1(a) In 10's-complement, 80 → 0080

-50 → 10000 − 50
= 9950

Add:

$$\begin{array}{r} 0080 \\ +\ 9950 \\ \hline \cancel{1}0030 \end{array} = 30_{10}$$

Ignore end carry

1(b) In 2's-complement, 80 → 01010000

$-50 \rightarrow 00110010 \xrightarrow{1's} 11001101$

$$\begin{array}{r} 11001101 \\ +\ \ \ \ \ \ \ \ \ 1 \\ \hline 11001110 \end{array}$$

Add:

$$\begin{array}{r} 01010000 \\ +\ 11001110 \\ \hline \cancel{1}00011110 \end{array} = 30_{10}$$

ignore end carry

1(c) We have 80 − (−50), so 80 + 50

$$\begin{array}{lr} & \boxed{01} \\ 80 \rightarrow & 01010000 \\ 50 \rightarrow & 00110010 \\ \hline & 10000010 \end{array}$$

Two last carries differ, so overflow has occurred

sign of sum is opposite of both augend, addend, so overflow has occurred

Result is negative, $10000010 \xrightarrow{1's} 01111101$

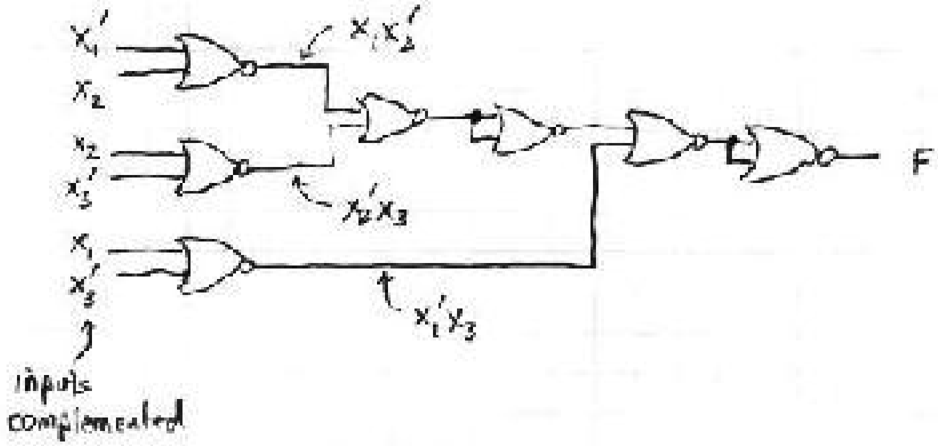
$$\begin{array}{r} 01111101 \\ +\ \ \ \ \ \ \ \ \ 1 \\ \hline 01111110 \end{array} = 126$$

Answer -126_{10}.

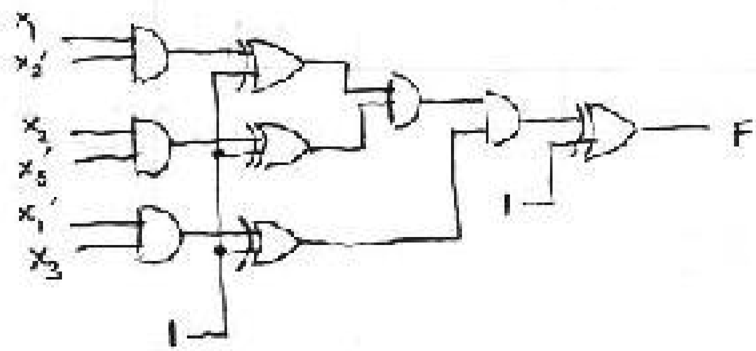
1(d) 8-bit sign-magnitude

80 → 01010000 = 120_8 = 50_{16}
−50 → 10110010 = 262_8 = $B2_{16}$

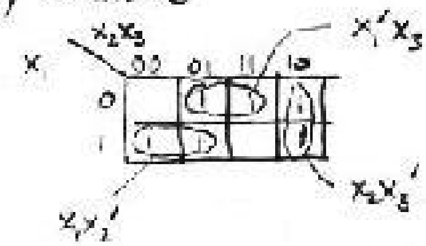
2(a) $F = x_1x_2' + x_2x_3' + x_1'x_3$



2(b) Several acceptable answers



More elegant solution by observing that three product terms are mutually exclusive



Then,

(3.) The truthtable

a_3	a_2	a_1	a_0	g_3	g_2	g_1	g_0	C_1	C_0	V
0	0	0	0	0	0	0	0	x	x	0
0	0	0	1	0	0	0	1	0	0	1
0	0	1	0	0	0	1	1	0	1	1
0	0	1	1	0	0	1	0	0	1	1
0	1	0	0	0	1	1	0	1	0	1
0	1	0	1	0	1	1	1	1	0	1
0	1	1	0	0	1	0	1	1	0	1
0	1	1	1	0	1	0	0	1	0	1
1	0	0	0	1	1	0	0	1	1	1
1	0	0	1	1	1	0	1	1	1	1
1	0	1	0	1	1	1	1	1	1	1
1	0	1	1	1	1	1	0	1	1	1
1	1	0	0	1	0	1	0	1	1	1
1	1	0	1	1	0	1	1	1	1	1
1	1	1	0	1	0	0	1	1	1	1
1	1	1	1	1	0	0	0	1	1	1

C_1, C_0, V are functions of a_3, a_2, a_1, a_0

$$C_1 = \Sigma(4,5,6,7,8,9,10,11,12,13,14,15) + d\,\Sigma(0)$$

$$C_1 = \Pi(1,2,3) + d\,\Pi(0)$$

$$C_0 = \Sigma(2,3,8,9,10,11,12,13,14,15) + d\,\Sigma(0)$$

$$C_0 = \Pi(1,4,5,6,7) + d\,\Pi(0)$$

$$V = \Sigma(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)$$

$$V = \Pi(0).$$

4 (a)

f_1

wx \ yz	00	01	11	10
00		1	1	
01			1	1
11	1	1	1	
10	1	1		

One of possible minimal SOP:

$$f_1 = w'x'z + w'xy + xyz + wy'$$

f_2:

wx \ yz	00	01	11	10
00	1			1
01	1	1		
11	1	1		1
10	1			1

One of possible minimal SOP:

$$f_2 = x'z' + xy' + w\,z'$$

OR

wx \ yz	00	01	11	10
00		0	0	
01			0	0
11			0	
10		0	0	

Minimal POS:

$$f_2 = (x+z')(y'+z')(w+x'+y')$$

f_3:

wx \ yz	00	01	11	10
00	1			1
01	1	1		
11				1
10			1	1

Minimal SOP:

$$f_3 = w'x'z' + w'xy' + wx'y + w\,yz'$$

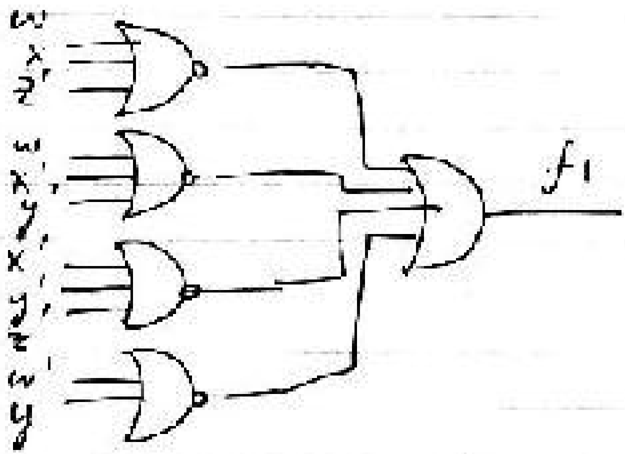
OR one of possible minimal POS:

wx \ yz	00	01	11	10
00		0	0	
01			0	0
11	0	0	0	
10	0	0		

$$f_3 = (w'+y)(x'+y'+z')\cdot(w+x'+y')(w+x+z')$$

4 (b) $f_1 = w'x'z + w'xy + xyz + wy' =$

$$= \overline{w+x+z'} + \overline{w+x'+y'} + \overline{x'+y'+z'} + \overline{w'+y}$$



4 (c) $f_1 = w'x'z + w'xy + xyz + wy'$

$f_2 = x'z' + xy' + w, z'$ or $f_2' = x'z + yz + w'xy$

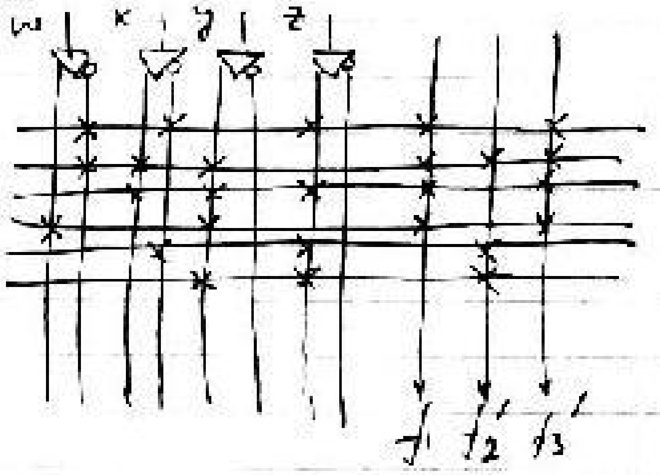
$f_3 = w'x'z' + w'xy' + wx'y + wyz'$ or

$f_3' = wy' + xyz + w'xy + w'x'z = f_1$

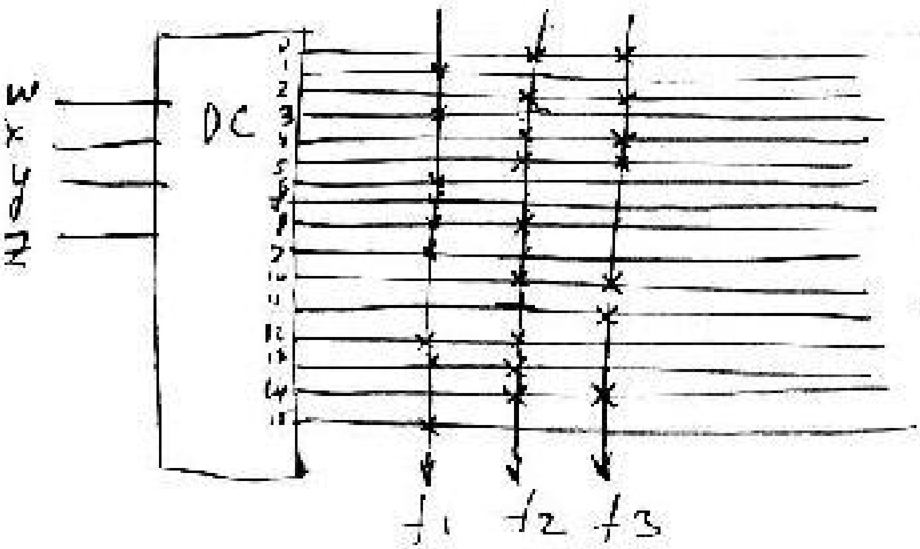
w	x	y	z	f_1	f_2	f_3
0	0	–	1	1	–	1
0	1	1	–	1	1	1
–	1	1	1	1	–	1
1	–	1	–	1	–	1
–	0	–	1	–	1	–
–	–	1	1	–	1	–

compl. compl.

f_1 f_2' f_3'

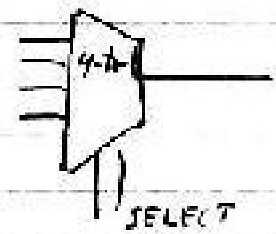


4 (d)

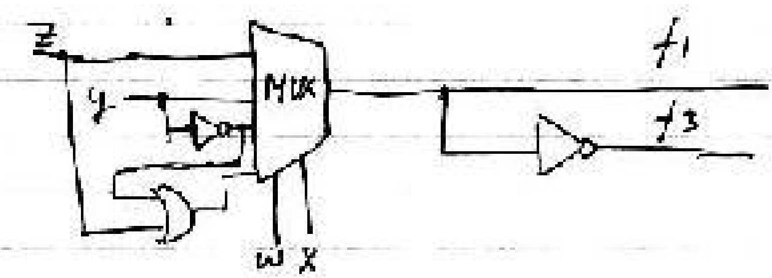


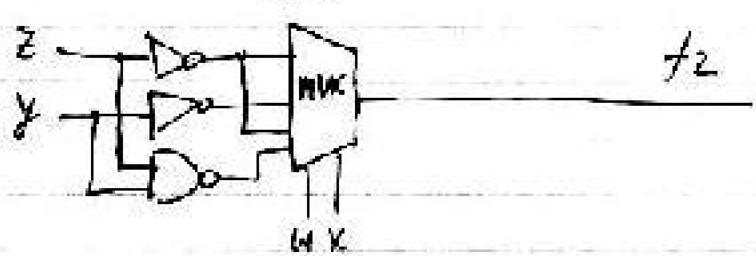
ROM is based on non minimized short hand SOP: Σ

4 (e) 4-to-1 MUX
has 4 inputs
and 2 select
lines



W X Y Z	f_1		f_2		f_3	or $f_3 = f_1'$
0000	0	z	1	z'	1	z'
0001	1		0		0	
0010	0		1		1	
0011	1		0		0	
0100	0	y	1	y'	1	y'
0101	0		1		1	
0110	1		0		0	
0111	1		0		0	
1000	1	y'	1	z'	0	y
1001	1		0		0	
1010	0		1		1	
1011	0		0		1	
1100	1	$y'+z$	1	$(yz)'$	0	yz'
1101	1		1		0	
1110	0		1		1	
1111	1		0		0	





(5) (a) Exitation equations

$$D_1 = X(Q_1 + Q_2)$$

$$D_2 = X(Q_1 + Q_2')$$

Transition equations:

$$Q_1^+ = D_1, \quad Q_2^+ = D_2$$

Output equation:

$$Z = Q_1' + X(Q_1 + Q_2')$$

To redesign, use: ⇒

Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Present state Q_1	Q_2	Inp. X	Next state Q_1^+	Q_2^+	out Z	J_1	K_1	J_2	K_2
0	0	0	0	0	1	0	X	0	X
0	0	1	0	1	1	0	X	1	X
0	1	0	0	0	1	0	X	X	1
0	1	1	1	0	1	1	X	X	1
1	0	0	0	0	0	X	1	0	X
1	0	1	1	1	1	X	0	1	X
1	1	0	0	0	0	X	1	X	1
1	1	1	1	1	1	X	0	X	0

J_1:

Q_1 \ Q_2X	00	01	11	10
0			1	
1	X	X	X	X

$J_1 = Q_2 X$

K_1:

Q_1 \ Q_2X	00	01	11	10
0	X	X	X	X
0	1			1

$K_1 = X'$

J_2:

Q_1 \ Q_2X	00	01	11	10
0	.	1	X	X
1		1	X	X

$J_2 = X$

K_2:

Q_1 \ Q_2X	00	01	11	10
0	X	X	1	1
1	X	X	0	1

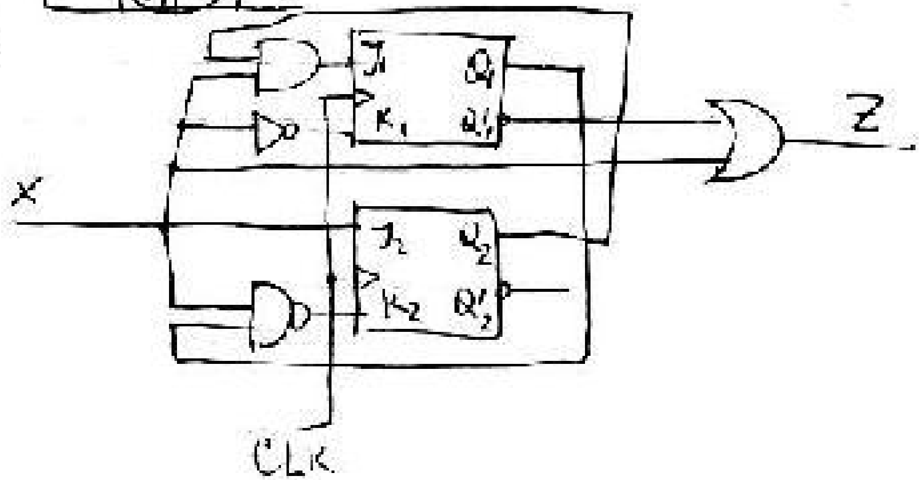
$K_2 = Q_1' + X' = \overline{Q_1 X}$

Z:

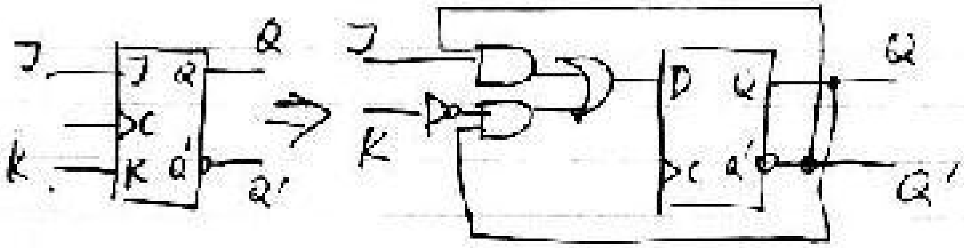
Q_1 \ Q_2X	00	01	11	10
0	1	1	1	1
1		1	1	

$Z = Q_1' + X$

Circuit on JK-FFs:



5 (b) JK FFs can be replaced with D FFs connected like this:

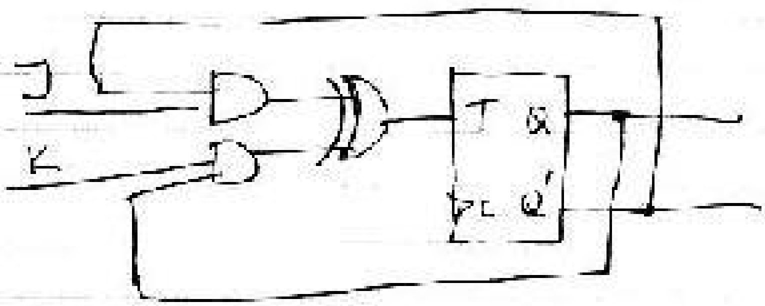


This is because $Q^+ = JQ' + K'Q$, thus

$$Q^+ = D = JQ' + K'Q$$

for each FF.

OR JK FF can be replaced with T FF:



$$Q^+ = JQ' + K'Q$$

and $Q^+ = T \oplus Q \Rightarrow$

$$\Rightarrow T = (JQ' + K'Q) \oplus Q =$$

$$= JQ' \oplus K'Q \oplus Q =$$

$$= JQ' \oplus (K' \oplus 1)Q =$$

$$= JQ' \oplus KQ$$

The rest of the circuit for each FF must not be changed

5. BCD down counter.

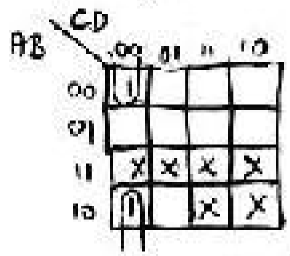
The state table :

Present State A B C D	Next state A B C D	FF inputs T_A	T_B	T_C	T_D	y
0 0 0 0	1 0 0 1	1	0	0	1	1
0 0 0 1	0 0 0 0	0	0	0	1	0
0 0 1 0	0 0 0 1	0	0	1	1	0
0 0 1 1	0 0 1 0	0	0	0	1	0
0 1 0 0	0 0 1 1	0	1	1	1	0
0 1 0 1	0 1 0 0	0	0	0	1	0
0 1 1 0	0 1 0 1	0	0	1	1	0
0 1 1 1	0 1 1 0	0	0	0	1	0
1 0 0 0	0 1 1 1	1	1	1	1	0
1 0 0 1	1 0 0 0	0	0	0	1	0
	x x x x	x	x	x	x	x

TFF excitation table :

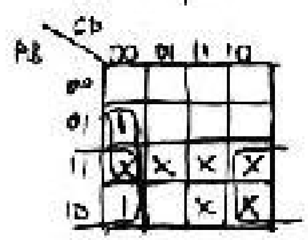
Q(t)	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

T_A - map :



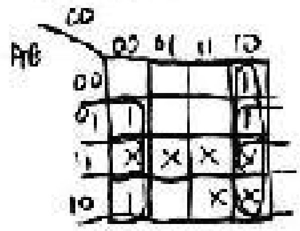
$T_A = BC'D'$

T_B - map :



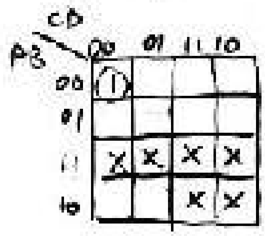
$T_B = AD' + BC'D'$

T_C - map :



$T_C = AD' + BD' + CD'$

y - map :



$y = A'B'C'D'$

And by inspection,

$T_D = 1$.

7(c) State table:

Current state	Input	Next state	Output
A	0	B	1
A	1	E	1
B	0	D	1
B	1	C	0
C	0	E	0
C	1	A	0
D	0	C	0
D	1	E	1
E	0	B	1
E	1	E	1

equivalent states

A = E

Throw away E (or A); redraw state table

Current state	Input	Next state	Output
A	0	B	1
A	1	A	1
B	0	D	1
B	1	C	0
C	0	A	0
C	1	A	0
D	0	C	0
D	1	E	1

7(b) Problem statement is sufficiently vague that there are many possible interpretations. Here is one possibility: