KEC-502

MICROPROCESSOR
&
MICROCONTROLLER

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UNIT I

- Introduction to Microprocessor: Microprocessor architecture and its operations, Memory, Input & output devices,

- The 8085 MPU- architecture, Pins and signals, Timing Diagrams, Logic devices for interfacing, Memory interfacing, Interfacing output displays, Interfacing input devices, Memory mapped I/O

UNIT II

- Basic Programming concepts:, Flow chart symbols, Data Transfer operations, Arithmetic operations, Logic Operations, Branch operation,

- Writing assembly language programs, Programming techniques: looping, counting and indexing. Additional data transfer and 16 bit arithmetic instruction, Logic operation: rotate, compare, counter and time delays, 8085 Interrupts.

UNIT III

- 16-bit Microprocessors (8086): Architecture, Pin Description, Physical address, segmentation, memory organization, Addressing modes.
- Peripheral Devices: 8237 DMA Controller, 8255 programmable peripheral interface, 8253/8254programmable timer/counter, 8259 programmable interrupt controller, 8251 USART and RS232C.

UNIT IV

- 8051 Microcontroller Basics: Inside the Computer, Microcontrollers and Embedded Processors, Block Diagram of 8051, PSW and Flag Bits, 8051 Register Banks and Stack, Internal Memory Organization of 8051, IO Port Usage in 8051, Types of Special Function Registers and their uses in 8051, Pins Of 8051. Memory Address Decoding, 8031/51 Interfacing With External ROM And RAM. 8051 Addressing Modes.

UNIT V

- Assembly programming and instruction of 8051: Introduction to 8051 assembly programming, Assembling and running an 8051 program, Data types and Assembler directives, Arithmetic, logic instructions and programs, Jump, loop and call instructions, IO port programming. Programming 8051 Timers. Serial Port Programming, Interrupts Programming,

- Interfacing: LCD & Keyboard Interfacing, ADC, DAC & Sensor Interfacing, External Memory Interface, Stepper Motor and Waveform generation.

TEXT BOOKS

- Ramesh Gaonkar, “Microprocessor Architecture, Programming, and Applications with the 8085”, 5 th Edition, Penram International Publication (India) Pvt. Ltd.,2009

- D. V. Hall : Microprocessors Interfacing, TMH (2nd Edition),2006

- Mazidi Ali Muhammad, Mazidi Gillispie Janice, and McKinlay Rolin D., “The 8051 Microcontroller and Embedded Systems using Assembly and C”, Pearson, 2nd Edition,2006

Basic Concepts of Microprocessors

- Differences between:
  - Microcomputer – a computer with a microprocessor as its CPU. Includes memory, I/O etc.
  - Microprocessor – silicon chip which includes ALU, register circuits & control circuits
  - Microcontroller – silicon chip which includes microprocessor, memory & I/O in a single package.

What is a Microprocessor?

- The word comes from the combination micro and processor.
  - Processor means a device that processes whatever. In this context processor means a device that processes numbers, specifically binary numbers, 0’s and 1’s.
    - To process means to manipulate. It is a general term that describes all manipulation. Again in this content, it means to perform certain operations on the numbers that depend on the microprocessor’s design.

What about micro?

- Micro is a new addition.
  - In the late 1960's, processors were built using discrete elements.
    - These devices performed the required operation, but were too large and too slow.
  - In the early 1970's the microchip was invented. All of the components that made up the processor were now placed on a single piece of silicon. The size became several thousand times smaller and the speed became several hundred times faster. The "Micro"Processor was born.

Was there ever a “mini”-processor?

- No.
  - It went directly from discrete elements to a single chip. However, comparing today’s microprocessors to the ones built in the early 1970’s you find an extreme increase in the amount of integration.

- So, What is a microprocessor?

Definition of the Microprocessor

The microprocessor is a programmable device that takes in numbers, performs on them arithmetic or logical operations according to the program stored in memory and then produces other numbers as a result.

Definition (Contd.)

- Lets expand each of the underlined words:
  - Programmable device: The microprocessor can perform different sets of operations on the data it receives depending on the sequence of instructions supplied in the given program.
    By changing the program, the microprocessor manipulates the data in different ways.

  - Instructions: Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.

Definition (Contd.)

- Takes in: The data that the microprocessor manipulates must come from somewhere.
  - It comes from what is called “input devices”.
  - These are devices that bring data into the system from the outside world.
  - These represent devices such as a keyboard, a mouse, switches, and the like.

Definition (Contd.)

- Numbers: The microprocessor has a very narrow view on life. It only understands binary numbers.

  A binary digit is called a bit (which comes from **b**inary dig**it**).

  The microprocessor recognizes and processes a group of bits together. This group of bits is called a “word”.

  The number of bits in a Microprocessor’s word, is a measure of its “abilities”.

Definition (Contd.)

– Words, Bytes, etc.

- The earliest microprocessor (the Intel 8088 and Motorola's 6800) recognized 8-bit words.
  - They processed information 8-bits at a time. That's why they are called "8-bit processors". They can handle large numbers, but in order to process these numbers, they broke them into 8-bit pieces and processed each group of 8-bits separately.

- Later microprocessors (8086 and 68000) were designed with 16-bit words.
  - A group of 8-bits were referred to as a "half-word" or "byte".
  - A group of 4 bits is called a "nibble".
  - Also, 32 bit groups were given the name "long word".

- Today, all processors manipulate at least 32 bits at a time and there exists microprocessors that can process 64, 80, 128 bits

Definition (Contd.)

- Arithmetic and Logic Operations:
  - Every microprocessor has arithmetic operations such as add and subtract as part of its instruction set.
    - Most microprocessors will have operations such as multiply and divide.
    - Some of the newer ones will have complex operations such as square root.
  - In addition, microprocessors have logic operations as well. Such as AND, OR, XOR, shift left, shift right, etc.
  - Again, the number and types of operations define the microprocessor's instruction set and depends on the specific microprocessor.

Definition (Contd.)

– Stored in memory :

- First, what is memory?
  - Memory is the location where information is kept while not in current use.
  - Memory is a collection of storage devices. Usually, each storage device holds one bit. Also, in most kinds of memory, these storage devices are grouped into groups of 8. These 8 storage locations can only be accessed together. So, one can only read or write in terms of bytes to and form memory.
  - Memory is usually measured by the number of bytes it can hold.

    It is measured in Kilos, Megas and lately Gigas. A Kilo in computer language is 2^{10} =1024. So, a KB (KiloByte) is 1024 bytes. Mega is 1024 Kilos and Giga is 1024 Mega.

Definition (Contd.)

– Stored in memory:

- When a program is entered into a computer, it is stored in memory. Then as the microprocessor starts to execute the instructions, it brings the instructions from memory one at a time.

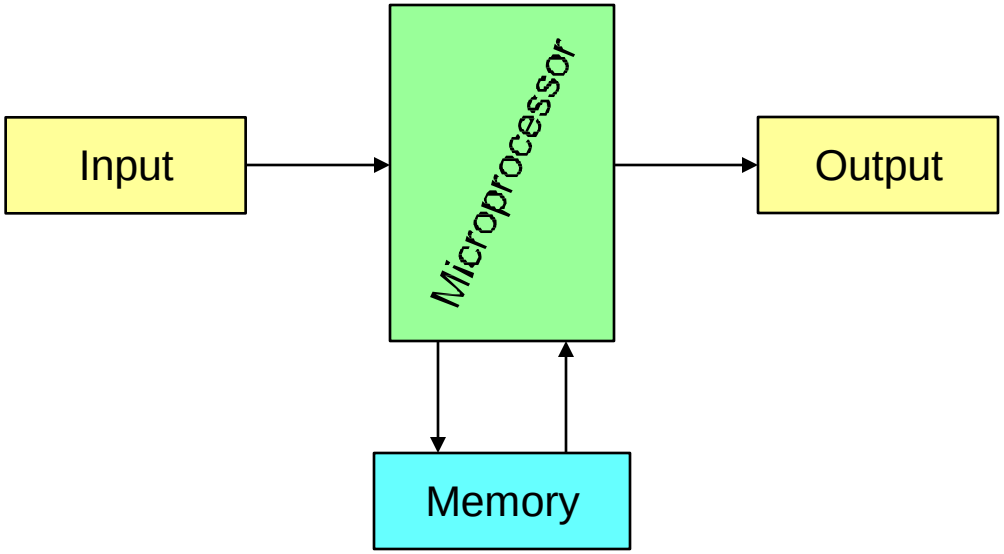
- Memory is also used to hold the data.
  – The microprocessor reads (brings in) the data from memory when it needs it and writes (stores) the results into memory when it is done.

Definition (Contd.)

- Produces: For the user to see the result of the execution of the program, the results must be presented in a human readable form.
  - The results must be presented on an output device.
  - This can be the monitor, a paper from the printer, a simple LED or many other forms.

A Microprocessor-based system

From the above description, we can draw the following block diagram to represent a microprocessor-based system:

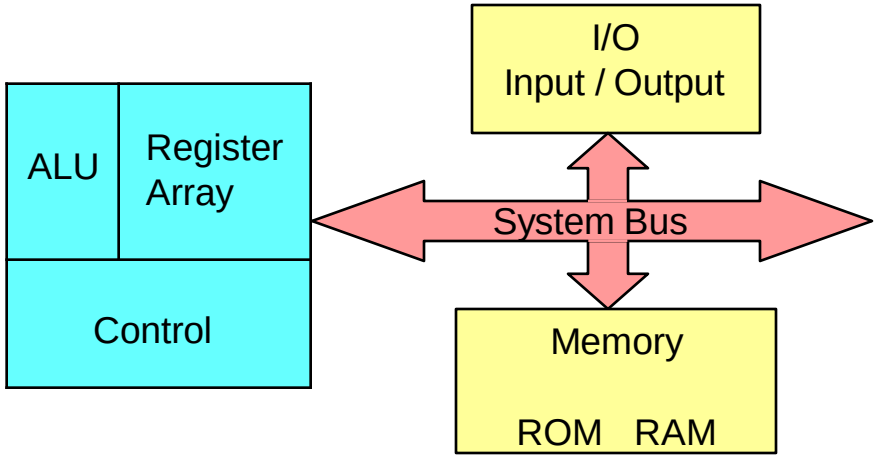


Inside The Microprocessor

- Internally, the microprocessor is made up of 3 main units.
  - The Arithmetic/Logic Unit (ALU)
  - The Control Unit.
  - An array of registers for holding data while it is being manipulated.

Organization of a microprocessor-based system

- Let's expand the picture a bit.



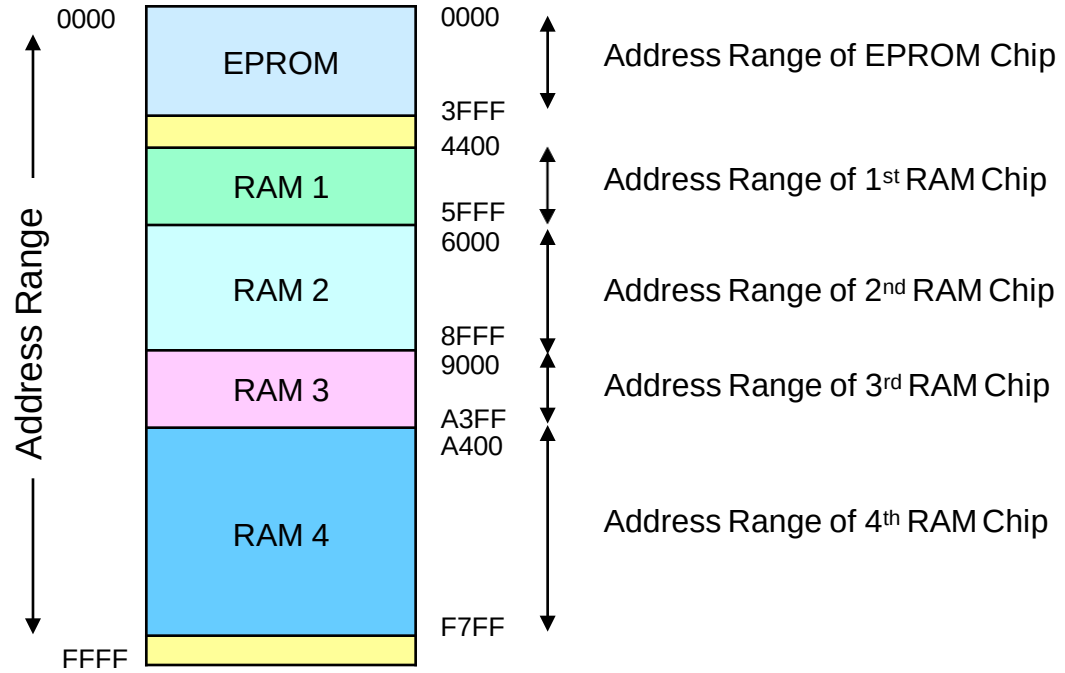
Memory

- Memory stores information such as instructions and data in binary format (0 and 1). It provides this information to the microprocessor whenever it is needed.

- Usually, there is a memory “sub-system” in a microprocessor-based system. This sub-system includes:
  - The registers inside the microprocessor
  - Read Only Memory (ROM)
    - used to store information that does not change.
  - Random Access Memory (RAM) (also known as Read/Write Memory).
    - used to store information supplied by the user. Such as programs and data.

Memory Map and Addresses

- The memory map is a picture representation of the address range and shows where the different memory chips are located within the address range.



Memory

- To execute a program:
  - the user enters its instructions in binary format into the memory.
  - The microprocessor then reads these instructions and whatever data is needed from memory, executes the instructions and places the results either in memory or produces it on an output device.

The three cycle instruction execution model

- To execute a program, the microprocessor “reads” each instruction from memory, “interprets” it, then “executes” it.

- To use the right names for the cycles:
  - The microprocessor **fetches** each instruction,
  - **decodes** it,
  - Then **executes** it.

- This sequence is continued until all instructions are performed.

Machine Language

- The number of bits that form the “word” of a microprocessor is fixed for that particular processor.
  - These bits define a maximum number of combinations.
    - For example an 8-bit microprocessor can have at most $2^8 = 256$ different combinations.

- However, in most microprocessors, not all of these combinations are used.
  - Certain patterns are chosen and assigned specific meanings.
  - Each of these patterns forms an instruction for the microprocessor.
  - The complete set of patterns makes up the microprocessor’s machine language.

The 8085 Machine Language

- The 8085 (from Intel) is an 8-bit microprocessor.
  - The 8085 uses a total of 246 bit patterns to form its instruction set.
  - These 246 patterns represent only 74 instructions.
    - The reason for the difference is that some (actually most) instructions have multiple different formats.
  - Because it is very difficult to enter the bit patterns correctly, they are usually entered in hexadecimal instead of binary.
    - For example, the combination 0011 1100 which translates into “increment the number in the register called the accumulator”, is usually entered as 3C.

Assembly Language

- Entering the instructions using hexadecimal is quite easier than entering the binary combinations.
  - However, it still is difficult to understand what a program written in hexadecimal does.
  - So, each company defines a symbolic code for the instructions.
  - These codes are called "mnemonics".
  - The mnemonic for each instruction is usually a group of letters that suggest the operation performed.

Assembly Language

- Using the same example from before,
  - 00111100 translates to 3C in hexadecimal (OPCODE)
  - Its mnemonic is: “INR A”.
  - INR stands for “increment register” and A is short for accumulator.

- Another example is: 1000 0000,
  - Which translates to 80 in hexadecimal.
  - Its mnemonic is “ADD B”.
  - “Add register B to the accumulator and keep the result in the accumulator”.

Assembly Language

- It is important to remember that a machine language and its associated assembly language are completely machine dependent.
  - In other words, they are not transferable from one microprocessor to a different one.

- For example, Motorolla has an 8-bit microprocessor called the 6800.
  - The 8085 machine language is very different from that of the 6800. So is the assembly language.
  - A program written for the 8085 cannot be executed on the 6800 and vice versa.

“Assembling” The Program

- How does assembly language get translated into machine language?
  - There are two ways:
  - 1st there is “**hand assembly**”.
    - The programmer translates each assembly language instruction into its equivalent hexadecimal code (machine language). Then the hexadecimal code is entered into memory.
  - The other possibility is a program called an “**assembler**”, which does the translation automatically.

Functions Of microprocessor

1. μp Initiated Operations
   - μp Performs 4 Operations- Memory Read, Memory Write, Input/Output Read, Input/Output Write.

   - To communicate with peripheral

     (i) μp Identifies the peripheral with its address

     (ii) transfer binary information

     (iii) Provide timing and synchronization signal

2. Internal Operations

- Store8 bit data
- Perform arithmetic and logic operations
- Test for conditions
- Sequence for the execution of instructions
- Store data temporarily during execution in Stack

3. External Operations

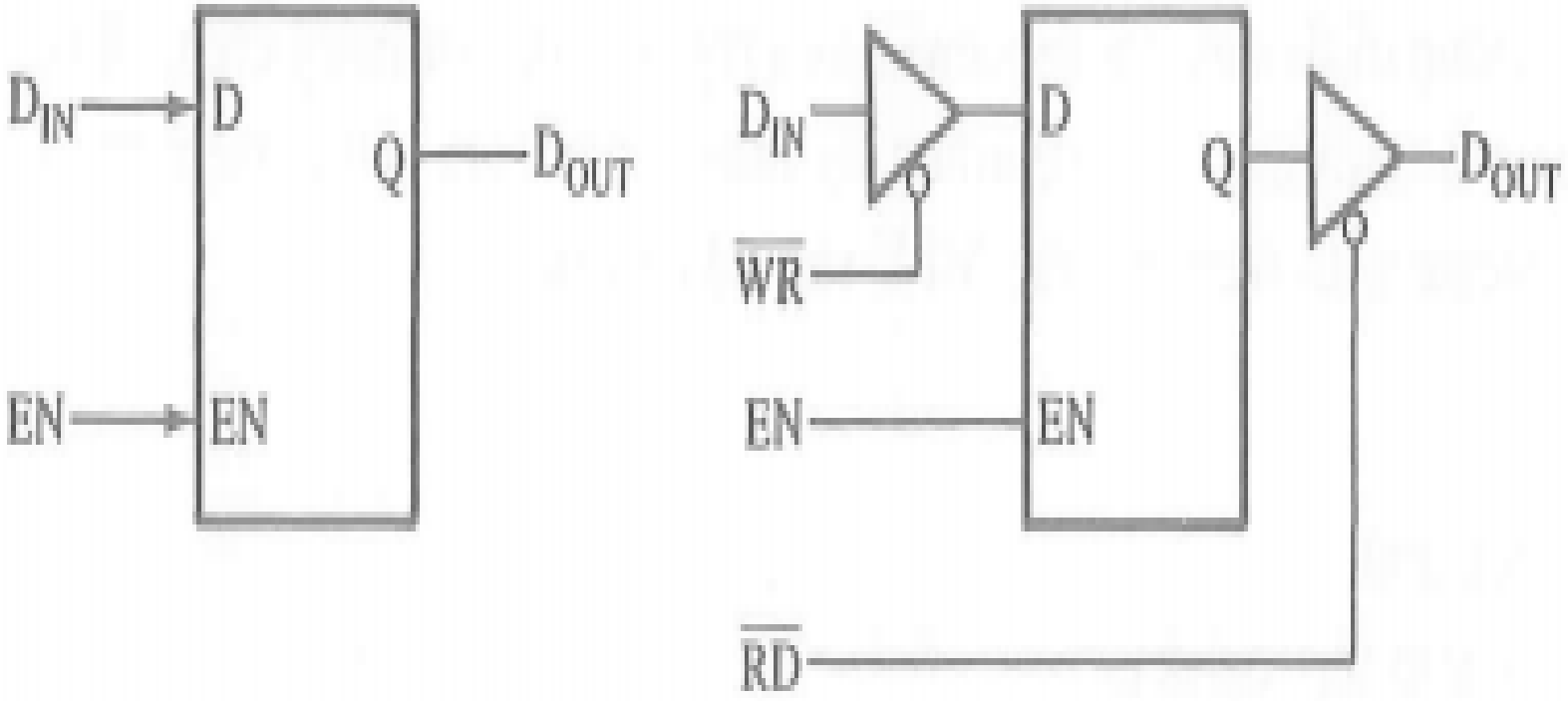
1. RESET:All internal operations are suspended and PC iscleared.

2. INTERRUPT: μp can be interrupted from normal execution and asked to execute some other instructions called service Routine.

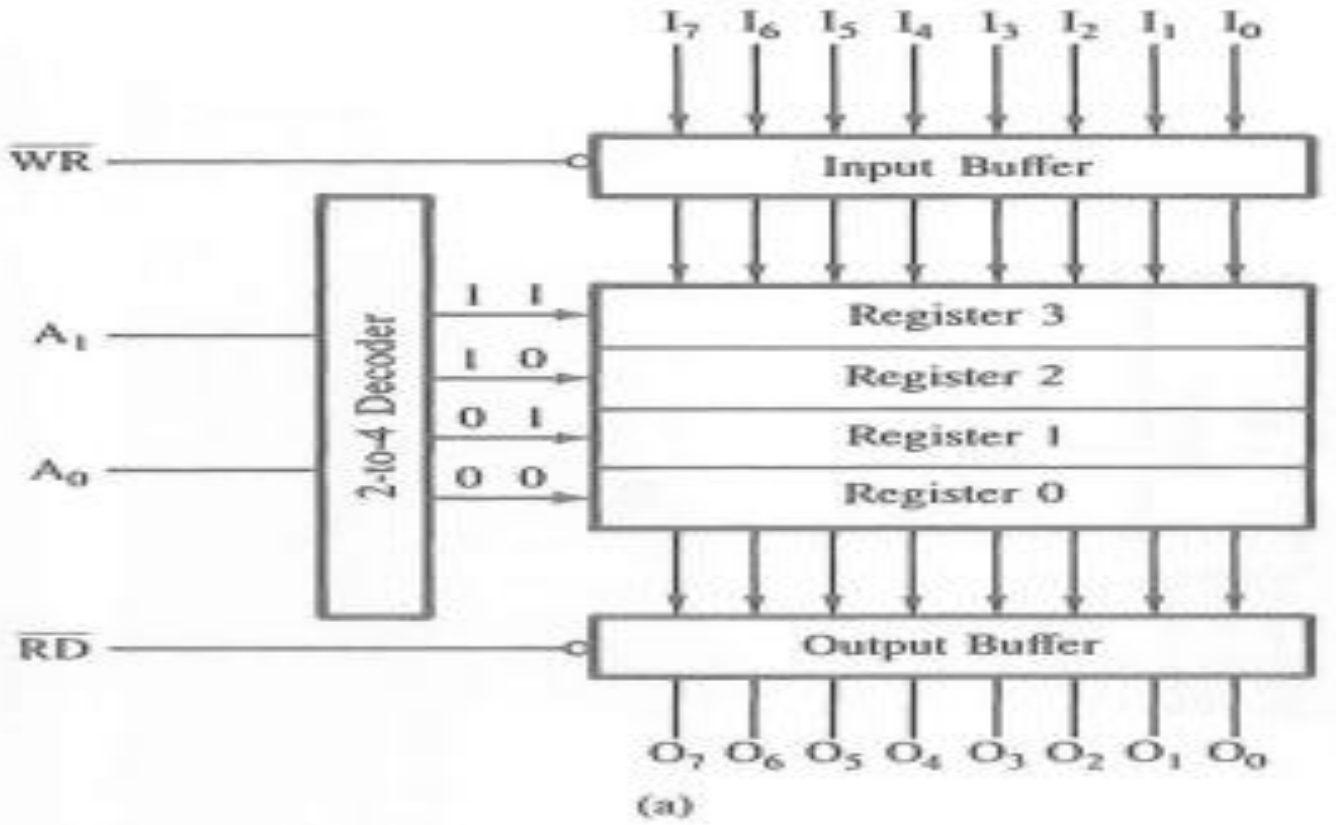
3. READY: If signal at READY pin is low, processor enters into WAIT state. This signal is used to synchronize slower peripherals with μp.

4. HOLD: It allows external peripherals to use the system bus.

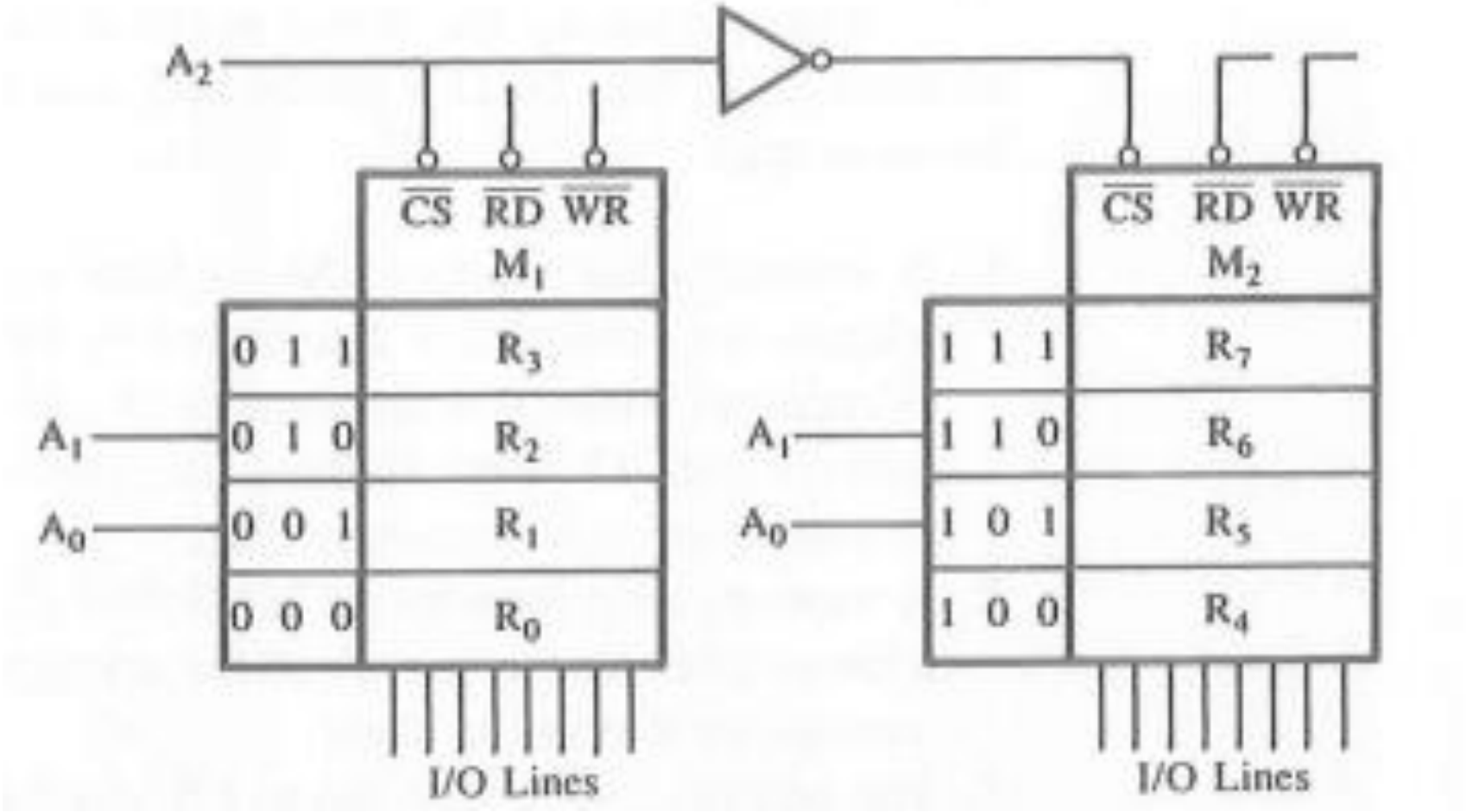
FLIP FLOP OR LATCH AS A STORAGE ELEMENT



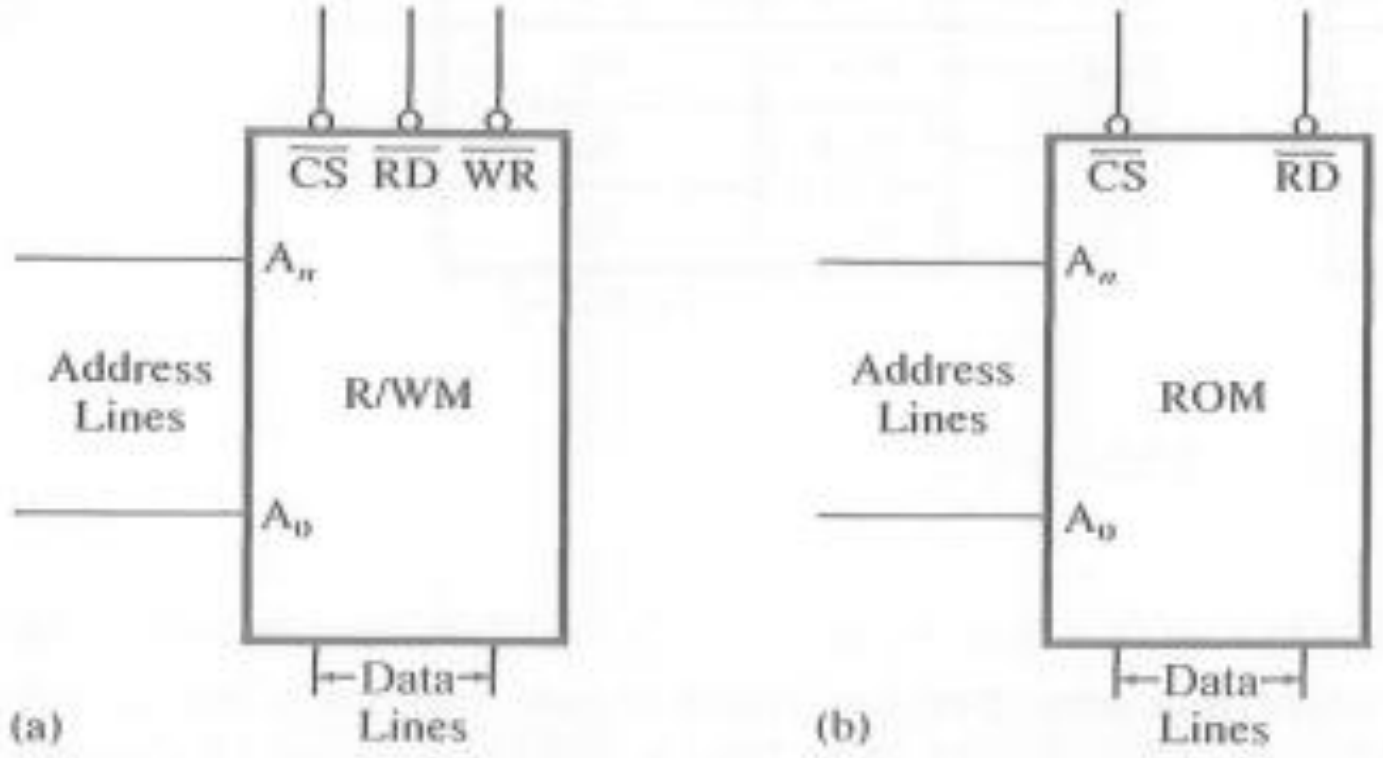
4 X 8 BIT REGISTER



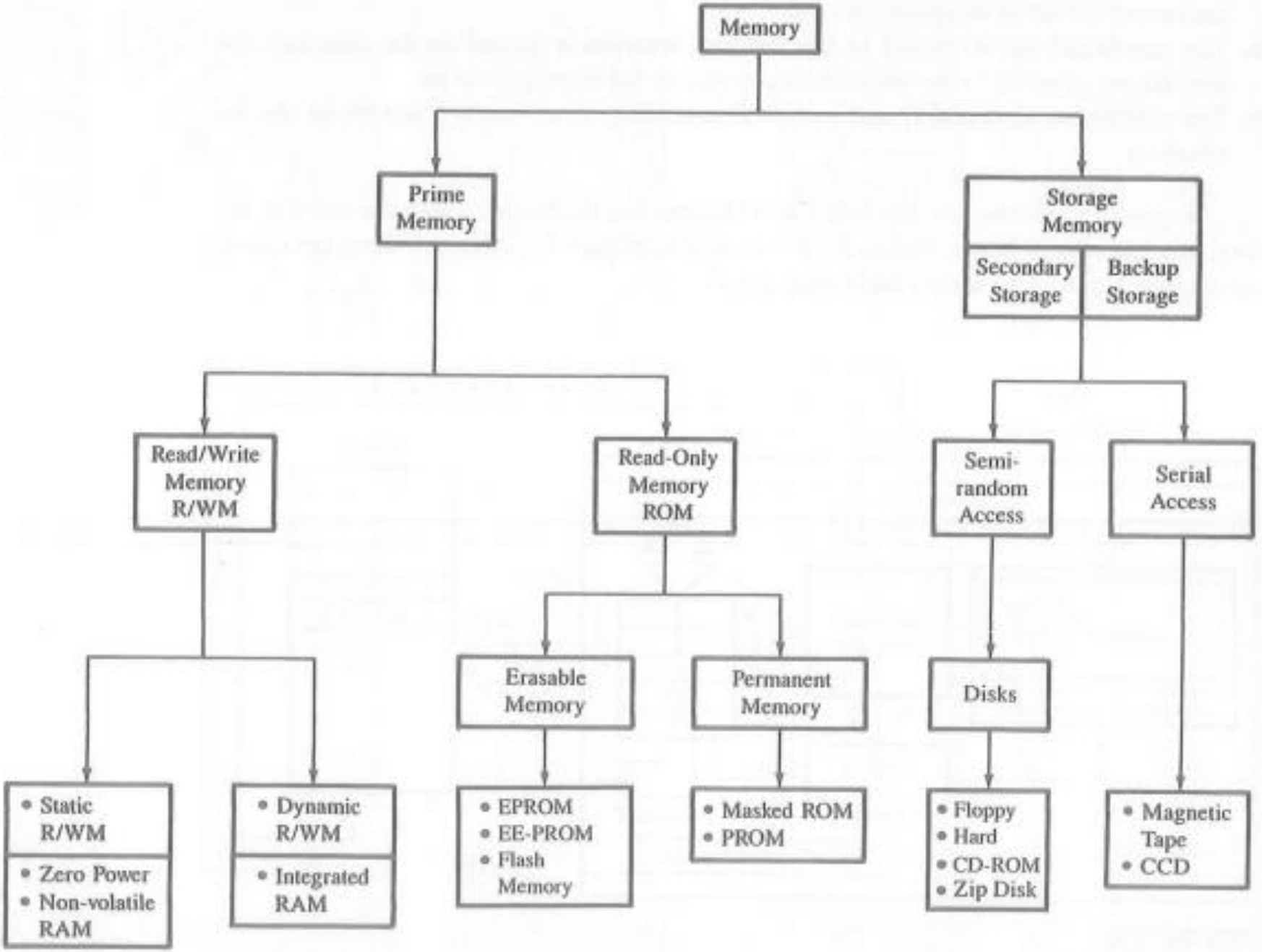
TWO MEMORIES WITH CHIP SELECT



R/W MEMORY MODEL & ROM MODEL



MEMORY


Memory
Prime Memory
Storage Memory
Secondary Storage
Backup Storage
Read/Write Memory R/WM
Read-Only Memory ROM
Semi-random Access
Serial Access
Erasable Memory
Permanent Memory
Disks
• Static R/WM
• Zero Power
• Non-volatile RAM
• Dynamic R/WM
• Integrated RAM
• EPROM
• EE-PROM
• Flash Memory
• Masked ROM
• PROM
• Floppy
• Hard
• CD-ROM
• Zip Disk
• Magnetic Tape
• CCD

INPUT/OUTPUT DEVICES

- I/O with 8-Bit address- peripheral mapped I/O
- I/O with 16-bit address- Memory Mapped I/O

- System Bus – wires connecting memory & I/O to microprocessor
  - Address Bus
    - Unidirectional
    - Identifying peripheral or memory location
  - Data Bus
    - Bidirectional
    - Transferring data
  - Control Bus
    - Synchronization signals
    - Timing signals
    - Control signal

8085 Microprocessor Architecture

- 8-bit general purpose µp
- 8 bit Data bus
- 16 bit address bus, Capable of addressing 64 k of memory
- Has 40 pins
- Requires +5 v power supply
- Operates on clock cycle with 50% duty cycle.
- It ahs on chip clock generator. The internal clock generator divides oscillator frequency by 2 and generates clock signal.
- Can operate with 3 MHz clock

Features (Contd….)

- The lower 8 bit address bus (A0-A7) & data bus(D0-D7) are multiplexed to reduce the number of pins.

- Supports 74 Instructions with 5 addressing modes.

- 5 hardware Interrupts-TRAP, RST 7.5, RST 6.5, RST 5.5 and INTR.

- It has serial I/O control which allows serial communication.