MODULE - III

Multiple Choice Type Questions

1. An 8-bit DAC has a maximum output voltage of 2V. If $V_{in} = 1.5V$, the digital output at the end of conversion will be [WBUT 2009, 2016]
   a) 0001 1100 b) 0010 0011 c) 0110 0000 d) 1100 0000
Answer: (d)

2. Which type of network connectivity is generally supported by DCS? [WBUT 2009, 2014]
   a) LAN b) MAN
   c) WAN d) none of these
Answer: (a)

3. CSMACD protocol is used in case [WBUT 2009, 2015]
   a) Ring topology b) Bus topology c) Star topology d) none of these
Answer: (b)

4. Fuzzy rule engine does the which of the following functionalities? [WBUT 2009, 2016]
   a) Generates the output b) Fuzzifies the input
   c) Determines the rule of fuzzy logic d) None of these
Answer: (c)

5. Fuzzy concept applies to the imprecision in [WBUT 2010, 2015]
   a) calculation b) logic c) data d) none of these
Answer: (b)

6. Network protocol used in multi-drop DCS communication is [WBUT 2010, 2014]
   a) Token bus b) Token ring c) both (a) and (b) d) TCP/IP
Answer: (d)

7. In fuzzy-logic system, the membership function is part of [WBUT 2011, 2014, 2018]
   a) rule base b) data base
   c) fuzzification technique d) none of these
Answer: (b)

8. Which one of the following is not a possible value of membership function in fuzzy logic? [WBUT 2011, 2017]
   a) 0.5 b) 1.5 c) 0.05 d) 0.95
Answer: (b)

9. Network type used by time division multiplex access (TDMA) protocol is [WBUT 2011, 2017]
   a) Ring topology b) Bus topology
   c) Star topology d) None of these
Answer: (b)

10. What are the maximum number of Fuzzy input membership functions that can have in Fuzzy Controller [WBUT 2015]
a) 5 b) 7 c) 3 d) 4
Answer: (c)

11. DCS architecture is [WBUT 2015, 2016]
a) physically distributed
b) functionally distributed
c) both physically and functionally distributed
d) not actually distributed
Answer: (c)

12. Token passing communication mode uses protocols [WBUT 2015]
a) FOUNDATION filed bus b) MODBUS
c) PROFIBUS d) none of these
Answer: (d)

13. Fuzzy rule engine does which of the following functionalities? [WBUT 2015]
a) generates the output b) fuzzifies the input
c) determines the rules of fuzzy logic d) none of these
Answer: (d)

14. An example of an industrial control system is [WBUT 2016, 2018]
a) PLC b) DCS
c) both PLC & DCS d) None of these
Answer: (c)

15. Which network protocol is used in MULTIDROP type DCS? [WBUT 2016]
a) Token ring Protocol b) Token Bus or CSMA/CD protocol
c) IP protocol d) TCP protocol
Answer: (b)

16. Which type of isolator is generally used in I/O module of PLC? [WBUT 2016]
a) Electrical isolator b) Optical isolator
c) Magnetic isolator d) Electronic isolator
Answer: (b)

17. The effect of cross-talk is reduced in [WBUT 2017]
a) thick coaxial cable b) twisted pair cable
c) thin coaxial cable d) all of these
Answer: (b)

18. Redundancy is a feature of [WBUT 2018]
a) supervisory control system b) distributed control system
c) open control system d) field control system
Answer: (d)

Short Answer Type Questions

1. What are the different International Field Bus standards for DCS? What is meant by data highway? Why is fiber optic more attractive for data highway design?
[WBUT 2010, 2014, 2016]

Answer:

DCS fieldbus Standard:

A fieldbus, which is a low-cost protocol, is necessary to perform efficient communication between the DCS and deuices that may be obtained from different vendors.

Presently there are several regional and industry based fieldbus standards, including the French standard (FIP) the German Standard (profitbus), and proprietary standards by DCS vendors.

International standards organizations have adopted there fieldbus standards rather than a signal unifying standard. There will be a further development at the standards in future.

Table: Comparison of field buses

Bus	Category	Physical media	Number of devices	Distance	Speed	Power from bus
ASI	Sensor	Twisted pair	31	100 m	167 kbps	Yes
Seriplex	Sensor	4-wire shielded	500	150 m	200 Mbps	No
CAN	Sensor	Twisted pair	127 nodes	25 m to 1 km (speed dependent)	10 kbps to 1 Mbps	No
Device net	Device	Twisted pair	64	500 m (6 km with repeater)	125 kbps to 500 kbps	No
LON works	All	Twisted pair fiber power line	32,000 per domain	2 km @ 78 kbps	1.25 Mbps	Yes
Profibus DP/PA	Field bus	Twisted pair fiber	127 nodes	100 m twisted pair 24 km fiber	DP: 500 kbps PA: 31.25 kbps	PA: Yes
Foundation (HI)	Field bus	Twisted pair fiber	Unlimited	100 m twisted pair 2 km fiber	100 Mbps	No
Industrial Ethernet	Field bus	Twisted pair fiber coax	Unlimited with routers	100 m twisted pair 2.5 km fiber	10 Mbps 100 Mbps	No

In process control:

The **data highway** is the communications device that allows a distributed control system to lineup to its name, permitting distribution at the controlling function throughout a large plant area. Data highways vary in length as a functions at traffic capability and speed transmission.

Fiber optics mainly preferred for data highways because:

i) It eliminates problems of electromagnetic and radio frequency interference, ground loops and common mode voltages.

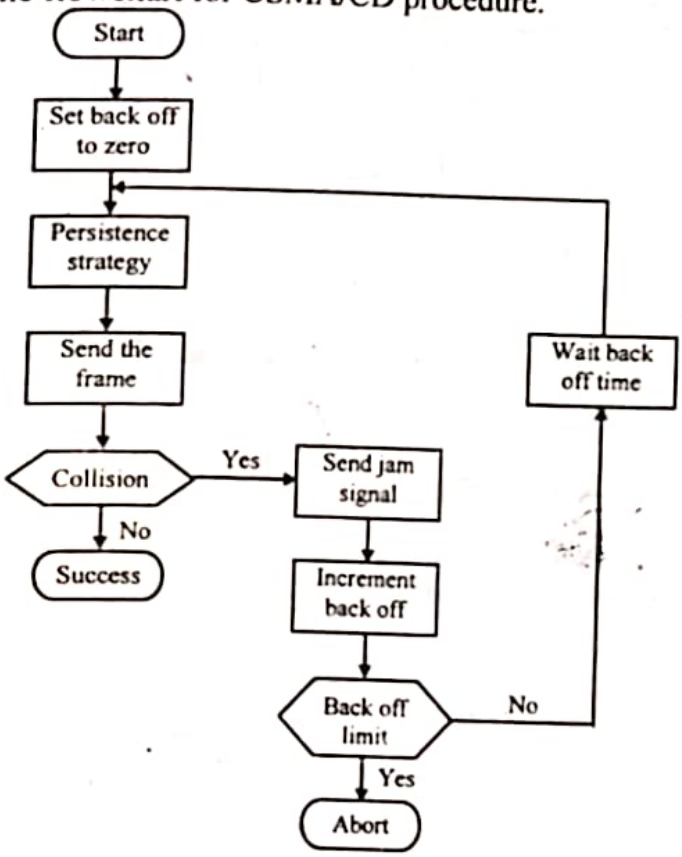
ii) It is safe in explosive or flammable environment

iii) It can carry mare information the copper conductors.
iv) It is higher and easier to handle then co-axial cable.

2. Describe the CSMA/CD procedure with the help of flow chart. **[WBUT 2014]**

Answer:

Figure below how the flowchart for CSMA/CD procedure.



3. Compare between analog, hybrid and digital communication techniques used in process automation networks. **[WBUT 2015, 2017]**

Answer:

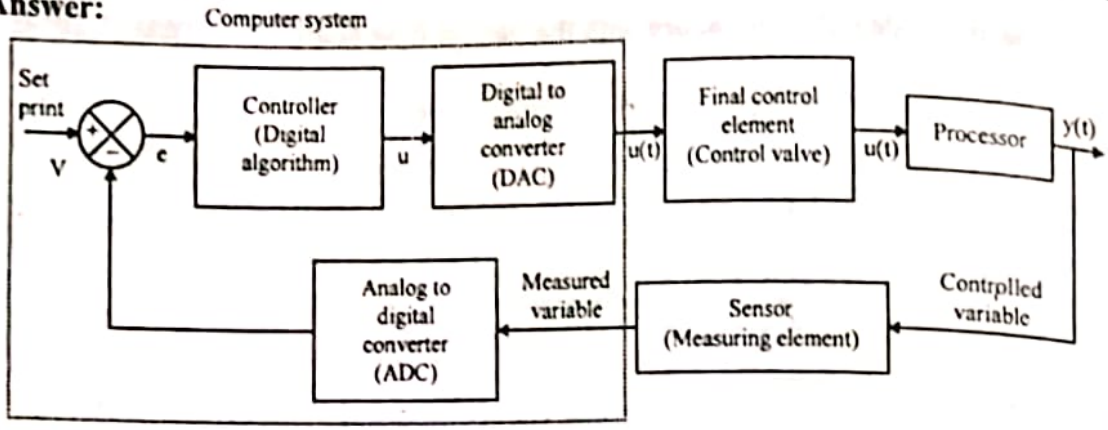
A comparison between the conventional 4–20 mA analog transmission, hybrid communication, and digital (fieldbus) communication protocols is given in Table 1.

Table 1: Comparison of analog, hybrid and digital communication protocols

Communication	Analog	Hybrid	Digital (Fieldbus)
Topology	One-to-one	One-to-one	Multidrop
Transmission method	4–20 mA dc analog signal	4–20 mA dc analog and digital signals	Digital signal
Transmission direction	One-way	One-way (analog signal) and bi-directional (digital signal)	Bi-directional
Type of signal	Single signal	Partially multiplexed	Multiplexed signal
Standard	Standardized	Differs depending on manufacturers	Standardized

4. Draw a block diagram showing different hardware components of digital computer control loop. [WBUT 2016]

Answer:



5. Explain the structure of a distributed control system with a neat sketch. Discuss the function of its various units. [WBUT 2017]

Answer:

Refer to Question No. 2(a) of Long Answer Type Questions.

6. Draw the basic block diagram of a fuzzy logic based control system (Mamdani's model) and briefly describe the role of each block. What is fuzzification? [WBUT 2018]

Answer:

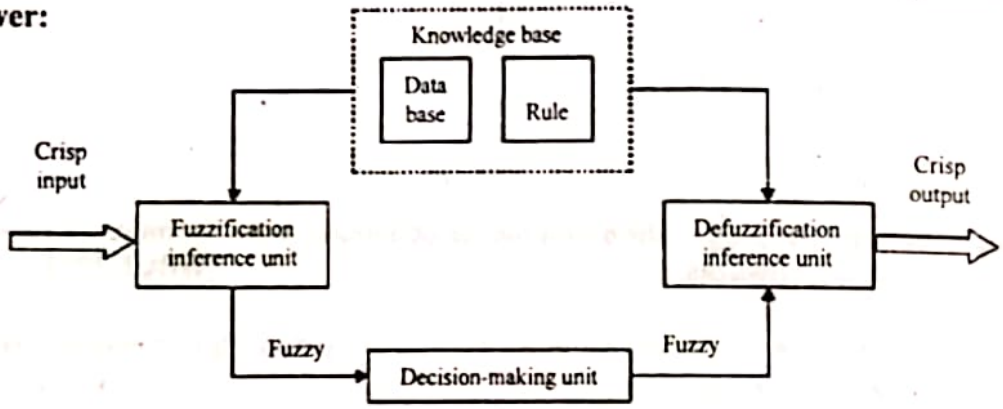


Fig: Mamdani's model

Functional Blocks of Frequency Inference System:

The following five functional blocks will help us to understand the construction of FIS –

- **Rule Base** – It contains fuzzy IF-THEN rules.
- **Database** – It defines the membership functions of fuzzy sets used in fuzzy rules.
- **Decision-making Unit** – It performs operation on rules.
- **Fuzzification Interface Unit** – It converts the crisp quantities into fuzzy quantities.
- **Defuzzification Interface Unit** – It converts the fuzzy quantities into crisp quantities. Following is a block diagram of fuzzy interference system.

Working of FIS

The working of the FIS consists of the following steps –

- A fuzzification unit supports the application of numerous fuzzification methods, and converts the crisp input into fuzzy input.
- A knowledge base - collection of rule base and database is formed upon the conversion of crisp input into fuzzy input.
- The defuzzification unit fuzzy input is finally converted into crisp output.

7. Discuss the comparison of field buses. **[MODEL QUESTION]**

Answer:

Table below shows some of the field buses in use in the process industry and gives their approximate properties as previously defined. Some of the buses use the Ethernet for layer-1 but it is possible to simply use the Ethernet directly without the other protocol. The advantage to this is that Ethernet is an old and established system and its widespread use for LANs and office automation in general makes it a very familiar technology. Two other field buses which are in wide use throughout the world are (1) Foundation field bus and (2) Profibus (Process field bus).

Table: Comparison of field buses

Bus	Category	Physical media	Number of devices	Distance	Speed	Power from bus
ASI	Sensor	Twisted pair	31	100 m	167 kbps	Yes
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Foundation (H1)	Field bus	Twisted pair fiber	Unlimited	100 m twisted pair 2 km fiber	100 Mbps	No
Industrial Ethernet	Field bus	Twisted pair fiber coax	Unlimited with routers	100 m twisted pair 2.5 km fiber	10 Mbps 100 Mbps	No

Long Answer Type Questions

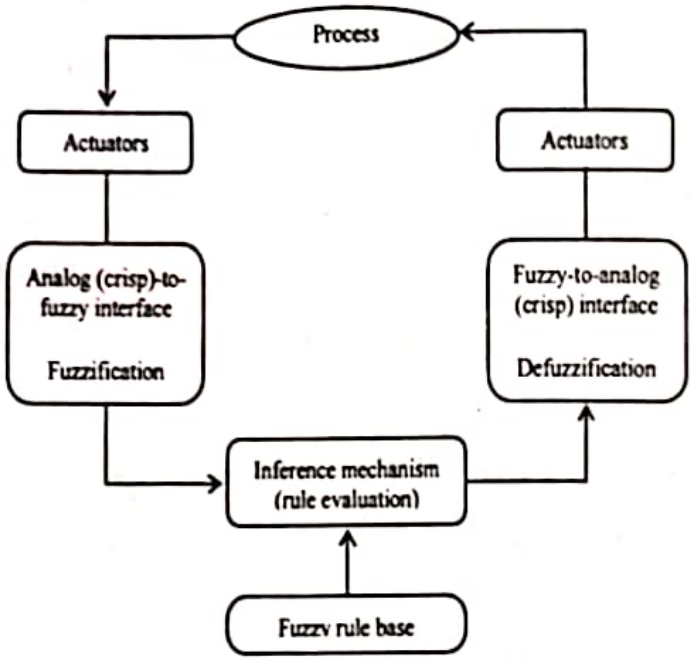
1. a) What is Fuzzy Logic? Describe a Fuzzy logic controller operation with block diagram. **[WBUT 2009, 2012, 2015]**

b) What is gateway connectivity in DCS? Describe the generic gateway in DCS. How many types of gateway configurations are there in DCS? **[WBUT 2009, 2015]**

c) Describe one of the more efficient DCS system with schematic diagram. **[WBUT 2009, 2015]**

Answer:

a) Fuzzy logic is a departure from classical two-valued sets and logic, that uses "soft" linguistic (e.g., large, hot, tall) system variables and a continuous range of truth values un the interval [0,1] rather than strict binary (True or False) decisions and assignments.
Fuzzy logic incorporates a simple, rule-based approach to solved a control problem rather then attempting to model a system mathematically. The FL model is an empirical model which is based on an operator's experience.



Fuzzy logic control system components

Components of Fuzzy Logic Control System

Fuzzy controllers consist of an input stage, a processing stage, and an output stage. The input stage mapes sensor or other inputs to the appropriate membership functions and degree of membership. The processing stage invokes appropriate rules and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a crisp control output value.

b) & c) Supervisory computers are interfaced to the DCS through a gateway, which is constructed to receive the data or messages from an originating source. The gateway resides on nodes of the local control network or data communication network of the DCS. Usually, the communication network topology is either a ring or bus type.
The modes on the communication network consist of the operator console, engineering console, process control unit, controller subsystem, and gateway. The gateways are usually configured through the DCS from the engineering console to establish a list of variables associated with the tag names of interest in the DCS node on the gateway data table.

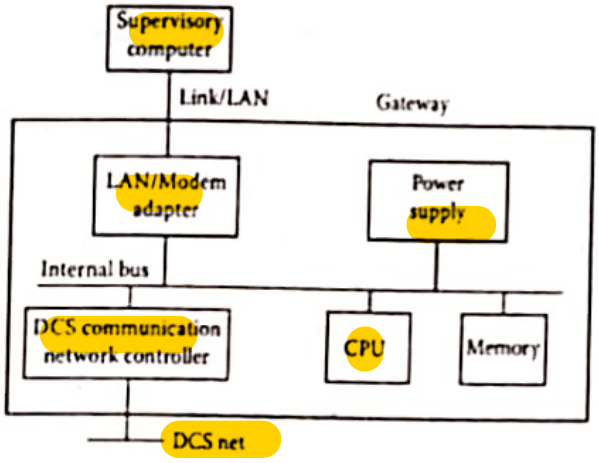


Fig 1: Generic Gateway

The gateway device collects the listed data from the DCS communication network or data highway and transfers them to the supervisory computer through a different communication link or network. At the same time, the gateway also receives the data from the supervisory computer or nodes on the computer local area network (LAN) and transfers these to the nodes of the DCS where the information was requested.

Two types of computer connections are explained here using Honeywell's configuration of the gateway to illustrate the functionality of each type. Type one, called a computer gateway, communicates with a computer via a dedicated link, as shown in Figure 2. Type two is the plant network module, which communicates with computers through LAN. The computer LAN usually differs from the proprietary DCS network in communication speed and protocol. This is shown in 3.

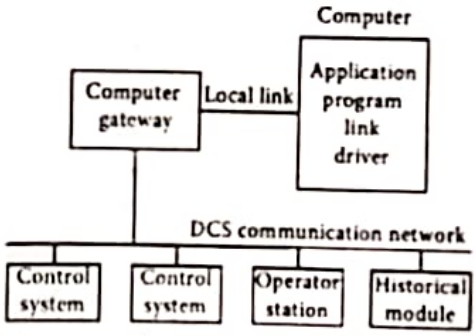


Fig 2: Gateway for supervisory computer and DCS

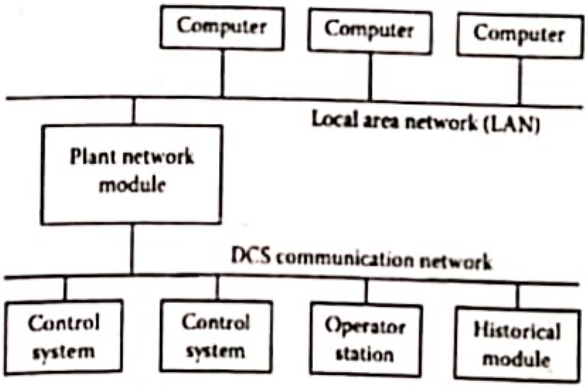


Fig 3: Gateway for computer LAN and DCS

The physical connection of the LAN is typically a bus-type topology.
One approach for computer-integrated manufacturing is to design the hardware and software for the gateway such that integration of manufacturing or process data and plant management information can be achieved easily. Such an interface gateway or network module requires:

1. Highly efficient information communication between the DCS network data or messages and the data or messages in the computers on the LAN nodes
2. High security and reliability for both the DCS network access and the computer LAN access.

2. a) Explain the structure of a distributed control system with a neat sketch. Discuss the functioning of its various parts.
b) What is a network access protocol? Discuss the methods used for distributed control highways.
c) What are the advantages of distributed control system?
d) How is fuzzy logic different from crisp logic? **[WBUT 2010, 2016]**

Answer:

a) DCS Structure

In a DCS, actual command and data topology of the system can be partitioned into either hierarchical structures or hierarchical structures.

Hierarchical structures have distinct command and data paths such that each element receives command from the level above it and sends information back to that level on the basis of information received from the elements at the same level. high level control may, for example, be more concerned with the overall performance strategy of the plant rather than immediate control of the plant environment. The control hardware on the lower level would deal more with digital control schemes to handle PID or adaptive control strategies.

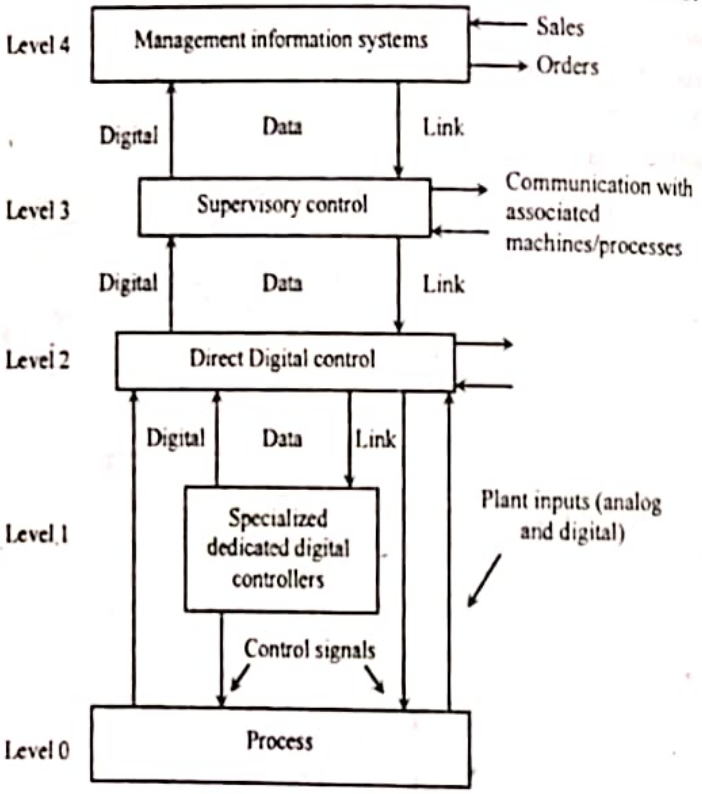


Fig: Hierarchical DCS

The most commonly used DCS structure with hierarchical levels is shown above. At first place, there are transducers and controllers installed in close proximity to the process.

The I/O parameters are communicated to the next level of controllers (which are usually computers) placed in the control room. Further monitoring is done by the supervisory control, which is at the next level in the hierarchy. Finally, the management level is at the highest level in the hierarchy; it manages and coordinates the entire system for the smooth functioning of the same. The detailed function of each is listed below.

Level 0: (Basic control) Control of basic parameters using PID type of regulatory control.

Level 1: (Advanced control) Dynamic computer control using certain advanced control techniques such as product quality control, feedforward control, adaptive gain control, local optimization, etc.

Level 2: (Real time supervisory systems) Real time data reconciliation, optimization of process units, computation of performance indicators, control of product movement, optimization of set points with minimization/maximization of suitably defined objective functions while ensuring quality and quantity of production.

Level 3: (Decision support system for production management) Scheduling, maintenance management, overall mass balance, product movement management, and spare scheduling.

Level 4: (Production and distribution corporate management) Operations research techniques for planning, database management systems, accounting facilities, staff management.

b) The term **"network access protocol"** is collectively used for the set of link layer (operational level) and network layer (physical level) protocols, which operate together in order to regulate and share control of data packets -- data associated with address and communication session management -- within a closed network hierarchy.

There are a number of communication methods used for distributed control highways, as follows:

- By placing a traffic controller on the highway to grant transmitting privileges based upon polling the various stations on the highway, or following a priority controlled sequence.
- By passing a token from station to station, granting it mastership. During the time it has the token, the station can communicate with any or all stations. When it has completed its transmitting tasks, which may not exceed a maximum time (typically a few milliseconds), its passes the token to the next station determined by a predetermined sequence. Some devices, such as an operating station, require more time than other stations, and may be in a high-priority loop, allowing the transmit when the low-priority stations have nothing to say.
- By using carrier sense multiple access (CSMA) in which all stations listen all the time. Any station that needs to transmit can do so, providing no other station is already transmitting. If two stations start simultaneously, both will stop and the higher-priority station begins after waiting a period of time.
- By broadcasting a shared memory from each station, making it available to every other station. The shared memory serves as an interface between the input circuitry of the station device and a high way controller device. Process input data is scanned

and stored in shared memory. The data is taken from memory once a second and broadcast, accessible to all stations. If any other station needs information, its data highway controller listens for the data and places what it needs in its shared memory section. The station input section then takes the data from the shared memory when it needs to execute a control or output display information.

c) The main advantages of distributed control system are:

1. Reduced installation and wiring cost
2. Higher operating efficiencies
3. Flexibility- Control function at each part of the system can be altered by software. There is to alter hardware settings.
4. Increase process safety.
5. Greater centralized of control function, e.g, more loops per operator.

Fuzzy logic is a departure from classical two-valued sets and logic, that uses "soft" linguistic system variables a continuous range of truth values in the interval [0,1], rather than strict binary decisions and assignments.

An ordinary/crisp set has only two membership states: inclusion and exclusion, true and false; while fuzzy set allows degree of memberships over the interval [0,1].

Crisp/classical logic interpolates the input into a crisp set.Every element in the universe of discourse, X, either belongs or does not belong to a set. For example, the element in the universe of discourse, X, belons to the set A or does not belong to A can be represented by the following function

$$\mu_A(x) = \begin{Bmatrix} 1 if (x \in A) \\ 0 if (x \notin A) \end{Bmatrix}$$

d) 'Crisp' in fact comes from the Latin *crispus*, which means either curly (especially of hair) or undulating, vibrating, in motion. It came to apply to a form of mortar that gave a rough, shaggy surface to walls, i.e., it made them 'fuzzy'. In modern English, it has come to refer to vegetables like lettuce, which are fresh and firm when they are 'crisp', or to food which is badly burnt ('burnt to crisp') and hence, to food which is well cooked till it is firm, as in 'potato crisps'.

So 'crisp' becomes a curious word to use, to oppose to 'fuzzy', since it contains within itself a tendency towards irregularity, even indeterminacy. Just as 'simple' still contains within itself a degree of 'complexity' through the common root of *plec*, so 'crisp' is less fuzzy than 'fuzzy' but it is not entirely flat. It lies on the same continuum as 'fuzzy', and the boundary between the two is 'fuzzy', not 'crisp' (in Zadeh's terms), or not absolute. But this is far from being a problem with the two terms. It makes their relationship to each other as fuzzy as it ought to be, in a theory of fuzzy logic.

3. Draw the basic architecture of a DCS. Why is it called "distributed"? What is a gateway in a DCS? **[WBUT 2011, 2018]**

Answer:

Refer to Question No. 2(a) of Long Answer Type Questions.

The main concept of distributed computer control system is that it distributes information and control functions that previously required a central computer. It implies that the actual control and management functions are distributed throughout the plant. They are not concentrated in a specific geographic location (control room) or around a single central computer. So it is called "distributed".

In process control plant supervisory computers are interfaced to the DCS through a gateway, which is constructed to receive the data or messages from an originating source. The gateway resides on nodes of the local control network or data communication network of the DCS. Usually, the communication network topology is either a ring or bus type.The modes on the communication network consist of the operator console, engineering console, process control unit, controller subsystem, and gateway. The gateways are usually configured through the DCS from the engineering console to establish a list of variables associated with the tag names of interest in the DCS node on the gateway data table. The gateway device collects the listed data from the DCS communication network or data highway and transfers them to the supervisory computer through a different communication link or network. At the same time, the gateway also receives the data from the supervisory computer or nodes on the computer local area network (LAN) and transfers these to the nodes of the DCS where the information was requested.

A typical diagram of gateway is given below-

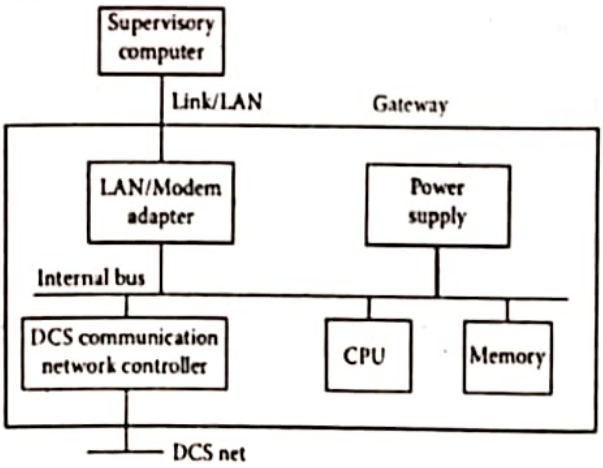


Fig 1: Generic Gateway

4. Draw the block diagram of a fuzzy control loop with respect to a process plant and explain its every part. What is the difference between a normal set and fuzzy set? [WBUT 2014, 2016]

Answer:

1st Part:

A block diagram of the closed-loop fuzzy control system is shown in figure below. The reactor's measured variables are neutron power, $n(t)$ and reactor period, T. The control input $\rho_{ext}(t)$ represents the external reactivity applied to the reactor by the insertion or withdrawal of the control rod. The crisp inputs to the fuzzy controller are T and the

normalized percentage of the neutron power deviation from its setpoint, %pd. The block diagram of the closed-loop fuzzy control system is shown in figure below, where the reactor behavior (controlled system) is simulated using the system's equations (1), $\rho_{ext}(t)$ is the system input variable (control variable) and $n(t)$ is the system output variable (controlled variable).

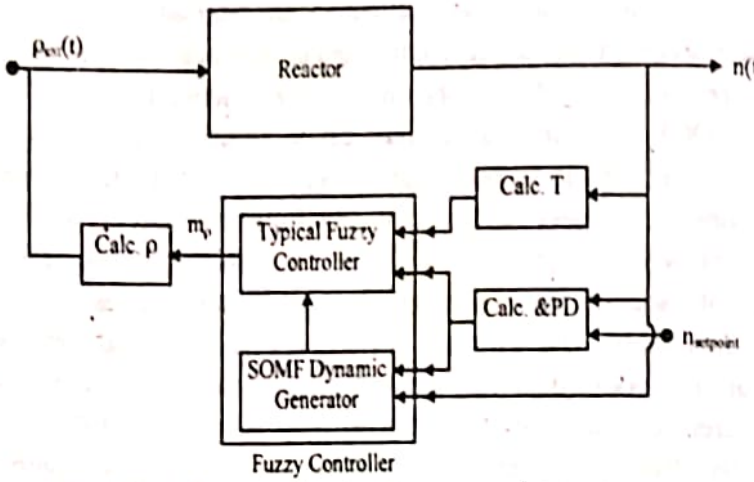


Fig: Block diagram of reactor fuzzy control system

One of the crisp input variables to the fuzzy controller is the reactor period (T), which represents the time required by the power, at any instant of time, to be increased by a factor "e", considering that the neutron power rate of change is kept constant. The reactor period has a universe of discourse from 0 to infinite seconds and is evaluated for simulation purposes as

$$T = \frac{t - t_i}{\ln\left(\frac{n(t)}{n(t_i)}\right)}$$

where $n(t) \neq n(t_i)$. The other crisp input to the fuzzy controller is the normalized percentage of the neutron power deviation from its setpoint, called %PD, which is computed by the expression

$$\%PD = \frac{n(t) - n_{setpoint}}{n_{setpoint} - n_0} \times 100\%$$

for which the universe of discourse takes on values from -110% to ±10%.

Each pair of crisp input variables to the fuzzy controller produces one crisp output variable, m_ρ, representing the rate of change of external reactivity. Once m_ρ is defined, it is used in the following expression, to obtain the external reactivity, $\rho_{ext}(t)$ (control variable):

$$\rho_{ext}(t_i) = \rho_{ext}(t_{i-1}) + m_\rho(t_i - t_{i-1})$$

Two blocks can be identified within the fuzzy controller the upper block is the typical fuzzy controller, whereas the lower one represents the SOMF dynamic generator.

2nd Part:

In classic sets, the transition of an element in the universe between being a member and non member in a given set is abrupt. In fuzzy sets, this transition occurs gradually A fuzzy set is a set containing elements that have varying degree of membership in the set. Accordingly, elements in a fuzzy sets can be members of other fuzzy set on the same universe. Elements of fuzzy sets are mapped to a universe of membership values using a function-theoretic form. His function maps elements of fuzzy set A to a real numbered value between 0 and 1.

5. Write down the main features of DCS. Draw and explain with the hierarchical block diagram of DCS. What is redundancy? What is batch processing?

[WBUT 2014, 2016]

Answer:

1st Part:

Features of DCS

The DCS architecture provides a single window to the process and control systems so that it can perform the following functions:

- Monitor and manipulate the process
- Retrieve historical data (batch history is required to facilitate display and analysis of key characteristics within a batch and between batches of similar types)
- Configure the system
- Build schematic displays
- Develop control programs
- Diagnose system failures.

The DCS manufacturers are offering smaller distributed control systems that fit at or slightly above the largest canned operator interface units and are smaller in size than the large DCS offerings. These smaller systems contain much of the power of the larger systems but are oriented towards smaller applications. They provide fewer graphic displays, I/O and front-end devices.

2nd Part: ***Refer to Question No. 2(a) of Long Answer Type Questions.***

3rd Part:

Redundancy in process control systems mean that system components, such as field-level, operating and monitoring units, and/or bus systems, are present two or more times. The types of redundancy practiced in technical systems are as follows:

Static redundancy

Instead of a single component, several components are installed in parallel. The system as a whole performs in the intended way as long as at least one unit is free of defects.

Dynamic backup redundancy

In case of malfunction, an additional components is switched in to replace the defective component. The additional component is not in operation when no malfunction is present.

- **Local dynamic backup redundancy**
  Assigned to every component is a redundant component, which is continuously reconfigured (hot standby).
- **Global dynamic backup redundancy**
  A redundant component is assigned to several components. In case of a malfunction, the redundant component is configured once (warm standby).
- **Dynamic functional redundancy**
  When no malfunction is present, the redundant component performs its own tasks; if a malfunction occurs, it takes over the functions of the defective unit by restricting the capacity or shutting down inessential functions.

Backup

The general term "backup" refers to dynamic backup redundancy for a single process measurement and control function, such as control.

4th Part:

A process in which the materials or work are stationary at one physical location while being treated is termed a 'Batch Process'. Batch processes are most often of the thermal type where materials are placed in a vessel or furnace and the system is controlled for a cycle of temperatures under controlled pressure for a period of time. Batch or Hood annealing of steel rolled coils, steel melting in Bessemer converters, coke making in coke ovens, furnaces in foundries, batch reactors in chemical plants etc. are some of the familiar batch processes. Idlies making in kitchen is one of the simplest example of batch process.

Batch processes are nearly always defined by temperature, pressure or associated conditions such as composition. The degrees of freedom are usually well-defined. The purpose of such processes is to produce one or more products at (a) a given composition, (b) a maximum amount and (c) best economy (employing least materials, energy and time). In short production rate (quantity), quality and economics are all to be taken care of.

6. a) Describe the CSMA/CD and token pass network access methods.
[WBUT 2015, 2017]

b) Discuss the structure of bus, ring and star topology with proper diagram.
[WBUT 2015, 2017]

OR,

Explain bus topology, ring topology and star topology with proper diagram.
[WBUT 2016]

c) Explain the transmission scheme of analog and digital signal through the same link in hybrid network. **[WBUT 2015, 2017]**

Answer:

a) 1st Part:

CSMA/CD is a modification of pure Carrier Sense Multiple Access (CSMA). The CSMA/CD - Carrier Sense Multiple Access with Collision Detection is a network access

technology that enables devices of Ethernet based LANs to check the channel for carrier availability before beginning to transmit data. A device transfers information in absence of a carrier. A collision occurs when two stations try to transmit at the same time and is resolved when a device transmits data after a random time interval.

CD (collision detection) defines what happens when two devices sense a clear channel, then attempt to transmit at the same time. A collision occurs, and both devices stop transmission, wait for a random amount of time, then retransmit. This is the technique used to access the 802.3 Ethernet network channel. This method handles collisions as they occur, but if the bus is constantly busy, collisions can occur so often that performance drops drastically.

2nd Part:

Token-Passing Access Method:

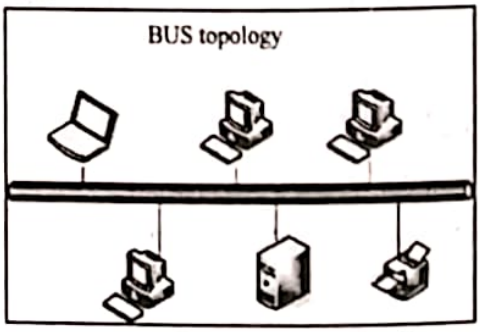
In token passing, a special type of packet, called a token, travels around a cable ring from computer to computer. When any computer on the ring network needs to send data across the network, it waits for a free token. When a free token is detected, the computer takes it. The computer can then transmit data. Computer sends data along with address information in the form of headers and trailers in frames.

While the token is in use by one computer, other computers cannot transmit data. Because only one computer at a time can use the token, no contention and no collision take occur and no time is spent waiting for computers to resend tokens due to network traffic on the cable.

b) Network topologies are categorized into the following basic types:

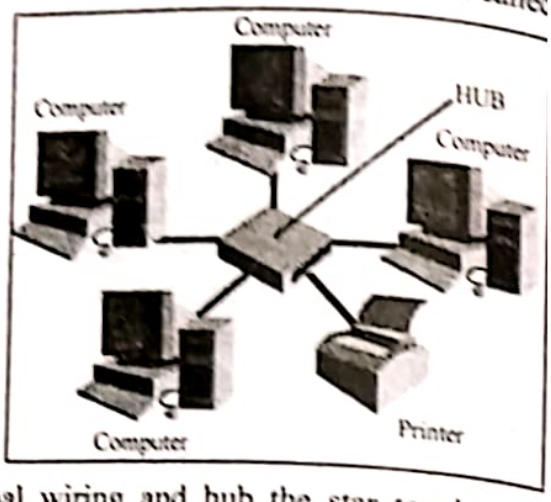
- bus
- star
- ring

A **bus topology** is the least complicated network configuration; it makes use of a single transmission medium called a coaxial cable. In most instances the cable is many different lengths joined by a T-connector, which allows the cable to divide into various directions enabling other computers to be connected to the network.



There exist several limitations with a bus topology. There is a limit to the number of computers that can be connected via a bus topology: The strength of the signal weakens as it travels along the cable, so if more computers need to be added to a network using a bus topology, a repeater will be needed at fixed intervals to strengthen the signal. A major problem with the bus topology is that were the cable to break at any point along the bus, the computers on either side of the break will lose their termination, causing the signals to repeat and corrupt data. Additionally, if the intranet has a bad network interface card, a card inside the computer providing a connector to plug into the network cable, the whole network will function improperly due to noisy signals.

The **star topology** is a computer network connected via cables to a central system called a hub. (picture a wagon wheel): there are no direct connections between any of the computers, although multiple hubs can be added to increase the number of computers that may be connected to the network. The star topology consists of shielded twisted pair wire (STP) or unshielded twisted pair wire (UTP).

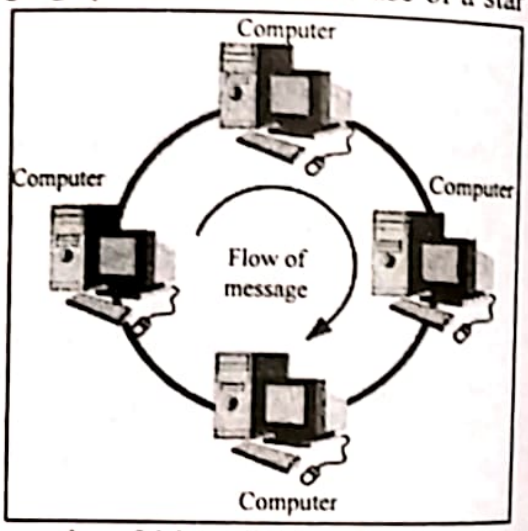


Since each computer is connected to the hub by a single cable more cable is used in a star topology than a bus topology network. The hub also adds an additional charge. Regardless of the higher cost of the additional wiring and hub the star topology is becoming more popular in current networks.

A significant advantage to using a star topology is a breakdown n communication between the hub and any one computer does not have any effect on other computers in the network. Additionally, because the data must travel through the hub during transmission, the network administrator is able to monitor the status of all the connections.

The ring topology is the most expensive of the three topologies. In a ring topology the network has no end, but forms a continuous ring from one computer to another. A ring topology enables more computers to be connected to the network than either of the previous two topologies. Each node can amplify and purify the data signal prior to sending it on to the next, producing less signal loss as the data travels along the ring.

The ring topology is often used to cover a large geographic location where use of a star topology would be complicated. Problems arise with the ring topology if a break arises anywhere along the ring, resulting in a stop in all network communications; a backup path may be employed for just such occasion to prevent the network from going down. A major drawback of ring topology: any user can access circulating data as it passes through his or her computer creating a sticky situation regarding confidentiality issues.



In a nut-shell: the bus topology is the least expensive, is fairly reliable, is not useful for geographic coverage, and it is difficult to troubleshoot; the star topology is moderately expensive, fairly reliable, able to cover some geography, and is the easiest to troubleshoot; and the ring topology is quite expensive, fairly reliable, fairly easy to troubleshoot, but its shining glory is its ability to cover geography.

c) Hybrid Topology

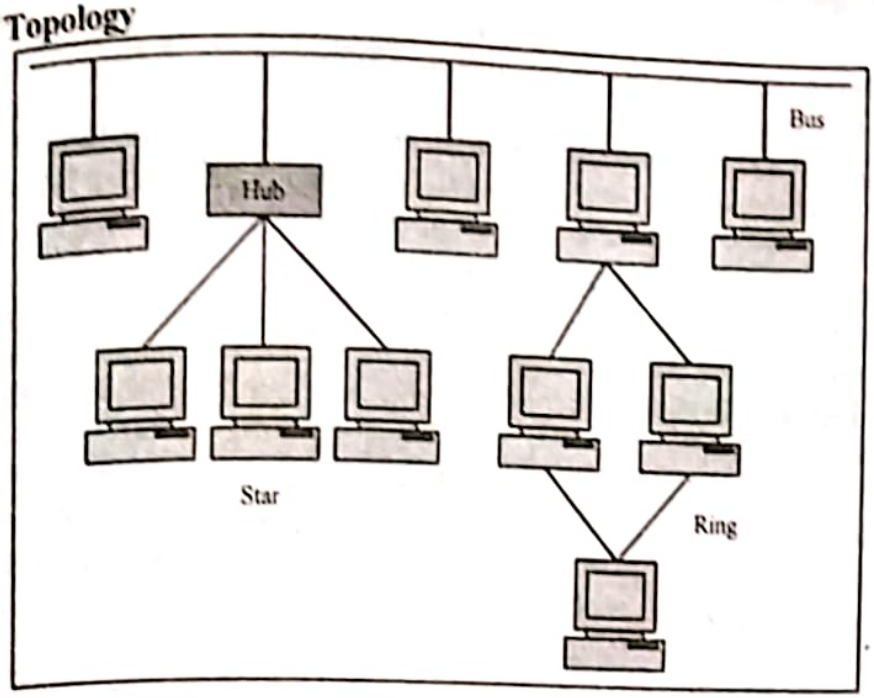


Fig: 1 Hybrid topology

Hybrid topology is the one, which uses two or more of the fundamental topologies .Fig. 1 depicts this. In this case, bus, star and ring topologies are used to create this hybrid topology. This could be created in multiple ways. In practice, many networks are quite complex but they could be reduced to some form of hybrid topology.

7. a) What is scan time of PLC? What are the advantages and disadvantages of PLC?
b) Draw the ladder diagram to implement the following Boolean logic.
OUT1 = (IN 1 OR IN 2) AND IN 3
OUT2 = $\overline{\text{OUT}}$ AND IN 4
OUT3 = $\overline{\text{OUT 2}}$ AND 5
c) Draw the diagram of OSI layer. Explain the working of physical layer.

[WBUT 2015]

Answer:
1st Part:

Layer 7	Application layer
Layer 6	Presentation layer
Layer 5	Session layer
Layer 4	Transport layer
Layer 3	Network layer
Layer 2	Data link Layer
Layer 1	Physical layer

2nd part:
The **first layer** of the seven layers of Open Systems Interconnection (OSI) network model is called the Physical layer. Physical circuits are created on the physical layer of

Open Systems Interconnection (OSI) model. Physical layers describe the electrical or optical signals used for communication.

The Data Link layer resides above the Physical layer and below the Network layer. Data link layer is responsible for providing end-to-end validity of the data being transmitted. The Data Link Layer is logically divided into two sublayers, The Media Access Control (MAC) sub layer and the Logical Link Control (LLC) sub layer.

The third layer of the seven layers of Open Systems Interconnection (OSI) network model is the Network layer. The Network layer of the OSI model is responsible for managing **logical addressing** information in the packets and the delivery of those packets to the correct destination.

The fourth layer of the seven layers of Open Systems Interconnection (OSI) network mode is the Transport layer. The Transport layer handles transport functions such as reliable or unreliable delivery of the data to the destination. On the sending computer,

The position of Session Layer of the Seven Layered Open Systems Interconnection (OSI) model is between Transport Layer and the Presentation Layer.

The position of Presentation Layer in seven layered Open Systems Interconnection (OSI) model is just below the Application Layer. When the presentation layer receives data from the application layer, to be sent over the network, it makes sure that the data is in the proper format.

Application Layer is the top-most layer of the seven layered Open Systems Interconnection (OSI) network model. Real traffic data are often generated from the Application Layer.

8. Draw and explain the block diagram of Fuzzy Logic Control system. **[WBUT 2017]**

Answer:

Refer to Question No. 1(a) of Long Answer Type Questions.

9. a) What are the network topologies used in implementing DCS network? Briefly describe them.

b) Why is redundancy used in DCS? **[WBUT 2018]**

Answer:

a) ***Refer to Question No. 2(b) of Long Answer Type Questions.***

b) Most distributed control systems are designed with redundant elements. Redundant engineering increases a system's reliability by using backup processors in case of primary processor failure. Redundant elements are necessary in DCSs because for two main reasons:

- Many DCSs control safety-critical processes in which failure or outage of equipment could cause personal injury or loss of life. A petroleum refinery is a good example of safety-critical plant. In such an environment, a control system governs flares that constantly burn gas. If the control system fails and the flares cease burning, gas collects and pools, causing an extremely dangerous situation.

- Redundancy increases equipment reliability, leaving the DCS operator to concentrate on displays, software, and applications. Because DCS systems require near-constant operator interaction at the HMI, redundancy is crucial.

10. Write short notes of the followings:
a) DCS architecture **[WBUT 2010]**
b) Field bus **[WBUT 2014, 2018]**
c) PLC **[WBUT 2016, 2017]**

Answer:

a) DCS architecture:

Refer to Question No. 2(a) of Long Answer Type Questions.

b) Field bus:

A field bus is used to communicate control signals in a process plant among the sensors, controllers and final control elements. Certain important characteristics of field bus are:

1. ***Physical Media Transmission:*** This refers to layer-1 of the OSI model and defines the actual communication carrier, such as twisted wire pairs, coaxial cable and fiber-optic cable.
2. ***Number of Devices:*** This refers to the fact that device addresses are carried in the information packet. Therefore, there will be a limit to the number of devices that can be addressed.
3. ***Distance Over which the Bus can Extend:*** The longer the bus, the weaker and more distorted the signals become. In some cases special repeater circuits can extend the basic bus distance.
4. ***Speed of Transmission:*** The serial data is like a square wave in the communication media where the state changes of the square wave represent bits. The bus speed refers to the frequency of the possible bit changes which is better described by the number of bits per second (bps) that the serial system can handle.
5. ***Bus Powered:*** This is a feature carried over from 4 to 20 mA analog systems. Some field buses have the capability that the data measurement serial bit stream rides on top of DC current providing power to the devices on the bus.

c) PLC:

A typical block diagram of PLC is show in Fig. 1 as clear from figure PLC consists of following basic parts

- CPU (Central processing unit)
- Programming device
- Input & output module

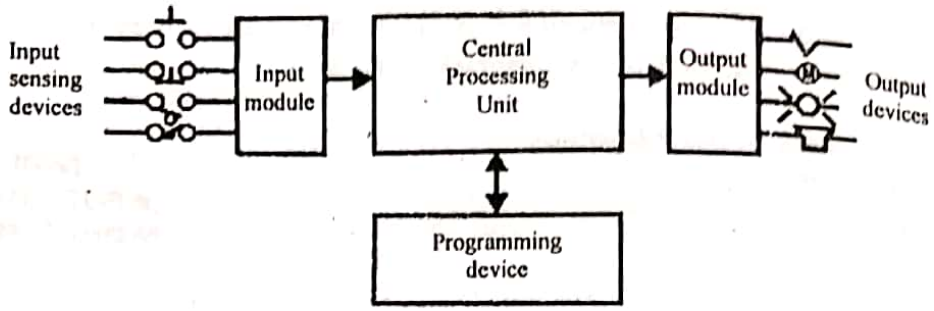


Fig: 1 PLC block diagram

The central processing unit is the heart of the PLC system. The CPU is a microprocessor-based control system that replaces central relays, counters, timers and sequencers. A processor appears only once in a PLC and it can be either a one-bit or a word processor. One bit processors are adequate for dealing with logic operations. PLCs with word processors are used when processing text and numerical data, calculations, gauging, controlling and recording, as well as the simple processing of signals in binary code are required.

The principle of operation of CPU can be briefly described as follow:

- The CPU accepts (reads) input data from various sensing devices, executes the user program from memory and sends appropriate output commands to control devices.
- A direct current (DC) power source is required to produce the low-level voltage used by processor and I/O modules. This power supply can be housed in the CPU unit or may be a separately mounted unit, depending on the PLC system manufactures. The CPU contains various electrical parts and receptacles for connecting the cables that go to the other units as well as to operational key switches.

Typical operation key switch positions are

- Off system cannot be run or programmed
- Run: allow the system to run, but no program alterations can be made
- Program disables output and allows creating modifying and deleting of programs