EE 221 Circuits II

Lecture 11

Feb. 27, 2023

$$a \cdot b \cdot c \cdot f = \frac{f}{\frac{1}{a \cdot b \cdot c}}$$

$$2\pi RCf = \frac{f}{\frac{1}{2\pi RC}} \rightarrow \frac{f}{f_{3dB}}$$

$$f_{3dB} = \frac{1}{2\pi RC}$$

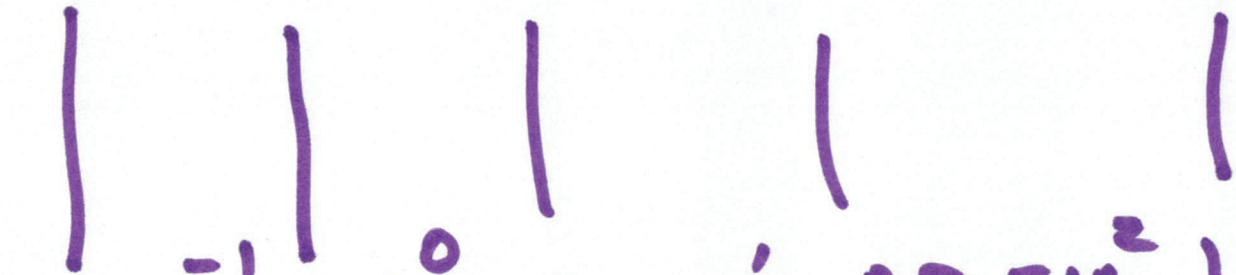
logarithms

log 10

log f

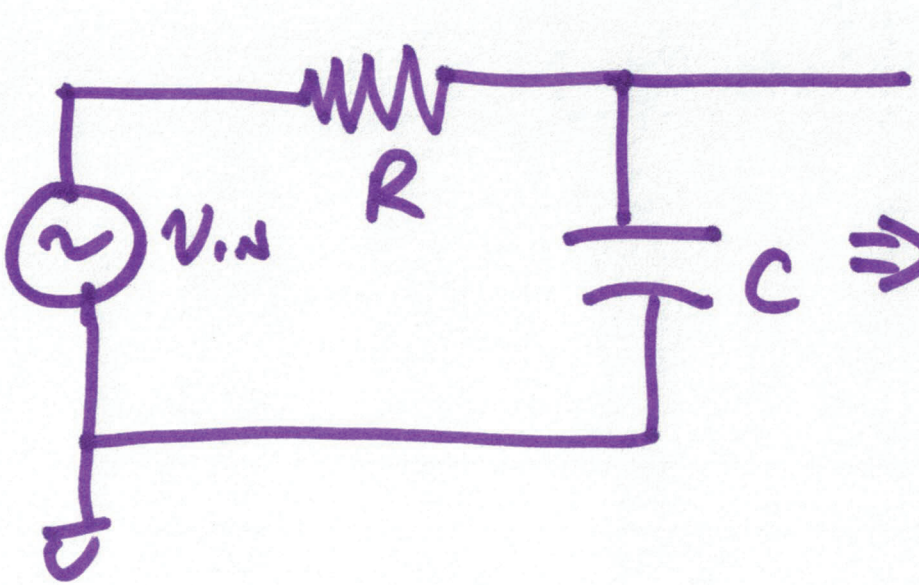
Big & small all the

0.1 10,000,000 same plot



$0.1 \quad 10^{-1} \quad 1 \quad 10^{0} \quad 10 = 10^{1} \quad 100 = 10^{2} \quad 1{,}000 = 10^{3}$

$-1 \quad 0 \quad 1 \quad 2 \quad 3$



$$C \Rightarrow \frac{1}{j \cdot 2\pi f \cdot C} = \frac{1}{j\omega C}$$

$$V_{OUT} = V_{in} \cdot \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R}$$

transfer function

$$\frac{V_{OUT}}{V_{in}} = \frac{1}{1 + j\omega RC}$$

$$|a+jb| = \sqrt{a^2+b^2}$$

$$\frac{1}{c+jd} \cdot \frac{c-jd}{c-jd}$$ ← complex conjugate

$$\frac{c}{c^2+d^2} + j\frac{-d}{c^2+d^2}$$

$$\left|\frac{1}{c+jd}\right| = \sqrt{\frac{c^2}{(c^2+d^2)^2} + \frac{(-d)^2}{(c^2+d^2)^2}}$$

$$\left|\frac{1}{c+jd}\right| = \sqrt{\frac{c^2+d^2}{(c^2+d^2)^2}} = \sqrt{\frac{1}{c^2+d^2}}$$

$$\star \left|\frac{1}{c+jd}\right| = \frac{1}{\sqrt{c^2+d^2}}$$

$$\star \angle \frac{1}{c+jd} = -\tan^{-1}\frac{d}{c}$$

$$= \tan^{-1}\left(-\frac{d}{c}\right)$$

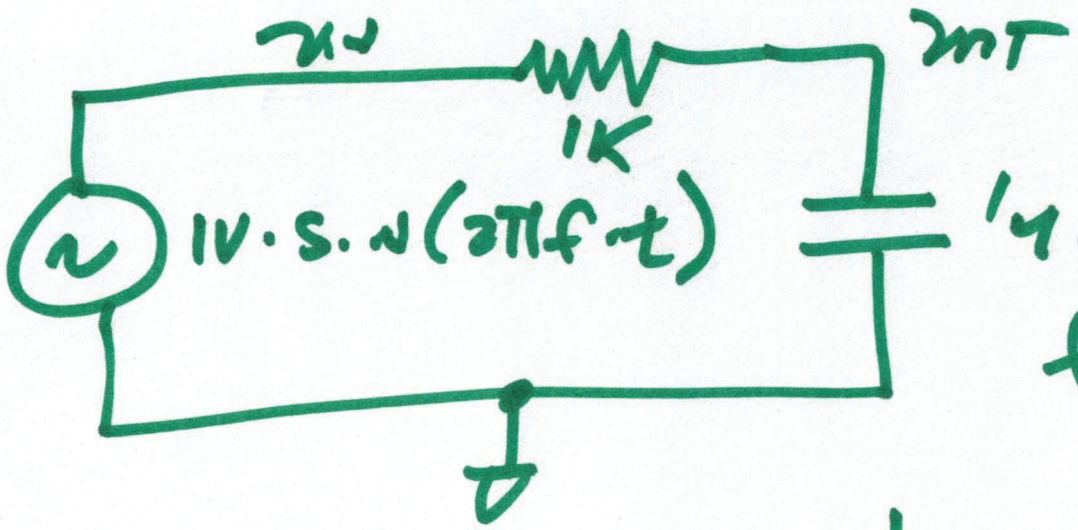
$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{\sqrt{1+(2\pi f R C)^2}}$$

$$\angle\frac{v_{out}}{v_{in}} = -\tan^{-1}\frac{2\pi f R C}{1}$$

$$f_{3dB} = \frac{1}{2\pi R C}$$

$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_{3dB}}\right)^2}}$$

$$\angle\frac{v_{out}}{v_{in}} = -\tan^{-1}\frac{f}{f_{3dB}}$$



$$f_{3dB} = \frac{1}{2\pi \cdot 10^3 \cdot 10^{-6}}$$

$$= 159\,Hz$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1 + \left(\frac{f}{159}\right)^2}}$$

$$\angle \frac{V_{out}}{V_{in}} = -\tan^{-1}\frac{f}{159}$$

$$10\log \frac{\frac{V_{out}^2}{R}}{\frac{V_{in}^2}{R}}$$

$$f = 159 \quad \frac{1}{\sqrt{1+\left(\frac{159}{159}\right)^2}} = \frac{1}{\sqrt{2}}$$

$$20\log\left|\frac{V_{out}}{V_{in}}\right| = -3\,dB$$

$$20 \log \frac{v_{nT}}{v_{nd}} = -36\,dB$$

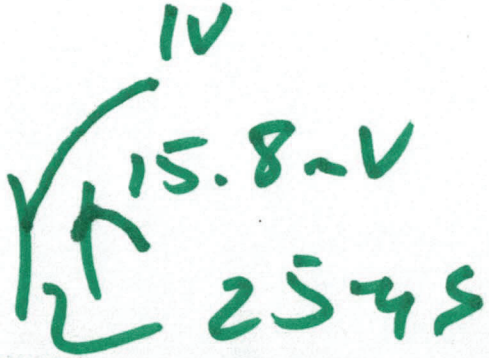
$$\log \frac{v_{nT}}{v_{nd}} = -\frac{36}{20}$$

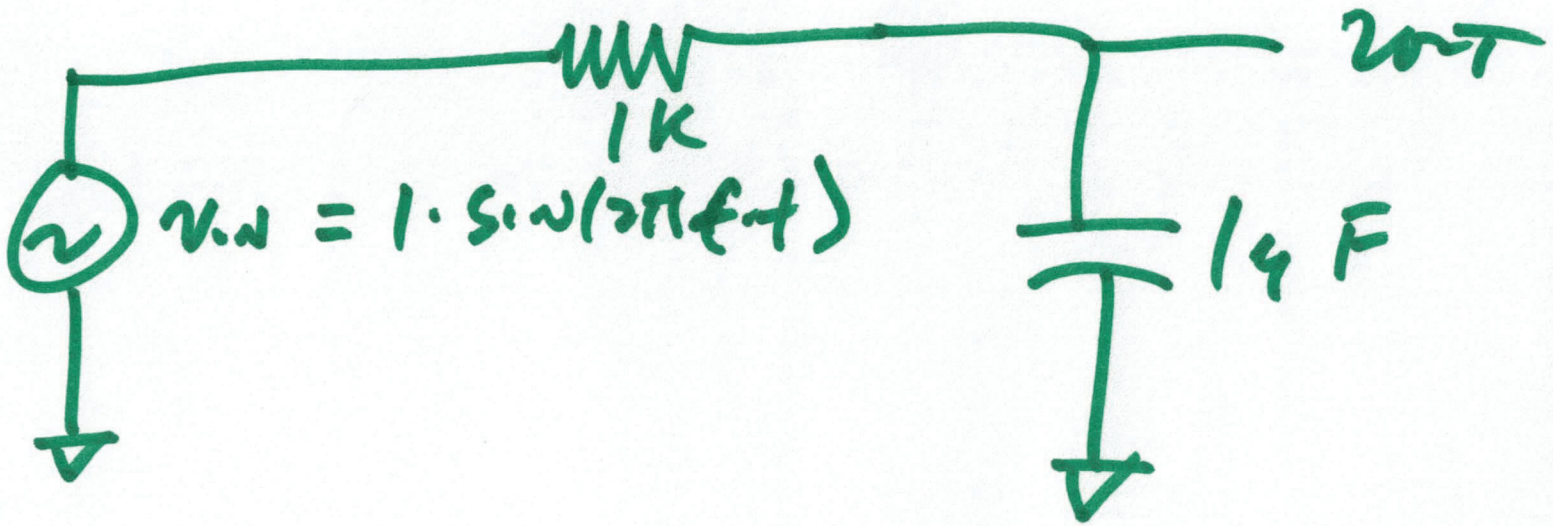
$$10^{\log \frac{v_{nT}}{v_{nd}}} = 10^{-\frac{36}{20}}$$

$f = 10^4 = 10\,kHz$ $\quad v_{nT} = 10^{-\frac{36}{20}}$

$T = 100\mu$ $\quad v_{nT} = 15.8\,\mu V$

$$-90 = \frac{t_d}{100\mu} \cdot 360, \quad t_d = -25\mu$$





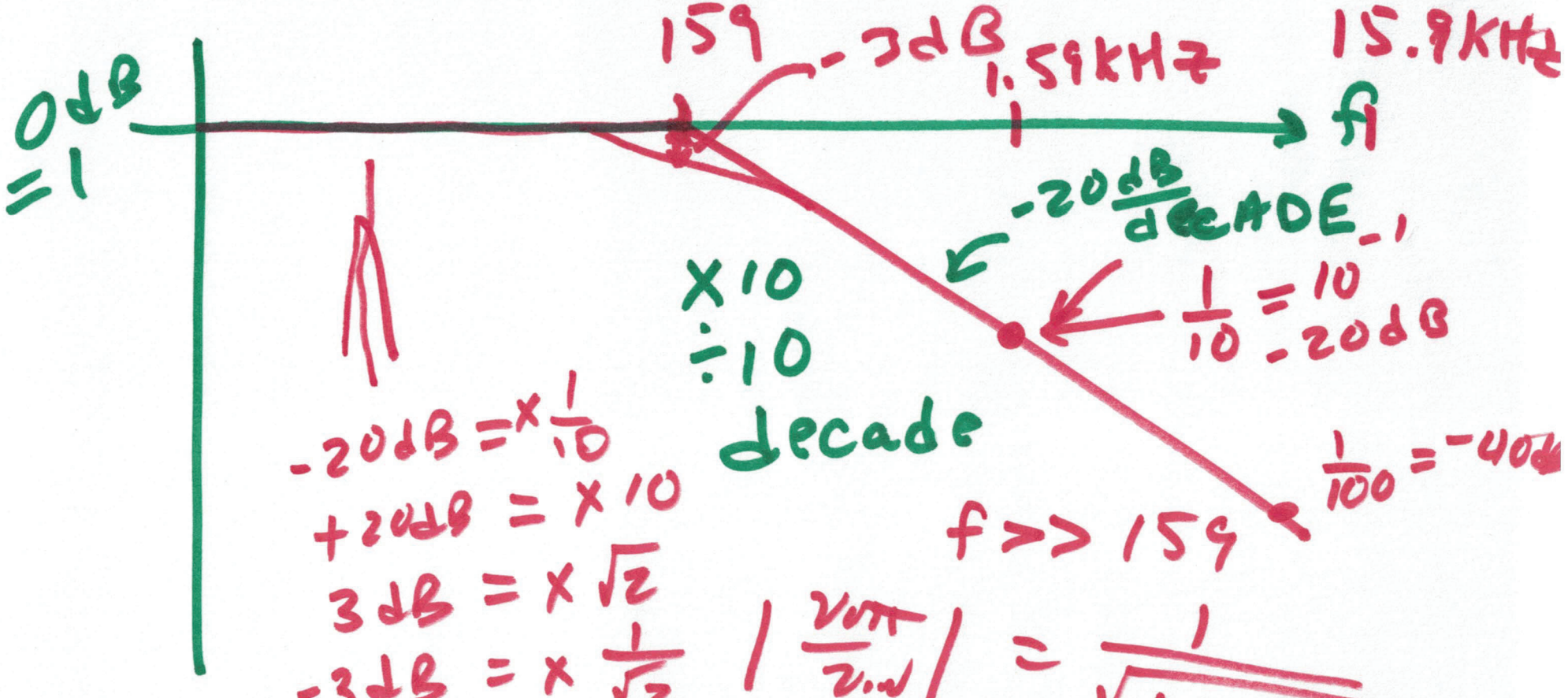
$$\frac{v_{out}}{v_{in}} = \frac{\frac{1}{jw1\mu}}{\frac{1}{jw1\mu} + 1K}$$

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + jw\,10^{-3}}$$

$$= \frac{1}{1 + j\frac{f}{159}}$$

Bode Response

$$v_{out} = \frac{1}{1 + j\frac{f}{159}}$$



-20dB = x 1/10

+20dB = x 10

3dB = x √2

-3dB = x 1/√2

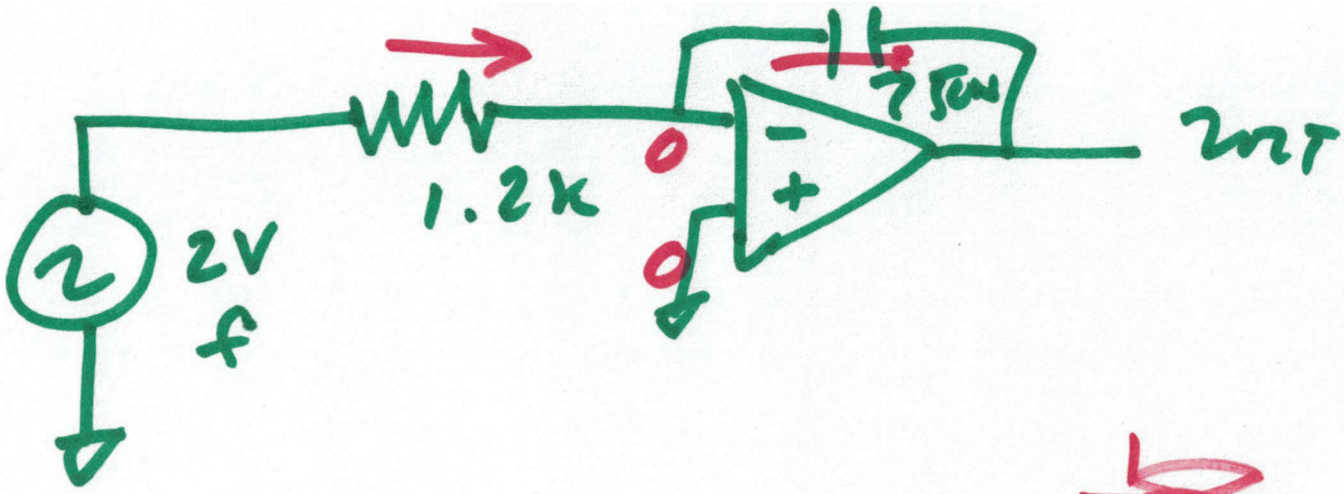
6dB = x 2

-6dB = x 1/2

14dB = x 5

$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{\sqrt{1 + \left(\frac{f}{159}\right)^2}}$$

$$\approx \frac{159}{f} = \frac{1}{\frac{f}{159}}$$



$$\frac{2-0}{1.2k} = \frac{0 - \frac{1}{jw \cdot 75cw} V_{out}}{\frac{1}{jw\,75cw}}$$

$$V_{out} = -\frac{2}{jw \cdot 75cw \cdot 1.2k}$$

$$\frac{a}{b \cdot f} = \frac{\frac{1}{f}}{\frac{a}{b}}$$

$$V_{out} = 0 + j\frac{2}{2\pi f \cdot 75cw \cdot 1.2k}$$

$$f_w = \frac{2}{2\pi \cdot 75w \cdot 1.2k} = 353$$

$$V_{mT} = j \cdot \frac{353}{f}$$

$$|V_{mT}| = \frac{353}{f}$$

$$\angle V_{mT} = \tan^{-1} \frac{353}{0} = 90^\circ$$