Circuits and Signals

Equivalent devices

Marek Rupniewski

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Faculty of Electronics and Information Technology

WARSAW UNIVERSITY OF TECHNOLOGY

Equivalent devices

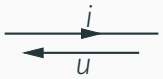
Devices are called equivalent if they are governed by equivalent equations.

Equivalent devices

In DC case

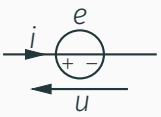
$u = 0$

short-circuit

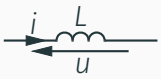


resistor $R = 0$

source $e = 0$

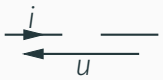


inductor



$i = 0$

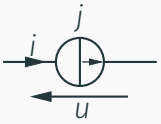
open-circuit



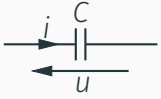
resistor $G = 0$

$(R = \infty)$

source $j = 0$

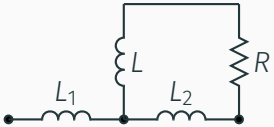


capacitor



Series connections of one-ports

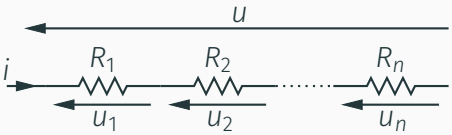
Two one-ports are said to be connected in a series if and only if they have exactly one common terminal and no other device is connected to that terminal.



Resistor R and inductor L do form a series connection.

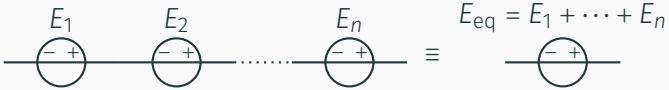
Inductors L_1 and L_2 do not form a series connection.

Series connections of resistors



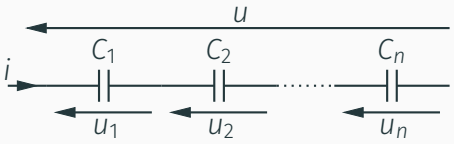
$$u \overset{\text{KVL}}{=} u_1 + \cdots + u_n \overset{u_k = R_k i}{=} i \underbrace{(R_1 + R_2 + \cdots + R_n)}_{R_{eq}}$$

Series connections of voltage sources



Series connections of inductors

Series connections of capacitors



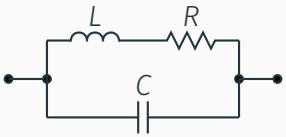
$$u' \overset{\text{KVL}}{=} u'_1 + \cdots + u'_n \overset{i=C_k u'_k}{=} i\left(\frac{1}{C_1} + \cdots + \frac{1}{C_n}\right)$$

$$i = \underbrace{\left(\frac{1}{C_1} + \cdots + \frac{1}{C_n}\right)^{-1}}_{C_{eq}} u'.$$

Series connections of current sources

Parallel connections of one-ports

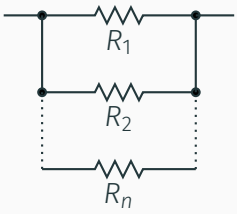
Two or more one-ports form a parallel connection if and only if there exist two distinct nodes that are terminals of each of the one-ports.



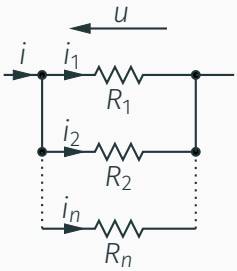
One-ports L and C do not form a parallel connection.

The capacitor is parallel connected with one-port that is a series connection of L and R.

Parallel connections of resistors



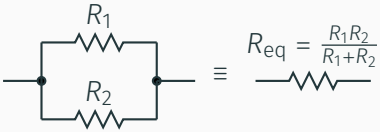
$$\equiv \quad R_{\text{eq}} = \left(\frac{1}{R_1} + \cdots + \frac{1}{R_n}\right)^{-1}$$



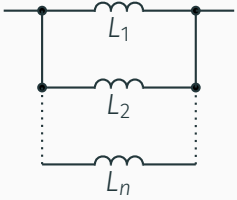
$$i \overset{\text{KCL}}{=} i_1 + \cdots + i_n \overset{u=R_k i_k}{=} u\left(\frac{1}{R_1} + \cdots + \frac{1}{R_n}\right)$$

$$u = \underbrace{\left(\frac{1}{R_1} + \cdots + \frac{1}{R_n}\right)^{-1}}_{R_{\text{eq}}} i.$$

Parallel connections of 2 resistors

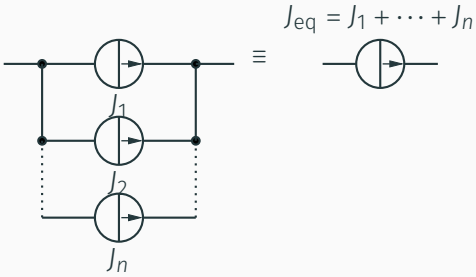


Parallel connections of inductors

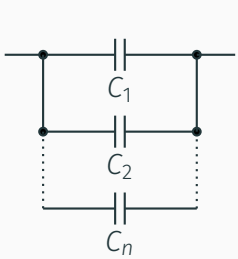


$$\equiv \quad L_{\text{eq}} = \left(\frac{1}{L_1} + \cdots + \frac{1}{L_n} \right)^{-1}$$

Parallel connections of current sources

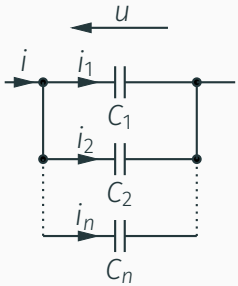


Parallel connections of capacitors



$\equiv$

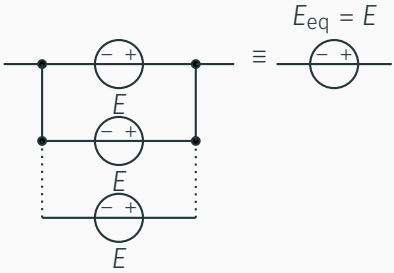
$$C_{eq} = C_1 + \cdots + C_n$$



$$i \overset{\text{KCL}}{=} i_1 + \cdots + i_n$$

$$\overset{i_k = C_k u'}{=} \underbrace{(C_1 + \cdots + C_n)}_{C_{eq}} u'$$

Parallel connections of voltage sources



One-port connections — reordering