SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
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SECA1404 – Microprocessor & Microcontroller Based Systems

Course Handled

By

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SECA1404	MICROPROCESSOR AND MICROCONTROLLER BASED SYSTEMS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the operation of microprocessors and microcontrollers.
- To understand the machine language programming.
- To understand the interfacing techniques and their applications.

UNIT 1 BASIC CONCEPTS **9 Hrs.**

8085 Microprocessor - Architecture and its operation, Concept of instruction execution and timing diagrams, fundamentals of memory interface - Addressing modes.

UNIT 2 8085 INSTRUCTION SET AND ASSEMBLY LANGUAGE PROGRAMMING **9 Hrs.**

Instruction classifications, Writing and executing simple programs - Arithmetic and logic operations – Data transfer - Branching - Looping – Indexing - Counter and time delays - Writing subroutine - Conditional call and return instruction, simple programs.

UNIT 3 INTERFACING **9 Hrs.**

Basic Interface concepts, memory mapped I/O and I/O mapped I/O, Interrupt and vectored interrupt, Programmable peripheral interface 8255 - Programmable Interval timer 8253 - Programmable interrupt controller 8259 - Programmable DMA controller 8257.

UNIT 4 8086 ARCHITECTURE **9 Hrs.**

Architecture – Minimum mode and Maximum mode operation – Address Generation - Addressing modes - Overview of 8086 instruction set - Instruction format - Assembler Directives – Designing a Single Board Computer.

UNIT 5 MICROCONTROLLER **9 Hrs.**

Introduction - Architecture of 8051 - Memory organization - Addressing modes - Instruction set – Assembly Language Programming - Jump, Loop and Call Instructions - Arithmetic and Logic Instructions - Bit Operations -Programs – Introduction to Arduino.

TEXT / REFERENCE BOOKS

1. Ramesh Goankar, "Microprocessor architecture programming and applications with 8085 / 8088", 5th Edition, Penram International Publishing.
2. A.K.Ray and Bhurchandi, "Advanced Microprocessor", 1st Edition, TMH Publication.
3. Kenneth J.Ayala, "The 8051 microcontroller Architecture, Programming and applications" 2nd Edition ,Penram international.
4. Doughlas V.Hall, "Microprocessors and Digital system", 2nd Editon, Mc Graw Hill,1983.
5. Md.Rafiquzzaman, "Microprocessors and Microcomputer based system design", 2nd Editon,Universal Book Stall, 1992.
6. Hardware Reference Manual for 80X86 family", Intel Corporation, 1990.
7. Muhammad Ali Mazidi and Janice Gillispie Mazidi, "The 8051 Microcontroller and Embedded Systems", 2nd Edition, Pearson.
8. "Arduino Made Simple" by Ashwin Pajankar.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the architecture and functional blocks of Processor 8085.

CO2 - Understand the addressing modes and instructions of Microprocessor 8085.

CO3 - Learn the architecture and functions of important interface chips.

CO4 - Understand the architecture and functional blocks of Processor 8086.

CO5 - Learn the architecture and functions of 8051 and basics of Arduino controller.

CO6 - Design and implement Microprocessor and Microcontroller based system.

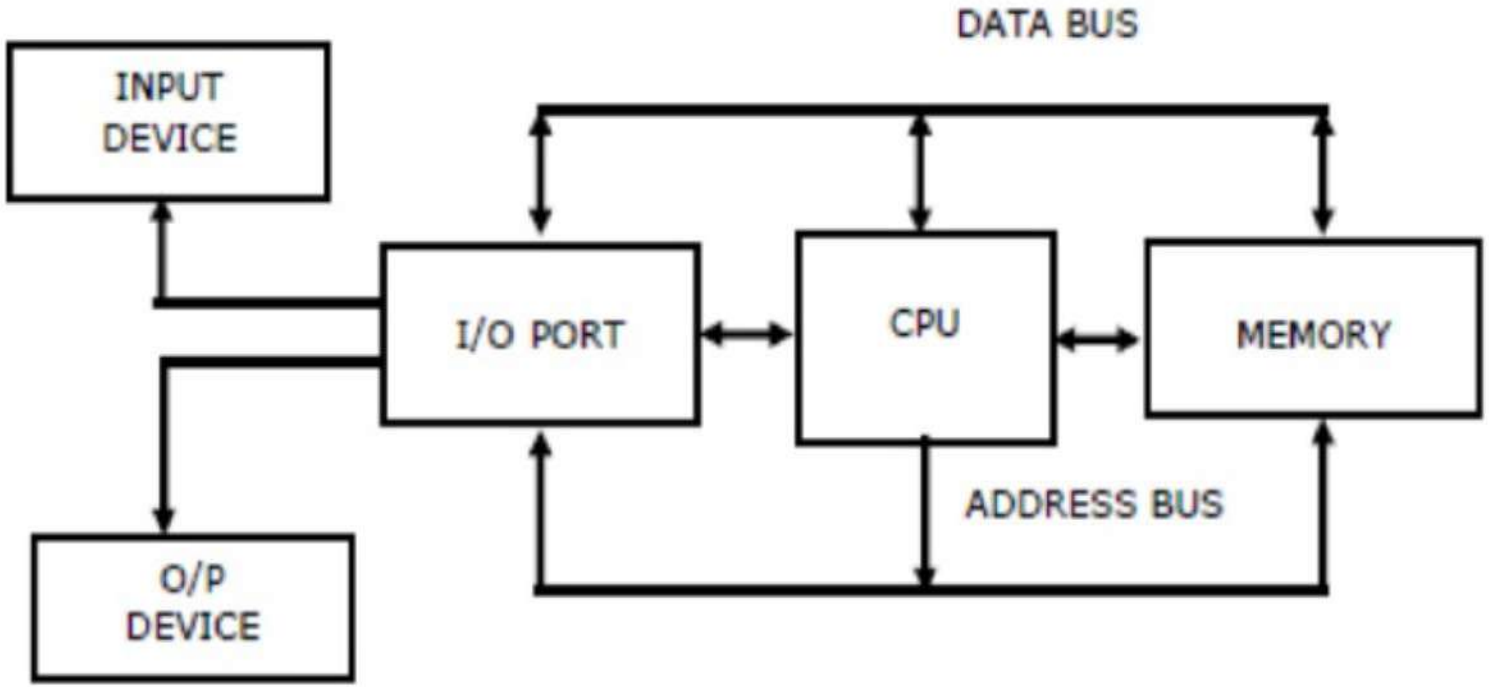
SECA1404 – Microprocessor & Microcontroller Based Systems

Topics to be covered

- Introduction
- Key points of Microprocessor & Microcontroller
- Features of 8085
- Bus Structure
- Architecture of 8085
- Timing & Control Unit
- Concepts of Registers
- PIN Description
- Concepts of Interrupts
- Concepts of Timing Diagrams
- Model University Questions

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller

General Structure of a Microcomputer system



Fig(1): General Structure

Key Points:

- CPU (Microprocessor or Microcontroller)
- Input Unit
- Output Unit
- Ports & Bus

(Fig-1) Image Adopted from: https://krisjavahmi.wordpress.com/2016/02/13/what-is-required-at-the-beginning

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller

Microprocessor: Is a Program controlled semiconductor device which reads data from memory, Decodes and executes the instructions. Also known as Central Processing Unit in computers (CPU).

An integrated circuit that contains all the functions of a central processing unit of a computer.

- **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 as Instructions, Words, Bytes, etc.**
- **They process 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 brakes them into 8-bit pieces and processes each group of 8-bits separately.**

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller

Microcontroller: Is a Programable semiconductor IC capable of performing Arithmetic and Logical operations. Microcontroller contains ALU, Registers, I/O Ports, Timing & Control circuits, **Memory**.

Microprocessor	**Microcontroller**
Moves code and data between processor and External memory **Presence of External Peripheral**	Moves code and data within the controller **RAM,ROM,EEPROM embedded in it**
Contains ALU/CPU, Registers, Control Units	Contains ALU, Registers, Timing &Control Units
Memory is connected externally with the CPU	Memory is present inside as an internal unit
Used to design General purpose systems	Used to design Application Specific Systems
High processing speed till 1 GHz	**Low processing speed 8 MHz – 50 MHz**
High Power consumption	**Low Power consumption**
Bulky	Compact

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller

4 bit processor - 4 bit data
Intel 4004 – first 4 bit programmable device – Used in calculators

8 bit processor – 8 bit data pipe

Intel 8008

Intel 8080 – Widely used in control applications, small computers

Motorola 6800

Zilog Z80

Intel 8085

16 bit processor – 16 bit data pipe

Intel 8086 / 88

Intel 80186 / 188

Intel 80286

Intel MCS-96

Zilog Z8000

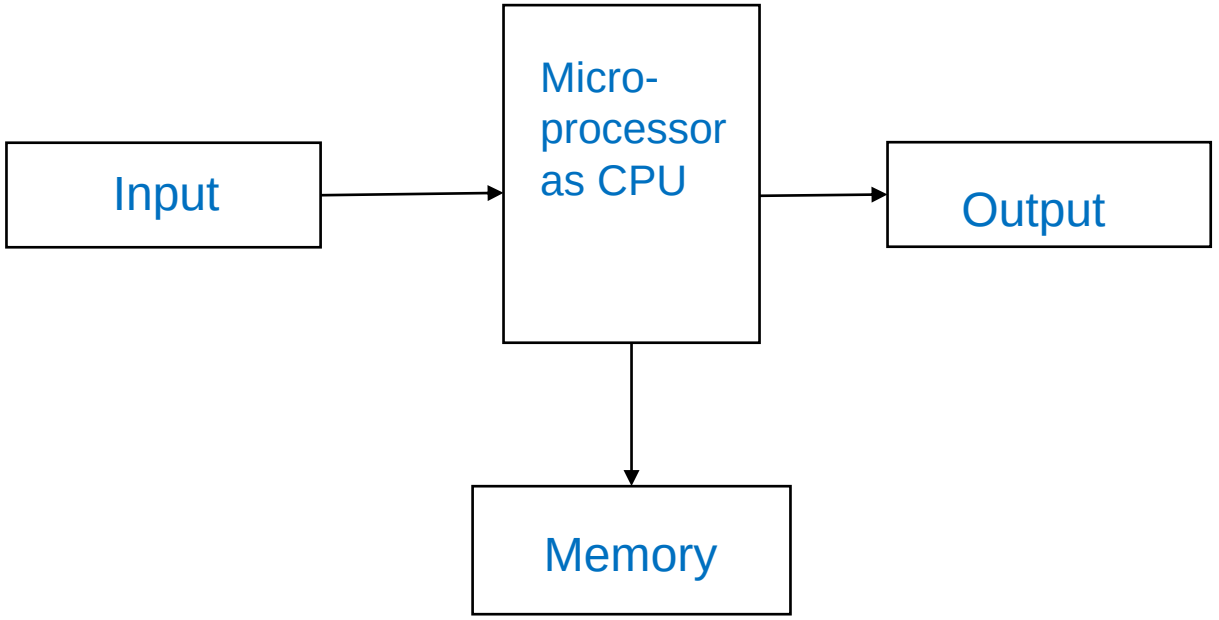
Motrola 68000

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller

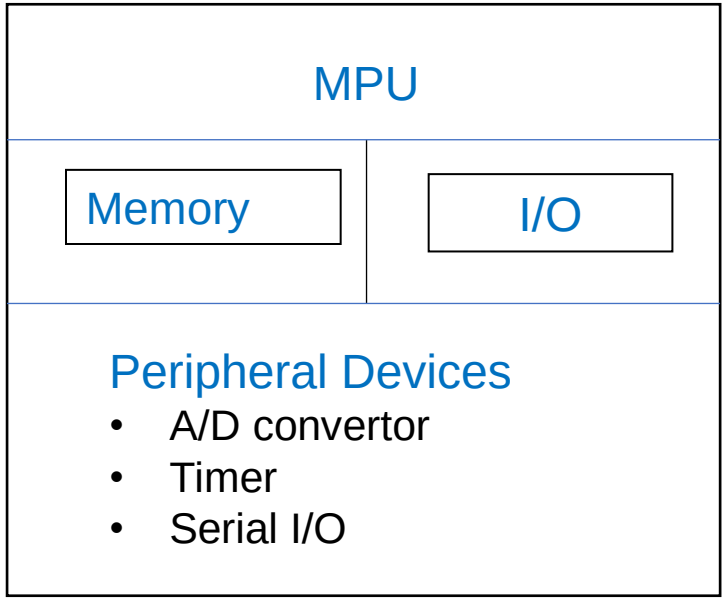
11th Generation Intel Core i9 Processors

Product Name	Status	Processor Base Frequency
Intel® Core™ i9-11900 Processor (16M Cache, up to 5.20 GHz)	Launched	2.50 GHz
Intel® Core™ i9-11900T Processor (16M Cache, up to 4.90 GHz)	Launched	1.50 GHz
Intel® Core™ i9-11900KF Processor (16M Cache, up to 5.30 GHz)	Launched	3.50 GHz

Introduction to Microcomputer – Concepts of Microprocessor & Microcontroller



Fig(2):Microcomputer with Microprocessor as CPU



Fig(3):Microcontroller Block

Points to remember:

- CPU = ALU & Control Unit
- MPU = Microprocessor Unit

Microprocessor & Microcontroller - Applications

Applications

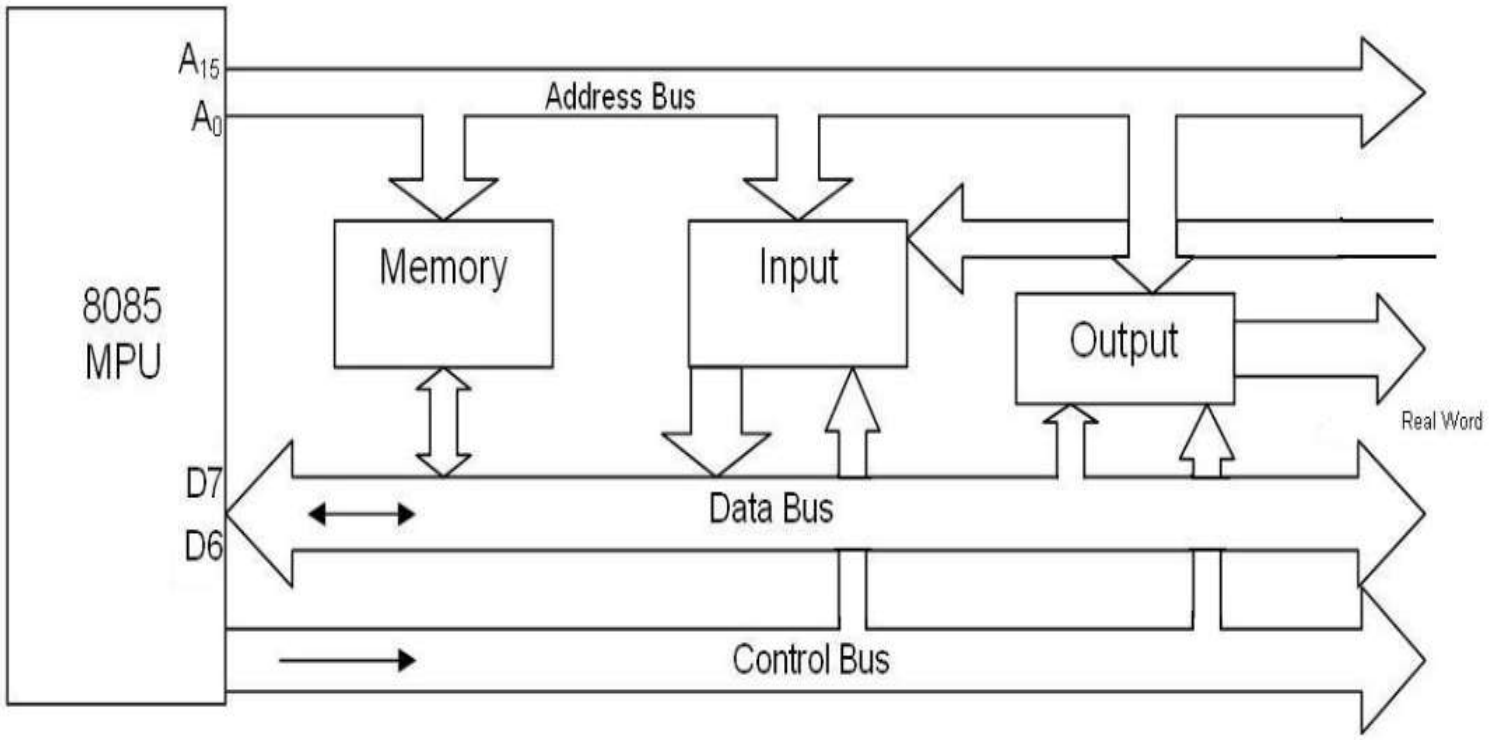
- braking system
- fuel system
- heating and air conditioning
- lighting system
- digital displays
- GPS system
- in car audio system
- Mobile phones
- Digital cameras
- Traffic light systems
- Car park barriers
- Cars
- Aircraft
- Lifts
- Rides at theme parks
- Computer controlled lighting systems at discos and concerts
- Remote controlled car
- Games console
- Washing machines
- Microwave cookers
- Dishwashers
- Electric kettles
- Fridges
- DVD players
- Remote control television
- Hairdryers
- Electric toothbrushes
- Central heating systems
- Burglar Alarm system
- External Security lights

Introduction – 8085

Features of 8085:

- 8-bit general purpose Microprocessor
- It is a 40 pin DIP IC &Requires +5 V power supply
- Can operate with 3 -6 MHz clock frequency
- It has 16 Bit Address lines
- 8 bit Data lines[Multiplexed with lower 8 bit address lines] (AD0- AD7)
- 16 Bit (PC)Program counter & 16 Bit Stack pointer (SP)
- Six 8 bit General purpose registers B,C,D,E,H,L (can be arranged in pairs BC,DE,HL)

Introduction – Bus Structure of 8085



Fig(4):8085 Bus structure

Points to remember:

Bus:

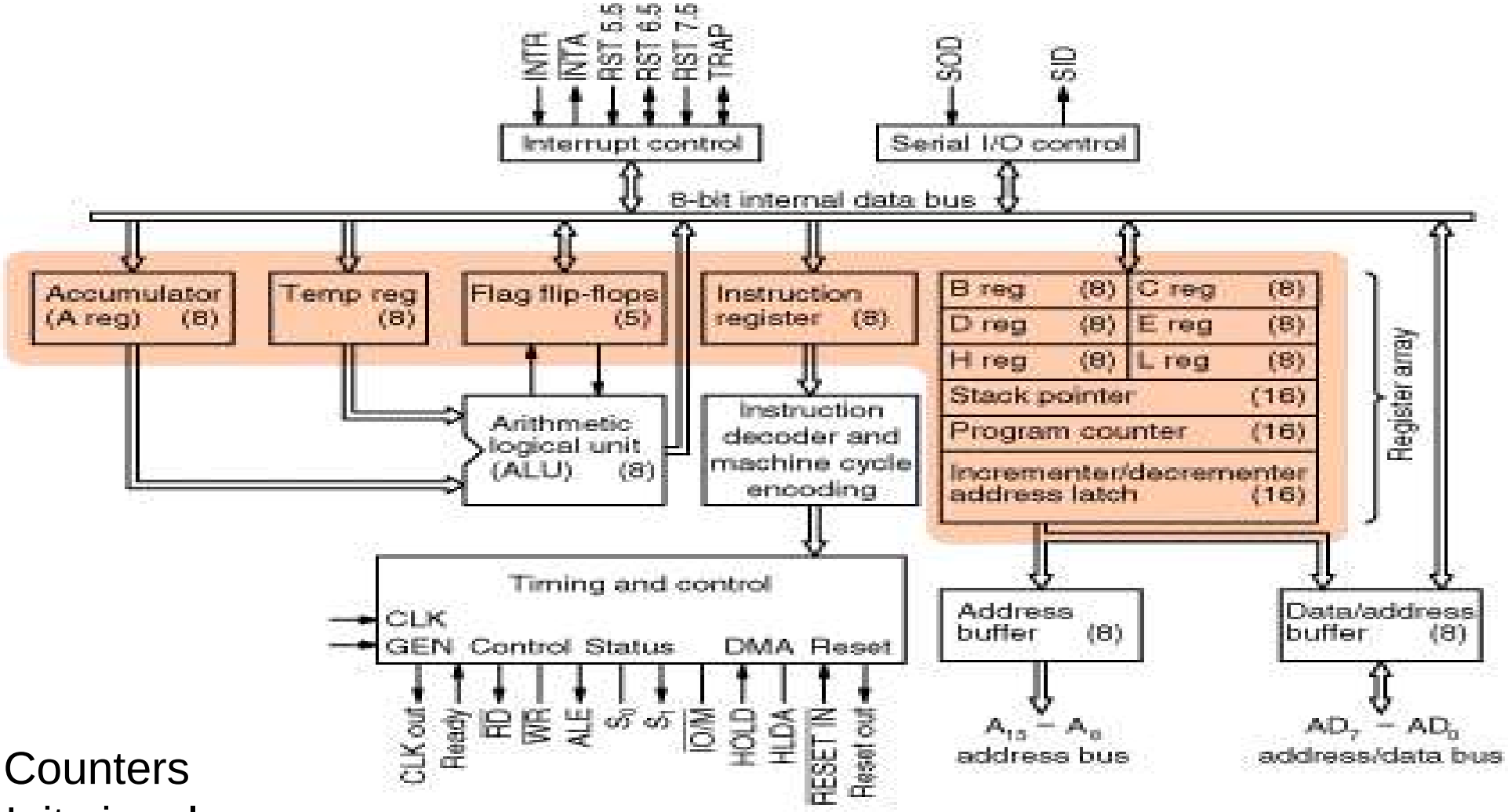
It is a collection of wire which is used to transfer the data or address information or control signals from source to destination.

Types:

1. Address Bus: To transfer 16 bit address (Unidirectional)
2. Data Bus: To carry 8 bit data(Bidirectional)
3. Control Bus: To carry control signals

(Fig-4) Image Adopted from: https://scanftree.com/microprocessor/Bus-Structure-8085

Architecture of 8085



Fig(5):8085 Architecture Diagram

Key Points:

- ALU
- Registers
- Flag Registers
- Stack & Program Counters
- Timing& Control Unit signals

(Fig-5) Image Adopted from: http://ce.sharif.edu/courses/86-87/1/ce126/resources/root/8085%20Microprocessor.pdf

Arithmetic and Logic Unit (ALU)

Performs the following operations:

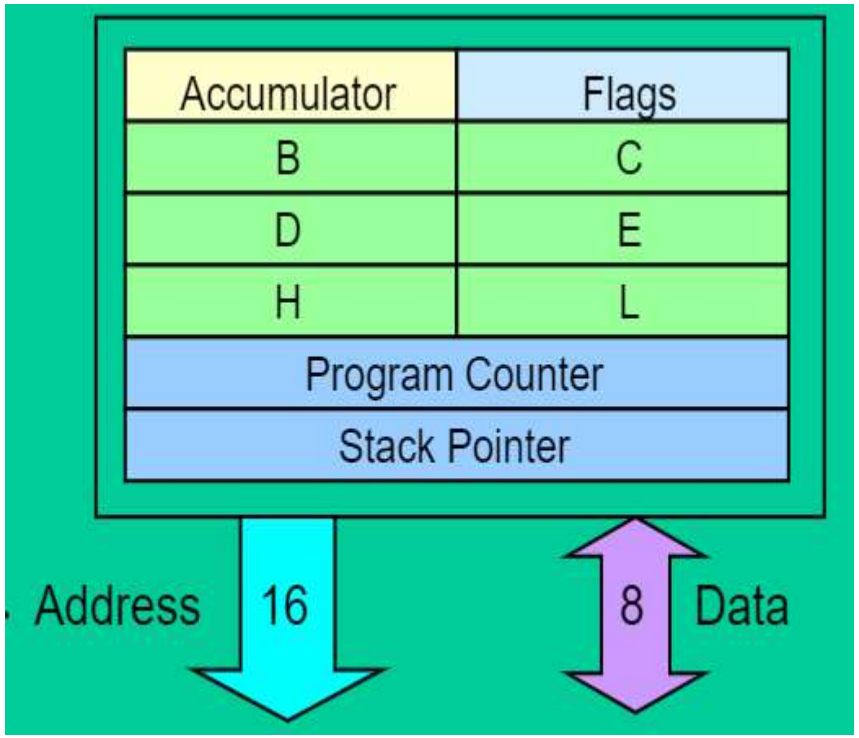
- Addition ,Subtraction
- Logical AND ,Logical OR, Logical EXCLUSIVE OR
- Complement (logical NOT), Compare operations
- Increment (add 1),Decrement (subtract 1) Operations
- Left shift / right shift

✓Accumulator (A) register & Temporary Registers holds the data during operation & After processing the result is stored in Accumulator(A)

✓Flag registers are set /reset based on the operation performed

Registers

- **Accumulator**
  - ✓The accumulator is an 8-bit register that is a part of arithmetic/logic unit (ALU).
  - ✓This register is used to store 8-bit data and to perform arithmetic and logical operations.
  - ✓ The result of an operation is stored in the accumulator. The accumulator is also identified as register A.
- **General Purpose Register:** B, C, D, E, H, and L.
- **Temporary Register-** W and Z register which is not available to programmer. Because it is used internally located above B and C register



Fig(6):8085 Registers

(Fig-6) Image Adopted from: inspirit.net.in/books/academic/8085%20Microprocessor%20-%20Ramesh%20Gaonkar.pdf

Special Purpose Register

Program Counter (PC)

- ✓16-bit Special Purpose register deals with sequencing the execution of instructions
- ✓This register is a memory pointer.
- ✓The function of the program counter is to point to the memory address from which the next byte is to be fetched.
- ✓When a byte (machine code) is being fetched, the program counter is incremented by one to point to the next memory location

Stack Pointer (SP)

- The stack pointer is also a 16-bit register which is used to point memory location called stack. Memory area in which data to be retrieved are placed. The beginning of the stack is defined by loading 16-bit address in the stack pointer. Accessed Last in First out(LIFO)

Special Purpose Register

Instruction Register / Decoder

- Temporary storage for the current instruction of a program
- Latest instruction sent here from memory prior to execution
- Decoder then takes instruction and ‘decodes’ or interprets the instruction
- Decoded instruction then passed to next stage
- Not programable
- Can’t accessed by instructions

Example: Assume A = 56H,When an instruction MOV C,A is given ,

Process Flow:

- The opcode for MOV C,A is 4FH.Its placed in data bus from memory
- From Data Bus 4FH is placed in Instruction Decoder (After this ,its decoded)
- Content of Accumulator(56H) is moved temporary register in ALU
- Now from Temporary register the content is moved to C register

Flag Registers

D7	D6	D5	D4	D3	D2	D1	D0
S	Z	X	AC	X	P	X	CY

→ Data bits

→ Flag Registers

Sign Flag(S): After the arithmetic or logical operation D7 bit is 1.sign flag will be SET. Otherwise RESET. Sign flag indicates that

Example 1: Lets assume an operation has resulted a value of 80H .It can be represented as

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	0	0	0	0	0

Now D7(MSB) =1 .Then it indicates a negative number (sign flag is set)

If D7 = 0 , the number is considered as positive

Zero Flag(Z): when arithmetic operation results in zero, then Zero (Z) flag is set to one

Example: Lets assume that a value of 5 is stored in accumulator (A register). Now a command to subtract the accumulator(A) with a value of 5 is given. Then the result will be ZERO. Now D6 bit =1.

D7	D6	D5	D4	D3	D2	D1	D0
1	1	0	0	0	0	0	0

Flag Registers

D7	D6	D5	D4	D3	D2	D1	D0
S	Z	X	AC	X	P	X	CY

→ Data bits

→ Flag Registers

Auxiliary Carry Flag(AC): Used in BCD number systems. In any arithmetic or logical operation a overflow from D3 to D4 bit occurs then AC Flag is =1 (set) otherwise RESET.

Example: Let us assume that, A=1BH& B=28H,when we add these two numbers the result is 4BH.In this operation a carry overflow occurs from D3 to D4.

Hence D4 bit = SET

Parity Flag(P): Number of one's present in accumulator. If there is even number of one's Even parity will set , P - 1. If there is odd number of one's odd parity will set, P- 0.

Carry Flag(CY): The flag is set if there is overflow out of bit 7.

When we add 45H & B3H as shown then we have a overflow at D7 bit, Then CY Flag is = 1(SET)

45H – 0 1 0 0 0 1 0 1

B3 H - 1 1 1 1 0 0 1 1

1] 0 0 1 1 1 0 0 0

Timing and Control Unit

- It synchronizes all microprocessor operations with the clock signal
- Contains an oscillator and a sequencer. Oscillator generates clock signals which are used to synchronize the registers

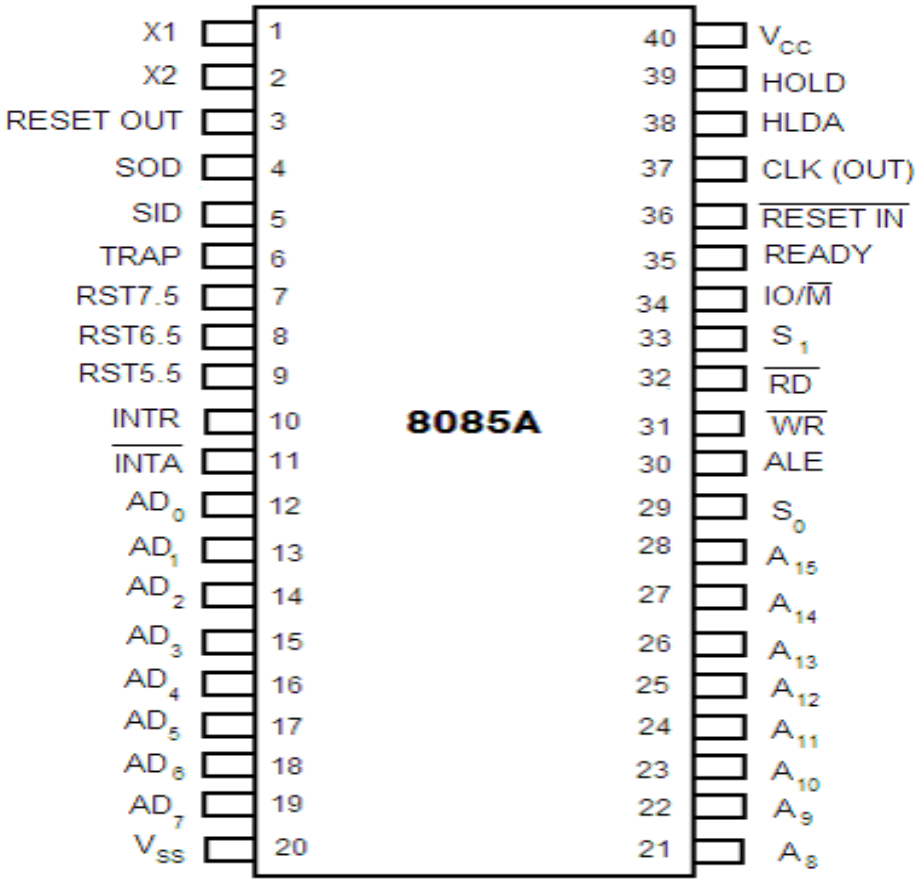
  Status Signals :S0,S1,IO/M'

  Control signals : READY,RD',WR',ALE

  DMA signals: HOLD,HLDA

  RESET Signals: RESETIN',RESETOUT'
- It controls the operation of different units of the CPU.
- It controls the data flow between CPU and Memory, CPU and peripheral devices.
- It provides control, status and reset signals to perform any memory and input output related operation.

8085 PIN DESCRIPTION



Fig(7):PIN Diagram of 8085

ALE (Address Latch Enable**)**

Address latch enable, during the first clock state of a machine cycle, it become high and enables the address to get latched either in to the memory or external latch.

Read(RD') (active low output):

The Read signal indicates that data are being read from the selected I/O or memory device and that they are available on the data bus.

WRITE(WR') (active low output):

The Write signal indicates that data on the data bus are to be written into a selected memory or I/O location.

IO/M':

It is a signal that distinguishes between a memory operation and an I/O operation. When IO/M= 0 it is a memory operation and IO/M= 1 it is an I/O operation.

8085 PIN DESCRIPTION - Continued

S1 and S0 (output): These are status signals used to specify the type of operation being performed;

The microprocessor performs primarily four operations:

I. Memory Read: Reads data (or instruction) from memory.

II. Memory Write: Writes data (or instruction) into memory.

III. I/O Read: Accepts data from input device.

IV. I/O Write: Sends data to output device.

Table1: Status Signal

Operation	S0	S1
Opcode Fetch	1	1
Read	0	1
Write	1	0
Halt	0	0

8085 PIN DESCRIPTION – Key points

Address and Data Buses:

- A8 – A15 (output, 3-state): Most significant eight bits of memory addresses and the eight bits of the I/O addresses.
- AD0 – AD7 (input/output, 3-state): Lower significant bits of memory addresses and the eight bits of the I/O addresses during first clock cycle. Behaves as data bus

Externally Initiated and Interrupt Signals:

- RESETIN': When the signal on this pin is low, the PC is set to 0, the processor is reset.
- RESETOUT': This signal indicates that the processor is being reset. The signal can be used to reset other devices.
- READY: When this signal is low, the processor waits for an integral number of clock cycles until it goes high.

Serial I/O Signals:

- SID: Serial input signal: Bit on this line is loaded to D7 bit of register A using RIM instruction.
- SOD: Serial output signal: Output SOD is set or reset by using SIM instruction.

Interrupts - Basics

- When 8085 receives an interrupt signal from a peripheral device, it stops its current process and the control is transferred to the external device.

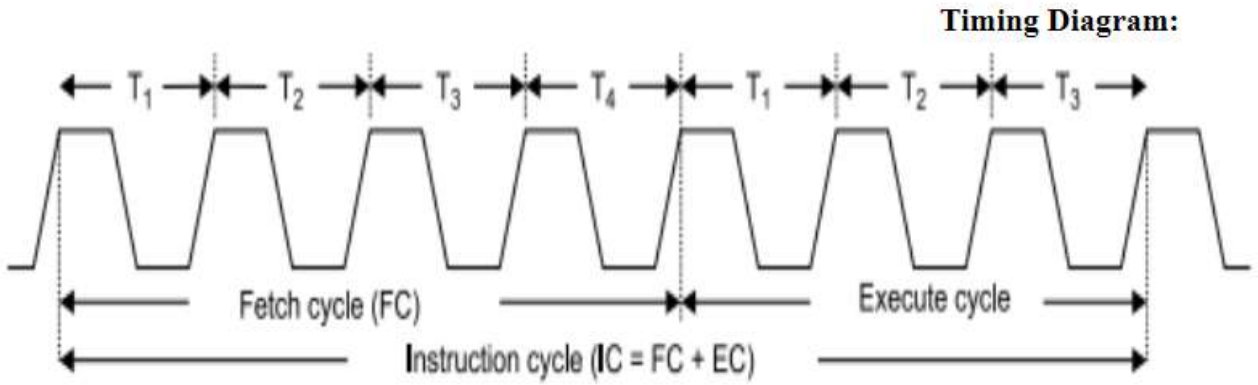
Table2: Interrupts Priority Table

Name	Priority	Address
TRAP	1	0024H
RST 7.5	2	003CH
RST6.5	3	0034H
RST 5.5	4	002CH

Points to remember

- **Types of Interrupts:**
  - Hardware & Software Interrupts
  - Vectored & Non vectored Interrupts
  - Maskable & Non Maskable Interrupts
- **HOLD:** This signal indicates that a peripheral like DMA (direct memory access)
- **HLDA:** This signal acknowledges the HOLD request.
- **INTR:** Interrupt request is a general-purpose interrupt.
- **INTA :** This is used to acknowledge an interrupt.
- **RST** 7.5, RST 6.5, RST 5.5 – restart interrupt: These are vectored interrupts and have highest priority than INTR interrupt
- **TRAP:** This is a non-maskable interrupt and has the highest priority.

Timing Diagram



Fig(8): 8085 Timing Cycle

8085 processor performs

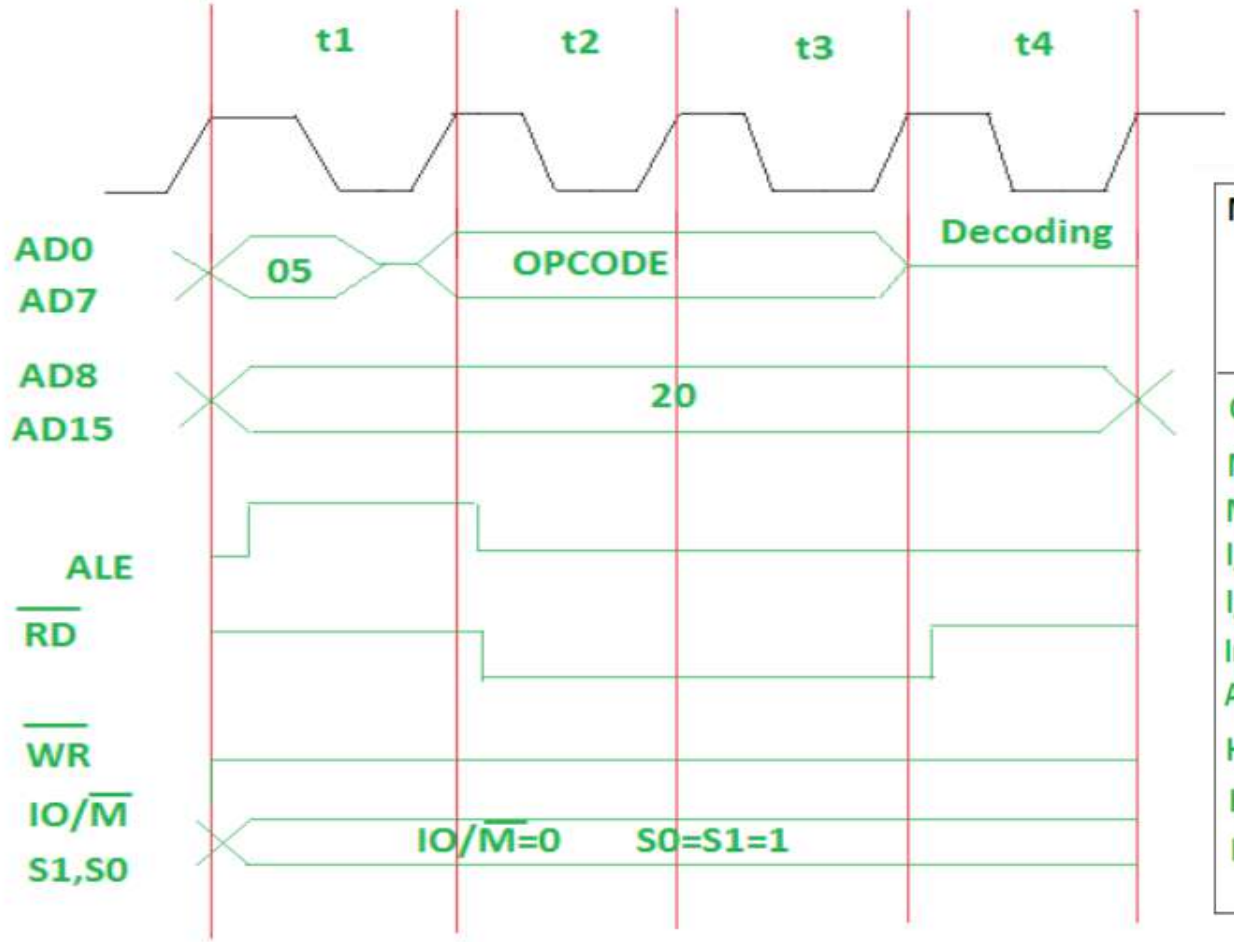
- Opcode fetch
- Operand fetch
- Memory read/write
- I/O read/write

Key Points to remember

- Instruction Cycle: Time taken by the processor to execute an instruction
  It can involve 1 to 6 Machine cycles
  Instruction cycle = Fetch cycle+ Execute cycle
- Machine cycle: Time required to complete one operation. Contains 3 to 6 T-States.
- T-States: Denotes one Clock period

Figure Adapted from: https://www.zseries.in/embedded%20lab/8085%20microprocessor/timing%20diagram.php

Timing Diagram – Opcode Fetch



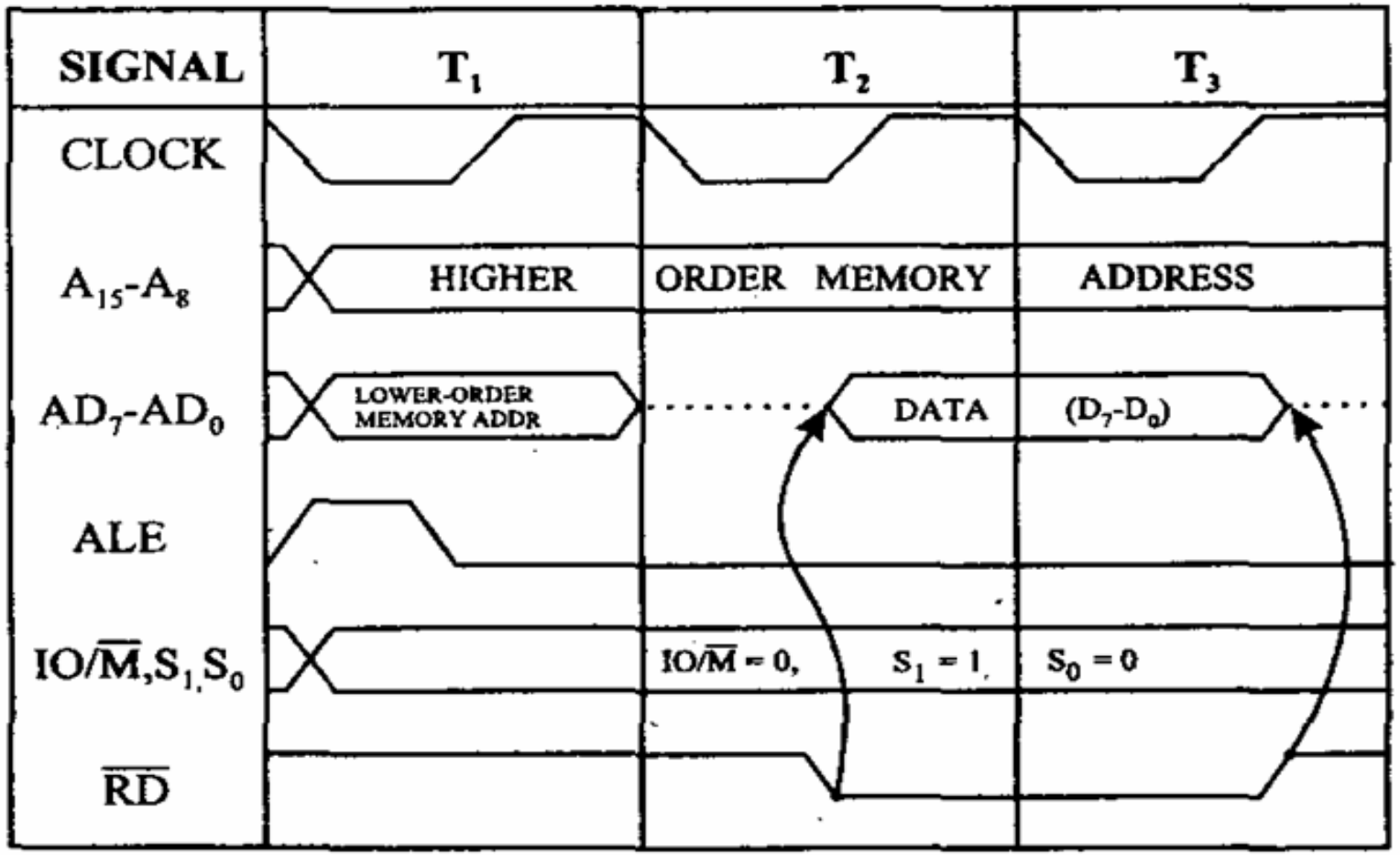
Timing diagram for opcode fetch

Machine Cycle	Status			Control Signals		
	IO/$\overline{M}$	S1	S0	$\overline{RD}$	$\overline{WR}$	$\overline{INTA}$
Opcode Fetch	0	1	1	0	1	1
Memory Read	0	1	0	0	1	1
Memory Write	0	0	1	1	0	1
I/0 Read	1	1	0	0	1	1
I/O Write	1	0	1	1	0	1
Interrupt Acknowledge	1	1	1	1	1	0
HALT	Z	0	0	Z	Z	1
HOLD	Z	X	X	Z	Z	1
RESET	Z	X	X	Z	Z	1

Fig(9): Opcode Fetch Timing Cycle

(Fig-9) Image & Table Adopted from: https://www.geeksforgeeks.org/instruction-cycle-8085-microprocessor

Timing Diagram – Memory Read



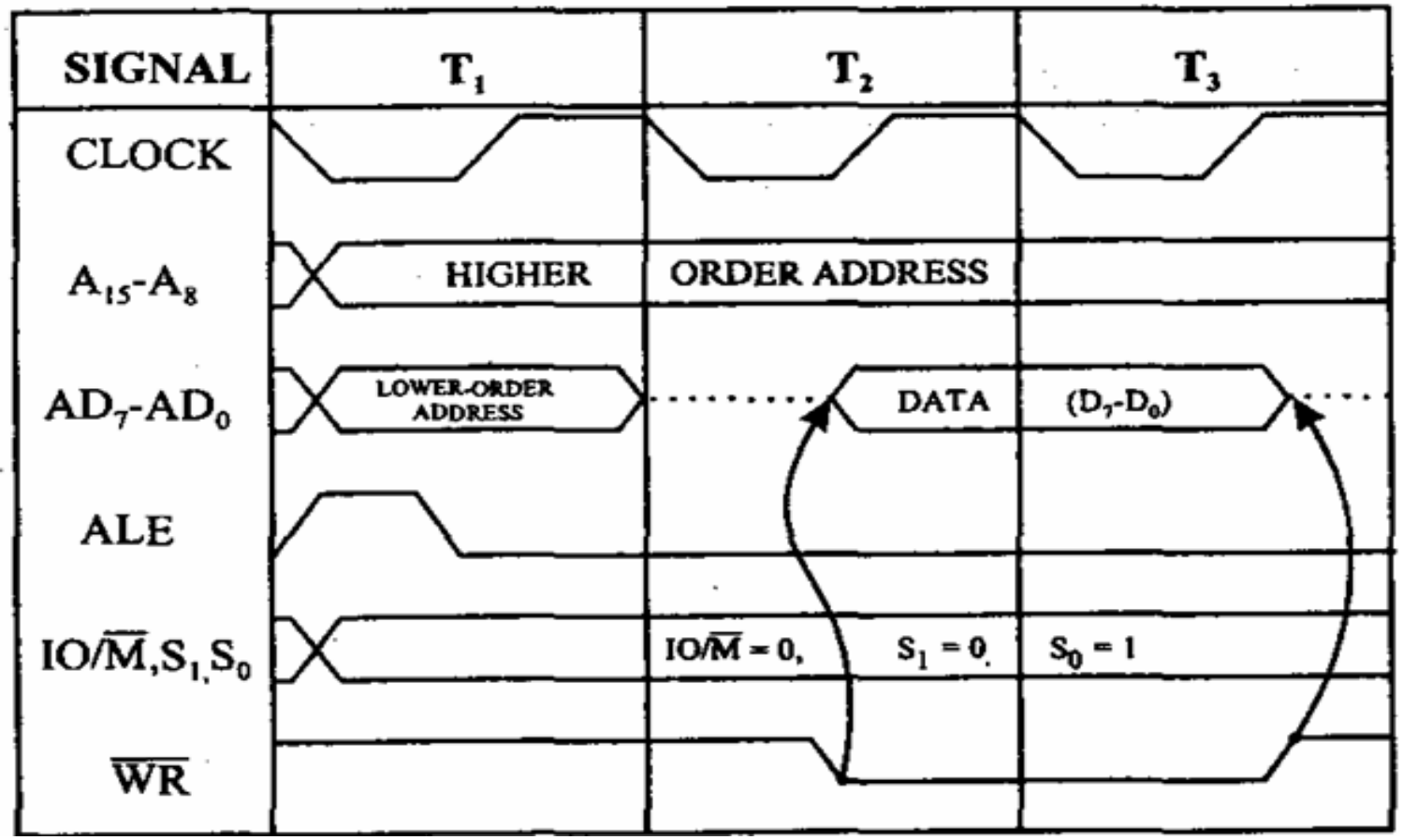
Key points:

- Fetches one byte from memory
- It has 3 T states
- Used to fetch opcode or operand from the memory

Fig(10): Memory Read Timing Diagram

Image Adapted from: https://www.zseries.in/embedded%20lab/8085%20microprocessor/timing%20diagram.php

Timing Diagram – Memory write



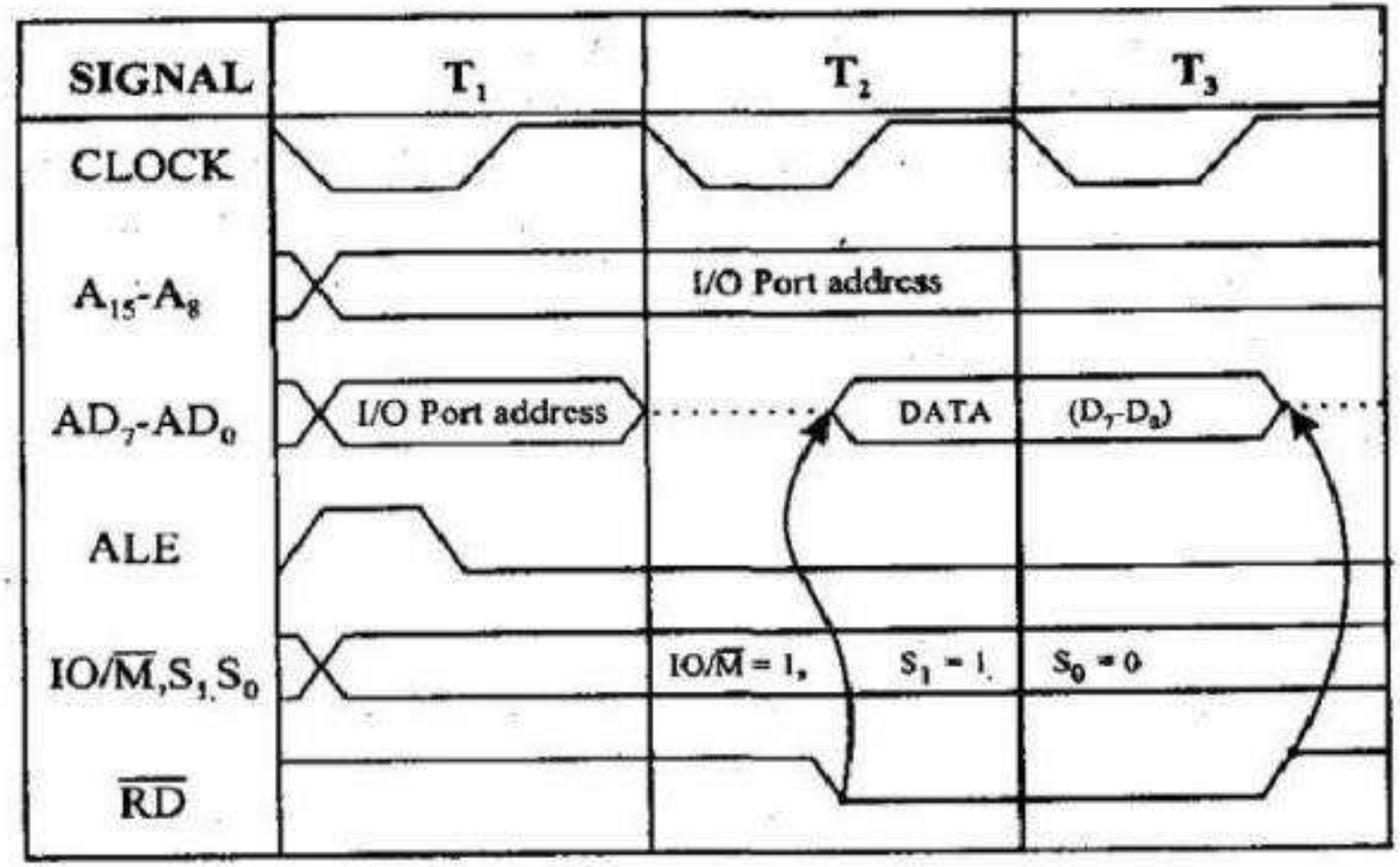
Fig(11): Memory Write Timing Diagram

Key points:

- Used to send one byte into memory
- It has 3 T states

Image Adapted from:
https://www.zseries.in/embedded%20lab/8085%20microprocessor/timing%20diagram.php

Timing Diagram – I/O Read



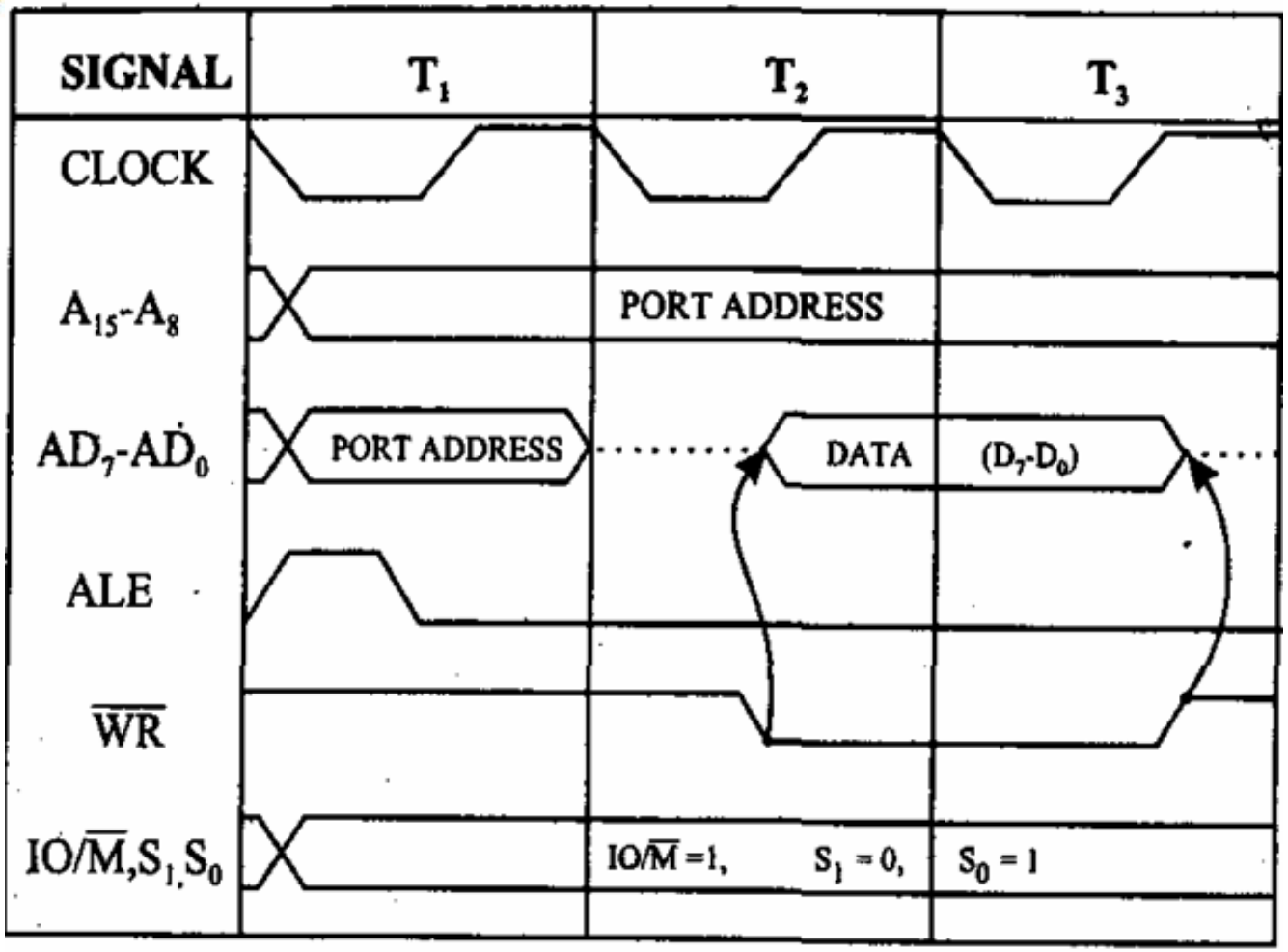
Fig(12): I/O Read Timing Diagram

Key points:

- Fetches one byte from I/O Port
- It has 3 T states

Image Adapted from:
https://www.zseries.in/embedded%20lab/8085%20microprocessor/timing%20diagram.php

Timing Diagram – I/O Write



Key points:

- Used to write one byte into IO device
- It has 3 T states

Fig(13): I/O Read Timing Diagram

Image Adapted from: https://www.zseries.in/embedded%20lab/8085%20microprocessor/timing%20diagram.php

Addressing modes for 8085:

The method of specifying the data or operand to be operated.

Types:

- Immediate Addressing Mode
- Register Addressing Mode
- Direct Addressing Mode
- Indirect Addressing Mode
- Implied Addressing Mode

Addressing modes for 8085:

Indirect Addressing Mode:

- The content of the register is used to specify the address of the operand

Ex: **MOV A, M** →Move the content of the memory location whose address is given in H and L register in the accumulator

ADD M →Addition of the content of the memory location whose address is given in H and L register and in the accumulator

Implied Addressing Mode:

- Opcode specifies the address of the operand

EX: **CMA** → Complements the content of the accumulator

RAL→ Rotate the content of the accumulator left through carry

Addressing modes for 8085:

Immediate Addressing Mode:

- The data is present in the instruction itself is called Immediate Addressing Mode.

Ex: **MVI A, 03H-**→The data 03 is moved to accumulator.

ADI 03H →The data 03 is added immediately to the accumulator.

Register Addressing Mode:

- The data is moved from one register to another register is called Register Addressing Mode .

Ex: **MOV A, B** → The data is moved from one register to another register

ADD C →The data present in C register is added with data present in accumulator and saved in accumulator.

Direct Addressing Mode:

- The address of the operand always exist with in the instruction.

Ex: **LDA 4500H** →Load the content of the memory location 4500 in to the accumulator

STA 4600H →Store the content of the accumulator in the memory location 4600

Model Questions
(Previous years University questions shown as samples)

Unit -1 / Part-B

1. Draw the Block diagram of 8085 and explain Each block. (Sathyabama – BE-ECE/EEE/P-EEE -SEP 2018)
2. Explain the Architecture of 8085 MPU with its functional Block Diagram.(Sathyabama – ECEEEE/NOV-2018, MAY 2015)
3. Explain the addressing modes & its types. (Sathyabama – ECEEEE/NOV-2018, MAY 2015)
4. Draw and Describe the timing Diagram for IO Read and Memory Write cycle diagram and its input, output waveforms. (Sathyabama – BE-CSE/IT-MAY2018)
5. Illustrate the Timing and Control circuitry for 8085 microprocessor.

Model Questions
(Previous years University questions shown as samples)

Unit -1 / Part-A

1. Write register Indirect addressing mode with example for 8085 processor. (Sathyabama – CSE/IT/ECE/EEE/MAY-2018,)
2. Give the format of Flag register.(Sathyabama – CSE/ECE/EEE/MAY-2018,)
3. Explain the SID & SOP pins. (Sathyabama – ECEEEE/ MAY 2015)
4. What are the Interrupts available in 8085. (Sathyabama – BE-CSE/IT/ ECE-SEP-2018)
5. Differentiate microprocessor and microcontrollers.
6. Define Vectored Interrupts.
7. What is Maskable Interrupt?

THANK YOU