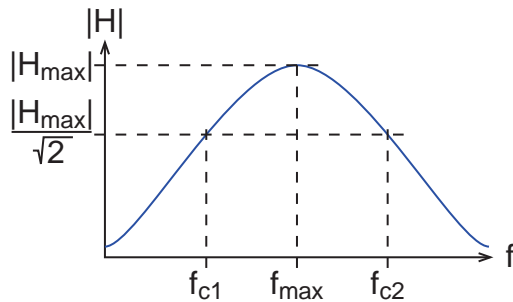


Lösningsskiss till Exempel-LAX

Förstå problemet



Teckna överföringsfunktionen

$$H = -\frac{1}{\frac{Z_2}{Z_4} + \frac{Z_1}{Z_4} + \frac{Z_1 Z_2}{Z_3 Z_4} + \frac{Z_1}{Z_3}} = -\frac{1}{\frac{1}{j\omega C_2 R_4} + \frac{R_1}{R_4} + \frac{R_1 j\omega C_3}{j\omega C_2 R_4} + j\omega C_3 R_1}$$

$$C_2 = C_3 = C \Rightarrow H = -\frac{1}{2\frac{R_1}{R_4} + j\left(\omega C R_1 - \frac{1}{\omega C R_4}\right)}$$

Sök maxbelopp

$$\omega_{\max} C R_1 = \frac{1}{\omega_{\max} C R_4} \Rightarrow \omega_{\max} = \pm \frac{1}{C} \frac{1}{\sqrt{R_1 R_4}} \Rightarrow$$

$$\max |H(\omega)| = |H(\omega_{\max})| = \frac{1}{\sqrt{4\frac{R_1^2}{R_4^2}}} = \frac{R_4}{2R_1}$$

Lös ut R_1 ur villkor för gränsvinkelfrekvens

$$|H(\omega_c)| = \frac{|H(\omega_{\max})|}{\sqrt{2}} = \frac{R_4}{2\sqrt{2}R_1} \Rightarrow |H(\omega_c)|^2 = \frac{R_4^2}{8R_1^2} \Rightarrow$$

$$\frac{1}{|H(\omega_c)|^2} = \frac{8R_1^2}{R_4^2} \Rightarrow 4\frac{R_1^2}{R_4^2} + \left(\omega_c C R_1 - \frac{1}{\omega_c C R_4}\right)^2 = 8\frac{R_1^2}{R_4^2} \Rightarrow$$

$$\omega_c C R_1 - \frac{1}{\omega_c C R_4} = \pm 2\frac{R_1}{R_4} \Rightarrow R_1 = \frac{1}{\omega_c^2 C^2 R_4 \pm 2\omega_c C}$$

Beräkna R_4 ur givet uttryck för bandbredd

$$f_{c2} - f_{c1} = \frac{1}{\pi R_4 C} \Rightarrow R_4 = \frac{1}{(f_{c2} - f_{c1})\pi C} = \frac{1}{3100\pi \cdot 10^{-8}} \Omega \approx 10.3 \text{ k}\Omega$$

Beräkna och välj R_1 samma vid båda gränsvinkelfrekvenser

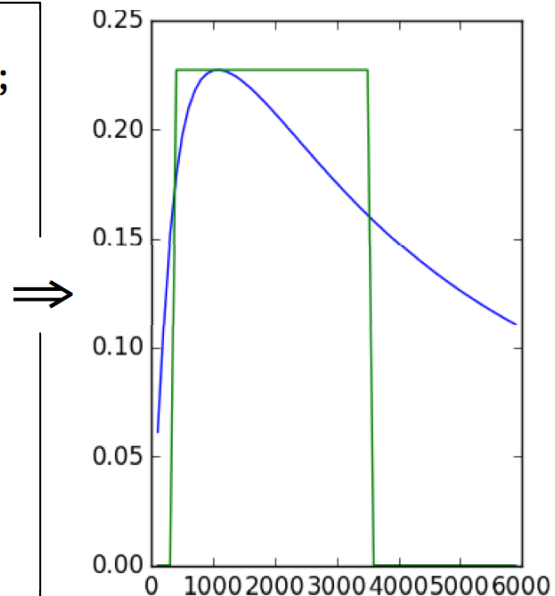
$$\omega_c = \omega_{c1} = 2\pi f_{c1} = 2\pi 300 \Rightarrow R_1 = \begin{cases} 24.2 \text{ k}\Omega \\ (-29.3 \text{ k}\Omega) \end{cases}$$

$$\omega_c = \omega_{c2} = 2\pi f_{c2} = 2\pi 3400 \Rightarrow R_1 = \begin{cases} (11.2 \text{ k}\Omega) \\ 24.2 \text{ k}\Omega \end{cases}$$

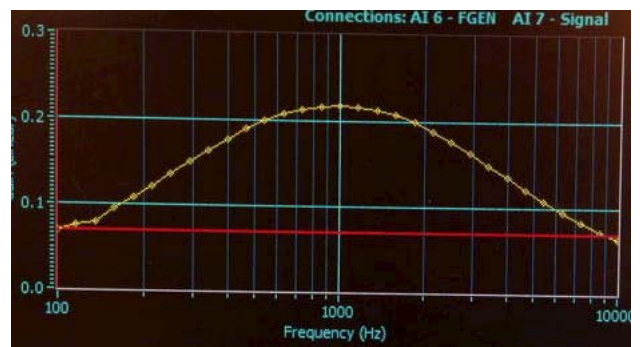
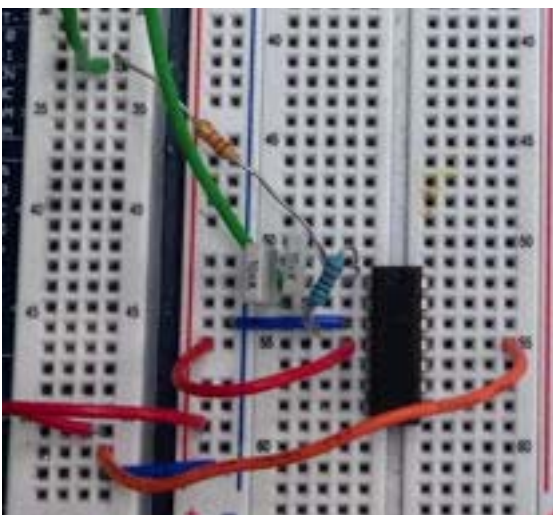
Välj E12-värden $\Rightarrow R_1 \approx 22 \text{ k}\Omega$ och $R_4 \approx 10 \text{ k}\Omega$

Kolla resultatet med SciPy, Matlab, grafisk skiss eller dylikt

```
from math import pi
x = range(100, 6000, 100); y = [];
for f in x:
    w = 2*pi*f
    Z1 = 24.2e3
    Z2 = 1/(10e-9j*w)
    Z3 = 1/(10e-9j*w)
    Z4 = 10.3e3
    H = -1/(Z2/Z4+2*Z1/Z4+Z1/Z3)
    y.append(abs(H))
Hmax = Z4/(2*Z1)
z = [float(k>Hmax*2**-0.5)*Hmax
     for k in y] # rita bandet
```



Koppla upp kretsen, gör en Bode-plott och visa upp...



...band $\sim 300\text{-}3400 \text{ Hz} \Rightarrow$ godkänt