UNIT2: DIGITAL LOGIC AND DATA PRESENTATION

INTRODUCTION: Many control systems are concerned with setting events in motion or stopping them when certain conditions are met. Digital circuitry is the basis of digital computers and microprocessor controlled systems.

Eg., In domestic washing machine, the heater is only switched ON when there is water in the drum & it is to the prescribed level. Such control involves digital signals where there are only two possible signal levels.

The two levels usually 5V and 0V are the high and low signals & represented by 1 & 0. The binary number system involves just the numbers 0 &1 and is widely used with such digital circuitry. These two levels 1 & 0 may represent levels of on or off, closed or open, yes or no, true or false, =5V or 0V etc.

With digital control for example, have the water input to the domestic washing machine switched on if we have both the door to the m/c. closed and a particular time in the operating cycle has been reached. The controller is programmed to give a yes output if both the input signals are yes. Such an operation is controlled by a logic gate (AND gate). There are many machines & processes which are controlled in this way.

The term combinational logic is used for combining two or more basic logic gates to form a required function.

Eg., A requirement might be that a buzzer sounds in a car if the key is in the ignition & a door is opened or if the headlights are ON and the driver's door is opened.

The sequential logic circuitry is used to exercise control in a specific sequence dictated by a control clock or enable-disable control signals. These are combinational logic circuits with memory.

NUMBER SYSTEMS:

The decimal system is based on the use of digits 0 to 9.

…….	10^3	10^2	10^1	10^0
	Thousands	Hundreds	Tens	Units

The binary system is based on just two symbols or states 0 &1. These are termed binary digits or bits.

2^3	2^2	2^1	2^0
bit3	bit2	bit1	bit0

eg., The decimal number 15 in binary system is 1111.

The octal system is based on eight digits 0 to 7. The decimal number 15 in the octal system is 17.

8^3	8^2	8^1	8^0	(8^1 8^0 8+7=15)

The hexadecimal system is based on 16 digits 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

…… 16^3 16^2 16^1 16^0

The decimal number 15 is F in the hexadecimal system.

BCD SYSTEM:

The binary coded decimal system (BCD) is widely used system with computers. Each decimal digit is coded separately in binary.

The decimal number 15 in BCD is 0001 0101. This code is useful for outputs from microprocessor based systems where the output has to drive decimal displays.

Table gives examples of numbers in number systems.

Table: Number systems

Decimal	Binary	BCD	Octal	Hexadecimal
0	0000	0000 0000	0	0
1	0001	0000 0001	1	1
2	0010	0000 0010	2	2
3	0011	0000 0011	3	3
4	0100	0000 0100	4	4
5	0101	0000 0101	5	5
6	0110	0000 0110	6	6
7	0111	0000 0111	7	7
8	1000	0000 1000	10	8
9	1001	0000 1001	11	9
10	1010	0001 0000	12	A
11	1011	0001 0001	13	B
12	1100	0001 0010	14	C
13	1101	0001 0011	15	D
14	1110	0001 0100	16	E
15	1111	0001 0101	17	F

ANALOG SIGNAL:

Analog signal is a continuous wave that keeps on changing over a time period. Digital signal is discrete in nature. The analog signal is represented by a sine wave where as digital signals are represented by square waves.

DIGITAL SIGNAL:

The output from most sensors tends to be in analogue form. A microprocessor is used as part of the measurement or control system, the analog output from the sensor has to be converted into a digital formbefore it can be used as an input to the microprocessor. Likewise, most actuators operate withanalog inputs and so the digital output from a microprocessor has to be converted into an analogform before it can be used as an input by the actuator.

The binary system is based on the two symbols or states 0 & 1. These are binary digits or bits. When a number is represented by this system, the digit position in the number indicates the weight attached to each digit, the weight increasing by a factor or 2 from right to left.

…….	2^3	2^2	2^1	2^0
	bit3	bit2	bit1	bit0

For example, the decimal number 15 is $2^0+2^1+2^2+2^3$ = 1111 in the binary system. In a binary number, the bit0 is termed the Least Significant Bit (LSB) and the highest bit the Most Significant Bit (MSB). The combination of bits to represent a number is termed a word. Thus, 1111 is a four-bit word. The term byte is used for a group of 8 bits.

ADCs: The input to an ADC is an analogue signal and the output is a binary word that represents the level of the input signal. There are a number of forms of ADC – successive approximations, ramp, dual ramp and flash.

SUCCESSIVE APPROXIMATIONS ADC:

It is probably the most commonly used method. Fig. illustrates the sub-systems involved. A voltage is generated by a clock emitting a regular sequence of pulses which are counted in a binary manner and the resulting binary word converted into an analogue voltage by a DAC. This voltage rises in steps and is compared with the analogue input voltage from the sensor. When the clock-generated voltage passes the input analogue voltage, the pulses from the clock are stopped from being counted by a gate being closed. The output from the counter at that time is then a digital representation of the analogue voltage. While the comparison could be accomplished by starting the count at 1, the LSB and then proceeding bit by bit upwards, a faster method is by successive approximations. This involves selecting the MSB that is less than the analogue value, then adding successive lesser bits for which the total does not exceed the analogue value.

For eg., we might start the comparison with 1000. If this is too large we try 0100. If this is too small we then try 0110. If this is too large, we try 0101. Because each of the bits in the word is tried in sequence, with an n-bit word it only takes n steps to make the comparison. Thus if the clock has a frequency f, the time between pulses is 1/f. Hence the time taken to generate the word i.e., conversion time is n/f.

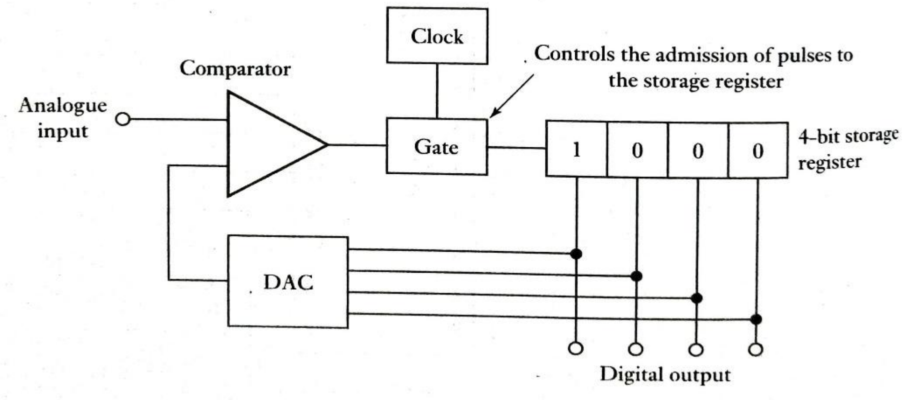
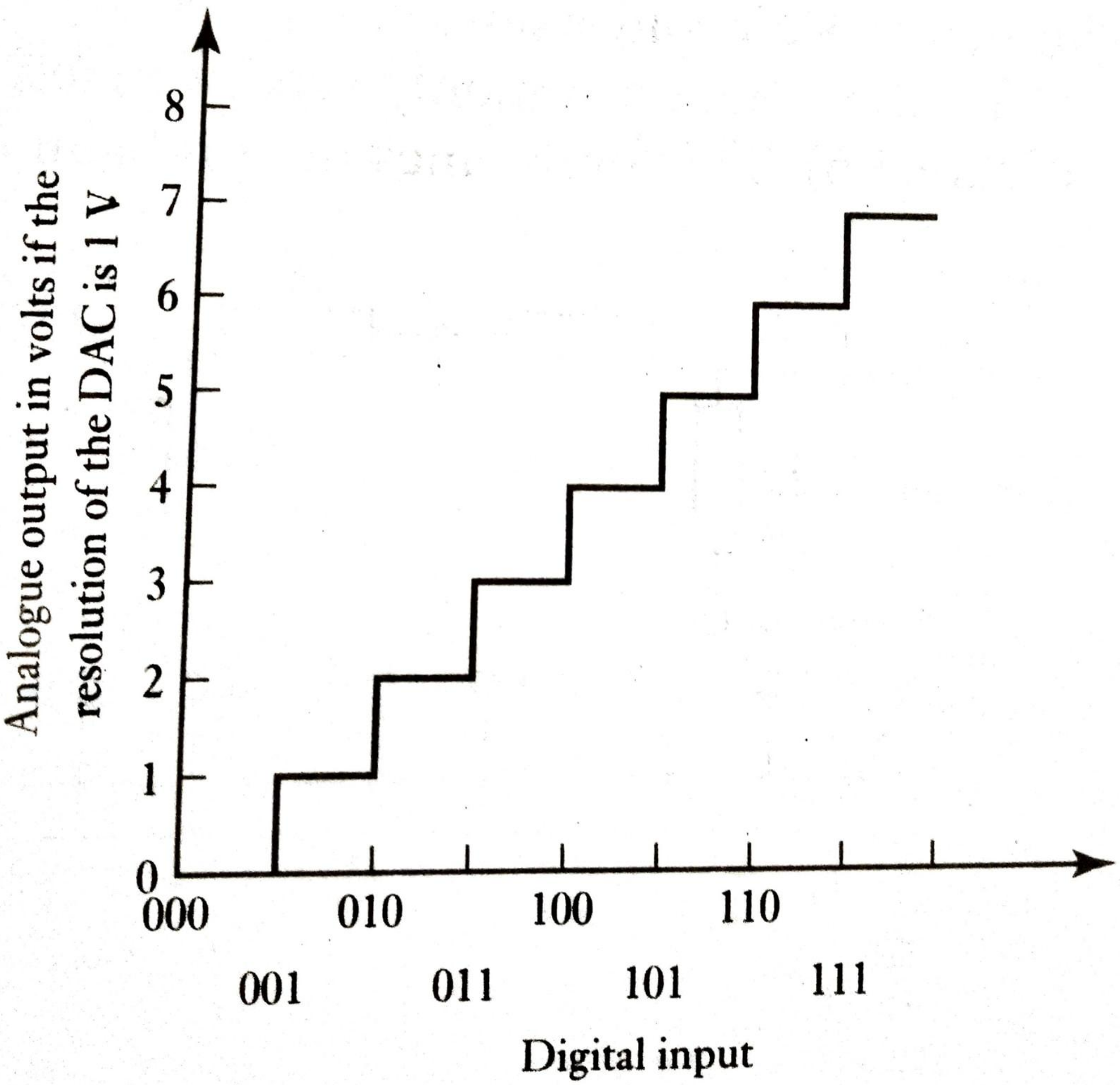


Fig. Successive approximations ADC

DIGITAL TO ANALOGUE CONVERSION:

The input to a DAC is a binary word, the output is an analogue signal that represents the weighted sum of the non-zero bits represented by the word. Thus for example, an input of 0010 must give an analogue output which is twice that given by an input of 0001.



DIGITAL TO ANALOGUE CONVERTERS:

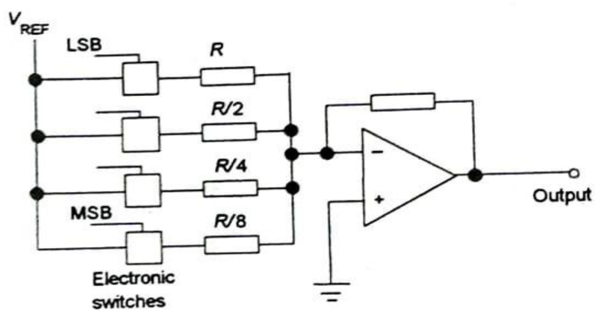


Fig. 3.31 Weighted-resistor DAC

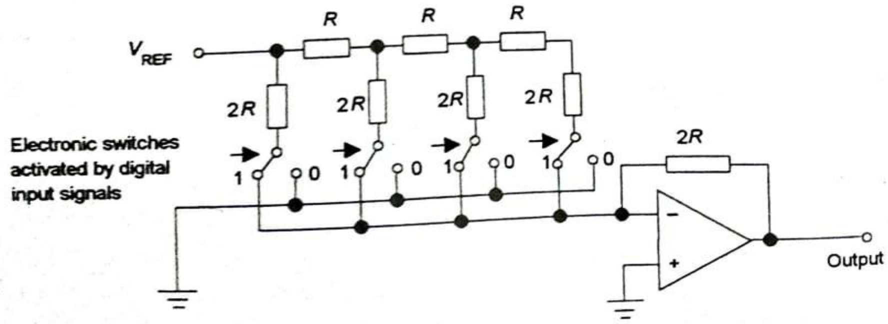


Fig. 3.32 *R*-2*R* ladder DAC

A simple form of DAC uses a summing amplifier to form the weighted sum of all the non-zero bits in the input word. The reference voltage is connected to the resistors by means of electronic switches which respond to binary 1. The values of the input resistances depend on which bit in the word a switch is responding to, the value of the resistor for successive bits from the LSB being halved. Hence, the sum of the voltages is a weighted sum of the digits in the word. Such a system is referred to as a weighted-resistor network.

A problem with the weighted-resistor network is that accurate resistances have to be used for each of the resistors and it is difficult to obtain such resistors over the wide range needed. As a result, this form of DAC tends to be limited to 4-bit conversions.

Another, more commonly used, version uses a R-2R ladder network (fig.) This overcomes the problem of obtaining accurate resistances over a wide range of values, only two values being required. The output voltage is generated by switching sections of the ladder to either the reference voltage or 0V according to whether there is a 1 or 0 in the digital input.

LOGIC GATES:

Logic gates are the basic building blocks for digital electronic circuits.

AND GATE: In AND logic gate, the output is high only when both input A and B are high, for all other conditions, it gives a low output. The Boolean equation for AND gate is Q = A.B

Inputs *A*	Inputs *B*	Output *Q*
0	0	0
0	1	0
1	0	0
1	1	1

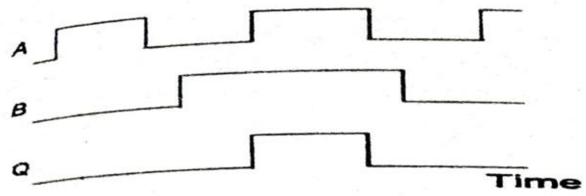


Fig. 14.2 AND gate

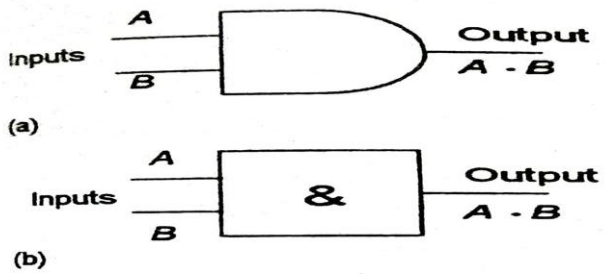


Fig. 14.3 Standard symbols for AND gates

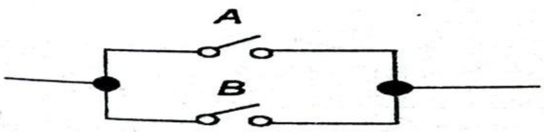


Fig. 14.4 OR gate representation

Eg., In an electrical circuit with two switches in series (fig.) only when switch A and switch B are closed, there is a current. Consider an AND gate interlock control system for a machine tool such that if the safety guard is in place and gives a 1 signal & the power is ON, giving a 1 signal, then there is an output, a 1 signal. The relationships between inputs to a logic gate & the outputs can be tabulated in a form known as Truth Table.

OR GATE: An OR gate with inputs A and B gives an output of a 1 when A or B is 1. The Boolean equation for an OR gate is Q = A+B

INPUTS		OUTPUT
A	B	Q=A+B
0	0	0
0	1	1
1	0	1
1	1	1

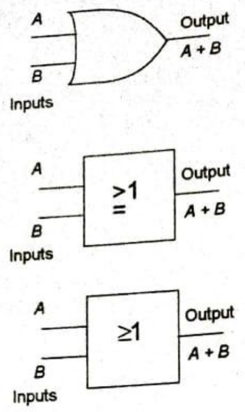


Fig. 14.5 Symbols for OR gate

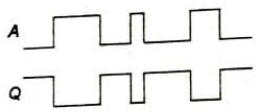


Fig. 14.6 NOT gate

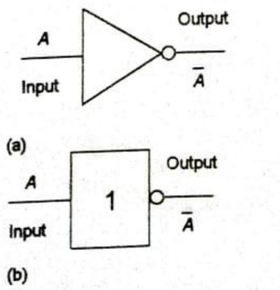


Fig. 14.7 Symbols for NOT gate

NOT GATE: A NOT gate has just one input and one output, giving a 1 output when the input is 0 and a 0 output when the input is 1. It is called an inverter because it inverts the input. The Boolean equation for NOT gate is Q =A'

INPUT	OUTPUT
A	Q=A'
0	1
1	0

NAND GATE: It can be considered as a combination of an AND gate followed by a NOT gate (fig.). Thus when input A is 1 and input B is 1, there is an output of 0, all other inputs giving an output of 1. The Boolean equation for NAND gate is Q=(A.B)'

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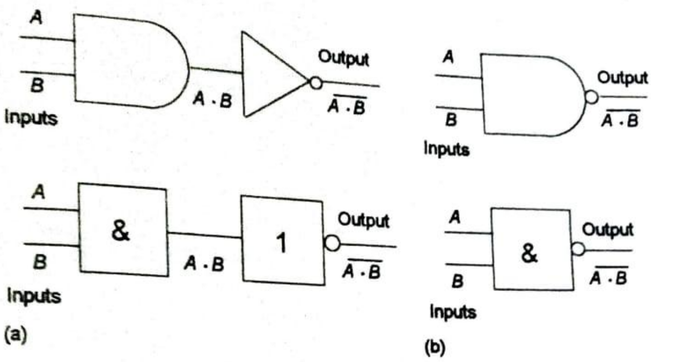

Fig. 14.8 NAND gate

Inputs		Output
A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE: It can be considered as a combination of an OR gate followed by a NOT gate (fig.). Thus when input A or input B is 1, there is an output of 0. It is the OR gate with outputs inverted. The Boolean equation for NOR gate is Q=(A+B)’

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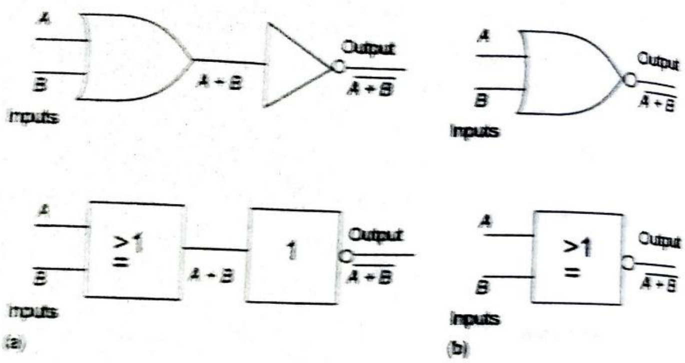
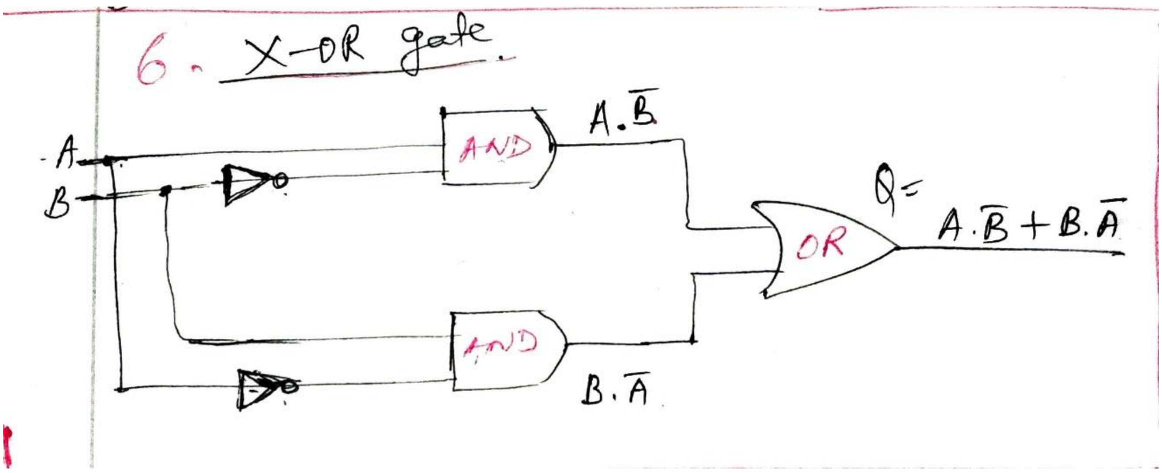


Fig. 14.10 NOR gate

Inputs		Output
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

X-OR GATE: The Exclusive-OR gate (XOR) can be considered to be an OR gate with a NOT gate applied to one of the inputs to invert it before the inputs reach the 2 AND gates. The = 1 depicts that the output is true if only one input is true.



Inputs A	Inputs B	Output Q
0	0	0
0	1	1
1	0	1
1	1	0

14.3.7 Combining gates

It might seem that to make logic systems we requ gates. However, as the following shows, we can m gates from just one. Consider the combination of th shown in Figure 14.12. The truth table, with the int final outputs, is as follows:

APPLICATIONS OF LOGIC GATES:

The applications of logic gates are

1. Parity bit generators
2. Digital Comparator
3. Code converter
4. Encoders
5. Flip-flops
6. Combinational logic system
7. Sequential logic system
8. Integrated Circuits
9. Coder

CODER:

gure 5.13 Traffic lights.

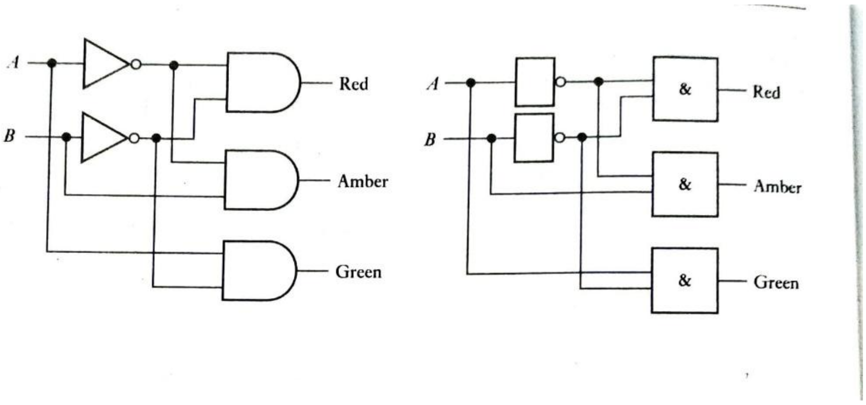


Fig. shows a simple system by which a controller can send a coded digital signal to a set of traffic lights so that the code determines which light red, amber or green, will be turned ON. To illuminate the red light we might use the transmitted signal A=0, B=0, for the amber light A=0, B=1 and for the green light A=1, B=0. We can switch on the lights using these codes by using three AND gates and two NOT gates.

SEQUENTIAL LOGIC SYSTEM:

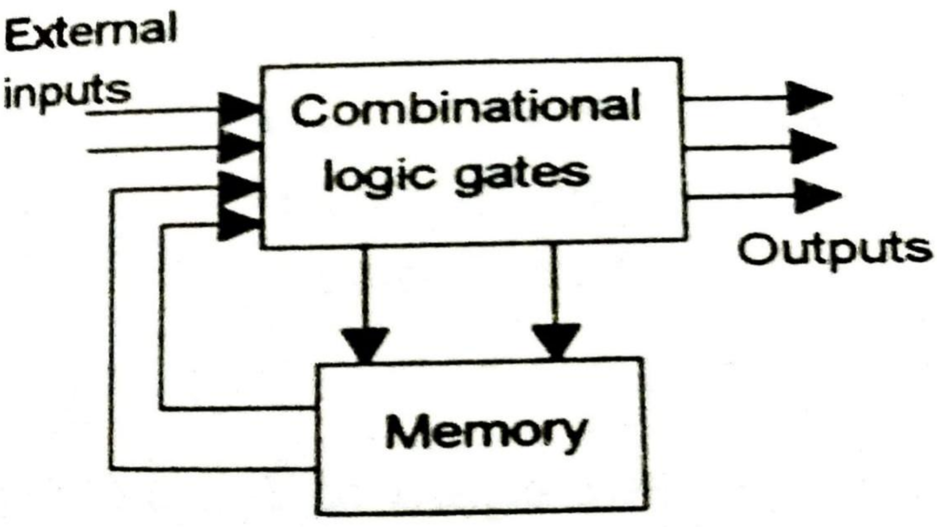


Fig. 14.34 Sequential logic system

The logic circuits are combinational logic systems. The output is determined by the combination of the input variables at a particular instant of time. The output does not depend on the previous inputs. Eg., AND gate gives an output if inputs A & B occur at the same time. Sequential logic system is required where a system requires an output which depends on earlier values of the inputs. It must have some form of memory.

Fig. shows the basic form of a sequential logic system. The combinational part of the system accepts logic signals from external inputs & outputs from memory. The system then operates on these inputs to produce its outputs. The outputs are thus a function of both its external inputs and the information stored in its memory.

ENCODER:

An encoder is a combinational circuit that has maximum of 2^n input lines and 'n' output lines. It will produce a binary code equivalent to the input, which is active high. Therefore, the encoder encodes 2^n input lines with 'n' bits.

Eg., An octal to binary encoder takes 8 input lines and generates 3 output lines. Only one output line is active at a time.

DECODER (CODE CONVERTER) :

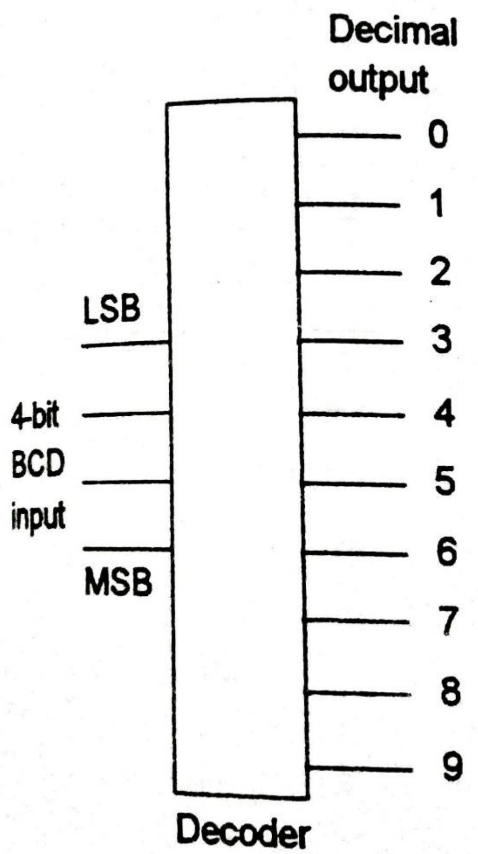


Fig. 14.29 Decoder

In many applications, there is a need to change data from one type of code to another. The output from the microprocessor might be BCD and need to be transformed into a suitable code to drive a seven segment display. The term data decoding is used for the purpose of converting some code group eg., BCD, binary, hex. Into an individual active output representing that group.

A decoder has ‘n’ binary input lines for the input of an n-bit word and gives m output lines such that only one line is activated for one possible combination of inputs.
Eg., a BCD to decimal decoder has a 4 bit input code and 10 output lines so that a particular BCD input will indicate a particular decimal number (fig.).

Thus, a decoder is a logic circuit that looks at its inputs and activates one output corresponding to that number. Decoders are widely used in microprocessor circuits. Decoders can have active output high and the inactive ones low or vice versa. For active high output a decoder can be assembled from AND gates while for active low output NAND gates can be used.

A decoder that is widely used is BCD-to-Seven.
Eg., 74LS244, for taking 4-bit BCD input and giving an output to drive the seven segment display.
74LS145 (BCD to decimal decoder for active low output)
74LS138 (3 to 8 line decoder).

FLIP-FLOPS:

In digital systems, binary bits are retained or stored in groups that represent either a number or information (code). The grouped bits are called DNS (Digital Number System) data and are to be stored electronically. An electronic circuit that retains a single bit of DNS data is called a flip-flop. It can be understood as a single unit of memory. These are designed using logic gates and are under the category of sequential logic circuits. Depending upon the way they retain a bit, there are various types of flip-flops. Some change state only when a clock edge or pulse is triggered. The types of flip-flops are SR flip-flops, JK and D flip-flops.

SR FLIP FLOP: SR flip-flop is a simple type of flip-flop that can retain or store a single bit. S stands for ‘Set’ and R stands for ‘Reset’. The truth table is given in fig.

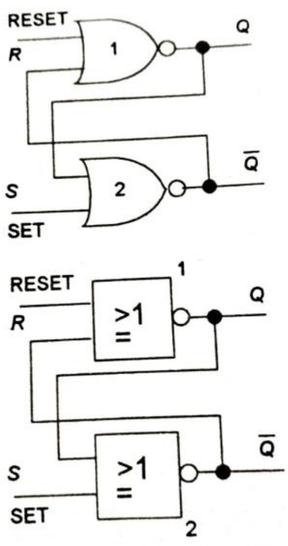


Fig. 14.35 SR flip-flop

S	R	$Q_t \rightarrow Q_{t+1}$	$\overline{Q}_t \rightarrow \overline{Q}_{t+1}$
0	0	$0 \rightarrow 0$	$1 \rightarrow 1$
0	0	$1 \rightarrow 1$	$0 \rightarrow 0$
0	1	$0 \rightarrow 0$	$1 \rightarrow 1$
0	1	$1 \rightarrow 0$	$0 \rightarrow 0$
1	0	$0 \rightarrow 1$	$1 \rightarrow 0$
1	0	$1 \rightarrow 1$	$0 \rightarrow 0$
1	1	Not allowed	
1	1	Not allowed	

Fig.(b) illustrates the realization of SR flip flops using NAND or NOR gates. Fig.(c) is its symbol. It behaves as a single bit memory cell but can be used for sequencing and triggering applications.

The process of storage of a bit is a king of 'Setting-Resetting' procedure. If the output 'Q' is '1' the flip-flop has been 'Set' and if the output is '0' the flip-flop has been 'reset'. The data bit to be stored is input through the input terminals and retrieved from the output terminals when needed.

In a digital system everything has to be carried out in a timely sequential manner. The clock input given to the SR flip-flop is to sequence the operation in terms of displaying the next-time status of the circuit. The outputs of the flip-flop depend on the status of the system. The next status depends on the current status of the input and output. When clocked, it displays the next time status.

JK FLIP-FLOPS:

A JK flip-flop is most versatile and frequently used in digital control systems. It has two data inputs like an SR flip-flop and a clock input. The two data inputs like an SR flip-flop and a clock input. The two data inputs are called the J & K terminals. It is like an SR flip-flop with additional logic circuits at the inputs that serve to overcome S R=1 1 state. Because of their basic operation and versatility JK flip-flops are used in designing registers, counters, encoders, decoders etc. Fig. shows the circuit diagram, truth table & symbol for JK flip-flop.

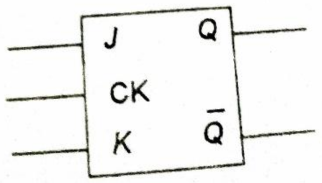


Fig. 14.41 JK flip-flop

J	K	$Q_t \rightarrow Q_{t+1}$	$\bar{Q}_t \rightarrow \bar{Q}_{t+1}$
0	0	$0 \rightarrow 0$	$1 \rightarrow 1$
0	0	$1 \rightarrow 1$	$0 \rightarrow 0$
0	1	$0 \rightarrow 0$	$1 \rightarrow 1$
0	1	$1 \rightarrow 0$	$0 \rightarrow 0$
1	0	$0 \rightarrow 1$	$1 \rightarrow 0$
1	0	$1 \rightarrow 1$	$0 \rightarrow 0$
1	1	$0 \rightarrow 1$	$1 \rightarrow 0$
1	1	$1 \rightarrow 0$	$0 \rightarrow 1$

D FLIP-FLOP:

D flip-flops are used in the design of an SR flip-flop in which the R terminal is shorted to the S terminal through a NOT gate (inverter). When clocked, the action takes place. Fig. (b) & (c) shows the truth table and symbol for flip-flop.

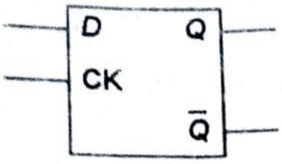


Fig. 14.44 Symbol for D flip-flop

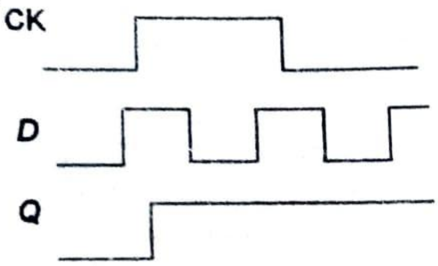


Fig. 14.45 Positive edge-triggered

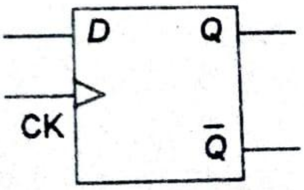


Fig. 14.46 Symbol for edge-triggered D flip-flop

CLOCK	D	Q
0	0	No Change
0	1	No Change
1	0	0
1	1	1

REGISTERS:

A register is a set of memory elements and is used to hold information until it is needed. It can be implemented by a set of flip-flops. Each flip-flop stores a binary signal i.e., a 0 or a 1. Fig. shows 4 bit register when using D flip-flops. When the load signal is 0, no clock input occurs to the D flip-flops.

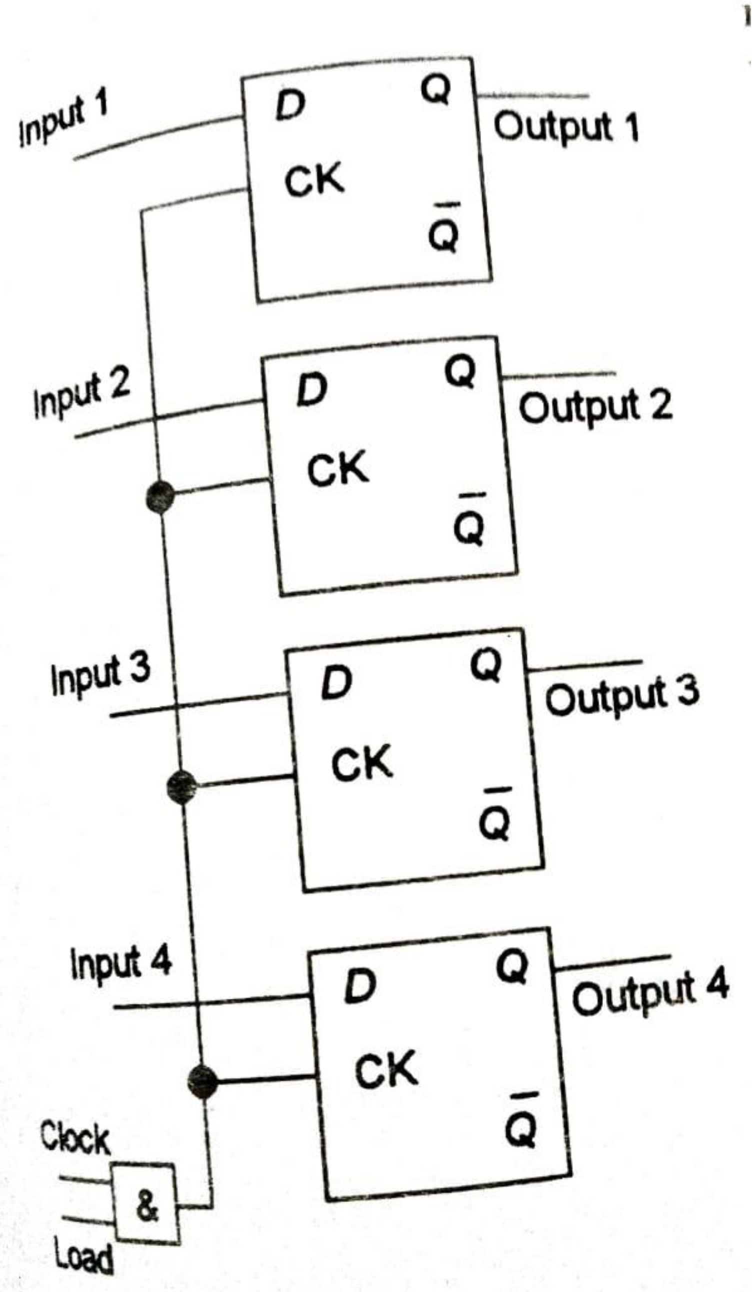


Fig. 14.48 Register

DATA PRESENTATION SYSTEMS

DISPLAYS: Data can be displayed as digits on a LED display or as a display on a computer screen and stored on a computer hard disc.

Measurement systems consist of three elements – sensor, signal conditioner and display or data presentation element. There are a wide range of elements that can be used for presentation of data. They have been classified into two groups.

1. Indicators and 2. Recorders

Indicators give an instant visual indication of the sensed variable while the recorders record the output signal over a period of time and give automatically a permanent record. The recorder is appropriate choice is the event is of high speed and cannot be followed by an observer or there are large amounts of data or it is essential to have a record of the data.

Both Indicators and recorders can be sub-divided into two groups 1) Analog devices and 2) Digital devices.

Eg., Ananalog indicator is a meter which has a pointer moving across a scale while digital meter has a display of a series of numbers.

Analog recorder is a Chart recorder which has pen moving across a moving sheet of paper while a digital recorder has the output printed out on a paper as a sequence of numbers.

DATA PRESENTATION ELEMENTS;

The commonly used data presentation elements are

1. Analog and Digital meters
2. Analog chart recorders
3. Cathode ray oscilloscope
4. Visual Display Unit
5. Printers

PRINTERS:

Printers provide a record of data on paper. The different types of printers are

The dot matrix printer, the ink/bubble jet printer and the laser printer.

Dot Matrix Printer:

The dot matrix printer has a print head (fig.) which consists of either 9 or 24 pins in a vertical line. Each pin propels the pin onto the inked ribbon. This transfers ink onto the paper. A character is formed by moving the print head in horizontal lines back & forth across the paper and firing the appropriate pins.

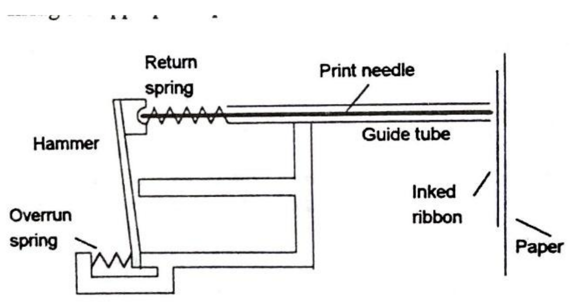


Fig. 4.9 Dot matrix print head mechanism

LASER PRINTER:

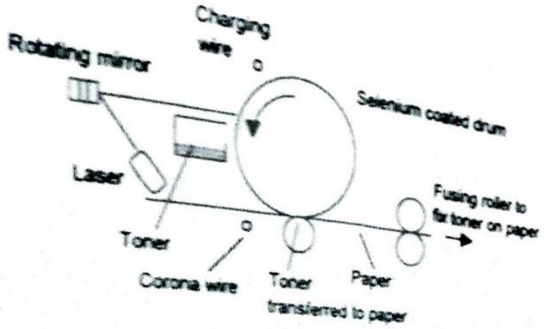


Fig. 4.12 Basic elements of a laser printer

The laser printer has a photosensitive drum which is coated with a selenium based light sensitive material (fig.). In the dark, the selenium has a high resistance and becomes charged as it passes close to the charging wire, this is a wire at a high voltage and off which charge leaks. A light beam is made to scan along the length of the drum by a small rotating eight-sided mirror. When light strikes the selenium, its resistance drops and it can no longer remain charges. By controlling the brightness of the beam of light, so drum can be discharged or left charged. As the drum passes through the toner reservoir the charged areas attract particles of toner which stick to the areas that have not been exposed to light and do not stick on the areas that have been exposed to light. The paper is given a charge as it passes close to another charging wire (corona wire), so that as it passes close to the drum, it attracts the toner off the drum. A hot fusing roller is used to melt the toner particles, so that after passing between rollers, they firmly adhere to the paper. General use laser printers are able to produce 600 dots per inch.

DISPLAYS:

Many display systems use light indicators to indicate on-off status or give alphanumeric displays with decimal points. One form of a display involves seven ‘light’ segments to generate the alphanumeric characters. Fig. shows the segments and table shows how a 4-bit binary code input can be used to generate inputs to switch on the various segments.

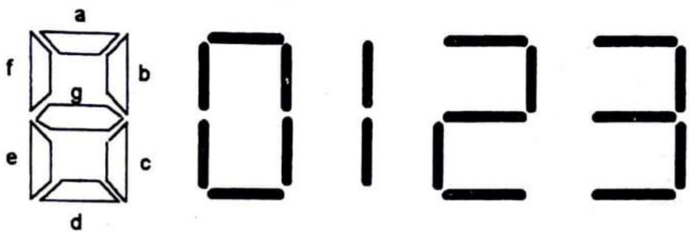


Fig. 4.24 Seven-segment display

Table 4.2 Seven-segment display

Binary input				Segments activated							Number displayed
				a	b	c	d	e	f	g	
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	0	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	0	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	1	1	1	0	0	1	1	9

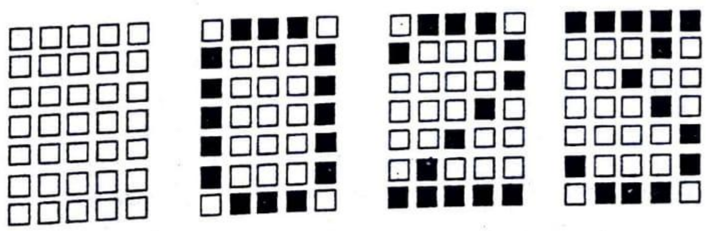
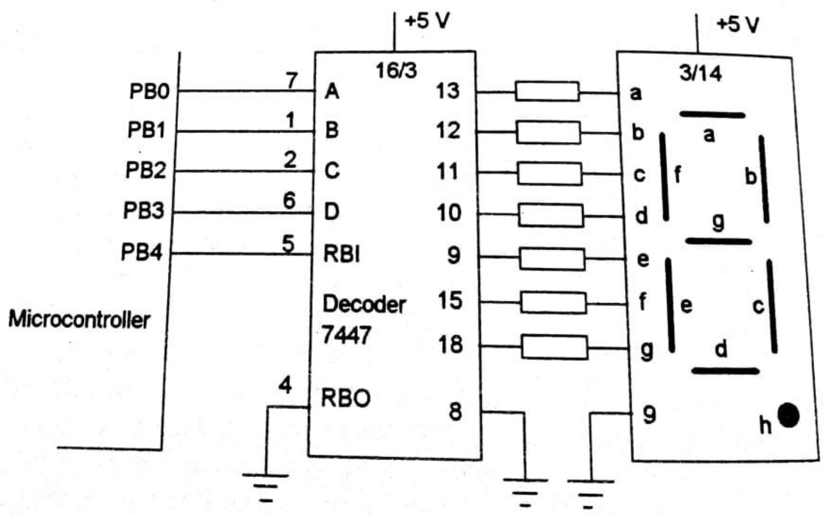


Fig. 4.25 7 by 5 dot matrix display

Another format involves a 7 by 5 or 9 by 7 dot matrix. The characters are then generated by the excitation of appropriate dots.

DECODER WITH A SEVEN SEGMENT DISPLAY:



Driving a display

Table 18.1 *7447 BCD decoder for a seven-segment display*

Display	Input pins 6	2	1	7	Output pins 13	12	11	10	9	15	14
0	L	L	L	L	ON	ON	ON	ON	ON	ON	OFF
1	L	L	L	H	OFF	ON	ON	OFF	OFF	OFF	OFF
2	L	L	H	L	ON	ON	OFF	ON	ON	OFF	ON
3	L	L	H	H	ON	ON	ON	ON	OFF	OFF	ON
4	L	H	L	L	OFF	ON	ON	OFF	OFF	ON	ON
5	L	H	H	L	ON	OFF	ON	ON	OFF	ON	ON
6	L	H	H	L	OFF	OFF	ON	ON	ON	ON	ON
7	L	H	H	H	ON	ON	ON	OFF	OFF	OFF	OFF
8	H	L	H	H	ON	ON	ON	OFF	OFF	OFF	OFF
9	H	L	H	L	ON	ON	ON	OFF	OFF	OFF	OFF

Consider where an output from a microcontroller is used to drive a seven segment LED display unit. A single LED is an on-off indicator and thus the display number indicated will depend on which LED's are ON. Fig. shows how we can use a microcontroller to drive a common anode display using a decoder driver, this takes BCD input and convert it to the appropriate code for the display.

For the 7447 decoder, pins 7,1,2 and 6 are the input pins of the decoder for the BCD input with pins 13,12,11,10,9,15 and 18 being the outputs for the segments of the display. Pin 9 of the display is the decimal point. Table shows the input and output signals for the decoder.

LIQUID CRYSTAL DISPLAYS:

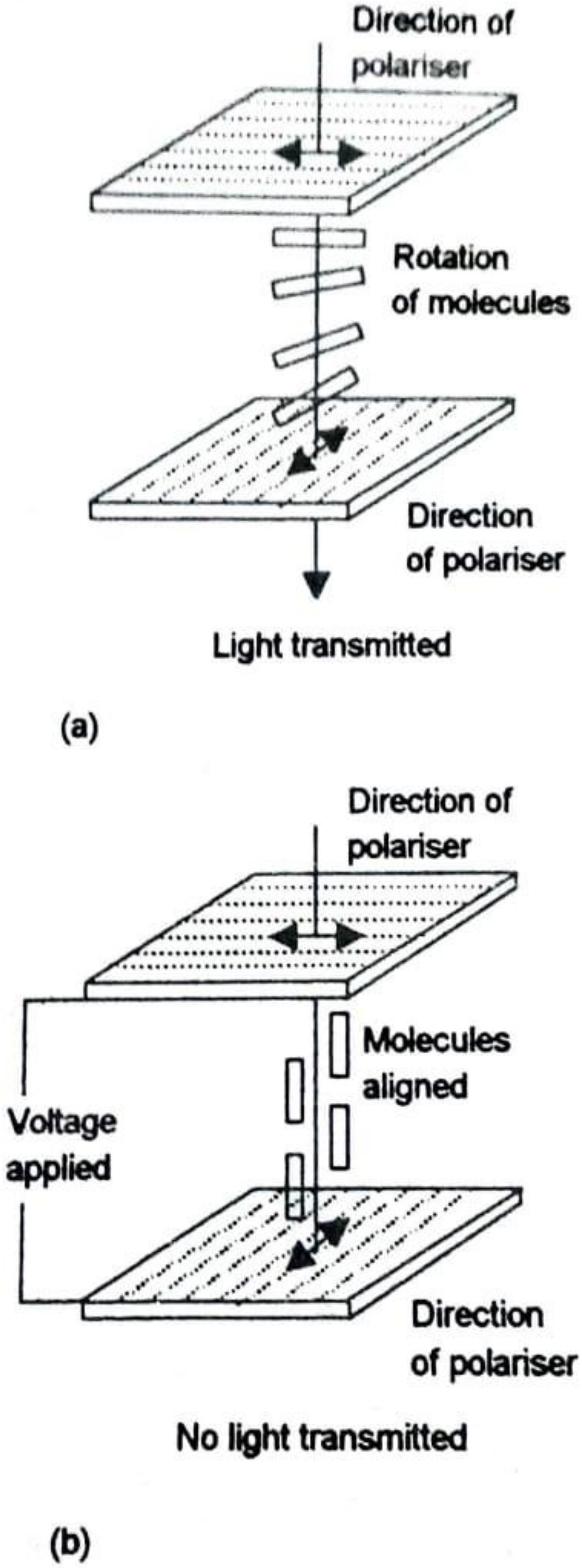


Fig. 4.31 Liquid crystal: (a) no electric field, (b) electric field

LCDs do not produce any light of their own but rely (depend) on reflected light or transmitted light. The liquid crystal material is a compound with long rod shaped molecules which is sandwiched between two sheets of polymer containing microscopic
grooves. The upper and lower sheets are grooved at 90^0 to each other. The molecules align with the grooves and adopt a smooth 90^0 twist between them.

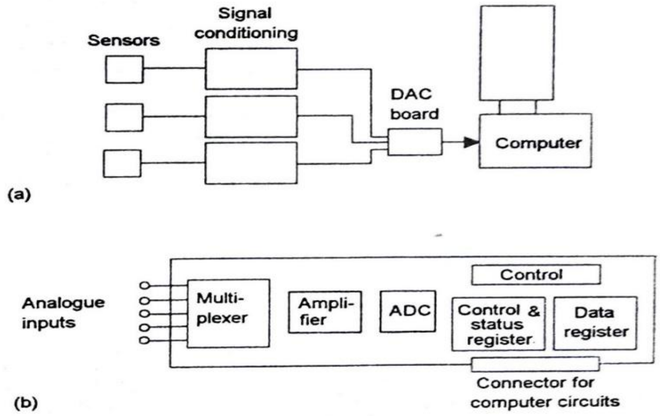
When plane polarized light is incident on the liquid crystal material, its plane of polarization is rotated as it passes through the material. The rotation allows the light to be transmitted and so the material appears light.

If an electric field is applied across the material, the light passing through the top polariser is not rotated and cannot pass through the lower polarizer but becomes absorbed. The material then appears dark.

The arrangement is put between two sheets of glass on which are transparent electrodes in the shape of the 7 segment display and thus the application of voltages to the various display elements results in them appearing black against the lighter display where there is no electric field. This form of display is used in battery operated devices such as watches and calculators. 5x7 dot matrix forms are also available.

DATA ACQUISITION (DAQ) SYSTEM:

The term data acquisition or DAQ is used for the process of taking data from sensors and inputting that data into a computer for processing. The sensors are connected via some signal conditioning, to a data acquisition board which is plugged into the back of a computer (fig.a). The DAQ board is a PCB that for analog inputs provides a multiplexer, amplification, A to D conversion, registers and control circuitry so that sampled digital signals are applied to the computer system. The signal conditioning prior to the inputs to the board depends on the sensors concerned, eg., it might be for thermocouples – amplification, cold junction compensation and linearisation; for strain gauges – wheatstone bridge, voltage supply for bridge and linearisation; for RTDs (Resistance Temperature Detectors) – current supply, circuitry and linearisation.



'ig. 3.45 DAQ system

Computer software is used to control the acquisition of data via the DAQ board. When the program requires an input from a particular sensor, it activates the board by sending a control word to the control & status register. Then, the board switches the multiplexer to the appropriate input channel. The input from the sensor is then passed via an amplifier to the A to D converter. Then the resulting digital signal is passed to the data register & the word in the control & status register changes to indicate the signal has arrived. Following that signal, the computer then issues a signal for the data to be read & taken into the computer for processing. This signal is necessary so that computer does not wait doing nothing while the board carries out its acquisition of data, but uses this to signal to the computer. When the acquisition is complete and then the computer can interrupt any program it is implementing, read the data from the DAQ & then continue with its program. A faster system does not involve the computer in the transfer of the data into memory but transfers the data directly from the board to memory without involving the computer, this is termed as Direct Memory Address (DMA).

The specifications for a DAQ board include the sampling rate for analog inputs, this might be 100 KS/s (100 thousand samples per second). The Nyquist criteria for sampling indicate that the maximum frequency of analog signal that can be sampled with such a board is 50KHZ, the sample rate having to be twice the maximum frequency component. In addition, it may also supply analog outputs, timers & counters which can be used to provide triggers for the sensor system.

DATA ACQUISITION SYTEMS:

Automated data acquisition systems can take the form of a dedicated instrument termed a data logger or a PC using plug-in DAQ boards.

Data Loggers:

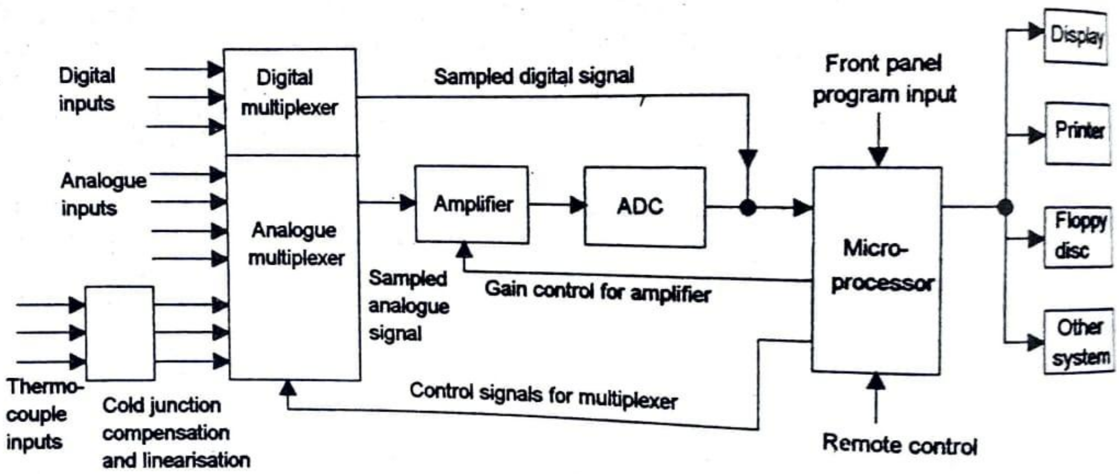


Fig. 4.33 Data logger system

Fig. shows the basic elements of a data logger system. It can monitor the inputs from a large number of sensors. Inputs from individual sensors after suitable signal conditioning, are fed into the multiplexer. The multiplexer is used to select one signal which is then fed after amplification, to the ADC. The digital signal is then processed by a microprocessor. The microprocessor is able to carry out simple arithmetic operations, taking the average of a number of measurements. The output from the system might be displayed on a digital meter that indicates the output and channel number, used to give a permanent record with a printer, stored on a pen drive or transferred to a computer for analysis.

The multiplexer can be switched to each sensor inturn and so the output consists of a sequence of samples. Scanning of the inputs can be selected by programming the microprocessor to switch the multiplexer to sample a single channel, carry out a single scan of all channels or periodic scan of all channels say every 1,5,15,30 or 60 minutes.

Typically, a data logger may handle 20 to 100 inputs, some handle 1000 inputs. It might have a sample and conversion time of 10 μs and be used to make 1000 readings per second. The accuracy is about 0.01% of full scale input and linearity is about ±0.005% of full scale input. Cross-talk is 0.01% of full scale input on any one input.

CRITERIA FOR SELECTION OF DAQ BOARDS:

In selecting the DAQ board to be used, the following criteria have to be considered.

1. What type of computer software system is being used. Eg., windows, MacOS?
2. What type of connector is the board to be plugged into.Eg., PCMCIA for laptops, NuBus for MacOS, PCI?
3. How many analog inputs will be required and what are their ranges.
4. How many digital inputs will be required?
5. What resolution will be required?
6. What is the minimum sampling rate required?
7. Are any timing or counting signals required?

All DAQ boards use drivers supplied by manufacturer. Before a board can be used three parameters have to be set. These are the addresses of the input and output channels, the interrupt level and the channel to be used for Direct Memory Access.