1130 **Code : 20EC53I**

Register Number | | | | | | | | | | |

V Semester Diploma Examination, June/July-2023

AUTOMATION & ROBOTICS

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

Instruction : Answer **one** full question from each Section.

SECTION – I

1. (a) Consider a paper plate manufacturing industry using manual production changing to automation production. Analyse the advantages of automation process over the manual process. **10**

   (b) A Laptop manufacturing industry having permanent automation was not able to meet the demands of market supply due to slow production. Explain how the change over to programmable automation by the Laptop industry could improve its productivity. **10**

2. (a) Robots play a very important role in packaging industries. Justify your answer. **10**

   (b) How does industry 4.0 technologies help to increase productivity of manufacturing sector ? Illustrate with an example. **10**

SECTION – II

3. (a) Analyse how would you test the functionality of Dam shutter control system to meet exact operational specifications. Explain the networking protocols used. **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**

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

(b) A person sees a car which is being driven without a driver. Can this be possible ? What is the technology involved ? Explain in detail the different types of sensors used in such cars. 10

SECTION – III

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

(b) Analyse the usage of SCADA and HMI in food processing industry. 10

6. (a) Consider a milk processing industry. Describes how the milk tank level and its flow are controlled between the milk packaging process and the milk stock container tank. 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 conveyor. 10

SECTION – IV

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

(b) Now a days Robots are used in different applications. Mention and analyse various industrial applications where it can be used to simplify the task of a human. 10

8. (a) Raw materials needs to move from the stockyard to the production line. Explain how robots can be used for this line following application. 10

(b) The Robot can be used for standard pick and place applications where objects are picked up and moved to other locations in a single plane. Discuss the various parts and functions of a Robot to perform the above task. 10

SECTION – V

9. (a) Illustrate with an example why is ROS preferred for development of Robots. 10

(b) Discuss how Maze solving Robot can be used in industrial applications. Mention its advantages. 10

10. (a) ROS plays a very important role in Robotics. Justify your answer. Explain its working and various communication tools. 10

(b) Discuss significance of Artificial Intelligence in Robotics with an example. 10

SCHEME OF VALUATION

V Semester Diploma Examination, June/ July – 2023

Department of Electronics and Communication Engineering

20EC53IT: AUTOMATION AND ROBOTICS

Note: Answer One full question from each section.

Q. No	SECTION – I	Marks
1. (a)	Analyse any 5 advantages of automation process each carries 2 Marks	5 * 2 = 10
1. (b)	Explanation	10
2. (a)	Justification with any 5 advantages or any 5 common tasks that robots undertake in the packaging industry	5 * 2 = 10
2. (b)	Explanation + Example	5 + 5 = 10
	SECTION – II	
3. (a)	Analyse + Explanation of the networking protocols (any two) used	4 + (2*3) =10
3. (b)	Troubleshoot the PLC processor module + Input + Output malfunctions	4+3+3 = 10
4. (a)	Analyse + Explain any 4 communication protocols	2 + (4*2) = 10
4. (b)	Identifying the technology involved + Explanation of 4 types of sensors	2 + (4*2) = 10
	SECTION – III	
5. (a)	Block digram/ Representation + PLC Ladder diagram + Explanation	3+3+4 = 10
5. (b)	Analyse 5 usage of SCADA & HMI	5 * 2 = 10
6. (a)	General block diagram containing controller, sensor & actuator + Explanation	4 + 6 = 10
6. (b)	Justification + Implementation (Block diagram + Explanation)	3+(3+4) = 10
	SECTION – IV	
7. (a)	Block diagram + Explanation	4 + 6 = 10
7. (b)	Mention & analyse any 5 industrial applications of Robots that can be used to simplify human tasks	5 * 2 = 10
8. (a)	Block diagram + Explanation	4 + 6 = 10
8. (b)	Discuss the various parts with figure + Explation	5 + 5 = 10
	SECTION – V	
9. (a)	Any 5 features of ROS (with explanation), which are preferred for development of robots.	5 * 2 = 10
9. (b)	Discussing Maze solving Robot industrial applications + Mention any 4 advantages	6 + 4 = 10
10. (a)	Justification + Working of ROS + Various communication tools explanation	3+2+5 = 10
10. (b)	Significance of Artificial Intelligence in Robotics + Any one Example	6 + 4 = 10

Note: *The Model answer are given for reference to valuators for valuation. The valuator may also consider answers, suitable sketches, programs and explanation which are most appropriate.*

MODEL ANSWERS

V Semester Diploma Examination, June/ July – 2023

Department of Electronics and Communication Engineering

20EC53IT: AUTOMATION AND ROBOTICS

Note: Answer One full question from each section.

SECTION – I

1. (a) Consider a paper plant manufacturing industry using manual production changing to automation production. Analyse the advantages of automation process over the manual process. ***10 Marks***

Ans: Manual processes involve human effort and rely on personal skills, while automated processes use technology and machines to complete tasks more efficiently. The following are the advantages of automation for paper plate manufacturing industry:

i) **Increase in Productivity:** These systems make automation possible for factories and industrial processes, allowing a continuous mass production 24/7, which improves productivity and reduces assembly times.

ii) **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.

iii) **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.

iv) **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.

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

vi) **Promotes Industrial Safety:** It is safer to use robots on production lines with dangerous working conditions for humans. Industrial automation systems play an important role in keeping employees out of harm's way. A lot of the processes that have been taken over by automation technology used to be done by hand by employees who had to get close to moving equipment. The more you automate, the more you're keeping people at a safe distance and allowing conveyors and hoppers to fill grinders and mixers with the material.

vii) **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.

viii) **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.

ix) **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.

x) **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

Reference → https://www.deskera.com/blog/benefits-of-investing-in-automation-for-paper-manufacturers/

1. (b) A Laptop manufacturing industry having permanent automation was not able to meet the demands of market supply due to slow production. Explain how the changeover to programmable automation by the laptop industry could improve its productivity. *10 Marks*

Ans: Industrial automation is a system that allows manufacturing companies to increase productivity through computerized technologies. Programmable automation is one such automated manufacturing system designed to accommodate batch processes and facilitate changeover of products. Like any Industrial Automation process, Programmable automation features production equipment tooled with computer-controlled devices that control and monitor a sequence of functions and tasks. In this the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program, which is a set of instructions coded so that the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products

Industrial automation systems are systems designed to replace the repetitive and mechanical tasks associated with one person and decisions made by them in the manufacturing process. Intended to operate automatically to achieve output at a higher and consistent level, automated devices can be programmed to control processes, but also have the capability of making decisions during

production processes. Programmable automation utilizes an assortment of CNC (Computer Numerical Controlled) machine tools, industrial robotic applications and programmable logic controllers (PLC) that work in real time. Operational efficiency is accomplished through the application of logical programming commands with automation technologies that power equipment and machinery. As an automated process, programmable automation:

- Dramatically increases production and output
- Lowers associated costs
- Improves the work environment for employees by not only intellectually engaging them in production
- Removes humans from performing repetitive or hazardous tasks

Reference → https://www.eaminc.com/blog/what-is-programmable-automation/#:~:text=Industrial%20automation%20is%20a%20system,and%20facilitate%20changeover%20of%20products.

2. (a) Robots play a very important role in Packaging Industries. Justify your answer. *10 Marks*

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.

Robotic packaging is the use of automated machinery and robots in order to carry out packaging tasks, often in an industrial setting. Robotic packaging systems allow a range of different packaging tasks, such as picking, placing and palletising, to be carried out safely, efficiently and effectively. Robot packaging equipment may include stand-alone robots, including the popular robotic arm that can be used for picking and placing, or they may be integrated into wider production processes, such as on car assembly lines.

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

Robotic packaging systems are incredibly versatile, and they may be used for a large number of different packaging tasks. From sorting sausages into packets to palletising crates in a warehouse, if the task can be automated then robots can do it with accuracy and speed.

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.

Reference → https://www.cyberweld.co.uk/how-are-robots-used-in-the-packaging-industry#:~:text=Robotic%20packaging%20is%20the%20use,out%20safely%2C%20efficiently%20and%20effectively. & https://blog.robotiq.com/top-7-robotic-applications-in-food-packaging

2. (b) How does Industry 4.0 technologies help to increase productivity of manufacturing sector? Illustrate with an example. *10 Marks*

Ans: Industry 4.0 is revolutionizing the way companies manufacture, improve and distribute their products. Manufacturers are integrating new technologies, including Robotics, Internet of Things (IoT), cloud computing and analytics, Large-scale Machine-to-Machine communication (M2M),

Artificial Intelligence (AI) and machine learning into their production facilities and throughout their operations. These smart factories are equipped with advanced sensors, embedded software and robotics that collect and analyze data and allow for better decision making. Even higher value is created when data from production operations is combined with operational data from ERP, supply chain, customer service and other enterprise systems to create whole new levels of visibility and insight from previously siloed information.

This digital technologies lead to increased automation, predictive maintenance, self-optimization of process improvements and above all, a new level of efficiencies and responsiveness to customers not previously possible. Developing smart factories provides an incredible opportunity for the manufacturing industry to enter the fourth industrial revolution. Analyzing the large amounts of big data collected from sensors on the factory floor ensures real-time visibility of manufacturing assets and can provide tools for performing predictive maintenance in order to minimize equipment downtime. Industry 4.0 concepts and technologies can be applied across all types of industrial companies, including discrete and process manufacturing, as well as oil and gas, mining and other industrial segments.

Example: How Bosch Automotive benefited from Industry 4.0

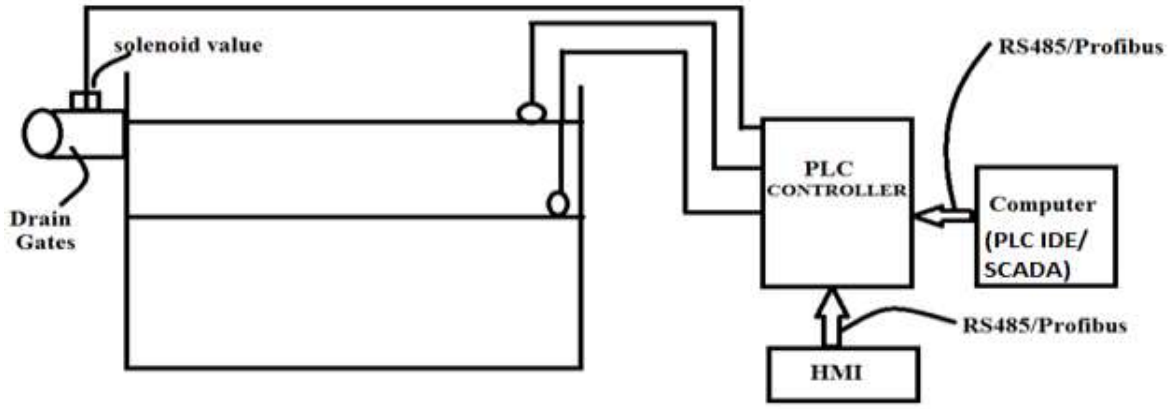
- Let's take a look at the business benefits that Bosch Automotive Diesel System factory realized after implementing Industry 4.0 to optimize production processes.
- Bosch was experiencing production failures and losses, leading them to search for a way to identify bottlenecks in their production operations in order to prevent them.
- As combining IIoT and big data is a big part of the digital transformation Bosch is undergoing, they connected their machinery to monitor the overall production process at the core of its plant. By using data analytics to process the data in real-time, they were able to predict production failures, enabling them to prevent future losses from happening before they even occur.
- They saw more than a 10% increase in throughput, and continually improved delivery time and customer satisfaction.
- The implementation of an AI-powered data solution, ultimately allowed for data-driven decision making, resulting in optimized production.
- By leveraging Industry 4.0 technologies, automotive manufacturers can address processes-driven quality and throughput losses in production and assembly processes. For example, surface quality issues, coating issues, paint thickness problems, dashboard assembly issues, interiors and more, can all be mitigated. By doing so, they experience the long term business benefits that translate to increased ROI (Return On Investment).

Reference → https://www.ibm.com/topics/industry-4-0#:~:text=We%20are%20now%20in%20the,productively%20across%20the%20value%20chain.

SECTION – II

3. (a) Analyse how would you test the functionality of Dam shutter control system to meet exact operational specifications. Explain the networking protocols used. ***10 Marks***

Ans: The ability to quickly and safely perform reservoir drawdown can be crucial to the protection and preservation of a dam. A reservoir low level outlet works and/or drain system with adequate capacity should be provided in all dams to provide a method of lowering the reservoir level in an emergency within a reasonable period. In several instances, dam failures have been averted by lowering the reservoir in response to emergency conditions detected at dams. "PLC based Automatic Dam Shutter Control System" will overcome the failures that occur in manual control system. It will manage the water level of the water reservoir automatically. At two different level, water is sensed according to which the gate is closed or open. That is when the water level goes above the threshold mark point level, door opens and it raises buzzer (or siren or GSM signal to a mobile phone) and the solenoid valve opens. When the water level goes down the door shuts automatically.



Block Diagram

The PLC integrated development environment allows us to monitor the status of the field devices while the application is running. The working can be tested before, during and after installation.

Before installing, the ladder logic functioning can be tested using simulator software in the PLC IDE.

During installation, the sensors working can be tested without connecting the field devices (solenoid controlled gates). The change in sensor state will reflect in 'Data file window' of the PLC IDE tool. The proper actuation of the output devices according to the sensor values can be analyzed in the same window.

After installation, the real time working can also tested using PLC IDE. As the water inflow to the dam changes, it is reflected though the sensors. As these sensors are connected to the input modules of PLC, the status of corresponding inputs can be seen in the IDE. When the water level

change is not reflected in 'Data file window' of PLC IDE, the corresponding connections/PLC Input module/Processor Module has to be trouble shooted.

When the sensor data is reflected properly, the actuators working has to monitored. Based on the sensors, actuator status has to change. This can be seen in the IDE tool. The status of the output port is proper, then only the field devices has to be checked.

Networking protocols used:

PLC and computers communicate using Profibus or RS485 communication protocols. Network Protocols are a set of guidelines governing the exchange of information in a simple, dependable and secure way. Serial communication is the basic communication system provided for every controller such as a PLC. This communication is implemented by using protocol standards such as RS232, RS422 and RS485. The acronym RS stands for Recommended Standard which specifies serial communication characteristics in terms of electrical, mechanical and functional features.

Serial communication interfaces are either built into the CPU or process module (consider, for a Programmable Logic Controller) or it can be a separate communication module. These RS interfaces are mainly used to transfer the data reasonably at high data rate between a PLC and the remote device.

Profibus: It is one of the well-known & widely implemented open-field networks. These networks are mainly used in process automation and factory automation fields. It is most suitable for complex communication tasks and time-critical applications such as Dam shutter control system. There are three different versions of Profibus namely, Profibus-DP (Decentralized Periphery), Profibus-PA (Process Automation) and Profibus-FMS (Fieldbus Message Specification)

Mostly PLC communication is done by the serial transmission of information, PLC's can be connected by using data cables (Ethernet, shielded pair, or coaxial) by using the data cables we can connect two PLC's. This data cable will be very useful to do the connection between the PLC and the RTU, HMI's, meters, and protective relays. By this data transmission can be achieved, the data could be either analog or discreet.

The real time working of Dam shutter control system can also be tested and analyzed using HMI and SCADA interfaces. The network protocols for communication between computer (SCADA) and HMI can be either Profibus /Serial communication.

3. (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 Marks*

In the event of a PLC fault, you should employ a careful and systematic approach to troubleshoot

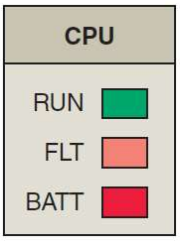
the system to resolve the problem. PLCs are relatively easy to troubleshoot because the control program can be displayed on a monitor and watched in real time as it executes. If a control system has been operating, you can be fairly confident of the accuracy of the program logic. For a system that has 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:



Processor diagnostics LEDs

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.

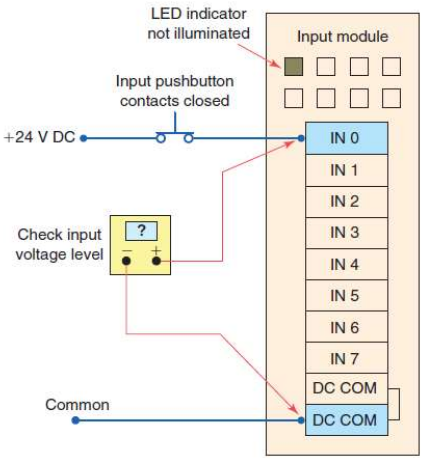
b) Input Malfunctions: If the controller is operating in the RUN mode but output devices do not operate as programmed, the faults could be associated with any of the following:

- Input and output wiring between field devices and modules

- Field device or module power supplies
- Input sensing devices
- Output actuators
- PLC I/O modules
- PLC processor

The following figure illustrates how to check for discrete input malfunctions. 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.



Checking for input malfunctions

- 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.

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

The Communication protocols 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. The communication protocols not only being to used expand the PLC network and also its used to expand number of IO devices by connecting additional modules (Expansion modules).

Most commonly used protocols with PLC in Beverage 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.

4. (b) A person sees a car which is being driven without a driver. Can this be possible? What is the technology involved? Explain in detail the different types of sensors used in such cars. *10 Marks*

Ans: Yes, which is Self-Driving Car or Driverless car, also called as Artificial Intelligence car. Self-driving cars rely on computers, sensor systems, algorithms, machine learning, and artificial intelligence to accurately perceive and safely navigate their environments.

Self-driving Cars Use Sensors to Work

Like people, self-driving cars must sense their surroundings to safely navigate. People use senses like hearing, sight, taste, smell, and touch to interact with their environments. Autonomous car technology developers provision self-driving cars with high-tech sensor systems to sense analogously. The following are the different sensors used in Driverless car:

i) Illuminating the world with LIDAR

LIDAR (light detection and ranging), also known as 3D laser scanning, is a tool that self-driving cars use to scan their environments with lasers. A typical LIDAR sensor pulses thousands of beams of infrared laser light into its surroundings and waits for the beams to reflect off environmental features. Many pulses create point clouds (sets of points representing 3D forms in space) of light.

Lidar systems measure the amount of time it takes to emit a laser signal and sense the same light beam reflected from a physical surface onto its photodetectors. Lidar uses the speed of light to calculate distances to objects. The longer it takes for a lidar photodetector to receive a return light signal, the farther away an object is.

ii) Reading the Environment with RADAR

RADAR (radio detection and ranging) is useful in many contexts such as weather forecasting, astronomy, communications, ocean navigation, military operations, and autonomous driving.

Autonomous cars can emit radio waves in known directions with radar transmitters. Reflected waves that return to a car's radar receiver help the car derive information about environmental objects like the objects' angles, ranges, and velocities.

iii) Hearing with SONAR

Self-driving cars can use SONAR (sound navigation and ranging) to detect and communicate with objects, and to navigate. Sonar can be passive or active. Passive sonar systems passively listen for sounds made by nearby objects. Active sonar systems emit sound pulses and read echoes returned from physical surfaces.

Self-driving cars can use sonar to detect large objects made of solid materials (e.g. metal, ceramic) at short distances. Sonar sensors don't require light to operate. However, sonar sensors are constrained by the speed of sound.

iv) Capturing Images with Cameras

Autonomous vehicles can visualize their environments with high-resolution digital camera images. Self-driving cars can use camera images to "see" and interpret environmental details (e.g. signs, traffic lights, animals) in ways that approximate human vision (aka computer vision).

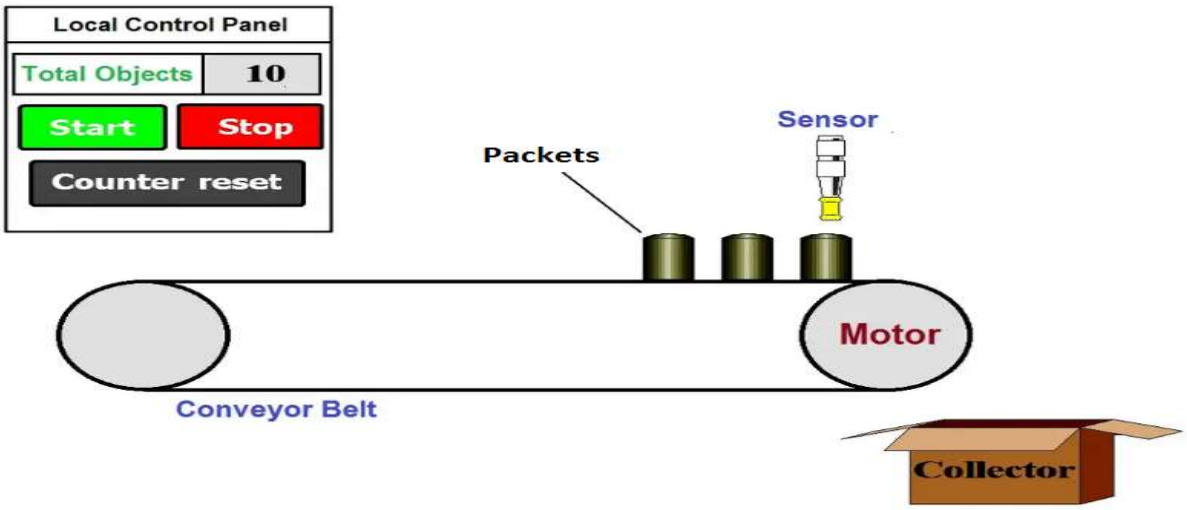
Self-driving cars can use many types of input data for computer vision. Examples include:

- Multi-dimensional data from 3D scanning devices
- Video segments
- Camera images captured from different viewing angles

Reference → https://www.udacity.com/blog/2021/03/how-self-driving-cars-work-sensor-systems.html#:~:text=Lidar%20(light%20detection%20and%20ranging,to%20reflect%20off%20environmental%20features

SECTION – III

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



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.

- Here we use PLC ladder program to implement this logic.
- Proximity sensors are used to detect the objects. Here we mount proximity sensor to detect the parts or objects moving on the conveyor.
- Inductive sensor are mostly used to detect metal objects. For other type of objects, we use Capacitive proximity sensor for detecting the objects moving on the conveyor. We connect this sensor to the PLC and by using counter logic, we will count the number of objects and display the total number on the local control panel display.
- Here we use UP counter for counting the collected Objects at the end of conveyor.
- We considered proximity sensor for detecting the objects. Proximity sensor will sense the object and PLC UP counter will count the collected objects.

List of inputs/outputs

Digital Inputs

Start :- I0.0

Stop :- I0.1

Proximity :- I0.2 (Objects detection)

Counter Reset PB :- I0.3

Digital Output

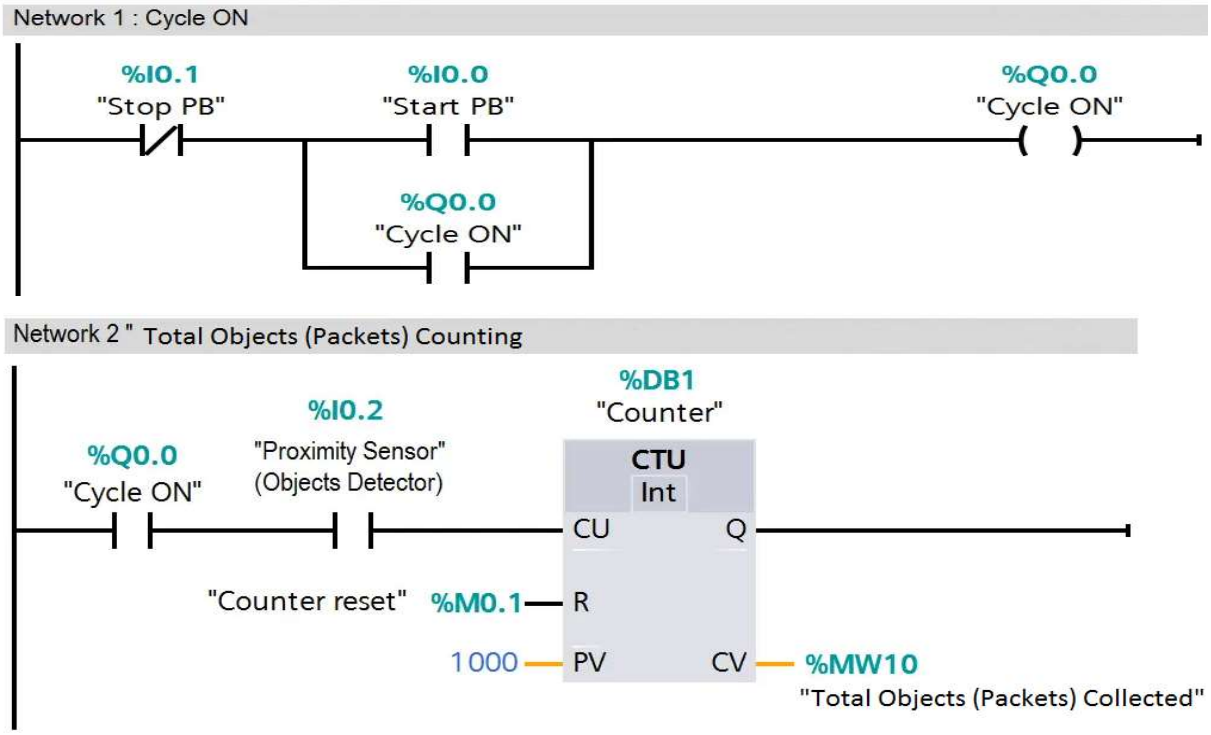
Cycle ON :- Q0.0

M memory

Counter Reset :- M0.1

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).

Reference → https://instrumentationtools.com/plc-program-for-counting-moving-objects-on-conveyor/

5. (b) Analyse the usage of SCADA and HMI in food processing industry. *10 Marks*

Ans: 5 ways SCADA & HMI can improve food processing industry.

Automation of food and beverage manufacturing processes provides manufacturers with value-adding 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 real-time 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

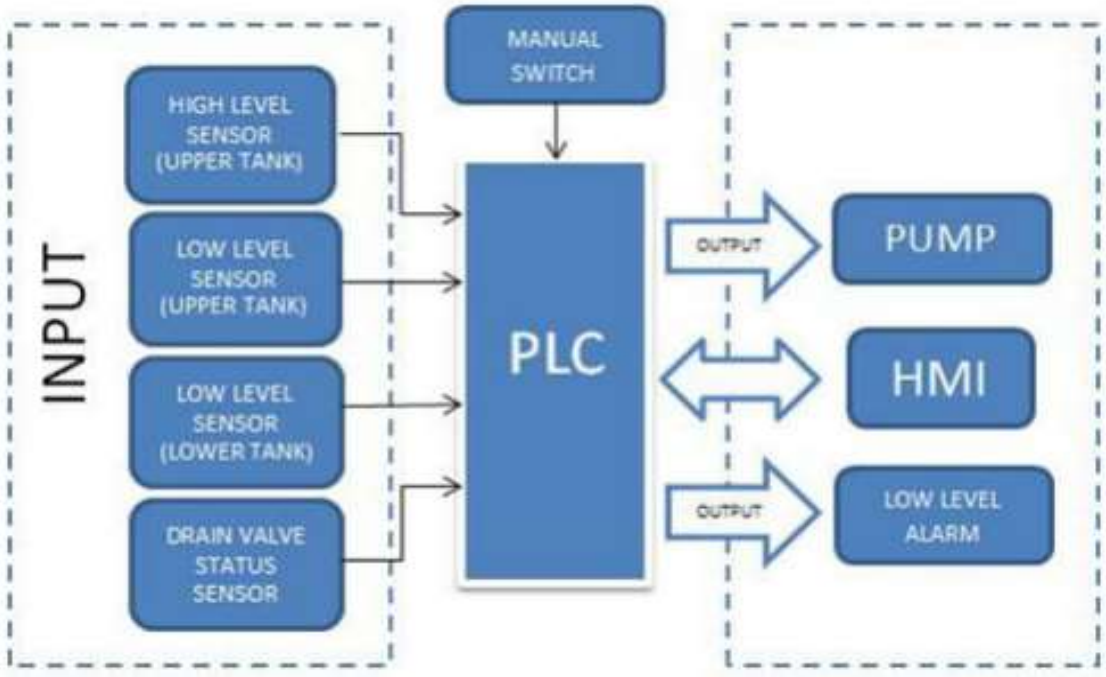
SCADA can also create reports, enabling manufacturers to identify, analyse and improve various processes within the organization. These reports can help identify bottlenecks, analyse production downtime causes, calculate key performance indicators and report the relevant information in a clear and concise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

Reference → https://www.automationit.com/blog/73-5-ways-scada-can-improve-food-and-beverage-manufacturing

6. (a) Consider a milk processing industry, describes how the milk tank level and its flow are controlled between the milk packaging process and the milk stock container tank. ***10 Marks***

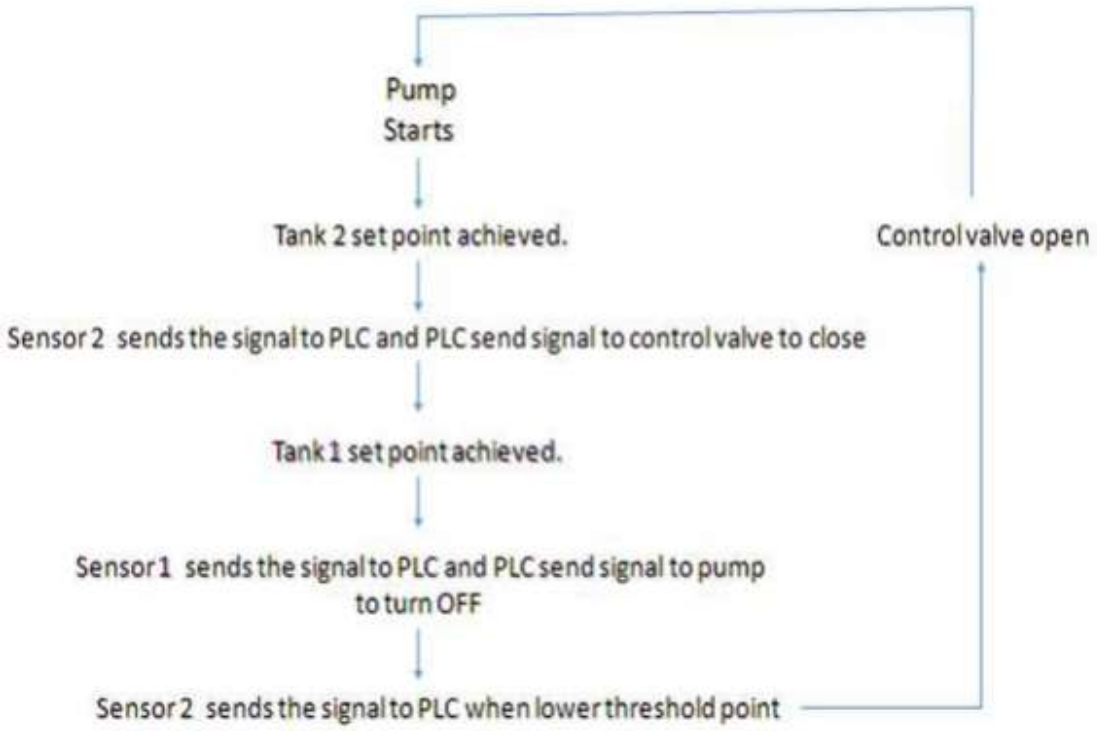
Ans: Milk level management using PLC is design to control the level of milk and avoid wastage of milk in the tank. The system has an automatic pumping system attach to it. We are controlling the milk level by using PLC, Sensors and motor. The purpose for doing this is reducing time consumption and human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



Control flow chart

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.

Reference →

ISSN XXXX XXXX © 2019 IJESC

IJESC

Research Article Volume 9 Issue No. 5

Water Tank Level Controller by using PLC

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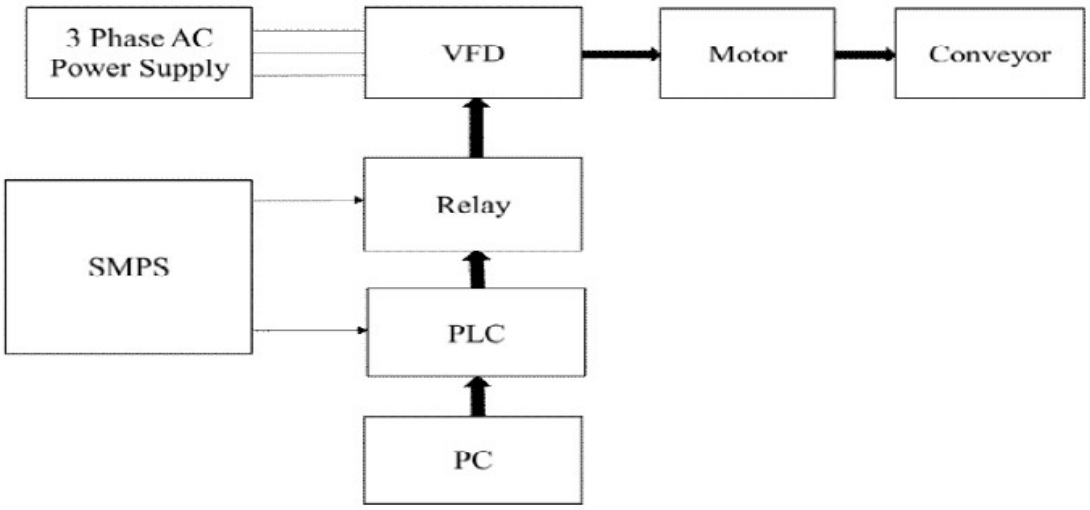
6. (b) VFD plays an important role in conveyor control system. Justify your answer and how it can be implemented in industries to control the speed of the conveyer. ***10 Marks***

Ans: The present industrial world needs advancement in the field of technology to build better automation process. The Motion control of the systems is one common scenario needed in all the industries. Earlier Gear boxes were used for control of machines and DC drives were mostly used for variation of speed in industries for small scale applications only. With the coming of AC drives there is a major breakthrough in which motion control of large devices became comfortable. Conveyor is being greatly used in the Industrial processes. Hence control of conveyor is of paramount need along with the PLC and VFD leading to work automatically.

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

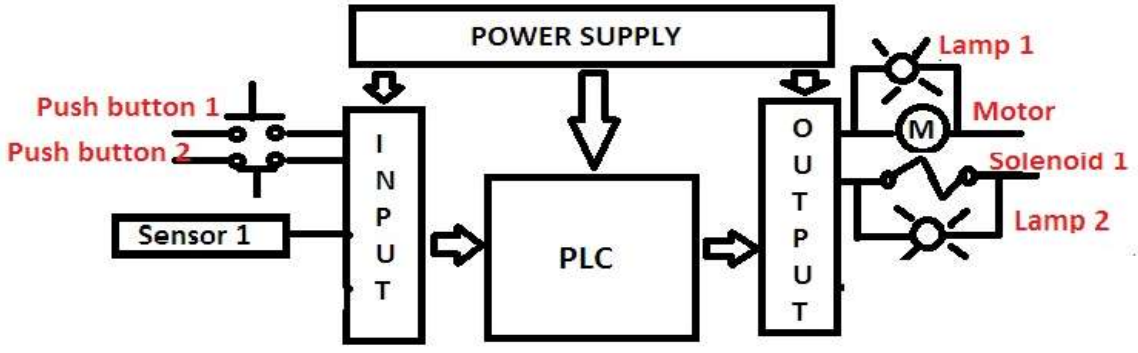
In order to execute this action an AC VFD Drive is utilized. This has the potential to control the speed of the conveyor by varying the frequency of the input supply which being an ac source eases the control action. An AC input is given to the VFD drive which is connected to the conveyor. Then through 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.

Reference → http://www.ijirset.com/upload/2019/ncfcsps/21_Batch%2022%20main.pdf

SECTION – IV

7. (a) How would you set-up pneumatic valves, actuators and sensors to build automatic stamping labelling machine? ***10 Marks***

Ans: 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 drive-pulley or transmission drum the other one only used to change conveyor belt movement direction-is 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.

Reference → https://nevonprojects.com/automatic-stamping-labeling-machine-using-plc/

7. (b) Now a days Robots are used in different applications. Mention and analyse various industrial applications where it can be used to simplify the task of a human. ***10 Marks***

Ans: The most industrial applications of Robots that can be used to simplify human tasks can be divided into the following categories:

1. Arc Welding: Arc welding, or robot welding, became commonplace in the 1980s. One of the driving forces for switching to robot welding is improving the safety of workers from arc burn and inhaling hazardous fumes.

2. Spot Welding: Spot welding joins two contacting metal surfaces by directing a large current through the spot, which melts the metal and forms the weld delivered to the spot in a very short time (approximately ten milliseconds).

3. Materials Handling: Material handling robots are utilized to move, pack and select products. They also can automate functions involved in the transferring of parts from one piece of equipment to another. Direct labor costs are reduced and much of the tedious and hazardous activities traditionally performed by human labor are eliminated.

4. Machine Tending: Robotic automation for machine tending is the process of loading and unloading raw materials into machinery for processing and overseeing the machine while it does a job.

5. Painting: Robotic painting is used in automotive production and many other industries as it increases the quality and consistency of the product. Cost savings are also realized through less rework.

6. Picking, Packing and Palletizing: Most products are handled multiple times prior to final shipping. Robotic picking and packaging increases speed and accuracy along with lowering production costs.

7. Assembly: Robots routinely assemble products, eliminating tedious and tiresome tasks. Robots increase output and reduce operational costs.

8. Mechanical Cutting, Grinding, Deburring and Polishing: Building dexterity into robots provides a manufacturing option that is otherwise very difficult to automate. An example of this is the production of orthopedic implants, such as knee and hip joints. Buffing and polishing a hip joint by hand can normally take 45-90 minutes while a robot can perform the same function in just a few minutes.

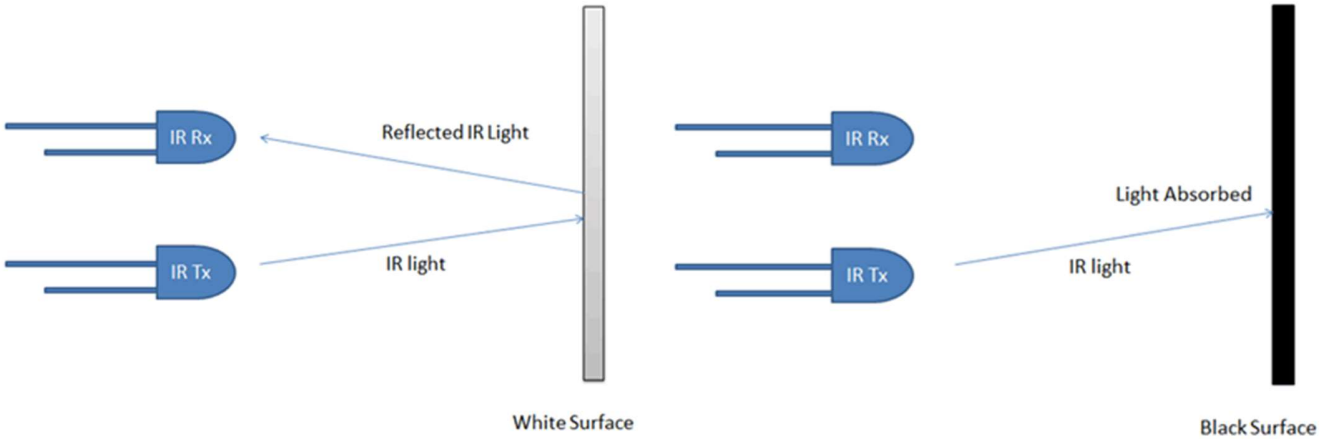
9. Gluing, Adhesive Sealing and Spraying Materials: Sealer robots are built with numerous robotic arm configurations that enable the robot to apply adhesives to any type of product. The primary benefit in this application is increased quality, speed and consistency of the final product.

10. Other Processes: These include inspection, waterjet cutting and soldering robots.

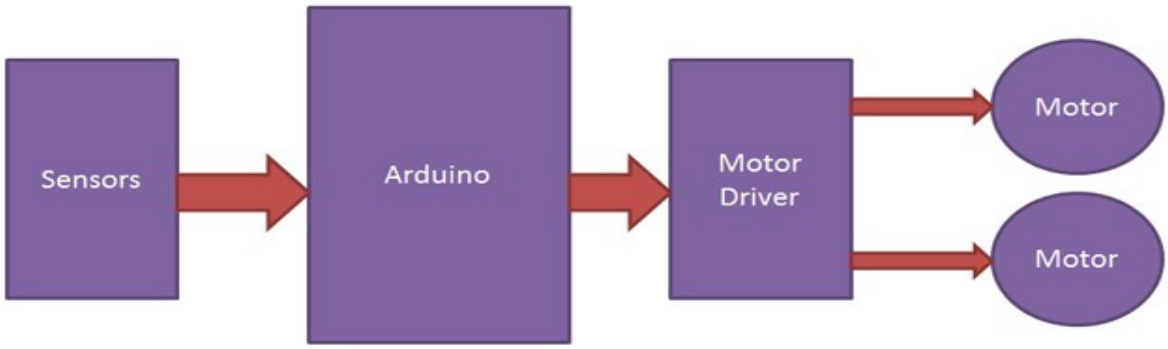
Reference → https://www.jabil.com/blog/ten-popular-industrial-robot-applications.html

8. (a) Raw materials needs to move from the stockyard to the production line. Explain how robots can be used for this line following application. *10 Marks*

Ans: The concept of working of line follower is related to light. We use here the behavior of light at the black and white surfaces. When light falls on a white surface it is almost fully reflected and in the case of a black surface light is completely absorbed. This behavior of light is used in building a line follower robot.



In this Arduino based line follower robot, we have used IR Transmitters and IR receivers also called photodiodes. They are used for sending and receiving light. IR transmits infrared lights. When infrared rays falls on the white surface, it's reflected back and caught by photodiodes which generate some voltage changes. When IR light falls on a black surface, light is absorbed by the black surface and no rays are reflected back, thus photo diode does not receive any light or rays. Here in this Arduino line follower robot when the sensor senses white surface then Arduino gets 1 as input and when senses black line Arduino gets 0 as input.



Block Diagram

The whole Arduino line follower robot can be divided into 3 sections: sensor section, a control section, and driver section.

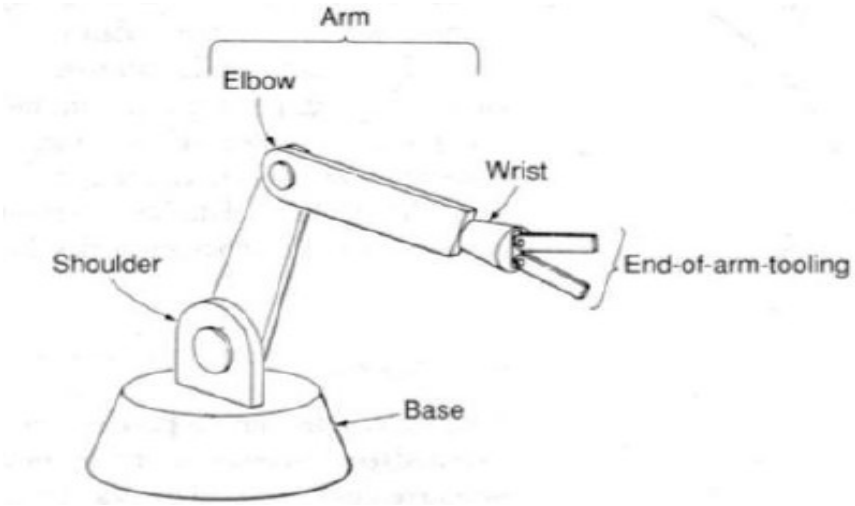
Sensor section: This section contains IR diodes, potentiometer, Comparator (Op-Amp) and LED's. The potentiometer is used for setting reference voltage at comparator's one terminal and IR sensors are used to sense the line and provide a change in voltage at the comparator's second terminal. Then the comparator compares both voltages and generates a digital signal at the output. Here in this line follower circuit, we have used two comparators for two sensors. LM 358 is used as a comparator. LM358 has inbuilt two low noise Op-amps.

Control Section: Arduino is used for controlling the whole the process of the line follower robot. The outputs of comparators are connected to digital pin numbers 2 and 3 of Arduino. Arduino read these signals and send commands to driver circuit to driveline follower.

Driver section: The driver section consists of motor driver and two DC motors. The motor driver is used for driving motors because Arduino does not supply enough voltage and current to the motor. So we add a motor driver circuit to get enough voltage and current for the motor. Arduino sends commands to this motor driver and then it drives motors.

Reference → https://circuitdigest.com/microcontroller-projects/line-follower-robot-using-arduino

8. (b) The Robot can be used for standard pick and place applications where objects are picked up and moved to other locations in a single plane. Discuss the various parts and functions of a Robot to perform the above task. *10 Marks*



Basic parts of Robot System

Robot structure is concerned with the physical construction & characteristics, Body, Arm, Wrist which are parts of the Robot.

- **Body** – Robot are mounted on a Base. The body is attached to the base.
- **Arm** – The arm is assembled to the body
- **Wrist** – At the end of the arm is wrist which holds the gripper or end effector that performs the work.

Arm and Body motion: Arm and Body moment include 3 motions like

- Vertical motion – This motion includes up and down movements of the arm.
- Radial motion – Radial motion includes in & out moments i.e. front and back.
- Rotational motion – This includes rotation of the arm.

Wrist Motion:

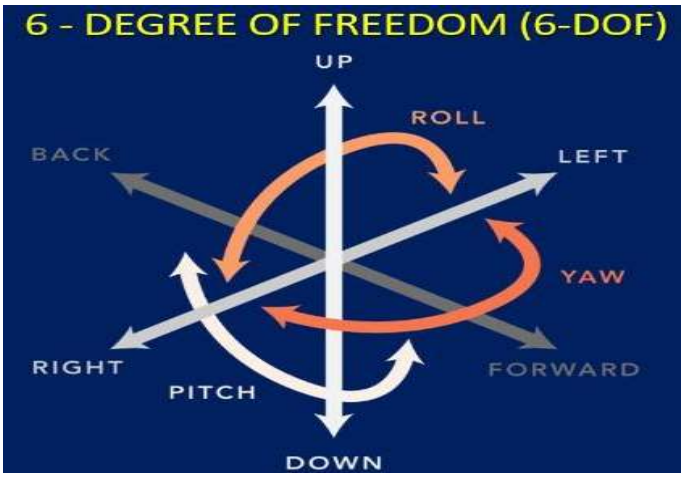
- Wrist rotation movement – It is the rotation of the wrist perpendicular to the end of the arm.
- Wrist bend – It is the movement of the wrist in up and down direction.

Degrees Of Freedom (DOF):

A typical robot arm will have 6 DOF. Only 3 DOF are necessary to get it anywhere in space, but 6 gives it more versatility.

To put it in simpler terms, each of the following is one degree of freedom:

1. Moving up and down (heaving)
2. Moving left and right (swaying)
3. Moving forward and back (surging)
4. Tilting up and down (pitching)
5. Turning left and right (yawing)
6. Tilting side to side (rolling)



SECTION – V

9. (a) Illustrate with an example why is ROS preferred for development of Robots? 10M

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

9. (b) Discuss how Maze solving Robot can be used in industrial applications? Mention its advantages. *10 Marks*

Ans: Modern robotics technologies are focused on developing self-navigating autonomous robots to automate our day-to-day processes. This means that most of the research focuses on improving sensors and algorithms to build flexible and accurate robots. The maze solving robot also known as a micro mouse is designed to find a path without any assistance or help. As a type of autonomous robot, it has to decode the path on its own to solve the maze successfully. So its logic is quite different from the line following robot which follows a predetermined route.

The possible applications for maze solving vehicles range from simple tasks such as transferring goods through factories, office buildings, classrooms and other workspaces, to hazardous tasks in

difficult to reach areas like evacuating people from dangerous buildings, bomb sniffing, etc. Autonomous maze solving robotic systems can be applied to:

Manufacturing: Robots can be used to transport items and tools from one location to another in a fast and accurate manner across a complicated terrain, where paths must first be explored to accomplish the delivery. The Flexible Manufacturing System (FMS) that employs autonomous robots are currently dominated by the use of Automatic Guided Vehicle (AGV).

Home automation: Domestic robots are designed to assist human with tasks including: lawn moving, vacuum cleaning and home monitoring. A mobile robot can be used as a vacuum cleaner, navigating itself effectively around the house whilst simultaneously cleaning.

Traffic control: This is a real example of maze solving technology that enables fire fighters or paramedics to find the best route to an emergency. Therefore, appropriate traffic control is a critical issue in highway work zone safety, in order to control the robotic system to safely travel from one location to another one.

Rescue operations: Rescue missions usually start with a search in the unknown environment before reaching the region where victims can be located. As rescuers progress along a particular path, therefore, they are required to report their location to the mission headquarters. This will help the rescuer to reach the final destination. Mobile robots have been employed widely in the search and rescue operations, such as searching victims in dangerous areas which is harmful for human, as to offer observation data for map building.

There are several **Advantages** to making a maze solving robot, including:

- **Problem-solving skills:** Building a maze solving robot requires the use of problem-solving skills, such as algorithm development and debugging. These skills can be transferred to other areas of robotics and computer science.
- **Real-world applications:** Maze solving robots can be used in a variety of real-world applications, such as search and rescue missions, warehouse automation, and navigation for self-driving cars.
- **Challenging and fun:** Building a maze solving robot can be a challenging and fun project, especially if you are interested in robotics and computer science.
- **Educational:** Building a maze solving robot can be a great educational tool, as it requires a combination of knowledge in programming, electronics and mechanics. It can be used to teach students about robotics and problem-solving.
- **Increasing efficiency:** Robots can solve mazes much faster than humans and with greater precision and consistency. This can be particularly useful in situations where speed and accuracy are critical, such as in manufacturing and logistics.

Reference → http://www.ijmerr.com/uploadfile/2021/0923/20210923035423618.pdf

10. (a) ROS plays a very important role in Robotics. Justify your answer. Explain its working and various communication tools. ***10 Marks***

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.

10. (b) Discuss significance of Artificial Intelligence in Robotics with an example.

Role of Artificial Intelligence (AI) technology used in Robotics ***10 Marks***

1) Computer Vision

- Robots can also see, and this is possible by one of the popular Artificial Intelligence technologies named Computer vision. Computer Vision plays a crucial role in all industries like health, entertainment, medical, military, mining, etc.
- Computer Vision is an important domain of Artificial Intelligence that helps in extracting meaningful information from images, videos and visual inputs and takes action accordingly.

2) Natural Language Processing (NLP)

- NLP can be used to give voice commands to AI robots. It creates a strong human-robot interaction.
- NLP is a specific area of Artificial Intelligence that enables the communication between humans and robots. Through the NLP technique, the robot can understand and reproduce human language.
- Some robots are equipped with NLP so that we can't differentiate between humans and robots.
- Similarly, in the health care sector, robots powered by Natural Language Processing may help physicians to observe the decease details and automatically fill in HER.
- Besides recognizing human language, it can learn common uses, such as learn the accent, and predict how humans speak.

3) Edge Computing

- Edge computing in robots is defined as a service provider of robot integration, testing, design and simulation.
- Edge computing in robotics provides better data management, lower connectivity cost, better security practices, more reliable and uninterrupted connection.

4) Complex Event Process

- Complex event processing (CEP) is a concept that helps us to understand the processing of multiple events in real time. An event is described as a Change of State, and one or more events combine to define a Complex event.
- The complex event process is most widely used term in various industries such as healthcare, finance, security, marketing, etc. It is primarily used in credit card fraud detection and also in stock marketing field.

Some examples of artificial intelligence applied to robotics are:

a) Robotics in Household - Robot vacuum cleaner can navigate around furniture using artificial intelligence. There is robot on wheels uses artificial intelligence and camera to navigate autonomously around the home, acting as eyes and ears when the owner of the house is not around.

b) Robotics in manufacturing - In manufacturing AI is used for robot to algorithmically navigating its way around a busy warehouse to perform complex tasks. It is also used to patrol a construction site, scan the project and analyze data for possible quality issues

c) Robotics in business - Equipped with mapping systems, sensors and AI, the little robot on wheels can figure out the best route to take on the fly, and can avoid the dangers of the outside world.

d) Robotics in healthcare - Robotics are capable of performing operations with incredible accuracy and a steady hand, these can be used as substitute for tried medical professionals. Robot can be used to administer needleless vaccination without needing any kind of human supervision.

e) Robotics in agriculture - AI can be used to assess the ripeness of each fruit harvested. AI with robotics can be used to increase plant yield and use less water.

f) Robotics in aerospace - Robots are designed to assist astronauts with their day-to-day tasks and reduce stress via speech recognition, while also operating as an early-warning system to detect problems.

g) Robotics for military - AI can be used to design autonomous military drones

h) Robotics also employed in volcanoes, deep oceans, extremely cold places, or even in space where normally humans can't survive.

Note: *The Model answer are given for reference to valuators for valuation. The valuator may also consider answers, suitable sketches, programs and explanation which are most appropriate.*

CERTIFICATE

This is to certify that the above model answers is prepared by me which are within the syllabus prescribed by DTE, and have given relevant solutions whose reference is taken from genuine websites / Industry / Real time exposure and model answer script and scheme of valuation prepared by me are correct.

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