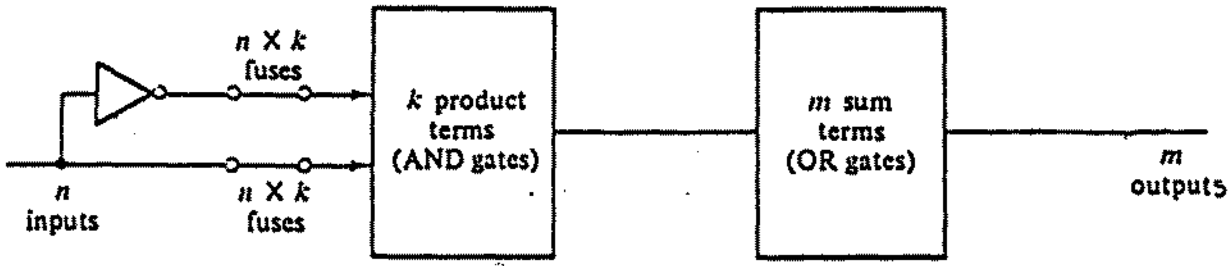
PAL (PROGRAMMABLE ARRAY LOGIC)



n x k x m PAL

IMPLEMENTING AN n-INPUT, m-OUTPUT COMBINATIONAL CIRCUIT

=

An n x k x m PAL and one level of PROGRAMMING

e.g., Given the following four functions in CSOP form

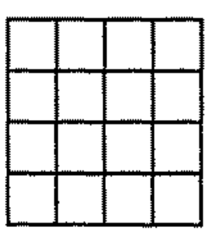
$$w(A, B, C, D) = \Sigma(2, 12, 13)$$

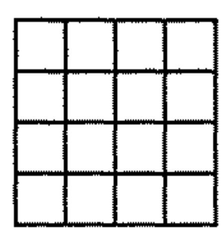
$$x(A, B, C, D) = \Sigma(7, 8, 9, 10, 11, 12, 13, 14, 15)$$

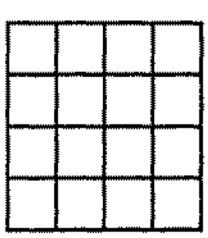
$$y(A, B, C, D) = \Sigma(0, 2, 3, 4, 5, 6, 7, 8, 10, 11, 15)$$

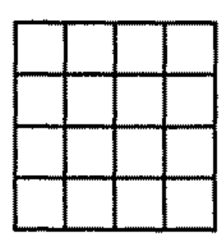
$$z(A, B, C, D) = \Sigma(1, 2, 8, 12, 13)$$

a) Obtain the minimal SOP form of w, x, y, z









$$w = ABC' + A'B'CD'$$

$$x = A + BCD$$

$$y = A'B + CD + B'D'$$

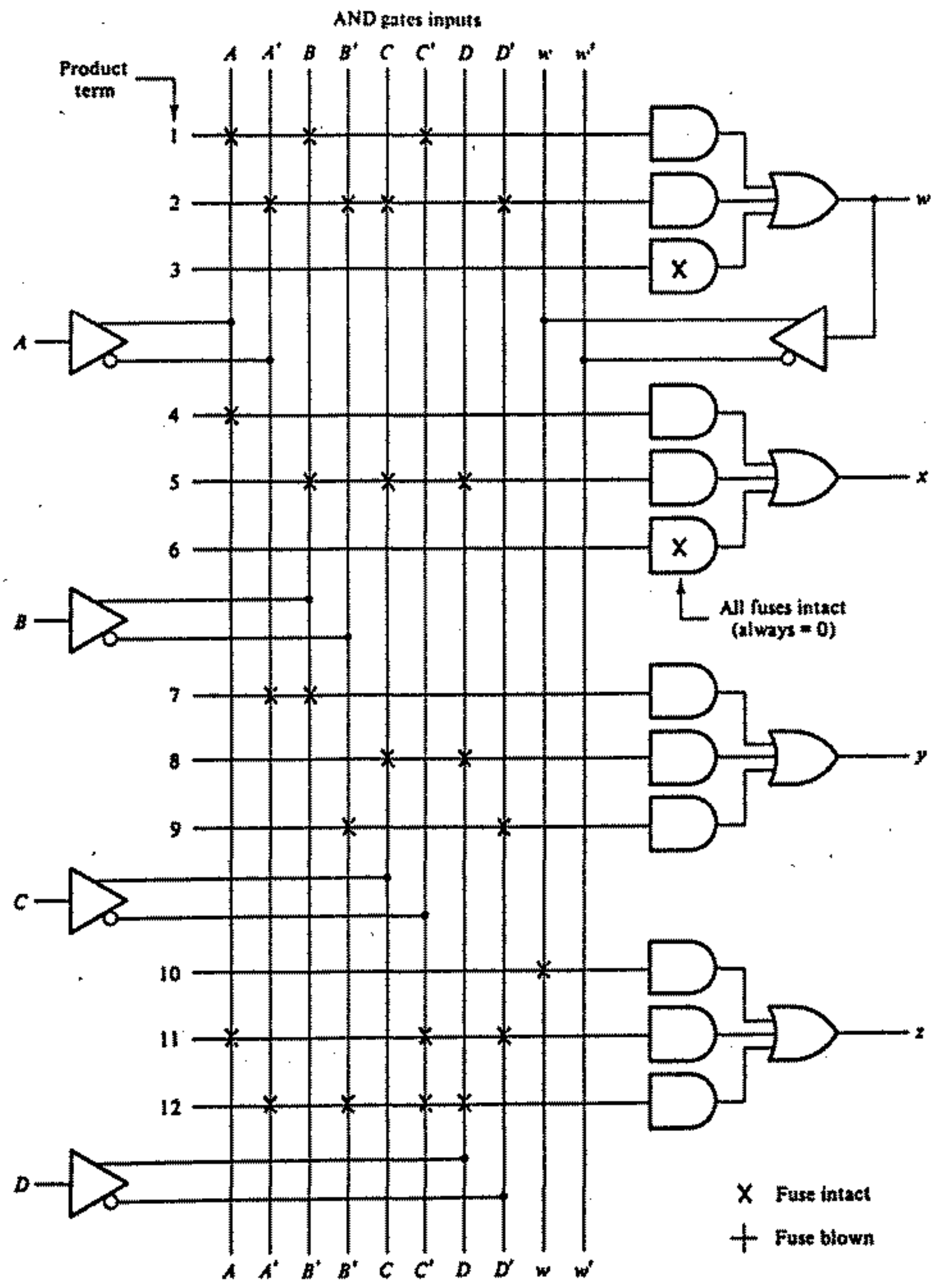
$$z = ABC' + A'B'CD' + AC'D' + A'B'C'D$$

$$= w + AC'D' + A'B'C'D$$

b) Construct the PAL Program Table for w, x, y, z

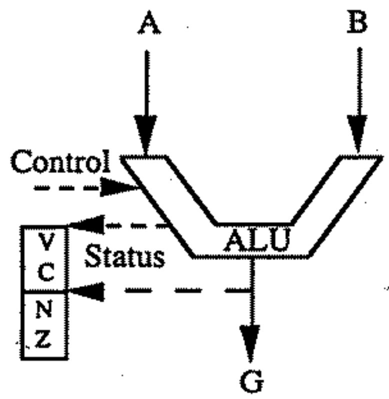
Product Term	A	B	C	D	W	Outputs
1	1	1	0	–	–	$w = ABC'$
2	0	0	1	0	–	$+ A'B'CD'$
3	–	–	–	–	–	
4	1	–	–	–	–	$x = A$
5	–	1	1	1	–	$+ BCD$
6	–	–	–	–	–	
7	0	1	–	–	–	$y = A'B$
8	–	–	1	1	–	$+ CD$
9	–	0	–	0	–	$+ B'D'$
10	–	–	–	–	1	$z = w$
11	1	–	0	0	–	$+ AC'D'$
12	0	0	0	1	–	$+ A'B'C'D$

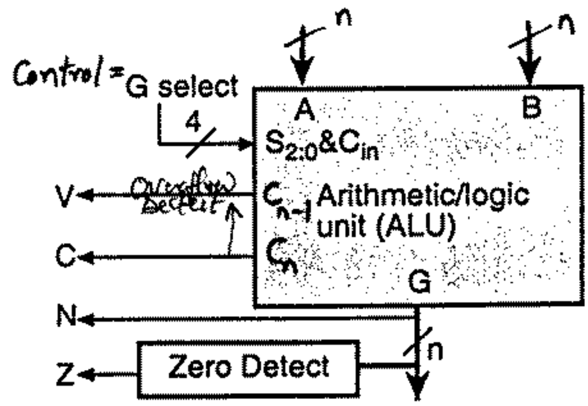
c) Implement w, x, y, z using a 4 x 3 x 4 PAL and programming



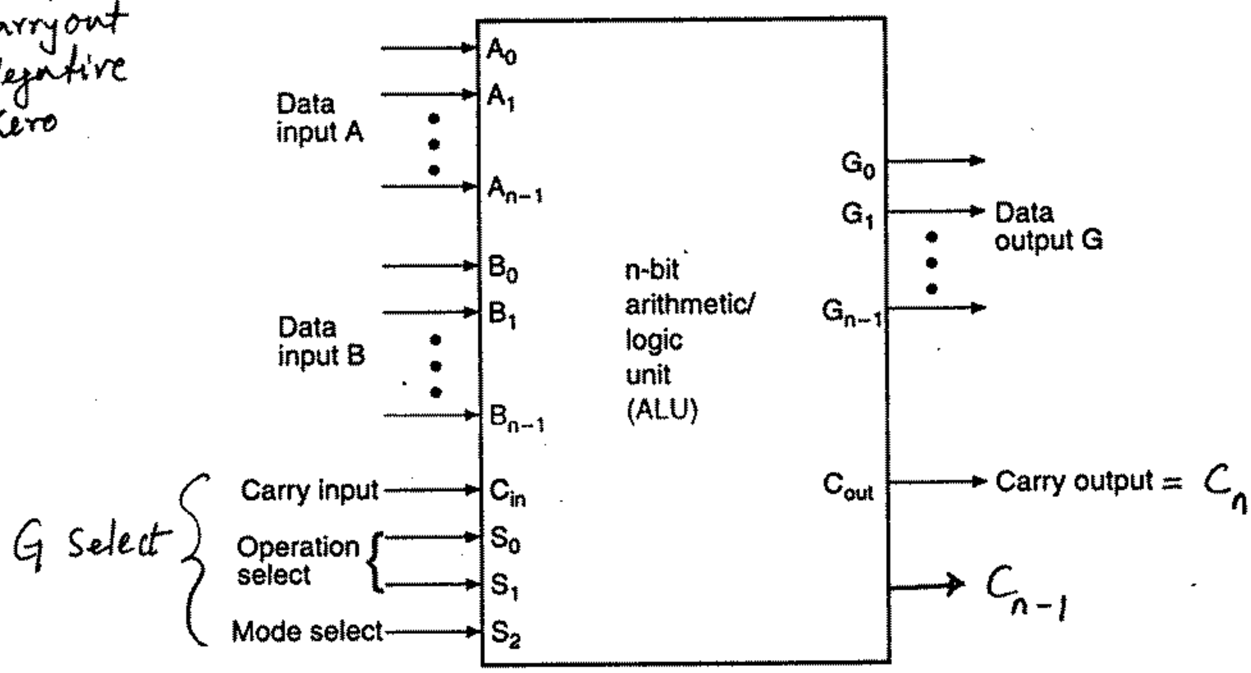
ALU (Arithmetic Logic Unit)

Section 7.7



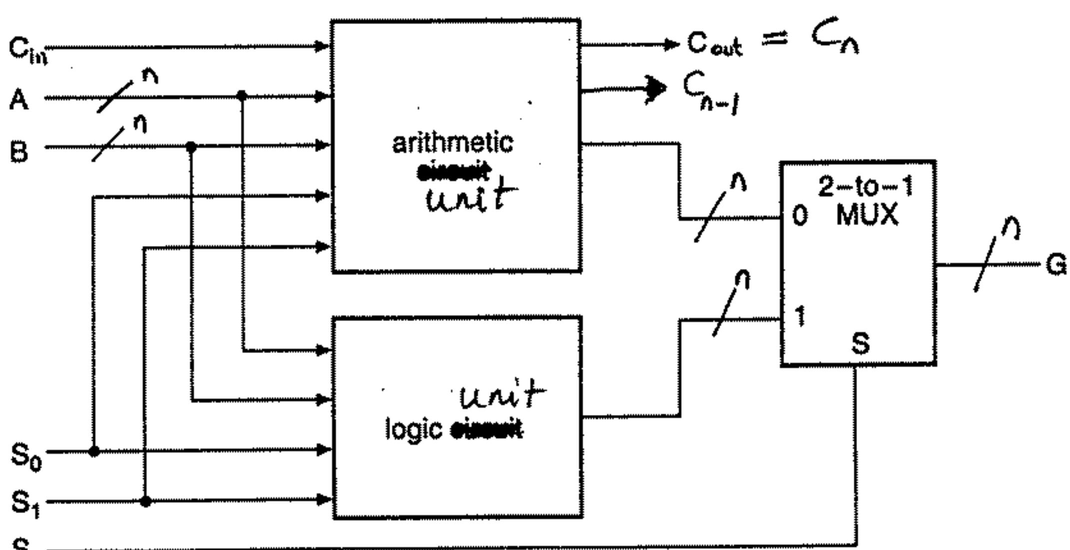


V: overflow detect
C: carryout
N: Negative
Z: Zero

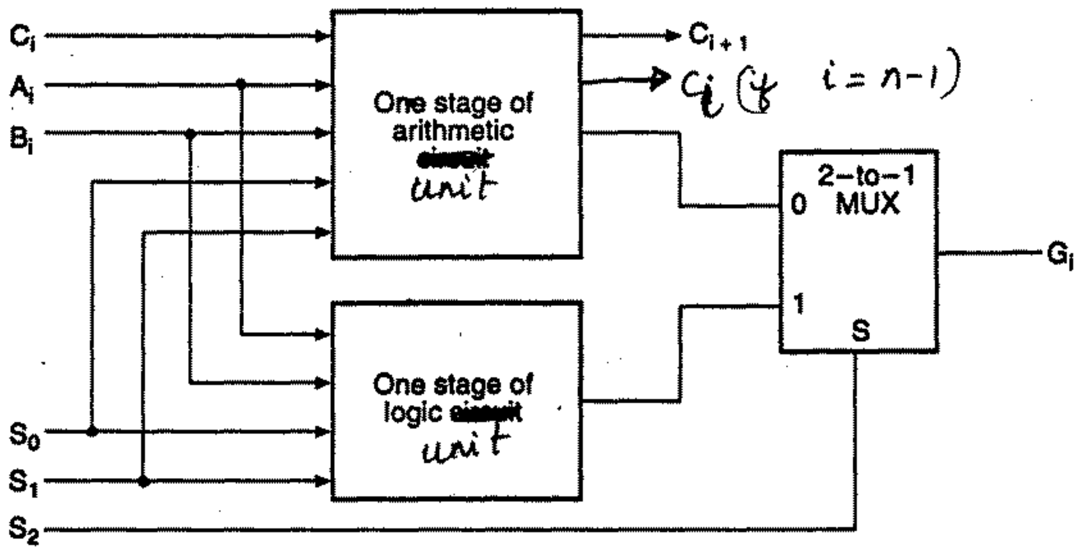


$S_2=0 \Rightarrow$ Arithmetic unit

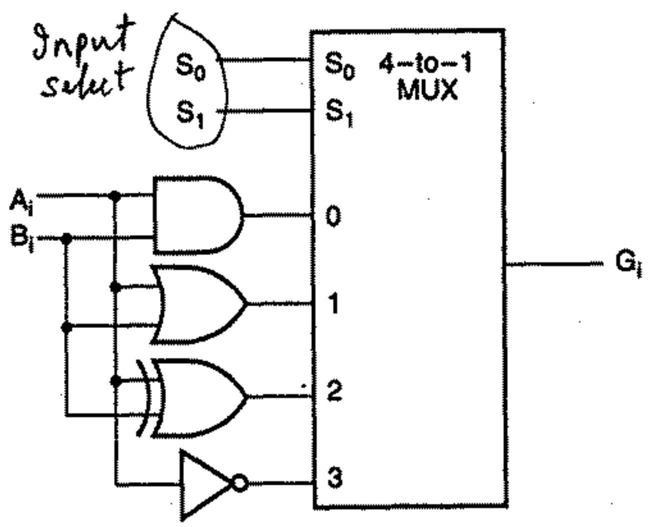
$S_2=1 \Rightarrow$ Logic Unit



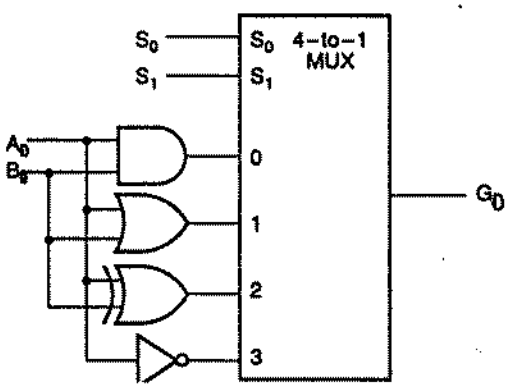
One Stage of ALU ($0 \le i \le n-1$)

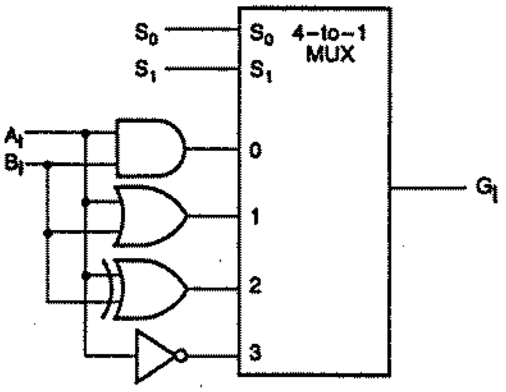


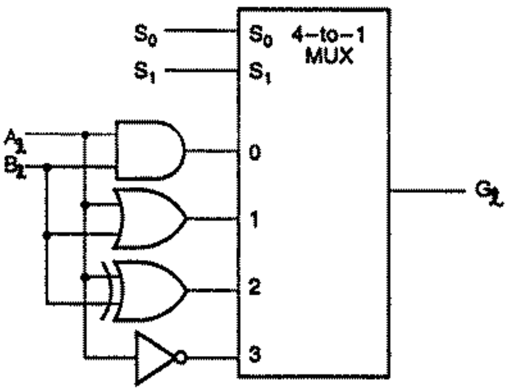
S_1	S_0	Output	Operation
0	0	$G_i = A_i \wedge B_i$	AND
0	1	$G_i = A_i \vee B_i$	OR
1	0	$G_i = A_i \oplus B_i$	XOR
1	1	$G_i = \overline{A}_i$	NOT

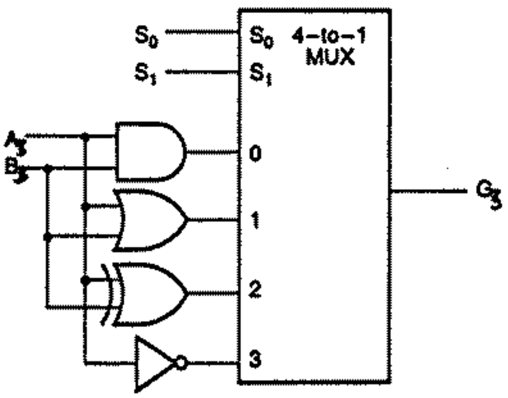


All stages of logic unit when n=4



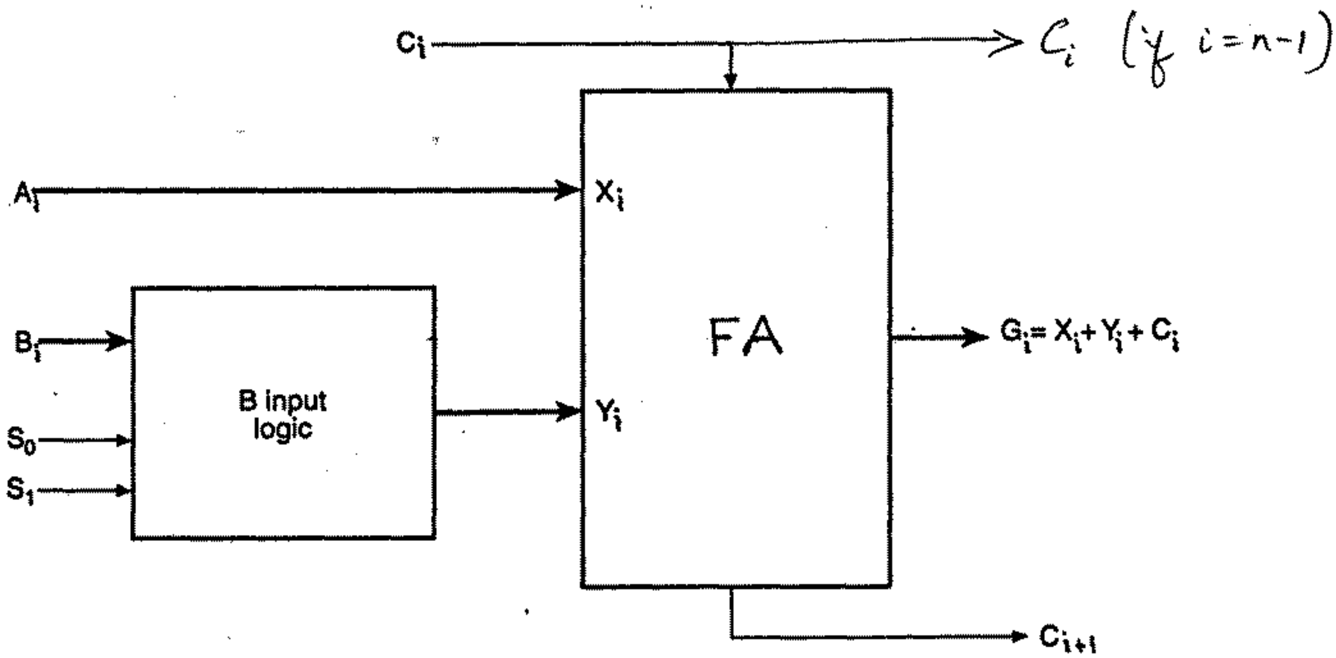




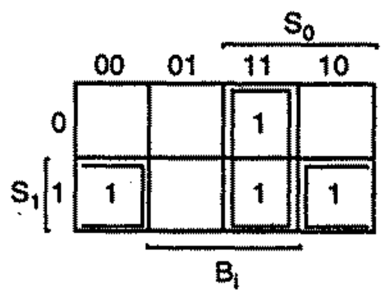


S_1	S_0	Output	Operation
0	0	$G = A \wedge B$	AND
0	1	$G = A \vee B$	OR
1	0	$G = A \oplus B$	XOR
1	1	$G = \overline{A}$	NOT

One stage of arithmetic unit

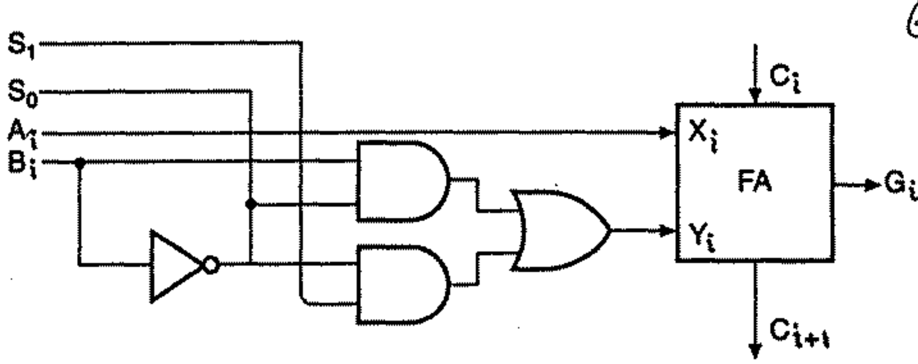


Inputs			Output	
S_1	S_0	B_i	Y_i	
0	0	0	0	$Y_i = 0$
0	0	1	0	
0	1	0	0	$Y_i = B_i$
0	1	1	1	
1	0	0	1	$Y_i = \overline{B}_i$
1	0	1	0	
1	1	0	1	$Y_i = 1$
1	1	1	1	

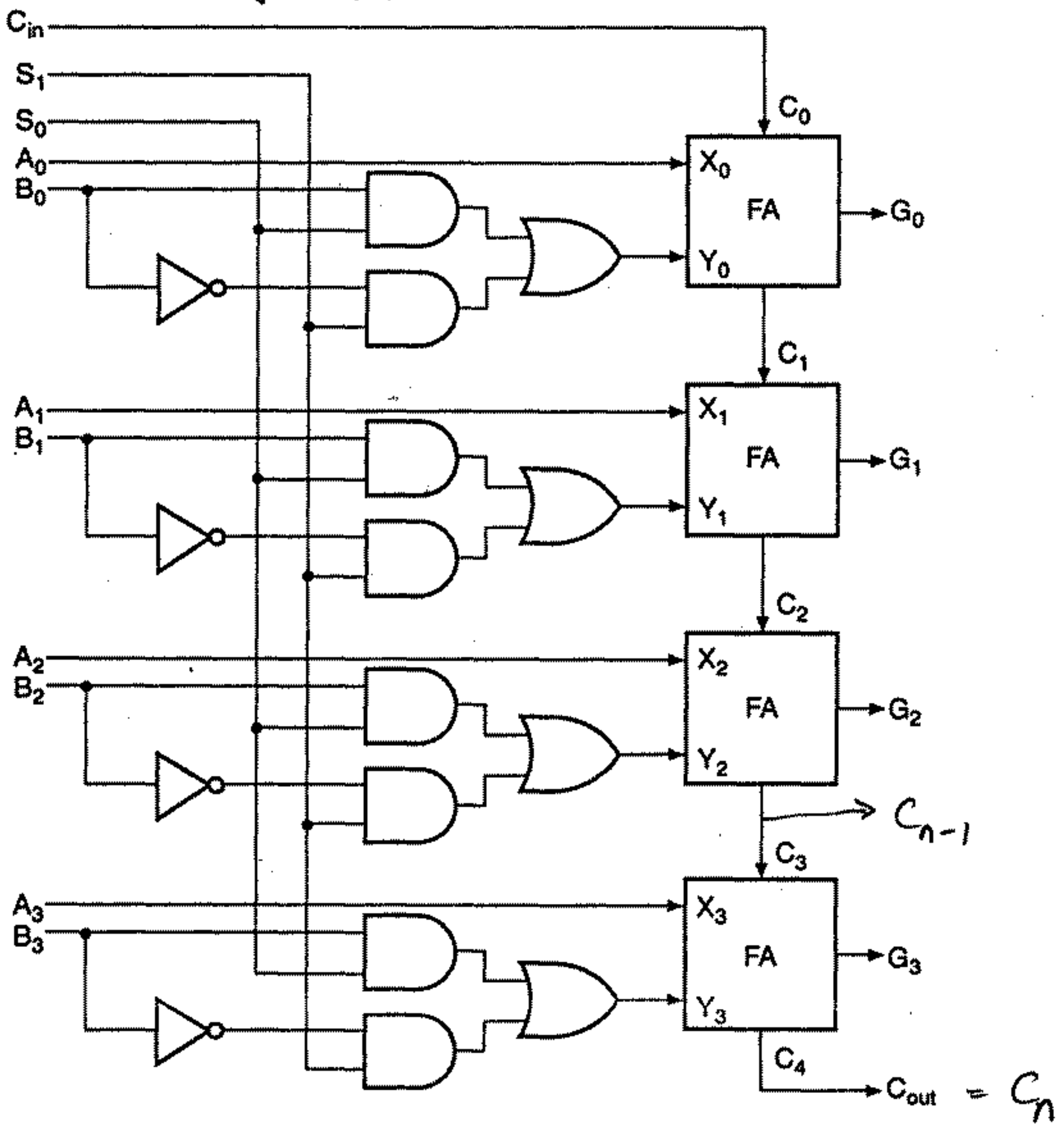


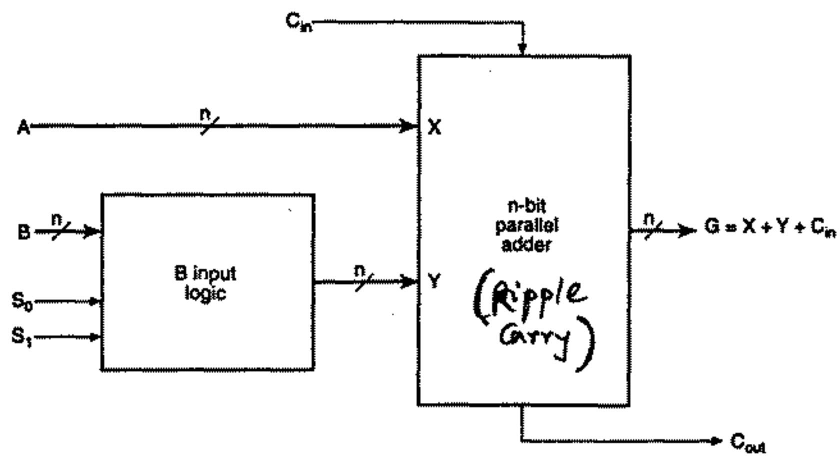
$$Y_i = S_0 B_i + S_1 B_i'$$

$$G_i = X_i + Y_i + C_i$$

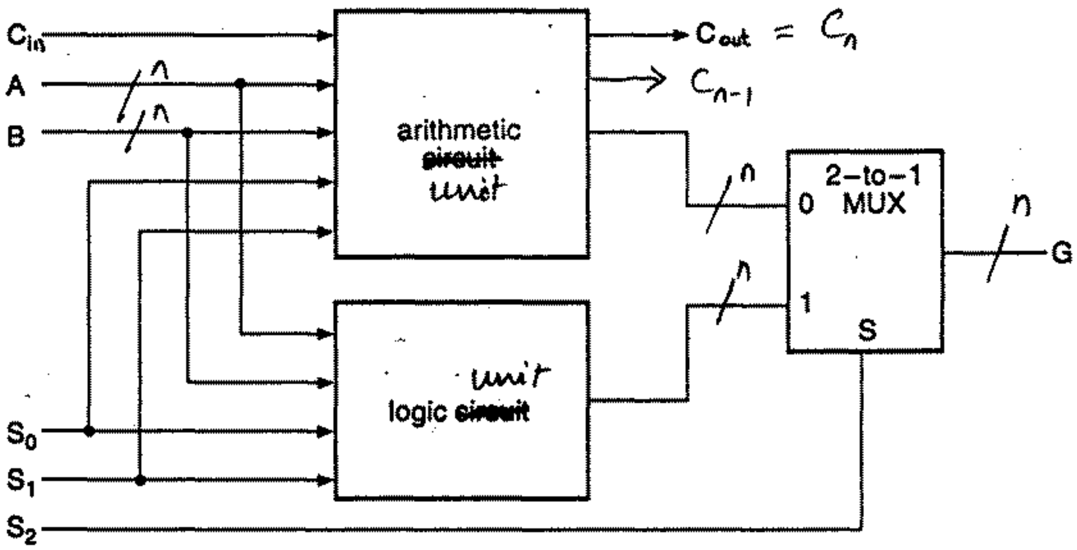


All stages of arithmetic unit when $n=4$





Select		Input	$G = A + Y + C_{in}$	
S_1	S_0	Y	$C_{in} = 0$	$C_{in} = 1$
0	0	all 0's	$G = A$ (transfer)	$G = A + 1$ (increment) $= A + 0 + 1$
0	1	B	$G = A + B$ (add)	$G = A + B + 1$
1	0	$\overline{B}$	$G = A + \overline{B}$	$G = A + \overline{B} + 1$ (subtract) in 2CF $(A - B)$
1	1	all 1's	$G = A - 1$ (decrement) $= A + (-1)$ in 2CF	$G = A$ (transfer) $= A + (-1) + 1$ in 2CF



Function Table for ALU

Control — Operation Select — G-select

	S_2	S_1	S_0	C_{in}	Operation	Function
	0	0	0	0	$G = A$	Transfer A
	0	0	0	1	$G = A + 1$	Increment A
arithmetic	0	0	1	0	$G = A + B$	Addition
	0	0	1	1	$G = A + B + 1$	Add with carry input of 1
	0	1	0	0	$G = A + \overline{B}$	A plus 1's complement of B
	0	1	0	1	$G = A + \overline{B} + 1$	Subtraction
	0	1	1	0	$G = A - 1$	Decrement A
	0	1	1	1	$G = A$	Transfer A
	1	0	0	X	$G = A \wedge B$	AND
logic	1	0	1	X	$G = A \vee B$	OR
	1	1	0	X	$G = A \oplus B$	XOR
	1	1	1	X	$G = \overline{A}$	NOT (1's complement)

Status Bits

Overflow: $V = C_{n-1} \oplus C_n$

Carry-out: $C = C_n$

Negative: $N = G_{n-1}$

Zero: $Z = G'_{n-1} \cdot G'_{n-2} \cdots G'_1 \cdot G'_0$

$= (G_{n-1} + G_{n-2} + \cdots + G_1 + G_0)'$