Circuits and Signals

Inspection method. Superposition Rule

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Recap: DC circuits solving

- Kirchhoff's laws (KCL, KVL),
- device equations,
- nodal method.

Superposition rule

A solution to a linear circuit with N independent sources is a sum of solutions to N circuits that result from the original circuit by reduction to zero all but one independent source (each time we let just a single independent source to act alone).

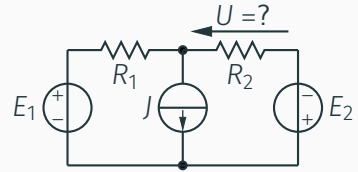
In this way one may find not only the whole solutions but also the individual voltages or currents.

Reduction of a source to zero

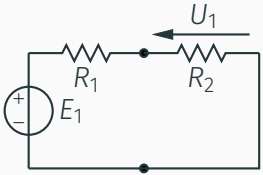
Reduction of a voltage source to zero is equivalent to replacing it with a short-circuit.

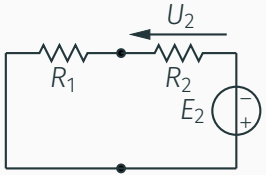
Reduction of a current source to zero is equivalent to replacing it with an open-circuit (a gap).

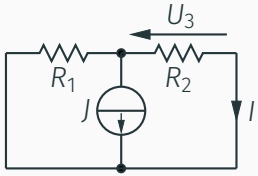
Superposition rule – example



$$U = U_1 + U_2 + U_3.$$







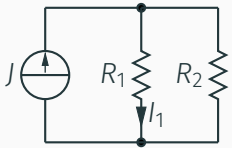
$$U_1 \overset{\text{VDF}}{=} E_1 \frac{R_2}{R_1 + R_2} \qquad U_2 \overset{\text{VDF}}{=} E_2 \frac{R_2}{R_1 + R_2} \qquad U_3 = -JR_2 \frac{R_1}{R_1 + R_2}$$

$$U = \frac{(E_1 + E_2 - JR_1)R_2}{R_1 + R_2}.$$

Circuit solving by inspection

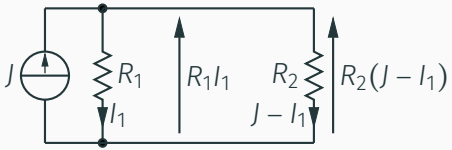
1. Introduce some unknown variables,
2. Determine a number of voltages and currents by means of KVL, KCL and device equations,
3. Setup a number of equations by means of KVL, KCL and device equations,
4. If the number of equations is not big enough go to 1.
5. Solve the equations.

Current Divider Formula (CDF)



$I_1 = ?$

CDF cont.



Ohm's law : $U_1 = R_1 I_1$

KCL : $I_2 = J - I_1$

Ohm's law : $U_2 = R_2 I_2$

KVL : $\underbrace{R_1 I_1}_{U_1} = \underbrace{R_2(J - I_1)}_{U_2}$

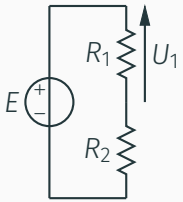
$$I_1(R_1 + R_2) = JR_2$$

$$I_1 = J\frac{R_2}{R_1 + R_2}$$

Similarly:

$$I_2 = J\frac{R_1}{R_1 + R_2}.$$

Voltage Divider Formula



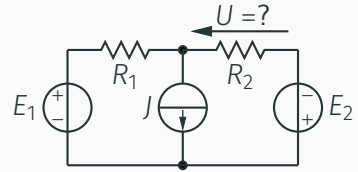
$$U_1 = E\frac{R_1}{R_1 + R_2}, \qquad U_2 = E\frac{R_2}{R_1 + R_2}.$$

Nodal method

Nodal method

1. Label all the nodes with variables $e_1, e_2, \ldots, e_{N-1}, e_N = 0$ denoting electric potentials,

Superposition rule – the example revisited



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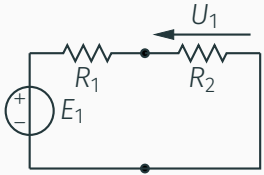

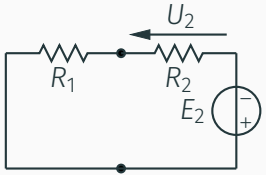

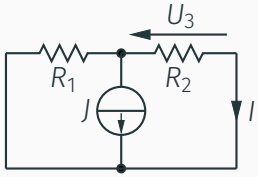

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