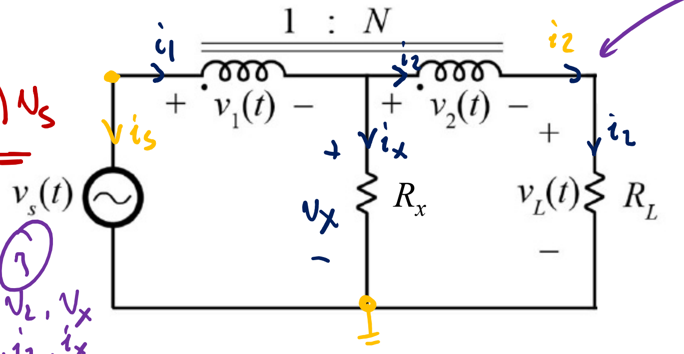
# Announcements

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

# Ideal Transformer Example

Autotransformer (variac)




$v_L = f(N, R_L, R_x)\, v_s$

Equations: 7

Unknowns: $v_L, v_1, v_2, v_x, i_1, i_2, i_x$ (7)

solve for $v_L(t)$

**Transformer equations**

$$v_1 = \frac{v_2}{N}$$

$$i_1 = -N i_2$$

**other elements**

$$v_x = i_x R_x$$

$$v_L = i_2 R_L$$

**KVL:**

$$v_x = v_2 + v_L$$

$$v_s = v_1 + v_2 + v_L$$

**KCL:**

$$i_1 = i_2 + i_x$$

$$i_x = i_1 - i_2$$

$$\frac{v_x}{R_x} = i_x = -(N+1)\, i_2 = -(N+1)\frac{v_L}{R_L}$$

$$v_x = -\frac{R_x}{R_L}(N+1)\, v_L$$

$$v_s = \left(\frac{1}{N} + 1\right) v_2 + v_L$$

$$v_s = \left(\frac{N+1}{N}\right)(v_x - v_L) + v_L$$

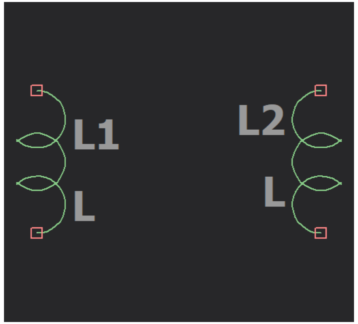
$$v_s = \frac{N+1}{N} v_x + v_L \frac{-1}{N}$$

$$v_s = \left[-\frac{(N+1)^2}{N}\frac{R_x}{R_L} - \frac{1}{N}\right] v_L$$

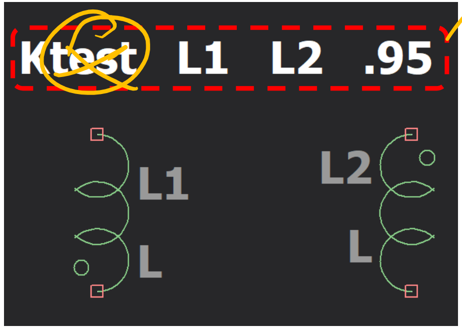
$$v_L = \left(\frac{-N}{1 + (N+1)^2 \frac{R_x}{R_L}}\right) v_s$$

# Spice Mutual Inductance and XFs

## Coupled Inductors








k
coupling coefficient

## Ideal Transformer


k = 1
⇕
$L_1, L_2$ "large"

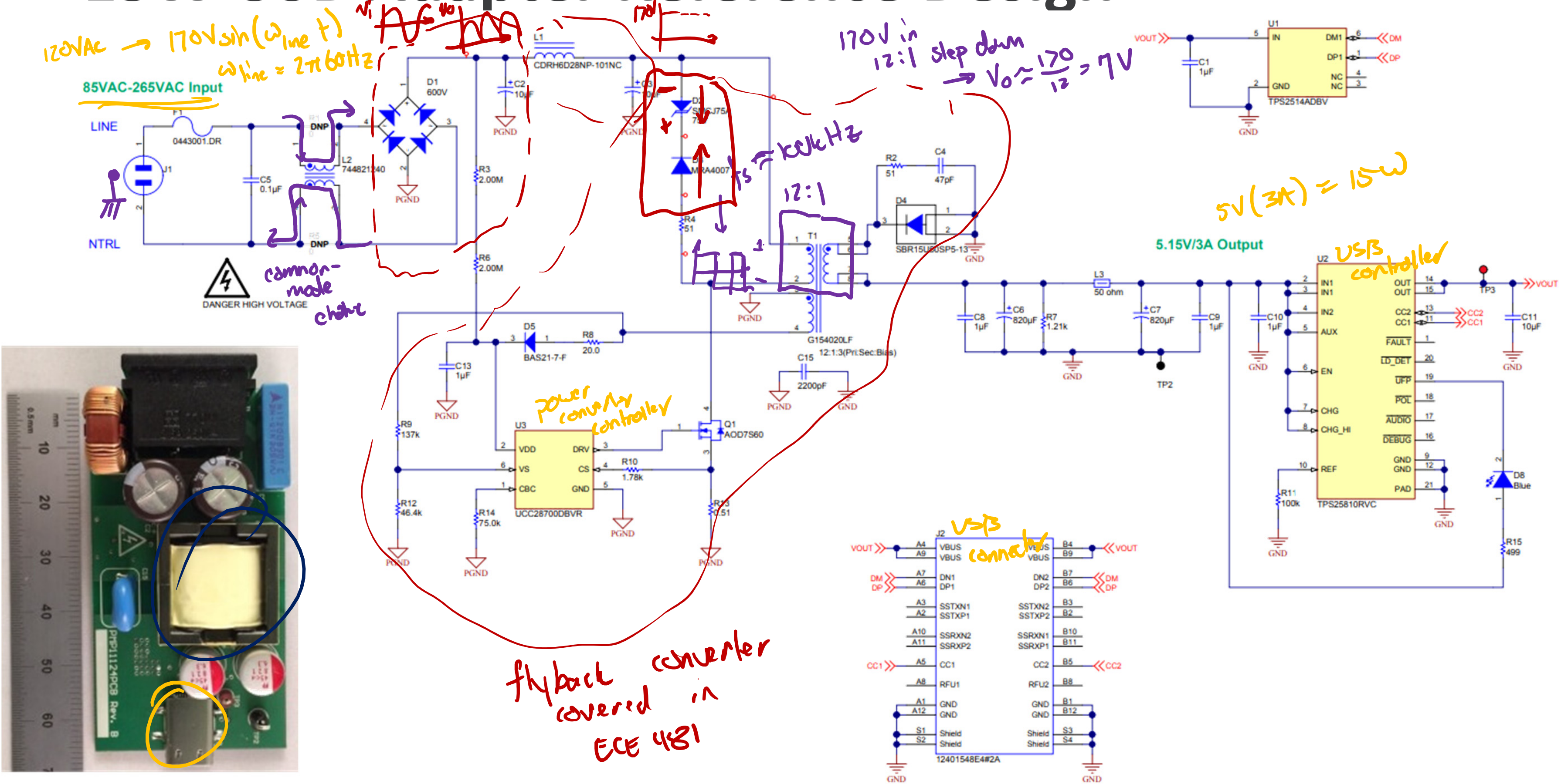
$L_1 = \alpha_1 N_1^2$

$L_2 = \alpha_2 N_2^2$

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

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

# 15W USB Adapter Reference Design



If we hook 170 $V_{pk}$ @ 60Hz up to the XF

XF part has $L_1 = 170\,\mu H$

$$\begin{cases} v_1 = L_1 \frac{di_1}{dt} \pm \cancel{M \frac{di_2}{dt}} \\ v_2 = \pm M \frac{di_1}{dt} + \cancel{L_2 \frac{di_2}{dt}} \end{cases}$$

No phone connected $i_2 = \phi$

$$i_1 = \frac{1}{L_1}\int_0^t v_1(t)\,dt = \frac{1}{L_1}\int_0^t 170\sin(2\pi 60 t)\,dt = -\frac{1}{L_1}\frac{1}{2\pi 60} 170 \cos(2\pi 60 t)$$

$$= \underline{2.6\,kA} \;!!$$ → Ideal XF equations don't apply

At 100kHz instead of 60Hz

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

$$= 1.5A$$ ≈ ok to apply ideal XF equations