Assembly Language Programming of 8085

Topics

1. Introduction
2. Programming model of 8085
3. Instruction set of 8085
4. Example Programs
5. Addressing modes of 8085
6. Instruction & Data Formats of 8085

1. Introduction

- A microprocessor executes instructions given by the user
- Instructions should be in a language known to the microprocessor
- Microprocessor understands the language of 0’s and 1’s only
- This language is called **Machine Language**

- For e.g.

  01001111

  - Is a valid machine language instruction of 8085
  - It copies the contents of one of the internal registers of 8085 to another

A Machine language program to add two numbers

00111110	;Copy value 2H in register A
00000010	
00000110	;Copy value 4H in register B
00000100	
10000000	;A = A + B

Assembly Language of 8085

- It uses English like words to convey the action/meaning called as MNEMONICS
- For e.g.
  - MOV to indicate data transfer
  - ADD to add two values
  - SUB to subtract two values

Assembly language program to add two numbers

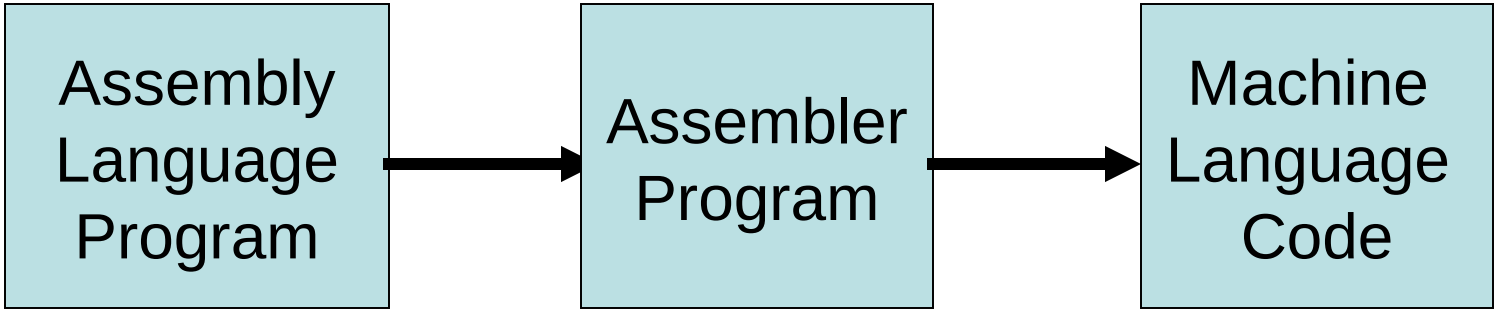
```
MVI A, 2H   ;Copy value 2H in register A
MVI B, 4H   ;Copy value 4H in register B
ADD B       ;A = A + B
```

Note:

- Assembly language is specific to a given processor
- For e.g. assembly language of 8085 is different than that of Motorola 6800 microprocessor

Microprocessor understands Machine Language only!

- Microprocessor cannot understand a program written in Assembly language
- A program known as **Assembler** is used to convert a Assembly language program to machine language

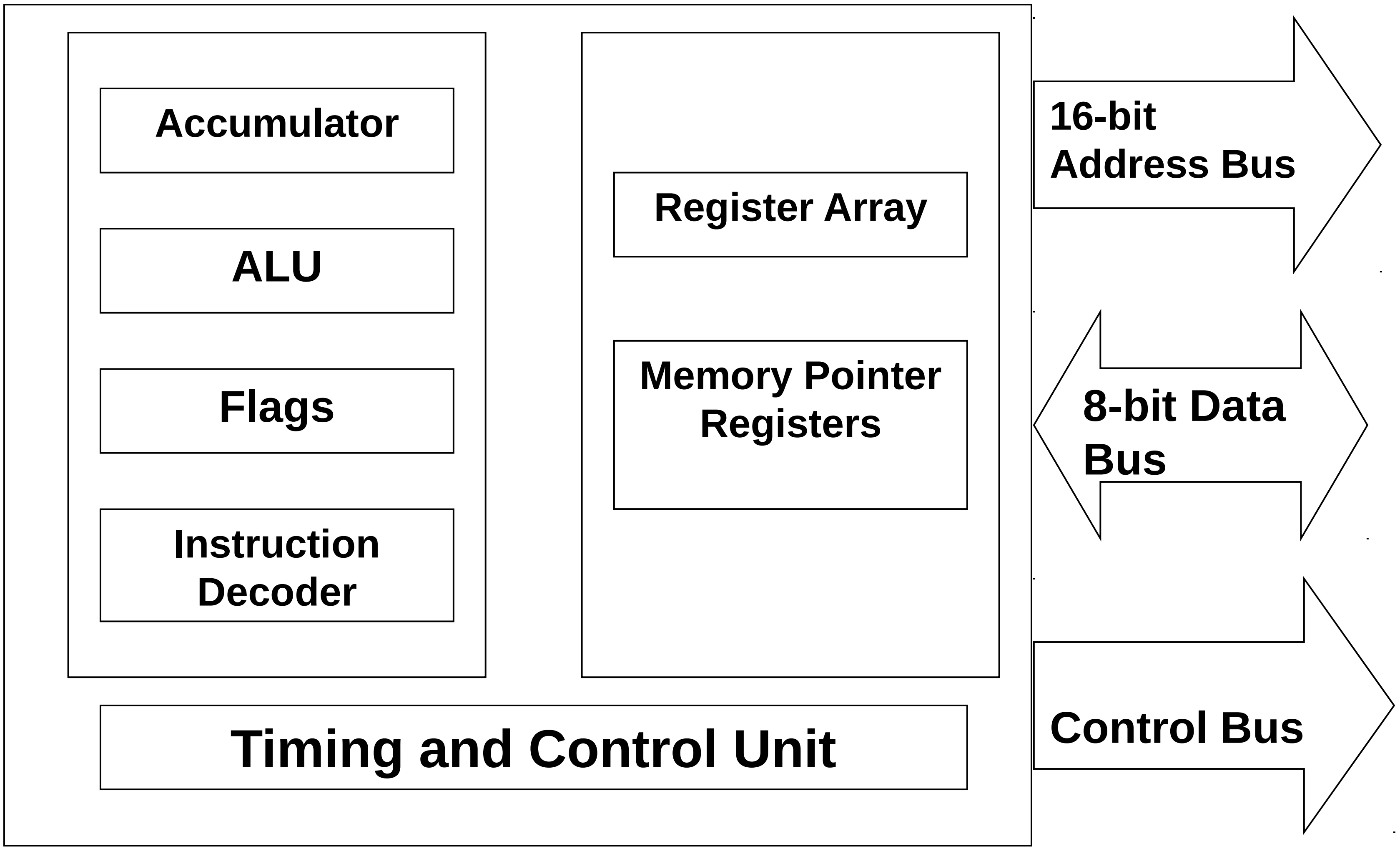


Low-level/High-level languages

- Machine language and Assembly language are both
  - Microprocessor specific (**Machine dependent**)

    so they are called
  - Low-level languages
- **Machine independent** languages are called
  - High-level languages
  - For e.g. BASIC, PASCAL,C++,C,JAVA, etc.
  - A software called **Compiler** is required to convert a high-level language program to machine code

2. Programming model of 8085



Accumulator (8-bit)	Flag Register (8-bit) **S** | **Z** | | **AC** | | **P** | | **CY**
B (8-bit)	C (8-bit)
D (8-bit)	E (8-bit)
H (8-bit)	L (8-bit)
Stack Pointer (SP) (16-bit)	
Program Counter (PC) (16-bit)	

8- Lines

Bidirectional

16- Lines

Unidirectional

Overview: 8085 Programming model

1. Six general-purpose Registers
2. Accumulator Register
3. Flag Register
4. Program Counter Register
5. Stack Pointer Register

1. **Six general-purpose registers**
   - B, C, D, E, H, L
   - Can be combined as register pairs to perform 16-bit operations (BC, DE, HL)
2. **Accumulator – identified by name A**
   - This register is a part of ALU
   - 8-bit data storage
   - Performs arithmetic and logical operations
   - Result of an operation is stored in accumulator

3. Flag Register

- This is also a part of ALU
- 8085 has five flags named
  - **Zero** flag (Z)
  - **Carry** flag (CY)
  - **Sign** flag (S)
  - **Parity** flag (P)
  - **Auxiliary Carry** flag (AC)

- These flags are five flip-flops in flag register
- Execution of an arithmetic/logic operation can **set** or **reset** these flags
- Condition of flags (set or reset) can be tested through software instructions
- 8085 uses these flags in decision-making process

4. Program Counter (PC)

- A 16-bit memory pointer register
- Used to sequence execution of program instructions
- Stores address of a memory location
  - where next instruction byte is to be fetched by the 8085
- when 8085 gets busy to fetch current instruction from memory
  - PC is incremented by one
  - PC is now pointing to the address of next instruction

5. Stack Pointer Register

- a 16-bit memory pointer register
- Points to a location in **Stack** memory
- Beginning of the stack is defined by loading a 16-bit address in stack pointer register

3.Instruction Set of 8085

- Consists of
  - 74 operation codes, e.g. MOV
  - 246 Instructions, e.g. MOV A,B
- 8085 instructions can be classified as

1. **Data Transfer (Copy)**
2. **Arithmetic**
3. **Logical and Bit manipulation**
4. **Branch**
5. **Machine Control**

1. Data Transfer (Copy) Operations

1. **Load** a 8-bit number in a Register
2. **Copy** from Register to Register
3. **Copy** between Register and Memory
4. **Copy** between Input/Output Port and Accumulator
5. **Load** a 16-bit number in a Register pair
6. **Copy** between Register pair and Stack memory

Example Data Transfer (Copy) Operations / Instructions

1. **Load** a 8-bit number 4F in register B
2. **Copy** from Register B to Register A
3. **Load** a 16-bit number 2050 in Register pair HL
4. **Copy** from Register B to Memory Address 2050
5. **Copy** between Input/Output Port and Accumulator

MVI B, 4FH

MOV A,B

LXI H, 2050H

MOV M,B

OUT 01H

IN 07H

2. Arithmetic Operations

1. **Addition** of two 8-bit numbers
2. **Subtraction** of two 8-bit numbers
3. **Increment/ Decrement** a 8-bit number

Example Arithmetic Operations / Instructions

Operation	Instruction
1. **Add** a 8-bit number 32H to Accumulator	**ADI 32H**
2. **Add** contents of Register B to Accumulator	**ADD B**
3. **Subtract** a 8-bit number 32H from Accumulator	**SUI 32H**
4. **Subtract** contents of Register C from Accumulator	**SUB C**
5. **Increment** the contents of Register D by 1	**INR D**
6. **Decrement** the contents of Register E by 1	**DCR E**

3. Logical & Bit Manipulation Operations

1. **AND** two 8-bit numbers
2. **OR** two 8-bit numbers
3. **Exclusive-OR** two 8-bit numbers
4. **Compare** two 8-bit numbers
5. **Complement**
6. **Rotate** Left/Right Accumulator bits

Example Logical & Bit Manipulation Operations / Instructions

Operation	Instruction
1. Logically **AND** Register H with Accumulator	**ANA H**
2. Logically **OR** Register L with Accumulator	**ORA L**
3. Logically **XOR** Register B with Accumulator	**XRA B**
4. Compare contents of Register C with Accumulator	**CMP C**
5. Complement Accumulator	**CMA**
6. Rotate Accumulator Left	**RAL**

4. Branching Operations

These operations are used to control the flow of program execution

1. **Jumps**
   - Conditional jumps
   - Unconditional jumps
2. **Call** & **Return**
   - Conditional Call & Return
   - Unconditional Call & Return

Example Branching Operations / Instructions

Operation	Instruction
1. Jump to a 16-bit Address 2080H if **C**arry flag is **SET**	**JC 2080H**
2. Unconditional **Jump**	**JMP 2050H**
3. Call a subroutine with its 16-bit Address	**CALL 3050H**
4. Return back from the Call	**RET**
5. Call a subroutine with its 16-bit Address if **C**arry flag is **RESET**	**CNC 3050H**
6. Return if **Z**ero flag is **SET**	**RZ**

5. Machine Control Instructions

These instructions affect the operation of the processor. For e.g.

HLT	Stop program execution
NOP	Do not perform any operation

4. Writing a Assembly Language Program

- Steps to write a program
  - Analyze the problem
  - Develop program Logic
  - Write an Algorithm
  - Make a Flowchart
  - Write program Instructions using Assembly language of 8085

Program 8085 in Assembly language to add two 8-bit numbers and store 8-bit result in register C.

1. Analyze the problem
   - Addition of two 8-bit numbers to be done
2. Program Logic
   - Add two numbers
   - Store result in register C
   - Example

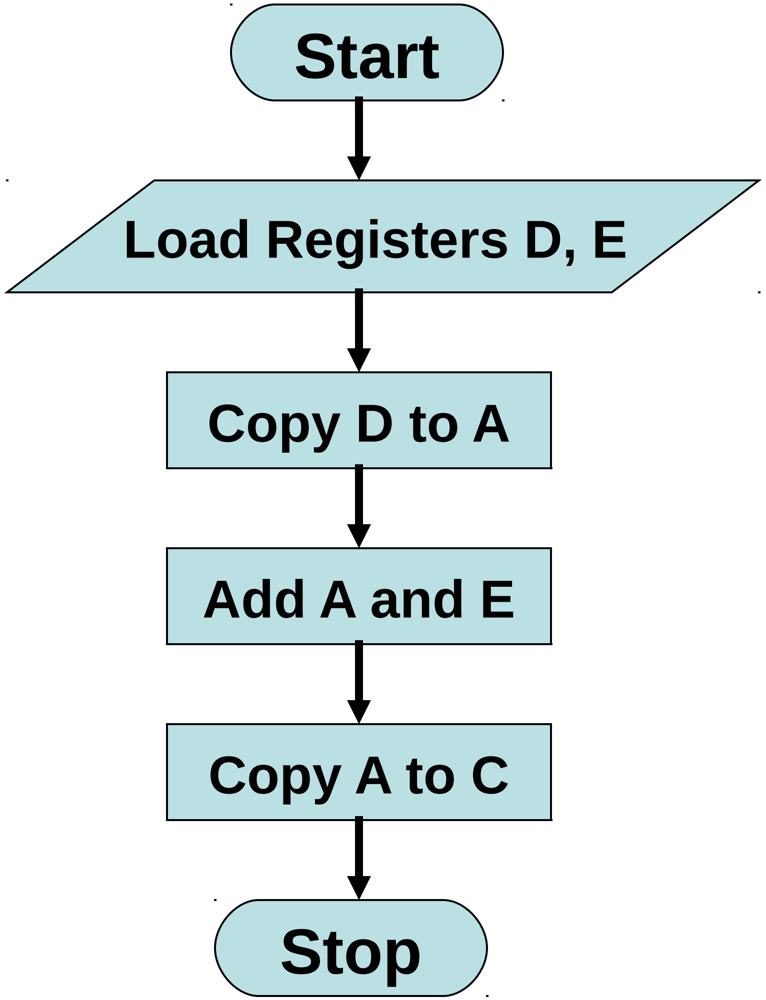
10011001	(99H)	A
+00111001	(39H)	D
11010010	(D2H)	C

3. Algorithm

Translation to 8085 operations

1. Get two numbers
   - Load 1st no. in register D
   - Load 2nd no. in register E
2. Add them
   - Copy register D to A
   - Add register E to A
3. Store result
   - Copy A to register C
4. Stop
   - Stop processing

4. Make a Flowchart



- Load 1st no. in register D
- Load 2nd no. in register E

- Copy register D to A
- Add register E to A

- Copy A to register C

- Stop processing

5. Assembly Language Program

1. Get two numbers
   a) Load 1st no. in register D
   b) Load 2nd no. in register E
2. Add them
   a) Copy register D to A
   b) Add register E to A
3. Store result
   a) Copy A to register C
4. Stop
   a) Stop processing

```
MVI D, 2H
MVI E, 3H

MOV A, D
ADD E

MOV C, A

HLT
```

Program 8085 in Assembly language to add two 8-bit numbers. Result can be more than 8-bits.

1. Analyze the problem
   - Result of addition of two 8-bit numbers can be 9-bit
   - Example

     10011001 (99H) A

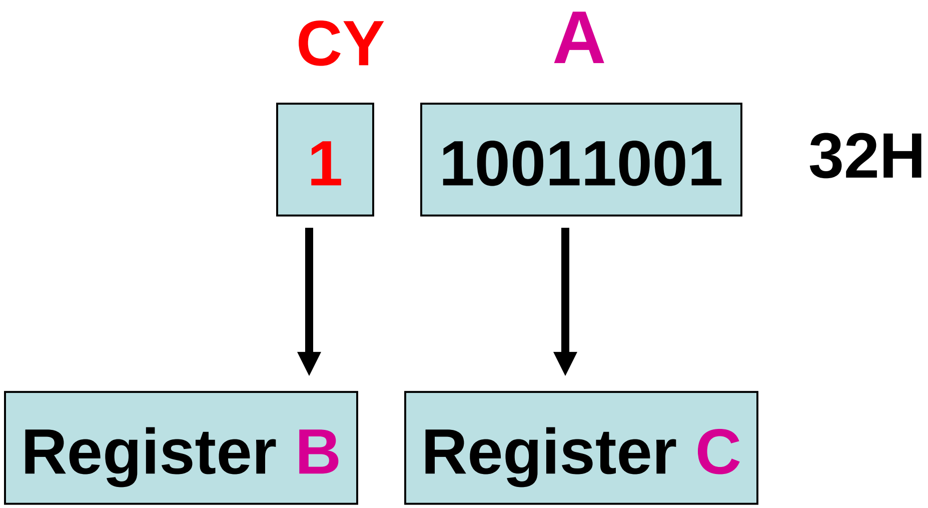
     +10011001 (99H) B

     100110010 (132H)
   - The 9th bit in the result is called CARRY bit.

- How 8085 does it?
  - Adds register A and B
  - Stores 8-bit result in A
  - SETS carry flag (CY) to indicate carry bit

	10011001	99H	A
			+
	10011001	99H	B
1	00110010	32H	A
CY			

- Storing result in Register memory



Step-1 Copy A to C

Step-2

a) Clear register B

b) Increment B by 1

2. Program Logic

1. Add two numbers
2. Copy 8-bit result in A to C
3. If CARRY is generated
   - Handle it
4. Result is in register pair BC

3. Algorithm

1. Load two numbers in registers D, E
2. Add them
3. Store 8 bit result in C
4. Check CARRY flag
5. If CARRY flag is SET
   - Store CARRY in register B
6. Stop

Translation to 8085 operations

- Load registers D, E

- Copy register D to A
- Add register E to A

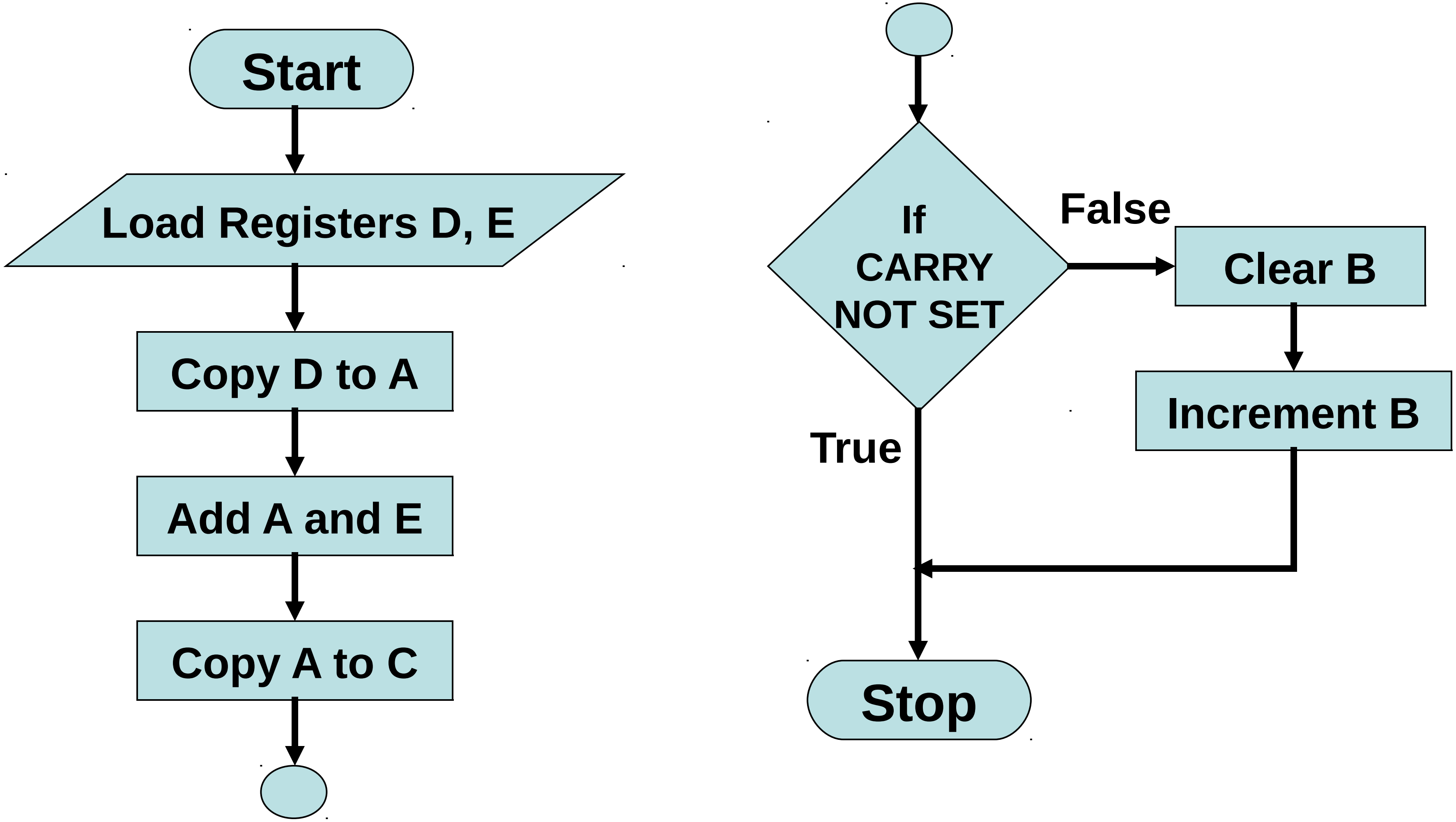
- Copy A to register C

- Use Conditional Jump instructions

- Clear register B
- Increment B

- Stop processing

4. Make a Flowchart



5. Assembly Language Program

- Load registers D, E
- Copy register D to A
- Add register E to A
- Copy A to register C
- Use Conditional Jump instructions
- Clear register B
- Increment B
- Stop processing

```
      MVI D, 2H
      MVI E, 3H
      MOV A, D
      ADD E
      MOV C, A
      JNC END
      MVI B, 0H
      INR B
END:  HLT
```

4. Addressing Modes of 8085

- Format of a typical Assembly language instruction is given below-

[Label:] Mnemonic [Operands] [;comments]

	HLT	
	MVI A, 20H	
	MOV M, A	**;Copy A to memory location whose address is stored in register pair HL**
LOAD:	**LDA 2050H**	**;Load A with contents of memory location with address 2050H**
READ:	**IN 07H**	**;Read data from Input port with address 07H**

- The various formats of specifying operands are called addressing modes
- Addressing modes of 8085

1. Register Addressing
2. Immediate Addressing
3. Memory Addressing
4. Input/Output Addressing

1. Register Addressing

- Operands are one of the internal registers of 8085
- Examples-

MOV A, B

ADD C

2. Immediate Addressing

- Value of the operand is given in the instruction itself
- Example-

MVI A, 20H

LXI H, 2050H

ADI 30H

SUI 10H

3. Memory Addressing

- One of the operands is a memory location
- Depending on how address of memory location is specified, **memory** addressing is of two types
  - **Direct** addressing
  - **Indirect** addressing

3(a) Direct Addressing

- 16-bit Address of the memory location is specified in the instruction directly
- Examples-

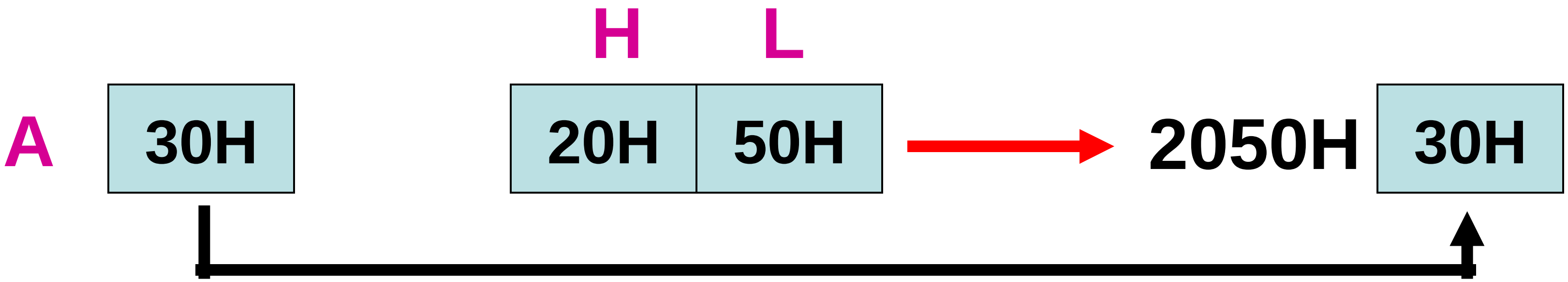
LDA 2050H **;**load A with contents of memory location with address 2050H

STA 3050H **;store** A with contents of memory location with address 3050H

3(b) Indirect Addressing

- A memory pointer register is used to store the address of the memory location
- Example-

MOV M, A ;copy register A to memory location whose address is stored in register pair HL



4. Input/Output Addressing

- 8-bit address of the port is directly specified in the instruction
- Examples-

  IN 07H

  OUT 21H

5. Instruction & Data Formats

8085 Instruction set can be classified according to size (in bytes) as

1. 1-byte Instructions
2. 2-byte Instructions
3. 3-byte Instructions

1. One-byte Instructions

- Includes Opcode and Operand in the same byte
- Examples-

Opcode	Operand	Binary Code	Hex Code
MOV	**C, A**	0100 1111	**4F**H
ADD	**B**	1000 0000	**80**H
HLT		0111 0110	**76**H

1. Two-byte Instructions

- First byte specifies Operation Code
- Second byte specifies Operand
- Examples-

Opcode	Operand	Binary Code	Hex Code
MVI	**A, 32H**	0011 1110 0011 0010	**3E**H **32**H
MVI	**B, F2H**	0000 0110 1111 0010	**06**H **F2**H

1. Three-byte Instructions

- First byte specifies Operation Code
- Second & Third byte specifies Operand
- Examples-

Opcode	Operand	Binary Code	Hex Code
LXI	**H, 2050H**	0010 0001 0101 0000 0010 0000	**21**H **50**H **20**H
LDA	**3070H**	0011 1010 0111 0000 0011 0000	**3A**H **70**H **30**H

Separate the digits of a hexadecimal numbers and store it in two different locations

- LDA 2200H ; Get the packed BCD number
- ANI F0H ; Mask lower nibble

0100 0101	45
1111 0000	F0

0100 0000	40

- RRC
- RRC
- RRC ; Adjust higher digit as a lower digit.
- RRC 0000 0100 after 4 rotations

Contd.

- STA 2300H ; Store the partial result
- LDA 2200H ; Get the original BCD no.
- ANI 0FH ; Mask higher nibble

0100 0100	45
0000 1111	0F

0000 0100	05

- STA 2301H ; Store the result
- HLT ; Terminate program execution

Block data transfer

- MVI C, 0AH ; Initialize counter i.e no. of bytes
  Store the count in Register C, ie ten
- LXI H, 2200H ; Initialize source memory pointer
  Data Starts from 2200 location
- LXI D, 2300H ; Initialize destination memory pointer

BK: MOV A, M ; Get byte from source memory block
i.e 2200 to accumulator.

- STAX D ; Store byte in the destination memory block i.e 2300 as stored in D-E pair
-

Contd.

- INX H ; Increment source memory pointer
- INX D ; Increment destination memory pointer
- DCR C ; Decrement counter

  to keep track of bytes moved
- JNZ BK ; If counter 0 repeat steps

- HLT ; Terminate program