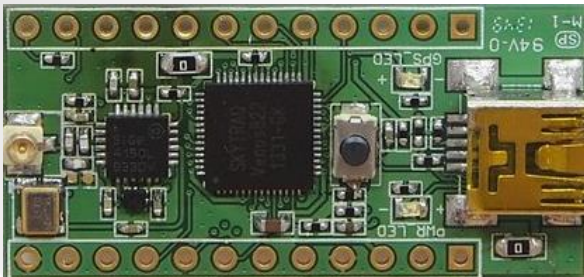


计算机组成原理

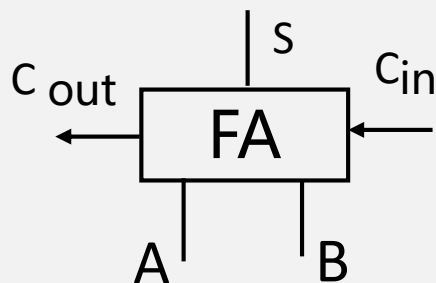
第三章 运算方法与运算器

3.2 定点数补码加、减运算器设计

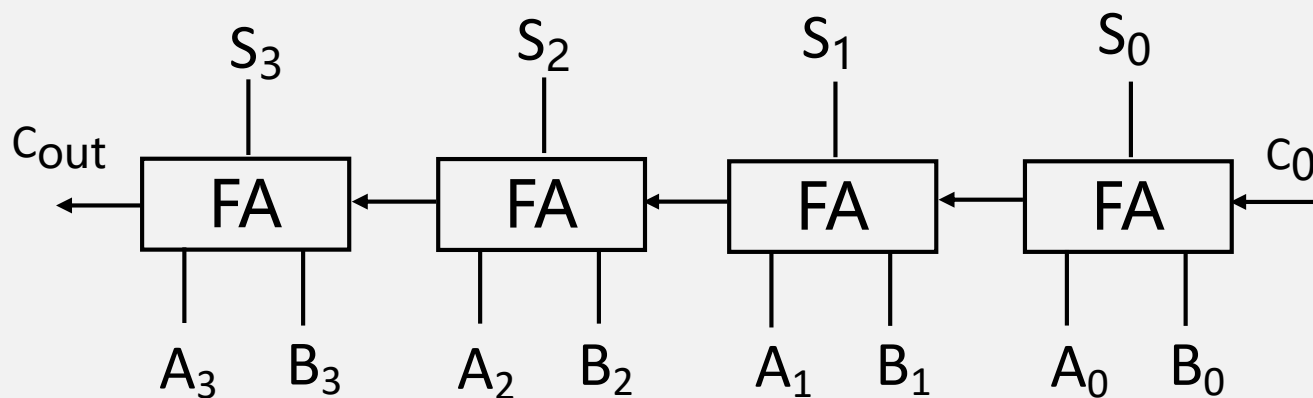


1

四位串行加法器的设计（基于一位全加器FA）

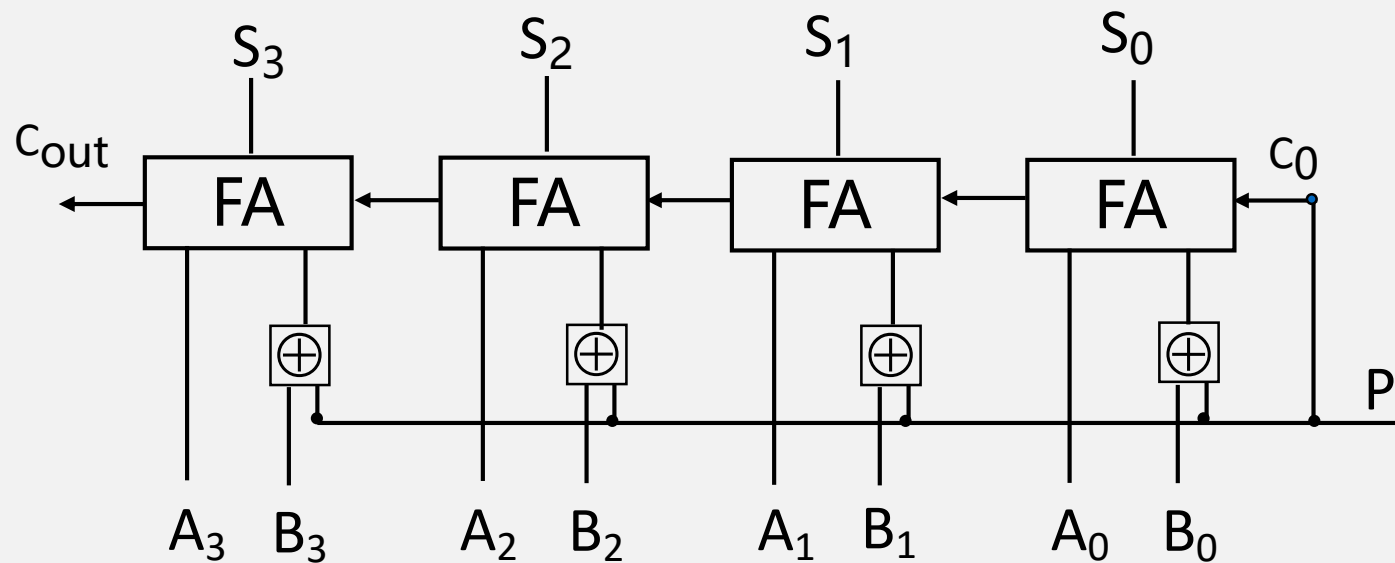


$$[X]_{\text{补}} + [Y]_{\text{补}} = [X]_{\text{补}} + [Y]_{\text{补}}$$



四位串行加/减法器设计

设计思路: $[X]_{\text{补}} - [Y]_{\text{补}} = [X]_{\text{补}} + [-Y]_{\text{补}}$



P=0 加法运算

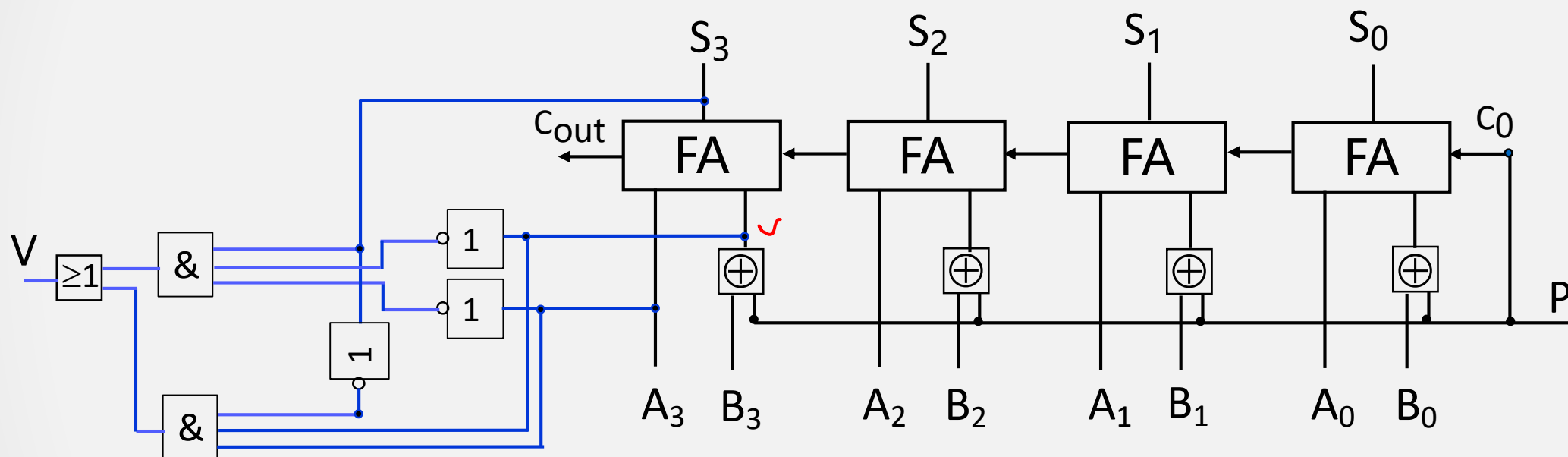
$$\begin{array}{r} 11011 \\ \oplus 00000 \\ \hline 11011 \end{array}$$

P=1 减法运算

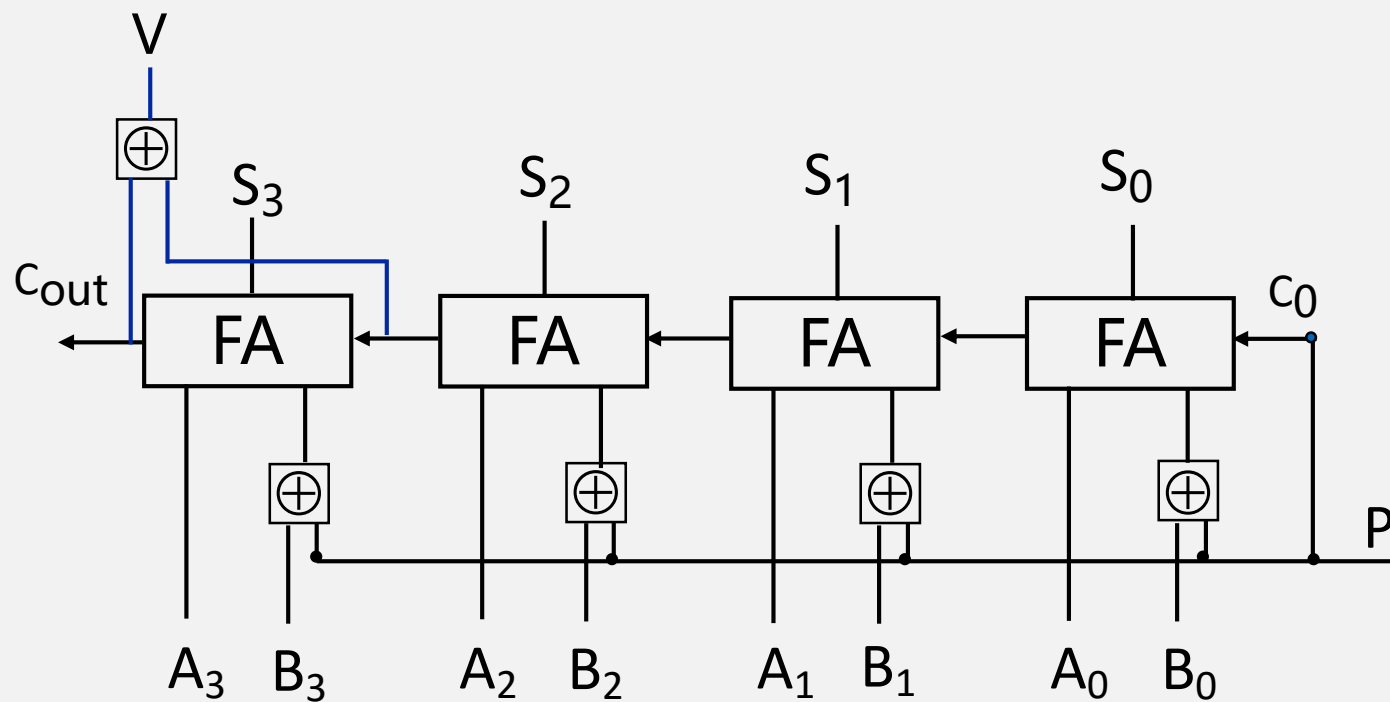
$$\begin{array}{r} 11011 \\ \oplus 11111 \\ \hline 00100 \end{array}$$

3

带溢出检测功能的加/减运算器



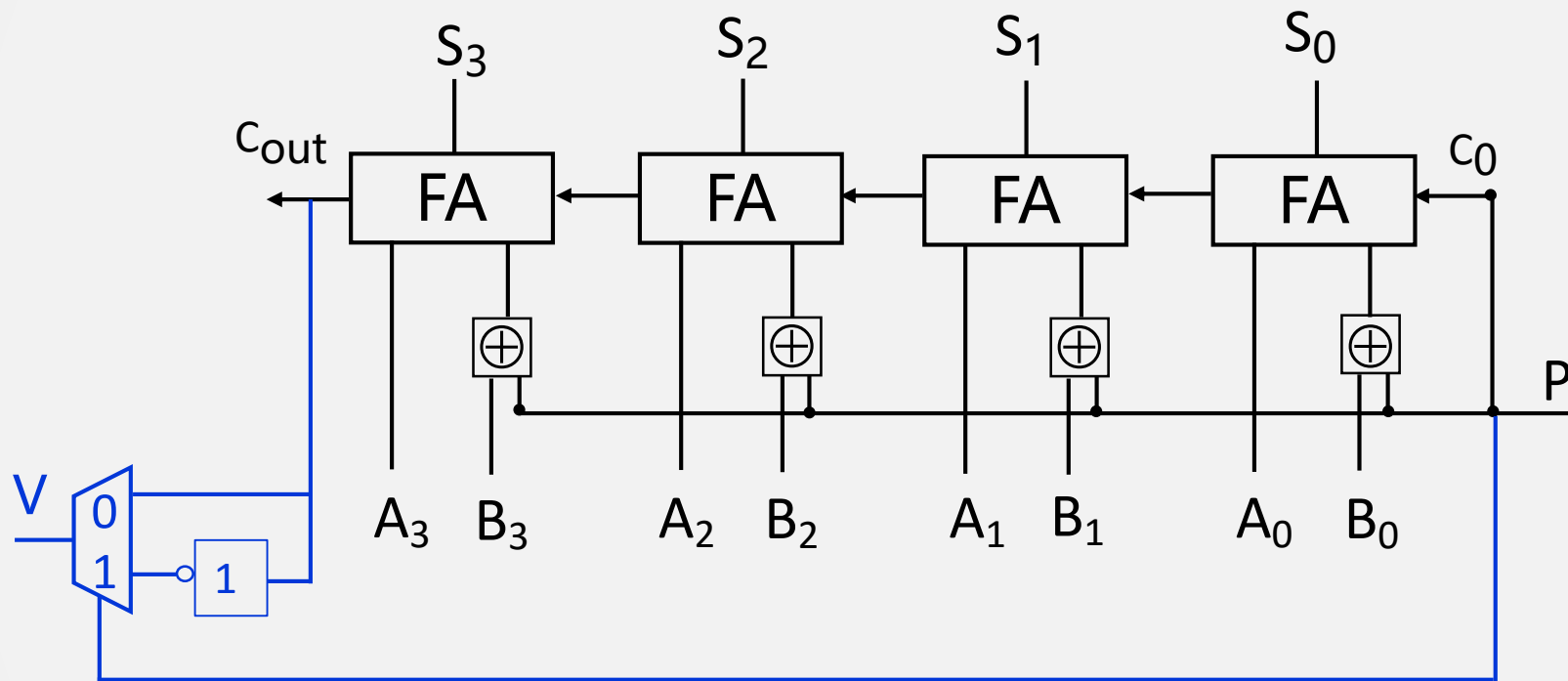
$$V = X_0 Y_0 \bar{S}_0 + \bar{X}_0 \bar{Y}_0 S_0$$



$$V = C_0 \oplus C_1$$

4

带无符号数溢出检测功能的加/减运算器

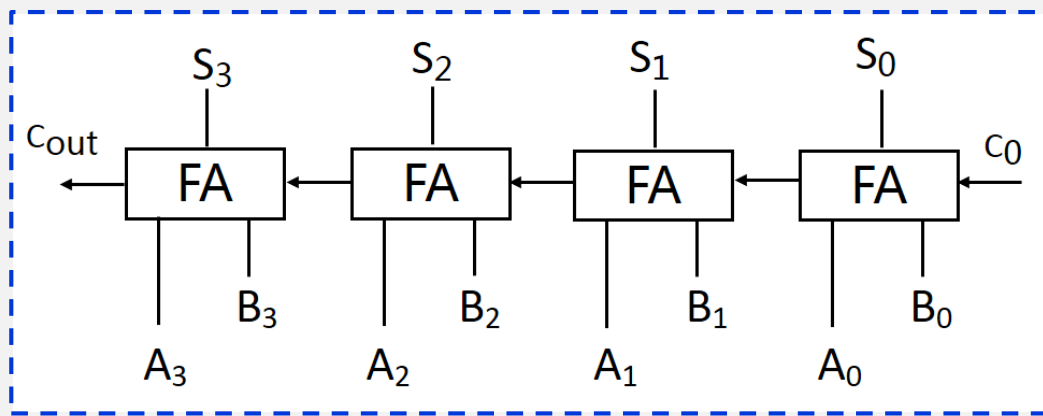


$P=1$ 选择无符号数减法溢出（借位）

$P=0$ 时，选择无符号加法溢出（进位）

5

串行进位



$$C_{out} = A_i B_i + (B_i + A_i) C_{in}$$

$$C_1 = A_0 B_0 + (B_0 + A_0) C_0$$

$$C_2 = A_1 B_1 + (B_1 + A_1) \underline{C_1}$$

$$C_3 = A_2 B_2 + (B_2 + A_2) \underline{C_2}$$

$$C_4 = A_3 B_3 + (B_3 + A_3) \underline{C_3}$$

串行进位：运算速度慢！

6

并行进位 (先行进位)

$$C_1 = A_0 B_0 + (B_0 + A_0) C_0$$

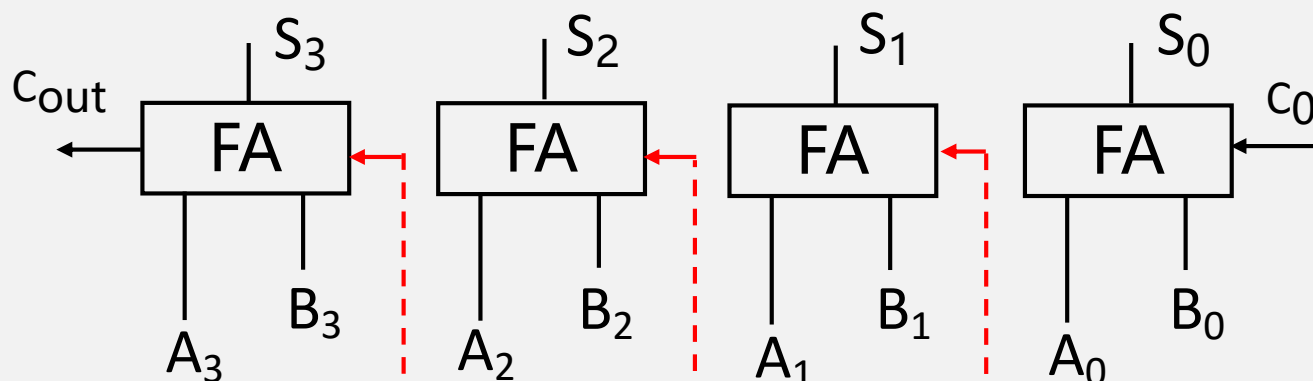
$$C_2 = A_1 B_1 + (B_1 + A_1) C_1 = A_1 B_1 + (A_1 + B_1) A_0 B_0 + (A_1 + B_1) (A_0 + B_0) C_0$$

$$C_3 = A_2 B_2 + (B_2 + A_2) C_2 = A_2 B_2 + (A_2 + B_2) (A_1 B_1 + (A_1 + B_1) A_0 B_0) + (A_2 + B_2) (A_1 + B_1) (A_0 + B_0) C_0$$

$$C_4 = A_3 B_3 + (B_3 + A_3) C_3 = A_3 B_3 + (A_3 + B_3) (A_2 B_2 + (A_2 + B_2) (A_1 B_1 + (A_1 + B_1) A_0 B_0) + (A_3 + B_3) (A_2 + B_2) (A_1 + B_1) (A_0 + B_0) C_0)$$

5

4位并行进位运算器



$$C_1 = A_0 B_0 + (B_0 + A_0) C_0$$

$$C_2 = A_1 B_1 + (A_1 + B_1) A_0 B_0 + (A_1 + B_1) (A_0 + B_0) C_0$$

$$C_3 = A_2 B_2 + (A_2 + B_2) (A_1 B_1 + (A_1 + B_1) A_0 B_0) + (A_2 + B_2) (A_1 + B_1) (A_0 + B_0) C_0$$

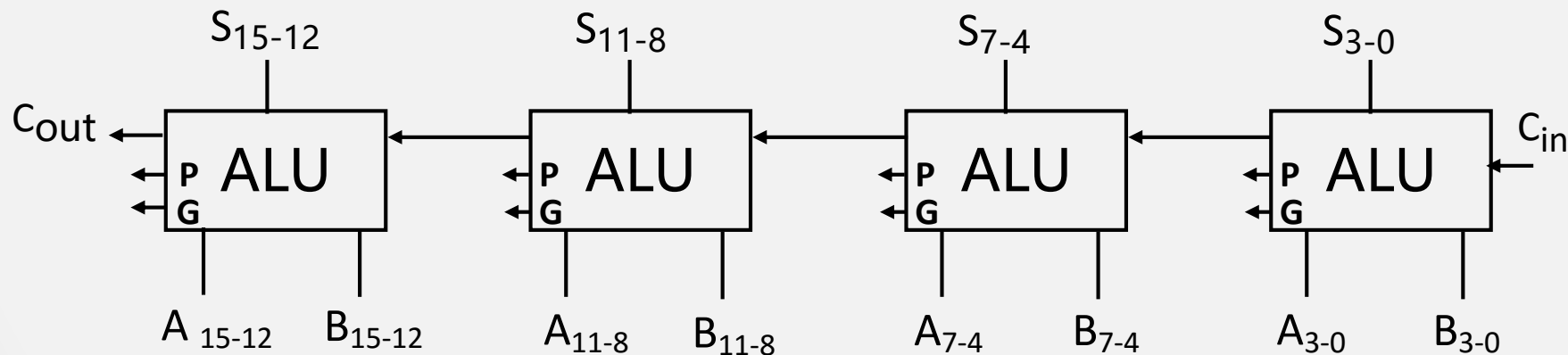
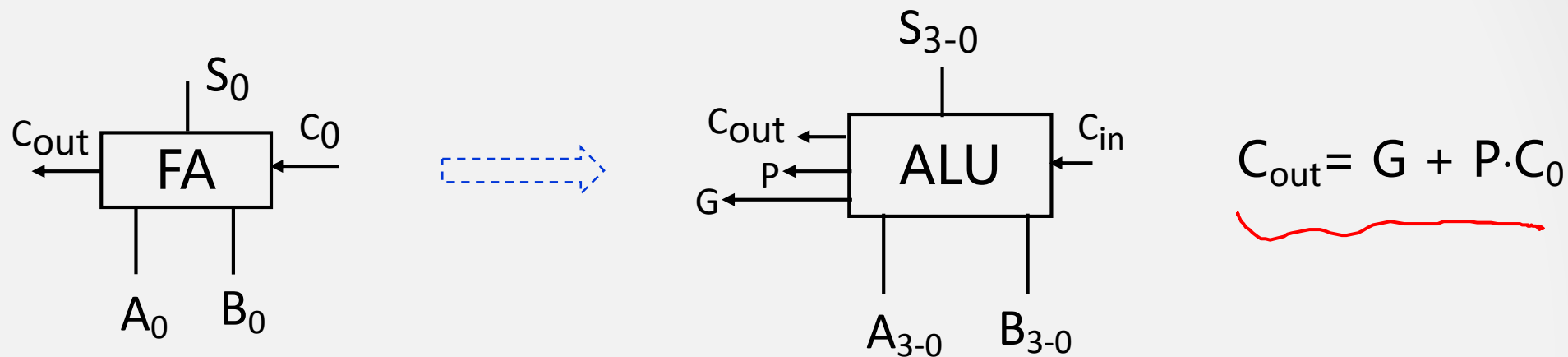
$$C_4 = A_3 B_3 + (A_3 + B_3) (A_2 B_2 + (A_2 + B_2) (A_1 B_1 + (A_1 + B_1) A_0 B_0)) + (A_3 + B_3) (A_2 + B_2) (A_1 + B_1) (A_0 + B_0) C_0$$

✓ $G = A_3 B_3 + (A_3 + B_3) (A_2 B_2 + (A_2 + B_2) (A_1 B_1 + (A_1 + B_1) A_0 B_0))$: 进位产生

✓ $P = (A_3 + B_3) (A_2 + B_2) (A_1 + B_1) (A_0 + B_0)$: 进位传递函数

5

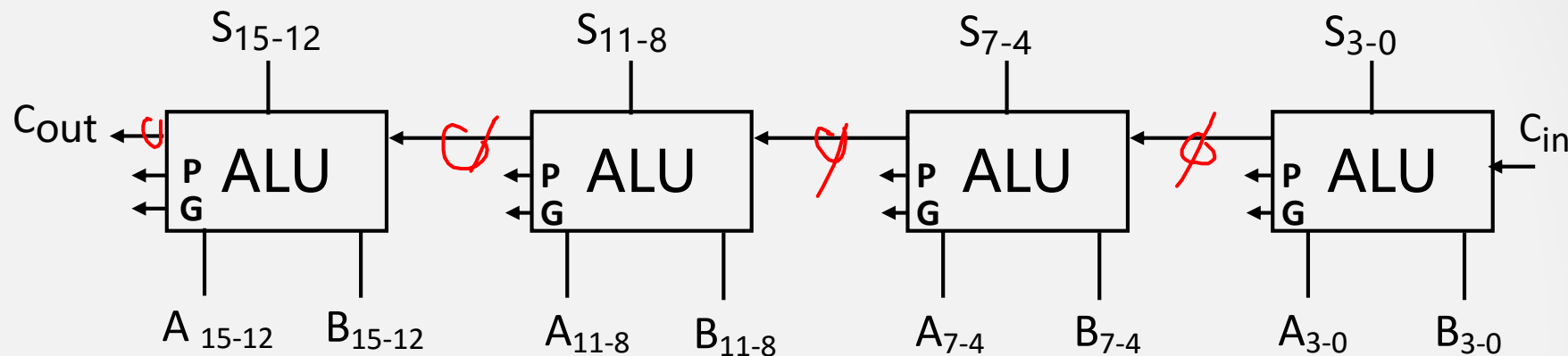
多位串行进位与并行进位运算器



5

多位串行进位与并行进位运算器

$$C_{out} = G + P \cdot C_0$$



$$C_4 = G_0 + P_0 \cdot C_0$$

$$C_8 = G_1 + P_1 \cdot C_4$$

$$C_{12} = G_2 + P_2 \cdot C_8$$

$$C_{16} = G_3 + P_3 \cdot C_{12}$$

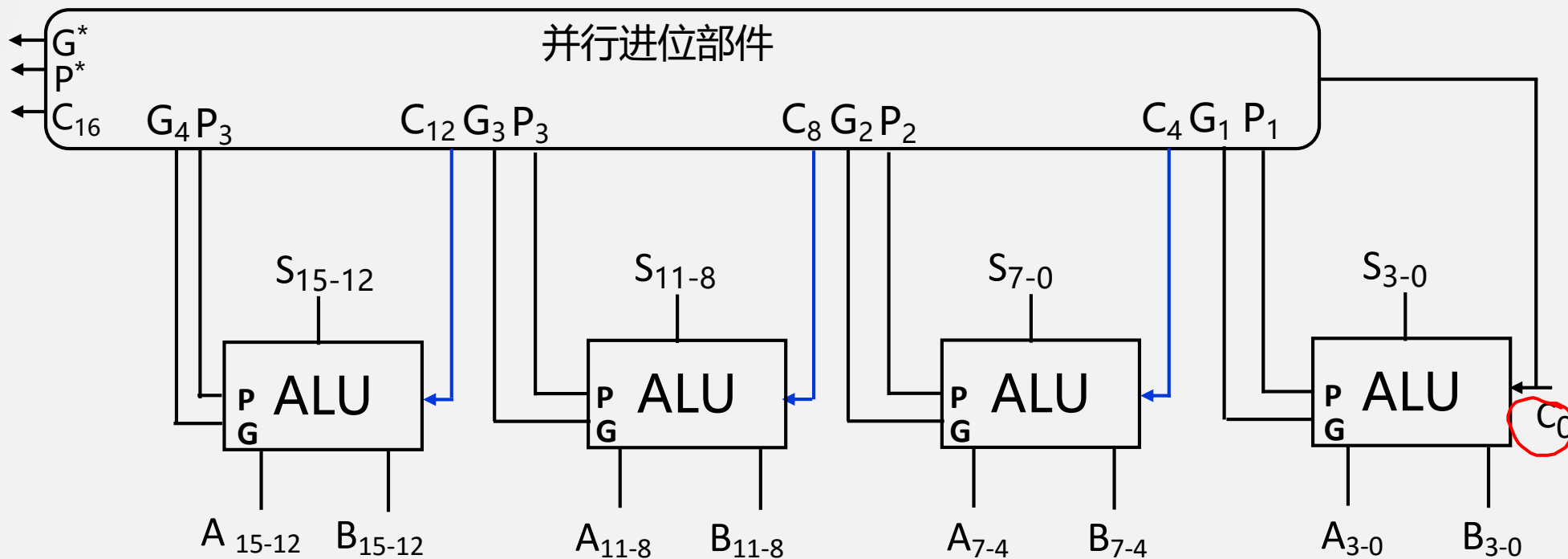
$$= G_1 + P_1 G_0 + P_1 P_0 \cdot C_0$$

$$= G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 \cdot C_0$$

$$= G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 \cdot C_0$$

5

多位串行进位与并行进位运算器



$$C_4 = G_1 + P_1 G_0 + P_1 P_0 \cdot C_0$$

$$C_8 = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 \cdot C_0$$

$$C_{12} = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 \cdot C_0$$

$$C_{16} = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 \cdot C_0$$