SREENIVASAINSTITUTEOFTECHNOLOGYANDMANAGEMENTSTUDIES
(Autonomous)

Minor - EMBEDDED SYSTEMS AND IOT - Offered by ECE Department

S.No	Course Code	CourseTitle	Scheme of Instructions HoursperWeek				Scheme ofExaminationMaximumMarks		
			L	T	P	C	I	E	Total
1	23MRESI1	Embedded Systems Technology	3	-	-	3	30	70	100
2	23MRESI2	Real Time Embedded systems design and Analysis	3	-	-	3	30	70	100
3	23MRESI3	Principles of IoT	3	-	-	3	30	70	100
4	23MRESI4	Wireless Sensor Networks	3	-	-	3	30	70	100
5	23MRESI5	Industrial Internet of things	3	-	-	3	30	70	100
6	23MRESI6	Principles of IoT Lab	-	-	3	1.5	30	70	100
7	23MRESI7	Industrial Internet of things Lab	-	-	3	1.5	30	70	100

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ECE Department

EMBEDDED SYSTEMS AND IOT

23MRESI1	EMBEDDED SYSTEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

- To introduce the fundamental concepts and classifications of embedded systems.
- To explore the architecture and processor models used in embedded system design.
- To study different communication interfaces and protocols in embedded systems.
- To understand rapid prototyping using platforms like Arduino and sensor modules.
- To develop embedded GUI interfacing and analyze case studies of real-world embedded applications.

UNIT –1: Introduction to Embedded system: (9)

Introduction to Embedded Systems, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Embedded Processor Requirements, Features, Types, RISC Processors, Harvard Architecture, Super Harvard Architecture, Selection of Processors &Microcontrollers.

UNIT –2: Architecture of Embedded System Processor: (9)

Embedded processor models, ARM core processor, Application specific processor like network processors, multimedia processors, industrial processors, superscalar processor, Advanced RISC processors.Architecture of Embedded OS, Categories of Embedded OS, Application Software, Communication Software, Development and Testing Tools

UNIT –3: Communication Interfaces: (9)

Need for Communication Interfaces, OSI Reference Model, Basic of Networks, Network Topology, RS232/UART, RS422/RS485, USB, Infrared, Ethernet, IEEE 802.11,Bluetooth, SPI, I2C, CAN, Wifi, FlexRay, LIN Bus, Zigbee.

UNIT –4: Rapid prototyping: (9)

Arduino platform, hardware and software, Sensor’s modules, RoboControlmodules, 3D printing module, ADC module, wearable systems. etc.

UNIT –5: Embedded GUI interfacing: **(9)**

Embedded GUI interfacing: Arduino based graphic LCD, Touch screen, joy stick, VGA camera interfacing and programming in Python. Creative applications of Arduino

Design Examples & Case Studies of Embedded System: Digital Thermometer, Navigation Systems, Smart Card, RF Tag.

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course- students will be able to		**Bloom's Level**
CO1	Understand the basics of embedded systems, including their history, classification, and processor selection.	
CO2	Analyze different embedded processor architectures, including ARM, RISC, and application-specific processors.	
CO3	Evaluate various communication interfaces and protocols, such as UART, USB, SPI, I2C, and Zigbee.	
CO4	Implement rapid prototyping techniques using Arduino, sensors, and wearable system modules.	
CO5	Develop and interface embedded GUI systems, including LCDs, touchscreens, and VGA cameras, for real-world applications.	

TEXT BOOKS:

1. David Simon, "An embedded Software Primer" PearsonPublication,2021.
2. Frank Vahid, "Embedded system — A unified Hardware Software Introduction" John Wiley and Sons,2005.

REFERENCE BOOKS:

1. Tammy Noergaard," EmbeddedSystem Architecture", Elsevier publication,2014.

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23MRESI2	REAL TIME EMBEDDED SYSTEMS DESIGN AND ANALYSIS	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. To understand the fundamental concepts of Real-Time Operating Systems (RTOS), kernel architecture, and synchronization mechanisms.
2. To study real-time embedded software development using Linux, RT Linux, and RTOS programming techniques.
3. To explore real-time task scheduling techniques, including table-driven, cyclic, EDF, and RMA scheduling.
4. To analyze real-time hardware architectures, software stacks, and best practices for embedded system programming.
5. To examine real-time communication protocols, database systems, and validation techniques for embedded systems.

UNIT –1: Introduction to RTOS (9)

Overview Of RTOS, Architecture of Kernel, Task & Task Scheduler, ISR, Semaphore, Mutex, Mailbox, Message Queues, Event Registers, Pipes,Signals, Timers, Memory Management, Priority Inversion Problem.

UNIT –2: Real Time Embedded Software: (9)

Linux, RT Linux, multiprocessor software developments, data flow graph, Study and programming of RTOS like RTX51, Free RTOS etc. timingdiagram analysis for fixed and dynamic priority software services.

UNIT –3: Real time Scheduling: (9)

Scheduling Real-Time Tasks: Types of Schedulers Table-driven scheduling Cyclic schedulers EDF RMA, Priority Pre-emptive Scheduler State Machine for Linux and VxWorks, Comparison of Cyclic Executive, Introduction to Worst Case Analysis, Example of scheduling, Real-Time Scheduling and Rate Monotonic Least Upper Bound.

UNIT –4: Overview of Real-time Hardware Architectures and Software Stacks: (9)

Embedded Linux on the Raspberry Pi ARM A-Series System-on-Chip processors, Tracing Linux kernel and network stack events. Best Practices for RTES Programming, System Integration Testing (Hardware, Firmware, and Software),

UNIT –5: Real Time Communication (9)

Real Time Communication: RT Services Communication and Synchronization, Performance of two Real-Time communication Protocols, Real time communication over network, Real Time database.

Verification and Validation of RTES project: Using Point-to-point Serial and TCP/IP for Embedded Systems, Case Study of Coding for Sending Application Layer Byte Streams on A TCP/IP Network Using RTOS. Building a simple Linux multi-service system using POSIX real-time extensions on Raspberry Pi 3b using sequencing and methods to log and verify agreement between theory and practice.

Total Hours: 45

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COURSE OUTCOMES:

On successful completion of the course- students will be able to		Bloom's Level
CO1	Explain the architecture of RTOS, task scheduling, and synchronization mechanisms such as semaphores, mutexes, and message queues.	
CO2	Demonstrate proficiency in real-time embedded software development using Linux, RT Linux, and various RTOS platforms.	
CO3	Apply real-time scheduling algorithms to optimize task execution and system performance.	
CO4	Analyze real-time embedded hardware architectures and software stacks for efficient system integration.	
CO5	Implement real-time communication protocols and perform validation and verification of embedded systems using case studies.	

TEXT BOOKS:

1. EmbeddedRealtimesystems",PrasadDreamtechWileyPublication,2003.
2. "Real-Time Systems: Theory and Practice, "RajibMall Pearson,2008.

REFERENCE BOOKS:

1. "Real-TimeSystemsDesignandAnalysis",PhilipLaplante,2nd Edition,PrenticeHall, 2013.

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23MRESI3	PRINCIPLES OF IOT	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. To introduce the fundamental concepts, characteristics, and design principles of the Internet of Things (IoT).
2. To explore IoT components, communication protocols, and networking techniques.
3. To understand IoT system management, including platform design and application development.
4. To study networking and computing in IoT, including Python-based IoT programming and cloud integration.
5. To analyzeIoT cloud platforms, data analytics, and real-world IoT applications in smart cities, homes, and industries.

UNIT –1: Introduction & Basic of IoT :: **(9)**

Definition, Characteristics, Physical and Logical Designs, challenges, Technological trends in IOT, IoT Examples, M2M.

UNIT –2: IoT: Components, Communication and Networking: **(9)**

Introduction to Sensing and Networking: Sensing & actuation, Wireless Senor network, Senor nodes, Communication Protocols,M2M Communication, Networking Hardware, Networking Protocols

UNIT –3: IoT System Management: **(9)**

Network Operator Requirements, IoT Platform Design Specification – Requirements, Process, Domain Model, Service, IoT Level, Function, Operational view, Device and Component Integration, Application development.

UNIT –4: Networking and Computing: **(9)**

File Handling, Python Packages for IoT, IoT Physical Servers – Cloud Storage Models, Communication APIs.

UNIT –5: **(9)**

IoT Clouds and Data Analytics: REST ful Web API, Amazon Web Services for IoT, Apache Hadoop, Batch Data Analysis, Chef, Chef Case Studies, Puppet, NETCONF-YANG

IoT Applications: Case studies: smart cities, smart home, connected vehicles, Industrial IOT.

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Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course- students will be able to		**Bloom's Level**
CO1	Understand the fundamentals of IoT, including its architecture, characteristics, and challenges.	
CO2	Analyze IoT communication protocols and networking techniques used in wireless sensor networks and M2M communication.	
CO3	Design and manage IoT platforms, including device integration, service models, and application development.	
CO4	Implement IoT networking and computing techniques, including cloud storage, APIs, and Python-based IoT programming.	
CO5	Develop and evaluate IoT applications in real-world domains such as smart cities, connected vehicles, and industrial automation.	

TEXT BOOKS:

1.Kamal, R.,"Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill,2017.
2.SimoneCirani,"InternetofThings-Architectures, Protocols and Standards", WILEY,2018.

REFERENCE BOOKS:

1. AlessandroBassi," Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model", Springer,2013.

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23MRESI4	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. To introduce the fundamental concepts and architecture of wireless sensor networks.
2. To explore various network architectures, optimization techniques, and design principles for wireless sensor networks.
3. To study MAC protocols, routing techniques, and addressing mechanisms for efficient sensor network communication.
4. To understand the infrastructure establishment of sensor networks, including topology control and synchronization.
5. To provide knowledge on sensor network platforms, programming challenges, and simulation tools.

UNIT –1: Overview of Wireless Sensor Networks (9)

Single-Node Architecture - Hardware Components- Network Characteristics- unique constraints and challenges, Enabling Technologies for Wireless Sensor Networks- Types of wireless sensor networks.

UNIT –2: Architectures: (9)

Network Architecture- Sensor Networks-Scenarios- Design Principle, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Gateway Concepts.

UNIT –3: Networking Sensors: (9)

MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts - SMAC, - B-MAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols Energy-Efficient Routing, Geographic Routing.

UNIT –4: Infrastructure Establishment: (9)

Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.

UNIT –5: Sensor Network Platforms and Tools : (9)

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node level Simulators, State-centric programming.

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course- students will be able to		Bloom's Level
CO1	Learn the fundamental concepts and architecture of wireless sensor networks.	
CO2	Explore various network architectures, optimization techniques, and design principles for wireless sensor networks.	
CO3	Gain knowledge of MAC protocols, routing techniques, and addressing mechanisms for efficient sensor network communication.	
CO4	Understand the infrastructure establishment of sensor networks, including topology control and synchronization.	
CO5	Grasp the knowledge on sensor network platforms, programming challenges, and simulation tools.	

TEXT BOOKS:

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2005.
2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks-An Information Processing Approach", Elsevier, 2007

REFERENCE BOOKS:

1. WaltenegusDargie , Christian Poellabauer, "Fundamentals Of Wireless Sensor Networks Theory And Practice", By John Wiley & Sons Publications, 2011
2. KazemSohraby, Daniel Minoli, &TaiebZnati, "Wireless Sensor Networks-Technology, Protocols, and Applications", John Wiley, 2007.
3. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003

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23MRESI5	INDUSTRIAL INTERNET OF THINGS	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. To understand the fundamental concepts of the Industrial Internet of Things (IIoT), its market potential, and applications in various industries.
2. To study the methodologies, networking protocols, and wireless communication technologies used in IIoT deployments.
3. To explore data-driven analytics in IIoT, including big data processing, machine learning algorithms, and neural networks.
4. To analyze IP and non-IP protocols used in IIoT, such as WPAN, Bluetooth, Zigbee, and MQTT.
5. To examine IoT cloud platforms, data analytics techniques, and their applications in industrial robotics and asset monitoring.

UNIT –1: Introduction IIoT; Market Size and Potential: (9)
Definition, IoT v IIoT, Next Generation Sensors, Sensor's calibration and validate sensor measurements, placement of IoT devices, sensors, low-cost communication system design, Top application areas include manufacturing, oil & gas, Embedded systems in the Automotive and Transportation market segment.

UNIT –2: I IoT Methodology: (9)
Top operating systems used in IIoT deployments, Networking and wireless communication protocols used in IIoT deployments. Smart Remote Monitoring Unit, components of monitoring system, control and management, Wireless Sensor Networ(WSN).

UNIT –3: Data driven Analytics of IIoT: (9)
Implementing of industrial IoT Data flow, big data and how to prepare data for machine learning algorithms, Machine Learning algorithms, supervised learning & Un-supervised learning algorithms, Basics of neural network, activation functions, back-propagation.

UNIT –4: IP and Non-IP Protocols for IoT: (9)
WPAN, IEEE 802.15.4, Bluetooth, NFC, 6LoWPAN; RFID, Zigbee Wireless HART Protocol, MQTT, IP and Non-IP Protocols, REST, CoAP

UNIT –5: (9)
IoT Clouds and Data Analytics: Develops a physics-based and data-driven digital equipment model to monitor assets and systems, Introduction to device localization and tracking; different types of localization techniques, Radio-Frequency Identification (RFID) and fingerprinting, Device diversity/heterogeneity issue in IIoT networks
Internet of Robotic Things (IoRT): Introduction to stationary and mobile robots, Brief introduction to localization, mapping, planning, and control of robotic systems; Introduction to cloud-enabled robotics; Applications of IIoT in robotics; Architectures for IoRT, Examples and case studies: Open issues and challenges.

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Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course- students will be able to		**Bloom's Level**
CO1	Explain the key differences between IoT and IIoT, sensor calibration, placement, and the role of communication systems in IIoT applications	
CO2	Demonstrate knowledge of IIoT methodologies, including operating systems, networking protocols, and wireless sensor networks.	
CO3	Apply data analytics techniques, including big data processing and machine learning, to industrial IoT applications.	
CO4	Analyze and implement IP and non-IP communication protocols for efficient IIoT connectivity and data exchange	
CO5	Utilize IoT cloud platforms for device localization, tracking, and robotics applications in industrial environments.	

TEXT BOOKS:

1. "Industry4.0:The Industrial Internet of Things",AlasdairGilchrist, Apress,2016"
2. Introduction to Industrial Internet of Things and Industry4.0", SudipMisra ,ChandanaRoy, Anadarup Mukherjee,CRCPress,2021

REFERENCE BOOKS:

1. "HandsonIndustrialInternetofThings", GiacomoVeneri,AntonioCapasso, PacktPress, 2018.

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23MRESI6	PRINCIPLES OF IOT LAB	L	T	P	C
		-	-	3	1.5

PRE-REQUISITES: Nil.

COURSE EDUCATIONAL OBJECTIVES:

1. To understand the fundamentals of IoT through hands-on experiments with sensors, actuators, and microcontrollers.
2. To develop skills in interfacing various sensors and actuators with microcontrollers like Arduino, ESP32, and Raspberry Pi.
3. To explore IoT communication frameworks such as HTTP, MQTT, and cloud-based data logging platforms like ThingSpeak.
4. To gain experience in remote monitoring and control of IoT devices using mobile and web applications.
5. To learn UAV/Drone integration with IoT through flight controller programming and GPS-based navigation.

Experiments:

List of Experiments: (Any 10 Experiments are to be conducted)

1. Serial Monitor, LED, Servo Motor - Controlling
- Controlling actuators through Serial Monitor. Creating different led patterns and controlling them using push button switches. Controlling servo motor with the help of joystick.

2. Distance Measurement of an object
- Calculate the distance to an object with the help of an ultrasonic sensor and display it on an LCD.

3. LDR Sensor, Alarm and temperature, humidity measurement
- Controlling relay state based on ambient light levels using LDR sensor.
- Basic Burglar alarm security system with the help of PIR sensor and buzzer.
- Displaying humidity and temperature values on LCD

4. Experiments using Raspberry Pi
- Controlling relay state based on input from IR sensors
- Interfacing stepper motor with R-Pi
- Advanced burglar alarm security system with the help of PIR sensor, buzzer and keypad. (Alarm gets disabled if correct keypad password is entered)
- Automated LED light control based on input from PIR (to detect if people are present) and LDR(ambient light level)

5. IOT Framework
- Upload humidity & temperature data to ThingSpeak, periodically logging ambient light level to ThingSpeak.

1. **Controlling LEDs, relay & buzzer using Blynk app**

7. HTTP Based
- Introduction to HTTP. Hosting a basic server from the ESP32 to control various digital based actuators (led, buzzer, relay) from a simple web page.

8. Displaying various sensor readings on a simple web page hosted on the ESP32.

9. MQTT Based
- Controlling LEDs/Motors from an Android/Web app, Controlling AC Appliances from an android/web app with the help of relay.

10. Displaying humidity and temperature data on a web-based application

11. UAV/Drone:
- Demonstration of UAV elements, Flight Controller
- Mission Planner flight planning design

12. Python program to read GPS coordinates from Flight Controller

Course Outcomes:

After completing the course, the student will be able to,

2. Demonstrate the ability to control and monitor sensors and actuators using microcontrollers and IoT platforms.
3. Implement IoT-based applications using cloud services like ThingSpeak and mobile applications like Blynk.
4. Develop web-based IoT applications using HTTP and MQTT protocols for remote device management.
5. Apply IoT principles in real-world applications such as home automation, security systems, and industrial monitoring.
6. Integrate UAV/Drone technologies with IoT for automated navigation and data acquisition.

Reference:

1. Adrian McEwen, Hakim Cassimally - Designing the Internet of Things, Wiley Publications, 2012.
2. Alexander Osterwalder, and Yves Pigneur – Business Model Generation – Wiley, 2011
3. ArshdeepBahga, Vijay Madisetti - Internet of Things: A Hands-On Approach, Universities Press, 2014.
4. The Internet of Things, Enabling technologies and use cases – Pethuru Raj, Anupama C. Raman, CRC Press.

Online Learning Resources/Virtual Labs:

https://www.arduino.cc/
https://www.raspberrypi.org/

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23MRESI7	INDUSTRIAL INTERNET OF THINGS LAB	L	T	P	C
		-	-	3	1.5

PRE-REQUISITES: Nil.

COURSE EDUCATIONAL OBJECTIVES:

1. To understand the fundamental concepts of IIoT, including its architecture, challenges, and differences from IoT.
2. To explore IIoT components such as sensors, actuators, and control systems for industrial applications.
3. To study various communication technologies and protocols like IEEE 802.15.4, ZigBee, BLE, and MQTT for IIoT applications.
4. To learn data visualization techniques and methods for connecting IIoT devices to the web.
5. To analyze data retrieval techniques and machine-to-machine (M2M) interactions for IIoT-based automation.
6. To gain hands-on experience with PLCs, SCADA, and real-time control systems used in industrial automation.

Course Outcomes:
After completing the course, the student will be able to,

1. Explain the architecture, challenges, and fundamental concepts of IIoT and differentiate it from IoT.
2. Demonstrate the interfacing of sensors and actuators with microcontrollers like Raspberry Pi and Node MCU for industrial automation.
3. Implement communication protocols such as MQTT, ZigBee, and Bluetooth to enable seamless IIoT connectivity.
4. Develop web-based dashboards for real-time visualization and control of IIoT devices.
5. Retrieve, analyze, and transmit industrial data using web-based interactions and M2M communication.
6. Implement PLC-based automation, Boolean logic programming, and process control using SCADA for industrial applications.

Experiments:
(All the modules need to be conducted and minimum one project to be done)

MODULE 1: Introduction & Architecture
What is IIoT and connected world? The difference between IoT and IIoT, Architecture of IIoT, IOT node, Challenges of IIOT. Practice
1. Introduction to Arduino, Introduction to raspberry Pi.
https://www.youtube.com/watch?v=AQdLQV6vhbk

MODULE 2: IIOT Components
Fundamentals of Control System, introductions, components, closed loop & open loop system.
Introduction to Sensors (Description and Working principle): What is sensor? Types of sensors, working principle of basic Sensors -Ultrasonic Sensor, IR sensor, MQ2, Temperature and Humidity Sensors (DHT-11).Digital switch, Electro Mechanical switches.
Practice

1. Measurement of temperature & pressure values of the process using raspberry pi/node mcu.
2. Modules and Sensors Interfacing (IR sensor, Ultrasonic sensors, Soil moisture sensor) using Raspberry pi/node mcu.
3. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry pi/node mcu.

MODULE 3: Communication Technologies of IIoT
Communication Protocols: IEEE 802.15.4, Zig Bee, Bluetooth, BLE, NFC, RFID Industry standards communication technology (MQTT), wireless network communication.
Practice

1. Demonstration of MQTT communication.

MODULE 4: Visualization and Data Types of IIoT

Connecting an Arduino/Raspberry pi to the Web: Introduction, setting up the Arduino/Raspberry pi development environment, Options for Internet connectivity with Arduino, Configuring your Arduino/Raspberry pi board for the IoT.

Practice

1. Visualization of diverse sensor data using dashboard (part of IoT's 'control panel')
2. Sending alert message to the user. ways to control and interact with your environment)

MODULE 5: Retrieving Data

Extraction from Web: Grabbing the content from a web page, Sending data on the web, Troubleshooting basic Arduino issues, Types of IoT interaction, Machine to Machine interaction (M2M).

Practice

1. Device control using mobile Apps or through Web pages.
2. Machine to Machine communication.

MODULE 6: Control & Supervisory Level of Automation

Programmable logic controller (PLC), Real-time control system, Supervisory Control & Data Acquisition (SCADA).

Practice

1. Digital logic gates programming using ladder diagram.
2. Implementation of Boolean expression using ladder diagram.
3. Simulation of PLC to understand the process control concept.

Projects:

IIoT based smart energy meter
Smart Agriculture system
Automation using controller via Bluetooth
Temperature controlled Fan/cooler using controller
Automatic streetlight
Smart Baggage Tracker

Textbooks

1. The Internet of Things in the Industrial Sector, Mahmood, Zaigham (Ed.) (Springer Publication)
2. Industrial Internet of Things: Cybermanufacturing System, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer Publication).
3. Industrial IoT Challenges, Design Principles, Applications, and Security by Ismail Butun (editor)