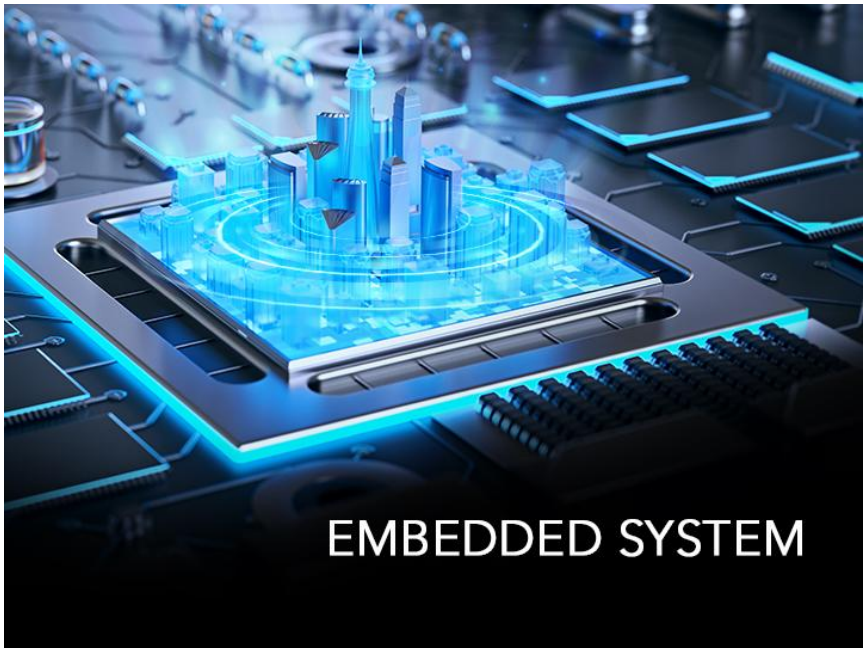


References:

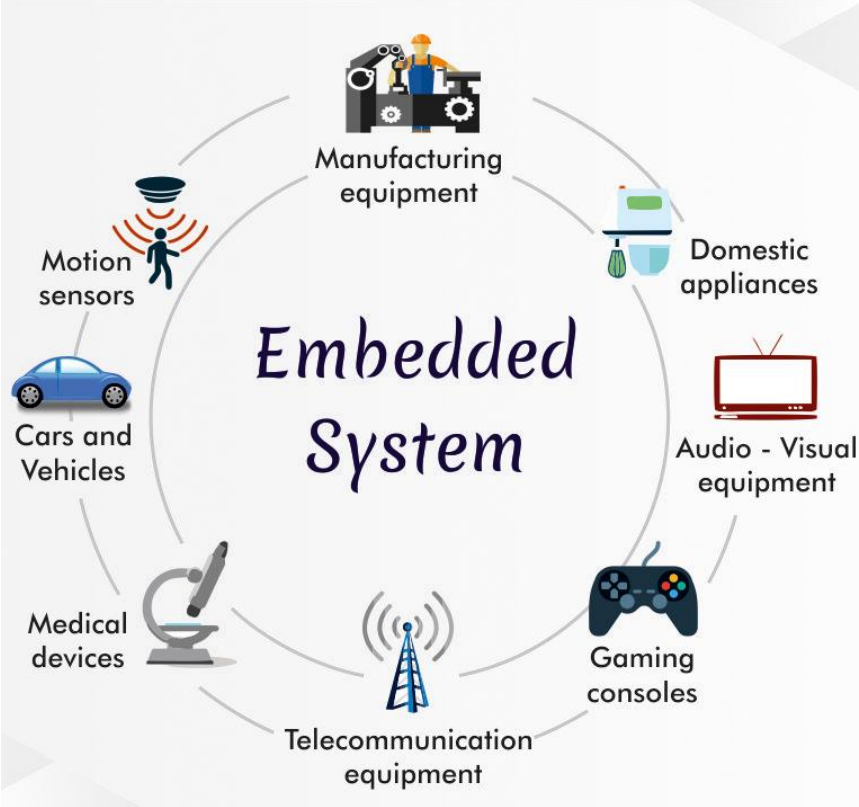
1- Jagadeesh Babu, LECTURE NOTES ON Embedded systems, 2018 2019 IV B. Tech I Semester (JNTUA-R15) Mr. M..
2- Peter Marwedel, Embedded System Design Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things Fourth Edition.
3- Jonathan W. Valvano, Embedded systems: introduction to ARM® Cortex(TM)-M microcontrollers.

Course Outcomes:

1. Introduction to embedded systems (ES), HW & SW components of embedded systems.
2. Signal conditioning, OPAMPs, ADC/DAC.
3. Embedded processor architectures.
4. GSM, GPS, IoT.
5. Introduction to hardware-software co-design.
6. Pulse Width Modulator (PWM)
7. Common use: control average voltage to electric device.
8. Special Microprocessor and Microcontroller.
9. The 8051 Microcontroller and Embedded Systems
10. Embedded System applications.
11. Communications and data transfer.
12. Model, languages and tools
13. Hardware/software co-design and synthesis
14. Reconfigurable Computing.
15. Real time Operating systems
16. Serial & Parallel Communication
17. Input and output devices.
18. Analog I/O Interfacing
19. Digital to Analog Conversion DAC, ADC
20. ES Design.
21. FPGA design for embedded Systems.
22. PIC **P**eripheral **I**nterface **C**ontroller Microcontroller
23. ARM & x86 Processors

Embedded System:

An Electronic/Electro mechanical system which is designed to perform a specific function and is a combination of both hardware and firmware (Software). this combination may be use as a component in a larger machine.



Key words of Embedded System

A- Software:

C Language packages like Adriano package

B- Hardware: Information Processing:

1- ❑ Processors

2- ❑ Memories

3- ❑ Communication

4- ❑ Peripherals

ESS Hardware Components:

It's the physical devices that can work with the microcontroller or microprocessor as input or output devices like.

Many Different Products Depend on Embedded Systems

Peripherals:

Peripherals like:

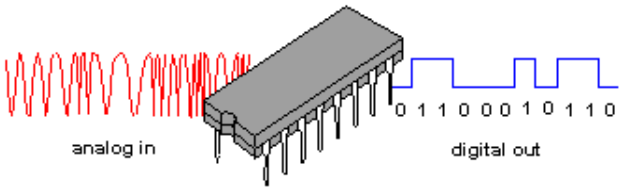
1- **Sensor** – It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory. Sensor is a transducer device which converts energy from one form to another for any

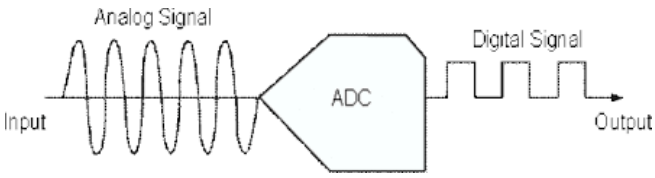
measurement or control purpose. Sensor acts as input devices. For example, IR, PIR, ultrasonic piezoelectric, smoke sensors

2- A-D Converter – An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.

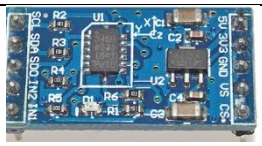
3- Processor & ASICs (Application specific Integrated circuits (Processors process the data to measure the output and store it to the memory.

4- D-A Converter – A digital-to-analog converter converts the digital data fed by the processor to analog data.

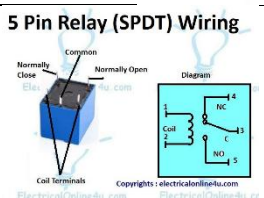
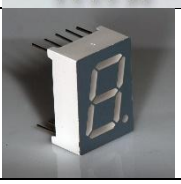
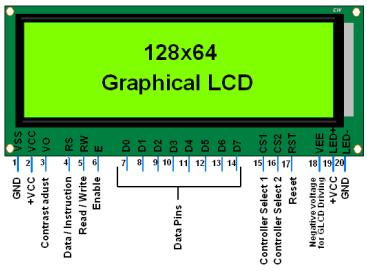




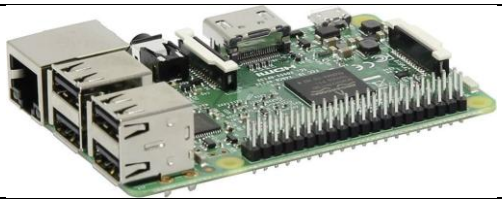
a- Photo Sensor	
b- Sound Sensor	
c- Motion Sensor	
d- Smoke Sensor	
e- Moisture Sensor	
f- Temperature Sensor	
g- Ultrasonic Sensor	

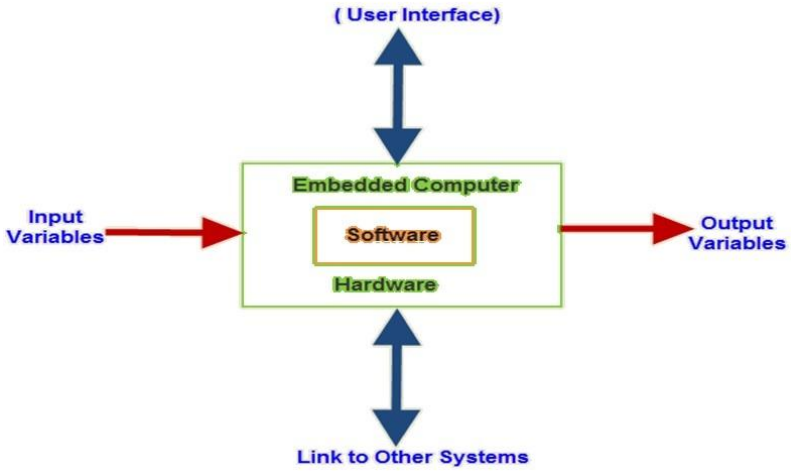
h- LDR Sensor	
i- Gravity Sensor	
j- Heat sensor	
k- Infrared sensor	

2- Actuators:

a- Servo Motors	
b- Stepper Motors	
c- Contactors	
d- Electric Solenoid Valves	
e- **LEDs**	
f- Seven or hexadecimal Segment display	
g- LCD display	
h- Buzzer	

3- Processing and controlling devices

a- Adriano Microcontroller	
b- Raspberry Microcontroller	



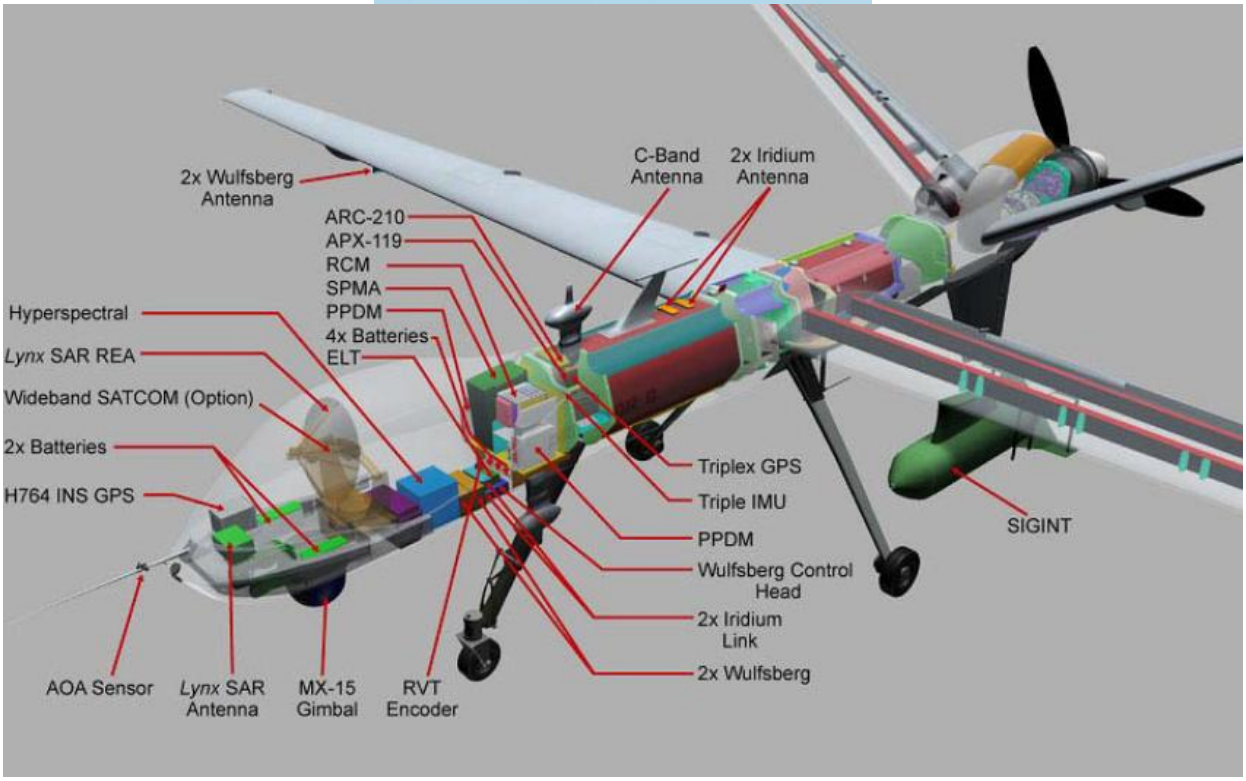
An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system is a microcontroller or microprocessor based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke.

An embedded system has three components −

1. It has hardware.
2. It has application software.

3. It has Real Time Operating System (RTOS) that supervises the application software and provide mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It sets the rules during the execution of application program. A small scale embedded system may not have RTOS.

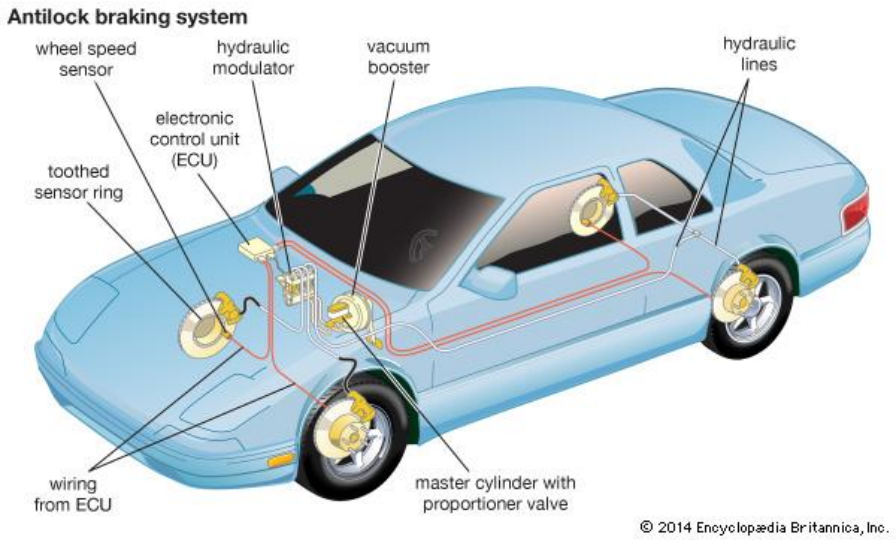
So we can define an embedded system as a Microcontroller based, software driven, reliable, real-time control system.



Typically, an embedded system is housed on a single microprocessor board with the programs stored in ROM. Virtually all appliances that have a digital Interface -- watches, microwaves, VCRs, cars, Drone,s -- utilize embedded systems. Some embedded systems include an operating system, but

many are so specialized that the entire logic can be implemented as a single program. Embedded systems programming is the development of programs intended to be part of a larger operating system or, in a somewhat different usage, to be incorporated on a microprocessor that can then be included as part of a variety of hardware devices. Several other definitions are:

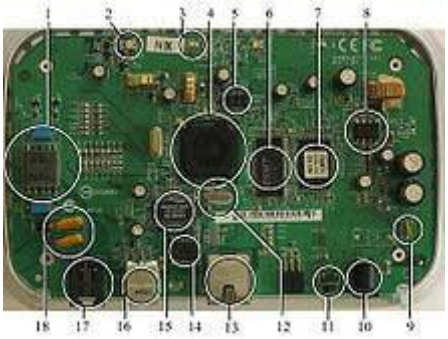
A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function. In some cases, embedded systems are part of a larger system or product, as in the case of an antilock braking system in a car. Contrast with general-purpose computer. A specialized computer system which is dedicated to a specific task.



Embedded systems range in size from a single processing board to systems with operating systems (ex, Linux, Windows® NT Embedded). Examples of embedded systems are medical equipment and manufacturing equipment. A computer system that is a component of a larger machine or system. Embedded systems can respond to events in real time. Most digital appliances, such as watches or cars, utilize an embedded system. Hardware and software that forms a component of some larger system and is expected to function without human intervention. Typically an embedded system consists of a single-board microcomputer with software in ROM, which starts running a dedicated application as soon as power is turned on and does not stop until power is turned off. ES is either fixed in capability or programmable, that is specifically designed for a particular kind of application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are among the myriad possible hosts of an embedded system.

ESS sometimes contains computer logic on a chip inside it. Such equipment is electrical or battery powered. The chip controls one or more functions of the equipment, such as remembering how long it has been since the device last received maintenance, and is a special-purpose computer system, which is completely encapsulated by the device it controls. An embedded system has specific requirements and performs pre-defined tasks, unlike a general-purpose personal computer.

We can classify embedded systems into different categories, size, and real time requirement as given below,



Embedded systems

ESS classifications:

1) Small scale embedded system
2) Medium scale embedded systems
3) Sophisticated embedded system
4) Real time embedded system
5) Standalone embedded system
6) Mobile embedded systems
7) Networked Embedded Systems

1- Small scale embedded system

Normally small scale embedded system is designed by using an 8-bit microcontroller that may even be activated by a battery. For developing embedded software for such system, an editor, assembler or cross assembler are used for specific microcontroller or processor used in the system.

Small scale embedded system

2- Medium scale embedded systems

The medium scale embedded systems are designed using single or multiple 16 bit or 32 bit microcontroller or digital signal processors (DSP's) or Reduced Instruction Set Computer (RISC's). These types of embedded systems have both hardware and software complexities. The development tools like real time operating system (RTOS), source code engineering tools, simulator, debugger and integrated development tools

are required for such complex software design system. These software tools also provide the solution for the hardware complexities, so assembler is used very rarely.

Medium scale embedded systems

3- Sophisticated embedded system

Sophisticated embedded systems consist of large quantity of hardware and software complexities hence they may required scalable processors or configurable processors and programmable logic arrays (PLA's) Programmable Logic Arrays. they are used for cutting-edge applications that need hardware and software Co-design and components which have to assemble in the final system.

Sophisticated embedded system

4- Real time embedded system

Real time embedded system are designed to perform some specific work in specific time. Real time embedded systems are classified into two types such as soft and hard real time systems.

Real time embedded system

5- Stand-alone embedded system

These type embedded systems are works in standalone made in which input i.e. electrical signals from sensors or keyword or push button are taken, then processed and produced the desired output to drive another system such as LED or LCD display for displaying some meaningful information to user. Such stand-alone embedded

systems are used in mp3 players, digital cameras, video game consoles, microwave ovens and temperature measurement systems.

Stand alone embedded system

6- Mobile embedded system

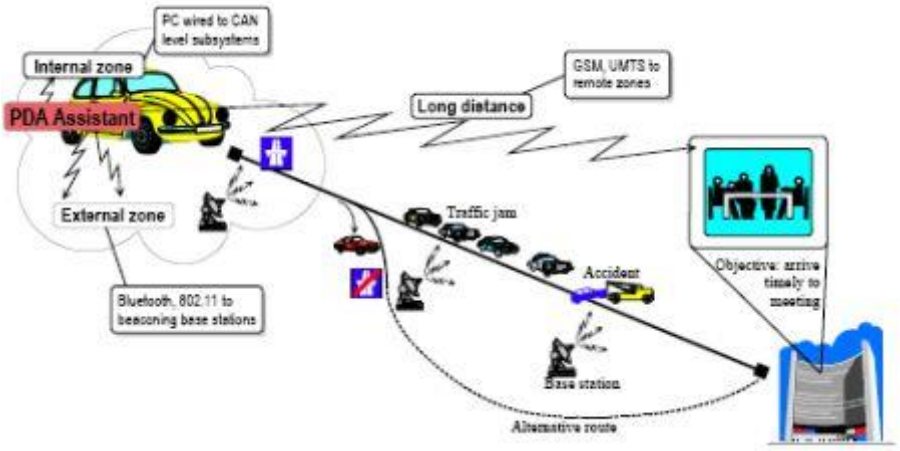
Mobile embedded systems are used in portable embedded devices like mobile phones, tablets, digital cameras, iPhones, smart phones and personal digital assistants PDAs etc. the systems have some limitation such as memory constrains, small in size and lack of good user interface such as keyboard and display.

Mobile embedded system

7- Networked embedded systems

These types of embedded systems consist of various components such as sensors, controllers, actuators etc. interconnected through a network using TCP/IP or UDP. The networked embedded system built on ASIP's (Application-specific instruction set processors)

or general purpose processors.



Characteristics of an Embedded System:

The important characteristics of an embedded system are:

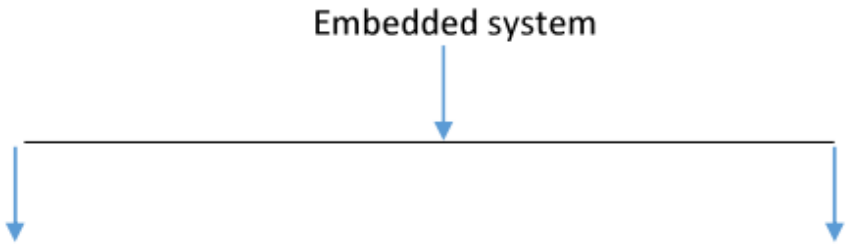
1) Speed (bytes/sec) : Should be high speed
2) Power (watts) : Low power dissipation
3) Size and weight : As far as possible small in size and low weight
4) Accuracy (% error) : Must be very accurate
5) Adaptability: High adaptability and accessibility.
6) Reliability: Must be reliable over a long period of time.

So, an embedded system must perform the operations at a high speed so that it can be readily used for real time applications and its power consumption must be very low and the size of the system should be as for as possible small and the readings must be accurate with minimum error. The system must be easily adaptable for different situations.

Every embedded system consists of certain input devices such as: key boards, switches, sensors, actuators; output devices such as: displays, buzzers, sensors; processor along with a control program embedded in the off-chip or on-chip memory, and a *real time operating system* (RTOS).

Also …

Embedded systems can be classified into the following 4 categories based on their functional and performance requirements.



Functional

1. Stand-alone embedded systems
2. Real time embedded system
   a) Hard real time E.S
   b) Soft Real time E.S
3. Networked embedded system
4. Mobile embedded system

Performance

1. Small scale embedded system
2. Medium scale embedded s/m
3. Large scale embedded system

Or

Sophisticated Embedded Systems

Basic Structure of an Embedded System:

The following illustration shows the basic structure of an embedded system: