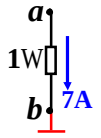
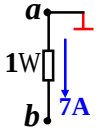
§3-6 结点电压法

结点电位的概念:

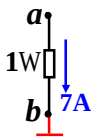
在电路中任选一结点，设其电位为零（用⊥标记），此点称为参考点。其它各结点对参考点的电压，便是该结点的电位。记为：“V_x”（注意：电位为单下标）。



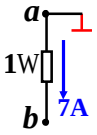
a点电位：$V_a = +7\text{V}$



b点电位：$V_b = -7\text{V}$

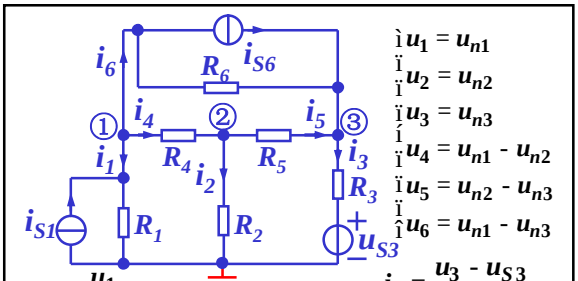


a点电位：$V_a = +7\text{V}$



b点电位：$V_b = -7\text{V}$

未知量：指定一个参考结点，其余各个结点电位和参考结点的电位之差称为**结点电压**,用 u_{n1}、u_{n2} 和 u_{n3} 来表示。

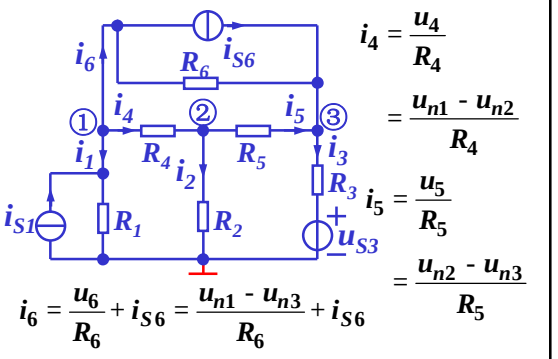


$$\begin{cases} u_1 = u_{n1} \\ u_2 = u_{n2} \\ u_3 = u_{n3} \\ u_4 = u_{n1} - u_{n2} \\ u_5 = u_{n2} - u_{n3} \\ u_6 = u_{n1} - u_{n3} \end{cases}$$

$$i_1 = \frac{u_1}{R_1} - i_{S1} = \frac{u_{n1}}{R_1} - i_{S1}$$

$$i_2 = \frac{u_2}{R_2} = \frac{u_{n2}}{R_2}$$

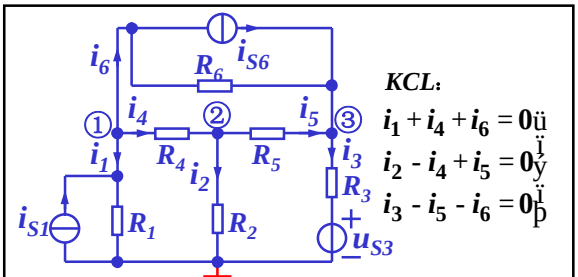
$$i_3 = \frac{u_3 - u_{S3}}{R_3} = \frac{u_{n3} - u_{S3}}{R_3}$$



$$i_4 = \frac{u_4}{R_4} = \frac{u_{n1} - u_{n2}}{R_4}$$

$$i_5 = \frac{u_5}{R_5} = \frac{u_{n2} - u_{n3}}{R_5}$$

$$i_6 = \frac{u_6}{R_6} + i_{S6} = \frac{u_{n1} - u_{n3}}{R_6} + i_{S6}$$



KCL:

$$\begin{cases} i_1 + i_4 + i_6 = 0 \\ i_2 - i_4 + i_5 = 0 \\ i_3 - i_5 - i_6 = 0 \end{cases}$$

$$\begin{cases} (G_1 + G_4 + G_6)u_{n1} - G_4 u_{n2} - G_6 u_{n3} = i_{S1} - i_{S6} \\ -G_4 u_{n1} + (G_2 + G_4 + G_5)u_{n2} - G_5 u_{n3} = 0 \\ -G_6 u_{n1} - G_5 u_{n2} + (G_3 + G_5 + G_6)u_{n3} = i_{S6} + G_3 u_{S3} \end{cases}$$

结点方程的标准形式

$$\begin{cases} G_{11}u_{n1} + G_{12}u_{n2} + G_{13}u_{n3} = i_{S11} \\ G_{21}u_{n1} + G_{22}u_{n2} + G_{23}u_{n3} = i_{S22} \\ G_{31}u_{n1} + G_{32}u_{n2} + G_{33}u_{n3} = i_{S33} \end{cases}$$

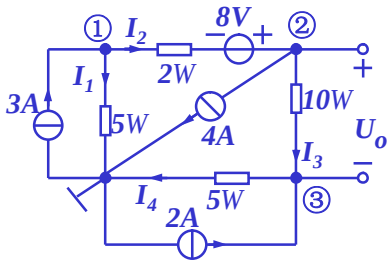
G_{ij} $\begin{cases} i = j: \\ i \neq j: \end{cases}$

自导，第i个结点联结的所有支路的电导值之和(恒为正)

互导，第i个结点和第j个结点相联的公共支路上的电导值之和取负

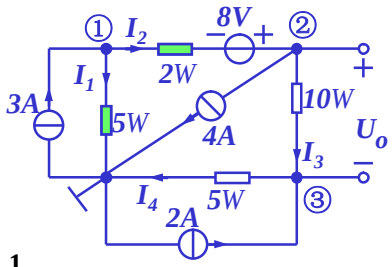
i_{S11}、i_{S22}等为流入各结点电流源的代数和

补例1 电路如图所示，按图示结点编号列出结点电压方程。



HOME BACK NEXT

补例1

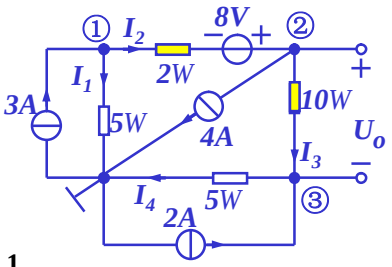


$$G_{11} = \frac{1}{5} + \frac{1}{2} = 0.7(S) \qquad G_{22}$$

$$G_{33}$$

HOME BACK NEXT

补例1

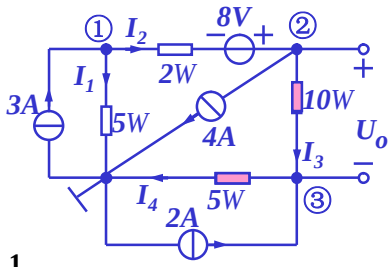


$$G_{11} = \frac{1}{5} + \frac{1}{2} = 0.7(S) \qquad G_{22} = \frac{1}{2} + \frac{1}{10} = 0.6(S)$$

$$G_{33}$$

HOME BACK NEXT

补例1

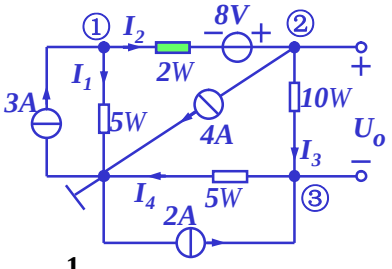


$$G_{11} = \frac{1}{5} + \frac{1}{2} = 0.7(S) \qquad G_{22} = \frac{1}{2} + \frac{1}{10} = 0.6(S)$$

$$G_{33} = \frac{1}{10} + \frac{1}{5} = 0.3(S)$$

HOME BACK NEXT

补例1

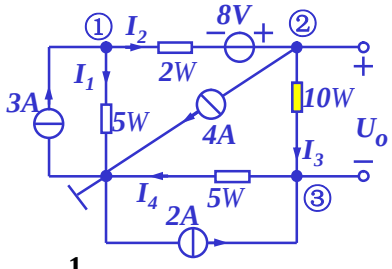


$$G_{12} = G_{21} = -\frac{1}{2}(S) \qquad G_{13} = G_{31} = 0$$

$$G_{23} = G_{32}$$

HOME BACK NEXT

补例1



$$G_{12} = G_{21} = -\frac{1}{2}(S) \qquad G_{13} = G_{31} = 0$$

$$G_{23} = G_{32} = -\frac{1}{10}(S)$$

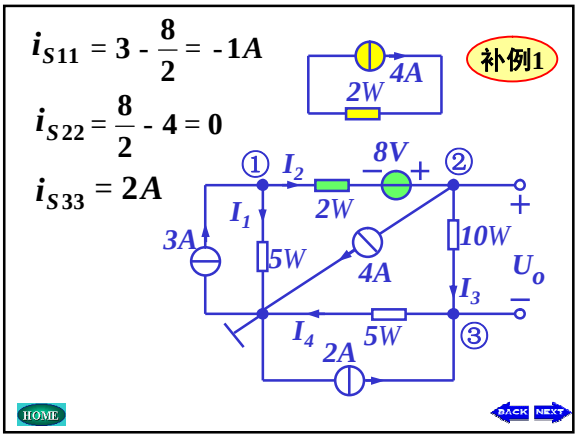
HOME BACK NEXT

$i_{S11} = 3 - \frac{8}{2} = -1A$

$i_{S22} = \frac{8}{2} - 4 = 0$

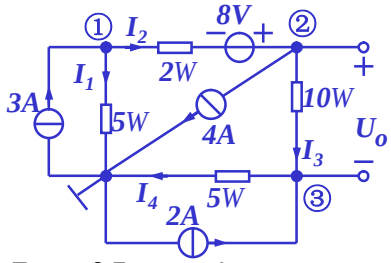
$i_{S33} = 2A$

补例1



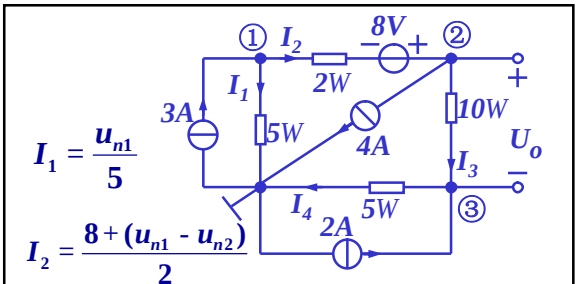
HOME BACK NEXT

补例1



$$\begin{cases} 0.7u_{n1} - 0.5u_{n2} = -1 \\ -0.5u_{n1} + 0.6u_{n2} - 0.1u_{n3} = 0 \\ -0.1u_{n2} + 0.3u_{n3} = 2 \end{cases}$$

HOME BACK NEXT



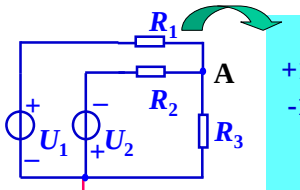
$$I_1 = \frac{u_{n1}}{5}$$

$$I_2 = \frac{8 + (u_{n1} - u_{n2})}{2}$$

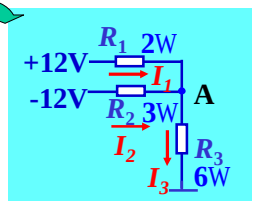
$$I_3 = \frac{u_{n2} - u_{n3}}{10} \qquad I_4 = \frac{u_{n3}}{5} \qquad U_o = u_{n2} - u_{n3}$$

HOME BACK NEXT

电位在电子电路中的表示法



$$V_A = \frac{\frac{U_1}{R_1} + \frac{-U_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = 2V$$



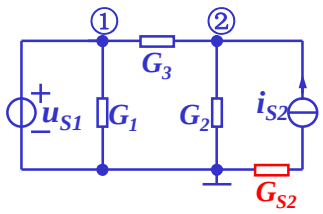
$I_1 = 5A$

$I_2 = -14/3A$

$I_3 = 1/3A$

HOME BACK NEXT

例3-7 列出电路的结点电压方程。



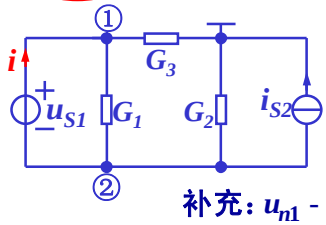
虚元件

解：电路含无伴电压源时，有两种处理方法，第一种是直接选取该电压源支路的任一结点作为参考结点

$$\begin{cases} u_{n1} = u_{S1} \\ -G_3 u_{n1} + (G_2 + G_3) u_{n2} = i_{S2} \end{cases}$$

HOME BACK NEXT

例3-7 列出电路的结点电压方程。



若无伴电压源两端都不接地，则给该电压源设定支路电流列写方程

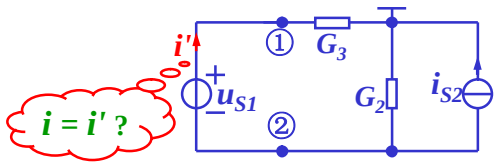
补充：$u_{n1} - u_{n2} = u_{S1}$

$$\begin{cases} (G_1 + G_3) u_{n1} - G_1 u_{n2} = i \\ -G_1 u_{n1} + (G_1 + G_2) u_{n2} = -i - i_{S2} \end{cases}$$

HOME BACK NEXT

例3-7 列出电路的结点电压方程。

把G_1当成虚元件列写方程



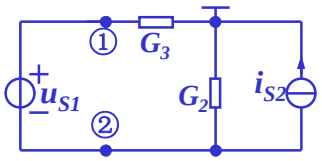
$$\begin{cases} G_3 u_{n1} = i' \\ G_2 u_{n2} = -i' - i_{S2} \end{cases}$$

补充：$u_{n1} - u_{n2} = u_{S1}$

HOME BACK NEXT

例3-7 列出电路的结点电压方程。

把G_1当成虚元件列写方程

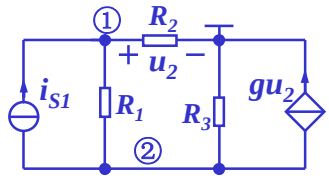


$$(G_2 + G_3)u_{n2} = -G_3 u_{S1} - i_{S2}$$

HOME BACK NEXT

补例2

列出电路的结点电压方程。

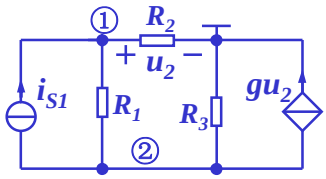


!! 先把受控源看成独立源列方程，再补充控制量和未知量的关系式

HOME BACK NEXT

补例2

列出电路的结点电压方程。



$$\begin{cases} (\frac{1}{R_1} + \frac{1}{R_2})u_{n1} - \frac{1}{R_1}u_{n2} = i_{S1} \\ -\frac{1}{R_1}u_{n1} + (\frac{1}{R_1} + \frac{1}{R_3})u_{n2} = -gu_2 - i_{S1} \end{cases}$$

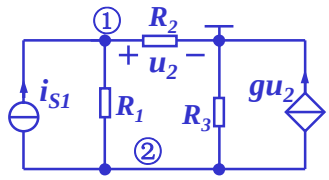
补充：$u_2 = u_{n1}$

!! 先把受控源看成独立源列方程，再补充控制量和未知量的关系式

HOME BACK NEXT

补例2

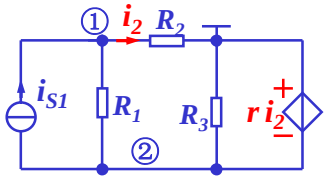
列出电路的结点电压方程。



$$\begin{cases} (\frac{1}{R_1} + \frac{1}{R_2})u_{n1} - \frac{1}{R_1}u_{n2} = i_{S1} \\ (g - \frac{1}{R_1})u_{n1} + (\frac{1}{R_1} + \frac{1}{R_3})u_{n2} = -i_{S1} \end{cases}$$

HOME BACK NEXT

列出电路的结点电压方程。



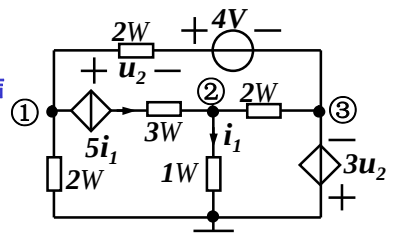
$$\begin{cases} (\frac{1}{R_1} + \frac{1}{R_2})u_{n1} - \frac{1}{R_1}u_{n2} = i_{S1} \\ u_{n2} = -ri_2 \end{cases}$$

补充：$i_2 = \dfrac{u_{n1}}{R_2}$

HOME BACK NEXT

补例3

列出电路的结点电压方程。



$$\begin{cases} u_{n1} - 0.5u_{n3} = 2 - 5i_1 \\ 1.5u_{n2} - 0.5u_{n3} = 5i_1 \\ u_{n3} = -3u_2 \end{cases}$$

补充:

$$u_2 = u_{n1} - u_{n3} - 4$$

$$i_1 = u_{n2}$$

HOME BACK NEXT

注意

结点电压法：含电压源和电阻串联支路，

含无伴电压源，

含受控源，

含虚元件(和电流源串联元件)。

THE END

HOME BACK