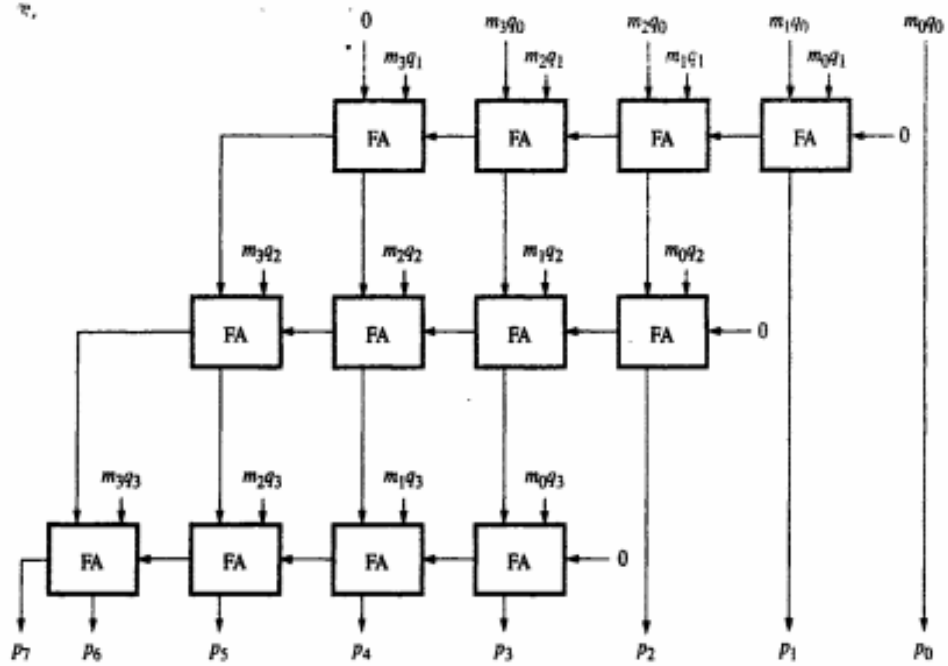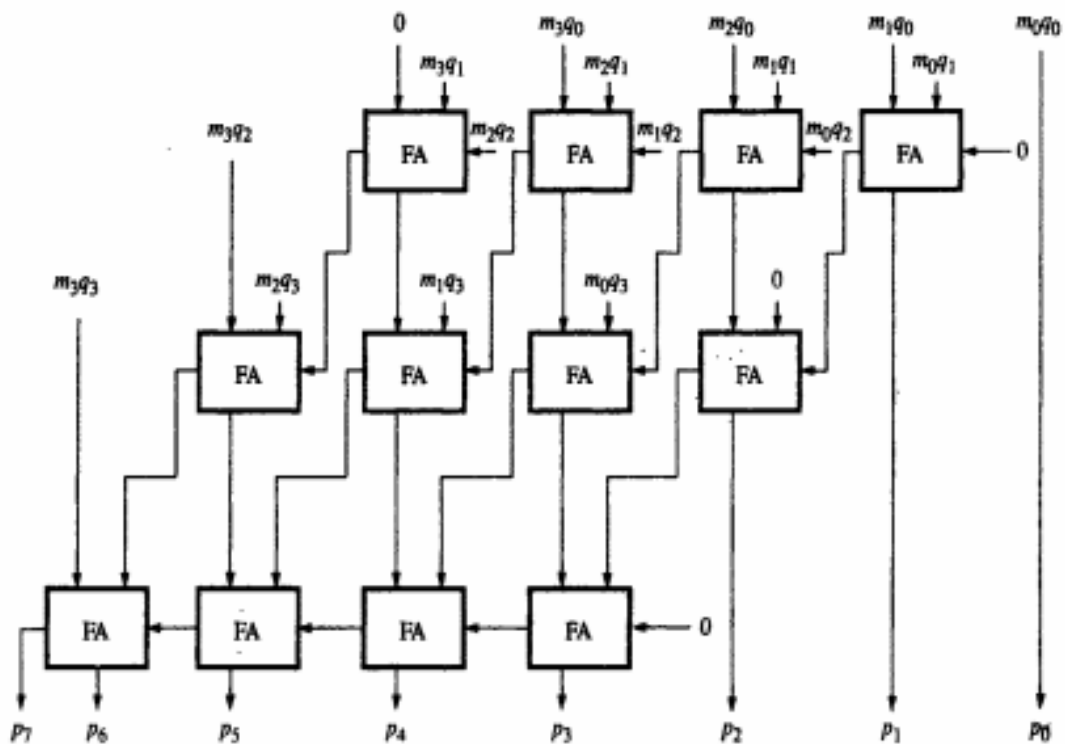# Carry-Save Addition of Summands

(a) Ripple-carry array (Figure 6.6 structure)
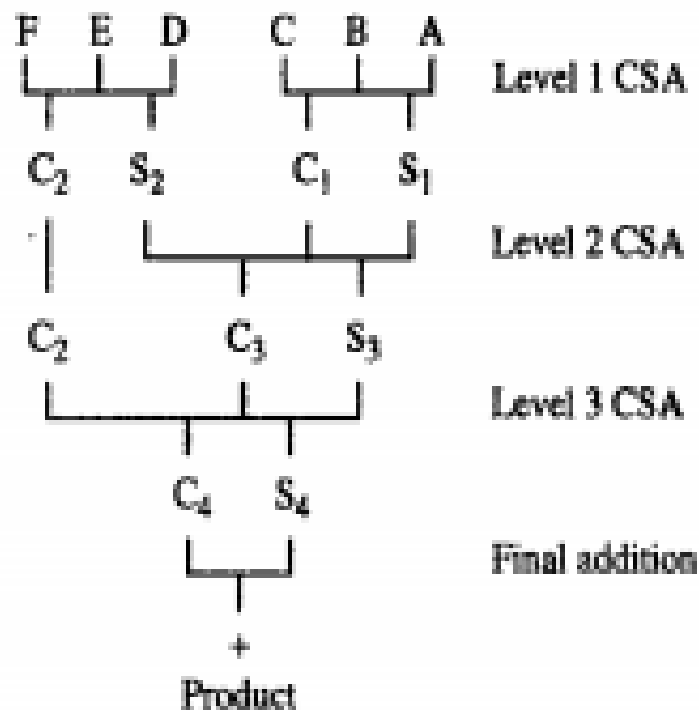
(b) Carry-save array

Figure 6.16 Ripple-carry and carry-save arrays for the multiplication operation M × Q = P for 4-bit operands.

```
            1  0  1  1  0  1        (45)      M
         x  1  1  1  1  1  1        (63)      Q
            ┌─┐
            │1│ 0  1  1  0  1                  A
            └─┘
         1  │0│ 1  1  0  1                     B
      1  0  │1│ 1  0  1                        C
            ┌─┐
   1  0  1  │1│ 0  1                           D
1  0  1  1  │0│ 1                              E
1  0  1  1  0  │1│                             F
            └─┘
1  0  1  1  0  0  0  1  0  0  1  1  (2,835)   Product
```

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

```
   F    E    D        C    B    A
   └────┴────┘        └────┴────┘     Level 1 CSA

  C₂        S₂       C₁        S₁
```


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

```
                1   0   1   1   0   1   M

            x   1   1   1   1   1   1   Q

                ┌───┐
                │ 1 │ 0   1   1   0   1       A
            1   │ 0 │ 1   1   0   1           B
        1   0   │ 1 │ 1   0   1               C
    ────────────┼───┼─────────────────
        1   1   │ 0 │ 0   0   0   1   1       S₁
    0   0   ┌───┤ 1 │ 1   1   0   0           C₁
            │   └───┘
            │       ┌───┐
        1   0   1   │ 1 │ 0   1               D
    1   0   1   1   │ 0 │ 1                   E
1   0   1   1   0   │ 1 │                     F
────────────────────┼───┼─────────
1   1   0   0   0   │ 0 │ 1   1               S₂
0   0   1   1   1   │ 1 │ 0   0               C₂

            1   1   0   0   0   0   1   1     S₁
            0   0   1   1   1   1   0   0     C₁
        1   1   0   0   0   0   1   1         S₂
    ────────────────────────────────
        1   1   0   1   0   1   0   0   0   1   1   S₃
    0   0   0   0   1   0   1   1   0   0   0       C₃
    0   0   1   1   1   1   0   0                   C₂
    ────────────────────────────────
    0   1   0   1   1   1   0   1   0   0   1   1   S₄
  + 0   1   0   1   0   1   0   0   0   0   0       C₄
  ──────────────────────────────────
    1   0   1   1   0   0   0   1   0   0   1   1   Product
```

Figure 6.18   The multiplication example from Figure 6.17 performed using carry-save addition.