

Announcements

- HW passwords username “student”
- Faculty candidates Feb 7th-23rd at 11:00
 - 7th, 9th, 12th – Dr. Costinett hosting

INSTITUTE FOR A SECURE & SUSTAINABLE ENVIRONMENT

JOIN OUR TEAM



JOB POSITION:

- Contribute to energy justice research and policy initiatives
- Aid in creating equitable energy solutions for diverse demographics
- Connect with the community, shape policy, and work on projects that create positive change

Make a difference in East Tennessee's energy landscape while earning a paycheck!

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ISSE

Ideal Transformer Example

Autotransformer (Variac)

$V_L = f(N, R_L, R_x) V_S$

Equations: $\textcircled{7}$ $\textcircled{7}$
 Unknowns: $N_L, N_1, N_2, V_L, V_x, i_1, i_2, i_x$

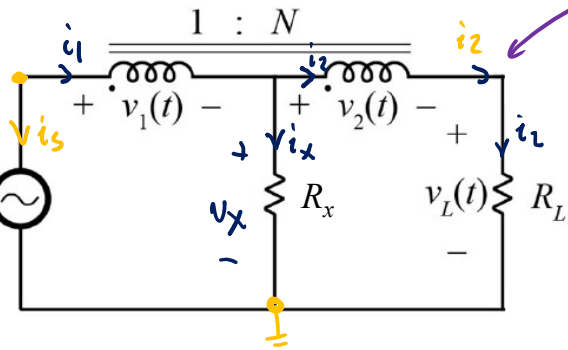
KVL: $N_x = N_2 + N_L$

$N_S = N_1 + N_2 + N_L$

$N_S = \left(\frac{1}{N} + 1\right) N_2 + N_L$

$N_S = \left(\frac{N+1}{N}\right) (N_x - N_L) + N_L$

$N_S = \frac{N+1}{N} N_x + N_L \frac{-1}{N}$



solve for $V_L(t)$

Transformer equations

$N_1 = \frac{N_2}{N}$

$i_1 = -N i_2$

other elements

$N_x = i_x R_x$

$N_L = i_2 R_L$

KCL: $i_1 = i_2 + i_x$

$i_x = i_1 - i_2$

$\frac{N_x}{R_x} = i_x = -(N+1) i_2 = -(N+1) \frac{V_L}{R_L}$

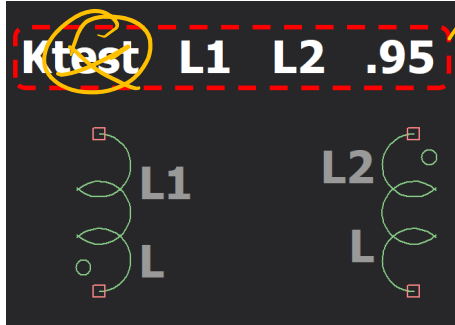
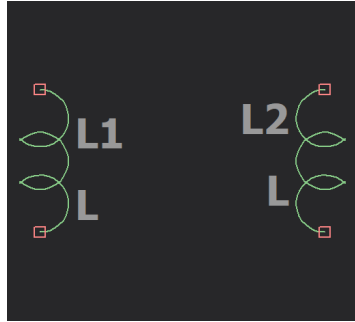
$N_x = -\frac{R_x}{R_L} (N+1) V_L$

$N_S = \left[-\frac{(N+1)^2 R_x}{N} - \frac{1}{N} \right] N_L$

$N_L = \left(\frac{-N}{1 + \frac{(N+1)^2 R_x}{R_L}} \right) V_S$

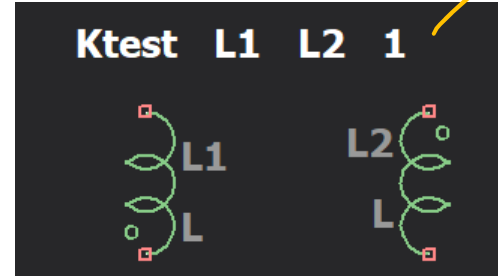
Spice Mutual Inductance and XFs

Coupled Inductors



coupling coefficient

Ideal Transformer



*k=1
\$
L1, L2 "large"*

$$L_1 = \alpha_1 N_1^2$$

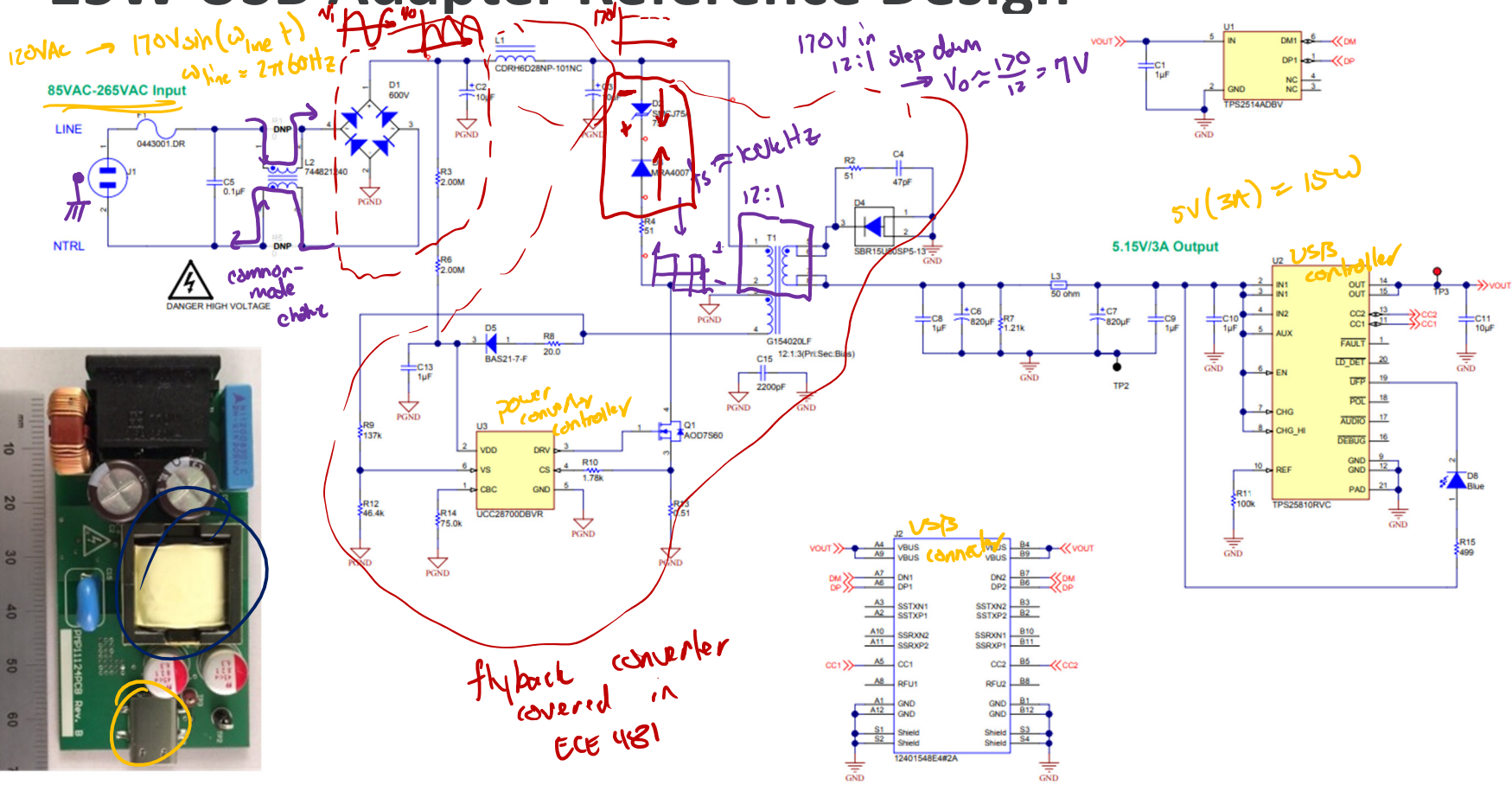
$$L_2 = \alpha_2 N_2^2$$

$\alpha_1 = \alpha_2$ when $k=1$

$$\frac{L_1}{L_2} = \frac{N_1^2}{N_2^2}$$

$$\frac{N_1}{N_2} = \sqrt{\frac{L_1}{L_2}}$$

15W USB Adapter Reference Design



If we hook 170Vpk @ 60Hz up to the XF

XF part has $L_1 = 170 \mu\text{H}$

$$\begin{cases} V_1 = L_1 \frac{di_1}{dt} \pm M \frac{di_2}{dt} \\ V_2 = \pm M \frac{di_1}{dt} + L_2 \frac{di_2}{dt} \end{cases}$$

No phase connected
 $i_2 = \emptyset$

$$i_1 = \frac{1}{L_1} \int_0^t V_1(t) dt = \frac{1}{L_1} \int_0^t 170 \sin(2\pi 60 t) dt = -\frac{1}{L_1} \frac{1}{2\pi 60} 170 \cos(2\pi 60 t) \\ = \underline{\underline{2.6 \text{ kA}}} !! \rightarrow \text{Ideal XF equations don't apply}$$

At 100kHz instead of 60Hz

$$i_1 = \frac{1}{L} \frac{1}{2\pi 100 \text{ kHz}} 170 \cos(2\pi (100 \text{ kHz}) t)$$

$= 1.5 \text{ A} \approx \alpha$ to apply ideal XF equations