

CHAPTER 3: HARDWARE AND COMPUTER COMPONENTS

3.1 COMPUTERS AND THEIR COMPONENTS

3.1.1 General-Purpose Computer System

A general-purpose computer system comprises:

1. **Processor (CPU):** Executes instructions
2. **Memory:** Stores data and instructions
3. **Input/Output (I/O):** Interfaces with external world

3.1.2 Essential Features of a Computer

Input:

- Takes in data from the outside world
- Devices: keyboard, mouse, scanner, microphone

Output:

- Displays data for human understanding
- Devices: monitor, printer, speaker

Primary Storage (Memory):

- Main memory storing critical program instructions and data
- RAM (Random Access Memory)
- Volatile (loses data when power off)

Secondary Storage:

- Non-volatile storage for data
- Examples: hard disk, SSD, USB flash drive

Removable Secondary Storage:

- File backup and archives
- Portable transfer of files

3.1.3 Embedded Systems

Definition: Miniature computer systems (microprocessors) that are often part of a larger system.

Characteristics:

- Perform few specific functions
- Not general-purpose computers
- No moving parts (more reliable)

Advantages:

- Reliable (no moving parts)
- Require less power
- Cheap to mass-produce

Disadvantages:

- Difficult to program (no interface)
- Expensive expert help needed for repair

3.1.4 Hardware Device Operations

Laser Printer:

1. Laser beam and rotating mirrors draw image on photosensitive drum
2. Image converted to electric charge
3. Charged toner attracts to image
4. Electrostatic-charged paper rolls against drum
5. Charge pulls toner onto paper
6. Heat in fuser fuses toner to paper

3D Printer:

1. Starts with saved digital file (blueprint)
2. Object built by adding layers of material (polymer resin)

3. Object cured (hardened by UV light)

Microphone:

1. Sound waves enter and cause diaphragm vibrations
2. Vibrations cause coil to move past magnetic core
3. Electrical current generated
4. Current digitized

Speaker:

1. Takes electrical signals
2. Voice coil generates electromagnetic field
3. Change in audio signal changes current direction
4. Electromagnet attracted/repelled to permanent magnet
5. Diaphragm vibrates, creating sound waves

Magnetic Hard Disk:

1. Platters covered with magnetizable material
2. Mounted on central spindle, rotated at high speed
3. Surface divided into concentric tracks & sectors
4. Data encoded as magnetic patterns
5. Read/write heads access data

Solid State (Flash) Memory:

- Uses NAND-based flash memory
- Grid of columns & rows with 2 transistors at each intersection
- Floating gate stores electrons (represents 0 or 1)
- Control gate controls charge flow

Optical Disc Reader/Writer:

1. Disc surface has reflective metal layer
2. Spun at high speed
3. Laser beam reads/writes
4. Tracks have amorphous and crystalline states
5. Different states encode bit patterns

Touchscreen:

Type	Description
Resistive	Two charged plates; pressure causes contact
Capacitive	Materials that store electric charge; touch transfers charge

3.1.5 Memory Types

RAM vs ROM:

Feature	RAM	ROM
Volatility	Volatile (loses data when power off)	Non-volatile
Read/Write	Can be read and written	Can only be read
Use	Stores currently executing program	Stores OS kernel, boot-up instructions

Static RAM vs Dynamic RAM:

Feature	SRAM	DRAM
Refresh	Doesn't need to refresh	Must be refreshed
Speed	Faster access time	Slower access time
Power	Uses less power	Needs higher power
Cost	More expensive (complex circuitry)	Less expensive
Structure	Each bit stored in flip-flop	Each bit stored as charge in capacitor
Density	Lower data density	Higher data density
Use	Cache memory	Main memory

PROM vs EPROM vs EEPROM:

Type	Description	Erasure Method
PROM	Programmable once after creation	Cannot be erased
EPROM	Can be reprogrammed	UV light exposure
EEPROM	Can be reprogrammed	Electrical signal

3.1.6 Monitoring and Control Systems

Monitoring System:

- Monitors state external to computer
- No changes made to environment
- No feedback required

Control System:

- Regulates behaviour of other devices/systems
- **Event-driven:** Responds to specific events
- **Time-driven:** Takes action at specific times

Components:

- **Sensor:** Measures analogue property, transmits to processing unit
- **Actuator:** Switches on/off heavy appliances (heater, fan)
- **ADC:** Converts analogue signals to digital
- **Transmission cable:** Transfers signals

Feedback Systems:

- Output affects input of sensors
- Ensures system operates within criteria
- Enables automatic adjustment of conditions

3.2 LOGIC GATES AND LOGIC CIRCUITS

3.2.1 Basic Logic Gates

AND Gate:

- Output is HIGH only if ALL inputs are HIGH
- Symbol: $A \cdot B$ or A AND B

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate:

- Output is HIGH if ANY input is HIGH
- Symbol: $A + B$ or A OR B

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

NOT Gate (Inverter):

- Output is opposite of input
- Symbol: \bar{A} or NOT A

A	Output
0	1
1	0

3.2.2 NAND and NOR Gates

NAND Gate:

- Opposite of AND (NOT-AND)
- Symbol: $A \cdot B$

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

NOR Gate:

- Opposite of OR (NOT-OR)
- Symbol: $A + B$

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

3.2.3 XOR Gate

XOR (Exclusive OR):

- Output is HIGH if inputs are DIFFERENT
- Symbol: $A \oplus B$

A	B	Output
---	---	--------

0	0	0
0	1	1
1	0	1
1	1	0

3.2.4 Constructing Circuits from Truth Tables

Process:

1. Identify required output for each input combination
2. Identify the logic expression
3. Design the circuit using appropriate gates
4. Test with truth table

Revision #1

Created 2026-03-16 12:00:47 UTC by Samuel Lee

Updated 2026-03-16 12:01:03 UTC by Samuel Lee