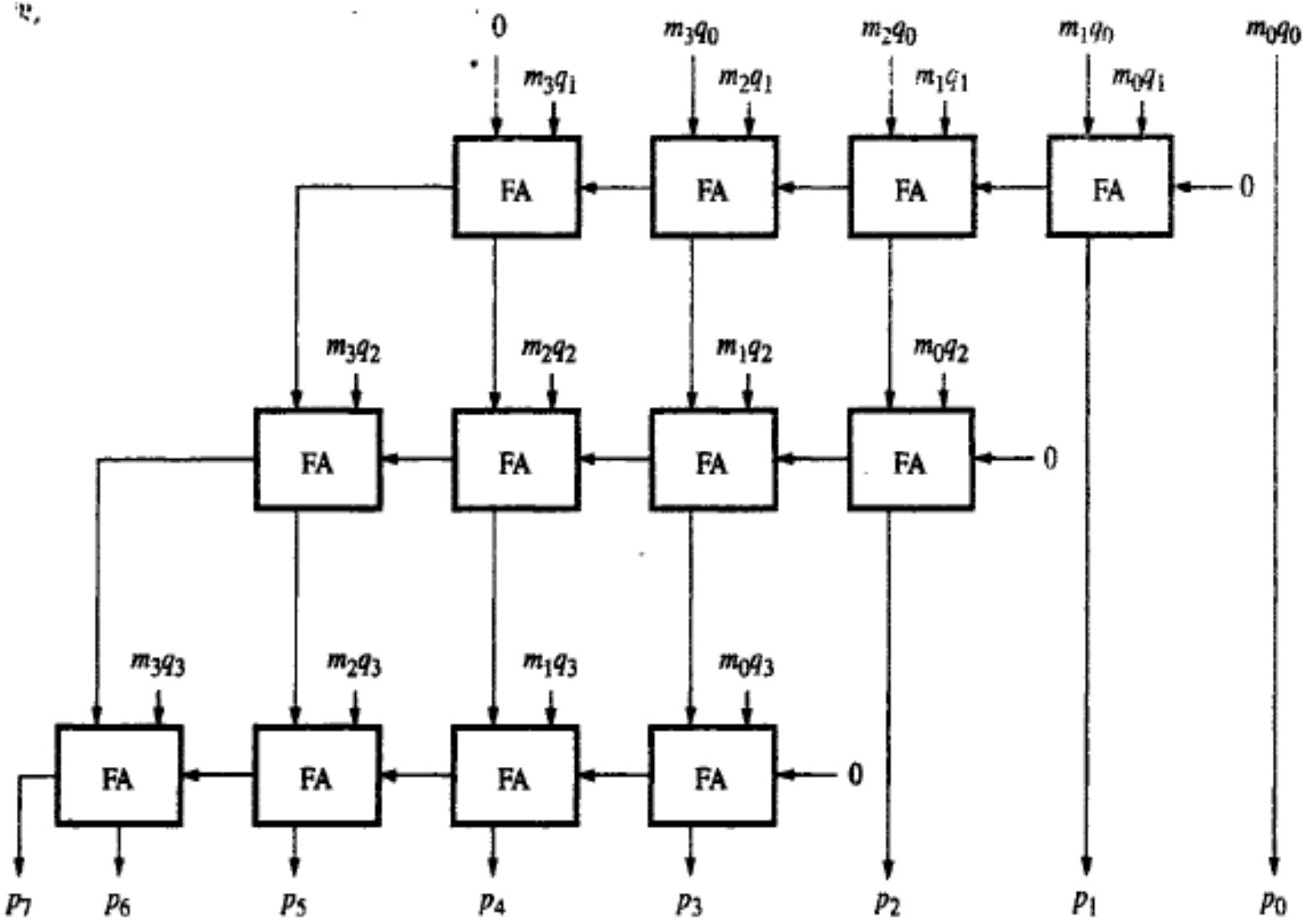
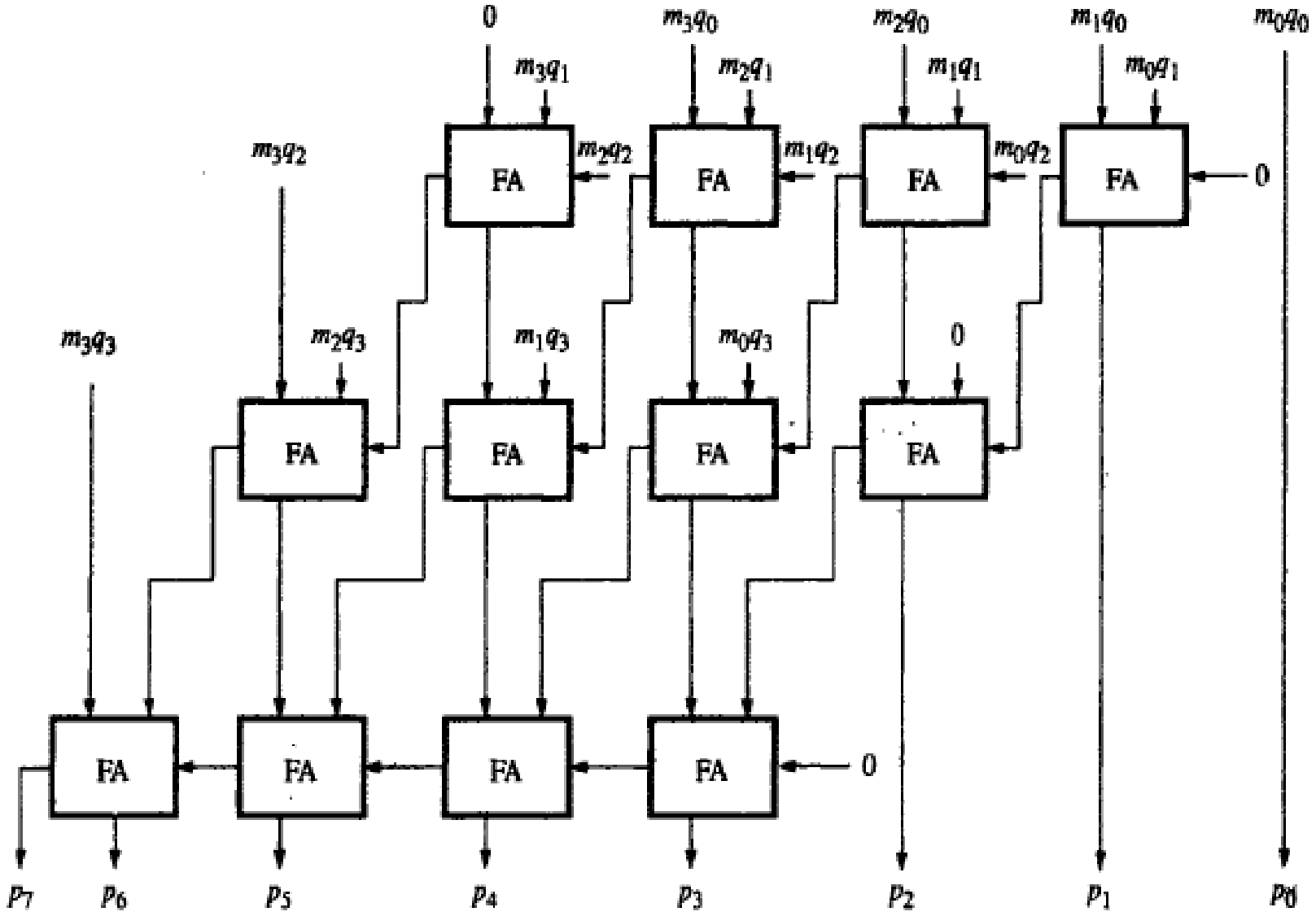
				m3	**m2**	**m1**	**m0**
				q3	**q2**	**q1**	**q0**
				m3q0	m2q0	m1q0	m0q0
			m3q1	m2q1	m1q1	m0q1	
		m3q2	m2q2	m1q2	m0q2		
	m3q3	m2q3	m1q3	m0q3			
p7=	p6=	p5=	p4=	p3=	p2=	p1=	P0= m0q0



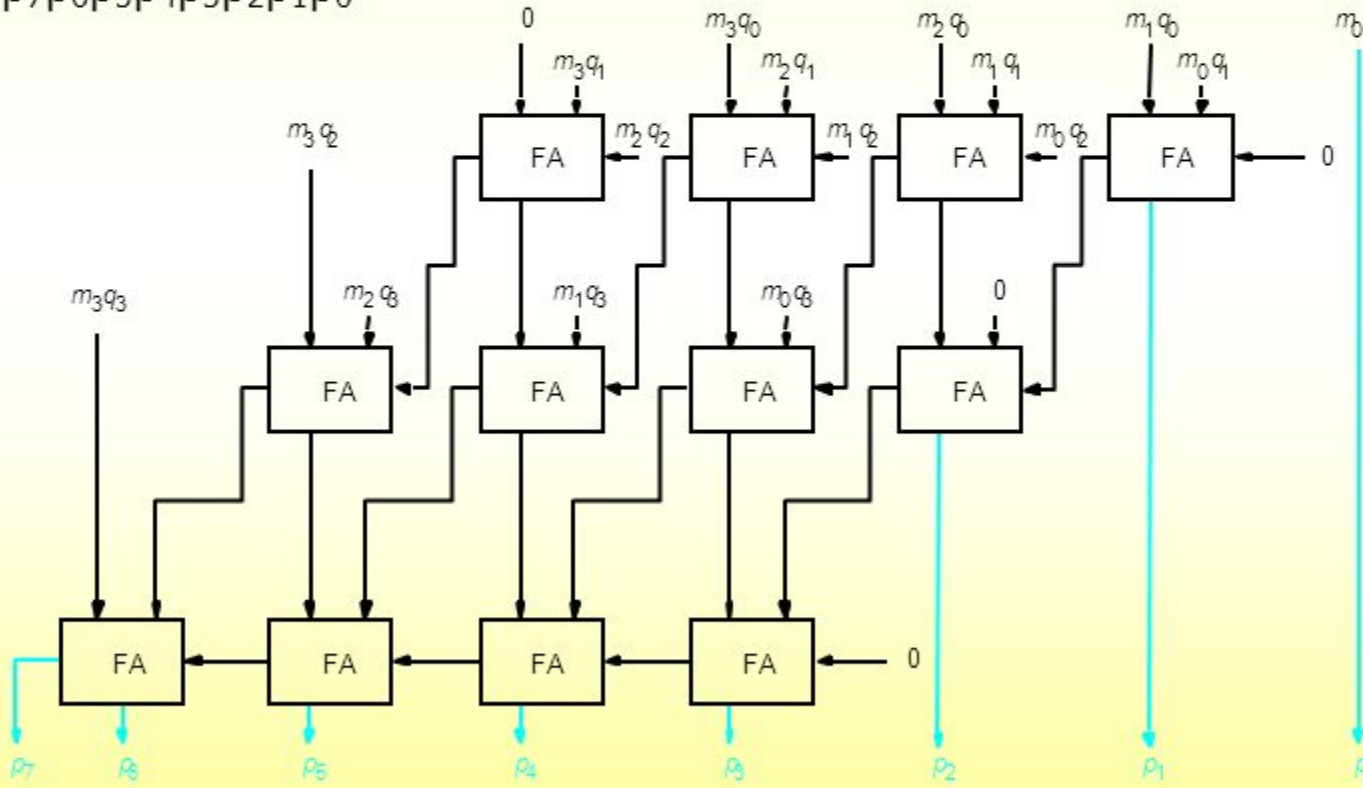
(a) Ripple-carry array (Figure 6.6 structure)



(b) Carry-save array

Carry Save Array

- For the multiplication operation M × Q = P for 4-bit operands
- M: $m_3m_2m_1m_0$
- Q: $q_3q_2q_1q_0$
- P: $p_7p_6p_5p_4p_3p_2p_1p_0$



Gate delay CSA:-
2(perFA) *2 (levels) + 1(and) + 4 (CLA)=9

Q: Do you see any saving here?

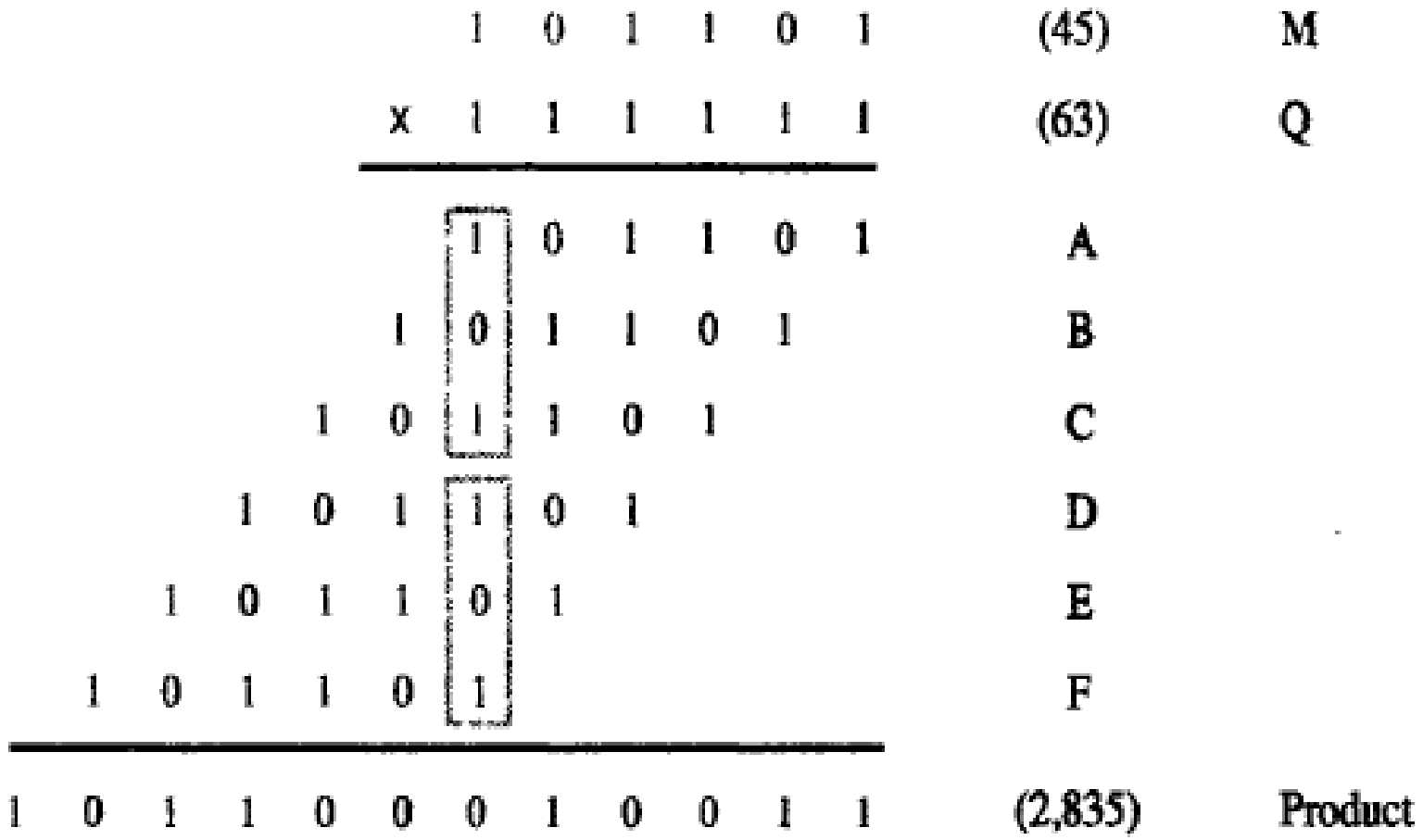
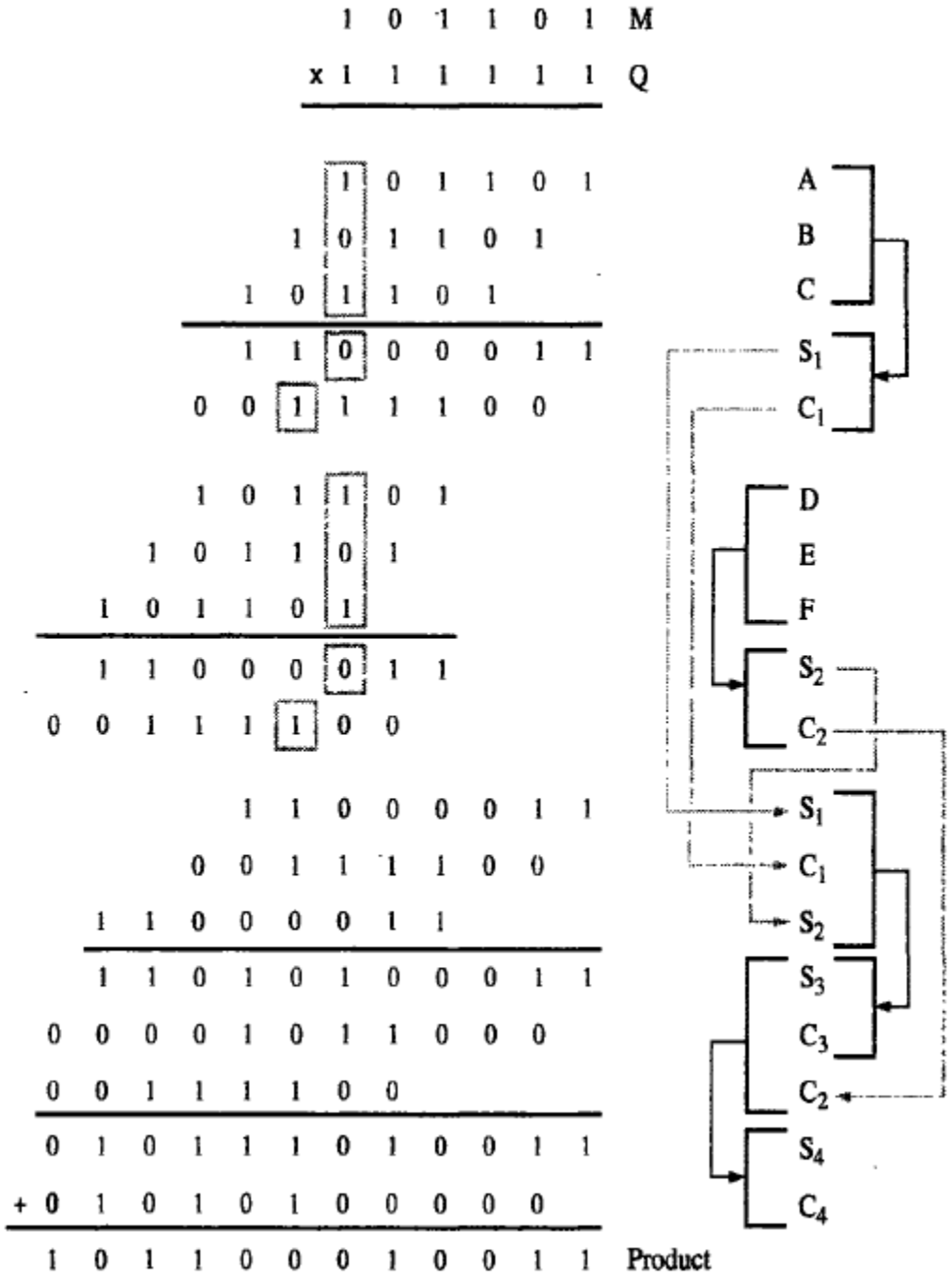


Figure 6.17 A multiplication example used to illustrate carry-save addition as shown in Figure 6.18.


1 0 1 1 0 1 M
x 1 1 1 1 1 1 Q
A
B
C
S1
C1
D
E
F
S2
C2
S1
C1
S2
S3
C3
C2
S4
C4
+ 0 1 0 1 0 1 0 0 0 0 0
1 0 1 1 0 0 0 1 0 0 1 1 Product

Carry Save Adder Tree for 6 Operands

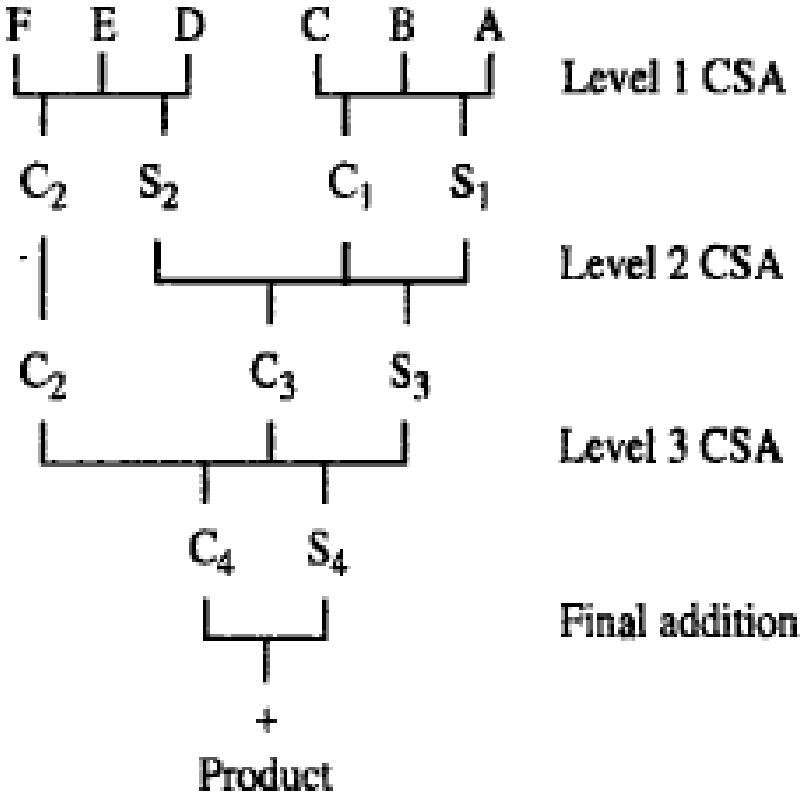
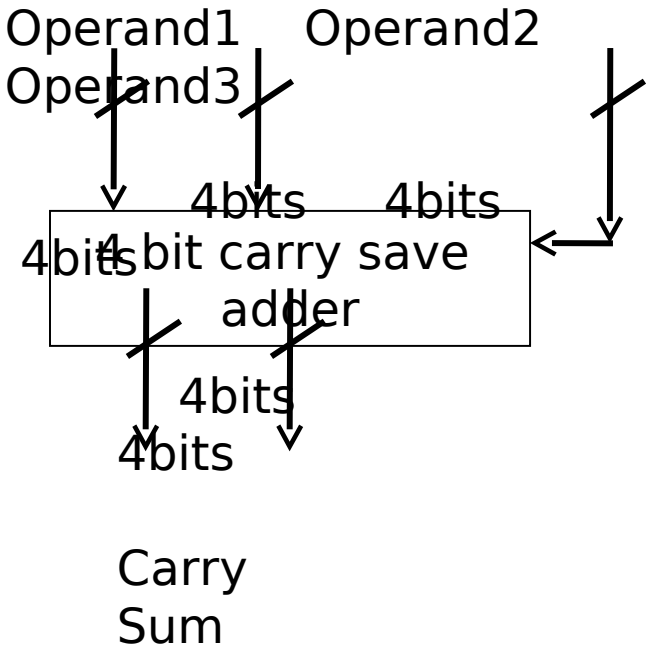


Figure 6.19 Schematic representation of the carry-save addition operations in Figure 6.18.

Exercise

- How many levels are needed to reduce
  - 8 summands to 2 ?
  - 5 summands to 2?

Carry Save Adder (CSA)



Levels in the CSA Tree

Approx 1.7log2k-1.7 to 1.7log2k-3.4 levels of CSA steps needed to reduce k summands to 2 vectors

TABLE 5.1 THE NUMBER OF LEVELS IN A CSA TREE FOR k OPERANDS.

Number of operands	Number of levels
3	1
4	2
$5 \le k \le 6$	3
$7 \le k \le 9$	4
$10 \le k \le 13$	5
$14 \le k \le 19$	6
$20 \le k \le 28$	7
$29 \le k \le 42$	8
$43 \le k \le 63$	9