Electrical Systems
Active Circuits

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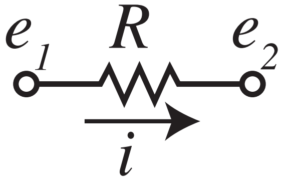
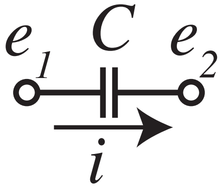
Basic elements

- Resistor



$$e_1 - e_2 = Ri$$

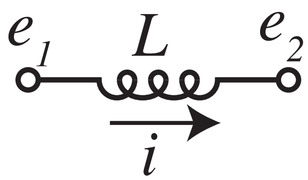
- Capacitor



$$e_1 - e_2 = \frac{1}{C}\int i \mathrm{d}t$$

$$i = C\frac{\mathrm{d}e_c}{\mathrm{d}t} = C\frac{\mathrm{d}}{\mathrm{d}t}(e_1 - e_2) = Cs(e_1 - e_2)$$

- Inductor



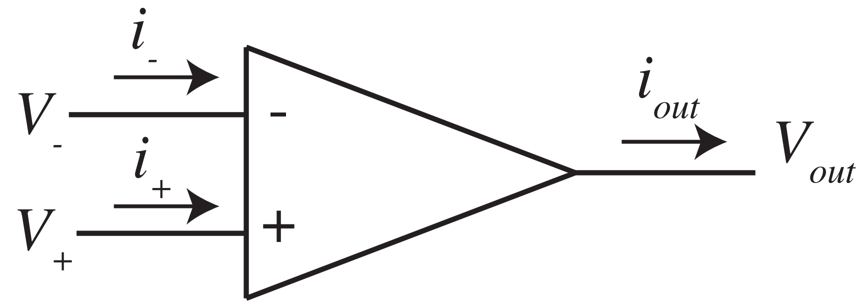
$$e_1 - e_2 = L\frac{\mathrm{d}i}{\mathrm{d}t}$$

$$si = \frac{\mathrm{d}i}{\mathrm{d}t} = \frac{1}{L}(e_1 - e_2)$$

Deriving equations of "motion"

1. Draw a schematic of the circuit. Identify each component with a unique symbolic value. It is usually helpful to give each component a unique number.
2. Identify the nodes of the circuit and assign each one a letter to identify it.
3. For each component, assign the direction of positive current flow and indicate it on the circuit diagram. The current in the n^{th} component will be known as i_n.
4. Write an equation for the current in each component using the established physical relation for each type of component.
5. Define state variables to be *capacitor voltages* and *inductor currents*. Write component equations for capacitors and inductors in state-variable form.
6. Write node equations using KCL for each node that is not directly connected to a voltage source. <u>Where possible, express node voltages in terms of capacitor and input voltages.</u>
7. Use the remaining component equations and node equations to reduce the differential equations so that they contain only the state variables and inputs.

Op-amps – The ideal model



Three assumptions:

1. Both inputs have infinite impedance. The op-amp does not draw current from any input.

$$i_- = i_+ = 0$$

2. The op-amp has infinite gain. When feedback is used, the input voltages are equal.

$$V_+ = V_-$$

3. The op-amp has zero output impedance. Any devices that draw current from the output will have no effect on the output voltage value.

Example P6.29