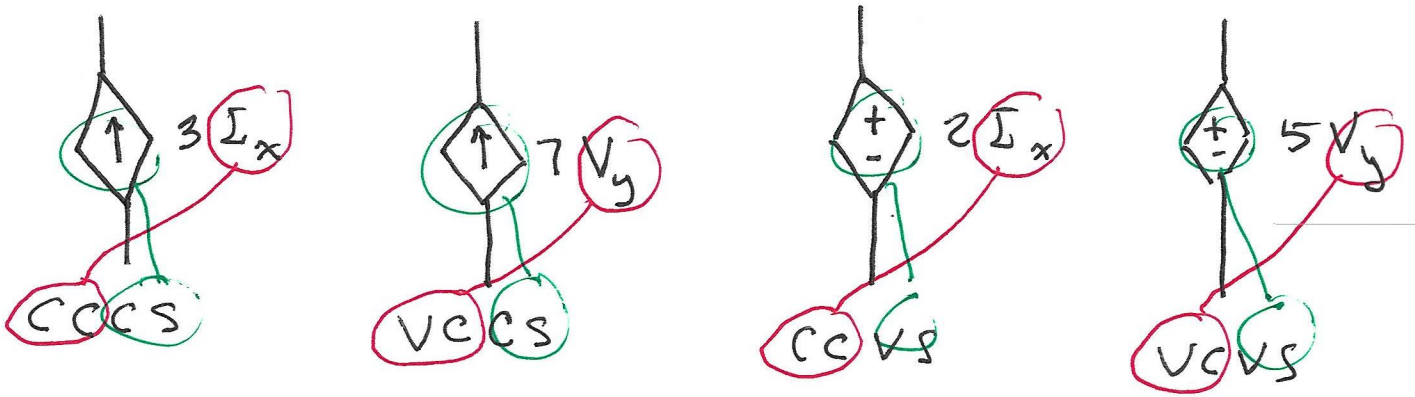
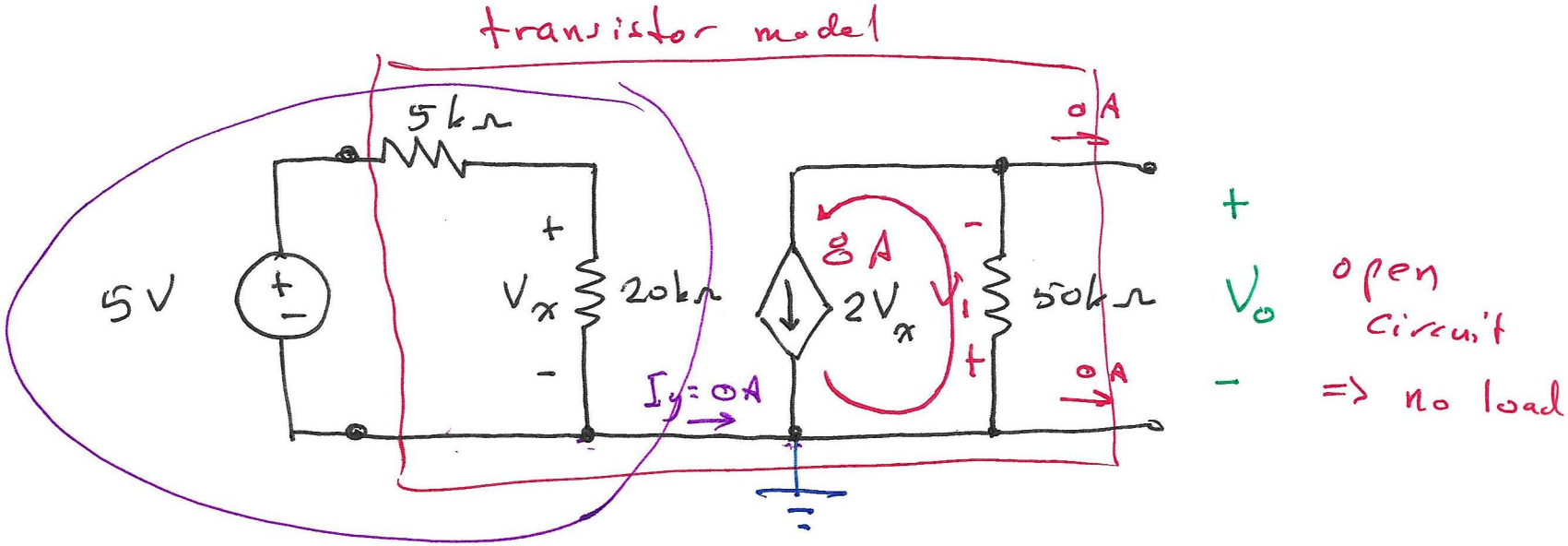
Dependent Source (Controlled)

Value of the output is determined by a variable somewhere else in the circuit.





only one wire crosses this KCL boundary

$\Rightarrow I_y = 0$

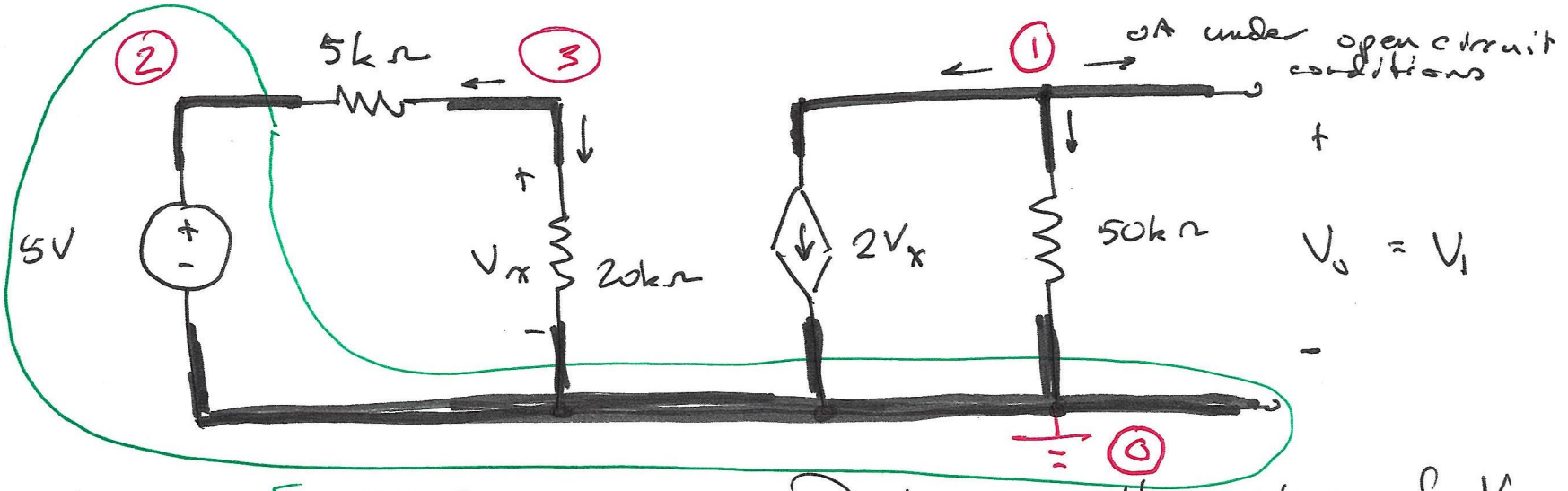
from the L.H.S.:

$$V_x = \frac{20k\Omega}{5k\Omega + 20k\Omega} \cdot 5V = 4V$$

from the R.H.S.:

$$V_1 = (8A)(50k\Omega) = 400kV \quad \text{or} \quad 4 \times 10^5 V$$

$$V_o = -V_1 = -400kV$$



Determine the value of V_o using nodal analysis.

$V_2 = 5V$ (constraint eqn. for the supernode)

$$\frac{V_3 - V_2}{5k\Omega} + \frac{V_3}{20k\Omega} = 0 \quad \text{(KCL for node 3)}$$

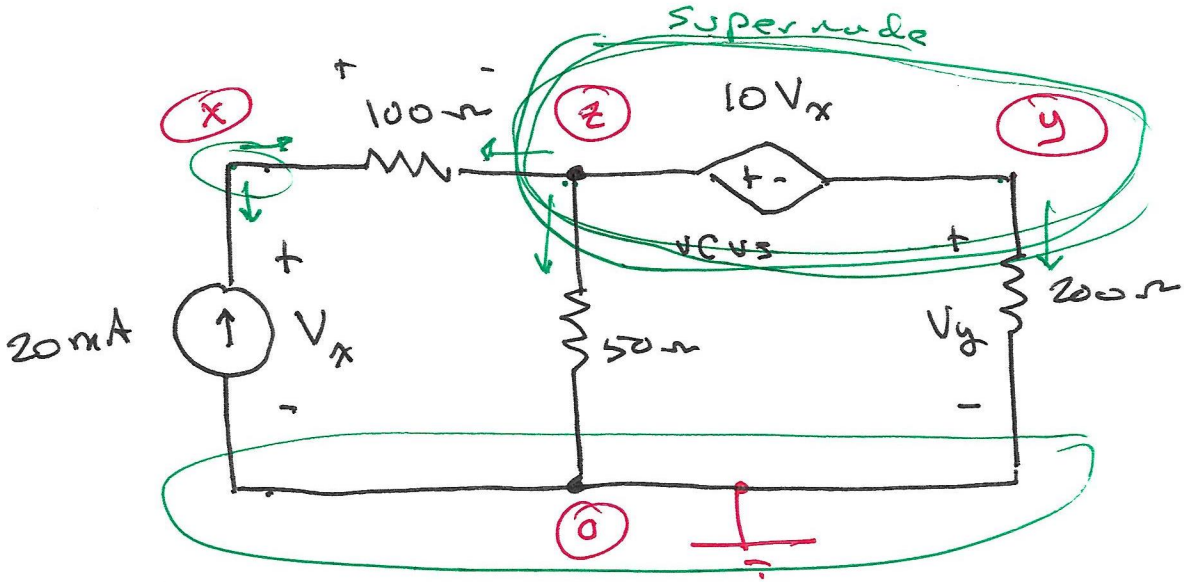
$$2V_x + \frac{V_1}{50k\Omega} + 0 = 0 \quad \text{(KCL for node 1)}$$

$V_x = V_3$ (Definition of V_x in terms of node voltages)

$V_o = V_1$ (Definition of V_o in terms of node voltages.)

In matrix form:

$$\begin{array}{c} \\ \text{eqn 1} \\ \text{eqn 2} \\ \text{eqn 3} \\ \text{eqn 4} \\ \text{eqn 5} \end{array} \begin{array}{c} \begin{array}{ccccc} V_1 & V_2 & V_3 & V_o & V_x \end{array} \\ \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & -1/5000 & \frac{1}{500}+\frac{1}{20000} & 0 & 0 \\ \frac{1}{50000} & 0 & 0 & 0 & 2 \\ 0 & 0 & -1 & 0 & 1 \\ -1 & 0 & 0 & 1 & 0 \end{bmatrix} \end{array} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_o \\ V_x \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$



Set up node eqns. required to solve for V_y.

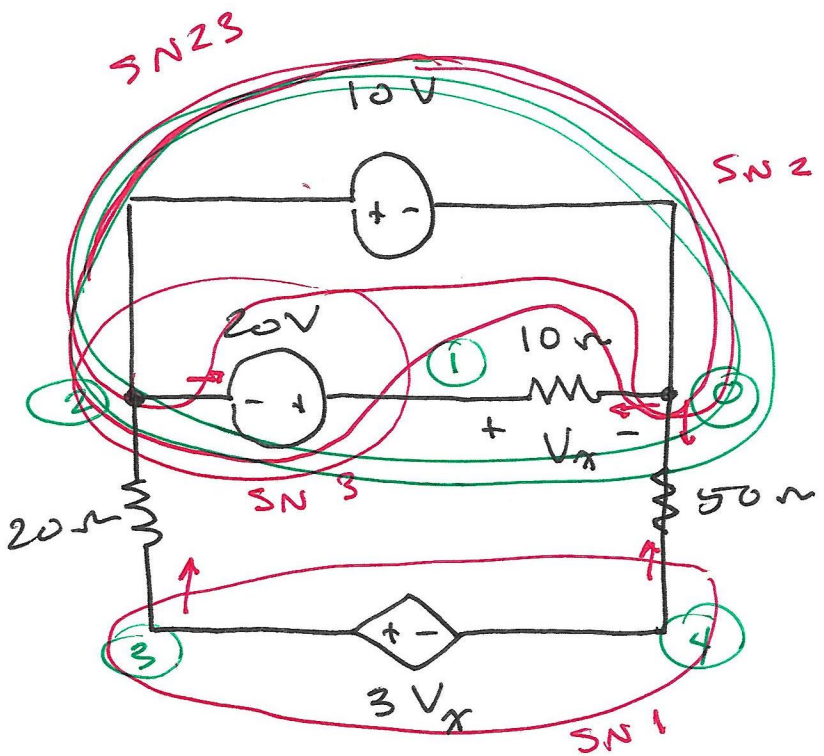
$V_z - V_y = 10\,V_x$ (constraint eqn. for the VCVS) supernode

$$\frac{V_x - V_z}{100} - 20\text{mA} = 0 \qquad \text{(KCL for node } x\text{)}$$

$$\frac{V_z - V_x}{100} + \frac{V_z}{50} + \frac{V_y}{200} = 0 \qquad \text{(KCL for the supernode)}$$

In matrix form:

$$\begin{bmatrix} -10 & -1 & 1 \\ \frac{1}{100} & 0 & -\frac{1}{100} \\ -\frac{1}{100} & \frac{1}{200} & \frac{1}{100}+\frac{1}{50} \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix} = \begin{bmatrix} 0 \\ 20\times10^{-3} \\ 0 \end{bmatrix}$$



For SN1 : $\frac{V_3 - V_2}{20} + \frac{V_4}{50} = 0$ (KCL)

For SN1 : $V_3 - V_4 = 3V_x$ (constraint)

For SN2 : $V_2 = 10$ (constraint)

For SN3 : $V_1 - V_2 = 20$ (constraint)

combine SN2 and SN3 because they have node 2 in common

Definition : $V_x = V_1$