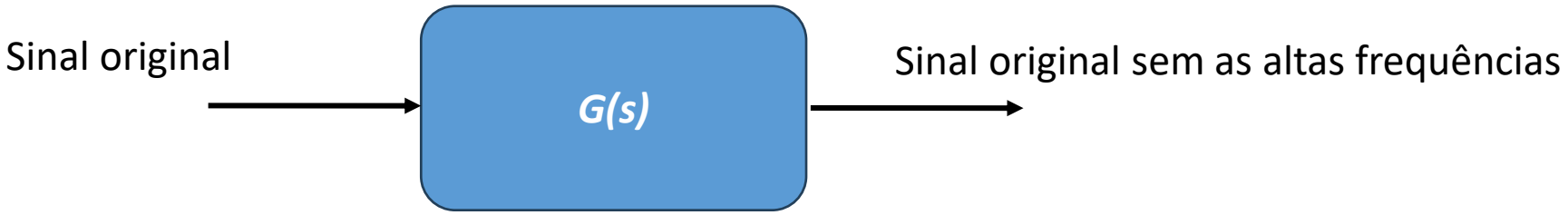
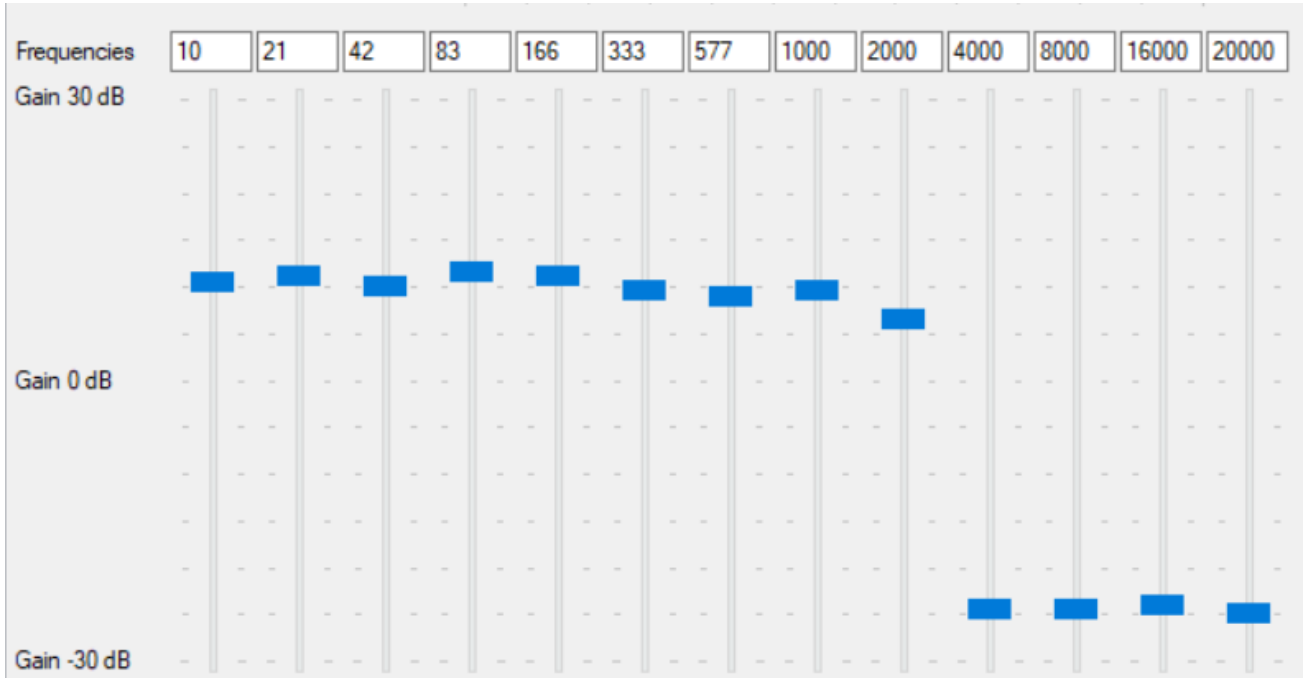
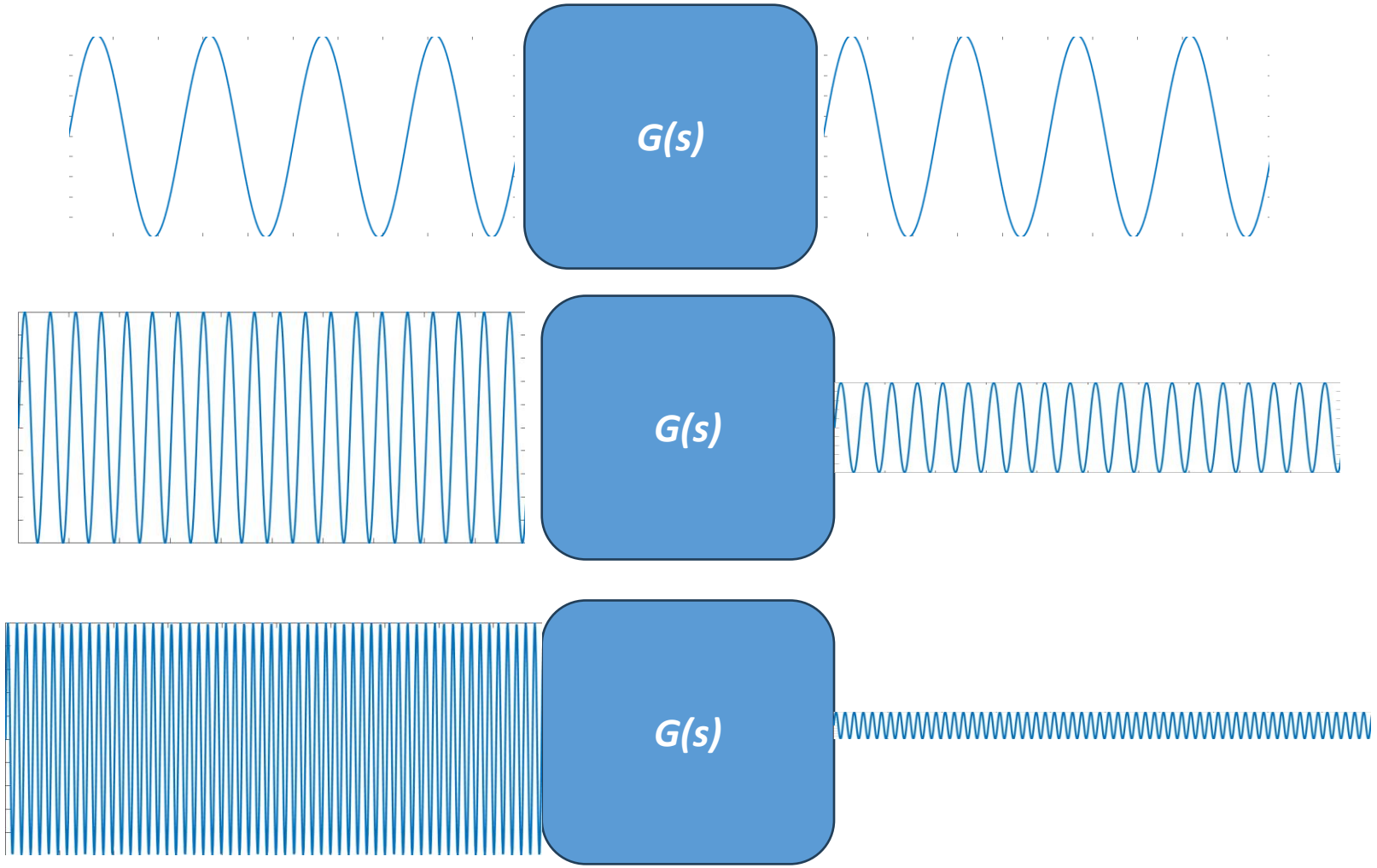
# Filtro passa baixa  (eliminando as altas frequências)

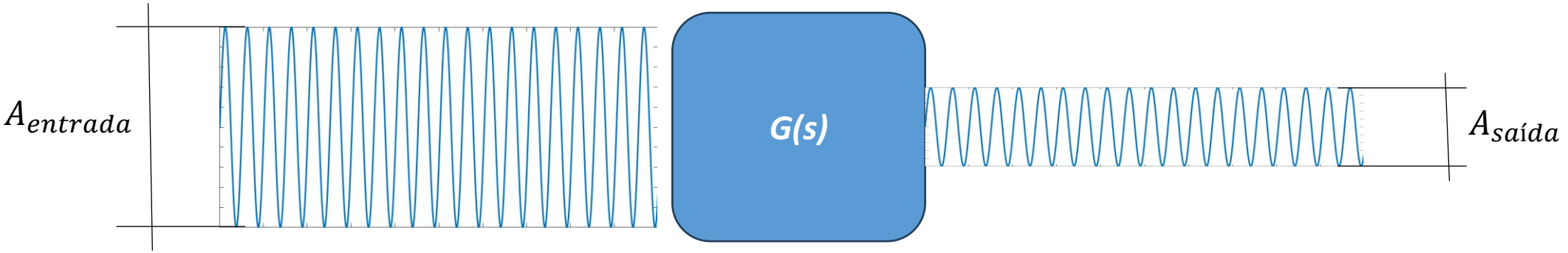


# Filtro passa baixa – eliminando as altas frequências



# Ganho em dB




$$Ganho = 20 \cdot \log\left(\frac{A_{saída}}{A_{entrada}}\right)$$

$$exemplo: \quad \frac{A_{saída}}{A_{entrada}} = 0{,}1 \quad \rightarrow \quad Ganho = 20\log(0{,}1) = -20dB$$

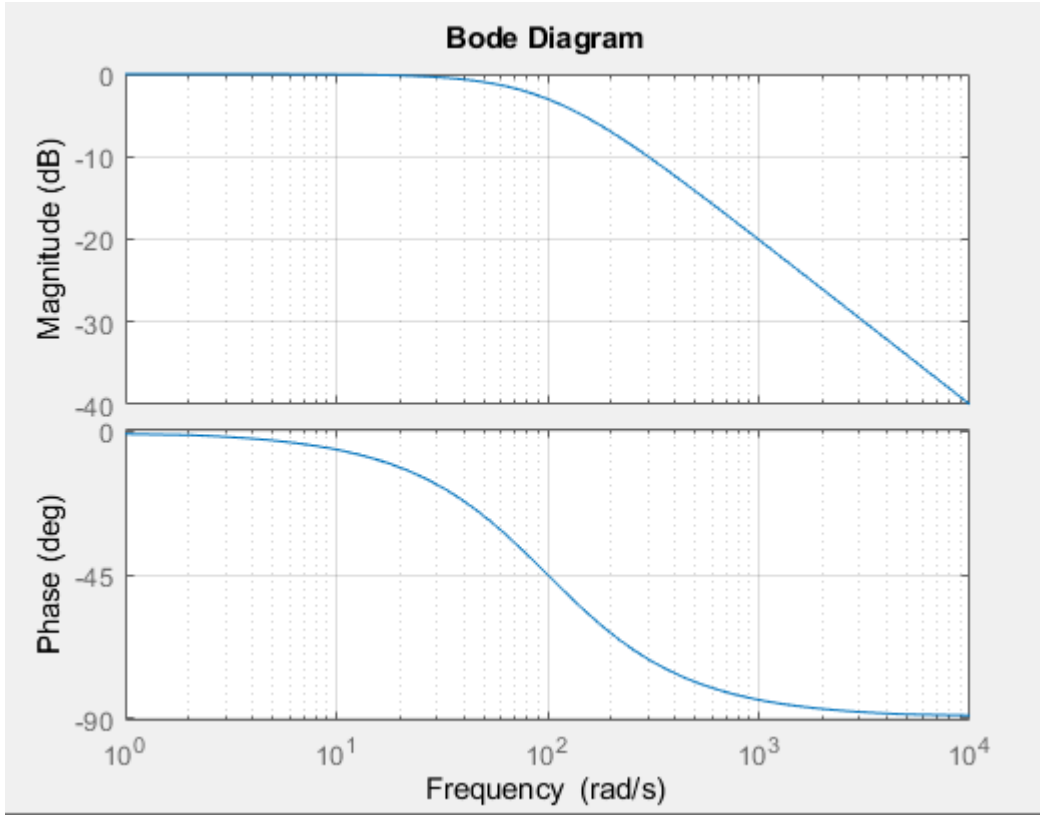
# Como saber o ganho de uma função de transferência?


$$G(s) = \frac{\omega_c}{s + \omega_c}$$

$$G(s) = \frac{\omega_c^2}{s^2 + 2\,\omega_c\, s + \omega_c^2}$$

# Filtro passa baixa – Diagrama de Bode

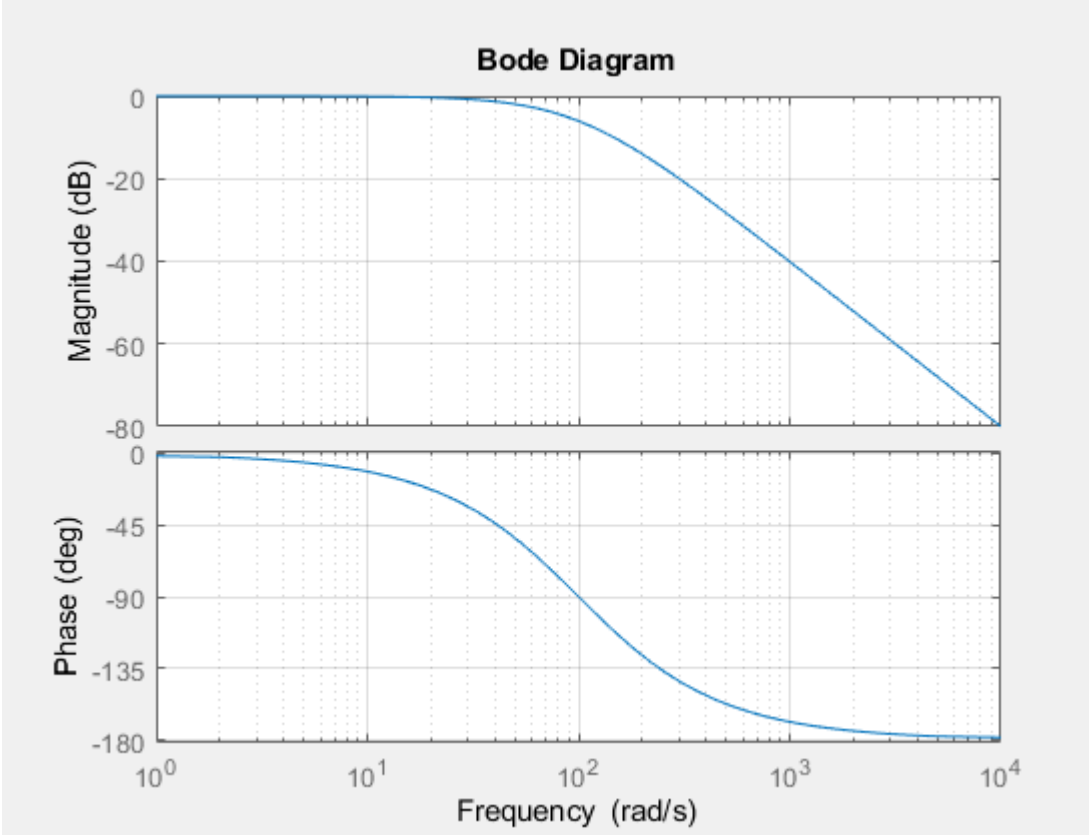

$$G(s) = \frac{100}{s+100} = \frac{Y(s)}{U(s)}$$



# Filtro passa baixa – Diagrama de Bode


$$G = \frac{100^2}{s^2+2\cdot 100\, s+100^2} = \frac{Y(s)}{U(s)}$$

$bode(G)$ →



# Como implementar computacionalmente?


$$\omega_c = 2500 \frac{rad}{s}$$

$$G(s) = \frac{\omega_c^2}{s^2 + 2\,\omega_c\, s + \omega_c^2}$$

# Operador Z


$$s \cdot Y \rightarrow \frac{dy}{dt} \qquad z \cdot Y(k) = Y(k+1)$$

$$s \cdot Y \rightarrow \frac{dy}{dt} \rightarrow \lim_{T \to 0} \left( \frac{y(k+1) - y(k)}{T} \right)$$

# Como implementar computacionalmente?


$$\omega_c = 2500 \frac{rad}{s}$$

$$G(s) = \frac{\omega_c^2}{s^2 + 2\,\omega_c\, s + \omega_c^2}$$

$$G(z) = c2d(G(s), T) \qquad T = \frac{1}{44100}\ segundos$$

$$G(z) = \frac{a\,Z + b}{c\,Z^2 + d\,Z + e}$$

# Filtro passa baixa – eliminando as altas frequências


$$G(z) = \frac{a\,Z + b}{Z^2 + d\,Z + e} = \frac{Y(z)}{U(z)}$$

$$a\,U(k+1) + b\,U(k) = Y(k+2) + \mathrm{d}\,\mathrm{Y(k+1)} + \mathrm{e}\,\mathrm{Y(k)}$$

$$a\,U(k-1) + b\,U(k-2) = Y(k) + \mathrm{d}\,\mathrm{Y(k-1)} + \mathrm{e}\,\mathrm{Y(k-2)}$$

$$Y(k) = -\mathrm{d}\,\mathrm{Y(k-1)} - \mathrm{e}\,\mathrm{Y(k-2)} + a\,U(k-1) + b\,U(k-2)$$