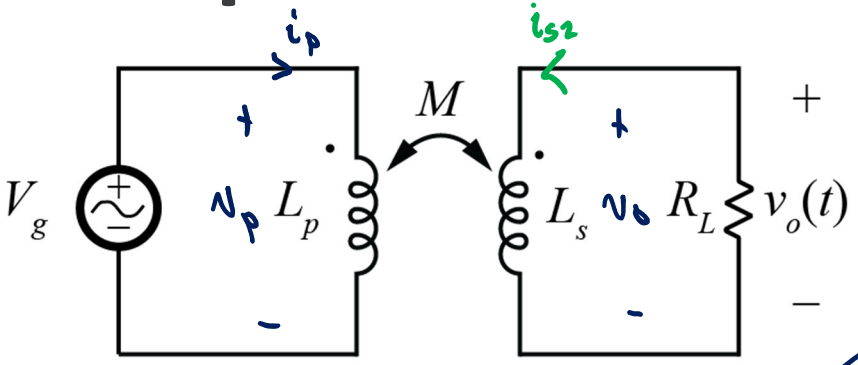
Announcements

- Homework 1 is posted, due 2/4 before 10:30am
  - Submitted to canvas as a single pdf
  - First two problems are ECE 201 review
- Can begin self-assigning lab groups of 2-3 in Canvas (people → Groups tab)
- No in-person office hours today
  - e-mail to set up alternative time or meet on Zoom

Coupled Inductor Example

unknowns ||||
equations ||||

Solve for $v_o(t)$



$$\begin{cases} v_p = L_p \dfrac{di_p}{dt} + M \dfrac{di_s}{dt} \\ v_s = M \dfrac{di_p}{dt} + L_s \dfrac{di_s}{dt} \end{cases}$$

$v_g = v_p$

$v_s = v_o$

$v_o = -i_s R_L$

$$\begin{cases} v_g = L_p \dfrac{di_p}{dt} + M \dfrac{di_s}{dt} \\ -i_s R_L = M \dfrac{di_p}{dt} + L_s \dfrac{di_s}{dt} \end{cases}$$

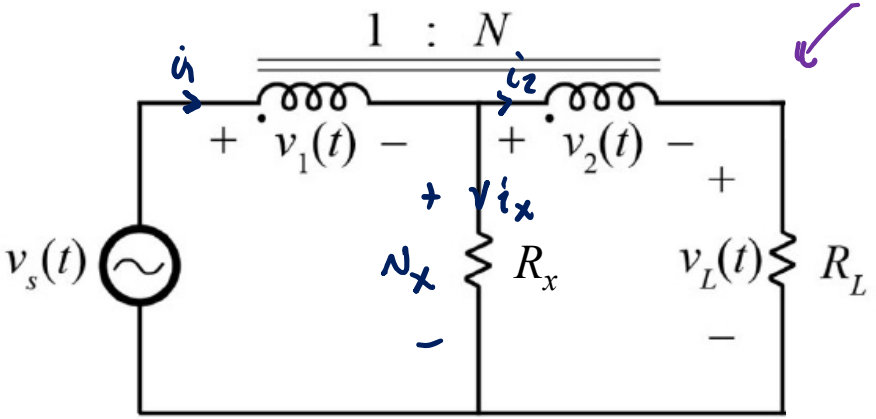
$$\frac{di_p}{dt} = \frac{v_g - M \frac{di_s}{dt}}{L_p}$$

$$-i_s R_L = \frac{M}{L_p}\left(v_g - M \frac{di_s}{dt}\right) + L_s \frac{di_s}{dt}$$

$$\boxed{\phi = \frac{M}{L_p} v_g + i_s R_L + \left(L_s - \frac{M^2}{L_p}\right) \frac{di_s}{dt}}$$

$i_s = -i_{s2}$

Ideal Transformer Example



"Autotransformer" → e.g. a variac

Solve for $v_L(t)$

Transformer Equations:

$$\frac{v_1}{1} = \frac{v_2}{N} \quad \& \quad i_1 + N i_2 = 0$$

KCL Node:

$$i_2 = i_L$$

$$i_1 = i_x + i_2$$

$$-N i_2 - i_2 = i_x$$

$$-i_2(N+1) = i_x$$

$$-\frac{v_L}{R_L}(N+1) = \frac{v_x}{R_x} = \frac{v_L + v_2}{R_x}$$

$$v_2 = -\frac{R_x}{R_L}(N+1)\,v_L - v_L$$

KVL Loop:

$$v_x = v_2 + v_L$$

$$v_s = v_1 + v_2 + v_L$$

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

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

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

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

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

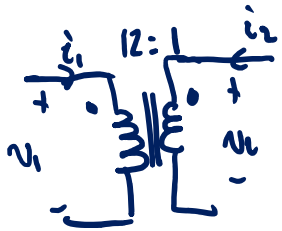
15W USB Adapter Reference Design

https://www.ti.com/tool/PMP11124

THE UNIVERSITY OF TENNESSEE KNOXVILLE

Full details of Flyback in FEEN81

Flyback transformer



$k \approx 1$

$L_1 = 170\,\mu H$

Assume $v_1 = \frac{170}{2}\sin(2\pi f_s t)$ $\quad f_s = 100\,kHz$

① Ideal Transformer: if $i_2 = 0$, $i_1 = 0$

$$v_2 = \frac{1}{12} v_1 = \frac{170}{24}\sin(2\pi f_s t) \approx 7\sin(2\pi f_s t)$$

② Non-ideal (still $k = 1$)

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

consider no phone connected $i_2 = 0$

$$i_1 = \frac{1}{L}\int_0^t v_1\,dt \quad = \quad i_1 = -\frac{1}{L}\frac{1}{2\pi f_s}\frac{170}{2}\cos(2\pi f_s t)$$

$$i_1 = -\left(\frac{1}{L_1}\frac{1}{2\pi f_s}\frac{170}{2}\right)\cos(2\pi f_s t)$$

$$I_{1A} = 796\,mA$$

If we run 60 Hz onto the transformer

$$I_{1A} = \left(-\frac{1}{L_1}\frac{1}{2\pi 60}\frac{170}{2}\right) = 1.3\,kA\,!!$$

Definitely not ideal