Makeup Examination – Sept. 2023
V Semester Diploma Examination

AUTOMATION AND ROBOTICS

(Exam Date / Time: 22nd Sep. 2023 / 2.00 PM)

Time: 3 Hours **Max.Marks:** 100

Instructions: (1) Answer one full question from each section.
(2) One full question carries 20 marks.

SECTION – I

Q1. a) Mention the role and benefits of automation in industry 4.0 10

b) List the various components used for laptop package automation industry. Describe any two. 10

Q2. a) Robots play a very important role in Packaging Industries. Justify your answer 10

b) How robots are revolutionizing medical device manufacturing. 10

SECTION – II

Q3. a) On what factors the communication protocols used in automation industries depends on ? Mention the specification of any 5 standard communication protocol/cable used with PLC modules connected over network. 10

b) List any five possible sensors used in potato manufacturing industry. Explain the purpose of using them. 10

Q4. a) Analyse the common industrial protocols that are used in a milk processing industry and explain any four communication protocols. 10

b) Consider a food processing industry using a PLC based automation system. How do you troubleshoot the PLC processor module, Input malfunctions and Output malfunctions in such industries? 10

SECTION – III

Q5. a) How do you realize PLC based automation system to count the packets passing on the conveyer belt in a packaging industry? 10

b) Why is PLC preferred over Microcontroller in industries 10

Q6. a) Analyse the usage of SCADA and HMI in food processing industry. 10

b) Consider a milk processing industry, describe how the milk tank level and its flow are controlled between the milk packaging process and the milk stock container tank. 10

SECTION – IV

Q7. a) What is typically inside a VFD control panel? 10

b) VFD plays an important role in conveyor control system. Justify your answer and how it can be implemented in industries to control the speed of the conveyer. 10

Q8. a) Mention some of the role of PAC in modern Industry. Compare PLCs and PACs. 10

b) How would you set-up pneumatic valves, actuators and sensors to build automatic stamping labelling machine? 10

SECTION – V

Q9. a) Discuss the various parts and functions of a Robot. 10

b) Why ROS is preferred for development of Robots? Justify with example 10

Q10.a) Explain working of ROS and various communication tools. Justify the importance of ROS in Robotics 10

b) Analyse Robot path planning for AGV. 10

SCHEME OF VALUATION

V Semester Diploma Examination, Make Up Exam September – 2023

Department of Electronics and Communication Engineering

20EC53IT: AUTOMATION AND ROBOTICS

Note: Answer one full question from each section.

Q. No	Description	Marks
1 a	Role & benefits any 5	5*2m = 10m
1b	Any 5 components, description of any 2 5	5m+2.5m*2 =10m
2a	Any 5 justification /advantage	5*2m =10m
2b	Any 5 explanation	5*2m = 10m
3a	Factors 5,Protocols 5 details	5m+5m=10m
3b	Sensors 5, Usage 5	5m+5m=10m
4a	Analysis 2, protocols explanation any 4	2+4*2m=10m
4b	Troubleshoot, i/o malfunction	4+6=10m
5a	Diagram/block diagram, ladder diagram with explanation	4m+3m+3m=10m
5b	Comparison 5	5*2m=10m
6a	Any 5 analysis and its usage	5*2m=10m
6b	Diagram, Explanation	4m+6m=10m
7a	Any 10 components	10*1m=10m
7b	Justification block diagram explanation	4m+6m=10m
8a	Any 4 roles , any 6 comparison	4m+6m=10m
8b	Block diagram, explanation	4m+6m=10m
9a	Parts , functions	5m+5m=10m
9b	Any 5 features	5*2m=10
10a	Working, communication tools	5m+5m=10
10b	Explanation on AGV +any 2 path planning	5m+2.5m*2=10m

SECTION 1

Q1a) Mention the role and benefits of automation in industry 4.0 10

1) Increase in Productivity: These systems make automation possible for factories and industrial processes, allowing a continuous mass production 24/7. 24 hours a day, seven days a week, which improves productivity and reduces assembly times

2) Enhances Quality: By means of adaptive control and monitoring in different stages and industrial processes, these systems are useful in eliminating human error and thus improve the quality.

3) Greater consistency: Machines and computers work at a constant and continuous pace. Therefore, automated production processes have a longer duration, stability and solidity when managed with an automation system.

4) Flexibility: Implementing a new task in a traditional production chain involves hours or days of user training. On the other hand, with an automated system, reprogramming a robot or machine is a simple and fast process that provides greater flexibility in the production process.

5) More precise information: Automation of data collection improves accuracy and reduces costs. Such increased accuracy enables company managers to make better decisions.

6) Cost reduction: Although the initial investment in industrial automation systems might be rather high, implementing this technology will translate into a reduction of data analytics costs.

7) More efficient material use: A good automation system keeps track of all the different materials, ingredients, or commodities moving through the system and monitors waste. This data can provide insights into opportunities for more efficient material use.

8) Predictive maintenance: A huge benefit of industrial automation is that it helps in monitoring and predictive maintenance. Production lines and the production floor can be continuously monitored using sensors. These sensors track temperature, acoustics, time, frequency, oil pressure, and other parameters related to the production process. If the sensors detect any change in these parameters, they will immediately send an alert.

9) Increase in human efficiency: The systems that a company implements to automate their services will not only perform the tasks that a human being would do, but these automated systems are capable of performing functions that exceed the capabilities of a real person.

b) List the various components used in laptop package industry. Describe any two. 10

Some of the Components used in Laptop packaging industry are :-

- Miniature Photoelectric Sensor
- Wireless Limit switch
- Ultrasonic Sensor
- VFD to control the speed of conveyor belt
- Servo motors
- Proximity sensor
- IR sensor

(Explanation any 2)

- Miniature Photoelectric Sensor- Ideal for mounting in limited mounting space. Used for object detection /Distance measurement.
- Wireless Limit switch o Used to tally the items or materials to a pre-determined limit.
- Used as interlocks to prevent machine parts from moving further.
- Used to activate or de-activate a device to prevent malfunctioning /emergencies
- Ultrasonic Sensors- detects both distance and proximity. It’s very useful in anti-collision detection or presence detection.
- VFD- Variable frequency drive that can be used to control the speed and movement of motors in conveyors.
- Servo motors- used in actuators for its movements in different dimensions for various purposes.

Q2a). Robots play a very important role in Packaging Industries. Justify your answer 10

Ans: The packaging industry has long taken advantage of the benefits of automation. Robotic packaging systems are an integral component of the packaging process, and they're found in warehouses and on production lines worldwide.

The advantages of automated robotic packaging systems include:

- Increase efficiency in the packaging process
- Reduce the need for monotonous manual tasks
- Improve health and safety in industrial settings
- Lower packaging costs
- Cut down on waste
- Can be run 24/7 without the need for breaks
- Have a versatile number of uses and applications
- Can achieve high levels of accuracy and precision

The following are the most common tasks that robots undertake in the packaging industry.

i) Pick and Place

Robots are well suited to pick and place tasks in the packaging industry. There are a number of different pick and place tasks they carry out, including assembling packaging parts, placing components or products into packaging, and picking objects off conveyor belts.

ii) Boxing

Products can be quickly boxed into their respective packaging when they have been assembled. In an industrial setting, packaging robots can carry out boxing tasks quickly and accurately.

iii) Depanning

One of the more niche tasks that robots carry out is depanning. This is required when foods, such as mass-produced cakes, need to be depanned after cooking and before being packaged.

iv) Inspection

Robots may be used for product inspection in warehouses and on production lines. They may inspect the final, packaged products or they may inspect the goods themselves prior to being packaged.

v) Palletising

Once products have been packaged, they often need to be palletised for transport. Packaging robots can quickly and safely palletise large numbers of goods, making them ready for the next stage in the distribution chain.

vi) Warehouse

Work Robots may carry out a variety of different warehouse tasks that are essential for the packaging of goods. For example, robots may be used to move goods or pallets around the warehouse, for inspecting and servicing mechanical parts, and for many more industrial tasks.

b) How robots are revolutionizing medical device manufacturing. 10

Technology Trends

Following are the technology trends that impacting the topic of Robotics in Medicine.

AI:

- AI technology, especially machine learning, is an integral part of developing intelligent industrial robots that can predict and adapt to specific situations based on the interpretation of data from various sensors.
- Taking industrial automation and robotics to the next level requires further advances in certain AI technologies such as computer vision, conversational platforms, and context-aware computing.

- Neuromorphic processors will be an important part of the next generation of robots. They are trained on a basic library of relevant data and learn how to think for themselves by processing sensory input. These processors will eventually use their acquired skills to perform assigned tasks.

Edge computing:
Robot operations can be performed from the cloud, but security and latency issues may require the robot to process real-time data about the operating environment and react immediately. Edge computing can improve robot performance due to lower latency. Security is also better because the edge is more secure than the cloud. Edge computing, combined with self contained "sense-decide-act" firmware loops in robotics, makes cyber-attacks more difficult.

Cyber security:
One of the biggest challenges to the widespread implementation of robots is the threat of cyber-attacks. Robots, especially those connected to the internet, are highly vulnerable to hacking. Left unprotected, it can allow unauthorized access to critical applications and systems, resulting in the loss, theft, destruction, or improper use of sensitive information.

Industrial Internet:
The Industrial Internet implies a higher level of connectivity between systems and assumes that monitoring and control data will flow beyond factory boundaries and be consumed and managed by cloud-based services. Existing factories, machines, and processes are prime opportunities for the Industrial Internet. • • The greatest short-term gains come from retrofitting today's industrial infrastructure with advanced communication and management capabilities. By giving industrial equipment manufacturers access to real-time performance data, they can offer new services and support new business models such as predictive maintenance and robotics as a service (RaaS).

Cloud robotics:
Advances in AI have enabled the evolution of robots, allowing them to become highly complex products rather than stand-alone, fixed-function machines, with an increasing number of roles that robots can play. Central to this development was the cloud computing. This enables faster, more secure and more scalable management of sensing, computing, and storage. Using the cloud in robotics could change the way we use technology. The RaaS market includes products that integrate cloud-based management and analytics services with physical robots. Major robot manufacturers have implemented cloud connectivity to enable remote monitoring, management and maintenance of their robots.

Robotics centres of excellence (CoEs):
The Robotics CoE is responsible for designing and implementing robotic solutions that are efficient, productive, and address industry needs. The CoE collects, evaluates, and manages information that facilitates the use of robotic solutions. A robotics CoE requires a strong governance model and the right mix of people, including sponsors, leads, project managers, business analysts, architects, developers, and controllers.

SECTION 2

Q3a). On what factors the communication protocols used in automation industries depends on? Mention the specification of any 5 standard communication protocol/cable used with PLC modules connected over network. 10

The communication protocols are dependent upon three fundamental parts/factors
1.baud rate
2.network length
3.number of nodes

The different types of standard communication protocols support different speeds (baud rate), distances (network length), and the number of connecting devices (nodes).

Slno	Protocol/cable	Baud rate	Length	Node
01	Ethernet	100 Mb/s	(Few Km)	255
02	Profibus	5-12 Mb/s	15 Km	127
03	MPI	19.2- 38.4 Kb/s	50 m	32
04	PPI	187.5 Kb/s	500 m	1
05	DH	230.4 Kb/s	3.048 Km	64
06	Control Net	5 Mb/s	30 K	
07	Device Net	500 Kb/s	0.487	64
08	USB Adapter	57.6 Kb/s	10 m	1
09	PC Adapter	9600 Kb/s	15 m	1
10	RS-232	19.2 Kb/s	10 m	1
11	RS-485	10 Kb/s	1.2 Km	32

b) List any five possible sensors used in potato manufacturing industry. Explain the purpose of using them. 10

The following main machines for potato chips line are used in potato manufacturing industry. 1.Potato sorting machine

Defect sorter-it detects defective potatoes

Components -colour sensors/camera sensors (to detect dark green/black spots) are used

2.Potato washing and peeling machine

It integrates the function of washing and peeling. It is equipped with a spiral discharge and spraying device.

Components- moisture sensors, vibration sensors, camera sensors (to detect residual peels)

3. Potato slicing machine

It is used for cutting the potatoes into slices.

Components- Cutter with motor and VFD can be used for slicing the potatoes into required sizes with necessary speed of cutting.

4. Potato blanching machine

It is used to blanch the chips to protect chips from changing color and protect the natural taste. Components – color sensors can be used.

5. Vibration de-watering machine It is used to remove extra water of potato chips by high frequency vibration. Its bottom is with discharging plates. Also prevents the potato slices sticking together. Components- vibration sensors, moisture sensor

6. Air blowing potato slices dewatering machine

The machine can remove water from the surface potato slices by blowing strong air at normal temperature.

Components- pressure sensors can be used.

7. Continuous potato chips frying machine – adopts oil-water mixing technology, also equipped with meshlifting system

Components- temperature sensors, color sensors can be used.

8. Vibration potato chips de-oiling machine

By high frequency vibration, it can remove extra oil on fried potato chips in an effective and efficient way. It also prevents potato chips sticking together.

Components- vibration sensors

9. Potato chips de-oiling cooling machine
Removes extra oil with cooling the chips to prevent from clogging
Components- temperature sensors, vibration sensors.

10. Potato chips flavouring machine

- Weigh Guard- ensures accurate dosing of salt and other flavouring to the potato flakesPressure sensors/weight sensors
- Vibrator sensor-is used while transferring to flavour drum uniformly
- Flavour drum- Flavouring is introduced at the same time as potato chips/pellets enter the drum-IR/ultrasonic sensors are used.

11. Automatic potato chips packing machine
Complete process of feeding, measuring and weighing, nitrogen filling and sealing is done. Components- Weighing sensor/load cell, pressure sensor, level sensor can be used.

Q4. a) Analyse the common industrial protocols that are used in a milk processing industry and explain any four communication protocols. 10

The Communication protocol is the way to trans-receive the data with a set of rules that sends or receives between two or more devices. The communication protocol is the media or channel between two or more communicating devices.
By using the communication protocols, two devices can connect and communicate with each other. Without communication protocol, devices can only be connected but not communicated.
Most commonly used protocols with PLC in milk processing industry are:

- Modbus RTU
- EtherNet/IP and Ethernet TCP/IP
- Modbus TCP/IP
- Profibus
- Profinet

Modbus RTU
Modbus RTU is an open serial protocol derived from the Master/Slave architecture. It is a widely accepted serial level protocol due to its ease of use and reliability. Modbus RTU is widely used within Industrial Automation Systems (IAS), Home Automation, Building Management, Robotics etc. This protocol primarily uses an RS-232 or RS-485 serial interfaces for communications and is supported by almost every commercial SCADA, HMI, OPC Server and data acquisition software program in the marketplace.

EtherNet/IP and Ethernet TCP/IP
EtherNet/IP is an open application protocol, maintained and distributed by ODVA. It is used by Ethernet modules for several PLC's including Allen Bradley, Schneider Electric and Omron. EtherNet/IP is an Ethernet adaptation of the Control Information Protocol (CIP) in the same way that DeviceNet is a CAN adaptation of CIP and ControlNet is a CTDMA adaptation of CIP.

EtherNet/IP I/O provides a mechanism of deterministically sending data in both directions between a PLC and remote device. This data is sent on an interval called the Requested Packet Interval (RPI). EtherNet/IP I/O is a very fast and easy-to-use method of communication. It reduces the amount of ladder logic required for communication, and communication occurs even when the PLC is in Program mode.

Ethernet TCP/IP is responsible for the transmission of the packets, which are composed of Modbus frames containing commands to read/write into the shared memory of a device.

Modbus TCP/IP

Modbus TCP/IP is a simple Modbus protocol running on Ethernet over a TCP interface. Modbus is an application protocol that assigns the ways of managing and passing data between various layers without being affected by the protocol used by the next immediate layer.

Profibus

- Profibus as process field bus, is a standard for fieldbus communication in automation technology, which is extensively used by Siemens.
- Profibus communicates via a serial protocol behind which a complex machinery is housed to transport the data reliably through an industrial environment.
- The Profibus protocol is designed for high-speed communications with distributed I/O devices (remote I/O).
- Profibus connection port look like DB-9 serial connector but protocol is totally different.

Profinet

- Profinet is process field net, is an Ethernet-based communication protocol. The physical interface used for Profinet is a standard RJ-45 Ethernet jack.
- Profinet cables are easily recognizable by their green color.
- Due to its high-speed operation and a response time of less than 1 millisecond, Profinet is ideal for high-speed applications.

b) Consider a food processing industry using a PLC based automation system. How do you troubleshoot the PLC processor module, Input malfunctions and Output malfunctions in such industries? 10

In the event of a PLC fault, you should employ a careful and systematic approach to troubleshoot the system to resolve the problem. PLCs are relatively easy to troubleshoot because the control program can be displayed on a monitor and watched in real time as it executes. If a control system has been operating, you can be fairly confident of the accuracy of the program logic. For a system that has never worked or is just being commissioned, programming errors should be considered. When a problem occurs, the first step in the troubleshooting procedure is to identify the problem and its source. The source of a problem can generally be narrowed down to the processor module, I/O hardware, wiring, machine inputs or outputs, or ladder logic program. Once a problem is recognized, it is usually quite simple to deal with.

The following sections will deal with troubleshooting these potential problem areas.

a) Processor Module:

The processor is responsible for the self-detection of potential problems. It performs error checks during its operation and sends status information to indicators that are normally located on the front of the processor module. You can diagnose processor faults or obtain more detailed information about the processor by accessing the processor status through programming software. The following figure shows sample diagnostics LEDs found on a processor module. What they indicate can be summarized as follows:

RUN (Green)

- On steady indicates that the process is in the RUN mode.
- Flashing during operation indicates that the process is transferring a program from RAM to the memory module.
- Off indicates that processor is in a mode other than RUN.

FLT (Red)

- Flashing at power-up indicates that the processor has not been configured.
- Flashing during operation indicates a major error either in the processor, chassis, or memory.

- On steady indicates that a fatal error is present (no communications).
- Off indicates there are no errors.

BATT (Red)

- On steady indicates the battery voltage has fallen below a threshold level, or the battery is missing or not connected.
- Off indicates that the battery is functional.

b) **Input Malfunctions**:

If the controller is operating in the RUN mode but output devices do not operate as programmed, the faults could be associated with any of the following:

- Input and output wiring between field devices and modules Processor diagnostics LEDs
- Field device or module power supplies
- Input sensing devices
- Output actuators
- PLC I/O modules
- PLC processor

The steps taken can be summarized as follows:

- When input hardware is suspected to be the source of a problem, the first check is to see if the status indicator on the input module illuminates when it is receiving power from its corresponding input device (e.g., pushbutton, limit switch).
- If the status indicator on the input module does not illuminate when the input device is on, take a voltage measurement across the input terminal to check for the proper voltage level. • If the voltage level is correct, then the input module should be replaced.
- If the voltage level is not correct, power supply, wiring, or input device may be faulty.

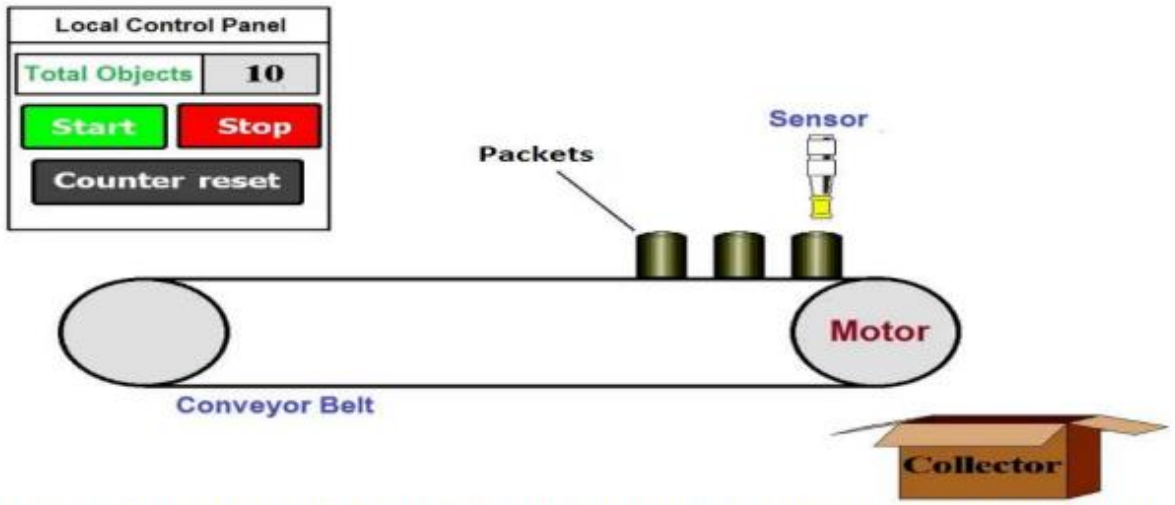
c) Output Malfunctions:

In addition to the logic indicator, some output modules incorporate either a blown fuse indicator or a power indicator or both. A blown fuse indicator indicates the status of the protective fuse in the output circuit, while a power indicator shows that power is being applied to the load. In general, the following items should be noted when troubleshooting discrete output modules:

- If the blown fuse indicator is not illuminated (fuse OK), then check to see if the output device is responding to the LED status indicator.
- An output module's logic status indicator functions similarly to an input module's status indicator. When it is on, the status LED indicates that the module's logic circuitry has recognized a command from the processor to turn on.
- If an output rung is energized, the module status indicator is on, and the output device is not responding, then the wiring to the output device or the output device itself should be suspected.
- If, according to the programming device monitor, an output device is commanded to turn on but the status indicator is off, then the output module or processors may be at fault.
- Check voltage at output; if incorrect, power supply, wiring, or output device may be faulty.

SECTION 3

Q5a) How do you realize PLC based automation system to count the packets passing on the conveyer belt in a packaging industry? 10



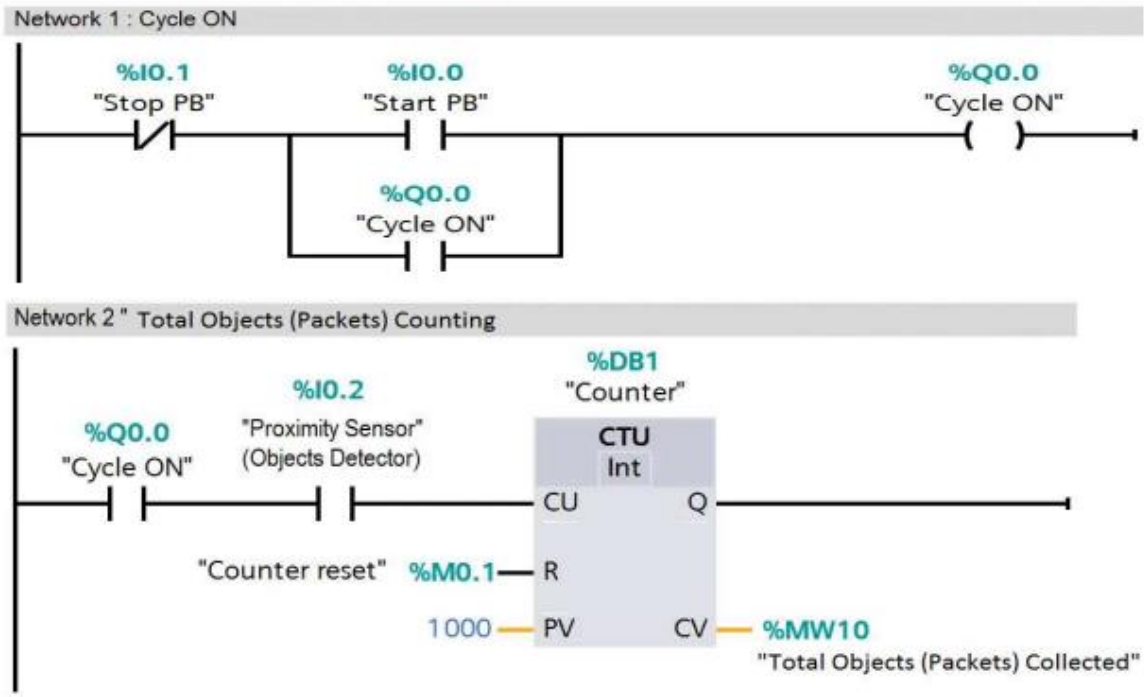
Representation of PLC based automation system to count the packets passing on the conveyer

Objects (Packets) are moving on the conveyor. We need to count the total number of packets collected at the end of conveyor and display it on the local control panel.

Write PLC program for this application.
List of inputs/outputs

Digital Inputs	Digital Output
Start :- I0.0	Cycle ON :- Q0.0
Stop :- I0.1	M memory
Proximity :- I0.2 (Objects detection)	Counter Reset :- M0.1
Counter Reset PB :- I0.3	Total Objects collected :- MW10

PLC Ladder Logic for counting Packets passing on the conveyor



Network 1:
In first network we used latching circuit for cycle ON. Here we used START PB (I0.0) to start the cycle and STOP PB (I0.1) to stop the cycle.
Network 2:
PLC Counter instruction is used to count the number of objects (Packets). Proximity sensors are mounted near to the conveyor. when an object comes near to the proximity sensor (I0.2), it will detect the object and output of the sensor becomes energize or changes to ON state. When there will be no object near to the proximity sensor then output of sensor becomes de-energize or changes to OFF state. PLC counter counts in the incremental way. Total counted Objects number will be stored in the memory word or register (MW10).

b). Why is PLC preferred over Microcontroller in industries **10**

Particulars	**PLC**	**Microcontroller**
Shock and vibration	PLC is capable of withstanding strong amount of both shock and vibration common to warehouse environment.	Microcontroller requires special mounting and connection considerations designed to hold the abuse
Corrosion	In some environments, equipment is around vapour/fumes that corrode wiring and other components.	PLC has coatings that cut down on the bare/exposed metal on their boards. Also their wires include corrosion resistant materials.
Noise	PLC has better level of protection against standard electronic noise or magnetic fields without issues.	Microcontroller could go into fault mode or lose its program if the noise interference is significant.
Temperature levels	PLC can withstand extreme temperatures even when installed in outdoor enclosure,	Microcontroller can work well only in temperature controlled environment.
Industry standards for testing	International electro technical commission (IEC) and Underwriters Laboratories (UL) include standards .as per it, each PLC system will include documentation that lists tests completed and methodologies used.	Most microcontrollers does not undergo such extensive testing, which becomes difficult to know their capabilities

Q6a). Analyse the usage of SCADA and HMI in food processing industry. **10**
Ans: 5 ways SCADA & HMI can improve food processing industry.
Automation of food and beverage manufacturing processes provides manufacturers with valueadding advantages along the entire supply chain, all the way from the field, through the factory to the end user. SCADA is one automation solution that can improve production efficiency and increase profitability. Here, we look at five areas of food and beverage manufacturing that benefit from SCADA. SCADA uses real-time data from process devices to monitor and control equipment, this improves production efficiency, visibility and increases profitability in food processing industries.

1. **Packaging**
   Packaging in food and beverage manufacturing operations are made up of various machines with differing functions, including cartoning, wrapping, labelling, shrinking, sealing, case and tray forming, capping, cleaning and sterilising, as well as inspection and detecting machines. SCADA can improve packing operations in a number of ways including:

Better alarming capabilities:
Better diagnostic and alarming capabilities can help reduce downtime and product waste. SCADA can help monitor packaging machines and send alarms to Human Machine Interface (HMI) devices when set parameters have been exceeded.

Predictive and preventative maintenance:
Unexpected downtime for food and beverage manufacturers can be costly, so having predictive and preventative maintenance capabilities mitigates these risks. SCADA systems can collect real-time performance data of all machines in operation, this allows informed decisions to be made about when maintenance should be performed or scheduled.

Improved integration:
Production requirements can change quickly in the food and beverage manufacturing industry, so having system flexibility is desirable for an efficient and scalable operation. SCADA can provide integration flexibility with disparate hardware and systems along with keeping the system or products updated if changes within the industry or company are required.

Traceability:
High food safety standards require manufacturers to trace products throughout the entire packaging process. SCADA automatically collects real-time data and collates it in one central system, allowing manufacturers to link a particular product to a shipment of ingredients, it's associated packaging line or even where it was distributed.

2. **Recipe re-creation**
SCADA can be used to create user-defined recipes within the system automatically, this removes the need for manual supervision each time a new product batch starts production, it also guarantees a high-quality and consistent product by monitoring recipes. These recipes can also be imported or exported along with real-time data, so provides many options for data gathering and reporting. The increased control over food and beverage production has several benefits for manufacturers, including:
    - Eliminating errors when entering step times for every recipe
    - Removes the need for traditional pen and paper systems of maintaining recipes
    - Automatic update of temperature set points rather than manual adjustment
    - Simplified operator control
    - Monitoring allows problems to be detected and corrected before any faulty product is distributed

3. **Maintaining quality standards**
Food and beverage manufacturers need to be able to meet the various standards that are applicable in the countries they operate in. The use of ingredients, processing aids, colourings, additives, vitamins and minerals, and the composition of some foods, as well as some labelling requirements for packaged and unpackaged food. SCADA can trace products through the packaging process in real time, it can also be used to track a food or beverage product throughout the entire production, process and distribution chain.

4. **Greater visualization of production**
SCADA can be used to get greater visualization on the status of production by tracking the realtime status of machines and its components. This information can be used to find trends and patterns, as well as for logging comparisons. Manufacturers can compare this data across their chosen timeframes - from minutes, to hours, and days - and use it to get a quick understanding of how a machine or its components are running, and identify when there is a problem or when maintenance needs to be performed.

5. **Creation of reports**

SCADA can also create reports, enabling manufacturers to identify, analyse and improve various processes within the organization. These reports can help identify bottlenecks, analyse production downtime causes, calculate key performance indicators and report the relevant information in a clear and concise format to the appropriate people allowing them to make the correct decisions at the right time.

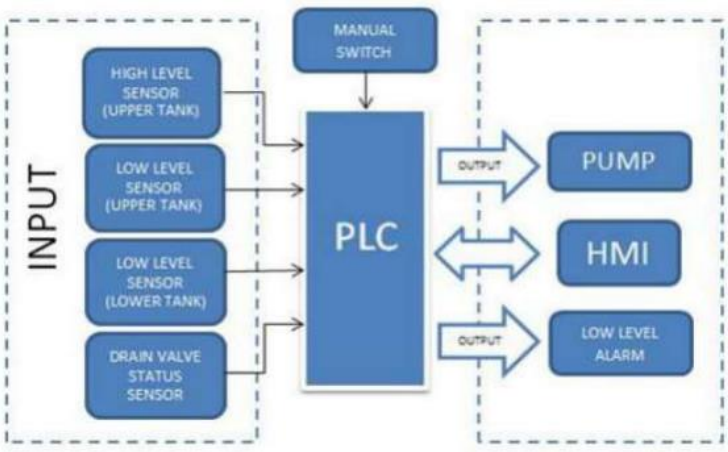
Note: Figure is optional

b) Consider a milk processing industry, describe how the milk tank level and its flow are controlled between the milk packaging process and the milk stock container tank. 10

Ans: Milk level management using PLC is design to control the level of milk and avoid wastage of milk in the tank. The system has an automatic pumping system attach to it. We are controlling the milk level by using PLC, Sensors and motor.

The purpose for doing this is reducing time consumption and human resource consumption, increase product revenue and greater accessibility or more security. Also by using this, the wastage of milk occurred by overflowing of tanks can be avoided. A PLC or Programmable Controller may be a computer used for automation of mechanical device processes. It is used to convert previously used "Relay Logic" or "Wired Logic" for automation of industrial purposes into "Ladder Logic".

The system has associate automatic pumping system hooked up thereto thus on refill the tank once the liquid gets to the lower threshold, while offing the pump once the liquid gets to the higher threshold. The proposed system will control the liquid level of the tank continuously and will ensure that a sufficient level of milk is maintained in tanks.



Block diagram

Block diagram represents the idea of processes that takes place when input is given by using ladder logic to the PLC. Level sensors are used as input to the PLC and according to that reading the PLC will give output by using pump and solenoid valves.
When we switch ON the power supply, pump will start pumping the milk in tank 2 through tank 1 and control valve (CV). When upper threshold of tank 2 is achieved then sensor 2 will sense the milk level of tank 2. Sensor 2 will send the signal to the PLC about upper threshold of tank 2. Now, PLC will send the analog signal to the control valve (CV) to interrupt the liquid flow. Then milk will fill the tank 1. When upper threshold of tank 1 is achieved then sensor 1 will sense the milk level of tank 1. Sensor 1 will send the signal to the PLC about upper threshold of tank 1. PLC will send the analog signal to the pump. Pump will stop pumping milk to tank. When milk from tank 2 is drained out sensor 2 will sense the lower threshold of milk level in tank 2. Sensor 2 will send the signal to the PLC about lower threshold of tank 2. PLC will send the analog signal to the control valve (CV) to let the liquid from tank 1 flow in tank 2. When lower threshold of tank 1 is achieved then sensor 1 will sense the milk level of tank 1. Sensor 1 will send the signal to the PLC about lower threshold of tank 1. PLC will send the analog signal to the pump. Pump will start pumping milk to tank. This operation will take place continuously and required result is obtained.

SECTION 4

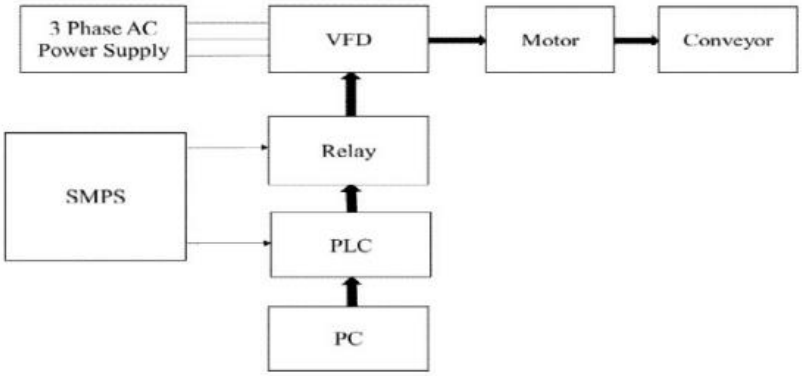
Q7a). What is typically inside a VFD control panel? 10

There are many components inside a VFD control panel. Some of them are

1) VFD – The main component of the motor control panel. The VFD inside will vary in voltage, horsepower, full load amps (FLA), and other specifications. It may contain redundant VFDs installed in case of a VFD failure.
2) Line reactors – 3% or 5% to reduce harmonic distortion.
3) Harmonic filters – a more effective way to reduce harmonic distortion.
4) Circuit breaker – protects the electrical circuit from overload or short circuit.
5) Bypass – keeps the system running even if the VFD fails.
6) PLC – Programmable Logic Controller – for more advanced operations.
7) Modem – for communication purpose.
8) AC or other cooling units – keeps the panel at a certain temperature depending on surrounding environment.
9) Soft-starter – starts motor slowly but without speed control.
10) Surge protector – protects the system from voltage spikes.
11) Multiple motor overloads – an option for powering multiple motors off one VFD, typically used on fan walls.
12) Anti-condensation heater (available in NEMA 3R panels) – eliminates the build-up of dew inside the VFD panel.
13) Motor starters – for running motors across the line.

b) VFD plays an important role in conveyor control system. Justify your answer and how it can be implemented in industries to control the speed of the conveyer. 10

Ans: To incur an accurate controlling of a Conveyor, PLC ought to be interfaced with VFD Drive, Personal computer and other equipment. Relay that is a switching device decides the operation of VFD and Induction Motor. Variable frequency Drive (VFD) is being utilized in the industry that can provide a control on various motor parameters. It finds its application in the manufacturing process, machines, pumps, rolling mills etc. Thus, VFD when compared with other starting and control methods is proved to be a better alternative. VFD raises the productivity in terms of quality and product system efficiency thereby reducing the cost of operation of the system.



Block diagram

PLC sequentially scans the input devices then it will update its memory and finally indicate the status of its action in a PLC ladder logic. It exploits the output coil of it in order to change condition of device at the output side. Then interfacing of VFD to the conveyor through induction motor is exercised. By means of logic functions like Start, Reverse, Reset and Jog the automatic control conveyor motor is accomplished. When Start is on, the first relay gets activated then the conveyor runs in forward direction

If Reverse action takes second relay runs, then the conveyor is in reverse direction. Reset operation is performed when there occurs error in execution then the conveyor doesn't run and simultaneously the third relay gets activated. The conveyor performs Jog operation when the Jog logic is being executed and fourth relay is in action. Four inputs to PLC is given by push buttons. By then the Outputs from PLC is fed to relays input. This will process inputs availing the logic given via ladder program. It will then initiate output to VFD which upon performing its operation send signals to the induction motor. Then, accordingly VFD control of speed and direction of the conveyor is caused. For the speed control of the Conveyor if the frequency of the induction motor which is connected to the conveyor then the speed of the conveyor can be easily regulated. The following formula clearly depicts this control action.

Speed (rpm) = f (hertz) x 120 / number of poles

In order to execute this action an AC VFD Drive is utilized. This has the potential to control the speed of the conveyor by varying the frequency of the input supply which being an ac source eases the control action. An AC input is given to the VFD drive which is connected to the conveyor. Then through SMPS a DC voltage is provided to the relay and Programmable Logic Unit (PLC unit). This way through the ladder logic programming is fed to PLC and the execution starts.

Q8. a) Mention some of the role of PAC in modern Industry. Compare PLCs and PACs. 10

Role of PAC in modern industry

1. Single development tool for multiple applications.:
   A PAC does tasks like counting, latching, PID loop control, and data acquisition and delivery without additional hardware
2. Provides single platform operating in Multiple Domains:
   The single PAC is capable of operating in multiple domains to monitor and manage a production line, a chemical process, a test bench, and shipping activities
3. It provides expandability and interconnection with other devices and business systems as it has open architecture and modular design
4. Support for Standard Communication Protocols:
   The PAC can control, monitor, and exchange data with this wide variety of devices and systems because it uses the same standard network technologies and protocols that they use.

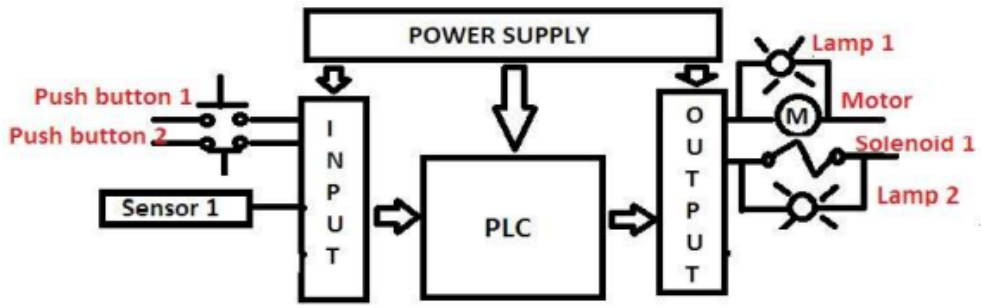
Comparison between PLCs and PACs:

Sl no	PLCs	PACs
1	PLC is a single microprocessor device which is used to control manufacturing, infrastructure, transportation and machine/station control automation equipment operation.	Programmable Automation Controller (PAC) is a multiprocessor device which is built with two or more number of processor like any other personal computers.
2	PLCs are programmed through ladder logic diagrams	PACs are programmed through structured text. Functional block diagrams and ladder logic diagrams
3	Programmable Logic Controllers (PLC) has built-in networks which enable them to communicate between multiple PLCs, I/Os, HMIs (human-machine interfaces) and SCADA (supervisory-control and data-acquisition) systems.	Programmable Automation Controllers (PAC) is incorporated with modular design open architecture use for communicating, monitoring, and controlling equipment covering multiple networks and devices.
4	PLCs comprise high-level program execution speed, but have limited memory and separate I/O device	PACs have huge memory size for larger projects and systems
5	Programmable Logic Controllers (PLC) uses Ladder Logic Diagram Programming	PAC programming is done through structured text, function block diagrams, ladder logic diagram and also other programming languages like C or C++ etc.
6	PLCs are the perfect model for simple and high-speed machinery controlling, such as automated spray equipment, assembly equipment, dispensing systems and motion control systems to name few.	Programmable Automation Controllers (PACs) are ideal for large-scale automation projects and operations.
7	PLC support around 3000 I/O devices	PACs support around 128000 analog and digital I/O devices

b) How would you set-up pneumatic valves, actuators and sensors to build automatic stamping labelling machine? 10

All product automation processes require stamping as a last step to brand the finished product. Different types of products require different types of stamps. Here a complete stamping system that stamps the logo on the finished product. The system is automated and controlled by PLC.

The system consists of a conveyor belt driven by a DC motor. The process is started using a start push button, and when the product reaches the stamping base, the sensor senses the product and the stamp mounted on the pneumatic cylinder is activated with the help of a solenoid valve which initiates the stamping process. After this the final stamped product is moved ahead and collected in the tray.



Block Diagram

Components/Instrumentation:

- Programmable Logic Controller (PLC)
- Push Buttons •Led's
- Relay card
- Metal Detector Sensor
- IR Sensor
- Self-inked stamp
- Conveyor Belt
- DC Motor
- Pneumatic Cylinders

It is based on the concept of Automatic Rubber Stamp object printing machine by using PLC. In order to ensure the reliable printing mechanism this replaces traditional hand stamping on any object. In this automated system we replace traditional hand stamping method by automatic printing. Now this automatic object printing machine consist of conveyor belt mechanism on which we place any object to be printed, also we interface two sensors that IR sensor and limit switch to detect the object. we use DC motor to run the conveyor belt and when the conveyor starts, IR sensor will detect the position of the object. When object is detected IR sensor will indicate a signal to the PLC and the PLC will stop the conveyor motor, the second motor will start to print the stamp on the object. After specified time the conveyor will start again and process will continue to print next object.

As shown in the block diagram, PLC with IR Sensors to detect the object. The proposed model has a conveyor belt run with the help of dc motor and corresponding pulleys at the motor and its opposite ends which constantly run at a desirable speed with the help of PLC. The conveyor belt is starts with the help DC motor and then the material is fed on the feed-side of the belt. This mechanism with the IR sensor it will detect the object on the conveyor as the object is detected the conveyor motor stops after that the stamp motor will start and the printing on the object is done and meanwhile the counting of object will display on the PLC display, after that the stamp motor will stop and the conveyor motor start and then next object will landed on the rotating conveyor belt and that will be detected by IR Sensor. The pulley that drives conveyor belt is called drivepulley or transmission drum the other one only used to change conveyor belt movement directionis called bend pulley. Drive pulley is driven by the DC motor. It can also have a guiding pulley which just guides the motion of the conveyor belt between the drive and the pulley.

SECTION 5

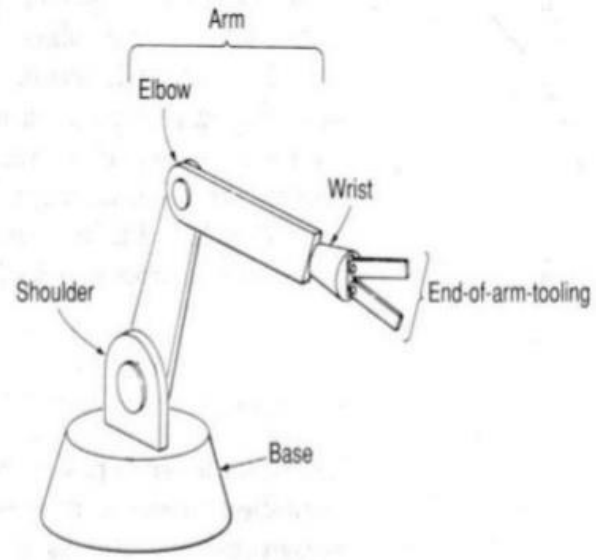
Q9a) Discuss the various parts and functions of a Robot. 10

BASIC PARTS OF ROBOT SYSTEM

1. Arm
2. Elbow
3. Shoulder
4. Wrist
5. End –of –tooling
6. Base

OR

1. Manipulators
2. End effectors
3. Feedback Drives
4. Controllers
5. Locomotive devices



Industrial functions of Robot

1.Material handling and machine loading and unloading applications.
In these applications the robot's function is to move materials or parts from One location in the work cell to some other location.

2.Processsing applications.
This category includes
spot welding
Arc welding
Spray painting

3.Assembly and inspection.
These are two separate operations, which we include together in this category. Robotic assembly is a field in which industry is showing great interest because of the economic potential.

Non-Industrial functionsof Robots

1.Ocean exploration
2.Agriculture and forestry
3.Construction industry
4.Mining and coal mining
5.Defence 6.Entertainment
7.Household jobs
8.Sports training
9.Nuclear applications
10.Medical applications
11.Space applications
12.Wool shearing

b) Why ROS is preferred over Robots justify your answer **10**

The following are the features of ROS required for development of robots.

1. ROS is general: The same base code and knowledge can be applied to many different kinds of robots: robotic arms, drones, mobile bases, once learned about how communication is done between all the nodes of the program, we can setup new parts of an application very easily.

2. ROS packages for everything: If we need to compute a trajectory for your robot, there is a package for that. If we use joystick to control the robot, there is also a package for that. If we want to map out a room with a drone, there are many packages to do that. There are many ROS packages for almost any robotic application.

3. ROS is language-agnostic (sub-programs can be written in any language): we can easily communicate between a Python node and a C++ node. It means a lot of reusability and possibilities of coworking. Many libraries also allow to use other languages (because ROS has mainly targeted C++ and Python). we can also get a web socket server running on your robot (rosbridge_suite) or an HTTP server, and thus use any language to communicate with it.

4. ROS has great simulation tools: we always get your robot running for real, so you need simulation tools. ROS has many great tools, such as Rviz and Gazebo. With Gazebo we can even add some physical constraints to the environment, so when we run the simulation and the real robot, the outcome is pretty much the same. Imagine mapping a room in 3D with a drone directly on your computer, that could save you a huge amount of time. The simulation tools also allow you to see and use other robots that you don't possess, for educational purposes or to test in a specific environment.

5. You can control multiple robots with ROS: ROS can work with multiple ROS masters. It means that you can have many independent robots, each with its own ROS system, and all robots can communicate between each other.

6. ROS is light: The core base of ROS doesn't take much space and resources. You can quickly install the core packages and get started in a few minutes. Plus, you can also use ROS on embedded computers, such as Raspberry Pi 3 boards. Thus we can easily start a new project without much trouble.

7. More compatible ROS products: When you build a robot, you don't necessarily want to reinvent or recreate every part of it. You might want to focus on some development points, and integrate the rest from other manufacturers. The good news here is you can find many robotics products – such as grippers, controller boards etc. – that already have a ROS package. So, in addition to the physical tool, the software that goes with it is directly compatible with your ROS system. 8. ROS is an open source project with a permissive license: One of the greatest strength of ROS is that it's open source. Most of the core packages are released under a BSD license. A BSD license allows you to modify and use the code for commercial purposes, without having to release your code with an open source license. This can be a good point when a company decides to integrate an open source software. But, hey, don't forget about the open source spirit

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10a) Explain the working of ROS and various communication tools. 10

Ans: ROS (Robot Operating System) is actually a set of software libraries and tools made to ease the development of robotic applications. ROS is widely used in robotics companies, universities and robotics research institutes for designing, building and simulating a robot model and interfacing it into real hardware. The point of ROS is to create a robotics standard, because it is open-source, you have the flexibility to decide where and how to use ROS, as well as the freedom to customize it for your needs.

ROS is a framework that is used by techies and various companies across the world in the field of Automation and Robotics. ROS acts as an easy entry point for beginners in the robotics programming field. As you can see ROS plays a major role in the robotics and automation industry. ROS is a BSD-licensed system for controlling robotic components from a PC.

A ROS system is comprised of a number of independent nodes, each of which communicates with the other nodes using a publish/subscribe messaging model. For example, a particular sensor's driver might be implemented as a node, which publishes sensor data in a stream of messages. These messages could be consumed by any number of other nodes, including filters, loggers, and also higher-level systems such as guidance, path finding, etc.
ROS comes with 3 main communication tools which help the programs communicate between each other:

- **Topics** – This tool is used mainly for sending data streams between nodes Ex: When monitoring the temperature of a motor on the Robot, the node monitoring this motor will send a data stream with temperature. Any other node can subscribe to this topic and get the data. Topic is like a shared mailbox. Nodes can put messages on this mailbox and are called publishers. Nodes that subscribed to that topic will receive a copy of the message. We can have multiple publishers, one publisher broadcasting to multiple subscribers or even one publisher and a single subscriber.
- **Services** – This will allow you to create a simple synchronous client/server communication between nodes. It's very useful for changing setting on the Robot or ask for a specific action like enable free drive mode, ask for specific data etc. Services can send inputs and receive a reply. The service node that sends the request is called a "service client" and the one that sends the response is called a "service server".
- **Actions** – A little bit more complex, they are in fact based on topics. They exist to provide you with an asynchronous client/server architecture, where the client can send a request that takes a long time (ex: asking to move the robot to a new location). The client can asynchronously monitor the state of the server and cancel the request anytime.

b) Analyse Robot path planning for AGV. 10

Automated guidance vehicles are actually mobile robots that are electrically powered and run on their own. They are guided by a computerized system that determines their movement with software applications. AGVs are powered by a battery or electric motor that enables the complete operation of warehouse loading, manufacturing, and other operations.

There are a wide variety of navigation systems that are used to guide these robots. The navigation system will be determined by the path and is classified in:

- A fixed path
- Free-ranging

The way an AGV calculates its current position (It has to know where it is and where to go) is classified as:

- Absolute: Vehicle knows it position at all times for example laser systems
- Relative: The vehicle does not always know its location, a calculation from the previous position determines its position for example iodometric systems.

Magnetic tape - This is a fixed relative system where the AGV is fitted with a magnetic reader in the front that detects magnetic field fluctuation. Tape embedded on the ground creates a magnetic field to guide the path. The magnetic reader, wheel turning, scanners are all connected to a control unit that guides the vehicle into performing complex manoeuvres. RFID cards are used in conjunction with the magnetic strip and are read at the same time.

This enables the vehicle to:

- Execute stops
- Changes of trajectory
- Take different paths, make stops
- Charge battery.

Optical vision - This system is a fixed relative system that is an optical vision-based. Through the use of cameras and sensors, the AGV acquires information about its environment and makes decisions.

There are various types of optical systems, such as:
• **QR code recognition**: Codes and reference points are arranged on the ground in advance with great precision. The AGV recognizes them and knows where it is and how far to move and the right detection or path to get to the next reference.

• **Ground guidance**: The AGVs path is painted on the ground in a contrasting colour to the ground. It is similar to the magnetic strip scenario.

• **3D cameras**: This system provides the AGV with images of its surrounding environment in real-time. It adds values like distance intensity and confidence thresholds, allowing detection of landmarks and recognizing obstacles and relating it to a pre-loaded map.

• **Laser systems**: These systems operate freely and are absolute. AGVs with laser navigation are also called Laser Guided Vehicles (LGVs). These vehicles are fitted with a device that emits thousands of light beams per second. These light beams bounce off reflectors (catadioptric) that are captured by a receiver. The system calculates the time that the beam takes to go and come in order to navigate distance. By being able to detect up to 3 reflectors the vehicle can calculate its position in a triangle and then compare it to a map stored in its memory. This is a very accurate and reliable system that lends to great flexibility and when changes are made to the management software, it does not affect the production environment. This allows the AGV to follow multiple paths.

• **Slam system**: This is a free and absolute system and the name is derived from the acronym “Simultaneous Localization and Mapping.” This navigation technique is quite natural as it allows the AGV to build a map of the environment and navigate through at the same time. This system can also use a laser to detect the environment but with SLAM it is not necessary to install reflectors. The navigation system has a preloaded map with a series of reference points. The secret is that SLAM uses complex algorithms.