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UNIT – IV CASE STUDIES ON MECHATRONIC SYSTEM

Introduction

Mechatronic systems are interdisciplinary systems that combine mechanical, electrical, and computer engineering to create complex and sophisticated systems. Mechatronic systems are used in a variety of applications, such as aerospace, automotive, robotics, and medical devices. Mechatronics has become increasingly important due to the demand for systems that are more efficient, cost-effective, and reliable. Here are some case studies on mechatronic systems:

1. Robotics: One of the most well-known applications of mechatronic systems is robotics. Robots are used in manufacturing, agriculture, and healthcare, among other industries. For example, the da Vinci surgical robot is a mechatronic system that is used in minimally invasive surgeries. The system combines advanced robotics with 3D imaging and other technologies to enable surgeons to perform surgeries with greater precision and control.
2. Autonomous Vehicles: Another popular application of mechatronic systems is autonomous vehicles. Self-driving cars and trucks use a combination of sensors, actuators, and computer systems to operate without human intervention. Mechatronic systems enable these vehicles to sense their environment, navigate, and make decisions based on real-time data.
3. Industrial Automation: Mechatronic systems are also widely used in industrial automation. Automated manufacturing systems use sensors, actuators, and computer control to streamline production processes and improve efficiency. For example, a mechatronic system may be used to control the movements of a robotic arm on an assembly line.
4. Medical Devices: Mechatronic systems are increasingly used in medical devices, such as prosthetic limbs, pacemakers, and diagnostic equipment. These systems use a combination of mechanical, electrical, and computer engineering to create devices that are more effective and efficient than traditional medical devices.

Overall, mechatronic systems are critical to many industries and applications. By combining multiple engineering disciplines, these systems enable more efficient, effective, and reliable operations.

Fuzzy based Washing machine

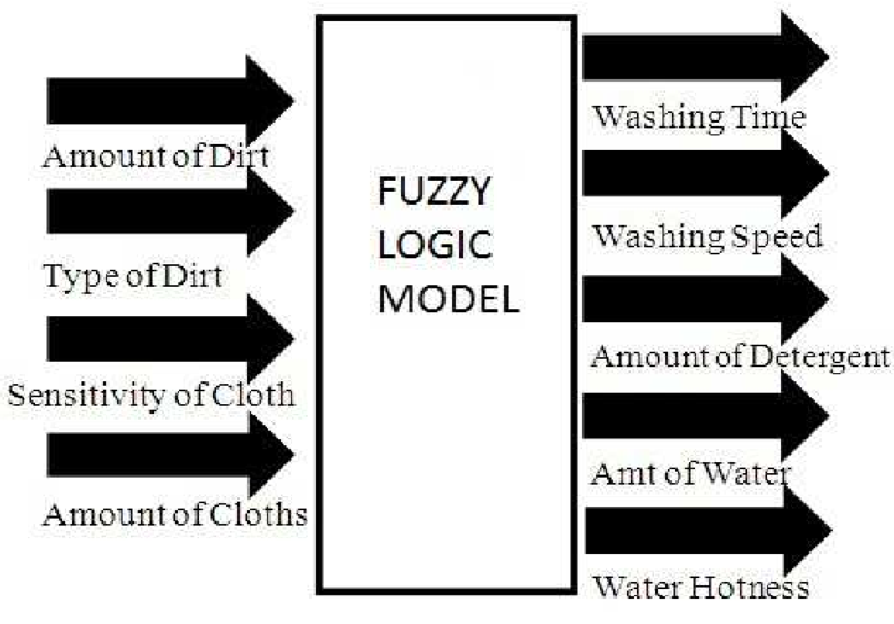


Figure 4. Inputs and Outputs of the System

Fuzzy logic is a powerful tool for controlling complex systems that are difficult to model mathematically. Washing machines are an example of such systems, where the input parameters can be difficult to define and vary greatly depending on the type and amount of clothing being washed. Fuzzy logic is used in washing machines to improve the quality of the wash, reduce energy consumption, and increase the lifespan of the machine.

Here are some notes on fuzzy-based washing machines:

1. Fuzzy Control: Fuzzy logic control (FLC) is used in washing machines to adjust the wash cycle based on the type and amount of clothing being washed. FLC uses a series of rules to determine the appropriate wash cycle, water temperature, and spin speed based on the input parameters. These rules are designed to mimic the decision-making process of a human operator and are based on expert knowledge of the washing process.
2. Input Parameters: Fuzzy logic-based washing machines use a variety of input parameters to determine the appropriate wash cycle. These parameters include the weight and type of clothing, the degree of soiling, the water hardness, and the desired level of cleanliness. FLC uses these parameters to adjust the wash cycle, including the duration of the wash, the water temperature, and the spin speed.
3. Energy Efficiency: Fuzzy logic-based washing machines can improve energy efficiency by reducing the amount of water and detergent used. FLC can determine the appropriate amount of water and detergent based on the input parameters, reducing waste and conserving resources. Additionally, FLC can optimize the spin cycle to reduce the amount of energy required to dry the clothing.

4. Longevity: Fuzzy logic-based washing machines can increase the lifespan of the machine by reducing wear and tear on the components. FLC can optimize the wash cycle to reduce the stress on the machine's components, such as the motor and bearings. This can help prevent breakdowns and extend the life of the machine.

Overall, fuzzy logic-based washing machines are a powerful tool for improving the quality of the wash, reducing energy consumption, and increasing the lifespan of the machine. FLC enables washing machines to make intelligent decisions based on a variety of input parameters, resulting in a more efficient and effective wash cycle.

pH control system

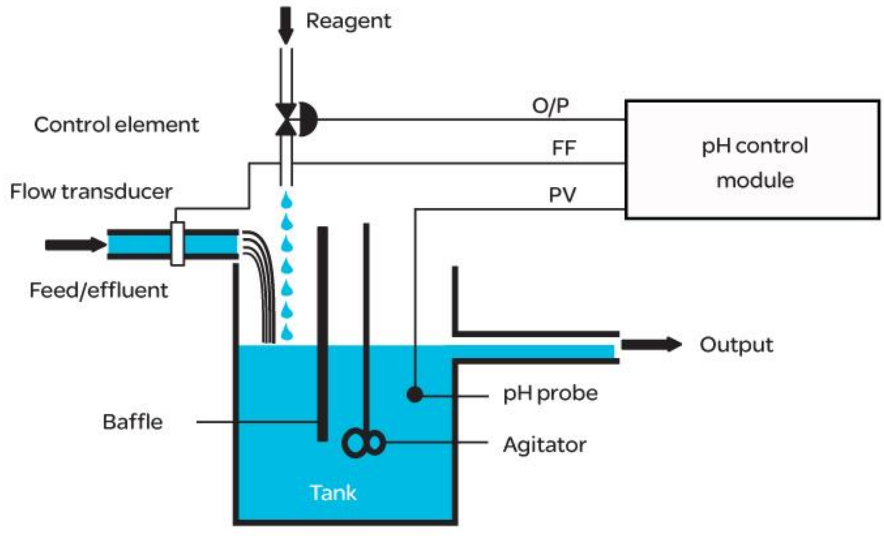


Figure 2: Correct Tank layout

A pH control system is used to maintain a specific pH level in a solution or process. pH is a measure of the acidity or alkalinity of a solution, with a pH of 7 being neutral, below 7 being acidic, and above 7 being alkaline. pH control systems are used in a variety of applications, including chemical processing, water treatment, and food and beverage production. Here are some notes on pH control systems:

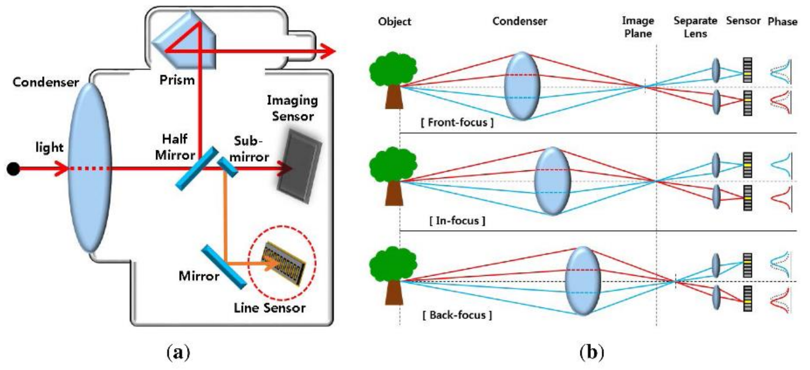
1. pH Measurement: A pH control system requires a method for measuring the pH of the solution. This can be done using a pH sensor, which consists of an electrode that measures the voltage difference between a reference electrode and a measuring electrode. The pH of the solution can be calculated from this voltage difference.
2. Control Strategy: The control strategy for a pH control system depends on the specific application. In most cases, the pH is maintained at a specific setpoint by adding acid or base to the solution. The pH control system monitors the pH of the solution and adjusts the amount of acid or base added to maintain the setpoint. In some applications, a feedforward control strategy may be used to anticipate changes in pH and adjust the acid or base feed accordingly.
3. Control Algorithms: pH control systems typically use proportional-integral-derivative (PID) control algorithms to adjust the amount of acid or base added to the solution. PID control algorithms use feedback from the pH sensor to adjust the control output in order to minimize

the error between the setpoint and the actual pH of the solution. More advanced control algorithms, such as adaptive control and fuzzy logic control, may also be used to improve the performance of the pH control system.

4. System Components: pH control systems typically include several components, including a pH sensor, a controller, a dosing system for adding acid or base to the solution, and a monitoring system for detecting faults or errors in the system. The dosing system may include pumps, valves, or other components for controlling the flow rate of acid or base into the solution.

Overall, pH control systems are essential for maintaining the desired pH level in a wide range of applications. These systems rely on accurate pH measurement and sophisticated control algorithms to maintain the setpoint and ensure the quality of the product or process.

Autofocus Camera,
exposure control



Autofocus cameras and exposure control are important features in modern cameras that help improve the quality of photos and videos. Here are some notes on these features:

Autofocus Camera:

1. Autofocus Technology: Autofocus cameras use various technologies to automatically focus the camera lens on the subject of the photo or video. These technologies include contrast detection, phase detection, and hybrid autofocus. Contrast detection measures the contrast between light and dark areas in the scene to determine the focus point. Phase detection uses two sensors to measure the phase difference of light passing through the lens to determine the focus point. Hybrid autofocus uses both contrast and phase detection for improved accuracy.
2. Focus Modes: Autofocus cameras typically offer several focus modes, including single-shot autofocus, continuous autofocus, and manual focus. Single-shot autofocus is used for stationary subjects, while continuous autofocus is used for

moving subjects. Manual focus allows the user to manually adjust the focus of the lens.

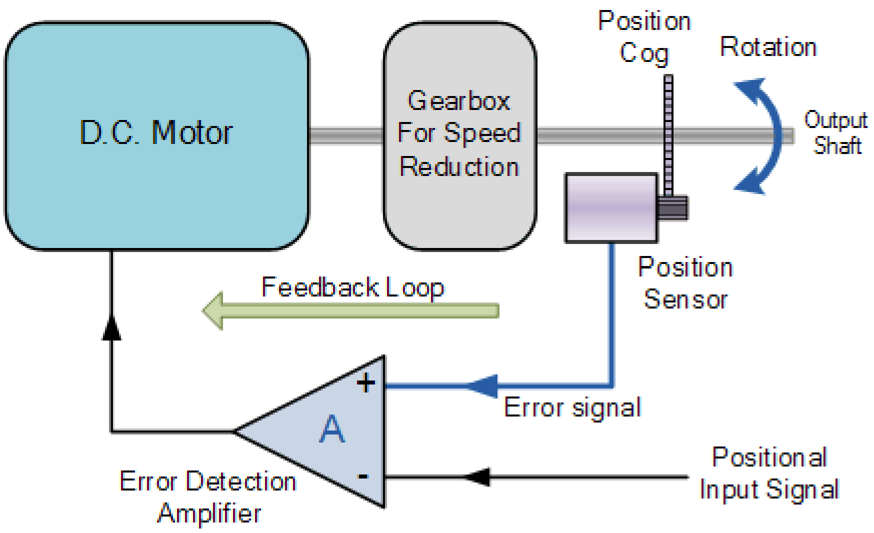
3. Focus Points: Autofocus cameras may have multiple focus points, which can be manually or automatically selected. The number and placement of focus points vary depending on the camera model.

Exposure Control:

1. Exposure Settings: Exposure control allows the user to adjust the amount of light that enters the camera's sensor, which affects the brightness and quality of the photo or video. Exposure settings include aperture, shutter speed, and ISO. Aperture controls the amount of light that enters the lens, while shutter speed controls the duration of the exposure. ISO controls the camera's sensitivity to light.
2. Metering Modes: Exposure control also includes metering modes, which determine how the camera measures the light in the scene. Metering modes include spot, center-weighted, and evaluative metering. Spot metering measures the light at the focus point, while center-weighted metering measures the light in the center of the frame. Evaluative metering measures the light in multiple areas of the frame and calculates an average exposure.
3. Exposure Compensation: Exposure compensation allows the user to adjust the exposure settings based on the brightness or darkness of the scene. Positive exposure compensation increases the exposure settings, while negative exposure compensation decreases the exposure settings.

Overall, autofocus cameras and exposure control are essential features for capturing high-quality photos and videos. These features rely on advanced technology and sophisticated algorithms to automatically adjust the focus and exposure settings for optimal results.

Motion control using D.C.Motor & Solenoids



Motion control using DC motors and solenoids is a common application in industrial automation, robotics, and other fields. Here are some notes on the basics of motion control using DC motors and solenoids:

DC Motor Motion Control:

1. DC Motor Basics: DC motors convert electrical energy into mechanical energy by using an electromagnetic field to rotate a shaft. The direction and speed of the motor are determined by the polarity and magnitude of the applied voltage.
2. Motor Control Techniques: DC motor control techniques include open-loop control, closed-loop control, and pulse-width modulation (PWM) control. Open-loop control applies a fixed voltage to the motor, while closed-loop control uses feedback from sensors to adjust the voltage based on the motor's speed and position. PWM control adjusts the voltage by rapidly switching the motor's power supply on and off to control the average voltage applied to the motor.
3. Motor Controllers: DC motor controllers are used to regulate the voltage and current applied to the motor. These controllers may include features such as speed control, torque control, and position control. Common types of motor controllers include H-bridge circuits, motor drivers, and motor control ICs.

Solenoid Motion Control:

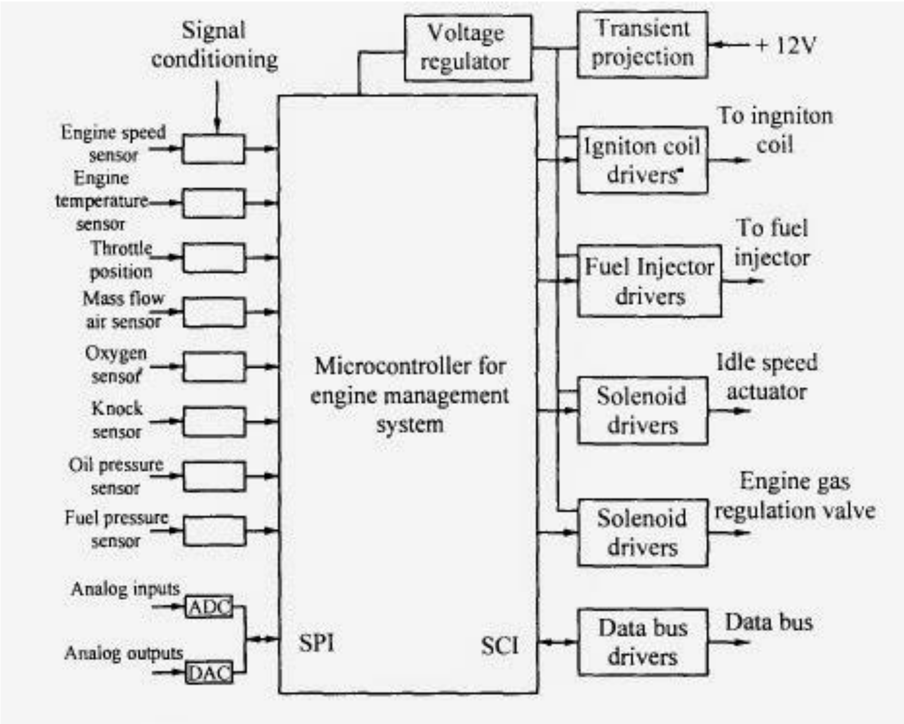
1. Solenoid Basics: A solenoid is an electromechanical device that converts electrical energy into linear motion. Solenoids consist of a coil of wire wrapped around a ferromagnetic core. When current flows through the coil, it creates an electromagnetic field that pulls the core into the center of the coil.
2. Solenoid Control Techniques: Solenoid control techniques include open-loop control, closed-loop control, and PWM control. Open-loop control applies a fixed voltage to the solenoid, while closed-loop control uses feedback from sensors to adjust the voltage based on the solenoid's position. PWM control adjusts the voltage by rapidly switching the solenoid's power supply on and off to control the average voltage applied to the solenoid.
3. Solenoid Drivers: Solenoid drivers are used to regulate the voltage and current applied to the solenoid. These drivers may include features such as speed control, position control, and force control. Common types of solenoid drivers include transistor drivers, solenoid drivers ICs, and MOSFET drivers.

Overall, motion control using DC motors and solenoids is an essential aspect of industrial automation and robotics. These technologies rely on advanced control techniques and specialized components to regulate the motion and position of mechanical systems.

Engine management systems

Engine management systems are used in modern cars to control various engine functions for improved performance, efficiency, and emissions. Here are some notes on the basics of engine management systems:

1. Engine Control Unit (ECU): The ECU is the brain of the engine management system. It receives data from various sensors in the engine and makes decisions based on that data to control the engine's functions. The ECU may control functions such as fuel injection, ignition timing, idle speed, and exhaust gas recirculation (EGR).
2. Sensors: The engine management system relies on various sensors to gather data about the engine's condition. These sensors may include the mass airflow sensor (MAF), oxygen sensor (O2), throttle position sensor (TPS), and engine coolant temperature sensor (ECT). The data from these sensors is used by the ECU to adjust the engine's functions.
3. Actuators: The engine management system also includes actuators that are used to control various engine functions. These actuators may include fuel injectors, ignition coils, and idle air control valves. The ECU controls these actuators to adjust the engine's functions based on the data from the sensors.



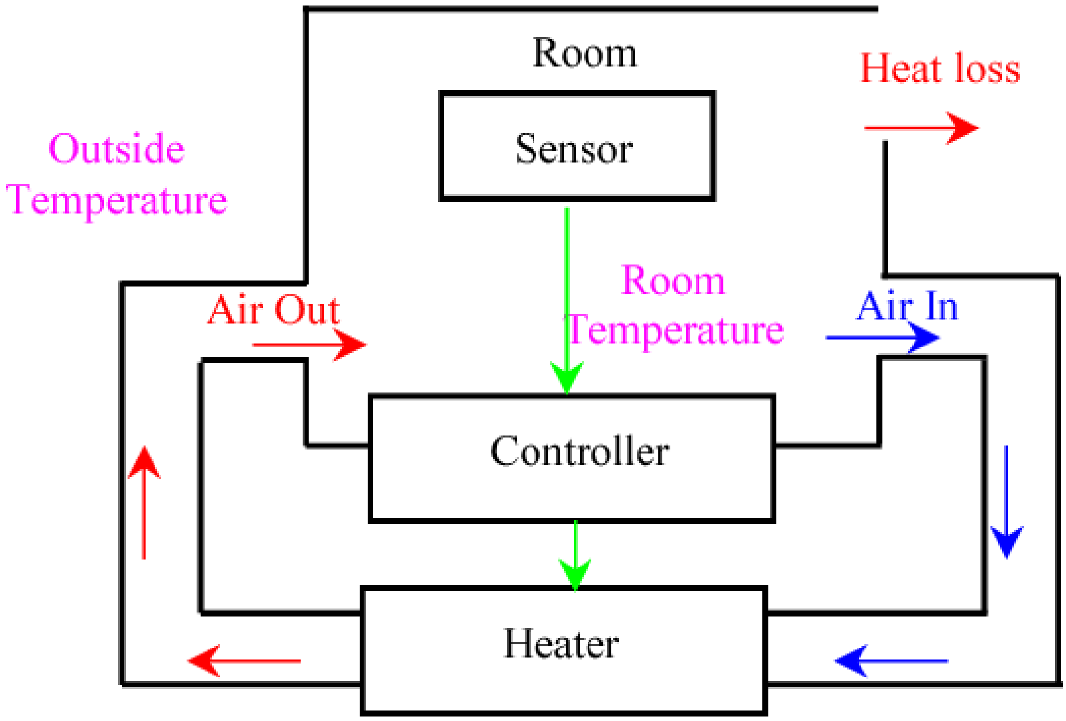
Block diagram of engine management system

4. Fuel Injection: The engine management system controls the fuel injection process to ensure the proper amount of fuel is delivered to the engine. The ECU adjusts the fuel injection timing and duration based on the data from the sensors to optimize the engine's performance, efficiency, and emissions.
5. Ignition Timing: The engine management system controls the ignition timing to ensure the spark plug fires at the optimal time for combustion. The ECU adjusts the ignition timing based on the data from the sensors to optimize the engine's performance and emissions.
6. Emissions Control: The engine management system includes various features for emissions control, such as EGR, catalytic converters, and evaporative emissions control systems. These features help reduce the engine's emissions to meet government regulations.

Overall, engine management systems play a crucial role in modern cars, improving performance, efficiency, and emissions. These systems rely on advanced technology and sophisticated algorithms to regulate the engine's functions for optimal performance.

Controlling temperature of a hot/cold reservoir using PID

Controlling the temperature of a hot or cold reservoir using a PID controller is a common application in many industries, such as food processing, chemical processing, and HVAC systems.



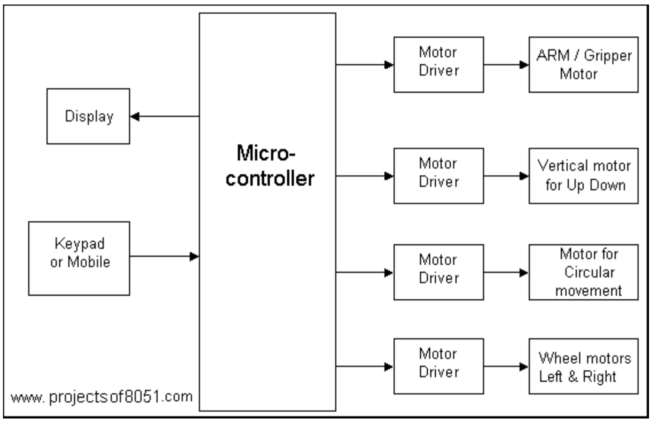
Here are some notes on the basics of temperature control using a PID controller:

1. PID Controller Basics: A PID controller is a closed-loop feedback control system that uses three control parameters - proportional (P), integral (I), and derivative (D) - to adjust the output based on the difference between the desired setpoint and the measured process variable. The P term responds to the current error, the I term adjusts for past errors, and the D term predicts future errors.
2. Temperature Sensors: To measure the temperature of the hot or cold reservoir, a temperature sensor such as a thermocouple or RTD is used. The sensor output is sent to the PID controller as the process variable.
3. Actuators: To adjust the temperature of the reservoir, an actuator such as a heater or cooler is used. The actuator output is controlled by the PID controller as the manipulated variable.
4. PID Tuning: Tuning the PID controller involves adjusting the P, I, and D parameters to achieve optimal control of the process variable. This can be done manually or using automated tuning methods.

5. Setpoint Adjustments: The PID controller can adjust the setpoint - the desired temperature of the reservoir - based on external factors such as ambient temperature, process demand, or time of day.
6. Output Limits: The PID controller can also be configured to limit the output of the actuator to prevent overshoot, undershoot, or damage to the system.

Overall, temperature control using a PID controller is a powerful tool for maintaining the desired temperature of a hot or cold reservoir. The PID controller uses feedback from temperature sensors to adjust the output of the actuator, ensuring precise control of the process variable.

Control of pick and place robot



Controlling a pick and place robot involves using sensors and programming to perform tasks such as picking up objects and placing them in a desired location. Here are some notes on the basics of controlling a pick and place robot:

1. Sensors: Sensors such as cameras or proximity sensors are used to detect the location of objects and the position of the robot. These sensors can also be used to detect obstacles or other hazards.
2. End Effectors: The end effector is the part of the robot that interacts with the object being picked up or placed. Grippers, suction cups, and magnets are common types of end effectors used in pick and place applications.
3. Programming: The robot's movements and actions are programmed using software. The program specifies the robot's path, speed, and actions to be taken when it encounters an object.
4. Control System: The control system for a pick and place robot typically involves a combination of hardware and software. The hardware includes the robot's motors and actuators, while the software controls the robot's movements and actions.
5. Feedback Control: Feedback control is used to ensure that the robot accurately picks up and places objects. Sensors and software are used to monitor the robot's position and adjust its movements in real time.
6. Safety Measures: Safety measures such as emergency stop buttons, protective barriers, and warning lights are used to prevent accidents and ensure the safety of operators and bystanders.

Overall, controlling a pick and place robot involves using sensors, end effectors, programming, and a control system to perform tasks such as picking up and placing objects. Feedback control and safety measures are also important to ensure accurate and safe operation of the robot.

Part identification and tracking using RFID

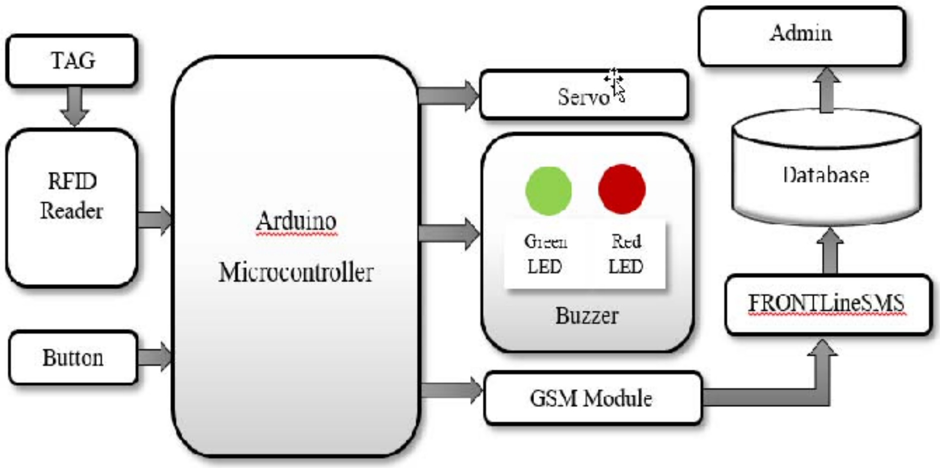


Fig. 2. Block Diagram A of RFID-Based Vehicle Monitoring

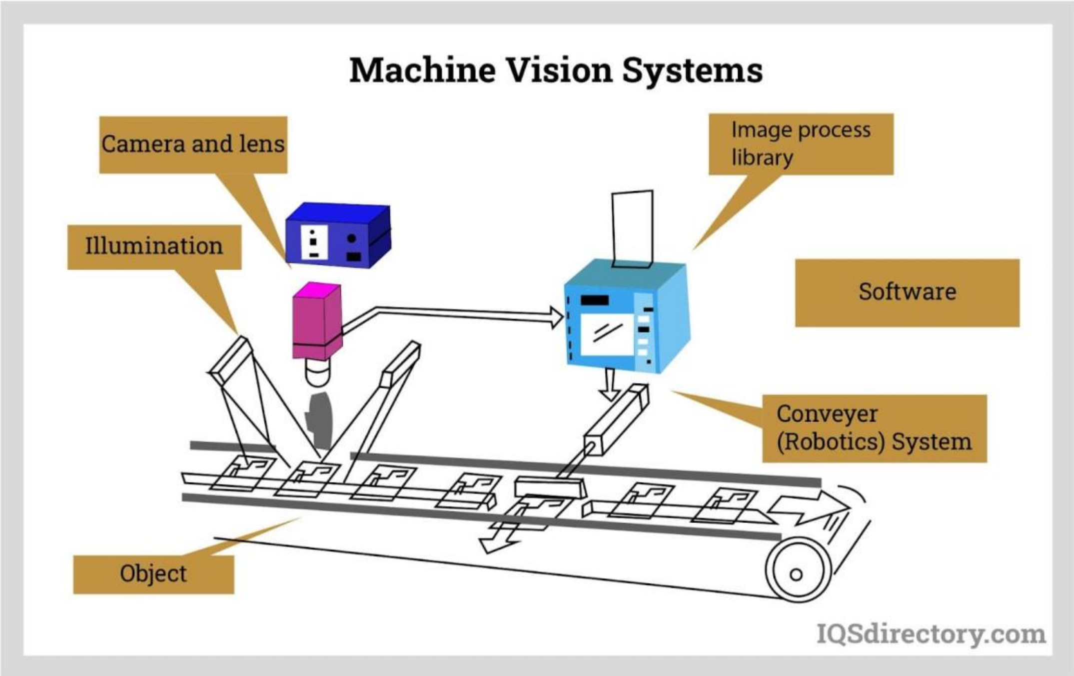
Part identification and tracking using RFID (Radio Frequency Identification) involves using RFID tags to identify and track individual parts or products as they move through a manufacturing or supply chain process. Here are some notes on the basics of part identification and tracking using RFID:

1. RFID Basics: RFID tags contain a microchip and antenna that transmit a unique identifier when scanned by an RFID reader. The reader uses radio waves to communicate with the tag, allowing for non-contact identification and tracking.
2. RFID Tags: RFID tags come in various shapes and sizes, and can be attached to parts or products using adhesive, clips, or other methods. Tags can be passive (no battery) or active (with a battery), and have different read ranges and storage capacities.
3. RFID Readers: RFID readers are used to scan RFID tags and collect data on the part or product being tracked. Readers can be fixed or mobile, and can communicate with tags using different frequencies and protocols.
4. Data Management: Data collected from RFID tags is typically managed using software systems that track the movement of parts or products through a manufacturing or supply chain process. This data can be used to monitor inventory levels, improve production efficiency, and prevent product loss or theft.
5. Benefits: RFID part identification and tracking can provide numerous benefits, including increased productivity, improved inventory accuracy, reduced labor costs, and enhanced supply chain visibility.

6. Challenges: Challenges associated with RFID part identification and tracking include the cost of implementing RFID systems, the need for proper tag placement and orientation, and the potential for interference from other radio frequency devices.

Overall, part identification and tracking using RFID is a powerful tool for improving manufacturing and supply chain processes. RFID tags and readers can be used to accurately identify and track individual parts or products, providing valuable data that can be used to optimize operations and improve efficiency.

Online surface measurement using image processing



Online surface measurement using image processing involves using cameras and software to analyze images of surfaces in real-time and extract quantitative measurements of features such as roughness, texture, and color. Here are some notes on the basics of online surface measurement using image processing:

1. Cameras: High-resolution cameras are used to capture images of surfaces in real-time. Different types of cameras can be used depending on the specific application, such as line-scan cameras for continuous measurements or 3D cameras for measuring surface height and depth.
2. Lighting: Lighting is important for obtaining high-quality images of surfaces. Different lighting techniques can be used to highlight specific surface features or reduce glare and shadows.
3. Image Processing: Image processing software is used to analyze the images captured by the cameras and extract quantitative measurements of surface features.

Algorithms can be customized to measure specific features such as roughness, texture, and color.

4. Calibration: Calibration is important for obtaining accurate measurements. Calibration standards are used to ensure that measurements are consistent and reliable over time.
5. Real-time Feedback: Real-time feedback can be provided to operators or control systems to adjust processes based on surface measurements. For example, if a surface is too rough, a process parameter can be adjusted to improve surface quality.
6. Applications: Online surface measurement using image processing can be used in a wide range of applications, including quality control in manufacturing, surface inspection in healthcare, and monitoring surface changes in natural environments.

Overall, online surface measurement using image processing is a powerful tool for obtaining accurate and quantitative measurements of surface features in real-time. Cameras, lighting, image processing, calibration, and real-time feedback are important components of this technology.