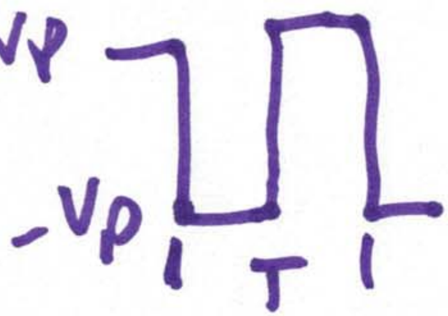
EE 220

Circuits 1

Lecture 25

find the Rms value

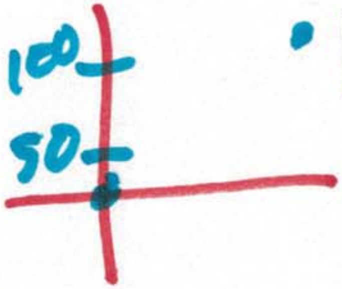


$$\sqrt{\frac{1}{T}\int_0^T V_p^2 \cdot dt} = V_{rms}$$

$f = \frac{1}{T}$

$$\sqrt{\frac{1}{T} V_p^2 (T-0} = V_{rms}$$

$$\underline{\underline{= V_p}}$$



- Decibels

$100 = 10^2$

100

$$dB = 20 \log \frac{V_{OUT}}{V_{IN}}$$

$\frac{1}{100}$

$20 \log 10^{-1}$

$20 \log 10^2$

logarithm used to $40 \log 10$

Compare/display

Big things with

small things.

$0.1 \rightarrow -20\,dB$

10^{-1}

$0.01 \rightarrow -40\,dB$

	dB
$\frac{V_{OUT}}{V_{IN}} = 1$	0 dB
$\frac{V_{OUT}}{V_{IN}} = 10$	20 dB
$\frac{V_{OUT}}{V_{IN}} = 100$	$\rightarrow$ 40 dB
1000	$\rightarrow$ 60 dB
10,000	$\rightarrow$ 80 dB

$5 \rightarrow 14\,dB$

$2 \rightarrow 6\,dB$

2)

$\frac{1}{100} \rightarrow -40dB$

order of magnitude

20 dB

$\times 10$

$\frac{1}{10} \rightarrow -20\,dB$

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

two orders of mag

40dB

$\times 100$

$\frac{1}{\sqrt{2}} \rightarrow -3\,dB$

$2 \rightarrow 6dB$

$\sqrt{2} \rightarrow 3dB$

$100 - 40dB$

$1000 \rightarrow 60dB$

$10 \rightarrow 20\,dB$

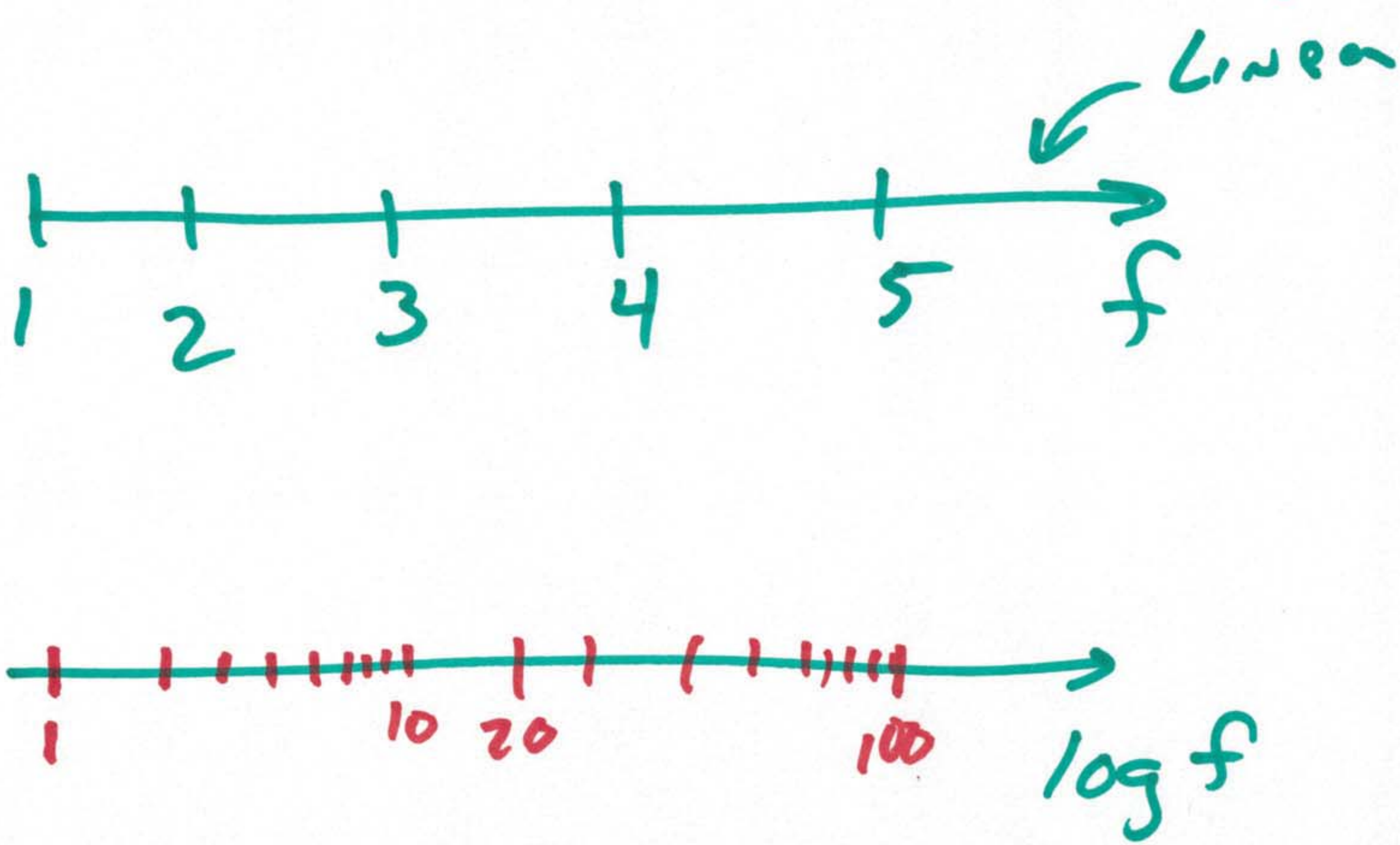
$1 \rightarrow 0\,dB$

$5 \rightarrow 14\,dB$

$50 \rightarrow 34dB$

$\log a \cdot b = \log a + \log b$

logarithmic axis



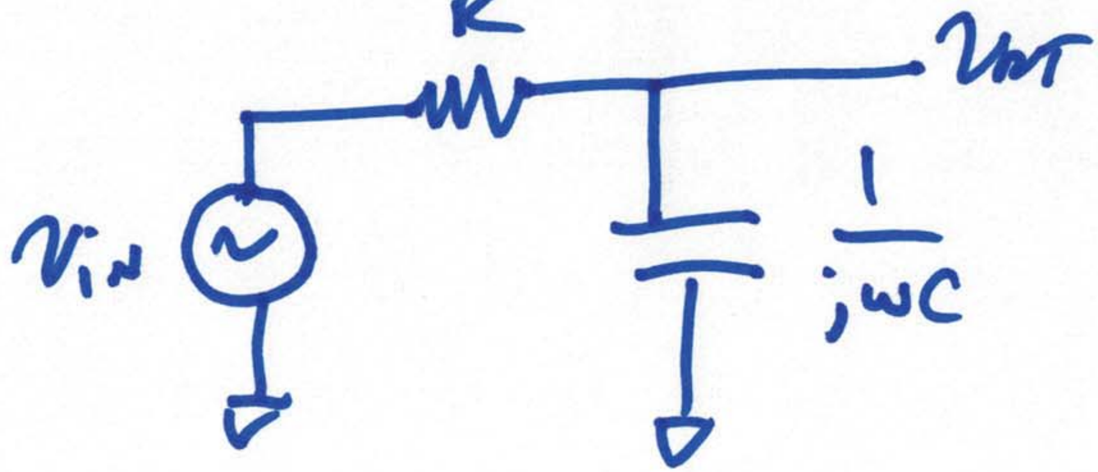
Power

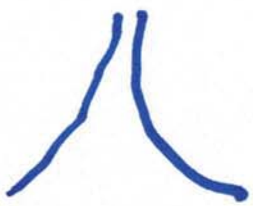
$$20 \log \frac{V_{OUT}}{V_{IN}}$$

$$10 \log \frac{V_{OUT}^2/R}{V_{IN}^2/R}$$

$$10\,dB = 10 \log \frac{P_{OUT}}{P_{IN}}$$

$$10 \log 10^1 = 10\,dB$$





$$v_{OUT} = v_{IN} \cdot \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R}$$

pole

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

$$\frac{v_{OUT}}{v_{IN}} = \frac{1}{1 + j2\pi f RC}$$

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

b)

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + j2\pi fRC}$$

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

$$\angle a + jb = \tan^{-1}\frac{b}{a}$$

$$\angle \frac{1}{a+jb} = -\tan^{-1}\frac{b}{a} = \tan^{-1}\frac{-b}{a}$$

$$\frac{1}{a+jb} \cdot \frac{a - jb}{a-jb} = \frac{a}{a^2+b^2} + j\frac{-b}{a^2+b^2}$$

Complex Conjugate

$(jb)(-jb)$

$-1 \cdot -1 \cdot b^2$

$$\left|\frac{1}{a+jb}\right| = \sqrt{\frac{a^2}{(a^2+b^2)^2} + \frac{(-b)^2}{(a^2+b^2)^2}} = \sqrt{\frac{\cancel{a^2+b^2}}{(a^2+b^2)^{\cancel{2}}}}$$

$$= \sqrt{\frac{1}{a^2+b^2}} = \frac{1}{\sqrt{a^2+b^2}}$$

$$\left|\frac{1}{a+jb}\right| = \frac{1}{\sqrt{a^2+b^2}}$$

$$\angle\frac{1}{a+jb} = -\tan^{-1}\frac{b}{a}$$

magnitude

$$\left|\frac{a+jb}{c+jd}\right| = \frac{\sqrt{a^2+b^2}}{\sqrt{c^2+d^2}}$$

Angle

$$\angle\frac{a+jb}{c+jd} = \tan^{-1}\frac{b}{a} - \tan^{-1}\frac{d}{c}$$

$$\frac{v_{OUT}}{v_{IN}} = \frac{1}{1+j2\pi fRC} = \frac{1}{1+j\frac{f}{f_{3dB}}}$$

$$\left|\frac{v_{OUT}}{v_{IN}}\right| = \frac{1}{\sqrt{1^2+(2\pi fRC)^2}} = \frac{1}{\sqrt{1+\left(\frac{f}{f_{3dB}}\right)^2}}$$

$$\angle\frac{v_{OUT}}{v_{IN}} = -\tan^{-1}2\pi fRC$$

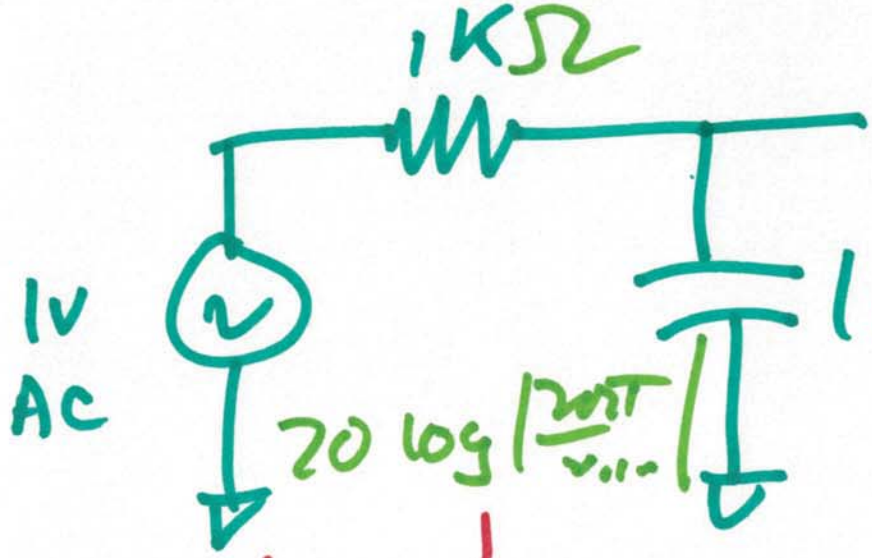
$$= -\tan^{-1}\frac{f}{f_{3dB}}$$

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

$$\frac{1}{\sqrt{2}} \rightarrow -3dB$$

$$= \frac{1}{2\pi\cdot 200\cdot 10^{-6}}$$

$$= 796\ Hz$$



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

$$20 \log \left| \frac{v_{OUT}}{v_{in}} \right|$$

$$f_{3dB} = \frac{1}{2\pi RC} = 796\,Hz$$

(R → 200, C → 1uF)

$$\frac{v_{OUT}}{v_{in}} = \frac{1}{1 + j2\pi RC \cdot f}$$

$$= \frac{1}{1 + j\frac{f}{796}}$$

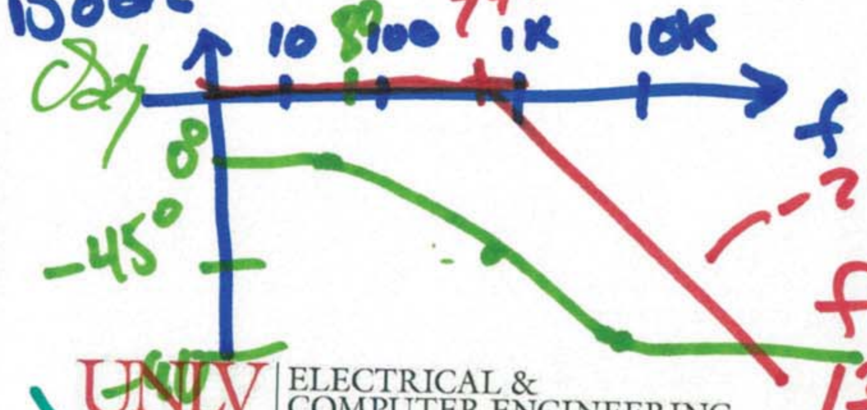
$$= \frac{1}{1 + j(1.256ms)f}$$

jay

$$\left| \frac{v_{OUT}}{v_{in}} \right| = \frac{1}{\sqrt{1 + \left(\frac{f}{796}\right)^2}}$$

$$\angle \frac{v_{OUT}}{v_{in}} = -\tan^{-1} \frac{f}{796}$$

Bode



$-6\frac{dB}{OCT}$

$-20\frac{dB}{dec}$

f ↗ 10

$\left|\frac{v_{OUT}}{v_{in}}\right|$ ↘ 10

$$\left|\frac{V_{out}}{V_{in}}\right| = -8.8\ dB \rightarrow -8.8 = 20\log\frac{V_{out}}{V_{in}}$$

$$\frac{V_{out}}{V_{in}} = 10^{-8.8/20} = .363$$

$T = 500\mu s$

$$\angle = -67^\circ$$

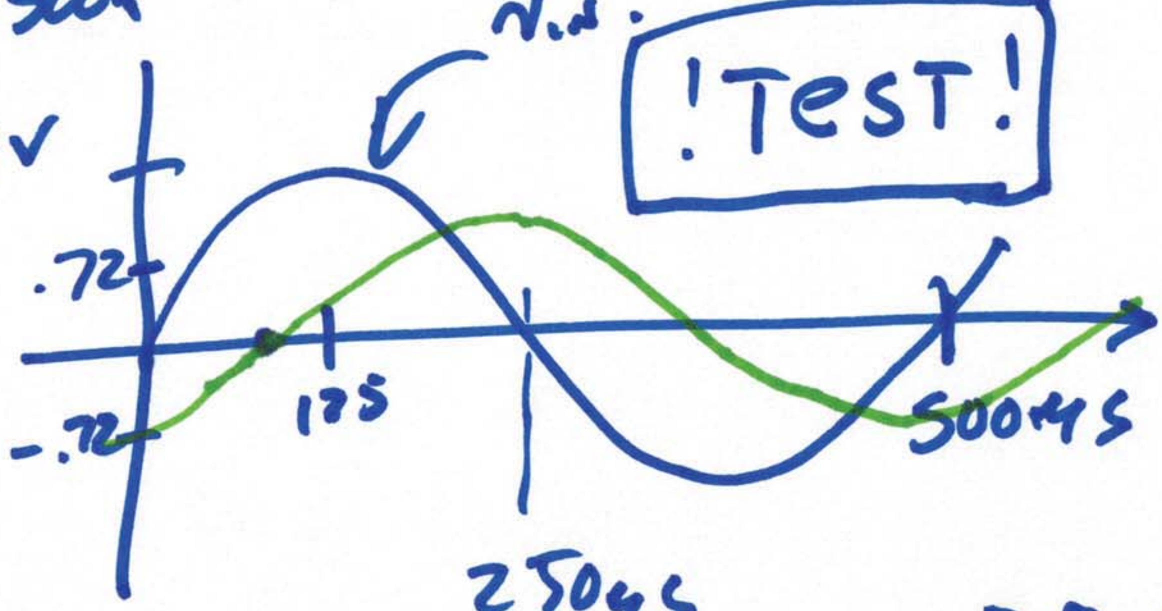
~~360 = td~~

$$67 = \frac{t_d}{500\mu}\cdot 360$$

If $v_{in} = 2V$ peak @ 2KHz

Sketch v_{out} & v_{in}

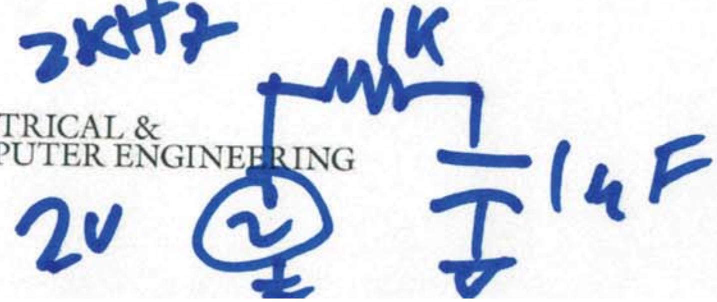
$\boxed{\text{!TEST!}}$



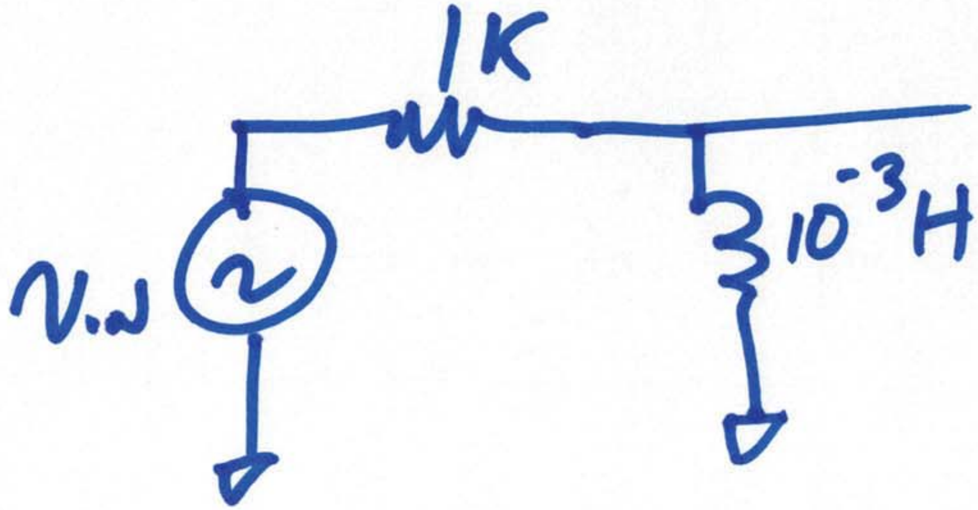
$V_{out} = 2 \cdot .363 = .72$

dB ↓

$$-8.8 = 20\log\frac{V_{out}}{V_{in}}$$



1)



imped of inductor

$$\frac{v_{out}}{v_{in}} = \frac{0 + j2\pi f\cdot 10^{-3}}{1000 + j2\pi f\cdot 10^{-3}}$$

$$\tan^{-1}\frac{2\pi f\cdot 10^{-3}}{0} - \tan^{-1}\frac{2\pi f\cdot 10^{-3}}{1000}$$

$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{\sqrt{0^2 + (2\pi f\cdot 10^{-3})^2}}{\sqrt{1000^2 + (2\pi f\cdot 10^{-3})^2}}$$

$$= \frac{2\pi f\cdot 10^{-3}}{\sqrt{1000 + (2\pi f\cdot 10^{-3})^2}}$$

$f_z = 0$

$f_p \Rightarrow \dfrac{1000}{2\pi f \cdot 10^{-3}} =$