Computer Interfacing

Chapter-1 : Embeded System

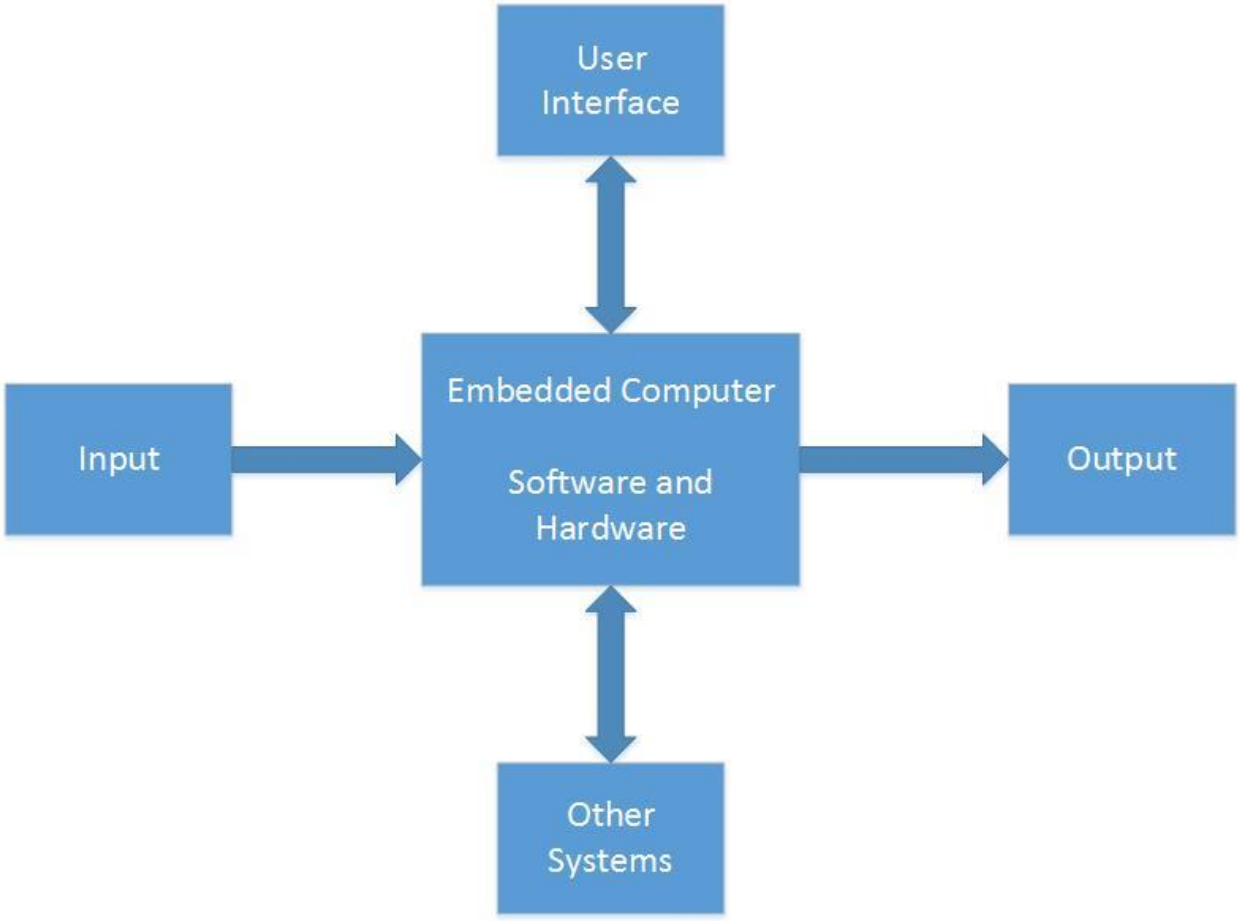
Embedded systems

An embedded system is a special purpose computer system that to performs a single or few dedicated functions, sometimes with real time constrains.

An embedded system is an electronic system that uses a CPU chip but that is not general purpose work station. It uses microcontroller or microprocessor or custom design chip.

Billions of units of various embedded systems are being produced yearly versus millions of desktop units. In a common household or automobile there are more than 50 embedded systems present.

For example: battery chargers, cell phones, land phones, music systems, disk drives, card readers, modems, network cards, keyboards, mice, printers, scanners, speakers, televisions, microwave ovens, washing machines and so on.



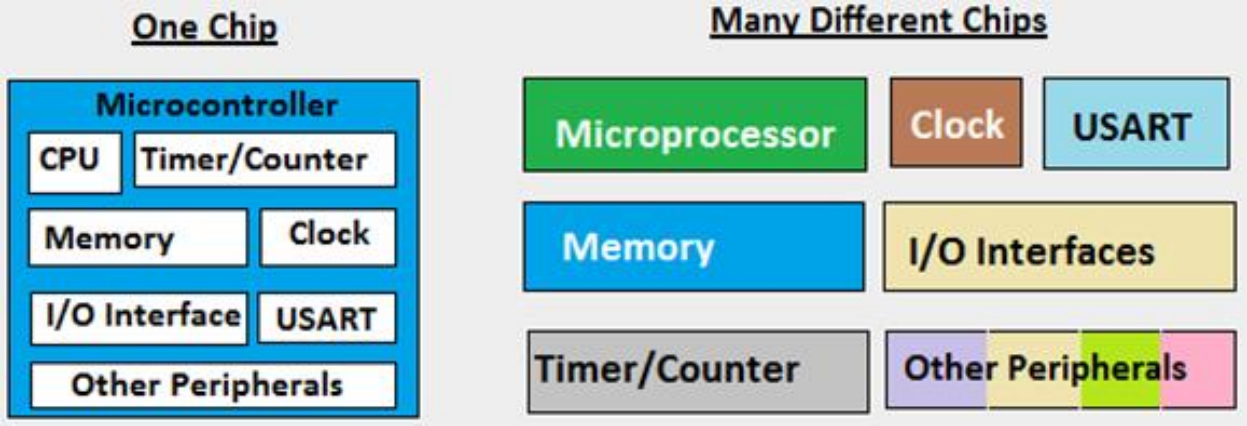
A basic diagram of embedded system

Common characteristics of embedded systems

- Single functioned:
  - Executes a single program repeatedly.
- Tightly constrained:
  - Low cost, low power, small, fast and so on.
- Reactive and real time:
  - Continually reacts to changes in the system's environment.
  - Must compute certain results in real time, without delay.
- Programmed in C or Java.

Microcontroller:

A microcontroller is basically a computer on a chip. Difference between a desktop and microcontroller is that a microcontroller is an application specific computer that usually runs a single program performing dedicated task(s) while a desktop or laptop is general purpose computer that can run numerous programs depending on user needs.



Microprocessor:

A microprocessor is just a Central Processing Unit (CPU). One has to add external memory, clock, input/output interfaces and all other needed peripherals. This is the reason why a microprocessor has so many pins.

Microcontroller VS Microprocessor

Microcontroller	Microprocessor
Considered as a small computer which has a processor and some other necessary components.	Carries functions of a CPU on to a single IC.
Used in automatically controlled devices.	Mainly used in designing general purpose systems.
Less computation capacity compared to microprocessors.	Computation capacity is very high.
Usually used for simpler tasks.	Can perform complex tasks.
Microcontroller based systems can perform single or very few tasks.	Microprocessor based systems can perform numerous tasks.
Do not have any Math Coprocessor. Uses software to perform complex calculations which slowdowns the device.	Have integrated Math Coprocessor. Can perform complex mathematical calculations with ease.
No need for external components to make a system.	To complete system, external components need to be connected.
Less costly.	Overall system cost is high.
Less power consumption.	Higher power consumption.
Lower clock frequency, usually in MHz.	Higher clock frequency, usually in GHz.

Microcontroller

- Microcontrollers were developed out of need for small and low power system in 1978
- They do not have expandability or performance as compared to microprocessors.
- The main intention behind their development is to use in the domains such as control, consumer application, personal electronics etc.
- Embedded system is physically small and cheap devices, with as much functionality of the system as possible squeezed onto one integrated circuit and the system is controlled mostly by microcontroller.
- A microcontroller is a particular type of microprocessor, optimized to perform control functions for the lowest cost and at the smallest size possible.

Microcontroller: a single chip.

Characteristics of Microcontroller

- I/O intensive, i.e. they are capable of direct interface to a significant number of sensors and actuators.
- A high level of integration with many peripheral devices.
- Physically small.
- Comparatively simple program and data storage requirements.
- Ability to operate in real time environment.
- Optimized instruction sets.
- Low cost and power consumption.

Types of Microcontroller

Microcontrollers are divided into categories according to their memory, architecture, bits and instruction sets.

- **Bits:**
  - 8-bits microcontroller executes logic & arithmetic operations. Examples of 8-bits micro controller is Intel 8031/8051.
  - 16-bits microcontroller executes with greater accuracy and performance in contrast to 8-bit. Example of 16-bit microcontroller is Intel 8096.
  - 32-bits microcontroller is employed mainly in automatically controlled appliances such as office machines, implantable medical appliances, etc. It requires 32-bit instructions to carry out any logical or arithmetic function. For example: SAMD21G of Atmel.
- **Memory:**
  - External Memory Microcontroller – When an embedded structure is built with a microcontroller which does not comprise of all the functioning blocks existing on a chip it is named as external memory microcontroller. For illustration- 8031 microcontroller does not have program memory on the chip.
  - Embedded Memory Microcontroller – When an embedded structure is built with a microcontroller which comprise of all the functioning blocks existing on a chip it is named as embedded memory microcontroller. For illustration- 8051 microcontroller has all program & data memory, counters & timers, interrupts, I/O ports and therefore its embedded memory microcontroller.
- **Instruction Set:**
  - CISC- CISC means **C**omplex **I**nstruction **S**et **C**omputer, it allows the user to apply one instruction as an alternative to many simple instructions.
  - RISC- RISC means **R**educed **I**nstruction **S**et **C**omputers. RISC reduces the operation time by shortening the clock cycle per instruction.

RISC VS CISC

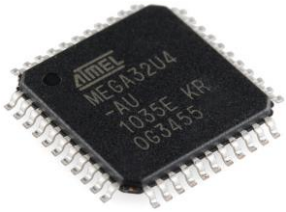
CISC	RISC
Emphasis on hardware	Emphasis on software
Multiple instruction sizes and formats	Instructions of same set with few formats
Less registers	Uses more registers
More addressing modes	Fewer addressing mode
Extensive use of microprogramming	Complexity in compiler
Instructions take a varying amount of cycle time	Instructions take one cycle time
Pipelining is difficult	Pipelining is easy

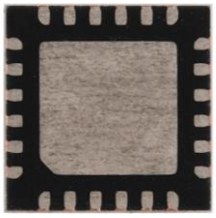
- **Packaging**

Dual In-line Packages (DIP):

DIP is an electronic component package with a rectangular housing and two parallel rows of electrical connecting pins. The package may be through-hole mounted to a printed circuit board or inserted in a socket.

Surface Mount (SMD/SMT):



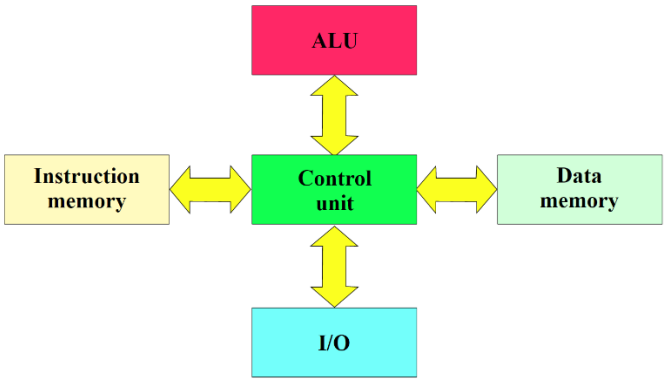


Surface-mount technology (SMT) is a method for producing electronic circuits in which the components are mounted or placed directly onto the surface of printed circuit boards (PCBs). An electronic device so made is called a surface-mount device (SMD).

Memory Architecture

- **Harvard Memory Architecture Microcontroller:**

The Harvard architecture is a computer architecture with physically separate storage and signal pathways for instructions and data.



The term originated from the Harvard Mark I relay-based computer, which stored instructions on punched tape (24 bits wide) and data in electro-mechanical counters. These early machines had data storage entirely contained within the central processing unit, and provided no access to the instruction storage as data. Programs needed to be loaded by an operator; the processor could not initialize itself.

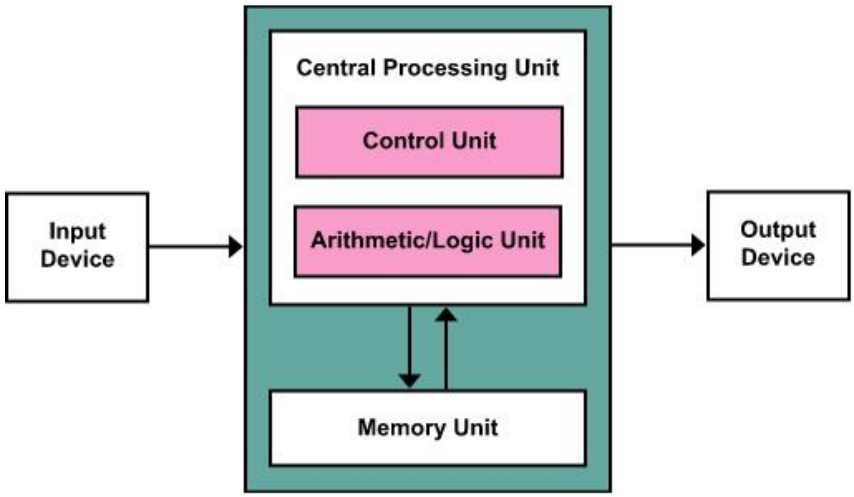
Today, most processors implement such separate signal pathways for performance reasons, but actually implement a modified Harvard architecture, so they can support tasks like loading a program from disk storage as data and then executing it.

Some Properties of the Harvard Memory Architecture:

- Two memories with two Buses allow parallel access to data and instructions. Execution can be 2x faster.
- Both memories can be produced by different technologies (Flash/EEPROM, SRAM/DRAM).
- Both memories can use different cell sizes.
- Program can't rewrite itself.
- Control unit for two Buses is more complicated and more expensive.
- Production of a computer with two Buses is more expensive.
- Development of a complicated Control Unit needs more time.
- Free data memory can't be used for instruction and vice-versa.

- **Princeton Memory Architecture Microcontroller:**

The Von Neumann Architecture, which is also known as Princeton Architecture describes a design architecture for an electronic digital computer with parts consisting of a processing unit containing an arithmetic logic unit and processor registers; a control unit containing an instruction register and program counter; a memory to store both data and instructions; external mass storage; and input and output mechanisms.



The meaning has evolved to be any stored-program computer in which an instruction fetch and a data operation cannot occur at the same time because they share a common bus. This is referred to as the von Neumann bottleneck and often limits the performance of the system.

Some properties of Von Neumann Memory Architecture:

- ❖ Programmers organize the content of the memory and they can use the whole capacity of the installed memory.
- ❖ One bus is simpler for the Control Unit design.
- ❖ Development of the Control Unit is cheaper and faster.
- ❖ Computer with one bus is cheaper.
- ❖ Data and instruction are accessed in the same way.
- ❖ One Bus (for data, instructions and devices) is a bottleneck.
- ❖ Error in a program can rewrite instructions and crash program execution.