Modele obwodów elektrycznych
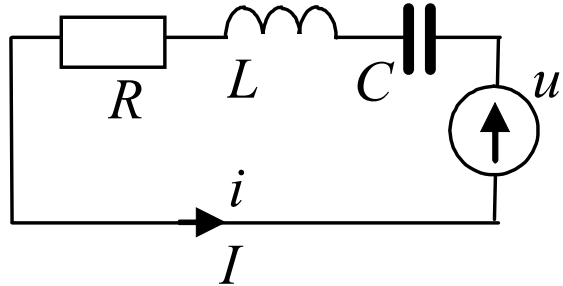
(1) $jωL\,I + R\,I + \dfrac{1}{jωC}\,I = U$

(2) $L\dfrac{di(t)}{dt} + Ri(t) + \dfrac{1}{C}\int i(t)\,dt = u(t)$

(3) $L\ddot{q}(t) + R\dot{q}(t) + \dfrac{1}{C}q(t) = u(t)$

(4) $sL\,i(s) + R\,i(s) + \dfrac{1}{sC}i(s) = u(s)$

(5) $i(s) = \dfrac{sC}{s^2 LC + sRC + 1}\,u(s)$

$u(t) = U\sin(ωt)$

$i(t) = I\sin(ωt + φ)$
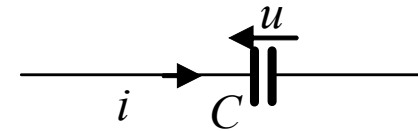
$s = jω$

$i(t) = \dfrac{dq(t)}{dt}$

$i(s) = sq(s)$

Obwody elektryczne
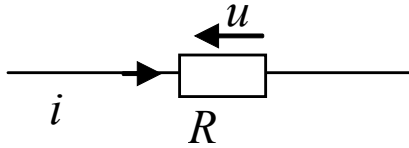
$$u(t) = Ri(t)$$
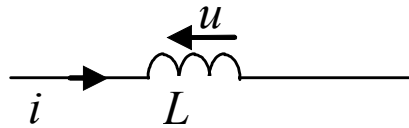
$$u(t) = -L\frac{di(t)}{dt}$$

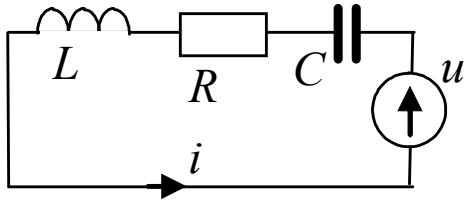$$u(t) = \frac{1}{C}q(t)$$

$$u(t) = \frac{1}{C}\int i(t)dt$$

Tab. I-6. Stosowane opisy podstawowych elementów elektrycznych

	$u(i)$		$i(u)$	$u(q)$	$Z(s)$
rezystor (R)	$u(t) = Ri(t)$	$u(s) = Ri(s)$	$i(t) = Gu(t)$	$u(t) = R\dot{q}(t)$	R
kondensator (C)	$u(t) = \frac{1}{C}\int i(t)dt$	$u(s) = \frac{1}{sC}i(s)$	$i(t) = C\frac{du(t)}{dt}$	$u(t) = \frac{1}{C}q(t)$	$\frac{1}{sC}$
cewka (L)	$e_L(t) = -L\frac{di(t)}{dt}$	$u(s) = sLi(s)$	$i(t) = \frac{1}{L}\int u(t)dt$	$u(t) = L\ddot{q}(t)$	sL

$$i(t) = \frac{dq(t)}{dt}$$

$$i(s) = sq(s)$$

Obwody elektryczne

$$jωLI + RI + \frac{1}{jωC}I = U$$

$$sLi(s) + Ri(s) + \frac{1}{sC}i(s) = u(s)$$

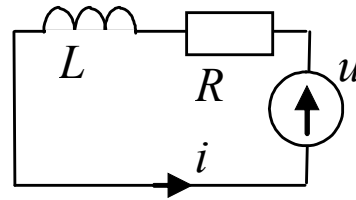$$L\frac{di(t)}{dt} + Ri(t) + \frac{1}{C}\int i(t)dt = u(t)$$

$$L\ddot{q}(t) + R\dot{q}(t) + \frac{1}{C}q(t) = u(t)$$

$$q(s) = \left(\frac{C}{s^2LC + sRC + 1}\right)u(s)$$

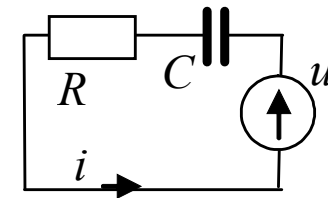$$i(s) = \left(\frac{sC}{s^2LC + sRC + 1}\right)u(s)$$

$$\boxed{i(s) = sq(s)}$$

$$L\frac{di(t)}{dt} + Ri(t) = u(t)$$

$$sLi(s) + Ri(s) = u(s)$$

$$i(s) = \left(\frac{1}{sL + R}\right)u(s)$$

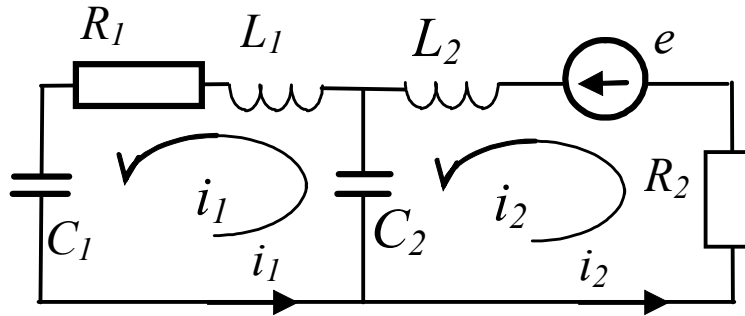$$Ri(t) + \frac{1}{C}\int i(t)dt = u(t)$$

$$Ri(s) + \frac{1}{sC}i(s) = u(s)$$

$$i(s) = \left(\frac{sC}{sRC + 1}\right)u(s)$$

$$R\dot{q}(t) + \frac{1}{C}q(t) = u(t)$$

$$sRq(t) + \frac{1}{C}q(t) = u(t)$$

$$q(s) = \left(\frac{C}{sCR + 1}\right)u(s)$$

Obwody elektryczne

$$\begin{cases} e = L_2 \dfrac{di_2}{dt} + R_2 i_2 + \int \dfrac{i_2 - i_1}{C_2} dt \\[4mm] 0 = L_1 \dfrac{di_1}{dt} + R_1 i_1 + \int \dfrac{i_1}{C_1} dt + \int \dfrac{i_1 - i_2}{C_2} dt \end{cases}$$

$$\begin{cases} e = sL_2 i_2 + R_2 i_2(s) + \dfrac{i_2 - i_1}{sC_2} \\[4mm] 0 = sL_1 i_1 + R_1 i_1 + \dfrac{i_1}{sC_1} + \dfrac{i_1 - i_2}{sC_2} \end{cases}$$

rząd?

$$\begin{cases} e = L_2 \ddot{q}_2 + R_2 \dot{q}_2 + \dfrac{q_2 - q_1}{C_2} \\[4mm] 0 = L_1 \ddot{q}_1 + R_1 \dot{q}_1 + \dfrac{q_1}{C_1} + \dfrac{q_1 - q_2}{C_2} \end{cases}$$

$$\begin{cases} sC_2 e = M_2 i_2 - i_1 \\ 0 = M_1 i_1 - C_1 i_2 \end{cases}$$

$$\begin{cases} C_2 e = M_2 q_2 - q_1 \\ 0 = M_1 q_1 - C_1 q_2 \end{cases}$$

$$M_2 = s^2 C_2 L_2 + s C_2 R_2 s + 1$$

$$M_1 = s^2 C_1 C_2 L_1 + s C_1 C_2 R_1 + C_2 + C_1$$
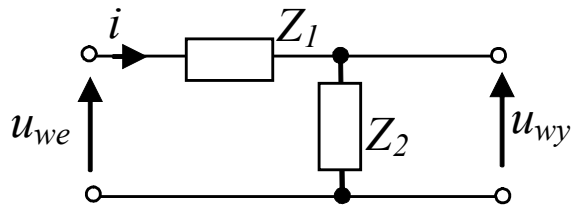
$$i_1 = \frac{sC_1 C_2}{M_1 M_2 - C_1} e$$

$$q_1 = \frac{C_1 C_2}{M_1 M_2 - C_1} e$$

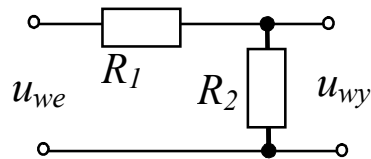$$i_2 = \frac{sC_2 M_1}{M_1 M_2 - C_1} e$$

$$\boxed{i(s) = sq(s)}$$

$$q_2 = \frac{C_2 M_1}{M_1 M_2 - C_1} e$$
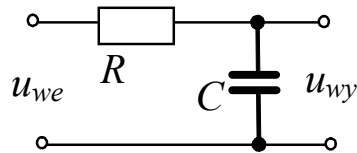
Obwody elektryczne - czwórniki

$$\begin{cases} u_{we} = (Z_1 + Z_2)i \\ u_{wy} = Z_2 i \end{cases}$$

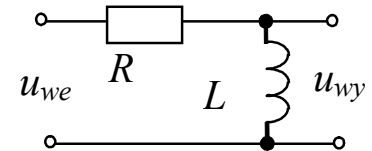$$u_{wy} = \left(\frac{Z_2}{Z_1 + Z_2} \right) u_{we}$$

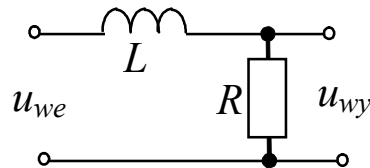$$u_{wy}(s) = \left(\frac{R_2}{R_1 + R_2} \right) u_{we}(s)$$

$$Z_1 = R$$
$$Z_2 = 1/sC$$
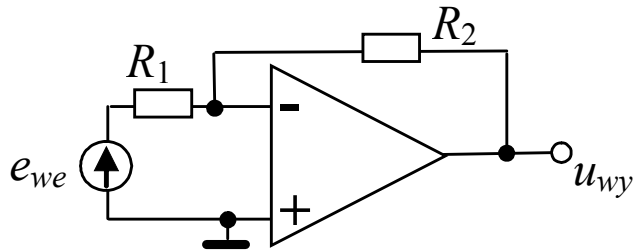
$$u_{wy}(s) = \left(\frac{1}{sCR + 1} \right) u_{we}(s)$$

$$Z_1 = R$$
$$Z_2 = sL$$

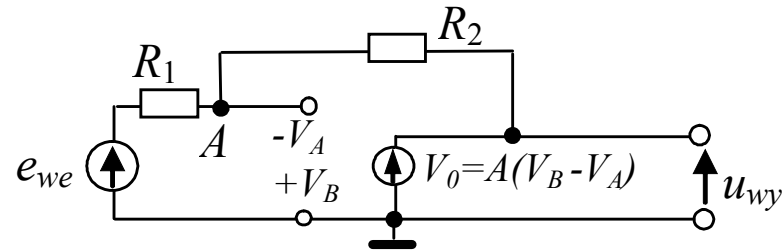$$u_{wy}(s) = \left(\frac{sL}{sL + R} \right) u_{we}(s)$$

$$u_{wy}(s) = \left(\frac{R}{sL + R} \right) u_{we}(s)$$

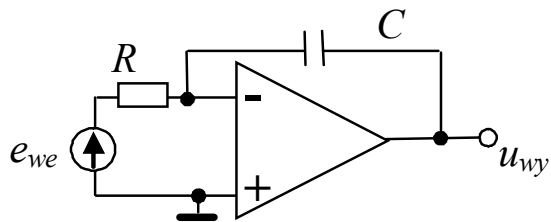# Obwody elektryczne – wzmacniacze operacyjne
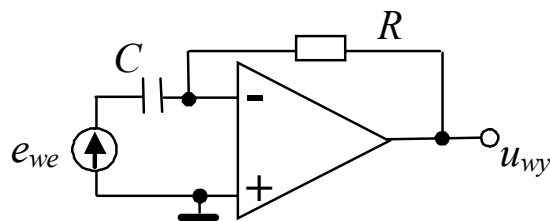

$$u_{wy} = \frac{-Z_2}{Z_1} e_{we}$$

$$\begin{cases} \dfrac{V_A - e_{we}}{R_1} = \dfrac{V_0 - V_A}{R_2} \\ u_{wy} = V_0 = A(V_B - V_A) = -A V_A \end{cases}$$

$$u_{wy} = \frac{-R_2}{R_1 + \dfrac{R_1 + R_2}{A}} e_{we} \xrightarrow{\;A \to \infty\;} u_{wy} = \frac{-R_2}{R_1} e_{we}$$

$$Z_1 = R$$
$$Z_2 = 1/sC$$

$$u_{wy} = \frac{-1}{sRC} e_{we}$$

$$Z_1 = 1/sC$$
$$Z_2 = R$$

$$u_{wy} = -sRC\, e_{we}$$

Układy mechaniczne
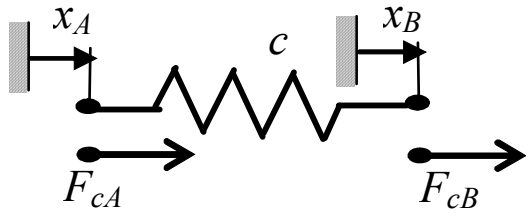
$$F_{cA}(t) = c\left(x_A(t) - x_B(t)\right)$$

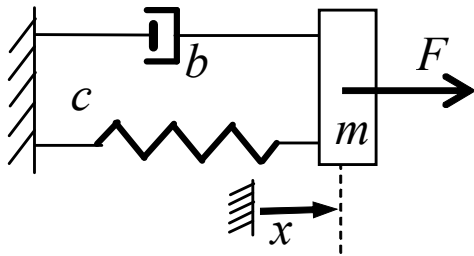$$F_{cB}(t) = c\left(x_B(t) - x_A(t)\right)$$
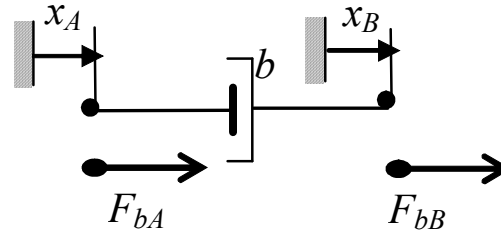
$$F_{bA}(t) = b\left(\dot{x}_A(t) - \dot{x}_B(t)\right)$$

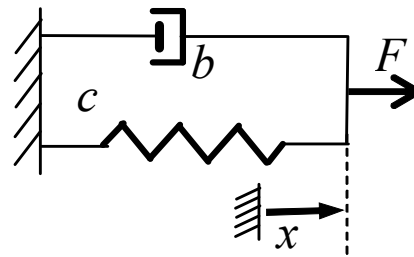$$F_{bB}(t) = b\left(\dot{x}_B(t) - \dot{x}_A(t)\right)$$
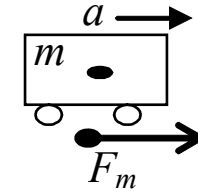
$$F_m(t) = m\ddot{x}(t)$$
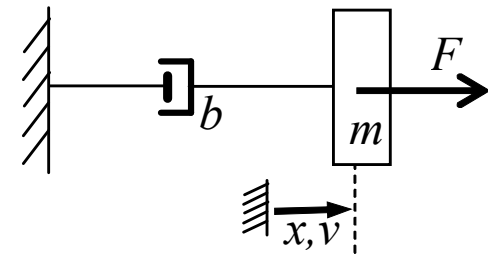
$$m\ddot{x}(t) + b\dot{x}(t) + cx(t) = F(t)$$

$$ms^2x(s) + bsx(s) + cx(s) = F(s)$$

$$b\dot{x}(t) + cx(t) = F(t)$$

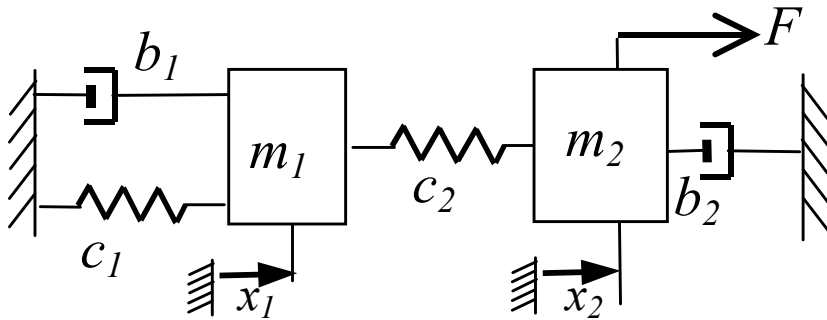$$bsx(s) + cx(s) = F(s)$$

$$x(s) = \left(\frac{1}{sb+c}\right)F(s)$$

$$m\ddot{x}(t) + b\dot{x}(t) = F(t)$$

$$m\dot{v}(t) + bv(t) = F(t)$$

$$v(s) = \left(\frac{1}{sm+b}\right)F(s)$$

$$\begin{cases} F = m_2\ddot{x}_2 + b_2\dot{x}_2 + c_2(x_2 - x_1) \\ 0 = m_1\ddot{x}_1 + b_1\dot{x}_1 + c_1x_1 + c_2(x_1 - x_2) \end{cases}$$

$$\begin{cases} F = s^2 m_2 x_2 + s b_2 x_2 + c_2(x_2 - x_1) \\ 0 = s^2 m_1 x_1 + s b_1 x_1 + c_1 x_1 + c_2(x_1 - x_2) \end{cases}$$