Microprocessor Based Speed Control of Brushless D. C. Motor

P-281

Project Report

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SYNOPSIS

A brushless D.C motor finds is applications in Electric traction and battery powered vehicles. The commutator and brushes used in conventional D.C motors are eliminated is a brushless D.C motor using electronic commutation.

An innovative method of micro processor based speed control of brushless D.C motor is developed is this project. A microprocessor based speed controller for a 2000 watts brushless D.C motor is designed and fabricated. An Assemble Language Programme (ALP) has been developed for the control. The speed control is done by sensing the angular position of the rotor by hall effect sensors and appropriately switching the power MOSFET's through the electronic commutator. The electronic commutation inturn is controlled by micro processor.

CONTENTS

CHAPTER I

INTRODUCTION

1.1 Brushless D.C. Motor

A brushless D.C motor is a polyphase motor with a permanent magnet rotor. A polyphase winding is the stator which is controlled by an electronic controller. In other words a brushless D.C motor is a motor drive system that combines into one unit an A.C motor, solid state inverter and a rotor position sensor. The solid state inverter uses transistors for low power drives and MOSFETS for high power drives. Rotor position sensor monitor the shaft position and sends the control signal for turning on the controlled switches of the inverter in an appropriate sequence.

A brushless D.C motor is also viewed as "INSIDE-OUT" D.C motor because to construction is opposite to that of a conventional D.C motor. It has permanent magnet field poles on the rotor and polyphase armature winding on the states Fig (1.1).

The functions of mechanical commutator is a conventional D.C motor is now performed by electronic commutator is a brushless D.C motor.

1.2 Difference between conventional D.C motor and brushless D.C. motor

- In brushless D.C motor there is no mechanical commutator and brush - this function is done by electronic controller.
- Field system is placed on rotor side and armature is placed on stator side in brushless D.C motor.
- Because of permanent magnet rotor does not contribute any heating. It is more stable mechanical device from a thermal point of view.
- Because of high moment of inertia of rotor the torque ripples are filter out.

1.3 Advantages of brushless D.C motor

i. Since there is no mechanical commutator and brush maintenance is very life and longer life of the machine.

ii. Problems relating to the radio frequency and electro magnetic interference are minimized.

iii. It can run at speeds much higher than these obtained in a conventional D.C motor

iv. Since there is no brush drop efficiency of the machine is high.

1.4 3 phase - 3 pulse brushless D.C motor

Fig 1.1 shows the elementary from of a 3 phase 3 pulse brushless D.C motor along with its electronic controller. The stator has three phase windings which is delta connected. The six power MOSFETS M_1, M_2, M_3, M_4, M_5 and M_6 are turned on in appropriate sequence. So that unidirectional torque is developed. When M_1 and M_6 are turned ON, Phase A gets energised, when M_5 and M_4 are turned ON, phase B gets energised and so on when phase windings are energised in sequence ABC, the rotor rotation is clockwise and with sequence ACB, the rotor revolves anticlockwise.

The rotor position sensor mounted on the motor shaft provides a position feed back. It monitors the shaft position and sends signals to the drive circuitry. In response to these signals, the drive circuitry allows the flow of current to stator phase windings is a controlled sequence so that motor produces the desired torque and speed. The commonly used rotor position sensor is hall effect sensor.

1.5 Block diagram representation

Fig 1.2 shows the block diagram representation of micro processor based speed control of brushless motor. In this the D.C supply for the brushless D.C motor is given through a power circuit which is appropriately turned on by the control circuit.

The power circuit consists of power MOSFET'S and power diodes which are connected to the stator winding of brushless D.C motor. The rotor position of the motor is sense by hall effect sensors which sends signals to the electronic commutator LM612, at the same time the microprocessor compare the speed of the motor with reference speed and accordingly sends the signals to the electronic commutator.

1.6 Basic operating principle

Fig 1.3 illustrates the operating principle of brushless D.C. motor. When phase A is energised S and N poles are created in the stator. Stator S pole repels rotor S pole and attracts rotor N pole, thus producing clockwise torque. The magnitude of this torque is given by

$$T = K * \phi_1 * \phi_2 + \text{Sin}\theta \qquad \text{———}(1.1)$$

Where ϕ_1 = stator yield flux

ϕ_2 = rotor field flux

θ = torque angle

K = torque constant

Strength of rotor yield flux ϕ_2 is constant as it is produced by a permanent magnet.

The magnet of stator flux is proportional to stator current. As stator current is constant the stator field flux $_2$ can be treated constant. In view of this the torque expression for phase A is

$$T_{ea} = K * I * Sin\theta \qquad (1.2)$$

Where I = constant stator current in phase A.

The torque developed by phase A varies sinvsoidally with torque angle as shown in Fig 1.4(a). As axis of phase winding B is displaced by 120° from phase A axis the torque T_{eb} developed by Phase B is shifted by 120° from torque T_{ea} as shown in figure 1.4(b). Similarly torque developed by phase C is shown as T_{ec} in figure 1.4(c). Actually for the operation of this motor as a brushless D.C motor, phase A is energized through transistor TR_1 from instant 1' ($\theta = 30°$) to instant 1 ($\theta = 150°$) so that positive torque T_{ea}

is developed. From Fig 1.4(b) space instant 2($\theta = 150^\circ$) to [illegible] phase winding B is energized through transistor TR_2 for 120° so th[illegible] ue T_{eb} is developed. From space position 3($\theta = 270^\circ$) to instan[illegible] ase winding C is excited through transistor TR_3 for 120° so that positive torque T_{ec} is produced. After this, phase winding A is again energize[illegible] as to result in continuous clockwise rotation of the brushless D.C motor, each winding carries current for 120° intervals in each cycle of 360°.

The direction of rotation can be reversed if the transistor conduction is delayed by 180° electrical, from instant at 4 to 4' for phase winding A from instant 5 to 5' for phase winding B etc. Reversal of the direction of rotation is also possible by reversing the sequence of currents in the stator windings. In case phase windings carry inst. currents i_1, i_b, i_c the instantaneous torque from equation 1 and fig (1.4) can be expressed as

$$T_{ea} = K * i_a * \sin\theta \qquad \text{———}(1.3)$$

$$T_{eb} = K * i_b * \sin(\theta - 120) \qquad \text{———}(1.4)$$

$$T_{ec} = K * i_c * \sin(\theta - 240) \qquad \text{———}(1.5)$$

if phase currents are assumed to vary simultaneously with then.

$$i_a = I_m * \sin\theta \qquad \text{———}(1.6)$$

$$i_b = I_m * \text{Sin}(\theta - 120) \quad \text{———(1.7)}$$

$$i_c = I_m * \text{Sin}(\theta - 240) \quad \text{———(1.8)}$$

with these currents, the torque expressions for the three phases becomes.

$$T_{ea} = K * I_m * \text{Sin}\theta \quad \text{———(1.9)}$$

$$T_{eb} = K * I_m * \text{Sin}(\theta - 120) \quad \text{———(1.10)}$$

$$T_{ec} = K * I_m * \text{Sin}(\theta - 240) \quad \text{———(1.11)}$$

Resultant torque

$$T_{er} = T_{ea} + T_{eb} * \text{Sin}^2\theta$$

$$T_{er} = K * I_m * [\text{Sin}^2\theta + \text{Sin}^2(\theta-120) + \text{Sin}^2(\theta-240)]$$

$$T_{er} = 3/2 * K * I_m \quad \text{———(1.12)}$$

The equation 1.12 shows that the shaft torque is independent of the rotor position and has lineal relationship with current amplitude as in a conventional D.C motor. It is seen from Fig (1.4) that actually the motor torque developed in a brushless D.C motor consists of torques pulsations. The ripple contest in the torque profile and the torque fluctuations can be reduced if four phases four pulse or 3 phase six pulse brushless D.C motors are used. For 4 phase 4 pulse three phase and 6 pulse motor each winding would conduct for 90° and 60° respectively.

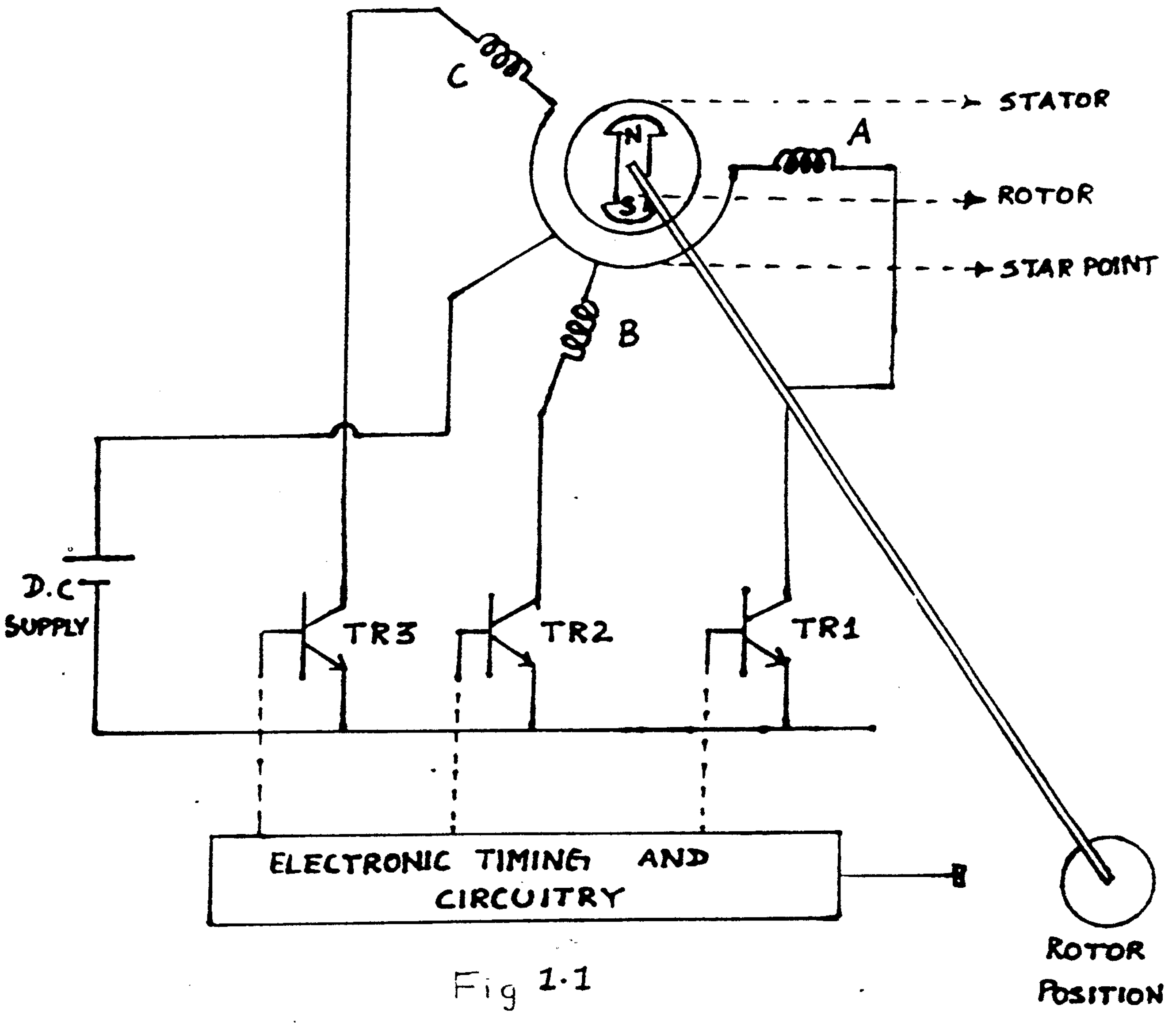


Fig 1.1
ELEMENTARY FORM OF THREE PHASE THREE PULSE BRUSHLESS DC MOTOR

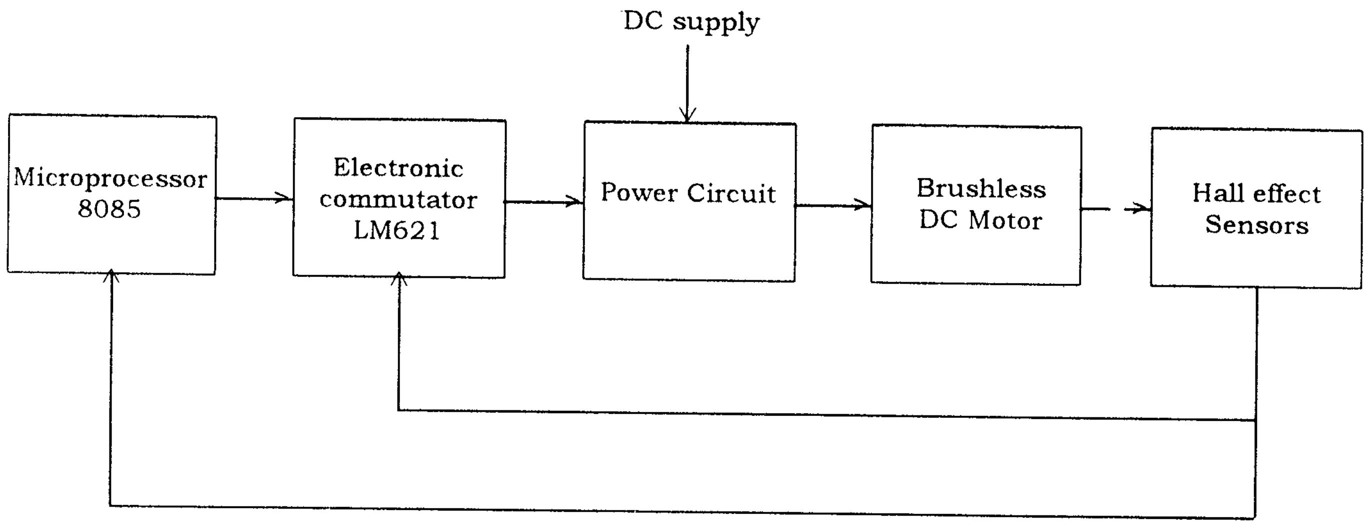


FIG. 1.2 BLOCK DIAGRAM

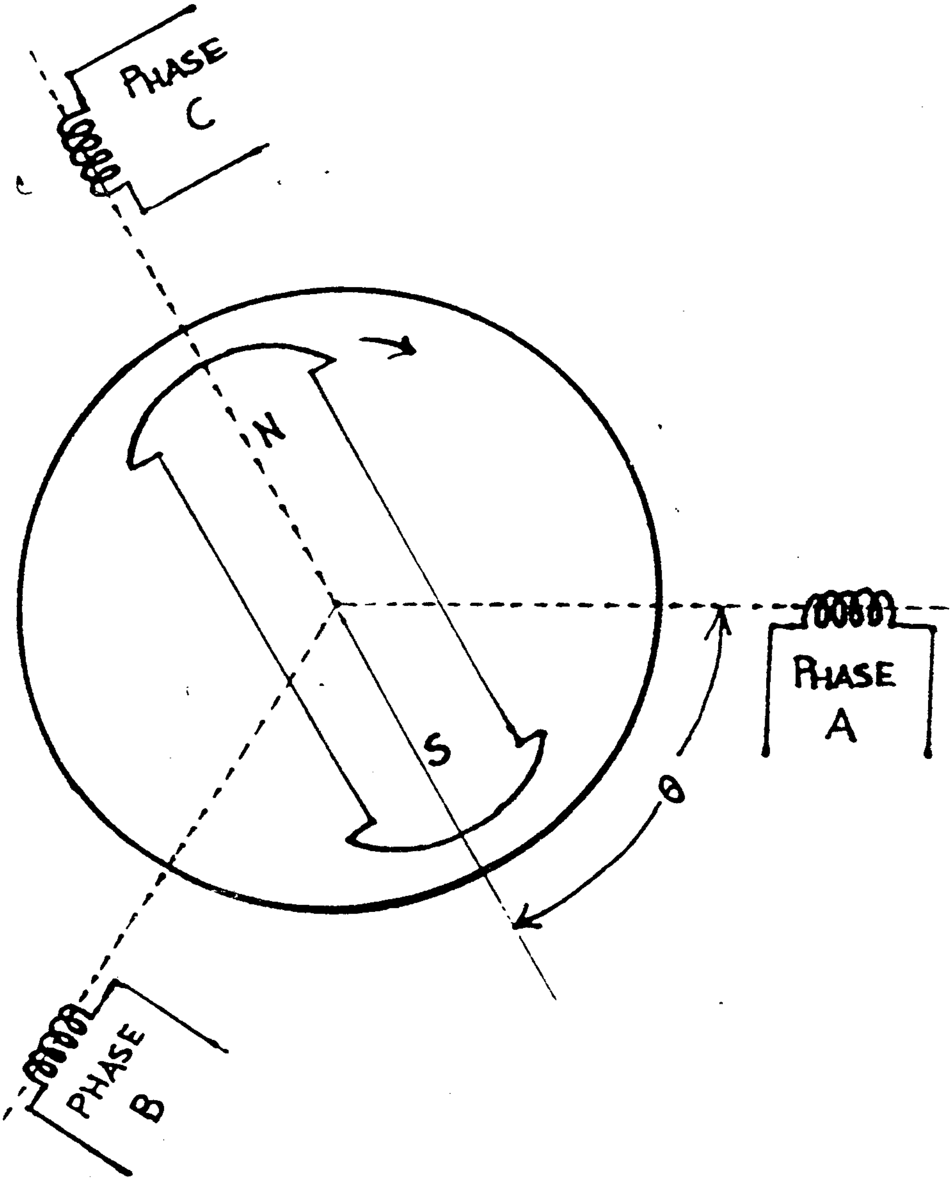


Fig 1.3
OPERATING PRINCIPLE

CHAPTER II

SPEED CONTROL OF B.L.D.C. MOTOR

2.1 Methods of speed control of brushless D.C motor

A brushless D.C motor can be viewed as a D.C motor without brush and commutator and hence speed of the B.L.D.C motor can be controlled by same technique adopted to D.C motor. Since the B.L.D.C motor field is permanent magnet type filed control is not possible. So we go for armature voltage control method.

In armature voltage control method we have 2 type of control.

i. Magnitude control method
ii. Pulse width modulation method.

2.2 Magnitude control method

In this method of speed control f B.L.D.C motor, the speed of the motor is varied and controlled by varying the magnitude of the applied D.C voltage to the stator winding.

In B.L.D.C motor torque developed is directly proportional to the stator current which is directly depends upon the voltage (for a particular level) and hence current and hence torque can be varied by varying the amplitude of applied voltage to the stator.

$$T_{res} \propto I$$

$$T_{res} \propto V$$

2.2.1 Speed torque characteristic

It may be seen from fig 2.1 that if voltage applied to the stator is increased then speed increases.

2.3 Disadvantages of magnitude control method

- Since in A B.L.D.C torque is directly proportional to the voltage, if we vary the voltage then torque also vary because of this for a particular load torque pulsation will be there.
- The varying amplitude D.C voltage is obtained by including a resistance in series (or) providing a short (a) Diverter Resistance which will increase losses.
- By this method speed control is not accurate.

- Reversed of direction of rotation takes long time, became of this heat generated will be high. Since the current reversal is not smooth.

- Regenerative braking is complicated.

To overcome the disadvantages of magnitude control method, pulse width modulation technique may be used.

2.4 PWM method of speed control of B.L.D.C motor

In this method of speed control of B.L.D.C motor, the amplitude of stator voltage is kept constant but the period for which voltage applied to the stator is varied as shown in fig (2.2) ie the time for which voltage applied and duration for which the voltage is off is varied.

In the method the total time period is kept constant and hence it is known as "constant - frequency operation".

$$T_{tot} - T_{ON} + T_{OFF} \qquad \text{———————}(2.1)$$

By varying the ON period of voltage, at the same time total time period is kept constant, the average voltage across the stator winding is varied. Which is given as

$$\text{Average voltage across the stator winding} = \frac{1}{T}\int_{0}^{T_{ON}} V_0\, dt$$

$$= \frac{1}{T}\, T_{ON}\, V_s$$

$$= \frac{T_{ON}}{T}\, T_{ON}\, V_s \tag{2.2}$$

$$= K\, V_s \tag{2.3}$$

$$\text{Where } K = \frac{T_{ON}}{T}$$

T = Total time period = $T_{ON} + T_{OFF}$

T_{ON} = ON period of voltage

T_{OFF} = OFF period of voltage

From equation 2.3 by varying the ON period of the voltage, we can vary the average voltage across the stator winding and hence we can vary the speed of the B.L.D.C motor.

2.5 Advantages of PWM method of speed control of B.L.D.C motor

- Since magnitude in rept constant, the torque pulsation are reduced very much.
- Because of direct control thro' self commutator switches, the losses are reduced and hence efficiency is higher.
- It provides very accurate method of speed control of B.L.D.C motor.
- Direction of ration can be changed easily through self commutator switches.
- Regenerative braking is less complicated when compared to magnitude control method.

Because of these advantages pulse-width modulation method of speed control of brushless D.C motor is used in this project.

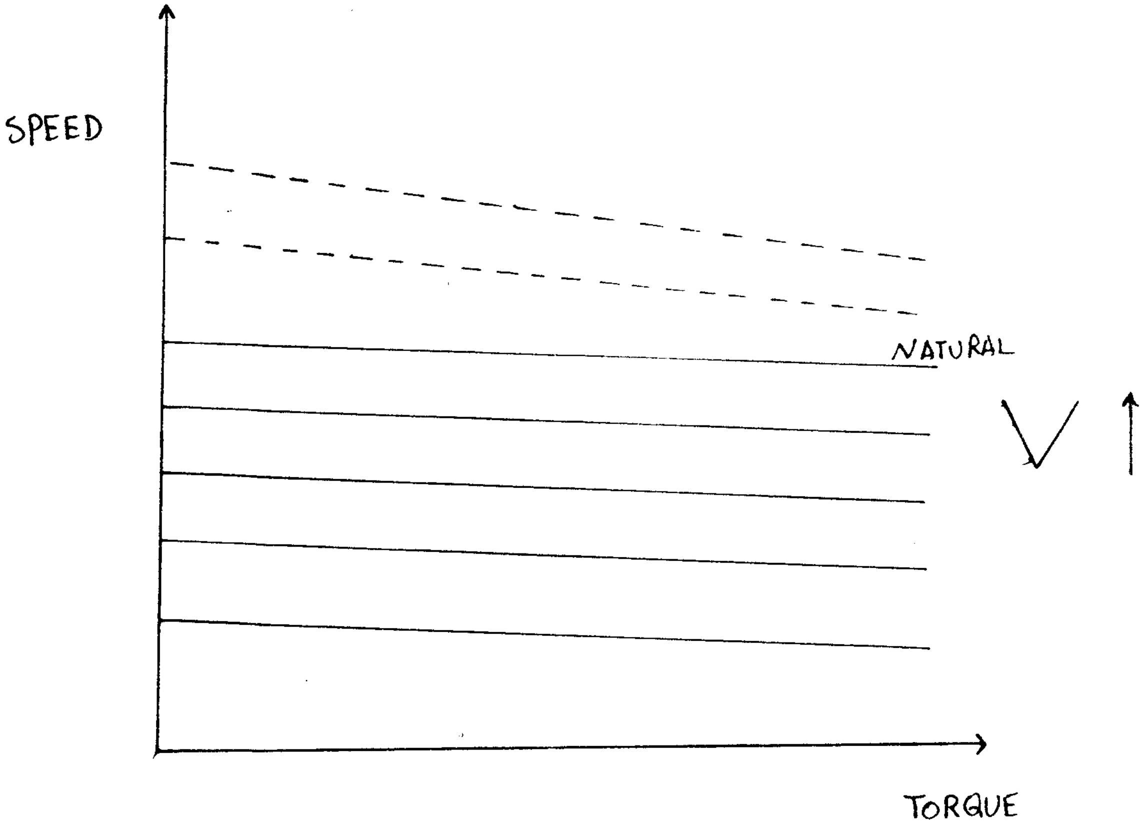


Fig 2.1 SPEED - TORQUE CHARACTERISTIC

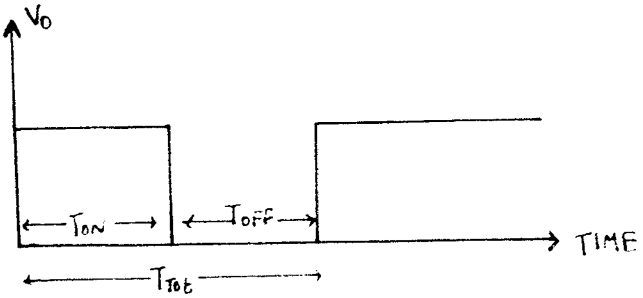


Fig 2.2 PULSE PERIOD

CHAPTER III

COMPONENTS OF SPEED CONTROL UNIT

3.1 Circuit diagram

Fig (3.1) shows the total circuit diagram, details of each component are given in this chapter.

3.2 Commutation sensor systems

The purpose of using commutation sensor is to detect the angular position of the rotor and to provide a signals to turn ON appropriate self commutator device like MOSFET through electronic commutator.

There are several methods to some the angular position of the permanent magnet rotor. Some of them are

i. Electro optical switch
ii. Shaft encoder
iii. Radio frequency sensor
iv. Photo electric sensors

v. Hall effect sensors

The details of each method are as follows.

3.2.1 Electro optical switch

The angular sensing is the electro - optical switch, most commonly a combination of light - emitting diode (LED) and a photo transistor. A shutter mechanism controls light transmission between the transmitter of the sensor. The sensor voltages can be processed to supply logic signals to the controller.

3.2.2 Shaft encoder

A shaft encoder consists of a rotating disc attached to the shaft and a light emitting source and a photo sensor. The disc is cut into teeth on cuter peripheral and No. of teeth is equal to NO. of pulse produced during a one revolution. The light emitting source and photo conductive cell are arranged in a line.

3.2.3 Radio frequency sensor

The ratio frequency sensing is based on inductive coupling between

RF coils. The angular sensing accuracy of such devices on several design factors. Which may limit their use in high performance systems.

3.2.4 Photo electric sensors

The principle of photo electric detection is based on a beam of light emitted by the sensors being affected by the object into be detected, the result being evaluated by a sensors receiver. An object entering the light beam will obscure the beam and reflect some light back towards the sensor.

It the sensor output is activated when light is received, it is known as "light operated" and when this is interrupted and the light level falls, it is known as "dark operated". The light level at which the sensor is switched is determined by several factors including reflectivity of the target and sensitivity.

3.2.5 Hall effect sensors

When a semiconductor carrying a current I is placed in a transverse magnetic field B, then an electric voltage is induced in the specimens in the direction perpendicular to both I and B as shown in fig (3.2). This phenomenons is called the "Hall effect".

This hall effect is used to determine

i. determining whether a semiconductor is n type (or) p type
ii. the carrier concentration and
iii. measure the magnetic field B.

The hall voltage V_H for a given current, is proportional to B hence measurement of V_H measures the magnetic field B.

3.2.6 Advantages of hall effect sensor over other sensors

i. It is a non contacting type of angular position sensor so there is no wear and tear and hence less maintenance.

ii. The output of these sensor can be given directly to the electronic commutator and micro processor.

iii. The operating frequency is very high.

iv. It is sensitive to magnetic polarity also.

In view of these advantages of hall effect sensor, hall effect sensor is as chosen angular position sensor.

3.3 Power circuit

The power circuit consists of power MOSFET's POWER DIODES and comparator. The connection of these components are shown in Fig 3.2.

3.3.1 Power MOSFET

The power MOSFET is a voltage - controlled device and requires only a small input current. The switching speed is very high and switching times are of the order of nanoseconds. In power circuit we use N channel MOSFET and P channel MOSFET.

3.3.2 N channel MOSFET

An N - channel depletion type - MOSFET is farmed on a P - type silicon substrate as shown in Fig 3.3 with two heavily doped n^+ silicon for low resistance connection. The gate is isolated from the channel by a this oxide layer. The three terminals are called as gate, drain and source. The substrate is normally connected to the source. The gate to source voltage, V_{GS} could be either +ve (or) -ve.

It V_{GS} is -ve, some of the electrons in the n - channel area will be repelled and a depletion region will be created below the oxide layer, resulting in a narrower effective channel and a high resistance from the drain to source, R_{DS}. It the V_{GS} is made -ve the channel will be completely depleted, offering a high value of R_{DS} and there will be no current flow from the drain to source $I_{DS} = 0$. The value V_{GS} is known as "pinch-off voltage V_P.

If V_{GS} is made +ve then the channel because wider and I_{DS} increases due to reduction in R_{DS} P channel.

3.3.3 P channel MOSFET

A P channel MOSFET is similar to an n-channel depletion type MOSFET only difference is it is farmed on a n-type silicon substrate with two heavily doped P^+ silicon for low resistance connection. With a P-channel depletion - type MOSFET, the polarities of V_{DS}, I_{DS} and V_{GS} are reversed as shown in Fig.3.4

3.3.4 Power diode

A power diode is a two-terminal P-n junction device and a Pn-junction is normally formed by diffusion (or) epitaxial growth. When the anode potential is positive with respect to the cathode, the diode is said to be forward biased and the diode conducts. A conductions diode has relatively small forward voltage drop across it and the magnitude of this drop would depend on the manufacturing process and junction temperature.

When the cathode potential is positive with respect to the anode, the diode is said to be reverse biased. Under reverse biased conditions, a small reverse current - leakage current in the range of micro to milliampere fluid and this leakage current increases in slowly is magnitude with the reverse voltage until the avalanche (or) zener voltage is reached.

3.4 Electronic commutator

A D.C motor can not run without a commutator. In B.L.D.C motor we replace the function of brush and commutator by a rotor position sensor an electronic commutator. ie we replace the mechanical commutator segment by an electronic commutator (or) controller.

The main function of the electronic commutator is to provide appropriate signals to the MOSFET's to turn ON and to provide appropriate current flow thro' the selected winding of the stator. This electronic commutator is achieved by using IC chip LM621.

The PIN details and block diagram of LM621 is given in appendix.

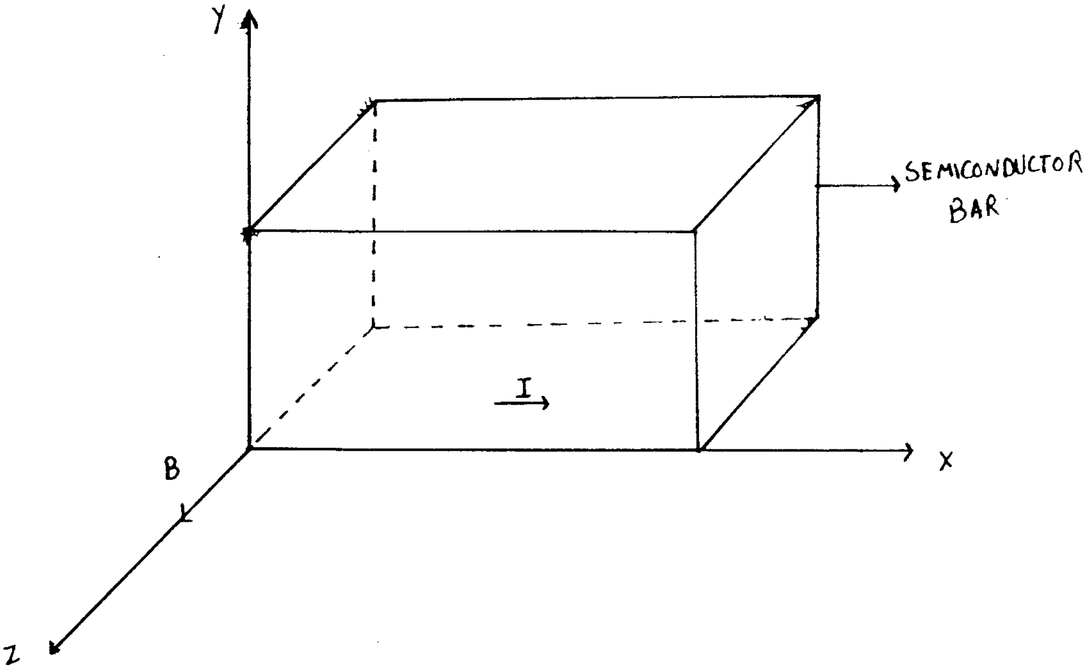


Fig 3.1 HALL EFFECT BLOCK

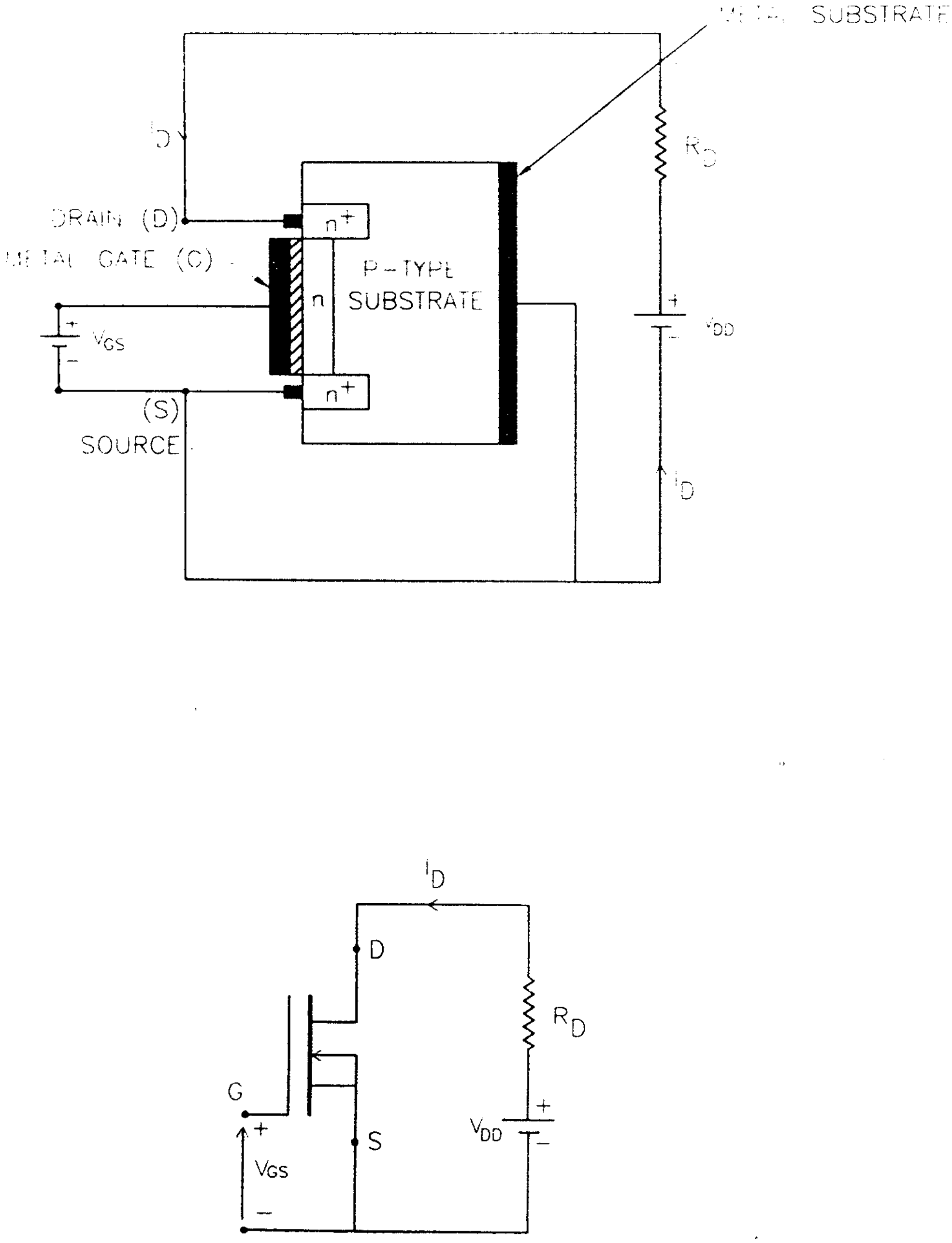
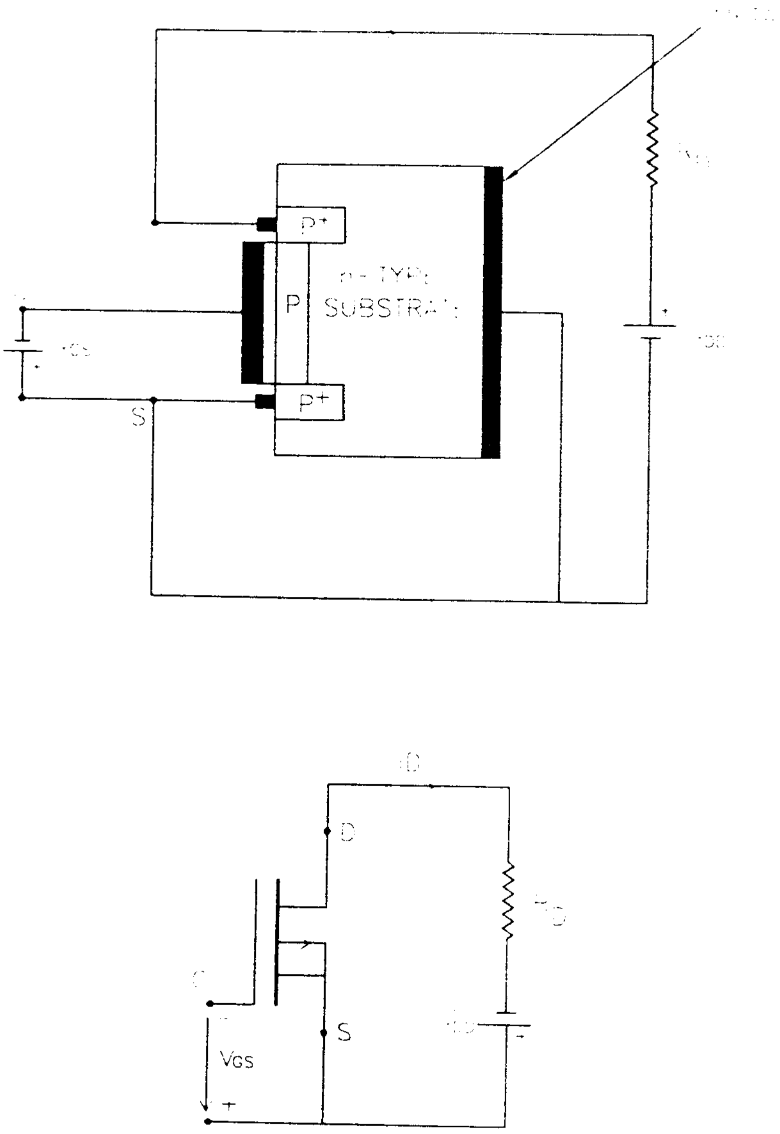


FIG 3.3 BASIC STRUCTURE OF N-CHANNEL DEPLETION TYPE MOSFET & SYMBOL



3.4 BASIC STRUCTURE OF P CHANNEL DEPLETION TYPE MOSFET & SYMBOL

CHAPTER IV

DESIGN

4.1 Introduction

Design may be defined as a creative physical realization of the critical concepts. In this chapter

i. Power circuit design

ii. Control circuit design are presented.

4.2 Power circuit

The power circuit for a 2 KW, 130 volts, 1500 rpm brushless D.C motor is designed.

$$\text{So the stator current at full load} = \frac{2000}{130}$$

$$= 15.384 \text{ Amp}$$

$$I_S = 15.38 \text{ AmP}$$

So the MOSFET selected for this is IRF 9220 which has rating of

Voltage : 200 V
Current : 16 Amp
Operating frequency : audio and low super sonic region
R_G : 10 KΩ

In order to provide sufficient gate voltage, we have to select a resistance which is connected in between the gate I source [R_G}. Each source and sink of electronic commutator capable of supplying 35 milliamp of current. So we select minimum resistance R_G as 10 K . This value also depends upon the input resistance of the MOSFET.

4.3 Comparator Design

If the load current exceeds the rated current of 15.5 Amp then the supply to the motor should stop. This sensing of current is sensed by a current sensing comparator.

Choose the reference voltage as 5 volts. If the voltage across the current sensing resistance exceeds this the comparator produce the signal to the electronic commutator.

Rated current = 15 Amp.

For this select a resistance value of R_{sen} = 10 KΩ.

4.4 Control circuit

Control circuit consists of electronic commutator LM 621 and micro processor kit. In this we have to select the RC value for the clock oscillator in LM 621, which determines the amount of decided time.

The value of R and C is calculated as

Freq of oscillation = 0.45 MHz = 450 KHz

then Time period T = $1/(450 \times 10^3)$ = 2.22×10^{-6} sec

then T = RC

Select resistance R = 11 K

then C = T/R

$$= \frac{2.22 \times 10^{-6}}{11 \times 10^{3}}$$

$= 2.0202 \times 10^{-10}$ farads

$\cong$ 0.202 nF

$\cong$ 0.2 nF

The resulted value of R & C is

$R = 11\ \mathrm{K\Omega}$

$C = 0.2\ \mathrm{nF}$

CHAPTER V

MICRO PROCESSOR BASED SPEED CALCULATION

5.1 SPEED CALCULATION USING MICROPROCESSOR

In the dedicated hardware system control using analog components, the speed sensing is accomplished by means of tachogenerator. For control of the drive using a microprocessor this analog speed signal can be converted to digital signal by an A/D Converter.

The speed measurement must be qualified by high resolution, high accuracy fast response over a wide range of speeds and quick sampling. Such a measuring system can be obtained only by using digital techniques. Therefore in system employing microprocessors the speed measurement is carried out by means of shaft encoder or pulse generator, which generate a train of pulse depending upon the speed.

The shaft encoder is circular light aluminium disc mounted on the shaft with equidistance holes drilled on its periphery. On the opposite side of the disc, a light source and photosensitive electronic device are placed. These are aligned such that the phototransistor gets light when there is a hole across. Light activated phototransistor generates a pulse. Thus the pulse train is produced. These pulses are not very sharp and must be shaped using suitable circuitry. These pulses are processed in a microprocessor to get the actual speed of the motor.

5.1.1 SPEED CALCULATION

a. The pulses are counted in a given period of time. This is suitable for high speeds.

b. The interval is measured between two consecutive pulses suitable for low speeds.

The high resolution of the sensing of speed signifies the stable control over a wide range of speeds. The high accuracy of speed measurement improves the steady stable control accuracy. The instantaneous speed can be sensed accurately if the detecting time is very small.

5.2 Hardware Design

The functions to be carried out by the dedicated hardware circuits are designed. If the microprocessor is sufficiently fast, it may be assigned to perform the functions necessary for the control. On the other hand, if it is slow the hardware oriented circuit may be used to cover the jobs of signal generation for the inverter, high speed protection fixing angle generation for the converter. The microprocessor can be used to perform the other jobs. While selecting a microprocessor the following points need consideration.

a. Suitability of the performance of the microprocessor for the intented purposes. This is identified by the bit size, operating time, memory capacity, memory access etc. The resolution required determines the bit size of the microprocessor. The sampling time of the processor is a measure of the resolution. The bit resolution to sampling time is identified as the figure of merit.

b. Suitability of the functions of the processor for intented purposes. The functional capacity of a microprocessor is identified by the kind and number of instructions, microprocessor control, I/O interface, peripheral LSI, number of microprocessor devices etc. Direct multiplication/division capability functional integration, etc show the effectiveness, of the microprocessor in the computation of feed back signals in the control.

c. The reliability of the system under operating conditions and temperature.

CHAPTER VI

SOFTWARE ASPECTS

6.1 Software design

An assembly language programme has been developed to control the speed of the B.L.D.C. motor. The main purpose of this programme is to compare the actual speed with reference speed and accordingly sends the signal to the electronic commutator LM 621.

The algorithm for ALP is given as follows.

6.2 Algorithm

Step 1

Clear all the registers and accumulator

Step 2

Call the count subroutine

Step 3

Get the pulse and start increment the counter upto the next pulse occur.

Step 4

Call the display subroutine

Step 5

Select the current seven segment code from the table and send it to the seven segment display.

Step 6

Call the output subroutine

Step 7

Compare the calculated speed - actual speed with reference speed.

Step 8

If the actual speed is less than reference speed set output = 1.

Step 9

If actual speed is greater than reference speed set output = 0.

Step 10

Repeat from step 2.

6.3 Flowchart

The detailed flowchart for the ALP is given in fig. 5.1. Detailed flow chart for subroutines count, display and output are shown in fig. 5.2, 5.3 and 5.4.

6.4 Program

An assembly language program written for 8085 is given at the end of this chapter.

6.5 ALP for speed control of B.L.D.C motor

Program

```
        LXa H,   4000 H
        XRA      A
        MOV      B, A
        MOV      C, A
        MOV      D, A
        MOV      E,A
YY      Call     Count
        Call     Display
        Call     int
        JMP      Count yy
```

```
            HLT
```

Count

```
            XRA     A
            MOV     C, A
    YY      IN      Add
            SUI     40
            JNZ     YY
            XRA     A
    YYY     INR     C
            IN      Add
            SUI     40
            JNZ     YYY
            MOV     D, C
            RET
```

Call display

```
            XRA     A
            LX1     SP, 2500
            MUI     B, 4H
            LXI     H, 4000
    YY      PUSH    H
            Call    Disp
```

```
          POP     H
          INX     H
          DLR     B
          JNZ     YY

Disp

          MOV     A, M
          OUT     CE
          INX     H
          MOV     A, M
          OUT     CC
          INX     H
          MOV     A, M
          OUT     C8
          RET

4000 H

          0       FTD
          1       60 H
          2       DA
          3       F2
          4       66
          5       B6
```

6	BE
7	F4
8	FF
9	F7

Call out

```
MOV     A, 15W
MOV     D,C
SUB     D
JS      Low
MOV     A,1
OUT     Add
```

Low

```
MOV     A,0
OUT     Add
RET
```

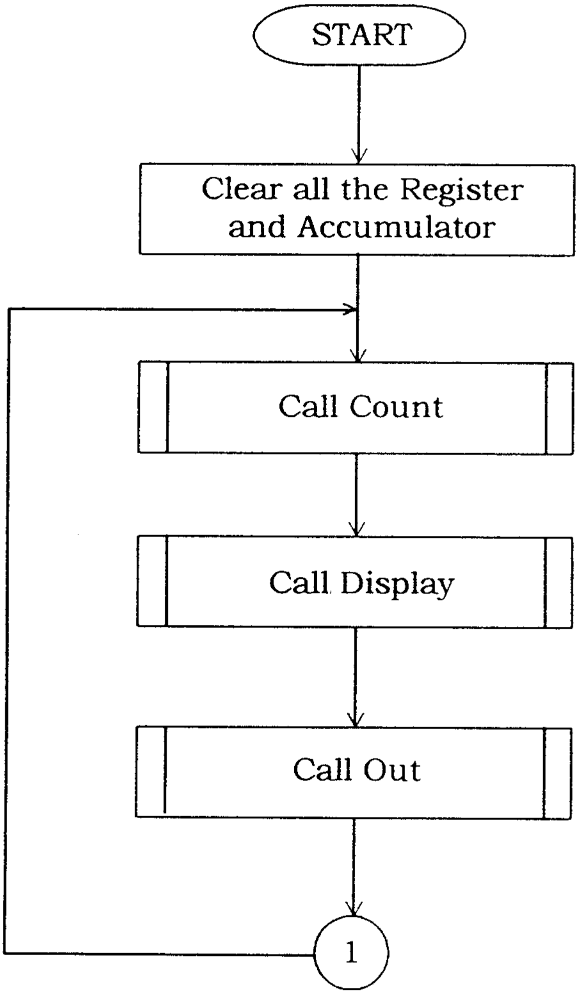


FIG. 5.1 FLOW CHART

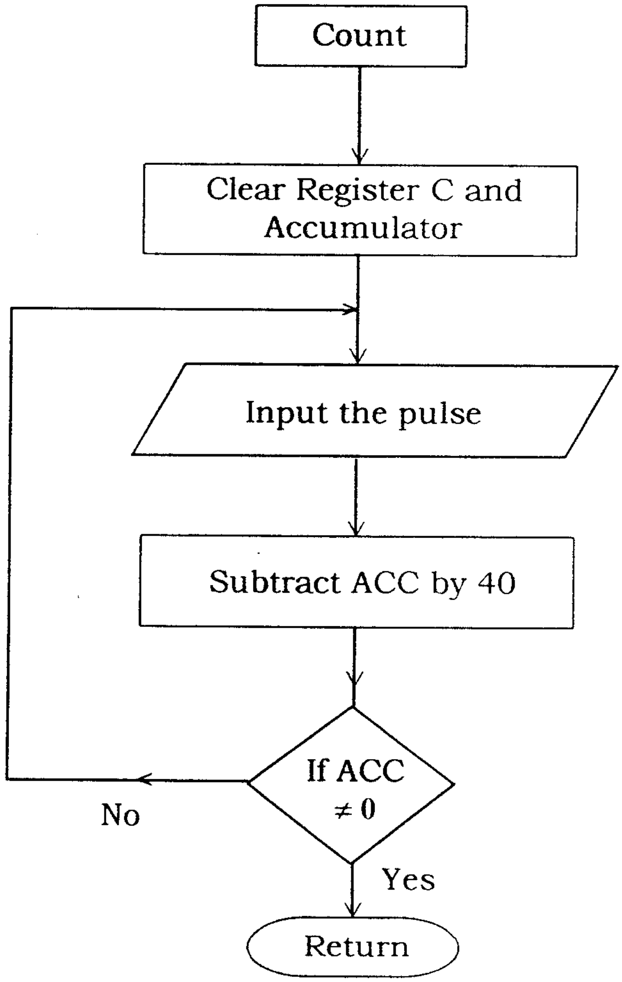


FIG. 5.2 COUNT SUBROUTINE

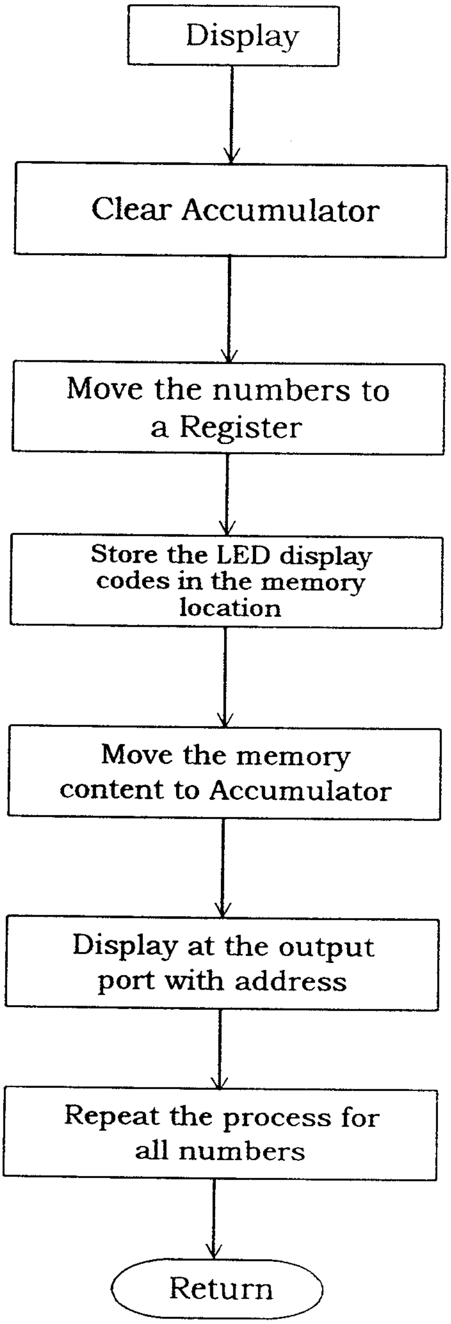


FIG. 5.3 DISPLAY SUBROUTINE

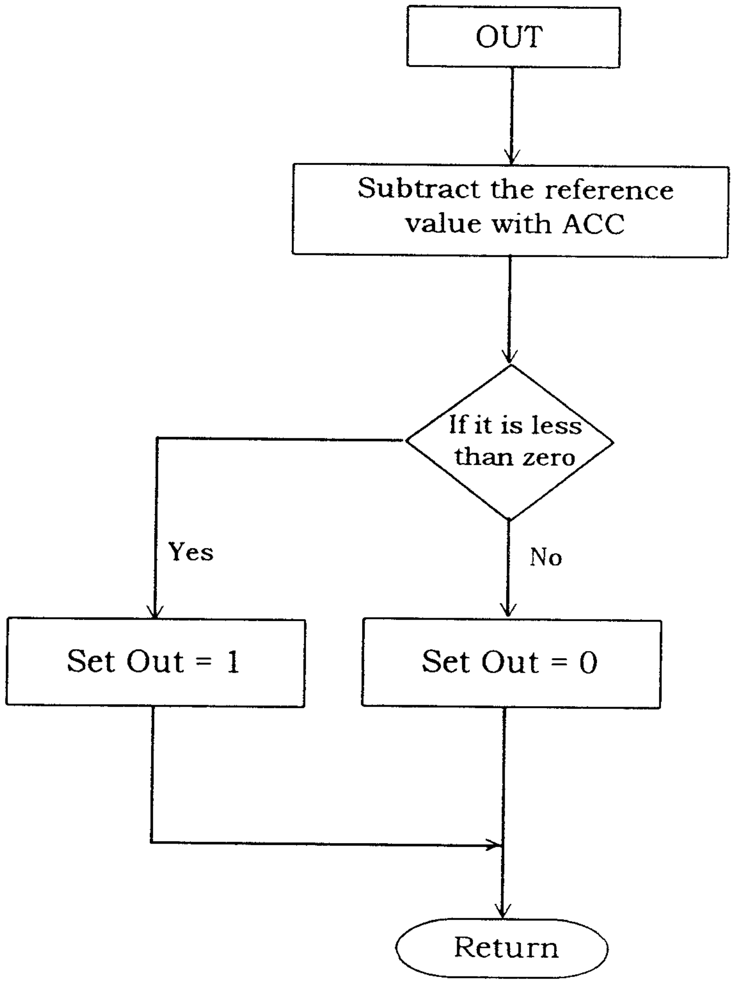


FIG. 5.4 OUT SUBROUTINE

CHAPTER VII

CONCLUSION

A micro processor based speed control unit for a brushless D.C. motor of 2000 watts has been designed and fabricated.

This control unit may be perhaps be considered for use in traction system and battery powered vehicles. The cost of this control unit is comparatively higher than the conventional D.C. motor control unit.

The speed control system can be improved using direct interfacing with computers and which can be controlled more effectively. By the direct control of micro processor this system can be used in hard disk drives more effectively and accurately.

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3. RAMESH S. GAONKAR, "MICROPROCESSOR ARCHITECTURE, PROGRAMMING AND APPLICATIONS WITH THE 8085/8080A", WILEY EASTERN LIMITED, 1990.

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5. MUHAMMAD H. RASHID, "POWER ELECTRONICS CIRCUITS, DEVICES, APPLICATIONS", PRENTICE HALL, U.S.A. 1993.

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APPENDIX

Pin details of LM 621

Pin 1

Vcc_1 (+5v). The logic and clock power supply pin.

Pin 2 : Direction

This input determines the direction of rotation of the motor. ie, clockwise Vs. counter clockwise.

Pin 3 : Dead-time enable

This input enables or disables the dead - time feature. Connecting +5v to pin 3 enables dead-time, and grounding pin 3 disables it. Pin 3 should not be allowed to float.

Pin 4 : CLOCK TIMING

An RC network connected between this pin and ground sets the period of the clock oscillator, which determines the amount of dead-time.

Pin 5 thru 7 : HS1, HS2 and HS3 (Hall-sensor inputs)

These inputs receive the rotor-position sensor inputs from the motor. Three-phase motors provide all three signals, four-phase motors provide only two, one of which is connected to both HS2 and HS3.

Pin 8 : 30/60 SELECT

This input is used to select required decoding for three-phase motors. i.e. either "30 degree" (+5V) or "60-degree" (ground). Connect pins to +5V when using a four-phase motor.

Pin 9 : LOGIC GROUND

Ground for the logic power supply.

Pin 10 : POWER GROUND

Ground for the output buffer supply.

Pins 11 thru 13 : SOURCE OUTPUTS

The three current sourcing outputs which drive the external power devices that drive the motor.

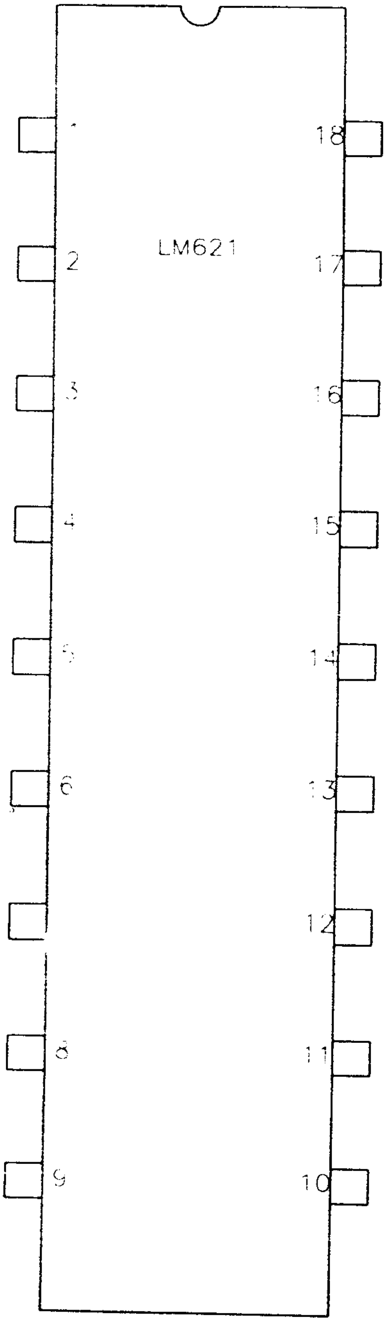


FIG **A-1** PIN DIAGRAM

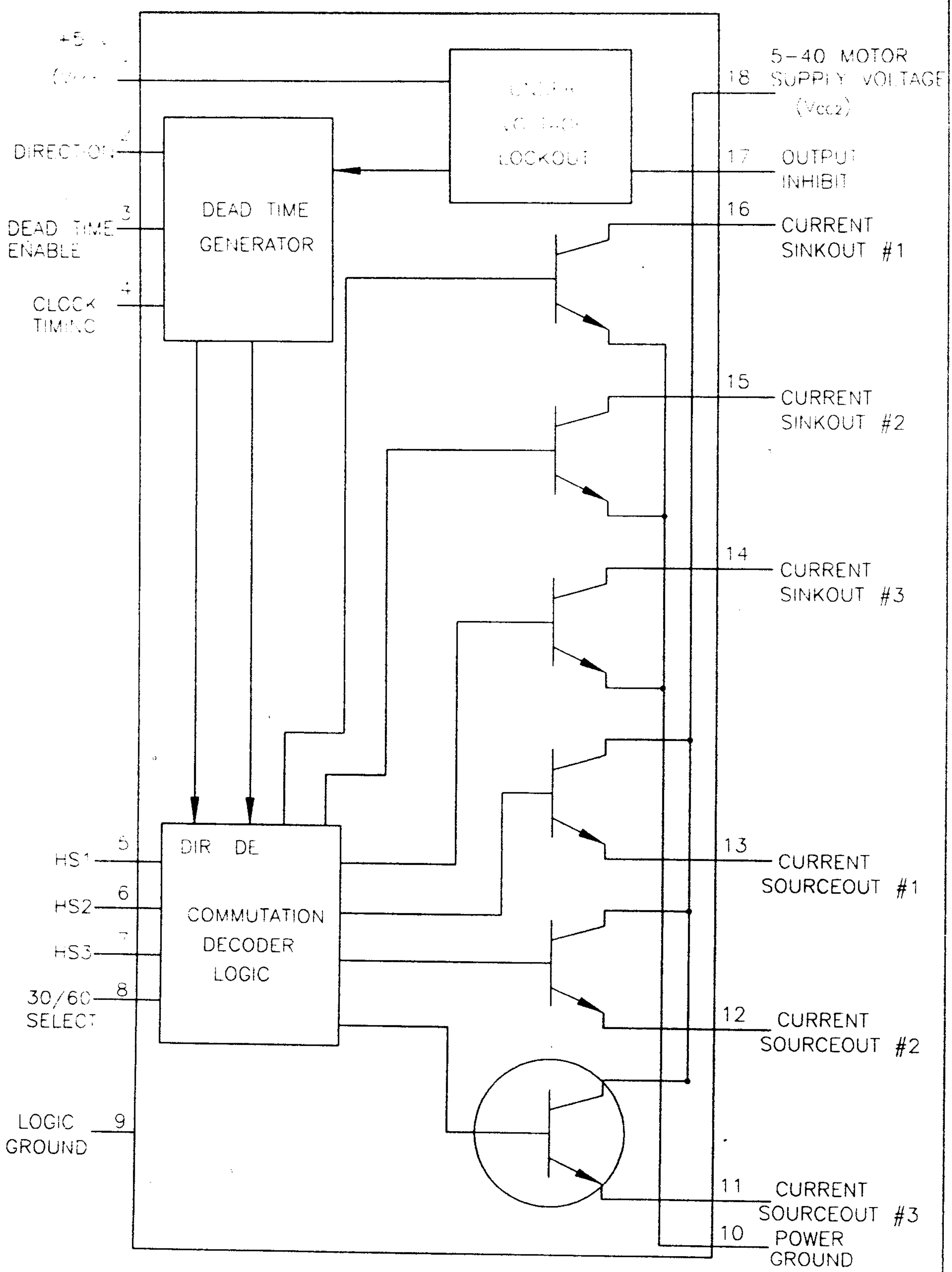
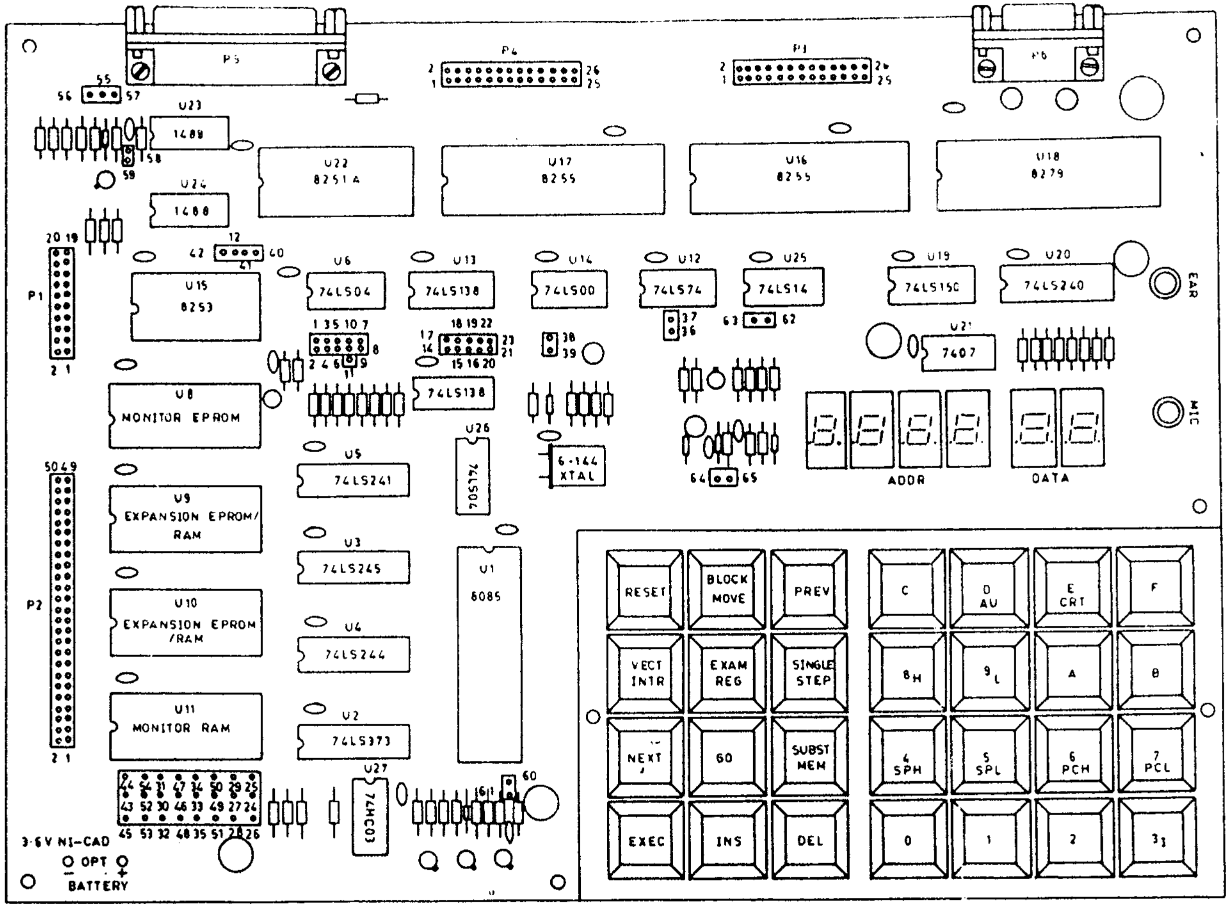
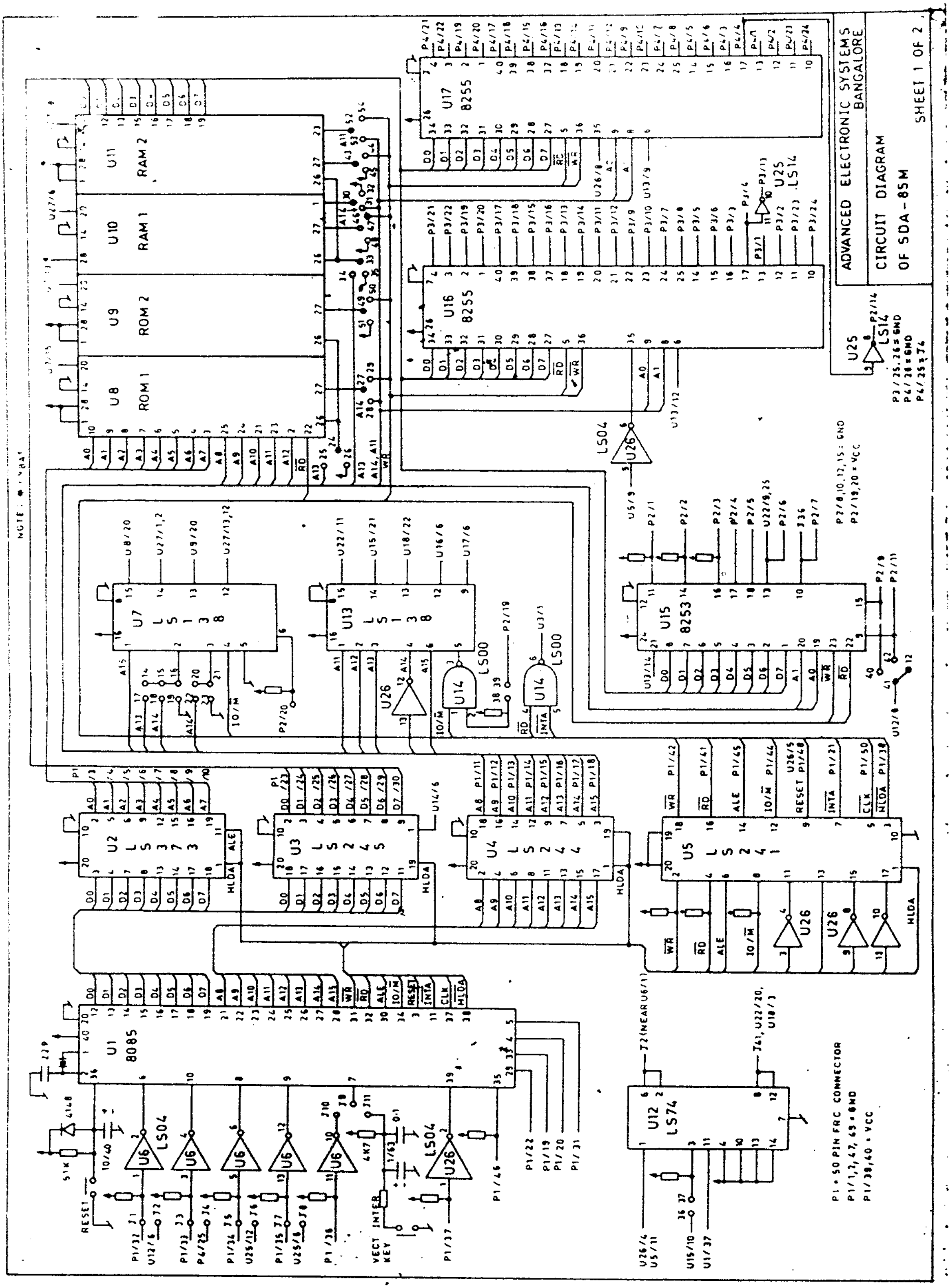


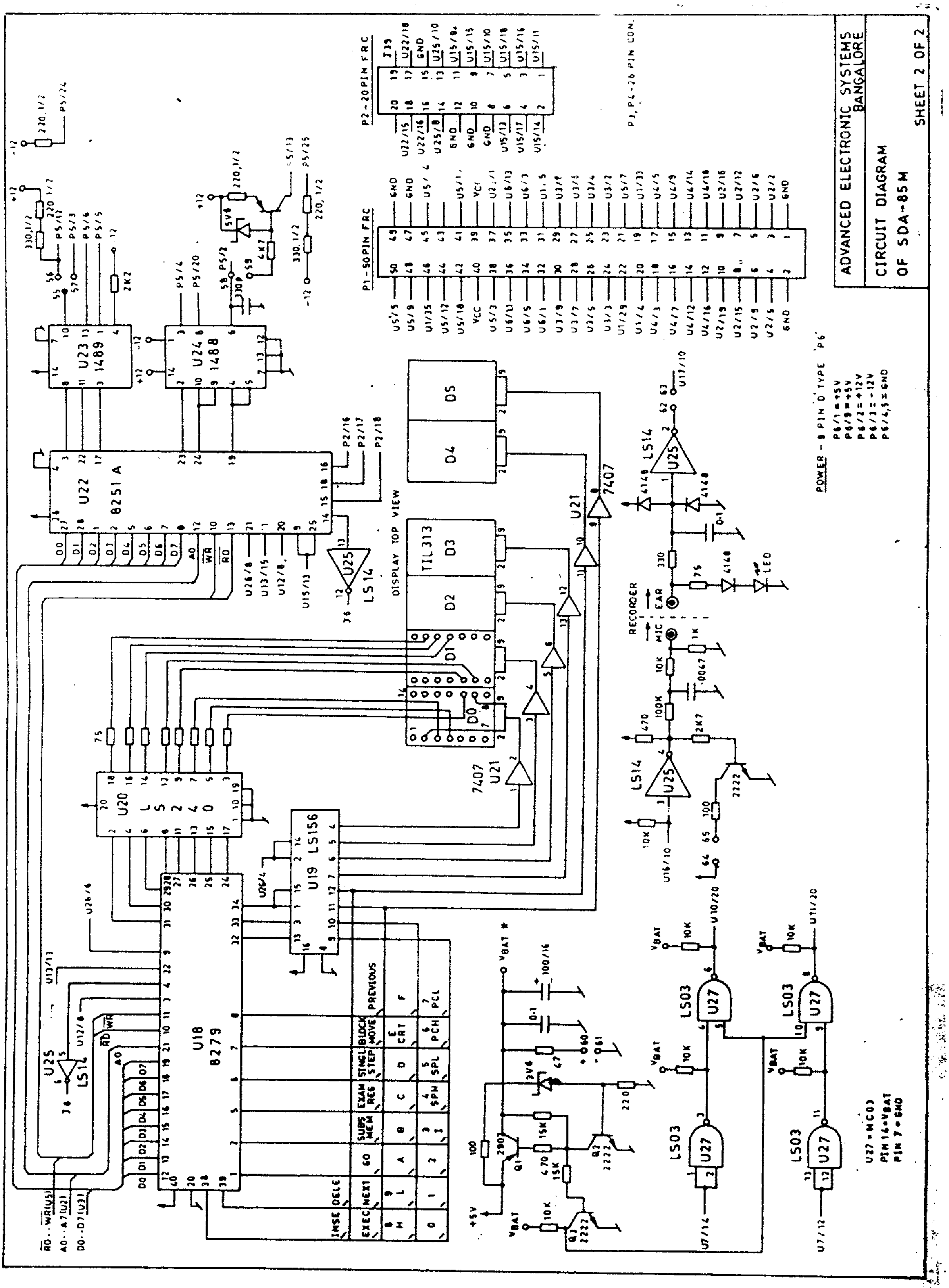
FIG A-2 BLOCK DIAGRAM OF LM621



ADVANCED ELECTRONIC SYSTEMS
BANGALORE

COMPONENT LAYOUT
OF SDA-85M


ADVANCED ELECTRONIC SYSTEMS
BANGALORE
CIRCUIT DIAGRAM
OF SDA-85M
SHEET 1 OF 2
U1 8085
U2 LS373
U3 LS245
U4 LS244
U5 LS241
U6 LS04
U7 LS138
U8 ROM 1
U9 ROM 2
U10 RAM 1
U11 RAM 2
U12 LS74
U13 LS138
U14 LS00
U15 8253
U16 8255
U17 8255
U25 LS14
U26 LS04
RESET
VECT INTER KEY
P1 = 50 PIN FRC CONNECTOR
P1/1,2,47,49 = GND
P1/38,40 = VCC
P2/8,10,12,15 = GND
P2/19,20 = VCC
P3/25,26 = GND
P4/26 = GND
P4/25 = +5
NOTE


ADVANCED ELECTRONIC SYSTEMS BANGALORE
CIRCUIT DIAGRAM OF SDA-85M
SHEET 2 OF 2
U22 8251 A
U23 1489
U24 1488
U20 LS240
U19 LS156
U18 8279
U21 7407
U25 LS14
U27 LS03
DISPLAY TOP VIEW
TIL313
D0
D1
D2
D3
D4
D5
P1 - 50PIN FRC
P2 - 20PIN FRC
P3, P4 - 26 PIN CON.
POWER - 9 PIN D TYPE 'P6'
P6/1 = +5V
P6/9 = +5V
P6/2 = +12V
P6/3 = -12V
P6/4,5 = GND
RECORDER
MIC
EAR
LED
U27 = MC03
PIN 14 = VBAT
PIN 7 = GND
VBAT
+5V
INSE
DELE
EXEC
NEXT
GO
SUBS MEM
EXAM REG
SINGL STEP
BLOCK MOVE
PREVIOUS
CRT
SPH
SPL
PCH
PCL
RD .. WR(U5)
A0 .. A7(U2)
D0 .. D7(U3)