ELECTRONICS & TELECOMMUNICATION ENGINEERING

4TH SEMESTER

SUBJECT CODE-TH3

SUB: MICROPROCEESER AND MICROCONTROLLER

LECTURES NOTE

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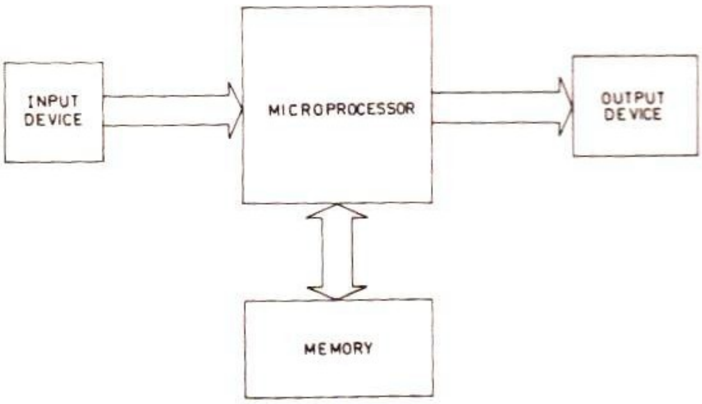
UNIT – 1

INTRODUCTION TO MICROPROCESSOR:

Introduction:

The microprocessor is one of the most important components of a digital computer.

Digital computer makes processing of numbers and it is a programmable machine. The main components are CPU, memory, input device and output device.



Schematic diagram of a microcomputer

CPU executes instruction. The memory is a storage device. It stores programs, data and result. Output device plays, prints programs, data and result.

The CPU built on a single chip or IC is called microprocessor.

A Digital computer in which one microprocessor has been provided to act as a CPU is called micro computer.

The CPU of a large powerful digital computer contains more than onemicroprocessor.

A computer whose CPU contains more than one microprocessor is called multi processor computer system.

Single chip microcomputers are called microcontroller.

Application:

It is used as CPU in computers.

In automobiles.

Microcontrollers are used to measure and control in industry for process and machine control in instrumentation, for commercial and consumer appliances control etc.

This microcontroller is used in military equipment, radars, tanks etc.

Evaluation of Microprocessor:

The 1st microprocessor, Intel 4004, a 4-bit PMOS microprocessor was introduced in the year 1971 by Intel Corporation, USA. After 4004 an enhanced version of Intel 4004 was developed i.e. Intel 4040 many other companies like Rock Well International, Toshiba etc are also developed 4-bit microprocessor.

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In 1972, Intel introduced the 1st 8-bit microprocessor i.e. Intel 8008 which is alsouses PMOS techniques. PMOS technologies were slow and not compatible with TTL Logic. So in 1973 Intel introduced on another powerful and faster 8-bit NMOS microprocessor i. e. Intel 8080. It is faster and compatible with TTL Logic but the drawback of it was it requires 3 power supplier.

In 1975 Intel developed an improved 8-bit NMOS microprocessor, Intel 8085 which uses only one +5V supply. It is an improved version of Intel 8080.

Other companies are also manufactured the 8-bit microprocessors like Zilog"s Z80 and Z800, National Semiconductor"s NSC800, Motorola etc.

These 8-bit microprocessors are mostly used in general purpose computers. It is having memory addressing capacity of 8-bit microprocessors and 64 KB. The clock frequency is of 1MHz to 6 MHz. It uses LSI technology and contains 5000 to 10,000 transistors.

In the year 1978 Intel introduced a 16-bit microprocessor, Intel 8086. Other 16-bit microprocessor are Intel 80186, Intel 8088, Intel 80188, Intel 80286.

The Intel 80286 has been designed for multi user system. Beside CPU it contains integrated memory, management unit, four level memory protection and support for vertical memory and operating system. These microprocessors are used VLSI technology. These can address memory in the range 1MB to 16 MB. It is used for multiprocessor environment.

After 1985 Intel introduced the 32-bit microprocessors i.e. Intel 80386 which became very popular and it was moistly used in desktop computers. In short it is also called as 386 microprocessor. These 32-bit microprocessor are 486, Pentium, Pentium pro, Pentium MMX, Pentium-II, Pentium-IIII and Pentium-IV.

Micro processor	Year of Introduct ion	Word Length	Memory addressing capacity	Pins	Clock	
4004	1971	4-bit	1 KB	16	750KHz	
4040	Advanced Version of 4004					
8008	1972	8-bit				PMOS technology
8080	1973	8-bit				NMOS technology
8085	1975-76	8-bit	64 KB	40	3-6MHz	8-bit up are based on LST technology and8085 is a NMOS up.
8086	1978	16- bit	1 MB	40	5-10 MHz	
8088	1980	8/16-bit	1 MB	40	5-8MHz	
80286	1982	16- bit	16MB /4GB	68	6-12.5 MHz	16 bits up are based on VLSI technology.
80836	1985	32-bit	4GB	132	20-33 MHz	
80486	1989	32-bit	4GB	168		
Pentium		32-bit	4GB	237 PGA		
Pentium Pro		32-bit	64 GB-	387 PGA		
Pentium-II		32-bit	-	-		
Pentium-III		32-bit	64 GB-	370 PGA		
Pentium-IV		32-bit	64 GB-	423		

*PGA= Programmable Gate Array.

DISTINGUISH BETWEEN MICROPROCESSOR AND MICROCOMPUTER :

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MICROPROCESSOR :

1.The central processing unit built on a single IC is called Miproprocessor.

2.It is more flexible.

3.Unit cost is high.

4.Memory and I/O devices are conneted externally.

5.In microprocessor memory connected externally.It can be used for large program.

MICROCOMPUTER :

1.A digital computer in which one microprocessor has been provided to act as CPU,is called Microcomputer.

2.It is less flexible.

3.Per unit cost is less.

4. Memory and I/O devices are conneted internally.

5.In microcomputer memory is fixed so it can be used for small program.

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BASIC ARCHITECTURE OF 8-BIT MICROPROCESSOR (8085):

Introduction:

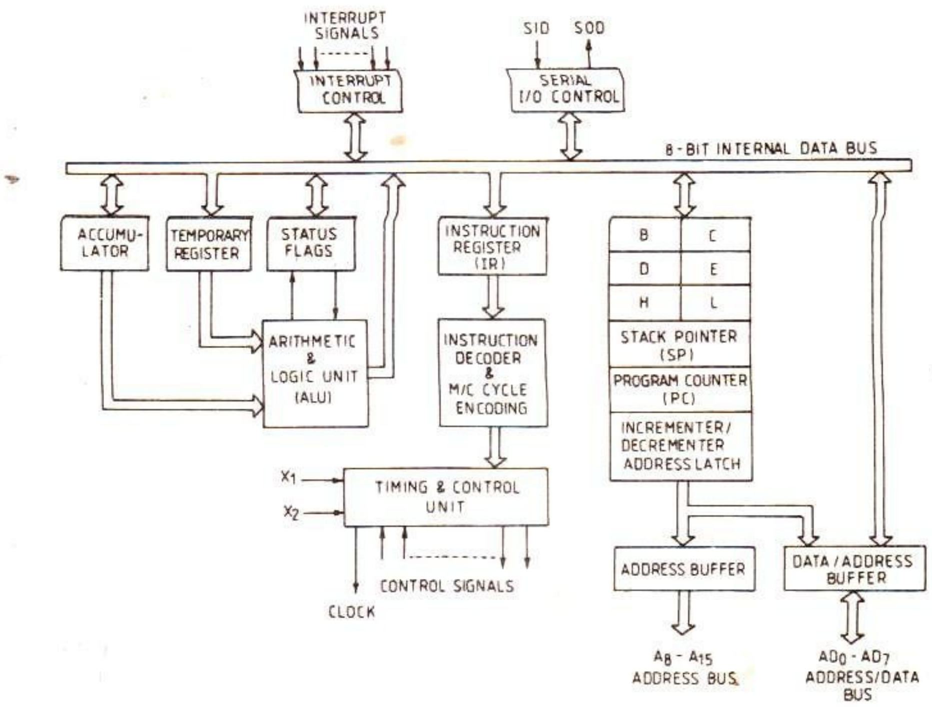
The microprocessor is a central processing unit of a computer. Intel 8085 is the 1st 8 -bit microprocessor. It was invented in the year 1975.

The main features of 8-bit microprocessor 8085 is

- It is an 8-bit NMOS microprocessor.
- It having 40 pins.
- Based on LSI (Large Scale Integrated) technology
- Its clock speed is of 3MHz
- The clock cycle is of 320 ms
- It has 80 basic instructions and 246 opcodes
- It is having 3 sections i.e.

  (1) ALU
  (2) Timing and control unit.
  (3) And a set of Registers.

Architecture of 8085 Microprocessor:



Block diagram of Intel 8085.

It is having 3 sections i.e.

(1) ALU
(2) Timing and control units.
(3) A set of Registers.

ALU :-

ALU – Arithmetic and Logic unit.

This ALU performs all the Arithmetic and Logical operations like

(1) Addition
(2) Substraction
(3) Logical AND
(4) Logical OR
(5) Logical Ex-OR

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(6) Complement (NOT)
(7) Increment (add 1)
(8) Decrement (Subtract 1)
(9) Left shift, Rotate left Rotate right
(10) Clear etc.

Timing and control unit:

This timing and control unit is a section of CPU. It generates timing and control signals which are necessary for the execution of instructions.

It provides status, control and timing signals which are required for the operation of memory and I/O devices.

It controls the entire operations of the microprocessor and peripherals of connected to it. So the control unit of the CPU acts as the brain of the computer system.

Registers:

There are various types of Registers in the microprocessor 8085.

These registers are used for temporary storage and manipulation of data and instructions. The data remains in the registers till they are sent to memory or I/O devices.

In large computer the no of registers are more but in small computer the no of registers are less due to limited size of the chip.

The registers of 8085 microprocessor are:

(1) Accumulator (Acc) i.e. register (One 8-bit)
(2) 6, 8-bit general purpose registers i.e. B,C,D,E,H and L
(3) 1, 16-bit Stack pointer, SP
(4) 1, 16-bit program counter, PC
(5) Instruction register
(6) Temporary register

Accumulator:-

It is a 8-bit special purpose register which is used to store one of the operand which is required during the application of arithmetic and logical operation.

After the logical and arithmetic operation, the result is by default stored in accumulator.

This accumulation can be called as general purpose register, if it is used to store the data or operand which is required during the execution of arithmetic and logical operation.

General Purpose Register:

The 8085 microprocessor contains 6, 8-bit general purpose Registers i.e. B, C, D, E, H and L.

To hold 16-bit data 2 8-bit general purpose registers are employed as a pair i.e. called as register pair. The pairing of registers are B-C, D-E and H-L.

This general purpose registers and accumulator are accessible to programmer. He can store data in these registers during writing the program.

Program Counter:

It is a 16-bit special purpose register which is used to hold the address of the next instruction.

When microprocessor reads one instruction from memory, the PC will automaticallyincremented and points to the address of the next instruction.

For the above purpose we have to first initialize the P.C. by starting address of 1st instruction of the programme.

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Stack Pointer (SP):

It is a special purpose 16-bit register which is used to store the address of the top of the stack.

Stack is a sequence of memory locations set aside by a programmer.

Stack operates in LIFO operation (Last in Fast Out).

Instruction Register:

This register is used to store the Opcode of the current instruction which is executed by the microprocessor.

Temporary Register:

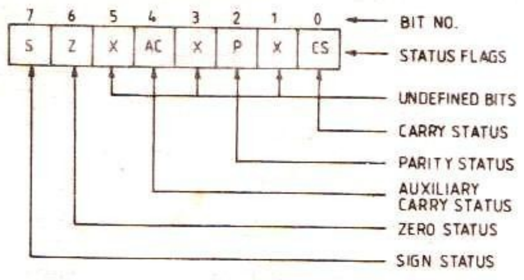
It is an 8-bit register associated with ALU. It holds data during an arithmetic or logical operation. It is used by the Microprocessor. It is not accessible to the programmer.

Flag Register:

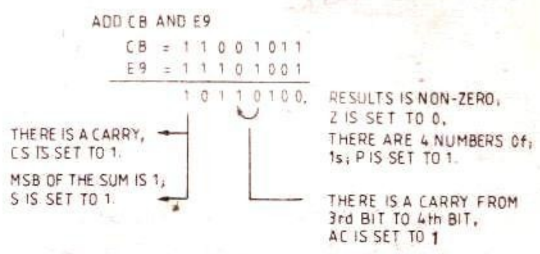
In 8085 microprocessor, it has an 8-bit flag register which is used to provide information about the result outcome from arithmetic and logical operation, out of 8-bits of this register, 3 bits are not used they are D1, D3 and D5.

The 5 status flags of Intel 8085 are:

(1) Carry flag (CS) – D0
(2) Parity Flag (P) – D2
(3) Auxiliary carry flag (AC) – D4
(4) Zero flag (Z) – D6
(5) Sign flag (S) – D7



Status Flags of Intel 8085



Status Flags for ADD operation

Carry Flag:

Carry flag is set to 1 when a carry is generated from D7 bit of the accumulator when a borrow is required foam a non-existing position to D7 bit, then we have to set the carry bit to 1.

Parity Flag:

The parity flag is set to 1 if the result of the arithmetic and logical operation is having even no. of „1".

Auxiliary Cary Flag (AC):

If there is a carry occurs from the 3 bit to 4th bit, at that time we have to set the Ac as 1.

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Zero Flag (Z):

The zero flag is set to be „1" if all the bits of the result are zero.

Sign Flag (S):

If the data are represented in signed binary form after execution of arithmetic and logical operation, if the D7 bit of the accumulation is „1" then sign flag is set to „1".

Example:

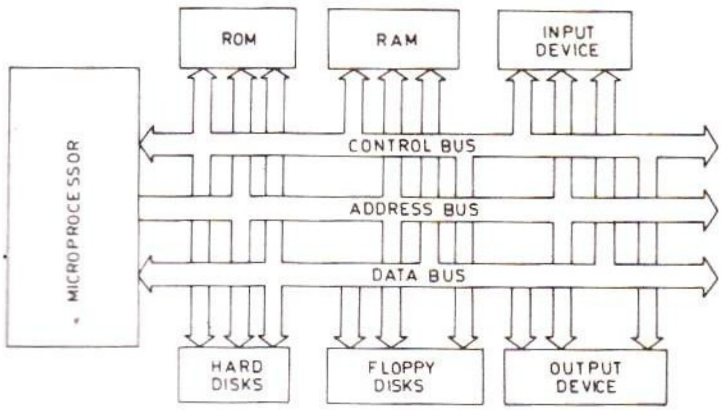
Q: - Add 1001011 with 11101001

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

Result –

1) Carry there is a carry so carry flag set to '1'.
2) There are 4 no"s of 1"s in the result so parity flag is set to „1".
3) There is a carry occurs in D3 to D4 so AC is set to „1".
4) The result is a non-zero so zero flag is set to „1".
5) The D7 bit of the result is 1 so sign flag is set to „1".

General Bus Structure Block Diagram:



Schematic connection of memory and I/O devices to microprocessor

Various I/O devices and memory devices and memory devices are connected to a CPU by groups of lines called buses. There are 3 types of Buses i.e.

(1) Address Bus
(2) Data Bus
(3) Control Bus

The address bus carries the address of a memory location or I/O device that the CPU wants to access. When an address is sent by the CPU, all devices will connected through the address bus, receives this address and responds to that device and also receives the enable signal from the CPU. The address bus is unidirectional. In short address bus is called as A-bus.

The data and control bus is also called as D-bus and C - bus respectively. The data and controlbus are bidirectional.

The data bus is used to transfer data between the processor, memory and I/O devices. The

control bus is used carry necessary control signals between the CPU and memory and I/O devices. Examples of control signals are R D , W R , IO/M etc.

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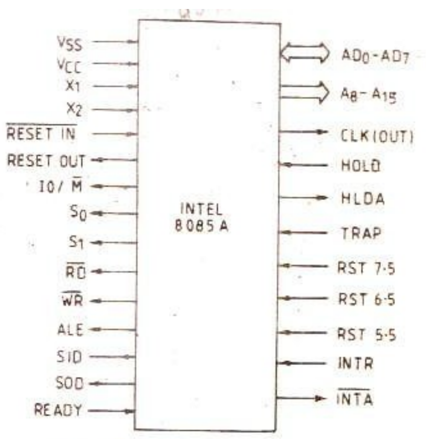
The microprocessor issues $IO/\overline{M}$ signal to indicate whether it will communicate with an I/O device or memory. If $IO/\overline{M}$ signal is high, CPU wants to communicate with an I/O device. If $IO/\overline{M}$ signal is law, the CPU wants to communicate with memory.

When the CPU sends a low $\overline{RD}$ signal, the activated devices understand that the CPU wants to read information.

The width of the data bus is same as the word length of the CPU. For example an 8-bit microprocessor has 8-bit data bus, a 16-bit microprocessor has 16-bit data bus, a 32-bit processor has 32-bit data bus and so on.

The width of the address bus is decided by the designed memory addressing capability of the CPU for example, Intel 8085 an 8-bit microprocessor and having 16-bit address bus which gives 64Kb memory addressing capability . A group of 8-bits is called as a byte.

PIN Configuration:



Schematic Diagram of Intel 8085.

A_{15} – A_8 and AD_0 – AD_7:

The address bus mean A15-A8 bit address bus means A_7-A_0, The LSB part and A_{15}-A_8 the MSB part.

As there are 2 buses available to transfer the address and data in the address bus A_{15}-A_8 (MSB) part. Each part of the address and data is passed to mp and AD_7-AD_0 is passed through data bus and mp.

A_0-A_{15} – 8 -bit

Data can"t be sent without address.

So AD_0-AD_7 =A_0-A_7=8-bits

<u>+ D_0-D7=8-bits</u>

=AD_0-AD_7=8-bits =Bidirectional

A_0-A_7-LSB

A_8-A_{15}-

MSB

A_8-A_{15} =Unidirectional

ALE:-

- Address latch enable signal.
- It is made high during the 1st clock cycle of the machine cycle.
- During this period it separates the lower bit address (A_7-A_0) and data (D_7-D_0) from AD_7 -AD_0.
- When it is made high LSB part of the address is passed.

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$\overline{RD}$:

It reads the control signal which is used for read operation when it is made low the read operation takes place.

$\overline{WR}$:

It is the control signal used for write operation when it is made low the write operation takes place.

$IO/\overline{M}$:

It indicates that the mp doing I/P, O/P operation or memory operation.

If $IO/\overline{M}$ = 1 I/O operation
= 0 Memory operation

S1 and S0:

These are the status signal set by the mp to distinguish between read / write operation.

S_1	S_0	
0	0	Halt
1	0	Read
0	1	Write
1	1	Fetch Operation

X1 and X2:

These are the RC and LC network which is used to connect the crystal oscillator to the microprocessor.

Clock:

This signal is used for the system clock which is provided by the microprocessor.

Its frequency is same as the frequency of the mp.

INTR: This is an interrupt signal used by the I/p O/p device to transfer the data to the microprocessor after getting the interrupt signal.

$\overline{INTA}$: This is the interrupt acknowledgement signal given by the microprocessor to the i/p o/p device after getting the interrupt signal.

RST 6.5, 7.5, 5.5:

TRAP – 0024, 5.5 – 0026, 6.5 – 0034, 7.5 – 0036
These are called restart interrupt.
These are mask able signal which can be enable or disable.
This signal causes an internal restart to be automatically inserted.

TRAP:

These are non-maskable with highest priority.

HOLD (in):

It indicates that another device is requesting for the use of address and data bus.

HLDA (out):

It indicates that HOLD request has been received.

RESET (in):

This signal reset the programme counter to zero.
It also reset the HLDA counter.

RESET (out):

It indicates that microprocessor is already reset.

SID (in):

It is a data line for serial I/P. The data lines are loaded into accumulation when RIM instruction is executed.

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SOD (out):

It is the data line for serial O/P. These data line are loaded into the accumulator where SIM instruction is executed.

VCC:

This pin indicates the power supply to the mp which is +5V.

VSS:

This pin indicates ground.

STACK :

During execution of a programme we need to save some of the contents of certain registers because those registers are required for other operation. These contents are moved to other location of memory by using PUSH operation. Then the registers are used for other operation.

After completing the operation again that contents are transferred back to its original location i.e. to the registers by POP operation. The memory location is set aside by the programmer at the beginning. A set of memory location is kept for this purpose is called stack. The last memory location occupied portion is called as the Stack top. Special 16-bit register known as Stack-Pointer holds the address of the stack top.

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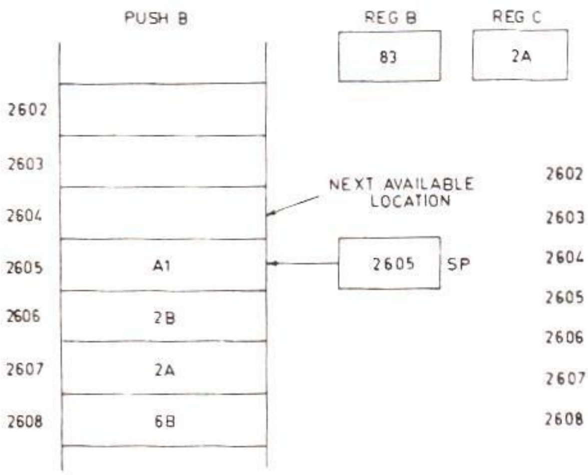
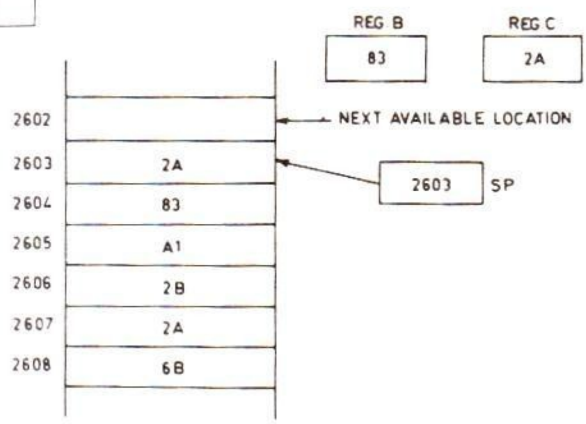
The stack pointer is initialized in the beginning of the programme by LXISP or SPHL instruction. Any area of the RAM can be used as stack. DATA are stored in the stack on LIFO (Last in fast out) Principle. Stack access are faster than memory access.

Before PUSH Operation **After PUSH Operation**

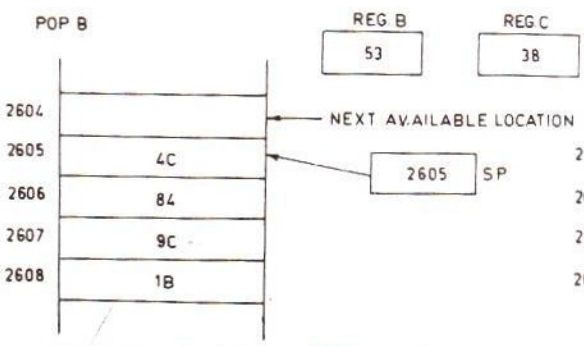


Stack before PUSH operation.

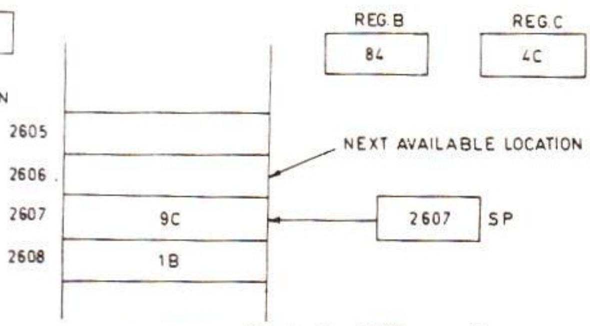


Stack after PUSH operation.

Before POP Operation **After POP Operation**



Stack before POP operation.



Stack after POP operation.

Stack Pointer (SP):

It is a special purpose 16-bit register which is used to store the address of the top of the stack.

Stack is a sequence of memory locations set aside by a programmer.

Stack operates in LIFO operation (Last in Fast Out).

The stack pointer controls the addressing of the stack.

DISTINGUISH BETWEEN SPR AND GPR :

Registers are 2 types
1.General Purpose Registers (GPR)(B,C,D,E,H & L)
2.Special Purpose Registers(SPR)(Accumulator,Program Counter,Stack pointer,Instructions Registers,Flag Registers)

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(UNIT-2)

Instructions sets of Assembly Language Programming

Introduction

An instruction is a command given to the computer to perform a specified operation on a given data. The instruction set of a microprocessor is the collection of instruction that the microprocessor is designed to execute.

DIFFERENT GROUPS OF INSTRUCTIONS:-

The programmer can write a programme in assembly language using these instructions .These instructionshave been classified in to the following groups

1. Data transfer group

2. Arithmetic group

3. Logical group

4. Branch control group

5. I/O and machine control group

Data transfer group: Instructions which are used to transfer data from one register to other, register tomemory, memory to register are comes under this group.exp: MOV, MVI, LXI, STA etc.

When an instruction is executed, the data are transferred from source to destination without altering thecontents of the source.

Ex: MOV A, B. when this instruction executed, the contents of register B is stored to the register A, and thecontents of register Remain unaltered.

Arithmetic group: This performs the arithmetic operation such as addition, Substraction, increment,decrements of the content of register or memory.

Ex: ADD, SUB, INR, DAD etc.

Logical group:

This group performs the logical operations such as AND, OR, compare, rotate

etc.Ex: ANA, XRA, ORA, CMP, RAL.

Branch control group: This group performs the conditional and unconditional jump, subroutine, calland return and

Ex: JMP, JC, JR, CALL.

I/O machine control group: This group performs the instructions for i/o ports, stack, and machinecontrol. Ex: IN, OUT, PUPH, POP, HLT.

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Instructions and Data Formats:

Intel 8085 is a 8 bit up. It handles 8 bit data at a time .One byte consists of 8 bits .A memory location for 8085 up is designed to accommodate 8 bit data. If 16 bit data are to be stored, they are stored in consecutive memory locationis 16 bits. There are various techniques to specify data for instructions are: 1 .A 8 bit or 16 bit data may be directly given in the instructions itself.

2. T he address of the memory location, i/o port device, where data resides , may be given in the instruction itself.

3. In some instructions only one register is specified. The content of the register is one of the operands.

4. In some instructions specifies 2 register. The content of the register are the required data.

5. In some instructions data is implied .Most of this type instructions operate on the content of the accumulator.

Due to different ways of specifying data for instructions, the machine codes of all instructions are not of the samelength.

There are 3 types of Intel 8085 instructions i.e1.single byte instruction

2. 2 byte instruction

3 . 3 byte

instruction.

ADDERESSING MODES:-

The technique which is used to specify the data for instruction is called addressing

mode.The addressing mode incase of 8085 microprocessor is divided in to 5 types

1. Direct addressing mode.

2. Register addressing mode.

3. Register indirect addressing mode

4. Immediate addressing mode.

5. Implicit addressing mode.

1. .Direct addressing mode. In this addressing mode the address of the operand is directly given to theinstruction.

STA2400. It means the data which is presents in the memory location 2400is stored to the accumulator .As theaddress of the above example is given directly in the instruction is direct addressing mode.

2. Register addressing mode: If one of the operand is in the general purpose register then the addressingmode of the instruction is called register addressing mode.

The pocode of the instruction gives the address of the instruction of the register where data is present.

Ex: MOV A,B Here data is general purpose of register B and pocode of the instruction is 78 .When we break the opcode in binary format(01111000) then last 3 zero(000) explains the address of the register B and (111) of theaddress of the accumulator and(01) the meaning of the operation.01-write&10-read.

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3. Register indirect addressing mode: In this mode address of the operand is specified by a register pair.Ex; LXIH, 2500H

MOV A, M

HLT

Here address of the memory location is stored in the H-L pair register and the data which is in the memory is movedto the accumulator.

4. Immediate addressing mode: If the data is given to the instruction, then the addressing mode of theinstruction is called immediate addressing mode.

Ex: MVI A, 05: Here 05 is the data is immediately moves to the accumulator.

5. Implicit addressing mode: There are certain instructions which operate only on the accumulator. Theaddressing mode which is used in this operation is called Implicit addressing mode.

Ex: CMA, RAR, RALETC.

Instructions of Intel 8085 microprocessor:

Data transfer group:

MOV r, M: Move the content of the memory to register.

The content of the memory location whose address is in H-L pair is moved to

register r.Opcode: MOV B, M-46
MOV C, M-4E
MOV D, M-56
MOV E, M-5E
MOV H, M-66
MOV L, M-6E

MOV M,r: Move the content of register s to memory.

Opcode:

MOV M, B-70
MOV M, C-71
MOV M, D-72
MOV M, E-73
MOV M, H-74
MOV M, L-75
MOV M, A-77

MVI r, data: move immediate data to the

register.Opcode:

MVI B-
06 MVI C
-0E MVI
D-16MVI
E-1E
MVI H-
26 MVI A
-3E

MVI M, data- move immediate data to the memory.

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Opcode-

MVI M-36

LXI rp, data 16: Load register pair immediate.

Load 16 bit immediate data into register pair

microprocessor.Opcode-

LXI D-
11LXI-
21
LDA addr; Load accumulator

direct.Opcode-

LDA-3A

STA addr: Store accumulator

direct.Opcode-

STA-32

LHLD: Load H-L pair direct.

The content of memory location is loaded to the register.

The content of the next memory location is loaded to the H

register.Opcode:

LHLD-2A

SHLD addr: store H-L pair direct.

The contents of register L is stored in the memory location.

The content of the register H is stored in the next memory

location.Opcode:

SHLD-22

LDAX rp: Load accumulator indirect

The content of the memory location, whose address is in the register pair rp is loaded in the

accumulator.Opcode:

LDAX B-0A
LDAX D-1A
STAX rp-store accumulator

indirect.Opcode:

STAX B-
02STAX D
-12
XCHG: exchange the content of H-L pair with D-E pair.

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Opcode:

XCHG-EB

Arithmetic group:

ADD r: add register to

accumulator.Opcode:

ADD B-80
ADD C-81
ADD D-82
ADD E-83
ADD H-84
ADD L-85
ADD M: Add memory to accumulator

The content of memory location addressed by H-L pair is added to the

accumulatorOpcode:

ADD M-86

ADC r: Add register with carry to

accumulator.Opcode:

ADC B-
88 ADC C
-89 ADC
D-8A
ADC E-
8B ADC
H-8C
ADC L-
8D
ADC M: Add memory with carry to

accumulatorOpcode:

ADC M-8E

ADI data: Add immediate data to

accumulatorOpcode:

ADI -C6

DAD rp: Add register pair to H L pair

Add the content of the register pair to the H-L pair and the result is stored in H

-L pairOpcode:

DAD B-
09DAD D
-19 DAD
H-29
SUB r: Substract register from

accumulatorOpcode:

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