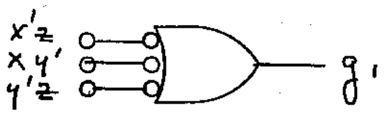
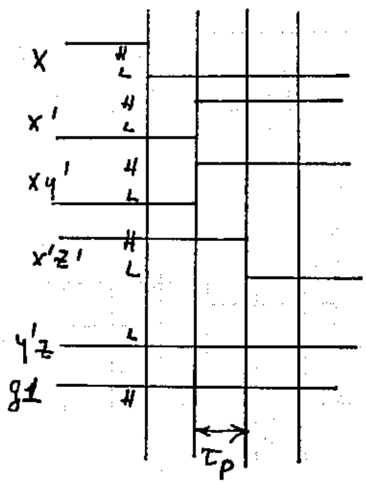
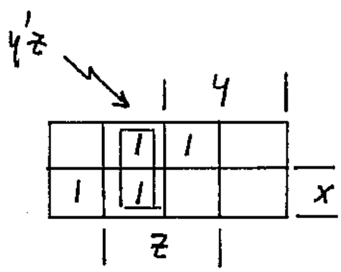
5.2 $g_1 = x'z + xy'$

$= x'z + xy' + zy'$

let $z = 1, y = 0$







$g_1 = m_1 + m_3 + m_4 + m_1$

5.3 $f = (xz + yz')$ xor z

$f = (xz + yz' + xy)$ xor z

let $x = y = 1$

$f = (\,\cdot z + 1 \cdot z' + 1 \cdot 1)$ xor z

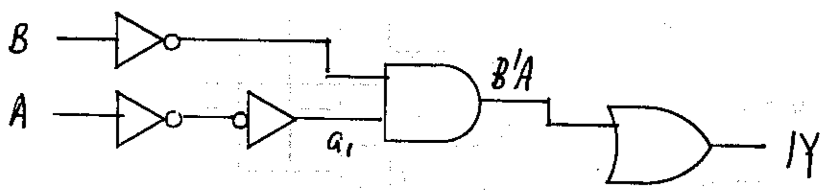
$= (z + z' + 1)$ xor z

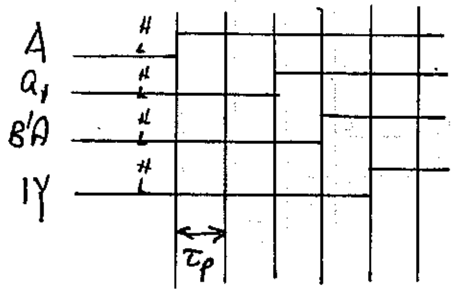
$= 1$ xor z

$= z'$ independent of $(z + z')$

NO GLITCH

5.4





5.5

(a) $f = (x \oplus y \oplus z)w = gw$

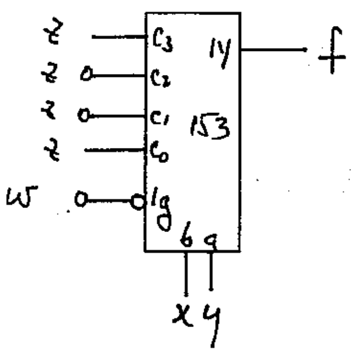
$g = x \oplus y \oplus z$

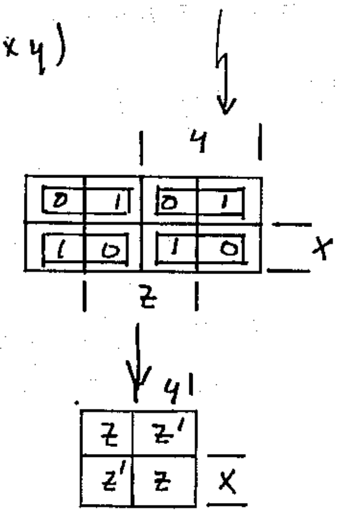
$= \alpha z' + \alpha' z \qquad \alpha = (x'y + xy') \qquad \alpha' = (xy + x'y')$

$g = x'yz' + xy'z' + xyz + x'y'z = m_2 + m_4 + m_7 + m_1$

$= z(x'y') + z'(x'y) + z'(xy') + z(xy)$

$= zm_0 + z'm_1 + z'm_2 + zm_3$





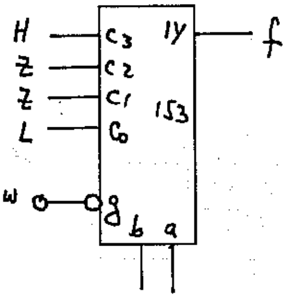
5.5

(b) $f = gw \quad g = xy + z(x \oplus y)$

$= xy + zx'y + zxy'$ →

		y	y	
	0	0	1	0	
x	0	1	1	1
		z	z	

		y
	0	z
x	z	1

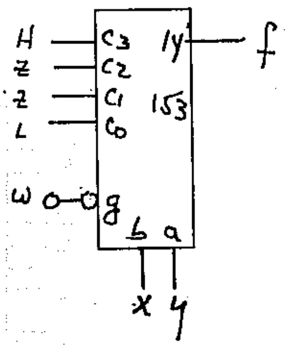


5.5

(c) $f = gw \quad g = xy + zx + zy$ →

		y	y	
	0	0	1	0
x	0	1	1	1
		z	z	

		y
	0	z
x	z	1

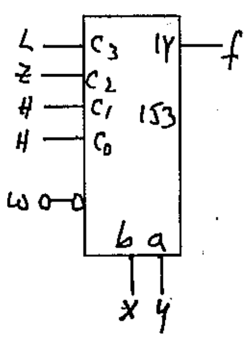


5.5

(d) $f = x' + y'z$

		y	y	
	1	1	1	1
x	0	1	0	0
		z	z	

		y
	1	1
x	z	0

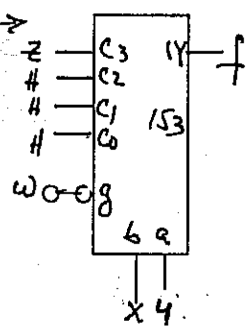


5.5

(e) $f = x' + z + y'$

		y	y	
	1	1	1	1
x	1	1	1	0
		z	z	

		y
	1	1
x	1	z

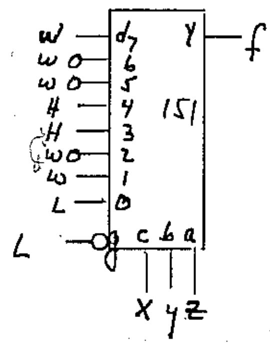


5.6 (a)

$$f = x \oplus y \oplus zw$$
$$= (xy' + x'y)(z' + w') + (xy + x'y')zw$$
$$= xy'z' + x'yz' + xy'w' + x'yw' + xyzw + x'y'zw$$

0	0	1	1
1	1	0	0
1	0	1	0
0	1	0	1

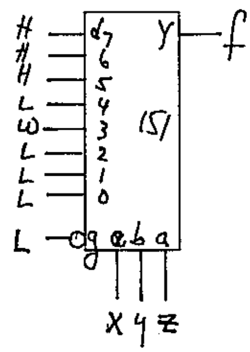
0	w	w'	1
1	w'	w	$\cancel{w'}$



5.6 (b)

$$f = xy + zx(w' + y') + zx'wy$$
$$= xy + w'xz + xy'z + wx'yz$$

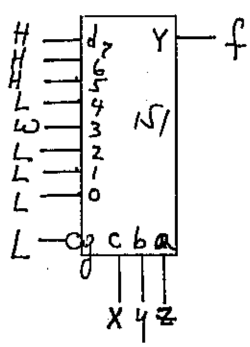
0	0	w	0
0	$\cancel{1}$	$\cancel{1}$	1



5.6 (c)

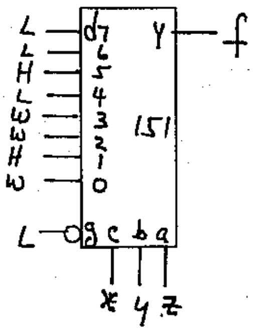
$$f = xy + zx + zyw$$
$$= xy + xz + wyz$$

0	0	w	0
0	1	$\cancel{1}$	1



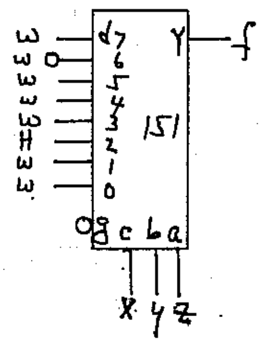
5.6 (d) $f = wx' + y'z$

		y	y	
w	1	w	w	
0	1	0	0	x
	z	z		



5.6 (e) $f = wx' + wz + wy' + w'yz'$

		y	y	
w	w	w	$w_{w'}$	← 1
w	w	w	w'	x
	z	z		



5.7 INFORMATION COMMON TO ALL PARTS

$q_3 = w$ (by inspection)

$q_2 = w \oplus x$

$q_1 = w \oplus x \oplus y$

$q_0 = w \oplus x \oplus y \oplus z$

q_0

			y	y	
	0	1	0	1	
	1	0	1	0	x
w	0	1	0	1	x
w	1	0	1	0	
		z	z		

q_1

			y	y	
	0	0	1	1	
	1	1	0	0	x
w	0	0	1	1	x
w	1	1	0	0	
		z	z		

q_2

			y	y	
	0	0	0	0	
	1	1	1	1	x
w	0	0	0	0	x
w	1	1	1	1	
		z	z		

MAPS FROM TRUTH TABLE

5.7

(a) q_0

w	w'	w	w'	
w'	w	w'	w	x

(columns 3–4: y; columns 2–3: z)

151, no gates

q_1

w	w	w'	w'	
w'	w'	w	w	x

(columns 3–4: y; columns 2–3: z)

151, no gates

q_2

w	w	w	w	
w'	w'	w'	w'	x

(columns 3–4: y; columns 2–3: z)

151, no gates

$q_3 = w$

wire
OR
151 all
inputs=w

(b) q_0

α	α'	α	α'

q_1

α	α	α'	α'

q_2

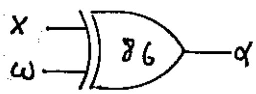
α	α	α	α

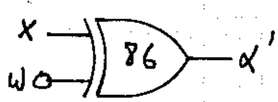
(columns 3–4: y; columns 2–3: z)

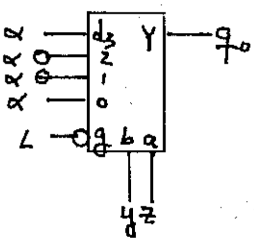
$q_3 = w$

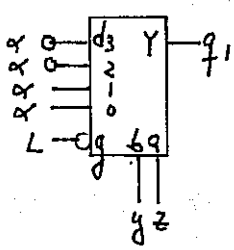
wire

$\alpha = xw' + x'w$
$\alpha' = xw + x'w'$









$\alpha \longrightarrow q_2$

153
WITH
α at
4 data inputs

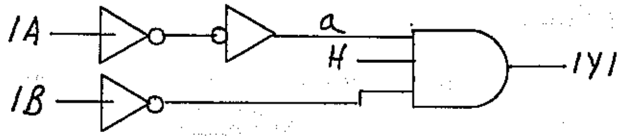
$w \longrightarrow q_3$

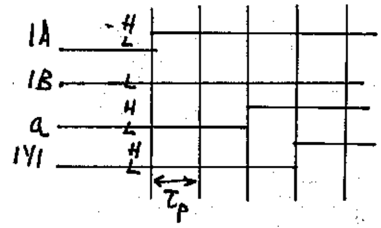
153
with
w at
4 data
inputs

(c) $q_3 = w$ → Cascade or
$q_2 = w \oplus x = \alpha$ See (b) above for q_2
$q_1 = q_2 \oplus y = \alpha \oplus y$ see (a) above for q_0, q_1
$q_0 = q_1 \oplus z$

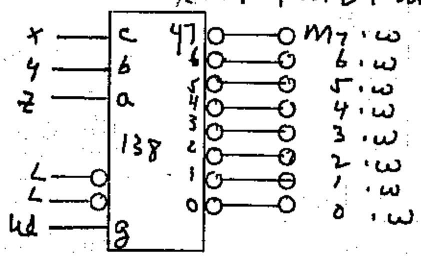
(d) See (b) above

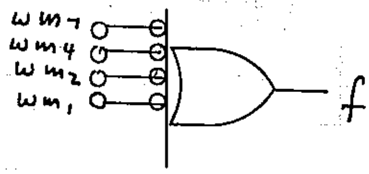
5.8





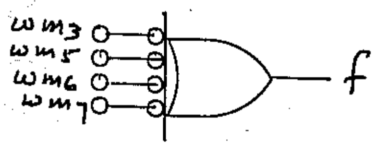
5.9
(a) from 5.5a $f = (m_1 + m_2 + m_4 + m_7)\omega$





5.9
(b) from 5.5b $f = \omega(m_3 + m_5 + m_6 + m_7)$

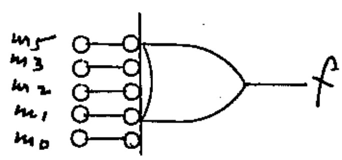
SEE 5.9a for
138 circuit



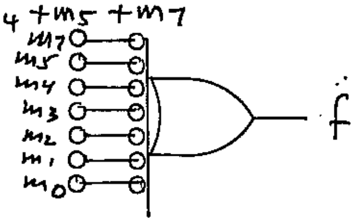
5.9
(c) see 5.9 b (from 5.5c)

5.9
(d) from 5.5d $f = m_0 + m_1 + m_2 + m_3 + m_5$

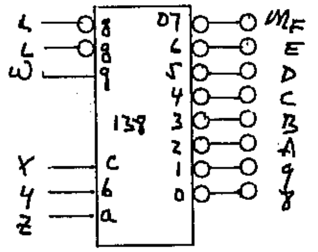
Change ω to L
in 5.9a 138
circuit

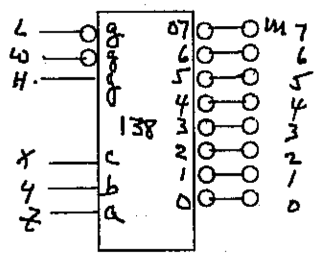


5.9
(e) from 5.5e = $f = m_0 + m_1 + m_2 + m_3 + m_4 + m_5 + m_7$



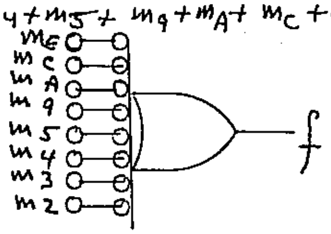
5.10





(a) from 5.6(a)

$$f = m_2 + m_3 + m_4 + m_5 + m_9 + m_A + m_C + m_E$$

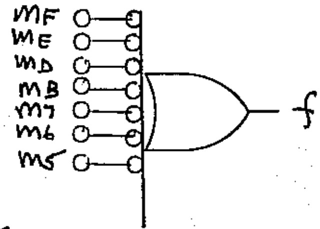


(b) from 5.6 b

y, x, w, z

0	0	0	0
0	1	1	1
0	1	1	1
0	0	1	0

$$f = m_5 + m_6 + m_7 + m_B + m_D + m_E + m_F$$

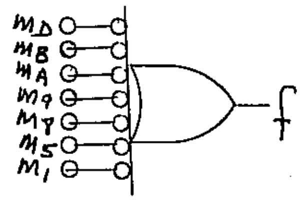


(c) same result as (b)

(d)

y, x, w, z

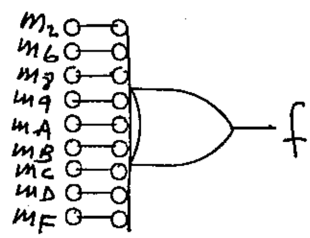
0	1	0	0
0	1	0	0
0	1	0	0
1	1	1	1



(e)

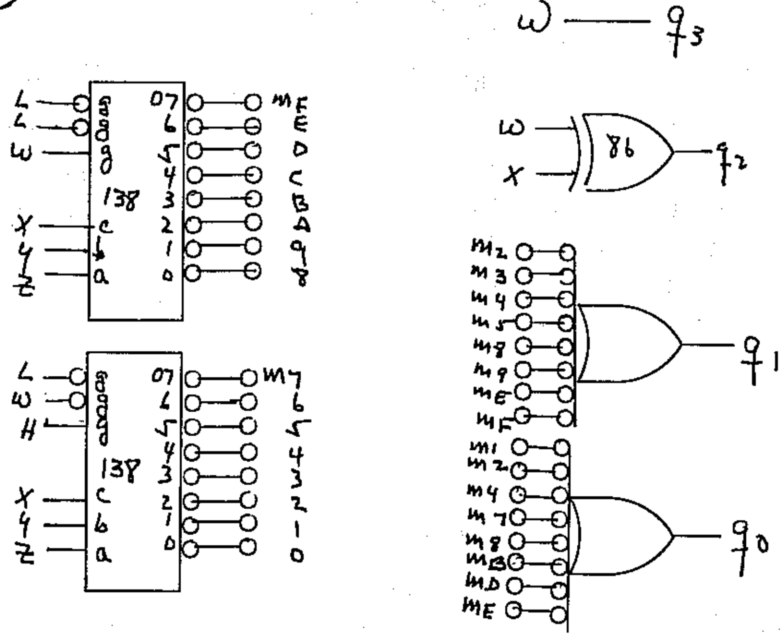
y, x, w, z

0	0	0	1
0	0	0	1
1	1	1	0
1	1	1	1



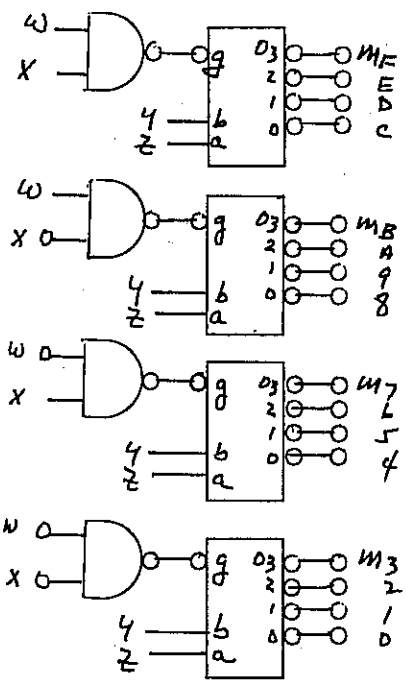
5.11 Reference 5.7 solution Kmaps

(a)



Here is one way.

(b)

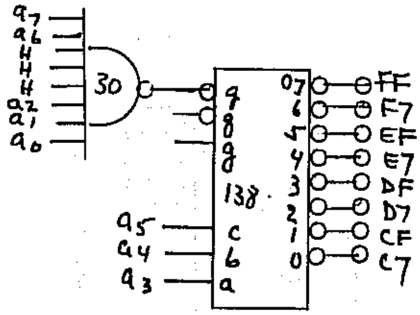


Same as above

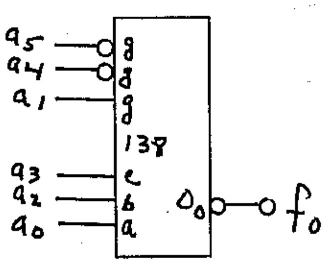
5.12

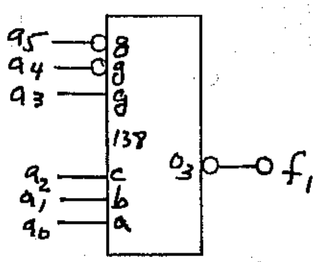
a_7	a_6	a_5	a_4	a_3	a_2	a_1	a_0	
1	1	0	0	0	1	1	1	C7x
1	1	0	0	1	1	1	1	CF
1	1	0	1	0	1	1	1	D7
1	1	0	1	1	1	1	1	DF
1	1	1	0	0	1	1	1	E7
1	1	1	0	1	1	1	1	EF
1	1	1	1	0	1	1	1	F7
1	1	1	1	1	1	1	1	FF

$\underbrace{a_5\ a_4\ a_3}_{\text{Variable 0 to 7}}$



5.13

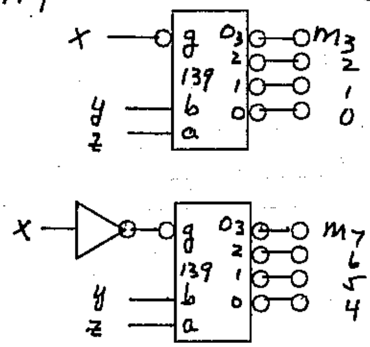




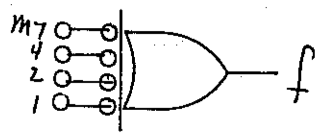
$$f_0 = a_5' a_4' a_3' a_2' a_1 a_0'$$
0 0 0 0 1 0

$$f_1 = a_5' a_4' a_3 a_2' a_1 a_0$$
0 0 1 0 1 1

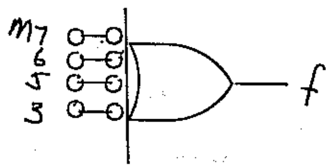
5.14 Reference 5.5 Solution K maps



ⓐ $f = m_1 + m_2 + m_4 + m_7$

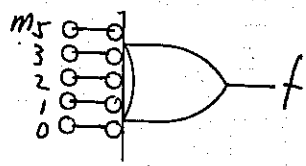


ⓑ $f = m_3 + m_5 + m_6 + m_7$



ⓒ $f =$ same as ⓑ

ⓓ $f = m_0 + m_1 + m_2 + m_3 + m_5$

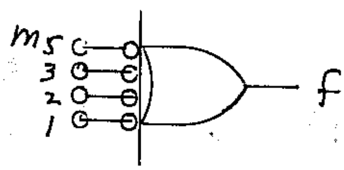


ⓔ $f = (y + z)(x' + y')$

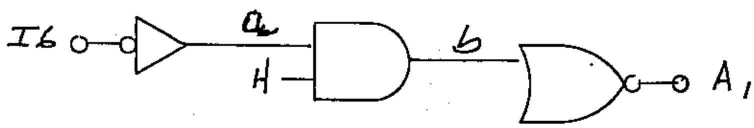
$= yx' + zx' + zy'$

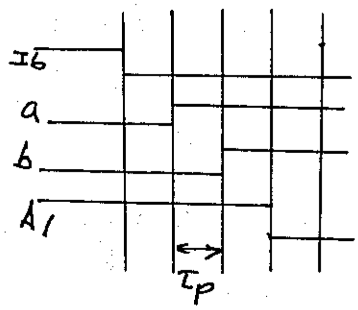
		y		
0	1	1	1	
0	1	0	0	x
	z			

$f = m_1 + m_2 + m_3 + m_5$



5.15

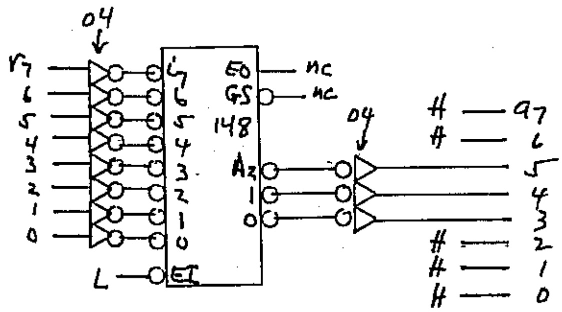




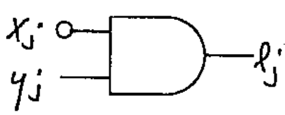
5.16 see 5.12 solution table

a_7	a_6	a_5	a_4	a_3	a_2	a_1	a_0
H	H	x	x	x	H	H	H

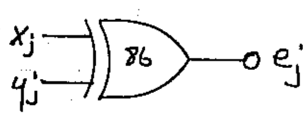
$\underbrace{x \quad x \quad x}_{\text{0 to 7 range.}}$



5.17



$x_j < y_j$



$x_j = y_j$

$$f = l_3 + e_3 l_2 + e_3 e_2 l_1 + e_3 e_2 e_1 l_0$$

f CIRCUIT IS STRAIGHTFORWARD

5.18 The 85 compares the magnitudes of two four bit nos. In all cases a 1 is greater than a 0. For signed numbers the leading digit a_3, b_3 is the sign digit where $1 < 0$.

0 0 0 0	0
0 0 0 1	1
0 0 1 0	2
0 0 1 1	3
0 1 0 0	4
0 1 0 1	5
0 1 1 0	6
0 1 1 1	7
1 0 0 0	−8
1 0 0 1	−7
1 0 1 0	−6
1 0 1 1	−5
1 1 0 0	−4
1 1 0 1	−3
1 1 1 0	−2
1 1 1 1	−1
a_3 2 1 0	
b_3 2 1 0	

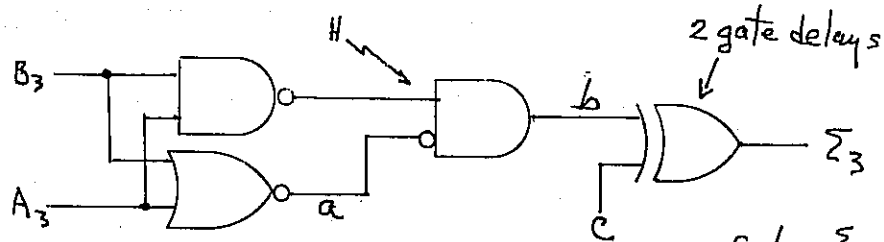
e.g. $-2 > -6$

$110 > 010$

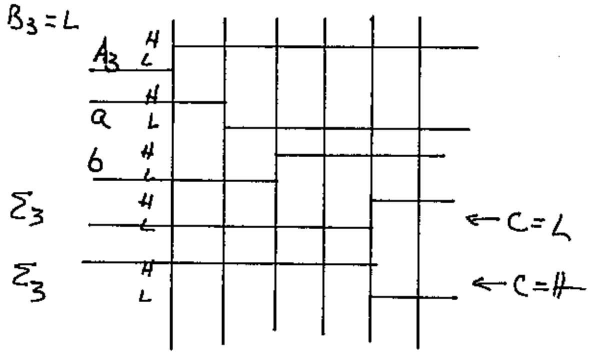
The 85 can compare two signed nos. $x_3x_2x_1x_0$ and $y_3y_2y_1y_0$ by assigning (wiring) the x_j, y_j digits to

$b_3a_2a_1a_0$ $a_3b_2b_1b_0$

5.19



c	b	Σ_3
L	L	L
L	H	H
H	L	H
H	H	L

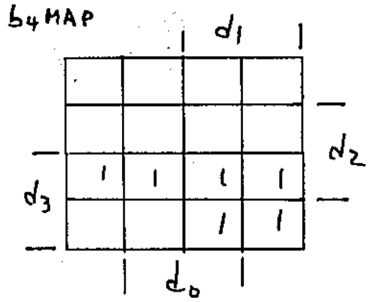


5.20

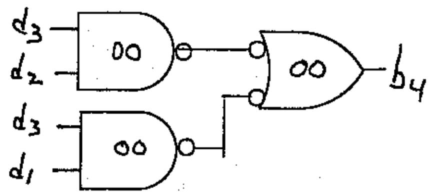
d_{3210}	b_4	b_{3210}
0 0 0 0	0	0 0 0 0
0 0 0 1	0	0 0 0 1
0 0 1 0	0	0 0 1 0
0 0 1 1	0	0 0 1 1
0 1 0 0	0	0 1 0 0
0 1 0 1	0	0 1 0 1
0 1 1 0	0	0 1 1 0
0 1 1 1	0	0 1 1 1
1 0 0 0	0	1 0 0 0
1 0 0 1	0	1 0 0 1
1 0 1 0	1	0 0 0 0
1 0 1 1	1	0 0 0 1
1 1 0 0	1	0 0 1 0
1 1 0 1	1	0 0 1 1
1 1 1 0	1	0 1 0 0
1 1 1 1	1	0 1 0 1

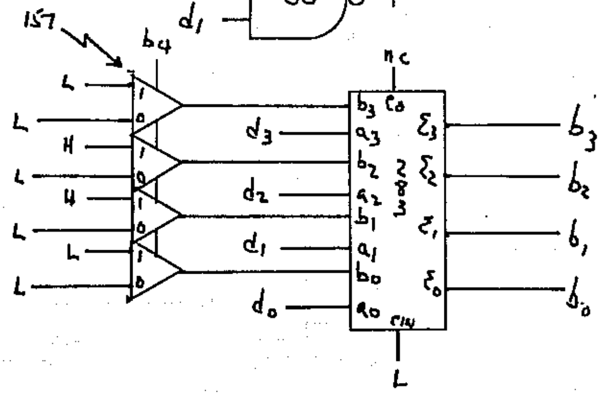
"plus 0" = b_4'

"plus 6" = b_4

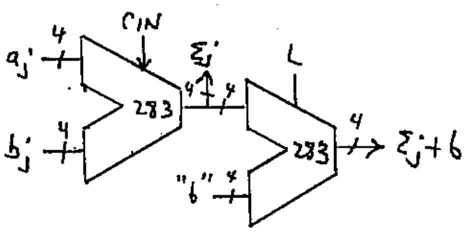


$$b_4 = d_3 d_2 + d_3 d_1$$

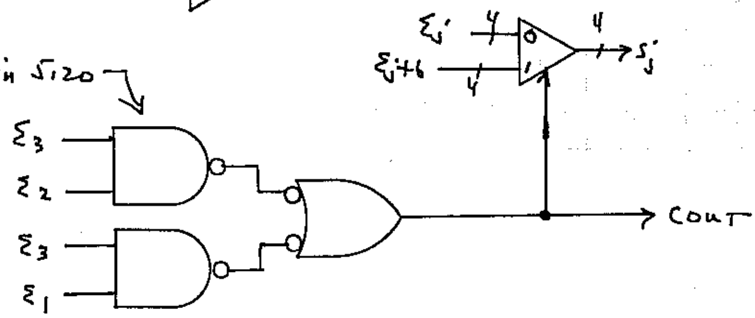




5.21



See b4 in 5.20



5.22 $x = 1011$ $y = 0101$ $c_{in} = 0$

Pencil + Paper

$$\begin{array}{rl} 1\,1\,1\,1\,0 & \text{carries, } c_{in} \\ 0101 & y \\ 1011 & x \\ \hline 10000 & x+y+c_{in} \end{array}$$

IN

0 $\Sigma_0 = 1 \oplus 1 \oplus 0 = 0$

1 $c_0 = g_0 + p_0 c_{in} = (1\cdot1) + (1+1)\cdot 0 = 1$

$\Sigma_1 = 1 \oplus \quad \oplus 1 = 0$

2 $c_1 = g_1 + p_1 g_0 + p_1 p_0 c_{in} = (1\cdot0) + (1+0)(1\cdot1) + (1+1)(1+0)\cdot 0 = 1$

$\Sigma_2 = 0 \oplus 1 \oplus 1 = 0$

3 $c_2 = g_2 + p_2 g_1 + p_1 p_2 g_0 + p_2 p_1 p_0 c_{in}$

$= 0\cdot1 + (0+1)(1\cdot0) + (1+0)(0+1)(1\cdot1) + p_2 p_1 p_0 \cdot 0 = 1$

$\Sigma_3 = 1 \oplus 0 \oplus 1 = 0$

OUT $c_3 = g_3 + p_3 g_2 + p_3 p_2 g_1 + p_3 p_2 p_1 g_0 + p_3 p_2 p_1 p_0 c_{in}$

$= 0\cdot1 + (1+0)(0\cdot1) + p_3 p_2 (1\cdot0) + (1+0)(0+1)(1\cdot0)(1\cdot1) + p_3 p_2 p_1 p_0 \cdot 0 = 1$

5.23 $p = a+b$ $g = ab$ $pg' = (a+b)(a'+b') = a \oplus b$

$\therefore\ p_j g_j' \oplus c_{ij} = b_j \oplus a_j \oplus c_{ij}$

$x = 1011$ $y = 0101$ $c_{in} = 1$

Pencil + paper

$$\begin{array}{rl} 1111 & \text{carries} \\ 1 & c_{in} \\ 0101 & y \\ 1011 & x \\ \hline 10001 & x+y+c_{in} \end{array}$$

Rest of solution like that of 5.22

IN	0	1	2	3	OUT
	$\Sigma_0 = 1$	$\Sigma_1 = 0$	$\Sigma_2 = 0$	$\Sigma_3 = 0$	
		$c_0 = 1$	$c_1 = 1$	$c_2 = 1$	$c_3 = 1 = c_{out}$

5.24 $z_j = (s_3 ba + s_2 b'a) \text{ xor } (s_1 b' + s_0 b + a)$ ← j subscripts omitted

code 6 $s_3 = 0$ $s_2 = 1$ $s_1 = 1$ $s_0 = 0$

$z_6 = (0 \cdot ba + 1 \cdot b'a) \text{ xor } (1 \cdot b' + 0 \cdot b + a)$

$= (b'a) \oplus (b' + a)$

$= (b'a)(b'+a)' + (b'a)'(b'+a)$

$= (b'a)(ba') + (b + a')(b'+a)$

$= 0 + \underbrace{bb'}_{0} + a'b' + ab + \underbrace{a'a}_{0}$

$z_{6j} = a_j' \oplus b_j = a_j \oplus b_j'$

5.25

j	b_j	a_j	a_j'	z_{6j}	c_j	Σ_j
0	1	1	1	1	1 IN	0
1	0	1	0	0	1	1
2	1	0	0	0	1	1
3	0	1	0	0	0	0
					1 OUT	

ck

a	1011	11_{10}
−b	−0101	−5
		6_{10}
	1011	
a	1011	
+ b'	1010	
+ c_{IN}	1	
	1 0110	

$z_{6j} = b_j' \oplus a_j'$

$\Sigma_j = z_{6j} \oplus c_j$

$c_j = g_j + p_j c_{j-1}$ $g_j = b_j a_j$ $p_j = b_j + a_j$

$c_0 = 1 + 1 \cdot 1 = 1$

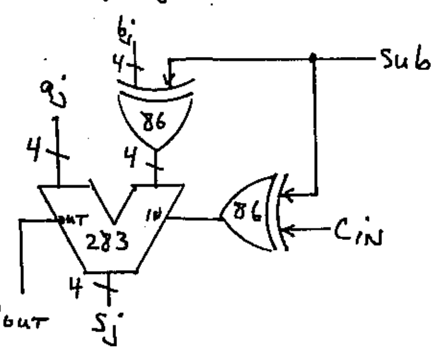
$c_1 = 0 + 1 \cdot 1 = 1$

$c_2 = 0 + 0 \cdot 1 = 0$

$c_3 = 0 + 1 \cdot 1 = 1$

5.26 Key is reconizing that 86 is a programmable inverter

b	a	g	
0	0	0	$g = a$ when $b = 0$
0	1	1	
1	0	1	$g = a'$ when $b = 1$
1	1	0	



$S_j = a_j \oplus (b_j \oplus sub) \oplus (c_{in} \oplus sub)$

Sub = 0 $S_j = a_j \oplus b_j \oplus c_{in} = a \text{ plus } (b + c_{in})$

Sub = 1 $S_j = a_j \oplus b_j' \oplus c_{in}' = a \text{ minus } (b + c_{in})$

5.27 $s_j = g m_j$ $s_0 = x z' y'$

$s_1 = x z' y$

$s_2 = x z y'$

$s_3 = x z y$

5.28 $s_1 = g b' a$ $b = wx$ $a = y + z$ $g = 1$

$s_1 = (wx)'(y+z)$

$s_1 = (w'+x')(y+z)$

5.29 $s_0 = r's'g$ $g = (p \oplus q)'$

$s_0 = (p \oplus q')r's'$

5.30 $f = m_1 + m_2 = y'x' + yx'$ $(g=1)$

Chapter 6

Sequential Circuit Elements

6.1