EXTENSION OF TORQUE CONTROL RANGE OF AN INDUCTION MOTOR USING MICROPROCESSOR

PROJECT REPORT 1998-99

Submitted by

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CERTIFICATE

March 16, 1999

THIS IS TO CERTIFY THAT THE FOLLOWING STUDENTS OF ELECTRICIAL AND ELECTRONICS ENGINEERING BRANCH OF **KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE** HAVE DONE A PROJECT TITLED **"EXTENSION OF TORQUE CONTROL RANGE OF AN INDUCTION MOTOR USING MICROPROCESSOR".**

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WE HAVE GIVEN TECHNICAL GUIDANCE IN CERTAIN ASPECTS OF THIS PROJECT.

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AUTHORISED SIGNATORY.

ACKNOWLEDGEMENT

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With a deep sense of respect we express our sincere thanks to our beloved professor **Dr.K.A.PALINISWAMY, B.E., MSc (Engg), Ph.D., M.I.S.T.E., C.Eng. (I), FIE**, Head of the Department, Electrical and Electronics Engineering for his kind encouragment.

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SYNOPSIS

The Speed-Torque characteristic of a Three-Phase Induction Motor is a straight line in the stable operating region. As the load is increased the speed falls. In this project it is proposed to design a circuit and interface with microprocessor to operate the Induction Motor at constant speed for different loads.

The speed is maintained constant by controlling the resistance in the rotor circuit by means of a chopper. The triggering gate pulse to the chopper circuit is controlled by means of a microprocessor. The hardware circuit is designed and fabricated and the software is developed. Test results are presented in this project.

Many applications require constant speed operation for varying loads. This project will be more suited for such applications.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The objective of our project is to run the three-phase wound rotor Induction Motor at constant speed at different load conditions.

The Induction Motor has a wide range of applications. They are employed in electrically driven ships, elevator motors, traction motors, cranes, conveyors etc. The method in which the speed of Induction Motor is controlled differs from one application to other.

Among all these control schemes we have concentrated in controlling the speed of Induction Motor using the scheme that is used in cranes.conveyors, machine tools etc.

A conventional rotor resistance control strategy is employed here. Therefore it is obvious that the Induction Motor used for this purpose is a wound rotor Induction Motor with control from the rotor side.

Compared with other methods of speed control this method of speed control is low cost and has high power factor .The external resistance is varied steplessly and statically using a high frequency thyristor chopper in the rotor circuit.

Thus the effective value of resistance across the dc terminals of the bridge is thus controlled from zero to maximum value by varying the duty ratio from unity to zero. But here, the maximum obtainable rotor resistance is limited, which has practical limitations for minimum value of speed and torque.

Therefore to overcome this limitation the advancement that we have made in our project is by designing a new strategy to overcome the above the above limitation. We have used a capacitor in series with the external resistance in the rotor circuit so that control area is widened.

The speed – torque control scheme that is designed and fabricated is microprocessor based. We use an Intel 8085 controller. The digital control system used here have advantages over conventional analog control system namely, much better speed accuracy's can be obtained.

1.2 SPEED CONTROL OF INDUCTION MOTOR

The rotor speed of a three-phase slip ring motor can be controlled either by varying the frequency of the supply keeping the frequency to voltage ratio constant or by controlling the power flow in the rotor circuit.

The control scheme we are applying is depended upon controlling the power flow in the rotor circuit by inserting an adjustable external resistance in the rotor circuit.

In the case of an Induction Motor the torque is directly related to the flux, rotor current and the rotor power factor. Thus we have

$T \;\alpha\; \phi\, I r \, \cos\phi r$ (1.1)

Where ϕ = flux

Ir = rotor current

$\cos\phi r$ = power factor (rotor)

Let E_2 be the rotor-induced emf per phase under standstill conditions and let X_2 be the rotor reactance per phase under standstill conditions. Since the rotor frequency at a slip S is fr = Sf, the rotor reactance varies

$Xr = SX_2$ (1.2)

Also $E_2 \;\alpha\; \phi$

Further under running conditions, the relative speed reduces and hence

$Er = SE_2$ (1.3)

Where Er is the rotor induced voltage under running conditions.

$$Ir = \frac{E_r}{\sqrt{R_2^2 + (sX_2)^2}} \quad (1.4)$$

$$\cos\phi r = \frac{R_2}{\sqrt{R_2^2 + (sX_2)^2}} \quad (1.5)$$

Hence the torque under running conditions is

$$T = \frac{KSE_2^2R^2}{R_2^2 + S^2X_2^2} \quad (1.6)$$

Since $\phi \;\alpha\; E_2$

At stand still, S=1 and therefore starting torque is

$$Tstart = \frac{KE_2^2R^2}{R_2^2 + X_2^2} \quad (1.7)$$

Where Id is the average chopper current, Vo the voltage across the capacitor at the end of on period and is given by

$$V0 = V' e^{-(K_D/T/R_{EX} C)} \quad (1.92)$$

From equations (1.91) and (1.92)

$$V' = (1 - K_D)\, T\, I_d / C[1 - e^{-(K_D T / R_{EX} C)}] \quad (1.93)$$

Now the energy lost in Rex during off period is written as

$$W_{off} = I_d^2 R_{EX} (1 - K_D) T \quad (1.94)$$

The energy lost is Rex during on period is written as

$$W_{on} = [(1/K_d)^2 T^2 I_d^2 / 2C] B \quad (1.95)$$

$$\text{Where } B = 1 + e^{-}(K_D T / R_{EX} C) / 1 - e^{-}(K_D T / R_{EX} C) \quad (1.96)$$

If W_T is the average power dissipated for resistance per cycle which is equal to (energy lost in one cycle) / T, then from equations (1.95) and (1.96) we have

$$W_T = I_d^2 R_{EX} (1 - K_D) [1 + (1 - K_D) TB / 2CR_{EX}] \quad (1.97)$$

From equation (1.97)

$$R_{eq} = R_{EX} (1 - K_D)[1 + (1 - K_d) TB / 2CR_{EX}] \quad (1.98)$$

This expression for R_{EX} is simplified to an approximate expression given by

$$R_{eq} = R_{EX} (1 - K_d) / K_d \quad (1.99)$$

This expression in equation (1.99) shows that as compared to equation (1.8), which permits only a limited value of maximum resistance R_{EX} to be obtained at $K_D = 0$, it is possible to control the equivalent resistance through the external capacitor from zero to infinity, as K_D is varied from unity to zero. Hence it is possible to control the Induction Motor over the entire range below its natural speed – torque characteristic.

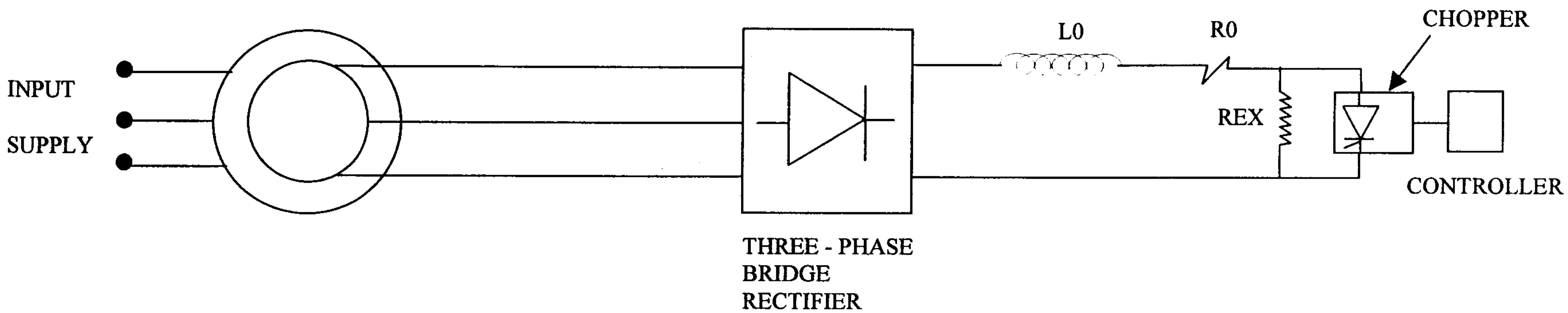


FIG1.1 CHOPPER CONTROL

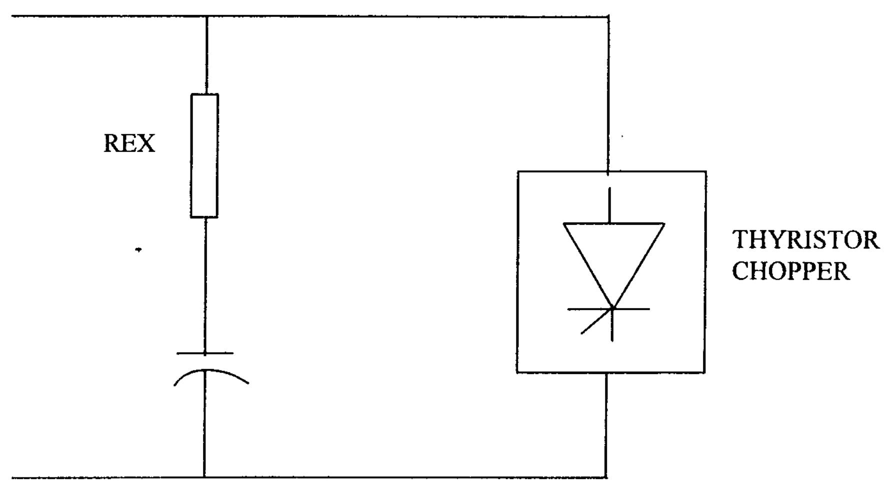


FIG.1.2 REX –C COMBINATION

CHAPTER 2

DIGITAL SPEED REGULATING SYSTEM

The main components of this scheme are:

1. Diode bridge rectifier
2. SCR chopper circuit
3. Overcurrent detection circuit
4. Speed feedback circuit
5. Digital speed regulator

The components of this system are described one by one

2.1 DIODE BRIDGE RECTIFIER

A three-phase bridge rectifier is commonly used in high power applications and it is shown in fig (2.2)

The diode bridge rectifier can operate with or without a transformer and gives six pulse ripples on the output voltage. The diodes are numbered in order of conduction sequences and each one conducts for 120°. The conduction sequence for diodes is 12,23,34,45,56 & 61. The pair of diodes, which are connected between the pair of, supply lines having the highest amount of instantaneous line to line voltage will conduct. The line to line voltages is $\sqrt{3}$ times the phase voltage of a three-phase wye-connected source.

The average output voltage is found from

$$Vdc = \frac{2}{2\pi/6} \int_0^{\pi/6} \sqrt{3}\, vn \cos\omega t \; d\,(\omega t)$$

$$= \frac{3\sqrt{3}}{\pi}\, vm \;=\; 1.654\,Vm \qquad (2.1)$$

Where Vm is the peak phase voltage.

The Rms output voltage is

$$Vrms \;=\; \left[\frac{2}{2\pi/6} \int_0^{\pi/6} 3\,Vm^2 \cos^2 \omega t\, d\;(\omega t)\right]^2$$

$$= 1.6554\,Vm \qquad (2.2)$$

The current value is depended upon the maximum voltage and the load.

2.1.1 DESIGN

The diodes which constitute the bridge rectifier has a high rating of 600V, 6A. This rating of diodes is higher than the voltage and current of the rotor. Thus these diodes are used to obtain an efficiently operating bridge rectifier.

2.2 SCR CHOPPER CIRCUIT

The SCR chopper circuit is shown in fig (2.3). This fig shows the doubly- fed chopper used in the rotor circuit. This chopper is designed on the basis of the analysis provided by Mr.Dubey. The elements Th1 and Th2 are the main and the auxillary scr's. C is the commutating capacitor. The diodes D2 ,Lc and C are the commutating circuit components. Rex is the external rotor resistance to be controlled, R is the resistance which is used to limit the current drain from the auxillary source, and inductance La is the smoothing inductor. The auxillary voltage source is used to ensure successful commutation of SCR's at all speeds, particularly at high speeds when the rectified voltage from the rotor becomes very small. The operation of the circuit is explained as follows:

Let us assume the polarity of the capacitor C as shown in fig2.3 .When thyristor Th1 is triggered, it short circuits the external resistance Rex . Thus the effective resistance across the rotor of the induction motor becomes practically zero. The load current starts flowing through Th1 and at the same time the capacitor discharges through the path consisting of Cc ,Th1 ,D2 and subsequently develops charge in the opposite polarity. After capacitor has reversed the charge, the diode D2 does not allow it to swing in the opposite direction because it gets reversed biased. Now when Th2 is fired, Th1 gets commutated off and the capacitor reverses its charge through Cc, Th2, Rex and D1 while carrying the constant load current. After Th1 gets commutated off, the resistance Rex that is now the effective rotor resistance carries the full load current. When Th2 is still conducting, a current equal to V/R keeps flowing from the auxillary source until Th1 is fired again. As shown in fig2.3 when Th1 is fired the chopper current from the rotor increases. Next when Th2 is fired to commutate Th1 off, the current starts decreasing. Under the steady state the current becomes constant for a given load and the duty ratio.

2.2.1 DESIGN

The requirements of design are

1. Thyristor Th_1 should conduct when a gate pulse is given to it.
2. Thyristor Th_2 should commutate Th_1 when a gate pulse is given to it.
3. The conduction of thyristors should be maintained even at high speeds when the rectified voltage from the rotor becomes very small.

R: A 15-ohm resistor is used to limit the current flow through SCR.

R_{ex}-C: 20.8-ohm rheostatic resistance in series with 330-microfarad capacitance.

Th_1: The thyristor used is TYN 416 which has a rating of 400V, 16A.

Th_2: The thyristor used is TYN 416 which has a rating of 400V, 16A.

Now we have toff time $= \sqrt{CL1}\ \tan^{-1}\left(\frac{Vo}{Im}\sqrt{\frac{C}{L_1}}\right)$ (2.3)

where toff = turn off time of the thyristor. Th1 .

Assuming C = 100 μ F

Im = 4.5 A

V_0 = 30v

then we get L1 = 25 μH .The nearest value available is 22 μ H.

A 12V voltage supply is given in order to maintain the conduction of SCR at different loads. A 120-ohm resistor is also provided to prevent current drain from this source.

2.3 OVERCURRENT DETECTION CIRCUIT.

The overcurrent detection circuit is a circuit, which is used for the protection of the rotor circuit from overcurrent. The reference voltage is kept at a constant value using the 5-kilo ohm potential divider. When the voltage corresponding to overcurrent is obtained, at that time the voltage at the non- inverting terminal of *LM4250 would exceed the reference voltage kept at the inverting terminal. The reference voltage should be kept in such a way that the non-inverting voltage would exceed the inverting voltage only when the voltage corresponding to overcurrent is obtained. When overcurrent occurs the output of LM4250 becomes positive and the diode start to conduct.

This makes the base of the transistor BC108 to go high. Thus BC108 starts to conduct. This conduction leads to the glowing of the LED placed inside the optoisolator MCT2E. The light emitted by it falls on the base of the phototransistor placed inside the optoisolator. This makes the phototransistor to conduct. The phototransistor is connected to a 5V supply (Vcc). The input to the microprocessor is taken from the collector after a resistance. Now, when the phototransistor is in conducting state there will be a large voltage drop at the resistance. This makes the input to the microprocessor to go low. *Refer appendix

Under normal working condition the phototransistor will not conduct, so the input to the microprocessor is high. Using these transitions the microprocessor is able to distinguish between normal working condition and overcurrent condition.

2.3.1 DESIGN

The requirements of design are:

1. To compare reference voltage with the voltage obtained from the chopper circuit.
2. To give an output based upon the result of this comparison.

Design for the overcurrent detection circuit is based on the circuitry obtained from IE journal. In the circuit we utilise programmable operational amplifier which has a non-inverting and inverting terminal. The output of the programmable operational amplifier is fed to the base of a transistor, which is working in the common emitter mode. The transistor, which is utilised, is BCI08.An optoisolator is utilised in order to have isolation between two circuits. The optoisolator used is MCT2E.The output of the optoisolator is fed to the microprocessor.

2.4 SPEED FEEDBACK CIRCUIT

To detect the speed of the induction motor we make use of a proximity sensor. Proximity sensor is a device, which will sense the presence of metals. The proximity sensor has to be given a dc supply between 10-30 V. these detectors incorporate built in amplifiers giving on/off outputs and will detect ferrous and non-ferrous metals. The type of proximity sensor used in this project is shown in fig2.5. This sensor is a NPN proximity sensor. They have nickel plated brass houstings with a polyamide and LED 'target sensed' indicators. The proximity sensor is placed at a small distance from the projection placed on the brakedrum. Whenever this projection comes in front of the proximity sensor a pulse is generated. These pulses which are generated are fed to the microprocessor in which they are counted. Each speed setting would generate different number of pulses, which will be counted by the microprocessor and compared with the reference number of pulses, which corresponds to a reference speed.

2.5 DIGITAL SPEED REGULATOR

The Digital speed regulator used in our project is an 8085 microprocessor .The Digital speed regulator consists of three main functions:

(1) Digital speed controller.

(2) Digital current limiter.

(3) Gate pulse generator.

The Digital speed controller is used to control and maintain the speed of the Induction Motor as a constant. This is done by varying the duty ratio of the chopper circuit by controlling the gate pulses. The gate pulses for the chopper circuit is generated by IC 8253 which has two operational counters and which are used to generate gate pulses for Th1 and Th2. The arrangement, which is used in our project, is shown in fig (2.6). The microprocessor also does the function of a Digital current limiter.

The overcurrent signal in the Digital form controls the output pulse for the main SCR. The Digital current limiter is operated by a software control. When load current becomes higher than the set current the output of the current sense circuit which is connected to the input bit PB1 goes low sensing this the firing pulses to the main SCR is withdrawn connecting the external resistance Rex in the rotor thus reducing the overcurrent.

2.6 HARDWARE

The overall circuit, which combines all the different circuits together, is shown in fig (2.7). This circuit mainly consists of

(1) The rectifier bridge circuit

(2) Chopper circuit

(3) Overcurrent detection circuit

The rectifier bridge circuit is used to rectify the three phase voltage which is obtained at the slip rings of the Induction Motor .The output of the rectifier bridge is given to chopper circuit as well as to the overcurrent detection circuit. During no load period the rectified voltage applied may be very small and thus an auxillary dc source is used so that the conditions of SCR's is maintained properly. The auxillary source we have used is a 12 volts power supply. As discussed earlier itself the chopper circuit has two SCR's Th1 and Th2.The two SCR's Th1 and Th2 are given gate pulse which is generated by IC 8253 of the microprocessor. The gate pulse is controlled in such a manner such that there is a pulse difference between the gate pulse given to Th1 and Th2.This phase difference corresponds to the duty ratio of the SCR. Thus by varying this phase difference between the gate pulses the duty ratio can be changed and thus the equivalent resistance to be added in the rotor circuit can be changed thus the speed of the motor can be varied and brought to a constant value.

In the overcurrent detection circuit we make use of programmable operational amplifier LM 4250.In the second pin of this IC that is inverting terminal the reference voltage is provided which has been tapped from 1.5 volts supply using a potential divider arrangement. Any particular reference voltage can be kept according to our convenience. At reduced load conditions the voltage at pin 3 of LM 4250 which is non inverting terminal is less than the reference voltage, thus output is negative and the output to the microprocessor is a high signal. When a voltage which corresponds to a high current which more than the preset value is obtained then at that time the voltage at pin 3 should exceed the reference voltage.

Thus the reference voltage has to be selected in such a way to allow this when the output of LM 4250 goes high then the output to the microprocessor goes low. The transition between high pulse and low pulse to a microprocessor is maintained properly by using a 10 Kilo Ohm variable potential divider.

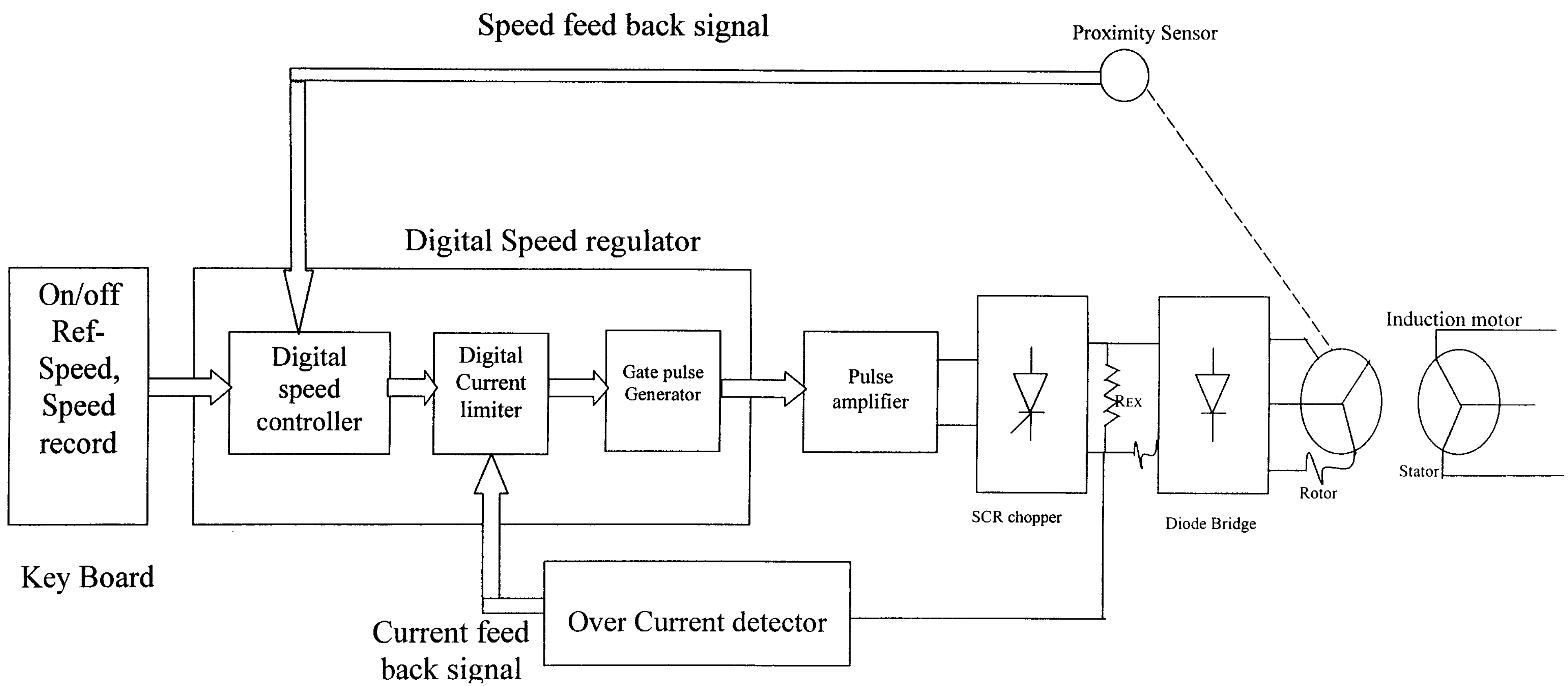


Fig. 2.1 Digital Speed regulating system

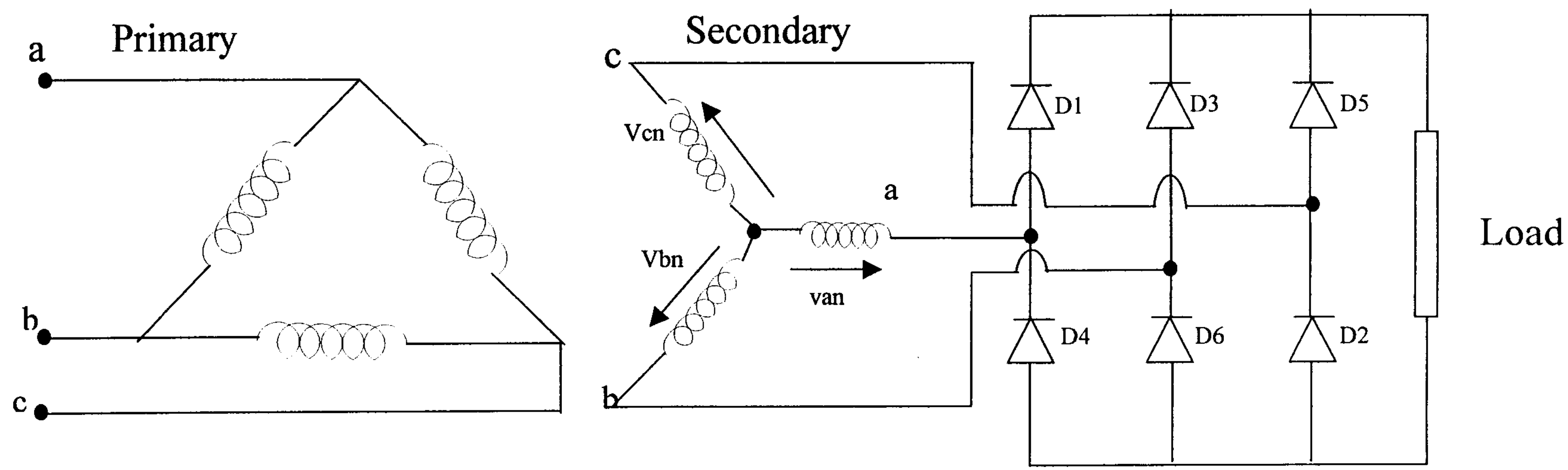


Fig.2.2 Diode bridge rectifier

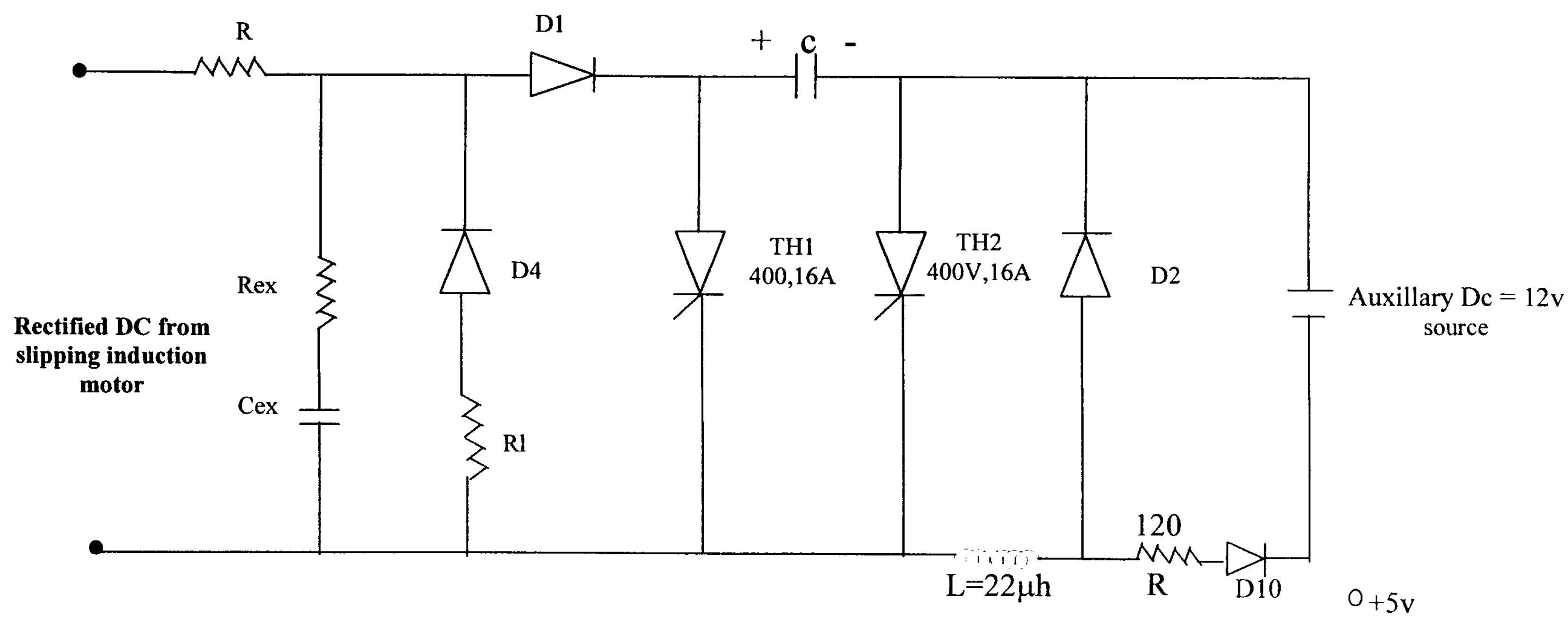
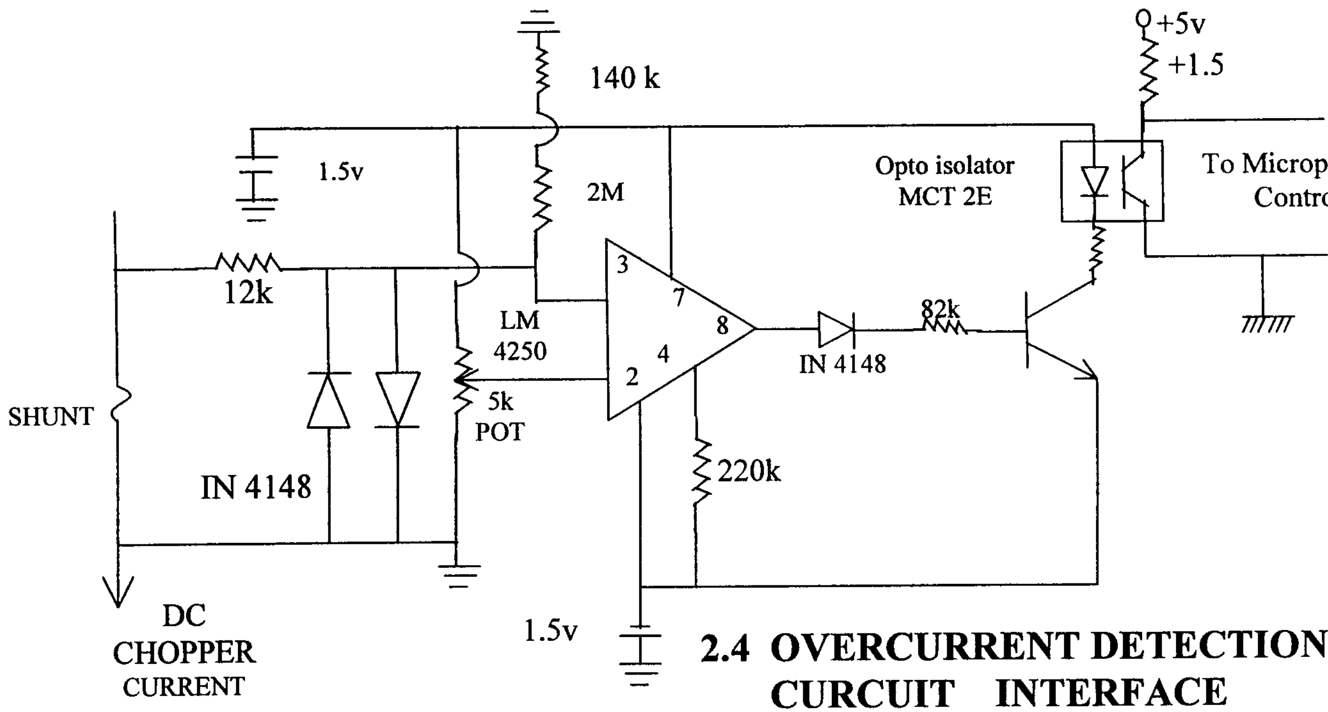


Fig.2.3 EXPERIMENTAL CHOPPER CIRCUIT WITH
$R_{EX} - C_{EX}$ IN SERIES



2.4 OVERCURRENT DETECTION CURCUIT INTERFACE

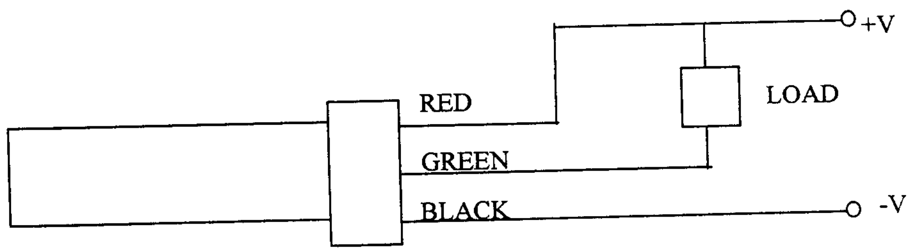


FIG.2.5 NPN TYPE PROXIMITY SENSOR

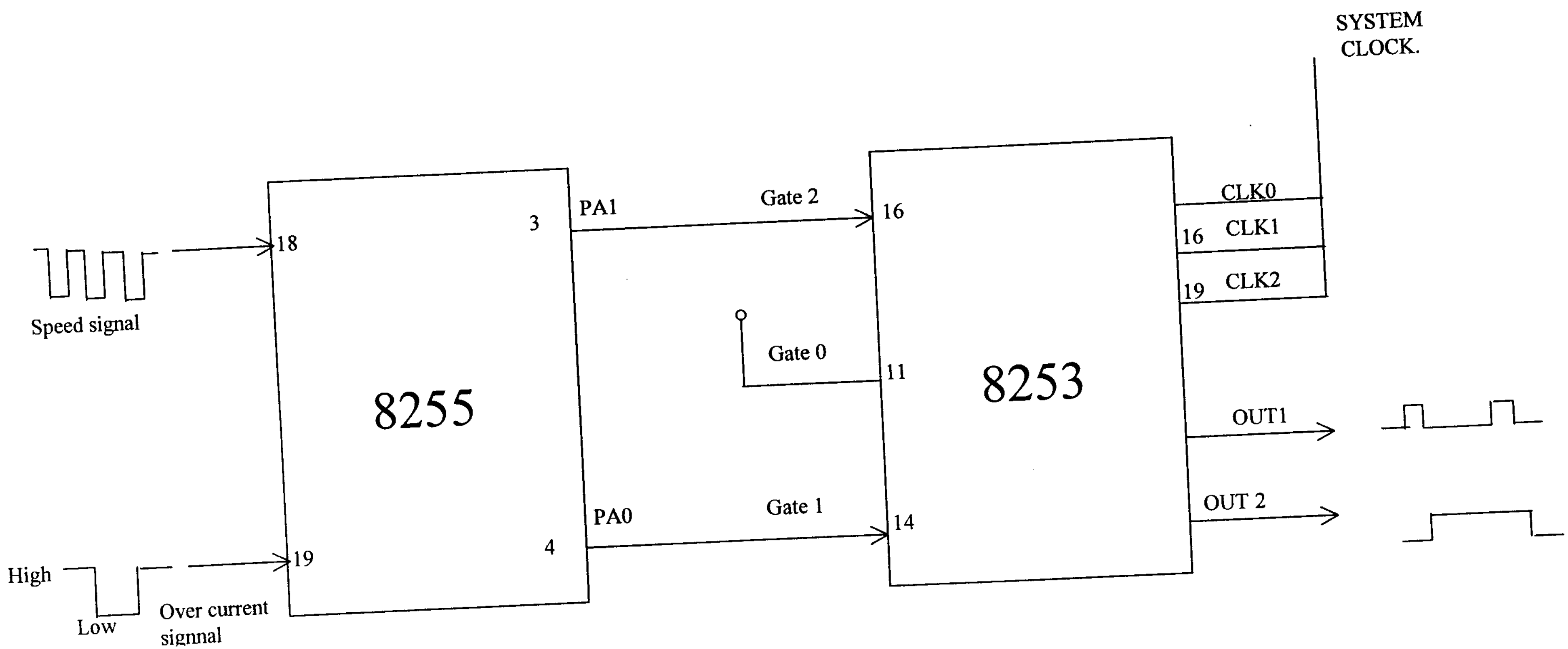
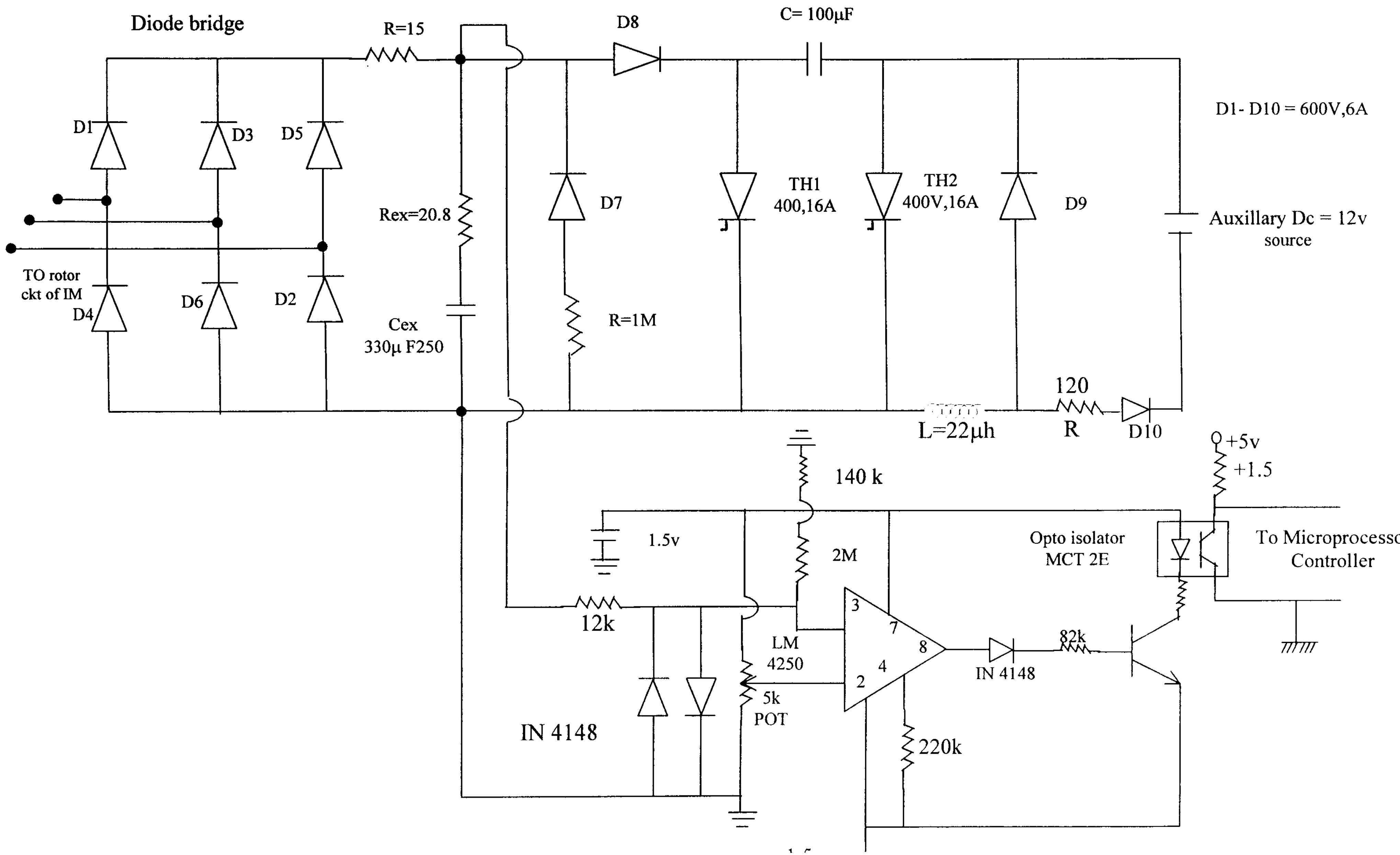


FIG. 2.6 PIN CONNECTION OF 8255 AND 8253
FOR INPUT /OUT PUT



Diode bridge
R=15
D8
C= 100µF
D1- D10 = 600V,6A
D1
D3
D5
D7
TH1
400,16A
TH2
400V,16A
D9
Rex=20.8
Auxillary Dc = 12v
source
TO rotor
ckt of IM
D4
D6
D2
Cex
330µ F250
R=1M
120
R
L=22µh
D10
+5v
+1.5
140 k
1.5v
2M
Opto isolator
MCT 2E
To Microprocesso
Controller
12k
LM
4250
3
7
8
4
2
IN 4148
82k
5k
POT
IN 4148
220k

CHAPTER 3

SOFTWARE DEVELOPMENT

The software contains three main ports. They are:

1. Soft start
2. Over current control program
3. Speed control program

3.1 SOFT START.

The suitable software is developed such that at the time of starting, the phase difference between the main and auxillary thyristor pulses is set to the minimum value, so as to have a fairly low value of Kd. This phase difference is increased at a presettable rate through the program, which causes the motor to softstart by slowly increasing Kd and hence reducing equivalent resistance, Req. By changing the value of duty ratio in steps through software the starting time and also the starting current of the motor can be controlled as desired depending upon the drive applications and supply system constraints.

3.2 OVERCURRENT CONTROL PROGRAM

The overcurrent control program is a program, which deals with the protection of the system from overcurrent. Whenever overcurrent occurs the pulse generated by the overcurrent detection circuit goes low and this is sensed by the microprocessor. Now as the microprocessor controlling the Kd value, it makes the Kd value to zero. This is done by withdrawing the gate pulses to the main SCR. Thus in this way a very high resistance gets added in the circuit, so that the current value is kept undercheck continuously. Now the operator has to reduce the load a little bit so as to reduce the current and the voltage. This causes the program to come out of the overcurrent control program.

3.3 SPEED CONTROL PROGRAM.

After the program comes out of the overcurrent control program the K_d is assigned the last value before the pulses to the main SCR are withdrawn. The pulse generator sends an output pulse through the output ports. Then the program goes to the speed sampling subroutine. After the speed is sampled it is checked with the set speed. The output from the pulse generator, which is IC8253, depends on which of the three error condition prevails. If speed error is zero, there is no change in the pulse controller. If however the speed feedback is greater than the set speed, the duty ratio K_d is reduced, so as to bring more resistance into rotor circuit, there by decreasing the speed. If however the speed feedback is less than the set speed, the duty ratio K_d is incremented thus reducing and increasing the speed of the motor.

Following steps are involved in one control cycle.

1. The motor speed is measured and compared with preset value of speed.
2. The error in set speed and measured speed is used to control the pulse generator, so as to adjust the duty ratio of the chopper by preset length.
3. Reset counter

It can be easily understood that small speed errors are corrected quickly by adjustment of phase shift brought about by the digital speed regulator. However for large speed errors more number of comparisons steps are required before the pulse generator can be properly adjusted.

3.4 ALGORITHM AND FLOWCHART

3.4.1 CLOSED LOOP SPEED CONTROL:

Step 1: Initialise the input ports, output ports, stack pointer, register, counters.

Step 2: Set Kd = Kdmin.

Step 3: Increment Kd.

Step 4: Compare Kd with a reference value, Kdset.

Step 5: If Kd is not equal to Kdset, go to step 3.Otherwise go to next step.

Step 6: check if current exceeds preset value.

Step 7: if yes then assign Kd=0 and go to step 6.if no then assign Kd to its Last value and go to its next step.

Step 8: Out the control pulses say in port A.

Step 9: Call the speed measurement subroutine.

Step 10: Compare the speed obtained with, Nm with the reference speed, Nset.

Step 11: If Nm and Nset are equal , maintain the Kd as (=Kdset) previous one and go to step 6.

Step 12: If Nm is less than Nset ,go to step 17.Otherwise go to step 13.

Step 13: Decrement the Kd value.

Step 14: Check whether Kd is less than Kd min .

Step 15: If yes, set Kd as Kd min and go to step 6.

Step 16: If no go to step 6.

Step 17: Increment Kd value.

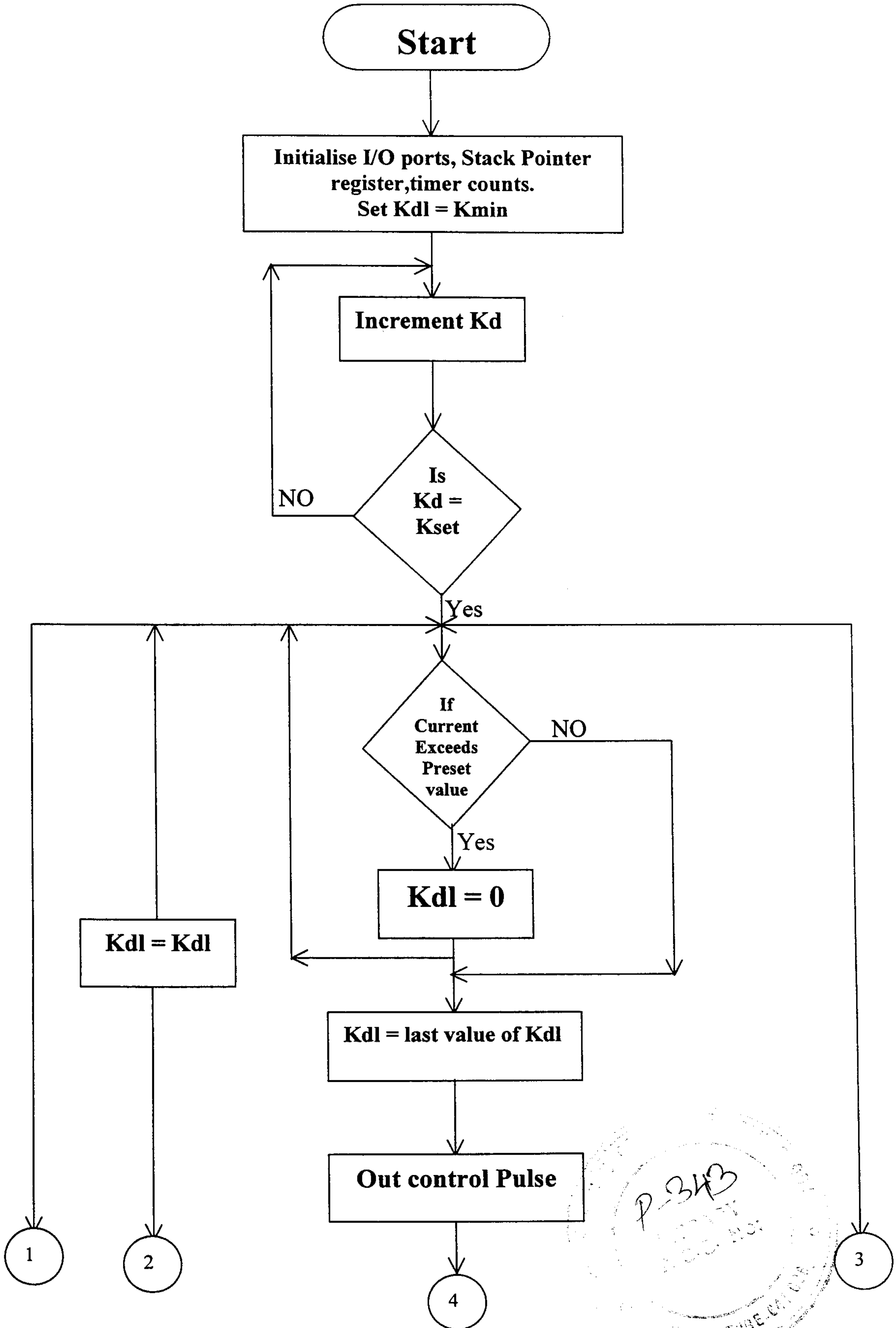
Step 18: Check whether Kd is greater than Kdmax.

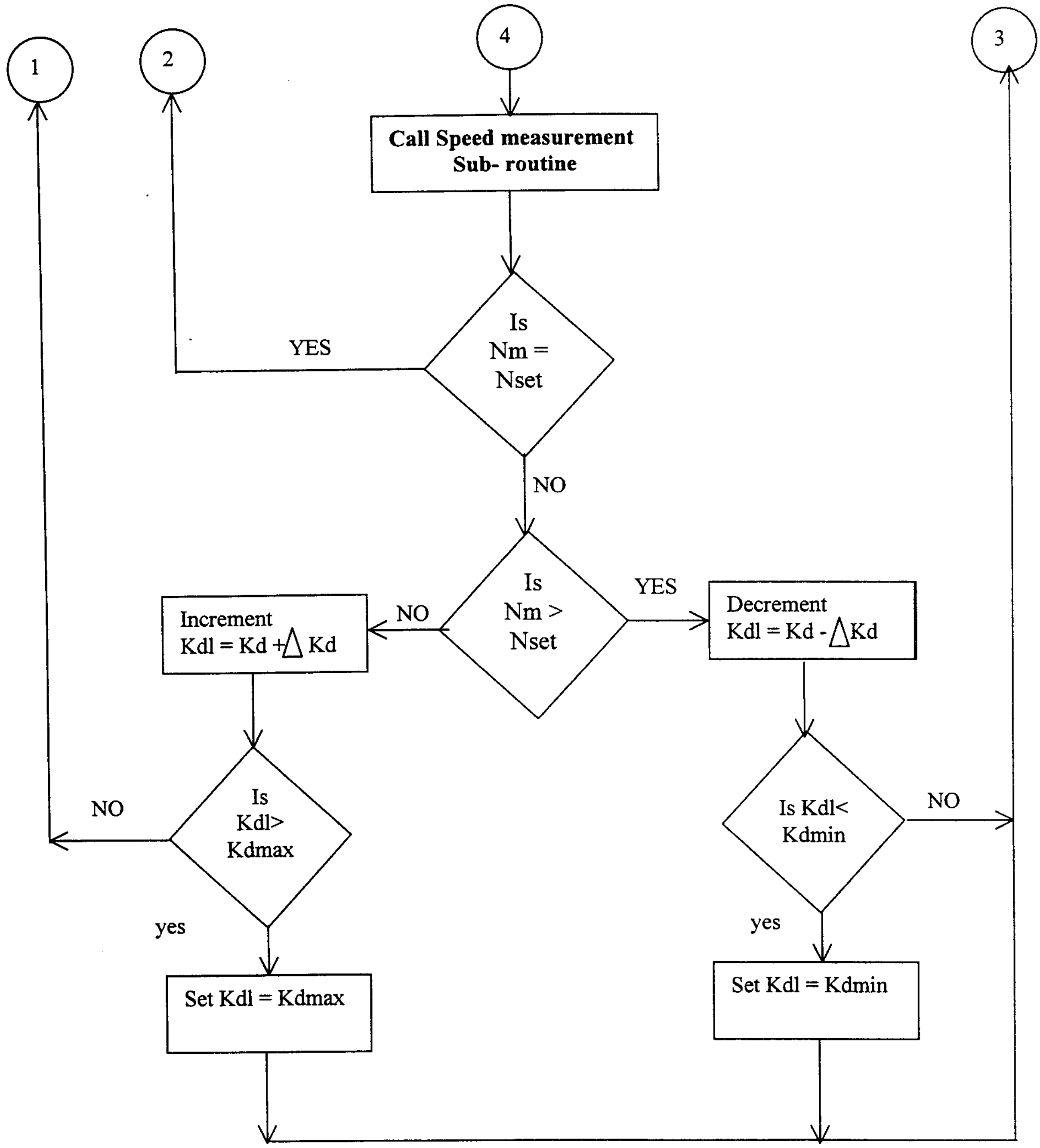
Step 19: If yes, set Kd as Kdmax and go to step 6.

Step 20: If no go to step 6.

CLOSED LOOP SPEED CONTROL

The detailed procedure for speed control is depicted in flow chart




1
2
4
3
Call Speed measurement Sub- routine
Is Nm = Nset
YES
NO
Is Nm > Nset
NO
YES
Increment Kdl = Kd +△ Kd
Decrement Kdl = Kd - △Kd
Is Kdl> Kdmax
NO
yes
Is Kdl< Kdmin
NO
yes
Set Kdl = Kdmax
Set Kdl = Kdmin

3.4.2 ALGORITHM FOR SPEED SUBROUTINE:

Step 1: Initialise the stack pointer, input port, register, counter with a particular Value.

Step 2: Input the speed pulses through the port.

Step 3: Check if port input is high.

Step 4: If yes, go to step 9.

Step 5: If no, decrement the counter.

Step 6: Check whether counter has become zero.

Step 7: If yes, go to step 14.

Step 8: If no, go to step 2.

Step 9: Increment the register.

Step 10: Decrement the counter.

Step 11: Check whether counter has become zero.

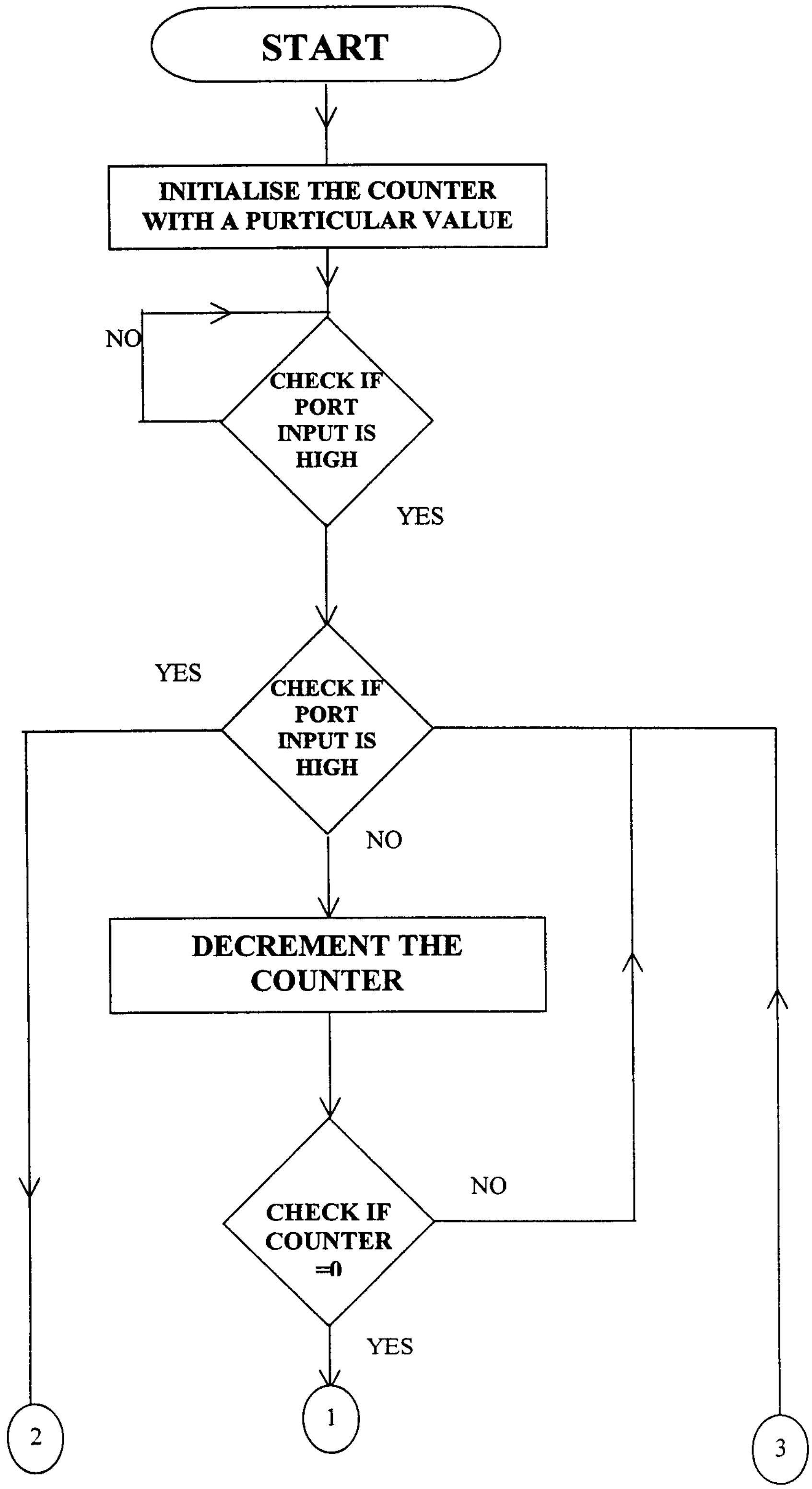
Step 12: If yes, go to step 14.

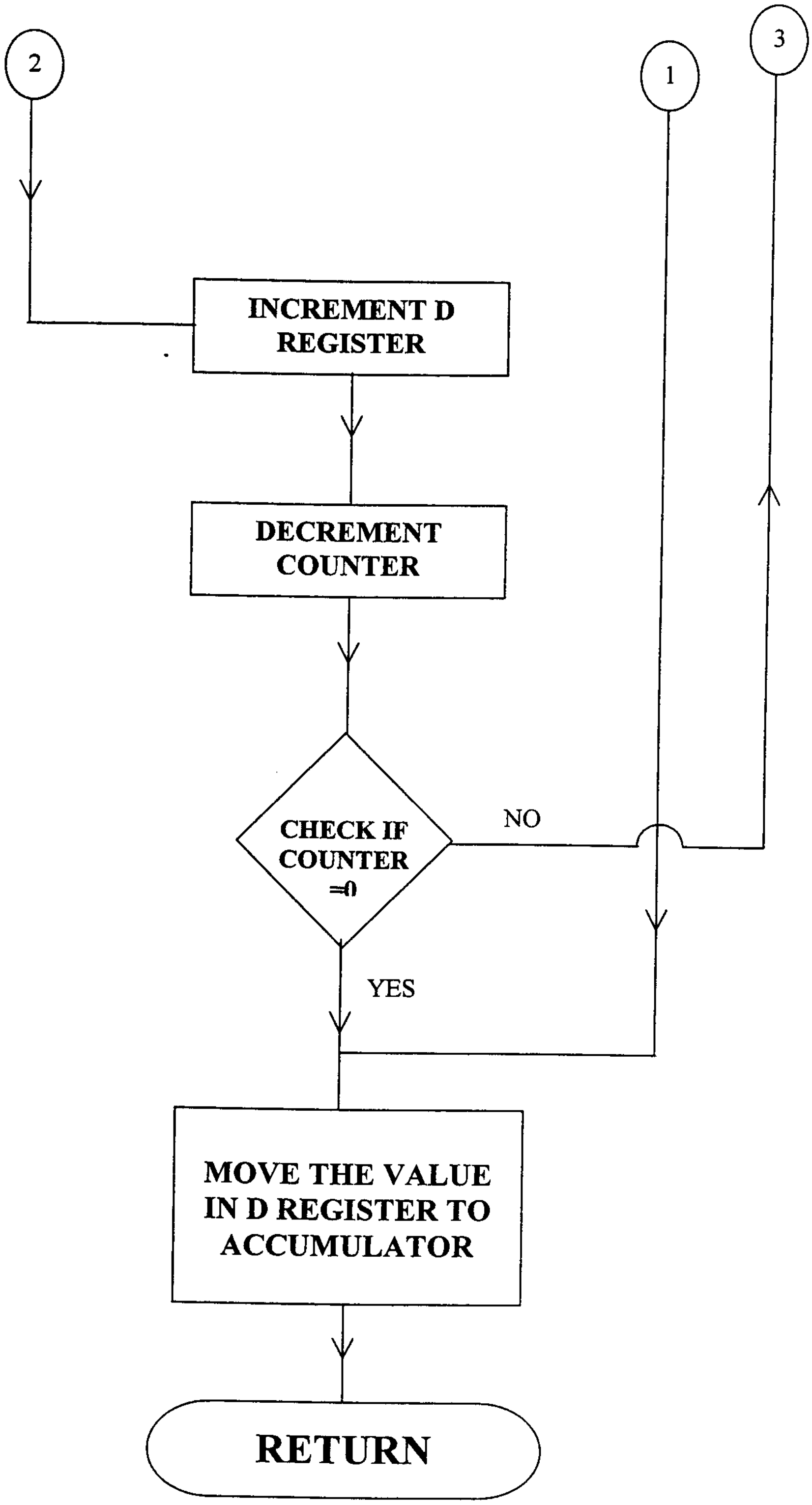
Step 13: If no, go to step 2.

Step 14: Move the value in register to accumulator.

Step 15: Return to main program.

SPEED SUBROUTINE




2
1
3
INCREMENT D REGISTER
DECREMENT COUNTER
CHECK IF COUNTER =0
NO
YES
MOVE THE VALUE IN D REGISTER TO ACCUMULATOR
RETURN

3.5 ASSEMBLY LANGUAGE PROGRAM

```
        LXI SP,8200
        LXI H,00A2
        LXI D,03E8
        PUSH H
        MVI A,82
        OUT 43
L1 :    MVI A,00
        OUT 40
        CALL COUNTER1
LOOP :  DCX H
        MOV A,L
        ORA H
        JNZ LOOP
        INX D
        CALL COUNTER2
        MVI A,02
        OUT 40
        POP H
        PUSH H
        LXI B,0416
```

```
L2 :        DCX B
            MOV A,C
            ORA  B
            JNZ  L2
            MOV A,E
            CPI C4
            JNZ  L1
            MOV  A,D
            CPI  4F
            JNZ  L1
            MVI  A,00
            OUT  40
            CALL COUNTER 1.1
LOOP3 :     DCX H
            MOV A,L
            ORA  H
            JNZ  LOOP3
            CALL COUNTER 2
            MVI A,00
            OUT  40
            LXI B,0076
```

```
LOOP4 :     DCX  B
            MOV A,C
            ORA  B
            JNZ  LOOP4
            LXI  H,02BC
            LXI  D,0202
            PUSH  H
            PUSH  D
START :     IN  41
            ANI  02
            CPI  02
            JC  CURRENT
            CALL SPEED
            CPI   62
            JNZ  LOOP5
            JC  LOOP6
            POP  D
            POP  H
            PUSH  H
            PUSH  D
            JMP  LOOP6
```

```
LOOP5 :     POP D
            POP H
            INX D
            PUSH H
            PUSH D
            JMP LOOP6
LOOP9 :     POP D
            POP H
            DCX D
            PUSH H
            PUSH D
LOOP6 :     MVI A,02
            OUT 40
            CALL COUNTER 1
LOOP10 :    DCX H
            MOV A,L
            ORA H
            JNZ LOOP10
            CALL COUNTER 2
            MVI A,02
            OUT 40
            LXI B,02F7
```

```
LOOP11 :        DCX  B
                MOV  A,C
                ORA  B
                JNZ  LOOP11
                JMP  START

COUNTER1:       MVI A,70
                OUT 13
                MVI A,0A
                OUT 11
                MVI A,00
                OUT 11
                MVI A,01
                OUT 40
                LXI B,0014
LOOP1:          DCX B
                MOV A,C
                ORA B
                JNZ LOOP1
                MVI A,00
                OUT 40
```

```
                CALL COUNTER1.1
                RET
COUNTER1.1      MVI A,70
                OUT 13
                MVIA,0A
                OUT 11
                MVI A,00
                OUT 11
                RET
COUNTER2:       MVIA,BO
                OUT 13
                MOV A,E
                OUT 11
                MOV A,D
                OUT 11
                RET
CURRENT:        MVI  A,00
                OUT  40
L0.0 :          LXI  H,OOA2
                DCX  H
                MOVA,L
                ORA  H
                JNZ  L0.0
```

```
        MVI  A,B0
        OUT  13
        MVI  A,C4
        OUT  11
        MVI  A,4F
        OUT  11
        MVI  A,02
        OUT  40
        LXIB,0394
L0.1 :  DCX  B
        MOV A,C
        ORA  B
        JNZ  L0.1
```

```
SPEED : LXI  H,00FF
        MVI  A,82
        OUT  43
        MVI  D,00
```

```
LOOP12 :    IN   41
            ANI  01
            CPI  00
            JZ   LOOP12
LOOP13 :    IN   41
            ANI  01
            CPI  01
            JZ   LOOP 7
            DCX  H
            MOV  A,L
            ORA  H
            JNZ  LOOP13
            JMP  LOOP 8
LOOP7 :     INR  D
            DCX  H
            MOV  A,L
            ORA  H
            JNZ  LOOP7
LOOP8 :     MOV  A,D
            RET
```

CHAPTER 4

FABRICATION AND TESTING

4.1 FABRICATION

The PCB layout for the overall circuit is designed and simulated using "smart" software. The PCB layout consists of both power circuitry as well as ordinary circuitry. As shown in fig4.1 the thick lines represent power circuitry. Now power circuitry is supposed to handle high current thus while soldering copper reinforcement has been given to these thick lines so that they are capable of handling the high current.

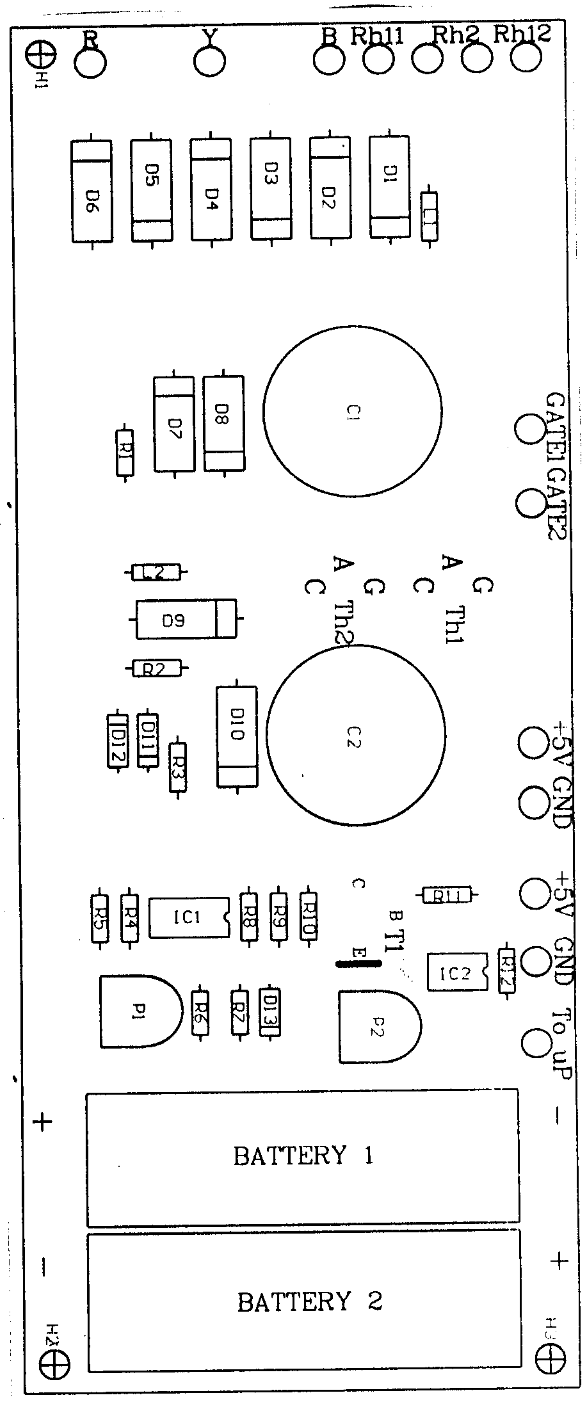
Proper leads were taken out of the PCB so as to enable the interfacing of the speed control circuiting with microprocessor. Provisions were also made for the power supply connections and also for rheostatic connections. Three lines were taken out from the PCB so as to enable connections with the slip rings of the Induction Motor. These lines were provided with the proper thickness. All the other components were fixed according to the PCB layout.

4.2 TESTING

The continuity in the PCB was tested. Initially the components testing were done individually. Then the components were fabricated in the PCB and tested. Initially all the connections were given and motor is started, simultaneously with the execution of microprocessor program. The motor is allowed to accelerate for a few seconds so that it reaches a specified speed. This speed is controlled by the soft start program. After it reaches the specified speed the motor is loaded and speed is noted. It is found that speed has reduced. Allow the motor to run for some time. Again note down the speed. It is found that the motor tries to gain back its initial speed. The above procedure is carried out for different loads and the results are obtained satisfactorily.

4.3 APPLICATOINS:

The rotor resistance control strategy discussed has many practical applications. This control strategy is mainly widely used with cranes, lifts, conveyors, machine tools and mine winders. As this strategy is relatively low cost and high power factor it can be used instead of dc motors.


R
Y
B
Rh11
Rh2
Rh12
H1
D1
D2
D3
D4
D5
D6
L1
C1
D7
D8
R1
GATE1
GATE2
A
G
C
Th1
Th2
L2
D9
R2
D10
C2
D11
D12
R3
+5V
GND
+5V
GND
To uP
R4
R5
IC1
R8
R9
R10
R11
B
C
E
T1
IC2
R12
P1
P2
R6
R7
D13
+
-
BATTERY 1
BATTERY 2
H2
H3

CHAPTER 5

CONCLUSION

A new digital speed control system for a slip ring Induction Motor has been designed, fabricated and tested. The speed of the motor for different loads has been controlled by a chopper circuit. The software developed controls the triggering circuit of the chopper. The speed control system fabricated controls not only the speed but also it can be used for soft – start and for overcurrent detection.

The soft – start characteristics of the motor and constant speed operation are of great importance in many applications in industry. Thus a slip ring motor with digital speed controller as done in this project can thus replace dc motors in many applications.

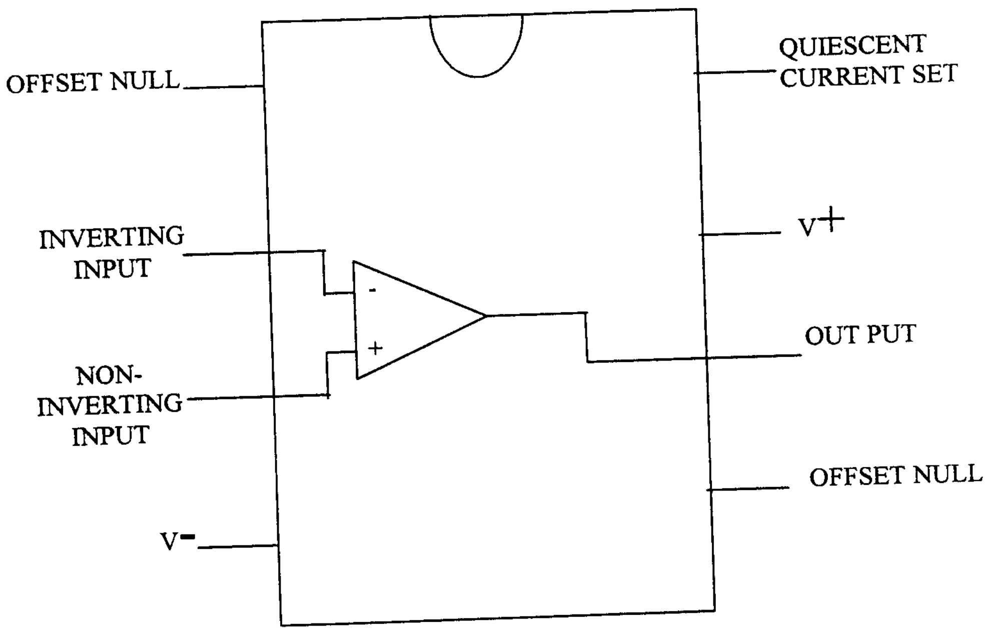
TEST RESULTS: SPEED AFTER SLOW START : 820 rpm

Rectified current (amps)	speed rpm	Recovered speed rpm
1.2	750	780
1.4	700	780
1.6	680	780
2.0	590	780

REFERENCES

1. Ramesh S.Goankar, " Microprocessor Architecture, Programming And Applications " Wiley Eastern Limited, Chennai, 1994.
2. Muhammad H.Rashid,"Circuits, Devices And Applications" Prentice Hall Of India Private Limited, Newdelhi, 1998.
3. W.Shepherd and L.N.Hulley "Power Electronics and Motor Control" Cambridge University press, Cambridge, 1987.
4. B.K.Bose "Power Electronics and AC Drives" Prentice-Hall Englewood Cliffs, New Jersey, 1986.
5. A.K.Sawhney "Electrical and Electronics Measurement and Instrumentation" Dhanpat Rai and sons, New Delhi, 1997.
6. William H.Gothmann "Digital Electronics", Prentice-Hall of India private limited, New Delhi, 1996.
7. Charles M.Gilmore "Microprocessors, Principles and Applications" Tata McGraw-Hill publishing company limited, New Delhi, 1997.

PROGRAMMABLE OPERATIONAL AMPLIFIER



DUAL – IN – LINE PACKAGE HALF
LM4250

FEATURES

1. + -1 V TO + - 18 V POWER SUPPLY OPERATION .
2. 3 n A INPUT OFFSET CURRENT

ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE +-18V

POWER DISSIPATION :500mw

DIFFERENTIAL INPUT VOLTAGE:+-30V

INPUT VOLTAGE:+-15 V

I_{SET} CURRENT:150μA

CHAPTER 1

INTRODUCTION

MPS85-2 is an extremely powerful microprocessor trainer based on the popular 8085 CPU. It can be used as a flexible instructional aid in academic institutions.

Following are the main features of MPS85-2:

* MPS85-2 can be operated either from on-board keyboard or from a CRT terminal through its RS-232C interface.
* Keyboard and serial monitor programs support the entry of user programs, editing and relocation, debug facilities like breakpoints and single-stepping, direct port input/output and full speed execution of user programs.
* 8K Bytes of CMOS static RAM is provided with battery backup option. Total on-board memory can be upto 64K Bytes.
* Allows multi-processor system design by supporting the HOLD and HLDA signals.

Options Available

a. Interface Modules for training purpose (Calculator Keyboard, Elevator, Display, ADC with DAC, Dual Slope ADC, Dual DAC, Logic Controller, Crystal Clock Divider, Traffic Lights, 8253 Demo, RTC, Tone Generator, Stepper Motor, Numerical Printer, etc.)

b. 8-bit, 16 Channel ADC

c. 5 1/4" Floppy Disk Drive Interface.

Serial I/O: RS-232C with standard MODEM control signals through on-board 25 pin D-type female connector.

Interrupts

All interrupts except TRAP (used for single-step implementation) are available to user.

Power Supply (Optional)

5V, (± 0.1V), 1.2A
+12V, (± 1.0V), 250mA
-12V, (± 1.0V), 100mA
30V, (± 2.0V), 100mA

Battery Option:

The RAM provided at U3 can be backed up by an optional battery. Holder is provided for two AA type cells with quick charger circuit. User may use either Ni-Cd or dry cells. Care must be taken to remove the discharged cells immediately to prevent leakage of corrosive fluids from the cell that may damage the PCB and the nearby components.

5.4 I/O ADDRESSING

I/O decoding is implemented using a 74 LS 138 at U13. BIO/M*, BA7, BA6, BA5 and BA4 only are used to derive the chip select signals. Thus foldback exists over the unused address lines. The I/O devices, their addresses and their usage is summarized below:

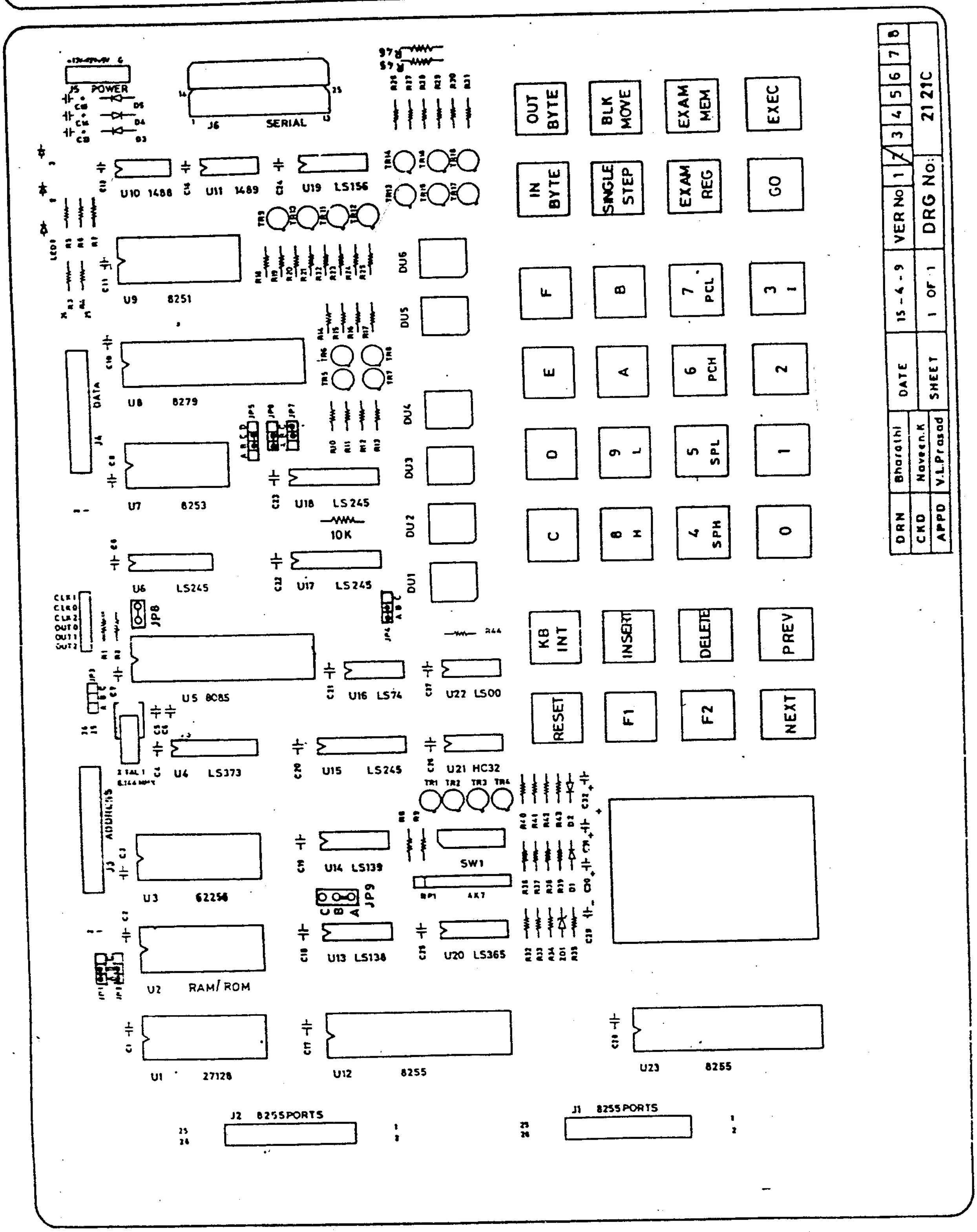
TABLE 5.2

I/O ADDRESS MAP

I/O Device	Address	Usage
8255 - 1 at U23 (Programmable Peripheral Interface)		
Port A	00H	Available to user
Port B	01H	
Port C	02H	The signals are available
Control Port	03H	on connector J1
8255 - 2 at U12 (Programmable Peripheral Interface)		
Port A	40H	
Port B	41H	The signals are available to user at connector J2
Port C	42H	
Control Port	43H	
8253 at U7 (Programmable Interval Timer)		
Timer 0	10H	Timer 0 is required for Single Step facility.
Timer 1	11H	Timer 1 is used for baud clock generation.
Timer 2	12H	Timer 2 is available to user. The signals are available on connector J4.
Control Port	13H	
8251A at U9 (Programmable Communication Interface)		
Data Port	20H	Used for implementing serial communication.
Command port	21H	

MPS 85-2

(COMPONENT PLACEMENT DIAGRAM)
(APPENDIX C)



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