Unit-I

Introduction to Embedded Systems

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1.3) Real time tasks.
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1.1) Embedded system :-

Embedded system is an electronic system. It is used to perform one or a limited set of fun using H/w & s/w.

Another name of embeded system is special purpose computing unit.

- Characteristics of Embedded system :-
  - As per defn, embedded systems are task specific. So they perform the same task constantly or continously over their existence.
  - Some embedded systems are real time system, they may have to perform its fns within specific time periods.
  - Many embedded systems are battery-powered system. So max use of system we need to preserve power.
  - Most of embedded system is small and inexpensive to manufacture. They are based on the size & and low complexity of the H/w.
  - Embedded system typically are configured with a modest set of resources. So they can easily meet the performance objectives of system.

1.2> Real Time Systems :-

- As we know that operating system is interface betn User and comp. H/w & s/w. It perform different set of tasks.
- The basic general purpose O.S handle comp. H/w, s/w, and dis task of comp but they are not capable to handle real time task so special O.S. are developed.
- Real time systems in which the accuracy of the system depend on the logical result of computation, and on the time at which the results are produce
- Some examples of real time system :-

1.> Air traffic control
2.> Robotics
3.> Real time database
4.> Telecommunication
5.> Internet Technology.

- For example, consider a Weapon Defense system. The job of system is to shoot down incoming missiles & protect the Naval Destroyer.
- We need this b'coz potential

threat can occur at any time and it is unpredictable. The 2nd real time computing is the firing coordinates, they are determined by the flight path of the target but are updated in real time as per the actual location of the target.

1.3) Real Time Tasks:-

- Real time system means that the system is produce the result in real time.
- The type of real time system is categorized if one of task misses any deadline then how system will react.
- The different types of real time task are hard, soft and firm real time tasks.

- Hard Real time Task:-

- In the Hard Real Time, all tasks must be begun to execute on predefined scheduling time.
- All tasks must be done within fixed time duration. any task miss the deadline then o/p of that task is useless. It means

o/p of the task is 0.
- The whole system fails if hard real time task miss the deadline.

Examples:-
- Automobile control system tries to reach deadline; but if a deadline is missed system is not fail. like as Anti lock & Air bag Airline control system, Diagnosis control system.

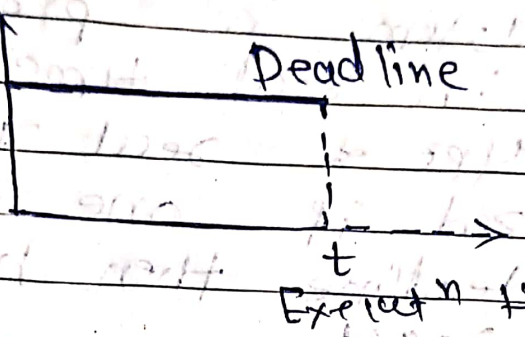
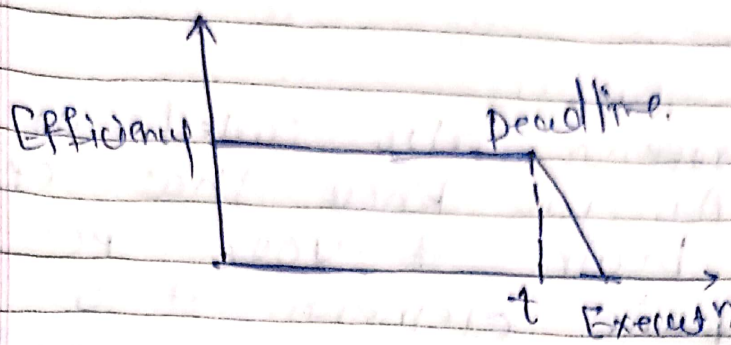


Fig. Hard Real Time Task execution efficiency.

- Soft Real Time Task:-
- Soft real-time systems try to reach deadlines but if a deadline is missed system is not fail. But they may degrade their quality of service in such an event.
- Examples of soft real-time systems audio and video delivery soft

for entertainment.



- As shown in fig., the outcomes of soft real time system is valid even if the deadline is missed & result is still accepted till it becomes zero.

- Firm Real Time Task:-
- Firm real time task is combination of hard real time task & soft real time task.
- In firm real time task, if the deadline is missed the value of o/p is zero.
- In firm real time system o/p is allowed to miss the deadline but not every time. If the system misses the deadline regularly then system failure occurs.

Example of firm real time system is Multimedia the deadline regularly then system failure occurs.

Example of firm real time system

is multimedia appln's.

1.4> Processor Basics: -

- The processor, also called as CPU. As we know that CPU is the brain of your PC.
- The basic elements of a processor include ALU to perform arithmetic & logical operation, FPU is numeric coprocessor, Registers used to hold the instn, other data and cache memory.
- Processor perform 4 types of fetch like fetch, decode, execute and write back.

1.4.1> General Processors in computer Vs Embedded Processors. -

- To understand the embedded system we need to understand the diff. betn a special-purpose comp. and a general-purpose computer.
- Desktops, laptops, and Macs are the general-purpose computers.
- Our smart phones also consider as a general-purpose and in the spectrum bcoz they perform more than one specific task.
- Special purpose computers are very specific to provide a perticular.

fun.

- The only job of a calculator is to do calculations. You can not use it for more than one purpose like general purpose computers.

1.4.2) microcontrollers :-

- A microcontroller is an IC device. It is used to control other components of an electronic system, using a microprocessor unit, memory, and some peripherals.
- A microcontroller also called Embedded comp. is a mini, powered comp., fixed in a compact Integrated circuit chip, contains on-chip one or more processor, memory & programmable i/p/o/p ports, for multiple fun. microcontroller is used in embedded system.
- For example, Security systems, laser printer, automation system, robotics etc. There are some languages available for programming a microcontroller like C, assembly lang. etc. Now we see in details of microcontroller in next section.

1.4.3> Microcontroller Properties:-

1) In recent technologies, some microcontroller devices compose complex design & are capable having word length more than 64 bit.

2) Microcontroller consists of built components with EPROM, EEPROM and RAM, ROM, timers, I/O ports and reset button.

3) In microcontroller RAM is used for data storage & ROM is used for program & other parameters storage.

4) Modern microcontrollers operate much lower power consuption compared to older ones.

5) They can operate at a low voltage ranging from 1.8 V to 5 V.

6) The latest feature of microcontroller is Flash memory like EPROM & EEPROM are very viable.

7) EPROM is faster and quick than EEPROM memory.

1.4.4> Components of microcontroller.-

- A microcontroller basically contains following components:-
  - Central processing unit (CPU)
  - Random acces memory (RAM)
  - Read only memory (ROM)

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- I/O / o/p ports
- Timers and counter
- Interrupt controls
- Analog to digital converters
- Digital analog converters
- Serial interfacing ports
- Oscillatory circuits

- Fig. shows the block diagram of a typical microcontroller. All components. All components are connected through an internal bus and are all integrated on one chip.

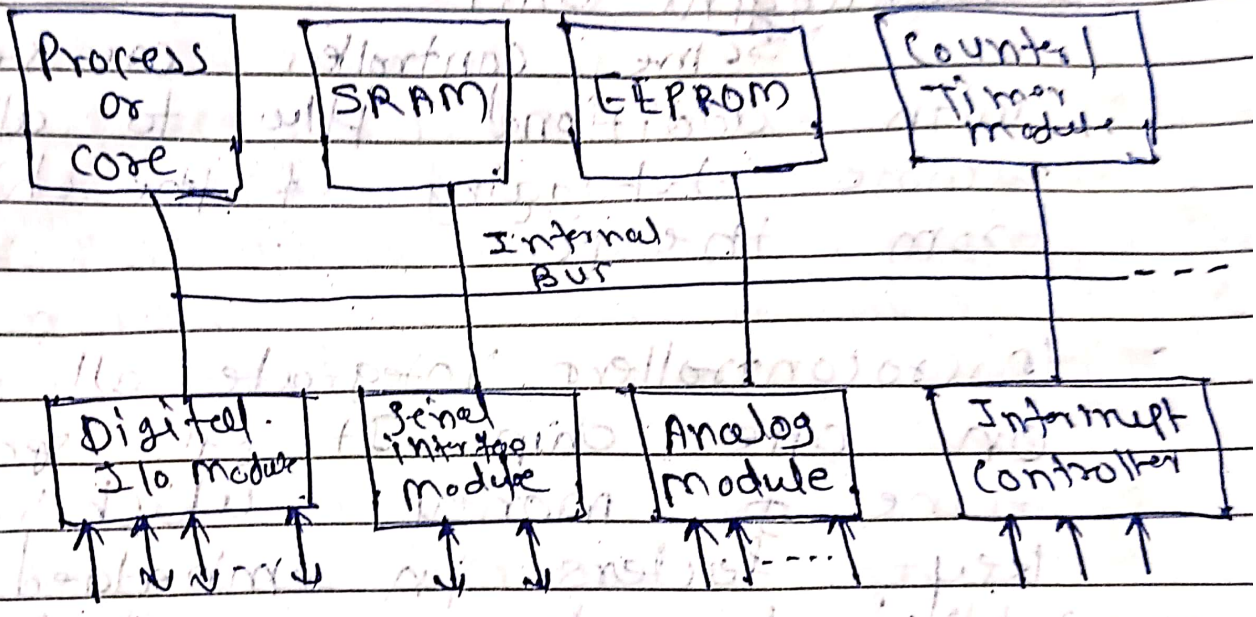

Fig. Microcontroller Architecture.

1.> Processor Core:
The main controller of CPU.

2> memory:
The memory is divided into program memory and data memory.

3> Interrupt controller:-
Intrupts means interrupt the normal program flows if any imp. external or internal event occur.

4> Timer/counter:-
Most controller have at least one and more Timer/counter.

5> Debuggint Unit:-
Some controllers are set with additional H/w to allow remote debugging of the chip from the pc.

- Microcontroller integrate all elements on one chip. It save space, time & money which is key factors in embedded system.
- Additional advantages of the microcontroller are easy upgradeable, lower power consuption, and higher reliability.

1.4.5) System-ON-Chip (SOC):-

- System on chip is an integrated circuit also known as an IC that contains all components of a computer or other electronic system.
- In SOC a single substrate contain digital, analog, mixed-signal, and often radio-frequency fun.

- Main Components of SOC:-
  Let's now have a brief look at a few major components of the SOC.

1. Processor:-
   - Processor is a major part of the SOC embedded in it.
   - All the operations done in the microcontroller on which the SOC is fixed.
2. Memory:-
   - As the ~~same~~ name suggests, the SOC contains both the RAM & ROM.
   - The entire component holds in the integrated chip (IC) that we call a system-on-chip.
3. Interfaces:-
   - We know that interface is used for communicatn purpose

with the external world.
- All the peripheral or component interface are rooted in this chip like UART, USB, I2C, and HDMI are supported by the SOC through an integrated circuit.

- Applicatn's of SOC:-
1) In mobile marked SOC is the most common & basic appln. SOC mostly used in smart phones, with the evaluatn of tech.
2) The 2 main features of SOC are high performance & low power consumption which is used in smart phones.
3) In modern tech., the SOC is used in almost every microcontrollers & microprocessors.
4) One more major example of the SOC is personal computers.
5) Now days many personal computers do not contain a motherboard but SOC. Bcoz today the need of high performance & small size computers.

1.4.6> Components of Embedded systems: —

- In previous section we learnt about the embedded system.
- An embedded system is special purpose computer used for a specific purpose or limited set of fun^n s.
- Fig. shows the basic components of embedded system.

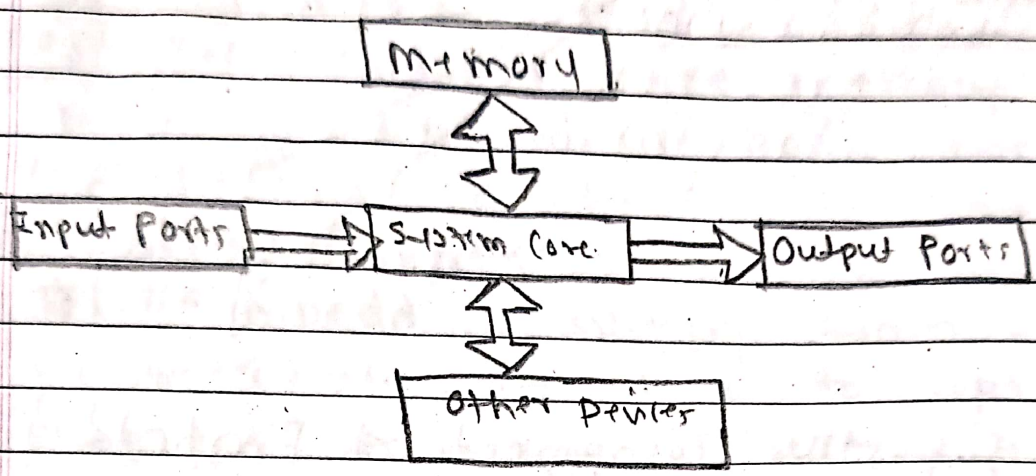

Fig. Basic components of embedded system

- The Basic components of embedded system are divided into 3 set.

I> Embedded System Hardware: —

- An embedded system require a H/w platform on which it perform the operation.
- The H/w elements of embedded system i/p o/p (I/o) interfaces, user interfaces, memory and the display.

The Fig. shows the H/w components of embedded system.

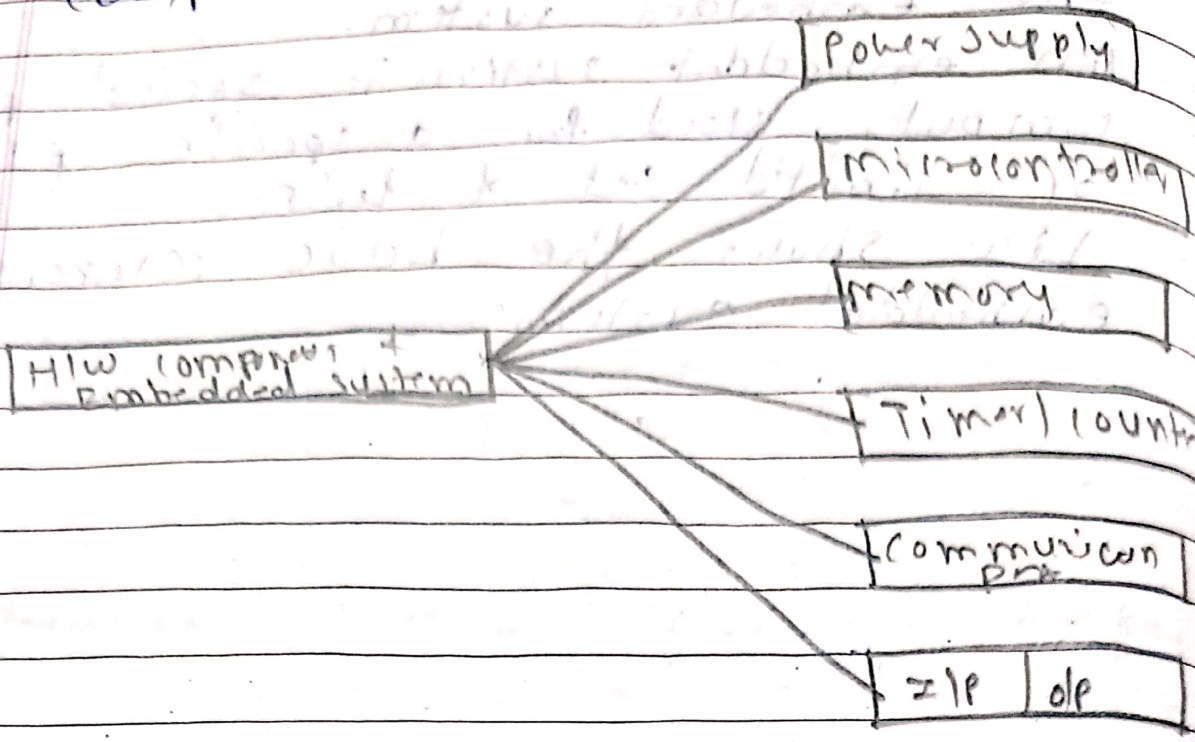

Fig. H/w components of Embedded System

1.) Power supply :-
- Power supply is key component for the embedded system. It provides the power to the embedded system circuit.
- The power supply is selected as per User requirements & applⁿ requirements.

2.) Processor :-
- The brain of any embedded system can act as microcontroller & microprocessor.

- In the market these are multiple type of processors available so the can select as per user requirement.

3> Memory :-
- As these are different microcontroller is used in the embedded system.
- The memory is present in microcontroller itself.
- RAM is volatile type memory.
- Rom is worked as code memory.

4> Timer / counter :-
- In Embedded system timer & counter can be used to provide some delay.
- eg :, in LED display appln (continuous blinking LED there is a requirement of some delay.

5> Communicatn ports :-
- The communicatn port is worked as interface.
- Multiple types of communicatn ports like UART, USB, Ethernet etc. are used in embedded system.

6> O/p & I/p :-
- In embedded system the I/p is needed to interact with the

system. The sensor collects i/p, process it and sends the o/p to embedded system.

II> Embedded System s/w:
- The embedded system is a grouping of both H/w & s/w modules.
- We have briefly explained about the H/w embedded system components.
- The embedded system s/w is used to perform a specific fun^n. It is typically written in a high level lang.
- Embedded system s/w is designed to keep in vision of the 3 points:
  - Availability of system memory
  - Availability of processor's speed
  - When the system runs continuously, there is a need to limit power dissipation for events like stop, run and wake up.

III> Real time Operating system (RTOS):
- system which works in real time and provides service in a time. It said to be real time

system.
- An RTOS is specially designed to run appl^n's with much desired timing and a high amount of reliability.
- In small scale embedded system may not need an RTOS. More details about RTOS we will see in case study.

1.4.7) Introduct^n to Embedded Processor:-
- Embedded processor is a microprocessor designed to perform need of embedded system.
- With the help of s/w program it interacts with diff. pieces of h/w.
- As we know that embedded systems require less power, so these processors are very small & depict less power from the source.
- Embedded processors are usually simple in design, limited in computational power, I/O capabilities, and have min^m power requirements.
- When fast processing fast context switching of atomic ALU operations are needed in that case embedded processor is used.
- In simple term embedded processor is a computing device placed inside

a system it controls.

• Introduction to ARM Processor:-
- The ARM microcontroller stands for Advanced RISC machine with 32 bit processor.
- ARM is most licensed & thus widespread processor cores in the world.
- In 1987 ARM 2 was developed after that ARM3, ARM4 and ARM5

• Advanced features of ARM core:-
- In this section we will discuss advanced features of ARM processor in detail.

1. Thumb:-
- In thumb mode the 16 bit instructions are executed and they are mapped to the normal ARM instruct's.

2. MMU and MPU:-
+ Another feature of ARM processor is memory mgnt unit & MPU. These 2 features are used to handle memory related issues.

3. Cache:-
- This feature is implanted in ARM processor for faster access

of frequently used data.

4. Debug Interface JTAG interface:
- ARM provides debug interface facility through JTAG. JTAG is Joint Test Action Group.

5. Embedded ICE Macrocell:
- macro level functionality handles by the prebuilt h/w unit macrocell.

- The Features of ARM which make it 'special'
- The following features of ARM processor are which make it special:

1. Data Bus width:
ARM has 32 bit bus width which means in one clock cycle ARM can process 32 bits of data.

2. Computational Capability:
The design of ARM processor is based on RISC capabilities which make the execution of ARM appln faster.

3. Low power:
With the use of RISC features the h/w requirement of

ARM processor is minimized.

4.) Pipelining:-
- This feature pipeline to increase the flow of instruct's to the processor.

5.) Multiple register instruct"s:-
- In ARM processor instruct"s use register or operands in instruct"

- Naming Rule of ARM:-
- All the features of ARM processor are used to represent name & version of ARM processor.

eg.
ARM {X}{Y}{Z}{T}{D}{M}{I}{E}{J}{F}{S}
it means.
- X: Series
- Y: memory mgnt/ protect" unit
- Z: cache
- T: Thumb decoder.
- D: JTAG debugger
- M: fast multiplier
- I: Embedded ICE macrocell
- E: enhance instruct"
- J: Jazelle
- F: Vector floating point unit
- S: Synthesizable.