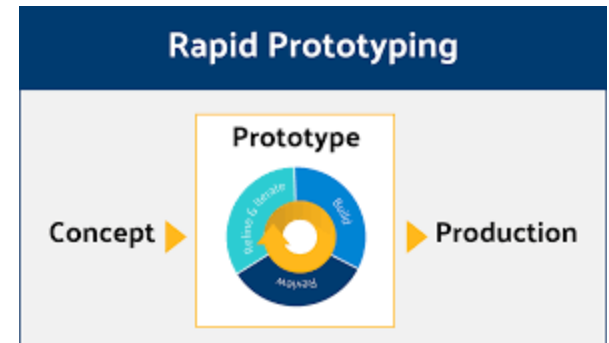


Computer Aided Manufacturing



**Dr.S.RAMABALAN,
PRINCIPAL,
E.G.S. PILLAY ENGINEERING COLLEGE,
NAGAPATTINAM.**



Unit II

DRIVES AND CONTROL

Spindle and feed drives - Sensors - Position, Encoders, Proximity, Limit switch -Interfacing system -Microcontroller and PLC based -**Introduction to Graphical User interface - Communication protocol -RS232, RS 485, USB, Ethernet - PLC -Ladder diagram** -Peripherals -Timer, Counter, Encoder interface, Human Machine Interface

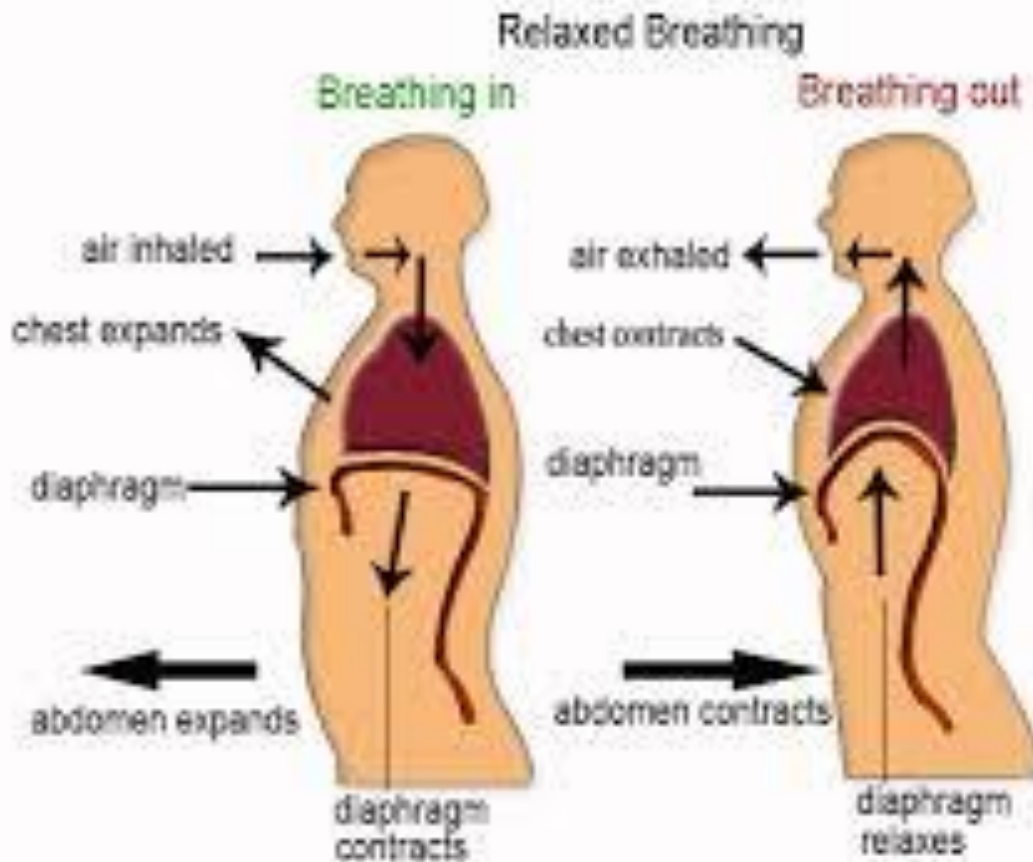
Prerequisites Knowledge

- PLC and Microcontroller

Relaxed Breathing



Belly breathing

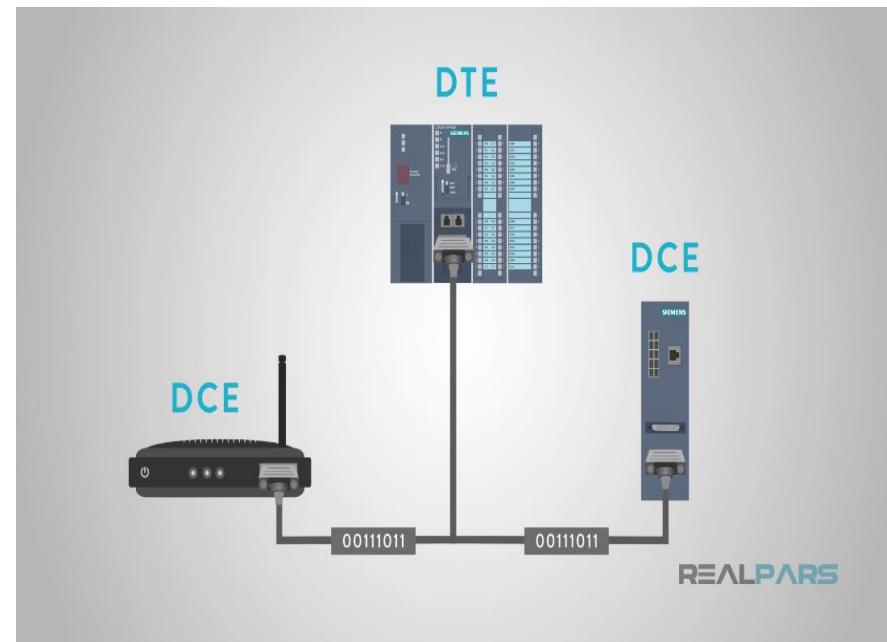
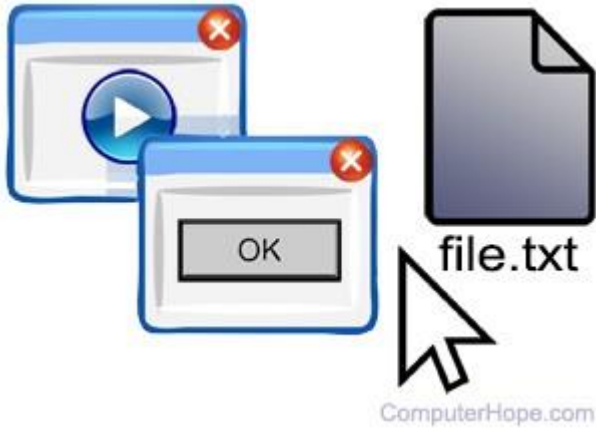


Recap and review of previous class

Let's
Recap



5 mins



General Objective (GO)

- Students will be able to understand the concept of Graphical User Interface (GUI) and four communication protocols used in CNC machines.

Specific Objectives

Students will be able to

- Recall the Graphical User Interface (GUI) concept. (R / F) (E)
- Explain the RS232 & RS485 protocols used for communication in CNC machines. (U / C) (E&T)
- Exemplify the usage of USB and Ethernet for communication in CNC machines. (U / C) (E)

Serial data communication

RS-232

- **DTE (data terminal equipment)** - is an end instrument that converts user information into signals or reconverts received signals.
- **DCE (data circuit-terminating equipment or data communication equipment)**- is a device that sits between the data terminal equipment (DTE) and a data transmission circuit.



Introduction



- It is basically a interface standards.
- It is commonly used in computer serial ports.
- The standard defines the electrical characteristics and timing of signals.

RS-232 Application

- An **RS-232 serial port** was once a **standard feature** of a personal computer, **used for connections to** modems, printers, mouse, data storage, uninterruptible power supplies, and other peripheral device.

Standard

- In RS-232, user data is sent as a time series of bits.
- Both synchronous and asynchronous transmissions are supported by the standard.
- RS-232 devices may be classified as Data Terminal Equipment (DTE) or Data Communication as modems, that are responsible for data transferring Equipment (DCE), this defines that each device which wires will be sending and receiving each signal.
- DTE refers to terminals and computers that sends and receives data. DCE refers to communication equipment, such user display, timers, etc

Limitation of the standard

- The limited **transmission speed**, relatively **large voltage swing**, and large standard connectors motivated development of the universal serial bus(USB) which has displaced RS-232.
- **Multi-drop connection among more than two devices** is not defined.
- Also multi-drop have limitations in **speed and compatibility**.

DIFFERENT TYPES OF RS-232 CABLES





00111011



RS-232

REALPARS

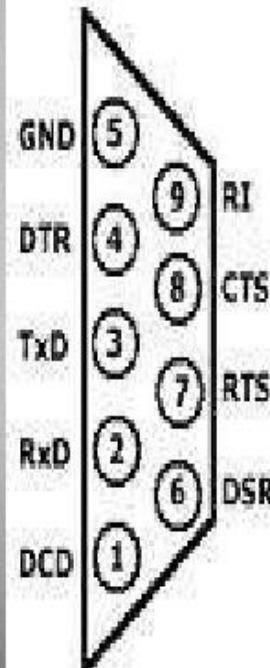
RS-232 pins

RS232 Pinout on DB25



- 2 Transmit Data (TxD)
- 3 Receive Data (RxD)
- 4 Request to Send (RTS)
- 5 Clear to Send (CTS)
- 6 Dataset ready (DSR)
- 7 Signal Ground
- 8 Data Carrier Detect (DCD)
- 15 Transmit Clock
- 17 Receive Clock
- 20 Data Terminal Ready (DTR)
- 24 Auxiliary Clock

RS-232 DB-9 Male Pinout



- PIN 1: Data Carrier Detect
- PIN 2: Receive Data
- PIN 3: Transmit Data
- PIN 4: Data Terminal Ready
- PIN 5: Signal Ground
- PIN 6: Data Set Ready
- PIN 7: Request to Send
- PIN 8: Clear to Send
- PIN 9: Ring Indicator

Examining RS-232 handshaking signals

- To ensure fast and reliable data transmission between two devices, the data transfer must be coordinated.
- Many of the pins of RS-232 connector are used for **handshaking signals**.

Advantage of RS232

- RS232 interface is supported in many compatible legacy devices due to its **simplicity**.
- It supports **long distances of about 50 feet** (for low baud rates) and with error correction capabilities.
- RS232 is **free from noise due to use of +/-5 Volts** or higher for binary **logic 0 and logic 1**.
- **RS232 is low cost interface.**
- **Converters or adaptors are available at cheaper rates for conversion from RS232 to RS485/USB/Ethernet etc**

Disadvantages of RS232

- Suitable for system to system communications. not suitable for chip to chip or chip to sensor device communications.
- Supports lower speed for long distances. Higher speed (i.e. 115200 baud) can be achieved for short distances only.
- RS232 interface requires separate transceiver chips which will add cost to the system.
- It is used for single master and single slave configuration and not for single master-multiple slaves mode.
- It is unbalanced transmission

What is RS-485?

- RS-485 is a EIA standard interface which is very common in the data acquisition world.
- RS-485 provides **balanced transmission line which also can be shared in Multidrop mode.**
- It allows high data rates **communications over long distances in real world environments.**
- **How fast can RS-485 be?**
- **RS-485 was designed for greater distance and higher band rates than RS-232.**
- **According to the standard, 100kbit/s is the maximum speed and distance up to 4000 feet (1200 meters) can be achieved.**

RS-485 Line Driver

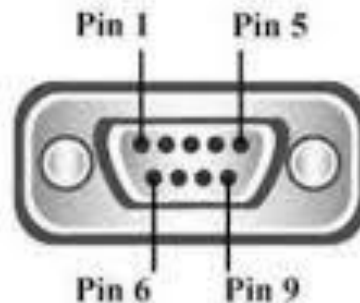
- **Balanced Line Drivers**

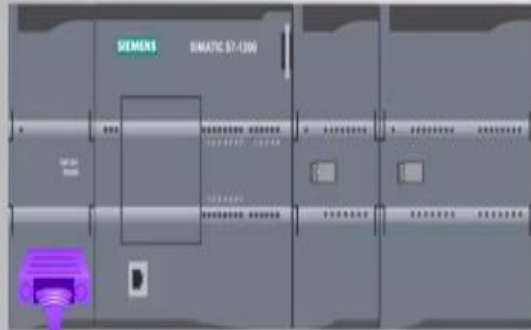
- Voltage produced by the driver appears across a pair of signal wires that transmit only one signal. Both wires are driven opposite. RS-485 driver has always the “Enable” direction control signal.
- **Differential system provides noise immunity**, because much of the common mode signal can be rejected by the receiver. So ground shifts and induced noise signals can be nullified.

RS422/485

Pin 1	TXD-
Pin 2	TXD+
Pin 3	RTS-
Pin 4	RTS+
Pin 5	GND
Pin 6	RXD-
Pin 7	RXD+
Pin 8	CTS
Pin 9	CTS+

RS422/485 Pinout (9 Pin)





RS-485



Terminal Strips



- ▶ Any station can communicate with any other station, but not at the same time.

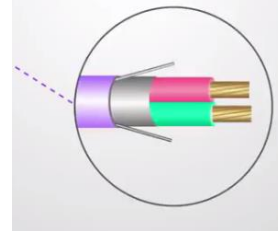
Advantages

- Very long distance, thousands of feet
- Widely used in industrial automation
- Higher speeds beyond 115200 baud

Disadvantages

- More suitable for system to system communications, not so much for chip to chip or chip to sensor
- Requires transceiver chips and twisted pair cable with terminating resistors which add to system cost.

RS-232 vs RS-485



	RS-232	RS-485
• Mode of Operation	SINGLE-ENDED	DIFFERENTIAL
• Total Number of Drivers and Receivers on One Line	1 DRIVER 1 RECEIVER	32 DRIVER 32 RECEIVER
• Maximum Cable Length	50 FEET	4000 FEET
• Maximum Data Rate @Max length	20kb/s	100kb/s
• Driver Output Signal Level (Loaded Min.) Loaded	+/-5V to +/-15V	+/-1.5V
• Driver Output Signal Level (Unloaded Max) Unloaded	+/-25V	+/-6V
• Driver Load Impedance	3kΩ to 7kΩ	54Ω
• Max. Driver Current in High Z State Power On	N/A	N/A
• Max. Driver Current in High Z State Power Off	+/-6mA @ +/-2v	+/-100uA
• Slew Rate (Max.)	30V/μS	N/A
• Receiver Input Voltage Range	+/-15V	-7V to +12V
• Receiver Input Sensitivity	+/-3V	+/-200mV
• Receiver Input Resistance	3kΩ to 7kΩ	≥ 12kΩ

USB BUS

- USB is host controlled so only one host can per bus and does not support any form of multi-master arrangement.
- The USB host is responsible for undertaking all transactions and scheduling bandwidth.
- Data can be sent by various transaction methods using a token-based protocol.
- The starting of implementation of USB idea was by Apple As **Apple Desktop Bus (ADB)**.
-

- Host is responsible for powering the nodes if there is no alternate power source.
- Up to **127 devices** can be attached to USB bus at once.
- It uses **4 shielded wires** such that two are power (+5v & GND) and The remaining two are twisted pair differential data signals.
- USB **supports plug & play** with dynamically loadable and unloadable drivers.

USB SPEEDS

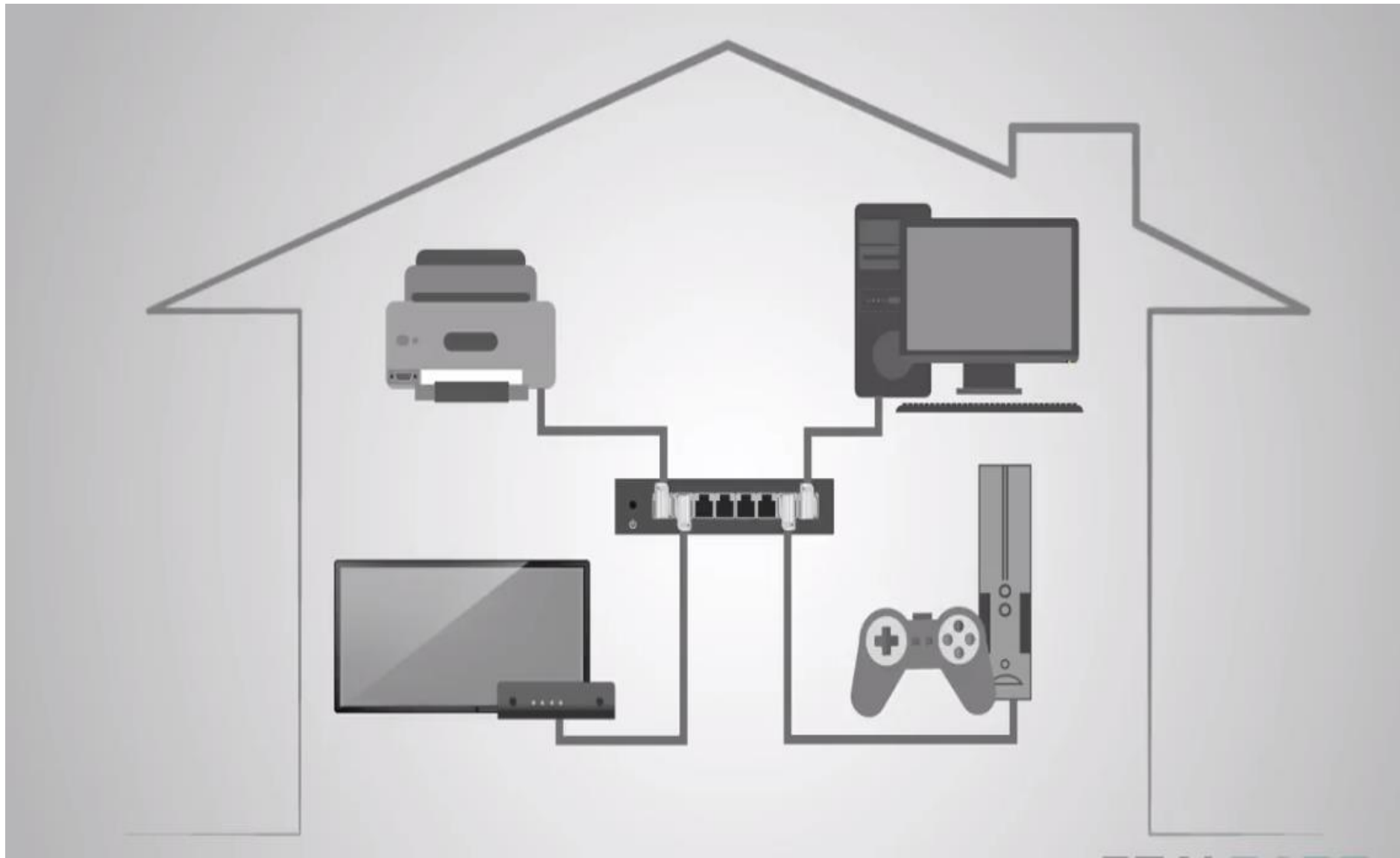
- High Speed - 480 Mbits/s.
 - Full Speed - 12 Mbits/s.
 - Low Speed - 1.5 Mbits/s.
-
- USB version 1 supports Low and Full speeds.
 - USB 2.0 that in our hands today supports the three speeds.

Advantages

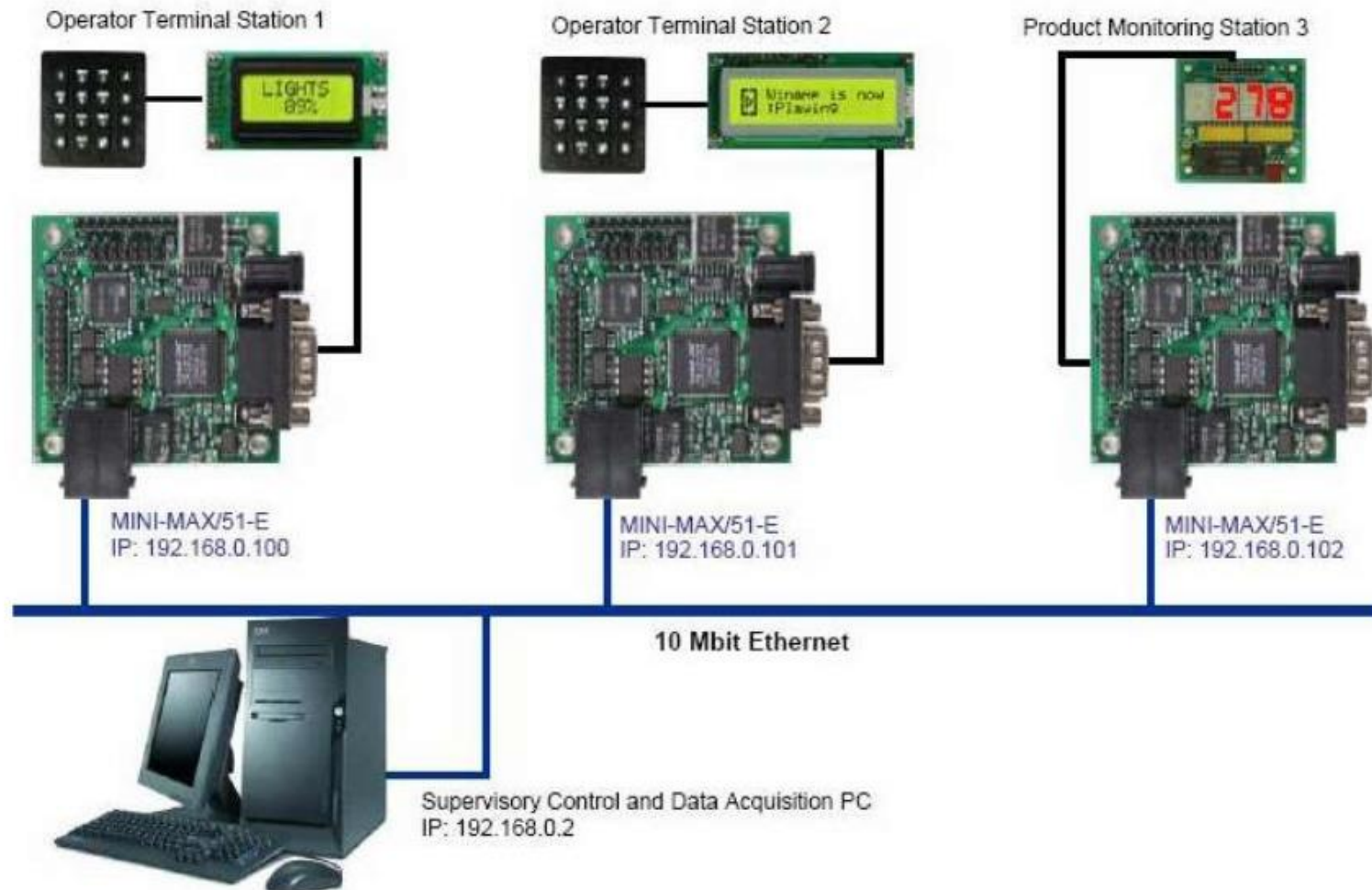
- Very high speed (10Mbit to 100Mbit/s)
- Very long distance, hundreds of feet can be achieved, more with hubs and switches, Immune to noise
- Widely used in industrial automation due to noise immunity

Disadvantages

- Cost
- More suitable for system to system comm.,, not so much for chip to chip/sensor
- Requires Ethernet chipset, transformer, jack, special cabling that add to system cost.
- Complicated to implement
- High code footprint

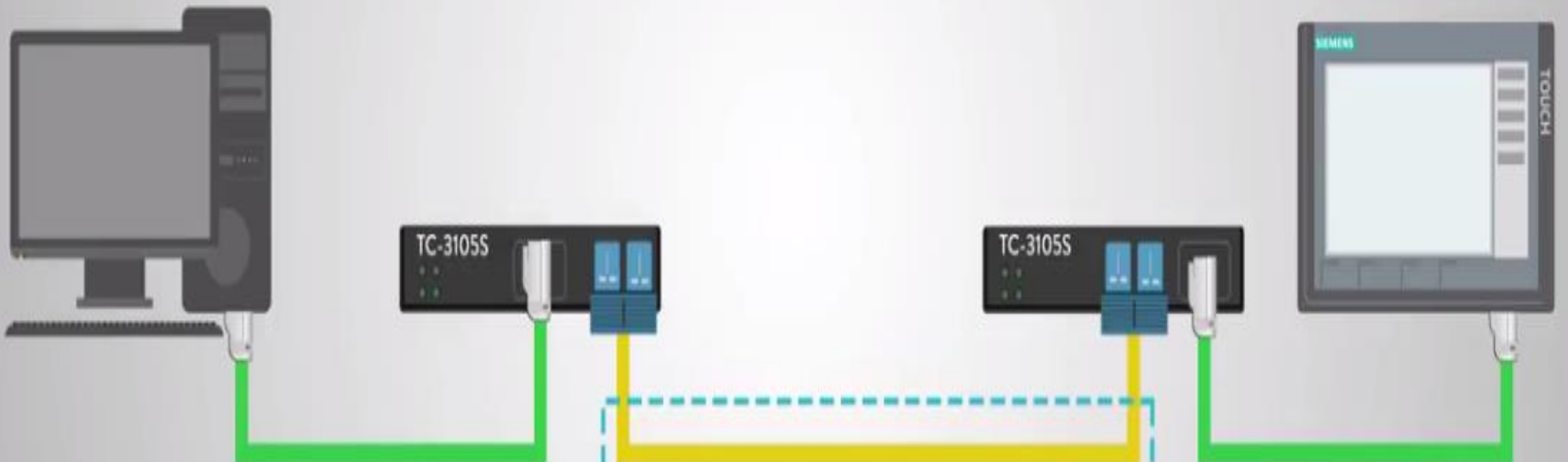


Ethernet – 10 Mbit Networking





Coaxial Cable



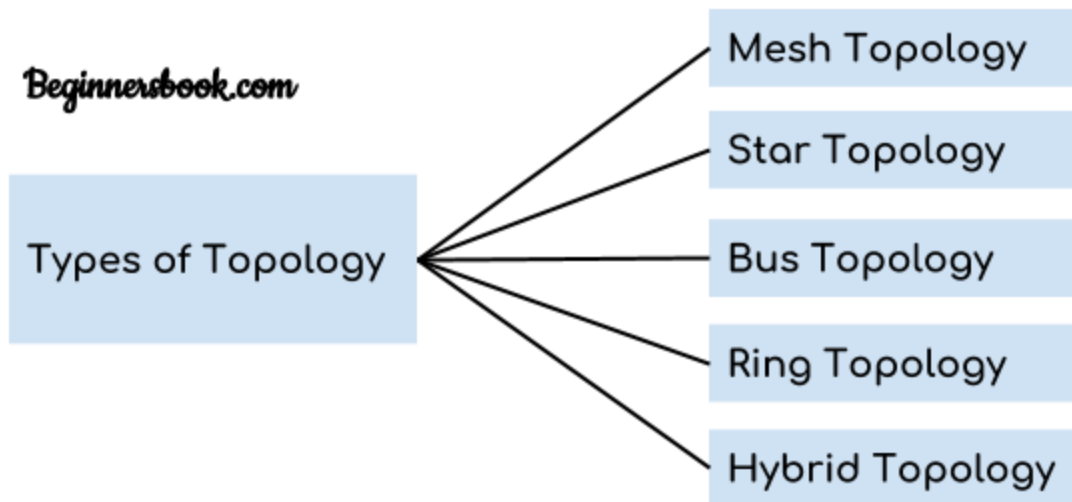
Twisted Pair Cable

Fiber Optic Cable

Twisted Pair Cable

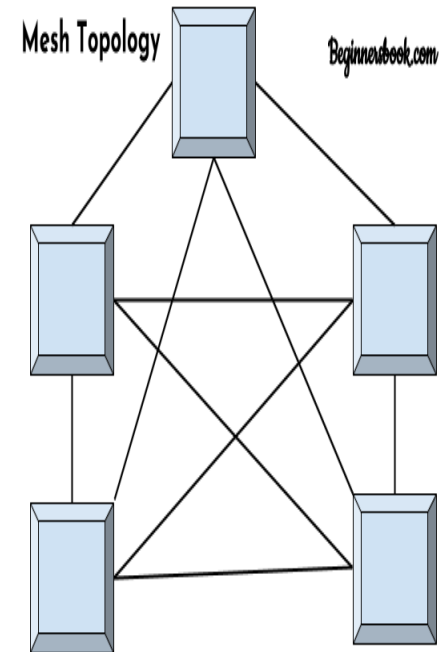
Types of Topology

- There are five types of topology in computer networks:



Mesh Topology

- In mesh topology each device is connected to every other device on the network through a dedicated point-to-point link.
- When we say dedicated it means that the link only carries data for the two connected devices only.
- Lets say we have n devices in the network then each device must be connected with (n-1) devices of the network.
- Number of links in a mesh topology of n devices would be $n(n-1)/2$.



Advantages of Mesh topology

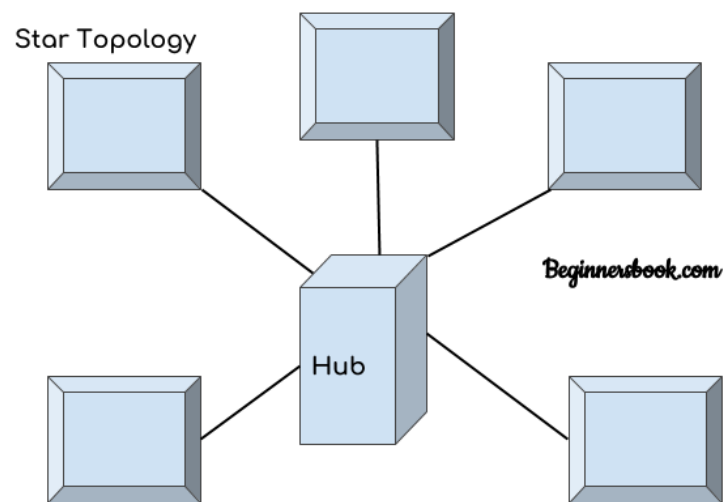
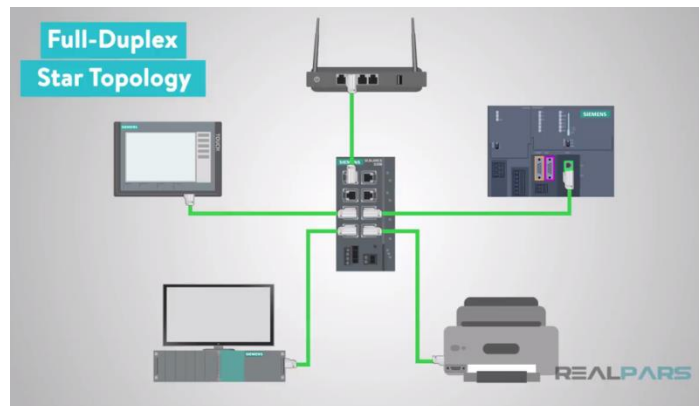
1. No data traffic issues as there is a dedicated link between two devices which means the link is only available for those two devices.
2. Mesh topology is reliable and robust as failure of one link doesn't affect other links and the communication between other devices on the network.
3. Mesh topology is secure because there is a point to point link thus unauthorized access is not possible.
4. Fault detection is easy

Disadvantages of Mesh topology

1. Amount of wires required to connected each system is tedious and headache.
2. Since each device needs to be connected with other devices, number of I/O ports required must be huge.
3. Scalability issues because a device cannot be connected with large number of devices with a dedicated point to point link.

Star Topology

- In star topology each device in the network is connected to a central device called hub.
- Unlike Mesh topology, star topology doesn't allow direct communication between devices, a device must have to communicate through hub.
- If one device wants to send data to other device, it has to first send the data to hub and then the hub transmit that data to the designated device.



- **Advantages of Star topology**

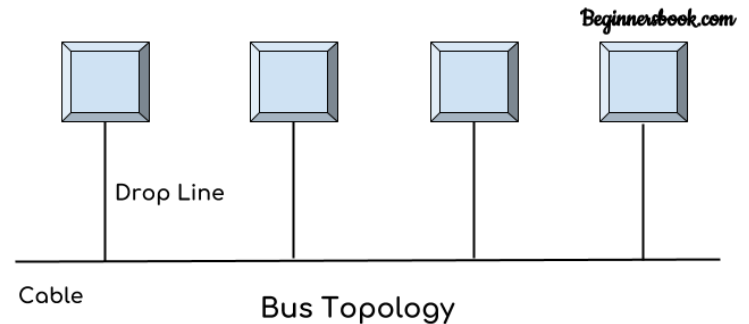
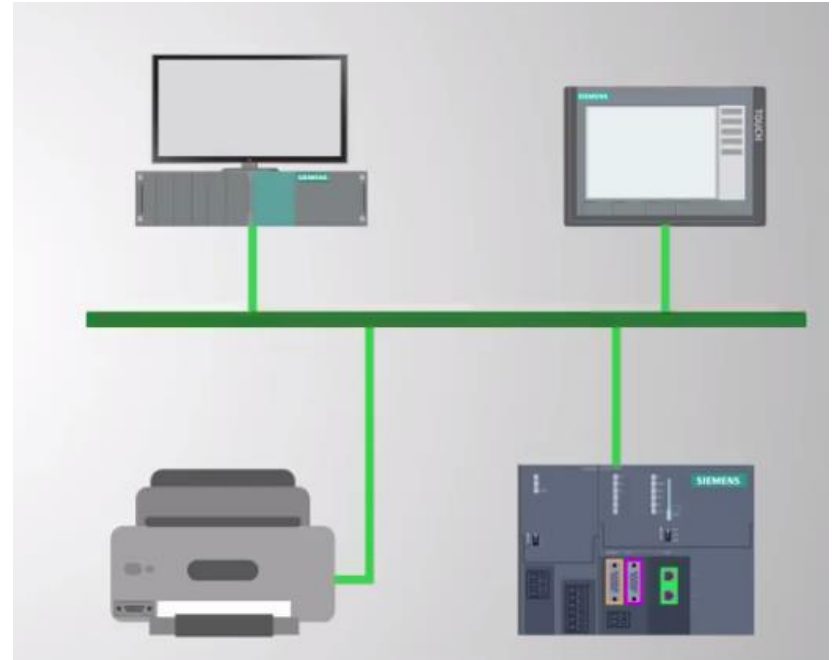
1. Less expensive because each device only need one I/O port and needs to be connected with hub with one link.
2. Easier to install
3. Less amount of cables required because each device needs to be connected with the hub only.
4. Robust, if one link fails, other links will work just fine.
5. Easy fault detection because the link can be easily identified

Disadvantages of Star topology

1. If hub goes down everything goes down, none of the devices can work without hub.
2. Hub requires more resources and regular maintenance because it is the central system of star topology.

Bus Topology

- In bus topology there is a main cable and all the devices are connected to this main cable through drop lines.
- There is a device called tap that connects the drop line to the main cable.
- Since all the data is transmitted over the main cable, there is a limit of drop lines and the distance a main cable can have.

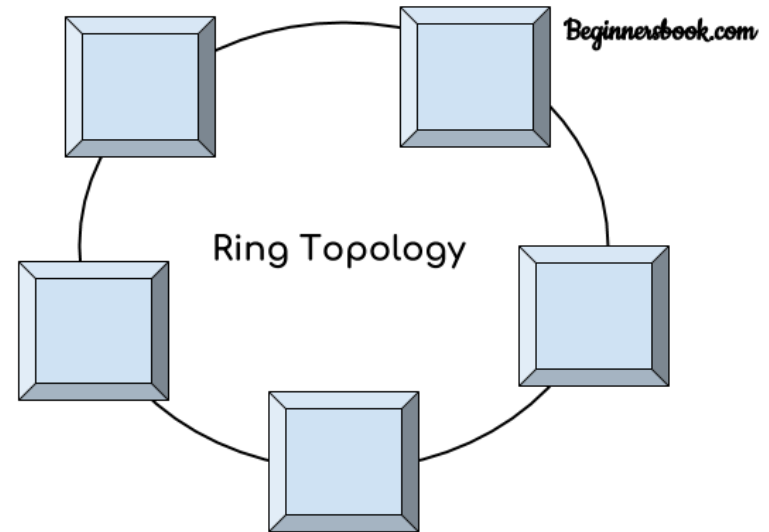


- **Advantages of bus topology**
- 1. Easy installation, each cable needs to be connected with backbone cable.
- 2. Less cables required than Mesh and star topology

- **Disadvantages of bus topology**
- 1. Difficultly in fault detection.
- 2. Not scalable as there is a limit of how many nodes you can connect with backbone cable.

Ring Topology

- In ring topology each device is connected with the two devices on either side of it.
- There are two dedicated point to point links a device has with the devices on the either side of it.
- This structure forms a ring thus it is known as ring topology. If a device wants to send data to another device then it sends the data in one direction, each device in ring topology has a repeater, if the received data is intended for other device then repeater forwards this data until the intended device receives it.



Advantages of Ring Topology

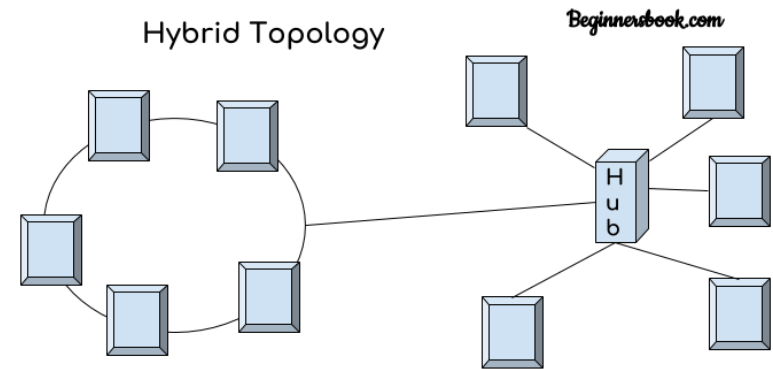
1. Easy to install.
2. Managing is easier as to add or remove a device from the topology only two links are required to be changed.

Disadvantages of Ring Topology

1. A link failure can fail the entire network as the signal will not travel forward due to failure.
2. Data traffic issues, since all the data is circulating in a ring.

Hybrid topology

- A combination of two or more topology is known as hybrid topology. For example a combination of star and mesh topology is known as hybrid topology.



Advantages of Hybrid topology

- 1. We can choose the topology based on the requirement for example, scalability is our concern then we can use star topology instead of bus technology.
- 2. Scalable as we can further connect other computer networks with the existing networks with different topologies.


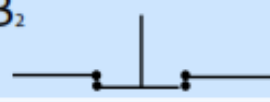

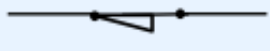

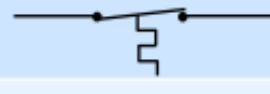
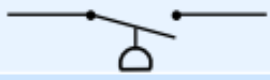
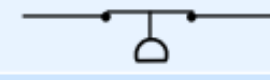
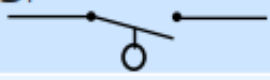
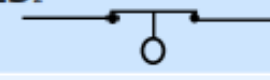



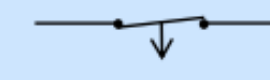
Disadvantages of Hybrid topology

- 1. Fault detection is difficult.
- 2. Installation is difficult.
- 3. Design is complex so maintenance is high thus expensive.

What is a Ladder Diagram

- A Ladder diagram is a **symbolic and schematic representation** of both the **process hardware and process control**.
- Its called a 'Ladder' because all the devices are connected across the supply lines making it **look like a ladder**.
- Each parallel connection is called a '**Rung**', it can contain many inputs but only one output.

Logic Symbols:

	Normally Open	Normally Closed
Push button Switches	PB ₁ 	PB ₂ 
Limit Switches	LS ₁ 	LS ₂ 
Temperature Limit Switches	TS ₁ 	TS ₂ 
Pressure Limit Switches		PS ₂ 
Level Limit Switches	LLS ₁ 	LLS ₂ 
On Delay Switches	Delayed closed 	Delayed open 
Off Delay Switches (Timer Contacts)		

OUTPUT DEVICES

Contact Relay



Normally closed



Normally Open



Relay



Contactors



Motor



Solenoid Valve



Indicating Lamp



Timer



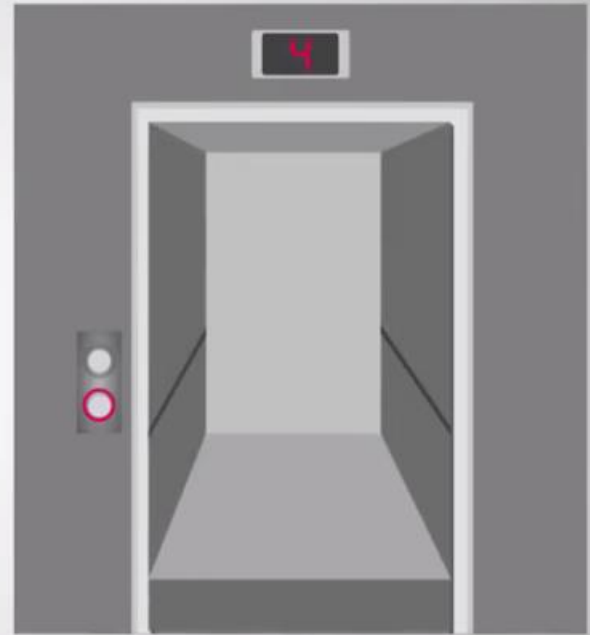
Counter

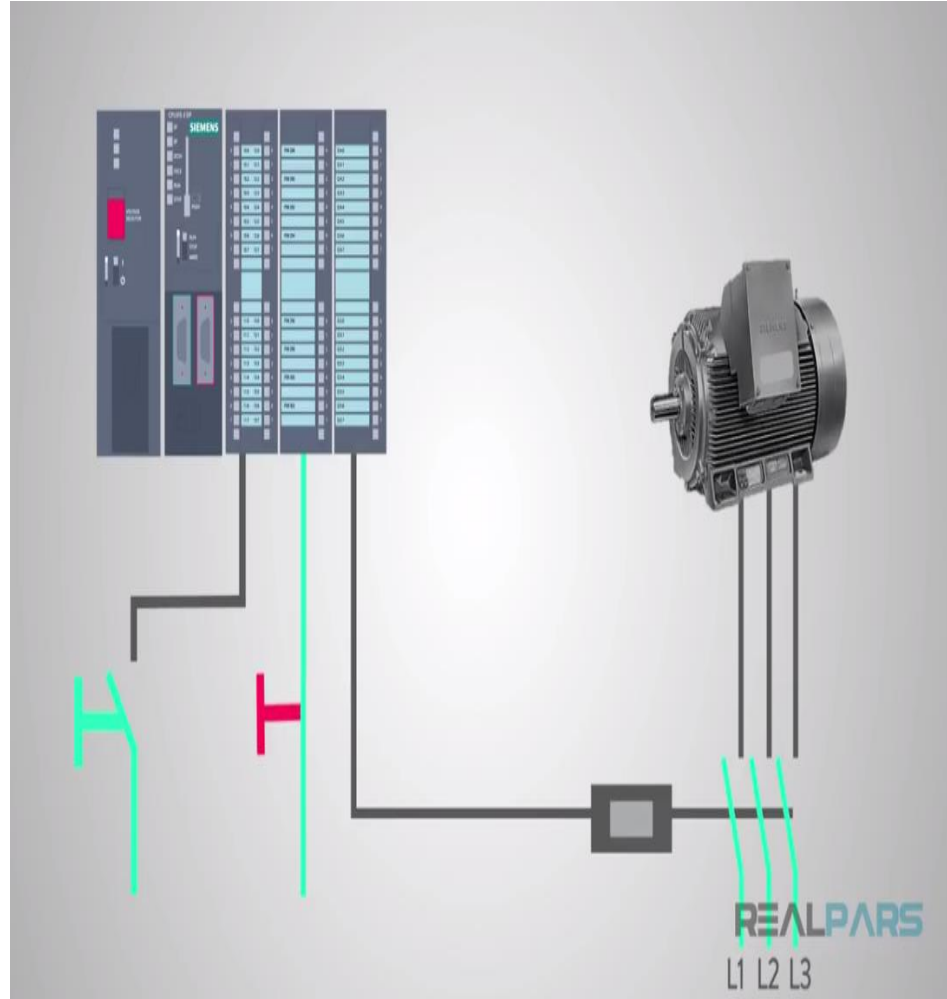
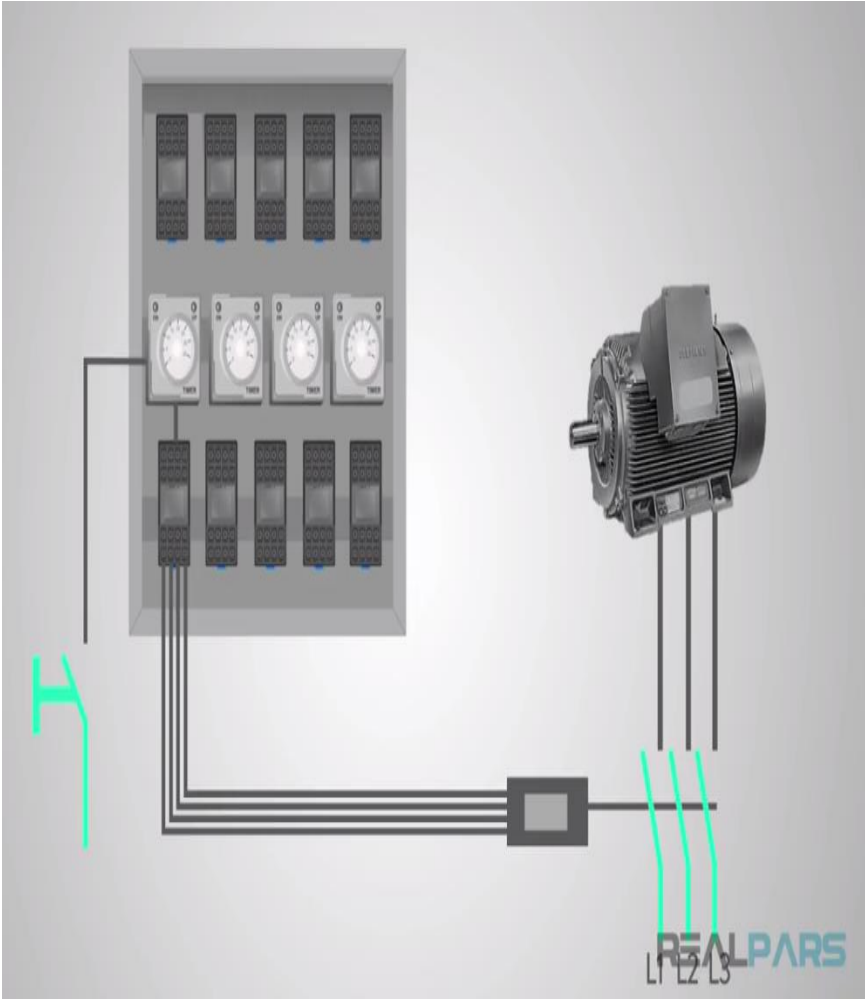
Up Counter

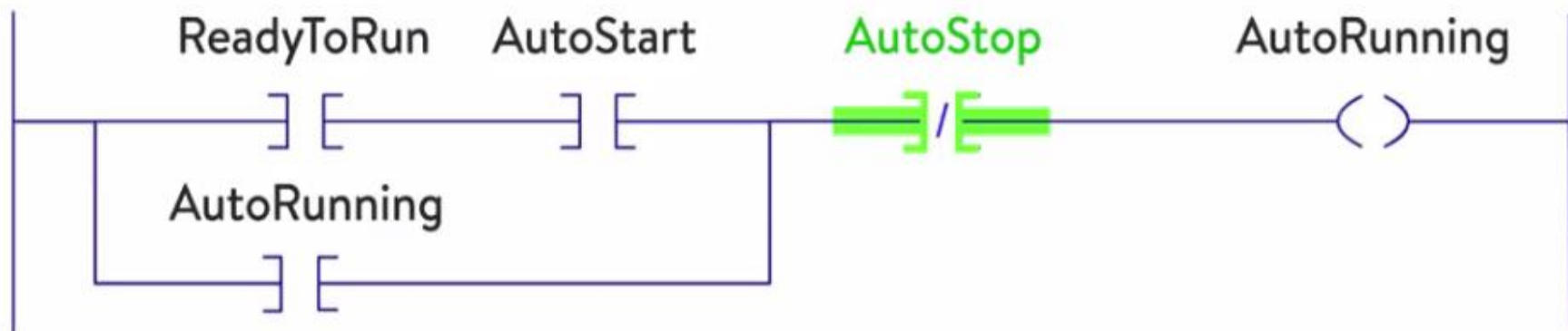


Down Counter

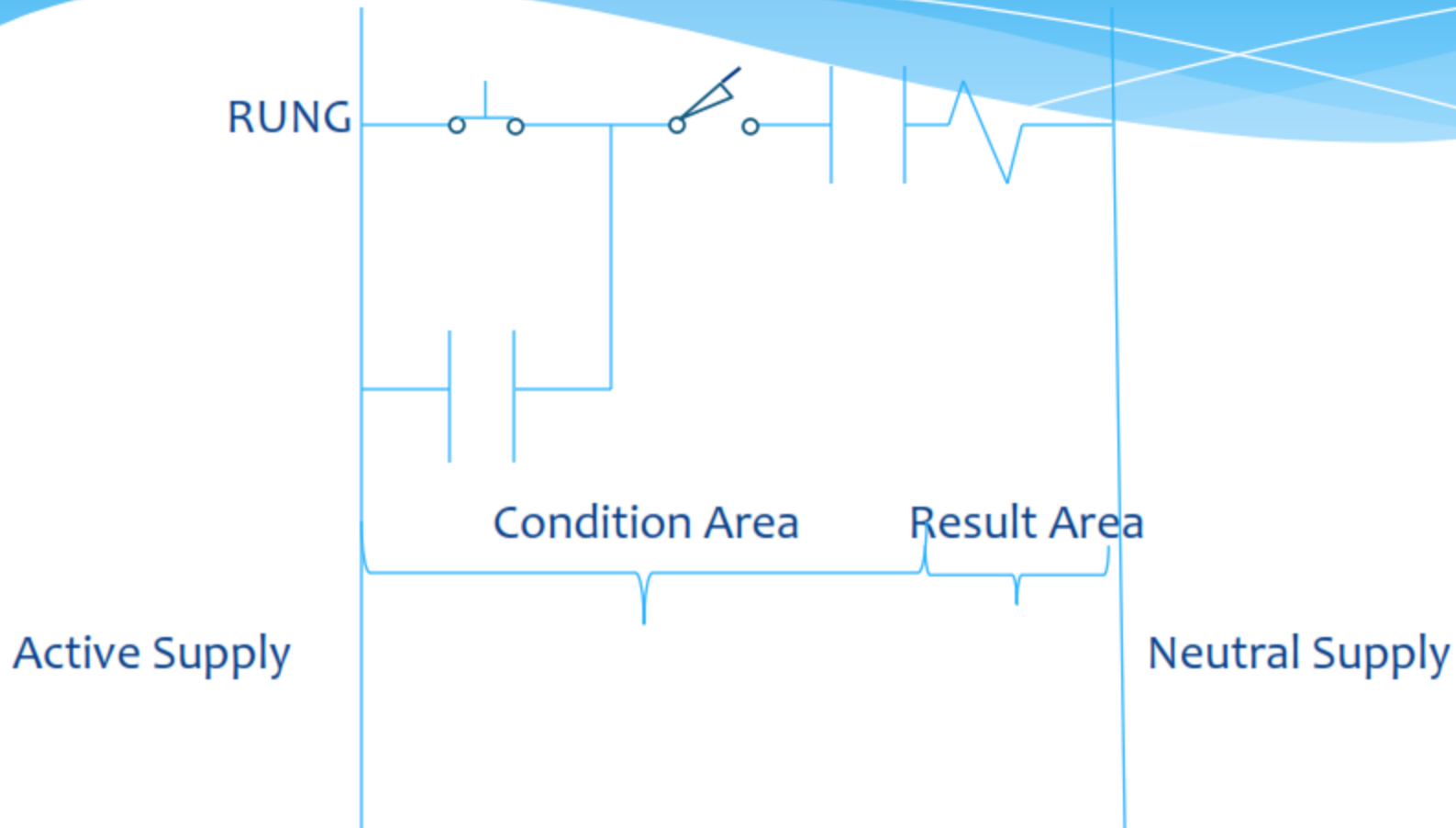








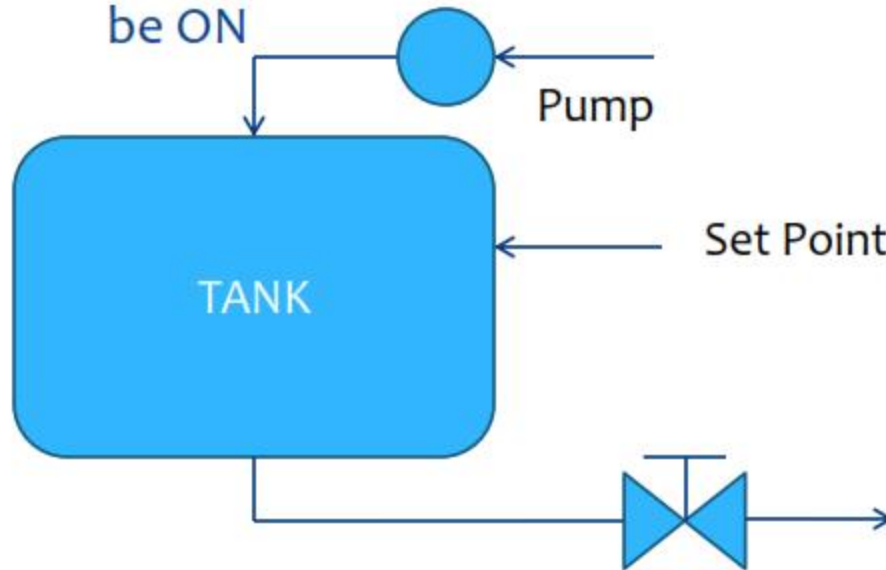
Physical or Relay Ladder Example



Example 1

- Water Level Control:

- It's a single point level control.
- When the Level is above set point the output pump should be OFF
- When the Level is below set point the output pump should be ON

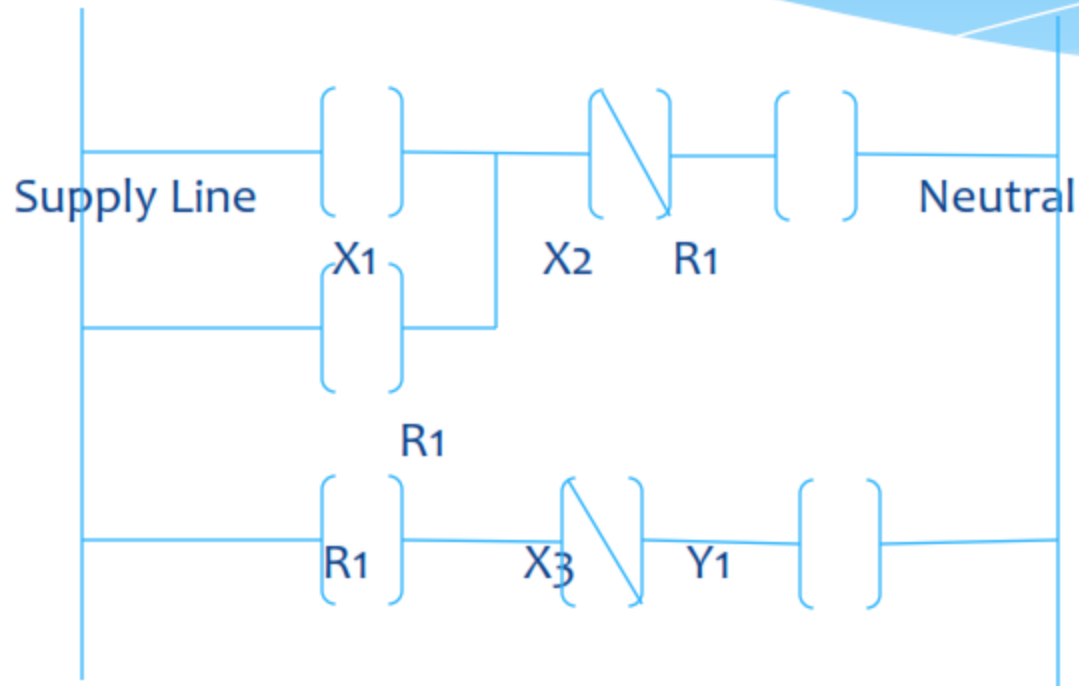


Solution 1

- * The number of inputs are Pump 'ON', Pump 'OFF' and Level Switch; I/P=3
- * The number of outputs; O/P=1
- * The conditions for inputs and outputs are:

X1 (Pump ON)	X2 (Pump OFF)	X3 (Limit Switch)	Y1 (Output)
High	Low	Low	High
---	High	---	Low
High	Low	High	Low

Ladder Diagram 1



* Here relay R1 acts as a Latch.

Example 2

Temperature Control

- i. A temperature control system consists of four thermostats. The system operates three heating units. The thermostats are set at 55°C , 60°C , 65°C and 70°C .
- ii. Below 55°C three heaters are to be in ON state
- iii. Between 55°C - 60°C two heaters are to be in ON state.
- iv. Between 60°C - 65°C one heater is to be in ON state.
- v. Above 70°C all heaters are to be in OFF state, there is a safety shutoff in case any heater is operating by mistake.
- vi. A master switch turns the system ON and OFF.

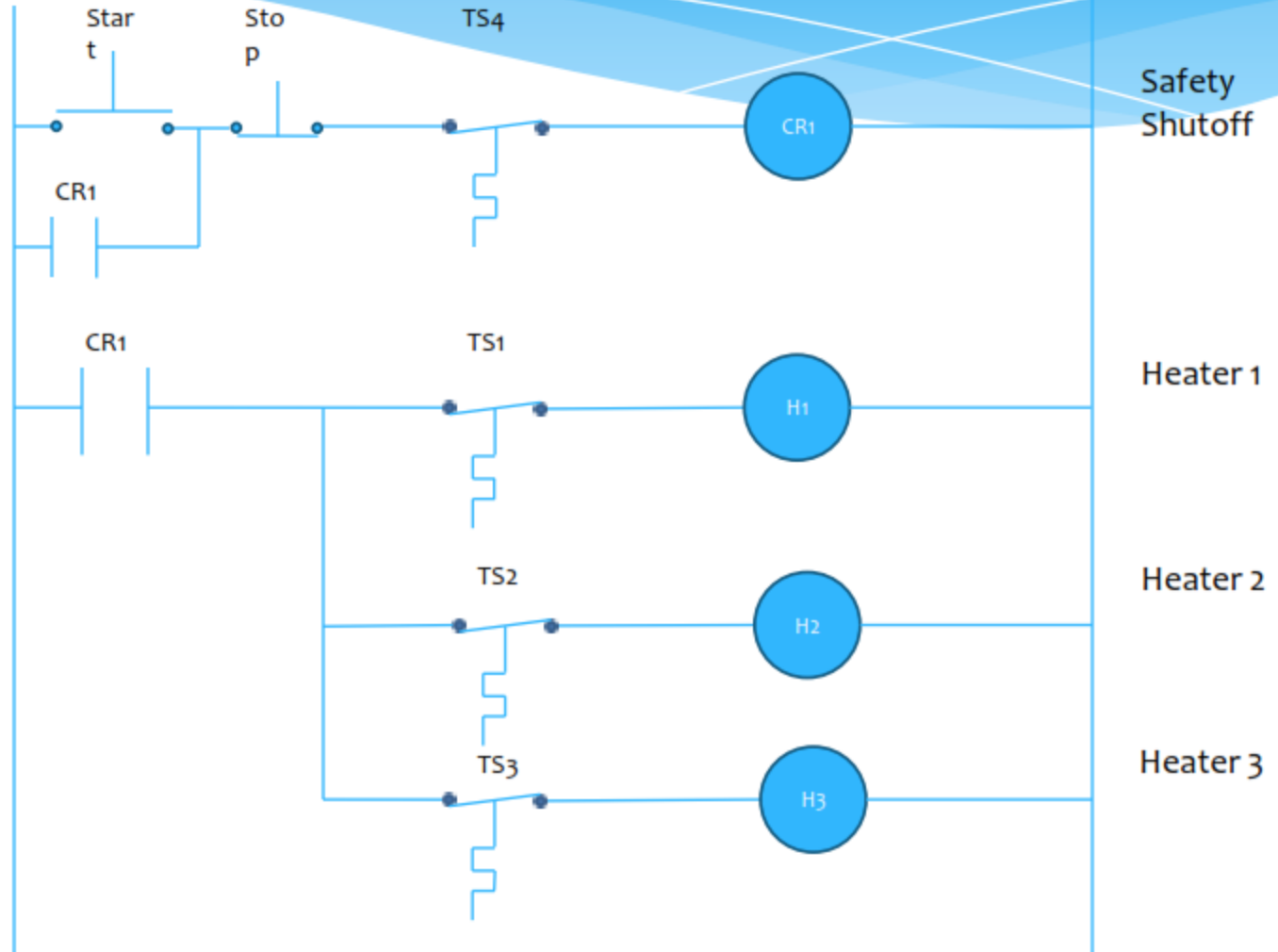
Solution 2

- * There are four thermostats; assume them be in NC state when the set point is not reached.
- * Let there be a control relay (CR1) to work as a safety shutoff.
- * The Start switch is NO and Stop switch NC type.

Solution 2

Temperature	Thermostats		Heater 1	Heater 2	Heater 3
Below 55°C	TS1 TS2 TS3 TS4	Closed Closed Closed Closed	ON	ON	ON
55°C-60°C	TS1 TS2 TS3 TS4	Open Closed Closed Closed	OFF	ON	ON
60°C-65°C	TS1 TS2 TS3 TS4	Open Open Closed Closed	OFF	OFF	ON
65°C-70°C	TS1 TS2 TS3 TS4	Open Open Open Closed	OFF	OFF	ON
Above 70°C	TS1 TS2 TS3 TS4	Open Open Open Open	OFF	OFF	OFF

Ladder Diagram 2



Discussion



10 mins