Lecture # 27 12/6/21

- Lab discussion
  - ↳ Get η w/ 24 V input, 48 (or 50) V output
    - → Configure meters to give avg/filtered readout.
    - → Use beefy banana cables (esp @ input).
    - → Can "double-up" wires on input side for higher η.

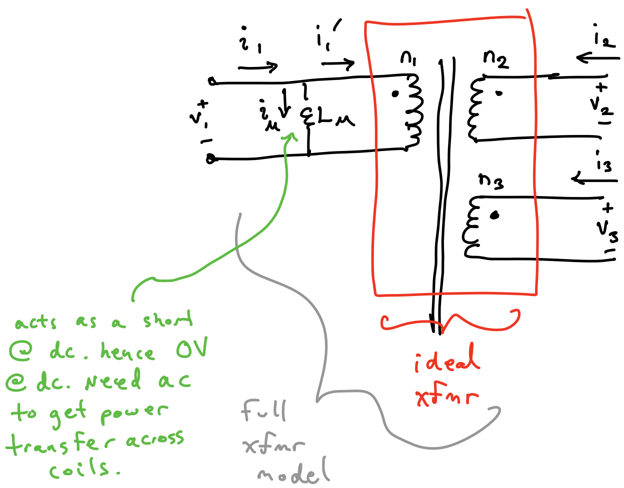
- Today
  - → Ch 6 continued
  - → Transformer-based converters
    - ↳ $\underbrace{\text{Flyback converter}}_{\text{HW 8, one problem only}}$

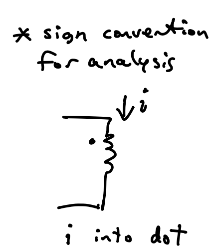
- Transformer Isolation (6.3 in book)

  why?

  - Gives isolation for safety
  - Push up f_s to get small/cheap xfmr.
  - Turns ratio can give very large conversion ratio
  - Multiple inputs/outputs w/ extra windings.

- Transformer analysis basics





Equiv model w/ 2 components

- L_M = magnetizing inductance
- Ideal xfmr.

• Golden eqn for ideal xfmr gives

$$\boxed{\frac{v_1}{n_1} = \frac{v_2}{n_2} = \frac{v_3}{n_3} = \dots \qquad (1)}$$

Ideal xfmr cannot absorb power

$\hookrightarrow P_{in} = P_{out}$

implies

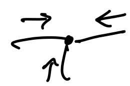
$$0 = v_1 i_1' + v_2 i_2 + v_3 i_3$$

$*$ use (1) to get $v_2 = \frac{n_2}{n_1} v_1$ & $v_3 = \frac{n_3}{n_1} v_1$

$$= \cancel{v_1} i_1' + \frac{n_2}{n_1} \cancel{v_1} i_2 + \frac{n_3}{n_1} \cancel{v_1} i_3 = 0$$

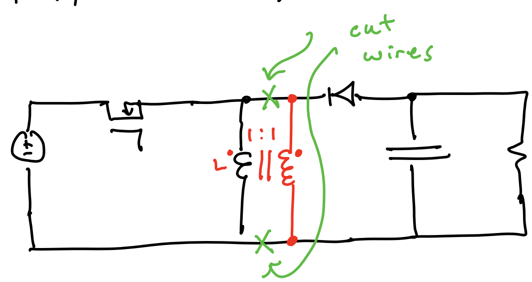
$$\Longrightarrow \boxed{n_1 i_1' + n_2 i_2 + n_3 i_3 = 0} \quad (2)$$

KCL-like eqn for xfmr



– Flyback Conv.

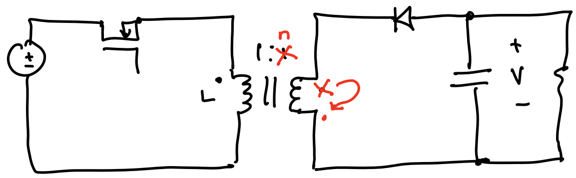
Start w/ buck-boost



● = step 1

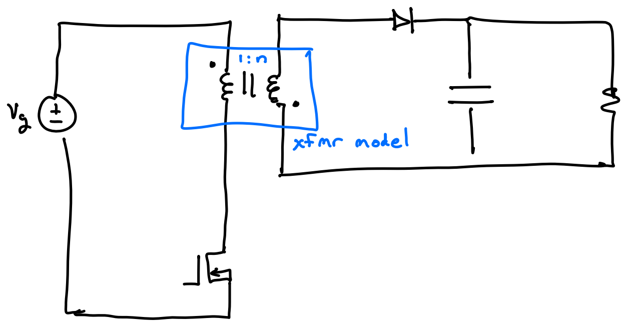
● = step 2

seperate halves

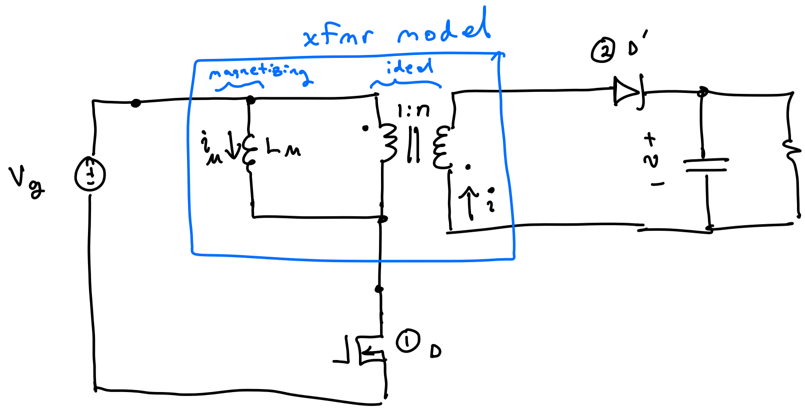


- Generalize to 1:n turns
- Invert polarity of 2nd coil to get ⊕ voltage V.
- Move sw to "low side" to simpify drive ckt.

"The flyback"



- Modeling for analysis. Add xfmr model



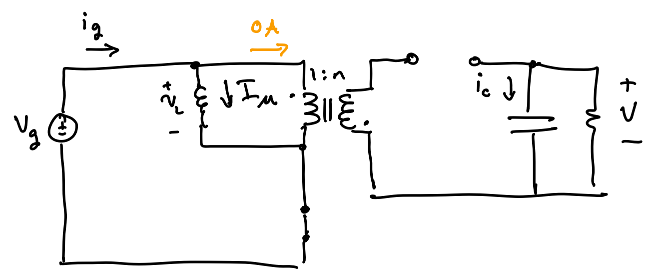
- L_M behaves like a "typical" inductor. In steady state, can use SRA

$$i_M \approx I_M$$

$$v \approx V$$

- Analyze config ① & ②

  - For ①



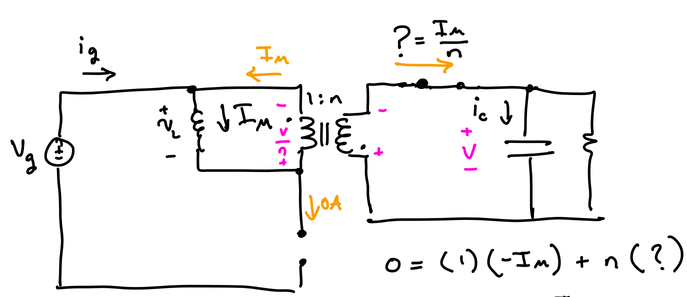
$$v_L = V_g \quad , \quad i_c = \frac{-V}{R}$$

$$i_g = i_m \approx I_M$$

  - For ②

$$\frac{?}{n_1} = \frac{-V}{n_2}$$

$$\hookrightarrow ? = -V\frac{n_1}{n_2} = -V\frac{1}{n}$$



$$0 = (1)(-I_M) + n(?)$$

$$\Rightarrow ? = \frac{I_M}{N}$$

$$v_L = \frac{-V}{n} \quad , \quad i_c = \frac{I_M}{n} - \frac{V}{R}$$

$$i_g = 0$$

Apply v-sec balance & Q balance

- $\langle v_L \rangle = 0 = D(V_g) + D'\left(\frac{-V}{n}\right) \qquad (1)$

  (1) gives $M = \frac{V}{V_g}$

  $\hookrightarrow \frac{V}{n} D' = D V_g$

  $\hookrightarrow M = \frac{V}{V_g} = n \frac{D}{D'} = \boxed{n \frac{D}{1-D} = M}$

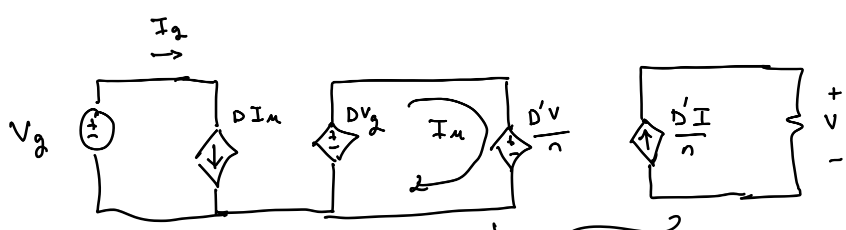
  like buck boost! but w/ n turns & no ⊖ sign.

- $\langle i_c \rangle = 0 = D\left(\frac{-V}{R}\right) + D'\left(\frac{I_M}{n} - \frac{V}{R}\right)$

  can solve for I_M

  $I_M = \frac{nV}{D'R}$ & $I_g = \langle i_g \rangle = D I_M$

get equiv ckt



captures physical xfmr

— Flyback application:

Phone charger