Sequential ckt

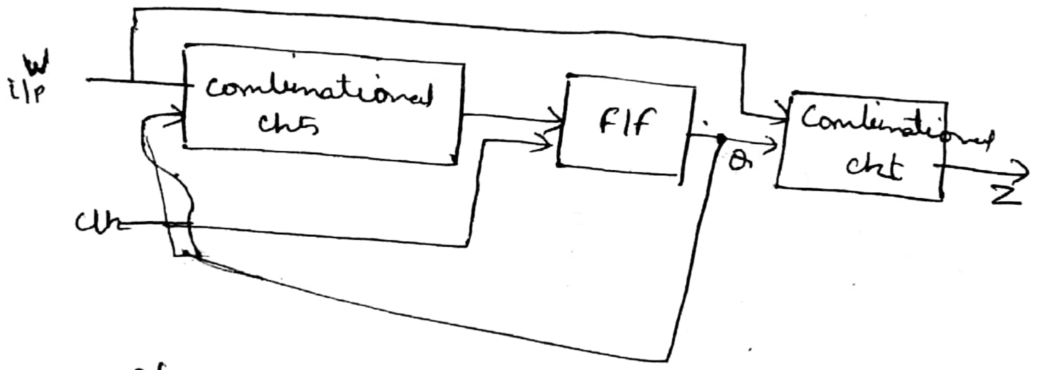
O/P ⇒ past behavior + present i/p

- Seq + clk — Syncronous
  - → easier to design
  - → used in vast majority
  - → combinational logic + 1 or more f/f
- Asyncronous SC — Seq without clk.

Combinational ckts

O/p are determined by present value of i/p

Syncronous Sequential Ckts



W → set of i/ps
Z → set of o/ps

- → O/p of f/f is referred to as the state, Q of the ckt.
- → F/F must be edge triggered.
- → Clk :- +ve or −ve edge ⇒ active clk edge.
- → Comb. logic that provides the i/p signals to the f/f derives its i/p from — W, — present o/p of the f/f Q.

∴ change in state is becoz of both present i/p & present state

Final o/p by another comb ckt. ~~that provides the i/p signals to the F/F derives its i/ps from~~ O/p are fun of present state of F/F & primary i/p. OR o/p is dependent only on present state.

Syn Seq Cht (also called Finite ...

Moore

→ Seq cht where o/p only on the state of the cht

Mealy

→ Seq cht o/p on present state + i/p

Basic Design Steps

Cht specification

1. One i/p w, one o/p z
2. +ve edge of clk.
3. o/p z = 1 if during two immediately preceding clk cycles the i/p w = 1 o/w z = 0

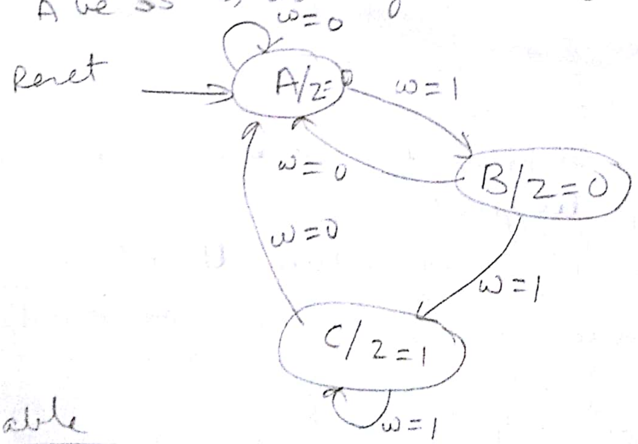
clk	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}
w :	0	1	0	1	1	0	1	1	1	0	1
z :	0	0	0	0	0	1	0	0	1	1	0

o/p z cannot depend solely on the present value of w

State Dig

⇒ Starting state - cht enters when power is on/or RESET is applied

⇒ Let A be SS ⇒ as long as w = 0 ckt do nothing



State Dig

State Table

Present State	Next state w = 0	Next state w = 1	o/p z
A	A	B	0
B	A	C	0
C	A	C	1

3 states ⇒ 2 variables $y_1 y_2$

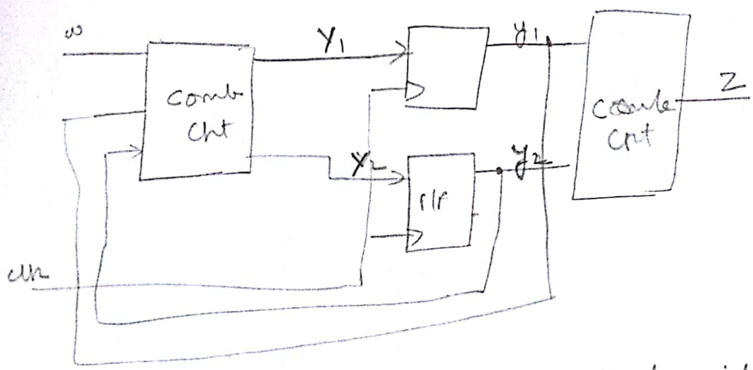
	$y_1 y_2$
A	00
B	01
C	10

Seq ckt clkd

State Assignment

State Assignment

	Present state $y_2\ y_1$	Next state $w=0$ Y_2Y_1	Next state $w=1$ Y_2Y_1	o/p z
A	0 0	0 0	0 1	0
B	0 1	0 0	1 0	0
C	1 0	0 0	1 0	1
	1 1	dd	dd	d



$Y_1\ Y_2 \rightarrow$ next state var

$y_1\ y_2 \rightarrow$ present state.

→ need to develope a CC, ~~who~~ that will take i/p w, y_1 & y_2 (all combinations) to lead to $Y_1\ Y_2$

→ Next design ckt for z

→ o/p z depends only on present state of the ckt. (y_1 & y_2)

→ ∴ design is <u>MOORE m/c</u>

→ Simple choice for the f/f is D. f/f.

w \ y_2y_1	00	01	11	10
0	0	0	x	0
1	1	0	x	0

$$Y_1 = w\bar{y}_1\bar{y}_2$$

w \ y_2y_1	00	01	11	10
0	0	0	x	0
1	0	1	x	1

$Y_2 = wy_1 + wy_2$ (using x)

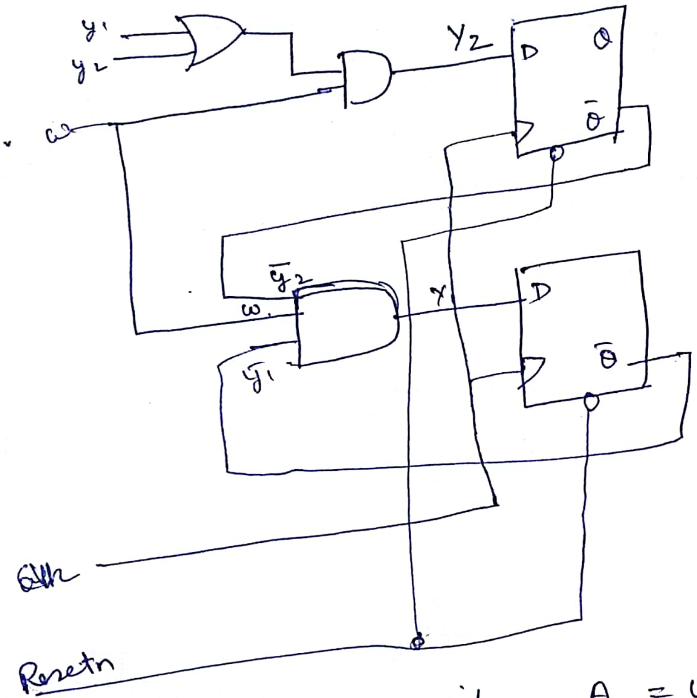
$Y_2 = wy_1\bar{y}_2 + w\bar{y}_1y_2$ (with out don't care)

y_2 \ y_1	0	1
0	0	0
1	1	d

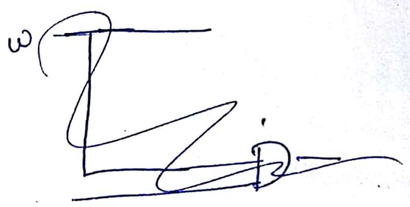
$z = \bar{y}_1y_2$ (without don't care)

$z = y_2$ (with don't care)

$Y_1 = w\bar{y}_1\bar{y}_2$ $\qquad$ $Y_2 = wy_1 + wy_2 = w(y_1+y_2)$ $\qquad$ $z = y_2$



when Resetn = 0
F/F will be cleared



if A = 00 B = 01 & C = 11

Design Steps

i) S

Present state	$y_2 y_1$	Next state $w=0$ $Y_2 Y_1$	Next state $w=1$ $Y_2 Y_1$	o/p z
A	0 0	0 0	0 1	0
B	0 1	0 0	1 1	0
C	1 1	0 0	1 1	1
	1 0	d d	d d	d

$Y_1 = D_1 = w$

$Y_2 = D_2 = wy_1$

$z = y_2$

Y_1

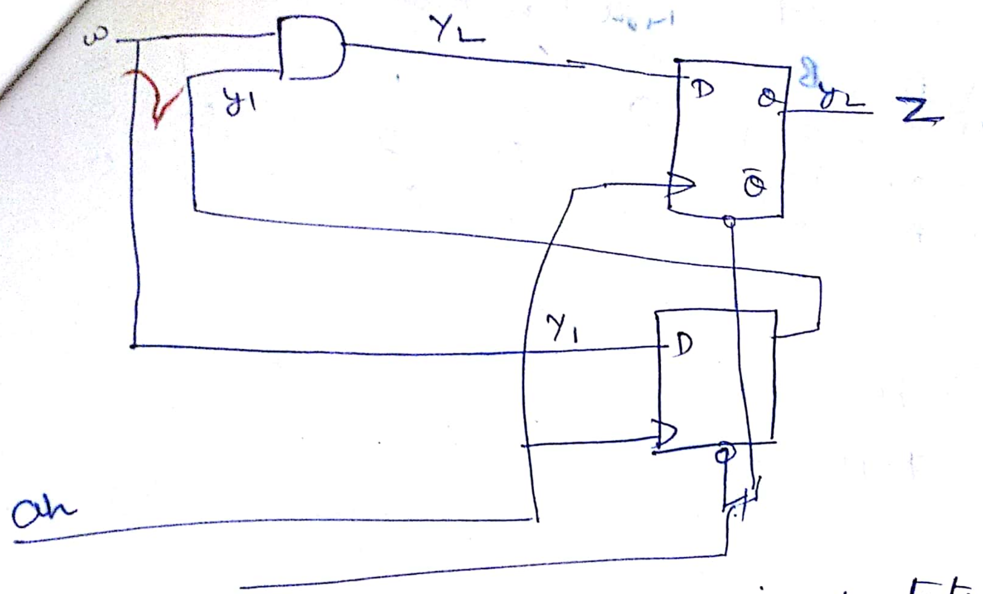
$w \backslash y_2 y_1$	00	01	11	10
0	0	0	0	d
1	1	1	1	d

Y_2

$w \backslash y_2 y_1$	00	01	11	10
0	0	0	0	d
1	0	1	1	d

$w y_1$

$y_2 \backslash y_1$	0	1
0	0	0
1	1	d

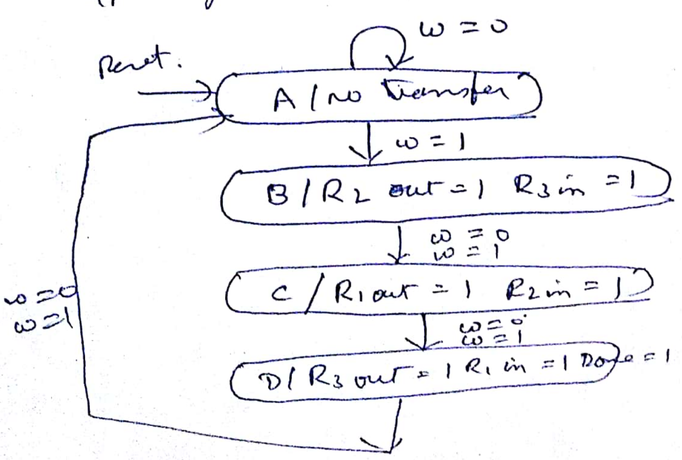


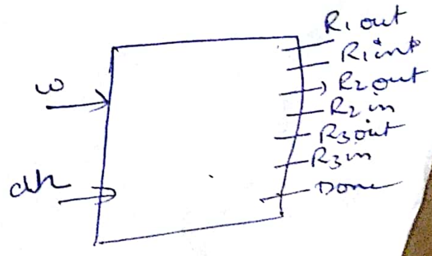
Cost is reduced with different state assignment

eg Swap the content of ~~two~~ two reg R_1 & R_2 using R_3

Steps
$R_2out = 1$ & $R_3in = 1$
$R_1 out = 1$ & $R_2in = 1$
$R_3 out = 1$ & $R_1in = 1$ Done = 1

Swapping is performed in response to a pulse on an i/p signal w.





~~Pent~~ Present		Next $w=0$		Next $w=1$		o/p R_1out	R_1in	R_2out	R_2in	R_3out	R
00	A	00	A	B	01	0	0	0	0	0	0
01	B	11	C	C	11	0	0	1	0	1	0
11	C	10	D	D	10	1	0	0	1	0	0
10	D	00	A	A	00	0	1	0	0	1	0

$$Y_1 = w\bar{y}_1 + \bar{y}_1 y_2$$

$$Y_2 = y_1\bar{y}_2 + \bar{y}_1 y_2$$

A – 00
B – 01
C – 11
D – 10

State minimization

only one i/p

	from	goes to	
$w=0$	S_i	$\longrightarrow S_u$	$\Rightarrow$ 0 successor of S_i
when $w=1$	S_i	$\longrightarrow S_v$	$\Rightarrow$ 1 " " S_i

When ~~k~~ mul. i/p s. then k successors (all possible comb. of i/p)

~~$S_i \Longleftrightarrow S_j$~~

$S_i \equiv S_j$ iff every poss i/p seq $\Rightarrow$ same o/p seq. whatever (not same states ?)

initially all ~~eq~~. states are eq. in P_1

Prest	Next $w=0$	Next $w=1$	o/p z
A	B	C	1
B	D	F	1
C	F	E	0
D	B	G	1
E	F	C	0
F	E	D	0
G.	F	G	0

$P_1 = (ABCDEFG)$

part based on o/p ie Z

$P_2 = (ABD)(CEFG)$

now based on i/p

$P_3 = (ABD)(CEG)(F)$

	0 suc	1 suc
P_2 ABD	BDB	CFG
CEFG	FFEF	ECDG
P_3 ABD	BDB	CFG
CEG	FFF	ECG
P_4 AD	BB	CG

$P_4 = (AD)(B)(CEG)(F)$

$P_5 = (AD)(B)(CEG)(F)$

Same so stop.

	next		op
	$w=0$	$w=1$	Z
A'	B'	C'	1
B'	A	F	1
C	F	C	0
F	C	A	0

$$\begin{array}{cccc} AD & B & CEG & F \\ \Downarrow & \Downarrow & \Downarrow & \Downarrow \\ A' & B' & C' & F' \end{array}$$