Introduction to Microcontroller

What is a Microcontroller ?

- A microcontroller is a single chip microprocessor system which contains:

  – A processor core.

  – Data and program memory (RAM & ROM).

  – Serial and parallel I/O.

  – Timers / Counters.

  – External and internal interrupt handling mechanism.
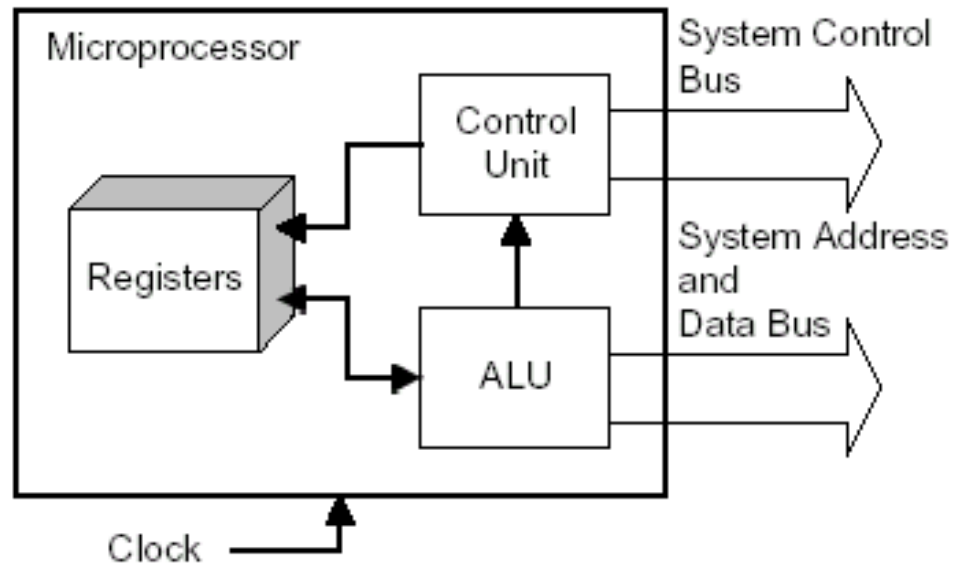
  – ….ADC, DAC,USB etc

  all integrated into a single chip.
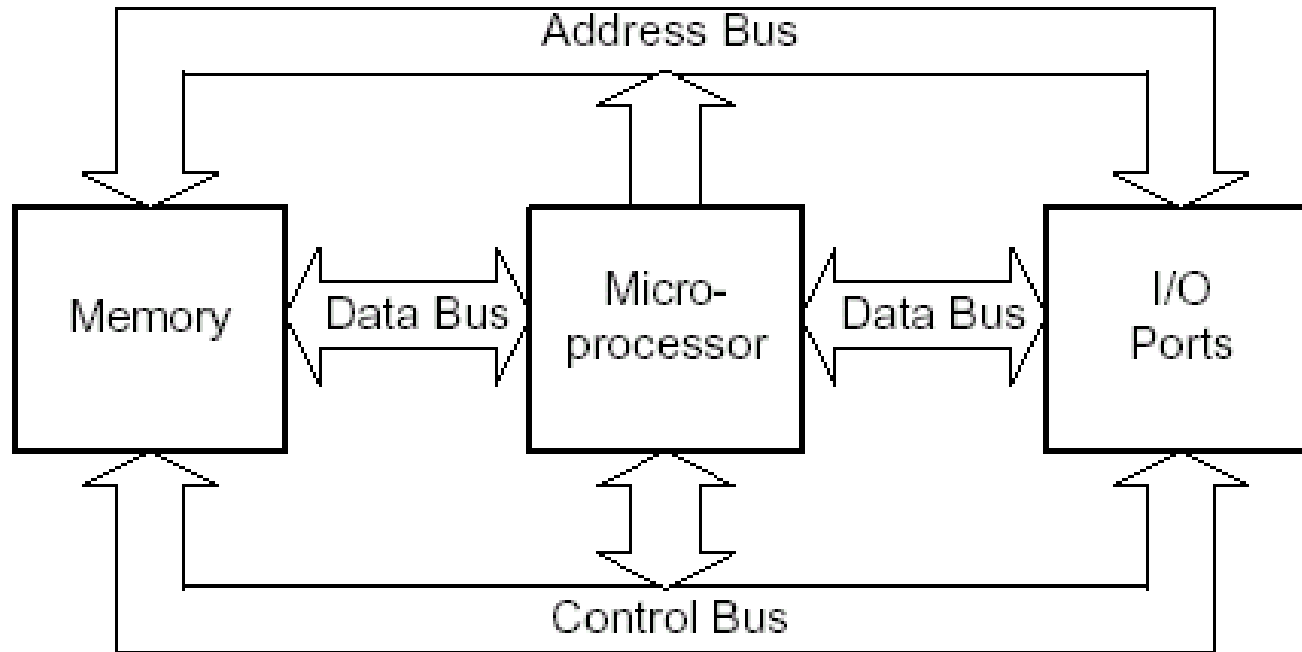
Block Diagram of a Microprocessor

- A microprocessor consists of an ALU to perform arithmetic and logic manipulations, registers, and a control unit.

- In addition, its has some interfaces to the outside world in the form of busses.

- What is missing?
  - Memory and the peripherals.

Block Diagram of a Microcomputer

- Too much.
  - For the limited applications intended, this system has too much of everything.
   - Meaning – too expensive.

How do we Define Expensive?

- Money.
  - The system requires parts that cost too much money.
- Size.
  - All of the additional functionality requires space.
    - Chip area or board space.
- Power.
  - We will need power to run all of these chips and devices.
- Heat.
  - Power = heat.
  - Operating "inside" another system may not afford us good heat dissipation.
- Efficiency.
  - Are we really utilizing all of these features and functionalities?

Block Diagram of a Microcontroller

- It is the specialized circuitry compared to the microprocessor that makes the microcontroller such a unique device.

- The microcontroller operates on data that is fed in through its serial or parallel input ports controlled by the software stored in the on-chip memory.
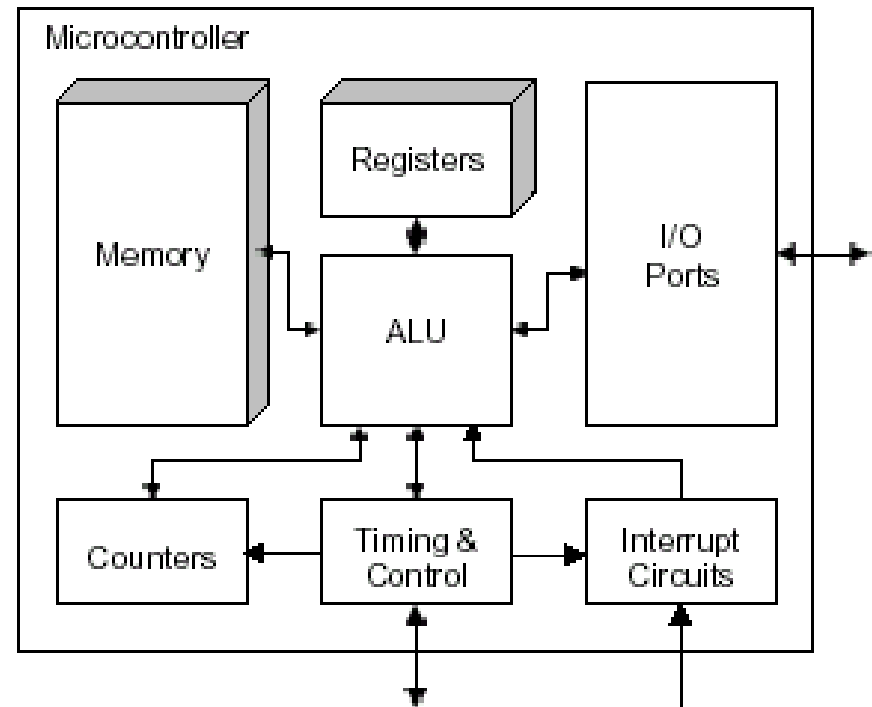
Special Features of the Microcontroller

- All of the additional functions built into the microcontroller would normally require additional circuitry external to the microprocessor.
    - I/O Ports.
    - Memory
    - ADC etc

- Some of these functions would normally be implemented in software.
    - Counters, timers, PWM

Memory Considerations

- When a PC executes an application, pieces of the application are read from disk and stored into an allocated section of the memory.

  – As more of the program is needed, additional pieces of the software are loaded into the memory.

- In a microcontroller there is no disk to read from. On-chip ROM space is the maximum size of the application that can be executed.

Additional Programming Considerations

- In a standard computer, there is a complicated operating system that handles all low-level operations.

  - Things like reading from interfacing to the different devices, and allocating memory.

- For the microcontroller system, the application stored in the ROM of the microcontroller is the only software that will execute.

  - Therefore, all low-level code and device interfaces necessary to execute the application have to be included.

Where are microcontrollers used ?

- Microcontrollers are "typically" used where processing power is not critical.

- It is estimated that on average a middle-class household has a minimum of 35 microcontrollers in it.

- About 34 % of microcontroller applications are in office automation such as laser printers, fax machines, intelligent telephones and so forth.

- Another 33 % of microcontrollers are used in consumer electronic goods such as CD players and hi-fi equipment.

- The remaining 33 % are used in the communications and automotive market.

Microcontroller Applications

List of Microcontroller Applications

Anti-lock brakes	Modems
Auto-focus cameras	MPEG decoders
Automatic teller machines	Network cards
Automatic toll systems	Network switches/routers
Automatic transmission	On-board navigation
Avionic systems	Pagers
Battery chargers	Photocopiers
Camcorders	Point-of-sale systems
Cell phones	Portable video games
Cell-phone base stations	Printers
Cordless phones	Satellite phones
Cruise control	Scanners
Curbside check-in systems	Smart ovens/dishwashers
Digital cameras	Speech recognizers
Disk drives	Stereo systems
Electronic card readers	Teleconferencing systems
Electronic instruments	Televisions
Electronic toys/games	Temperature controllers
Factory control	Theft tracking systems
Fax machines	TV set-top boxes
Fingerprint identifiers	VCR's, DVD players
Home security systems	Video game consoles
Life-support systems	Video phones
Medical testing systems	Washers and dryers
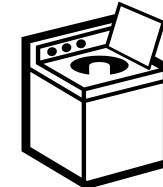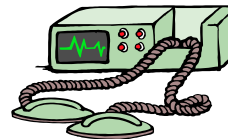
Advantages of using microcontrollers

- Fast and effective
  - The architecture correlates closely with the problem being solved (control systems).
- Low cost / Low power
  - High level of system integration within one component.
  - Only a handful of components needed to create a working system.
- Compatibility
  - Opcodes and binaries are the SAME for all 80x51 variants.
- Multi-sourced
  - Over 12 manufacturers, hundreds of varieties.
- Constant improvements
  - Improvements in silicon/design increase speed and power annually.

Microcontroller Types

- ## 8051 (Intel and others)
  - The 8051, Intel's second generation of microcontrollers, rules the microcontroller market at the present time.

- ## 68HC11 (Motorola)
  - The 68HC11 has a common memory architecture in which instructions, data, I/O, and timers all share the same memory space.

- ## PIC (MicroChip)
  - The first RISC microcontroller family (33 instructions) – PIC16F84

Microcontroller Types

- ATMega32 & ATMega8 AVR microcontroller (Atmel)

  - The AVR microcontrollers are based on the advanced RISC architecture. AVR can execute 1 million instructions per second if cycle frequency is 1 MHz.

- H8 (Hitachi)