MICROPROCESSOR BASED CONTROLLER FOR LINEAR STEPPER MOTOR

Project Report

SUBMITTED IN PARTIAL FULFILMENT
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Submitted by

M. D. SENTHIL KUMAR
V. RAJKUMAR
A. SANTHA KUMAR

Guided by

Mrs. N. KALAIARASI B.E.

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Department of Electrical and Electronics Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE - 641 006

Department of Electrical and Electronics Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE - 641 006

Certificate

This is to certify that the project report entitled

" Microprocessor Based Controller for Linear Stepper Motor "

has been submitted by

Mr. M.D. SENTHIL KUMAR, V. RAJKUMAR [illegible]

In partial fulfilment for the award of

Bachelor of Engineering

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during the academic year 1993 - '94.

Guide 13/4/94

Dr. K. [illegible] Head of the Department

Certified that the candidate with University Register No. ....

was examined in project work Viva-Voce by us on ....

Internal Examiner

External Examiner

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SYNOPSIS

Linear Electric motors are finding applications where motion in a straight line is required. Conventional rotary motors can be used for these applications. However a special arrangement is to be made to convert rotary motion into linear motion. Instead a linear motor can be used directly. In application like robotics, the linear motion is to be in steps for which a linear stepper motor can be used.

In this project a controller for a linear stepper motor using a microprocessor is designed, constructed and tested.

CONTENTS

NOTATIONS

Ts	:	Slot-pitch	mm
Vgs	:	Gate-source voltage	V
Vds	:	Drain-source voltage	V
Vt	:	Threshold voltage	V
L	:	Inductance of the motor winding	mH
Rs	:	Resistance of the suppressor circuit	Ω
Rw	:	Resistance of the motor winding	Ω
Re	:	External series resistor	Ω

CHAPTER I

INTRODUCTION

Most applications require motion in a straight line make use of conventional rotary motors. Special mechanisms are used to convert the rotary motion into linear motion.

There are motors which are designed to perform linear motion directly. These motors are called as Linear Electric Motors (LEM). They eliminate other mechanisms with added benefits of quietness and reliability. There are many types of linear motors of which Linear Stepper Motor (LSTM) IS THE most important for control applications like robotics, laser cuttings, PCB assemblies and plotters where motors with fast and bi-directional linear motors are required.

1.1 LINEAR STEPPER MOTOR

Linear Stepper Motors are electromechanical devices that convert pulse input to incremental linear motion outputs. When controlled properly, the number of linear steps of a motor equals the number of input pulses. Thus each input pulse to the motor moves it by one linear step.

LSTMs are mechanically much simpler than rotary motors to solve linear positioning problems. LSTMs overcome many of linear velocity and acceleration limitations inherent in systems which convert rotary to linear motion.

The difficulty in LSTM operation is the drive system which sequentially energize the windings of the motor for getting the operation.

1.2 CLASSIFICATION OF LSTMs

The two types of LSTMs are

1. Variable reluctance type (VR-LSTM).
2. Hybrid permanent magnet type (HPM-LSTM).

1.2.1 VARIABLE RELUCTANCE LSTM

The VR LSTM operates on the principle that it magnetic circuit reluctance varies with an along the direction of motion. With reference to Fig. 1.1, when phase A is energized, the moving member aligns with two poles of phase A corresponding to the path of minimum reluctance. The position of phase 'A' (tooth against tooth) is called stable equilibrium position. Next when phase 'B' is energized and phase A de-energized the moving member moves to the left and stops at the next stable equilibrium position. Instead of phase ´B' if phase ´D' is energized the motion will be to the right.

1.2.2 HYBRID PERMANENT MAGNET ~~LINEAR~~ STEPPER MOTOR

The HPM-LSTM is the linear counterpart of the PM rotary stepper motor. Fig. 1.2 shows a typical two-phase motor. Each of the two phase has two pole faces displays with respect to the secondary slotting by half of the slot pitch (Ts).

The two pole faces of the second phase are displaced by Ts/4 with respect to the pole faces of the first phase.

For positions shown in Fig. 1.2, if phase II is energized with a DC supply and the current has the polarity shown, the magnetic field of the permanent magnet is canceled under the pole face to the right of phase II. The motion is then to the left by a distance Ts/4 to occupy a position similar to the occupied by phase II. Next, phase I is energized to obtain one more step to the left by a distance (Ts/4).

1.3 CONSTRUCTION OF HPM-LSTM (2)

HPM-LSTM consists of two major components as shown in Fig.1.3. Platen is made up of magnetic material and has uniform teeth and slot machined on the tops of surface. Forcer consists of one strong permanent magnet, sandwiched between two electromagnets I and II. Each electromagnet has two pole phases get aligned with that of the platen.

In order to satisfy the above condition, the four pole faces should have three tooth and two slots put together and having a length of 2 1/2 slot pitches. The gap between the pole faces belonging to each electromagnet should be two slot pitches. In addition to this, the gap between two electromagnets should be 4 1/4 slot pitches. Thus the total length of the forcer is equal to 18 1/4 slot pitches.

Around each pole face, pre-wound field coils are fitted and coils belonging to two pole faces of each electromagnet should be connected in series opposition. These coils are to be energized with alternating positive and negative voltages, so that the flux produced by the current in these coils tend to reinforce the permanent magnetic flux at one pole face and cancel it at the other. By reversing the direction of field current, the reinforcement and cancellation are reversed.

These changes in the direction of magnetic field may cross hystersis and eddy current losses in the two electromagnets of the forcer and hence they are to be fabricated with laminated silicon steel sheets.

1.4 PRINCIPLE OF OPERATION OF HPM-LSTM

The directions of magnetic field set up by the permanent magnet are as shown in Fig. 1.3. They are from the forcer to the platen under pole faces ´a' and ´c' belonging to electromagnet I, and from the platen to the forcer under the pole faces ´b' and ´d' belonging to the electromagnet II.

The two phases alternating square waveform is shown in Fig. 1.4. Field coils ´a' and ´c' connected in series opposition are energized with phase I voltage (Fig. 1.4). Field coils ´b' and ´d' connected in series opposition are energized with phase II voltage (Fig. 4.2).

In the first quarter cycle, the direction of current in the field coils a, b, c, d are as marked in Fig. 1.5. Magnetic field set up by these currents reinforces the magnetic field set up by the permanent magnet at pole face ´a' and cancels at pole face ´b'. Hence the pole face ´a' tends to align with the platen teeth as shown in the Fig.

When pole face ´a' gets aligned with the platen teeth, pole face ´b' is on the range of alignment.

Now the directions of currents in coils ´b' and ´d' are changed as found in Fig. 1.5.2 in the second quarter cycle. Then the pole face ´b' tends to align with the platen teeth as shown in the Fig. When the pole face ´b' gets aligned with the platen teeth the pole face ´c' is on the range of alignment.

Then the directions of current in coils ´a' and ´c' are changed as shown in Fig. 1.5.3 in the third quarter cycle. Now the pole face ´c' tends to align with the platen teeth as shown in the fig. When the pole face ´c' gets aligned with teeth pole face ´d' is on the range of alignment.

In the fourth quarter cycle, directions of currents in coils ´b' and ´d' are changed as found in Fig. 1.5.4. Now the pole face ´d' tends to align with the platen teeth as shown in the figure. When the pole face ´d' gets aligned with the platen teeth, pole face ´a' is on the range of alignment.

This cycle is repeated for continuous linear motion from right to left. However, the direction of motion can be reversed by changing the current sequence to the coils.

1.5 MERITS AND DEMERITS LSTM

1.5.1 MERITS

They can produce direct linear motion in steps as usual as 0.1mm. They can operate as an open loop system and yet yield a precise control of position. They are mechanically simple and robust and can be repeatedly stalled without any damage. They require simple electronic controllers.

1.5.2 DEMERITS

Step size is fixed. Also for stroke lengths excluding 0.2mm the motor mass may be very large. They have a low power efficiency and also limited capability of handling large and massive loads. The step response may have a large overshoot and motor may then undergo oscillations.

1.6 APPLICATION

Linear stepper motors find applications in the following

1. Automobiles.
2. Automatic typesetting for printing industry.
3. Banking terminals.
4. Clocks and watches.
5. Coil winding machines.

6. Wire-wrapping machines.
7. Photo-copying machines.
8. X-Y plotters.
9. Sun tracking control for solar panels.
10. Serial and line printers.
11. Robots-translating machines.
12. Textile machines.
13. Aircraft control systems.
14. Medical equipment (automatic-controlled microscopes).
15. Random-access disk memories.
16. Punched tape readers and punches.

With the use of microprocessor controllers, linear stepper motors are extensively used in computer peripheral industry. They can also be used in head positioning, controlled laser beam positioning for fabric cutting, and three-axis accurate positioning in semiconductor wafer manufacture.

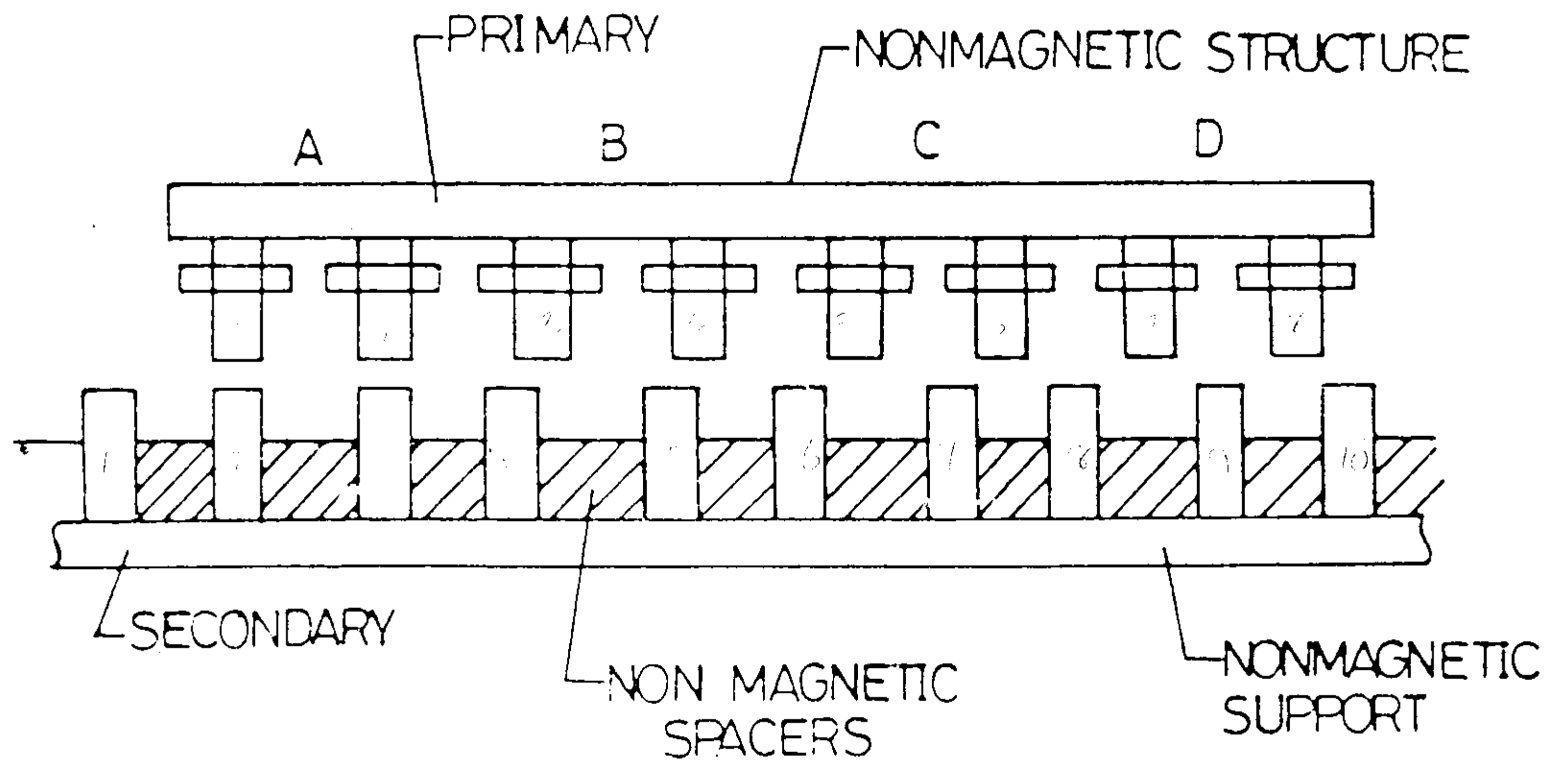


FIG. 1.1.

VARIABLE RELUCTANCE LINEAR STEPPER MOTOR

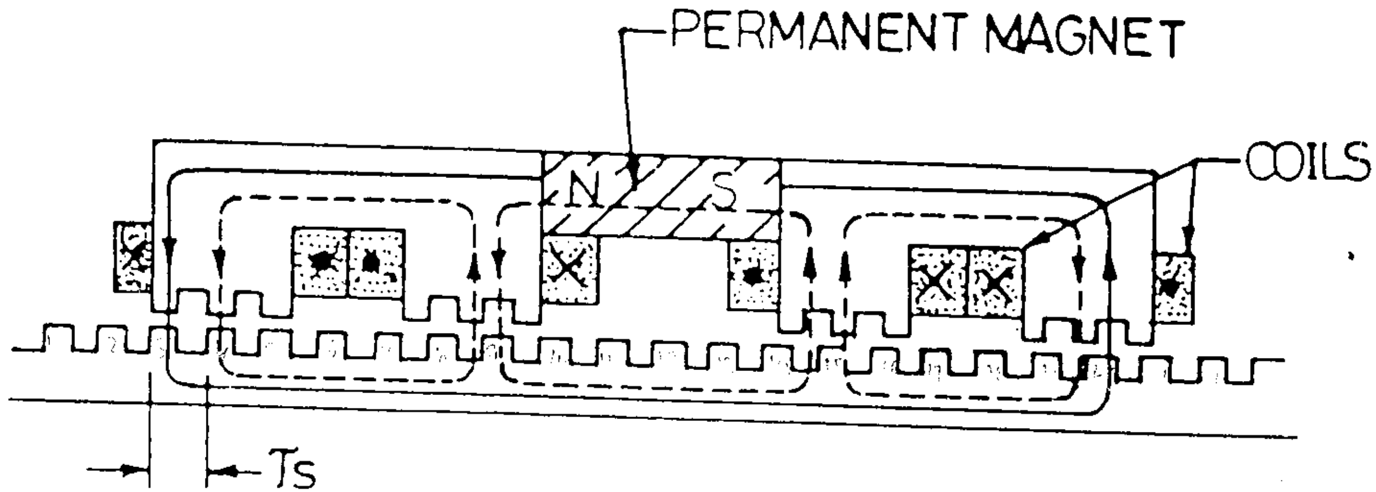


FIG. 1.2 HYBRID PERMANENT MAGNET LINEAR STEPPER MOTOR

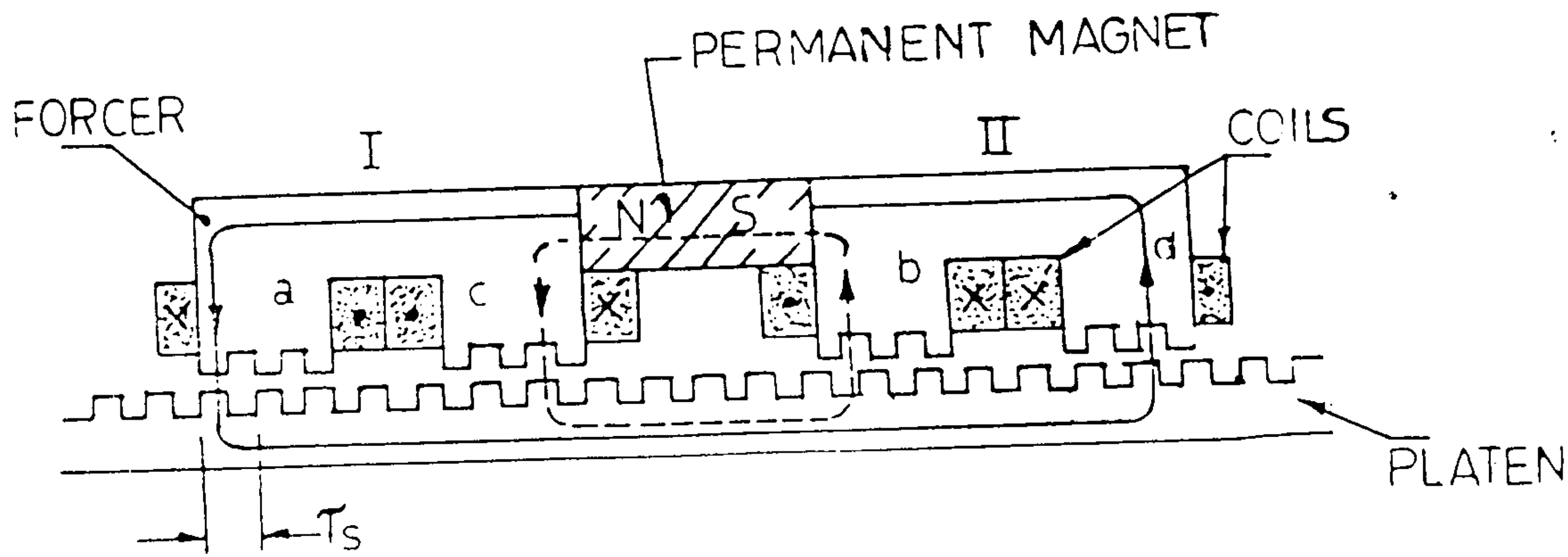


FIG.1.3 CONSTRUCTIONAL DETAILS OF HPM-LSTM

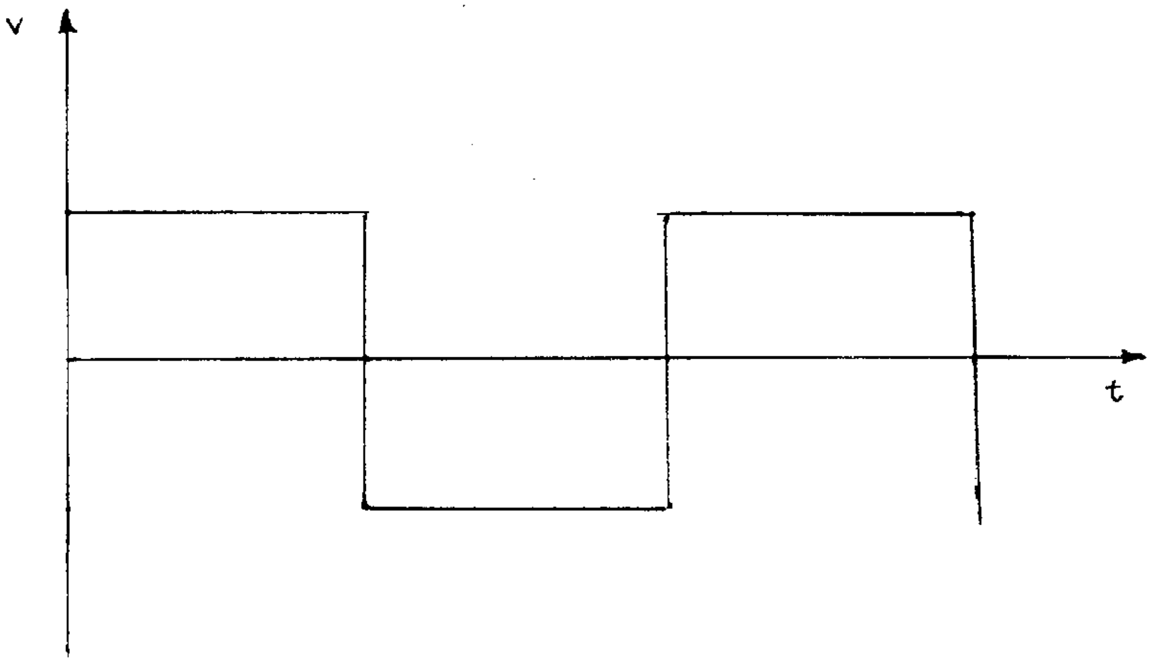


FIG.1.4.1 PHASE I VOLTAGE

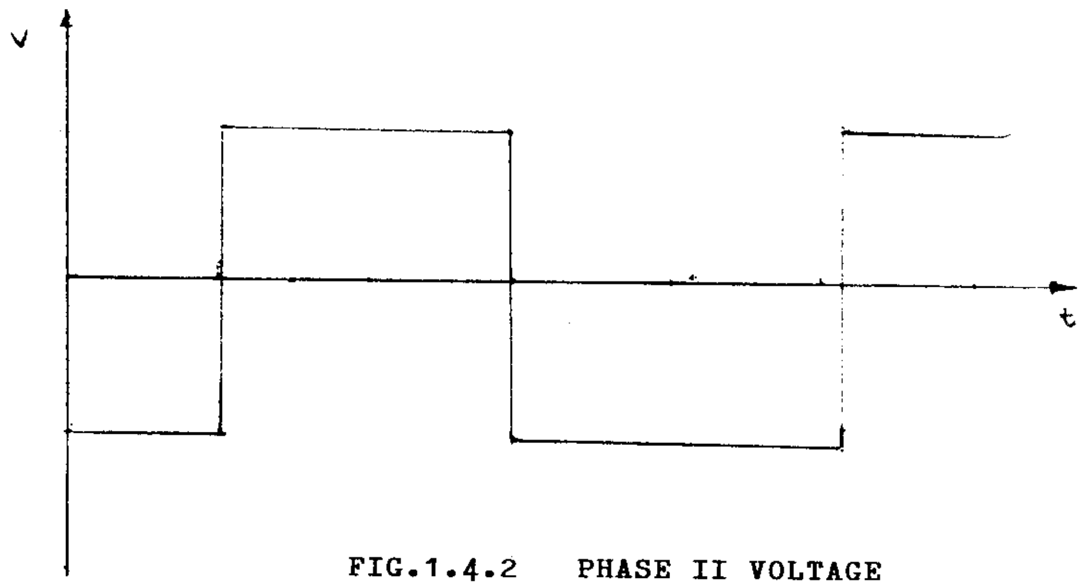


FIG.1.4.2 PHASE II VOLTAGE

FIG. 1.4 II PHASE SUPPLY FOR HPM - LSTM

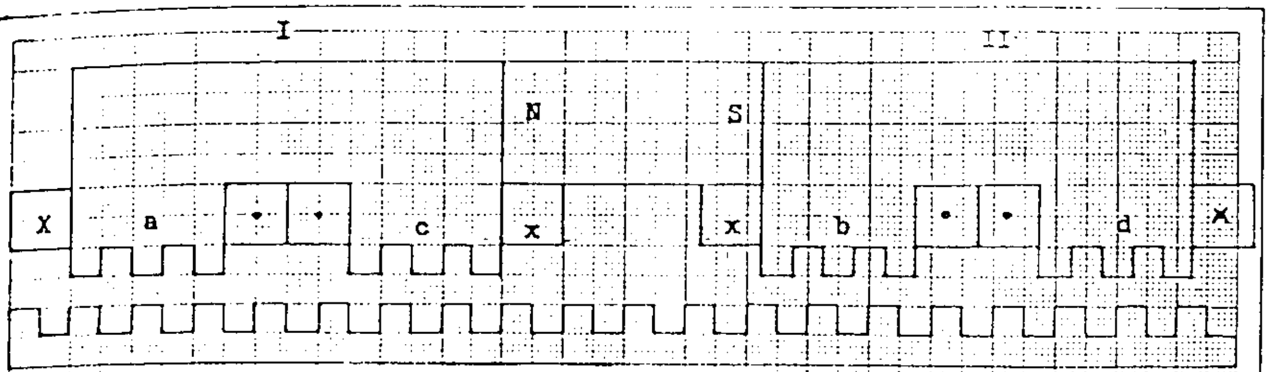


FIG. 1.5.1 ALIGNMENT OF POLE FACE 'a'

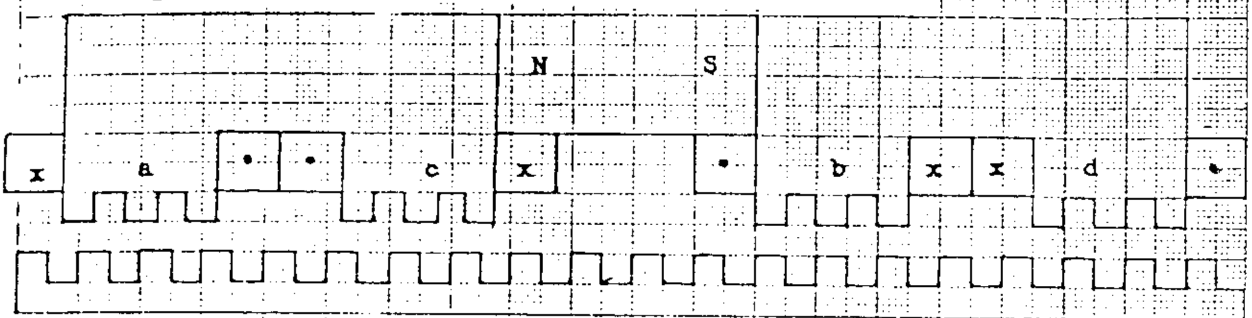


FIG. 1.5.2 ALIGNMENT OF POLE FACE 'b'

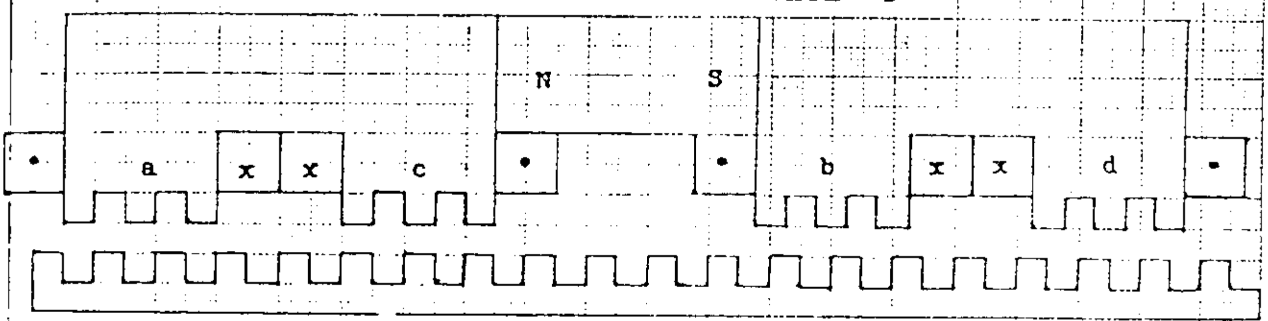


FIG. 1.5.3 ALIGNEMNT OF POLE FACE 'c'

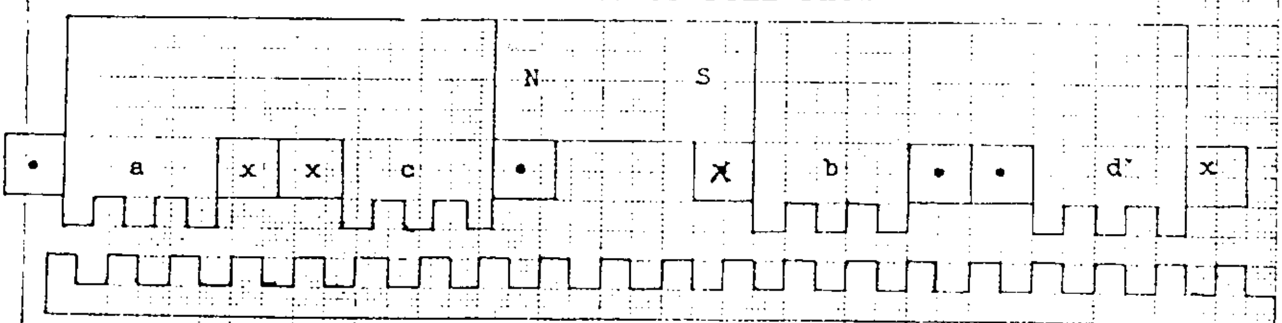


FIG. 1.5.4 ALIGNMENT OF POLE FACE 'd'

FIG. 1.5 ALIGNMENT OF FORCER AND PLATEN

CHAPTER II

CONTROLLER FOR LINEAR STEPPER MOTOR

2.1 INTRODUCTION

The phase winding of this two phase 2 STM have to be energized sequentially to get the motion. This requires a 2-phase square wave variable frequency supply.

The two phase square wave supply is generated using the controller to get as output voltage upto a value of 60V and a current of 10A.

The controller consist of a ´power circuitry ' and a ´control circuitry'. The power circuitry built up winding of the motor. The control circuitry consists of the logic sequencer (8085 P and 8255 A PPI) which generates the control signals. An opto-isolator is also used to electrically isolate the sequencer from the power circuitry. The power circuitry can be switched on unidirectionally or bi-directional by the control circuitry. The overall block diagram of the controller is shown in Fig. 2.1. It consists of logic sequencer, opto-isolator, power circuitry and power supply.

2.2. POWER CIRCUITRY

Power semi conductor devices like Thyristors, GTOs, power transistors and power MOSFETs are generally used in the power circuitry. These devices must be capable of handling large power and must be capable of being operated into inductive loads.

By considering factors like voltage, current and frequency, power MOSFETs can be used in the power circuitry as the switching device. It is faster in operation and hence can be operated at high frequencies. Also it is possible tc eliminate the voltage and current amplification stages that are required when power transistors are used as the switching devices. Thus the control circuitry becomes simple.

2.2.1 POWER MOSFET

A power MOSFET is a voltage controlled device and requires negligible gate current at the steady state. The switching speed is very high and the switching times are of the order of nanoseconds. MOSFETs do not have the problems of second breakdown phenomena as do BJTs. However, MOSFETs have the problem of electrostatic discharge and require special care in handling. In addition it is relatively difficult to protect then under short-circuited fault conditions.

MOSPETs are of two types.

1. Depletion MOSFETs and
2. Enhancement MOSFETs.

A n-channel enhancement type shown in Fig. 2.2.1 has been made use of in this work. The three terminals are gate, drain and source. One problem associated with the power MOSFET is that it will operate only when the gate is given the threshold voltage (the minimum voltage required to turn on the MOSFET).

2.2.2. STEADY-STATE CHARACTERISTICS OF MOSFETs

MOSFETs are voltage controlled devices and have very high input impedance. The gate draw s a very small leakage current in the order of nanoamperes.

These are three regions of operations

1. Cut of region, where $V_{GS} < V_T$
2. Pinch-off or saturation region, where $V_{DS} > V_{GS}-V_T$
3. Linear region, where $V_{DS} < V_{GS}-V_T$

The pinch-off occurs at $V_{DS} = V_{GS}-V_T$. In the linear region, the drain current I_D varies in proportion to the

Drain source voltage VDs. Due to high Drain current and low Drain voltage, the power MOSFETs are operated in the linear region for switching actions.

2.2.3. MOSFET AS A SWITCH IN POWER CIRCUITRY

MOSFETs are used in the power circuitry to sequentially energize the windings of the motor. It acts as a switch and turns on and OFF according to the input sequence.

The sequence with which the windings are excited is given below for the movement in one direction.

T1	T2	T3	T4
1	0	1	0
1	0	0	1
0	1	1	0
0	1	0	1

T1, T2, T3, T4 are the power MOSFETs used to sequentially energize the motor windings and shown in Fig. 2.3 `1' stands for ON state and `0' for OFF state. The working of the power circuitry is as follows.

Case (i) : When T1 and T3 are ´ON', the direction of current will be from ´a' to ´c' and ´d' to ´b'.

Case (ii) : When T1 and TH str ´ON', the direction of current will be from ´a' to ´c' and ´b' to ´d'.

Case (iii) : When T2 and T3 are ´ON', the direction of current will be from ´c' to ´a' and ´d' to ´b'.

Case (iv) : When T2 and T4 are ´ON', the direction of current will be from ´c' to ´a' and ´b' to ´d'.

The coils ´a' and ´c' and the coils ´b' to ´d' are connected in series opposition.

2.2.4. PROBLEMS WITH POWER CIRCUITRY [1]

Two of the major problems of LSTMs are related to the build-up and decay of phase currents as phase are turned ´ON' and ´OFF'. When the frequency of the input signal increases, the phase current does not have enough time to built up, or decay, as the motor phase circuit is highly inductive. When turned off, the voltage across the power MOSFET is L(di/dt) and this voltage may damage the MOSFET. Therefore, this voltage must be suppressed. Typical suppression circuits are given in Fig. 2.4.

In the resistor-diode circuit by Fig. 2.4.1 when the phase current is turned off the phase voltage is applied to the Rs diode circuit, thereby producing a current im. The voltage drop across Rs thus reduces the voltage spike sensed by the power MOSFET during the current decay.

Faster current decay is obtained with the Zener-diode circuit of Fig. 2.4.2. After turning off the phase, the voltage rises until the Zener diode begins to conduct, the energy being dissipated in the diode.

BUILD UP OF PHASE CURRENT

When the MOSFET is turned on to excite a phase, the power supply must overcome the effect of winding inductance which has a tendency to oppose the current build up in this case. As the switching speed increases, there is insufficient time for the current and the thrust to build up to sustain the motion. This results in decreased torque and slow response.

To shorten the build-up time, a resistor is added in series with the winding as shown in Fig. 2.5. The power supply V is selected to device the rated current through windings under steady state conditions. The twice-constant of the circuit is decreased from L/Rw to L/(Re + Rw). Though series resistance is the simplest method it is disadvantages is that much power is dissipated in the series resistors.

2.3 CONTROL CIRCUITRY [1]

The control circuitry consists of a logic sequencer and opto-isolater. Logic sequence is a logic circuit that controls the excitation of the windings sequentially, responding to the input step and direction signals. It converts these signals into gate signals for the power MOSFETs in the power circuitry.

The logic sequence can be built for one phase on or two phase on operation. For a four-phase LSIM motor, the timing diagrams of one phase on and two phase on operation are respectively shown in Fig. 2.6.1 and Fig. 2.6.2 similar timing diagrams are valid for two phase LSTM also.

Numerous types of logic circuits are commercially available. In a typical four-phase STM one phase on logic sequence, using binary counting technique and two flip-flops for unidirectional motion is shown in Fig. 2.7.1. The circuit consists of conventional up-counter made up of flip-flops. The AND gates decode the counter to provide the four device signals for the output. As only one phase is on at a time, the sequence of switching is abcda.... . The counter will start up in the RESET condition when power is applied due to the RC network connected to the direct reset inputs of the flip-flops. By adding gating networks that control the direction of counting, the unidirectional motion sequences may be converted to bi-directional motion mode. The timing diagram is still valid, but should be read from left to right for rightwise (RW) direction and from right to left for leftwise (LW) direction.

A bi-directional motion four-phase, two phase on logic sequences is shown in Fig.2.7.2.

The easiest way of generating these control signals is by using a microprocessor. The P can be programmed to change the frequency of supply and hence speed of the motor.

The advantages of using a microprocessor based scheme are accuracy, good reproducibility.

The required control signals for the two phase LSTM under investigation can be generated using a 8255 A Programmable Peripheral Interface(PPI) along with a 8085 microprocessor. The details of the 8085 P and 8255 PPI given in Appendix A and Appendix B respectively. An assembly language program written for the 8085 processor to generate the signals indicated in Fig. 2.4. is given in chapter (iv).

2.3.1. OPTO-ISOLATOR

The power circuitry can be connected to the logic sequencer by using an Opto-Isolator.

Opto-Isolater is a device with a light source (LED) coupled to a light sensor (photo-transistor). It transmits the control signal while maintaining a high degree of isolation between its input and output. Previously this isolation was provided by relays, isolation transformers etc. There are basically three types of opto-isolators namely LED-photo diode, LED-Photo transistor, LED-Photo Darlington. A LED-photo transistor type (MCT-2E) isolator is considered in this work.

The output of the P is given as the input to the opto-isolator. The output voltage from the up is in the order of 5 volts. If the threshold voltage of the MOSFET is move than 5 volts, then an intermediate stage of voltage amplification is necessary. This can be done by using the transistor in the opto-Isolator itself.

2.4 POWER SUPPLY

The power circuitry requires a power supply which gives the required voltage and current for the motor winding. A variable D.C Power supply is used for this purpose.

To turn ON and OFF each MOSFET in the power circuitry, separate power supplies are used. The general block diagram of the power supply is given in Fig. 2.8.

The transformer steps down the voltage to the required level and also provides isolation. The rectifier converts this stepped down A.C. voltage. The pulsating D.C voltage is filtered by using a capacitor.

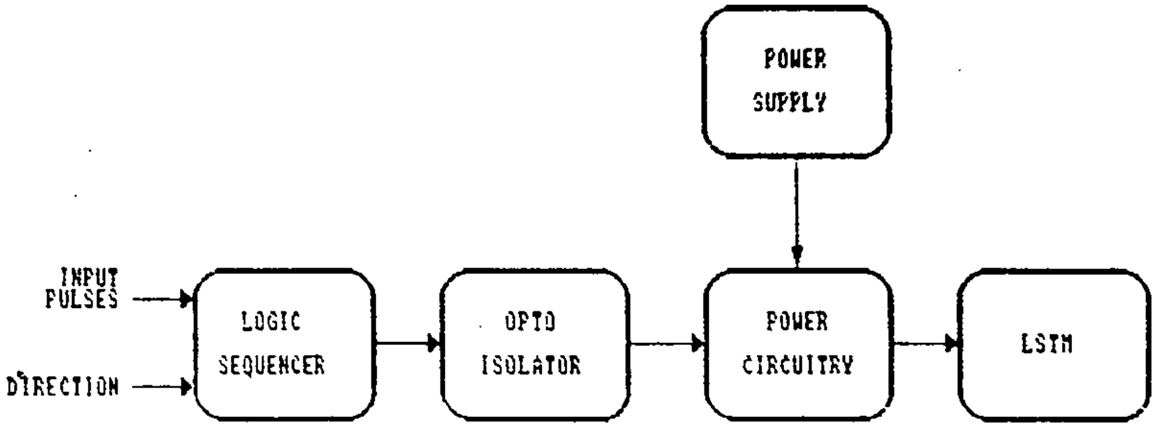
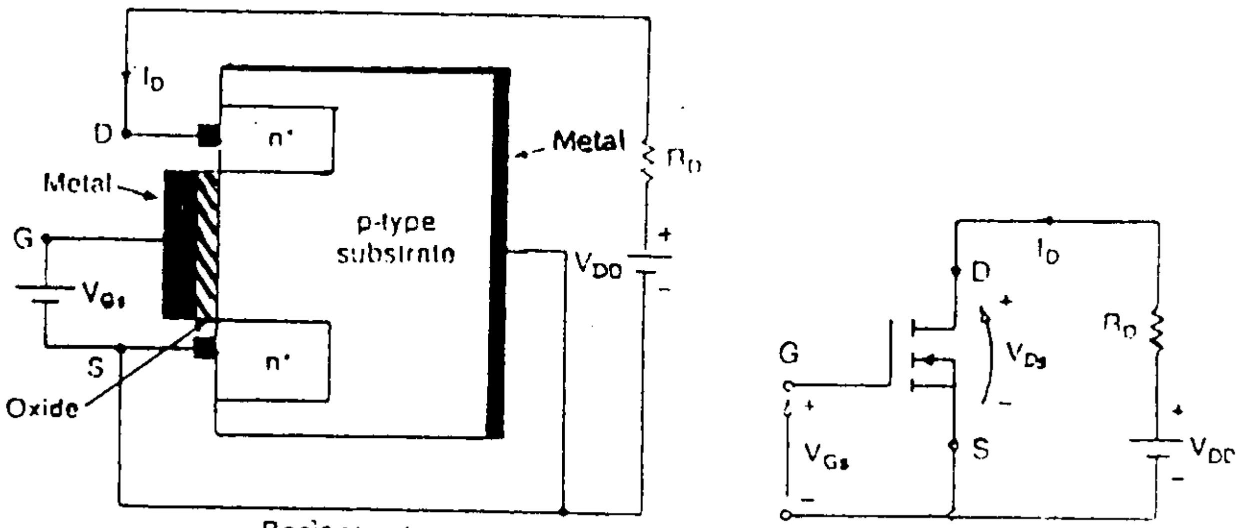
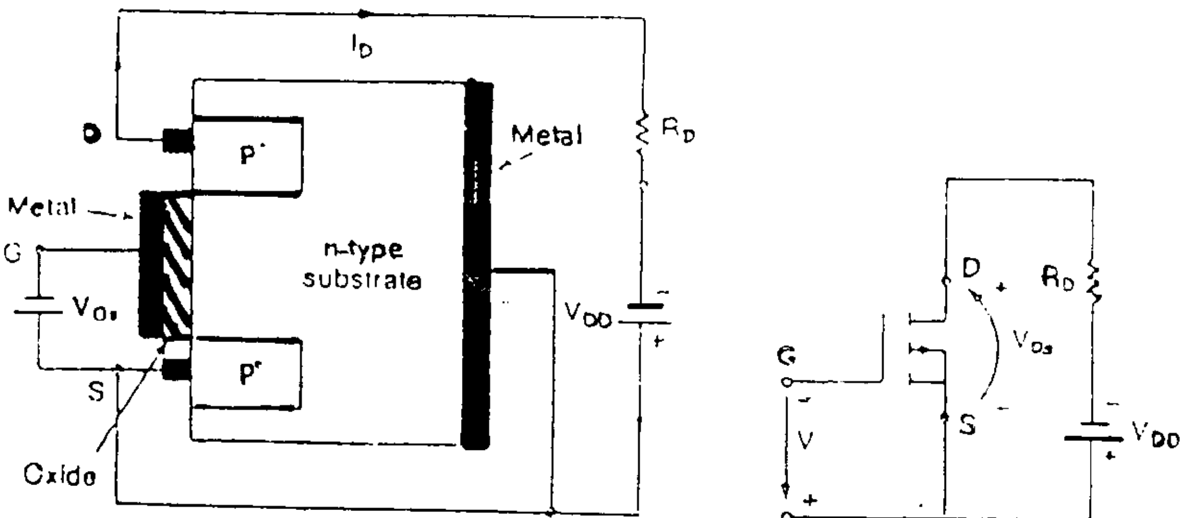


FIG. 2.1 OVERALL BLOCK DIAGRAM OF CONTROLLER FOR HPM-LSTM



Basic structure Symbol

FIG.2.2.1 n channel enhancement type MOSFET



Basic structure Symbol

FIG. 2.2.2 p-channel enhancement type MOSFET

FIG. 2.2 Enhancement-type MOSFETs

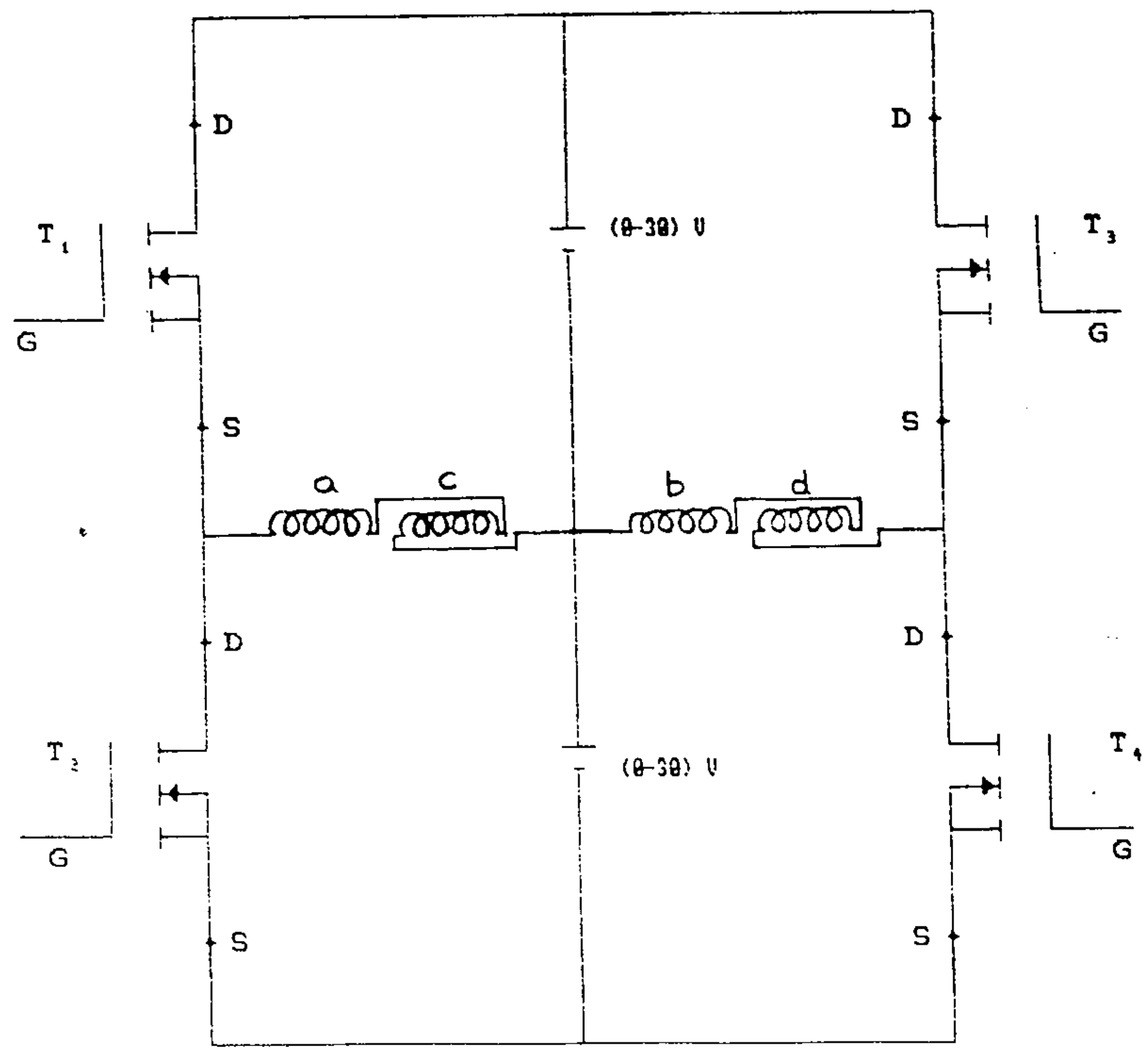


FIG. 2.3 POWER CIRCUITRY

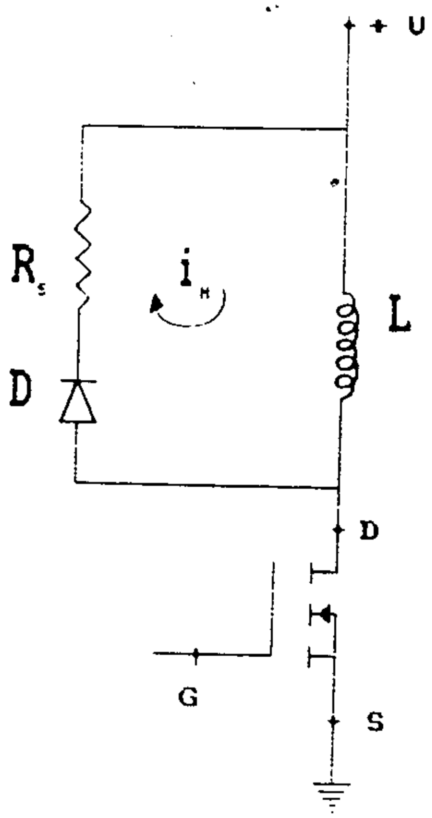


FIG. 2.4.1 DIODE-RESISTOR SUPPRESSOR

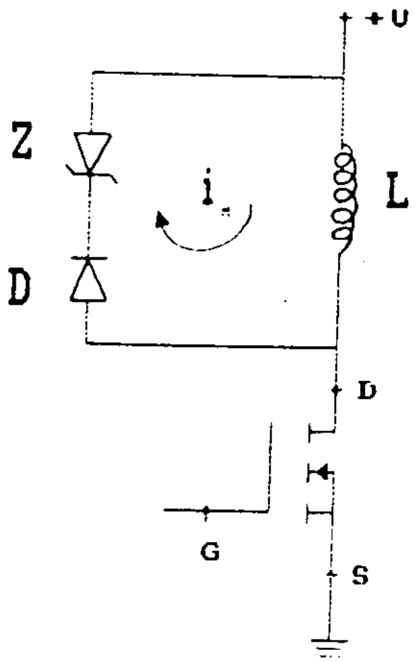


FIG. 2.4.2 ZENER-DIODE SUPPRESSOR

FIG. 2.4 SUPPRESSION CIRCUITS

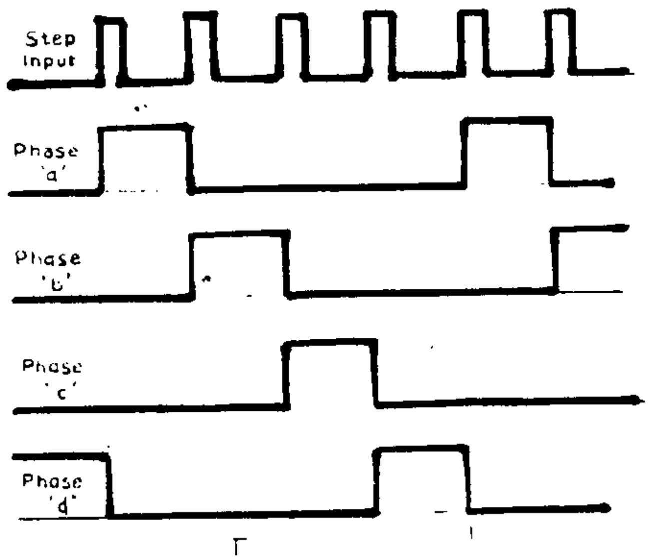


FIG. 2.6.1 TIMING DIAGRAMS FOR ONE PHASE-ON OPERATION OF FOUR-PHASE LSTM.

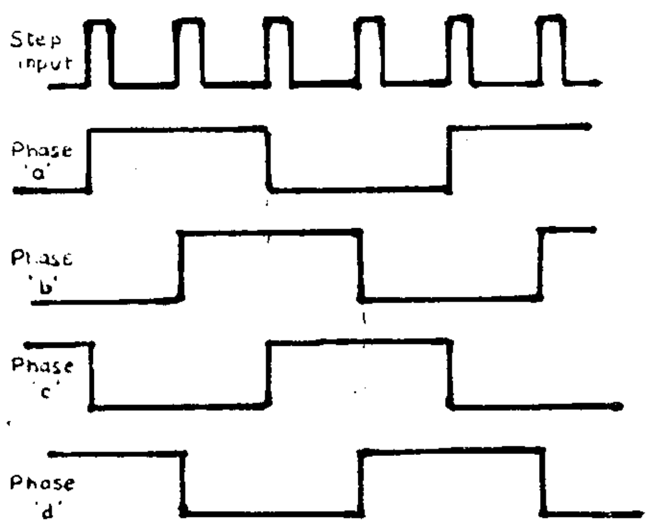


FIG. 2.6.2 TIMING DIAGRAMS FOR TWO PHASE-ON OPERATION OF FOUR-PHASE LSTM

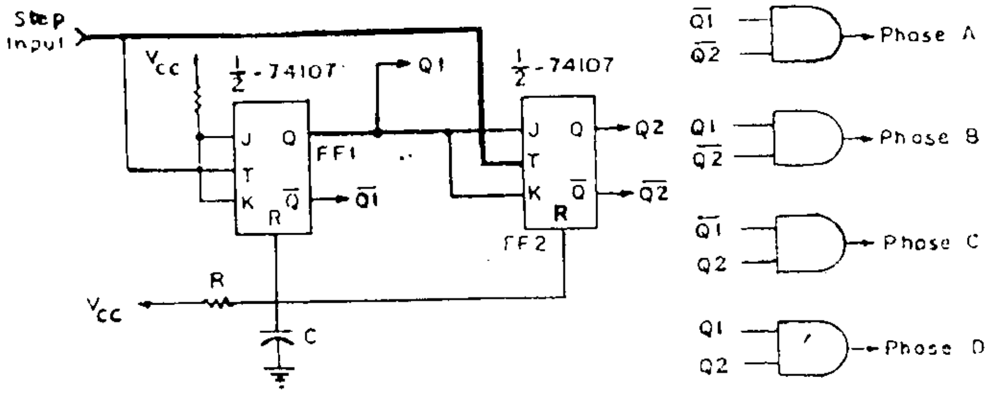


FIG. 2.7.1 UNIDIRECTIONAL LOGIC SEQUENCER FOR ON OPERATION OF FOUR-PHASE MOTOR.

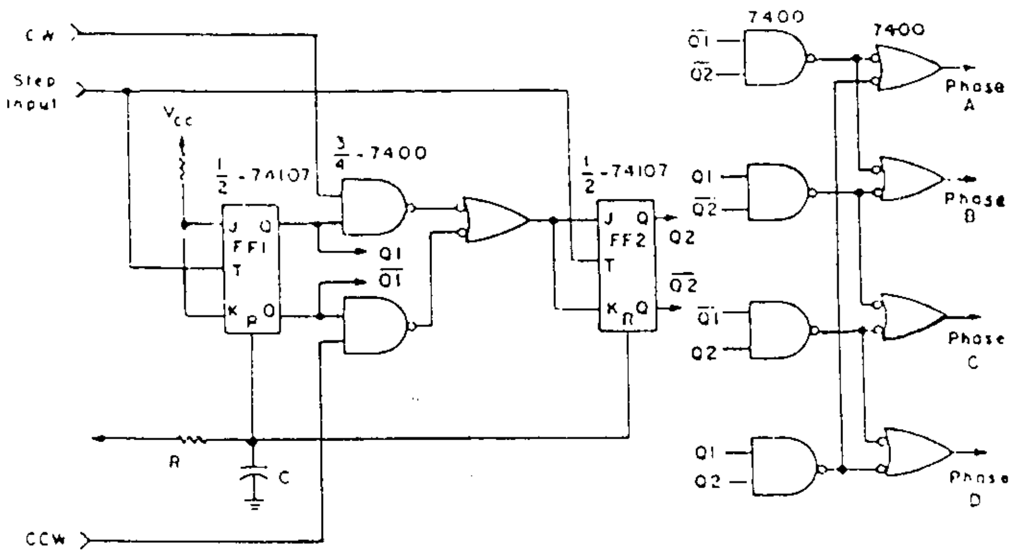


FIG. 2.7.2 BIDIRECTIONAL LOGIC SEQUENCER FOR A TWO-PHASE ON OPERATION OF A FOUR-PHASE MOTOR.

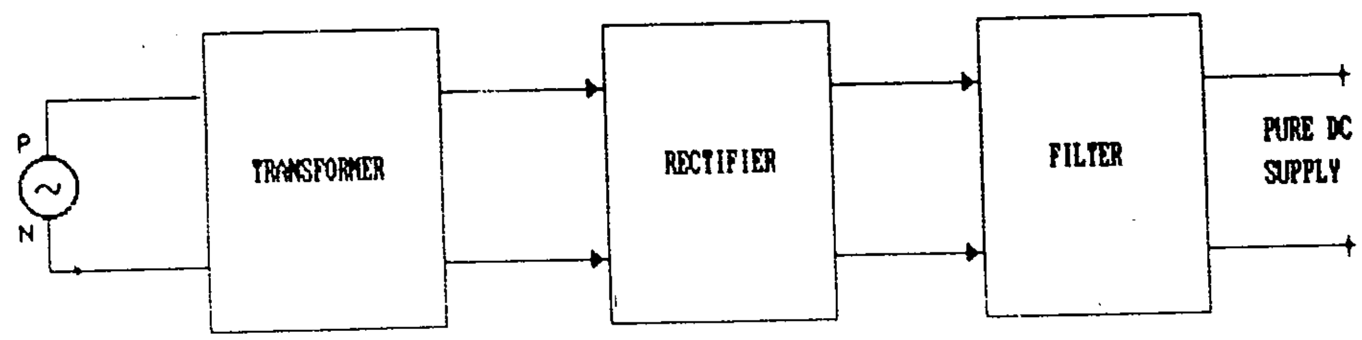


FIG. 2.8 POWER SUPPLY

CHAPTER III

DESIGN AND DEVELOPMENT OF CONTROLLER

3.1 INTRODUCTION

A microprocessor based controller has been designed it operate the HPM-LSTM with the following specifications.

Number of phases	:	2
Phase current (max)	:	5A
Linear step size	:	1.25mm
Max. frequency of operation	:	1.92KHz
Maximum speed	:	2.4 m/sec
Resistance / phase	:	2.610 Ω
Inductance / phase	:	50.27mH

3.2 DESIGN OF POWER CIRCUITRY

The power circuitry shown in Fig. 3.2 has been designed using power MOSFETs.

In this work, the power MOSFET IRF 133 was chosen to satisfy the voltage and current ratings of the motor. The voltage and current rating of the MOSFET are 60 volts and 12 Amps respectively.

3.3 DESIGN OF CONTROL CIRCUITRY

The control circuitry consists of the logic sequences and an Opto-Isolator. The 8085 microprocessor along with a 8255 A PPI was chosen as the logic sequences.

The control signals for the power MOSFET in the power circuitry are generated by the microprocessor by giving the direction and frequency as the input. ~~To get there control signals an assembly language program was written and given in chapter IV.~~

The Opto-Isolator MCT 2E was chosen to electrically isolate the up from the power circuitry. The voltage and current requirements of the LED of Opto-Isolator are met by the output of the 8085 processor. The photo transistor in the Opto-Isolator is used to amplify the voltage from the P and is given to the gate terminals of the MOSFET.

3.4 DESIGN OF POWER SUPPLY

Four isolated power supplies are required. Four center-tapped transformers 230 V/6V to step down the AC voltage, diodes IN 4001 for rectification and capacitors 2500 F/25V are used.

The two coils shown in the power circuitry are connected in series opposition. The overall circuitry, designed and developed is shown in Fig. 3.1.10(b).

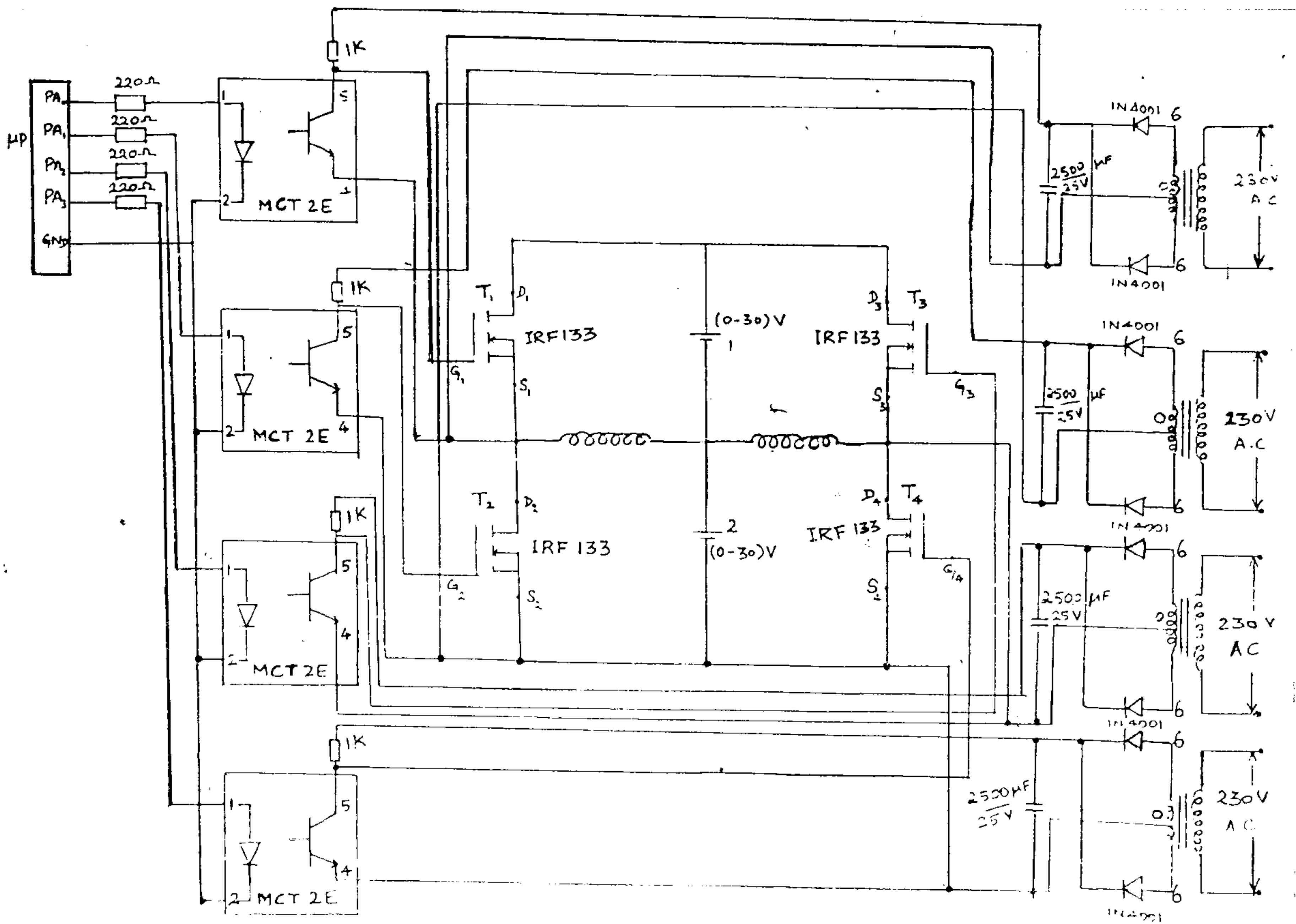


FIG. 1 CONTROLLER FOR HPM-LSTM

CHAPTER IV

TESTING

TESTING OF CONTROLLER

Testing was carried out on the motor by exiting the windings. INTEL 8085 microprocessor is used to produce control pulses, whose frequency is varied by changing the delays routine. The software written in assembly language for the above purpose is given in Table 4.1.

The circuit and the waveforms obtained , are in Fig 4.1.

PROGRAM

~~TABLE 4.1~~

LABEL	ADDRESS	OPCODE	MNEMONIC
START	2000	3E 80	MVI A, 80H
	2002	D3 33	OUT 33H
LOOP	2004	3E 09	MVI A, 094
	2006	D3 30	OUT 30H
	2008	CD 00 21	CALL DELAY
	200B	3E 0A	MVI A, 0AH
	200D	D3 30	OUT 30H
	200F	CD 00 21	CALL DELAY
	2012	3E 06	MVI A, 06H
	2014	D3 30	OUT 30H
	2016	CD 00 21	CALL DELAY
	2019	3E 05	MVI A, 05H
	201B	D3 30	OUT 30H
	201D	CD 00 21	CALL DELAY
	2020	C3 04 20	JMP LOOP
DELAY	2100	01 - -	LXI B, COUNT
DEL	2103	0B	DCX B
	2104	79	MOV A, C
	2105	B1	ORA C
	2106	C2 03 21	JNZ DEL
	2109	C9	RET

CHAPTER V

CONCLUSION

A microprocessor based controller for a linear stepper motor has been designed, constructed and tested. The power circuitry has been fabricated using Power MOSFETs. The control circuitry consisting of 8085 microprocessor and 8255A PPI is used to generate the control signals. Testing of the controller was carried out for all the windings of LSTM and the result is satisfactory.

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APPENDIX A

SDA 85 MICROPROCESSOR KIT

SPECIFICATION

CPU	: 8085 A
MEMORY	: ROM 2716*1 (EXPANSION 2716*1)
INPUT/OUTPUT	: PARALLEL 48 LINES, 8255*2 SERIAL THROUGH SID/SOD LINES. INTERFACES PROVIDED FOR TTY, CRT AND TELEPRINTER.
INTERRUPTS	: TRAP, RST 7.5, RST 6.5, RST 5.5 AND INTR. AN 8BIT INTERRUPT INSTRUCTION PORT IS PROVIDED.
TIMER	: 8253*1
INTERFACES	: ALL BUS AND PARALLEL INPUT/OUTPUT SIGNALS ARE TTL COMPATIBLE. OPTIONAL BUS DRIVERS FOR BUS EXPANSION AVAILABLE INPUT/OUTPUT CONNECTION AND BUS CONNECTION TO FLEXIBLE FLAT CABLES.
KEY BOARD/ DISPLAY	: IMPLEMENT USING 8279 KEY BOARD DISPLAY, FOUR FOR THE ADDRESS FIELD AND TWO FOR DATA FIELD.

ADDRESSES

ROM	0	TO	7FF	H
	800	TO	FFF	H (OPTIONAL)
RAM	1C00	TO	1FFF	H
	1800	TO	1BFF	H (OPTIONAL)
8279	2000H	-		DATA
	2001H	-		CONTROL
8255(1)	30H			PORT A
(PPI)	31H			PORT B
	32H			PORT C
	33H			CONTROL 1
8255(2)	38H			PORT A
(PPI)	39H			PORT B
	3AH			PORT C
	3BH			CONTROL 2
8253	28H			COUNTER 0
(TIMER)	29H			COUNTER 1
	2AH			COUNTER 2
	2BH			CONTROL
8212	10H			INPUT PORT
	INTA			INTERRUPT INSTRUCTION PORT (RST INSTRUCTION)

MONITOR COMMANDS : GO, SUBSTITUTE MEMORY, EXAMINE REGISTER, SINGLE STED, BLOCK MOVE, INSERT, DELETE, DISPLAY, PUNCH A PAPER TAPE, READ AN EPROM, PROGRAM AN EPROM.

Power supply, Basic kit, requirement

5V + 5%, 1.5A + 12V + 10% 100mA OPTION

001 and 003 Integral supply specification

5V + 5%, 2.5A

+ 12V + 10%, 250 mA

20V TO 26V, 100 mA

Ordering information port number MS-SDA 85-4

APPENDIX B

PROGRAMMABLE PERIPHERAL INTERFACE

The 8255 may also treated as four memory locations as shown in Fig.3.1. The group 1 consists of PORT A and PORT C upper and GROUP2 consists of PORT C lower and PORT B. The SDA 85 bit has two 8255 PPIs.

The control word is determined by selecting the mode of operation and groups being individually selected as input ports. This is stored in the control word register thus initialising the port operations. The control word format is shown in Fig. 3.2.

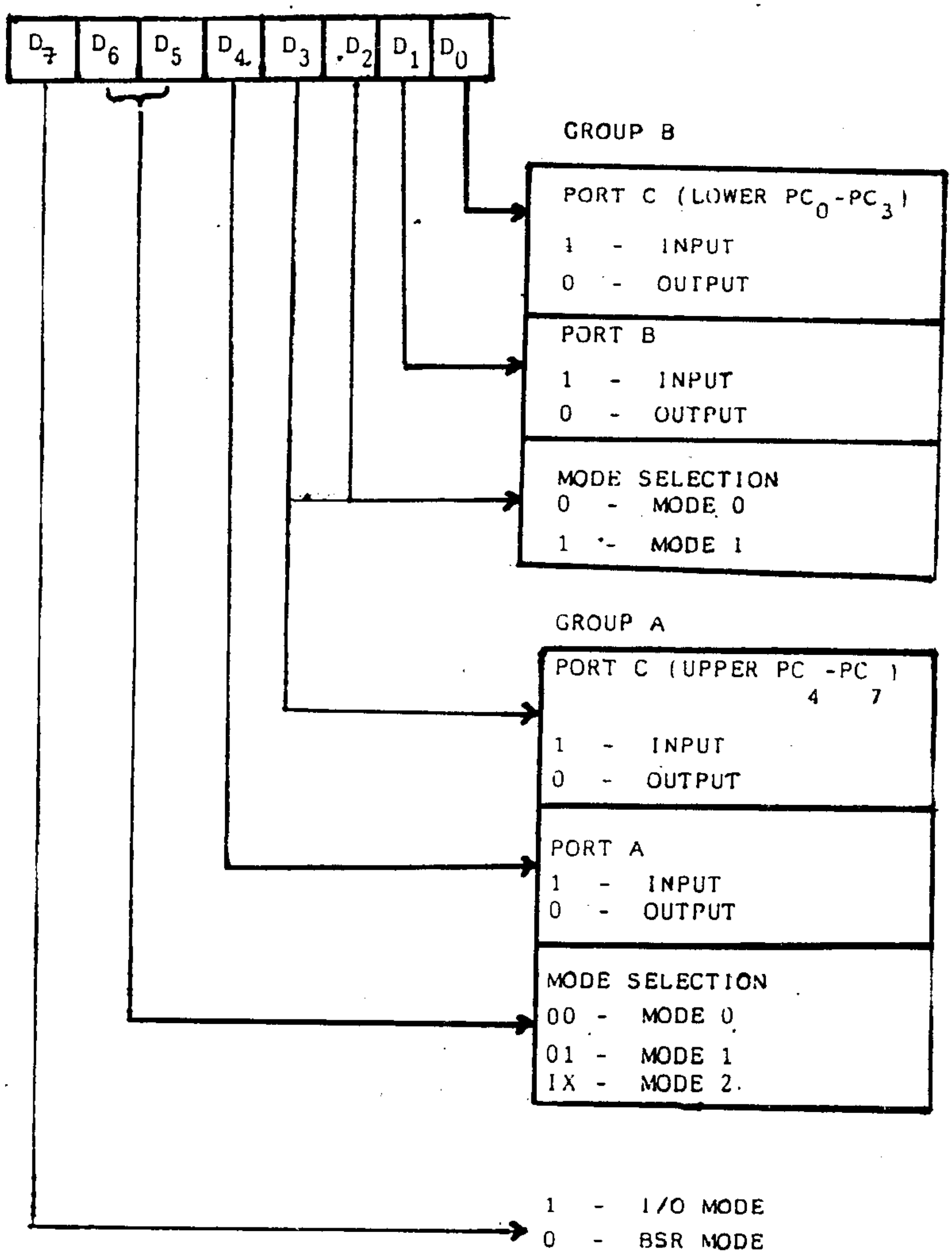

FIG. B.2 8255A PPI CONTROL WORD FORMAT FOR I/O MODE