Microcontroller & Embedded Systems-Module-3-1

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Text book 2: Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education, Private Limited, 2nd Edition.
Chapter 1(Sections 1.2 to 1.6) ,Chapter 2(Sections 2.1 to 2.6)

3.1.1 What is an Embedded System?

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- **An Embedded system is an electronic/electro-mechanical system designed to perform a specific function and a combination of both hardware and firmware (software).**
- Every embedded system is unique and the hardware as well as the firmware is highly specialized to the application domain.
- Embedded systems are becoming an inevitable part of any product or equipment in all fields including household appliances, telecommunications, medical equipment, industrial control, consumer products, etc.

3.1.1 Examples of an Embedded System

3.1.2 Embedded Systems vs General Computing Systems

Criteria	General Purpose Computing System	Embedded System
Contents	A system which is a combination of a generic hardware and a General Purpose Operating System for executing a variety of applications.	A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications.
OS	It contains a general purpose operating system (GPOS).	It may or not contain an operating system for functioning.
Alterations	Applications are alterable (programmable) by the user. (It is possible for the end user to re-install the OS and also add or remove user applications.)	The firmware of the embedded system is preprogrammed and it is non-alterable by the end-user.

3.1.2 Embedded Systems vs General Computing Systems

Criteria	General Purpose Computing System	Embedded System
Key factor	Performance is the key deciding factor in the selection of the system. Faster is better.	Application specific requirements (like performance, power requirements, memory usage, etc.) are key deciding factors.
Power Consumption	More	Less
Response Time	Not critical	Critical for some applications
Execution	Need not be deterministic	Deterministic for certain types of ES like 'Hard Real Time'systems.

3.1.3 History of Embedded Systems

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- The first recognised modern embedded system is the Apollo Guidance Computer (AGC) developed by MIT Instrumentation Laboratory for the lunar expedition.
- They ran the inertial guidance system of both the Command Module(CM) and the Lunar Excursion Module(LEM).
- The Command Module was designed to encircle the moon while the Lunar Module and its crew were designed to go down the moon surface and land there safely.
- The first mass-produced embedded system was the guidance computer for the Minuteman-I missile in 1961.

3.1.4 Classification of Embedded Systems

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- Based on Generation
- Based on Complexity & Performance Requirements
- Based on deterministic behavior
- Based on Triggering

3.1.4 Classification- Based on Generation

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- **First Generation:** The early embedded systems built around 8bit microprocessors like 8085 and Z80 and 4bit microcontrollers
- **Second Generation**: Embedded Systems built around 16bit microprocessors and 8 or 16bit microcontrollers, following the first generation embedded systems
- **Third Generation:** Embedded Systems built around high performance 16/32 bit Microprocessors/controllers, Application Specific Instruction set processors like Digital Signal Processors (DSPs), and Application Specific Integrated Circuits (ASICs)
- **Fourth Generation:** Embedded Systems built around System on Chips (SoCs), Re-configurable processors and multicore processors

3.1.4 Classification- Based on based on Complexity & Performance

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- **Small Scale:** Embedded systems which arc simple in application needs and where the performance requirements are not time critical fall under this category.
- **Medium Scale**: Embedded systems which arc slightly complex in hardware and firmware (software) requirements fall under this category.
- **Large Scale/Complex:** Embedded systems which involve highly complex hardware and firmware requirements fall under this category. They are employed in mission critical applications demanding high performance.

3.1.4 Classification- Based on deterministic behaviour

3.1.4 Classification- Based on trigerring

3.1.5 Major Application Areas of ES

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- Computer Peripherals: Printers, Scanners, Fax machines etc.
- Computer Networking Systems: Network Routers, Switches, Hubs, Firewalls etc.
- Health Care: Different Kinds of Scanners, EEG, ECG Machines etc.
- Measurement & Instrumentation: Digital multi meters, Digital CROs, Logic Analyzers PLC systems etc.
- Banking & Retail: Automatic Teller Machines (ATM) and Currency counters, Point of Sales (POS)
- Card Readers: Barcode, Smart Card Readers, Hand held Devices etc.

3.1.6 Purpose of Embedded Systems

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Each Embedded Systems is designed to serve the purpose of any one or a combination of the following tasks.

- **A.Data Collection/Storage/Representation**
- **B.Data Communication**
- **C.Data (Signal) Processing**
- **D.Monitoring**
- **E.Control**
- **F. Application Specific User Interface**

3.1.6 A.Data Collection/Storage/Representation

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- Performs acquisition of data from the external world.
- The collected data can be either analog or digital
- Data collection is usually done for storage, analysis, manipulation and transmission
- The collected data may be stored directly in the system or may be transmitted to some other systems or it may be processed by the system or it may be deleted instantly after giving a meaningful representation

Fig: Digital Camera for Image capturing/storage/display

3.1.6 B.Data Communication

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- Embedded Data communication systems are deployed in applications ranging from complex satellite communication systems to simple home networking systems
- Embedded Data communication systems are dedicated for data communication
- The data communication can happen through a wired interface (like Ethernet, RS-232C/USB/IEEE1394 etc) or wireless interface (like Wi-Fi, GSM,/GPRS, Bluetooth, ZigBee etc)
- Network hubs, Routers, switches, Modems etc are typical examples for dedicated data transmission embedded systems

Fig: Wireless Network Router for Data Communication

3.1.6 C.Data (Signal) Processing

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- Embedded systems with Signal processing functionalities are employed in applications demanding signal processing like Speech coding, synthesis, audio video codec, transmission applications etc
- Computational intensive systems
- Employs Digital Signal Processors (DSPs)

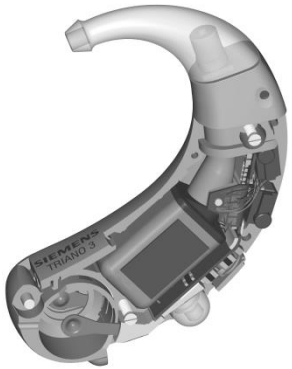

Fig: Digital hearing Aid employing Signal Processing Technique
Siemens TRIANO 3 Digital hearing aid;

3.1.6 D.Monitoring

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- Embedded systems coming under this category are specifically designed for monitoring purpose
- They are used for determining the state of some variables using input sensors
- They cannot impose control over variables.
- Electro Cardiogram (ECG) machine for monitoring the heart beat of a patient is a typical example for this
- The sensors used in ECG are the different Electrodes connected to the patient's body
- Measuring instruments like Digital CRO, Digital Multi meter, Logic Analyzer etc used in Control & Instrumentation applications are also examples of embedded systems for monitoring purpose

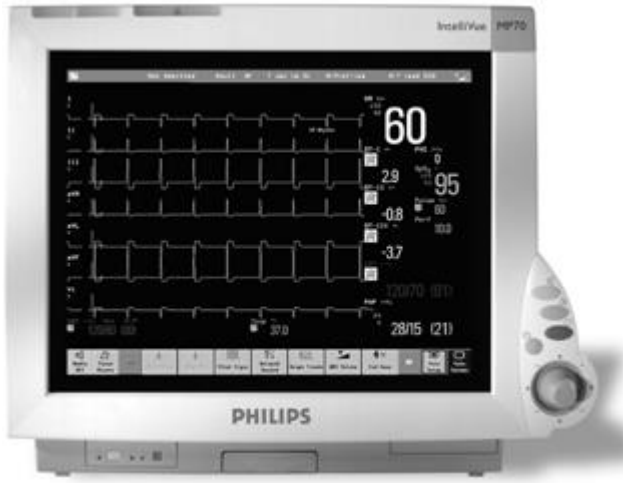

Fig Patient Monitoring system
Photo courtesy of Philips Medical Systems

3.1.6 E. Control

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- Embedded systems with control functionalities are used for imposing control over some variables according to the changes in input variables
- Embedded system with control functionality contains both sensors and actuators
- Sensors are connected to the input port for capturing the changes in environmental variable or measuring variable
- The actuators connected to the output port are controlled according to the changes in input variable to put an impact on the controlling variable to bring the controlled variable to the specified range

3.1.6 E. Control-cont

- Air conditioner for controlling room temperature is a typical example for embedded system with ‘Control’ functionality
- Air conditioner contains a room temperature sensing element (sensor) which may be a thermistor and a handheld unit for setting up (feeding) the desired temperature
- The air compressor unit acts as the actuator. The compressor is controlled according to the current room temperature and the desired temperature set by the end user.

Fig:Air Conditioner for controlling room temperature
Photo Courtesy of Electrolux Corporation

3.1.6 F. Application Specific User Interface

- Embedded systems which are designed for a specific application
- Contains Application Specific User interface (rather than general standard UI) like key board, Display units etc
- Aimed at a specific target group of users
- Mobile handsets, Control units in industrial applications etc are examples for this

Fig:An Embedded System with an application specific user

Thank You