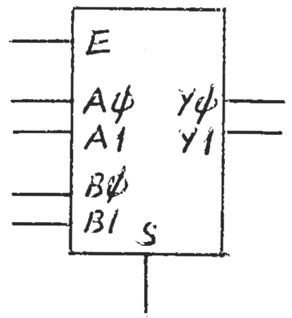
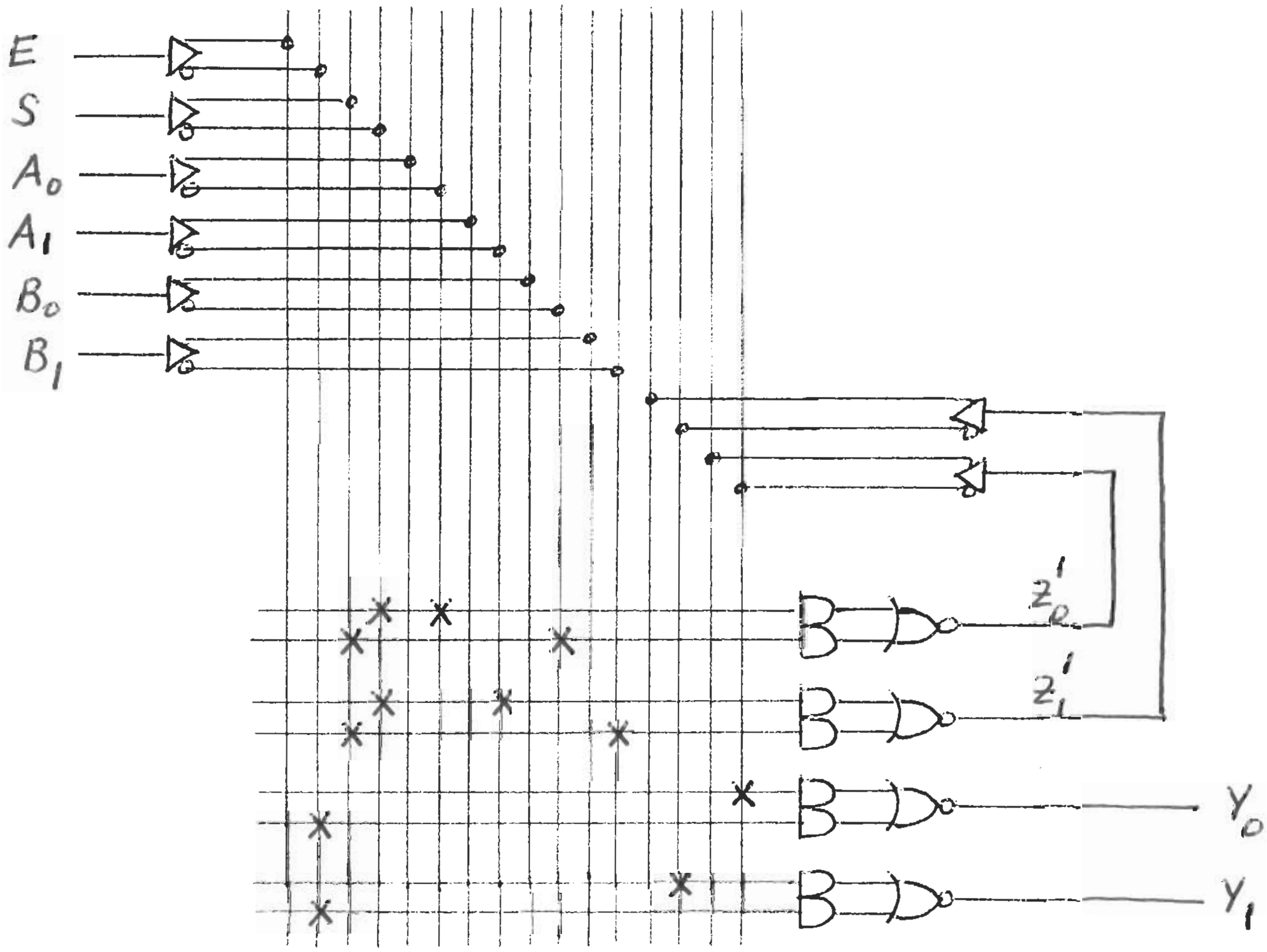
1. Below is the block diagram and the function table of a 2-to-1 2-bit generic multiplexer with enable input.



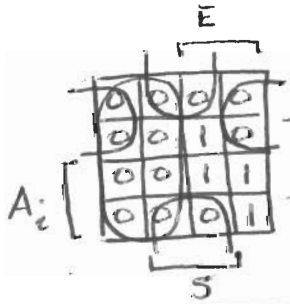
E	S	Y1	Yϕ
0	x	0	0
1	0	A1	Aϕ
1	1	B1	Bϕ

Implement this multiplexer using the following PAL without using any additional gates. Note that PAL outputs are inverted.



SOLUTION :

$Y_i = E_i(S'.A_i + S.B_i)$



$Y_i' = E' + \underbrace{S'A_i' + SB_i'}_{Z_i}$

2. Implement a 1-bit full adder using a generic 4-to-1 2-bit multiplexer using no more than one additional gate.

SOLUTION

MUX :

S_1	S_0	F_0	F_1
0	0	A_0	A_1
0	1	B_0	B_1
1	0	C_0	C_1
1	1	D_0	D_1

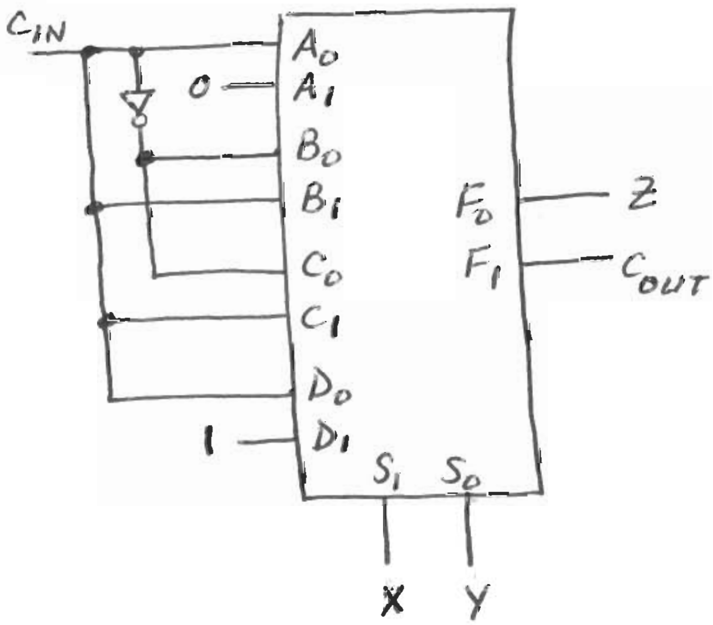
FULL ADDER :

X	Y	C_{IN}	Z	C_{OUT}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Let $XY = S_1 S_0$, $Z = F_0$, $C_{OUT} = F_1$.

FULL ADDER :

S_1	S_0	F_0	F_1
0	0	C_{IN}	0
0	1	C_{IN}'	C_{IN}
1	0	C_{IN}'	C_{IN}
1	1	C_{IN}	1



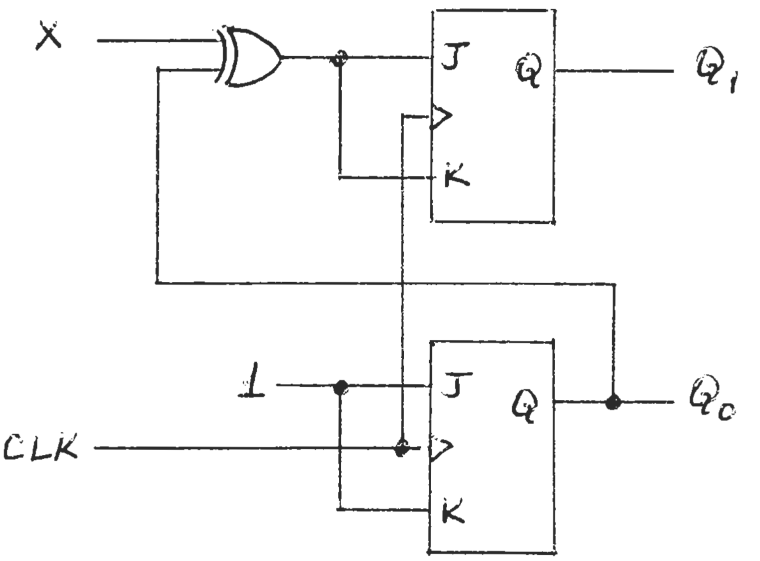
3. Consider the following synchronous machine.

a) Draw the state diagram with the following state assignment

Q_1 Q_0	State
0 0	A
0 1	B
1 0	C
1 1	D

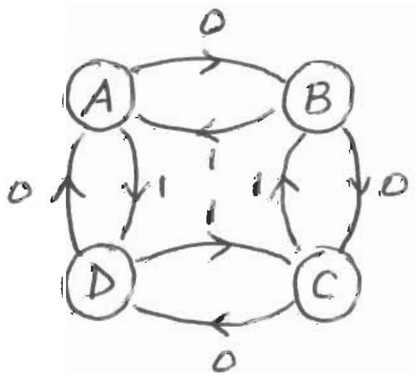
b) Assuming $Q_1 = Q_0 = 0$ initially, find the state sequence corresponding to the following input sequence.

X :	0	0	0	0	0	1	1	1	0	0	1	0
State :	A	B	C	D	A	D	C	B	C	D	C	D



SOLUTION:

Q_1	Q_0	X	$J_1 = K_1$	$J_0 = K_0$	Q_1^*	Q_0^*
0	0	0	0	1	0	1
0	0	1	1	1	1	1
0	1	0	1	1	1	0
0	1	1	0	1	0	0
1	0	0	0	1	1	1
1	0	1	1	1	0	1
1	1	0	1	1	0	0
1	1	1	0	1	1	0



4. Design a Mealey machine with one input X and one output Y such that $Y=1$ if the present input is the same as the input two clock periods before, an
$Y=0$ otherwise. Use only two D-flip flops. Assume that the initial state is $Q_1 = Q_0 = 0$. A typical input, output sequence is given below.

X : 0 0 0 1 0 0 1 0 1 1 1 0 1 0 0 0
Y : * * 1 0 1 0 0 1 1 0 1 0 1 1 0 1

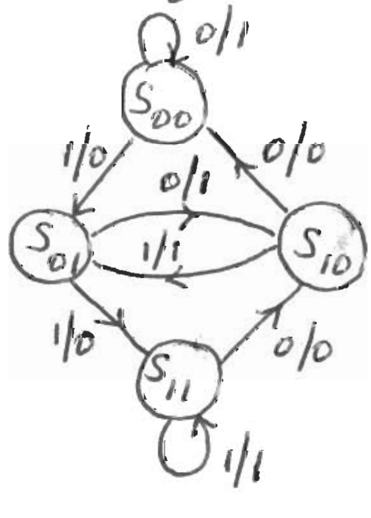
SOLUTION :

States :

S_{00} : Prev. two inputs are 00
S_{01} : " " " " 01
S_{10} : " " " " 10
S_{11} : " " " " 11

$\}$ → Use as state codes

State Diagram :



Next State/Output Table :

Q_1	Q_0	X	Q_1^*	Q_0^*	Y
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	1	0	1
0	1	1	1	1	0
1	0	0	0	0	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	1	1

$$D_0 = Q_0^* = X$$
$$D_1 = Q_1^* = Q_0$$
$$Y = (X \oplus Q_1)'$$