MICROPROCESSOR BASED SEQUENTIAL CONTROLLER

PROJECT REPORT

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF BACHELOR OF ENGINEERING IN COMPUTER TECHNOLOGY AND INFORMATICS ENGINEERING OF THE BHARATHIYAR UNIVERSITY, COIMBATORE-46

SUBMITTED BY

Prakash John Thomas
V. P. Narayanan
M. Hari Swaroop

UNDER THE GUIDANCE OF

Mr. M. Ramasamy M.E.

Department of Computer Technology and Informatics Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

Coimbatore - 641 006

1989-90

Department of Computer Technology and Informatics
Kumaraguru College of Technology
Coimbatore - 641 006

Certificate

This is to certify that the Report entitled

"Microprocessor Based Sequential Controller"

has been submitted by

Mr ____________________________

in partial fulfilment for the award of Bachelor of Engineering in the Computer Technology and Informatics Engineering Branch of the Bharathiyar University, Coimbatore-641 046 during the academic year 1989-90

Guide

Head of the Dept.

Certified that the candidate was examined by us in the Project Work Viva-Voce Examination held on ______________ and the University Register Number was ______________

Internal Examiner

External Examiner

DEDICATED TO OUR BELOVED PARENTS

Acknowledgement

ACKNOWLEDGEMENT

We would like to record our sincere thanks to our beloved Principal **Prof. R. PALANIVELU, B.E., M.Sc. (Engg), F.I.E., M.I.S.T.E., M.I.S.P.R.S**, for providing the necessary facilities in the college for successful completion of the project.

We thank **Prof. P. SHANMUGAM, B.E., M.Sc., (Engg), M.S. (Hawai), M.I.E.E., M.I.C.S.I., M.I.S.T.E**, Head of Department, Computer Technology and informatics for his valuable suggestions and comments during the project proceedings.

We, the members of this project wish to convey our gratitude and indebtedness solemnly to our guide **Mr. MUTHURAMAN RAMASAMY, B.E., M.E., M.I.S.T.E.**, Assistant Professor, Computer Technology and Informatics Department for his whole hearted, tireless and relentless effort in helping us complete the project successfully.

We wish to thank Miss. **R.PAVAI, B.E., M.I.S.T.E.**, for her innovative ideas and perseverance in seeing us through with the project in time.

We thank **Miss R. GEETHA**, for availing us of the LAB facilities during our project work.

Finally, we would like to thank the staff members of Computer Technology and Informatics Department for their encouragement and valuable suggestions given to us.

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SYNOPSIS

The microprocessor based sequential controller is a device capable of generating ON/OFF pulses through different channels as per user requirement which can be used for any process. The time delay of the pulse is fixed. The user can use upto a maximum of 16 channels but here only 4 channels are used. The user gives his ON/OFF sequence with the help of a keyboard for all the 4 different channels. The ON/OFF sequence are stored in the device's memory. The software will take the user's data and outputs it through the 4 channels specified.

Besides generating the pulses, the device can do process, , monitor and control. Process monitor and control can be done for temperature, pressure, flow etc., The basic circuit remains the same only the sensors and conditioning circuits will be different for the various processes. Here the process control is done for temperature. The temperature sensor output is amplified and fed to the device through one of the channels. This input value is compared with the optimal value or set value. If the temperature value read in is above the set value then the device gives an indication to switch OFF the Relay, thereby stopping heating process, otherwise the Relay contact is made to continue heating.

Similarly, process control can be done simultaneously for flow, pressure etc. Only the software has to be modified.

Introduction

CHAPTER - 1

INTRODUCTION

A Microprocessor based sequential Controller is a device that is able to generate pulses sequentially with a fixed time delay. The ON/OFF periods of the waves are fully user defined. Besides generating sequential waves, the device can be used for Process Control such as temperature, pressure, etc....

The main aim in using this kind of device is generate a particular sequence of pulses for any process, then all that the user has to do is select the particular channel in which the output is required and to give the ON/OFF sequence of the waveform with the help of keyboard. The device automatically does the rest of the work of generating the required output waveform in the required output channels according to the user defined conditions.

The device finds wide usage in the Industry especially in European countries. A specific example is a chemical plant. Suppose it is required to heat a chemical continously according to some sequence like 1 minute ON, 2 minutes OFF, 3 minutes ON..... The Microprocessor based sequential controller device will output this sequence to the heater via the Relay controls. At the same time, there is already a set point or optimal temperature above which the heating should not be carried out. Here a temperature sensor AD590 is used to detect if the temperature of the chemical exceeds above the setpoint. As soon as the temperature exceeds, the device activates the controller circuits and which will in turn shut down the heating system.

The Microprocessor used for the microprocessor based sequential controller is 8085.

The advantage in using this device is

(1) Manual operations can be reduced.

(2) Much more easier to use

(3) Once set with required condition, the system need not be looked after.

(4) The operator is relieved of his duties and can tend to other important duties.

Working Description

CHAPTER - 2

WORKING DESCRIPTION

2.1 SEQUENCING

Sequencing is done by the user specifying the sequence of ON/OFF pulses that the user requires. This is done with the help of a Keyboard. Here the 4 different sequence of pulses can be generated in the 4 output channels.

The assumption made here is that for channel1 the bit Bo is used. To specify the pulse to be ON, the Key is pressed. Before this to select Channel 1 the first Key is pressed. The sequence of ON/OFF requirements are stored in a particular memory location upto a maximum of 15 datas. Here when the ON key is pressed, the data 01 is stored and when the OFF key is pressed, the data 00 is stored in memory location.

For channel 2, the bit B1 is used. To select channel 2, the second key is pressed. To specify the pulse is ON, the ON key is pressed and the data 02 is stored in memory location. To specify the pulse is OFF, the OFF key is pressed and data 00 is stored in memory location. The sequence of ON/OFF requirements are stored in a particular memory location upto a maximum of 15 datas.

For channel 3, the bit B2 is used. To select channel 3, the third key is pressed. To specify the pulse is ON, the ON key is pressed and the data 04 is stored in memory location. To specify the pulse is OFF, the OFF key is pressed and the data 00 is stored in memory location. The sequence of ON/OFF requirements are stored in memory location upto a maximum of 15 datas.

Lastly, for channel 4, the bit B3 is used. To select channel 4, the fourth key is pressed. To specify the pulse is ON, the ON key is pressed and the data 08 is stored in memory location. To specify the pulse is OFF, the OFF key is pressed and the data 00 is stored in memory location. The sequence of ON/OFF requirements are stored in memory location upto a maximum of 15 datas.

Finally all the corresponding memory locations are ORed together and outputted through Port B of 8255A PPI. When the corresponding bits are checked on the CRO, the required sequence of ON/OFF pulses are generated.

2.2 PROCESS CONTROL - INTRODUCTION :-

A system which is designed to have at all times a very small sensitivity to variations in plant characteristics so that the complex, overall system remains unchanged is called as process control system. This means that a process control system is basically a feed back system which automatically achieves a desired response in the presence of extreme changes in the controlled system's parameters and/or major external disturbances.

We can define process control as one of that provides a means of continuously measuring the system's performance in relation to a give criterion, and a means of automatically modifying the system's adjustable parameters by closed loop action.

The definition implies that the process control system must react or adapt itself to changes in its environment. For this purpose, 'environment' can in turn be defined as that set of conditions which should be taken into account by the system's designer. This set will obviously include such elements as the nature of system's input signals, the noise against which the system should discriminate, and the values of the various factors upon which the parameters of the system may be dependent.

Such a system must, therefore, automatically measure the characteristics of the output control system, and of the process under control, and on the basis of these measurements, adjust the overall system towards some previously defined optimim conditions or characteristics. The 3 main functions that a process control system must do are:-

(i) Identification

(ii) Decision

(iii) Modification

In any particular application, it may be difficult to separate those parts of the overall system which are associated with each of these functions, especially the first two; however, all three are necessary for process control. Also, for the purpose of identification, it may be necessary to formulate an index of performance by which the quality level of system performance may be established. Besides these, it is also needed to have special monitoring of the system inputs and/or outputs, and a means of randomly or otherwise disturbing the system or the parameters so that deductions about the system performance can be made.

2.3 TEMPERATURE MONITOR AND CONTROL

Temperature sensing is done with the sensor AD590. Refering Figure 1. The IC AD590 is in close proximity with the soldering iron which does the heating up process. The soldering iron is controlled by the Relay Contacts. The Relay contacts are in turn controlled by Bit B4 through channel 5.

The function of the IC AD590 is to convert the temperature of the system into an equivalent current output. The current output of AD590 is converted into a voltage output. IC LM723 acts as a voltage regulator and the two IC's LM741 are Op-Amps which helps in converting the current output of IC AD590 to an equivalent voltage. Thus an analog signal is got. This analog signal is fed to the Micro Processor based sequential controlle r.

The analog signal is fed to the Analog to Digital convertor (ADC). The ADC converts the analog signal to an equivalent digital output. The software in the MicroProcessor initialises the ports of the 8255A PPI to read in this value and is stored in Hexadecimical format.

After getting the Hexadecimal value, it is converted to Binary Coded Format (BCD). Now the Hex value is split each time into 1's, 10's and 100'sdigits. The most significant bits are each time compared with the Look-up Table Contents for the 7 segment equivalent. The 7 segment equivalents got are stored in a particular memory from where the message is to be displayed onto the ADD-ON Board.

Next the 7 segments of the ADD-ON Board are addressed and the message "Tep= - - - - " is made to come on. 'Tep' indicates Temperature. The blank spaces indicate the BCD value to be displayed. The range of BCD values that can be displayed are from 0°C to 255°C. Upto this stage temperature monitor is done.

The next important thing to be done is temperature control. In the initial conditions, the optimal value or set value of temperature is stored in a particular location in Hex Format. The input temperature value that has just been read in has to be compared with the set value and then the decisions have to be made.

As soon as the software finds that the value read in has exceeded the set value then through channel 5 Bit B5 is made high. Since here negative logic is used, the Relays break contact thereby cutting off the power from the soldering iron which in turn stops heating. Once the value read in is below or equal to the set value, the Relay contacts are made which in turn will continue the heating process. This is the function of the Process Control by the MicroProcessor based sequential controller.

TEMPERATURE SENSING CIRCUIT

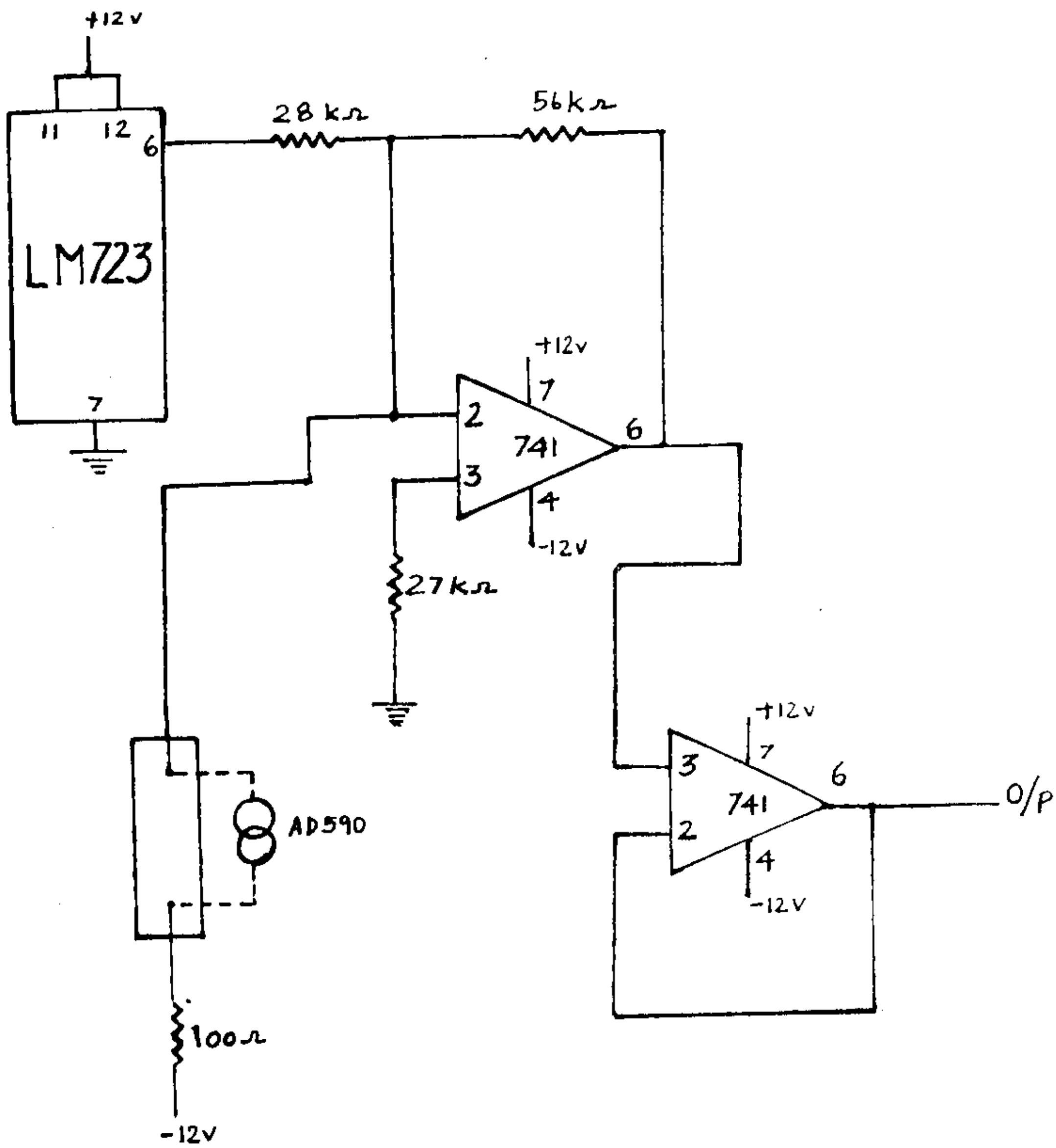


Figure 1

Software Development

CHAPTER - 3

SOFTWARE DEVELOPMENT

3.1 Introduction

The software has been developed with the help of 8085. The programs are divided and organised into a structure that can be easily understood. Program structure is the division of the program into parts of decomposition and subsequently composition of the parts will interact with each other and these interactions must be defined and controlled to allow reliable, robust software to be written. The main reason for program division is to make the program writing more tractible from the human view point. There are also hardware/software physical constraints.

3.2. Delaytime Calculation

T states	Mneumonic Instruction
12	PUSH PSW
12	PUSH H
12	PUSH D
12	PUSH B
7	MUI C, FF
4	DCR C
7/10	JNZ
10	POP B
10	POP D

10	POP B
10	POP D
10	POP H
10	POP PSW
10	RET

T_a = (PUSH PSW + PUSH H + PUSH D + PUSH B) + JN2 +

(POP B + POP D + POP H + POP PSW + RET)

= (12 x 4) + 10 + (10 x 5)

= 108

T_t = (MVI FF + DCR C) x 255 + JNZ + T_a

= (4 + 7) x 255 + 7 + 108

= 2805 + 7 + 108

= 2920

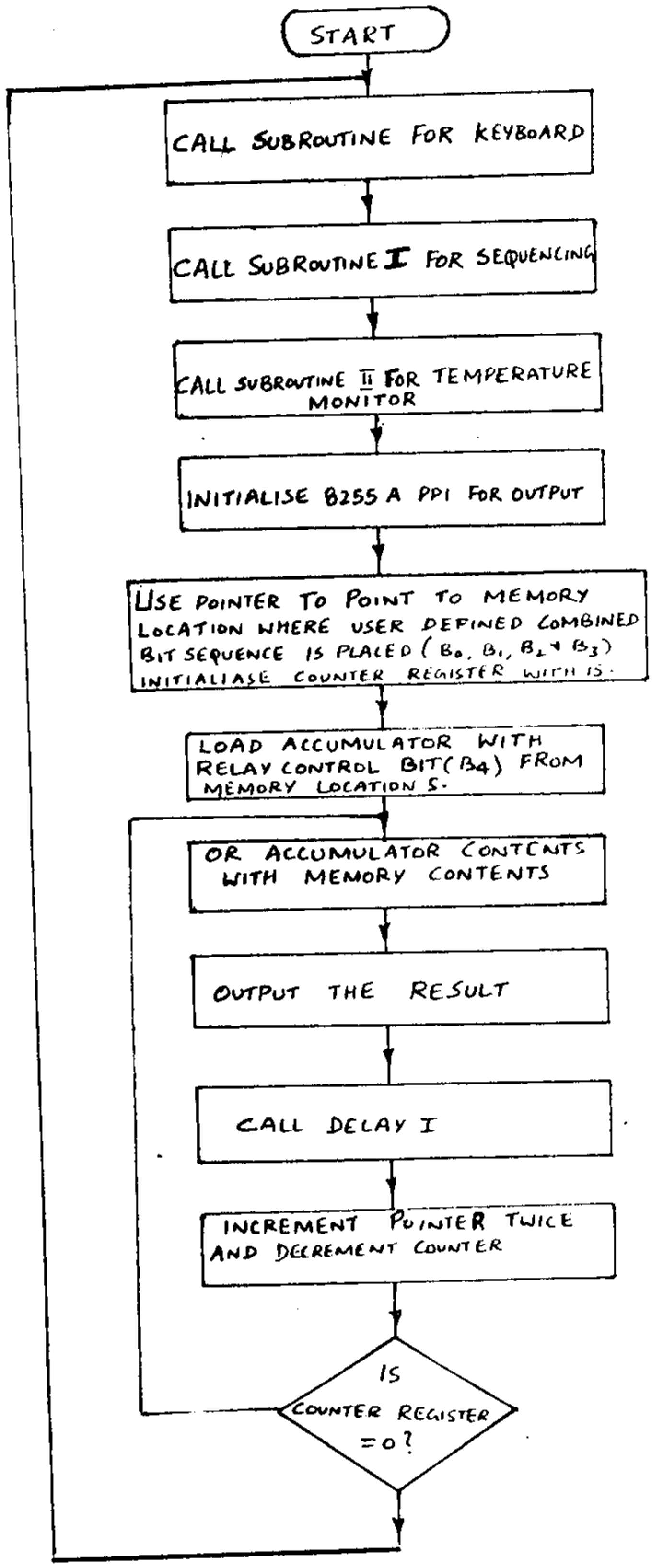
Delay time = Total time x clock frequency

= 2920 x 3.14

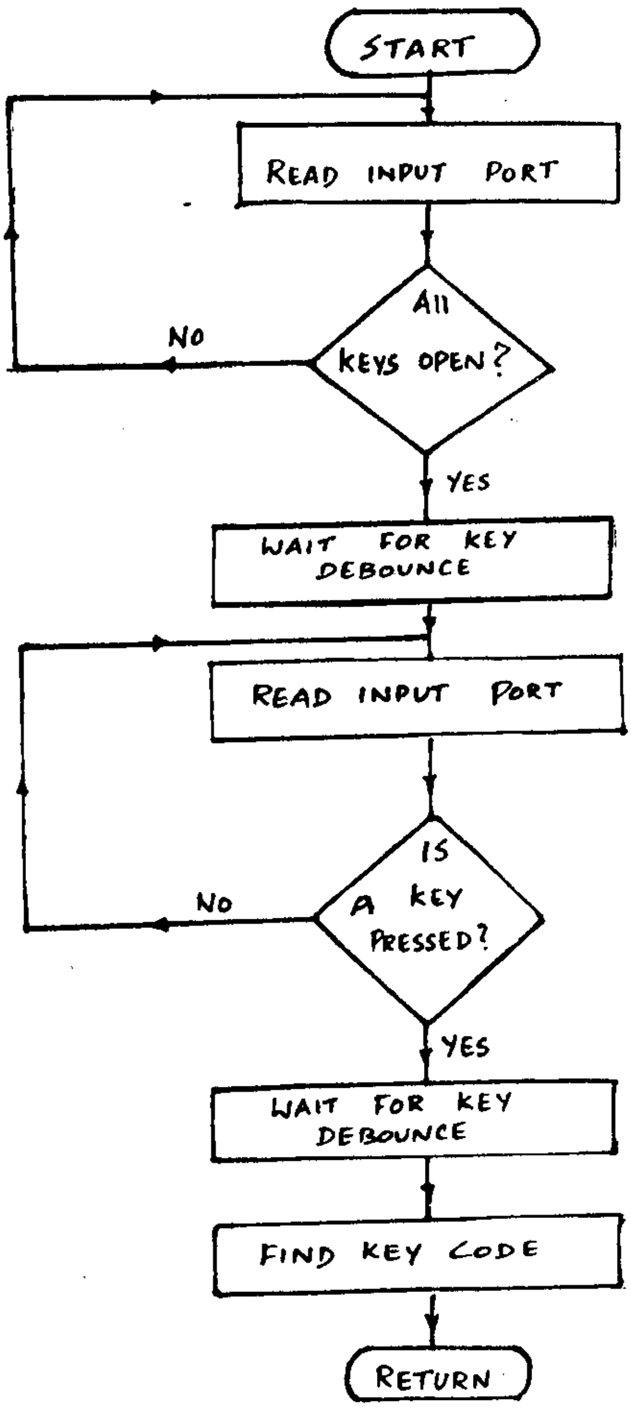
= 9168.8 M Sec.

This is the time delay the pulses take during the ON/OFF periods.

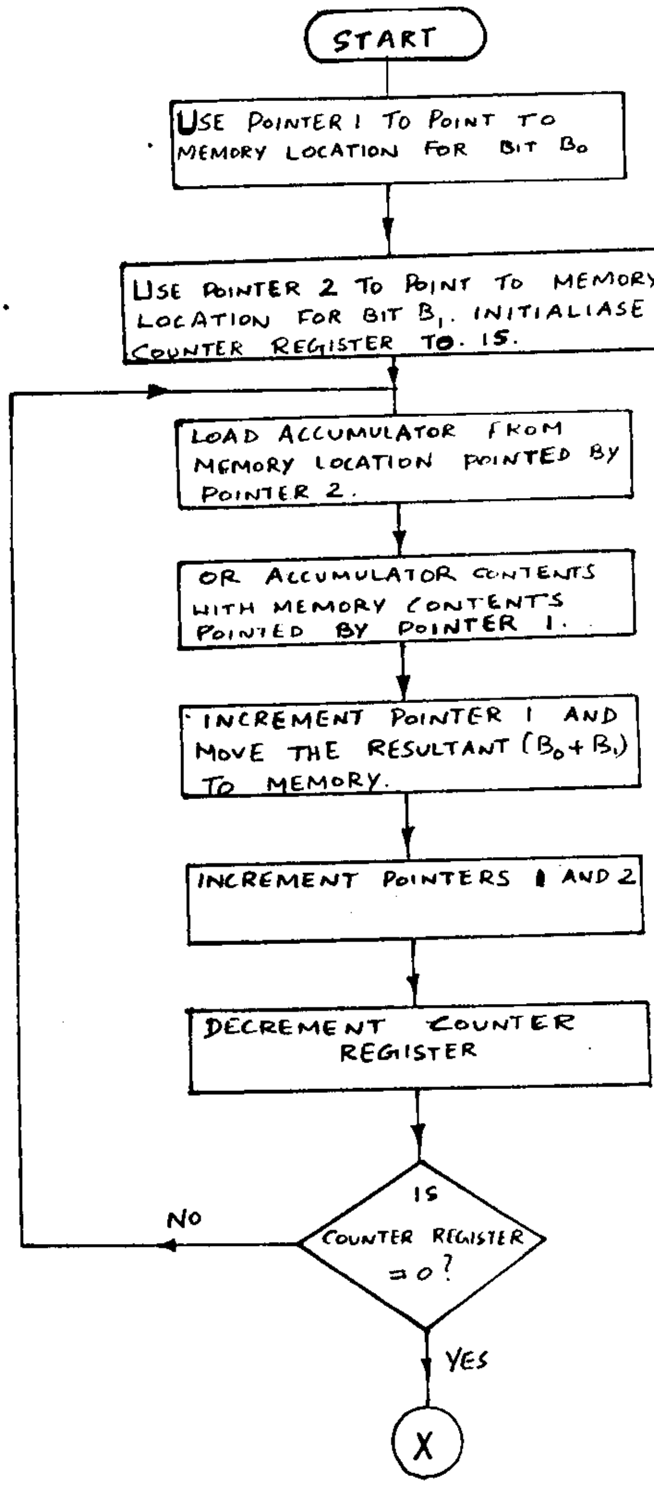
33 MAIN PROGRAM

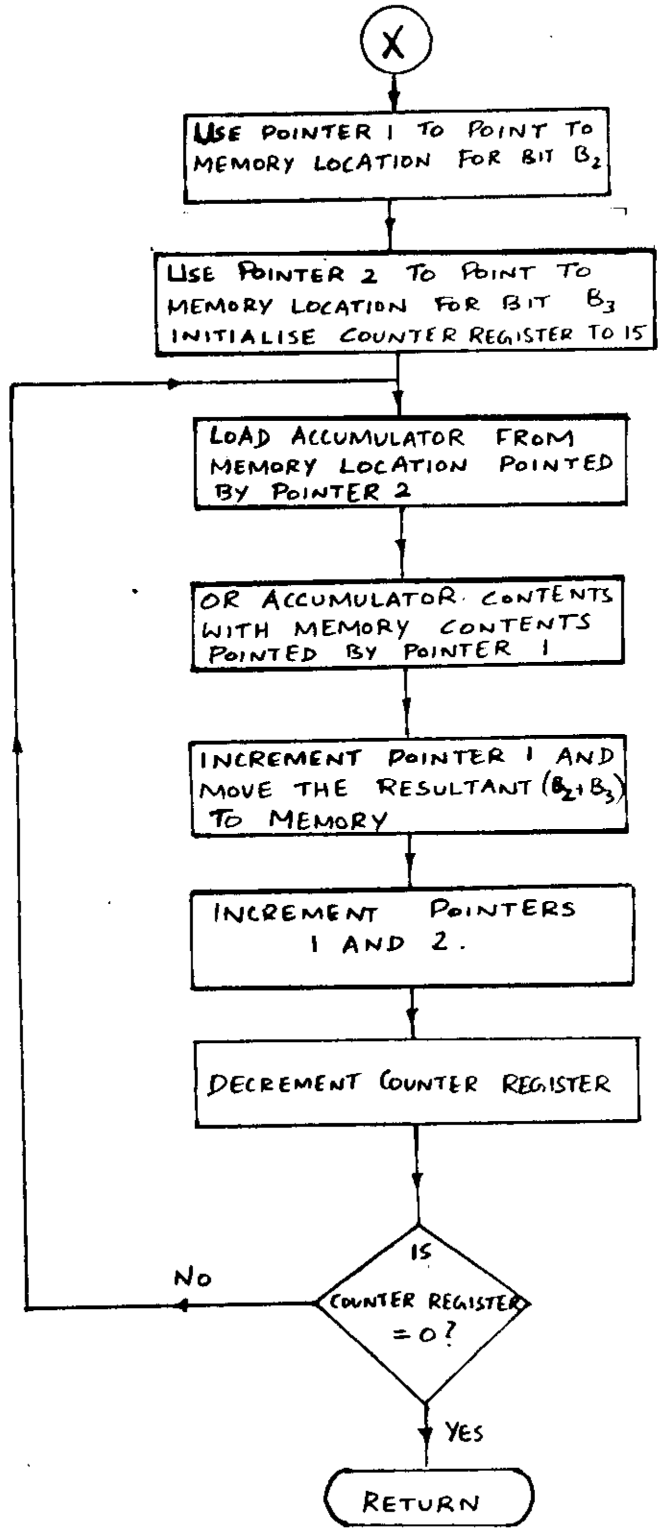


SUBROUTINE FOR KEYBOARD

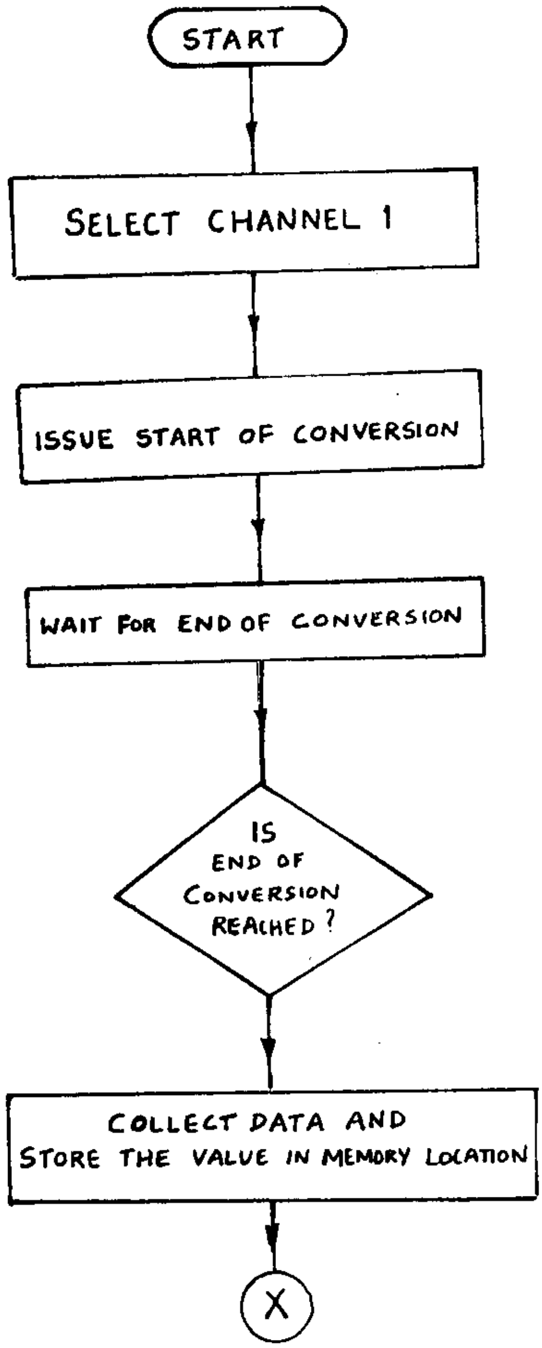


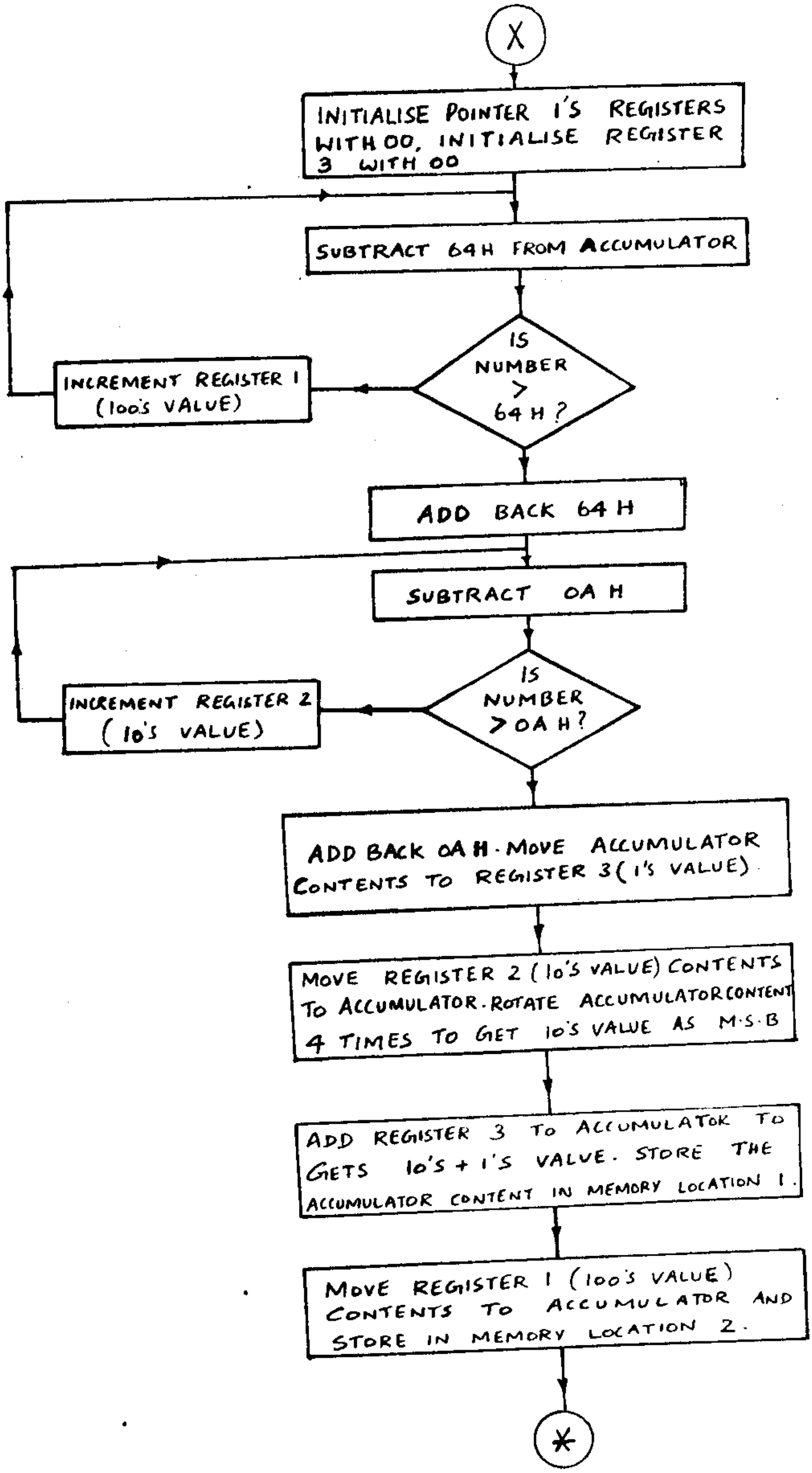
SUBROUTINE I FOR SEQUENCING

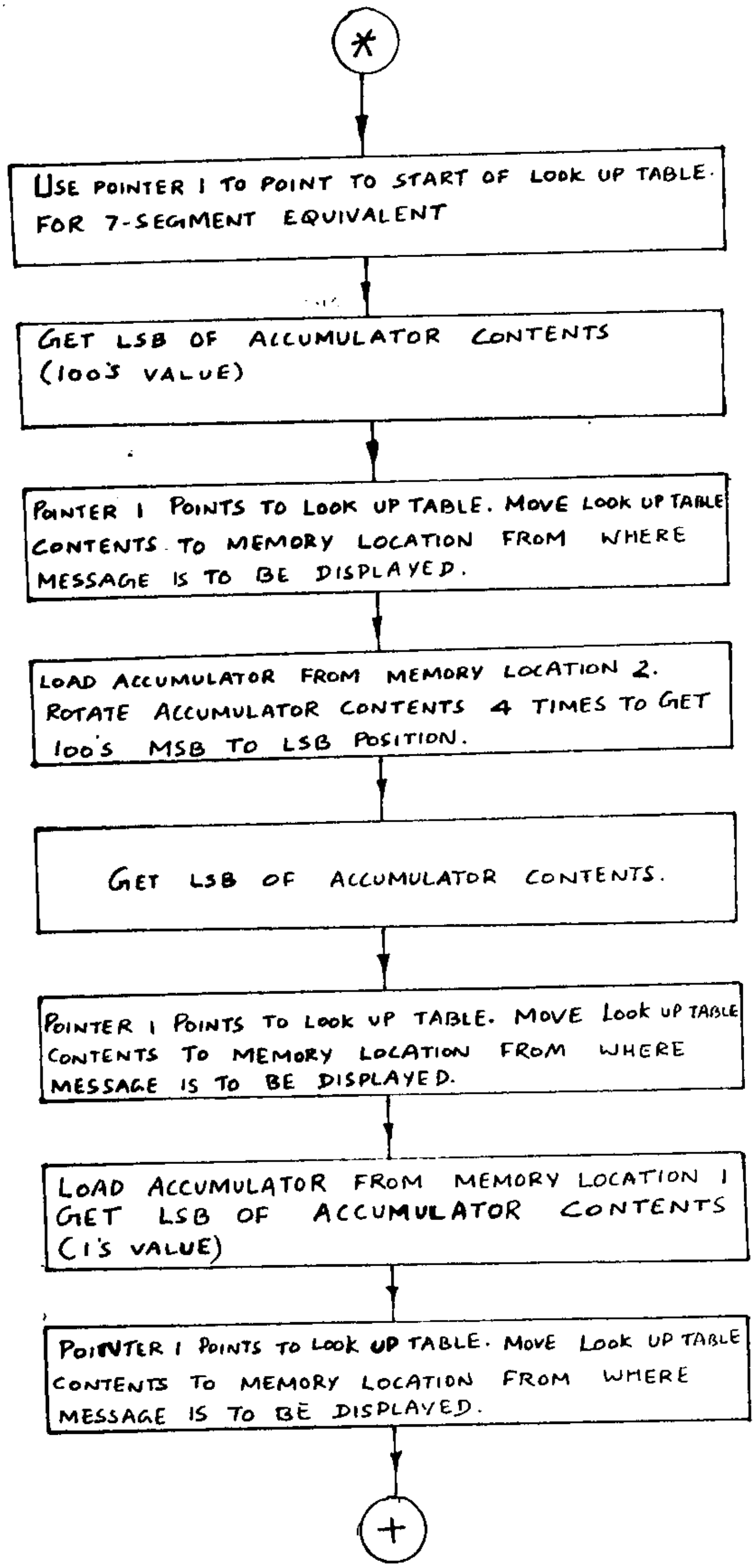


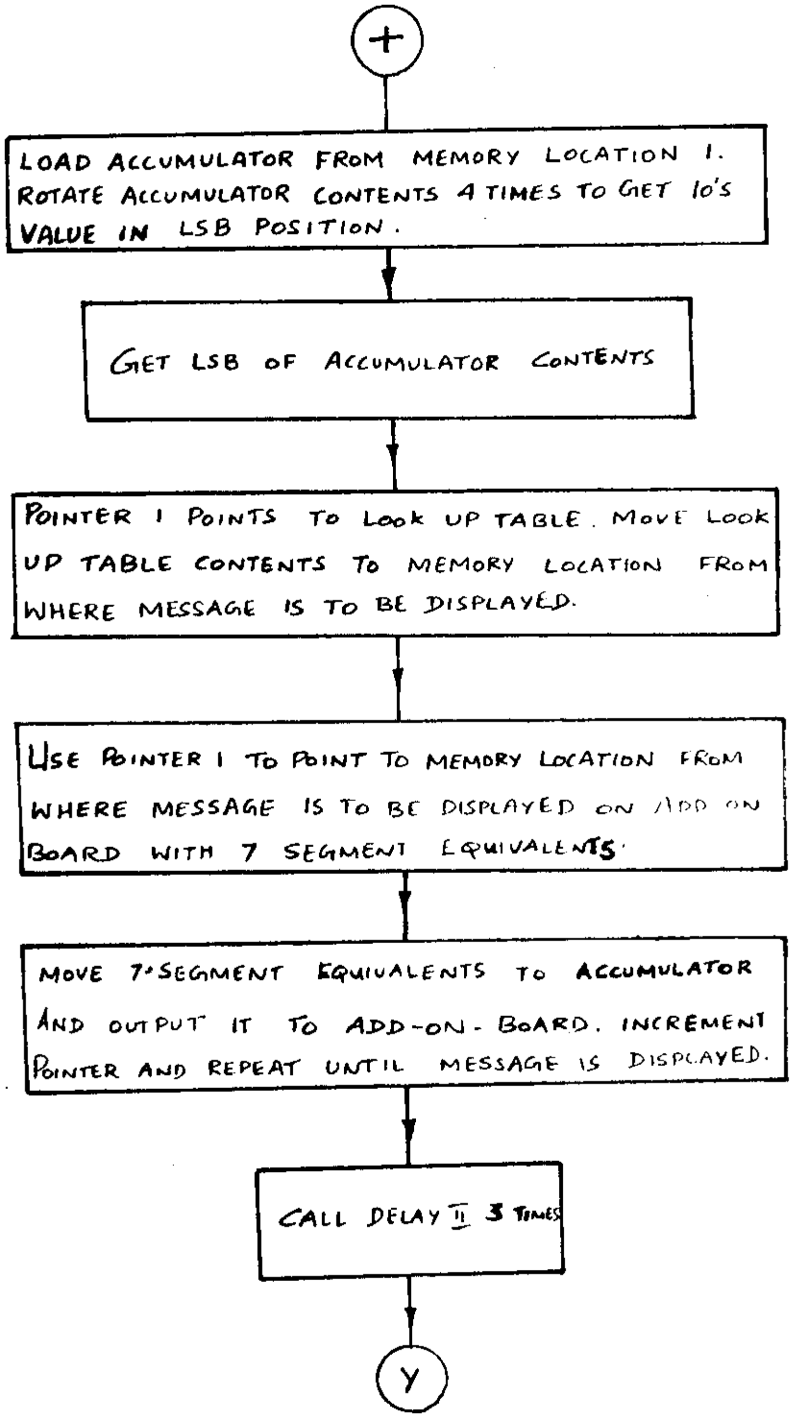

X
USE POINTER 1 TO POINT TO MEMORY LOCATION FOR BIT B2
USE POINTER 2 TO POINT TO MEMORY LOCATION FOR BIT B3 INITIALISE COUNTER REGISTER TO 15
LOAD ACCUMULATOR FROM MEMORY LOCATION POINTED BY POINTER 2
OR ACCUMULATOR CONTENTS WITH MEMORY CONTENTS POINTED BY POINTER 1
INCREMENT POINTER 1 AND MOVE THE RESULTANT (B2+B3) TO MEMORY
INCREMENT POINTERS 1 AND 2.
DECREMENT COUNTER REGISTER
IS COUNTER REGISTER = 0?
NO
YES
RETURN

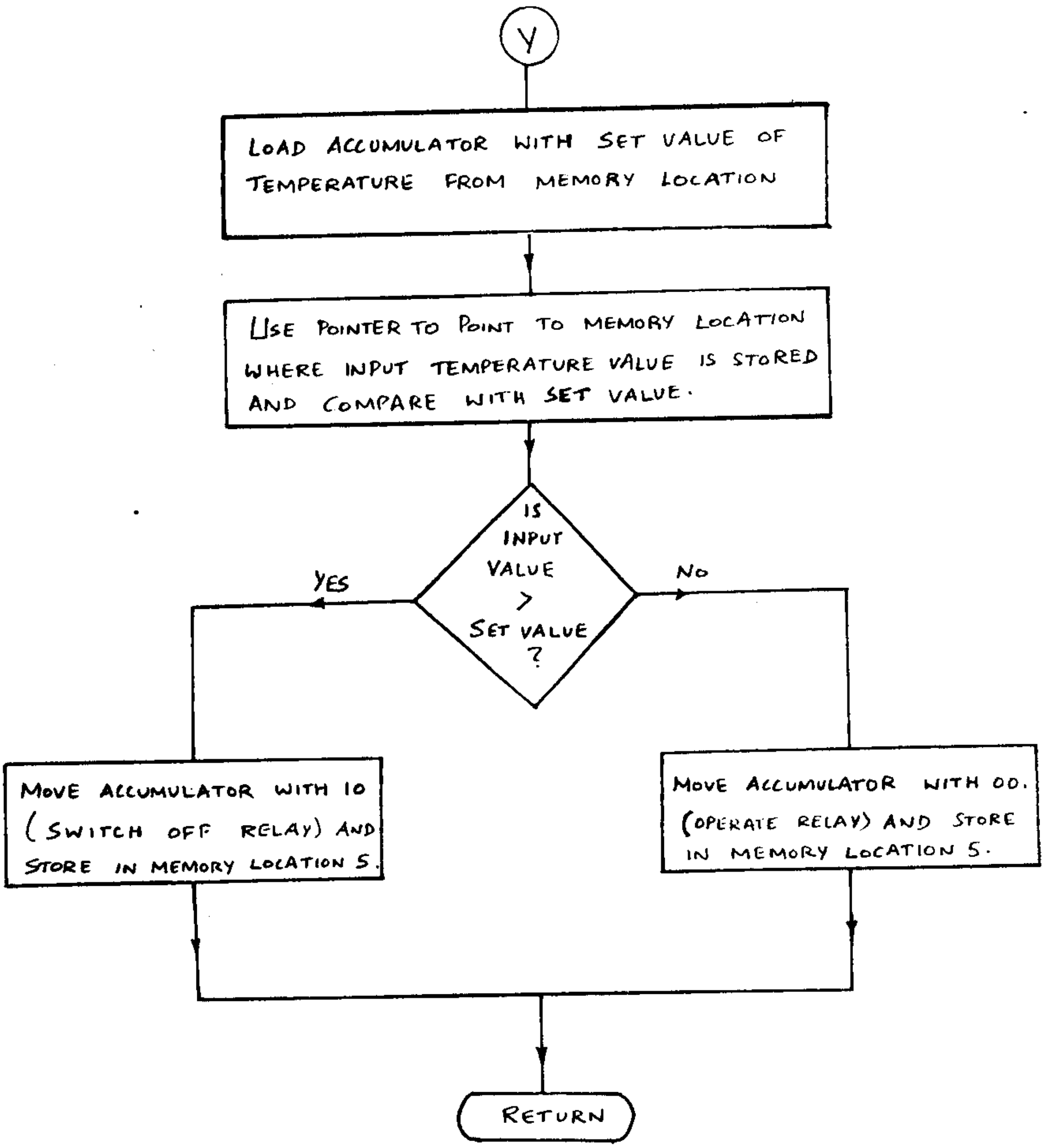
SUBROUTINE II FOR TEMPERATURE MONITOR



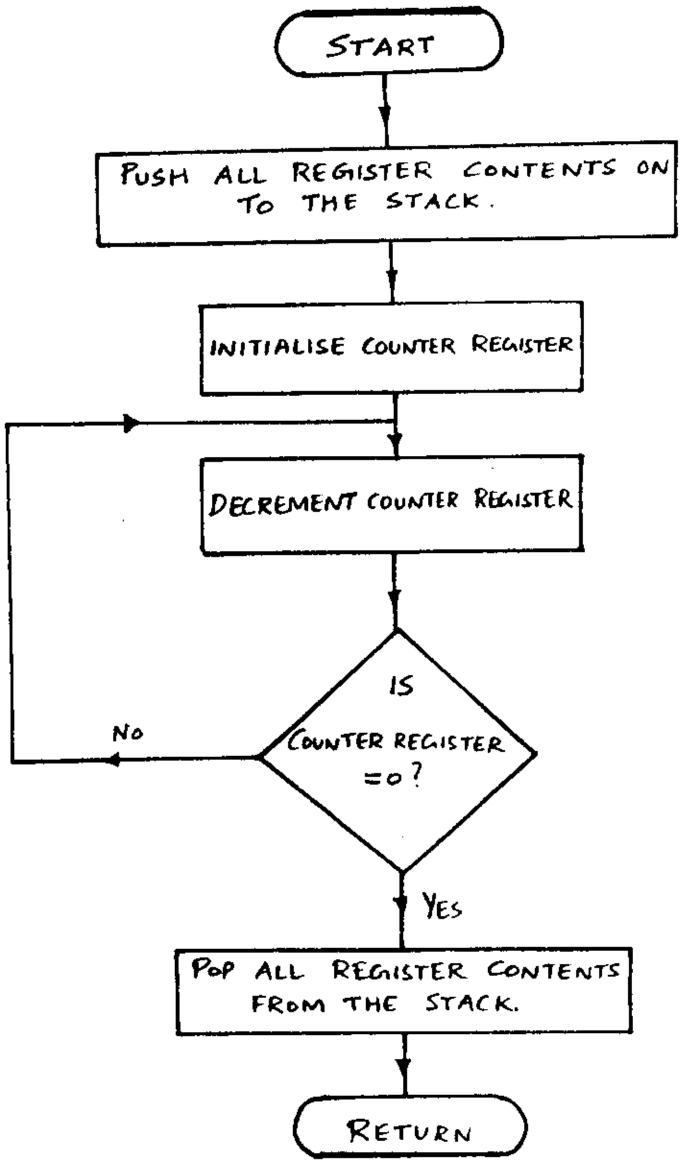

X
INITIALISE POINTER 1'S REGISTERS WITH 00, INITIALISE REGISTER 3 WITH 00
SUBTRACT 64H FROM ACCUMULATOR
IS NUMBER > 64 H ?
INCREMENT REGISTER 1 (100's VALUE)
ADD BACK 64 H
SUBTRACT 0A H
IS NUMBER > 0A H?
INCREMENT REGISTER 2 (10's VALUE)
ADD BACK 0A H. MOVE ACCUMULATOR CONTENTS TO REGISTER 3 (1's VALUE)
MOVE REGISTER 2 (10's VALUE) CONTENTS TO ACCUMULATOR. ROTATE ACCUMULATOR CONTENT 4 TIMES TO GET 10's VALUE AS M.S.B
ADD REGISTER 3 TO ACCUMULATOR TO GETS 10's + 1's VALUE. STORE THE ACCUMULATOR CONTENT IN MEMORY LOCATION 1.
MOVE REGISTER 1 (100's VALUE) CONTENTS TO ACCUMULATOR AND STORE IN MEMORY LOCATION 2.
*


*
USE POINTER 1 TO POINT TO START OF LOOK UP TABLE. FOR 7-SEGMENT EQUIVALENT
GET LSB OF ACCUMULATOR CONTENTS (100'S VALUE)
POINTER 1 POINTS TO LOOK UP TABLE. MOVE LOOK UP TABLE CONTENTS TO MEMORY LOCATION FROM WHERE MESSAGE IS TO BE DISPLAYED.
LOAD ACCUMULATOR FROM MEMORY LOCATION 2. ROTATE ACCUMULATOR CONTENTS 4 TIMES TO GET 100'S MSB TO LSB POSITION.
GET LSB OF ACCUMULATOR CONTENTS.
POINTER 1 POINTS TO LOOK UP TABLE. MOVE LOOK UP TABLE CONTENTS TO MEMORY LOCATION FROM WHERE MESSAGE IS TO BE DISPLAYED.
LOAD ACCUMULATOR FROM MEMORY LOCATION 1 GET LSB OF ACCUMULATOR CONTENTS (1'S VALUE)
POINTER 1 POINTS TO LOOK UP TABLE. MOVE LOOK UP TABLE CONTENTS TO MEMORY LOCATION FROM WHERE MESSAGE IS TO BE DISPLAYED.
+

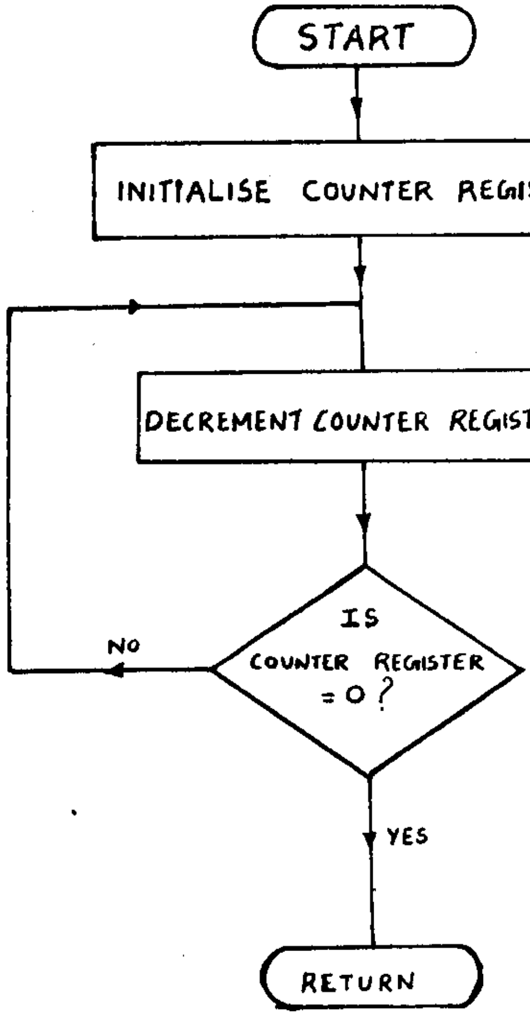

+
LOAD ACCUMULATOR FROM MEMORY LOCATION 1. ROTATE ACCUMULATOR CONTENTS 4 TIMES TO GET 10's VALUE IN LSB POSITION.
GET LSB OF ACCUMULATOR CONTENTS
POINTER 1 POINTS TO LOOK UP TABLE. MOVE LOOK UP TABLE CONTENTS TO MEMORY LOCATION FROM WHERE MESSAGE IS TO BE DISPLAYED.
USE POINTER 1 TO POINT TO MEMORY LOCATION FROM WHERE MESSAGE IS TO BE DISPLAYED ON ADD ON BOARD WITH 7 SEGMENT EQUIVALENTS.
MOVE 7-SEGMENT EQUIVALENTS TO ACCUMULATOR AND OUTPUT IT TO ADD-ON-BOARD. INCREMENT POINTER AND REPEAT UNTIL MESSAGE IS DISPLAYED.
CALL DELAY II 3 TIMES
Y


Y
LOAD ACCUMULATOR WITH SET VALUE OF TEMPERATURE FROM MEMORY LOCATION
USE POINTER TO POINT TO MEMORY LOCATION WHERE INPUT TEMPERATURE VALUE IS STORED AND COMPARE WITH SET VALUE.
IS INPUT VALUE > SET VALUE ?
YES
NO
MOVE ACCUMULATOR WITH 10 (SWITCH OFF RELAY) AND STORE IN MEMORY LOCATION 5.
MOVE ACCUMULATOR WITH 00. (OPERATE RELAY) AND STORE IN MEMORY LOCATION 5.
RETURN

DELAY I


START
PUSH ALL REGISTER CONTENTS ON TO THE STACK.
INITIALISE COUNTER REGISTER
DECREMENT COUNTER REGISTER
IS COUNTER REGISTER =0?
NO
YES
POP ALL REGISTER CONTENTS FROM THE STACK.
RETURN

DELAY II


START
INITIALISE COUNTER REGISTER
DECREMENT COUNTER REGISTER
IS
COUNTER REGISTER
= 0 ?
NO
YES
RETURN

3.4 Program Listing

Address	Mneumonic Instruction	Opcodes
0500	CALL 052A	CD
0501		2A
0502		05
0503	CALL 0561	CD
0504		61
0505		05
0506	MVI A, 80	3E
0507		80
0508	OUT OF	D3
0509		0F
050A	LXI H, 2001	21
050B		01
050C		20
050D	MVI C, 0F	0E
050E		0F
050F	LDA 2175	3A
0510		75
0511		21
0512	ORA M	B6
0513	OUT OD	D3
0514		0D
0515	CALL 062F	CD
0516		2F
0517		06

0518	CALL 062F	CD
0519		2F
051A		06
051B	CALL 062F	CD
051C		2F
051D		06
051E	CALL 062F	CD
051F		2F
0520		06
0521	INX H	23
0522	INX H	23
0523	DCR C	0D
0524	JNZ 050F	C2
0525		0F
0526		05
0527	JMP 0500	C3
0528		00
0529		05
052A	LXI H 2000	21
052B		00
052C		20
052D	LXI D 201E	11
052E		1E
052F		20
0530	MVI C, 0F	0E
0531		0F
0532	LDAX D	1A

0533	ORA M	B6
0534	INX H	23
0535	MOV M,A	77
0536	INX H	23
0537	INX D	13
0538	DCR C	0D
0539	JNZ 0532	C2, 05
053A		32
053B	LXI H 202D	21
053C		2D
053D		20
053E	LXI D 204B	11
053F		4B
0540		20
0541	MVI C, 0F	0E
0542		0F
0543	LDAX D	1A
0544	ORA M	B6
0545	INX H	23
0546	MOV M, A	77
0547	INX H	23
0548	INX D	13
0549	DCR C	0D
054A	JNZ 0543	C2
054B		43
054C		05
054D	LXI H, 2001	21

054E		01
054F		20
0550	LXI D, 202E	11
0551		2E
0552		20
0553	MVI C, 0F	0E
0554		0F
0555	LDAX D	1A
0556	ORA M	B6
0557	MOV M,A	77
0558	INX D	13
0559	INX D	13
055A	INX H	23
055B	INX H	23
055C	DCR C	0D
055D	JNZ 0555	C2
055E		55
055F		05
0560	RET	C9
0561	MVI A, 01	3E
0562		01
0563	OUT 38	D3
0564		38
0565	MVI A, 09	3E
0566		09
0567	OUT 38	D3
0568		38

0569	MVI A, 01	3E
056A		01
056B	OUT 28	D3
056C		28
056D	XRA, A	AF
056E	OUT 38	D3
056F		38
0570	OUT 28	D3
0571		28
0572	IN 2C	DB
0573		2C
0574	ANI 02	E6
0575		02
0576	JZ 0572	CA
0577		72
0578		05
0579	IN 24	DB
057A		24
057B	STA 2159	32
057C		59
057D		21
057E	LXI D, 0000	11
057F		00
0580		00
0581	MVI C, 00	0E
0582		00
0583	SUI 64	D6
0584		64

0585	JC 058C	DA
0586		8C
0587		05
0588	INR D	14
0589	JMP 0583	C3
058A		83
058B		05
058C	ADI, 64	C6
058D		64
058E	SUI, 0A	D6
058F		0A
0590	JC 0597	DA
0591		97
0592		05
0593	INR E	1C
0594	JMP 058E	C3
0595		8E
0596		05
0597	ADI, 0A	C6
0598		0A
0599	MOV C, A	4F
059A	XRA, A	AF
059B	MOV A, E	7B
059C	RLC	07
059D	RLC	07
059E	RLC	07
059F	RLC	07
05A0	ADD C	81

05A1	STA 2158	32
05A2		58
05A3		21
05A4	MOV A, D	7A
05A5	STA 2157	32
05A6		57
05A7		21
05A8	MVI B, 00	06
05A9		00
05AA	LXI H, 061C	21
05AB		1C
05AC		06
05AD	ANI OF	E6
05AE		0F
05AF	MOV L, A	6F
05B0	MOV A, M	7E
05B1	STA 2151	32
05B2		51
05B3		21
05B4	LDA 2157	3A
05B5		57
05B6		21
05B7	RAR	1F
05B8	RAR	1F
05B9	RAR	1F
05BA	RAR	1F
05BB	ANI, 0F	E6

05BC		0F
05BD	MOV L,A	6F
05BE	MOV A, M	7E
05BF	STA 2150	32
05C0		50
05C1		21
05C2	XRA, A	AF
05C3	LDA 2158	3A
05C4		58
05C5		21
05C6	ANI, 0F	E6
05C7		0F
05C8	MOV L, A	6F
05C9	MOV A, M	7E
05CA	STA 2153	32
05CB		53
05CC		21
05CD	LDA 2158	3A
05CE		58
05CF		21
05D0	RAR	1F
05D1	RAR	1F
05D2	RAR	1F
05D3	RAR	1F
05D4	ANI, 0F	E6
05D5		0F
05D6	MOV L, A	6F

05D7	MOV A, M	7E
05D8	STA 2152	32
05D9		52
05DA		21
05DB	LXI H, 214C	21
05DC		4C
05DD		21
05DE	MOV A, M	7E
05DF	OUT CE	D3
05E0		CE
05E1	INX H	23
05E2	MOV A, M	7E
05E3	OUT CC	D3
05E4		CC
05E5	INX H	23
05E6	MOV A, M	7E
05E7	OUT CA	D3
05E8		CA
05E9	INX H	23
05EA	MOV A, M	7E
05EB	OUT C8	D3
05EC		C8
05ED	INX H	23
05EE	MOV A, M	7E
05EF	OUT C6	D3
05F0		C6
05F1	INX H	23

05F2	MOV A, M	7E
05F3	OUT C4	D3
05F4		C4
05F5	INX H	23
05F6	MOV A, M	7E
05F7	OUT C2	D3
05F8		C2
05F9	INX H	23
05FA	MOV A, M	7E
05FB	OUT C0	D3
05FC		C0
05FD	CALL 0628	CD
05FE		28
05FF		06
0600	CALL 0628	CD
0601		28
0602		06
0603	CALL 0628	CD
0604		28
0605		06
0606	LDA 2170	3A
0607		70
0608		21
0609	LXI H, 2159	21
060A		59
060B		21
060C	CMP M	BE

060D	JC 0618	DA
060E		18
060F		06
0610	MVI A, 00	3E
0611		00
0612	STA 2175	32
0613		75
0614		21
0615	JMP 061D	C3
0616		1D
0617		06
0618	MVI A, 10	3E
0619		10
061A	STA 2175	32
061B		75
061C		21
061D	RET	C9
061E	0	FC
061F	1	0C
0620	2	DA
0621	3	F2
0622	4	66
0623	5	B6
0624	6	BE
0625	7	E0
0626	8	FE
0627	9	E6

0628	MVI E, FF	1E
0629		FF
062A	DCR E	1D
062B	JNZ 062A	C2
062C		2A
062D		06
062E	RET	C9
062F	PUSH PSW	F5
0630	PUSH H	E5
0631	PUSH D	D5
0632	PUSH B	C5
0633	MVI C, FF	0E
0634		FF
0635	DCR C	0D
0636	JNZ 0635	C2
0637		35
0638		06
0639	POP B	C1
063A	POP D	D1
063B	POP H	E1
063C	POP PSW	F1
063D	RET	C9

Chip Details

<u>CHAPTER - 4</u>

CHIP DETAILS

4.1 AD590 - Temperature Transducer

4.1.a Working:

AD590 is used for measuring temperature and converting into a proportional analog signal.

In electronic circuits, the silicon transducer can be used as a high quality temperature sensing device with certain precautions. The current across any PN junction of a silicon transistor under forward biased conditions consists of atleast three major components in

1) Diffusion current
2) Recombination current
3) Leakage current

It is well known that the forward bias voltage of a PN junction varies linearly with temperature for a constant forward current. In a transistor, the collector current I_c is proportional to the emitter current I_e and is related by the equation

$$- I_c = X I_e - I_{co}$$

Where 'X' is the short circuit forward transfer ratio and I_{co} is the reverse collector current. The emitter current I_e in turn depends upon the emitter reverse current I_{EO} absolute temperature and the emitter base forward bias V_{BE} is given by:-

$$I_E = I_{ED} \left(\exp \frac{q\, V_{BE}}{KT} - 1 \right)$$

where 'q' - electronic charge

'k' - Boltzmann's constant

'T' - Temperature

$$V_{BE} = \frac{KT}{q} \ln \left(\frac{I_E + I_{EO}}{I_{ED}} \right)$$

$$T = \frac{V_{BE}}{K_q \ln} \times \frac{1}{\left(\frac{IE + IED}{IED} \right)}$$

If the emitter current is held constant then the term in the parentheses becomes a constant and the emitter base voltage is a linear function of temperature. However, in practise, the linearity between temperature and voltage differs from transistor to transistor. In large scale production, the V_{BE} for a particular transistor vary as much as + 100 mV.

In order to use the transistor with good interchangeability, the spread in V_{BE} values of individual transistors should be taken care along with the current operation.

Thus AD590 is an integrated circuit temperature transducer which produces an output current proportional to the absolute temperature.

4.1.b Characteristics:

AD590 device acts as a high impedance constant current regulator, passing 1 A/K for supply voltages between +4V and +30V. Laser trimming of the chips thin film resistors is used to calibrate the device to 298.2K

This AD590 should be used in any temperature sensing application between -55°C and +150°C in which conventional electrical temperature sensors are currently employed. This inherent low cost of a monolithic integrated circuit combined with the elimination of support circuitry makes the AD590 an attractive alternative for many temperature measurement situations. linearization circuitry, precision voltage amplifiers, resistance measuring circuitry and cold junction compensation are not needed in applying the AD590. In the simplest application, a resistor power source and any voltmeter can be used to measure temperature.

4.1.c. Other Applications:

In addition to temperature measurement, applications also include temperature compensation or correction of discrete components and biasing proportional to absolute temperature.

The AD590 is available in chip form making it suitable for hybrid circuits and fast temperature measurement protected environments.

The AD590 is particularly useful in remote sensing applications. The device is insensitive to voltage drops over for lines due to its high impedance current output. Anyway insulated twisted pair is sufficient for operation of hundreds of feet from the receiving circuitry. The output circuits also make AD590 easy to multiplex. The current can be switched by a CMOS multiplexer or the supply voltage can be switched by a logic gate.

4.2 ADC 0809:

It contains of an 8 bit A/D convertor, 8 channel multiplexer with an address input latch and associated control logic. These devices provide most of the logic to interface to a variety of microprocessors with the addition of minimum number of parts.

Depending upon the function, it can be divided into two basic subcircuits. Refer figure 3. They are an analog multiplexer and an A/D convertor. The multiplexer uses 8 standard CMOS analog switches to provide for upto 8 analog inputs. The switches are selectively turned ON, depending on the data latched onto a 3 bit multiplexer address register.

The second function block is the successive approximation A/D convertor transforms the analog output of the multiplexer to an 8 bit digital word. The output of the multiplexer goes to one of the two comparator inputs. The other input is derived from a 256 R resistor ladder, which is tapped by MOSFET transistor switch tree. The convertor control logic controls the switch tree, funneling a particular tap voltage to the comparator based on the result of comparison the control logic and successive approximation register (SAR) will decide whether the next tap to be selected should be higher or lower than the present tap on the resistance ladder. This algorithm is executed 8 times per conversion. Once every 8 clock period, yielding a total conversion time of 64 clock periods.

When the conversion cycle is completed, the resulting data is loaded into the tri-state output latch. The data in the output latch can then be read by the host system any time before the end of the next conversion. The tri-state capability of the latch allows easy interface to bus oriented system.

The controlling device first selects the desired input channel. To do this, a 3 bit channel address is placed on A, B, C input pins and the ALE input is pulsed positively clocking the address into the multiplexer address register. To begin the conversion, the START pin is pulsed. On the rising edge of this pulse the internal registers are cleared and on the falling edge the start conversion is initiated. As long as the start pin is high no conversion begins, but when the start pin is made low the conversion will start within 8 clock periods.

As soon as the conversion is over, EOC (Interrupt) will go high indicating that the converted data ready to be read and also it will enable (OE) (output enable) line so as to allow the data to be read.

4.2.a. Features:

* Resolution - 8 bits.
* Total unadjusted error - ± 1/2 LSB and ± 1 LSB.
* No missing codes.
* Conversion time - 100 sec.
* Single supply - 5 V_{DC}.
* Operate ratiometrically or with 5 V_{DC} or analog span adjusted voltage reference.
* 8 - channel multiplexer with latched control logic.
* Easy interface to all microprocessors, or operates "stand alone".

* Outputs meet T L voltage level specifications.

* 0V to 5V analog input voltage range with single 5V supply.

* No zero or full-scale adjust required.

* Standard hermetic or molded 28-pin DIP package.

* Temperature range - 40°C to +85°C or -55°C to +125°C.

* Low power consumption - 15 mW.

* Latched TRI-STATE output.

4.2.b. Functional Description:

Multiplexer: The device contains an 8-channel single ended analog signal multiplexer. A particular input channel is selected by using the address decoder. Table I shows the input states for the address lines to select any channel. The address is latched into the decoder on the low-to-high transition of the address latch enable signal.

4.3 8255A - Programmable Peripheral Interface

The 8255A can be used as a programmable, parallel I/O device. It can be programmed to transfer data under various conditions, from simple I/O to interrupt I/O. It is flexible, versatile and economical. It is an important general purpose I/O device that can be used with almost any microprocessor.

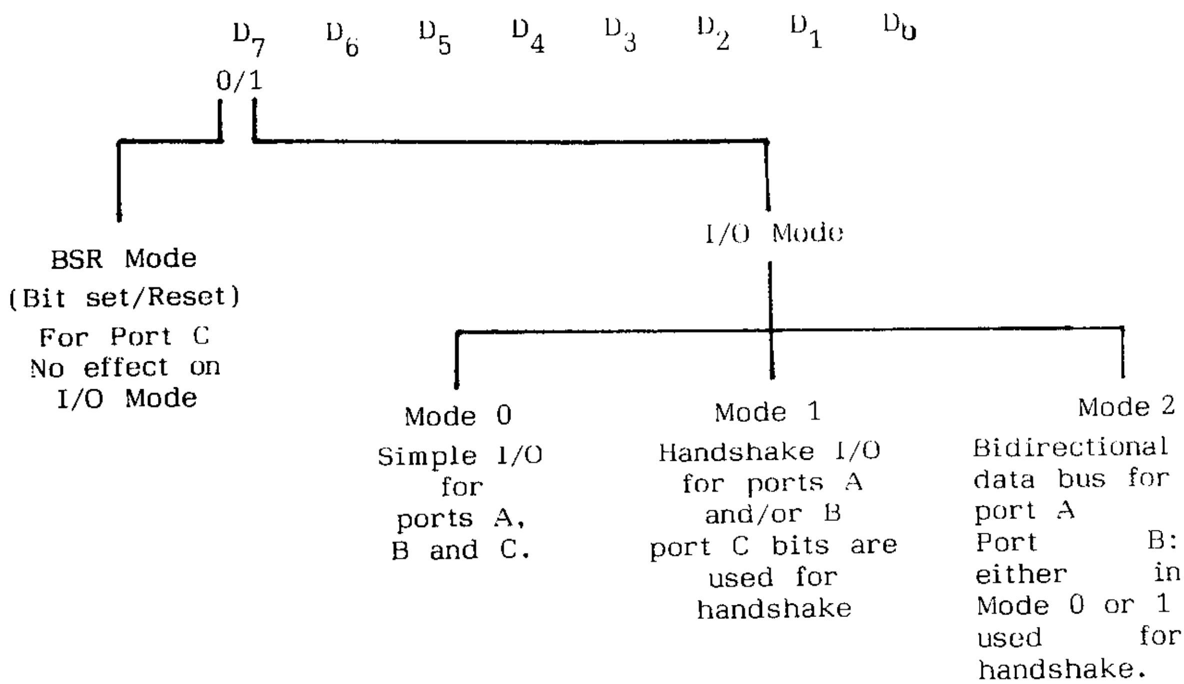
The 8255A has 24 I/O pins that can be grouped primarily in two 8-bit parallel ports: A and B, with the remaining 8 bits as port C. The 8 bits of port C can be used as individual or be grouped in two

4-bit ports: C_{UPPER} (Cu) and C_{LOWER} (C_L). The functions of the ports are defined by writing a control word in the control register.

The following figure shows all the functions of the 8255A, classified according to two modes: Bit set/Reset (BSR) mode and the I/O mode. The BSR mode is used to set or reset the bits in Port C. The I/O mode is further divided into 3 modes: Mode 0, Mode 1 and Mode 2.

In mode 0, all ports function as simple I/O ports. Mode 1 is a handshake mode whereby ports A and/or B use bits from port C as handshake signals. In the handshake mode, two types of I/O data transfer can be implemented: status check and interrupt. In Mode 2, port A can be set up for bidirectional data transfer using handshake signals from port C, and port B can be set up either in Mode 0 or Mode 1.

CONTROL WORD



4.3.a. Control Logic:

The control section has 6 lines and their functions are as follows:-

* $\overline{RD}$ (Read): This control signal enables the read operation. When the signal is low, the Microprocessor reads data from a selected I/O port of the 8255 A.

* $\overline{WR}$ (Write): This control signal enables the write operation. When the signal is low, the Microprocessor writes into a selected I/O port or the control register.

* **RESET** (Reset): This is an active high signal ; it clears the control register and sets all ports in the input mode.

* **$\overline{CS}$, A0 and A1** : These are device select signals. $\overline{CS}$ is connected to a decoded address, and A_0 and A_1 are generally connected to microprocessor address lines A_0 and A_1 respectively.

The $\overline{CS}$ signal is the master chip select, and A_0 and A_1 specify one of the I/O ports or the control register as given below.

$\overline{CS}$	A_1	A_0	**Selected**
0	0	0	Port A
0	0	1	Port B
0	1	0	Port C
0	1	1	Control Register
1	X	X	8255A is not selected.

4.3.b. Control Word:

Figure 5 shows a register called the control Register. The contents of the control register is called the control word, specifying an I/O function for each port. This register can be accessed to write a control word when A_0 and A_1 are at logic 1. At this time, the register is not accessible for a Read operation.

Bit D_7 of the control register specifies either the I/O function or the Bit set/reset function. If bit $D_7 = 1$, bits $D_6 - D_0$ determine I/O functions in various modes. If bit $D_7 = 0$, port C operates in the Bit set/Reset mode. The BSR control word does not affect the functions of the ports A and B.

To communicate with peripherals through the 8255A, the following 3 steps are required:

1. Determine the addresses of port A, B and C of the control register according to the chip select logic and address lines A_0 and A_1.
2. Write a control word in the control register.
3. Write I/O instructions to communicate with peripherals through ports A, B and C.

4.4. LM723C

4.4.a General Description:

The LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents upto 150 mA. but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics are:-

* 150 mA output current without external pass transistor
* Output currents in excess of 10 A possible by adding external transistors.
* Input voltage 40 V maximum
* Output voltage adjustable from 2 V to 37V
* Can be used as either a linear or a switching regulator.

The LM723C is also useful in a wide range of other applications such as shunt regulator, a current regulator or a temperature controller.

4.4.b. Absolute Maximum Ratings

Pulse voltage V^+ to V^- (50 ms)	-	50V
Continuous voltage from V^+ to V^-	-	40V
Input - Output voltage differential	-	40V
Maximum Amplifier Input Voltage (Either input)	-	7.5V
Maximum Amplifier Input Voltage (Differential)	-	0.5V

Current from V_Z	-	25 mA
Current from V_{REF}	-	15 mA
Internal Power Dissipation Metal can	-	800 mW
Cavity DIP	-	900 mW
Molded DIP	-	660 mW
Operating Temperature Range Metal Can	-	-65°C to +150°C
DIP	-	-55°C to +125°C
Lead temperature (soldering, 10 seconds)	-	300°C

4.5 LM741

4.5.a General Description:

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like LM709.

The amplifier, offer many features which make their application nearly foolproof; overload protection on the input and output; no latch-up when the common mode range is exceeded, as well as free from oscillations.

4.5.b. Absolute maximum Ratings:

Supply voltage	-	± 22V
Power Dissipation	-	500 mW
Different Input voltage	-	± 30V
Input voltage	-	±15V
Output short circuit duration	-	Indefinite
Operating temperature Range	-	-55°C to +125°C
Storage temperature Range	-	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	-	300°C
DC amplification	-	200,000
Maximum input bias current	-	500 nA
Maximum input offset current	-	200 nA
Maximum input offset voltage	-	5mV
Temperature coefficient of input offset voltage	-	30 μV/°C
Minimum dc common mode rejection ratio	-	70 dB
Differential input resistance	-	2 MΩ
Minimum supply voltage rejection ratio	-	77 dB
Corner frequencies	-	10 Hz 10 MHz
Slew rate	-	0.5 V/μS

4.6 Hardware Details.

4.6. a. 8085 Processor with Buffered data and Address Buses:-

The Microprocessor used here is 8085. The system uses multiple chips. The 8085 requires buffered data and address lines to be used. Referring to Fig. I, 'U_2' and 'U_3' form the buffering circuit for buffering out the address lines. 'U_4' is used to buffer the data bus. 8085 (U_1) uses multiplexed address and data Bus. So the address and data should be separated before it is used for external connections. Here the lower 8 bits of the multiplexed address and data Bus is used as the data.

The addressing is done by AD_0-AD_7 lines. During addressing, the ALE line will be high. This is the facility made use of by 'u_2'. When ALE is high, the 8 bits of 'u_2' will be buffered out onto the Address Bus lines.

$\overline{\textbf{MEMRD}}$, $\overline{\textbf{MEMWD}}$, $\overline{\textbf{IORD}}$, $\overline{\textbf{IOWR}}$ are also buffered out from the available **IO/$\overline{\textbf{M}}$**, $\overline{\textbf{RD}}$, $\overline{\textbf{WR}}$ lines using 'u_5' and 'u_6'.

4.6. b. Memory Control:-

Reffering Fig. II memory devices used in the circuit are **ROM** and **RAM.**

The **ROM** used here is 2732 'u_8'. The memory capacity of this **ROM** is 4K Bytes. This **ROM** is selected by $\overline{\textbf{CE}}_1$ (control) which has an address capability from 0000 to OFFF.

The **RAM** used here is 6116, 'u_9'. The memory capacity of this **RAM** is 2K Bytes. This **RAM** is selected by $\overline{CE_2}$ which has an address capability 2000 to 27FF.

The inputs to these chips are from address buffer chips u_2 and u_3 and the data is from buffer chip u_4.

4.6. c. Decoder Circuit:-

In the Fig. III the decoder IC 'u_{10}' selects the different types of outputs depending on the addresses given. This is done by using BA_{15}, BA_{14}, BA_{13} and BA_7, BA_6 and BA_5.

The control logic for selection is as shown below:-

BA_{15}	BA_{14}	BA_{13}	
0	0	0	Selects ROM
0	0	1	Selects RAM

BA_7	BA_6	BA_6	
1	0	0	Selects 8255(I)
1	1	0	Selects 8255(II)

4.6 d. 8255 (I) Interface:-

The 8255(I) PPI has 3 ports as explained in previous chapters. Referring Fig. IV PA_0-PA_7 are used as input port for data. Pc_0-Pc_3 will be output and will initiate ADC conversion. After ADC conversion, indication is given back to 8255(I) for input of digital data. This is indicated with the help of Pc_7.

The final output ON/OFF pulses used for sequencing is got from PB_0-PB_3 channels. The controlls for temperature Relay circuit is done by PB_4.

4.6 e. Keyboard and Display:-

Referring Fig. V the keyboard consists of 4 keys to select channels C1, C2, C3 and C4. Once a key is pressed, the 8255(II) PPI reads the corresponding location in the **RAM** and stores the sequence of ON/OFF pulse sequence required, which is got by pressing the ON or OFF key. Once the software has done this and the temperature is to be displayed, it is taken care of by 7448 which displays the appropriate temperature onto the Display.

PIN CONFIGURATION OF ADC 0809

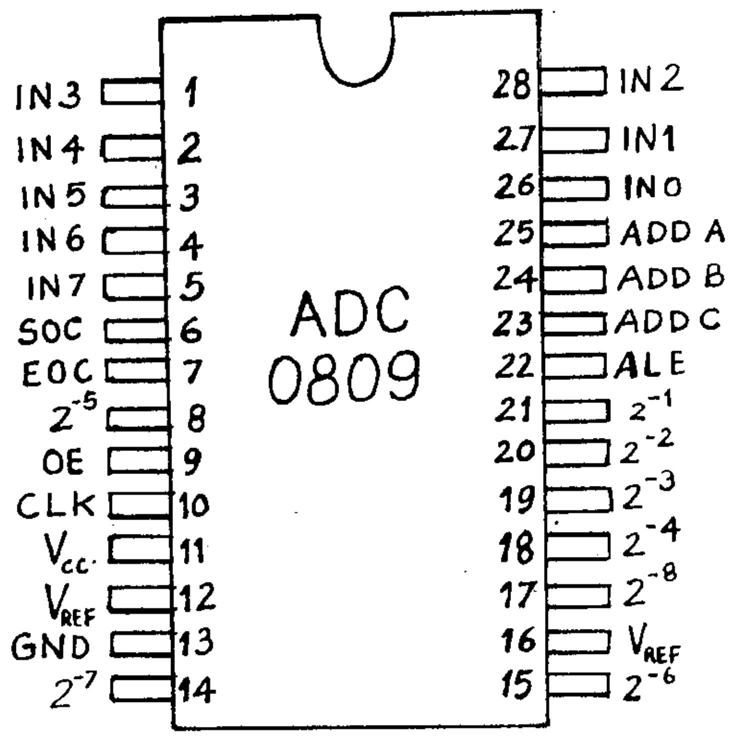


Figure 2

ADC INTERNAL LOGIC

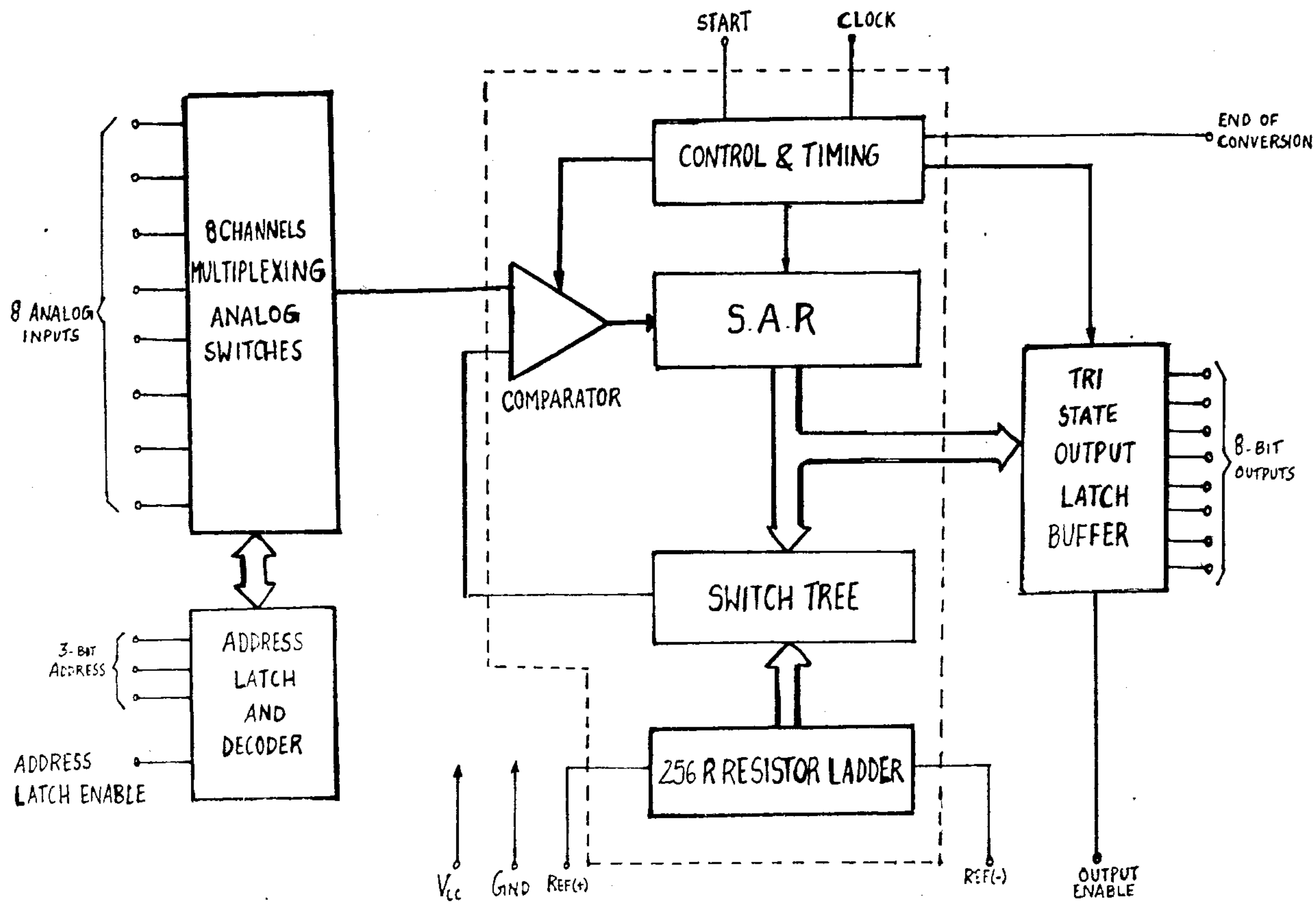


Figure 3.

PIN CONFIGURATION OF 8255A PPI

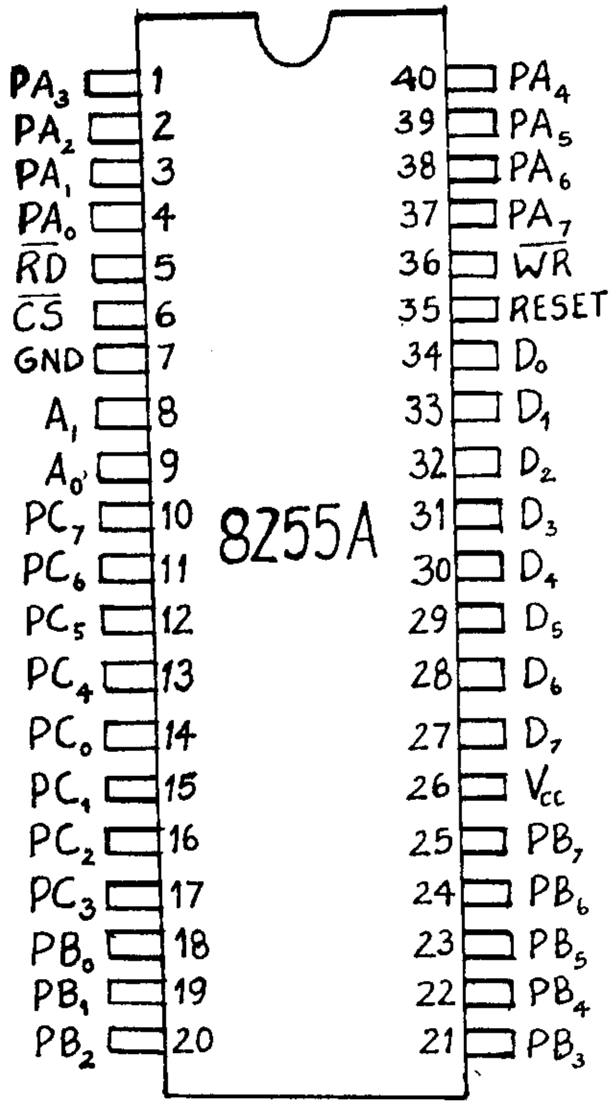


Figure 4

CONTROL LOGIC OF I/O PORTS FOR 8255 A

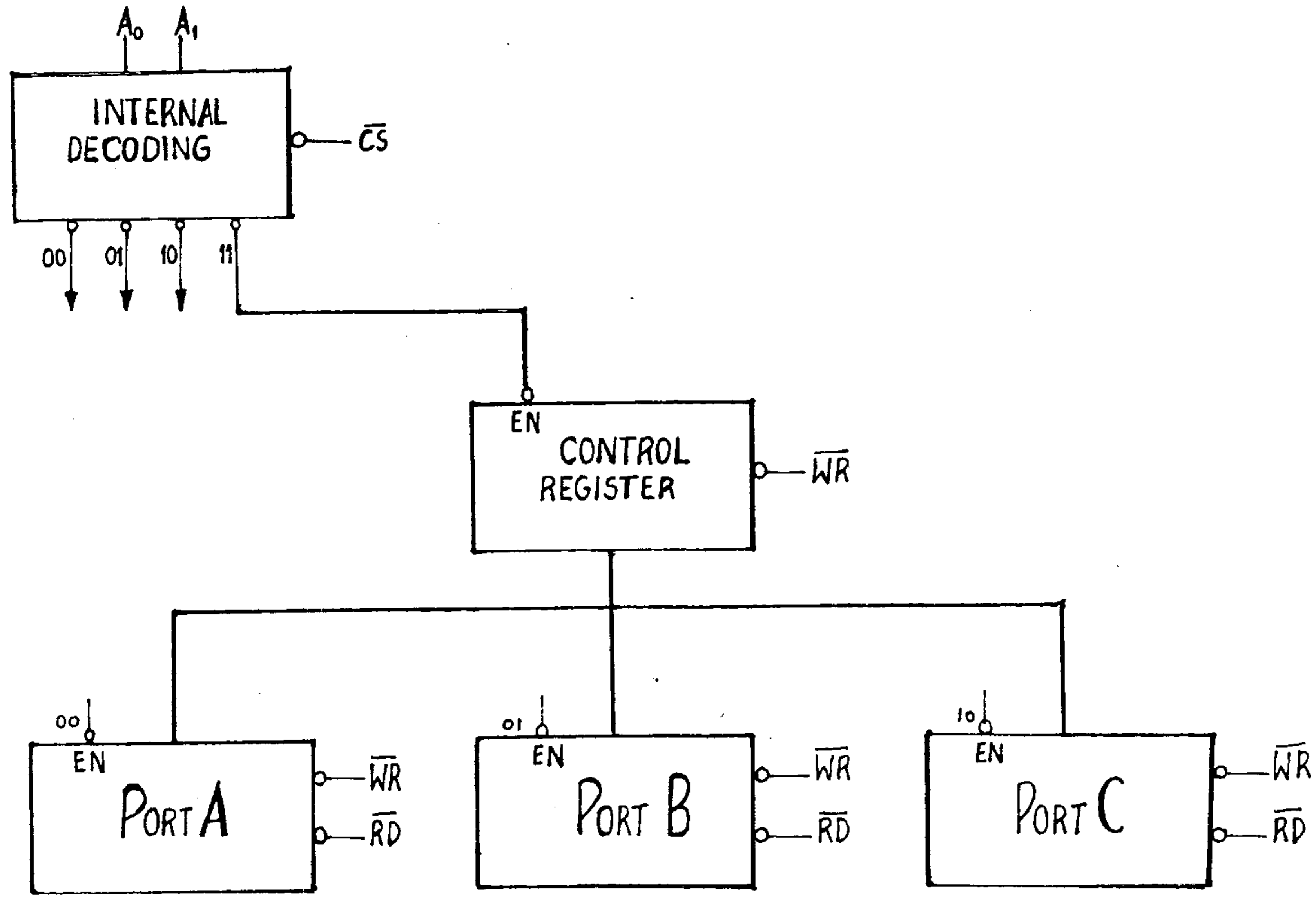


Figure 5.

CHANNEL SELECTION

SELECTED ANALOG CHANNEL	ADDRESS LINE		
	C	B	A
IN 0	L	L	L
IN 1	L	L	H
IN2	L	H	L
IN3	L	H	H
IN4	H	L	L
IN5	H	L	H
IN6	H	H	L
IN7	H	H	H

Table I

PIN CONFIGURATION OF LM 723

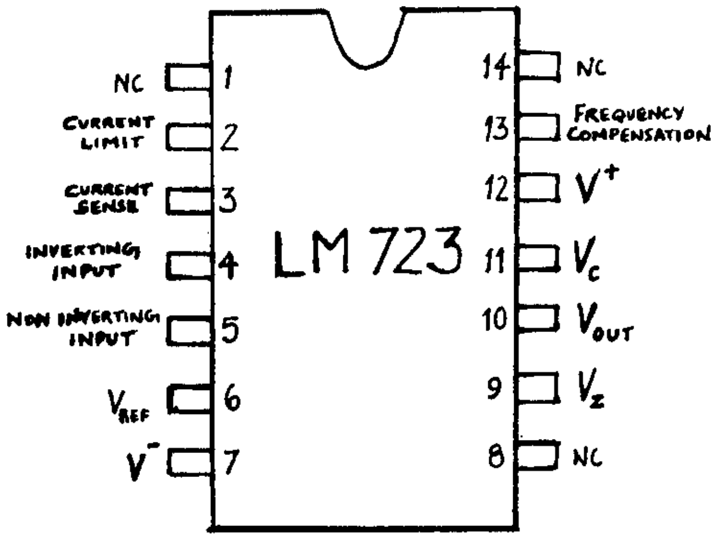


Figure 6

PIN CONFIGURATION OF LM741

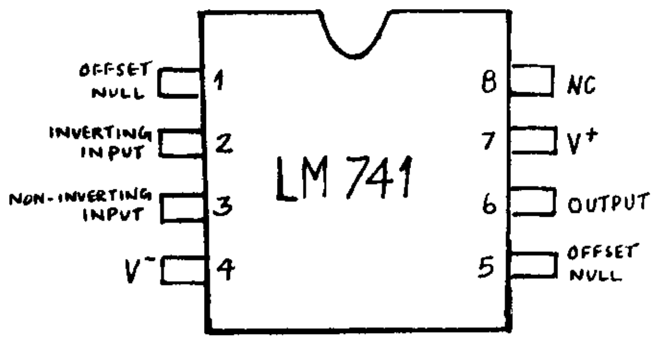
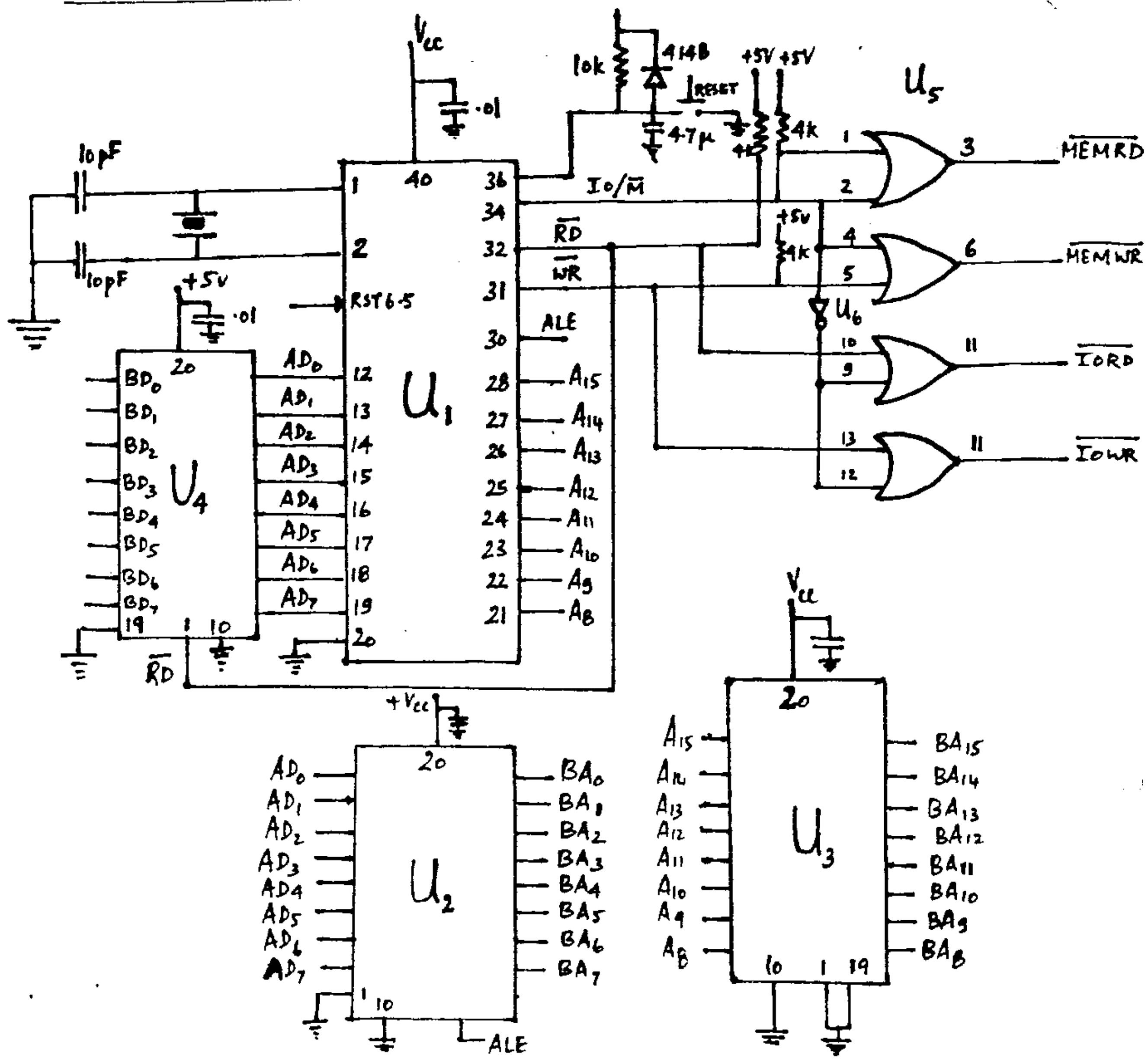


Figure 7

8085 PROCESSOR WITH BUFFERED DATA AND ADDRESS BUSES.



U1 - 8085
U2 - LS 373
U3 - LS 244
U4 - LS 245
U5 - LS 32
U6 - LS06

Fig. I

MEMORY CONTROL

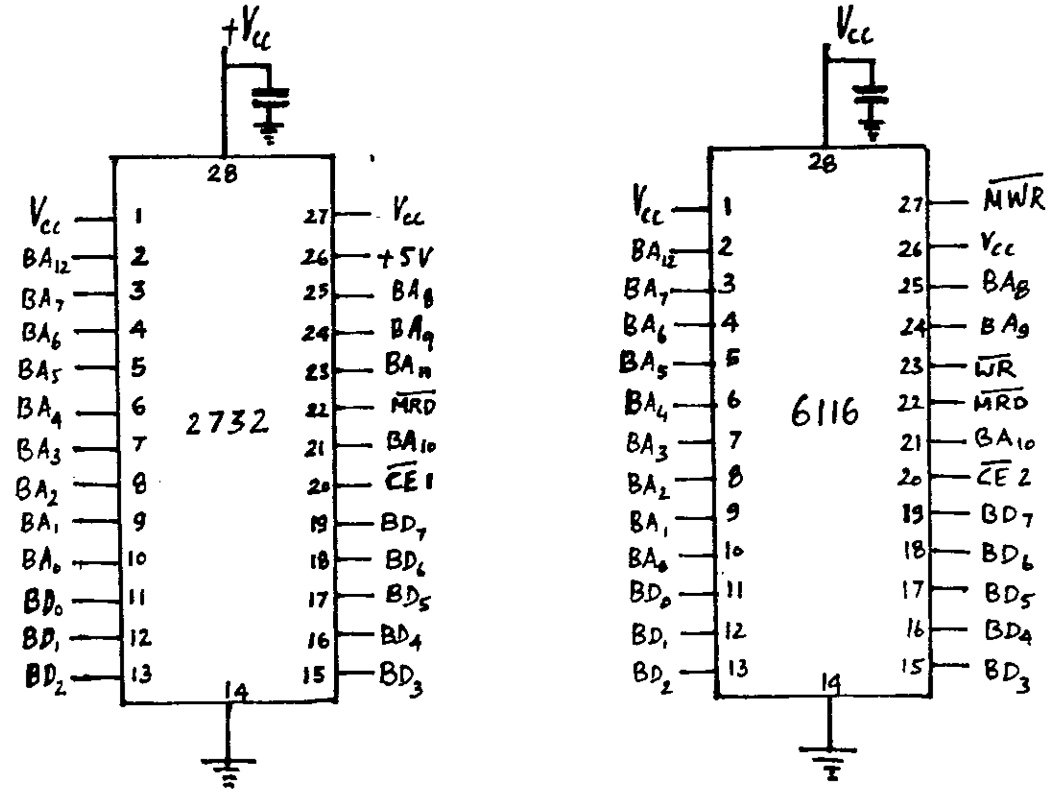
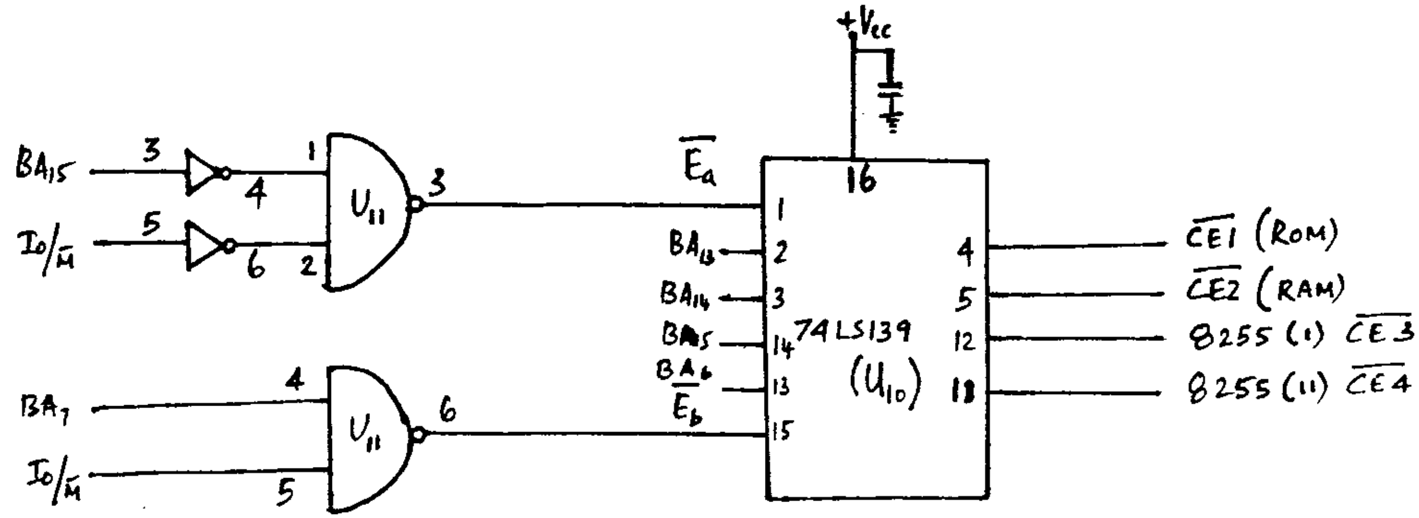


Fig II

DECODER CIRCUIT



U_{10} - 74LS139.
U_{11} - 74LS00.

Fig III

8255(1) INTERFACE

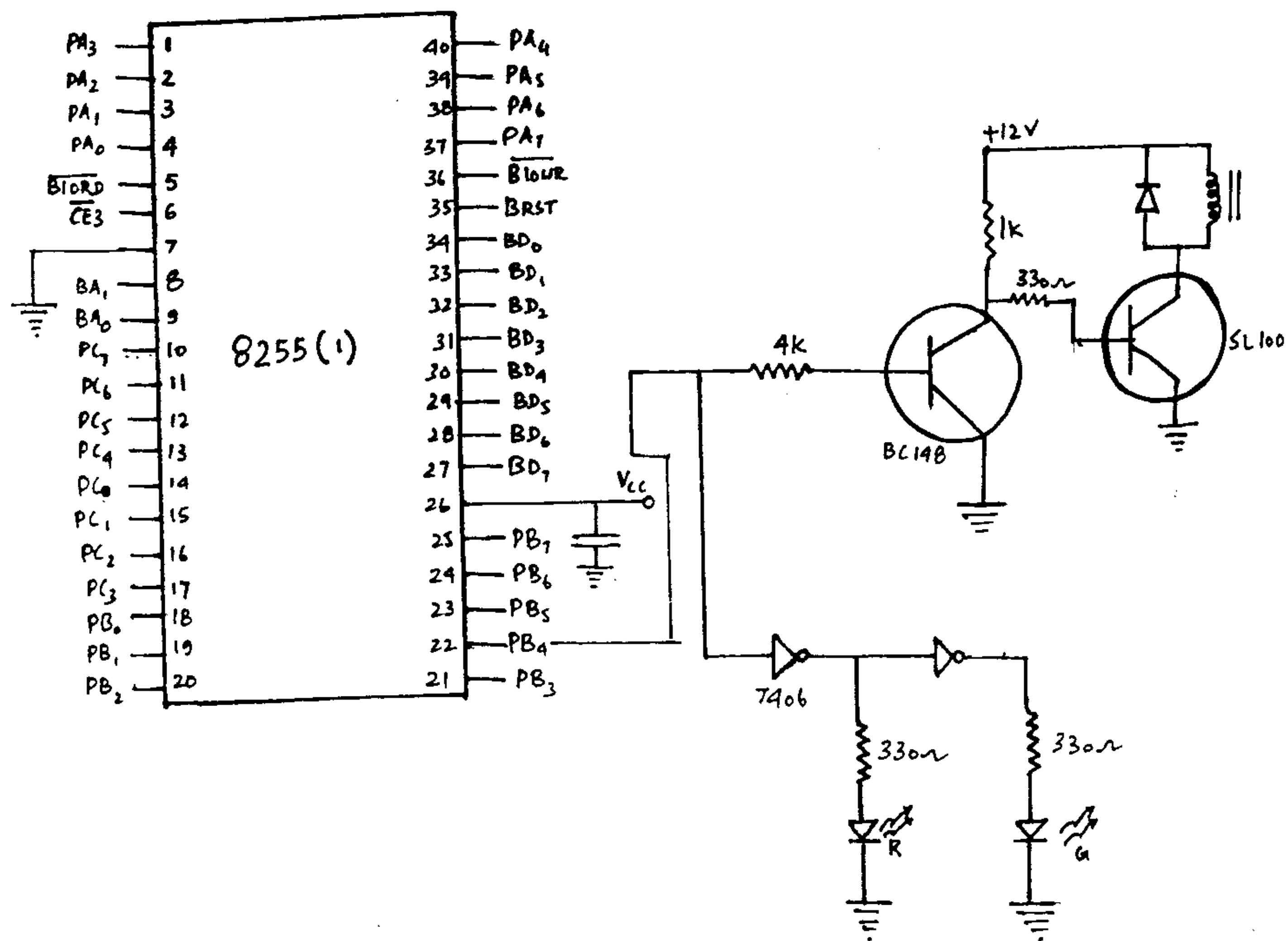


Fig IV

KEYBOARD AND DISPLAY INTERFACE

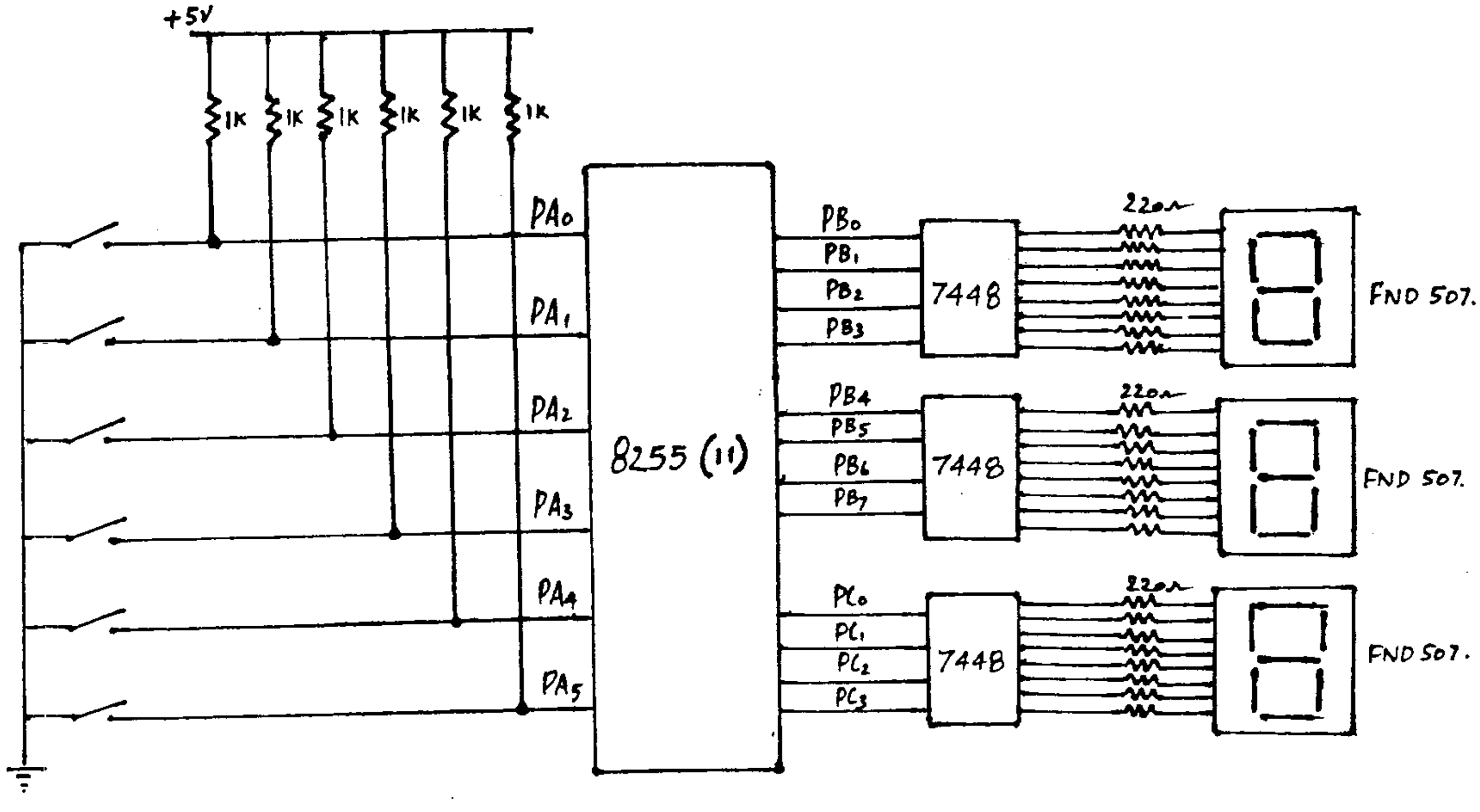


Fig V

Conclusion

CHAPTER - 5

CONCLUSION

The user defined ON/OFF pulse sequences were generated and at the same time temperature monitor and control were done.

This sequential controller can be used for any process control application and the software can be developed for different processes to be looked after at the same time.

The temperature sensor used here has no need for complex linearisation circuits, precision voltage amplifiers, resistance measuring circuits or cold junction compensation.

Within the limitations of 4 channels, the output sequence defined by the user is available. The Microprocessor based sequential controller is used for temperature monitor and control for process control. One channel output is decided by the system on predeterminant conditions fed to the system depending on the actual sensing of the condition. Thus this device can be used as an intelligent instrument in process control application.

The 4 channels that are user defined outputs, can be increased to 16 channels depending on requirements in future which are discussed in the chapter 6. Sensing systems can be increased and may have multiple

Sensings and multiple outputs can be generated for each sensing. Another important aspect that is advantageous to the user. The delay time can be changed for the outputs by changing the count in the delay part of the software.

Thus the aim of the project has been realised.

Future Enhancement

CHAPTER - 6

FUTURE ENHANCEMENT

6.1 Pressure Measurement

6.1.a Introduction

Pressure is an important measurand in science and industry but it cannot be measured directly. Generally a mechanical device provides a displacement in response to a pressure change. This in turn is translated into an electrical signal by means of a displacement transducer. Force is a common effect in the measurement of weight and pressure and certain load weighing techniques carry over into pressure measurements. Pressure is also an important measurand in many industrial applications as it is used to derive fluid flow rates and liquid levels. Pressure changes are usually considered to occur faster than temperature changes but slower than most other variables. Refer figure 8.

6.1.b Basic Concept

Pressure can be defined as 'A fluid at rest has a pressure (P) that can be defined as the force (F) exerted perpendicularly by the fluid on a unit area (A) of any bounding surface:

$$P = F/A$$

Thus by changing force exerted and the are cf exertion, the pressure is varied.

6.1.c. Types of Pressure Transducer:

In all transducers energy from the measured system is converted to energy proportional to the measurand. Conventional pressure transducers achieve this by converting pressure to a mechanical displacement.

There are two main groups of pressure measuring instruments. those that make measurements directly and those that make measurements directly and those that make measurements indirectly. The first group includes manometers and pressure balances. The indirect group is based on elastic elements, which deflect under pressure, such as diaphragms, bellows and tubes. It is this second group, which is coupled to mechanical to electrical converters to provide an electrical output suitable for electronic processing. Mechanical/Electrical converters range from slide wire potentiometers to strain gauges to inductive/capacitive pickups.

The output of the pressure transducer can be given to any one of the channels of the microprocessor. The software can be modified to take care pressure monitoring. Thus pressure can also be incorporated for sequential controlling.

6.2. Flow Measurements

6.2.a Introduction

Flow measurement is mainly concerned with fluids; solid flow being dealt with by weighing and counting techniques.

The flows may be in open or closed ducts except for gas flows, which are always measured in closed ducts resulting in different techniques being applied in each case. Three basic flow measuring situations can occur:

(i) Flow velocity or point velocity in m/s, in association with a sensing area to deduce gross flow volumes in m^3/sec. These systems are called velocity meters.

(ii) gross volume flow rate in m^3/sec, where the whole volume of a fluid flow is measured. These systems are called rate-meters.

(iii) gross mass flow rate in kg/sec, where the weight of the fluid flowing past a point is to be measured. These systems are called quantity meters.

6.2. b. Basic Definitions:

For flow measurement we require density, viscosity and Reynold's number.

$$\text{Density } (\rho) = \frac{\text{Mass}}{\text{Volume}} \quad \text{kg/m}$$

viscosity (μ) is a tangential force between a fixed and a moving horizontal unit plane separated by a unit distance in newton second/sq.m. in Pa s. It should be noted that viscosity increases for gases and decreases for liquids with increasing temperature.

Reynold's number (Re) gives the flow form by a ratio of inertia and viscosity.

$$Re = \frac{\rho}{\mu} Vl \qquad (i)$$

Where 'V' is the flow velocity in m/sec and 'l' is the flow length defined by:

$$\rho = \frac{4 \times \text{Surface area of the flow section}}{\text{Parameter of the flow section}}$$

Hence for a round pipe of diameter D, when l = D, thus equation (i) becomes

$$Re = \frac{\rho}{\mu} VD$$

6.2.c Point Velocity Measurements:

Fluid flows can be obtained by making point measurements of fluid velocity in a sensing volume of finite size. A sensing volume is a section of open or closed duct of sufficient length to ensure stable flow patterns and with a known cross section. Additionally, the velocity needs to be measured at a point where it represents the mean velocity over the cross section. Thus volumetric flow can be calculated. The most common point velocity measuring devices used are pitotic-static probes, hot-wire anemometers and transit time velocimeters.

6.2. d. Pitot-Static Probes

Pressure measurement in moving fluids introduces the additional component of dynamic (or velocity) pressure to add to the existing static pressure. Figure 9 illustrates the relationship for measurements in an open duct (a) and a closed duct (b). In both cases, a tube (A) is inserted transversly into the fluid flow and another tube (B), has a right angle bend to cause it to face the oncoming fluid. This is given by the equation:

$$\text{Total pressure } (P_T) = \text{Static pressure } (P_S) + \text{Dynamic pressure } (P_D)$$

Dynamic pressure has a proportional relationship to the fluid velocity according to Bernoulli's equation:

$$V = \sqrt{\frac{2(P_T - P_S)}{\rho}}$$

Thus velocity of the liquid flow can be calculated or measured. The advantage of pitotic-static tube is that it can be easily inserted into fluid flow. The output of the sensor is a differntial pressure, by using electrical techniques it can convert to an equivalent current output which can be given to any one of the channels of the micropro-cessor. The software can be modified to take care of flow monitoring. Thus flow can also be incorporated in sequential controlling.

BASIC PRINCIPLE OF A PRESSURE TRANSDUCER.

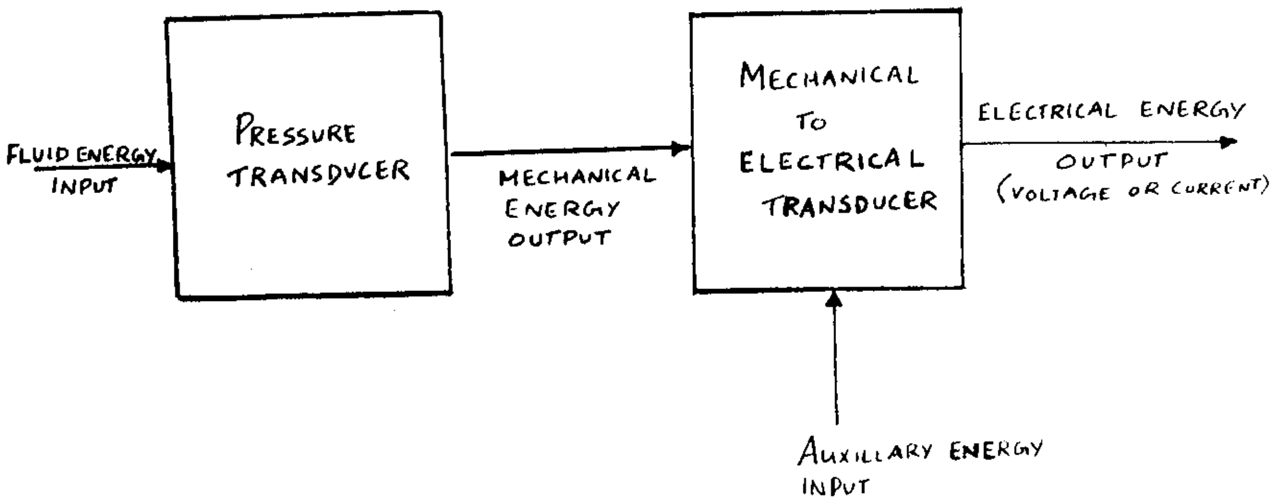


Figure 8

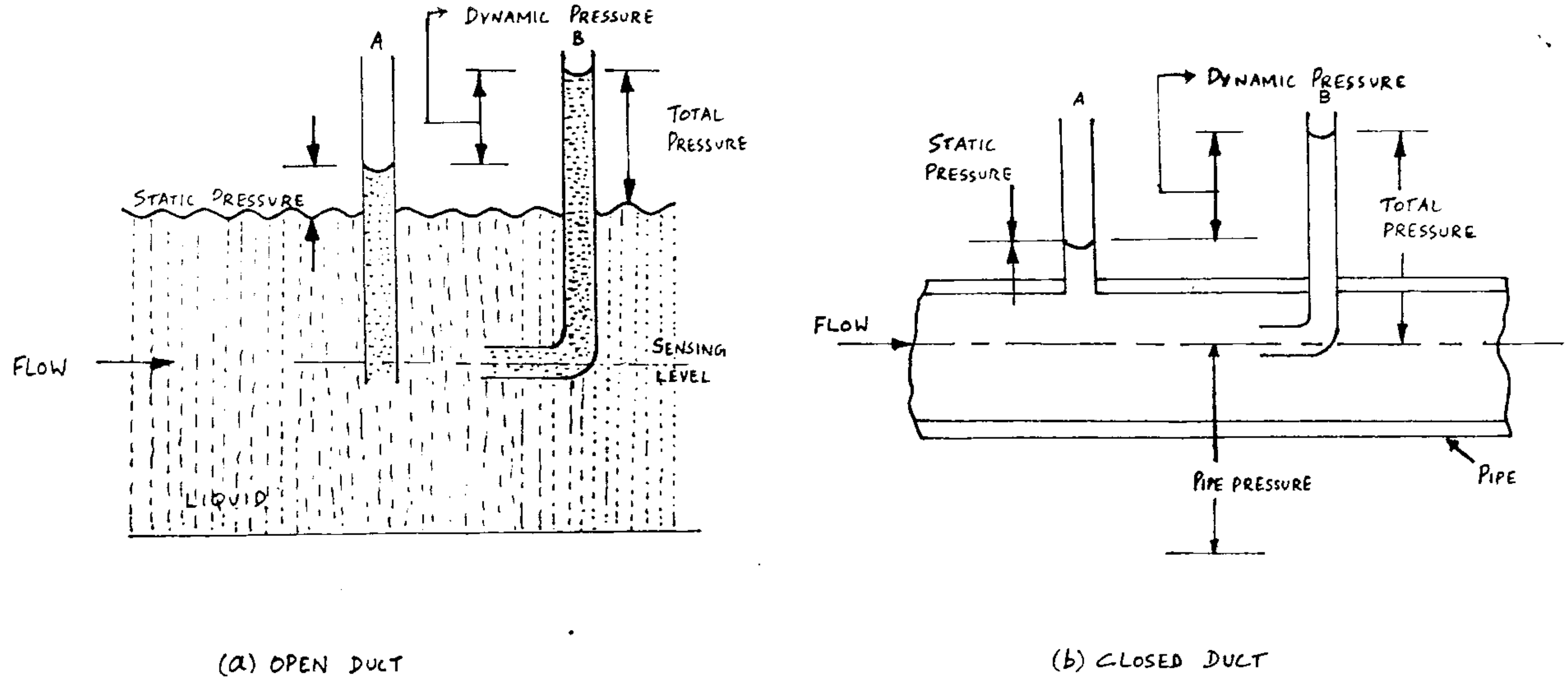


Figure 9 PRESSURE RELATIONSHIPS IN FLUID FLOWS

References

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2. Gaonkar,MICROPROCESSOR ARCHITECTURE, PROGRAMMING, AND APPLICATIONS WITH THE 8085/8080A", Willey Eastern Limited, 1988.

3. Aditya, P.Mathur, "INTRODUCTION TO MICROPROCESSORS", Tata Mcgraw-Hill publishing company limited, second edition, 1988.

4. K.K.Agarwal, "CONTROL SYSTEM ANALYSIS AND DESIGN", Khanna pulishers, First edition, 1981.

5. K.Short, "MICROPROCESSORS AND PROGRAMMED LOGIC".

6. Intel Microprocessor Manual.

7. TTL Manual

Appendix

APPENDIX

Cost Estimation

Items	Quantity	Price (Rs)
1. 8085	1	80
2. 8255	2	400
3. 0809	1	200
4. LM741	2	15
5. Display	7	100
6. 6116	1	80
7. 2732	1	120
8. 7490	1	10
9. LS244	1	20
10. LS373	1	20
11. LS245	1	20
12. LS32	1	10
13. LS06	1	10
14. LS00	1	10
15. Crystal	1	50
16. LM723	1	15
17. Misc.	-	100
	TOTAL	1260