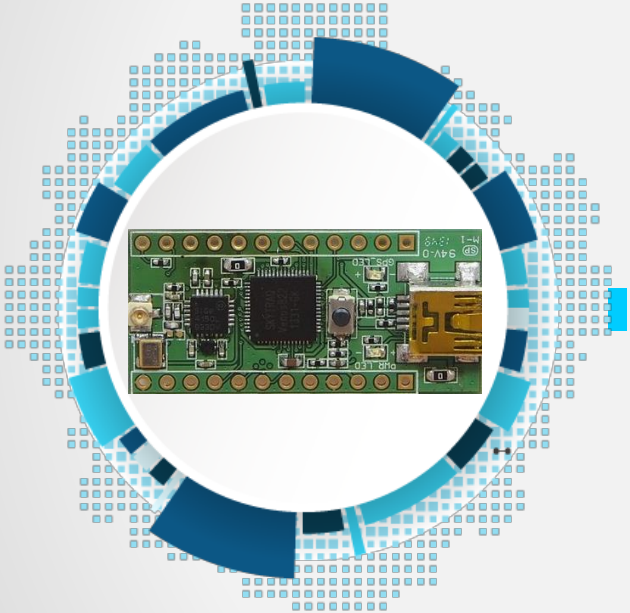
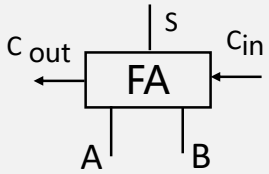


计算机组成原理

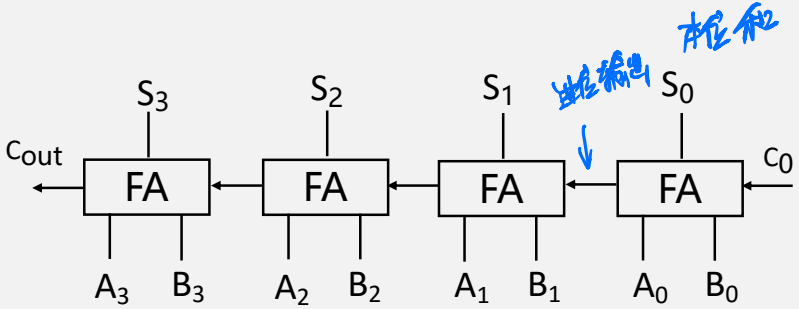
第三章 运算方法与运算器

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）

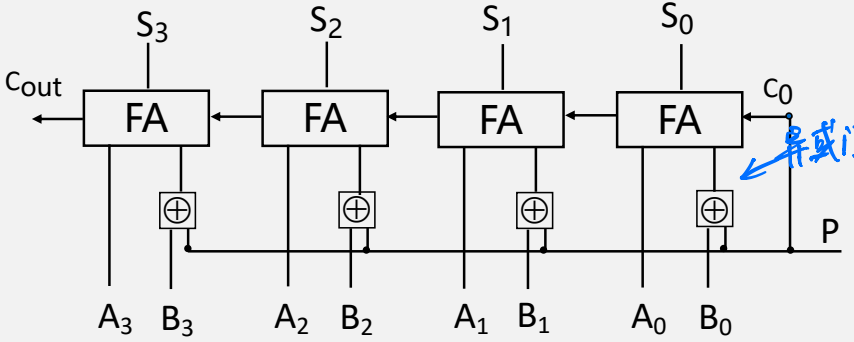


$$[X]_{补} + [Y]_{补} = [X]_{补} + [Y]_{补}$$



2 四位串行加/减法器设计

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



操作控制信号 0：正常
1：对B求反码 且 $C_0=1$(+1)

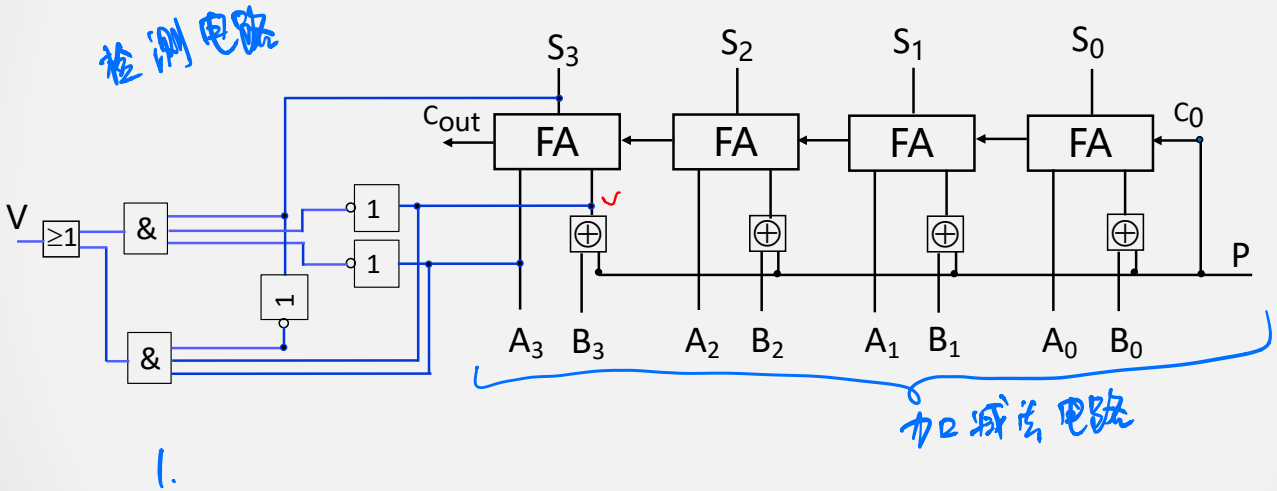
P=0 加法运算

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

P=1 减法运算

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

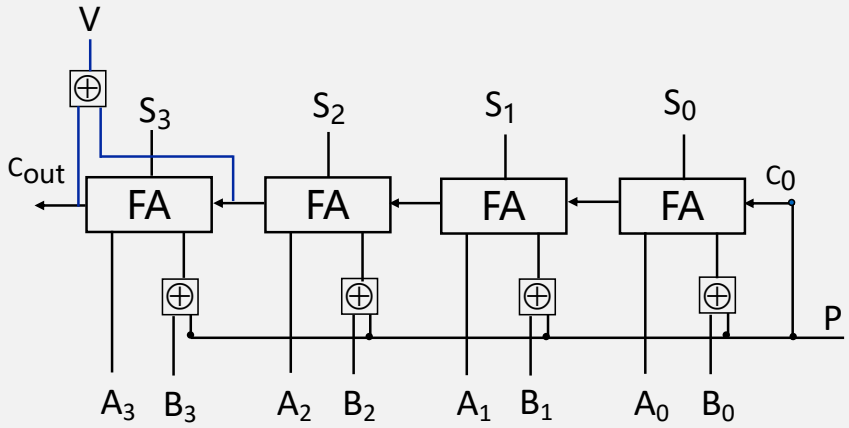
3 带溢出检测功能的加/减运算器



1.

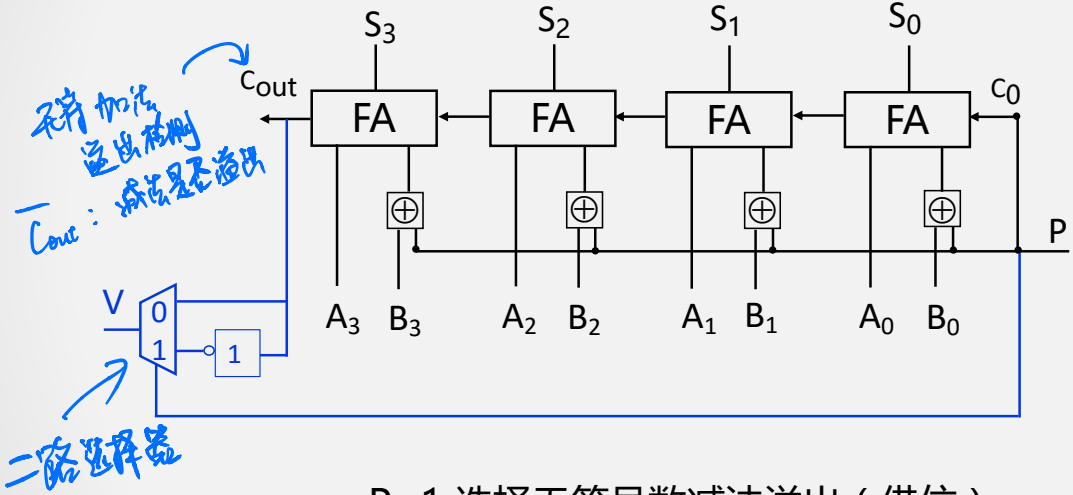
$$V = X_0 Y_0 \overline{S}_0 + \overline{X}_0 \overline{Y}_0 S_0$$

3 带溢出检测功能的加/减运算器



2. $V = C_0 \oplus C_1$

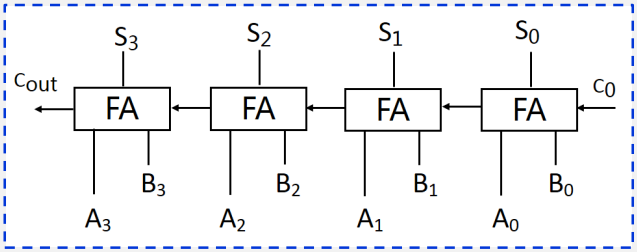
4 带无符号数溢出检测功能的加/减运算器



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



进位输出 $C_{out}= A_iB_i+ (B_i+A_i) C_{in}$ 进位输入

$C_1= A_0B_0+ (B_0+A_0)C_0$

$C_2= A_1B_1+ (B_1+A_1)C_1$

$C_3= A_2B_2+ (B_2+A_2)C_2$

$C_4= A_3B_3+ (B_3+A_3)C_3$

串行进位：运算速度慢！

6 并行进位 (先行进位)

$C_1 = A_0B_0 + (B_0+A_0)C_0$

代入

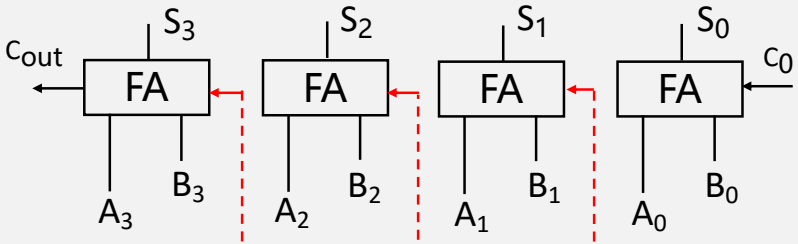
$C_2 = A_1B_1 + (B_1+A_1)C_1 = A_1B_1 + (A_1+B_1)A_0B_0 + (A_1+B_1)(A_0+B_0)C_0$

Ai, Bi, Co

$C_3 = A_2B_2 + (B_2+A_2)C_2 = A_2B_2 + (A_2+B_2)(A_1B_1 + (A_1+B_1)A_0B_0) + (A_2+B_2)(A_1+B_1)(A_0+B_0)C_0$

$C_4 = A_3B_3 + (B_3+A_3)C_3 = A_3B_3 + (A_3+B_3)(A_2B_2 + (A_2+B_2)(A_1B_1 + (A_1+B_1)A_0B_0) + (A_3+B_3)(A_2+B_2)(A_1+B_1)(A_0+B_0)$

5 4位并行进位运算器



$C_1 = A_0B_0 + (B_0+A_0)C_0$

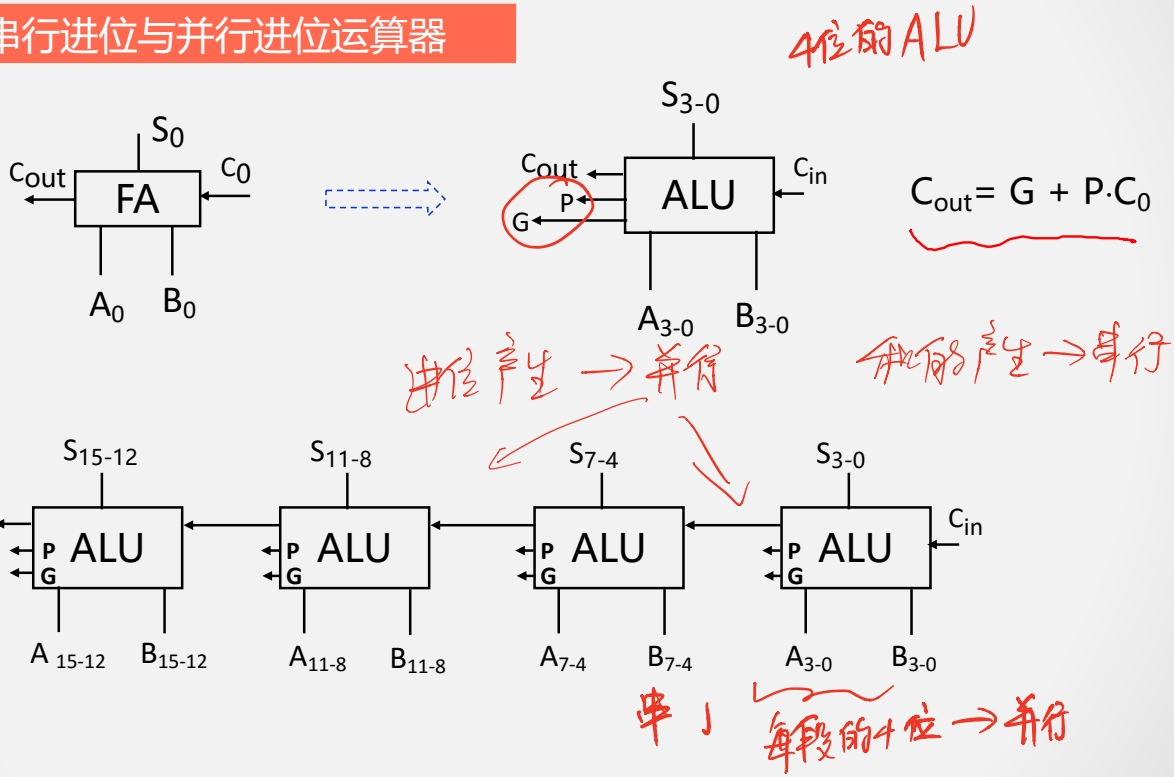
$C_2 = A_1B_1 + (A_1+B_1)A_0B_0 + (A_1+B_1)(A_0+B_0)C_0$

$C_3 = A_2B_2+(A_2+B_2)(A_1B_1+(A_1+B_1)A_0B_0) + (A_2+B_2)(A_1+B_1)(A_0+B_0)C_0$

$C_4 = A_3B_3+(A_3+B_3)(A_2B_2+(A_2+B_2)(A_1B_1+(A_1+B_1)A_0B_0)) + (A_3+B_3)(A_2+B_2)(A_1+B_1)(A_0+B_0)C_0$

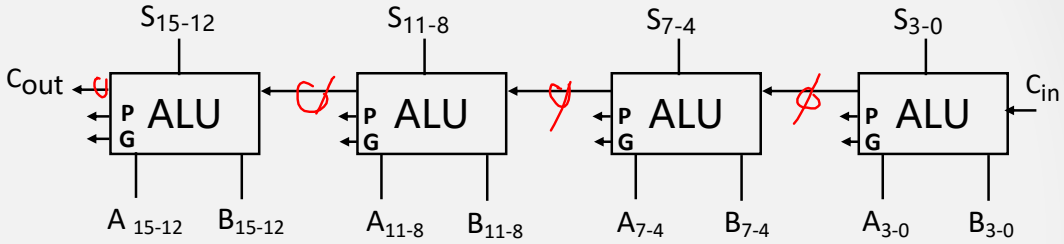
- $G = A_3B_3+(A_3+B_3)(A_2B_2+(A_2+B_2)(A_1B_1+(A_1+B_1)A_0B_0))$：进位产生函数
- $P = (A_3+B_3)(A_2+B_2)(A_1+B_1)(A_0+B_0)$：进位传递函数

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

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



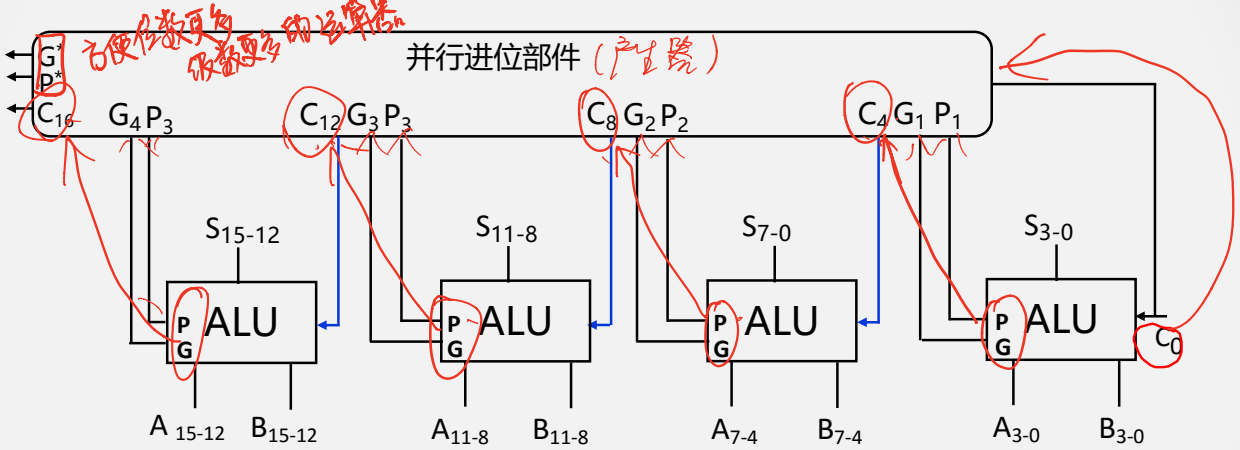
$C_4 = G_0 + P_0 \cdot C_0$

$C_8 = G_1 + P_1 \cdot C_4 = G_1 + P_1G_0 + P_1P_0 \cdot C_0$

$C_{12} = G_2 + P_2 C_8 = G_2 + P_2G_1 + P_2P_1G_0 + P_2P_1P_0 \cdot C_0$

$C_{16} = G_3 + P_3C_{12} = G_3 + P_3G_2 + P_3P_2G_1 + P_3P_2P_1G_0 + P_3P_2P_1P_0 \cdot C_0$

5 多位串行进位与并行进位运算器



$C_4 = G_1 + P_1G_0 + P_1P_0 \cdot C_0$

$C_8 = G_2 + P_2G_1 + P_2P_1G_0 + P_2P_1P_0 \cdot C_0$

$C_{12} = G_2 + P_2G_1 + P_2P_1G_0 + P_2P_1P_0 \cdot C_0$

$C_{16} = G_3 + P_3G_2 + P_3P_2G_1 + P_3P_2P_1G_0 + P_3P_2P_1P_0 \cdot C_0$