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Date : / /
Page No.

CO - Assignment -3
Control Signals

* Assigning Control Signals :-

$C_0 \leftarrow LD_{MAR}$ Load enabled MAR
$C_1 \leftarrow OE_{PC}$ Output enabled PC
$C_2 \leftarrow LD_{IR}$ Load enabled IR
$C_3 \leftarrow RD_M$ Read Memory
$C_4 \leftarrow PC_{INR}$ PC Increment
$C_5 \leftarrow OE_{IR}$ Output enabled IR (Instruction Register)
$C_6 \leftarrow LD_{DR}$ Load enabled DR
$C_7 \leftarrow OE_{R1}$ Output enable R_1
$C_8 \leftarrow LD_{ACC}$ Load enabled ACC
$C_9 \leftarrow ALU_{ADD}$ ADD operation in ALU
$C_{10} \leftarrow OE_{ALU}$ Output enabled ALU
$C_{11} \leftarrow ALU_{CMP}$ Complement operation in ALU
$C_{12} \leftarrow ALU_{AND}$ AND operation in ALU
$C_{13} \leftarrow OE_{MAR}$ Output enabled MAR
$C_{14} \leftarrow LD_{PC}$ Load enabled PC
$C_{15} \leftarrow LD_{R1}$ Load enabled R_1
$C_{16} \leftarrow OE_{R2}$ Output enabled R_2
$C_{17} \leftarrow LD_{R2}$ Load enabled R_2
$C_{18} \leftarrow OE_{DR}$ Output enabled DR
$C_{19} \leftarrow OE_{ACC}$ Output enable ACC
$C_{20} \leftarrow OE_X$ Output enable Immediate Variable(X)

Date : / /
Page No.

1. ADD R_1

=> •
$T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{DR}, OE_{R_1}$
$T_4 \leftarrow LD_{ACC}, ALU_{ADD}, OE_{ALU}$

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T	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	0	0	1	1	0	0	0	0	0	0	04	1
T_4	1	1	1	0	0	0	0	0	0	0	0	00	1

• All Control Signal that used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_M$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_6 \leftarrow LD_{DR}$
$C_7 \leftarrow OE_{R_1}$
$C_8 \leftarrow LD_{ACC}$
$C_9 \leftarrow ALU_{ADD}$
$C_{10} \leftarrow OE_{ALU}$

2. CMP

⇒ • $T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_m, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{ACC}, ALU_{CMP}, OE_{ALU}$

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	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	1	1	0	1	0	0	0	0	0	0	0	0	00	1

• All Control Signal that used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_m$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_8 \leftarrow LD_{ACC}$
$C_{10} \leftarrow OE_{ALU}$
$C_{11} \leftarrow ALU_{CMP}$

3. AND R_1

=> •
$T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_m, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{DR}, OE_{R_1}$
$T_4 \leftarrow LD_{ACC}, ALU_{AND}, OE_{ALU}$

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	C_{12}	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	0	0	0	0	1	1	0	0	0	0	0	0	04	1
T_4	1	0	1	0	1	0	0	0	0	0	0	0	0	00	1

• All Control Signals that used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_m$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_6 \leftarrow LD_{DR}$
$C_7 \leftarrow OE_{R_1}$
$C_8 \leftarrow LD_{ACC}$
$C_{10} \leftarrow OE_{ALU}$
$C_{12} \leftarrow ALU_{AND}$

Date : / /
Page No.

Q) JMP

=> •
$T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_m, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{MAR}, OE_{R_1}$
$T_4 \leftarrow LD_{PC}, OE_{MAR}$

•

	C_{14}	C_{13}	C_{12}	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	04	0
T_4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	00	0

• All Control Signal used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_m$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_7 \leftarrow OE_{R_1}$
$C_{13} \leftarrow OE_{MAR}$
$C_{14} \leftarrow LD_{PC}$

Date : / /
Page No.

Q: MOV R_1 R_2

$T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{R_1}, OE_{R_2}$

	C_{16}	C_{15}	C_{14}-C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	1	0	0	0	0	1	03	1
T_3	1	1	0	0	0	0	0	0	0	00	1

- ALL Control Signals that need

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_M$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_{15} \leftarrow LD_{R_1}$
$C_{16} \leftarrow OE_{R_2}$

Date : / /
Page No.

6 MOV R_2 R_1

- $T_0 \leftarrow LD_{MAR}, OE_{PC}$
- $T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$
- $T_2 \leftarrow LD_{MAR}, OE_{IR}$
- $T_3 \leftarrow LD_{R_2}, OE_{R_1}$

	C_{17}	C_{16}-C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	1	0	0	0	0	1	03	1
T_3	1	0	1	0	0	0	0	0	0	0	00	1

- All Control Signal that used

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_M$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_7 \leftarrow OE_{R_1}$
$C_{17} \leftarrow LD_{R_2}$

7. MOV ACC, R1

=> • $T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{PR}, OE_{R1}$
$T_4 \leftarrow LD_{ACC}, OE_{PR}$

•

	C_{18}	C_{17}	C_{16}	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	0	0	1	1	0	0	0	0	0	0	04	1
T_4	1	0	1	0	0	0	0	0	0	0	0	00	1

• All control signal that are used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_M$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_6 \leftarrow LD_{PR}$
$C_7 \leftarrow OE_{R1}$
$C_8 \leftarrow LD_{ACC}$
$C_{18} \leftarrow OE_{PR}$

Ex. • MOV ACC R_2

$T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_m, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{DR}, OE_{R_2}$
$T_4 \leftarrow LD_{ACC}, OE_{DR}$

	C_{18}	C_{17}	C_{16}	C_{15}–C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	0	1	0	0	0	1	0	0	0	0	0	0	04	1
T_4	1	0	0	0	1	0	0	0	0	0	0	0	0	00	1

• All Control Signal that are used:-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_m$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_6 \leftarrow LD_{DR}$
$C_8 \leftarrow LD_{ACC}$
$C_{16} \leftarrow OE_{R_2}$
$C_{18} \leftarrow OE_{DR}$

9. MOV R_1, ACC

⇒ $T_0 \leftarrow LD_{MAR}, OE_{PC}$

$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$

$T_2 \leftarrow LD_{MAR}, OE_{IR}$

$T_3 \leftarrow LD_{R_1}, OE_{ACC}$

	C_{19}	C_{18}	C_{17}	C_{16}	C_{15}	C_{14}–C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	1	0	0	0	1	0	0	0	0	0	0	0	00	1

- All Control Signal that are used :-

$C_0 \leftarrow LD_{MAR}$

$C_1 \leftarrow OE_{PC}$

$C_2 \leftarrow LD_{IR}$

$C_3 \leftarrow RD_M$

$C_4 \leftarrow PC_{INR}$

$C_5 \leftarrow OE_{IR}$

$C_{15} \leftarrow LD_{R_1}$

$C_{19} \leftarrow OE_{ACC}$

Date : / /
Page No.

10 MOV R_L, ACC

→ T_0 ← LD_{MAR}, OE_{PC}
T_1 ← LD_{IR}, RD_M, PC_{INR}
T_2 ← LD_{MAR}, OE_{IR}
T_3 ← LD_{R_L}, OE_{ACC}

	C_{19}	C_{18}	C_{17}	$C_{16}-C_6$	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	1	0	0	0	0	1	03	1
T_3	1	0	1	0	0	0	0	0	0	0	00	1

- All Control Signals that are used :-

C_0 ← LD_{MAR}
C_1 ← OE_{PC}
C_2 ← LD_{IR}
C_3 ← RD_M
C_4 ← PC_{INR}
C_5 ← OE_{IR}
C_{17} ← LD_{R_L}
C_{19} ← OE_{ACC}

11 MOV ACC M

⇒ • $T_0 \leftarrow LD_{MAR}, OE_{PC}$
$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$
$T_2 \leftarrow LD_{MAR}, OE_{IR}$
$T_3 \leftarrow LD_{ACC}, OE_{MAR}$

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	C_{19}-C_{14}	C_{13}	C_{12}-C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	0	0	0	0	0	1	1	1	0	0	02	1
T_2	0	0	0	0	0	0	0	1	0	0	0	0	1	03	1
T_3	0	1	0	0	1	0	0	0	0	0	0	0	0	00	1

• All Control Signal that are used :-

$C_0 \leftarrow LD_{MAR}$
$C_1 \leftarrow OE_{PC}$
$C_2 \leftarrow LD_{IR}$
$C_3 \leftarrow RD_M$
$C_4 \leftarrow PC_{INR}$
$C_5 \leftarrow OE_{IR}$
$C_8 \leftarrow LD_{ACC}$
$C_{13} \leftarrow OE_{MAR}$

Date : / /
Page No.

12 MOV, M ACC

=> • T_0 ← LD_{MAR}, OE_{PC}
T_1 ← LD_{IR}, RD_M, PC_{INR}
T_2 ← LD_{MAR}, OE_{IR}
T_3 ← LD_{MAR}, OE_{ACC}

•

	C_{19}	$C_{18}-C_6$	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	1	1	01	1
T_1	0	0	0	1	1	1	0	0	02	1
T_2	0	0	1	0	0	0	0	1	03	1
T_3	1	0	0	0	0	0	0	1	00	1

• All Control Signal that are used :-

C_0 ← LD_{MAR}
C_1 ← OE_{PC}
C_2 ← LD_{IR}
C_3 ← RD_M
C_4 ← PC_{INR}
C_5 ← OE_{IR}
C_{19} ← OE_{ACC}

13. MVI

=>. $T_0 \leftarrow LD_{MAR}, OE_{PC}$

$T_1 \leftarrow LD_{IR}, RD_M, PC_{INR}$

$T_2 \leftarrow LD_{MAR}, OE_{IR}$

$T_3 \leftarrow LD_{R_1}, OE_X$

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	C_{20}	C_{19}-C_{16}	C_{15}	C_{14}-C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1	C_0	BA	M
T_0	0	0	0	0	0	0	0	0	0	1	1	01		1
T_1	0	0	0	0	0	1	1	1	0	0		02		1
T_2	0	0	0	0	1	0	0	0	0	1		03		1
T_3	1	0	1	0	0	0	0	0	0	0		00		1

• All Control Signal that are used :-

$C_0 \leftarrow LD_{MAR}$

$C_1 \leftarrow OE_{PC}$

$C_2 \leftarrow LD_{IR}$

$C_3 \leftarrow RD_M$

$C_4 \leftarrow PC_{INR}$

$C_5 \leftarrow OE_{IR}$

$C_{15} \leftarrow LDR_1$

$C_{20} \leftarrow OE_X$