Topic
Embedded design Process
Tutorial Questions

1. Consider a wearable ECG monitor with GPRS functionality in a remote healthcare monitoring system. Analyze its design, including the selection of sensors, data processing units, and communication protocols to ensure reliability and accuracy.

2. Consider a scenario where an agricultural drone is used to monitor crop health and relay data to a cloud server. Examine the design and operational functionality of its embedded system, including data acquisition, processing, and transmission.

3. Consider an autonomous delivery robot that uses embedded systems for path planning, obstacle detection, and communication with a central hub. Examine the system's architecture, focusing on hardware design and software algorithms.

4. Consider a fleet telematics system that tracks vehicle locations, monitors engine diagnostics, and optimizes fuel efficiency. Discuss the architecture and operational aspects of the embedded system used in such a system.

5. Consider a railway safety system where embedded systems monitor train speeds, detect track faults, and transmit safety alerts. Discuss the design, including sensor selection, real-time communication, and fault tolerance.

6. Consider a weather monitoring station where embedded systems collect meteorological data and transmit it to a central server via IoT protocols. Analyze the design, including sensor integration and data processing.

7. Consider a smart waste management system where embedded sensors detect bin fill levels and optimize garbage collection routes. Examine the system's design, focusing on sensor integration and data communication.

8. Consider a power distribution system that automates substation operations using embedded systems. Discuss its design, including monitoring, control interfaces, and remote data logging.

9. Consider an emergency response system where data from disaster zones is collected and transmitted to a central command in real time. Discuss the design of the embedded system, focusing on reliability and communication protocols.

10. Consider a factory automation system that uses embedded systems to control robotic arms, monitor production lines, and report predictive maintenance data. Discuss its design, focusing on real-time control and scalability.

Tutorial answers - 1

1) Design Analysis of a wearable ECG Monitor with GPPS for remote Health Monitoring.

a) Selection of Sensors:-

* It is a wearable ECG Monitor is its Sensor Module, whichs Ensure **high sensitivity** and noise resistance.

The Criteria :-

- Electrodes: Dry or wet Sensor

Amplification: A low noise instrumentation amplifier.

filtering :- High pass & low pass filters

Analog-to-digtbl:- A high resolution resolution ADC

- Data processing unit :-

+ Micro Controller M(U) or Micro processor

+ Pre processing Algorithms.

+ AI/ML Integration

3) Communication protocols :-

→ GPRS Module
→ Alternative connectivity
→ Data security

4) Power Management :-

• Battery
• Power optimization
• Charging System.

5) Cloud and data storage :-

→ Cloud integration
* Data transmission protocols
# Remote access.

7) Consider a Senario where an agriculture drone is used to monitor crop health and relay data to a cloud server. Examine the design and operational functionally of its embedded system including data acquisition, processing & transmission.

→ Embedded System Components & designs :-

→ A data Acquisition System :-

→ Its drone collects & contists of several agricultural critical components.

Key Sensors/ Module :-

→ Multi spectral & Hyper spectral camera
→ RGB camera
→ Thermal camera
→ LIDAR (light detection & Ranging)
→ GPS Module
→ Environmental sensors like (D#T22, SHT31)
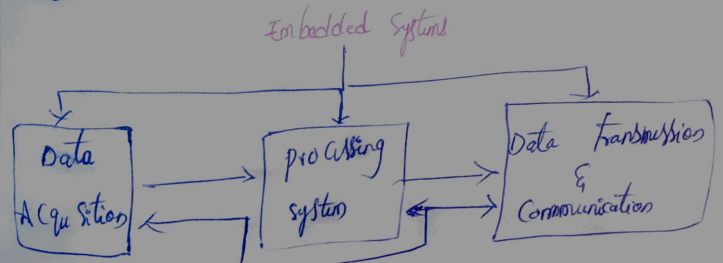→ On board processing System :-
→ its is responsible for filtering analysing & compressing sensor data before transmission

→ Data Transmission & Communication :-
data transmitted to a cloud server or a framer's device.
→ using Communication Modules:
→ Wi Fi (ESP8266)
* 4G / 5G Module
* LORA   * satellite Communication.

Embedded System

3) Consider an autonomous delivery robot that uses embedded system for path planning, obstacle detection and communication, with a central hob. Examine the system architecture focusing on hardware design.

4) and software algorithm.
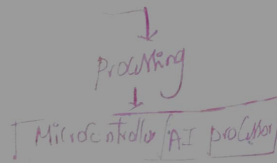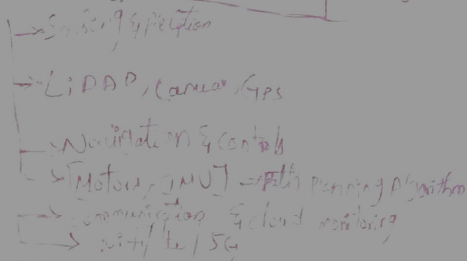
→ Hardware design:-

It contains of key components like,

* LIDAR
* Camera
* inertial
* GPS Modules.
* ultra sonic Sensors.

⇒ Processing unit :-

* Micro Controller (STM 32, ESP32)
* Controls Motor actuators
* Embedded AI processor.

Block diagram :-

Autonomous Delivery Robot

→ Sensor perception
→ LIDAR, camera, Gps
→ Navigation & controls
→ [Motors, IMU] → path planning algorithm
→ communication & load monitoring
→ wifi / 4/5G

Processing
↓
[Microcontroller / AI processor]

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4) Consider a Fleet telematics system that tracks vehicle locations, monitors engine diagnostics, optimizes fuel efficiency. Discuss the architecture and operation aspects of the embedded system used in such system.

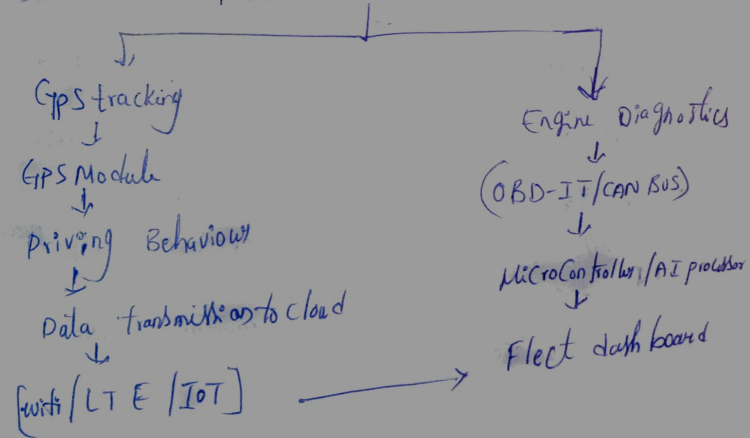A) Telematics System – Architecture & operation

1) Architecture :-
* Hardware Components
  * GPS Module
  * OBD-III / CAN Bus Interface
  * Accelerometer & Gyroscope.

2) Operational Aspects :-
  * Real time tracking
  * Diagnostics
  * Optimization

Block diagram :-

Fleet vehicle with telematics

GPS tracking
↓
GPS Module
↓
Driving Behaviour
↓
Data transmission to Cloud
↓
[wifi / LTE / IoT]

Engine Diagnostics
↓
(OBD-II / CAN BUS)
↓
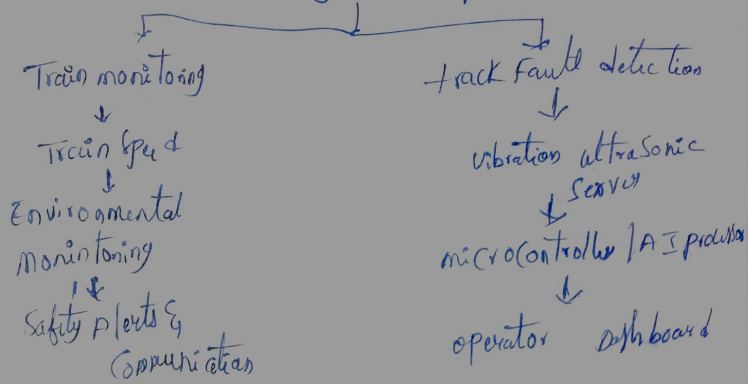Microcontroller / AI processor
↓
Fleet dash board

5) Railway Safety System where Embedded System monitor train Speeds, detects track Faults, and transmit Safety alerts. Discuss the design, including Sensor Selection, real time Communications and fault tolerance.

Sol.— Railway Safety System — Design & Operation.

A railway Safety System user Embedded System to monitor train speeds, detect track Fault & transmit Safety alerts for accident Prevention.

→ Design Exposints
   → Sensor Selection
→ Speed Sensor
→ Fault tolerance.
→ AI based predictive maintenance

Railway Safety System

Train monitoring
↓
Train Speed
↓
Environmental
Monitoring
↓
Safety Alerts &
    Communication

Track Fault detection
↓
Vibration ultrasonic
      Sensor
↓
microController / AI processor
↓
operator Dashboard

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6) Consider a weather monitoring Station where Embedded Systems Collect meteorological data & transmit it to a central server via IoT protocols.

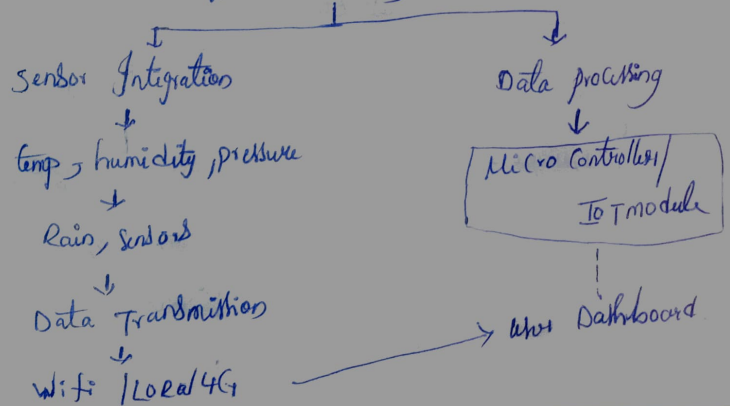**Sol.—** Weather monitoring Station Design & Functionally.

A weather monitoring Station uses Embedded Systems to Collect meteorological data & transmit it to an Central Server via IoT Protocols

1) Sensor Integration :—
→ Temperature & humidity sensors (DHT22, SHT31) measure atmospheric Conditions.
→ Barometric pressure Sensor (BMP280, MS5611): Detects pressure changes for weather Prediction
→ Wind Speed & Direction Sensors (Anemometer, wind pressure) Track wind behaviour.
→ Rain Coverage : Measure Precipitation levels.

Block diagram
weather monitoring Station

Sensor Integration
↓
temp, humidity, pressure
↓
Rain, Sensors
↓
Data Transmission
↓
Wifi / LoRa / 4G

Data processing
↓
Micro Controller/
      IoT module
↓
→ User Dashboard

7) Consider a Smart waste management system where embedded sensors detect bin full levels and optimize garbage collection routes.

A) Smart waste management system design functionality:-

A smart waste management system uses embedded sensors to detect bin full levels and optimize garbage collection routes, improving efficiency & reducing costs.

1) Sensors Integration :—
   * ultra Sonic/infrared Sensors :—
   * Gas Sensors (MQ-135)
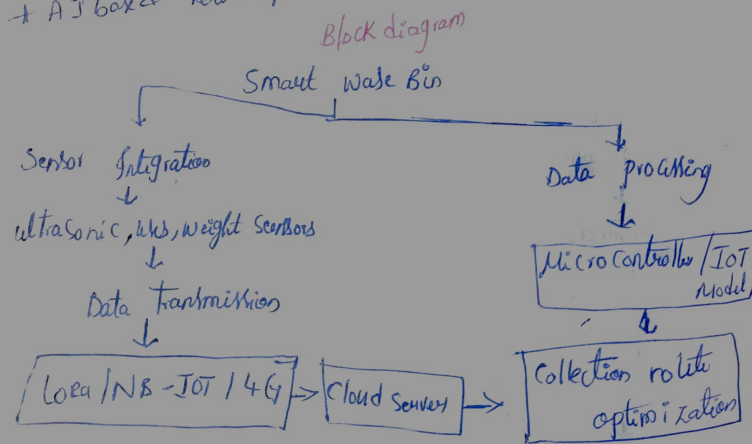   * Weight Sensors:

2) Data Communication & processing :-
   * Micro controller
   * Wireless Communication
   * AI based Route optimization.

Block diagram

8) Consider a power distribution system that automates substation operation using embedded systems.

A) Automated Power distribution System – Design & functionality

A power distribution system automates substation operations using embedded.

B) 1) Monitoring & Sensors:
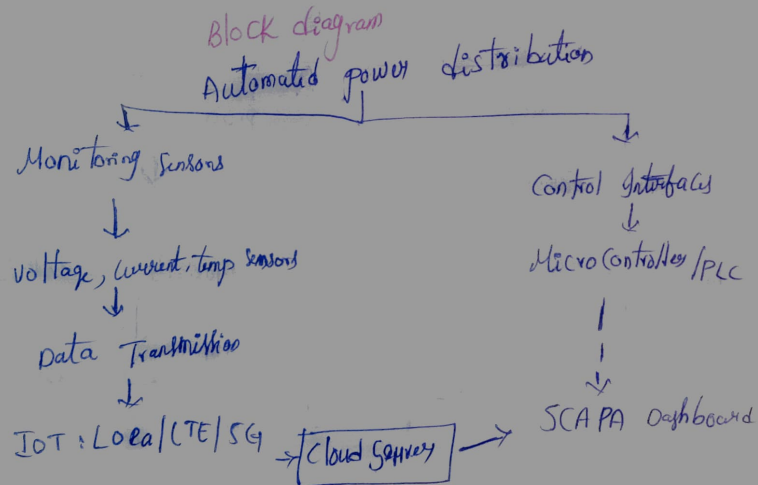   * Voltage & current Sensors (CT/PT):
   * Temperature & Humidity Sensors:
     Monitor Substation Environment

2) Circuit Breaker & Transformer Sensor:
   Track Equipment health.

3) Remote data logging & Communication :-
   * IOT   + Cloud based Monitoring

Block diagram

1s) Consider a factory automation System and user end
Systems to Control robotic arms, monitors Production.

A) i) Real time Control:

* Robotic Arms & Acuats : Controlled by PLC /micro

* Industrial Sensors (proximity, load, temperature)

* SCADA System:

2) predictive maintainence Sensors

* vibration & temperature

* Defect & temperature Sensors

* AI based analytics

* IOT communication.

Block diagram

Factory automation System

Robotic Arm Control

↓

PLC, microcontroller

↓

Predictive Maintanere

↓

vibration, AI Analytics

production monitoring

↓

[Industrial Sensors:

proximity, board, Temp

↓

SCAPA Dash
board

→ Cloud Server →