① Phys 2426 2015-10-20 Lec 16

Exam 2 Thu 10/29

Covers	Magnetism	Chap	29-30
	EM Induction		31-32
	AC Circuits		33

AC Voltages Oscillate

Ex: $V_{max} \sin(2\pi f t)$

$$V_{max} \sin(2\pi f t + \phi)$$

Phase angle

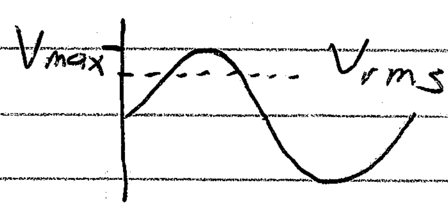
$$V_{max} \sin(2\pi f (t - t_0))$$

$$V_{max} \cos(2\pi f t)$$

$$V_1 \sin(2\pi f t) + V_2 \cos(2\pi f t)$$

$$\rightarrow V_{max} = \sqrt{V_1^2 + V_2^2}$$

$$\sqrt{2}\, V_{rms} \sin(2\pi f t)$$



$$V_{rms} = \frac{1}{\sqrt{2}} V_{max}$$

Resistors Ohm's Law $V = IR$

In AC: $V(t) = I(t)\, R$

$$\sqrt{2}\, V_{rms} \sin(2\pi f t) = I(t)\, R$$

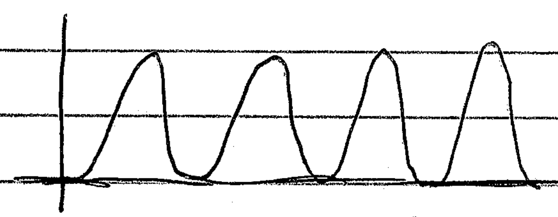
$$I = \sqrt{2}\, \underbrace{\frac{V_{rms}}{R}}_{I_{rms}} \sin(2\pi f t)$$

Ohm's Law for R in AC: $V_{rms} = I_{rms} R$

Power: $P = VI$

$$P(t) = \sqrt{2}\, V_{rms} \sin(2\pi f t)\, \sqrt{2}\, I_{rms} \sin(2\pi f t)$$
$$= 2\, V_{rms} I_{rms} \sin^2(2\pi f t)$$

$$\sin^2\theta = \frac{1}{2}(1 - \cos 2\theta)$$



$$P(t) = V_{rms} I_{rms} \left(1 - \cos(2\pi (2f) t)\right)$$

$P_{avg} = V_{rms} I_{rms}$

Pulses are at double the freq.

③

Inductors $\quad \mathcal{E} = -L\,dI/dt$

Inductor's EMF opposes change in current.
Resistors oppose current but $V = IR$
with no minus sign. This is the
"voltage drop" of the resistor
So, voltage drop of inductor is:

$$V_L = L\frac{dI}{dt}$$

Suppose $I = \sqrt{2}\,I_{rms}\sin(2\pi f t)$

$$V_L = L\left(\sqrt{2}\,I_{rms}\cos(2\pi f t)\,2\pi f\right)$$

$$= \sqrt{2}\underbrace{(2\pi f L)\,I_{rms}}\cos(2\pi f t)$$

$$V_{Rms} = \underbrace{2\pi f L}_{\text{Like } R}\,I_{rms}$$

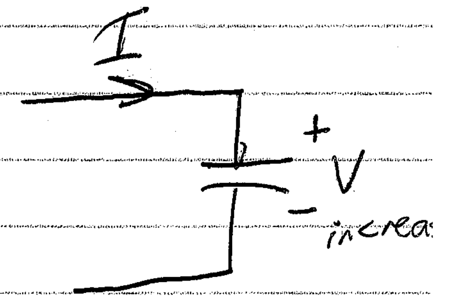
$X_L = 2\pi f L$ inductive reactance

Just inductor: $Z = X_L$ impedance

$V_{rms} = I_{rms}\,Z$ AC Ohm's Law

Capacitors $\quad Q = CV$

$$I = \frac{dQ}{dt} = C\frac{dV}{dt}$$



$$\sqrt{2}\, I_{rms} \sin(2\pi f t) = C \frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{\sqrt{2}\, I_{rms}}{C} \sin(2\pi f t)$$

$$V(t) = \frac{\sqrt{2}\, I_{rms}}{C} \left(-\cos(2\pi f t)\frac{1}{2\pi f}\right)$$

$$= -\sqrt{2}\, \underbrace{\frac{1}{2\pi f C} I_{rms}}_{V_{rms}} \cos(2\pi f t)$$

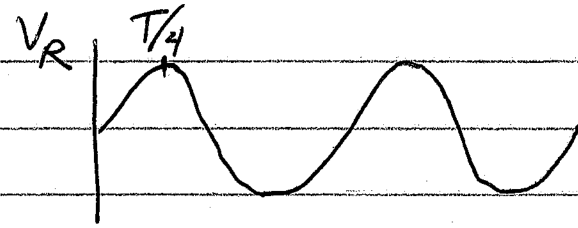
$$V_{rms} = \underbrace{\frac{1}{2\pi f C}}_{\text{Like } R} I_{rms}$$

$X_C = \frac{1}{2\pi f C}$ $\quad$ Capacitive Reactance

$V_{rms} = I_{rms} Z$ $\quad$ $I \propto \sin(\sim)$

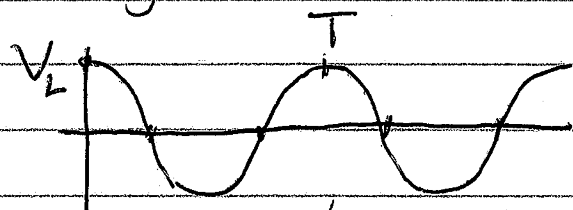
Resistor: $Z = R$ $\quad$ doesn't care about freq.

$V_R \propto \sin(\sim)$



Inductor: $Z = 2\pi f L$ $\quad$ hates change
high-f is blocked

$V_L \propto \cos(\sim)$

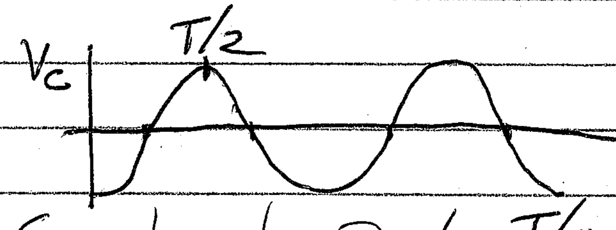


Voltage peaks @ $t = 0$
Current peaks @ $t = T/4$

"Current lags" in an inductor.

Capacitor: $Z = 1/(2\pi f C)$ $\quad$ blocks DC
almost blocks low-f

$V_C \propto -\cos(\sim)$



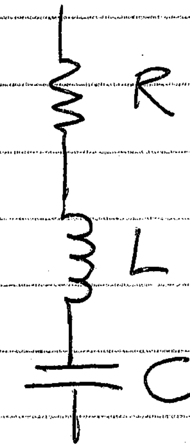
Current peaks @ $t = T/4$
Voltage peaks @ $t = T/2$

"Voltage lags" in a capacitor

⑥

Series RLC Circuit

$I = \sqrt{2} I_{rms} \sin(2\pi f t)$



$V_R = \sqrt{2} I_{rms} R \sin(2\pi f t)$

$V_L = \sqrt{2} I_{rms} (2\pi f L) \cos(2\pi f t)$

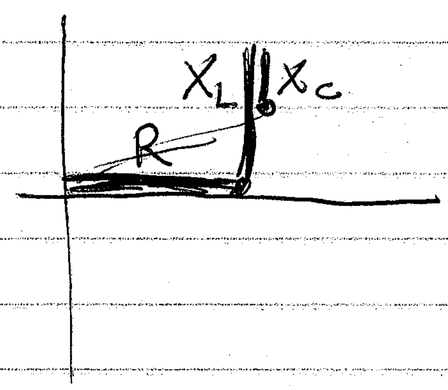
$V_C = \sqrt{2} I_{rms} \left(\frac{1}{2\pi f C}\right)(-\cos(2\pi f t))$

$V_{Tot} = V_R + V_L + V_C$ (As functions of time)

$= V_1 \sin(\sim) + V_2 \cos(\sim)$

$= \sqrt{2} V_{rms} \sin(\sim + \phi)$

Adding impedances as vectors



	x	y
R	R	
L		$X_L = 2\pi f L$
C		$-X_C = -1/(2\pi f C)$
Tot	R	$(X_L - X_C)$

$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$ $\qquad V_{rms} = I_{rms} Z$

$\phi = \operatorname{atan}\left(\frac{X_L - X_C}{R}\right)$ $\qquad P_{avg} = V_{rms} I_{rms} \cos\phi$