

This oscillator runs at a frequency of 7.5 times the frequency of oscillator 1 thus clocks the counter.

Therefore only the capacitors used for the oscillator are different $C = 680nf \times 10^{-9}/(15)$

$290.66\ 7 \times 10^{-9}.$

R still remains the same as in oscillator 1.

To get 90nf, three 270nf capacitors at connected in series.

i.e. 1/G = 1/C1 + 1/C2 + 1/C3.

1/CT = 1/270 + 1/270 + 1/270.

= 3/270 G = 270/3 = 90nf.

R2 for the two oscillators is ganged

CHAPTER THREE

STEPPER MOTORS

Stepper motors are motors whose shaft is able to assume only discreet angular position. The rotary motion occurs in stepwise manner from one equilibrium position to the next. They have found applications in robots, computer peripherals such as printers, tape drivers, capstan drives and memory access systems. They are also being used in equipment related to process control, machine tools, and medicine

3.10: TYPES OF STEPPER MOTORS.

There are large varieties of stepper motors; these can be grouped into three basic categories; variable reluctance stepper motors, permanent magnet stepper motors and the hybrid stepper motors.

3.11: Variable reluctance stepper motors

In the variable reluctance stepper motors both the stator and the rotor have different magnetic reluctance along various radial axes. The basic principle of operation of the variable reluctance stepper motor is that, the phase windings are placed in two, diametrically opposite the teeth. As the number of teeth on the stator are not equal to the number of teeth on the rotor, when the stator is energized the rotor teeth nearest to the energized phase move to align itself with the stator. The step angle is given by;

Step angle =$360/qN_r$ where q is the number of teeth in the rotor. Nr = N_s/q Ns no of stator teeth. This is the type used in this project.

3.12: Permanent magnet stepper motors

In this type of motor the rotor is magnetized to consist of four permanent magnets poles and the stator contains two phase winding that can be excited with either polarity current. Each step windings produces the same number of poles as the rotor .the magnetic poles produce by the stator current caused the rotor to move.

These motors suffer from the disadvantage of higher inertia- to-torque ratio and the difficulty of manufacturing a fairly small step angle. They have an advantage that there is some torque to maintain position if the driver fails.

3.13:Hybrid stepper motors

These are also called synchronous induction motors. They combine the principles of variable reluctance and permanent magnet stepper motors. The permanent magnet placed parallel to the shaft axis to create a pair of poles, on each magnet two end caps are fitted at both ends.

These consist of equal number of teeth .the stator consists of two-phase windings and each phase winding produce s four poles. Excitation of a stator phase creates flux in radial direction through the two air gaps. When a phase winding is excited a torque is exerted on the rotor because of its excited phase.

Torque in hybrid stepper motor is produced by interaction of the rotor and a stator field .the rotor field is produced by per magnet hence stays constant to the phase current. Hence the stator field is proportional to the phase current. Commonly available hybrid stepper motors have step angles of 1.8 (200 steps per revolution)

3.20: GENERAL CHARACTERISTICS OF STEPPER MOTORS

- The device can be operated in an open loop manner with apposition accuracy of +/-1step thus if a certain angular distance is specified .the motor can be commanded to rotate and appropriate number of steps and the mechanical element coupled to the shaft will move the required distance.
- The motor exhibit high torque at a certain angular velocity .of course this is useful in accelerating a payload up to speed.
- The motor exhibit allergen holding torque with a dc excitation. Thus it has the property of being "a self locking" when the rotor is stationary. In fact the rotor can move only when the terminal voltage change with time.
- The stepper motor is directly compatible with digital control techniques. Consequently it can readily be interfaced with digital controller and computers.
- It exhibits s excellent position accuracy, and ever more important errors are not cumulative.
- Since open loop control can be employed with the motor it is often unnecessary to use tachometer and /or an encoder. Thus cost is reduced considerably.
- Motor construction is simple and rugged. There are usually only two bearing and the motor generally is accost –effective actuator.
- The stepper can be stalled without causing damage due to over heating.

3.30: EXCITATION OF STEPPER MOTOR

There are different types of stepper motor excitation but the most common ones are going to be discussed.

1.**one phase excitation**: this is also called wave step sequence; each phase is energized in turn, by connecting it to the power supply for a short period of the motor shaft turns, Fraction of a revolution. In this mode the stepper motor move the rated step angle of the motor.

2. **Two phase excitation**: two phases are energized at the same time, this provide a more precise shaft rotation and increase driving power of the motor. it also help damp rotor oscillations compared .

3. **Half step excitation**: this is a combination of the one and two phase mode .the motor attain an equilibrium half way in-between its step angle for any change in step angle.

4. **Micro step excitation:** in this method the magnitude of the phase current is precisely controlled to achieve micro steps per step angle excitation. the motor could be made to move at fraction of its step angle.

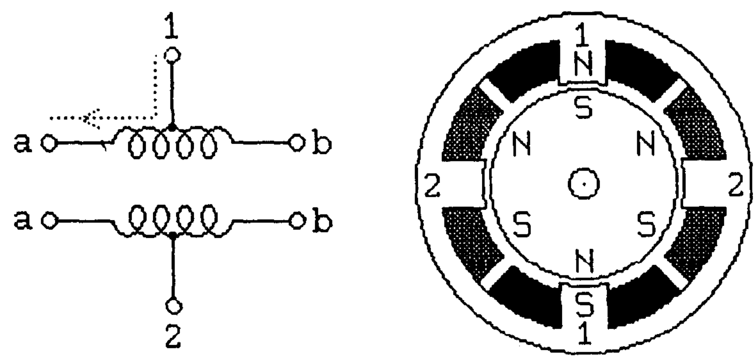


Fig2.23: Internal diagram of permanent magnet stepper motor

3.40 STEPPER MOTOR DRIVES

2.41: ***introduction***

Stepper motors are normally driven by intelligent integrated circuits such as the ***SIGNETICS SAA 1027***,the ***SPRAGUE UCN4202***. These are mainly design to control the common four phase stepper motor by providing the needed stepping sequence and output current of over 300mA which is needed to drive the stepper motors directly.

Another sophisticated drive is the ***CY500*** intelligent controller, which beside providing the needed stepping sequence for the stepper motor, can be directly connected to the computer RS232 parallel or serial port.

Still more ***microprocessors***, ***micro controllers*** and *counter timers*, ***EPROM***'s and other memory devices can be programmed to provide the stepper motors step sequence, acceleration, direction and breaking.

Each of the methods mentioned above has its own limitations, the Sprague UCN4202, the signetic SAA1027 and CY500 have all disappeared from the Nigerian market, if found at all are very expensive. Micro controllers, microprocessors, EPROMS and other memory devices are expensive to program due to non-availability of programmers, They also seem to be under utilized if used to drive less than four motors.

To supplement this a translator circuit using MSI chips with CMOS or TTL can be designed using locally available ICs. In this project the CMOS version was used. CMOS has higher output voltage and current compared to TTL.

3.42: TRANSLATOR CIRCUIT

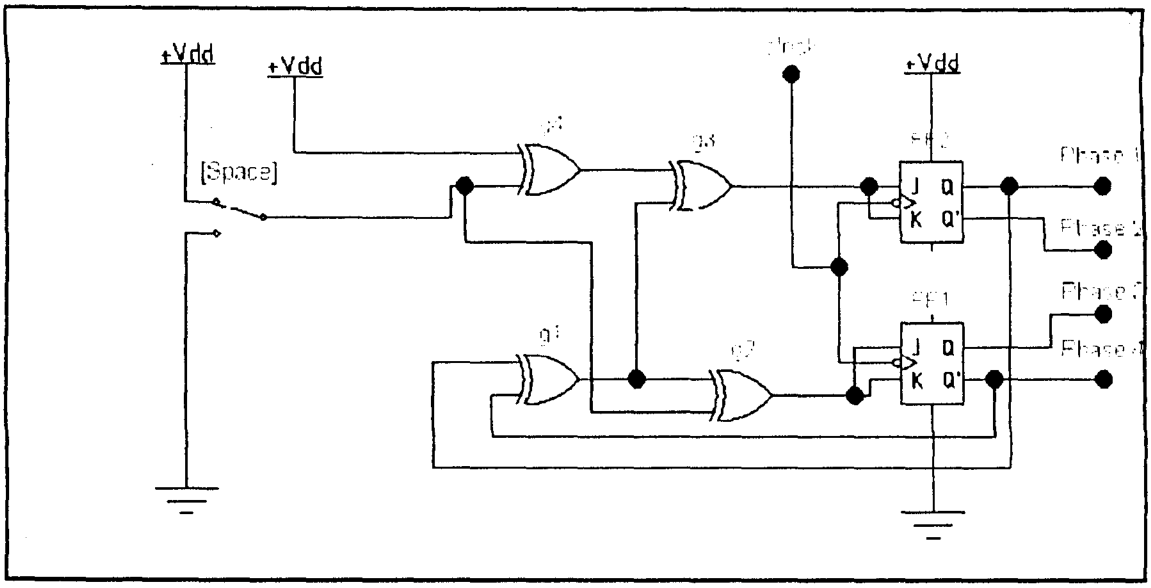


Fig 3.4 translator circuit

The circuit is triggered by an external oscillator osc1 .the translator can control sequence in two directions, clockwise and counter clockwise. The set and reset pins for FF1and FF2, pins 4,7,9,12 are all grounded. JK of FF1 are tied and connected to pin 4 of XOR gate2. JK of FF2 are also tied and connected to output of XOR gate 3. The FF changes state only when JK and the clock pulse are high and the outputs Q and $\overline{Q}$ always complement each other. The FFs are connected in the toggling mode. (j=k=1) and the hold mode. (j=k=0).

3.421Clockwise stepping sequence (CW)

In the CW sequence the input pin 12 and 6 to XOR gate 4 and 2 are pulled High, hence output of XOR gate 2 will be high there by pulling JK1 HIGH this set FF1 on TOGGLE. the out put of XOR gate 3 will be low, pulling JK2 low and setting FF2 on HOLD.

The first clock pulse set Q high and $\bar{Q}$ low for FF1 while FF2 is on hold. With this phase 2 and 3 are energized. This quickly reset FF1on hold and FF2 on toggle by pulling XOR 1 low XOR 2 low.

The second clock pulse will set Q high and $\bar{Q}$ low for FF2. In this case phase 1and 3 are energized. This again quickly reset FF2 to hold and FF1 on toggle.

The third clock pulse set Q low and $\bar{Q}$ high and phase1and 4 will be energized. This again reset FF2 on toggle and FF1on hold.

The fourth clock pulse will set Q low and $\bar{Q}$high for FF1, this energizes phase 2 and 4. FF 2 is reset to toggle and FF1to hold. The sequence continues to repeat itself over and over again. The truth table is shown below.

3.422: Counter Clockwise Stepping Sequence. (CCW)

In this mode the pin 12 and 6 are pulled low by connecting them to ground FF1 will be on hold while FF2 will be on toggle this is due to the output of XOR gate 3 going high and XOR gate 2 going low.

The first clock pulse will set FF_2 Q at high and $\bar{Q}$ at low, FF_1 Q low and $\bar{Q}$ high. Energizing phases 1 and 4. This puts FF_2 on hold and FF_1 on toggle.

The second clock will set FF_1 Q high and $\bar{\bar{Q}}$ at low hence energizing phase 1 and 3. This quickly put FF_2 on toggle and FF_1 on hold.

The third clock pulse sets FF_2 Q on low and $\bar{Q}$ on high and then phases 2 and 3 are energized this quickly set FF_1 on toggle and FF_2 on hold.

The fourth clock pulse set FF_1 Q on low and $\bar{Q}$ high, hence phases 2 and 4 are energized. This is also indicated in the truth table below.

TRUTH TABLE OF STEPPER MOTOR TRANSLATOR CIRCUIT STEPPING SEQUENCE

STEP	PHASE 1	PHASE 2	PHASE 3	PHASE 4	STATE OF FF1	STATE OF FF2
1	L	H	H	L	TOGGLE	HOLD
2	H	L	H	L	HOLD	TOGGLE
3	H	L	L	H	TOGGLE	HOLD
4	L	H	L	H	HOLD	TOGGLE
5	H	L	L	H	HOLD	TOGGLE
6	H	L	H	L	TOGGLE	HOLD
7	L	H	H	L	HOLD	TOGGLE
8	L	H	L	H	TOGGLE	HOLD

H-high L-low ↑ CW ↓ CCW

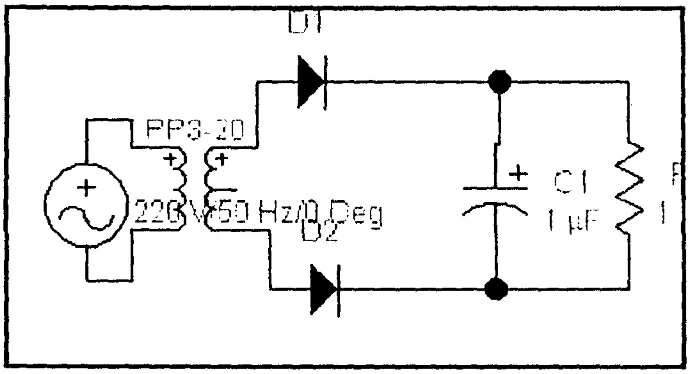
3.423: Acceleration. Increasing the frequency of the clock pulses from the triggering oscillator circuit OSC1 can simply accelerate the stepper motor.

3.424: Breaking this is achieved by energizing the circuit. If no clock pulse is applied the stepper motor remains in fixed position and cannot be moved easily. This is the braking mode.

3.50: TRANSLATOR ENHANCEMENT CIRCUIT

The output voltage from transistor circuit and the current might not drive the stepper motor directly because about 150mA is needed to drive a phase and CMOS IC 's (4027$4070) at 12v outputs -2.6mA.

A Tip 31 transistor is used to drive the motor four are used and connected as switches with their base been driven by the output of the translator. The connection of one phase is shown below.



The resistor R_B is a current limiting resistor; the diode D_1 is a flywheel diode. When the transistor is turned "ON" by a step pulse, the supply voltage is just sufficient to produce the rated winding current. When the transistor is turned "OFF", D_1 provides a path so that the current can decay without damaging the transistor. It reduces the amplitude of the voltage over swing.

3.51: Design procedures;

The transistor used is TIP31, it parameters are given below V_{ceo}=60V, V_{cbo}=60V, V_{ebo}=5V, I_c=3A, P_d=40mW, Ft=3, hfe=25@3A.

For a switching transistor it is required that $\frac{I_C}{I_B} < 5h_{fe}$

Motor resistance per phase =40Ω

$$I_C = \frac{V_{CC}}{R_C} = \frac{12}{40} = 300mA$$

Since $\frac{I_C}{I_B} < 5h_{fe}$

$$\frac{300 \times 10^{-3}}{I_B} < 5 \times 25$$

$$I_B = \frac{300 \times 10^{-3}}{125} = 2.4 \times 10^{-3}$$

$= 2.4mA$

$V_i = V_B + V_{BE}$

$= I_B R_B + V_{BE}$

$V_i - V_{BE} = I_B R_B$

V_i is voltage output from CMOS at 12V

$V_i = 11.95$

$$R_B = \frac{V_i - V_{BE}}{I_B}$$

$$= \frac{11.95 - 0.7}{2.4 \times 10^{-3}}$$

$$= \frac{11.25}{2.4 \times 10^{-3}}$$

$= 4.6875 \times 10^{-3}$

$= 4.7K\Omega$.

LED's are connected in parallel to each phase to give a visual display of the stepping sequence.

From the diagram below,

$I_T = I_D + I_B$ where I_T is translator output current I_B is the current driving the transistor, and I_D is the current sink by the LED.

I_T=2.6 mA and I_B=2.4mA

$I_D = I_T - I_B$

$= 2.6 - 2.4 = 0.2mA$

$V_i = V_D + V_d$ where V_d is 1.2V, this the voltage drop across the LED

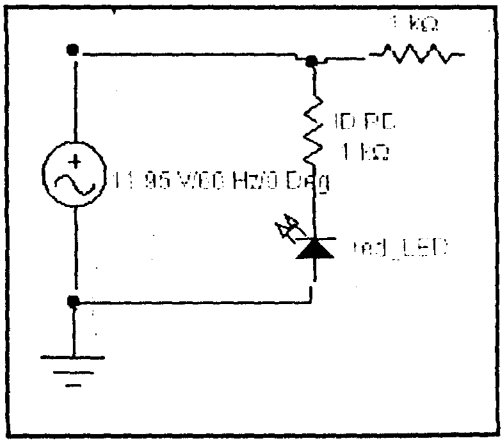


Fig 3.51 LED drive

$V_i = I_D R_D + V_d$

$$\frac{V_i - V_d}{I_D} = R_D$$

$$R_D = \frac{11.95 - 1.2}{0.2 \times 10^{-3}}$$

$$= \frac{10.75}{0.2 \times 10^{-3}}$$

= 53.75 , R_D=54KΩ

TIP31

all the characteristics are the same as those of its complement discussed earlier except that it is NPN

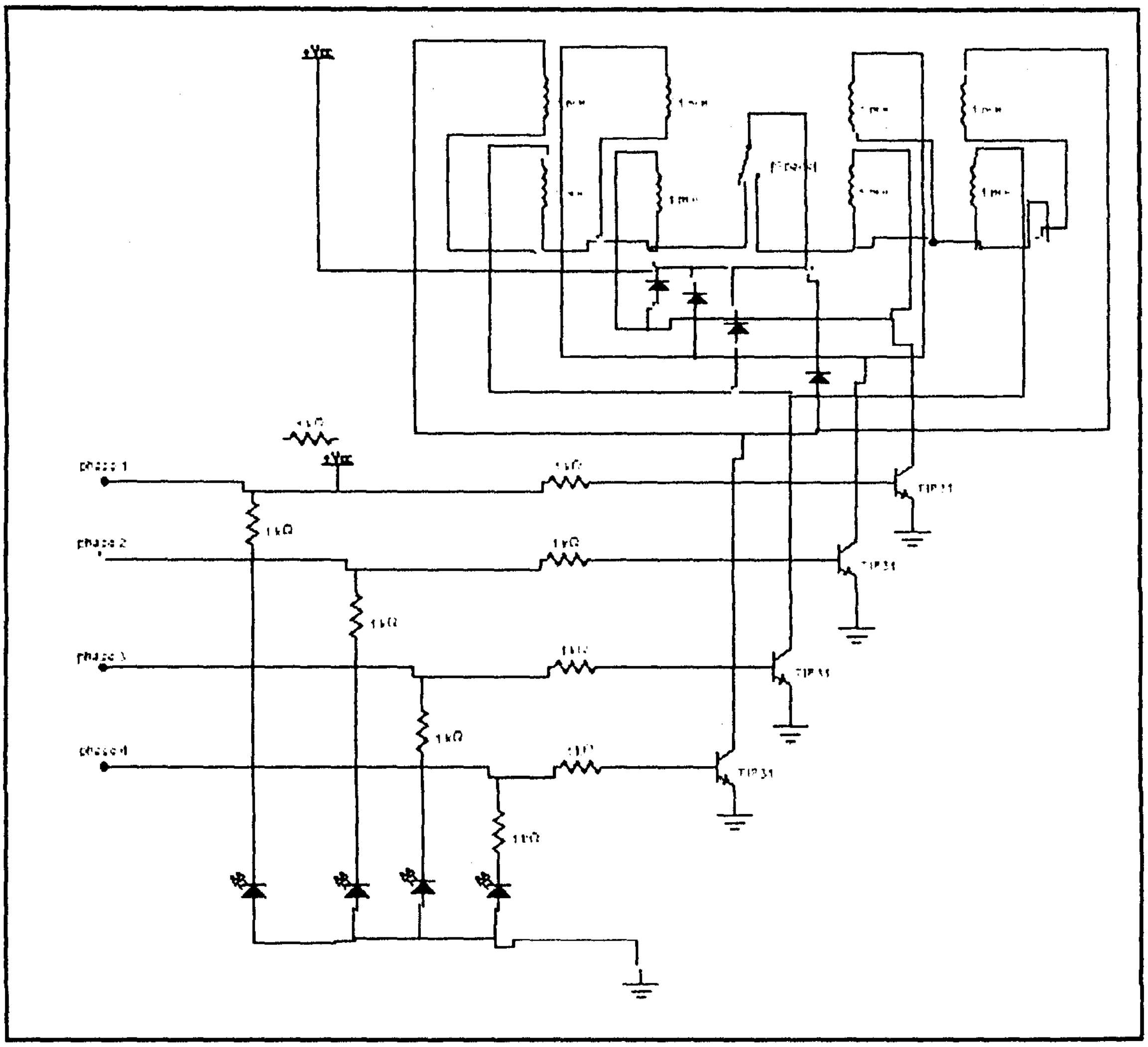
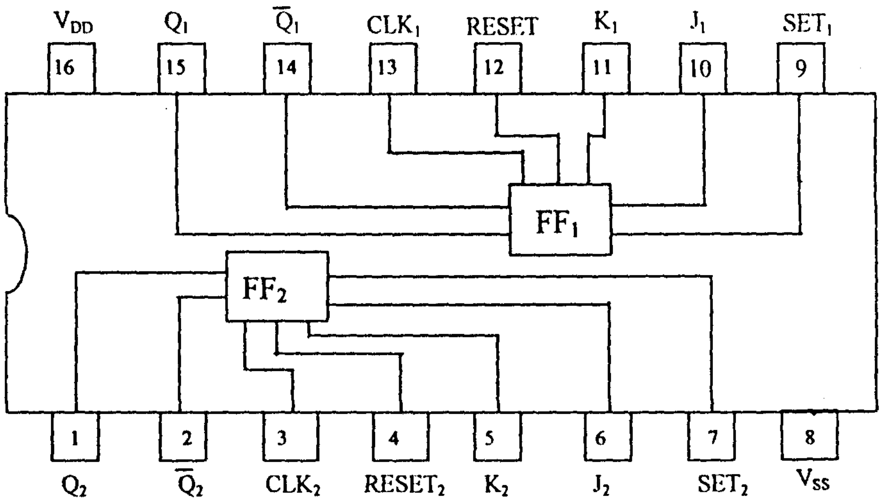


Fig 3.44 complete circuit diagram of stepper motor phases drive

3.52 : CD4027 DUAL JK MASTER SLAVE FLIPFLOP



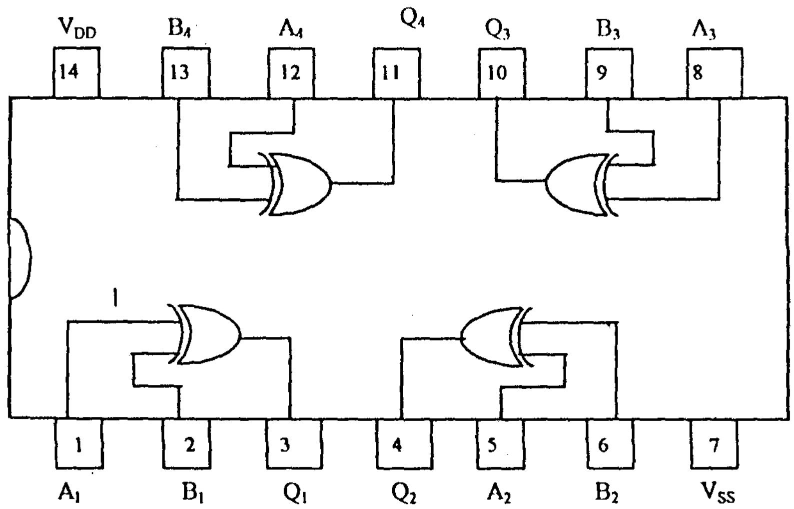
4027 DUAL JK MASTER SLAVE FLIP FLOP

This JK flip-flop s is monolithic complementary MOS (CMOS) integrated circuits constructed with N-channel and P-channel enhancement mode transistor. Each flip-flop has independent JK, set, reset, clock input and buffered Q and Q'outputs.

These flip-flops are edge sensitive to the clock input and change state on the positive –going transition of the clock pulse .set and reset are independent of the clock and is accomplished by a high level on the respective inputs. All inputs are protected against damage due to static discharge by diode clamps to V_{DD} and V_{ss}

Supply range	3V-15V
Noise immunity	.45V_{DD}
Power dissipation	50mW
Speed of operation	12MHz

3.53:CD4070 QUAD TWO IMPUT XOR GATE



CD 4070 QUAD XOR GATE

A 4070 is a CMOS chip in 4000 series range of chips. The chip performs XOR function on 4 sets of 2 digital inputs and create separately powered digital signal out put. An XOR gate is similar in behavior to the OR gate with exception that its 2 high signals create a low output, instead of a high.

The truth table to the bit wise behavior of an XOR gate is shown below.

A	B	Q
1	1	0
1	0	1
0	1	1
0	0	0

3.60 PARABOLIC REFLECTOR ANTENNA

3.61 **Introduction**

This is the design of a conventional circular parabolic dish, the simplest and the cheapest. It is most commonly used for small earth station, the scalar feed it uses produce symmetrical radiation pattern that is broad. It is also frequency independent over a wide bandwidth .all the design specifications for the design of a normal dish were followed.

3.62 **Design calculations**

The angle of the reflector is chosen to obtain a particular edge illumination with a given feed .OF is called the focal length and denoted by F the curvature of the reflector can be specified by F/D.

$$\tan \theta_o = \frac{1}{2} \frac{D/F}{1 - D^2/16F^2}$$

D = Diameter of dish

And the surface of the reflector is given by.

$X^2 + Y^2 = 4F_Z$

$r^2 = 4F_Z$

Where , F_Z = focal length of feed

r = radial distance from the axis OF

The **focal plane reflector** is the main focus of designers because its focus lies on the aperture plane and have a wider range.

The focal plane reflector has **F/D =0.25**

Where **30cm** was chosen as D for the prototype dish

Hence F=0.25 x D

F=0.25 x 0.30

= 0.075m

but $r^2 = X^2 + Y^2 = 4Fz$

$r^2 = 4(0.075)$

= 0.3m

$r = \sqrt{(0.3)}$

$= \sqrt{(300)}$mm

$= 10\sqrt{3}$mm **$r = 10\sqrt{3}$mm**

The angle of reflection and the dept of the dish can further be calculated thus

$$\tan \Theta_o = \frac{1}{2} \frac{D/F}{1 - D^2/16F^2}$$

$$= \frac{1}{2} \frac{D/F}{\frac{16F^2 - D^2}{16F^2}}$$

$$= \frac{8FD}{16F^2 - D^2}$$

$$= \frac{8(0.075)(0.3)}{16(0.075)^2-(0.3)^2}$$

$$= \frac{0.18}{0}$$

$$= \alpha$$

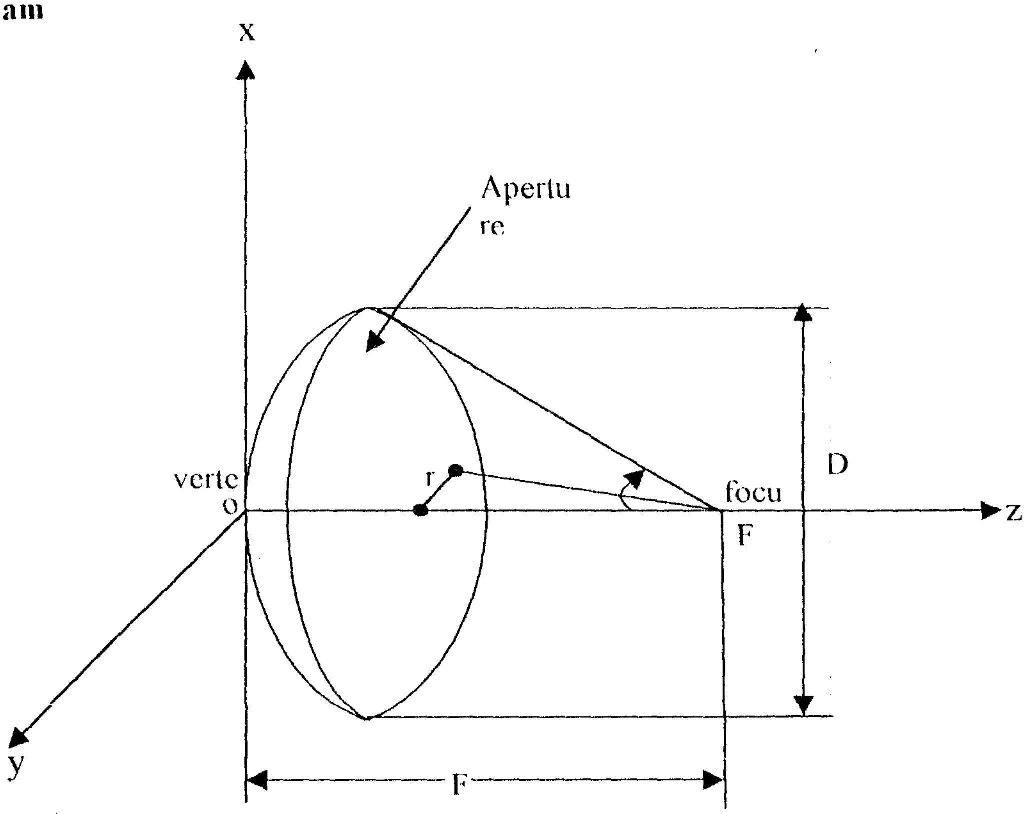
$$Tan^{-1}\alpha = 90^0$$

The dept = $(0.3)^2 / 16 \times (0.075)^2$

$= 0.09/0.09$

$=1cm$

3.63 Diagram



Geometry of a parabolic reflector

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.10 PRINTED CIRCUIT BOARD

Stage by stage construction and testing was adopted during the building of this project. To facilitate this each stage was fist built and tested separately.

The power supply was built on bread board or project board and tested
The construction of the power supply was followed closely by the building of the translator circuit with it's sister circuit the *translator enhance*ment circuit they were tested likewise. When it was found to be working, though different methods of excitation were tried before this method was finally selected.

The display circuit was the next to be constructed; there were a lot of problems with the counters, e.g. harmonizing the frequencies etc at the end of the day it was tested with an oscillator to confirm the frequency and angle display by this circuit.

The melody generator was the last and was equally tested and found to be good while on breadboard.

Anew circuit layout was then designed with each block well positioned in such a manner as to avoid the crossover of wires. The position of each component was well provided for.

2.20: DISH AND STAND

After the designs calculations were carried out the 30cm dish was fabricated. The dish it self was made up of wire gauge as its surface, and an ion frame was used. Though this was a prototype the focal length used by standard focal plane reflector was used. This with a good feed can be used to receive signals.

4.30 CASING

A 150mm x 200mm x 100mm wooden casing was used. The transformer was placed at the far left and screwed to the case this is to avoid over heating of the components, the PCB used were well spaced from each others to avoid unnecessary contact.

Two windows were carved for the display, five 0.6cm holes drilled for the LED's one indicating power on and four for the stepping sequence

A toggle switch in front is fitted for as a power on switch.

Four push to make switches on top of the box were fitted for controlling elevation azimuth, clockwise and counter clockwise.

CHAPTER FIVE

CONCLUSSION AND RECOMMENDATIONS

5.10 CONCLUSION

The design and construction of a satellite dish actuator, as been presented in this Work has the ability to move a 30cm parabolic antenna (dish) clockwise and counter clockwise both on azimuth and elevation.

This was achieved using medium scale integrated circuit and small-scale integrated circuit. A display meant to measure the angle moved by the dish between 0 and 360 was included. A melody generator circuit was included to add glamour this was tested and has proved it worth.

This project is a new innovation and can be improved in areas like; remote control, computer interface, memory preset, e.t.c my dream is to see it take it place in the electronic market far beyond the project level.

5.2 RECOMMENDATIONS

This dream was almost abandoned due to lack of components to implement it, limited literatures on the subject matters, ignorance of Nigerian electronics component marketers of what stepper motors are all about, absent of chips in the market, very low reliability and finally erratic power supply.

Based on the above I make the following recommendations:

1. The school should be on line (connected to internet).
2. There should be a standard departmental library.

3. Exhibition of some star project to encourage student-doing project.
4. Sourcing well many Nigerians and private organizations to sponsor project.
5. Finally a standard 24 hours school laboratory should be establish to accommodate student-doing project.

REFERENCES

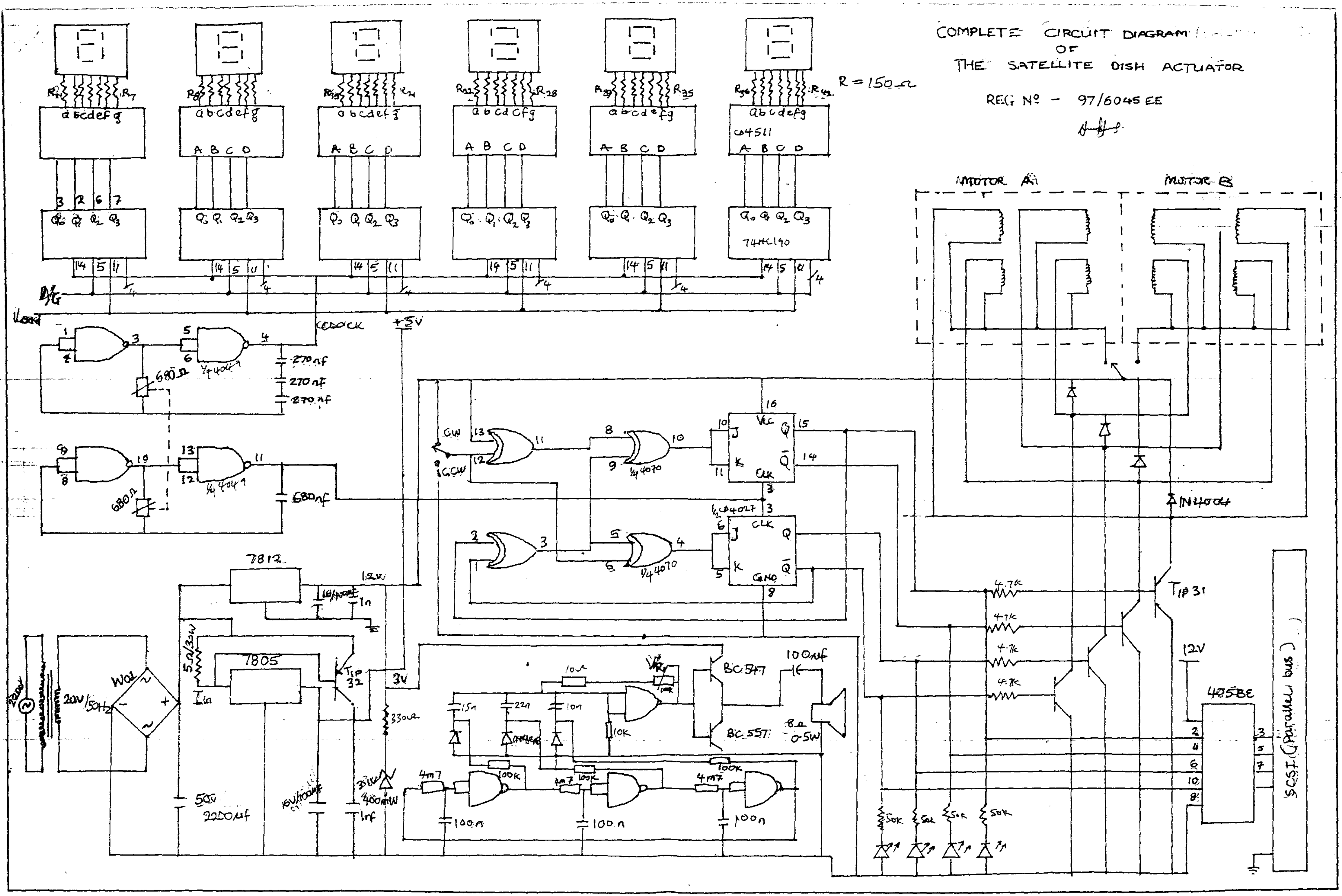
1. DIGITAL TECHNIQUES, K.J BOHLMAN, DICKSON PRICE PUBLISHERS LID, BROOKEAND.
2. . RICHARD D. KLASTER ET ALL, ROBOTIC ENGINEERING AND INTEGRAL APPROACH, 1989, PRENTICE HALL NEW JERSEY.
3. GEOGE M. CHUTE & ROBERT D. CHUT, ELECTRONICS IN INDUSTRY, MAGRAW HILL PUBLICATION
4. S. A. KNIGHT, 1990,ELECTRICAL AND ELECTRONIC PRINCIPLES BOOK 3,SECOND EDITION.
5. JACK FISHER AND GARTH &BRUCE GATHLAND, 1976,ELECTRONICS FROM THEORY TO PRACTICE.
6. TOM DUNCAN, 1983,SUCCES IN ELECTRONICS, JOHN MURRAY PUBLISHERS.
7. COMSUMERS GUIDE TO ELECTRONIC COMPONENTS, MAPLIN, 1987 EDITION
8. FLOYD, DIGITAL FUNDAMENTALS, 1997, SIXTH EDITION, PRENTICE HALL PUBLICATION
9. TIMOTHY PRATT&CHARLES W.BOSTIAN, SATELLITE COMMUNICATIONS, 1999,JOHN WILLEY ANDSONS PUBLICATION
10. K. A. STRAUD, FURTHER ENGINEERING MATHMATICS

APPENDIX I

LIST OF COMPONENTS AND PRICES

Component	*Qty*	*Unit Price* (#)	*Total Cost*(#)
Resistors			
1. Carbon resistors 0.5 watt	20	5	100
2. Variable resistor 100k	1	30	30
3. Variable resistor 680k	1	60	60
4. Choke resistor 5 10w	1	30	30
Capacitors			
1. Ceramic capacitors	15	30	450
2. Electrolytic capacitor 50v/2200uf	1	50	50
3. Electrolytic capacitor 16v/100uf	4	30	120
Diodes			
1. IN4004	4	10	40
2. IN4148	4	10	40
3. 3.1V Zener diode	1	10	10
4. LED	5	10	50
Transistors			
5. BC557	1	30	50
6. BC547	1	30	30
7. Tip 31	4	60	240
8. Tip 32	1	60	60
Integrated circuits			
1. Bridge rectifier WOI	1	50	50
2. I.C Regulator 7812	1	50	50

Component	Qty	Unit Price (N)	Total Cost(N)
3. I.C Regulator 7805	1	50	50
4. CD4093	2	150	300
5. CD4027	1	150	150
6. CD4070	1	150	150
7. CD4050	1	150	150
8. CD4511	6	150	900
9. 74HC190	6	150	900
Others			
1. Transformer	1	300	300
2. 31/2 seven segment display	2	250	500
3. Stepper motors	2	500	1000
4. Toggle switch 250v	1	80	80
5. Micro switches	5	20	100
6. RS232 serial port	1	300	300
7. IC sockets	1	740	680
8. Radio cable	1	30	30
9. Telephone cable	10yrd	20	200
10. Fabrication of dish			1000
11. Casing			600
12. Literatures and internet services			2000
TOTAL			**10850**


COMPLETE CIRCUIT DIAGRAM
OF
THE SATELLITE DISH ACTUATOR
REG Nº - 97/6045 EE
R = 150 Ω
MOTOR A
MOTOR B
CD4511
74HC190
a b c d e f g
A B C D
Q0 Q1 Q2 Q3
U/D
Load
CLOCK
+5V
270nf
680 Ω
1/4 4049
680nf
CW
CCW
1/4 4070
1/2 CD4027
Vcc
CLK
GND
7812
7805
Tip 32
Tip 31
220V
20V/50Hz
W01
5.0/3W
Iin
50V
2200μf
16V/1000μf
1n
3V
330Ω
33V 400mW
4m7
100k
100n
15n
22n
10n
10k
BC547
BC557
100μf
8Ω 0.5W
4.7k
12V
405BE
50k
IN4004
SCSI (Parallel bus)