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Passive Components

Resistor - Opposes Current. $V = IR$

$V_{rms} = I_{rms} R$

Inductor - Opposes change in current. $V = L \frac{\Delta I}{\Delta t}$

$X_L = 2\pi f L$ $V_{rms} = I_{rms} X_L$

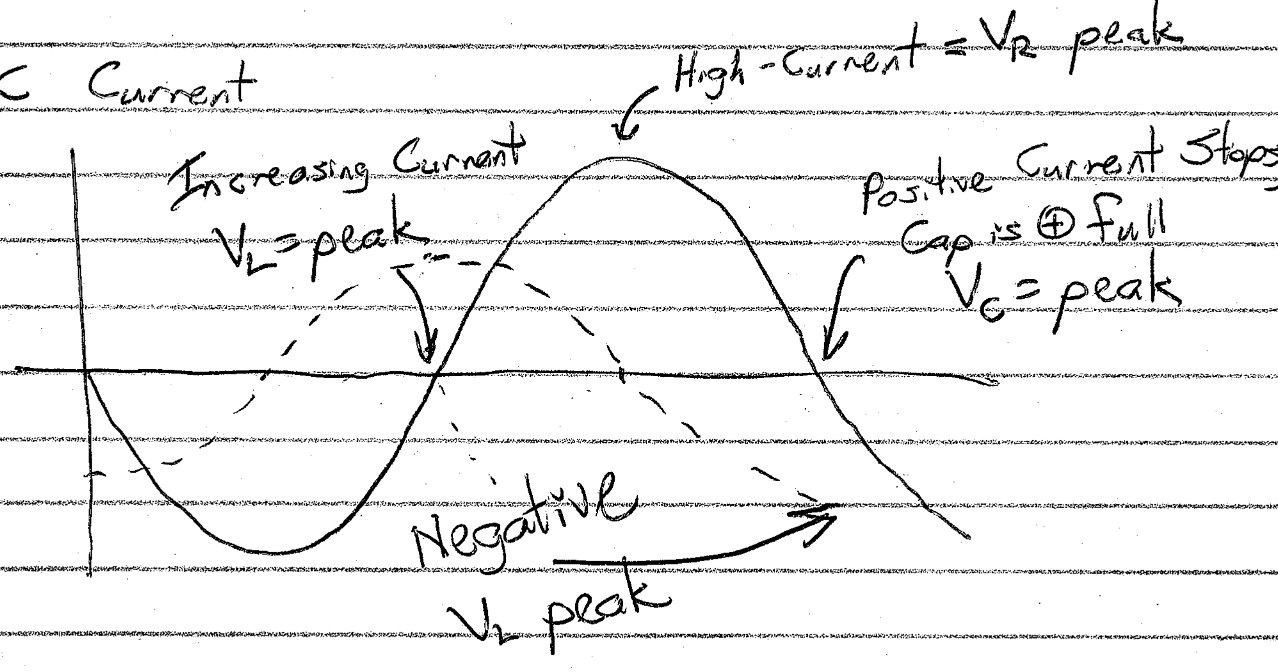
↑ opposes high-f

Capacitor - Current fills capacitor $I = \frac{\Delta Q}{\Delta t}$ $V = Q/C$

$X_C = \frac{1}{2\pi f C}$ $V_{rms} = I_{rms} X_C$

↑ passes high-f

AC Current



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Series DC Circuit

$I = \text{const}$

Same I in each component

Voltage adds $V_{tot} = V_1 + V_2 + \ldots$

Inductor: $X_L = 2\pi f L = 0$ Doesn't get in the way

Acts like a wire

Capacitor: $X_C = \frac{1}{2\pi f C} = \infty$ Blocks current

Caps get all of the voltage.

Resistors:

$$R_{eq} = R_1 + R_2 + \ldots$$
$$IR_{eq} = IR_1 + IR_2 + \ldots$$
$$V_{tot} = V_1 + V_2 + \ldots$$

Series AC Circuit

$I = I_0 \sin(2\pi f t)$

Same I in each component

$$V_L = +I_0 X_L \cos(2\pi f t)$$
$$V_R = I_0 R \sin(2\pi f t)$$
$$V_C = -I_0 X_C \cos(2\pi f t)$$

opposite

Must Add these voltage graphs.

- Know Lots of trig identities
- Graphical Method

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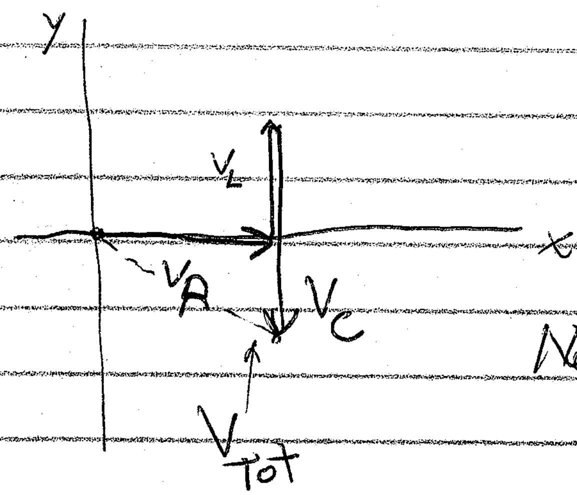
Add Voltages as vectors!

$V_R \rightarrow V_R\,\hat{x}$ (in the x-dir)
$V_L \rightarrow V_L\,\hat{y}$ (in the y-dir)
$V_C \rightarrow V_C\,(-\hat{y})$



Total x: V_R

Total y: $V_L - V_C$

Net Tot $= \sqrt{V_R^2 + (V_L - V_C)^2}$

$$IZ = I\sqrt{R^2 + (X_L - X_C)^2}$$

Net Impedance

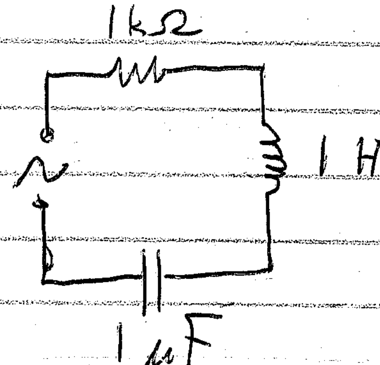
$V_R = IR$
$V_L = X_L I$
$V_C = X_C I$
(All RMS or All peak)

① Calculate Reactance $X = X_L - X_C$
② Calc Impedance $Z = \sqrt{R^2 + X^2}$
③ Apply AC Ohm's Law

$$V_{Tot} = IZ$$

Ex: $V = 140 \sin(500\, t) = \mathcal{E}$

- $V_{rms} = \frac{140}{\sqrt{2}} = 99\ V$
- $2\pi f = 500 \qquad f = \frac{500}{2\pi} = 79.6\ Hz$



- $R = 1000\ \Omega$
- $X_L = 2\pi f L$
  $= (500)(1.0)$
  $= 500\ \Omega$
- $X_C = \frac{1}{2\pi f C} = \frac{1}{(500)(1\times10^{-6})}$
  $= 2000\ \Omega$
- $X = X_L - X_C = -1500\ \Omega$
- $Z = \sqrt{R^2 + X^2} = \sqrt{\cancel{500}^{\,1000}{}^2 + 1500^2}$
  $= 1803\ \Omega$
  Z is always (+)
- $I = \frac{V}{Z} = (99\,v)/(1803\ \Omega)$
  $= 0.0549\ A = 54.9\ mA$
- Power is only used by the resistor
  $P = VI = I^2 R = (0.0549)^2 (1000)$
  $= 3.02\ W$
- Volt-Amp rating $= (99\,v)(0.0549\,A) = 5.44\ \cancel{W}\ V\cdot A$

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Resonance - If $X_L = X_C$, they cancel.

$$X_L = X_C$$

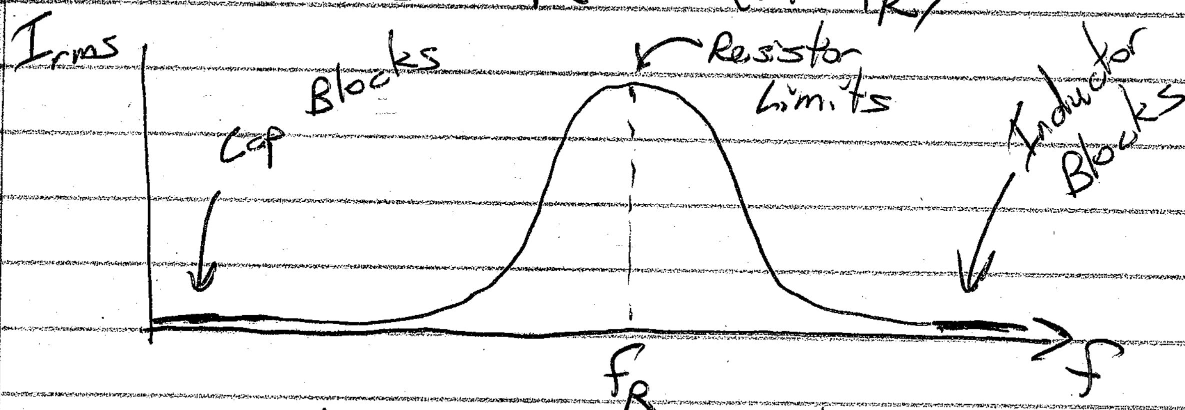
$$2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{(2\pi)^2 LC}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

This is a special frequency: resonant frequency.
The inductor & capacitor cooperate to pass current at f_R. Only the resistor impedes the current.

$$Z = R \quad (\text{at } f_R)$$



Same V_{rms} @ every point