INTEGRATED CIRCUITS

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MODULE: Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

INTRODUCTION

In general the electronic circuits are consists of **active components** and **passive components**.

Those which have the ability to produce gain. Example: Triode valve, Transistors, FET etc.

Those which do not have the ability to produce gain. Example: resistors, capacitors and inductors.

➢After the invention of triode (1907) the application and development of electronics rigorously increased. But, initially, the circuit components were separate and distinct units connected by soldered leads (**discrete components**).

➢But with the invention of transistors in 1948 the circuits became considerably small in size.

✓ Transistors are cheaper, reliable, less power consuming and smaller in size compare to valve.

✓ To take the advantage of small size of transistors, the size of passive components were greatly reduced.

✓ Development of PCB (printed circuit board) further reduce the size of circuits.

INTEGRATED CIRCUIT

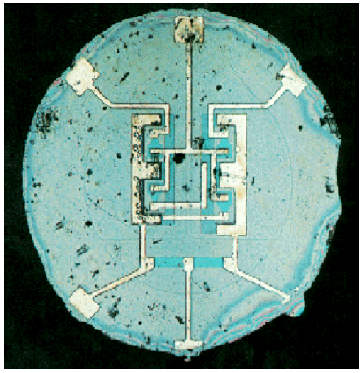
➢Early 1960s a new field was born called **Microelectronics**, where the microelectronic circuits were developed which are called **INTEGRATED CIRCUITS (ICs).**

So small that their actual construction is done by technicians using microscopes.

In 1958, Jack S. Kilby (*Texas Instruments*) showed that it was possible to fabricate a simple IC in germanium. He used wire to interconnect the components.

Kilby's first integrated circuit in germanium.

In 1959, Robert Noyce (*Fairchild Semiconductor*) demonstrated an IC made in silicon using SiO_2 as the insulator and Al for the metallic interconnects.



The first planar IC (actual size: 0.06 in. diameter)

Thus, an IC consists of interconnected electronic components in a single piece ("chip") of semiconductor material.

Wafer

- **Dictionary** meaning - **a thin piece of something**.
- But in electronics, a wafer is a thin slice of semiconductor (generally silicon), which is mainly used for the fabrication of integrated circuits. The wafer serves as the substrate for microelectronic devices built in and upon the wafer.

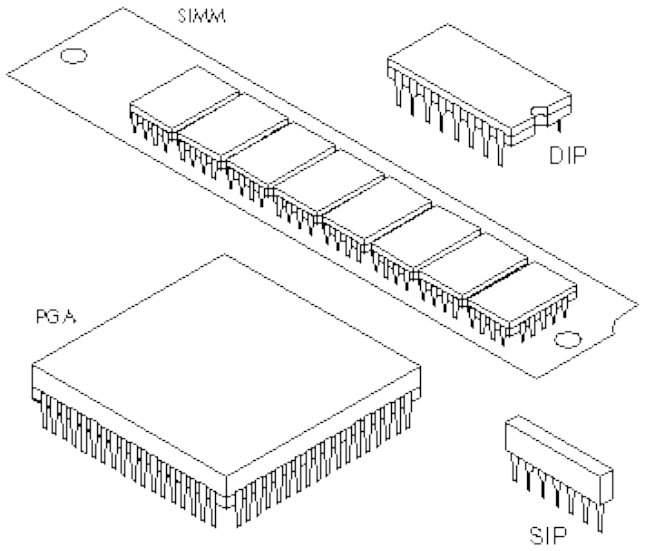
- The silicon wafers are approximately 1/30th-inch to 1/50th-inch (0.5 mm to 1 mm) thick and 3 to 6 inches in diameter. Using these wafers, a manufacturer can place 10 to several hundred ICs onto it, which are later cut out and used in computers and other electronics.

- Wafers are also used in photovoltaics and solar cells.

Chip

A small piece of semiconducting material (usually silicon) on which an IC is embedded. A typical chip can contain millions of electronic components (like transistors etc.) within a very small area.

There are different types of chips. They are differentiated depending upon there functionality. For example, microprocessor chips contain an entire processing unit to process various works according to instruction, whereas memory chips contain blank memory to store data.



Chips come in a variety of packages.

DILP: Dual in-line packages are the traditional bug-like chips that have anywhere from 8 to 40 legs, evenly divided in two rows.

PGA: Pin-grid arrays are square chips in which the pins are arranged in concentric squares.

SILP: Single in-line packages are chips that have just one row of legs in a straight line like a comb.

In addition to these types of chips, there are also single in line memory modules (SIMMs), which consist of up to nine chips packaged as a single unit.

ADVANTAGES OF ICs

1. Miniaturization and hence increased equipment density. The various components are distinguishable only under a powerful microscope

2. Cost reduction due to batch processing. i.e. all circuit components are fabricated in or on the wafer at the same time and hundreds of similar wafers are produced simultaneously.

3. Reliability is the most important advantage of an IC. Increased system reliability due to the elimination of soldered joints. Small temperature rise due to low power consumptions of ICs also improves their reliability.

4. Improved functional performance. Since the components are very close to each other chance of stray electrical pickup is practically nil.

5. Increased operating speeds.

6. Reduction in power consumption.(small size)

7. Easy replacements.

DRAWBACKS OF ICs

1. Coils or inductors cannot be fabricated.
2. ICs function at fairly low voltages.
3. They are quite delicate and cannot with stand with rough handling or excessive heat.

However, the advantages of ICs far outweigh their disadvantages.

SCALE OF INTEGRATION

Scale of integration is defined as the number of electronic circuits or components that can be fitted into a standard size IC. Level of integration in ICs has been dramatically increasing with each passing year. Now–a-days, in fact whole electronic systems rather than just a circuit are incorporated in one package.

An approximate method of classification:

1. SSI-Small Scale Integration

Number of circuits/components in one IC< 30 (e.g- Logic gate, Flip-flop)

2. MSI-Medium Scale Integration

Number of circuits/components in one IC 30-100 (e.g- Counter, Multiplexer)

3. LSI-Large Scale Integration

Number of circuits/components in one IC 100-100000 (e.g- 8-bit microprocessor)

4. VLSI-Very Large Scale Integration

Number of circuits/components in one IC>100000 (e.g- 16-32-bit microprocessor)

5. ULSI-Ultra Large Scale Integration

Number of circuits/components in one IC>10^6 (e.g- Smart sensor)

CLASSIFICATION OF ICS

BY STRUCTURE-THREE TYPES

1. **Monolithic ICs**

   All the components are fabricated inseparably within a single continuous piece of silicon wafer (Monocrystalline). It is a complete circuit requiring no "add ons".

2. **Thick and Thin Film ICs**

   The essential difference is not their relative thickness but the method of depositing the film. This ICs are not formed within a silicon wafer. They are formed on the surface of an insulating substrate (such as glass). Only passive components are formed through thick and thin film technique. The active elements are externally added.

THIN FILM	THICK FILM
Vacuum evaporation, cathode sputtering	Silk screen printing

3. **Hybrid or Multichip ICs**

   Such circuits are formed either by inter-connecting a number of individual chips or by a combination of film and monolithic IC techniques.

COMPARISON

	Advantages	Disadvantages
Monolithic	▪Low cost ▪High reliability	▪Isolation is poor. ▪Range of values of passive components are small. ▪Inductors cannot be fabricated. ▪No flexibility.
Film	▪Isolation is good. ▪Range of values of passive components are large. ▪Inductors can be inserted. ▪flexibility.	▪Active component cannot be fabricated ▪Higher cost ▪Larger in size.
Hybrid	▪Higher flexibility.	▪Expensive ▪Least reliable.

CLASSIFICATION OF ICS

BY FUNCTION-TWO TYPES

1. Linear ICs

- LICs are also known as analog ICs. The outputs are generally proportional to input and can take continuous range of values.
- Find wide use in military and industrial application.

Example: 1. OP-Amp 2. Power Amp 3. Voltage comparators etc.

2. Digital ICs

The input and output voltages are limited to two possible levels- low or high. It is also because digital signals are usually binary. Sometimes digital circuits are called switching circuits.

Example: 1. Logic gates, 2. Flip-flops, 3.Counter, 4. Memory etc.

References:

1. Different Web sites.
2. Different PPT as available from INTERNET.
3. Digital Electronics: Circuits and Systems by Prof. B. C. Sarkar and Dr. S. Sarkar