INTEGRATED CIRCUITS

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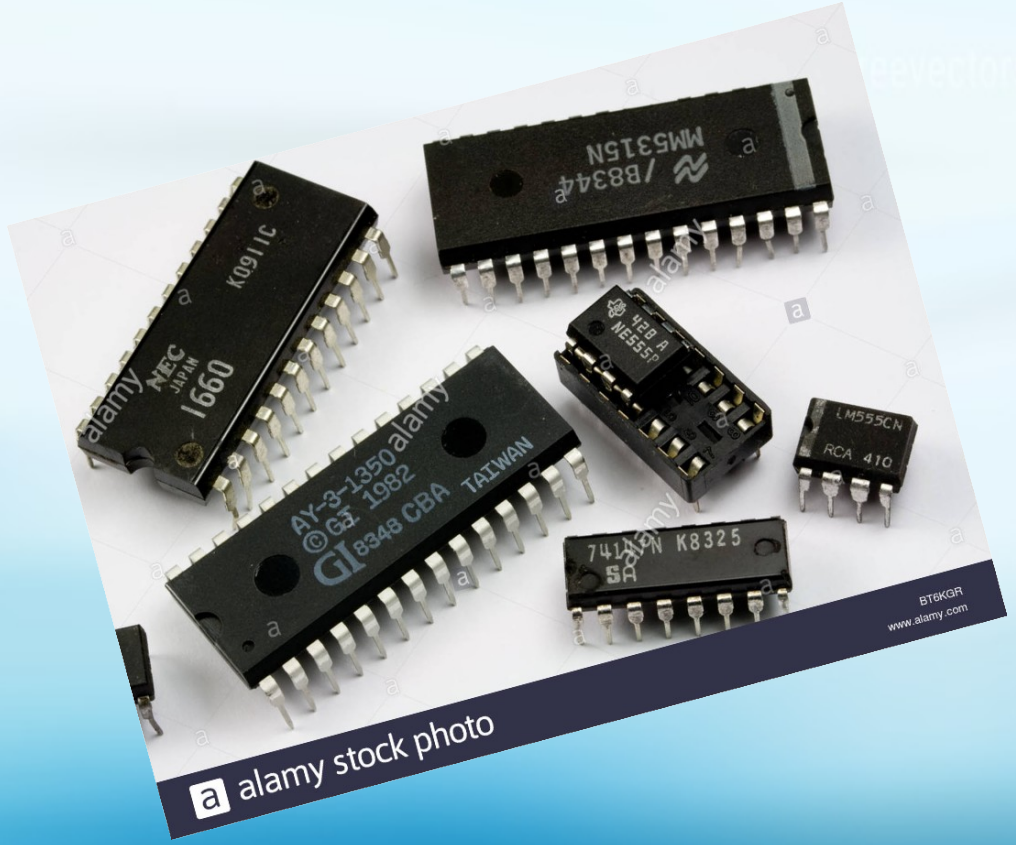
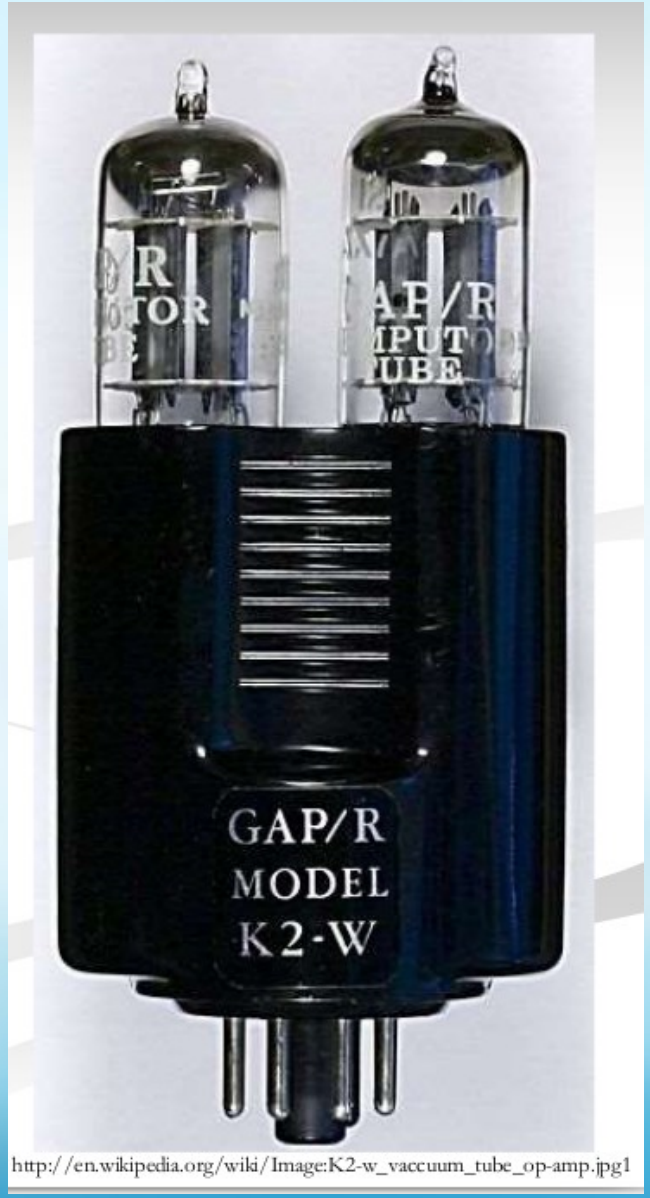
In electronics, an integrated circuit is a miniaturized electronic circuit (semiconductor devices, as well as passive components) that has been manufactured in the surface of a thin substrate of semiconductor material.



Early history

- First op amps built in 1930's-1940's
- Used in WW-II to help how to strike military targets.
- Took ±300V to ± 100V to power

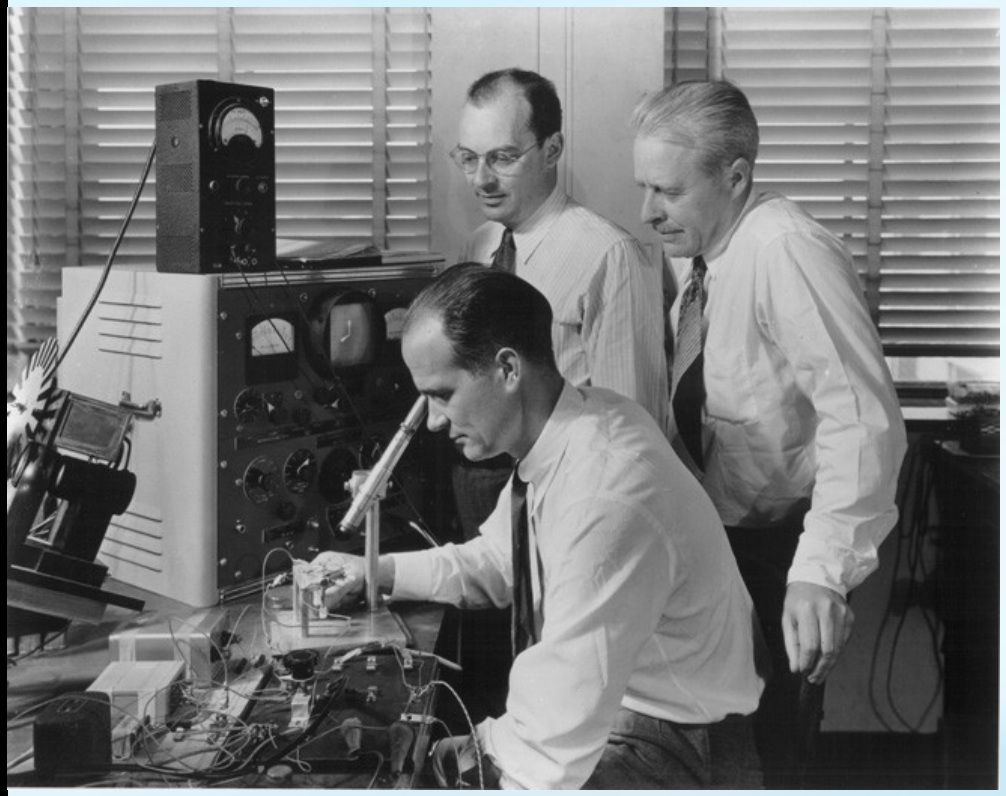


http://en.wikipedia.org/wiki/Image:K2-w_vaccuum_tube_op-amp.jpg1

Early history

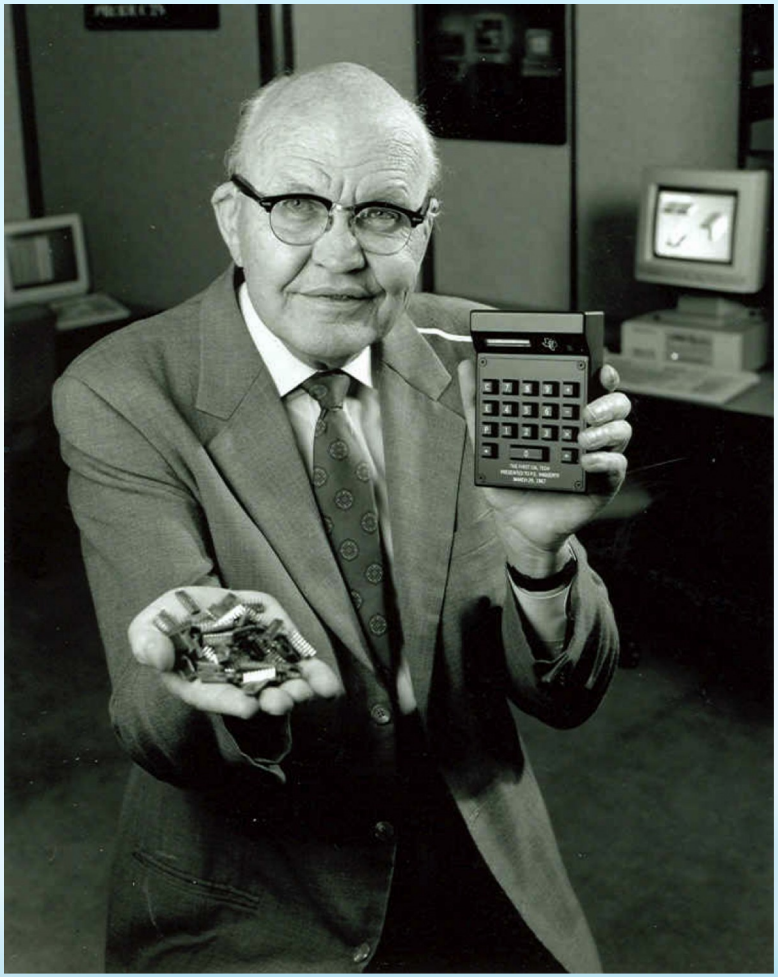
- *In 1945, Bell Labs established a group to develop a semiconductor replacement for the vacuum tube. The group was led by William Shockley, included, John Bardeen, Walter Brattain and others.*
- *In 1947, Bardeen and Brattain and Shockley succeeded in creating an amplifying circuit utilizing a point-contact "transfer resistance" device that later became known as a Transistor.*
- *In 1951 Shockley developed the junction transistor, a more practical form of the transistor.*
- *By 1954 the transistor was an essential component of the telephone system and the transistor first appeared in hearing aids followed by radios.*

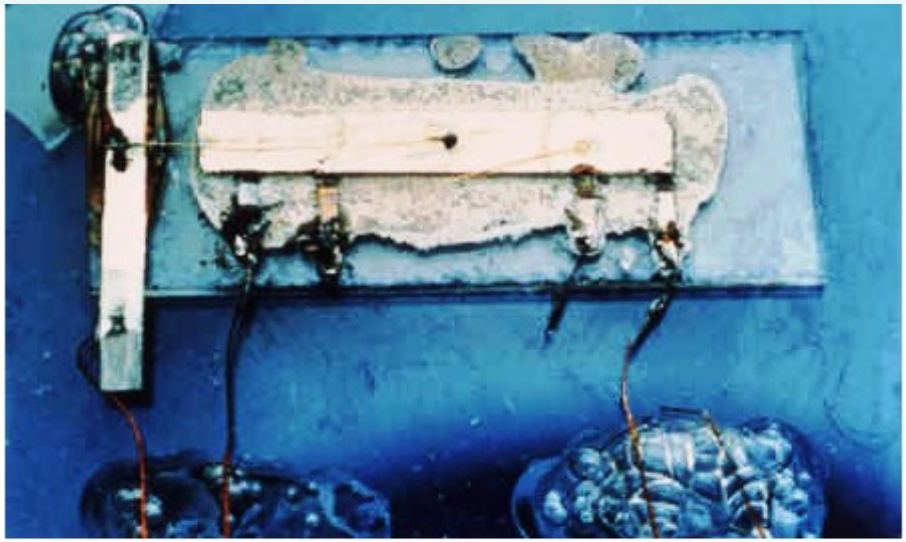
The transistor invented at Bell Lab in 1947



Early history

- **In 1958 Jack Kilby an American electrical engineer of Texas instruments demonstrated successfully the first working integrated circuit device. The first costumer to this new invention was the US Air Force. In the year 2000 Jack Kilby won the Nobel Prize in Physics for miniaturized electronic circuits.**





Jack Kilby's Original Integrated Circuit

Early history

- Kilby's invention had a serious drawback, the individual circuit elements were connected together with gold wires making the circuit difficult to scale up to any complexity.
- **1960 – Epitaxial deposition developed**

  Bell Labs developed the technique of Epitaxial Deposition whereby a single crystal layer of material is deposited on a crystalline substrate. Epitaxial deposition is widely used in bipolar and sub-micron CMOS fabrication.
- **1960 - First MOSFET fabricated**

  Kahng at Bell Labs fabricates the first MOSFET.
- **1961 - First commercial Ics**

  Fairchild and Texas Instruments both introduce commercial Ics.
- **1962 – Transistor-transistor logic invented**
- **1963 – First MOS IC**

Early history

- **1964 – Bob Widlar designs the first op-amp: the 702.**

  Using only 9 transistors it attained a gain of over 1000

- **After Widlar left Fairchild, Dave Fullagar continued Op-amp design and came up with the uA741 which is the most popular operational amplifier of all time.**

  This op-amp has a gain of around 250,000

FABRICATION OF IC

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ADVANTAGES OF IC

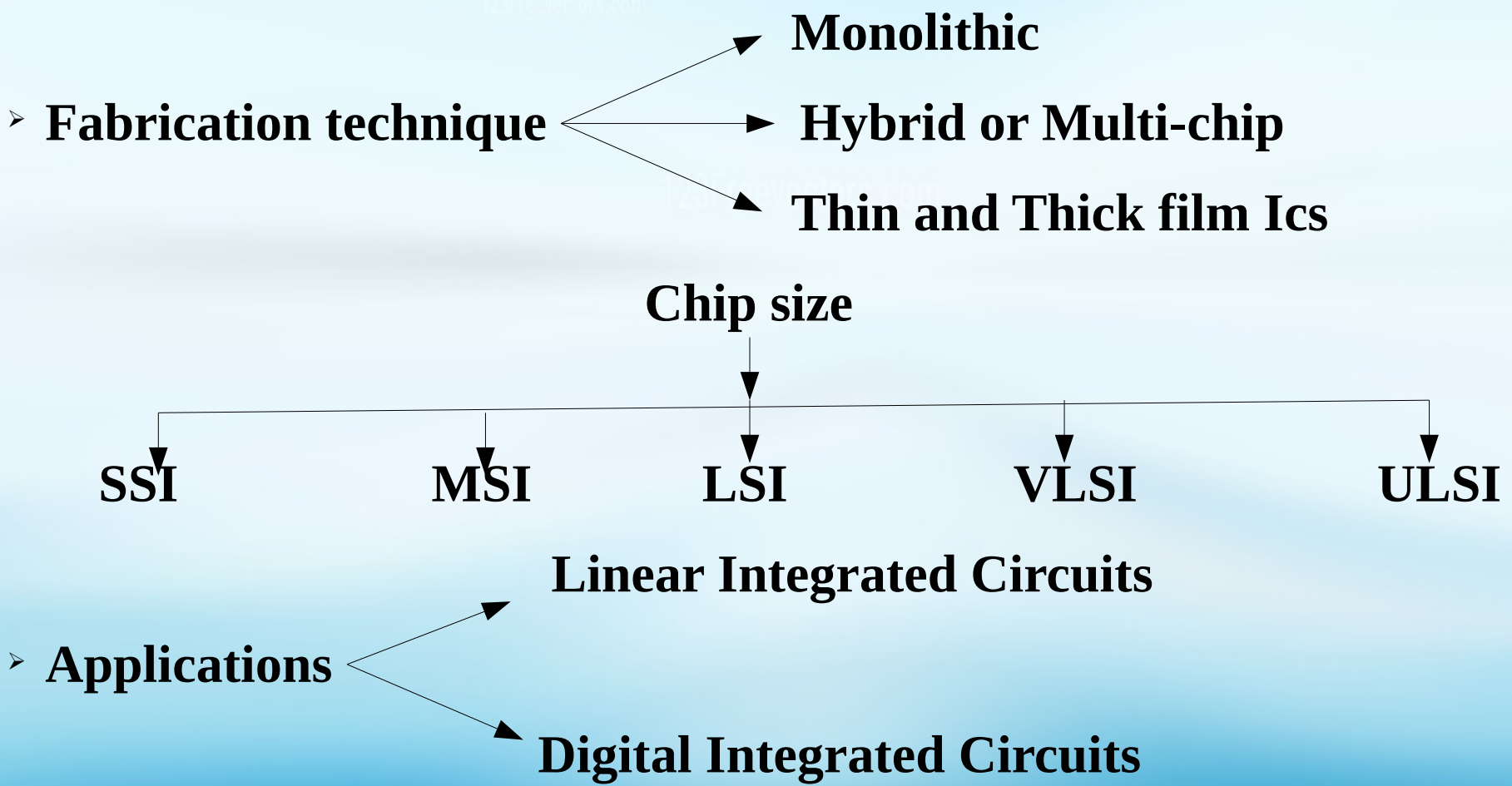
- SMALL SIZE
- LOW COST
- IMPROVED PERFORMANCE
- HIGH RELIABILITY AND RUGGEDNESS
- LOW POWER CONSUMPTION
- LESS AFFECTED TO PARAMETER VARIATION
- EASY TROUBLESHOOTING
- INCREASED OPERATING SPEED
- LESS WEIGHT, VOLUME
- EASY REPLACEMENT

DISADVANTAGES OF IC

- **If one component in an integrated fails, that means the whole circuit has to be replaced.**
- **Integrated circuits have limited capacitances. This calls for external components if the capacitance needs an extension.**
- **It is impossible to fabricate transformers or any other kind of inductor onto the integrated circuits.**
- **Power that integrated circuits can produce is limited and calls for extension.**
- **Integrated circuits are not flexible. Their components cannot be modified and neither can the parameters of operation.**

CLASSIFICATION OF ICs

- **IC s can be classified, depending on**



MONOLITHIC ICs

- **Monolithic circuit is built into a single piece of silicon or other semiconductor, a typical physical size being 1.25 mm square (or about fifty thousandths of an inch square).**
- **Such a circuit may contain fifty or more components such as transistors or resistors. The word monolothic is derived from the two Greek words ‘monos’ and ‘lithos’, meaning single and stone, respectively. The word ‘monolithic’ implies that the circuit is manufactured within a single crystal. This type of integrated circuit is sometimes described as a planar IC, since it takes the form of a flat surface.**
- **Monolithic ICs are by far the most common type of ICs used in practice, because of mass production , lower cost and higher reliability.**

HYBRID OR MULTI-CHIP ICs

- **The circuit is fabricated interconnecting a number of individual chips.**
- **A Hybrid circuit often ceramic substrate carrying one or more silicon chips. A hybrid can also use mixed technology, such as GaAs chips along with silicon chips.**
- **Large in size compared to monolithic Ics**
- **Hybrid ICs are less expensive, low speed compared to monolithic IC**
- **It provides greater flexilbilty in circuit design.**

THIN AND THICK FILM ICs

- **These devices are larger than monolithic ICs but smaller than discrete circuits. These ICs can be used when power requirement is comparatively higher.**
- **With a thin- or thick-film IC, the passive components like resistors and capacitors are integrated, but the transistors and diodes are connected as discrete components to form a complete circuit. Therefore, commercially available thin- and thick-film circuits are combination of integrated and discrete components.**
- **The essential difference between the thin- and thick-film ICs is not their relative thickness but the method of deposition of film. Both have similar appearance, properties and general characteristics.**
- **Thin-film ICs are fabricated by depositing films of conducting material on the surface of a glass or ceramic base. By controlling the width and thickness of the films and by using different materials selected for their resistivity, resistors and conductors are fabricated**

THIN AND THICK FILM ICs

- **One method used for producing thin films is vacuum evaporation in which vapourized material is deposited on a substrate contained in a vacuum.**
- **Thick-film ICs are sometimes referred to as printed thin-film circuits. In their manufacturing process silk-screen printing techniques are used to create the desired circuits pattern on a ceramic substrate.**
- **ICs produced by thin- or thick-film techniques have the advantages of forming passive components with wider range and better tolerances, better isolation between their components, greater flexibility in circuit design and of providing better high-frequency performance than monolithic ICs.**

CHIP SIZE

- **SSI (small-scale integration)**
- **MSI (medium-scale integration)**
- **LSI (large-scale integration)**
- **VLSI (very large-scale integration)**
- **ULSI (ultra large-scale integration)**

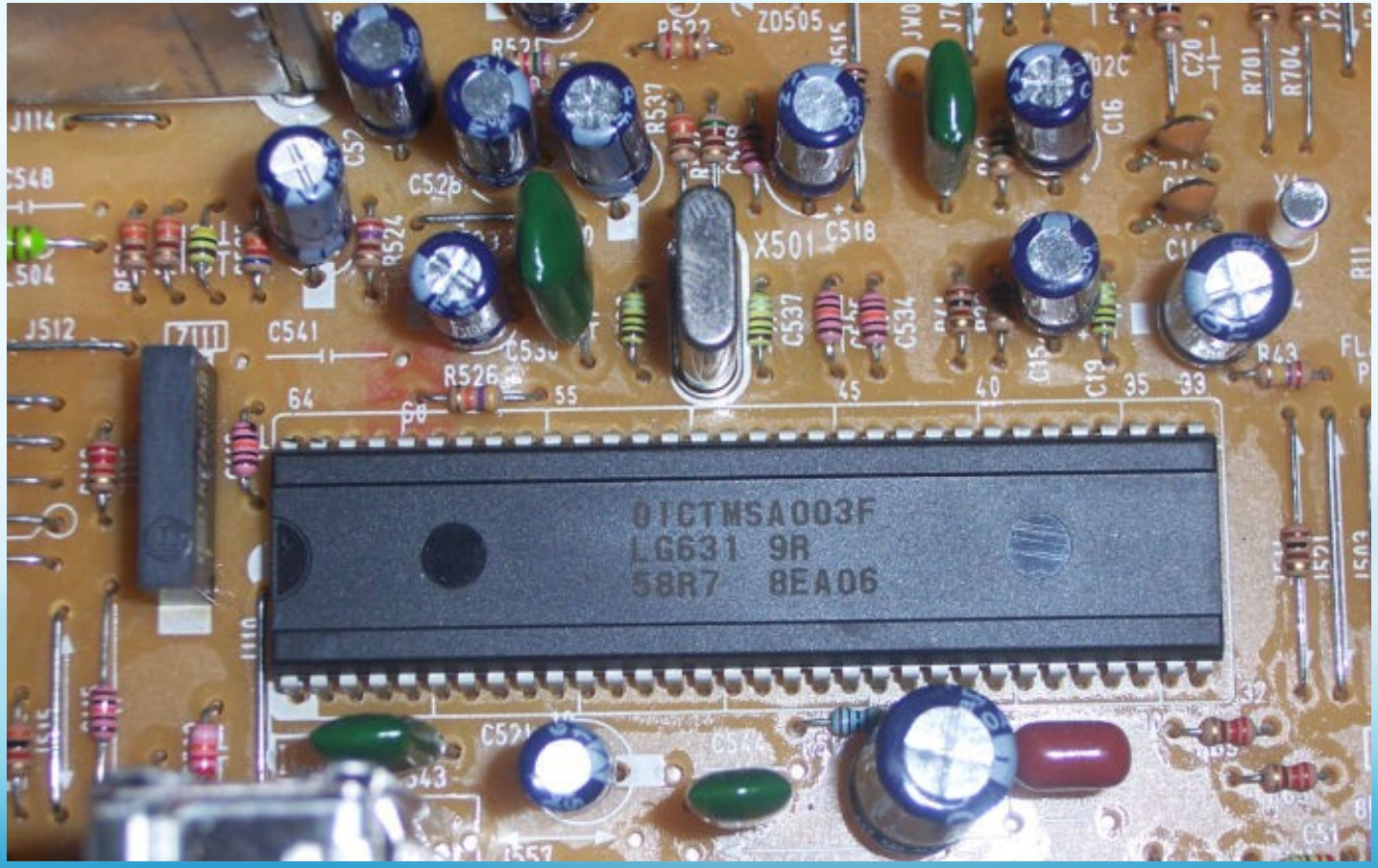
CHIP SIZE

Integrated circuit classification

Name	Signification	Year	Number of Transistors	Number of Logic Gates
SSI	small-scale integration	1964	1 to 10	1 to 12
MSI	medium-scale integration	1968	10 to 500	13 to 99
LSI	large-scale integration	1971	500 to 20,000	100 to 9,999
VLSI	very large-scale integration	1980	20,000 to 1,000,000	10,000 to 99,999
ULSI	ultra-large-scale integration	1984	1,000,000 and more	100,000 and more

SSI (Small scale integration)

- **Small scale integration (SSI) has less than 10 gates/chip or Up to 100 electronic components per chip**



MSI (Medium scale integration)

- **Medium scale integration (SSI) has upto 100 gates/chip or Up to 100 electronic components per chip**

4-bit binary full adder with fast carry 74HC/HCT283

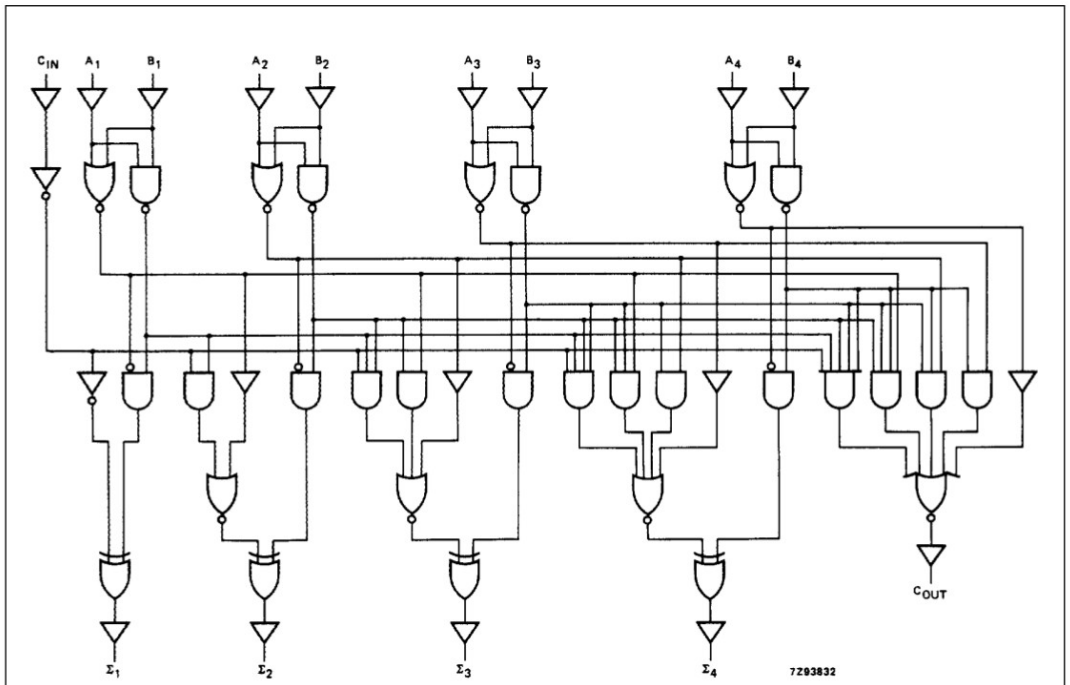


Fig.5 Logic diagram.

LSI (Large scale integration)

- **Large scale integration (SSI) has upto thousands of transistors per chip. This was conceived in mid-1970s when computer processor microchips were under development.**

VLSI (Very Large scale integration)

- **Is the process of creating an integrated circuit (IC) by combining thousands of transistors into a single chip. VLSI began in the 1970s when complex semiconductor and communication technologies were being developed. The microprocessor is a VLSI device.**
- **Before the introduction of VLSI technology most ICs had a limited set of functions they could perform. An electronic circuit might consist of a CPU, ROM, RAM and other glue logic. VLSI lets IC designers add all of these into one chip**

VLSI (Very Large scale integration)

ULSI (Ultra Large scale integration)

- **It is the process of integrating or embedding millions of transistors on a single silicon semiconductor microchip. ULSI technology was conceived during the late 1980s when superior computer processor microchips, specifically for the Intel 8086 series, were under development. ULSI is a successor to large-scale integration (LSI) and very large-scale integration (VLSI) technologies but is in the same category as VLSI.**

On basis of applications :

- **Analog Integrated circuits**
- **Digital Integrated circuits**

Analog Integrated Circuits :

- **Integrated circuits that operate over an entire range of continuous values of the signal amplitude are called as Analog Integrated Circuits.**

  These are further classified into the two types :

- **Linear Integrated Circuits: An analog IC is said to be Linear, if there exists a linear relation between its voltage and current. IC 741, an 8-pin Dual In-line Package (DIP)op-amp, is an example of Linear IC.**

- **Radio Frequency Integrated Circuits: An analog IC is said to be Non-Linear, if there exists a non-linear relation between its voltage and current. A Non-Linear IC is also called as Radio Frequency IC.**

Digital Integrated Circuits :

- **Digital IC's are the one's which work only on two defined levels 1's and 0's. They work on binary mathematics. They can contain millions of logic gates, flip-flops etc integrated on a single chip.**
- **Microprocessors and microcontrollers are examples of digital IC's.**