

F

8085 Instruction Set

Appendix F describes each instruction fully in terms of its operation and the operand, including details such as number of bytes, machine cycles, T-states, Hex code, and affected flags. The instructions appear in alphabetical order and are illustrated with examples.

The following abbreviations are used in the description of the instruction set.

Flags					
Reg.	= 8080A/8085 Register	S	= Sign		
Mem.	= Memory Location	Z	= Zero		
R	= Register	AC	= Auxiliary Carry		
Rs	= Register Source	P	= Parity		
Rd	= Register Destination	CY	= Carry		
M	= Memory				
()	= Contents of				
XX	= Random Information				

ACI: Add Immediate to Accumulator with Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
ACI	8-bit data	2	2	7	CE

Description The 8-bit data (operand) and the Carry flag are added to the contents of the accumulator, and the result is stored in the accumulator.

Flags All flags are modified to reflect the result of the addition.

Example Assuming the accumulator contains 26H and the previous operation has set the Carry flag, add byte 57H to the accumulator.

Instruction: ACI 57H Hex Code: CE 57

Addition:

$$\begin{array}{l}
 \text{(A): } 26H = 0\ 0\ 1\ 0\ 0\ 1\ 1\ 0 \\
 \text{(Data): } 57H = 0\ 1\ 0\ 1\ 0\ 1\ 1\ 1 \\
 \text{CY 1} = \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \\
 \text{7EH} = 0\ \underline{1}\ 1\ 1\ \underline{1}\ \underline{1}\ \underline{1}\ 0 \\
 \text{Flags: } S = 0 \quad Z = 0 \quad AC = 0 \\
 \quad \quad P = 1 \quad CY = 0
 \end{array}$$

Comments:

- After addition the previous Carry flag is cleared.
- This instruction is commonly used in 16-bit addition. This instruction should not be used to account for a carry generated by 8-bit numbers.

ADC: Add Register to Accumulator with Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
ADC	Reg. Mem.	1 1	1 2	4 7	Reg. B C D E H L M A 8F

Description The contents of the operand (register or memory) and the Carry flag are added to the contents of the accumulator and the result is placed in the accumulator. The contents of the operand are not altered; however, the previous Carry flag is reset.

Flags All flags are modified to reflect the result of the addition.

Example Assume register pair BC contains 2498H and register pair DE contains 54A1H. Add these 16-bit numbers and save the result in BC registers. The steps in adding 16-bit numbers are as follows:

- Add the contents of registers C and E by placing the contents of one register in the accumulator. This addition generates a Carry. Use instruction ADD (explained on the next page) and save the low-order 8-bits in register C.

$$\begin{array}{l}
 98H = \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \\
 AH = \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \\
 \text{CY} = \underline{\hspace{8em}} \quad \underline{\hspace{1em}}
 \end{array}$$

- Add the contents of registers B and D by placing the contents of one register in the accumulator. Use instruction ADC.

The result will be as follows.

$$\begin{array}{l}
 24H = 0\ 0\ 1\ 0\ -0\ 1\ 0\ 0 \\
 - 54H = 0\ 1\ 0\ 1\ 0\ 0\ 0\ 0 \\
 \hline 1 = \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \quad \underline{\hspace{8em}} \quad \underline{\hspace{1em}} \\
 79H = 0\ 1\ 1\ 1\ 1\ 0\ 0\ 1 \quad \text{Store in register B}
 \end{array}$$

Comments: This instruction is generally used in 16-bit addition. For example, to add the contents of BC registers to the contents of DE registers this instruction is used to account for the carry generated by low-order bytes.

ADD: Add Register to Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
ADD	Reg. Mem.	1 1	1 2	4 7	Reg. Hex

Description The contents of the operand (register or memory) are added to the contents of the accumulator and the result is stored in the accumulator. If the operand is a memory location, that is indicated by the 16-bit address in the HL register.

Flags All flags are modified to reflect the result of the addition.

Example Register B has 51H and the accumulator has 47H. Add the contents of register B to the contents of the accumulator.

Instruction: ADD B Hex Code: 80

Register contents before instruction

Addition

A	47 X	F
B	51 X	C
98H = 1 0 0 1	1 0 0 1	1 0 0 0

Flags: S = 1, Z = 0, AC = 0
P = 0, CY = 0

Example Memory location 2050H has data byte A2H and the accumulator has 76H. Add the contents of the memory location to the contents of the accumulator.

Instruction: ADD M Hex Code: 86
Before this instruction is executed, registers HL should be loaded with data 2050H.

Register contents before instruction

A	76 X	F
B	X X	C
D	X X	E
H	20 50	L

A	76 X	F
B	X X	C
D	X X	E
H	20 50	L

Registers after instruction

Addition:

Flags: S = 0, Z = 0, AC = 0,
P = 1, CY = 1

ADI: Add Immediate to Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
ADI	8-bit data	2	2	7	C6

Description The 8-bit data (operand) are added to the contents of the accumulator, and the result is placed in the accumulator.

Flags All flags are modified to reflect the result of the addition.

Example The accumulator contains 4AH. Add the data byte 59H to the contents of the accumulator.

Instruction: ADI 59H Hex Code: C6 59
Addition:

(A) : 4AH = 0 1 0 0 1 0 1 0
+ (Data) : 59H = 0 1 0 1 1 0 0 1
----- A3H = 1 0 1 0 0 0 1 1

Flags: S = 1, Z = 0, AC = 1
P = 1, CY = 0

ANA: Logical AND with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
Reg.	Mem.	1	1	4	Reg. Hex
ANA	Reg.	1	2	7	B A0
	Mem.				C A1
					D A2
					E A3
					F A4
					G A5
					H A6
					I A7

Description The contents of the accumulator are logically ANDed with the 8-bit data (operand) and the results are placed in the accumulator.

Flags S, Z, P are modified to reflect the results of the operation. CY is reset. In 8085, AC is set.

Example AND data byte 97H with the contents of the accumulator, which contains A3H.

Instruction: ANI 97H Hex Code: E6 97

Logical AND:

(A) :	A3H = 1 0 1 0 0 0 1 1
AND	
(Data) :	97H = 1 0 0 1 0 1 1 1
	1 0 0 0 0 0 1 1

CALL: Unconditional Subroutine Call

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
CALL	16-bit	3	5	18	CD

Description The program sequence is transferred to the address specified by the operand. Before the transfer, the address of the next instruction to CALL (the contents of the program counter) is pushed on the stack. The sequence of events is described in the example below.

Flags No flags are affected.

Example Write CALL instruction at memory location 2010H to call a subroutine located at 2050H. Explain the sequence of events when the stack pointer is at location 2099H.

Registers	Memory	Registers	Memory
Register contents before instruction	-	Register contents after instruction	-
	SZ AC P CY		

A 54 X F	54H = 0 1 0 1	0 1 0 0	A 00 [01, 1, 1, 0] F
B 82 X E	AND		

Flags: S = 0, Z = 1, P = 1

AC = 1, CY = 0
(for 8080A, AC = 0)

Memory Address	Hex Code	Mnemonics
-	-	-
2010	CD	CALL 2050H
2011	50	
2012	20	

ANI: AND Immediate with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
ANI	8-bit data	2	2	7	E6

Note: See the difference between writing a 16-bit address as mnemonics and code. In the code, the low-order byte (50) is entered first, then the high-order byte (20) is entered. However, in mnemonics the address is shown in the proper sequence. If an assembler is used to obtain the codes, it will automatically reverse the sequence of the mnemonics.

Execution of CALL: The address in the program counter (2013H) is placed on the stack as follows.

Stack pointer is decremented to 2098H
MSB is stored
Stack pointer is again decremented
LSB is stored
Call address (2050FD) is temporarily stored in internal W/Z registers and placed on the bus for the fetch cycle

Comments: "The CALL instruction should be accompanied by one of the return (RET or conditional return) instructions in the subroutine.

2097	13
2098	20
SP → 2099	

CMC: Complement Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
CMC	None	1	1	4	3F

Description The Carry flag is complemented.

Flags The Carry flag is modified, no other flags are affected.

CMP: Compare with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
CMP	Reg: Mem.	1 1	1 2	4 7	Reg. B8 B9

Conditional Call to Subroutine

Op Code	Flag	Hex Code	M-Cycles	T-States
CC	Status	DC	2/9	(if condition is not true)
CNC	Call on Carry	D4	5/18	(if condition is true)
CP	Call with No Carry	F4	<i>Note:</i> If condition is not true it continues the sequence, and thus requires fewer T-states.	
CM	Call on Positive	S = 0	If condition is true it calls the subroutine, thus requires more T-states.	
CN	Call on minus	S = 1		
CPE	Call on Parity Even	P = 1		
CPO	Call on Parity Odd	P = 0		
CZ	Call on Zero	Z = 1		
CNZ	Call on No Zero	Z = 0		
		C4		

Flags No flags are affected.

CMA: Complement Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
CMA	None	1	1	4	2F

Description The contents of the accumulator are complemented.

Flags No flags are affected.

Example

Complement the accumulator, which has data byte 89H.

Instruction: CMA Hex Code: 2F

Before instruction		After instruction	
A	1 0 0 1 0 0 1	= 89H	A 0 1 1 0 1 1 0 = 76H

CMC: Complement Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
CMC	None	1	1	4	3F

Description The Carry flag is complemented.

Flags The Carry flag is modified, no other flags are affected.

CMP: Compare with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
CMP	Reg: Mem.	1 1	1 2	4 7	Reg. B8 B9

Operand—16-Bit Address

Op Code	Flag	Hex Code	M-Cycles	T-States
CC	Status	DC	2/9	(if condition is not true)
CNC	Call on Carry	D4	5/18	(if condition is true)

Note: If condition is not true it continues the sequence, and thus requires fewer T-states.
If condition is true it calls the subroutine, thus requires more T-states.

Description The contents of the operand (register or memory) are compared with the contents of the accumulator. Both contents are preserved and the comparison is shown by setting the flags as follows:

- If (A) < (Reg/Mem): Carry flag is set and Zero flag is reset.
- If (A) = (Reg/Mem): Zero flag is set and Carry flag is reset.
- If (A) > (Reg/Mem): Carry and Zero flags are reset.

The comparison of two bytes is performed by subtracting the contents of the operand from the contents of the accumulator; however, neither contents are modified.

Flags S, P, AC are also modified in addition to Z and CY to reflect the results of the operation.

Example Register B contains data byte 62H and the accumulator contains data byte 57H. Compare the contents of register B with those of the accumulator.

Instruction: CMP B Hex Code: B8

Before instruction		After instruction	
A	57 XX	F	
B	62 XX	C	
Flags: S = 1, Z = 0, AC = 1			
P = 1, CY = 1			

Results after executing the instruction:

- No contents are changed.
- Carry flag is set because $(A) < (B)$.
- S, Z, P, AC flags will also be modified as listed above.

CPI: Compare Immediate with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
CPI	8-bit	2	2	7	FE

Description The second byte (8-bit data) is compared with the contents of the accumulator. The values being compared remain unchanged and the results of the comparison are indicated by setting the flags as follows.

- If $(A) < \text{Data}$, Carry flag is set and Zero flag is reset.
- If $(A) = \text{Data}$, Zero flag is set and Carry flag is reset.
- If $(A) > \text{Data}$, Carry and Zero flags are reset.

The comparison of two bytes is performed by subtracting the data byte from the contents of the accumulator; however, neither contents are modified.

Flags S, P, AC are also modified in addition to Z and CY to reflect the result of the operation.

Example Assume the accumulator contains data byte C2H. Compare 98H with the accumulator contents.

Instruction: CPI 98H Hex Code: FE 98

Results after executing the instruction:

- The accumulator contents remain unchanged.
- Z and CY flags are reset because $(A) > \text{Data}$.
- Other flags: S = 0, AC = 0, P = 0.

Example Compare data byte C2H with the contents of the accumulator in the above example.

Instruction: CPI C2H Hex Code: FE C2

Results after executing the instruction:

- The accumulator contents remain unchanged.
- Zero flag is set because $(A) = \text{Data}$.
- Other flags: S = 0, AC = 1, P = 1, CY = 0.

DAA: Decimal-Adjust Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
DAA	None	1	1	4	27

Description The contents of the accumulator are changed from a binary value to two 4-bit binary-coded decimal (BCD) digits. This is the only instruction that uses the auxiliary flag (internally) to perform the binary-to-BCD conversion; the conversion procedure is described below.

Flags S, Z, AC, P, CY flags are altered to reflect the results of the operation. Instruction DAA converts the binary contents of the accumulator as follows:

1. If the value of the low-order four bits (D_3-D_0) in the accumulator is greater than 9 or if AC flag is set, the instruction adds 6 (06) to the low-order four bits.
2. If the value of the high-order four bits (D_7-D_4) in the accumulator is greater than 9 or if the Carry flag is set, the instruction adds 6 (60) to the high-order four bits.

Example Add decimal 12_{BCD} to the accumulator, which contains 39_{BCD}.

$$(A) = \begin{array}{r} 39_{\text{BCD}} = 0\ 0\ 1\ 1\ 1\ 0\ 0\ 1 \\ + 12_{\text{BCD}} = 0\ 0\ 0\ 1\ 0\ 0\ 1\ 0 \\ \hline 51_{\text{BCD}} = 0\ 1\ 0\ 0\ 1\ 0\ 1\ 1 \end{array}$$

The binary sum is 4BH. The value of the low-order four bits is larger than 9. Add 06 to the low-order four bits.

$$\begin{array}{r} 4B = 0\ 1\ 0\ 0\ 1\ 0\ 1\ 1 \\ + 06 = 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0 \\ \hline 51 = 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1 \end{array}$$

Example Add decimal 68_{BCD} to the accumulator, which contains 85_{BCD}.

$$(A) = \begin{array}{r} 85_{\text{BCD}} = 1\ 0\ 0\ 0\ 0\ 1\ 0\ 1 \\ + 68_{\text{BCD}} = 0\ 1\ 1\ 0\ 1\ 0\ 0\ 0 \\ \hline 153_{\text{BCD}} = 1\ 1\ 1\ 0\ 1\ 1\ 0\ 1 \end{array}$$

The binary sum is EDH. The values of both, low-order and high-order, four bits are higher than 9. Add 6 to both.

$$\begin{array}{r} = ED = 1\ 1\ 1\ 0\ 1\ 1\ 0 \\ + 66 = 0\ 1\ 1\ 0\ 0\ 1\ 1\ 0 \\ \hline 153 = \boxed{1\ 0\ 1\ 0\ 1\ 0\ 1\ 1} \\ CY \end{array}$$

The accumulator contains 53 and the Carry flag is set to indicate that the sum is larger than eight bits (153). The program should keep track of the Carry; otherwise it may be altered by the subsequent instructions.

DAD: Add Register Pair to H and L Registers

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
DAD	Reg. pair	1	3	10	Reg. Pair Hex B 09 D 19 H 29 SP 39

Description The 16-bit contents of the specified register pair are added to the contents of the HL register and the sum is saved in the HL register. The contents of the source register pair are not altered.

Flags If the result is larger than 16 bits the CY flag is set. No other flags are affected.

Example Assume register pair HL contains 0242H. Multiply the contents by 2.

Instruction:	DAD H	Hex Code:	29
	Before instruction	DAD operation	After instruction
		0242 +0242 0484	H [04] 84 L

Example Assume register pair HL is cleared. Transfer the stack pointer (register) that points to memory location 2099H to the HL register pair.

Instruction:	DAD SP	Hex Code:	39
	Before instruction	DAD operation	After instruction
		0000 +2099 2099	H 20 [99] L SP 2099

Note: After the execution of the instruction, the contents of the stack pointer register are not altered.

DCR: Decrement Source by 1

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
DCR	Reg. Mem.	1	1	4	Reg. Hex B 05 C 0D D 15 E 1D H 25 L 2D M 35 A 3D

Description The contents of the designated register/memory is decremented by 1 and the results are stored in the same place. If the operand is a memory location, it is specified by the contents of the HL register pair.

Flags S, Z, P, AC are modified to reflect the result of the operation. CY is not modified.

Example Decrement register B, which is cleared, and specify its contents after the decrement.

Instruction:	DCR B	Hex Code:	05
	Before instruction	A [XX] F B [00] XX C	Decrement operation (B) = 0 0 0 0 0 0 0 0

Subtraction is performed in 2's complement:

$$(B) = \begin{array}{r} 0 0 0 0 \\ + \\ 2^8 \text{ complement of } 1 = \begin{array}{r} 1 1 1 1 \\ 1 1 1 1 \end{array} \\ \hline (B) = \begin{array}{r} 1 1 1 1 \\ 1 1 1 1 \end{array} \end{array}$$

After the execution of the DCR instruction register B will contain FFH; however, this instruction does not modify the CY flag.

Example Decrement the contents of memory location 2085, which presently holds A0H.

Assume the HL register contains 2085H.

Instruction:	DCR M	Hex Code:	35
Before instruction			Memory
H	20	85	L
	2085		2084
		A0	
			2086

After instruction

Instruction:	DCR M	Hex Code:	35
Before instruction			Memory
H	20	85	L
	2085		2084
		9F	
			2086

DCX: Decrement Register Pair by 1

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Codes
DCX	Reg. pair	1	1	6	Reg. Pair B 0B D 1B H 2B SP 3B

Description The contents of the specified register pair are decremented by 1. This instruction views the contents of the two registers as a 16-bit number.

Flags No flags are affected.

Example Register pair DE contains 2000H. Specify the contents of the entire register if it is decremented by 1.

Instruction: DCX D Hex Code: 1B

After subtracting 1 from the DE register pair the answer is

D	1F	FF	E
---	----	----	---

HLT: Halt and Enter Wait State

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
HLT	None	1	2 or more	5 or more	76

Description The MPU finishes executing the current instruction and halts any further execution. The MPU enters the Halt Acknowledge machine cycle and Wait states are inserted in every clock period. The address and the data bus are placed in the high impedance state.

For BC pair:

↑ DCX B	:Decrement register pair BC
↓ MOV A,C	:Load accumulator with the contents of register C
ORA B	
INZ	:Set Zero flag if B and C are both 0
↓ pair	:If Zero flag is not set, go back and decrement the contents of BC

DI: Disable Interrupts

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
DI	None	1	1	4	F3

Description The interrupt Enable flip-flop is reset and all the interrupts except the TRAP (8085) are disabled.

Flags No flags are affected.

Comments This instruction is commonly used when the execution of a code sequence cannot be interrupted. For example, in critical time delays, this instruction is used at the beginning of the code and the interrupts are enabled at the end of the code. The 8085 TRAP cannot be disabled.

EI: Enable Interrupts

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
EI	None	1	1	4	FB

Description The interrupt Enable flip-flop is set and all interrupts are enabled.

Flags No flags are affected.

Comments After a system reset or the acknowledgement of an interrupt, the interrupt enable flip-flop is reset, thus disabling the interrupts. This instruction is necessary to reenable the interrupts (except TRAP).

HLT: Halt and Enter Wait State

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
HLT	None	1	2 or more	5 or more	76

Description The MPU finishes executing the current instruction and halts any further execution. The MPU enters the Halt Acknowledge machine cycle and Wait states are inserted in every clock period. The address and the data bus are placed in the high impedance state.

Instruction: INX H Hex Code: 23

After adding 1 to the contents of the HL pair the answer is

H A0 00 L

JMP: Jump Unconditionally

Opcde	Operand	Bytes	M-Cycles	T-States	Hex Code
JMP	16-bit	3	3	10	C3

Description The program sequence is transferred to the memory location specified by the 16-bit address. This is a 3-byte instruction; the second byte specifies the low-order byte and the third byte specifies the high-order byte.

Example Write the instruction at location 2000H to transfer the program sequence to memory location 2050H.

Instruction:

Memory Address	Code	Mnemonics
2000	C3	JMP 2050H
2001	50	
2002	20	

Comments: The 16-bit address of the operand is entered in memory in reverse order, the low-order byte first, followed by the high-order byte.

Jump Conditionally

Operand: 16-bit address

Op Code	Description	Flag Status	Hex Code	M-Cycles/T-States
JC	Jump on Carry	CY = 1	DA	2M/7T (if condition is not true)
JNC	Jump on No Carry	CY = 0	D2	
JP	Jump on positive	S = 0	F2	3M/10T (if condition is true)
JM	Jump on minus	S = 1	FA	
JPE	Jump on Parity Even	P = 1	EA	
JPO	Jump on Parity Odd	P = 0	E2	
JZ	Jump on Zero	Z = 1	CA	
JNZ	Jump on Non Zero	Z = 0	C2	

Flags No flags are affected.

Comments: The 8085 requires only seven T-states when condition is not true. For example, instruction JZ 2050H will transfer the program sequence to location 2050H when the Zero flag is set ($Z = 1$) and the execution requires ten T-states. When the Zero flag is reset ($Z = 0$), the execution sequence will not be changed and this requires seven T-states.

LDA: Load Accumulator Direct

Opcde	Operand	Bytes	M-Cycles	T-States	Hex Code
LDA	16-bit address	3	4	13	3A

Description The contents of a memory location, specified by a 16-bit address in the operand, are copied to the accumulator. The contents of the source are not altered. This is a 3-byte instruction; the second byte specifies the low-order address and the third byte specifies the high-order address.

Flags No flags are affected.

Example Assume memory location 2050H contains byte F8H. Load the accumulator with the contents of location 2050H.

Instruction:	LDA 2050H	Hex Code:
	A F8 X	3A 50 20 (note the reverse order)

Opcde	Operand	Bytes	M-Cycles	T-States	Hex Code
LDAX	B/D reg. pair	1	2	7	Reg. BC 0A DE 1A

LDAX: Load Accumulator Indirect

Description The contents of the designated register pair point to a memory location. This instruction copies the contents of that memory location into the accumulator. The contents of either the register pair or the memory location are not altered.

Flags No flags are affected.

Example Assume the contents of register B = 20H, C = 50H, and memory location 2050H = 9FH. Transfer the contents of the memory location 2050H to the accumulator.

Instruction:	LDAX B	Hex Code:	0A											
Register contents before instruction		Memory contents	Register contents after instruction											
A <table border="1"><tr><td>XX</td><td>XX</td></tr><tr><td>B</td><td>20</td></tr></table> F B <table border="1"><tr><td>XX</td><td>50</td></tr></table> C	XX	XX	B	20	XX	50		A <table border="1"><tr><td>9F</td><td>XX</td></tr><tr><td>B</td><td>20</td></tr></table> F B <table border="1"><tr><td>50</td></tr></table> C	9F	XX	B	20	50	
XX	XX													
B	20													
XX	50													
9F	XX													
B	20													
50														

LHLD: Load H and L Registers Direct

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
LHLD	16-bit address	3	5	16	2A

Description The instruction copies the contents of the memory location pointed out by the 16-bit address in register L and copies the contents of the next memory location in register H. The contents of source memory locations are not altered.

Flags No flags are affected.

Example Assume memory location 2050H contains 90H and 2051H contains 01H. Transfer memory contents to registers HL.

Instruction: LHLD 2050H Hex Code: 2A 50 20

Memory contents before instruction		Register contents after instruction				
2050 <table border="1"><tr><td>90</td></tr></table>	90		H <table border="1"><tr><td>01</td><td>90</td></tr></table>	01	90	L
90						
01	90					
2051 <table border="1"><tr><td>01</td></tr></table>	01					
01						

LXI: Load Register Pair Immediate

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
LXI	Reg. pair, 16-bit data	3	3	10	Reg. Pair B D H SP

Description The instruction loads 16-bit data in the register pair designated in the operand. This is a 3-byte instruction; the second byte specifies the low-order byte and the third byte specifies the high-order byte.

Flags No flags are affected.

Instruction: MOV B,C Hex Code: 41

Note the first operand B specifies the destination and the second operand C specifies the source.

Register contents before instruction
B

72	9F
----	----

 C

Register contents after instruction
B

9F	9F
----	----

 C

Example Load the 16-bit data 2050H in register pair BC.

Instruction: LXI B,2050H Hex Code: 01 50 20

This instruction loads 50H in register C and 20H in register B.

Comments: Note the reverse order in entering the code of 16-bit data. This is the only instruction that can directly load a 16-bit address in the stack pointer register.

MOV: Move—Copy from Source to Destination

Opcode	Operand	Bytes	M-Cycles	Bytes	M-Cycles	T-States	Hex Code
MOV	Rd,Rs	1	1	1	1	4	See table below
MOV	M,Rs	2	2	7	7	7	Rd,M

Description This instruction copies the contents of the source register into the destination register; the contents of the source register are not altered. If one of the operands is a memory location, it is specified by the contents of HL registers.

Flags No flags are affected.

Hex Code

Source Location							
B	C	D	E	H	L	M	A
B	40	41	42	43	44	45	46
C	48	49	4A	4B	4C	4D	4F
D	50	51	52	53	54	55	56
E	58	59	5A	5B	5C	5D	5F
Destination Location	H	60	61	62	63	64	65
	L	68	69	6A	6B	6C	6F
	M	70	71	72	73	74	77
	A	78	79	7A	7B	7C	7D

Example Assume register B contains 72H and register C contains 9FH. Transfer the contents of register C to register B.

Instruction: MOV B,C Hex Code: 41

Note the first operand B specifies the destination and the second operand C specifies the source.

Register contents before instruction
B

72	9F
----	----

 C

Register contents after instruction
B

9F	9F
----	----

 C

Example Assume the contents of registers HL are 20H and 50H, respectively. Memory location 2050H contains 9FH. Transfer the contents of the memory location to register B.

Instruction: MOV B,M Hex Code: 46

Register contents before instruction	Memory contents	Register contents after instruction
B XX XX	C 9F XX	B 9F XX
D XX XX	E XX XX	D XX XX
H 20 50	L 20 50	L C

MVI: Move Immediate 8-Bit

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
MVI	Reg., Data Mem., Data	2 2	2 3	7 10	Reg. Hex

Description The 8-bit data are stored in the destination register or memory. If the operand is a memory location, it is specified by the contents of HL registers.

Flags No flags are affected.

Example Load 92H in register B.

Instruction: MVI B,92H Hex Code: 06 92
This instruction loads 92H in register B.

Example Assume registers H and L contain 20H and 50H, respectively. Load 3AH in memory location 2050H.

Instruction:	MVI M,3AH	Hex Code:	36	Contents before instruction	Contents after instruction	Flags: CY = 0, AC = 0
	H H 20 50	L —> 2050 [3A]	H [20] 50 L			

NOP: No Operation

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
NOP	None	1	1	4	00

Description No operation is performed. The instruction is fetched and decoded; however, no operation is executed.

Flags No flags are affected.

Comments: The instruction is used to fill in time delays or to delete and insert instructions while troubleshooting.

ORA: Logically OR with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
ORA	Reg. Mem.	1	1	4	Reg. Hex

Description The contents of the accumulator are logically ORed with the contents of the operand (register or memory), and the results are placed in the accumulator. If the operand is a memory location, its address is specified by the contents of HL registers.

Flags Z, S, P are modified to reflect the results of the operation. AC and CY are reset.

Example Assume the accumulator has data byte 03H and register C holds byte 81H. Combine the bits of register C with the accumulator bits.

Instruction:	ORA C	Hex Code:	B1
	Register contents before instruction	Logical OR	Register contents after instruction

A	03	XX	F	03H = 0 0 0 0 0 0 1 1	SZ AC P CY
B	XX	81	C	81H = 1 0 0 0 0 0 0 1	

S = 1, Z = 0, P = 0
Flags: CY = 0, AC = 0

Comments: The instruction is commonly used to

- reset the CY flag by ORing the contents of the accumulator with itself.
- set the Zero flag when 0 is loaded into the accumulator by ORing the contents of the accumulator with itself.
- combine bits from different registers.

Comments: This instruction is equivalent to a 1-byte unconditional Jump instruction. A program sequence can be changed to any location by simply loading the H and L registers with the appropriate address and by using this instruction.

ORI: Logically OR Immediate

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
ORI	8-bit data	2	2	7	F6

Description The contents of the accumulator are logically ORed with the 8-bit data in the operand and the results are placed in the accumulator.

Flags S, Z, P are modified to reflect the results of the operation. CY and AC are reset.

OUT: Output Data from Accumulator to a Port with 8-Bit Address

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
OUT	8-bit port address	2	3	10	D3

Description The contents of the accumulator are copied into the output port specified by the operand.

Flags No flags are affected.

Comments: The operand is an 8-bit address; therefore, port addresses can range from 00H to FFH. While executing the instruction, a port address is placed on the low-order address bus ($A_7 - A_0$) as well as the high-order address bus ($A_{15} - A_8$). Any of the sets of address lines can be decoded to enable the output port.

PCHL: Load Program Counter with HL Contents

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
PCHL	None	1	1	6	E9

Description The contents of registers H and L are copied into the program counter. The contents of H are placed as a high-order byte and of L as a low-order byte.

Flags No flags are affected.

Comments: Operand PSW (Program Status Word) represents the contents of the accumulator and the flag register; the accumulator is the high-order register and the flags are the low-order register.

Note that the contents of the source, stack locations, are not altered after the POP instruction.

POP: Pop off Stack to Register Pair

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
POP	Reg pair	1	3	10	B C1 D D1 H E1 F1 PSW

Description The contents of the memory location pointed out by the stack pointer register are copied to the low-order register (such as C, E, L, and flags) of the operand. The stack pointer is incremented by 1 and the contents of that memory location are copied to the high-order register (B, D, H, A) of the operand. The stack pointer register is again incremented by 1.

Instruction:	POP H	Hex Code:	E1
Register contents before instruction		Stack contents	Register contents after instruction
H XX SP 2090	L	2090 F5 01	H 01 F5 SP 2092

Comments: Operand PSW (Program Status Word) represents the contents of the accumulator and the flag register; the accumulator is the high-order register and the flags are the low-order register.

Note that the contents of the source, stack locations, are not altered after the POP instruction.

PUSH: Push Register Pair onto Stack

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
PUSH	Reg. pair	1	3	12	Reg. Hex Hex B C5 D D5 H E5 PSW F5

Description The contents of the register pair designated in the operand are copied into the stack in the following sequence. The stack pointer register is decremented and the contents of the high-order register (B, D, H, A) are copied into that location. The stack pointer register is decremented again and the contents of the low-order register (C, E, L, flags) are copied to that location.

Flags No flags are modified.

Example Assume the stack pointer register contains 2099H, register B contains 32H and register C contains 57H. Save the contents of the BC register pair on the stack.

Instruction:	PUSH B	Hex Code: C5	Register contents after instruction
Register contents before instruction			B [32] [57] C
			2097 [57] 2098 [32] 2099 [XX]

SP [2099]

Comments: Operand PSW (Program Status Word) represents the contents of the accumulator and the flag register; the accumulator is the high-order register and the flags are the low-order register.

Note that the contents of the source registers are not altered after the PUSH instruction.

RAL: Rotate Accumulator Left through Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RAL	None	1	1	4	17

Description Each binary bit of the accumulator is rotated left by one position through the Carry flag. Bit D₇ is placed in the bit in the Carry flag and the Carry flag is placed in the least significant position D₀.

Flags CY is modified according to bit D₇, S, Z, AC, P are not affected.

Example Rotate the contents of the accumulator through Carry, assuming the accumulator has A7H and the Carry flag is reset.

Instruction:	RAL	Hex Code: 17	Accumulator content before instruction
			CY [0]

Accumulator contents after instruction	Accumulator contents before instruction
CY [1]	CY [0]

Comment: This instruction effectively provides a 9-bit accumulator. The original contents of the accumulator can be restored by using instruction RAR (Rotate Accumulator Right through Carry). However, the contents will be modified if the instruction RRC (Rotate Accumulator Right) is used to restore the contents.

RAR: Rotate Accumulator Right through Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RAR	None	1	1	4	1F

Description Each binary bit of the accumulator is rotated right by one position through the Carry flag. Bit D₀ is placed in the Carry flag and the bit in the Carry flag is placed in the most significant position, D₇.

Flags CY is modified according to bit D₀, S, Z, P, AC are not affected.

Example Rotate the contents of the accumulator assuming it contains A7H and the Carry flag is reset to 0.

Instruction:	RAR	Hex Code: 1F	Accumulator contents after instruction
			CY [1]

Accumulator contents before instruction	Accumulator contents after instruction
CY [0]	CY [1]

Accumulator contents after instruction	Accumulator contents before instruction
CY [0]	CY [1]

RLC: Rotate Accumulator Left

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RLC	None	1	1	4	07

Description Each binary bit of the accumulator is rotated left by one position. Bit D₇ is placed in the position of D₀ as well as in the Carry flag.

Flags CY is modified according to bit D₇, S, Z, P, AC are not affected.

Example Rotate the contents of the accumulator left, assuming it contains A7H and the Carry flag is reset to 0.

Instruction: RLC Hex Code: 07

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RLC	None	1	1	4	07

Accumulator contents
before instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
1	0	1	0	0	1	1	1

Accumulator contents
after instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	0	1	1	1	1

Accumulator contents
before instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
1	0	1	0	0	1	1	1

Accumulator contents
after instruction

Comments: The contents of bit D₇ are placed in bit D₀, and the Carry flag is modified accordingly. However, the contents of the Carry are not placed in bit D₀ as in instruction RAL.

RRC: Rotate Accumulator Right

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RRC	None	1	1	4	0F

Description Each binary bit of the accumulator is rotated right by one position. Bit D₀ is placed in the position of D₇ as well as in the Carry flag.

Flags CY is modified according to bit D₀, S, Z, P, AC are not affected.

Example Rotate the contents of the accumulator right, if it contains A7H and the Carry flag is reset to 0.

RRC: Rotate Accumulator Right

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RRC	None	1	1	4	0F

Description Each binary bit of the accumulator is rotated right by one position. Bit D₀ is placed in the position of D₇ as well as in the Carry flag.

Flags CY is modified according to bit D₇, S, Z, P, AC are not affected.

Example Rotate the contents of the accumulator right, assuming it contains A7H and the Carry flag is reset to 0.

Instruction: RRC Hex Code: 0F

Accumulator contents
before instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
1	0	1	0	0	1	1	1

Accumulator contents
after instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
----------------	----------------	----------------	----------------	----------------	----------------	----------------	----------------

Accumulator contents
before instruction

D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
----------------	----------------	----------------	----------------	----------------	----------------	----------------	----------------

Accumulator contents
after instruction

Description The program sequence is transferred from the subroutine to the calling program. The two bytes from the top of the stack are copied into the program counter and the program execution begins at the new address. The instruction is equivalent to POP Program Counter.

Flags No flags are affected.

Example Assume the stack pointer is pointing to location 2095H. Explain the effect of the RET instruction if the contents of the stack locations are as follows:

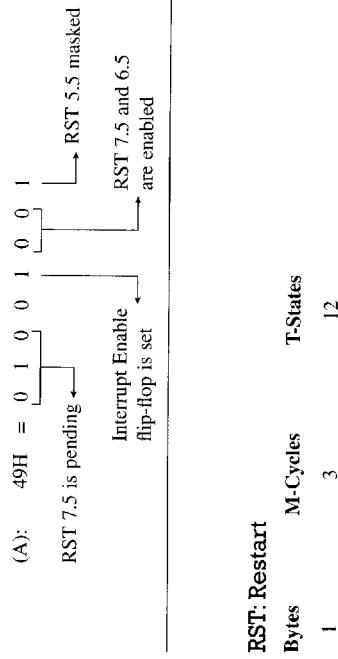
Address	Content
2095	50
2096	20

After instruction RET, the program execution is transferred to location 2050H and the stack pointer is shifted to location 2097H.

Comments: This instruction is used in conjunction with CALL or conditional call instructions.

Return Conditionally

Op Code	Description	Flag Status	Hex Code	M-Cycles/T-States
RC	Return on Carry	CY = 1	D8	1/6 (if condition is not true) 3/12 (if condition is true)
RNC	Return with No Carry	CY = 0	D0	1/6 (if condition is not true) 3/12 (if condition is true)
RP	Return on positive	S = 0	F0	Note: If condition is not true, it continues the sequence and thus requires fewer T-states.
RM	Return on minus	S = 1	F8	If condition is true, it returns to the calling program and thus requires more T-states.
RPE	Return on Parity Even	P = 1	E8	
RPO	Return on Parity Odd	P = 0	E0	
RZ	Return on Zero	Z = 1	C8	
RNZ	Return on No Zero	Z = 0	C0	

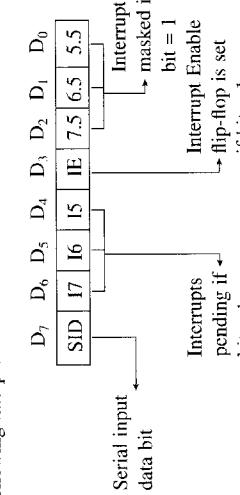
Flags No flags are affected.**RST: Restart**

Bytes	M-Cycles	T-States
1	3	12

Restart**Address (H)**

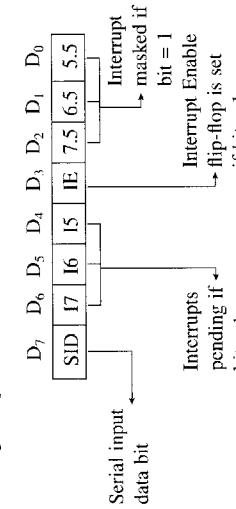
Opcode/Operand	Binary Code	Hex Code	Address (H)
RST 0	1 1 0 0 0 1 1 1	C7	0000
RST 1	1 1 0 0 1 1 1	CF	0008
RST 2	1 1 0 1 0 1 1 1	D7	0010
RST 3	1 1 0 1 1 1 1 1	DF	0018
RST 4	1 1 1 0 0 1 1 1	E7	0020
RST 5	1 1 1 0 1 1 1 1	EF	0028
RST 6	1 1 1 1 0 1 1 1	F7	0030
RST 7	1 1 1 1 1 1 1 1	FF	0038

Description This is a multipurpose instruction used to read the status of interrupts 7.5, 6.5, 5.5 and to read serial data input bit. The instruction loads eight bits in the accumulator with the following interpretations:

**RIM: Read Interrupt Mask**

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
RIM	None	1	1	4	20

Description This is a multipurpose instruction used to read the status of interrupts 7.5, 6.5, 5.5 and to read serial data input bit. The instruction loads eight bits in the accumulator with the following interpretations:

**Flags** No flags are affected.**Restart****Address**

Interruptions	Address
TRAP	24H
RST 5.5	2CH
RST 6.5	34H
RST 7.5	3CH

Description The RST instructions are equivalent to 1-byte call instructions to one of the eight memory locations on page 0. The instructions are generally used in conjunction with interrupts and inserted using external hardware. However, these can be used as software instructions in a program to transfer program execution to one of the eight locations.

Flags No flags are affected.

Additional 8085 Interrupts The 8085 has four additional interrupts and these interrupts generate RST instructions internally and thus do not require any external hardware. These instructions and their Restart addresses are as follows:

- Example** After the execution of instruction RIM, the accumulator contained 49H. Explain the accumulator contents.

SBB: Subtract Source and Borrow from Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SBB	Reg. Mem.	1 1	1 2	4 7	98 99

Description The contents of the operand (register or memory) and the Borrow flag are subtracted from the contents of the accumulator and the results are placed in the accumulator. The contents of the operand are not altered; however, the previous Borrow flag is reset.

Flags All flags are altered to reflect the result of the subtraction.

Example Assume the accumulator contains 37H, register B contains 3FH, and the Borrow flag is already set by the previous operation. Subtract the contents of B with the borrow from the accumulator.

Instruction: SBB B Hex Code: 98

The subtraction is performed in 2's complement; however, the borrow needs to be added first to the subtrahend:

$$\begin{array}{r}
 \text{(B):} \quad 3F \\
 \text{Borrow:} \quad + \frac{1}{40H} = 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \\
 \text{Subtrahend:} \quad 40H = 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \\
 \text{2's complement of} \quad = 0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \\
 \text{(A)} \quad 0F1 \ 1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 = F7H
 \end{array}$$

Complement Carry:

The Borrow flag is set to indicate the result is in 2's complement. The previous Borrow flag is reset during the subtraction.

Description The 8-bit data (operand) and the borrow are subtracted from the contents of the accumulator, and the results are placed in the accumulator.

Flags All flags are altered to reflect the result of the operation.

Example Assume the accumulator contains 37H and the Borrow flag is set. Subtract 25H with borrow from the accumulator.

Instruction: SBI 25H Hex Code: DE 25

$$\begin{array}{l}
 \text{(Data): 25H} \\
 + \text{(Borrow): } \frac{1H}{26H} = 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 0 \\
 \text{Subtrahend: } 26H = 1 \ 1 \ 0 \ 1 \ 1 \ 0 \ 1 \ 0 \\
 \text{2's complement of } 26H = 1 \ 1 \ 0 \ 1 \ 1 \ 0 \ 1 \ 0 \\
 \text{(A) } 37H = 0 \ 0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \\
 \hline
 1\cancel{0} \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 = 11H
 \end{array}$$

Complement Carry: 0/0 0 0 1 0 0 0 1 = 11H
 Flags: S = 0, Z = 0, AC = 1
 P = 1, CY = 0

SHLD: Store H and L Registers Direct

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SHLD	16-bit address	1	3	5	16 22

Description The contents of register L are stored in the memory location specified by the 16-bit address in the operand, and the contents of H register are stored in the next memory location by incrementing the operand. The contents of registers HL are not altered. This is a 3-byte instruction; the second byte specifies the low-order address and the third byte specifies the high-order address.

Flags No flags are affected.

Example Assume the H and L registers contain 01H and FFH, respectively. Store the contents at memory locations 2050H and 2051H.

Instruction: SHLD 2050H Hex Code: 22 50 20

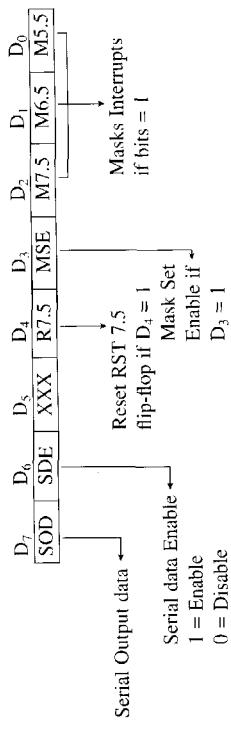
Register contents before instruction	Memory and register contents after instruction
H [01] FF L	H [01] FF L

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SBI	8-bit data	2	2	7	DE 01

SIM: Set Interrupt Mask					
Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SIM	None	1	1	4	30

Description This is a multipurpose instruction and used to implement the 8085 interrupts (RST 7.5, 6.5, and 5.5) and serial data output.

The instruction interprets the accumulator contents as follows:



SOD—Serial Output Data: Bit D₇ of the accumulator is latched into the SOD output line and made available to a serial peripheral if bit D₆ = 1.

SDE—Serial Data Enable: If this bit = 1, it enables the serial output. To implement serial output, this bit needs to be enabled.

XXX—Don't Care

R7.5—Reset RST 7.5: If this bit = 1, RST 7.5 flip-flop is reset. This is an additional control to reset RST 7.5.

MSF—Mask Set Enable: If this bit is high, it enables the functions of bits D₂, D₁, D₀. This is a master control over all the interrupt masking bits. If this bit is low, bits D₂, D₁, and D₀ do not have any effect on the masks.

M7.5—D₂ = 0, RST 7.5 is enabled

M6.5—D₁ = 1, RST 6.5 is masked or disabled

M5.5—D₀ = 0, RST 5.5 is enabled

M5.5—D₀ = 1, RST 5.5 is masked or disabled

Example Write instructions to enable interrupt RST 5.5 and mask other interrupts.

Instruction: MVI A, 0EH
SIM
;Bits D₃ = 1 and D₀ = 0
;Enable RST 5.5

Example A TTY receiver line is connected to the SOD pin of the 8085. Disable all interrupts and send START bit (logic 0) to TTY without affecting interrupt masks.

Instructions:	MVI A,40H	:D ₇ = 0, START bit at logic 0
		:D ₆ = 1, Enables serial output bit D ₇
		:D ₃ = 0, Does not affect masks

Comments: This instruction does not affect TRAP interrupt.

SPHL: Copy H and L Registers to the Stack Pointer					
Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SPHL	None	1	1	6 (8085) 5 (8080)	F9

Description The instruction loads the contents of the H and L registers into the stack pointer register; the contents of the H register provide the high-order address, and the contents of the L register provide the low-order address. The contents of the H and L registers are not altered.

Flags No flags are affected.

STA: Store Accumulator Direct					
Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
STA	16-bit	3	4	13	32

Description The contents of the accumulator are copied to a memory location specified by the operand. This is a 3-byte instruction; the second byte specifies the low-order address and the third byte specifies the high-order address.

Flags No flags are affected.

Example Assume the accumulator contains 9FH. Load the accumulator contents into memory location 2050H.

Instruction:	STA 2050H	Hex Code:	32 50 20
		Register contents before instruction	Memory contents after instruction
		A [9F XX] F	2050 [9F] 20

STAX: Store Accumulator Indirect

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
STAX B/D reg-pair		1	2	7	

Description The contents of the accumulator are copied into the memory location specified by the contents of the operand (register pair). The contents of the accumulator are not altered.

Flags No flags are affected.

Example Assume the contents of the accumulator are F9H and the contents of registers B and C are 20H and 50H, respectively. Store the accumulator contents in memory location 2050H.

Instruction: STAX B Hex Code: 02

Register contents before instruction
Register and memory contents after instruction

A	F9	XX	F	2050	F9	A	F9	XX	F
B	20	50	C			B	20	50	C

Comments: This instruction performs the same function as MOV A,M except this instruction uses the contents of BC or DE as memory pointers.

SUB: Subtract Register or Memory from Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SUB	Reg. Mem.	1	1	4	37

Description The contents of the register or the memory location specified by the operand are subtracted from the contents of the accumulator, and the results are placed in the accumulator. The contents of the source are not altered.

Flags All flags are affected to reflect the result of the subtraction.

Example Assume the contents of the accumulator are 37H and the contents of register C are 40H. Subtract the contents of register C from the accumulator.

Instruction: SUB C Hex Code: 91

(C):	40H = 0 1 0 0	0 0 0 0
2's complement (C):	= 1 1 0 0	0 0 0 0
(A):	37H = 0 0 1 1	0 1 1 1
		0' 1 1 1 1 0 1 1 1 = F7H
Complement Carry:	V 1 1 1 1	0 1 1 1
Flags: S = 1, Z = 0, AC = 0	P = 0, CY = 1	

The result, as a negative number, will be in 2's complement and thus the Carry (Borrow) flag is set.

STC: Set Carry

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
STC	None	1	1	4	37

Description The Carry flag is set to 1.

Flags No other flags are affected.

SUI: Subtract Immediate from Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
SUI	8-bit data	2	2	7	D6

Description The 8-bit data (the operand) are subtracted from the contents of the accumulator, and the results are placed in the accumulator.

Flags All flags are modified to reflect the results of the subtraction.

Example Assume the accumulator contains 40H. Subtract 37H from the accumulator.

Instruction: SUI 37H Hex Code: D6 37

	Subtrahend: 37H =	0 0 1 1	0 1 1 1
	2's complement of 37H =	1 1 0 0	1 0 0 1
	+		
(A): 40H =	0 1 0 0	0 0 0 0	
	0 0 0 0	1 0 0 1	
Complement Carry: 0/	0 0 0 0	1 0 0 1	= 09H
Flags: S = 0, Z = 0, AC = 0			
P = 1, CY = 0			

Flags Z, S, P are altered to reflect the results of the operation. CY and AC are reset.

Example Assume the contents of the accumulator are 77H and of register D are 56H. Exclusive OR the contents of the register D with the accumulator.

Instruction: XRA D Hex Code: AA

Subtrahend: 37H =	0 0 1 1	0 1 1 1
2's complement of 37H =	1 1 0 0	1 0 0 1
+		
(A): 40H =	0 1 0 0	0 0 0 0
	0 0 0 0	1 0 0 1
Flags: S = 0, Z = 0, AC = 0		
CY = 0, AC = 0		

XCHG: Exchange H and L with D and E

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
XCHG	None	1	1	4	EB

	Subtrahend: 37H =	0 0 1 1	0 1 1 1
	2's complement of 37H =	1 1 0 0	1 0 0 1
	+		
(A): 40H =	0 1 0 0	0 0 0 0	
	0 0 0 0	1 0 0 1	
Flags: S = 0, Z = 0, AC = 0			
CY = 0, AC = 0			

Description The contents of register H are exchanged with the contents of register D, and the contents of register L are exchanged with the contents of register E.

Flags No flags are affected.

XRA: Exclusive OR with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
XRA	Reg. Mem.	1 1	1 2	4 7	Reg. Hex

Description The contents of the operand (register or memory) are Exclusive ORed with the contents of the accumulator, and the results are placed in the accumulator. The contents of the operand are not altered.

Flags Z, S, P are altered to reflect the results of the operation. CY and AC are reset.

Instruction: XRI A2H Hex Code: EEA2

Subtrahend: 37H =	0 0 1 1	0 1 1 1
2's complement of 37H =	1 1 0 0	1 0 0 1
+		
(A): 40H =	0 1 0 0	0 0 0 0
	0 0 0 0	1 0 0 1
Flags: S = 0, Z = 0, P = 1		
CY = 0, AC = 0		

Description The contents of the operand (register or memory) are Exclusive ORed with the contents of the accumulator, and the results are placed in the accumulator. The contents of the operand are not altered.

XRI: Exclusive OR Immediate with Accumulator

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
XRI	8-bit data	2	2	7	EE

Description The 8-bit data (operand) are Exclusive ORed with the contents of the accumulator, and the results are placed in the accumulator.

Flags Z, S, P are altered to reflect the results of the operation. CY and AC are reset.

Example Assume the contents of the accumulator are 8FH. Exclusive OR the contents of the accumulator with A2H.

Instruction: XRI A2H Hex Code: EEA2

Subtrahend: 37H =	0 0 1 1	0 1 1 1
2's complement of 37H =	1 1 0 0	1 0 0 1
+		
(A): 40H =	0 1 0 0	0 0 0 0
	0 0 0 0	1 0 0 1
Flags: S = 0, Z = 0, P = 1		
CY = 0, AC = 0		

Description The contents of the operand (register or memory) are Exclusive ORed with the contents of the stack top, and the results are placed in the stack top. The contents of the operand are not altered.

Opcode	Operand	Bytes	M-Cycles	T-States	Hex Code
XTHL	None	1	5	16	E3

Description The contents of the L register are exchanged with the stack location pointed out by the contents of the stack pointer register. The contents of the H register are exchanged with the next stack location ($SP + 1$); however, the contents of the stack pointer register are not altered.

Flags No flags are affected.

Example The contents of various registers and stack locations are as shown:

Stacks	L
2095	38
2096	67

Illustrate the contents of these registers after instruction XTHL.

Register contents	after XTHL
H	67
SP	2095
L	38
A2	57
Stacks	2095 57 2096 A2

Illustrate the contents of these registers after instruction XTHL.

8085

Instruction Summary: Hexadecimal Order							
Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	
00	NOP	11	LXI D	21	LXI H	31	LXI SP
01	LXI B	12	STAX D	22	SHLD	32	STA
02	STAX B	13	INX D	23	INX H	33	INX SP
03	INX B	14	INR D	24	INR H	34	INR M
04	INR B	15	DCR D	25	DCR H	35	DCR M
05	DCR B	16	MVI D	26	MVI H	36	MVI M
06	MVI B	17	RAL	27	DAA	37	STC
07	RLC	19	DAD D	29	DAD H	39	DAD SP
09	DAD B	1A	LDAX D	2A	LHLD	3A	LDA
0A	LDAX B	1B	DCX D	2B	DCX H	3B	DCX SP
0B	DCX B	1C	INR E	2C	INR L	3C	INR A
0C	INR C	1D	DCR E	2D	DCR L	3D	DCR A
0D	DCR C	1E	MVI E	2E	MVI L	3E	MVI A
0E	MVI C	1F	PAR	2F	CMA	3F	CMC
0F	PBC	20	PIM	30	SIM	40	MOV R,B

Hex	Mnemonic								
41	MOV B,C	70	MOV M,B	9F	SBB A	C7	RST 1		
42	MOV B,D	71	MOV M,C	A0	ANA B	D0	RNC		
43	MOV B,E	72	MOV M,D	A1	ANA C	D1	POP	D	
44	MOV B,H	73	MOV M,F	A2	ANA D	D2	JNC		
45	MOV B,L	74	MOV M,H	A3	ANA E	D3	OUT		
46	MOV B,M	75	MOV M,L	A4	ANA H	D4	CNC		
47	MOV B,A	76	HLT	A5	ANA L	D5	PUSH	D	
48	MOV C,B	77	MOV M,A	A6	ANA M	D6	SUI		
49	MOV C,C	78	MOV A,B	A7	ANA A	D7	RST	2	
4A	MOV C,D	79	MOV A,C	A8	XRA B	D8	RC		
4B	MOV C,E	7A	MOV A,D	A9	XRA C	DA	JC		
4C	MOV C,H	7B	MOV A,E	AA	XRA D	DB	IN		
4D	MOV C,L	7C	MOV A,H	AB	XRA E	DC	CC		
4E	MOV C,M	7D	MOV A,I	AC	XRA H	DE	SBI		
4F	MOV C,A	7E	MOV A,M	AD	XRA L	DF	RST	3	
50	MOV D,B	7F	MOV A,A	AE	XRA M	E0	RPO		
51	MOV D,C	80	ADD B	AF	XRA A	E1	POP	H	
52	MOV D,D	81	ADD C	B0	ORA B	E2	JPO		
53	MOV D,E	82	ADD D	B1	ORA C	E3	XTHL		
54	MOV D,H	83	ADD E	B2	ORA D	E4	CPO		
55	MOV D,L	84	ADD H	B3	ORA E	E5	PUSH	H	
56	MOV D,M	85	ADD L	B4	ORA H	E6	ANI		
57	MOV D,A	86	ADD M	B5	ORA L	E7	RST	4	
58	MOV E,B	87	ADD A	B6	ORA M	E8	RPE		
59	MOV E,C	88	ADC B	B7	ORA A	E9	PCHL		
5A	MOV E,D	89	ADC C	B8	CMP B	EA	JPE		
5B	MOV E,E	8A	ADC D	B9	CMP C	EB	XCHG		
5C	MOV E,H	8B	ADC E	BA	CMP D	EC	CPE		
5D	MOV E,L	8C	ADC H	BB	CMP E	EE	XRI		
5E	MOV EM	8D	ADC L	BC	CMP H	EF	RST	5	
5F	MOV EA	8E	ADC M	BD	CMP L	F0	RP		
60	MOV H,B	8F	ADC A	BE	CMP M	F1	POP	PSW	
61	MOV H,C	90	SUB B	BF	CMP A	F2	JP		
62	MOV H,D	91	SUB C	C0	RNZ F	F3	DI		
63	MOV H,E	92	SUB D	C1	POP B	F4	CP		
64	MOV H,H	93	SUB E	C2	JNZ JNZ	F5	PUSH	PSW	
65	MOV H,L	94	SUB H	C3	JMP C3	F6	ORI		
66	MOV H,M	95	SUB L	C4	CNZ C4	F7	RST	6	
67	MOV H,A	96	SUB M	C5	PUSH B	F8	RM		
68	MOV L,B	97	SUB A	C6	ADI C6	F9	SPHL		
69	MOV L,C	98	SBB B	C7	RST 0	FA	IM		
6A	MOV L,D	99	SBB C	C8	RZ	FB	EL		
6B	MOV L,E	9A	SBB D	C9	RET	FC	CM		
6C	MOV L,H	9B	SBB E	CA	JZ	FF	CPI		
6D	MOV L,L	9C	SBB H	CC	CZ	CC	CALL		
6E	MOV L,M	9D	SBB I	CD	CE	CE	ACI		
6F	MOV L,A	9E							

BRANCH CONTROL GROUP
DATA TRANSFER GROUP

Move	Move (cont)	Move Immediate	Add*	Increment**	Logical
A.A 7F	[EA 5F	[A 87	[A 87	[A A7	
A.B 78	EB 58	B byte 06	B 04	B A0	
	EC 59	C byte 0E	C 0C	C A1	
MOV-A.D 7A	ED 5A	MVI	D 14	ANA	D A2
MOV-E.D 7B	EE 5B		E 1C	E A3	
A.H 7C	EH 5C	H byte 1E	H 24	H A4	
A.L 7D	EL 5D	H byte 26	L 34	L A5	
A.M 7E	EM 5E	M byte 36	M 34	M A6	
B.A 47	[HA 67				
B.B 40	HB 60	Load	A 88	A AF	
B.C 41	HC 61	Immediate	C 89	C A8	
MOV-C.D 42	HD 62		D 9A	D AA	
B.E 43	HE 63	LXI	E 8B	E AB	
B.H 44	HH 64		F 9C	H AC	
B.L 45	HL 65		G 0D	L AD	
B.M 46	HM 66		H 0E	M AE	
C.A 48	LA 6F		I 05	A 87	
C.B 49	LB 68	Load/Store	J 0D	B B0	
MOV-C.D 4A	LC 69	LDAX B	K 1A	C B1	
MOV-L.D 4B	LD 6A	LDAX D	L 1D	D B2	
C.H 4C	LE 6B	LHLD adr	M 2A	E B3	
C.H 4C	LC 6C	LHLD adr	N 91	H B4	
C.L 4D	LL 6D	STA X J2	O 92	L B5	
C.M 4E	LM 6E	STAX B 02	P 93	M B6	
D.A 57	MA 77	SHLD adr 12	Q 94	N B7	
D.B 50	MB 70	STA adr 32	R 95	O B8	
MOV-D.C 51	MC 71		S 96	P B9	
MOV-M.D 52	MD 72		T 9F	Q BA	
D.F 53	ME 73		U 98	R BB	
D.H 54	M.H 74		V 9A	S BC	
D.L 55	M.L 75		W 9B	T BD	
D.M 56	XCHG EB		X 9C	U BE	

byte = constant or logical/arithmetic expression that evaluates to an 8-bit data quantity (Second byte of 2-byte instructions).

addr = 16-bit address (Second and Third bytes of 3-byte instructions).

* = all flags except CARRY affected.

** = all flags except CARRY affected. (exception: INX and DCR

† = only CARRY affected.

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ARITHMETIC AND LOGICAL GROUP		DATA TRANSFER GROUP		I/O AND MACHINE CONTROL		ASSEMBLER REFERENCE (Cont.)	
Jump	Stack Ops	Jump	Stack Ops	General	Pseudo Instruction	Macro	ENDM
JMP adr	C3	PUSH B	C5	ORG			
JNZ adr	C2	PUSH D	D5	END			
JZ adr	CA	PUSH E	E5	EQU			
JNC adr	D2	POP B	C0	SET			
JPO adr	E2	POP D	D0	DS			
JP adr	F2	POP H	E1	DB			
JM adr	FA	PSW F1	F1	DW			
PCHL	E9	XTHL E3					
SPHL	F9	SPHL F9					
CALL adr	CD	Call					
CHZ adr	C4	Input/Output					
CZ adr	CC	OUT byte D3					
CNC adr	D4	OUT byte DB					
CC adr	DC	IN byte DB					
CPO adr	E4	Control					
CPY adr	EC						
CMR adr	F4						
FC							
DI	F3						
EI	FB						
NOP	00						
HLT	76						
RRET	C9						
RN2	C0						
RZ	C8						
RNC	D0						
RC	D8						
New Instructions (8085 Only)							
IF							
ELSE							
ENDIF							
Conditional Assembly:							
Restart							
0 C7							
1 CF	RST 10	C7	000016				
2 D7	RST 12	CF	000106				
3 DF	RST 14	D7	001016				
4 E7	RST 16	DF	001816				
5 EF	TRAP	E7	002416				
6 F7							
7 FF	RST 5	F7	002816				
	RST 55	FF	002C16				
	RST 6		003016				
	RST 65		003416				
	RST 7		003816				
	RST 75		003C16				
RESTART TABLE							
Name	Code	Restart Address					
RST							
0	C7						
1	CF						
2	D7						
3	DF						
4	E7						
5	EF						
6	F7						
7	FF						

*NOTE: The hardware functions refer to the on-chip interrupt feature of the 8085 only.

8085

Instruction Set with Machine Cycles and Flag Status (see notes at end of table)

Instruction			Code ¹	B/M/T ²	Machine ³ Cycles	S D ₇	Z D ₆	Flags ⁴		
								AC D ₄	P D ₂	CY D ₀
ACI	DATA	: Add 8-bit and CY to A	CE data	2/2/7	F R	✓	✓	✓	✓	✓
ADC	REG	: Add Reg. and CY to A	1000 ISSS	1/1/4	F	✓	✓	✓	✓	✓
ADC	M	: Add Mem. and CY to A	8E	1/2/7	F R	✓	✓	✓	✓	✓
ADD	REG	: Add Reg. to A	1000 OSSS	1/1/4	F	✓	✓	✓	✓	✓
ADD	M	: Add Mem. to A	86	1/2/7	F R	✓	✓	✓	✓	✓
ADI	DATA	: ADD 8-BIT TO A	C6 DATA	2/2/7	F R	✓	✓	✓	✓	✓
ANA	REG	: AND Reg. with A	1010 OSSS	1/1/4	F	✓	✓	1	✓	0
ANA	M	: AND Mem. with A	A6	1/2/7	F R	✓	✓	1	✓	0
ANI	DATA	: AND 8-bit with A	E6 data	2/2/7	F R	✓	✓	1	✓	0
CALL	ADDR	: Call Unconditional	CD addr	3/5/18	S R R W W					
CC	ADDR	: Call On CY	DC addr	3/5/9-18	S R R W W					
CM	ADDR	: Call On Minus	FC addr	3/5/9-18	S R R W W					
CMA		: Complement A	2F	1/1/4	F					
CMC		: Complement CY	3F	1/1/4	F					
CMP	REG	: Compare Reg. with A	1011 ISSS	1/1/4	F	✓	✓	✓	✓	✓
CMP	M	: Compare Mem. with A	BE	1/2/7	F R	✓	✓	✓	✓	✓
CNC	ADDR	: Call On No CY	D4 addr	3/5/9-18	S R R W W					
CNZ	ADDR	: Call On No Zero	C4 addr	3/5/9-18	S R R W W					
CP	ADDR	: Call On Positive	F4 addr	3/5/9-18	S R R W W					
CPE	ADDR	: Call On Parity Even	EC addr	3/5/9-18	S R R W W					
CPI	DATA	: Compare 8-bit with A	FE data	2/2/7	F R	✓	✓	✓	✓	✓
CPO	ADDR	: Call On Parity Odd	E4 addr	3/5/9-18	S R R W W					
CZ	ADDR	: Call On Zero	CC addr	3/5/9-18	S R R W W					

DAA	: Decimal-Adjust A	27	1/1/4	F	✓	✓	✓	✓	✓
DAD	Rp	: Add Reg. Pair to HL	00Rp 1001	1/3/10	F B B				
DCR	REG	: Decrement Reg.	00SS S101	1/1/4	F	✓	✓	✓	✓
DCR	M	: Decrement Mem. Contents	35	1/3/10	F R W	✓	✓	✓	✓
DCX	Rp	: Decrement Reg. Pair	00Rp 1011	1/1/6	S				
DI		: Disable Interrupt	F3	1/1/4	F				
EI		: Enable Interrupt	FB	1/1/4	F				
HLT		: Halt	76	1/2/5	F B				
IN	PORT	: Input from 8-bit Port	DB data	2/3/10	F R I				
INR	REG	: Increment Reg.	00SS S100	1/1/4	F	✓	✓	✓	✓
INR	M	: Increment Mem. Contents	34	1/3/10	F R W	✓	✓	✓	✓
INX	Rp	: Increment Reg. Pair	00Rp 0011	1/1/6	S				
JC	ADDR	: Jump On Carry	DA addr	3/3/7-10	F R R				
JM	ADDR	: Jump On Minus	FA addr	3/3/7-10	F R R				
JMP	ADDR	: Unconditional Jump	C3 addr	3/3/10	F R R				
JNC	ADDR	: Jump On No Carry	D2 addr	3/3/7-10	F R R				
JNZ	ADDR	: Jump On No Zero	C2 addr	3/3/7-10	F R R				
JP	ADDR	: Jump On Positive	F2 addr	3/3/7-10	F R R				
JPE	ADDR	: Jump On Parity Even	EA addr	3/3/7-10	F R R				
JPO	ADDR	: Jump On Parity Odd	E2 addr	3/3/7-10	F R R				
JZ	ADDR	: Jump On Zero	CA addr	3/3/7-10	F R R				
LDA	ADDR	: Load A Direct	3A addr	3/4/13	F R R R				
LDAX	Rp	: Load A from M; memory address is in BC/DE	000X 1010	1/2/7	F R				

Codes¹

DDD = Binary digits identifying a destination register

SSS = Binary digits identifying a source register

B = 000, C = 001, D = 010, Memory = 110

E = 001, H = 100, I = 101, A = 111

Rp = Register Pair BC = 00, HL = 10

DE = 01, SP = 11

B/M/T²

B = Bytes

M = Machine cycles

T = T-states

Machine Cycles³

F = Fetch with 4 T-states

S = Fetch with 6 T-states

R = Memory Read

I = I/O Read

W = Memory Write

O = I/O Write

B = Bus Idle

Flags⁴

✓ = Flag is modified according to result

0 = Flag is cleared

1 = Flag is set

Blank = No change in flag, remains in previous state

8085

Instruction Set with Machine Cycles and Flag Status (see notes at end of table)

		Instruction	Code ¹	B/M/T ²	Machine ³ Cycles	S D ₇	Z D ₆	AC D ₄	P D ₂	CY D ₀	Flags ⁴
LHLD	ADDR	: Load HL Direct	2A	addr	3/5/16	F R R R R					
LXI	Rp, 16-bit	: Load 16-bit in Reg. Pair	00Rp	0001 16-bit	3/3/10	F R R					
MOV	Rd,Rs	: Move from Reg. R _d to Reg. R _s	01DD	DSSS	1/1/4	F					
MOV	M,R	: Move from Reg. to Mem.	0111	0SSS	1/2/7	F W					
MOV	R,M	: Move from Mem. to Reg.	01DD	D110	1/2/7	F R					
MVI	R,DATA	: Load 8-bit in Reg.	00DD	D110 data	2/2/7	F R					
MVI	M,DATA	: Load 8-bit in Mem.	36	data	2/3/10	F R W					
NOP		: No Operation	00		1/1/4	F					
ORA	R	: OR Reg. with A	1011	0SSS	1/1/4	F	✓	✓	0	✓	0
ORA	M	: OR Mem. Contents with A	B6		1/2/7	F R	✓	✓	0	✓	0
ORI	DATA	: OR 8-bit with A	F6	data	2/2/7	F R	✓	✓	0	✓	0
OUT	PORT	: Output to 8-bit Port	D3	data	2/3/10	F R O					
PCHL		: Move HL to Program Counter	E9		1/1/6	S					
POP	Rp	: Pop Reg. Pair	11Rp	0001	1/3/10	F R R					
PUSH	Rp	: Push Reg. Pair	11Rp	0101	1/3/12	S W W					
RAL		: Rotate A Left through CY	17		1/1/4	F					
RAR		: Rotate A Right through CY	1F		1/1/4	F					
RC		: Return On Carry	D8		1/3/6-12	S R R					
RET		: Return	C9		1/3/10	F R R					
RIM		: Read Interrupt Mask	20		1/1/4	F					
RLC		: Rotate A Left	07		1/1/4	F					
RM		: Return On Minus	F8		1/3/6-12	S R R					
RNC		: Return On No Carry	D0		1/3/6-12	S R R					
RNZ		: Return On No Zero	C0		1/3/6-12	S R R					
RP		: Return On Positive	F0		1/3/6-12	S R R					

RPE		: Return On Parity Even	E8		1/3/6-12	S R R					
RPO		: Return On Parity Odd	E0		1/3/6-12	S R R					
RRC		: Rotate A to Right	0F		1/1/4	F					
RST	N	: Restart	11XX	X111	1/3/12	S W W					
RZ		: Return On Zero	C8		1/3/6-12	S R R					
SBB	R	: Subtract Reg. from A with Borrow	1001	ISSS	1/1/4	F					
SBB	M	: Subtract Mem. Contents from A with Borrow	9E		1/2/7	F R	✓	✓	✓	✓	✓
SBI	DATA	: Subtract 8-bit from A	DE	data	2/2/7	F R	✓	✓	✓	✓	✓
SHLD	ADDR	: Store HL Direct	22	addr	3/5/16	F R R W W					
SIM		: Set Interrupt Mask	30		1/1/4	F					
SPHL		: Move HL to Stack Pointer	F9		1/1/6	S					
STA	ADDR	: Store A Direct	32	addr	3/4/13	F R R W					
STAX	Rp	: Store A in M, memory address is in BC/DE	000X	0010	1/2/7	F W					
STC		: Set Carry	37		1/1/4	F					
SUB	R	: Subtract Reg. from A	1001	0SSS	1/1/4	F					
SUB	M	: Subtract Mem. from A	96		1/2/7	F R	✓	✓	✓	✓	✓
SUI	DATA	: Subtract 8-bit from A	D6	data	2/2/7	F R	✓	✓	✓	✓	✓
XCHG		: Exchange DE with HL	EB		1/1/4	F	✓	✓	✓	✓	✓
XRA	R	: Exclusive OR Reg. with A	1010	1SSS	1/1/4	F					
XRA	M	: Exclusive OR Mem. with A	AE		1/2/7	F R	✓	✓	0	✓	0
XRI	DATA	: Exclusive OR 8-bit with A	EE	data	2/2/7	F R	✓	✓	0	✓	0
XTHL		: Exchange Stack with HL	E3		1/4/16	F R R W W	✓	✓	0	✓	0

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