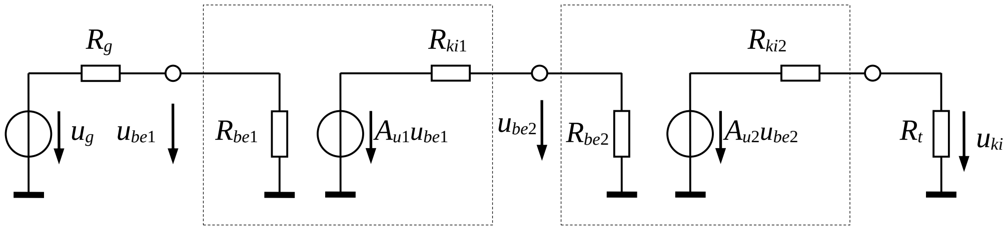
Kaszkád kapcsolású fokozatok eredő átvitelének számítása:



$$\frac{u_{ki}}{u_g} = \frac{u_{be1}}{u_g}\frac{A_{u1}u_{be1}}{u_{be1}}\frac{u_{be2}}{A_{u1}u_{be1}}\frac{A_{u2}u_{be2}}{u_{be2}}\frac{u_{ki}}{A_{u2}u_{be2}} = L_{be}A_{u1}L_{12}A_{u2}L_{ki}$$

Ahol:

$$\frac{u_{be1}}{u_g} = L_{be1} = \frac{R_{be1}}{R_g + R_{be1}}, \qquad \frac{A_{u1}u_{be1}}{u_{be1}} = A_{u1}, \qquad \frac{u_{be2}}{A_{u1}u_{be1}} = L_{12} = \frac{R_{be2}}{R_{ki1} + R_{be2}}$$

$$\frac{A_{u2}u_{be2}}{u_{be2}} = A_{u2}, \qquad \frac{u_{ki}}{A_{u2}u_{be2}} = L_{ki} = \frac{R_t}{R_{ki2} + R_t}$$

$$\boxed{\frac{u_{ki}}{u_g} = L_{be}A_{u1}L_{12}A_{u2}L_{ki}}$$

A fokozatok közötti leosztás speciális esetekben elmarad:

$L_{be} = 1$ ha $R_g = 0$ és/vagy $R_{be1} = \infty$

$L_{12} = 1$ ha $R_{ki1} = 0$ és/vagy $R_{be2} = \infty$

$L_{ki} = 1$ ha $R_{ki2} = 0$ és/vagy $R_t = \infty$

Kisjelű frekvencia függő vizsgálat

Frekvencia függést okozó áramköri elemek:

Beépített:

- Csatoló kondenzátor
- Emitter kondenzátor
- Csatoló tekercs
- Csatoló transzformátor

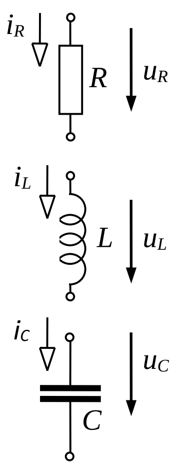
Parazita elemek

- Kábel kapacitás
- Félvezetők belső kapacitásai
- Szórt kapacitás/induktivitás (szerelési hatások)

Áramköri elemek:

Idő tartomány **- *t*** Operátor tartomány: ***s***

Laplace transzformáció $\longrightarrow$

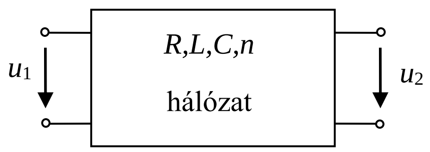


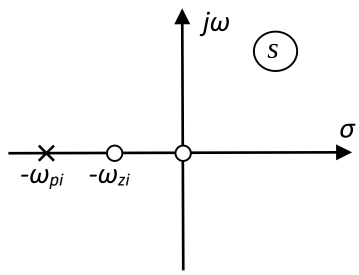
$$u_R(t) = Ri_R(t) \qquad Z_R = \frac{U_R(s)}{I_R(s)} = R$$

$$u_L(t) = L\frac{di_L(t)}{dt} \qquad Z_L(s) = \frac{U_L(s)}{I_L(s)} = sL$$

$$i_C(t) = C\frac{du_C(t)}{dt} \qquad Z_C(s) = \frac{U_C(s)}{I_C(s)} = \frac{1}{sC}$$

Bode diagram:





A transzfer függvény *Bode* gyöktényezős alakban:
$$H(s) = \frac{U_2(s)}{U_1(s)} = ks^n \frac{\prod_i \left(1 + \frac{s}{\omega_{zi}}\right)}{\prod_i \left(1 + \frac{s}{\omega_{pi}}\right)}$$

$$H(j\omega) = H(s)\big|_{s=j\omega} = A(\omega)e^{j\varphi(\omega)}$$

$A(\omega)$: amplitúdó karakterisztika

$\varphi(\omega)$: fázis karakterisztika

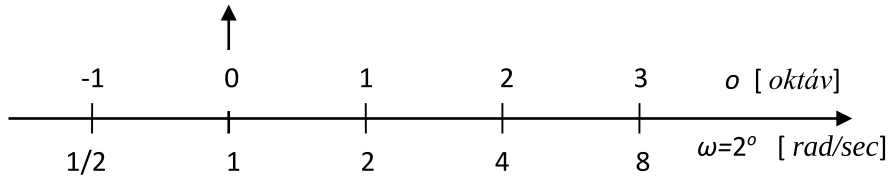
Pld.: $$H(j\omega) = A(\omega)e^{j\varphi(\omega)} = \frac{A_1(\omega)A_2(\omega)}{A_3(\omega)} e^{j[\varphi_1(\omega)+\varphi_2(\omega)-\varphi_3(\omega)]}$$

Kétszer logaritmikus koordináta rendszert használunk, mivel:

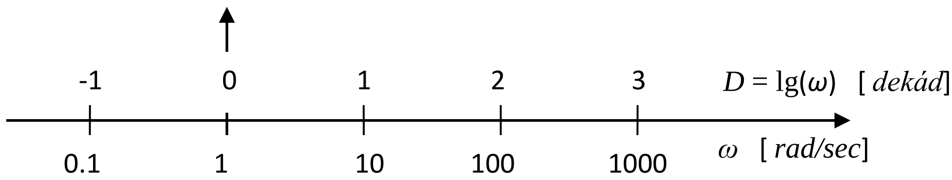
- Ebben a rendszerben a hatványfüggvények egyenesek
- $\lg \frac{A_1 A_2}{A_3} = \lg A_1 + \lg A_2 - \lg A_3$ (grafikusan összeadni/kivonni tudunk)

Logaritmikus „x" tengely (frekvencia) (abszcissza)

Oktáv rendszer:



Dekadikus rendszer:



Logaritmikus „y" tengely (ordináta)

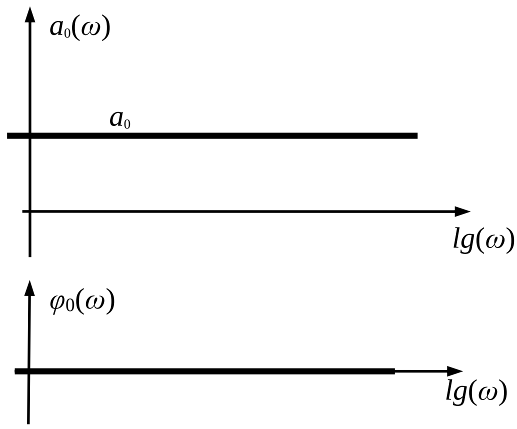
$$a^{dB}(\omega) = 10\lg\left|\frac{U_2}{U_1}\right|^2 = 20\lg A(\omega)$$

A	1	10	100	1000	0.1	2	$\sqrt{2}$	5	$1/\sqrt{2}$
a [dB]	0	20	40	60	-20	6	3	14	-3

Bode alaptagok:

1.) Konstans: $H_0 = k$

$$a_0 = 20\lg|k| \qquad \varphi_0 = \begin{cases} 0 & ha \quad k \geq 0 \\ \pm\pi & ha \quad k < 0 \end{cases}$$

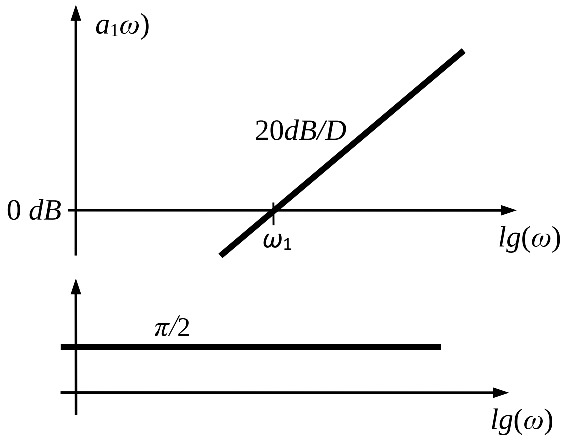


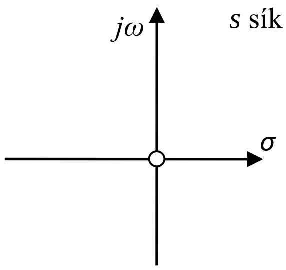
2.) $H_1(s) = \dfrac{s}{\omega_1}$

$$H_1(j\omega) = j\frac{\omega}{\omega_1}$$

$$A_1(\omega) = \frac{\omega}{\omega_1}$$

$$\varphi(\omega) = +\frac{\pi}{2}$$



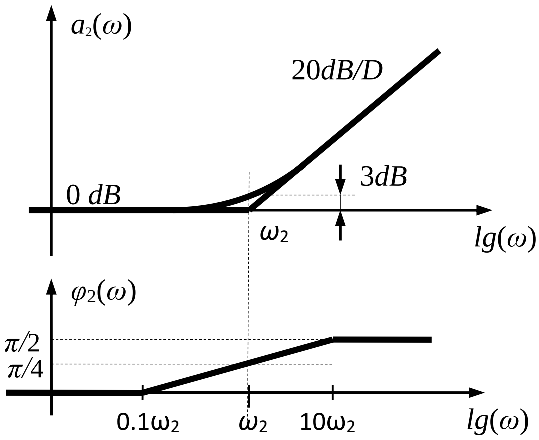


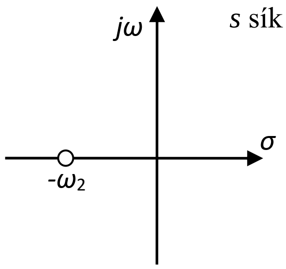
3.) $H_2(s) = 1 + \dfrac{s}{\omega_2}$

$$H_2(j\omega) = 1 + j\frac{\omega}{\omega_2}$$

$$A_2(\omega) = \sqrt{1 + \left(\frac{\omega}{\omega_2}\right)^2}$$

$$\varphi_2(\omega) = arctg\left(\frac{\omega}{\omega_2}\right)$$



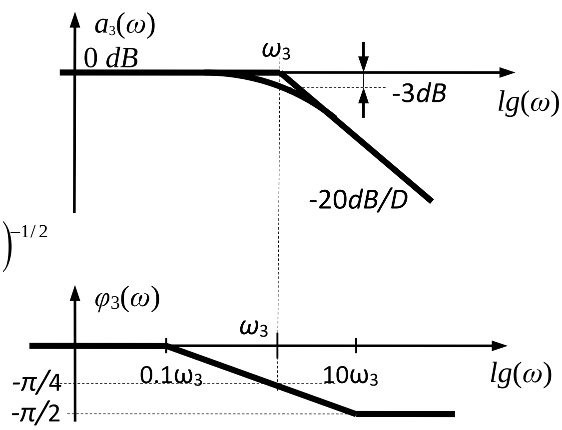


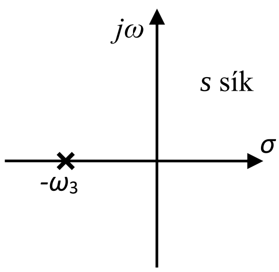
4.) $H_3(s) = \dfrac{1}{1 + s/\omega_3}$

$$H_3(j\omega) = \frac{1}{1 + j\omega/\omega_3}$$

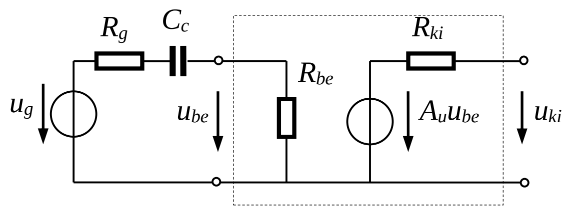
$$A_3(\omega) = \left(1 + (\omega/\omega_3)^2\right)^{-1/2}$$

$$\varphi_3(\omega) = -arctg\left(\frac{\omega}{\omega_3}\right)$$





A csatoló kondenzátor hatása (C_c):

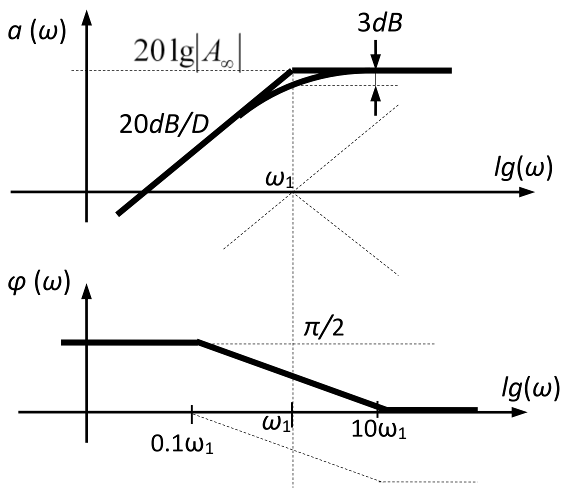


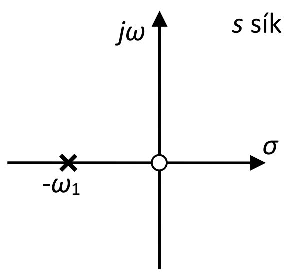
$$L_{be0} = \left.\frac{u_{be}}{u_g}\right|_{C_c\to\infty} = \frac{R_{be}}{R_g + R_{be}} \qquad A_\infty = \left.\frac{u_{ki}}{u_g}\right|_{C_c\to\infty} = L_{be0} A_u$$

$$L_{be}(s) = \frac{R_{be}}{R_g + \frac{1}{sC_c} + R_{be}} = \frac{sC_c R_{be}}{1 + sC_c\left(R_g + R_{be}\right)} = \frac{R_{be}}{R_g + R_{be}} \frac{sC_c\left(R_g + R_{be}\right)}{1 + sC_c\left(R_g + R_{be}\right)} = L_{be0} \frac{s/\omega_1}{1 + s/\omega_1}$$

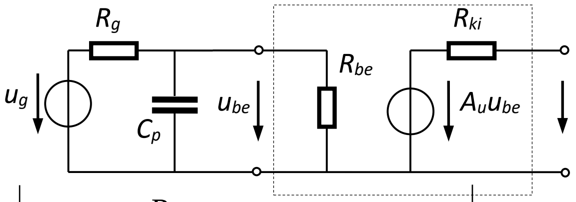
Ahol: $$\omega_1 = \frac{1}{C_c\left(R_g + R_{be}\right)} = \omega_{alsó}$$

$$\frac{u_{ki}}{u_g}(s) = L_{be}(s) A_u = L_{be0} A_u \frac{s/\omega_1}{1 + s/\omega_1} = A_\infty \frac{s/\omega_1}{1 + s/\omega_1}$$





Párhuzamos kondenzátor hatása (C_p):



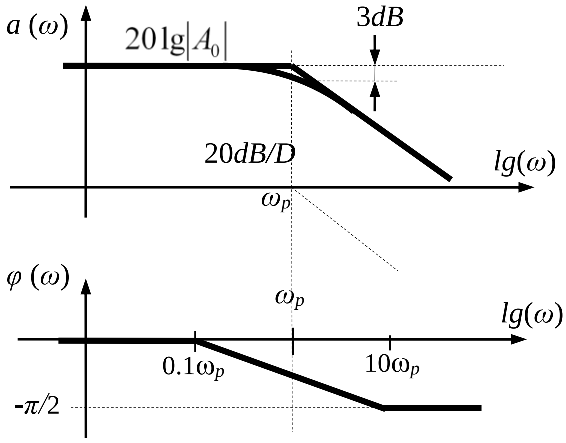
$$L_{be0} = \left.\frac{u_{be}}{u_g}\right|_{C_c \to \infty} = \frac{R_{be}}{R_g + R_{be}} \qquad A_0 = \left.\frac{u_{ki}}{u_g}\right|_{C_p = 0} = L_{be0} A_u$$

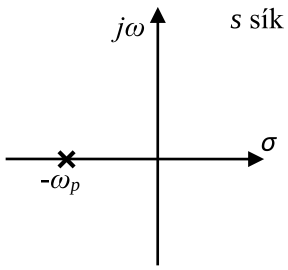
$$L_{be}(s) = \frac{R_{be} \times (1/sC_p)}{R_g + R_{be} \times (1/sC_p)} = \frac{\dfrac{R_{be}}{1 + sC_p R_{be}}}{R_g + \dfrac{R_{be}}{1 + sC_p R_{be}}} =$$

$$= \frac{R_{be}}{(R_g + R_{be}) + sC_p R_g R_{be}} = \frac{R_{be}}{R_g + R_{be}} \frac{1}{1 + sC_p (R_g \times R_{be})} = L_{be0} \frac{1}{1 + s/\omega_p}$$

Ahol: $\omega_p = \dfrac{1}{C_p (R_g \times R_{be})} = \omega_{felső}$

Ezzel: $\dfrac{u_{ki}}{u_g}(s) = L_{be}(s) A_u = L_{be0} A_u \dfrac{1}{1 + s/\omega_p} = A_0 \dfrac{1}{1 + s/\omega_p}$





Csatoló- + párhuzamos kondenzátor együttes hatása: