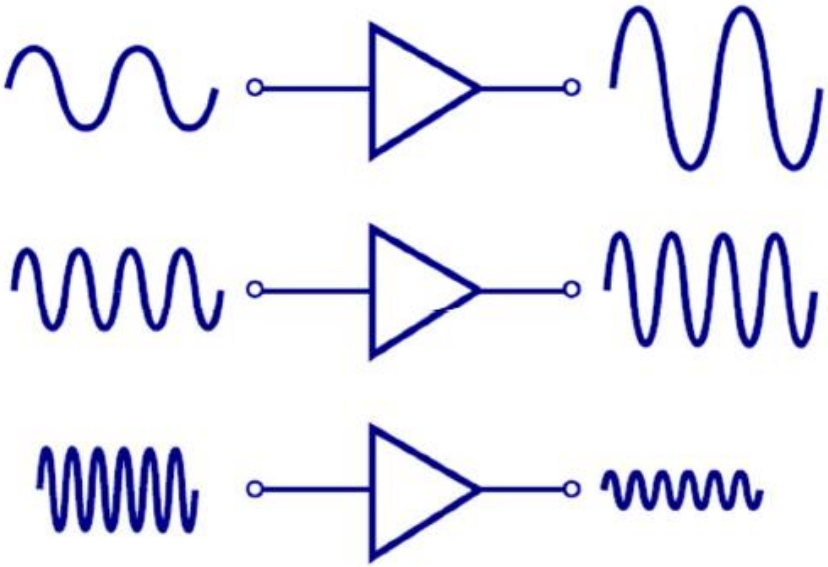
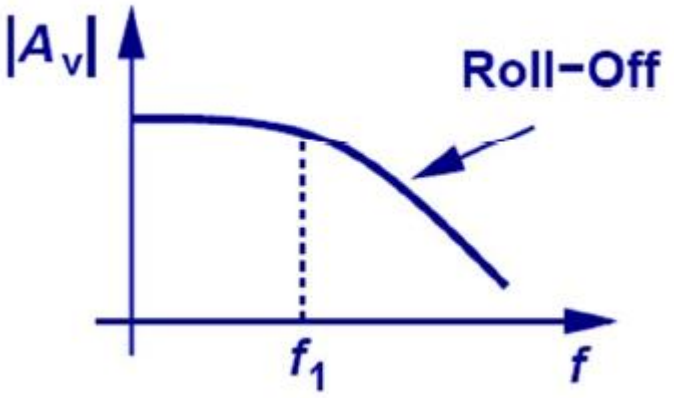
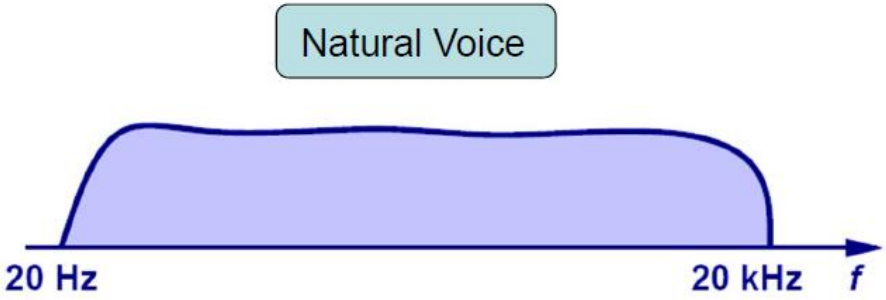
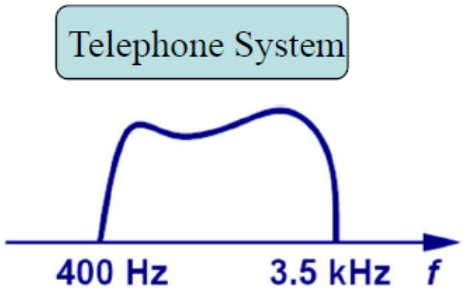



|Av|
Roll-Off
f1
f

- Examples of Frequency Roll-off

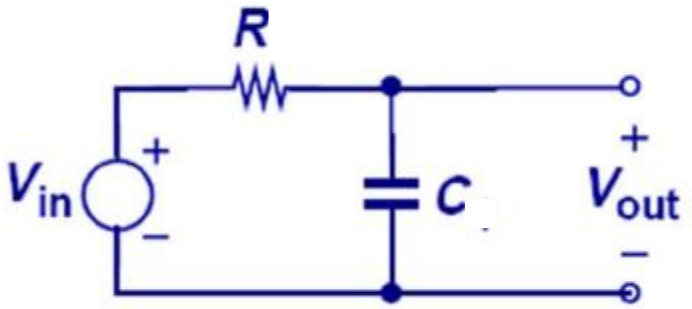




Lect. 10: Pole, Zero, Bode Plot

- How do we express frequency-domain characteristics of circuits?

➔Transfer functions in s-domain (Laplace Transform)

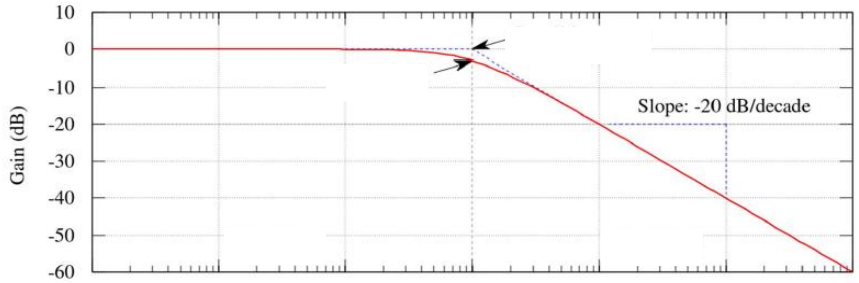


$$H(s)=\frac{V_{out}(s)}{V_{in}(s)}=\frac{1/sC}{1/sC+R}=\frac{1}{1+sRC}$$

- How do magnitude and phase of $H(s)$ change as frequency changes?

$$H(j\omega)=\frac{1}{1+j\omega RC}$$

$$|H(j\omega)|=\frac{1}{\sqrt{1+(\omega RC)^2}}$$



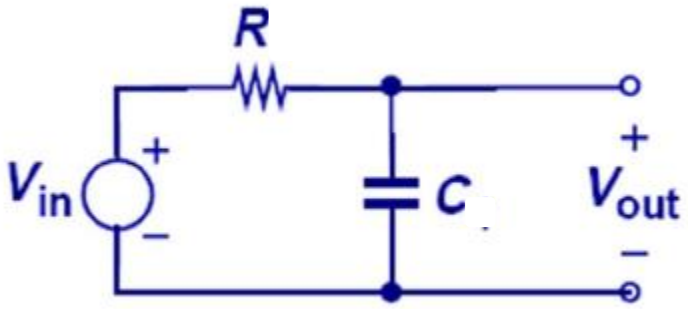
Magnitude Bode Plot: $20\log_{10}|H(j\omega)|$ **(dB) vs** $\log\omega$

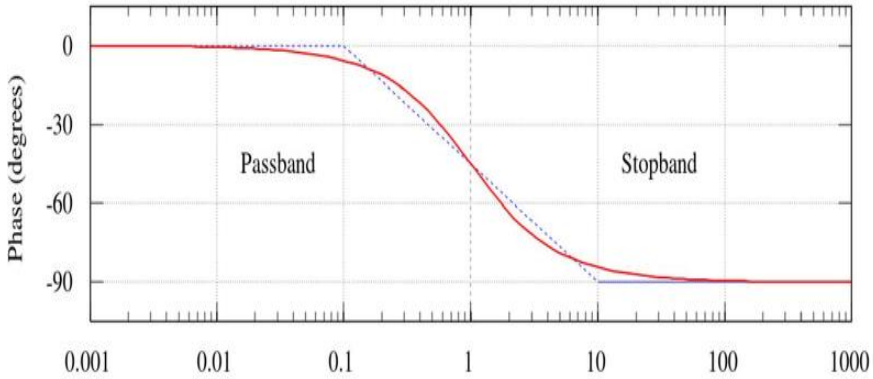
Low-frequency limit? High-frequency limit?

At $\omega=\frac{1}{RC}$? ➔ Pole at s = - 1/RC

Lect. 10: Pole, Zero, Bode Plot

- Phase Bode Plot (One-pole system)





$$H(j\omega)=\frac{1}{1+j\omega RC}$$

$$\angle H(j\omega)=-\tan^{-1}(\omega RC)$$

Low-frequency limit?

High-frequency limit?

At $\omega=\frac{1}{RC}$?

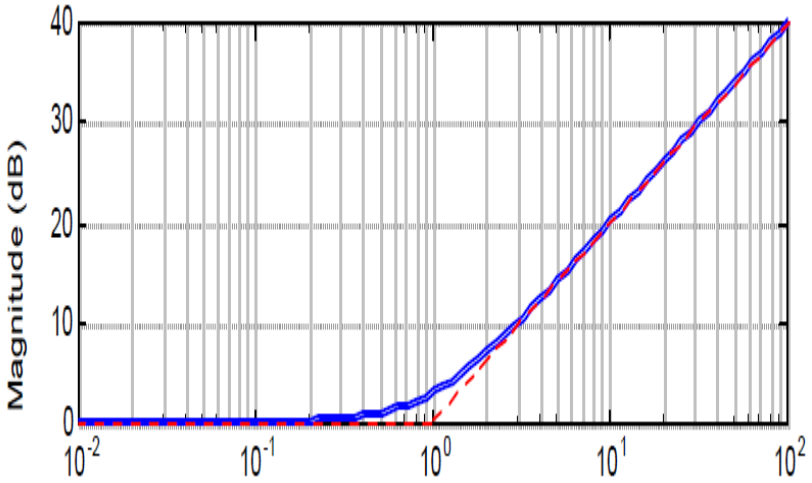
Lect. 10: Pole, Zero, Bode Plot

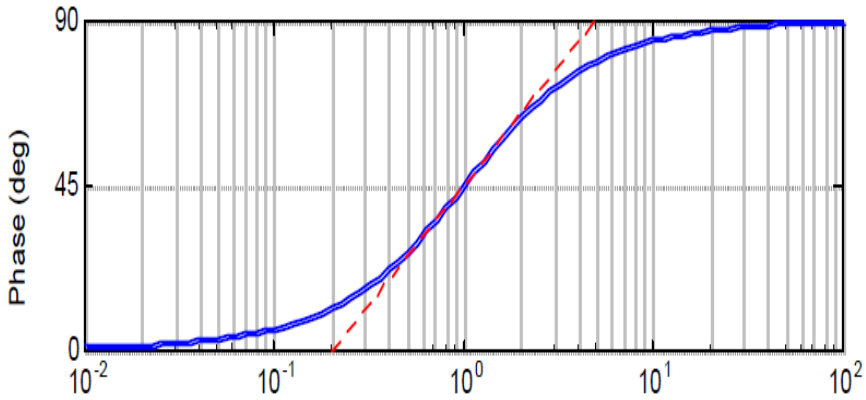
- How about $H(s)=1+sRC$?

$$H(j\omega)=1+j\omega RC$$

$$|H(j\omega)|=\sqrt{1+(\omega RC)^2}$$

$$\angle H(j\omega)=\tan^{-1}(\omega RC)$$





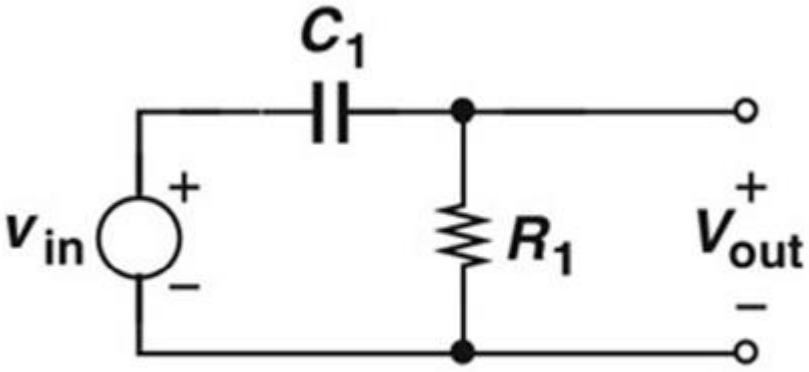
Lect. 10: Pole, Zero, Bode Plot

In general, electronic circuits have multiple poles and zeros

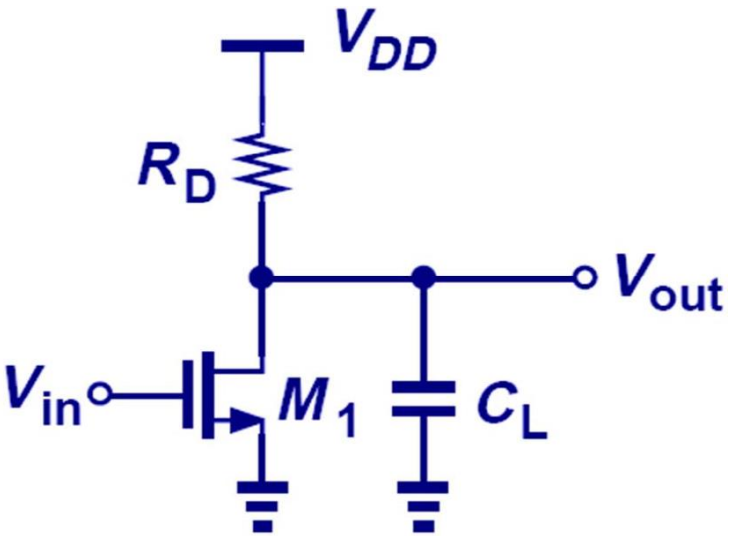
$$H(s) = A_0 \frac{\left(1+\frac{s}{\omega_{z1}}\right)\left(1+\frac{s}{\omega_{z2}}\right)\mathrm{L}}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{p2}}\right)\mathrm{L}}$$

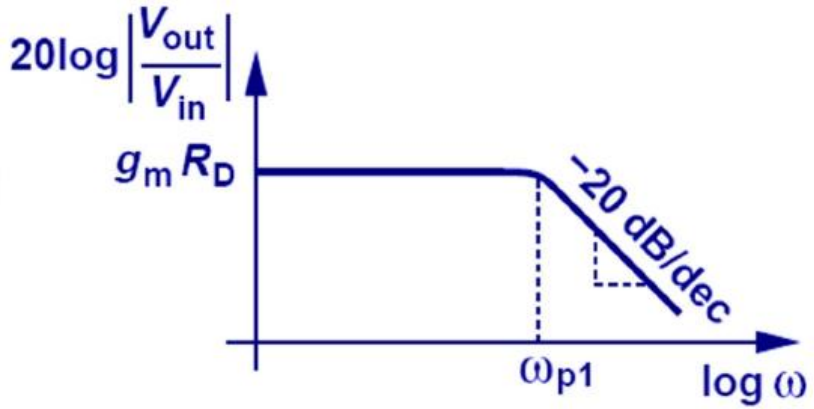
(Assuming poles and zeros are all real)

➔ Frequency response can be determined by pole, zero identification and 'addition' of each pole and zero response

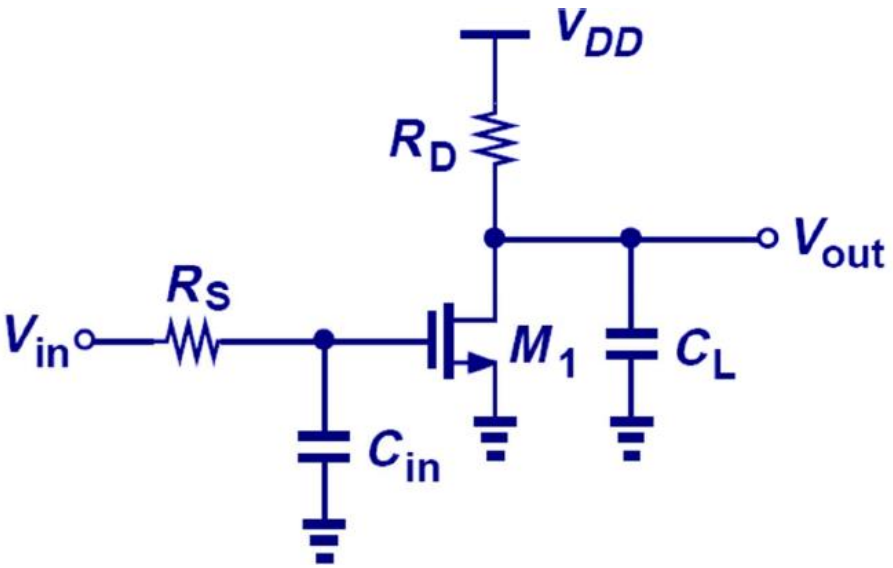


- Magnitude Bode Plot for MOS circuit
(Ignoring MOS frequency response, $\lambda = 0$)



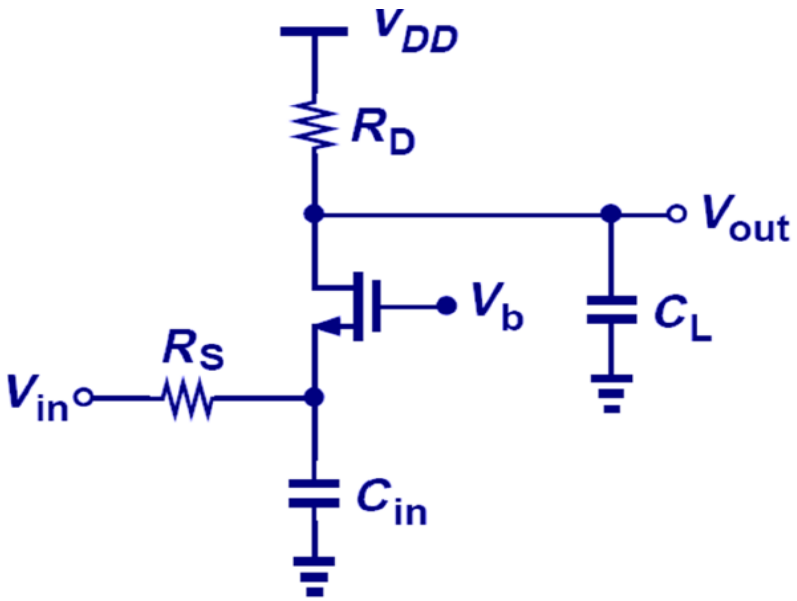


- Magnitude Bode Plot for MOS circuit
(Ignoring MOS frequency response, $\lambda = 0$)



Lect. 10: Pole, Zero, Bode Plot

- Magnitude Bode Plot
(Ignoring MOS frequency response, $\lambda = 0$)



Lect. 10: Pole, Zero, Bode Plot

- Homework: Determine magnitude Bode plot for V_{out}/V_{in}
(Ignoring MOS frequency response, $\lambda = 0$.
Assume input pole frequency is lower than output pole, zero frequency)