CHAPTER

13

MICROPROCESSOR APPLICATIONS

In this chapter.....

13.1 INTRODUCTION

The microprocessor is a programmable integrated device that has computing and decision making capabilities. The word 'programmable' specifies that the microprocessor can be instructed to perform different operations according to the given application. Any microprocessor based system or application has three basic components as follows :

(i) Micropocessor

(ii) Memory

(iii) Input/output devices.

The keyboard and display devices are examples of input and output devices respectively. These two are main components of microprocessor based system.

13.2 DISPLAY INTERFACING

Display devices are used by the microprocessor based systems to provide the information from microprocessor to external world. Most of the microprocessor-based applications display the letters of alphabets and numbers to the users. This information can be displayed using different display devices libe CRT, LED, LCD etc. CRT display is used to display a large amount of information. For small amount of data display, LED and LCD can be used.

13.2.1 LED Displays

LED (Light Emitting Diode) displays are commonly available in 7-segment format. A seven segment display, as its name indicates, is composed of seven elements. This type of displays are generally used as numerical indicators and consists of seven LEDs as shown in fig. 13.1

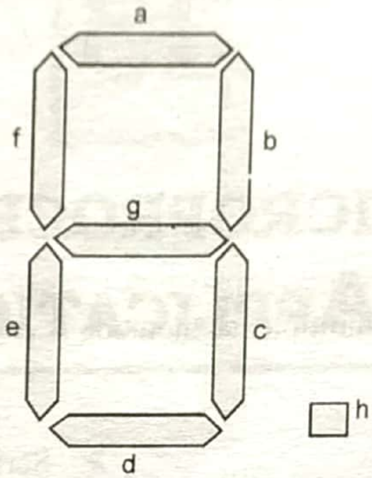

Fig. 13.1 : Seven Segment Display Arrangement

The seven segments of the display are labelled from *a* to *g* and dot is labeled as *h*. By lighening up the particular segments, a number or alphabet is displayed.

The seven segment displays are of two types :

(i) Common Anode Type.

(ii) Common Cathode Type.

In common anode, all anodes of LEDs are connected together whereas in common cathode all cathodes are connected together. Intefacing circuit to drive a single, seven segment, common anode LED display is shown in fig. 13.2

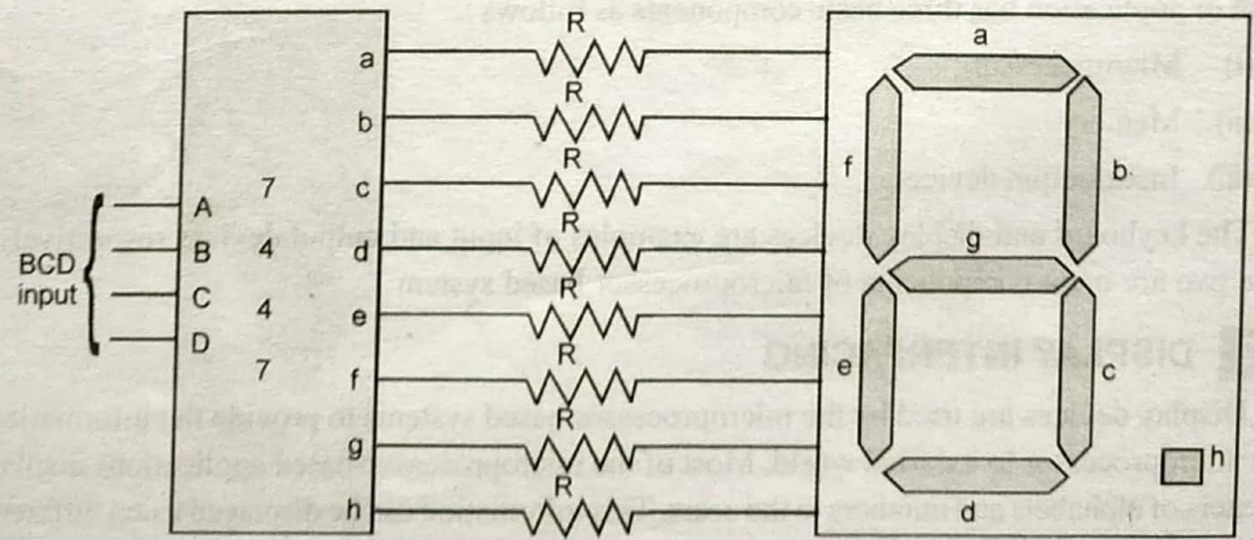

Fig. 13.2 : Interfacing Circuit to LED Display

To interface LED display with microprocessor, an additional IC (7447-BCD to 7-segment decoder) is required. The BCD to 7 segment decoder IC 7447 provides the signals on the segments of the LED display.

This kind of arangement to display, works properly for just one or two digits. When there are more number of digits, the power requirements may increase and this results the decreament in the LED glow. The another problem which will be there is that each display digit requires a separate BCD to 7-segment decode IC 7447.

13.2.2 Multiplexed Display

To solve the problems occur with LED displays, multiplexed displays are used. Multiplexed displays are electronic displays where entire display is not driven at one time. Fig. 13.3 shows the four 7-segment displays connected in multiplexed method.

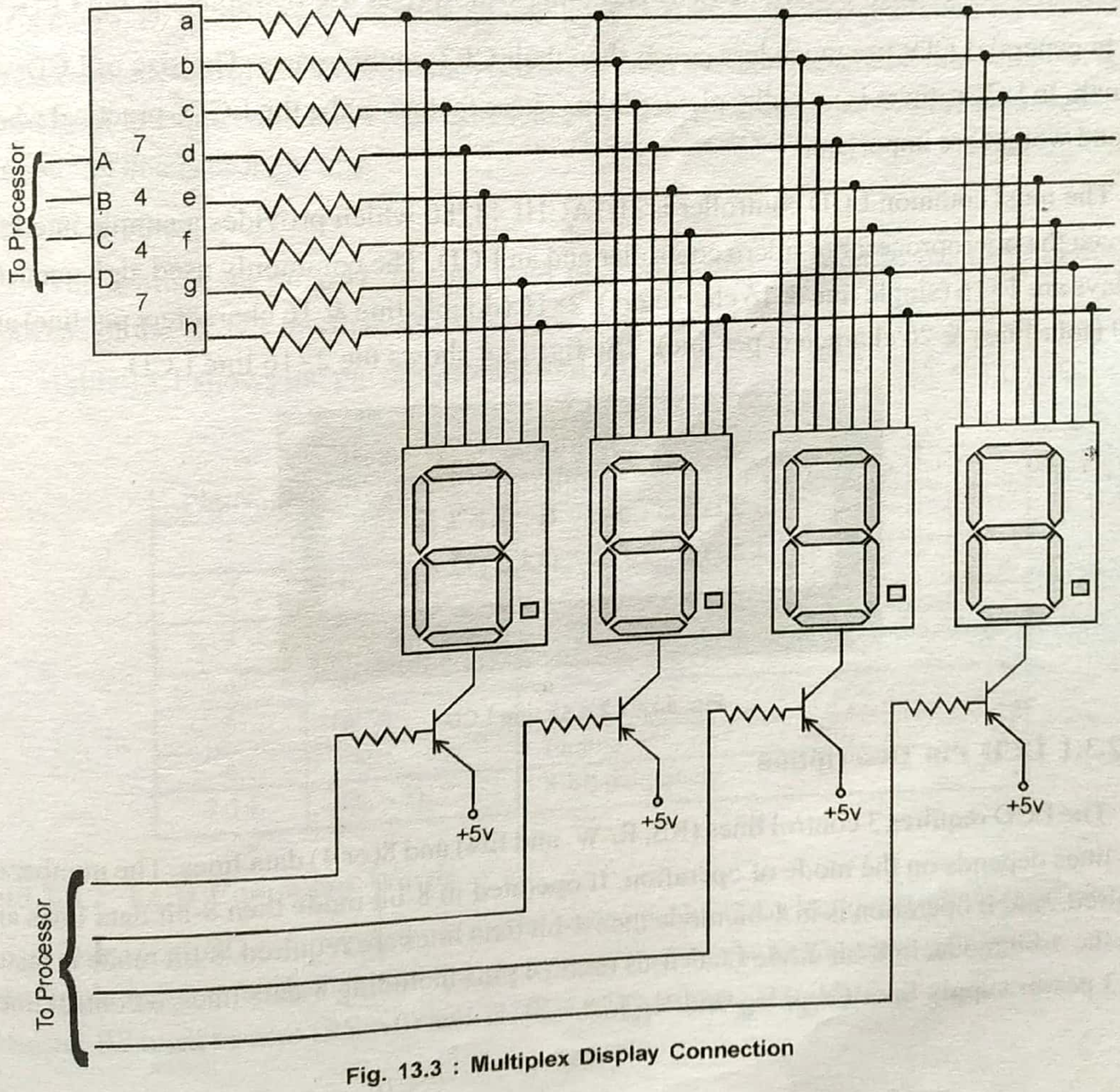

Fig. 13.3 : Multiplex Display Connection

The fig. 13.3 shows that the four 7-segment displays with one BCD to 7 segment decoder. The microprocessor can select one 7-segment display through the transistor circuit. It means, in multiplexed display, the segment information is sent for all digits on the common lines but only one display digit is turned on at a time.

In multiplexed display, the segment current is hept in between 40 mA to 60mA so that they will appear as bright as they would if not multiplexed.

13.2.3 Liquid Crystal Display (LCD)

A liquid crystal display is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures. In LCD, each pixel consists of a layer of modecules aligned between two transparent electrodes and two polarizing filters, the axes of transmission of which are perpendicular to each other. The LCD is finding widespread use by replacing the LEDs.

In general, LCDs use much less power than their CRT counterparts. The size of LCDs are all small. In LCDs, there is no bulky picture tube. These factors mabe the LCDs practical where size and weight are important.

The most common LCD controller is HITACHI 44780 which provides a simple interface between the microprocesor or micro controller and an LCD. The commonly used alphanumeric displays are 1×16 (single line & 16 characters), 2×16 (double line & 16 characters per line) and 4×20 (four lines & 20 characters per line). The fig. 13.4 shows the 2×16 line LCD.

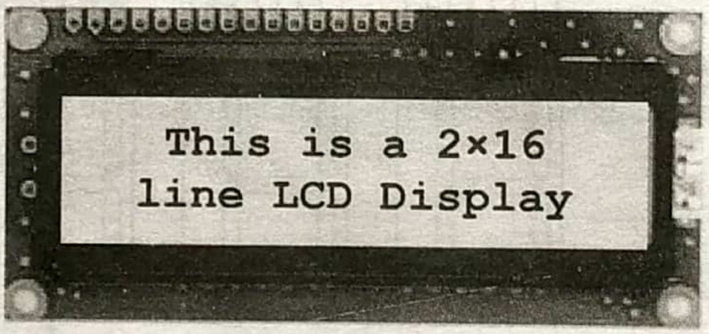

Fig. 13.4 : 2 × 16 line LCD

13.2.3.1 LCD Pin Description

The LCD requires 3 control lines (RS, R/$\overline{W}$ and EN) and 8(or 4) data lines. The number of data lines depends on the mode of operation. If operated in 8-bit mode then 8-bit data lines are required. And if operation is in 4-bit mode then 4-bit data lines are required. 8-bit mode is faster than the 4-bit mode. In 8-bit mode LCD uses total 14 pins including 8-data lines, 3 control lines and 3 power supply lines (V_{CC}, V_{SS} and V_{EE}).

1. **Power Supply**

The LCD discussed here uses three power supply pins (V_{CC}, V_{SS} and V_{EE}). V_{CC} and V_{SS} pins are used to provide +5V and ground respectively. The pin V_{EE} is used for controlling LCD contrast.

2. **Control Lines**

There are three control lines in LCD. These three are used to control the LCD operations. There are two very important registers inside the LCD : command register and data register. The RS (Register select) pin is used to select the register out of these two. If RS = 0, the command register is selected and user is allowed to send the command to the LCD. If RS = 1, the data register is selected and the data sent by the user is displayed on the LCD.

$R/\overline{W}$ (Read/ $\overline{\text{Write}}$) pin allows the user to read/write the information (data or code) to/ from the LCD. $R/\overline{W} = 1$ when reading and $R/\overline{W} = 0$ when writing operation is performed.

Another control pin EN (Enable) is used to latch the data present on the data pins. A high-low signal is required to latch the data. The LCD interprets and executes the commands at the instant EN line is brought low.

3. **Data lines**

The 8-bits data pins, D_0-D_7, are used to send the information to the LCD or read the contents of the LCD's internal register.

Table 13.1 shows the pin description for LCD.

Table 13.1 : Pin Description for LCD

Pin No.	Symbol	Description
1	V_{SS}	Ground
2	V_{CC}	+5V power supply
3	V_{EE}	Power supply to control the contrast
4	RS	Register select
5	$R/\overline{W}$	Read/ $\overline{\text{Write}}$
6	EN	Enable
7-14	$D_0 - D_7$	8-bit data lines.

13.2.3.2 LCD Command Words

There are LCD commands those can be sent to the LCD to clear the display or to shift cursor from right to left or left to right or blink the cursor. To write the LCD command word in command register RS must be zero (RS = 0) and $R/\overline{W} = 0$. The LCD commands are given in table 13.2.

Table 13.2 : LCD Commands Words

Hex Code	Description
01	Clear display screen
02	Return home
04	Decrement cursor (shift cursor from right to left)
06	Increment cursor (shift cursor from left to right)
05	Shift display right
07	Shift display left
08	Display off, cursor off
0A	Display off, cursor on
0C	Display on, cursor off
0E	Display on, cursor blinking
0F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Shift entire display to left
1C	Shift entire display to right
80	Force cursor to beginning of 1st line
C0	Force cursor to beginning of 2nd line
38	2 lines and 5×7 matrix

13.2.3.3 LCD Interfacing

The LCD can be interfaced to the microprocessor 8085 using the programmable peripheral interface (PPI-8255) IC. To display letters and numbers, ASCII code for the letters A to Z, a to z and number 0 to 9 is sent to the data lines (D_0 –D_7). These codes may be sent to LCD data lines through one port of 8255 (PPI) as shown in fig. 13.5. In this figure, port A is used as output port and send the data to the LCD. The EN pin and RS pin are connected to the port B of the 8255. Since it is used as normal display $R/\overline{W}$ is made low by connecting to ground directly. Power supply connections are provided to V_{CC} and V_{SS} pins. The V_{EE} pin is connected to the moving node of potentiometer which is connected in between V_{CC} and V_{SS} pins. By moving the potentiometer the contrast of LCD can be changed.

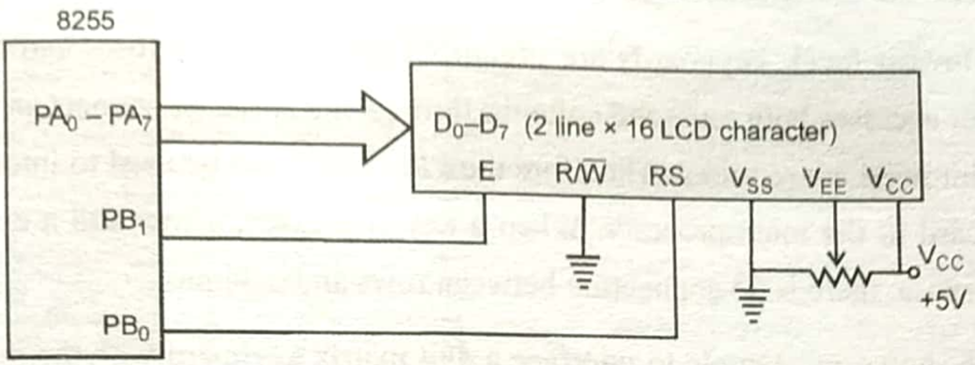

Fig. 13.5 : LCD interfacing scheme.

13.3 KEYBOARD MATRIX INTERFACING

Keyboard is the most widely used input device of any microprocessor. For interfacing keyboard to the microprocessor based systems, usually push buttons are used. These push button keys when pressed, bounces a few times, closing and opening the contacts before providing a steady reading. The microprocessor must wait until the key reaches to a steady state. This is known as key debounce. The problem of key bounce can be eliminited using key debounce technique either hardware or software.

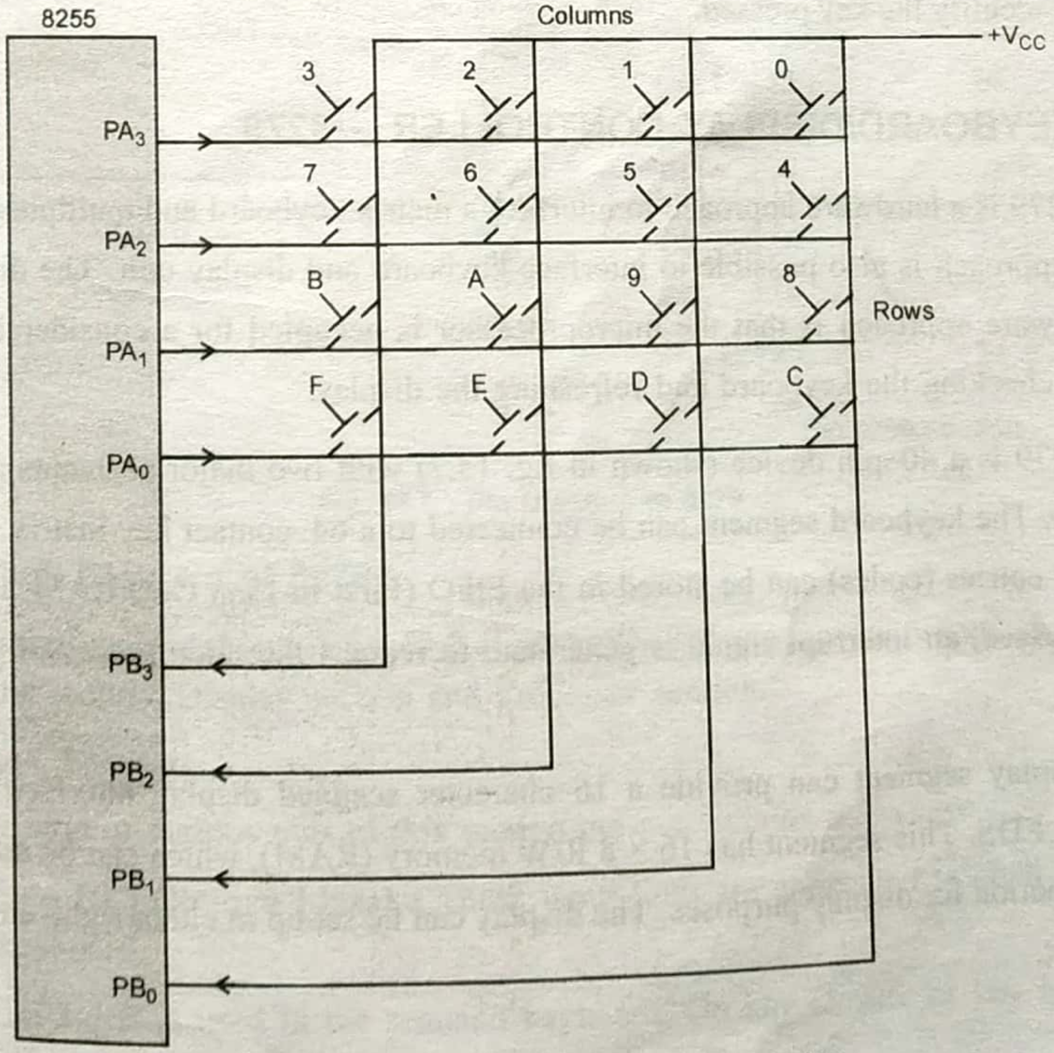

Fig. 13.6 : 4 × 4 keyboard matrix interfacing

At the lowest level, keyboards are organized in a matrix of rows and columns. The microprocesor accesses both rows and columns through the ports. To connect an 8×8 matrix of keys, two 8-bit ports are required. Therefore the PPI (8255) can be used to interface an 8 × 8 matrix keyboard to the microprocesor. When a key is pressed, a row and a column make a contact; otherwise, there is no connection between rows and columns.

Fig. 13.6 shows an example to interface a 4×4 matrix keyboard with the microprocessor using port A and port B of 8255.

A 4×4 keyboard matrix is connected to port A and port B of 8255 (PPI). The port A is considered as output and port B as input port. The rows are connected to port A (output) and the columns are connected to port B (input). All the rows are made low through port A. If no key has been pressed, reading the port B will yield 1s for all columns since they are all conncted to high (V_{CC}). If a key is pressed, one of the columns will have low since the key pressed provides the path to ground. It is the function of the microprocessor to scan the keyboard continuously to detect and identify the key pressed.

13.5 PROGRAMMABLE COMMUNICATION INTERFACE (USART) 8251

Most of the microprocessors are designed for parallel communication. In parallel communication number of lines required to transfer data depend on the number of bits to be transferred. The 8085 microprocessor transfers 8-bit of data simultaneously over 8 data lines. However in many applications parallel communication is either impractical or impossible. In these applications serial communication is used, whereby one bit at a time is transferred over a single line.

In serial communication, an 8-bit parallel data should be converted into a stream of eight serial bits. After the conversion, serial bits are transmitted to the peripheral over a single line. The hardware approach to serial communication includes the programmable communication interface (USART) 8251.

The USART stands for **U**niversal **S**ynchronous **A**synchronous **R**eceiver **T**ransmitter. It is a programmable device i.e. its functions and specifications for serial communication can be determined by writing instructions in its internal registers. This is an universally acceptable IC which can operate in synchronous and asynchronous mode as receiver as well as transmitter.

The 8251 (USART) is a 40 pin IC as shown in fig. 13.17.

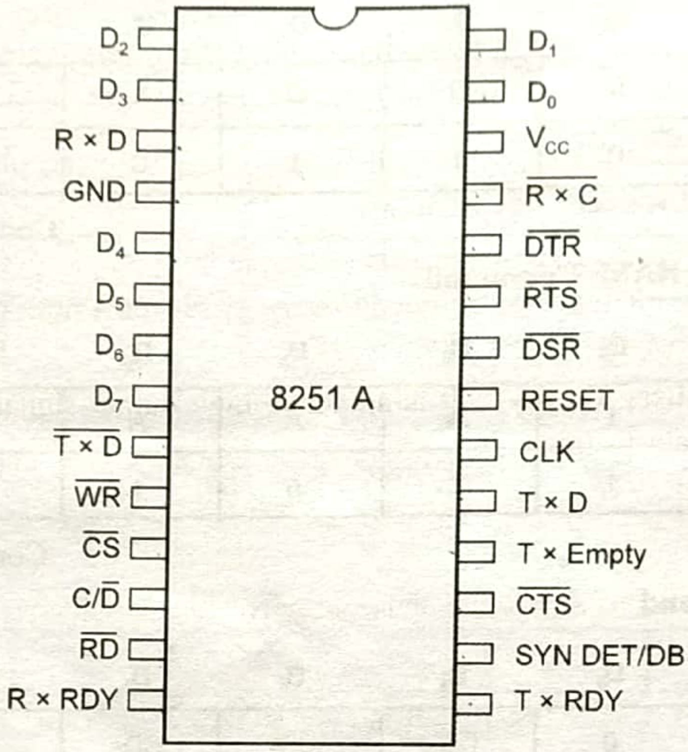

Fig. 13.17 : Pin diagram of 8251

13.5.1 Block Diagram

Fig. 13.18 shows the block diagram of 8251. It is divided into five groups.

1. R/W Control Logic

It performs interfacing and determines the function of the chip according to the control word in the register the signals associated with this block are as follows :

(i) **$\overline{RD}$ (Read) :** It is active low signal. It goes low for read operations, like, reading status or input data from data buffer.

(ii) **$\overline{WR}$ (Write) :** It is active low signal. it goes low for write operations, like, writing control word or send output to data buffer.

(iii) **CLK (Clock) :** It is the connection to the system clock to communicate with the microprocessor.

(iv) **$C/\overline{D}$ (Control/data) :** When this signal is at logic 1, control register or status register is addressed, and when it goes low data buffer is addressed.

(v) **$\overline{CS}$ (Chip Select) :** It is an active low signal. When it goes low, 8251 chip is selected.

(vi) **RESET :** It is an active high signal. When it goes high, reset the 8251.

2. **Transmitter Section**

It consist of buffer register to hold eight bits and an output register to convert all the eight bits to serial bits. It consists following signal.

(i) **TXD (Transmitter Data Output) :** It is an active high output pin. It is used to transmit serial data bits along with other information like start bit, stop bit and parity bit.

(ii) **$\overline{\text{TXC}}$ (Transmitter Clock Input) :** It is an active low output pin. It controls the rate at which the character is to be transmitted.

(iii) **TXRDY (Transmitter Ready) :** It is an active high output pin. It is used to inform the microprocessor that transmitter is ready to accept a new data for transmission from microprocessor.

(iv) **TXE (Transmitter Empty) :** It is an active high output signal. It goes high, when 8251 has no data to transmit.

3. **Receiver Section**

It consist following signals :

(i) **RXD (Receiver Data Input) :** It is an active low input pin. It is used to receive serial data.

(ii) **$\overline{\text{RXC}}$ (Receiver Clock Input) :** It is an active low input pin. It controls the rate at which the character is to be received.

(iii) **RXRDY (Receiver Data Read) :** It is an active high output pin. It is used to indicate that the 8251 contains a data to be read by the microprocessor. This pin can be used to check the status or to interrupt microprocessor.

(iv) **SYNDET/BD (Synchronous Detect/Break Detect) :** In synchronous mode it is used for detecting synchronous characters. In this mode, it may be used as input or output. When used as an input, a signal at this pin causes 8251 to start assembling a data character. When used as an output, the SYNDET pin goes high, to indicate that 8251 has located a synchronous character. In asynchronous mode, the pin acts as a break detect output. It goes high whenever RXD pin goes low, through two consecutive stop bit sequence.

4. **Modem Control**

It is used to establish data communication. It converts digital data into audio tone frequencies for transmission over telephone lines and convert audio frequencies into digital data for reception.

5. **Data Bus Buffer**

It is bidirectional register, which is used as input/output port to accept/send data, with $C/\overline{D}$ signal low.

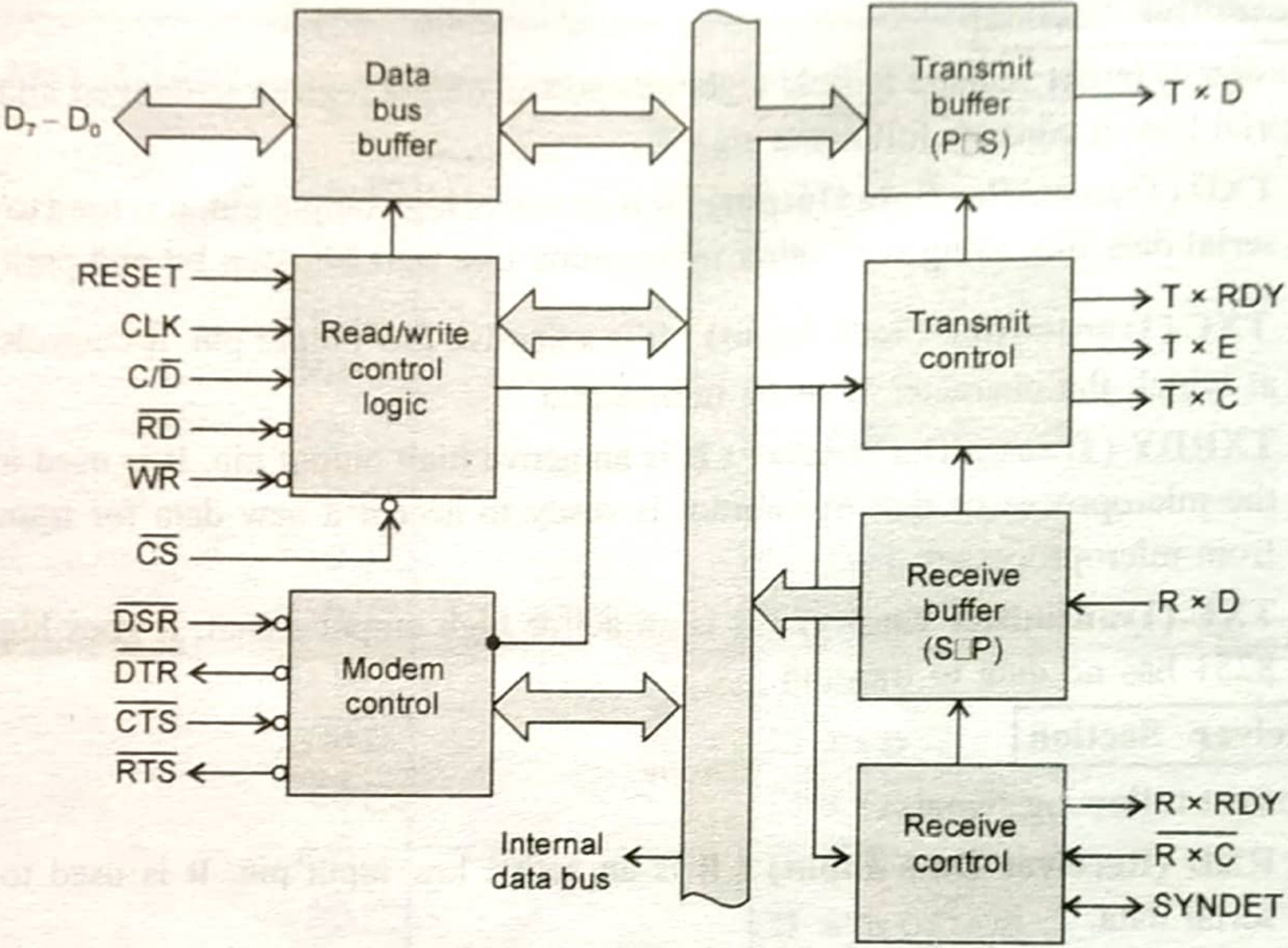

Fig. 13.18 : Block diagram of 8251

13.6 SERIAL COMMUNICATION STANDARDS

Various devices like printers and modems use the serial communication with microprocessor. Hence, there is a requirement of some common standards. A standard in normally defined by the professional organizations like IEEE. In serial communication, data can be transmitted in form of current or voltage.

13.6.1 RS 232

When data is transmitted in form of voltage, this standard is used. It is widely accepted for single ended data transmission over short distances with low data rates. This standard describes the functions of 25 signal and handshake pins for serial communication. It also describes the voltage level, speed of data transfer, rise and fall time, maximum capacitance for these signal lines. The 25 pin connector (RS 232C) is shown in fig. 13.23.

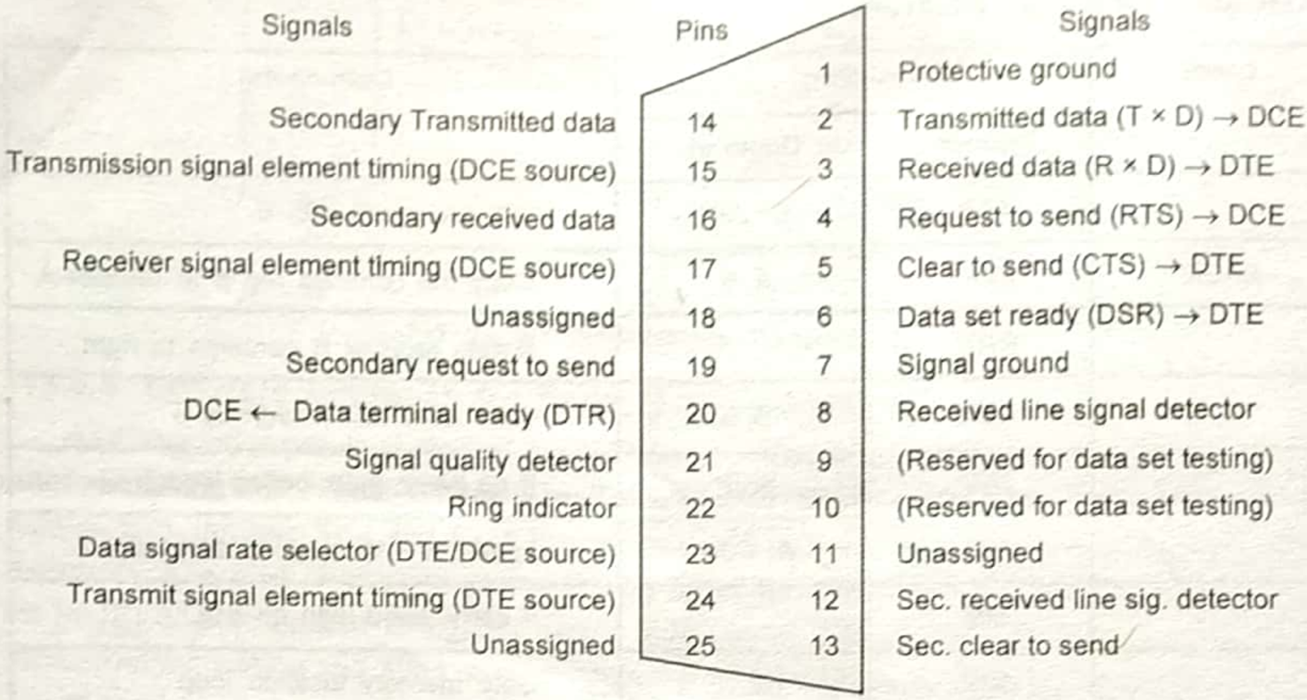

Fig. 13.23 : 25 Pin connector (RS – 232C)

The RS–232C standard is defined in reference to Data Terminal Equipment (DTE) and Data Communication Equipment (DCE). The voltage level methods are having following limitations :

(i) The voltage levels are not compatible to TTL levels.

(ii) The rate of data transmission is limited (upto 20k baud).

(iii) The maximum distance is only 50ft.

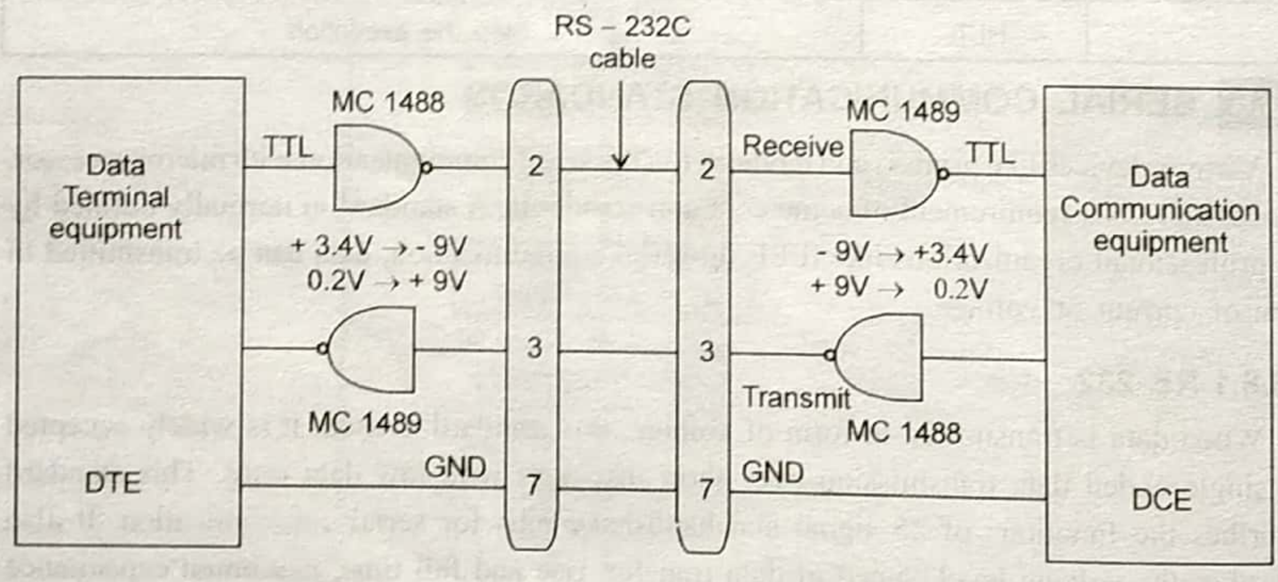

Fig. 13.24 : Interfacing between TTL and RS 232

The fig. 13.24 shows the interfacing between TTL and RS–232 signals. The line driver, MC 1488, converts logic '1' into approximately – 9V and logic '0' into approximately + 9V. These levels, at the receiving end, are again converted by the line receiver, MC 1489, into TTL compatible logic.

For high speed transmission, the standards RS – 422A and RS – 423A are used. These standards are differential amplifiers to reject noise levels and can transmit data at higher speed with larger cable.

The comparison of these serial communication standards in shown in table 13.3.

Table 13.3 : Comparison of serial communication standards

Specification	RS–232C	RS–422A	RS–423A
Speed	20k baud	10M baud at 40ft	100 k baud at 30ft
		100k baud at 4000ft	1k baud at 4000ft
Distance	50ft	4000ft	4000ft
Logic '0'	> + 3V + 24V	B > A*	+ 4 to + 6V
Logic '1'	< – 3V to – 25V	B < A	– 4 to – 6V
Receiver Input Voltage	± 15V	± 7V	± 12V

* A and B are different input to the operational amplifier.

13.6.2 MC 1488 (Line Driver)

The MC–1488 is a quad line driver. It is used to interface DTE and DCE through RS–232C bus standard. The pin diagram of MC – 1488 is shown in fig. 13.25. It converts TTL logic '1' (> 3.4V) into approximately – 9V and TTL logic '0' (< 0.2V) into + 9V. The MC–1488 contains four drivers and each driver converts a TTL level into RS–232 level.

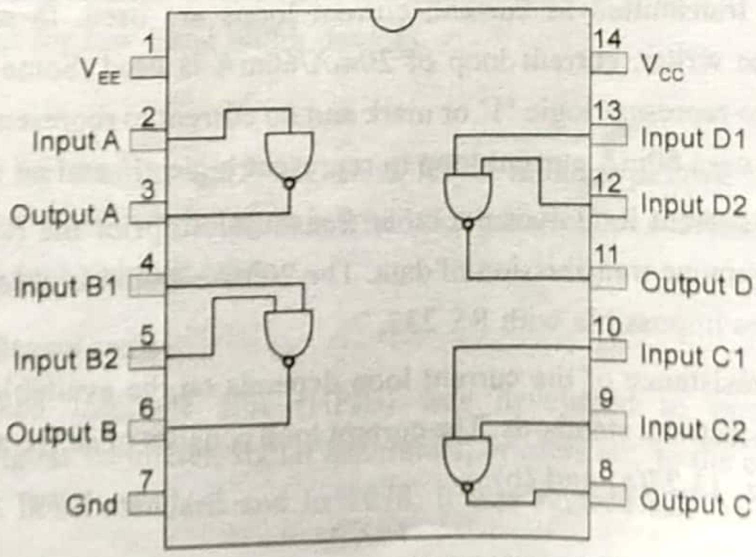

Fig. 13.25 : Pin Diagram of Line Driver MC 1488

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13.7 SYSTEM BUSES

The bus is defined as a channel over which information is transferred between two or more devices. Following are the standard buses used in computer systems.

13.7.1 ISA Bus

The ISA stands for **Industry Standard Architecture**. It is the most common bus in the PC systems. The original ISA bus on the IBM PC was 8 bit wide, reflecting the 8 bit data width of the Intel 8088 processor's system but and ran at 4.77 MHz. It was expanded to 16–bits in 1984 using the Intel 80286.

After that, processor got faster and eventually data buses got wider, but due to compatibility of this bus with existing devices doesn't allow more changes to this. The ISA bus provides reasonable throughput for low band width devices.

13.7.2 STD Bus

The STD stands for **S**imple **To** **D**esign and is yet another passive "reach" similar to the PC/AT bus. It is designed by pro–log. It is 8 bit wide parallel bus accommodating relatively small (4.5 inch × 6.5 inch) circuit cards.

13.7.3 IEEE 488 Standards

The Hewlet-Packed Interface Bus (HPIB) was developed to interface smart test instruments such as digital voltmeter, signal generators, printers etc. to the computer. In 1875, it was adopted as an IEEE standard and in 1978, it was revised and named as IEEE 488 standards.

This standard define the communicating devices as talker, listener and controller. The devices which are capable of putting data on the bus for transmission are named as **talkers**. Examples for talkers are digital voltmeter, frequency counter etc.

Listeners are devices which are capable to read data from bus. Examples for listeners are printers, and display devices. The devices which can control the devices to be talker or listener are named as **Controller**. This is important to note that one device can be both talker and listener.

The IEEE 488 standard bus architecture has eight bidirectional data lines. These data lines are supported by three handshake control signals and five general purpose interface management lines. The data lines are used to transfer data addresses, commands, and status bytes among as many as 8 to 10 instruments.