# Lecture 10D

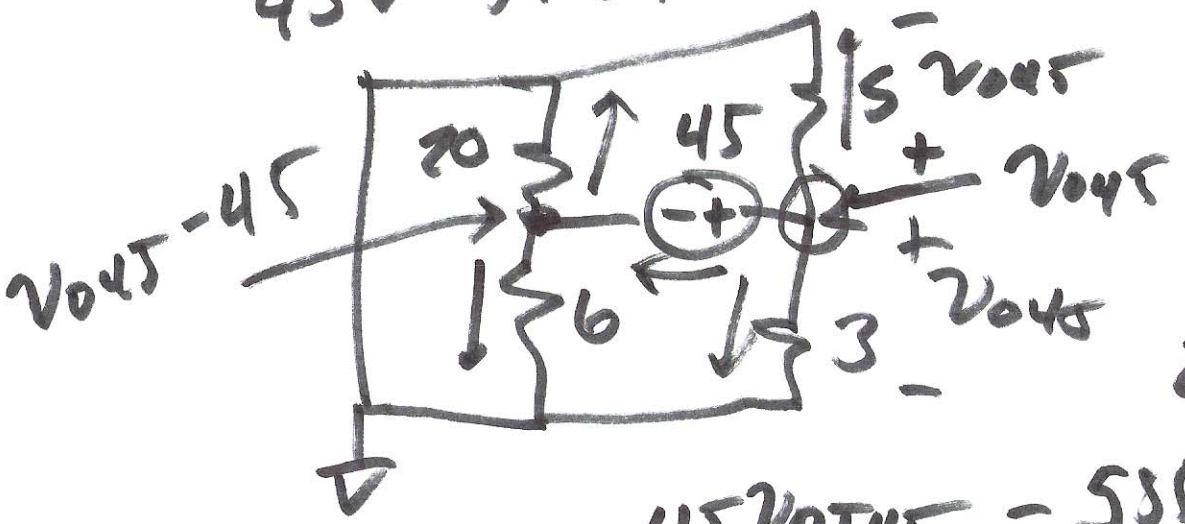
7/2/14

# EE 220D

## frequency response

## Bode plots

45V first

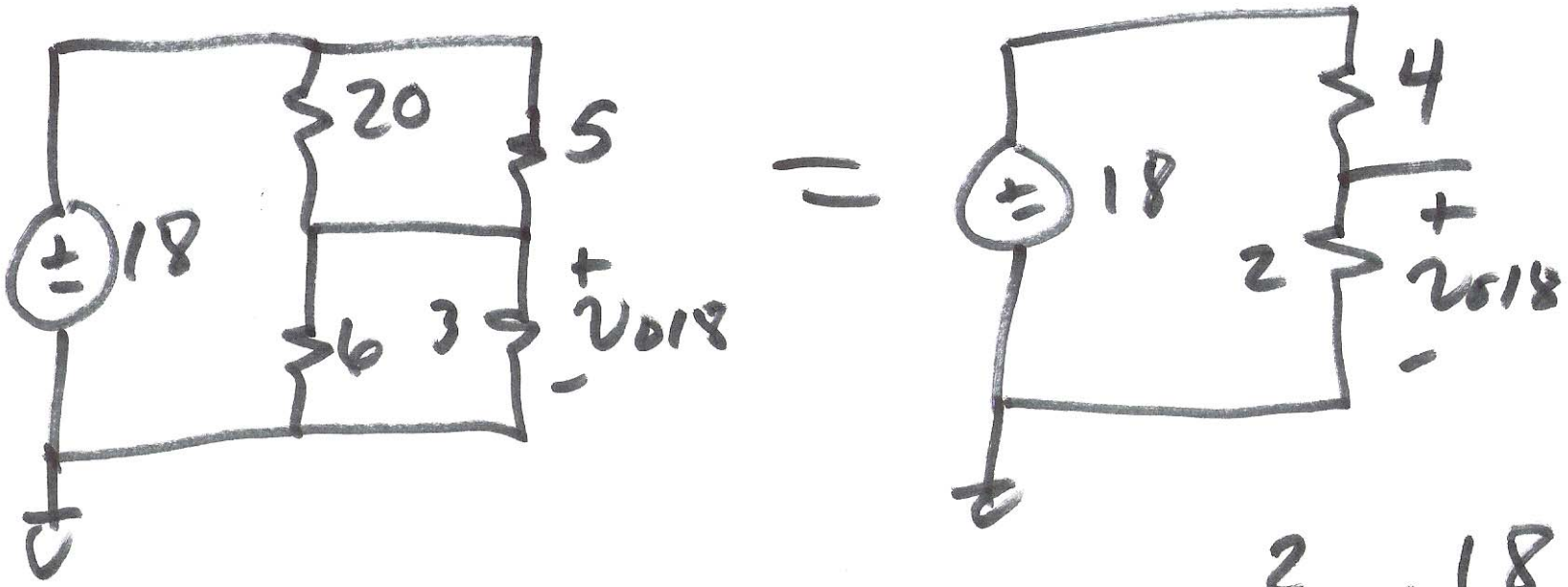



$$V_{OUT}\left(\frac{1}{3}+\frac{1}{5}\right)+\frac{(V_{OUT}-45)}{\left(\frac{1}{6}+\frac{1}{20}\right)}=0$$

$$20V_{OUT}+12V_{OUT}+45V_{OUT}=535(V_{OUT}-45)\cdot 10+(V_{OUT}-45)\cdot 3=0$$

$$V_{OUT}=\frac{535}{45}$$

$$\boxed{V_{OUT}=13V}$$



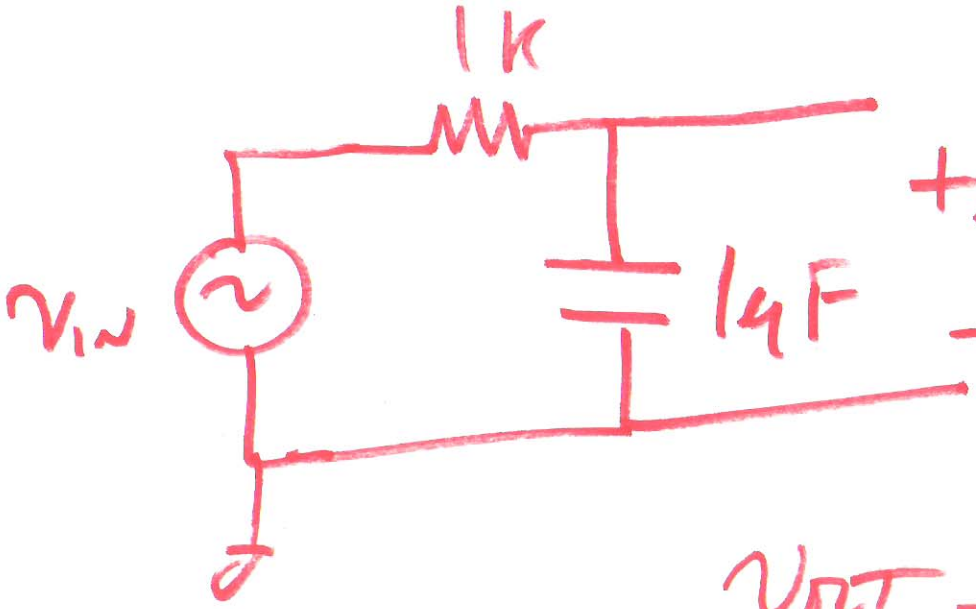

$$\frac{5 \cdot 20}{25} = 4$$

$$\frac{3 \cdot 6}{9} = 2$$

$$v_{018} = \frac{2}{2+4} \cdot 18$$

$$\boxed{v_{018} = 6V}$$

$$\boxed{v_0 = v_{045} + v_{018} = 19V}$$




$$v_{out} = v_{in} \cdot \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}}$$

$$2\pi RC = 0.00628 \qquad \frac{v_{out}}{v_{in}} = \frac{1}{1 + j(2\pi RC \cdot f)}$$

$$\frac{1}{2\pi RC} = 159 = f_{3dB} = \frac{1}{1 + j\,\frac{f}{1/2\pi RC}}$$

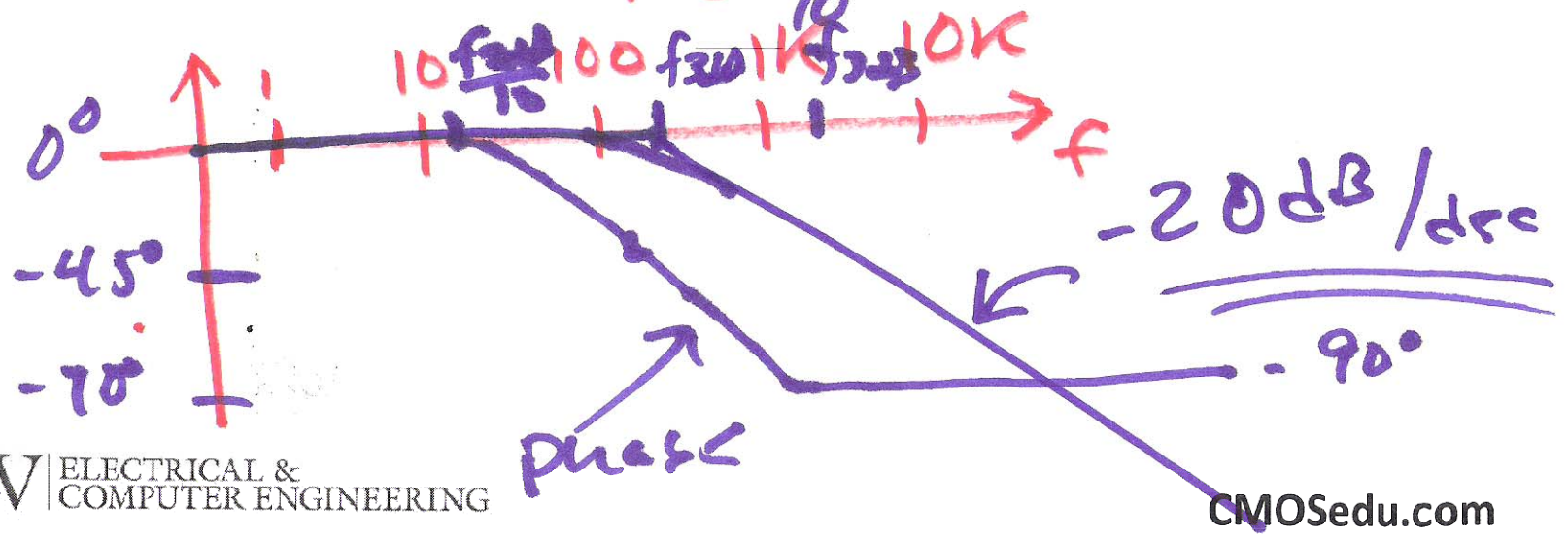
$$\left|\frac{1}{\sqrt{2}}\right| \Rightarrow -3dB = \frac{1}{1 + j\,\frac{f}{f_{3dB}}}$$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j0}{1 + j\frac{f}{f_{3dB}}} \qquad \left|\frac{V_{out}}{V_{in}}\right| = \frac{\sqrt{1^2 + 0^2}}{\sqrt{1^2 + \left(\frac{f}{f_{3dB}}\right)^2}}$$

$$\angle\frac{V_{out}}{V_{in}} = \frac{\tan^{-1}\frac{0}{1}}{\tan^{-1}\frac{f/f_{3dB}}{1}} = \frac{\angle 0°}{\angle\tan^{-1}\frac{f}{f_{3dB}}} = \frac{1}{\sqrt{1 + \left(\frac{f}{f_{3dB}}\right)^2}}$$

$$= -\tan^{-1}\frac{f}{f_{3dB}}, \quad f_{3dB} = 159\,Hz$$

Bode



$$\frac{V_{nT}}{V_{in}} = \frac{1}{\sqrt{1+\left(\frac{f}{f_{3dB}}\right)^2}} = \frac{1}{\sqrt{1+16}}$$

$$f = 4 f_{3dB}$$

$$f \gg f_{3dB}$$

$$\left|\frac{V_{nT}}{V_{in}}\right| \simeq \frac{1}{\sqrt{\left(\frac{f}{f_{3dB}}\right)^2}} = \frac{1}{\frac{f}{f_{3dB}}}$$

$$20 \log \left|\frac{V_{nT}}{V_{in}}\right| = 20 \log \frac{f_{3dB}}{f}$$

$$20 \log \frac{f_{3dB}}{10 f}$$

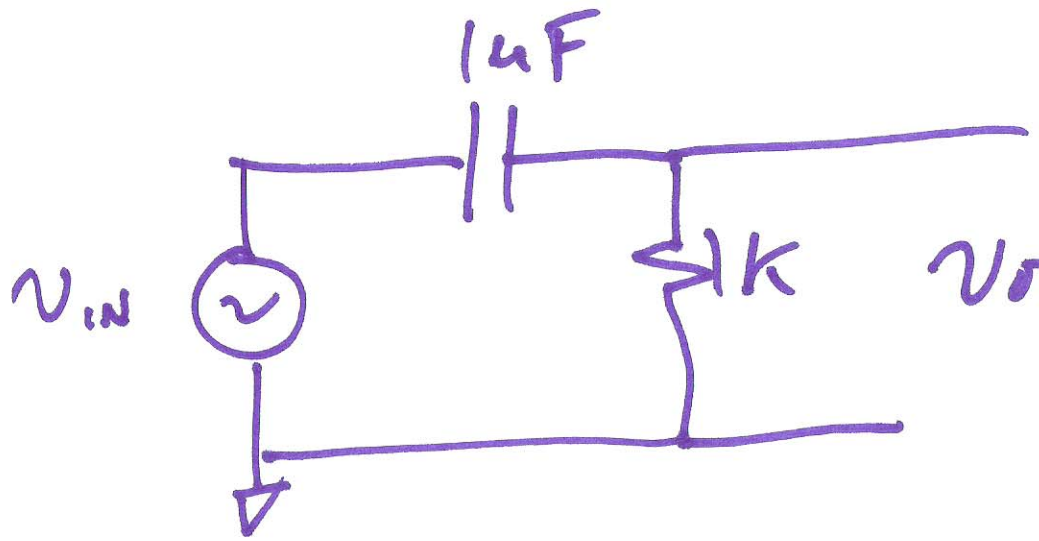
-20dB

$$20 \log \frac{f_{3dB}}{f} + 20 \log \frac{1}{10}$$





5)




Bode plot

$\frac{V_{out}}{V_{in}}$

$$\frac{1}{2\pi RC} = V_{out} = V_{in} \cdot \frac{1K}{1K + \frac{1}{jwC}} = \frac{R}{R + \frac{1}{jwC}}$$

$$f_z = f_p = \frac{1}{2\pi RC} \left\{ \frac{V_{out}}{V_{in}} \right\} = \frac{0 + jwRC}{1 + jwRC}$$

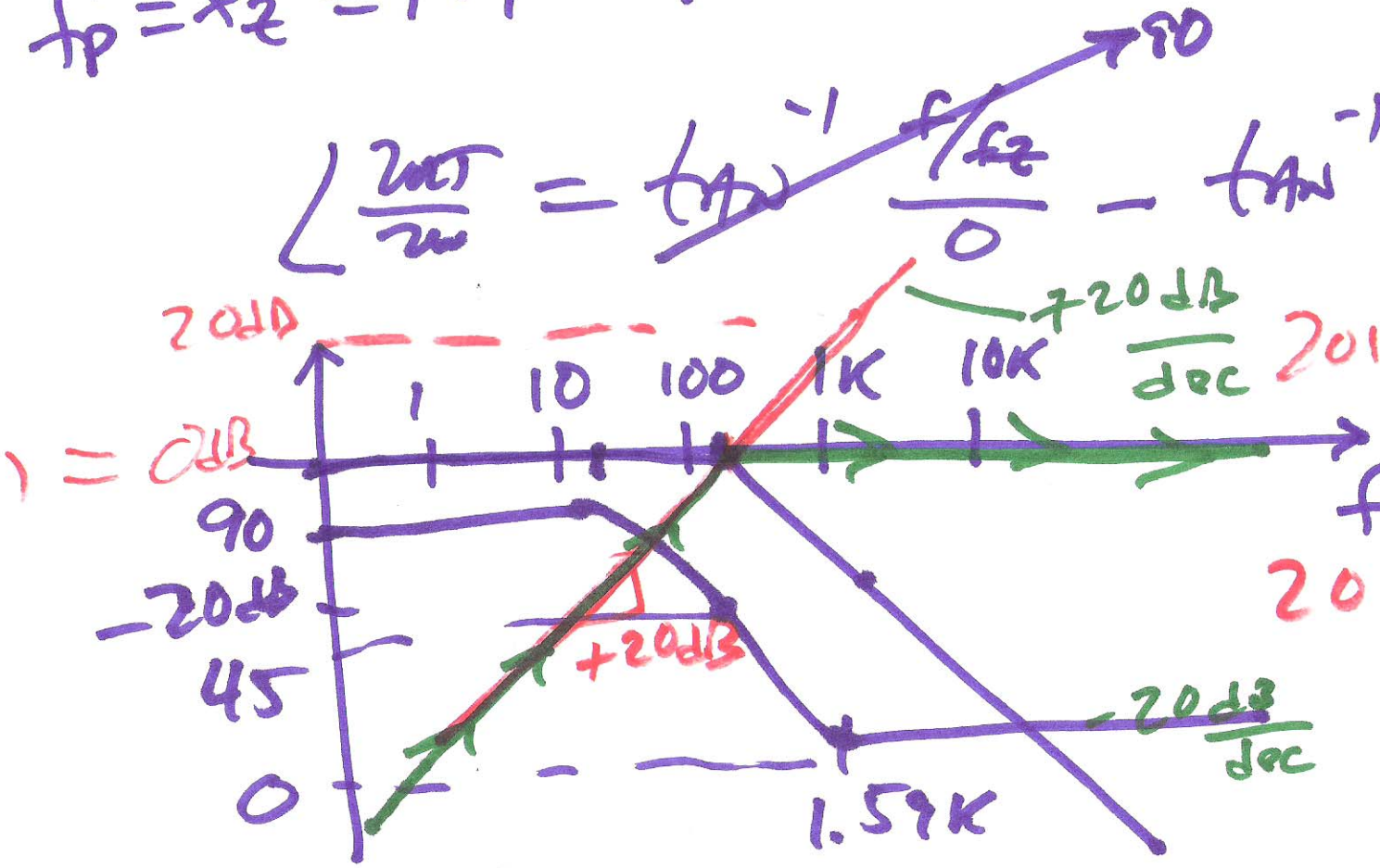
$$\frac{V_{out}}{V_{in}} = \frac{0 + j\frac{f}{f_z}}{1 + j\frac{f}{f_p}}$$

b)

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\sqrt{0^2 + \left(\frac{f}{f_z}\right)^2}}{\sqrt{1^2 + \left(\frac{f}{f_p}\right)^2}} = \frac{\frac{f}{f_z}}{\sqrt{1 + \left(\frac{f}{f_p}\right)^2}}$$

$f_p = f_z = 1.59$

$$\angle \frac{V_{out}}{V_{in}} = \tan^{-1}\frac{f/f_z}{0} - \tan^{-1}\frac{f}{f_p}$$




$20\log\left|\frac{f_z}{f_z}\right| = 0dB$, 1

$20\log\left|\frac{10f_z}{f_z}\right| =$

$20dB$

$20\log\frac{f_z}{10}$

$= -20dB\ f_z$

$$\left|\frac{V_{OUT}}{V_{IN}}\right| = -12\,dB, \quad \angle\frac{V_{OUT}}{V_{IN}} = 76^\circ$$

$$\theta = \frac{t_d}{T} \cdot 360$$

$$\frac{1}{2} = -6\,dB$$

$$\frac{1}{2}\cdot\frac{1}{2} = \frac{1}{4} = -12\,dB = -6\,dB - 6\,dB$$

$40\,Hz \rightarrow T = 0.025\,s$

$10\,Hz \rightarrow 0.1\,s$

$$25\,ms \cdot \frac{76}{360} = 5.28\,ms$$

$V_{OUT}$ leads $V_{IN}$!

8)