Lecture 5

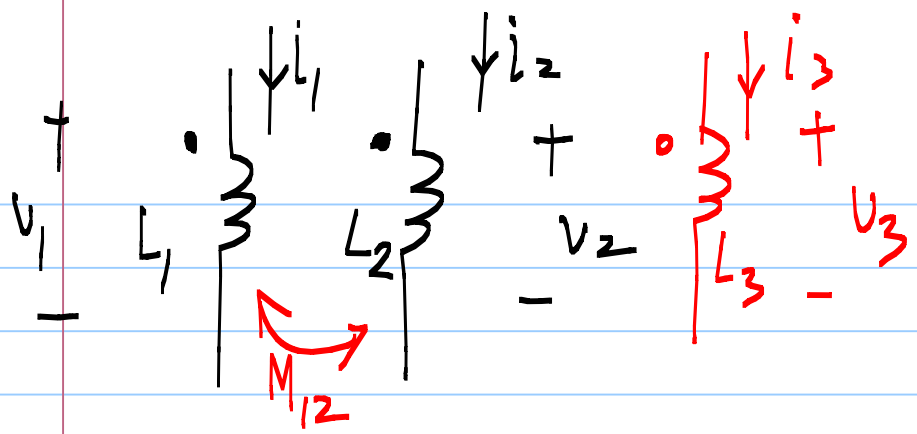
Energy in a mutual inductor : $\frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 + M \cdot I_1 I_2$

For $I_2 = -\frac{M}{L_2} \cdot I_1$

$$\left(L_1 - \frac{M^2}{L_2}\right) \frac{I_1^2}{2} = \left(\frac{L_1 L_2 - M^2}{L_2}\right) \frac{I_1^2}{2}$$

$L_1 L_2 \geq M^2$ $\quad M \leq \sqrt{L_1 L_2}$

$k = \frac{M}{\sqrt{L_1 L_2}} \leq 1$

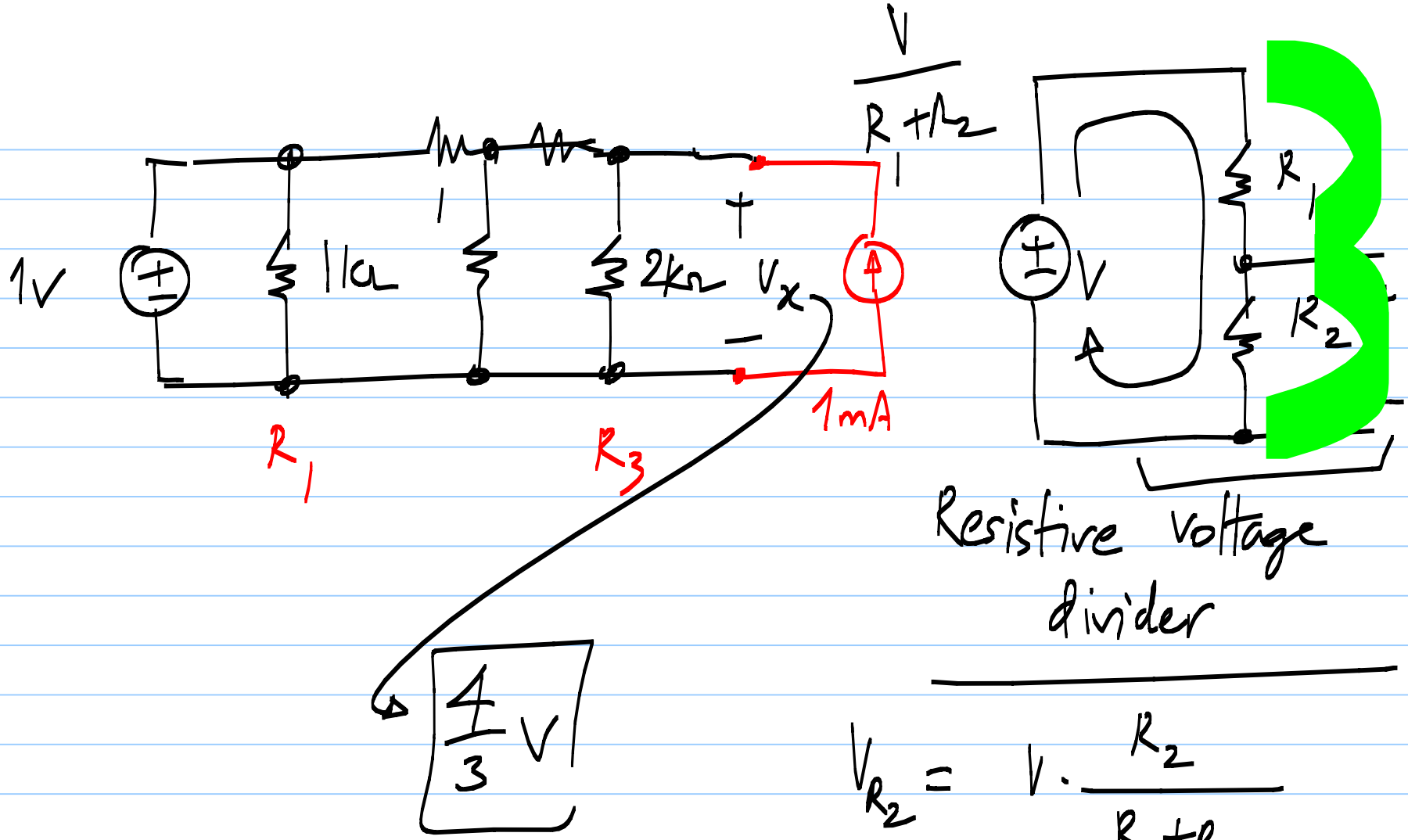


$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} L_1 & M \\ M & L_2 \end{bmatrix} \begin{bmatrix} di_1/dt \\ di_2/dt \end{bmatrix}$$

$$\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} L_1 & M_{12} & M_{13} \\ M_{12} & L_2 & M_{23} \\ M_{13} & M_{23} & L_3 \end{bmatrix} \begin{bmatrix} di_1/dt \\ di_2/dt \\ di_3/dt \end{bmatrix}$$

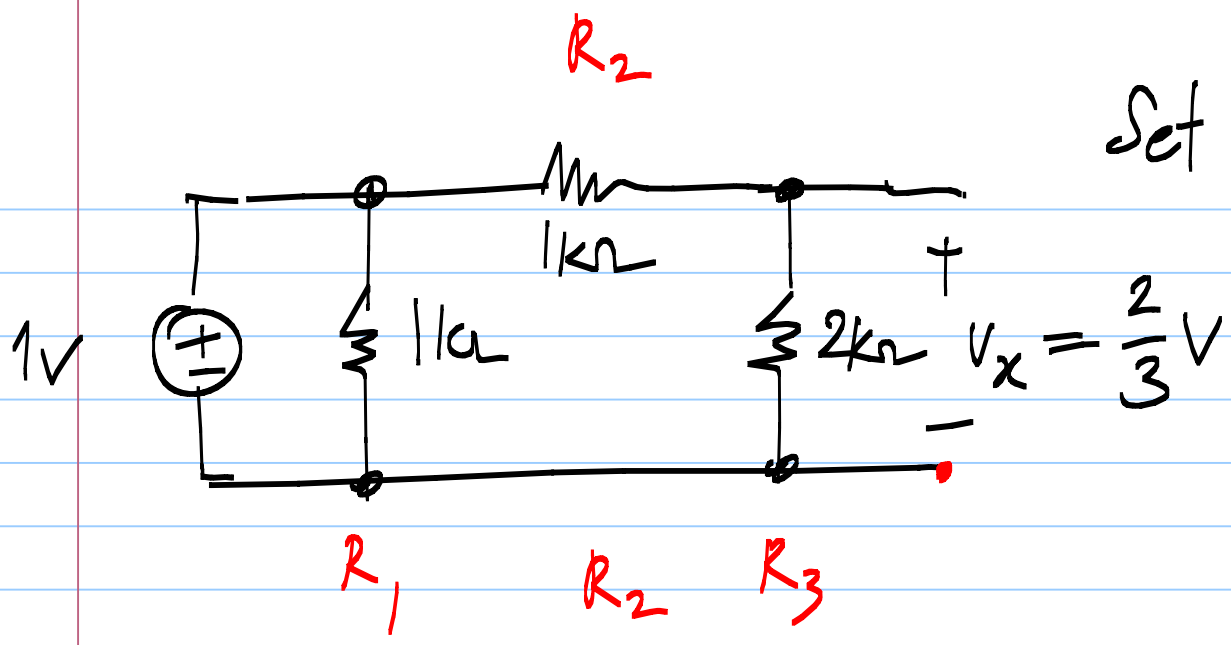
Linear elements: R, L, C, M, Controlled sources

Independent sources: Current source
voltage source

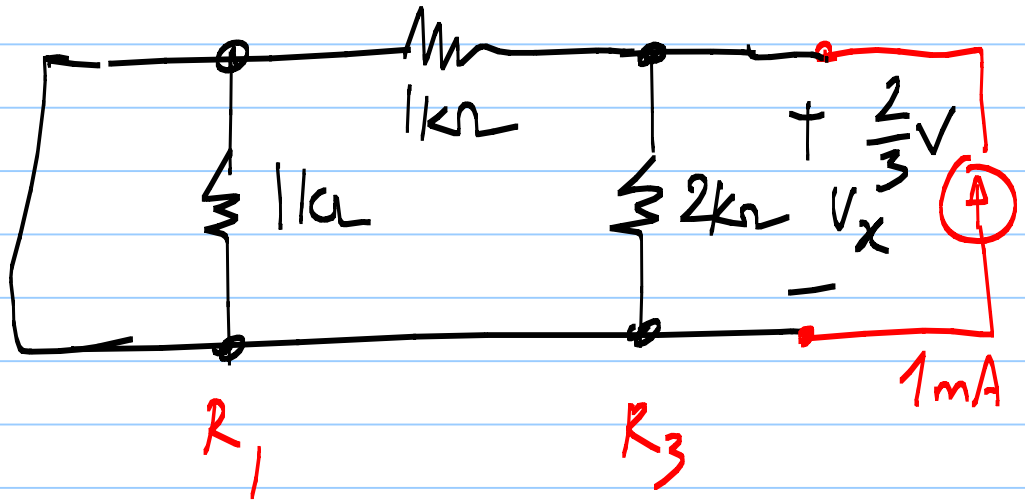


Resistive voltage divider

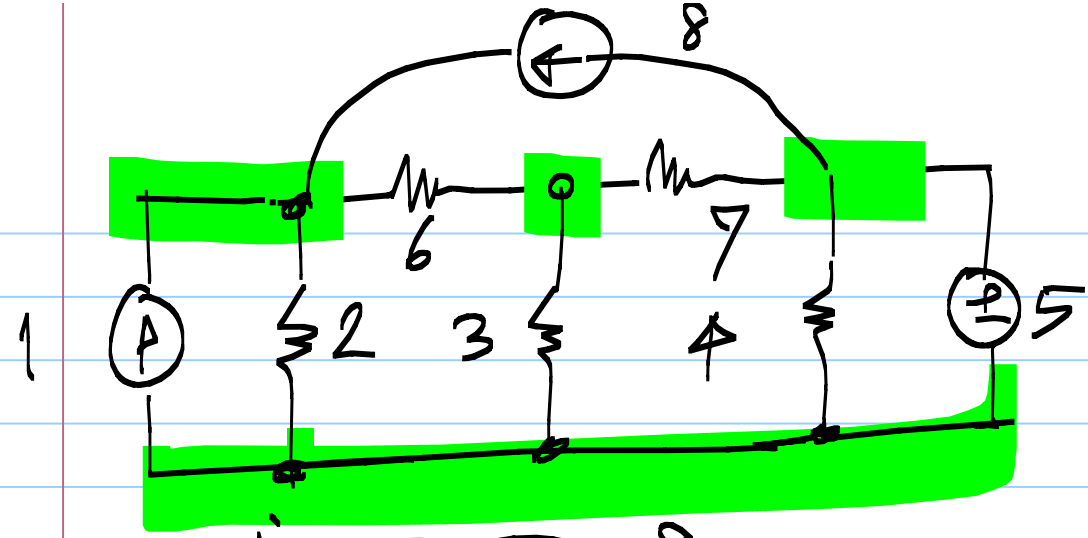
$$V_{R_2} = V \cdot \frac{R_2}{R_1 + R_2}$$



Set the current source value → 0



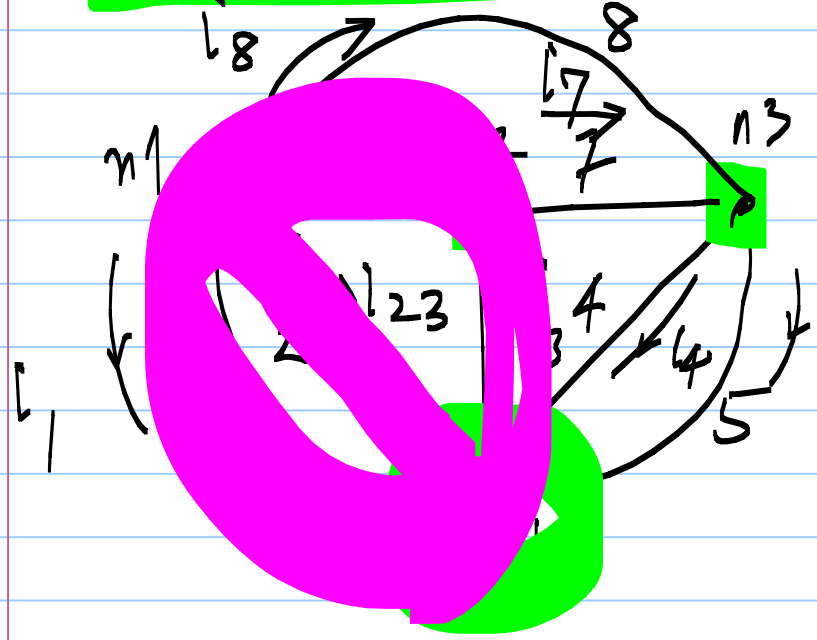
Set Voltage Source value → 0



B branches / N nodes

B voltages &
B currents

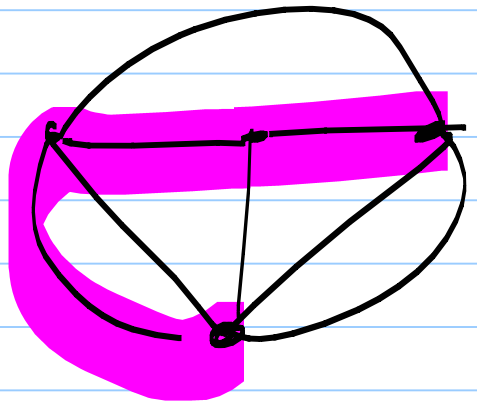
2B variables



$$-i_1 - i_2 - i_6 - i_8 = 0$$
$$i_6 - i_7 - i_3 = 0$$
$$i_7 + i_8 - i_4 - i_5 = 0$$
$$-i_1 - i_2 - i_3 - i_4 - i_5 = 0$$

(3)

Tree: Sub-graph containing all nodes without forming a loop {N-1 branches}



Adding a branch to a tree {which is not in the tree} forms a loop.

$B - (N-1) = B - N + 1$ loops

$B - N + 1$ KVL equations

Circuit with B branches & N nodes

* N-1 independent KCL equations
* B-N+1 " KVL "
* B V-1 relationships for each branch

start with KCL eq: Nodal analysis ✓

start with KVL eq: Link / Mesh analysis

Nodal analysis :