UNIT III

PROGRAMMABLE PERIPHERAL INTERFACE

- ❖Introduction to Programmable Peripheral Interface
- ❖ Architecture of 8255
- ❖Keyboard interfacing
- ❖LED display
- ❖ADC interface
- ❖DAC interface
- ❖Temperature Control
- ❖Stepper Motor Control
- ❖Traffic Control interface

Introduction to Programmable Peripheral Interface

- **A programmable peripheral interface** is a **multiport device**. The ports may be programmed in a variety of ways as required by the programmer. The device is very useful for interfacing peripheral devices.
- The 8255 **PPI** (**Programmable peripheral interface**) is a device through which we can achieve the basic method of communication between humans or machines and the microprocessor.
- Programmable peripheral interface 8255. PPI 8255 is a general purpose programmable I/O device designed to interface the CPU with its outside world such as ADC, DAC, keyboard etc. We can program it according to the given condition. It can be used with almost any microprocessor. It consists of three 8-bit bidirectional I/O ports.

3.1 Features of 8255

1. The 8255 is a widely used, programmable parallel I/O device or parallel communication interface.
2. It can be programmed to transfer data under various conditions, from simple I/O to interrupt I/O.
3. It is flexible, versatile and economical (when multiple I/O ports are required).
4. It has three 8 bit ports port A, Port B and Port C.
5. It is a 40 pin Dip chip.
6. It is completely TTL compatible.
7. All I/O Pins of 8255 has 2.5 mA d.c driving capacity.
8. The 8255 can operate in three I/O modes :

   Mode 0 : Simple input/ output

   Mode 1 : Input/ output with handshake

   Mode 2 : Bi-directional I/O data transfer

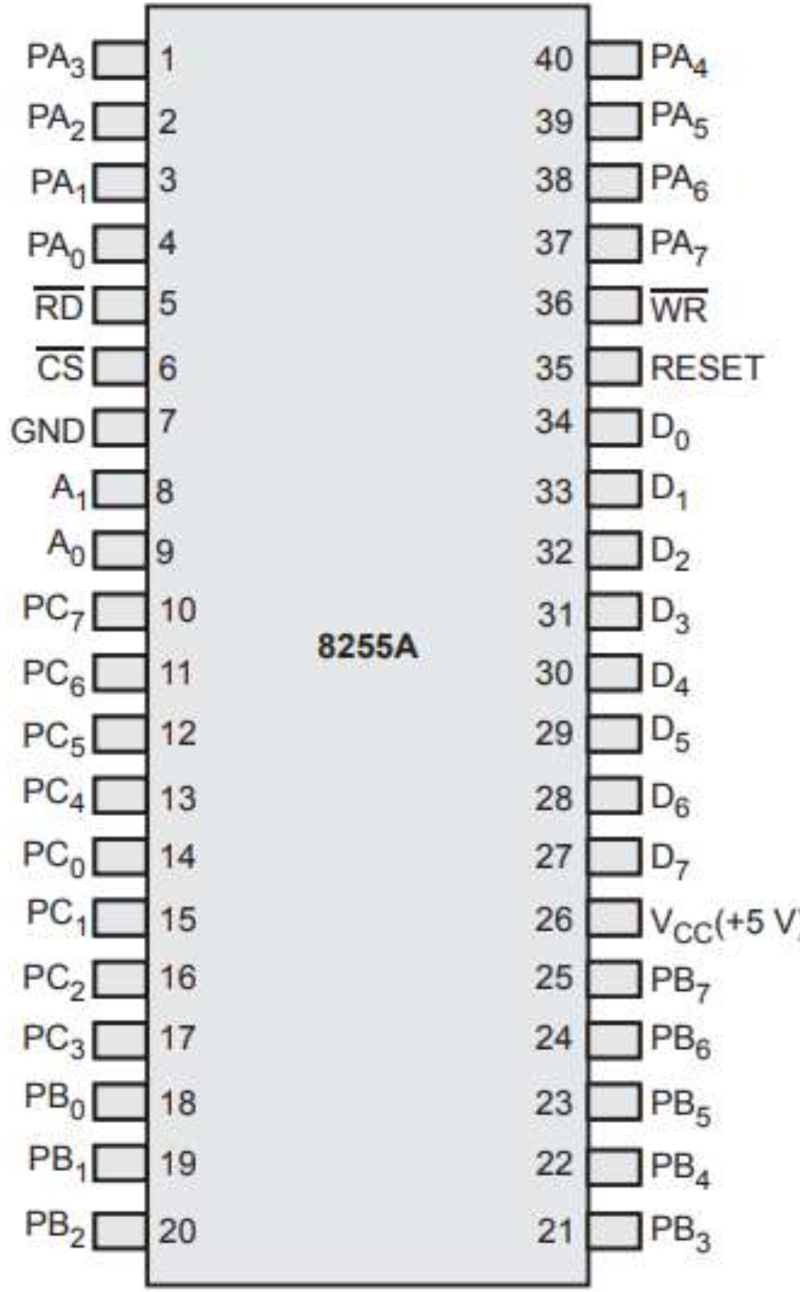


Fig. 3.3.1 Pin diagram of 8255

Architecture of 8255

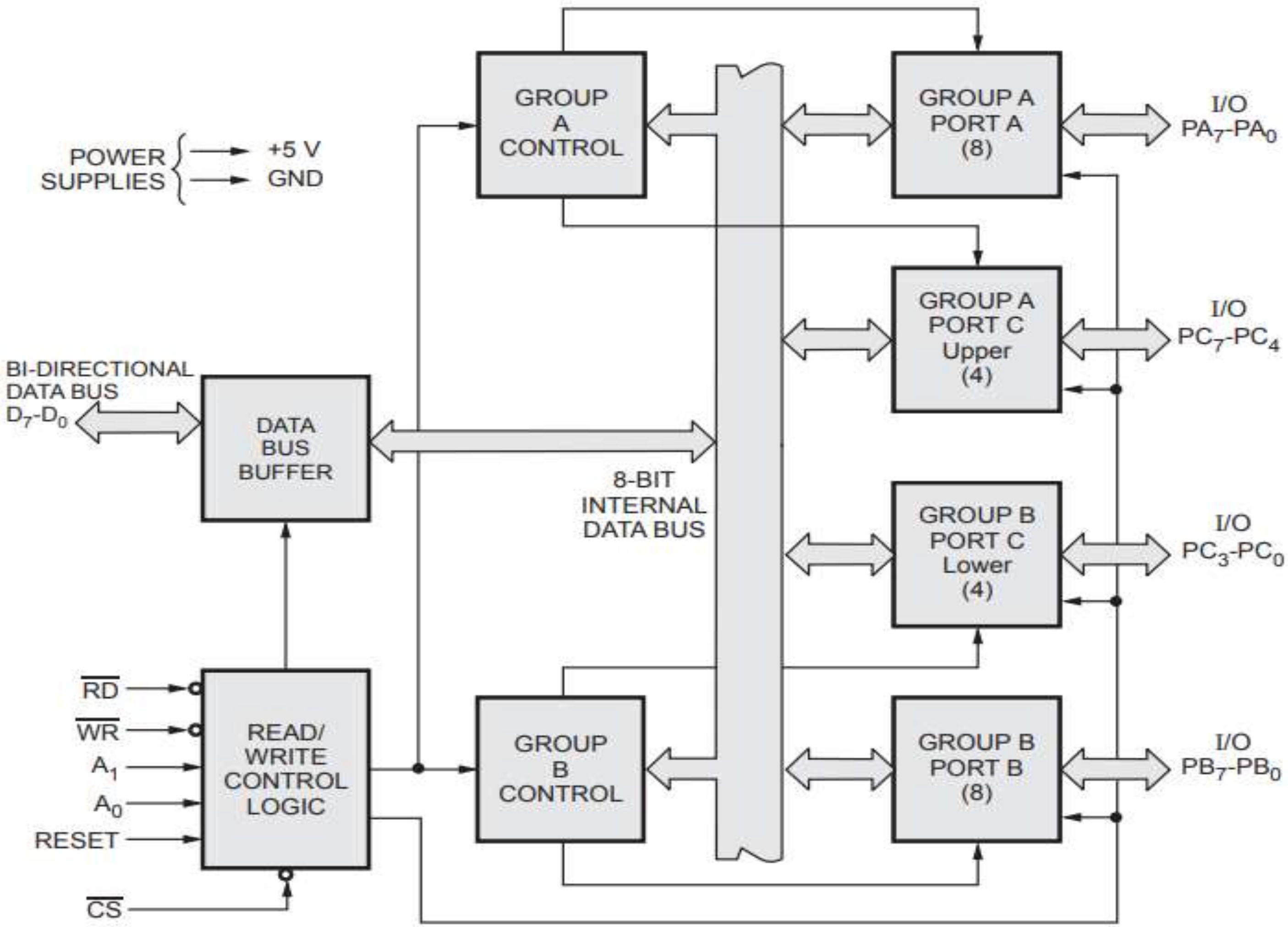


Fig. 3.2.1 Block diagram of the 8255

3.2 Block Diagram of 8255

- Fig. 3.2.1 shows the internal block diagram of 8255A.
  (See Fig. 3.2.1 on next page.)
- It consist of data bus buffer, control logic and Group A and Group B Controls.

1. Data Bus Buffer

- This three-state bi-directional 8-bit buffer is used to interface the 82C55A to the system data bus.
- Data is transmitted or received by the buffer upon execution of input or output instructions by the CPU.
- Control words and status information are also transferred through the data bus buffer.

2. Read/Write and Control Logic

☞ **[AU : Dec. - 2016, 2 Marks]**

- The function of this block is to manage all of the internal and external transfers of both Data and Control or Status words.
- It accepts inputs from the CPU Address and Control busses accepts inputs from the CPU Address and Control busses and in turn, issues commands to both of the Control Groups.

i. (A_0 and A_1) Port Select 0 and Port Select 1 :

- These input signals, in conjunction with the RD and WR inputs, control the selection of one of the three ports or the control word register.
- They are normally connected to the least significant bits of the address bus (A_0 and A_1).

ii. (CS) Chip Select :

- A "low" on this input pin enables the communication between the 82C55A and the CPU.

iii. (RD) Read :

- A "low" on this input pin enables 82C55A to send the data or status information to the CPU on the data bus.

iv. (WR) Write :

- A "low" on this input pin enables the CPU to write data or control words into the 82C55A.

v. (RESET) Reset :

- A "high" on this input initializes the control register to 9Bh and all ports (A, B, C)are set to the input mode.
- "Bus hold" devices internal to the 82C55A will hold the I/O port inputs to a logic "1" state with a maximum hold current of 400 mA.

3. Group A and Group B Controls

- The functional configuration of each port is programmed by the systems software.
- In essence, the CPU "output" a control word to the 8255A.
- The control word contains information such as mode, bit set, bit reset, etc. that initializes the functional configuration of the 8255A.
- Each of the Control blocks (Group A and Group B) accepts commands from the Read/Write Control Logic, receives control words from the internal data bus and issues the proper commands to its associated ports.

  Port A : One 8 bit data output latch/buffer and one 8-bit data input latch.

  Port B : One 8-bit data output latch/buffer and one 8-bit data input buffer.

  Port C : One 8-bit data output latch/buffer and one 8-bit data input buffer (no latch for input). This port can be divided into two 4-bit ports under the mode control. Each 4-bit port contains a 4-bit latch and it can be used for the controls signal outputs and status signal inputs in conjunction with ports A and B.

Keyboard interfacing

3.5 Keyboard Interfacing

- Keyboards are organized in a matrix of rows and columns.
- The CPU accesses both rows and columns through ports.
- Therefore, with two 8-bit ports, an 8 x 8 matrix of keys can be connected to a microprocessor.
- When a key is pressed, a row and a column make a contact.
- Otherwise, there is no connection between rows and columns.
- A 4 x 4 matrix connected to two ports.
- The rows are connected to an output port and the columns are connected to an input port.
- Getting meaningful data from a keyboard requires three major tasks :
  1. Detect a keypress
  2. Debounce the keypress.
  3. Encode the keypress (produce a standard code for the pressed key).
- Logic 0 is read by the microprocessor when the key is pressed.

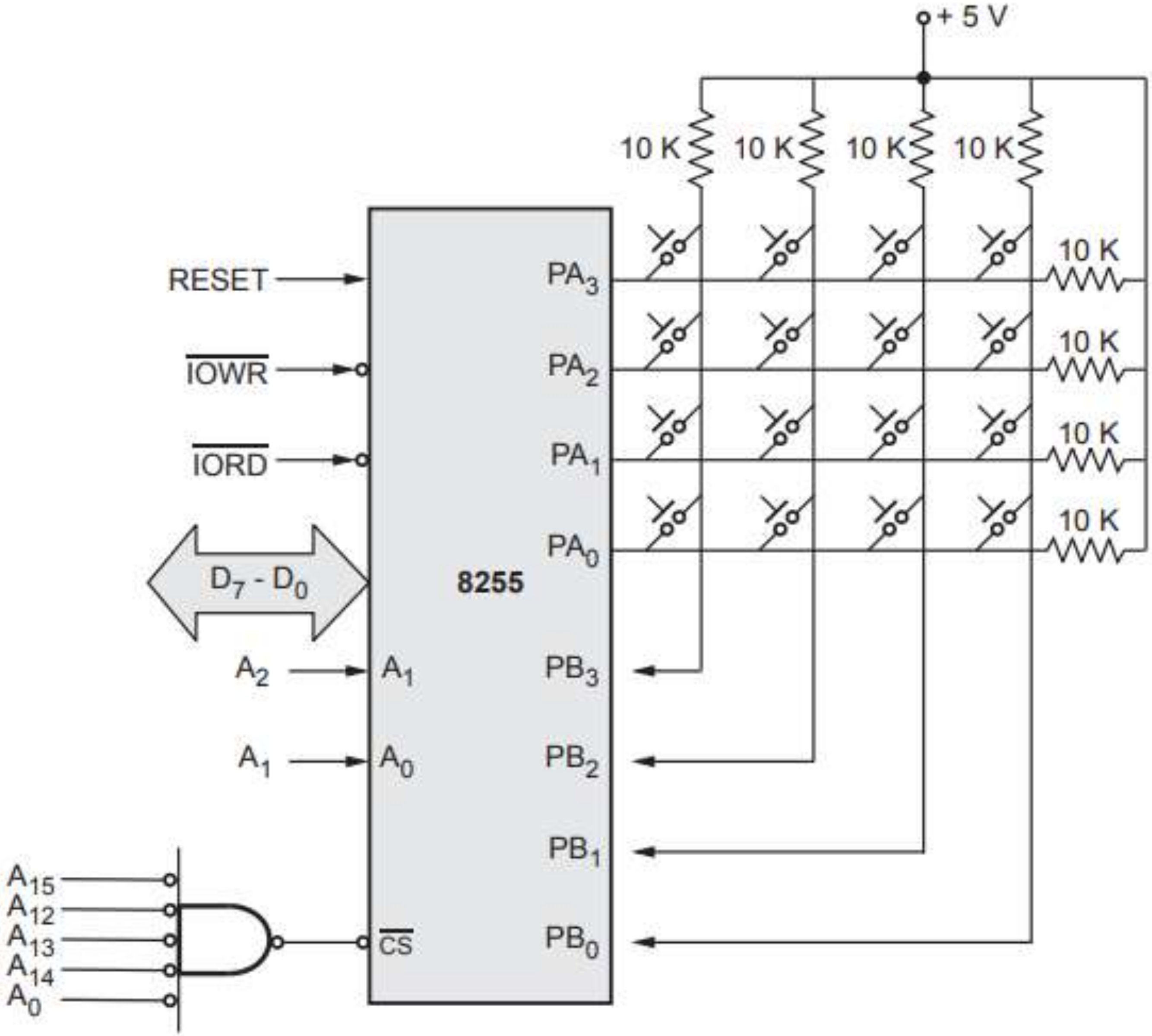


Fig. 3.5.3 Interfacing 4x4 keyboard

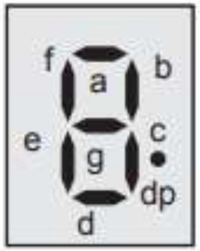
LED display

3.6 Display Interfacing

- The most popular display is the Light Emitting Diode (LED) which is available in a variety of forms : single LED, bi-colour LED, and seven segments LED.
- Another popular display device is the Liquid Crystal Display (LCD) , which is also gaining popularity because of its low power consumption.

3.6.1 Seven Segment LEDs

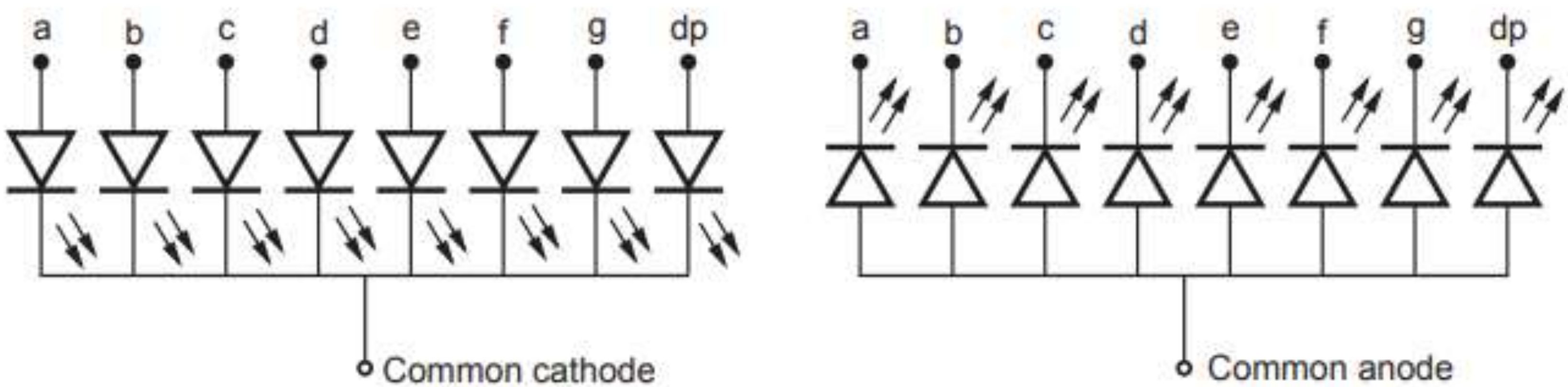
- There are many applications where you have to display numbers.
- The most popular display device used for displaying numbers is seven - segment LED displays.
- Seven Segment displays are used in a number of systems to display the numeric information.
- The seven segments can display one digit at a time.
- Thus the number of segments used depends on the number of digits in the number to be displayed.



(a) Seven-segment LED display module

Fig. 3.6.1

- In each module, seven (eight including the display point) LED segments are fabricated in a pattern as shown in Fig. 3.6.1 (a).
- The seven segments are numbered as a, b, c, d, e, f, g and the decimal point as dp.
- To reduce the number of pin counts, either all the cathodes are connected together inside the module providing common cathode type display as shown in Fig. 3.6.1 (b) or all the anodes are connected together providing common anode type display as shown in Fig. 3.6.1 (c).



(b) Common cathode type seven-segment LED **(c) Common anode type seven-segment LED**

Fig. 3.6.1

- Both the types are commercially available.
- Depending on the type used, interface circuitry has to be made accordingly.
- All hex character from 0 to F can be conveniently displayed using seven segment LED displays as shown in Fig. 3.6.2.
- One disadvantage of LED is that the readability of display becomes poor in bright light.
- To improve readability, the display is covered with an amber coloured plastic sheet.

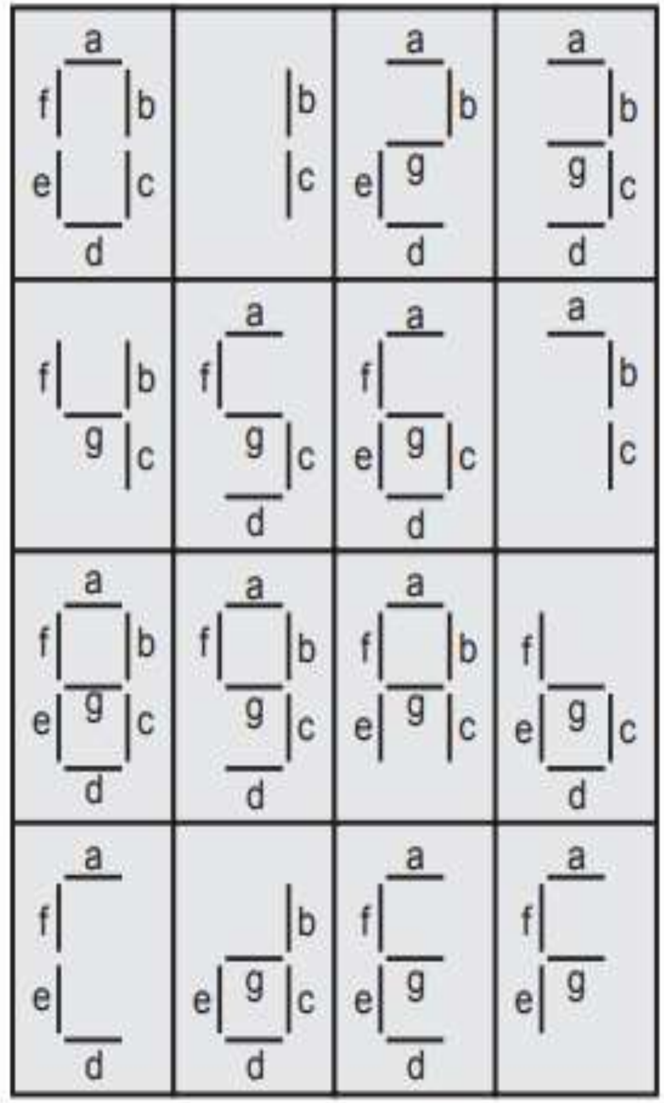


Fig. 3.6.2 Display of hex characters using seven-segment LEDs

3.6.2 Interfacing LED Display

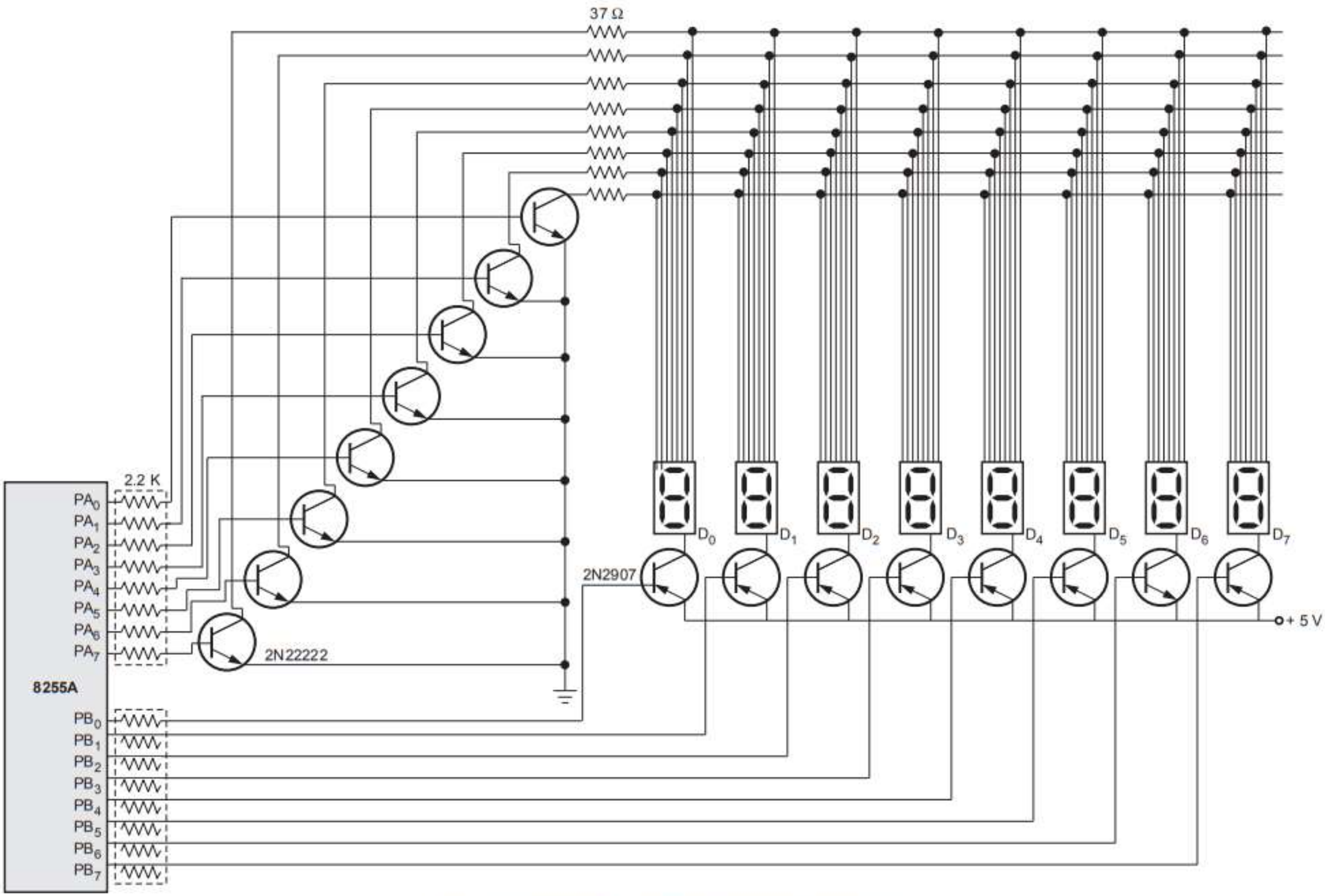


Fig. 3.6.3 Interface of 7 segment display through 8255 A

- Fig. 3.6.3 shows the 8255A connected to set of 8, seven segment LED displays.

- In this circuit ports A and B are programmed as (mode-0) simple latched output ports.

- Port-A provides the segment data inputs to the display and port-B provides a means of selecting a display.

- The resistor in series with the base of the segment switch assumes that the minimum gain of the transistors is 100.

- The base current is, therefore, 80 Ma/100 = 0.8 mA.

3.7.1 Analog to Digital Converter (ADC)

- An Analog to Digital Converter (ADC or A/D or A to D) is a device that converts a continuous physical quantity to a digital number that represents the quantity's amplitude.

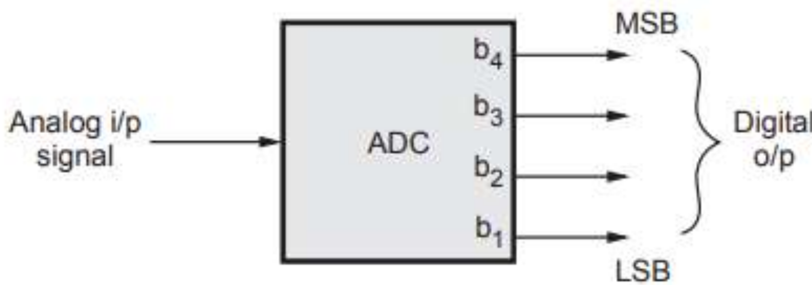


Fig. 3.7.1 Block schematic of ADC

- To convert an analog signal to digital, the time axis has to be divided into a number of equally spaced intervals.
- This process is knows as "Quantisation".
- The input to ADC is the analog signal and output is in digital form.

Types of ADC

Various types of ADCs are

1. Flash type ADC
2. Counter / ramp type ADC
3. Successive approximation type ADC

ADC interface

3.7.5 Interfacing

- Fig. 3.7.5 shows typical interfacing circuit for ADC 0808 with microprocessor system.

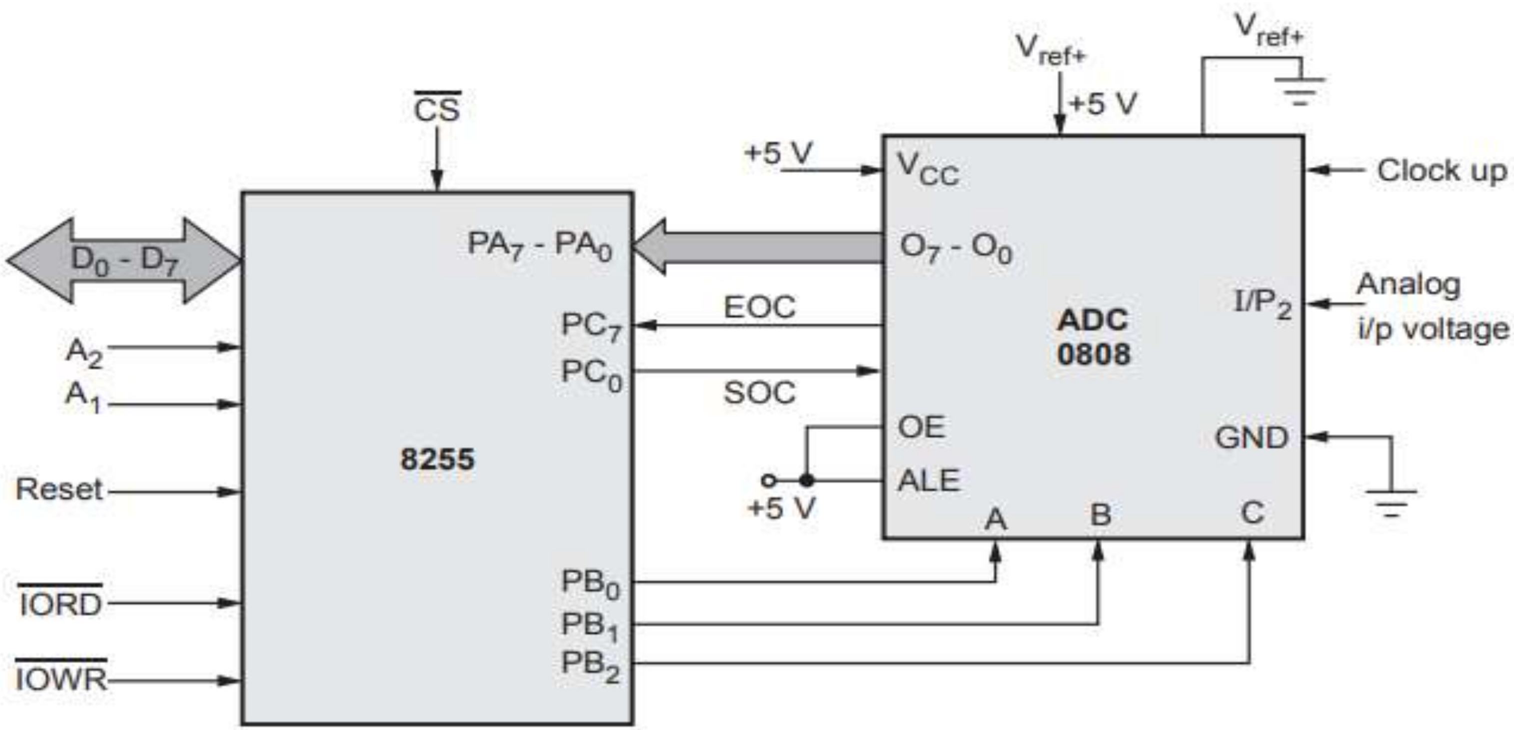


Fig. 3.7.5 Interfacing 0808 with 8086

DAC interface

3.8 DAC

- Digital to analog converter is used to convert digital quantity into analog quantity.
- DAC converter produces an output current of voltage proportional to digital quantity (binary word) applied to its input.
- Today microcomputers are widely used for industrial control.
- The output of the microcomputer is a digital quantity.
- In many applications the digital output of the microcomputer has to be converted into analog quantity which is used for the control of relay, small motor, actuator etc.
- In communication system digital transmission is faster and convenient but the digital signals have to be converted back to analog signals at the receiving terminal.
- DAC converters are also used as a part of the circuitry of several ADC converters.
- The input to a ADC is an n-bit binary signal available in parallel form $(b_1, b_2, b_3 \ldots b_n)$.
- The output can be either voltage or current.
- Fig. 3.8.1 shows inputs and outputs of DAC.

- The output voltage of DAC is given as

$$V_o = K_V V_{ref} \left(b_1 2^{-1} + b_2 2^{-2} + \ldots\ldots\ldots + b_n 2^{-n}\right)$$

where V_{ref} - Reference voltage

K_V - Scaling constant

b_n - '0' or '1' depending on logic level of corresponding input.

V_o - The result of multiplying the analog reference signal by the digital input.

- Full scale range, V_{FS} is given by -

$$V_{FS} = K_V V_{ref}$$

MSB contribution to $V_o = \frac{V_{fs}}{2}$

LSB contribution to $V_o = \frac{V_{fs}}{2^n}$

The LSB contribution is called as **resolution of DAC.**

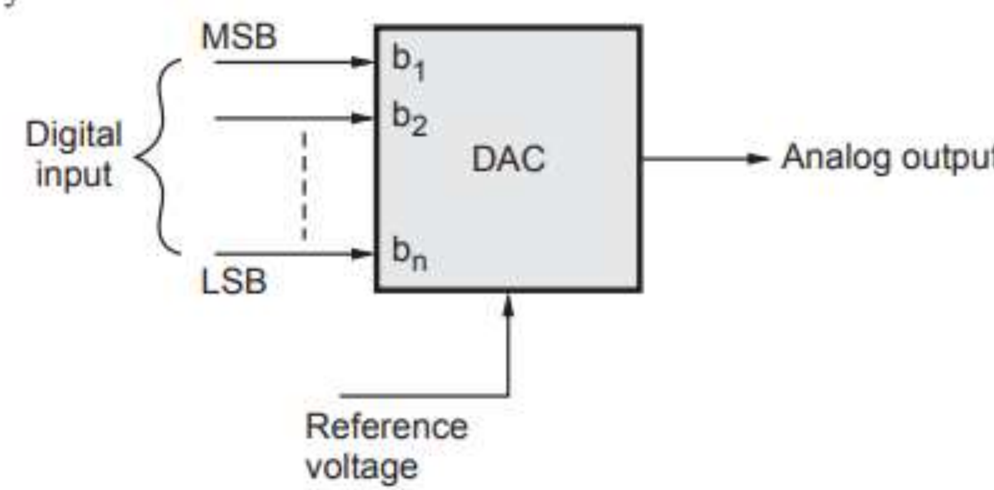


Fig. 3.8.1 Block schematic of DAC

3.8.1 Types of DACs

- There are two main types of DACs
  1. Weighted resistor type DAC
  2. R-2R ladder type DAC.

3.8.2 Weighted Resistor Type DAC

- Fig. 3.8.2 shows a 4-bit weighted-resistor D/A converter which includes a reference voltage source, a set of four electronically controlled switches, a set of four binary-weighted precision resistors, and an op amp.

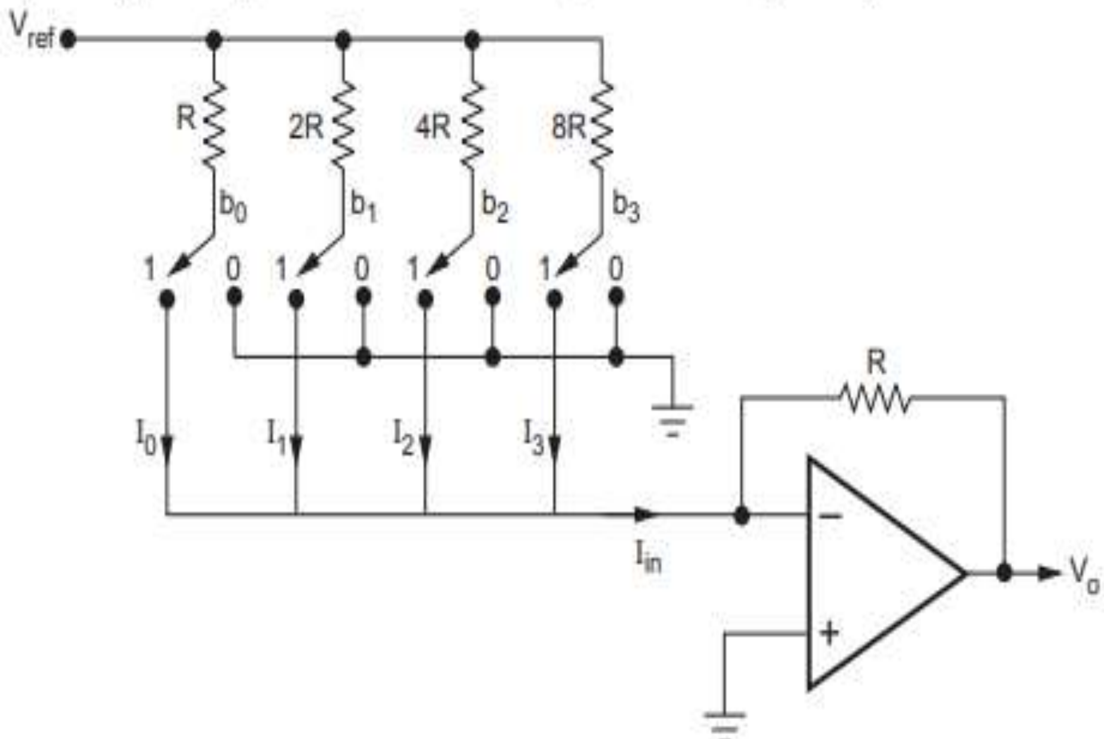


Fig. 3.8.2 4 Bit weighted resistor D/A converter

- Each binary bit of digital input code controls its own switch.
- The switch closes with a bit value of 1, and the switch stays open with binary 0.
- The resistor connected to the most significant bit (MSB), b0, has a value of R; b1 is connected to 2R, b2 to 4R, and b3 to 8R.
- Thus, each low-order bit is connected to a resistor that is higher by a factor of 2. For a 4-bit D/A converter, the binary input range is from 0000 to 1111.
- An important design parameter of a D/A converter is the resolution, which is the smallest output voltage change, V , which for an n-bit D/A converter is given by

$$\Delta V = \frac{V_{ref}}{2^n - 1}$$

- The range of resistor values becomes impractical for binary words longer than 4 bits.
- Also, the dynamic range of the op amp limits the selection of resistance values.
- To overcome these limitations, the R-2R ladder D/A converter is developed.

Advantages :

1. It is Simple in Construction.
2. It provides fast conversion.

Disadvantages :

1. This type requires large range of resistors with necessary high precision for low resistors.
2. Requires low switch resistances in transistors.
3. Can be expensive. Hence resolution is limited to 8-bit size.

3.8.3 R-2R Ladder Type DAC

- The 4-bit R-2R ladder type DAC is the most popular DAC.
- It uses a ladder network containing series-parallel combinations of values R and 2R.
- It is easily scalable to any desired number of bits.
- Its uses only two values of resistors which make for easy and accurate fabrication and integration.
- Output impedance is equal to R, regardless of the number of bits, simplifying filtering and further analog signal processing circuit design.

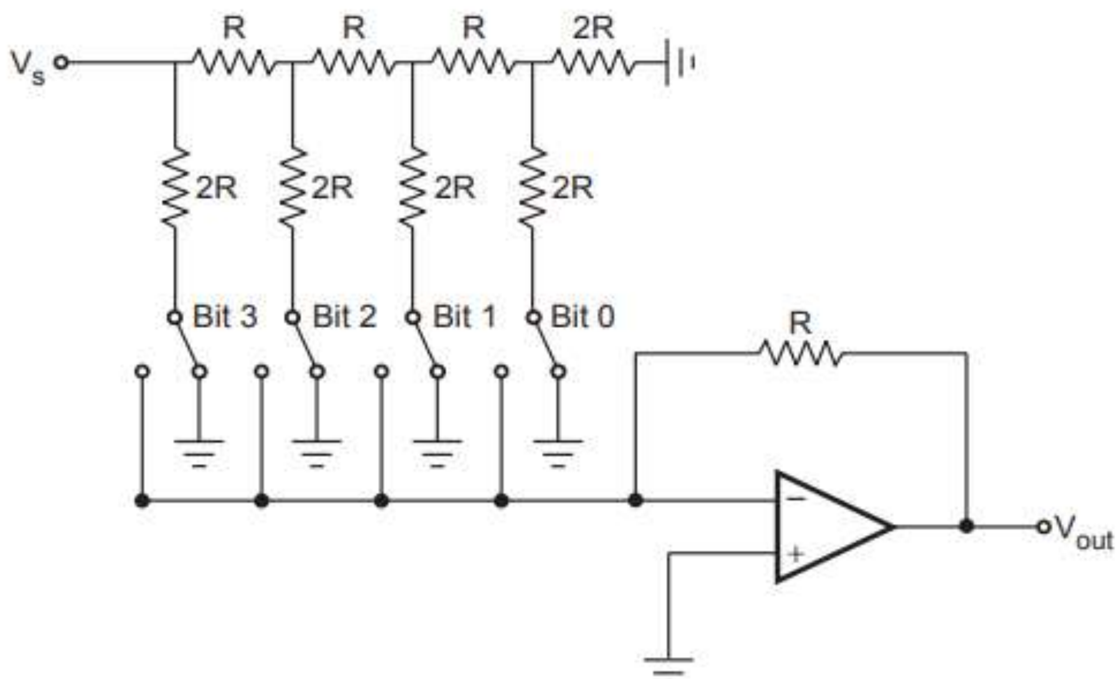


Fig. 3.8.3 (a) 4 bit R-2R Ladder Type DAC

- Each bit corresponds to a switch:

i. If the bit is high, the corresponding switch is connected to the inverting input of the op-amp.

ii. If the bit is low, the corresponding switch is connected to ground.

- Requires only two precision resistance value (R and 2R).

Advantages of R-2R Ladder Type DAC

1. Only two resistor values.
2. Does not need as precision resistors as Binary weighted DACs
3. Cheap & Easy to manufacture
4. Faster response time

Disadvantages of R-2R Ladder Type DAC

1. Slower conversion rate
2. More confusing analysis

3.8.6 Interfacing of DAC0800 with 8086

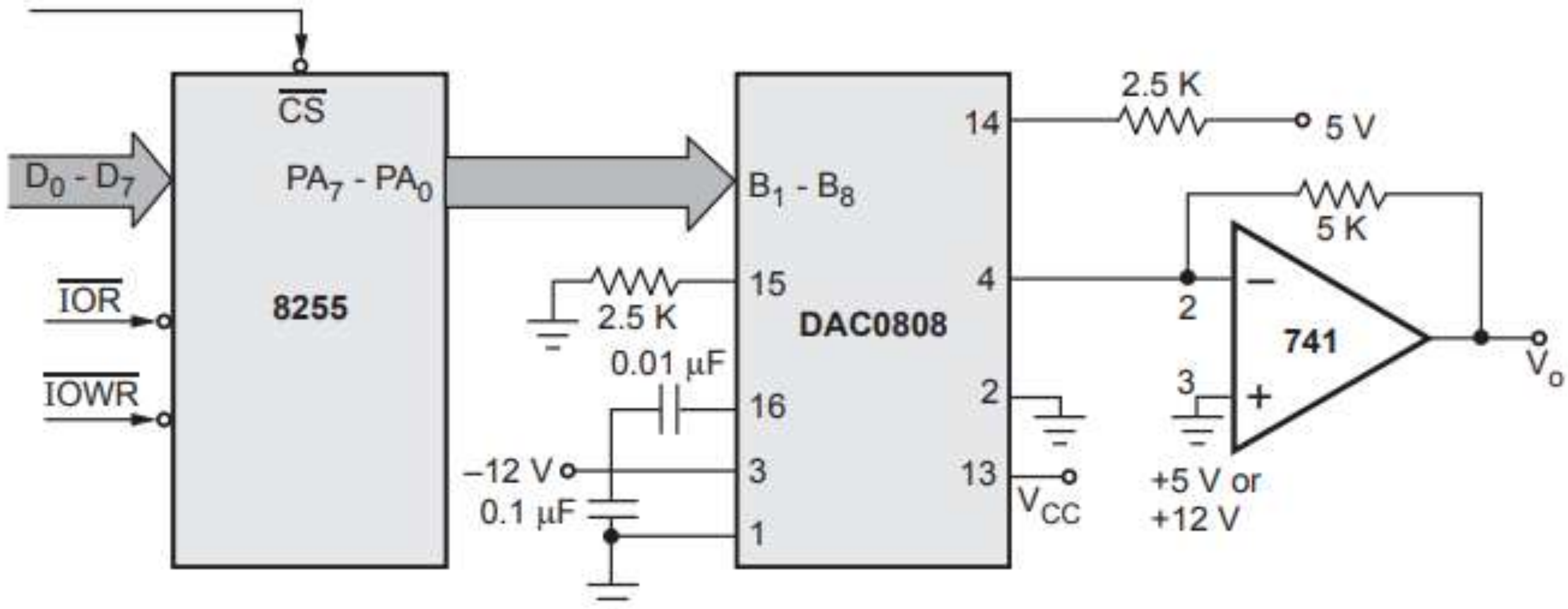


Fig. 3.8.5 Interfacing of DAC0800 with 8086

3.8.6 Interfacing of DAC0800 with 8086

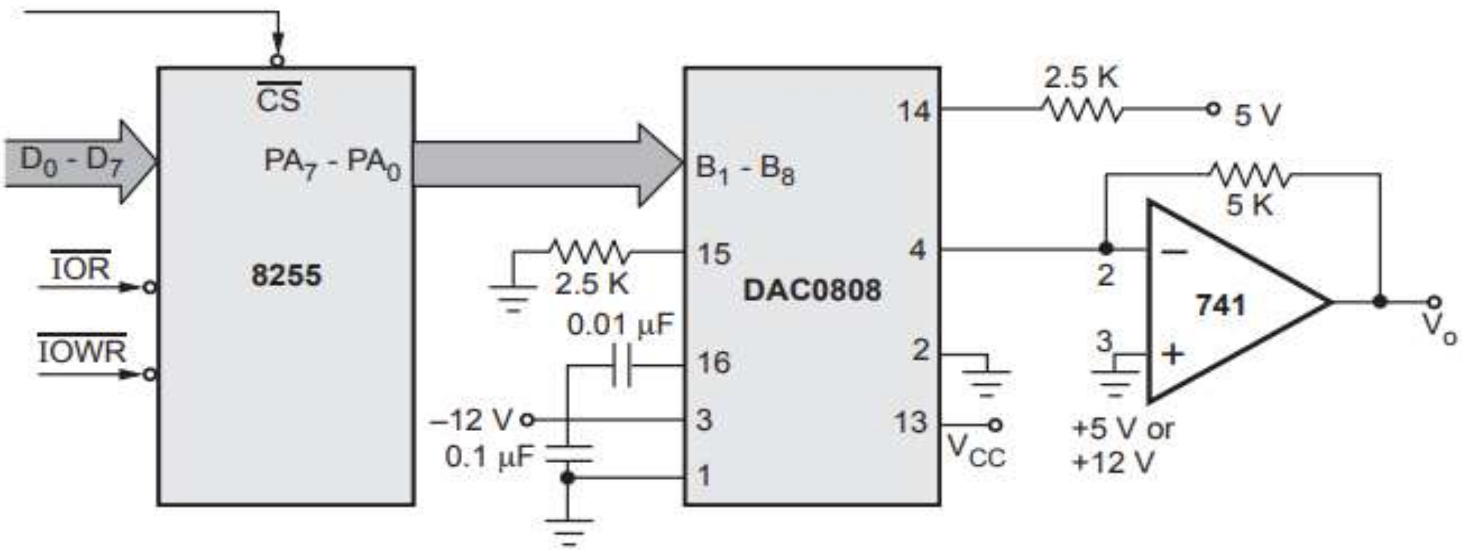


Fig. 3.8.5 Interfacing of DAC0800 with 8086

3.8.4 Features of DAC0800

i. DAC0800 is a monolithic 8-bit DAC manufactured by National semiconductor.

ii. It has settling time around 100 ms

iii. It can operate on a range of power supply voltage i.e. from 4.5 V to +18 V. Usually the supply V+ is 5 V or +12 V. The V- pin can be kept at a minimum of –12 V.

iv. Resolution of the DAC is 39.06 mV

3.9 Temperature Control Interfacing

- Temperature control is a process in which change of temperature of a space (and objects collectively there within) is measured or otherwise detected, and the passage of heat energy into or out of the space is adjusted to achieve a desired average temperature.

  - An Automatic Temperature Control Unit mainly divided into three parts-
    1. Temperature input unit
    2. Processing unit
    3. Control output unit
  - The 8085 based trainer kit forms the basic processing unit.
  - The Analog-to-Digital converter unit and temperature sensor forms the temperature input unit.
  - The switching ON/OFF of the heater / cooler controls the heat supplied to the plant.
  - Basic operation of the temperature control unit.

  Operationally, the system requires two set points.

    i) Upper set point

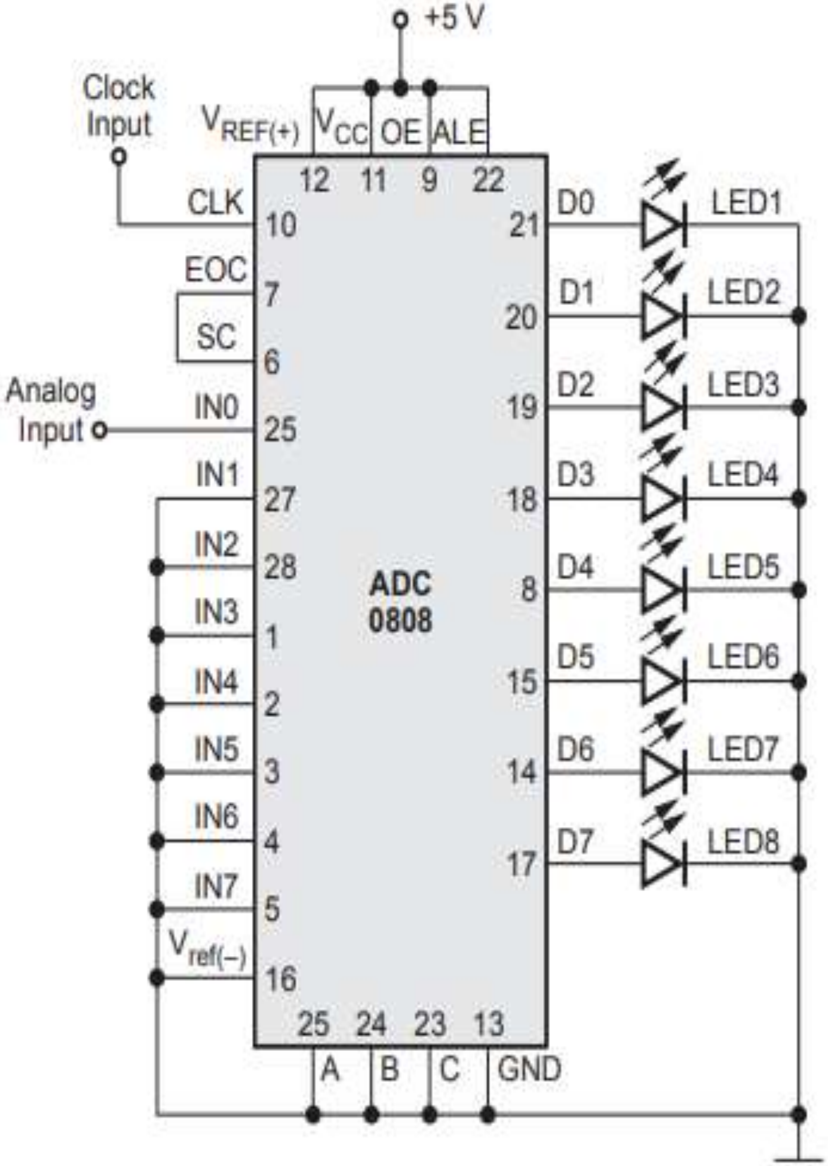
    ii) Lower set point

  - Whenever the temperature of the plant exceeds the upper limit or recede the lower limit heater/cooler is turned-off, so that a temperature is maintained within limits.

- The main hardware consists of automatic temperature control system
  1) 8085 Microprocessor unit
  2) ADC interface board
  3) AD 590 temperature sensor
  4) Amplifier (741 op-Amp)
- The 8085 trainer kit consists of
  1. 8085 MPU IC
  2. 8KB EPROM
  3. 8KB RAM
  4. Keyboard and display controller 8279
  5. Programmable Peripheral interface 8255(PPI)
  6. 21 key hex-keypad
  7. Six numbers of seven segment LED's

The ADC interface board consists of

- ADC 0808, which is an 8-bit converter with eight channels of input.
- Interfaced with the 8085 through 50-pin bus expansion connector.



- Programming logic :
  - Configure 8255 I/O ports
  - 8085 sends SOC command to ADC
  - 8085 waits for EOC signal from ADC
  - 8085 reads 8-bit temperature value from port A
  - 8085 compares the value with set point value
  - 8085 generates the control signal to control load

Different types of temperature sensors

1. Thermistor
2. Thermocouples
3. Solid state temperature sensor
4. I.C. Temperature sensor (LM134-3)

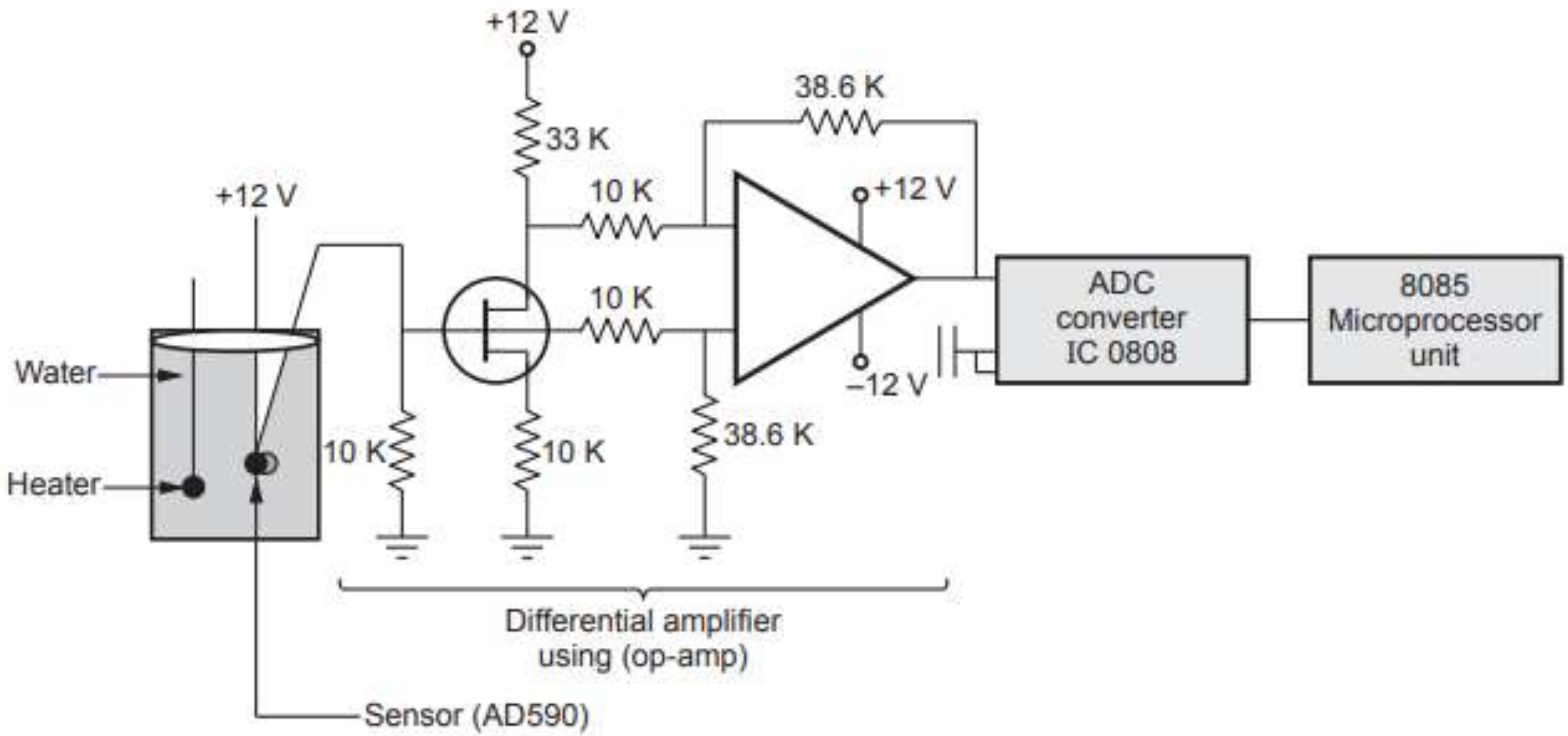
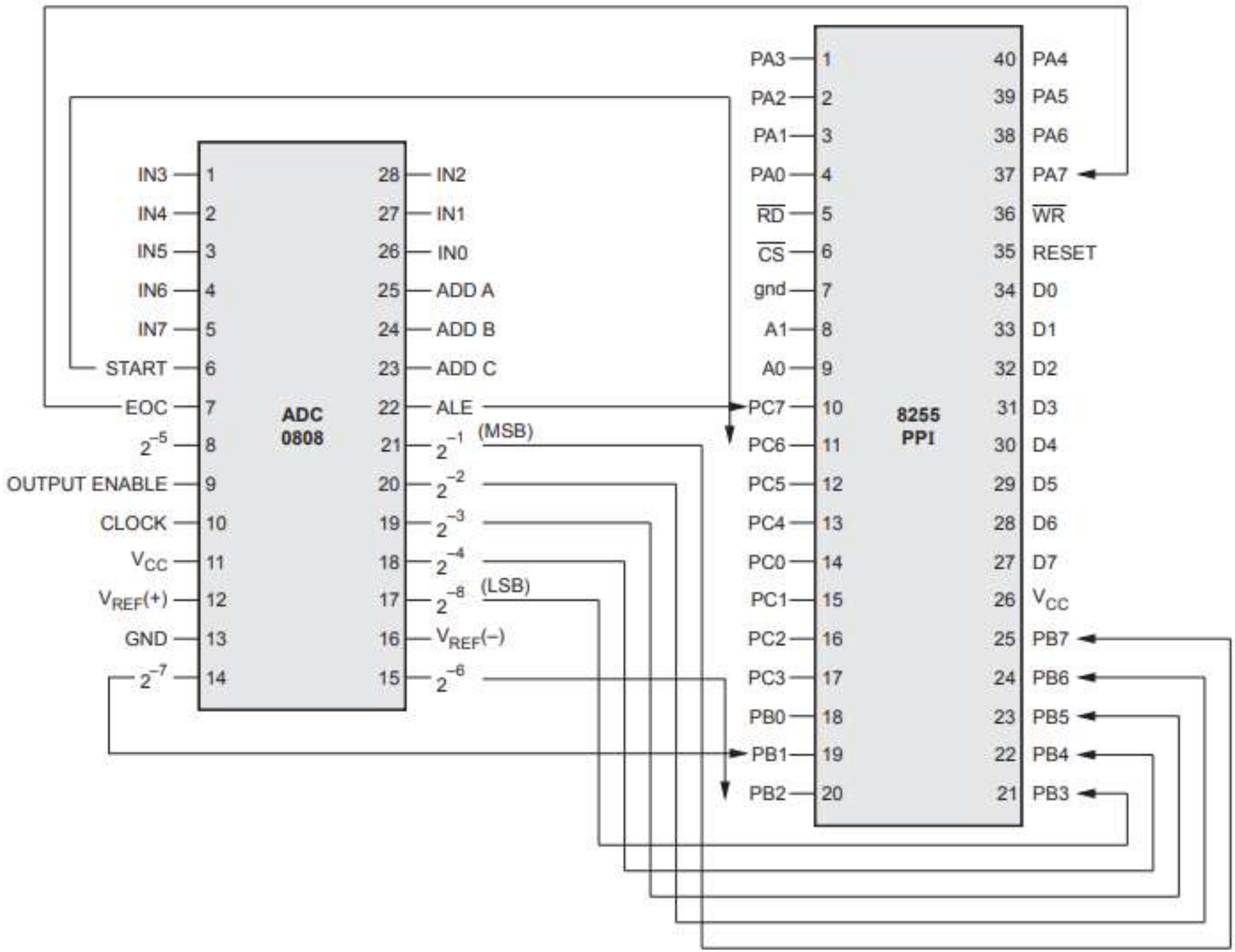


Fig. 3.9.2 Entire circuit diagram of control unit

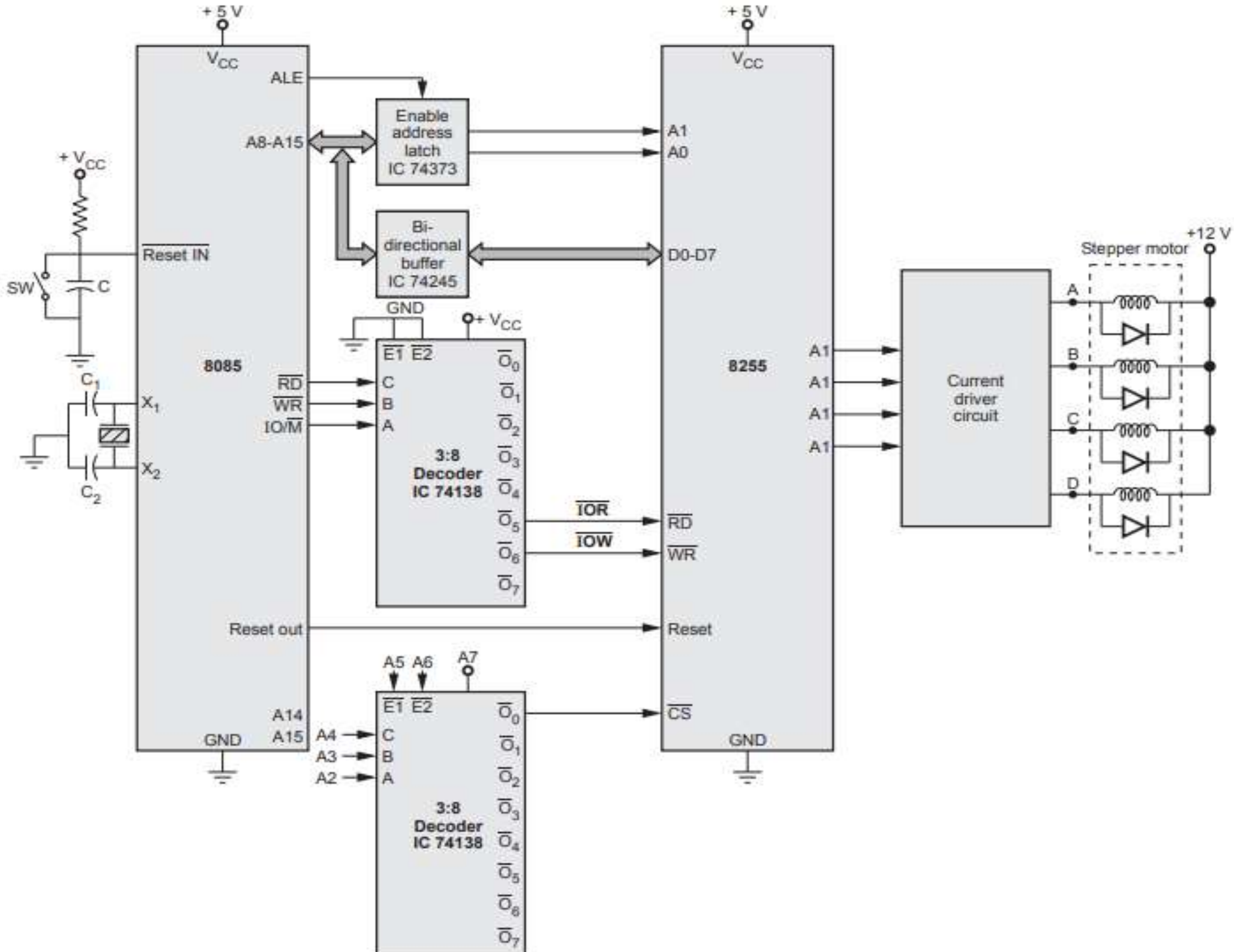


3.9.3 ADC interfacing with microprocessor

3.10 Stepper Motor Interfacing

- Stepper motor is an electromechanical device that rotates through fixed angular steps when digital inputs are applied.
- It is suitable for precise position, speed and direction control which are required in automation system.
- The angle through which stepper motor rotates with a fixed angle for each digital data is called step angle.
- Different stepper motor has different step angle. The more frequently used stepper motor has step angle of 0.9 degrees and 1.8 degrees.
- Depending on the sequence applied to stepper motor, it can be classified in two category :
  1. 4- Step sequence or full step sequence
  2. 8- Step sequence or half step sequence

Interfacing diagram of Stepper motor with 8085 :



3.11 Traffic Control Interface

- Nowadays microprocessors are used to implement the traffic control system.
- Fig. 3.11.1 shows the simple model of microprocessor based traffic control system.
- The various control signals such as red, green, orange, forward arrow, right arrow and left arrow are used in this scheme.
- The forward, right and left arrows are used to indicate forward, right and left movement respectively.
- The red(R) signal is used to stop the traffic in the required lane and the yellow(Y) signal is used as standby, which indicates that the traffic must wait for the next signal.

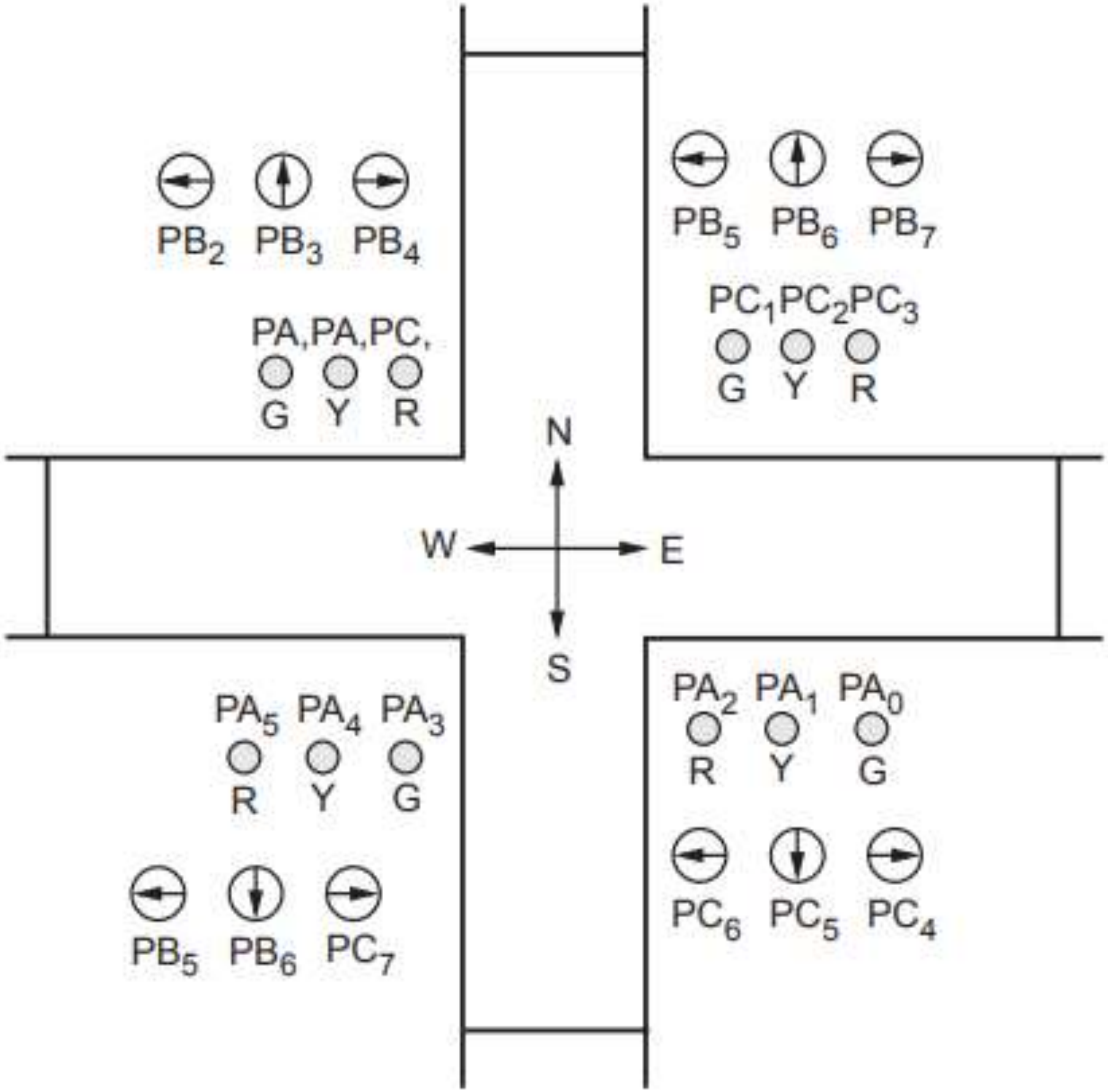


Fig. 3.11.1 Traffic light control

- The green (G) light for a particular lane remains ON for DELAY-1 seconds followed by the standby signal for DELAY-2 seconds.
- However, at a time for 3 out of the four roads, the left signal or the left arrow remains on even though that lane may have a red signal.
- The traffic light control is implemented using the 8085 microprocessor kit having 8255 on board and the interfacing circuit is illustrated in Fig. 3.11.2.
- Each signal is controlled by a separate pin of I/O ports.
- The total number of logic signals required for this arrangement is twenty-four.
- The programmable peripheral interface device 8255 is used to interface these 24 logic signals with the lamps.
- The logic '0' and '1' represents the state of the lamp.
- Logic '1' represents ON and '0' represents OFF.
- All ports of 8255 are used as output ports.
- The control word to make all ports as output ports for Mode 0 operation is 80H.

- The traffic light control program can be written by the following steps :

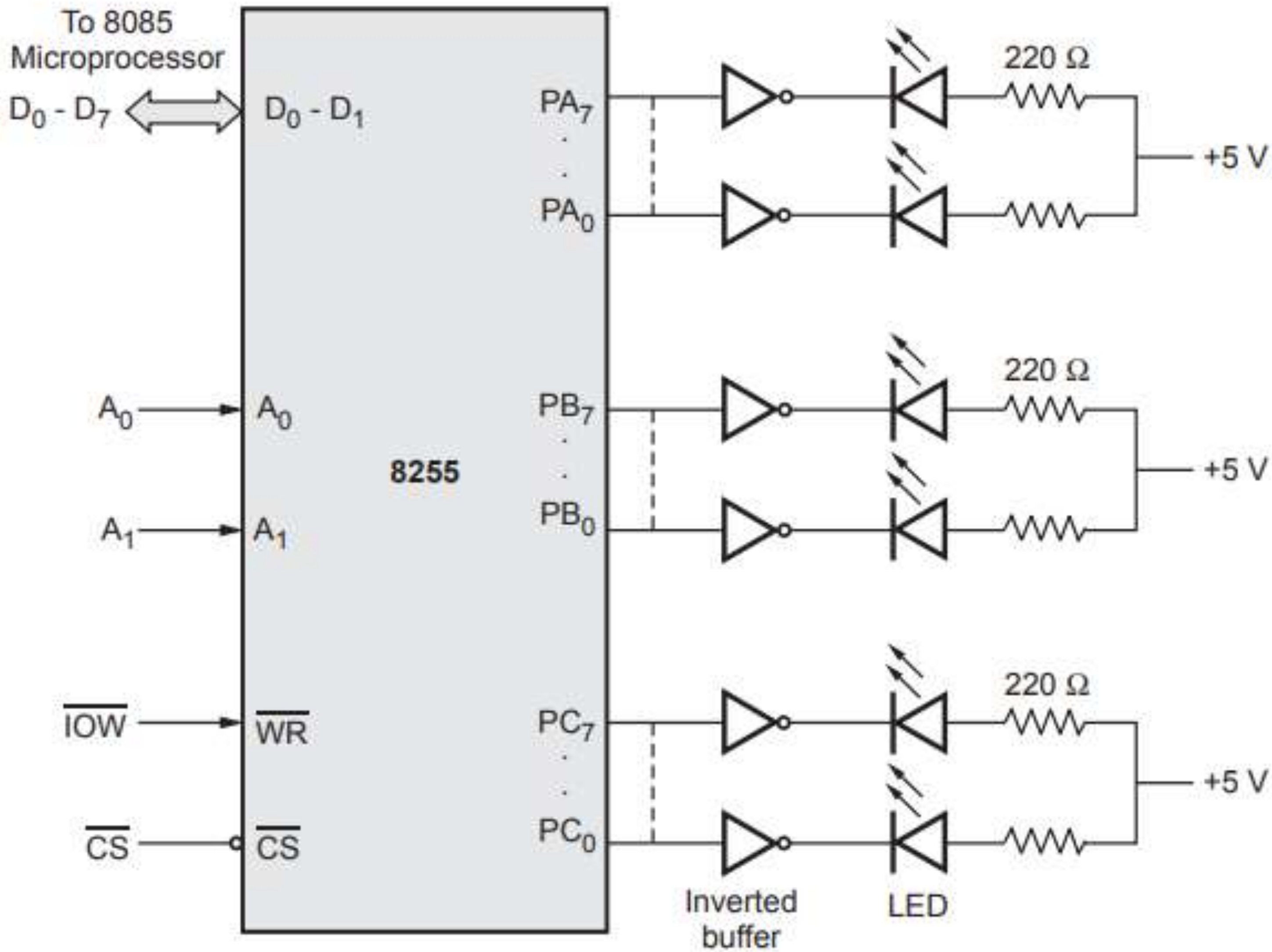


Fig. 3.11.2 The interfacing circuit for traffic tight control