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Microprocessors

Introduction

- A microprocessor is a computer processor which incorporates the functions of computer's central processing unit (CPU) on a single integrated (IC) circuit, or at most a few ICs.
- The microprocessor is a multipurpose, clock driven, register based, digital-integrated circuit which accepts binary data as input, processes it according to instructions stored in its memory, and provides results as output.
- Microprocessors contain both combinational logic and sequential digital logic.
- Microprocessors operate on numbers and symbols represented in the binary numeral system.

Generation of Microprocessor

(1) INTEL 4004 (1971)

- 4-bit microprocessor
- 4 KB main memory
- 45 instructions
- PMOS technology [p-channel metal oxide semiconductor]
- was first programmable device which was used in calculators.

(2) INTEL 8008 (1972)

- 8 bit version of 4004
- 16 KB main memory
- 48 instructions
- PMOS technology
- slow

PMOS logic was dominant semiconductor technology for large scale ICs before being superseded by NMOS and CMOS devices

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(3) INTEL 8080 (1973)

- 8-bit microprocessor
- 64 KB main memory
- 2 microseconds clock cycle time
- 500,000 instructions/sec
- 10x faster than 8008
- NMOS technology [N-channel metal oxide semiconductor]
- Drawback was that it needed three power supplies.
- Small computers (Microcomputers) were designed in mid 1970's
- Using 8080 as CPU

(4) INTEL 8086/8088 (1978 for 8086 & 1979 for 8088)

- 16-bit microprocessor
- Data bus width of 8086 is 16 bit and 8 bit for 8088.
- 1 MB main memory
- 400 nanoseconds clock cycle time.
- 6 byte instruction set cache for 8086 and 4 byte for 8088
- Other improvements included more registers and additional instructions.
- In 1981 IBM decided to use 8088 in its personal computer.

(5) INTEL 80186 (1982)

- 16-bit microprocessor - upgraded version of 8086
- 1 MB main memory.
- contained special hardware like programmable counters, interrupt controller etc.
- Never used in PC
- Was ideal for systems that required a minimum of hardware

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(6) INTEL 80286 (1982)

- 16-bit high performance microprocessor with memory management and protection.
- 16 MB main memory.
- Few additional instructions to handle extra 15 MB.
- Instruction execution time is as little as 250 ns.
- concentrates on features needed to implement 'Multi-tasking'.

(7) Intel 80386 (1985)

(11) Pentium II (1997)

(8) Intel 80486 (1989)

(12) Pentium III (1999)

(9) Pentium (1993)

(13) Pentium IV (2002)

(10) Pentium Pro (1995)

(14) Latest in Intel i9 processor

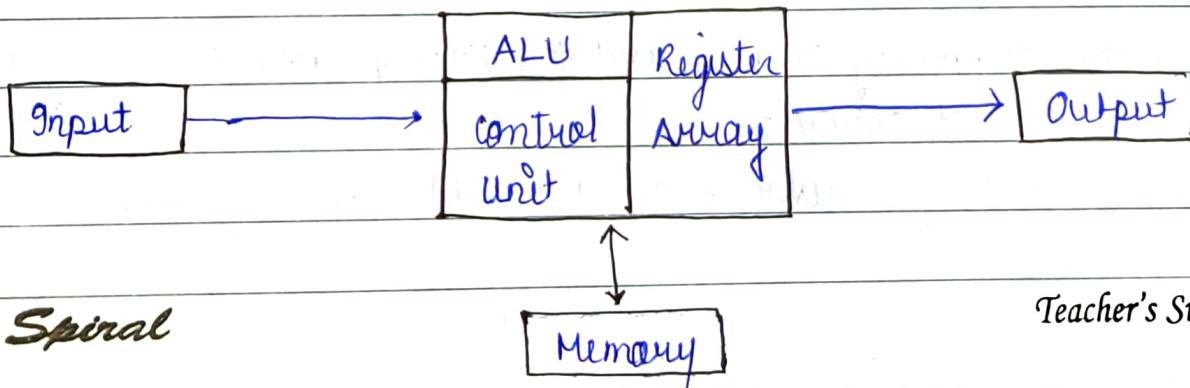
Microcomputer

A microcomputer is a complete computer on a small scale, designed for use by one person at a time. Device based on a single-chip microprocessor. Common microcomputers include laptops & desktops.

8085 Microprocessor

- 8 bit general purpose CPU
- Capable of addressing 64 K of memory
- 40 PIN IC
- Requires +5 V power supply
- Operate with 3 MHz clock.
- 8085 upward compatible
- NMOS technology.

8085 Hardware Module (General Architecture)



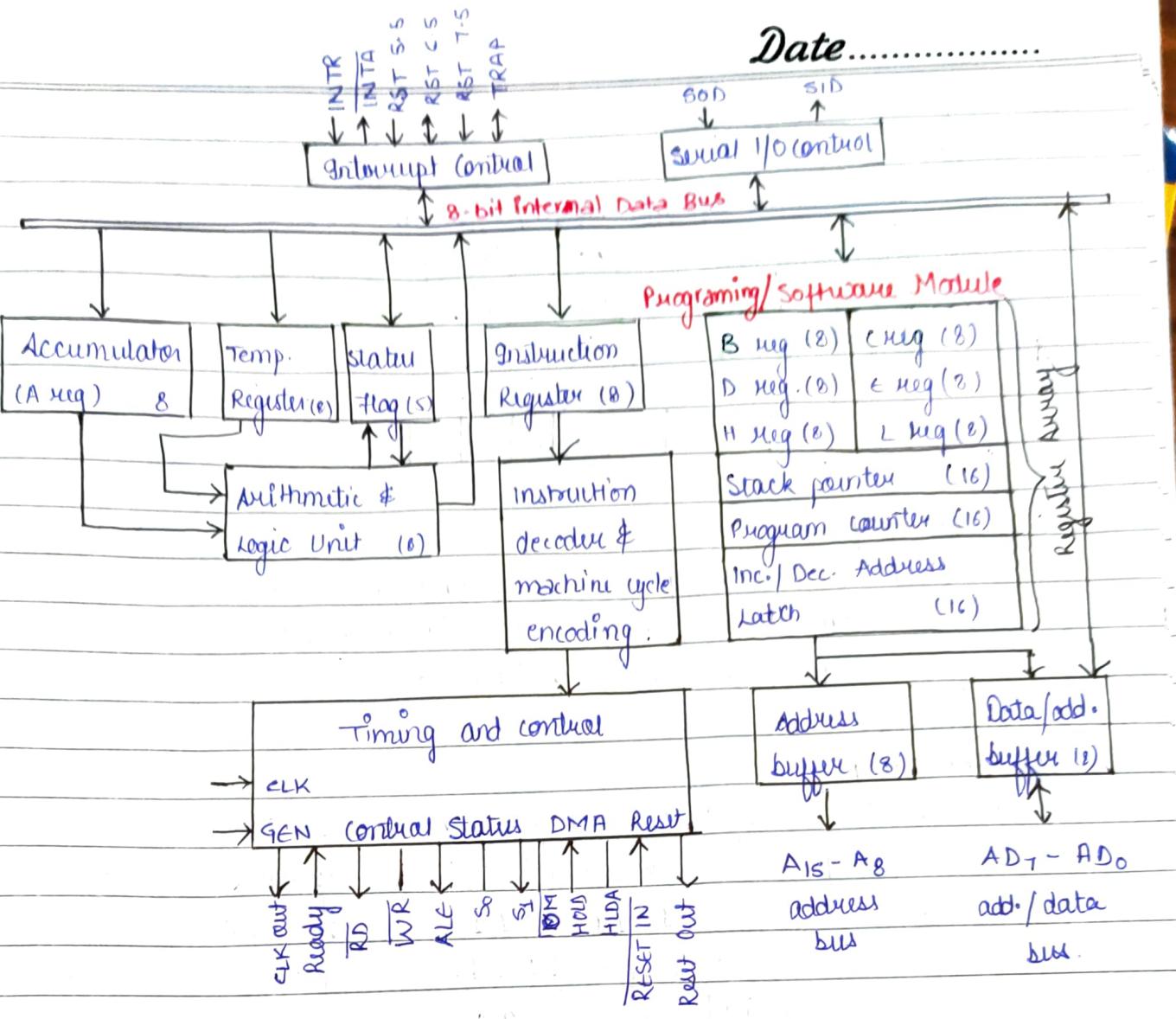
1) Select the chip
2) Identify required
3) enable appropriate buffer

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- ALU : ALU stands for Arithmetic and logical unit. All arithmetic operation, eg. subtraction, addition and logical operations are performed using ALU. apart from these, ALU also perform **rotation, shifting, clearing and refreshing**.
- Register Array : 8085 have 6 general purpose ~~and~~ register. Each of 8 bit long (BC DE HL)
It is used for temporary storage during execution of instruction.
- CU : CU stands for control unit. It controls flow of signal required for operation of instruction for transferring of data from CPU to memory or to output devices.
- System Bus : Group of wires used to transfer the data from one functional block to another.
 - ~~Address~~ Bus / Unidirectional : It is unidirectional by nature.
It is used to specify memory locations for data being transferred.
 - Data Bus / Bidirectional : It is in a bidirectional path.
Carries the actual data b/w the processor, the memory and peripherals.
 - Control Bus : Carries the control, timing and coordination signals to manage the various functions across the system.

Architecture of Intel 8085 Microprocessor

- ALU : Includes temporary registers used for holding data temporarily during the execution of operation.
This temporary register is not accessible by programmer.



→ Register Array

(i) General Purpose Register

- B, C, D, E, H & L (8 bit registers)
- Can be used singly.
- or can be used as 16 bit register pair - BC, DE, HL
- H & L can be used as data pointer (**holds memory address**)

(ii) Special Purpose Register

(a) Accumulator (8 bit Register)

- Store 8 bit data
- Store result of an operation
- Store 8 bit data during I/O transfer.

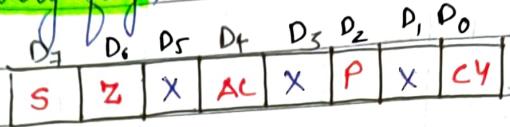
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A (Accumulator)	Flags
B	C
D	E
H	L
Program Counter	
Stack pointer	
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(1) Flag Register :

- 8 bit register
- show status of CPU before / after an operation
- S (sign flag)
- Z (zero flag)
- CY (carry flag)
- AC (auxiliary carry flag)
- P (Parity flag)



(1) Sign Flag :

- used for indicating the sign of data in accumulator.
- The sign flag is set if negative (1 - negative)
- The sign flag is set if positive (0 - positive)

(2) Zero Flag :

- is set if result obtained after an operation is 0.
 - is set following an increment or dec. operation of register.
- Ex:
- | | |
|--------------------------------|--------------------------------------|
| 1011 0011 | if Z=1 \Rightarrow result = 0 |
| + 0100 1101 | if Z=0 \Rightarrow result \neq 0 |
| $\Sigma = \boxed{1} 0000 0000$ | |

(3) Carry Flag .

- is set if there is carry or borrow from arithmetic operation.

Ex:
$$\begin{array}{r} 1011 0101 \\ + 0110 1100 \\ \hline \end{array}$$

$$\begin{array}{r} 1011 0101 \\ - 1100 1100 \\ \hline \end{array}$$

Carry $\boxed{1} 0010 0001$

Borrow $\boxed{1} 1110 1001$

(4) Auxiliary Carry Flag

- is set if there is a carry out of bit 4
- $AC = 1$, carry from D₃ to D₄
- $AC = 0$, no carry

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(5) Parity Flag.

→ It is set if parity is even

→ It is cleared if parity is odd.

Ex: $80H \rightarrow 1000\ 0000$

If $P=1 \Rightarrow$ even no. of 1's , $P=0 \Rightarrow$ odd no. of 1's

Ans →

$$\begin{array}{r} \text{FF H} \\ + 01 H \\ \hline \text{100} \end{array} \quad \begin{array}{r} 1111\ 1111 \\ + 0000\ 0001 \\ \hline 1000\ 0000 \end{array} \quad \begin{array}{l} Z=1, P=1 \\ CF=1, S=0 \\ AC=1 \end{array}$$

(iii) Program Counter (PC) :

- Register that is used to control the sequencing of execution of instruction.
- Register always holds address of next instruction.
- Since it holds address, it must be 16 bits wide.

(iv) Stack pointer :

- 16 bit register that is used to point into memory.
- Memory this register points to is special area called stack.
- Stack is an area of memory used to hold data that will be retrieved soon.
- It is usually accessed in LIFO fashion.

→ NON PROGRAMMABLE REGISTERS

Instruction Register & Decoder

• Instruction is stored in IR after fetched by processor.

• Decoder decodes instruction in IR

• Internal Clock generator

- 3.125 MHz internally

- 6.25 MHz externally.

Temporary Register

• 8 bit long

• Will store data temporarily before execution of instruction

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→ Address / Data Buffer Bus :

- Address bus has 8 signal lines A8-A15 which are unidirectional
- Other 8 address bits are multiplexed (time shared) with 8 data bits.
 - AD₀-AD₇ are bi-directional and serve as A0-A7 and D0-D7 at same time.

During execution of instruction, these lines carry the address bits during early part, then during late parts of execution, they carry 8 data bits.

- In order to separate the address from data, we can use a latch to save the value before func. of bits changes.

PIN DIAGRAM OF 8085

Frequency generator is connected to this pin (6MHz)	X ₁	1	11	40	V _{cc}	Power Supply : +5V
	X ₂	2		39	HOLD	
	RESET OUT	3		38	HLD A	
	SOD	4		37	CLK (OUT)	
	SID	5	8085	36	RESET IN	
Priority in descending order.	TRAP	6	A	35	READY	
	RST 7.5	7		34	I _O /M (IP/OP/Memory)	
	RST 6.5	8		33	S _i	
	RST 5.5	9		32	RD (Read)	
Multiplexed address Data bus	INTR	10		31	WR (Write)	
	INTA	11		30	ALE (Address Latch Enable)	
	AD ₀ -AD ₇	12		29	S ₀	
	V _{ss}	20		21	A ₈ -A ₁₅ (Address Bus)	

(i) AD₀-AD₇ : In this bus, transfer 8 bit address as well as the data in transfer depending upon timings given by control circuit using address latch.

- (i) $A_8 - A_{15}$: This bus carry higher 8 bit address which will be present for all store cycle when lower 8 bit address as well as data is sending in bidirectional bus.
- (ii) Clock : This pin generates clock frequency of 3.07 mHz and will be applied to other digital pin IC's which require same clock pulse.
- (iv) TRAP (RST 7.5, RST 6.5, RST 5.5) : These pins are known as interrupt and also define as hardware interrupt because these are generated through microprocessor. These interrupt are initialised on basis of priorities. Interrupt can be differentiated on the basis of priority i.e. maskable & non-maskable interrupt.
- Maskable (RST 7.5, 6.5, 5.5) : These processing can be stop at anytime.
- Non-Maskable (TRAP) : Exceptional interrupt bcz if execute, can never be disable.
- (v) INTR : Also known as hardware interrupt. Amongst all interrupt, this interrupt have lower priority. When this interrupt activated program counter does not increase its content.
- (vi) INTA : Interrupt acknowledge signal. But defined as active low signal. If 0 will apply, it will activate main acknowledge signal in general only interrupt request signal is received by CPU.
- (vii) V_{SS} : Ground Signal
- V_{CC} : Power Supply +5V.
- (viii) $I/O/\bar{M}$: Used to define whether address of memory or I/O device.
- (ix) RESET/IN : When low, used to reset system.
- (x) RESET/OUT : When high show system has been reset.

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(xi) ALE : When high, lower bit address is transferred on bus and when low dat is transferred only using IC 7437.

(xii) $S_0 \neq S_1$: Status signal used to define instruction operation.

S_1	S_0	Operation
0	0	Opcode fetch operation
0	1	Write Write operation
1	0	Read operation
1	1	Halt operation

(xiii) SIO (Serial In Data) & SOO (Serial Out Data) : Use for serial operation

Ex: copy data from pendium to computer or vice-versa.

(xiv) \overline{RD} : Read operation, active low, data is easily recognise from memory if $\overline{RD} = 0$.

(xv) \overline{WR} : Any operation is performed on memory

Ex: Moving content from accumulator to memory.

(vi) READY : Active high show, peripheral device is high for data transferring.

(vii) HOLD signal : When activated, show that any other device is requesting for address & data bus. When activated, it reduce the use of these buses.

(viii) HLDA : Hold request is received by 40P.

UNIT - II

INSTRUCTION OF 8085 :

Instruction is a command given by computer to perform specific operation.

8085 has 80 instruction sets.

Each instruction has two parts "opcode" & "operand."

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Instruction

Data Transfer	Arithmetic	Logic	Branch	Machine Control
COPY the data from source to destination → MOV : Data b/w Registers. → MVI : Data Byte to register or memory location → LDA : B/w memory location & register → STA : Blw I/o device & accumulator. → LXI : 16 bit data into register pair in one step.	• Addition → ADD : Content of Register (8 bit) → ADI : Content of memory location (8 bit) → SUB : Content of register (8 bit) → SUI : content of memory location (8 bit) → INR : Increment register value. → DCR : Decrement register value → INY : Increment pair. → DCX : Decrement pair.	→ ANA : AND with R/M → ANI : AND Acc with 8-bit → ORA : OR Acc with R/M. → ORI : OR Acc with 8-bit → XRA : XOR Acc with RIM. → XRI : XOR Acc with 8-bit → CMA : 1's complement	(i) Unconditional Go to new location no matter what. → JMP Address Jump to address specified (Go to) Jump to address specified but treat it as subroutine → RET : Return to subroutine → JC : Jump on carry → JNC : Jump on non-carry → JP : Jump on Plus if Sign flag is not set → JM : Jump on Minus if sign flag is set	→ HLT : Stop executing the program. → NOP : • No operation • exactly as it says, do nothing • Used for delay or replace init? during debugging.
LXI B, 02H // [B] ← 02 → LDAX : From memory to accumulator. Used with BC & DE only. → STAX : Accumulator to memory		→ RLC : Rotate acc. left. → RAL : Rotate acc. left through carry. → RRC : Rotate acc. right. → RAR : Rotate acc. right through carry.	(ii) Conditional Go to new location if cond" is true. JZ : Jump on 0 if zero flag is set → JNZ : Jump on Non-0 if zero flag is not set → JC : Jump on carry if carry flag is set → JNC : Jump on non-carry if carry flag is not set → JP : Jump on Plus if Sign flag is not set → JM : Jump on Minus if sign flag is set	
[L] ← [2500] [H] ← [2501]	→ ADC : Add with carry. → SBC : Subtract with borrow	→ to carry, carry to 0. 0 bit to 7 0 to carry & carry to I.		
→ SHLD : [250U] ← [L] [250L] ← [H]				

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CMP : Compare registers & Acc.
COL : compare bit to acc.



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ADDRESSING MODES

- (1) These are defined as the way of data transferring between registers either having direct address or indirect address.
- (2) Operation on data either self operation means single register will be used for whole of the operation or with the help of another register.

5 modes come under this category.

(1) Direct Addressing Mode : Address is given in the given instruction
Ex: LDA 16 bit Address // $[A] \leftarrow [16 \text{ bit Add.}]$

(2) Register Addressing Mode : This instruction copy content from register to register.
Ex: MOV A, B // $[A] \leftarrow [B]$

(3) Indirect Addressing Mode : Data to be operated is available inside memory location and that memory location is indirectly specified by register pair.

Ex: MOV A, M // $[A] \leftarrow [M]$

LDAX B // $[A] \leftarrow [B][C]$

LXI H 9570 // (load immediate HL pair with add. of the location 9570)

(4) Immediate Addressing Mode : Source operand is always data. If data is 8-bit, then the instruction will be of 2 bytes, if data is of 16-bit then instruction will be of 3 bytes.

Ex: MVI B 45

LXI H 3050

JMP Address.

Implied / Implicit Addressing Mode : Operand is hidden and the data to be operated is available in instruction itself.

Ex: CMA, RRC, RLC

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