Electronics Devices & Circuits

Detailed Notes for Engineering Students

Chapter 9
INTEGRATED CIRCUITS

Topics Covered

9.1 Basic Idea of ICs – Classifications: Linear and Digital ICs
9.2 SSI, MSI, LSI and VLSI – Field of Applications

Notes • Diagrams • Tables • 15 MCQs with Answer Key • 10 Broad Questions

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How to use these notes

- Read the paragraphs first for the concept, then the lists and tables for quick revision.
- Figures are simple line diagrams – practise redrawing them for the exam.
- Attempt the 15 MCQs and 10 broad questions at the end after finishing both topics.

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Chapter 9: Integrated Circuits

9.1 Basic Idea of ICs – Classifications: Linear and Digital ICs

9.1.1 Introduction and Definition

Early electronic equipment was built with **discrete components** – separate transistors, resistors, capacitors and diodes – soldered together on a printed circuit board (PCB) or wired point to point. As circuits became more complex, this approach produced bulky, power-hungry, costly and unreliable systems, because every soldered joint was a possible point of failure. The need for smaller, cheaper and more dependable electronics led to the invention of the **integrated circuit**.

An **Integrated Circuit (IC)** is a complete electronic circuit in which the active devices (transistors, diodes), the passive components (resistors, small capacitors) and all the interconnections between them are fabricated together, in one process, on a single tiny piece of semiconductor material (usually silicon) called a **chip** or **die**. The chip is then sealed in a protective package that provides external connecting pins (leads).

Historical milestones

Year	Event
1947	Invention of the transistor at Bell Laboratories (Bardeen, Brattain, Shockley).
1958	Jack Kilby (Texas Instruments) builds the first working IC on a germanium slice; he later received the Nobel Prize in Physics (2000).
1959	Robert Noyce (Fairchild Semiconductor) develops the planar silicon IC with metal interconnections – the basis of modern ICs.
1965	Gordon Moore observes that the number of components on a chip keeps growing rapidly (Moore’s law, see 9.2).
1971	First microprocessor (Intel 4004) – a complete CPU on a single chip.

Important terms

Term	Meaning
Wafer	Thin circular slice of pure silicon crystal on which hundreds of identical ICs are made at the same time.
Die / Chip	One small rectangular piece cut from the wafer, containing a single complete circuit.
Substrate	The base semiconductor material on which the other layers and components are formed.
Package	Protective enclosure (plastic, ceramic or metal) with pins that connect the chip to the outside world.
Pin / Lead	External terminal used for power supply, inputs, outputs and control signals.

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9.1.2 Advantages and Limitations of ICs

Because all components are formed together in a microscopic area, an IC offers major benefits over a discrete circuit that performs the same job. At the same time, the fabrication process imposes certain restrictions on what can be built on a chip.

Advantages

- **Small size and weight** – thousands to billions of components fit in a space smaller than a fingernail.
- **Low cost** – batch fabrication of many chips on one wafer makes each chip very cheap in mass production.
- **High reliability** – very few soldered joints; components are made in a single process, so failure rates are low.
- **Low power consumption** – tiny devices need small currents and voltages.
- **High operating speed** – very short interconnections give low parasitic capacitance and inductance.
- **Good matching and temperature tracking** – components made side by side on one chip have nearly identical characteristics.
- **Ease of design and replacement** – ICs act as ready-made building blocks, so equipment is easier to design, repair and maintain.
- **Reduced external noise pick-up** – fewer external connections and shorter paths.

Limitations

- **Limited power handling** – ICs usually dissipate only a few watts; high-power circuits still need discrete power devices.
- **Inductors and transformers** cannot be fabricated with useful values on a chip (they are avoided or simulated using active circuits).
- **Large capacitors** (beyond about 100 pF) need too much chip area; large values are connected externally.
- **Poor absolute tolerance of resistors and capacitors** (about ±20 %), although the *ratio* of two on-chip components is very accurate.
- **Low voltage rating** – breakdown voltages of tiny junctions are small.
- **No repair** – a faulty IC cannot be repaired; it has to be replaced.
- **High initial set-up cost** – a fabrication plant and photomasks are very expensive, so ICs are economical only for large volumes.

9.1.3 Components Inside an IC

A transistor is the cheapest and easiest element to make on a chip, so IC designers use transistors wherever possible – even as diodes, resistors (active loads) and current sources. The table shows how the common components are realised.

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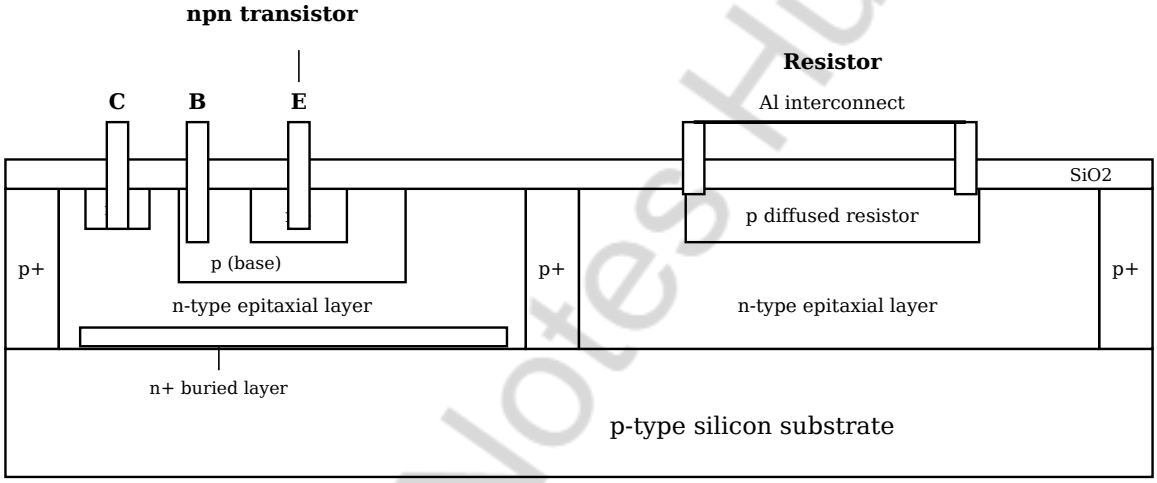
Component	How it is realised on the chip	Remarks
Transistor (BJT / MOSFET)	Formed by diffusion or ion implantation of n and p regions.	Basic building block; occupies least area.
Diode	A transistor with base and collector joined, or a single p-n junction.	Used for rectification, protection, clamping.
Resistor	Diffused or implanted strip of p-type (or n-type) material; thin-film metal strip.	About 100 Ω to 30 kΩ; larger values need more area.
Capacitor	Reverse-biased p-n junction or MOS (metal–oxide–silicon) structure.	Values up to about 100 pF only.
Inductor	Generally avoided; simulated by gyrator circuits using transistors.	Large coils cannot be integrated.
Interconnections	Thin aluminium (or copper) metal layers deposited over an oxide layer.	Connect all components as per the circuit.



Cross-section of a monolithic IC (two isolated islands on one substrate)

Fig. 9.1 Cross-section of a monolithic IC showing an npn transistor and a diffused resistor

9.1.4 Classification of ICs

ICs can be classified in several ways: by the method of fabrication, by the type of active device used, by the function they perform (type of signal handled) and by the number of components integrated on the chip. The overall scheme is shown in Fig. 9.2.

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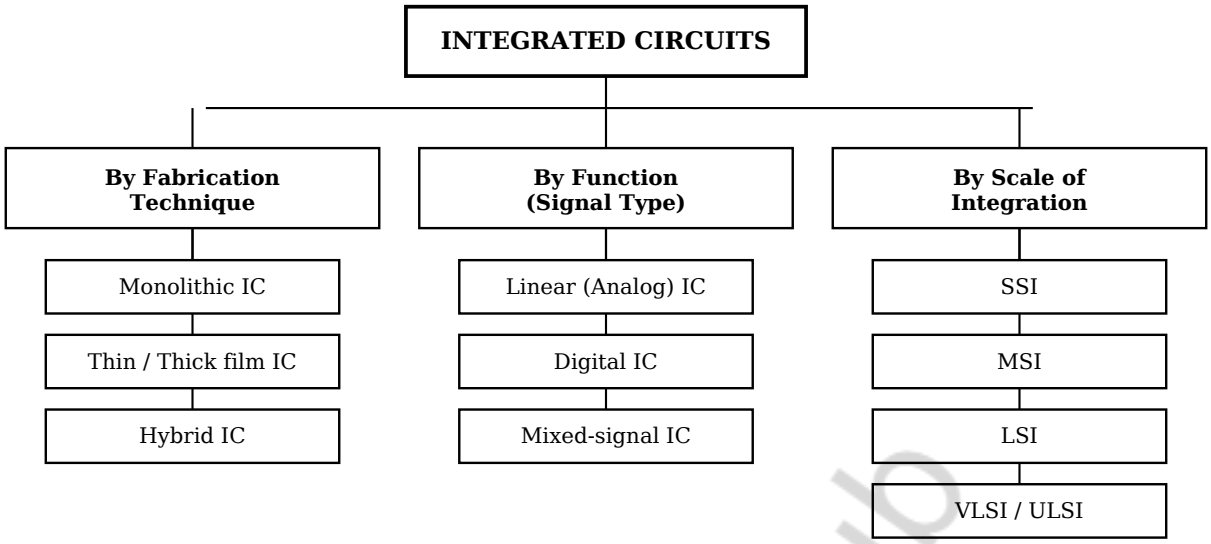

Fig. 9.2 Classification of integrated circuits

(a) Classification by fabrication technique

Type	Description	Typical use
Monolithic IC	All active and passive components and interconnections are formed on a **single silicon crystal** ("monolithic" = single stone). Most common type.	Op-amps, logic gates, microprocessors, memories
Thin-film / thick-film IC	Passive components (R, C) and interconnections are deposited as thin or thick films on an insulating substrate (glass or ceramic). Active devices cannot be made by this method.	Precision resistor networks, filters
Hybrid (multichip) IC	Combination of monolithic chips, discrete transistors and film components assembled on one substrate in a single package.	High-power, RF/microwave, high-precision circuits

(b) Classification by active device

- **Bipolar ICs** – use BJTs; examples of families: TTL, ECL, I^2L. High speed and strong drive capability, but higher power consumption.
- **MOS (unipolar) ICs** – use MOSFETs: PMOS, NMOS and CMOS. Higher packing density and very low power; dominant in VLSI.
- **BiCMOS ICs** – combine bipolar and CMOS on one chip to get both high speed and low power.

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(c) Classification by function

- **Linear (analog) ICs** – process continuously varying signals.
- **Digital ICs** – process signals having only two discrete levels (logic 0 and logic 1).
- **Mixed-signal ICs** – contain both analog and digital circuitry on the same chip, e.g. ADC, DAC, microcontrollers with analog inputs.

(d) Classification by scale of integration – SSI, MSI, LSI, VLSI and ULSI; discussed in detail in Section 9.2.

9.1.5 Linear (Analog) ICs

A **linear IC** produces an output that varies **continuously** and (ideally) in direct proportion to its input. The transistors inside operate mainly in the **active region**, so the output can take any value within the supply limits. The name "linear" is used even though some of these ICs (for example comparators or timers) are not strictly linear; the term simply separates them from digital ICs. The most important linear IC is the **operational amplifier (op-amp)**, a high-gain direct-coupled differential amplifier.

Characteristics of linear ICs

- Handle analog signals such as audio, video, sensor and radio-frequency signals.
- Transistors operate in the active (amplifying) region; output varies continuously.
- Need careful biasing, a stable supply (often dual supply such as ±12 V or ±15 V) and negative feedback for stable gain.
- Performance is described by parameters like gain, bandwidth, input/output impedance, offset voltage, slew rate and CMRR.
- Designed using small-signal and frequency-response analysis.

Typical parameters of the 741 op-amp (for reference)

Parameter	Ideal op-amp	Typical IC 741
Open-loop voltage gain	Infinite	about 2×10^5
Input resistance	Infinite	about 2 MΩ
Output resistance	Zero	about 75 Ω
Bandwidth (unity gain)	Infinite	about 1 MHz
Slew rate	Infinite	about 0.5 V/µs
Supply voltage	–	±5 V to ±18 V
Input offset voltage	Zero	about 1 – 2 mV

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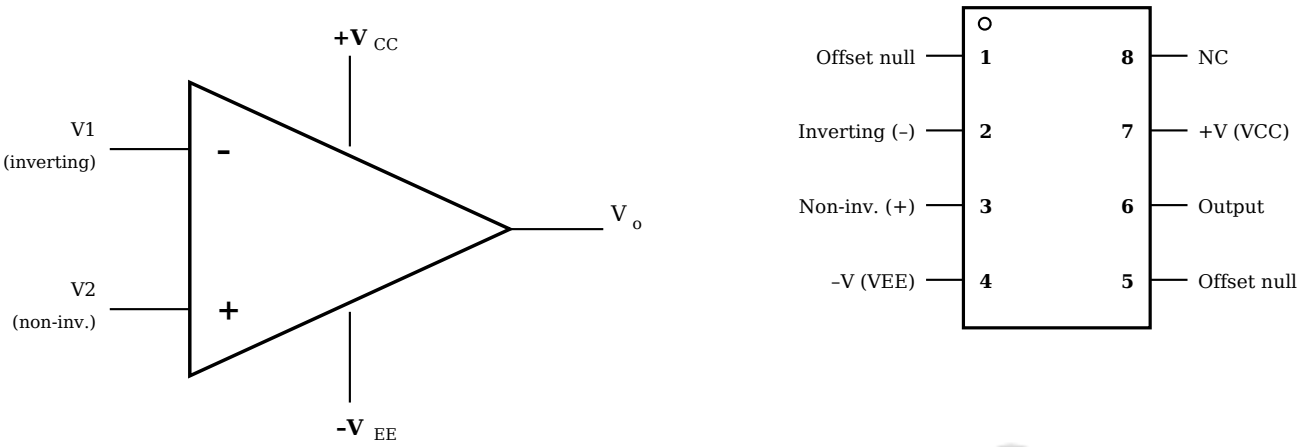

(a) Op-amp symbol (b) 741 op-amp, 8-pin DIP (top view)

Fig. 9.3 (a) Op-amp symbol and (b) pin configuration of IC 741

Common linear ICs and their uses

IC number	Function	Typical application
741 / LM324	General-purpose op-amp (single / quad)	Amplifiers, filters, integrators, signal conditioning
LM311	Voltage comparator	Zero-crossing detector, level detector
555	Timer (monostable / astable)	Pulse generation, delays, oscillators, flasher circuits
565	Phase-locked loop (PLL)	FM demodulation, frequency synthesis
7805 / 7812	Fixed voltage regulator (+5 V / +12 V)	Regulated DC power supplies
LM317	Adjustable voltage regulator	Variable bench power supplies
LM386	Low-power audio amplifier	Radios, small speakers, intercoms
LM35	Precision temperature sensor IC	Temperature measurement and control
MC1496	Balanced modulator / demodulator	AM/DSB modulation, product detection

Applications of linear ICs:

- Audio and video amplification, radio and television receivers.
- Active filters, oscillators and waveform generators.
- Voltage regulators and power-supply control.
- Instrumentation, sensor interfacing and data acquisition.
- Analog computation (adders, integrators, differentiators), modulators and demodulators.

9.1.6 Digital ICs

A **digital IC** processes signals that exist at only **two distinct voltage levels** – HIGH (logic 1) and LOW (logic 0). The transistors act as **switches**, being either fully ON (saturation) or fully OFF (cut-off). Because intermediate levels are not used, digital ICs have excellent noise immunity and their output is exact – it does not drift with small component variations. Digital ICs are built from basic logic gates (AND, OR, NOT, NAND, NOR, XOR) combined to form larger circuits.

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Characteristics of digital ICs

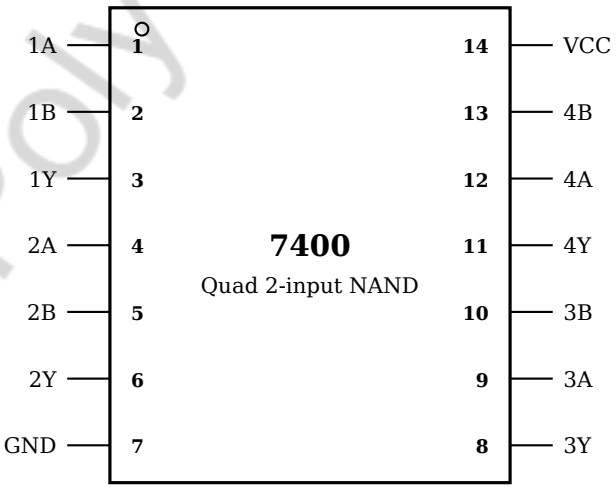
- Only two logic levels; transistors work as ON/OFF switches.
- High noise immunity and easy to cascade – outputs of one stage drive inputs of the next.
- Described by *truth tables* and Boolean algebra rather than gain and bandwidth.
- Important parameters: propagation delay, fan-in, fan-out, noise margin, power dissipation and speed-power product.
- Easy to integrate in very large numbers because each gate is simple and uses little area.
- Usually operate from a single supply (for example +5 V for TTL).

Classification of digital ICs by function

- **Combinational ICs** – output depends only on present inputs: gates, adders, multiplexers, decoders, encoders, comparators.
- **Sequential ICs** – output depends on present inputs and past state: flip-flops, registers, counters.
- **Memory ICs** – RAM, ROM, EPROM, flash for storing data.
- **Processor ICs** – microprocessors, microcontrollers, digital signal processors (DSP).

Logic families (groups of digital ICs sharing the same circuit technology and compatible voltage levels)

Family	Series example	Supply	Main features
TTL (Transistor–Transistor Logic)	74xx, 74LSxx	+5 V	Bipolar; speed about 10 ns per gate (standard TTL); moderate power; widely used for teaching and general logic.
CMOS (Complementary MOS)	4000 series, 74HCxx	3 – 15 V (4000); 2 – 6 V (HC)	Very low static power; high noise margin; high packing density; used in VLSI and battery equipment.
ECL (Emitter-Coupled Logic)	10K / 100K series	–5.2 V	Fastest bipolar family (about 1 – 2 ns) because transistors never saturate; high power dissipation.



Pin diagram of IC 7400 (14-pin DIP, top view)

Fig. 9.4 Pin diagram of IC 7400 – four 2-input NAND gates in a 14-pin DIP

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Examples of common digital ICs

IC number	Description	Type
7400	Quad 2-input NAND gate	SSI
7402 / 7408 / 7432	Quad 2-input NOR / AND / OR gate	SSI
7404	Hex inverter (NOT gate)	SSI
7486	Quad 2-input XOR gate	SSI
7474	Dual D-type flip-flop	Sequential
7483	4-bit binary full adder	MSI
7447	BCD to 7-segment decoder/driver	MSI
74138	3-line to 8-line decoder	MSI
74151	8-to-1 multiplexer	MSI
7490	Decade (BCD) counter	MSI

Applications of digital ICs:

- Computers, calculators and digital watches.
- Digital communication, networking and data storage.
- Industrial control, automation, counters and timers.
- Digital instruments, displays and consumer electronics.
- Microprocessor and microcontroller based embedded systems.

9.1.7 Linear ICs versus Digital ICs

Basis	Linear (analog) IC	Digital IC
Signal handled	Continuous, any value in a range	Discrete, two levels (0 and 1)
Transistor operation	Active region (amplifier)	Cut-off and saturation (switch)
Output	Proportional to input	Logic 0 or logic 1
Design / analysis	Gain, bandwidth, impedance, frequency response	Boolean algebra, truth tables, timing
Noise immunity	Lower – noise adds to the signal	High – small noise does not change the logic level
Accuracy	Depends on component tolerances and drift	Exact; independent of small variations
Supply	Often dual supply (±V)	Usually single supply
Feedback	Negative feedback widely used	Used in sequential circuits (latches, flip-flops)
Examples	741, 555, LM317, LM386	7400, 7474, 7490, 8085

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9.1.8 IC Packages and Grades

After fabrication the chip is bonded to a lead frame with very fine gold wires and enclosed in a package. The package protects the chip, helps remove heat and provides pins for connection. **Pin numbering** of a DIP is counted **anticlockwise** from a notch or dot mark when viewed from the top, starting at the pin just below the mark (see Fig. 9.3(b) and 9.4).

Package	Features
DIP (Dual In-line Package)	Two parallel rows of pins, through-hole mounting, 8 to 40 pins; plastic or ceramic. Popular for breadboards and lab work.
SIP (Single In-line Package)	One row of pins; used for resistor networks and some power ICs.
Metal can (TO-5, TO-99)	Round metal case with 8 to 12 leads; good heat dissipation; used in older op-amps and power devices.
SOIC / SMD packages	Small outline, surface-mount; much smaller than DIP; used in modern compact PCBs.
QFP / PLCC	Pins on all four sides; used for microprocessors and large-pin-count ICs.
BGA (Ball Grid Array)	Array of solder balls under the package; very high pin count in a small area (processors, FPGAs).

Temperature grades

Grade	Operating temperature range	Use
Commercial	0 °C to +70 °C	Consumer products, computers
Industrial	–40 °C to +85 °C	Industrial controls, outdoor equipment
Military / Aerospace	–55 °C to +125 °C	Defence, space, high-reliability equipment

9.1.9 Outline of IC Fabrication

The planar process used to manufacture monolithic ICs consists of a sequence of steps repeated on a wafer:

1 **Wafer preparation** – a pure silicon crystal ingot is grown, sliced into wafers and polished.

2 **Epitaxial growth** – a thin, lightly doped single-crystal layer is grown on the substrate.

3 **Oxidation** – a layer of silicon dioxide (SiO_2) is grown to insulate and to act as a mask.

4 **Photolithography** – a light-sensitive photoresist and a photomask define the pattern of each layer; the oxide is etched away in the selected windows.

5 **Diffusion / ion implantation** – n-type and p-type impurities are introduced through the windows to form transistors, diodes and resistors.

6 **Metallisation** – aluminium (or copper) is deposited and patterned to interconnect the components.

7 **Testing, dicing and packaging** – each die is tested, cut from the wafer, bonded, packaged and given a final test.

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Key points – Section 9.1

- An IC fabricates active devices, passive components and interconnections on one chip.
- Monolithic ICs use a single silicon crystal; hybrid ICs combine chips and film components.
- Linear ICs handle continuous signals (transistors in the active region); digital ICs handle two-level signals (transistors as switches).
- Inductors and large capacitors are difficult to integrate; transistors are the cheapest elements on a chip.
- TTL, CMOS and ECL are the main digital logic families.

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9.2 SSI, MSI, LSI and VLSI – Field of Applications

9.2.1 Scale of Integration

The **scale of integration** tells us how many components (transistors) or logic gates are packed on one chip. As fabrication technology improved, the number of components per chip grew from a handful to several billions. According to the level of complexity, ICs are grouped as **SSI, MSI, LSI, VLSI** and, further, **ULSI**. The boundaries given by different authors vary slightly, so the figures below are approximate values commonly used in textbooks.

Level	Full name	Logic gates per chip	Approx. components (transistors)	Period
SSI	Small Scale Integration	Less than 12 (up to about 10)	Up to about 100	Early 1960s
MSI	Medium Scale Integration	12 to 99	100 to 1,000	Late 1960s
LSI	Large Scale Integration	100 to 9,999	1,000 to 100,000	1970s
VLSI	Very Large Scale Integration	10,000 to 10 lakh (10^6)	More than 100,000 (10^5) up to millions	1980s onward
ULSI	Ultra Large Scale Integration	More than 10 lakh	More than 10^7 (now billions)	1990s onward

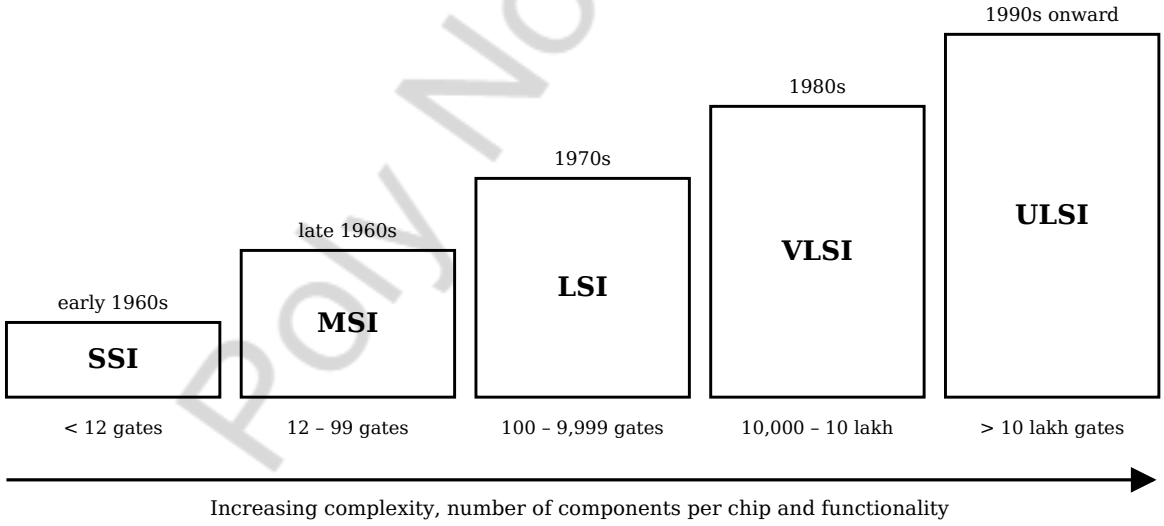

Fig. 9.5 Growth in the scale of integration

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9.2.2 Small Scale Integration (SSI)

SSI chips contain only a few **basic gates or a few components** – typically fewer than about a dozen gates or about 100 transistors. They perform very simple functions and were the first generation of digital ICs. Even today they are used as “glue logic” to connect larger blocks.

- **Examples:** 7400 (NAND), 7402 (NOR), 7404 (NOT), 7408 (AND), 7432 (OR), 7486 (XOR); single op-amp ICs such as 741; small transistor arrays.
- **Features:** simple internal circuit, easy to understand and test, low cost, low complexity.
- **Applications:** basic logic implementation, interfacing and glue logic, simple control circuits, early calculators, lab experiments and prototypes.

9.2.3 Medium Scale Integration (MSI)

MSI chips contain roughly **12 to 99 gates** (100 to 1,000 components) and implement a complete **functional block** rather than a single gate. They made it possible to build arithmetic and data-handling units with only a few ICs.

- **Examples:** decoders (7447, 74138), encoders (74147), multiplexers (74151, 74153), demultiplexers, adders (7483), magnitude comparators (7485), counters (7490, 74193), shift registers (74194), small ROMs/RAMs.
- **Features:** a complete function per chip, reduced PCB size and wiring compared with SSI, moderate cost.
- **Applications:** arithmetic circuits, data selection and routing, code conversion, seven-segment display drivers, digital counters and clocks, small control units.

9.2.4 Large Scale Integration (LSI)

LSI chips hold about **100 to 9,999 gates** (1,000 to 100,000 components). A whole **subsystem** or even a complete small processor can be built on one chip. LSI marked the arrival of the microprocessor and large semiconductor memories in the 1970s.

- **Examples:** 8-bit microprocessors (8080, 8085, Z80, 6502); programmable peripheral interface 8255; UART 8251; calculator chips; RAM/ROM chips of a few kilobits to tens of kilobits.
- **Features:** very small size and low power for the function performed, high speed, mostly MOS technology (NMOS, CMOS), fewer external connections.
- **Applications:** first-generation microcomputers, pocket calculators, digital watches, memory modules, peripheral controllers, printers and keyboards.

9.2.5 Very Large Scale Integration (VLSI)

VLSI chips contain **more than about 10,000 gates and over 100,000 transistors**, and today commonly millions to billions. A complete **system** – processor, memory and input/output interfaces – can be placed on a single chip, called a **System-on-Chip (SoC)**. VLSI is almost entirely based on **CMOS** technology because of its very low power and high density, and it is designed with the help of computer-aided design (CAD/EDA) tools.

- **Examples:** 16-bit and 32-bit microprocessors (8086, 80386 and later), 8051 and ARM based microcontrollers, large DRAM/flash memories, digital signal processors (DSP), FPGAs, ASICs, graphics processors.
- **Features:** very high packing density, very low cost per function, high speed, low power per gate, high reliability, complete systems on a chip.

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- **Applications:** personal computers and servers, smartphones and tablets, embedded systems, digital cameras, networking equipment, medical imaging, automotive electronics and artificial-intelligence hardware.

ULSI / GSI: Modern processors with more than ten million, and now billions, of transistors are described as ULSI (or sometimes “giga-scale integration”). The term VLSI is still widely used for the whole class of such chips.

9.2.6 Comparison of SSI, MSI, LSI and VLSI

Basis	SSI	MSI	LSI	VLSI
Gates per chip	< 12	12 – 99	100 – 9,999	≥ 10,000
Components	Up to ~100	100 – 1,000	1,000 – 100,000	> 100,000
Function level	Single gate / basic element	Functional block	Subsystem / small processor	Complete system (SoC)
Main technology	Bipolar (TTL)	Bipolar and MOS	MOS (NMOS, CMOS)	CMOS, BiCMOS
Typical examples	7400, 7404, 7408	7483, 74138, 7490	8085, 8255, small RAM	8086 and later, 8051, DSP, FPGA
Design effort	Very low	Low	High	Very high; uses EDA tools
Power per function	High	Medium	Low	Very low
Cost per function	Highest	High	Low	Lowest

9.2.7 Moore’s Law

In 1965 Gordon Moore (co-founder of Intel) observed that the number of components on an IC was increasing at a steady, rapid rate; in 1975 he revised the rate to **doubling about every two years**. This trend, known as **Moore’s law**, has guided the semiconductor industry for decades. It has been made possible by shrinking the minimum feature size (the transistor channel length) from several micrometres in the 1970s to a few nanometres today.

- More transistors per chip means more functions, lower cost per transistor and higher speed.
- Smaller transistors switch faster and use less power each.
- Limits now being faced: heat dissipation, leakage current, quantum effects, and the very high cost of fabrication plants.

9.2.8 Field of Applications

The application of ICs covers almost every area of modern life. The level of integration used depends on the complexity of the job: simple control and interface logic uses SSI/MSI, while computing and communication systems rely on LSI and VLSI chips.

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Field	Examples of use	Level mostly used
Computers	Processors, RAM, cache, chipsets, graphics and storage controllers	VLSI / ULSI
Communication	Mobile phones, modems, routers, satellite and radio equipment, modulators	VLSI, linear ICs
Consumer electronics	TV, radio, audio amplifiers, cameras, washing machines, microwave ovens, toys	LSI, VLSI, linear ICs
Industrial control	PLCs, motor drives, timers, counters, temperature and process control	SSI, MSI, LSI
Automotive	Engine control unit, ABS, airbags, infotainment, battery management	LSI, VLSI, linear ICs
Medical electronics	ECG/EEG amplifiers, pacemakers, ultrasound and imaging systems, digital thermometers	Linear ICs, VLSI
Instrumentation	Digital multimeters, oscilloscopes, data loggers, sensor interfacing	MSI, LSI, linear ICs
Defence and space	Radar, missile guidance, satellites, avionics (high-reliability grade)	VLSI, hybrid ICs
Education and labs	Logic trainers, breadboard experiments, microcontroller kits	SSI, MSI

9.2.9 Advantages and Challenges of Higher Integration

Advantages	Challenges
Smaller size and weight of equipment	Heat dissipation – many transistors in a small area produce a lot of heat
Lower power per function	Complex design – requires CAD tools and large design teams
Higher speed due to short interconnections	Testing a chip with millions of gates is difficult and costly
Lower cost per function in mass production	Very high cost of fabrication plants and photomasks
Higher reliability – fewer external connections	Leakage current and short-channel effects in very small transistors
Complete systems on a single chip (SoC)	Not repairable – a defect means replacing the whole chip

Key points – Section 9.2

- SSI: < 12 gates; MSI: 12 – 99 gates; LSI: 100 – 9,999 gates; VLSI: 10,000 gates and more.
- Examples – SSI: 7400; MSI: 74138, 7483; LSI: 8085; VLSI: 80386, 8051, FPGA, ASIC.
- VLSI is based mostly on CMOS and allows a complete system on a chip.
- Moore’s law: number of transistors on a chip doubles roughly every two years.

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Practice Section

A. Multiple Choice Questions (15)

Choose the correct option. The answer key is given at the end of this section.

Q1. Who built the first working integrated circuit in 1958?

(A) Robert Noyce (B) Jack Kilby
(C) Gordon Moore (D) William Shockley

Q2. In a monolithic IC, all components are fabricated on:

(A) Separate ceramic substrates (B) A single silicon crystal (chip)
(C) A glass substrate using thick films (D) A printed circuit board

Q3. Which of the following is a **linear** IC?

(A) 7400 (B) 7490
(C) 741 (D) 74138

Q4. Which component is the most difficult to fabricate on an IC chip?

(A) Transistor (B) Diode
(C) Small resistor (D) Large-value inductor

Q5. IC 7400 contains:

(A) Four 2-input NAND gates (B) Six inverters
(C) Four 2-input NOR gates (D) Two 4-input AND gates

Q6. Transistors in a digital IC mainly operate in:

(A) Active region only (B) Cut-off and saturation regions
(C) Breakdown region (D) Reverse active region

Q7. An IC containing about 100 to 9,999 gates belongs to:

(A) SSI (B) MSI
(C) LSI (D) VLSI

Q8. The 8085 microprocessor is an example of:

(A) SSI (B) MSI
(C) LSI (D) Hybrid IC

Q9. A decoder such as the 74138 is classified as:

(A) SSI (B) MSI
(C) Linear IC (D) ULSI

Q10. A VLSI chip typically contains more than:

(A) 100 transistors (B) 1,000 transistors
(C) 10,000 transistors (D) 100,000 transistors

Q11. The IC 555 is generally classified as a:

(A) Linear IC (B) Memory IC
(C) Microprocessor (D) Decade counter

Q12. Which of the following is a limitation of ICs?

(A) Small size (B) Low cost in mass production
(C) Limited power handling capacity (D) High reliability

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Q13. Moore's law states that the number of transistors on a chip doubles approximately every:

(A) 6 months
(B) 2 years
(C) 10 years
(D) 20 years

Q14. A hybrid IC is made by:

(A) Only diffusion in silicon
(B) Combining monolithic chips, discrete devices and film components
(C) Using only thin-film resistors
(D) Using only bipolar transistors

Q15. The commercial temperature grade of an IC is:

(A) –55 °C to +125 °C
(B) –40 °C to +85 °C
(C) 0 °C to +70 °C
(D) +70 °C to +150 °C

Answer Key – MCQs

Q	Ans	Q	Ans	Q	Ans
1	B	6	B	11	A
2	B	7	C	12	C
3	C	8	C	13	B
4	D	9	B	14	B
5	A	10	D	15	C

Quick explanations:

- Q1 – Jack Kilby (Texas Instruments) made the first IC; Noyce developed the planar silicon IC.
- Q3 – 741 is an op-amp (linear); 7400, 7490 and 74138 are digital ICs.
- Q4 – Large inductors cannot be integrated on a chip.
- Q6 – Digital transistors act as switches (cut-off / saturation).
- Q7, Q8 – LSI = 100 to 9,999 gates; the 8085 is an LSI device.
- Q10 – VLSI has more than about 100,000 transistors per chip.
- Q12 – ICs cannot handle high power; discrete power devices are needed.

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B. Broad Questions (10)

Answer in detail with neat diagrams, tables and examples wherever required.

1 Define an integrated circuit. Explain the advantages and limitations of ICs over discrete circuits.

2 Classify integrated circuits. Draw a neat block diagram showing the classification and explain monolithic, thin/thick-film and hybrid ICs.

3 What are linear ICs? Explain their characteristics and list any six linear ICs with their functions and applications.

4 What are digital ICs? Explain their characteristics and discuss the TTL, CMOS and ECL logic families in brief.

5 Differentiate between linear and digital ICs with the help of a comparison table and suitable examples.

6 Explain how resistors, capacitors, diodes and transistors are realised in a monolithic IC. Why are inductors avoided?

7 What is meant by scale of integration? Explain SSI, MSI, LSI and VLSI with the number of gates/components and two examples of each.

8 Compare SSI, MSI, LSI and VLSI in tabular form on the basis of complexity, technology, examples and applications.

9 State and explain Moore’s law. Discuss the advantages and challenges of increasing the level of integration.

10 Discuss the field of applications of ICs in computers, communication, consumer, industrial, automotive and medical electronics.

– End of Chapter 9 –

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