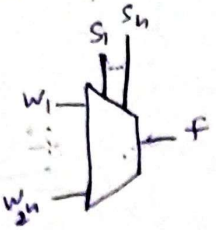
11-8-18 **Multiplexers**

$f = W_1 \oplus W_2$

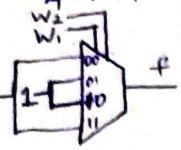
S_1 W_1	S_2 W_2	f
0	0	0 W_0
0	1	1 W_1
1	0	1 W_2
1	1	0 W_3

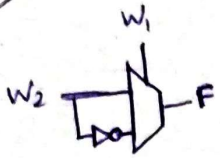


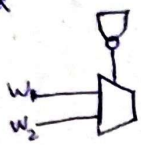
4:1 MUX

Inputs → $W_1 : W_{2^n}$

Selects → $S_1 : S_n$

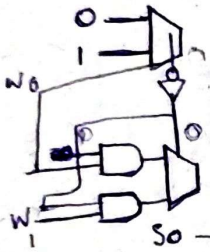


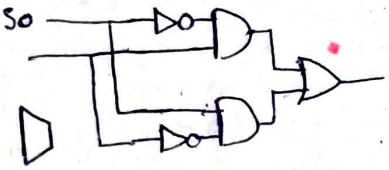


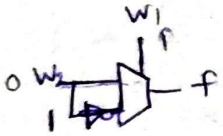


XOR

W_1	f
0	W_2
1	$\bar{W}_2$



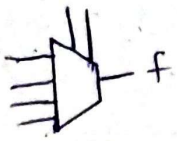


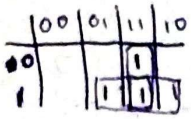


$f_1 = \Sigma m(3, 5, 6, 7)$

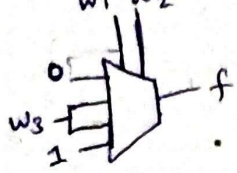
4:1 Mux

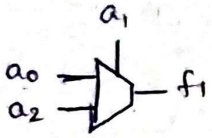
W_1	W_2	W_3	f_1	
0	0	0	0	0
0	0	1	0	
0	1	0	0	W_3
0	1	1	1	
1	0	0	0	W_3
1	0	1	1	
1	1	0	1	0
1	1	1	1	



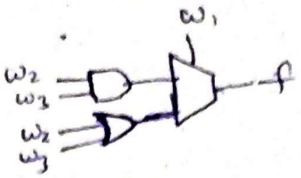


$f = w_1 w_3 + w_1 w_2 + w_2 w_3$





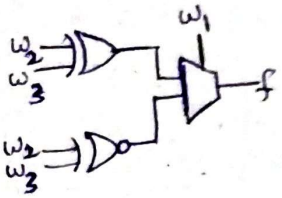
w_1 w_2	f
0 0	0
0 1	w_3
1 0	w_3
1 1	1



w_1	f
0	$w_2 w_3$
1	$w_2 + w_3$

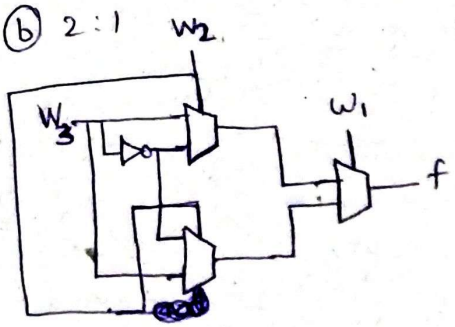
$f = w_1 \oplus w_2 \oplus w_3$

w_1	w_2	w_3	f
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1



$f = w_1 \oplus w_2 \oplus w_3$

(b) 2:1



① $f = w_1 \oplus w_2 \oplus \bar{w}_3$
only using (a) 4:1
(b) 2:1

② $f = \bar{w}_1 \bar{w}_3 + w_1 w_2 + w_1 w_3$
using (a) 4:1 (b) 2:1

③ $f = w_1 w_2 + w_1 w_3 + w_2 w_3$
using 2:1

④ $f = \bar{w}_2 w_3 + \bar{w}_1 w_2 \bar{w}_3 + w_2 \bar{w}_3 w_4 + w_1 \bar{w}_2 \bar{w}_4$

Common cath, Common anode, when preferred, why?

H·W

13-8-18

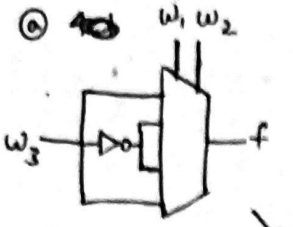
Decoder

$n : 2^n$

no. of inputs, no. of outputs

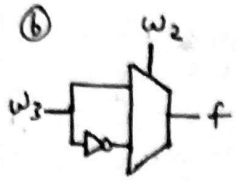
① $f = \omega_1 \oplus \omega_2 \oplus \omega_3$

ⓐ



ω_1	ω_2	ω_3	f	
0	0	0	0	ω_3
0	0	1	1	
0	1	0	1	$\bar{\omega}_3$
0	1	1	0	
1	0	0	1	$\bar{\omega}_3$
1	0	1	0	
1	1	0	0	ω_3
1	1	1	1	

ⓑ

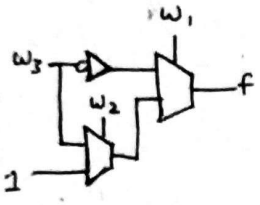


ω_1	ω_2	f	
0	0	0	ω_3
0	1	1	
1	0	1	$\bar{\omega}_3$
1	1	0	

ω_2	f	
0	0	ω_3
1	1	$\bar{\omega}_3$

② $f = \bar{\omega}_1\bar{\omega}_3 + \omega_1\omega_2 + \omega_1\omega_3$

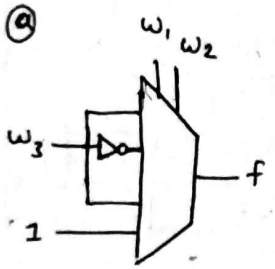
ⓑ



ω_1	ω_2	ω_3	f	
0	0	0	1	$\bar{\omega}_3$ ω_3
0	0	1	0	
0	1	0	1	$\bar{\omega}_3$
0	1	1	0	
1	0	0	0	$\omega_2\omega_3$ ω_3
1	0	1	1	
1	1	0	1	1
1	1	1	1	

ω_2	ω_3	f	
0	0	1	$\bar{\omega}_3$
0	1	0	ω_3
1	0	1	1
1	1	1	

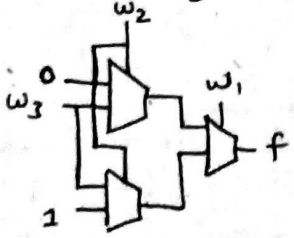
ⓐ



③ $f = \omega_1\omega_2 + \omega_1\omega_3 + \omega_2\omega_3$

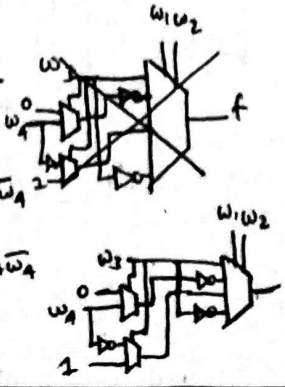
ω_1	ω_2	ω_3	f	
0	0	0	0	$\omega_2\omega_3$
0	0	1	0	
0	1	0	0	$\omega_2 + \omega_3$
0	1	1	1	
1	0	0	0	
1	0	1	1	
1	1	0	1	
1	1	1	1	

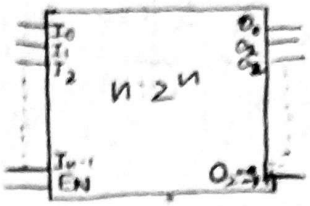
ω_2	ω_3	f	
0	0	0	0
0	1	1	ω_3
1	0	1	
1	1	1	

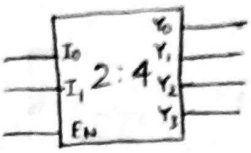


④

ω_1	ω_2	ω_3	ω_4	f	
0	0	0	0	0	ω_3
0	0	0	1	0	
0	0	1	0	0	$\bar{\omega}_3\omega_4$
0	0	1	1	1	
0	1	0	0	0	
0	1	0	1	0	
0	1	1	0	0	$\omega_3 + \bar{\omega}_4$
0	1	1	1	1	
1	0	0	0	0	
1	0	0	1	0	
1	0	1	0	0	
1	0	1	1	1	$\bar{\omega}_3$
1	1	0	0	0	
1	1	0	1	0	
1	1	1	0	0	
1	1	1	1	1	



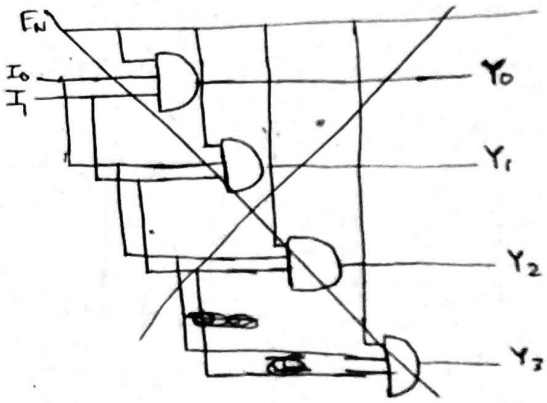


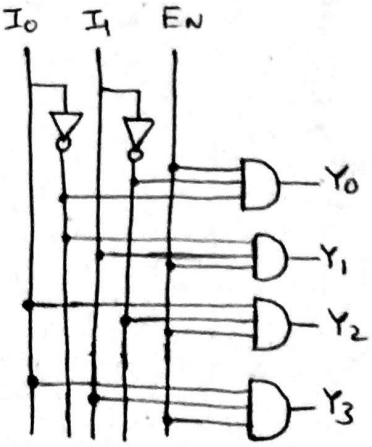


EN	I_0	I_1	Y_0	Y_1	Y_2	Y_3
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	0	0	0

$Y_0 = E_N\bar{I}_0\bar{I}_1 \quad Y_1 = E_N\bar{I}_0 I_1$

$Y_2 = E_N I_0\bar{I}_1 \quad Y_3 = E_N I_0 I_1$

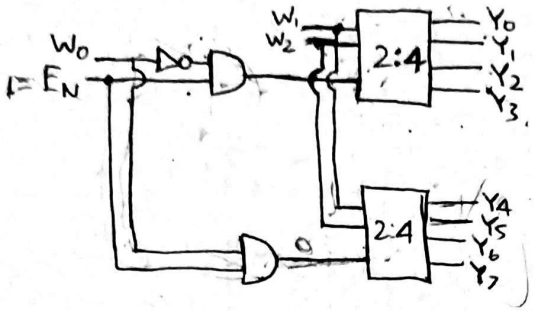


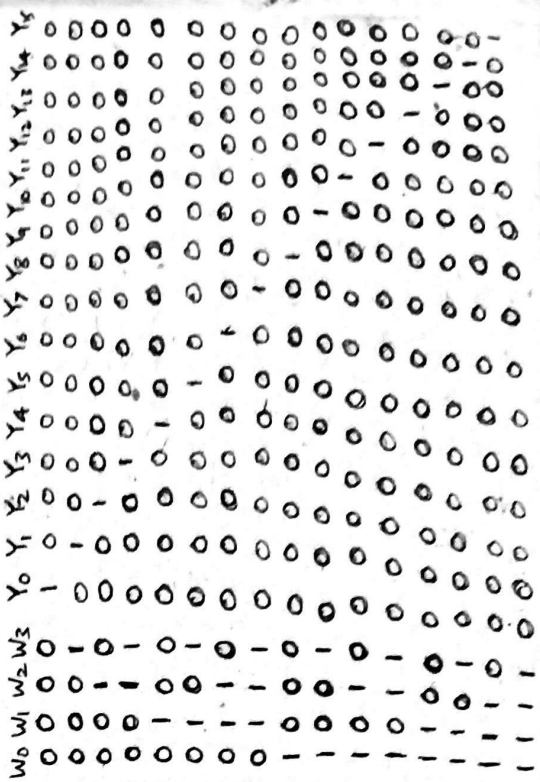


3:8 Decoder

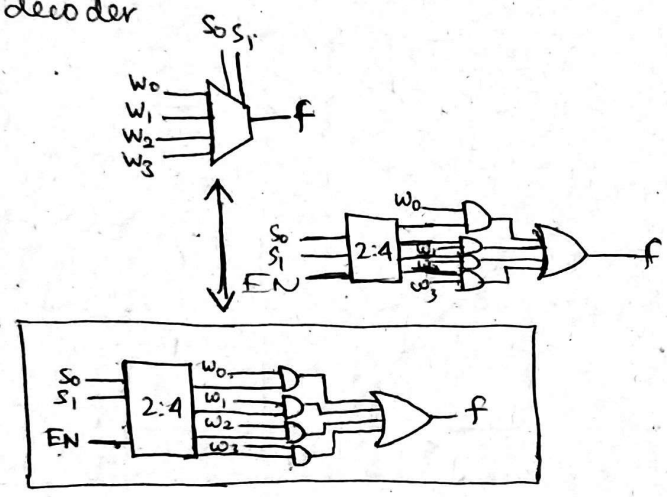
$Y_0 = E_N \overline{W_0} \overline{W_1} \overline{W_2}$
$Y_1 = E_N \overline{W_0} \overline{W_1} W_2$
$Y_2 = E_N \overline{W_0} W_1 \overline{W_2}$
$Y_3 = E_N \overline{W_0} W_1 W_2$
$Y_4 = E_N W_0 \overline{W_1} \overline{W_2}$
$Y_5 = E_N W_0 \overline{W_1} W_2$
$Y_6 = E_N W_0 W_1 \overline{W_2}$
$Y_7 = E_N W_0 W_1 W_2$

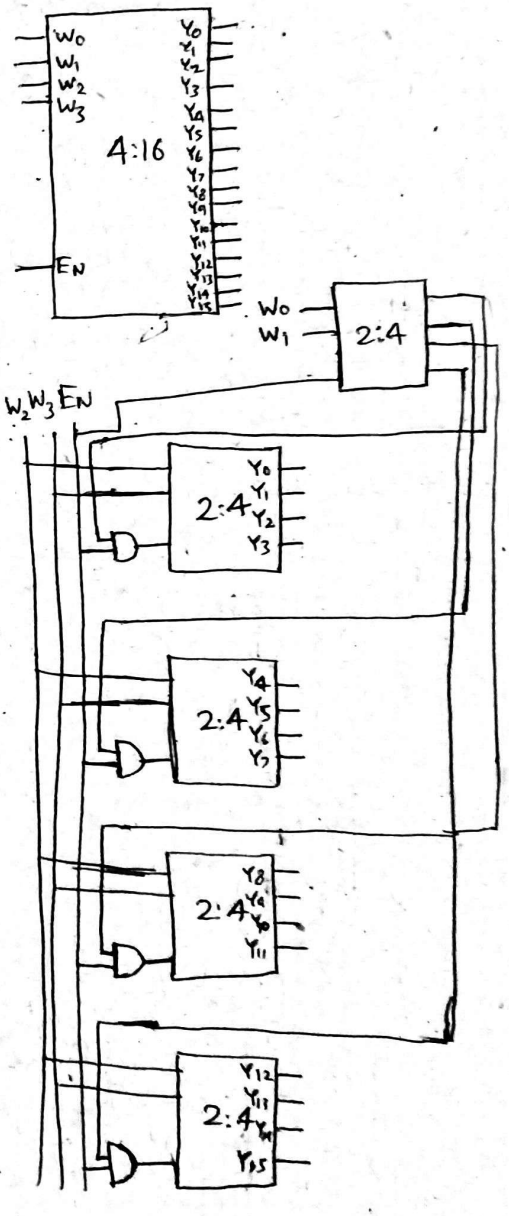
W_0	W_1	W_2	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1





Implement 4:1 mux using 2:4 decoder



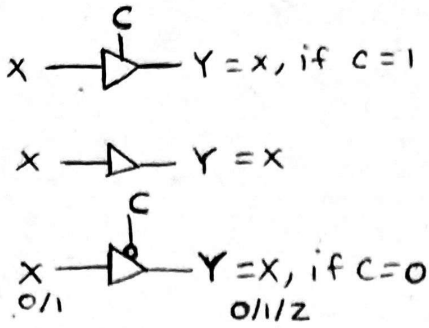


Draw 4:16 decoder, truth table, functions
Implementing 4:16 using 2:4 decoder.

$Y_0 = E_N \overline{W_0} \overline{W_1} \overline{W_2} \overline{W_3}$
$Y_1 = E_N \overline{W_0} \overline{W_1} \overline{W_2} W_3$
$Y_2 = E_N \overline{W_0} \overline{W_1} W_2 \overline{W_3}$
$Y_3 = E_N \overline{W_0} \overline{W_1} W_2 W_3$
$Y_4 = E_N \overline{W_0} W_1 \overline{W_2} \overline{W_3}$
$Y_5 = E_N \overline{W_0} W_1 \overline{W_2} W_3$
$Y_6 = E_N \overline{W_0} W_1 W_2 \overline{W_3}$
$Y_7 = E_N \overline{W_0} W_1 W_2 W_3$
$Y_8 = E_N W_0 \overline{W_1} \overline{W_2} \overline{W_3}$
$Y_9 = E_N W_0 \overline{W_1} \overline{W_2} W_3$
$Y_{10} = E_N W_0 \overline{W_1} W_2 \overline{W_3}$
$Y_{11} = E_N W_0 \overline{W_1} W_2 W_3$
$Y_{12} = E_N W_0 W_1 \overline{W_2} \overline{W_3}$
$Y_{13} = E_N W_0 W_1 \overline{W_2} W_3$
$Y_{14} = E_N W_0 W_1 W_2 \overline{W_3}$
$Y_{15} = E_N W_0 W_1 W_2 W_3$

14-8-18

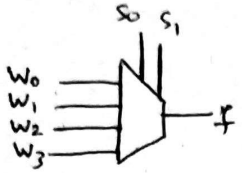
Buffer gates

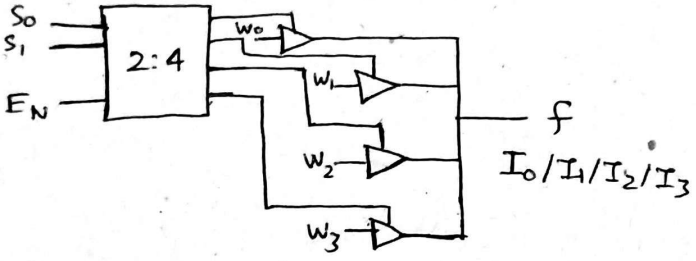


C	X	Y
1	0	0
1	1	1
0	X	Z

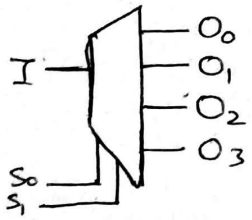
C	X	Y
0	0	0
0	1	1
0	X	Z

Tx gate / Tri state buffer

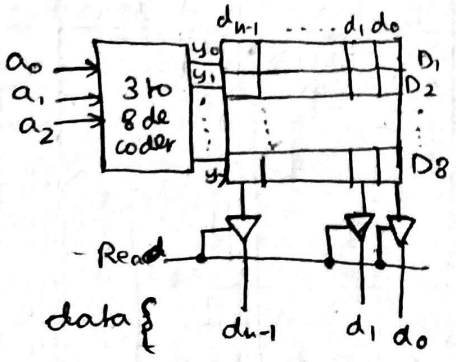




Demux

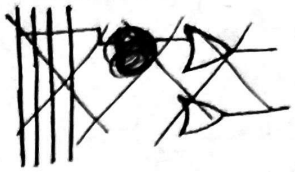


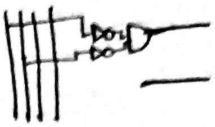
I	S0	S1	O0	O1	O2	O3
D	0	0	D	0	0	0
D	0	1	0	D	0	0
D	1	0	0	0	D	0
D	1	1	0	0	0	D



16-8-18

Encoder





y0 y1 y2 y3	x0	x1
1 0 0 0	0	0
0 1 0 0	0	1
0 0 1 0	1	0
0 0 0 1	1	1

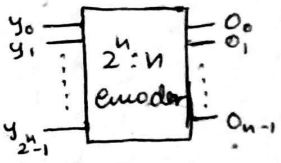
$\bar{y_0} y_1 y_2 \bar{y_3} + \bar{y_0} y_1 \bar{y_2} y_3$

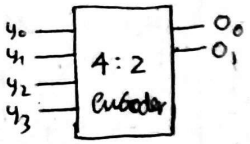
$\bar{y_0} \bar{y_1} (y_2 \oplus y_3)$

$\bar{y_0} y_1 \bar{y_2} \bar{y_3} + \bar{y_0} \bar{y_1} \bar{y_2} y_3$

$\bar{y_0} \bar{y_2} (\bar{y_3} y_1 + y_3 \bar{y_1})$

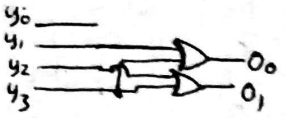
$2^n : n$ encoder



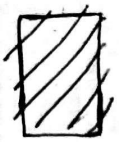


$O_0 = y_1 + y_3$

$O_1 = y_2 + y_3$



Priority encoder:



y_3	y_2	y_1	y_0	O_1	O_0	Z
0	0	0	0	d	d	0
0	0	0	1	0	0	1
0	0	1	X	0	1	1
0	1	X	X	1	0	1
1	X	X	X	1	1	1

$i_0 = \bar{y_3} \bar{y_2} \bar{y_1} y_0$

$i_1 = \bar{y_3} \bar{y_2} y_1$

$i_2 = \bar{y_3} y_2$

$i_3 = y_3$

$O_1 = i_2 + i_3$

$O_0 = i_1 + i_3$

$Z = i_1 + i_2 + i_3 + i_0$

21-8-18 Codes

Binary	BCD	Gray code
0000	0000	000
0001	0001	001
0010	0010	011
0011	0011	010
⋮	⋮	110
1110	1000	111
1111	1001	100

Weighted sum	Excess 3

Converting BCD to gray code

$B_3B_2B_1B_0$	$G_3G_2G_1G_0$
0000	0000
0001	0001
0010	0011
0011	0010
0100	0110
0101	0111
0110	0101
0111	0100
1000	1100
1001	1101

$G_3 = B_3$ $\quad G_1 = B_2 \oplus B_1$

$G_2 = B_3 \oplus B_2$ $\quad G_0 = B_1 \oplus B_0$

$G_3 = B_3$

$G_2 = B_2 + B_3\bar{B}_2\bar{B}_1\bar{B}_0 + B_3\bar{B}_2\bar{B}_1B_0$

$= B_2 + B_3\bar{B}_2\bar{B}_1$

$= (B_2 + B_3)\cdot(B_2 + \bar{B}_1)$

$G_1 = \bar{B}_3\bar{B}_2B_1\bar{B}_0 + \bar{B}_3\bar{B}_2\bar{B}_1B_0 + \bar{B}_3B_2\bar{B}_1\bar{B}_0 + \bar{B}_3B_2B_1\bar{B}_0$

$= \bar{B}_3\bar{B}_2B_1 + \bar{B}_3B_2\bar{B}_1$

$= \bar{B}_3(\bar{B}_2B_1 + B_2\bar{B}_1)$

$= \bar{B}_3(B_1 \oplus B_2)$

$G_0 = \bar{B}_3\bar{B}_2\bar{B}_1B_0 + \bar{B}_3\bar{B}_2B_1\bar{B}_0 + \bar{B}_3B_2\bar{B}_1B_0 + \bar{B}_3B_2B_1\bar{B}_0 + B_3\bar{B}_2\bar{B}_1B_0$

$= \bar{B}_2\bar{B}_1B_0 + \bar{B}_3B_1\bar{B}_0 + \bar{B}_3B_2\bar{B}_1B_0$

$= \bar{B}_3\bar{B}_1B_0 + \bar{B}_2\bar{B}_1B_0 + \bar{B}_3B_1\bar{B}_0$

$=$

$B_2B_1B_0$	$G_2G_1G_0$
000	000
001	001
010	011
011	010
100	110
101	111
110	101
111	100

$G_0 = B_1 \oplus B_0$

$G_1 = B_2 \oplus B_1$

$G_2 = B_2$

Comparator :

$A = a_3a_2a_1a_0$

$B = b_3b_2b_1b_0$

i) $A > B$

ii) $A < B$

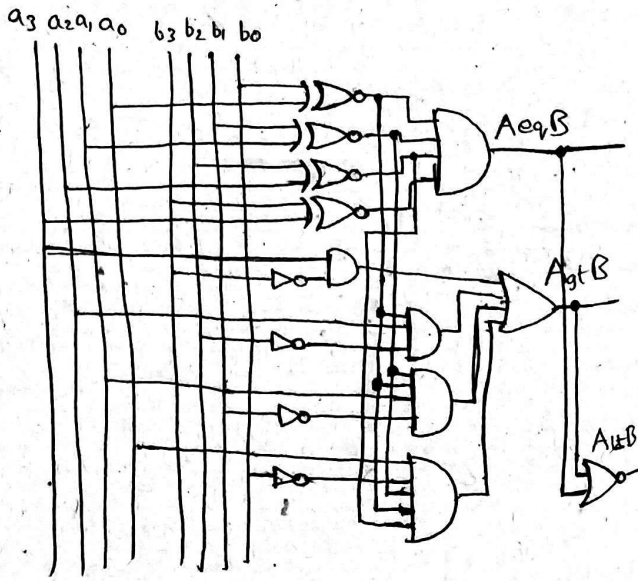
(iii) $A = B$

$i_k = a_k \odot b_k$

$= \overline{a_k \oplus b_k}$

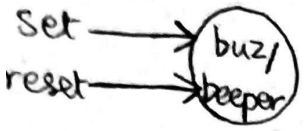
$A_{eq}B = \overline{A_{gt}B + A_{lt}B}$

$A_{gt}B = a_3\bar{b}_3 + i_3a_2\bar{b}_2 + i_3i_2a_1\bar{b}_1 + i_3i_2i_1a_0\bar{b}_0$



Sequential circuit: 28-8-18

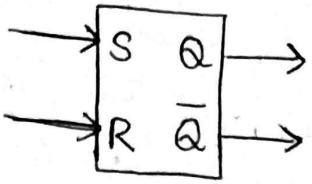
Alarm:

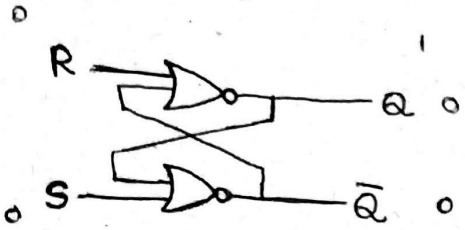


SR Latch

S	R	Q
0	0	NC (No change)
1	0	1
0	1	0
1	1	X

Latch





Timing diagram