BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

TIMING DIAGRAMS OF INSTRUCTIONS

Note: Any Operation that is performed within the μP does not require a machine cycle and hence is not shown in timing diagrams.

1) MVI B, 25H

B ← 25 H

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	25	**3**
		Total	**7**

2) LXI B, 2000H

BC ← 2000 H

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00	**3**
Memory Read	PC + 2	20	**3**
		Total	**10**

3) LDA 2000H

A ← [2000H]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
Memory Read	2000	[2000]	**3**
		Total	**13**

4) STA 3000H

A → [3000H]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	30 (W)	**3**
Memory Write	3000	A	**3**
		Total	**13**

5) LDAX B

A ← [BC]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	BC	[BC]	**3**
		Total	**7**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

6) STAX D

A → [DE]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Write	DE	A	**3**
		Total	**7**

7) LHLD 2000H

L ← [2000H], H ← [2001H]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
Memory Read	2000	[2000]	**3**
Memory Read	2001	[2001]	**3**
		Total	**16**

8) SHLD 5140H

L → [5140H], H → [5141H]

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	40 (Z)	**3**
Memory Read	PC + 2	51 (W)	**3**
Memory Write	5140	L	**3**
Memory Write	5141	H	**3**
		Total	**16**

9) MOV B,C

B ← C

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
		Total	**4**

10) PCHL

PC ← HL

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
		Total	**6**

Cell: 98204 08217
BharatSir@hotmail.com

11) SPHL

SP ← HL

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
		Total	**6**

12) ADD B {all 8 bit arithmetic operations using register addressing mode}

A ← A + B

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
		Total	**4**

13) INR B

B ← B + 1

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
		Total	**4**

14) INX B

BC ← BC + 1

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
		Total	**6**

Instructions Involving "M" – Memory Pointer

15) MVI B, 25H

B ← B + 1

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	25	**3**
Memory Write	HL	25	**3**
		Total	**10**

16) MOV B, M

B ← M

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	HL	M	**3**
		Total	**7**

Cell: 98204 08217
BharatSir@hotmail.com

17) MOV M, B

M ← B

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Write	HL	B	**3**
		Total	**7**

18) INR M {Very Important}

M ← M + 1

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	HL	M	**3**
Memory Write	HL	M + 1	**3**
		Total	**10**

19) ADD M

A ← A + M

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	HL	M	**3**
		Total	**7**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

Stack Operations

20) PUSH B

SP ← SP – 1 … internal operation
[SP] ← B … memory write
SP ← SP – 1 … internal operation
[SP] ← C … memory write

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Write	SP – 1	B	**3**
Memory Write	SP – 2	C	**3**
		Total	**12**

21) POP B

C ← [SP] … memory read
SP ← SP + 1 … internal operation
B ← [SP] … memory read
SP ← SP + 1 … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	SP	[SP]	**3**
Memory Read	SP +1	[SP + 1]	**3**
		Total	**10**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

Branch Operations

22) JMP 2000H

PC ← 2000 H

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
		Total	**10**

23) JC 2000H

If CF = 1 then condition is true hence,

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
		Total	**10**

If CF = 0 then condition is false hence,

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read (Idle)	---	---	**3**
		Total	**7**

24) Call 2000H

SP ← SP – 1 … internal operation
[SP] ← PCH … Memory Write
SP ← SP – 1 … internal operation
[SP] ← PCL … Memory Write
PC ← 2000 H … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
Memory Write	SP – 1	PCH	**3**
Memory Write	SP – 2	PCL	**3**
		Total	**18**

25) CC 2000H

If CF=1 then condition is true hence,

SP ← SP – 1 … internal operation
[SP] ← PCH … Memory Write
SP ← SP – 1 … internal operation
[SP] ← PCL … Memory Write
PC ← 2000 H … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Read	PC + 1	00 (Z)	**3**
Memory Read	PC + 2	20 (W)	**3**
Memory Write	SP – 1	PCH	**3**
Memory Write	SP – 2	PCL	**3**
		Total	**18**

If CF = 0 then condition is false hence,

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Read (Idle)	---	---	**3**
		Total	**9**

26) RET

PCL ← [SP] … Memory Read
SP ← SP + 1 … internal operation
PCH ← [SP] … Memory Read
SP ← SP + 1 … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	SP	[SP]	**3**
Memory Read	SP + 1	[SP + 1]	**3**
		Total	**12**

27) RC

If CF = 1 then condition is true hence,

PCL ← [SP] … Memory Read
SP ← SP + 1 … internal operation
PCH ← [SP] … Memory Read
SP ← SP + 1 … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Read	SP	[SP]	**3**
Memory Read	SP + 1	[SP + 1]	**3**
		Total	**12**

If CF = 0 then condition is false hence,

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
		Total	**9**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

28) RSTn

SP ← SP – 1 … internal operation
[SP] ← PCH … Memory Write
SP ← SP – 1 … internal operation
[SP] ← PCL … Memory Write
PC ← (n x 8) … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**6**
Memory Write	SP – 1	PCH	**3**
Memory Write	SP – 2	PCL	**3**
		Total	**12**

I/O Operations

29) IN 80H

A ← $[80]_{I/O}$

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	80	**3**
I/O Read	80	[80]	**3**
		Total	**10**

30) OUT 80H

A → $[80]_{I/O}$

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	PC + 1	80	**3**
I/O Write	80	A	**3**
		Total	**10**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

Additional Instructions

31) DAD D

HL ← HL + DE

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Bus Idle	---	---	**3**
Bus Idle	---	---	**3**
		Total	**10**

32) HLT

Halt F/F ← 1

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4T +1T**
		Total	**5**

33) XTHL

Z ← [SP] … Memory Read
W ← [SP + 1] … Memory Read
[SP + 1] ← H … Memory Write
[SP] ← L … Memory Write
HL ← WZ … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
Memory Read	SP	[SP]	**3**
Memory Read	SP + 1	[SP + 1]	**3**
Memory Write	SP + 1	H	**3**
Memory Write	SP	L	**3**
		Total	**16**

34) XCHG

DE ←→ HL … internal operation

Machine Cycle	Address Bus	Data Bus	T-States
Opcode Fetch	PC	Opcode (Eg: 3E)	**4**
		Total	**4**

BHARAT ACHARYA EDUCATION
Cell: 98204 08217
BharatSir@hotmail.com

Call 2000 H