

LEVEL L

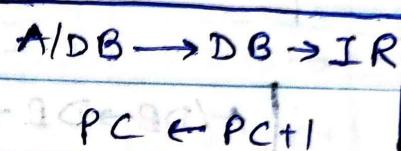
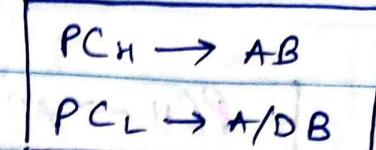
(1)

MOV R₁, R₂

800 → 92 → 110M → ①

TTH OT

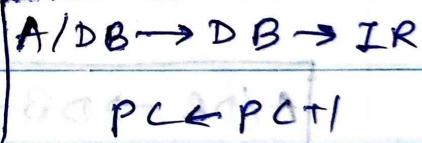
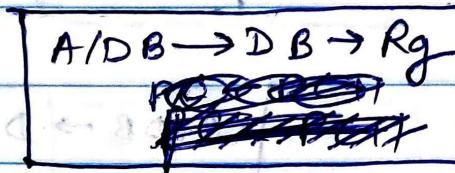
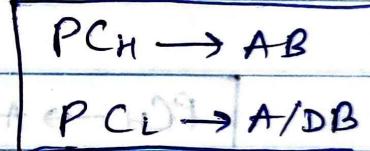
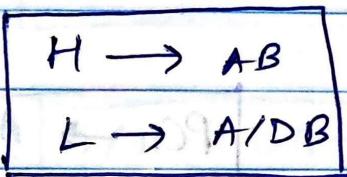
HKT



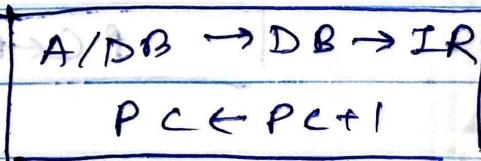
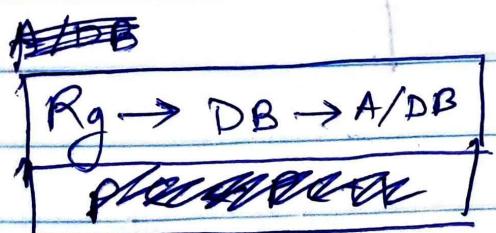
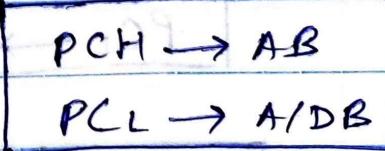
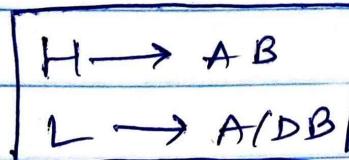
(2)

MOV Rg, M

810, 92, 98 → 110J → ②



(3)

MOV M, Rg

④ MVI Rg~~RR~~, D08

M.8 VOM

OT+

TO HKT

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$A/DB \rightarrow DB \rightarrow Rg$$

$$PC \leftarrow PC + 1$$

$$A/DB \rightarrow DB \rightarrow IR$$

$$PC \leftarrow PC + 1$$

⑤ LXI R_P/SP, D16

M.8 VOM

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$A/DB \rightarrow DB \rightarrow R_P/SP$$

$$PC \leftarrow PC + 1$$

$$A/DB \rightarrow DB \rightarrow IR$$

$$PC \leftarrow PC + 1$$

$$PC_H \rightarrow AB$$

$$PC_D \rightarrow A/DB$$

$$A/DB \rightarrow DB \rightarrow R_P/SP_H$$

$$PC \leftarrow PC + 1$$

(6)

LDA & D16

TXH OT

JIC NT2

HKT

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$D/AB \rightarrow DB \rightarrow Z$$

$$PC \leftarrow PC + 1$$

$$A/DB \rightarrow DB \rightarrow IR$$

$$PC \leftarrow PC + 1$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$QA \leftarrow HZ$$

$$D/AB \rightarrow DB \rightarrow W$$

$$PC \leftarrow PC + 1$$

$$W \leftarrow QC \leftarrow QA/ID$$

$$W \rightarrow AB$$

$$Z \rightarrow A/DB$$

$$QA/AS \leftarrow S$$

$$D/AB \rightarrow DB \rightarrow AC$$

$$QA/AS \leftarrow S-A$$

(F)

STA D16

OT

HKT

$$\boxed{\begin{array}{l} PCH \rightarrow AB \\ PCL \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} PCH \rightarrow AB \\ PCL \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} D/AB \rightarrow DB \rightarrow Z \\ PCE \leftarrow PCT+1 \end{array}}$$

$$\boxed{\begin{array}{l} D/AB \rightarrow DB \rightarrow IR \\ PC \leftarrow PCL+1 \end{array}}$$

$$\boxed{\begin{array}{l} PCH \rightarrow AD \\ PCL \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} DATA \leftarrow DB \\ DATA \leftarrow Z \end{array}}$$

$$\boxed{\begin{array}{l} D/AB \rightarrow DB \rightarrow W \\ PC \leftarrow PCT+1 \end{array}}$$

$$\boxed{\begin{array}{l} DATA \leftarrow DB \\ DATA \leftarrow Z \end{array}}$$

$$\boxed{\begin{array}{l} W \rightarrow A/B \\ Z \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} DATA \leftarrow DB \\ DATA \leftarrow Z \end{array}}$$

$$\boxed{\begin{array}{l} AC \rightarrow DB \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} DATA \leftarrow DB \\ DATA \leftarrow Z \end{array}}$$

(3)

ADC Rg

OT → HDB

HDB → DB

DB → IR

IR → ACK

ACK → CY

ACK

HKT

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow IR$ $PC \leftarrow PC + 1$ $ACK \leftarrow ACK + RG + CY$

(9)

ACI DO8

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow TMP$ $PC \leftarrow PC + 1$ $A/DB \rightarrow DB \rightarrow IR$ $PC \leftarrow PC + 1$ $ACK \leftarrow ACK + TMP + CY$

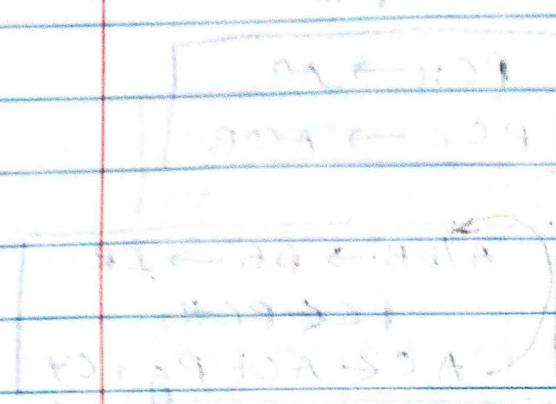
(10)

SBB Rg

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow IR$ $PC \leftarrow PC + 1$ $ACK \leftarrow ACK - RG - CY$

(1)

ANA Rg

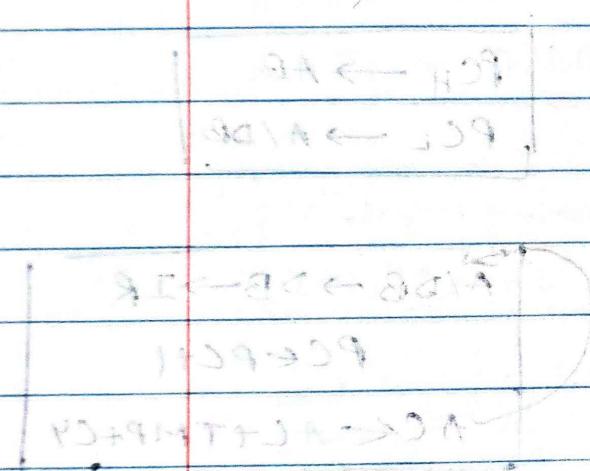


$$\begin{aligned} PC_H &\rightarrow AB \\ PC_L &\rightarrow A/DB \end{aligned}$$

$$\begin{aligned} A/DB &\rightarrow DB \rightarrow IR \\ PC &\leftarrow PC + 1 \\ AC &\leftarrow AC \wedge Rg \end{aligned}$$

(2)

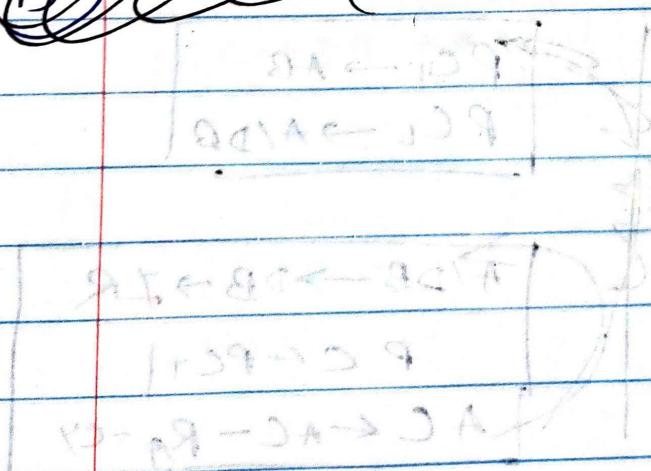
CMP Rg



$$\begin{aligned} PC_H &\rightarrow AB \\ PC_L &\rightarrow A/DB \end{aligned}$$

$$\begin{aligned} A/DB &\rightarrow DB \rightarrow IR \\ PC &\leftarrow PC + 1 \\ AC &\leftarrow Rg \end{aligned}$$

(3) CMP DC6



(3)

JMP D16

J10 J140 (21)

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow Z$ $PC \leftarrow PC + 1$ $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow IR$ $PC \leftarrow PC + 1$ $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow W$ $\{W, Z\} \rightarrow PC$ $PC \leftarrow PC + 1$ $W \leftarrow PC$ $Z \leftarrow PC$

(4)

JC D16

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow Z$ $PC \leftarrow PC + 1$

C = 1

|

C = 0

 $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $A/DB \rightarrow DB \rightarrow IR$ $PC \leftarrow PC + 1$ $PC_H \rightarrow AB$ $PC_L \rightarrow A/DB$ $PC \leftarrow PC + 1$ $A/DB \rightarrow DB \rightarrow W$ $\{W, Z\} \rightarrow PC$ $PC \leftarrow PC + 1$

(15)

CALL D16

OT

HKT

$$\boxed{PCH \rightarrow AB}$$

$$PCL \rightarrow A/DB$$

$$\boxed{PCH \rightarrow AB}$$

$$PCL \rightarrow A/DB$$

$$\boxed{A/DB \rightarrow DB \rightarrow Z}$$

$$PC \leftarrow PC + 1$$

$$\boxed{A/DB \rightarrow DB \rightarrow IR}$$

$$PC \leftarrow PC + 1$$

$$\boxed{PCH \rightarrow AB}$$

$$PCL \rightarrow A/DB$$

$$\boxed{A/DB \rightarrow DB \rightarrow W}$$

$$PC \leftarrow PC + 1$$

$$\boxed{SP \leftarrow SP - 1}$$

$$SP_H \rightarrow AB$$

$$SP_L \rightarrow A/DB$$

$$\boxed{PCH \rightarrow D/AB}$$

$$\boxed{SP \leftarrow SP - 1}$$

$$SP_H \rightarrow A/DB$$

$$SP_L \rightarrow A/DB$$

$$\boxed{PCL \rightarrow D/AB}$$

$$\boxed{PC \leftarrow \$W, Z}$$

(16) CZ DIG

TNT OT

T.78

(17)

THKT

$$\boxed{\begin{array}{l} PC_H \rightarrow AB \\ PC_L \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} PC_H \rightarrow AB \\ PC_L \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} A/DB \rightarrow DB \rightarrow Z \\ PC \leftarrow PC + 1 \end{array}}$$

$$\boxed{\begin{array}{l} A/DB \rightarrow PB \rightarrow IR \\ PC \leftarrow PC + 1 \end{array}}$$
 $\downarrow Z = 1$

$$\boxed{\begin{array}{l} PC_H \rightarrow AB \\ PC_L \rightarrow A/DB \end{array}}$$
 $\downarrow Z = 0$

$$\boxed{\begin{array}{l} PC \leftarrow PC + 1 \end{array}}$$

$$\boxed{\begin{array}{l} A/DB \rightarrow DB \rightarrow Z \\ PC \leftarrow PC + 1 \end{array}}$$

$$\boxed{\begin{array}{l} SP \leftarrow SP - 1 \\ SP_H \rightarrow A \oplus B \\ SP_L \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} PC_H \rightarrow D/A/B \end{array}}$$

$$\boxed{\begin{array}{l} SP \leftarrow SP - 1 \end{array}}$$

$$\boxed{\begin{array}{l} SP_H \rightarrow A/AB \end{array}}$$

$$\boxed{\begin{array}{l} SP_L \rightarrow A/DB \end{array}}$$

$$\boxed{\begin{array}{l} PC_L \rightarrow D/A/B \end{array}}$$

$$\boxed{\begin{array}{l} PC \leftarrow SW, 73 \end{array}}$$

(17)

RBT

TOP

$$SP_H \rightarrow A/B$$

$$SP_L \rightarrow D/AB$$

$$D/AB \rightarrow DB \rightarrow PC_L$$

$$SP \leftarrow SP + 1$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$SP_H \rightarrow A/B$$

$$SP_L \rightarrow D/AB$$

$$D/AB \rightarrow DB \rightarrow PC_H$$

$$SP \leftarrow SP + 1$$

$$A/DB \rightarrow DB \rightarrow IR$$

$$PC \leftarrow PC + 1$$

(18)

RZ

~~STOP~~

$$Z = 1$$

$$Z = 0$$

$$SP_H \rightarrow A/B$$

$$SP_L \rightarrow D/AB$$

$$PC_H \rightarrow AB$$

$$PC_L \rightarrow A/DB$$

$$D/AB \rightarrow DB \rightarrow PC_L$$

$$SP \leftarrow SP + 1$$

$$A/DB \rightarrow DB \rightarrow IR$$

$$PC \leftarrow PC + 1$$

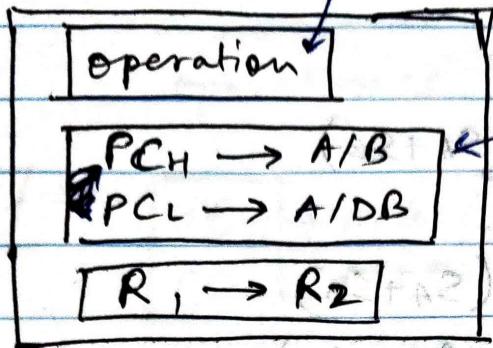
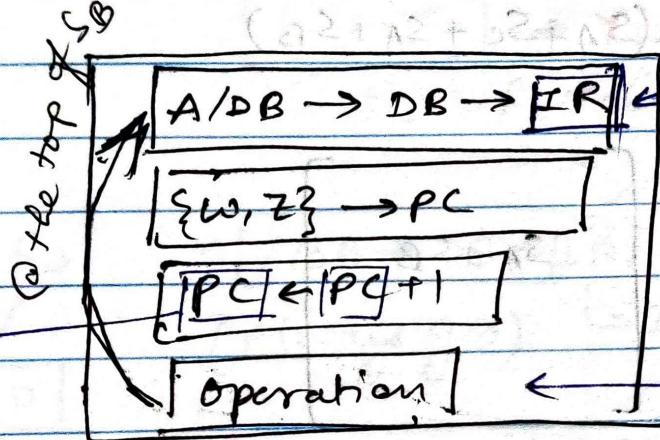
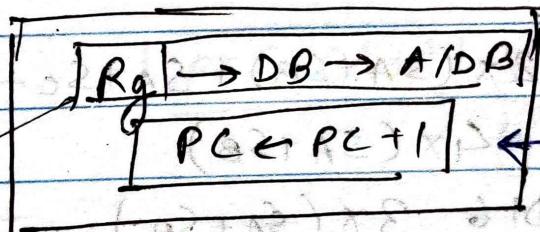
$$SP_H \rightarrow A/B$$

$$SP_L \rightarrow A/DB$$

$$D/AB \rightarrow DB \rightarrow PC_H$$

$$SP \leftarrow SP + 1$$

States

 $SP \leftarrow SP - 1$ S_A 
 $PCH - PCL / H - L / W - Z /$
 $SP_H - SP_L$
 S_B 
 $IR / Rg / SP / W / Z / AC$
 $PC/SP \leftarrow$
 All arithmetic &
 CMP & ANA
 S_C  Rg / AC
 To use this
 individually
 S_C can be used
 ~~S_D~~
 $\{W, Z\} \rightarrow PC$ ← Using S_B for this
 will be inefficient
 S_E
 $PCH / PCL \rightarrow A/DB$ ← Using S_A for this
 will be inefficient

~~00000~~ $SA + SB \rightarrow \text{MEM READ}$
 $SA + SC \rightarrow \text{MEM WRITE}$
 $SC \rightarrow \text{PC UPDATE}$
 $SD \rightarrow \{W, Z\} \rightarrow \text{PC}$
 $SE \rightarrow \text{PCH/PCL} \rightarrow A/DB$

HAWA MAHAL
PAGE NO.
DATE :

OPCODE

00000 MOV R₁, R₂ ($SA + SB$)

00100 MOV R, M $2x(SA + SB)$

00101 MVI R, D08 $2x(SC + SB)$

00110 MOV M, R ($SA + Sc + SA + SB$)

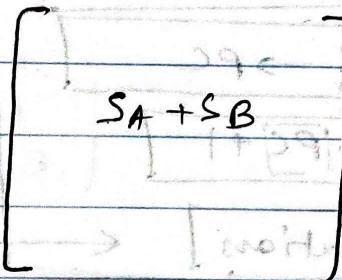
01000 ADC Rg

01001 S BB Rg

01010 ANA Rg

01011 CMP Rg

01100 ACI D08 $2x(SA + SB)$



00001 STA D16 $(2x(SA + SB) + SA + Sc + SA + SB)$

00010 LDA D16 $4x(SA + SB)$

00011 LX / Rp/SP, D16 $3x(SA + SB)$

10100 JMP D16

10101 RET

$[3x(SA + SB)]$

11000 JC D16

$[3x(SA + SB) \text{ or } SA + SB + Sc + SA + SB]$

11001 RZ

$[3x(SA + SB) \text{ or } SA + SB]$

11110 CALL

$[2x(SA + SB) + 2x(SA + SE) + SD + SA + SB]$

11111 CZ

$\downarrow \text{or } SA + SB + Sc + SA + SB)$

State control points.

(1)

SA

operation \rightarrow Yes/No (A)

00001

PC _H	\rightarrow A/B
-----------------	-------------------

PC _L	\rightarrow A/DB
-----------------	--------------------

(B) (00) (01) (10) (11)
 \rightarrow PC_H-PC_L/HL/WZ/SP_H-SP_L

Always yes

$R_2 \rightarrow R_1$	\rightarrow Yes/No (C)
-----------------------	--------------------------

R₂ & R₁ values comes from instruction

(2)

SB

A(DB \rightarrow DB \rightarrow IR)

(3 bit)

(Always yes) \rightarrow IR/Rg/SP_H/SP_L/AC/TMP/
 \rightarrow W/Z/PC_L/PC_H

00010

{W, Z} \rightarrow PC

Yes/No

PC \leftarrow PC+1

(F) Yes/No

(G) MPC or SPM

t t

(I)

operation (I) AC \leftarrow AC + Rg + Cy(H) Yes/No (I) AC \leftarrow AC + TMP + Cy (00)AC \leftarrow AC - Rg - Cy (01) SUBAC \leftarrow AC ^ Rg AND (10)

AC - Rg] CMP (11)

00100

0 \rightarrow PC _H

1 \rightarrow PC _L

(Rg values from
instruction)

(3)

SC

Rg \rightarrow DB \rightarrow A/DB
--

(K) Yes/No

(L) Rg/AC \leftarrow 1

from instruction

1010000

10000

PC \leftarrow PC+1

(M) Yes/No

(4) & (5)

SD & SC

Simple states

using Latency slot 3

~~DATA~~
~~ALE~~

~~DATA & GATE~~

(A) $oh(68Y \leftarrow \text{read} \# 9)$ a2 (1)

(1) MOV R1, R2 (2)

$92-92/SW/JA/59-109 \leftarrow 21A \leftarrow [N37] \rightarrow 100001$

$S_A \rightarrow 0 A \rightarrow 0$ $\boxed{ALE = 1}$
 $B \rightarrow 00$

(B) $oh(C \rightarrow 1 \rightarrow [R2 - 59])$

initial value $S_B \rightarrow 0 D \rightarrow 0000$ a2

$E \rightarrow 0 \quad \boxed{ALE = 0}$
 $F \rightarrow 1 \leftarrow 00 \leftarrow \overline{RD} = 0$ a2 (3)

$G \rightarrow 0 \quad (\text{cop word}) A$
 $H \rightarrow 0$

$I \rightarrow XX \quad (R2 \rightarrow 59)$
 $J \rightarrow X$

(2) MOV Rg, M

$S_A \rightarrow A \rightarrow 0$ $\boxed{ALE = 1}$
 $B \rightarrow 01$
 $C \rightarrow 0$

$S_B \rightarrow D \rightarrow 001$ (Rg from instruction)

$E \rightarrow 0$

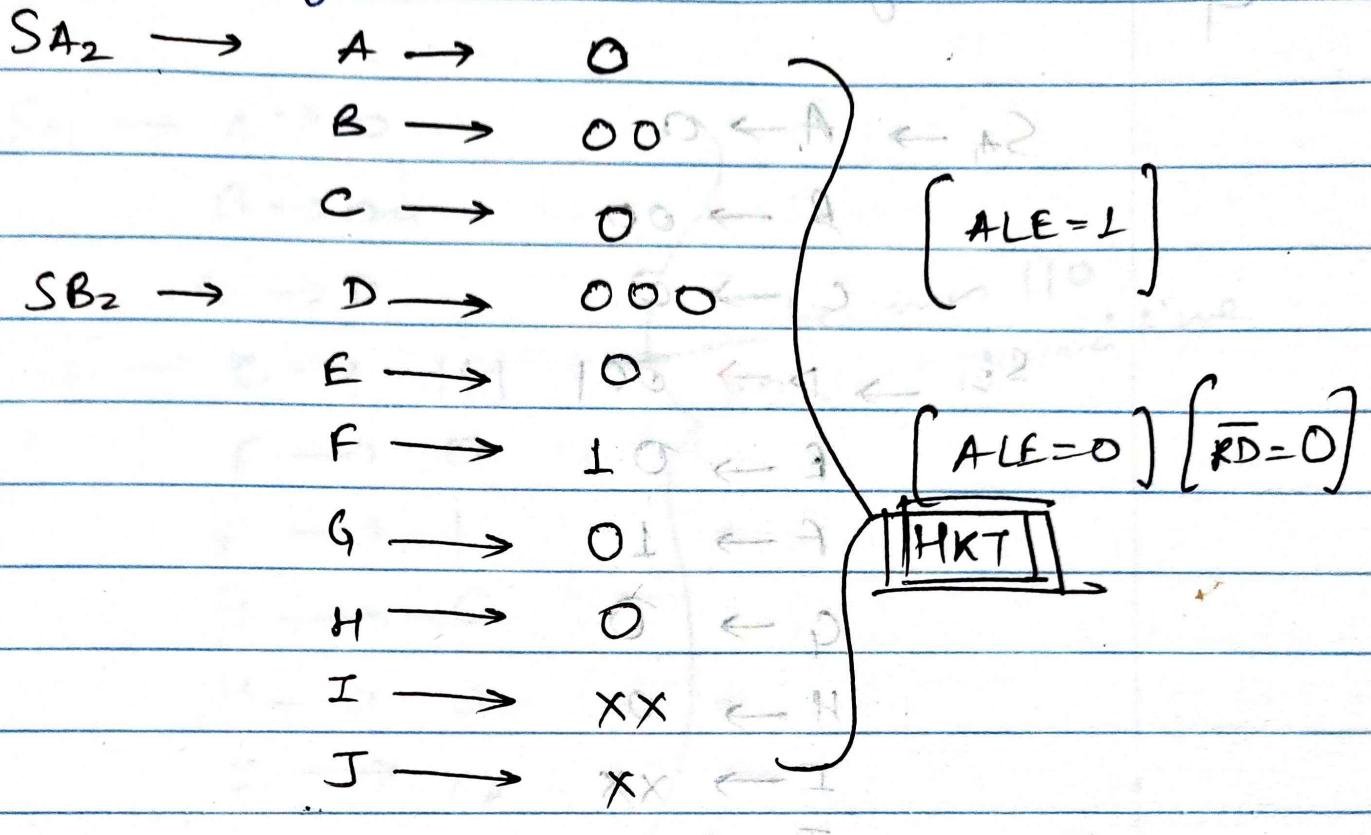
$F \rightarrow 0 \quad \boxed{ALE = 0}$
 $G \rightarrow X \quad \boxed{\overline{RD} = 0}$

$H \rightarrow 0$

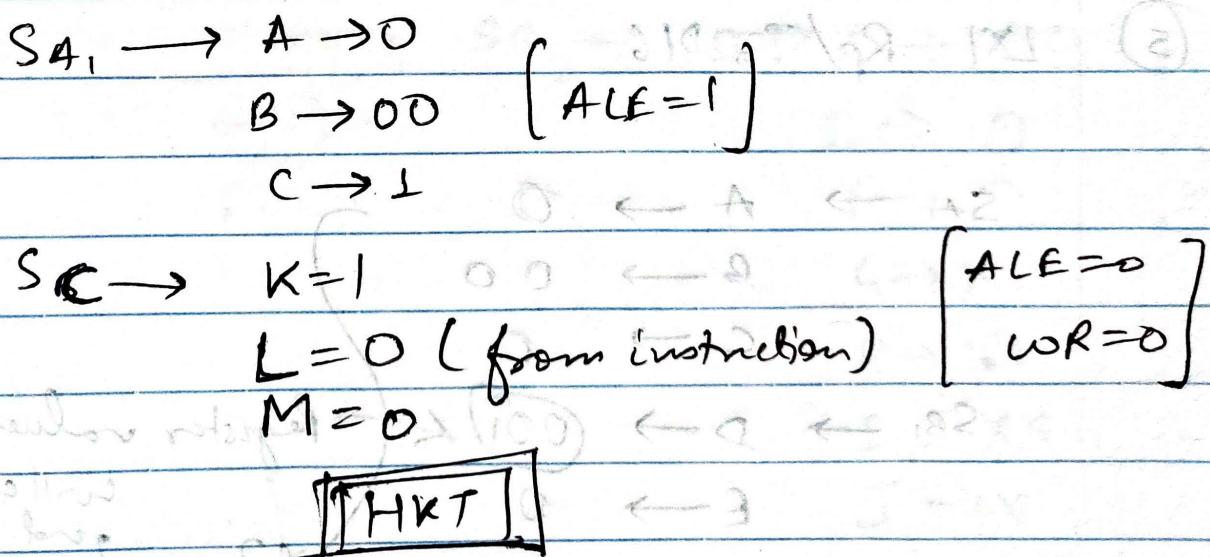
$I \rightarrow XX$

initial value $J \rightarrow X$

(3) ~~MOV M, Rg~~



(3) MOV M, Rg



(2)

MV Rg, D08

$S_A \rightarrow A \rightarrow 000 \leftarrow 8$

$B \rightarrow 00 \leftarrow 9$

$C \rightarrow 000 \leftarrow 10$

$S_B \rightarrow D \rightarrow 001 \leftarrow 11$

$E \rightarrow 01 \leftarrow 12$

$F \rightarrow 10 \leftarrow 13$

$G \rightarrow 0 \leftarrow 14$

$H \rightarrow 0X \leftarrow 15$

$I \rightarrow XX \leftarrow 16$

$J \rightarrow X \leftarrow 17$

HKT

(5)

LXI Rp/SP, DIG

 $S_A \rightarrow A \rightarrow 0$ $B \rightarrow 00$ $S_B \rightarrow D \rightarrow 001$ $E \rightarrow 0$ $F \rightarrow 1$ $G \rightarrow 0$ $H \rightarrow 0$ $I \rightarrow XX$ $J \rightarrow X$

Register values

will change
2nd timeHKT

(6)

LDA DIG

$$S_A \rightarrow A \rightarrow 0$$

$$B \rightarrow 00$$

$$C \rightarrow 0$$

$$S_B \rightarrow B \rightarrow 111$$

$$E \rightarrow 0$$

$$F \rightarrow 1$$

$$G \rightarrow 0$$

$$H \rightarrow 0$$

$$I \rightarrow XX$$

$$J \rightarrow X$$

becomes 110
second time

x_2

$$S_B \rightarrow A \rightarrow 0$$

$$B \rightarrow 10$$

$$C \rightarrow 0$$

$$S_B \rightarrow D \rightarrow 100$$

$$E \rightarrow 0$$

$$F \rightarrow 0$$

$$G \rightarrow X$$

$$H \rightarrow 0$$

$$I \rightarrow XX$$

$$J \rightarrow X$$

$$T \rightarrow 0 \leftarrow A \leftarrow 10$$

JHK

$$00 \leftarrow B$$

$$0 \leftarrow C$$

$$000 \leftarrow D \leftarrow 10$$

$$0 \leftarrow E$$

(7)

STA D16

DATA (5)

$S_A \rightarrow A \rightarrow 0$

$B \rightarrow 00$

$C \rightarrow 0$

$S_B \rightarrow D \rightarrow 111$

$E \rightarrow 0$

$F \rightarrow 1$

$G \rightarrow 0$

$H \rightarrow 0$

$I \rightarrow X$

$O \leftarrow A \rightarrow J \rightarrow X$

~~$S_D \rightarrow K \rightarrow L \rightarrow M \rightarrow O$~~

$S_C \rightarrow K \rightarrow L \rightarrow M \rightarrow O$

~~$O \leftarrow C \rightarrow L \rightarrow M \rightarrow O$~~

$O \leftarrow J \rightarrow M \rightarrow O$

$O \leftarrow I \rightarrow M \rightarrow O$

$X \leftarrow J \rightarrow M \rightarrow O$

$O \leftarrow H \rightarrow M \rightarrow O$

$X \leftarrow I \rightarrow M \rightarrow O$

$T \leftarrow K \rightarrow M \rightarrow O$

$J \leftarrow T \rightarrow M \rightarrow O$

$S_A \rightarrow A \rightarrow 0$

$B \rightarrow 00$

$C \rightarrow 0$

$S_B \rightarrow D \rightarrow 000$

$E \rightarrow 0$

$F \rightarrow 1$

$G \rightarrow 0$

$H \rightarrow 1$

$I \rightarrow 00$

(8)

ADC Rg

$X \leftarrow T$

$S_A \rightarrow A \rightarrow 0$

$B \rightarrow 00$

$C \rightarrow 0$

$S_B \rightarrow D \rightarrow 000$

$E \rightarrow 0$

$F \rightarrow 1$

$G \rightarrow 0$

$H \rightarrow 1$

$I \rightarrow 00$

$J \rightarrow 0$

⑨

ACI D08

 $S_{A_1} \rightarrow A \rightarrow O$ $B \rightarrow O$ $C \rightarrow O$ $S_{B_1} \rightarrow D \rightarrow O$ $E \rightarrow O$ $F \rightarrow O$ $G \rightarrow O$ $H \rightarrow O$ $I \rightarrow X$ $J \rightarrow X$ ~~██████████~~ $S_{A_2} \rightarrow A \rightarrow O$ $B \rightarrow O$ $C \rightarrow O$ $S_{B_2} \rightarrow D \rightarrow O$ $E \rightarrow O$ $F \rightarrow O$ $G \rightarrow O$ $H \rightarrow O$ $I \rightarrow O$ $J \rightarrow E$

(10)

SBB Rg

800 IDA

 $S_{A_1} \rightarrow A \rightarrow O$ $B \rightarrow OO \leftarrow A2$ $C \rightarrow O$ $S_{B_1} \rightarrow D \rightarrow OOO$ $E \rightarrow O \leftarrow A2$ $F \rightarrow I$ $G \rightarrow O$ $H \rightarrow I$ $I \rightarrow OI$ $J \rightarrow X$ $X \leftarrow I$

(11)

ANA Rg

 $S_{A_1} \rightarrow A \rightarrow AO \leftarrow A2$ $O \rightarrow BO$ $C \rightarrow O$ $S_{B_1} \rightarrow D \rightarrow OOO \leftarrow A2$ $OE \rightarrow BO$ $IF \rightarrow I$ $Og \rightarrow PO$ $HI \rightarrow I$ $OI \rightarrow IO$ $J \rightarrow X$

(12)

CMP Rg

$S_A \rightarrow A \rightarrow 0 \leftarrow 0 \rightarrow 0$

$B \rightarrow 00 \leftarrow 0 \rightarrow 0$

$C \rightarrow 0 \leftarrow 0 \rightarrow 1$

$S_B \rightarrow D \rightarrow 000$

$E \rightarrow 0 \leftarrow p$

$F \rightarrow 1 \leftarrow H$

$G \rightarrow 0 \leftarrow I$

$H \rightarrow 1 \leftarrow C$

$I \rightarrow 11$

$J \rightarrow X$

(13)

JMP D16

$S_A \rightarrow A \rightarrow 0$

$B \rightarrow 00 \leftarrow 0 \rightarrow 0$

$C \rightarrow 0 \leftarrow 0$

$S_B \rightarrow D \rightarrow 011 \leftarrow 0$

$E \rightarrow 00 \leftarrow C \leftarrow 0$

$F \rightarrow 01 \leftarrow 3$

$G \rightarrow 00 \leftarrow 3$

$H \rightarrow 00 \leftarrow p$

$I \rightarrow 0xx \leftarrow H$

$J \rightarrow x \leftarrow E$

$S_{A_2} \rightarrow A \rightarrow 0$

$B \rightarrow 00$

$C \rightarrow 0 \leftarrow D \leftarrow A_2$

$S_{B_2} \rightarrow D \rightarrow 110 \leftarrow A$

$E \rightarrow 1 \leftarrow B$

$F \rightarrow L \leftarrow C \leftarrow A_2$

$G \rightarrow 0 \leftarrow J$

$H \rightarrow 0 \leftarrow I$

$I \rightarrow xx \leftarrow P$

$J \rightarrow x \leftarrow H$

$HKT \leftarrow I$

81C 9MT (8)

(14)

JC D16

$\rightarrow A \leftarrow A_2$

$S_{A_1} \rightarrow A \rightarrow 00 \leftarrow B$

$B \rightarrow 00 \leftarrow J$

$C \rightarrow 10 \leftarrow D \leftarrow A_2$

$S_{B_1} \rightarrow D \rightarrow 011 \leftarrow J$

$E \rightarrow 10 \leftarrow J$

$F \rightarrow 01 \leftarrow P$

$G \rightarrow 00 \leftarrow H$

$H \rightarrow x0 \leftarrow I$

$I \rightarrow xx \leftarrow I$

$J \rightarrow x$

Condition check

if ($c == 1$)

$0 \leftarrow A \leftarrow B$

else

$00 \leftarrow A$

$S_{A_2} \rightarrow A \rightarrow 0 \quad 0 \leftarrow S_{C_1} \rightarrow K \rightarrow 0$

$B \rightarrow 0011 \leftarrow D \rightarrow L \rightarrow X$

$C \rightarrow 0 \quad 0 \leftarrow A \rightarrow M \rightarrow L$

$S_{B_2} \rightarrow D \rightarrow 110 \leftarrow A$

$E \rightarrow 1 \quad 0 \leftarrow P$

$F \rightarrow 1 \quad 0 \leftarrow H$

$G \rightarrow 0X \leftarrow I$

$H \rightarrow 0X \leftarrow C$

$I \rightarrow XX$

$J \rightarrow X \quad 1 \leftarrow A \leftarrow B^2$

HKT

$0 \leftarrow J$

$0 \leftarrow O \leftarrow B^2$

(15)

CALL DLG

$S_A \rightarrow A \rightarrow 0 \quad 11 \leftarrow A$

$B \rightarrow 00 \leftarrow J$

$C \rightarrow 01 \leftarrow O \leftarrow B^2$

$S_{B_1} \rightarrow D \rightarrow 111$

$E \rightarrow 0$

$F \rightarrow 1$

$G \rightarrow 0XH$

$H \rightarrow 0$

$I \rightarrow XX$

$J \rightarrow X$

$S_{A_2} \rightarrow A \rightarrow 0$ (1 = 0) j

$B \rightarrow 00$

$0 \leftarrow X \leftarrow 1, 2 C \rightarrow 0$ (0 → A → 0, 2)

$X \leftarrow S_{B_2} \rightarrow D \rightarrow 110$ (g ← s)

$L \leftarrow H \leftarrow E \rightarrow 0$ (b ← s)

$F \rightarrow L \leftarrow H \leftarrow C \leftarrow 0, 2$

$G \rightarrow 0$ (t ← g)

$H \rightarrow 0$ (t ← g)

$I \rightarrow XX \leftarrow P$

$J \rightarrow X \leftarrow H$
 $XX \leftarrow I$

$S_{A_3} \rightarrow A \rightarrow 1X \leftarrow I$

$B \rightarrow 11$

$C \rightarrow 0$ 

$S_{E_1} \rightarrow O \rightarrow 0$

$S_{A_4} \rightarrow A \rightarrow L$

$B \rightarrow 11$ (0 → A → 0, 2)

$C \rightarrow 0$ (0 ← g)

$S_{E_2} \rightarrow O \rightarrow 1$ (0 ← g)

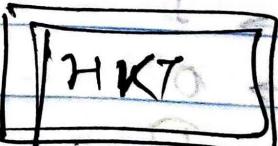
$11 \leftarrow F \leftarrow 0, 2$

S_P

$0 \leftarrow B$

$1 \leftarrow F$

$0 \leftarrow D$



HKT

$I \rightarrow XX \leftarrow S$

$X \leftarrow L$

(B)

CZ D16

 $S_A \rightarrow A \rightarrow 0$ $0 \rightarrow B \rightarrow 00$ $C \rightarrow$ 0 $S_B \rightarrow D \rightarrow$ 111 $E \rightarrow 0$ $F \rightarrow 1$ $G \rightarrow 0$ $H \rightarrow 0$ $I \rightarrow XX$ $J \rightarrow X$ J Condition check

if (Z=1)

else

 $S_C \rightarrow K \rightarrow 0$ $S_{A2} \rightarrow A \rightarrow 0$ $B \rightarrow 00$ $C \rightarrow 00$ $S_{B2} \rightarrow D \rightarrow 110$ $E \rightarrow 0$ $F \rightarrow 1$ $G \rightarrow 0$ $H \rightarrow 0$ $I \rightarrow XX$ $J \rightarrow X$ $L \rightarrow X$ $M \rightarrow 1$

$S_{A_3} \rightarrow A \rightarrow 1$

$B \rightarrow 11$

$C \rightarrow 0 \quad 0 \leftarrow 4 \leftarrow A_2$

$S_{E_1} \rightarrow D \rightarrow 0$

$0 \leftarrow 2 \leftarrow A_1$

$0 \leftarrow 3 \leftarrow C$

$S_{A_4} \rightarrow A \rightarrow 1$

$B \rightarrow 11 \quad 0 \leftarrow 3$

$C \rightarrow 0 \quad 1 \leftarrow 7$

$S_{E_2} \rightarrow D \rightarrow 1$

$0 \leftarrow 0 \leftarrow H$

$xx \leftarrow I$

$x \leftarrow E$

$xx \leftarrow E$

$S_D \rightarrow$

HKT

(17)

RET

(18) f

$x \leftarrow J. S_A, \rightarrow A \rightarrow 0 \quad 0 \leftarrow A \leftarrow A_2$

$B \rightarrow 11 \quad 0 \leftarrow 2$

$C \rightarrow 0 \quad 0 \leftarrow 3$

$S_B \rightarrow D \rightarrow P_C$

$E \rightarrow 0 \quad 0 \leftarrow 3$

$F \rightarrow 1 \quad 1 \leftarrow 4$

$G \rightarrow 1 \quad 1 \leftarrow 5$

$H \rightarrow 0 \quad 0 \leftarrow 6$

$I \rightarrow xx \quad xx \leftarrow 1$

$J \rightarrow xx \quad xx \leftarrow 2$

$S_{A_2} \rightarrow A \rightarrow O$

$B \rightarrow 11$

$C \rightarrow O$

$S_{B_2} \rightarrow D \rightarrow PCH_7$

$E \rightarrow O$

$F \rightarrow 11$

$G \rightarrow 1$

$H \rightarrow O$

$I \rightarrow XX$

$J \rightarrow S5XN11$

HKT

(13)

RZ

Condition
check

if ($Z = -1$)

else

REF
except HKT

HKT

States redefined

Q) $S_{AA} \rightarrow$ operation (dc / SP) redundant

$$\begin{aligned} S_{AB} \rightarrow & \boxed{PC_H \rightarrow A/B} \\ & \boxed{PC_L \rightarrow A/DB} \end{aligned}$$

$$S_{AC} \rightarrow \boxed{R_1 \rightarrow R_2}$$

$S_{BA} \rightarrow$ operation (Arithmetic & logical)

$$S_{BB} \rightarrow \boxed{A/DB \rightarrow DB \rightarrow IR}$$

$$S_{BC} \rightarrow \boxed{\{W, Z\} \rightarrow PC}$$

$$S_{BD} \rightarrow \boxed{PC \leftarrow PC + 1}$$

* order changed
operation moved to the top

$$S_{CA} \rightarrow \boxed{R_2 \rightarrow DB \rightarrow A/DB}$$

$$S_{CB} \rightarrow \boxed{PC \leftarrow PC + 1}$$

redundant

$$S_D \rightarrow \boxed{\{W, Z\} \rightarrow PC}$$

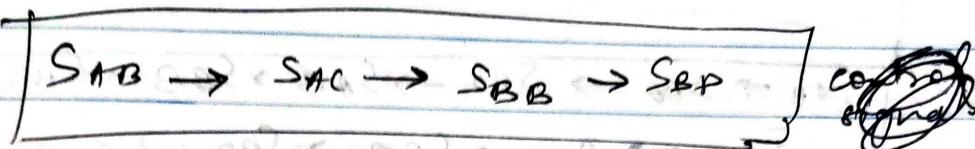
$$S_E \rightarrow \boxed{PC_H / PC_L \rightarrow A/DB}$$

Control signals as

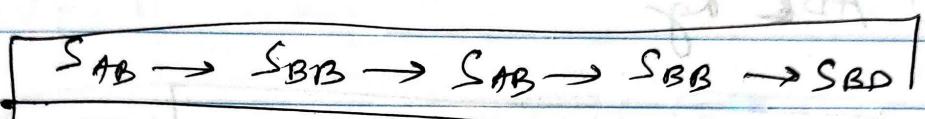
defined earlier

① MOV R₁, R₂

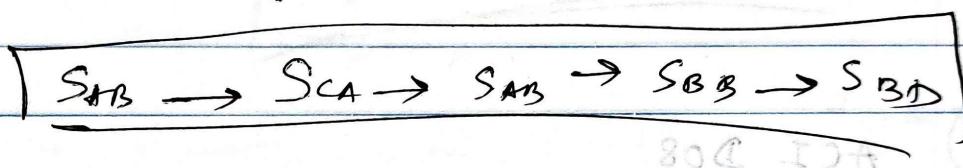
11C AT 2



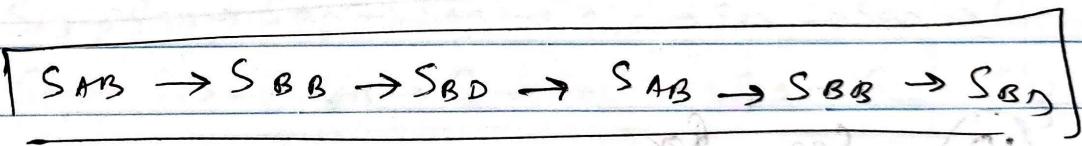
② MOV Rg, M



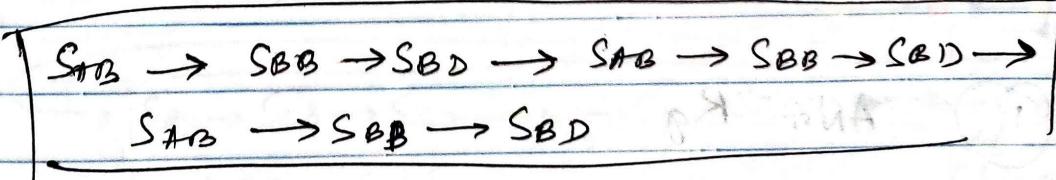
③ MOV M, Rg



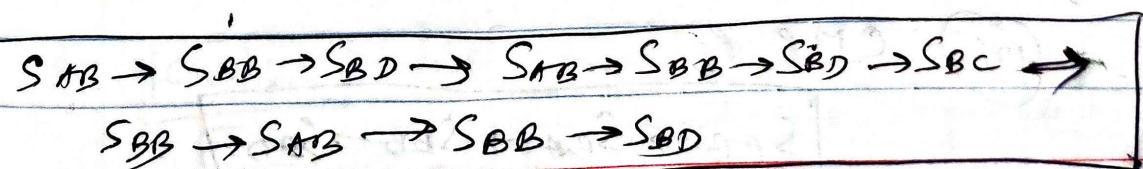
④ MVI Rg, D08



⑤ LXI RP/SP, D16



⑥ LDA D16



(7) STA D16

$S_{AB} \rightarrow S_{BB} \rightarrow S_{BD} \rightarrow S_{AB} \rightarrow S_{BB} \rightarrow S_{BD} \rightarrow S_{BC} \rightarrow S_{CA} \rightarrow S_{AB} \rightarrow S_{BB} \rightarrow S_{BD}$

(8) ADC Rg

$S_{AB} \rightarrow S_{BA} \rightarrow S_{BB} \rightarrow S_{BD}$

(9) ACI D08

$S_{AB} \rightarrow S_{BB} \rightarrow S_{BD} \rightarrow S_{MB} \rightarrow S_{BA} \rightarrow S_{BB} \rightarrow S_{BD}$

(10) SBB Rg

$S_{AB} \rightarrow S_{BA} \rightarrow S_{BB} \rightarrow S_{BD}$

(11) ANA Rg

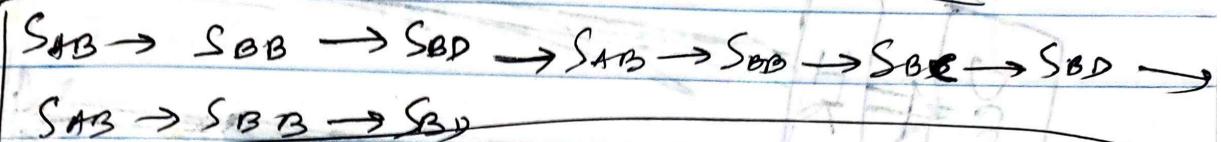
$S_{AB} \rightarrow S_{BA} \rightarrow S_{BB} \rightarrow S_{BD}$

(12) CMP Rg

$S_{AB} \rightarrow S_{BA} \rightarrow S_{BB} \rightarrow S_{BD}$

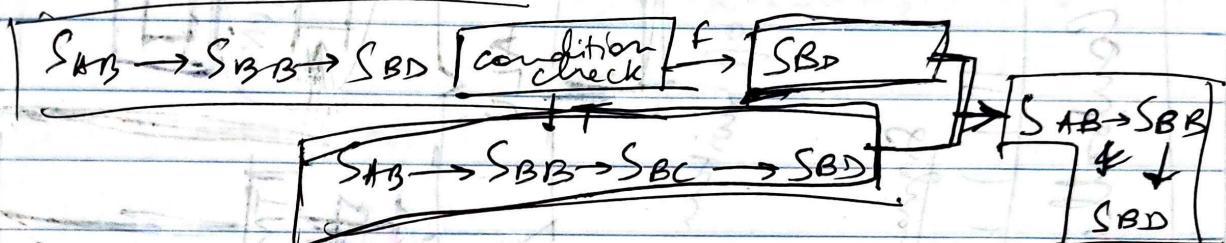
(13)

JMP D16



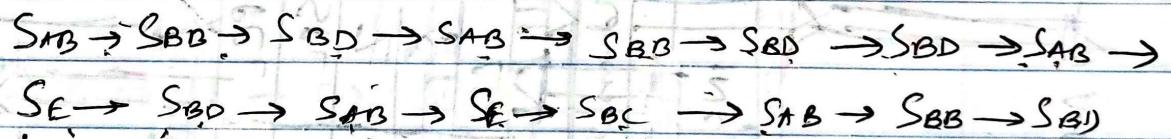
(14)

JC D16

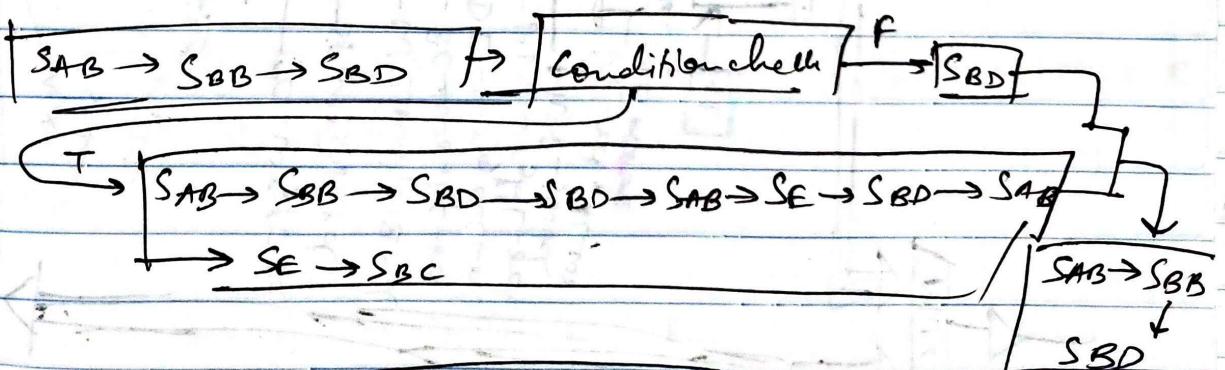


(15)

CALL D16



(16)

C \geq D16

(17)

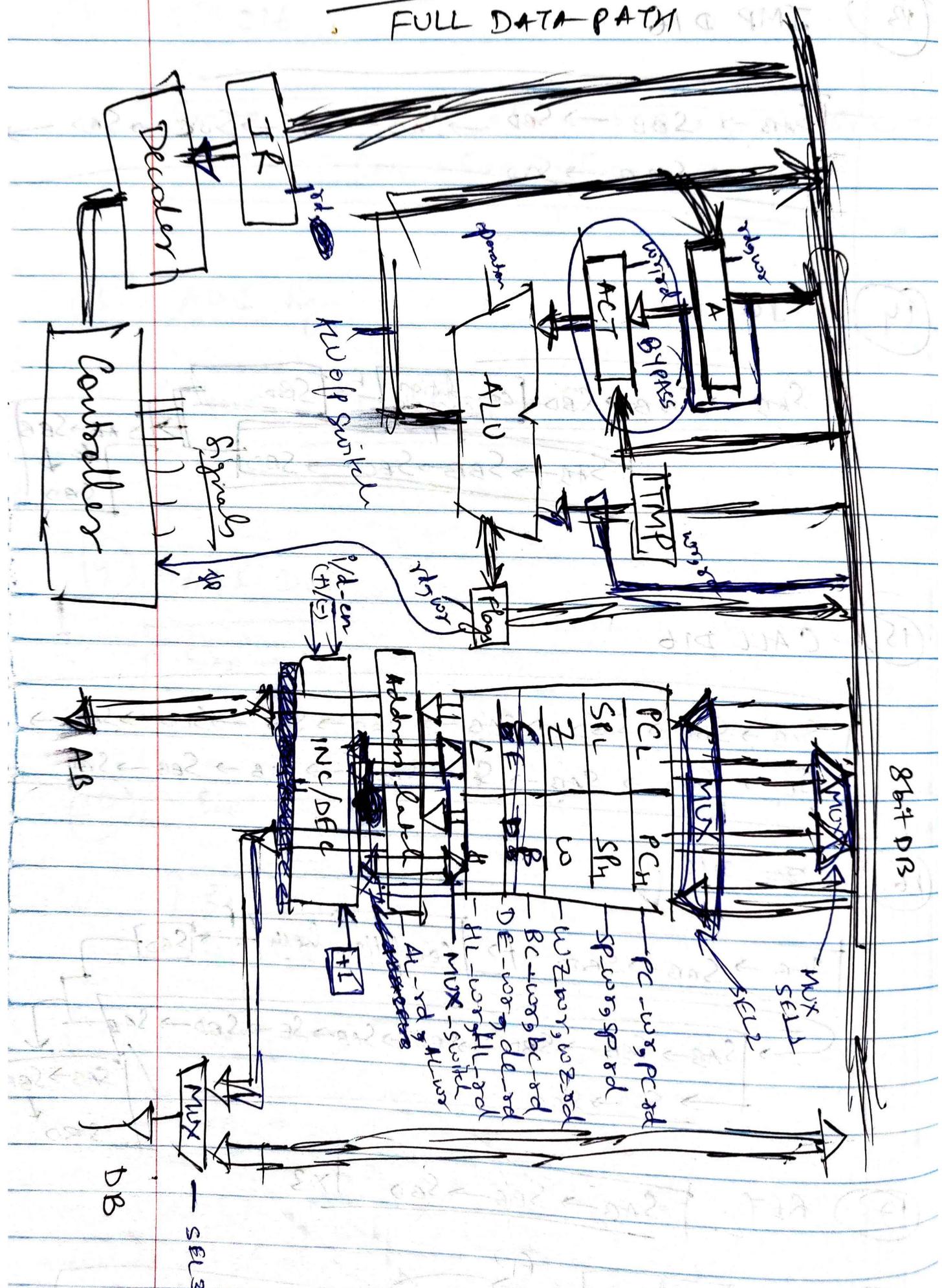
RET $\xrightarrow{f} S_{AB} \rightarrow S_{BB} \rightarrow S_{BD} \times 3$

(18)

RZ [Condition check] \xrightarrow{f} $\xrightarrow{T} S_{AB} \rightarrow S_{BB} \rightarrow S_{BD} \times 2$

~~All Controls~~

FULL DATA PATH



Control signals

ALE, \overline{RD} , \overline{WR}

MUX-SEL1, MUX-SEL2, MUX-SEL3, MUX-SWITCH

PC-RD, PC-WR, SP-RD, SP-WR, HL-RD, HL-WR, WZ-RD,
WZ-WR, BC-RD, BC-WR, DE-RD, DE-WR, AL-WR, AL-RD

IN/DC-EN, IN/DC

The IN/DC clk is combinational, so it is always driven
but the movement of result back to the
register is protected by MUX ($\begin{cases} 1 \rightarrow \text{connected} \\ 0 \rightarrow \text{disconnected} \end{cases}$)
i.e., a switch is present there.

OPERATION — (+), (-), (\wedge)

for \rightarrow MUX-ALU-FLAG-INP [either 0
operation only or the particular flag]

FLAG-RD, FLAG-WR, AC-RD, AC-WR, TMP-RD, TMP-WR
to ALU \rightarrow TMP-DR-DB-MUX

ALU-OP SWITCH

AC-IN-MUX-ALU-OP-DR-DB

FLAG-TO-ALU-MUX, ALU-TO-FLAG-DEMUX