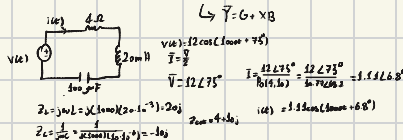


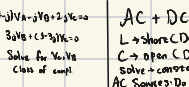
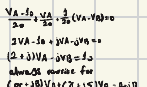
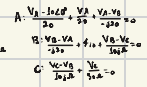
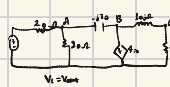
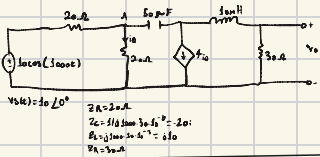
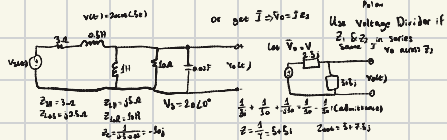
Z's add like R's, Y's add like G's



AC Circuits

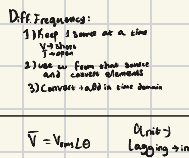
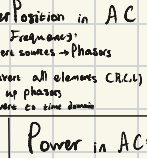
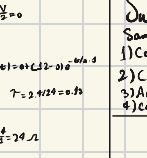
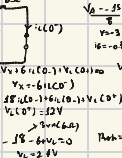
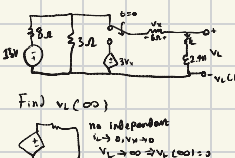
- Convert to phasor domain
Source → phasor
passives → impedance
- Solve for quantities as Phasors
- Convert to time domain

Current Peaks after lagging
Current Peak before leading



AC + DC:
L → short (DC)
C → open (DC)
Solve constants
AC Sources: Do phasors
V(t) = V_{AC} + V_{DC}

Lag: $\phi > 0$
Lead: $\phi < 0$
Unit: ϕ
 $-90^\circ < \phi < 90^\circ$



AC + DC:
L → short (DC)
C → open (DC)
Solve constants
AC Sources: Do phasors
V(t) = V_{AC} + V_{DC}

Lag: $\phi > 0$
Lead: $\phi < 0$
Unit: ϕ
 $-90^\circ < \phi < 90^\circ$

Superposition in AC

- Same Frequency:
1) Convert sources to Phasors
2) Convert all elements (R, L, C)
3) Add up phasors
4) Convert to time domain

- Diff. Frequencies:
1) Keep 1 source at a time
2) Use all from other sources and calculate elements
3) Convert each to time domain

Power in AC

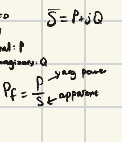
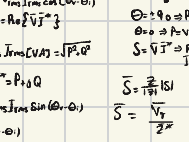
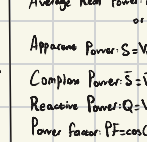
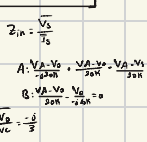
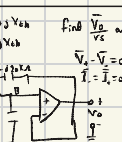
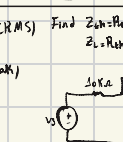
Average Real Power: $P = V_{rms} I_{rms} \cos(\phi)$
or $P = Re\{V I^*\}$
Apparent Power: $S = V_{rms} I_{rms} [VA] = \sqrt{P^2 + Q^2}$
Complex Power: $\tilde{S} = V I^* = P + jQ$
Reactive Power: $Q = V_{rms} I_{rms} \sin(\phi)$
Power Factor: $PF = \cos(\phi)$

Unit: $Q [var]$
 $\phi = 90^\circ \Rightarrow P=0$
 $\phi = 0 \Rightarrow P=S$
 $S = \sqrt{P^2 + Q^2}$
Imaginary: Q
Real: P
 $P_f = \frac{P}{S}$
Lagging → Inductive
Leading → Capacitive

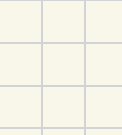
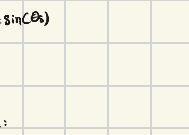
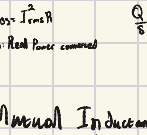
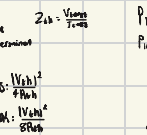
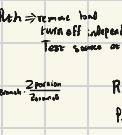
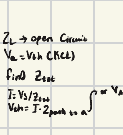
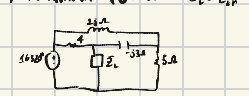
Unit: Q
 $\phi = 90^\circ \Rightarrow P=0$
 $\phi = 0 \Rightarrow P=S$
 $S = \sqrt{P^2 + Q^2}$
Imaginary: Q
Real: P
 $P_f = \frac{P}{S}$
Lagging → Inductive
Leading → Capacitive

Max Power:

$Z_L = Z_{th}$ i.e. $R_L = R_{th}$
 $V_L = V_{th}$
 $P_{max} = \frac{V_{th}^2}{4R_{th}}$ (Peak)
Op-amps and Phasors
 $i = L \cdot \frac{dv}{dt}$ Inverting: $\tilde{V}_o = -\frac{Z_f}{Z_{in}} \tilde{V}_{in}$



Maximum Power:



Power Factor Correction: $Z = R + jX$

Use: $Q_c = P(\tan \theta - \tan \theta_c)$
 θ : Initial
 θ_c : Desired
Step 1) Get initial
 θ : $\arccos(\frac{P}{S})$ or $\arccos(pf)$
Step 2) Read P from
 $P = V_{rms} I_{rms} \cos \theta$
Step 3) Plug in

Make $PF = 1$ (Target value)
 $X > 0$: lagging
 $X < 0$: leading
 $\tilde{S} = P + jQ$
 $pf = \cos(\theta) = \frac{P}{S}$

If inductive: add capacitor
If capacitive: add inductor
 $Q_c = \frac{P}{\tan \theta_c} - \frac{P}{\tan \theta} \Rightarrow C = \frac{Q_c}{\omega V}$
 $Q_L = \frac{P}{\tan \theta} - \frac{P}{\tan \theta_c} \Rightarrow L = \frac{Q_L}{\omega V}$

$RMS: \frac{V_{th}}{\sqrt{2}}$
Peak: $\frac{V_{th}}{\sqrt{2}}$
 $RMS: \frac{V_{th}}{\sqrt{2}}$
Peak: $\frac{V_{th}}{\sqrt{2}}$

Power: $I_{rms} R$
Power: Real Power consumed
Ideal Transformer:
Trans. ratio: $n = N_2/N_1$
 $V_2 = \frac{V_1}{n} = \frac{N_1}{N_2} V_1$ Step up: $n < 1$ (Secondary V_2 , I_2)
 $I_2 = \frac{I_1}{n} = \frac{N_1}{N_2} I_1$ Step down: $n > 1$ (Secondary V_2 , I_2)

Total Inductance:
 $L = L_1 + L_2 + 2M$ (dots same end)
 $L = L_1 + L_2 - 2M$ (dots opposite end)
 $V = \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} M...$

Total Inductance:
 $L = L_1 + L_2 + 2M$ (dots same end)
 $L = L_1 + L_2 - 2M$ (dots opposite end)
 $V = \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} M...$

Solving for minimum:

- Label currents, check dot convention
- Write V_1/V_2
- Solve with KVL/KCL

Ideal Transform:

- Identify what side to reflect
- Reflect Impedance/Voltage/Current
- Solve reflected circuit
- Transform back if needed

$\tilde{S}_1 = \tilde{V}_1 \tilde{I}_1^* = \tilde{V}_2 \tilde{I}_2^* = \tilde{S}_2$
 $P_1 = P_2$
 $Q_1 = Q_2$

$\tilde{S}_1 = \tilde{V}_1 \tilde{I}_1^* = \tilde{V}_2 \tilde{I}_2^* = \tilde{S}_2$
 $P_1 = P_2$
 $Q_1 = Q_2$

$\tilde{S}_1 = \tilde{V}_1 \tilde{I}_1^* = \tilde{V}_2 \tilde{I}_2^* = \tilde{S}_2$
 $P_1 = P_2$
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$\tilde{S}_1 = \tilde{V}_1 \tilde{I}_1^* = \tilde{V}_2 \tilde{I}_2^* = \tilde{S}_2$
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