Applications of Electronics:
Digital Electronics Module

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Reference:

- *Neil Storey "Electrical &Electronic System" (Prentice Hall) 2007-ISBN 0-13-20930466.*

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Outline :

- Chapter 1: Introduction
- Chapter 2: Binary arithmetic.
- Chapter 3: Boolean algebra and combinatorial Logic
- Chapter 4: Pulse with modulation, PWM .
- Chapter 5: Sampling.
- Chapter 6: Analog to Digital Converters, ADCs and Digital to Analog converters, DACs
- Chapter 7: Digital filtering.

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Method of working

- Lectures, reading, and laboratories are all important in understanding the material.
- The lectures will address all the topics but will emphasise the more difficult concepts.
- If you don't understand something, please ask me!
- A good student is a student who ask questions.
- Feedback after each lecture please !!!!

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Chapter 1: Introduction

- Learning objectives:

Understanding:

- What is electronic and its main components.
- Difference between analogue and digital electronics.
- Main components of an electronic system.

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What is electronic ?

- **Electronic** is the study and/or use of electrical components and/or circuits to achieve a design application.

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What are the main electronic components ?

The main electronic components, used in electronics are:

- Resistors,
- Capacitors,
- Inductors, (coils of wire)
- Transistors,
- Integrated circuits, (miniature semiconductor circuits), see next slide
- Connection wires,
- and circuit boards.

- Older electronics:
- vacuum tubes (obsolete)
- New electronics: to be invented by you !!

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What is a semiconductor?

- A ***semiconductor*** is a material that has an electrical resistivity in between a conductor and an insulator.

Properties:

- At very low temperatures, pure or intrinsic semiconductors behave like insulators (no conduction of electricity) .
- At higher temperatures or under light, intrinsic semiconductors can become conductive.
- At ambient temperature, it conducts electricity more easily than an insulator, but less readily than a conductor.

The main commercial semiconductors are made of Silicon (Si), Germanium (Ge), Gallium arsenide (GaAs) and silicon Germanium (SiGe)

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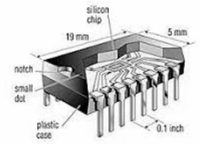
Integrated Circuit, **IC**

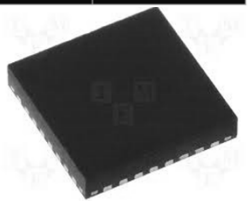
Also known as microcircuit, microchip, silicon chip, or chip)

Integrated circuits, IC's are single chips that contain millions of transistors on a single chip, allowing computers to be made smaller. (with up to 1 million transistors per mm².)

Eg. Apple A10 (quad-core ARM64 "mobile SoC") in 2016	~ 3,300,000,000 transistors	125 mm²

IC's were introduced in the late 1960's and the level of integration (number of transistors on a chip) have been gradually increased.





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Jack Kilby at Texas Instruments & Robert Noyce at Fairchild co-invent the integrated circuit.

What is the difference between Analogue and Digital Electronics?

- **Analogue electronics** are electronic systems that use continuous signals.
- **Digital electronics** are electronic systems that use discrete signals.

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What is the difference between digital and analogue circuits?

Analogue circuitry is achieved by using analogue components such as:

- Resistors.
- Capacitors.
- Inductors.

The inherent tolerances associated with these components, temperature, voltage changes and mechanical vibrations can dramatically affect the effectiveness of the analogue circuitry.

Digital circuitry work with discrete components and therefore always produce the same results.

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Digital circuits

Basic blocks:
- Logic gates
- Flip-flops
- Counters

Complex devices:
- Microprocessors
- Microcontrollers
- Digital Signal Processors, DSPs
- Graphic Processor, GPU
- FPGAs Field Programmable Gate Arrays

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Basic Elements in Digital circuitry: on/off switches

- **Relays: Late 1930s**
- **Vacuum tube computers (1940s - 1950s)**
- **Transistors: 1950s**

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on/off switches

- Relays: Late 1930s early 1940's
  - solenoid with mechanical contact points

  Limitations:
  - Very bulky,
  - Very slow,
  - Had a short life .

  Vacuum tubes : Late 1945s early 1960's no physical contacts
  - Mainly used in radios at first

  Limitations:
  - Very bulky,
  - Required high power,
  - Had a relatively short life .

- Transistors 1950's to present
  - invented at Bell Labs in 1948

  Advantages
  - Small,
  - Low cost,
  - Long life .

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Basic blocks: logic gate

- A **logic gate** performs a logical operation such AND, OR, NOT and are identified by their function: AND, OR, NOT etc.

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Basic blocks: Flip-flops

A **flip-flop** has two stable states and thereby is capable of serving as one bit memory.

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Basic blocks: Counters

A **counter** is a device which stores the number of times a particular event has occurred. Often this event is a clock signal.

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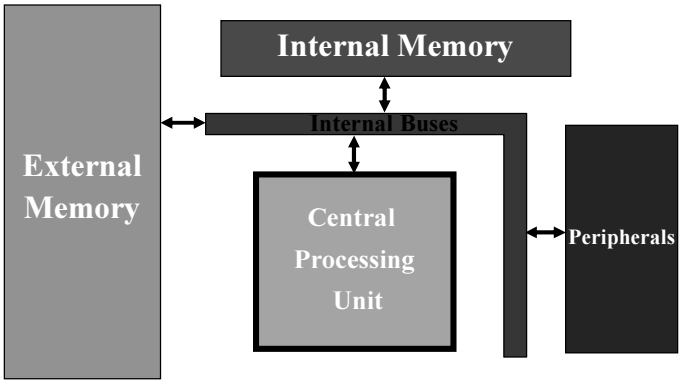
Complex Devices: General Computer System Block Diagram



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Memory

- A memory is a storage device. Normally used for storing programs and/or data.

Different types of memory exist:

- **RAM** is Random Access Memory, and is the basic kind of internal memory.
- **ROM** is Read Only Memory.
- **Flash memory** is a non-volatile memory that can be electrically erased and reprogrammed.

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Buses

- A bus is an electrical connection between multiple electrical devices, e.g. PCI bus.

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Peripherals

- A **peripheral** is a device attached to a computer, microcontroller or a DSP.
- Common peripheral devices are memories, printers, scanners and speakers.

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Central Processing Unit, CPU

- A **Central Processing Unit** (**CPU**) is an electronic circuit that can execute computer instructions.

Note: A group of instructions constitute a program.

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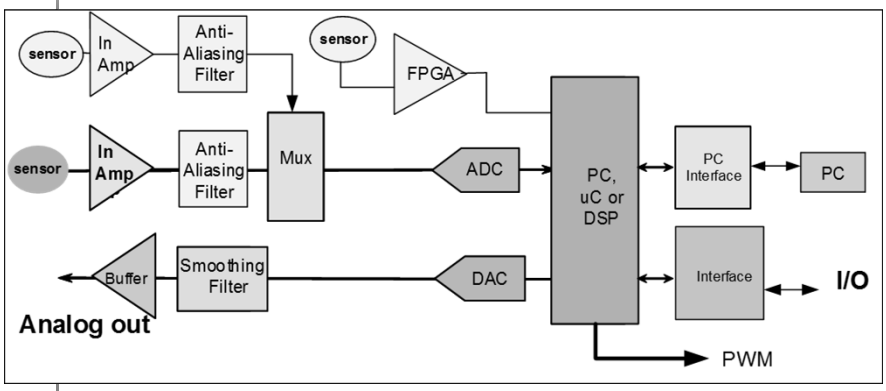
Example of a complete electronic system



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- End of Chapter 1

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Digital vs. Analogue

Digital circuits have the following advantages:

- Signals can be represented very accurately.
- More stable.
- Flexible: Can be modified by software.
- Digital storage easier than analogue.
- In general Digital is less expensive.

Remember "Digital circuits are made from analogue components"

Disadvantages of Digital.

- Sampling Error.
- Digital communications require greater bandwidth than analogue to transmit the same information.

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