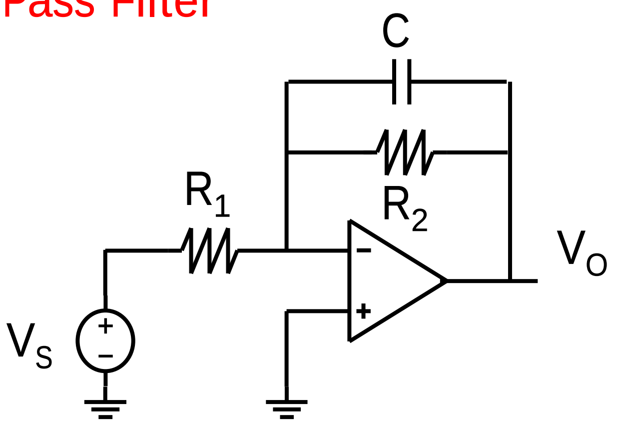
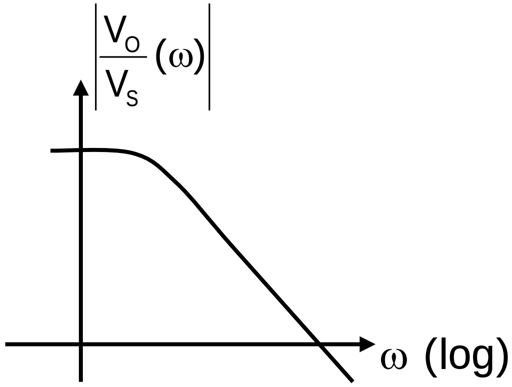
LAB 5 (1)

Low-Pass Filter

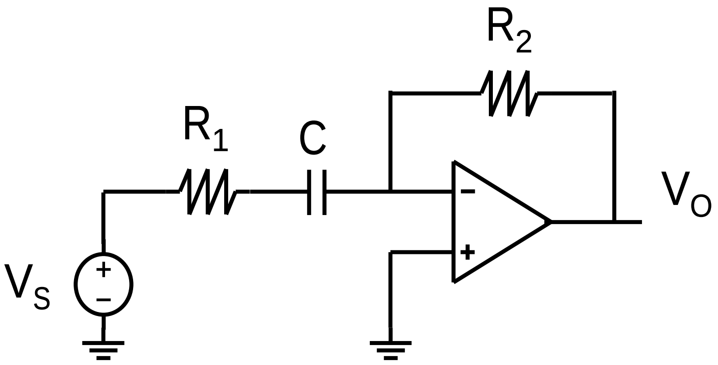


At low frequency, $\dfrac{V_O}{V_S}(\omega) \approx -\dfrac{R_2}{R_1}$

At high frequency, $\dfrac{V_O}{V_S}(\omega) \approx -\dfrac{1}{j\omega C R_1}$

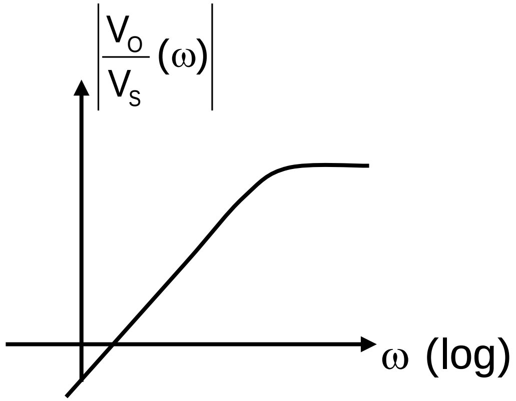


High-Pass Filter

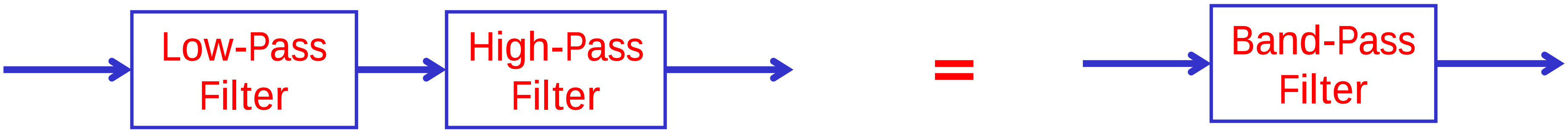


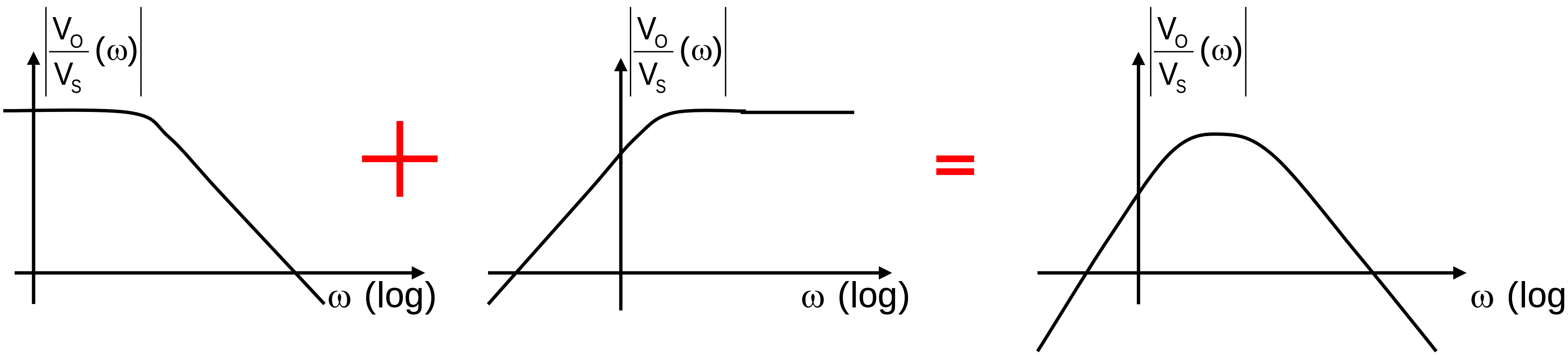
At low frequency, $\dfrac{V_O}{V_S}(\omega) \approx -j\omega C R_2$

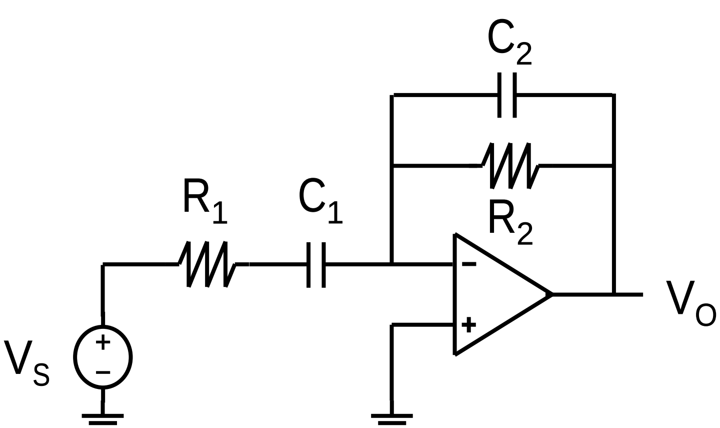
At high frequency, $\dfrac{V_O}{V_S}(\omega) \approx -\dfrac{R_2}{R_1}$



LAB 5 (2)



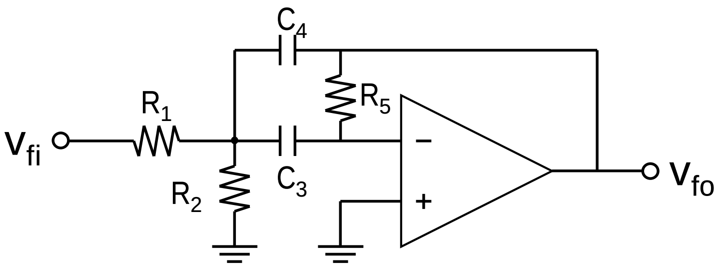




At low frequency, $\dfrac{V_O}{V_S}(\omega) \approx -j\omega C_1 R_2$

At high frequency, $\dfrac{V_O}{V_S}(\omega) \approx -j\omega C_2 R_1$

In Lab 5, a multiple-feedback is used to implement the band-pass filter.



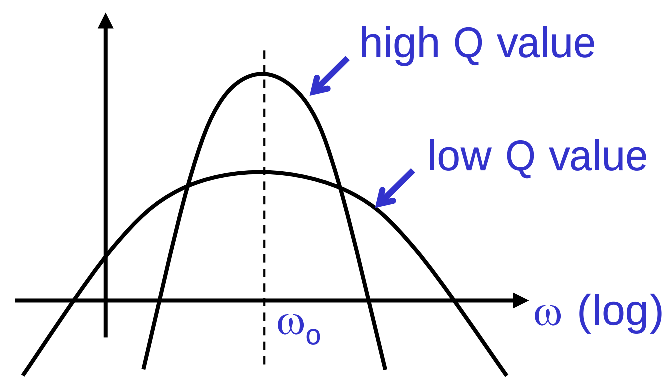
$$\frac{V_{fo}}{V_{fi}} = \frac{-s\left(\frac{1}{R_1C_4}\right)}{s^2 + s\left(\frac{1}{R_5}\right)\left(\frac{1}{C_3}+\frac{1}{C_4}\right) + \left(\frac{1}{R_5C_3C_4}\right)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)}$$

With $R_2 >> R_1$ and $C_3 = C_4 = C$,
$$\frac{V_{fo}}{V_{fi}} \approx \frac{-s\left(\frac{1}{R_1C}\right)}{s^2 + s\left(\frac{2}{R_5C}\right) + \left(\frac{1}{R_1R_5C^2}\right)}$$

Compare the quadratic equation of $s^2 + \frac{s\omega_o}{Q} + \omega_o{}^2$

gives

$$\omega_o = \frac{1}{\sqrt{R_5R_1}C} \quad \text{and} \quad Q = \frac{1}{2}\sqrt{\frac{R_5}{R_1}}$$



Three-Band Audio Equalizer:

- Use an adder to combine the output of 3 band-pass filters (BPF1 to BPF3)
- Need to design each band-pass filter with different ω_o and Q value to optimize the performance of the equalizer
- An average human can usually receive audible frequencies from 20Hz to 20kHz.